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Status of scatterometer ocean wind vector data assimilation in Environment Canada's global variational analysis and forecast system

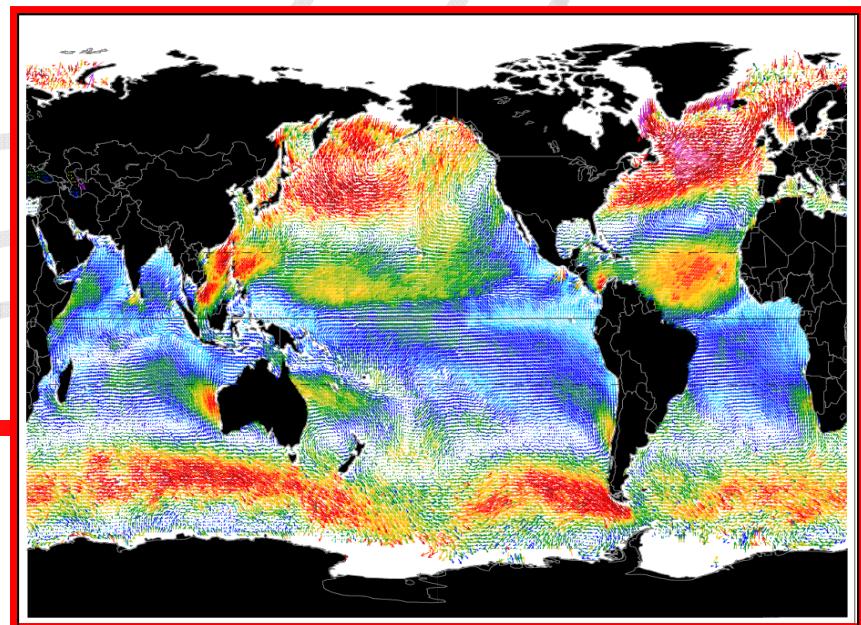
Robert Tardif, Stéphane Laroche

Data Assimilation & Satellite Meteorology

Mateusz Reszka, Judy St-James

Meteorological Service of Canada

IOVWST meeting
Barcelona
18-20 May 2010





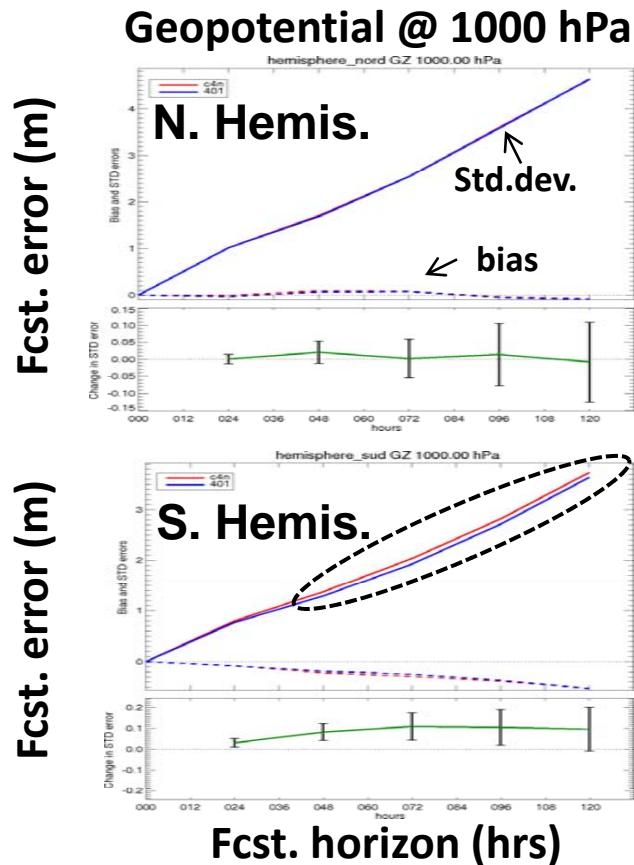
Current usage of scatterometer winds

- Operationally assimilated in:
 - Global **4Dvar** deterministic system (~33 km resolution)
 - Global **EnKF** ensemble forecast system (~100 km)
 - Regional **3Dvar FGAT** (First Guess at Appropriate Time) deterministic system (15 km resolution)
- Users of **KNMI (OSI-SAF)** quality-controlled wind products
 - **QuikSCAT 100-km** winds
 - Operationally assimilated from **May 2008 to Nov. 2009**
 - **ASCAT 25-km** winds
 - Thinned to ~100 km (closest obs. to center of lat-lon box)
 - Operationally assimilated **since April 2009**
 - **Ambiguity removal:** use KNMI “most probable” solution
 - Observations with wind **speeds < 4 m s⁻¹** not considered
- All forecast systems based on the **Global Environmental Multiscale (GEM)** model

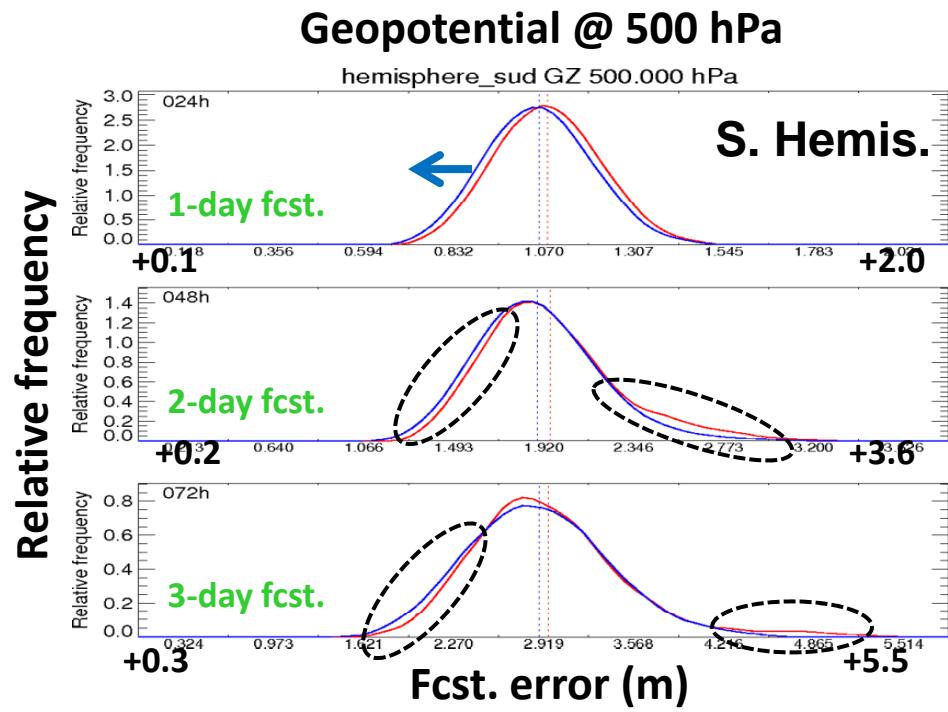


Current usage of scatterometer winds

- Positive impact on atmospheric forecasts (particularly in S. Hemis.)
- Verif. against 4Dvar analyses (January 2009)



— without scat.
— with scat. (Quikscat+ASCAT)

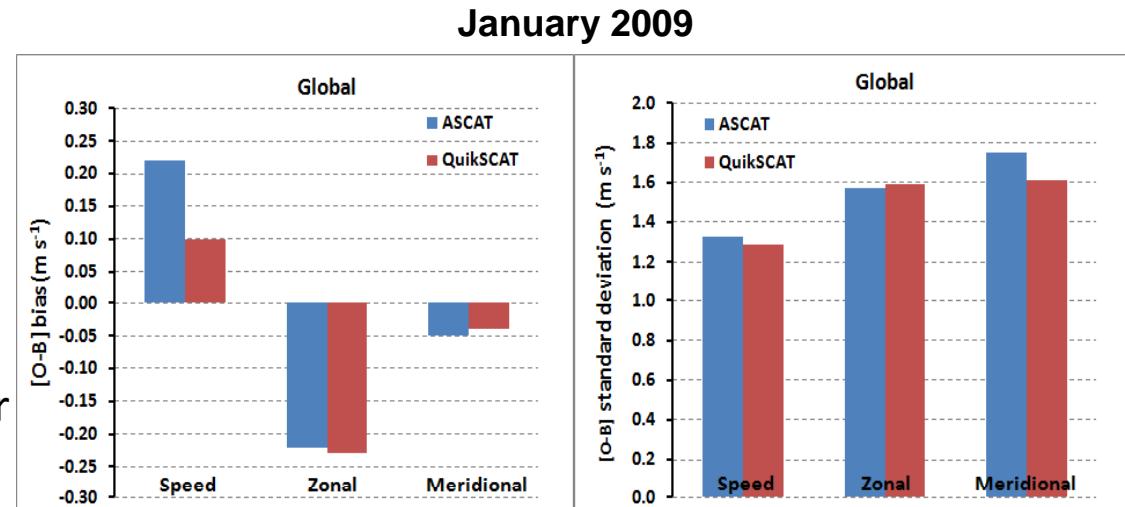


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Most recent & ongoing efforts

- Investigating possible **improvements** to scatterometer wind **data assimilation** (funding from Canadian Search & Rescue)
- Aiming to obtain:
 - Improved atmospheric analyses & forecasts
 - Improved surface winds
 - More accurate **drift forecasts** (Search & Rescue applications)
 - Improved **coupling** with ocean/wave models...
- More specific “**data assimilation**”-related objectives :
 - Reduce biases in “observation-model background” differences -> [O-B] or innovations
 - Eliminate outlier [O-B]



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Most recent & ongoing efforts

- **Items under investigation:**

- **New observation operator** (equivalent neutral wind), to be consistent with the observation
- Improved **quality control + data thinning**
- Characterization/role of **model behavior (errors)**
- Use of **flow-dependent background error statistics** (from EnKF system) to improve propagation of scatterometer (surface) information to entire model state

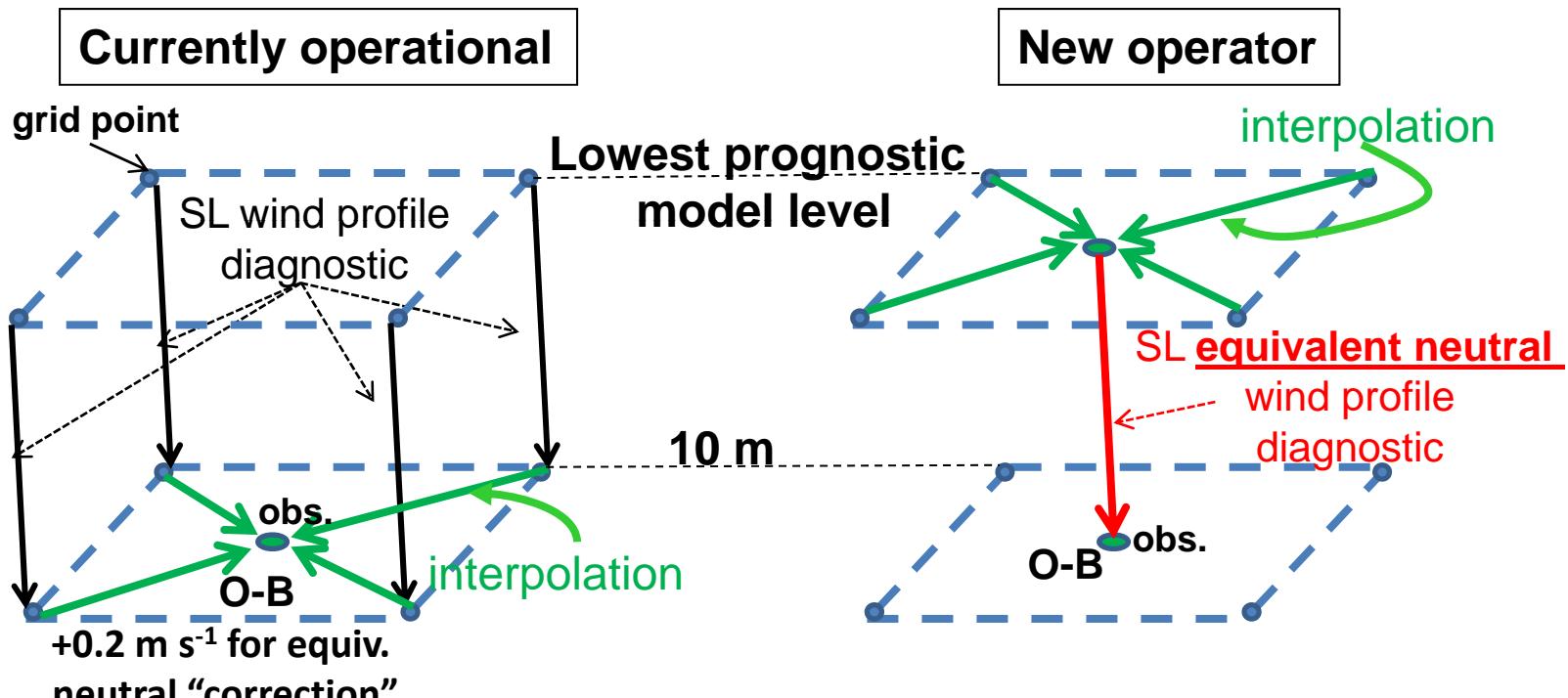


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Observation operator

- Proper model-to-obs. correspondence (**observation operator**) important in data assimilation



$$\begin{bmatrix} U(z) \\ V(z) \end{bmatrix}_{\text{en}} = \frac{u_*}{k} \left[\ln \left(z/z_o + 1 \right) + \psi_m \left((z+z_o)/L \right) - \psi_m \left(z_o/L \right) \right] \begin{bmatrix} \cos \theta \\ \sin \theta \end{bmatrix}$$

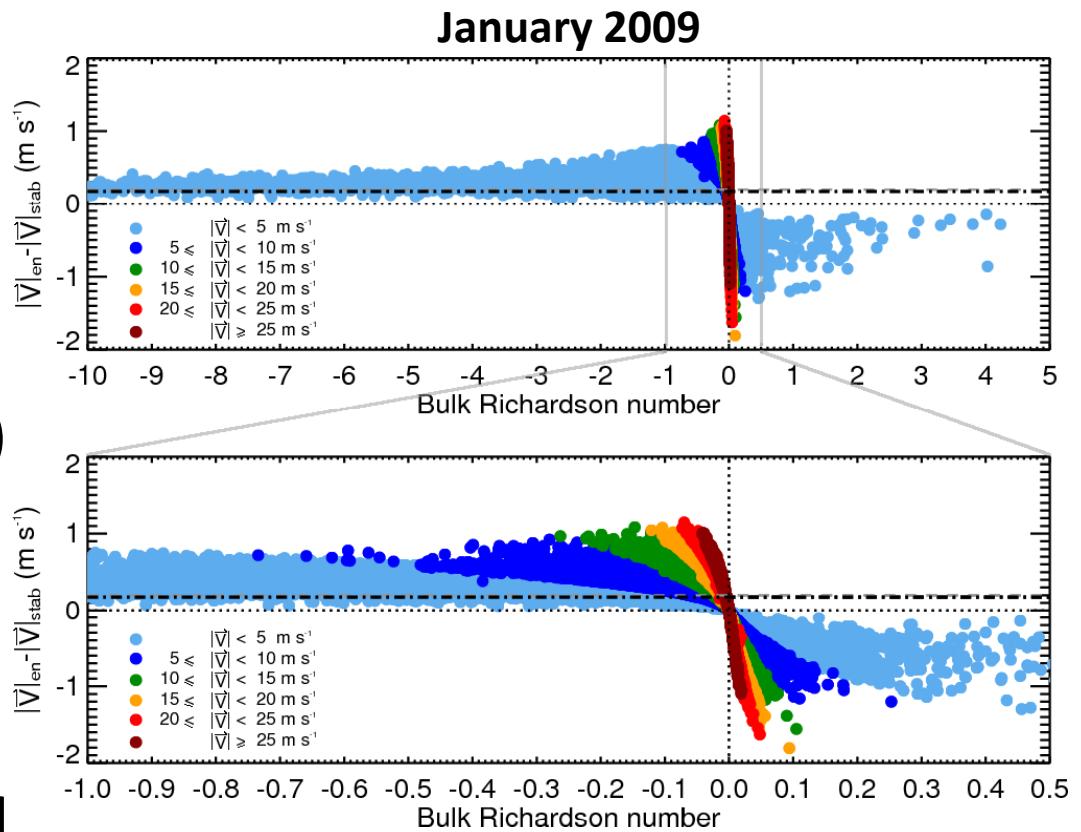


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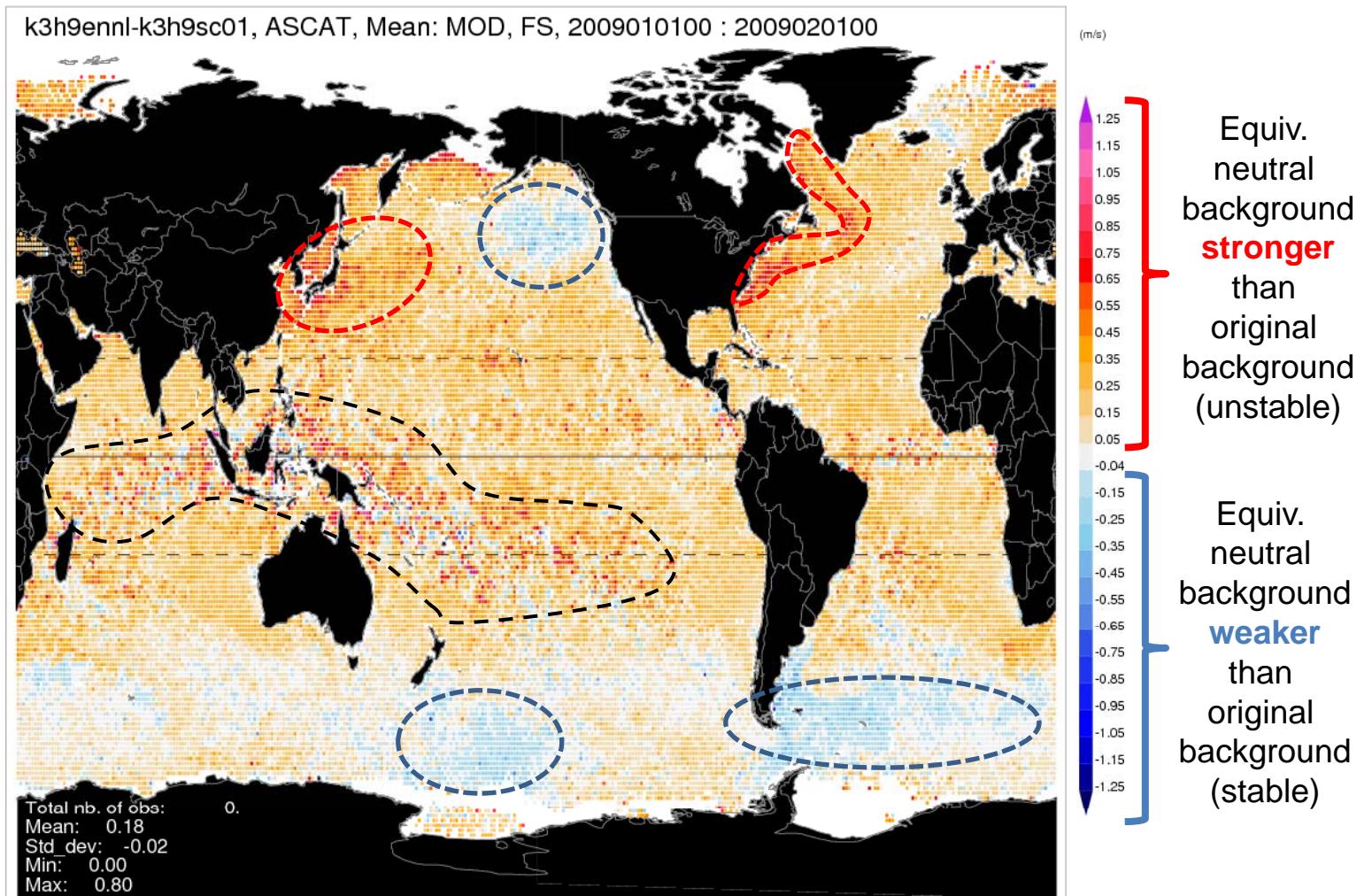
Observation operator

- Difference between equivalent neutral & stability-dependent wind speed
- Average difference
 $\approx +0.2 \text{ m s}^{-1}$
- In accord with Portabella & Stoffelen (JAOT,09) & Kara et al. (JGR,08)
- But:
 - Dependence on surface layer stratification
 - Dependence on wind speed



Observation operator - impact

- Model background difference

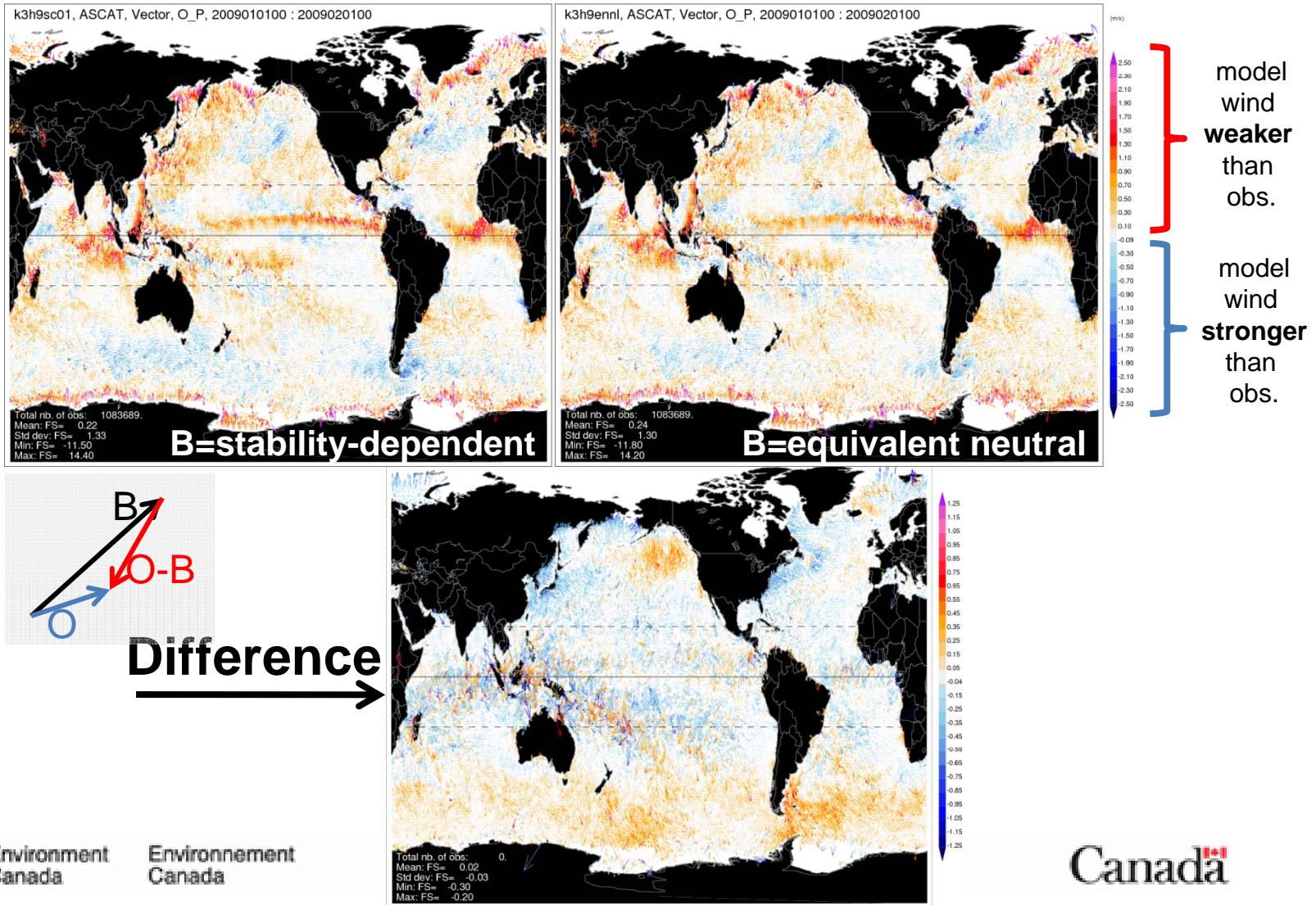


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Observation operator - impact

- [O-B] (ASCAT innovations) - 3Dvar FGAT cycle



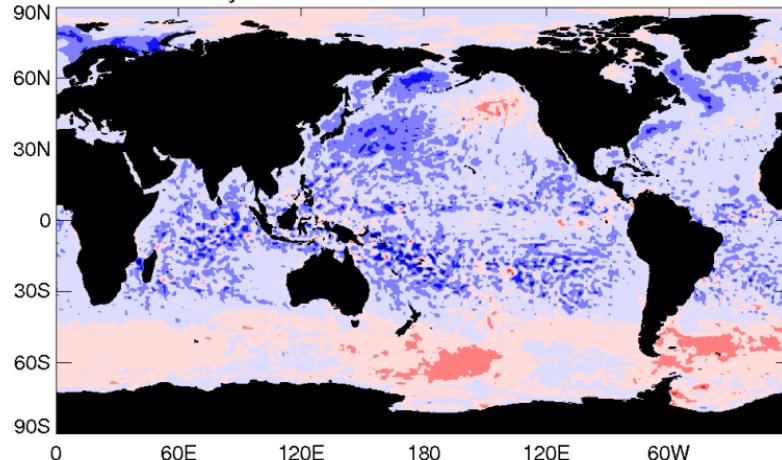
Observation operator - impact

- 3Dvar FGAT analyses

Analysis differences (new operator – control)
averaged over Jan. 2009

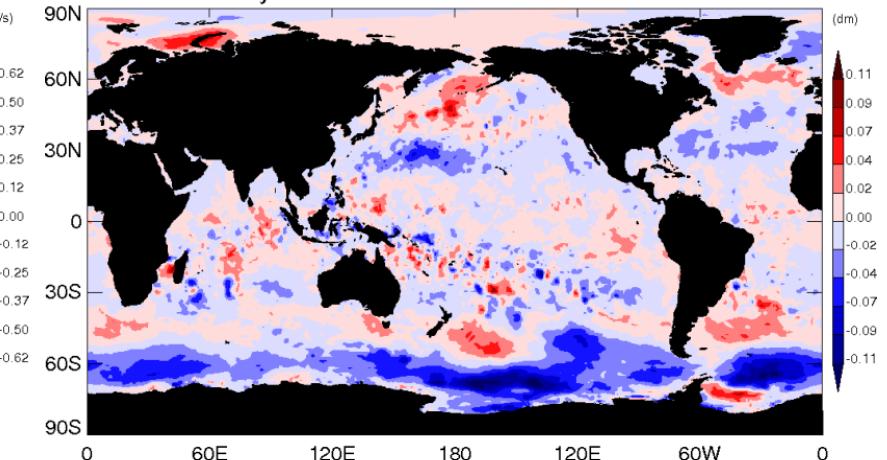
Near-surface wind speed

Moy ANA de UV niveau 1000.00 nnl-c01



Geopotential @ 1000 hPa

Moy ANA de GZ niveau 1000.00 nnl-c01



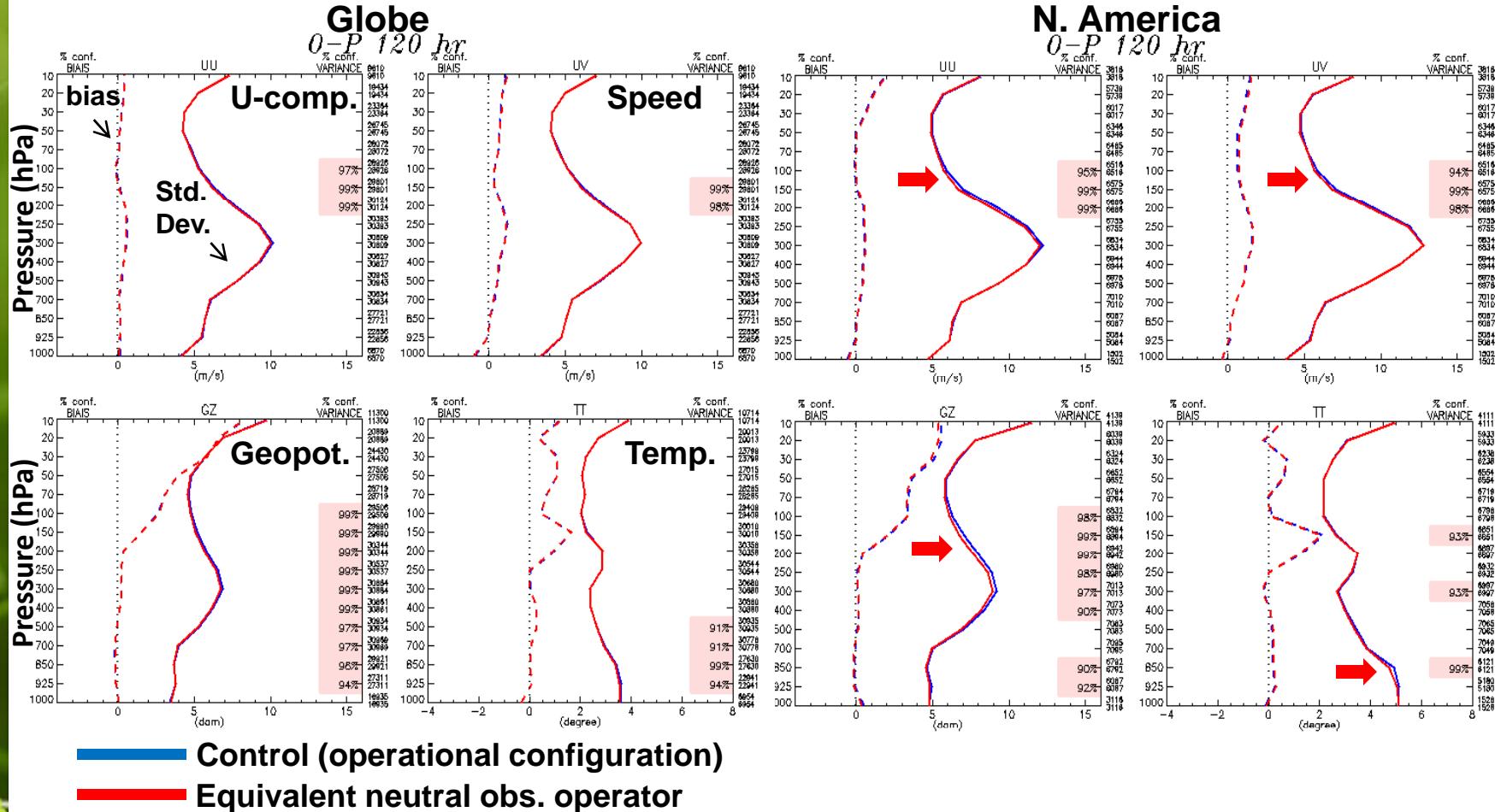
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Observation operator - impact

Forecasts

Verification against radiosondes, 5-day forecasts, January 2009

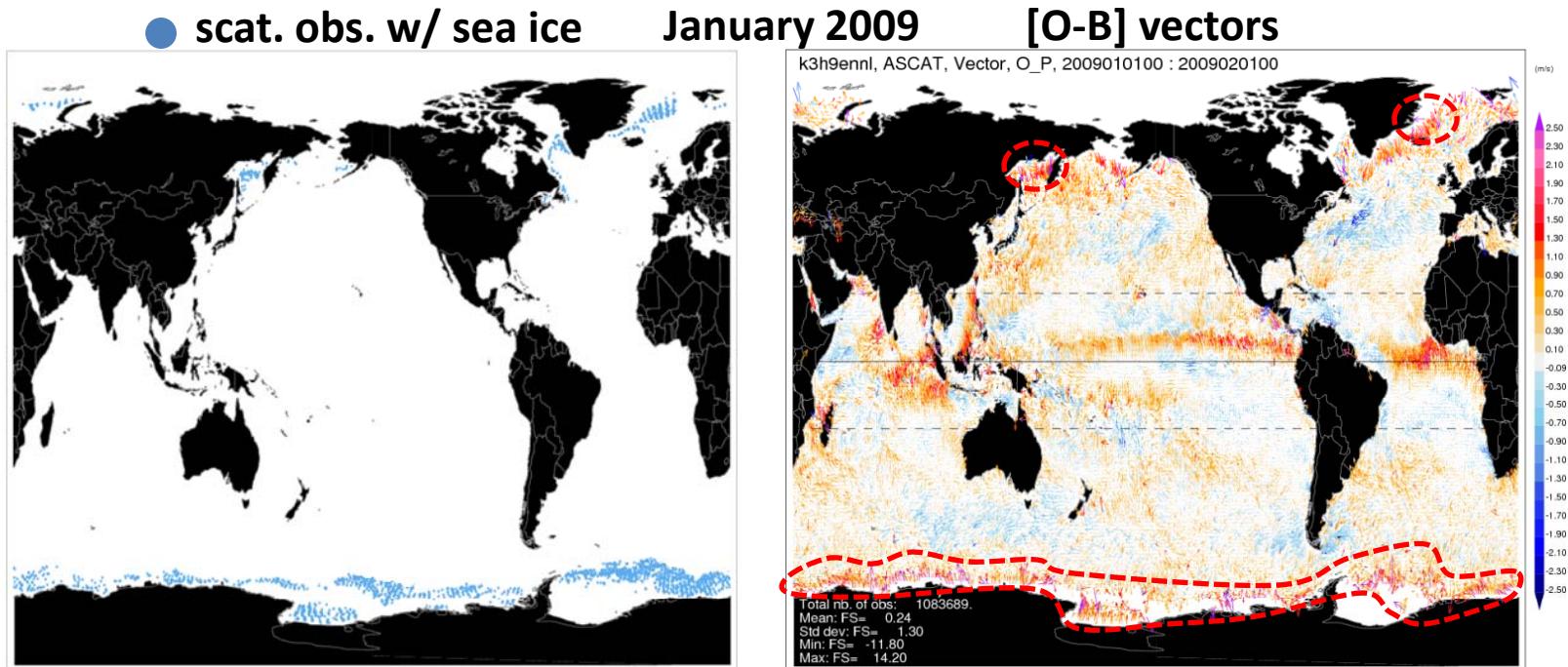


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Sea-ice contamination - ASCAT

- Inconsistencies with “in-house” sea-ice analysis lead to large (undesirable) O-B values:

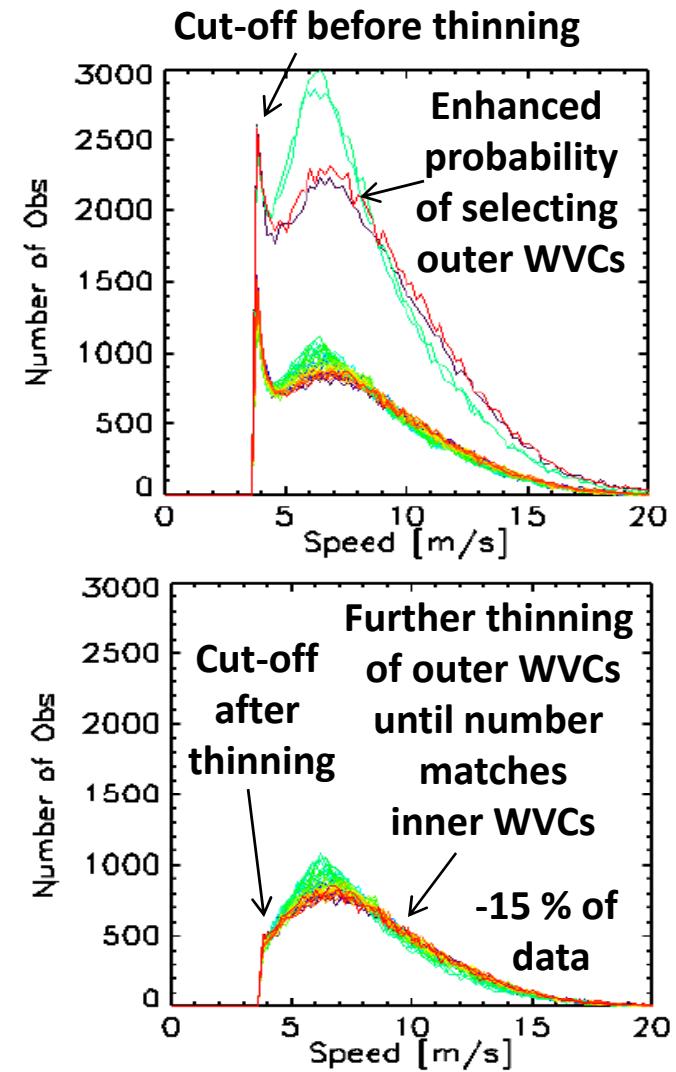
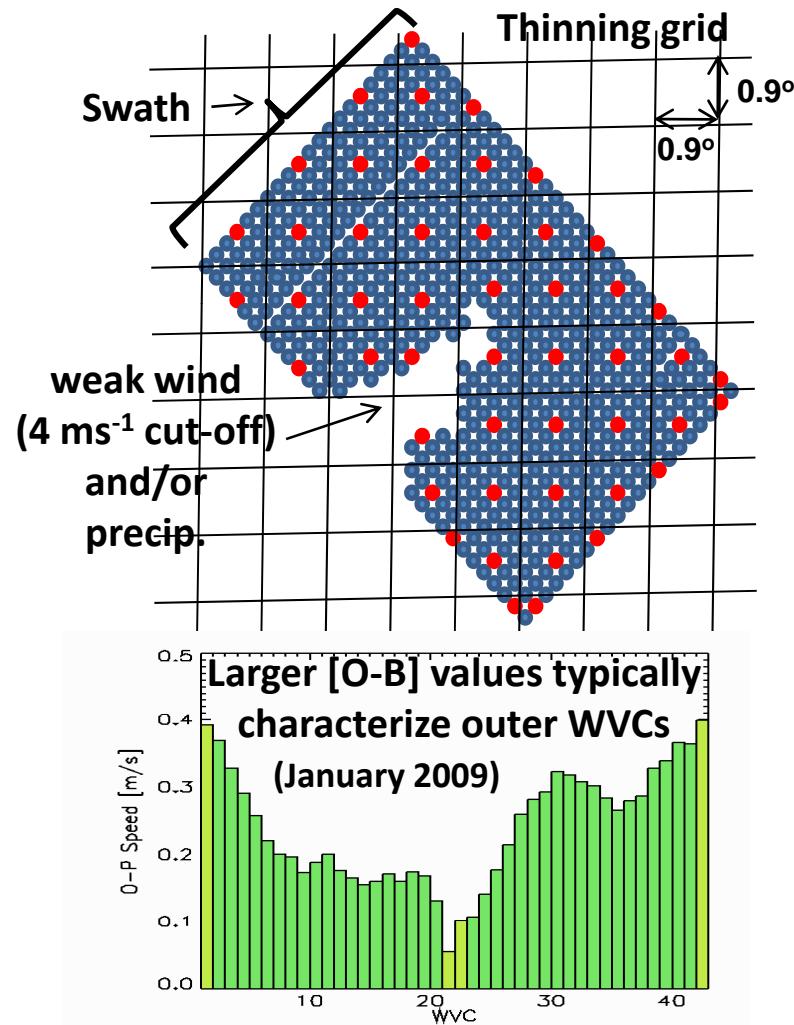


- Modification: eliminate obs. within 550 km from analyzed ice edge → -10% of data



Data thinning – ASCAT outer WVCs

- Data thinning artifacts

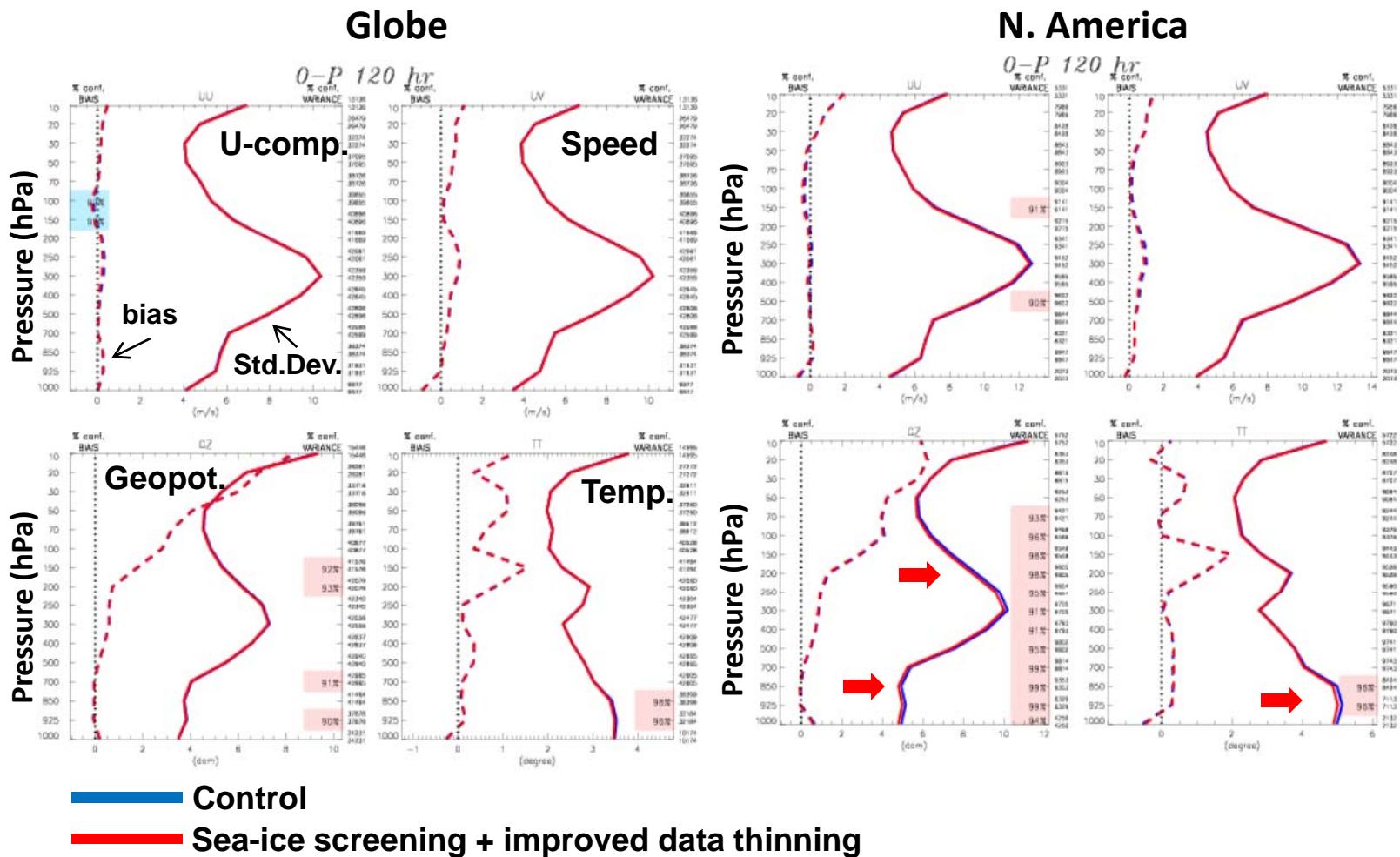


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Impact of new QC & thinning

5-day forecasts – verification against radiosondes (Jan. 2009)



Concluding remarks

- Scatterometer winds assimilated with **positive impact** on our global assimilation /forecast system (particularly in the southern hemisphere)
- Further encouraging **improvements** over our current practices with:
 - More sophisticated non-linear **observation operator** [[testing various configurations of its tangent linear and adjoint is underway](#)]
 - More sophisticated **data thinning** and **consistency check with own sea-ice analysis**
- Looking ahead...
 - Better handle on instrument-dependent biases (to more accurately characterize our NWP model)
 - Data availability from other recent & future scatterometer missions (Oceansat-2 + follow-on METOP + others)?





Extra slides...

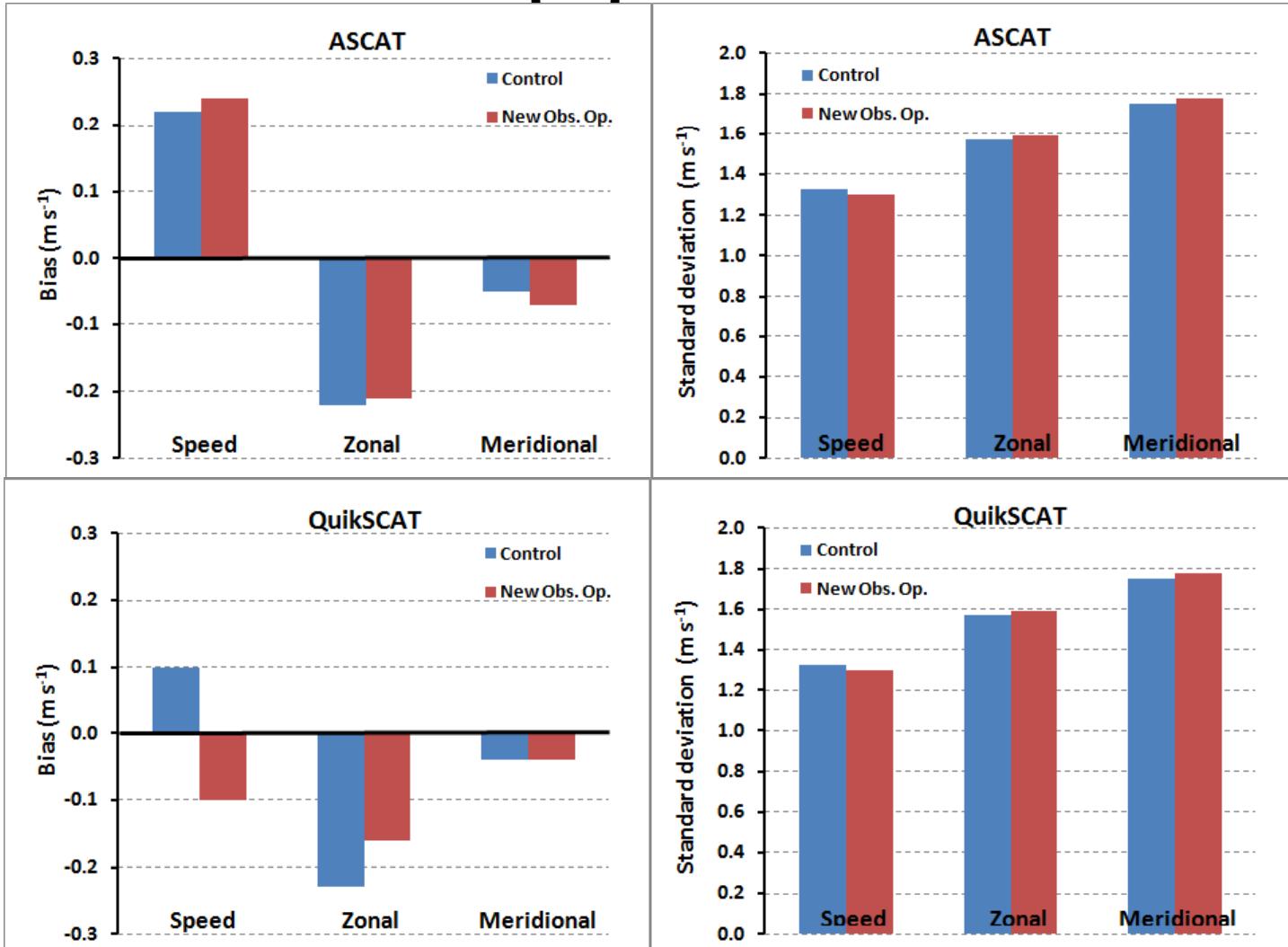


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Impact of new observation operator

Jan. 2009 [O-B] statistics - Global

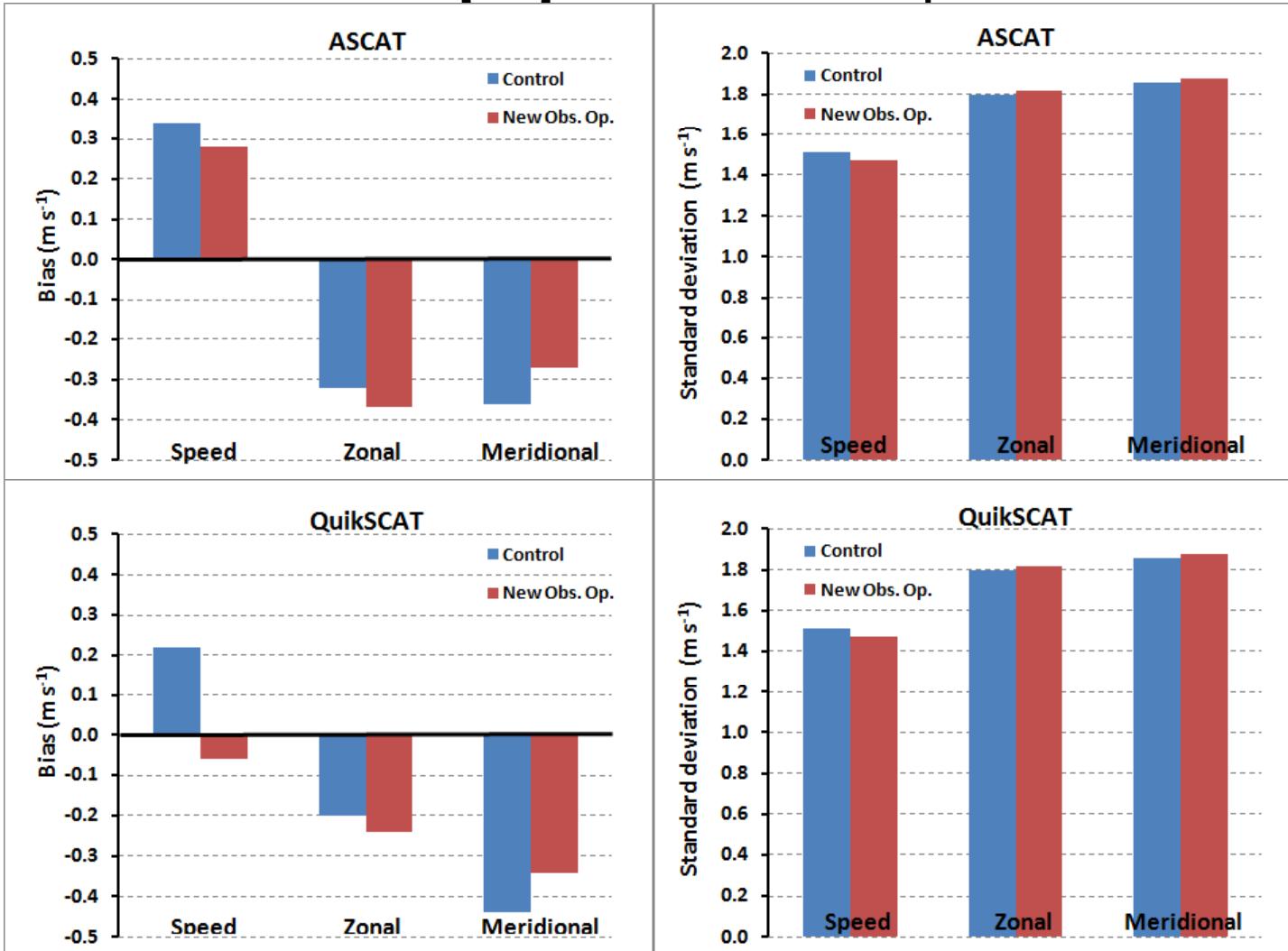


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Jan. 2009 [O-B] statistics – N. Hemisphere

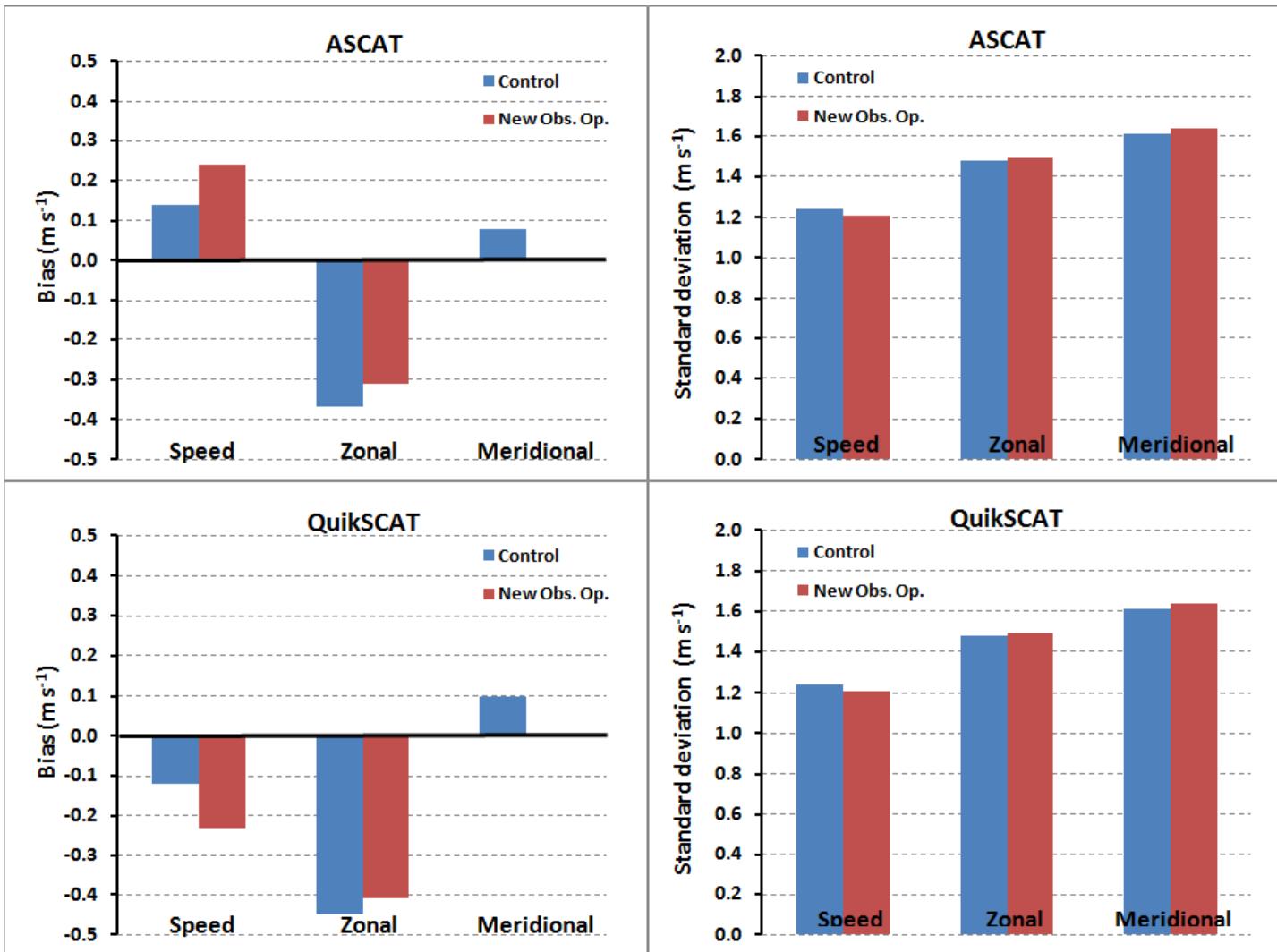


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Jan. 2009 [O-B] statistics – S. Hemisphere

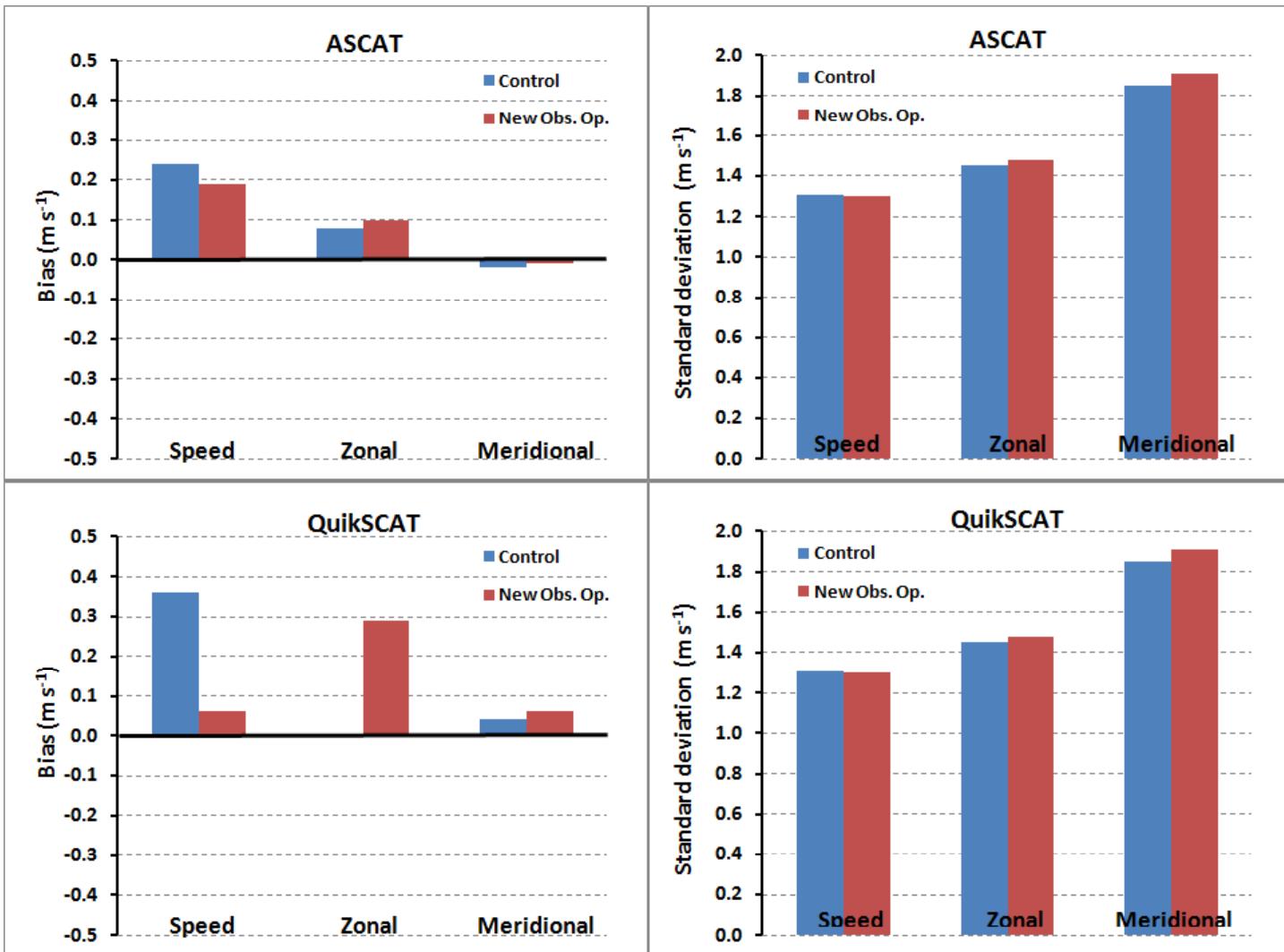


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Jan. 2009 [O-B] statistics – Tropics



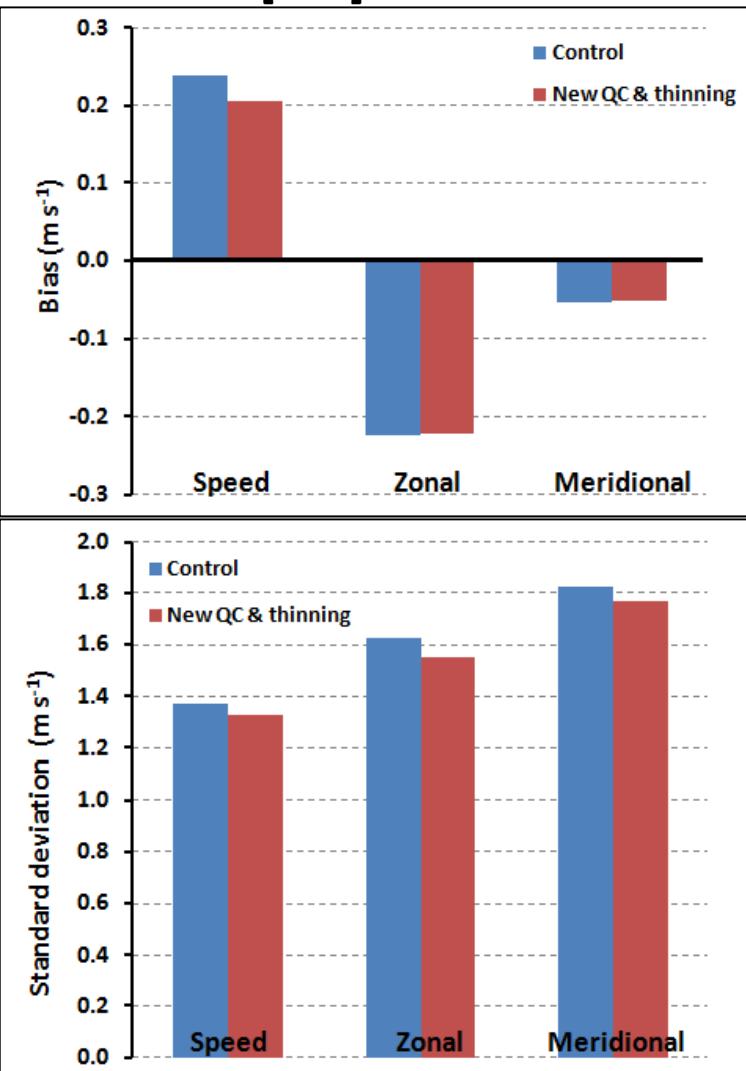
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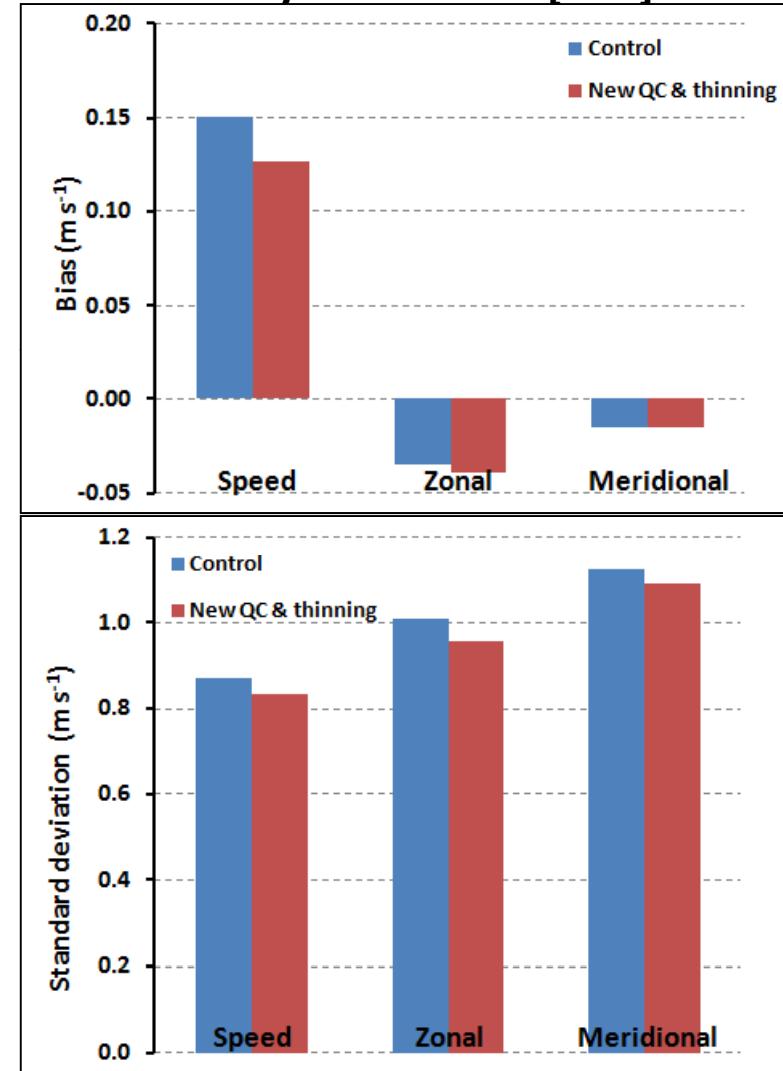
Impact of new QC & thinning on analyses

15 Dec. 2008 – 31 Jan. 2009

[O-B] statistics



Analysis residuals [O-A]

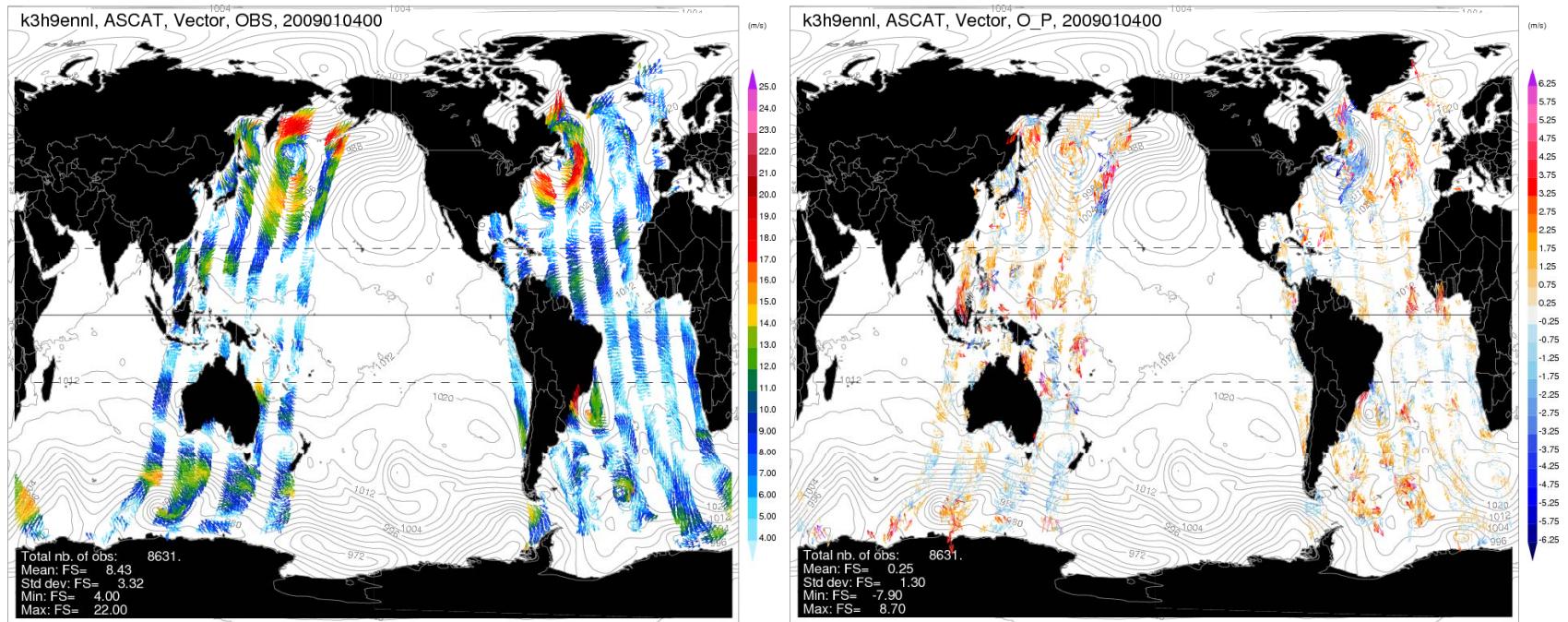


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Learning from specific cases

- Dependency on “meteorology” of background state



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