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, area, vectors, and intensity regarding the West Coast landfalling Atmospheric Rivers. In this poster a few selected MET/MODE attributes (see columns to right) are studied as metrics to assess 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 columns to the right.

What is a MODE Object?

MODE is a Method for Object Based Diagnostic Evaluation of gridded data fields. The objects to be evaluated are constructed as shown to the right.

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 or all extreme cool season precipitation events along the California coast. This 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.

Legend

Table of Selected MODE Calculated Object Attributes:

<table>
<thead>
<tr>
<th>Individual Objects</th>
<th>Mode Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centroid Location</td>
<td>Centroid Deletion</td>
</tr>
<tr>
<td>Interiors Intersection: Interiors Union, Non-intersection, etc.</td>
<td></td>
</tr>
<tr>
<td>Relative Location</td>
<td>Intensity Variance, Intensity Ratio (aka: Mask-Grid Objects)</td>
</tr>
<tr>
<td>Total Intensity</td>
<td>Intensity Difference for a given percentile</td>
</tr>
<tr>
<td>Percentile Ranges: 2.5—25 — Median = o, 25—75, 75—97.5</td>
<td></td>
</tr>
</tbody>
</table>

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

Uncertainty in IVT Centroid Location

In the figure to the left the upper panels illustrate the uncertainty in object area of IVT forecast objects relative to the analysis objects. The black pluses and red dots represent the 24 h and 96 h forecasts, respectively. It is apparent that the uncertainty is larger for 96 h. Analysis of the statistics reveals that this connection is particularly strong for larger events. As expected, both the uncertainty in the centroid location decreased with shorter lead time and increased with larger object size.

Uncertainty in IVT Object Area

In the 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 (Observation) are outlined in blue. The 24 h forecast objects are much closer to the analysis objects.

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 0.2 and 1.2 GFS valid times. As anticipated, the uncertainties recorded by the attributes in location, object area, and flux intensity increased significantly with lead time. A southern control bias of about 20 km in these GFS runs for lead times longer than 24 h and less than 96 h was noted. We hypothesized 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 area becomes 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 the percentage of overlap that may be expected. This can be related to traditional skill scores by noting 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.

Takes together these results are consistent with uncertainties in location and timing being the biggest sources of error in accurate prediction of AR driven extreme precipitation events.

Two Basic References:

MODE: www.doiwet.net/users/support/online_tutorials/03/02/MODE/index.php