TAIL DOPPLER RADAR (TDR) EXPERIMENT

Science Description

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Requirements: Clear air and TCs at any stage

Science Objectives:

1) Gather airborne Tail Doppler Radar wind measurements that permit an accurate initialization of HWRF, and also provide three-dimensional wind analyses for forecasters [*IFEX Goals 1, 3*]

Description of Science Objectives:

SCIENCE OBJECTIVE #1: *Gather airborne Tail Doppler Radar wind measurements that permit an accurate initialization of HWRF, and also provide three-dimensional wind analyses for forecasters* [Tail Doppler Radar, TDR, Experiment]

Motivation: This experiment is a response to the requirement listed as Core Doppler Radar in Section 5.4.2.9 of the National Hurricane Operations Plan (NHOP). The goal of that particular mission is to gather airborne-Doppler wind measurements that permit an accurate initialization of the Hurricane Weather Research and Forecasting (HWRF) model, and also provide three-dimensional wind analyses for forecasters.

There are five main goals: 1) to provide a comprehensive data set for the initialization (including data assimilation) and validation of numerical hurricane simulations (in particular HWRF), 2) to improve understanding of the factors leading to TC intensity and structure changes by examining as much of the life cycle as possible, 3) to improve and evaluate technologies for observing TCs, 4) to develop rapid real-time communication of these observations to NCEP, and 5) to contribute to a growing tropical-cyclone database that permits the analysis of statistics of quantities within tropical cyclones of varying intensity.

Background: The real-time analysis of tail Doppler radar data was made possible by an automated quality control process (Gamache 2005) and variational wind synthesis method (Gamache 1997; Reasor et al. 2009).

Hypotheses:

1. Improving representation of a storm's inner core in the HWRF initial conditions through assimilation of P-3 and G-IV TDR data leads to reduced error in short-term structure and intensity forecasts.

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Aircraft Pattern/Module Descriptions:

P-3 Pattern #1: TDR
P-3 Pattern #2: TDR (Clear Air)

NOAA will conduct a set of flights during several consecutive days, encompassing as much of a particular storm life cycle as possible. This would entail using P-3s on back-to-back flights on a 12-h schedule when the system is at depression, tropical storm, or hurricane strength.

The ultimate requirement for EMC is to obtain the three-dimensional wind field of Atlantic TCs from airborne Doppler data every 6 h to provide an initialization of HWRF through assimilation every 6 h. The maximum possible rotation of missions is two per day or every 12 h. A "poor man's" version of the 6-h data collection is to collect data in the last half of one 6-h observing period, and in the first half of the next 6-h observing period.

At times when more than one system could be flown, one may take precedence over others depending on factors such as storm strength and location, operational tasking, and aircraft availability. All other things being equal, the target will be an organizing tropical depression or weak tropical storm, to increase the observations available in these systems. One scenario could likely occur that illustrates how the mission planning is determined: 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 flights, with single-P-3 missions, while the TC is below hurricane strength (preferably starting at depression stage), with continued single-P-3 missions at 12-h intervals until the system is out of range or makes landfall. During the tropical depression or tropical-storm portion of the vortex lifetime, 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 than the highest temporal resolution of the eyewall. In all cases adequate spatial coverage is preferred over increased temporal resolution during one sortie.

The highest vertical resolution is needed in the boundary and outflow layers. This is assumed to be where the most vertical resolution is needed in observations to verify the initialization and model. For this reason it is desirable that *if sufficient dropwindsondes are available*, they should be deployed in the radial penetrations to verify that the boundary layer and surface wind forecasts produced by HWRF resemble those in observations. These observations will also supplement airborne Doppler observations, particularly in sectors of the storm without sufficient precipitation for radar reflectivity. *If sufficient dropwindsondes are not available*, a combination of SFMR and airborne Doppler data will be used for verification.

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G-IV Pattern #1: TDR
G-IV Pattern #2: TDR (Clear Air)

The ultimate requirement for EMC is to obtain the three-dimensional wind field of Atlantic TCs from airborne Doppler data every 6 h to provide an initialization of HWRF through assimilation every 6 h. The maximum possible rotation of missions is two per day or every 12 h. The TDR on the G-IV will be considered operational; therefore velocity data will be transmitted in real-time to EMC. We recommend storm overflight whenever possible during synoptic surveillance missions. The most effective pattern, fulfilling the needs for inner-core assimilation and the current operational requirement for synoptic measurement, will be refined through experiments using the Hurricane Ensemble Data Assimilation System (HEDAS) and consultation with NHC and EMC.

Beyond operationally-tasked G-IV missions, among some specific scenarios in which this experiment would be carried out are as follows: 1) at the conclusion of NHC tasking for a landfalling TC, likely coordinated with the P-3 aircraft; 2) prior to NHC tasking for a TC of interest to EMC (priority is coordination with P-3 aircraft); 3) a recurving TC (priority is coordination with P-3 aircraft). Since coordination with the P-3 aircraft is an early requirement, this experiment would have to be weighed against other experiments, which stagger the P-3 and G-IV flight times. This initial coordination is necessary for 1) comparing and synthesizing storm structure derived from the two radar platforms and 2) the most thorough testing of HEDAS with this new data source. Subsequent flights may relax this requirement for P-3 coordination as the quality of the G-IV data is established and G-IV overflight of systems becomes more routine.

Analysis Strategy: The emphasis here is on "real-time" products. Quality-controlled, thinned Doppler radials are output, packaged and transmitted to NCEP Central Operations (NCO) for assimilation into the operational HWRF model. Similarly, Doppler radial superobs are transmitted for use by research groups. Three-dimensional and vertical profile analyses of wind and reflectivity are also produced. Plan-view images derived from the analyses are transmitted to a location where NHC hurricane specialists can view them. Additional products include composite analysis images with dropwindsonde winds overlaid and, most recently, wind and reflectivity structure images for real-time mission planning and viewing by NHC specialists.

References:

Gamache, J. F., 1997: Evaluation of a fully three-dimensional variational Doppler analysis technique. Preprints, *28th Conf. on Radar Meteorology,* Austin, TX, Amer. Meteor. Soc., 422–423.

Gamache, J. F., 2005: Real-time dissemination of hurricane wind fields determined from airborne Doppler radar data. National Hurricane Center, 38 pp. [Available online at http://www.nhc.noaa.gov/jht/2003-2005reports/DOPLRgamache_JHTfinalreport.pdf.]

Reasor, P. D., M. Eastin, and J. F. Gamache, 2009: Rapidly intensifying Hurricane Guillermo (1997). Part I: Low-wavenumber structure and evolution. *Mon. Wea. Rev.*, **137**, 603–631.