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A Case Study of Four Atmospheric River Events Over the Pacific West Coast of the United States

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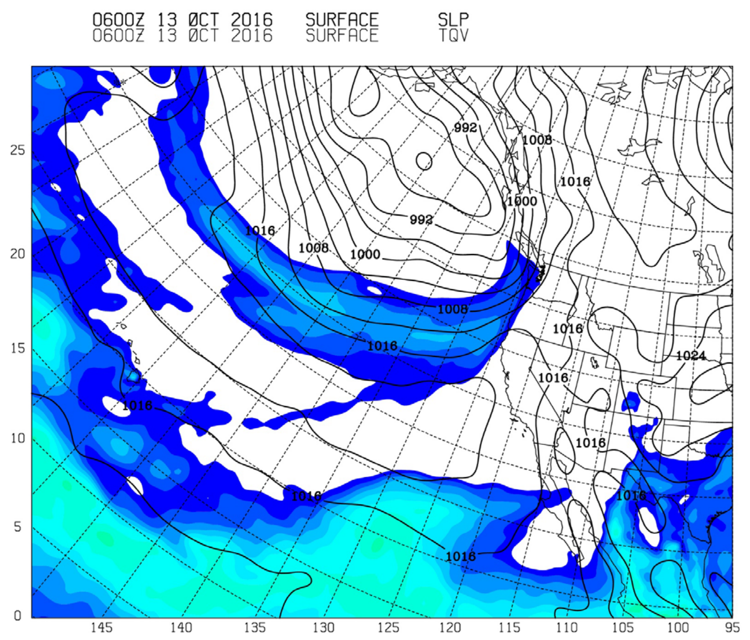
Abstract

Atmospheric Rivers (AR) are moisture phenomena related to cyclones which bring moisture and large amounts of precipitation to areas of enhanced elevation along coastal areas. These events bring much of the rain received by the state of California, and the past winter many AR events brought much-needed rain to the region. Four different events from the 2016 fall through 2017 spring seasons are examined to better identify the relative roles of long-range moisture transport versus local moisture fluxes in AR events. Cross-sections of areas and times of interest during each event are generated, along with trajectory analyses of each event which will aid in determining the origin of the moisture being moved over land. Both the cross-sections and the trajectory analysis are taken from the CFSR (Climate Forecast System Reanalysis) model. It is expected that the results of these processes will support the findings of Dacre et al. (2015), which show that the moisture anomaly present during AR events is not actually due to moisture transport directly along the AR itself. Rather, the AR is the result of moisture convergence due to a combination of the warm conveyor belt forcing the ascent of moisture over the warm front and the trailing cold front forcing ascent as it closes the gap between itself and the warm front. The importance of this research is first and foremost evident in the California region, as water conservation in naturally dry areas is extremely important to the ever-expanding cities and communities present there and require long-term planning. Such planning is made more effective when we better understand the forces that bring much of the precipitation to the area.



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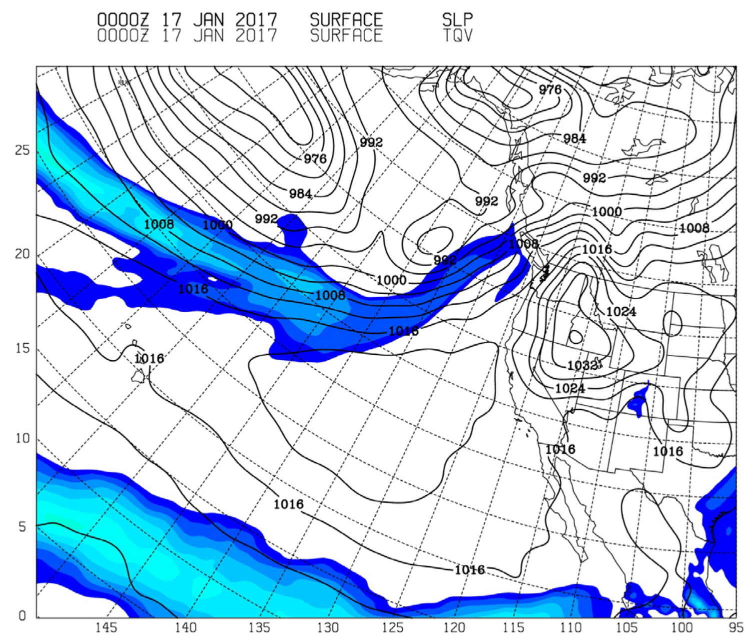

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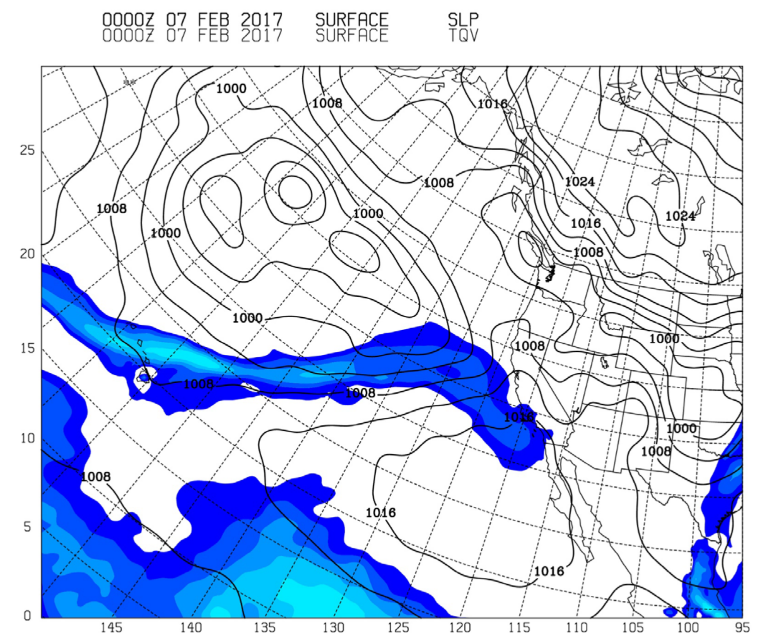

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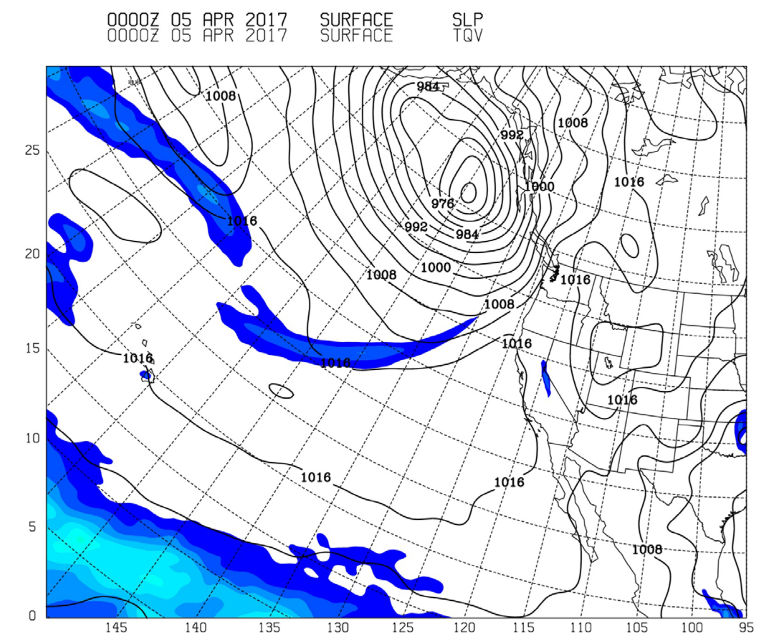

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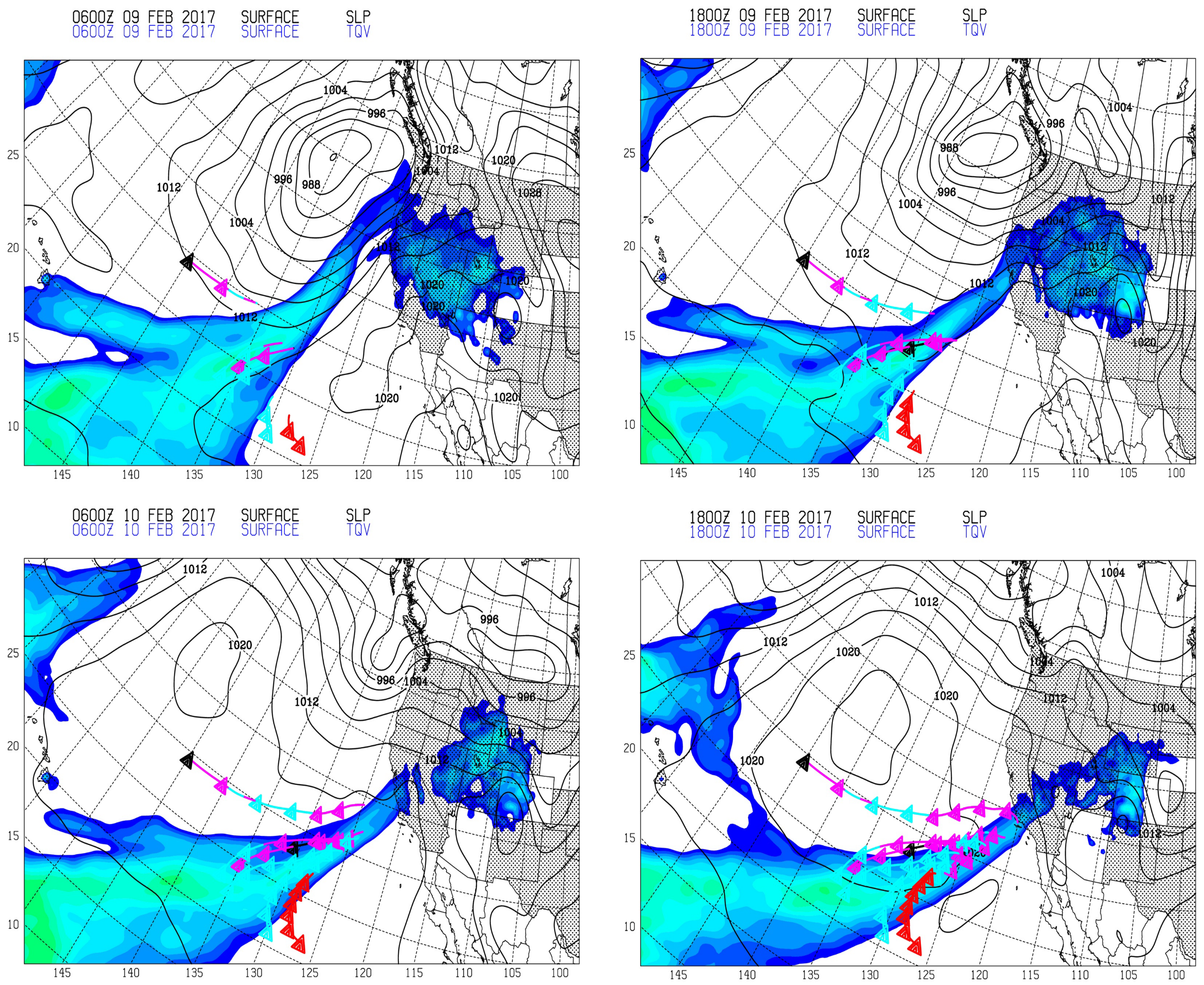
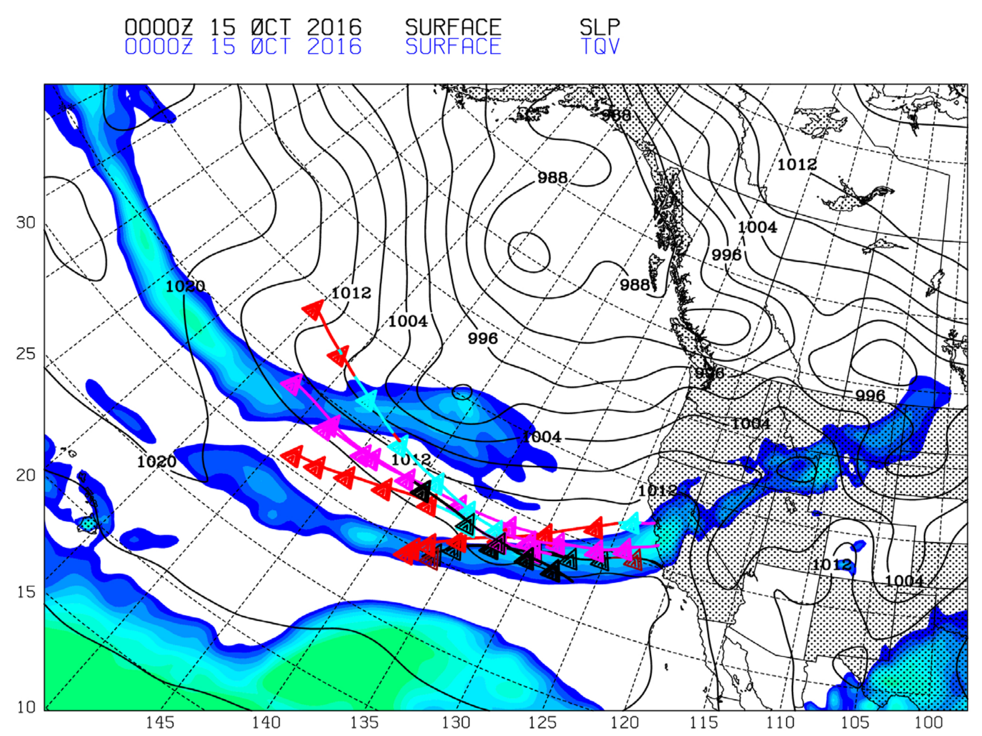
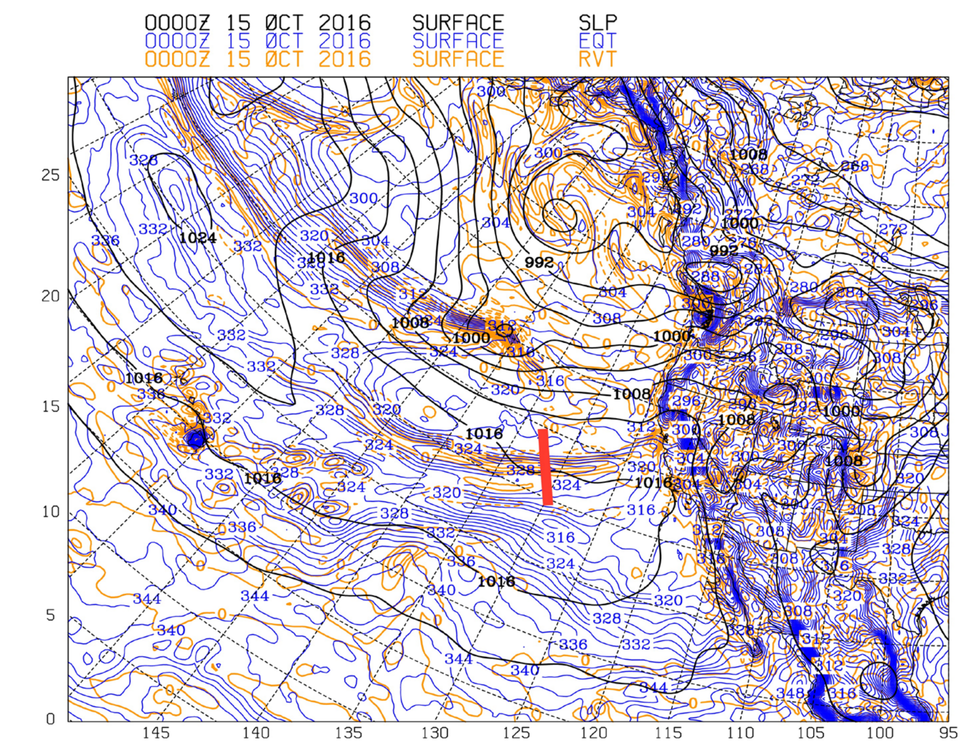
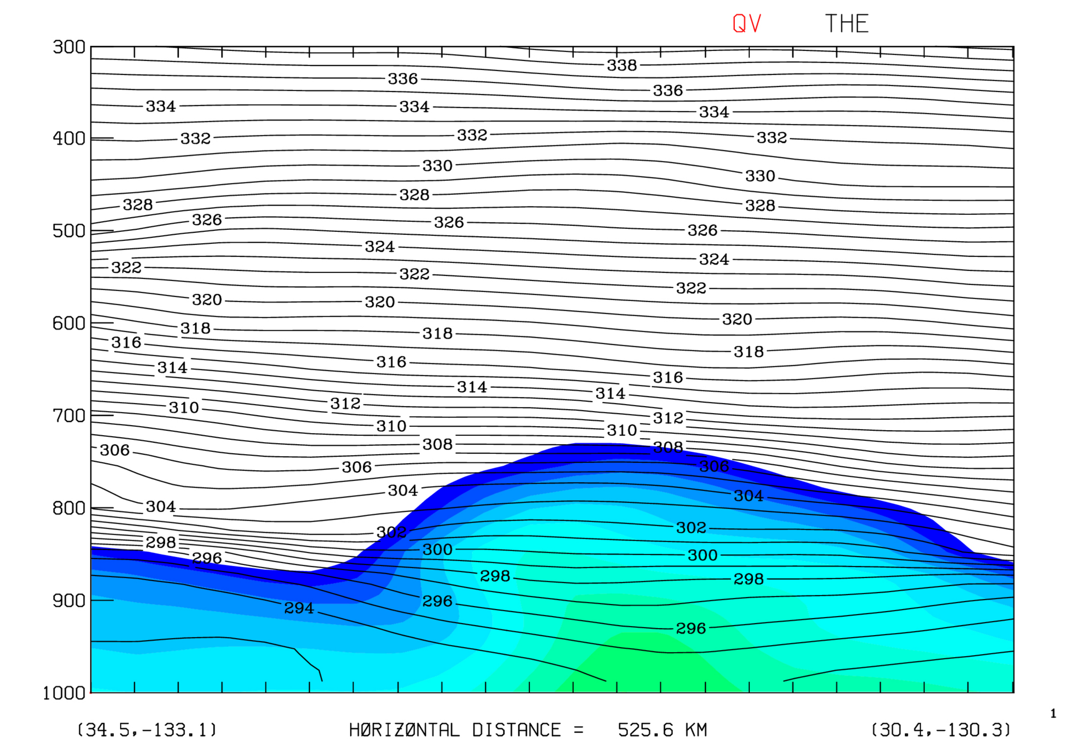


Methods

For each of the four cases several times of interest were chosen to be more closely examined, including the approximate time of landfall for each event and when the AR begins to decay. To examine the relationship between ARs and cold fronts, vertical cross-sections showing mixing ratio (QT) and potential temperature (THE) and plots of absolute vorticity (AVT) and equivalent potential temperature (EQT) were generated. In addition, backwards trajectories were calculated and plotted along with the movement of each AR event at the chosen times of interest over vertically integrated moisture (TQV) (left). Below, a comparison between the three plot types described can be seen, where the line in red on the map of EQT and AVT represents the location of the vertical cross-section. It should be noted that the boundary shown by the gradients of EQT and AVT correspond with the moisture plume shown in both the cross-section and the trajectory plot.



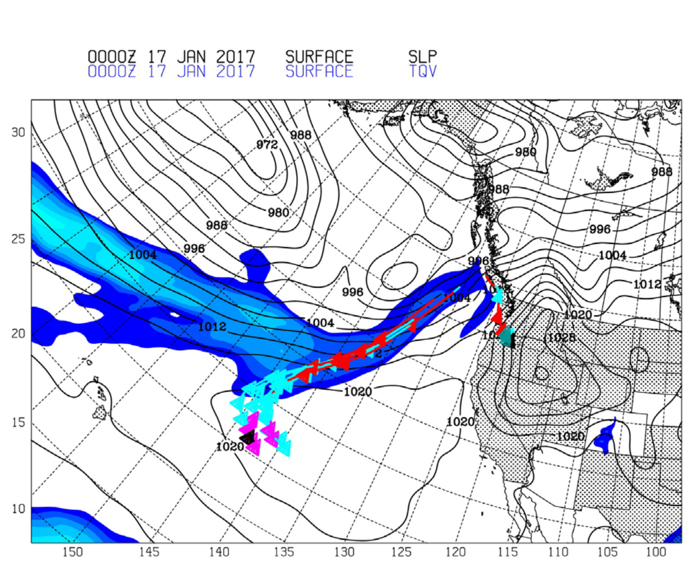




Results

Each of the four events were strongly associated with what are typically analyzed (by the WPC) as cold fronts, although they were sometimes analyzed as stationary fronts, especially later on during each event. This boundary can be seen especially well on plots of EQT and AVT. The backwards trajectories revealed an interesting pattern as well: there seem to be three distinct behavior being exhibited, depending on the level and starting location of each air parcel. The three behaviors are as listed: moisture which originated from ahead of the boundary (1), moisture which originated from a very localized source (2), and moisture which originated from and stayed within the plume (3). Each was observed at some level of the atmosphere in each event, implying that the origin of moisture within atmospheric rivers is not simply one location or behavior, but several simultaneously depending on the structure of the plume itself. More research must be done in order to determine what relationship, if any, exists between these behaviors and precipitation impacts.

1.



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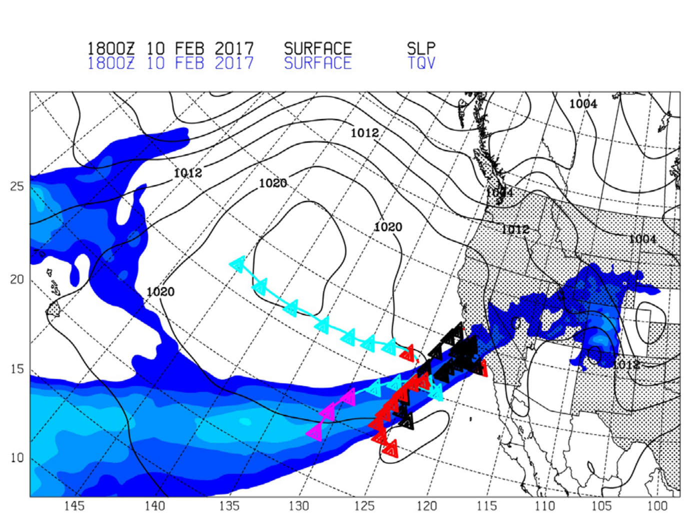

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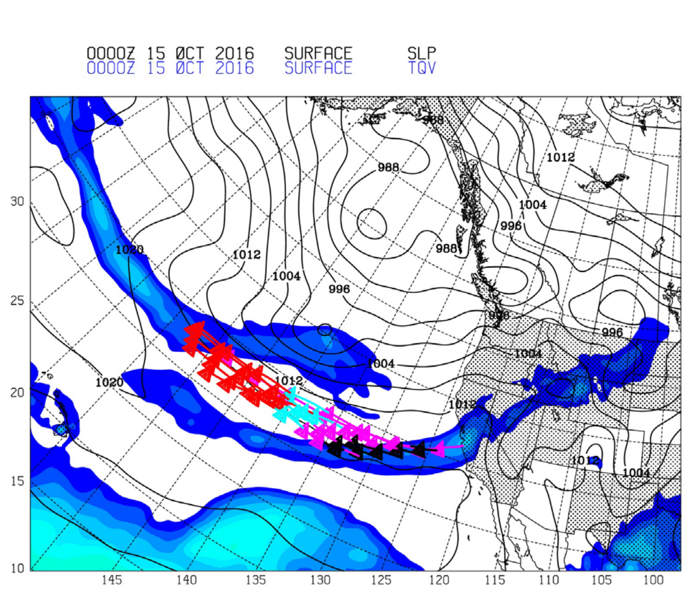

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