A comparison of West Coast atmospheric river axes of orientation using objective and subjective methods during the 2016-2017 cool season

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Introduction

- Atmospheric Rivers (ARs) are prominent drivers of orographic precipitation on the West Coast and the orientation of the AR as it makes landfall could have a large impact on the upslope orographic precipitation of the event, on the basis that perpendicular vapor flux is correlated to storm total precipitation
- This project focuses on two methods for determining the orientation angle of the AR at landfall
  - Objective computational method - Method for Object-Based Diagnostic Evaluation (MODE) of the Model Evaluation Tool (MET) created by the National Center for Atmospheric Research (NCAR) Developmental Testbed Center (DTC) (Bullock and Brown n.d.)
  - Hand collected data method - Video and Annotation Reference System (VARS), created by the Monterey Bay Aquarium Research Institute (MBARI) (Schlining et al. 2006)

VARS

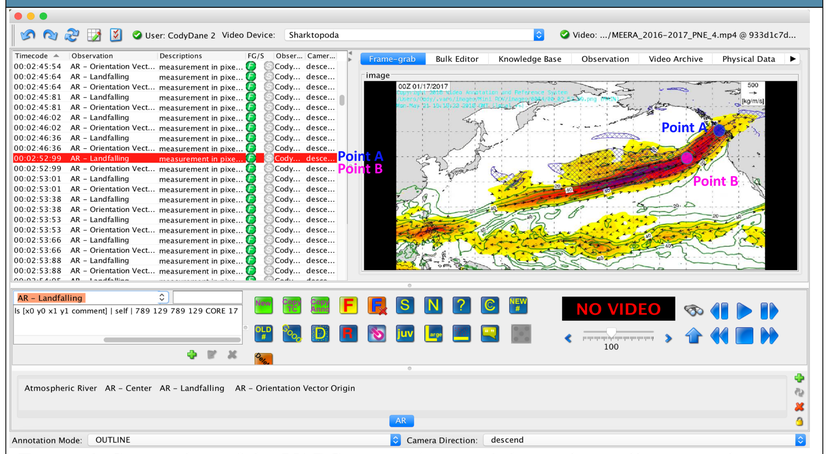


Figure 1: Screenshot of the VARS annotation module used to collect metadata points on a composite video of the MERRA-2 data set for the WY 2017. The red F surrounded in yellow is a button that captures a frame from the video so that the time step of interest can be annotated by the user. The two points are used to produce the AR orientation vector (Point A = AR - Landfalling, Point B = AR – Orientation Vector Origin [also depicted in *Figure. 2*]).

Data

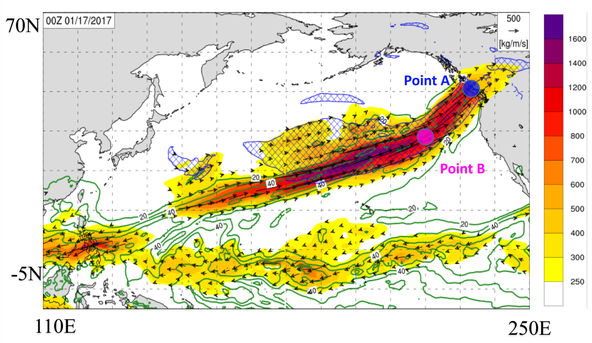
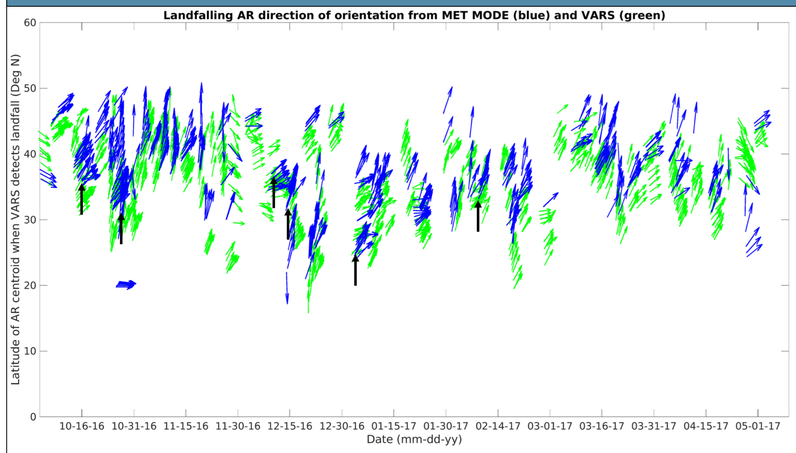


Figure 2 : MERRA-2 (Rienecker et al. 2011) 850 hPa winds (m/s) (Blue Hatched Marks), IVT magnitude (kg/m/s) (color fill), IVT vector (kg/m/s) (Black Arrows), and IWV contour lines (Green Lines) for 01/17/2011 00Z.

Methodology

- AR storm criteria
  - IVT > 250 kg/m/s
  - Length ≥ 20º
  - Crossing over west coast
- Orientation vector construction (VARS)
  - Landfall location - middle of highest density IVT portion of AR (AR core) over coastline (Point A)
  - Vector Origin location - AR core rotates away from landfall insuring orientation vector bisects AR core, IVT vectors used to fine tune line (Point B)
- Object selection (MET MODE)
  - IVT > 500 kg/m/s
  - Aspect Ratio = 2/1
  - Vector intersects object along its axis

VARS vs MET MODE



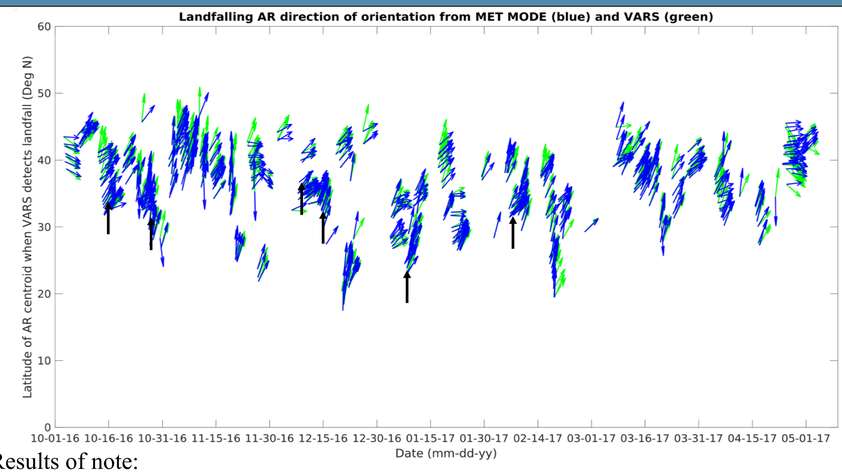


Figure 3 (left): Composite Image of the AR orientation vectors at landfall produced by VARS (green) and MET MODE (blue) for WY 2017. The Y axis represents the latitude of the AR centroid (vector origin) and the AR orientation vector drawn towards landfall. The X axis is the date of each landfalling AR event through its lifetime. (Black arrows point to the case studies represented by *Figures. 5,6,& 7*)
Figure 4 (right): Same as *Figure. 3* for matched AR objects between VARS and MET MODE at landfall. (Black arrows point to the case studies represented by *Figures. 5,6,& 7*)

Results of note:

- Propagation of storms throughout their lifetime
- Difference in the centroid position of AR throughout WY 2017
- *Figure. 3* highlights the skill and variation between the two methods at selecting AR events
- *Figure. 4* highlights the skill of the two methods at constructing AR orientation vectors and the variance set by the differing method structures

Case study comparing two methods

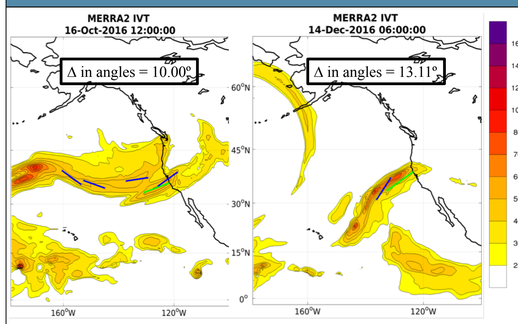


Figure 5: MERRA-2 IVT magnitude (kg/m/s) (color fill) map with AR orientation vectors plotted for the two methods (MET MODE (blue) and VARS (green)) for 10/16/2016 12Z & 12/14/2016 06Z (Black arrows in *fig. 3 & 4*)

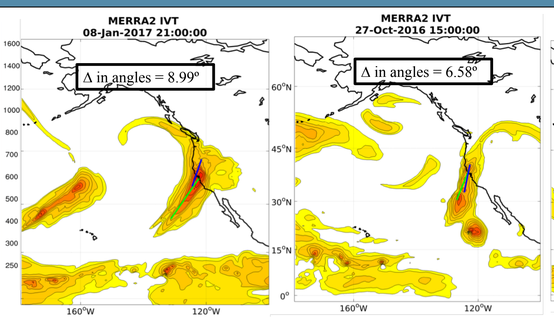


Figure 6: Same as *Figure. 5* for dates 1/8/2017 21Z & 10/27/2016 15Z (Black arrows in *fig. 3 & 4*)

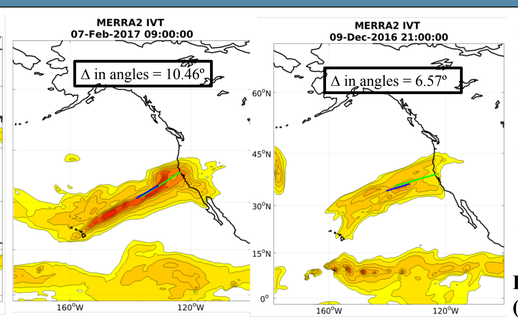


Figure 7: Same as *Figure 5.* for dates 2/7/17 09Z & 12/9/2016 21Z (Black arrows in *fig. 3 & 4*)

VARS Succeeds (*fig. 5*): IVT < 500 kg/m/s, Irregular shaped ARs/AR cores, Multiple AR cores, AR cores located away from landfall

MET MODE Succeeds (*fig. 6*) :

- **Linear AR core**
- **High Density IVT storms**
- **Large AR cores**

Both Succeed (*fig. 7*):

- **Linear storms with non complex AR cores**

Rain out efficiency case study

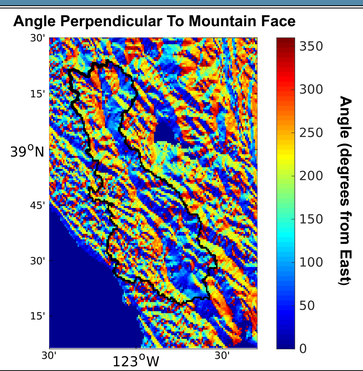


Figure 8. Direction of maximum topographical gradient (defined as mountain face direction angle (degrees from East) computed from National Digital Elevation Model (DEM) 90 m topography with the Russian River watershed outlined in black.

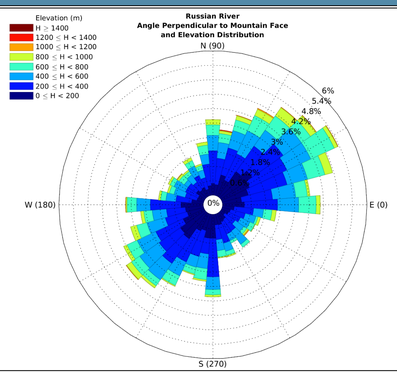


Figure 9. Wind rose showing the angle perpendicular to the mountain face as a function of elevation (azimuth angle). The radial distance represents the % of grid cells within each 10 degree bin.

Conclusions:

- Highest elevations are oriented southwest/northeast
- Orographic precipitation efficiency could be most affected when AR angle is from due South or West
- Average difference in angle between VARS and MET MODE = 2.9 degrees +/-29.85 degrees

Citations/Acknowledgments

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Bullock, Randy, and Barbara Brown. "Method for Object- Based Diagnostic Evaluation NCAR Technical Notes NCAR / TN-532 + STR."
Rienecker, Michele M. et al. 2011. "MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications." *Journal of Climate* 24(14): 3624–48.
Schlining, B.M., and N. Jacobson Stout. 2006. "MBARI's Video Annotation and Reference System." *OCEANS 2006*: 1–5.