P2.11 UNDERSTANDING THE DYNAMIC LINK BETWEEN TROPICAL CLIMATE VARIATION AND WINTER STORMS ALONG THE US WEST COAST THROUGH NUMERICAL SIMULATIONS

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1. Introduction

Satellite integrated water vapor (IWV) images over the central and eastern Pacific frequently show bands of enhanced water vapor on order of 200 km width and several 1000's km length. These bands are often associated with the low-level jet of wintertime extratropical cyclones, which produce most of the U.S. West Coast's precipitation. In many cases, these bands extend far enough south that it appears possible that a tropical moisture source may be contributing to West Coast precipitation. However, from the satellite images alone it is not possible to determine whether these bands originate from tropical moisture advection or solely from local low-level moisture convergence. To address the question of the source of moisture in these storms, six case studies of IWV bands have been selected between 1997-2001, all of which produced significant precipitation in California. They are 1-5 Jan 1997, 6 Dec 1997, 2-3 Feb 1998, 5-6 Feb 1998, 23 Feb 1998, and 3-5 Mar 2001. These six cases include El Nino, La Nina, and neutral El Nino/Southern Oscillation (ENSO) conditions.

2. Numerical Model

Numerical simulations using the NCAR/Penn State mesoscale model were used to perform trajectory analyses to physically interpret the satellite IWV images. The numerical model (MM5) was initialized with both NCEP and ECMWF analyses. The model domain is centered at 40 N, 145 W with 300 X 300 grid points in the horizontal and 50 vertical levels. The grid size is 36km such that the domain covers a great portion of the Pacific Ocean and western North America, stretching from Alaska to ~ 10N. Preliminary comparisons show that the simulations initialized with the two different analyses are similar in the evolution of the synoptic flow.

3. Results

Figures 1 and 2 present two examples of the satellite IWV images, illustrating the bands of enhanced water vapor in connection with land-falling storms. Figure 1 is for a neutral ENSO case while Fig. 2 is for an El Nino case. The trajectory analyses using the output from MM5 simulations are depicted in Figs. 3 and 4 respectively for the two cases. It can be seen that in the neutral ENSO case, the air parcels feeding into the broad IWV band originated from the high IWV reservoir in the tropics, indicating the moist tropical low-level air is tapped into and transported northeastward by the storm. However, for the El Nino case, the trajectories of air parcels feeding the IWV plume indicate that they originated from the extratropics and that there is no direct tapping of the tropical low-level moisture into the storm.

Further examination of all the results from the simulations of the aforementioned six cases indicates that the ability of these extratropical cyclones to tap tropical moisture depends on the strength of the Hadley circulation in the eastern Pacific. In the case study from a neutral ENSO year, the flow associated with mid-latitude storms penetrates the sinking branch of the Hadley circulation, creating a break in the sinking branch somewhere between 120W and 180 W. As a result of this, low-level moisture over the tropical ocean feeds into the extratropical storm. On the other hand, during an El Nino year, the sinking branch of the Hadley circulation is enhanced in such a way that it does not have a break in the eastern Pacific. This prevents air parcels over the eastern tropical Pacific from moving northward and interacting with the mid-latitude storms. Seasonal climate analysis confirms the aforementioned ENSO cycle in the strength of the sinking branch of the Hadley circulation (to be shown at the symposium).

In this study, it is shown that a regional weather prediction model can be used as an effective tool to provide a detailed picture of how low-level moisture over the eastern tropical Pacific can feed the mid-latitude storms that produce significant precipitation over the US West Coast. They also provide a better understanding of how the transport of low-level moisture from the low-latitudes to mid-latitudes changes with the ENSO cycle.

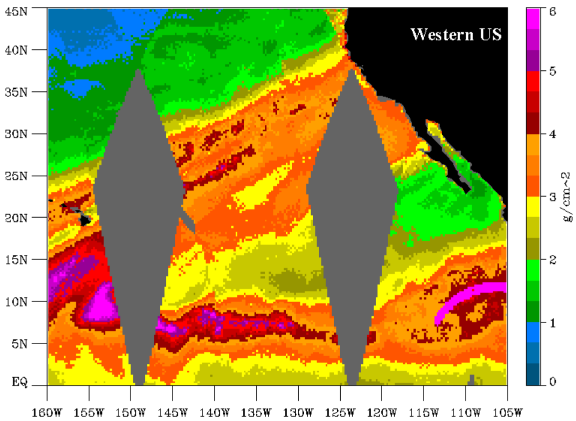

Figure 1 Composite satellite image of integrated water vapor (IWV, g cm^{-2} ~cm) image for 2 January 1997.

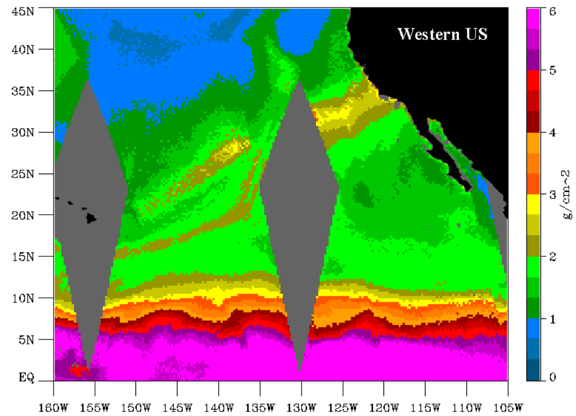

Figure 2 Same as Fig. 1, except for 2 February 1998.

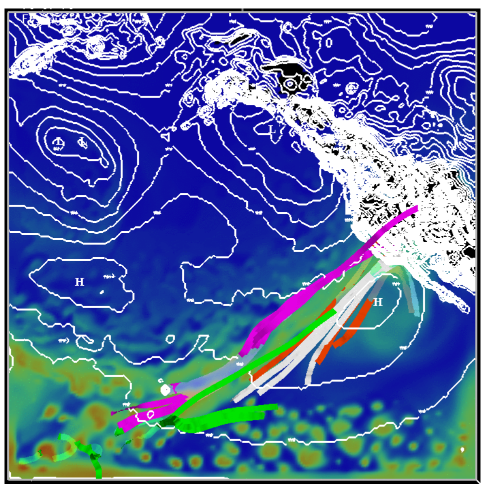

Figure 3 Vis5d image of MM5 output. Contours (white) are of sea level pressure at 00 UTC 3 Jan 1997 (contour interval of 4 mb). Color shading is mixing ratio at 1 km above sea surface. Colored ribbons are backward trajectories released at 00 UTC 3 Jan 1997 (with each color indicating parcels released from similar locations).

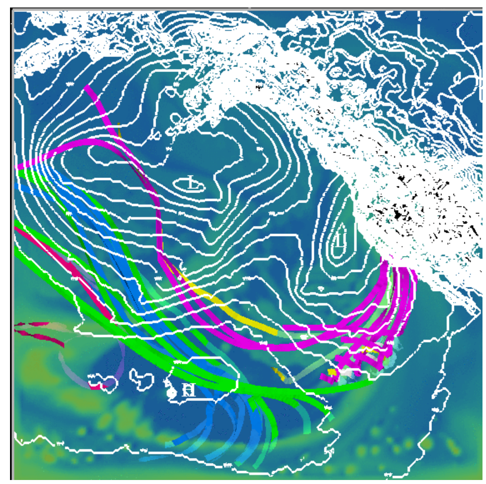

Figure 4 Vis5d image of MM5 output. Contours are of sea level pressure at 09 UTC 3 Feb 1998 (contour interval of 2 mb). Color shading is mixing ratio at 1 km above sea surface. Colored ribbons are backward trajectories released at 09 UTC 3 Feb 1998 (with each color indicating parcels released from similar locations).