Estimating the Uncertainty of Satellite Microwave Ocean Surface Wind Observations and the Resulting Cross-Calibrated, Multi-Platform (CCMP) Ocean Surface Wind Analyses

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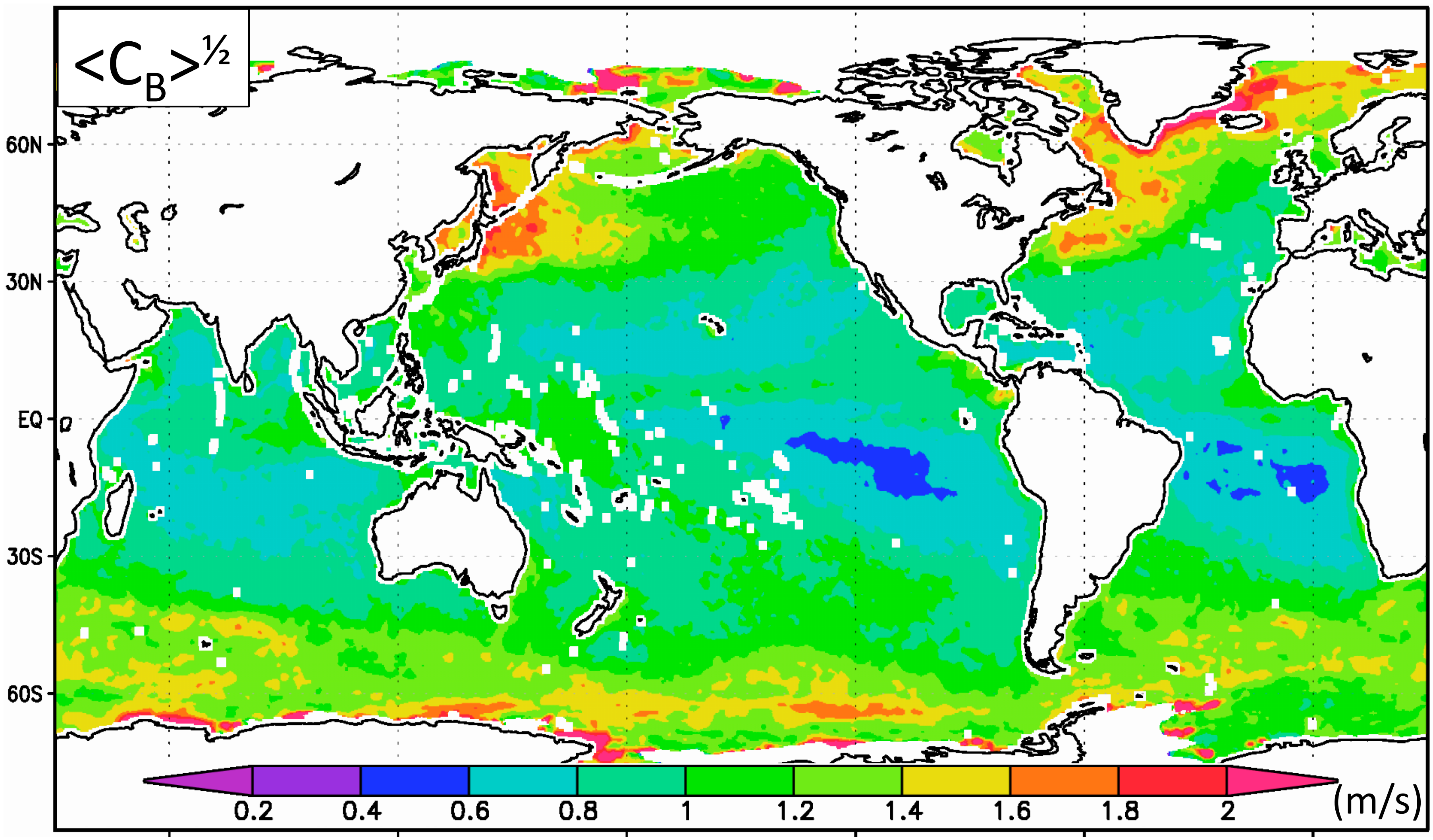
Introduction :: Desroziers diagnostics (DD)

- DD provide estimates of background (B), observation (O) and analysis (A) errors.
  - Desroziers et al., 2005, QJRMS, Oct, doi:10.1256/qj.05.108
  - (NB: There are two Desrozier et al. 2005 papers in that issue!)
- DD are exact provided the analysis system is optimal
- DD can help to iteratively refine the analysis system towards optimality
- DD are essentially a no-cost output of analysis procedures
  - (Do you already calculate rms increments of A-B, O-B, & O-A?)

Summary

- We examine B, O, A wind speed errors for the
  - Cross-Calibrated, Multi-Platform (CCMP) ocean surface wind data for 2004
  - CCMP is produced using a variational analysis method (VAM) and is hosted at JPL/PO.DAAC
    - Atlas et al., 2011, BAMS, Feb, doi:10.1175/2010BAMS2946.1.
- Error standard deviations vary with latitude for the
  - ECMWF operational surface wind speed error in the range 0.7-1.5 m/s
  - Cross-calibrated RSS wind speed retrievals in the range 0.5-0.8 m/s
  - CCMP analysis wind speed in the range 0.2-0.4 m/s
- DD will help address two VAM issues:
  - Specification of observation errors and the weights used in the VAM cost function
  - Assignment of analysis uncertainty for the CCMP products

Global variation of background errors



- Plotted at each ¼° grid box for all observations in a centered 5 × 5 grid box stencil

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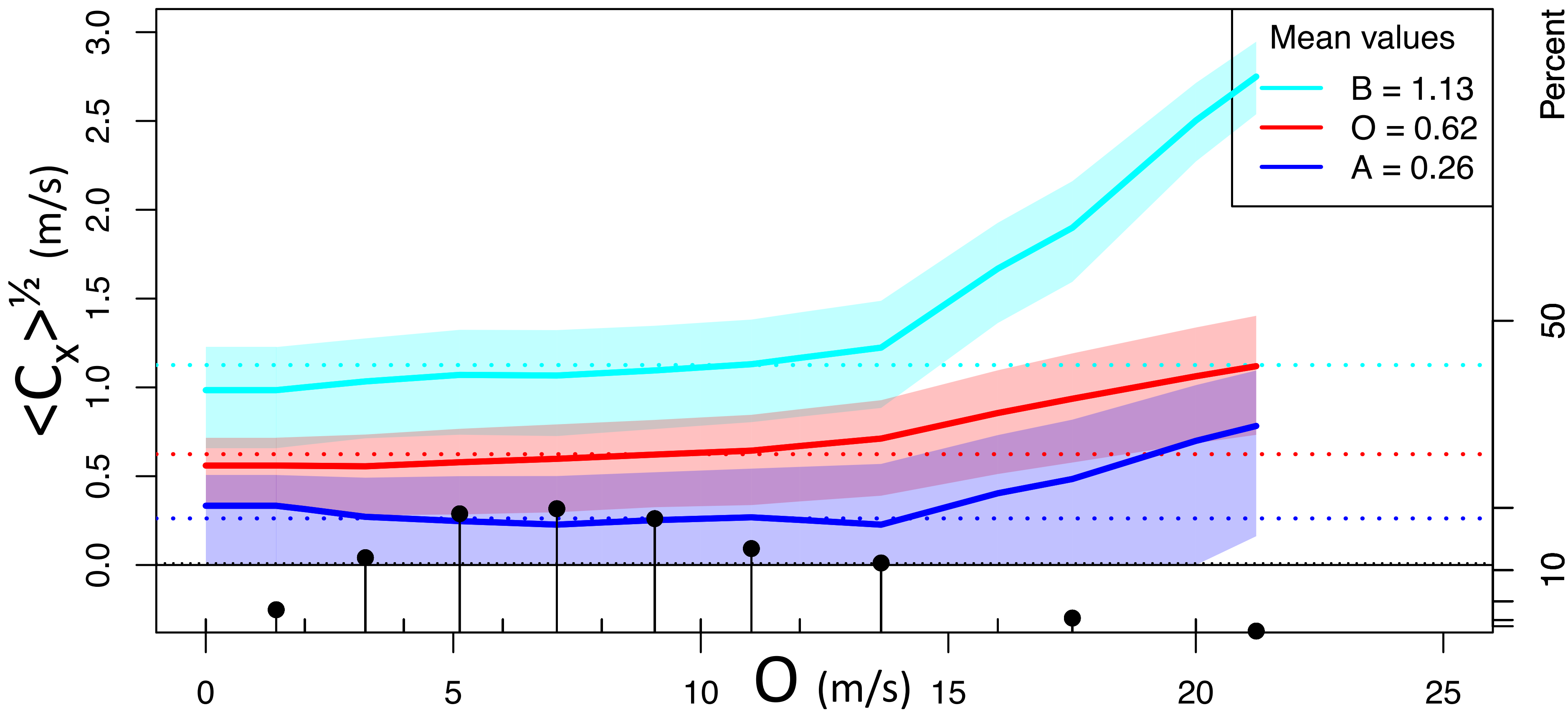
Desroziers diagnostics (DD)

- The contribution (C) to the estimated covariances from any two observations, i and j are
  - $C_B=(A_i-B_i)(O_j-B_j)$
  - $C_O=(O_i-A_i)(O_j-B_j)$
  - $C_A=(A_i-B_i)(O_j-A_j)$
- The estimated covariance is the sample mean of the C_x (x=A,B,O)
- Everything is in observation space
- Generally O_i and O_j may be at different locations and different times
- Any sensible sample can be used for averaging

Quality control

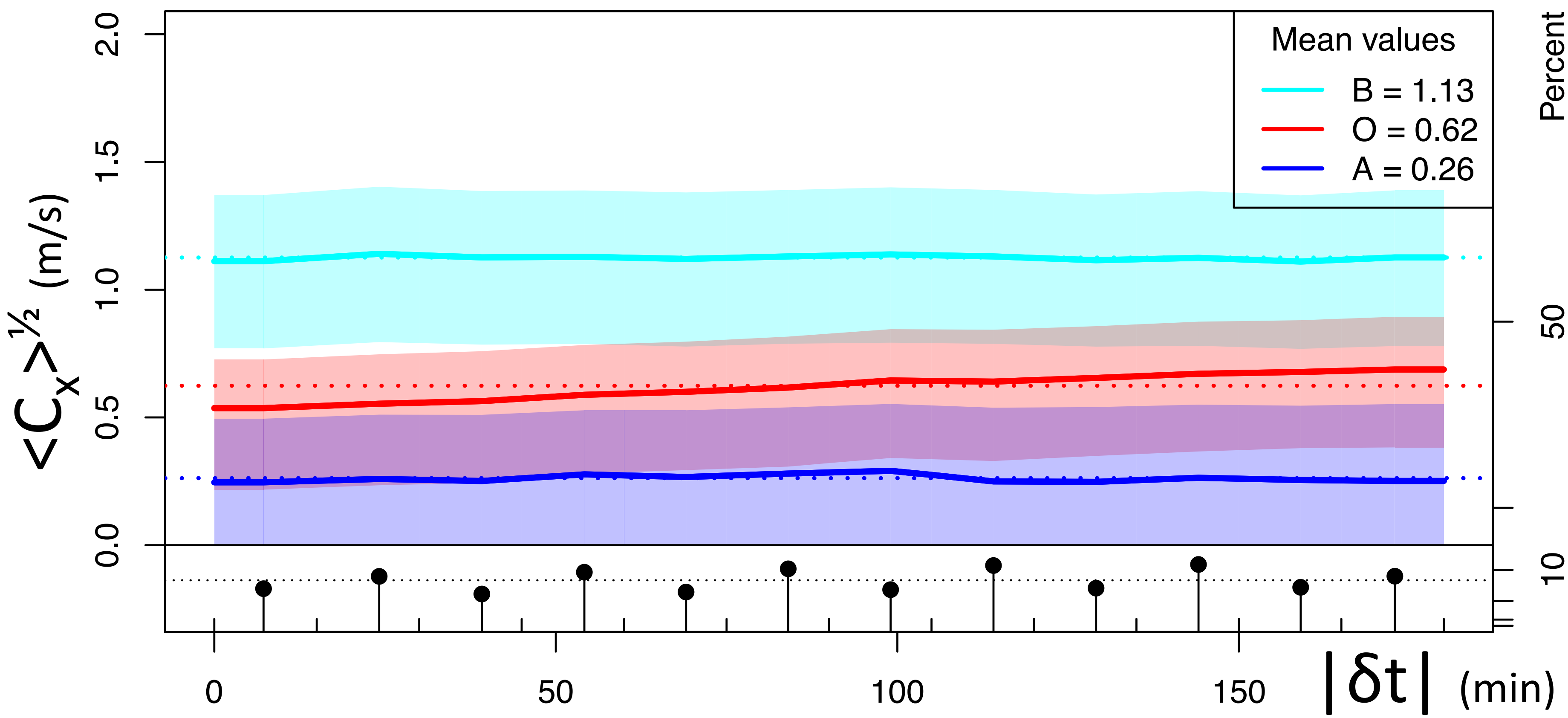
- The C_x are very noisy
  - QC the observations based on the values of C_x
  - We call this VC-QC (variance contribution QC)
- VC-QC is a gross QC
  - Observations are QC'd when at least one of the C_x is more than 6 std. dev. from the mean
- VC-QC greatly reduces uncertainty in error estimates, with little effect on those estimates
  - One exception noted later

Variation with wind speed



- For observed wind speed bins < 16 m/s, $<C_x>^{½}$ is nearly constant
- For higher wind speeds $<C_x>^{½}$ increase very rapidly

Variation with time difference



- No trends for A or B errors, linear trend for O errors
- $<C_O>^{½}$ increases from 0.53 (at |δt|=0) to 0.70 m/s (at |δt|=3 h)

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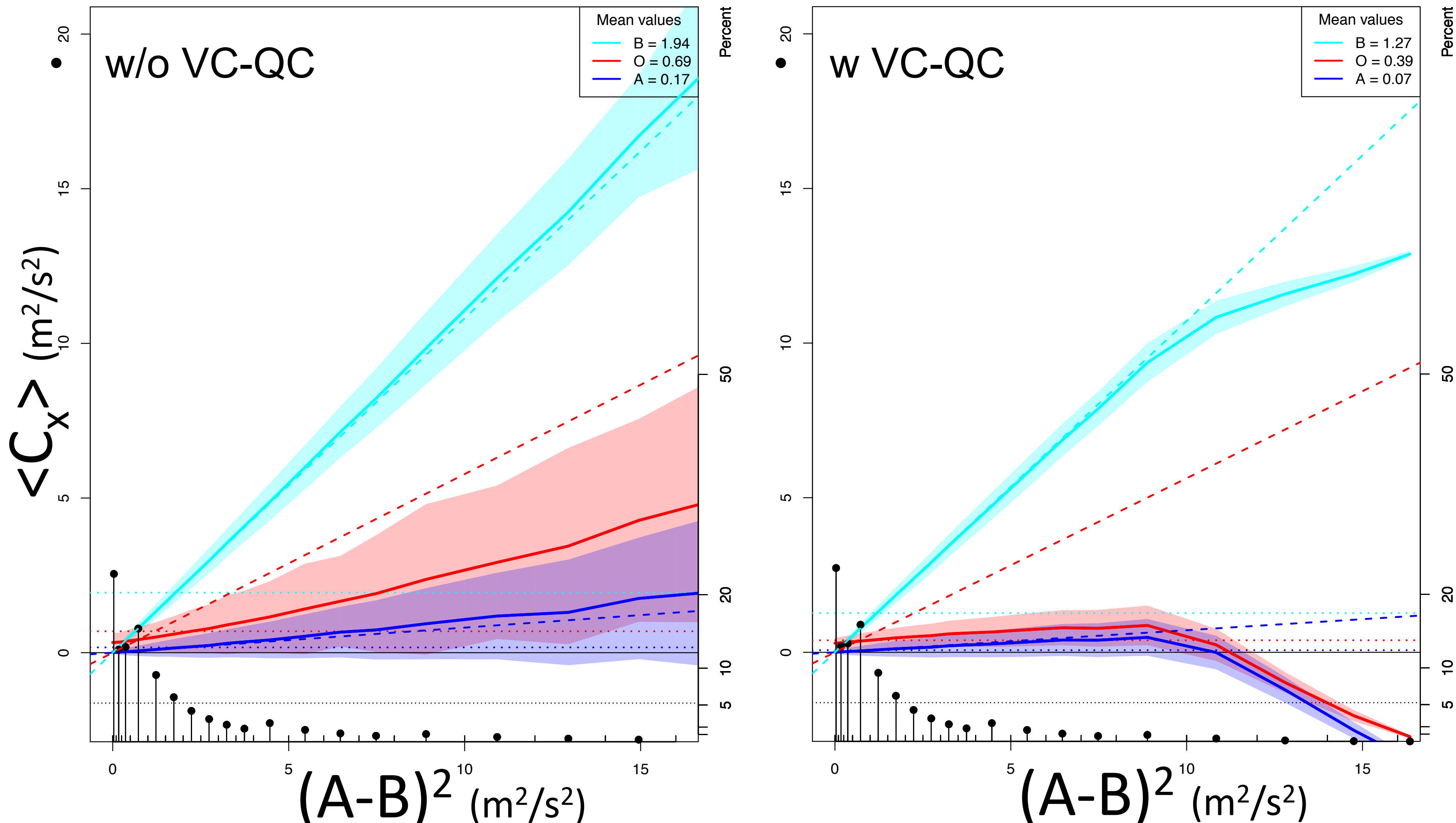
Large increments → large errors

- Rewrite the basic DD equations specialized for variance (i=j) in terms of $\Upsilon=(O-B)/(A-B)$
  - $C_B=\Upsilon\,(A-B)^2$
  - $C_O=\Upsilon\,(\Upsilon-1)(A-B)^2$
  - $C_A=(\Upsilon-1)(A-B)^2$
    - (Similar relationships can be obtained in terms of $1/\Upsilon$ and $(O-B)$)
- Parameterizing $\langle C_x \rangle$ in terms of $(A-B)^2$ is potentially very useful in estimating the analysis errors of the VAM for each synoptic time and for each grid cell

Large increments ➔ large errors



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Conclusions

- Applied DD to the VAM outputs of the CCMP project for 2004
- Globally wind speed error standard deviations vary with latitude for the
  - ECMWF operational surface wind speed error in the range 0.7-1.5 m/s
  - Cross-calibrated RSS wind speed retrievals in the range 0.5-0.8 m/s
  - CCMP analysis wind speed in the range 0.2-0.4 m/s
- Errors are fairly constant for observed wind speed up to 16 m/s and are much higher for higher wind speeds
- Observational errors increase with time relative to the analysis time, and vary with platform and the number of observations
- The error variances depend linearly on $(A\text{-}B)^2$ and on $(O\text{-}B)^2$

Lessons learned :: DD inconsistencies

- If there are no DD inconsistencies then the data assimilation system (DAS) is internally consistent
- By refining and specializing the samples, inconsistencies are likely to be observed
  - This approach presents opportunities to discover and then mitigate errors in the formulation of the DAS
- Possible sources of inconsistencies
  - Incorrect B or O error covariances in the DAS
  - Unaccounted for biases in the DAS or DD
  - Improper QC in the DAS
  - Non-Gaussian errors
  - Small sample sizes
  - Applying DD in non-observation space (QuikSCAT wind speeds)

Future work

- Tune the VAM and iterate the process
- Apply to wind vectors from QuikSCAT
- Estimate CCMP analysis errors
- Apply to correlations of errors
    - Earth relative geometry
    - Satellite swath geometries

Thank you

- doi:10.1256/qj.05.108
  - » Desroziers et al., 2005, QJRMS, Oct
- doi:10.1175/2010BAMS2946.1
  - » Atlas et al., 2011, BAMS, Feb
- http://podaac.jpl.nasa.gov/datasetlist?search=ccmp
- ross.n.hoffman@aer.com