The Development of a Long-term, Continually Updated Global Solar Resource at 10 km Resolution: Preliminary Results From Test Processing and Continuing Plans

P. Stackhouse[1], R Perez[3], M. Sengupta[4] and K Knapp[5]

Stephen Cox, J. Colleen Mikovitz[1], T. Zhang[1], K. Hemker[3], J. Schlemmer[3], S. Kivalov[3]

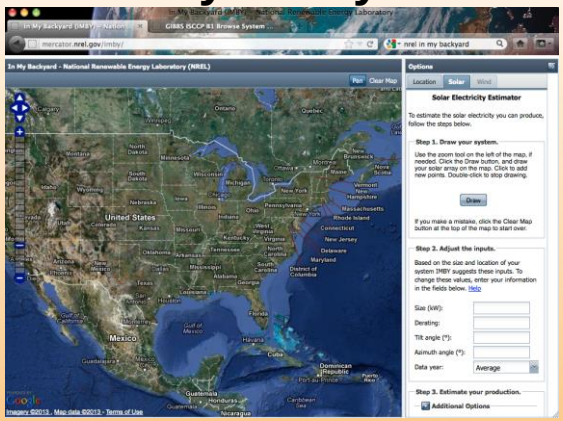
[1]NASA LaRC, [2]SSAI/NASA LaRC, [3]SUNY Albany, [4]NREL, [5]NCDC

Improving Long-term Solar Resource Maps: Goals

- **Solar irradiance maps**
  - At least 30 year record of surface solar energy & components (direct normal and diffuse); TSI
  - Global coverage at 10 km horizontal resolution
  - At least 3-hourly temporal resolution (interpolated to 1 hour)
  - Other ancillary parameters for DSS including: 2m T, Td, ps; 10 m Ws & Wd (from latest NASA data assimilation, i.e., MERRA)
  - Time series by lat/lon coordinate; statistics
- **Sustained Capabilities**
  - Production system runnable from NREL integrating chief inputs including ISCCP (satellite radiance & cloud properties), MERRA, Ozone, Snow/Ice
  - Resource maps updated on annual basis
  - Web services for data distribution

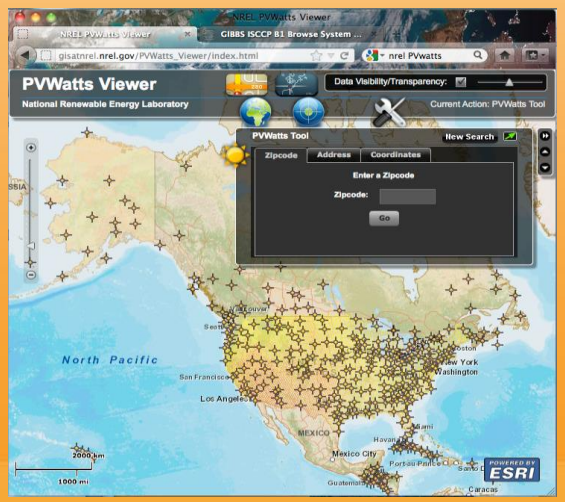
NREL Decision Support Tools

In My Backyard



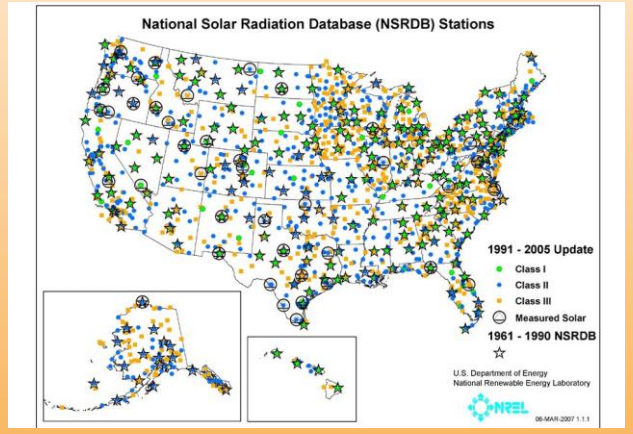
(residential system design)

PV Watts



(photovolatic system design)

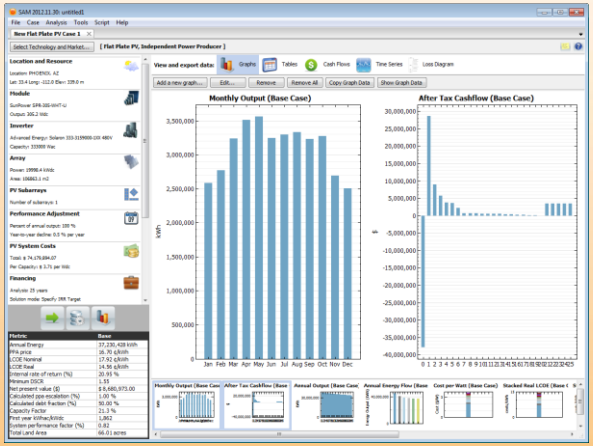
NSRDB – US Solar Resource



US Surface ('76-'05) and Satellite ('98-'05) Derived Climatology

Addition Int'l Surface Measurements

Solar Advisor Model

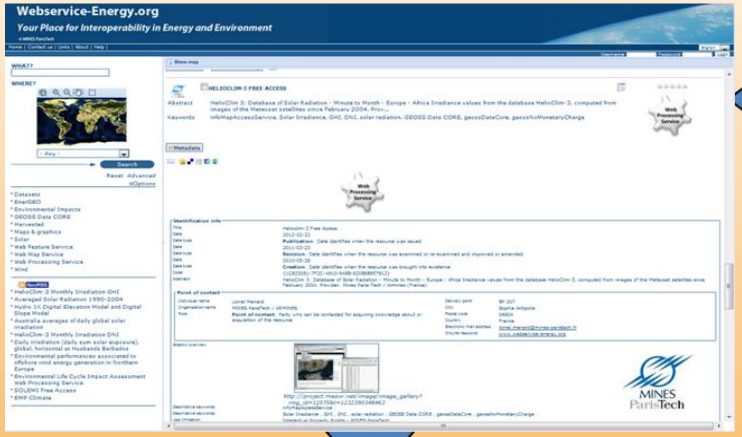


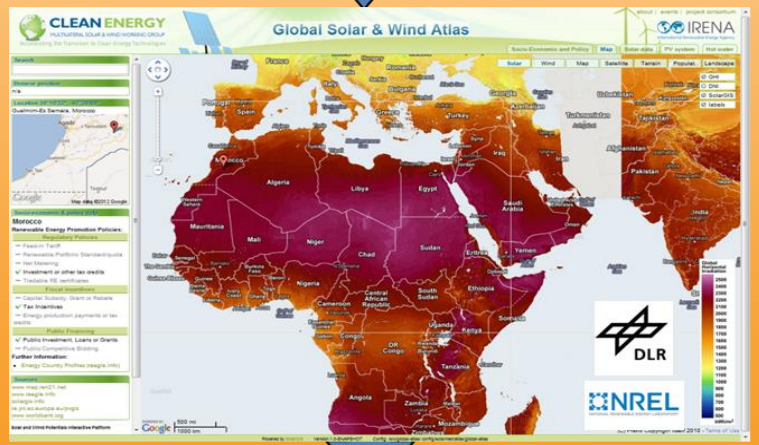
(renewable energy financial)

Solar Prospector

(concentrated solar power)

Additional Plan: Provide Global Long-term Solar Resource Maps for IRENA





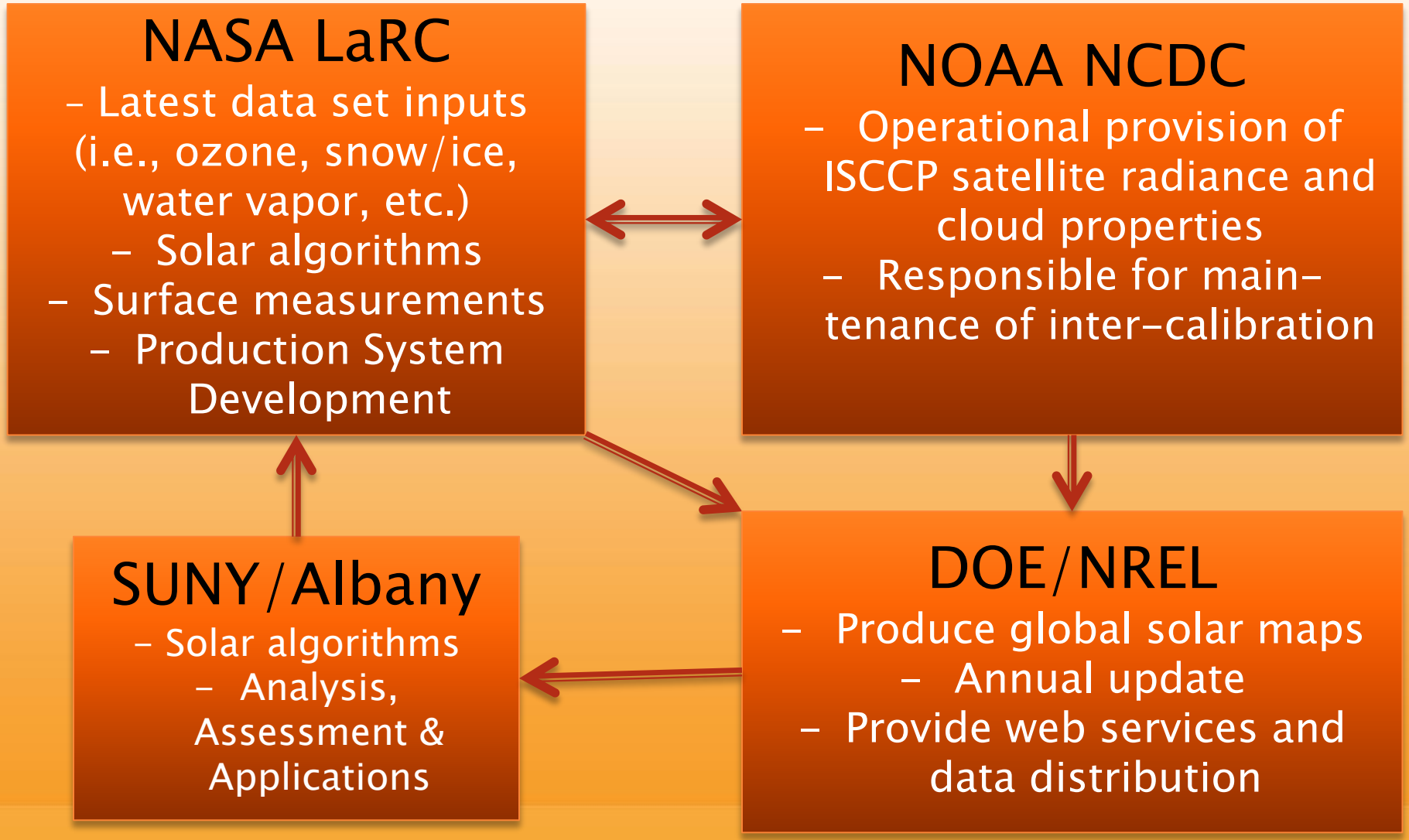
Source	Shared by	Scope	Location
SWERA Archive	NREL	Solar / Wind	
HelioClim 1	Mines ParisTech	Solar	
HelioClim 3 (part.)	Mines ParisTech	Solar	
PACA	Mines ParisTech	Solar	
Solar-Med atlas	DLR	Solar	
NASA solar dataset	NREL	Solar	
Solar GIS	Geomodel	Solar	GeoModel SOLAR
CENER dataset	CENER	Solar / Wind	
Reanalysis data	DTU Wind	Wind	
Global wind data	DTU Wind	Wind	
India	MNRE	Solar/Wind	
WASA	SANERI	Wind	
GCC solar	MASDAR	Solar	
Complementary datasets	Geomodel	Terrain, population, landcover	GeoModel SOLAR
Complementary datasets	TBD	Policy, Grid infrastructure, roads	REN21, JRC
Future partnerships: UNDP GEF, ADB, ESMAP, WMO, AFRETEP/EU JRC, Chile, Lebanon. GL/GH…			

Hosting and dissemination

IRENA Masdar INSTITUTE NREL

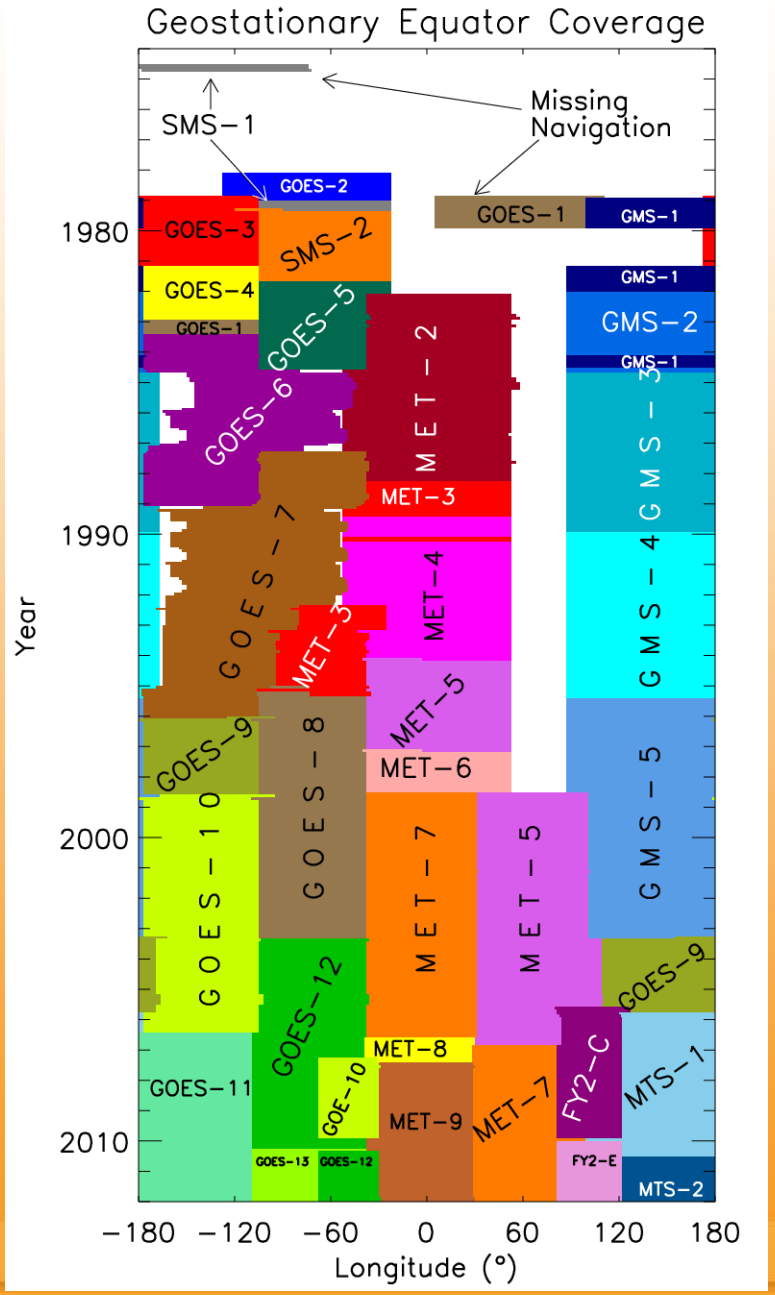
All partners

Multi-agency Configuration

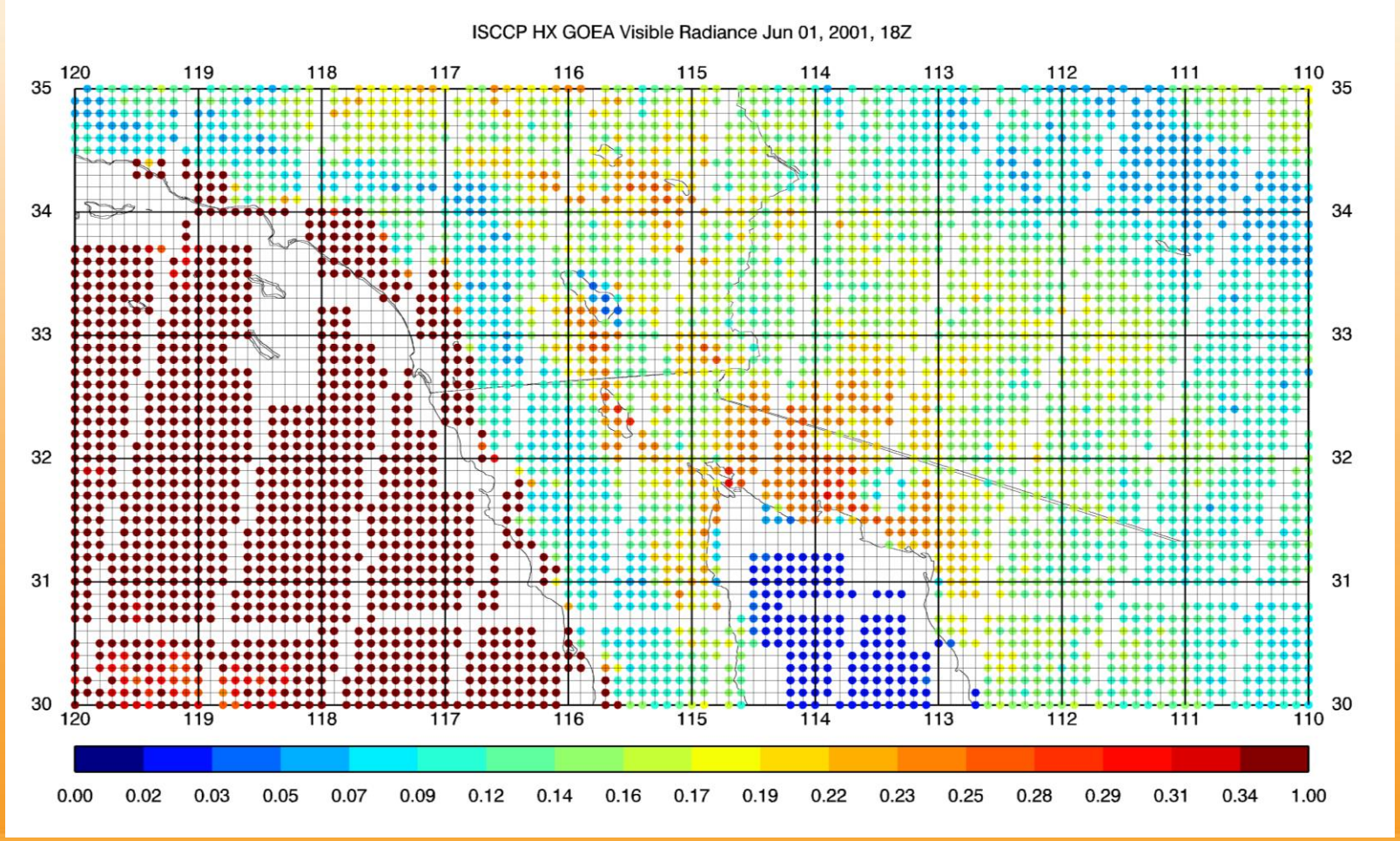


Key Input: Satellite Radiance from ISCCP

- ISCCP = International Satellite Cloud Climatology Project
- Provides cross-calibrated radiance and cloud properties since 1983
- All world's geosynchronous
- NOAA AVHRR
- New ISCCP "H" products (in Beta)



Improved Spatial Resolution for ISCCP HX



Testing New Satellite Radiance Sources

- ISCCP "H" Data sets
  - ISCCP H => original plan to use new version, planned for release in late 2009, 2010
  - Still not released (but now in beta) => needed alternative for initial development and testing

- Multi-Satellite Option: NCDC GridSat (global stitch)
  - Long-term, all pixels blended satellite, but no polar data
  - Improved navigation over ISCCP B1U
  - Improved IR calibration, similar vis calibration to B1U
  - Gridded to 8 km
  - *Used to develop and test concepts and production system*

Improved Inputs and Solar Algorithms:

- SUNY/Albany (Perez): requires vis radiances, aerosol, ozone, snow/ice, other meteorological and surface information.
  - Most versatile and self-calibrating, but physical parameterization
  - Uses IR for improved snow coverage treatment
  - *Will be used exclusively for today's talk*
- NASA GEWEX (Pinker/Laszlo based): requires radiances plus cloud fraction information, aerosol, snow/ice, column H2O, ozone, spectral albedo, etc.
  - Radiative transfer based using Fu/Liou bands for spectral treatment from UV to near-IR (0.2 – 4.0 μm).
  - Developed version to produce pixel fluxes rather than gridded fluxes.

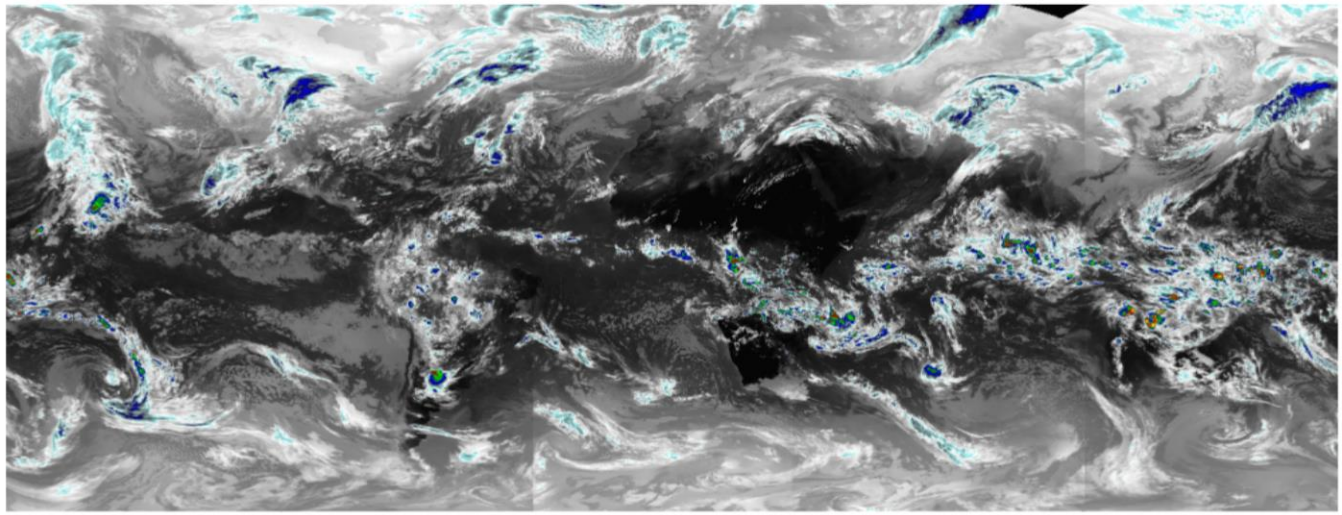
Proof of Concept: 3 Year Test Solar Irradiance from GridSat v2

- Data set delivered to NREL to test formats and place into GIS tools; GridSat v2 is a precursor to the ISCCP HX

Global Processing: NCDC GridSat v1
(Sample Images)

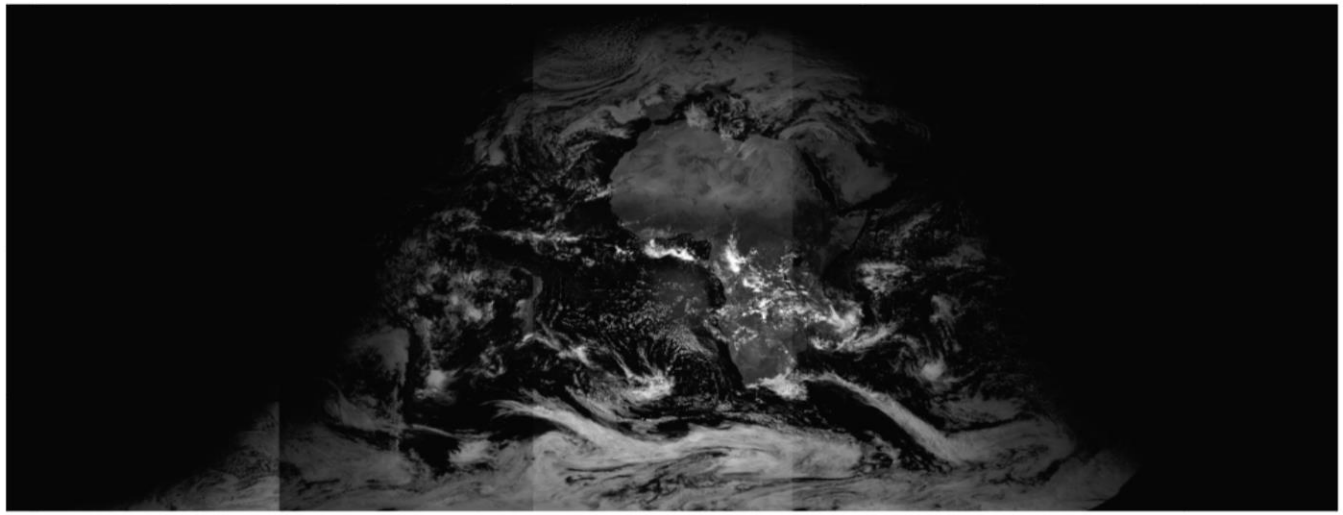
Enhanced IR Image

(1/1/05, 12UT)

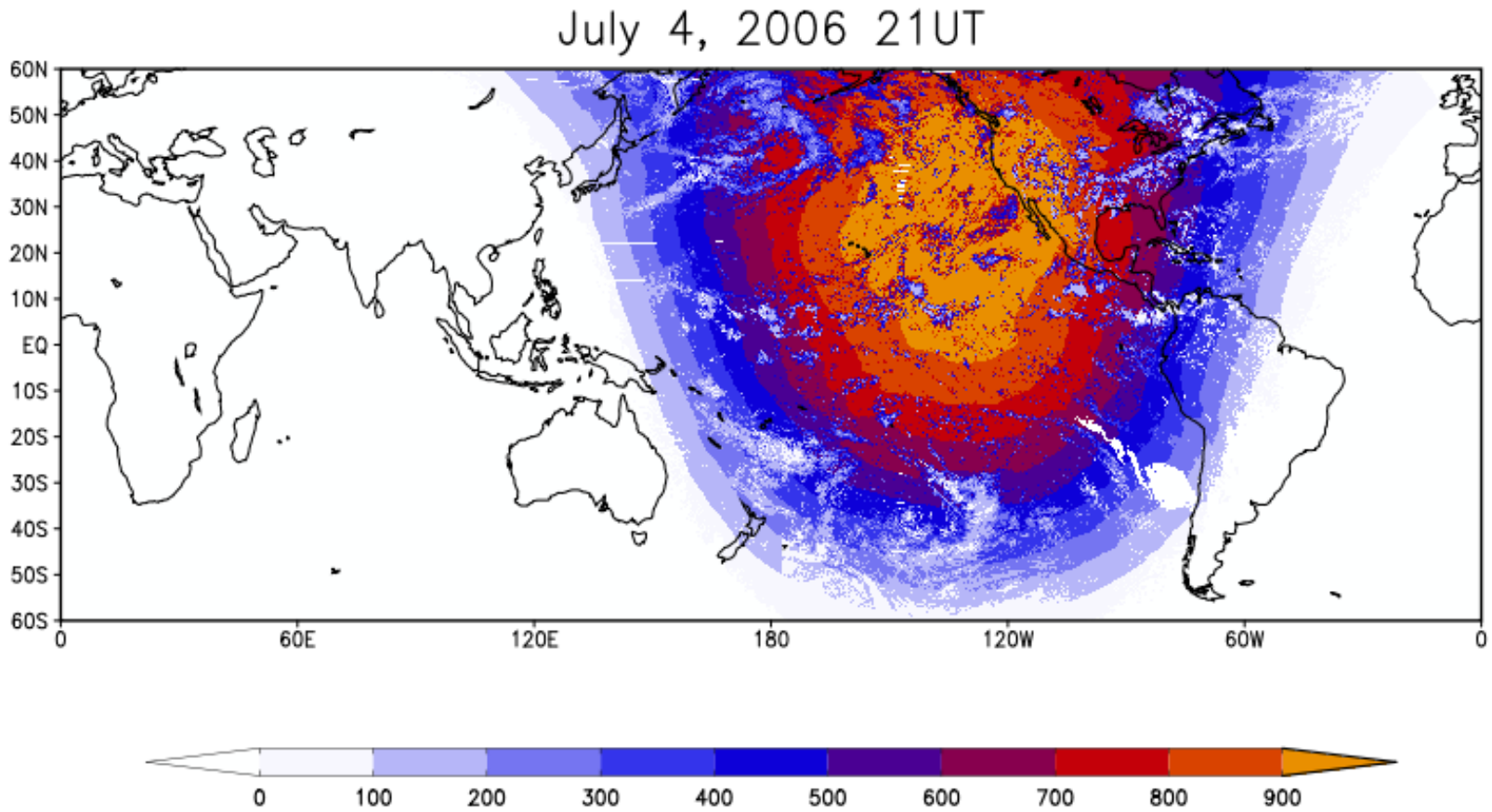


Visible Image

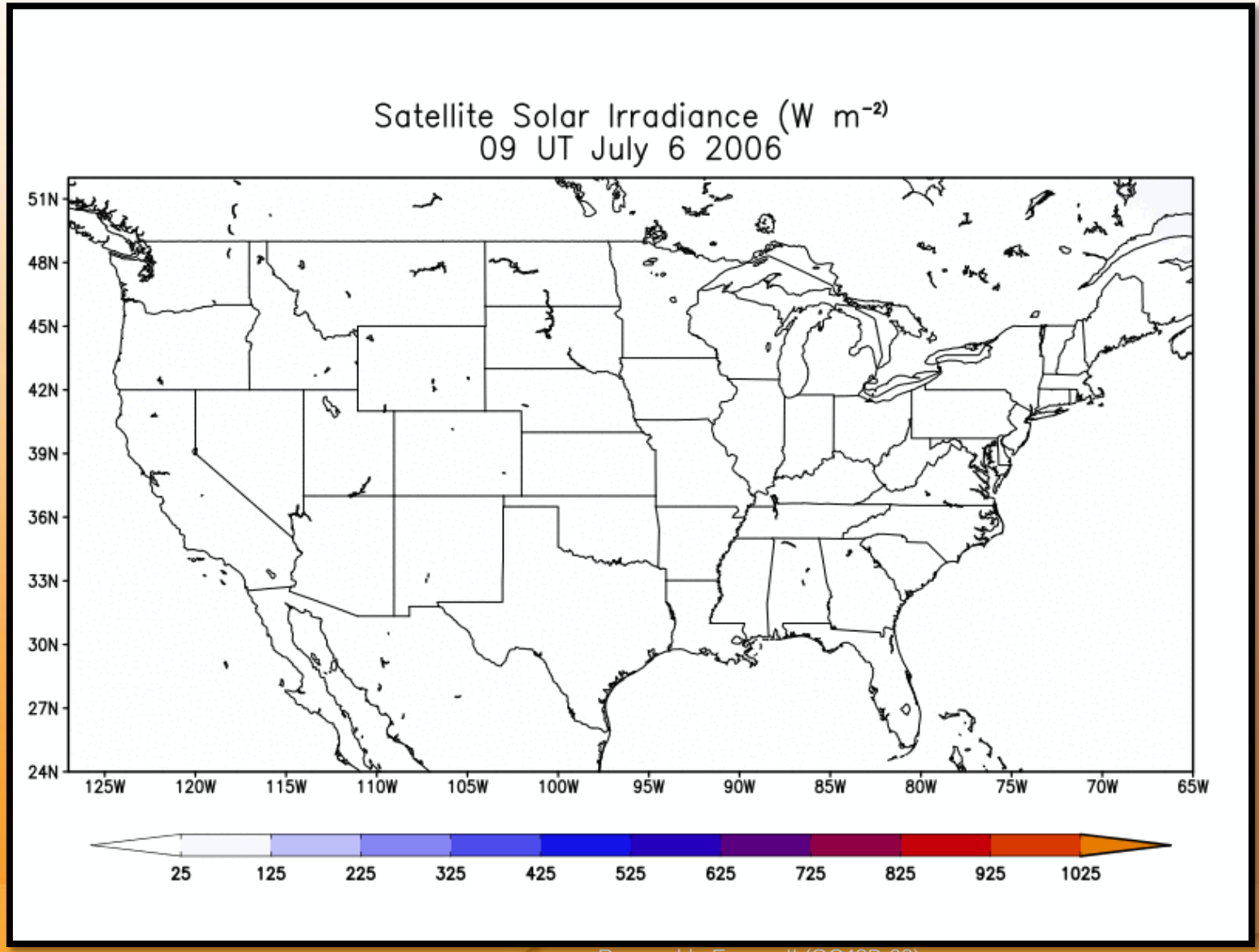
(1/1/05, 12UT)



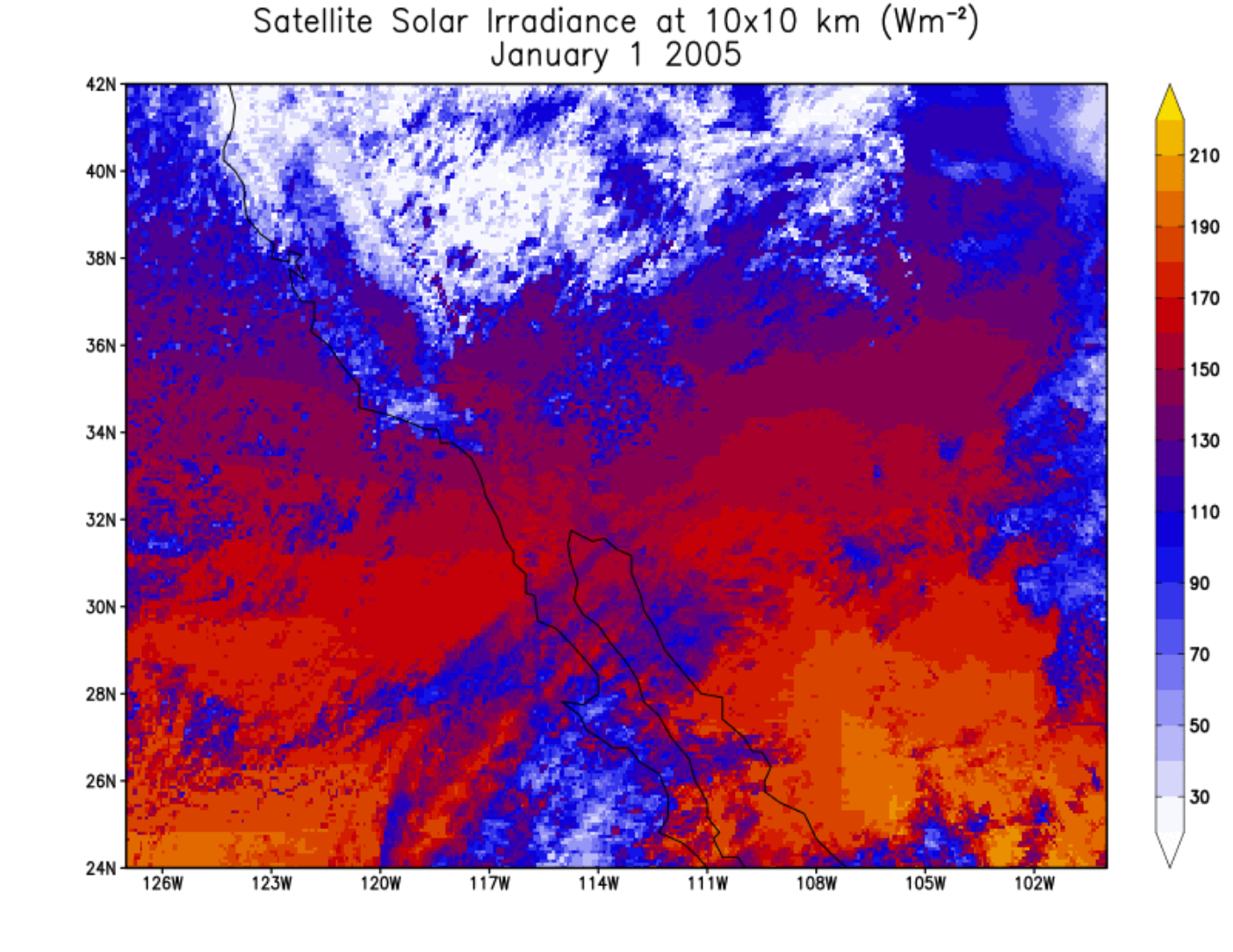
60N-60S 3 Hour Average



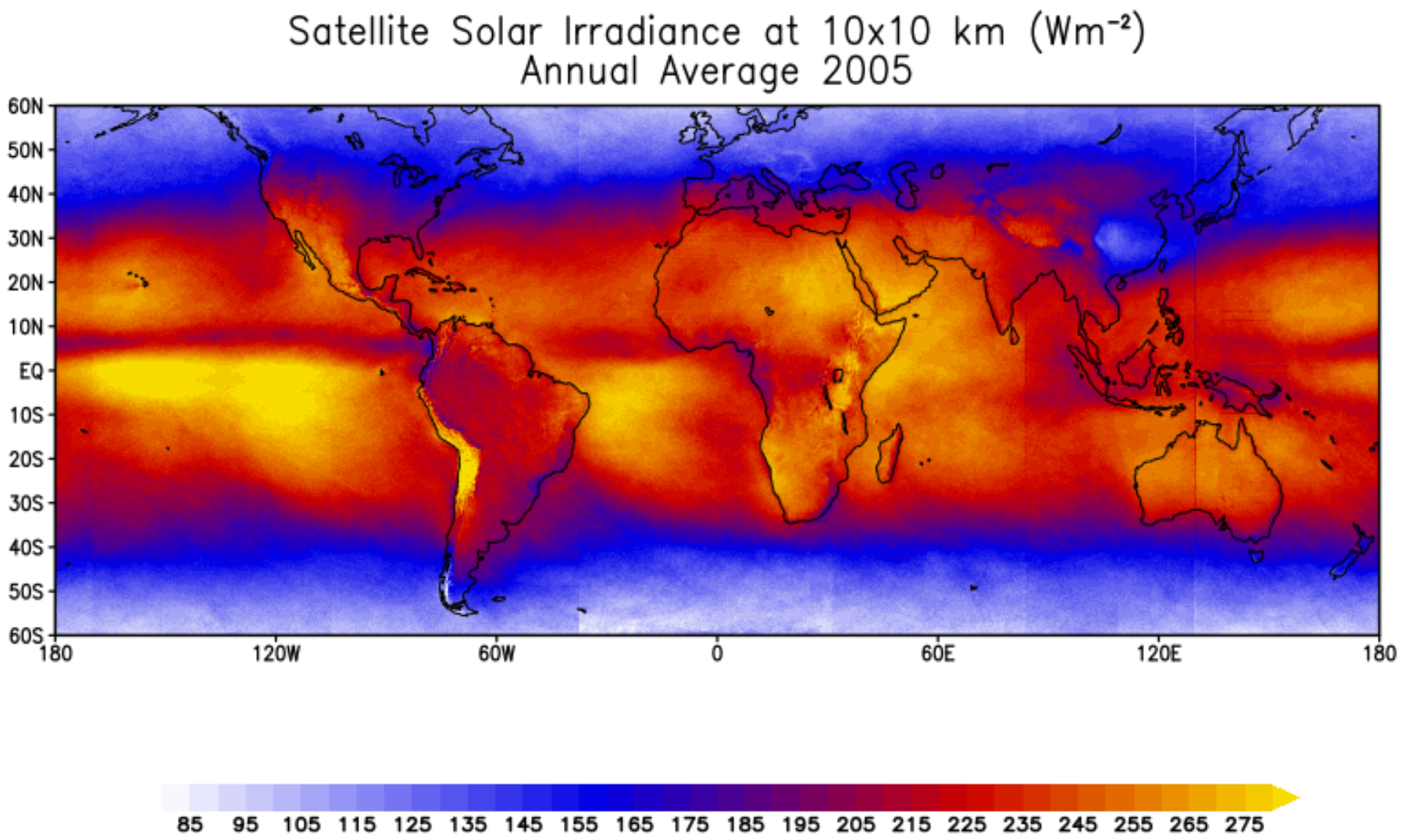
3 Hourly Loop for US Region



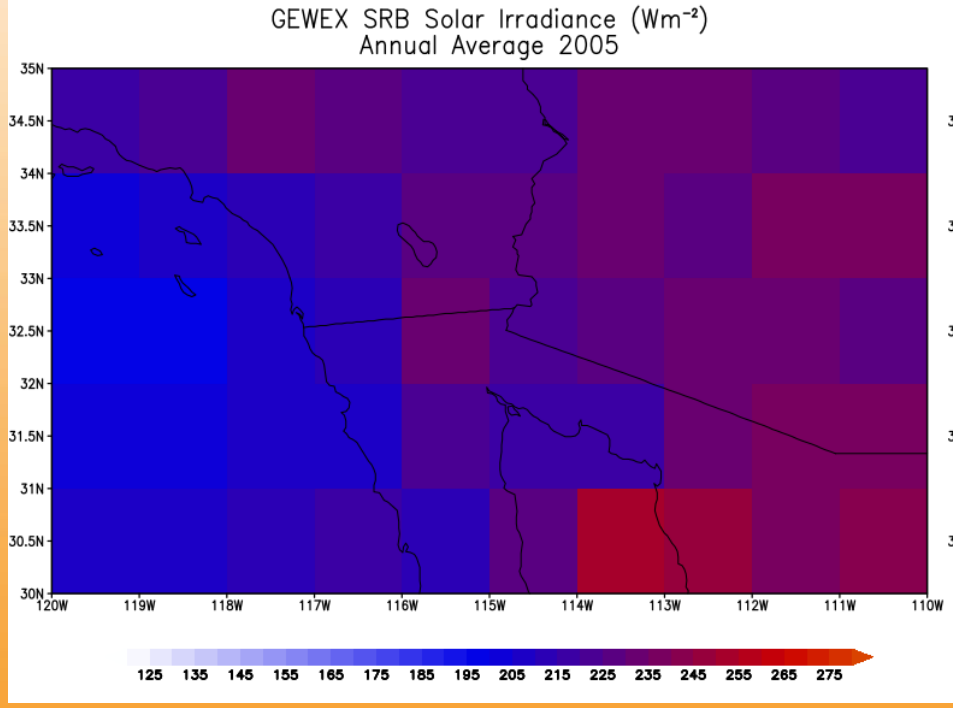
Daily Averages for January 2005

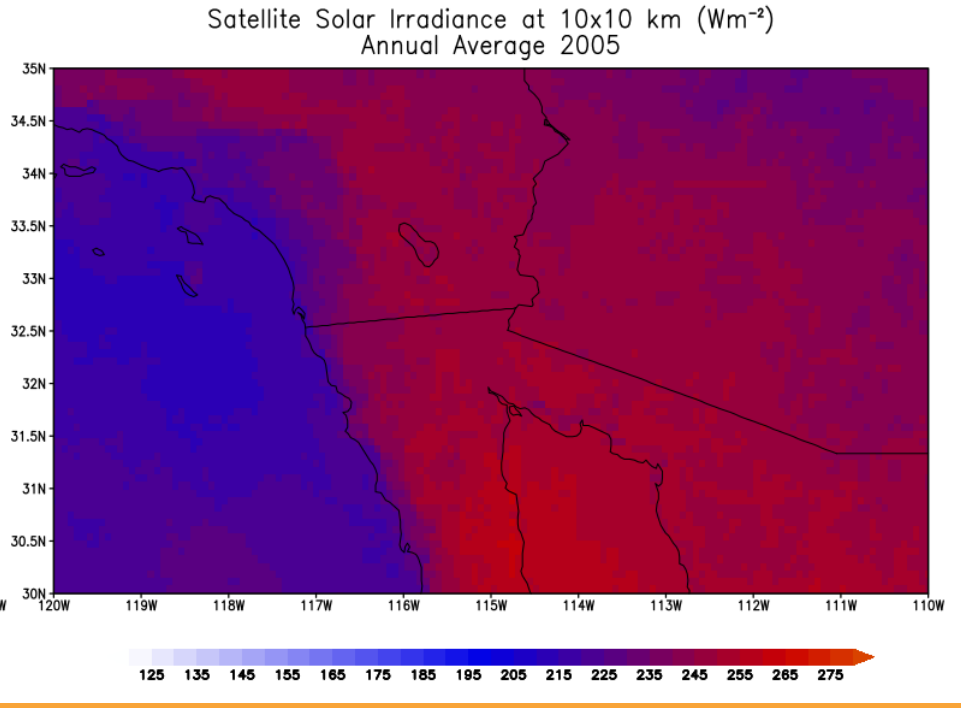


Annual Averaged Solar Map (60N – 60S)



Regional Annual Averages





First Results Using ISCCP HXG (10 km pixel data set)

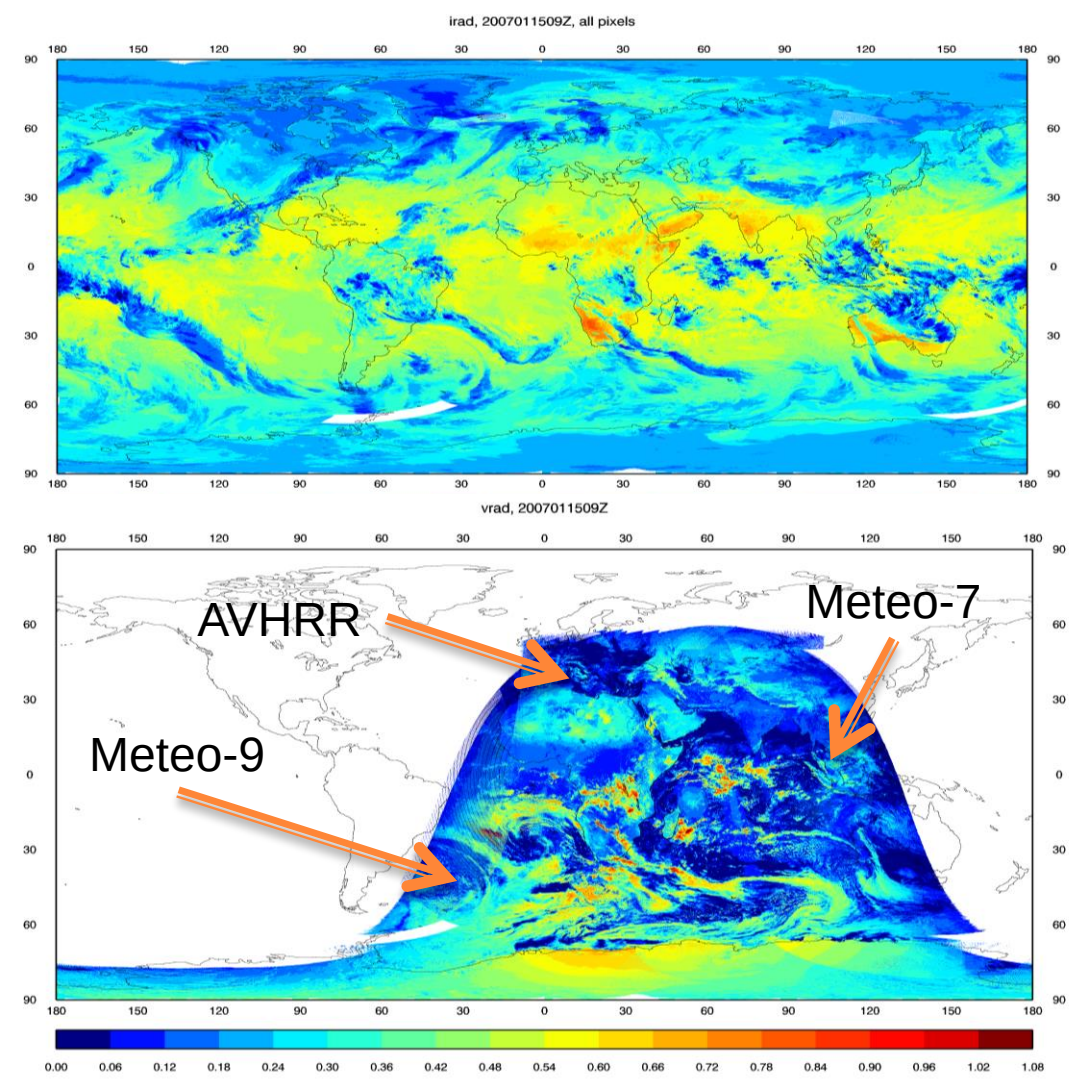
- Results from Beta Version

ISCCP HXG (Beta) IR & VIS Radiances

IR Radiance
January 15, 2007, 9Z

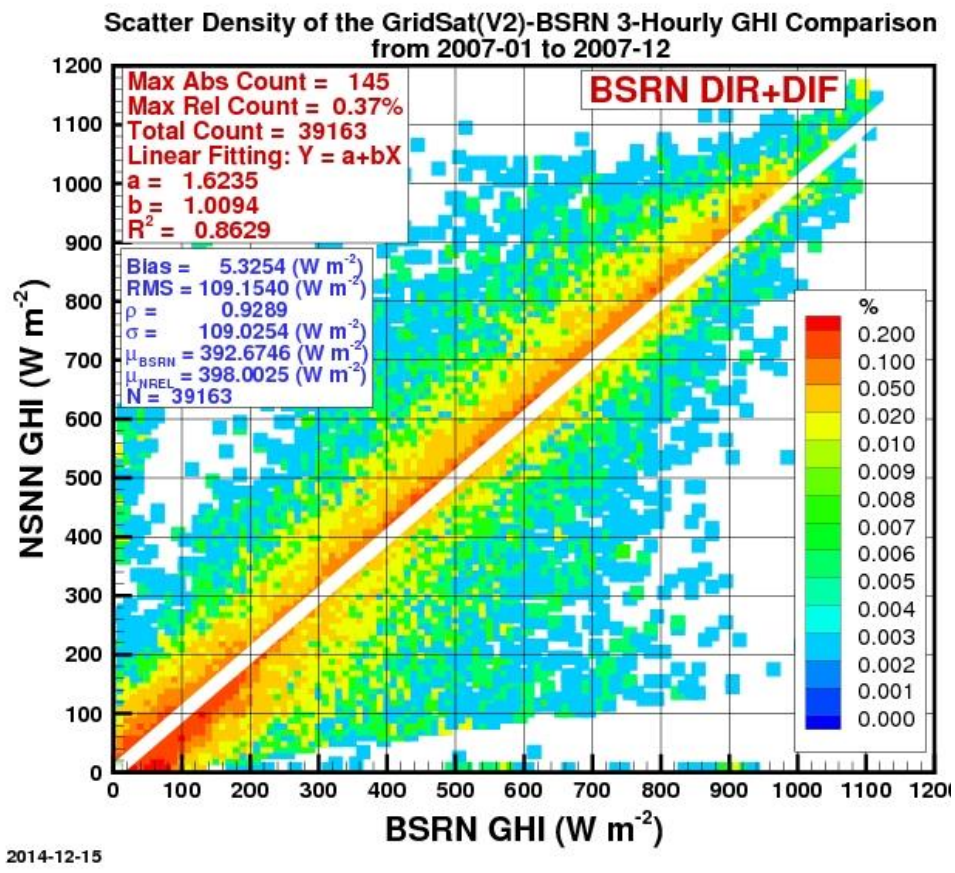
VIS Radiance
January 15, 2007, 9Z

- clear, cloudy and clear-sky composite radiances
- cloud optical property estimates

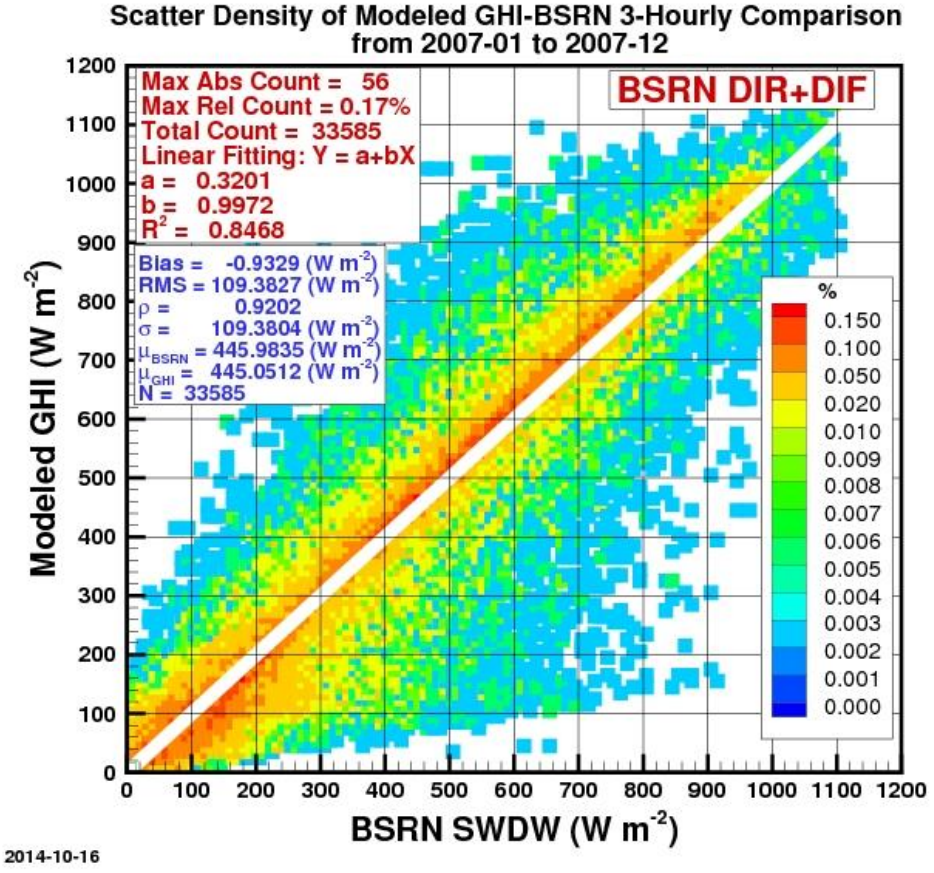


First Look Validation

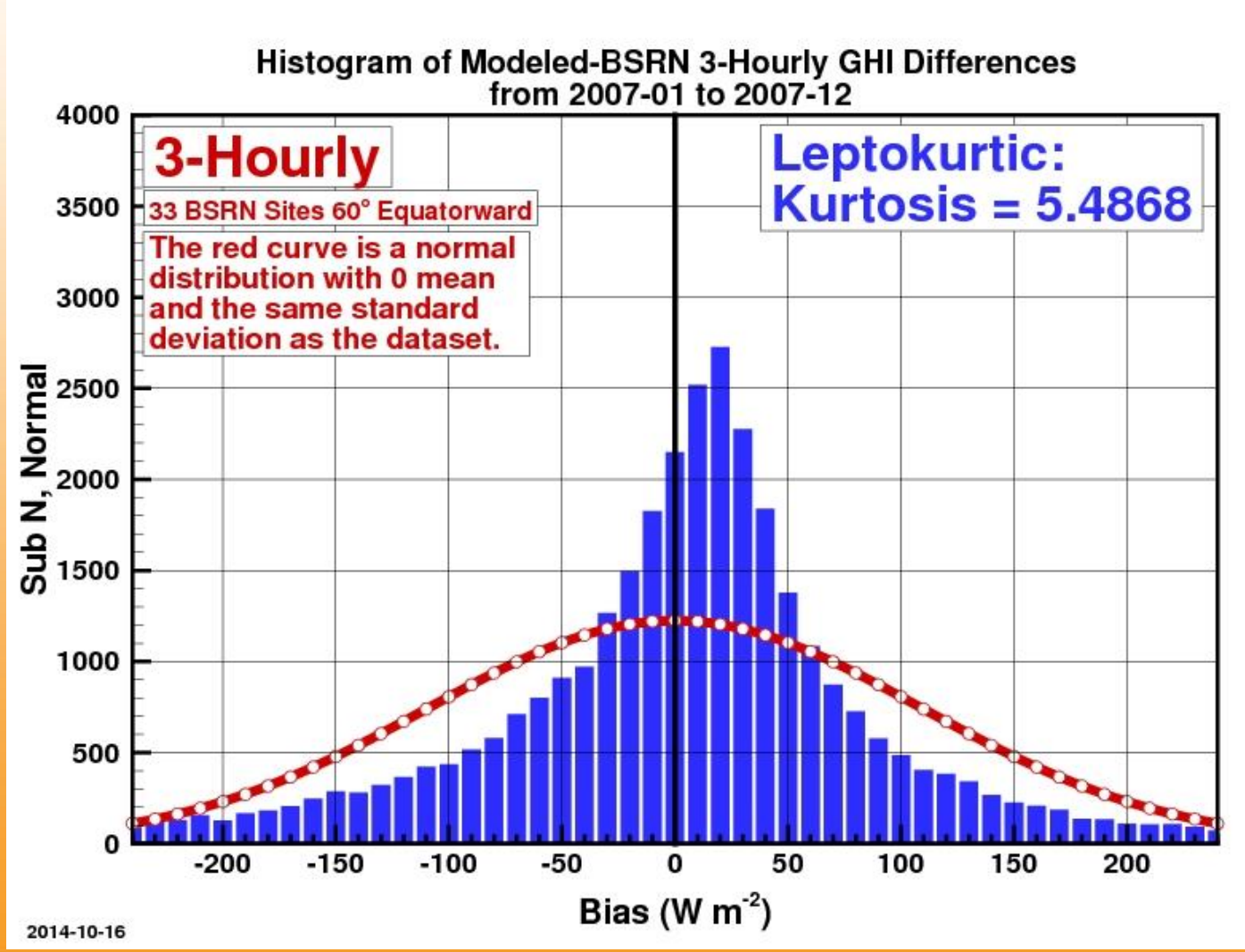
GridSat v2 2007



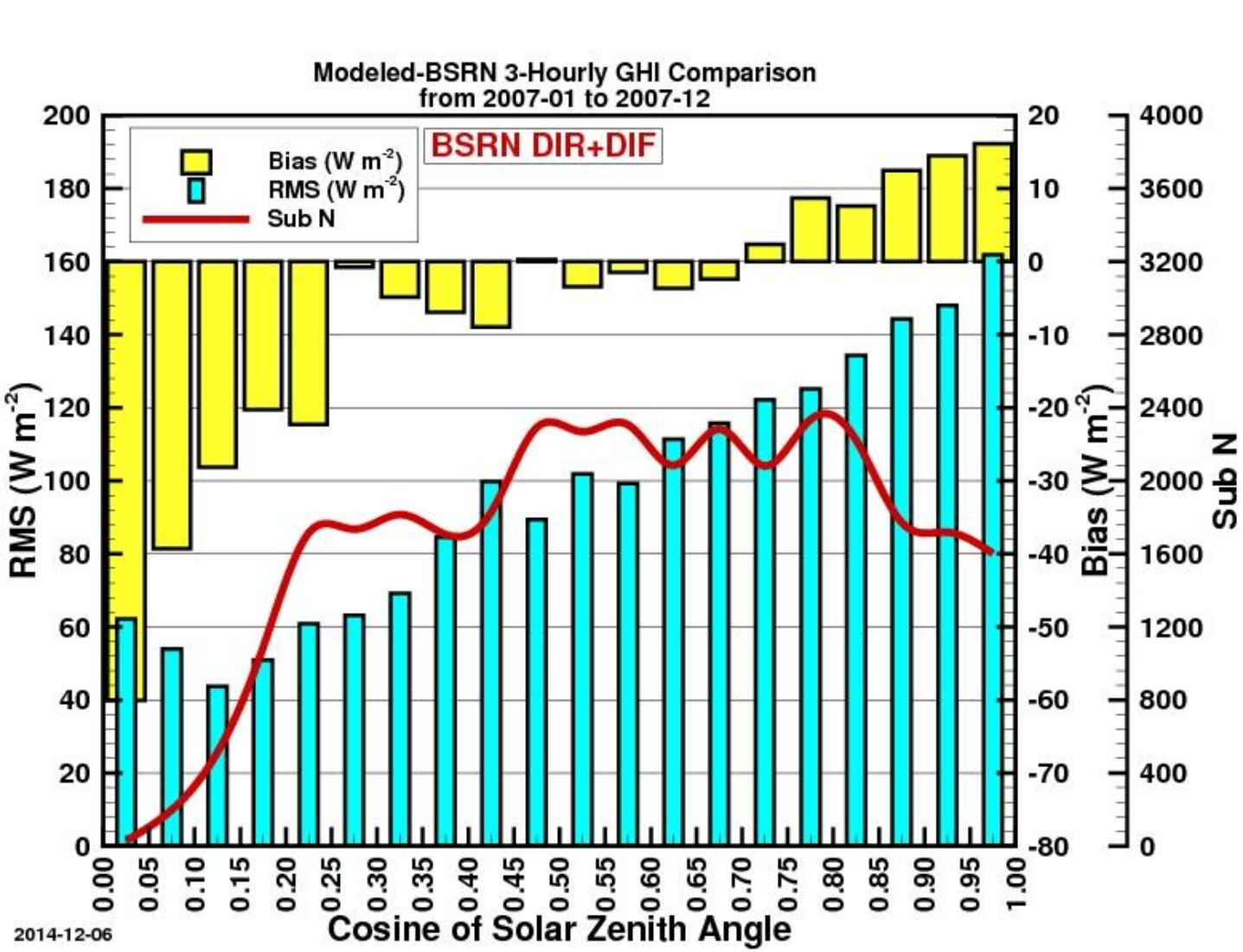
HXG beta 2007



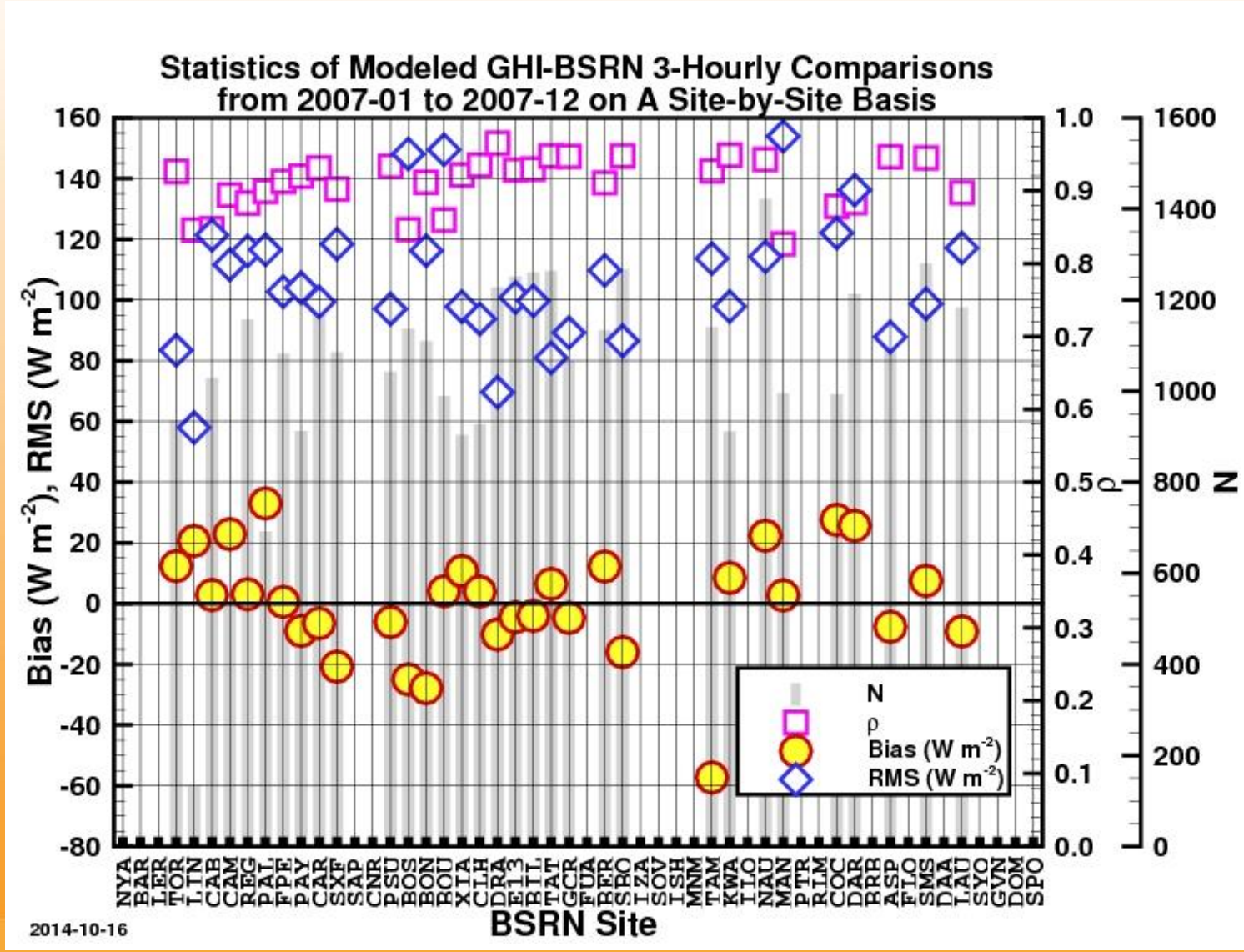
HXG Beta Validation 2007



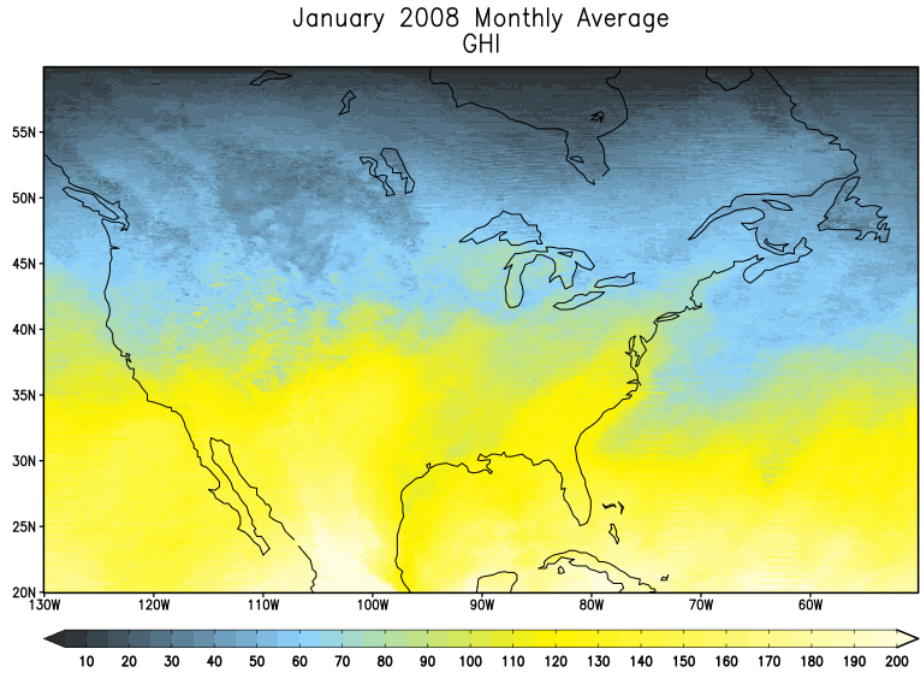
HXG Beta Validation 2007

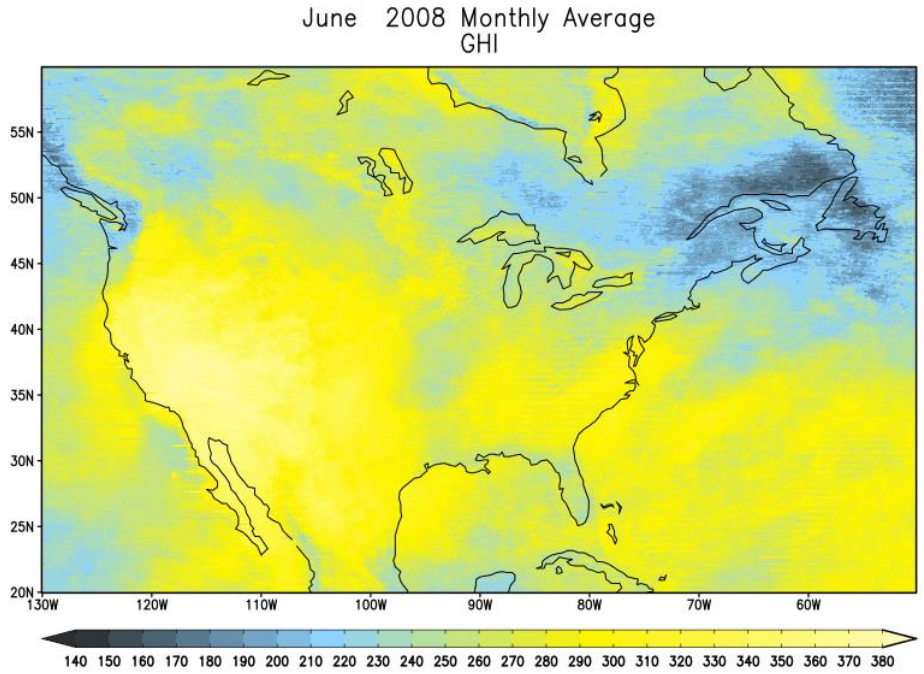


HXG Beta Validation 2007

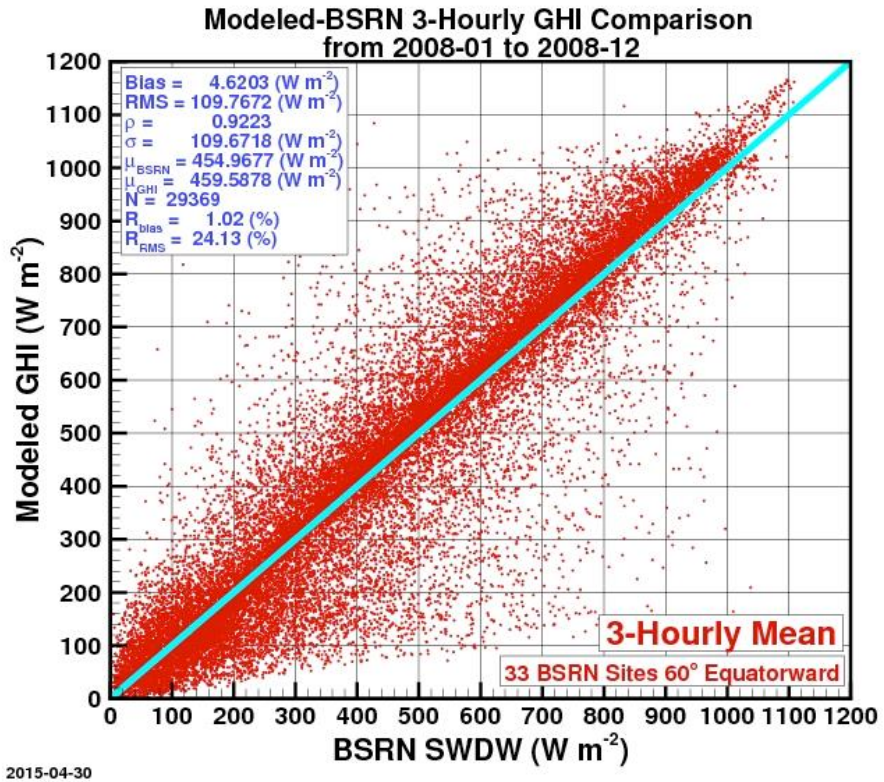


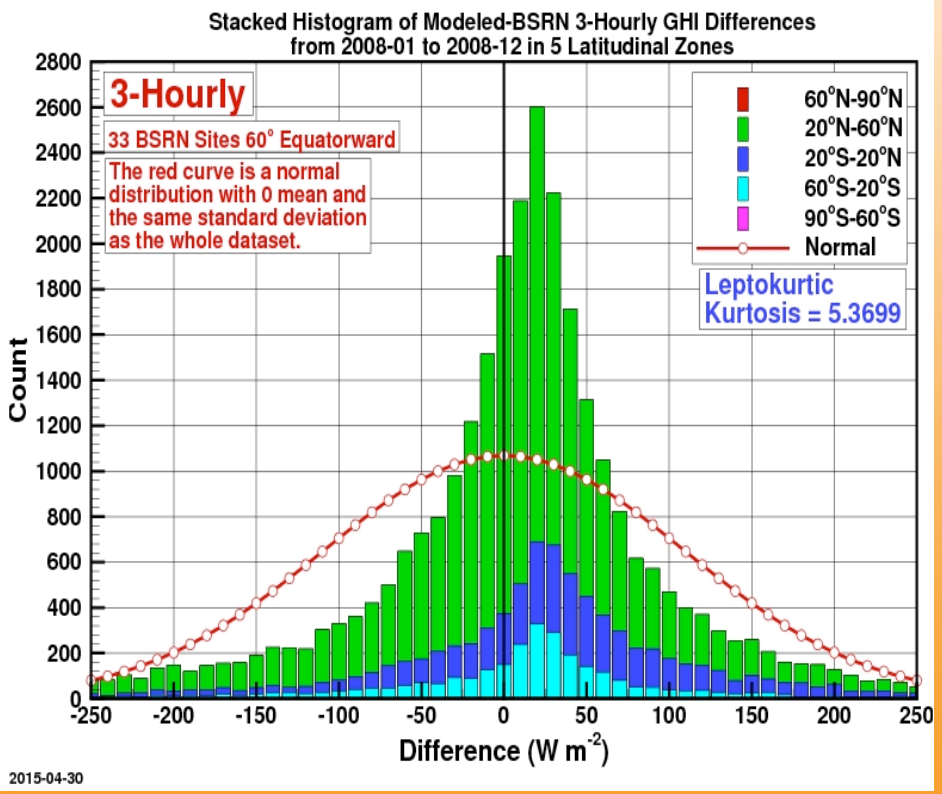
HXG pre-Beta: 2008





HXG Reprocessed BSRN Validation: 2008





Summary and Conclusions

- Future Work

Conclusions and Future Work

- Work is progressing towards a long-term, sustainable global solar resource data set
- The collaboration between NASA LaRC, SUNY, NCDC and NREL has lead to:
  - development of a 3 year, 10 km solar resource mapping prototype; validation is promising
  - Delivered to NREL for testing in GIS system tools
- NCDC has processed ISCCP H Series products for the year 2007 & reprocessed 2008
  - Pre-Beta version is being assessed and tested (does required reprocessing)
  - Validation of 2007/2008 relatively consistent compared between GridSat v2 and ISCCP HXG data sets

Solar Mapping Project Plans

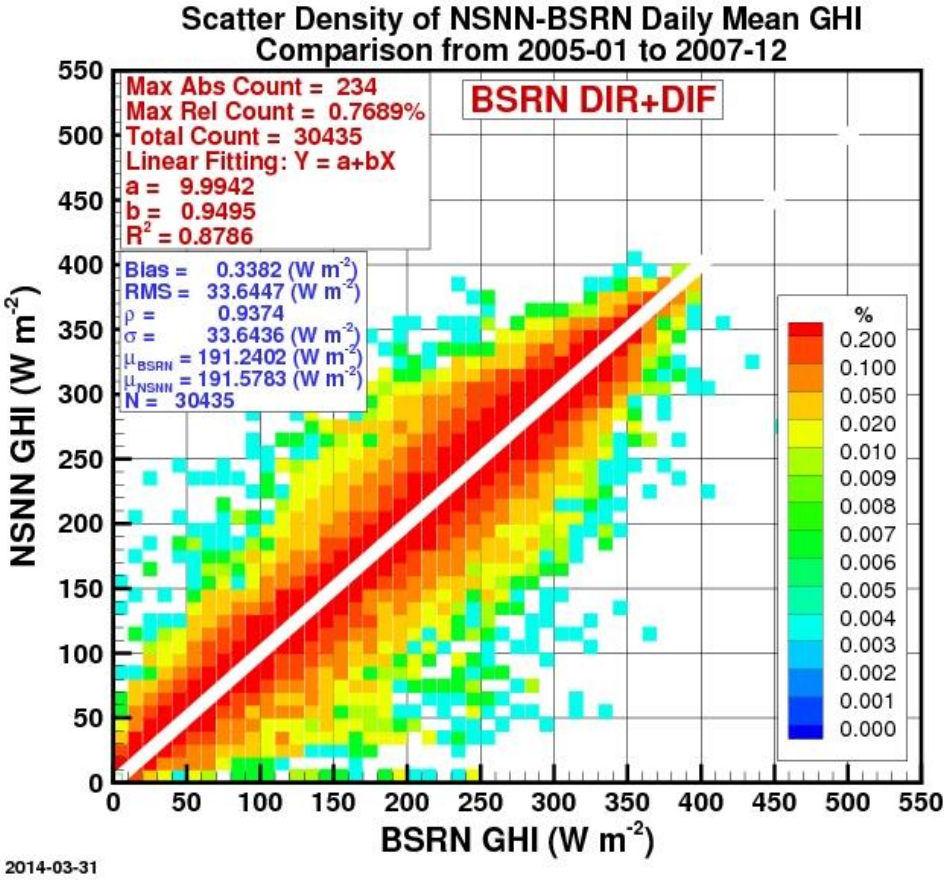
- Continue testing/evaluating solar resource estimates from ISCCP HXG
  - Improve inputs (e.g., aerosols) and algorithms using surface measurement.
  - Get feedback from NREL regarding test data
  - Incorporate parameter, format changes
  - Production system for long-term production
- Transition production system to NREL for sustained production and annual update
  - Test NREL production by comparing to NASA produced sample data sets
  - NREL is developing web service interface for user interface
  - Evaluate and adapt tools for release

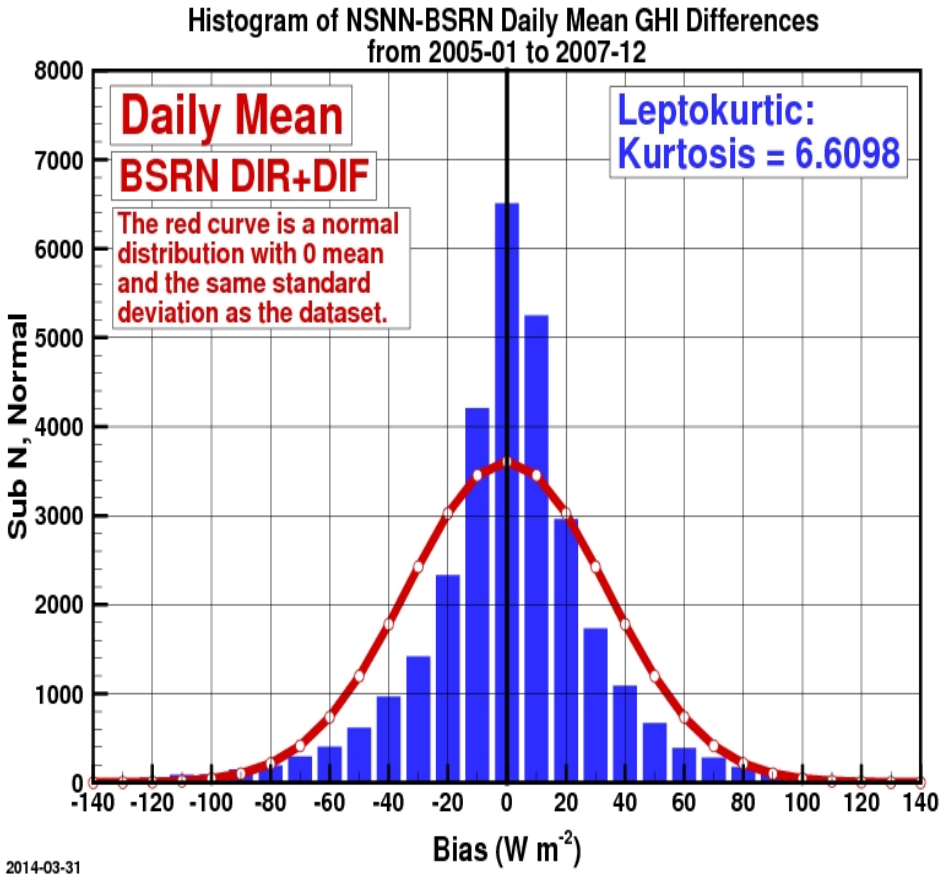
Extras

Why is NASA Developing Solar Resource Information?

- NASA investigates atmospheric and climate sciences on global scales
  - Resulting data sets represent NASA's latest instruments, calibration techniques, analysis and models
  - The data sets are steadily improved over time
  - Aims to pioneer efforts in "research to operations"
- NASA makes provision of these data sets for societal benefit
  - Applied Science program partners with data users spanning a wide variety of fields such as solar energy
  - Also provide data sets specifically adapted for various decision making tools
  - Now NASA is developing capabilities to provide data sets in new geospatial formats

Validation Against BSRN: Years 2005-2007





NASA Solar Resource Mapping Data Sets