Observing System Simulation Experiments for a Space-borne Doppler Wind Lidar in the Joint Center for Satellite Data Assimilation

Lars Peter Riishojgaard[1,2], Zaizhong Ma[1,2], Michiko Masutani[3], Jack Woollen[3], Dave Emmitt[4], Sid Wood[4], Steve Greco[4]

[1]Joint Center for Satellite Data Assimilation
[2]University of Maryland Baltimore County
[3]NCEP Environmental Modeling Center
[4]Simpson Weather Associates

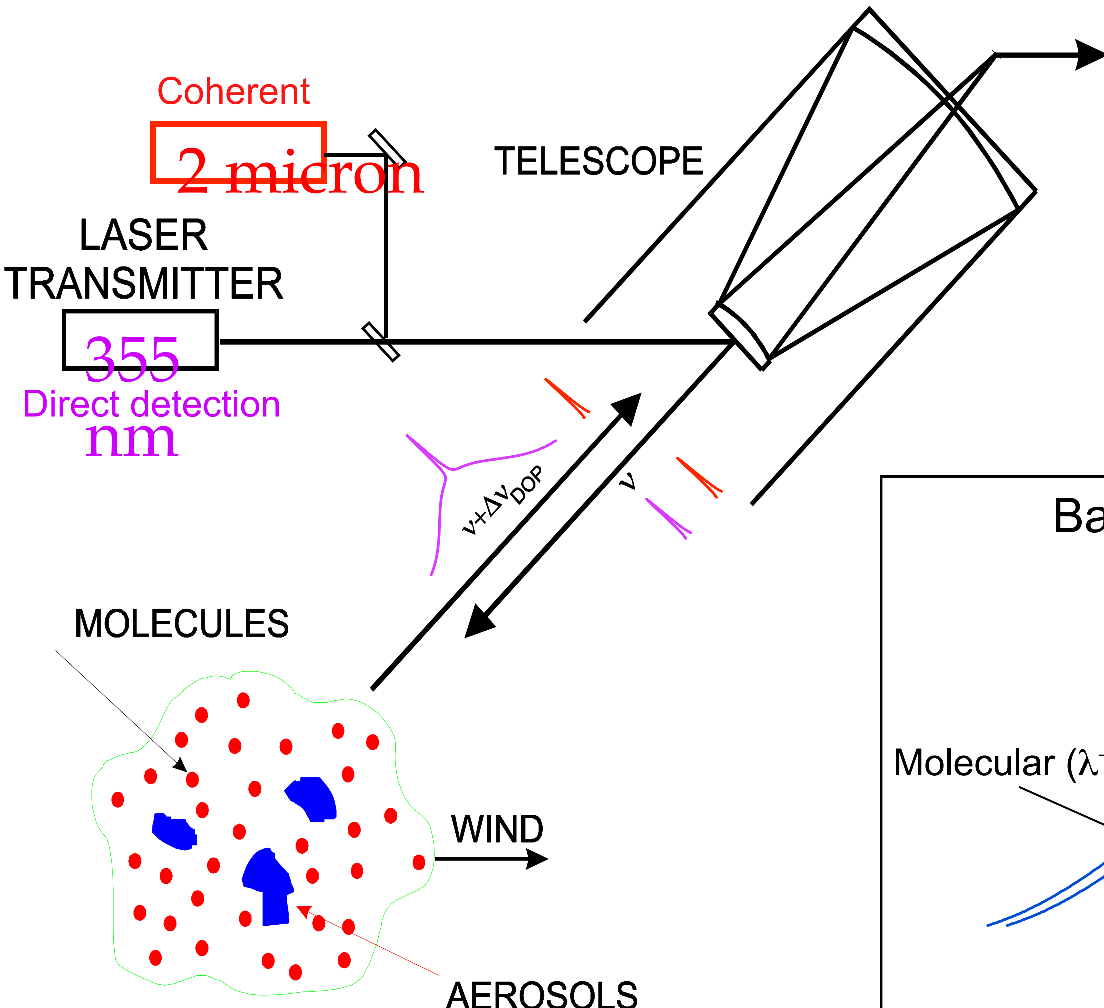
Joint OSSE history

- NASA/NOAA collaboration started in 2007, involving NASA/GSFC, NOAA/NESDIS, NOAA/NWS, NOAA/OAR
- Centered around common use of Nature Run provided free of charge by ECMWF
- Coordinated through JCSDA
  - Informal, loosely structured nature, lack of common funding stream has presented challenges
- Successful joint validation of ECMWF Nature Run
- Some collaboration on simulation and calibration of observations
- ADM experiments (GMAO)
- GWOS experiments (JCSDA)
- UAS experiments (OAR)

Wind Lidar OSSEs

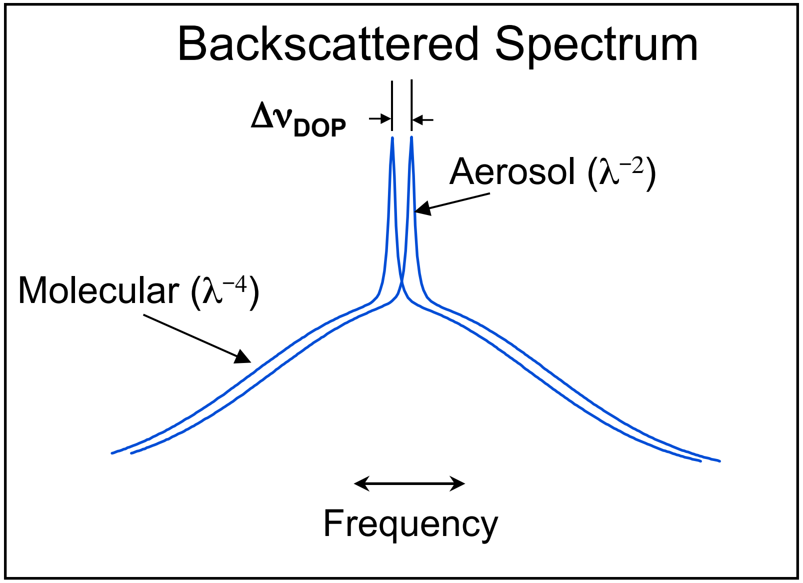
- Impact experiments for GWOS mission concept
  - NASA Tier-3 Decadal Survey mission concept
  - Four telescopes, full vector winds on either side of spacecraft
  - Two technologies, direct and coherent detection
- Experiments funded under Wind Lidar Science element of NASA's ROSES 2007
- GWOS observations simulated by Simpson Weather Associates using DLSM

Doppler Lidar Measurement Concept

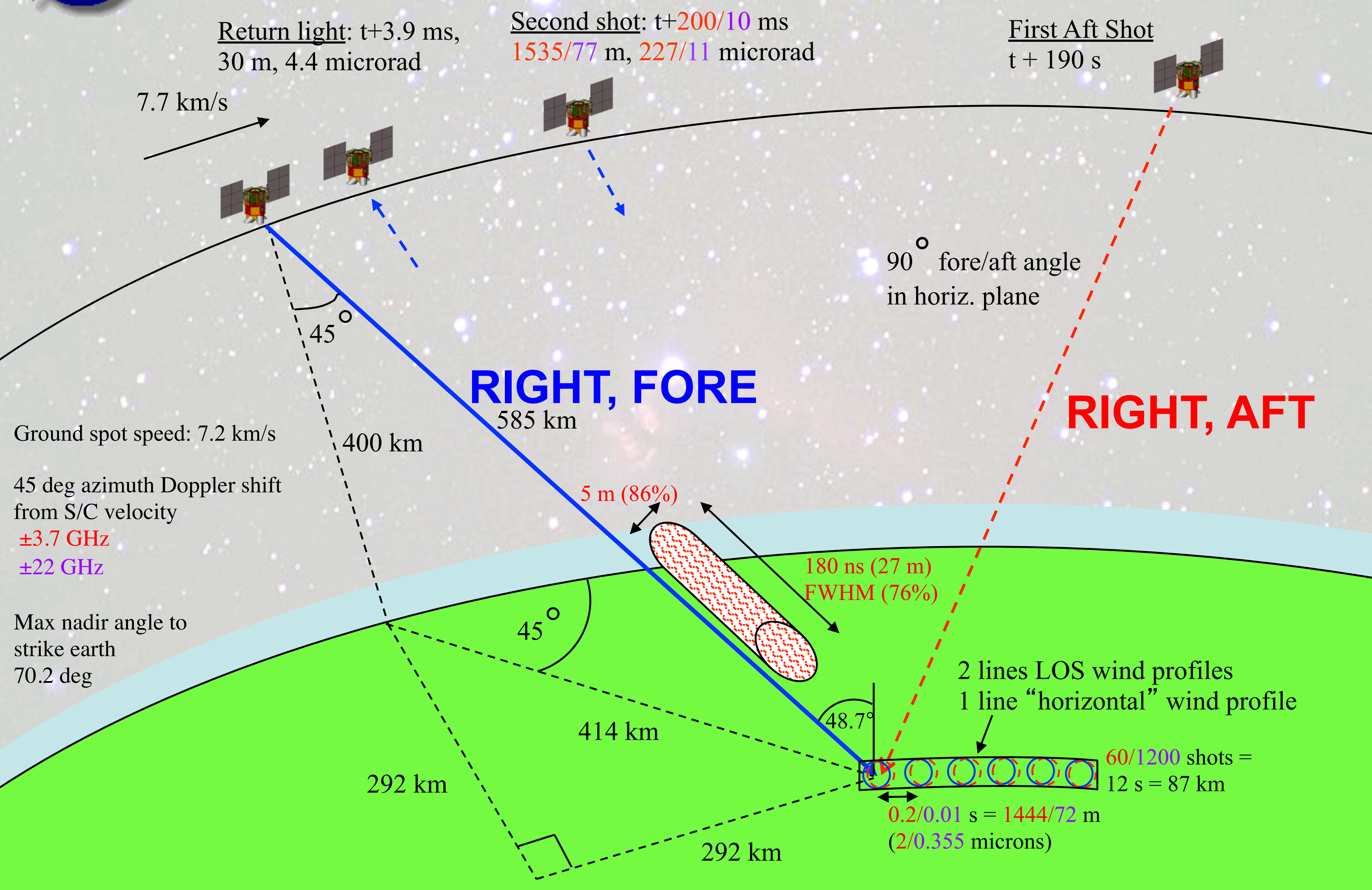


DOPPLER RECEIVER - Multiple flavors - Choice drives science/ technology trades

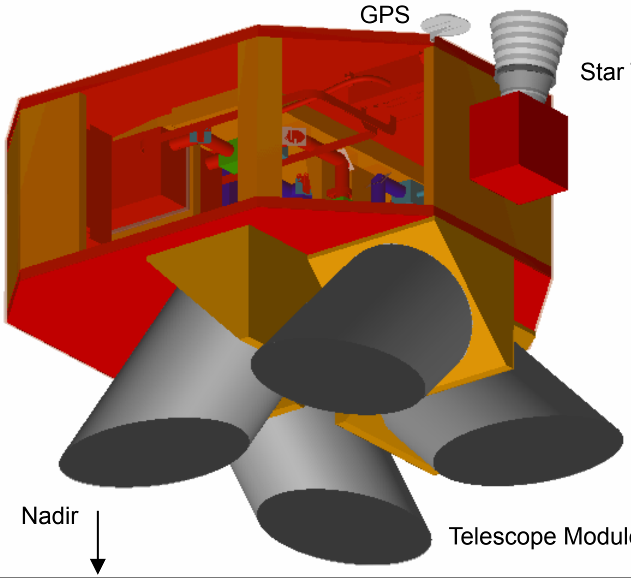
- Coherent or heterodyne aerosol Doppler receiver
- Direct detection molecular Doppler receiver



Hybrid Doppler Wind Lidar Measurement Geometry: 400 km



GWOS ISAL Instrument Quad Chart



Features of the Instrument Concept

- Utilizes Doppler lidar detection method
  - Coherent (aerosol) detection @ 2 μm
  - Direct (molecular) detection @ 355 nm
- Direct channel laser based on GLAS;
- Direct channel receiver based on TWiLiTE IIP
- Coherent channel laser and receiver based on DAWN IIP
- Telescopes are shared among all lasers
- Pointing and knowledge requirements met with co-located star tracker and GPS

Payload Data

Dimensions	1.5m x 2m x 1.8m
Mass	567 Kg
Power	1,500 W
Data Rate	4 Mbps

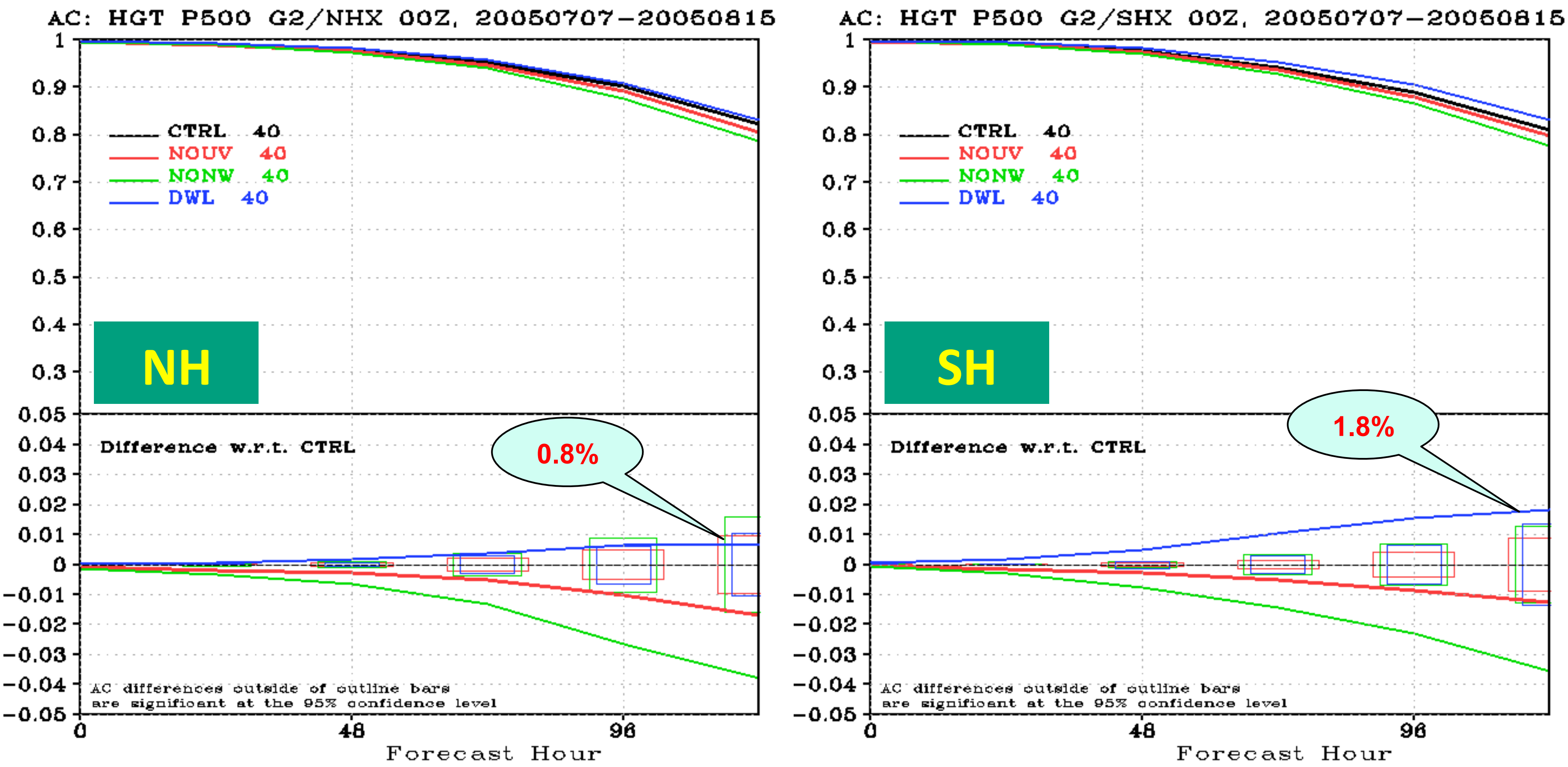
Technology Development Needs

- Direct detection system requires 6 billion shots for mission lifetime (2 years)
  - Direct channel baseline is 3 lasers + 1 backup
  - Demonstration of reliable performance at higher or lower lifetimes will determine number of lasers for direct detection channel, impacting mission cost
- Coherent detection system requires demonstration of the 316M shot lifetime in a fully conductively cooled laser
- Both Lidar technologies require aircraft validation flights

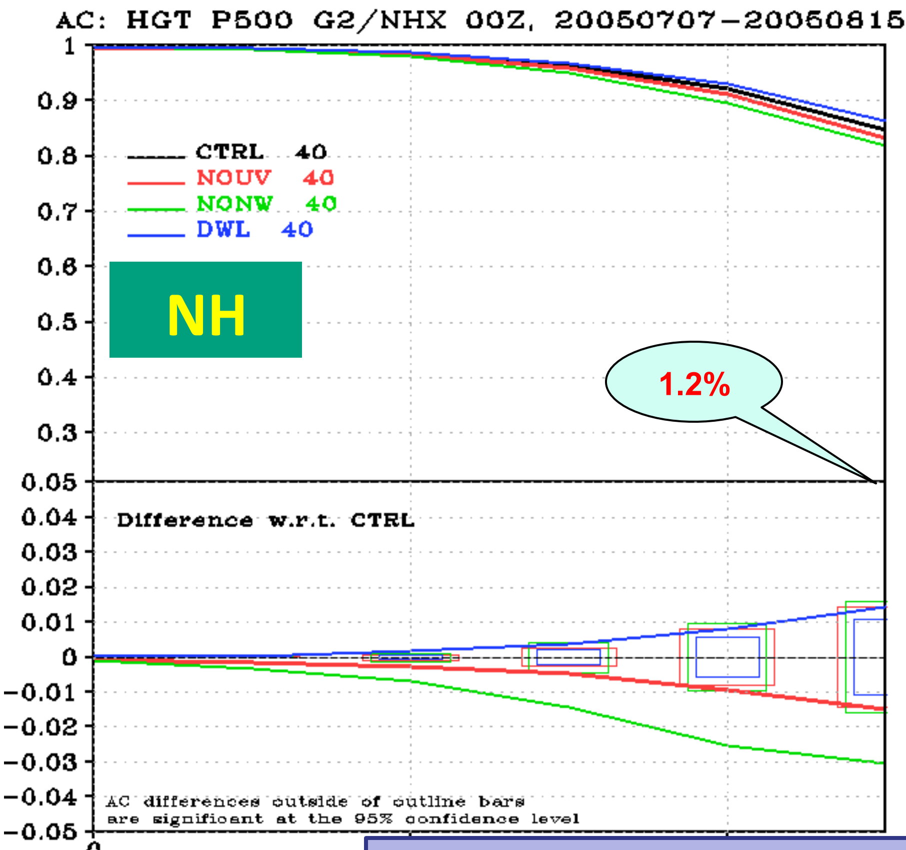
Experimental setup

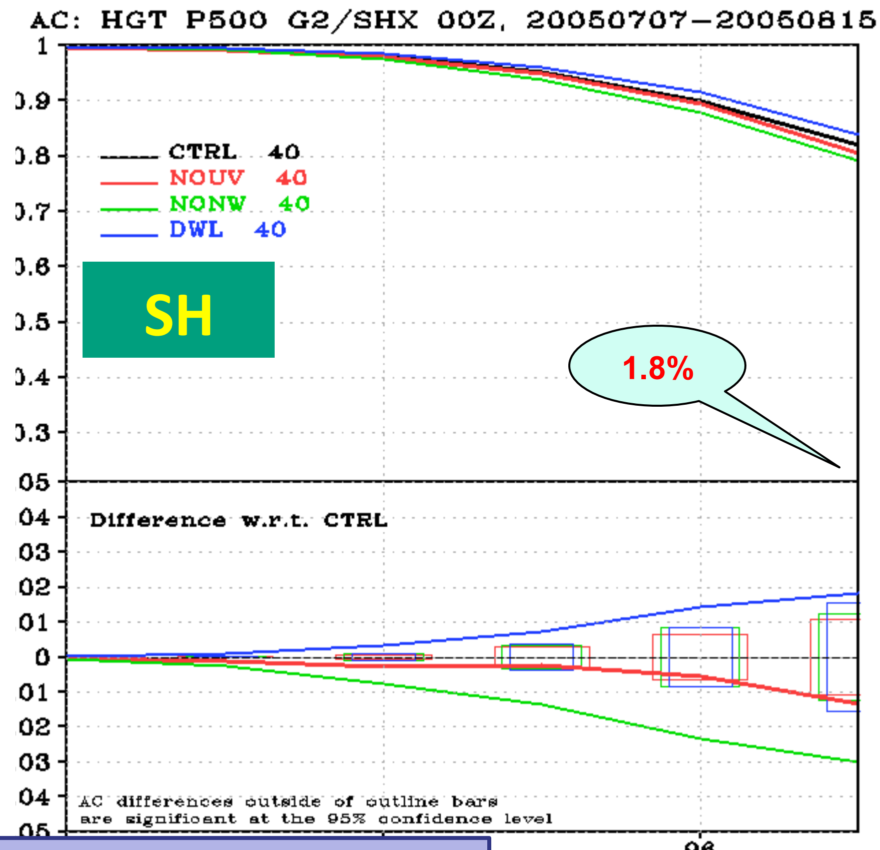
- NCEP GFS at horizontal resolutions T-126 and T-382
- "OSSE period": July 01-Aug 15, 2005 (simulated)
  - Five-day forecast launched every day at 00Z
  - Most observing systems used for routine operational NWP included, except GPSRO and IASI (will be corrected once we simulate 2010/11 GOS)
- Four experiments, all verified against Nature Run
  - CRTL: Observations as assimilated operationally by NCEP
  - NOUV: as CTRL, but without RAOBS (220, 221 and 232)
  - NONW: as CTRL, but without any wind observations
  - DWL : as CTRL, plus simulated GWOS lidar wind data

500hPa HGT anomaly correlation coefficients (T126)



500hPa HGT anomaly correlation coefficients (T382)



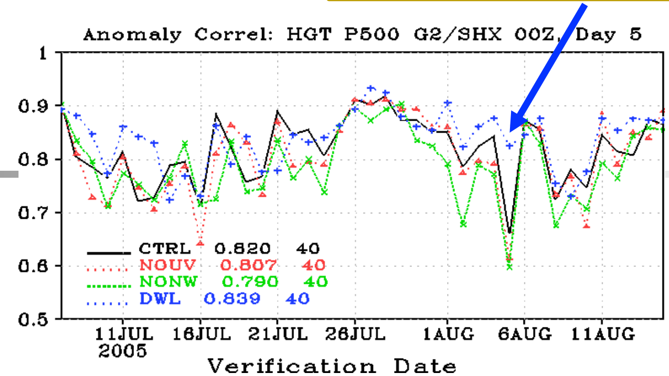


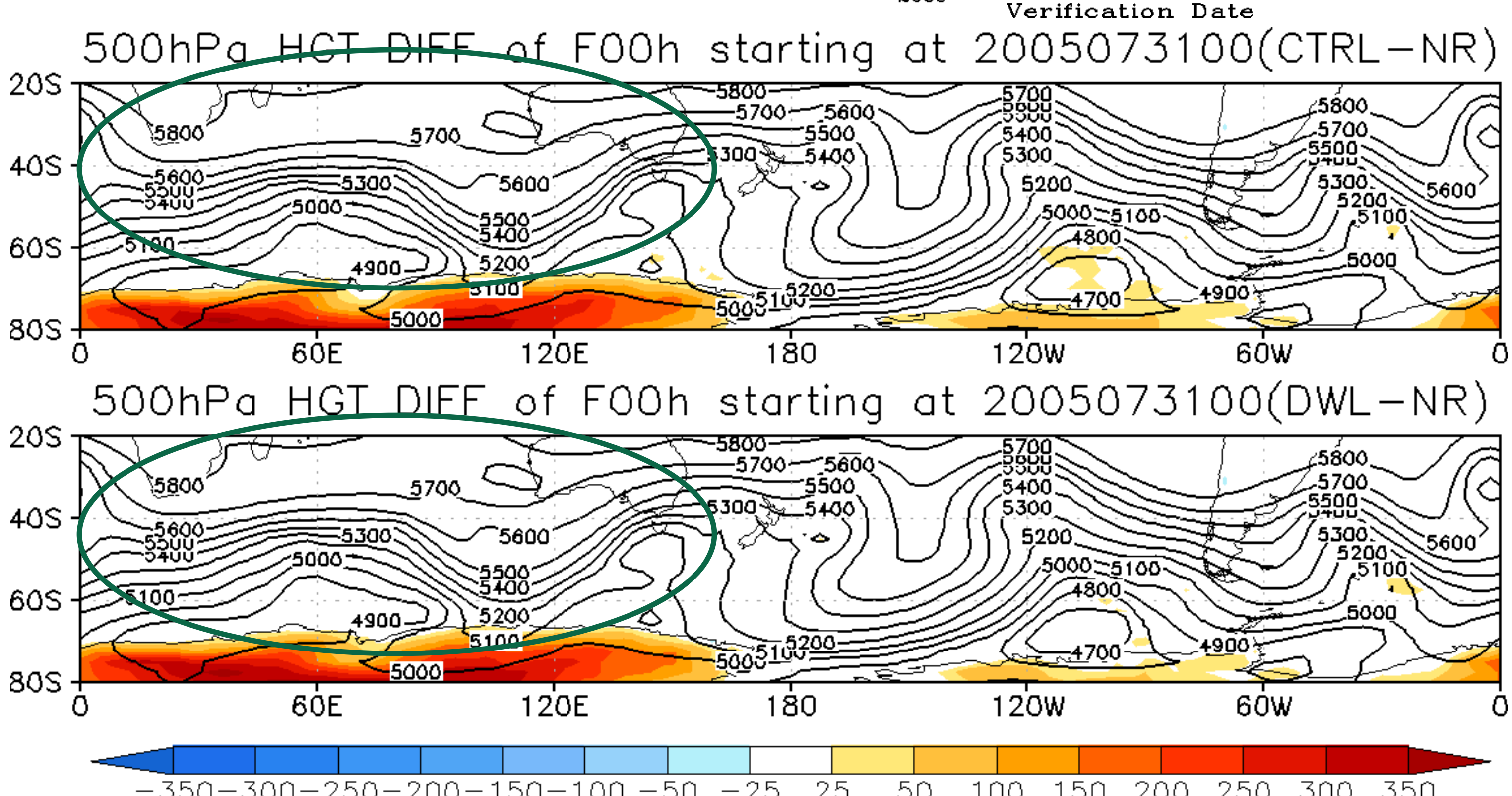
Impact of DWL observations is larger at the higher resolution (T382), even though skill of control is higher

Special Case Study (T-382)

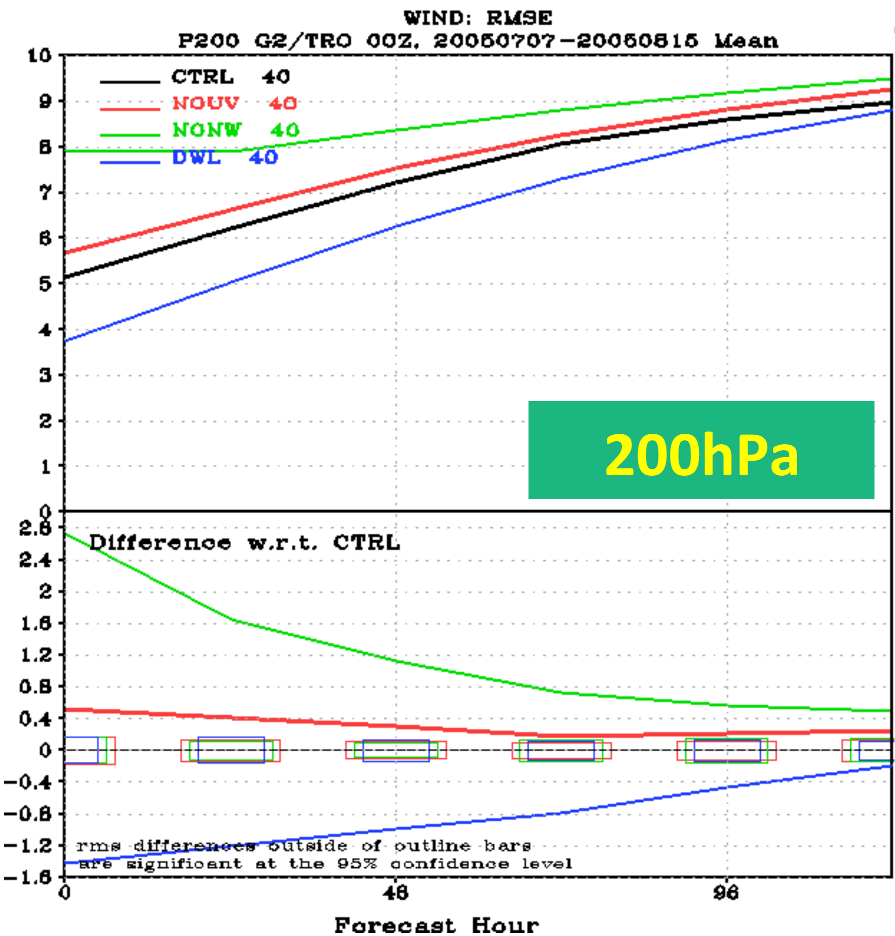
Date: Aug 5th , 2005
SH: (20°~80°S)

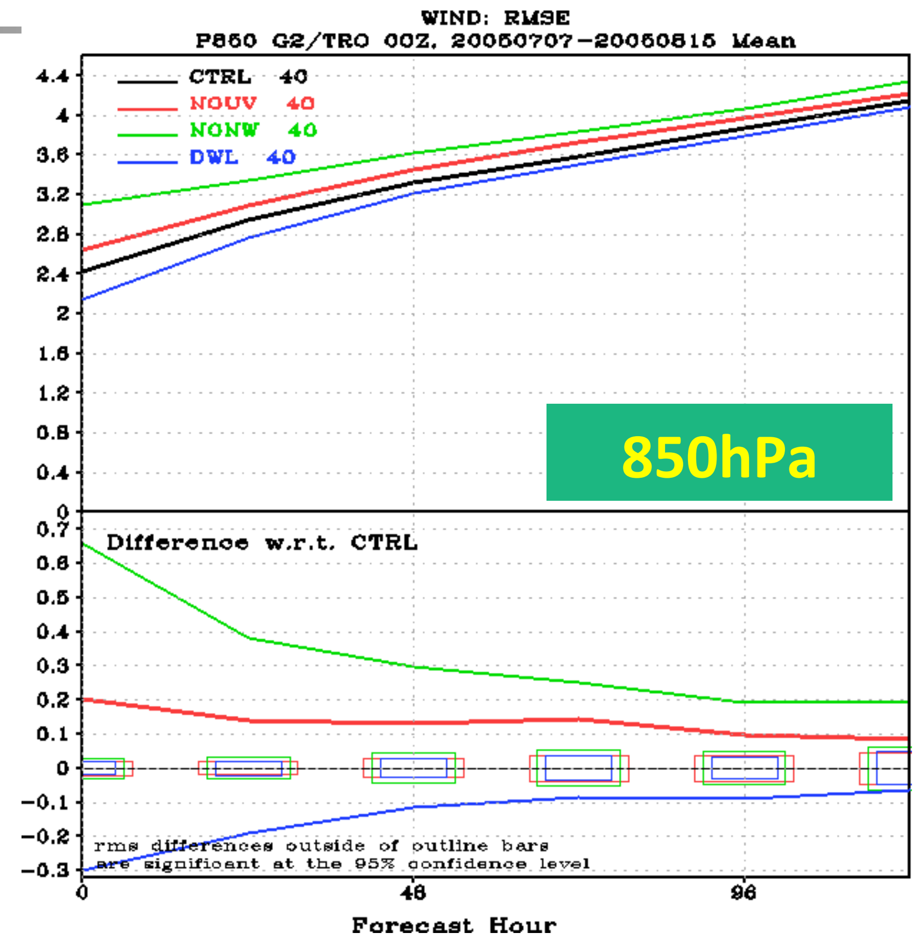
Candidates for additional study





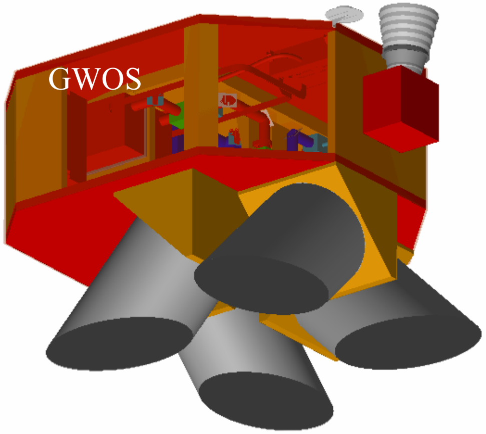
RMSE: 200, 850hPa Wind error in tropics (T382)





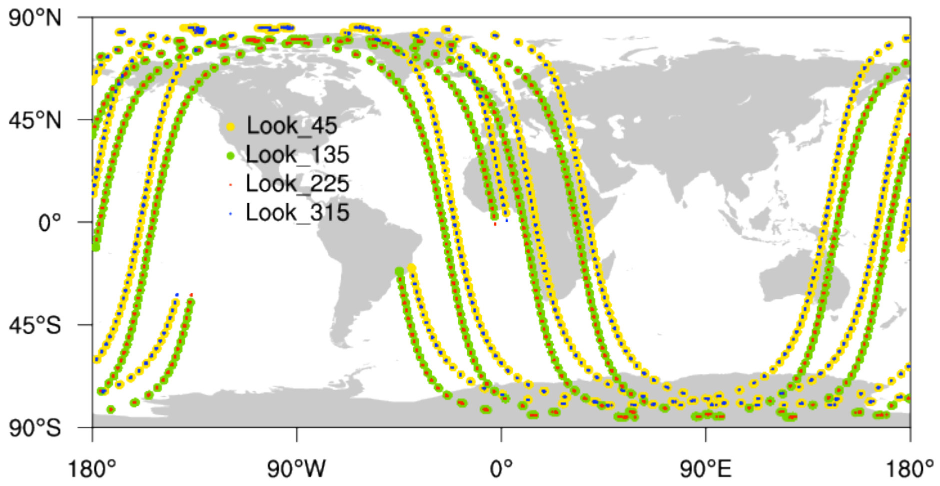
Single LOS or Vector Winds?

- Important configuration issue for GWOS (impact vs. cost)
- Experiments performed with variable number of perspectives:
  - One; single line of sight, similar to ADM/Aeolus
  - Two; full horizontal wind vectors, left or right side of satellite track
  - Four; full GWOS coverage; wind vectors on both sides of satellite track



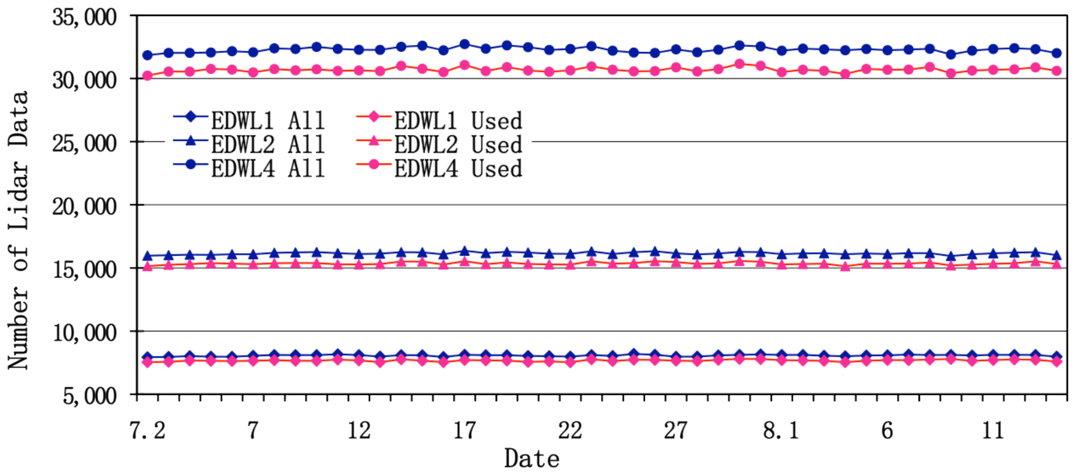
Impact of Different Wind Lidar Configurations on NCEP Forecast Skill.

GWOS Lidar Wind obs

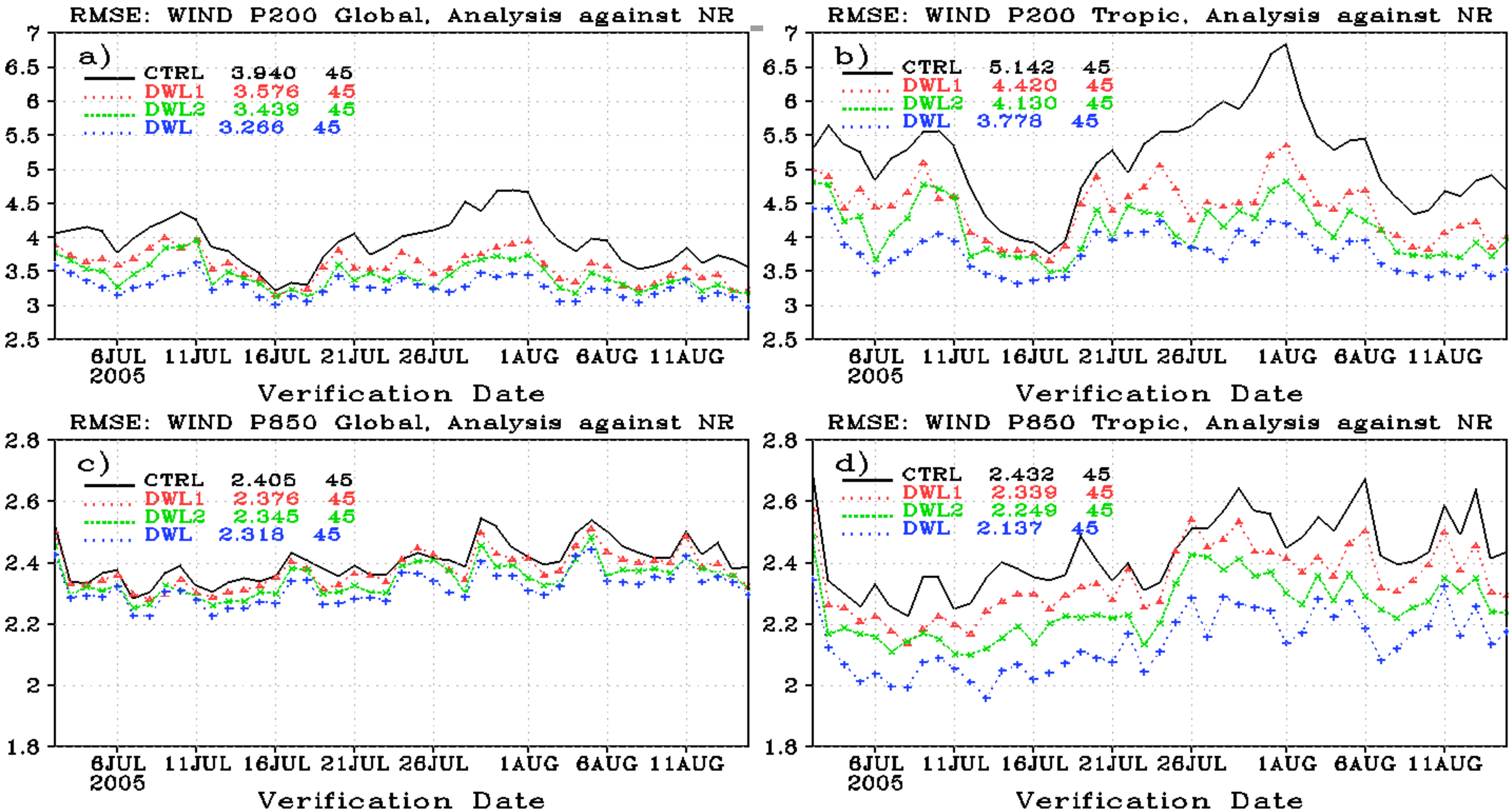


Distribution of Lidar observations for one analysis cycle (July 7 2005, 00Z)

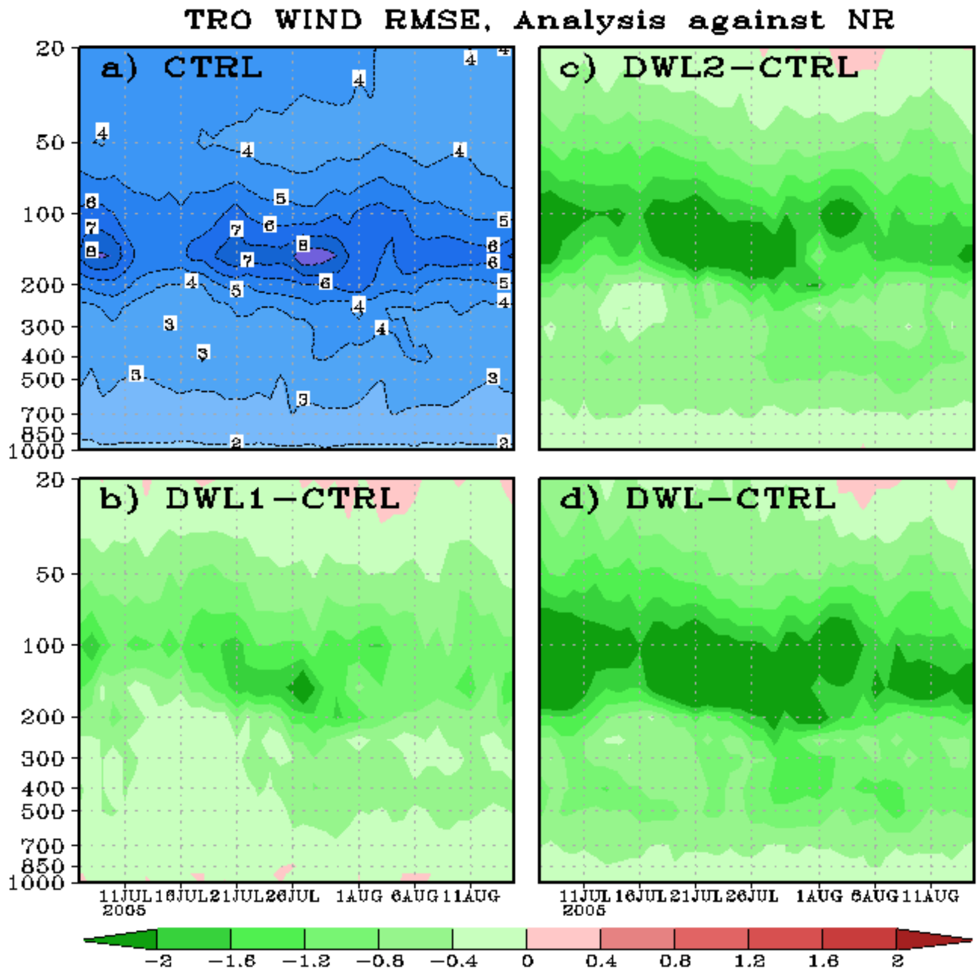
Number of Lidar obs per analysis cycle, before and after QC (shown only for 00Z)



Analysis Impact: Wind

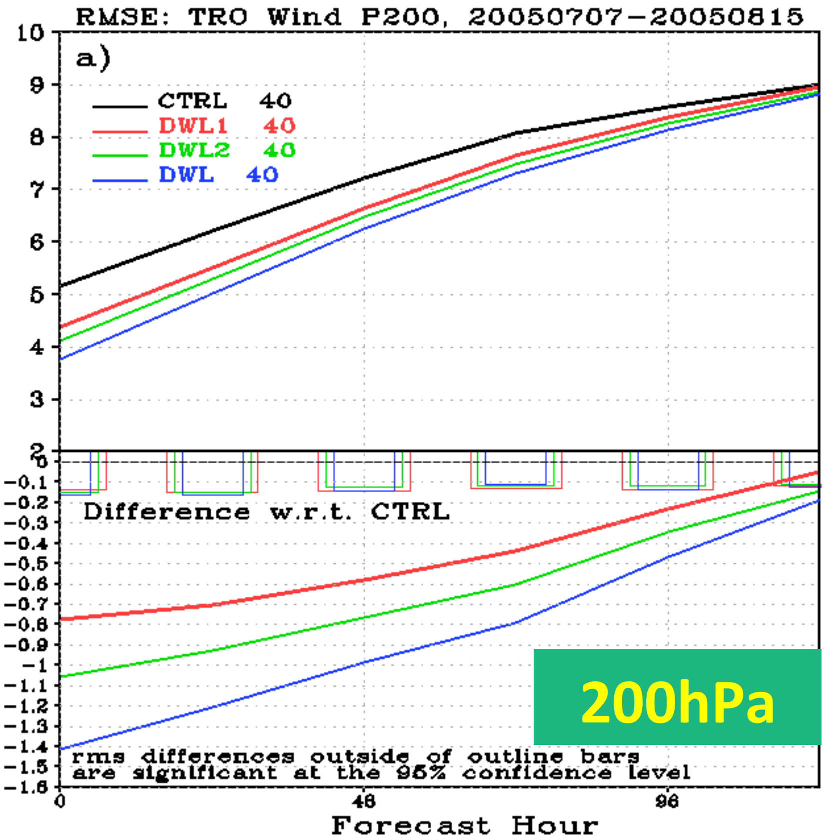


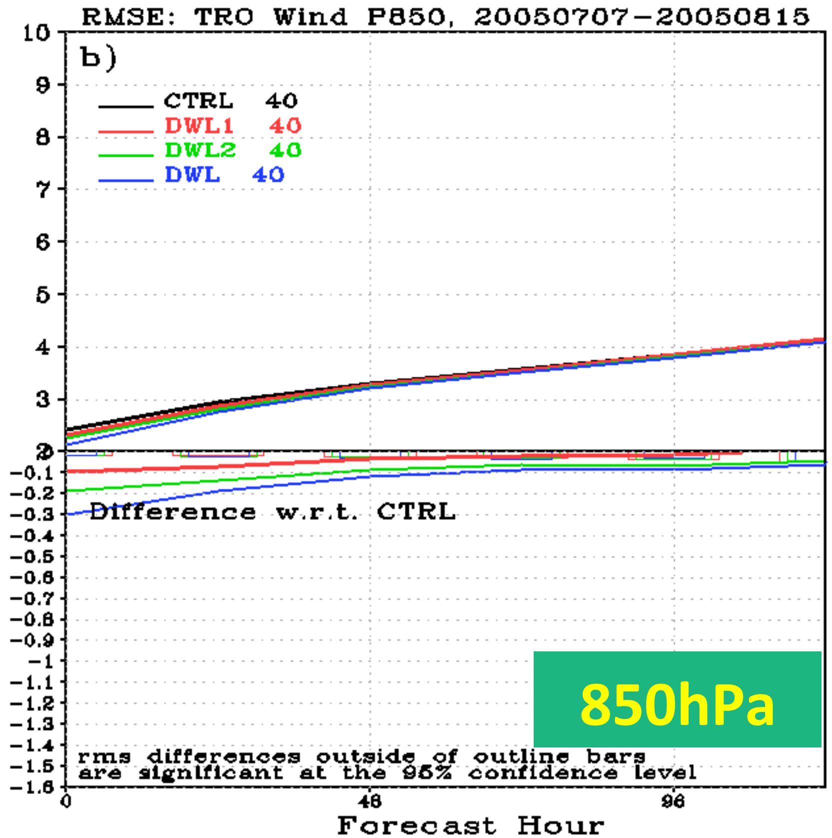
Analysis Impact:
Tropical winds



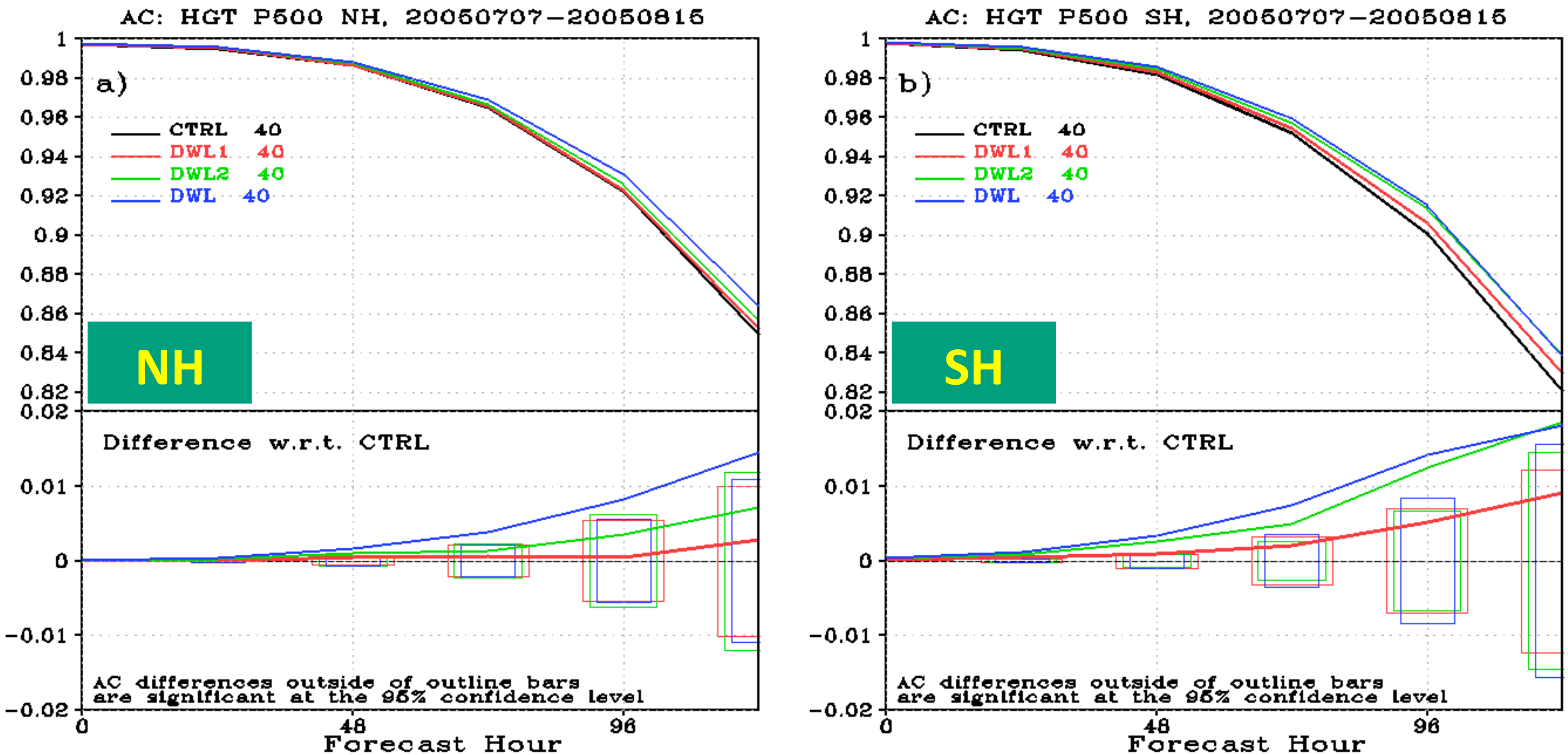
Forecast: Tropical Wind

(RMS error at 200, 850hPa)





Forecast skill: 500 hPa height AC



Summary and conclusions

- 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
  - Two perspectives, more coverage lead to larger impact

Outlook

- Experiment in opposite season (NH winter/SH summer)
- Increased horizontal resolution (T-574 and higher; requires new Nature Run)
- Detailed case studies
- Separate assessments of the impacts of Direct Detection and Coherent Detection
- Other orbits, e.g. different altitude, lower inclination
- Impact on applications other than NWP, e.g. chemical transport models

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