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GFS water vapor forecast error evaluated over the 2009-2010 West Coast cool season using the MET/MODE object analyses package

NOAA/ESRL/PSD
Wallace Clark, affiliated with the **Science and Technology Corporation**
Ellen Sukovich, affiliated with **Univ. of Colorado, CIRES**
Gary Wick

NOAA/ESRL/GSD
Ed Tollerud, affiliated with **NCAR/RAL/DTC**
Huiling Yuan, now with Nanjing, Univ., China
Isidora Jankov

NCAR/RAL/DTC
Tara Jensen
John Halley-Gotway
Randy Bullock
Paul Oldenburg

Introduction

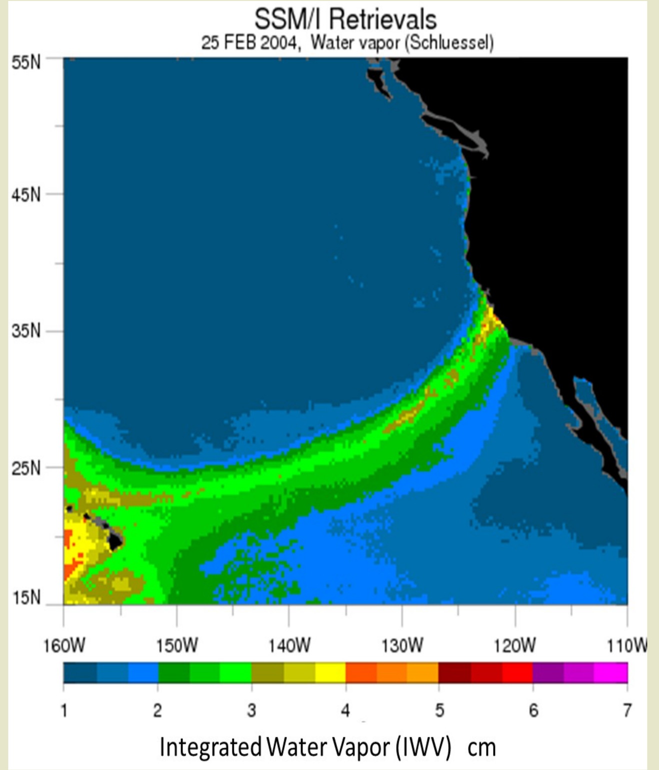
Purpose

Development and trial application of verification methods that quantify uncertainties in forecasts of AR track, areal extent, and intensity regarding U. S. West Coast landfalling Atmospheric Rivers.

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) Developmental Testbed Center (DTC).

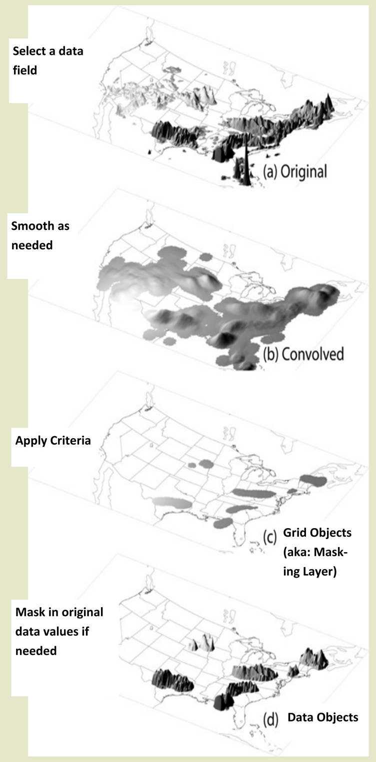
What is an Atmospheric River?



The classic atmospheric river is an intense, elongated low level flux of water vapor located 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. With satellite observation, as in the above figure, ARs show up while out at sea as intense narrow ribbons of integrated water vapor (IWV) .

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 found as shown to the right.



Example Comparing Two Grid Objects:

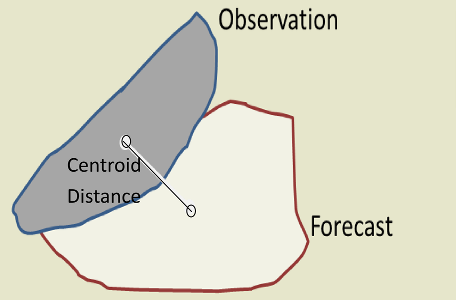
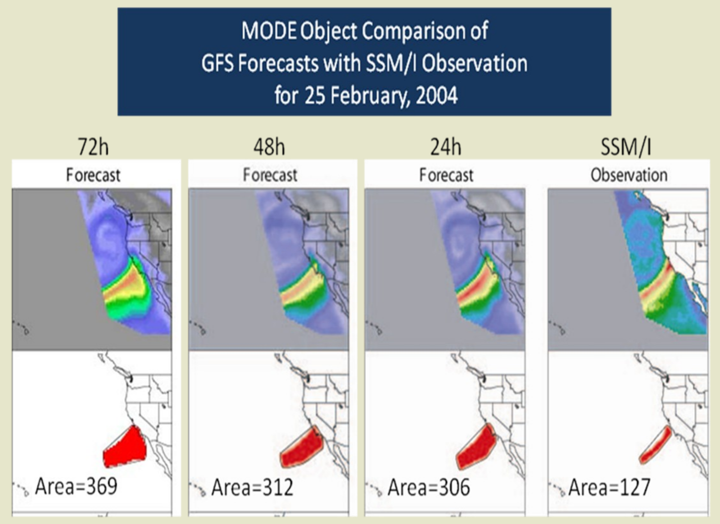


Table of Selected MODE-Calculated Object Attributes:

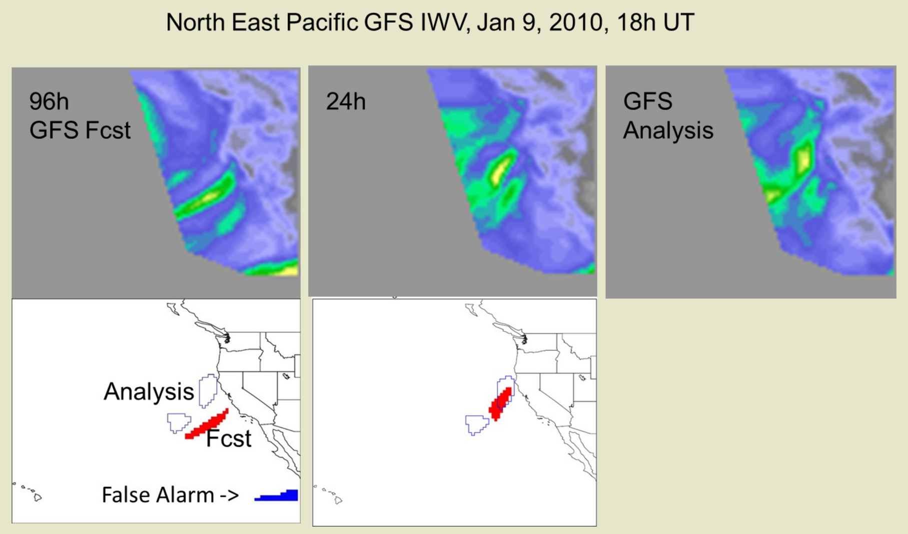
	Individual Objects	Paired Objects
Grid Object	Centroid Location Area	Centroid Distance Area Comparisons: Intersection, Union, Non-Intersection, etc.
Data Object	Peak Intensity Percentile Intensity Total Intensity	Intensity Difference for a given percentile Intensity Ratio for a given percentile

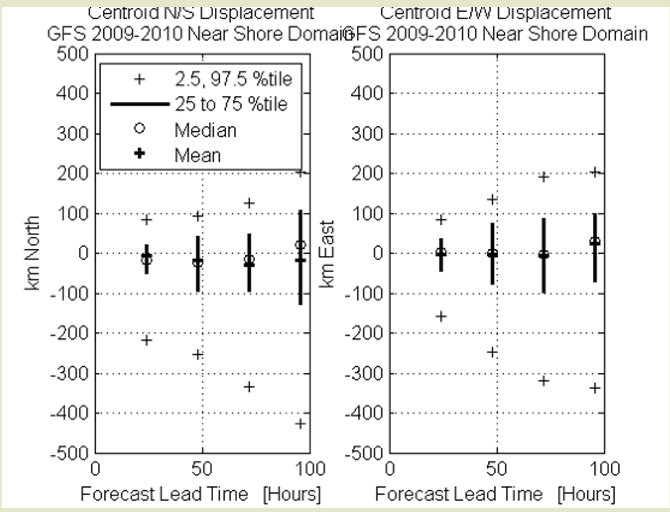
For Example: Inspection of the figure to the right illustrates the use of the graphical output of MODE to depict the changes in area and landfall location that occur with forecast lead time.



MODE Attribute Analysis of the 2009-2010 Cool Season

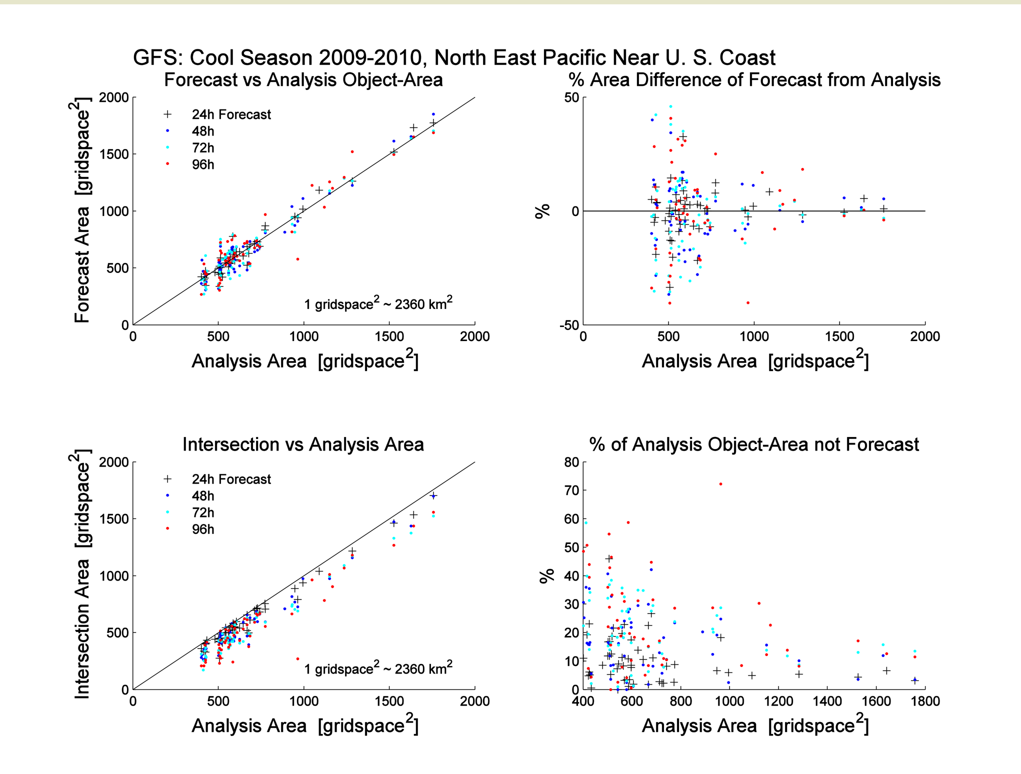
Uncertainty in Centroid Location





The left most figure above was built from the graphical output of MODE. From left to right it shows the 96 h and 24 h GFS forecast of Integrated Water Vapor (IWV), to be compared with the third panel on the right, the GFS analysis. The two attached lower panels show the MODE determined IWV objects, where the forecast objects are in solid color and the Analysis objects are outlined. 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) given in the plot above and to the right. It clearly demonstrates the increase in uncertainty of location as the lead time increases, and suggests a 10 to 20 km forecast bias to the south for lead times larger than 24 h.

Uncertainty in Object Area

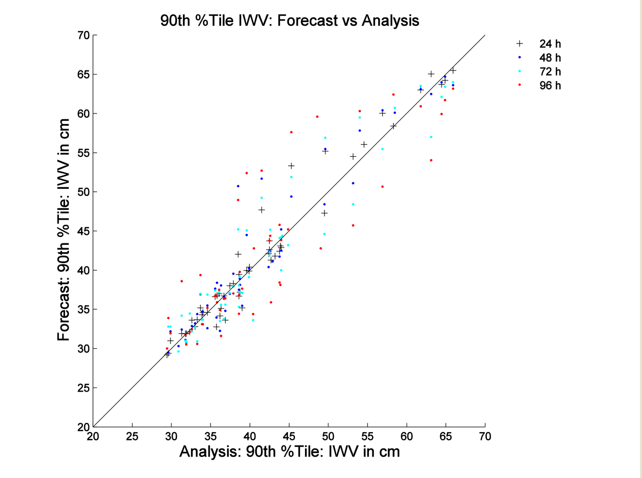


The figure to the left examines the uncertainty in object area present in IWV forecasts relative to the analysis objects. Focusing on the black plus and red dot symbols, representing the 24 h and 96 h forecasts, respectively, it is clear that the uncertainty is indeed larger by 96 h. Still, for the large areas the uncertainty is within a few percent.

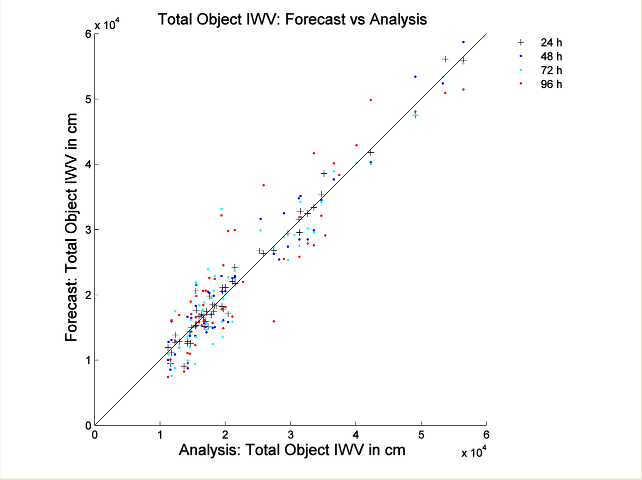
The lower panel presents the area of intersection of the forecast object with the analysis object. Again, the uncertainty is less with shorter lead time. The difference between the intersection area and the analysis area is surprisingly constant with area, so that the percentage error decreases as the area becomes larger, although only the 24 h forecast has an error less than 10 %.

Uncertainty in Object Intensity

(i.e., IWV value)



The 90th percentile of the IWV values within an object can be used as a measure of the peak intensity of the object. The panel to the left demonstrates that even the 24 h forecast exhibits significant uncertainty with respect to peak intensity, although it is a better estimate than that from the 96 h forecast..



The total IWV contained in an object is directly related to the potential rainout of an event. The uncertainty in this quantity is much better for the 24 h forecast than the 96 h forecast.

Discussion

A first step using MODE to quantitatively diagnose the uncertainty in the location, size, and intensity of U. S. West Coast landfalling atmospheric river events has been described here. The study focuses on the GFS 6 h and 18 h forecasts and analyses over the 2009-2010 cool season. As anticipated, the uncertainties found 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.

The 96 h forecasts, although more uncertain, still were sufficiently precise for a 'heads up'.

This first effort compared the GFS forecasts with the GFS analysis. Future work will compare other fields than IWV, models with other models, and models with observations.

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.