Impact of Atmospheric River Reconnaissance Dropsonde Data on NCEP GFS Forecast: A Case Study

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1. Introduction

Atmospheric rivers (ARs) are long narrow corridors of water vapor transport that serve as the primary mechanism to advect moisture into mid-latitude continental regions, including the U.S. West Coast. They are responsible for most of the horizontal water vapor flux outside of the tropics and are an important source of precipitation. Although the advances in satellite data assimilation have greatly improved global model forecast skill, including the NCEP global forecast system (GFS), forecasting AR features and the corresponding precipitation remains a challenge due in part to their formation and propagation over the ocean, where in-situ and ground-based observations are extremely limited (Zheng *et al*. 2021). The AR Reconnaissance (AR Recon) Campaigns (Ralph *et al*. 2020) that took place during the winters of 2016 and 2018-2021 provide additional data by supplementing conventional data assimilation with dropsonde observations of the full atmospheric profile of water vapor, temperature, and winds within the ARs.

2. Experiments

In this study the NCEP GFS version 15 (GFSv15) was used to examine the impact of AR supplemental dropsonde observation data on the GFS forecast. GFSv15 was implemented into operations in June 2019 at NCEP. It was developed with the finite volume cubed-sphere dynamical core and microphysics from GFDL, and 4D-Hybrid En-Var data assimilation (DA). The dropsonde data used were from the AR Recon 2020 campaigns, including 17 intensive observation periods (IOPs) from January 24 to March 11. Global control (CTRL) and denial (DENY) experiments were conducted by using or denying the dropsonde data in the GFSv15 in the period from January 24 to March 18 for both DA and model forecasts; the additional 7 days of runs are needed to verify the forecasts from the last IOP of March 11.

3. Results

The standard NCEP *vsdb* verification system [1] was used to evaluate the CTRL and DENY experiments. Overall the global verification metrics were very similar between CTRL and DENY, with slightly better forecast skill noted over the Pacific North American (PNA, 180-320E, 20-75N) region when the supplemental dropsonde data were used (Figure 1). For cases where the prediction skill is relatively low (i.e., the prediction is challenging), the data collected from the dropsondes helped to improve AR related precipitation forecasts and increase the 5-day anomaly correlation, including geopotential height, temperature, and wind (Figure 1). Precipitation observations are critical for verifying AR impact. The impact of the dropsonde data over the CONUS was small and insignificant. However, precipitation prediction over the U.S. West Coast improved significantly in the CTRL when dropsonde data are used (Figure. 2). It is also associated with improvement in the water vapor transport forecasts in the CTRL (not shown).

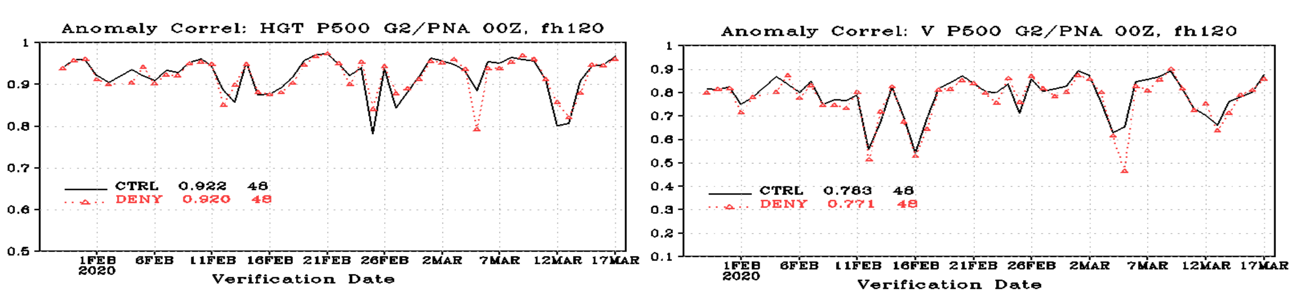

Figure 1. Anomaly correlation of day-5 forecast for geopotential height (HGT) and meridional wind (V) at 500 hPa over PNA.

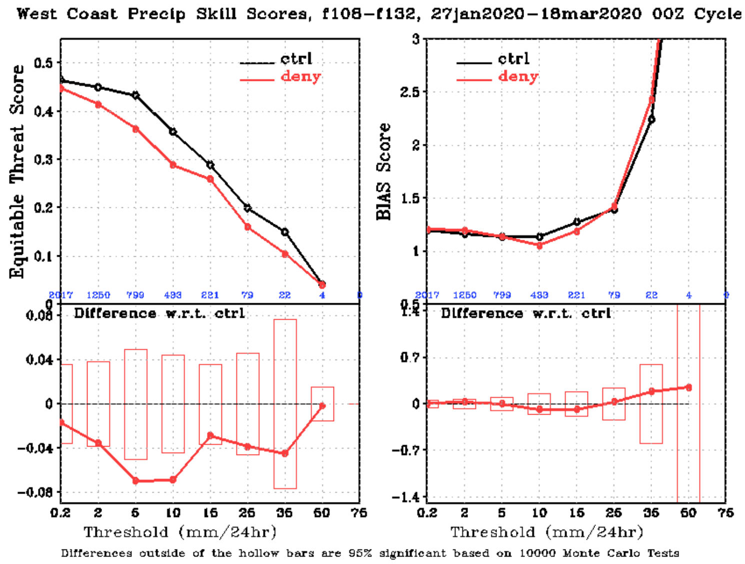

Figure 2. 24-h precipitation Equitable Threat Scores of day-5 forecast for CTRL and DENY over the U.S West Coast.

4. Summary

This study indicates that there was a small overall positive impact on the GFS forecast skill for the PNA region when dropsonde data were available and used. Data impact was greater when dropsonde observations from consecutive IOPs were available and used. The AR supplemental observations helped fill the data gaps needed for DA to provide better model initial conditions (Zheng *et al*. 2021). There is a systematic improvement in the precipitation prediction over the U.S. West Coast when the dropsonde data are used. This is associated with improvement in the water vapor transport forecast.

References

Ralph F.M., and Coauthors, 2020: West Coast forecast challenges and development of Atmospheric River Reconnaissance. *Bull. Amer. Meteor. Soc.*, **101**, E1357–E1377, https://doi.org/10.1175/BAMS-D-19-0183.1.

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[1] https://github.com/yangfanglin/gfs_verif/tree/vsdb_grib2