## FLORIDA STATE UNIVERSITY

***Planning Grant: Meteorological Factors Affecting Solar Energy Efficiency in the Tropics***

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**Description:** We propose to develop meteorological guidance in support of engineers and others needing to estimate solar energy efficiency across the tropics by analyzing the required meteorological data as well as installing monitoring weather stations in three locations at cooperating sites in Jamaica, Trinidad & Tobago, and at a site to be determined in the northeastern Caribbean. In addition we will add components to an already existing site at Key West, Florida. The relevant meteorological parameters important for this work are summarized in Case et al. (2008). The meteorological parameters needed are routinely available from conventional government-operated weather stations in general, but lack some of the required details. In particular, measured solar radiation is usually absent. Some areas across the moist tropics in particular will exhibit substantial mesoscale variation (on the order of km to a few hundreds of km) due to local terrain, orographic circulation, and surface land use variations. Surface stations used for this part of the study routinely collect most of the required hourly data. A limited number of stations also collect upper air profile data from radiosonde balloons twice daily that can be used to assess directly the precipitable water in the atmosphere.

**Budget:** $15,000 (February 2009 – December 2010)
**Universities:** Florida State University
**External Collaborators:** NOAA/National Weather Service Key West, University of the West Indies and Caribbean Solar Energy Center (Trinidad & Tobago), University of Technology (Jamaica), NOAA Global Systems Division, Earth Science Resource Laboratory (Boulder, CO)

## Progress Summary

We have identified two of our three partners in the Caribbean for data collection points, and purchased the necessary hardware to be installed in summer 2010 (July – September time frame). Either St. Lucia or St. Maarten will provide support for a third station. National Weather Service Key West also will be installing a pyranometer on their weather station to provide solar radiation data there. Data collection continues in Tallahassee and at several other locations in Florida, and will be part of the comprehensive data analysis provided.

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The SMARTS version 2.9.5 software (Gueymard 2001) has been installed and is being used to develop calculations of the impacts of the various meteorological variables on available surface solar energy. Atmospheric factors generally limit efficiency of solar systems, with cloud cover playing a major role, but the other variables listed previously also contributing to reductions. Most problematic is that most solar systems are rated for an atmosphere of 1.5, characteristic of drier, higher altitude air of a continental origin, not appropriate for the tropics. By using a different model with higher air mass value and varying the parameters according to observed atmospheric variability, we will come up with a much more appropriate model for energy utilization and efficiency appropriate for the tropics in the Caribbean. It is hoped that this model could then find widespread use across the developing nations in the tropics and subtropics. The table below summarizes the variability in some of the meteorological factors involved, for

which gross oversimplifications are often made (if factored in at all) by designers and end users of solar systems

The educational value of this project and system is also tremendous. By utilizing existing scientific protocols for measuring these atmospheric variables in an educational setting (e.g., using GLOBE protocol measurements, we should be able to interest schools to get involved in energy efficiency projects while at the same time increasing public scientific literacy about the complexities involved in design and use of energy systems. Much of the data collected in this project come from relatively inexpensive measurement systems and we will demonstrate their utility in this educational context, as well.

**Typical Meteorological and Surface Factors Affecting Calculations of Available Solar Energy Potential Tropics)**

| Variable | Surrogate/Description | Symbol | Range/Typical Values |
|---|---|---|---|
| Aerosol optical depth | aerosol optical depth | $\sigma$ | |
| Air mass factor (latitude $\phi$, zenith angle $\zeta$) | | AM | 0-10 (1.5) |
| Air temperature | Dry-bulb temperature | $T_a$ | 0-40°C |
| Albedo | | $\alpha$ | 0.05 - 0.95 |
| Barometric pressure | | p | 700-1040 hPa |
| Carbon dioxide | Ground concentration $CO_2$ | | 370 (–390) ppm |
| Cloud cover | Cloud fraction (reduced set) | cc | 0-1.0 (in tenths or oktas) |
| Irradiance | | I | |
| Land surface type | | | Lookup table |
| Panel temperature | Brightness temperature | $T_b$ | 0-50°C |
| Precipitable water | Relative humidity, Dew point | PW | 0-70 mm |
| Total ozone | (Column Total) | | 344 DU (0.344 atm cm) |
| Visibility | Runway visual range | VR | 0-50 km |
| Wind speed | | V | 0-25 m $s^{-1}$ |