Geostationary Hyperspectral Infrared Constellation: Global Observing System Simulation Experiments for Five Geo-HSS Instruments

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Outline

- Motivation (slide 3)
- Improvements for 2015 experiments (slides 4-9)
- Geostationary IASI Constellation experiment set-up (slides 10-13)
- Summary (slide 14)

Motivation

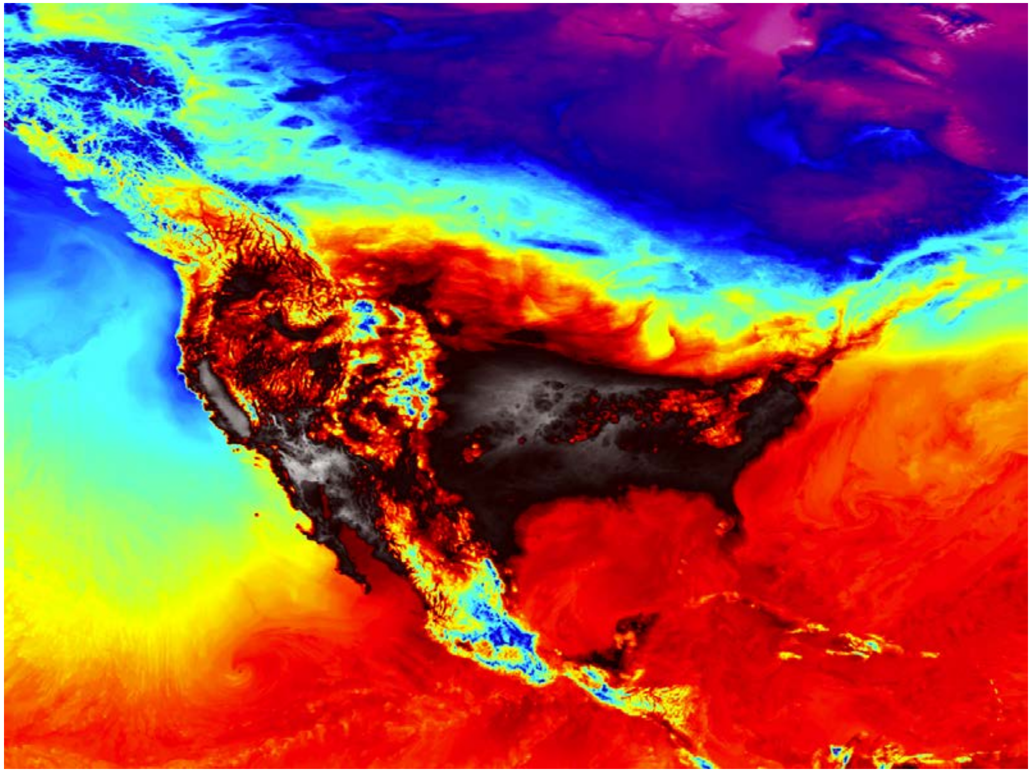
- Disaster Relief Appropriations Act of 2013 (H.R. 152), Title X, Chapter 2, Section 4 included funding "to improve weather forecasting and hurricane intensity forecasting capabilities, to include data assimilation from ocean observing platforms and satellites"
- NOAA OAR awarded a portion of these funds to AOML (R. Atlas, PI) for a larger Observing System Simulation Experiment (OSSE) investigating prospective new observations, including geostationary hyperspectral-IR sounders
- As part of this larger project, UMD/ESSIC scientists at the Joint Center for Satellite Data Assimilation (JCSDA) are working with the Global Forecast System (GFS) developed by NOAA/NCEP to investigate global impacts of new sensors, as well as providing boundary conditions for regional studies by other project partners and investigate improvements to be made to simulated observation experiments

Geo-Hyper Experiments, 2014 vs. 2015

- Last year's CICS-MD Science Meeting, I presented preliminary results for one Geo-HSS instrument
- Nine areas of concern for 2014 study that have been remedied for 2015 study
- Cover each aspect of OSSE process:
    - Nature Run (1)
    - Simulation (5)
    - Analysis (2)
    - Forecast (1)
    - Verification (1)

System Tool	2014 study	Current 2015 study
Nature Run (NR)	ECMWF T511	GMAO 7-km
Conventional obs errors	None	Assigned random errors as appropriate
GPSRO obs type	Refractivity	Bending-angle
GPSRO obs errors	None	Assigned random errors as appropriate
CRTM version	2.0.5 (control obs only)	2.1.3
Test obs simulation	SARTA (U. Wisconsin)	CRTM (JCSDA)
GDAS/GFS resolution	T382 analysis, forecast; T190 3D-hybrid ensemble	T670 forecast; T254 analysis, 3D-hybrid ensemble
Radiance bias correction	Two-factor (one internal to GSI assimilation, one external)	One-factor (internal in GSI assimilation)
VSDB	Version 16	Version 17

Improvements for 2015: G5NR

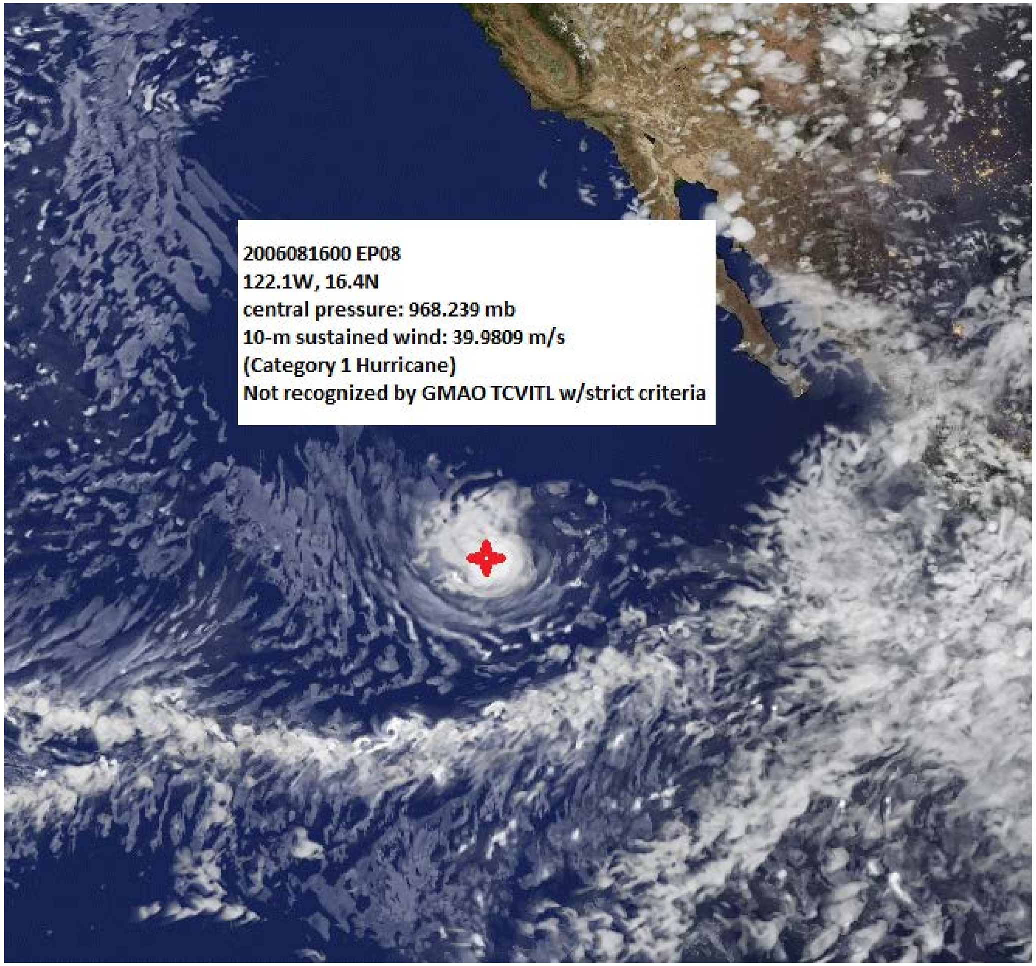


- Above: Surface Temperature, 2006081500, GMAO Version-5 Nature Run (G5NR)
- 7 km resolution (much higher than previous ECMWF T511 NR)
- Simulating PS, UV, T, Q, RAD, GPS, & TCP obs from these for two seasons:
    - August-September 2006 (including focus on TC making landfall in Alabama)
    - April-May 2006 (including focus on strong MCS over Great Plains)

GFS upgrades

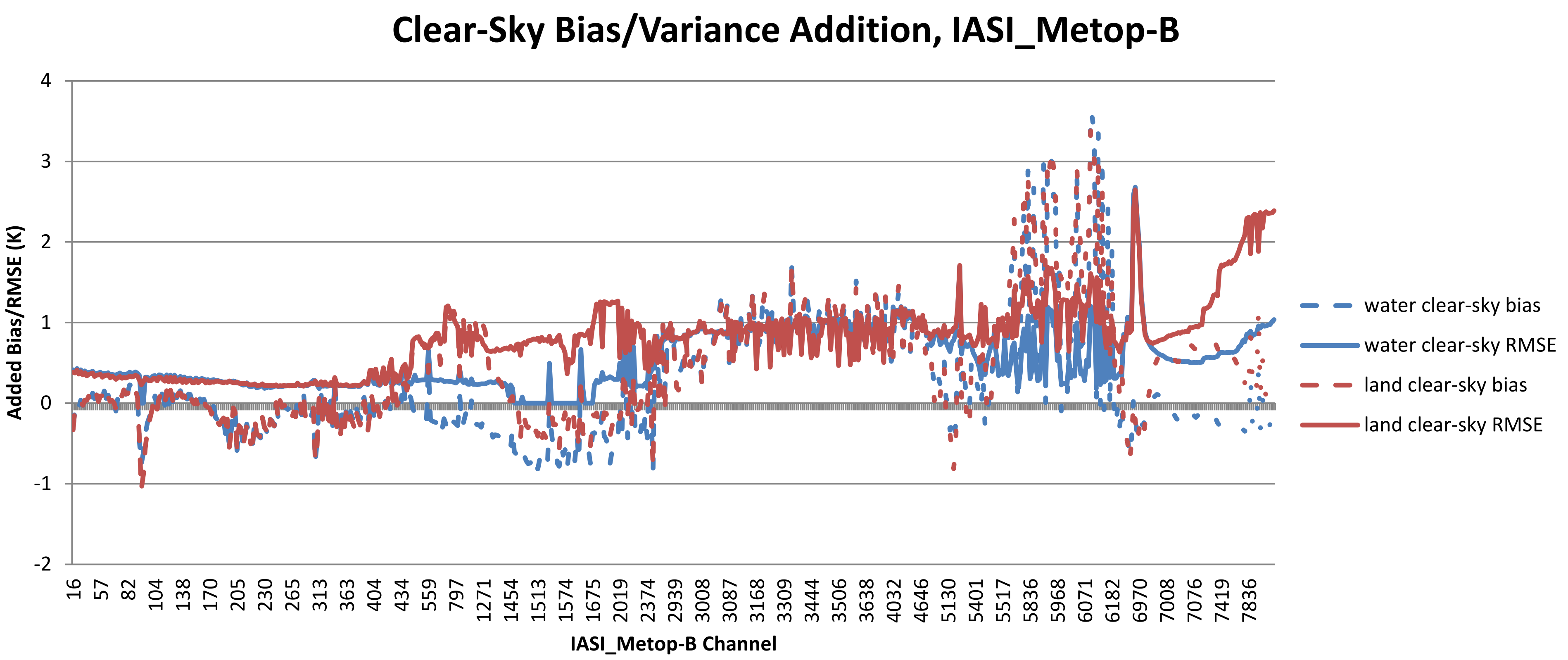
- Previous work used a 2012 version of NWPROD ported onto the NCCS JIBB cluster
- Current study to use 2014 operational version
- Modified as needed for OSSE setting
- Allows for:
  - Newer RTM assimilation (CRTM-2.1.3)
  - Higher-resolution (T1534 forecast, T574 analysis/ensemble) given higher-resolution NR
  - Improved radiance bias correction scheme (Zhu et al. 2013, QJRMS), allowing for less spin-up time

Tropical Cyclone Pressure Observations



- Simulated by GMAO from the G5NR using Putman/Reale algorithm
- Four strict criteria were used to identify storms:
  - alignment
  - vorticity
  - presence of a warm core
  - wind speed
- Tracks strong storms effectively, but misses genesis and lysis stages
- Left: Cat 1 hurricane missed by algorithm (during lysis stage)
- Developed algorithm to expand tracks through genesis, lysis stage
  - Only works on storms identified by Putman/Reale algorithm
  - Considers central pressure, maximum 10-m wind speed

Adding random errors to observations



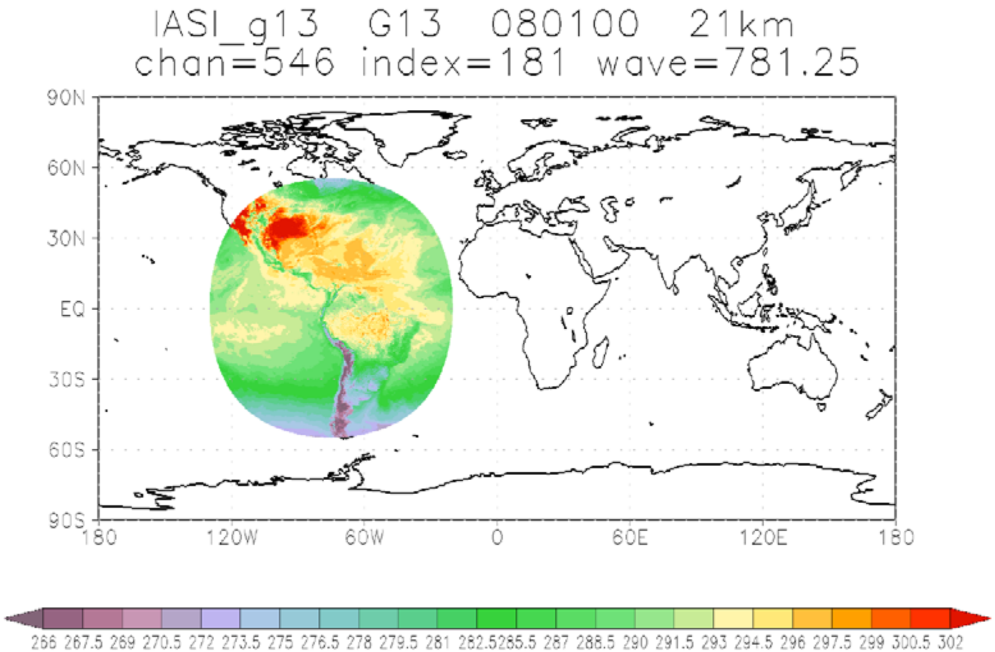
- Assimilation package identifies RMSE (O-B) for each observation type
- Most obs types show significant differences in RMSE for real, simulated obs
- Above: Bias/RMSE added to IASI_Metop-B simulated radiances (clear-sky) in order to match error characteristics noted in real observations
- Similar methodology applied to all other observation types (except TCP…)

Adding random errors to observations

Basin/Metric	Tropical Storms	Category 1-2	Category 3-5
Atlantic west of 60°			
-pressure (mb)	3.8	4.4	4.9
-location (n mi)	27.5	18.6	14.0
All other observations			
-pressure (mb)	7.3	9.6	11.9
-location (n mi)	43.1	29.0	15.4

- Many more TCs in G5NR than in real-world comparison period
- Small number of observations in real-world comparison period renders direct comparison/calibration ineffective
- Instead, adding central pressure, location errors based on Landsea/Franklin 2013 (above)
- Numbers converted from Mean Absolute Error to 1-sigma (above)
- Chi-squared distribution used for position magnitude errors (2 degrees of freedom)

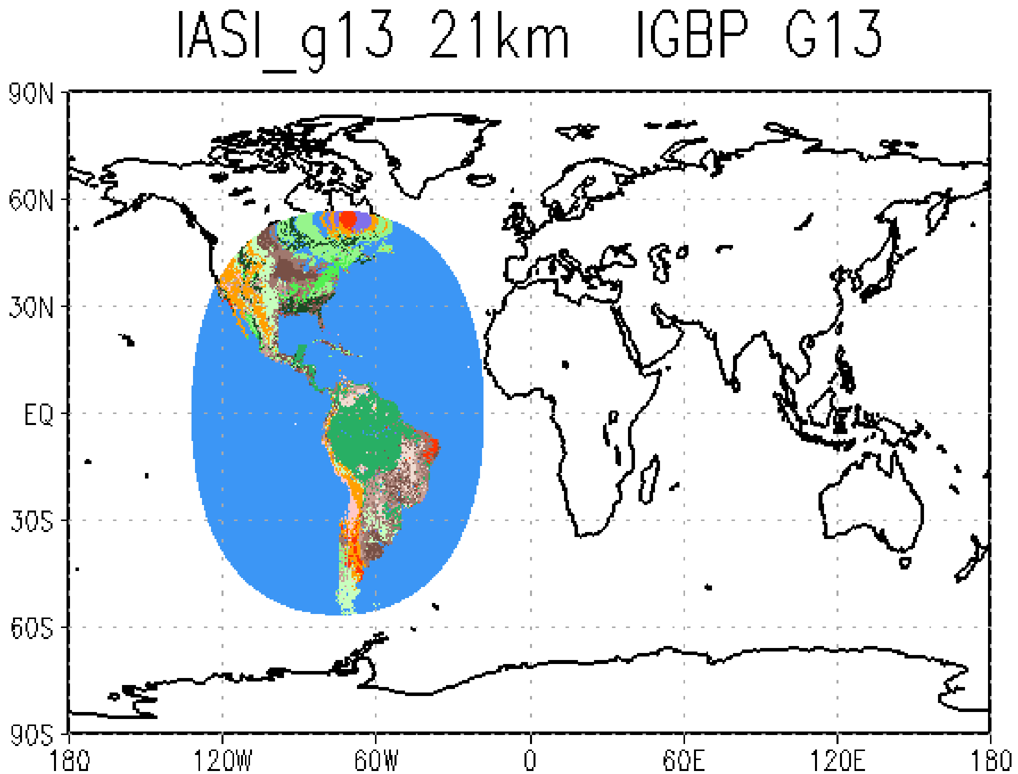
Geo-IASI



Sim. T_B courtesy M. Masutani

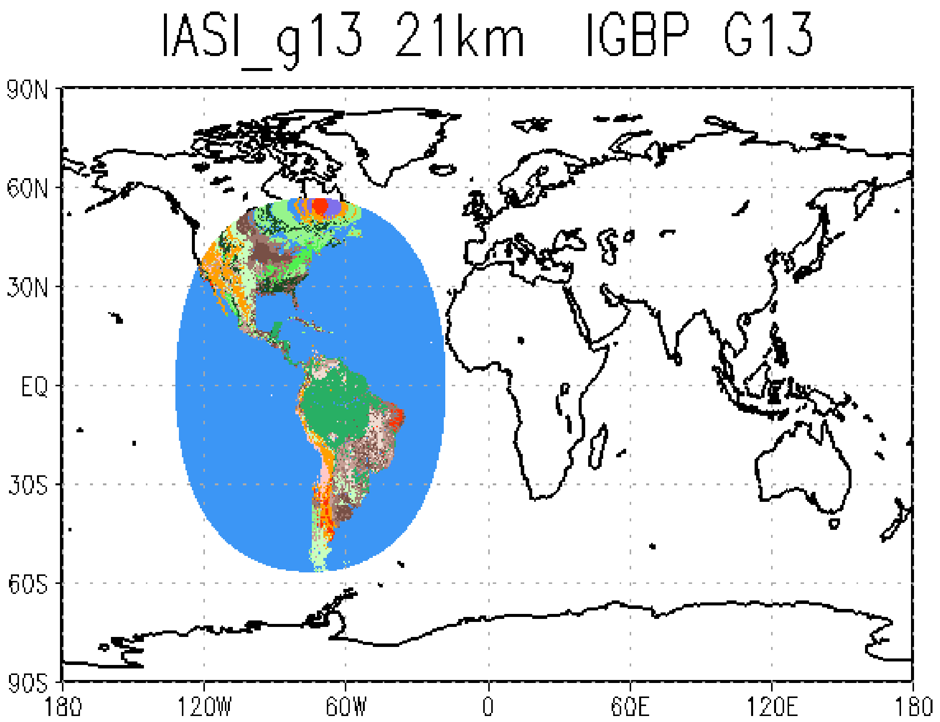
- Experiment will be testing a data-gap scenario with no early-afternoon orbit
- Only satellite radiances to be used for control observations are:
  - Metop-B (AMSUA/MHS/IASI)
  - F18 (SSMIS)
  - GOES Sounder
  - SEVIRI-M10
- IASI only hyperspectral IR instrument included in control obs
- Will use IASI as the test Geo-Hyper IR instrument, to simplify addition of representative errors

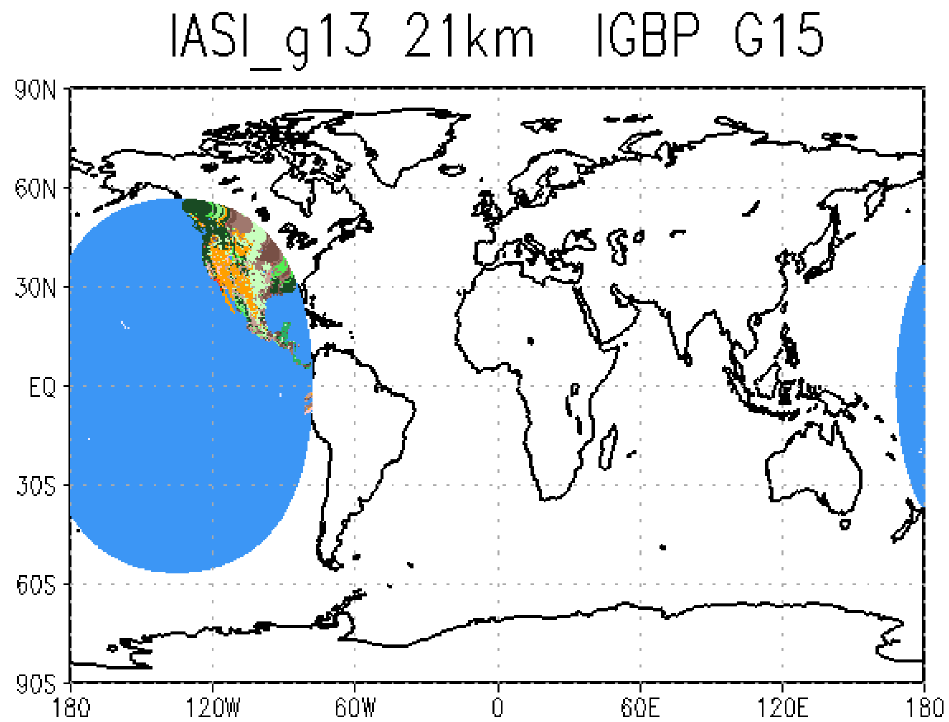
IASI – GOES East (HSS1)



- Testing impact of one Geostationary Hyper-IR instrument over 285°E (plotted above, land type)
- Covers area of hurricane making landfall along Gulf Coast, strong MCS over Great Plains in NR
- Low impact for western US, as well as on global forecasts

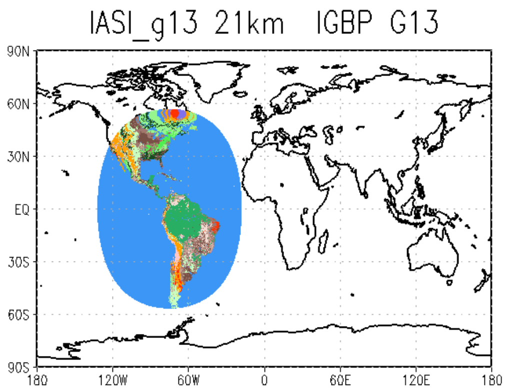
IASI – GOES West and East (HSS2)

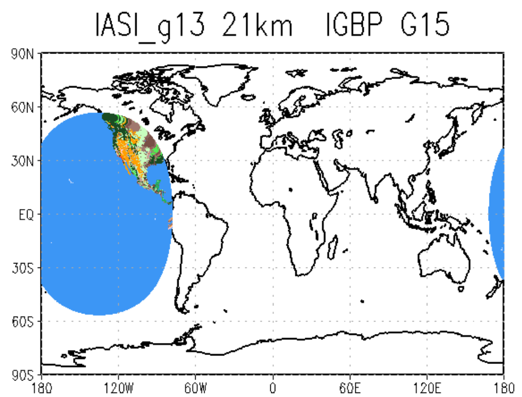


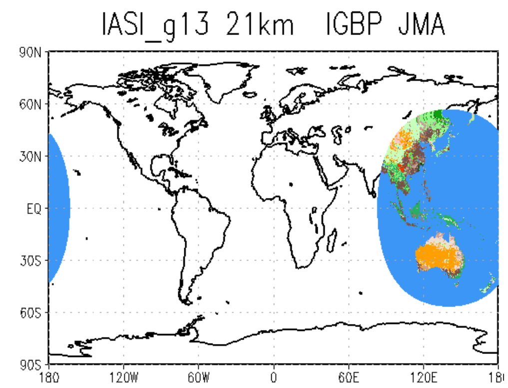


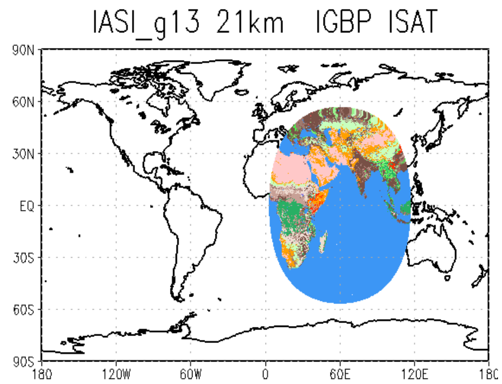
- Adds a second Geo-IASI over 225°E
- Full coverage over Central/East Pacific, 49 out of 50 states (sorry Alaska)
- Global impacts still limited due to large Eastern-Hemispheric gap

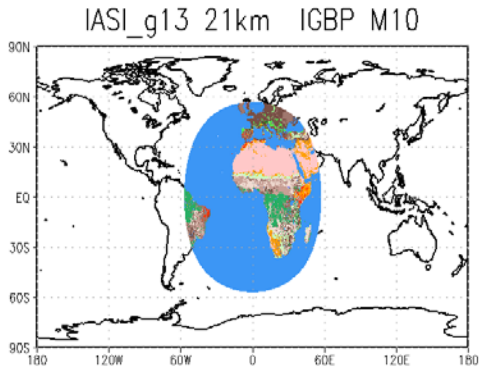
IASI – Full Constellation (HSS5)











- Tests full Constellation requested by DRAA (2013)
- Adds satellites over 0°E, 60°E, 140°E
- Full tropical coverage, as well as most of the midlatitudes (~50°N/S)
- Should be considered “best-case scenario” in terms of global impact

Summary

- Preliminary testing for a geo-Hyper IR showed promise, highlighted areas for improvement
- Numerous system improvements in place for 2015/2016 OSSEs
- Geostationary Hyperspectral IR Constellation OSSE will begin next month (following calibration of errors)

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