An Assessment of Numerical Weather Prediction Models in Forecasting Atmospheric Rivers

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A Costly Double-Edged Sword

- The Winter of 1996-1997 was one of the most destructive on record for the West Coast. According to NOAA, damage from flooding events is estimated to have reached about $4.2 billion.
- Likewise, in 2014 the western United States saw a continuation of one of its worst droughts on record, with damage also estimated at $4.2 billion for 2014 alone.
- Is there a link between these two seemingly dichotomous disasters?

What is an atmospheric river (AR)?

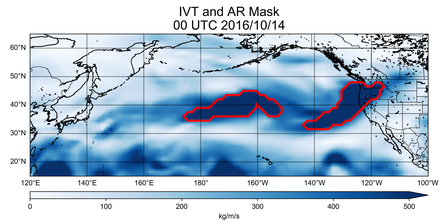
- An atmospheric river is a narrow plume of high water vapor transport in the atmosphere. ARs can be found across the globe.
- These features, often associated with intense wintertime storm systems, meander across the Pacific Ocean and can interact with land.

Why are ARs important?

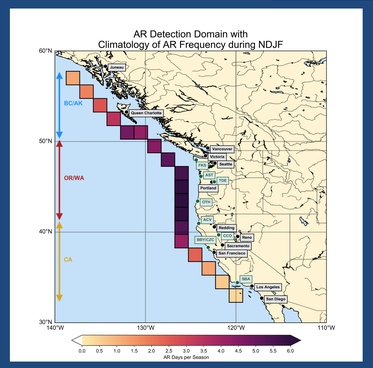
- Upon interacting with large land masses, ARs can produce high amounts of precipitation for both coastal and inland locations.
- Interests in the western United States rely on precipitation from ARs for a large portion of annual precipitation. A prolonged absence of AR activity can cause severe droughts, such as the event from 2014.
- By contrast, excessive AR activity in a short period of time can lead to intense flooding and infrastructure failure, as seen in 1996-1997.

Are ARs skillfully predicted?

- To answer this question, re-forecast data from 9 state-of-the-art weather prediction models is analyzed. This data comes from the Seasonal-to-Subseasonal (S2S) International Project database (Vitart et al. (2017)). Model data is input into an atmospheric river detection algorithm based on one introduced by Mundhenk et al. (2016). Integrated water vapor transport (IVT) is used for detection. See below.
- Re-forecast data is compared to re-analysis data from ERA-Interim (1979 through 2016).



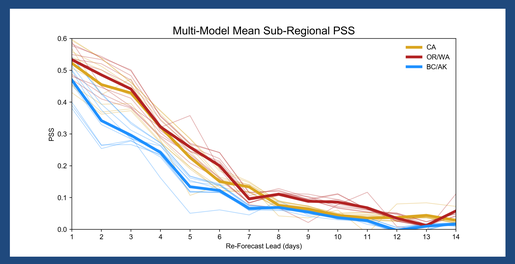
Region of Interest



In order to isolate atmospheric river features making landfall along the coast, the analysis region is located just offshore of the West Coast of North America, extending from near Santa Barbara, CA, northward to Juneau, AK.

The region can be divided into sub-regions in order to examine differences in skill between areas of varying climatological AR frequencies.

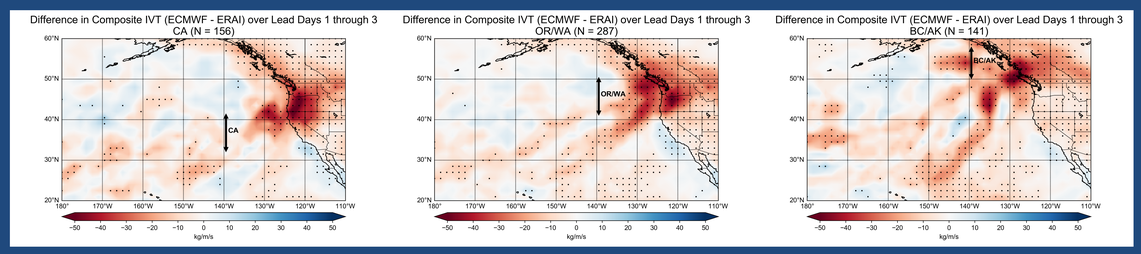
Landfall Occurrence



Re-forecast skill for AR occurrence decreases as lead time increases. Model re-forecasts past 10 days provide little additional skill.

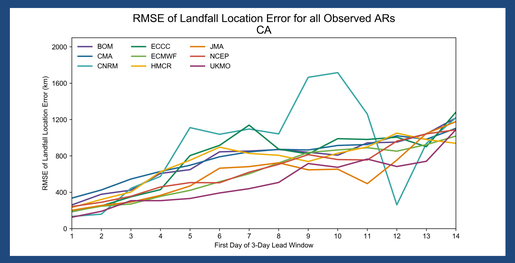
Skill varies between sub-regions, with lower re-forecast skill in BC/AK compared to CA or OR/WA.

Landfall Intensity



On average, even reasonably good AR re-forecasts from ECMWF (a commonly-used model) appear to have a dry bias in terms of water vapor transport near the coast for AR landfalls.

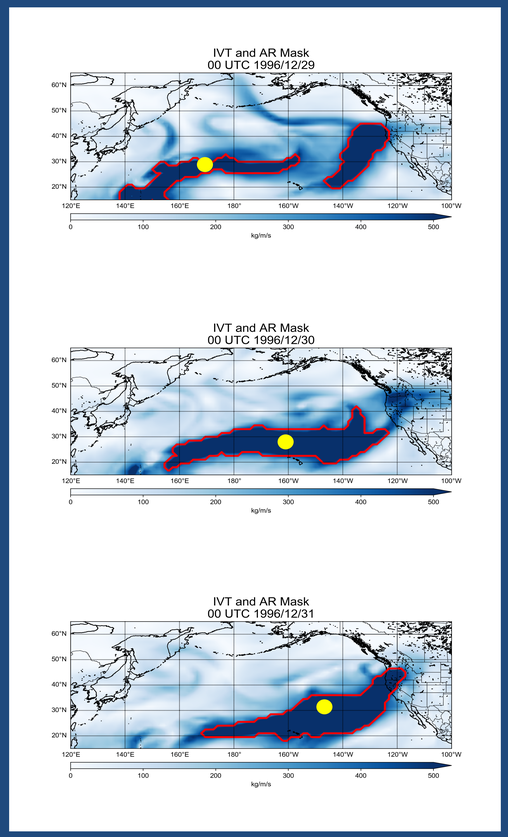
Landfall Location



As lead time increases, re-forecasts trend toward a larger landfall location error along the coast. Even at early lead times, landfall location errors can still be greater than 100 km. Along a diverse and densely-populated coastline, even a relatively-small error can have major consequences.

How can these results be used?

- Like tropical cyclones, atmospheric rivers can be characterized by a location and intensity.
- The ability to track AR features in time and space could provide further insight into where these features develop and how they evolve.
- Tracking of atmospheric rivers in a forecast may help to identify sources of model forecast error.
- Tracking could also highlight favored source regions of atmospheric river development in the North Pacific basin.



References

Mundhenk, B., E. Barnes, and E. Maloney, 2016: All-season climatology and variability of atmospheric river frequencies over the North Pacific. J. Climate, 29, 4885–4903, doi:10.1175/JCLI-D-15-0655.1.

Vitart, F., and Coauthors, 2017: The subseasonal to seasonal (S2S) prediction project database. *Bull. Amer. Meteor. Soc.*, **98**, 163–176, doi:10.1175/BAMS-D-16-0017.1.

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