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Evaluation of GFS water vapor forecast errors during the 2009-2010 West Coast cool season using the MET/MODE object analyses package

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Introduction

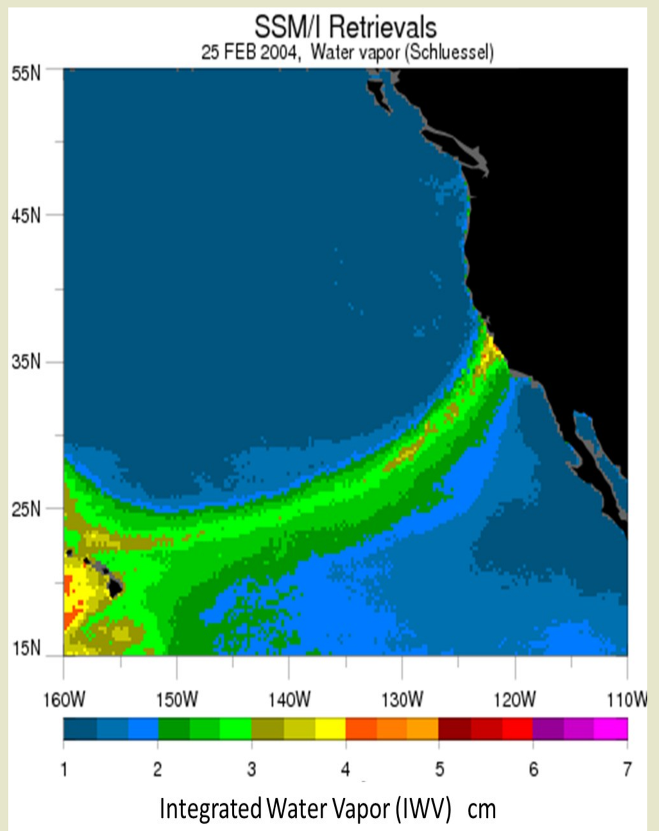
Purpose

Development and trial application of an object verification method (MET/MODE) to quantify uncertainties in forecasts of AR track, areal extent, and intensity regarding U. S. West Coast landfalling Atmospheric Rivers. In this poster a few selected MODE attributes (see column to right) are studied as metrics quantifying the uncertainty in location, area, and intensity of GFS forecast Integrated Vapor Transport (IVT) forecast objects versus GFS analysis objects.

Approach

The metrics used here are based on the attributes built into the Method for Object based Diagnostic Evaluation, which is provided as a part of the Model Evaluation Tools (MET) verification package developed by the National Center for Atmospheric Research (NCAR) for the Developmental Testbed Center (DTC). A few relevant attributes are described in the column to the write.

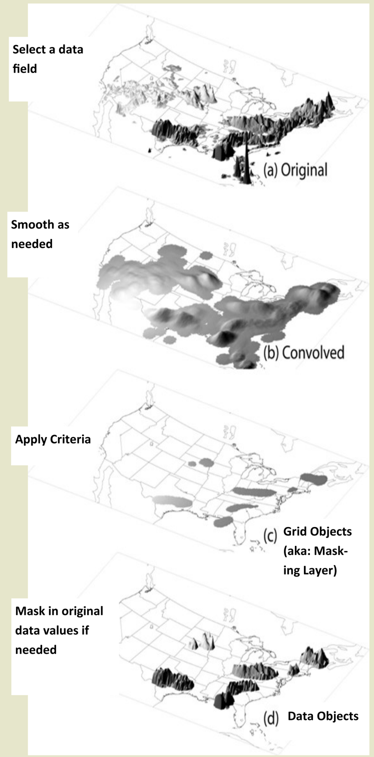
What is an Atmospheric River?



The classic atmospheric river is an intense, elongated low altitude flux of water vapor embedded along and in front of the surface cold front of extratropical or mid-latitude cyclones. ARs are responsible for most if not all extreme cool season precipitation events along the California coast. The integrated water vapor (IWV) satellite observation shown above depicts a particularly extensive AR that illustrates particularly well an AR's IWV signature while at sea.

What is a MODE Object?

MODE is a **M**ethod for **Ob**ject based **D**iagnostic **E**valuation of gridded data fields. The objects to be evaluated are constructed as shown to the right.



Example Comparing Two MODE Grid Objects:

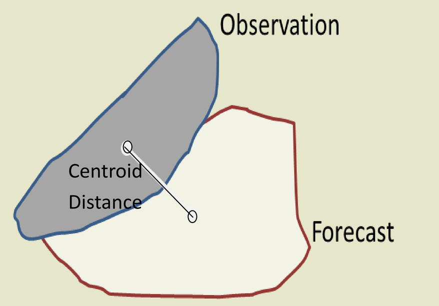
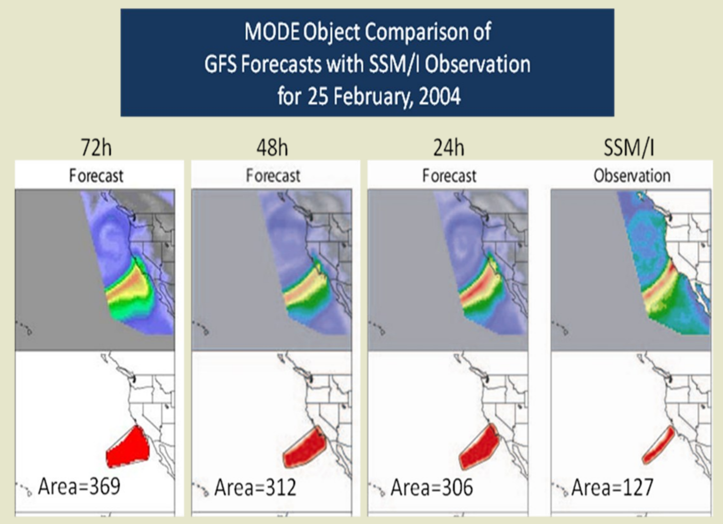


Table of Selected MODE-Calculated Object Attributes:

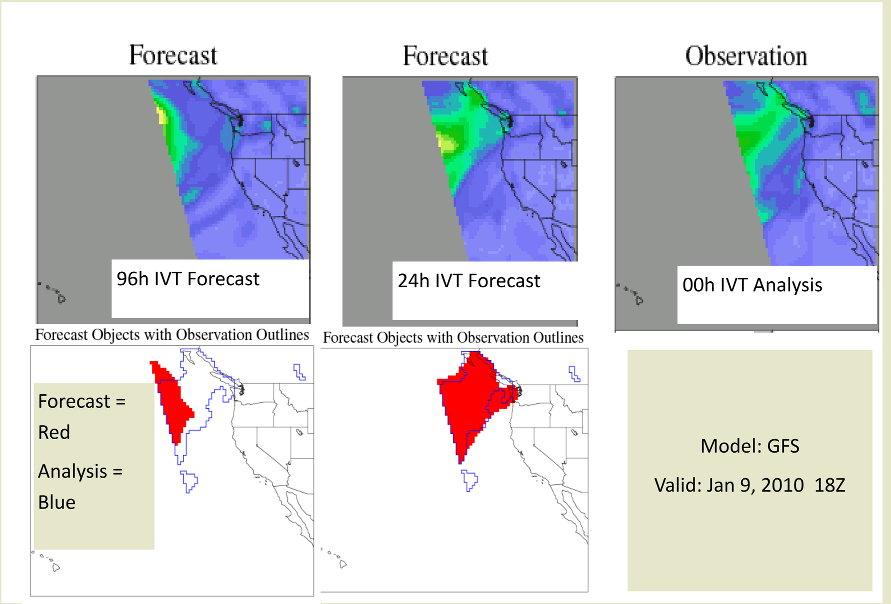
	Individual Objects	Paired Objects
Grid Object	Centroid Location Area	Centroid Distance Area Comparisons: Intersection, Union, Non-Intersection, etc.
Data Object	Peak Intensity Percentile Intensity Total Intensity	Intensity Difference for a given percentile Intensity Ratio for a given percentile

For Example: Inspection of the figure to the right illustrates the use of the graphical output of MODE to depict the changes in area and landfall location that occur with forecast lead time as shown in an IWV field.

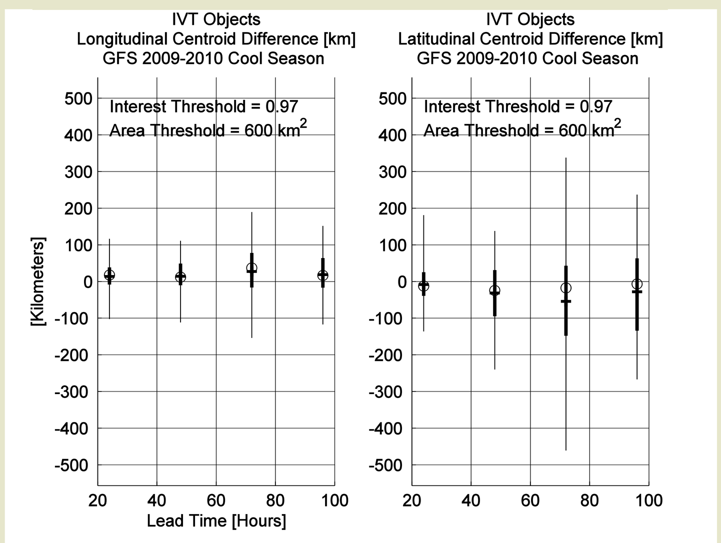


MODE Attribute Analysis of IVT over the 2009-2010 Cool Season

Uncertainty in Centroid Location

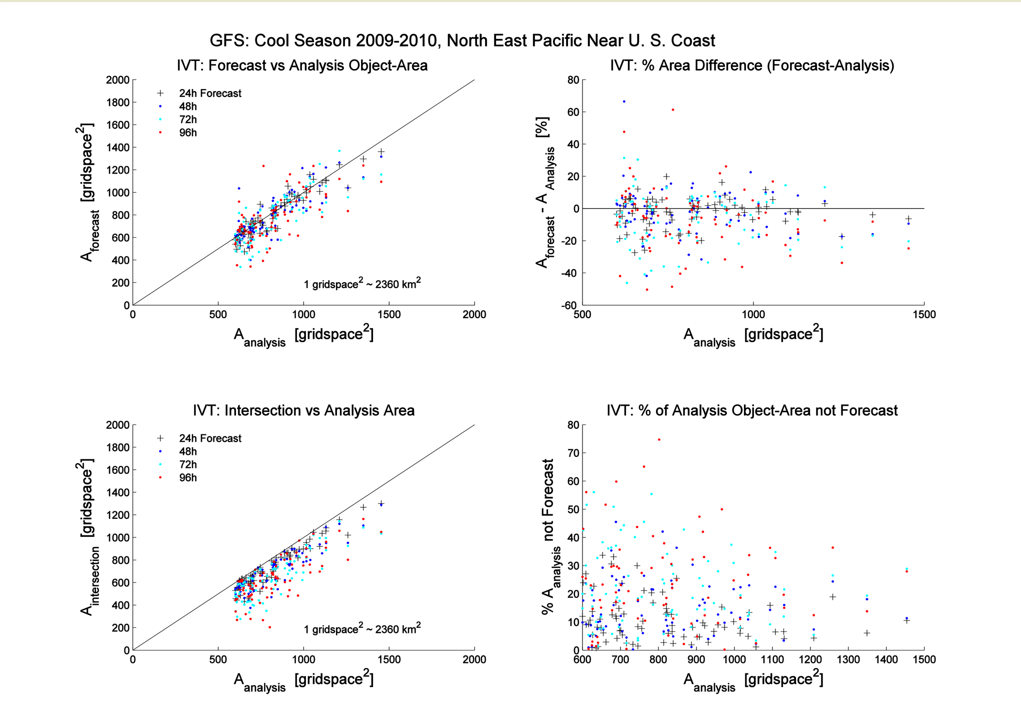


Percentile Ranges: 2.5—97.5 = Thin line, 25—75 = Thick line
Median = o, Mean = +



The left most figure above was built from the graphical output of MODE. From top left to top right it shows the 96 h and 24 h GFS forecast of Integrated Vapor Transport , to be compared with the third panel, the GFS analysis. The two lower panels show the MODE determined IVT objects, where the forecast objects are in solid red and the Analysis objects ('Observations') are outlined in blue. Clearly the 24 h forecast object is much closer to the analysis. A measure of correct placement is the centroid distance between the forecast and the analysis. A statistical summary plot (in kilometers) is given in the plot above and to the right. It is plausible but not yet demonstrated that this uncertainty of location, which increased as the lead time increased and suggests a 10 to 20 km forecast bias to the south for lead times larger than 24 h, reflects the uncertainty in the models ability to forecast precipitation event locations and timing.

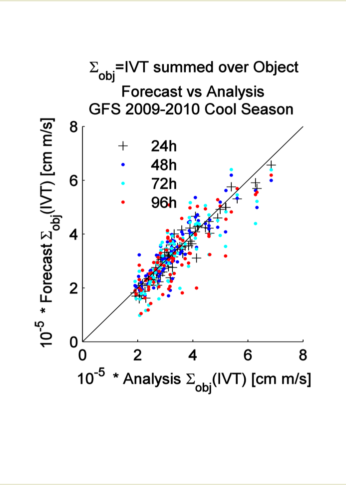
Uncertainty in IVT Object Area



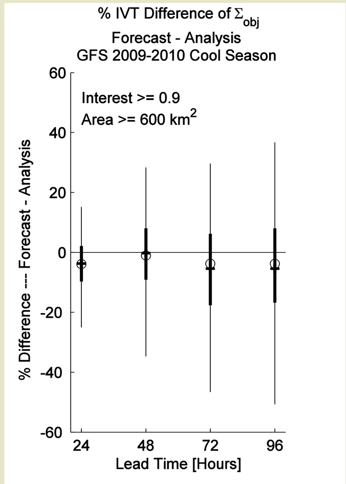
The upper panels in the figure to the left examine the uncertainty in object area present in IVT forecasts relative to the analysis objects. Focusing on the black plus and red dot symbols, representing the 24 h and 96 h forecasts, respectively, it is clear that the uncertainty is indeed larger by 96 h. During this season the GFS forecasts apparently tended to under predict analysis object size by 10% or so.

The lower panels present the area of intersection of the forecast object with the analysis object. Again, the uncertainty is less with shorter lead time. The difference between the intersection area and the analysis area is constant with area, so that the percentage error decreases as the area becomes larger. The bottom right panel shows the percent of the analysis area missed by the forecast objects. In traditional skill scores, grid point comparisons in these non-intersection regions would be recorded as misses.

Uncertainty in IVT Object Intensity



Percentile Ranges:
2.5—97.5 Thin line
25—75 Thick line
Median o
Mean +



The total IVT found by summing over an object is directly related to the potential rainout of an event. Note that 50% of the comparisons boxplot-illustrated in the lower panel differ outside the range of the thick vertical . Again as expected, the uncertainty in total IVT was smaller for the 24 h forecast than the 96 h forecast. The suggested negative bias of 5% or so seems relatively constant with lead time, although the 48 h forecast was closer.

Discussion

A first step using MODE object attributes to quantitatively diagnose the uncertainty in the location, size, and intensity of U. S. West Coast landfalling atmospheric river events was described here. The study focused on the 2009-2010 cool season, utilizing forecasts and analyses for the 6 Z and 18 Z GFS valid times . As anticipated, the uncertainties indicated by the attributes in location, object area, and flux intensity increased significantly with lead time. A southerly centroid bias of about 20 km in these GFS runs for lead times larger than 24 h and less than 96 h was noted. We hypothesize that the centroid difference is reflective of the precision with which forecasters can predict the timing and location of landfalling AR events, but this remains to be demonstrated.

The absolute error on object area was observed to be independent of the area, so that the relative error decreases as the objects become larger. The same was true for the error in overlap of the forecast with the analysis objects, so that the larger the object the higher percentage of overlap that may be expected. This can be related to traditional skill scores by noting that this implies that there will be fewer misses and more hits for larger events. As expected, both area and intersection uncertainty increased with forecast lead time.

With respect to the total IVT summed over the forecast and analysis objects the differences were observed to be independent of intensity, but to increase with lead time. This implies that for big events the percent error in object intensity will decrease as events get larger.

Taken together these results suggest that the biggest source of error in predicting precipitation events may well be due to the uncertainties in location and timing.

Two Basic References:
MODE ://www.dtcenter.org/met/users/support/online_tutorial/METv2.0/mode/index.php
Atmospheric Rivers : Neiman, P. J., et al., 2008, J. Hydrometeorology, Vol. 9, pg. 22.