So it's a Land-falling Atmospheric River, Can That Help the Forecaster Make a Better QPF?

David W. Reynolds, *Senior Research Meteorologist, Cooperative Institute for Research in the Environmental Sciences, Monterey, CA 93940 USA; David.Reynolds@noaa.gov; (831)521-9262*

Brian Kawzenuk, *Center for Western Weather and Water Extremes (CW3E), Scripps Institution of Oceanography, La Jolla, CA USA*

The lead author, having been an operational forecaster for many years in California, has watched closely the evolution of the use of the term and meaning of an Atmospheric River (AR). In the earlier years it was defined by Ralph et al. (2004) as a long narrow filament of atmospheric moisture having dimensions of several hundred kilometers in width and several thousand kilometers in length with Integrated Water Vapor (IWV) values of 2 cm or greater and could be easily identified on SSMI imagery. Wick et al. (2012) used this definition to develop an automated AR detection tool (ARDT) from gridded model data. It was quickly identified that strong winds within the AR are necessary to produce significant water vapor transport (IVT) which can be more directly related to precipitation falling at the surface. Knowing the direction and speed of the low level winds within land-falling ARs is critical to forecasting orographic enhancement of precipitation (Neiman et al, 2008, Ralph et al, 2013). Thus the transition from the original definition used in the ARDT to one that considers vapor transport (IVT), used in Rutz et al (2015) and on the CW3E AR web portal, http://woodland.ucsd.edu/?page_id=827#forecasts. From monitoring the ARDT web page (http://www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/ar_detect_gfs.html) and the AR Portal it is noted that a large majority of mid-latitude cyclones occurring during the period from late October to early April are identified as ARs using either the ARDT or classification of IWV > 2 cm and IVT >250 kg $m^{-1}s^{-1}$. Many of these ARs as detected offshore make landfall along the Canadian or US West Coast before dissipating.

The forecaster's dilemma is this:

1. The ARDT using IWV alone provides little information on rainfall rates or expected rainfall
2. AR's defined using IVT do not specifically tell the forecaster where the strongest vapor flux is occurring in the vertical and thus what elevations will be most impacted.
3. Numerical forecast models do provide explicit model QPF. Given sufficient resolution to resolve terrain, these models, in a majority of cases, can identify significant orographic rainfall events from the weak transient rain events utilizing 1 to 3 day rainfall totals.

Given this, how does the forecaster modify his thinking of model QPF if he knows that the incoming frontal system is associated with an AR? Utilizing several AR landfall cases from the past two winters, comparisons will be made of the relationship between layer- averaged IVT, duration of IVT above thresholds identified on the AR Portal, and observed 6-hr rainfall and forecasted 6-hr rainfall for a watershed in northern California (see Fig.1 below). The challenge for the research community to help the operational forecaster make a better QPF is to 1) categorize the strength and duration of the AR at landfall to estimate rainfall potential, 2) quantify the relationship between AR strength, IWV, and layer IVT vs total IVT, and 3) demonstrate how one would use this information to adjust up or down model QPF dependent on elevation, slope and aspect of the terrain being impacted.

Neiman, P.J., F.M. Ralph, G.A. Wick, J.D. Lundquist, and M.D. Dettinger, 2008: Meteorological Characteristics and overland precipitation impacts of atmospheric rivers affecting the west coast of North America based on eight years of SSMI satellite observations, *J. Hydrometeor,9,* 22-47.

Ralph, F.M. P.J. Neiman, and G.A. Wick, 2004: Satellite and CALJET aircraft observations of atmospheric rivers over the eastern North-Pacific Ocean during the El-Nino winter of 1997-98.

Wick, G. A., P. J. Neiman, and F. M. Ralph, 2013: Description and validation of an automated objective technique for identification and characterization of the integrated water vapor signature of atmospheric rivers. *IEEE Trans. Geosci. Remote Sens.*, **51**, 2166–2176, doi:10.1109/TGRS.2012.2211024.

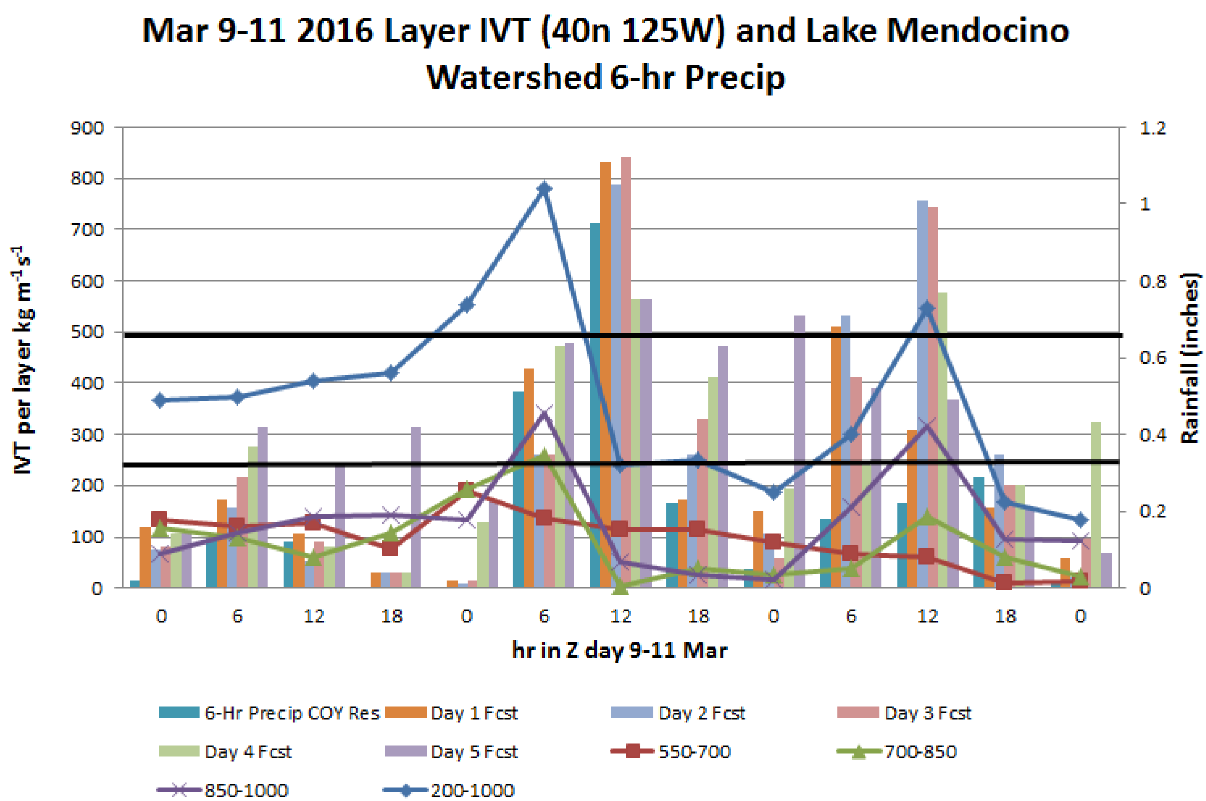

Figure 1 Layer averaged IVT versus Day 1-5 CNRFC 6-hr QPF and QPE for March 9-11, 2016. The 250 and 500 total IVT are highlighted.