# The Impact of Dropsonde Data on GFS Forecasts from 2022-2023 Atmospheric River Reconnaissance

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## 1. Introduction

Atmospheric Rivers (ARs) are a global weather phenomenon that are responsible for most of the water vapor fluxes outside of the tropics and a major source of precipitation and water supply for the U.S. West Coast. AR Reconnaissance (ARR) directly supports critical water management and flood control objectives in the western United States (Ralph et al. 2020). ARR observations are now officially part of the U.S. National Winter Season Operations Plan (NWSOP). During the winter of 2022-2023 AR Recon campaigns, there were 39 successful Intense Observing Periods (IOPs) using Air Force WC-130 flights and NOAA G-IV flights, which provided additional data by supplementing conventional data with dropsonde observations of the full atmospheric profile of water vapor, temperature, and winds within and around ARs. Near real-time data impact experiments had been carried out with the National Centers for Environmental Prediction (NCEP) operational global forecast system (GFS) version 16 (GFSv16) during the 2022-2023 ARR to examine and document the dropsonde impact, including landfalling ARs and associated precipitation.

## 2. Model and Experiments

In this study the NCEP operational GFSv16 was used to examine the impact of the ARR supplemental dropsonde observations on GFS forecasts during the winter of 2022-2023 ARR, including 39 successful IOPs from 5 November 2022 to 14 March 2023.

GFSv16 is the NCEP operation system, with the finite volume cubed-sphere dynamical core and improved GFDL microphysics. The model has 127 vertical layers, with the model top at 80 km, and a horizontal grid with 13 km resolution. The data assimilation (DA) system uses a 4-Dimensional Incremental Analysis Update (4D-IAU) technique. The dropsonde data collected from the 39 IOPs during the ARR 2022-2023 campaign are assimilated in the operational (OPR) run. Global denial (DENY) experiments were conducted by denying the dropsonde data in the GFSv16 for both DA and model forecast.

## 3. Results

The standard NCEP *Metplus* verification system is used to evaluate the DENY experiment against the OPR run. Overall the global verification metrics are very similar between the two runs, with slightly better overall forecast skill (1-5 days) noted over the Pacific North American (PNA, 180-320E, 20-75N) region when the supplemental dropsonde data were used in OPR. The most significant improvement is for the temperature (99% significance) and wind (99.9% significance) forecast at 200hPa with a 72-hour lead, when the mean absolute error (MAE) reduced by about 2.5% each (not shown).

One objective of this study is to examine and document the impact of the dropsonde on the GFS forecast skill of landfalling ARs and the associated precipitation. The MAE of GFS precipitation forecast over the U.S. West Coast domain (as in Lord et al. 2023) is calculated from the 39 IOPs. The difference of precipitation MAE (DENY-OPR) from 48-72-h forecast is shown in Fig. 1. There are more improvements (positive values) than degradation (negative values) from the 39 IOP cases. The average reduction of MAE for all IOPs is 3.5%. Most of the improved forecast cases are associated with improvement of the moisture forecast and AR landfalling in OPR (not shown).

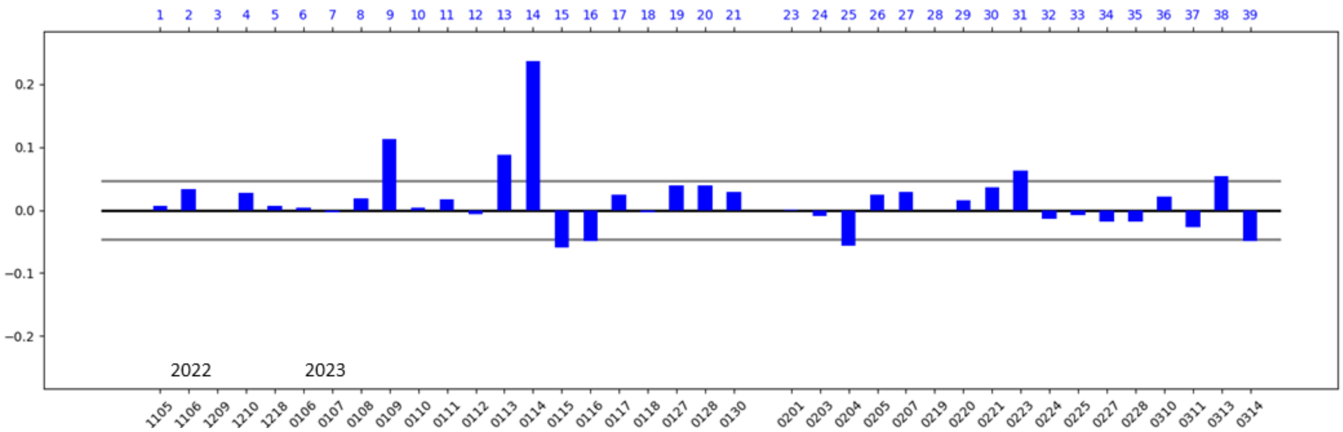


**Figure 1.** The accumulated 24-h precipitation MAE difference (DENY-OPR, inches) from 48-72-h GFSv16 forecast in each of the 39 IOPs from 5 November 2022 to 14 March 2023 averaged over U.S. West Coast domain (107-127 W, 28-49.5 N). The Stage IV precipitation is used as the truth, where the accumulated 24-h precipitation is at least 0.5 inches are used for the forecast verification (IOP 22 is void, i.e. the precipitation from Stage IV is less than 0.5 inches). The gray line is the 95% significant level based on all the IOP cases.

## 4. Summary

This study indicates that there is a positive dropsonde impact on the GFS forecast skill (1-5 days lead) during the 2022-2023 ARR. The ARR observations helped fill the data gaps needed for DA to provide better model initial conditions (Zheng et al. 2021), with reduced cold bias for the temperature, dry bias for the specific humidity, and low bias for the wind. The improved initial conditions set up a more accurate environment for predicting the AR and associated precipitation. The systematic improvement for the precipitation prediction over the U.S. West Coast, in particular with 48-72-h lead, is associated with improvement in the moisture and water vapor transport forecast, which also leads to improvement in AR landfalling, for the location and IVT (integrated water vapor transport) magnitude, with reduced error in the OPR run. The improved precipitation forecast over the U.S. West from the 2022-2023 ARR is similar to that of ARR 2020 study with GFS version 15 (Lord et al. 2023).

## Reference:

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