CERES FLASHFlux Working Group: Status & Plans

Low Latency Surface Radiative Fluxes and Meteorological Parameters for Research and Applications

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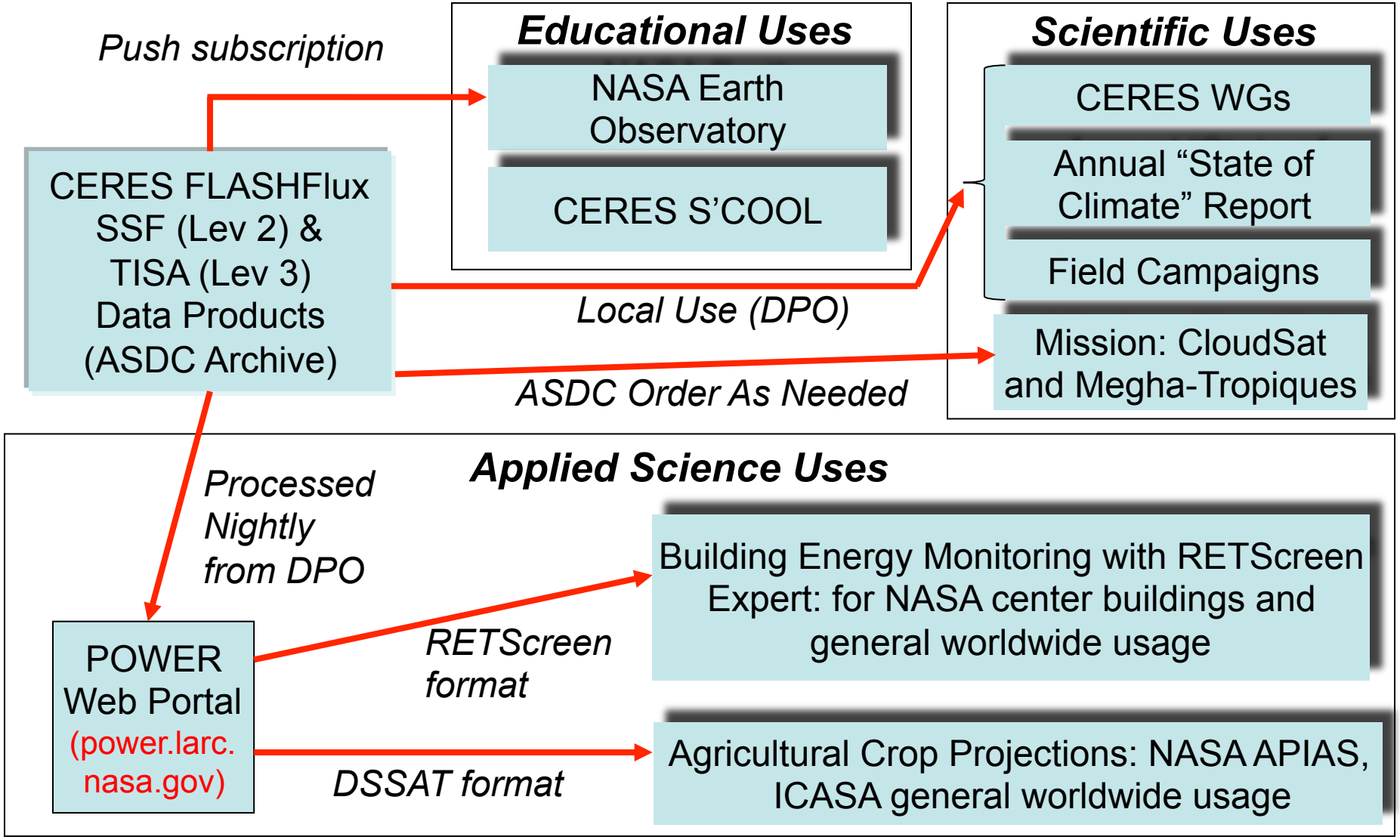
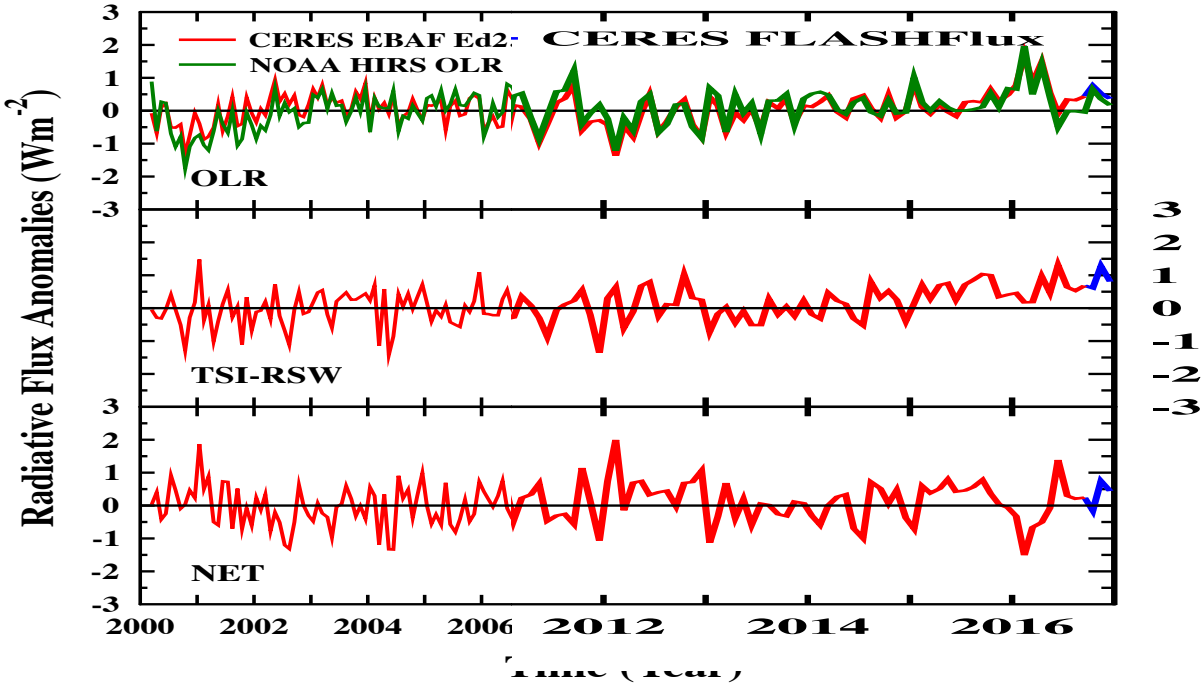
FLASHFLUX: Schematic of Current Uses



FLASHFlux v3C Status

- ***Completed production with v3B through Dec. 31, 2016***
  - "State of the Climate 2016" results
  - Validation for 2016 vs. BSRN/ARM/Buoy
- ***Started production with v3C (since Jan 1, 2017)***
  - Now uses FP-IT (GEOS 5.12.4) and MODIS Collection 6 (after March 28)
  - V3B v V3C and MODIS Coll. 5/6 differences evaluated
- ***Current Latency***
  - FLASHFlux SSF available via CERES subsetter and ASDC 4-5 days latency
  - FLASHFlux TISA available via CERES subsetter, ASDC and specialized formats through POWER web portal (power.larc.nasa.gov) 5-6 days latency
  - Some latency improvements made through CATALYST; more later
- ***FLASHFlux Data Usage:***
  - Mandatory conversion to https: broke user pipe; but usage picking up again
  - Agricultural and Energy usage continues => New web site coming
  - Anecdotal information being collected

State of Climate 2016 Results



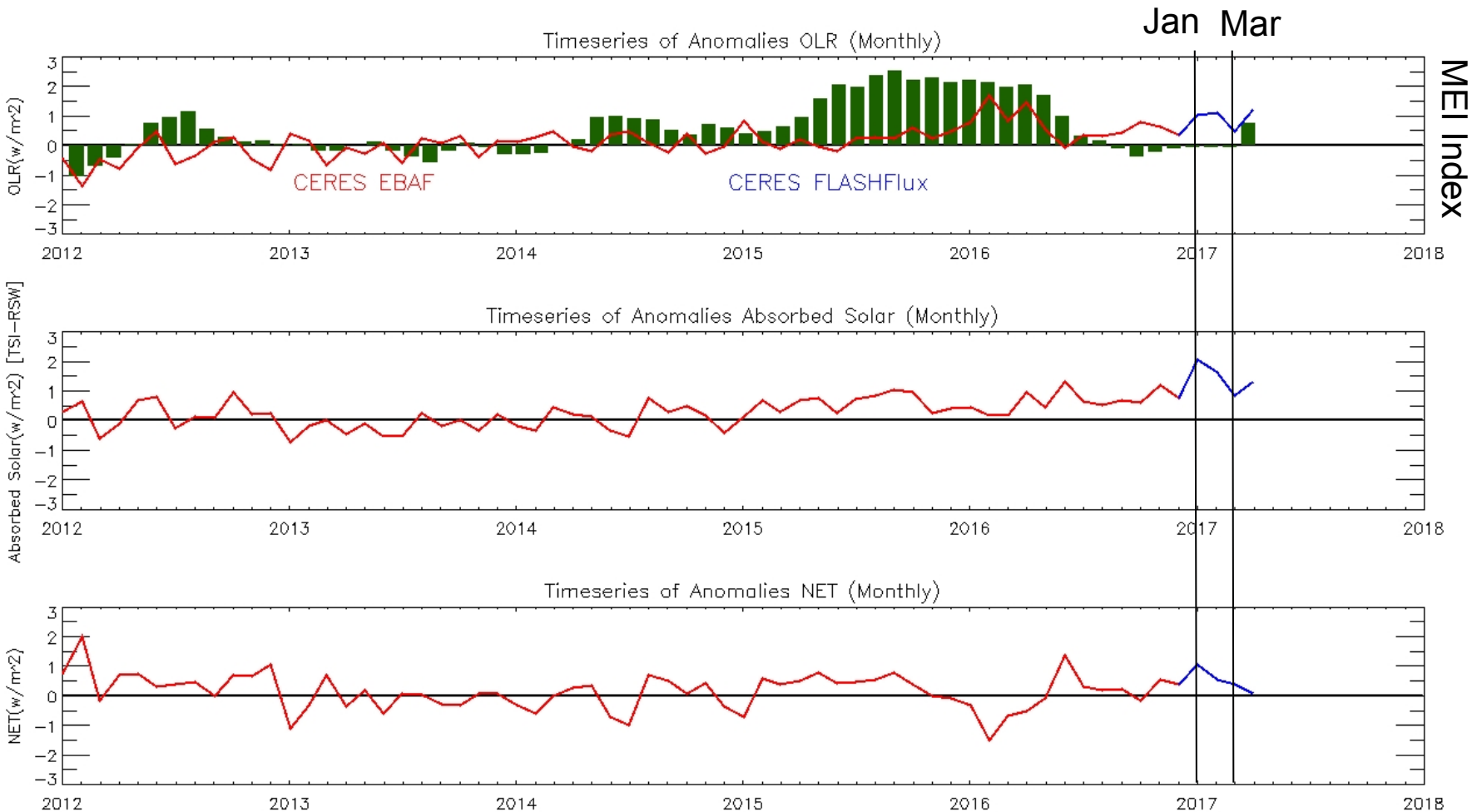
- Global monthly mean deseasonalized anomalies from CERES EBAF TOA Ed2.8 and CERES FLASHFlux product.
- FLASHFlux TOA are normalized to the EBAF TOA fluxes from both datasets for the six-year overlap period 1/2009 – 12/2014.

	Global-annual Mean Difference (2016 minus 2013) (Wm^{-2})	Global-annual Mean Difference (2016 minus 2015) (Wm^{-2})	2016 Anomaly (relative to climatology) (Wm^{-2})	Inter-annual variability (2001 to 2015) (Wm^{-2})
OLR	+0.70	+0.40	+0.65	±0.60
TSI	−0.05	−0.10	−0.05	±0.15
RSW	−0.90	−0.15	−0.70	±0.55
Net	+0.15	−0.35	+0.00	±0.65

- Annual averaged OLR and RSW anomalies > 2-sigma interannual variability, but largely cancel in 2016

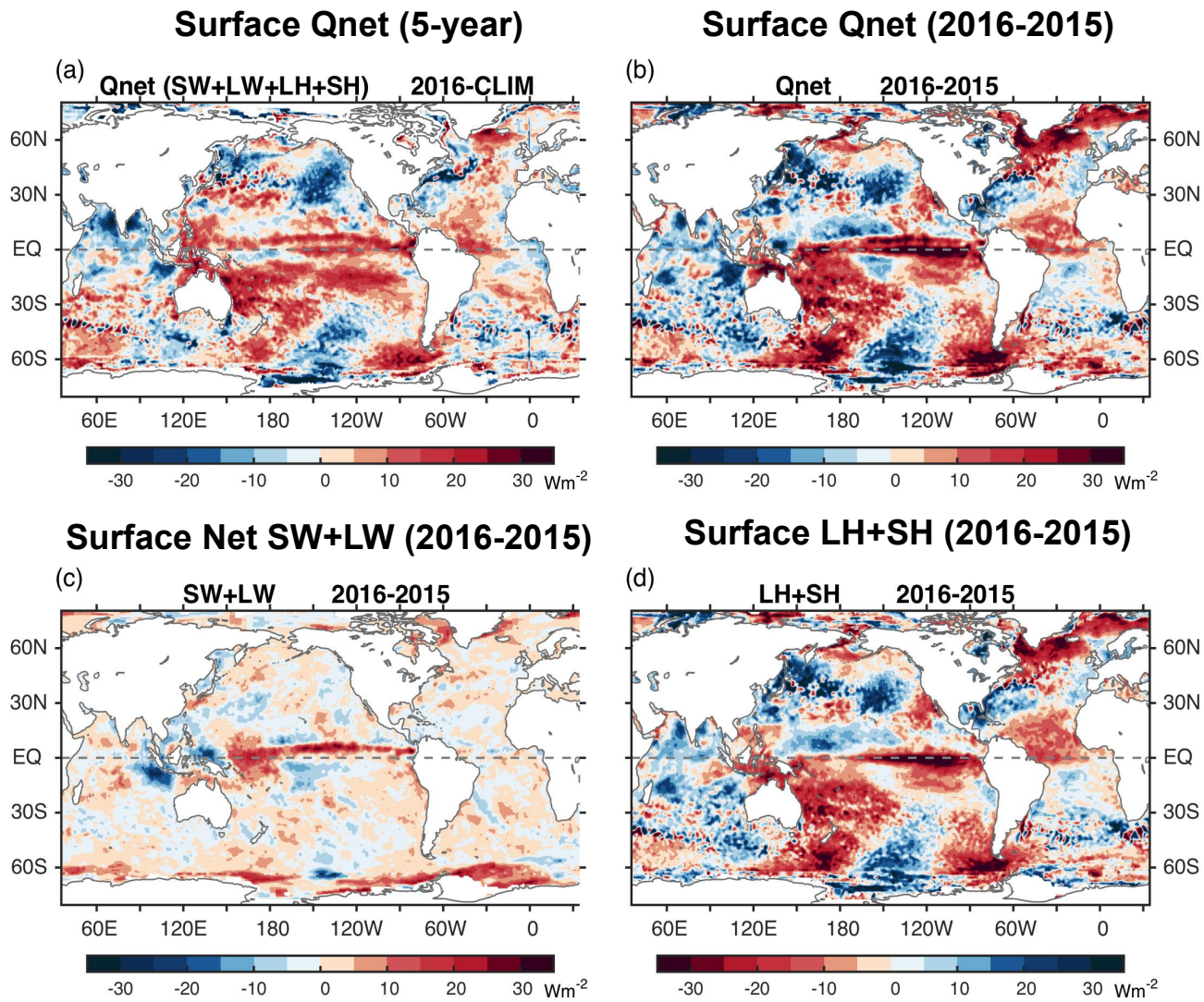
Kratz et al., 2017: Earth Radiation Budget [submitted to "State of the Climate in 2016"].

Extending Deseasonalized Anomalies



Globally averaged EBAF and normalized FLASHFlux deseasonalized monthly anomalies relative to EBAF climatology extended to April 2017.

State of Climate 2016 Results



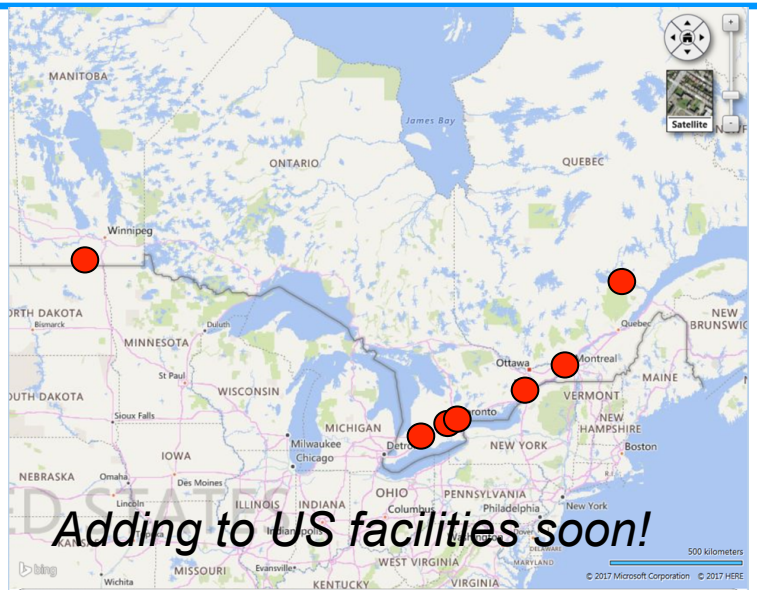
Yu et al., 2017: Earth Radiation Budget [submitted to "State of the Climate in 2016", BAMS].

WHOI OAflux Latent & Sensible Heat fluxes + CERES FLASHFlux year-to-year difference for radiative fluxes

Positive values denote ocean heat gain.

FLASHFlux Data Usage Through POWER Applied Science

- ***3M Company manages 11 facilities using RETScreen and FLASHFlux data:*** "The NASA datasets we use are critical to our energy analysis since they are used as major variables that predict our energy use."
- ***Renewable energy engineers use daily solar irradiance to assess performance of multiple solar systems for clients: users in Ottawa region and Customer First Renewables (e.g., MIT, Lockheed Martin, Corning)***
- ***A Stanford University Professor uses data for classroom studies in modeling, including crop modeling***
- ***HCO Hazelnut Company (Ferrero Corp. – makers of Nutella) uses data to assess suitability of crops in different regions; then uses for crop modeling simulations***

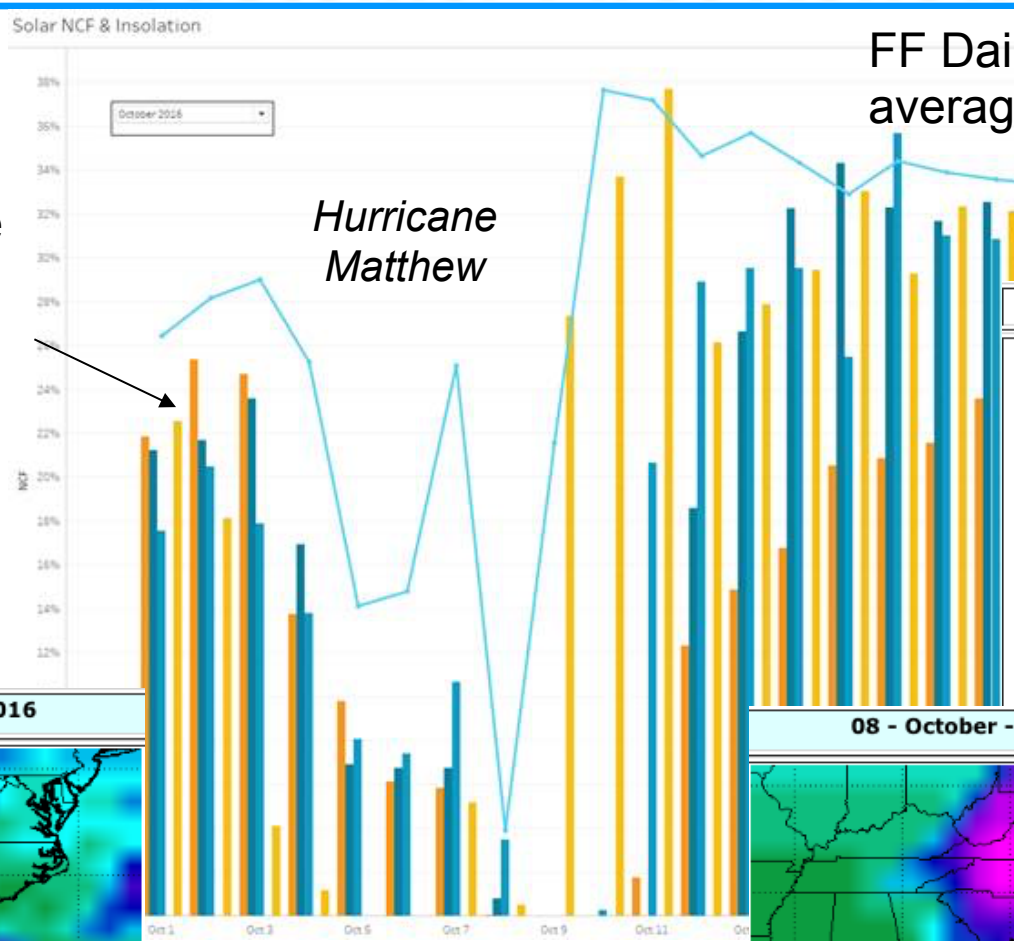


FLASHFlux Usage Example: Customer First Renewables

4 NC Solar Panel Field Performance

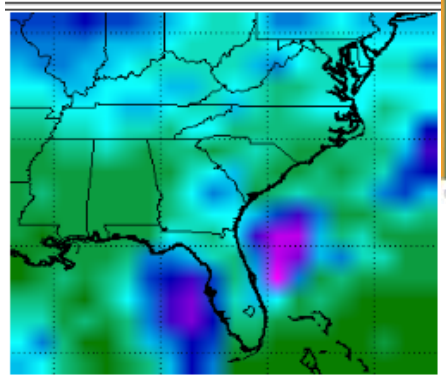
Bright yellow is inland

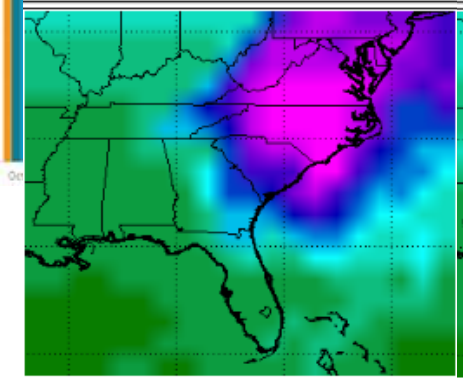
Others coastal

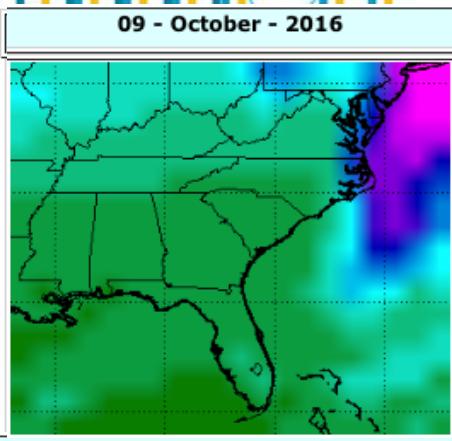


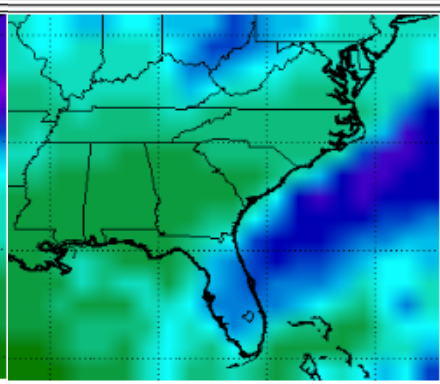
Hurricane Matthew

FF Daily average solar irradiance; averaged over site locations





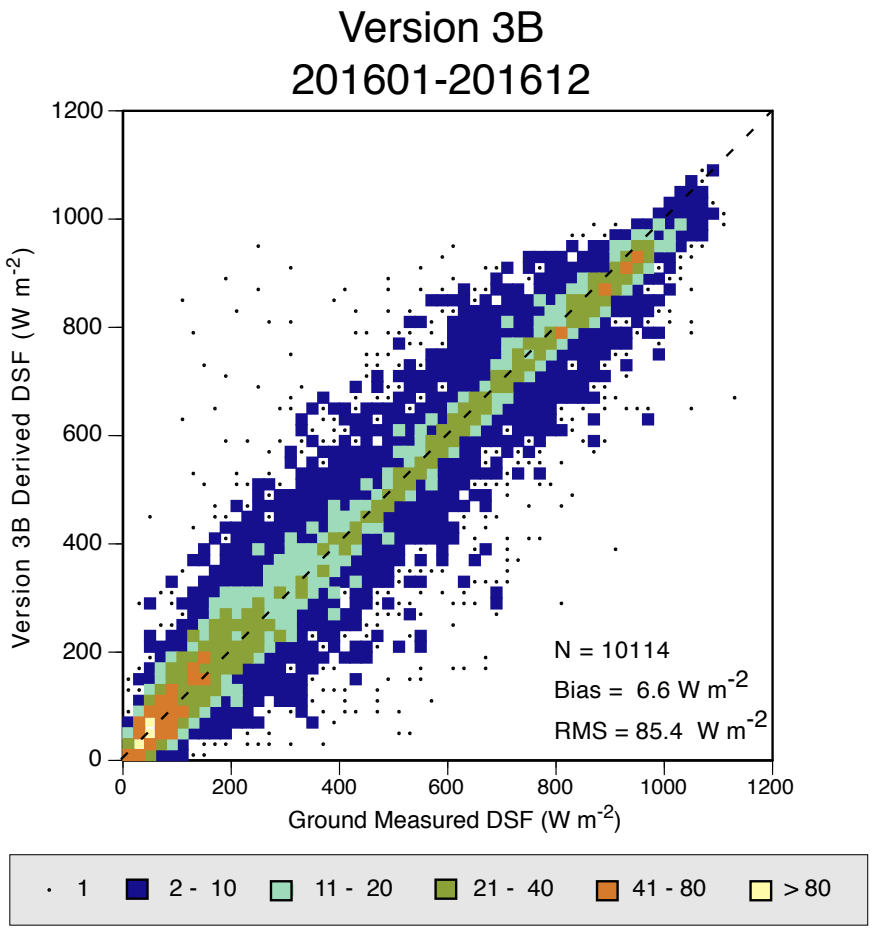




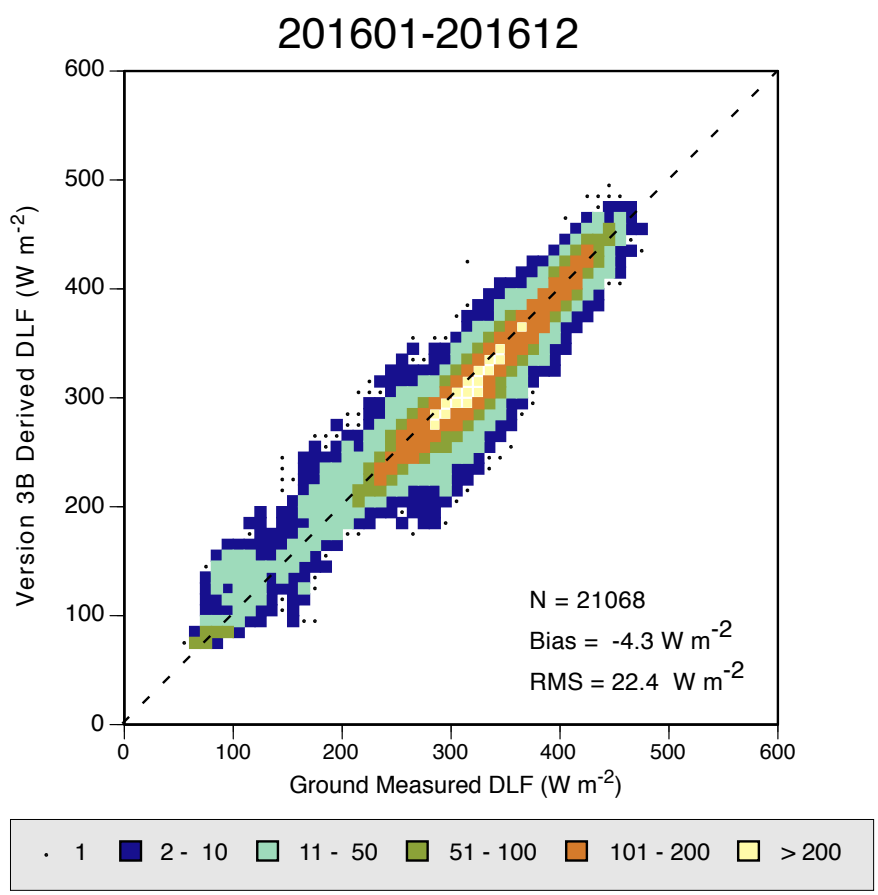
Oct 8, 2016

FF v3B SSF Validation Summary: All-Sky

FF v3B SW



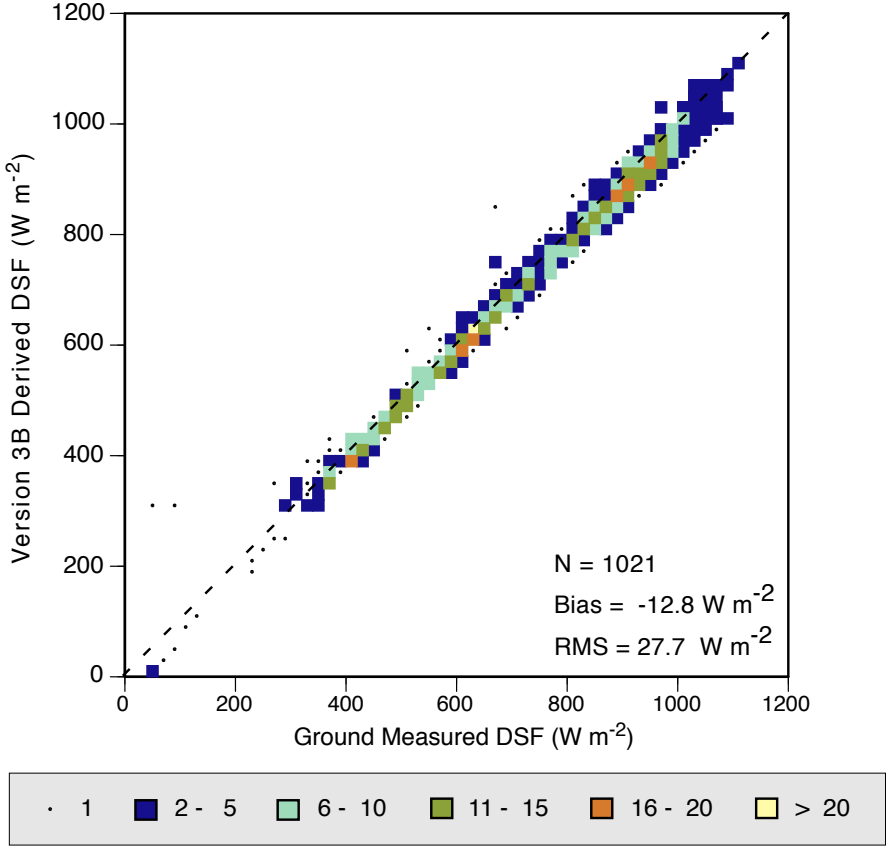
FF v3B LW



FF v3B SSF Validation Summary: Clear-Sky

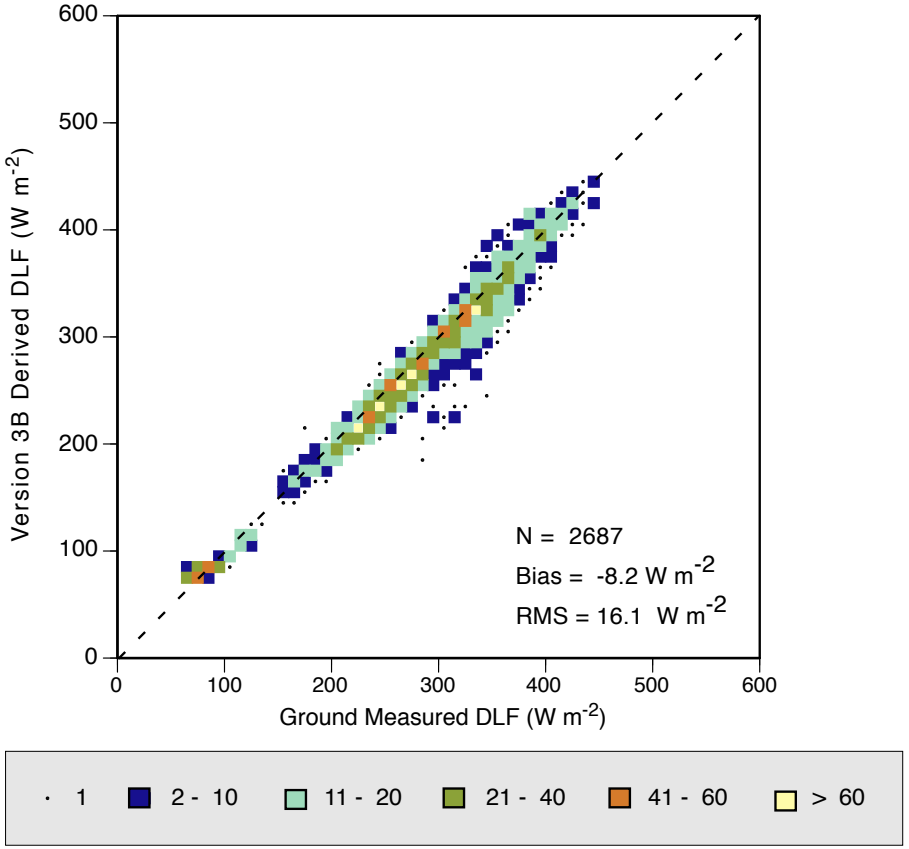
FF v3B SW

Version 3B
201601-201612

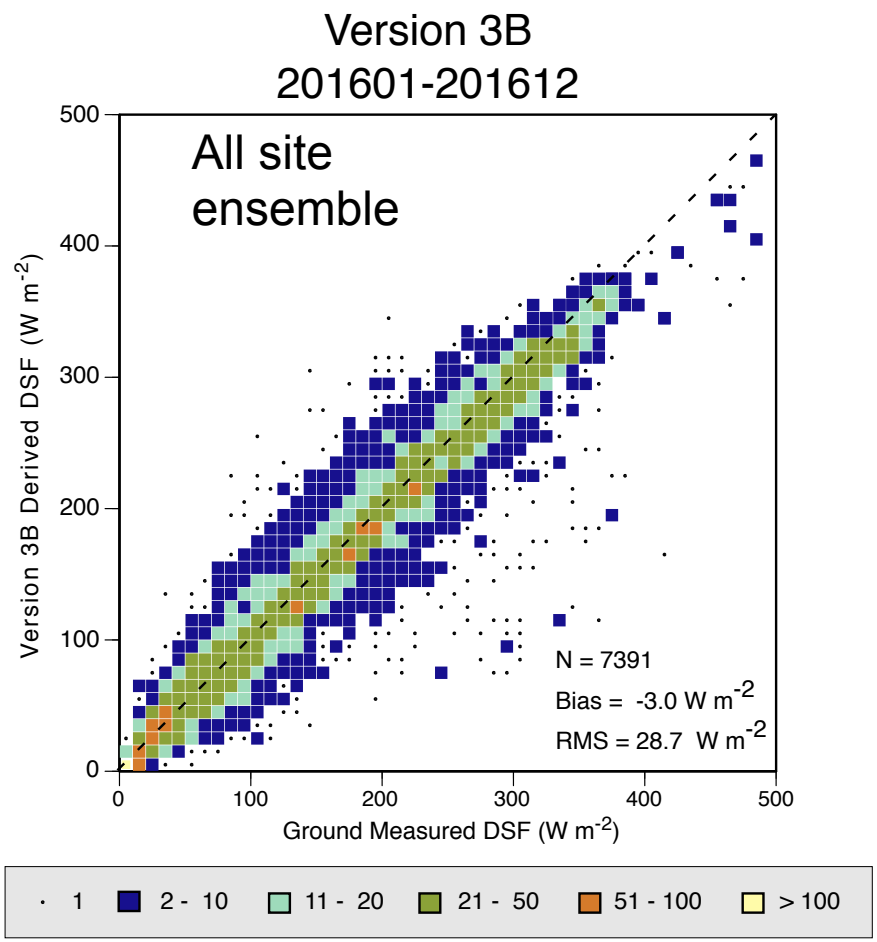


FF v3B LW

Version 3B
201601-201612



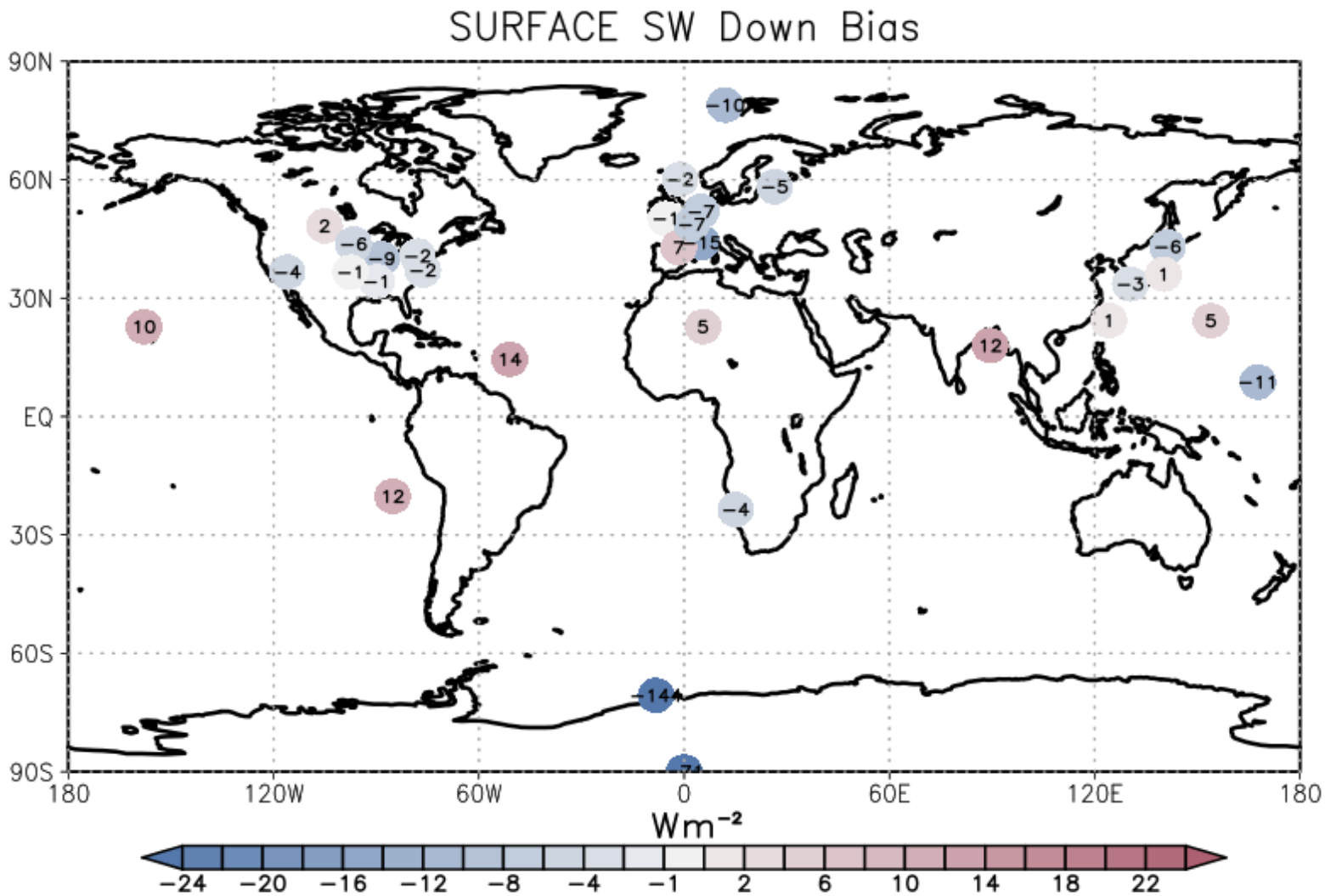
FF TISA SW v3B Validation: All-Sky



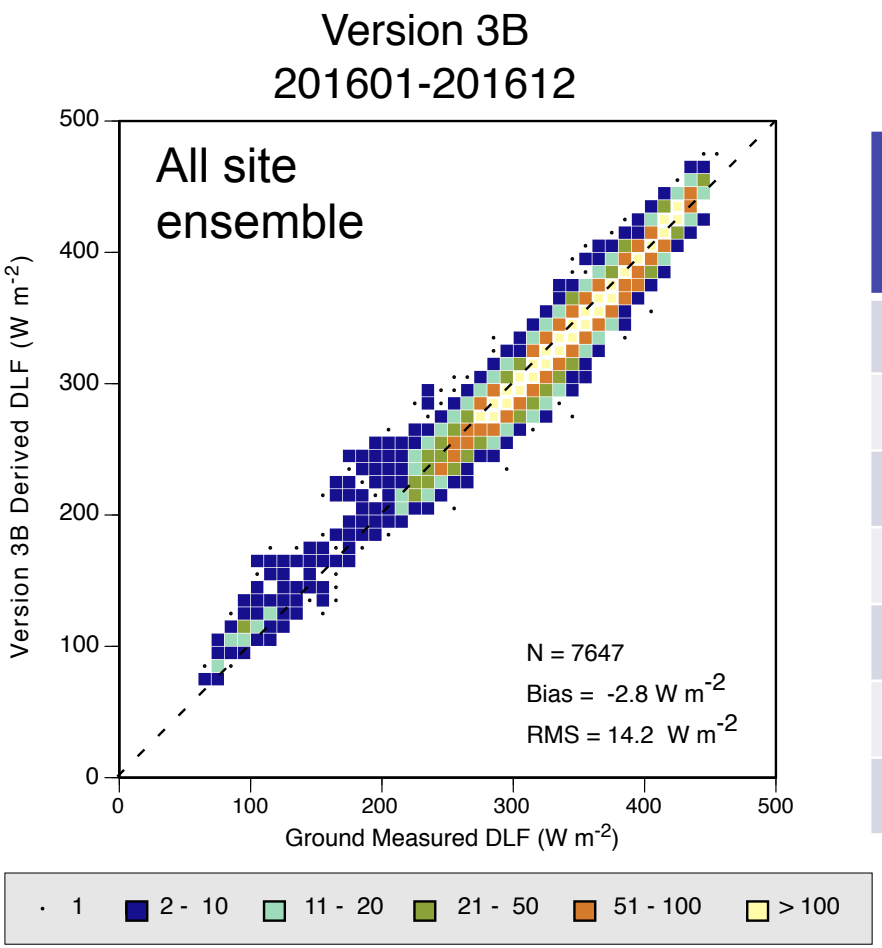
Daily Averaged TISA Comparison

Ensemble Type	Bias ($W\ m^{-2}$)	RMS ($W\ m^{-2}$)	N
All Obs	-3.0	28.7	7391
Continental	-2.0	24.8	2715
Coastal	-2.5	25.3	2737
Desert	-4.4	18.0	727
High Latitude	-39.0	75.3	301
Island	-0.7	25.7	498
Buoy	11.3	31.1	413

Recent SW Validation: 1/2016 –12/2016



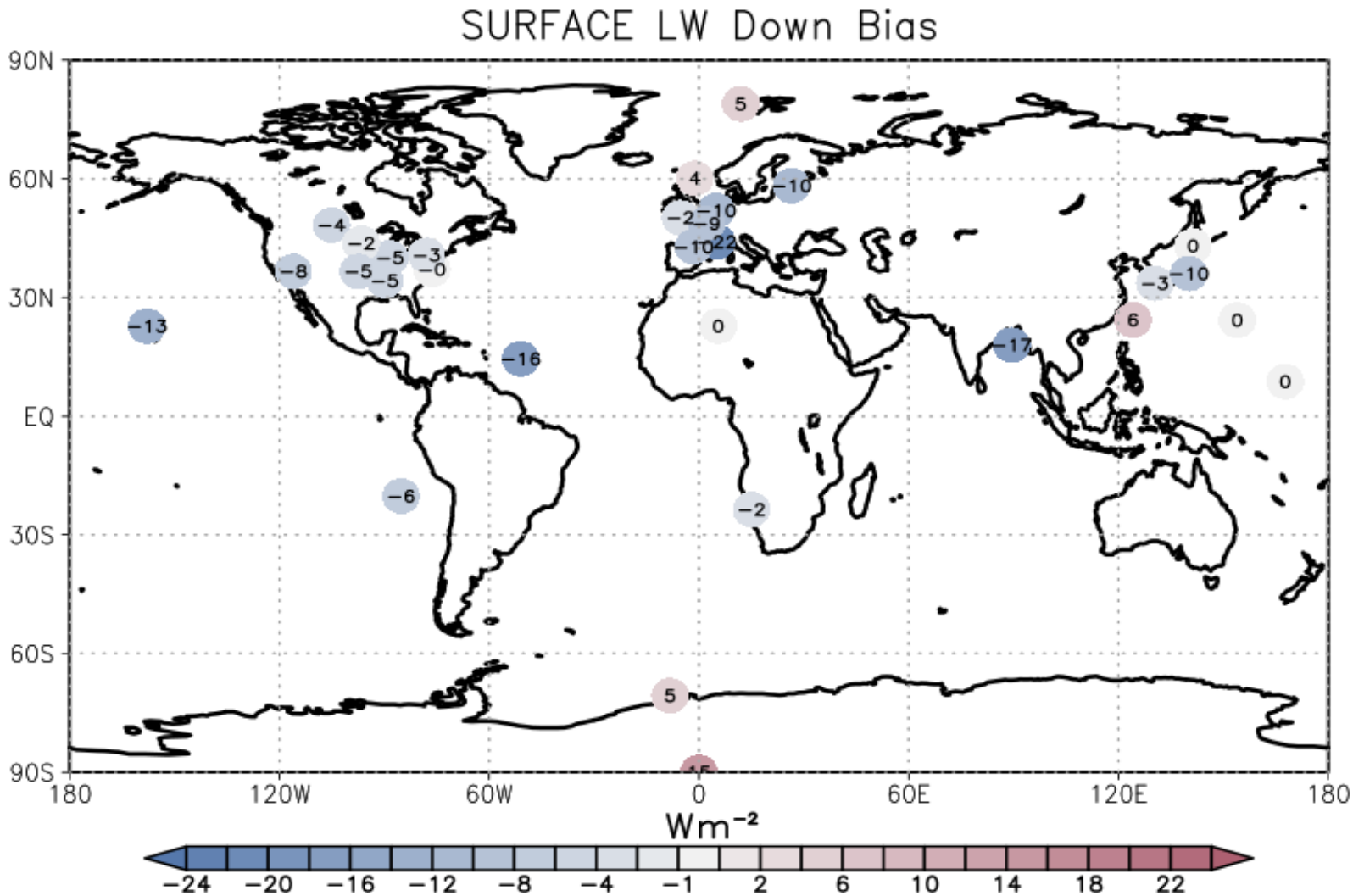
FF TISA LW v3B Validation: All-sky



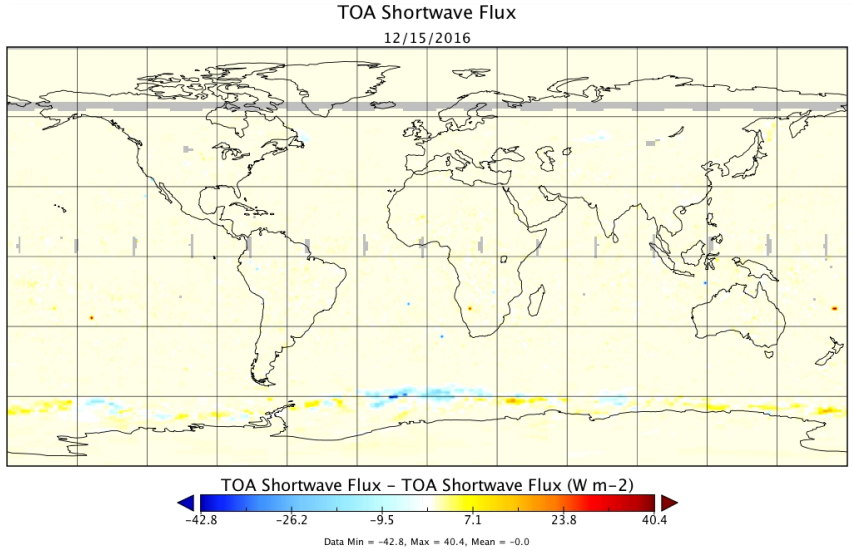
Daily Averaged TISA Comparison

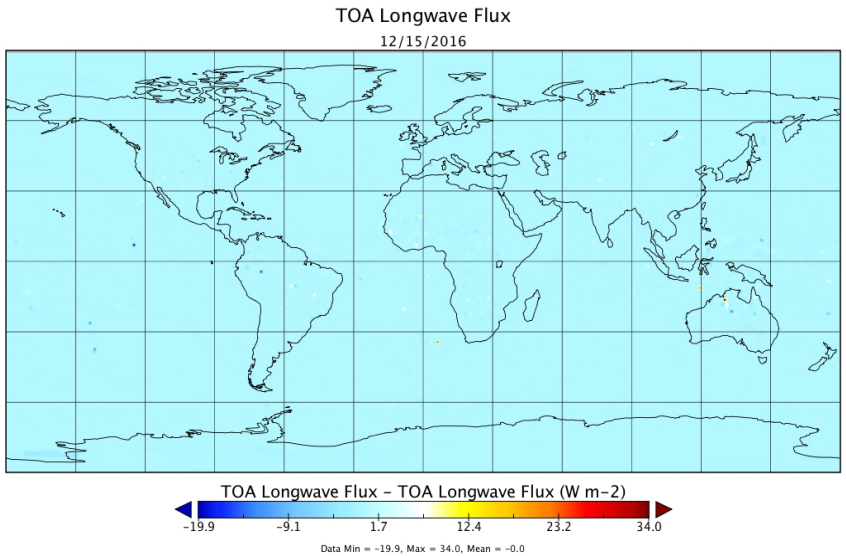
Ensemble Type	Bias (W m^{-2})	RMS (W m^{-2})	N
All Obs	-2.8	14.2	7647
Continental	-5.5	13.1	2653
Coastal	-1.8	12.5	2744
Desert	-4.9	17.6	710
High Latitude	9.3	12.6	635
Island	-0.3	10.0	497
Buoy	-10.5	15.5	408

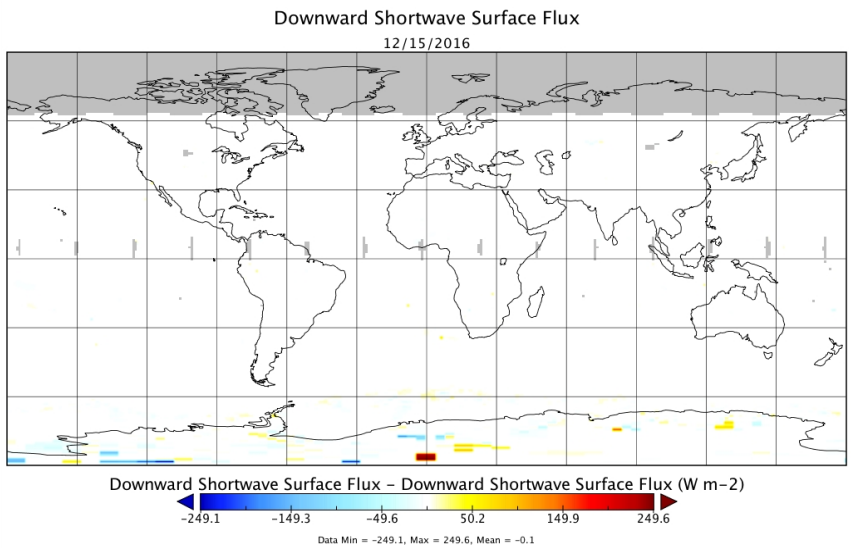
Recent LW Validation: 1/2016 –12/2016

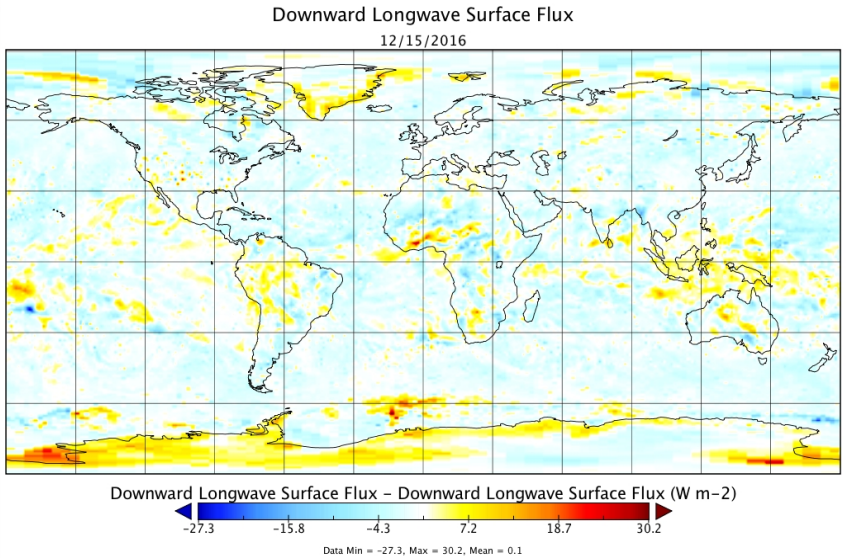


V3C Minus V3B Differences: (GEOS 5.12.4 – GEOS 5.9)

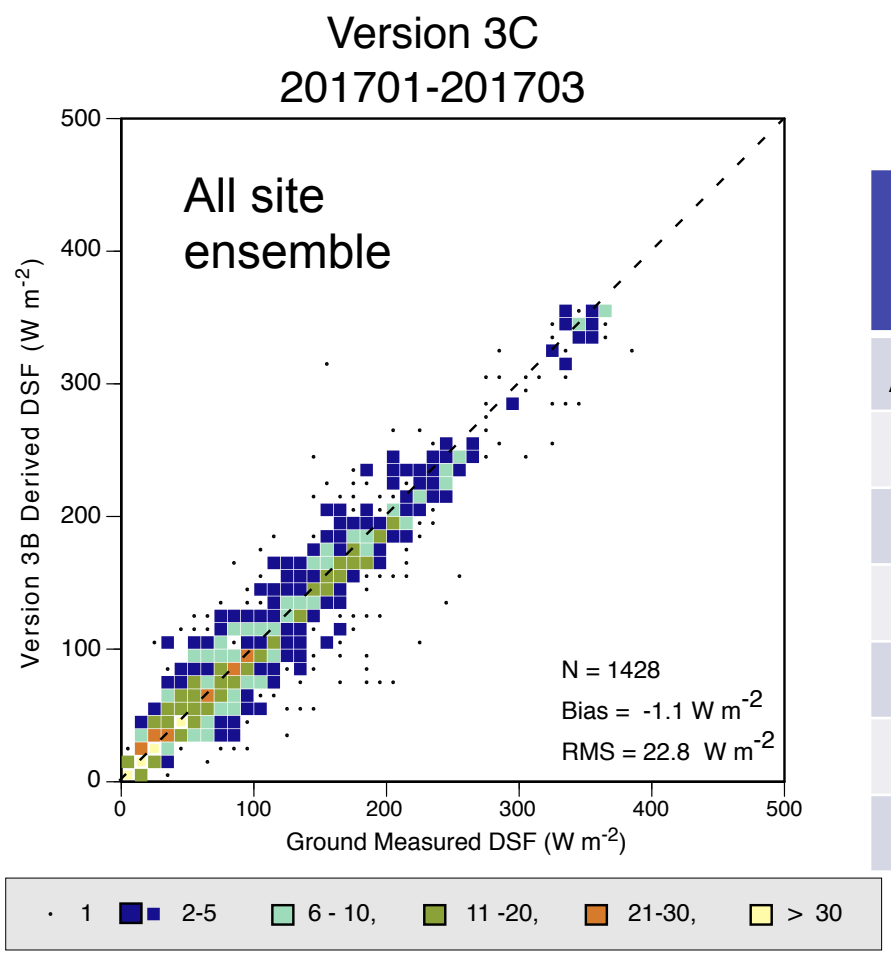








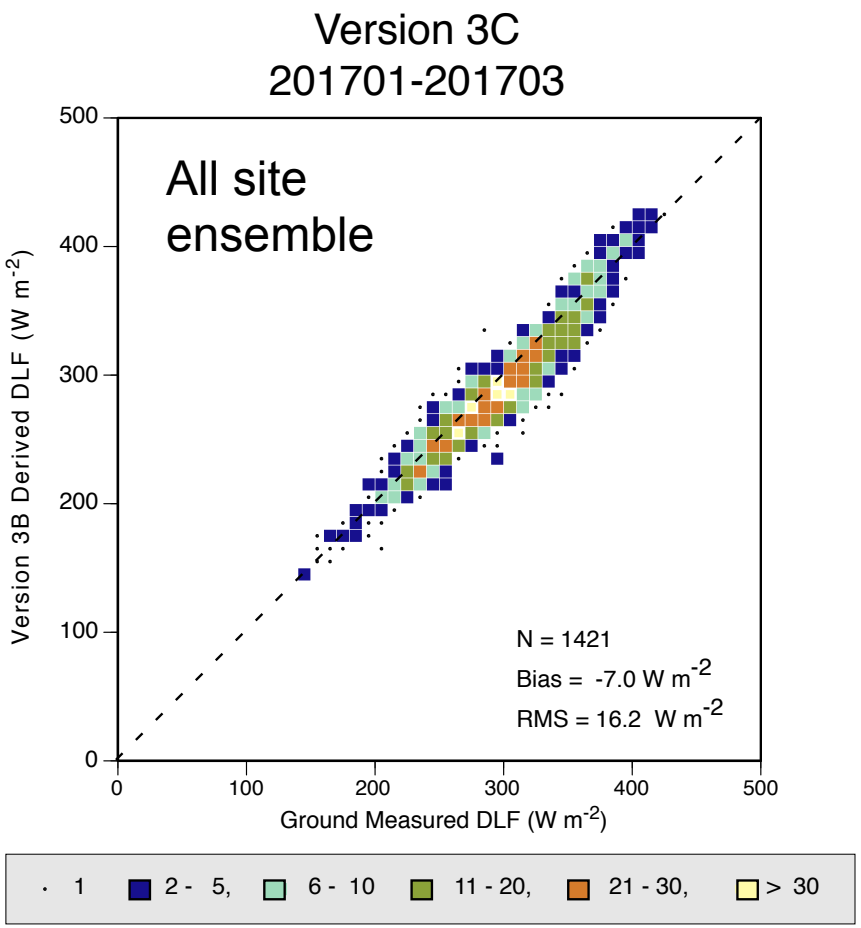
Recent SW Validation: 1/2017– 3/2017



Daily Averaged TISA Comparison

Ensemble Type	Bias ($W\ m^{-2}$)	RMS ($W\ m^{-2}$)	N
All Obs	-1.1	22.8	1428
Continental	-0.3	25.7	733
Coastal	-1.8	17.9	491
Desert	-4.2	23.0	147
High Latitude			0
Island	2.0	20.1	57
Buoy			0

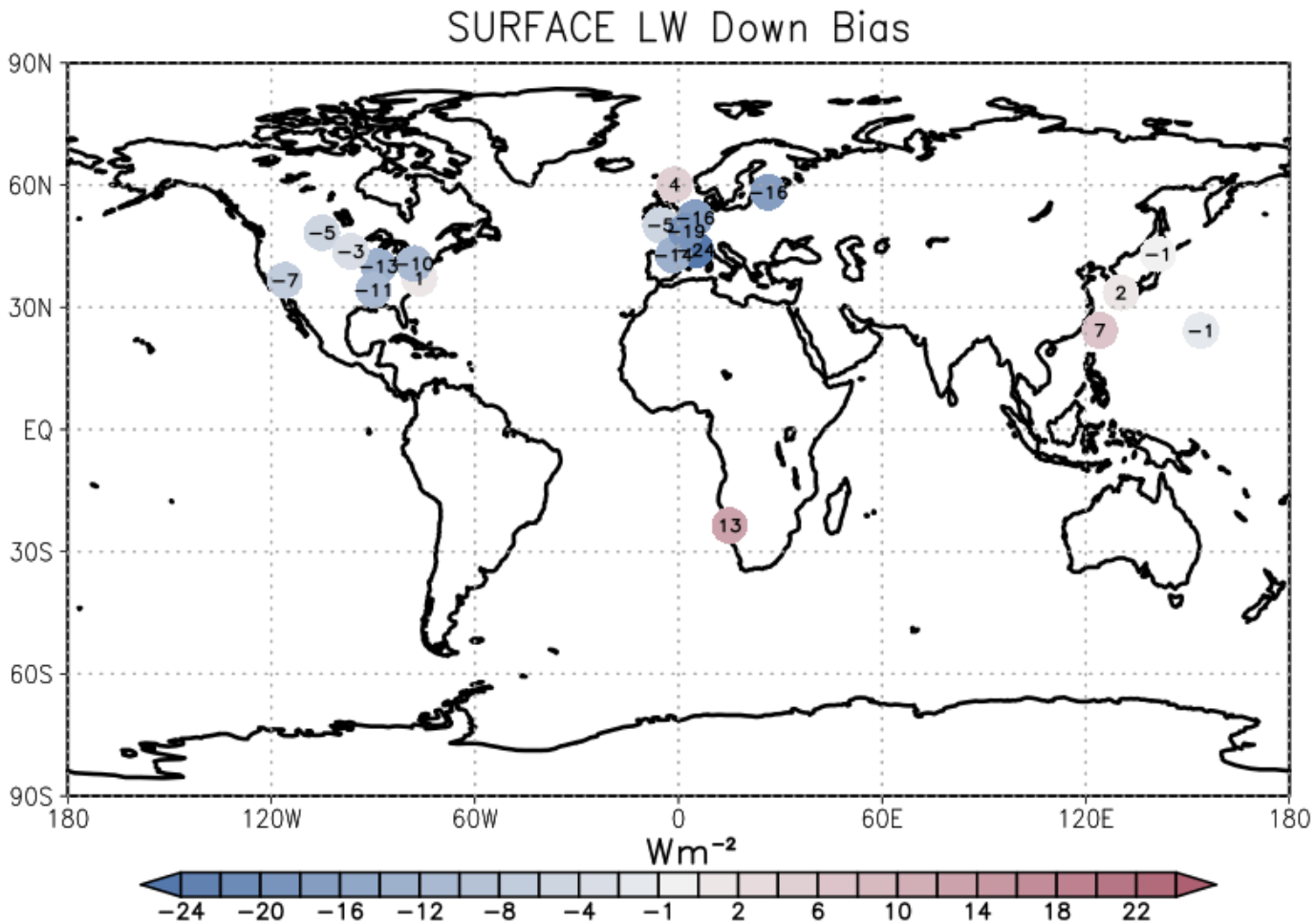
Recent LW Validation: 1/2017 –3/2017



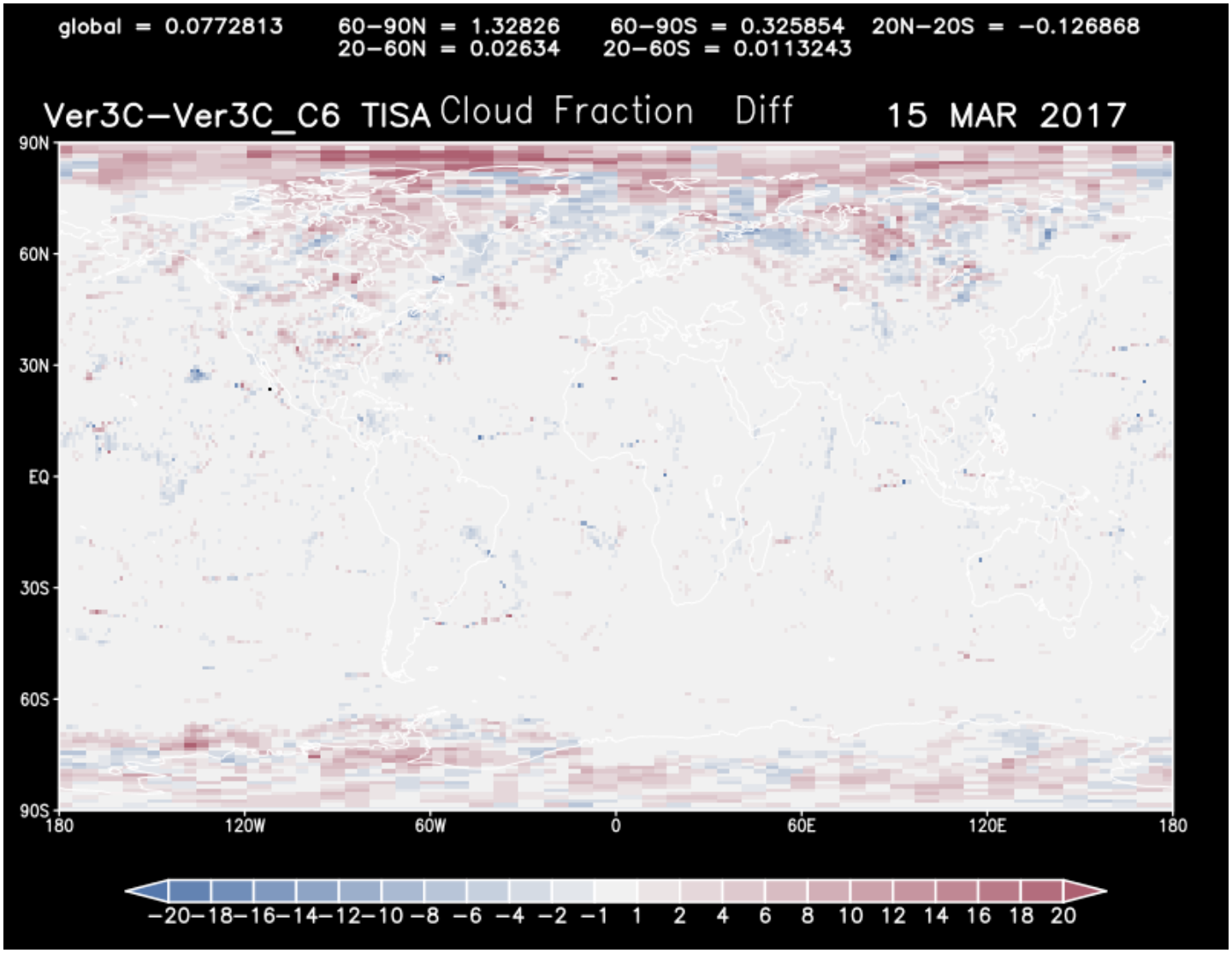
Daily Averaged TISA Comparison

Ensemble Type	Bias ($W\ m^{-2}$)	RMS ($W\ m^{-2}$)	N
All Obs	-7.0	16.2	1421
Continental	-12.6	18.3	725
Coastal	-1.9	14.1	494
Desert	1.2	14.4	145
High Latitude			0
Island	-1.3	18.3	57
Buoy			0

Recent LW Validation: 1/2017 –3/2017



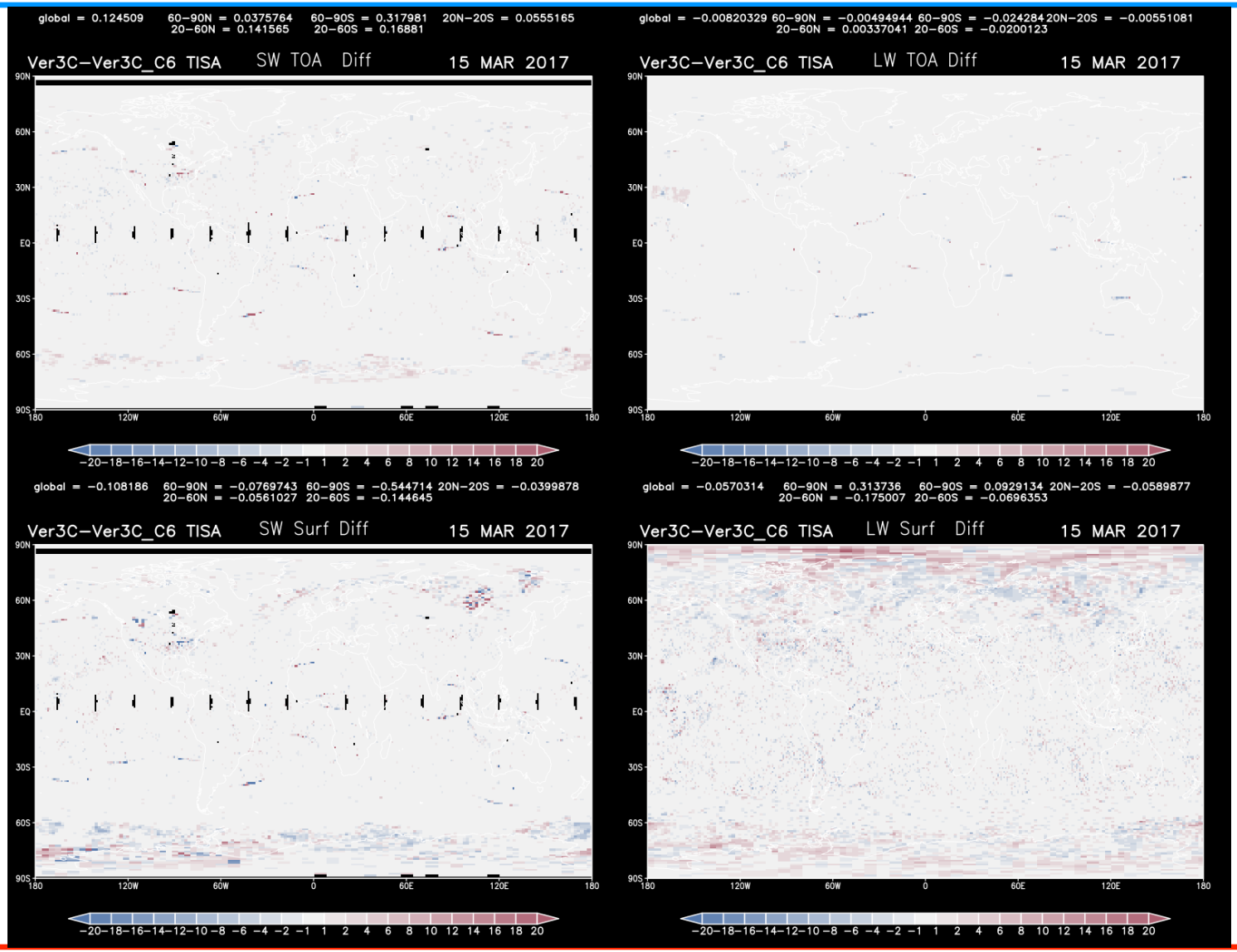
V3C-MODIS C6 Minus V3C MODIS C5 Differences



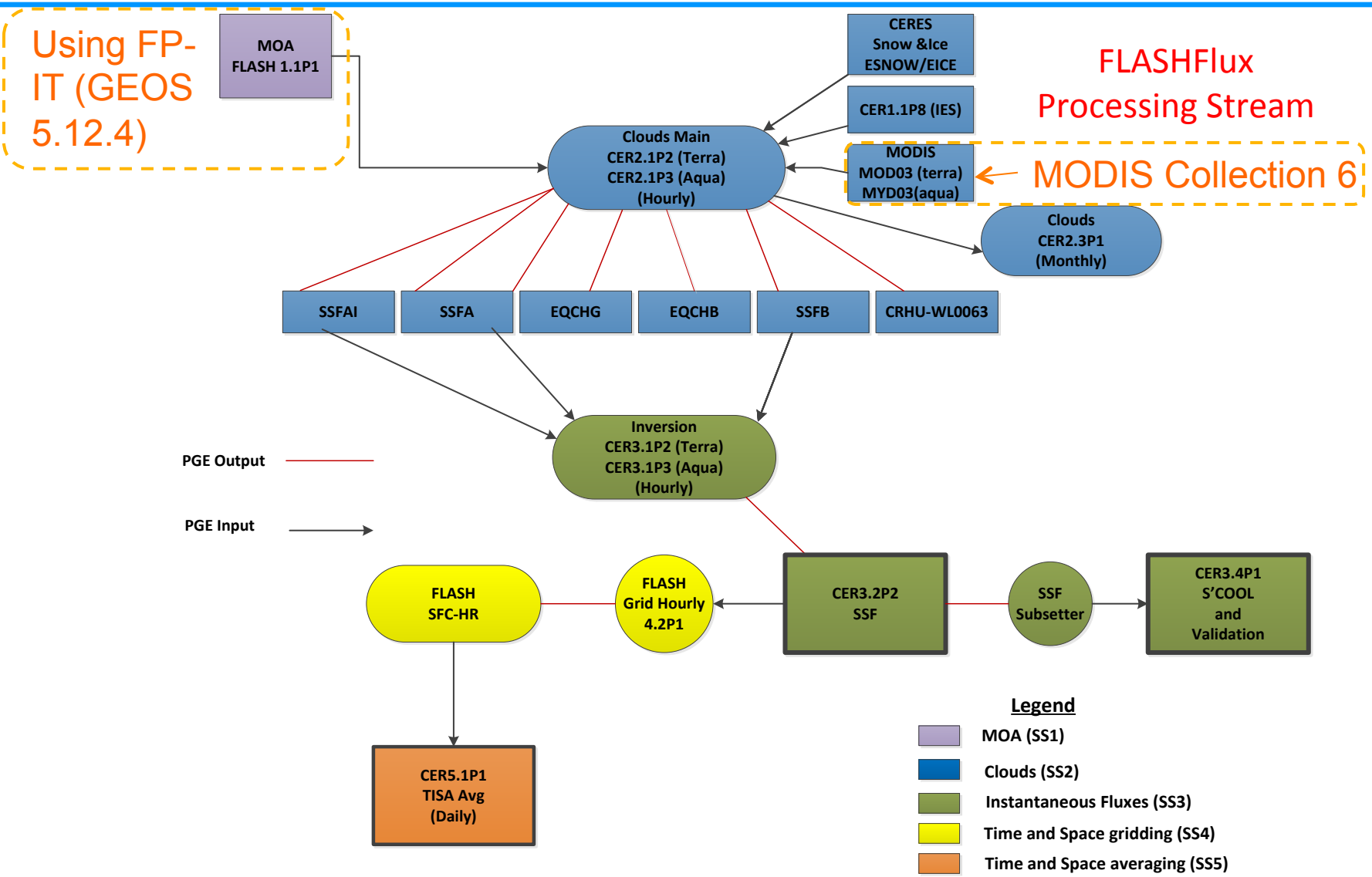
V3C-MODIS C5 Minus V3C MODIS C6 Differences

TOA Flux Differences

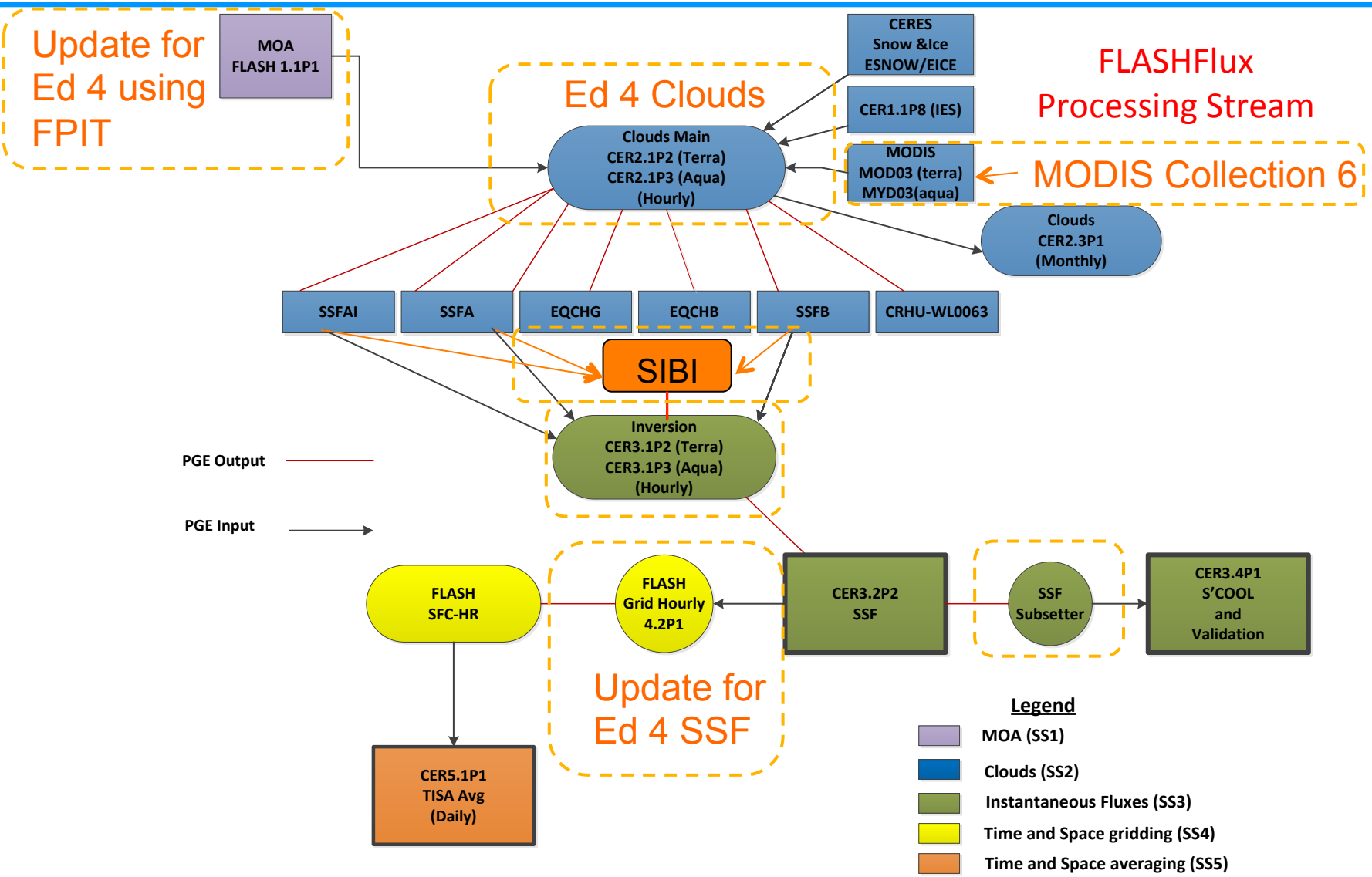
Surface Flux Differences



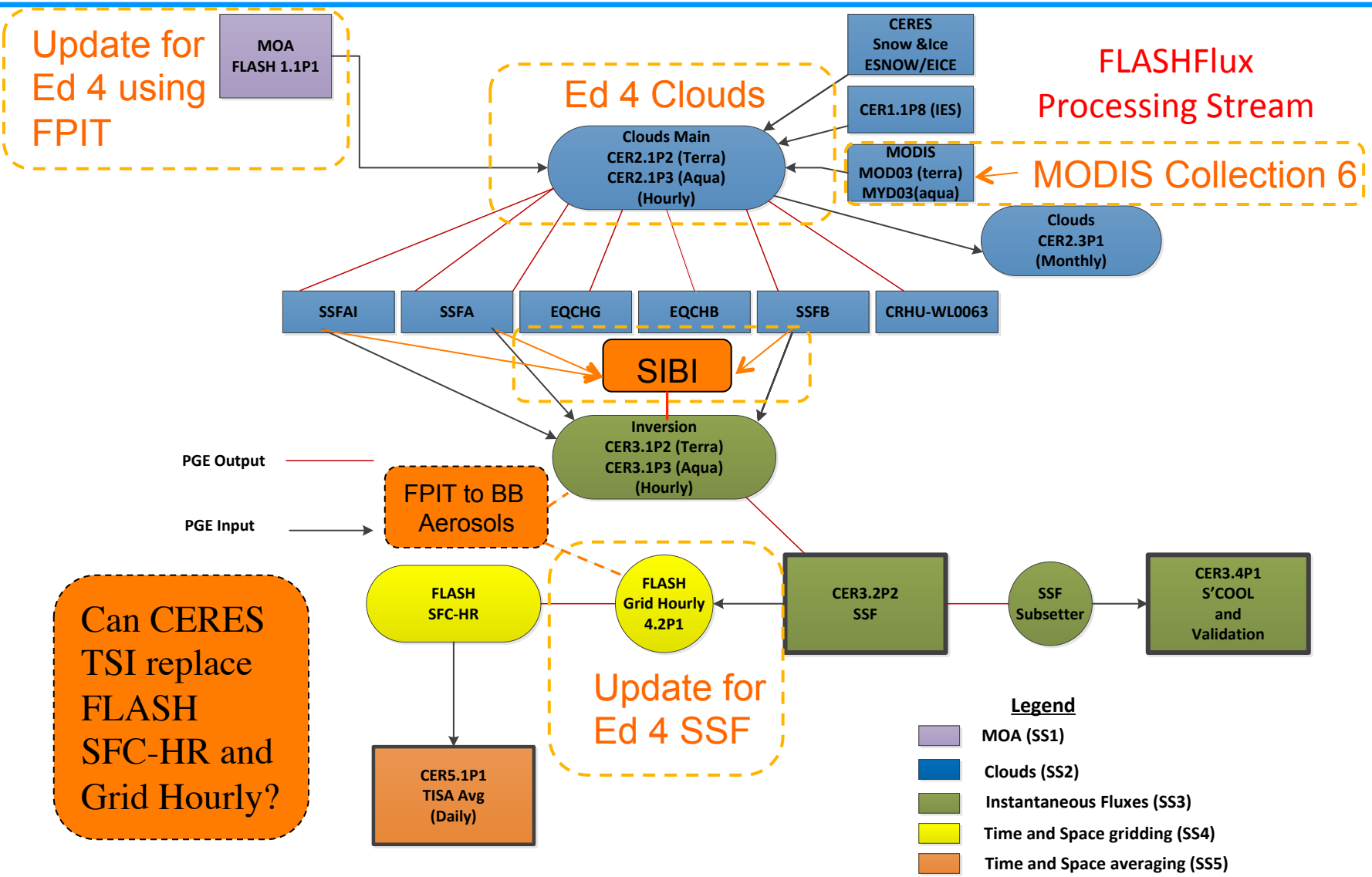
Current v3C Production System



Planned v4A Production System (Jul '17)



FF Future Production System



Summary and Conclusions

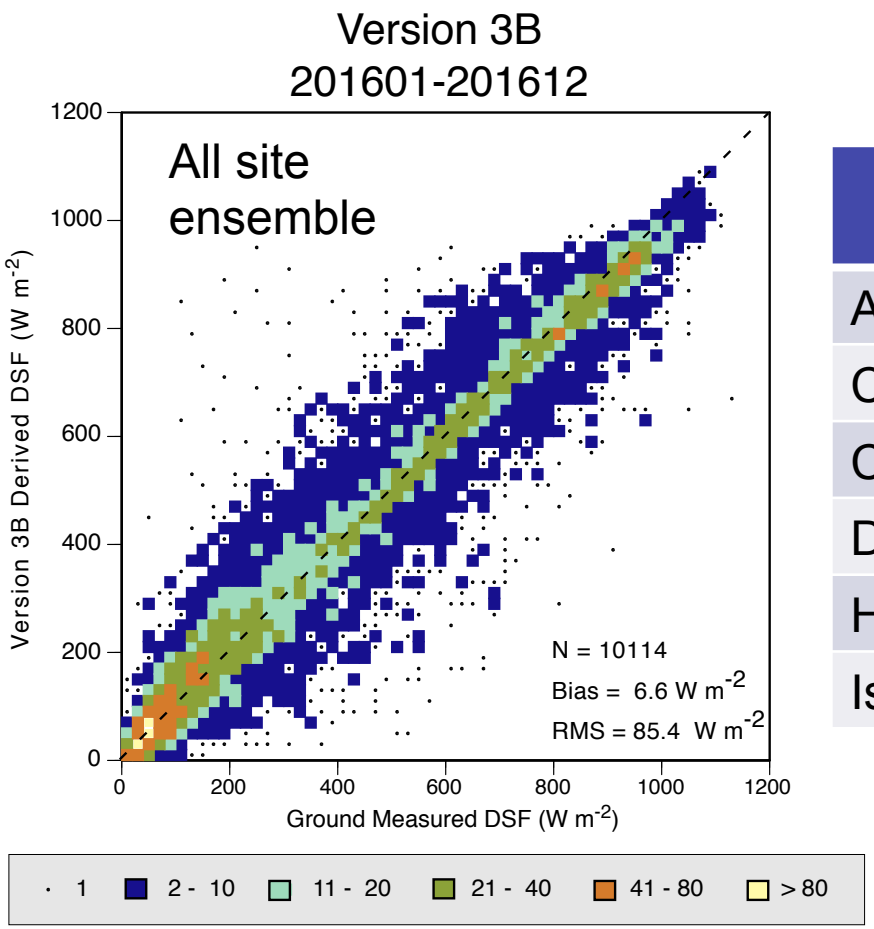
- ***FLASHFlux 3C***
  - Updated from v3B (MODIS C5) to v3C (MODIS C6); evaluation
  - Continuing production and validation for v3C
- ***FLASHFlux Applications:***
  - Continued usage of FLASHFlux through POWER project
  - Developing new web site featuring GIS tools for CERES/FF/POWER and with ASDC to raise discoverability and accessibility
- ***FLASHFlux publications:***
  - 2016 SotC reports submitted; contributed to Nature Climate Change
  - Future papers: FLASHFlux TISA applications including energy
- ***Future Versions***
  - Developing v4A by migrating CERES Ed 4 Clouds (collection 6) and Inversion; must adapt current FF TISA => target July '17
  - Longer-term Upgrades (Fall '17):
    - Assess FPIT aerosol assimilation
    - Assess & adapt CERES TSI to FLASHFlux TISA

FLASHFlux Web Sites:

https://flashflux.larc.nasa.gov

Extras

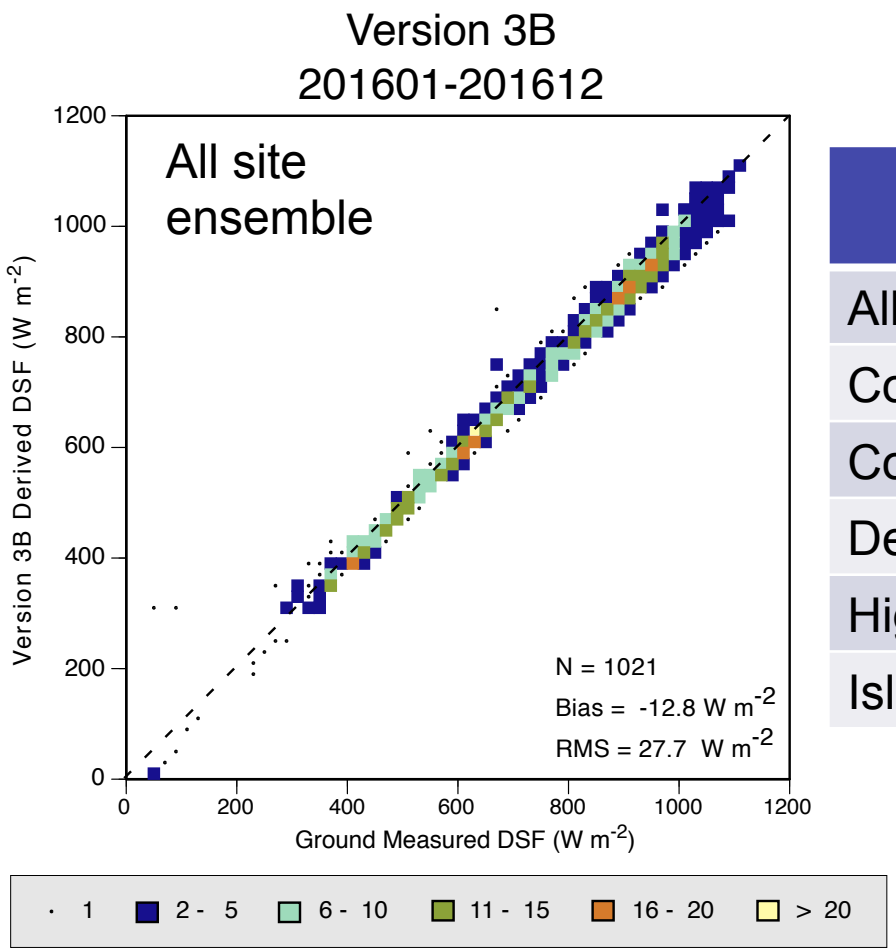
FF SSF SW V3B Validation: All-sky



Aqua & Terra SSF Comparison
All-Sky

Ensemble Type	Bias (W m^{-2})	RMS (W m^{-2})	N	r^2
All Obs	6.6	85.4	10114	0.92
Continental	13.5	83.0	3389	0.92
Coastal	10.9	90.1	3436	0.90
Desert	-5.4	60.2	766	0.93
High Latitude	-13.2	84.2	2059	0.72
Island	31.8	104.4	464	0.83

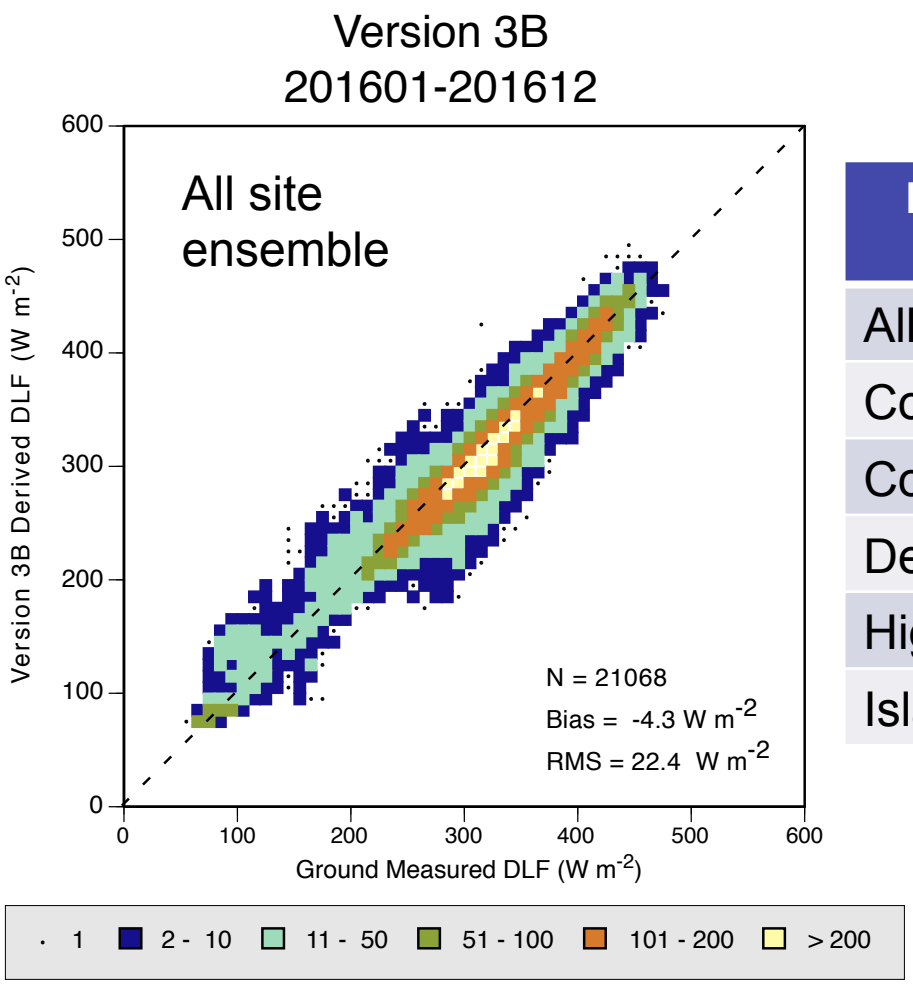
FF SSF SW V3B Validation: Clear-sky



Aqua & Terra SSF Comparison Clear-Sky

Ensemble Type	Bias ($W\ m^{-2}$)	RMS ($W\ m^{-2}$)	N	r^2
All Obs	-12.8	27.7	1021	0.99
Continental	-10.3	29.2	464	0.98
Coastal	-19.2	30.3	162	0.98
Desert	-11.6	25.9	303	0.98
High Latitude	-19.3	20.4	66	1.00
Island	-12.8	21.2	26	0.98

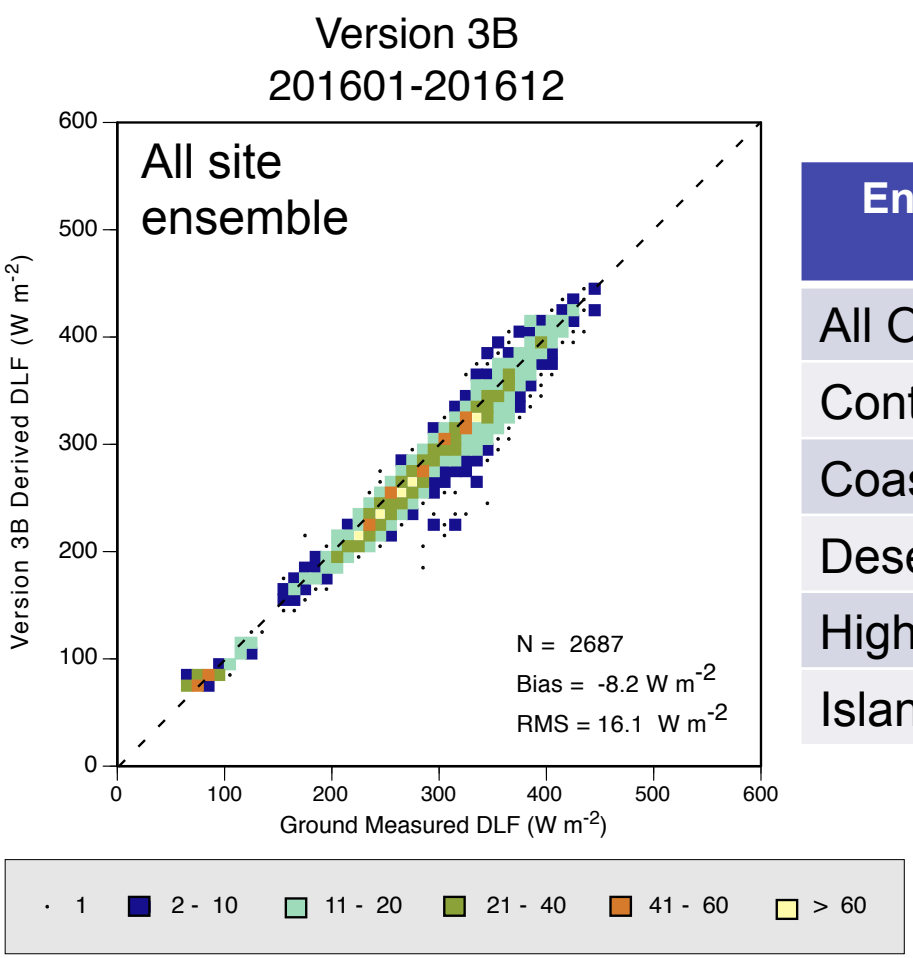
FF SSF LW V3B Validation: All-sky



Aqua & Terra SSF Comparison
All-Sky

Ensemble Type	Bias ($W\ m^{-2}$)	RMS ($W\ m^{-2}$)	N	r^2
All Obs	-4.3	22.4	21068	0.92
Continental	-5.7	19.6	6821	0.91
Coastal	-2.4	20.2	6870	0.89
Desert	-7.0	23.4	1509	0.80
High Latitude	-4.5	29.0	4936	0.89
Island	-1.6	13.4	932	0.79

FF SSF LW V3B Validation: Clear-sky



Aqua & Terra SSF Comparison
Clear-Sky

Ensemble Type	Bias ($W\ m^{-2}$)	RMS ($W\ m^{-2}$)	N	r^2
All Obs	-8.3	16.1	2687	0.97
Continental	-7.5	13.6	1383	0.97
Coastal	-5.6	14.4	501	0.95
Desert	-16.5	25.9	504	0.87
High Latitude	-1.9	11.8	254	0.95
Island	-4.5	10.1	45	0.86

FLASHFlux Data Usage Through POWER Applied Science

- ***3M Company manages 11 facilities using RETScreen and FLASHFlux data:*** "The NASA datasets we use are critical to our energy analysis since they are used as major variables that predict our energy use."
- ***A renewable energy engineer users daily solar irradiance to assess performance of 36 solar systems in Ottawa region***
- ***A Stanford University Professor uses data for classroom studies in modeling, including crop modeling***
- ***HCO Hazelnut Company uses data to assess suitability of crops in different regions; then uses for crop modeling simulations***

Assignment 6: Model Intercomparison for Potential Evapotranspiration

In homework #1 you wrote six functions to compute PET using six different methods. Now we will use those functions to explore the importance of PET and precipitation changes for water availability (measured as P - PET). By using multiple models and locations, you will be able to assess the importance of model uncertainty and spatial variability in making this assessment.

1 Retrieving the data (2 pts)

Choose five locations around the world that you wish to evaluate, e.g., research sites, hometowns, cities of interest, etc. Download daily weather data for any ten-year period you like from the NASA POWER dataset, available at http://earth-www.larc.nasa.gov/cgi-bin/cgiwrap/solar/agro.cgi. The GUI allows you to pick the lat, lon, dates, and variables that you want. After clicking the "Yes" button (so that it gives you the ICASA ASCII format that it mentions), a text file will appear in your browser window (it might take a couple minutes for processing). You can right-click and save as a .txt to your local directory, which you can then call `read.table()` on.

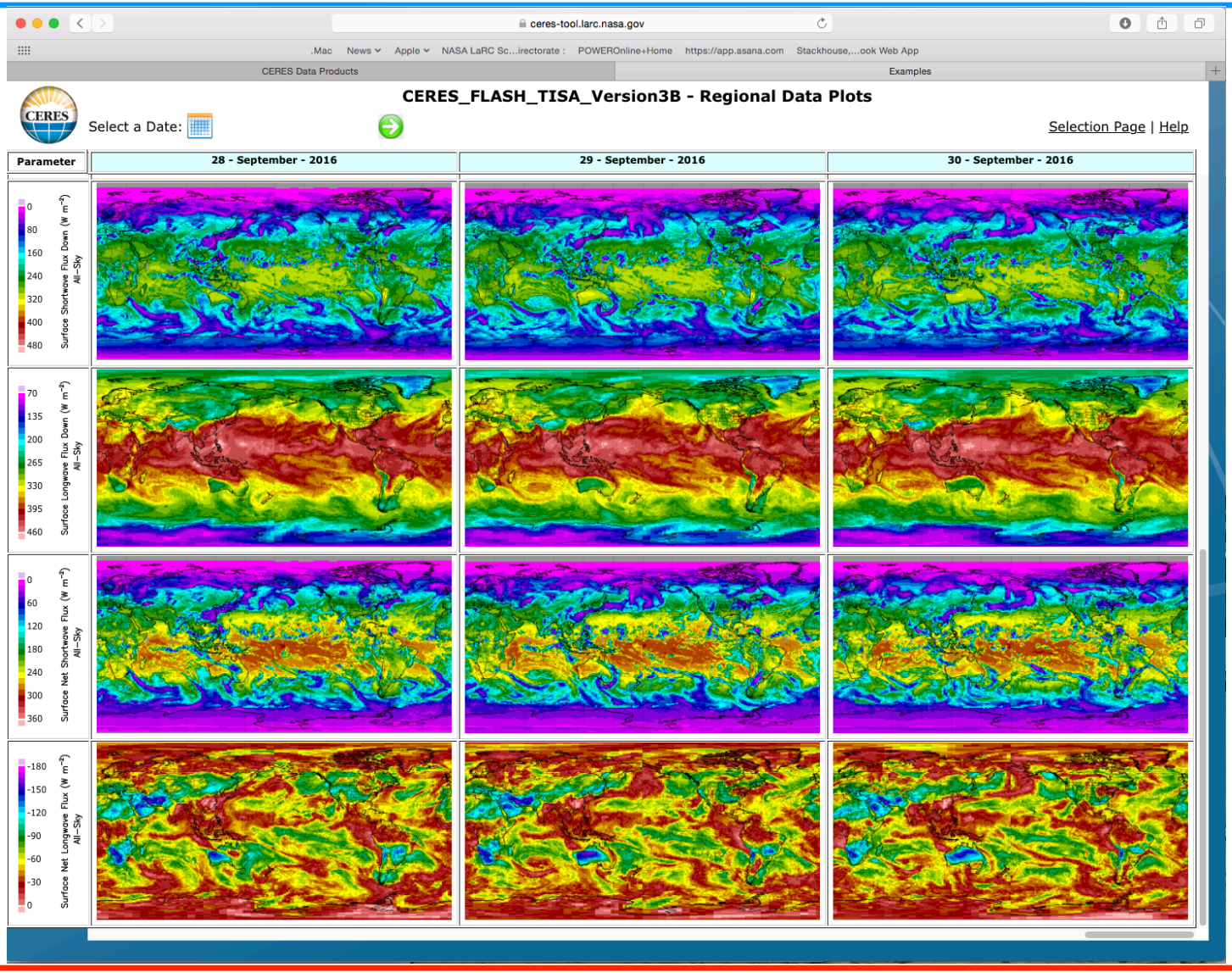
FLASHFlux TISA Available Via Subsetter

SW Down

LW Down

Net SW

Net LW



Progress Toward CERES GIS Support

Folder: ceres

https://dev-asdc-arcgis.larc.nasa.gov/server/rest/services/ceres

ArcGIS REST Services Directory

Home > **services** > **ceres**

JSON | SOAP

Published CERES SYN1DEG Image Services In Development Environment

Folder: ceres

Current Version: 10.4

View Footprints In: ArcGIS Online map viewer

Services:

- ceres/arcgis_arcgis_CERES_SYN1degDayEd3A_sfc_comp_lw_down_all_daily (ImageServer)
- ceres/arcgis_arcgis_CERES_SYN1degDayEd3A_sfc_comp_sw_down_all_daily (ImageServer)
- ceres/arcgis_arcgis_CERES_SYN1degDayEd3A_sfc_comp_sw_down_clr_daily (ImageServer)
- ceres/arcgis_arcgis_CERES_SYN1degDayEd3A_toa_comp_sw_down_all_daily (ImageServer)

Supported Interfaces: REST SOAP Sitemap Geo Sitemap

Enhancing Data Discovery Points

DATA ACCESS VIEWER

Download, Interact, analyze and visualize data in a responsive web mapping application on desktop and mobile platforms.

WEB DATA SERVICES

Consume data into your applications and code using ArcGIS Image Services, Web Mapping Services, REST API, OPeNDAP.

WEB PROCESSING SERVICES

Utilize our ArcGIS GeoProcessing Services and/or OGC Web Processing Services for direct access and analysis of data.

DOWNLOADABLE TOOLS & CODE

Download the POWER ArcGIS Toolbox and ArcGIS Raster Function Templates for analytical and data accessibility capabilities.

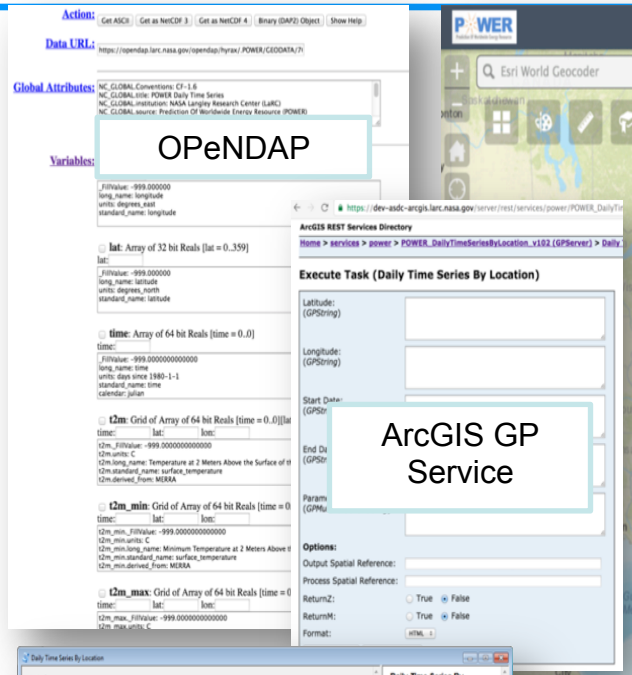
POWER Website serves as a platform for discovery of multiple data access points

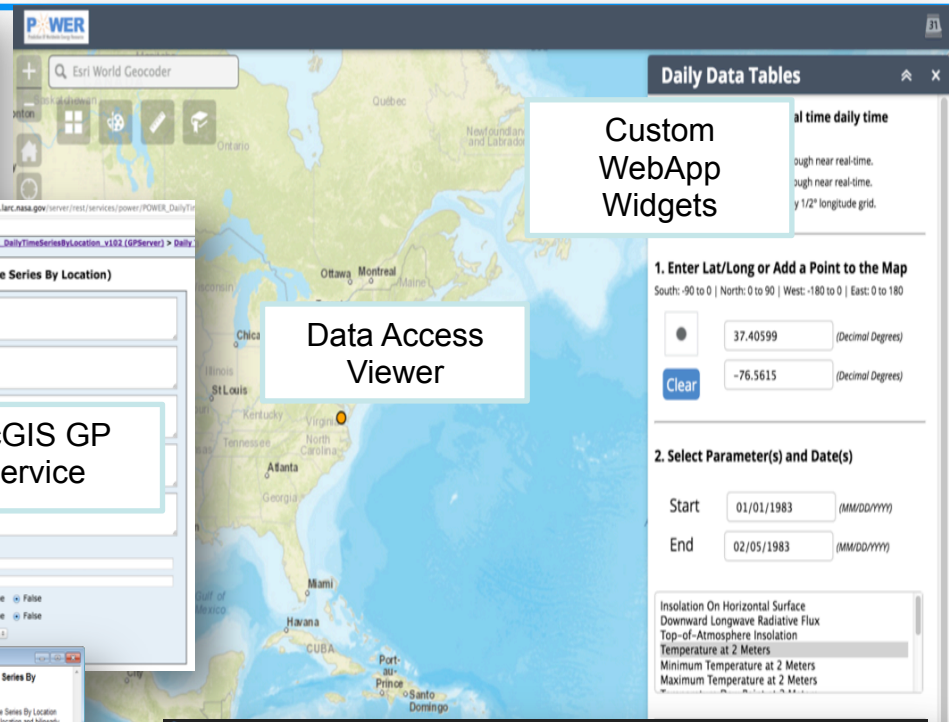
Website is a Responsive Platform for Desktop, Tablet, and Smartphone

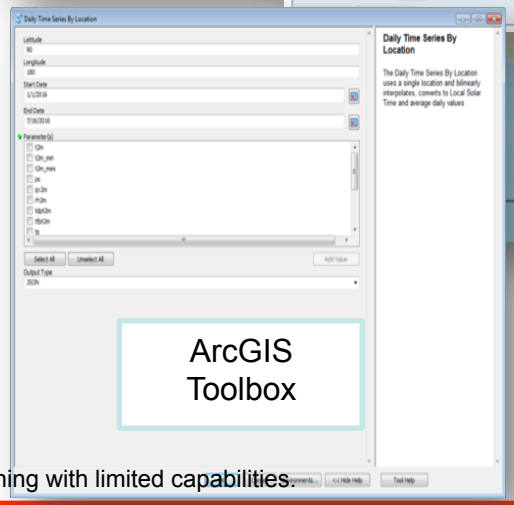
Enhancing Data Access Points

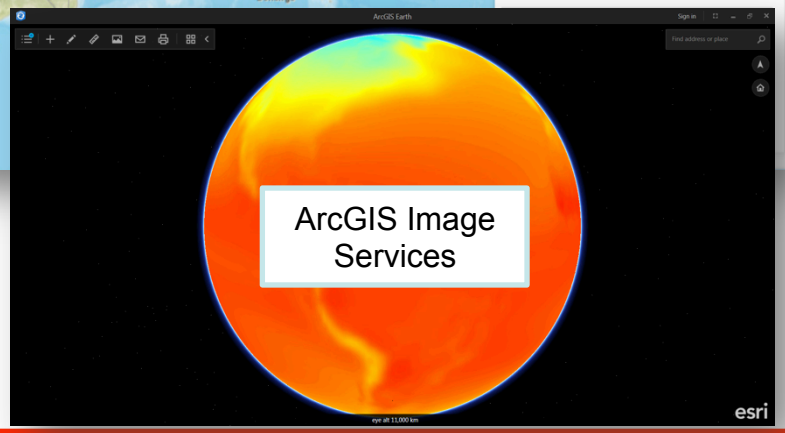
POWER
Prediction Of Worldwide Energy Resource

- ***Data Access Viewer****
- ***Web Data Services***
  - ArcGIS Image Services
  - OGC Web Map Services
  - OPeNDAP*
- ***Web Processing Services***
  - ArcGIS GP Services*
  - OGC Web Processing Services
- ***Downloadable Tools/ Code***
  - ArcGIS Toolbox*
  - ArcGIS Raster Function Templates
  - ArcGIS Custom WebApp Builder Widgets









*Items to be initially released in POWER soft opening with limited capabilities.

Enabling Data Usage Applications

Visualization & Analysis

- Panoply
  - NetCDF, OPeNDAP
- Esri ArcGIS Suite
  - NetCDF, OPeNDAP, ArcGIS Image Services, ArcGIS GP Services, ArcGIS Toolbox, GeoTIFF, Shapefile
- MatLab
  - Netcdf, OPeNDAP, GeoTiff
- QGIS
  - OGC Web Map Service, OGC Web Process Service, GeoTIFF
- DSSAT
  - ICASA
- HDFView
  - NetCDF
- Microsoft Office
  - CSV, ASCII
- R Statistics
  - NetCDF, CSV
- ERDAS Imagine
  - NetCDf, GeoTiff

POWER
Prediction Of Worldwide Energy Resource

Programming

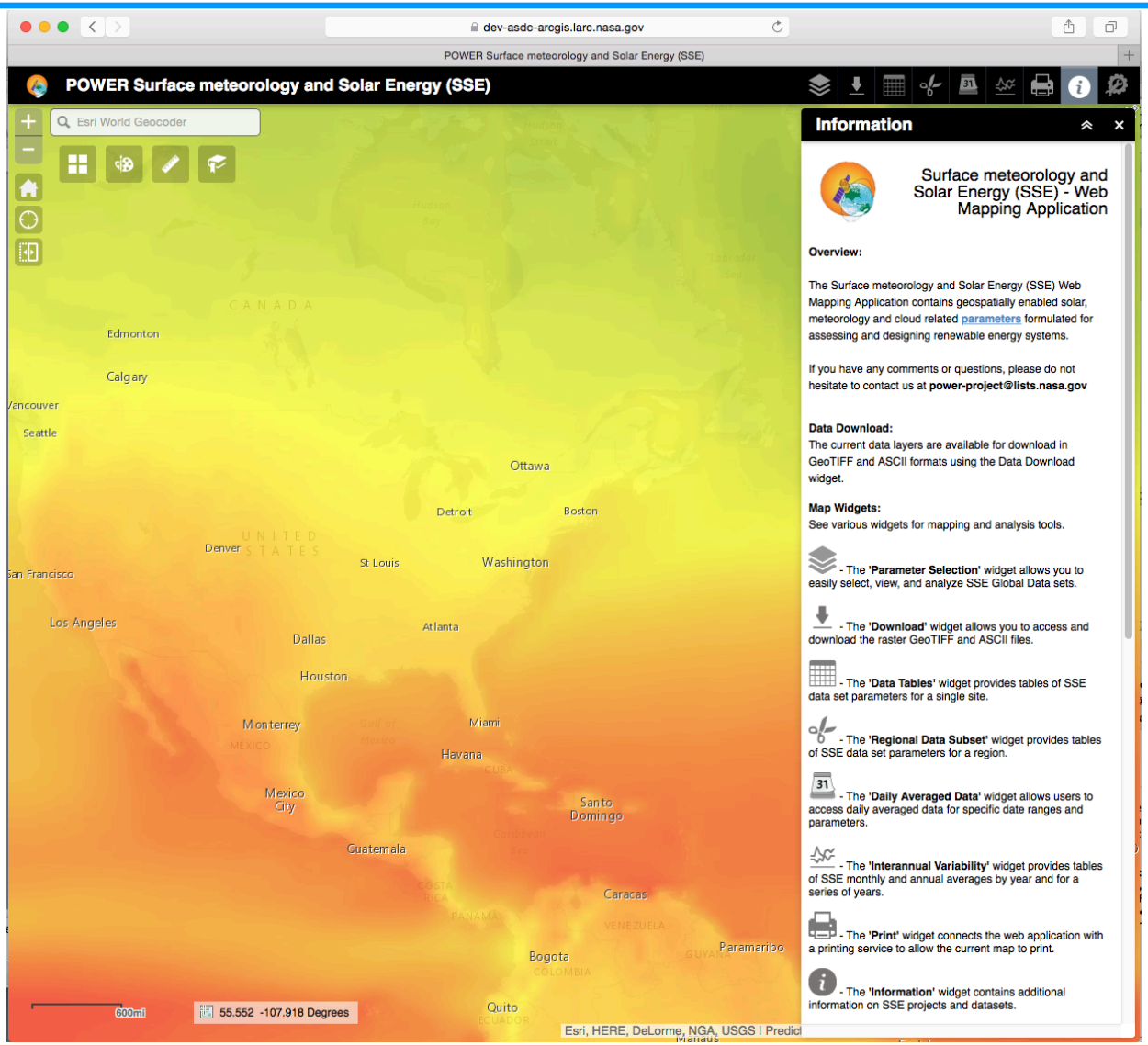
- Python
  - Esri ArcGIS for Python API, ArcGIS Image Service REST Endpoint, ArcGIS Toolbox Functions, OPeNDAP, ArcGIS GP Services, JSON, CSV, Shapefile, GeoTIFF, NetCDF
- JavaScript
  - Esri ArcGIS For JavaScript API, ArcGIS Image Services, ArcGIS GP Services, JSON, CSV
- Microsoft .NET
  - ArcGIS Runtime SDK for .NET, ArcGIS Image Services, ArcGIS GP Services, JSON, CSV

FLASHFlux Near Future Updates

- **Upgrade to CERES Ed 4 subsystems underway**
  - Meteorological input migration from GEOS 5.9.1 to 5.12.4 => the replacement of FP-IT
  - Upgrade Ed 4 Clouds with MODIS Collection 6 inputs
  - Upgrade to Ed 4 Inversion
  - Upgrade to FF TISA to support Ed 4 formatted inputs
- **Advance Web based GIS services**
  - New POWER web site to enhance data access and usage with GIS web and image services
  - Migrate FLASHFlux datasets to POWER and eventually EBAF/ SYN1Deg
- **Build Compatibility with CERES TSI**
  - Assess & adapt CERES TSI for FLASHFlux global fluxes
  - Build capability for GEO processing

SSE-GIS Beta v1.0.3

- Nearing public release of SSE-GIS
- Provides users an opportunity interact with time series data sets of energy related data sets using web based GIS services from ESRI
- Services are hosted from ASDC servers
- Users can display maps, work with multiple layers, obtain data tables and geotiff files of the parameters



Using ArcGIS To Enhance Applied Science Usage of Data Products

GEOPLATFORM.gov

DATA.GOV

Enhancing Applied Science Usage with ArcGIS

ArcGIS Capabilities

- High quality viewing (Desktop/ Mobile) and printing
- Data Extraction/Subsetting => Python code to support a variety of data formats from ASCII, to .netCDF, to geoTIF
- Simultaneous Dataset Visualization (Swiping)
- Temporal Visualization (time slider)
- Custom Color Ramps
- Pixel/Attribute Value Identification at Selected Location
- Python code to support computation of on-the-fly parameter computation

Technologies

- Esri ArcGIS Server & Portal
- OPeNDAP
- PostgreSQL & PostGIS

Connectivity

- Climate.gov
- GEOSS (AIP-8)

Progress Toward CERES GIS Support

- Published four CERES SYN1DEG ArcGIS Image Services in ***the development environment***. Allows users to 1) access the data via a REST endpoint/protocols, via JSON REST response, 2) utilize online web mapping application development tools via the ArcGIS API for JavaScript, 3) consume the services directly into ArcGIS Desktop and custom applications for further visualization and analysis.
- Data served directly from the CERES SYN1Deg Native NetCDFs:
  - SFC COMP LW DOWN ALL DAILY
  - SFC COMP SW DOWN ALL DAILY
  - SFC COMP SW DOWN CLR DAILY
  - TOA COMP SW DOWN ALL DAILY
- The 2 systems purchased by CERES have had systems software installed and are integrated into the WebRA production environment. Each server has 2 Intel Xeon E5-2643 v3 Processors (20M cache, 3.40 Ghz, 6 cores), 2.4TB of storage, 256 GB RAM (DDR4-2133MHz).
- A process was developed for integrating the machines into the production architecture for dedicated hosting of geospatial web services for CERES data products.
- These systems will be added to the ArcGIS cluster for dedicated hosting of CERES data product geospatial web services.

Progress Toward CERES GIS Support

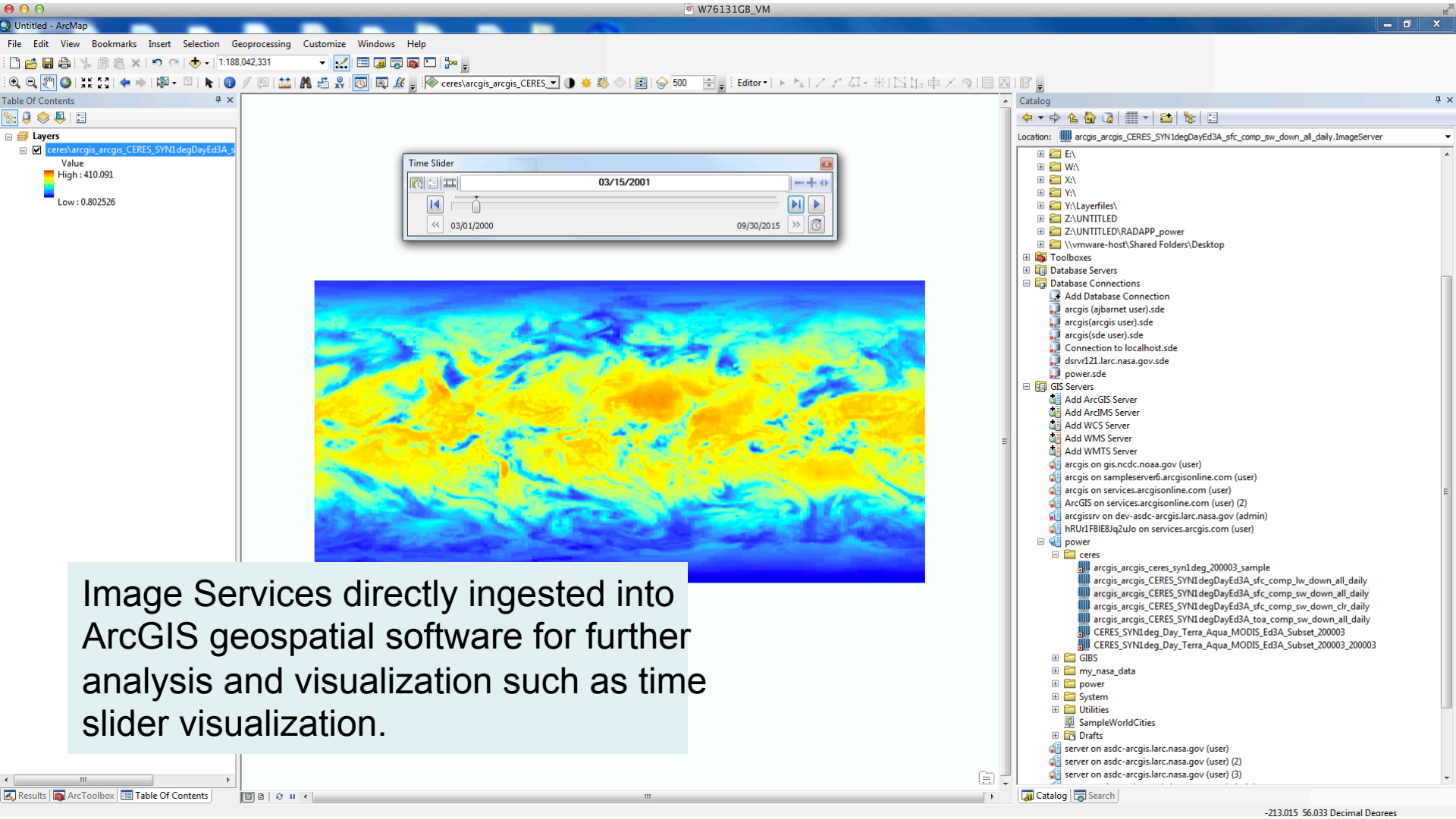


Image Services directly ingested into ArcGIS geospatial software for further analysis and visualization such as time slider visualization.