SATELLITE VALIDATION EXPERIMENT
Science Description

Experiment/Module: ADM-Aeolus Satellite Validation Module

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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 winds in the environment of tropical cyclones. This will be accomplished by coordinating NOAA's P-3s and G-IV high altitude jet with overpasses of the ADM-Aeolus satellite.

Satellite Validation Science Objective(s) Addressed:

1. Test new (or improved) satellite technologies with the potential to fill gaps, both spatially and temporally, in the existing suite of airborne measurements in TCs. These measurements include improved three-dimensional representation of the hurricane wind field and thermodynamic structure and more accurate measurements of ocean surface winds and underlying ocean conditions [*APHEX Goal 2*]

Motivation: ADM-Aeolus represents the first satellite mission to measure profiles of Earth's wind globally and can also be used to detect atmospheric aerosols (Flamant et al. 2008). The validation and evaluation efforts proposed in this module are motivated by several factors: 1) ADM-Aeolus can provide 2,400 atmospheric wind profiles globally per day and can provide data in traditionally data sparse regions of the globe; 2) although the radius of tropical storm force winds (R34) is an important component of the TC forecast process, determining these winds in the periphery of TCs can be difficult in data sparse regions. ADM-Aeolus can provide valuable wind observations to help forecasters determine R34; 3) the Saharan Air Layer (SAL) has been shown to suppress TC formation and intensification in the Atlantic. ADM-Aeolus can detect the SAL's suspended mineral dust and 600-800 hPa (z~4.4-2.1 km) mid-level easterly jet and can be used to help assess SAL-TC interactions.

Background: ADM-Aeolus was launched on 22 August 2018 and represents the first satellite mission to acquire profiles of Earth's wind on a global scale. The Aeolus satellite is instrumented with the Atmospheric Laser Doppler Instrument (Aladin, Ansmann et al. 2007), a Doppler wind lidar that probes the lowermost 30 km of the atmosphere to measure winds and aerosols Tan et al. 2008). This laser system generates a series of short light pulses in the ultraviolet spectrum at 355 nm, a wavelength where backscatter from atmospheric molecules is particularly strong (Li et al. 2010). Two optical analyzers measure the Doppler shift of the molecular scattering (Rayleigh) and scattering from aerosols and water droplets (Mie). The telescope is pointed 35° away from the orbit plane in order to transmit and receive light perpendicular to the speed of the satellite. This allows Aladin to determine the east-west horizontal component of the atmosphere. The dusk/dawn orbit – where the satellite crosses the equator at 0600 and 1800 (local time) – provides maximum illumination from the Sun and a stable thermal environment. Observations of the wind will be taken from the night-side of the satellite to avoid the solar background. The ADM-Aeolus mission will:

- Measure global wind profiles (along a single line-of-sight) up to an altitude of 30 km
- Measure wind to an accuracy of 1 m s^{-1} in the planetary boundary layer (up to an altitude of 2 km)
- Measure wind to an accuracy of 2 m s^{-1} in the free troposphere (up to 16 km)
- Determine the average wind velocity over ~100 km along-track footprints (for cross-track, measurements are line-of site)

Goal(s): Coordinate P-3 Orion and G-IV under-flights of the ADM-Aeolus satellite that will provide opportunities to calibrate and validate the satellite-based wind observations against the remote sensing and in situ observations that will be collected by the NOAA aircraft.

Hypotheses:

1. ADM-Aeolus can provide valuable wind profiles in the peripheral TC environment from just outside the TC inner core [i.e., R~80 n mi (150 km)] to the radius of tropical storm force (34 kt) winds [R~125 n mi (230 km for Atlantic hurricanes)].
2. ADM-Aeolus can detect the mid-level easterly jet [~600-800 hPa (z~4.4-2.1 km)] and suspended mineral dust [surface to ~500 hPa (z~5.9 km)] associated with SAL outbreaks.
3. Reference wind and aerosol profiles obtained from aircraft observations in partly cloudy scenes can be used to assess the representativeness of ADM-Aeolus wind measurements and the effectiveness of ADM-Aeolus processing algorithms to correct for effects of clouds, as well as to infer error characterization of the satellite retrievals.
4. Observing System Experiments (OSEs) can be used to evaluate and potentially enhance the impact of ADM-Aeolus data on both global and regional numerical weather prediction with an emphasis on hurricanes.

Objectives:

1. Coordinate G-IV GPS dropsonde observations and overpasses by the ADM-Aeolus satellite that are coincident in time (preferably ≤30 min) and space [preferably ≤15 n mi (≤25 km)].
2. Collect GPS dropsonde and tail Doppler radar (TDR) data to validate ADM-Aeolus atmospheric profiles of winds derived from ADM-Aeolus satellite in a variety of tropical environments using aircraft data.
3. Evaluate and potentially enhance the impact of ADM-Aeolus data on both global and regional numerical weather prediction of tropical cyclones (TCs).

Aircraft Pattern/Module Descriptions (see *Flight Pattern* document for more detailed information): This is a break-away module that includes an underflight of an ADM-Aeolus ascending or descending orbital pass. Since ADM-Aeolus is in low Earth orbit, timing of this module will vary depending on the location of the target area, but for reference: in order to limit solar contamination, the satellite crosses the equator at ~0600 LST (descending pass) and ~1800 LST (ascending pass). Also, since the Aladin lidar instrument is aimed 35° from nadir and 90° to the satellite track (on the side away from the Sun), underflights of ADM-Aeolus will require an offset of 125 n mi (230 km) to the east (west) of nadir for ascending (descending) passes.

P-3 Module 1: This is a break-away module that includes an underflight of ADM-Aeolus. The module requires a straight-line leg, the timing, location and length of which will be coordinated by the Co-PIs before the mission. During the satellite underflight, sampling will include a series of GPS dropsondes and TDR measurements. This module can also be conducted during ferries to/from the target of interest.

G-IV Module 1: This is a break-away module that includes an underflight of ADM-Aeolus. The module requires a straight-line leg, the timing, location and length of which will be coordinated by the Co-PIs before the mission. During the satellite underflight, sampling will include a series of GPS dropsondes. This module can also be conducted during ferries to/from the target of interest.

Links to Other Experiments/Modules: The ADM-Aeolus Satellite Validation Module can be flown in conjunction with nearly all HFP Genesis, Early, and Mature Stage experiments. P-3 and/or G-IV GPS dropsonde targeting can also be performed during ferries to/from targets of interest (e.g., African easterly wave, invest or TC).

Analysis Strategy: Guidance for this P-3/G-IV module will be determined by the timing and location of ADM-Aeolus satellite overpasses in the area of the target(s) of interest. The GPS dropsonde and TDR sampling strategies will be determined by the environmental conditions (e.g., cloudiness that could limit ADM-Aeolus wind and aerosol retrievals) relative to the satellite overpass times and locations. Observing System Experiments (OSEs) will be used to evaluate and potentially enhance the impact of ADM-Aeolus data on both global and regional numerical weather prediction. Future work will include assimilating these observations into the global and hurricane prediction systems when the tuning of the assimilation algorithms in GSI are finalized.

References:

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