2022 NOAA/AOML/HRD Hurricane Field Program - APHEX

SATELLITE VALIDATION EXPERIMENT
Science Description

Experiment/Module: TROPICS Satellite Validation Module

Investigator(s): Brittany Dahl (co-PI), Jason Dunion (co-PI), Rob Rogers (co-PI), Jon Zawislak (co-PI), Trey Alvey, William Blackwell (MIT, Lincoln Laboratory)

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

Plain Language Description: This experiment is designed to calibrate and validate temperature, moisture, and precipitation measurements obtained from the new TROPICS satellites. These profiles will be compared to NOAA P-3 and G-IV aircraft observations, whose flight patterns will be coordinated in space and time with overpasses from the 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:
The TROPICS satellite mission will deliver unprecedented rapid-update microwave measurements over the tropics that can be used to observe the evolution of the mesoscale precipitation structure and thermodynamic environment of tropical cyclones (TCs). These observations, produced from TROPICS retrieval algorithms, will require calibration and validation, which can be achieved by comparing them to in-situ and remotely-sensed observations from the NOAA aircraft.

Background:
The Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) satellite mission will deliver unprecedented rapid-update microwave measurements over the tropics that can be used to observe the evolution of the mesoscale precipitation structure and thermodynamic environment of tropical cyclones (TCs). TROPICS consists of six MicroMAS-2 CubeSats that are arranged in pairs across three low-Earth orbital planes at an altitude of 550 km and an inclination of 30°. Each satellite hosts a passive microwave radiometer that will provide radiance observations sensitive to atmospheric temperature, water vapor, precipitation, and precipitation-size ice particles (Blackwell et al. 2018). For the scan geometry, the satellite temperature channels have a footprint of ~17 km, while the water vapor channels have a footprint of ~24 km. At 90 GHz (the frequency most sensitive to precipitation detection), the nadir footprint is ~30 km. The full TROPICS satellite swath width is ~2000 km with the most useful data for comparison being located within ~750 km of nadir. Data products from the satellites include radiance observations as well as derived profiles of temperature and moisture. Currently, launch of the six satellites included in the original TROPICS mission is pending but is anticipated to occur over the summer of 2022. Ahead of the planned constellation,

however, an extra TROPICS CubeSat known as the TROPICS Pathfinder was launched in 2021 in a sun-synchronous orbit and will continue to provide data during this season.

Goal(s): Coordinate NOAA P-3 and G-IV under-flights of TROPICS satellites that will provide opportunities to calibrate and validate the satellite-based temperature, moisture, and precipitation observations against the remote sensing and in-situ observations that will be collected by the NOAA aircraft.

Hypotheses:

1. Temperature, moisture, and precipitation profiles from aircraft observations can be used to evaluate the performance of the TROPICS retrieval algorithm and characterize the retrieval errors.
2. Observing system experiments (OSEs) can be used to evaluate, and potentially enhance, the impact of TROPICS data on regional numerical weather prediction of tropical cyclones.

Objectives:

1. Collect GPS dropsonde and aircraft tail Doppler radar (TDR) data to validate TROPICS satellite-derived temperature, moisture, and precipitation profiles in a variety of tropical environments.
2. Coordinate G-IV GPS dropsonde releases and TROPICS satellite overpasses co-located in time (within 30 min) and space (within 750 km of satellite nadir).
3. Evaluate and potentially enhance the impact of TROPICS data on regional numerical prediction of tropical cyclones.

Aircraft Pattern/Module Descriptions (see *Flight Pattern* document for more detailed information): This is a breakaway module that includes an underflight of a TROPICS orbital pass. The Pathfinder satellite is in a sun-synchronous orbit and crosses the equator at ~1330 LT during its ascending pass. This time will vary for the six constellation satellites, which are inclined at a 30° angle from the equator. Although the full satellite swath width is ~2000 km, the most useful data for comparison is within ~750 km of nadir and should therefore be the focus.

P-3 Module 1: This is a breakaway module that includes an underflight of TROPICS. The timing, location and length of the flight leg required for this module will be coordinated by the Co-PIs before the mission. A straight flight leg is ideal but not required. During the satellite underflight, sampling will include a series of GPS dropsondes and continuous collection of TDR measurements. This module can also be conducted during ferries to/from the target of interest.

G-IV Module 1: This is a breakaway module that includes an underflight of TROPICS. The timing, location and length of the flight leg required for this module will be coordinated by the Co-PIs before the mission. A straight flight leg is ideal but not required. During the satellite

underflight, sampling will include a series of GPS dropsondes and continuous collection of TDR measurements. This module can also be conducted during ferries to/from the target of interest.

Links to Other Experiments/Modules: The TROPICS 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 TROPICS satellite overpasses in the area of the target(s) of interest. The GPS dropsonde and TDR sampling strategies will be determined based on the environment being sampled (TC inner core, near environment, etc.). Observing system experiments (OSEs) will be used to evaluate and potentially enhance the impact of TROPICS data on regional numerical weather prediction of tropical cyclones.

References:

Blackwell W.J. and Coauthors, 2018: An overview of the TROPICS NASA Earth Venture Mission. *Q. J. R. Meteorol. Soc.,* **144** (Suppl. 1):16–26. https://doi.org/10.1002/qj.3290.