A New Atmospheric River Quantification Metric

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1. Introduction

Atmospheric rivers (ARs) are long, narrow bands of atmospheric moisture that are responsible for most of the horizontal transport of water vapor outside the tropics. They play a critical role in creating extreme precipitation, flooding, drought, etc. Despite the fact that ARs are attracting increasing interest from various communities, no consensus has yet been reached on a metric to track and measure AR related quantities for an AR forecast. A preferred metric should help scientists, forecasters, and the public easily interpret and understand the characteristics of ARs.

2. AR Quantification Metric

Our new AR quantification metric is inspired by the widely used automated tropical cyclone forecasting (ATCF) hurricane system track. We define AR tracks as the path of the selected AR centers in consecutive time steps. A few other quantities would also be calculated and recorded along an AR track. The AR scale proposed by CW3E [1] categorizes the impacts of ARs into 5 scales, based on duration and magnitude of the Integrated Water Vapor Transport (IVT). It does not fully reflect the locations and time-varying characteristics of an AR. Our new metric covers both the intensity and tracks of ARs to provide a more comprehensive perspective on location related AR characteristics, impacts, and landfalls. The time series of a few AR quantities recorded along the path would also provide a simplified data set for AR studies, to reduce requirements for data archive and transfer.

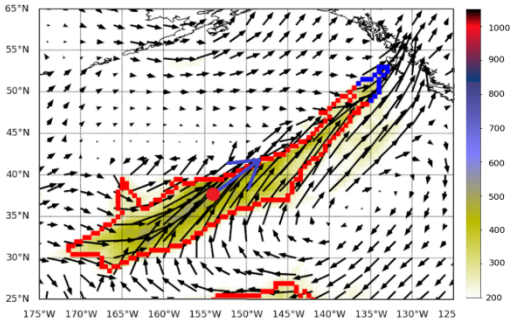

Figure 1. AR quantification by AR Center (red dot), AR Intensity (maximum IVT), AR size (area measurement of the AR region), AR direction (blue arrow), and AR front (blue curve).

First, ARs are extracted from regions with *IVT > 200 kg m^{-1} s^{-1}*, region length > *2000 km*, length/width ratio > *2*, and other conditions based on Guan and Waliser's AR extraction method [2]. From an extracted AR (Figure 1), we calculate *AR Center* as the mean center of the AR region weighted by IVT values, *AR intensity* as the maximum IVT within the AR region, *AR Size* as the region area, *AR direction* as the direction of the mean IVT vector within the AR region, and *AR front* (front part of AR boundary along the AR direction). The AR size and maximum IVT are good indicators of an AR's impact. AR centers in consecutive time steps form an *AR track*, which, along with AR fronts, project an AR's paths and landfalls.

3. Applications

The new metric is applied to study AR forecast uncertainty using the NCEP global ensemble forecast system version 12 (GEFSv12) reanalysis and reforecast data.

Figure 2 shows tracks from different ensemble members and also spaghetti plots showing the contours of AR boundaries. The purple shades show the degree of overlap among the AR regions predicted by different ensemble members. The overlaid AR tracks indicate the uncertainty of AR paths among ensemble members.

Figure 3 shows composite tracks from a few consecutive GEFSv12 cycles. The tracks are generated from the ensemble mean of each cycle. The background color map shows the swath of maximum IVT. Plotting these AR tracks in a single map provides a quick overview of the variance among the same ARs predicted at

different initial times. For example, even when the ensemble means are used, different AR predictions can still occur with different cycles' forecast data.

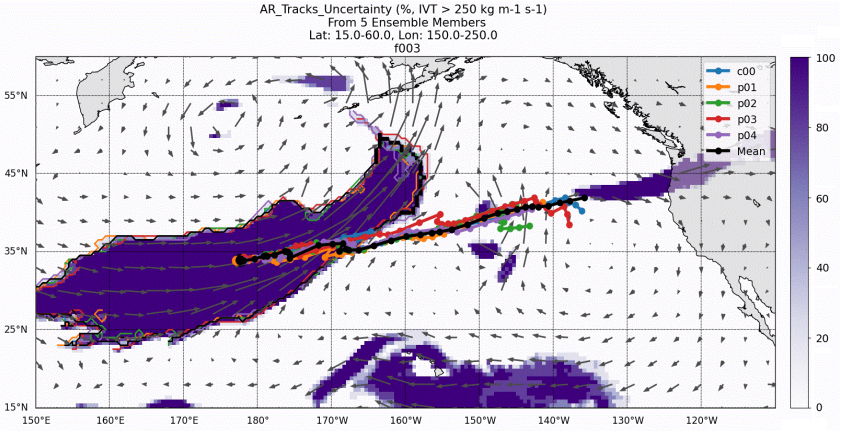

Figure 2. AR tracks of GEFSv12 ensemble in East Pacific Ocean on 12/30/2018 (5 members).

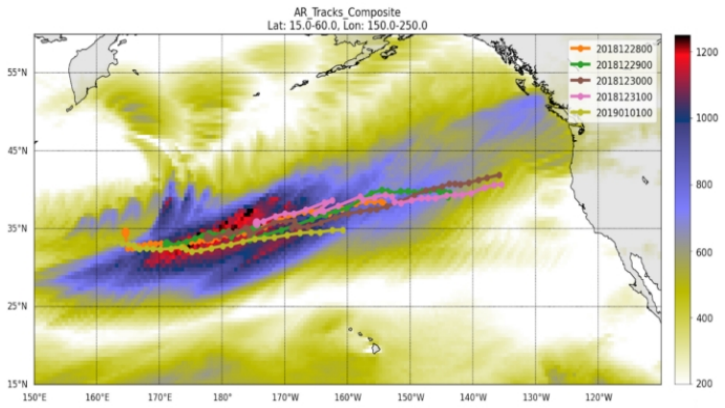

Figure 3. Composite AR tracks of GEFSv12 in East Pacific Ocean (cycle 2018122800 - 2019010100).

4. Conclusion and Future Work

We propose a new AR quantification metric based on AR path extraction. The example applications demonstrate that the new metric provides an effective tool to study ARs. Future work may include refining the calculation of AR centers, so the AR tracks may reflect times and locations of the ARs' landfalls and the maximum impacts more precisely, collectively selecting the set of AR related quantities along the tracks with the community, and including more applications to verify the usefulness of those AR quantities.

References

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