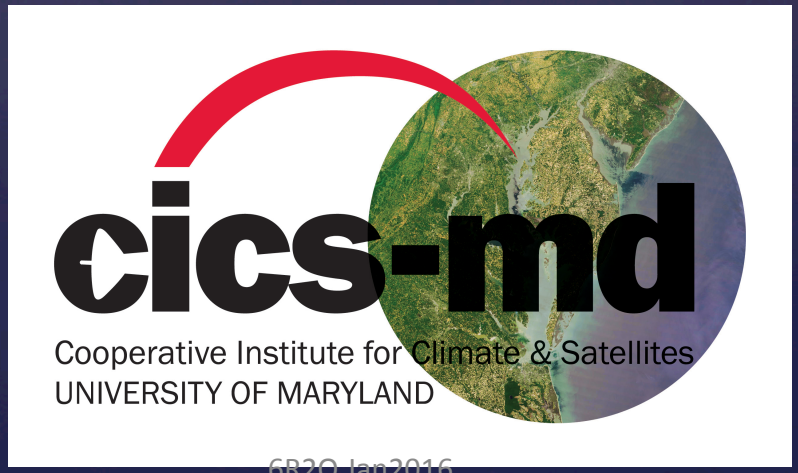
Observing System Simulation Experiments to link Research and Operation

Michiko Masutani

University of Maryland
Earth System Science Interdisciplinary Center
Cooperative Institute for Climate & Satellite-Maryland

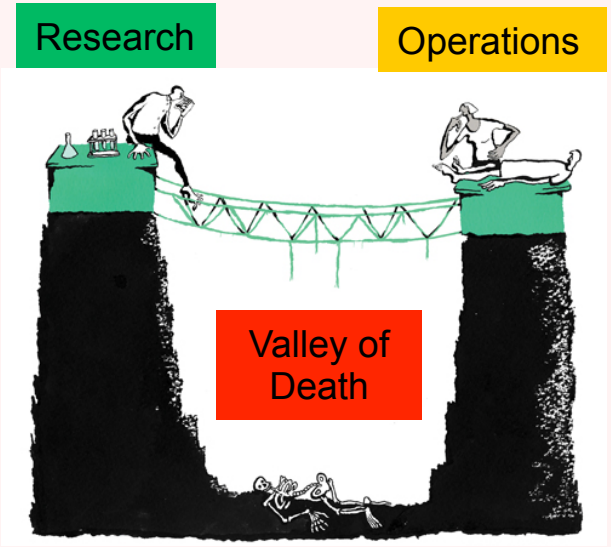
NOAA/NWA/NCEP, JCSDA
masutani@umd.edu



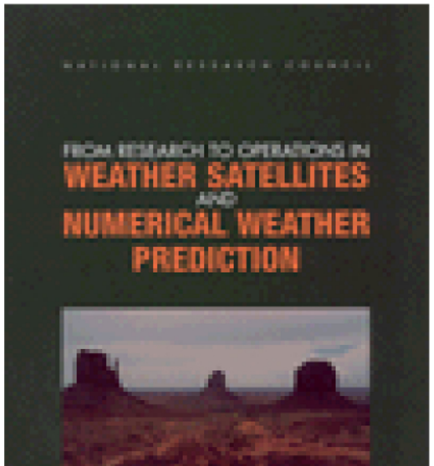
Motivation

OSSE could be a best tool to bridge between Research and Operation.

OSSE could be a painful example of a dead body in the Valley of Death.



From a presentation by Tom Auligne



From Research to Operations in Weather Satellites and Numerical Weather Prediction: Crossing the Valley of Death

Board on Atmospheric Sciences and Climate, National Research Council

ISBN: 0-309-56291-0, 96 pages, 6 x 9, (2000)

Observing System Simulation Experiment (OSSE)

Full global OSSE

- A Nature Run (NR, proxy true atmosphere) is produced from a free forecast run (So called AMIP type run with observed SST, ICE, and Land unless they are not coupled) which is significantly different from the NWP model used in Data Assimilation Systems.

- Calibrations is performed to provide quantitative data impact assessment. Data impact on analysis and forecast will be evaluated.

- A Full OSSE is capable provide detailed quantitative evaluations of the configuration of observing systems in detail.

- A Full OSSE can use an existing operational system including diagnostic tools and utilities. OSSE can also help the development of an operational system.
  - **No special development for OSSE system required for assimilation**

Collaboration in Full OSSE

Collaboration

- Full OSSEs are expensive
  - Sharing one Nature Run and simulated observation saves costs
  - Sharing diverse resources
  - Regional OSSE can be done with less resource at other institutes.
- 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

Reservation towards sharing

Loosing own fund by sharing the product and resources.

Empty promise to share to receive fund, data and software.

May lose credibility by using produce with less credibility.

Sharing enhanced the total interest and total resource to OSSEs but need good scientific manner and rules.

International Joint OSSE Since 2006

Joint OSSE Nature Run by ECMWF

ECMWF Nature run used at NOAA
Spectral resolution : T511
13 month long. Starting May 1st,2005
Vertical levels: L91, 3 hourly dump

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

Simulated observation for Control experiments are available from NASA/NCCS and NCAR

Data distribution
NASA/NCCS
Contact:
Ellen Salmon Ellen.M.Salmon@NASA.gov

NCAR
Currently saved in HPSS Data ID: ds621.0
Contact:
Chi-Fan Shih chifan@ucar.edu

Various OSSEs with Joint OSSE NR

Evaluation of Infrared sounders on the geostationary Hyperspectral Environmental Suite (HES)
Evaluation of Future configuration of GNSS-RO
Evaluation of OAWL and WISCCR DWL
Evaluation of DWSS and JPSS
Simulation of DWL planned from NASA (GWOS, ISS)
Simulation and assimilation of Cloud Motion Vector, ASCAT
Evaluation of Wind Lidar (GWOS, ISS) impact and configuration experiments for NASA
Evaluation of Impact of GWOS on monsoon,
PREMIER InfraRed and MicroWave Limb Sounder measurements by ESA/ESTEC (Environment of Canada)

Polar Communications and Weather mission (PCW)(Environment of Canada)
ADM-Aeolus and follow up mission (KNMI, NASA/GSFC/GMAO)
Studies of Observational errors (NASA/GSFC/GMAO)
Regional OSSE to Evaluate DWL data on Hurricane forecast (Univ Utah)
Rigional OSSE on severe storm (Mississippi State University)
Global OSSE forUnmanned Aircraft System (NOAA/AOML, NOAA/ESRL)
Evaluation of Hybrid Data assimilation system (NOAA/EMC, UMD)
Global OSSE for WISDOM balloons (NOAA/ESRL, NOAA/AOML)
Evaluation of RAOB over India (National Centre for Medium Range Weather Forecasting (NCMRWF))
Analysis and Evaluation of Observing System Simulation Experiments (OSSEs) forecast data for Indian Summer Monsoon (ISM), Indian Institute of Tropical Meteorology
Impact of CYGNSS data: Univ of Miami
Hurricane OSSE:NOAA/AOML

Given to EMC and shared internationally.
No-cost NR helped promote OSSEs internationally.

New Nature runs by NASA/GMAO (2014)
G5NR

GOES-5 Nature Run
By NASA/GSFC/GMAO
(G5NR)

GOCART model with full aerosol, full chemistry, and cloud types

Non-Hydrostatic

Global, 7 km, 72 level model from May 16, 2005-June2007

Data are available in 0.5deg and model resolution with 30min write up.

Pressure level data are provided in 0.5 deg

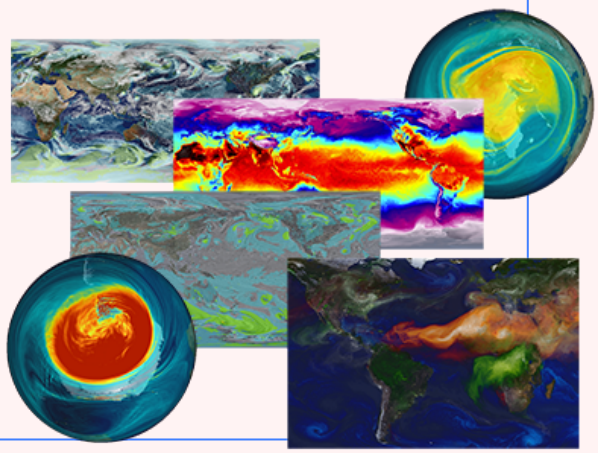
Various time mean data are also provided

Data are available through OPeNDAP to registered users.

For more detail visit:

http://gmao.gsfc.nasa.gov/projects/G5NR/

Comprehensive evaluation is posted.



G5NR image by NASA/NCCS

Interest and reservations

Operational community (developers)

+ OSSE may help to prepare DA system before it become available and speed up operational implementation
+ Operational community are willing to share
+ Opportunity for publication if researchers remember the support provided.
- Resource taken up by OSSE might affect operational development and duty
- Often lose credit when the work is published

Resource for O2R task and tracking record of support may help

The goal is to improve weather and climate forecast. Technology Neutral

Instrument community (Operational or Research)

+ Provides specification of the new instruments
+ Provide plans for future configuration
+ Main stakeholders and funders for OSSE
+ Use OSSE results to work toward recognition of the specific instrument
- Often lack the understanding of Atmosphere. Need help from meteorological community
- Stop fund when they receive results what they need.

The goal is to launch the specific instrument. Not technology neutral.

Interest and reservation (cont.)

Research Community

+ OSSE can provide many answers to fundamental questions in data and data assimilation in ideal setup.

+ Potentially OSSE produce many small project which can be completed by students ***if*** basic resource become available by operation resource.

- Otherwise global OSSE is difficult in a university environment

O2R Require close collaboration with operation to be updated and realistic. Need substantial support from operational community

R2O Make OSSE results in publication (Operational community are less interest in publication)

R2O Research community are now capable to conduct assimilation in OSSE and make feedback to developers.

The goal is publication and personal promotion.

Interest and reservation (cont.)

It is essential to involve operational community to conduct effective OSSEs.

Potential effective collaborations with reanalysis project.

Making Nature run which is same as so-called AMIP run conducted by climate community.

Reanalysis project collect information about past observation

Verification of the OSSE experiments and NR

Need careful plans for an effective OSSE

- Clear question to be answered by OSSE. Decide the resources depends on the question.
  - The requirement for the resolution for NR in horizontal, vertical and time depends on the scale event to be evaluated. Low resolution forecast model NR or high resolution research model NR.
  - OSSE for wind data, error in radiance data does not have to be perfect. But some observational error are vital to evaluation of radiance data. Need effective plan for designing of observational error.
  - Boundary and climatological constant SST,ICE, Land etc used for NR. SST (and other boundary) for OSSE should be same as NR. The difference could ruin the OSSE.

- Assess any simplification

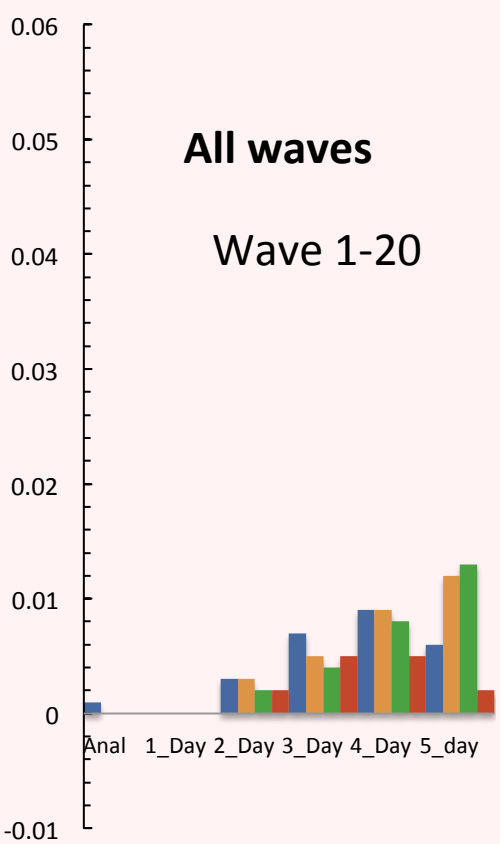
Selection of a Nature run

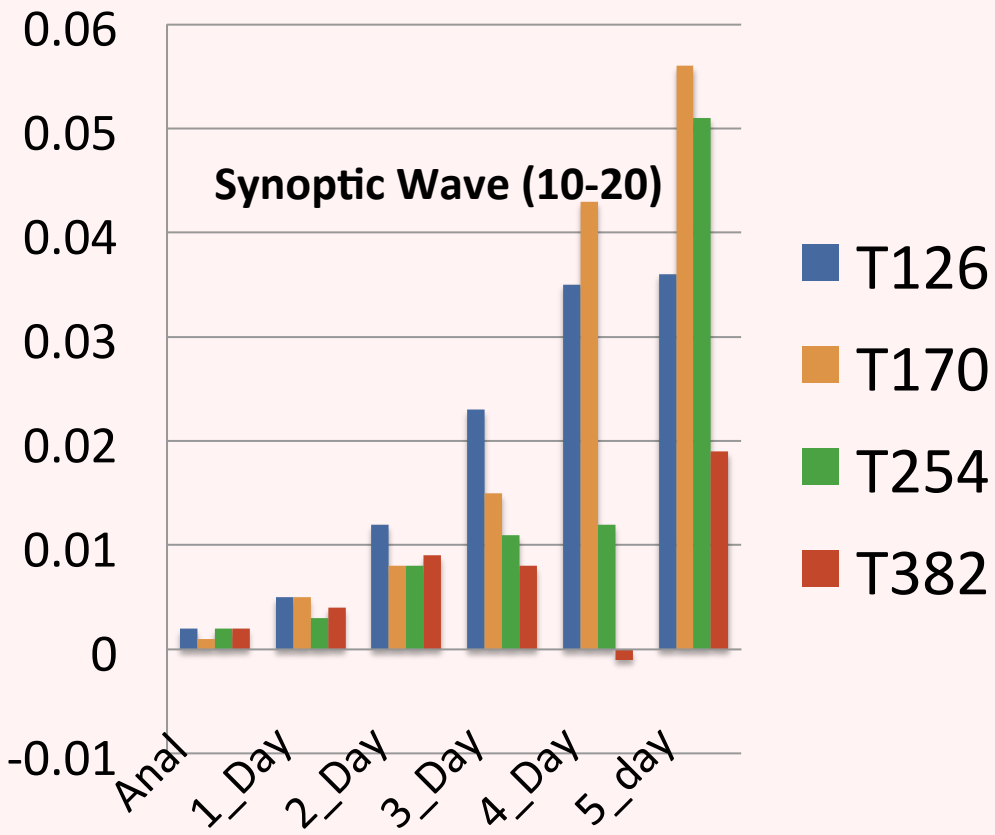
- Well evaluated forecast model with highest forecast skill
  - AMIP type run has to be tested (The latest operational model may not be tested for AMIP run)
- Research model
  - State of arts feature (non hydrostatic, aerosol, cloud, chemistry, in highest resolution) can be involved.
  - Less confidence in forecast skill
- Do not use Analysis
  - The system is forced by observation
  - May be able to use analysis out side of OSSE area
- Recent year
  - Use initial condition and SST ICE from recent year in better quality. This will allow better verification of simulated observation.

Highest demand for the NR make OSSE unaffordable.
We could select one forecast model NR to evaluate large scale data impact and a research model for small scale analysis and short range forecast.
Currently OSSE need NR from good forecast model.(ECMWF NR has been negotiated.

Selection of resolution in OSSE experiments

Improvement in vertically averaged Anomaly correlation by adding GWOS DWL. T511NR is used





Using the highest model for OSSE will not help. Impact in small scale is different from total scale..

Selection of Observing System for the control experiment

The year for the template for the distribution of observation does not have to be same year as NR.

Best to use a set of control observation which is available for the time the new observation.

If observation is simulated at the beginning of NR. Simulated observation can be directly compare with real observation.

It is worth while to produce short NR for the period of OSSE using the same model for the NR to verify simulated observation. They can be compare with real observation.

Two Polar satellite scenario as control configuration used for JCSDA OSSE

2polar = a more reasonable data-gap scenario

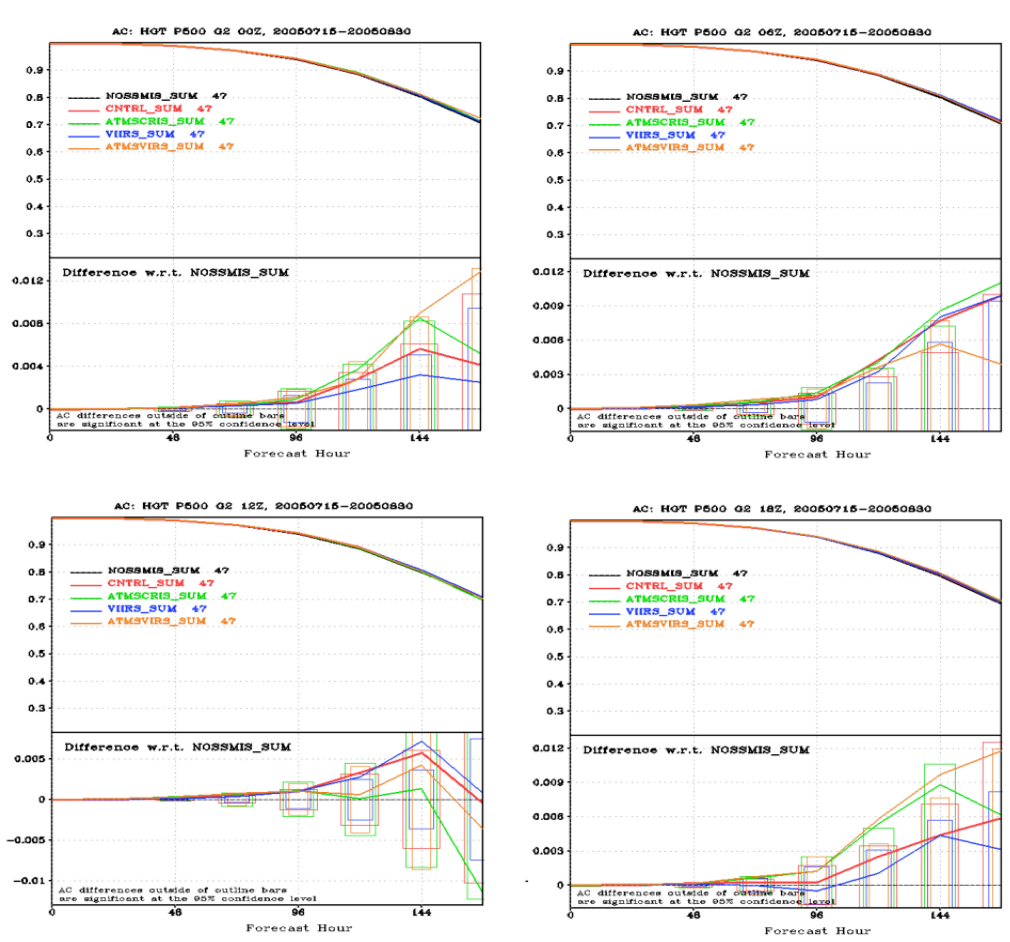
Control	3polar	2polar (PM Gap)	1polar (Mid-AM Only)	Orbit
F16 (SSMI/S)	F16	F16	F16	Early-AM
F17 (SSMI/S)	F17	F17	F17	Early-AM
F18 (SSMI/S)	F18	F18	F18	Early-AM
Metop-A (AMSU/MHS/IASI/HIRS)	Metop-A	Metop-A	Metop-A	Mid-AM
Metop-B (AMSU/MHS/IASI)	Metop-B	Metop-B	Metop-B	Mid-AM
N15 (AMSU)	N15	N15	N15	Late PM
N18 (AMSU/MHS)	N18	N18	N18	PM
N19 (AMSU/MHS)	N19	N19	N19	PM
SNPP (ATMS/CrIS)	SNPP	SNPP	SNPP	PM
Aqua MODIS IR Winds	Aqua MODIS IR*	Aqua MODIS IR	Aqua MODIS IR	PM
Aqua AIRS	Aqua AIRS	Aqua AIRS	Aqua AIRS	PM
Aqua MODIS WV Winds	Aqua MODIS WV	Aqua MODIS WV	Aqua MODIS WV	PM
Terra MODIS IR/WV Winds	Terra MODIS	Terra MODIS	Terra MODIS	AM
WindSat	WindSat	WindSat	WindSat	Early-AM
GOES Sounder, AMVs	GOES	GOES	GOES	GEO
JMA AMVs	JMA AMVs	JMA AMVs	JMA AMVs	GEO
METEOSAT AMVs	METEOSAT AMVs	METEOSAT AMVs	METEOSAT AMVs	GEO

By NOAA/NESDIS

Some unique questions answered by OSSE

- A non scan DWL (ADM-AEOLS) may not have as much as impact as RAOB even though it was expected as "RAOB everywhere". (Masutani et al 2010, Ma et al 2014)
- DWL with two look which produce vector wind increase the impact compared to two look without match in tropics. The impact is more than double of one look. (Ma et al 2014, Masutani,2012)
- Number of vertical resolution in analysis is essential. Horizontal resolution is more important for forecast skill. (Woollen et al, 2008)
- Producing significant impact from targeted observation is not simple even with idealized experiments (Woollen et al, 2008)
- Early morning orbit in DWSS at 00Z, 06Z, 12Z, and 18Z are all different. (Sean Casey et al in JCSDA Quarterly No 42 March 2013)

Experiences with OSSEs demonstrates that they often produce unexpected results. Theoretical predictions of the data impact and theoretical backup of the OSSE results are very important as they provide guidance on what to expect. On the other hand, unexpected OSSE results will stimulate further theoretical investigations. When all efforts come together, OSSEs will help with timely and reliable recommendations for future observing systems. (Masutani et al 2010)



Global impacts on 500 hPa geopotential height anomaly correlation (AC), for forecasts valid at (above left) 00Z, (above right) 06Z, (below left) 12Z, and (below right) 18Z. Upper portions of each diagram represent the AC for each experimental run; lower portions are the differences in AC with respect to the NO SSM/IS (no early morning satellite) forecasts. AC differences outside of their corresponding color bars are significant at the 95% confidence level.

By Sean Casey,JCSDA Quarterly No 42 March 2013

Difficulty in current OSSEs

OSSE verification involve the area where forecast model and RTM are still under development. Cloud, moisture etc.

Data sampling depend on weather pattern is important, this require significant effort and which may not be justified the resource.

- Aircraft data depends on jet location. Cloud track wind depends on cloud. No wind data from center of storm in real world.

NR grid is much smaller than FOV but treated as one point in JCSDA OSSE. (Univ. Wisconsin is working on this issues.)

Possible Future OSSEs Proposed

Observing System Simulation Experiment to evaluate and improve the usage ice observations in global weather forecasts
Proposal by Robert Grumbine and M. Masutani

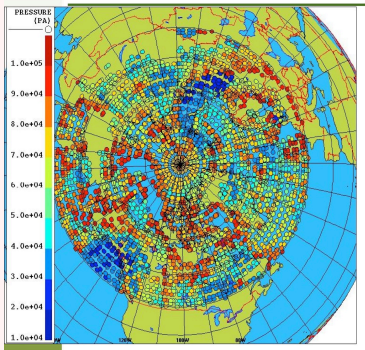
Evaluation of ice require development of emissivity from ice. The verification package at NCEP need improvement in Arctic. Support to for development of verification for Arctic and Emissivity model need to be requested. Using OSSE to evaluate degraded ice observation against perfect ice observation, which is same as ice in NR.

International collaboration in OSSE to improve Arctic observing system

Masutani, M., L. Garand, W. Lahoz, L.-P. Riishojgaard, E. Andersson, Y. Rochon, M. Tsyrulnikov, J. McConnell, L. Cucurull, Y. Xie, S. Ishii, R. Grumbine, G. Brunet, J. S. Woollen, and Y. Sato, 2013: Observing System Simulation Experiments: Justifying new Arctic Observation Capabilities, White paper on OSSE Optimized Modeling, National Centers for Environmental Prediction Office Notes No 473. http://www.lib.ncep.noaa.gov/ncepofficenotes/files/on473.pdf

Complementary role of DWL in ISS orbit and PCW

PCW AMV used in assimilation

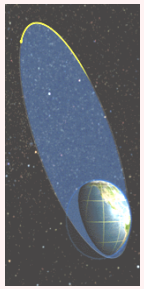


- thinning at 180 km
- no data where cloud free
- 50-90 N/S coverage
- allowed range 100-925 hPa
- every 6-h
- same obs error (by level) for all AMVs

Conditions similar to operational AMVs except +-3-h window for OPE and range 100-700 hPa

Environment Canada Environnement Canada

Canada

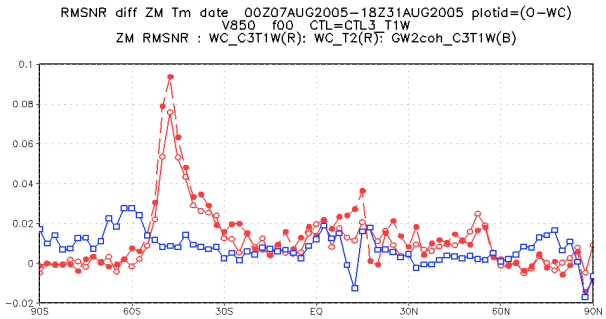


PCW: Polar Communication and Weather satellite
ISS: International Space Station
DWL: Space based Doppler Wind Lidar

ISS allow heavier instruments but just more data to area to data rich area. Current interests are focused on ISS orbit only.

Need to improve assimilation of DWL on ISS orbit

Impact on V 850 hPa



Analysis impact (reduction of RMS Diff from NR, compared to control experiment (existing obs only). Only results from coherent Lidar are presented.

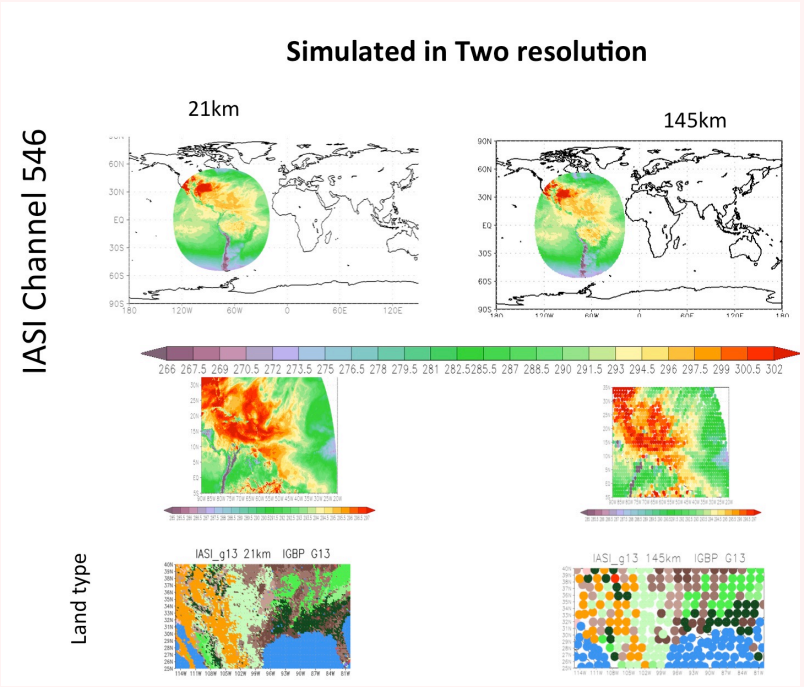
DWL with two looks to produce vector wind measurement.

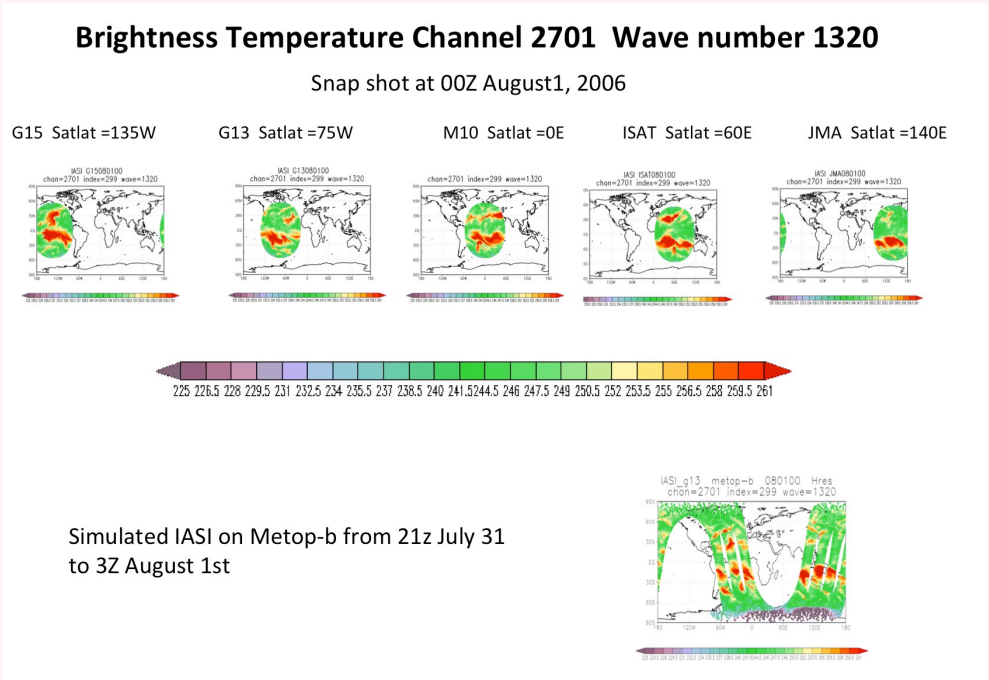
Red, Solid line,open circle:ISS orbit T126 experiment

Red, Dashed line, closed circle: ISS orbit T254 experiment

Blue, Solid line, open circle: Polar orbit T126 experiment

Comparison between spacial and temporal resolution of observation





Preparation for GOES-R data. Plan for sampling strategies using OSSE

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