

NASA Energy Management Stakeholder Ideation Workshop

Earth Observations for Energy Management

Dr. Paul Stackhouse
NASA Langley Research Center



April 27, 2016 • Arlington, Virginia, USA

Topics

- Earth Observations relevant for Energy Management
 - General classes of parameters
 - Data access tools
- Model Based Data Products relevant for Energy Management
 - Assimilation data products: MERRA
 - Model based products: short-term to climate scale; downscaled products
- Specific Examples:
 - NASA-funded energy application projects



NASA Earth Science Missions



Current NASA Missions Providing Data Related to Energy Sector Needs

Parameter Type	Satellite Missions/Instruments (Parameter)
Solar Resources	Solar Radiation and Climate Experiment (SORCE) STPSat-3 Total Solar Irradiance Calibration Transfer Experiment (TCTE) (non-NASA) (extraterrestrial solar irradiance)
	Aqua/Terra/NPP Cloud and Earth Radiant Energy System (CERES) (surface solar fluxes including direct and diffuse)
	DISCOVER NISTAR (surface solar flux) (products not available yet)
Meteorological Parameters	CALIPSO, CloudSat, GPM/GMI and DPR, Terra/Aqua/MODIS, Terra MISR, Aqua AIRS, Aura OMI, Suomi NPP VIIRS, DISCOVER/NISTAR and EPIC (cloud water and other cloud information)
	GPM/GMI and DPR, CloudSat (precipitation)
	Aqua AIRS/AMSU/HSB, Aura HIRDLS (atmospheric temperature)
Atmospheric Composition	Terra/Aqua/MODIS, Aqua AIRS, Aura MLS, Suomi NPP CRIS, GPM GMI, Joasn-2 (water vapor)
	CALIPSO, Terra/Aqua/MODIS, Terra MISR, Suomi NPP VIIRS, Aura OMI, DISCOVER/EPIC (aerosols)
	Aura OMI, Aura MLS, Aura TES, Aura HIRDLS, Aqua AIRS, OCO-2, DISCOVER/EPIC (ozone, gases)
Land Parameters	Shuttle Radar Topography Mission (SRTM, flown in 2000) (elevation/topography)
	Terra/Aqua/MODIS, Terra MISR, Terra ASTER, Suomi NPP VIIRS, Aura OMI DISCOVER/EPIC, Landsat (surface reflectance, albedo)



Current NASA Missions, Cont'd

Parameter Type	Satellite Missions/Instruments (Parameter)
Land Parameters	Terra ASTER, Terra/Aqua/MODIS, Aqua AIRS, Suomi NPP VIIRS (land surface temperature)
	Terra/Aqua/MODIS, Suomi NPP VIIRS, Landsat (thermal anomalies, active fires, burned area)
	Terra/Aqua/MODIS, Landsat, Terra MISR, Suomi NPP VIIRS (land cover, surface type)
	Terra/Aqua/MODIS, Suomi NPP VIIRS, Landsat (snow cover)
	Suomi NPP VIIRS, Terra/Aqua/MODIS (nighttime lights)
Offshore Environment	ISS-RapidScat (ocean surface winds)
	Jason-2, 3 (ocean altimetry)
Vegetation and Soil	Terra/Aqua/MODIS, Sumoi NPP VIIRS (enhanced vegetation index [EVI], normalized difference vegetation index [NDVI])
	SMAP, Landsat TM (soil moisture)
Water	Jason-2 (lake/reservoir/ocean height)
	Terra/Aqua/MODIS (near-surface water and sea-surface temperature)
	GRACE (data that can be used to study groundwater storage)



Accessing NASA Data

- NASA Mission Web Sites
 - *Each mission is responsible for developing, validating and releasing data products for public usage*
 - *Example: CERES*
- NASA EOSDIS Distributed Active Archive Centers (DAACs) for processing, archiving, documenting, distributing data and data visualizations
 - <https://earthdata.nasa.gov/about/daacs>
- Giovanni – select parameters, date ranges, geographical area to visualize EO data
 - <http://giovanni.gsfc.nasa.gov/giovanni/>



Mission Specific Web Site: CERES Data Product Access



NASA CERES — Clouds and the Earth's Radiant Energy System

Who are we?

As part of the NASA Langley Science Directorate, the CERES Science Teams are devoted to providing valuable Earth Radiation Budget data, one of the highest priority scientific satellite instruments developed for NASA. The instrument was launched in December of 1997 aboard NASA's Tropical Rainfall Measuring Mission (TRMM). CERES is now collecting observations on three separate satellite missions, including the Suomi National Polar-orbiting Partnership (S-NPP) observatory.



CERES Data Products

To subset, visually browse, and download CERES data products in netCDF format, click the "**Browse & Subset**" button in the tables below. For more information and documentation on a specific product, click on the "Data Product" name. Or as a quick reference, click on the icon.

Level 3B: Spatially (regional, global, etc.) and temporally (daily, monthly, etc) averaged fluxes where the net flux has been energy balanced.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
EBAF-TOA	Monthly and climatological averages of TOA clear-sky (spatially complete) fluxes, all-sky fluxes, and cloud radiative effect (CRE), where the TOA net flux is constrained to the ocean heat storage . Data Quality Summary				Browse & Subset
EBAF-Surface	Monthly and climatological averages of computed surface clear-sky fluxes, all-sky fluxes, and cloud radiative effect (CRE), consistent with the CERES EBAF-TOA fluxes. Data Quality Summary				Browse & Subset

Level 3: Spatially (regional, global, etc.) and temporally (daily, monthly, etc) averaged fluxes and clouds.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
SYN1deg	CERES geostationary (GEO) enhanced temporally interpolated TOA fluxes, MODIS and 3-hourly GEO cloud properties, MODIS aerosols, and computed TOA, surface and in-atmospheric (profile) fluxes consistent with the observed TOA fluxes, clouds and aerosols. Data Quality Summary				Browse & Subset
SSF1deg	CERES constant meteorology temporally interpolated TOA fluxes, MODIS clouds and aerosols.				Browse & Subset
ISCCP-D2like	CERES-MODIS and GEO daytime cloud properties stratified by ISCCP cloud types and in the similar D2 format. Data Quality Summary				Browse & Subset

Level 2: CERES instantaneous footprint level (20km nominal) fluxes and cloud properties.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
SSF	CERES observed TOA fluxes, MODIS clouds and aerosols, and parameterized surface fluxes. Terra Data Quality Summary Aqua Data Quality Summary		FOV*		Browse & Subset
FLASH_SSF	Near real-time CERES fluxes and clouds in the SSF format, Not of climate quality or to be appended with any other CERES dataset.		FOV*		Browse & Subset



NASA Distributed Data Archive Centers (DAAC): *Example LaRC DAAC*

Atmospheric Science Data Center

Processing, archiving and distributing Earth science data at the NASA Langley Research Center

Search

Home Data Descriptions Order Data Citing ASDC Data Help Forum

Aerosols	Clouds	Radiation Budget	Tropospheric Chemistry	Field Campaigns
AirMSPI	AirMSPI	ACRIM II	ARB 48-inch LIDAR	AirMISR
ARB 48-inch LIDAR	CALIPSO	ACRIM III	Biomass Burning	AirMSPI
Biomass Burning	CATS	AirMISR	GTE	ARESE
CALIPSO	CERES	ARESE	INTEX-A	ATOST
CATS	CLAMS	ATOST	INTEX-B	ATTREX
CLAMS	FIRE	CAMEX-4	LASE	Biomass Burning
FIRE	ISCCP	CERES	MAPS	CAMEX-4
GTE	LASE	CLAMS	MOPITT	CLAMS
INTEX-A	LITE	DSCOV	MY NASA DATA	DC3
LASE	MISR	ERBE	NARSTO	DISCOVER-AQ
LITE	MY NASA DATA	FIRE	SCAR-B	FIRE
MISR	NIMBUS-7	GEWEX-RFA	SMMR	GTE
MY NASA DATA	NVAP-M	ISCCP	TARFOX	INTEX-A
NARSTO	SUCCESS	MAS	TES	INTEX-B
POAM II		MISR		LASE
POAM III		MY NASA DATA		LITE
SAGE I		NIMBUS-7		MAS
SAGE II		SCAR-A		NARSTO
SAGE III		SCAR-B		NASA Airborne Lidar
SAM II		SRB		SCAR-A
SCAR-B		SSE		SCAR-B
TARFOX		THORpex		SEAC4RS

Here is a side-by-side comparison of views of our planet from the 1960s and 1990s, decades apart. The iconic "Blue Marble" view on the left is from the Apollo 17 mission, the way to the Moon. The view on the right is from Lagrange 1, (about four times farther than the moon) and was provided by the Deep Space Climate Observatory (DSCOVR).

READ MORE

Featured Projects

News

CALIPSO

CERES SYN1deg

Monday, April 18, 2016

The CERES Syno



DAACS United Through EOSDIS EarthData

EarthData Data Discovery - DAACs - Community - Science Disciplines

EarthData Search

Search datasets, news, articles, and information

EOSDIS National Aeronautics and Space Administration
NASA's Earth Observing System Data and Information System

Reverb | ECHO
The Next Generation Earth Science Discovery Tool

EOSDIS Home | Reverb Home | About | Tutorial

Shopping Cart (0) | Order Status | Service Request Status | Sign In

Search Options

- Spatial
- Search Terms
- Temporal
- Platforms & Instruments (7)
- Campaigns (7)
- Processing Levels (7)
- Science Keywords (7)

Save Query | Clear Criteria

Feedback?
Tell us what you think.

Availability (7)

LaRC ASDC Maintenance
2016-04-27 8:00AM (GMT-4:00) to 2016-04-28 8:00AM (GMT-4:00)
More

Notice (7)

Degraded service due to release deployment
2016-04-27 8:00AM (GMT-4:00) to 2016-04-27 1:00PM (GMT-4:00)
More

ASTER GOEM V2 Tutorial
2011-10-17 4:00AM (GMT-4:00) to [End Date Not Provided]
More

Log in required to order LP DAAC data
2016-04-20 8:00AM (GMT-4:00) to 2016-05-30 8:00AM (GMT-4:00)
More

Release Information (7)

Upcoming Features
2016-09-18 11:00AM (GMT-4:00)
An overview of features available in future versions of Reverb.
More

Step 1: Select Search Criteria

Spatial Search (7)

Bounding Box: e.g. -90.736, 163.477, -11.144, 105.880 (S,E,W,N)

Satellite

Click and drag to set a bounding rectangle
Images ©2016 NASA | Terms of Use | Report a Problem

Search by ESRI shape file (7)

Search Terms (7)

e.g. MODIS Fire-ART-L1A

Try out this query in Earthdata Search

Temporal Search (7)

START

[Calendar Icon] [YYYY-MM-DD HH:MM:SS] Clear

END

[Calendar Icon] [YYYY-MM-DD HH:MM:SS] Clear

* all times must be specified in CMT

Date Range | Annual Repeating Dates

Step 2: Select Datasets

Found 8071 datasets, Total Query Time: 6.12s

- 15 Minute Stream Flow Data: USGS (FPE)
Archive Center: DRI, DAAC | Short Name: DR13334DRIUSDAAG1 | Version: 1
- 170 Excess from WAM Divisi, 0 to 25 kg BP
Archive Center: Not Provided | Short Name: NSDC-086 | Version: 1
- 1,100,000-scale Digital Line Graphs (DLG) from the U.S. Geological Survey
Archive Center: Not Provided | Short Name: DLD100K | Version: Not provided
- 2000 Pilot Environmental Sustainability Index (ESI)
Archive Center: SEDAC | Short Name: CESI, SEDAC_ESI_2000 | Version: 2000.00
- 2001 Environmental Sustainability Index (ESI)
Archive Center: SEDAC | Short Name: CESI, SEDAC_ESI_2001 | Version: 2001.00
- 2002 Environmental Sustainability Index (ESI)

Step 3: Discover Granules

No Datasets Selected

ABOUT EOSDIS

The Earth Observing System Data and Information System is a key core capability in NASA's Earth Science Data Systems Program. It provides end-to-end capabilities for managing NASA's Earth science data from various sources—satellites, aircraft, field measurements, and various other programs.

American Customer Satisfaction Index®

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Our Customers Have Spoken: EOSDIS Continues to Provide High Levels of Satisfaction

GIOVANNI The Bridge Between Data and Science

v 4.19 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

MODIS Collection 6... [1 of 1 messages] [Read More](#)

Select Plot



Select Data

YYYY-MM

Valid Range

Select Region

Format: W

-180, -90

Select Variables

► Discip

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► Platfo

► Spatia

► Tempo

► Wavel

► Depth

► Specif

► Portal

giovanni.gsfc.nasa.gov

nasa.gov Inbox - CERES Science Te... (1) Parameter Python/Equation Statu... ceres.larc.nasa.gov/documents/ST... Giovanni - Animation SURFACE INCIDENT SHORTWAV...

GIOVANNI The Bridge Between Data and Science v 4.19 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

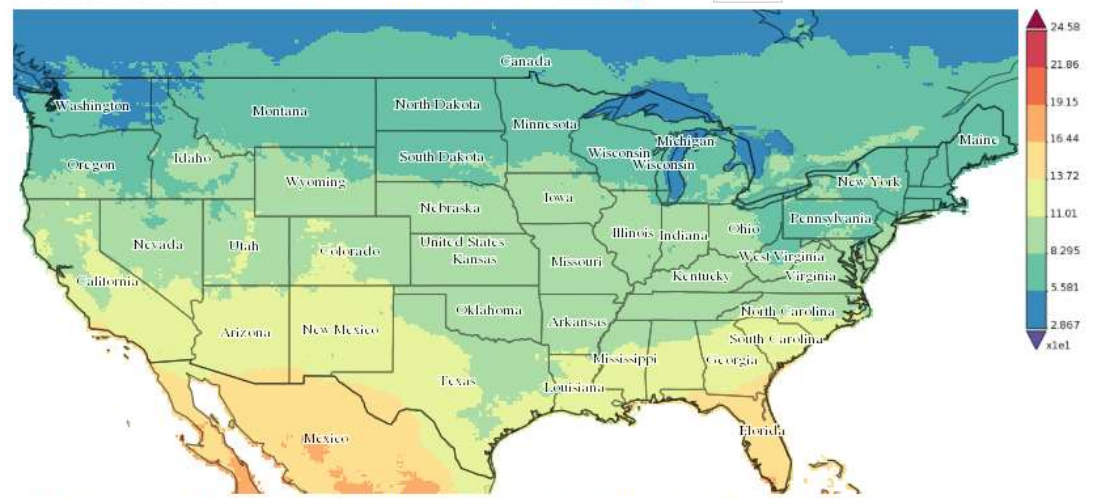
MODIS Collection 6... [1 of 1 messages] [Read More](#)

1. Animation

Download As... Options

Surface Incident Shortwave Radiation Flux monthly 0.125 deg. [NLDAS Model NLDAS_FORA0125_M v002] W/m²

1 / 2 2015-01-01 00:00 Frame Delay: 0.250s Go To:



- Selected date range was 2015-Jan - 2015-Feb. Title reflects the date range of the granules that went into making this result.

- ### History
- 1. Animation
 - User Input
 - Plots
 - Lineage
 - Downloads



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NASA Model Based Data Products

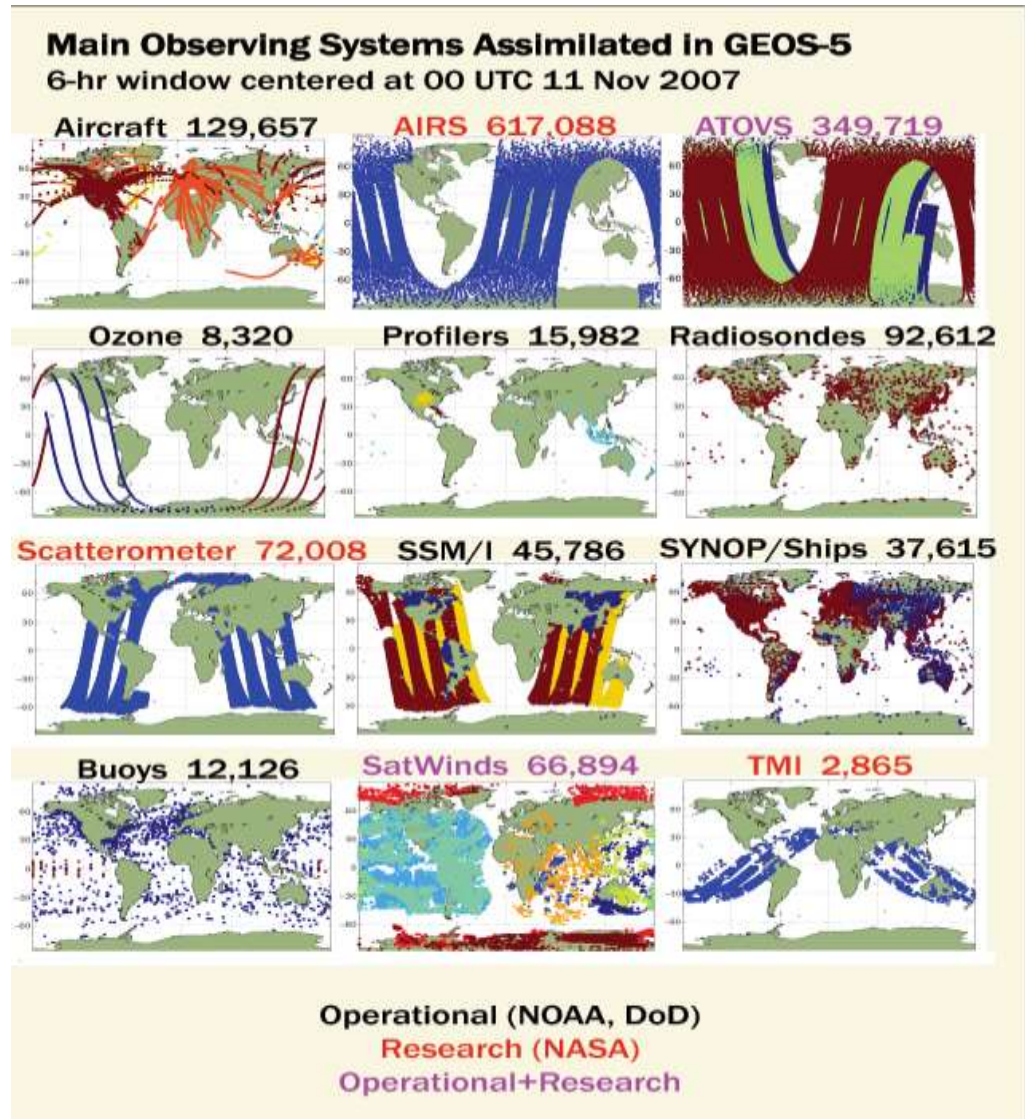
- Atmospheric Data Assimilation (GMAO)
 - Near-real time products:
 - FP ($1/4 \times 5/16$) and FPIT ($1/2 \times 5/8$) => hourly surface data; 6 hour latency (2nd day through Goddard DAAC)
 - Historical Analysis:
 - MERRA and now MERRA2 => 1979 to present global ($1/2 \times 5/8$) containing estimates for nearly all energy related parameters
 - MERRA replay=> high resolution (12 km) limited domain long-term reanalysis (under production)
 - High Resolution Land-Surface Assimilation data:
 - North American Land Data Assimilation System (NLDAS-2): US only; $1/8$ degree, hourly and monthly)
 - Global Land Data Assimilation System (GLDAS): Most globe; $1/4$ degree, 3-hourly and monthly)



NASA Assimilation Data Products: Example MERRA Overview

- Assimilation is a process of optimizing an global to regional scale atmospheric model with observational input.
- MERRA assimilates satellite radiances and in situ measurements from a large set of sources.
- MERRA was generated with version 5.2.0 of the Goddard Earth Observing System (GEOS) atmospheric model and a 3-D data variational assimilation system.
- MERRA provides a complete suite of meteorological parameters at a $1/2^\circ$ latitude $2/3^\circ$ longitude with 72 vertical levels, from the surface to 0.01 hPa, spanning from 1979 to near-present

(Rienecker et al 2008, 2011 describe MERRA in detail)



NASA Model Based Data Products

- Weather and Seasonal Forecasts (GMAO)
 - GMAO ensemble forecasts (FP): daily 10-d forecast; Operational submitted to NWS ensemble
 - GMAO Seasonal forecasts submitted to National Multi-Model Ensemble (NMME)
 - SERVIR: <http://climateserv.nsstc.nasa.gov> (under development)
 - High resolution regional: SPoRT (Case Study only)
- Climate Modeling
 - GISS climate modeling; family of models
 - Simulations for Climate Model Intercomparison project (CMIP)
 - Data products obtainable through PCMDI servers
- Alternative NASA Climate Model Outputs Methods
 - NEX: Multiple data sets from satellite to CMIP5 climate model



SERVIR Climate Server: NMME-based Seasonal Forecasts of Rainfall and Temperature

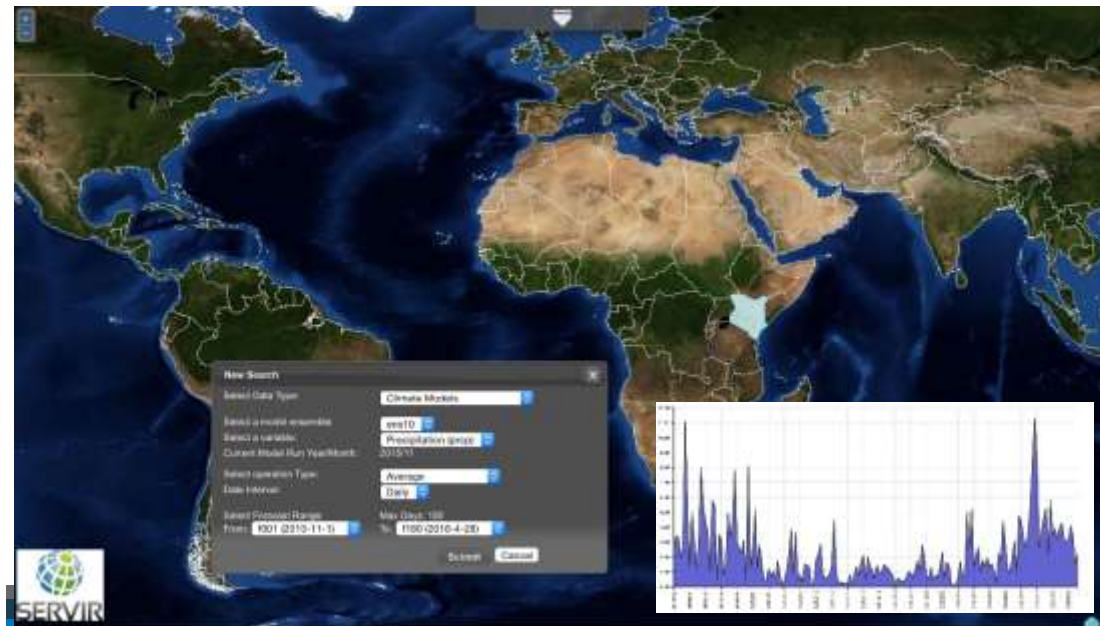
The problem: SERVIR end users need an efficient way to access seasonal climate projections and daily scenarios for decision making in water resources and agricultural crop estimation.

What we did: Bias-corrected and spatially disaggregated (BCSD) seasonal projections based on North American Multi-model Ensemble (NMME) experimental forecasts. The SERVIR Science Coordination Office makes spatially downscaled 180-day projections available to SERVIR users on an easy-to-use web-system: *100+ ensemble members (9 NMME models) are bias corrected over the 180-day periods. Statistical disaggregation using a historical analogue approach (Wood et al; 2002) provides daily-resolution stochastic realizations consistent with NMME monthly forecasts.*

Output:

- Climate projections
- 180 days in extent
- updated monthly
- Resolution: 0.5° global grid, daily
- Variables: Rainfall, Temperature

Significance: SERVIR end users in Himalaya and Eastern Africa have started to use the ensembles to generate hydrologic and seasonal crop assessments.



NEX: A Collaborative NASA Resource

NEX Facts

Home
Resources
Members

NEX Data and Storage

shared by Petr Votava on Nov 11, 2012

Summary

This page describes the datasets currently available to science users.

Updated: 2/23/2016

Current NEX filesystem size: 2.3PB

Current NEX filesystem usage: 1.3PB

Planned FY16 Addition: TBD

LANDSAT

Landsat 5 and Landsat 7 (TM and ETM+)	198
Landsat 8	201
Landsat CLS	193
Web-Enabled Landsat (WELD)	12

MODIS (Land) Collection 5

Data available for all years = 2000 - present (Terra), 2

- MCD12Q1: Annual Landcover (Terra+Aqua) 500m
- MCD12Q2: Annual Landcover Dynamics (Terra+Aqua)
- MCD15A2: 8-day LAI/FPAR (Terra+Aqua) 1km
- MCD43A2: 16-day BRDF-Albedo Quality (Terra+Aqua)
- MCD43A4: 16-day Nadir BRDF-Adjusted Reflectances
- MCD43B2: 16-day BRDF-Albedo Quality (Terra+Aqua)
- MCD43B3: 16-day Albedo (Terra+Aqua) 1km
- MCD45A1: Monthly Burned Area (Terra+Aqua) 500m
- MOD09CMG: Daily Surface Reflectances (Terra) 0.05°
- MOD09CA: Daily Surface Reflectances (Terra) 500m
- MYD09GA: Daily Surface Reflectances (Aqua) 500m
- MOD09Q1: 8-day Surface Reflectances (Terra) 250m
- MYD09Q1: 8-day Surface Reflectances (Aqua) 250m

MODIS (Atmosp)

Data available for all years

- MOD04_L2: Aerosol Prodi
- MYD04_L2: Aerosol Produ
- MOD05_L2: Precipitable W
- MYD05_L2: Precipitable W
- MOD06_L2: Cloud Produc
- MYD06_L2: Cloud Produc
- MOD07_L2: Atmospheric
- MYD07_L2: Atmospheric I

ASTER

ASTGTM2: Global Digital I

TRMM

3B42: TRMM-adjusted me

AVHRR

AVH13C1: Daily NDVI at 0
CIMMS 3G NDVI

Ecosystem Mod

FLUXNET point datasets
Forest Inventory and Anal
NCEP/NCAR Reanalysis: at

Climate Datasets

PRISM: Monthly at 4km	1895-2010	USA
PRISM: Monthly normals - 800m	1971-2000	USA
PRISM: Monthly normals - 800m	1981-2010	USA
DAYMET: Daily at 1km	1980-2009	USA, Canada, Mexico
CRU-NCEP at 0.5 deg	1980-2010	Global
3-hr North American Regional Reanalysis - 32 km	1980-2010	North America
NEX-DCP30: NEX Downscaled Climate Projections - 30 arc second	1950-2100	CONUS
NEX-GDDP: NEX Global Daily Downscaled Projections - 0.25 deg	1950-2100	Global

Landcover

GlobCover Land Cover v2 2008 (ESA) at 300 m	Global
The National Land Cover Database at 30m	USA

DEM

CTOPO30 at 30 arc-sec	Global
The Shuttle Radar Topography Mission (SRTM) at 1, 3 and 30 arc-sec	Near Global

Soils

STATSGO at 1km	USA
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Aerial

USDA NAIP aerial data at 1m	USA
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Energy Related Applied Science Projects



POWER Overview

- Objectives: Improve the Nation's public/private capability for integrating environmental data from NASA research to support increased renewable energy development, energy efficiency and agricultural modeling.
- Goals: Through partnerships, derive/validate/provide parameters relevant to industry needs, link to decision support, and transition capabilities when possible.
- Website: <http://power.larc.nasa.gov>



Prediction
Of
Worldwide
Energy
Resource

Surface meteorology and Solar Energy (SSE-release 6.0) :
A renewable energy resource web site sponsored by NASA's Applied Sciences
Program in the Science Mission Directorate, Applied Sciences Program

Earth Science for Society: Accelerating the realization of economic and societal
benefits from Earth science, information, and technology

Home Renewable Energy Parameters Sustainable Buildings Parameters Agrometeorology Parameters

Access Data

- SSE-Renewable Energy
- Sustainable Buildings
- Agrometeorology

Documentation

- About the POWER Project
- About Renewable Energy
- About Sustainable Buildings

Processing, archiving, and distributing solar insolation and meteorological parameters for:

- SSE-RENEWABLE ENERGY: Satellite and modeled derived data supporting Renewable Energy Technologies (RET's).
 - Over 200 satellite-derived meteorology and solar energy parameters
 - Monthly averaged parameters for the period July 1, 1983 through June 30, 2005
 - Daily averaged solar and meteorological data over the time period July 1983 - June 2005

NREL
NATIONAL RENOVABLE ENERGY LABORATORY

Leading Clean Energy Innovation

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Facilities -
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RETScreen Software Suites - Download Free

RETScreen is a Clean Energy Management Software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis.

Click here to download RETScreen Suite

Downloading and running RETScreen Software Suite on your computer will install two separate programs, RETScreen 4 and RETScreen Plus, described below.

RETScreen 4 is an Excel-based clean energy project analysis software tool that helps decision makers quickly and inexpensively determine the technical and financial viability of potential clean energy projects.

RETScreen Plus is a Windows-based energy management software tool that allows project owners to easily verify the ongoing energy performance of their facilities.

RETScreen Online Training - Free Webcasts

Introduction to Clean Energy Project Analysis
Energy Efficiency Project Analysis
Heating & Cooling Project Analysis
Power Project Analysis
Cogeneration Project Analysis
Energy Performance Analysis (Wides only)

41937 users in 222 countries

Repowering an Existing Hydropower Station in Norway

City of Toronto Green Building Standards Specify RETScreen

Climate Change Mitigation Environment by RETScreen

Weston Foods Attributes Sustainable Gas Services to RETScreen Plus

More...

Managed by Corewell MEMOIX

NASA ENERGY UNIT

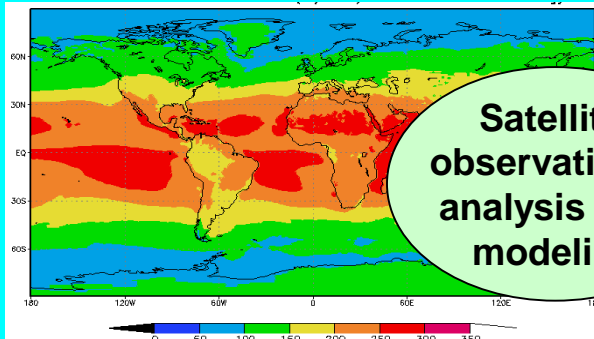
Date Modified: 2014-10-10

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Important Notices

POWER Approach: Research to Decisions

NASA Earth-Sun Satellite Analysis and Modeling Projects: (ISCCP, GEWEX SRB, CERES FLASHFlux, GMAO GEOS)

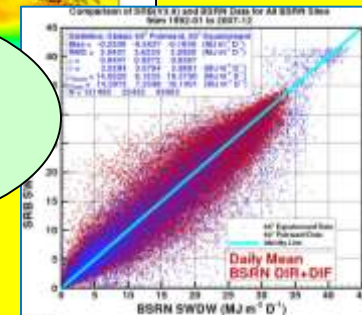
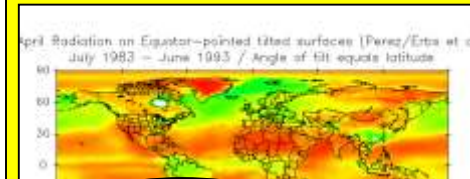


Surface Solar Irradiance ($W m^{-2}$)

Satellite observations, analysis and modeling

POWER/SSE Project

Solar and meteorological parameters in specialized units



Adaptation and validation of parameters

RETScreen® International



~ 450,000 Global Users

Decision Support System design and planning tool

Data Accessibility through Web Interface

POWER/SSE Datasets and Web interface

200+ Parameters (most on-the-fly)

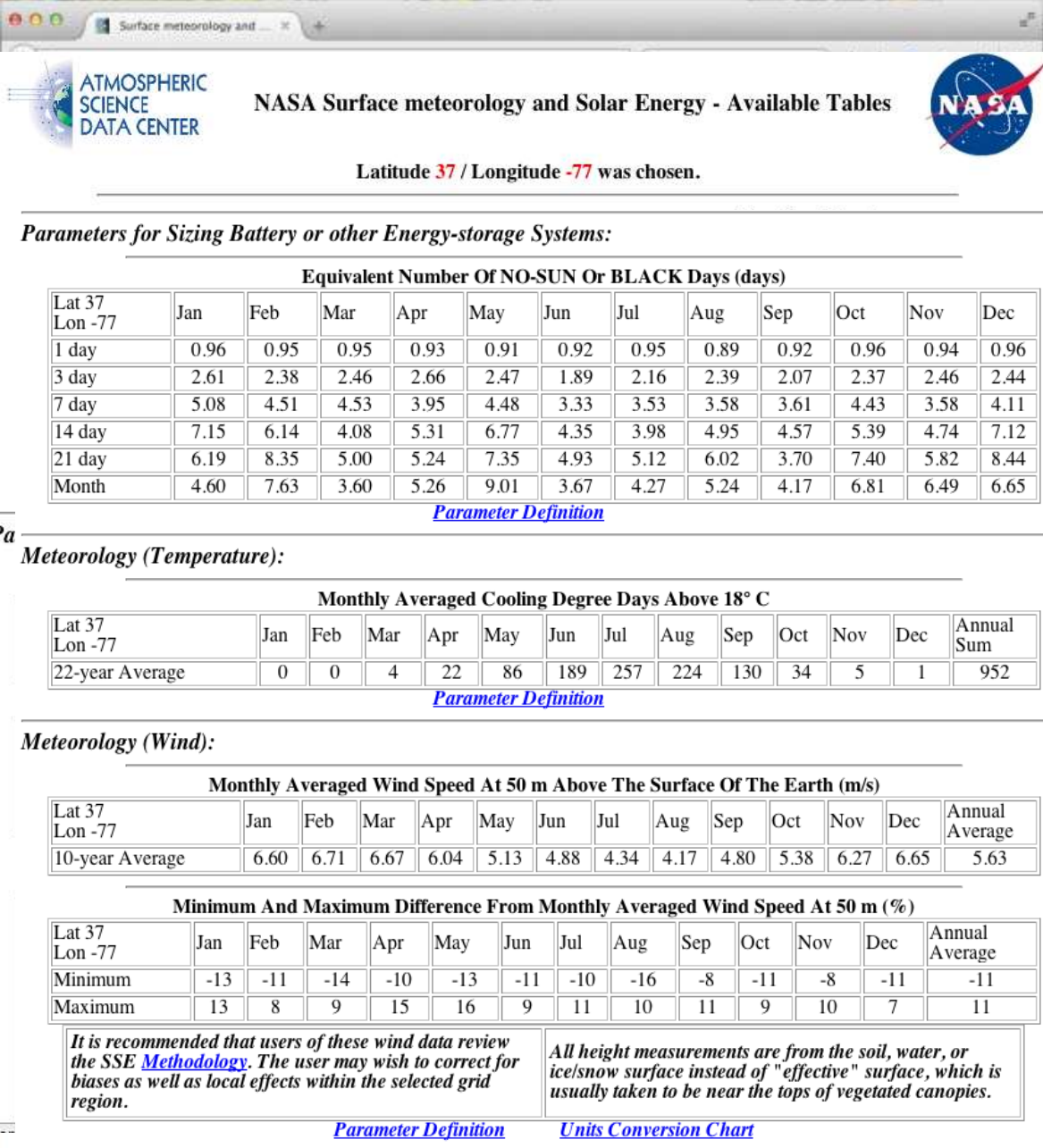
(~15,000 unique users, ~ 1,200,000 hits and 230,000 data downloads per month)



SSE Renewable Energy Data Products from NASA

SSE v6

- 22 Years
- Over 200 parameters, many on the fly, tailored for renewable energy
- Data quality information
- ASCII tables, time series, regional plots/data
- Direct connection to 2 renewable energy DSS tools
- 20 Millionth data request fulfilled in July for release 6.0
- **Website:**
<http://eosweb.larc.nasa.gov/sse>



ATMOSPHERIC SCIENCE DATA CENTER NASA Surface meteorology and Solar Energy - Available Tables

Latitude 37 / Longitude -77 was chosen.

Parameters for Sizing Battery or other Energy-storage Systems:

Equivalent Number Of NO-SUN Or BLACK Days (days)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 day	0.96	0.95	0.95	0.93	0.91	0.92	0.95	0.89	0.92	0.96	0.94	0.96
3 day	2.61	2.38	2.46	2.66	2.47	1.89	2.16	2.39	2.07	2.37	2.46	2.44
7 day	5.08	4.51	4.53	3.95	4.48	3.33	3.53	3.58	3.61	4.43	3.58	4.11
14 day	7.15	6.14	4.08	5.31	6.77	4.35	3.98	4.95	4.57	5.39	4.74	7.12
21 day	6.19	8.35	5.00	5.24	7.35	4.93	5.12	6.02	3.70	7.40	5.82	8.44
Month	4.60	7.63	3.60	5.26	9.01	3.67	4.27	5.24	4.17	6.81	6.49	6.65

[Parameter Definition](#)

Meteorology (Temperature):

Monthly Averaged Cooling Degree Days Above 18° C

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
22-year Average	0	0	4	22	86	189	257	224	130	34	5	1	952

[Parameter Definition](#)

Meteorology (Wind):

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth (m/s)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	6.60	6.71	6.67	6.04	5.13	4.88	4.34	4.17	4.80	5.38	6.27	6.65	5.63

Minimum And Maximum Difference From Monthly Averaged Wind Speed At 50 m (%)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Minimum	-13	-11	-14	-10	-13	-11	-10	-16	-8	-11	-8	-11	-11
Maximum	13	8	9	15	16	9	11	10	11	9	10	7	11

It is recommended that users of these wind data review the SSE [Methodology](#). The user may wish to correct for biases as well as local effects within the selected grid region.

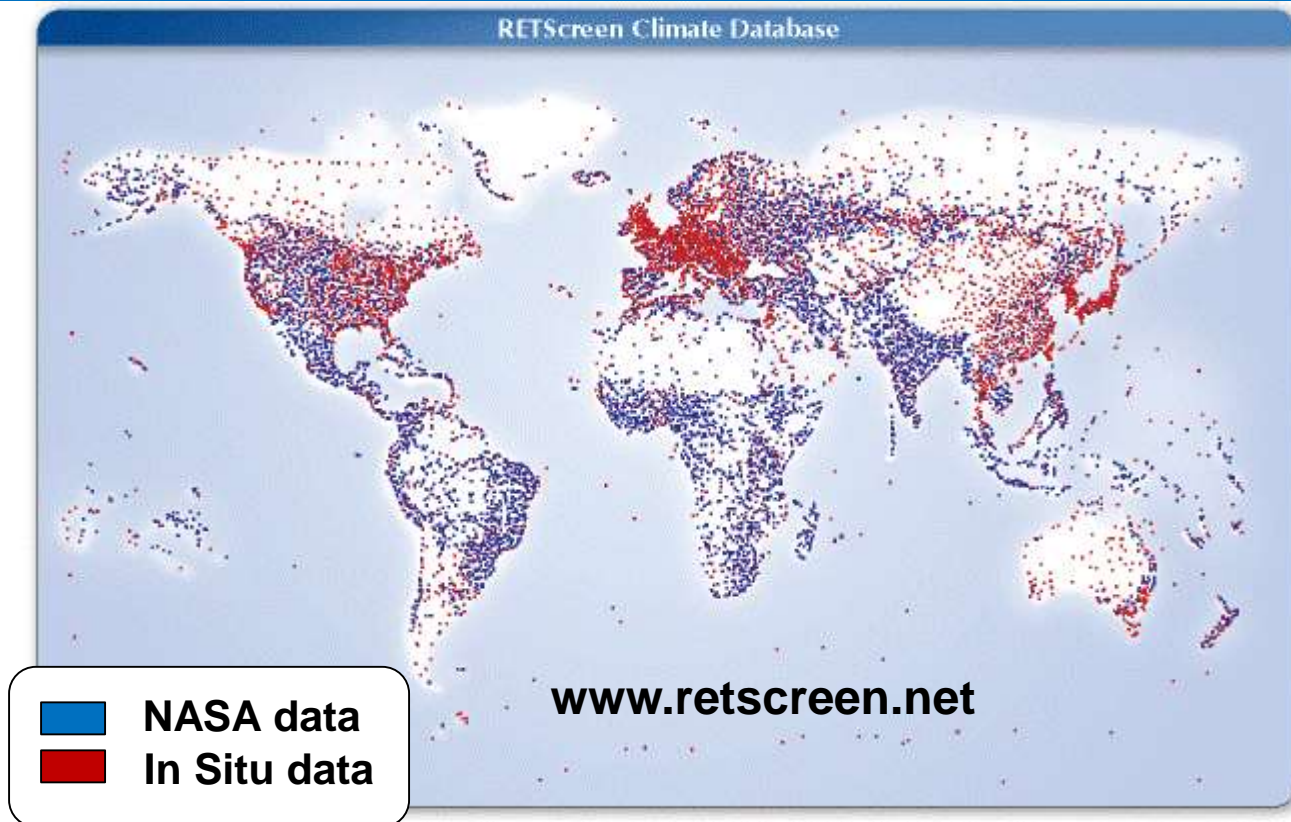
All height measurements are from the soil, water, or icel/snow surface instead of "effective" surface, which is usually taken to be near the tops of vegetated canopies.

[Parameter Definition](#) [Units Conversion Chart](#)

SSE for Decision Support: RETScreen Clean Energy Analysis

- Under Natural Resources Canada
- Aimed for both feasibility and detailed scenario analysis of clean energy projects
- Data for built-in cities of world or direct query of SSE data through web
- **~450,000+ users**
- Release 4: 36 languages

RETScreen Climate Database



Points represent world's cities (~10,000). Red have in situ observations. Blue defer to NASA LaRC data sets (~5,000). Data for locations between points are found through a direct link to SSE.

POWER Supports Near-Real Time: NASA LaRC Building Energy Analysis

NASA data
and/or surface
measurements

**CERES
FLASHFLux
(using
GMAO
FP-IT)**

**NRT Time
Series POWER
web
portal**

**RETScreen
Energy
Analysis**

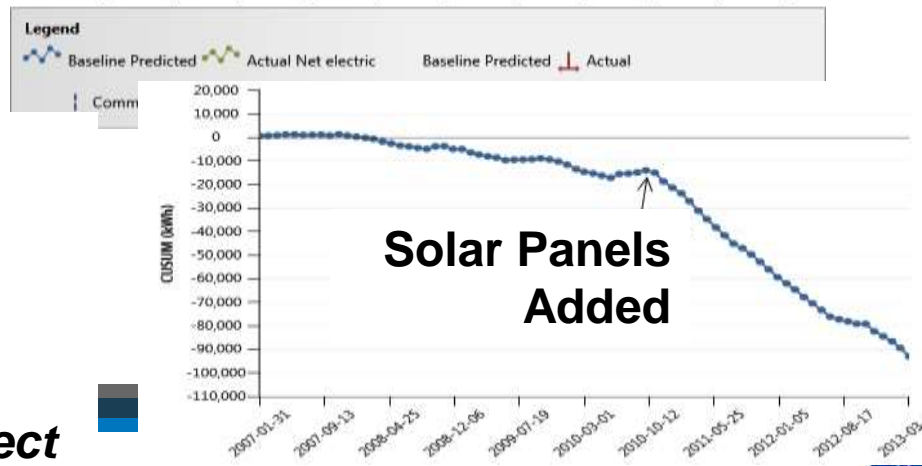
4 building
energy
assessments
working with
center energy
management
officials and
RETScreen



Steady state RETScreen regression
models now complete (NASA TMs
available).

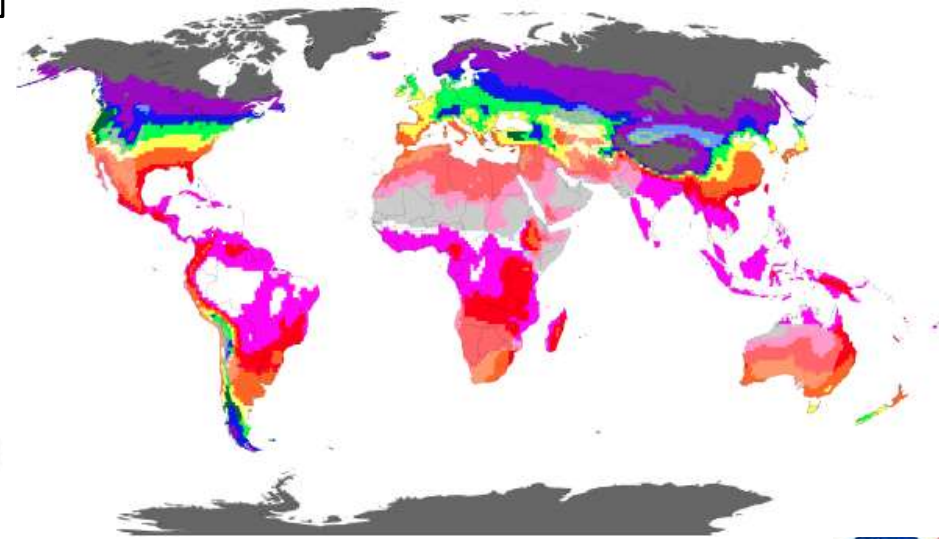
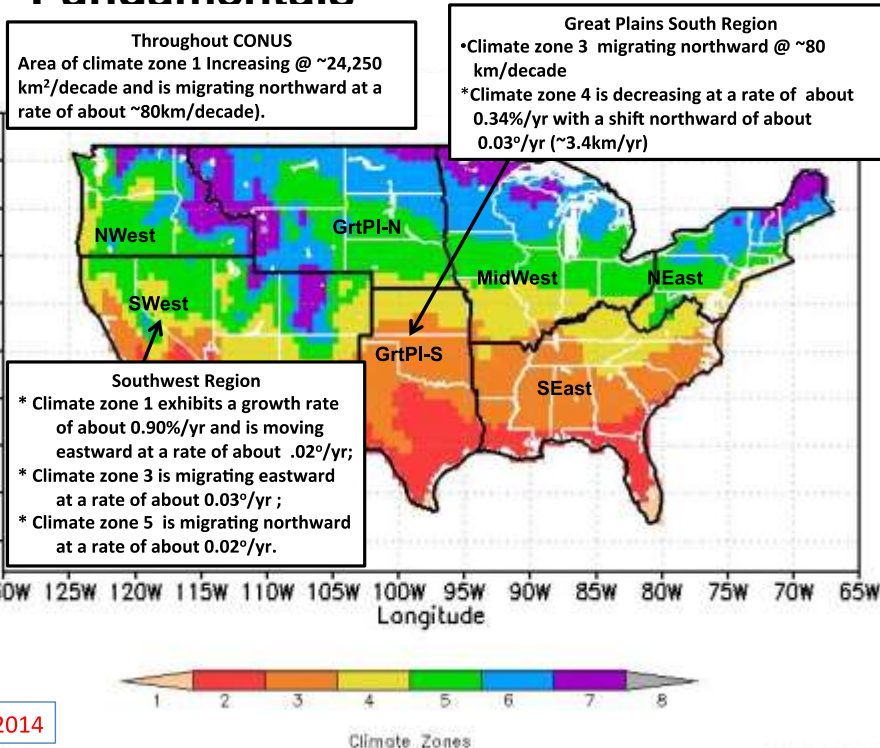
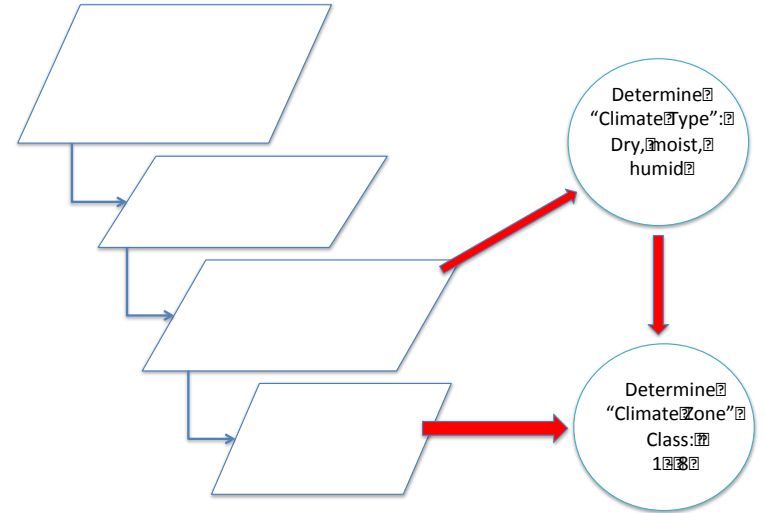
*Supported by NASA's Climate
Adaptation Science Investigator Project
(CASI)*

Net Savings 160 MWh (2/10 – 3/13)



POWER and ASHRAE Collaboration: Assessing Building Climate Zone Changes

- Collaborated with ASHRAE to provide/assess Building Climate Zones from NASA reanalysis (GEOS-4 and MERRA)
- Provided to ASHRAE and it was included ASHRAE Handbook of Fundamentals



Using ArcGIS To Enhance Applied Science Usage of Data Products



Featured Maps and Apps



22 Year Climatologies Image Service
Prediction Of Worldwide Energy Resource Surface meteorology and Solar Energy v.8



Daily Average Parameters Arclmage Service
Prediction Of Worldwide Energy Resource Surface meteorology and Solar Energy v.7



POWER SSE Web Mapping Application

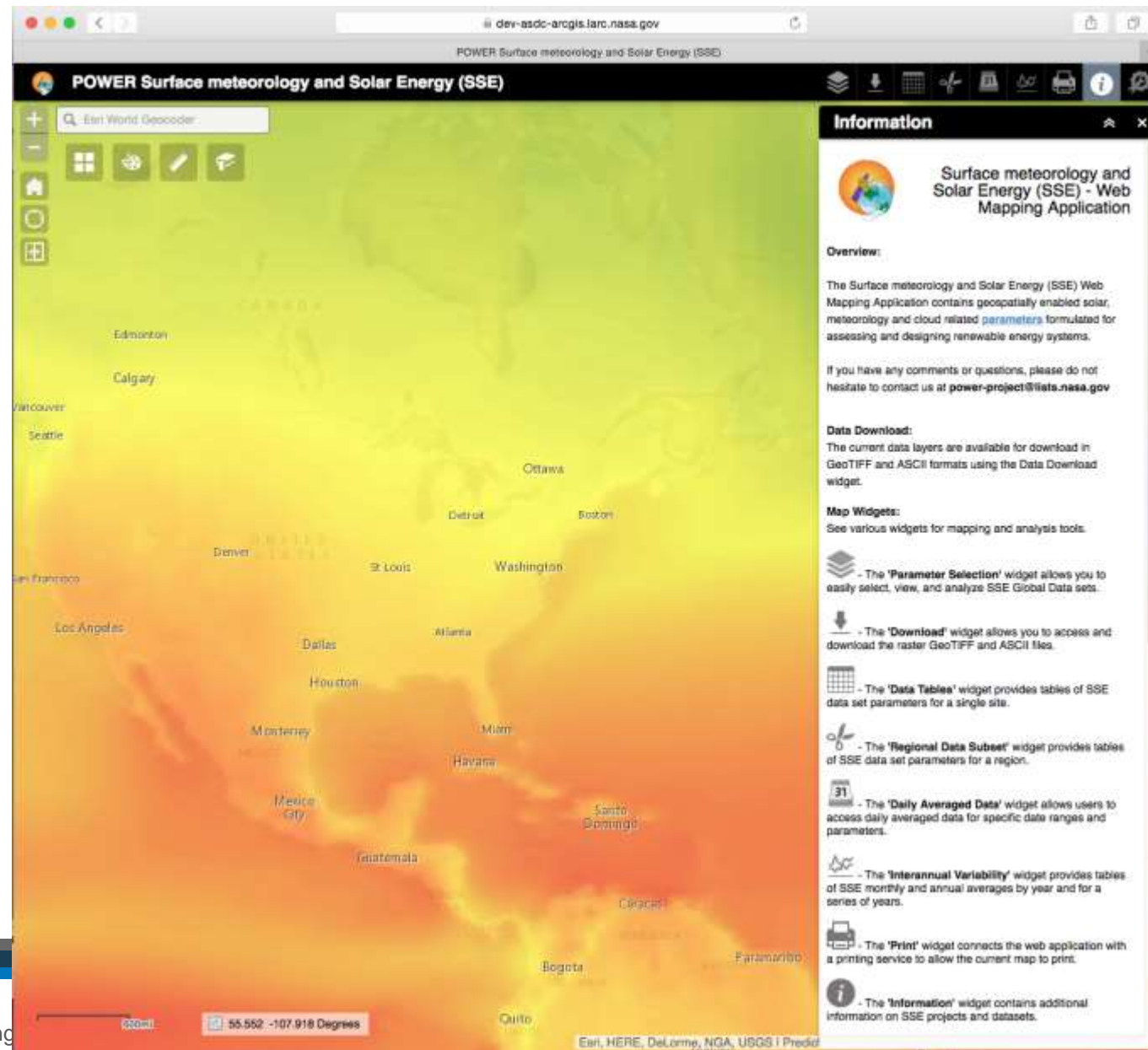
The Atmospheric Science Data Center (ASDC) at [NASA Langley Research Center](#) is responsible for the processing, archiving, and distribution of NASA Earth science data in the areas of radiation budget, clouds, aerosols, and tropospheric chemistry.

The Data Center was established in 1991 to support the [Earth Observing System \(EOS\)](#) as part of [NASA's Earth Science Global Change Research Program](#), and is one of several Distributed Active Archive Centers (DAACs) sponsored by NASA as part of the [Earth Observing System Data and Information System \(EOSDIS\)](#).



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



Summary and Conclusions

- NASA has considerable investments in satellite measurements and analysis of those products for various earth science data products
- NASA also has an extensive modeling and assimilation capability comprising both long-term analysis, short-term and climate forecasts
- Many of those data products could be useful for an Energy context
 - However, data products are archived at team web sites and/or DAACs making retrieval complicated
 - Science based tools have been developed for simplified data access such as GIOVANNI, ClimateServ and NEX



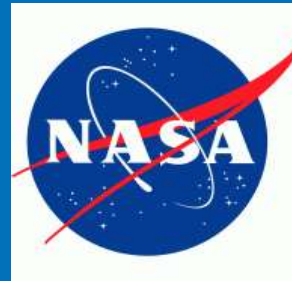
Conclusions

- Applied Sciences has supported projects like POWER throughout the years aiming to bring some of these data quantities to the Energy Management sector needs
 - POWER/SSE web capabilities are being further developed using GIS to continue to enable data access
- What are the evolving needs of energy sector? What types and sorts of data are needed? Is there a role NASA can play?



Thank you!

Battelle
The Business of Innovation



Extras

Battelle
The Business of Innovation

Projects Facilitated by RETScreen

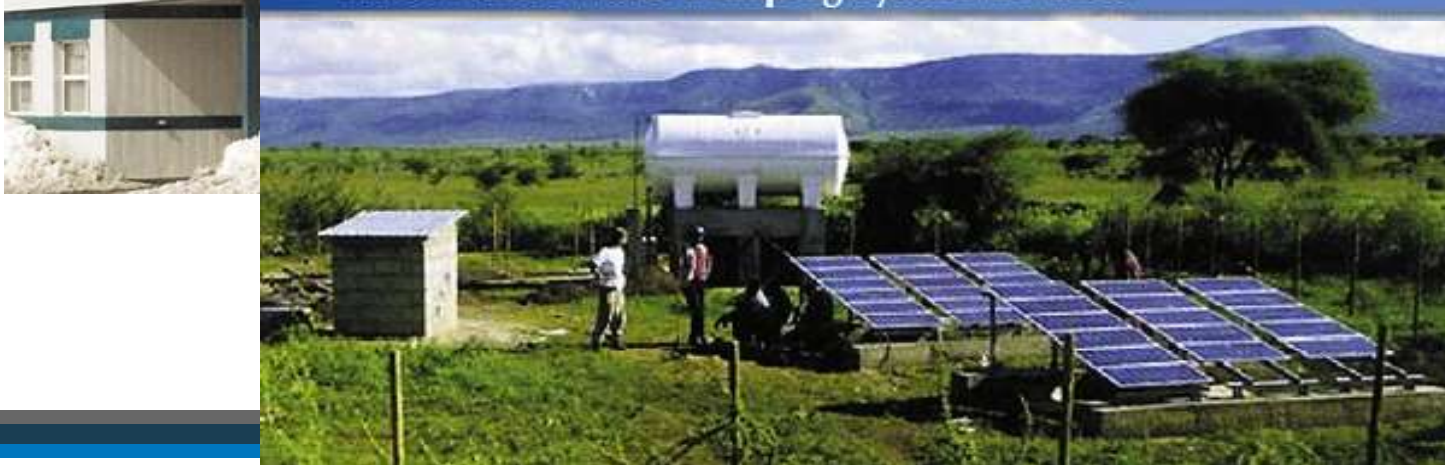
Solarwall® on High School in Northern Canada



Solar Water Heating at Vancouver International Airport



Photovoltaic Water Pumping System in Africa



http://www.retscreen.net - RETScreen International

RETScreen

Country: China
 Province / State: Shanghai
 Climate data location: Shanghai

Latitude: 31.4 °N
 Longitude: 121.5 °E
 Elevation: 4.0 m
 Heating design temperature: -0.4 °C
 Cooling design temperature: 33.2 °C
 Earth temperature amplitude: 14.7 °C

Source: NASA

	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°F	%	kWh/m ² /d	kPa	m/s	°C	°C-d	°C-d
Jan	31.1	73.0%	2.61	102.5	3.1	5.4	406	0
Feb	45.2	70.4%	3.08	102.4	3.0	6.4	330	0
Mar	49.1	75.1%	3.54	102.0	3.3	9.5	264	0
Apr	59.0	73.9%	4.46	101.5	3.2	14.3	90	150
May	68.9	74.6%	5.05	101.0	3.2	18.9	0	326
Jun	74.8	81.5%	4.64	100.6	3.2	22.8	0	414
Jul	82.6	80.0%	5.15	100.4	3.3	26.6	0	561
Aug	81.9	81.3%	4.82	100.5	3.5	26.6	0	549
Sep	75.9	76.6%	4.09	101.1	3.4	23.1	0	432
Oct	66.7	73.8%	3.47	101.8	2.9	18.4	0	288
Nov	56.3	73.0%	2.91	102.3	3.0	13.2	135	105
Dec	46.0	71.7%	2.56	102.6	2.9	7.7	316	0
Annual	62.2	75.4%	3.87	101.6	3.2	16.1	1,541	2,825
Source	Ground	Ground	NASA	NASA	Ground	NASA	Ground	Ground

Measured at: 10 m, 0

Five Step Start



Settings & Site Conditions



Enter data in shaded cells from top to bottom of each worksheet

Integrated Features

Climate Data



Sensitivity & Risk Analysis



Simulation

Learning Course Material

- Engineering Textbook
- Case Studies
- Marketplace & Maps

Next Steps: Adding GIS for Web Site Modernization and Mobile Devices

- End-users of NASA data products increasingly requesting geospatial tool compatibility
- LaRC ASDC is working to stand up “Web services” used to make the application platform and technology independent by following standards (i.e. DAP, WCS, WMS, etc.), promoting interoperability
- One of those is an ArcGIS Image Service => NASA’s license with Esri allows the agency to acquire access to Esri ArcGIS software at no additional cost to programs
- ***POWER/SSE now leading project, collaborating with ASDC, to add GIS capabilities and web services for access to data products.***



POWER/SSE GIS Sample

- Browser enabled GIS functionality
- Display parameters from global to small scale
- Add background maps
- Point for values
- Download data to support ASCII or GeoTIFF applications
- Scales to mobile devices
- Release May '16

