An Algorithm for the Use of Tropical Cyclone GPS Dropsondes within Operational Numerical Weather Prediction Systems

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1 Introduction

Global positioning system (GPS) dropsondes, which are deployed during North Atlantic and Eastern Pacific ocean basins during tropical cyclone (TC) aircraft reconnaissance missions, are transmitted to the National Centers for Environmental Prediction (NCEP) and encoded using the TEMP-DROP format [1]. Currently, and for data assimilation purposes, the observation locations are specified as the GPS dropsonde launch position for all thermodynamic and kinematic variables. Although at large radii, relative to the TC center of circulation (i.e., the environment) this practice may only lead to small errors in observation positions, the errors may become very large as the circulation of the TC is encountered. For this reason NCEP rejects all wind observations within the TC vortex. In this study, we evaluate the implications upon TC track forecasts when the trajectory of the GPS dropsondes is estimated and assimilated.

2 Methodology

The reconnaissance aircraft missions considered in this study are both piloted (e.g., the NOAA P3 and the United States Air Force C-130) and unmanned (i.e., the NASA/NOAA Global Hawk). The GPS dropsondes are launched via a chute installed on the respective aircraft and a parachute is immediately deployed as the dropsonde falls. The collected observations for height, temperature, dew point-depression, wind speed, and wind direction are recorded at standard isobaric levels and encoded using the TEMP-DROP format. Also encoded are the time and location of the first wind observation (e.g., launch) and time and location of the last wind observation (e.g., surface impact).

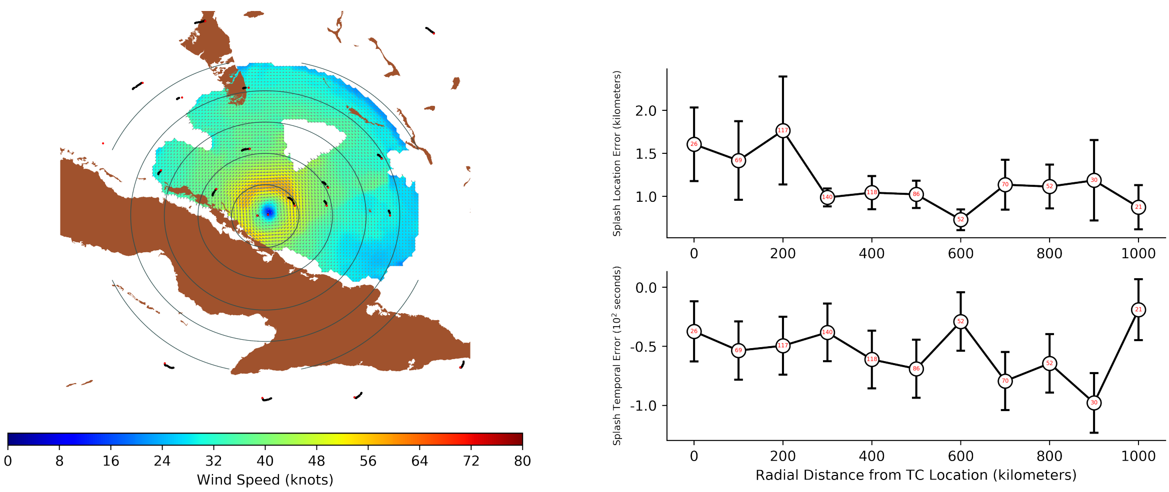

Figure 1: (left) The column integrated HRD radar winds (shaded) and wind vectors (gray arrows) valid 08 September for TC Irma (2017). The dropsonde release locations (red) and subsequent advection trajectories (black), temporally concurrent with the respective the NOAA 42 mission commencing 1710 UTC 08 September and ending 0123 UTC 09 September, are super-imposed. (right) (a) The distance and (b) temporal error error for 1147 dropsonde TEMP-DROP message encodings that contain a SPL (e.g., dropsonde impact location) message as a function of the distance from the TC center of circulation. The mean, the 95% confidence intervals, and the respective interval sample size are denoted by the black circles, error bars, and red text, respectively.

The respective TEMP-DROP observation messages are decoded into NOAA/AOML HSA formatted files

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[2]. Using the launch time and location, theoretical fall-speed for the GPS dropsonde, and observed vector wind components, the advected position for the GPS dropsonde is deduced. Figure 1 illustrates the GPS dropsonde launch and predicted positions super-imposed upon the HRD composite wind analysis valid for TC Irma (2017) on 08 September. The absolute distance and time errors, as determined by computing the difference between the estimated dropsonde trajectory and surface impact information within the TEMP-DROP encoded message for all drops in Figure 1 (left), are 0.932-km and 45.4 seconds, respectively. Also provided is an analysis of the spatial and temporal errors, as a function of radial distance from the respective TC, for all GPS dropsondes containing a splash location message and collected within North Atlantic ocean basin TCs during the period 2015 - 2017.

3 Forecast Experiments

In this section, we compare results for NWP forecast experiments without GPS dropsonde drift assimilation (CNTRL) to experiments without estimation of drift or assimilation of inner-core winds (CTRL) to experiments where the drift is estimated and all winds are assimilated. The Hurricane Weather Research and Forecasting (HWRF) model provides the dynamical atmospheric predictions while the NCEP Grid-point Statistical Interpolation (GSI) system enables the assimilation of all atmospheric observations.

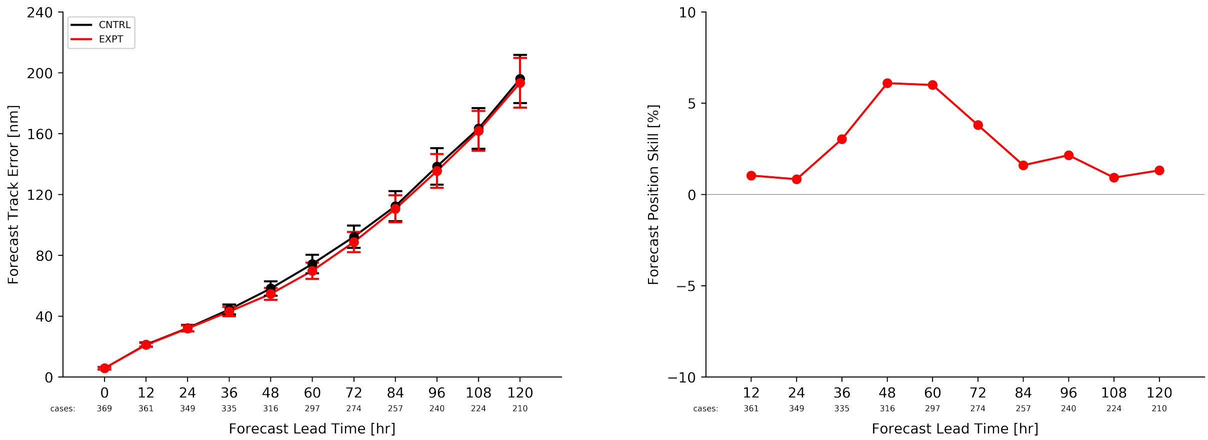

Figure 2: (left) The TC track forecast error for CNTRL (black) and EXPT (red) compared to observations and (right) the TC track forecast skill for EXPT (red) compared to CNTRL.

Figure 2 (left) illustrates the TC track forecast error (compared to observations) for EXPT and CNTRL and (right) the TC track forecast skill for EXPT when compared to the baseline experiment (CNTRL). Overall, the TC track forecast error is reduced for EXPT, in particular at medium range forecast lead times. This is further illustrated when assessing the TC track forecast skill at medium range lead-times where the improvement is on the order of nearly 7%.

4 Ongoing Research and Future Applications

The 2018 NCEP operational HWRF forecasting system will include dropsonde drift assimilation when reconnaissance observations are available.

References

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