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Wavelet Satellite Thinning for Improving Data Assimilation and Forecasts Using Targeted Observation Schemes

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INTRODUCTION

The targeting observation experiment has two components. The first of which, is an examination of satellite thinning on the final GSI analysis. This was executed this past fiscal year and is shown in this poster. The goals here were essentially to:

- Run full-resolution AMSU A and B satellite data through a comparable (30km) resolution grid to establish the "finest assimilation field" that GSI could produce
- Thin the same data set using GSI thinning to a coarser density, the density chosen was 120km (which is nominal thinning for GSI).
- Obtain and read the bufr AMSU satellite data files using GSI and perform the experiment on a Mercator grid set up over the north central Pacific Ocean.
- Compare the output of the two GSI runs to examine subjectively how and if they differ.

Targeting Strategy – Big Picture

Following these completed milestones, the next step in the process is to employ wavelet filtering to enable a new "revised" bufr file to be generated for GSI ingest. This new file will contain high resolution data in a selected area that would be the typical "targeted" area, for a targeted forecast test. The remainder of the satellite data field would be at coarser resolution. Wavelets would be the key in inserting the high resolution data inside the coarse area with a filtered transition for the bounding area surrounding the high density data.

The subsequent step would be to take the wavelet filtered data and generate a new bufr data file that would be both smaller in overall size because it contained mostly coarse data, but it would also offer high resolution data in the region simulating the "targeted" area. The test would be to see what GSI does with this new bufr data. Will GSI retain the high density information where inserted? Will GSI output suffer from noise, potentially induced by edge affects in the boundary region around the full-resolution data?

If a smooth transition can be achieved, then we have confidence that there is a way to both target an area for full-resolution data density and make the satellite data more efficient to use by assimilating thinned data elsewhere. Typically it is too expensive for GSI to assimilate full-resolution data routinely, and it is data thinning that is the nominal approach in GSI satellite data assimilation.

Wavelet Approach

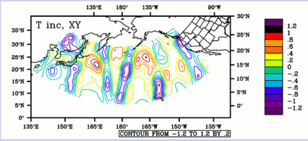
Wavelets can be used to maintain high resolution inside a region of lower resolution. The advantage of this approach is filtering, elimination of edge effects bounding the high-resolution area and ultimately a data field that can be efficiently compressed resulting in lower storage costs, less radiative transfer model costs, and faster data transfer rates given limited bandwidths. The wavelet approach as applied here is only one of many applications. As satellite data grows in volume with both increase sensor technology and higher resolution samplings, efficient storage and transmission will become more and more important in the future.

Shown below are two figures, one with high resolution satellite data everywhere, the second with low resolution everywhere except in the outlined box. In Fig. 2, the entire field is described by one data set using wavelets to preserve the high-resolution data within the boxed area.

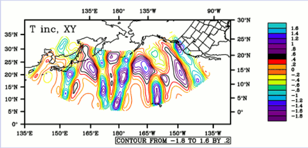
GSI Thinning Tests

The GSI thinning tests used AMSU A (thermal) and AMSU B (moisture) data over the Pacific for 24 Dec 2010. GSI error co-variances were left as nominal for typical operational use and these pre-selected the channels used in the assimilation. All channels that GSI earmarked for assimilation were incorporated in the analysis. The following results where obtained. The plots shown compare the analysis using satellite data at the given resolution compared to the no-satellite analysis. In all cases, there appears to be more structure and better spatial information using the high-resolution data.

Results Temperature (K)

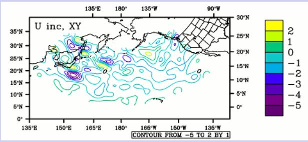


120 km

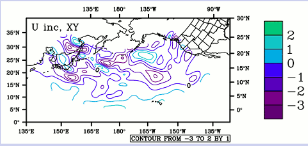


30 km

Results U (wind m/s)

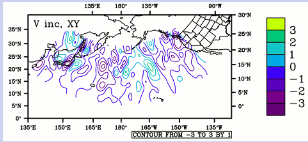


120 km

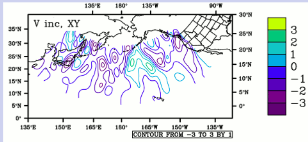


30 km

Results V (wind m/s)

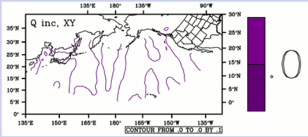


120 km

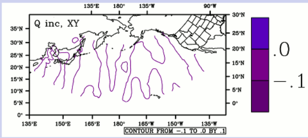


30 km

Results q (specific humidity kg/kg)



120 km



30 km

Summary

In this initial test of GSI assimilation of thinned (120km) and high resolution data (no thinning – 30km), we see the majority of the fields demonstrate higher spatial structure and larger amplitude features in the high-resolution assimilation. One would logically expect this result since thinning would ignore small-scale features. The primary results of this test shows the degree to which analysis using high-resolution satellite data are superior to thinned satellite data. Illustrating the degree of improvement that can be achieved by using data at close to full resolution.

Wavelet Transform and Filtering Demonstrated

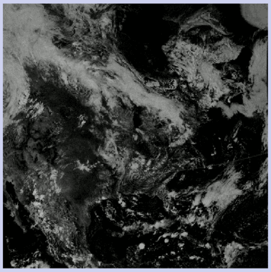


Fig. 1 - Full resolution GOES image

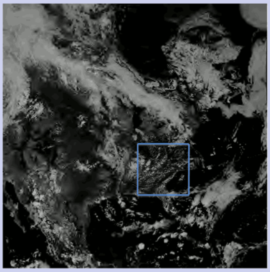


Fig. 2 - Wavelet transformed image with low-resolution everywhere except in the boxed in area.

Results and Conclusions

These results show that indeed there is much to be gained by utilizing full resolution data in GSI assimilation. It follows, that there is merit to advance to the next step in this investigation; that being the insertion of high resolution data in a particular area of interest while using thinned data in other regions. Thus, if the area of importance is identified and higher resolution data are used in this region, both a faster assimilation can be achieved (since thinned data are used most everywhere except where needed) and the solution will benefit by more structure in the high resolution area (target zone). The high resolution data can be inserted in the coarser field using the wavelet transform approach.

Future Work

- Next step now that we see high resolution data does have an impact to the GSI run is to produce a wavelet transformed data set
- Take that set and produce a bufr input file to the GSI
- Run the GSI with that data set and examine the impact in regions of high and low data density.

Acknowledgements: The authors wish to thank NOAA/ESRL/GSD/FAB staff members for contributions and the THORPEX project for support.