Simulation of observation for Joint OSSE based on 2012 systems

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http://www.emc.ncep.noaa.gov/research/JointOSSEs/

Acknowledgement

The nature runs for Joint OSSEs were produced by Dr. Erik Andersson of ECMWF.

Full OSSEs

There are many types of simulation experiments. Sometimes, we have to call our OSSE a 'Full OSSE' to avoid confusion.

- A Nature Run (NR, proxy true atmosphere) is produced from a free forecast run using the highest resolution operational model which is significantly different from the NWP model used in Data Assimilation Systems.
- Calibrations is performed to provide quantitative data impact assessment.
- . Without calibration quantitative evaluation of data impact is not possible.

Advantages

- Data impact on analysis and forecast will be evaluated.
- A Full OSSE can provide detailed quantitative evaluations of the configuration of observing systems.
- A Full OSSE can use an existing operational system and help the development of an operational system

OSSE Calibration

Calibration of OSSEs verifies the simulated data impact by comparing it to real data impact. In order to conduct an OSSE calibration, the data impact of existing instruments has to be compared to their impact in the OSSE.

Existing Data assimilation system and verification method are used for Full OSSEs. This will help development of DAS and verification tools.

International Joint OSSE capability

- Full OSSEs are expensive
  - Sharing one Nature Run and simulated observation saves costs
  - Sharing diverse resources
- OSSE-based decisions have international stakeholders
  - Decisions on major space systems have important scientific, technical, financial and political ramifications
  - Community ownership and oversight of OSSE capability is important for maintaining credibility
- Independent but related data assimilation systems allow us to test the robustness of answers

Joint OSSE Nature Run by ECMWF

Based on discussion with JCSDA, NCEP, GMAO, GLA, SIVO, SWA, NESDIS, ESRL, and ECMWF

ECMWF Nature run used at NOAA
Spectral resolution : T511
13 month long. Starting May 1st,2005
Vertical levels: L91, 3 hourly dump
Daily SST and ICE: provided by NCEP
Model: Version cy31r1

Supplemental in 1degx1deg

Pressure level data: 31 levels,
Potential temperature level data: 315,330,350,370,530K
Selected surface data for T511 NR:

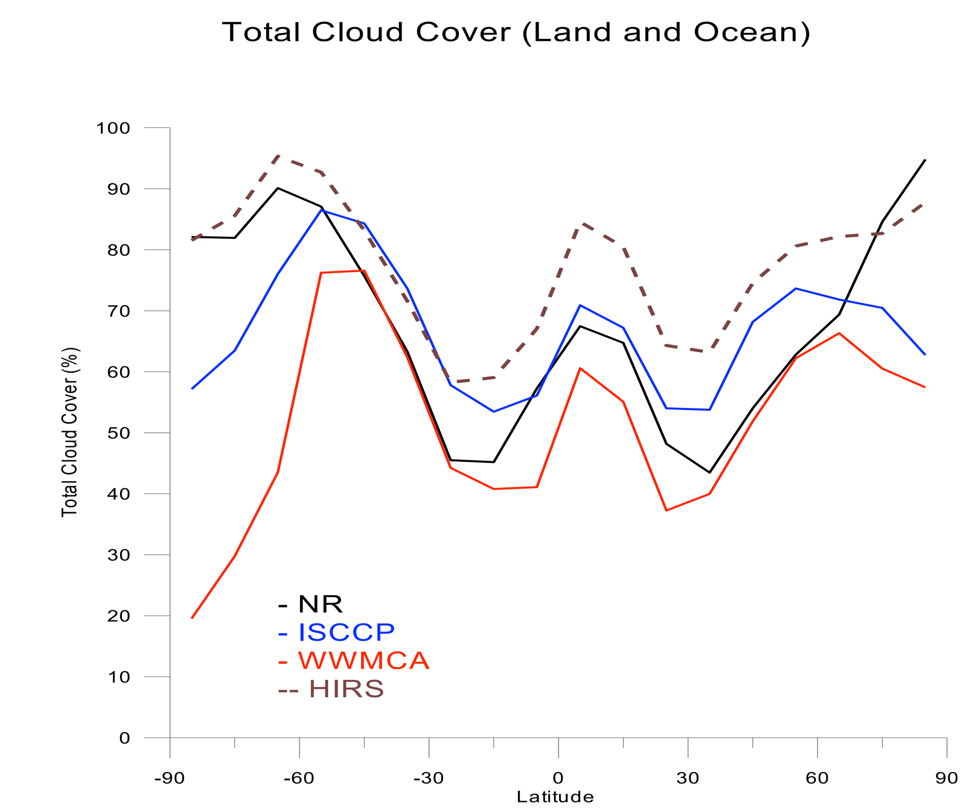
Andersson, Erik and Michiko Masutani 2010: Collaboration on Observing System Simulation Experiments (Joint OSSE), ECMWF News Letter No. 123, Spring 2010, 14-16.

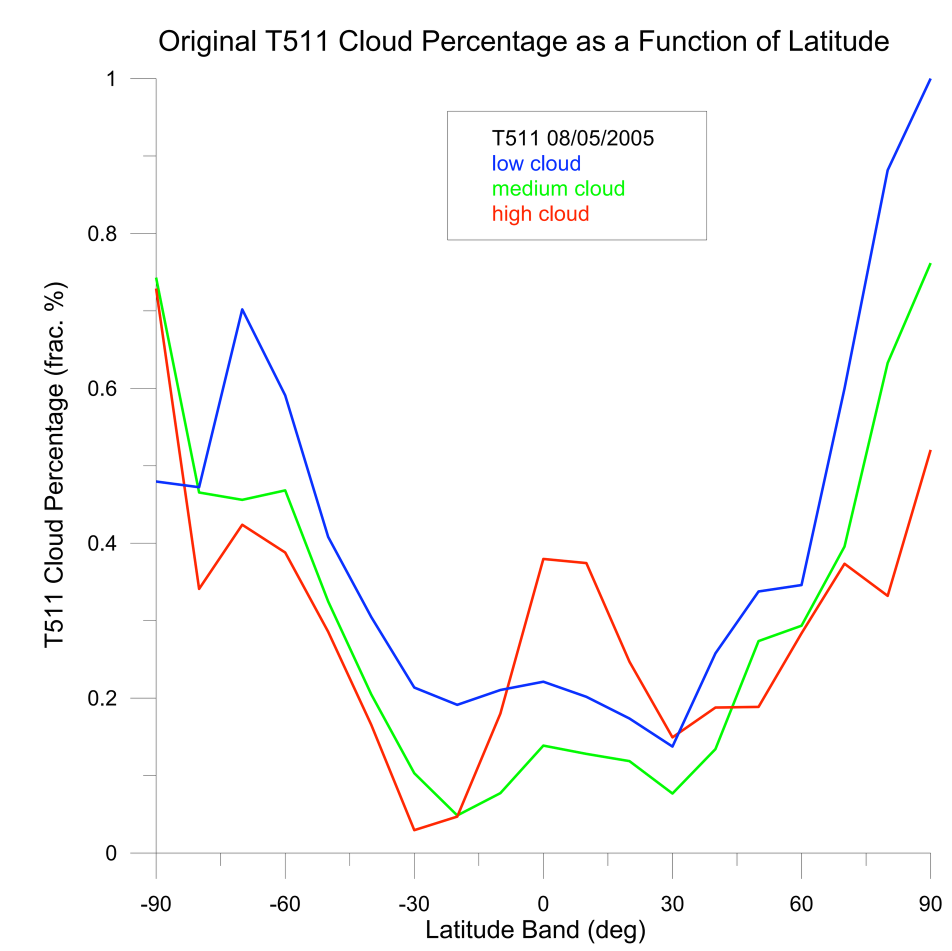
Evaluation of Nature Run cloud
Steve Greco (SWA)

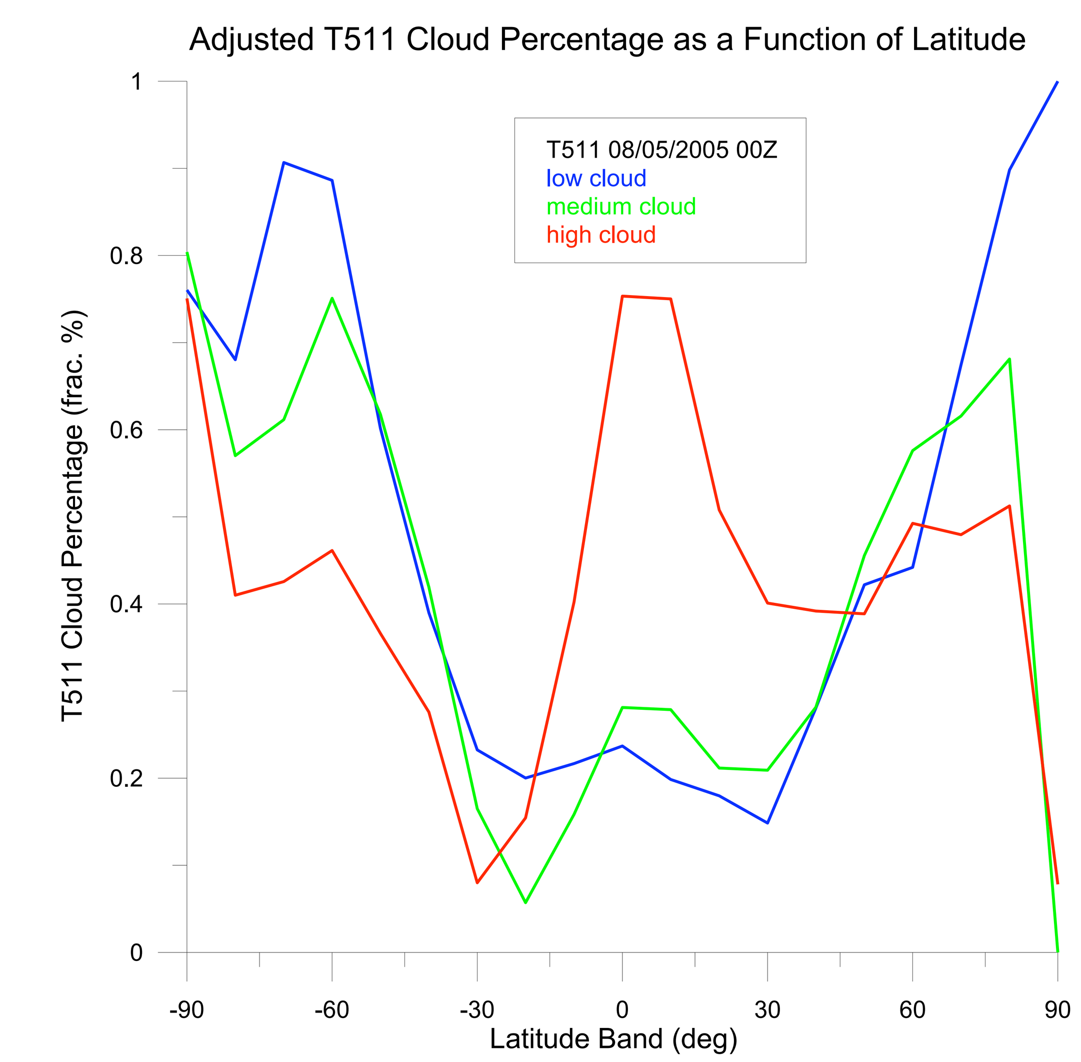
GLOBAL CLOUD COVER PERCENTAGE (Land and Sea)

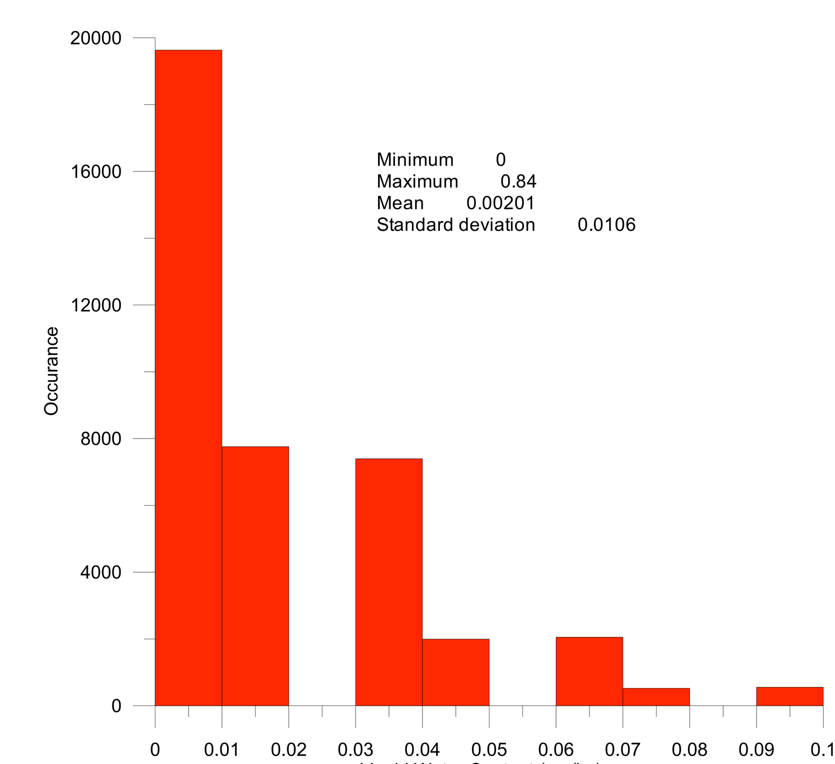
	T511 NR* (1 X 1)	ISCCP**	WWMCA*	HIRS**	GLAS[1]	CALIPSO[2]
Total CC	68.3/59.8	65.9	49.6	76.9	72.0 (80.0)	77.0
Low CC	44.0/34.3	27.4	32.2	30.6	33.5	32.5
Mid CC	28.0/22.9	17.8	21.9	28.2	21.0	13.0
High CC	32.9/30.6	21.1	14.2	32.8	21.0	24.5

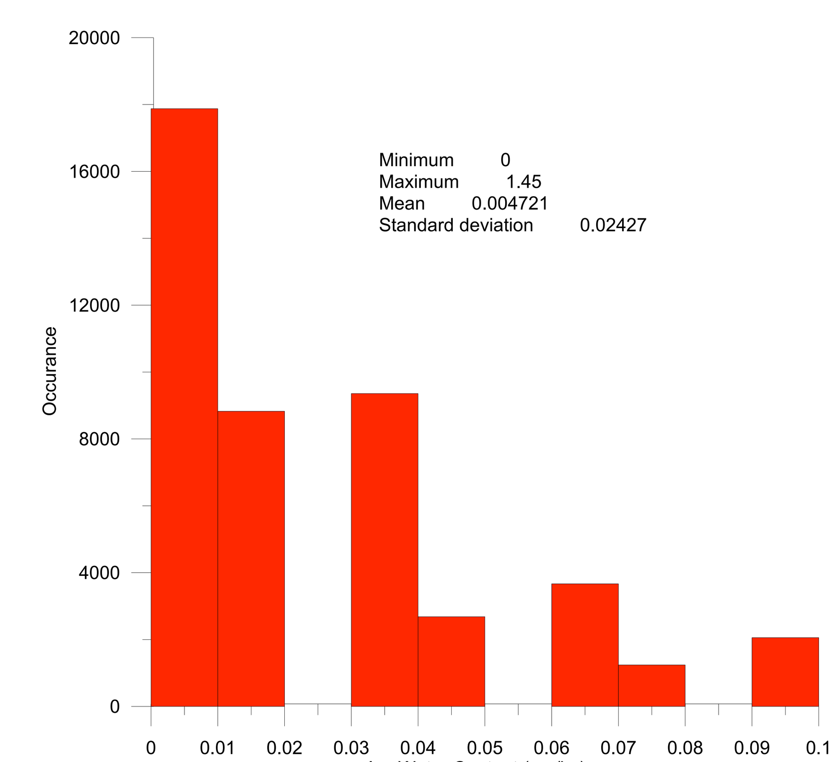
* - August 2005
** - Long term mean for August
GLAS[1] - Nov 2003 (from Seze et al., 2007); 2nd Study by Emmitt and Greco (2006)
CALIPSO[2] - August 2006 (from Seze et al., 2007)











Note: This data must not be used for commercial purposes and re-distribution rights are not given. User lists are maintained by Michiko Masutani and ECMWF

Simulated observation for Control experiments posted from NASA/NCCS portal and NCAR - Entire Nature run Period -

Michiko Masutani and Jack Woollen (NOAA/NCEP/EMC)

NASA/NCCS
http://portal.nccs.nasa.gov/osse/index.pl
ID and Password required

http://portal.nccs.nasa.gov/josse/index.pl

Ellen Salmon Ellen.M.Salmon@NASA.gov
Bill McHale wmchale@nccs.nasa.gov

NCAR
Currently saved in HPSS
Data ID: ds621.0
http://dss.ucar.edu/datasets/ds621.0/matrix.html
Contact:
Chi-Fan Shih chifan@ucar.edu
Steven Worley worley@ucar.edu

Simulated radiance data,

with and without MASK in BUFR format for entire Nature run period

Type of radiance data and location used for reanalysis from May 2005-May2006

Simulated using CRTM1.2.2
No observational error added

Conventional data
Entire Nature run Period
Restricted data removed
Cloud track wind is based on real observation location
No observational error added

Upgrade in Simulated observation for Control experiments at JCSDA

Only Clear Sky radiance are posted
(Cloudy radiance are also simulated. Radiance with mask based on GSI usage is also simulated. But these data are not posted.)
Saved in BUFR format
No observational error added

Set A
Entire Nature run period
Type of radiance data and location used for reanalysis from May 2005-May2006
Simulated using CRTM1.2.2 (OPTRAN)

Set B
Type of radiance data location used in 2012
July, August, January and February (July and August completed)
CRTM 2.0.5 (RTTOV) are used.

Set A
AIRS (Aqua),
AMSU-A (Aqua, NOAA-15, 16, 18),
AMSU-B (NOAA-15, 16, 17),
HIRS2 (NOAA 14),
HIRS-3 (NOAA 15, 16, 17),
HIRS-4 (NOAA-18),
MSU (NOAA-14),
MHS (NOAA-18)
GOES sounder (GOES-10, 12)

All conventional data available in 2005-2006

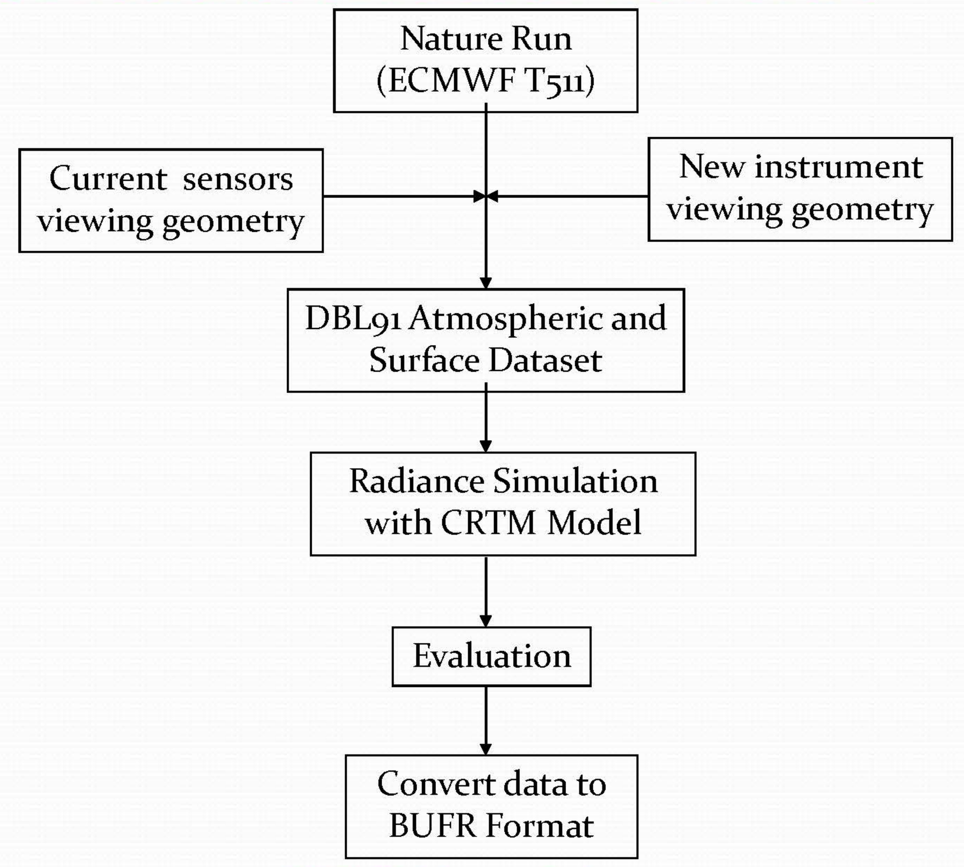
Set B
IASI(METOP-A), AIRS(AQUA), ATMS(NPP), CrIS(NPP)
HIRS-2(NOAA14),
HIRS-3(NOAA 15, 16,17),
HIRS-4(NOAA 18, 19, METOP-A), AMSUA(NOAA 15, 16, 17,18,19, AQUA, METOP-A),
AMSUB(NOAA 15, 16, 17),
MSU(NOAA 14), HSB(AQUA), MHS(METOP-A,NOAA18,19), SSMIS(DMSP F16), SEVIRI(MSG)
GOES sounder (10,12, and 13)

GPSRO,
Addition to Set A ASCAT and WINDSAT are included in conventional data.

Evaluation of simulated radiance of the Nature Run simulated with 2012 template

Tong Zhu, Fuzhong Weng (NESDIS) et al.

OSSE Radiance Simulation Flow Chart



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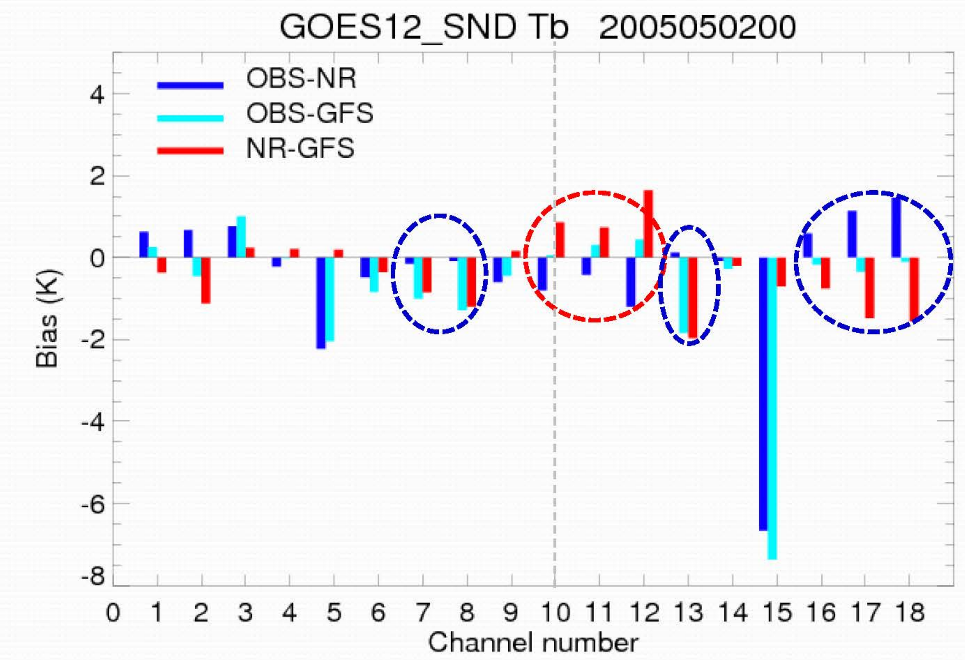
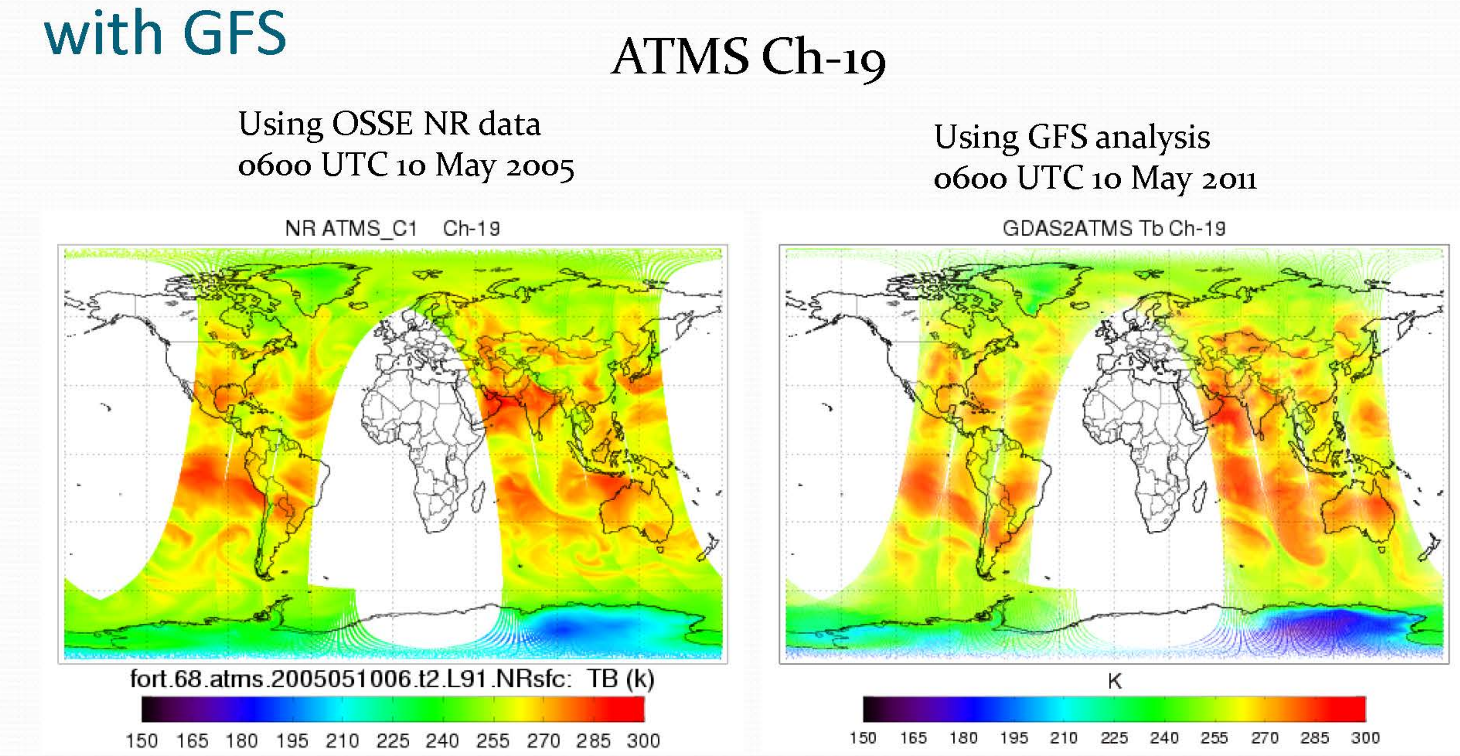
Comparison of GOES-12 Sounder Simulation Biases

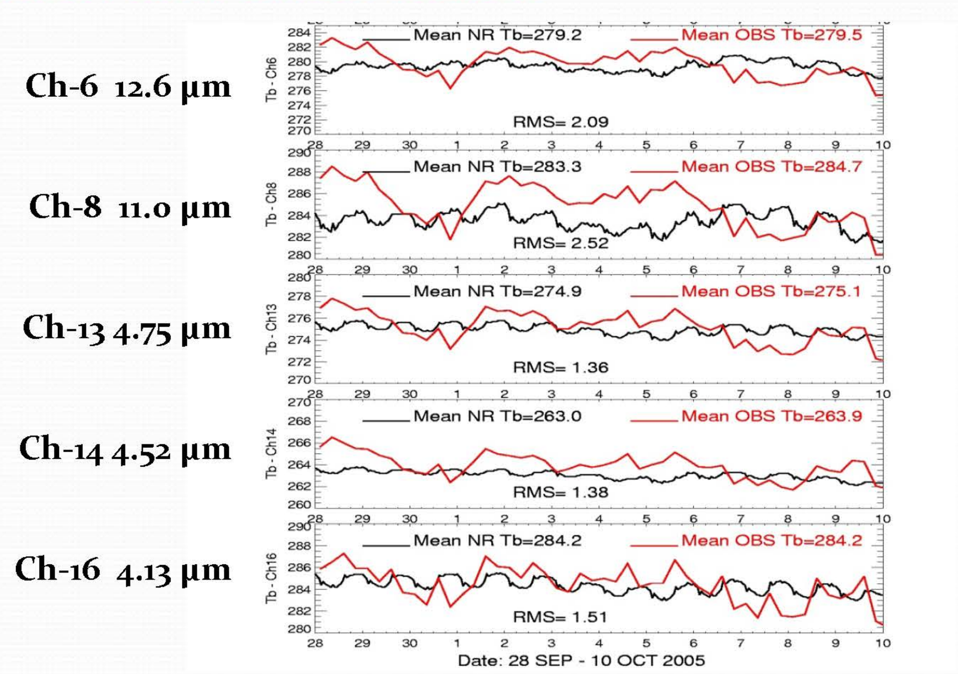


- Biases of OBS-NR and OBS-GFS have similar sign and magnitude at most channels, except following bands.
- O-B large differences can be found at Ch10-12, atmospheric moisture bands. NR field is more moist than GFS field.
- Compared with GFS Tb, there is about 1 K – 2 K cold bias of NR simulated Tb at Ch7-8, ch13, Ch16-18, which are PBL and surface temperature bands. At short wave window bands, NR Tb is close to OBS, while GFS Tb is close to OBS at longwave window.

Simulation of ATMS with OSSE NR vs. simulation with GFS



Time series of GOES12 Sounders radiance simulation and observation



- Averaged over the North Atlantic Ocean scan sector, for the time period over 09/28 - 10/10, 2005.
- Surface temperature sensitive channels (Ch8, 13, 16) show strong diurnal cycle variation.
- RMS errors are small for atmospheric sounding channels, and larger than 2 K for surface and moisture channels.

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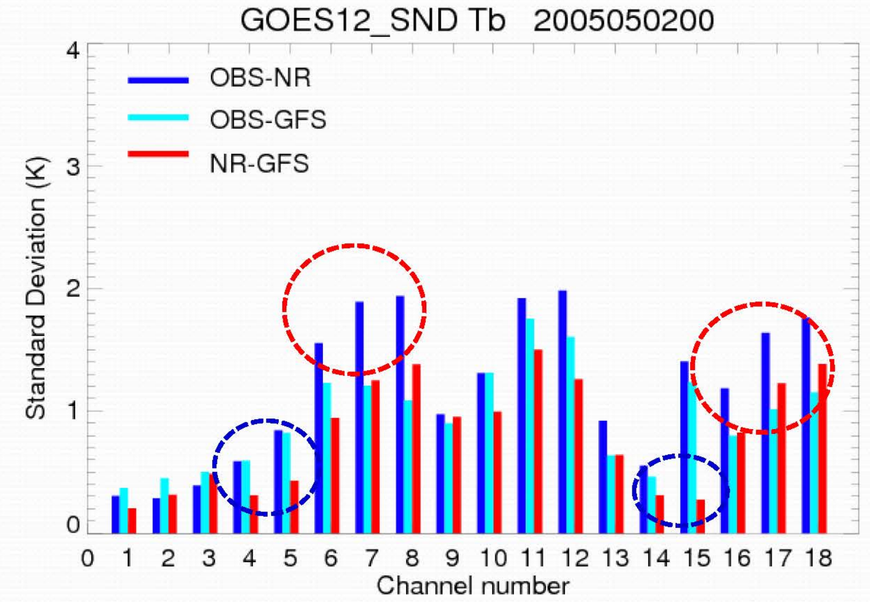
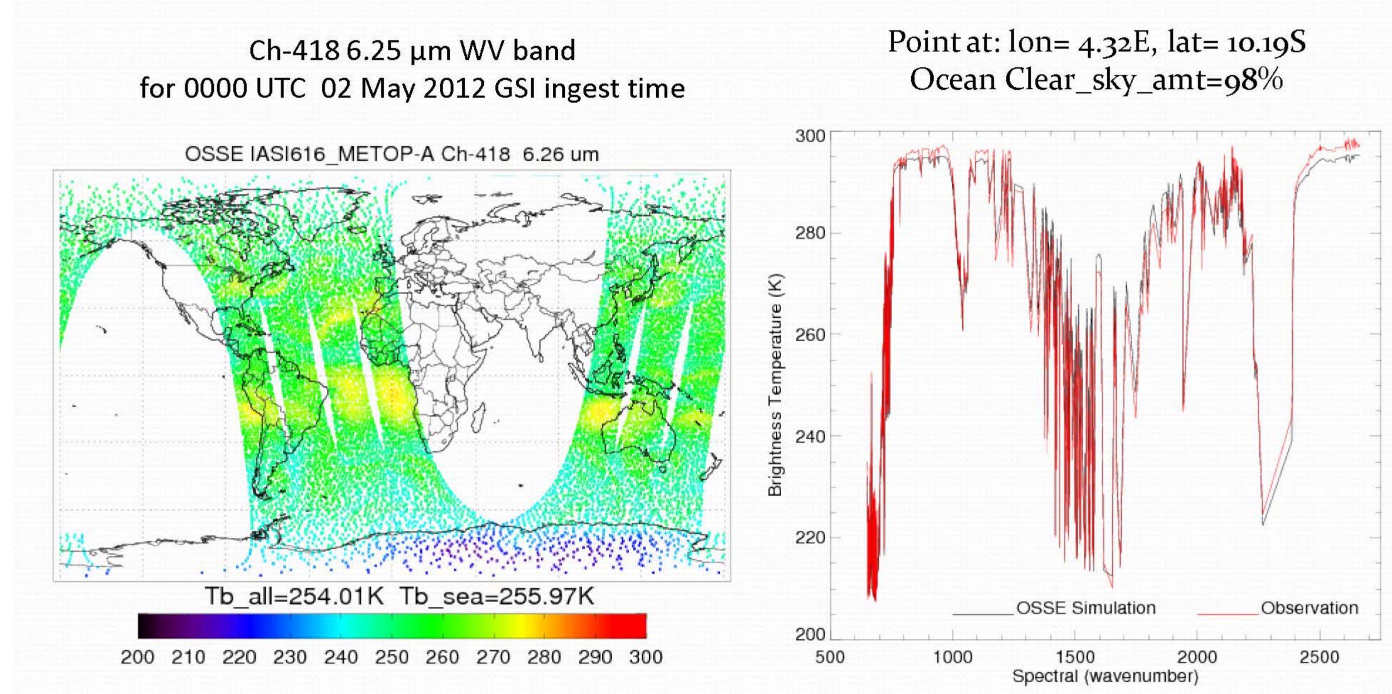
GOES-12 Sounder Simulation Standard Deviations



- STDs of OBS-NR and OBS-GFS are similar, except Ch6-8 and Ch16-18, which are surface sensitive temperature and moisture bands.
- At a few channels, like Ch4, 5, 15, NR-GFS STDs are smaller than that of OBS-GFS.

OSSE IASI Simulation vs. Observation



- ♦ In general, the simulated radiances display similar statistical characteristics (bias & STD) as those derived from the operational GSI analysis for AMSU-A.
- ♦ The AMSU-A synthetic radiances can reproduce inter-channel correlation features, and symmetric angular dependent features. The asymmetric angular dependent bias cannot be simulated.
- ♦ The error characteristics of simulated GOES-12 temperature sounding channels are similar to those from operational GFS analysis; while those biases of moisture and surface channels are approximately 2K.
- ♦ Using the ECMWF T511 NR data, we are simulating all satellite radiances data for 2012 in order to include the sensors used in GSI after 2006.
- ♦ Simulate future instruments, such as GOES-R ABI.
- ♦ Simulate synthetic radiance with ECMWF T799 NR data.

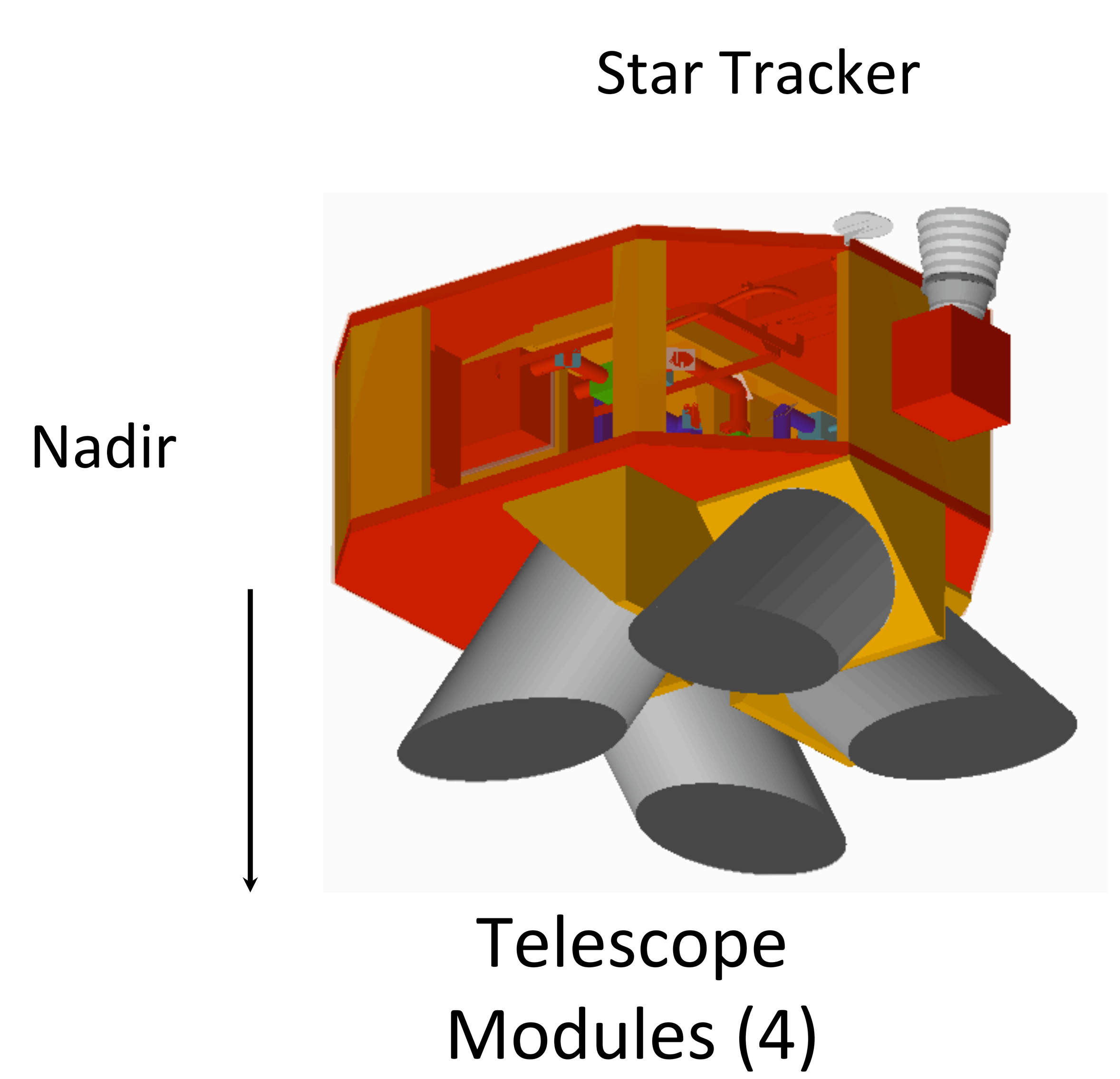
OSSE to evaluate Impact of GWOS DWL
GWOS: Global Wind Observing Sounder

(TJ43.7 IOAS-AOLS)

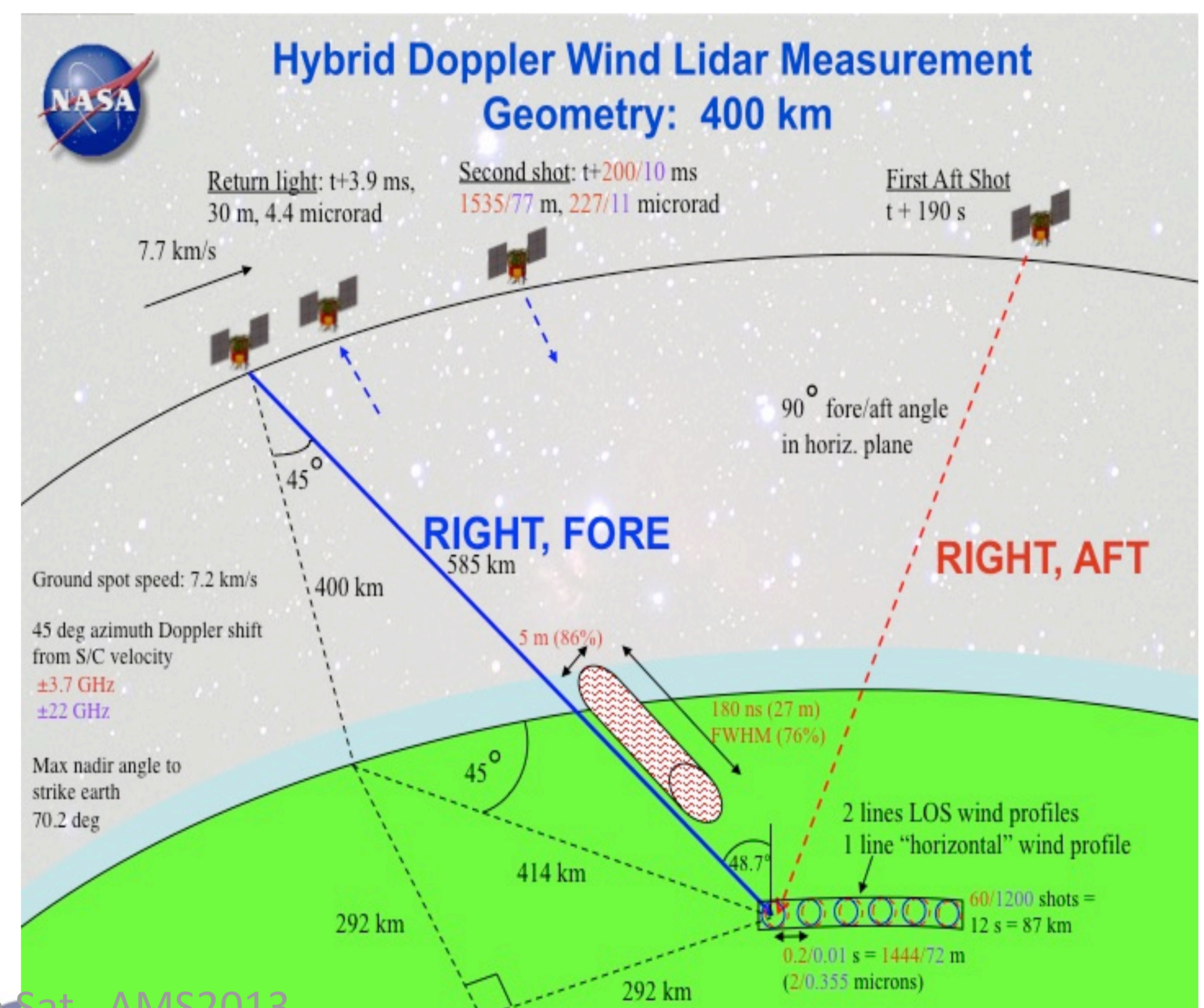
Riishojgaard, L. P., Z. Ma, M. Masutani, J. S. Woollen, G. D. Emmitt, S. A. Wood, and S. Greco 2012: "Observation System Simulation Experiments for a Global Wind Observing Sounder," *Geophys. Res. Lett.*, **39,** L17805, doi:10.1029/2012GL051814.

Simulated observation
Control data: Observation type and distribution used by reanalysis for 2005.
Observational error is not added to the control data but calibration was performed to demonstrate the impact of observational error in control data.

DWL data: GWOS concept DWL simulated by Simpson weather associates.



- The coherent subsystem provides very accurate (< 1.5m/s) observations when sufficient aerosols (and clouds) exist.
- The direct detection (molecular) subsystem provides observations meeting the threshold requirements above 2km, clouds permitting.



Case Study to compare impact of DWL with model resolution

AC difference in AC, with and without GWOS

Atlantic Hurricane in the nature run for the analysis period of 9/25-10/10

L22810 REALE ET AL.: PRELIMINARY EVALUATION OF THE ECMWF NATURE RUN L22810

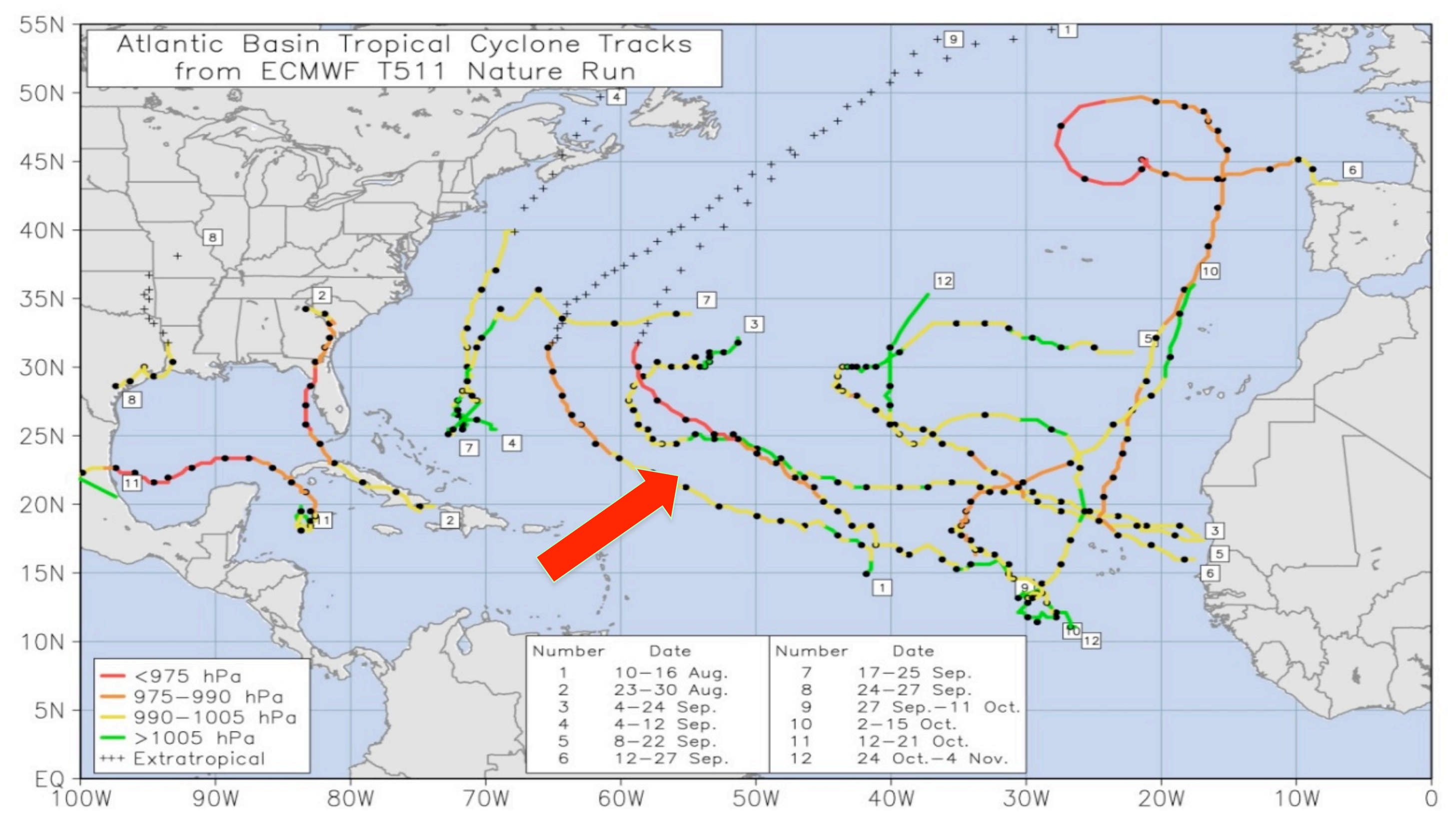
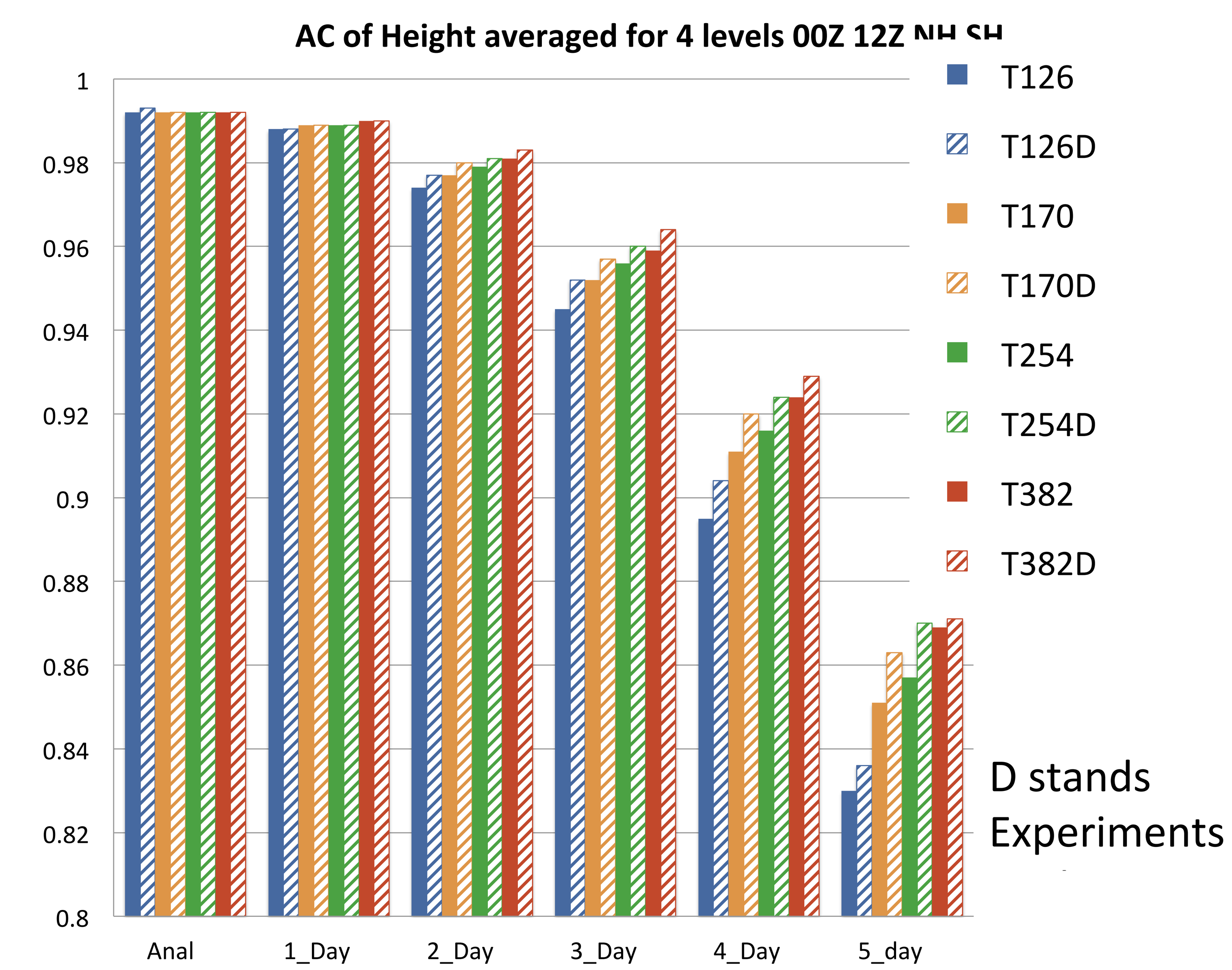
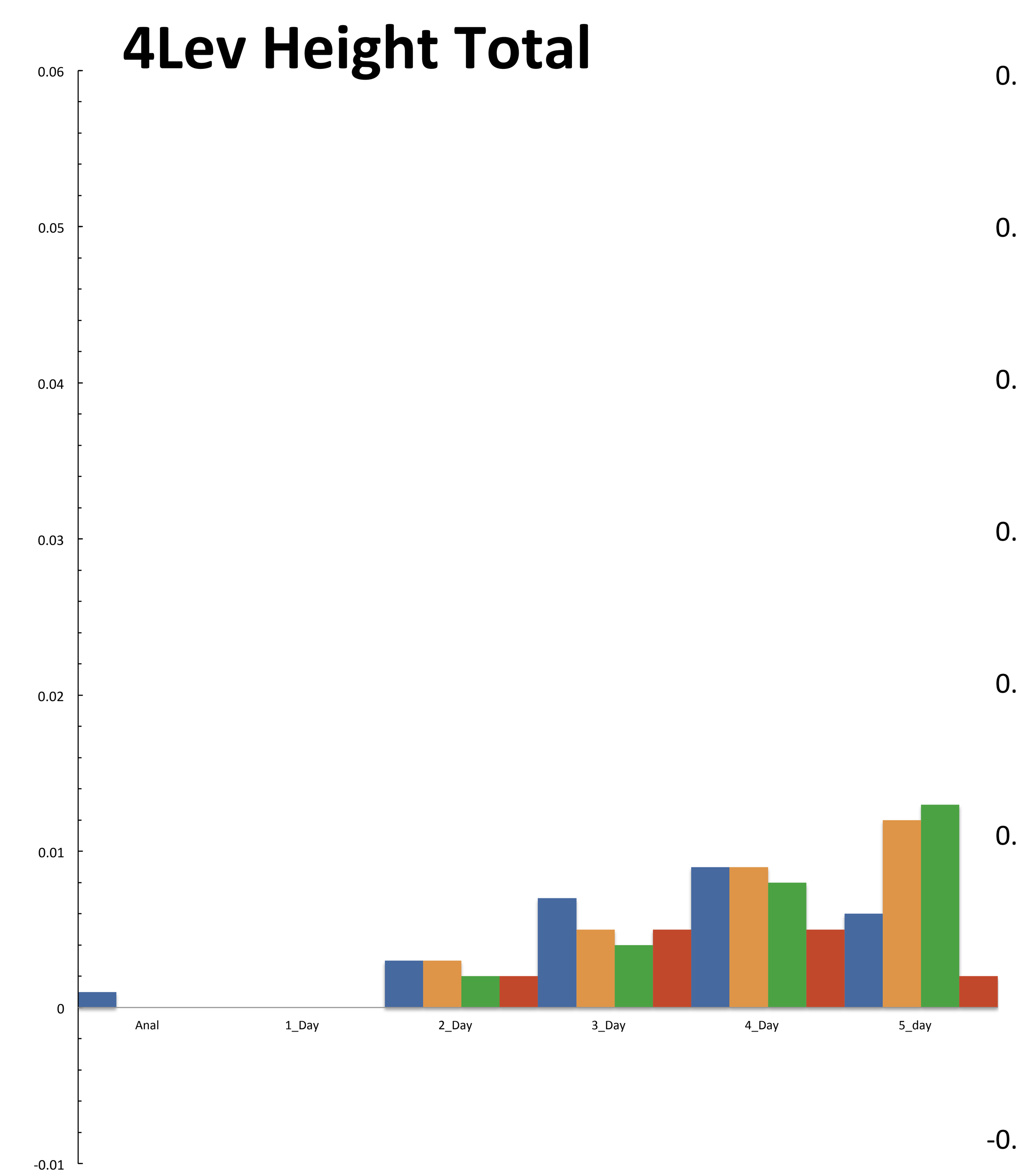


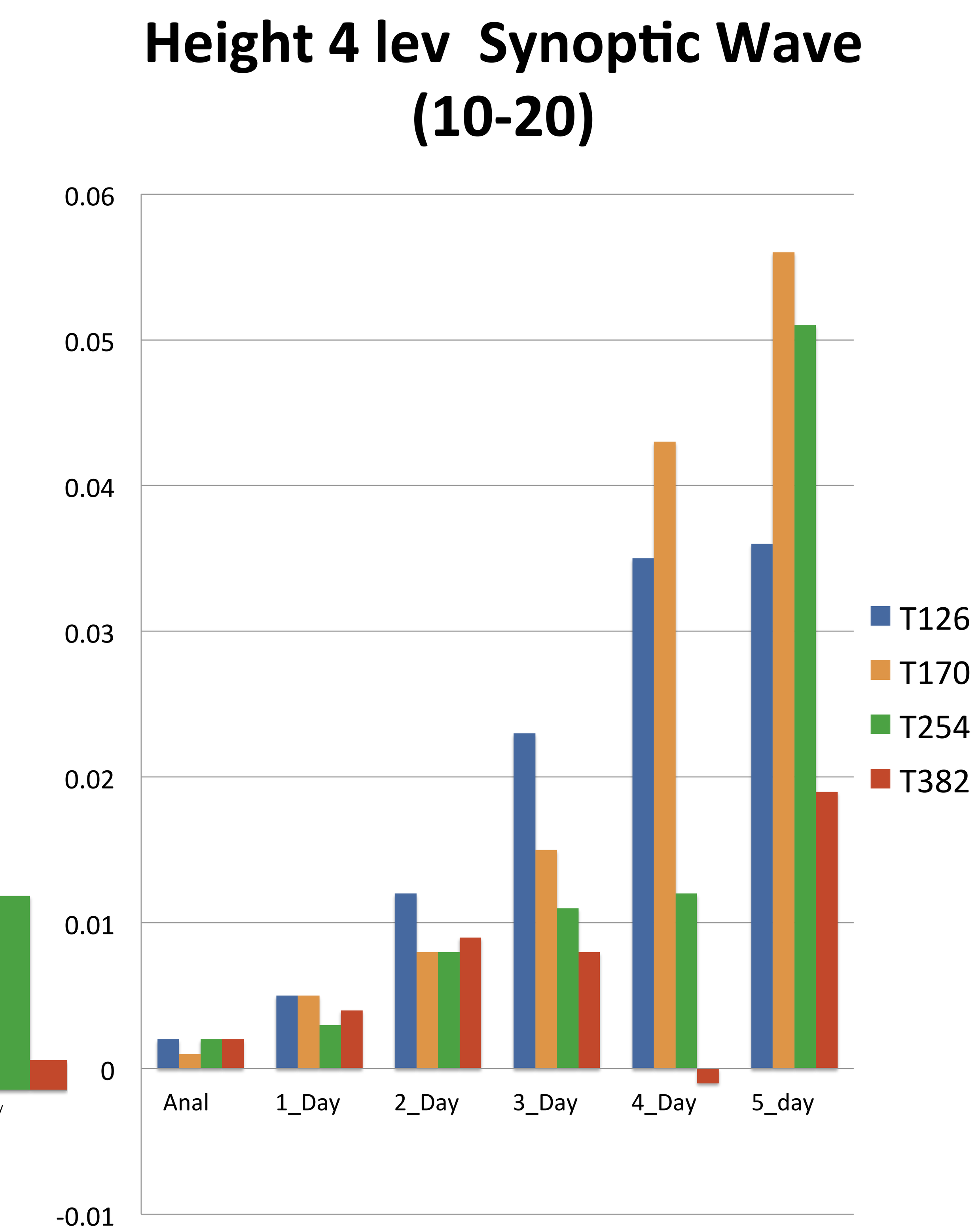
Figure 3. Atlantic TCs in the NR 'hurricane season.' Different colors show center pressure in the full resolution surface fields. Crosses indicate extratropical storms defined when the 200 hPa minus 850 hPa shear exceeds 10 ms^{-1}. Tracks are from original full-resolution T511 surface fields.

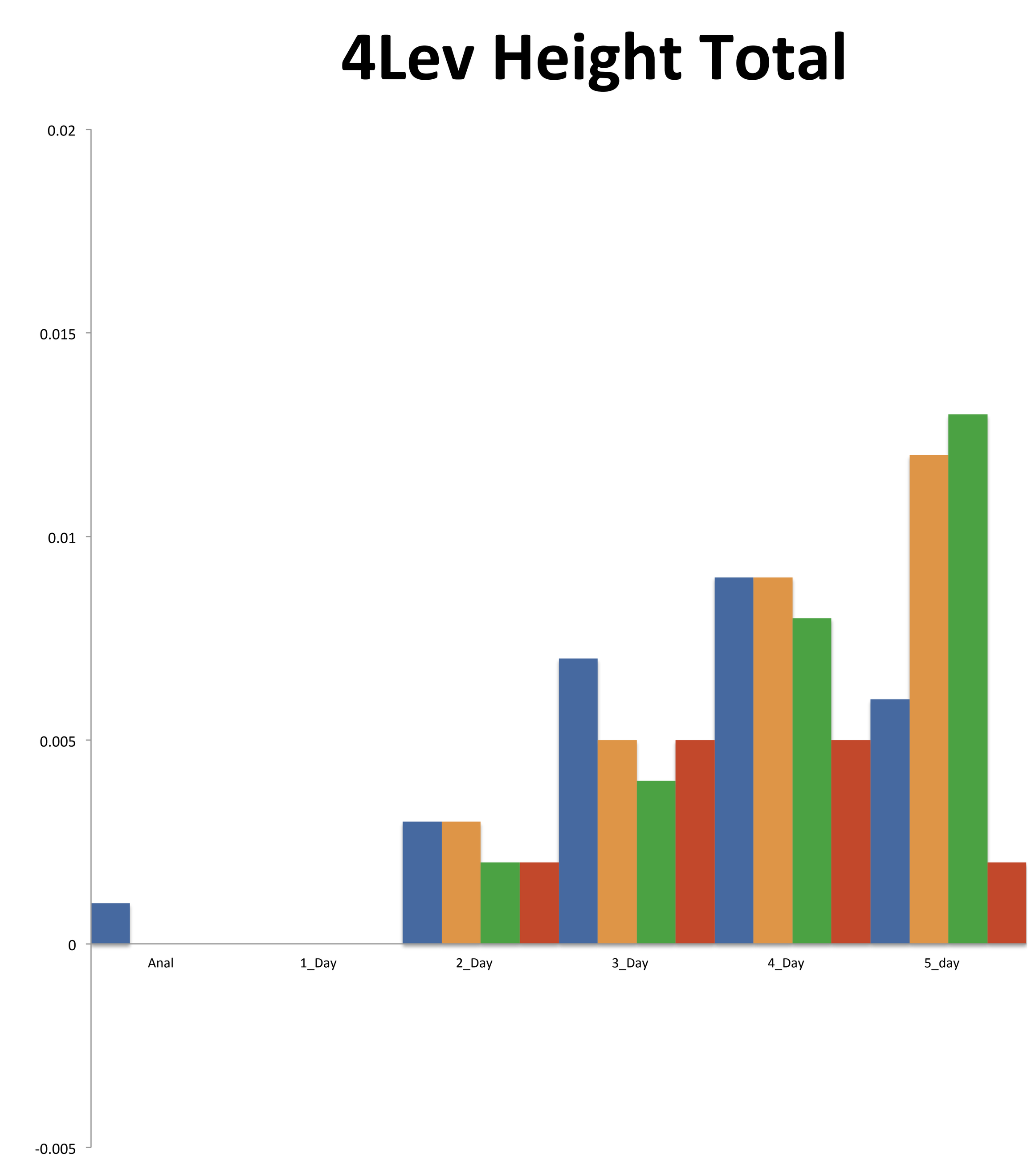
NH 12 hourly sampling, Average of 1000, 700, 500, 250 hPa Height Oct1-Oct10, 2005

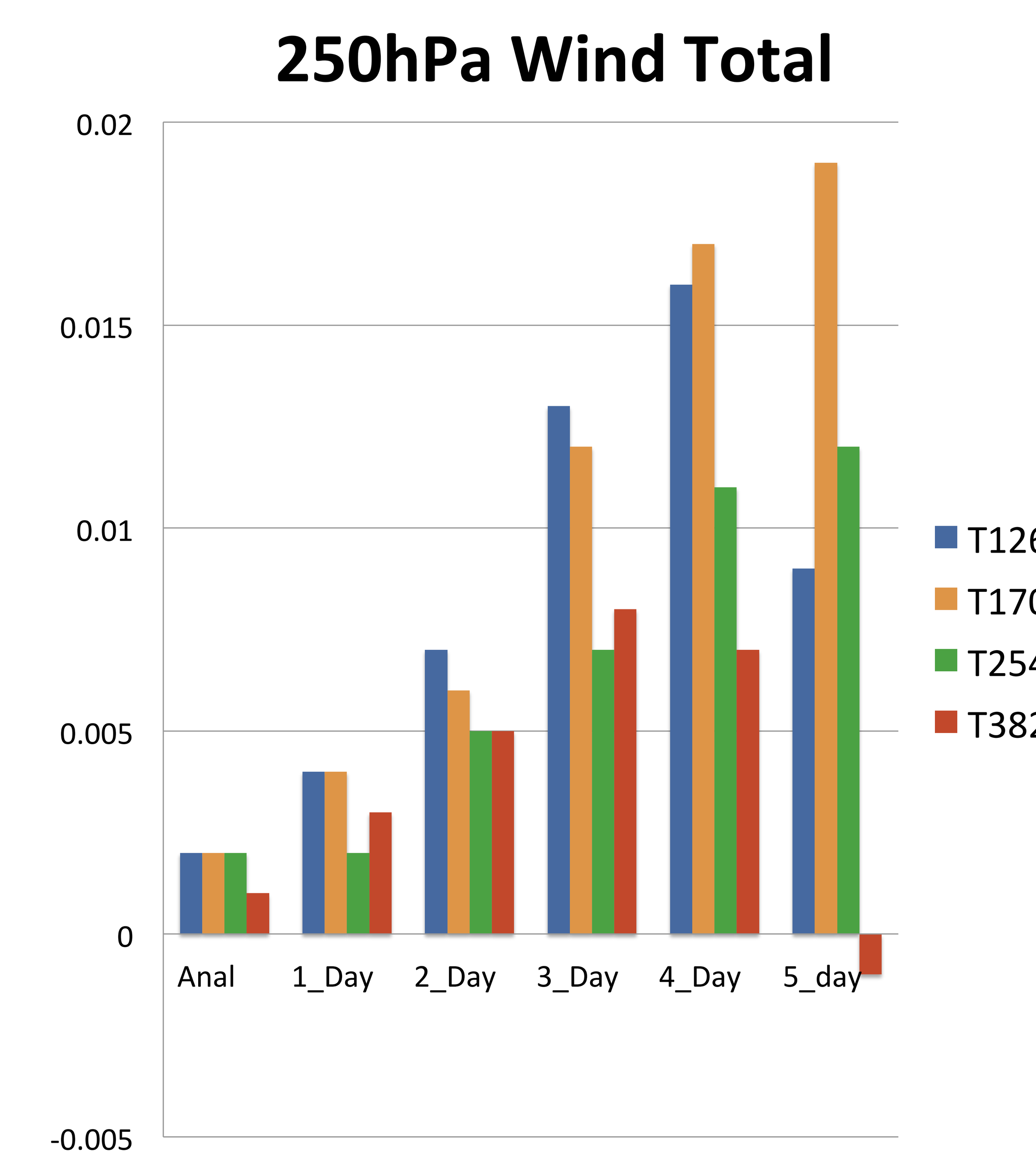


D stands Experiments









Initial Summary of Hurricane OSSE

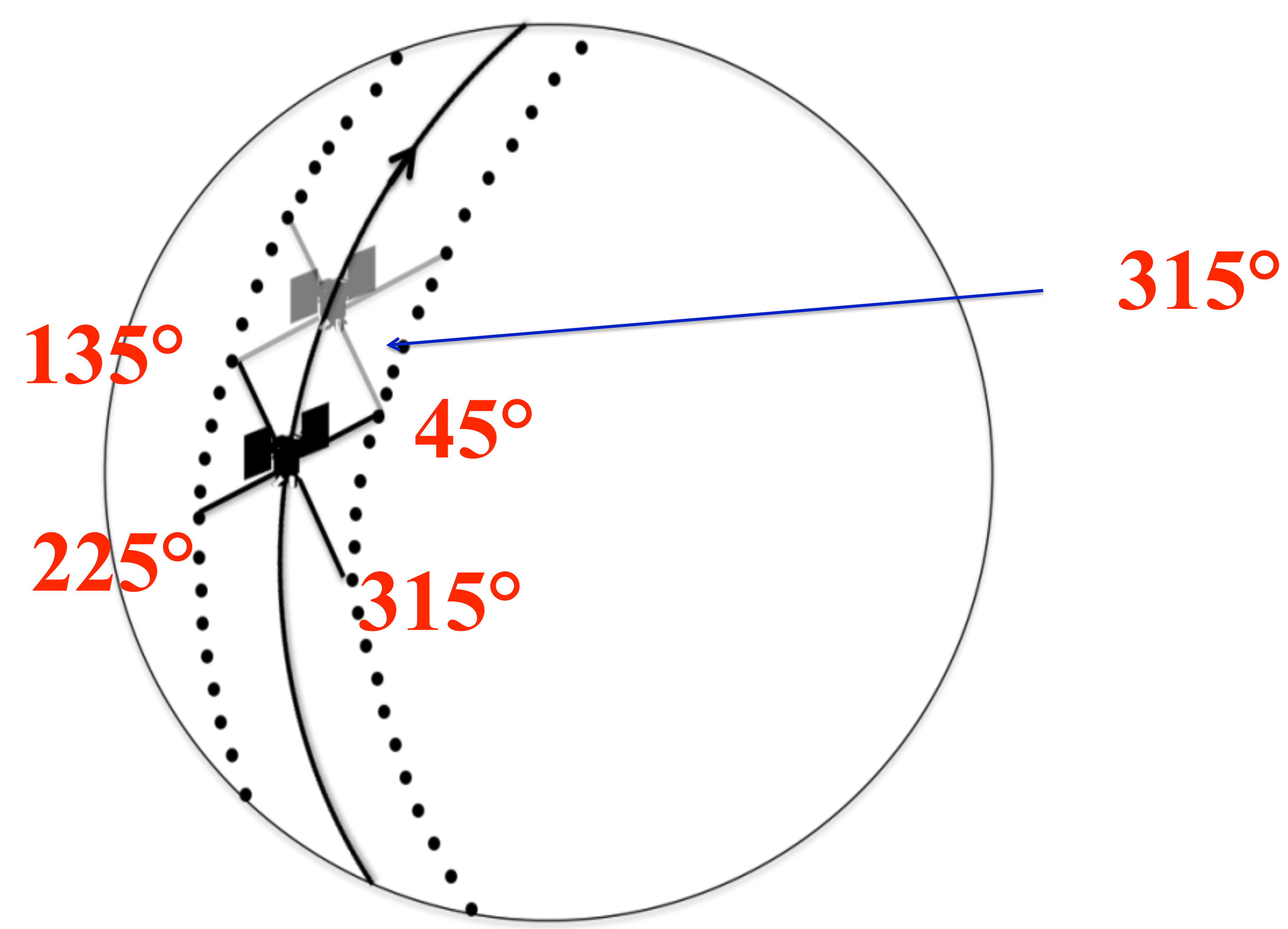
- At least T170 resolution is required to utilize DWL data for hurricane case. Impact of DWL is larger in T254 than in T170 model forecast. T382 model for OSSE with T511 Nature run may not be the best.
- Increasing resolution and adding DWL are equally important to improve large scale forecast skill.
- DWL data is more effective in improving forecast for small scale event.
- OSSE with control observation without observational error is useful to provide initial outlook of data impact a new type of observation.
- Further experiments with observational error is required.

Impact in short wave is much stronger than that in large scale wave. Impact in wind is stronger than that in height.in fact the impact on V only is even stronger

Some subtle results which require OSSEs

Testing advantage of producing vector wind.

GWOS Lidar Wind obs



Distribution of Lidar observations at 2005072100

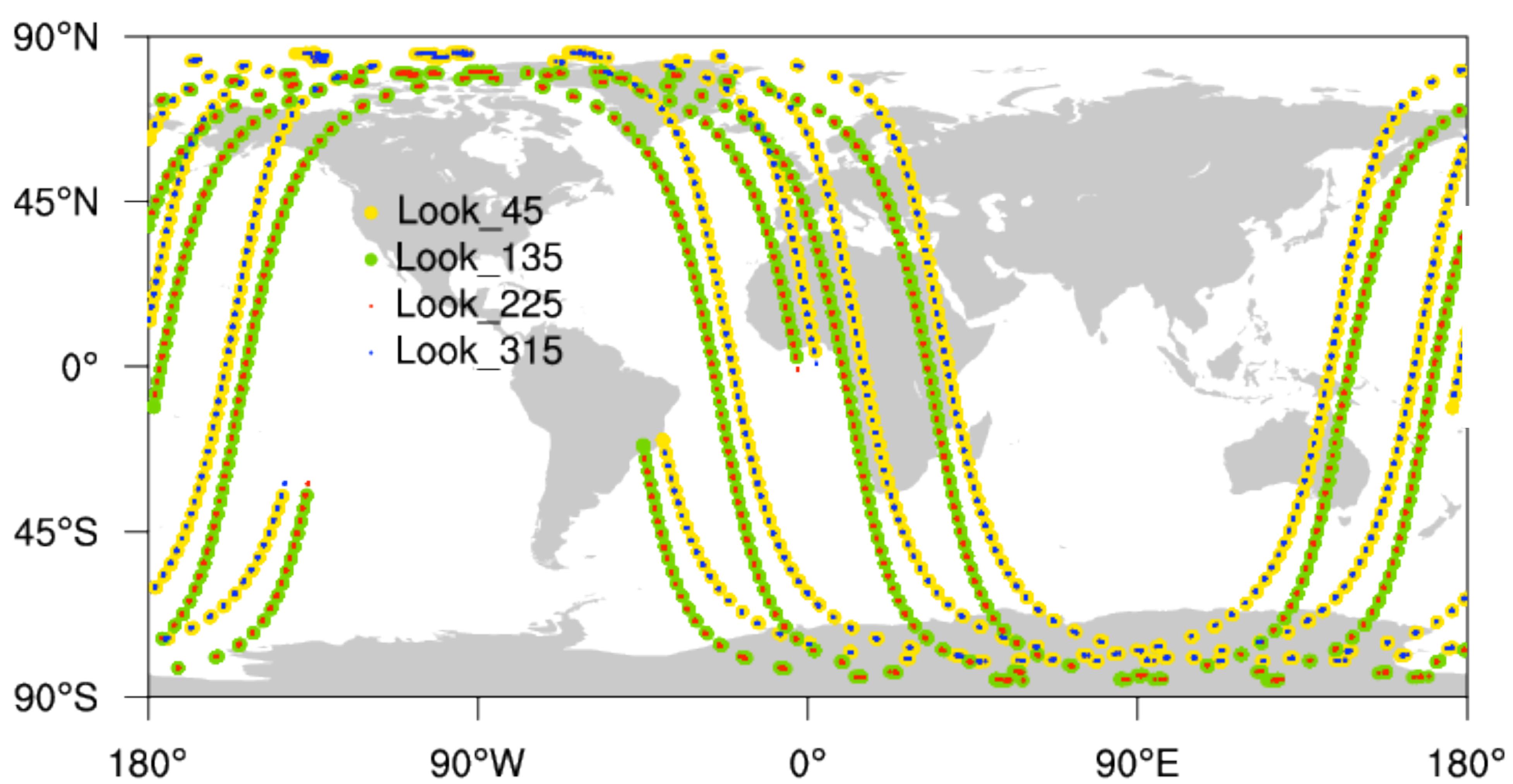


Diagram by Zaizhong Ma

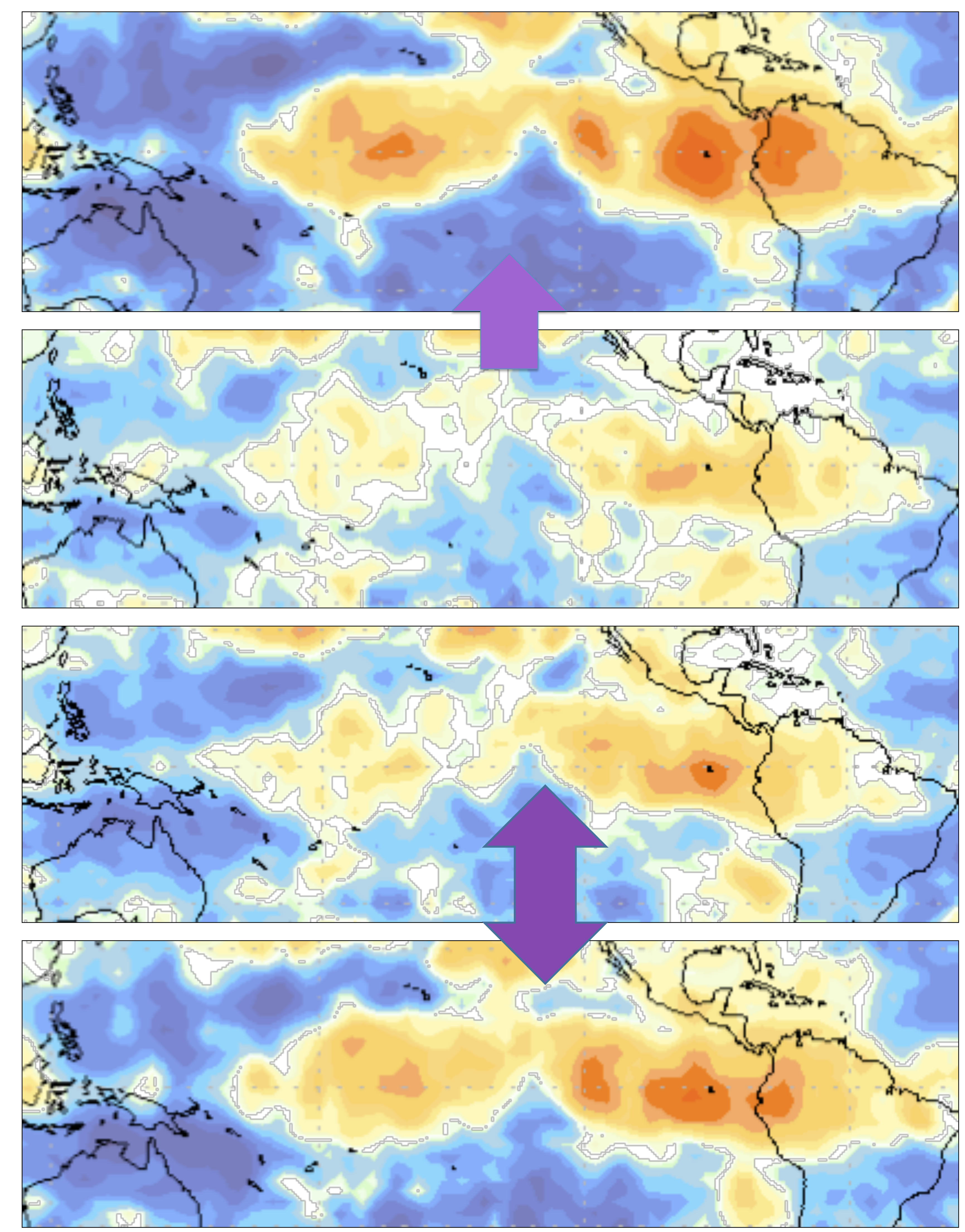
Reduction of RMSE from NR in H500 Analysis
(Averaged between July 7-August 15)

Four Looks

One Look
(right fore only)

Two front looks
(righr fore and left fore)

Two one side looks
(right fore and right aft deg)
To produce vector wind



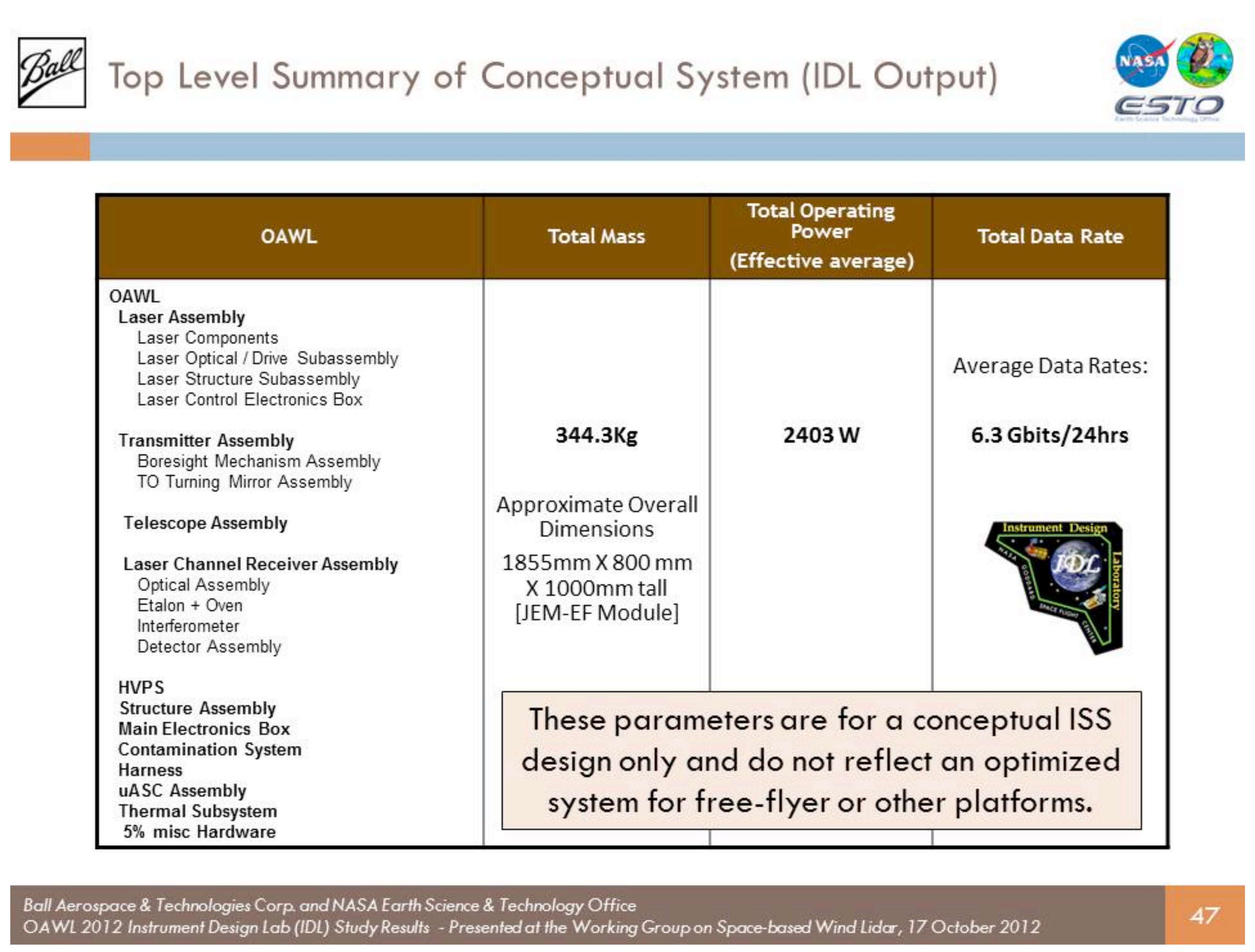
Four time more observation

Same number of observation

Two synchronized one side looks right fore and right aft look which provide vector winds show advantage in tropics compare with two left and right fore look. To be published in *Masutani et al (2012), proceeding for SPIE Asia-Pacific Remote Sensing 2012.*

Work in progress on OSSE at JCSDA

- ◆Conduct OSSE to evaluate satellite system in early-morning orbit (The third polar orbit)
- ◆Conduct OSSE to evaluate Optical Autocovariance Wind Lidar (OAWL) developed by Ball Aerospace
- ◆Further evaluation of space based DWL (Stand by for further resource)
- ◆Add various observational errors to control observations and study data sensitivity to the data impact. Use teplate from real observation.
- ◆Designing OSSE on Arctic Observing Network
- ◆Upgrade simulation of radiance
- ◆Exchange control observation with other institutes



Top Level Summary of Conceptual System (IDL Output)

OAWL	Total Mass	Total Operating Power (Effective average)	Total Data Rate
OAWL **Laser Assembly** Laser Components Laser Optical / Drive Subassembly Laser Structure Subassembly Laser Control Electronics Box **Transmitter Assembly** Boresight Mechanism Assembly TO Turning Mirror Assembly **Telescope Assembly** **Laser Channel Receiver Assembly** Optical Assembly Etalon + Oven Interferometer Detector Assembly **HVPS** **Structure Assembly** **Main Electronics Box** **Contamination System** **Harness** **uASC Assembly** **Thermal Subsystem** **5% misc Hardware**	**344.3Kg** Approximate Overall Dimensions 1855mm X 800 mm X 1000mm tall [JEM-EF Module]	**2403 W**	Average Data Rates: **6.3 Gbits/24hrs**

These parameters are for a conceptual ISS design only and do not reflect an optimized system for free-flyer or other platforms.

Ball Aerospace & Technologies Corp. and NASA Earth Science & Technology Office
OAWL 2012 Instrument Design Lab (IDL) Study Results - Presented at the Working Group on Space-based Wind Lidar, 17 October 2012

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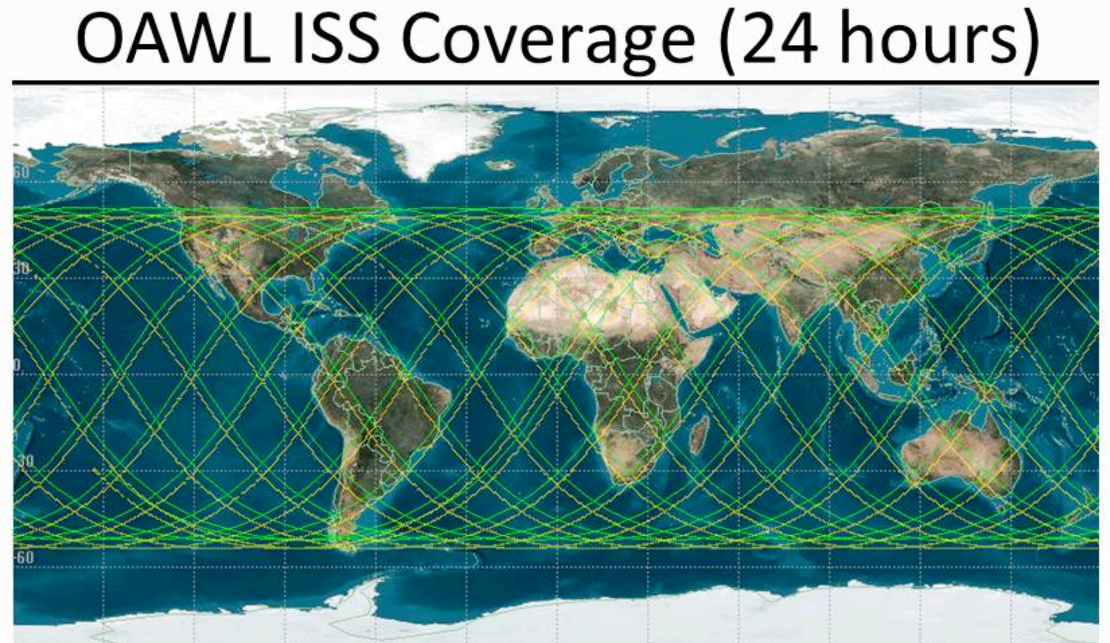
OAWL ISS Coverage (24 hours)



- Green = ground track
- Yellow = coverage (observation) swath

OSSE to evaluate the third polar orbits

From Sean Casey et al (JCSDA) , J4.4 JCSDA session part3

- Following the cancellation of the NPOESS program in February 2010, U: plans for sounding coverage in the early morning orbit (~5:30 AM ECT) were put on hold indefinitely. How might the lack of early morning sounding coverage affect medium-range weather forecasts? Which of three suggested replacement satellite would have the greatest forecast impact?

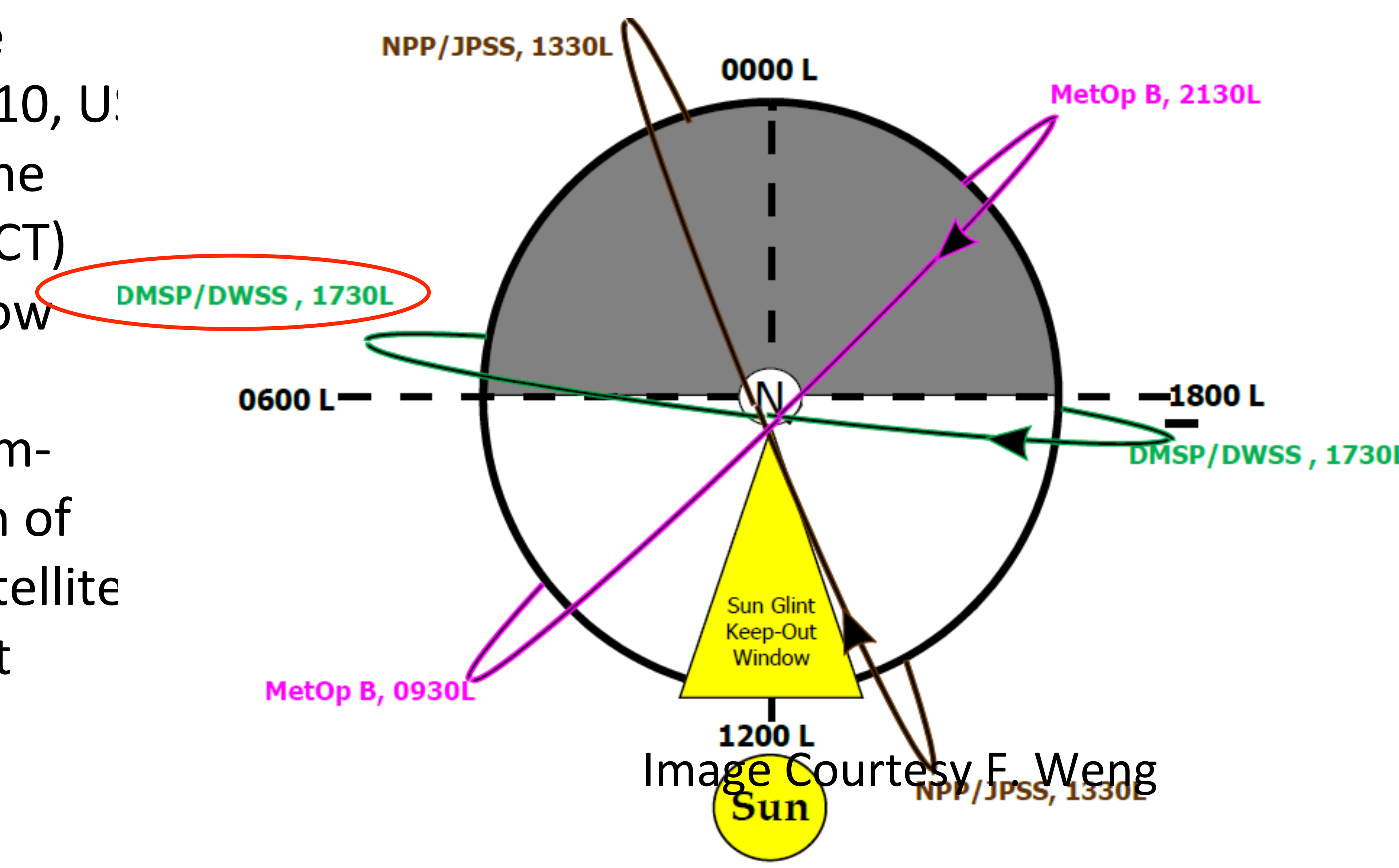


Image Courtesy F. Weng

Key Questions

Three polar orbits? Or two?

- How might the lack of early morning sounding coverage affect medium-range weather forecasts?
- Which of three suggested replacement satellites would have the greatest forecast impact?

Initial outlook of the results

- Current OSSE work demonstrates the importance of a meteorological satellite in the early-morning orbit
- Losing SSMI/S causes significant decreases in model analysis and forecast skill, especially in Southern Hemisphere and tropical winds
- Best performing replacements for SSMI/S are a combination of ATMS/CrIS or a combination ATMS/VIIRS; VIIRS alone causes little improvement
- Future work will include continuing experiment for Jan/Feb, to compare hemispheric seasonal effects