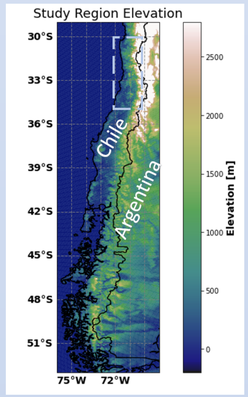
An Evaluation of Reanalysis and High-Resolution Model Simulations of Orographic Precipitation and Snowpack in the Southern Andes

Erin Potter, Justin Minder: University at Albany, State University of New York

Introduction

Orographic precipitation and snowpack are important for water resources and hydrometeorological disasters in the Andes Mountain range. Improved understanding of orographic precipitation and snowpack in a warming climate is needed to provide a foundation for understanding future hydroclimate change over the Andes.



The goal of this research is to evaluate how well variations in high-resolution regional climate simulations agree with observations of (1) orographic precipitation and (2) snowpack over the central and southern Andes (35-55°S).

Data and Methods

1. Model Precipitation (SAAG-WRF):

- ERA-5-forced Weather Research and Forecasting (WRF) simulations with 4-km grid spacing for 2000-2015 South America by the NCAR-led South America Affinity Group (SAAG).

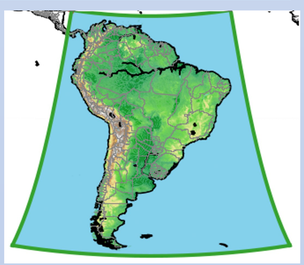


Fig 2: SAAG-WRF domain[2]

- SAAG-WRF precipitation compared to rain gauge observations from the Chilean National Weather Service (DMC), the Chilean Bureau of Water (DGA), and the Argentina National Water Information System

2. Model Snow Analysis (SAAG-WRF):

- SAAG-WRF compared to snow water equivalent (SWE) data from the high-resolution Andean Snow Reanalysis (ASR) by the Margulis Research Group for the domain 28-37°S.
- As described in Cortes and Margulis (2017)[1] "SWE estimates were generated by integrating observed snow depletion data from Landsat together with a snow model forced by the Modern-era Retrospective Analysis for Research and Applications."
- The grid is a regular lat/lon grid at a 0.001 degree resolution (i.e. ~100 m). Data are daily temporal resolution.

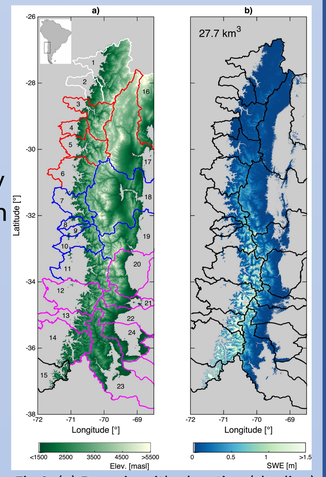


Fig 3. (a) Domain with elevation (shading) and delineation of watersheds; (b) 31 year average pixelwise peak SWE climatology. (Cortes & Margulis 2017).

Results

1. Precipitation-SAAG-WRF and Observation Analysis :

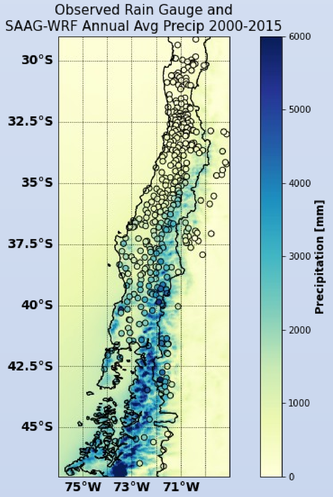


Fig 4: Observations against SAAG-WRF output. Circles indicate rain gauges, shading indicates model output

- Orographic enhancement is apparent in the model output for all latitudes, especially the southern portion of the domain on the windward side and along the crest.
- Highest amounts are shown in model output where ground stations are scarce.
- The model captures the dry conditions of central Chile and the leeward side in Argentina.

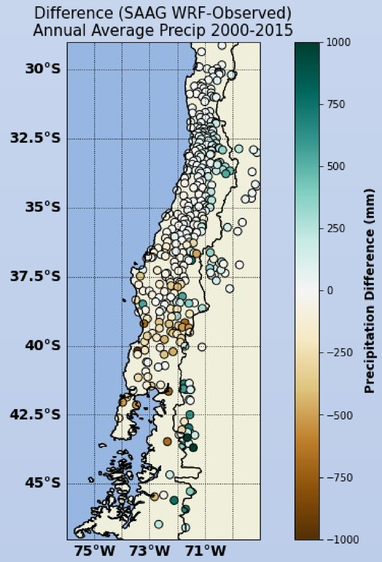


Fig 5: Difference in annual average precipitation between SAAG-WRF and rain gauges.

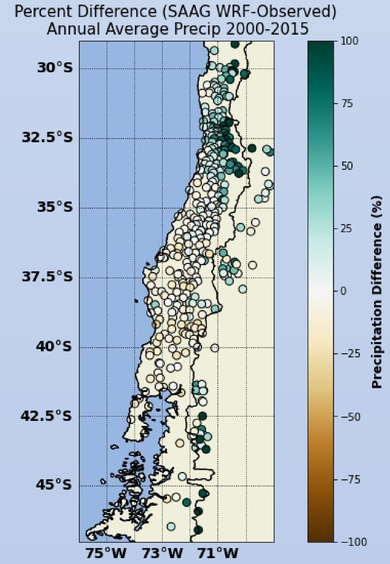


Fig 6: Percent difference in annual average precipitation between SAAG-WRF and rain gauges.

- The model mostly agrees with the drier observations in the valley and leeside, when looking at raw amount.
- The percent difference is larger on the windward slopes and crest from 29-34.5°S where annual mean precipitation is relatively low.
- There is some underestimation in stations around 40°S
- The greatest overestimation by amount is on leeward slopes at and south of 42°S.

Results

2. SWE- SAAG-WRF and Observation Analysis :

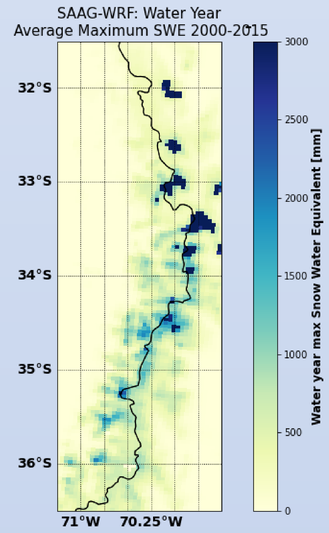


Fig 7: SAAG-WRF water year average of maximum SWE for domain.

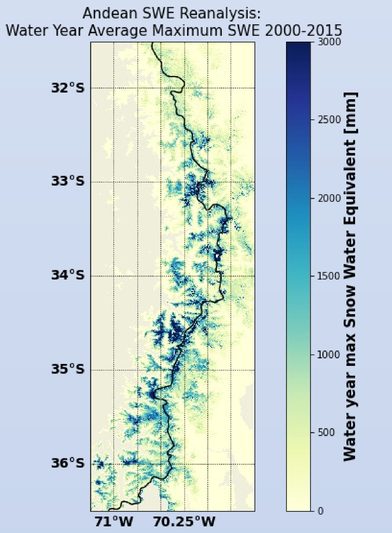


Fig 8: Andean Snow Reanalysis water year average of maximum SWE for domain.

- SAAG-WRF seems to show much higher max SWE for many of the leeside locations (in Argentina). This may explain the precipitation biases from the previous section.
- ASR seems to show higher max SWE for many of the windward ridges (in Chile).
- The high resolution of the reanalysis allows for more detail on the complex terrain that the model is not capable of yet.

Conclusions and Future Work

- SAAG-WRF overestimates precipitation primarily north of 35°S on the windward slopes and south of 42.5°S crest and leeside slopes. SAAG-WRF mostly agrees with dry observations in the valley/along the coast.
- Percent difference analysis shows that small absolute biases can lead to large percentage biases.
- SAAG-WRF SWE analysis reveals a higher maximums on the leeside slopes and ASR shows higher maximums on the windward slopes.

Additional snow data will be used to extend the domain of SWE analysis. Further analysis may determine overestimations are due to gauge undercatch where much of the precipitation is snow. Summary statistics will be calculated, including significance tests. Analysis of atmospheric river impacts on these variables will be conducted. Future changes in precipitation and SWE will be analyzed in the SAAG-WRF pseudo global warming runs.

Acknowledgments and References

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1. Cortés, G., and Margulis, S. (2017), Impacts of El Niño and La Niña on interannual snow accumulation in the Andes: Results from a high-resolution 31 year reanalysis, *Geophys. Res. Lett.*, 44, 6859– 6867, doi: 10.1002/2017GL073826.
2. NCAR-SAAG website: https://ral.ucar.edu/projects/south-america-affinity-group-saag