Observing System Simulation Experiments for a US Wind Lidar space mission

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Overview

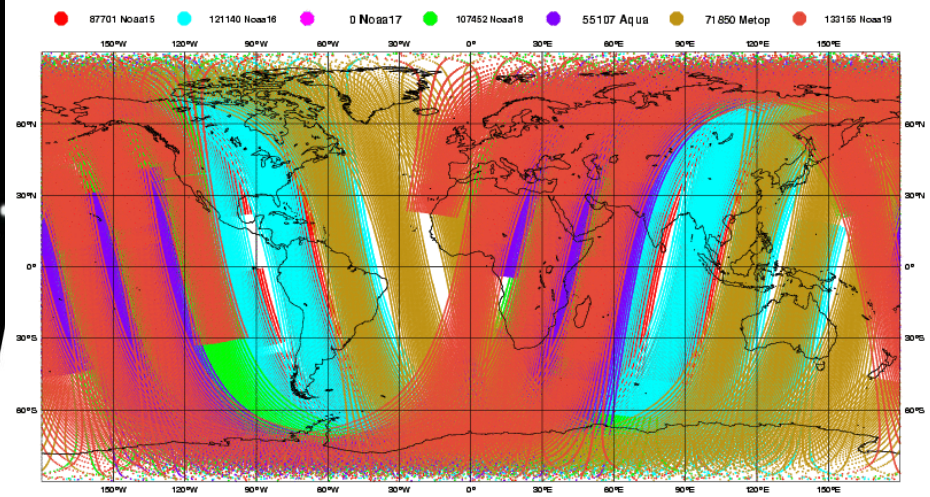
- NWP and wind observations
- GWOS mission concept
- OSSE setup
- Initial results
- Future work
- Summary and conclusions

Upper-air observation requirements for NWP

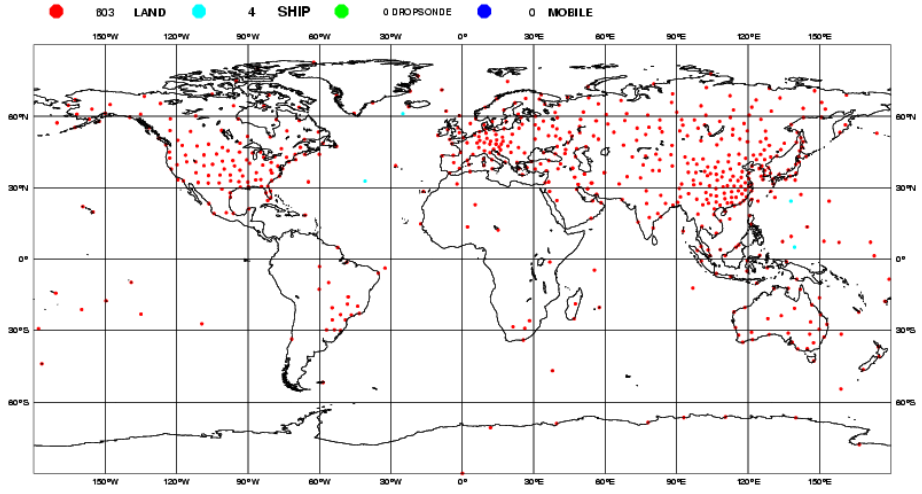
- Numerical weather prediction requires independent and global observations of the **mass** (temperature) and **wind** fields
- The global three-dimensional **mass field is well observed from space**
- **No existing space-based observing system provides vertically resolved wind information** => horizontal coverage of wind profiles is sparse
- The lack of wind measurements is widely believed to be one of the main limiting factors for progress in NWP skill at all temporal ranges
  - Especially critical as we progress to smaller and smaller scales where wind/mass balance assumptions break down

Current Upper Air Mass & Wind Data Coverage

ECMWF Data Coverage (All obs DA) - AMSU-A
26/MAY/2010; 00 UTC
Total number of obs = 576405



ECMWF Data Coverage (All obs DA) - TEMP
26/MAY/2010; 00 UTC
Total number of obs = 607



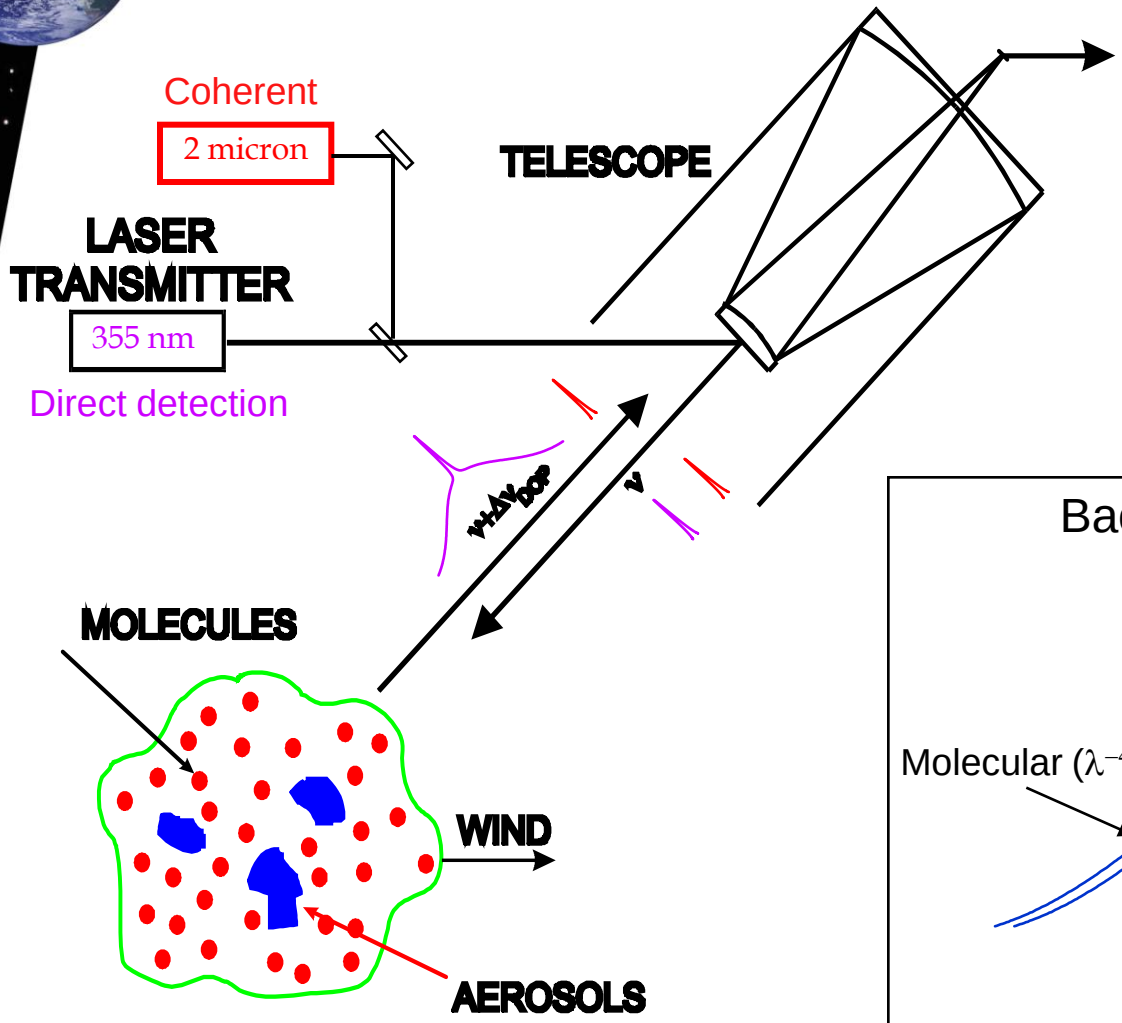
Vertically resolved Mass Observations

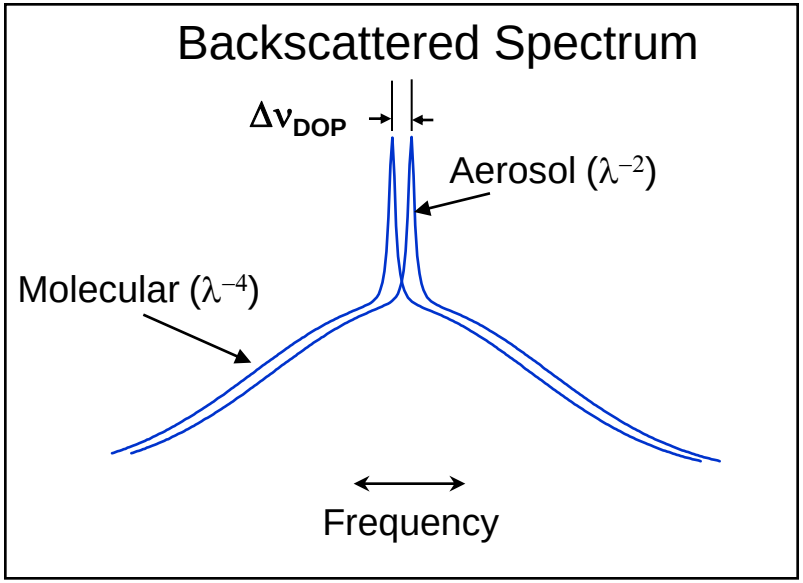
Vertically resolved Wind Observations

Measuring Wind with a Doppler Lidar

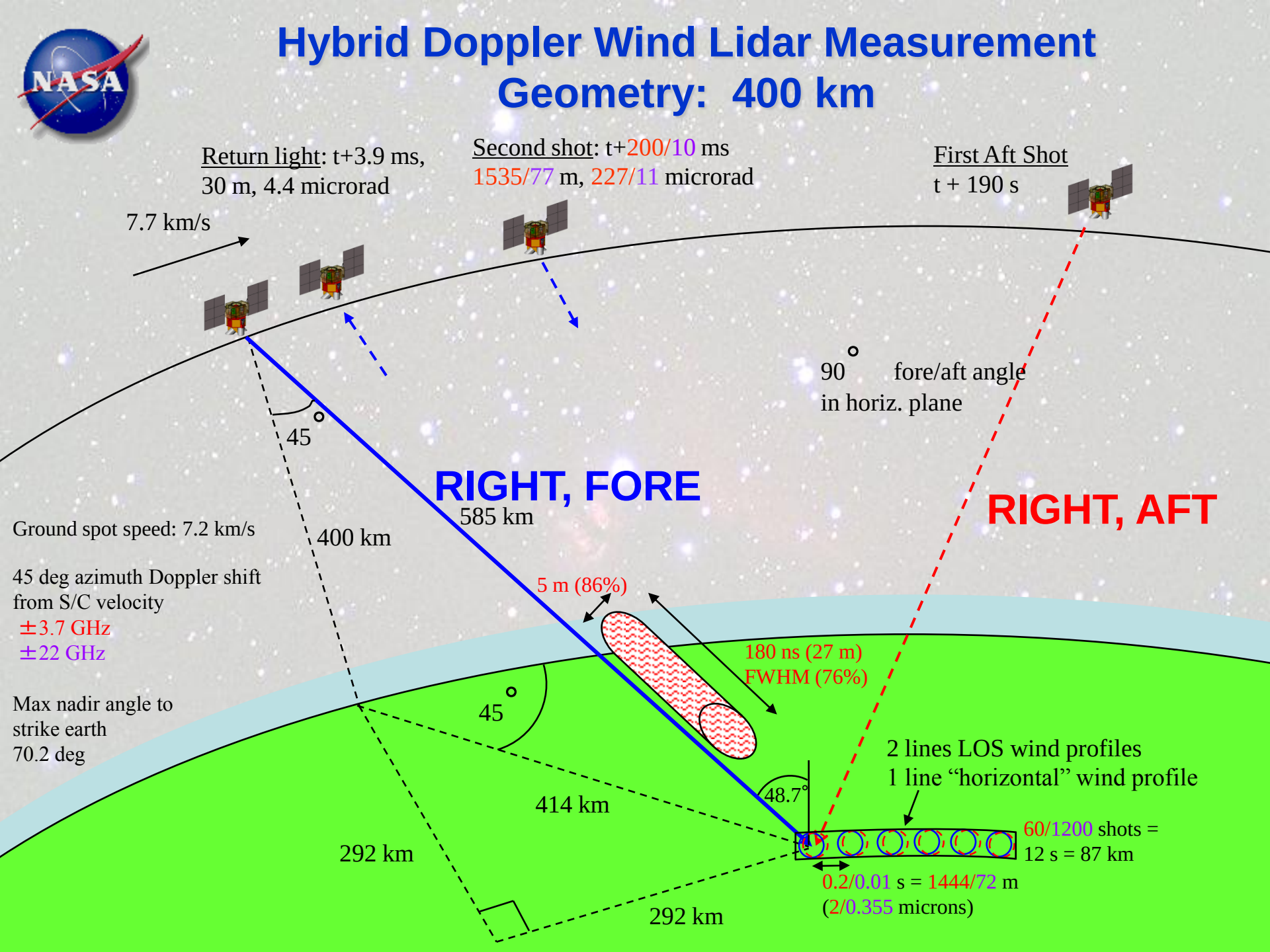
DOPPLER RECEIVER - Multiple flavors - Choice drives science/ technology trades

- Coherent or heterodyne aerosol Doppler receiver
- Direct detection molecular Doppler receiver





Hybrid Doppler Wind Lidar Measurement Geometry: 400 km



Wind Lidar OSSEs

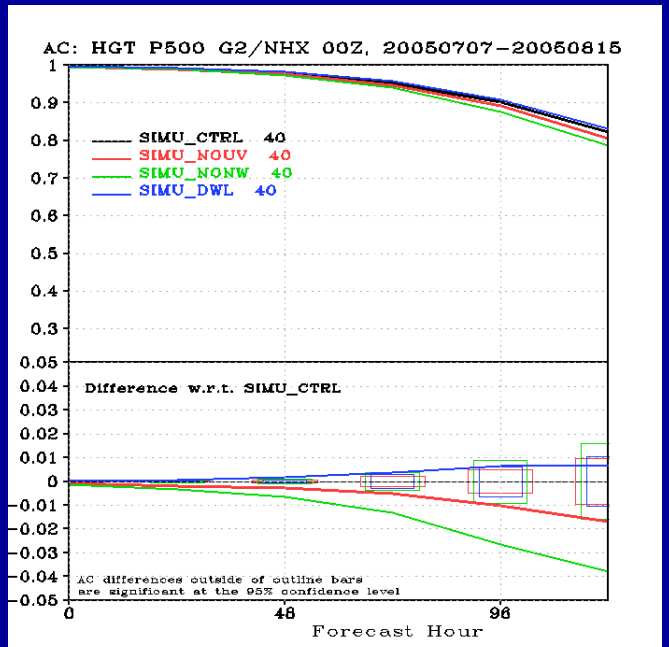
- Impact experiments carried out as part of NASA-NOAA Joint OSSE collaboration
  - Common Nature Run supplied by ECMWF
    - (comprehensive validation presented at past AMS meetings)
  - Shared simulation of reference observations; contributions by NESDIS, GMAO, NCEP, et al.
  - See poster by Masutani et al. (PS1, no. 199)

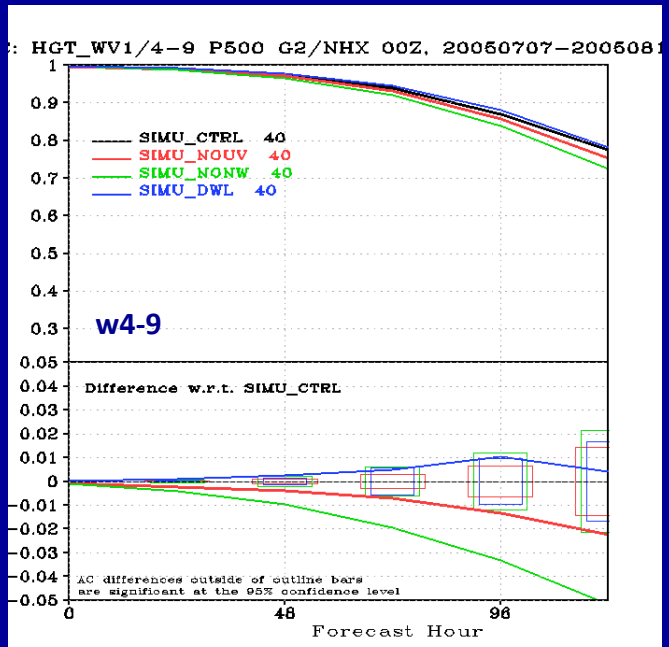
- Wind Lidar OSSE project funded by NASA (Kakar and Lee) under ROSES 2007

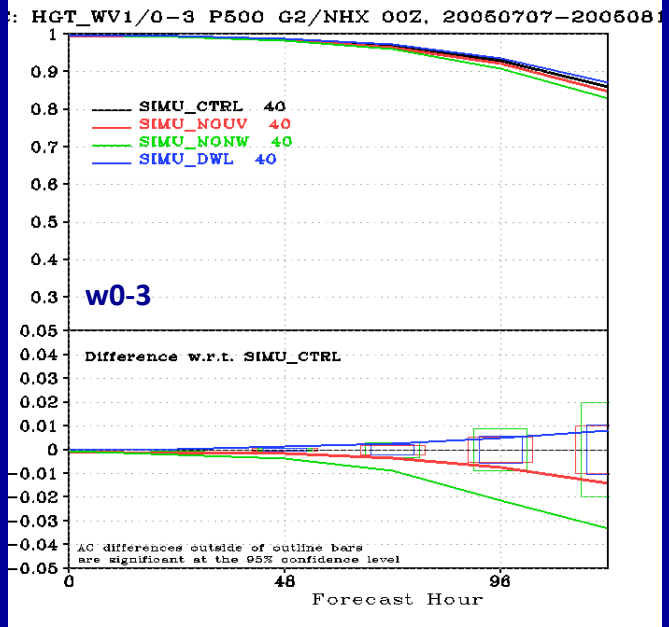
Experimental setup

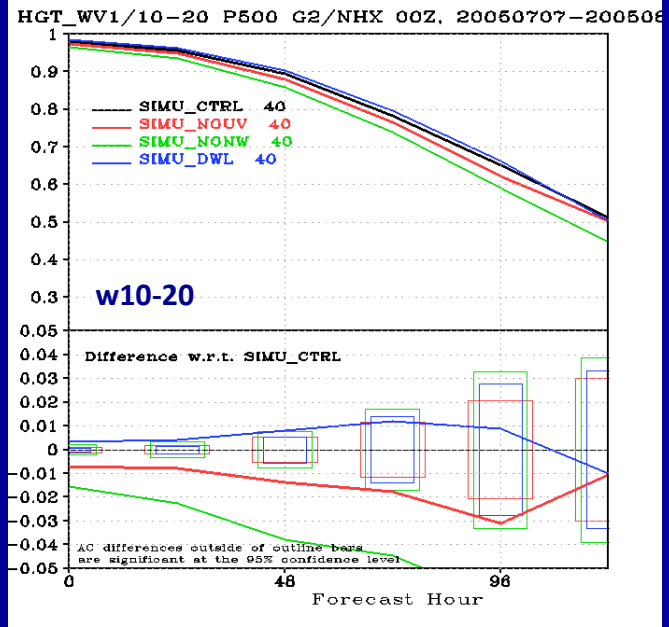
- NCEP GFS at T-126 horizontal resolution
- “OSSE period”: July 01-Aug 15, 2005 (simulated)
  - Five-day forecast launched every day at 00Z
  - Most observing systems used for routine operational NWP included, except GPSRO and IASI
- Four experiments, all verified against Nature Run
  - Simu_ctrl: NCEP GFS analysis assimilating the “observation” data from NR
  - Simu_nouv: CTRL without raob (220, 221 and 232)
  - Simu_nonw: CTRL without all wind
  - Sinu_dwl : CTRL + hybrid Satellite lidar wind data

500 hPa anomaly correlation coefficients, NH

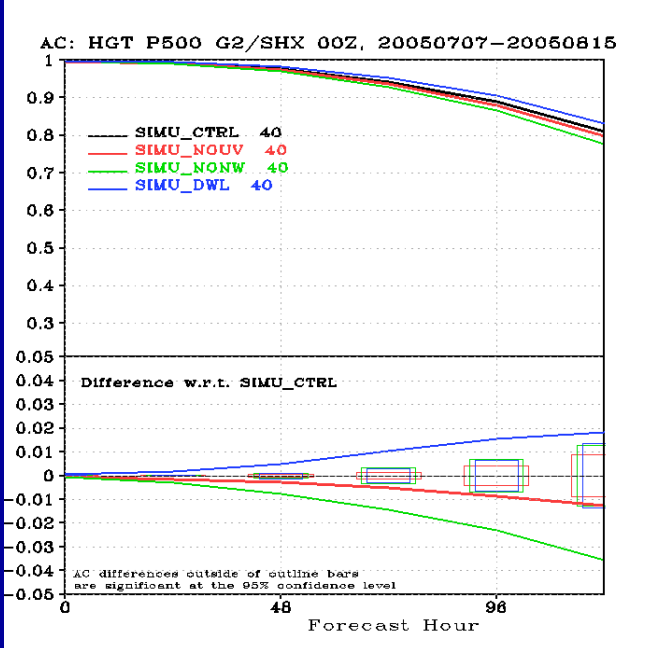


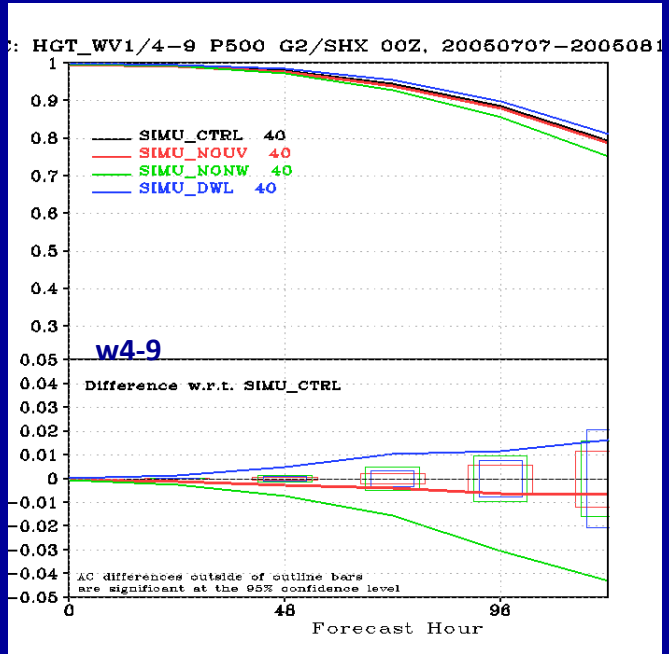


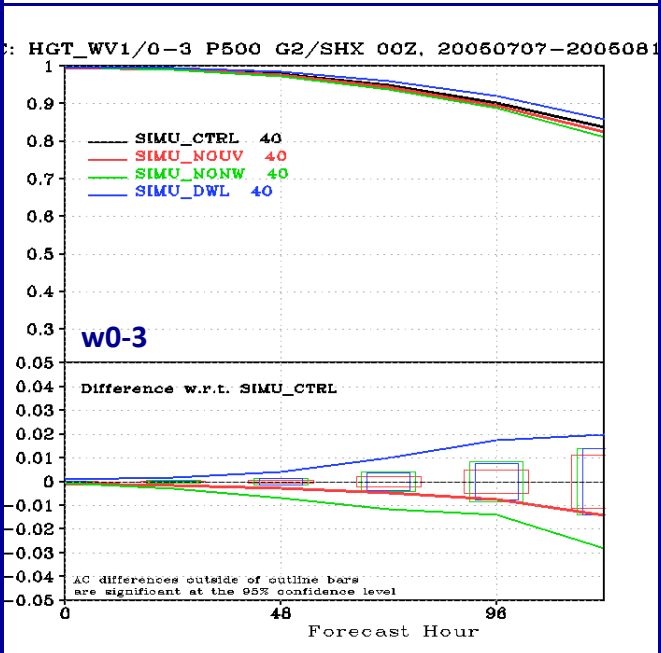


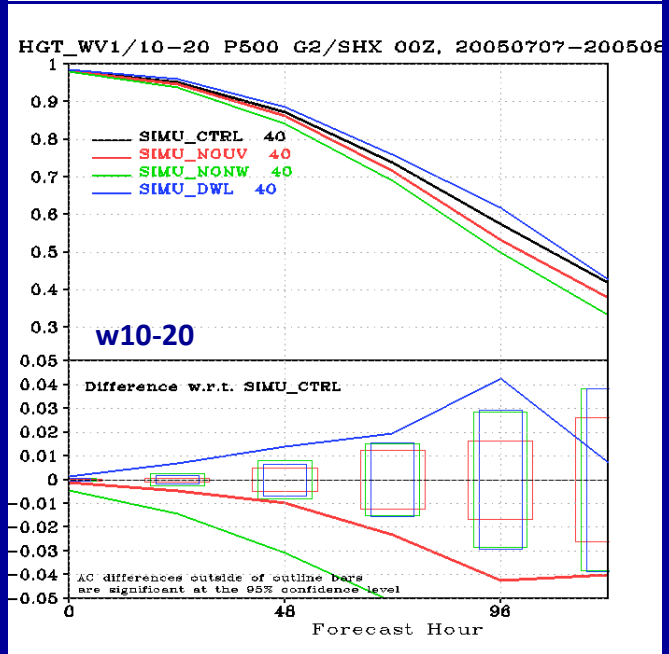


500 hPa anomaly correlation coefficients, SH

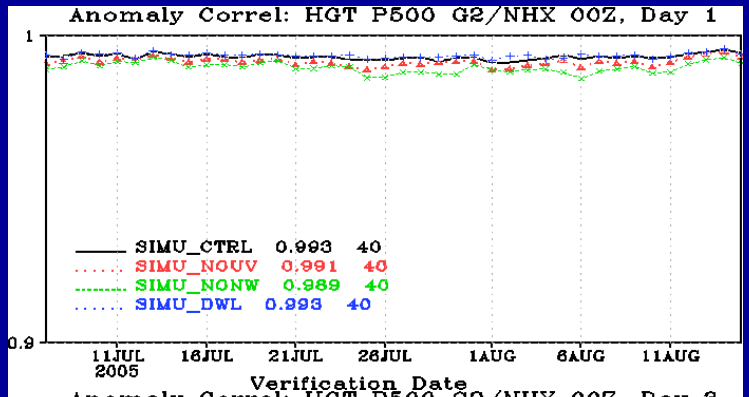
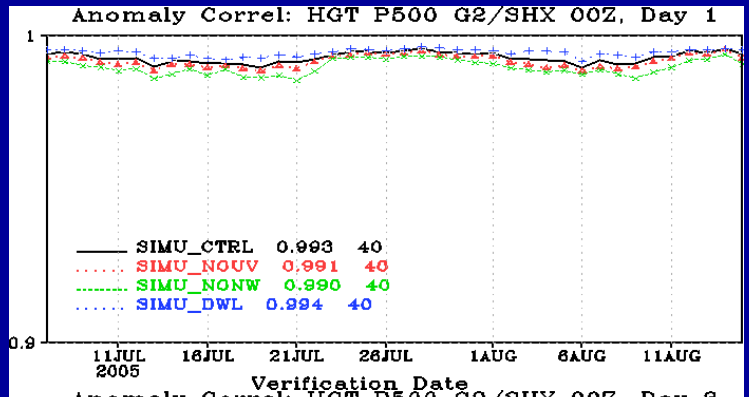
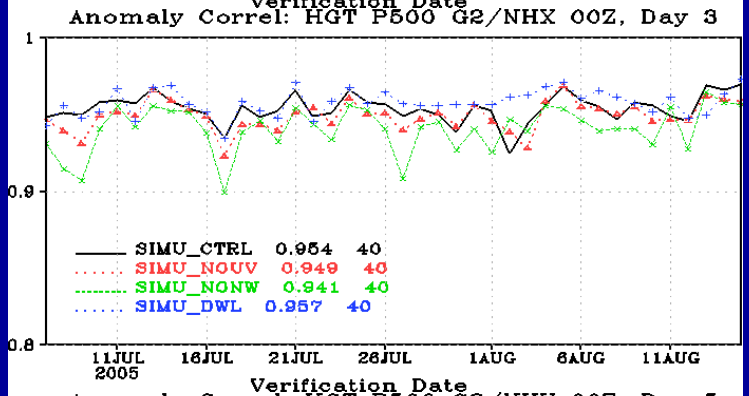
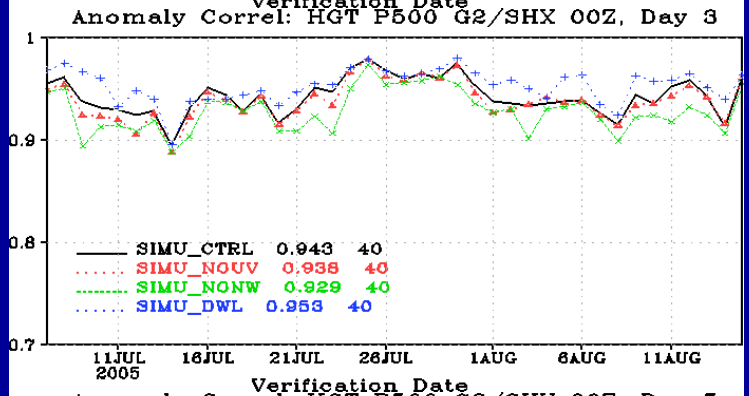
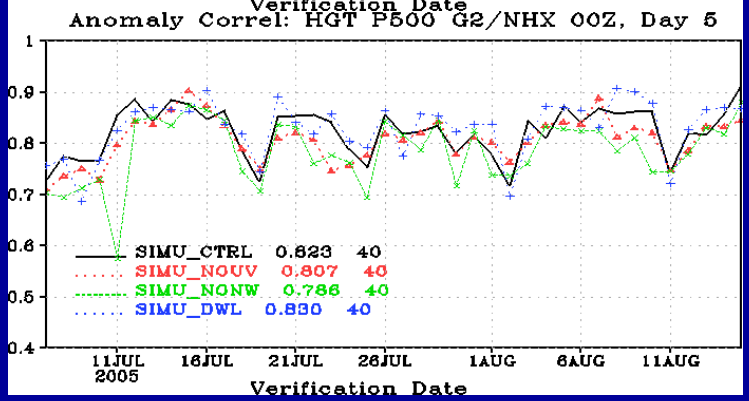
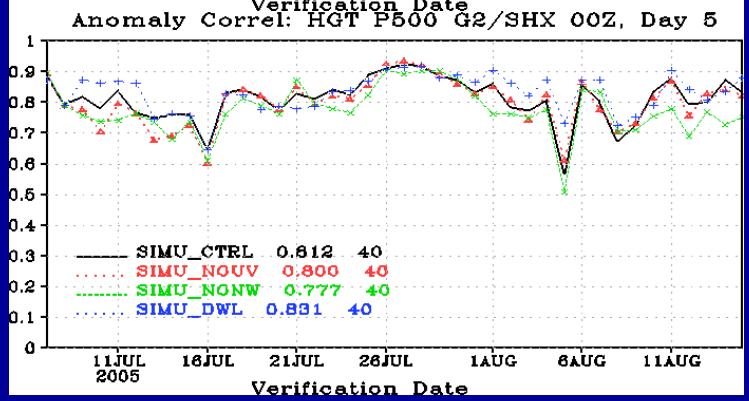






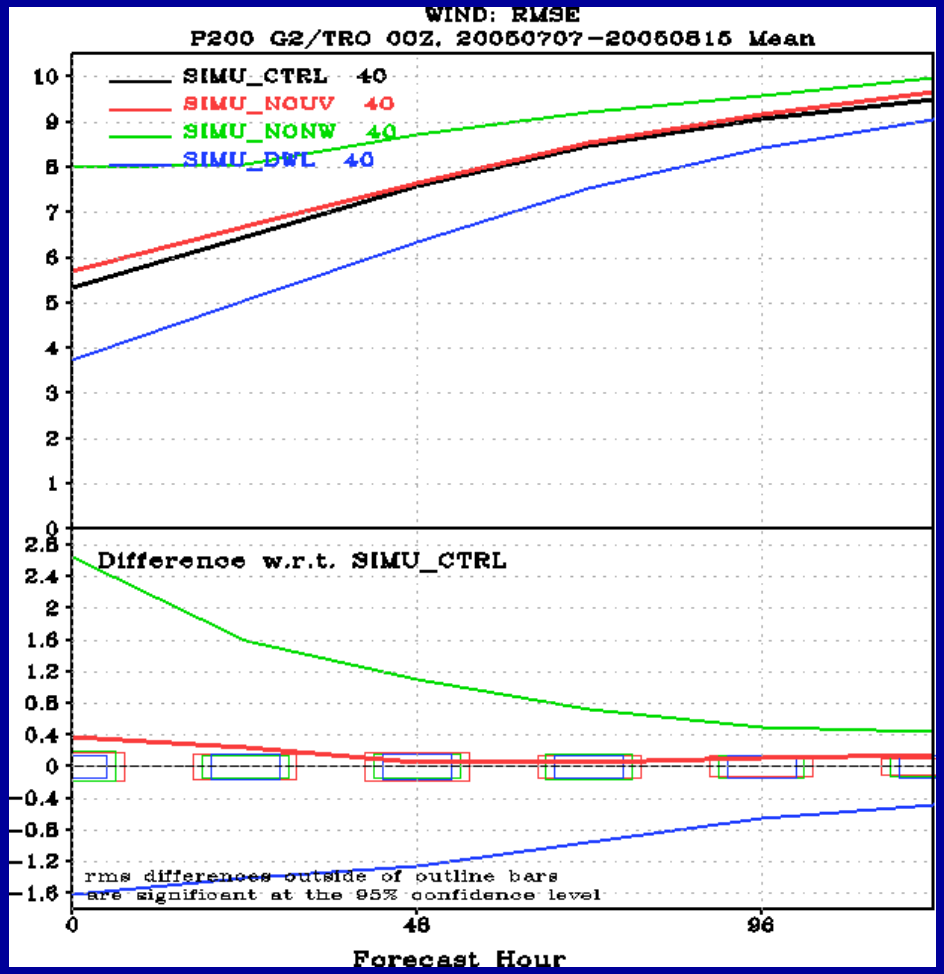


Time series of 500 hPa geopotential height AC

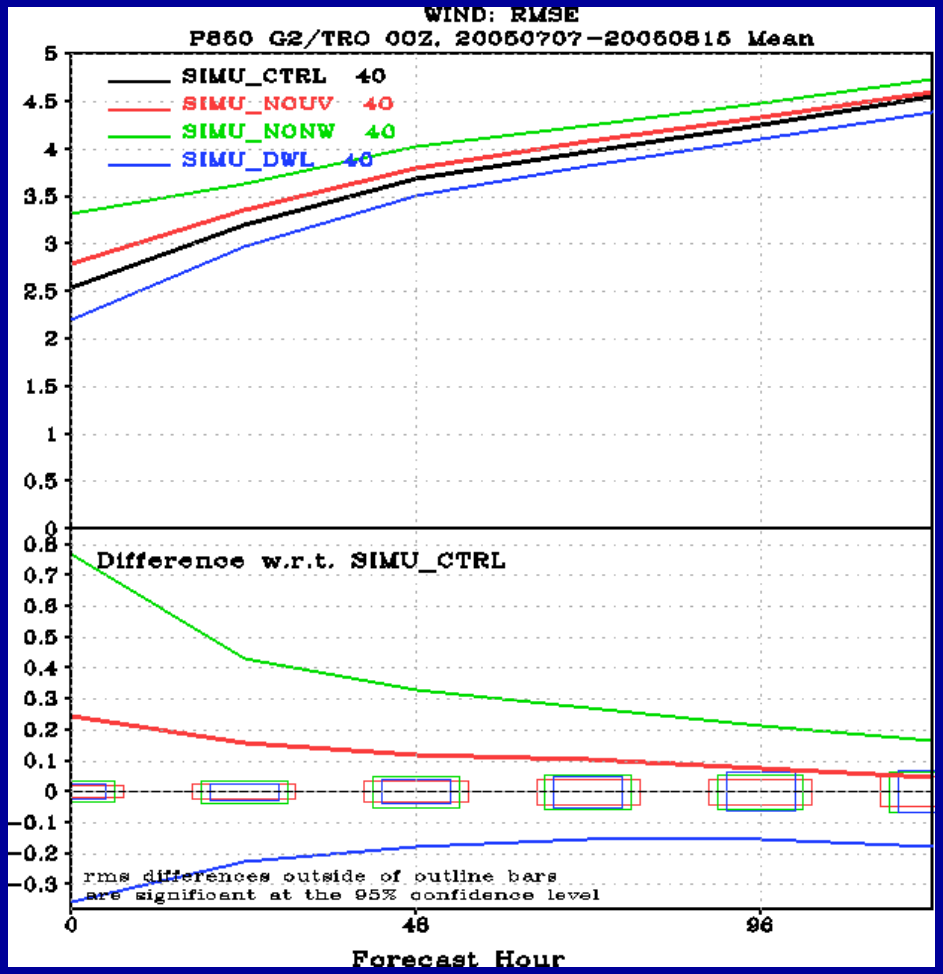
	NH	SH
Day 1		
Day 3		
Day 5		

RMSE: 200, 850hPa Wind error in tropics

200 hPa



850 hPa

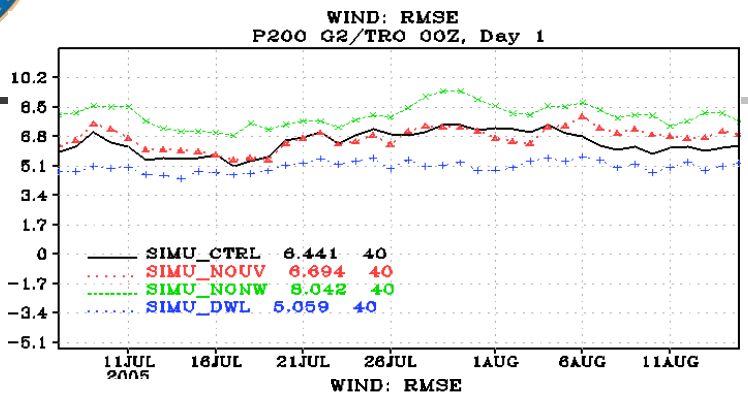


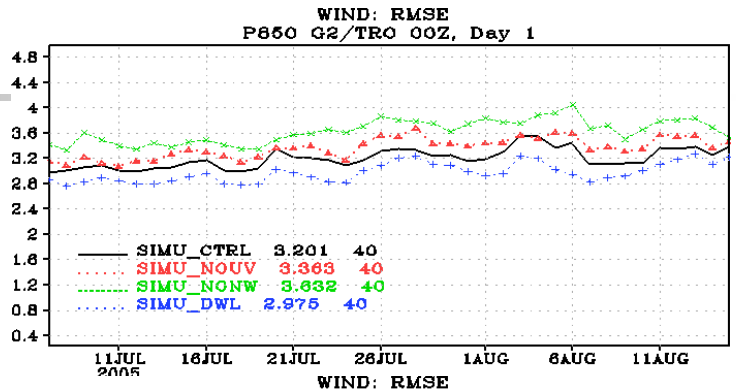
RMSE: 200hPa, 850hPa Wind in tropics

200 hPa

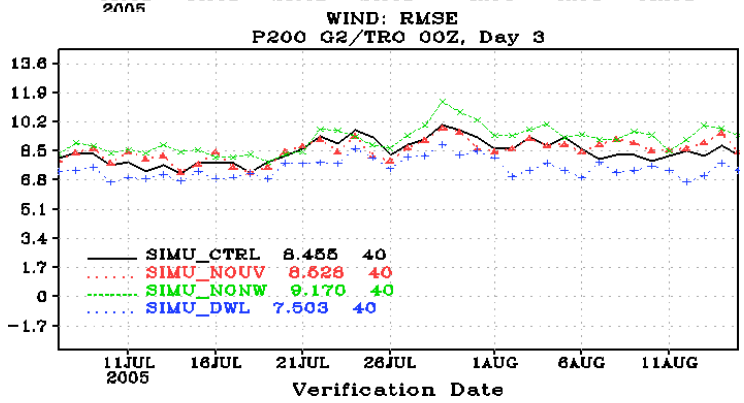
850 hPa

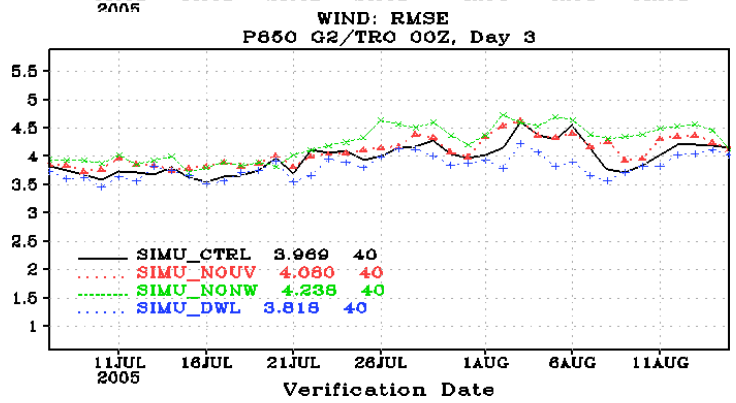
Day 1



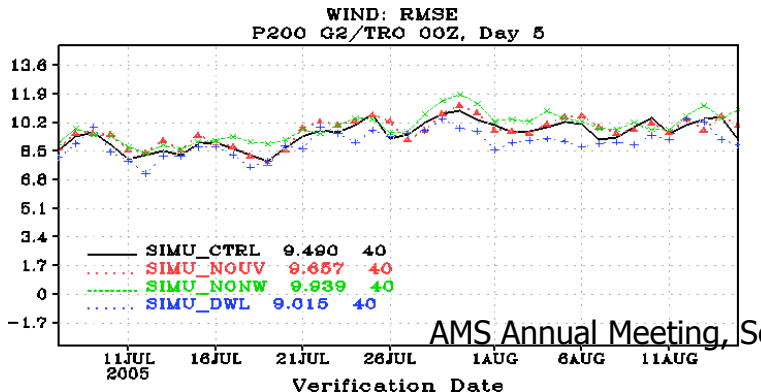


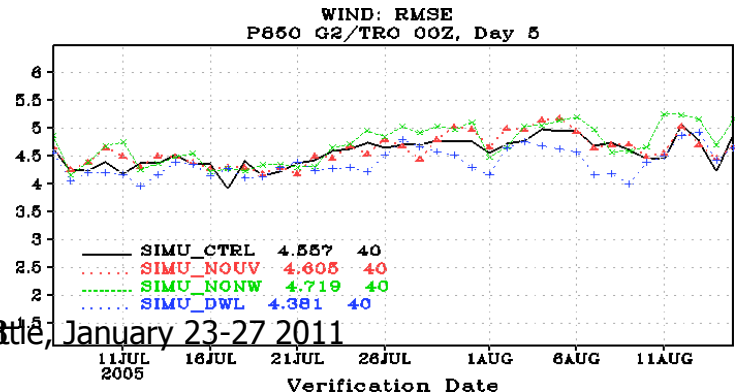
Day 3





Day 5

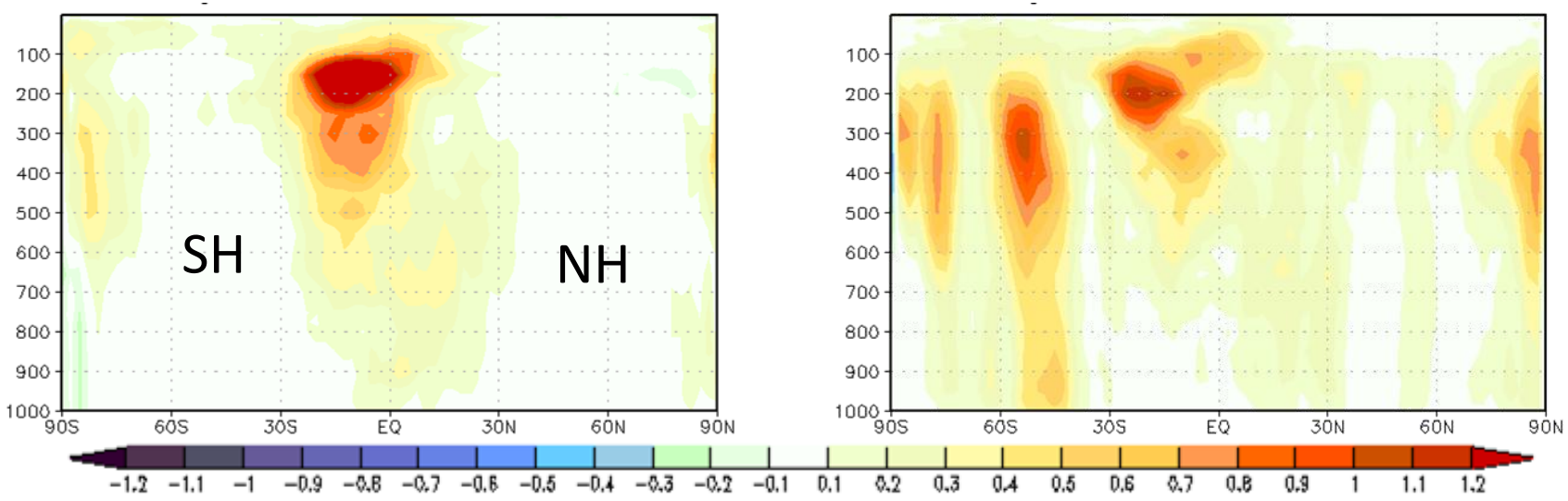




RMS difference between DWL experiment and NR

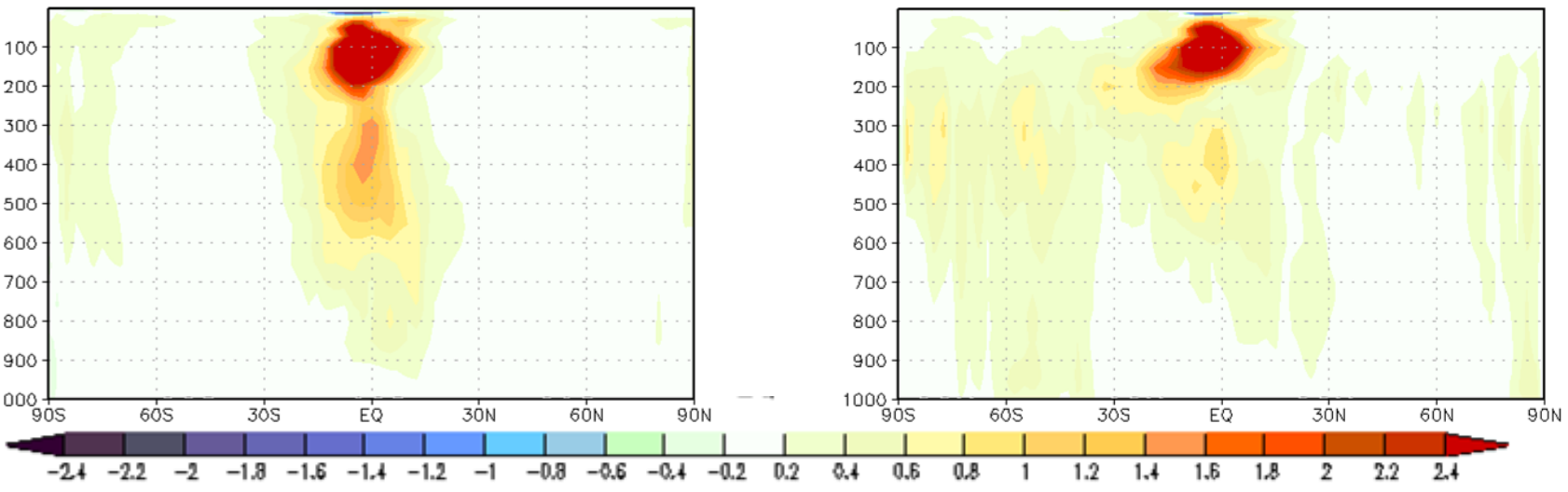
V (analysis)

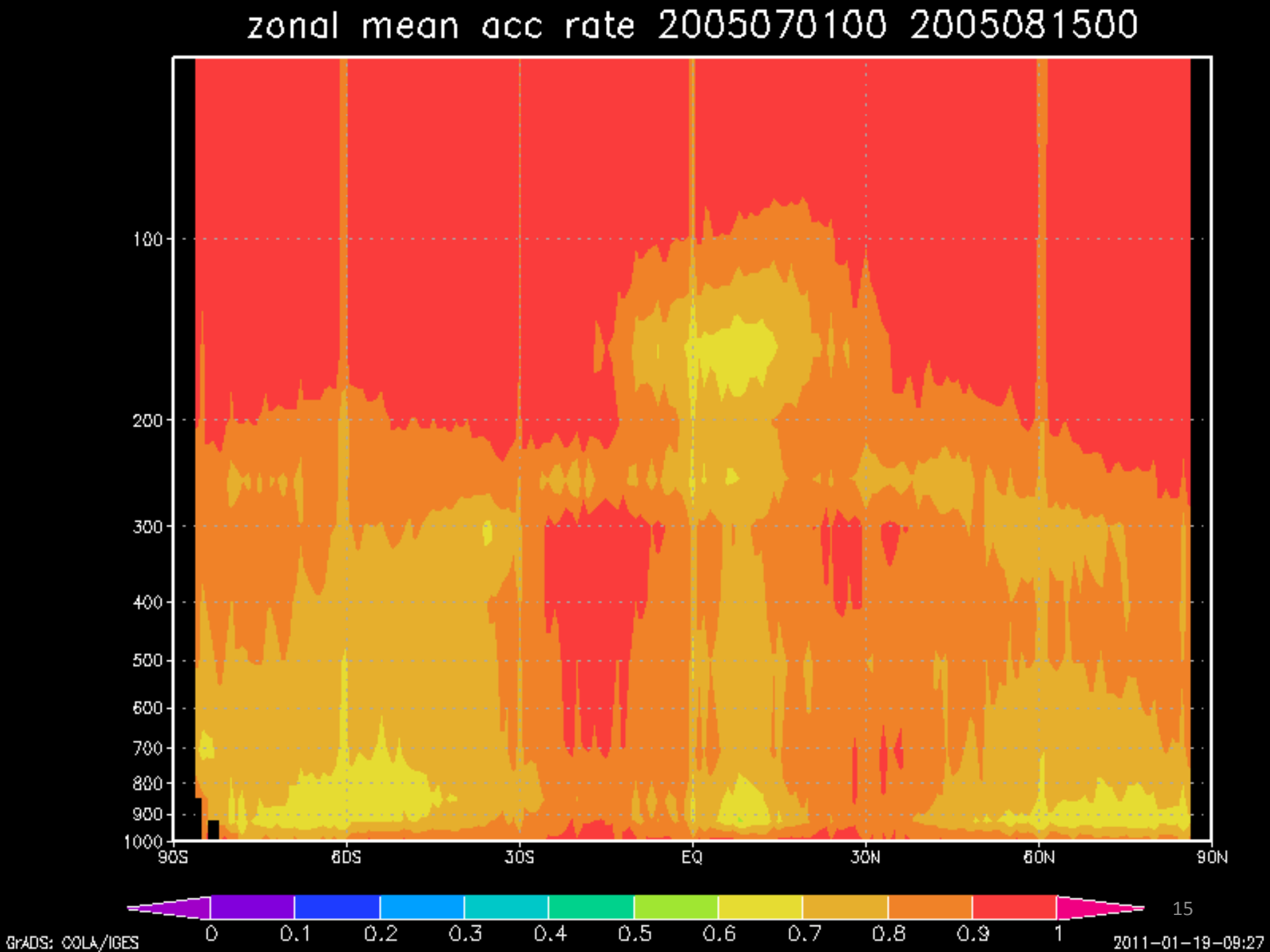
V (72 hour forecast)



U (analysis)

U (72 hour forecast)




zonal mean acc rate 2005070100 2005081500
100
200
300
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800
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1000
90S
60S
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30N
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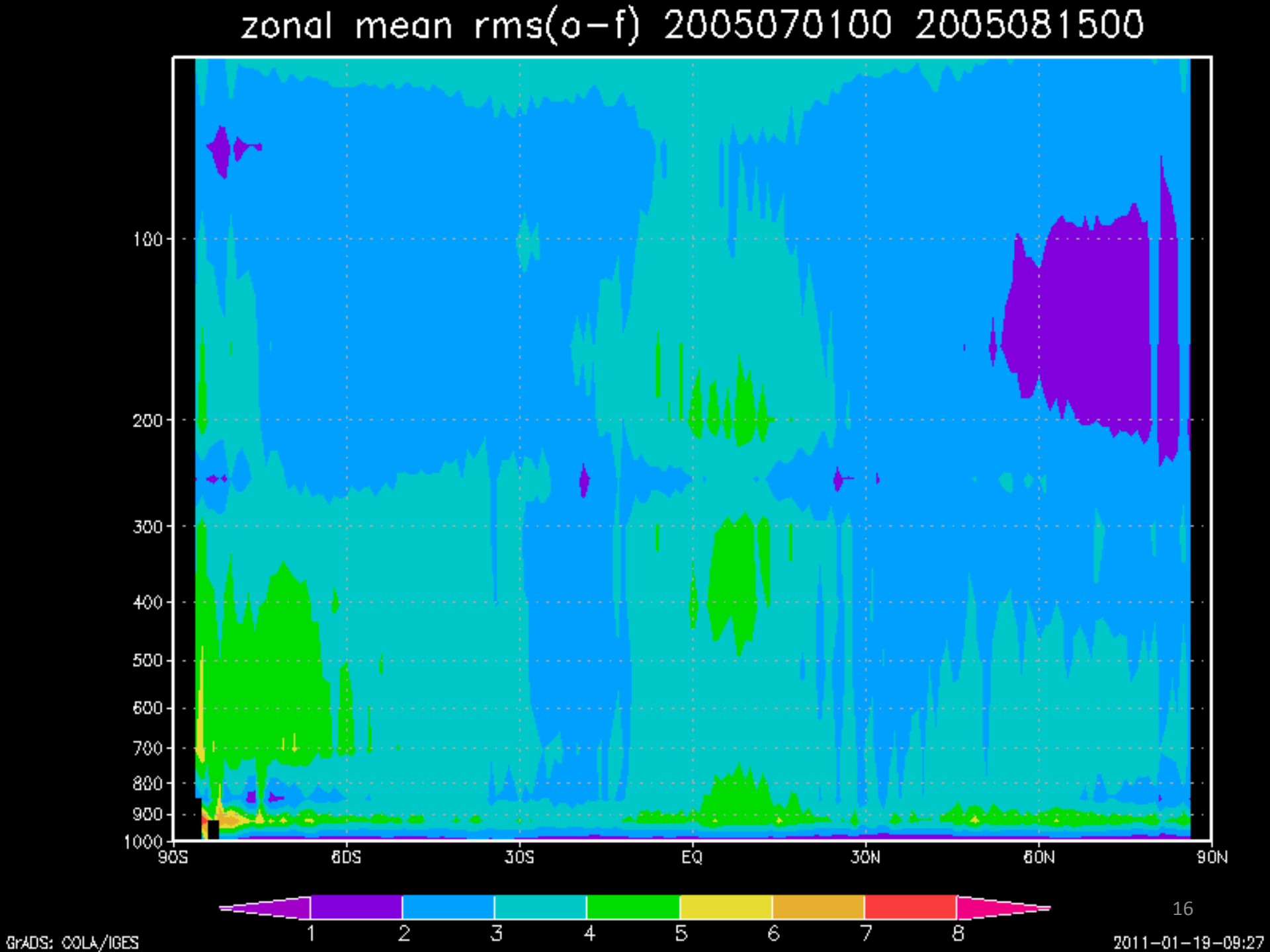
0.9
1
GrADS: COLA/IGES
2011-01-19-09:27


zonal mean rms(o-f) 2005070100 2005081500
100
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30N
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90N
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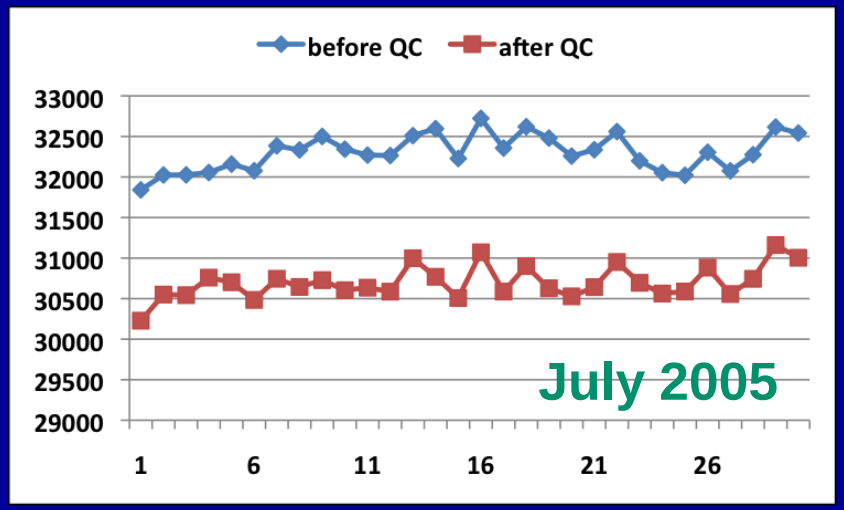
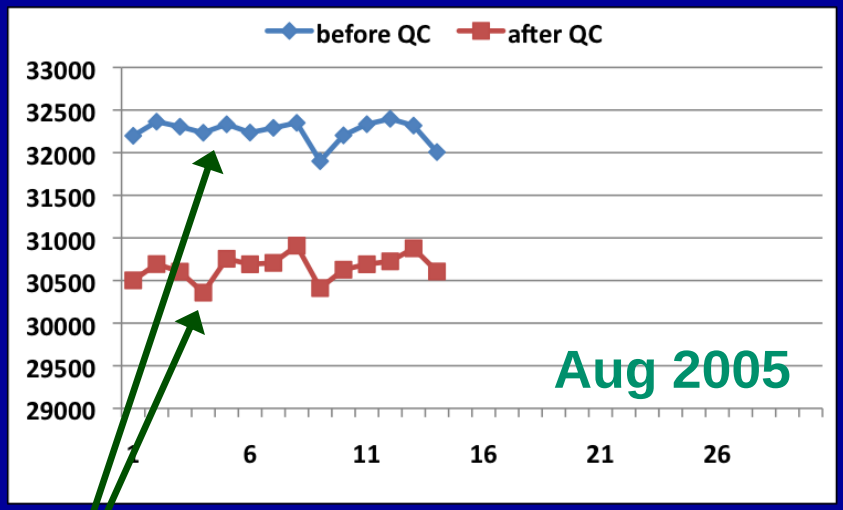
7
8
GrADS: COLA/IGES
2011-01-19-09:27

Number of lidar observations per analysis cycle (shown only for 00Z)





Total rejection rate around 6%

Summary and conclusions

- The lack of vertically resolved wind observations continue to be a major shortcoming of the Global Observing System
  - Space-borne wind lidar is the best option to meet this need
- A comprehensive OSSE system has been developed under the Joint OSSE collaboration
- Initial results simulating expected impact of GWOS observations on NCEP GFS system are very encouraging
  - Small positive impact in NH extratropics (summer)
  - Larger positive impact in SH extratropics (winter)
  - Very large positive impact in tropics; implications for hurricane forecasting

Outlook

- Extend simulation into hurricane season (several Atlantic hurricanes in Nature Run "Oct 2005")
- Experiment in opposite season (NH winter/SH summer)
- Increased horizontal resolution (T-382 and higher)
- Detailed case studies
- Separate assessments of the impacts of Direct Detection and Coherent Detection
- Impact of one, two or four telescopes on spacecraft
- Other orbits, e.g. different altitude, lower inclination
- Impact on applications other than NWP, e.g. chemical transport models

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