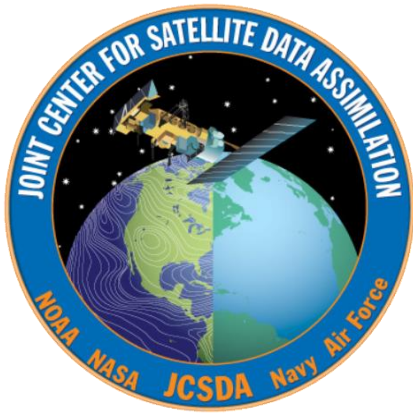




Progress in OSSE Evaluation of Space-based DWL

Lars Peter Riishojgaard (JCSDA), Michiko Masutani (EMC,JCSDA) and
David Emmitt (SWA),

Joint OSSE Team

NCEP: Michiko Masutani, Jack Woollen, Yucheng Song, Stephen J. Lord, Zoltan Toth

ECMWF: Erik Andersson

KNMI: Ad Stoffelen, Gert-Jan Marseille

JCSDA: Lars Peter Riishojgaard, Lidia Cucurull

NESDIS: Fuzhong Weng, Tong Zhu, Haibing Sun,

SWA: Dave Emmitt, Sidney A. Wood, Steven Greco

NASA/GFSC: Ron Errico, Oreste Reale, Runhua Yang, Emily Liu, Joanna Joiner, Harper Pryor, Alindo Da Silva, Matt McGill, Will McCarthy, Ron Gelaro

NOAA/ESRL: Yuanfu Xie, Nikki Prive, Steve Weygandt

MSU/GRI: Valentine Anantharaj, Chris Hill, Pat Fitzpatrick

MSFC: Tim Miller

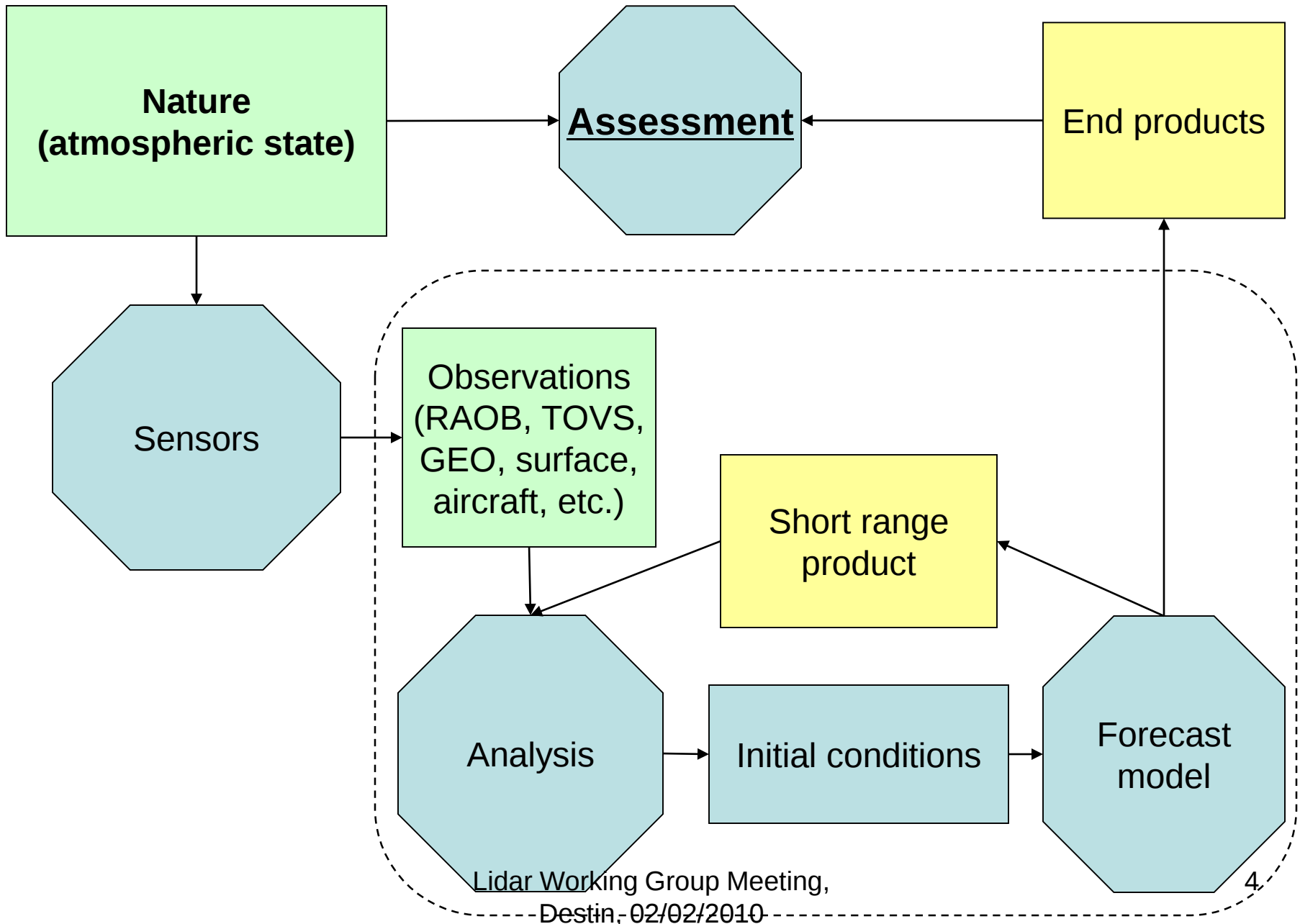
AOML: Bob Atlas

*Underlined individuals involved in Wind Lidar Science proposal funded by NASA HQ
Most other work is done by volunteers.*

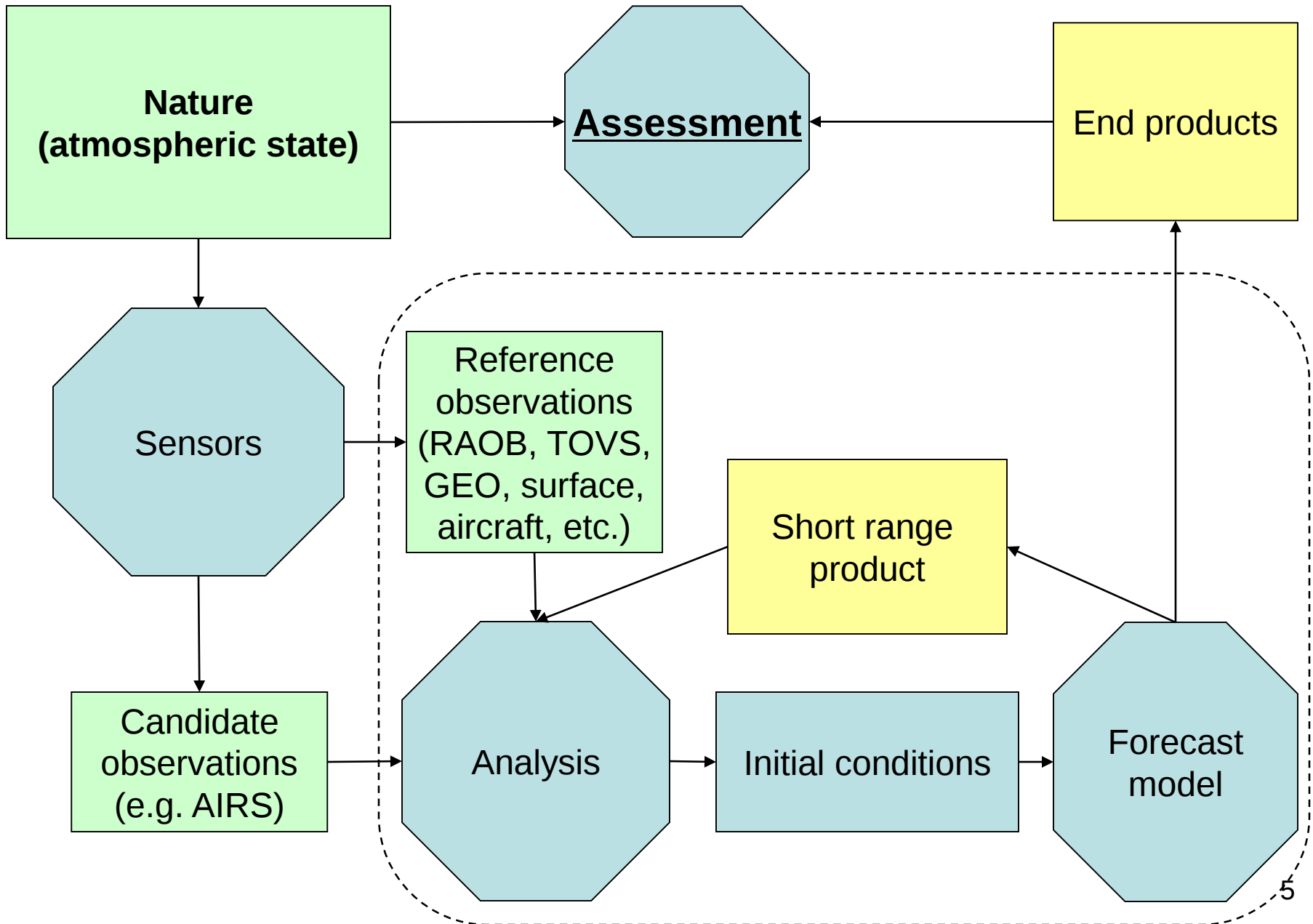
Role of a National (or International) OSSE Capability

- Impact assessment for future missions
 - Decadal Survey and other science and/or technology demonstration missions (NASA)
 - Future operational systems (NOAA)
- Objective way of establishing scientifically sound and technically realistic user requirements for observing systems
- Tool for assessing performance impact of engineering decisions made throughout the development phases of a space program or system
- Preparation/early learning pre-launch tool for assimilation users of data from new sensors

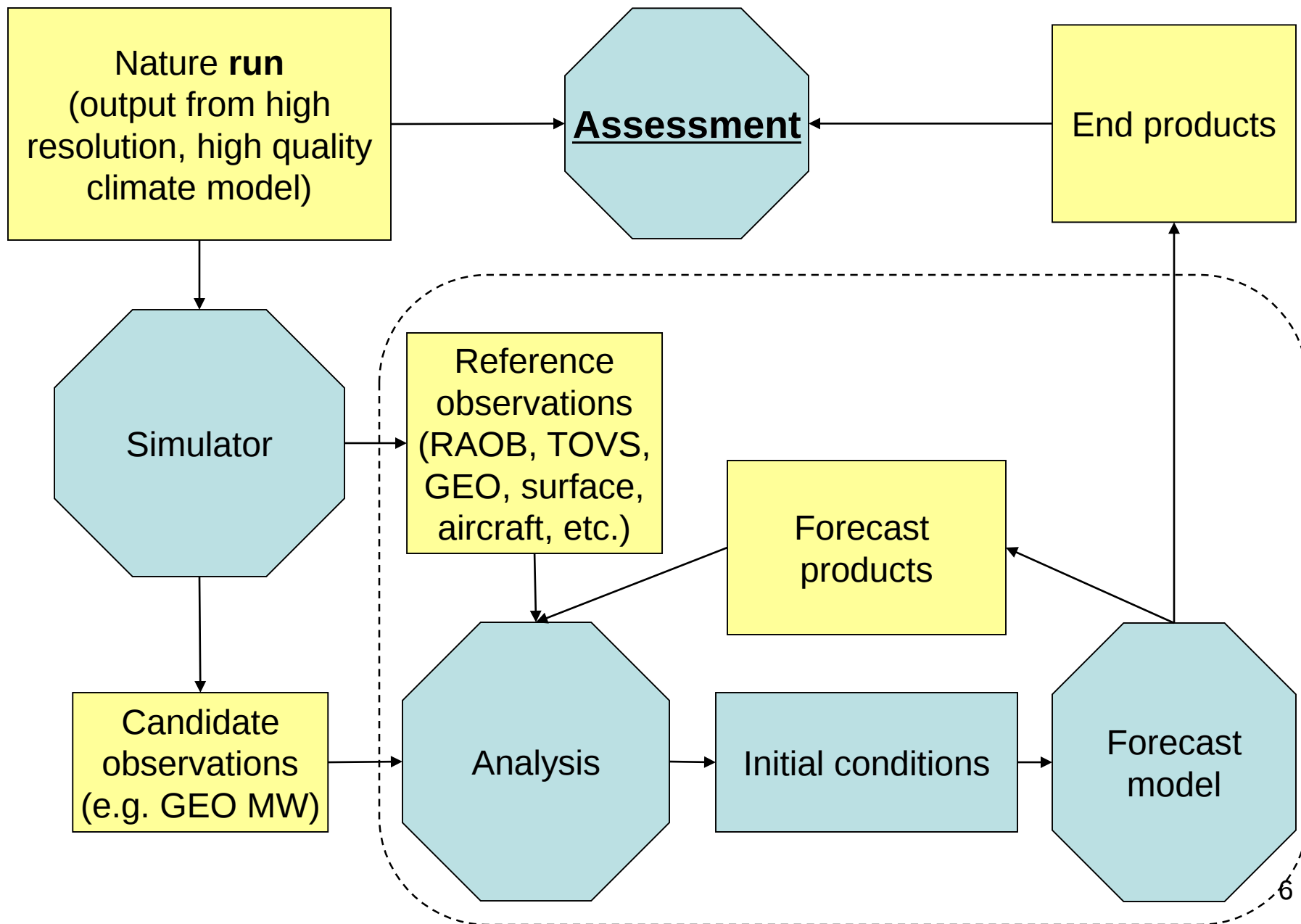
Data assimilation



OSE, conceptual model



OSSE, conceptual model



Main OSSE components

- Data assimilation system(s)
 - NCEP/EMC GFS
 - NASA/GMAO GEOS-5
 - NCAR WRF-VAR
- Nature run
 - ECMWF
 - Plans for embedded WRF Regional NR
- Simulated observations, including calibrated errors
 - Reference observations
 - Perturbation (“candidate”) observations
- Diagnostics capability
 - “Classical” OSE skill metrics
 - Adjoint sensitivity studies

ECMWF Nature Run *(Erik Andersson)*

- Based on recommendations/requirements from JCSDA, NCEP, GMAO, GLA, SIVO, SWA, NESDIS, ESRL
- “Low Resolution” Nature Run
 - Free-running T511 L91 w. 3-hourly dumps
 - May 12 2005 through June 1 2006
- Two “High Resolution” periods of 35 days each
 - Hurricane season: Starting at 12z September 27, 2005,
 - Convective precipitation over CONUS: starting at 12Z April 10, 2006
- T799 L91 levels, one-hourly dump
- Initial condition from T511 NR

Nature Run validation

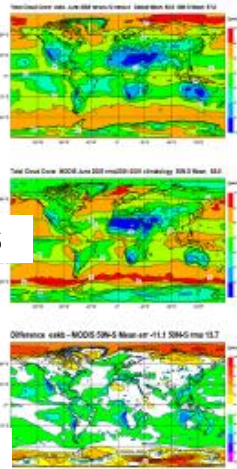
- Purpose is to ensure that pertinent aspects of meteorology are represented adequately in NR
- Contributions from Emmitt, Errico, Masutani, Prive, Reale, Terry, Tompkins and many others
- Clouds
- Precipitation
- Extratropical cyclones (tracks, cyclogenesis, cyclolosis)
- Tropical cyclones (tracks, intensity)
- Mean wind fields
-

Simulation of observations

- Conventional observations (non-radiances)
 - “Resample NR at OBS locations and add error”
 - Problem areas:
 - Atmospheric state affects sampling for RAOBS, Aircraft observations, satellite AMVs, wind lidars, etc.
 - Correlated observations errors
 - J. Woollen (NCEP), R. Errico (GMAO)
- Radiance observations
 - “Forward radiative transfer on NR input profiles”
 - Problem areas:
 - Treatment of clouds has substantial impact on availability and quality of observations
 - Desire to avoid “identical twin” RTMs
 - H. Sun (NESDIS), R. Errico (GMAO)

Evaluation of the Nature run

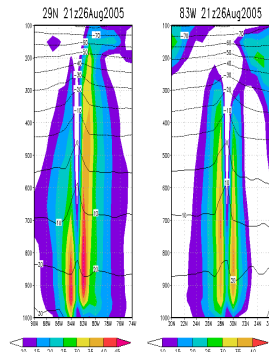
**Comparison between NR
the ECMWF T511
Nature Run against
climatology**
20050601-20060531, exp=e MODIS
cycle=31r1
Adrian Tompkins, ECMWF



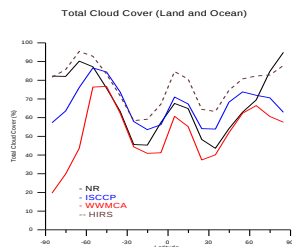
NR-
MODIS

Tropics by Oreste Reale (NASA/GSFC/GLA)

Vertical structure of a HL vortex shows, even at the degraded resolution of 1 deg, a distinct eye-like feature and a very prominent warm core. Structure even more impressive than the system observed in August. Low-level wind speed exceeds 55 m/s.

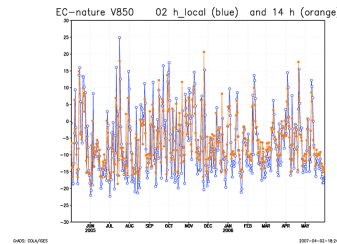


**Evaluation of
T511(1°) clouds
by SWA**

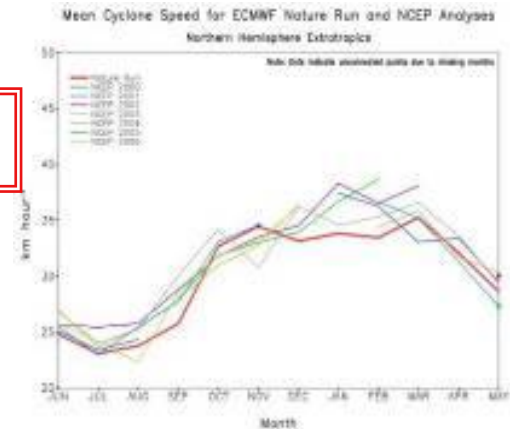


**Utilize Goddard's cyclone tracking
software. - By J. Terry(NASA/GSFC)**

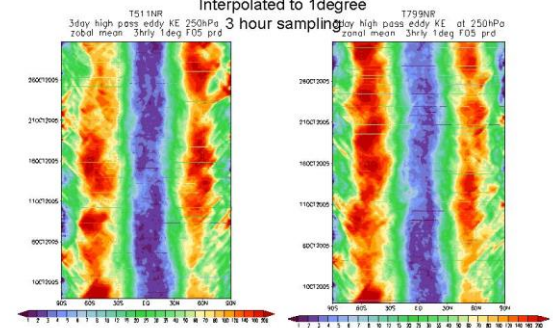
**THE SOUTH AMERICAN
LOW LEVEL JET**
Juan Carlos Jusem
(NASA/GSFC)



Time series showing the night
intensification of the LLJ at
the lee of the Andes in the
simulation.
Gridpoint at 18 S / 63 W

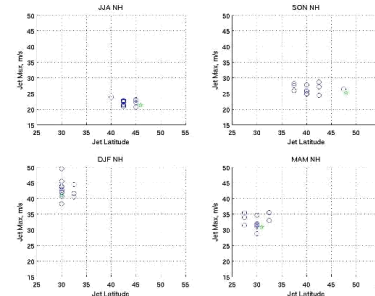


Zonal mean high pass eddy KE at 250hPa
Three day running mean subtracted
Interpolated to 1degree



Toward end of October, SH become erroneously active in T799 NR.

M.Masutani (NOAA/NCEP)



Seasonal mean zonal mean zonal
wind jet maximum strength and
latitude of the jet maxima for the
ECMWF reanalysis (1989-2001,
blue circles) and the Nature Run
(⊗), northern hemisphere. (N.
Prive.)

OSSE Calibration

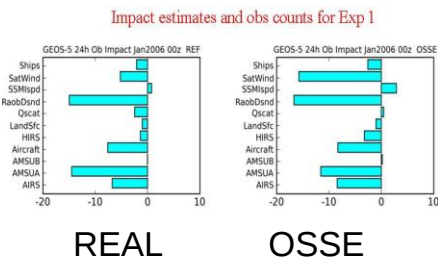
- The purpose of calibration is to ensure credible results of OSSEs
- In a properly calibrated OSSE system,
 - the overall level of skill in the simulated world is comparable to that of the real-world operational counterpart
 - all major individual components of the global observing system have the same relative contributions to forecast skill in the simulated world as in the real world
- The term “calibration” refers to tuning the simulated observation errors to achieve these characteristics

Calibration at ESRL-EMC

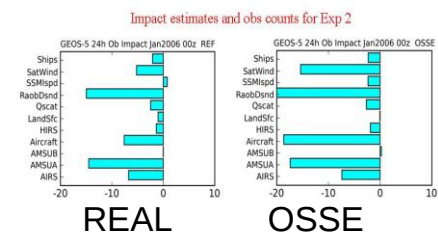
- Data denial experiments (OSEs) done for selected components of Global Observing System
- Analysis impact (global RMS difference in control and data denial analysis) is calculated for synthetic obs and compared to analysis impact for data denial with real archived data from July 2005
- Standard deviation of synthetic errors are adjusted, errors are regenerated
- New data denial case is run and compared to real data, errors adjusted, etc
- Repeat until analysis impact matches real data analysis impact, or until satisfied that calibration is not possible

Calibration for Joint OSSEs at NASA/GMAO

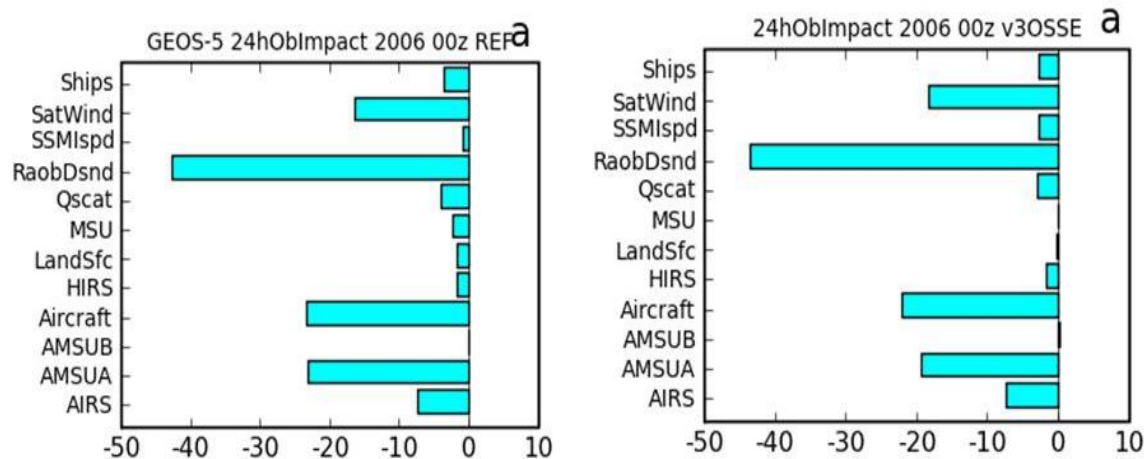
Version 1



Version 2



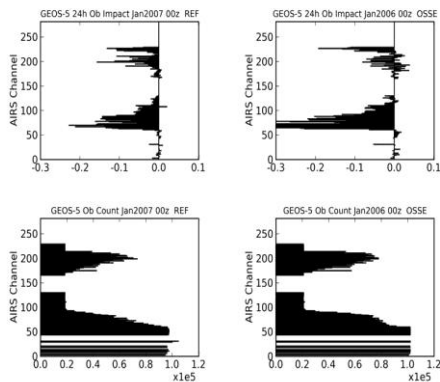
Latest version



Calibration using adjoint technique

Version 1

Exp 1 OSSE Calibration for Jan 2006 vs. Jan 2007 Reference
GEOS-5 DAS version and impact calculation same

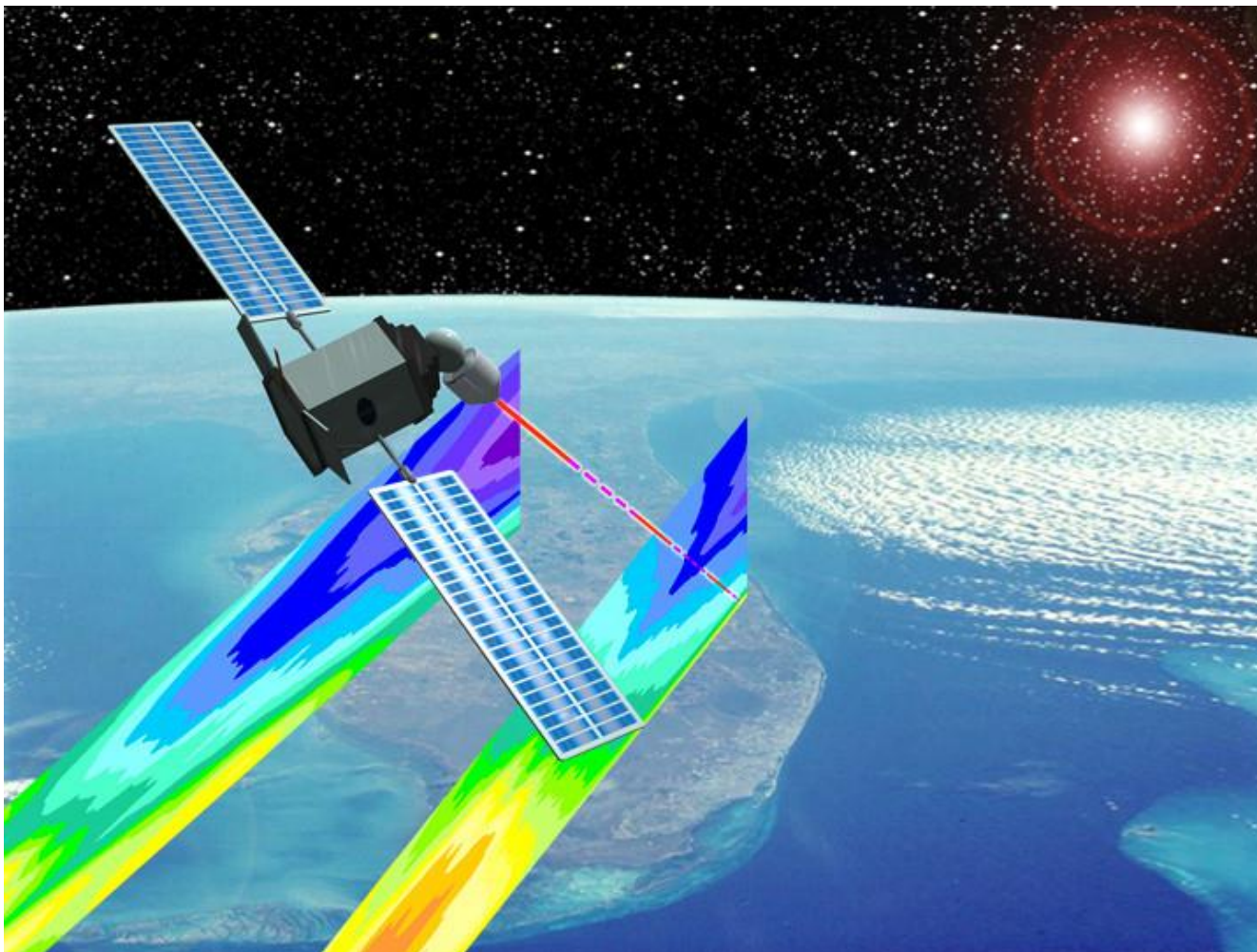


Real Data

OSSE

- Overall impact of simulated data seems realistic
- Tuning parameter for cloud clearing
- Surface emissivity
- Improved simulation of AMVs

Concept for a U.S. Space-Based Wind Lidar

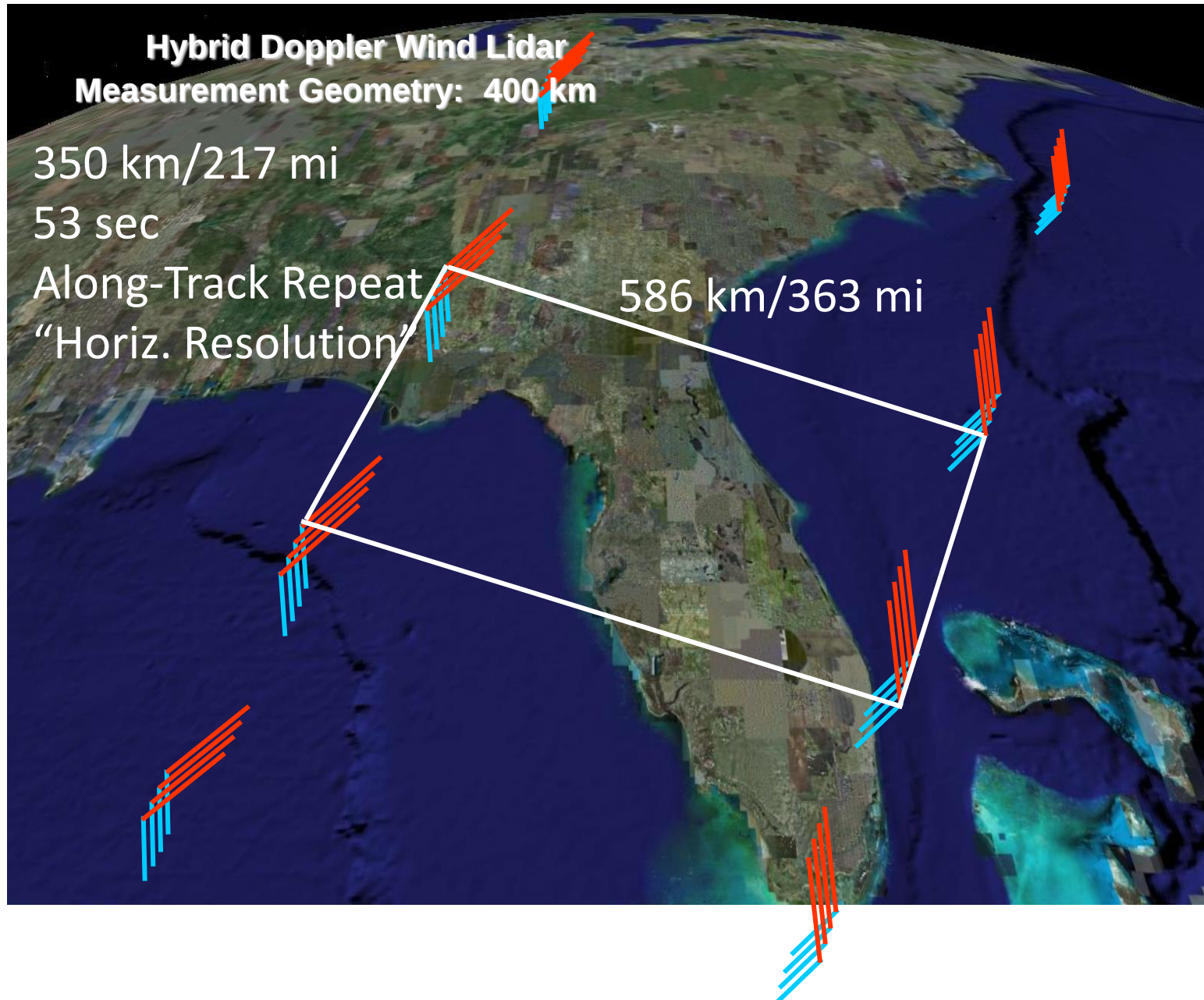


**Global Wind Observing Sounder
(GWOS)**

Dual Technology Sampling

- The coherent subsystem provides very accurate ($< 1.5\text{m/s}$) observations when sufficient aerosols (and clouds) exist.
- The direct detection (molecular) subsystem provides observations meeting the threshold requirements above 2km, clouds permitting.
- When both sample the same volume, the most accurate observation is chosen for assimilation.
- The combination of direct and coherent detection yields higher data utility than either system alone. Note that in the background aerosol mode, the combination of the coherent and direct provide $\sim 20\%$ more coverage near 3-5 km than could either technology by itself.

GWOS Sampling

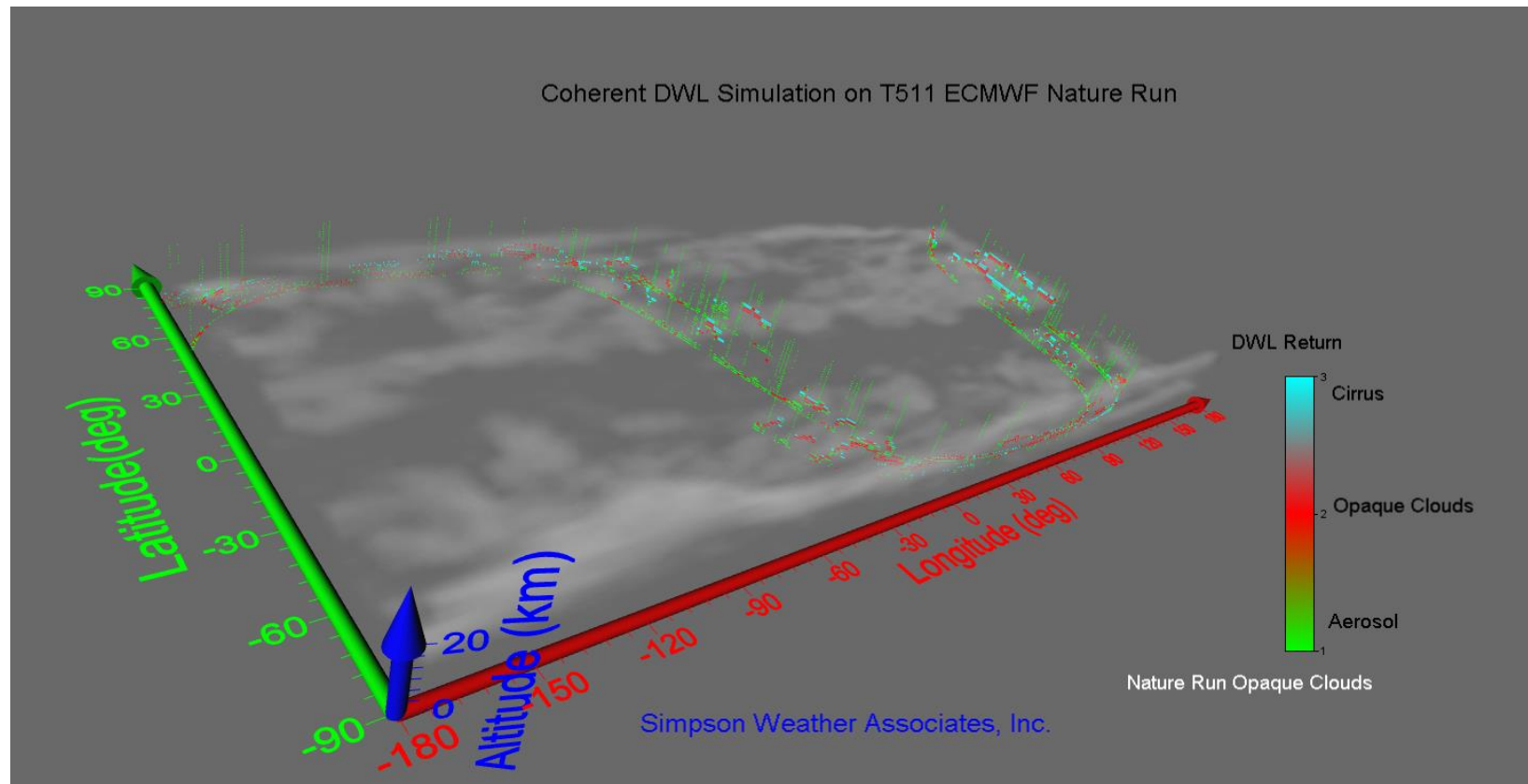


Progress in GWOS DWL Simulations (SWA)

- 1) Acquired the ECMWF T511 Nature Run (NR) model level data in GRIB format
- 2) Developed software to read and unpack the T511 NR model level GRIB data
- 3) Unpacked the T511 NR model level GRIB data for July 1 - Aug 10, 2005
- 4) Created global atmospheric data sets for July 1 - Aug 10, 2005 to be used by the Doppler Lidar Simulation Model (DLSM)
- 5) Modified the LSM to work with the variables, levels and resolutions/grids of the T511 NR model level data
- 6) Conducted a test run of a GWOS DWL simulation using the T511 NR
- 7) Will continue the GWOS DWL simulations for July 1 - August 10, 2005 upon final quality check

Simulation of GWOS data

Simpson Weather Associates

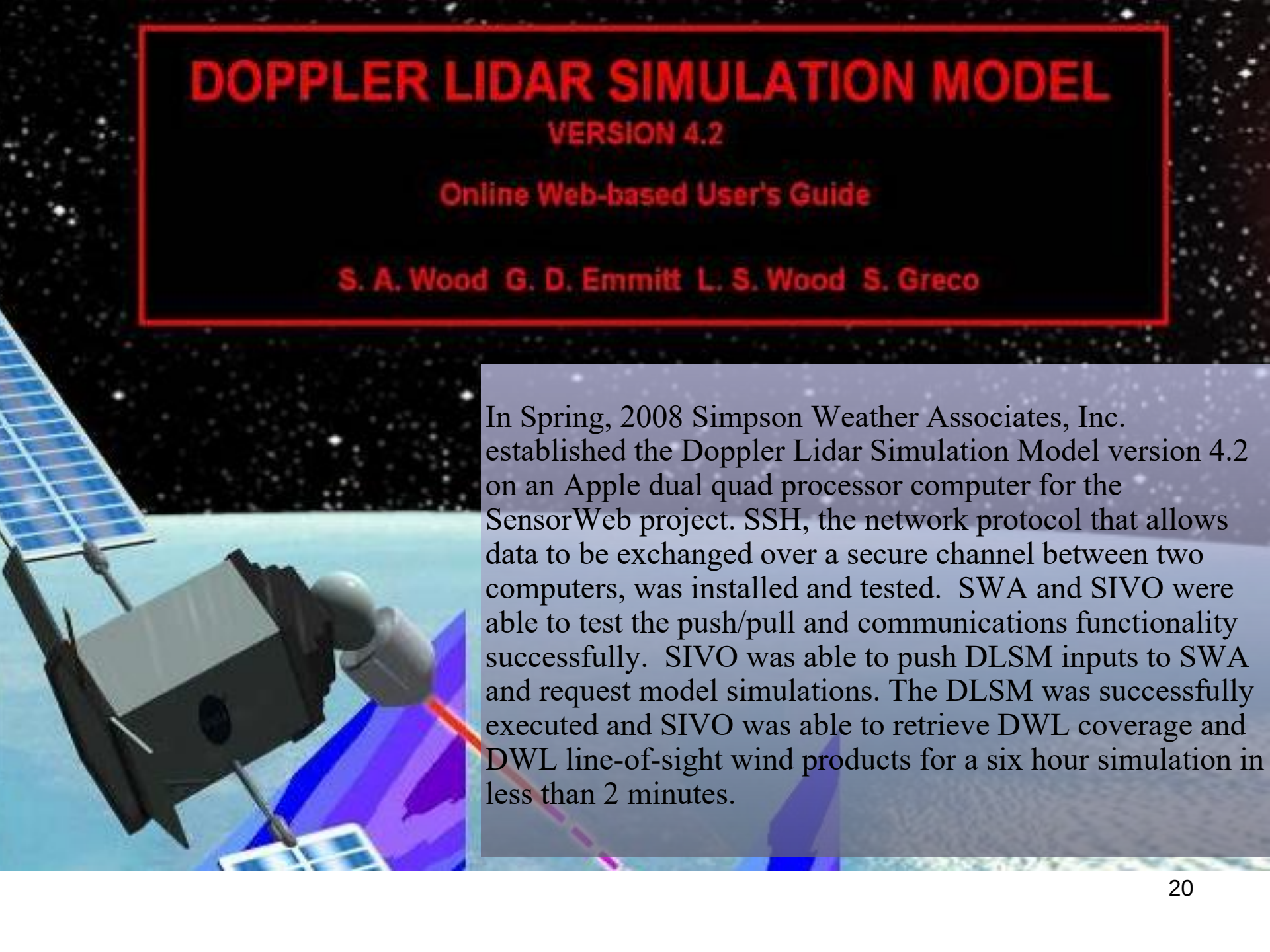


DOPLER LIDAR SIMULATION MODEL

VERSION 4.2

Online Web-based User's Guide

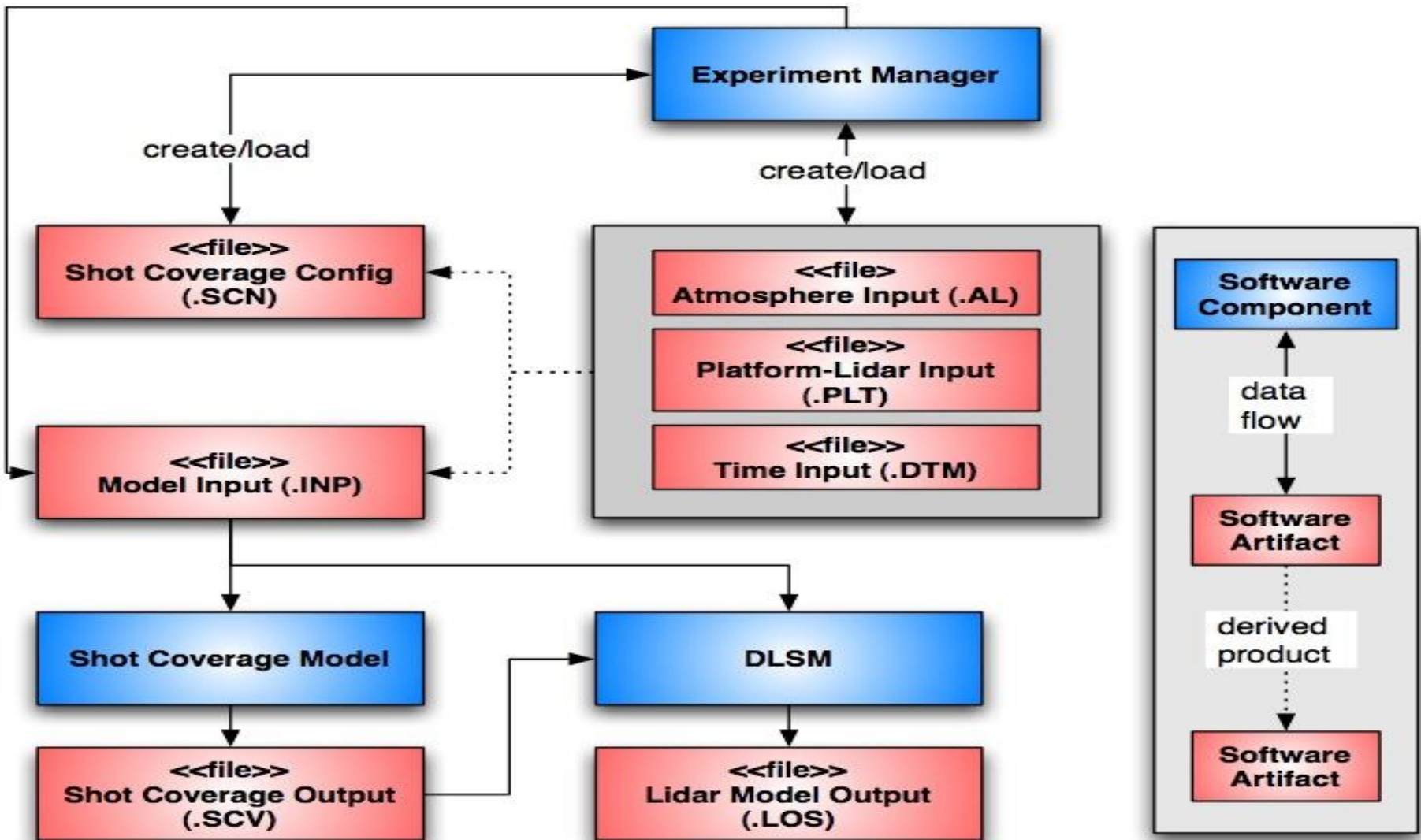
S. A. Wood G. D. Emmitt L. S. Wood S. Greco

A satellite is shown in space, with solar panels visible. A red laser beam is emitted from the satellite, pointing towards the Earth's surface. The background is a starry space.

In Spring, 2008 Simpson Weather Associates, Inc. established the Doppler Lidar Simulation Model version 4.2 on an Apple dual quad processor computer for the SensorWeb project. SSH, the network protocol that allows data to be exchanged over a secure channel between two computers, was installed and tested. SWA and SIVO were able to test the push/pull and communications functionality successfully. SIVO was able to push DLSM inputs to SWA and request model simulations. The DLSM was successfully executed and SIVO was able to retrieve DWL coverage and DWL line-of-sight wind products for a six hour simulation in less than 2 minutes.

Doppler Wind Lidar Simulation Model

Simpson Weather Associates



OSSE Progress and Plans at EMC

- GSI analysis update; improved handling of LOS winds
- OSSE assimilation system will be upgraded to June 2010 version
- GWOS DWL data provided by SWA to be tested for July-August 2005
- NCEP will generate additional reference observations (additional periods)
- GWOS OSSE will be extended to tropical cyclone and winter storm periods
- (Data impacts of SWA and KNMI product for ADM will be compared)
- Coordination with GMAO OSSE to test robustness of results

Summary

- OSSEs are a cost-effective way to optimize investment in future observing systems
- OSSE capability should be broadly based (multi-agency)
 - Credibility
 - Cost savings
- Joint OSSE collaboration remains only partially funded but appears to be headed in right direction
- DWL OSSEs are behind schedule, but we are now ready to test simulated GWOS observations from Simpson Weather