SATELLITE VALIDATION EXPERIMENT
Science Description

Experiment/Module: NESDIS JPSS Satellite Validation Experiment

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Requirements: No requirements: flown at any stage of the TC lifecycle

Plain Language Description: This experiment seeks to use aircraft observations to validate satellite measurements of temperature and moisture in a variety of environments that can affect tropical cyclone intensity and structure. This will be accomplished by coordinating NOAA's G-IV jet to fly below the NOAA-20 and Suomi-NPP satellites when they are passing overhead.

Motivation: NUCAPS atmospheric soundings (temperature, moisture, and trace gases) produced from the NOAA-20 and Suomi-NPP polar orbiting satellites provide global coverage and have been extensively validated using ground-based and ship-launched rawinsondes (Nalli et al. 2013). However, the performance of NUCAPS in tropical environments with strong horizontal and vertical gradients in temperature and moisture [e.g., the Saharan Air Layer and the environments of tropical disturbances (e.g., African easterly waves (AEWs), invests, and TCs)] has not been extensively assessed. The validation (NUCAPS) and evaluation (forecast models) efforts proposed in this experiment are motivated by two factors: 1) NUCAPS can provide thousands of atmospheric soundings in the environments of TCs globally; and 2) thermodynamics can be an important factor governing the intensity and structure of AEWs, invests, TCs, and TCs undergoing extratropical transition (ET). NUCAPS ozone retrievals may also be useful for detecting ET and have not been evaluated in the context of TCs. Stratospheric intrusions are associated with ET and can increase ozone concentrations and decrease tropospheric temperatures. Since the tropospheric-stratospheric exchange occurs above the cloud top, NUCAPS retrievals are not impacted by precipitation and cloudy scenes, which typically cause unrealistic retrievals below the cloud top.

Background: The NOAA Unique Combined Atmospheric Processing System (NUCAPS) provides atmospheric soundings of temperature, water vapor, cloud fraction, cloud top pressure, trace gases, dust, and volcanic emissions. NUCAPS is a heritage algorithm based upon the Atmospheric Infrared Sounder (AIRS) Science Team algorithm (Susskind et al. 2003), implemented operationally at NOAA since 2002. These soundings are derived from the CrIS (1,305 IR channels; 3.9-15 μm) and ATMS (22 microwave channels; 23-183 GHz) instruments flying onboard the Suomi-NPP & NOAA-20 polar orbiting satellites. NUCAPS provides ~324,000 soundings per day with 20-30 min latency and is also now available in a gridded format in AWIPS. NUCAPS grids are geolocated and provide two-dimensional views of temperature, humidity, and ozone. Stability metrics that are useful for monitoring TC intensification, such as lapse rates, can be derived from profiles and are available in gridded form.

Goal(s): Use GPS dropsondes launched from the NOAA G-IV jet to validate NUCAPS 3-dimensional temperature and moisture profiles produced from the NOAA-20 and Suomi-NPP polar orbiting satellites. Use GPS dropsonde data to assess the skill of NUCAPS soundings and evaluate analyses from the GFS and FV3-GFS models.

Hypotheses:

1. NUCAPS may not fully detect dryness in the SAL when its top (~550 hPa) is capped by a moist layer and may not completely capture the strong temperature inversions (~1-5°C) found at its base (~850 hPa).
2. NUCAPS soundings may be less skillful in areas with high horizontal gradients of temperature and moisture, including the periphery and especially leading edges of SAL outbreaks and the periphery of tropical disturbances (e.g., AEWs, invests, and TCs).
3. NUCAPS soundings will be more robust in the (near) cloud-free environment outside the TC inner core [R≥80 n mi (150 km)] but may be less skillful in areas where TC outer rainbands and cirrus clouds associated with the TC outflow layer are present.
4. NUCAPS soundings may be useful for anticipating ET by examining the environment aloft in terms of thermodynamics and ozone anomalies but may not capture changes in the internal TC structure.

Objectives:

1. Coordinate G-IV GPS dropsonde observations and overpasses by the NOAA-20 and Suomi-NPP satellites that are coincident in time (preferably ≤1 hr) and space [preferably ≤27 n mi (≤50 km)].
2. Collect GPS dropsonde thermodynamic observations in environments where the SAL is interacting with an AEW or TC and use those soundings to validate coincident NUCAPS atmospheric profiles.
3. Collect GPS dropsonde thermodynamic observations in the near environment [R~80-160 n mi (150-300 km)] of TCs where the atmospheric profile contains a mixture of clear/subsiding air, outer rainbands, and the outer edges of the TC cirrus canopy. Use those soundings to validate coincident NUCAPS atmospheric profiles.
4. Collect GPS dropsonde thermodynamic observations in environments where a TC is undergoing ET to validate coincident NUCAPS atmospheric profiles.

Aircraft Pattern/Module Descriptions (see *Flight Pattern* document for more detailed information):

G-IV Pattern 1/Module 1: This can be a stand-alone pattern or a break-away module that samples the environment of the SAL. Targets will include sampling the SAL's thermodynamics (warmth and low to mid-level dry air) for satellite validation, as well as the SAL's mid-level easterly jet. Although not a requirement, the SAL would preferably be interacting with a tropical disturbance (e.g., AEW, invest, or TC). For SAL-only sampling, a standard (or modified) Lawnmower pattern will be flown. For tropical disturbances interacting with the SAL, the following standard patterns can be flown: Figure-4, Rotated Figure-4, Butterfly, Lawnmower, Square Spiral, G-IV Circumnavigation, G-IV Star, or G-IV Star with Circumnavigation. For TC targets, circumnavigations will be flown as close to the inner core as safety permits [e.g., R~60-90 n mi (110-165 km)] and legs should extend out to the (near) cloud free region in the periphery of the storm [e.g., R=80-215+ n mi (150-400+ km)] to sample regions where NUCAPS soundings will experience less cloud contamination and therefore likely to be more robust. Take-off times will be adjusted to maximize temporal and spatial overlap with overpasses by the NOAA-20 and Suomi-NPP satellites. Targets of interest can also be sampled during ferries to/from the storm.

G-IV Pattern 2/Module 2: This can be a stand-alone pattern or a break-away module that samples the peripheral environment (e.g., R~90-215 n mi/165-400 km) of a tropical disturbance (e.g., AEW, invest, or TC) or the environment of a TC undergoing ET. Depending on the intensity of the target of interest, the following standard patterns can be flown: Figure-4, Rotated Figure-4, Butterfly, Lawnmower, Square Spiral, G-IV Circumnavigation, G-IV Star, or G-IV Star with Circumnavigation. For TC targets, circumnavigations will be flown as close to the inner core as safety permits [e.g., R≥60-90 n mi (110-165km)]. For TCs undergoing ET at higher latitudes (e.g., north of 35°N), the lower climatological altitude of the tropopause may allow the G-IV to more easily overfly the storm center and will be assessed on a case by case basis. Take-off times will be adjusted to maximize temporal and spatial overlap with overpasses by the NOAA-20 and Suomi-NPP satellites. Targets of interest can also be sampled during ferries to/from the storm.

Links to Other Mature Stage Experiments/Modules: The NESDIS JPSS Satellite Validation Experiment and Modules can generally be flown in conjunction with AIPEX, TCDC Experiment, Gravity Wave Module, and ADM-Aeolus Satellite Validation Experiment.

Analysis Strategy: Guidance for G-IV take-off times will be determined by the timing and location of NOAA-20 and Suomi-NPP satellite overpasses in the area of the target(s) of interest. The GPS dropsonde sampling strategy will be determined by the tropical disturbance and/or SAL outbreak locations relative to the satellite overpass times and locations. Retrospective analyses will be conducted to assess the skill of NUCAPS and numerical model analyses (e.g., GFS and FV3-GFS) to represent the environments that are sampled by GPS dropsondes.

References:

Nalli, N. R., Barnet, C. D., Reale, A., Tobin, D., Gambacorta, A., Maddy, E. S., Joseph, E., Sun, B., Borg, L., Mollner, A. K., Morris, V. R., Liu, X., Divakarla, M., Minnett, P. J., Knuteson, R. O., King, T. S., & Wolf, W. W, 2013: Validation of satellite sounder environmental data records: Application to the Cross-Track Infrared Microwave Sounder Suite. *J. Geophys. Res.: Atmos.*, **118 (24)**, 13628-13643.

Susskind, J., C. Barnet, and J. Blaisdell, 2003: Retrieval of atmospheric and surface parameters from AIRS/AMSU/HSB data in the presence of clouds." *IEEE Transactions on Geoscience and Remote Sensing*, **41 (2)**, 390-409.