Predictability of Atmospheric Rivers and Associated Precipitation on Sub-Seasonal Scale over Antarctica using NCEP Global Ensemble Reforecasts

Vijay Tallapragada*[1] and M.m. Nageswara Rao[2]

[1]EMC/NCEP/NWS/NOAA – College, Park, United States
[2]CPAESS/UCAR and EMC/NCEP/NWS/NOAA – United States

Abstract

Atmospheric Rivers (ARs) are narrow corridors of concentrated moisture transport that significantly influence precipitation patterns, surface mass balance, and the stability of ice sheets in Antarctica (Maclennan et al. 2023). Accurate sub-seasonal forecasts of ARs and their associated precipitation are crucial for understanding climate variability and improving risk assessments related to extreme weather events. NOAA NCEP has operationalized the Global Ensemble Forecast System Version 12 (GEFSv12) in September 2020 for supporting sub-seasonal forecasts and hydrological applications. This system offers reanalysis and reforecast data from 2000-2019, with 5 ensembles at 00 UTC every day up to 16 day lead time, except Wednesdays when 11 members and the integrations extend lead time up to 35 days. This study evaluates the ability of the GEFSv12 to predict ARs and their precipitation over Antarctica at sub-seasonal lead times. The analysis focuses on weekly forecasts (Weeks 1-4) and monthly predictions during the austral winter, using ERA5 reanalysis data as a reference. Forecast skill is assessed using a combination of deterministic and probabilistic metrics, including the Correlation Coefficient, Index of Agreement, Mean Bias, and Root Mean Square Error. Additionally, categorical skill scores such as the Hit Rate, Success Rate, Critical Success Index, and Equitable Threat Score are employed to evaluate forecast accuracy. To enhance predictive performance, a Feedforward Neural Network (FNN) is utilized, consisting of two hidden layers, each comprising 16 neurons. The first hidden layer applies the ReLU activation function, while the second layer employs Tanh. Artificial Neural Networks (ANNs) are well-suited for capturing complex, nonlinear relationships in high-dimensional datasets, making them an effective tool for post-processing numerical weather model outputs. This study incorporates GEFSv12 ensemble forecasts (11 members) as input data and employs a leave-one-out cross-validation approach, where 70% of the data is used for training and 30% for validation. Predictions are conducted independently to ensure robustness and reliability. The ANN-based calibration method is independently applied to the GEFSv12 reforecast products (IVT-U, IVT-V, and precipitation) for each lead time (Day-1 to 35) at each grid point. By integrating an ANN-based calibration approach, this study successfully minimizes systematic biases in GEFSv12 forecasts, leading to improved predictability of ARs and their extreme precipitation impacts over Antarctica at sub-seasonal timescales. These findings contribute to advancing operational forecasting capabilities and enhancing climate risk management strategies in polar regions.

*Speaker