



Earth Observations Informing Climate & Energy Decision Making

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Energy Modeling Forum – Urban IAV Program
Snowmass 2009

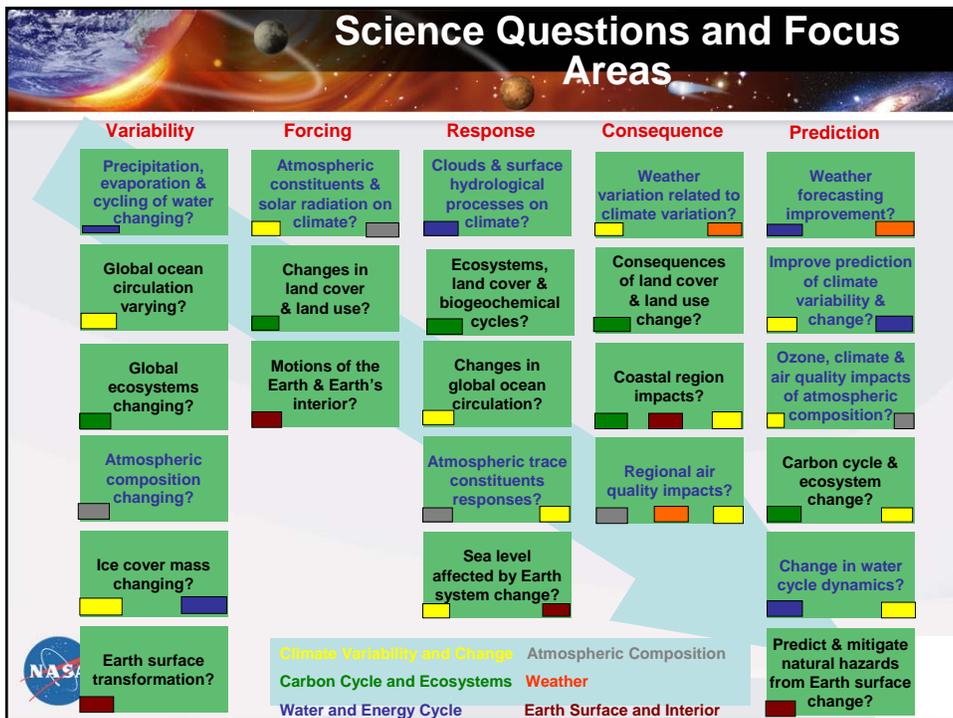
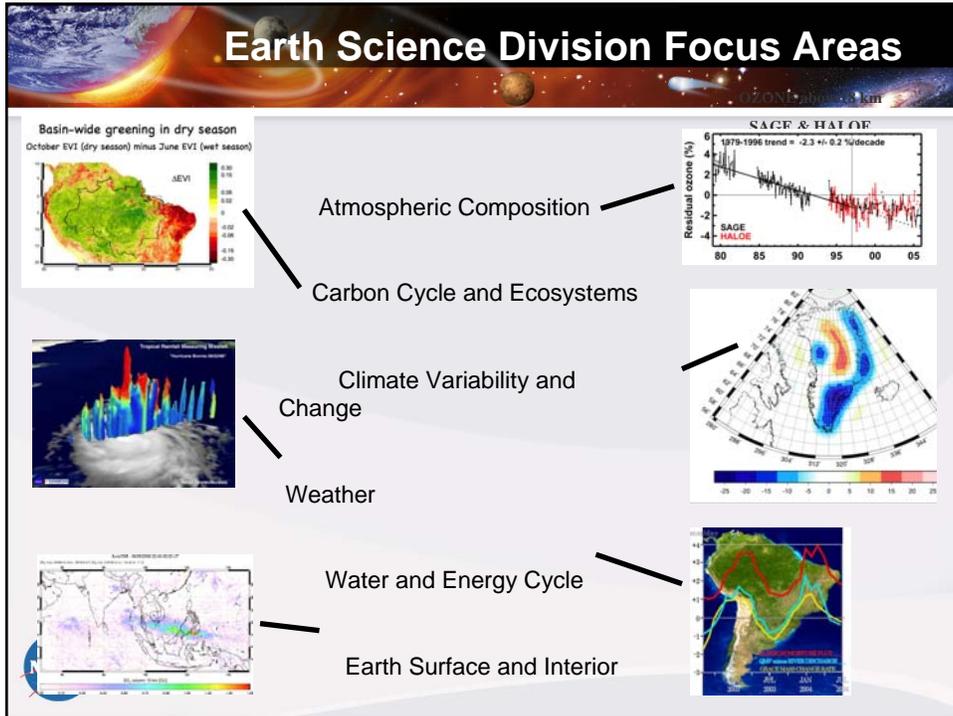
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Outline

- **Agency/Targeted Activities in Climate Change**
 - Mostly from the Earth Sciences perspective
- **Collaborations and Interactions**
 - Engaging the Stakeholder: **From Research to Energy Applications**
 - Examples of successful partnerships with renewable energy and energy efficiency decision makers
- **Access & Resources (solicitations, reports & links)**
- **Conclusions**

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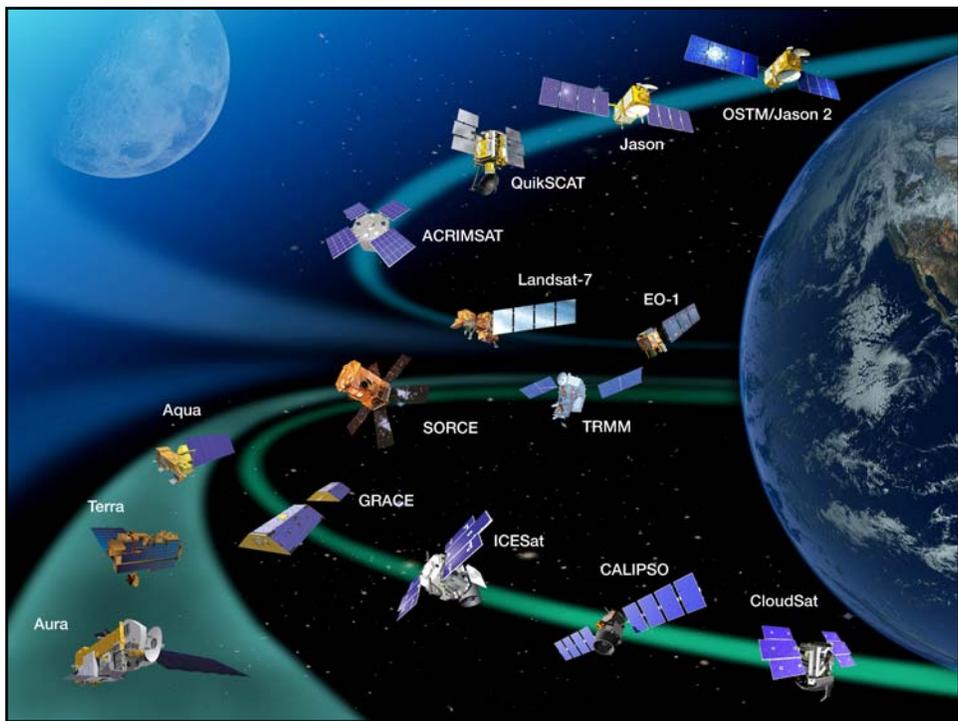


R&A “Disciplines” and Science Focus Areas

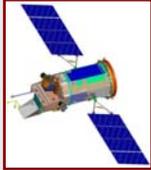
R&A Discipline	Science Focus Area					
	Atmospheric Composition	Climate Variability & Change	Carbon Cycle & Ecosystems	Global Water and Energy Cycle	Weather	Earth Surface & Interior
Upper Atmosphere Research	P	S				
Tropospheric Chemistry	P	S	S	S	S	
Radiation Sciences	P	S		S	S	
Atmospheric Chemistry Modeling & Analysis	P	S	S	S		
Modeling and Analysis	S	P	S	S	S	
Physical Oceanography		P		S	S	
Cryospheric Science		P		S	S	S
Terrestrial Ecology	S	S	P	S		
Land Cover Land Use Change	S	S	P	S	S	S
Ocean Biology and Biogeochemistry	S	S	P	S		
Biodiversity*		S	P			
Terrestrial Hydrology		S	S	P	S	S
Atmospheric Dynamics	S	S		P	S	
Research-Operations Transition Activities	S	S			P	
Space Geodesy		S		S		P
Earth's Planetary Interior						P
Geohazards	S	S		S		P



*Nascent Program



Missions in Formulation and Implementation



GLORY



AQUARIUS



NPP



LDCM



GPM



SMAP



ICESat-II



Key Satellites for Focus Areas

Atmospheric Composition*

- Terra
- Aqua
- Aura
- CALIPSO
- Glory
- NPP

Climate Variability and Change

- ACRIMSAT
- SORCE
- Aqua
- Jason/OSTM
- QuikScat
- CALIPSO
- Aquarius
- Glory
- NPP
- GRACE

Carbon Cycle and Ecosystems

- Terra
- SeaWiFS
- Landsat 7
- LDCM
- NPP

Global Water and Energy Cycle

- Aqua
- Cloudsat
- TRMM
- GPM
- GRACE

Weather

- TRMM
- GPM
- QuikScat
- Aqua
- NPP
- Terra
- Cloudsat

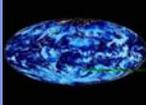
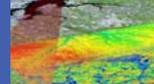
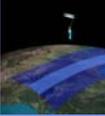
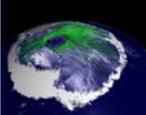
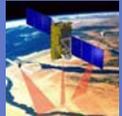
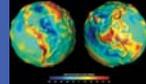
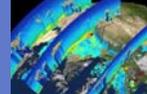
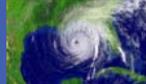
Earth Surface and Interior*

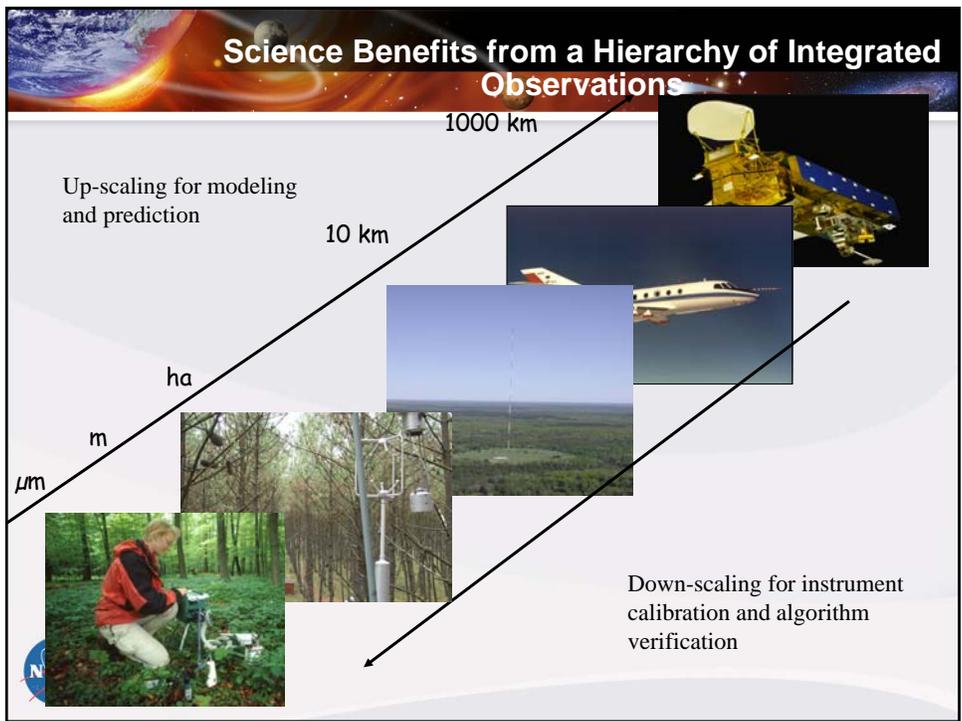
- GRACE
- Terra
- Landsat 7
- LDCM
- MOOs (CHAMP, SAC-C, TerraSAR-X, Lageos 2)



*NASA-supported Ground Networks also key

NASA Earth Science Decadal Survey Missions

<p>Climate Absolute Radiance and Refractivity Observatory (CLARREO)</p> 	 <p>Hyperspectral Infrared Imager (HYSPIRI)</p>	<p>LIDAR Surface Topography (LIST)</p> 
 <p>Soil Moisture Active Passive (SMAP)</p>	<p>Active Sensing of CO2 Emissions (ASCENDS)</p> 	 <p>Precipitation and All-Weather Temperature and Humidity (PATH)</p>
<p>Ice, Cloud, and land Elevation Satellite II (ICESat-II)</p> 	 <p>Surface Water and Ocean Topography (SWOT)</p>	<p>Gravity Recovery and Climate Experiment - II (GRACE - II)</p> 
 <p>Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI)</p>	<p>Geostationary Coastal and Air Pollution Events (GEO-CAPE)</p> 	 <p>Snow and Cold Land Processes (SCLP)</p>
	 <p>Aerosol - Cloud - Ecosystems (ACE)</p>	<p>Three-Dimensional Winds from Space Lidar (3D-Winds)</p> 
<p>Tier I</p>	<p>Tier II</p>	<p>Tier III</p>





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NASA Applied Sciences Program

- **Goal:** The Applied Sciences program extends NASA Earth Science research and observations for practical use in environmentally-related decision and policy making
- **Serves society through:**
 - Demonstrating, through partnerships with public organizations, improvements to their ability to manage and plan natural resources and to make better environmental predictions, decisions, and policy.
- **Serves the Earth science community by:**
 - Demonstrating and communicating the utility and potential of Earth science for societal benefit to a broad audience
 - Complementing R&A programs through applied research in strategic areas
 - Providing the applications “viewpoint” to the research community
 - Forging partnerships with “nontraditional” organizations (e.g., NREL, USDA, Battelle, NRCAN, ESA, DLR, Universities, Private Sector)

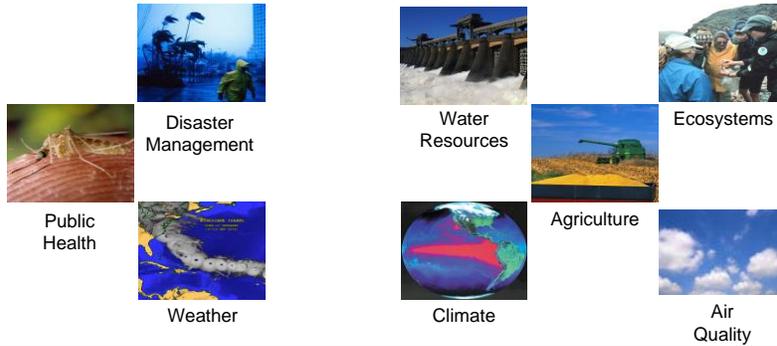
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Societal Benefit Areas

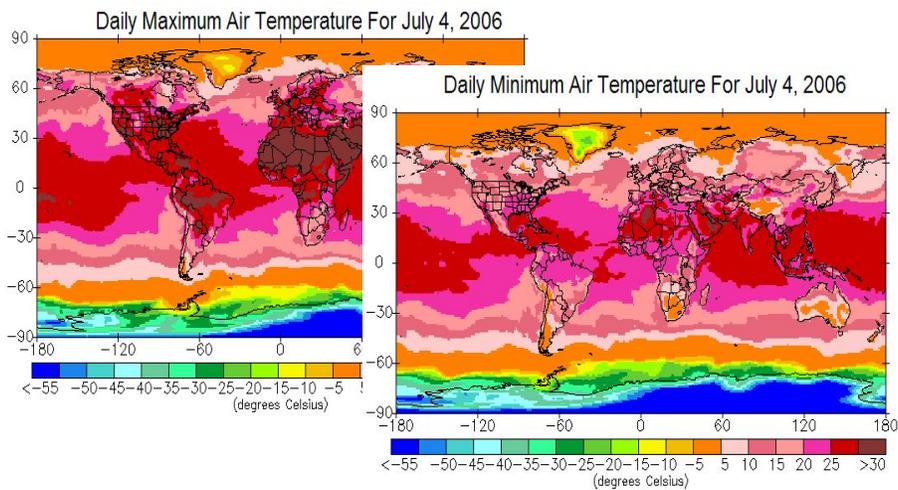
Applied Sciences aligns with GEO Societal Benefit Areas, with a focus on those areas where:

- NASA has capability and expertise
- NASA can have greatest impact
- Societal need is greatest



Relevant NASA Science Data Sets

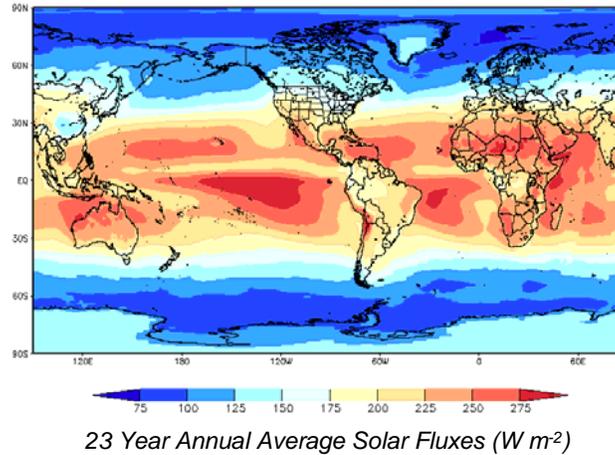
Meteorological Information: 23-year history





Relevant NASA Science Data Sets

GEWEX Surface Radiation Budget



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The NASA "POWER" Project

POWER = Prediction of Worldwide Energy Resource

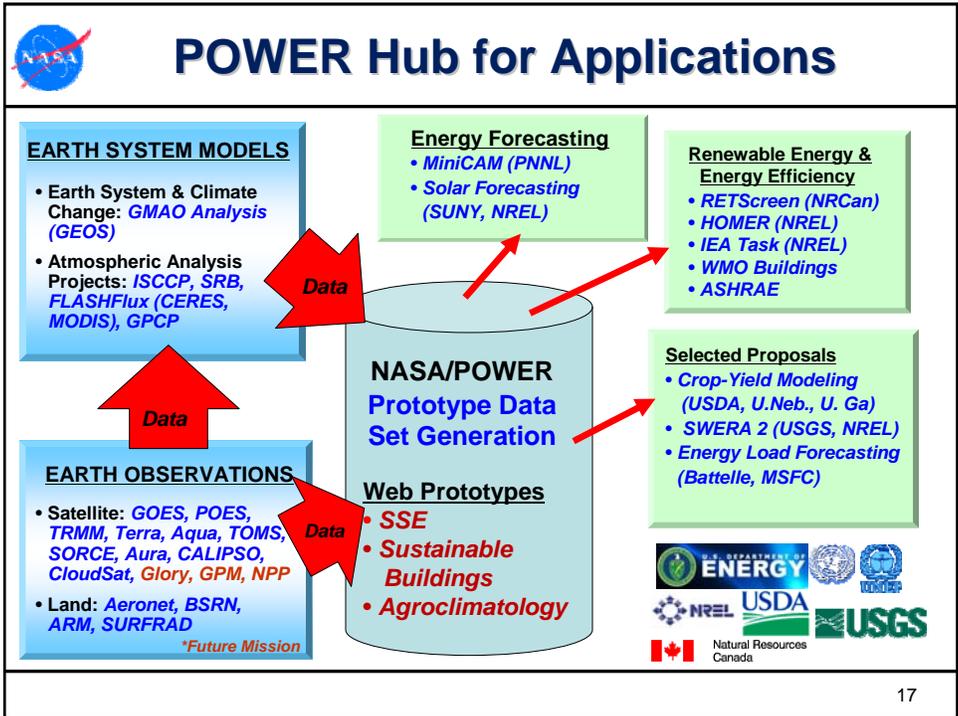
Objective: Improve the public and private capability for integrating environmental data from NASA's satellite-based analysis and modeling research into sound management of energy production and energy efficiency systems.

Goals:

- Establish partnerships to facilitate the integration and adaptation of NASA satellite analysis and modeling data into power industry Decision Support Systems and databases
- Target datasets for Electric Power, Renewable Energy, Energy-Efficient Building Design, and Biomass Crop Development Industries
- Transition operational capabilities to other government and/or private sector entities



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POWER Web Site

power.larc.nasa.gov

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Visit NASA.gov

Prediction Of World Energy Resource

Surface meteorology and Solar Energy (SSE-release 5): A renewable energy resource web site sponsored by NASA's Science Mission Directorate, Earth-Sun System Division, Applied Sciences Program

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

Home
SSE - Renewable Energy Parameters
Sustainable Buildings Parameters
Agroclimatology Parameters

Access Data

- Data Format
- SSE - Renewable Energy
- Sustainable Buildings
- Agroclimatology

Documentation

- About the POWER Project
- About SSE - Renewable Energy
- About Sustainable Buildings
- About Biomass Fuel- Agroclimatology
- Global Geometry/Resolution
- Parameter Accuracy/Validation
- Methodology of Satellite Inferred Parameters
- Power Publications

Related Links

- Science Mission Directorate
- NASA's Applications Program
- Atmospheric Science Data Center
- Other Related Sites

Navigation and Help

- Partners
- POWER Archive Statistics
- Release Notes
- Acknowledgments Please
- Join POWER Mailing List
- Submit Questions
- FAQs

Processing, archiving, and distributing solar insolation and meteorological parameters

- **SSE - RENEWABLE ENERGY:** Satellite-derived data supporting Renewable Energy Technologies (RETs).
 - Over 200 primary and derived meteorology and solar energy parameters
 - Monthly averaged parameters from July 1, 1983 through June 30, 1993
 - Global coverage on a 1° latitude by 1° longitude grid
 - Color plots on both global and regional scales
 - Solar energy data for 1195 ground sites
 - Data for the RETScreen® Renewable Energy Project Analysis Software
- **SUSTAINABLE BUILDINGS:** Satellite-derived data for the preliminary design of buildings and associated renewable-energy power systems.
 - Global coverage on a 1° latitude by 1° longitude grid
 - Twenty Two year monthly averaged temperatures, wind and solar radiation from July 1, 1983 through June 30, 2005
 - Daily averaged solar radiation from July 1983 through June 2005
 - Daily humidity and air temperatures for 1983 and December 2005
 - Temperature and relative humidity on 3-hourly time steps
 - Psychrometer chart and Global and/or regional plots
- **AGROCLIMATOLOGY:** Satellite-derived solar and meteorological data supporting agro-technology
 - Global coverage on a 1° latitude by 1° longitude grid
 - Daily total solar radiation from July 1983 through June 2005; and July, 2005 through current with one month delay
 - Daily averaged dew point and air temperatures from January 1983 through December 2005;
 - Daily averaged precipitation from January 1997 - current with two month delay

NASA Privacy Statement/Disclaimer
Freedom of Information Act

Responsible Official:
Paul W. Stachowicz, Jr., Ph.D.
(email: paul.w.stachowicz@nasa.gov)
Last Updated: Wed May 09 2007 05:42:21 GMT-0400 (EDT)



RETScreen-NASA Partnership

- Natural Resources Canada-funded program
- RETScreen goals:
 - Build the capacity of planners, decision-makers and industry to implement renewable energy, cogeneration and energy efficiency projects
 - Reduce the cost of clean energy pre-feasibility studies
- Partnering with NASA since 2000
- www.etscreen.net



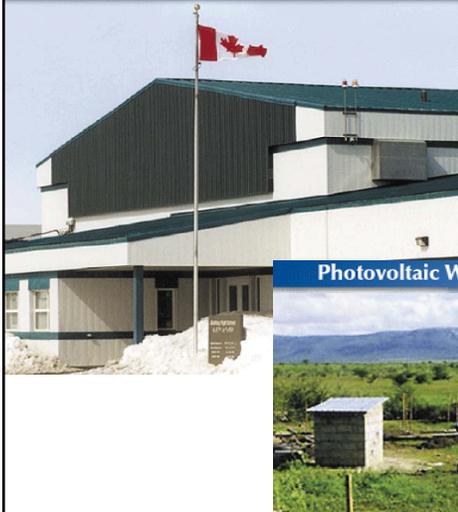
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Projects Facilitated by RETScreen

RETScreen® INTERNATIONAL
Solarwall® on High School in Northern Canada

www.etscreen.net
Solar Water Heating at Vancouver International Airport



Photovoltaic Water Pumping System in Africa

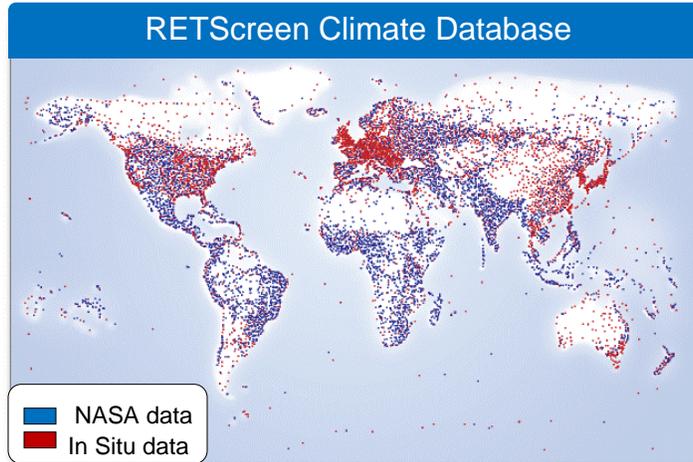


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RETScreen's Reliance on NASA Data

- Direct query of NASA SSE data
- >155,100 users in 222 countries
- 1000 new users every week
- Release 4: in 26 languages



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.

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NASA/HOMER (NREL) Partnership

- **NREL HOMER Micropower Optimization Model**
 - HOMER is a computer model that simplifies the task of evaluating design options for both off-grid and grid-connected power systems for remote, stand-alone, and distributed generation (DG) applications.
 - NASA and other Earth observation data sources critical to its success
 - Used extensively around the world for determining the optimal mix of power technologies for meeting specified load conditions at specified locations
 - HOMER automatically accesses and inputs the NASA SSE data for the specific location that the model is analyzing.



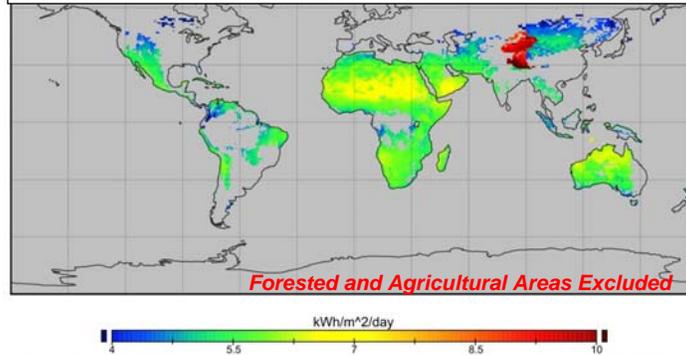
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PNNL Integrated Assessment Model Initialization with NASA Data

PNNL/Joint Global Change Research Center uses NASA POWER data sets for initiation of MiniCAM 50-year energy market forecasts for policy planning

Direct Solar Irradiance for areas with 50 or less no-sun days per year



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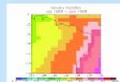
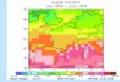


Group on Earth Observations

SSE Data Set



Access through:
<http://eosweb.larc.nasa.gov/sse/>

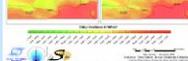


- Monthly averaged from 11 years of data (1983-1993)
- Data tables for a particular location
- Color plots on both global and regional scales
- Over 200 satellite-derived meteorology and solar energy parameters
- Data for the RETScreen® Clean Energy Project Analysis Software

Helioclim Database



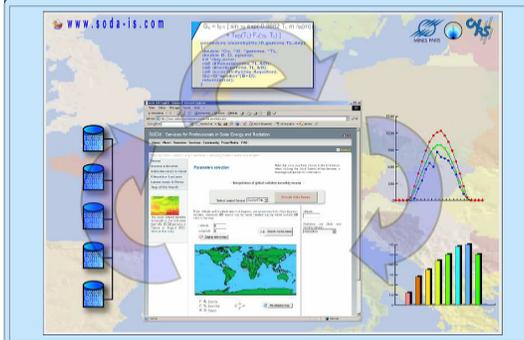
Access through SoDa:
<http://www.soda-is.com/>



- Database and time-series of irradiance or irradiation
- Produced by the processing of satellite images, especially from the Meteosat series of satellites
- Covering Europe, Africa, the Mediterranean Basin, the Atlantic Ocean and part of the Indian Ocean
- Period runs from 1985 onwards

GEOSS: First Energy Demonstration

The SoDa Service Integrator



Hosted by École des Mines de Paris



Regional Effects of Climate Change on Energy Sector (Shindell, GISS)

1. Incorporate projections of the effects of climate change on temperature, humidity, wind speed and water supplies into electric distribution and utility planning, and
 2. Quantify the joint air quality and climate impacts of potential changes in transportation sector emissions
- Projections of the evolution of atmospheric composition and the resulting climate change will use the high-resolution global-regional climate-air pollution modeling system (GRE-CAPS) driven by output from the NASA Goddard Institute for Space Studies (GISS) global composition and climate model's IPCC AR5 simulations
 - Analyses in collaboration with the California Air Resources Board (CARB) will form part of an integrated examination of the relative technology costs and economic, health and climate benefits of potential policies in a changing climate.
 - Global climate fields will also be provided to the EPA, with whom we will collaborate on assessment of climate change impacts on the US and characterization of uncertainty in the climate and energy results.

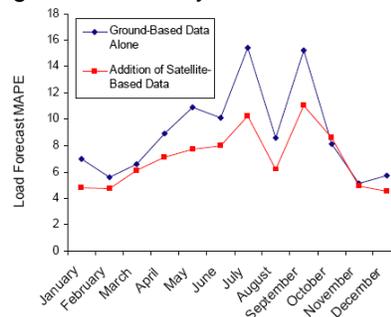
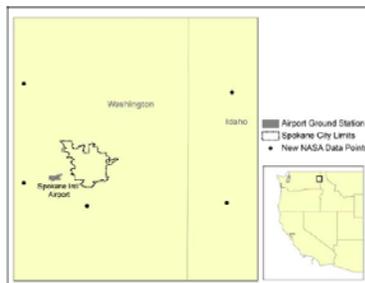
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Energy Load Forecasting

Project led by Battelle and Ventyx to evaluation NASA long-term data sets and high resolution forecasts (SPORT/MSFC)

Spokane, Washington Case Study



Courtesy Erica Zell, Battelle

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Interdisciplinary Research ROSES 2009 Element (A.22)

- **ROSES element (LOI due 7/10, proposals due 9/10) has five sub-elements:**
 - Integrated Earth System Responses to Extreme Disturbances
 - Impacts of Varying or Changing Climate, Local Weather, and Land Use on Watersheds and their Connected Coastal Environments
 - Hydrologic, Biological, Biogeochemical, and Geological Impacts of Melting Ice
 - Sea Level Change
 - Water and Energy Cycle Impacts of Biomass Burning
- **“In this element, proposers are encouraged to follow through in their analyses to address societal impacts. NASA is very interested in studies that cross the traditional boundaries between analysis of the physical science basis for Earth system change (e.g., as is the focus of IPCC Working Group I) and analysis of impacts, adaptation and vulnerability to climate change (e.g., as is the focus of IPCC Working Group II).”**

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Web Resources

- **NASA NSPIRES website (research solicitations)**
<http://nspires.nasaprs.com>
- **NASA Earth Observations Informing Energy studies**
http://aspires.gsfc.nasa.gov/upload/EM_proj-230_5887_NASAEnergy.pdf
http://aspires.gsfc.nasa.gov/upload/EM_proj-231_5888_NASAEnergy2.pdf
- **NASA Energy Management Stakeholders workshop**
http://aspires.gsfc.nasa.gov/upload/EM_proj-233_5890_EM_eval_report.pdf

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NASA Science/Infrastructure Workshop

- **Science Mission Directorate / Office of Infrastructure Joint Workshop (7/28-30 at KSC)**
 - Introduce the climate science and operations communities to each other
 - Gain an understanding of current and future climate change risks
 - Start to develop a comprehensive list of NASA's vulnerabilities (unique infrastructure, sea level rise, extreme weather, energy needs)
 - Develop next steps so flexible adaptation strategies can be developed and implemented

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Summary

- **Interdisciplinary science is at heart of what the Earth Science Division does**
- **Science benefits from integrated use of surface networks, airborne platforms, and satellites**
- **Models are used to interpret data, test hypotheses, and provide predictive capability**
- **Decadal survey missions for future will enhance NASA's ability to address interdisciplinary science**

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Summary (cont'd.)

- NASA Energy Management applications have yielded significant results in national and international energy programs through transfer of science results to improve decision making
- Successes involve supporting renewable energy and energy efficient technology optimization
- Model of success has been **long-term partnerships** featuring the development and dissemination of **specifically tailored** data sets
- Data sets made available through **web-based interfaces** provide opportunities for new projects and new partnerships worldwide

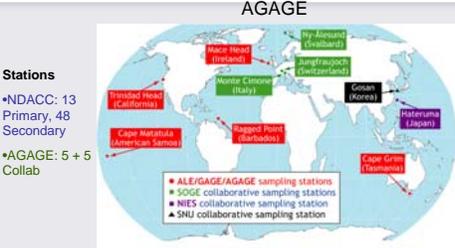
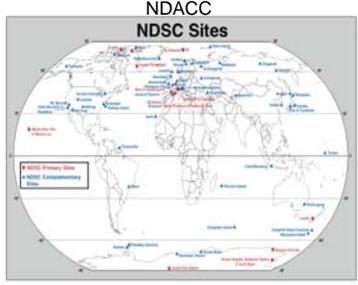
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Backup Slides

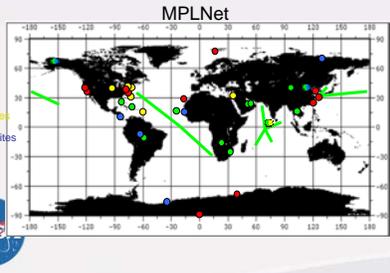
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Major NASA ESD Ground Networks



Stations

- NDACC: 13 Primary, 48 Secondary
- AGAGE: 5 + 5 Collab

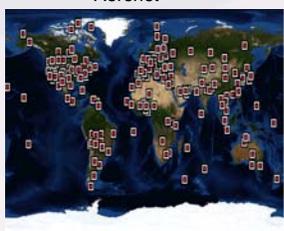


Aeronet

- 352 Network Instruments (116 NASA owned)
- 237 Operational sites reporting in 2007

Status:

- 12 active sites
- 6 planned sites (in preparation)
- 6 proposed sites (funding dependent)
- 12 short-term field campaigns
- 1 Ocean cruise (two cruises pre-dating MPLNET are available)



Airborne Science Program Operations

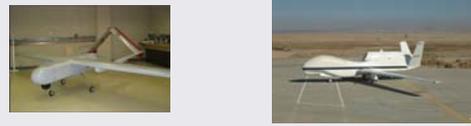
Core Airborne Systems:

ER-2 WB-57 DC-8. P-3. G-III



New Technology Airborne Systems

Global Hawk, Sierra, OTH



B-200 (LaRC, DOE, etc), S-3 (GRC), Learjet (GRC), Twin Otter, Caravan, Aerosonde, etc



Over 50 aircraft available to the Program



SWERA 2: Renewable Resources for Developing Nations

- USGS-led effort
- Data archive, user interface at UNEP GRiD facility
- *NASA role:* supply global data parameters derived from Earth observations



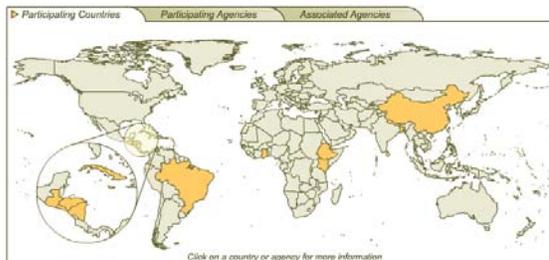
Solar and Wind Energy Resource Assessment



Welcome To SWERA

The SWERA website provides information about solar and wind energy resources in thirteen partner countries around the world. Products held in the SWERA archive include data on wind and solar energy potential, plus detailed country energy analyses. To learn more about renewable energy in each country or the partner agencies, click on the map or the menu. SWERA is a UNEP (United Nations Environment Programme) project with co-financing from GEF. The goal is to provide solar and wind energy assessments to potential investors and the public to promote more effective use of alternative energy resources.

Now with the completion of the successful pilot project, SWERA is being expanded into a full Programme offering resource information and mapping tools across the spectrum of renewable energy sources. All information and tools can be found in one on-line location with a common user interface... click here for more details.



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NASA POWER Contributes to International Energy Agency Task

- International collaboration representing 8 nations and 15 organizations
- Led by National Renewable Energy Laboratory (NREL)
- NASA contributing expertise on solar resource estimation and validation, user and interface information, data sets and research

IEA-SHC | Task 36 - Solar Resource Knowledge Management

Getting Started | Latest Headlines

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

TASK 36

What's New | Objectives | Scope of Project | Subtasks | Task Participants | Publications / Outcomes | Related Sites | Task Work Area | Home

Task 36 - Solar Resource Knowledge Management

OVERVIEW

This web site is the official web site of IEA-SHC Task 36 "Solar Resource Knowledge Management" - a five-year task initiated by IEA Solar Heating and Cooling Programme Implementing Agreement.

Task Information

Duration
July 1, 2009 to June 30, 2010

Operating Agent
U.S. Department of Energy's National Renewable Energy Laboratory
Dr. David Remick
david_remick@nrel.gov

Task News

[Check Back](#)

SHC Home | Objectives | Scope | Subtasks | Task Participants | Publications | Task Work Area | Home

International Energy Agency Solar Heating and Cooling Programme



NASA Energy Program Contributions to GEO and CEOS

- **Core member of GEO energy community of practice**
 - Applied Sciences-funded activities contribute directly to GEO work plan tasks EN06-04, EN07-01, EN07-03
 - IEA activity, leveraged with ESA partnership, provided first **GEO energy early achievement project**, “Solar Information for Developing Countries”
 - One of principal authors of **GEO Energy Strategic Plan**, which closely mirrors Applied Sciences Program plan
 - **Lead for CEOS Energy SBA activities** (GEO-CEOS remapping activities)
 - Energy articles published in **GEO summit publication** (two with NASA involvement)

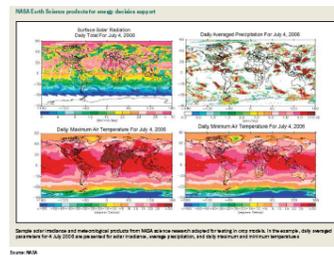


Informing decision making in the energy sector using NASA spaceborne observations and model predictions

Richard S. Eckman and Paul W. Stachurski, Jr. NASA Langley Research Center

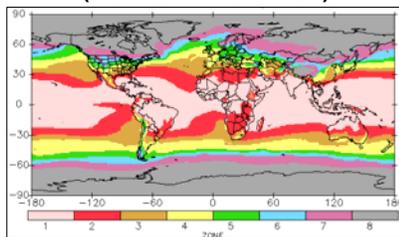
A keying global use of spaceborne observations... also made the former research program... in related and earth observation... NASA Langley Research Center... The Applied Sciences Program... NASA Langley Research Center... The Applied Sciences Program... NASA Langley Research Center...

International Institute for Earth System Science (IIEES) and... NASA Langley Research Center... The Applied Sciences Program... NASA Langley Research Center... The Applied Sciences Program... NASA Langley Research Center...

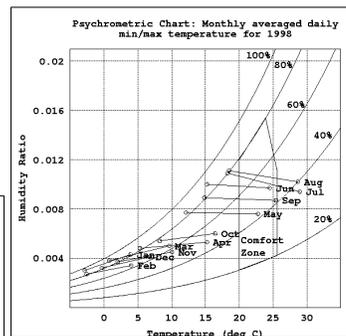


Long-term Climate Information For Building Design

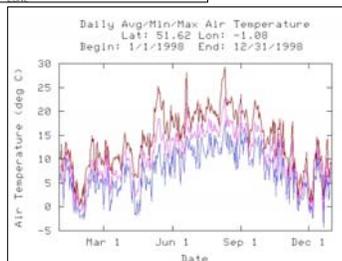
Global Building Design Climate Zones (with ASHRAE and DOE)



Location Specific Traditional Architectural Comfort Zone Design Charts (with AIA)



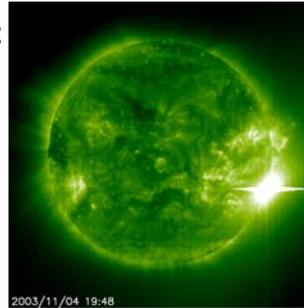
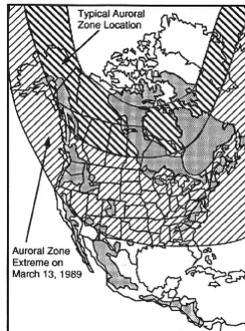
Location Specific Daily/Monthly Averaged Climate Information





Space Weather Impacts on Power Grid

March 1989 X-class flare led to GIC-induced 10-hour blackout throughout Quebec



Power systems in areas of igneous rock (gray) are the most vulnerable to the effects of intense geomagnetic activity because the high resistance of the igneous rock encourages geomagnetically induced currents (GICs) to flow in the power transmission lines situated above the rock. Shown in cross-hatching are the auroral zone and the extremes that the aurora can reach during severe disturbances such as March 13, 1989. (J. Kappenman, EOS, January 29, 1997, p. 37)

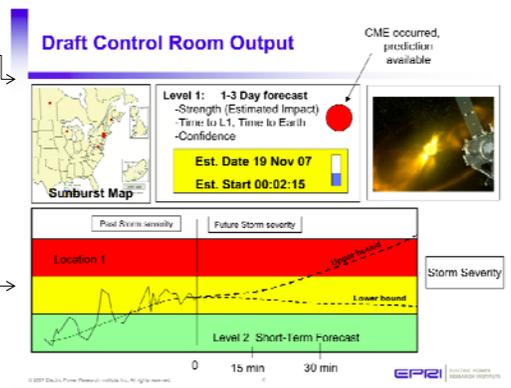


Space Weather Impacts on Power Grid

NASA-EPRI Collaboration

```
% Level 1 GIC forecast produced by REALTIMEGIC_LEVEL1
%
% The format of the data is as follows:
% 0 0 0 0 0 lat1 lon1 lat2 lon2 ...
% yy mm dd hh mi GIC1low GIC1high GIC2low GIC2high ...
%
0 0 0 0 0 53.16 -99.29 45.39 -68.53
2006 12 14 14 6 76 15 153
```

```
% Level 2 GIC forecast produced by REALTIMEGIC_LEVEL2
%
% The format of the data is as follows:
% 0 0 0 0 0 0 lat1 lon1 lat2 lon2 ...
% yy1 mm1 dd1 hh1 mi1 ss1 GIC1 0 GIC2 0 ...
% yy1 mm1 dd1 hh1 mi1 ss1 GIC1 0 GIC2 0 ...
%
%
%
%
0 0 0 0 0 0 53.16 -99.29 45.39 -68.53
2008 03 19 11 02 31 -0.11 0.00 0.13 0.00
2008 03 19 11 04 31 0.02 0.00 0.03 0.00
2008 03 19 11 06 31 -0.02 0.00 0.04 0.00
2008 03 19 11 08 31 0.00 0.00 0.01 0.00
```





Building Monitoring and Targeting

- **Monitoring and Targeting:** gaining and maintaining control over energy consumption through measurement and analysis followed by well-directed actions.
 - Comparison between energy consumption and influencing factors such as weather; establish and evaluate consumption targets
 - Purpose: energy cost savings for budgeting, evaluation of energy efficiency upgrades, product/service costing
- **NRCAN RETScreen leading effort for newly-formed building monitoring and targeting program**
 - Need global near-real time (within 1 month) solar and meteorological (e.g., heating degree day) data sets
 - FLASHFlux with operational GMAO assimilation perfectly suited by providing daily and monthly estimates of parameters

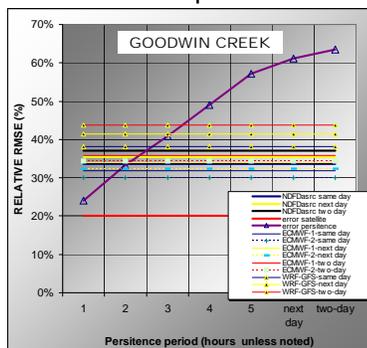
43



Benchmarking Solar Forecasts

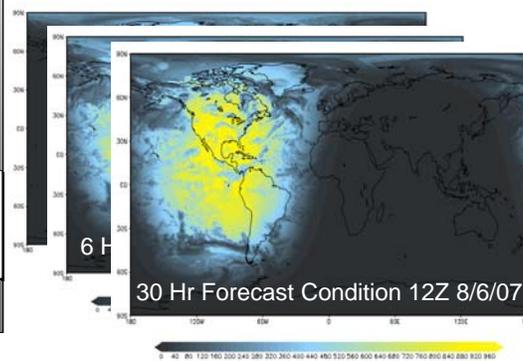
Vital for assessing potential large scale PV and/or CSP production when integrating into power grid

Multi-Model Solar Irradiance Comparison



Draft courtesy R. Perez, SUNY

GMAO Solar Irradiance Forecast



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Plan for 2009 and Beyond

- **Proposed additions to GEO Task EN-07-01 for 2009-11 work plan:**
 - Assess the utility of Earth system models to inform energy sector decision making on the future availability of resources in a changing climate (ESA/DLR: Space4Energy project, NASA: Collaboration with Ventyx Energy)
 - Assess the utility of downscaled global climate model projections to regional climate change impacts on the energy sector to examine their potential utility to energy sector decision making (NASA/GISS: pilot study)
- **Inventory of renewable energy resources in Africa (DLR, universities, GEO UIC)**
- **Advanced long-term solar energy mapping (NASA, NREL)**
- **Building targeting and monitoring (NASA, Natural Resources Canada)**
- **Satellite-derived building data sets for design (NASA, DOE, ASHRAE)**
- **GEOSS Architecture Implementation Pilot: multiple energy-related proposals to call for participation (École des Mines/DLR/NASA, NOAA)**