A robust representation of rain microwave radiances and scatterometer winds for data assimilation

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1-slide summary of our approach:

• Start with HWRF simulations (say HEDAS Earl 2010 h3vk, 2010-08-29-12Z to 2010-09-03-18Z),
using stream ψ, potential χ, P, T, RH, W, q_{cliq}, q_r, q_{cli}, q_s, q_g, q_h
at 42 vertical levels for a total of 504 variables $x_1, \dots, x_{504}$
• for each of these 12million columns, forward-calculate $T_{b1}, \dots, T_{b9}$

- Step 1: find the principal components $x_1', \dots, x_{504}'$
- Step 2: find the principal components $T_1', \dots, T_9'$

- Step 3: find
  combos of $x_1', \dots, x_{504}'$ that correlate most with combos of $T_1', \dots, T_9'$

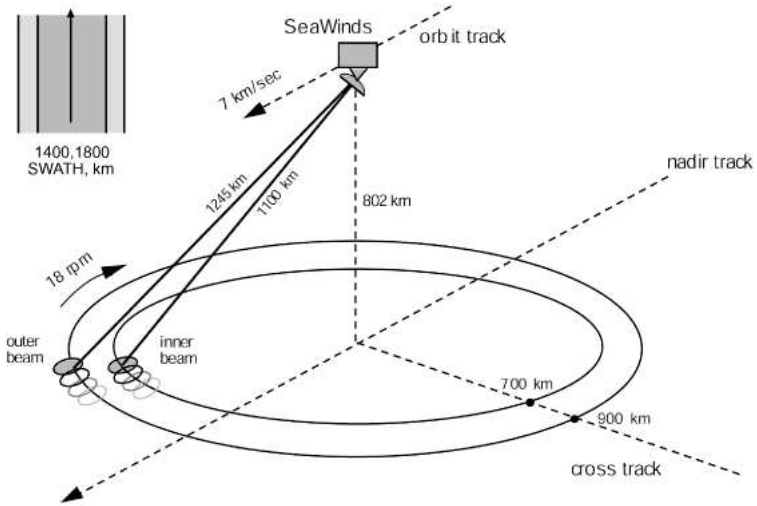
  and express T_1'', T_2'', T_3'' in terms of x_1'', x_2'', x_3''
  (with differentiable expression, in order to compute derivatives):

$$T_i''(x_1'', x_2'', x_3'') = \sum T_i''^{(n)} \exp(-[x_1''-x_1''^{(n)}]^2 -[x_2''-x_2''^{(n)}]^2 -[x_3''-x_3''^{(n)}]^2)$$

where the weighted sum over n runs over the 12million training points – and normalize by the same sum without T"

Scatterometer:

$$\sigma \;=\; GMF(U_{10}e^{i\theta})$$



when in fact σ is determined by …
… the surface wave roughness

which is correlated (but not perfectly) with wind shear stress
and therefore (even less perfectly) with the 10-meter wind field itself

$$U_{15}?\;\; U_{20}?\;\; \theta_{50}?\;\; \theta_{100}?$$

Do we really want to tell the assimilation that

$$\frac{\partial\sigma}{\partial\theta_{10}} \neq 0 \quad \text{but} \quad \frac{\partial\sigma}{\partial\theta_{100}} = 0\;?$$

Start with variables: V_t, V_r at every vertical level

(tangential and radial relative to storm center)

use a simulation,

1) define set of “independent” (uncorrelated) variables in a column
2) find which combos of these vars are most sensitive to σ

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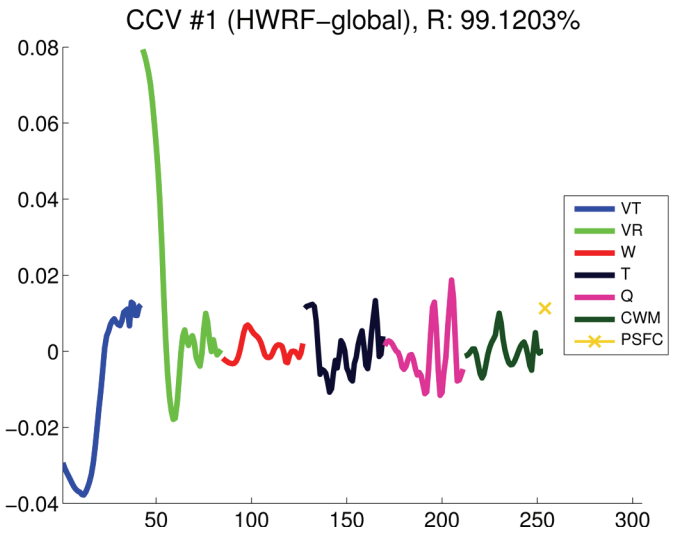
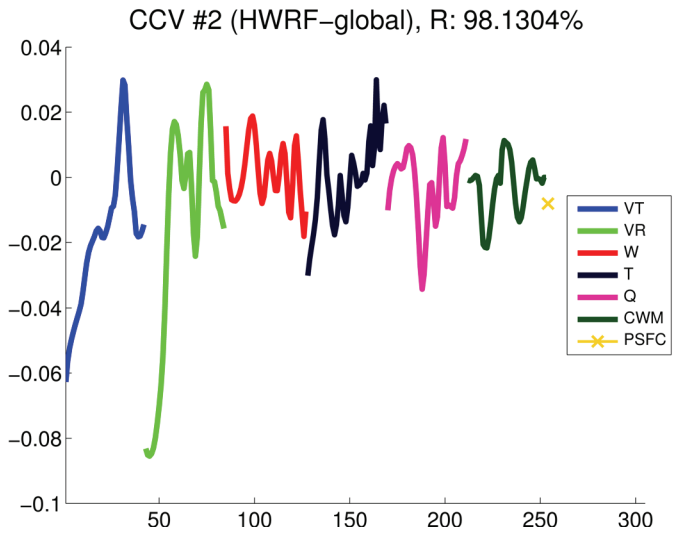
most correlated with ~ $\sigma_{direction}$:



most correlated with ~ σ_{speed} :



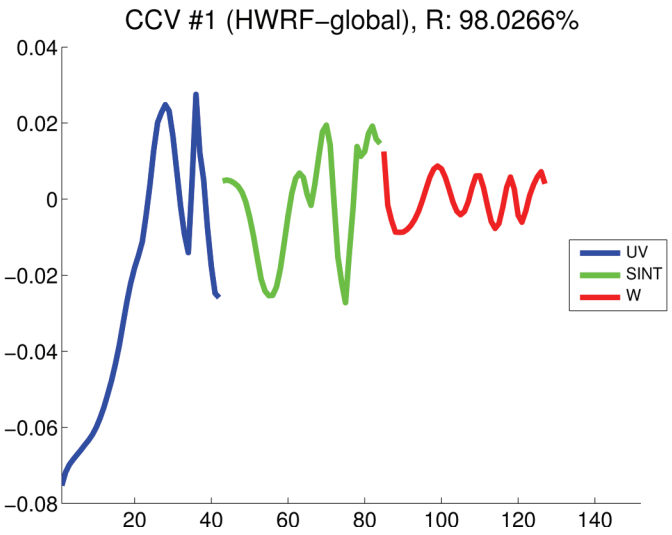
Start with variables: $(V_t^2+V_r^2)^{1/2}$, angle from V_t, at every vertical level

(tangential and radial relative to storm center)

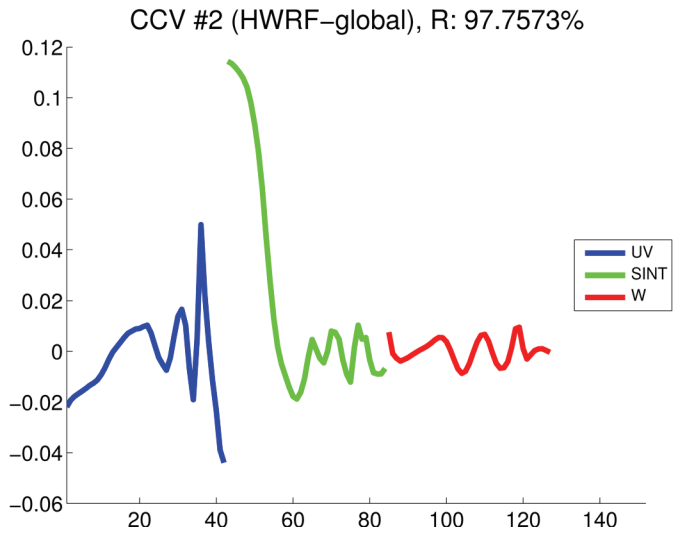
use a simulation,

1) define set of "independent" (uncorrelated) variables in a column
2) find which combos of these vars are most sensitive to σ^o

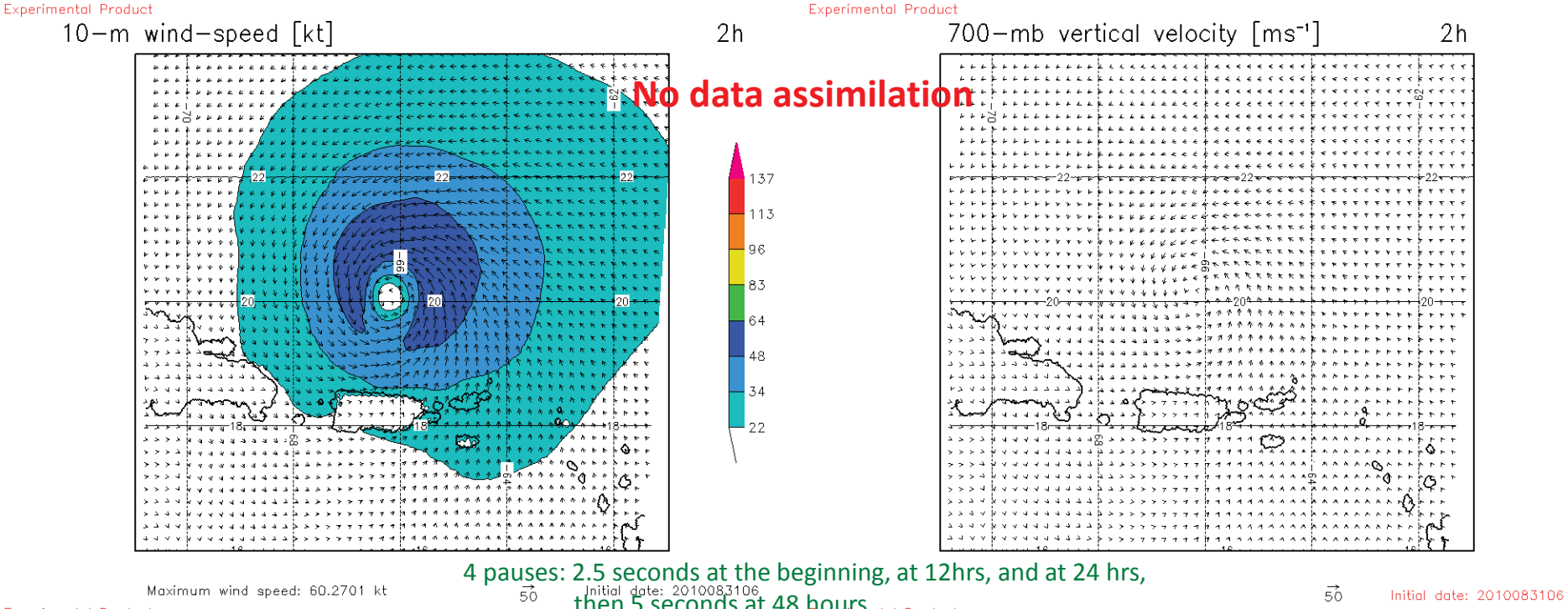
most correlated with ~ σ_{speed} :



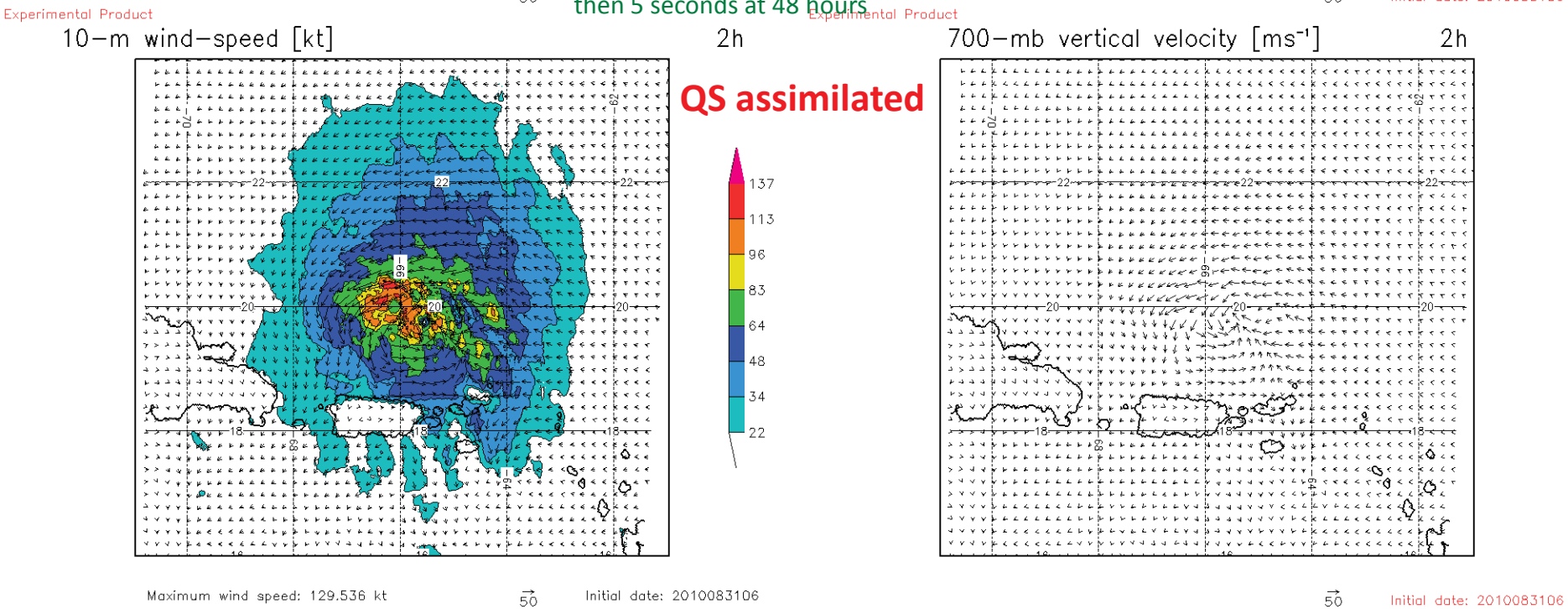
most correlated with ~ σ_{dir}' :

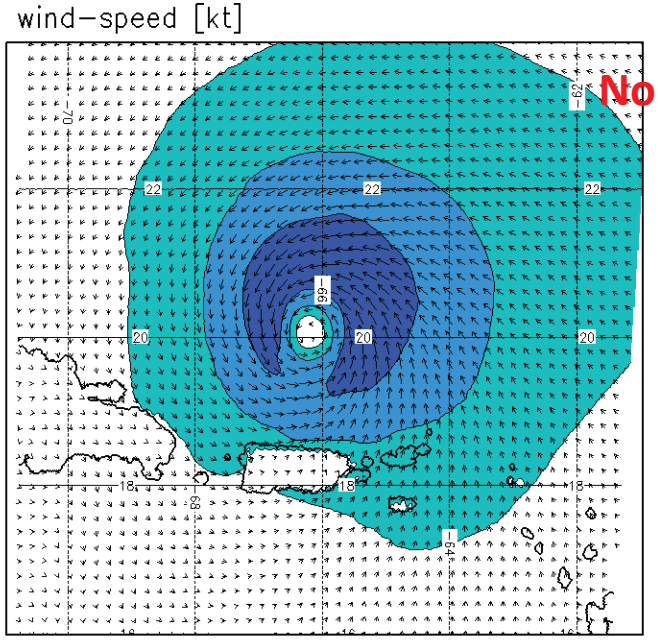


That is what we used to assimilate QuikScat pass over Earl:

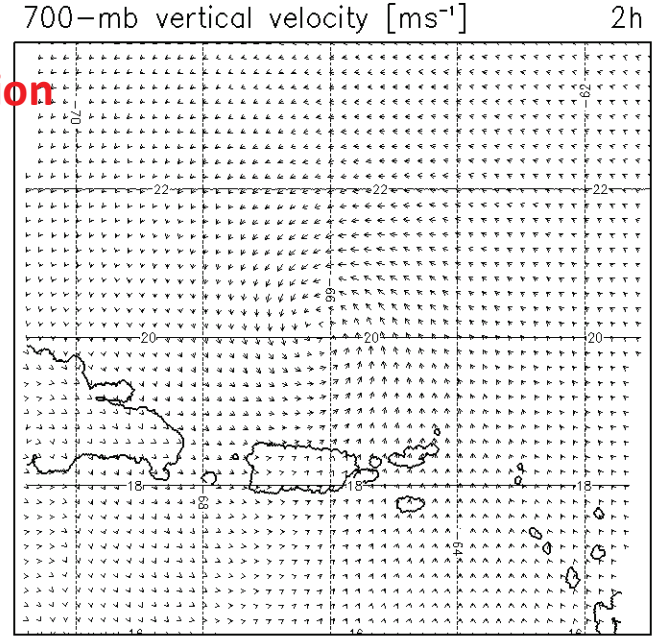


4 pauses: 2.5 seconds at the beginning, at 12hrs, and at 24 hrs,
then 5 seconds at 48 hours





No data assimilation



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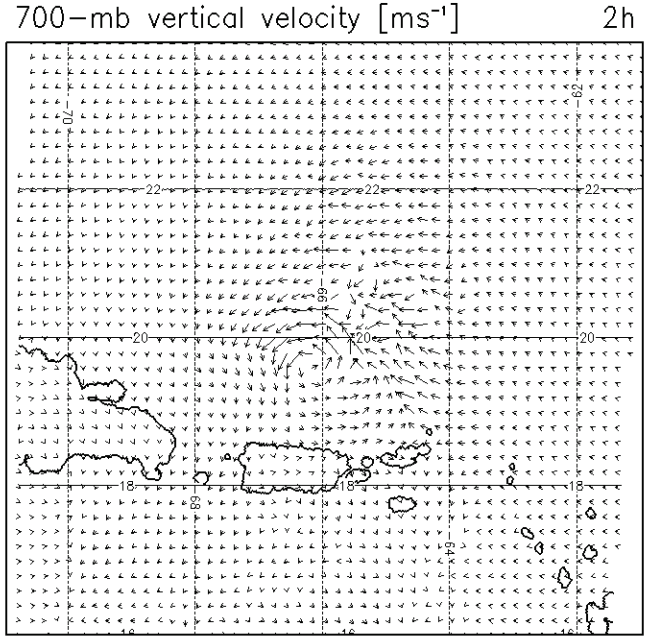
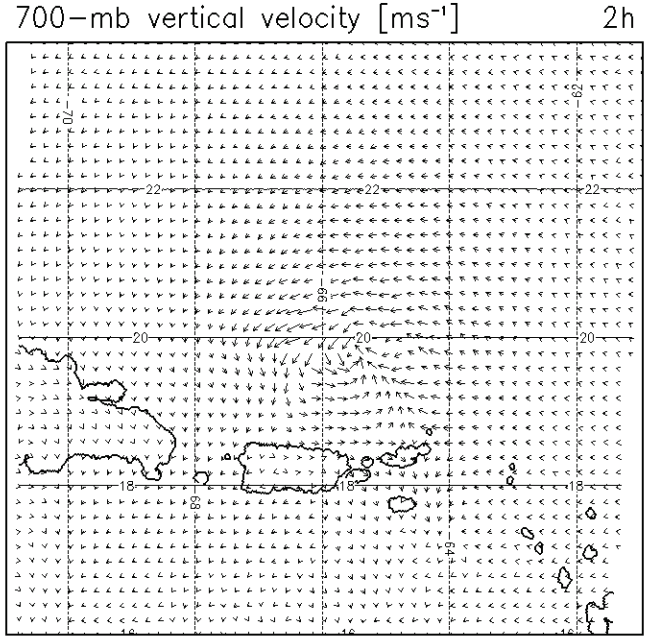


QS assimilated



Ensemble background covariance in the vertical

background covariance limiting vertical correlations

Need to modify Hwrf Ensemble DA System

so that if the model variables are written in vertical principal component space,

$$\begin{pmatrix} VPC_{1;1,1} \\ \cdots \\ VPC_{1;500,500} \\ \\ VPC_{2;1,1} \\ \cdots \\ VPC_{2;500,500} \\ \\ . \\ . \\ . \\ \\ VPC_{300;1,1} \\ \cdots \\ VPC_{300;500,500} \end{pmatrix}$$

the background covariance is block diagonal, with block covariances calculated from the ensemble:

$$B = \left(\begin{array}{c|c|ccc|c} B_1 & 0 & \cdot & \cdot & \cdot & 0 \\ \hline 0 & B_2 & & & & \cdot \\ \hline \cdot & & \cdot & & & \cdot \\ \cdot & & & \cdot & & \cdot \\ \cdot & & & & \cdot & 0 \\ \hline 0 & \cdot & \cdot & \cdot & 0 & B_{300} \end{array}\right)$$

$$B_1 = \left(\sqrt{v_i^{(1)} v_j^{(1)}} \, \frac{c_{ij}}{(c_{ii} c_{jj})^{1/2}} \right)$$