Status and Short-Term Plans for the GMAO OSSE
and
Why We Are Developing the OSSE the Way We Are

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Outline

1. Principles
2. Strategy
3. Latest results
4. Future plans
5. Other issues

Principles

1. Re-think requirements, rather than simply copy past procedures.
2. Recognize that DA is a fundamentally statistical problem.
3. Recognize that, as with any simulation, validation is the key.
4. Concentrate first on what is both important and known.
5. Implement a phased approach to expedite development.

Simulating appropriate errors is the key

Innovations: $\mathbf{d} = \mathbf{y} - H(\mathbf{x}_b)$

Simulated obs: $\mathbf{y} = H_z(\,\mathbf{z}\,) + \mathbf{e}$

1. Analysis and forecast errors are functions of:
   (a) instrument errors,
   (b) representativeness errors (i.e., errors in the formulation of H),
   (c) forecast model (formulation) errors,
   (d) characteristics of atmospheric and model chaos.
2. We already know how to simulate the information content that we currently assimilate; What we do not know well enough now, however is how to simulate the errors (**e**) in such simulations.
3. As we make H_z more "realistic" but more different than H, we are modifying representativeness error rather than information content.
4. For estimating the potential of future observations, anticipating their realistic error characteristics is critical.

Guiding Philosophy

1. It is much more difficult but not as critical to simulate observations as realistically as possible compared with the ease and importance of simulating the error statistics as realistically as necessary.

2. Validation against a real DAS requires flexibility to address possible shortcomings in the NR that may be encountered.

3. In order to expedite development, a phased approach is preferable.

Our Phased Approach

Phase 1: First generate a prototype baseline set of simulated observations that is significantly "more realistic" than the baseline set used for the former NCEP/ECMWF OSSE, allowing flexibility for possible unrealistic aspects in the NR and accounting for limited resources. (Also, try to ignore what we don't yet know how to do well.)

Phase 2: Correct somewhat easily addressed shortcomings or omissions recognized in the Phase 1 development.

Phase 3: Add more realism that still seems both important and reasonable.

Current Experimental Design

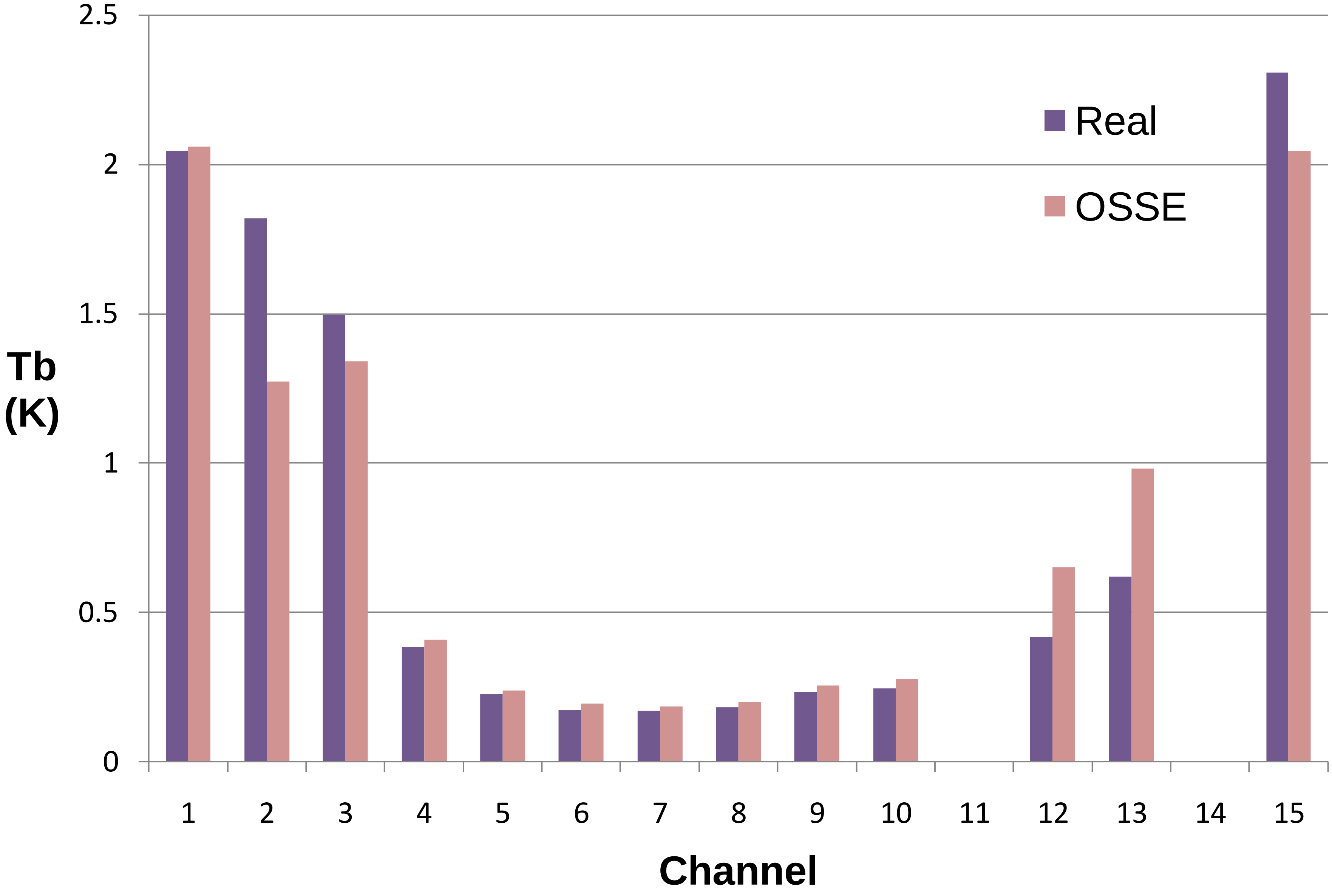
ECMWF Nature Run

1. Operational model from 2006
2. Analyzed SST as lower boundary condition
3. T511L91 reduced linear Gaussian grid (40 km)
4. 13-month “forecast” starting 10 May 2005
5. 3 hourly output

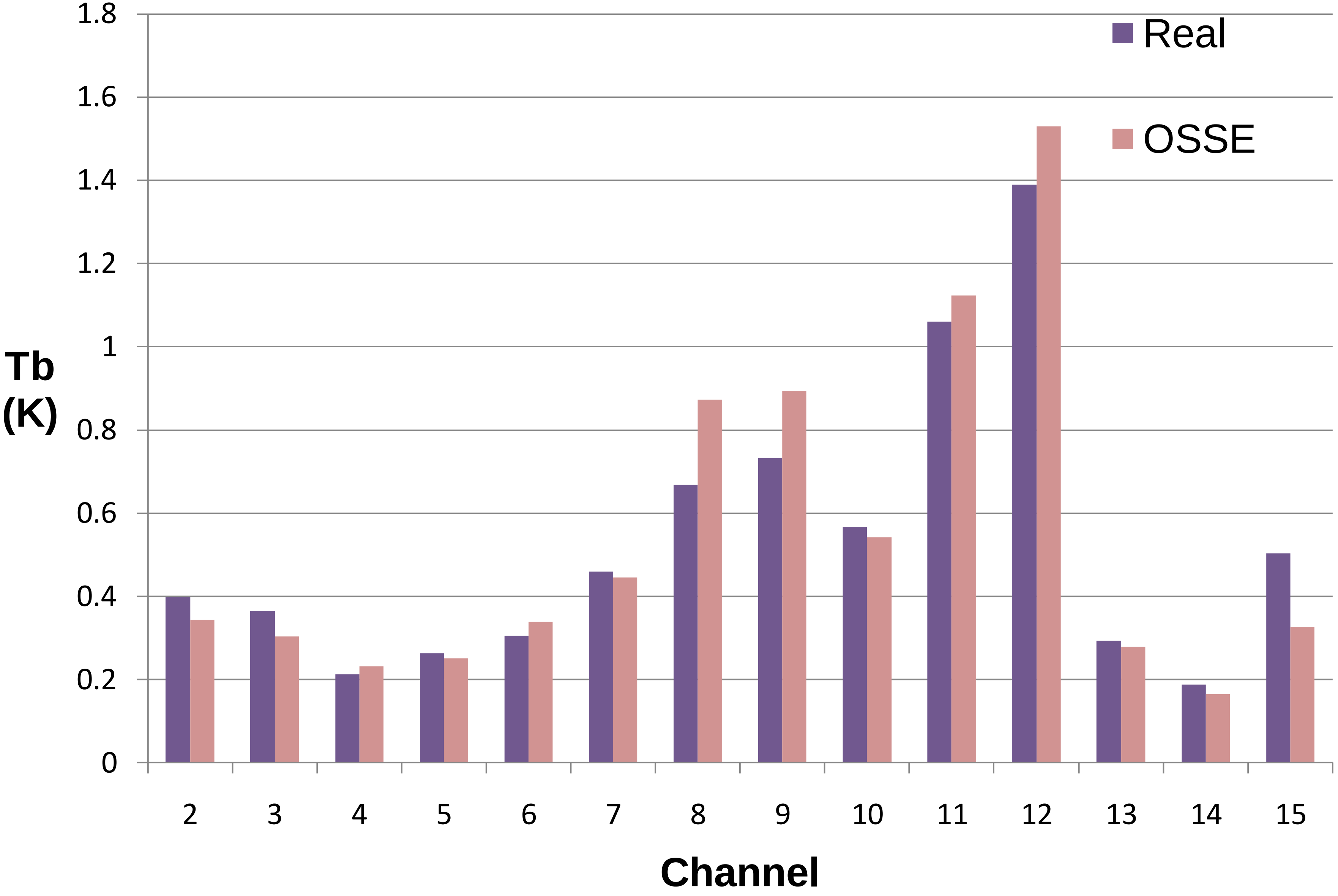
NCEP/GMAO GSI DAS

1. GSI 3DVAR every 6 hours
2. GMAO GEOS-5 forecast model with FV dynamical core
3. Resolution in current experiments: 1x1.25 degree grid, 72 levels
4. 2-month spin-up starting 1 Nov. 2005
5. Validation statistics averaged for month of Jan. 2006
6. Observations from 2005 include: HIRS2/3, AMSUA/B, AIRS, most conventional obs. (notably excluding precipitation related).

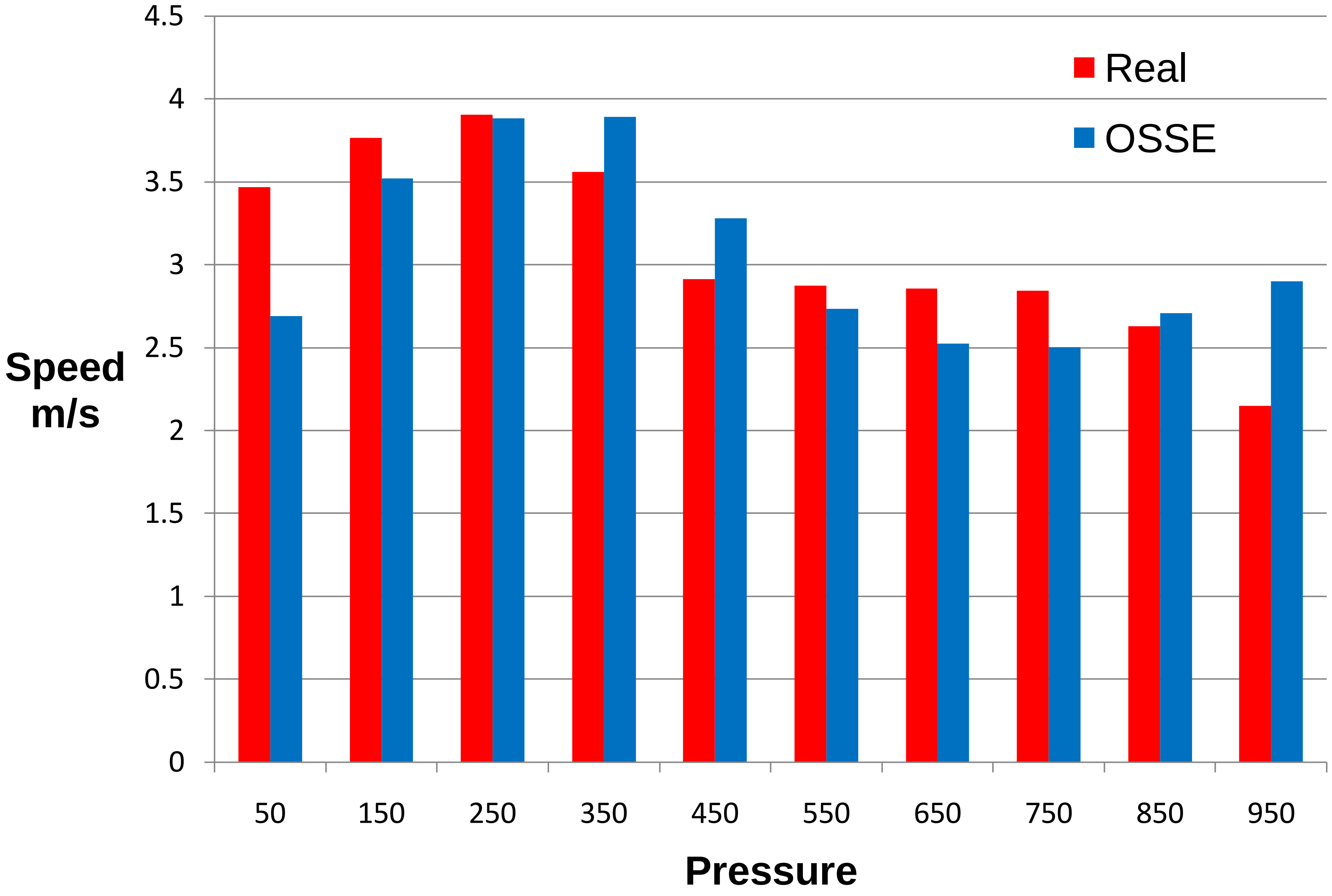
Standard Deviations of O-F for AMSU-A NOAA-15



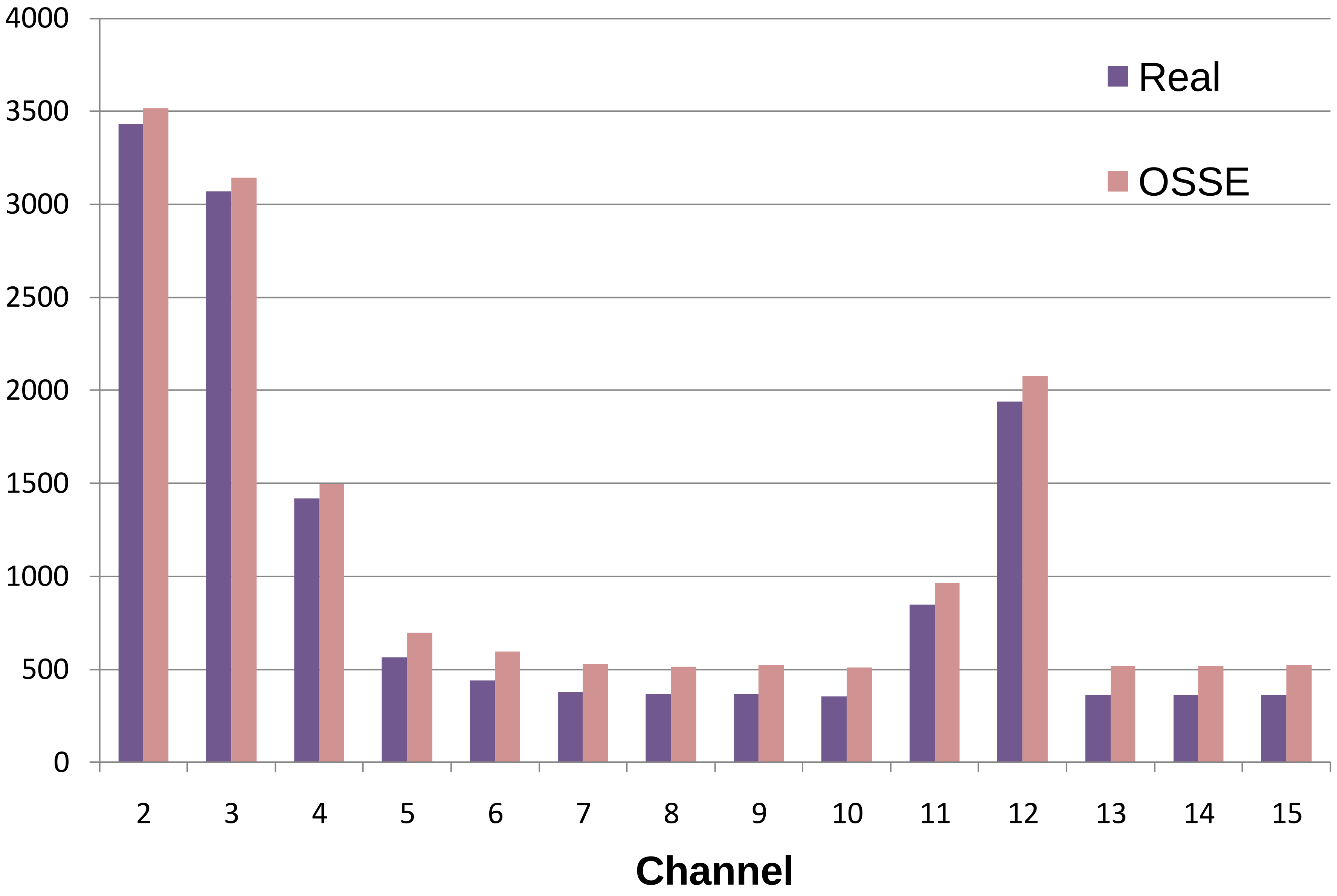
Standard Deviations of O-F HIRS-2 on NOAA-14

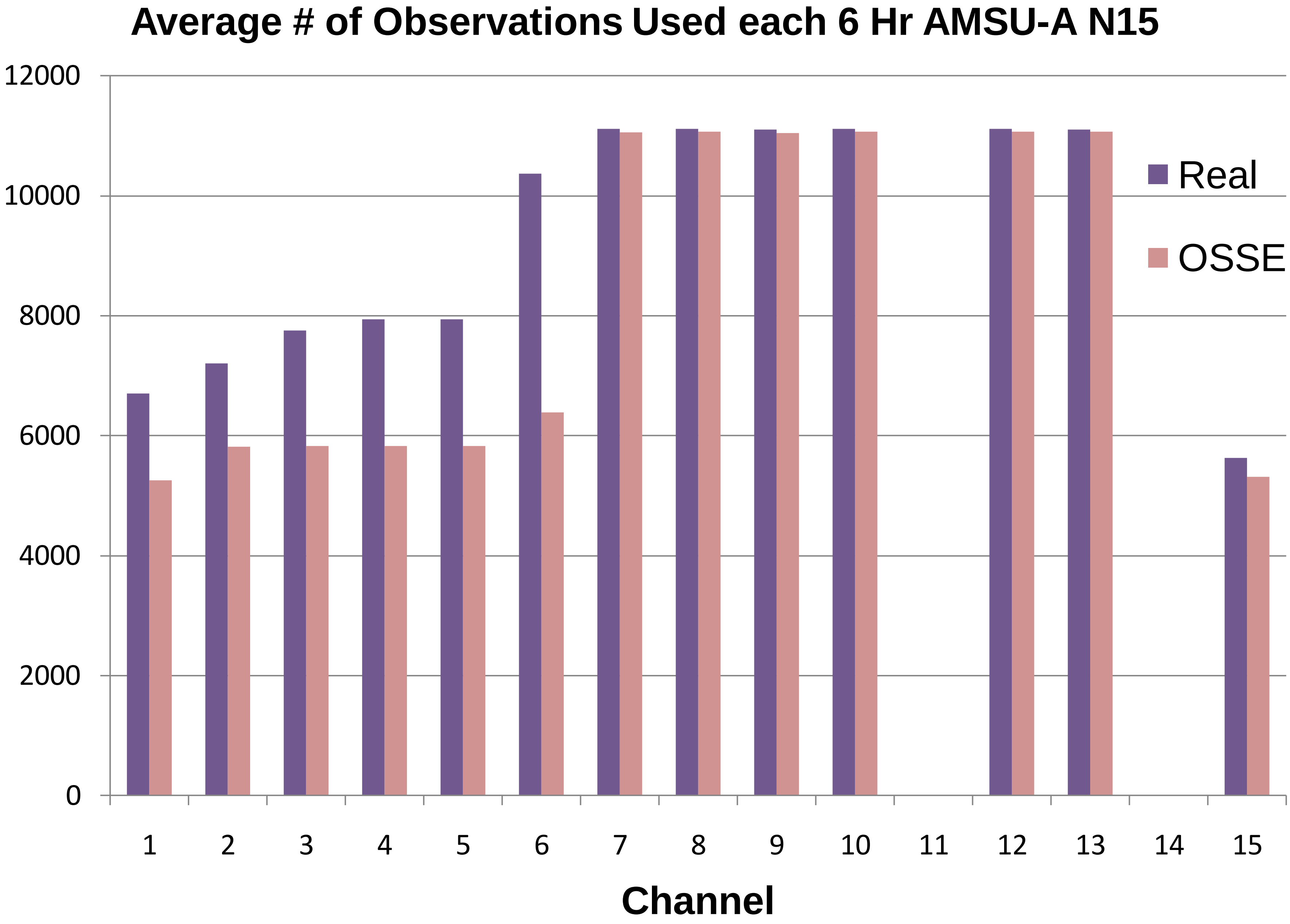


Standard Deviations of O-F for All Wind Observations



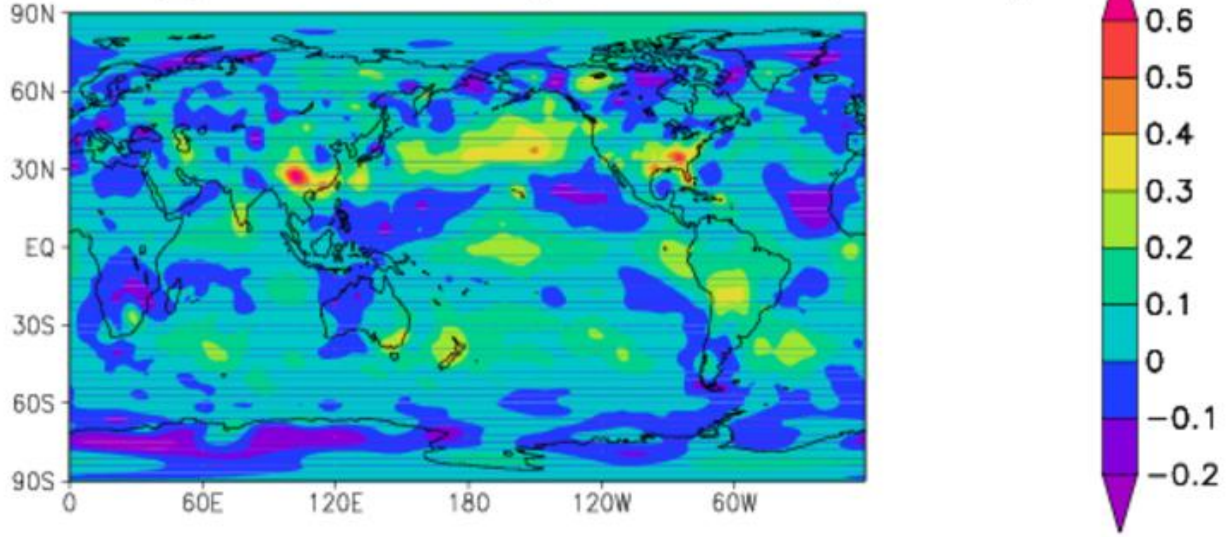
Average # of Observations Used Each 6 Hr HIRS-2 N-14



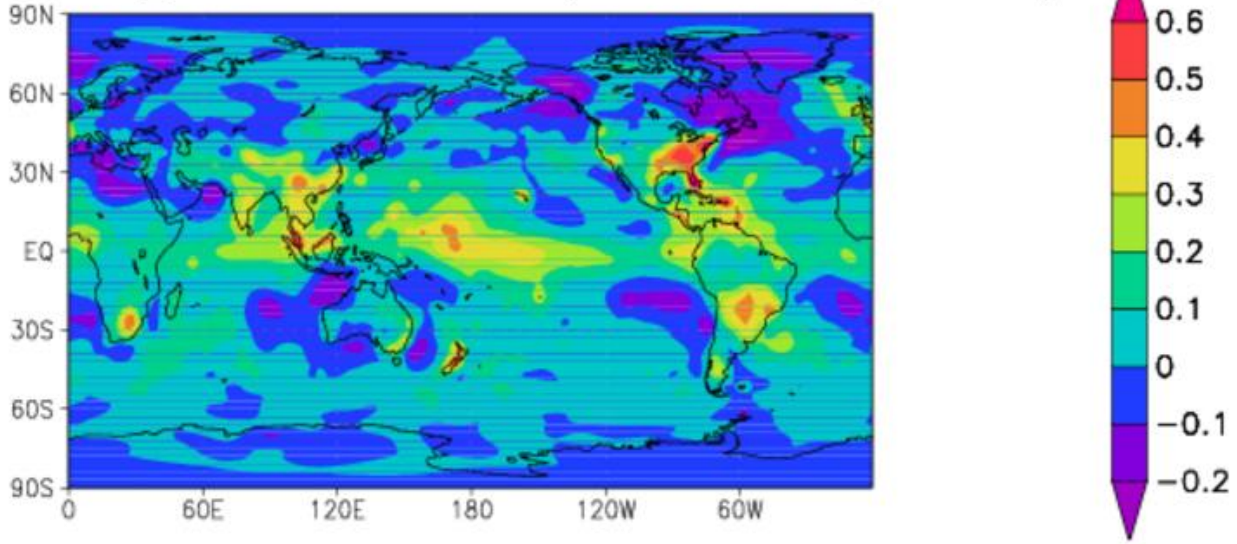


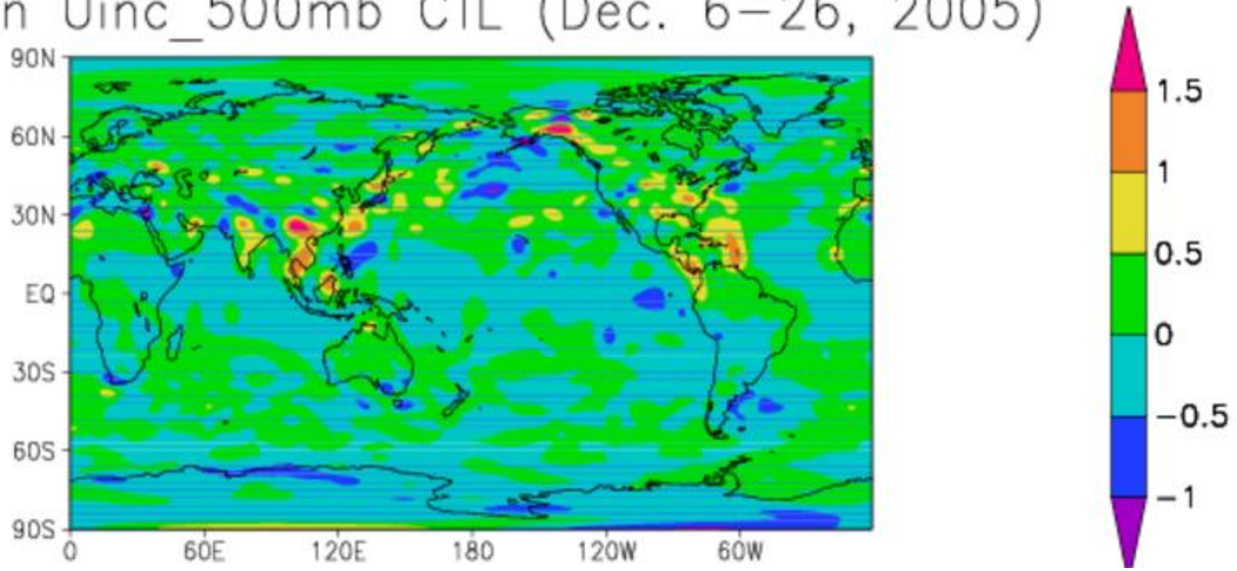
Average # of Observations Used each 6 Hr AMSU-A N15

Mean Tinc_500mb CTL (Dec. 6–26, 2005)



Mean Tinc_500mb OSSE (Dec. 6–26, 2005)





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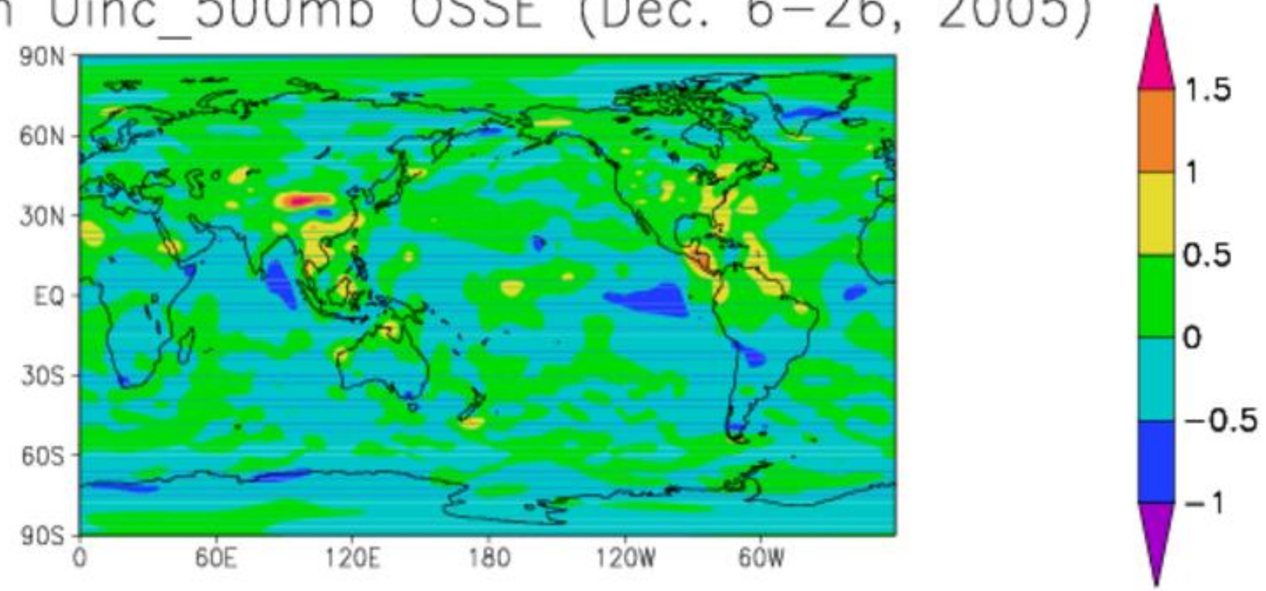
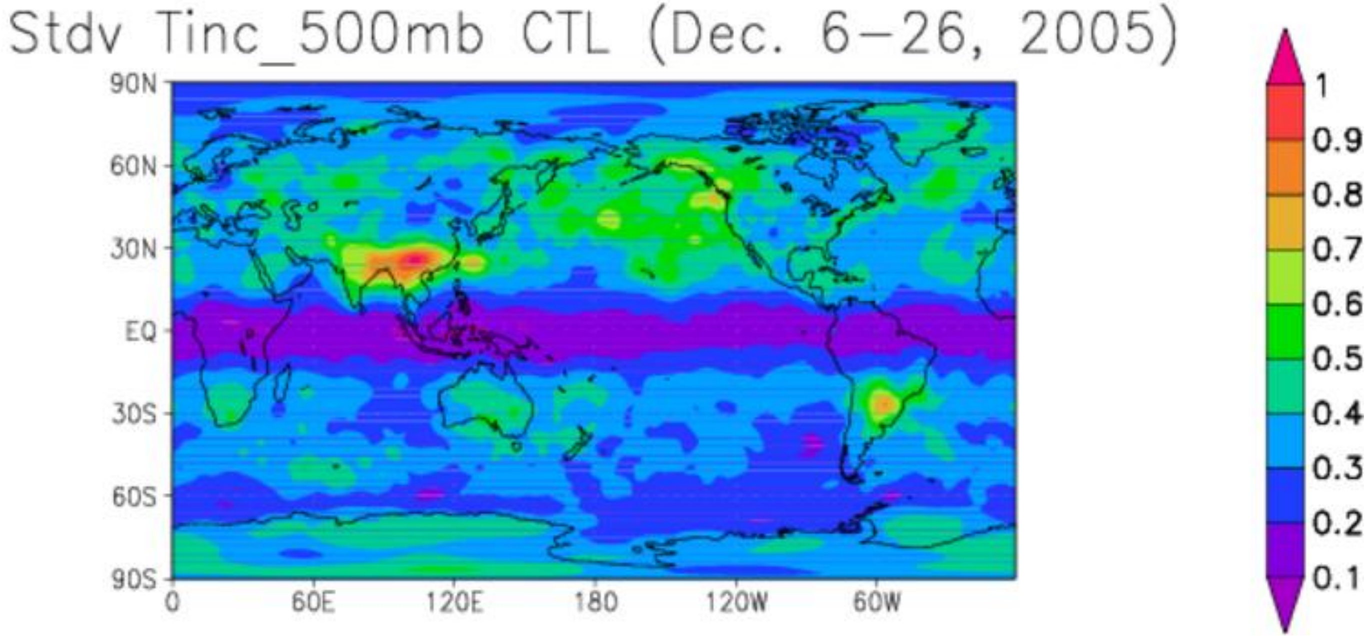
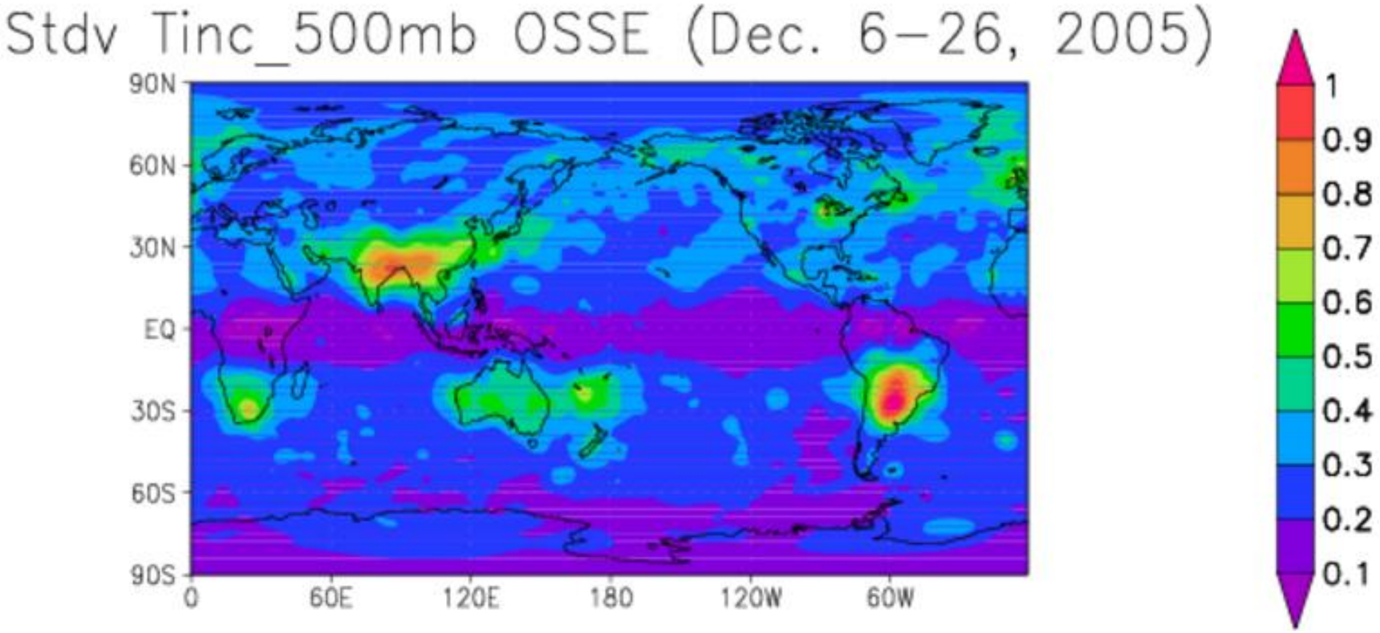


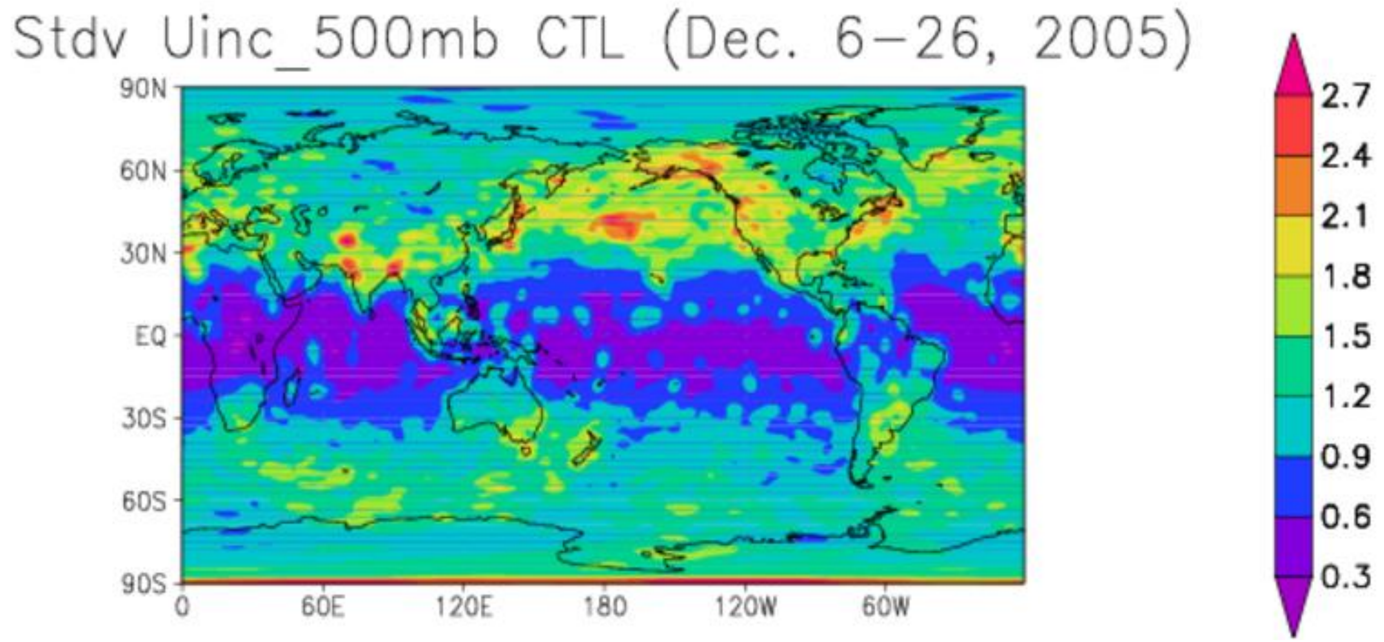
Mean Uinc_500mb OSSE (Dec. 6-26, 2005)



Stdv Tinc_500mb CTL (Dec. 6–26, 2005)



Stdv Tinc_500mb OSSE (Dec. 6–26, 2005)



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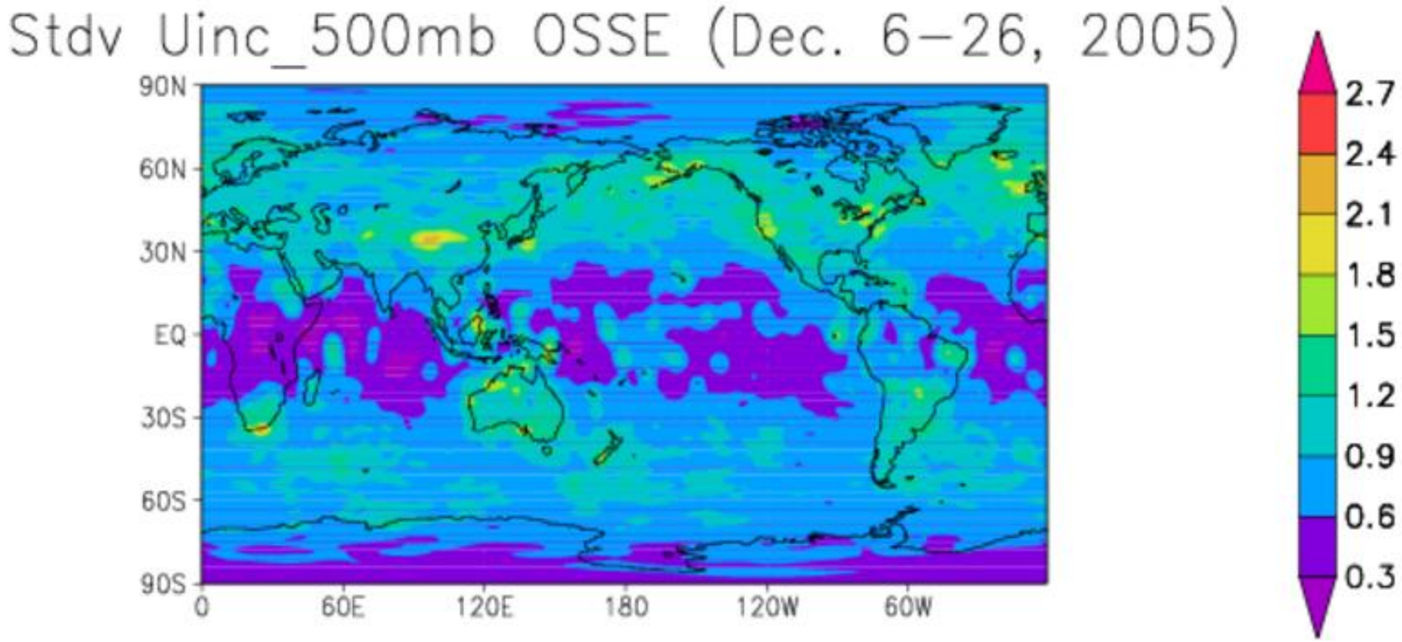
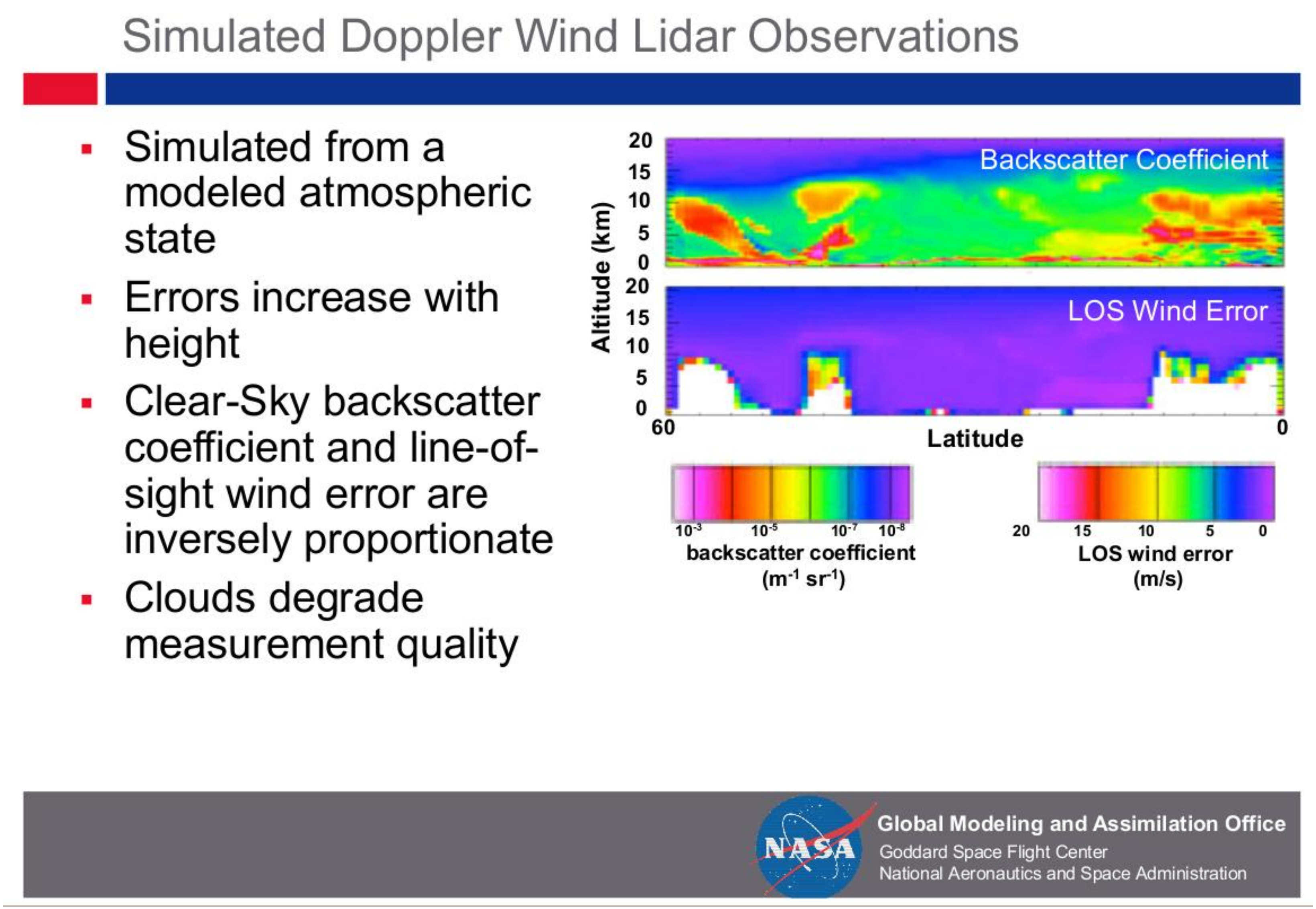


Stdv Uinc_500mb OSSE (Dec. 6–26, 2005)

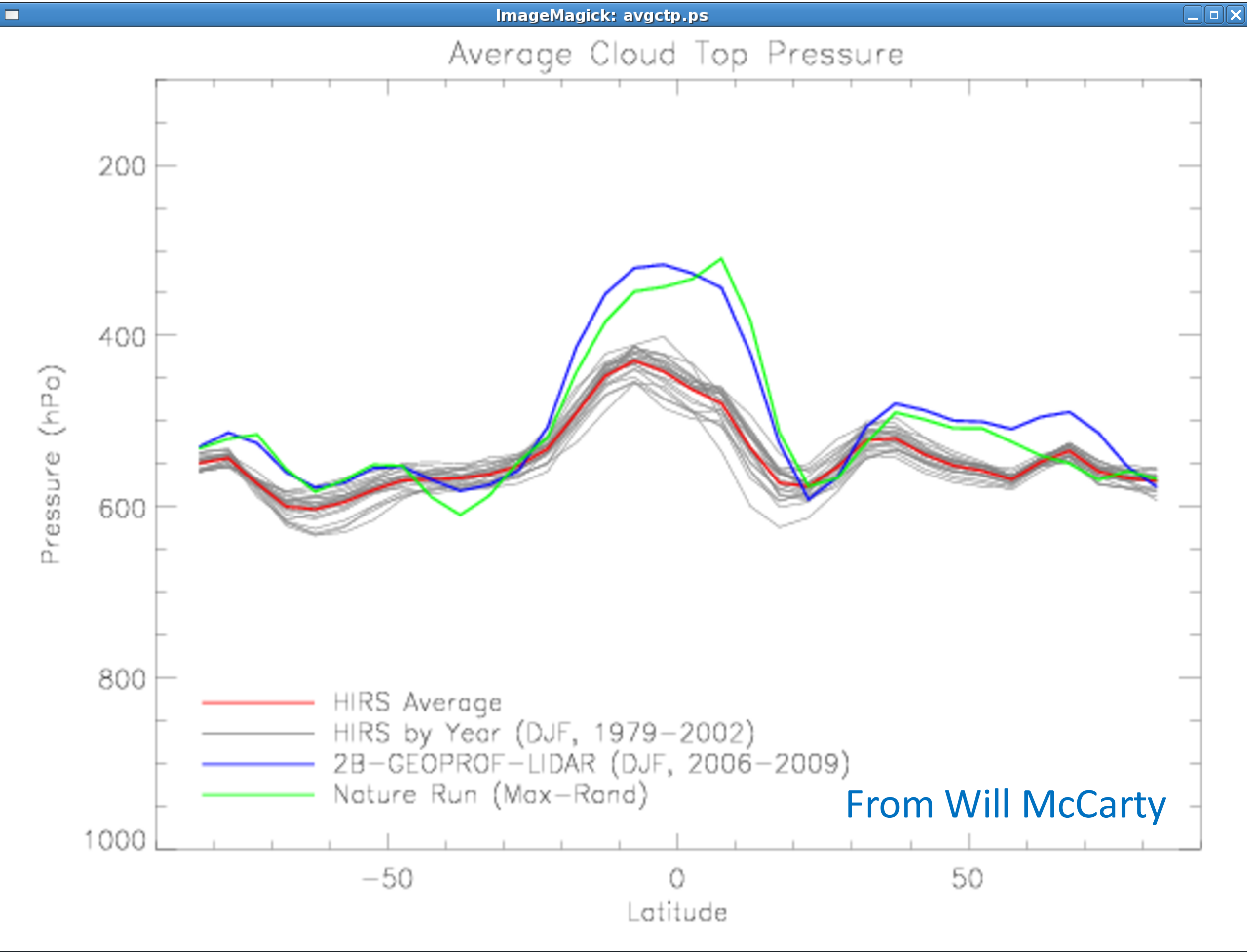


Simulated Doppler Wind Lidar Observations

- Simulated from a modeled atmospheric state
- Errors increase with height
- Clear-Sky backscatter coefficient and line-of-sight wind error are inversely proportionate
- Clouds degrade measurement quality

Global Modeling and Assimilation Office
Goddard Space Flight Center
National Aeronautics and Space Administration

From Will McCarty



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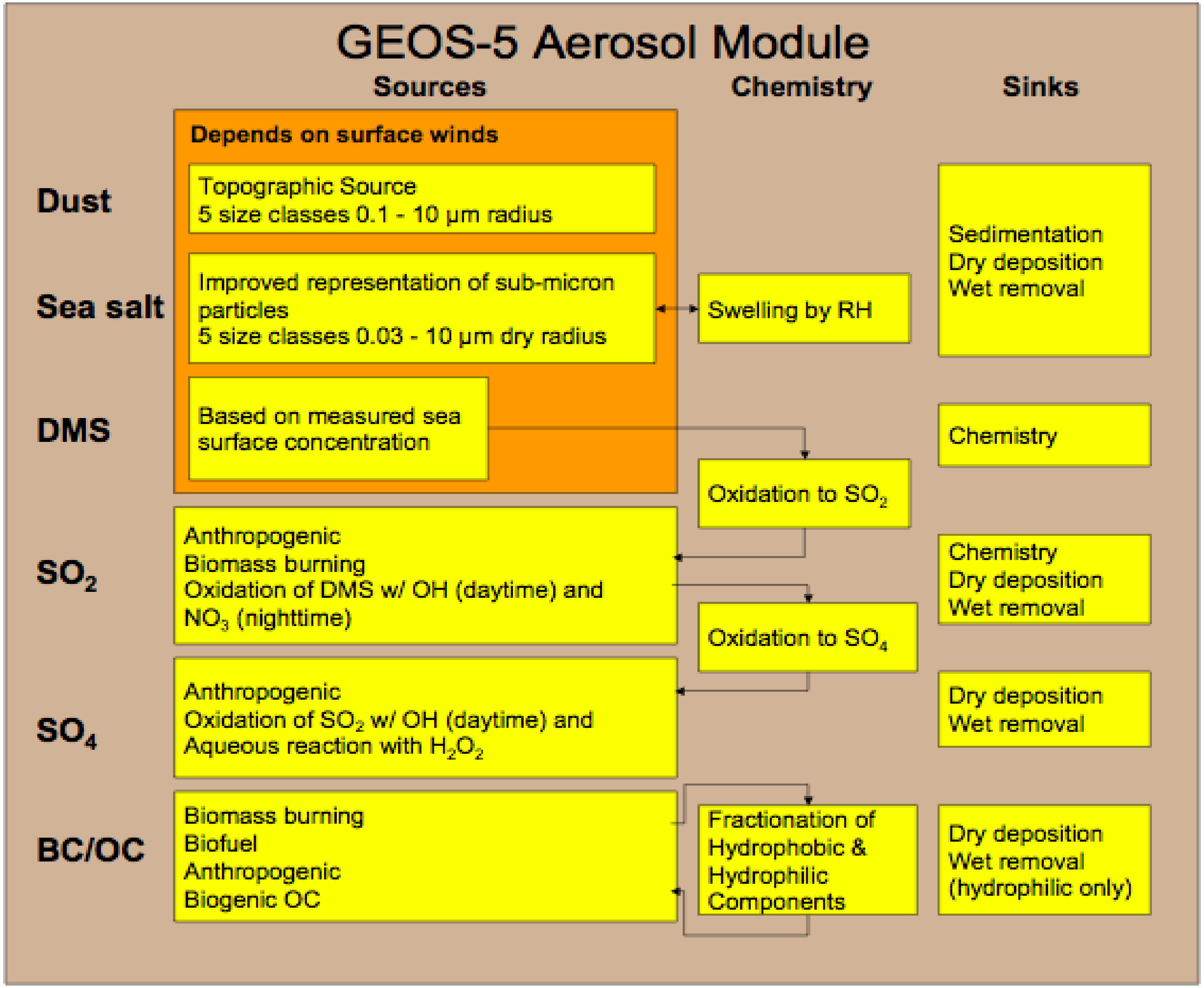


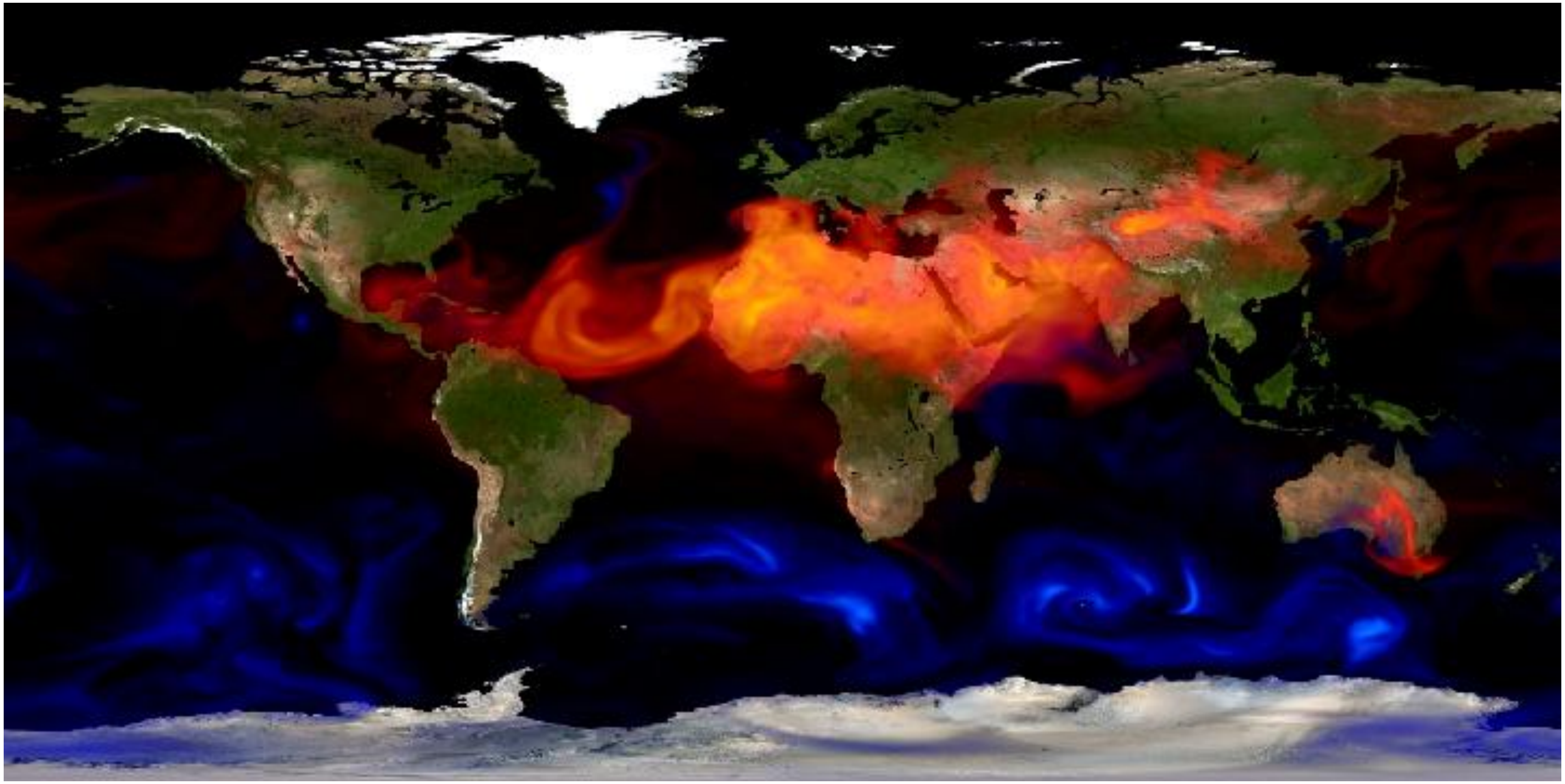
GEOS-5 Aerosol Module

Depends on surface winds (Dust, Sea salt, DMS sources)

	Sources	Chemistry	Sinks
Dust	Topographic Source 5 size classes 0.1 - 10 μm radius		Sedimentation Dry deposition Wet removal
Sea salt	Improved representation of sub-micron particles 5 size classes 0.03 - 10 μm dry radius	Swelling by RH	
DMS	Based on measured sea surface concentration	Oxidation to SO_2	Chemistry
SO_2	Anthropogenic Biomass burning Oxidation of DMS w/ OH (daytime) and NO_3 (nighttime)	Oxidation to SO_4	Chemistry Dry deposition Wet removal
SO_4	Anthropogenic Oxidation of SO_2 w/ OH (daytime) and Aqueous reaction with H_2O_2		Dry deposition Wet removal
BC/OC	Biomass burning Biofuel Anthropogenic Biogenic OC	Fractionation of Hydrophobic & Hydrophilic Components	Dry deposition Wet removal (hydrophilic only)

From Arlindo Da Silva

Dust and Sea Salt



From Arlindo Da Silva

List of Completed Tasks

1. Software for creating obs and errors for both conventional data and radiances for AIRS, HIRS2/3, AMSUA/B, MSU (modularized, well tested, extensively documented, partially parallelized).

2. Tuning experiments being performed for *error.rc* and *cloud.rc* parameters.

3. An aerosol data set to accompany the NR data exists.

Short-Term Plans

1. Further examination of current OSSE tuning results, including determination of adjoint-derived observation impacts on 24-hour forecast-error reduction (estimated completion in March 2010)
2. Improvement of observation simulations planned for spring 2010
   a. using land-affected microwave radiances by incorporating suitable emissivity model errors
   b. locating satellite feature-tracked winds based on NR clouds and moisture
   c. assigning significant levels in RAOB reports based on NR gradients and, of lesser importance, RAOB locations based on balloon drift
   d. using better cloud height assignments for affected IR radiances
3. Inclusion of aerosols consistent with N.R. (Arlindo da Silva)
4. OSSE with satellite wind lidar (Will McCarty)

Warnings

a. Past flaws in OSSE design must be avoided.
b. A sufficient understanding of data assimilation and the behaviors of such systems are required to design or employ an OSSE.
c. Design choices should be competed based on scientific arguments.
d. Conflicts of interest must be avoided.
e. Time and patience are required to develop an adequate simulation.
f. Many metrics must be examined.
g. Entraining users should be discouraged until phase 1 is completed (or better, phase 2).
h. Only limited knowledge can be obtained from case studies (e.g., the spin-up of background error statistics is excluded).

Some Requirements for Successful Collaborations

1. Common working definitions of science (traditional vs. contemporary)
2. Similar commitments to quality (tradeoffs vs. expediency)
3. General agreement regarding priorities and requirements
4. Willingness to contribute what is necessary before what is desired
5. Willingness to develop diagnostic tools
6. A “conductor” who adequately understands the issues