Next Generation LEO Hyperspectral Sensor IFOV Size Impact on the High-Resolution NWP Model Forecast Performance – An OSSE Study

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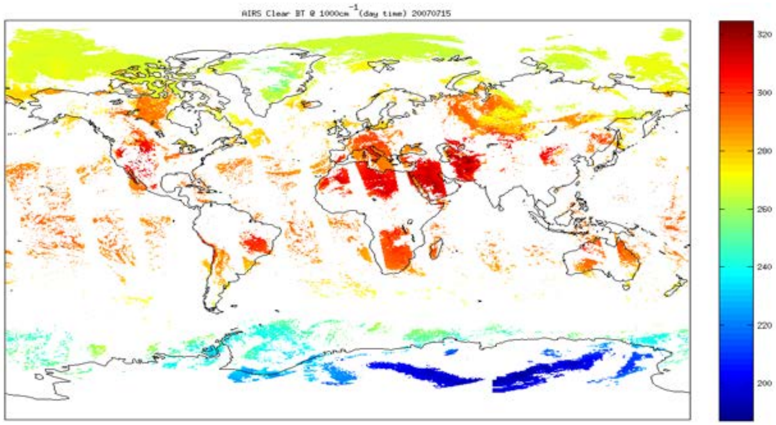
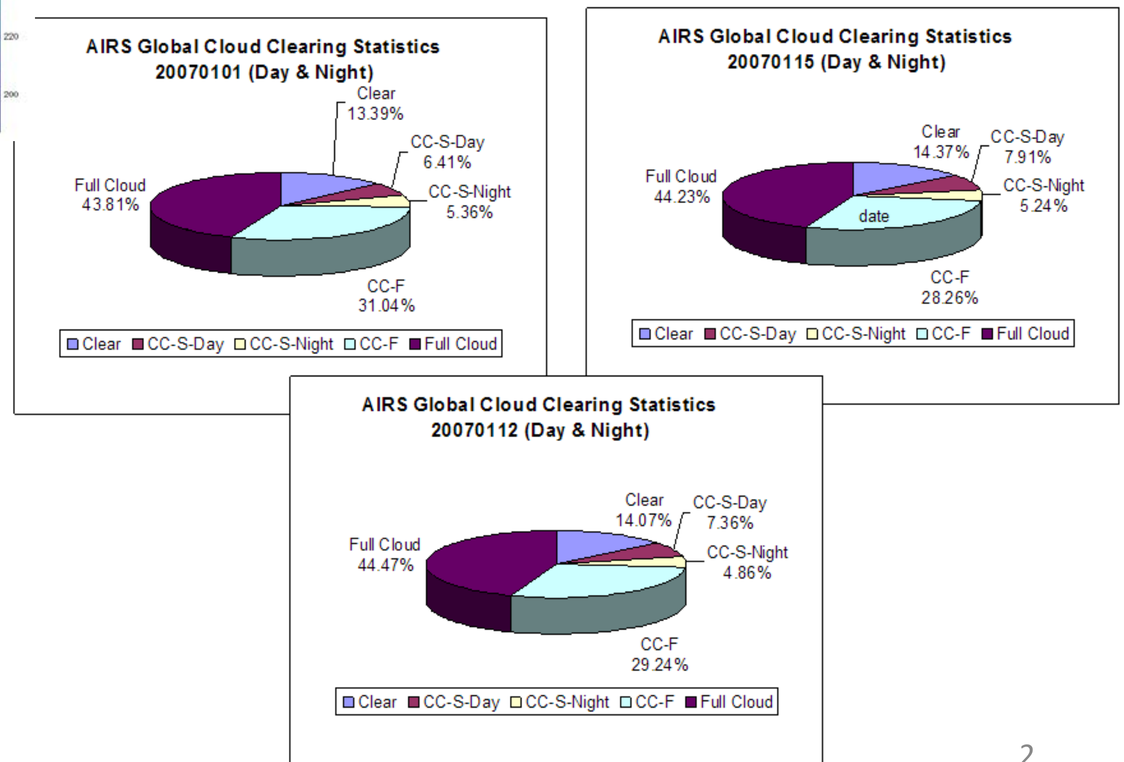
Current Infrared Hyperspectral Sounder greatly impacted by clouds due to large IFOV size (>12 km)



Only 13%-14% IFOV is clear, globally (AIRS study)

AIRS Global Cloud Clearing Statistics



Cloud contamination on Sounding measurements

(Numbers are for a global sample over sea)

Columns: ***Using departures only*** (Clear, Cloudy); Rows: ***Using imager only*** (Clear, Cloudy)

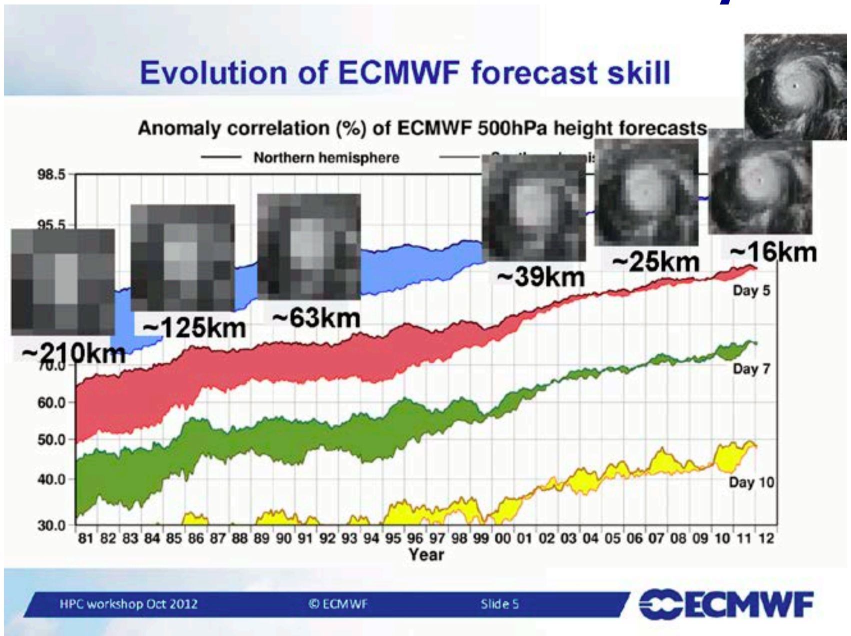
	Clear	Cloudy	Total
Clear	**5.2%**	3.4%	8.6%
Cloudy	5.5%	85.9%	91.4%
Total	**10.7%**	89.3%	100.0%

An independent imager-based cloud flag is determined from the collocated cluster statistics and used as additional input in the imager-assisted scheme

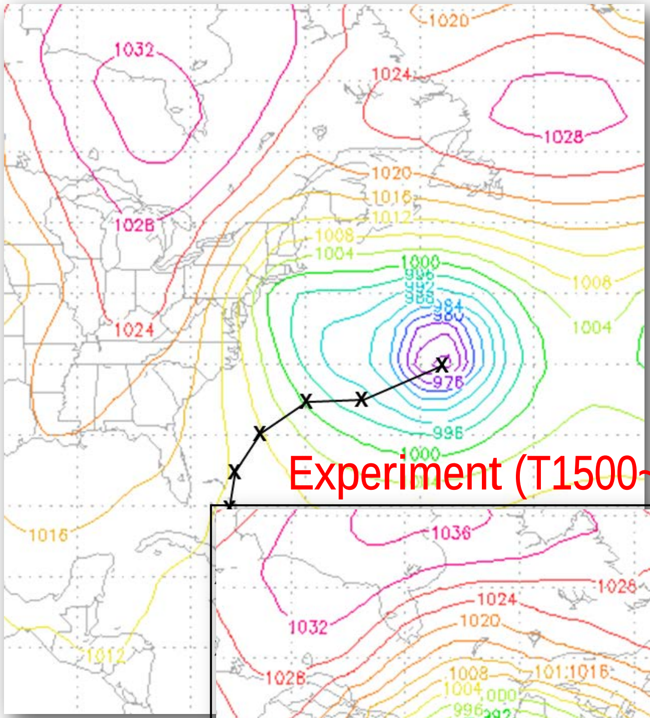
→ Instead of using the departure-based scheme and having ~11% of FOVs completely clear, we use the imager-assisted scheme and reduce the fraction of completely clear FOVs to ~5%

Adopted from Reima Eresmaa of ECMWF

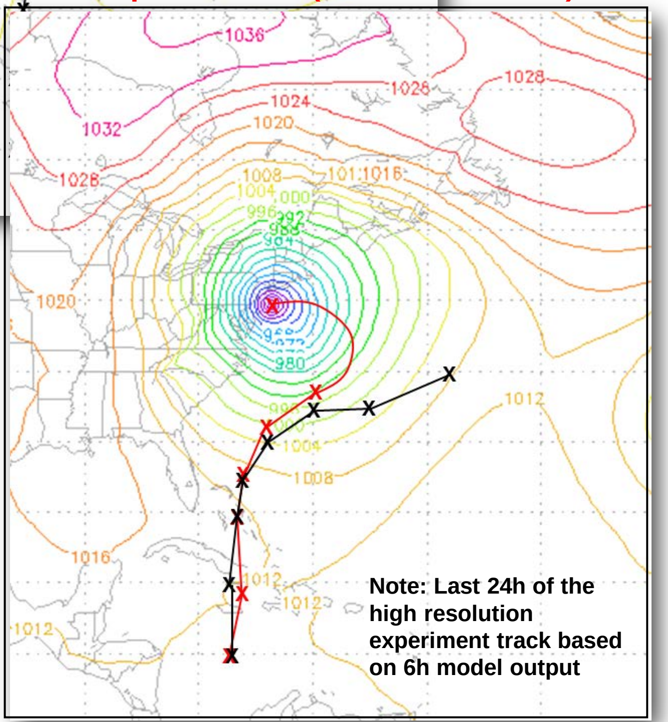
Coarse Model Resolution Greatly Limit Weather Forecast Accuracy



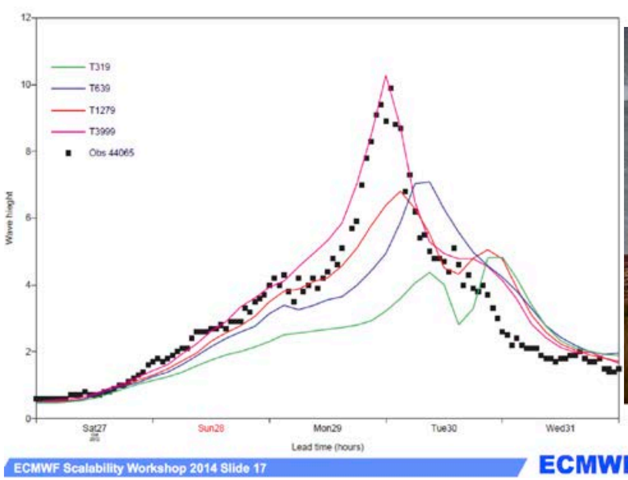
Operational (T574~ 27km)

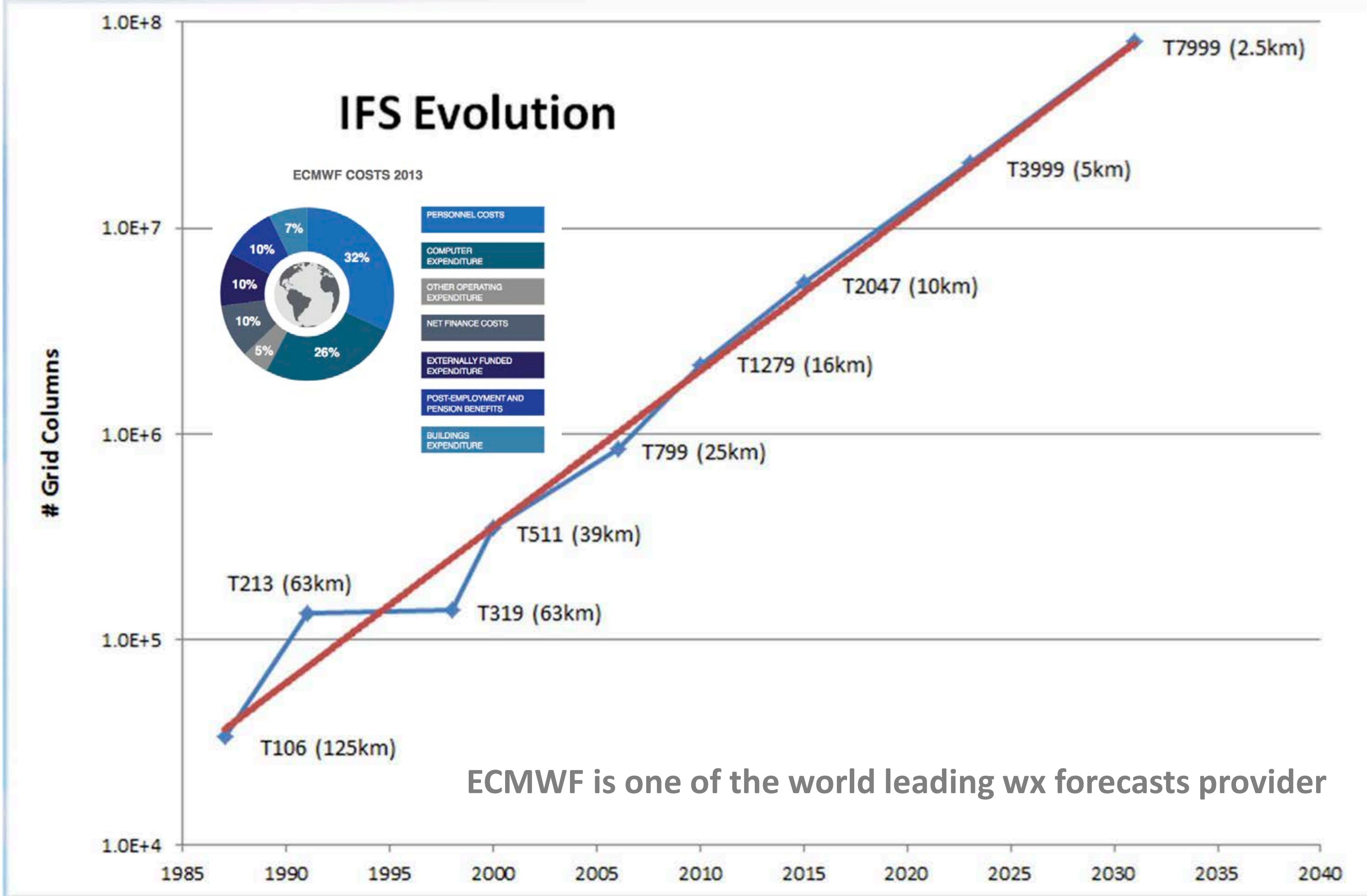


Experiment (T1500~ 13km)



Wave height 72h forecast, T3999 (~5km)




IFS Evolution
ECMWF COSTS 2013
32%
26%
5%
10%
10%
10%
7%
PERSONNEL COSTS
COMPUTER EXPENDITURE
OTHER OPERATING EXPENDITURE
NET FINANCE COSTS
EXTERNALLY FUNDED EXPENDITURE
POST-EMPLOYMENT AND PENSION BENEFITS
BUILDINGS EXPENDITURE
Grid Columns
1.0E+8
1.0E+7
1.0E+6
1.0E+5
1.0E+4
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
T106 (125km)
T213 (63km)
T319 (63km)
T511 (39km)
T799 (25km)
T1279 (16km)
T2047 (10km)
T3999 (5km)
T7999 (2.5km)
ECMWF is one of the world leading wx forecasts provider

Rapid Refresh and HRRR
NOAA hourly updated models
(situational awareness for energy, aviation, severe weather, etc.)

13km Rapid Refresh (RAP) (mesoscale)

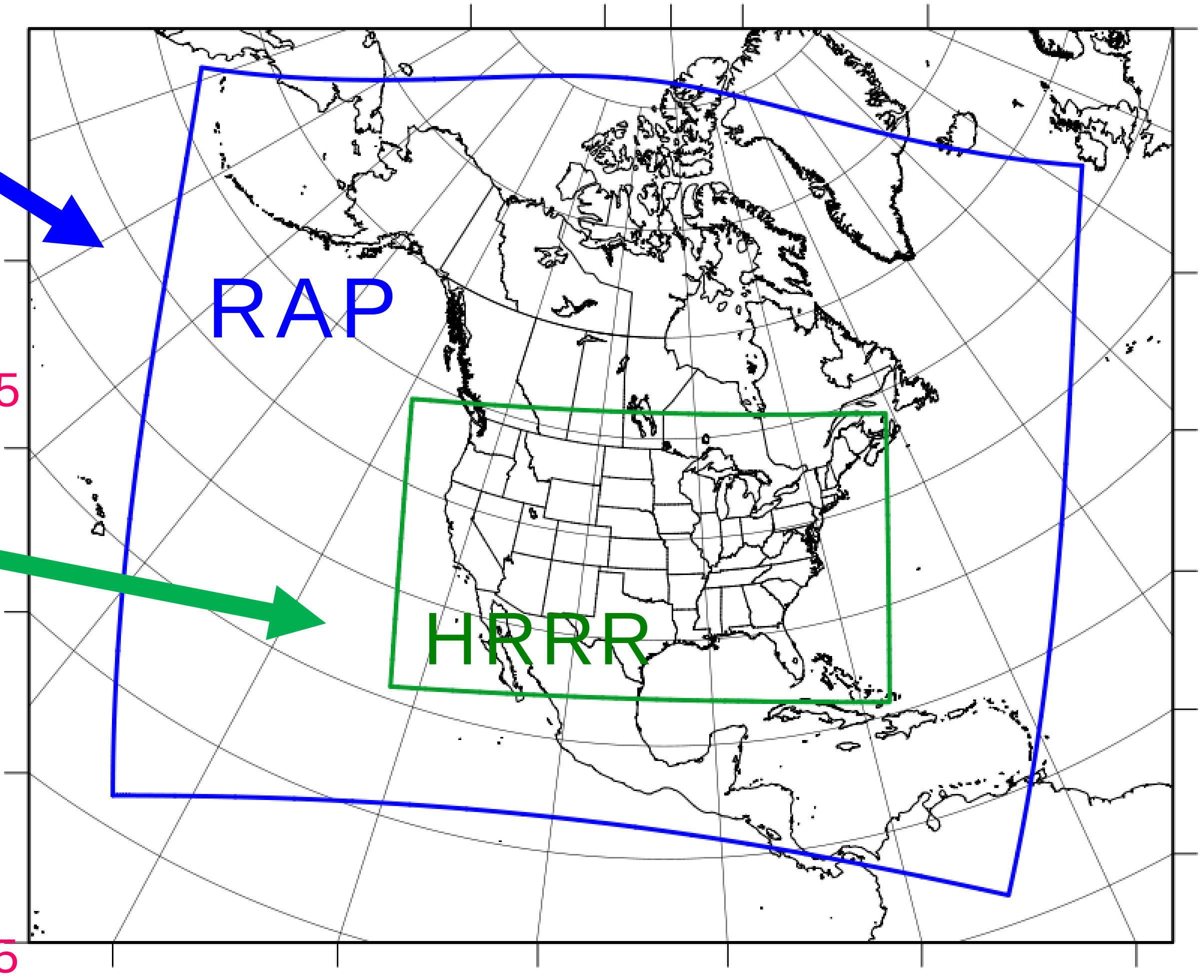
Version 2 -- NCEP implement 25 Feb 2014

Version 3 – GSD Planned NCEP –June 2015

3km High Resolution Rapid Refresh (HRRR) (storm-scale)

Initial -- NCEP implement 30 Sept 2014

Version 2 – GSD Planned NCEP –June 2015



Motivation

To assess the forecast impact obtained from the assimilation of next generation CrIS observations with increased spatial resolution in a high resolution global model
(since the coarse model resolution greatly limit weather forecast accuracy and small IFOV CrIS matters to the model)

Overview of an Observing Simulation System Experiment (OSSE)

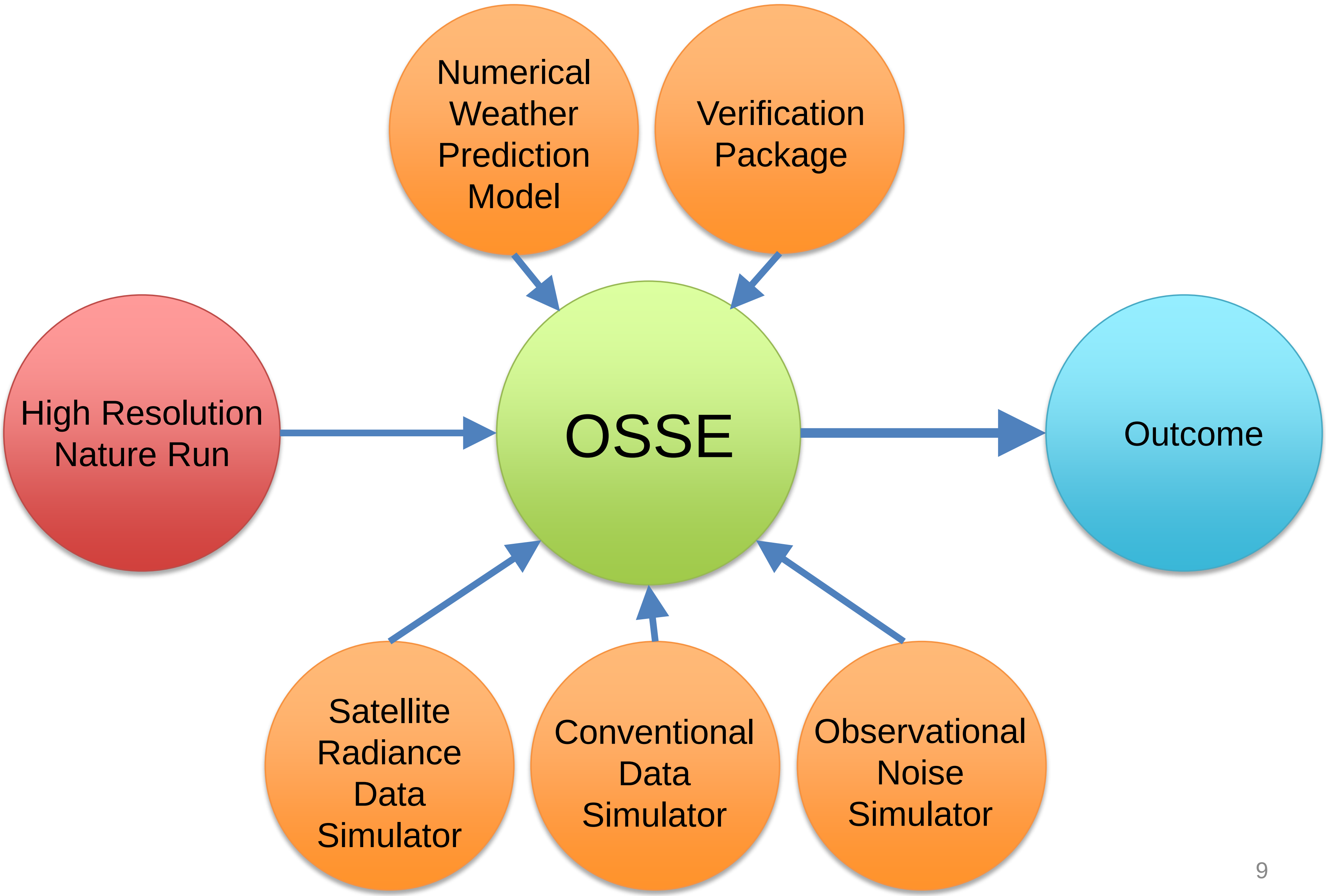
Design to use data assimilation ideas to provide quantitative assessment of the potential impacts of prospective observing systems

Nature Run (NR) – free atmosphere simulated by a state of the art NWP model for an extended period of time.

Use of simulated observations with simulated errors - drawn from NR for current and future observing systems in data assimilation

Key requirement – NWP model used for NR should be **different** from that used for assimilation/forecast to avoid **"identical twin"** problem.

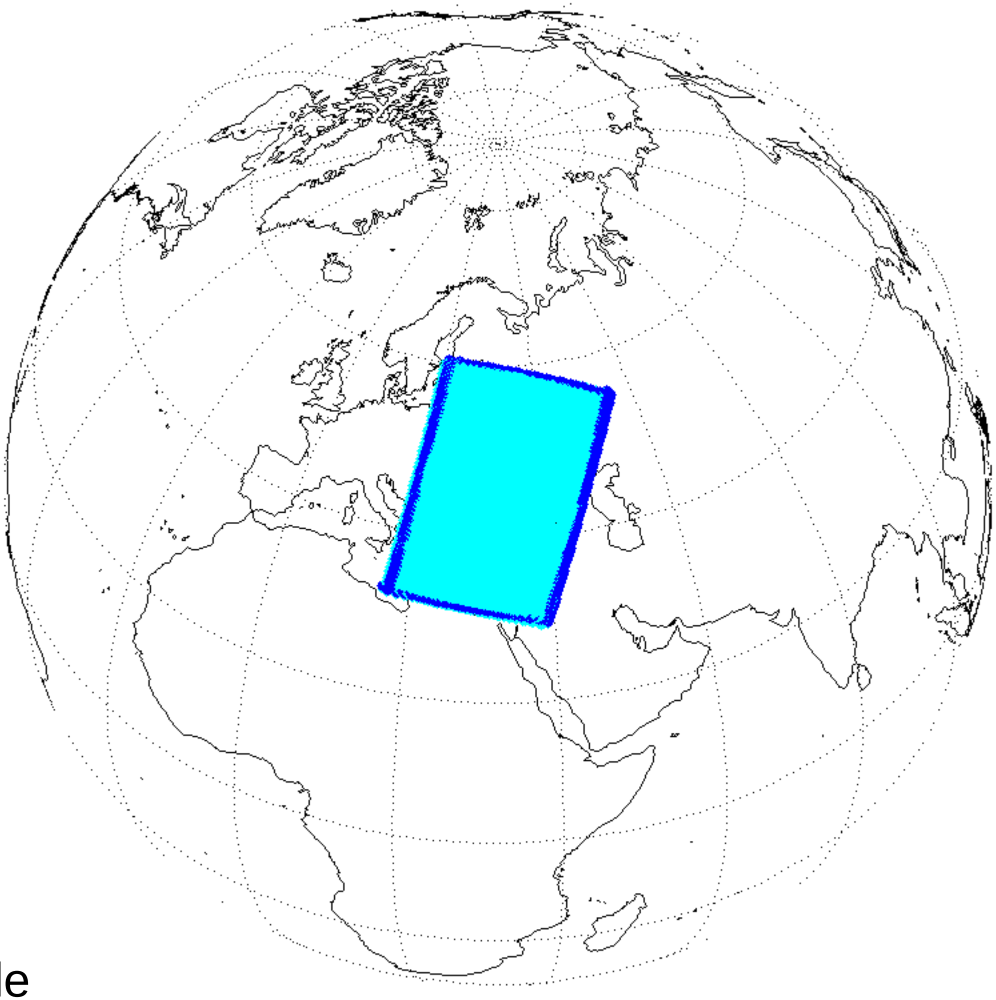
Ingredients needed by an OSSE



Simulation of Satellite Observations

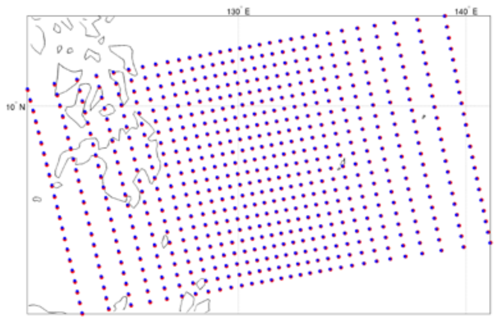
- Flying satellites in the NR.
- Orbit simulator
- **80%** of the sensors assimilated in the operational GDAS included in the OSSE.
- Maintain the same channel usage as the operational
- Community Radiative Transfer Model (CRTM)

Comparison of real CrIS orbits with that generated from the orbit simulator

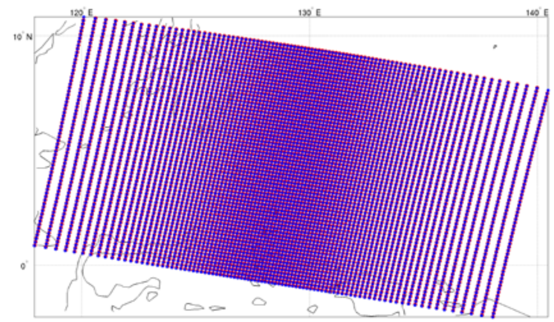


Cyan – real granule
Blue outline – simulated granule

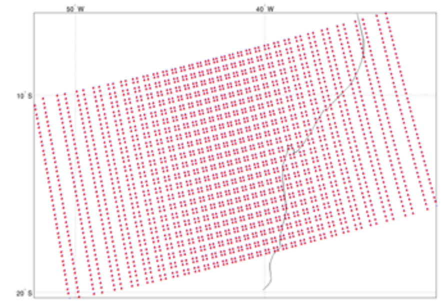
Real satellite orbits versus that generated from the orbit simulator



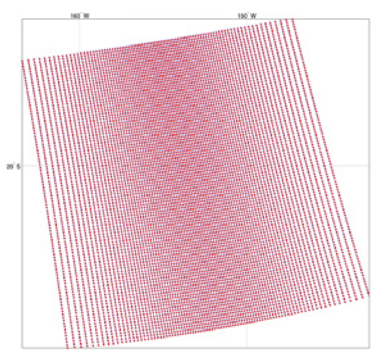
NOAA-15 AMSU-A



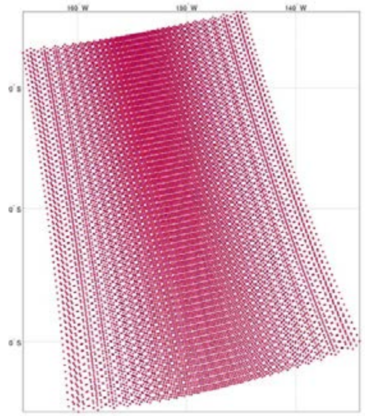
NOAA-18 MHS



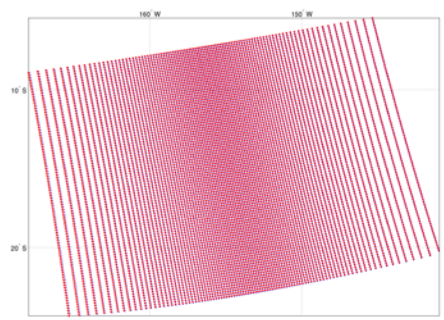
METOP-A IASI



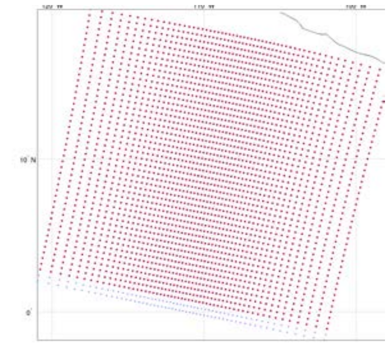
AQUA AIRS



S-NPP CrIS



S-NPP ATMS



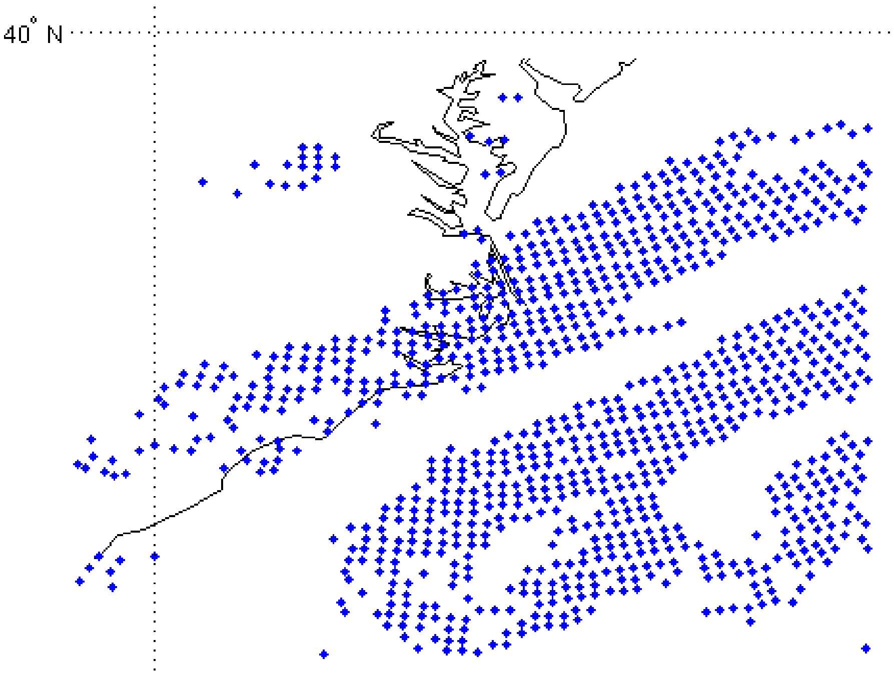
METOP-A HIRS-4

Simulated satellite orbits

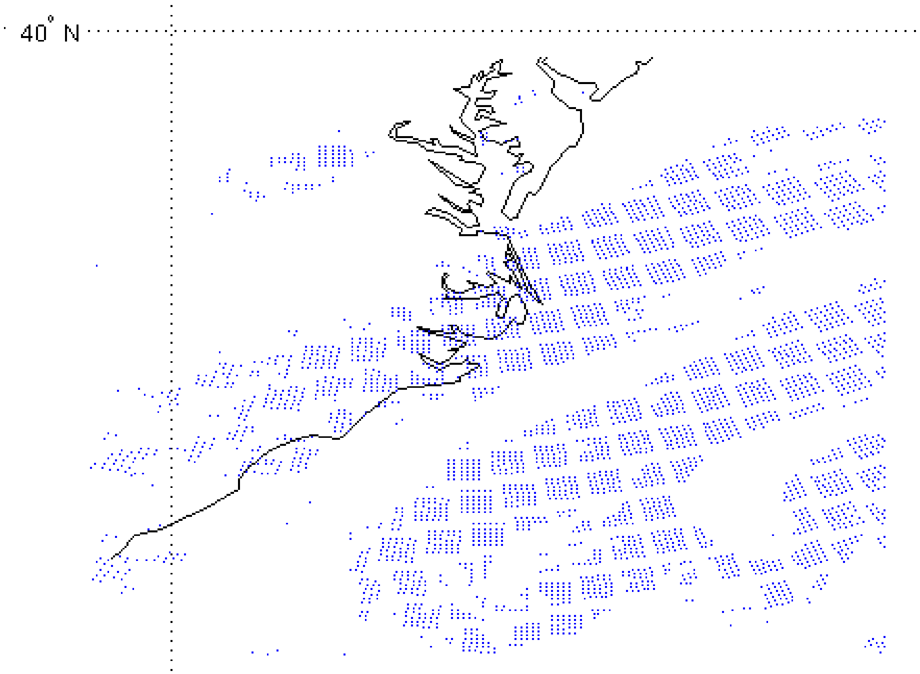
Real satellite orbits

Comparison of current CrIS FOVs with the next generation CrIS FOVs

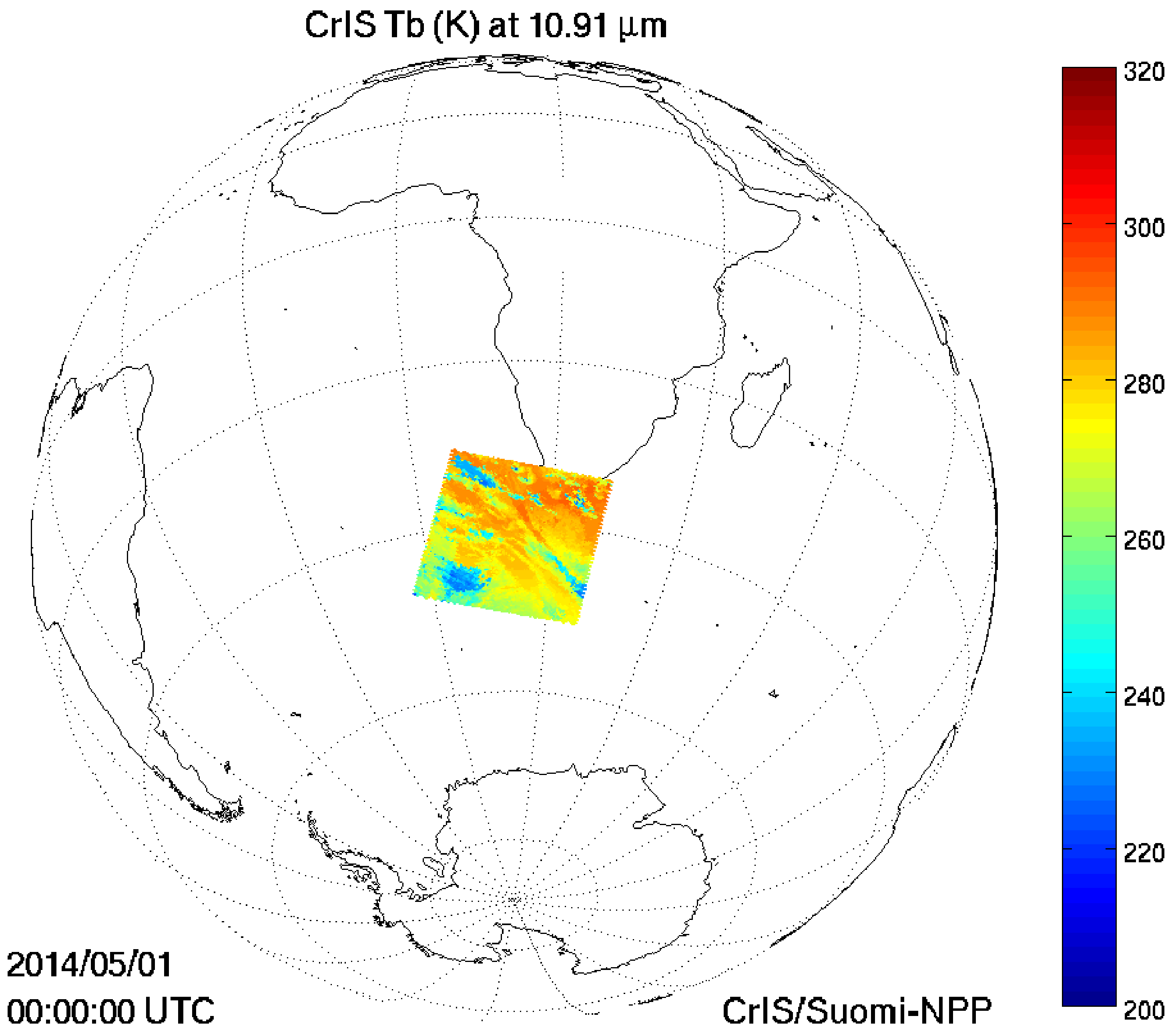
Current CrIS

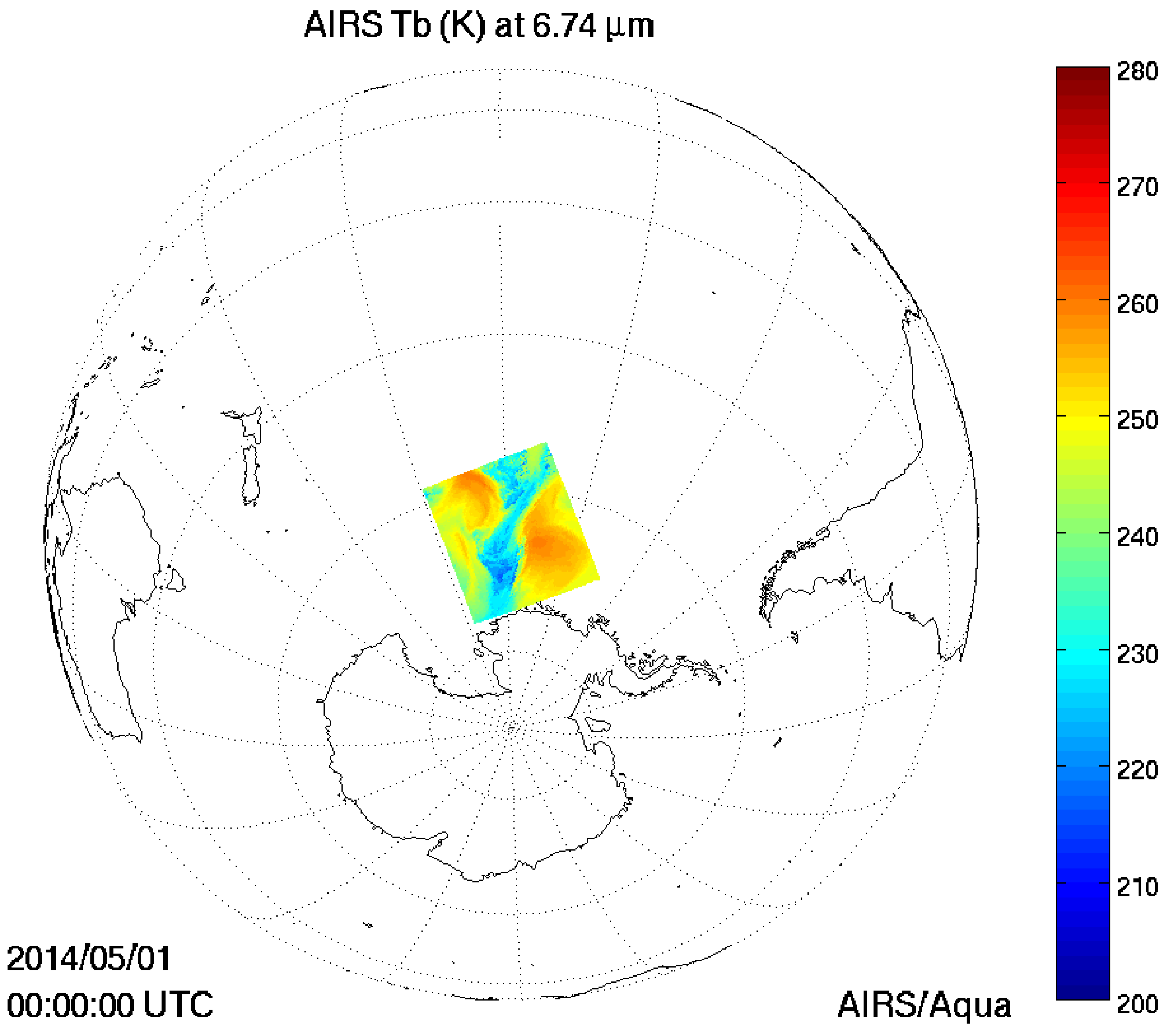


Potential next Gen CrIS



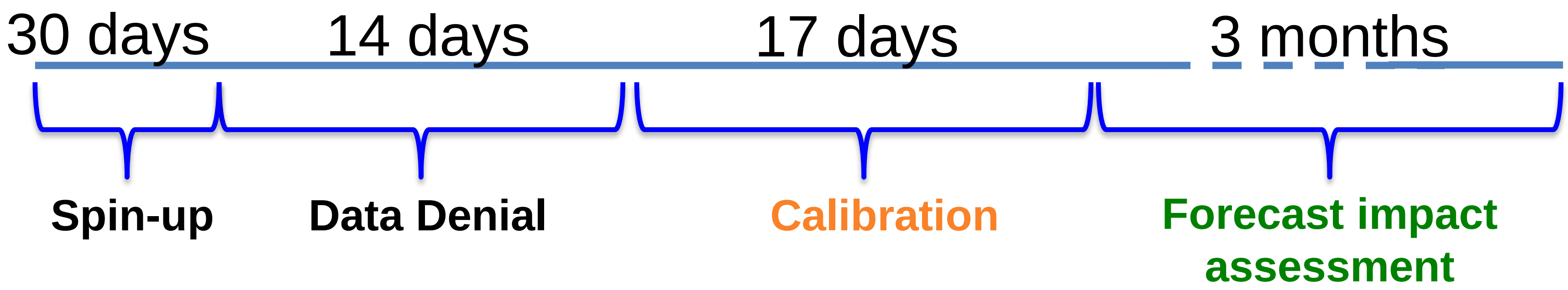
Cloud Mask


CrIS Tb (K) at 10.91 µm
320
300
280
260
240
220
200
2014/05/01
00:00:00 UTC
CrIS/Suomi-NPP



AIRS Tb (K) at 6.74 μm
280
270
260
250
240
230
220
210
200
2014/05/01
00:00:00 UTC
AIRS/Aqua

Experiment Framework



Spin-up: GFS model, bias coefficients and generation of initial conditions for OSSE from NR through high density pseudo rawinsonde assimilation

Data Denial: Model adjustment time for data withheld

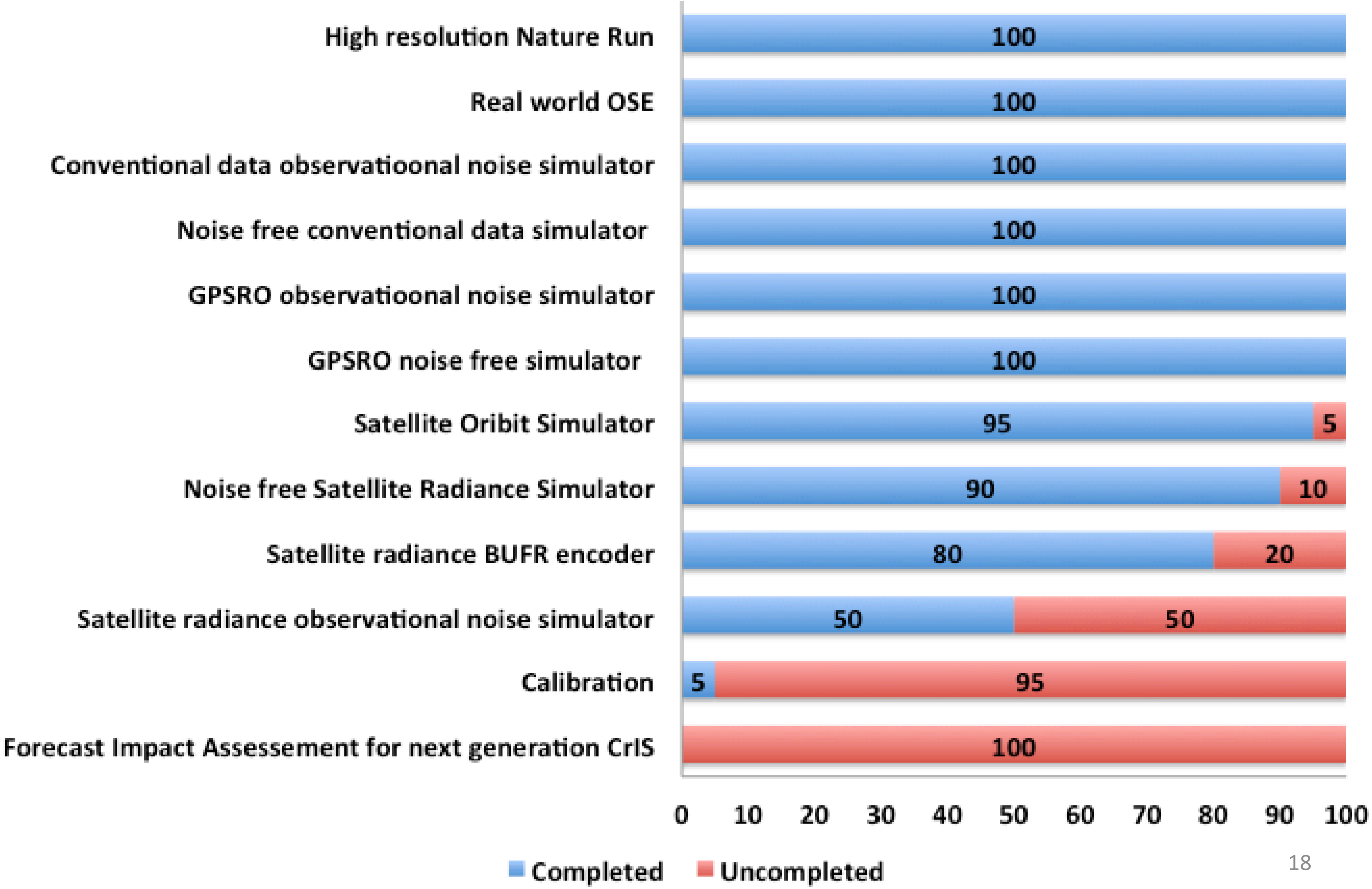
Calibration: Period where statistics are drawn for comparison between real world OSE and simulated world OSE.

Forecast impact assessment: Period where statistics are drawn for evaluation of the performance of next generation CrIS on NWP forecast

Experiments to be conducted

Calibration (both real world and simulated world)
Control
Rawinsonde Data Denial
METOP-A AMSU-A Data Denial
AIRS Data Denial
OSSE
Control + Current CrIS
Control + Next Generation CrIS

Progress so far



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Summary

- Working with NOAA OSSE team a creditable CrIS OSSE infrastructure is under development to support JPSS program in optimizing CrIS IFOV size
  - Note that current CrIS (14 km IFOV @nadir) has excellent signal to noise (S/N) and can achieve acceptable S/N level at much higher IFOV resolution.
  - Exelis now Harris, has a practical design to improve CrIS IFOV resolution with minor engineering effort (i.e. small cost incremental).
- Once built, this OSSE can also be readily adopted for the study of Geo-Hyperspectral IR sounder impacts on NWP model

Thank you for your attention Questions are Welcomed

We wish to thank:

- NASA GMAO for providing the Nature Run.
- Nigel Atkinson (UK Met Office) and Psacal Brunel (Meteo France) for providing information/test code for the modeling of unsteady non-zero yaw angles of METOP-A/B
- Radio Occultation Meteorology SAF for providing the Radio Occultation Processing Package as well as /technical support on the software usage.
- Sean Casey, Hongli Wang and Michiko Masutan for sharing their experience and providing various ancillary files needed by GFS.
- Szuchia Moeller, Nick Bearson and Derrick Herndon for post processing ATOVS data for orbit simulation comparison.
- NOAA/NESDIS. The experiments were run on the Supercomputer for Satellite Simulations and data assimilation Studies (S4) located at the University of Wisconsin– Madison