Forecast Impact of Additional Radiosonde Ascents During the Year of Polar Prediction – Southern Hemisphere (YOPP-SH) Winter Campaign

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Given the high interest in polar regions for climate change research, there is a critical need to enhance existing polar prediction capabilities. In particular, weather forecasts for Antarctica exhibit lower predictive skill compared to other regions of the planet, in part due to limited conventional observations. The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) aims to improve weather prediction for Antarctica and the Southern Ocean. The project is centered around the winter Special Observing Period (SOP) that spanned April 15 - August 31, 2022. During the SOP, seven Targeted Observing Periods (TOPs) featured extra radiosonde launches to capture intense weather events, such as major oceanic cyclones and atmospheric rivers. To investigate the impact of these extra radiosondes in numerical weather prediction, NCAR performed experiments using Polar WRF in the Antarctic Mesoscale Prediction System (AMPS) framework. Two different simulation methodologies were performed. The first consisted of assimilating the standard set of observations into the initial conditions for Polar WRF, and these simulations are termed Routine. The second consisted of assimilating in addition to the standard observations, the extra radiosondes from the TOPs, called Extra.
Two data assimilation approaches were used: Multi-Resolution Incremental-Four Dimensional Data Assimilation (MRI-4DVAR) and Three Dimensional Ensemble Variational Data Assimilation (3DEnVAR). The forecasts generated covered all the seven TOP periods, starting at each 0000 UTC and 1200 UTC and had a duration of 5 days.

To quantify the benefits of the additional soundings during the TOPs, statistical analyses on Polar WRF forecast runs that were initialized using both MRI-4DVAR and 3DEnVar were performed. These were generated for both forecasts (Extra and Routine) and were validated against ECMWF 5th generation reanalysis (ERA5) for geopotential height, temperature, wind speed, and specific humidity throughout the troposphere and lower stratosphere. Another aspect of this study is to investigate the prediction of the ubiquitous mixed phase clouds, which is being investigated by a collaborator. The cloud microphysics schemes are not well represented in the Southern Ocean. This can lead to biases in cloud phase and precipitation, having a big influence on the surface radiation budget. Improved representations of cloud processes are key for enhancing atmospheric predictability.

The extra soundings improve model forecast skill across the Southern Ocean. The positive impacts are particularly pronounced at latitudes south of 60°S, aligning with the findings from the austral summer YOPP-SH campaign. Ongoing research is assessing the impact of additional soundings for all the seven YOPP-SH TOPs with an additional focus on the key meteorological events. Based on current findings and previous work in the literature, it is evident that the extra observations are fundamental to mitigate forecast discrepancies.

Overall, enhancing the representation of the Southern Ocean can yield several good outcomes, including improvement in mid-latitude forecasts and better safeguard of personnel at the Antarctic stations. Moreover, having improved representation of physical processes in the climate models, can strengthen their ability to project long term trends and assess the impacts of climate change, ultimately contributing to more accurate global climate assessments.