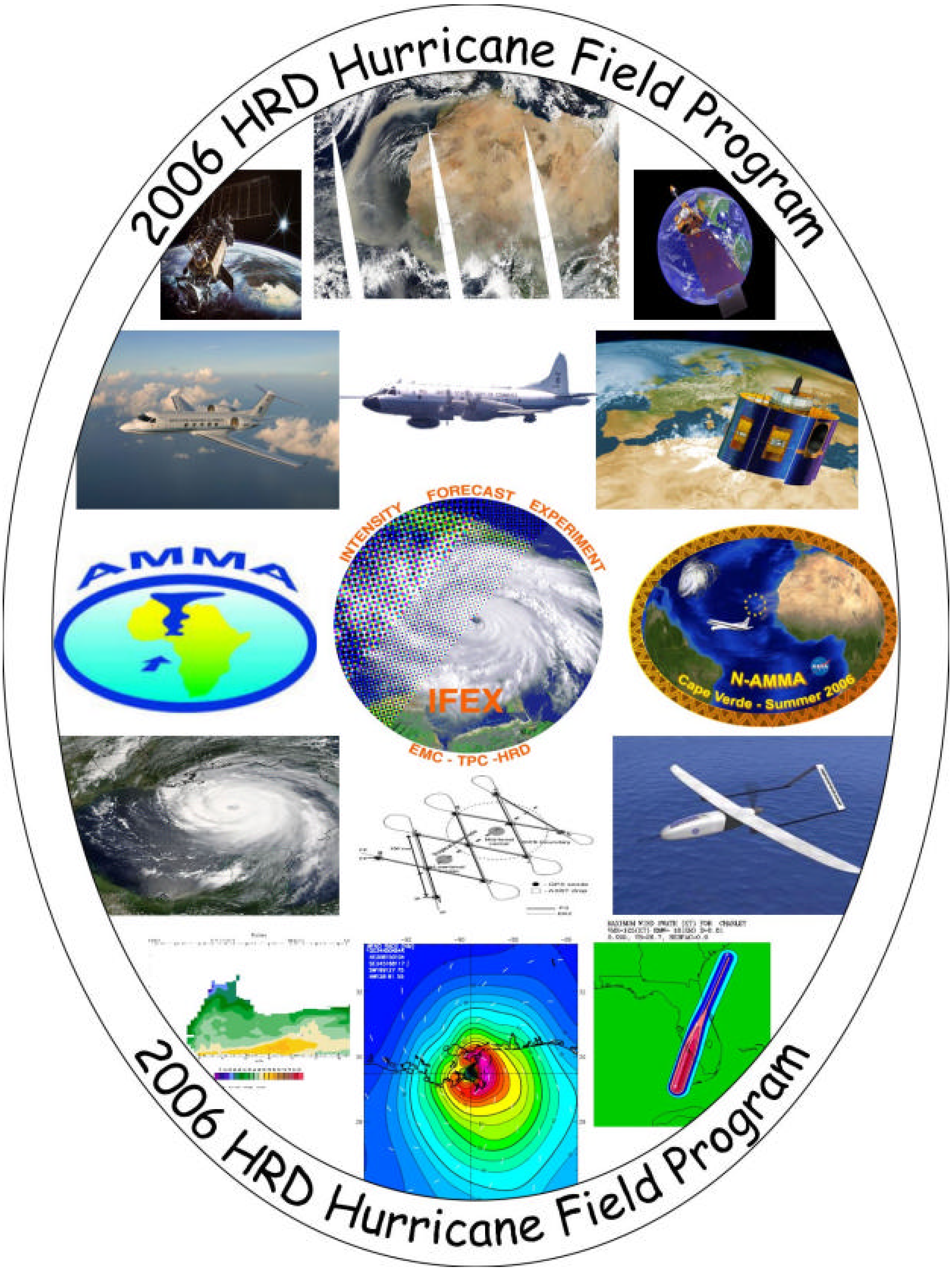
2006 HRD Hurricane Field Program
INTENSITY FORECAST EXPERIMENT
IFEX
EMC - TPC -HRD
AMMA
N-AMMA
Cape Verde - Summer 2006
2006 HRD Hurricane Field Program

2006 Hurricane Field Program Plan

Hurricane Research Division
National Oceanographic and Atmospheric Administration
Atlantic Oceanographic and Meteorological Laboratory
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Date

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Cover: NOAA's Intensity Forecasting Experiment (IFEX), NASA's NAMMA field campaign, and the African Monsoon Multidisciplinary Analyses (AMMA) will provide the framework for HRD's 2006 hurricane field program. Several of the aircraft platforms, satellites, aircraft research experiments, and aircraft operational missions that will be conducted in 2006 appear on the cover and are discussed in detail in the hurricane field program

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2006 HURRICANE FIELD PROGRAM PLAN

INTRODUCTION

National Oceanic and Atmospheric Administration
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One of the key activities in NOAA's Strategic Plan Mission Goal 3 ("Reduce Society's Risks from Weather and Water Impacts") is to improve the understanding and prediction of tropical cyclones (TCs). The National Centers for Environmental Prediction (NCEP) Tropical Prediction Center (TPC) is responsible for forecasting tropical cyclones in the Atlantic and East Pacific basins, while the Environmental Modeling Center (EMC) provides NWP guidance for the forecasters. Together they have made great strides in improving forecasts of TC track. With support from the research community, forecast errors of TC track have decreased by about 50% over the past 30 years. However, there has been much less improvement in forecasts of TC intensity and rainfall. The lack of improvement in intensity and rainfall forecasting is largely the result of deficiencies in routinely collecting inner-core data and assimilating it into the modeling system, limitations in the numerical models themselves, and gaps in our understanding of the physics of TCs and their interaction with the environment. Accurate forecasts will rely heavily on the use of improved numerical modeling systems, which in turn will rely on accurate observational datasets for assimilation and validation.

The next-generation TC model, the Hurricane Weather Research and Forecasting model (HWRF), is currently under development at EMC and is anticipated to become operational in 2007. The HWRF will run at high resolution (~10 km grid length initially), using improved data assimilation techniques and physical parameterizations. Such a configuration holds the hope of improving our understanding and forecasting of tropical cyclone track, intensity, structure, and rainfall. In order to realize such improvements, however, new data assimilation techniques must be developed and refined, physical parameterizations must be improved and adapted for TC environments, and the models must be reliably evaluated against detailed observations from a variety of TCs and their surrounding environments.

To conduct the research necessary to address the issues raised above, NOAA has proposed an experiment designed to improve operational forecasts of TC intensity, called the Intensity Forecasting EXperiment (IFEX). The goals of this experiment have been developed through a partnership involving NOAA's Hurricane Research Division (HRD), TPC, and EMC. The goals of IFEX are to improve operational forecasts of tropical cyclone intensity and rainfall by providing data to improve the operational numerical modeling system (i.e., HWRF) and by improving our understanding of the physics of intensity change and rainfall. These goals will be accomplished by satisfying a set of requirements and recommendations guiding the collection of the data:

- **Goal 1**: Collect observations that span the TC lifecycle in a variety of environments;
- **Goal 2**: Develop and refine measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment;
- **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

A unique, and critical, aspect of IFEX is the focus on providing measurements of TCs at all stages of their life cycle, from pre-genesis to intensification and subsequent landfall, decay over water, or extratropical transition. The focus of hurricane research flights during the past 25 years has been on mature storms, leading to a dataset biased toward these types of systems. The strategy of observing the entire life cycle of a TC is new and unique, and it will provide invaluable information, particularly in sparsely observed environments. The ability to target multiple basins provides greater flexibility for observing TCs at different stages of their life cycle.

The field program aircraft missions presented in this document are separated into two distinct sections: 1) HRD Research Experiments; and 2) NHC and EMC Operational Missions. The flight patterns that comprise these various research experiments and operational missions address various aspects of the tropical cyclone lifecycle, and they all specifically address the main goals of IFEX. There is an experiment to investigate the impact of a phenomenon called the Saharan Air Layer on tropical cyclone intensity change, an experiment that will involve the use of the Aerosonde unmanned aircraft system (UAS) to sample the tropical cyclone environment, including the low-level regions of the tropical cyclone boundary layer, an experiment to study tropical cyclogenesis, an experiment to measure the structural and subsequent decay of tropical cyclones that make landfall, an experiment to sample mesovortices in the eye of intense hurricanes, an operational mission designed to improve model forecasts of tropical cyclone track by sampling the surrounding tropical cyclone environment, an operational mission to sample mature tropical cyclones to investigate tropical cyclone intensity/structure, provide data to initialize/validate operational forecast models, and improve/evaluate technologies for observing tropical cyclones, and a research experiment designed to improve understanding of microwave scatterometer retrievals of the ocean surface wind. These research experiments and operational missions will be conducted with the NOAA/Aircraft Operations Center (AOC) WP-3D N42RF and Gulfstream IV-SP aircraft. A summary of each experiment/operational mission, along with which IFEX goals each specifically addresses, is included below. A more detailed description of each experiment/operational mission follows, which includes a description of the scientific rationale for the experiment/operational mission and details of the associated flight patterns.

(1) Saharan Air Layer Experiment: This is a multi-option, multi-aircraft experiment which uses GPS dropwindsondes launched from the NOAA GIV and NOAA WP-3D to examine the thermodynamic and kinematic structure of the Saharan Air Layer (SAL) and its potential impact on tropical cyclone (TC) genesis and intensity change. The GPS dropwindsonde drop points will be selected using real-time GOES SAL tracking imagery from UW-CIMSS and mosaics of SSM/I total precipitable water from the Naval Research Laboratory. Specific effort will be made to gather atmospheric information within the Saharan Air Layer as well as regions of high moisture gradients across its boundaries and the region of its embedded mid-level easterly jet. The goals of this experiment are to better understand and predict how the SAL's dry air, mid-level easterly jet, and suspended mineral dust affect Atlantic TC intensity change and to assess how well these components of the SAL are being represented in forecast models. This experiment addresses IFEX Goals 1 and 3.

(2) Aerosonde Experiment: This is a multi-option, multi-aircraft experiment that uses the Aerosonde UAS and GPS dropwindsondes/aircraft expendable bathythermographs (AXBTs) launched from the NOAA WP-3D to fully demonstrate and utilize the unique capabilities of the Aerosonde platform to document areas of the tropical cyclone environment that would otherwise be either impossible or impractical to observe. It is planned that this effort will be based in Key West, FL. The immediate focus of this experiment is to document and significantly improve our understanding of the rarely-observed tropical cyclone boundary layer and undertake detailed comparisons between in-situ and remote-sensing observations obtained from manned aircraft (NOAA WP-3D and AFRES C-130) and satellite based platforms. In addition, a primary objective of this effort is to provide real-time, near-surface wind observations to the National Hurricane Center in direct support of NOAA operational requirements. These unique data will also be made available to EMC for both data initialization and forecast verification purposes. . This experiment addresses IFEX Goals 1, 2, and 3.

(3) Tropical Cyclogenesis Experiment*:* This multi-option, multi-aircraft experiment is designed to study how a tropical disturbance becomes a tropical depression with a closed surface circulation. This experiment seeks to answer the question through multilevel aircraft penetrations using dropsondes, flight-level data, and radar observations on the synoptic, mesoscale, and convective spatial scales. It will focus particularly on dynamic and thermodynamic transformations in the low- and mid-troposphere and lateral interactions between the disturbance and its synoptic-scale environment. This experiment addresses IFEX Goals 1 and 3.

(4) Tropical Cyclone Landfall and Inland Decay Experiment: This experiment is a multi-option, single-aircraft experiment designed to study the changes in TC surface wind structure near and after landfall. The experiment has several modules that could also be incorporated into operational surveillance of reconnaissance missions. An accurate description of the TC surface wind field is important for warning, preparedness, and recovery efforts. This experiment addresses IFEX Goals 1, 2, and 3.

(5) Tropical Cyclone Eye Mixing Module: This is a multi-option, single aircraft experiment designed to use the NOAA WP-3D to collect observations within the eye below the inversion to investigate the dynamic and thermodynamic structures of eyewall mesovortices and improve our knowledge of small-scale features and intensity changes in very strong TCs. This experiment addresses IFEX Goal 3.

(6) Hurricane Synoptic-Flow Experiment: This is a multi-option, single or multi-aircraft operational mission that uses GPS dropwindsondes launched from the NOAA G-IV, the NOAA WP-3D, or the Air Force Reserve C-130 to improve landfall predictions of TCs by releasing GPS dropwindsondes in the environment of the TC center. These data will be used by TPC/NHC and NCEP to prepare objective analyses and official forecasts through their assimilation into operational numerical prediction models. Because the atmosphere is known to be chaotic, very small perturbations to initial conditions in some locations can amplify with time. However, in other locations, perturbations may result in only small differences in subsequent forecasts. Therefore, targeting locations in which the initial conditions have errors that grow most rapidly may lead to the largest possible forecast improvements. Locating these regions that impact the particular forecast is necessary. When such regions are sampled at regularly-spaced intervals the impact is most positive. The optimal targeting and sampling strategies is an ongoing area of research. This experiment addresses IFEX Goal 1.

(7) Mature Storms Experiment: This is a multi-option, single-aircraft operational mission designed to use the NOAA WP-3D to sample tropical cyclones ranging in intensity from tropical depression to a major hurricane. The definition is meant to separate this category from tropical waves and disturbances that have yet to develop a well-defined warm-core circulation. The main goals of these missions is: 1) to improve our understanding of the factors which modify the intensity and structure of tropical cyclones, 2) to provide a comprehensive data set for the initiation (including data assimilation) and validation of numerical hurricane simulations (in particular the Hurricane Weather and Research Forecasting model (HWRF), 3) to improve and evaluate technologies for observing tropical cyclones, and 4) to develop rapid "real-time" communication of these observations to the National Centers for Environmental Prediction (NCEP) of the National Weather Service (NWS). Two experiments comprise the overall Mature Storms Experiment: the Frequent-Monitoring Experiment, designed to obtain regular 12- or 24-h resolution airborne Doppler-radar observations of hurricanes, with optional GPS dropsondes and the NESDIS Ocean Winds and Rain Experiment, designed to improve our understanding of microwave surface scatterometery in high-wind conditions over the ocean by collecting surface scatterometery data and Doppler data in the boundary layer of hurricanes.

In addition to the experiments presented above that comprise IFEX, there are several experiments that are also occurring simultaneously and will be partnering with HRD's IFEX:

1. NOAA/NESDIS will be conducting the Ocean Winds Experiment, using N42RF for part of the season. The goal of this experiment is to further our understanding of the ocean surface wind vector retrievals in high wind speed conditions and in the presence of rain for all wind speeds from microwave remote-sensing measurements.
2. NASA has planned an experiment called the NASA African Monsoon Multidisciplinary Analyses (NAMMA). The major research topics of this mission will be to examine the formation and evolution of tropical cyclones in the eastern and central Atlantic and their impact on the U.S. east coast, the composition and structure of the Saharan Air Layer, and whether aerosols affect cloud precipitation and influence cyclone development. NASA's DC-8 medium altitude research aircraft will serve as the primary research tool for the NAMMA investigations and will be based in Sal, Cape Verde from 15 August to 15 September. HRD plans include the coordination of WP-3D and G-IV aircraft research

missions downstream from NAMMA DC-8 missions. An overview of the NAMMA program can be found at:
http://namma.nsstc.nasa.gov/index.html

3. An international field campaign called the African Monsoon Multidisciplinary Analysis (AMMA) is planning a series of "Special Observing Periods" (SOPs) during the summer of 2006. AMMA is an international project designed to improve our knowledge and understanding of the West African Monsoon (WAM) and its variability. AMMA is motivated by an interest in fundamental scientific issues and by the societal need for improved prediction of the West African Monsoon and its impacts on West African nations. HRD plans include the coordination of WP-3D and G-IV aircraft research missions downstream from AMMA aircraft and land-based tropical cyclone-related research activities. An overview of the international and U.S. components of the AMMA field campaign can be found at:
http://amma.mediasfrance.org/index
http://www.joss.ucar.edu/amma/

OPERATIONS

1. Locations

Starting on 05 July, the NOAA WP-3D (N42RF) and Gulfstream IV-SP aircraft will be available for possible HRD research missions. Operations for both aircraft will primarily base out of Tampa, Florida, with provision for deployments to Barbados, St. Croix, and Bermuda for storms in the Atlantic basin (including the Atlantic Ocean and the Caribbean Sea) and deployments to U.S. coastal locations in the western Gulf of Mexico for suitable Gulf storms. Occasionally, post mission recovery may be accomplished elsewhere.

2. Field Program Duration

The HRD hurricane field research program will be conducted from 05 July through 30 September 2006.

3. Research Mission Operations

The decision and notification process for hurricane research missions is shown, in flow chart form, in Appendix A of the HFP (Figs. A-1, A-2, and A-3). The names of those who are to receive primary notification at each decision/notification point shown in Figs. A-1, A-2, and A-3 are also listed in Appendix A of the HFP. Contacts are also maintained each weekday among the directors of HRD/AOML, TPC/NHC, NCEP/EMC, and AOC to discuss the "storm outlook."

Research operations must consider that the research aircraft are required to be placed in the National Hurricane Operations "Plan of the Day" (POD) 24 h before a mission. If operational "fix" requirements are accepted, the research aircraft must follow the operational constraints described in Section 7.

4. Task Force Configuration

The NOAA WP-3D aircraft (N42RF), equipped as shown in Appendix G of the HFP, will be available for research operations on a non-interference basis with operational “tasked” missions from 05 July to 30 September 2006. Also, the G-IV aircraft should be available, on a non-interference basis with operational “tasked” missions from 05 July to 30 September 2006.

5. Field Operations

5.1 Scientific Leadership Responsibilities

The implementation of the HRD 2006 Hurricane Field Program Plan is the responsibility of the field program director, who in turn, reports directly to the HRD director. The field program director will be assisted by the field program ground team manager. In the event of deployment, the field program ground team manager shall be prepared to assume overall responsibility for essential ground support logistics, site communications, and HRD site personnel who are not actively engaged in flight. Designated lead project scientists are responsible to the field program director or designated assistants. While in flight, lead project scientists are in charge of the scientific aspects of the mission.

5.2 Aircraft Scientific Crews

Tables B-2.1 through B-2.4 (Appendix B of the HFP) list the NOAA scientific crewmembers needed to conduct the 2006 hurricane field experiments. Actual named assignments may be adjusted on a case-by-case basis. Operations in 2006 will include completion of detailed records by each scientific member while on the aircraft. General checklists of NOAA science-related functions are included in Appendix E of the HFP.

5.3 Principal Duties of the Scientific Personnel

A list of primary duties for each NOAA scientific personnel position is given in Appendix D of the HFP.

5.4 HRD Communications

The HRD/Miami Ground Operations Center (MGOC) will operate from offices at AOML on Virginia Key (4301 Rickenbacker Causeway, Miami, Florida) or from TPC/NHC (11691 S.W. 17th Street, Miami, Florida).

During actual operations, the senior team leader of the MGOC, or his/her designee, can be reached by commercial telephone at (305) 221-4381 (HRD/TPC/NHC) or at (305) 361-4400 (HRD/AOML). At other times, an updated, automated telephone answering machine [(305) 221-3679] will be available at the MGOC. In addition, MGOC team leaders and the field program director can be contacted by calling their cell phones or pager (phone numbers available at a later date).

MGOC, operating from AOML or TPC/NHC, will serve as "communications central" for information and will provide interface with AOC, TPC/NHC, and CARCAH (Chief, Aerial Reconnaissance Coordinator, All Hurricanes). In the event of a deployment of aircraft and personnel for operations outside Miami, HRD's field program ground team manager will provide up-to-date crew and storm status and schedules through the field program director or the named experiment lead project scientist. HRD personnel who have completed a flight will provide information to MGOC, as required.

6. Data Management

Data management and dissemination will be according to the HRD data policy that can be viewed at:
http://www.aoml.noaa.gov/hrd/data2.html

A brief description of the primary data types and HRD personnel contact information may be found at:
http://www.aoml.noaa.gov/hrd/data/products.html

Raw data are typically available to all of NOAA-sponsored personnel and co-investigators immediately after a flight, subject to technical and quality assurance limitations. Processed data or other data that has undergone further quality control or analyses are normally available to the principle and co-investigators within a period of several months after the end of the Hurricane Field Program. Examples of co-investigators are NASA-sponsored NAMMA investigators and associated university or other Governmental partners.

All requests for NOAA data gathered during the 2006 Hurricane Field Program should be forwarded by email to the associated contact person in the HRD data products description (link above) or in writing to: Director, Hurricane Research Division/AOML, 4301 Rickenbacker Causeway, Miami, Florida 33149.

7. Operational Constraints

NOAA WP-3D aircraft are routinely “tasked” by NHC through CARCAH to perform operational missions that always take precedence over research missions. Research objectives can frequently be met, however, on these operational missions. Occasionally, HRD may request, through NHC and CARCAH, slight modifications to the flight plan on operational missions. These requests must not deter from the basic requirements of the operational flight as determined by NHC and coordinated through CARCAH.

Hurricane research missions are routinely coordinated with hurricane reconnaissance operations. As each research mission is entered into the planned operation, a block of time is reserved for that mission and operational reconnaissance requirements are assigned. A mission, once assigned, *must be flown in the time period allotted and the tasked operational fixes met.* Flight departure times are critical. Scientific equipment or personnel not properly prepared for the flight at the designated pre-take-off time will remain inoperative or be left behind to insure meeting scheduled operational fix requirements. Information on delays to or cancellations of research flights must be relayed to CARCAH.

8. Calibration of Aircraft Systems

Calibration of aircraft systems is described in Appendix B of the HFP (B.1 en-route calibration of aircraft systems). True airspeed (TAS) calibrations are required for each NOAA flight, both to and from station and should be performed as early and as late into each flight as possible (Fig. B-1).

HRD RESEARCH EXPERIMENTS

1. Saharan Air Layer Experiment (SALEX)

INTRODUCTION

Saharan Air Layer Experiment: This is a multi-option, multi-aircraft experiment which uses GPS dropwindsondes launched from the NOAA G-IV (flying at ~175-200 hPa/~45,000-41,000 ft) and NOAA WP-3D (flying at ~500-700 hPa/18,000-10,000 ft) to examine the thermodynamic and kinematic structure of the Saharan Air Layer (SAL) and its potential impact on tropical cyclone (TC) genesis and intensity change. The GPS dropwindsonde drop points will be selected using real-time GOES SAL tracking imagery from UW-CIMSS and mosaics of SSM/I total precipitable water from the Naval Research Laboratory. Specific effort will be made to gather atmospheric information within the Saharan Air Layer as well as regions of high moisture gradients across its boundaries and the region of its embedded mid-level easterly jet. The goals of this experiment are to better understand and predict how the SAL's dry air, mid-level easterly jet, and suspended mineral dust affect Atlantic TC intensity change and to assess how well these components of the SAL are being represented in forecast models.

Program Significance: The Saharan SAL has been investigated fairly extensively during the past several decades, buts its role in influencing Atlantic TCs has not been thoroughly examined. The SAL is characterized by a well-mixed layer that originates over the arid regions of the Sahara and often extends up to ~500 hPa (~18,000 ft) over the African continent. This air mass is extremely warm and dry, with temperatures that are markedly warmer (~0.5-5.0^{o}C in the western North Atlantic and ~5-10^{o}C in the eastern North Atlantic) than a typical tropical sounding. Additionally, the RH (mixing ratio) in the SAL is ~30-35% (~3 g kg^{-1}) drier than a typical moist tropical sounding. The SAL is often associated with a mid-level easterly jet centered at about 700 hPa (~10,000 ft) and concentrated along its southern boundary.

SAL outbreaks typically move westward off the western coast of North Africa every 3-5 days during the summer months. There are several characteristics of these frequent outbreaks that can act to suppress Atlantic TC formation:

1) The SAL contains **dry, stable air** that can diminish local convection by promoting convectively driven downdrafts in the TC environment.
2) The SAL contains a **mid-level easterly jet** that can significantly increase the local vertical wind shear. The low-level circulations of TCs under the influence of this jet tend to race out ahead of their mid and upper-level convection, decoupling the storm and weakening it.
3) **Mineral dust** suspended within the SAL absorbs solar energy and subsequently releases longwave infrared energy. These thermal emissions act to warm the SAL and can re-enforce the tropical inversion that already exists in the tropical North Atlantic. This warming helps to stabilize the environment and also limits vertical mixing through the SAL, allowing it to maintain its distinctive low humidity for extended periods of time (several days) and over long distances (1000s of km)

Objectives: The main objectives of SALEX are to:

- Better understand how the SAL's dry air, mid-level easterly jet, and suspended mineral dust affect Atlantic TC intensity change.
- Include the moisture information from the GPS dropwindsondes in operational parallel runs of the NOAA Global Forecast System (GFS) model. The impact of this data on the GFS (and GFDL) initial/forecast humidity fields and its forecasts of TC track and intensity will be assessed.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- o **Goal 1**: Collect observations that span the TC lifecycle in a variety of environments;
- o **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

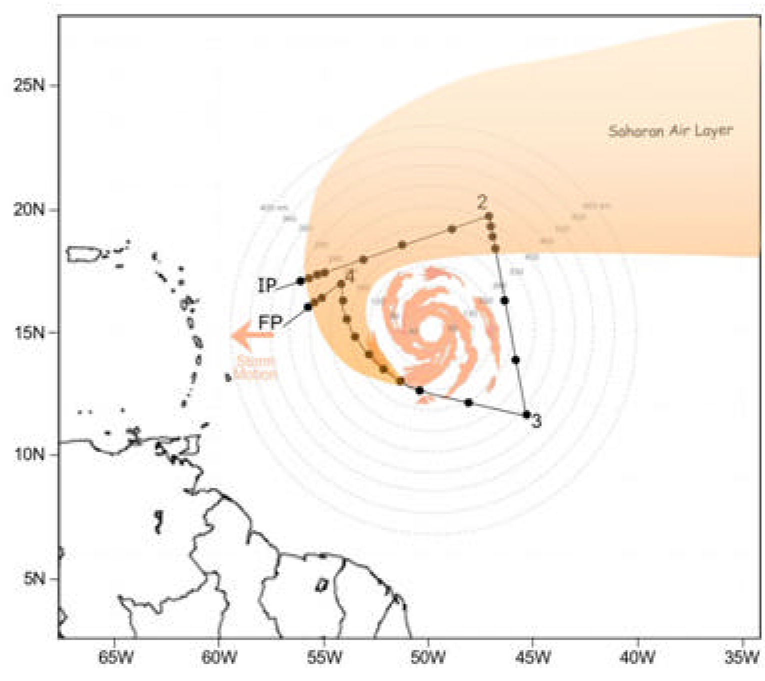
Mission Description: The NOAA G-IV (flying at ~175-200 hPa/~45,000-41,000 ft) and NOAA WP-3D (flying at ~500-700 hPa/~18,000-10,000 ft) GPS dropwindsonde drop points will be based on a flight pattern selected using information from the UW-CIMSS/HRD GOES SAL tracking product and mosaics of SSM/I TPW from NRL Monterey. Specific effort will be made to gather atmospheric information within the SAL, the transitional environment (regions with high gradients of humidity) across its boundaries, its embedded mid-level easterly jet, and the immediate surrounding moist tropical environment. When possible, SALEX missions will be coordinated with the HRD Tropical Cyclone Genesis Experiment (GenEx). This coordination will involve the WP-3D and/or GIV and be executed on a case-by-case basis. Several SAL/TC interaction scenarios are candidates for SALEX missions:

Option 1:

Single TC located along the southern edge of the SAL (Fig. 1). Depending on the proximity of these two features, the SAL's dry air may be wrapping into the TC's low-level circulation (western semicircle).

G-IV: The G-IV **IP** will be in the NW quadrant of the TC (preferably west of the SAL's leading edge) and the initial portion of the 1st leg (**IP-2**) will focus a GPS dropwindsonde sequence across the high gradient region of humidity at the SAL's leading edge. There will be intermittent GPS dropwindsondes along the remainder of the first leg (**IP-2**), with higher density sequences along pre-determined regions of interest (e.g. dry SAL air). The 2nd leg (**2-3**) will focus a GPS dropwindsonde sequence across the SAL's southern boundary to capture gradients of humidity and wind shear (associated with the SAL's mid-level easterly jet). Subsequent intermittent drops will be made along this leg (**2-3**) to sample the ambient moist tropical environment. The 3rd leg (**3-4**) will include a GPS dropwindsonde sequence that will be focused along the dry air inflow region on the west semicircle of the TC. This drop sequence will focus on sampling the intrusion of low humidity SAL air into the TC circulation and how the SAL's vertical structure and moisture content modify as it advects closer to the TC inner core. The SAL's leading edge ("rooster tail") will be sampled by a GPS dropwindsonde sequence during the final leg (**4-FP**).

WP-3D: The WP-3D **IP** will be in the SW quadrant of the TC and the initial portion of the 1st leg (**IP-2**) will focus on sampling the ambient moist tropical environment south of the TC. The 2nd leg (**2-3**) will include sampling the ambient moist tropical environment east of the TC as well as focusing a GPS dropwindsonde sequence across the SAL's southern boundary to capture gradients of humidity and wind shear (associated with the SAL's mid-level easterly jet). The 3rd leg (**3-4**) will include a GPS dropwindsonde sequence that will be focused along the dry air inflow region on the west semicircle of the TC. This drop sequence will focus on sampling the intrusion of low humidity SAL air into the TC circulation and how the SAL's vertical structure and moisture content modify as it advects closer to the TC inner core. The final leg (**4-FP**) will include a penetration of the TC center of circulation followed by GPS dropwindsonde sequences targeting the SAL west of the TC. The final GPS dropwindsonde sequence will sample the SAL's leading edge ("rooster tail") west of the TC.



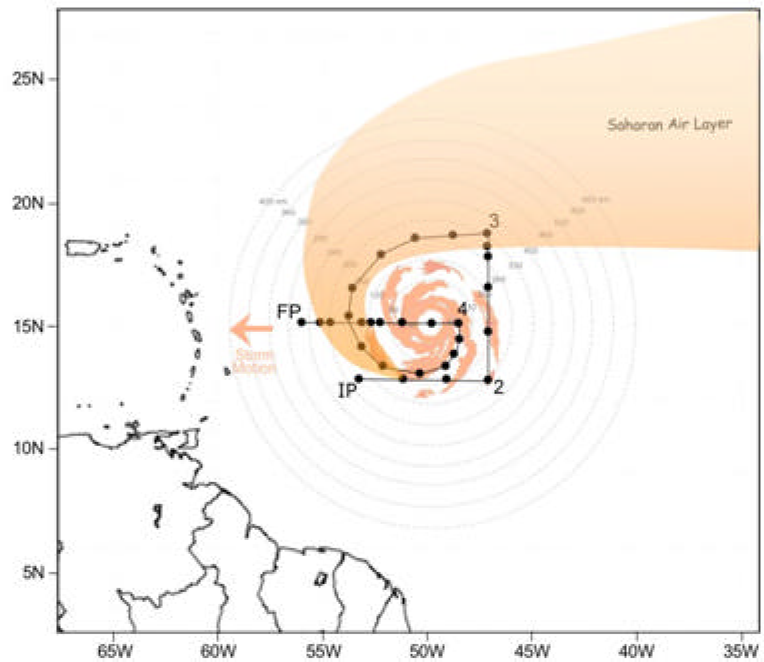


Fig. 1: Sample G-IV (top) and WP-3D (bottom) flight tracks for a TC positioned along the southern edge of the SAL

- Note 1: During the ferry to the **IP**, the G-IV (WP-3D) should climb to ~200 hPa/41,000 ft (500 hPa/18,000 ft) as soon as possible and climb as feasible to maintain the highest altitude for the duration of the pattern.
- Note 2: In order to capture the SAL's horizontal/vertical structure, particular attention should be paid to regions of high moisture gradients across its boundaries (G-IV: **IP-2**, **2-3**, and **4-FP**; WP-3D: **2-3**, and **4-FP**).
- Note 3: The SAL's mid-level easterly jet (~20-50 kt at 600-700 hPa/12,000-15,000 ft) may be evident from GPS dropwindsondes dropped near the SAL's southern boundary (G-IV: **IP-2** and **2-3;** WP-3D: **2-3** and **3-4**).

Option 2: Single TC is embedded within the SAL and intensifies upon emerging. These systems are often candidates for rapid intensification.

G-IV: The G-IV **IP** will be west of the TC and preferably within the SAL. The 1st leg (**IP-2**) will include a GPS dropwindsonde transect across the northern boundary of the SAL. This dropwindsonde sequence will focus on sampling the large humidity gradients across the northern edge of the SAL. The 2nd (**2-3**) and 3rd (**3-4**) legs of the flight pattern will intermittently sample the moist tropical environment out ahead of the TC and north of the SAL. The 4th leg (**4-5**) will include a GPS dropwindsonde transect across the northern boundary of the SAL (NE of the TC), intermittent GPS dropwindsondes within the SAL (in the middle of the flight leg), and a GPS dropwindsonde transect across the southern boundary of the SAL (southeast of the TC). The northern and southern dropwindsonde sequences will focus on sampling the large humidity gradients along the SAL's boundaries. The intermittent dropwindsondes and southern dropwindsonde sequence will concentrate on sampling the SAL's mid-level easterly jet. The 5th (**5-6**) and 6th (**6-FP**) flight legs will include intermittent GPS dropwindsondes that will help identify how the SAL's vertical structure and moisture content are being modified by the TC circulation closer to the storm.

WP-3D: The WP-3D **IP** will be west of the TC and preferably within the SAL. The 1st leg (**IP-2**) will include a GPS dropwindsonde transect across the northern boundary of the SAL. This dropwindsonde sequence will focus on sampling the large humidity gradients across the northern edge of the SAL. The 2nd leg (**2-3**) of the flight pattern will sample the boundary between moist tropical air north of the TC center and the SAL to the south and will include a penetration of the TC center of circulation. Particular attention will be focused on sampling dry SAL air near the TC inner core. The 3rd leg (**3-4**) will include a GPS dropwindsonde transect across the northern boundary of the SAL to sample the humidity gradients at the SAL's northern boundary. The 4th leg (**4-FP**) will sample the boundary between moist tropical air north of the TC center and the SAL to the south and will include a penetration of the TC center of circulation. Particular attention will be focused on sampling dry SAL air near the TC inner core.

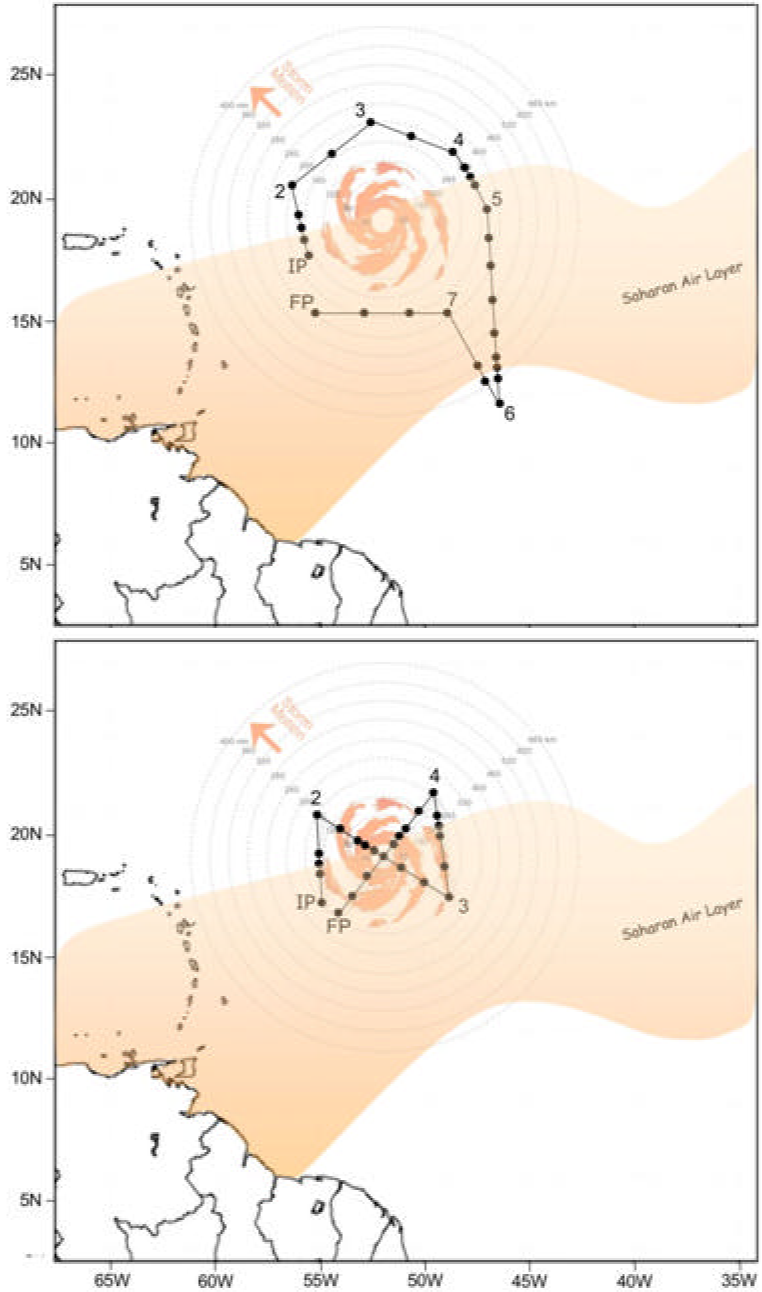


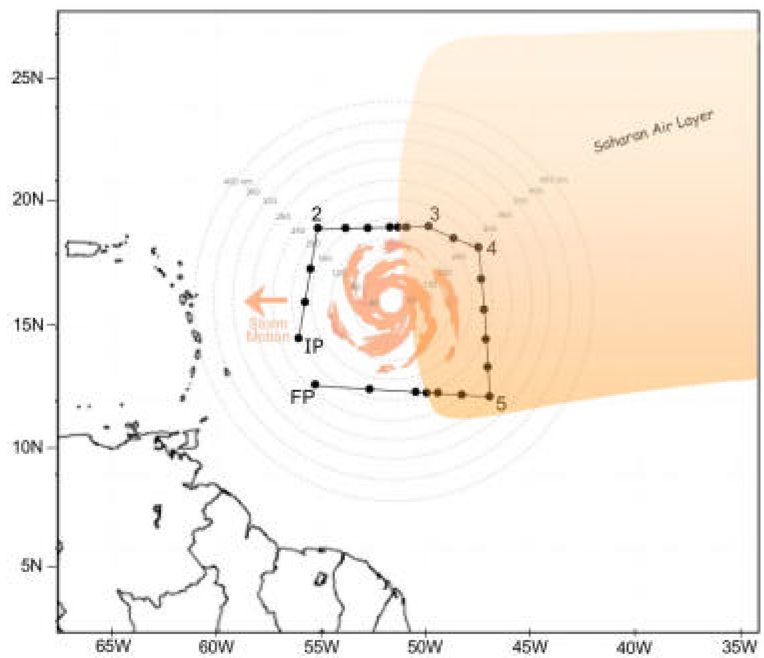
Fig. 2: Sample G-IV (top) and WP-3D (bottom) flight tracks for a TC emerging from the SAL.

- Note 1: During the ferry to the **IP**, the G-IV (WP-3D) should climb to ~200 hPa/41,000 ft (500 hPa/18,000 ft) as soon as possible and climb as feasible to maintain the highest altitude for the duration of the pattern.
- Note 2: The TC may undergo a period of rapid intensification as it emerges from the SAL.
- Note 3: In order to capture the SAL's horizontal/vertical structure, particular attention should be paid to regions of high moisture gradients across its boundaries (G-IV: **IP-2** and **4-5;** WP-3D: **IP-2** and **3-4**).
- Note 4: The SAL's mid-level easterly jet (~20-50 kt at 600-700 hPa/12,000-10,000 ft) may be evident from GPS dropwindsondes dropped near the SAL's southern boundary (G-IV: **5-6** and **6-7**).

Option 3: Single TC embedded located along the leading edge of the SAL. These systems are often struggle to intensify as they are overtaken by the SAL surge, but do occasionally separate from the SAL and intensify. These systems are often characterized by their low-level circulations racing out ahead (west) of their mid-level convection.

G-IV: The G-IV **IP** will be west of the TC. The 1st leg (**IP-2**) will include intermittent GPS dropwindsonde sampling of the moist tropical environment out ahead of the TC and west of the SAL. The 2nd (**2-3**) leg will sample the moist tropical environment north of the TC and west of the SAL followed by a GPS dropwindsonde transect across the leading edge of the SAL (north of the TC). The 3rd (**3-4**) and 4th (**4-5**) legs of the flight pattern will intermittently sample the SAL with specific focus on sampling the gradients associated SAL's mid-level easterly jet (typical located along the southern edge of the SAL). The 5th (**5-IP**) flight leg will include intermittent GPS dropwindsonde sampling of the SAL, followed by a transect across the SAL's leading edge, followed by intermittent GPS dropwindsonde sampling of the moist tropical environment out ahead of the TC and west of the SAL.

WP-3D: The WP-3D **IP** will be west of the TC. The 1st leg (**IP-2**) will include intermittent GPS dropwindsonde sampling of the moist tropical environment out ahead of the TC and west of the SAL. The 2nd leg (**2-3**) of the flight pattern will sample the boundary between moist tropical air north of the TC center and the SAL to the south and will include a penetration of the TC center of circulation. Particular attention will be focused on sampling dry SAL air near the TC inner core. The 3rd leg (**3-4**) will include intermittent GPS dropwindsonde sampling within the SAL with specific focus on sampling the gradients associated SAL's mid-level easterly jet (typical located along the southern edge of the SAL). The 4th leg (**4-FP**) will sample the boundary between moist tropical air west of the TC center and the SAL to the east and will include a penetration of the TC center of circulation. Particular attention will be focused on sampling dry SAL air near the TC inner core.



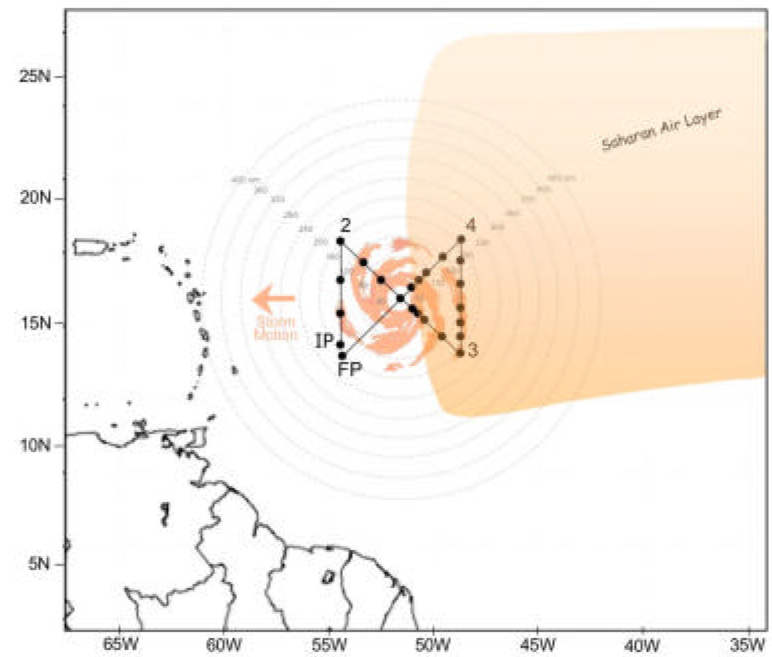


Fig. 3: Sample G-IV (top) and WP-3D (bottom) flight tracks for a TC along the leading edge of the SAL.

- Note 1: During the ferry to the **IP**, the G-IV (WP-3D) should climb to ~200 hPa/41,000 ft (500 hPa/18,000 ft) as soon as possible and climb as feasible to maintain the highest altitude for the duration of the pattern.
- Note 2: The TC will likely struggle to intensify as it is overtaken by the SAL. Slow intensification is possible if the TC is able to separate from the SAL.
- Note 3: In order to capture the SAL's horizontal/vertical structure, particular attention should be paid to regions of high moisture gradients across its boundaries (G-IV: **2-3** and **5-FP**; WP-3D: **2-3** and **4-FP**).
- Note 4: The SAL's mid-level easterly jet (~20-50 kt at 600-700 hPa/12,000-10,000 ft) may be evident from GPS dropwindsondes dropped near the SAL's southern boundary (G-IV: **4-5** and **5-FP**; WP-3D: **2-3** and **3-4**).

Option 4: Single TC embedded within the SAL throughout most or all of its lifecycle. These systems struggle to intensify and are often characterized by their low-level circulations racing out ahead (west) of their mid-level convection. Depending on the proximity of these features, the SAL's dry air may be wrapping into the TC's low-level circulation (western semicircle).

G-IV: The **IP** will be north of the TC and preferably north of the SAL. The 1st leg (**IP-2**) will include a GPS dropwindsonde transect across the northern and southern boundaries of the SAL. These dropwindsonde sequences will focus on sampling the large humidity gradients across the SAL boundaries as well as the SAL's mid-level easterly jet (typical located along the southern edge of the SAL). These scenarios (TC embedded within the SAL) are typically cases where the TC is under the influence of a strong SAL easterly jet. The 2nd leg (**2-3**) of the flight pattern will intermittently sample the moist tropical environment south of the SAL. The 3rd leg (**3-4**) will include a GPS dropwindsonde sequence that will be focused along the dry air inflow region on the west semicircle of the TC. This drop sequence will sample the intrusion of low humidity SAL air into the TC circulation and help to define how the SAL's vertical structure and moisture content modify as it advects closer to the TC inner core. A final GPS dropwindsonde transect (**4-FP**) will be made across the area of high moisture gradients at the SAL's northern boundary and in the relatively moister tropical environment north and northwest of the SAL.

WP-3D: The **IP** will be NW of the TC and preferably north of the SAL. The 1st leg (**IP-2**) will include a GPS dropwindsonde transect across the northern boundary of the SAL. This dropwindsonde sequences will focus on sampling the large humidity gradients across the SAL. The 2nd leg (**2-3**) of the flight pattern will intermittently sample the moist tropical environment south of the SAL and will include a GPS dropwindsonde transect across the southern boundary of the SAL as well as the SAL's mid-level easterly jet (typical located along the southern edge of the SAL). The 3rd (**3-4**) and 4th (**4-5**) legs will include a GPS dropwindsonde sequence that will be focused along the dry air inflow region on the west semicircle of the TC. This drop sequence will sample the intrusion of low humidity SAL air into the TC circulation and help to define how the SAL's vertical structure and moisture content modify as it advects closer to the TC inner core. The final leg (**4-FP**) will sample the boundary between moist tropical air west of the TC center and the SAL to the east and will include a penetration of the TC center of circulation. Particular attention will be focused on sampling dry SAL air near the TC inner core.

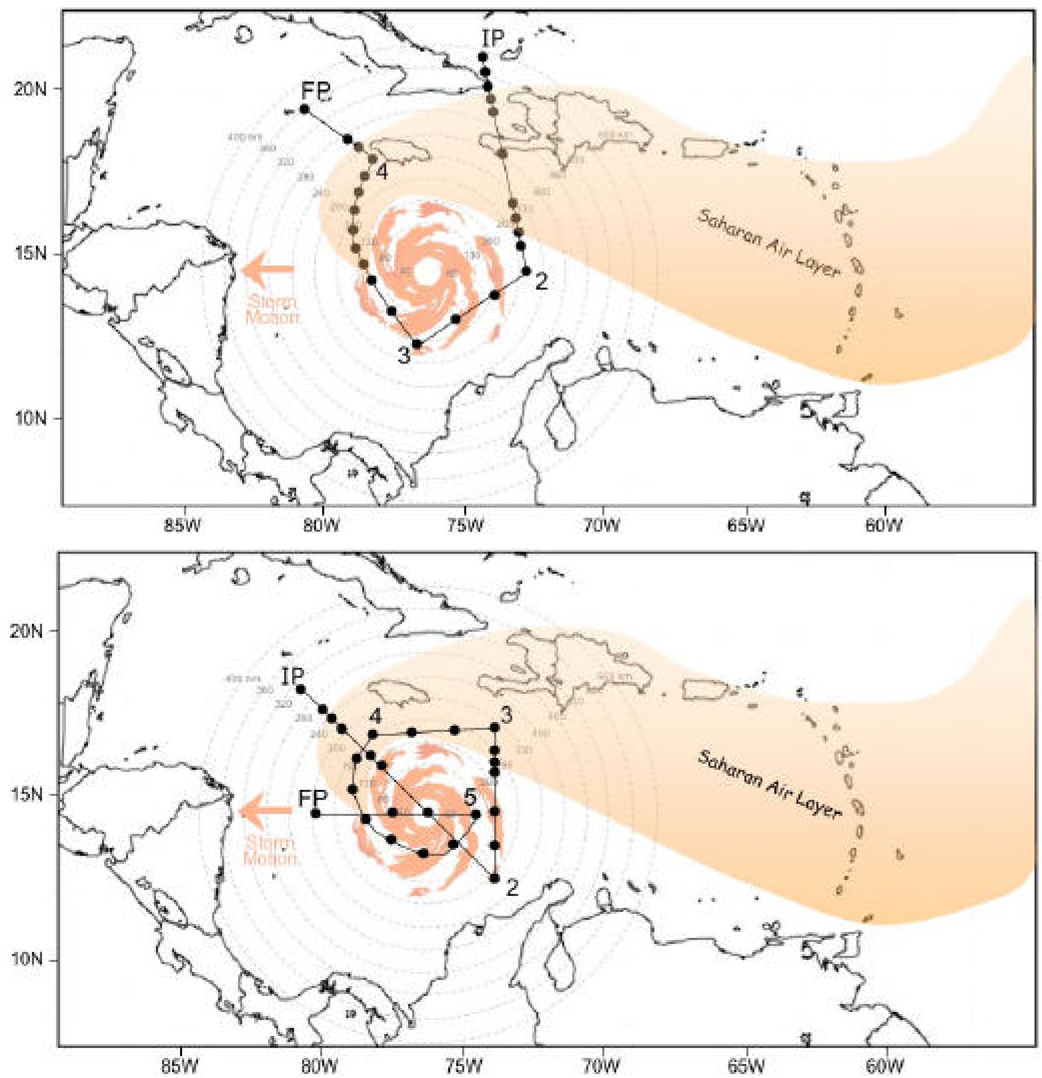


Fig. 4: Sample G-IV (top) and WP-3D (bottom) flight track for a TC embedded in the SAL for most or all of its lifecycle.

- Note 1: During the ferry to the **IP**, The G-IV (WP-3D) should climb to ~200 hPa/~41,000 ft (500 hPa/18,000 ft) as soon as possible and climb as feasible to maintain the highest altitude for the duration of the pattern.
- Note 2: In order to capture the SAL structure, particular attention should be paid to regions of high moisture gradients across its boundaries (G-IV: **IP-2** and **4-FP**; WP-3D: **IP-2** and **2-3**).
- Note 3: The TC's low-level circulation may race ahead of its mid-level convection due to the influence of the SAL's mid-level easterly jet.
- Note 4: The SAL's mid-level easterly jet (~20-50 kt at 600-700 hPa/15,000-10,000 ft) may be evident from GPS dropwindsondes dropped near the SAL's southern boundary (G-IV: **IP-2**; WP-3D: **2-3**).

2. Aerosonde Tropical Cyclone Inflow Experiment

Hurricanes and tropical storms cause many deaths and average billions of dollars in damages each year. More than 1000 lives were lost in Hurricane Katrina (2005) alone, and the financial impact on the U.S. economy has already exceeded $200 Billion. Improved forecasts and warnings also reduce the costs inherent in responding to the hurricane threat. The devastating impacts of Hurricanes like Katrina or Wilma (2005) require that we make the best possible and most authoritative information available to decision-makers to help them determine whether to implement mandatory evacuations and other costly actions for approaching hurricanes.

NOAA is working with its international and domestic partners to cost-effectively increase the number, breadth, accuracy, and availability of observation systems. As part of this effort, NOAA is investing in new technologies, such as Unmanned Aircraft Systems (UAS) in order to improve the accuracy and timeliness of our Nation's existing weather observation and forecast system. This experiment plans to demonstrate the capabilities of the versatile Aerosonde UAS within the context of low-level hurricane reconnaissance. It will also build upon recent NOAA UAS success (Ophelia 2005) and directly tie into one of the GoM CI major themes (Coastal Hazards).

Ultimately, the value of this proposed work will be measured in lives saved and money not spent from improved understanding, forecasts and preparation. Specific benefits that directly link to NOAA's stated strategies within the Weather and Water mission goal include detailed documentation of the rarely-observed hurricane boundary layer environment (*Monitor and Observe*), an improved physical understanding of this critically important region (*Understand and Describe*), and enhanced observations that directly lead to improved future forecasts of tropical cyclone intensity change (*Assess and Predict*).

The Aerosonde UAS

The Aerosonde UAS is fully summarized in Holland et al (2000). It has been undertaking civilian operations since 1995, was the first UAV to cross the Atlantic Ocean and has an impressive endurance record of over 32 hrs. It has a sophisticated command and control system and the flexibility to be deployed and commanded from virtually any location. Initially developed for meteorological and environmental applications in remote and dangerous conditions, the Aerosonde has been specifically designed for all-weather operations under harsh conditions and is well suited to the hurricane reconnaissance role. The aircraft has evolved through to the current Mark 4 version and its relevant specifications are provided in Table 1.

Table 1. Specifications of Mark 3 Aerosonde UAV

Specifications	
Weight, wing span	26-30 lb, 10 ft
Engine	24 cc, Fuel Injected engine using unleaded petrol
Navigation	GPS
Operation	
Staff for Launch and Recovery	3 staff: Controller, Engineer, Pilot/Maintenance
Ground Equipment	Proprietary Staging Box, Personal Computer, GPS, Radio Antennae and Iridium Satellite modem
Flight	Fully autonomous, under Base Command
Launch and Recovery	Launch from car roof rack, or catapult, land on belly. Able to operate from remote and unprepared surfaces
Ground & air communications	UHF or Satcoms to Aerosonde, VHF to field staff and other aircraft, internet or phone to command center and users.
Performance	
Speed, Climb	Speed 35-80 kt, Climb 3 m/s at sea level
Endurance, Range	20 to >30 h, up to 3000 km (depending on payload weight and configuration)

Aerosonde Payload

A range of payloads are operational or under development for the Aerosonde. Those that are relevant to the hurricane boundary layer mission are listed in Table 2

Table 2. Operational Aerosonde instruments of relevance to boundary layer monitoring.

Measurement	Instrument	Manufacturer	Technical	Comments
Air temp, press., hum.	Vaisala RSS901 sensor	Vaisala	P<.5 hPa, T<.2K, RH<2% 0.1 hz standard, capable of 1 hertz	Standard met observations
Winds	Proprietary	AeNA	u,v < .5 m/s	Standard met observations
Surface temperature	IR KT11	Heitronics	SST < 0.5K	Surface ocean and land temperatures.
	IR KT15	Heitronics	SST < 0.5K	
Liquid water content and ice crystal concentration	Heymsfield VIPS	NCAR	Video recording of impacts on oiled plastic	Cloud physics and potential spray/ salt distributions
Sea state, ocean surface winds, soil moisture	GPS reflectance	NASA	<10 m resolution. Accuracy unknow n	Detailed observations of surface conditions
Surface visible imaging	Digital still camera Olympus 5050	Olympus	5 megapixel 3x Optical zoom	High resolution surface imaging
Surface visible imaging	Sony 555 Video camera, fixed mount	Sony		Video of surface conditions
Infrared imaging	Indigo Omega camera	Indigo Systems	8-12 micron IR imaging	IR surface imagery

Aerosonde Launch, Command and Control

Aerosonde command and control is accomplished by:

- UHF command for LOS up to 120 miles, which may be back to a launch site or can be transferred to a mobile or other site as required;
- Iridium Satcom for OH command to any location on earth.

The required equipment is a lap top computer, a small staging box (briefcase size) and relevant antennae. AeNA has often operated from a vehicle and has transferred control to ships and other sites under operational conditions. All Aerosonde commanders and technicians are fully qualified under Australian Civil Air Operator Certificate Number VT585156-U-01, issued to Aerosonde on 30 May 2003. This is the only current Aviation Authority Certification in the world.

Use of the Aerosonde UAS for Hurricane Reconnaissance

While recent composite analyses from Cione et al (2000) and Cione and Uhlhorn (2003) have led to new insights regarding structural details of the hurricane air-sea interface, sustained and comprehensive observations of the thermodynamic (temperature and moisture) and kinematic (wind) structure of the near-surface hurricane environment have never been undertaken. Yet this environment, where the atmosphere meets the sea, is critically important:

- This is where the critical oceanic energy supply is transferred to the atmosphere
- Here we find the strongest winds in a hurricane and especially those that are most critical for forecasts and warnings

Improved observations in this region will lead to better understanding, and improved capacity for forecasting tropical cyclone intensity change. A major uncertainty in forecasting landfall intensity is the potential for rapid intensification or decay in the critical 24 h period when major response decisions have been already made. Enhancing this predictive capability would save our economy billions of dollars and help reduce the risk of death and injury for vulnerable populations

Successful utilization of the WP-3D Orion and Gulfstream IV-SP aircraft have made NOAA a global leader in the area of hurricane aircraft surveillance and reconnaissance. However, the danger of near-surface operations in the extreme hurricane conditions has precluded comprehensive monitoring of this critical region. Satellites are also unable to monitor this region, so we are currently left with scattered local observations from dropsondes. We propose to use the unique low-flying capacity of the Aerosonde UAS platform to address this significant observational shortcoming. The Aerosonde is capable of flying at altitudes of 500 feet or less within the high-wind hurricane eyewall environment. This is thousands of feet lower than any manned aircraft is able to operate.

We consider that the payoff for using the Aerosonde platform within the hurricane environment would be both significant and immediate. The benefits would include detailed documentation of a heretofore poorly observed region of the tropical cyclone (*Monitor and Observe*) together with providing real-time, high-resolution, low-level wind observations of the hurricane maximum winds in support of NOAA's Tropical Prediction Center's (TPC) forecasting requirements (*Assess and Predict*). In addition, the low flying Aerosonde would greatly enhance our physical understanding of the rarely observed hurricane air-sea interface (*Understand and Describe*). Ultimately, this will lead to improved forecasts of tropical cyclone intensity change by enhancing today's boundary layer parameterization schemes and providing invaluable initialization and verification data sets for numerical models (*Assess and Predict*). The data also will provide ground truth for aircraft and satellite derived remote measurements.

These observations and related benefits can be obtained at a cost that is quite low by normal hurricane reconnaissance costing standards.

The potential importance of this UAS role in hurricane reconnaissance is emphasized by the findings of the Hurricane Intensity Research Working Group established by the NOAA Science Advisory Board. There preliminary recommendation, presented to the last meeting of the SAB, is that:

"Low and Slow" Unmanned Aircraft Systems (UAS) have demonstrated a capacity to operate in hurricane conditions last season. A full demonstration program should be instituted in 2006 to assess their ability to provide low altitude in situ observations in a critical region where manned aircraft satellite observations are lacking.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- **Goal 1**: Collect observations that span the TC lifecycle in a variety of environments;
- **Goal 2**: Develop and refine measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment;
- **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

Summary of Relevant Prior Research and Results

On September 16th 2005, NOAA, NASA and Aerosonde partners successfully flew into tropical storm Ophelia. This landmark event marked the first time an autonomous vehicle was flown into the core of a mature tropical system (see http://www.noaanews.noaa.gov/stories2005/s2508.htm and http://www.magazine.noaa.gov/stories/mag193.htm). At the time, Ophelia was a 55kt tropical storm and was located off the North Carolina coastline (Figure 1). Winds were reported in near-real time to NOAA's National Hurricane Center and directly impacted NHC operational forecasts for the tropical system at that time.

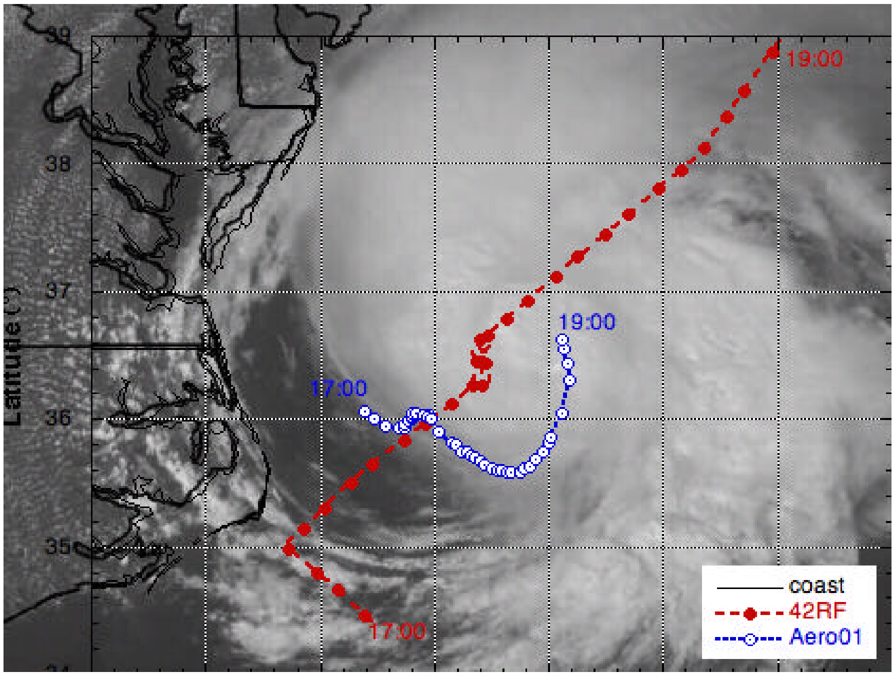


Fig. 1: *Aerosonde (blue) and WP-3D (red) flight tracks into tropical storm Ophelia on September 16th 2005. This mission marked the* ***first-ever successful unmanned flight*** *into a tropical cyclone. Storm intensity at the time was 55kts.*

This experiment is designed to build on the success and strong momentum attained in 2005. Using the experience gained from the Ophelia mission, it is believed that the time is right for a focused and concerted effort to fly additional missions into stronger storms (hurricanes) at lower altitudes. We also feel that we can build upon recent operational success and continue to transmit critical data to NOAA's operational centers (NHC and EMC) that might otherwise go un-sampled. With additional support, significant improvements to data quality, quantity, resolution and transmission efficiency are all possible in the very near future. It is also believed that the scientific insights and benefits gained by conducting additional low-level Aerosonde missions into the rarely observed, yet critically important hurricane boundary layer environment are potentially very significant.

Mission Description

The primary objective of this experiment is fully demonstrate and utilize the unique capabilities of the Aerosonde platform to document areas of the tropical cyclone environment that would otherwise be either impossible or impractical to observe. It is planned that this effort will be based somewhere on the east coast of the Florida peninsula or possible within the Florida Keys. The immediate focus of this experiment is to document and significantly improve our understanding of the rarely-observed tropical cyclone boundary layer and undertake detailed comparisons between in-situ and remote-sensing observations obtained from manned aircraft (NOAA WP-3D and AFRES C-130) and satellite based platforms. In addition, a primary objective of this effort is to provide real-time, near-surface wind observations to the National Hurricane Center in direct support of NOAA operational requirements. These unique data will also be made available to EMC for both data initialization and forecast verification purposes.

The NOAA WP-3D (flying initially at 5000ft) GPS dropwindsonde and AXBT drop points will be regularly spaced (see notes below). Only mature tropical systems positioned offshore the SE US coast that are of at least tropical storm intensity would be considered viable candidates for this mission. When possible, Aerosonde Tropical Cyclone Inflow Experiment missions will be coordinated with the TC Landfall and Inland Decay Experiment. This coordination will involve the WP-3D and be executed on a case-by-case basis.

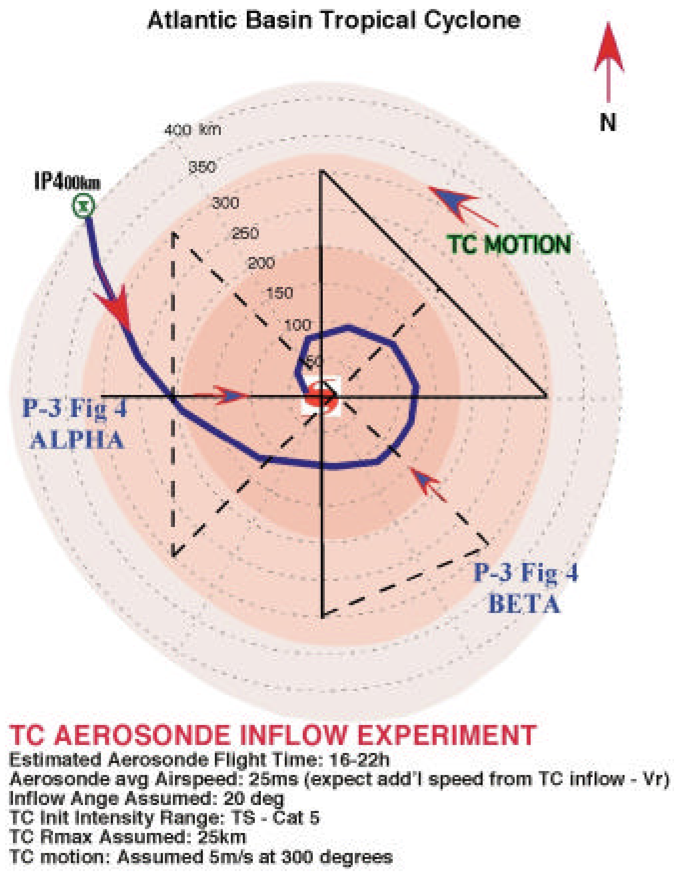


Fig. 2: TC Inflow Experiment flight tracks for both the AEROSONDE and WP-3D Aircraft.

- Note 1: AEROSONDE Take-off/Recovery: East Coast US (Florida)
- Note 2: Pre-IP: AEROSONDE-Coastal Buoy/C-Man 150m comparisons (SST,Ta,Td,P,V)
- Note 3: AEROSONDE IP: 400km from TC center (Initial IP flight level: 750m)
- Note 4: AEROSONDE Descend to 150m (IR SST retrieval). Remain at 150m until 350km. At 350km, ascend to 700m, remain at 700m until 300km
- Note 5: AEROSONDE Descend to 150m, remain at 150m until 250km. At 250km, ascend to 700m, and remain at 700m until 200km.
- Note 6: **When the AEROSONDE is ~200km from the TC center: BEGIN WP-3D Figure 4 ALPHA Pattern.**
- Note 7: WP-3D will fly at 5000 ft and drop co-located AXBT and GPS pairs every 100 km between 300-100km from the center (and every 50km from 0-100km from the TC center). For non-penetration legs, an additional AXBT/GPS drop will be launched at the leg mid-point.
- Note 8: **After completing the ALPHA pattern, the WP-3D will begin pattern BETA by climbing to 10000 ft and repeating the identical drop pattern conducted during the ALPHA pattern. A total of 38 AXBT and GPS expendables are required for this mission.**
- Note 9: Post storm-comparisons with WP-3D Doppler radar winds and SFMR are desired so both instruments will need to be fully functional.
- Note 10: At 250km, AEROSONDE ascend to 700m, and remain at 700m until 200km. From 200-100km, continuous 700m-150m soundings (briefly below 150m if possible)
- Note 11: At 100km, AEROSONDE ascend from 150m to 500m for eyewall penetration (~40-50km from center). In eye, AEROSONDE descend to 100-150m (IR SST retrieval) then corkscrew eye sounding to 3km
- Note 12: AEROSONDE Begin final eyewall penetration at 3km altitude (if no manned aircraft in storm)
- Note 13: **IF AFRES C-130 PRESENT NO EYE SOUNDINGS WILL BE CONDUCTED**
- Note 14: **RETURN TO AEROSONDE BASE OF OPERATIONS**

3. Tropical Cyclogenesis Experiment

Motivation

While forecasts of tropical cyclone track have shown significant improvements in recent years (Aberson 2001), corresponding improvements in forecasts of tropical cyclone intensity have been much slower (DeMaria and Gross 2003). The lack of improvement in intensity forecasting is the result of deficiencies in the numerical models (e.g., resolution limitation and parameterization inadequacies), deficiencies in the observations, and deficiencies in our basic understanding of the physical processes involved. The problem becomes even more acute for forecasting tropical cyclogenesis. While global models have shown some skill in recent years in predicting tropical cyclogenesis, our understanding of the physical processes involved remains limited, largely because observing genesis events is a difficult task. However, a key aspect of the NOAA Intensity Forecasting Experiment (IFEX; Rogers et al. 2006) is the collection of observations during all portions of a tropical cyclone's lifecycle, particularly on the early lifecycle stages. This emphasis on the early stages of the lifecycle will provide an opportunity to observe several genesis events and improve our understanding of this key process, leading to better predictions of tropical cyclogenesis, organization, and intensification.

Since both tropical cyclogenesis and tropical cyclone intensity change can be defined by changes in low- and mid-level vorticity, knowledge of the processes that play a significant role in genesis will also advance our understanding of intensity change. A better understanding of the processes that lead to an increase in low- and mid-level cyclonic vorticity will also allow NHC to better monitor and forecast tropical cyclogenesis and intensity change, improvements that would be especially valuable for those events that threaten coastal areas. Data obtained by aircraft investigating potential genesis events will positively impact operations and research in other ways as well. The collection of three-dimensional data at all stages in a tropical cyclone's lifecycle is one of the key requirements for NCEP as a part of the IFEX experiment. Such data will provide information that will guide the development of balance assumptions and error covariance matrices important in the development of data assimilation schemes for models (i.e., HWRF) that will be used in these environments. They will also provide important datasets for evaluating the performance of HWRF. In addition to improving the understanding and forecasting of tropical cyclogenesis and intensity change, the proposed experiment will yield useful insight into the structure, growth and ultimately the predictability of the systems responsible for almost all of the weather-related destruction in the tropical Atlantic and East Pacific. Investigation of systems that fail to complete the genesis process will also result in a better understanding and prediction of easterly disturbances in general so that distinction can be better made between developing and non-developing tropical disturbances.

Background

Tropical cyclogenesis can be viewed as a rapid increase of low-level cyclonic vorticity organized on the mesoscale within a region of enhanced convective activity. Numerous hypotheses have been advanced in the literature to explain how this vorticity develops and amplifies. One of the key aspects differentiating these hypotheses centers on whether the lower-tropospheric cyclonic vorticity begins in the mid-levels and develops downward to the surface or begins in the lower troposphere and builds upward to the middle troposphere – the so-called "top-down" vs. "bottom-up" mechanisms. Prominent "top-down" theories include one study which showed observations of multiple midlevel vortices prior to genesis in the West Pacific (Ritchie et al. 1997) that led them to view the genesis process as a stochastic one whereby chance merger and axisymmetrization of these midlevel vortices leads to growth of the circulation to the surface by increasing the Rossby-Prandtl-Burger penetration depth of potential vorticity anomalies associated with the vortices. Another study supporting the "top-down" approach showed observations of genesis in the East Pacific (Bister and Emanuel 1997) and hypothesized that downdrafts driven by evaporational cooling advected the vorticity of the midlevel vortex downward, enhancing convection and low-level vorticity production.

The set of hypotheses supporting the "bottom-up" approach generally describes the genesis process as being driven by low-level convergence that increases cyclonic vorticity near the surface through vortex stretching. One such "bottom-up" hypothesis emphasizes the role of a parent midlevel vortex in axisymmetrizing nearby low-level convectively-generated cyclonic vorticity, called vortical hot towers, that leads to the spin-up of the surface circulation (e.g., Montgomery and Enagonio 1998; Davis and Bosart 2001; Montgomery et al 2004). A similar hypothesis was advanced by Rogers and Fritsch (2001) and Chen and Frank

(1993) who emphasized the role of the midlevel vortex and high midlevel humidity in providing a favorably-reduced local Rossby radius of deformation to retain the heating from convective bursts and spin up low-level vorticity through low-level stretching caused by the convective heating. Another set of theories focuses on the reduction of the lower tropospheric effective static stability to low values in the core of incipient cyclones. Suppression of convectively-induced downdrafts is one means of accomplishing this (Emanuel 1995; Raymond, Lopez, and Lopez 1998). Eliminating low-level outflows produced by the downdrafts allows the inflow of updraft air to spin up the low-level circulation, leading to the development of the warm-core characteristic of the tropical cyclone.

Objectives

With the above background in mind, the objectives of this experiment are defined as follows:

1. Test prevailing hypotheses relating to top-down vs. bottom-up development
   This objective will be addressed by documenting the development of low-level vorticity in the presence of a midlevel vortex center, and vice versa. It will also be addressed by documenting the interactions between low- and mid-level vortices in pre-genesis environments.

2. Document aspects of mesoscale and synoptic-scale environment of incipient disturbances to identify characteristics necessary in genesis
   Key tasks in addressing this objective involve assessing the importance of pre-existing vorticity and broad areas of high humidity and determining the importance of their spatial and temporal distribution in tropical cyclogenesis. Another important question to address is the role, if any, that a midlevel vortex plays in governing the distribution and magnitude of deep convection, and to determine the importance of downdraft suppression in limiting boundary layer stabilization. A final task is to examine hypotheses relating humidity and static stability profiles to downdraft morphology and the vortex response to convective heating.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- **Goal 1**: Collect observations that span the TC lifecycle in a variety of environments;
- **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

Experiment Description

The physical processes that are important in tropical cyclogenesis span a wide spectrum of temporal and spatial scales, with time scales ranging from minutes to days and space scales ranging from mm to hundreds of km. Furthermore, many of the processes are highly nonlinear and transient. For these reasons, an experimental approach that combines observations and numerical modeling is required to adequately address the questions posed above. When possible, GenEx missions will be coordinated with the HRD Saharan Air Layer Experiment (SALEX). This coordination will involve the WP-3D and/or G-IV and be executed on a case-by-case basis.

Observational component

Recent observations from airborne Doppler radar have identified important processes on the mesoscale that contribute to tropical cyclogenesis. For example, results obtained from a WP-3D aircraft investigation of Dolly in 1996 (Reasor et al. 2005) indicate its genesis was strongly influenced by persistent, deep convection in the form of mesoscale convective systems (MCSs) that developed in association with an easterly wave over the Caribbean. Within this deep convection an eye-like feature formed, after which time the system was declared a depression. The initial development of the low-level circulation in both Dolly (1996) and Guillermo (1991) occurred in the presence of multiple midlevel vortices. The close proximity of the low- and mid-level vorticity maxima (often within 50-100 km horizontally) observed in these two genesis cases supports a further examination of the aforementioned vortex merger ideas. To adequately diagnose the role of these vortices, it is vital that they be sampled in their entirety (which will invariably depend on the distribution of precipitation scatterers) and with a temporal resolution that allows time continuity of the vortices to be established when possible.

In addition to the wind and rainfall measurements provided by the Doppler radars, measurements of temperature and moisture are vital to address the thermodynamic issues described above. Dropsondes released in a regular grid will enable the determination of thermodynamic fields in the vicinity of the incipient system, as well as enable the calculation of mean divergence and vorticity fields around the system, important in determining the strength and depth of the downdrafts (provided time aliasing is minimized). The dropsondes should be released from as high an altitude as possible to provide observations of mid-level humidity and winds where scatterers are not present. The tail radars on the WP-3D's will also enable a determination of the presence of saturation when scatterers are observed.

This experiment may be executed with the NOAA WP-3D alone, but optimally it will involve the participation of the NOAA G-IV aircraft as well. Flights will occur into incipient tropical disturbances over the western Caribbean Sea, Gulf of Mexico, and tropical Atlantic Ocean. For these missions the WP-3D will be based primarily in Barbados, though operations can also occur from St. Croix and Tampa. The systems flown here will primarily be incipient systems. If a system undergoes genesis and continues to develop, however, the WP-3D's will continue to fly the system using flight patterns from the Frequent-Monitoring Experiment (in this Field Program Plan).

The primary mission will require the WP-3D flying back-to-back missions. It will fly mesoscale survey patterns designed to document any suspected low- and mid-level vortices and sample any changes in the low- and mid-level thermodynamic fields associated with the incipient systems. Crucial to a complete understanding of the genesis process is the collection of observations with high temporal and spatial resolution. Therefore, the staggered WP-3D missions are designed to commence on station at midnight (12 AM) local and again on station at noon (12 PM) local. If it is not possible to fly the WP-3D at 12-h staggering, then 24-h staggering will be performed. If available, the G-IV aircraft would fly simultaneously at upper levels (42,000 ft or 175 hPa) and collect observations to a distance of ~1500 km from the center of the disturbance. This G-IV mission would only occur if operations happened in the tropical Atlantic or Western Caribbean and there were indications of mid- or low-level dry air in the vicinity of the disturbance.

The main aircraft for the mesoscale flights will be the WP-3D. Doppler radar observations, GPS-sondes, and flight level observations obtained during these flights will help locate low- and mid-level vortices and help document their structures and life cycles. Primary aspects of this experiment will be to observe the complete life cycle and interaction of low- and mid-level vortices, understand how these vortices are influenced by the diurnal cycle of convection, and observe the evolution of the thermodynamic fields as the incipient system evolves. The location of persistent areas of deep convection and candidate vortices will be determined using high-resolution visible and infrared GOES-winds produced available online, supplemented by NASA TRMM imagery when available. Additionally, favorable environments for deep convection and vortex development, such as those described in the Introduction, will be identified using water vapor loops, model analysis fields enhanced by satellite winds, and QuikSCAT imagery, also available online.

Staggered missions with the WP-3D aircraft will begin with the aircraft flying one of two survey patterns at 14,000 ft (4 km). The primary purpose of these patterns will be to collect F/AST Doppler radar and GPS dropsonde data in the area of deep convection in order to map the evolution of the three-dimensional wind and thermodynamic structure of the deep convection and incipient vortex. Two possible patterns can be flown, with the decision of which pattern determined by the degree of organization of the system. For incipient systems that are relatively disorganized, a sawtooth pattern is flown (Fig. 1) along the axis of an easterly wave. Leg lengths will be 150-200 nmi (250-300 km), with some variability dependent on the size of the system and the time available on station. The pattern will be centered approximately on any discernible circulation, if identifiable, or on a dominant area of convective activity. After the circulation center or convective area is passed, the sawtooth pattern is mirrored and the aircraft completes a return trip, creating a series of diamond shapes to complete the pattern. This return trip will provide some greater temporal continuity to the observations.

As a system becomes better organized, a second survey pattern is flown (Fig. 2), consisting of a square-spiral configuration centered on a broad low- or mid-level circulation center. If multiple mesoscale convective systems exist embedded within a parent circulation, the pattern will be centered on the parent circulation. Dropsondes are released at regular intervals to create a near uniform grid covering the circulation and including any MCS's, if possible. The spacing between the outer spiral and the inner box pattern is nominally set for 60 nm (111 km), but it can be varied to ensure optimal representation of the convective and mesoscale features.

Once a persistent low-level vortex is identified, subsequent missions will fly a pattern centered on the vortex. This pattern will be a rotating figure-4 pattern (Fig. 3). Flight legs for the figure-4 pattern will be 60-120 nm (111-225 km) to allow for the collection of data with high temporal and spatial resolution in the vicinity of the vortex center. The length of these flight legs is designed to completely include the low-level vortex and convection associated with it. Depending on the leg lengths and the time available on station, the pattern may consist of higher azimuthal resolution. The tail radar will operate in F/AST mode during the entirety of these patterns. For the WP-3D using the NOAA antenna, the tail radar will operate in continuous mode during the Microphysics Module.

If available, the G-IV will be most beneficial flying a synoptic-scale pattern. It will fly at maximum altitude observing the upper and lower troposphere with GPS dropsondes in the pre-genesis and incipient tropical disturbance environment. The most likely scenario calls for the G-IV to fly a Saharan Air Layer Experiment (SALEX) pattern as the system is interacting with a Saharan Air Layer (Fig. 4).

The possible availability of multiple aircraft during this experiment leads to several different scenarios. A summary of the potential combinations of aircraft during genesis experiments follows:

- **Option 1 (Optimal experiment):**
  The NOAA WP-3D aircraft will fly in the tropical Atlantic, Gulf of Mexico, or western Caribbean basins, either diamond or square-spiral survey patterns to locate low- and mid-level vortices (Figs. 1 or 2). These flights will be flown in coordination with the G-IV aircraft, providing synoptic-scale measurements of upper- and lower-tropospheric observations around the incipient disturbance. Once a persistent mid-level vortex is located, the WP-3D will fly either rotating figure-4 (Fig. 3) or square-spiral patterns.

- **Option 2 (Lesser experiment):**
  Option 1 but with only the WP-3D aircraft.

Auxiliary Storm Modules: These are stand-alone "plug-in" modules that are one hour or less in duration and can be executed after the selected primary storm module. Execution is dependent on system attributes, aircraft fuel and weight restrictions, and proximity to operations base.

(1) Convective Burst Module: The objectives of the convective burst module are to obtain quantitative description of the kinematic, thermodynamic, and electrical properties of intense convective systems (bursts) and the nearby environment to examine their role in the cyclogenesis process. This module can be flown separately within a mission designed to study local areas of convection or at the end of one of the survey patterns. The module can be flown independently with one of the WP-3D aircraft or with a WP-3D and the NASA ER-2 plane (Fig. 4). Once a local area of intense convection is identified, the WP-3D will transit at altitude (14,000 ft.) to the nearest point just outside of the convective cores and fly a circumnavigation of the convective area. The circumnavigation will consist of a series of straight legs just outside of the main convection. The tail radar should be operated in F/AST sector scan and regularly spaced dropsondes (10-20 km apart) will be released during this time. Once the circumnavigation is completed, and the WP-3D is near the original IP, two straight-line crossings of the convective area should be performed with the WP-3D avoiding the strongest cores, as necessary for safety considerations. The WP-3D can fly at either at a constant radar altitude of 14,000 ft. or, if conditions warrant, to perform a slanted ascent through the melting layer on the first pass and a slanted descent on the return pass. If time permits, the WP-3D should descend to the lowest safe altitude and perform another circumnavigation (or partial one) of the convective burst. No dropsondes will be released during the low-level run.

Modeling component

A modeling component is a necessary complement to the observational component because it provides spatial and temporal continuity to the dynamics and thermodynamics fields in incipient systems. It also provides a framework for testing the various hypotheses regarding the structure and environment of the incipient vortex that is undergoing tropical cyclogenesis. For the tests to be conducted here, a high-resolution numerical model (grid length < 2 km) is necessary to adequately resolve the deep convective towers that are key to the genesis process. A variety of models are available to suit this need; initially the MM5 mesoscale model will be used, which is a well-tested model that provides a variety of options for physical parameterizations. In addition, the WRF-ARW model can be used. Ultimately, the desired model will be the WRF-NMM model, otherwise known as the HWRF model. The HWRF model will be the NOAA operational model, so it is desirable to perform research using this model once it has the capability of being run at sufficiently high resolution.

A variety of experiments can be run with such a modeling framework. Simulations of observed genesis cases can be performed to test the performance of the model and evaluate the importance of the various physical processes observed by the aircraft. Vorticity, heat, and moisture budgets can be calculated from the model and compared with comparable budgets from the Doppler radar and GPS dropsonde data. The statistical properties (e.g., means, distributions, correlations) of various fields and their variation with time and altitude can be compared between the model and the observations to gain a better understanding of the structural evolution of incipient systems and how well they are reproduced in the model. Observing system simulation experiments (OSSEs) can also be performed to determine the optimal flight tracks for initializing HWRF for incipient systems.

To complement the real-data simulations, idealized simulations can be performed that will better be able to isolate specific physical processes important in tropical cyclogenesis. For example, tests could be run that vary the amplitude and altitude of the initial midlevel vortex and the humidity of the synoptic and mesoscale environment of the incipient system. The observations could be used to guide the formulation of idealized experiments by providing a physically realistic range for specifying the structures of the system and its environment and evaluating the performance of the idealized simulations.

Tropical Cyclogenesis Experiment

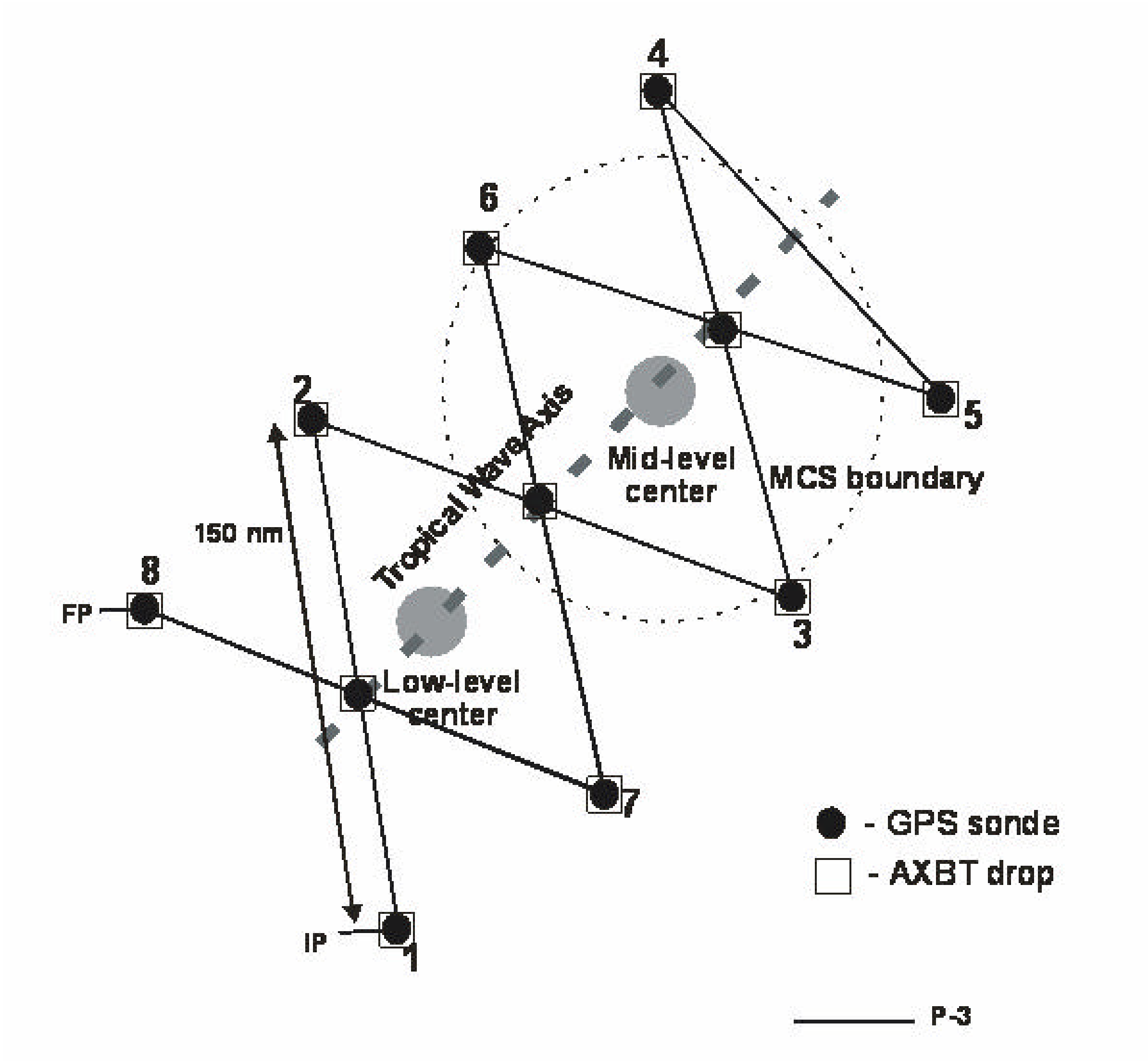


Figure 1: WP-3D Pre-genesis early organization vortex survey pattern – Diamond pattern

- Note 1: True airspeed calibration is required.
- Note 2. The pattern is flown with respect to the wave axis, typically inclined at 30-40° from N, or relative to circulation or vorticity centers.
- Note 3. Length of pattern (axis parallel to wave axis) should cover both low- and mid-level vortices, leg lengths range from 150 – 200 nm (275-375 km).
- Note 4. Fly 1-2-3-4-5-6-7-8 at 14,000 ft (4 km) altitude, dropping sondes at all locations denoted by black circles.
- Note 5. Set airborne Doppler radar to scan F/AST on all legs.

Tropical Cyclogenesis Experiment

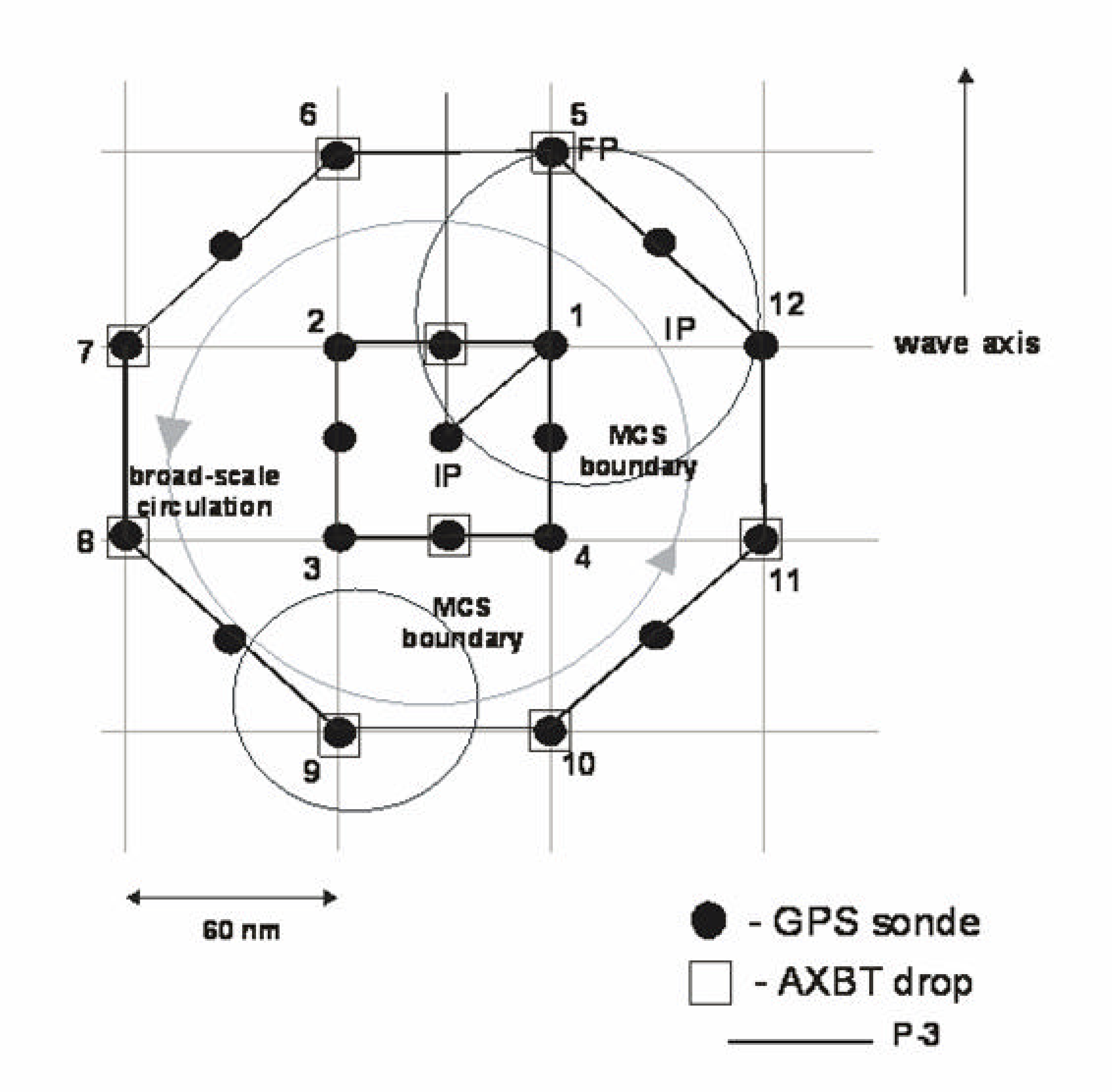


Figure 2: WP-3D Pre-genesis late organization vortex survey pattern – Square-spiral pattern

- Note 1. True airspeed calibration is required.
- Note 2. The pattern is flown with respect to the wave axis, typically inclined at 30-40° from N, or relative to circulation or vorticity centers.
- Note 3. Drop sondes at all numbered points. Drops at intermediate points can be omitted if dropsonde supply is insufficient.
- Note 4. The spacing between the outer spiral and inner box (nominally set to 60 nm (111 km)) can be increased or decreased depending on the size of the disturbance.
- Note 5. Fly 1-2-3-4-5-6-7-8-9-10-11-12 at 14,000 ft (4.0 km) altitude.
- Note 6. Set airborne Doppler radar to scan F/AST on all legs.
- Note 7. ER-2 track is offset 5-10 nm (10-15 km) from track of WP-3D.

Tropical Cyclogenesis Experiment

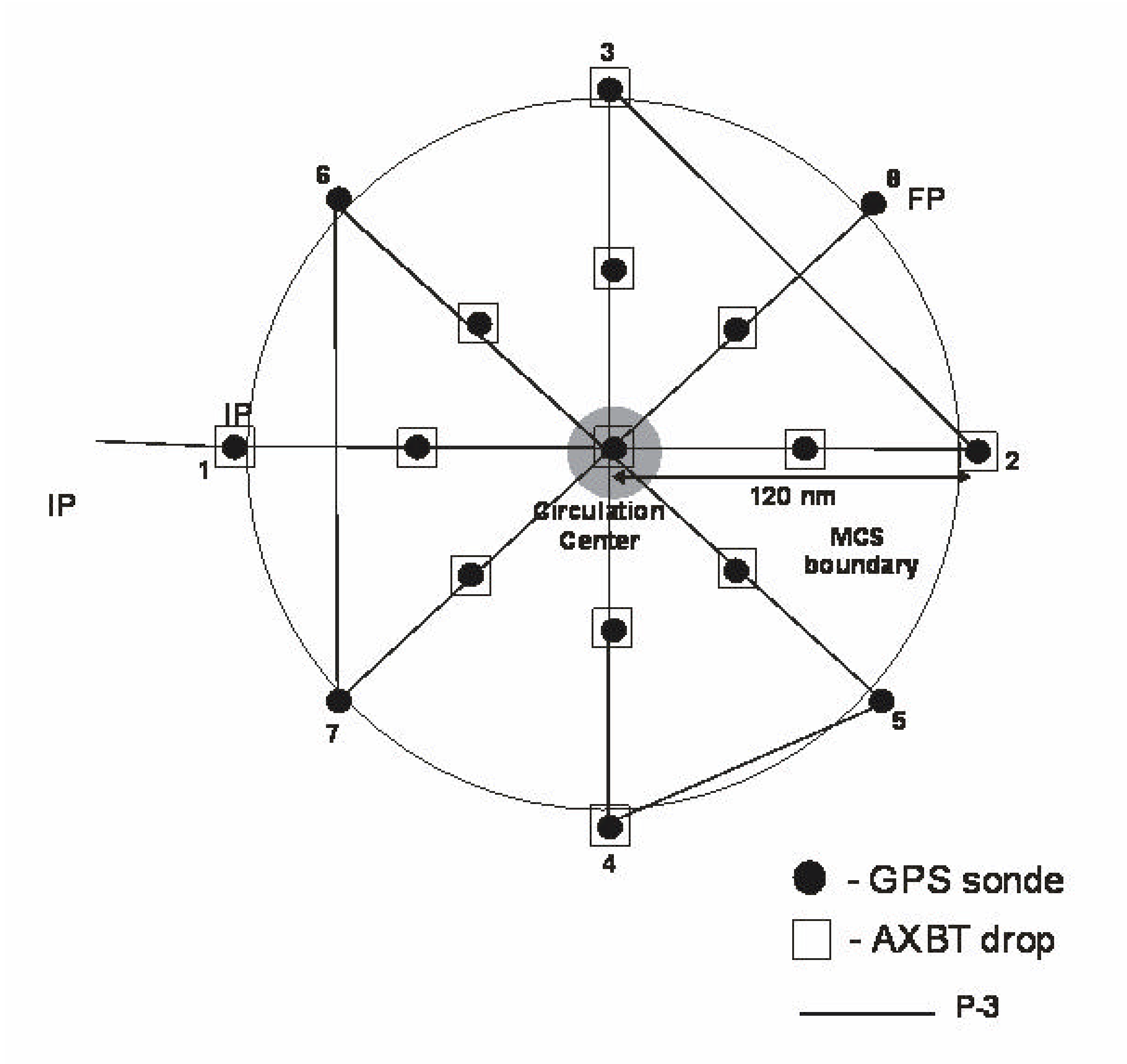


Figure 3: WP-3D Post-genesis rotating Figure-4 pattern

- Note 1: True airspeed calibration is required.
- Note 2. The pattern may be entered along any compass heading.
- Note 3. Fly 1-2-3-4-5-6-7-8 at 14,000 ft altitude, 60-120 nm (111-225 km) leg length.
- Note 4 Set airborne Doppler radar to scan F/AST on all legs.

Tropical Cyclogenesis Experiment

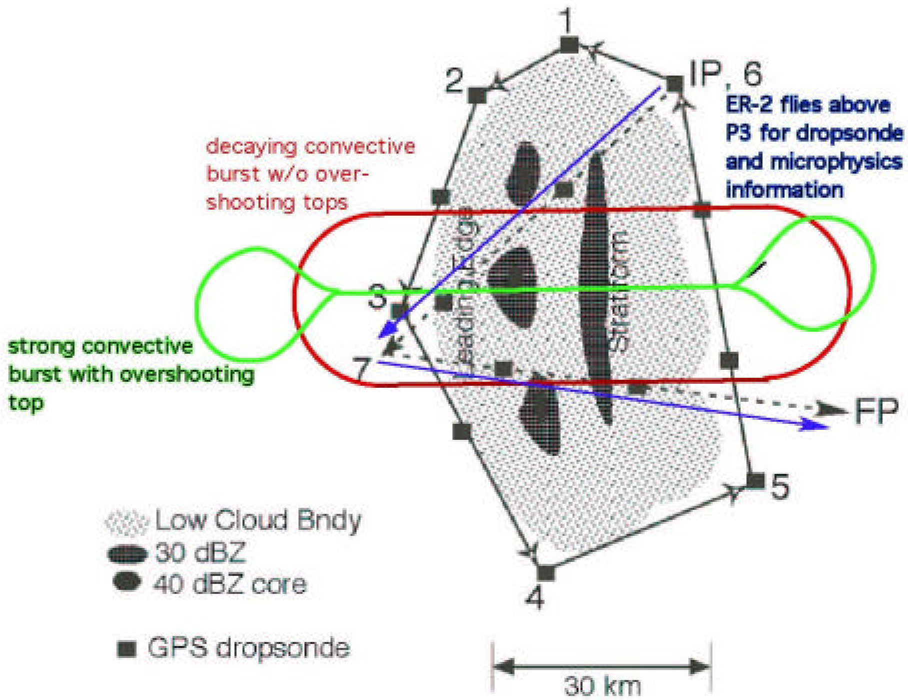


Figure 4: Convective Burst module

- Note 1: True airspeed calibration is required.
- Note 2: Circumnavigation (IP to point 6) by single WP-3D at 14 kft.
- Note 3: Convective crossing (6-7-FP) at 14 kft.
- Note 4: Repeat circumnavigation (time permitting) at low altitude (200 ft in day, 1000 ft at night).
- Note 5: No GPS sondes for low-altitude option.
- Note 6: ER-2 flies either racetrack or bowtie pattern during WP-3D circumnavigation, flies vertically aligned with WP-3D during convective crossing.

HRD RESEARCH EXPERIMENTS (CONT'D)
4. Tropical Cyclone Landfall and Inland Decay Experiment

Program Significance: The lifecycle of a tropical cyclone often ends when it makes landfall and decays as it moves inland. Research has shown that the rate of decay is a function of the
Storm intensity at landfall; accurate real-time description of the TC surface wind field near and after landfall is important for warning, preparedness, recovery efforts, and post-storm analysis. During a hurricane threat, an average of 300 nm (550 km) of coastline is placed under a hurricane warning, which costs about $50 million in preparation per event. The size of the warned area depends on the extent of hurricane and tropical storm force winds at the surface, evacuation lead-times, and the forecast of the storm's track. Research has helped reduce uncertainties in the track and landfall forecasts, and now one of the goals of HRD's Intensity Forecasting Experiment (IFEX) is to improve the accuracy of the surface wind fields in TCs, especially near and after landfall. Improvements in diagnosing surface wind fields could reduce uncertainties in the size of hurricane warning areas.

There are still uncertainties in deriving surface wind estimates from flight level and Stepped Frequency Microwave Radiometer (SFMR) wind speeds collected near the coast. Currents and changing bathymetry could change the breaking wave field, which could change both the roughness length at higher wind speeds as well as changing the microwave emissions. Evaluation of these effects may lead to adjustments to the operational surface wind speed algorithms. Data collected at the coast will also help to refine the inland decay model being developed and evaluated in the Joint Hurricane Test bed (JHT). Airborne Doppler radar data will be transmitted to TPC/NHC and EMC as part of another JHT project to assimilate radar data into the HWRF model.

Analysis of Doppler radar, GPS sonde, SFMR, flight-level and SRA or IWRAP data collected during hurricane flights can help achieve the Intensity Forecasting Experiment (IFEX) goals for the 2006 Field Program. A major goal is to capture the lifecycle of a TC and landfall is usually at the end of the lifecycle. Data collection strategies developed for mature hurricanes over the open ocean can also be applied at landfall. Subsets of the data collected can be transmitted to NHC and to EMC, for assimilation into HWRF. The Doppler and GPS sonde data can be analyzed to derive three-dimensional wind fields to compare with output from the HWRF and data from the NASA Scanning Radar Altimeter (SRA) can be compared to HWRF wavefields. In addition to shear and heat flux from the ocean, hurricanes at landfall experience other conditions that may affect intensity change. These include change in ocean wave action in shallow waters, change in surface roughness, drier and cooler inflow from the land, and topography. Radar, dropsonde, and SFMR data can help define those conditions. Decay over land is also important. Data collected during and shortly after landfall should help refine operational statistical decay models as well as provide validation for HWRF.

HRD developed a real-time surface wind analysis system to aid the TPC/NHC in the preparation of warnings and advisories in TCs. The surface wind analyses are now used for post-storm damage assessment by emergency management officials. The surface wind analyses are also used to validate and calibrate an operational inland wind forecast model that HRD has developed under Federal Emergency Management Agency (FEMA) sponsorship. The operational storm surge model (SLOSH) could also be run in real-time with initial data from the surface wind analysis.

As a TC approaches the coast, surface marine wind observations are normally only available in real-time from National Data Buoy Center (NDBC) moored buoys, C-MAN platforms, and a few ships. Surface wind estimates must therefore be based primarily on aircraft measurements. Low-level (<5,000 ft (1.5 km] altitude) NOAA and Air Force Reserve aircraft flight-level winds are adjusted to estimate surface winds. These adjusted winds, along with C-SCAT and SFMR wind estimates, are combined with actual surface observations to produce surface wind analyses. These surface wind analyses were initially completed after Hurricane Hugo's landfall in South Carolina and Hurricane Andrew's landfall in South Florida in support of post-landfall damage surveys conducted by FEMA. In recent years, these analyses have been produced in real-time for operational use by the NHC for many of the TCs that have affected the Western Atlantic basin, including such notable landfalling storms as Opal (1995), Fran (1996), Georges (1998), Bret and Floyd (1999), Isidore (2003) and Frances, Ivan and Jeanne (2004), and Dennis, Katrina, Rita and Wilma (2006).

Dual-Doppler analysis provides a more complete description of the wind field in the inner core. Recently the analysis techniques have been streamlined so real-time wind analyses can be computed aboard the aircraft and wind fields at selected levels transmitted from the aircraft to NHC and NMC. These wind fields are also quite useful for post-storm analysis. An observational study of Hurricane Norbert (1984), using a PDD analysis of airborne radar data to estimate the kinematic wind field, found radial inflow at the front of the storm at low levels that switched to outflow at higher levels, indicative of the strong shear in the storm's environment. Another study used PDD data collected in Hurricane Hugo near landfall to compare the vertical variation of winds over water and land. The profiles showed that the strongest winds are often not measured directly by reconnaissance aircraft.

Recent GPS sondes dropped at and inside the flight-level radius of maximum winds (RMW) in strong hurricanes have shown remarkable variations of the wind with height. A common feature is a wind speed maximum at 300-500 m altitude. Theoretical and numerical modeling of the hurricane boundary layer suggests that the low-level jets are common features. The height of the jet varies by storm quadrant, and modeling indicates that this variation can be enhanced as a hurricane crosses land.

While collection of dual-Doppler radar data by aircraft alone requires two WP-3D aircraft flying in well-coordinated patterns, time series of dual-Doppler data sets have been collected by flying a single WP-3D toward or away from a ground-based Doppler radar. In that pattern, the aircraft Doppler radar rays are approximately orthogonal to the ground-based Doppler radar rays, yielding true Dual-Doppler coverage. Starting in 1997 the Atlantic and Gulf coasts were covered by a network of Doppler radars (WSR-88D) deployed by the National Weather Service (NWS), Department of Defense, and Federal Aviation Administration (Fig C-5 in the Appendix). Each radar transmits the base data (Level II) in near real-time to a central site. These data are subsequently archived at the National Climatic Data Center. In precipitation or severe weather mode the radars collect volume scans every 5-6 min.

If a significant tropical cyclone moves within 215 nm (440 km) of the coast of the Eastern or Southern United States, then (resources permitting) a WP-3D will obtain Doppler radar data to be combined with data from the closest WSR-88D radars in dual-Doppler analyses. The tail radar is tilted to point 20 deg forward and aft from the track during successive sweeps (the fore-aft canning mode: F/AST). These analyses could resolve phenomena with time scales <10 min, the time spanned by two WSR-88D volume scans. This time series of dual-Doppler analyses will be used to describe the storm's inner core wind field and its evolution. The flight pattern for this experiment is designed to obtain dual-Doppler analyses at intervals of 10-20 min in the inner core. The Doppler data will be augmented by dropping GPS sondes near the coast, where knowledge of the boundary-layer structure is crucial for determining what happens to the wind field as a strong storm moves inland. GPS sondes will also be dropped in the eye wall in different quadrants of the hurricane. To augment the inner core analyses, dual-Doppler data can also be collected in the outer portions of the storm, beyond the range of the WSR-88D, because the alternating forward and aft scans in F/AST mode intersect at 40 deg, sufficient for dual-Doppler synthesis of winds.

Objectives:

- **A)** Collect flight level wind data and make surface wind estimates to improve real-time and post-storm surface wind analyses in hurricanes.
- **B)** Collect airborne Doppler radar to combine with WSR-88D radar data in post-storm three-dimensional wind analyses.
- **C)** Document thermodynamic and kinematic changes in the storm during and after landfall.
- **D)** Measure the characteristics of the middle troposphere and the hurricane boundary layer with GPS sondes.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- **Goal 1**: Collect observations that span the TC lifecycle in a variety of environments;

- o **Goal 2**: Develop and refine measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment;
- o **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

Mission Description:
This experiment is a *multi-option, single-aircraft* experiment designed to study the changes in TC surface wind structure near and after landfall. The experiment has several modules that could also be incorporated into operational surveillance or reconnaissance missions. This experiment is designed to be conducted by flying one or two single aircraft missions with a NOAA WP-3D aircraft when a hurricane moves within 215 nm (400 km) of the U.S. coastline. The first of these 2 flights will typically consist of the real-time module followed by SFMR and/or Coastal Wind Profile modules. A second flight could complete the post-landfall module. If the storm either moves parallel to the coastline or moves slowly inland and resources permit, the experiment may be repeated with a second flight. While the storm's location relative to the coastline will dictate which combination of these modules will be flown, the real-time module will generally precede all of the other modules.

The aircraft must have working lower fuselage and tail radars. The HRD workstation should be on board, so we can ingest, analyze, and transmit radar and GPS sonde data back to TPC/NHC. The SFMR should be operated, to provide estimates of wind speed at the surface. If the IWRAP or C-SCAT is on the aircraft then it should also be operated to provide another estimate of the surface winds. If the NASA SRA is working it also should collect wave and sweep heights to characterize the storm surge and breaking wavefield near the coast.

If some of the portable Doppler radars (SMART-R and/or DOW), portable profilers and portable wind towers are deployed between ~65 and 130 km inland in the onshore flow regime as depicted in Fig. LF_1, this will provide valuable data for the inland decay model. If possible, one of the DOWs should be positioned relative to the nearest WSR-88D such that the dual-Doppler lobes cover the largest area of onshore flow possible. In the schematic shown in Fig. LF_1, one of the DOWs is positioned northwest of the Melbourne WSR-88D so that one dual-Doppler lobe is over the coastal waters and the other covers the inland region. The profiler is positioned in the inland dual-Doppler lobe to provide independent observations of the boundary layer to anchor the dual-Doppler analysis.

All of the modules support real-time and post-storm surface wind analyses. The flight patterns will depend on the location and strength of the storm relative to surface observing platforms and coastal radars. The first two modules could be easily incorporated into a tasked operational mission. The other three modules are more suited to research missions, where the patterns are not constrained by fix or gale force wind radii requirements. When possible, TC Landfall and Inland Decay missions will be coordinated with the Aerosonde Tropical Cyclone Inflow Experiment. This coordination will involve the WP-3D and be executed on a case-by-case basis.

Real-time module:
The real-time module combines passes over marine surface platforms with one or more figure four patterns in the core of the hurricane (Fig. LF_1.) The aircraft flies at or below 5,000 ft (1.5 km) (ideally at 2,500 ft [750 m]), so that flight level winds can be adjusted to 30 ft (10 m) to combine with measurements from marine surface platforms. Flight-level data and GPS sondes dropped near the platforms will be used to validate the adjustment method. Note that if the storm is outside of WSR-88D Doppler range then the figure-4 pattern could be repeated before returning home.

The landfall flight pattern should take advantage of buoys or C-MAN sites nearby, if those platforms are expected to experience winds > 25 m/s. The aircraft descends at the initial point and begins a low-level figure-4 pattern, possibly modifying the legs to fly over the buoys (Fig. LF_1). The radar will be in F/AST mode. If time permits the aircraft would make one more pass through the eye and then fly the dual-Doppler option. In this example, the pattern would be completed in about 2.5 h. GPS sondes would be dropped near the buoys or C-MAN sites, and additional sondes will be dropped at or just inside the flight level radius of maximum winds (RMW).

Note that the optimal volume scans for this pattern will be obtained when the storm is 32-80 nm (60-150 km) from the radar, because beyond 80 nm (150 km) the lowest WSR-88D scan will be above 5,000 ft (1.5 km) which is too high to resolve the low-level wind field. Within 32 nm (60 km) the volume scan will be incomplete, because the WSR-88D does not scan above 19.5%. It is essential that these passes be flown as straight as possible, because turns to fix the eye will degrade the Doppler radar coverage.

Coastal Survey module:
When the hurricane is making landfall, this module will provide information about the boundary layer in the onshore and offshore flow regimes. FigureLF_2 shows an example for a hurricane making landfall near Melbourne, Florida. On the first coastal pass the WP-3D would fly parallel 10-15 km offshore to obtain SFMR surface winds (1-2 in Fig. LF_2). The track should be adjusted so that the SFMR footprint is out of the surf zone. The second pass should as close to the coast as safety permits, to sample the boundary layer transitions at the coast in onshore and offshore flow (3-4 in Fig. LF_2). The first pass should be at 5,000 ft (1.5 km) or less, and the aircraft could climb to higher altitudes for the second pass. On both of these passes the aircraft should fly to 150 km or the radius of gale-force winds and drop GPS sondes at the RMW and at intervals of 12.5, 25, 50, 75 and 100 or 125 km on either side of the storm track, to sample both onshore and offshore flow regimes. Finally, to better sample the adjustment of the off shore flow from land to ocean a short leg would be flown from the coast spiraling towards the storm center. 3-4 dropsondes would be dropped quite near the coast, followed by 3-4 dropsondes spaced every 20-30 km along the trajectory. The Doppler radar will be in F/AST mode, to provide wind estimates on either side of the aircraft track. This module could be flown when the hurricane is making landfall or after the storm moves inland. The pattern could be flown in ~2 h.

SFMR Evaluation Module:
This module is similar to the Coastal Survey module, except that it concentrates on the region with hurricane force winds and is designed to collect data to evaluate the performance of the SFMR in varying ocean conditions near landfall where strong oceanic currents (like the Gulf Stream) and shallower bathymetry could cause changes to the breaking wave field that would cause changes in microwave emissions, besides those changes that correlate directly to wind speed. As shown in Fig. LF_3, the aircraft would fly a leg toward the coast, preferably at 1200' above MSL, to gather high resolution SRA data to define the wave field. A sequence of combined AXBT and GPS sonde drops will map out the thermodynamic and boundary layer wind speeds. This leg is followed by a run along the coast to the maximum offshore flow, where the plane turns and flies offshore, dropping a further sequence of AXBTs and sondes. The final leg of the pattern, in this example, is parallel to the Gulf Stream back to the onshore flow region. From here the module could be repeated or the aircraft could execute the next module.

Onshore Wind Profile Evaluation Module:
In this module, the aircraft will collect vertical profiles of wind speed in various near shore environments to test the hypothesis that near the coast surface wind speeds may be lower than the operational flight level wind reduction would suggest. Data collected will help evaluate various effects. For example, roughness lengths may change, especially in higher wind speeds. The boundary layer changes at the coast; sonde data will help indicate whether there are similar changes from open ocean to coastal waters.

To evaluate the adjustment of winds from normal reconnaissance altitude to the surface in near-shore conditions, the aircraft should fly this module at 700 hPa (10000', ~3000 m). The aircraft follows the flow to the coast (Fig. LF_4), deploying GPS sondes every 5-10 nmi. Then the aircraft turns and flies into the center of the storm, back off shore, and then upwind to a point to start a new onshore profile, where each sequence of sondes is closer to the radius of maximum winds. The last sequence could be along the inside edge of the eye wall. To maintain good SFMR, tail Doppler radar, SRA and IWRAP data collection, the onshore flow segments should be flown in short straight segments with quick turns rather than smooth curves.

Post Landfall Module:
This module is designed to collect kinematic and thermodynamic data ~1-2 h prior to and up to 6 h after a hurricane makes landfall. It is essential that ground based measurements are obtained in conjunction with those that are being made by aircraft, since the primary goal of this module is to determine the kinematic and thermodynamic changes that occur after a hurricane makes landfall, throughout the depth of the lower troposphere.

The WP-3D will fly a coastal survey pattern followed by a figure-4 pattern (Fig. LF_5) over land with leg lengths ~150 km at an altitude of ~15,000 ft (5 km). The WP-3D tail radar should be in F/AST mode. These data will aid in rainfall estimation and will help document the changes in vortex and rain band structure over land that are crucial to understanding the environment that supports tornado and mesovortex development.

Over land, available portable wind towers, mesonet stations, profilers and DOW radars should be deployed along the path of the landfalling hurricane to identify the changes in storm structure as the hurricane moves inland. The wind towers and mesonet stations will obtain high-resolution surface wind, temperature, pressure, relative humidity, and perhaps rainfall measurements. If available, a profiler could be placed at the center of each line of mesonet stations. The profilers and RASS sounder will provide wind and temperature measurements within the lowest 3 and 1 km, respectively. Rain gauges should be located at each profiler and DOW radar site to obtain high-resolution rainfall measurements, both for calibrating the radar rainfall algorithms and for documentation of storm rainfall.

The first set of towers and mesonet stations should be placed as close as possible to the coastline (<10 km) to enable accurate documentation of the surface wind field just after landfall. Other towers or mesonet stations should be placed ~65 and 135 km inland respectively; however, these distances will vary depending upon the intensity and speed of motion of the landfalling storm as well as safety considerations. Fig. LF_6 shows the estimated time after landfall that is required for the TC winds to decay to various wind threshold levels as determined using the HRD empirical inland wind decay model. The spacing between the mesonet stations located within each group should be ~30 nm (50 km) perpendicular to the track to maximize the likelihood that one of the mesonet stations will be located near the radius of maximum wind of the landfalling storm.

If the inland profilers are mobile, it will be possible to follow severe weather producing rainbands if safety and logistical considerations allow. The DOW Doppler radars should be placed roughly halfway between the two rear lines of mesonet and profiler stations. The DOW radars in combination with the profilers with RASS will aid in documenting the changes in kinematic and thermodynamic structure of the hurricane after landfall. An accurate analysis of such changes is crucial to learning more about the development of mesovortices and/or tornadoes spawned by landfalling hurricanes. They will also help document the changes in winds within the PBL of a landfalling hurricane. Finally, the radars will aid in the measurement of the rainfall associated with the landfalling hurricane.

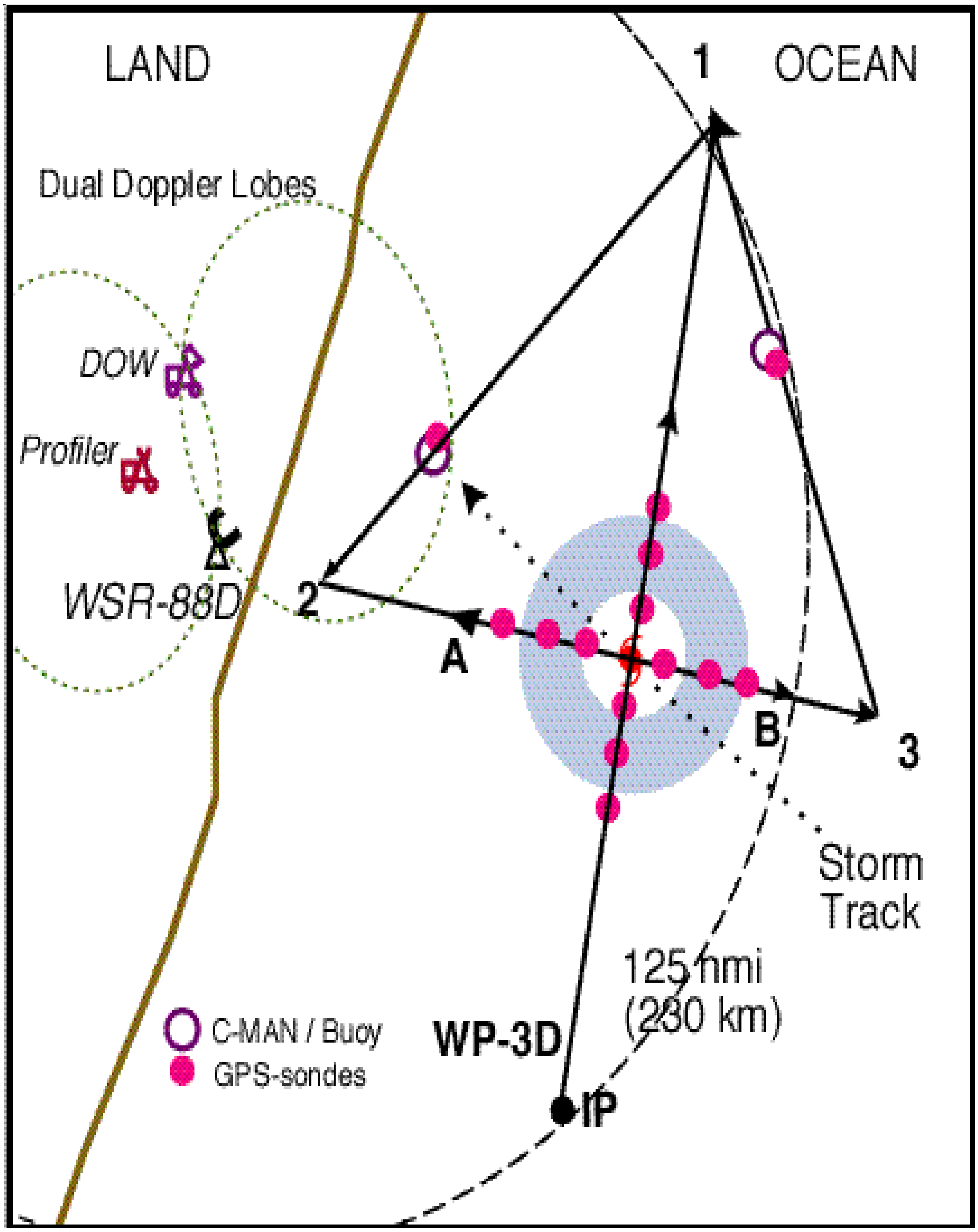


Figure LF_1 (Real-time module): True airspeed calibration required. The legs through the eye may be flown along any compass heading along a radial from the ground-based radar. The **IP** is approximately 100 nm (185 km) from the storm center. Downwind legs may be adjusted to pass over buoys. WP-3D should fly legs along the WSR-88D radials. Set airborne Doppler radar to F/AST scanning on all legs. Aircraft should avoid penetration of intense reflectivity regions (particularly those over land). Wind center penetrations are optional.

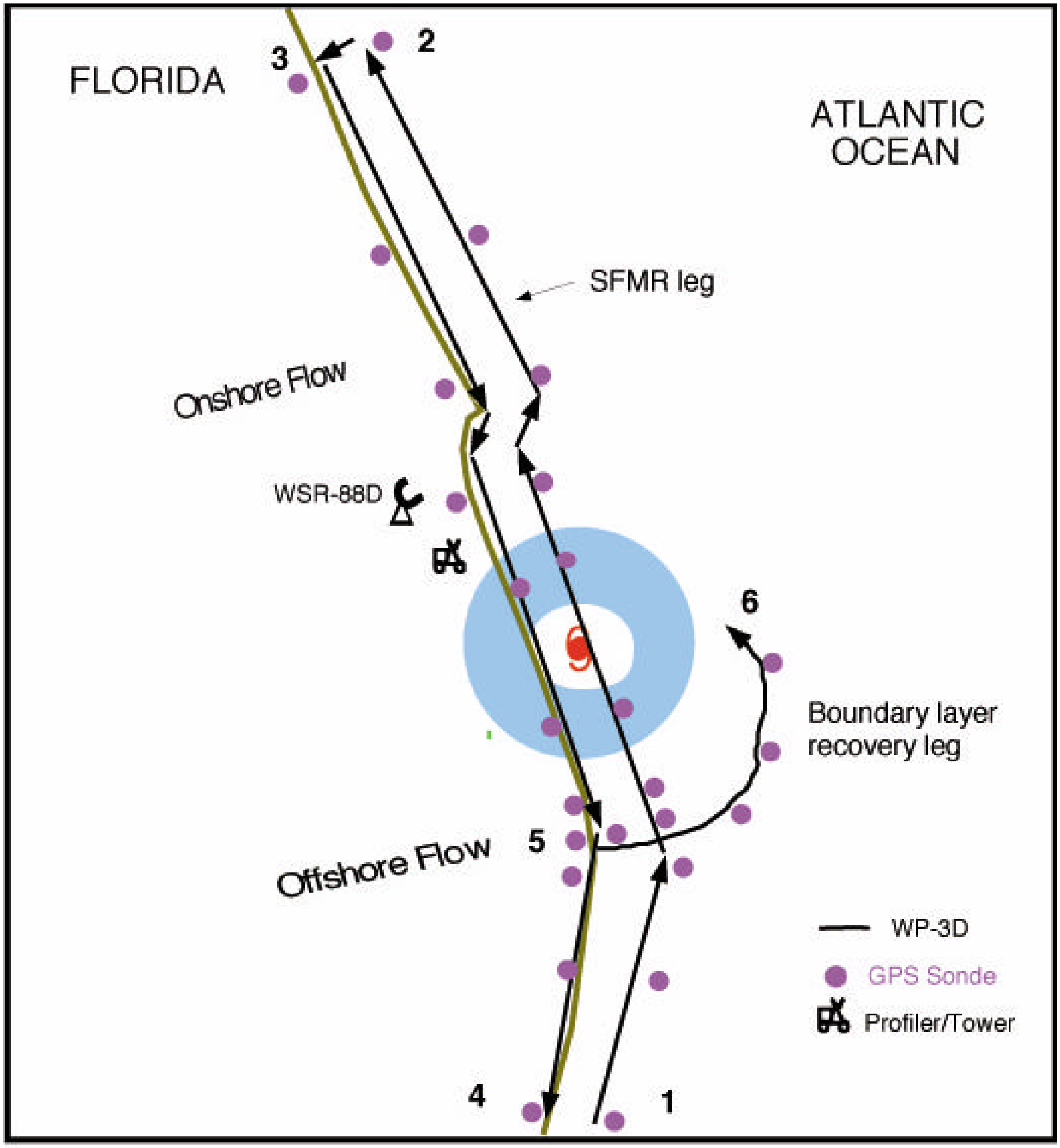


Figure LF_2 (Coastal Survey pattern): First pass starts 150 km from center or radius of gale-force winds, whichever is closer. Pass from **1-2** should be 10-15 km offshore for optimum SFMR measurements. Drop sondes at RMW, and 12.5, 25, 50, 75 and 100 or 125 km from RMW on ether side of storm in legs **1-2** and **3-4**. Dropsondes should be deployed quickly at start of leg **5-6**, and then every 10-15 km hereafter. Set airborne Doppler to scan in F/AST scanning on all legs, with single PRF > 2400 and 20% tilt. Aircraft should avoid penetration of intense reflectivity regions (particularly those over land).

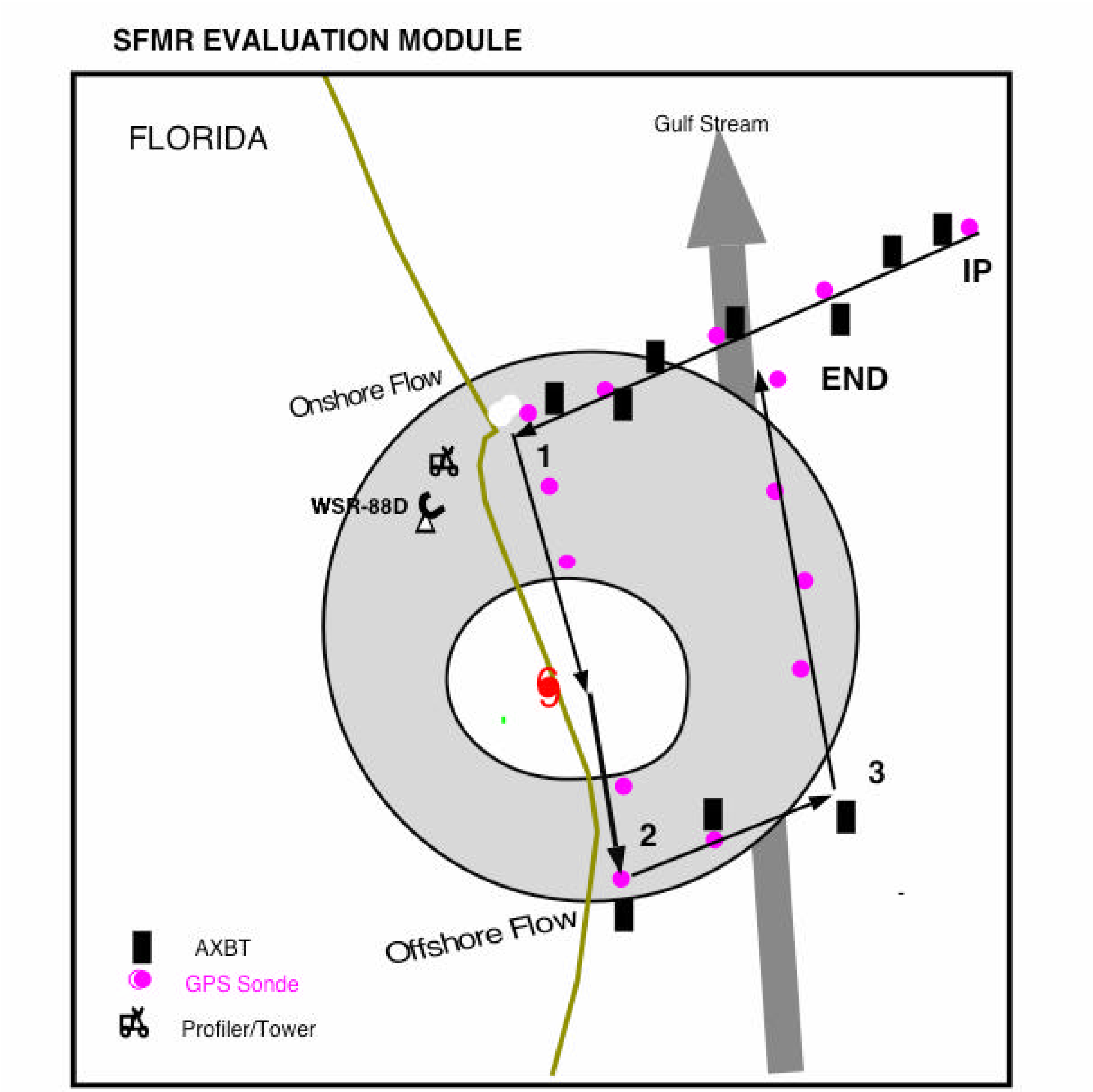


Figure LF_3 (SFMR Evaluation Module): Gray area encloses hurricane inner core with winds > hurricane force. True airspeed calibration is required. The legs are at 1500-3000 ft (500 - 1000 m) altitude. Set airborne Doppler radar to F/AST mode at a single PRF 2400 and 20° tilt on all legs. Aircraft should avoid penetration of intense reflectivity regions (particularly those over land). Wind center penetrations are optional.

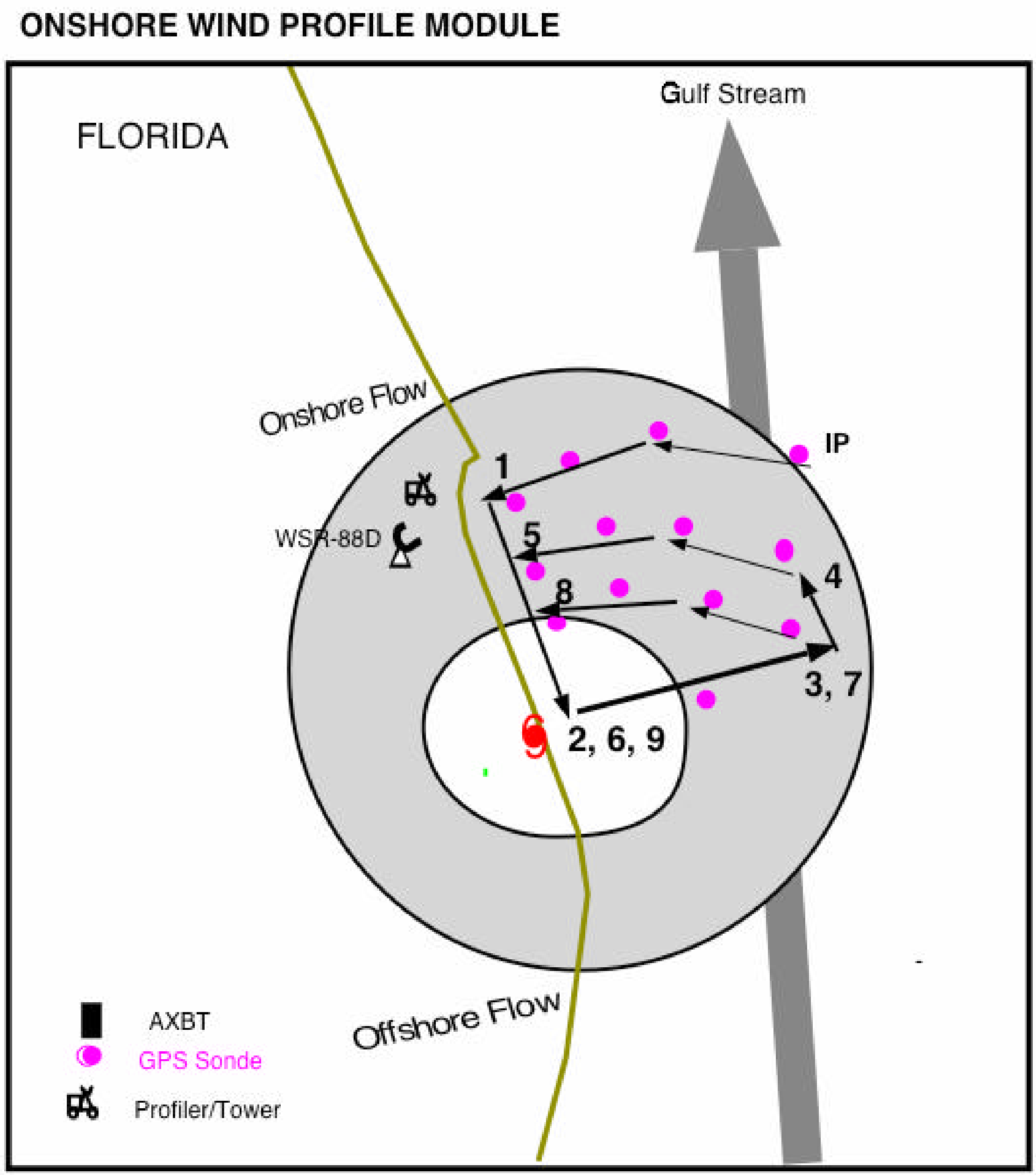


Figure LF_4 (Coastal Wind speed Profile Evaluation Module): True airspeed calibration is required. The legs are at 700 hPa (10000 ft, 3000 m) altitude. Set airborne Doppler radar to F/AST mode at a single PRF 2400 and 20° tilt on all legs. Aircraft should avoid penetration of intense reflectivity regions (particularly those over land). Wind center penetrations are optional.

TROPICAL CYCLONE LANDFALL WINDFIELDS EXPERIMENT

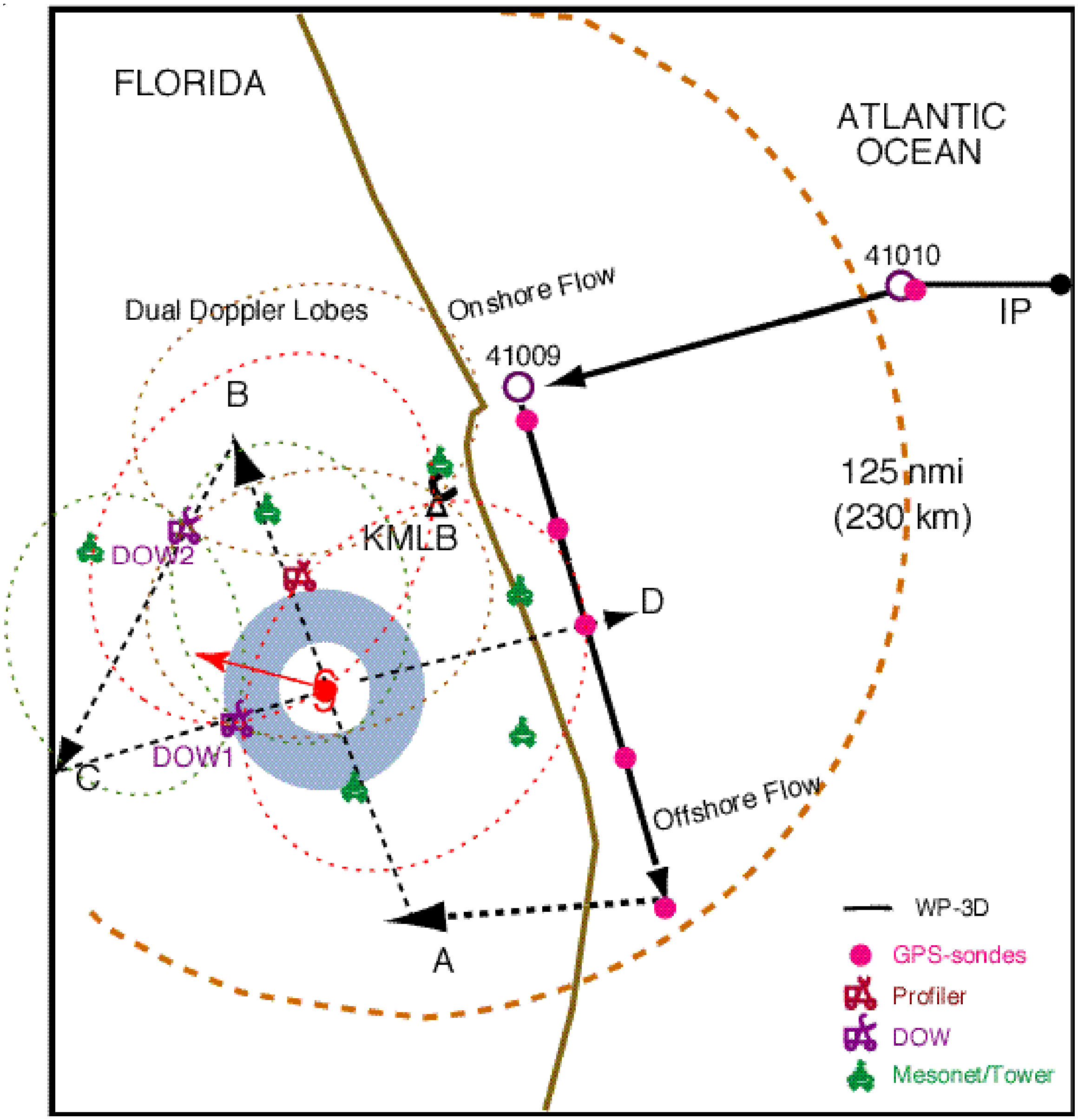


Figure LF_5 (Post landfall module flight pattern): Coastal survey pattern (sold line) at an altitude of ~10,000-15,000 ft (3-4 km) dropping GPS sondes near buoys of opportunity and within 10-20 km of the shore in both the onshore and offshore flow. Inland figure-4 pattern (dashed line) centered on the storm with leg lengths of ~80 nm (150 km) at an altitude of ~15,000 ft (5 km). WP-3D should fly legs along the WSR-88D radials. Set airborne Doppler radar to F/AST scanning on all legs. Aircraft should avoid penetration of intense reflectivity regions (particularly those over land). Wind center penetrations are optional.

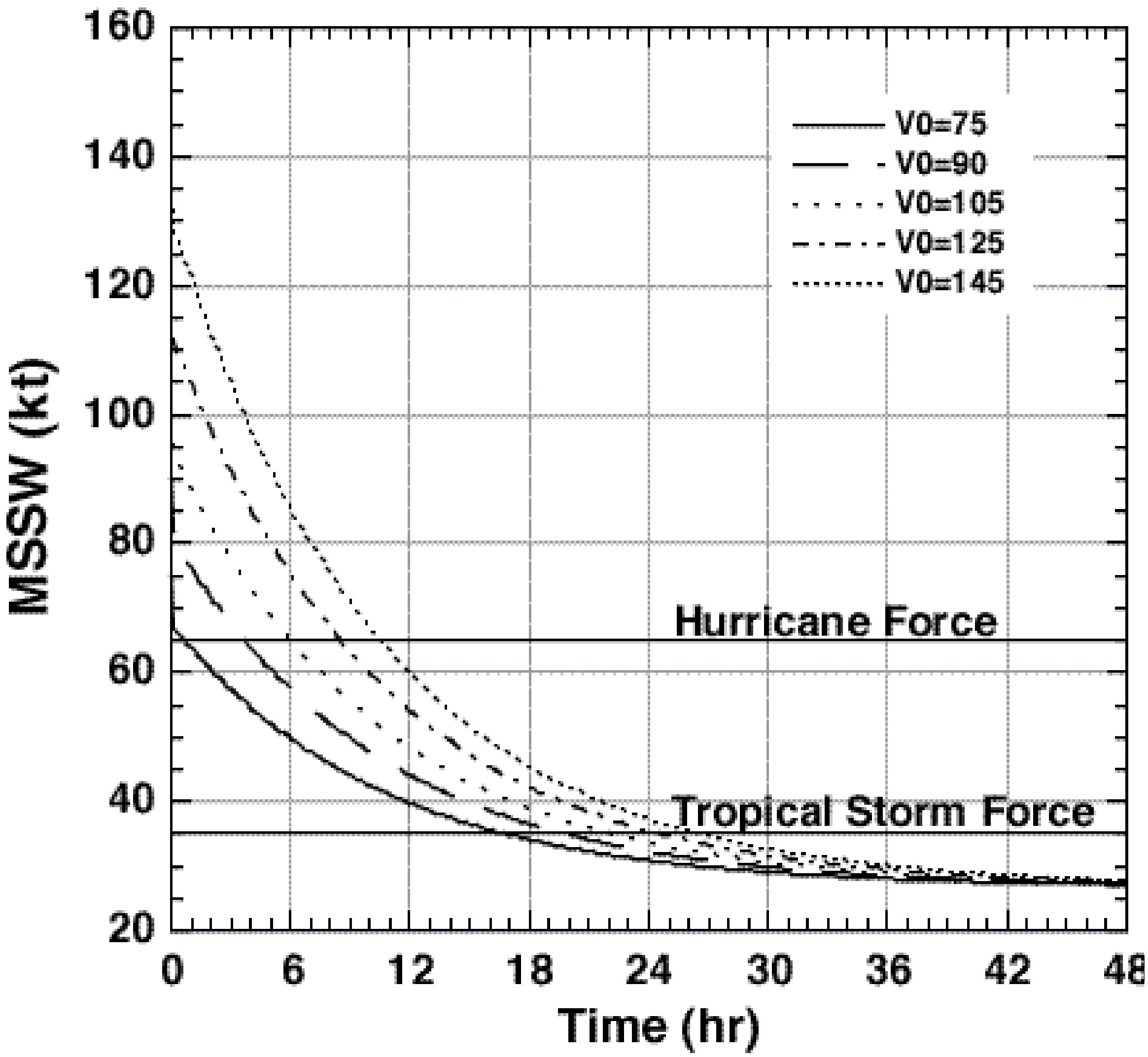


Figure LF_6 (Maximum sustained surface winds after landfall): Maximum sustained surface winds (MSSW) after landfall estimated using the Kaplan/DeMaria (1995) inland wind decay model for TCs with landfall intensities (V0) of 75, 90,105,120, and 145 kt.

5. Tropical Cyclone Eye Mixing Module

Program Significance: Eyewall mesovortices have been hypothesized to mix high entropy air from the eye into the eyewall, thus increasing the amount of energy available to the hurricane. Signatures of such mesovortices have been seen in cloud formations within the eyes of very strong TCs, and from above during aircraft penetrations. Observations within the eye below the inversion can allow for the study of the dynamic and thermodynamic structures of these mesovortices and improve our knowledge of small-scale features and intensity changes in very strong TCs.

Objectives: The main objective of the Eye Mixing Module is to:

- Collect observations within the eye below the inversion to investigate the dynamic and thermodynamic structures of these mesovortices and improve our knowledge of small-scale features and intensity changes in very strong TCs.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

Mission Description: Although this WP-3D research module is not a standalone experiment it could be included as a module within any of the following HRD research missions: Saharan Air Layer Experiment, Aerosonde Experiment, or TC Landfall and Inland Decay Experiment. For this module, a Category 4 or 5 TC with a clearly-defined eye and eyewall and an eye diameter of at least 25 nm is needed (Fig. EYE-1). The WP-3D will penetrate the eyewall at the altitude proposed for the rest of the experiment. Once inside the eye, the WP-3D will descend from that altitude to a safe altitude below the inversion (about 2500 ft) while performing a figure-4 pattern. The leg lengths will be determined by the eye diameter, with the ends of the legs at least 2 nm from the edge of the eyewall. Upon completion of the descent, the WP-3D will circumnavigate the eye about 2 nm from the edge of the eyewall in the shape of a pentagon or hexagon. Time permitting; another figure-4 will be performed during ascent to the original flight level. Depending upon the size of the eye, this pattern should take between 0.5 and 1 h.

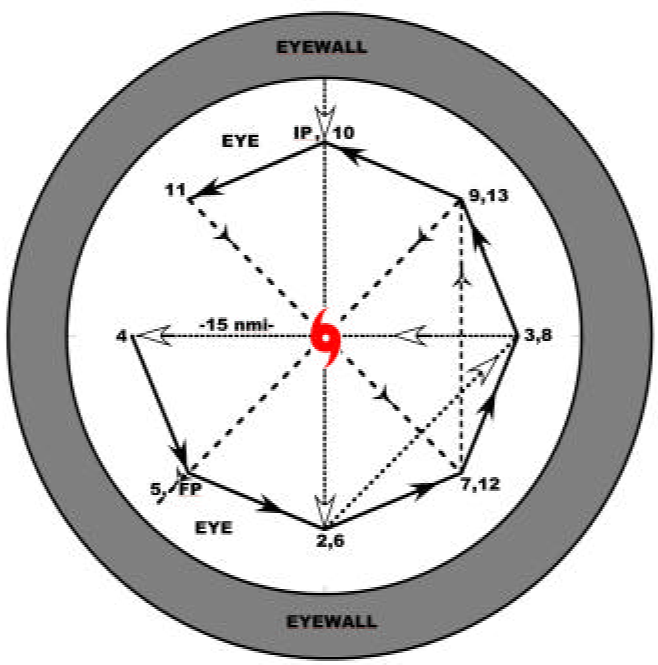


Figure EYE-1 (Mature Storm Eye Module): The WP-3D approaches from the north, penetrates the eyewall into the eye, and descends below the inversion to 2500 ft while performing a figure-4 (dotted line) in the eye. The WP-3D circumnavigates the eye in an octagon or pentagon (solid line), and then ascends while conducting another figure-4 (time permitting) rotated 45 degrees from the original (dashed line).

NHC AND EMC OPERATIONAL MISSIONS

1. Hurricane Synoptic-Flow Experiment

Program Significance: Accurate numerical TC forecasts require the representation of meteorological fields on a variety of scales, and the assimilation of the data into realistic models. Omega dropwindsonde (ODW) observations from WP-3D aircraft obtained between 1982 and 1996 during the Hurricane Synoptic Flow Experiment produced significant improvement in the guidance for official track forecasts. Since 1997, more than 130 operational "Synoptic Surveillance" missions have been flown with the NOAA G-IV jet in the environments of TCs threatening the United States coastline; some of these have been supplemented with dropwindsonde observations from one or two WP-3D or USAF C-130 aircraft. An improved dropwindsonde based on the Global Positioning System has been developed by the National Center for Atmospheric Research and has replaced the ODW. With further operational use of the G-IV aircraft, and as other mobile observing platforms become available, optimal sampling and utilization techniques must be devised to provide the greatest possible improvement in initial condition specification.

Objectives: The goal of the NHC/HRD synoptic flow experiment is to improve landfall predictions of TCs by releasing dropwindsondes in the environment of the TC center. These data will be used by TPC/NHC and NCEP to prepare objective analyses and official forecasts through their assimilation into operational numerical prediction models. Because the atmosphere is known to be chaotic, very small perturbations to initial conditions in some locations can amplify with time. However, in other locations, perturbations may result in only small differences in subsequent forecasts. Therefore, targeting locations in which the initial conditions have errors that grow most rapidly may lead to the largest possible forecast improvements. Locating these regions that impact the particular forecast is necessary. When such regions are sampled at regularly spaced intervals the impact is most positive. The optimal targeting and sampling strategies is an ongoing area of research.

A number of methods to find targets have been investigated, mainly in the wintertime extratropics. Potential vorticity diagnosis can help to find the cause of forecast failure. Singular vectors of the linearized equations of motion can estimate the growth of small perturbations in the model. This method is relatively expensive, and full implementation in the Tropics where adiabatic processes dominate has proven difficult, and the linear assumption tends to break down at the 72 h forecast time necessary for the posting of hurricane watches and warnings. Related strategies involve the sensitivity vector, and quasi-inverse linear method. All these methods may depend on the accuracy of the initial conditions determined without the supplemental data.

A fully nonlinear technique uses the breeding method, the operational NCEP perturbation technique in which initially random perturbations are repeatedly evolved and rescaled over a relatively short cycling time. These vectors are related to local Lyapunov vectors and, therefore, define the fastest growing modes of the system. Changes to initial conditions due to dropwindsonde data obtained from operational synoptic surveillance missions during the 1997 and 1998 hurricane seasons grow (decay) in regions of large (small) perturbation in the operational NCEP Ensemble Forecasting System. Therefore, these bred-modes provide a good estimate of the locations in which supplemental observations are likely to have the most impact. However, though the breeding method can find locations of probable error growth in the model globally, it does not distinguish those locations, which impact the particular forecast from those which do not.

A more generalized method which can use any dynamical ensemble forecast system is the ensemble transform. This method transforms an ensemble of forecasts appropriate for one observational network into one appropriate for other observational networks. Ensemble forecasts corresponding to adaptations of the standard observational network are computed, and the expected prediction error variance at the observation time is computed for each potential network. The prediction error variance is calculated using the distances between the forecast tracks from all ensemble members and the ensemble mean. These last two methods are currently undergoing testing with Observing System Experiments to discern an optimal targeting technique.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- **Goal 1**: Collect observations that span the TC lifecycle in a variety of environments;

Mission Description: To assess targeting strategies a relatively uniform distribution of dropwindsondes will be released over a minimum period by various aircraft operating *simultaneously*. Specific flight tracks will vary depending on such factors as the location of the storm, relative both to potential bases of operation and to particular environmental meteorological features of interest.

In 2006, it is unlikely NHC/HRD will perform synoptic flow missions with the WP-3D aircraft unless NOAA is tasked by NHC to do so. The flight patterns described here can be adopted for implementation by the USAF C-130 aircraft on tasked surveillance missions which could be augmented by one of the NOAA WP-3Ds only on a non-interference basis with other research or operationally-tasked missions. A current goal is to obtain oversampled datasets with which to study the effectiveness of the various targeting techniques described above. This goal usually requires the deployment of more than one aircraft during a particular mission.

A sample mission is shown in Fig. SYN-1. The two WP-3D or C-130 aircraft and the G-IV will begin their missions at the same time. Subject to safety and operational constraints, each WP-3D or C-130 will climb to the 500 hPa level (about FL 180) or above, then proceed, step-climbing, along the routes assigned during preflight. *It is particularly important that both aircraft climb to and maintain the highest possible altitude as early into the mission as aircraft performance and circumstances allow, and attain additional altitude whenever possible during the mission.*

Beyond 60 nm (111 km) from the storm center, drops are made at pre-assigned locations, generally every 120 nm (222 km). These drop locations are provided with the particular mission flight tracks 24 h before departure and may potentially be modified in-flight. Since dropwindsonde data within 60 nm (111 km) of the storm center are automatically rejected by the operational data assimilation schemes, such observations are not made unless requested as part of other tasking requirements.

If a NOAA WP-3D aircraft is involved in the missions, at least one will fly through the TC center and execute a figure-4 pattern. This aircraft's Doppler radar should be set to record forward and aft (F/AST) continuously. If both aircraft penetrate the storm, the figure-4 pattern will generally be executed by the *second* aircraft through the storm, and the first aircraft through will collect vertical incidence Doppler data. Coordination with potential USAF reconnaissance is necessary to ensure adequate aircraft separation. The in-storm portion of the missions is shown schematically in Fig. SYN-2, although the actual orientation of these tracks may be rotated.

Of paramount importance is the transmission of the dropwindsonde data to NCEP and TPC/NHC for timely incorporation into operational analyses, models, forecasts, and warnings. Operational constraints dictate an 0600 or 1800 UTC departure time, so that most of the dropwindsonde data will be included in the 1200 or 0000 UTC analysis cycle. Further, limiting the total block time to 9 h allows adequate preparation time for aircraft and crews to repeat the mission at 24-h intervals. These considerations will ensure a fixed, daily real-time data collection sequence that is synchronized with NCEP and TPC/NHC's analysis and forecasting schedules.

HURRICANE SYNOPTIC FLOW EXPERIMENT

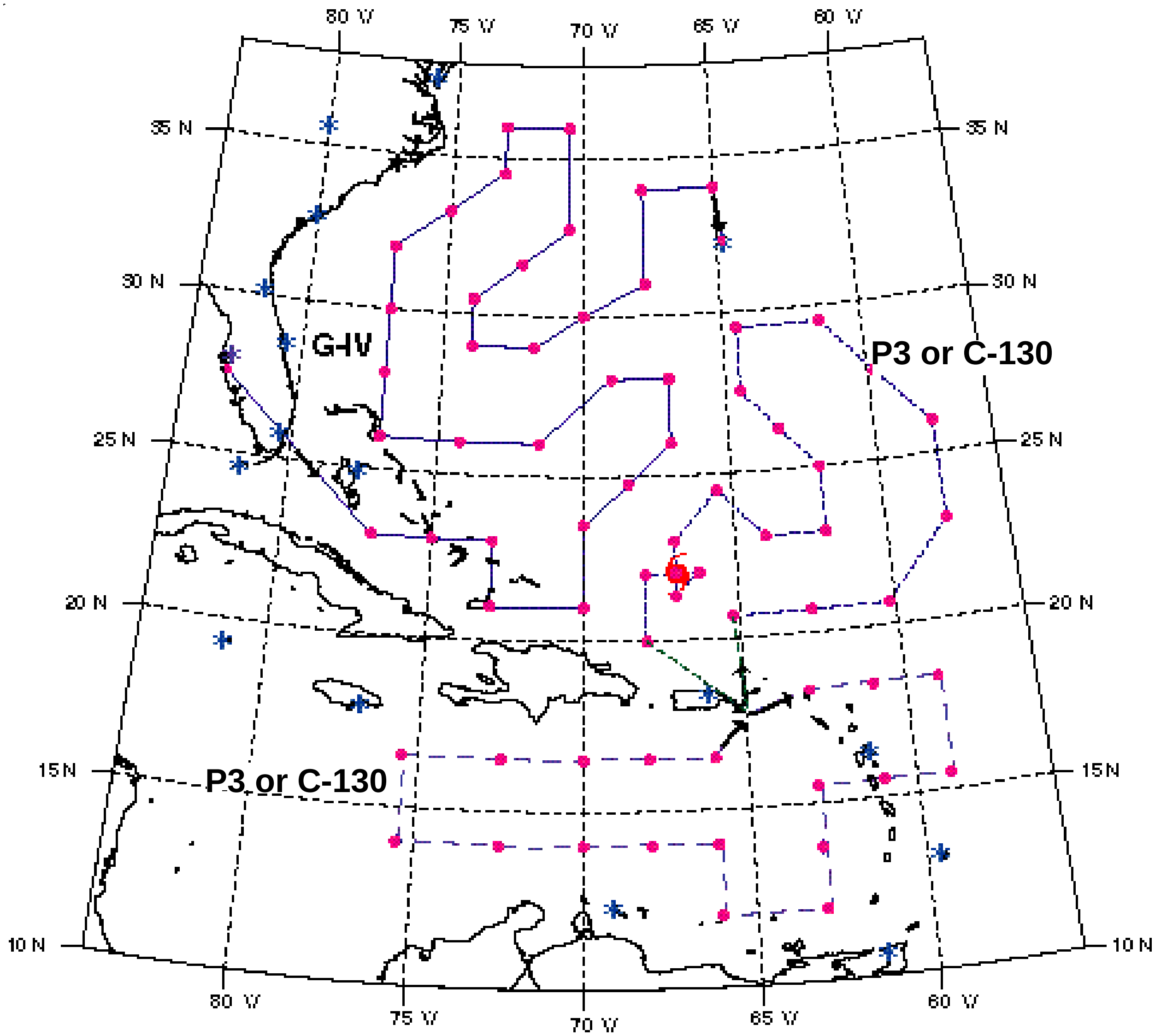


Figure SYN-1: Sample Environmental Patterns

• Note 1:	During the ferry to the IP, the WP-3D or C-130 aircraft will climb to the 500 hPa level (about FL 180). The 400 hPa level (about FL 250) should be reached as soon as possible and maintained throughout the remainder of the pattern, unless icing or electrical conditions require a lower altitude.
• Note 2.:	During the ferry to the IP, The G-IV should climb to the 41,000 ft (200 hPa) as soon as possible and climb as feasible to maintain the highest altitude for the duration of the pattern.

HURRICANE SYNOPTIC FLOW EXPERIMENT

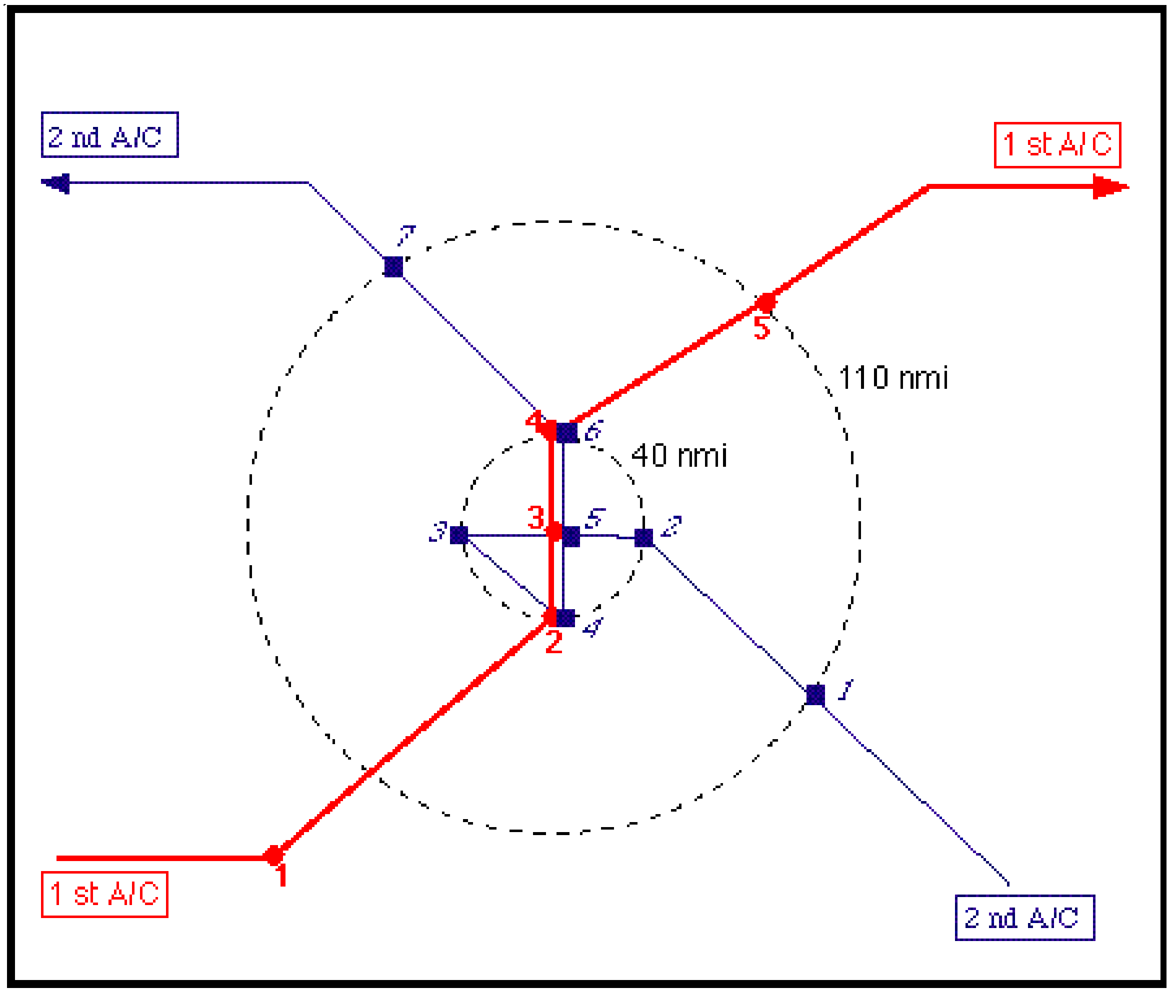


Figure SYN-2: In-Storm Patterns

• Note 1:	Within the 40 nm (75 km) range ring, all legs are on cardinal tracks.
• Note 2:	The second aircraft through the storm will execute the Doppler "figure-4" pattern. The Doppler radar should be set to continuously scan perpendicular to the track during radial penetrations and to F/AST on the downwind leg.
• Note 3:	Numbered symbols (u, n) reflect scheduled drops for each aircraft.
• Note 4:	Drop #5 in the "figure-4" pattern occurs on the second pass through the eye.
• Note 5:	A/C 1 should collect vertical incidence Doppler data during storm penetration.
• Note 6:	If missions are not repeated, then block times may exceed 9 h. In addition to the GPS dropsonde data, 3-4 RECCO's h^{-1} should be transmitted during each mission.

Special Notes: Missions similar to the Synoptic Flow missions may be flown in non-hurricane conditions to collect GPS dropsonde data sets for satellite sounding evaluations. These missions differ from the normal experiment as follows:

- Block times are 10 h, and the experiment is not repeated on the following day.
- In-storm portion of the pattern (Fig. SYN-2) is omitted and no Doppler data are collected.
- The G-IV does not participate in the mission.

Saharan Air Layer - Synoptic Surveillance Follow-on

Mission Description: This follow-on module will be executed by HRD, using HRD resources and will be carried out within the constraints of the pre-determined operational flight track. Additional intermediate GPS dropwindsondes (HRD supplied) may be requested along the flight track to target specific areas of interest. GPS dropwindsondes will be launched from the G-IV (flying at ~200 hPa/~41,000 ft) or the WP-3D (flying at ~500 hPa/~20,000 ft) along the operational Synoptic Surveillance flight pattern. These additional drop locations will be selected using real-time GOES Saharan Air Layer (SAL) tracking imagery from UW-CIMSS and mosaics of SSM/I total precipitable water from the Naval Research Laboratory. Specific effort will be made to gather atmospheric information within the SAL as well as regions of high moisture gradients across its boundaries. The main goals of this experiment are to:

- Better understand how the SAL's dry air, mid-level easterly jet, and suspended mineral dust affect Atlantic TC intensity change.
- Include the moisture information from the GPS dropwindsondes in operational parallel runs of the NOAA Global Forecast System (GFS) model. The impact of this data on the GFS initial/forecast humidity fields and its forecasts of TC track and intensity will be assessed.

Several SAL/TC interaction scenarios are candidates for this follow on mission:

1) Single tropical cyclone (TC) located along the southern edge of the SAL. Depending on the proximity of these two features, the SAL's dry air may be wrapping into the TC's low-level circulation (western quadrants). GPS dropwindsonde sequences will be focused along this dry air inflow region (west of the TC), across regions of high moisture gradients at the SAL's leading edge (northwest of the TC), and across the southern boundary of the SAL (north and northeast of the TC). The SAL's mid-level jet will also be sampled in the region of the latter transect.

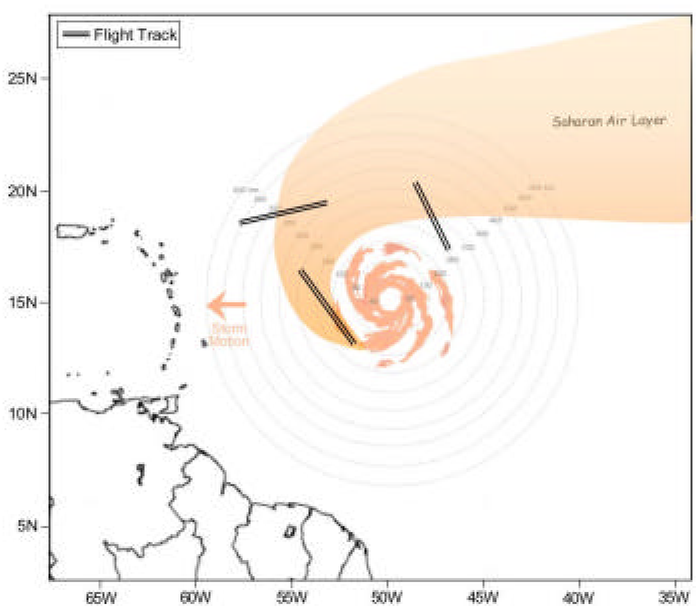


Figure SYN-3: Sample flight track for a TC positioned along the SAL's southern boundary.

2) Single TC is embedded within the SAL and intensifies upon emerging. These systems are often candidates for rapid intensification. GPS dropwindsonde transects perpendicular to the northern boundary of the SAL and near to possible points of the TC's emergence from the SAL are desirable. Additional transects will be focused along the SAL's southern boundary (south of the TC). The SAL's mid-level jet will also be sampled, particularly along those transects on the eastern sides of the TC.

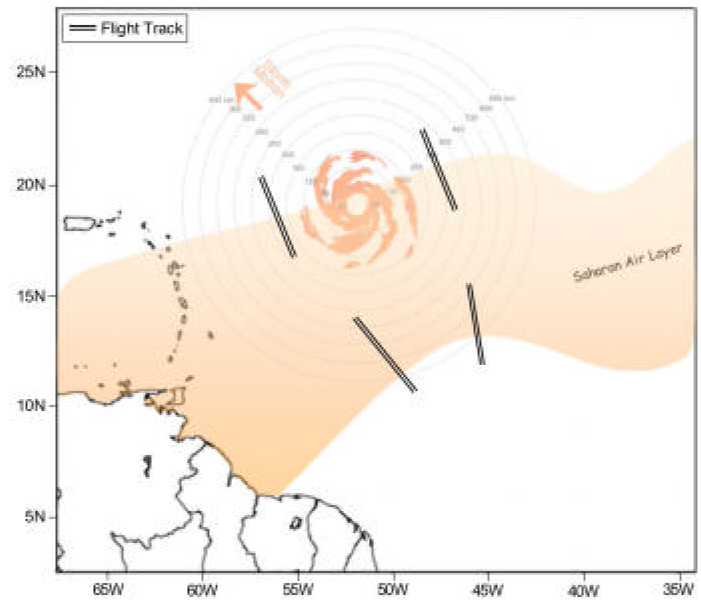


Figure SYN-4: Sample flight track for a TC emerging from the SAL.

3) Single TC embedded within the SAL throughout most or all of its lifecycle. These systems struggle to intensify and are often characterized by their low-level circulation racing out ahead (west) of their mid-level convection. Depending on the TC's proximity to the SAL, the SAL's dry air may be wrapping into its low-level circulation (western semicircle). GPS dropwindsonde sequences will be focused along this dry air inflow region (west of the TC), across regions of high moisture gradients at the SAL's northern boundary (north of the TC), and across regions of high moisture gradients at the SAL's southern boundary (east of the TC). The SAL's mid-level jet will also be sampled, particularly in the region of the latter transect.

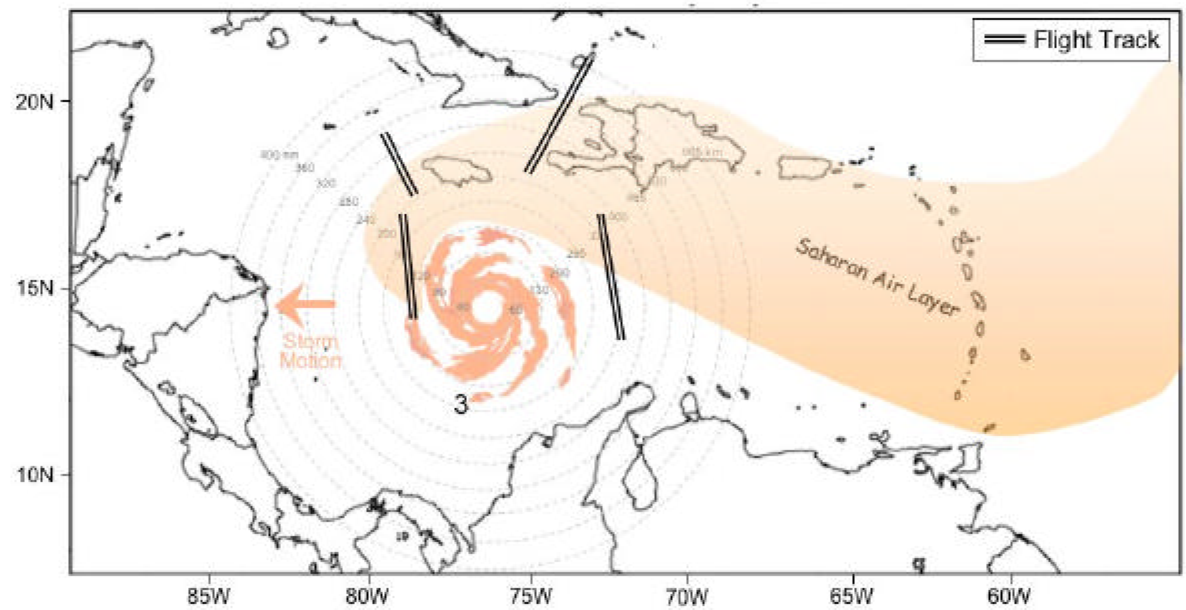


Figure SYN-5: Sample flight track for a TC embedded in the SAL for most or all of its lifecycle.

- Note 1: During the ferry to the IP, the WP-3D aircraft will climb to the ~500 hPa level (~20,000 ft). The 400 hPa level (~25,000 ft) should be reached as soon as possible and maintained throughout the remainder of the pattern, unless icing or electrical conditions require a lower altitude.
- Note 2: During the ferry to the IP, The G-IV should climb to the ~200 hPa (~41,000 ft) as soon as possible and climb as feasible to maintain the highest altitude for the duration of the pattern.
- Note 3: In order to capture the SAL's horizontal/vertical structure, particular attention should be paid to regions of high moisture gradients across its boundaries.

2. Mature Storms Experiment

Program significance: By "mature storm" we mean a tropical cyclone that has developed a closed circulation and a warm core. Thus this could include anything from a tropical depression to a major hurricane. The definition is meant to separate this category from tropical waves and disturbances that have yet to develop a well-defined warm-core circulation.

There are four main goals of this experiment: 1) to improve our understanding of the factors which modify the intensity and structure of tropical cyclones, 2) to provide a comprehensive data set for the initiation (including data assimilation) and validation of numerical hurricane simulations (in particular the Hurricane Weather and Research Forecasting model (HWRF), 3) to improve and evaluate technologies for observing tropical cyclones, and 4) to develop rapid "real-time" communication of these observations to the National Centers for Environmental Prediction (NCEP) of the National Weather Service (NWS).

Two experiments comprise the overall Mature Storms Experiment. The first is the Frequent-Monitoring experiment, designed to obtain regular 12- or 24-h resolution airborne Doppler-radar observations of hurricanes, with optional GPS dropsondes. The second is the NESDIS Ocean Winds and Rain Experiment, designed to improve our understanding of microwave surface scatterometery in high-wind conditions over the ocean by collecting surface scatterometery data and Doppler data in the boundary layer of hurricanes.

Frequent Monitoring: This experiment is designed specifically to address the IFEX goal of obtaining hurricane data sets that can address both the assimilation and validation needs of hurricane modelers, and in particular, the needs of those at NCEP/EMC (National Centers for Environmental Prediction/Environmental Modeling Center) developing modeling and assimilation techniques to work with the Hurricane Weather and Research Forecasting model (HWRF). EMC experience with assimilation and initialization have led to the following conclusions about data requirements: 1) When possible, data in mature storms should be collected to the outermost closed isobar, 2) wavenumbers 0 and 1 should be sufficient to obtain a good initialization of strong hurricanes, 3) azimuthal resolution needs increase for weaker storms which are less-completely organized. Resolutions finer than wavenumber 2 may be impractical from flight-level *in situ* data, but might be possible from airborne Doppler observations if azimuthal Doppler coverage within the radius of the outermost isobar is nearly complete. Fortunately, the radius of the outermost closed isobar tends to decrease with decreased age or intensity of the tropical cyclone.

There is a goal within IFEX to better define the structure and evolution of a tropical cyclone throughout its lifetime. Also, to verify hurricane simulations, measurements collected over several observation cycles are needed to better assess the models. The Frequent Monitoring experiment gets its name from its 12-24 hour monitoring schedule. This schedule will allow the results of several model initializations to be compared with actual observations of the same system.

It appears from running of operational models that the most vertical resolution is needed in the boundary and outflow layers to assimilate numerical simulations. One might also assume that this is where the most vertical resolution is needed in observations to verify the initialization and forecasts of the model. For this reason it is desirable that if sufficient dropsondes are available, they should be dropped in the radial penetrations in the Frequent-Monitoring experiment to verify that the boundary-layer and surface winds produced in HWRF resemble those in observations. If sufficient dropsondes are not available, a combination of SFMR, IWRAP, and airborne Doppler data will be used for verification.

NESDIS Ocean Winds and Rain Experiment: This experiment will be executed by NOAA/NESDIS and aims to improve understanding of microwave scatterometer retrievals of the ocean surface wind. The NOAA/ NESDIS/ Office of Research and Applications in conjunction with the University of Massachusetts' (UMASS) Microwave Remote Sensing Laboratory and the OMAO/Aircraft Operations Center have been conducting flights as part of the Ocean Winds and Rain Experiment for the past several years. The Ocean Winds and Rain experiment is part of an ongoing field program whose goal is to further our understanding of microwave scatterometer and radiometer retrievals of the ocean surface wind vector in high wind speed conditions and in the presence of rain for all wind speeds. This knowledge will be used to help improve and interpret operational wind retrievals from current and future satellite-based scatterometers. The hurricane environment provides the adverse atmospheric and ocean surface conditions required. The Integrated Wind and Rain Airborne Profiler (IWRAP) and the Stepped Frequency Microwave Radiometer (USFMR), both designed and built by UMASS, are the critical sensors for these experiments. IWRAP consists of two scatterometers operating at Ku-band and C-band, which measure the reflectivity profile in precipitation in addition to the surface backscatter. The capabilities of IWRAP are essential in unraveling the effects of precipitation on scatterometer wind retrievals. A raw data mode acquisition system was tested for IWRAP during the Winter Storms Experiment this year, and it will be fully implemented during this hurricane season. Collecting the raw data allows spectral processing to be done which will allow the rain and surface contributions in the IWRAP data to be decoupled. This is critical in understanding the impacts of rain on the measurements, and thus, the ocean surface wind vector retrievals.

A secondary objective of the NESDIS experiments is to explore how much of this remotely-sensed data collected on the WP-3D can be processed and sent off the plane in near real-time. NESDIS has been working with Remote Sensing Solutions, Inc. in developing an effective data processing, distribution and display system to accomplish this within the constraints of a satellite phone data connection. The NOAA Aircraft Operations Center and Hurricane Research Division have been integral partners in accomplishing this task. Remotely-sensed surface data is not only extremely useful for experiment flight planning but also to the hurricane analysts at the Tropical Prediction Center as has been demonstrated with the experimental use of the SFMR on the NOAA P-3s over the past several years, which became fully operational last year. For this season N42RF will be equipped with a dedicated Globalstar satellite phone and a computer system to process and distribute to the ground the flight level serial data stream and the lower fuselage radar data in near real-time. Additionally on N42, a second Globalstar satellite data connection will be used to test dissemination of products derived from the X-band tail radar, a near real-time processing system for IWRAP and USFMR, and the serial data stream from the AVAPS station. The transmission of full resolution tail radar data packets may also be tested if a higher bandwidth satellite phone system becomes available on N42.

Links to IFEX: This experiment supports the following NOAA IFEX goals:

- **Goal 2**: Develop and refine measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment;
- **Goal 3**: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

Mission Descriptions:

The NESDIS Ocean Winds and Rain Experiment will be executed by NOAA/NESDIS. Specific details regarding these NESDIS missions are not included here.

Frequent Monitoring: Two different options are possible with this experiment. These are 1) the single-aircraft "rotating figure 4" (Fig. FM-1) and the hexagonal pattern (Fig. FM-2). These two options permit the maximum flexibility at the time of the aircraft missions.

Single-aircraft option: In most cases temporal resolution is also important, for both initialization and verification. This has been verified in communication with EMC. At the time of this writing, the preferred mode of operation will be 24-hour turnaround with the one available WP-3D aircraft, launch times to be determined by HWRF assimilation needs, but within AOC operational and safety constraints. A complete "rotating figure 4" pattern, as shown in Fig. FM-1, provides the most complete coverage for the proposed single-aircraft missions, but takes longer to complete than the "hexagonal" pattern shown in Fig. FM-2. The nominal flight-level for these missions is 10,000 ft, but can be lower without compromising the mission objectives.

Mature Storms Experiment Flight Planning Approach:

During the 2006 Hurricane Field Program (05 July to 30 September), the primary objective will be to meet IFEX goals 1 through 3, which involve collecting airborne Doppler radar and flight-level data over a period of several days in storms of varying intensity and structural type, but with emphasis during this period on intensity changes throughout the tropical-cyclone lifecycle. A subset of these goals will be accomplished in the context of the Mature Storms Experiment, with flight patterns that involve the one available NOAA WP-3D (N42RF).

EMC and NHC will conduct a set of frequent monitoring missions over several days encompassing as much of a particular storm's life cycle as possible. This would entail using the one available NOAA WP-3D on back-to-back flights on a 24-hour schedule when the system is at depression, tropical storm, or hurricane strength.

At times, one set of flights may take precedence over others depending on factors such as storm strength and location, operational tasking, and aircraft availability. One scenario could likely occur that illustrate how the mission planning is determined:

1) An incipient TC, at depression or weak tropical storm stage is within range of an operational base and is expected to develop and remain within range of operational bases for a period of several days. Here, the highest priority would be to start the set of frequent-monitoring flights, with single NOAA WP-3D missions while the TC is below hurricane strength, with continued single NOAA WP-3D missions at 24-hour intervals until the system is out of range or makes landfall. During the tropical depression or storm portion of the frequent monitoring, higher azimuthal resolution of the wind field is preferred over radial extent of observations, while in the hurricane portion, the flight plan would be designed to get wavenumber 0 and 1 coverage of the hurricane out to the largest radius possible, rather then the highest time resolution of the eyewall winds.

Mature Storms Experiment

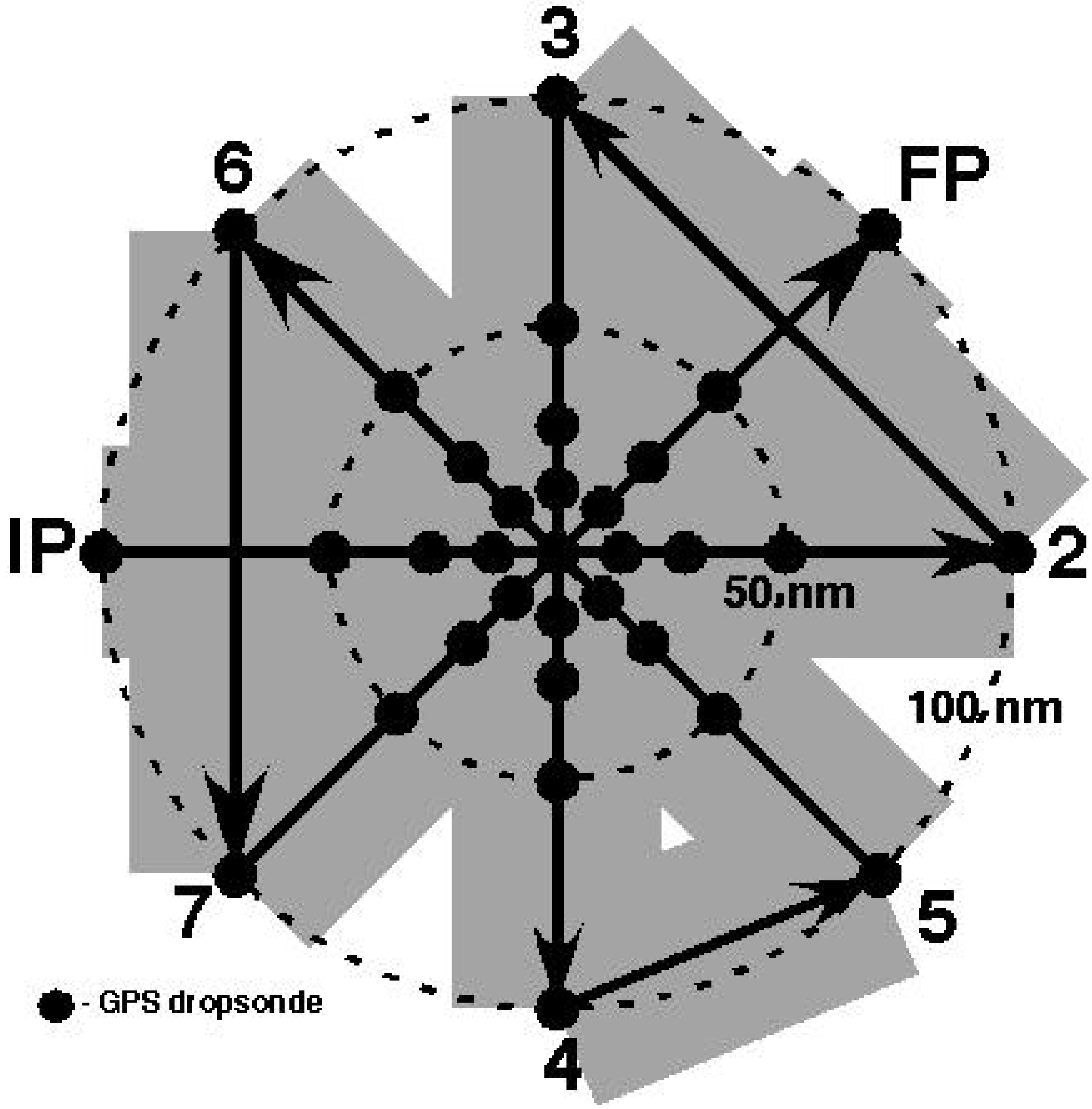


Figure FM-1: Single-aircraft "rotating figure 4" pattern (100 nm maximum radius)

Note 1.	Doppler radars should be operated in single-PRF mode, at a PRF of 2400-3200. The default will be 2400 PRF. Radar scientist should verify this mode of operation with AOC engineers. If there is no assigned radar scientist, LPS should verify. *This is crucial for the testing and implementation of real-time quality control.*
Note 2.	Unless specifically requested by the LPS, both tail Doppler radars should be operated in fore/aft continuous scanning with a fore/aft angle of 20^o relative to fuselage.
Note 3.	IP can be at any desired heading relative to storm center
Note 4.	To maximize sonde coverage aircraft should operate at highest altitudes that still minimize icing
Note 5.	Shaded areas show airborne-Doppler radar coverage with a maximum flight radius of 100 nm
Note 6.	Maximum radius may be decreased or increased within operational constraints
Note 7.	Dropsondes shown are not a required part of this flight plan and are optional.
Note 8.	Flight pattern should be centered around either the 18, 00, 06, or 12 GMT operational model analysis times.
Note 9.	Maximum radius may be changed to meet operational needs while conforming to flight-length constraints.

Mature Storms Experiment

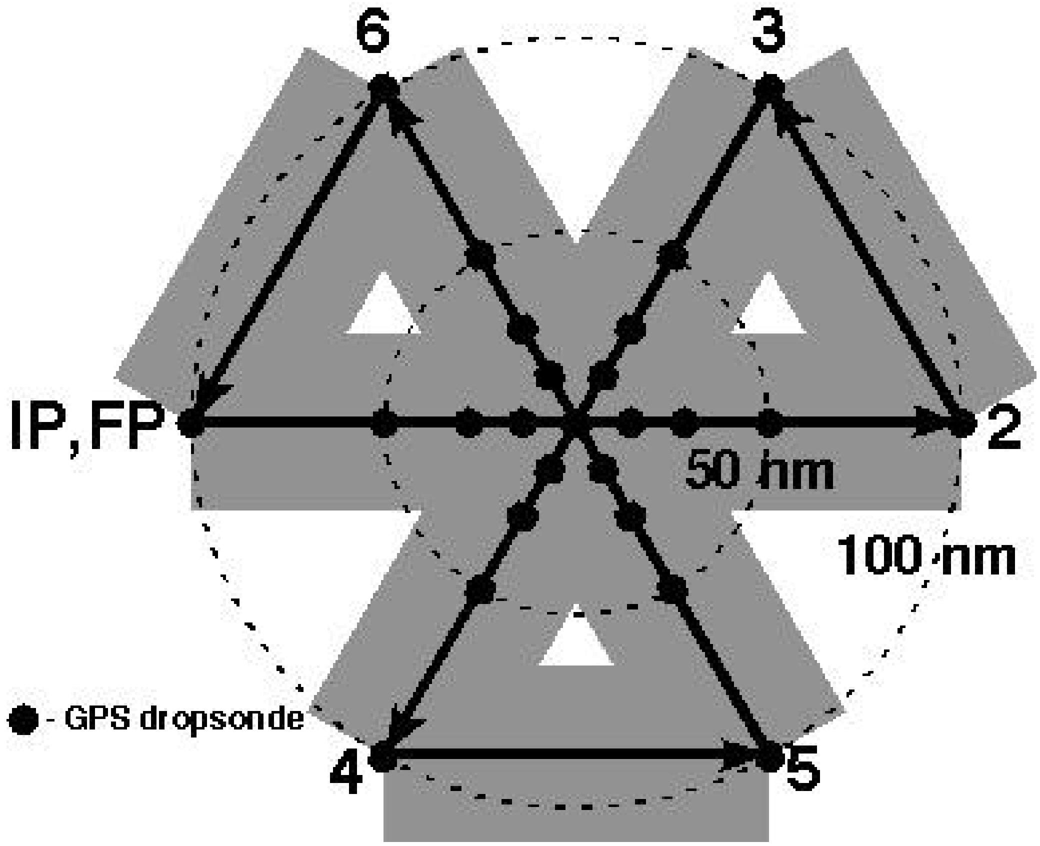
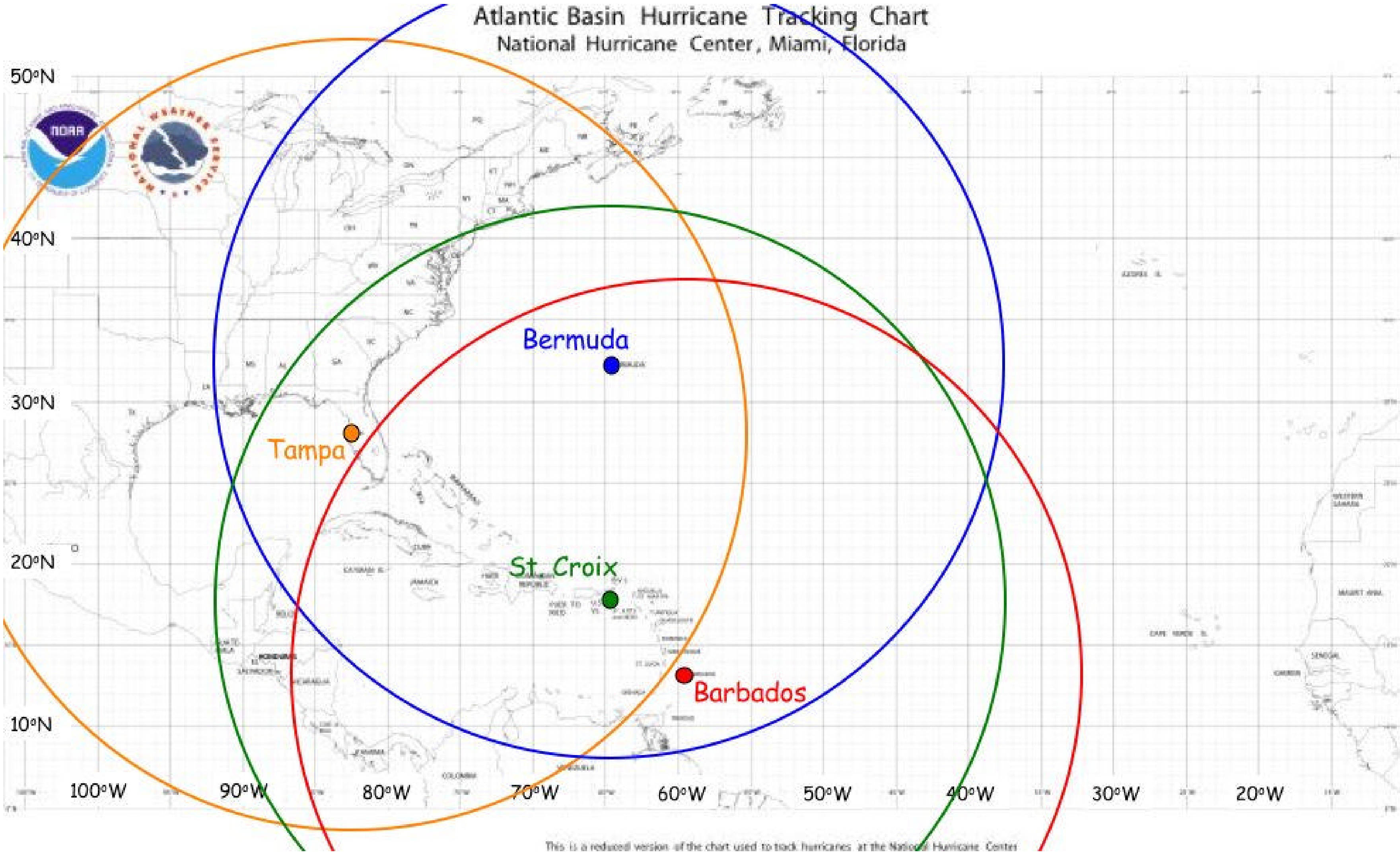


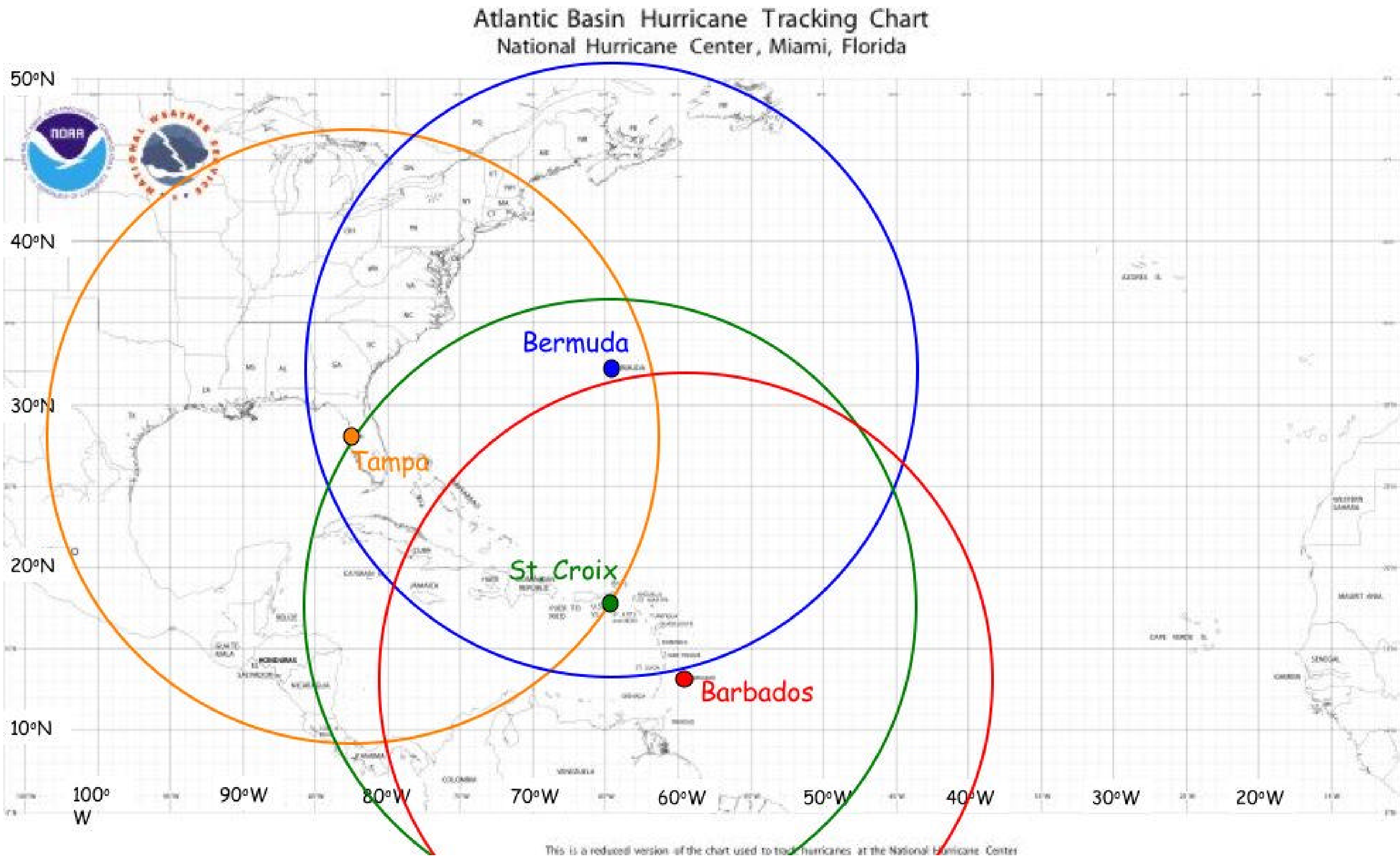
Figure FM-2. Single-aircraft "Hexagonal flight pattern" (100 nm maximum radius)

Note 1.	Doppler radars should be operated in single-PRF mode, at a PRF of 2400-3200. The default will be 2400 PRF. Radar scientist should verify this mode of operation with AOC engineers. If there is no assigned radar scientist, LPS should verify. *This is crucial for the testing and implementation of real-time quality control.*
Note 2.	Unless specifically requested by the LPS, both tail Doppler radars should be operated in fore/aft continuous scanning with a fore/aft angle of 20^o relative to fuselage.
Note 3.	IP can be at any desired heading relative to storm center
Note 4.	To maximize sonde coverage aircraft should operate at highest altitudes that still minimize icing
Note 5.	Shaded areas show airborne-Doppler radar coverage with a maximum flight radius of 100 nm
Note 6.	Maximum radius may be decreased or increased within operational constraints
Note 7.	Dropsondes shown are not a required part of this flight plan and are optional.
Note 8.	Flight pattern should be centered around either the 18, 00, 06, or 12 GMT operational model analysis times.
Note 9.	Maximum radius may be changed to meet operational needs while conforming to flight-length constraints.

Supplemental: Operational Base Maps



Map 1: Primary Atlantic operating bases and approximate operating ranges for the NOAA G-IV.



Map 2: Primary Atlantic operating bases and approximate operating ranges for the NOAA WP-3D.

Hurricane Field Program Plan
Part II Appendices

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Hurricane Field Program Plan

Part II

Appendix A

DECISION AND NOTIFICATION PROCESS

The decision and notification process is illustrated in Figs. A-1, A-2, and A-3. This process occurs in four steps:

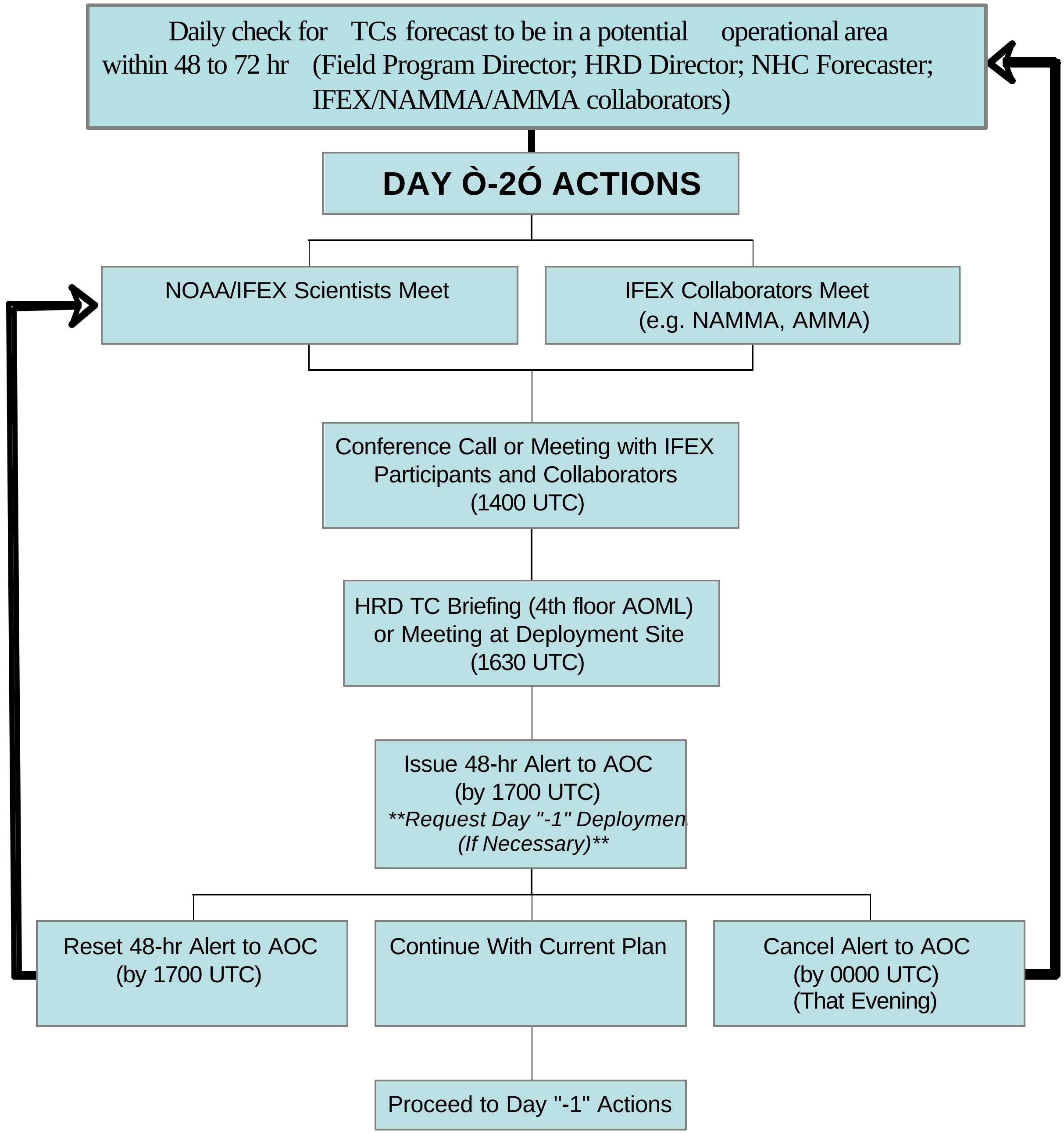
1) A research mission is determined to be probable within 72 h [field program director]. Consultation with the director of HRD, and the AOC Project Manager determines: flight platform availability, crew and equipment status, and the type of mission(s) likely to be requested.

2) The Field Program Advisory Panel [F Marks (Director, HRD), J. Dunion (Director, Hurricane Field Program), R. Rogers, M. Black, P. Black, J. Cione, P. Dodge, J. Gamache, J. Kaplan, S. Murillo and J. McFadden (or AOC designee) meets to discuss possible missions and operational modes. Probable mission determination and approval to proceed is given by the HRD director (or designee).

3) Primary personnel are notified by the Hurricane Field Program Director [J. Dunion].

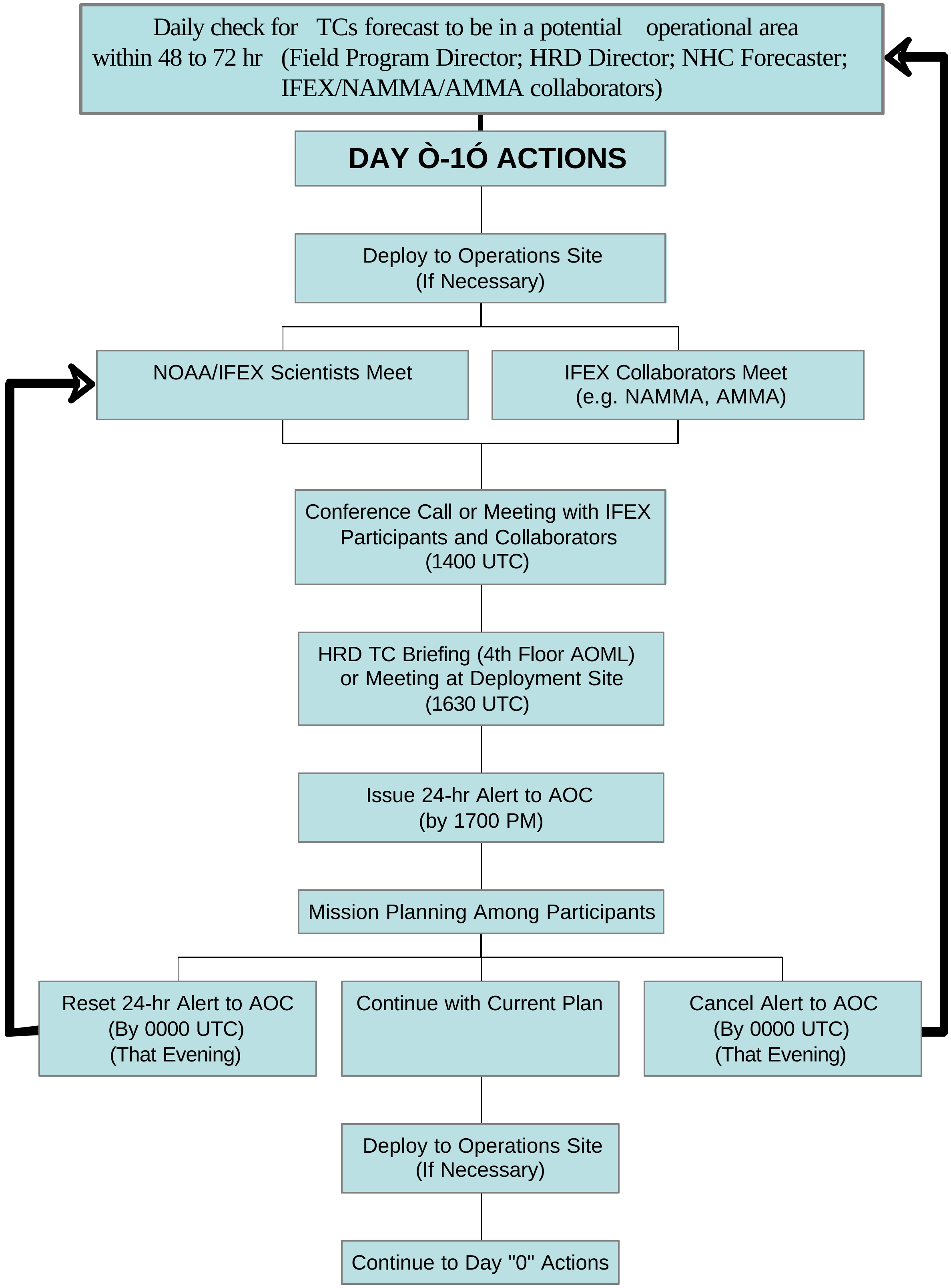
4) Secondary personnel are notified by their primary affiliate (Table A-2).

General information, including updates of program status, are provided continuously by tape. Call (305) 221-3679 to listen to the recorded message. During normal business hours, callers should use (305) 361-4400 for other official inquiries and contacts. During operational periods, an MGOC team member is available by phone at (305) 229-4407 or (305) 221-4381. The MGOC team leader and the HRD field program director will be available by cell phone and/or telepager (appropriate contact information will be provided to program participants before the start of the field program).



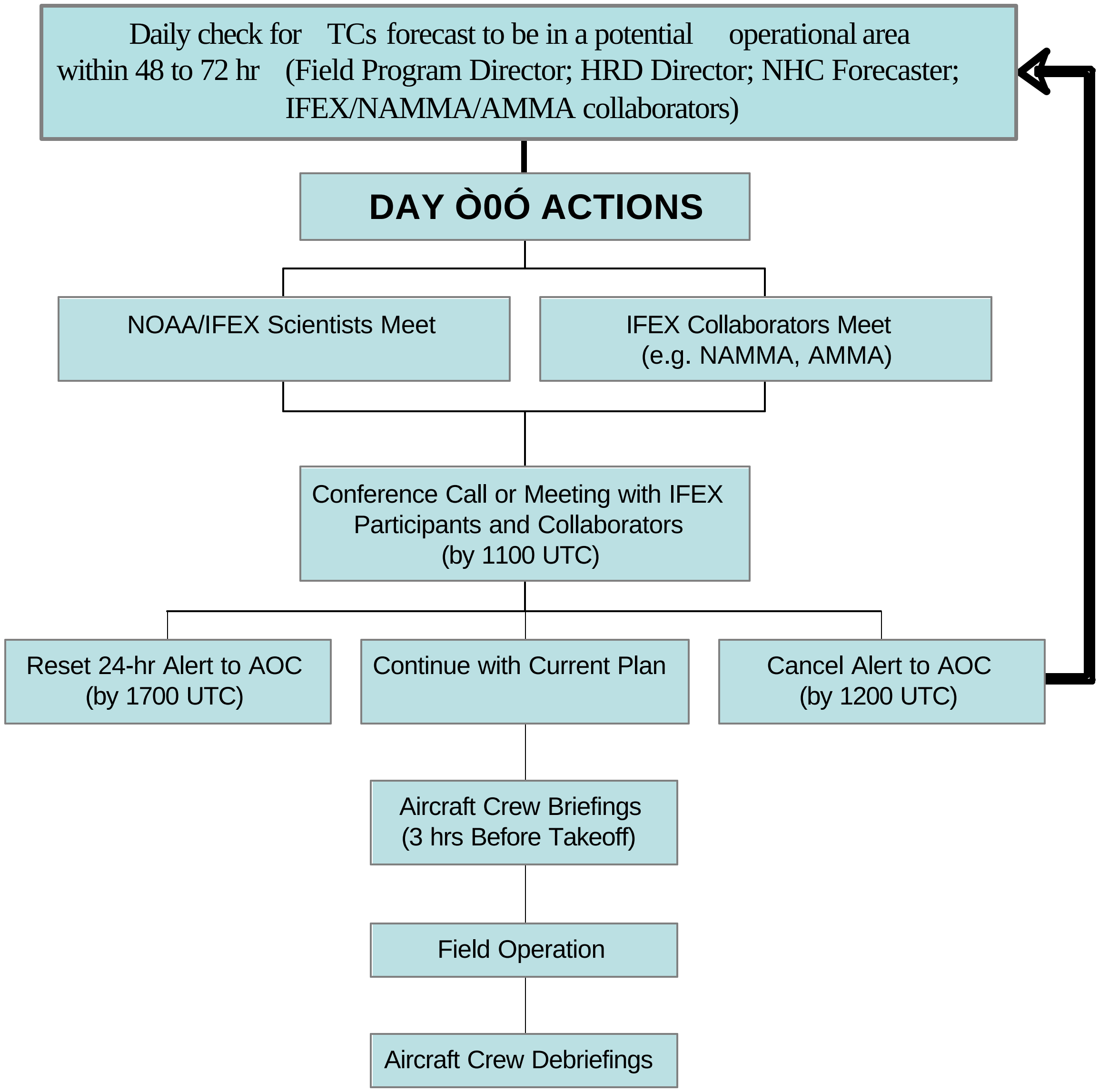
**Note: Time of briefings, conference calls, decisions, and deployments are dictated by timing limitations imposed by the AOC crew.

Fig. A-1: Decision and notification process for Day “-2”.



**Note: Time of briefings, conference calls, decisions, and deployments are dictated by timing limitations imposed by the AOC crew.

Fig. A-2: Decision and notification process for Day "-1"



**Note: Time of briefings, conference calls, decisions, and deployments are dictated by timing limitations imposed by the AOC crew.

Fig. A-3: Decision and notification process for Day “0”

Appendix B: Calibration; Scientific Crew Lists; Data Buoys

B.1 En-Route Calibration of Aircraft Systems

Instrument calibrations are checked by flying aircraft intercomparison patterns whenever possible during the hurricane field program or when the need for calibration checks is suggested by a review of the data. In addition, an over flight of a surface pressure reference is advisable en route or while on station when practicable. Finally, all flights enroute to and from the storm are required to execute a true airspeed (TAS) calibration pattern. This pattern is illustrated in Fig. B-1.

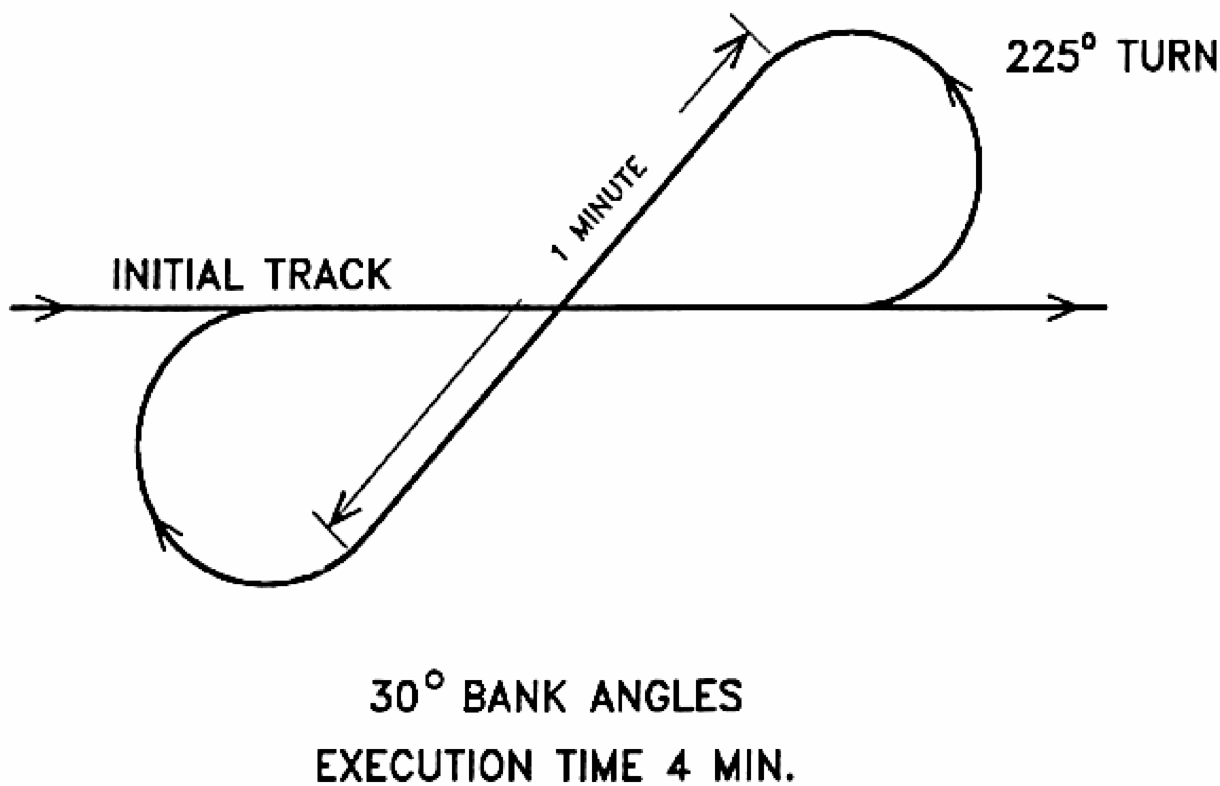


Fig. B-1 En-Route TAS calibration pattern.

B.2 Aircraft Scientific Crew Lists

Table B-2.1 Saharan Air Layer Experiment (multi-option, single or dual-aircraft mission)

Position	N49 (G-IV SP)	N42RF
Lead Project Scientist	J. Dunion	R. Rogers; M. Black
Cloud Physics Scientist	n/a	(radar scientist)
Radar Scientist	n/a	J. Gamache; S. Aberson
Dropsonde Scientist	S. Aberson;	S. Murillo
Workstation Scientist	n/a	(radar scientist)
IWRAP Scientist	n/a	P. Chang

Table B-2.2 Aerosonde Experiment (single-option, single aircraft mission)

Position	N49 (G-IV SP)	N42RF
Lead Project Scientist	n/a	J. Cione
Cloud Physics Scientist	n/a	(radar scientist)
Radar Scientist	n/a	J. Gamache; S. Aberson
Dropsonde Scientist	n/a	M. Black
Workstation Scientist	n/a	(radar scientist)
IWRAP Scientist	n/a	P. Chang

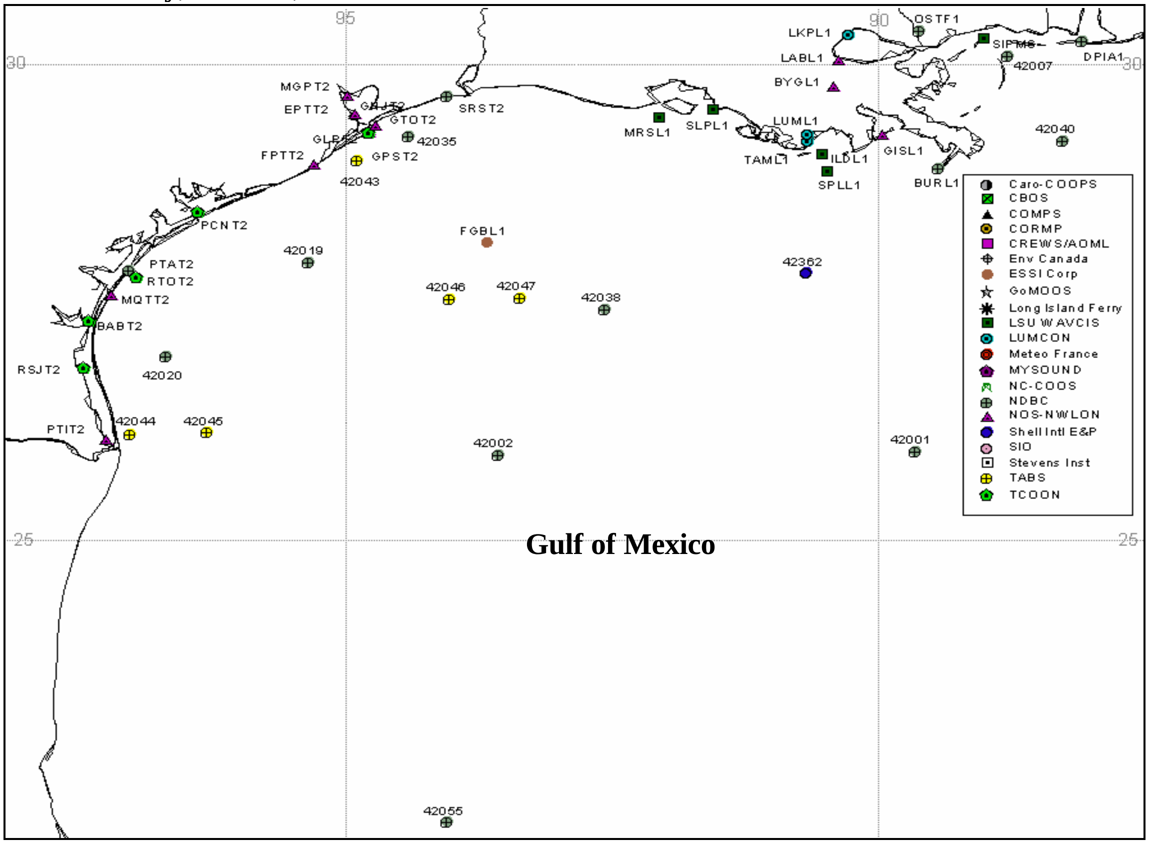
Table B-2.3 Tropical Cyclogenesis Experiment: (multi-option, single or dual-aircraft mission)

Position	N49 (G-IV SP)	N42RF
Lead Project Scientist	J. Dunion	R. Rogers
Cloud Physics Scientist	n/a	(radar scientist)
Radar Scientist	n/a	J. Gamache; S. Aberson
Dropsonde Scientist	P. Leighton	P. Leighton
Workstation Scientist	n/a	(radar scientist)
IWRAP Scientist	n/a	P. Chang

Table B-2.4 Tropical Cyclone Landfall and Inland Decay Experiment (dual-option, single-aircraft mission)

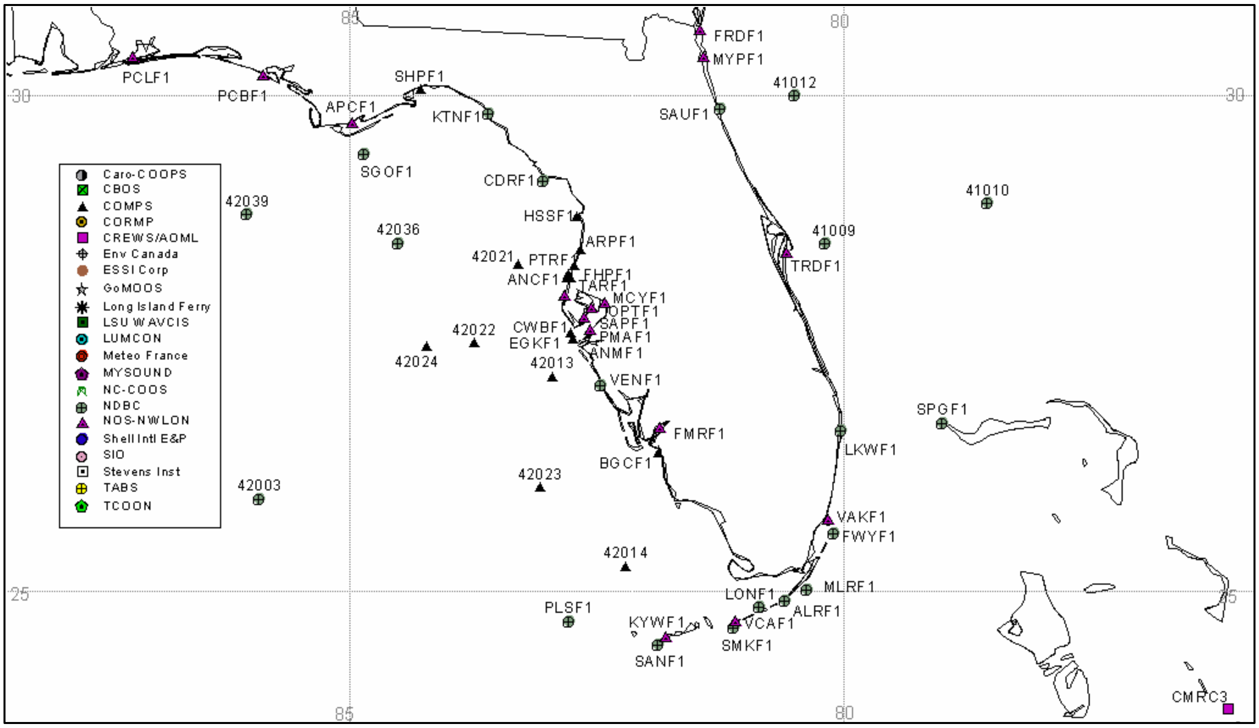
Position	N49 (G-IV SP)	N42RF
Lead Project Scientist	n/a	P. Dodge; J. Kaplan
Cloud Physics Scientist	n/a	(radar scientist)
Radar Scientist	n/a	J. Gamache; S. Aberson
Dropsonde Scientist	n/a	P. Leighton
Workstation Scientist	n/a	(radar scientist)
IWRAP Scientist	n/a	P. Chang

B-3. Buoy, C-MAN, and NOS Platform Locations



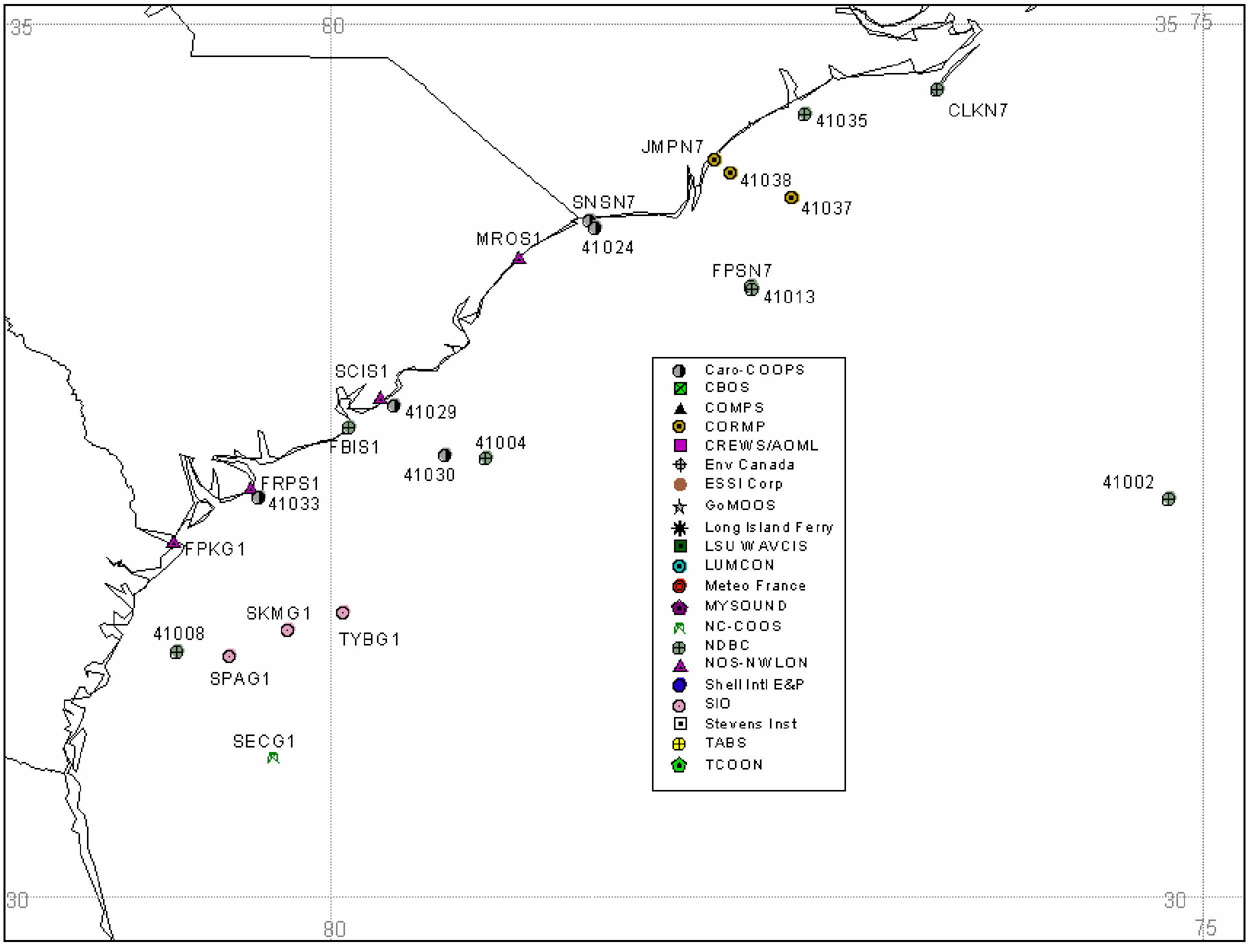
Station	Lat	Lon	Height	Provider	Station Location	Payload Comments
RSJT2	26.801	-97.47	10 (m)	TCOON	RINCON DEL SAN JOSE POTRERO LOPENO SW	
BABT2	27.3	-97.42	10	TCOON	BAFFIN BAY POINT OF ROCKS	
PTIT2	26.06	-97.26	10	NOS-NWLON	PORT ISABEL, TX, 8779770	
MQTT2	27.58	-97.22	10	NOS-NWLON	8775870 - MALAQUITE BEACH, CORPUS CHRISTI, TX	
PTAT2	27.83	-97.05	14.9	NDBC	PORT ARANSAS, TX	
42044	26.11	-97.03	4	TABS	PS-1126 TABS J	TABS II
RTOT2	27.76	-96.98	20	TCOON	RTNS OFFSHORE	
42020	26.916	-96.7	5	NDBC	50 NM SOUTHEAST OF CORPUS CHRISTI, TX	3-meter discus buoy, DACT payload
PCNT2	28.45	-96.4	9	TCOON	MATAGORDA BAY PORT O'CONNOR	
42045	26.13	-96.31	4	TABS	PI-745 TABS K	TABS II
42019	27.916	-95.36	5	NDBC	FREEPORT, TX 60 NM SOUTH OF FREEPORT, TX	3-meter discus buoy, DACT payload
FPTT2	28.95	-95.31	10	NOS-NWLON	8772440 - FREEPORT, TX	
MGPT2	29.68	-94.99	10	NOS-NWLON	8770613 – MORGAN'S POINT, TX	
EPTT2	29.48	-94.92	10	NOS-NWLON	8771013 - EAGLE POINT, TX	
42043	28.99	-94.9	4	TABS	GA-252 TABS B	TABS II
GTOT2	29.31	-94.79	10	NOS-NWLON	8771450 - GALVESTON PIER 21, TX	
GPST2	29.29	-94.79	7	NOS-NWLON	8771510 - GALVESTON PLEASURE PIER, TX	
GLPT2	29.285	-94.788	15	TCOON	GALVESTON PLEASURE P IER	
GNJT2	29.3583	-94.725	10	NOS-NWLON	8771341 - GALVESTON BAY (NORTH JETTY), TX	
42035	29.246	-94.41	5	NDBC	GALVESTON 22 NM EAST OF GALVESTON, TX	3-meter discus buoy, DACT payload
SRST2	29.67	-94.05	12.5	NDBC	SABINE, TX	
42055	22.02	-94.05	10	NDBC	BAY OF CAMPECHE	12-meter discus buoy, ARES payload
42046	27.53	-94.02	4	TABS	HI-A595 TABS N	TABS II
FGBL1	28.118	-93.67	22.9	ESSI Corp	FOREST OIL - HIGH ISLAND - HI-334B	
42002	25.892	-93.568	10	NDBC	W GULF 240 NM SOUTH-SOUTHEAST OF SABINE, TX	10-meter discus buoy, MARS payload
42047	27.54	-93.36	4	TABS	HI-A389 TABS V	TABS II
42038	27.42	-92.57	5	NDBC	NORTH MID GULF OF MEXICO	3-meter discus buoy, ARES payload
MRSL1	29.441	-92.061	23.42	LSU WAVCIS	MARSH ISLAND, CSI03	
SLPL1	29.516	-91.557	5.5	LSU WAVCIS	SALT POINT, CSI14	
42362	27.8	-90.67	122	Shell Intl E&P	BRUTUS - GREEN CANYON 158	Fixed Drilling Platform
TAML1	29.187	-90.665	10	LUMCON	TAMBOUR BAY	
LUML1	29.253	-90.663	13.2	LUMCON	LUMCON MARINE CENTER	
ILDL1	29.053	-90.533	19.2	LSU WAVCIS	ISLE CERNIERES, CSI05	
SPLL1	28.867	-90.483	40.34	LSU WAVCIS	SOUTH TIMBALIER BLOCK 52,CSI06	
BYGL1	29.78	-90.42	9.1	NOS-NWLON	8762483 - BAYOU GAUCHE, LA	
LABL1	30.05	-90.37	9.1	NOS-NWLON	8762482 - BAYOU LABRANCH, LA	
LKPL1	30.31	-90.28	13	LUMCON	WESTERN LAKE PONCHARTRAIN	
GISL1	29.263	-89.957	9.5	NOS-NWLON	8761724 - GRAND ISLE, LA	
42001	25.928	-89.653	10	NDBC	MID GULF 180 NM SOUTH OF SOUTHWEST PASS, LA	12-meter discus buoy, ARES payload
OSTF1	30.3567	-89.6125	10	NDBC	STENNIS TEST FACILITY	
BURL1	28.906	-89.429	30.5	NDBC	SOUTHWEST PASS, LA	
SIPM6	30.266	-89.007	10.98	LSU WAVCIS	SHIP ISLAND PASS,CSI13	
42007	30.091	-88.772	5	NDBC	BILOXI 22 NM SOUTH-SOUTHEAST OF BILOXI, MS	3-meter discus buoy, DACT payload
42040	29.195	-88.253	5	NDBC	64 NM SOUTH OF DAUPHIN ISLAND, AL	3-meter discus buoy, DACT payload
DPIA1	30.25	-88.07	17.4	NDBC	8735180 - DAUPHIN ISLAND, AL	

B-3. Buoy, C-MAN, and NOS Platform Locations (cont'd)



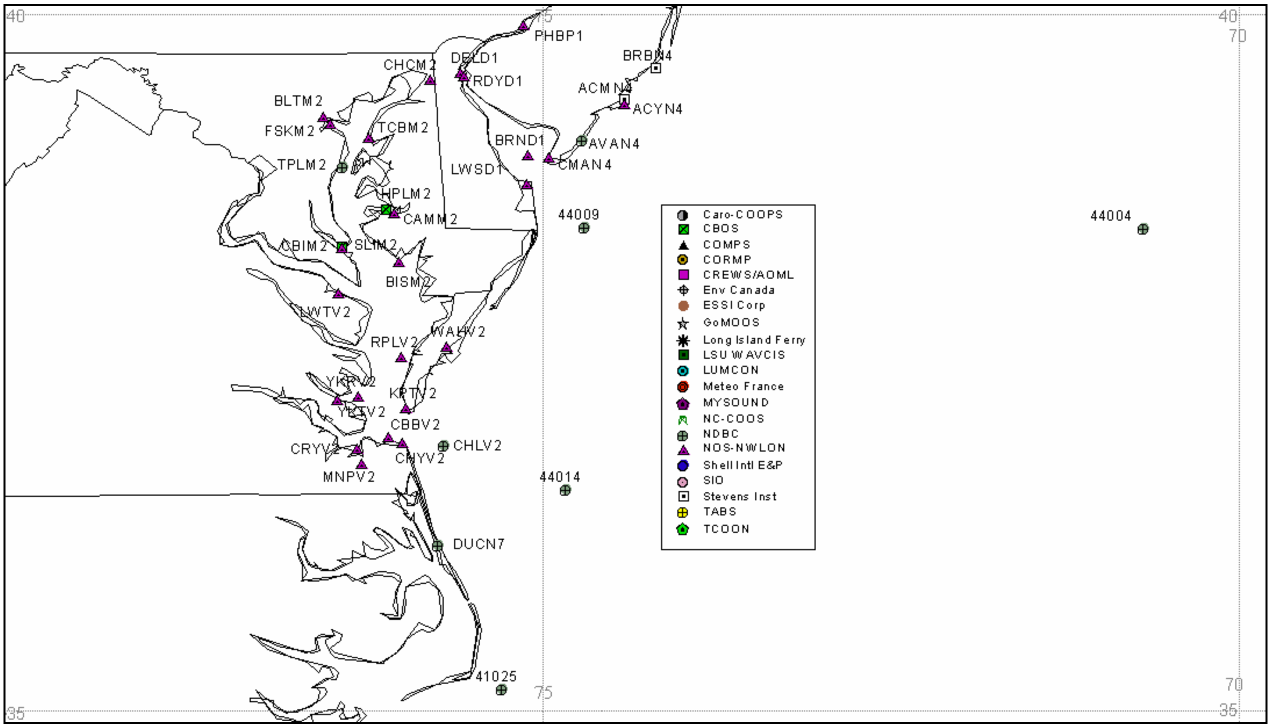
Station	Lat	Lon	Height	Provider	Station Location	Payload Comments
PCLF1	30.40	-87.21	10 (m)	NOS-NWLON	8729840 - PENSACOLA, FL	
42039	28.80	-86.04	5	NDBC	PENSACOLA - 115NM EAST SOUTHEAST OF PENSACOLA, FL	3-meter discus buoy, DACT payload
42003	25.94	-85.92	10	NDBC	E GULF 260 NM SOUTH OF PANAMA CITY, FL	10-meter discus buoy, ARES payload
PCBF1	30.21	-85.88	6.1	NOS-NWLON	8729210 - PANAMA CITY BEACH, FL	
APCF1	29.73	-84.98	10	NOS-NWLON	8728690 - APALACHICOLA, FL	
SGOF1	29.41	-84.86	35.1	NDBC	TYNDALL AFB TOWER C (N4), FL	
42036	28.51	-84.51	5	NDBC	W. TAMPA 106 NM WEST NORTHWEST OF TAMPA, FL	3-meter discus buoy, ARES payload
SHPF1	30.06	-84.29	10	COMPS	SHELL POINT, FL	
42024	27.46	-84.22	3.2	COMPS	W. FL MERHAB	
42022	27.50	-83.74	3.2	COMPS	CMP24 - WEST FLORIDA CENTRAL BUOY	
KTNF1	29.82	-83.59	10	NDBC	KEATON BCH, FL	
42021	28.30	-83.30	2.8	COMPS	CMP4 - PASCO COUNTY BUOY, FL	
42023	26.05	-83.07	3.2	COMPS	CM3 - WEST FLORIDA SOUTH BUOY	
CDRF1	29.14	-83.03	10	NDBC	CEDAR KEY, FL	
42013	27.16	-82.95	2.8	COMPS	NA2 - NAVY-2	
CWBF1	27.98	-82.83	6.4	NOS-NWLON	8726724 - CLEARWATER BEACH, FL	
FHPF1	28.15	-82.80	10	COMPS	FRED HOWARD PARK, FL	
ANCF1	28.19	-82.79	10	COMPS	ANCLOTE GULF PARK, FL	
PLSF1	24.69	-82.77	10	NDBC	PULASKI SHOAL LIGHT, FL	
EGKF1	27.60	-82.76	10	COMPS	EGMONT KEY, FL	
TARF1	28.16	-82.76	7	COMPS	TARPON SPRINGS, FL	
ANMF1	27.54	-82.74	10.8	COMPS	ANNA MARIA, FL	
PTRF1	28.29	-82.73	10.1	COMPS	PORT RICHEY, FL	
HSSF1	28.77	-82.71	6.6	COMPS	HOMOSASSA, FL	
ARPF1	28.44	-82.67	10.3	COMPS	ARIPEKA, FL	
SAPF1	27.76	-82.63	6.1	NOS-NWLON	8726520 - ST. PETERSBURG, FL	
PMAF1	27.64	-82.56	10	NOS-NWLON	8726384 - PORT MANATEE, FL	
OPTF1	27.86	-82.55	10	NOS-NWLON	8726607 - OLD PORT TAMPA, FL	
VENF1	27.07	-82.45	11.6	NDBC	VENICE, FL	
MCYF1	27.91	-82.42	10	NOS-NWLON	8726667 - MCKAY BAY ENTRANCE, FL	
42014	25.25	-82.21	2.8	COMPS	W. FL SEA-COOS	
BGCF1	26.40	-81.88	12	COMPS	BIG CARLOS PASS, FL	
SANF1	24.46	-81.88	13.1	NDBC	SAND KEY, FL	
FMRF1	26.65	-81.87	6.1	NOS-NWLON	8725520 - FORT MYERS, FL	
KYWF1	24.55	-81.81	6.4	NOS-NWLON	8724580 - KEY WEST, FL	
FRDF1	30.67	-81.47	6.4	NOS-NWLON	8720030 - FERNANDINA BEACH, FL	
MYPF1	30.40	-81.43	10	NOS-NWLON	8720218 - MAYPORT (BAR PILOTS DOCK), FL	
SAUF1	29.86	-81.26	16.5	NDBC	ST. AUGUSTINE	
SMKF1	24.63	-81.11	48.5	NDBC	SOMBRERO KEY, FL	
VCAF1	24.71	-81.11	6.4	NOS-NWLON	8723970 - VACA KEY, FL	
LONF1	24.84	-80.86	7	NDBC	LONG KEY, FL	
ALRF1	24.90	-80.60	47.5	NDBC	ALLIGATOR REEF	
TRDF1	28.42	-80.59	6.4	NOS-NWLON	8721604 - TRIDENT PIER, FL	
41012	30.00	-80.50	5	NDBC	ST. AUGUSTINE, FL 40NM ENE OF ST AUGUSTINE, FL	3-meter discus buoy, ARES payload
MLRF1	25.01	-80.38	15.8	NDBC	MOLASSES REEF, FL	
41009	28.50	-80.18	5	NDBC	CANAVERAL 20 NM EAST OF CAPE CANAVERAL, FL	6-meter NOMAD buoy, ARES payload
VAKF1	25.73	-80.16	9.1	NOS-NWLON	8723214 - VIRGINIA KEY, FL	
FWYF1	25.59	-80.10	43.9	NDBC	FOWEY ROCKS, FL	
LKWF1	26.61	-80.03	13.7	NDBC	LAKE WORTH, FL	
SPGF1	26.69	-79.00	9.8	NDBC	SETTLEMENT POINT, GBI	
41010	28.91	-78.55	5	NDBC	CANAVERAL EAST 120NM EAST OF CAPE CANAVERAL	6-meter NOMAD buoy, ARES payload
CMRC3	23.80	-76.10	10	CREWS/AOML	NORTH NORMAN'S REEF, BAHAMAS	

B-3. Buoy, C-MAN, and NOS Platform Locations (cont'd)



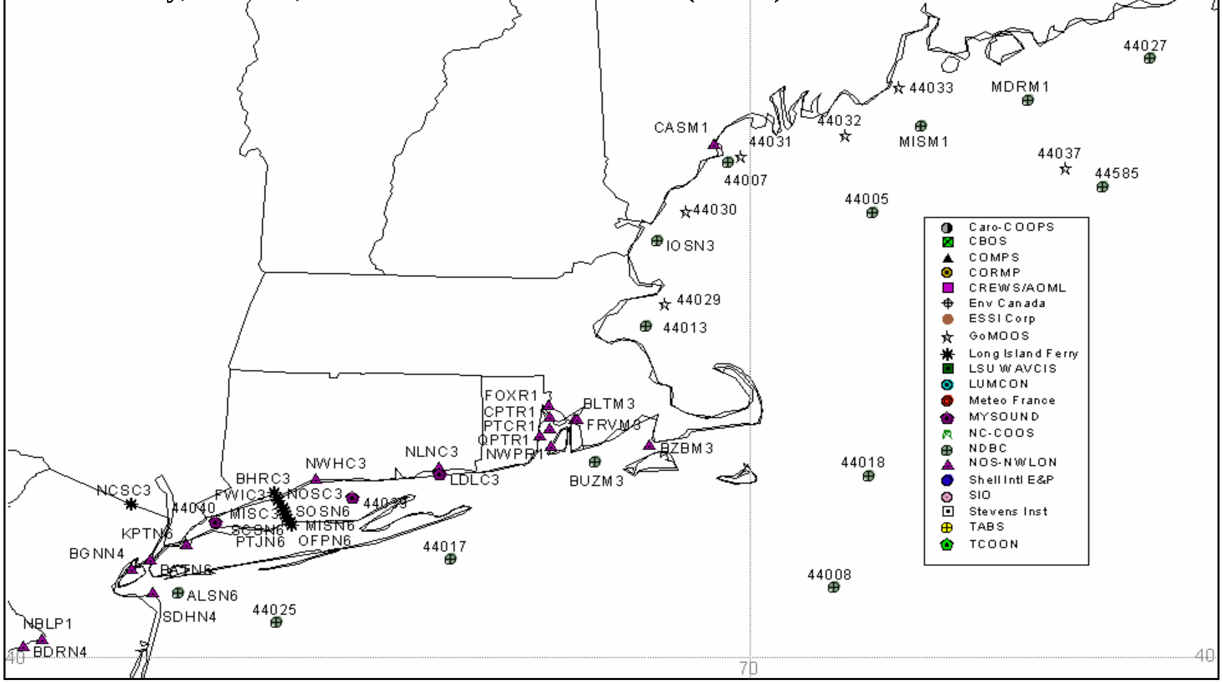
Station	Lat	Lon	Height (m)	Station Provider	Station Location	Payload Comments
FPKG1	32.03	-80.9	6.7	NOS-NWLON	8670870 - FORT PULASKI, FL	
41008	31.40	-80.87	5	NDBC	GRAY'S REEF, SAVANNAH, GA	3-meter discus buoy, ARES payload
SPAG1	31.38	-80.57	50	SIO	U.S. NAVY TOWER R2 GA	
FRPS1	32.34	-80.46	10	NOS-NWLON	8668498 - FRIPPS INLET, SC	
41033	32.28	-80.41	3	Caro-COOPS	FRIPP NEARSHORE (FRP 2)	
SECG1	30.80	-80.32	35	NC-COOS	U.S. NAVY TOWER R4 GA	
SKMG1	31.53	-80.24	50	SIO	U.S. NAVY TOWER M2R6 GA	
TYBG1	31.63	-79.92	34	SIO	U.S. NAVY TOWER R8 GA	
FBIS1	32.68	-79.89	9.8	NDBC	FOLLY ISLAND, SC	
SCIS1	32.86	-79.71	10	NOS-NWLON	8664941 - S CAPERS ISLAND, SC	
41029	32.81	-79.63	3	Caro-COOPS	CAPERS NEARSHORE (CAP 2)	
41030	32.52	-79.34	3	Caro-COOPS	CAPERS MID-SHELF (CAP 3)	
41004	32.51	-79.10	5	NDBC	EDISTO, CHARLESTON, SC	3-meter discus buoy, VEEP payload
MROS1	33.66	-78.92	10	NOS-NWLON	8661070 - SPRINGMAID PIER, SC	
SNSN7	33.87	-78.51	10	Caro-COOPS	8659897 - SUNSET BEACH, NC	
41024	33.83	-78.48	3	Caro-COOPS	SUNSET NEARSHORE (SUN 2)	
JMPN7	34.21	-77.80	10	CORMP	8658163 - JOHNNY MERCER PIER, WRIGHTSVILLE BEACH, NC	
41038	34.14	-77.71	3	CORMP	ILM2, WRIGHTSVILLE BEACH, NC	
FPSN7	33.49	-77.59	44.2	NDBC	FRYING PAN SHOALS, NC	
41013	33.48	-77.58	5	NDBC	FRYING PAN SHOALS, NC BUOY	3-meter discus buoy, DACT payload
41037	33.99	-77.36	3	CORMP	ILM3, WRIGHTSVILLE BEACH, NC	
41035	34.48	-77.28	5	NDBC	ONSLOW BAY, NC	3-meter discus buoy, ARES payload
CLKN7	34.62	-76.52	9.8	NDBC	CAPE LOOKOUT, NC	
41002	32.28	-75.19	5	NDBC	S HATTERAS - CHARLESTON, SC	6-meter NOMAD buoy, VEEP payload

B-3. Buoy, C-MAN, and NOS Platform Locations (cont'd)



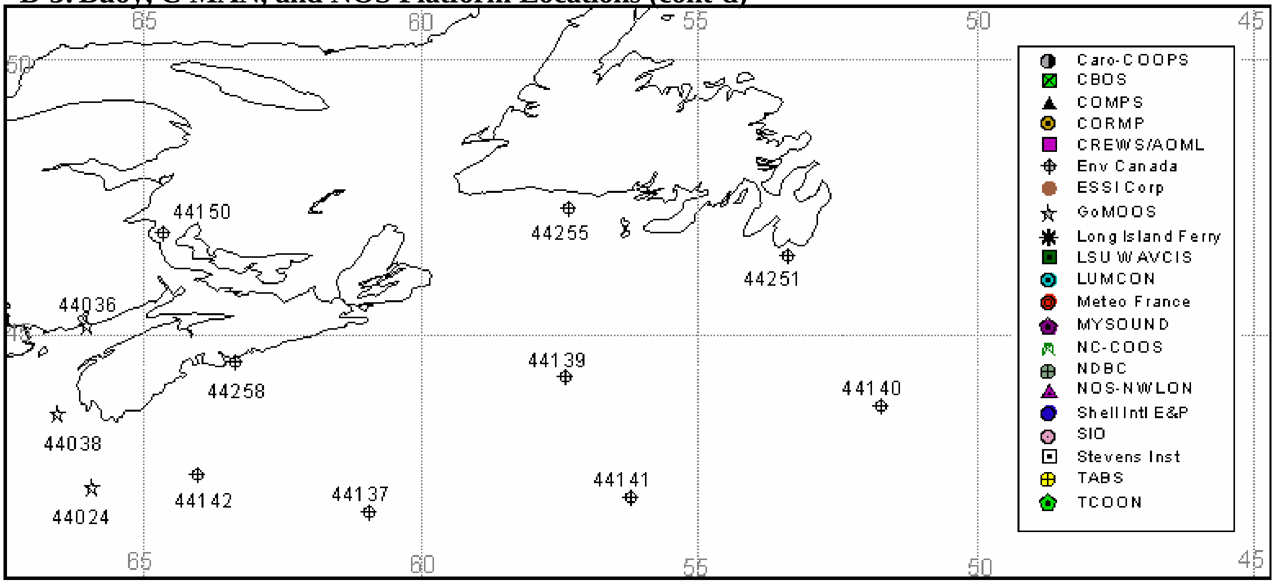
Station	Lat	Lon	Height	Station Provider	Station Location	Payload Comments
BLTM2	39.27	-76.58	10(m)	NOS-NWLON	8574680 - BALTIMORE, MD	
FSKM2	39.22	-76.53	10	NOS-NWLON	8574728 - FRANCIS SCOTT KEY BRIDGE, MD	
YKTV2	37.23	-76.48	10	NOS-NWLON	8637689 - YORKTOWN, VA	
LWTV2	38.00	-76.47	10	NOS-NWLON	8635750 - LEWISETTA, VA	
CBIM2	38.32	-76.45	10	CBOS	CHESAPEAKE BIO LAB WEATHER STATION, MD	
SLIM2	38.32	-76.45	10	NOS-NWLON	8577330 - SOLOMON'S ISLAND, MD	
TPLM2	38.90	-76.44	18	NDBC	THOMAS POINT, MD	
CRYV2	36.89	-76.34	10	NOS-NWLON	8638595 - SOUTH CRANEY ISLAND, VA	
YKRV2	37.25	-76.33	10	NOS-NWLON	8637611 - YORK RIVER E. REAR RANGE LIGHT, VA	
MNPV2	36.78	-76.30	10	NOS-NWLON	8639348 - MONEY POINT, VA	
TCBM2	39.12	-76.25	10	NOS-NWLON	8573364 - TOLCHESTER BEACH, MD	
HPLM2	38.59	-76.13	10	CBOS	HORN POINT WEATHER STATION MD	
CBBV2	36.97	-76.11	13	NOS-NWLON	8638863 - CHESAPEAKE BAY BRIDGE TUNNEL, VA	
CAMM2	38.57	-76.07	6.1	NOS-NWLON	8571892 - CAMBRIDGE, MD	
BISM2	38.22	-76.04	10	NOS-NWLON	8571421 - BISHOPS HEAD, MD	
RPLV2	37.54	-76.02	10	NOS-NWLON	8632837 - RAPPAHANNOCK LIGHT, VA	
CHYV2	36.93	-76.01	10	NOS-NWLON	8638999 - CAPE HENRY, VA	
KPTV2	37.17	-75.99	6.4	NOS-NWLON	8632200 - KIPTOPEKE, VA	
CHCM2	39.53	-75.81	10	NOS-NWLON	8573927 - CHESAPEAKE CITY, MD	
DUCN7	36.18	-75.75	20.4	NDBC	DUCK PIER, NC	
CHLV2	36.90	-75.71	43.3	NDBC	CHESAPEAKE LIGHT, VA	
WAHV2	37.61	-75.69	10	NOS-NWLON	8631044 - WACHAPREAGUE, VA	
DELD1	39.58	-75.59	10	NOS-NWLON	8551762 - DELAWARE CITY, DE	
RDYD1	39.56	-75.57	10	NOS-NWLON	8551910 - REEDY POINT, DE	
41025	35.15	-75.29	5	NDBC	DIAMOND SHOALS	3-meter discus buoy, ARES payload
PHBP1	39.93	-75.14	6.4	NOS-NWLON	8545240 - PHILADELPHIA, PA	
LWSD1	38.78	-75.12	10	NOS-NWLON	8557380 - LEWES, DE	
BRND1	38.99	-75.11	10	NOS-NWLON	8555889 - BRANDYWINE SHOAL LIGHT, DE	
CMAN4	38.97	-74.96	12.2	NOS-NWLON	8536110 - CAPE MAY, NJ	
44014	36.58	-74.83	5	NDBC	64 NM EAST OF VIRGINIA BEACH, VA	3-meter discus buoy, DACT payload
AVAN4	39.09	-74.72	10	NDBC	STEVENS INST	
44009	38.46	-74.70	5	NDBC	26 NM SOUTHEAST OF CAPE MAY, NJ	3-meter discus buoy, VEEP payload
ACMN4	39.38	-74.42	15	Stevens Inst	ATLANTIC CITY MARINA, NJ	
ACYN4	39.36	-74.42	10	NOS-NWLON	8534720 - ATLANTIC CITY, NJ	
BRBN4	39.61	-74.20	10	Stevens Inst	AVALON, NJ	
44004	38.46	-70.69	5	NDBC	HOTEL 200 NM EAST OF CAPE MAY,NJ	6-meter NOMAD buoy, ARES payload

B-3. Buoy, C-MAN, and NOS Platform Locations (cont'd)



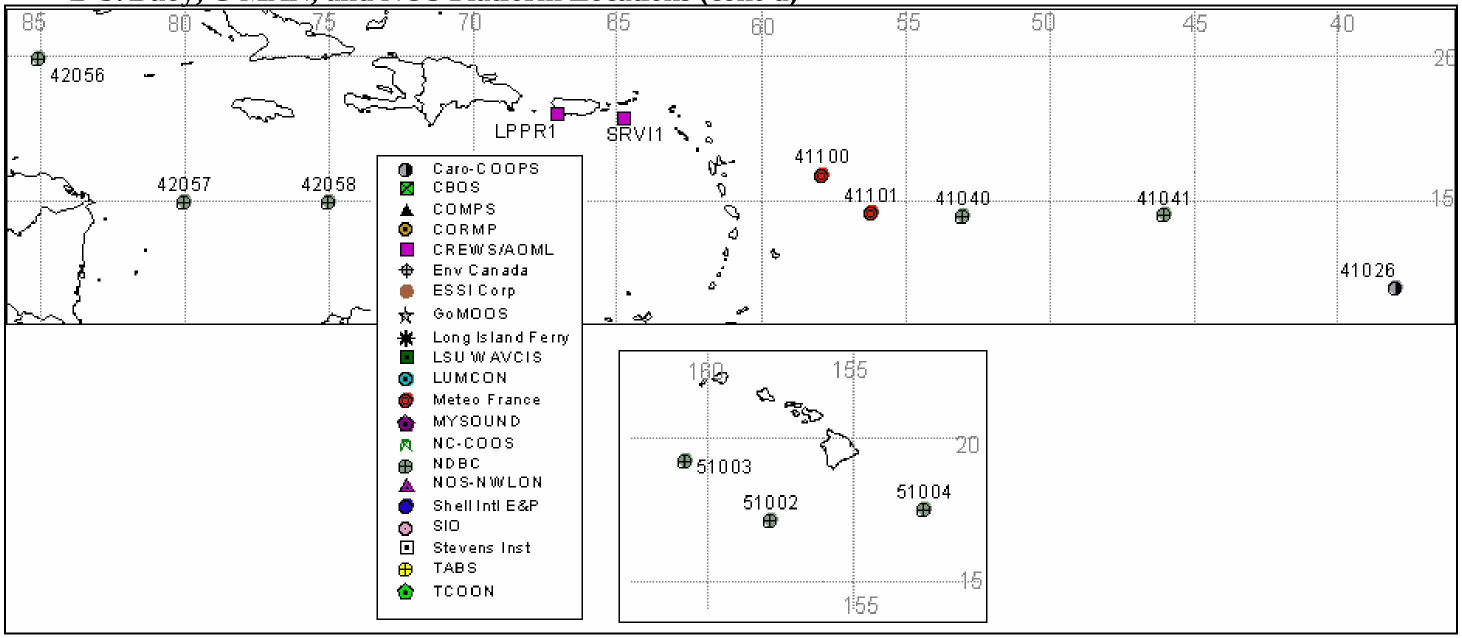
Station	Lat	Lon	Height (m)	Provider	Station Location	Payload Comments
BDRN4	40.08	-74.87	10	NOS-NWLON	8539094 - BURLINGTON, DELAWARE RIVER, NJ	
NBLP1	40.14	-74.75	10	NOS-NWLON	8548989 – NEW BOLD, PA	
BGNN4	40.64	-74.15	9.1	NOS-NWLON	8519483 - BERGEN POINT WEST REACH, NJ	
NCSC3	41.10	-74.15	16	Long Island Ferry	NORTH CENTRAL SOUND, CT	
BATN6	40.70	-74.02	10	NOS-NWLON	8518750 - THE BATTERY, NY	
SDHN4	40.47	-74.01	10	NOS-NWLON	8531680 - SANDY HOOK, NJ	
ALSN6	40.46	-73.83	49.1	NDBC	AMBROSE LIGHT, NY	
KPTN6	40.81	-73.78	10	NOS-NWLON	8516945 - KING'S POINT, NY	
44040	40.96	-73.58	3.5	MYSOUND	WESTERN LONG ISLAND SOUND	buoy
BHRC3	41.18	-73.19	16	Long Island Ferry	BRIDGEPORT TERMINAL, CT	
FWIC3	41.15	-73.17	16	Long Island Ferry	FAYER WEATHER ISLAND, CT	
44025	40.25	-73.17	5	NDBC	LONG ISLAND 33 NM SO UTH OF ISLIP, NY	3-meter discus buoy, DACT payload
NOSC3	41.12	-73.16	16	Long Island Ferry	NORTHERN OPEN SOUND, CT	
MISC3	41.07	-73.13	16	Long Island Ferry	NORTH MIDDLE SOUND, CT	
MISN6	41.05	-73.12	16	Long Island Ferry	SOUTH MIDDLE SOUND, NY	
SCSN6	41.02	-73.11	16	Long Island Ferry	SOUTH CENTRAL SOUND, NY	
SOSN6	41.00	-73.10	16	Long Island Ferry	SOUTHERN OPEN SOUND, NY	
OFPN6	40.97	-73.08	16	Long Island Ferry	OLD FIELD ISLAND, NY	
PTJN6	40.95	-73.07	16	Long Island Ferry	PORT JEFFERSON, NY	
NWHC3	41.28	-72.91	6.4	NOS-NWLON	8465705 - NEW HAVEN, CT	
44039	41.14	-72.66	3.5	MYSOUND	CENTRAL LONG ISLAND SOUND	2.4-meter foam hull buoy
NLNC3	41.36	-72.09	10	NOS-NWLON	8461490 - NEW LONDON, CT	
LDLC3	41.31	-72.08	20	MySound	LEDGE LIGHT WEATHER STATION, CT	
44017	40.70	-72.00	5	NDBC	23 NM SOUTHWEST OF MONTAUK POINT, NY	3-meter discus buoy, ARES payload
QPTR1	41.59	-71.41	6.4	NOS-NWLON	8454049 - QUONSET POINT, RI	
FOXR1	41.81	-71.35	4.2	NOS-NWLON	8454000 - PROVIDENCE, RI	
PTCR1	41.64	-71.34	10	NOS-NWLON	8452951 - POTTER COVE, PRUDENCE ISLAND, RI	
CPTR1	41.72	-71.34	4.3	NOS-NWLON	8452944 - CONIMICUT LIGHT, RI	
NWPR1	41.51	-71.33	6.4	NOS-NWLON	8452660 - NEWPORT, RI	
BLTM3	41.71	-71.17	10	NOS-NWLON	8447387 - FALL RIVER, MA	
FRVM3	41.71	-71.16	3.6	NOS-NWLON	8447386 - FALL RIVER, MA	
BUZM3	41.40	-71.03	24.8	NDBC	BUZZARDS BAY, MA	
44013	42.35	-70.69	5	NDBC	BOSTON 16 NM EAST OF BOSTON, MA	3-meter discus b uoy, DACT payload
BZBM3	41.52	-70.67	10	NOS-NWLON	8447930 - WOODS HOLE, MA	
IOSN3	42.97	-70.62	19.2	NDBC	ISLE OF SHOALS, NH	
44029	42.52	-70.57	4	GoMOOS	BUOY A0102 - MASS. BAY/STELLWAGEN	2-meter discus buoy
44030	43.18	-70.43	4	GoMOOS	BUOY B0102 - WESTERN MAINE SHELF	2-meter discus buoy
CASM1	43.66	-70.25	10	NOS-NWLON	PORTLAND, ME, 8418150	
44007	43.53	-70.14	5	NDBC	PORTLAND 12 NM SOUTH EAST OF PORTLAND, ME	3-meter discus buoy, ARES payload
44031	43.57	-70.06	4	GoMOOS	BUOY C0201 - CASCO BAY	2-meter discus buoy
44008	40.50	-69.43	5	NDBC	NANTUCKET 54 NM SOUTHEAST OF NANTUCKET	3-meter discus buoy, ARES payload
44032	43.72	-69.36	4	GoMOOS	BUOY E0104 - CENTRAL MAINE SHELF	2-meter discus buoy
44018	41.30	-69.20	5	NDBC	SE CAPE COD 30 NM EAST OF NANTUCKET, MA	3-meter discus buoy, ARES payload
44005	43.17	-69.18	5	NDBC	GULF OF MAINE, NH	6-meter NOMAD buoy, DACT payload
44033	44.06	-69.00	4	GoMOOS	BUOY F0103 - WEST PENOBSCOT BAY	2-meter discus buoy
MISM1	43.78	-68.85	16.5	NDBC	MATINICUS ROCK, ME	
MDRM1	43.97	-68.13	22.6	NDBC	MT DESERT ROCK, ME	
44037	43.49	-67.88	4	GoMOOS	BUOY M0102 - JORDAN BASIN	2-meter discus buoy
44585	43.35	-67.64	10	NDBC		Drifting Buoy
44027	44.27	-67.31	5	NDBC	JONESPORT, MAINE	3-meter discus buoy, ARES payload
44035	44.89	-67.02	4	GoMOOS	BUOY J0201 - COBSCOOK BAY	2-meter discus buoy
PSBM1	44.90	-66.99	6.4	NOS-NWLON	8410140 - EASTPORT, ME	

B-3. Buoy, C-MAN, and NOS Platform Locations (cont'd)



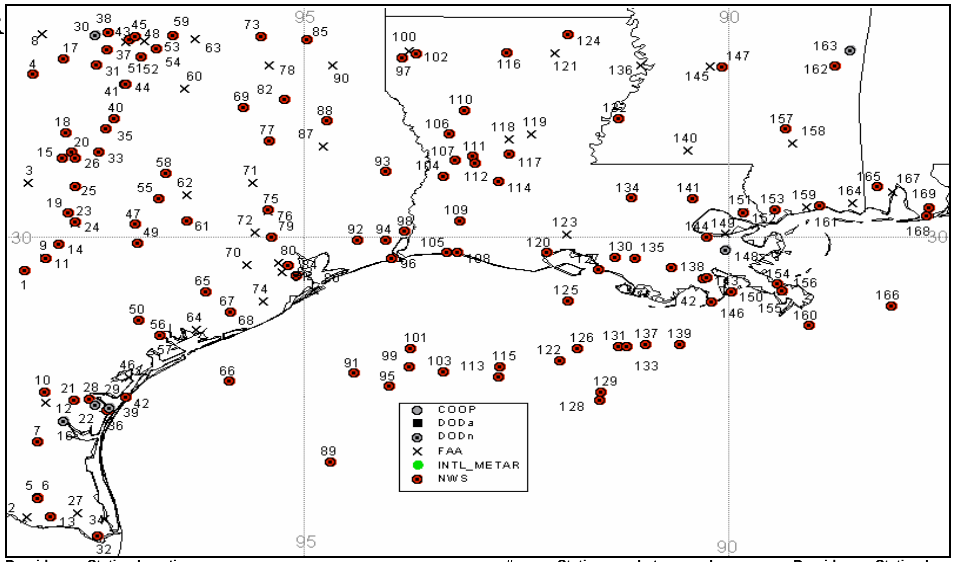
Station	Lat	Lon	Height	Provider	Station Location	Payload Comments
44137	41.83	-60.94	5(m)	Env Canada	EAST SCOTIA SLOPE	
44141	42.10	-56.22	5	Env Canada	LAURENTIAN FAN	
44024	42.31	-65.93	4	GoMOOS	BUOY N - NORTHEAST CHANNEL	2-meter discus buoy
44142	42.50	-64.02	5	Env Canada	LA HAVE BANK	
44038	43.62	-66.55	4	GoMOOS	BUOY L0102 - SCOTIAN SHELF	2-meter discus buoy
44140	43.75	-51.74	5	Env Canada	TAIL OF THE BANK	
44034	44.11	-38.11	4	GoMOOS	BUOY I0103 - EASTERN MAINE SHELF	2-meter discus buoy
44139	44.26	-57.39	5	Env Canada	BANQUREAU BANKS	
44258	44.54	-63.35	5	Env Canada	HALIFAX HARBOR	
44036	45.20	-66.02	4	GoMOOS	BUOY K0102 - SAINT JOHN	2-meter discus buoy
44251	46.44	-53.39	5	Env Canada	NICKERSON BANK	
44150	46.85	-64.64	5	Env Canada	LA HAVE BANK	3-meter discus buoy
44255	47.28	-57.35	5	Env Canada	NE BURGEO BANK	

B-3. Buoy, C-MAN, and NOS Platform Locations (cont'd)



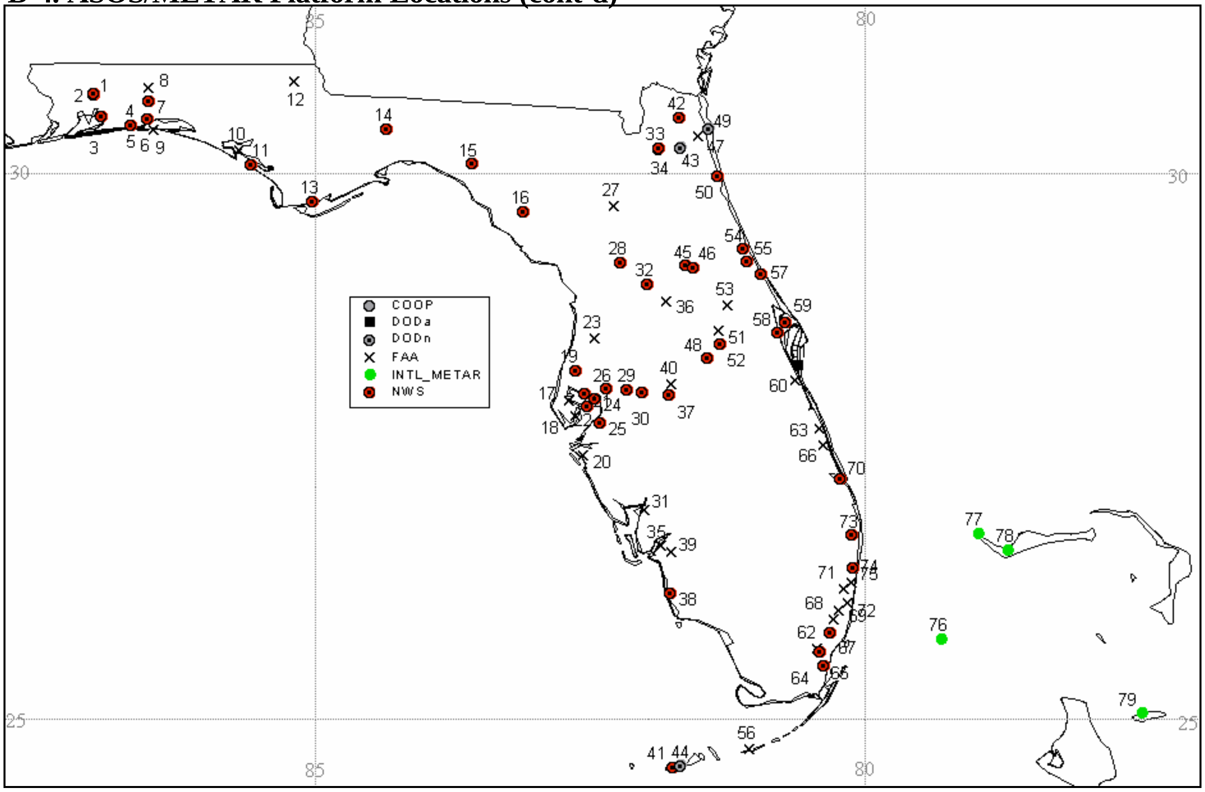
Station	Lat	Lon	Height	Station Provider	Station Location	Payload Comments
51003	19.16	-160.74	5 (m)	NDBC	205 NM SOUTHWEST OF HONOLULU, HI	6-meter NOMAD buoy, VEEP payload
51002	17.15	-157.79	5	NDBC	215 NM SOUTH SOUTHWEST OF HILO, HI	6-meter NOMAD buoy, ARES payload
51004	17.52	-152.51	5	NDBC	SE HAWAII 185 NM SOUTHEAST OF HILO, HI	6-meter NOMAD buoy, ARES payload
42056	19.87	-85.06	10	NDBC	YUCATAN BASIN	12-meter discus buoy, ARES payload
42057	14.99	-79.99	10	NDBC	WESTERN CARIBBEAN	10-meter discus buoy, ARES payload
42058	14.98	-74.99	10	NDBC	CENTRAL CARIBBEAN	10-meter discus buoy, ARES payload
LPPR1	17.94	-67.05	10	CREWS/AOML	LA PARGUERA, PR	
SRVI1	17.78	-64.76	10	CREWS/AOML	ST. CROIX, USVI	
41100	15.90	-57.90	3.6	Meteo France	LESSER ANTILLES	
41101	14.60	-56.20	3.6	Meteo France	EAST OF MARTINIQUE	
41040	14.50	-53.02	5	NDBC	WEST ATLANTIC	6-meter NOMAD buoy, ARES payload
41041	14.53	-46.00	5	NDBC	MIDDLE ATLANTIC	6-meter NOMAD buoy, ARES payload
41026	12.00	-38.00	5	Caro-COOPS	SUNSET MID-SHELF (SUN 3)	

B-4. ASOS/METAR Platform Locations

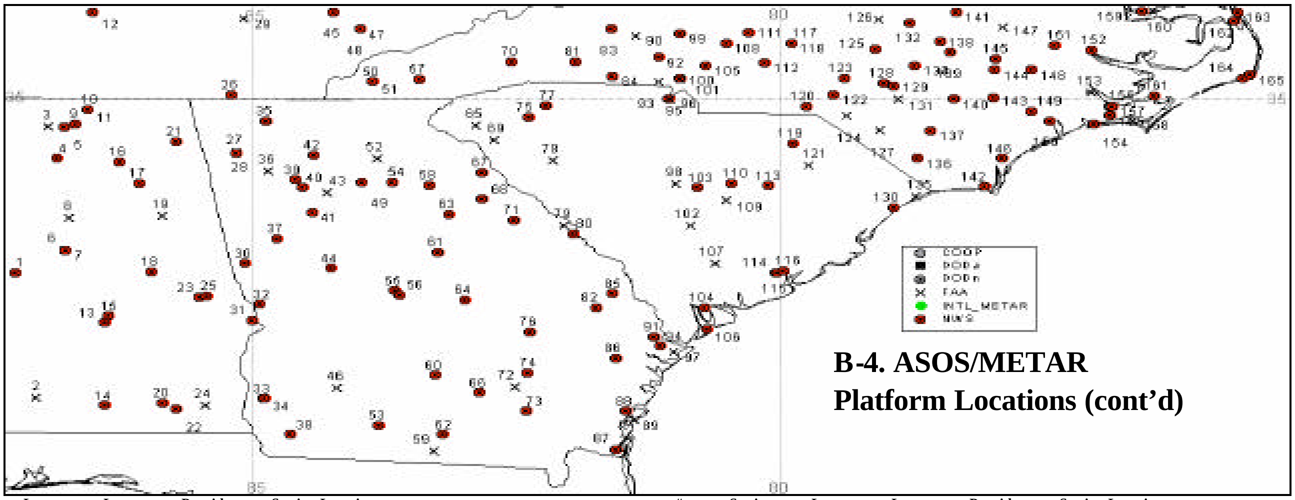


#	Station	Lat	Lon	Provider	Station Location
1	KRND	29.53	-98.28	NWS	RANDOLPH AFB TX
2	KMFE	26.18	-98.24	FAA	MCALLEN MILLER INTL ARPT, MCALLEN, TX
3	KBMQ	30.74	-98.24	FAA	BURNET MUNI ARPT, BURNET, TX
4	KSEP	32.22	-98.18	NWS	STEPHENVILLE/CLARK T X
5	K25R	26.44	-98.13	NWS	EDINBURG INTL ARPT, TX
6	KEBG	26.43	-98.12	NWS	EDINBURG INTL ARPT, TX
7	KBKS	27.21	-98.12	NWS	BROOKS CO ARPT, TX
8	KMWL	32.78	-98.07	FAA	MINERAL WELLS MUNI T X
9	KBAZ	29.71	-98.05	FAA	NEW BRAUNFELS MUNI ARPT, NEW BRAUNFELS, TX
10	KNOG	27.89	-98.04	NWS	ORANGE GROVE NALF, TX
11	KEWX	29.70	-98.03	NWS	AUSTIN/SAN ANTONIO NEXRAD & SCD, TX
12	KALI	27.74	-98.03	FAA	ALICE INTL ARPT, ALICE, TX
13	KT65	26.18	-97.97	NWS	MID VALLEY ARPT, TX
14	KHYI	29.90	-97.87	NWS	SAN MARCOS (AWOS) TX
15	KGRK	31.07	-97.83	NWS	FORT HOOD/GRAY AAF TX
16	KNQI	27.50	-97.82	DODn	KINGSVILLE, KINGSVILLE, TX
17	KGDJ	32.43	-97.82	NWS	GRANBURY MUNI ARPT, TX
18	KGOP	31.42	-97.80	NWS	GATESVILLE/CITY-CO ARPT, TX
19	KATT	30.32	-97.77	NWS	AUSTIN CITY/CAMP MABRY, TX
20	KHLR	31.15	-97.72	NWS	FT HOOD AAF/KILLEEN TX
21	KRBO	27.78	-97.69	NWS	ROBSTOWN, NUECES CO ARPT, TX
22	KT53	27.78	-97.69	NWS	NUECES CO ARPT, TX
23	KAUS	30.18	-97.68	FAA	AUSTIN-BERGSTROM INTL ARPT, TX
24	KBSM	30.20	-97.68	NWS	BERGSTROM AFB/AUSTI TX
25	KGTU	30.68	-97.68	NWS	GEORGETOWN (AWOS) TX
26	KILE	31.08	-97.68	NWS	KILLEEN MUNI (AWOS) TX
27	KHRL	26.23	-97.66	FAA	HARLINGEN RIO GRANDE VALLEY ARPT, TX
28	KCRP	27.79	-97.51	NWS	CORPUS CHRISTI INTL ARPT, CORPUS CHRISTI, TX
29	KNGW	27.72	-97.45	DODn	CABANISS NAVY AUXILIARY LANDING FLD,,T X
30	KNFW	32.77	-97.45	DODn	FORT WORTH NAS TX
31	KCPT	32.35	-97.43	NWS	CLEBURNE MUNI ARPT, TX
32	KBRO	25.91	-97.42	NWS	BROWNSVILLE S PADRE ISL INTL ARPT, TX
33	KTPL	31.15	-97.40	NWS	TEMPLE/MILLER (AWOS)TX
34	KPIL	26.16	-97.34	FAA	PORT ISABEL CAMERON CO ARPT, PORT ISABEL, TX
35	KPWG	31.48	-97.32	NWS	MC GREGOR (AWOS) TX
36	KNVT	27.63	-97.31	NWS	CORPUS CHRISTI/WALDRON FLD, TX
37	KFWS	32.56	-97.31	NWS	FORT WORTH SPINKS/DFW NEXRAD, TX
38	KFWD	32.79	-97.30	NWS	FORT WORTH, TX
39	KNGP	27.68	-97.28	DODn	CORPUS CHRISTI NAVAL AIR STATION, TX
40	KACT	31.62	-97.22	NWS	WACO-MADISON COOPER TX
41	K5T5	32.08	-97.10	NWS	HILLSBORO MUNI ARPT,TX
42	KRAS	27.81	-97.09	NWS	MUSTANG BEACH ARPT, TX
43	KGKY	32.66	-97.09	FAA	ARLINGTON MUNI ARPT,TX
44	KINJ	32.08	-97.08	NWS	HILLSBORO MUNI ARPT,TX
45	KGPM	32.70	-97.05	NWS	GRAND PRAIRIE, TX
46	KRKP	28.08	-97.05	FAA	ROCKPORT ARANSAS MUNI ARPT, ROCKPORT, TX
47	KGYB	30.17	-96.98	NWS	GIDDINGS-LEE CO ARPT, TX
48	KNBE	32.73	-96.97	NWS	DALLAS NAS/HENSLEY T X
49	K3T5	29.91	-96.95	NWS	FAYETTE RGNL AIR CTRARPT, TX
50	KVCT	28.86	-96.93	NWS	VICTORIA RGNL ARPT, VICTORIA, TX
51	K4T6	32.46	-96.91	NWS	MID-WAY RGNL ARPT, TX
52	KJWY	32.46	-96.91	NWS	MID-WAY RGNL ARPT, TX
53	KRBD	32.68	-96.87	FAA	DALLAS/REDBIRD ARPT TX
54	KLNC	32.57	-96.72	NWS	LANCASTER ARPT, TX
55	KRWV	30.52	-96.70	NWS	CALDWELL MUNI ARPT,TX
56	KPKV	28.65	-96.68	NWS	CALHOUN CO ARPT, TX
57	KT97	28.65	-96.68	NWS	CALHOUN CO ARPT, TX
58	KLHB	30.87	-96.62	NWS	HEARNE MUNI ARPT, TX
59	KHQZ	32.75	-96.53	NWS	MESQUITE METRO ARPT,TX
60	KCRS	32.03	-96.40	FAA	CORSICANA/CAMPBELL FLD, TX
61	K11R	30.22	-96.37	NWS	BRENHAM/BRENHAM MUNI APT, TX
62	KCLL	30.58	-96.37	FAA	COLLEGE STATION TX
63	KTRL	32.71	-96.27	FAA	TERRELL MUNI ARPT, T X
64	KPSX	28.73	-96.25	FAA	PALACIOS MUNI TX
65	KARM	29.25	-96.15	NWS	WHARTON RGNL ARPT, T X
66	KT46	28.02	-95.87	NWS	SOUTH BRAZOS A70 TX
67	K3R1	28.97	-95.86	NWS	BAY CITY MUNI ARPT, TX
68	KBYY	28.97	-95.86	NWS	BAY CITY MUNI ARPT, TX
69	KPSN	31.77	-95.70	NWS	PALESTINE MUNI ARPT, TX
70	KSGR	29.62	-95.66	FAA	HOUSTON/HULL FLD, TX
71	KUTS	30.74	-95.59	FAA	HUNTSVILLE MUNI ARPT , HUNTSVILLE, AL
72	KDWH	30.07	-95.56	FAA	HOUSTON HOOKS MEMORIAL ARPT, HOUSTON, TX
73	KJDD	32.74	-95.50	NWS	WOOD CO ARPT, TX
74	KLBX	29.12	-95.46	FAA	ANGLETON / LAKE JACKSON BRAZORI ARPT,, TX
75	KCXO	30.36	-95.41	FAA	CONROE MONTGOMERY CO ARPT, CONROE, AL
76	KXCO	30.36	-95.41	NWS	CONROE ARPT, TX
77	KDKR	31.31	-95.40	NWS	CROCKET/HOUSTON CO ARPT, TX
78	KTYR	32.35	-95.40	FAA	TYLER/POUNDS FLD TX
79	KIAH	29.99	-95.36	NWS	HOUSTON BUSH INTERCONTINENTAL ARPT, TX
80	KHOU	29.64	-95.28	FAA	HOUSTON WILLIAM P HOBBY ARPT, HOUSTON, T X
81	KLVJ	29.52	-95.24	FAA	HOUSTON CLOVER FLD, HOUSTON, TX
82	KJSO	31.87	-95.22	NWS	CHEROKEE CO ARPT, TX
83	KEFD	29.60	-95.17	NWS	HOUSTON/ELLINGTON TX
84	KHGX	29.47	-95.08	NWS	HOUSTON/GALVESTON NEXRAD & SCD, TX
85	KJXI	32.70	-94.95	NWS	FOX STEPHENS FLD/GILMER MUNI, TX
86	KGLS	29.27	-94.87	FAA	GALVESTON SCHOLES ARPT, GALVESTON, TX
87	KLFK	31.24	-94.75	FAA	LUFKIN ANGELINA CTY ARPT, LUFKIN, TX
88	KOCH	31.58	-94.72	NWS	NACOGDOCHES (AWOS) TX
89	K25T	26.93	-94.68	NWS	PHILLIPS OIL PLATFORM, TX
90	KGGG	32.35	-94.65	FAA	LONGVIEW/GREGG CO. T X
91	K01T	28.13	-94.40	NWS	HIGH ISLAND LA
92	KBPT	29.95	-94.36	NWS	PORT ARTHUR JEFFERSON CO, BEAUMONT, TX
93	KJAS	30.89	-94.03	NWS	JASPER CO/BELL FLD ARPT, TX
94	KLCH	29.95	-94.03	NWS	LAKE CHARLES RGNL ARPT, LAKE CHARLES, LA
95	KH39	27.95	-93.98	NWS	HIGH ISLAND A572C LA
96	KRPE	29.70	-93.95	NWS	SABINE PASS TX
97	KSHV	32.45	-93.82	NWS	SHREVEPORT RGNL ARPT , SHREVEPORT, LA
98	KORG	30.07	-93.80	NWS	ORANGE CO ARPT, TX
99	K5R0	28.22	-93.75	NWS	EAST ADDITION B323 T X
100	KDTN	32.54	-93.75	FAA	SHREVEPORT DOWNTOWN ARPT, SHREVEPORT, LA
101	KH08	28.47	-93.73	NWS	HIGH ISLAND 264C (SAWRS), LA
102	KBAD	32.50	-93.67	NWS	BARKSDALE AFB LA
103	KW60	28.15	-93.35	NWS	WEST CAMERON 560, LA
104	KDRI	30.83	-93.34	NWS	BEAUREGARD RGNL ARPT , LA
105	K7R5	29.78	-93.30	NWS	CAMERON HELIPORT LA
106	KAQV	31.40	-93.28	NWS	PEASON RIDGE FT POL, LA
107	KPOE	31.05	-93.20	NWS	FORT POLK (ARMY) LA
108	K4C0	29.78	-93.18	NWS	OIL PLATFORM, LA
109	KCWF	30.22	-93.15	NWS	CHENAULT AIRPARK LA
110	KIER	31.73	-93.10	NWS	NATCHITOCHES, LA
111	KDNK	31.10	-93.00	NWS	SELF LANDING STRIP, LA
112	KBKB	31.00	-92.97	NWS	FULLERTON LANDING, LA
113	KE12	28.08	-92.70	NWS	EAST CAMERON 345 (SAWRS), LA
114	KACP	30.75	-92.69	NWS	ALLEN PARISH ARPT, LA
115	K3B6	28.22	-92.68	NWS	EUGENE ISLAND 330 (SAWRS), LA
116	KRSN	32.51	-92.59	NWS	RUSTON RGNL ARPT, LA
117	K01R	31.13	-92.57	NWS	CLAIBORNE RNG (AFS) LA
118	KAEX	31.33	-92.57	FAA	ALEXANDRIA INTL ARPT , ALEXANDRIA, LA
119	KESF	31.40	-92.30	FAA	ALEXANDRIA ESLER RGNL, ALEXANDRIA, LA
120	K7R4	29.78	-92.13	NWS	INTRACOASTAL CITY LA
121	KMLU	32.52	-92.03	FAA	MONROE RGNL LA
122	K7R8	28.30	-91.98	NWS	SOUTH MARSH ISLAND LA
123	KARA	30.03	-91.89	FAA	NEW IBERIA ACADIANA RGNL, NEW IBERIA, LA
124	K2F8	32.76	-91.88	NWS	MOREHOUSE MEM ARPT/BASTROP LA US
125	KSRN	29.12	-91.87	NWS	SOUTH MARSH 268A (SAWRS), FL
126	K41I	28.47	-91.78	NWS	EUGENE ISLAND B266C LA
127	KP92	29.55	-91.53	NWS	SALT POINT, SALT POINT, LA
128	KXCN	27.77	-91.52	NWS	GREEN CANYON 184 (SAWRS), LA
129	K28K	27.88	-91.50	NWS	GRNCYN BLK52 (SAWRS) LA
130	KPTN	29.72	-91.33	NWS	PATTERSON MEMORIAL LA
131	KS02	28.50	-91.30	NWS	SHIP SHOAL B224A LA
132	KHEZ	31.62	-91.30	NWS	NATCHEZ/HARDY (AWOS) MS
133	KS65	28.50	-91.20	NWS	SHIP SHOAL 198G LA
134	KBTR	30.53	-91.14	NWS	BATON ROUGE RYAN ARPT, BATON ROUGE, LA
135	K7R3	29.70	-91.10	NWS	AMELIA/LAKE PALOURD LA
136	KTVR	32.35	-91.03	FAA	VICKSBURG/TALLULAH RGNL (ASOS), MS
137	KGSM	28.53	-90.98	NWS	SHIP SHOAL 207A (SAWRS), LA
138	KHUM	29.57	-90.67	NWS	HOUMA-TERREBONNE LA
139	KS58	28.53	-90.58	NWS	SOUTH TIMBALIER LA
140	KMCB	31.18	-90.47	FAA	MCCOMB PIKE CO ARPT, MCCOMB, MS
141	KHDC	30.52	-90.42	NWS	HAMMOND MUNI ARPT, LA
142	K2GL	29.42	-90.30	NWS	GALLIANO HELIPORT L, LA
143	KGAO	29.44	-90.26	NWS	GALLIANO/SOUTH LAFOURCHE ARPT, LA
144	KMSY	29.99	-90.25	NWS	NEW ORLEANS INTL ARPT, NEW ORLEANS, LA
145	KHKS	32.33	-90.22	FAA	JACKSON HAWKINS FLD JACKSON, MS
146	K9F2	29.10	-90.20	NWS	FOURCHON (SAWRS) LA
147	KJAN	32.32	-90.08	NWS	JACKSON/THOMPSON MS
148	KNBG	29.83	-90.03	DODn	NEW ORLEANS NAS LA
149	KNEW	30.05	-90.03	FAA	NEW ORLEANS LAKEFRONT ARPT, NEW ORLEANS, LA
150	KAXO	29.25	-89.97	NWS	GRAND ISLE (SAWRS) LA
151	KASD	30.34	-89.82	FAA	SLIDELL ARPT, SLIDELL, LA
152	KLIX	30.33	-89.82	NWS	SLIDELL WSFO & NEXRAD & SCD, LA
153	KHSA	30.37	-89.45	NWS	STENNIS INTL ARPT, MS
154	K1B7	29.35	-89.43	NWS	BOOTHVILLE HELIPORT, LA
155	K7R1	29.26	-89.36	FAA	VENICE PHI HELIPORT LA
156	KBVE	29.26	-89.36	NWS	VENICE PHI HELIPORT, VENICE, LA
157	KPIB	31.47	-89.33	NWS	PINE BELT RGNL AWOS MS
158	KHBG	31.28	-89.25	FAA	HATTIESBURG CHAIN MUNI A HATTIESBURG, MS
159	KGPT	30.41	-89.08	FAA	GULFPORT - BILOXI RGNL ARPT, GULFPORT, MS
160	K1G7	28.78	-89.05	NWS	MISSISSIPPI CANYON LA
161	KBIX	30.42	-88.92	NWS	KEESLER AFB/BILOXI MS
162	KMEI	32.33	-88.75	NWS	MERIDIAN/KEY FLD MS
163	KNMM	32.55	-88.57	DODn	MERIDIAN NAS/MCCAIN MS
164	KPQL	30.46	-88.53	FAA	PASCAGOULA LOTT INTLARPT, PASCAGOULA, MS
165	KMOB	30.69	-88.25	NWS	MOBILE RGNL ARPT, MOBILE, AL
166	KRAM	29.05	-88.08	NWS	PHILLIPS PLATFORM, AL
167	KBFM	30.62	-88.06	FAA	MOBILE DOWNTOWN ARPT , MOBILE, AL
168	KJKA	30.29	-87.67	NWS	JACK EDWARDS ARPT/GULF SHORES AL US
169	KNBJ	30.39	-87.63	NWS	BARIN FLD NAF, AL

B-4. ASOS/METAR Platform Locations (cont'd)



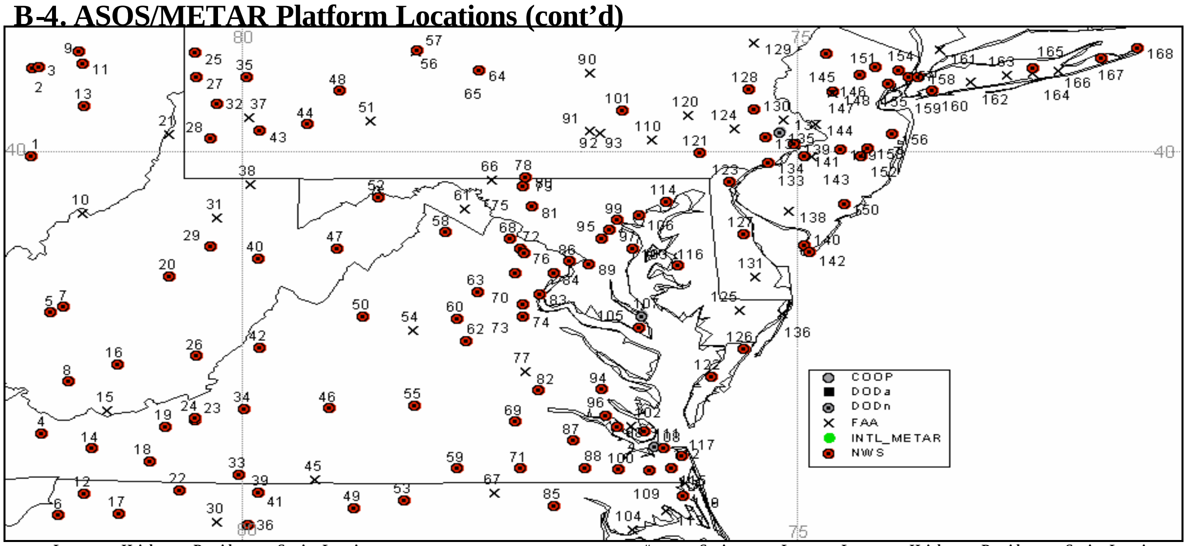
#	Station	Lat	Lon	Height	Provider	Station Location	#	Station	Lat	Lon	Height	Provider	Station Location
1	KNDZ	30.70	-87.02	10 (m)	NWS	MILTON/WHITING FIELD S	41	KEYW	24.55	-81.75	10 (m)	NWS	KEY WEST INTL ARPT
2	KNSE	30.72	-87.02	10	NWS	MILTON/WHITING FIELD NAS-N.	42	KJAX	30.50	-81.69	10	NWS	JACKSONVILLE INTL ARPT
3	KNFJ	30.51	-86.95	10	NWS	MILTON/PENSACOLA NALF	43	KNIP	30.23	-81.68	10	DODn	JACKSONVILLE NAS
4	KHRT	30.43	-86.68	10	NWS	HURLBURT FLD (AF)	44	KNQX	24.57	-81.68	10	DODn	KEY WEST NAS
5	KQBL	30.42	-86.68	10	NWS	AFCWC NTFS	45	KNAE	29.14	-81.63	10	NWS	ASTOR/BOMBING RANGE DET
6	KVPS	30.48	-86.53	10	NWS	EGLIN AFB	46	K90J	29.12	-81.57	10	NWS	ASTOR NAS
7	KEGI	30.65	-86.52	10	NWS	DUKE FLD/EGLIN AUX	47	KCRG	30.34	-81.51	8	FAA	JACKSONVILLE CRAIG MUNI ARPT
8	KCEW	30.78	-86.52	10	FAA	BOB SIKES ARPT, CRESTVIEW	48	KISM	28.29	-81.44	10	NWS	KISSIMMEE MUNI ARPT
9	KDTS	30.39	-86.47	10	FAA	FT. WALTON BCH ARPT, DESTIN	49	KNRB	30.40	-81.42	10	DODn	MAYPORT NS
10	KPFN	30.21	-85.69	10	FAA	BAY CO ARPT, PANAMA CITY	50	KSGJ	29.96	-81.34	10	NWS	ST AUGUSTINE ARPT
11	KPAM	30.07	-85.58	10	NWS	TYNDALL AFB	51	KORL	28.55	-81.34	10	FAA	ORLANDO EXECUTIVE ARPT
12	KMAI	30.84	-85.18	10	FAA	MARIANNA MUNI ARPT	52	KMCO	28.42	-81.33	8	NWS	ORLANDO INTL ARPT, ORLANDO
13	KAAF	29.73	-85.03	9	NWS	APALACHICOLA ARPT	53	KSFB	28.78	-81.24	10	FAA	ORLANDO SANFORD ARPT
14	KTLH	30.39	-84.35	10	NWS	TALLAHASSEE RGNL ARPT	54	KOMN	29.30	-81.11	10	NWS	ORMOND BCH MUNI ARPT
15	K40J	30.07	-83.57	10	NWS	PERRY-FOLEY ARPT,	55	KDAB	29.17	-81.07	10	NWS	DAYTONA BCH INTL ARPT
16	KCTY	29.63	-83.11	10	NWS	CROSS CITY ARPT, CROSS CITY	56	KMTH	24.73	-81.05	10	FAA	MARATHON ARPT
17	KPIE	27.91	-82.69	10	FAA	ST. PETERSBURG ARPT	57	KEVB	29.06	-80.95	10	NWS	NEW SMYRNA BCH MUNI ARPT
18	KSPG	27.77	-82.63	8	FAA	ALBERT-WHITTED ARPT	58	KTIX	28.52	-80.80	10	NWS	TITUSVILLE
19	KRRF	28.18	-82.62	10	NWS	PORT RICHEY (ASOS)	59	KTTS	28.62	-80.72	10	NWS	NASA SHUTTLE FCLTY
20	KSRQ	27.40	-82.56	10	FAA	SARASOTA-BRADENTON ARPT	60	KMLB	28.10	-80.64	10	FAA	MELBOURNE INTL ARPT
21	KTPA	27.96	-82.54	8	NWS	TAMPA INTL ARPT, TAMPA	61	KCOF	28.23	-80.61	10	DODa	COCOA BCH PATRICK AFB
22	KMCF	27.85	-82.52	10	NWS	MACDILL AFB, TAMPA	62	KTMB	25.64	-80.44	10	FAA	MIA/KENDALL-TAMIAMI ARPT
23	KBKV	28.47	-82.45	10	FAA	HERNANDO CO. ARPT	63	KVRB	27.66	-80.41	10	FAA	VERO BEACH MUNI ARPT
24	KTPF	27.92	-82.45	10	NWS	PETER O KNIGHT ARPT/ TAMPA	64	KA	25.61	-80.41	10	NWS	MIAMI NEXRAD
25	KTBW	27.70	-82.40	10	NWS	TAMPA BAY FL	65	KHST	25.48	-80.38	10	NWS	HOMESTEAD AFB
26	KVDF	28.01	-82.35	10	NWS	TAMPA VANDENBURG ARPT	66	KFPR	27.50	-80.38	8	FAA	FT. PIERCE/ST. LUCIE CO. INTL
27	KGNV	29.69	-82.28	10	FAA	GAINESVILLE RGNL ARPT	67	KMIA	25.78	-80.32	10	NWS	MIAMI INTL ARPT, MIAMI
28	KOCF	29.17	-82.22	10	NWS	OCALA_MUNI_(AWOS)	68	KOPF	25.91	-80.28	10	FAA	OPA LOCKA ARPT, MIAMI
29	KPCM	28.00	-82.16	10	NWS	PLANT CITY MUNI ARPT	69	KHWO	26.00	-80.23	10	FAA	HOLLYWOOD N PERRY ARPT (ASOS
30	KLAL	27.98	-82.02	10	NWS	LAKELAND RGNL	70	KSUA	27.18	-80.22	10	NWS	STUART/WITHAM FLD ARPT
31	KPGD	26.92	-81.99	10	FAA	PUNTA GORDA ARPT	71	KFXE	26.20	-80.13	10	FAA	FT. LAUDERDALE EXECUTIVE ARP
32	KVVG	28.97	-81.97	10	NWS	THE VILLAGES ,FL	72	KFLL	26.07	-80.15	10	FAA	FT LAUD/HOLLYWOOD INTL ART
33	KNZC	30.22	-81.88	10	DODn	CECIL FLD NAS FL	73	KPBI	26.68	-80.12	10	NWS	WEST PALM BCH
34	KVQQ	30.22	-81.88	10	NWS	CECIL FLD NAS,FL	74	KPMP	26.25	-80.12	10	FAA	POMPANO BEACH
35	KFMY	26.59	-81.86	8	FAA	FT MYERS PAGE FIELD	75	KBCT	26.38	-80.11	10	NWS	BOCA RATON ARPT
36	KLEE	28.82	-81.81	10	FAA	LEESBURG MUNI ARPT	76	MYBS	25.73	-79.30	10	INTL	ALICE TOWN/S BIMINI, BA
37	KBOW	27.95	-81.78	10	NWS	BARTOW MUNI ARPT	77	MYGW	26.70	-78.97	10	INTL	WEST END INTL ARPT, BA
38	KAPF	26.15	-81.77	10	NWS	NAPLES MUNI ARPT	78	MYGF	26.55	-78.70	10	INTL	FREEPORT INTL ARPT, BA
39	KRSW	26.53	-81.77	10	FAA	FT. MYERS SW RGNL ARPT	79	MYNN	25.05	-77.47	10	INTL	NASSAU INTL ARPT, BA
40	KGIF	28.06	-81.76	10	FAA	WINTER HAVEN'S GILBERT ARPT							



B-4. ASOS/METAR Platform Locations (cont'd)

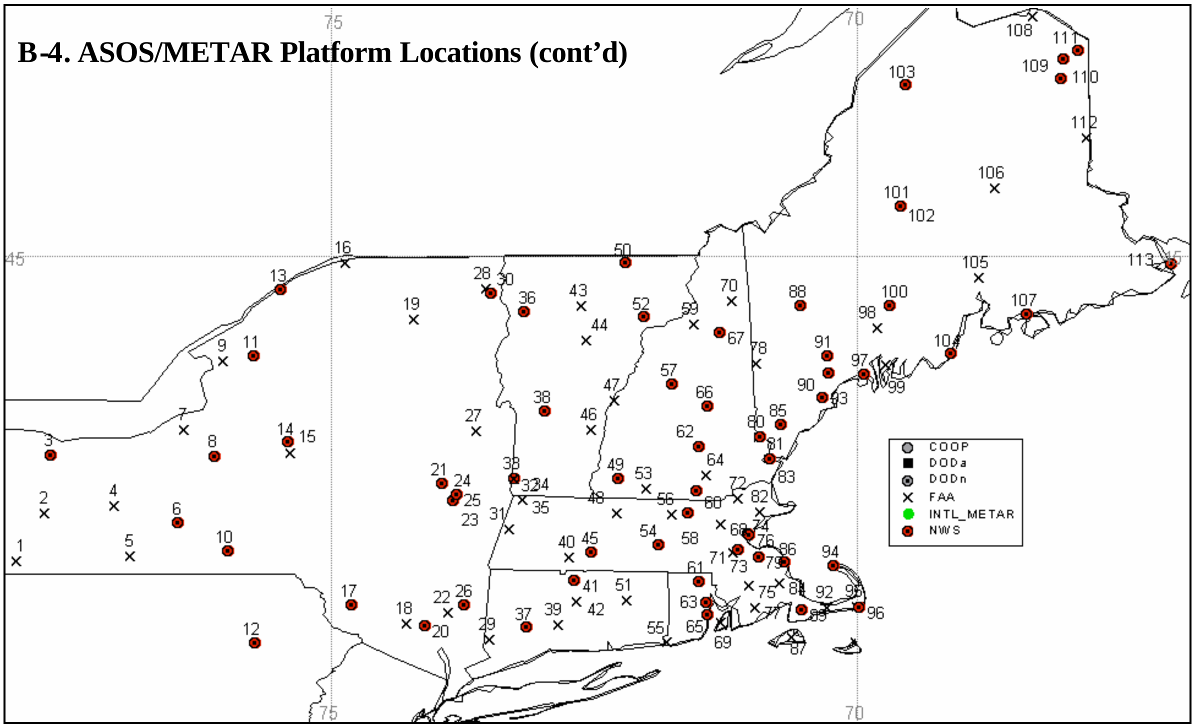
#	Station	Lat	Lon	Provider	Station Location
1	KCKL	32.90	-87.25	NWS	CENTREVILLE/BIBB CO AL
2	KGZH	31.42	-87.05	FAA	EVERGREEN MIDDLETON FLD, EVERGREEN, AL
3	KDCU	34.66	-86.94	FAA	DECATUR PRYOR FLD, DECATUR, AL
4	K3A1	34.27	-86.86	NWS	FOLSOM FLD ARPT, AL
5	KHSV	34.64	-86.77	NWS	HUNTSVILLE INTL/ JONES FLD, HUNTSVILLE, AL
6	KEET	33.18	-86.78	FAA	ALABASTER SHELBY CO ARPT, ALABASTER, AL
7	KBMX	33.17	-86.77	NWS	BIRMINGHAM NEXRAD, AL
8	KBHM	33.57	-86.75	FAA	BIRMINGHAM INTL ARPT, BIRMINGHAM, AL
9	KHUA	34.68	-86.68	NWS	REDSTONE ARMY AIRFLD, AL
10	KM82	34.86	-86.56	NWS	MADISON CO EXEC ARPT, AL
11	KMDQ	34.86	-86.56	NWS	MADISON CO EXEC ARPT, AL
12	KMQY	36.02	-86.52	NWS	SMYRNA, TN
13	KMGM	32.30	-86.41	NWS	MONTGOMERY DANNELLY ARPT, AL
14	K79J	31.32	-86.40	NWS	ANDALUSIA/OPP ARPT AL
15	KMXF	32.38	-86.37	NWS	MAXWELL AFB/MONTGOM AL
16	K8A0	34.23	-86.26	NWS	ALBERTVILLE MUNI ARPT, AL
17	KGAD	33.97	-86.08	NWS	GADSEN MUNI (AWOS) AL
18	KALX	32.91	-85.96	NWS	THOMAS C RUSSELL FLD ARPT, AL
19	KANB	33.59	-85.86	FAA	ANNISTON METRO ARPT, ANNISTON, AL
20	KSXS	31.35	-85.85	NWS	SCHELL AHP AL
21	K4A9	34.47	-85.72	NWS	ISBELL FLD ARPT, AL
22	KOZR	31.28	-85.72	NWS	CAIRNS AAF/OZARK AL
23	KAUB	32.60	-85.50	NWS	AUBURN UNIV. (AMOS) AL
24	KDHN	31.32	-85.45	FAA	DOTHAN RGNL ARPT, DOTHAN, AL
25	KAUO	32.62	-85.43	NWS	AUBURN-OPELIKA APT AL
26	KCHA	35.03	-85.20	NWS	CHATTANOOGA/LOVELL, TN
27	KFFC	34.35	-85.15	FAA	PEACHTREE CITY FLACON FLD, ATLANTA, GA
28	KRMG	34.34	-85.15	NWS	ROME RB RUSSELL ARPT, ROME, GA
29	KCSV	35.95	-85.08	FAA	CROSSVILLE MEMORIAL, TN
30	KLGC	33.01	-85.07	NWS	LA GRANGE/CALLAWAY ARPT, GA
31	KLSF	32.33	-85.00	NWS	FORT BENNING GA
32	KCSG	32.52	-84.93	NWS	COLUMBUS METRO ARPT GA
33	K11J	31.40	-84.90	NWS	EARLY CO ARPT, GA
34	KBIJ	31.40	-84.89	NWS	EARLY CO ARPT GA
35	KDNN	34.72	-84.87	NWS	DALTON MUNI ARPT, GA
36	KVPC	34.12	-84.85	FAA	CARTERSVILLE ARPT, GA
37	KCCO	33.31	-84.77	NWS	NEWNAN COWETA ARPT, GA
38	KBGE	30.97	-84.64	NWS	DECATUR CO INDUS AIR PARK, GA
39	KRYY	34.01	-84.60	NWS	MARIETTA/COBB CO ARPT, GA
40	KMGE	33.92	-84.52	NWS	DOBBINS AFB/MARIETT GA
41	KATL	33.62	-84.44	NWS	ATLANTA HARTSFLD INTL ARPT, ATLANTA, GA
42	K47A	34.31	-84.42	NWS	CHEROKEE CO ARPT, GA
43	KPDK	33.87	-84.27	FAA	ATLANTA DEKLAB-PEACHTREE ARPT, GA
44	KOPN	32.95	-84.26	NWS	THOMASTON-UPSON CO ARPT, GA
45	KOQT	36.02	-84.23	NWS	OAK RIDGE
46	KABY	31.54	-84.20	FAA	ALBANY SW GA RGNL ARPT, ALBANY, GA
47	KMRX	35.82	-83.98	NWS	KNOXVILLE
48	KTYS	35.82	-83.98	NWS	KNOXVILLE MUNI
49	KLZU	33.98	-83.96	NWS	LAWRENCEVILLE/GWINNETT CO, GA
50	K6A3	35.19	-83.86	NWS	ANDREWS, NC
51	KRHP	35.19	-83.86	NWS	ANDREWS-MURPHY ARPT, NC
52	KGVL	34.27	-83.82	FAA	GAINESVILLE LEE GLIMER MEM ARPT, GA
53	KMGR	31.08	-83.80	NWS	MOULTRIE MUNI ARPT, GA
54	KWDR	33.98	-83.67	NWS	WINDER-BARROW ARPT, GA
55	KMCN	32.68	-83.65	NWS	MACON MIDDLE RGNL ARPT, MACON, GA
56	KWRB	32.63	-83.60	NWS	WARNER ROBINS AFB GA
57	K1A5	35.22	-83.42	NWS	MACON CO ARPT, NC
58	KAHN	33.95	-83.33	NWS	ATHENS BEN EPPS ARPT, ATHENS, GA
59	KVLD	30.78	-83.27	FAA	VALDOSTA RGNL ARPT, VALDOSTA, GA
60	KFZG	31.68	-83.27	NWS	FITZGERALD MUNI ARPT, GA
61	KMLJ	33.14	-83.24	NWS	MILLEDGEVILLE/BALDWIN CO ARPT, GA
62	KVAD	30.97	-83.20	NWS	MOODY AFB/VALDOSTA GA
63	K3J7	33.60	-83.14	NWS	GREENE CO RGNL ARPT, GA
64	KDBN	32.57	-82.99	NWS	DUBLIN/W H BUD BARRON ARPT, GA
65	KCEU	34.67	-82.88	FAA	CLEMSON-OCONEE CO ARPT, CLEMSON, SC
66	KDQH	31.47	-82.85	NWS	DOUGLAS MUNI ARPT, GA
67	K27A	34.10	-82.82	NWS	ELBERT CO ARPT/PATZ FLD, GA
68	KIIY	33.78	-82.82	NWS	WASHINGTON-WILKES CO ARPT, GA
69	KAND	34.50	-82.71	FAA	ANDERSON CO ARPT, ANDERSON, SC
70	KAVL	35.43	-82.54	NWS	ASHVILLE RGNL ARPT, ASHVILLE, NC
71	KHQU	33.53	-82.52	NWS	THOMSON, GA
72	KAMG	31.54	-82.51	FAA	ALMA BACON CO ARPT, ALMA, GA
73	KAYS	31.25	-82.40	NWS	WAYCROSS/WARE CO. GA
74	KBHC	31.71	-82.39	NWS	BAXLEY MUNI ARPT, GA
75	KGYH	34.76	-82.38	NWS	DONALDSON CENTER ARPT, SC
76	KVDI	32.19	-82.37	NWS	VIDALIA MUNI APRT, GA
77	KGSP	34.91	-82.21	NWS	GREER GREENVILLE-SPARTANBRG ARPT, SC
78	KGRD	34.25	-82.15	FAA	GREENWOOD CO ARPT, GREENWOOD, SC
79	KDNL	33.47	-82.04	FAA	AUGUSTA DANIEL FLD ARPT, AGUSTA, GA
80	KAGS	33.37	-81.96	NWS	AUGUSTA BUSH FLD, AUGUSTA, GA
81	KFQD	35.43	-81.94	NWS	RUTHERFORDTON/MARCHMAN FLD, NC
82	KTBR	32.48	-81.74	NWS	STATESBORO-BULLOCH CO ARPT, GA
83	KMRN	35.82	-81.61	NWS	MORGANTON-LENOIR ARPT, NC
84	KEHO	35.25	-81.60	NWS	SHELBY MUNI ARPT, NC
85	KJYL	32.65	-81.60	NWS	SYLVANIA/PLANTATION AIRPARK, GA
86	KLHW	31.88	-81.57	NWS	FT STEWART/WRIGHT GA
87	KNBQ	30.79	-81.56	NWS	KINGS BAY NAVAL STN, GA
88	KBQK	31.25	-81.47	NWS	BRUNSWICK/GLYNCO GA
89	KSSI	31.15	-81.39	FAA	BRUNSWICK MALCOLM MCKINNON ARPT, GA
90	KHKY	35.74	-81.38	FAA	HICKORY RGNL ARPT, HICKORY, NC
91	KSAV	32.13	-81.20	NWS	SAVANNAH INTL ARPT, SAVANNAH, GA
92	KIPJ	35.48	-81.16	NWS	LINCOLNTON NC
93	KAKH	35.20	-81.16	FAA	GASTONIA MUNI ARPT, GASTONIA, NC
94	KSVN	32.02	-81.15	NWS	HUNTER (AAF) GA
95	K29J	34.98	-81.06	NWS	ROCK HILL, SC
96	KUZA	34.98	-81.06	FAA	ROCK HILL YORK CO ARPT, ROCK HILL, SC
97	KTOI	31.96	-81.01	FAA	TROY MUNI ARPT, TROY, AL
98	KCUB	33.97	-80.99	FAA	COLUMBIA OWENS FLD ARPT, COLUMBIA, SC
99	KSVH	35.77	-80.96	NWS	STATESVILLE MUNI ARPT, NC
100	KCLT	35.22	-80.96	NWS	CHARLOTTE DOUGLAS INTL ARPT, NC
101	KGMU	35.22	-80.96	FAA	GREENVILLE DOWNTOWN ARPT, GREENVILLE, SC
102	KOGB	33.46	-80.85	FAA	ORANGEBURG ARPT, ORANGEBURG, SC
103	KMMT	33.92	-80.80	NWS	MCENTIRE ANG BASE SC
104	KNBC	32.48	-80.72	NWS	BEAUFORT MCAS SC
105	KJQF	35.38	-80.71	NWS	CONCORD NC
106	KHXD	32.22	-80.70	NWS	HILTON HEAD (AWOS) SC
107	KEQY	33.01	-80.62	FAA	MONROE ARPT, MONROE, NC
108	KRUQ	35.65	-80.52	NWS	SALISBURY/ROWAN CO ARPT, NC
109	KFTY	33.77	-80.52	FAA	ATLANTA FULTON CO ARPT, ATLANTA, GA
110	KSSC	33.97	-80.47	NWS	SHAW AFB/SUMTER SC
111	KEXX	35.78	-80.30	NWS	LEXINGTON DAVIDSON CO ARPT, NC
112	KVUJ	35.42	-80.15	NWS	ALBEMARLE/STANLY CO ARPT, NC
113	KCAE	33.94	-80.12	NWS	COLUMBIA METROPOLITAN ARPT, COLUMBIA, SC
114	KIGC	32.90	-80.05	NWS	CHARLESTON AFB SC
115	KCHS	32.90	-80.04	NWS	CHARLESTON INTL ARPT, CHARLESTON, SC
116	KNEX	32.92	-79.98	NWS	NISE CHARLESTON SC
117	KHBI	35.65	-79.90	NWS	ASHEBORO MUNI ARPT, NC
118	KW44	35.65	-79.90	NWS	ASHEBORO MUNI ARPT, NC
119	KUDG	34.45	-79.88	NWS	DARLINGTON, SC
120	K45J	34.89	-79.76	NWS	ROCKINGHAM-HAMLET ARPT, NC
121	KFLO	34.19	-79.73	FAA	FLORENCE RGNL ARPT, FLORENCE, SC
122	KHFF	35.03	-79.50	NWS	MACKALL AAF NC
123	KSOP	35.23	-79.40	NWS	SOUTHERN PINES AWOS NC
124	KMEB	34.78	-79.37	FAA	MAXTON/LAURINBURG MAXTON ARPT, NC
125	KTTA	35.58	-79.10	NWS	SANFORD-LEE CO RGNL ARPT, NC
126	KIGX	35.94	-79.06	FAA	CHAPEL HILL WILLIAMS ARPT, CHAPEL HILL, NC
127	KLBT	34.61	-79.06	FAA	LUMBERTON MUNI ARPT, LUMBERTON, NC
128	KPOB	35.17	-79.02	NWS	POPE AFB NC
129	KFBG	35.13	-78.93	NWS	FORT BRAGG/SIMMONS NC
130	KMYR	33.68	-78.93	NWS	MYRTLE BEACH (CIV) SC
131	KFAY	34.98	-78.88	FAA	FAYETTEVILLE RGNL NC
132	KRDU	35.89	-78.78	NWS	RALEIGH DURHAM INTL, RALEIGH, NC
133	K37W	35.38	-78.73	NWS	ERWIN/HARNETT CO ARPT, NC
134	KHRJ	35.38	-78.73	NWS	ERWIN/HARNETT CO ARPT, NC
135	KCRE	33.82	-78.72	FAA	N. MYRTLE BCH GRAND STRAND ARPT, SC
136	KCPC	34.27	-78.71	NWS	COLUMBUS CO MUNI ARPT, NC
137	KEYF	34.60	-78.58	NWS	CURTIS L BROWN JR FLD ARPT, NC
138	KRAX	35.67	-78.49	NWS	RALEIGH/DURHAM NEXRAD, NC
139	KJNX	35.54	-78.39	NWS	SMITHFLD/JOHNSTON CO ARPT, NC
140	KCTZ	34.98	-78.36	NWS	SAMPSON CO ARPT/CLINTON, NC
141	KLHZ	36.02	-78.33	NWS	LOUISBURG/FRANKLIN CO ARPT, NC
142	KSUT	33.93	-78.07	NWS	OAK ISL/BRUNSWICK CO ARPT, NC
143	KDPL	35.00	-77.98	NWS	KENANSVILLE/DUPLIN CO, NC
144	KGSB	35.33	-77.97	NWS	SEYMOUR-JOHNSON AFB NC
145	KGWW	35.46	-77.96	NWS	GOLDSBORO-WAYNE MUNI ARPT, NC
146	KILM	34.27	-77.90	NWS	WILMINGTON INTL ARPT, WILIMINGTON, NC
147	KRWI	35.85	-77.90	FAA	ROCKY MOUNT WILSON ARPT, ROCKY MOUNT, NC
148	KISO	35.33	-77.62	NWS	KINSTON/STALLINGS NC
149	KOAJ	34.83	-77.62	NWS	JACKSONVILLE (AWOS) NC
150	KNCA	34.72	-77.45	NWS	NEW RIVER MCAS NC
151	KPGV	35.63	-77.4	NWS	PITT-GREENVILLE ARP NC
152	KOCW	35.57	-77.05	NWS	WASHINGTON/WARREN FLD APRT, NC
153	KEWN	35.07	-77.05	FAA	NEW BERN CRAVEN RGNL ARPT, NEW BERN, NC
154	KNJM	34.68	-77.03	NWS	BOGUE FLD MCALF NC
155	KMHX	34.78	-76.88	NWS	NEWPORT NC
156	KNKT	34.90	-76.88	DODn	CHERRY POINT MCAS NC
157	KNIS	34.89	-76.86	NWS	CHERRY POINT MCAS, NC
158	KMRH	34.73	-76.66	FAA	BEAUFORT M SMITH FLD ARPT, BEAUFORT, NC
159	KEDE	36.03	-76.57	NWS	EDENTON/NORTHEASTERN ARPT, NC
160	KBUY	36.05	-76.47	FAA	BURLINGTON ALAMANCE RNGL ARPT, NC
161	KNBT	35.02	-76.46	NWS	PINEY ISLAND BT-11 BOMBING RG, NC
162	KMQI	35.92	-75.70	NWS	MANTEO/DARE CO RGNL NC
163	KFFA	36.02	-75.67	NWS	KILL DEVIL HILLS/FIRST FLT ARPT, NC
164	KHSE	35.23	-75.62	NWS	HATTERAS BILLY MITCHELL FLD, NC
165	KHAT	35.27	-75.55	NWS	CAPE HATTERAS NC

B-4. ASOS/METAR Platform Locations (cont'd)



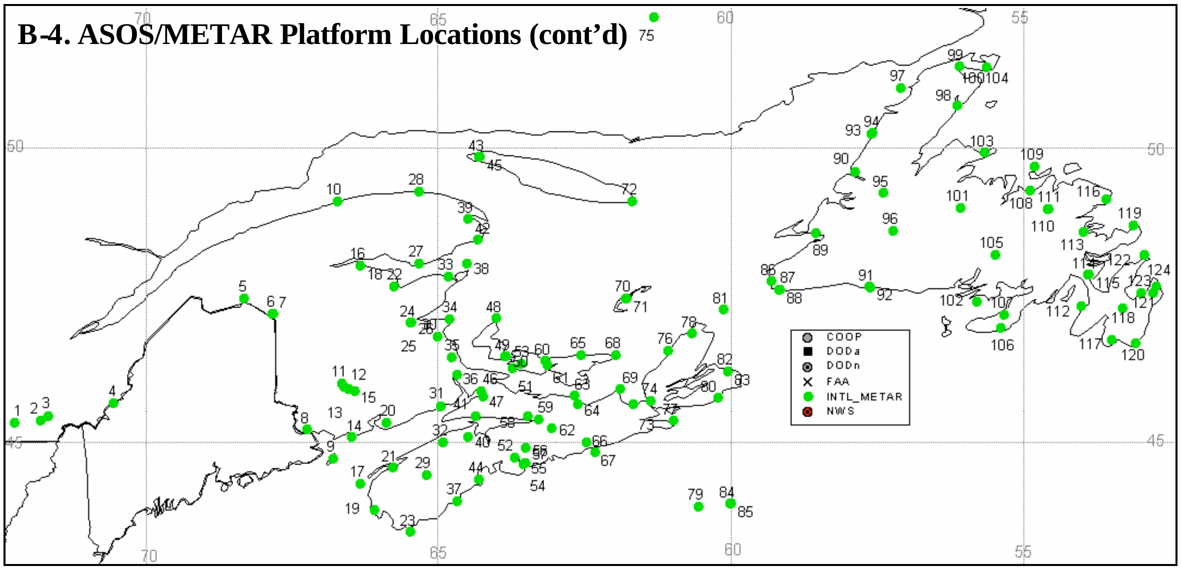
#	Station	Lat	Lon	Height	Provider	Station Location	#	Station	Lat	Lon	Height	Provider	Station Location
1	KZZV	39.95	-81.90	10 (m)	NWS	ZANESVILLE MUNI, OH	85	KASJ	36.30	-77.17	10	NWS	AHOSKIE/TRI-CO ARPT, NC
2	KBJJ	40.87	-81.88	10	NWS	WOOSTER/WAYNE CO ARPT, OH	86	KDCA	38.85	-77.03	10	NWS	WASHINGTON REAGAN NATL ARPT
3	KSLW	40.88	-81.83	10	NWS	SMITHVILLE/WOOSTER, OH	87	KAKQ	36.98	-77.00	8	NWS	WAKEFIELD MUNI ARPT, WAKEFIELD, VA
4	K6V3	37.06	-81.80	10	NWS	TAZEWELL CO ARPT, VA	88	KFKN	36.70	-76.90	10	NWS	FRANKLIN/JB ROSE
5	KRLX	38.31	-81.72	10	NWS	CHARLESTON NEXRAD,WV	89	KADW	38.82	-76.87	10	NWS	ANDREWS AFB, MD
6	KTNB	36.20	-81.65	10	NWS	BOONE/WATAUGA CO HOSP HELIPAD, NC	90	KSEG	40.82	-76.86	10	FAA	SELINSGROVE PENN VALLEY ARPT
7	KCRW	38.37	-81.60	10	NWS	CHARLESTON/KANAWHA, WV	91	KCXY	40.22	-76.86	10	FAA	HARRISBURG CAPITAL CITY ARPTPA
8	KI16	37.60	-81.56	10	NWS	KEE FLD ARPT, WV	92	KTHV	40.20	-76.77	10	FAA	YORK MUNI ARPT, YORK, PA
9	KAKR	41.04	-81.46	10	NWS	AKRON FULTON INTL ARPT (ASOS), OH	93	KMDT	40.20	-76.77	10	FAA	MIDDLETOWN HARRISBURG INTL ARPT, PA
10	KPKB	39.35	-81.43	10	FAA	PARKERSBURG/WILSON, WV	94	KFYJ	37.52	-76.76	10	NWS	MID PENINSULA RGNL ARPT, VA
11	KCAK	40.92	-81.43	10	NWS	AKRON-CANTON RGNL, OH	95	KFME	39.09	-76.76	10	NWS	FT MEADE/TIPTON ARPT, MD
12	KGEV	36.43	-81.42	10	NWS	JEFFERSON/ASHE CO ARPT, NC	96	KJGG	37.24	-76.72	10	NWS	WILLIAMSBURG-JAMESTOWN ARPT, VA
13	KPHD	40.47	-81.42	10	NWS	NEW PHILA/HARRY CLEVER FLD, OH	97	KBWI	39.17	-76.68	10	NWS	BALTIMORE WASHINGTON INTL, MD
14	KMKJ	36.90	-81.35	10	NWS	MARION/WYTHEVILLE	98	KFAF	37.13	-76.62	10	NWS	FT EUSTIS/FELKER
15	KBLF	37.30	-81.20	8	FAA	BLUEFIELD MERCER CO. ARPT, WV	99	KDMH	39.28	-76.62	10	NWS	BALTIMORE/INNER HARBOR (ASOS), MD
16	KBKW	37.78	-81.12	10	NWS	BECKLEY MEMORIAL, WV	100	KSFQ	36.68	-76.60	10	NWS	SUFFOLK MUNI ARPT, VA
17	KUKF	36.22	-81.10	10	NWS	N WILKESBORO/WILKES CO ARPT, NC	101	KMUI	40.43	-76.57	10	NWS	MURI AAF/INDIANTOWN, PA
18	KHLX	36.77	-80.82	10	NWS	HILLSVILLE	102	KPHF	37.13	-76.49	10	FAA	NEWPORT NEWS INTL ARPT, VA
19	KPSK	37.13	-80.68	10	NWS	DUBLIN/NEW RIVER VALLEY, VA	103	KNAK	38.98	-76.48	10	NWS	US NAVAL ACAD ANNAPOLIS, MD
20	K48I	38.69	-80.65	10	NWS	BRAXTON CO ARPT, WV	104	KBUY	36.05	-76.47	10	FAA	BURLINGTON ALAMANCE RNGL ARPT, NC
21	KHLG	40.18	-80.65	10	FAA	WHEELING/OHIO CO, WV	105	KNUI	38.15	-76.42	10	NWS	ST INIGOES/WEBSTER FLD, MD
22	KMWK	36.46	-80.55	10	NWS	MT AIRY/SCURRY CO ARPT, NC	106	KMTN	39.33	-76.42	10	NWS	BALTIMORE/MARTIN, MD
23	KRNK	37.20	-80.42	10	NWS	ROANOKE/BLACKBURG, VA	107	KNHK	38.28	-76.40	10	DODn	PATUXENT RIVER NAS, MD
24	KBCB	37.22	-80.42	10	NWS	VIRGINIA TECH ARPT, VA	108	KLFI	37.08	-76.37	10	NWS	LANGLEY AFB
25	KUCP	41.03	-80.41	10	NWS	NEW CASTLE MUNI ARPT, PA	109	KCPK	36.67	-76.32	10	NWS	CHESAPEAKE MUNI ARPT, VA
26	KLWB	37.87	-80.40	10	NWS	LEWISBURG/GREENBRIE, WV	110	KLNS	40.12	-76.30	8	FAA	ELIZABETHTOWN, LITITZ, PA
27	KBVI	40.77	-80.40	10	NWS	BEAVER FALLS ARPT, PA	111	KNGU	36.93	-76.28	10	DODn	NORFOLK NAS/CHAMBER
28	KAFJ	40.13	-80.28	10	NWS	WASHINGTON (AWOS), PA	112	KORF	36.90	-76.19	10	NWS	NORFOLK INTERNATIONAL ARPT, VA
29	KW22	39.00	-80.27	10	NWS	UPSHUR CO RGNL ARPT, WV	113	KECG	36.26	-76.17	10	FAA	ELIZABETH CITY CG ARPT, NC
30	KINT	36.13	-80.22	10	FAA	WINSTON-SALEM/SMITH, NC	114	KAPG	39.47	-76.17	10	NWS	PHILLIPS AAF/ABERDN, MD
31	KCKB	39.30	-80.22	10	FAA	CLARKSBURG/BENEDUM, WV	115	KNFE	36.70	-76.13	10	NWS	FENTRESS/NAS AUX, VA
32	KPIT	40.50	-80.22	10	NWS	PITTSBURG INTL, PA	116	KESN	38.80	-76.07	10	NWS	EASTON/NEWMAN FLD, MD
33	KMTV	36.63	-80.02	10	NWS	MARTINSVILLE	117	KNTU	36.82	-76.03	10	NWS	OCEANA NAS/SOUCEK
34	KROA	37.32	-79.97	10	NWS	ROANOKE REGIONAL ARPT, VA	118	KONX	36.40	-76.02	10	NWS	CURRITUCK CO ARPT, NC
35	KBTP	40.78	-79.95	10	NWS	BUTLER CO (AWOS), PA	119	K9W7	36.40	-76.02	10	NWS	CURRITUCK CO ARPT, NC
36	KGSO	36.10	-79.94	10	NWS	GREENSBORO PIEDMONT TRIAD INTL, NC	120	KRDG	40.38	-75.97	10	FAA	READING/SPAATZ FLD, PA
37	KAGC	40.35	-79.93	10	FAA	PITTSBURG/ALLEGEN, PA	121	K40N	39.98	-75.87	10	NWS	CHESTER CO ARPT, PA
38	KMGW	39.65	-79.92	10	FAA	MORGANTOWN/HART FLD, WV	122	KMFV	37.65	-75.77	10	NWS	MELFA/ACCOMACK ARPT
39	K78N	36.44	-79.85	10	NWS	ROCKINGHAM CO SHILOH ARPT, NC	123	KILG	39.68	-75.60	10	NWS	WILMINGTON ARPT, DE
40	KEKN	38.88	-79.85	10	NWS	ELKINS/RANDOLPH FLD	124	KPTW	40.23	-75.55	10	FAA	POTTSTOWN LIMERICK ARPT, PA
41	KSIF	36.44	-79.85	10	NWS	ROCKINGHAM CO SHILOH ARPT, NC	125	KSBY	38.34	-75.51	8	FAA	SALISBURY WICOMICO RGNL ARPT, MD
42	KHSP	37.95	-79.83	10	NWS	HOT SPRINGS/INGALLS	126	KWAL	37.94	-75.47	10	NWS	WALLOPS ISLAND FLIGHT, VA
43	KFWQ	40.21	-79.83	10	NWS	MONONGAHELA/ROSTRAVER ARPT, PA	127	KDOV	39.13	-75.47	10	NWS	DOVER AFB, DE
44	KLBE	40.28	-79.40	10	NWS	LATROBE/WESTMORLAND, PA	128	KABE	40.65	-75.43	10	NWS	ALLENTOWN-BETHLEHEM, PA
45	KDAN	36.57	-79.33	10	FAA	DANVILLE REGIONAL ARPT,DANVILLE, VA	129	KMPO	41.13	-75.38	10	FAA	MT POCONO, MT POCONO, PA
46	KLYH	37.32	-79.21	10	NWS	LYNCHBURG ARPT,LYNCHBURG, VA	130	KUKT	40.44	-75.38	10	NWS	QUAKERTOWN ARPT, PA
47	KW99	38.98	-79.13	10	NWS	PETERSBURG/GRANT CO ARPT, WV	131	KGED	38.68	-75.37	10	FAA	GEORGETOWN SUSSEX CO ARPT, DE
48	KIDI	40.63	-79.11	10	NWS	INDIANA/STEWART FLD, PA	132	KLOM	40.14	-75.27	10	NWS	WINGS FLD ARPT, PA
49	KTDF	36.28	-78.98	10	NWS	ROXBORO/PERSON CO ARPT, NC	133	KPHL	39.88	-75.25	10	NWS	PHILADELPHIA INTL PA
50	KSHD	38.27	-78.90	10	NWS	STAUNTON/SHENANDOAH	134	KPHI	39.88	-75.25	10	NWS	PHILADELPHIA, PA
51	KJST	40.32	-78.84	10	FAA	JOHNSTOWN CAMBRIA ARPT, JOHNSTOWN, PA	135	KNXX	40.20	-75.15	10	DODn	WILLOW GROVE NAS
52	KCBE	39.52	-78.76	10	NWS	GREATER CUMBERLAND RGNL ARPT, MD	136	KOXB	38.31	-75.13	10	FAA	OCEAN CITY MUNI ARPT, MD
53	KHNZ	36.36	-78.53	10	NWS	HENDERSON-OXFORD ARPT, NC	137	KDYL	40.33	-75.12	10	FAA	DOYLESTOWN ARPT, PA
54	KCHO	38.13	-78.45	10	FAA	CHARLOTTESVILLE ALBEMARLE ARPT, VA	138	KMIV	39.37	-75.07	10	FAA	MILLVILLE MUNI, NJ
55	KFVX	37.35	-78.43	10	NWS	FARMVILLE	139	KPNE	40.08	-75.02	10	NWS	PHILADELPHIA NW, PA
56	KFIG	41.04	-78.42	10	FAA	CLEARFIELD LAWRENCE ARPT, PA	140	KWWD	39.02	-74.92	10	NWS	WILDWOOD (AWOS), NJ
57	KN97	41.05	-78.41	10	NWS	CLEARFIELD, PA	141	KTYZ	39.95	-74.92	10	NWS	MONMOUTH BCH (ASOS), NJ
58	KOKV	39.15	-78.15	10	NWS	WINCHESTER RGNL	142	KN91	38.95	-74.88	10	NWS	CAPE MAY (CGS), NJ
59	KAVC	36.69	-78.05	10	NWS	S HILL/MECKLENBURG-BRUNSWICK	143	KVAY	39.95	-74.85	10	FAA	MT HOLLY S JERSEY RGNL, NJ
60	KOMH	38.25	-78.05	10	NWS	ORANGE CO ARPT, VA	144	KTTN	40.28	-74.82	10	FAA	TRENTON/MERCER CO. NJ
61	KMRB	39.40	-77.98	10	FAA	MARTINSBURG RGNL	145	K12N	41.02	-74.73	10	NWS	ANDOVER AEROFLEX, NJ
62	KLKU	38.01	-77.97	10	NWS	LOUISA CO /FREEMAN FLD, VA	146	KSJB	40.62	-74.67	10	NWS	SOMERVILLE, NJ
63	KCJR	38.53	-77.86	10	NWS	CULPEPER RGNL ARPT, VA	147	KN52	40.62	-74.67	10	NWS	SOMERVILLE, NJ
64	KUNV	40.85	-77.85	10	NWS	STATE COLLEGE, PA	148	KSMQ	40.62	-74.67	10	FAA	SOMERVILLE SOMERSET ARPT, NJ
65	KCTP	40.85	-77.85	10	NWS	STATE COLLEGE, PA	149	KWRI	40.02	-74.60	10	NWS	MCGUIRE AFB, NJ
66	KHGR	39.70	-77.73	10	FAA	HAGERSTOWN WASHINGTON CO. RGNL, , MD	150	KACY	39.45	-74.57	10	NWS	ATLANTIC CITY INTL, NJ
67	KRZZ	36.44	-77.71	10	FAA	ROANOKE RAPIDS/HALIFAX ARPT, NC	151	KMMU	40.80	-74.42	10	NWS	MORRISTOWN MUNI, NJ
68	KJYO	39.08	-77.57	10	NWS	LEESBURG/GODFREY	152	KDIX	39.95	-74.41	10	NWS	PHILADELPHIA NEXRAD, PA
69	KPTB	37.18	-77.52	10	NWS	PETERSBURG (AWOS)	153	KNEL	40.03	-74.35	10	NWS	LAKEHURST NAS, NJ
70	KHEF	38.72	-77.52	10	NWS	MANASSAS MUNI (AWOS)	154	KCDW	40.88	-74.28	10	NWS	CALDWELL/ESSEX CO., NJ
71	KEMV	36.69	-77.48	10	NWS	EMPORIA-GREENSVILLE RGNL ARPT, VA	155	KEWR	40.70	-74.17	10	NWS	NEWARK INTL ARPT, NJ
72	KLWX	38.98	-77.48	10	NWS	STERLING, VA	156	KBLM	40.18	-74.13	10	NWS	BELMAR-FARMDALE, NJ
73	KRMN	38.40	-77.46	10	NWS	STAFFORD RGNL ARPT, VA	157	KTEB	40.85	-74.07	10	NWS	TETERBORO ARPT, NJ
74	KEZF	38.27	-77.45	10	NWS	SHANNON ARPT	158	KNYC	40.77	-73.98	10	NWS	NEW YORK CITY, NY
75	KQBV	39.63	-77.45	10	NWS	CAMP DAVID, MD	159	KLGA	40.77	-73.90	10	NWS	NY LA GUARDIA, NY
76	KIAD	38.94	-77.45	10	NWS	DULLES INTL ARPT, WASHINGTON, DC	160	KJFK	40.63	-73.77	10	NWS	NY JFK INTL ARPT, NY
77	KOFP	37.71	-77.44	10	FAA	RICHMOND ASHLAND HANOVER CO, VA	161	KHPN	41.07	-73.70	10	FAA	WHITE PLAINS, NY
78	KQAH	39.73	-77.43	10	NWS	SITE R, PA	162	KFRG	40.73	-73.42	10	FAA	FARMINGDALE/REPUBLIC, NY
79	KJWX	39.73	-77.43	10	NWS	FT RITCHIE, MD	163	KISP	40.80	-73.10	10	FAA	ISLIP LONG ISLAND MC ARTHUR ARPT, NY
80	K43M	39.73	-77.43	10	NWS	FT RITCHIE/SITE R, MD	164	KHWV	40.82	-72.86	10	FAA	BROOKHAVEN ARPT, NY
81	KFDK	39.42	-77.37	10	NWS	FREDERICK MUNI ARPT, MD	165	KOKX	40.87	-72.86	10	NWS	BROOKHAVEN, NY
82	KRIC	37.51	-77.32	10	NWS	RICHMOND INTL ARPT, RICHMOND, VA	166	KFOK	40.85	-72.63	10	FAA	WEST HAMPTON BCH, NY
83	KNYG	38.50	-77.30	10	NWS	QUANTICO MCAF	167	KHTO	40.97	-72.25	10	NWS	EAST HAMPTON, NY
84	KDAA	38.72	-77.18	10	NWS	FT BELVOIR/DAVISO	168	KMTP	41.08	-71.92	10	NWS	MONTAUK ARPT, NY

B-4. ASOS/METAR Platform Locations (cont'd)



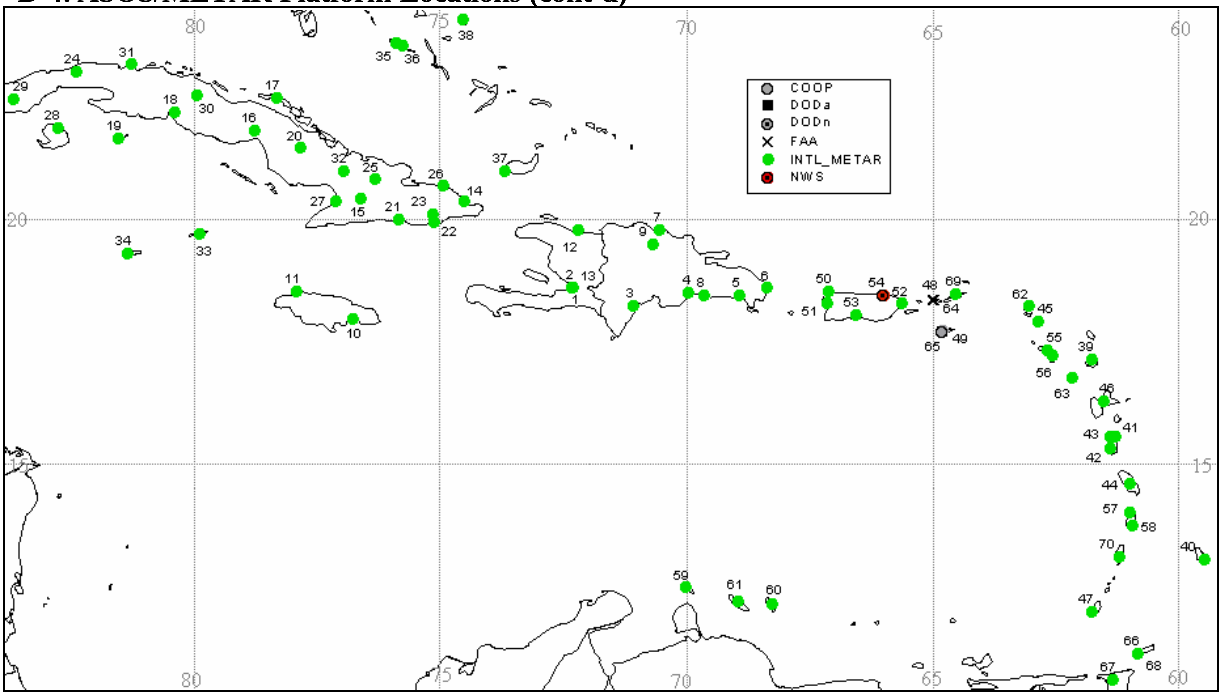
#	Station	Lat	Lon	Provider	Station Location
[illegible]	KELZ	42.11	-77.99	FAA	WELLSVILLE MUNI ARPT, NY
[illegible]	KDSV	42.57	-77.72	FAA	DANSVILLE, NY
[illegible]	KROC	43.12	-77.67	NWS	ROCHESTER/MONROE CO, NY
[illegible]	KPEO	42.64	-77.05	FAA	PENN YAN ARPT, PENNYAN, NY
[illegible]	KELM	42.16	-76.90	FAA	ELMIRA CORNING RGNL ARPT, ELMIRA, NY
[illegible]	KITH	42.48	-76.45	NWS	ITHACA/TOMPKINS CO., NY
[illegible]	KFZY	43.35	-76.39	FAA	FULTON/OSWEGO CTY ARPT, NY
[illegible]	KSYR	43.11	-76.10	NWS	SYRACUSE HANCOCK INTL ARPT
[illegible]	KART	44.00	-76.02	FAA	WATERTOWN INTL ARPT, NY
0	KBGM	42.21	-75.98	NWS	BINGHAMTON RGNL ARPT
1	KGTB	44.05	-75.73	NWS	FORT DRUM/WHEELER, NY
2	KAVP	41.33	-75.72	NWS	WILKES-BARRE SCRANTON INTL ARPT
3	KOGS	44.68	-75.47	NWS	OGDENSBURG INTL, NY
4	KRME	43.23	-75.40	NWS	GRIFFISS AFB/ROME, NY
5	KUCA	43.14	-75.38	FAA	UTICA ONEIDA CO ARPT, UTICA, NY
6	KMSS	44.93	-74.85	FAA	MASSENA/RICHARDS, NY
7	KMSV	41.70	-74.80	NWS	MONTICELLO (AWOS), NY
8	KMGJ	41.52	-74.27	FAA	MONTGOMERY/ORANGE CTY ARPT, NY
9	KSLK	44.40	-74.20	FAA	SARANAC LAKE/ADIRONDACK, NY
0	KSWF	41.50	-74.10	NWS	NEWBURGH/STEWART, NY
1	KSCH	42.85	-73.93	NWS	SCHENECTADY ARPT, NY
2	KPOU	41.63	-73.88	FAA	POUGHKEEPSIE DUTCHESS CO ARPT, NY
3	KALY	42.69	-73.83	NWS	ALBANY WFO & SCD, NY
4	KALB	42.75	-73.80	NWS	ALBANY, NY
5	KALB	42.75	-73.80	NWS	ALBANY CO ARPT, ALBANY, NY
6	K44N	41.70	-73.73	NWS	MILLBROOK/SKY ACRES, NY
7	KGFL	43.34	-73.61	FAA	GLENS FALLS ARPT,GLENS FALLS, NY
8	KPLB	44.69	-73.52	FAA	PLATTSBURGH/CLINTON CNTY ARPT, NY
9	KDXR	41.37	-73.48	FAA	DANBURY MUNI, CT
0	KPBG	44.65	-73.47	NWS	PLATTSBURGH AFB, NY
1	KPSF	42.42	-73.29	FAA	PITTSFIELD MUNI ARPT, PITTSFIELD, NY
2	K5B5	42.89	-73.25	NWS	BENNINGTON, VT
3	KDDH	42.89	-73.25	FAA	BENNINGTON MORSE STATE ARPT, VT
4	KAQW	42.70	-73.17	FAA	NORTH ADAMS HARRIMAN, MA
5	KAQW	42.70	-73.17	FAA	NORTH ADAMS MA
6	KBTV	44.47	-73.15	NWS	BURLINGTON INTL, VT
7	KOXC	41.48	-73.13	NWS	OXFORD (AWOS) CT
8	KRUT	43.53	-72.95	NWS	RUTLAND STATE (AWOS) VT
9	KMMK	41.51	-72.83	FAA	MERIDEN MARKHAM MUNI APT, CT
0	KBAF	42.15	-72.72	FAA	WESTFIELD/BARNES MA
1	KBDL	41.93	-72.68	NWS	HARTFORD/BRADLEY CT
2	KHFD	41.73	-72.65	FAA	HARTFORD/BRAINARD CT
3	KMVL	44.53	-72.62	FAA	MORRISVILLE (ASOS) VT
4	KMPV	44.20	-72.57	FAA	BARRE-MONTPELIER VT
5	KCEF	42.20	-72.53	NWS	CHICOPEE/WESTOVER MA
6	KVSF	43.35	-72.52	FAA	SPRINGFIELD/HARTNES VT
7	KLEB	43.63	-72.30	FAA	LEBANON MUNI NH
8	KORE	42.57	-72.28	FAA	ORANGE MUNI ARPT, ORANGE, MA
9	KEEN	42.90	-72.27	NWS	KEENE/DILLANT (AWOS) NH
0	K9B2	44.93	-72.20	NWS	NEWPORT VT
1	KIJD	41.74	-72.18	FAA	WILLIMANTIC WINDHAM ARPT, CT
2	K1V4	44.42	-72.02	NWS	ST. JOHNSBURY (AMOS) VT
3	KAFN	42.80	-72.00	FAA	JAFFREY NH
4	KORH	42.27	-71.88	NWS	WORCESTER (AMOS) MA
5	KWST	41.35	-71.80	FAA	WESTERLY STATE ARPT, WESTERLY, RI
6	KFIT	42.55	-71.76	FAA	FITCHBURG MUNI ARPT, FITCHBERG, MA
57	K1P1	43.78	-71.75	NWS	PLYMOUTH MUNI ARPT, NH
58	KAYE	42.57	-71.60	NWS	FORT DEVENS/AYER MA
59	KHIE	44.35	-71.55	FAA	WHITEFIELD (ASOS) NH
60	KASH	42.78	-71.52	NWS	NASHUA/BOIRE FIELD NH
61	KSFZ	41.92	-71.50	NWS	PAWTUCKET (AWOS) RI
62	KCON	43.20	-71.50	NWS	CONCORD MUNI NH
63	KPVD	41.723	-71.43	NWS	PROVIDENCE GREEN STATE ARPT, RI
64	KMHT	42.93	-71.43	FAA	MANCHESTER AIRPARK NH
65	KOQU	41.60	-71.42	NWS	N. KINGSTON/QUONSET RI
66	KLCI	43.57	-71.42	NWS	LACONIA MUNI (AWOS) NH
67	KMWN	44.27	-71.30	NWS	MOUNT WASHINGTON NH
68	KBED	42.47	-71.29	FAA	BEDFORD HANSCOM FIELD,BEDFORD,MA
69	KUUU	41.53	-71.28	FAA	NEWPORT STATE ARPT, NEWPORT, RI
70	KBML	44.58	-71.18	FAA	BERLIN MUNI NH
71	KOWD	42.19	-71.17	FAA	NORWOOD MEMORIAL ARPT, NORWOOD, MA
72	KLWM	42.71	-71.13	FAA	LAWRENCE MUNI ARPT, LAWRENCE, MA
73	KMQE	42.22	-71.12	NWS	EAST MILTON (ASOS), MA
74	KBOX	42.37	-71.03	NWS	BOSTON MA
75	KTAN	41.88	-71.02	FAA	TAUNTON MUNI ARPT,TAUNTON,MA
76	KBOS	42.36	-71.02	NWS	BOSTON LOGAN INTL ARPT, BOSTON, MA
77	KEWB	41.68	-70.96	FAA	NEW BEDFORD MUNI ARP T, MA
78	KIZG	43.98	-70.95	FAA	FRYEBURG (ASOS) ME
79	KNZW	42.15	-70.93	NWS	SOUTH WEYMOUTH NAS MA
80	KDAW	43.28	-70.93	FAA	ROCHESTER/SKYHAVEN ARPT, NH
81	K6B1	43.28	-70.92	NWS	ROCHESTER, NH
82	KBVY	42.58	-70.92	FAA	BEVERLY MUNI ARPT, BEVERLY, MA
83	KPSM	43.08	-70.82	NWS	PEASE AFB/PORTSMOUT NH
84	KPYM	41.91	-70.73	FAA	PLYMOUTH MUNI ARPT, PLYMOUTH, MA
85	KSFM	43.40	-70.72	NWS	SANFORD MUNI (AWOS) ME
86	K3B2	42.10	-70.68	NWS	MARSHFIELD ARPT MA
87	KMVY	41.39	-70.62	FAA	MARTHA'S VINEYARD ARPT, MA
88	KRUM	44.53	-70.53	NWS	RUMFORD ME
89	KFMH	41.65	-70.52	NWS	OTIS ANGB MA
90	KPWM	43.65	-70.32	NWS	PORTLAND INTL JET ME
91	KLEW	44.05	-70.28	NWS	AUBURN-LEWISTON ME
92	KHYA	41.67	-70.27	FAA	HYANNIS BARNSTABLE MUNI ARPT, MA
93	KGYX	43.89	-70.26	NWS	GRAY ME
94	KPVC	42.07	-70.22	NWS	PROVINCETOWN (AWOS) MA
95	KCQX	41.69	-69.99	FAA	CHATHAM MUNI ARPT, CHATHAM, MA
96	KCHH	41.67	-69.97	NWS	CHATHAM MA
97	KNHZ	43.88	-69.93	NWS	BRUNSWICK NAS ME
98	KAUG	44.32	-69.80	FAA	AUGUSTA STATE ARPT ME
99	KIWI	43.97	-69.72	FAA	WISCASSET ME
100	KWVL	44.53	-69.68	NWS	WATERVILLE (AWOS) ME
101	KGNR	45.47	-69.58	NWS	GREENVILLE (AMOS) ME
102	KGNR	45.47	-69.58	NWS	GREENVILLE (AMOS) ME
103	K40B	46.62	-69.53	NWS	CLAYTON LAKE, ME
104	KRKD	44.07	-69.10	NWS	ROCKLAND/KNOX (AWOS) ME
105	KBGR	44.80	-68.83	FAA	BANGOR INTL ARPT ME
106	KMLT	45.65	-68.68	FAA	MILLINOCKET MUNI ME
107	KBHB	44.45	-68.37	NWS	BAR HARBOR (AWOS) ME
108	KFVE	47.28	-68.32	FAA	FRENCHVILLE, ME
109	KPQI	46.68	-68.05	NWS	PRESQUE ISLE (AWOS), ME
110	KCAR	46.87	-68.02	NWS	CARIBOU MUNI, ME
111	KLIZ	46.95	-67.88	NWS	LORING AFB/LIMESTON, ME
112	KHUL	46.12	-67.80	FAA	HOULTON INTL ARPT, ME
113	KEPO	44.92	-67.00	NWS	EASTPORT ME

B-4. ASOS/METAR Platform Locations (cont'd)



#	Station	Lat	Lon	Station Location
1	CWHY	45.32	-72.25	MONT-ORFORD QB
2	CWQH	45.36	-71.81	LENNOXVILLE, QB
3	CYSC	45.43	-71.68	SHERBROOKE ARPT QB
4	CWPQ	45.63	-70.55	MONTREAL-EST QB
5	CERM	47.42	-68.32	EDMUNSTON NB
6	CYSL	47.16	-67.83	ST LEONARD ARPT NB
7	CWIY	47.15	-67.82	ST LEONARD AUTO8 NB
8	CWSS	45.20	-67.25	ST STEPHEN (MARS) NB
9	CXGM	44.71	-66.80	GRAND MANAN SAR CS NB
10	CWSG	49.08	-66.73	CAP CHAT (MAPS) QB
11	CWZF	45.97	-66.65	FREDERICTON AQUATIC NB
12	CAFC	45.92	-66.60	FREDERICKTON CDA CS NB
13	CYFC	45.87	-66.53	FREDERICTON ARPT NB
14	CWPE	45.07	-66.47	POINT LEPREAU NB
15	CYCX	45.83	-66.43	GAGETOWN (CAN-MIL) NB
16	CZCR	47.98	-66.33	CHARLO AUTO NB
17	CWVU	44.28	-66.33	BRIER ISLAND (AUT) NS
18	CYCL	47.98	-66.33	CHARLO ARPT NB
19	CYQI	43.83	-66.08	YARMOUTH ARPT NS
20	CYSJ	45.32	-65.88	SAINT JOHN ARPT NB
21	CYID	44.55	-65.78	DIGBY ARPT (AWRS) NS
22	CZBF	47.63	-65.75	BATHURST ARPT (AWRS) NB
23	CWCP	43.45	-65.47	BACCARO POINT NS
24	CWCQ	47.00	-65.47	CHATHAM (AUTO8) NB
25	CACQ	47.00	-65.45	MIRAMICHI RCS NB
26	CYCH	47.00	-65.45	CHATHAM (CAN-MIL) NB
27	CWOC	48.02	-65.33	NEW CARLISLE1 QB
28	CWSF	49.25	-65.33	CAP MADELEINE (MAPS) QB
29	CWKG	44.43	-65.20	KEJIMKUJIK 1 NS
30	CAKC	46.77	-65.00	KOUCHIBOUGUAC CS NB
31	CAFY	45.60	-64.95	FUNDY PARK CS NB
32	CYZX	44.98	-64.92	GREENWOOD (CAN-MIL) NS
33	CWXS	47.80	-64.83	BAS CARAQUET NB
34	CWPJ	47.07	-64.80	PT. ESCUMINAC(MAPS) NB
35	CABT	46.42	-64.77	BUCTOUCHE CDA CS NB
36	CYQM	46.12	-64.68	MONCTON ARPT NB
37	CWWE	4398	-64.67	WESTERN HEAD (MARS) NS
38	CWMI	48.02	-64.50	MISCOU ISL (MARS) NB
39	CYGP	48.77	-64.48	GASPE ARPT QB
40	CXKT	45.07	-64.48	KENTVILLE NS
41	CAPR	45.42	-64.35	PARRSBORO NS
42	CWRZ	48.42	-64.32	CAP D'ESPOIR (MAPS) QB
43	CWBY	49.83	-64.30	PORT ME NIER (MARS) QB
44	CXLB	44.35	-64.30	LUNENBERG NS
45	CYPN	49.83	-64.28	PORT MENIER (MAN) QB
46	CWAH	45.84	-64.26	AMHERST NS
47	CXNP	45.75	-64.23	NAPPAN AUTO NS
48	CWNE	47.08	-64.00	NORTH POINT (AUTO8) PE
49	CWSD	46.43	-63.85	SUMMERSIDE (AUTO8) PE
50	CYSU	46.43	-63.83	SUMMERSIDE (CAN-MIL) PE
51	CXBP	46.23	-63.73	CONFEDERATION BRIDGE PE
52	CWAZ	44.72	-63.68	BEDFORD NS
53	CXMP	46.30	-63.58	MAPLE PLAINS PE
54	CXMI	44.60	-63.53	MCNABS ISLAND NS
55	CWAW	44.63	-63.52	SHEARWATER JETTY NS
56	CYAW	44.63	-63.50	SHEARWATER (CAN-MIL) NS
57	CYHZ	44.88	-63.50	HALIFAX INTL ARPT NS
58	CZDB	45.42	-63.47	DEBERT NS
59	CWUR	45.37	-63.27	TRURO (MARS) NS
60	CAHR	46.35	-63.17	HARRINGTON CDA CS PE
61	CYYG	46.28	-63.13	CHARLOTTETOWN ARPT PE
62	CAOH	45.23	-63.05	UPPER STEWIACKE RCS NS
63	CWBK	45.76	-62.68	CARIBOU NS
64	CYTN	45.61	-62.62	TRENTON MUNI ARPT NS
65	CZSP	46.45	-62.57	ST PETERS PE
66	CXMY	44.98	-62.48	MALAY FALLS NS
67	CWBV	44.81	-62.33	BEAVER ISLAND (MAPS) NS
68	CWEP	46.45	-61.97	EAST POINT (MARS) PE
69	CWGU	45.87	-61.90	CAPE GEORGE (AUTO8) NS
70	CWGR	47.42	-61.80	ILES-DE-LA-MADELEIN QB
71	CYGR	47.42	-61.78	ILES DE LA MADELEIN QB
72	CWHP	49.08	-61.70	HEATH POINT (MAPS) QB
73	CXTD	45.61	-61.68	TRACADIE NS
74	CYPD	45.67	-61.38	PORT HAWKESBURY NS
75	CWFU	52.23	-61.32	LITTLE MACATINA NF
76	CWZQ	46.53	-61.08	GRAND ETANG (AUTO8) NS
77	CWRN	45.35	-60.98	HART ISLAND (MAPS) NS
78	CXNM	46.82	-60.67	NORTH MOUNTAIN NS
79	CWXO	43.88	-60.55	ROWAN GORILLA III NS
80	CWRW	45.72	-60.23	FOURCHU HEAD (MAPS) NS
81	CWEF	47.23	-60.13	ST PAUL ISL (MAPS) NS
82	CYQY	46.17	-60.05	SYDNEY ARPT NS
83	CAQY	46.17	-60.05	SYDNEY RCS NS
84	CWSA	43.93	-60.02	SABLE ISLAND NS
85	CYSA	43.93	-60.00	SABLE ISLAND (APT) NS
86	CXWR	47.71	-59.31	WRECKHOUSE NF
87	CWOF	47.57	-59.18	PORT BASQUES (AUTO) NF
88	CWZB	47.56	-59.16	PORT-AUX-BASQUES, NF
89	CYJT	48.53	-58.55	STEPHENVILLE ARPT NF
90	CXRH	49.57	-57.88	ROCKY HARBOUR CS NF
91	CWBF	47.62	-57.63	BURGEO (AUTO) NF
92	CWBD	47.61	-57.61	BURGEO NF
93	CWDX	50.23	-57.60	DANIEL'S HARBOUR (AUTO) NF
94	CWDH	50.24	-57.58	DANIEL'S HARBOUR NF
95	CYDF	49.22	-57.40	DEER LAKE ARPT NF
96	CWHU	48.58	-57.23	STAR BROOK NF
97	CWXI	51.02	-57.10	FEROLLE PT. (MAPS) NF
98	CWDA	50.72	-56.12	ENGLEE (MAPS) NF
99	CWDW	51.38	-56.10	ST ANTHONY NF
100	CYAY	51.38	-56.09	ST ANTHONY ARPT NF
101	CWDI	48.97	-56.07	BADGER (MARS) NF
102	CWZN	47.37	-55.80	SAGONA ISL (MAPS) NF
103	CWAG	49.91	-55.66	LA SCIE NF
104	CWAX	51.37	-55.63	ST ANTHONY NF
105	CWFY	48.17	-55.48	CONNE RIVER NF
106	CWDS	46.92	-55.38	ST LAWRENCE NF
107	CXWT	47.14	-55.33	WINTERLAND NF
108	CWHW	49.27	-54.88	COMFORT COVE NF
109	CWDO	49.68	-54.80	TWILLINGATE (MAPS) NF
110	CXGD	48.94	-54.58	GANDER ARPT CS NF
111	CYQX	48.95	-54.57	GANDER INTL ARPT NF
112	CWAR	47.29	-54.00	ARGENTIA NF
113	CXTP	48.56	-53.97	TERRA NOVA NATL PARK CS NF
114	CWXJ	47.82	-53.90	BULL ARM AUTO8 NF
115	CWZY	47.82	-53.87	GBS PLATFORM NF
116	CWYI	49.12	-53.58	POOLS ISLAND NF
117	CWFH	46.72	-53.48	ST SHOTTS NF
118	CXSA	47.26	-53.29	SALMONIER NATURE PARK NF
119	CWVA	48.67	-53.12	BONAVISTA NF
120	CWRA	46.65	-53.07	CAPE RACE (MARS) NF
121	CWWU	47.52	-52.98	LONG POND NF
122	CWVW	48.17	-52.93	GRATES COVE (AUTO) NF
123	CXSW	47.52	-52.78	ST JOHN'S WEST CDA CS NF
124	CYYT	47.62	-52.73	ST JOHN'S ARPT NF

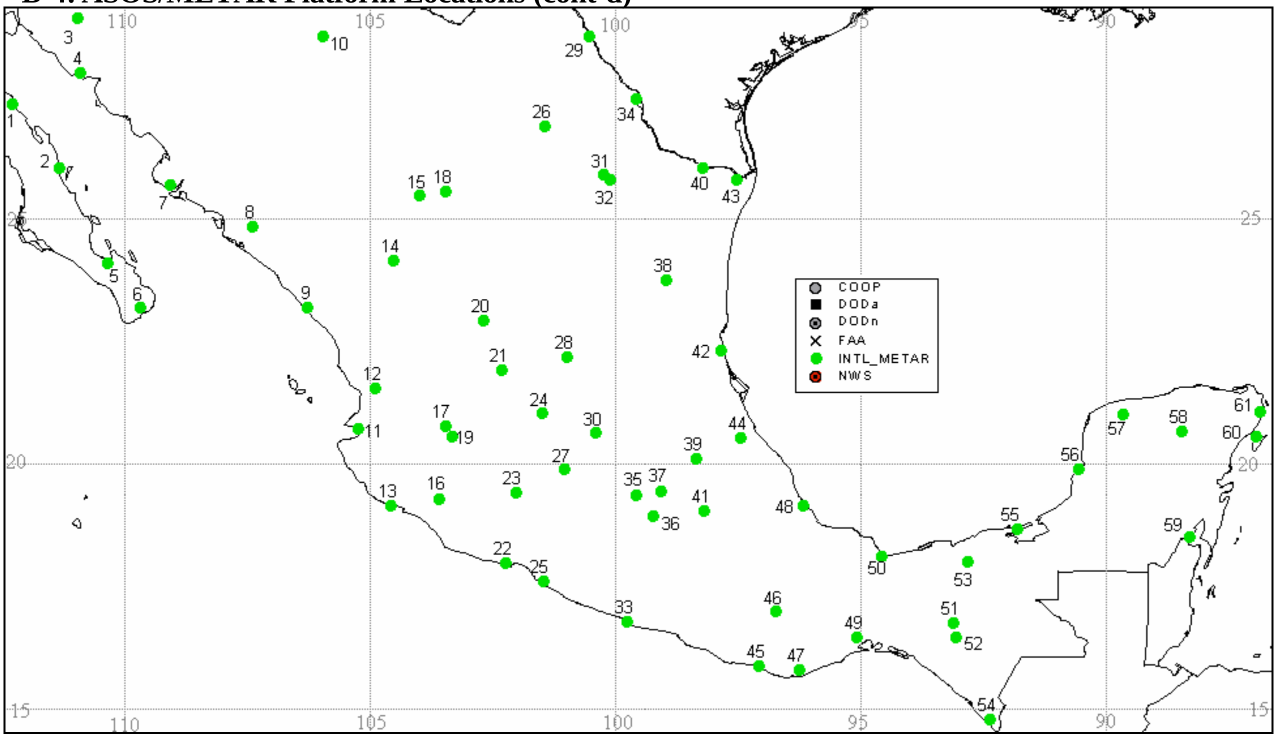
B-4. ASOS/METAR Platform Locations (cont'd)



#	Station	Lat	Lon	Station Location
1	CTPP	18.57	-72.32	CAMP_CANARGUS HA
2	KQAR	18.58	-72.30	PORT_AU_PRINCE HA
3	MDBH	18.22	-71.10	BARAHONA DR
4	MDHE	18.47	-69.97	HERRERA DR
5	MDLR	18.42	-68.95	LA_ROMANA_INTL_ARPT DR
6	MDPC	18.57	-68.37	PUNTA_CANA DR
7	MDPP	19.75	-70.55	PUERTO_PLATA_INTL DR
8	MDSD	18.43	-69.67	CAUCEDO/DE_LAS_AMER DR
9	MDST	19.47	-70.70	SANTIAGO_INTL_ARPT DR
10	MKJP	17.93	-76.78	NORMAN_MANLEY/KINGS JM
11	MKJS	18.50	-77.92	SANGSTER/MONTEGO JM
12	MTCH	19.75	-72.18	CAP-HAITIEN_INTL HA
13	MTPP	18.57	-72.30	PORT-AU-PRINCE_ARPT HA
14	MUBA	20.35	-74.50	BARACOA_(CIV/MIL) CU
15	MUBY	20.40	-76.62	BAYAMO CU
16	MUCA	21.78	-78.78	CIEGO_AVILA/VENEZUE CU
17	MUCC	22.45	-78.32	CAYO_COCO/JARDINES_DEL_RAY
18	MUCF	22.15	-80.40	CIENFUEGOS(CIV/MIL) CU
19	MUCL	21.62	-81.55	CAYO_LARGO_DEL_SUR CU
20	MUCM	21.42	-77.85	CAMAGUEY/IGANCIO CU
21	MUCU	19.97	-75.85	SANTIAGO_DE_CUBA CU
22	MUGM	19.90	-75.13	GUANTANAMO_BAY_NAS CU
23	MUGT	20.08	-75.15	GUANTANAMO CU
24	MUHA	22.98	-82.40	HAVANA/JOSE_MARTI CU
25	MUHG	20.78	-76.32	HOLGUIN_(CIV/MIL) CU
26	MUMO	20.65	-74.92	MOA_(MIL) CU
27	MUMZ	20.33	-77.12	MANZANILLO CU
28	MUNG	21.83	-82.78	NUEVA_GERONA_(MIL) CU
29	MUPR	22.42	-83.68	PINAR_DEL_RIO_NORTE CU
30	MUSC	22.50	-79.95	ABEL_SANTAMARIA CU
31	MUVR	23.13	-81.28	VARADERO CU
32	MUVT	20.95	-76.95	LAS_TUNAS/VICTORIA CU
33	MWCB	19.68	-79.89	GERRARD_SMITH_INTL/CAYMAN_
34	MWCR	19.28	-81.35	OWEN_ROBERTS_INTL GC
35	MYEF	23.57	-75.89	EXUMA_INTL BA
36	MYEG	23.50	-75.77	GEORGE_TOWN/EXUMA BA
37	MYIG	20.95	-73.68	MATTHEW_TOWN/INAGUA BA

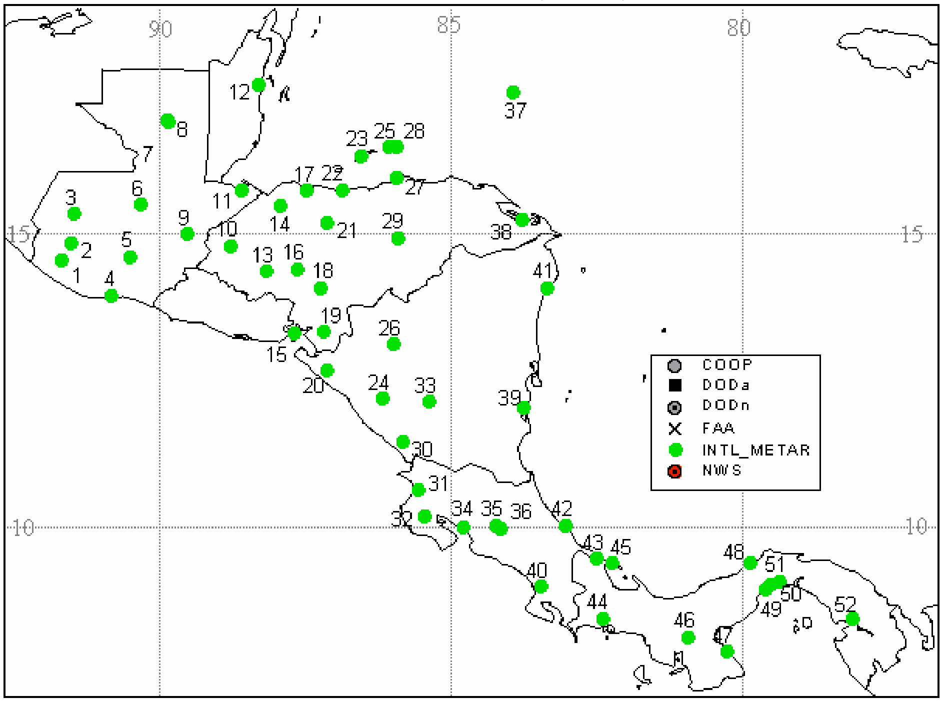
#	Station	Lat	Lon	Station Location
38	MYSM	24.05	-74.53	COCKBURN/SAN_SALVAD BA
39	TAPA	17.12	-61.78	COOLIDGE_ARPT AT
40	TBPB	13.07	-59.48	GRANTLEY_ADAMS_INTL BR
41	TDCF	15.53	-61.40	CANEFIELD_AIRPORT DO
42	TDPD	15.53	-61.30	MELVILLE_HALL_ARPT DO
43	TDPR	15.30	-61.40	ROSEAU DO
44	TFFF	14.60	-61.00	LE_LAMENTIN MR
45	TFFJ	17.90	-62.85	GUSTAVIA/ST BARTHEL MF
46	TFFR	16.27	-61.52	LE_RAIZET/GUADELOUP MF
47	TGPY	12.00	-61.78	POINT_SALINES_INTL GD
48	TIST	18.33	-64.97	C._AMALIE/CYRIL_E. VI
49	TISX	17.70	-64.80	CHRISTIANSTED/ALEXA VI
50	TJBQ	18.50	-67.13	AQUADILLA/BORINQUEN PU
51	TJMZ	18.27	-67.15	MAYAGUEZ/EUGENIO PU
52	TJNR	18.25	-65.63	ROOSEVELT_ROADS_NAS PU
53	TJPS	18.02	-66.57	PONCE/MERCEDITA PU
54	TJSJ	18.43	-66.00	LUIS MUNOZ ARPT, SAN JUAN PR
55	TKPK	17.30	-62.68	GOLDEN_ROCK AT
56	TKPN	17.20	-62.58	CHARLESTOWN/NEWCAST AT
57	TLPC	14.02	-61.00	CASTRIES/VIGIE LC
58	TLPL	13.75	-60.95	HEWANORRA_INTL_ARPT LC
59	TNCA	12.50	-70.02	REINA_BEATRIX_INTL NU
60	TNCB	12.15	-68.28	FLAMINGO_AIRPORT NU
61	TNCC	12.20	-68.97	HATO_ARPT_(CIV/MIL) NU
62	TQPF	18.20	-63.05	WALL_BLAKE VI
63	TRPM	16.75	-62.17	BLACKBURNE/PLYMOUTH AT
64	TSTT	18.33	-64.98	CYRIL E. KING INTL ARPT, ST. TOMAS, USVI
65	TSTX	17.7	-64.80	CHRISTIANSTED ARPT, ST. CRIOX, USVI
66	TTCP	11.15	-60.85	CROWN_PT./SCARBOROU TD
67	TTPP	10.62	-61.35	PIARCO_INTL_ARPT TD
68	TTPT	11.15	-60.83	CROWN_POINT_ARPT TD
69	TUPJ	18.45	-64.53	BEEF_ISL/ROADTOWN VI
70	TVSV	13.13	-61.20	ARNOS_VALE/KINGSTON LC

B-4. ASOS/METAR Platform Locations (cont'd)



#	Station	Lat	Lon	Height	Station Location
1	MMCN	27.32	-112.30	10 (m)	SANTA ROSALIA
2	MMLT	26.02	-111.35	10	LORETO
3	MMHO	29.07	-110.97	10	HERMOSILLO INTL
4	MMGM	27.97	-110.93	10	GUAYMAS INTL ARPT
5	MMLP	24.07	-110.37	10	LA PAZ INTL ARPT
6	MMSD	23.15	-109.70	10	SAN JOSE DEL CABO
7	MMLM	25.68	-109.08	10	LOS MOCHIS ARPT
8	MMCL	24.82	-107.40	10	CULIACAN (CITY)
9	MMMZ	23.17	-106.27	10	MAZATLAN/G BUELNA
10	MMCU	28.70	-105.97	10	CHIHUAHUA INTL ARPT
11	MMPR	20.68	-105.25	10	PUERTO VALLARTA/LIC
12	MMEP	21.52	-104.90	10	TEPIC
13	MMZO	19.15	-104.57	10	MANZANILLO INTL
14	MMDO	24.13	-104.53	10	DURANGO ARPT
15	MMIO	25.45	-103.98	10	SALTILLO
16	MMIA	19.27	-103.58	10	COLIMA
17	MMZP	20.75	-103.47	10	ZAPOPAN (MIL)
18	MMTC	25.53	-103.45	10	TORREON ARPT
19	MMGL	20.52	-103.32	10	DON MIGUEL/GUADALAJ
20	MMZC	22.90	-102.68	10	ZACATECAS ARPT
21	MMAS	21.88	-102.30	10	AGUASCALIENTES
22	MMLC	17.98	-102.22	10	LAZARO CARDENAS
23	MMPN	19.40	-102.03	10	URUAPAN/GEN RA YON
24	MMLO	21.00	-101.48	10	DEL BAJIO/LEON
25	MMZH	17.60	-101.47	10	IXTAPA-ZIHUATANEJO
26	MMMV	26.88	-101.42	10	MONCLOVA
27	MMMM	19.85	-101.03	10	MORELIA NEW
28	MMSP	22.15	-100.98	10	SAN LUIS POTOSI
29	MMPG	28.70	-100.52	10	PIEDRAS NEGRAS
30	MMQT	20.60	-100.38	10	QUERETARO
31	MMAN	25.87	-100.23	10	MONTERREY INTL ARPT
32	MMMY	25.78	-100.1	10 (m)	MONTERREY/GEN MARIA
33	MMAA	16.77	-99.75	10	ACAPULCO/G. ALVAREZ
34	MMNL	27.43	-99.57	10	NUEVO LAREDO INTL
35	MMTO	19.35	-99.57	10	TOLUCA/JOSE MARIA
36	MMCB	18.92	-99.25	10	CUERNAVACA
37	MMMX	19.43	-99.10	10	MEXICO CITY/LICENCI
38	MMCV	23.72	-98.97	10	CIUDAD VICTORIA APT
39	MMTL	20.08	-98.37	10	TULANCINGO
40	MMRX	26.02	-98.23	10	REYNOSA INTL ARPT
41	MMPB	19.03	-98.20	10	PUEBLA
42	MMTM	22.28	-97.87	10	TAMPICO/GEN FJ MINA
43	MMMA	25.77	-97.53	10	MATAMOROS INTL
44	MMPA	20.50	-97.47	10	POZA RICA/PALIZADA
45	MMPS	15.87	-97.08	10	PUERTO ESCONDIDO
46	MMOX	16.97	-96.73	10	OAXACA/XOXOCOTLAN
47	MMBT	15.78	-96.27	10	BAHIAS DE HUATULCO
48	MMVR	19.15	-96.18	10	GEN. HERIBERTO JARA
49	MMIT	16.45	-95.08	10	IXTEPEC OX
50	MMMT	18.10	-94.58	10	MINATITLAN
51	MMTG	16.75	-93.12	10	TUXTLA GUTIERREZ A
52	MMTB	16.45	-93.07	10	TUXTLA GUTIERREZ
53	MMVA	18.00	-92.82	10	VILLAHERMOSA
54	MMTP	14.78	-92.38	10	TAPACHULA
55	MMCE	18.65	-91.80	10	CIUDAD DEL CARMEN
56	MMCP	19.85	-90.55	10	CAMPECHE/IGNACIO
57	MMMD	20.98	-89.65	10	MERIDA INTL ARPT
58	MMCT	20.64	-88.45	10	CHICHEN-ITZA
59	MMCM	18.50	-88.30	10	CHETUMAL
60	MMCZ	20.53	-86.93	10	COZUMEL (CIV/MIL)
61	MMUN	21.03	-86.87	10	CANCUN INTL ARPT

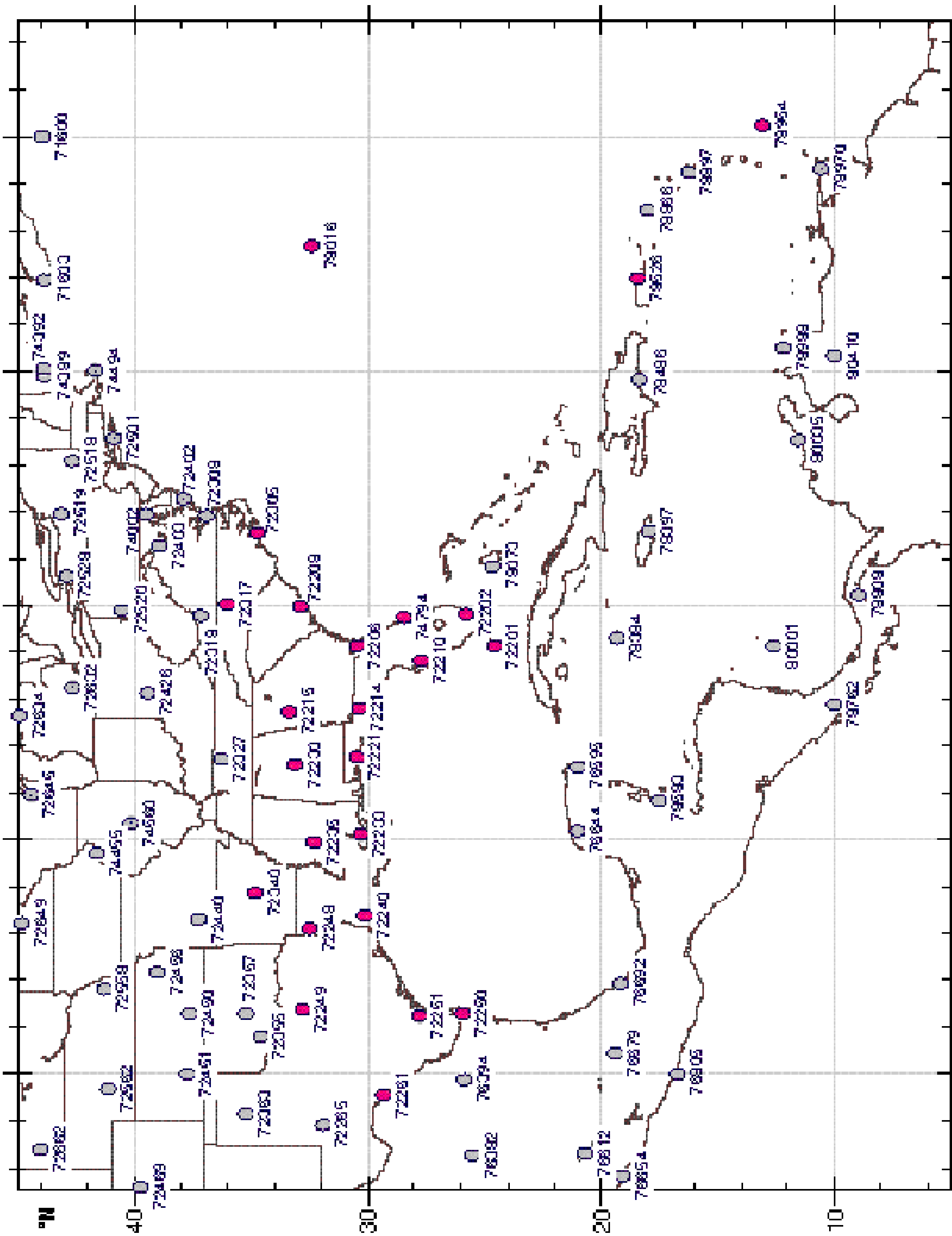
B-4. ASOS/METAR Platform Locations (cont'd)

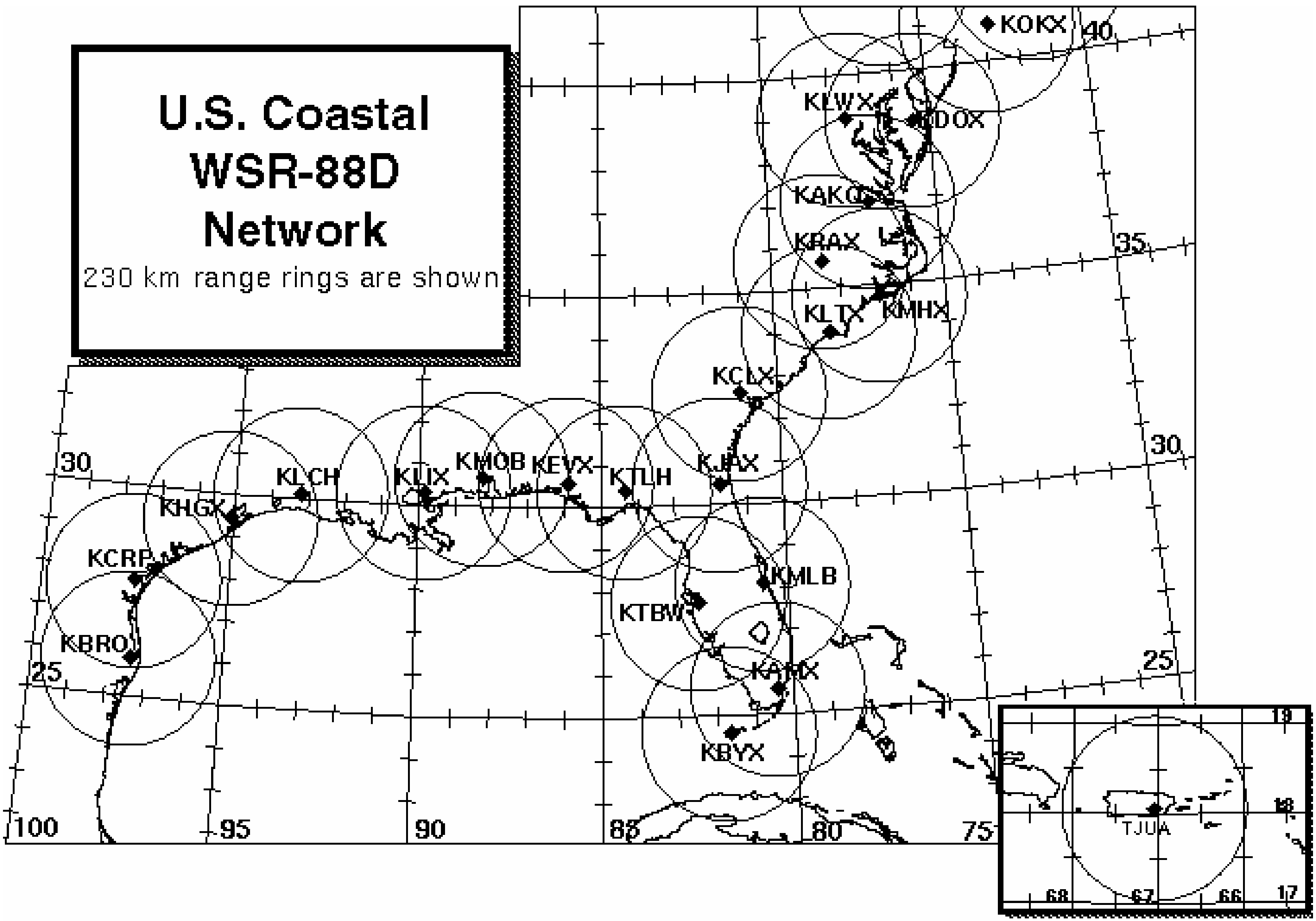


#	Station	Lat	Lon	Station Location
1	MGRT	14.53	-91.67	RETALHULEU (MIL) GU
2	MGQZ	14.83	-91.52	QUEZALTENANGO GU
3	MGHT	15.32	-91.47	HUEHUETENANGO GU
4	MGSJ	13.92	-90.82	SAN JOSE (CIV/MIL) GU
5	MGGT	14.58	-90.52	GUATEMALA/LA AURORA GU
6	MGCB	15.48	-90.32	COBAN GU
7	MGFL	16.92	-89.88	FLORES/SANTA ELENA GU
8	MGTK	16.90	-89.85	TIKAL GU
9	MGZA	14.97	-89.53	ZACAPA GU
10	MHSR	14.78	-88.78	SANTA ROSA DE COPAN HO
11	MGPB	15.72	-88.60	PUERTO BARRIOS(MIL) GU
12	MZBZ	17.53	-88.30	BELIZE INTL ARPT BH
13	MHLE	14.33	-88.17	LA ESPERANZA HO
14	MHLM	15.45	-87.93	LA MESA/PEDRO SULA HO
15	MHAM	13.28	-87.67	AMAPALA/LOS PELONAS HO
16	MHSC	14.38	-87.62	SOTO CANO AB HO
17	MHTE	15.72	-87.48	TELA HO
18	MHTG	14.05	-87.22	TEGUCIGALPA/TONCONT HO
19	MHCH	13.30	-87.18	CHOLUTECA HO
20	MNCH	12.63	-87.13	CHINANDEGA NK
21	MHYR	15.17	-87.12	YORO HO
22	MHLC	15.73	-86.87	LA CEIBA/GOLOSON HO
23	MHRO	16.32	-86.53	ROATAN HO
24	MNMG	12.15	-86.17	MANAGUA/AUGUSTO CES NK
25	MHNO	16.47	-86.07	GUANAJA HO
26	MNJG	13.08	-85.98	JINOTEGA NK

#	Station	Lat	Lon	Station Location
27	MHTR	15.93	-85.93	TRUJILLO HO
28	MHNJ	16.47	-85.92	GUANAJA HO
29	MHCA	14.90	-85.91	CATACAMAS HO
30	MNRS	11.42	-85.83	RIVAS NK
31	MRLB	10.60	-85.55	LIBERIA/TOMAS GUARD CS
32	MRNC	10.15	-85.45	NICOYA CS
33	MNJU	12.10	-85.37	JUIGALPA NK
34	MRCH	9.98	-84.78	CHACARITA CS
35	MROC	10.00	-84.22	SAN JOSE/SANTAMARIA CS
36	MRPV	9.95	-84.15	TOBIAS BOLANOS INTL CS
37	MHIC	17.40	-83.93	ISLAS DEL CISNE HO
38	MHPL	15.22	-83.80	PUERTO LEMPIRA HO
39	MNBL	12.00	-83.77	BLUEFIELDS NK
40	MRPM	8.95	-83.47	PALMAR SUR CS
41	MNPC	14.05	-83.37	PUERTO CABEZAS(MIL) NK
42	MRLM	10.00	-83.05	LIMON INTL ARPT CS
43	MPCH	9.43	-82.52	CAPTAIN MANUEL NINO PM
44	MPDA	8.40	-82.42	DAVID/ENRIQUE MALEK PM
45	MPBO	9.35	-82.25	BOCAS DEL TORO INTL PM
46	MPSA	8.08	-80.95	SANTIAGO PM
47	MPNU	7.83	-80.28	AUGUSTO VERGARA PM
48	MPCF	9.35	-79.87	ENRIQUE ADOLFO JIME PM
49	MPHO	8.92	-79.60	HOWARD AFB PM
50	MPMG	8.98	-79.52	MARCOS A. GELABERT PM
51	MPTO	9.05	-79.37	TOCUMEN/GEN. OMAR PM
52	MPLP	8.40	-78.13	LA PALMA PM

Appendix C: DOD/NWS RAWIN/RAOB and NWS Coastal Land-based Radar Locations




U.S. Coastal
WSR-88D
Network
230 km range rings are shown
KOKX
KLWX
KDOX
KAKQ
KRAX
KLTX
KMHX
KCLX
KJAX
KMLB
KTBW
KAMX
KBYX
KTLH
KEVX
KMOB
KLIX
KLCH
KHGX
KCRP
KBRO
TJUA
100
95
90
85
80
75
40
35
30
25
19
18
17
68
67
66

APPENDIX D: PRINCIPAL DUTIES OF THE NOAA SCIENTIFIC PERSONNEL

CAUTION

Flight operations are routinely conducted in turbulent conditions. Shock-mounted electronic and experimental racks surround most seat positions. Therefore, ***for safety onboard the aircraft all personnel should wear a flight suit and closed toed shoes***. For comfort, personnel should bring a jacket or sweater, as the cabin gets cold during flight.

Smoking is prohibited within 50 ft of the aircraft while they are on the ground. No smoking is permitted on the aircraft at any time.

Section 4-401, of the NOAA Safety Rules Manual state that: "Don't let your attention wander, either through constant conversation, use of cell phone or sightseeing while operating vehicles. Drivers must use caution and common sense under all conditions. Operators and passengers are not permitted to smoke or eat in the government vehicles. Cell phone use is permitted while car is parked."

GENERAL INFORMATION FOR ALL SCIENTIFIC MISSION PARTICIPANTS

Mission participants are advised to carry the proper personal identification [i.e., travel orders, "shot" records (when appropriate), and passports (when required)]. Passports will be checked by AOC personnel prior to deployment to countries requiring it. All participants must provide their own meals for in-flight consumption. AOC provides a refrigerator, microwave, coffee, utensils, condiments, ice, water, and soft drinks for a nominal fee per flight.

D.1 Field Program Director/ IFEX Chief Scientist;

(1) Responsible to the HRD director for the implementation of the Hurricane Field Program Plan.

(2) Only official communication link to AOC. Communicates flight requirements and changes in mission to AOC.

(3) Only formal communication link between AOML and CARCAH during operations. Coordinates scheduling of each day's operations with AOC only after all (POD) reconnaissance requirements are completed between CARCAH and AOC.

(4) Convenes the Hurricane Field Program Operations Advisory Panel. This panel selects missions to be flown.

(5) Provides for pre-mission briefing of flight crews, scientists, and others (as required).

(6) Assigns duties of field project scientific personnel. Ensures safety during the field program.

(7) Coordinates press statements with NOAA/Public Affairs.

D.2 Assistant Field Program Director

(1) Assumes the duties of the field program director in his absence.

D.3 Miami Ground Operations Center: Senior Team Leader

(1) During operations, the MGOC senior team leader is responsible for liaison between HRD base and field personnel and other organizations as requested by the field program director, the director of HRD, or their designated representatives.

D.4 Named Experiment Lead Project Scientist

(1) Has overall responsibility for the experiment.

(2) Coordinates the project and sub-project requirements.

(3) Determines the primary modes of operation for appropriate instrumentation.

(4) Assists in the selection of the mission.

(5) Provides a written summary of the mission to the field program director (or his designee) at the experiment's debriefing.

D.5 Lead Project Scientist

(1) Has overall scientific responsibility for his/her aircraft.

(2) Makes in-flight decisions concerning alterations of: (a) specified flight patterns; (b) instrumentation operation; and (c) assignment of duties to on-board scientific project personnel.

(3) Acts as project supervisor on the aircraft and is the focal point for all interactions of project personnel with operational or visiting personnel.

(4) Conducts preflight and post flight briefings of the entire crew. Completes formal checklists of safety, instrument operations - noting malfunctions, problems, etc.

(5) Provides a written report of each mission day's operations to the field program director at the mission debriefing.

D.6 Cloud Physics Scientist

(1) Has overall responsibility for the cloud physics project on the aircraft.

(2) Briefs the on-board lead project scientist on equipment status before takeoff.

(3) Determines the operational mode of the cloud physics sensors (i.e., where, when, and at what rate to sample).

(4) Operates and monitors the cloud physics sensors and data systems.

(5) Provides a written preflight and post flight status report and flight summary of each mission day's operations to the on-board lead project scientist at the post flight debriefing.

D.7 Boundary-Layer Scientist

(1) Insures that the required number of AXCPs, AXBTs, and AXCTDs are on the aircraft for each mission.

(2) Operates the AXCP, AXBT, and AXCTD equipment (as required) on the aircraft.

(3) Briefs the on-board lead project scientist on equipment status before takeoff.

(4) Determines where and when to release the AXCPs, AXBTs, and AXCTDs (as appropriate) subject to clearance by flight crew.

(5) Performs preflight, inflight, and post flight checks and calibrations.

(6) Provides a written preflight and post flight status report and a flight summary of each mission day's operations to the on-board lead project scientist at the post flight debriefing.

D.8 Radar Scientist

(1) Determines optimum meteorological target displays. Continuously monitors displays for performance and optimum mode of operations. Thoroughly documents modes and characteristics of the operations.

(2) Provides a summary of the radar display characteristics to the on-board lead project scientist at the post flight debriefing.

(3) Maintains tape logs.

(4) During the ferry to the storm, the radar scientist should record a tape of the sea return on either side of the aircraft at elevation angles varying from -20° through +20°. This tape will allow correction of any antenna mounting biases or elevation angle corrections.

D.9 Dropsonde Scientist

(1) Processes dropsondes observations on HRD workstation for accuracy.

(2) Provides TEMP drop message for ASDL, transmission or insures correct code in case of automatic data transmission.

D.10 Workstation Scientist

(1) Operates HRD's workstation.

(2) Runs programs that determine wind center and radar center as a function of time, composite flight-level and radar reflectivity relative to storm center and then process and code dropwindsonde observations.

(3) Checks data for accuracy and sends appropriate data to ASDL computer.

(4) Maintains records of the performance of the workstation and possible software improvements.

APPENDIX E: NOAA RESEARCH OPERATIONAL PROCEDURES AND CHECK LISTS

Hurricane Field Program Deployment Safety Checklist

The Field Program Director is responsible for making sure safety is enforced and ensuring necessary materials are in place and/or any actions have been completed before the start of the HFP. Field program participants are responsible for reviewing this checklist.

Scientist________________________________ Date ______________

Before leaving AOML

_____ 1. Contact MGOC personnel to notify departure time.

_____ 2. Things to take

a. Flight bag (s)
b. Cell phone
c. List of HFP important numbers
d. HRD Field program plan
e. Flight suit

Ground transportation

_____ 1. Arrange for ground transportation

_____ 2. Visual inspection of government vehicle

a. Make sure tires do not appear to be flat
b. Check for any cracked/broken lights, windshield and mirrors
c. Check for any major dents around the vehicle

_____ 3. Inspection inside the government vehicle

a. Check all lights work properly (head and tail lights, dome lights, dashboard and turn signal lights)
b. Make sure the engine, oil, or temperature light does not flash. *If so, contact facilities management.*
c. **Note** the gas and mileage

_____ 4. Contents inside the government vehicle

a. Make sure there is first aid kit and fire extinguisher
b. Proper jack and lug wrench
c. Spare tire
d. Basic auto repair kit (i.e. road hazard reflector or flares)
e. *Consider carrying a flashlight*

_____ 5. If possible, return vehicle with full tank (regular unleaded gasoline)

_____ 6. **Note** mileage on AOML log when returning vehicle keys

_____ 7. Contact MGOC personnel upon returning

E.1 "Conditions-of-Flight" Commands

Mission participants should be aware of the designated "conditions-of-flight." There are five designated basic conditions of readiness encountered during flight. The pilot will set a specific condition and announce it to all personnel over the aircraft's PA (public address) and ICS (interphone communications systems). All personnel are expected to act in accordance with the instructions for the specific condition announced by the pilot. These conditions and appropriate actions are shown below.

CONDITION 1: TURBULENCE/PENETRATION. All personnel will stow loose equipment and fasten safety belts.

CONDITION 2: HIGH ALTITUDE TRANSIT/FERRY. There are no cabin stations manning requirements.

CONDITION 3: NORMAL MISSION OPERATIONS. All scientific and flight crew stations are to be manned with equipment checked and operating as dictated by mission requirements. Personnel are free to leave their ditching stations.

CONDITION 4: AIRCRAFT INSPECTION. After take-off, crew members will perform wings, engines, electronic bays, lower compartments, and aircraft systems check. All other personnel will remain seated with safety belts fastened and headsets on.

CONDITION 5: TAKE-OFF/LANDING. All personnel will stow or secure loose equipment, don headsets, and fasten safety belts/shoulder harnesses.

E.2 Lead Project Scientist

E.2.1 Preflight

_____ 1. Participate in general mission briefing.

_____ 2. Determine specific mission and flight requirements for assigned aircraft.

_____ 3. Determine from field program director whether aircraft has operational fix responsibility and discuss with AOC flight director/meteorologist unless briefed otherwise by field program director.

_____ 4. Contact HRD members of crew to:
a. Assure availability for mission.
b. Review field program safety checklist
c. Arrange ground transportation schedule when deployed.
d. Determine equipment status.

_____ 5. Meet with AOC flight director and navigator at least 3 hours before take-off for initial briefing.

_____ 5. Meet with AOC flight crew at least 2 hours before take-off for crew briefing. Provide copies of flight requirements and provide a formal briefing for the flight director, navigator, and pilots.

_____ 6. Report status of aircraft, systems, necessary on-board supplies and crews to appropriate HRD operations center (MGOC in Miami).

_____ 7. Before take-off, brief the on-board GPS dropsonde operator on times and positions of drop times.

_____ 7. Make sure each HRD flight crew members have life vests

_____ 7. Perform a headset operation check with all HRD flight crew members. Make sure everyone can hear and speak using the headset.

_____ 8. Collect “mess” fee ($2.00) from all on-board HRD flight crew members.

E.2.2 In-Flight

_____ 1. Confirm from AOC flight director that satellite data link is operative (information).

_____ 2. Confirm camera mode of operation.

_____ 3. Confirm data recording rate.

_____ 4. Complete Lead Project Scientist Form.

_____ 5. Check in with the flight director to make sure the mission is going as planned (i.e. turns are made when they are supposed to be made).

E.2.3 Post flight

_____ 1. Debrief scientific crew.

_____ 2. Report landing time, aircraft, crew, and mission status along with supplies (tapes, *etc.*) remaining aboard the aircraft to MGOC.

_____ 3. Gather completed forms for mission and turn in at the appropriate operations center. [**Note**: all data removed from the aircraft by HRD personnel should be cleared with the AOC flight director.]

_____ 4. Obtain a copy of the 10-s flight listing from the AOC flight director. Turn in with completed forms.

_____ 5. Obtain a copy of the radar DAT tapes and if possible a copy of the radar data-packet files should be copied onto a flash drive. Turn in with completed forms.

_____ 6. Obtain a copy of the all VHS videos form aircraft cameras (3-4 approx.). Turn in with completed forms.

_____ 7. Obtain a copy of CD with all flight data. Turn in with completed forms.

_____ 8. Determine next mission status, if any, and brief crews as necessary.

_____ 9. Notify MGOC as to where you can be contacted and arrange for any further coordination required.

_____ 10. Prepare written mission summary using **Mission Summary** form (due to Field Program Director 1 week after the flight).

Form E-2
Page 1 of 5

Lead Project Scientist Check List

Date ______________ Aircraft _____________ Flight ID ___________________

A. —Participants:

HRD		AOC	
Function	**Participant**	**Function**	**Participant**
Lead Project Scientist	________	Flight Director	________
Radar	________	Pilots	________
Workstation	________	Navigator	________
Cloud Physics	________	Systems Engineer	________
Photographer/Observer /Guests	________	Data Technician	________
Dropwindsonde	________	Electronics Technician	________
AXBT/AXCP		Other	

B. Take-off and Landing Locations:

Take-Off: ________ Location: _______________

Landing: ________ Location: _________________

Number of Eye Penetrations: ______

C. Past and Forecast Storm Locations:

Date/Time	Latitude	Longitude	MSLP	Maximum Wind

D. Mission Briefing:

Form E-2

E. Equipment Status (Up↑, Down↓, Not Available **—**, Not Used **O**)

Equipment	**Pre-Flight**	**In-Flight**	**Post-Flight**	# DATs / Cds **/Expendables/ Printouts**
Radar/LF				
Doppler Radar/TA				
Cloud Physics				
Data System				
GPS sondes				
AXBT/AXCP				
Ozone instrument				
Workstation				
Videography				

REMARKS:

Mission Summary
Storm name
YYMMDDA# Aircraft 4__RF

Scientific Crew (4_ RF)
Lead Project Scientist ____________________
Radar Scientist____________________________
Cloud Physics Scientist____________________
Dropwindsonde Scientist___________________
Boundary-Layer Scientist__________________
Workstation Scientist______________________
Observers________________________________

Mission Briefing: (include sketch of proposed flight track or page #)

Mission Synopsis: (include plot of actual flight track)

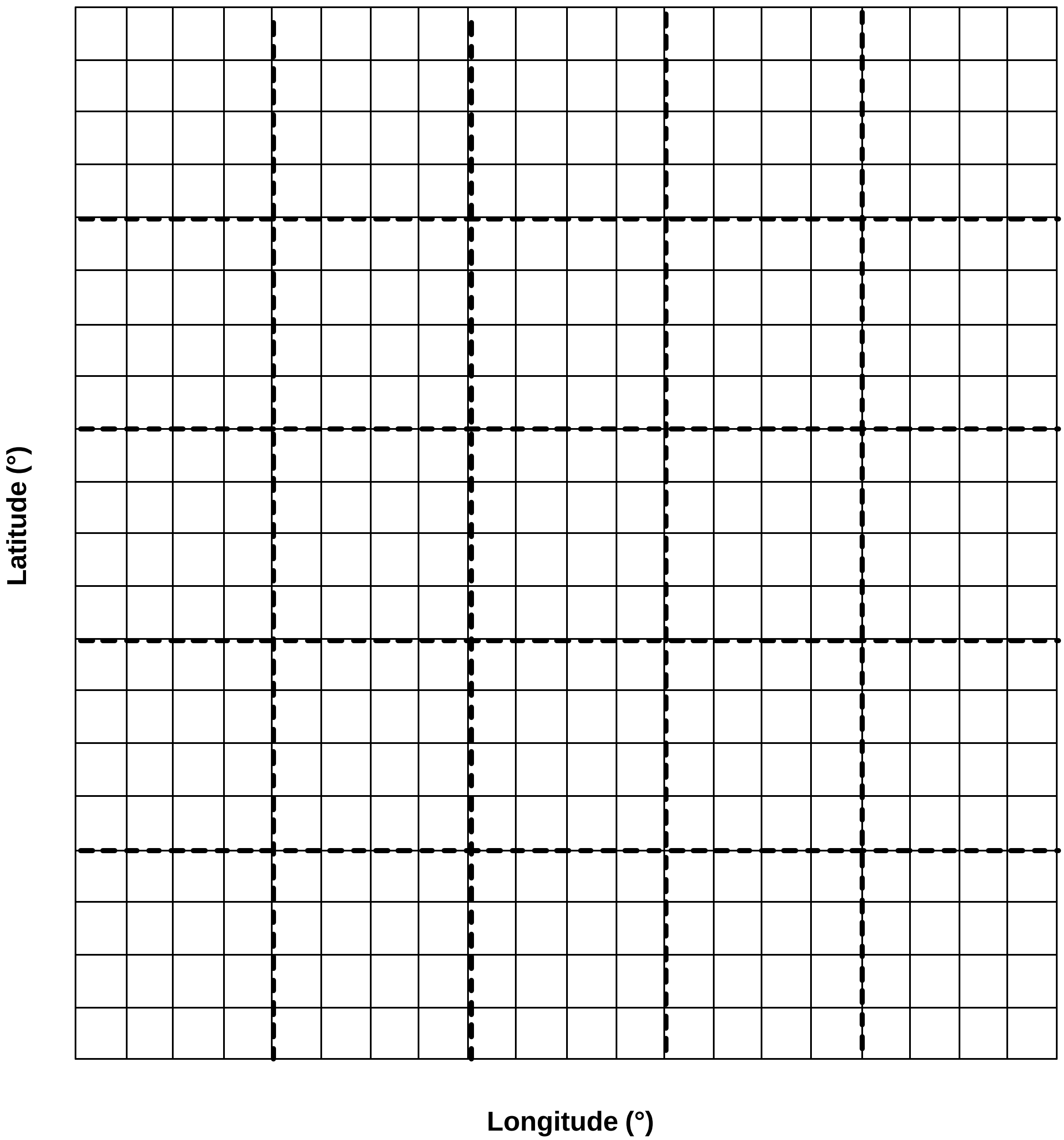
Evaluation: (did the experiment meet the proposed objectives?)

Problems: (list all problems)

Expendables used in mission:
GPS sondes : ________________
AXBTs :__________________
Sonobuoys: _________________

Observer's Flight Track Worksheet

Date ____________________ Flight ____________________ Observer _____________________



Lead Project Scientist Event Log

Date _________________ Flight _________________ LPS ______________________

Time	Event	Position	Comments

E.3 Cloud Physics Scientist

The on-board cloud physics scientist (CPS) is responsible for cloud physics data collection on his/her assigned aircraft. Detailed operational procedures are contained in the cloud physics kit supplied for each aircraft. General procedures follow. (Check off and initial.)

E.3.1 Preflight

_____ 1. Determine status of cloud physics instrumentation systems and report to the on-board lead project scientist (LPS).

_____ 2. Confirm mission and pattern selection from the on-board LPS.

_____ 3. Select mode of instrument operation.

_____ 4. Complete appropriate instrumentation preflight check lists as supplied in the cloud physics operator's manual.

E.3.2 In-Flight

_____ 1. Operate instruments as specified in the cloud physics operator's manual and as directed by the on-board LPS.

E.3.3 Post flight

_____ 1. Complete summary checklist forms and all other appropriate forms.

_____ 2. Brief the LPS on equipment status and turn in completed check sheets to the LPS.

_____ 3. Take cloud physics data tapes and other data forms and turn these data sets in as follows:

a. Outside of Miami-to the LPS.
b. In Miami-to AOML/HRD. [**Note**: all data removed from the aircraft by HRD personnel should be cleared with the AOC flight director.]

_____ 4. Debrief as necessary at MGOC or the hotel during a deployment.

_____ 5. Determine the status of future missions and notify MGOC as to where you can be contacted.

Cloud Physics Scientist Check List

Date ___________________ Aircraft ____________ Flight ID __________________

A. —Instrument Status and Performance:

System	Pre-Flight	In-Flight	Downtime
PMS Probes 2D-P			
PMS Probes 2D-C			
PMS Probes FSSP			
Data System			
DRI Field Mills			
King Probe			
NCAR/NOAA CIP			
NCAR PIP			
NCAR FSSP			

B. —Remarks:

E.4 Boundary-Layer Scientist

The on-board boundary-layer scientist (BLS) is responsible for data collection from AXBTs, AXCPs, AXCTDs, BUOYs, and SST radiometers (if these systems are used on the mission). Detailed calibration and instrument operation procedures are contained in the air-sea interaction (ASI) manual supplied to each operator. General supplementary procedures follow. (Check off and initial.)

E.4.1 Preflight

_____ 1. Determine the status of equipment and report results to the on-board lead project scientist (LPS).

_____ 2. Confirm mission and pattern selection from the LPS.

_____ 3. Select the mode of operation for instruments after consultation with the HRD/BLS and the LPS.

_____ 4. Complete appropriate preflight check lists as specified in the ASI manual and as directed from the LPS.

E.4.2 In-Flight

_____ 1. Operate the instruments as specified in the ASI manual and as directed by the on-board LPS.

E.4.3 Post flight

_____ 1. Complete summary checklist forms and all other appropriate forms.

_____ 2. Brief the on-board LPS on equipment status and turn in completed checklists to the LPS.

_____ 3. Debrief as necessary at MGOC or the hotel during a deployment.

_____ 4. Determine the status of future missions and notify MGOC as to where you can be contacted.

Form E-4
Page 1 of 2

AXBT and Sonobuoy Check Sheet Summary

Flight _________________ Aircraft _____________ Operator _________________

Number

(1) Probes dropped _______

(2) Failures _______

(3) Failures with no signal _______

(4) Failures with sea surface temperature, but terminated above thermocline _______

(5) Probes that terminated above 250 m, but below thermocline _______

(6) Probes used by channel number CH12 _______

CH14 _______

CH16 _______

CH__ _______

NOTES:

Form E-4
Page 2 of 3

AXBT and Sonobuoy Check Sheet (revised 6/23/04)

Flight Number ____________ Storm ______________ Storm Direction/Speed ______________

Take-Off Time ____________ Landing Time ______________

Drop #	Channel Number	Drop Time (HHMMSS)	Latitude (Decimal)	Longitude (Decimal)	Splash Time (HHMMSS)	Sfc Temp. AXBT	MLD (m) (#secs **x** 1.5)	Comments

E.5 Radar Scientist

The on-board radar scientist is responsible for data collection from all radar systems on his/her assigned aircraft. Detailed operational procedures and checklists are contained in the operator's manual supplied to each operator. General supplementary procedures follow. (Check off and initial.)

E.5.1 Preflight

_____ 1. Determine the status of equipment and report results to the lead project scientist (LPS).

_____ 2. Confirm mission and pattern selection from the LPS.

_____ 3. Select the operational mode for radar system(s) after consultation with the LPS.

_____ 4. Complete the appropriate preflight calibrations and check lists as specified in the radar operator's manual.

E.5.2 In-Flight

_____ 1. Operate the system(s) as specified in the operator's manual and as directed by the LPS or as required for aircraft safety as determined by the AOC flight director or aircraft commander.

_____ 2. Maintain a written commentary in the radar logbook of tape and event times, such as the start and end times of F/AST legs. Also document any equipment problems or changes in R/T, INE, or signal status.

E.5.3 Post flight

_____ 1. Complete the summary checklists and all other appropriate check lists and forms.

_____ 2. Brief the LPS on equipment status and turn in completed forms to the LPS.

_____ 3. Hand-carry all radar tapes and arrange delivery as follows:

a. Outside of Miami-to the LPS.
b. In Miami-to MGOC or to AOML/HRD. [**Note**: all data removed from the aircraft by HRD personnel should be cleared with the AOC flight director.]

_____ 4. Debrief at MGOC or the hotel during a deployment.

_____ 5. Determine the status of future missions and notify MGOC as to where you can be contacted.

Form E-5
Page 1 of 2

HRD Radar Scientist Check List

Flight ID: ________________________________

Aircraft Number: __________________________

Radar Operators: __________________________

Radar Technician: _________________________

Number of digital magnetic tapes on board: ______

Component Systems Status:

MARS ________________________ Computer __________________________

DAT1_________________________ DAT2 _____________________________

LF ___________________________ R/T Serial # _______________________

TA ___________________________ R/T Serial # _______________________

Time correction between radar time and digital time: _____

Radar Post flight Summary

Number of digital tapes used: DAT1 ______________________

DAT2 ______________________

Significant down time:

DAT1 _____________________ Radar LF ___________________

DAT2 _____________________ Radar TA ___________________

Other Problems:

Form E-5
Page 2 of 2

HRD Radar Tape Log

Flight ______________ **Aircraft** _______ **Operator** _______________ Sheet ____ of ____

LF RPM _______________ TA RPM ______________

(Include start and end times of DATs, as well as times of F/AST legs and any changes of radar equipment status)

Tape #	F/AST On?	Event Time (HHMMSS)	Event

Item List: DAT1, DAT2, COMP, MARS, LF, and TA.
Include serial numbers of any new R/Ts.

E.6 Dropsonde Scientist

The lead project scientist (LPS) on each aircraft is responsible for determining the distribution patterns for dropwindsonde releases. Predetermined desired data collection patterns are illustrated on the flight patterns. However, these patterns often are required to be altered because of clearance problems, etc. Operational procedures are contained in the operator's manual. The following list contains more general supplementary procedures to be followed. (Check off and initial.)

E.6.1 Preflight

_____ 1. Determine the status of the AVAPS and HAPS. Report results to the LPS.

_____ 2. Confirm the mission and pattern selection from the LPS and assure that enough dropsondes are on board the aircraft.

_____ 3. Modify the flight pattern or drop locations if requested by AOC to accommodate changes in storm location or closeness to land.

_____ 4. Complete the appropriate preflight set-up and checklists.

E.6.2 In-Flight

_____ 1. Operate the system as specified in the operator's manual.

_____ 2. Ensure the AOC flight director is aware of upcoming drops.

_____ 3. Ensure the AVAPS operator has determined that the dropsonde is (or is not) transmitting a good signal. Recommend if a backup dropsonde should be launched in case of failure.

_____ 4. Report the transmission of each drop and fill in the Dropwindsonde Scientist Log.

E.6.3 Post flight

_____ 1. Complete Dropwindsonde Scientist Log.

_____ 2. Brief the LPS on equipment status and turn in reports and completed forms.

_____ 3. Hand-carry all dropwindsonde data tapes or CDs as follows:

a. Outside of Miami-to the LPS or PI.
b. In Miami-to AOML/HRD. [**Note**: all data removed from the aircraft by HRD personnel should be cleared with the AOC flight director.]

_____ 4. Debrief at the MGOC or the hotel during a deployment.

_____ 5. Determine the status of future missions and notify MGOC as to where you can be contacted.

N42/3RF HRD GPS Dropwindsonde Scientist Log (Revised 5/2002)

Storm__________ Dropwindsonde Scientists____________________ Page ____ of ____

Flight ID__________ Flight Director____________________ Takeoff from __________ at ______ UTC

Mission ID__________ AVAPS Operators____________________ Recovery at __________ at ______ UTC

Drop #	Sonde ID #	Time (UTC)	Lat (°N)	Lon (°W)	Surface Pressure (mb)	Wind closest to surface dir/spd (kt)	hgt (m)	IR SST (°C)	Eye, Eyewall, Rainband (direction)	Comments	Ob #

N43RF ERD GPS Dropwindsonde Scientist Log (Revised 5/2002)

Storm ________ Dropwindsonde Scientists ________________________ Page ____ of ____

Flight ID ________ Flight Director ________________ Takeoff from ________ at ______ UTC

Mission ID ________ AVAPS Operators ________________ Recovery at ________ at ______ UTC

Drop #	Sonde ID #	Time (UTC)	Lat (°N)	Lon (°W)	Surface Pressure (mb)	Wind closest to surface dir/spd (kt)	hgt (m)	DLM wind (kt)	Comments	Processed	SATCOM tries	Ob #

APPENDIX F: SYSTEMS OF MEASURE AND UNIT CONVERSION FACTORS

Table F-1 Systems of measure: Units, symbols, and definitions

Quantity	**SI Unit**	**Early Metric**	**Maritime**	**English**
length	meter (m)	centimeter (cm)	foot (ft)	foot (ft)
distance	meter (m)	kilometer (km)	nautical mile (nm)	mile (mi)
depth	meter (m)	meter (m)	fathom (fa)	foot (ft)
mass	kilogram (kg)	gram (g)		
time	second (s)	second (s)	second (s)	second (s)
speed	meter per second (mps)	centimeter per second (cm s^{-1})	knot (kt) (nm h^{-1})	miles per hour (mph)
		kilometers per hour (km h^{-1})		
temperature -sensible	degree Celsius (°C)	degree Celsius (°C)	---	degree Fahrenheit (°F)
-potential	Kelvin (K)	Kelvin (K)	---	Kelvin (K)
force	Newton (N) (kg m s^{-2})	dyne (dy) (g cm s^{-2})	poundal (pl)	poundal (pl)
pressure	Pascal (Pa) (N m^{-2})	millibar (mb) (10^3 dy cm^{-2})	inches (in) mercury (Hg)	inches (in) mercury (Hg)

Table F-2. Unit conversion factors

Parameter	**Unit**	**Conversions**
length	1 in 1 ft 1 m	2.540 cm 30.480 cm 3.281 ft
distance	1 nm (nautical mile)	1.151 mi 1.852 km 6080 ft
	1 mi (statute mile)	1.609 km 5280 ft
	1° latitude	59.996 nm 69.055 mi 111.136 km
depth	1 fa	6 ft 1.829 m
mass	1 kg	2.2 lb
force	1 N	10^5 dy
pressure	1 mb	102 Pa 0.0295 in Hg
	1 lb ft^{-2}	4.88 kg m^{-2}
speed	1 m s^{-1}	1.9
	at. 6 h^{-1}	10 kt

APPENDIX G: AIRCRAFT SCIENTIFIC INSTRUMENTATION

Instrument	**Parameter**	**PI**	**Group**	**Electronics Location**	**Instrument Location**	**42RF**	**43RF**
Navigational							
INE1/2	LAT, LON		AOC			X	
GPS1/2	LAT, LON		AOC			X	
APN-159 altimeter (C-band)	Radar altitude		AOC			X	
Standard Meteorologial							
dew point	Td		AOC			X	
Rosemount temp	T, TÕ		AOC			X	
Static pressure	P		AOC			X	
Dynamic pressure	PÕ		AOC			X	
Horizontal wind	U, V		AOC			X	
Vertical wind	W		AOC			X	
Infrared Radiation							
Side CO2 radiometer	T		AOC			X	
AOC down radiometer	SST		AOC	Under floor,	Down radiometer port	X	
Weather Radar							
LF radar#	RR	Gamache	HRD	Station 3	Lower fuselage	X	
TA Doppler radar#	U, V, W vs Z, RR	Gamache	HRD	Station 3	Fuselage tail	X	
Passive Microwave							
AOC SFMR/pod #	U10, RR	Goldstein	AOC	pod	Inner right pylon	X	
USFMR (UMASS)	U10, RR	Zhang/ Chang	UMASS/ MIRSL	Station 7	Laser hole	X	
Active Microwave							
IWRAP (CSCAT, KSCAT)	U10, V10; RR; U , V, W vs Z	Zhang/ Chang	UMASS/ MIRSL, NESDIS	Station 7	Fore & aft pressure domes	X	
Passive GPS							
GPS bistatic altimeter	ocean height	Walsh	NASA GSFC, ETL	Station 5	Field mill ports (up/downlooking)	X	
Airbome Ocean Profiler							
AOC DAT recorder#	TS vs Z	Smith	AOC	Station 2	Free-fall chute (aft station 5)	X	
AOC AXBT receivers#	TS vs Z	Smith	AOC	Station 5		X	
Dropsonde Systems							
GPS AVAPS Dropsonde-4CH #	U, TA , RH vs Z	Smith	AOC	Station 5	Aft station 5	X	
GPS Dropsonde-full-up systemÕ	U, TA , RH vs Z	Smith	AOC	Station 5	Aft station 5	X	

Table G.1: NOAA/AOC WP-3D (N42RF) instrumentation

APPENDIX G: AIRCRAFT SCIENTIFIC INSTRUMENTATION (CONT'D)

Video Systems							
AOC video down	F(%), WD		AOC		Vert. Camera port	X	
Side, nose video	LCL		AOC		Side, nose camera port	X	
Cloud Mcrophysics/ Sea Spray							
DMT CIP probe[1]	Spray spectra, cloud LWC	Fairall	ETL	Station 2	Outer left pylon	X	
DMT DAS	processor	Fairall	ETL	Station 2	-----------	X	
2D-P PMS grey probe	Precip size spectra, RR	R. Black	HRD/AOC	Station C3X	Outer left pylon	X	
SEA M200 DAS	processor		AOC	Station 4	-----------	X	
Electric field mills[2] (5)	3-axis electric field	R. Black	HRD			X	
TECO Ozone sampler	ozone	Carsey	AOML			X	
Turbulence Systems							
Friehe radome gust probe system[3]	UÕ,VÕ,WÕ,TÕ	Drennan	UM/ RSMAS	Nose radome bulkhead	Nose radome	X	
BAT probe[#]	UÕ,VÕ,WÕ,TÕ	French	ARL/FRD	C3X	Nose boom	X	
FAST Hygrometer[1]	RH, qÕ	Drennan, Hubler	UM/RSMAS ,AL		fuselage	X	
LICOR -750 water vapor analyzer	qÕ	Drennan	RSMAS/ AOC	Nose radome bulkhead	Nose Radome bulkhead	X	
On board processing							
HRD Workstation[#]	GPS sonde, LF radar processing, real-time Doppler processing	Griffin	HRD	Station 3		X	
Real-time data communications systems[#]	Real-time transmission of FL, LF radar data	Chang, Carswell	NESDIS	??	??	X	

1 Re-installation, user supplied
2 If upgrade funds (~12K) become available
3 Lower Priority
Installation on NOAA-43 if aircraft becomes available
* STD - data on standard DAT tape and CD- one each per aircraft

Table G.1 (Cont'd): NOAA/AOC WP-3D (N42RF) instrumentation

APPENDIX H: NOAA EXPENDABLE AND RECORDING MEDIA

Experiment	GPS Dropwindsondes		AXBTs	CADs
	G-IV	*42RF*	*42RF*	*42RF*
Saharan Air Layer	25	25	-	-
Aerosonde	-	25	19	19
Tropical Cyclogenesis	-	25	12	12
TC Landfall and Decay	-	25	15	15
TC Eye Mixing Module	-	-	-	-
TC Synoptic Flow (operational mission)	-	-	-	-
EMC Tasking (operational mission)	-	-	12	12

Table H-1.1: Required expendables for 2006 experiments per flight day for 42RF and the G-IV.

	DATs[1]	CDs[2]	D-Audio	DVD +R DL
Experiment			**AXBTs**	**Nose/Side/Down**
Saharan Air Layer 42RF or 49	42RF: 2 / 2 / 1 = 5	42RF: 3 / 2 / 1 = 6 49: 0 / 0 / 1 = 1	-	1 / 2 / 1 = 4
Aerosonde 42RF	2 / 2 / 1 = 5	3 / 2 / 1 = 6	6	1 / 2 / 1 = 4
Tropical Cyclogenesis 42RF	2 / 2 / 1 = 5	3 / 2 / 1 = 6	6	1 / 2 / 1 = 4
TC Landfall and Decay 42RF	2 / 2 / 1 = 5	3 / 2 / 1 = 6	6	1 / 2 / 1 = 4
TC Eye Mixing Module 42RF	-	-	-	-
TC Synoptic Flow (operational mission) 42RF or 49	-	-	-	-
EMC Tasking (operational mission) 42RF	2 / 2 / 1 = 5	3 / 2 / 1 = 6	6	-

1 DATs required for Slow and Fast flight-level / Radar data / HRD Workstation Data
2 CDs required for Slow and Fast flight-level / Cloud Physics / AVAPS
NOTE: 1 DAT and 1 CD are required for G-IV missions

Table H-1.2. Required recording media for 2006 experiments per flight day for 42RF and the G-IV

ACRONYMS AND ABBREVIATIONS

?e	equivalent potential temperature
ABL	atmospheric boundary-layer
A/C	aircraft
ACLAIM	Airborne Coherent Lidar for Advanced In-flight Measurements
AES	Atmospheric Environment Service (Canada)
AFRES	U. S. Air Force Reserve
AOC	Aircraft Operations Center
AOML	Atlantic Oceanographic and Meteorological Laboratory
ASDL	aircraft-satellite data link
AXBT	airborne expendable bathythermograph
AXCP	airborne expendable current probe
AXCTD	airborne expendable conductivity, temperature, and depth probe
CARCAH	Chief, Aerial Reconnaissance Coordinator, All Hurricanes
CDO	central dense overcast
CIRA	Cooperative Institute for Research in the Atmosphere
C-MAN	Coastal-Marine Automated Network
CP	coordination point
CW	cross wind
DLM	deep-layer mean
DOD	Department of Defense
DOW	Doppler on Wheels
DRI	Desert Research Institute (at Reno)
E	vector electric field
EPAC	Eastern Pacific
ETL	Environmental Technology Laboratory
EVTD	extended velocity track display
FAA	Federal Aviation Administration
F/AST	fore and aft scanning technique
FEMA	Federal Emergency Management Agency
FL	flight level
FP	final point
FSSP	forward scattering spectrometer probe
GFDL	Geophysical Fluid Dynamics Laboratory
G-IV	Gulfstream IV-SP aircraft
GOMWE	Gulf of Mexico Warm Eddy
GPS	global positioning system
HL	Hurricanes at Landfall
HRD	Hurricane Research Division
INE	inertial navigation equipment
IP	initial point (or initial positionIWRS Improved Weather Reconnaissance System
JW	Johnson-Williams
Ku-SCAT	Ku-band scatterometer
LF	lower fuselage (radar)
LIP	Lightning Instrument Package
LPS	Lead Project Scientist
MCS	mesoscale convective systems
MGOC	Miami Ground Operations Center

MLD	Mixed Layer Depth
MPO	Meteorology and Physical Oceanography
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NDBC	NOAA Data Buoy Center
NESDIS	National Environmental Satellite, Data and Information Service
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OML	oceanic mixed-layer
PDD	pseudo-dual Doppler
PMS	Particle Measuring Systems
POD	Plan of the Day
PPI	plan position indicator
PV	potential vorticity
RA	radar altitude
RAOB	radiosonde (upper-air observation)
RAWIN	rawinsonde (upper-air observation)
RECCO	reconnaissance observation
RHI	range height indicator
RSMAS	Rosenstiel School of Marine and Atmospheric Science
SFMR	Stepped-Frequency Microwave Radiometer
SLOSH	sea, lake, and overland surge from hurricanes (operational storm surge model)
SRA	Scanning Radar Altimeter
SST	sea-surface temperature
TA	tail (radar)
TAS	true airspeed
TC	tropical cyclone
TOPEX	The Ocean Topography Experiment
TPC	Tropical Prediction Center (at NHC)
UMASS	University of Massachusetts (at Amherst)
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USWRP	U. S. Weather Research Program
UTC	universal coordinated time (U.S. usage; same as “GMT” and "Zulu" time)
VTD	velocity-track display

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