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Assessing and Comparing Real-Time Northeast Pacific Atmospheric River IWV and IVT Intensities Provided by Model (GFS) and Satellite (SSM/I, SSMIS) Using DTC 's MET/MODE Object Attributes

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Purpose: Examine strategic use of domain size to enhance MODE object analysis

Introduction

Accurate forecasts of atmospheric river landfall events **require** accurate forecast of:

- Low level atmospheric water vapor flux (~ Integrated Vapor Transport, IVT)
- Atmospheric Water Vapor (~ Integrated Water Vapor, IWV)
- Associated wind field (speed and direction)

Here we use DTC's MODE package to:

- compare IWV: GFS forecast/analysis data fields against SSM/I observations
- compare IVT: GFS forecast data fields against GFS analysis

Main strategic tool examined: Choice of domain size

- Northeast Pacific Domain (~4400 km scale)
- Boundary 1000 km from West Coast
- Along Coast strip domain ~150 km longitudinally and 2740 km latitudinally.

Domain 1: Northeast Pacific

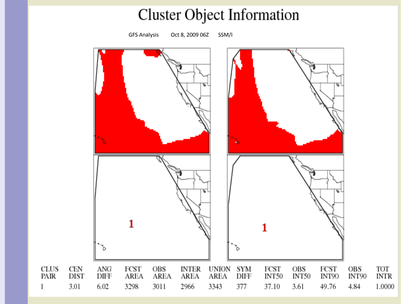
The NEP domain is big enough for IWV and IVT verification studies, although IWV objects reach global scale.

Example of MODE IWV analysis for a single time:

Integrated Water Vapor for Oct 8, 2009 06Z

GFS Analysis | SSM/I 12h Composite | mm IWV

MODE was applied using a 25 mm IWV threshold, generating matched object pairs like the pair below. Selected attribute values for this pair are tabulated.

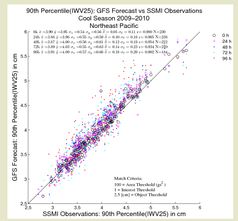


CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYM DIFF	FCST INT50	OBS INT50	FCST INT90	OBS INT90	TOT INTR
1	3.01	6.02	3298	3011	2966	3343	377	37.10	3.61	49.76	4.84	1.0000

Selected Statistical Summary of IWV Object Characteristics for the 2009-2010 Cool Season

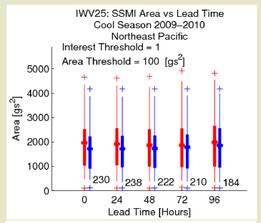
1.Intensity

The plot below compares the forecast versus observed 90th percentile value of IWV intensity within the matched objects. A few objects contained values exceeding IWV = 5.7 cm.



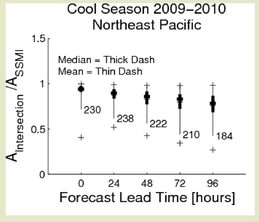
2. Object Area

The paired box plots below show that the number of hits (matchable objects) decreased with lead time (230 matches at 00h lead, 184 hits at 96h). Some objects had areas approaching 5000 grid squares (1/2°x1/2°). A positive area bias of GFS (red) over SSM/I (blue) is evident.



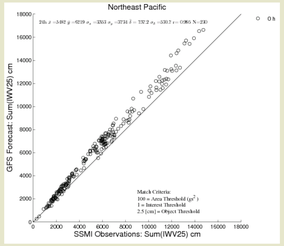
3. Object Overlap Ratio

A perfect fit = 1. The fit deteriorates with lead time, indicating differences in location or shape.

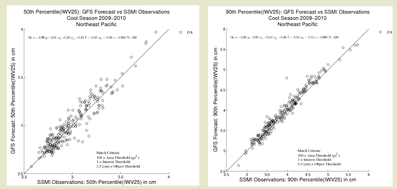


Example Result: An apparent effect of grid size differences

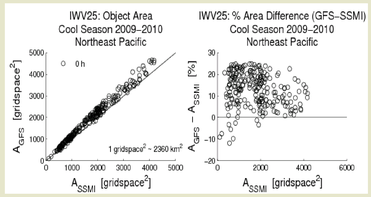
The Puzzle: The 2009-2010 cool season plot below of GFS total-within-object IWV versus SSM/I indicates a positive total-IWV model bias that increases with amount. **Why?**



It isn't intensity. The plots below of 50th and 90th percentile values of intensities within the objects imply that the GFS and SSM/I pixel values are in good agreement .



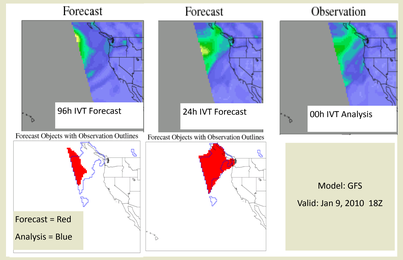
It is apparently due to object area. The median GFS areas are about 12% larger (with a lot of scatter) than the SSM/I objects, although the bias appears to change non-linearly at the smaller values.



The positive bias in object area may be a side effect of requiring intensity values at one spatial resolution to match those of a different spatial resolution. A close study of the down and upscaling procedures used here, and the methods used to bring these GFS results and SSM/I observations into line performed elsewhere, should clarify the cause.

Domain 2: 1000 km from Shore
Integrated Vapor Transport (IVT)

To restrict attention to landfalling objects a smaller , more focused domain is tempting. Problems inherent with this focus for IWV and IVT objects are discussed below. The figure shows MODE analysis of GFS IVT forecasts versus analysis fields for a particular time.



1. **Visually** - This domain looks promising.

   For example: The 96h forecast clearly underestimates the intensity in the leading part of the event relative to the analysis, so that the 96h forecast of no landfall would be a miss.

2. **Quantitatively** - This domain is problematic.

   A. Object truncation at the western boundary makes the MODE attributes hard to interpret.

   B. There is no built in automatic way to ascertain if and where landfall is occurring.

3. **Post Processing Possibilities**

   A. Post processing of the pixels in the objects could ascertain if landfall is occurring.

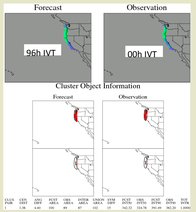
   B. Post processing could incorporate the time domain allowing determination of time, location, and duration of landfall events.

   C. Matching objects over time is in development.

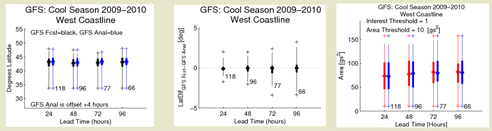
   D. To be definitive for IVT object landfall studies, data fields more closely spaced in time than the 12h currently available are required, as the GFS objects are snapshots and not time averages.

Domain 3: Latitudinal Strip 150 km from Shore
IVT

MODE attributes can provide attributes relevant to atmospheric river landfall by restricting the domain to a latitudinal coastal strip. The following examples compare GFS forecasts to GFS analyses because grid-matched vector wind observations over the NEP were not available.



Defining landfall as the presence of an object within the strip gives some MODE attributes a physically meaningful interpretation. For example, over the 2009-2010 cool season the figures below show:



- 50% of matched landfall centroids were between 43° and 45° latitude.
- Hits (matches) decreased from 118 to 66 betweemn24h and 96h lead time.
- There is little if any centroid bias in latitudinal location but there is significant uncertainty that increases with lead time.
- 50% of the objects cover 930 to 1830 km of coastline (i.e., 1 latitudinal gs = 55 km, and the strip is 3 gs wide).
- At least one matched pair covered the whole domain (2750 km of coastline)

Three Basic References:

Atmospheric Rivers :

Neiman, P. J., et al., 2008, J. Hydrometeorology, Vol. 9, pg. 22.

MODE :

www.dtcenter.org/met/users/support/online_tutorial/METv2.0/mode/index.php

Object-Based Verification of Precipitation Forecasts:

Davis, C.., B. Brown, and R. Bullock, 2006, Monthly Weather Rev.,, Vol. 134, pg. 1772.