NASA Earth Observations Informing Renewable Energy Management and Policy Decision Making

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1 Introduction

The NASA Applied Sciences Program partners with domestic and international governmental organizations, universities, and private entities to improve their decisions and assessments. These improvements are enabled by using the knowledge generated from research resulting from spacecraft observations and model predictions conducted by NASA and providing these as inputs to the decision support and scenario assessment tools used by partner organizations. The Program is divided into eight societal benefit areas, aligned in general with the Global Earth Observation System of Systems (GEOSS) themes. The Climate Application of the Applied Sciences Program has as one of its focuses, efforts to provide for improved decisions and assessments in the areas of renewable energy technologies, energy efficiency, and climate change impacts.

The goals of the Applied Sciences Program are aligned with national initiatives such as the U.S. Climate Change Science and Technology Programs and with those of international organizations including the Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS).

Activities within the Program are funded principally through proposals submitted in response to annual solicitations and reviewed by peers.

2 Methods

The approach of the Applied Sciences Program is to provide relevant data sets derived from NASA, and secondarily, other spacecraft observations and Earth system modeling to decision support tools (DST) supporting renewable energy resource management and improvements in energy efficiency. These external entities require historical, near-real time, and forecasted environmental observations as inputs to their DSTs. NASA works with its partners to ensure that these specialized data sets are in consistent units and formatted to meet the needs of the partner's DST.

3 Results

The NASA Langley Research Center (LaRC) Surface Meteorology and Solar Energy (SSE) data set is a 22-year time series of solar insolation and over 200 meteorological parameters relevant to designing and assessing the feasibility of renewable energy systems (http://power.larc.nasa.gov). The parameters were defined based on discussions with our partners and end-users. The data are available globally on a 1° x 1° grid. The data are derived from NASA spaceborne measurements and reanalyses, including the Earth Radiation Budget Experiment (ERBE), Surface Radiation Budget (SRB), and the Langley Research Center FLASHFlux project, which provides near-real time surface radiative flux.

The SSE data set supports multiple DSTs and models. Natural Resources Canada's RETScreen clean energy project feasibility tool uses the NASA SSE data as an input source of climate data (http://www.retscreen.net). RETScreen is a DST that reduces the cost of pre-feasibility studies for a wide array of renewable energy and energy efficiency projects. RETScreen is available free of charge and presently has over 150,000 registered users in 222 countries and is available in 26 languages. The use of RETScreen is applicable for most houses, buildings, factories and power plants around the world.

Satellite-derived surface solar energy measurements and meteorological parameters (e.g., precipitation, maximum and minimum temperatures, relative humidity) are particularly useful where surface-based observations are sparse or non-existent. This is

often the case in the developing world, where in-situ observations are frequently unavailable. In the latest release of RETScreen, NASA climate data are available directly for approximately 5000 key cities. Data for points lying in between these city locations are available via a direct link to the SSE data set. Figure 1 shows the flow of satellite-derived observations through to the construction of specialized data sets and their ultimate use in the RETScreen DST to inform renewable energy project feasibility decisions.

NASA also supports the U.S. National Renewable Energy Laboratory's (NREL) HOMER DST. 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 applications (https://analysis.nrel.gov/homer). HOMER is used extensively around the world for determining the optimal mix of power technologies for meeting specified load conditions at specified locations. NASA and other Earth observation data sources are critical to its success. These data include LaRC solar data sets, aerosol optical depth from the NASA Goddard GOCART model, measurements from MODIS, MISR, TOMS, and digital land cover data sets from NASA and the U.S. Geological Survey (USGS).

Responding to the needs for improved energy efficiency, prototype data sets derived from NASA research products targeting sustainable buildings have been developed. These prototypes are being used for architectural and facility design applications and are being evaluated by professional societies such as the American Institute of Architects and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for potential use in upcoming revisions to their design and standards manuals.

The data sets have been tailored to the needs of these two communities. In the case of the data sets of interest to ASHRAE, the NASA products have been reformatted onto U.S. Department of Energy (DOE) climate zones, which are employed in the definition of location specific building codes. We found that the architectural community often uses psychrometric charts for building design studies. We, therefore, provided data sets in this format. Examples of these products are illustrated in Figure 2.

The Program has also established a collaboration with the Pacific Northwest National Laboratory's MiniCAM integrated assessment modeling team. NASA SSE data sets are used for the initiation of MiniCAM 50-year energy market forecasts for policy planning purposes.

A recent collaboration with researchers at the Universities of Nebraska and Georgia and the U.S. Department of Agriculture has demonstrated the viability of using 1° resolution regional-to-global NASA SSE solar energy and meteorological data as inputs to agricultural crop yield models for improved agriculture production, including the examination of biofuels and carbon sequestration. Initial results show that NASA solar radiation measurements were highly correlated with ground observations on flat terrain in temperate regions [*Yang et al*., 2007].

4 Discussion/Conclusions

We are engaged with the Group on Earth Observations (GEO) energy community of practice. This working group consists of government and university researchers, as well as representatives from commercial firms and NGOs interested in the uptake of the Earth observations to inform decision making in the energy sector. We recently participated in composing a 5-10 year strategic plan for enhancing the deployment of Earth observations for use by energy sector policy and management decision makers. The plan was delivered to the GEO Plenary and Ministerial Summit in Cape Town, South Africa in November, 2007. Among the goals of GEO are to ensure that Earth observation data sets are made available to users in the developing world.

The Program is also engaged in activities conducted by the Committee on Earth Observation Satellites (CEOS). CEOS is tasked to lead co-ordination of the space observations required by the GEOSS. As a result of recent initiatives, CEOS is ensuring that its tasks are aligned with the three-year GEO work plan priorities. NASA is supporting this "re-mapping" exercise by ensuring that

current and future space-based observation systems of relevance to the energy sector (and the other GEO societal benefit areas) are identified by understanding the needs of end-users. Several tasks relating to renewable energy decision support, in particular relating to the use of solar and wind energy measurements, have been put forward.

In collaboration with other partner agencies worldwide, we are participating in an International Energy Agency (IEA) Solar Heating and Cooling Programme task, "Solar Resource Knowledge Management," to provide standardization of solar resource products for better data reliability and availability, and improved spatial and temporal coverage.

Through this IEA task, we are enhancing solar energy resource assessment through the creation and validation of products derived from spaceborne measurements in collaboration with external partners and decision makers. NASA is providing information of the surface solar radiation field, with products ranging from historic data sets, to current products, and towards forecasts on the future availability of solar resources in a changing climate. The expected result of this task is to improve the quality of solar energy resource assessment products using Earth observations and increase their ease of access to users worldwide.

Leveraging on these IEA task activities, we have recently participated in a recent GEO near-term demonstration task led by the École des Mines de Paris for improving the dissemination of solar energy data to developing countries for resource assessments. The "Service for Knowledge in Solar Radiation: Data, Applications, Education" (SoDA) project integrates diverse sources of information presently available separately within a smart integrating network to develop and operate a prototype service of high-quality customer-tailored information on solar radiation (http://www.soda-is.com). This prototype project uses either NASA SSE data or the European Helioclim database, as appropriate for a given location, to provide solar information for end-user decision making needs. The GEO project specifically targets the needs of end-users in developing countries where in-situ observations are sparse and fast web access is often a challenge.

The Program continues to support the United Nations Environment Programme Solar and Wind Resource Assessment (SWERA) program. SWERA provides information on renewable energy resources worldwide, along with the tools needed to apply these data in ways that facilitate renewable energy policies and investments. The Applied Sciences Program is presently funding a three-year project led by the USGS to expand the SWERA DST to serve all countries (from its original focus of 13 developing world countries) using global renewable energy data created by the NASA SSE project, to incorporate small hydroelectric power assessments using NASA Shuttle Radar Topography Mission (SRTM) measurements, and to improve access to SWERA data through the implementation of improved data and message passing among the components and the incorporation of investor- and developer-centric components.

In summary, data sets derived from NASA spaceborne measurements and models are being used to support renewable energy and sustainable building decision making applications. In consultation with end users, specialized data sets are created in formats and units applicable to the end-user community [for additional information, see *Eckman and Stackhouse*, 2007]. We have discussed a number of case studies showing the use of these data sets to support end-user policy and management decision making

References

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Yang, H., K. Cassman, P. Stackhouse, J. Hoell (2007), Usability of NASA satellite imagery-based daily solar radiation for crop yield simulation and management decisions, paper presented at 2007 Fall American Geophysical Union Meeting , San Francisco, Calif., 10-14 Dec.

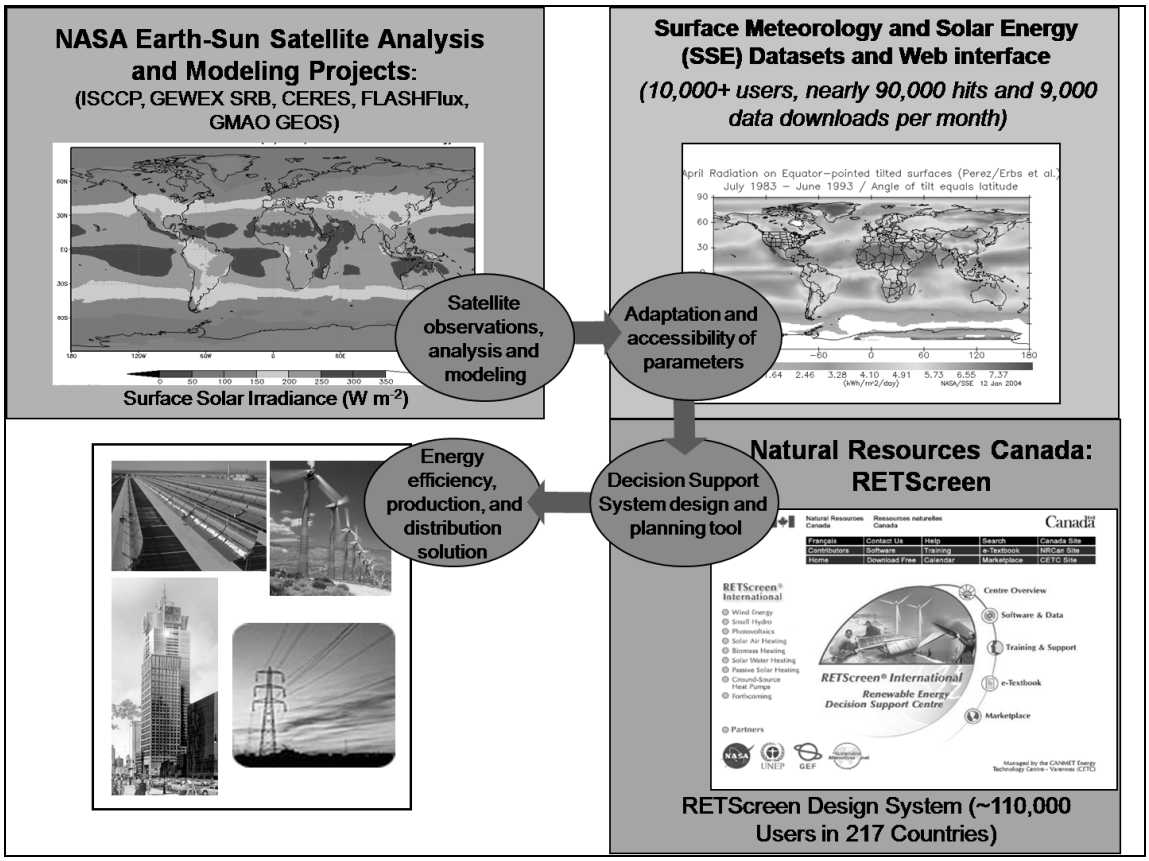

Figure 1: Process flow showing integration of NASA Earth science measurements and models into the user-accessible SSE data set supporting the RETScreen decision support system to implement renewable energy and energy efficiency projects.

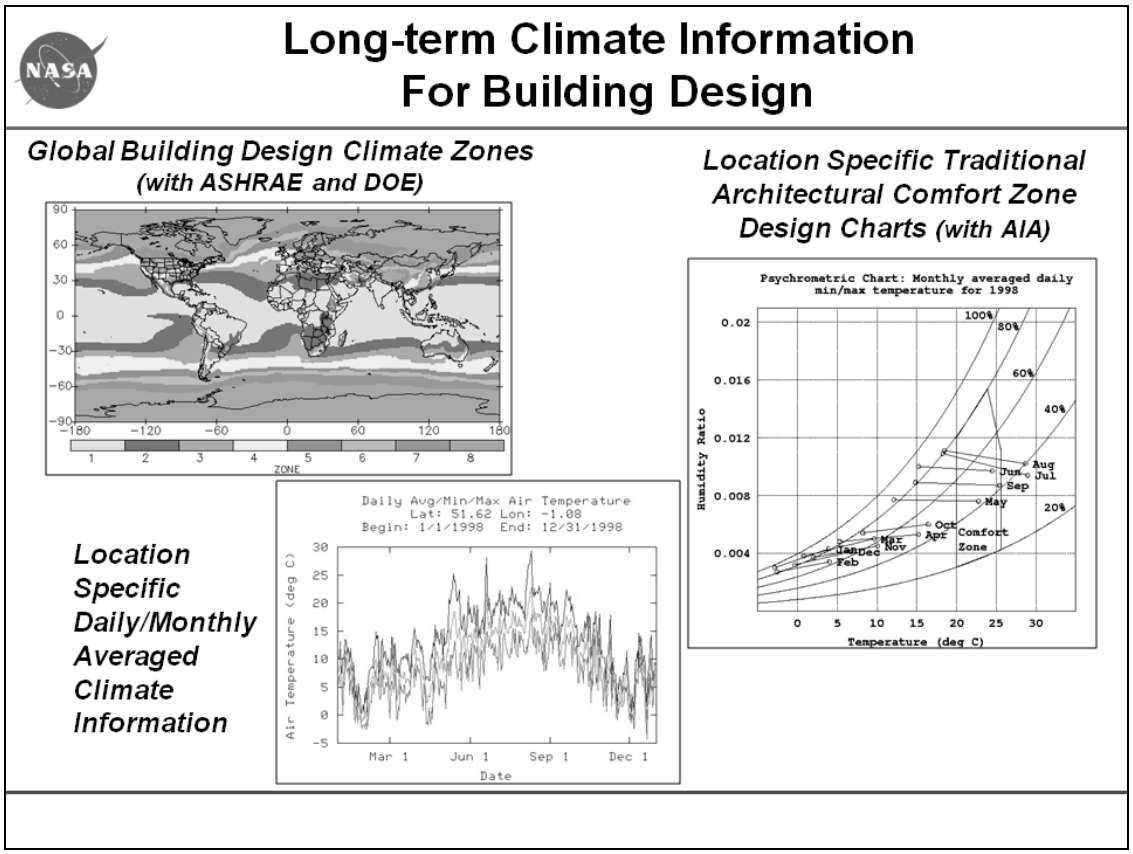

Figure 2: NASA specialized climate information products used for sustainable building design.