GRAVITE Support for NOAA-20 VIIRS SDR Reprocessing

Wayne McCullough
wayne.mccullough@noaa.gov
DPES Sustainment Team

Overview

- Background
  - GRAVITE
  - PGEs
  - ADL
- Request
  - NOAA 20 VIIRS had unexpected conditions after launch
  - SDR team wanted to reprocess with new LUTs
- Process
  - Strong user interaction
- Results
  - First run
  - Second run
- Conclusion

GRAVITE IPS

- GRAVITE has *a lot* of data
  - 112 Million Files, 91 Million unique granules (SNPP and NOAA-20)
  - All RDRs since launch, 34 day rolling storage of other XDRs
  - 560 TB of data
- GRAVITE has available resources
  - Computer
    - Workstations (at GSFC L40)
    - ICF Servers: dedicated to remote access and compute tasks
    - PGE Servers: dedicated to automated processing
    - *All servers have direct access to data*
    - 1.1 PB of dedicated disk space for operational system
  - Tools
    - IDL, Matlab, Python, Redmine, PGEs, etc.
  - Support
    - Operators, Developers, Engineers, etc.
- It is there for the JPSS Cal-Val & Data Quality community to use

GRAVITE PGEs

- What is a PGE?
  - Product Generation Executable
  - Any code we automatically run against data for time periods
    - E.g., Run this analysis every hour when the data is available, etc.
- Initially used heavily for ground comparison
- Broader use now:
  - Instrument DQ Checks
  - Static plot generation
  - Data Preview Tile sets
  - Granulated Ancillary generation (uses ADL)
  - Reprocessing

GRAVITE PGEs

- Conditions for running a PGE:
  - Have rules defining the time periods (Execution Blocks)
    - Hourly, daily, etc.
    - Orbit
    - Custom lookup
  - Define input products
    - Input products may be optional or required.
    - A minimum number or maximum time gap may be set.
    - A geo-spatial area may be set.
    - E.g. *“If I have full coverage for VIIRS M7, the cloud mask, and the GEOs, run xxx for this hour”*
  - Automatically run PGE when conditions are met
    - Queue task
    - Execute code on available node
  - Selected Outputs are archived by GRAVITE

ADL Architecture

- Simplified reflection of IDPS architecture:
  - Processing Subsystem (PRO)
  - Data Management Subsystem (DMS)
  - No Ingest Subsystem (ING), No Data Delivery Subsystem (DDS), No Infrastructure Subsystem (INF)
    - Some functions replaced by ADL Toolkit

Request

- STAR VIIRS SDR team needed to regenerate SDRs from RDRs
  - Unexpected conditions shortly after launch
  - New Lookup Tables needed
  - Wanted to reprocess all NOAA-20 VIIRS Science RDRs (from launch November 2017 to end of February 2018)
- February 2018 DPES and STAR VIIRS SDR team met
  - Various approaches considered
    - All centered on many runs of ADL
  - SDR team needed more time to finalize LUTs
  - DPES team needed more time to test and refine ADL calls
- Goal:

Start Processing by August 2018

Process

- DPES dedicated three computers in GRAVITE for run
  - Each machine 24 core, 256 GB RAM
    - Dell PowerEdge R430 servers, with two Intel Xeon E5-2680v3 CPUs at 2.5GHz, eight 32GB RDIMM with Advanced ECC, and two Intel Ethernet X540 DP 10GBASE-T
  - Each machine to run a max of 16 ADL processes
- Set up ADL to run in a PGE
  - STAR VIIRS SDR team provided significant support:
    - patch to ADL to turn on compression
    - Testing and reference data
    - Final LUT package for reprocessing
- Runs as part of operational PGE system
  - No impact to current PGEs, only minor configuration changes needed
  - Reprocessing PGE delivered in GRAVITE v4.4

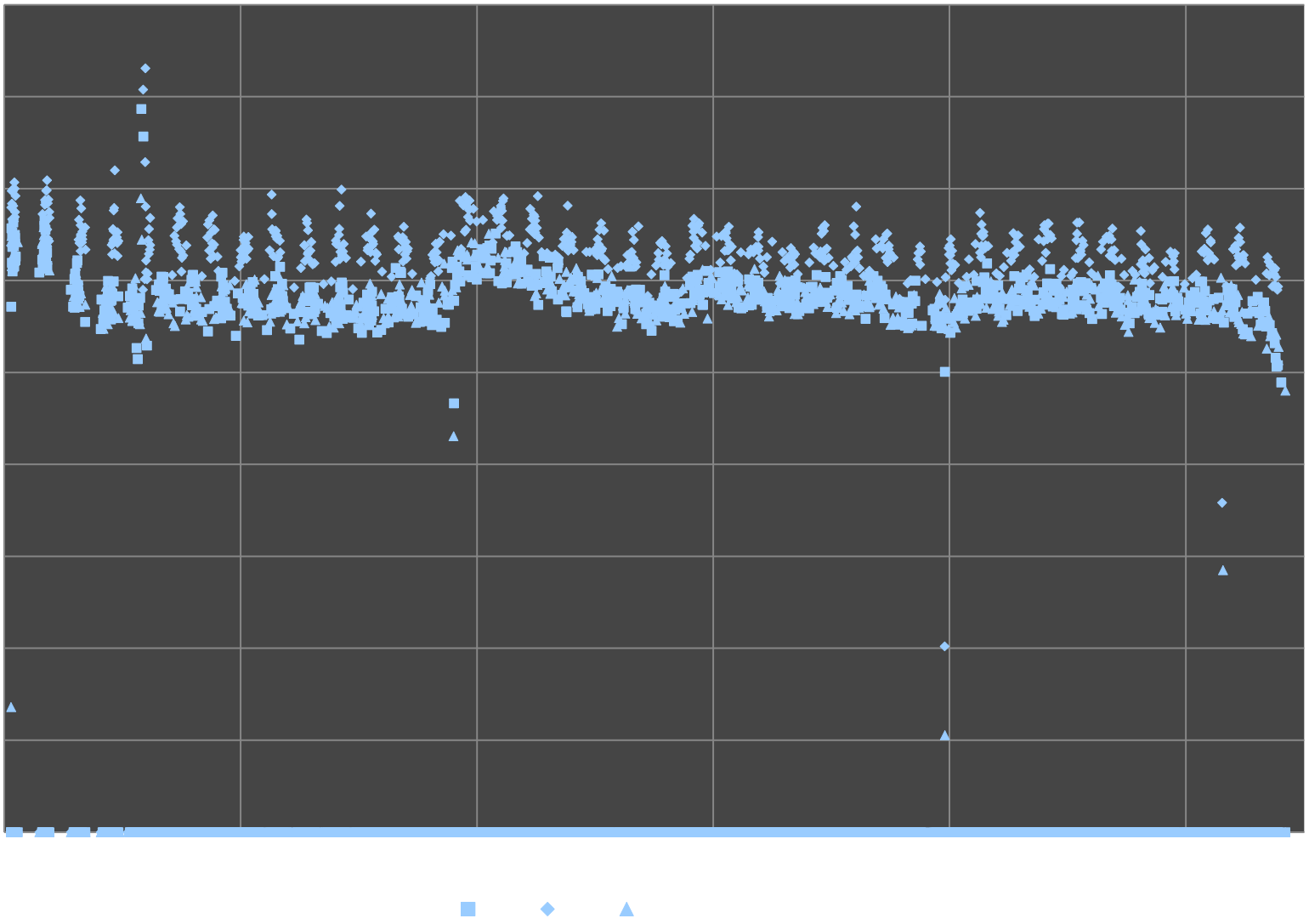
Results

- First Run start 2018-07-05
- Finish 2018-07-17
- VIIRS SDR team noted that about 1% of outputs were missing
  - ADL was not called properly to handle A2 Granules
  - A fix was developed
- Decided to re-run everything
  - Ensure all data was correctly processed.
  - Avoid duplicates.

Results

- Second Run start 2018-08-16 19:22
- Finish 2018-08-27 19:01
- Performance: ~85 days of data processed in 11 days
  - Average time to run each hour of data: 6 hours
  - Run 48 simultaneously across three computers
  - Net: ~*7.8x faster than real time*
  - If needed, we could parallelize it more
- Outputs: ~42 TB of data
  - Segmented into the **gvo** domain. (i.e., Not ops, pop, or int)
  - DPES will keep for 1 year
  - Available for all GRAVITE users

Time to Run ADL



Conclusion

- GRAVITE can use ADL to reprocess large amounts of data
  - ADL is a complex utility
  - Requires a bit of trial an error
- GRAVITE IPS PGE system can support large reprocessing runs
  - This is the first run of this nature we have tried
  - Overall, the GRAVITE IPS system did what it is supposed to do
- DPES can support JPSS Reprocessing via ADL
  - ADL available on ICF machines
  - Talk with DPES for larger runs

Contacts

- To subscribe to DQA alerts, contact:
  - ops-gravite-dpes-jpss@lists.nasa.gov

  (Subscribers need to have a GRAVITE account)
- New GRAVITE account request, contact:
  - Erica Handleman: erica.handleman@nasa.gov
- System access issues, contact:
  - gravite.service@noaa.gov
- DQA functions, contact:
  - dqst-dpes-jpss@lists.nasa.gov
- All other issues, contact:
  - ops-gravite-dpes-jpss@lists.nasa.gov

CRTM and Data Assimilation activities at STAR supporting JPSS

Kevin Garrett[1]

CRTM Federal Manager

NESDIS Associate Director for the Joint Center for Satellite Data Assimilation

Tong Zhu[1,2], Ming Chen[1,3], Biljana Orescanin[1,3], Yingtao Ma[4]

Acknowledgments: Jean-Luc Moncet[4], Mark Liu[1], Benjamin Johnson[5], Hui Shao[5]

1: NOAA/NESDIS/STAR 2: CIRA 3: CICS 4: AER, Inc. 5.UCAR/JCSDA

Outline

- CRTM
  - Status
  - Cal/Val and algorithm support
  - Current and future development

- Data Assimilation
  - Current activities
  - STAR plans/priorities

CRTM activities

CRTM development history

Impacting JPSS Applications

CRTM Version	Date	Enhancements
2.0/2.0.5	12/2011	• New user interface
2.1/2.1.1	3/2012	• SOI solver • Fastem5 • MW Land Surface Emissivity Model • NLTE Correction
2.1.3	6/2013	• Implement reflection correction in Fastem (use clear-sky trx) • Enhanced absorption coefficients (6 absorbers) • Solar irradiance in spectral coefficient files (CrIS) • IRSSEM improvements
2.2.1	4/2015	• Enable reflection correction for non-scattering clouds • Fastem6 • Revert to box car SRF for SNPP ATMS
2.2.3	8/2015	• IRRSEM improvements
2.3 (current)	11/2017	• NOAA-20 coefficients • ATMS snow and sea-ice emissivity models • Cloud fraction capability • Reflection correction (use cloudy trx)

CRTM Cal/Val and algorithm support

Applications applied to JPSS data

Algorithm	CRTM v.	Current use	Some desired enhancements?
ICVS	2.0.5-2.3	Forward operator, clear-sky, ocean	Ocean emissivity/reflectance modeling
MiRS	2.1.1	Forward operator, K-matrix, all-sky variational retrieval	Hydrometeor handling (scattering properties)
ACSPO	2.1.3	Forward operator, clear-sky, ocean	IRSSEM, reflectance enhancements, aerosol handling (species, scattering)
Enterprise Cloud Products	2.1.3	Long-wave IR clear-sky transmittance profiles	Shortwave IR transmittance, cloudy transmittances
Enterprise Volcanic Ash	2.1.3	Long-wave IR clear-sky transmittance profiles	Shortwave IR transmittance, cloudy transmittances

*All applications could benefit from improved efficiency

CRTM current development

Expected to have impacts on JPSS sensors

- JCSDA partners collectively manage CRTM development (B. Johnson lead)
- STAR-led contributions to JCSDA CRTM project
  - Code management, new sensors, testing & maintenance, package/delivery of software
  - Surface emissivity modeling, BRDF improvements (CSEM)
  - Modernization of LBLRTM with through the Community Line-By-Line Model (CLBLM)
  - Extension to UV sensors
- Summary of other JCSDA projects
  - Fast solvers for scattering
  - Full Stokes polarization
  - Improvements to aerosol/hydrometeor scattering properties/LUTs
  - Improved code efficiency (vectorization/OpenMP)
- Next release is v3.0 ~Jan/Feb 2019

CRTM current developments

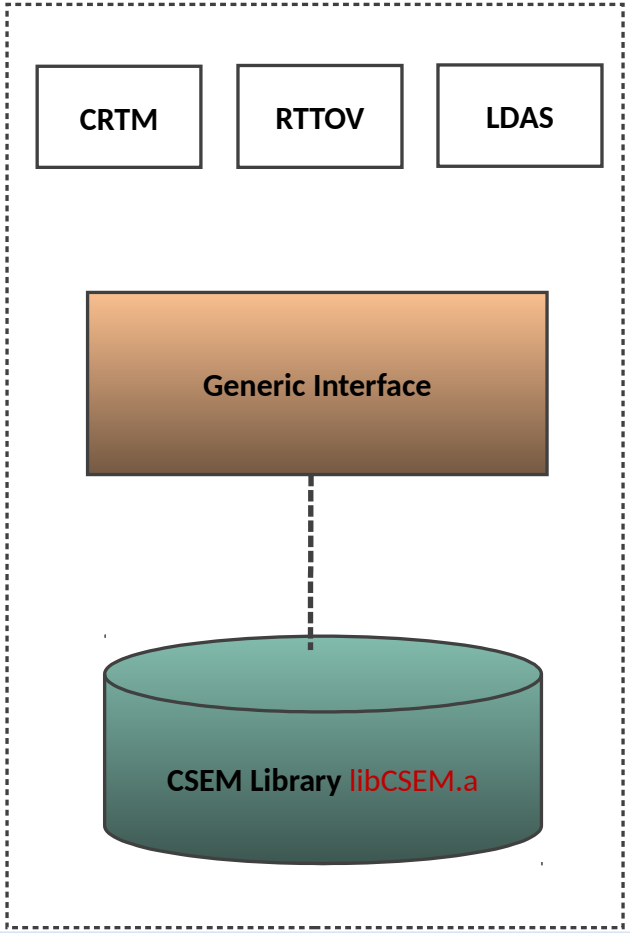
The Community Surface Emissivity Model (CSEM)

Objective: Release of the CSEM package and integration into CRTM

- CSEM is OOP-based system to compute emissivity and BRDF over all surfaces, in the MW, IR and Vis
  - Easy to integrate and test new emissivity models
  - Easy to interface with other tools (e.g. CRTM)
  - Includes tangent-linear and adjoint

Enhancements over existing CRTM surface emissivity models

Microwave	Vis/IR
Improved NESDIS Land Phys. Model	UW IR Emissivity Atlas (SEEBOR)
Semi-physical ATMS Snow Model	UW Vis/NIR BRDF Atlas (Vidot & Borbas)
Semi-Physical ATMS Sea-ice Model	
TELSEM 1, 2 (climatology)	



CSEM can be used as a stand-alone package or interface with other tools

CRTM current developments (CSEM)

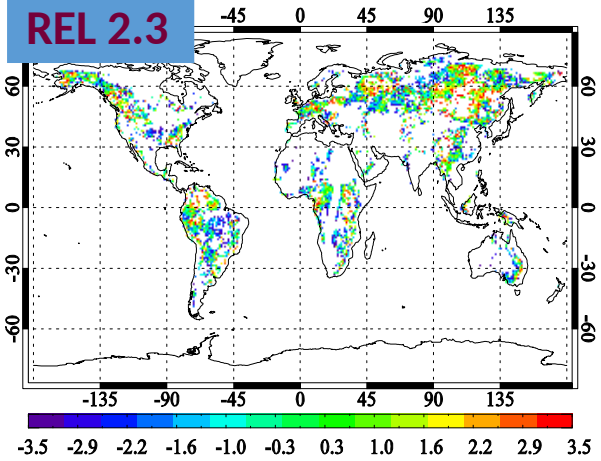
The Community Surface Emissivity Model (CSEM)

O-B over land using NESDIS Land Physical Model (TOP: CRTM 2.3) (Bottom: CSEM)

O-B over sea-ice for 50.3 GHz (TOP: TELSEM) (Bottom: CSEM)

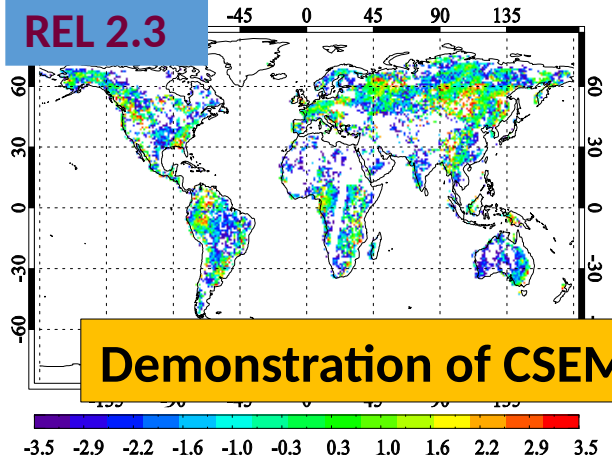
23.8GHz

REL 2.3

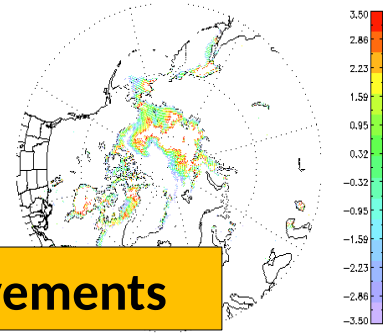


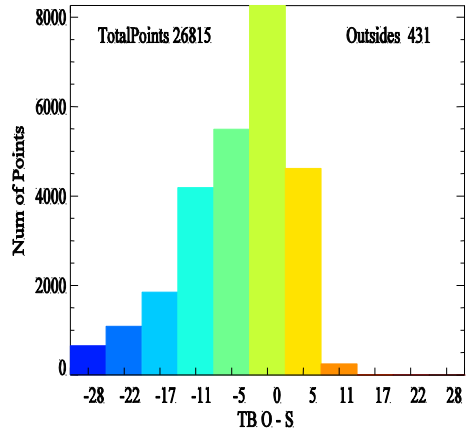
50.3GHz

REL 2.3



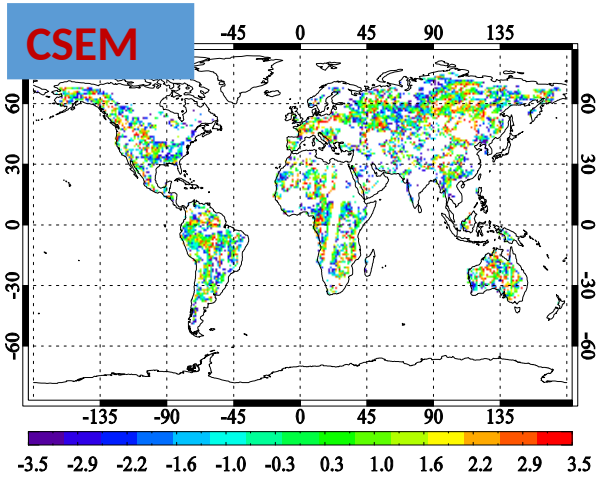
TELSEM



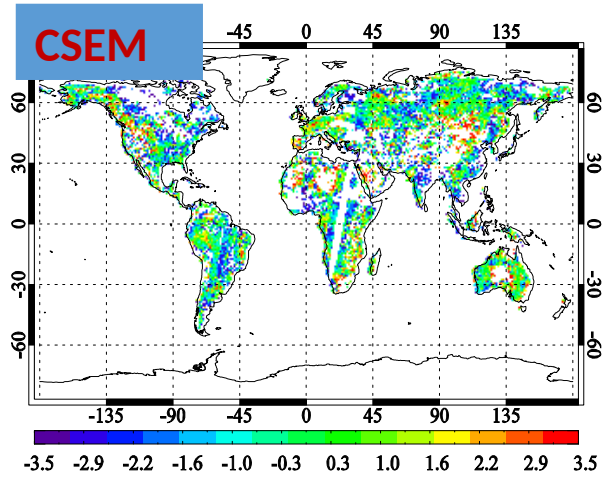


Demonstration of CSEM improvements

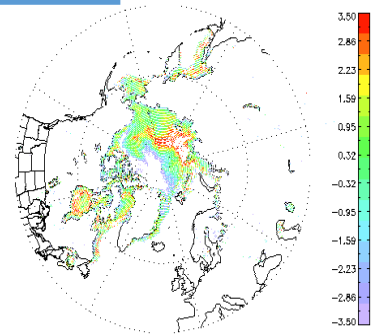
CSEM

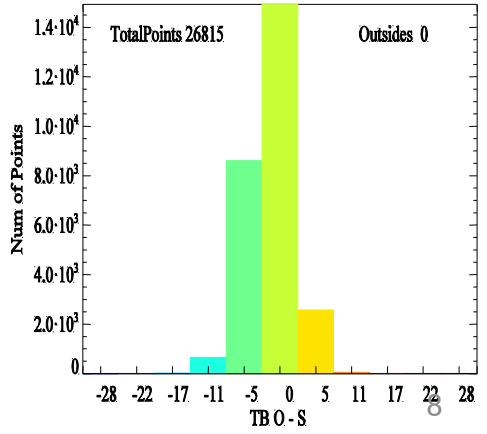


CSEM



CSEM





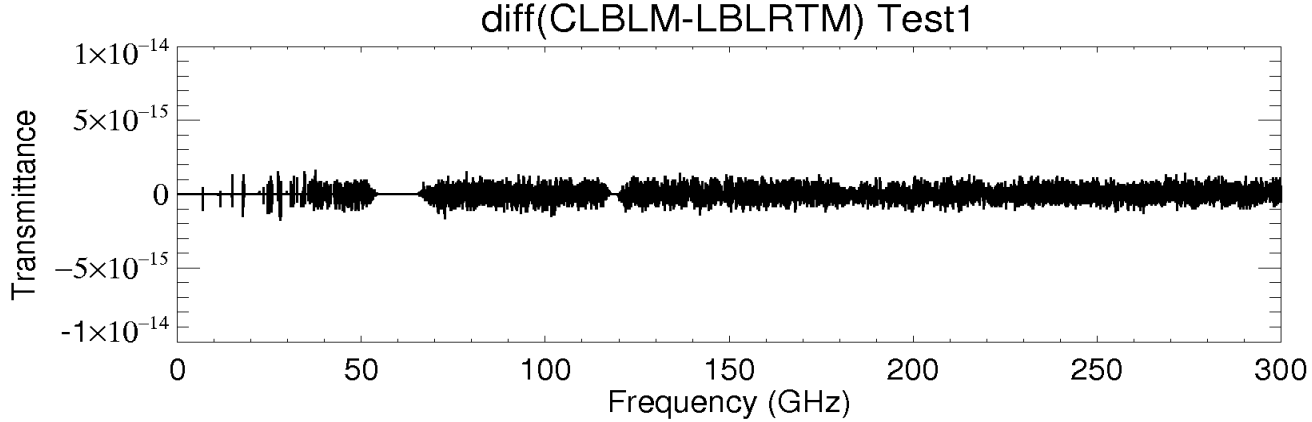
CRTM current developments

The Community Line-By-Line Model (CLBLM)

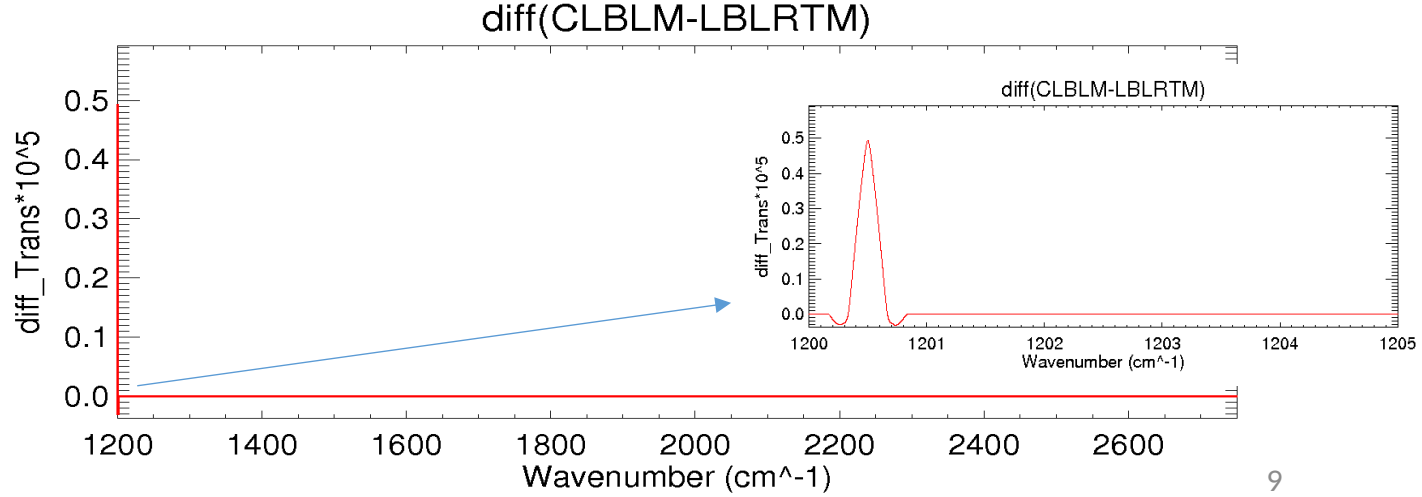
Objective: Development/release of the Community Line-By-Line Model (CLBLM)

- Monochromatic RTM to train CRTM fast model
- Modernization of heritage LBLRTM
  - Refactored/modular code
  - Improved I/O
  - Redesigned RT/Jacobian routines
  - Double line-shape convolution scheme for improved narrow-lines
- CLBLM Alpha released 1/2018
- CLBLM v1.0 released 8/2018

Transmittances over MW Spectrum



Transmittances over IR Spectrum



Data assimilation activities

Data assimilation activities

ATMS surface-sensitive radiance assimilation

Objective: Increase the number and quality of ATMS surface-sensitive (non-ocean) observations assimilated (NOAA GDAS/GFS)

- Requires accurate forward operator
- …which requires accurate surface characterization (e.g. emissivity)

Implement in 2 phases

- Improve the background surface emissivity
- Implement surface emissivity as a control variable in the GSI

Compare Current Land Model in CRTM and TELSEM2 for background

	CRTM	TELSEM 2
Surface type	All	Land & sea-ice only
Frequency	3 – 190 GHz	10 – 700 GHz
Polarization	H + V	H + V
Spatial Resolution	0.25°	0.25°
Temporal Resolution	Instantaneous	Monthly
Base	“Physical”	Empirical

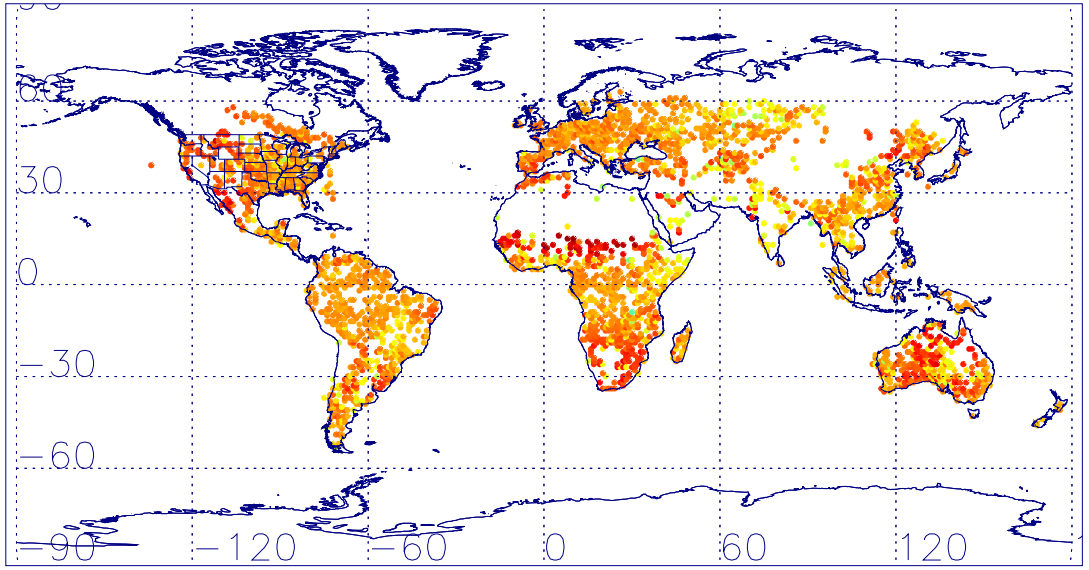
CSEM improved Land Emissivity physical model will also be tested

Data assimilation activities

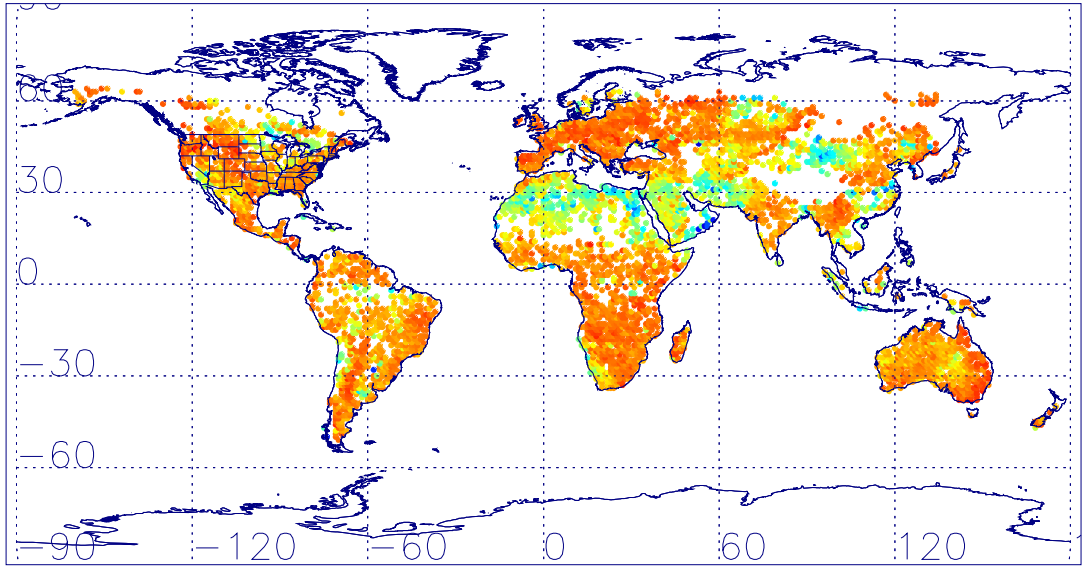
ATMS surface-sensitive radiance assimilation

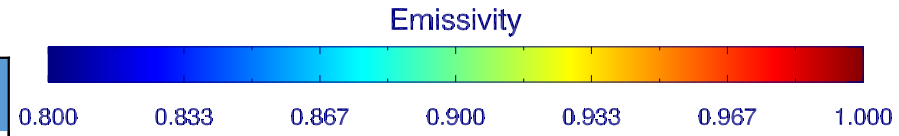
Improving the background: 31 GHz Emissivity from 2 GDAS Cycles

CRTM



TELSEM 2





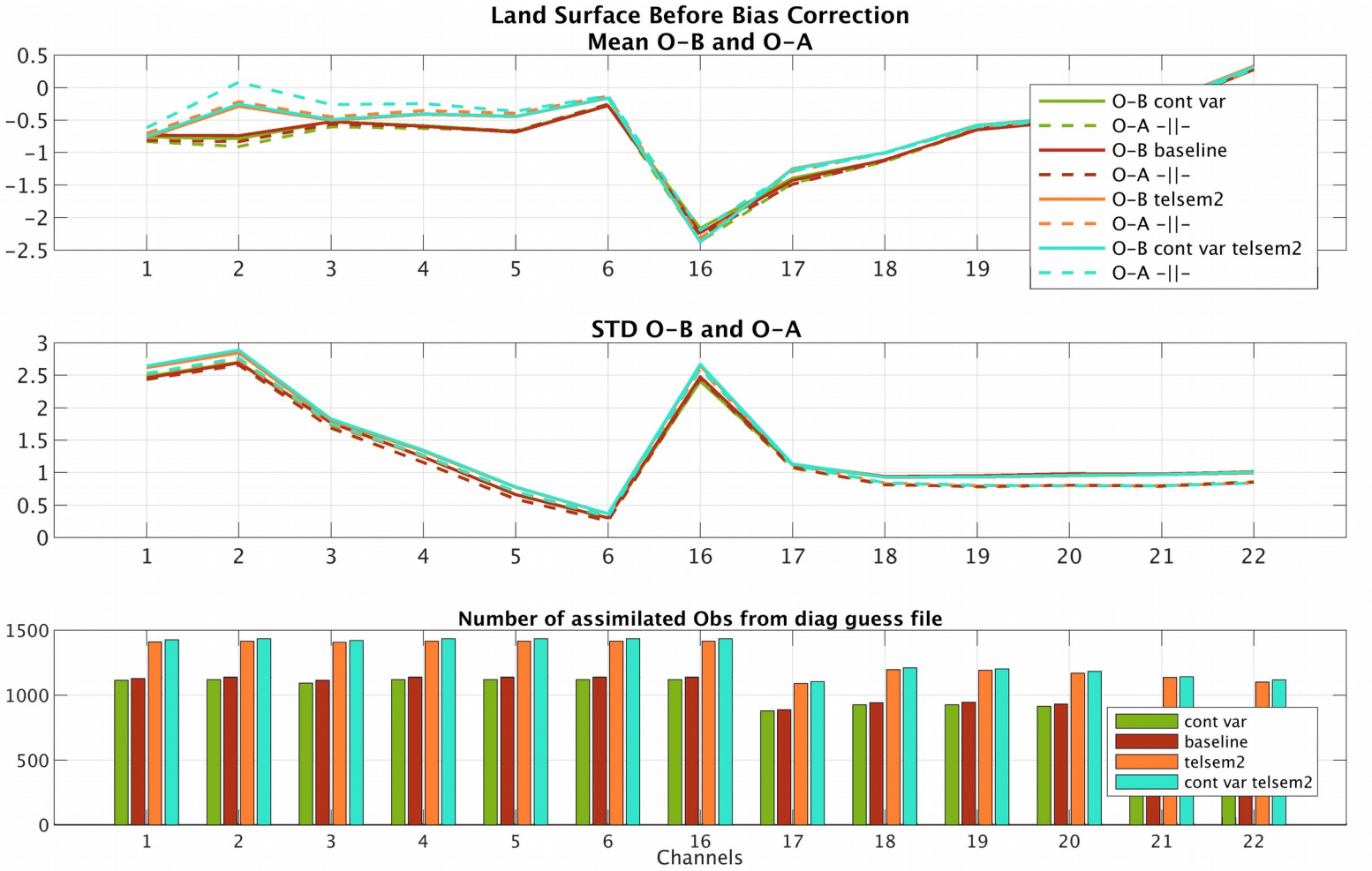
O-B Stats	CRTM	TELSEM 2
Number count	**4104**	**8050**
Bias	-0.4	0.05
Std. dev.	2.0	1.9

Replacing the background to use TELSEM2 increases x2 the number of observations assimilated (from 2 GDAS cycles)

Data assimilation activities

ATMS surface-sensitive radiance assimilation

Improving the analysis: O-B, O-A, and Obs Count from 9 GDAS Cycles



While replacing the background (orange) improves the observation count, implementing emissivity as control variable improves the analysis.

Further improvement can be realized:

- **Use off-diagonal elements of emissivity covariance matrix**
- **Improve bias correction over land**

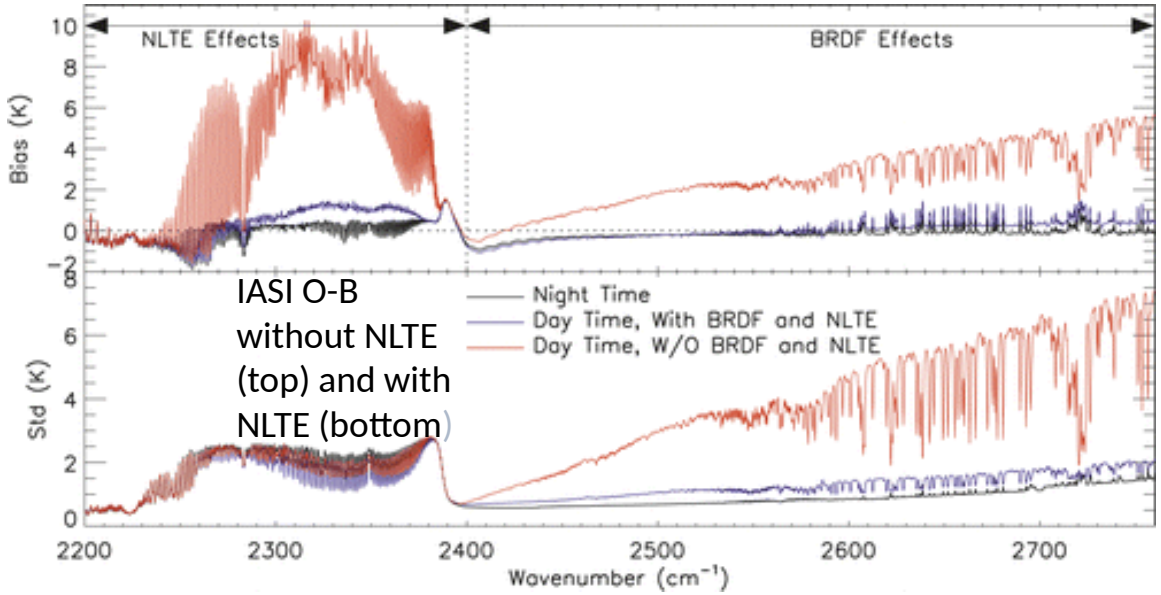
Data assimilation/CRTM activities

Other efforts at STAR

CrIS and IASI shortwave IR 4 µm band assimilation

(Boukabara, Ide, Garrett, Barnet)

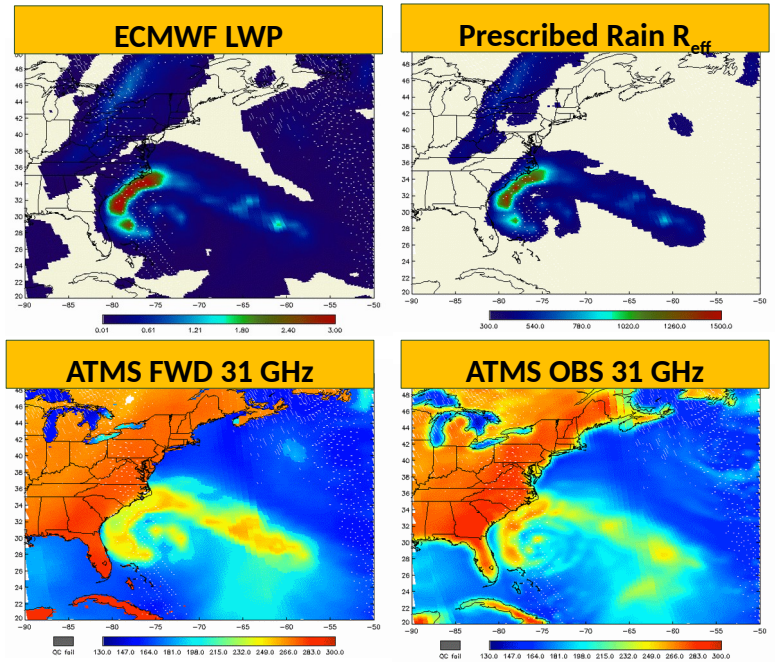
- Assess CRTM capability
  - NLTE, shortwave reflectance
- Extend global DA
  - Dynamic CO2/N2O, obs errors, etc.
- Assess analysis and forecast impact vs longwave IR



Chen et al. 2013

Improve PMW all-sky radiance retrieval/assimilation

- Utilize datasets like GPM 2BCSATGPM
  - Quantify accuracy of CRTM in precip for ATMS
- … or GPROF
  - Training set to improve a-priori of hydrometeor microphysical properties



Summary

Focus on Future Efforts

Cal/Val Systems and Science Support from CRTM

- Address priorities and needs of STAR EDR, Cal/Val teams
  - Science needs, e.g. improvements to quality of output
  - Technical needs, e.g. supporting transitions to new versions

Science/Coordination Support for Data Assimilation

- Address priorities across STAR, NESDIS (program offices)
  - Assimilation of land EDRs (LST, GVF, soil moisture)
  - Assimilation of ocean EDRs (SST, color)
  - Assimilation of cryospheric products (IST, SIC, Snow Cover/SWE)
  - Assimilation of trace gases, aerosol (V8Tot/Pro, AOD)

OSPO

CLASS Access and Future Trends for S-NPP and JPSS Data

Brent Hefner, CLASS Program Manager (Acting)

Alan Hall, CLASS System Owner & Operations Manager

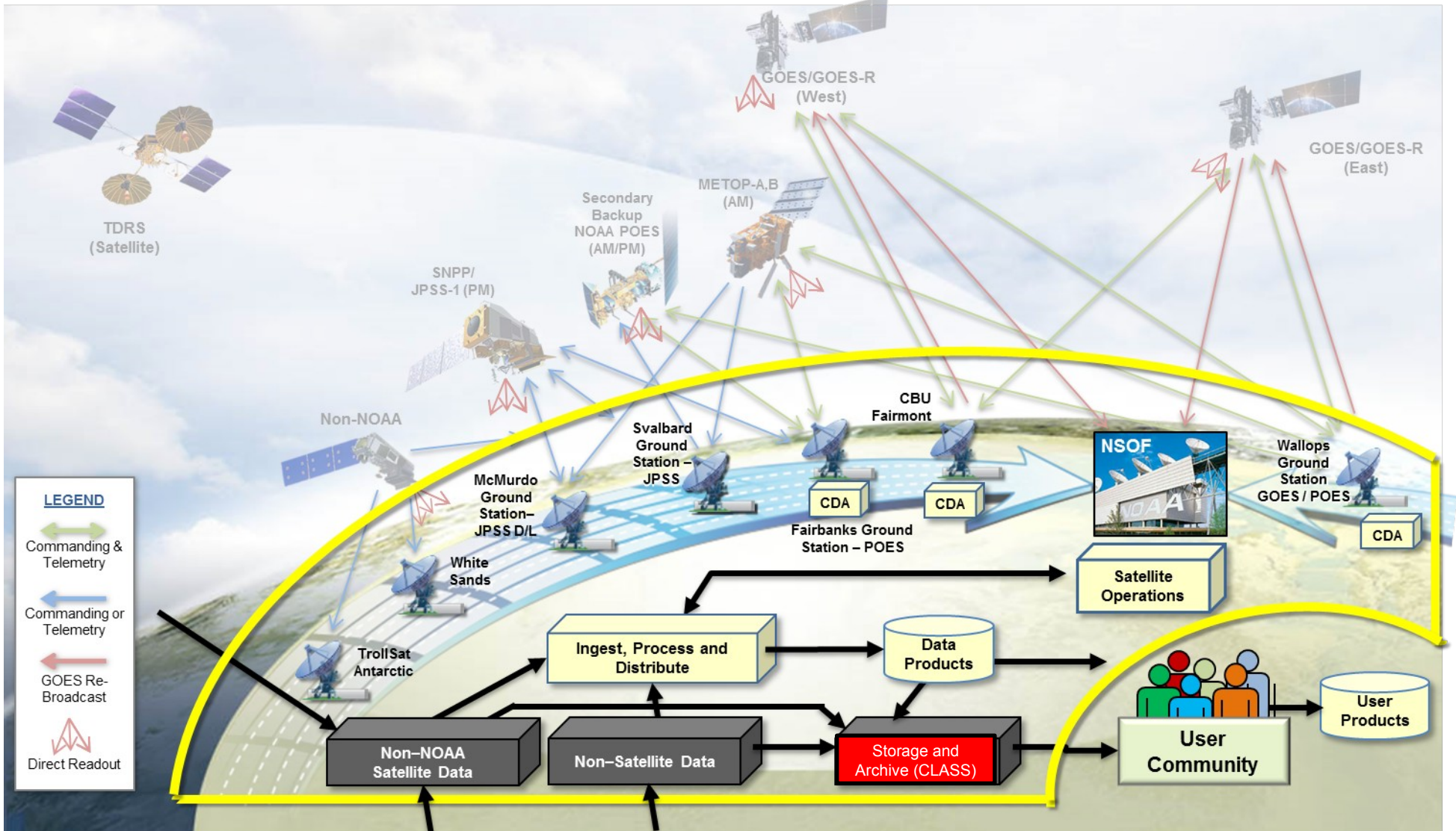
2018 STAR JPSS Annual Science Team Meeting
August 28, 2018

Overview- Comprehensive Large Array data Stewardship System (CLASS)

- **CLASS provides long-term, secure storage of NOAA-approved data, information, and metadata and to enable access to these holdings through both human and machine-to-machine (M2M) interfaces**
- **CLASS is not intended to support near-real-time nor mission-critical product delivery**
- **CLASS follows the concepts defined in the Open Archival Information System Reference Model (OAIS-RM)**
- **CLASS Development phase completed on June 30, 2017**
- **CLASS has transitioned to Sustainment:**
  - Minor problem resolution and enhancements are delivered through regularly scheduled Sustainment Software Releases
  - Software Releases are scheduled once per quarter

CLASS is fully operational and meeting all performance objectives

CLASS within the NESDIS Ground Enterprise



S-NPP and J1 Archive & Dissemination Metrics

- Recent Archive metrics

	May		June		July	
	No. of Files	Volume (TB)	No. of Files	Volume (TB)	No. of Files	Volume (TB)
S-NPP	965,298	40.5	775,771	40.14	805,603	41.33
NOAA-20	877,245	39.1	724,863	38.17	743,578	39.1

- July Dissemination metrics

S-NPP	July	
	No. of Files	Volume (TB)
Subscriptions	1,852,940	135.34
Ad-Hoc	1,172,499	55.4

NOAA-20	July	
	No. of Files	Volume (TB)
Subscriptions	1,047,550	91.06
Ad-Hoc	548,604	50.88

CLASS Website

- Provides access to CLASS information holdings
- Requires registration to order data
- www.class.noaa.gov
- Manage Subscription orders
- Place Ad-Hoc Orders

CLASS Access Services

Order types	Avg Time to Available	File Limit
Subscription (Standing orders)	< 6-7 hours (As little as 45m depending on data)	No limit
NPP-FTP (Rolling ~90 days)	< 6-7 hours	No limit
Ad-Hoc (Historical/older data)	~24 hours	Up to 3,000 files
Bulk (Large/non-typical)	24-48 hours	3000 to 6000

NOTES:

Some data types are available as fast as can be processed, others are delayed by the Program (i.e. JPSS)

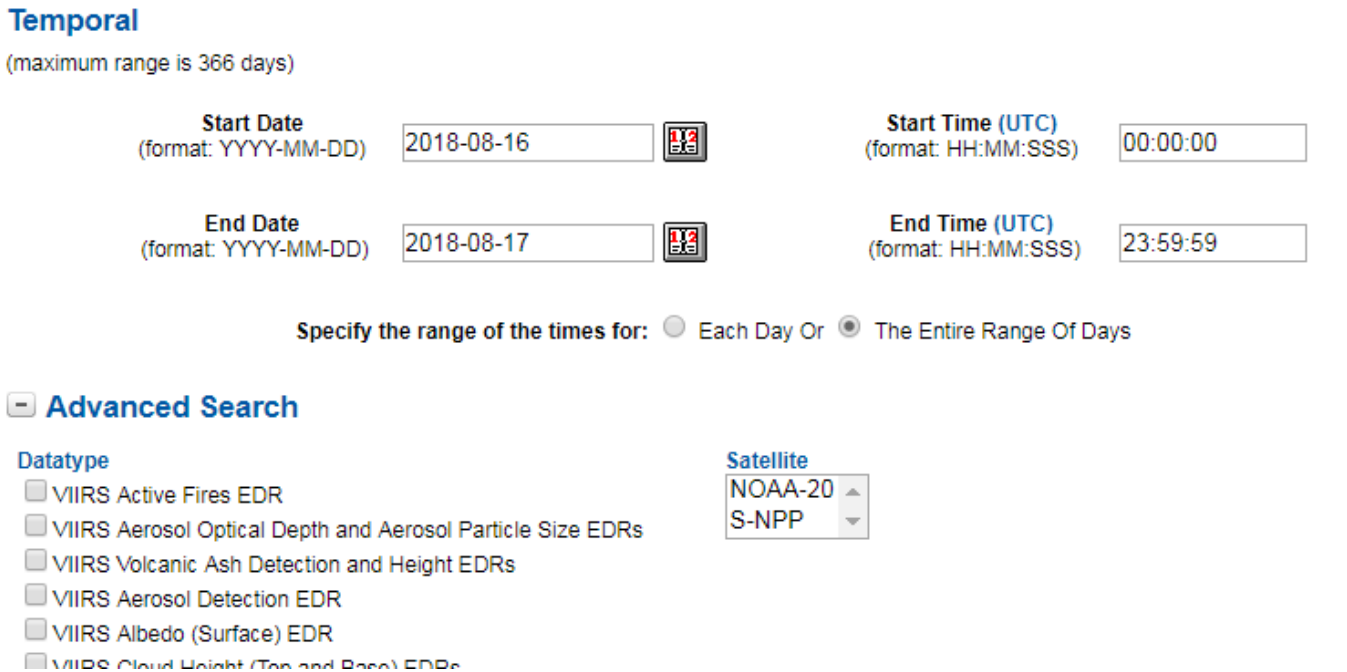
CLASS is a tape Library System, retrieval times can vary. Operators work with large data requests to facilitate best delivery.

Subscription Orders

- Subscriptions are standing orders for newly archived data which are fulfilled automatically
- Users can manage Subscription orders via the CLASS website

Ad-Hoc Orders

- Ad-Hoc orders can be placed through the CLASS website
- Data is grouped into product families which can be searched



NPP and J1 Rolling FTP Directory

- Located at ftp://ftp-npp.bou.class.noaa.gov/
- Easy to navigate directory of recently archived NPP and J1 data
- ~90 day rolling window

Index of /20180817/VIIRS-EDR/VIIRS-Near-Constant-Contrast-NCC-EDR-GTM-Geo/J01/

[parent directory]

Name	Size	Date Modified
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VIIRS-EDR_VIIRS-Near-Constant-Contrast-NCC-EDR-GTM-Geo_20180817_28955.tar.manifest.xml	6.4 kB	8/17/18, 2:00:00 AM
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VIIRS-EDR_VIIRS-Near-Constant-Contrast-NCC-EDR-GTM-Geo_20180817_32095.tar	1.9 GB	8/17/18, 9:31:00 AM
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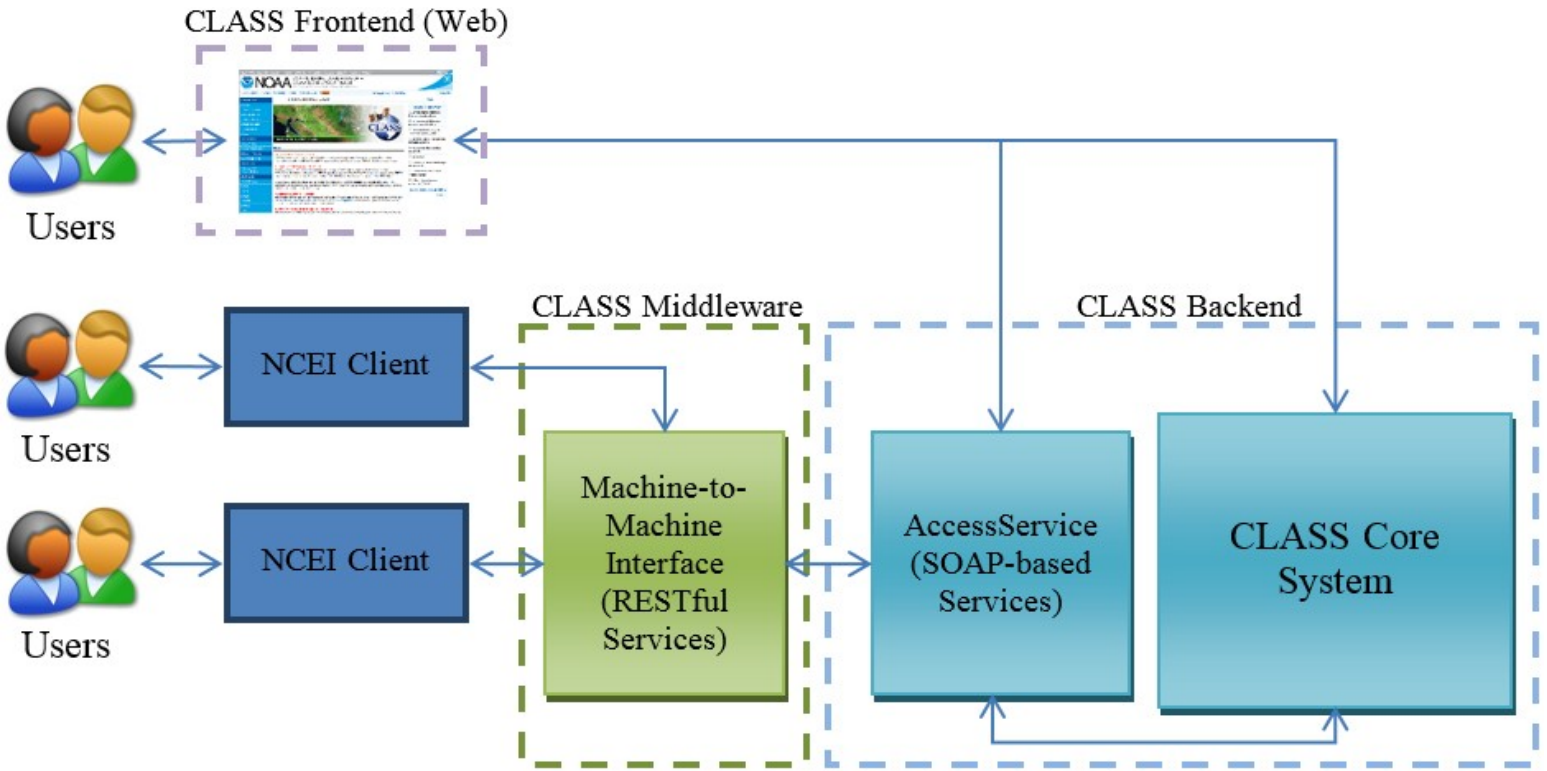
VIIRS-EDR_VIIRS-Near-Constant-Contrast-NCC-EDR-GTM-Geo_20180817_32595.tar	1.9 GB	8/17/18, 11:02:00 AM
VIIRS-EDR_VIIRS-Near-Constant-Contrast-NCC-EDR-GTM-Geo_20180817_32595.tar.manifest.xml	6.4 kB	8/17/18, 11:02:00 AM

Machine to Machine (M2M) Interface

- M2M API was designed for the purpose of enabling software developers to create access clients capable of searching for and ordering datasets held within CLASS
- NCEI has implemented M2M Clients



M2M Next Steps

- CLASS is planning an Engineering Assessment to determine the feasibility of extending the M2M interface to STAR
  - Performance impact analysis
  - Cost estimate

Summary

- CLASS is the archive for NPP and J1 data
- Multiple options exist for ordering data from CLASS
- CLASS is investigating making the M2M interface available to STAR