2018 NOAA/AOML/HRD Hurricane Field Program - IFEX

SYNOPTIC FLOW EXPERIMENT
Science Description

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

Science Objectives:

1) Investigate new strategies for optimizing the use of aircraft observations to improve numerical forecasts of TC track, intensity, and structure [*IFEX Goal 1*]

Description of Science Objectives:

SCIENCE OBJECTIVE #1: *Investigate new strategies for optimizing the use of aircraft observations to improve numerical forecasts of TC track, intensity, and structure*
(Synoptic Flow)

Motivation: Operational G-IV Synoptic Surveillance missions have resulted in average GFS track-forecast improvements of 5–10% and statistically significant intensity improvements through 72 h (Aberson 2007). However, the basic G-IV flight-track design and observational sampling strategies have remained largely unchanged for the past decade while the model, ensemble and data-assimilation systems have been upgraded considerably. The Synoptic Flow Experiment is designed to investigate new strategies for optimizing the use of aircraft observations to improve numerical forecasts of TC track, intensity, and structure.

Background: Accurate numerical TC forecasts require the representation of meteorological fields on a variety of scales, and the assimilation of the data into realistic models. Based on this requisite, HRD re-designed a Synoptic Flow Experiment in the 1998 to improve track predictions of TCs during the watch and warning period by targeting dropsonde observations in the storm environment and assimilating those data into numerical models. Optimal sampling was attained using a fully nonlinear technique that employed the breeding method, the operational NCEP ensemble-perturbation technique at the time, in which initially random perturbations in the model were repeatedly evolved and rescaled. This technique helped define the fastest growing modes of the system, where changes to initial conditions due to additional data grow (decay) in regions of large (small) perturbation in the operational NCEP Ensemble Forecasting System. Although this approach provides a good estimate of the locations in which supplemental observations are likely to have the most impact by identifying locations of probable error growth in the model, it does not distinguish those locations which impact the particular TC forecast of interest from those which do not. The G-IV flight track designs and targeting techniques developed from the series of 1996–2006 HRD Synoptic Flow Experiments were transitioned to operations at NOAA NHC and AOC in 2007 and have continued to be an integral part of operations since then. These operational missions resulted in average GFS track-forecast improvements of 5–10% and statistically significant intensity improvements through 72 h (Aberson 2007).

Hypotheses: New, more advanced targeting techniques that optimize aircraft sampling of the TC environment can improve numerical forecasts of TC track, intensity, and structure, and could potentially be transitioned to operations.

Aircraft Pattern/Module Descriptions:

P-3 Pattern #1: Synoptic Flow

When ensemble prediction systems suggest sensitivity of TC-related forecast metrics (position, intensity and track, etc.) in/near the inner core (i.e. R≤105 n mi/R≤200 km), fly any standard pattern that provides symmetric coverage (e.g., Figure-4, Rotated Figure-4, Butterfly, P-3 Circumnavigation).

G-IV Pattern #1: Synoptic Flow

When ensemble prediction systems suggest sensitivity of TC-related forecast metrics (position, intensity and track, etc.), fly a non-standard pattern that will vary from storm to storm and be defined by regions that are identified using model targeting techniques. These patterns will typically resemble a Lawnmower pattern. The over storm or near storm portion of the pattern could incorporate the following standard patterns: Figure-4, Rotated Figure-4, Butterfly, Lawnmower, Square Spiral, G-IV Circumnavigation, G-IV Star, or G-IV Star with Circumnavigation.

Analysis Strategy: Guidance from ensemble prediction systems will be used to compute the sensitivity of TC-related forecast metrics (position, intensity and track, etc.) and will be used to guide GPS dropsonde sampling of the TC and its environment. Retrospective data denial experiments will be conducted post mission to assess the impact of the GPS dropsonde data on model forecasts of TC track, intensity and structure.

References:

Aberson, S.D., 2010: 10 years of hurricane synoptic surveillance (1997–2006). *Mon. Wea. Rev.*, **138**, 1536–1549.

Torn, R.D., R. Rios-Berrios, Z. Zhang, and A. Brammer, 2017: Application of ensemble-based sensitivity analysis during SHOUT. *97th AMS Annual Meeting*, Seattle, WA.

Torn, R.D., 2014: The impact of targeted dropwindsonde observations on tropical cyclone intensity forecasts of four weak systems during PREDICT. *Mon. Wea. Rev.*, **142**, 2860–2878.