Selection technique for thinning satellite data for numerical weather prediction

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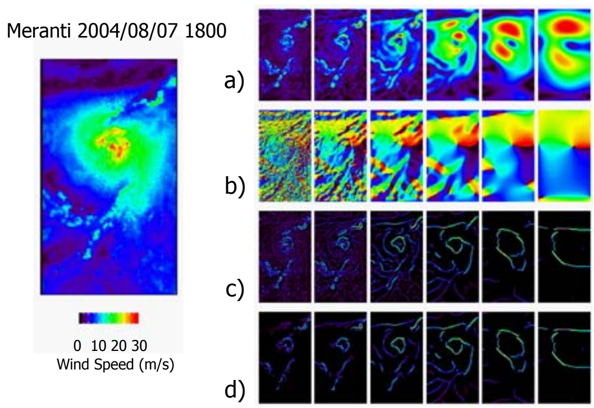
Satellite Data Selection

- Enormous volumes of satellite data arrive at NWP centers in real-time
- Thinning is needed for efficiency
- Current practice is decimation (every n^{th} data point)

Wavelet-based data selection

- Analyze two-dimensional scalar field using the Continuous Wavelet Transform (CWT).
- Identify wavelet transform modulus maxima (WTMM, c) for each scale using the wavelet magnitude (a) and phase (b).
- Create wavelet maxima chains from the WTMM for each scale by comparing nearest neighbors.
- Perform wavelet noise reduction to eliminate extraneous WTMM chains (d).
- Connect remaining wavelet maxima chains through scales to create wavelet ridge (signal skeleton).
- Select data points along wavelet ridge lines



Wavelet noise thresholding

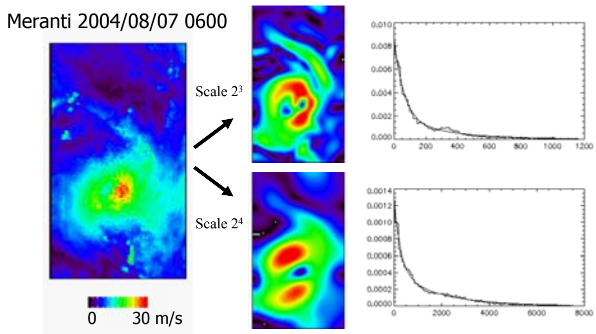
- Calculate square modulus from wavelet components for each scale:

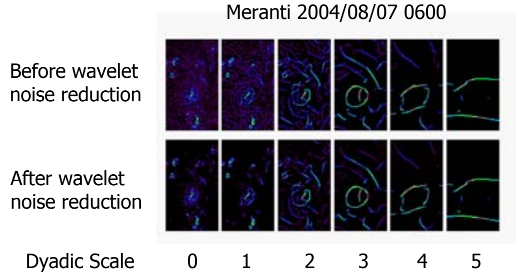
$$M_j^2[m,n] = \left|d_j^H[m,n]\right|^2 + \left|d_j^V[m,n]\right|^2$$

- Model squared modulus as two-component Gamma distribution using Nelder-Mead simplex method:

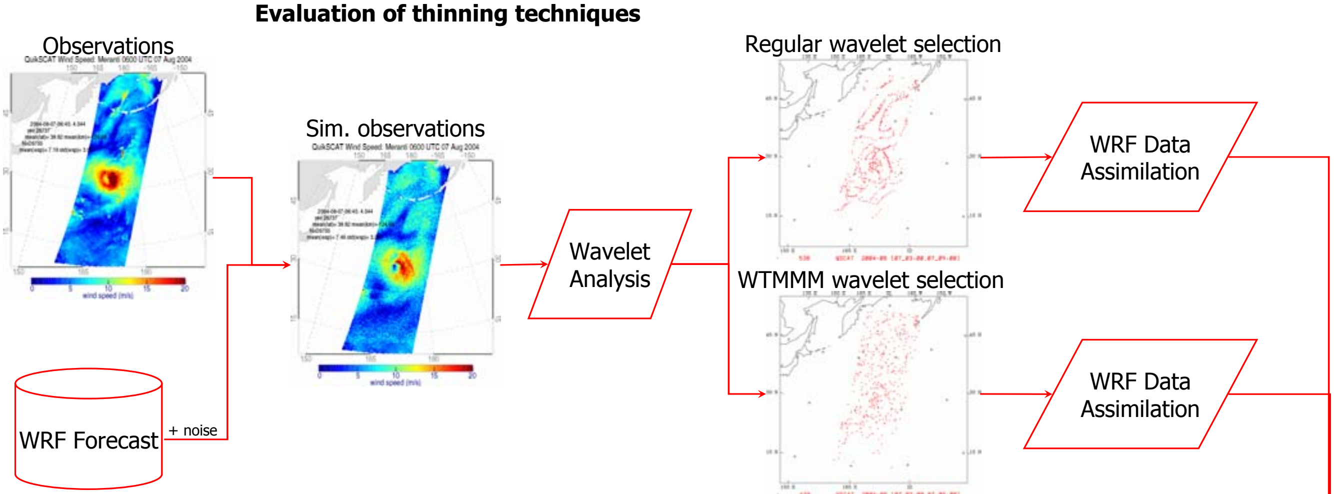
$$p_{M_j^2}(x) = w_0 \frac{1}{\lambda_0} e^{-x/\lambda_0} + w_1 \frac{1}{\lambda_1} e^{-x/\lambda_1}$$

- Calculate posterior probability that wavelet coefficient is significant using Bayes Method.





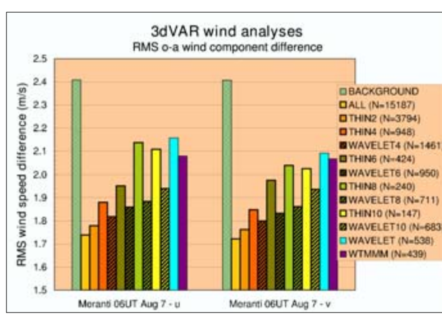
Evaluation of thinning techniques



- Weather Research and Forecasting (WRF) model used to generate "nature run" (truth).
- Observations simulated by sampling "nature run" and adding observation noise (+/- 2 m/s random).
- Wavelet analysis performed on simulated obs.
- Sub-sets of simulated observations generated in other ways also, for a total of twelve treatments.
- Generate atmospheric analysis with WRF VAR.
- Validate WRF VAR analyses using all observations (see bar chart, right).

Summary:

- Wavelet analysis identifies meteorological features
- Atmospheric analysis of wavelet-selected points does not yet deliver gains in accuracy or efficency
- Alternative basis functions or data assimilation methodologies will be explored



Thanks to NASA's Earth Science Technology Office (ESTO) for supporting this work (award #AIST-QRS-04-3019).