Atmospheric River Reconnaissance 2021: Dropsonde Data Impact on GFSv16 Precipitation Forecasts for California

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1. Introduction

Atmospheric rivers (ARs) are long, flowing regions of the atmosphere that carry water vapor through the sky. Water management and flood control in the western United States are heavily influenced by AR storms that produce both beneficial water supply and hazards (Ralph et al. 2020). Due to limited in-situ and ground-based observations (Zheng et al. 2021), aircraft are deployed to collect data in and around the AR systems during AR Reconnaissance (ARR) observational campaigns (Ralph et al. 2020) over the winter of 2016 and 2018-2022. ARR provides additional data by supplementing conventional data assimilation with dropsonde observations of the full atmospheric profile of water vapor, temperature, and winds within ARs. The positive impact of dropsonde data on AR has been reported in several studies (e.g., Lord et al. 2022, Wu et al. 2021, and Zheng et al. 2021).

2. Model and Experiments

In this study the NCEP operational Global Forecast System (GFS) version 16 (GFSv16) was used to examine the impact of the ARR supplemental dropsonde observations on GFS forecasts for a major AR that made landfall along the California coast during January 26-29, 2021. This case study is focused on evaluating a significant weather event that impacted Central California, which experienced AR 2 conditions (based on Ralph et al. 2019 scale) with heavy precipitation. During this ARR observation campaign a series of consecutive flights sampling the same synoptic system from January 23 to 28 were planned and executed.

GFSv16 was implemented into operations in March 2021 at NCEP, with the finite volume cubed-sphere dynamical core and improved GFDL microphysics. Compared to the previous version (GFSv15), GFSv16 increased the number of model vertical layers from 64 to 127, and extended the model top from 55 km to 80 km. The data assimilation (DA) system was upgraded to use a 4-Dimensional Incremental Analysis Update (4D-IAU) technique. The dropsonde data used were from the ARR 2021 campaign during the intensive observation periods (IOPs) from January 17 to March 18, 2021. Global control (Ctrl) and denial (Deny) experiments were conducted by using or denying the dropsonde data in the GFSv16 for both DA and model forecast; the results presented here focus on the forecast from January 24-28 (IOPs 4-8, Cobb 2022).

3. Results

The standard NCEP Metplus verification system was used to evaluate the Ctrl and Deny experiments. Overall the global verification metrics were very similar between Ctrl and Deny, with somewhat better overall forecast skill noted over the Pacific North American (PNA, 180-320E, 20-75N) region when the supplemental dropsonde data were used (not shown). For the case where the prediction skill is relatively low (i.e., the prediction is challenging), the data collected from the dropsondes helped to improve the forecasts and increase the 5-day anomaly correlations, including geopotential height, temperature, and wind. The precipitation prediction over California during January 26-29 improved significantly in Ctrl when the dropsonde data are used (Fig. 1). The improved forecast is associated with improvement in the moisture forecast in Ctrl (not shown), similar to the ARR impact on precipitation forecast for ARR 2020 in GFS version 15 (GFSv15) (Lord et al. 2022).

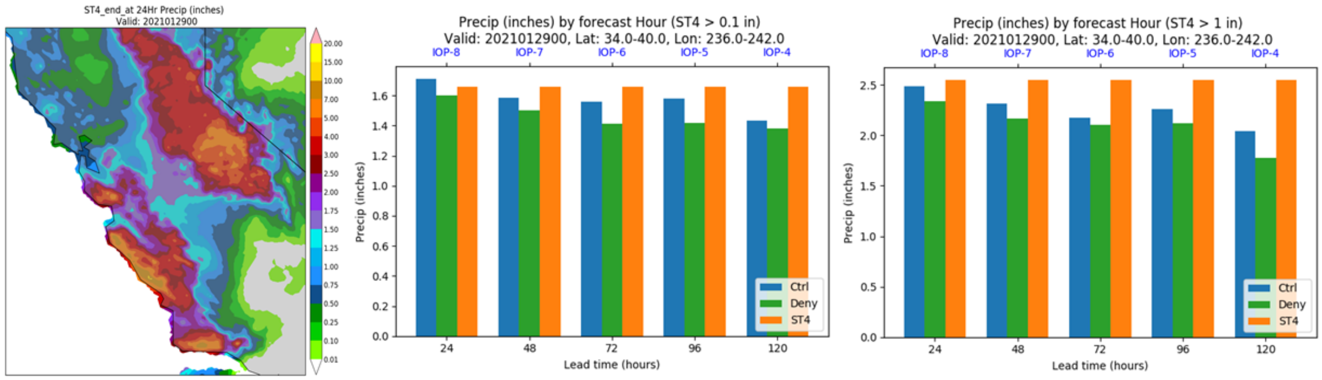

Figure 1 The 24-hour precipitation from January 28 00Z to January 29 00Z over Central and Southern California from Stage IV (left) and the area average precipitation with a cut-off of 0.1 inches (middle) and 1 inches (right) from Stage IV, GFSv16 Ctrl (blue) and Deny (green).

4. Summary

This study indicates that there was a positive impact on the GFS forecast skill for the January 2021 California heavy precipitation event when the dropsonde data were used from consecutive IOPs from the ARR. This is associated with improvement in the moisture and water vapor transport forecasts. The ARR observations helped fill the data gaps needed for DA to provide better model initial conditions (Zheng et al. 2021). There is also a systematic improvement in the precipitation prediction over the U.S. West Coast when the dropsonde data are used, similar to that of ARR 2020 from GFSv15 forecasts (Lord et al. 2022).

Reference:

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