GRAFIIR and JAFIIR (GOES-R/JPSS Analysis Facility for Instrument Impacts on Requirements)

Efficient End-to-End Semi-Automated Algorithm Performance Analysis and Implementation Verification Systems

NOAA 2013 Satellite Conference for Direct Readout, GOES/POES, and GOES-R/JPSS Users; NOAA Center for Weather and Climate Prediction (NCWCP) College Park, MD; April 8-12, 2013

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STAR Center for Satellite Applications and Research
formerly ORA — Office of Research and Applications

GOES-R ABI and JPSS VIIRS

GRAFIIR and JAFIIR OBJECTIVEs

- **Leverage existing capabilities and those under development for current GOES, its successor ABI, MODIS, and VIIRS in data processing and product evaluation to support analysis of instruments impacts on meeting user and product requirements.**
- **"Connecting the dots", the components that have been built and/or are under development, to provide a flexible frame work to effectively adopt component algorithms toward analyzing the sensor measurements with different elements of sensor characteristic (i.e. noise, navigation, band to band co-registration, etc.) and its impact on products.**
- **Assess and evaluate data and products (i.e. imagery, clouds, derived products, soundings, winds, etc.) in a consistent way to ensure the instrument effects on the products can be fully accounted for, characterized and product performance can be analyzed.**
- **This is a coordinated team effort from GOES-R and JPSS Risk Reductions, Algorithm Working Groups, Calibration Working Groups, and other related projects. It will not independently develop any new algorithms or processing, but will leverage work already available or under development.**
- **GRAFIIR is a key component of the government's waiver analysis plan concerning the ABI and JAFIIR is developing this capability for JPSS.**

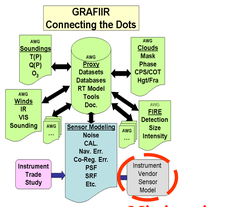
ABI Spectral Characteristics

Future GOES imager (ABI) band	Wavelength range (μm)	Central wavelength (μm)	Nominal subsatellite IGFOV (km)	Sample use
1	0.45–0.49	0.47	1	Daytime aerosol over land, coastal water mapping
2	0.59–0.69	0.64	0.5	Daytime clouds fog, insolation, winds
3	0.846–0.885	0.865	1	Daytime vegetation/burn scar and aerosol over water, winds
4	1.371–1.386	1.378	2	Daytime cirrus cloud
5	1.58–1.64	1.61	1	Daytime cloud-top phase and particle size, snow
6	2.225–2.275	2.25	2	Daytime land/cloud properties, particle size, vegetation, snow
7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall
9	6.75–7.15	6.95	2	Mid-level atmospheric water vapor, winds, rainfall
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2
11	8.3–8.7	8.5	2	Total water for stability, cloud phase, dust, SO_2, rainfall
12	9.42–9.8	9.61	2	Total ozone, turbulence, and winds
13	10.1–10.6	10.35	2	Surface and cloud
14	10.8–11.6	11.2	2	Imagery, SST, clouds, rainfall
15	11.8–12.8	12.3	2	Total water, ash, and SST
16	13.0–13.6	13.3	2	Air temperature, cloud heights and amounts

VIIRS Spectral Characteristics

	Band No.	Wavelength (um)	Nadir Horiz Sample Interval (km Downtrack x Crosstrack)	Driving EDR
VIS/NIR Bands	M1	0.412	0.742 x 0.259	Ocean Color Aerosols
	M2	0.445	0.742 x 0.259	Ocean Color Aerosols
	M3	0.488	0.742 x 0.259	Ocean Color Aerosols
	M4	0.555	0.742 x 0.259	Ocean Color Aerosols
	I1	0.640	0.371 x 0.387	Imagery
	M5	0.672	0.742 x 0.259	Ocean Color Aerosols
	M6	0.746	0.742 x 0.776	Atmospheric Correction
	I2	0.865	0.371 x 0.387	NDVI
	M7	0.865	0.742 x 0.259	Ocean Color Aerosols
CCD	DNB	0.7	0.742 x 0.742	Imagery
S/MWIR Bands	M8	1.24	0.742 x 0.776	Cloud Particle Size
	M9	1.379	0.742 x 0.776	Cirrus/Cloud Cover
	I3	1.61	0.371 x 0.387	Binary Snow Map
	M10	1.61	0.742 x 0.776	Snow Fraction
	M11	2.25	0.742 x 0.776	Clouds
	I4	3.74	0.371 x 0.387	Imagery Clouds
	M12	3.70	0.742 x 0.776	SST
	M13	4.05	0.742 x 0.259	SST Fires
LWIR Bands	M14	8.55	0.742 x 0.776	Cloud Top Properties
	M15	10.763	0.742 x 0.776	SST
	I5	11.450	0.371 x 0.387	Cloud Imagery
	M16	12.013	0.742 x 0.776	SST

GRAFIIR primarily uses AWG Proxy Team simulated ABI data:
- ABI data generated from WRF model analysis performed on a super computer.
- Full disk (15-min, 6-km)
- CONUS (5-min, 2-km)
- Mesoscale (1-min, 667-m)
- All 16 bands



JAFIIR is able to use Suomi-NPP VIIRS data.

Realtime RDRs collected at SSEC, direct broadcast
- RDR to SDR to EDR processing done in real-time.
- All data archived locally.

Modeling of Instrument Effects
(Using Instrument Specifications)

Four basic instrument effects have been applied to simulated (from WRF) ABI data which have been remapped to the ABI Fixed Grid Format and to Suomi NPP VIIRS:

Noise (NEdT or NEdR)

Random noise is generated such that for m lines by n elements in an image a random number generator is used on all mXn points where the standard deviation of what will be added to those mXn points is the noise (such as the NEdR equivalent of 0.1K at 300K for ABI IR bands).

Calibration Offset
- IR Bands: Example, add radiance equivalent to 1K to every pixel.
- Vis/NIR Bands: Example, add reflectance factor to every pixel.

Navigation Error

To simulate this error a random compass direction (0-359.99 degrees) is selected for each pixel and a normalized random distribution for distance based on 21 micro radians (0.75km, ABI spec) is added. Then the radiance for that pixel is "smudged" in that direction using linear interpolation. The result is a new image with the original Lat/Lon grid but slightly altered radiances. A few pixels may have large differences from the original because they were on the edge of a feature such as a cloud.

Striping

A calibration offset on the order of the noise for any given band is added to every nth line, to simulate a certain number of bad detectors.

Combination of the above instrument effects: (1x & 3x)

Datasets were created for ABI that applied all four instrument effects at 1x spec and 3x spec to determine their effects on certain algorithms.

Glance: An Efficient Evaluation and Validation Tool

baseline_cld_hght_seviri_cloud_top_temperature Variable Comparison

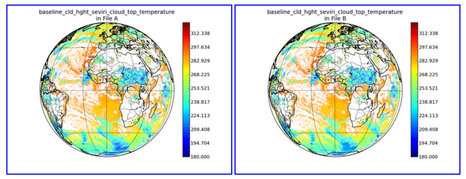
report produced with glance, version 0.2.6.10
comparison generated Mon Oct 19 17:54:38 2009 by user wstraka on craackly.ssec.wisc.edu

file A:
path: /home/wstraka/geocat/data_in_out/geocatL2.Meteosat-8.2006237.120000.ALLATONCE.ALLALG.hdf
md5sum for file A: 56cb4b93e00b78944387788ca9439737f
last modified: Thu Oct 15 00:47:36 2009

file B:
path: /home/wstraka/geocat/data_in_out/geocatL2.Meteosat-8.2006237.120000.hdf
md5sum for file B: 36d63d0044e721c4608d8263739c0494
last modified: Mon Oct 19 17:45:05 2009

latitude: pixel_latitude
longitude: pixel_longitude

Original Data



Comparison Information

variable name: baseline_cld_hght_seviri_cloud_top_temperature
epsilon value: 0.1
"missing" data value in A: -32768
"missing" data value in B: -32768

Statistical Summary

Finite Data Statistics
a_finite_count*: 5839352
a_finite_fraction*: 0.4238
b_finite_count*: 5830257
b_finite_fraction*: 0.4231
common_finite_count*: 5829663
common_finite_fraction*: 0.4231
finite_in_only_one_count*: 10283
finite_in_only_one_fraction*: 0.0007463

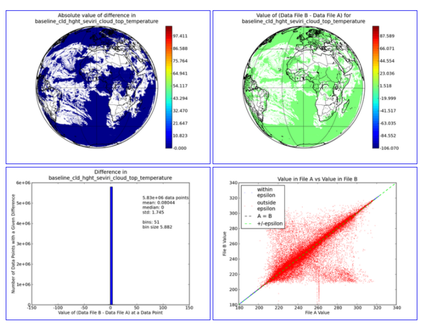
General Statistics
a_missing_value*: -32768
b_missing_value*: -32768
epsilon*: 0.1
max_a*: 324.1
max_b*: 324.1
min_a*: 180
min_b*: 180
num_data_points*: 13778944
shape*: (3712, 3712)
spatially_invalid_pts_ignored_in_a*: 3498035
spatially_invalid_pts_ignored_in_b*: 3498035
trouble_points_count*: 87676
trouble_points_fraction*: 0.006363

Numerical Comparison Statistics
correlation*: 0.9979
diff_outside_epsilon_count*: 77393
diff_outside_epsilon_fraction*: 0.01328
max_diff*: 106.1
mean_diff*: 0.08044
median_diff*: 0
perfect_match_count*: 5666354
perfect_match_fraction*: 0.972
rmse_diff*: 1.748
std_diff*: 1.745

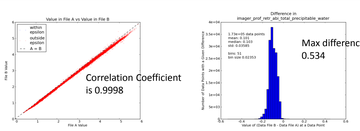
- GLANCE is a Python software tool in development by the UW-CIMSS GRAFIIR team to efficiently & consistently compare two datasets in a semi-automated way. "Glance at the differences."
- The code is user input driven, so statistics, such as epsilon (threshold) are dynamically changed by user input for each variable.
- Glance can generate a report in html format which includes product images, difference images, scatter plots, and histograms; also included are various statistics.
- Compare algorithm output to ensure processing system, algorithm and ancillary datasets are installed correctly.
- Compare algorithm outputs and obtain useful statistics for varying instrument effect(s)/added noise
- Automating time consuming manual GRAFIIR analyses
- Glance will be used as a validation tool for Imagery and other AWG teams

This Glance report demonstrates Cloud Top Height run on SEVIRI data (12:00 UTC 25 Aug 2006)
- File A is the entire full disk processed at one time.
- File B is the full disk divided into "chunks" and processed one chunk at a time.

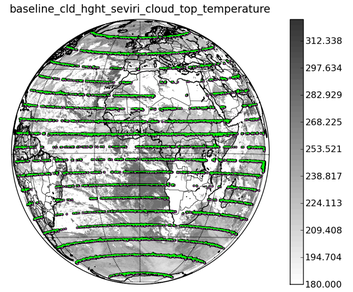
What happens when certain algorithms, such as cloud top temperature which rely on n by n uniformity values, are processed in multiple chunks and then processed later as a single chunk (full disk at a time) for comparison?
Trouble spots manifest themselves in "stripes" along the beginning and ending lines of each chunk as well as a spread in the data greater than machine precision, as exhibited by the scatter plot.



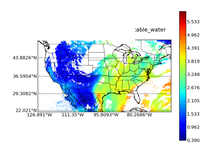
Soundings Example
"Pure" Proxy Team CONUS image vs "1x" instruments effects



Areas of trouble data in baseline_cld_hght_seviri_cloud_top_temperature

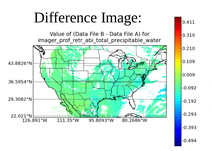


Total Precipitable Water (TPW)



Spec-level (1x) noise, calibration offset, navigation error, and striping affects TPW, but the algorithm appears robust.

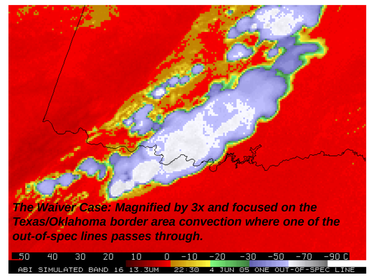
Difference Image:



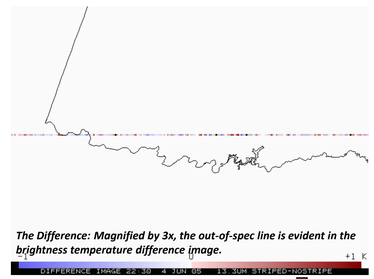
Epsilon used here is 0.0

GRAFIIR Response to ABI Waivers

- Most of GRAFIIR's waiver tasks are to measure the effects of a change on product output
- Many algorithm teams have a need to validate their product against another type of measured data to quantify product performance.

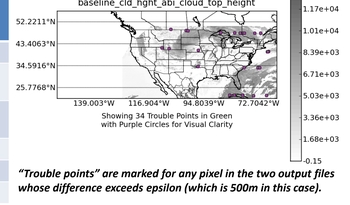


The Waiver Case: Magnified by 3x and focused on the Texas/Oklahoma border area convection where one of the out-of-spec lines passes through.



The Difference: Magnified by 3x, the out-of-spec line is evident in the brightness temperature difference image.

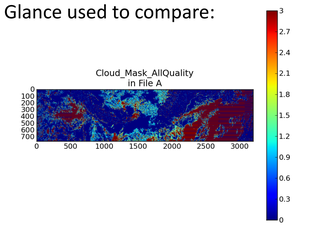
Product	Trouble Points	Trouble Point Fraction	Max Difference	Mean Difference
Height (500m)	34	1.048e-05	6,456	0.2491
Pressure (50hPa)	14	4.317e-06	280.3	0.01163
Temperature (3K)	50	1.542e-05	47.47	0.002161
Cloud Mask	0	0	0	0
Cloud Phase	0	0	0	0
Cloud Type	0	0	0	0



"Trouble points" are marked for any pixel in the two output files whose difference exceeds epsilon (which is 500m in this case).

JAFIIR Makes Use of Glance

Example:
- Calibration offset (1K) added to VIIRS 10.8um Band M15
- Cloud Mask and Cloud Phase generated
- Glance used to compare:



GRAFIIR SUMMARY

GRAFIIR is to
1. **Implement a facility environment (including leveraging GEOCAT and the AIT "Framework") to allow easy and consistent use of AWG application team proxy data and product algorithms.**
2. **Design an efficient approach in coordination with ABI sensor and algorithm scientists to analyze the effects of sensor components such as noise, navigation, band to band co-registration, optical diffraction, striping and other effects identified to be significant on product algorithms and imagery.**
3. **Assist the government's response to ABI instrument waivers requested by industry by providing statistical analysis, reports, and imagery.**
4. **The CIMSS GOES-R AWG GRAFIIR Team has responded to 9 ABI waiver/deviation requests to date.**

JAFIIR Summary

JAFIIR is to
1. **Implement a facility environment (including leveraging CSPP direct broadcast real-time RDR to SDR to EDR functionality) to allow easy and consistent use of Suomi-NPP VIIRS data and product algorithms.**
2. **Design an efficient approach in coordination with VIIRS sensor and algorithm scientists to analyze the effects of sensor components such as noise, navigation, band to band co-registration, optical diffraction, striping and other effects identified to be significant on product algorithms and imagery.**
3. **Assist the government's response to future VIIRS instrument waivers requested by industry by providing statistical analysis, reports, and imagery.**
4. **The CIMSS JPSS JAFIIR Team has demonstrated the key components of responding to waiver/deviation requests.**