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Bridging the Radiative Transfer Models for Meteorology and Solar Energy Applications

Yu Xie and Manajit Sengupta

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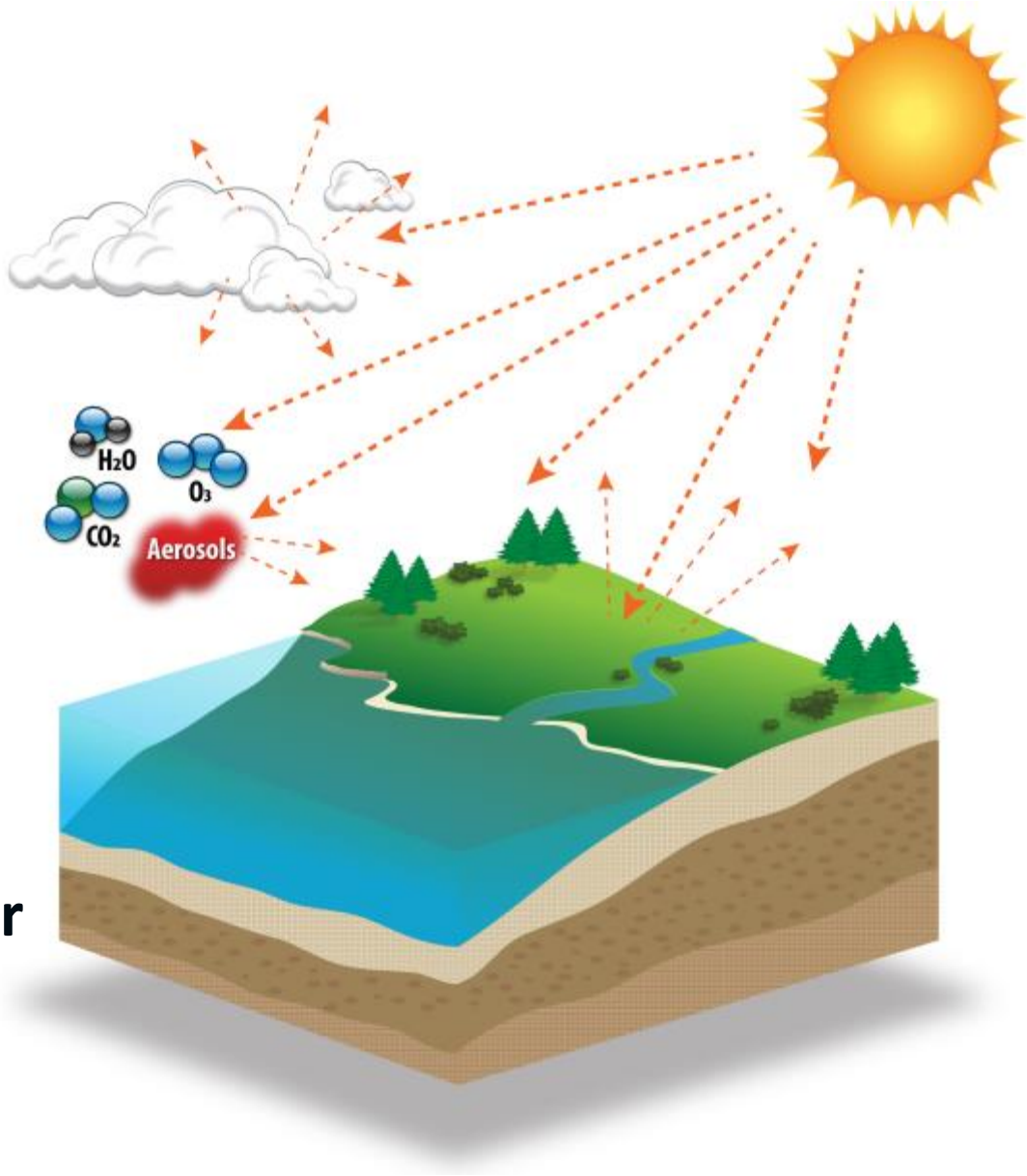
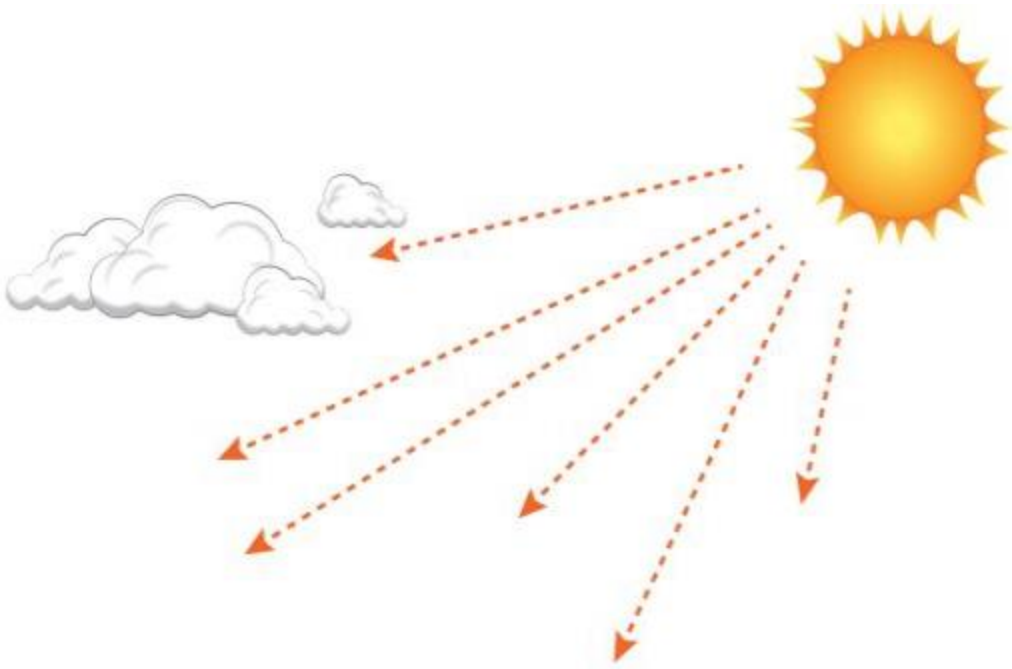
Radiative Transfer Model

- Considers interactions with atmospheric constituents and land surface.
- Important in changes of temperature, wind and precipitation.
- Also important in solar energy industry: policy decisions, design of solar energy system, and power systems integration.

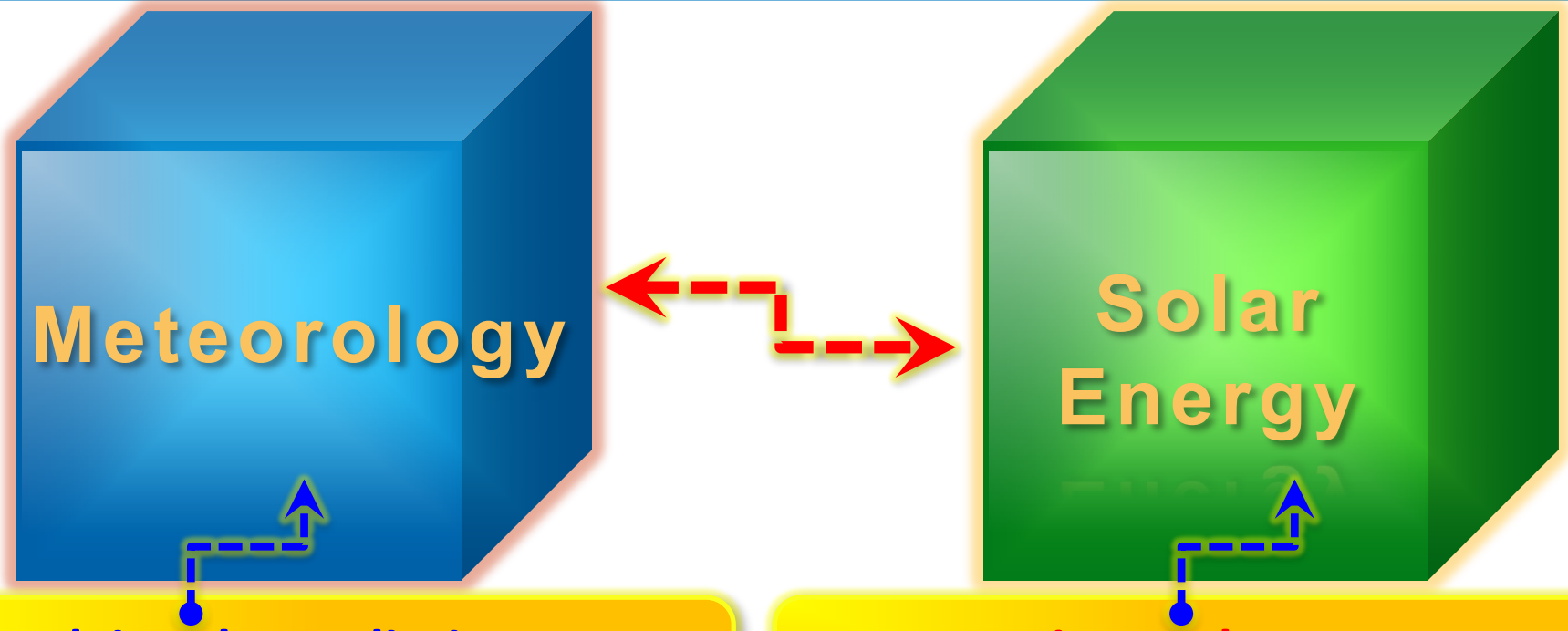


Solar energy has unique requirements on models

- Inclined Surfaces
- Fast Computation
- Bifacial PV
- Inhomogeneous surfaces
- Spectral radiation



Solar energy models are empirical and time efficient

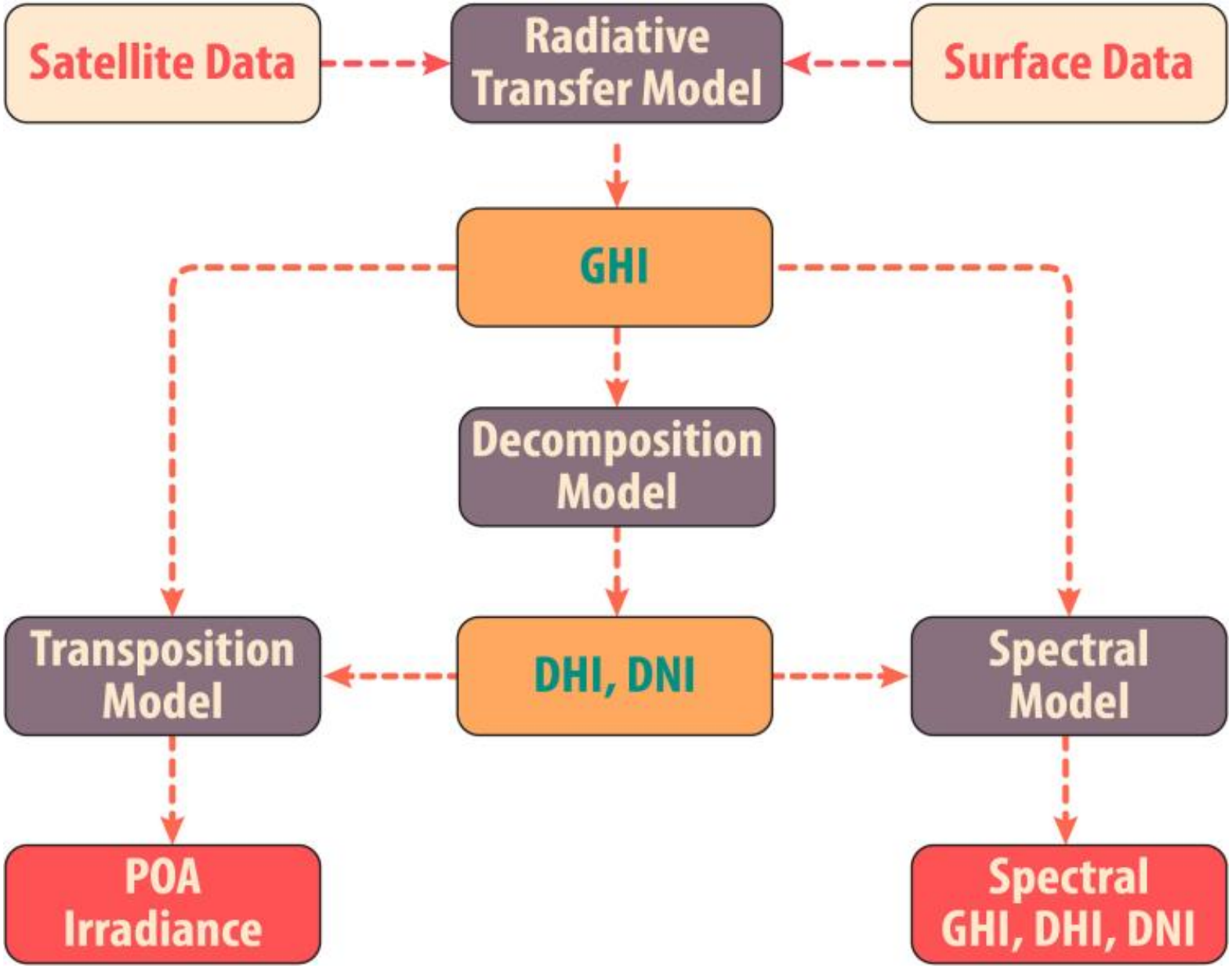


- Solving the Radiative transfer equation for clear and cloudy conditions
- Time consuming

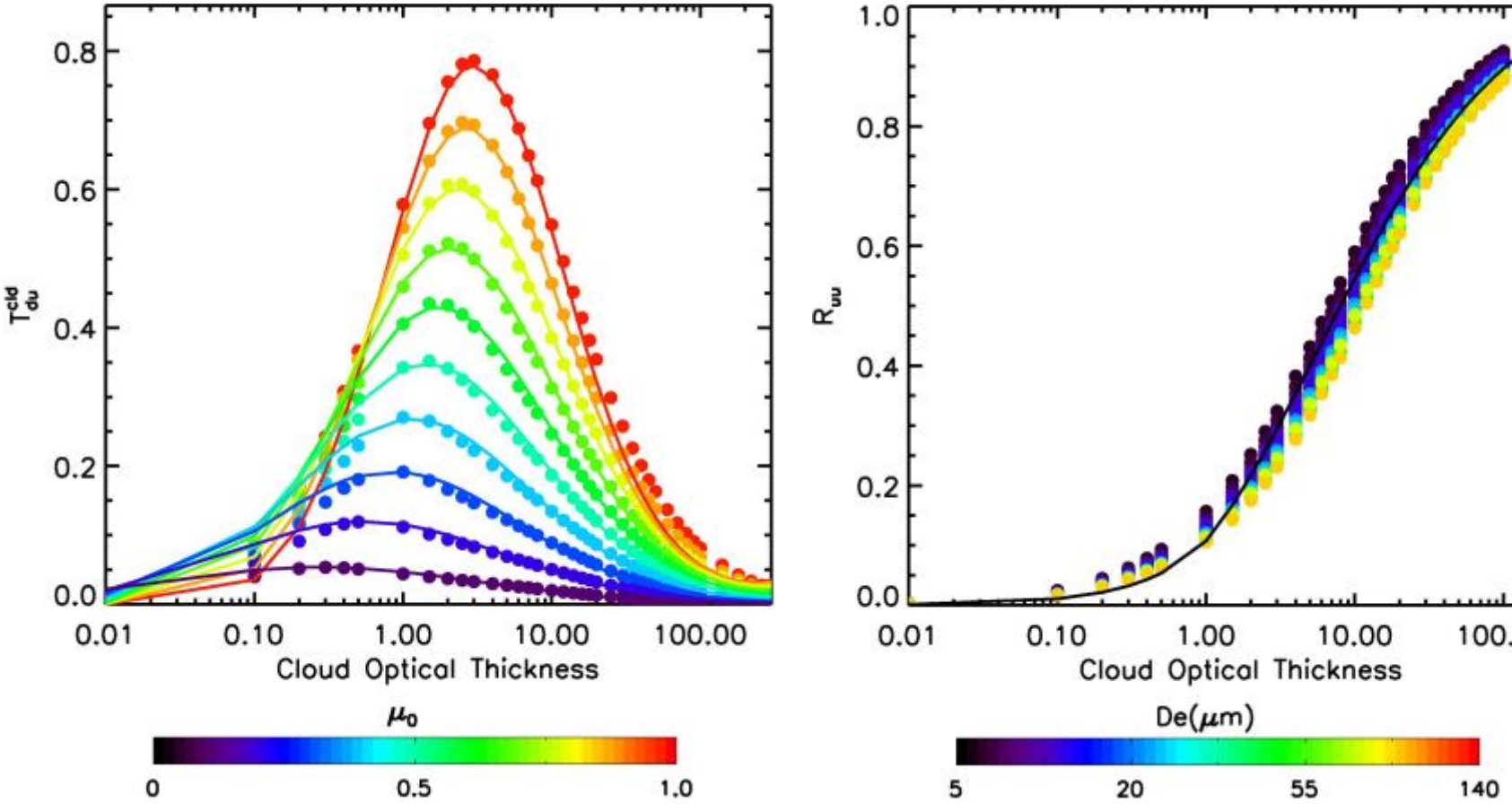
- Regression and parameterization
- Most for clear sky
- Time efficient

The Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS) computes clear-sky solar irradiances in 2002 wavelengths using <0.1 second.

Solar energy models have uncertainties

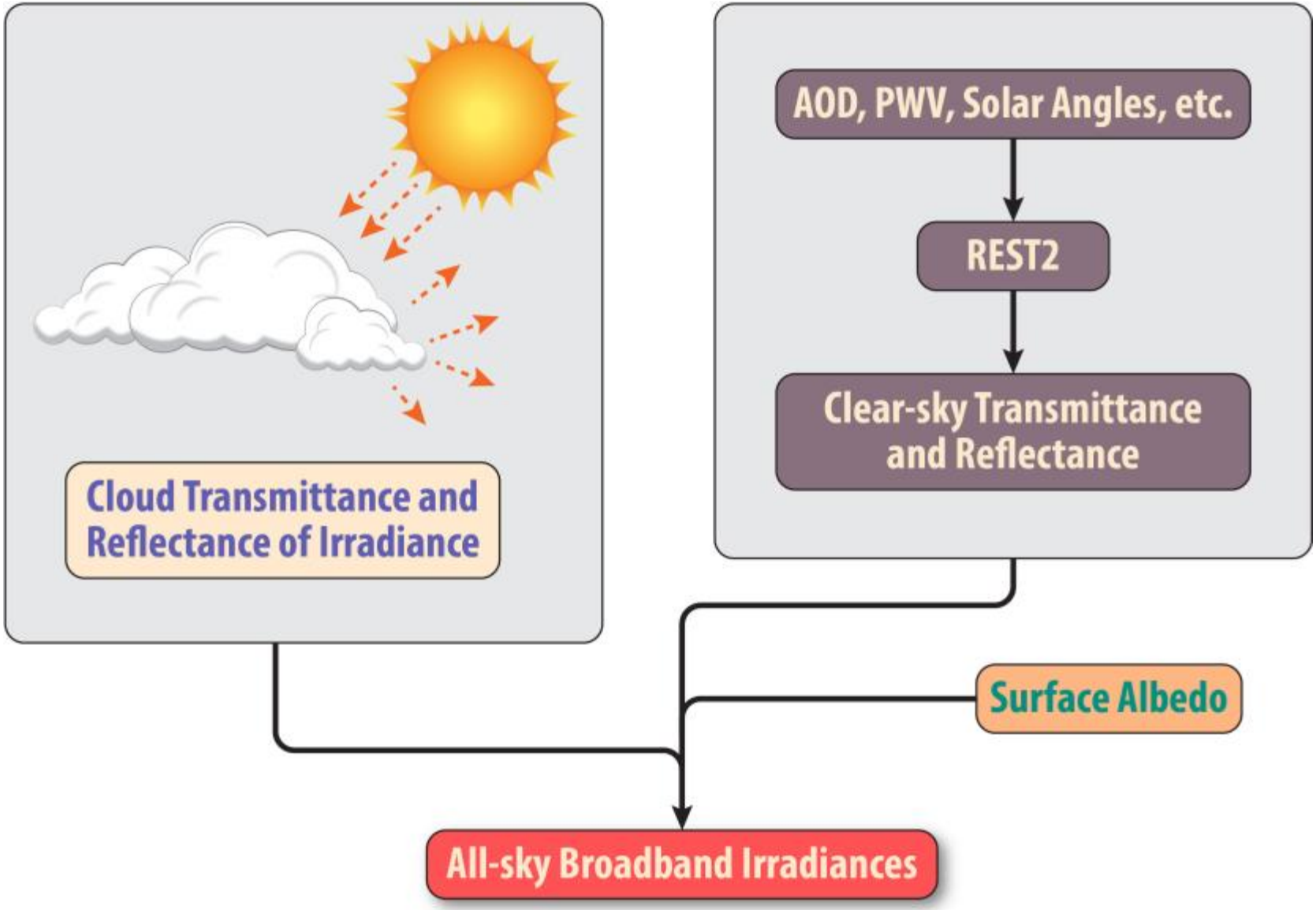


Parameterization of cloud transmittance and reflectance



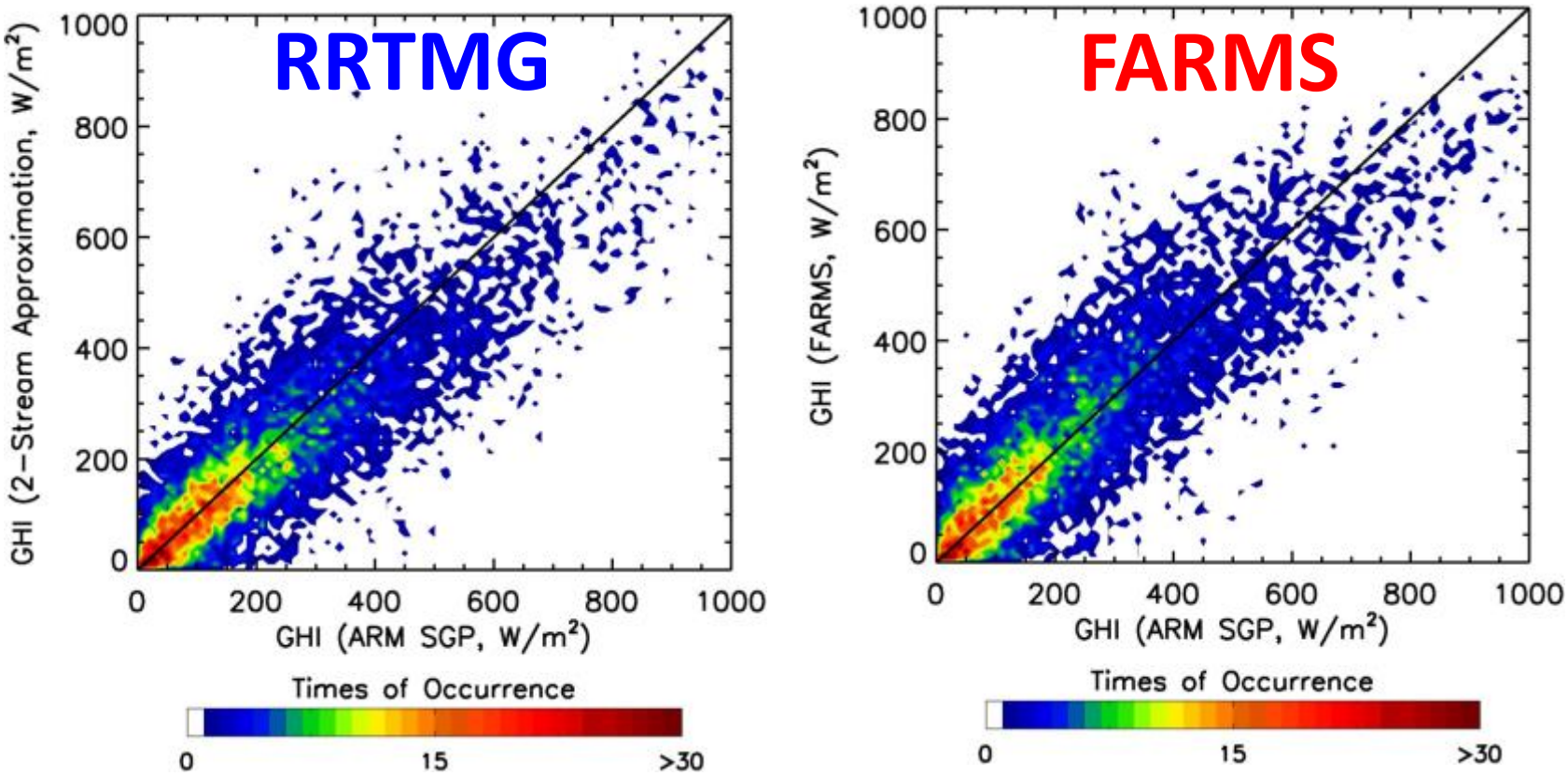
- **Cloud transmittances are parameterized as exponential functions of cloud optical thickness and solar zenith angles.**
- **Cloud reflectances are parameterized using simple equations of cloud optical thickness.**

Fast All-sky Radiation Model for Solar applications (FARMS)



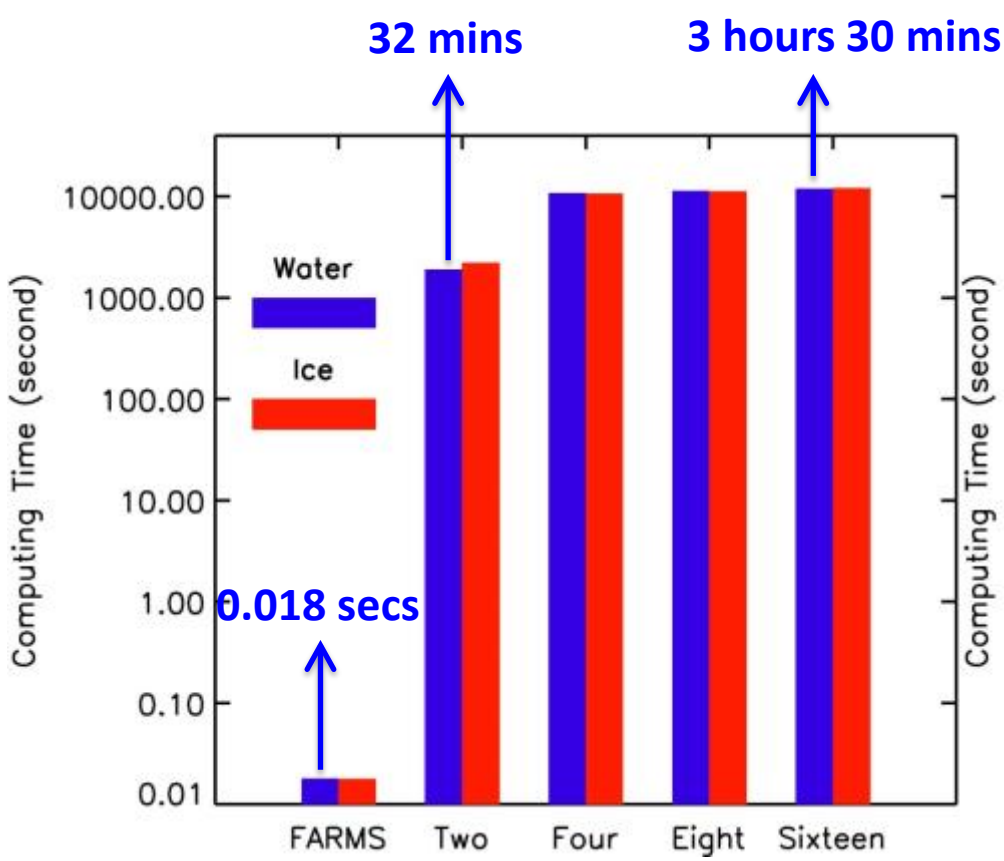
Xie et al., *Solar Energy (2016)*

FARMS is as accurate as RRTMG

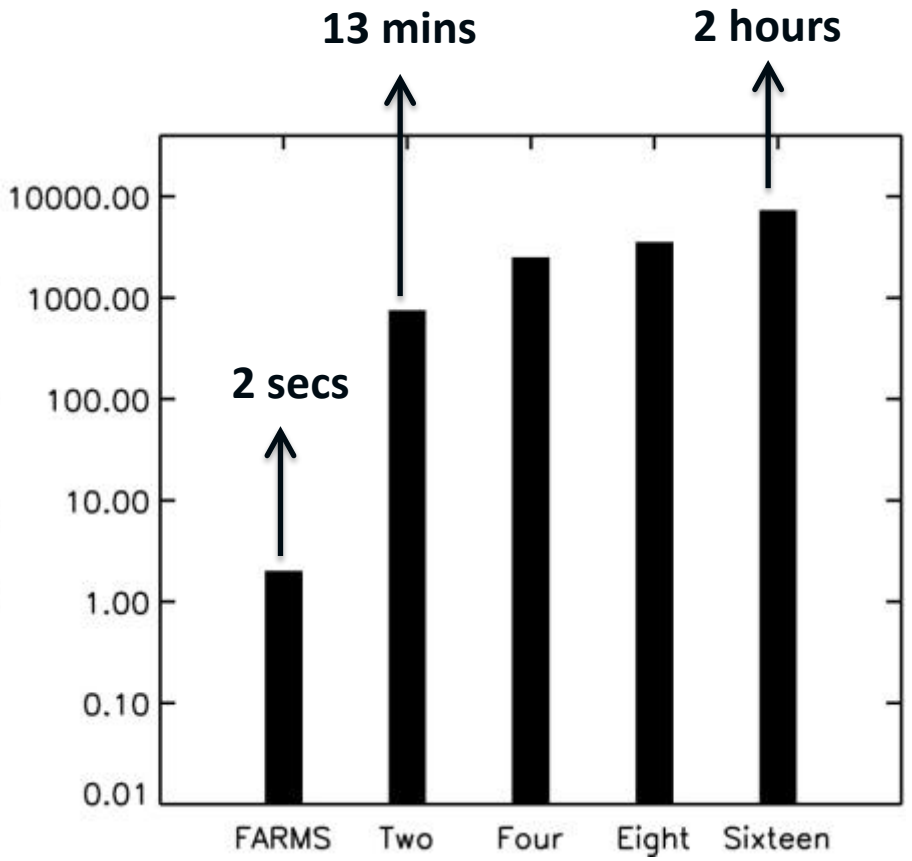


GOES satellite data is collocated to ARM SGP site. The satellite-based retrievals of cloud properties are used as inputs to two stream and FARMS. A total number of 9669 scenarios associated with cloudy-sky are selected during 2009-2012.

FARMS is much more time efficient

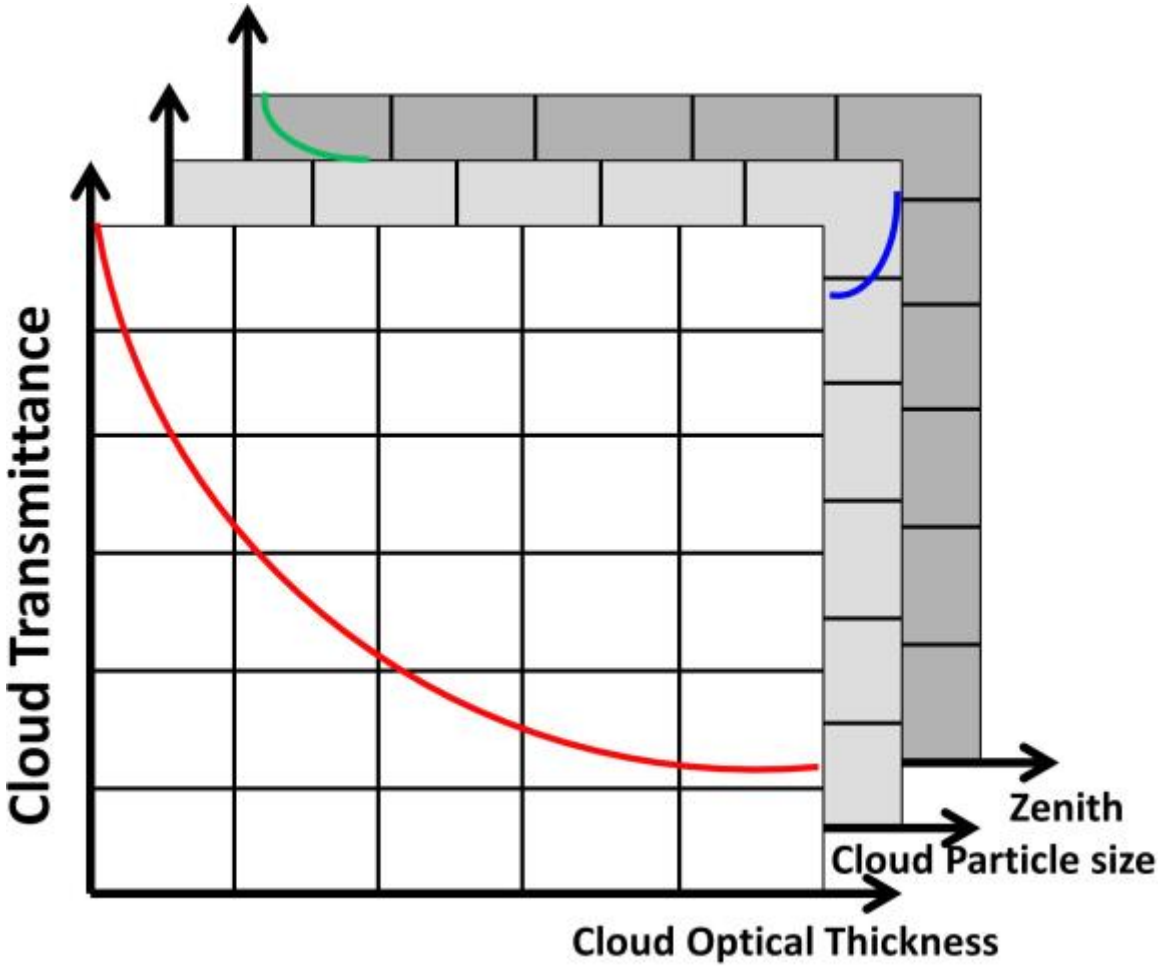


Computation of cloud T for 39 cloud optical thicknesses, 28 particle sizes, and 50 solar zenith angles.



Computation of solar radiation for 9669 scenarios of cloudy sky conditions over ARM SGP.

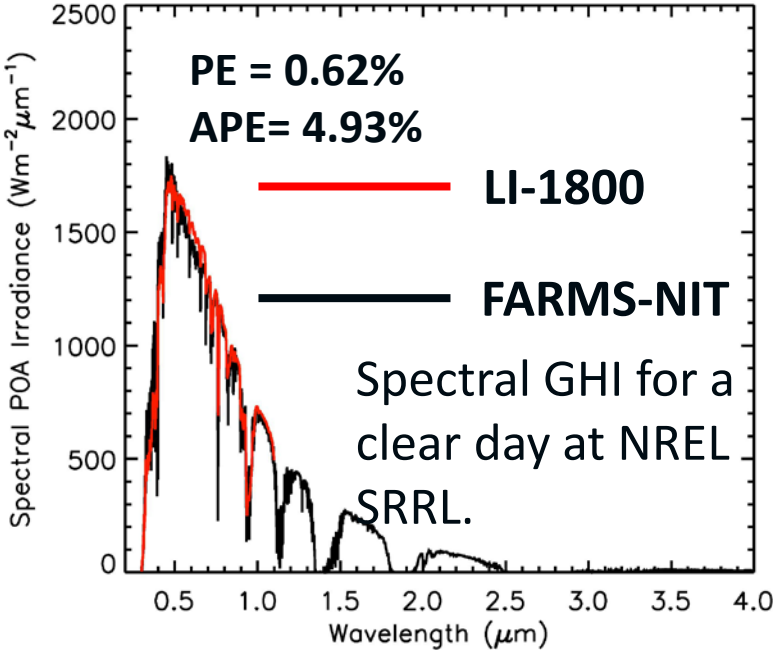
Narrowband Irradiances on Tilted surfaces (FARMS-NIT)

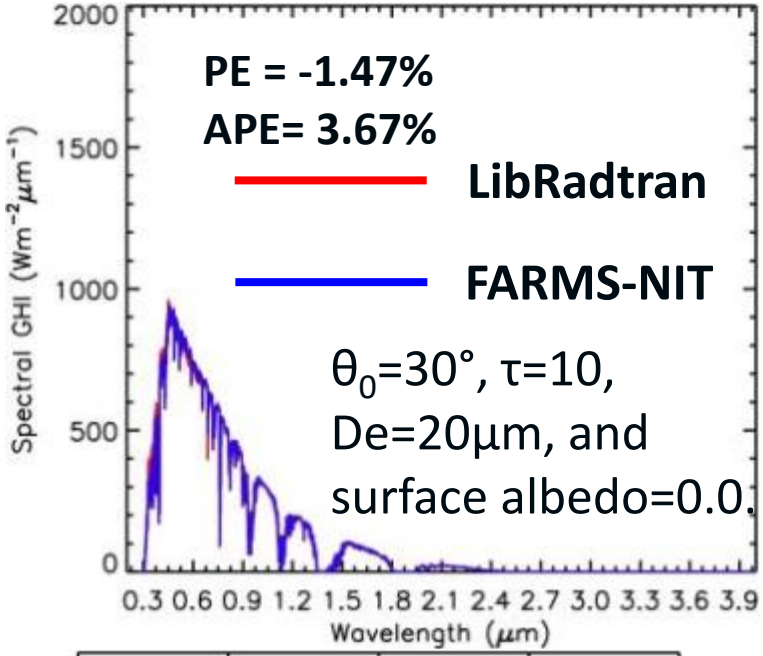


A lookup table of cloud transmittance was computed.

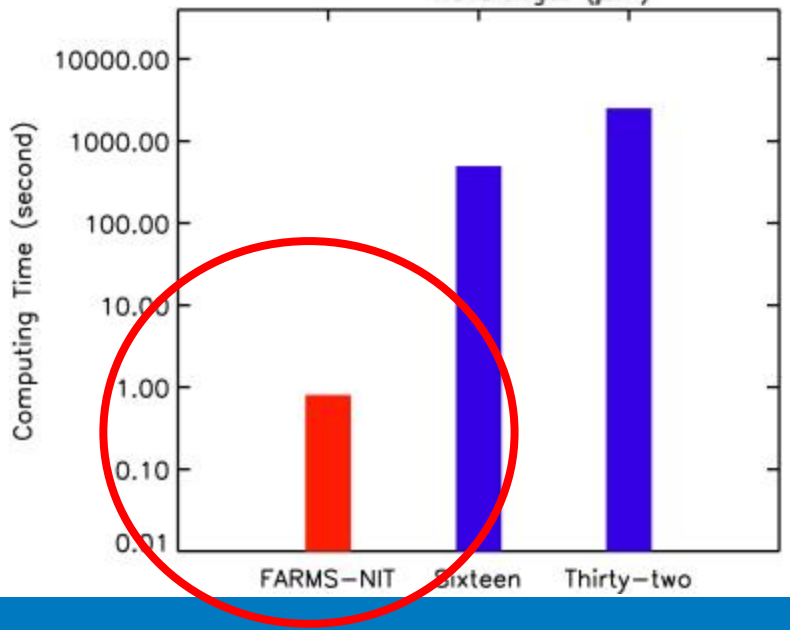
POA irradiance is computed by integrating radiances over inclined surfaces.

Bias of FARMS-NIT is within 5%

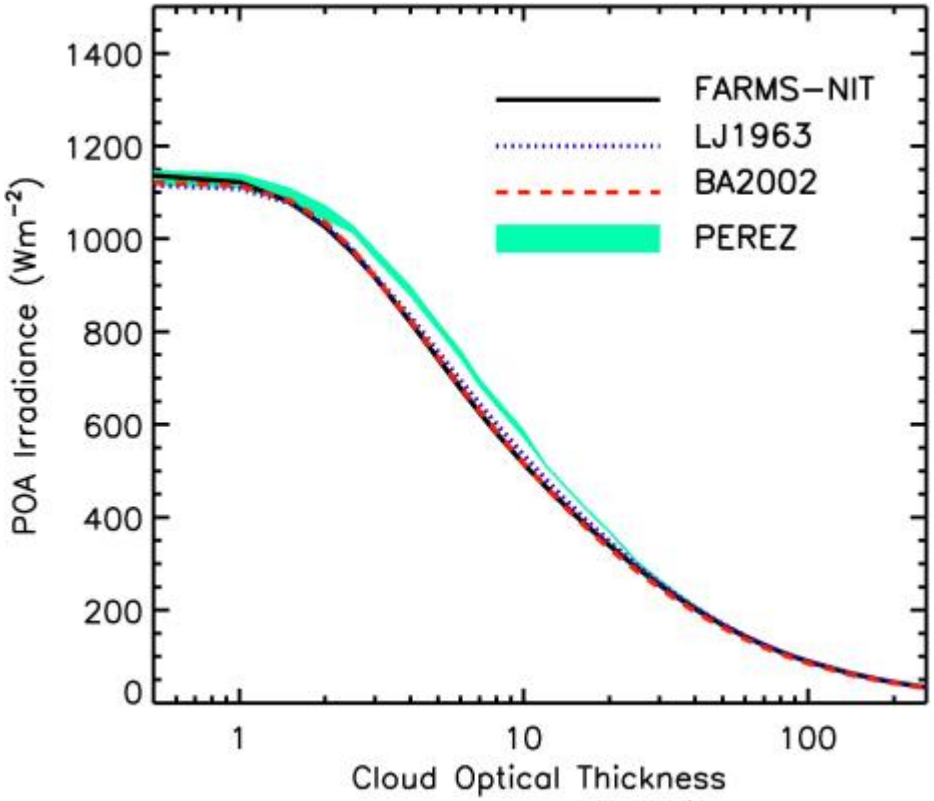


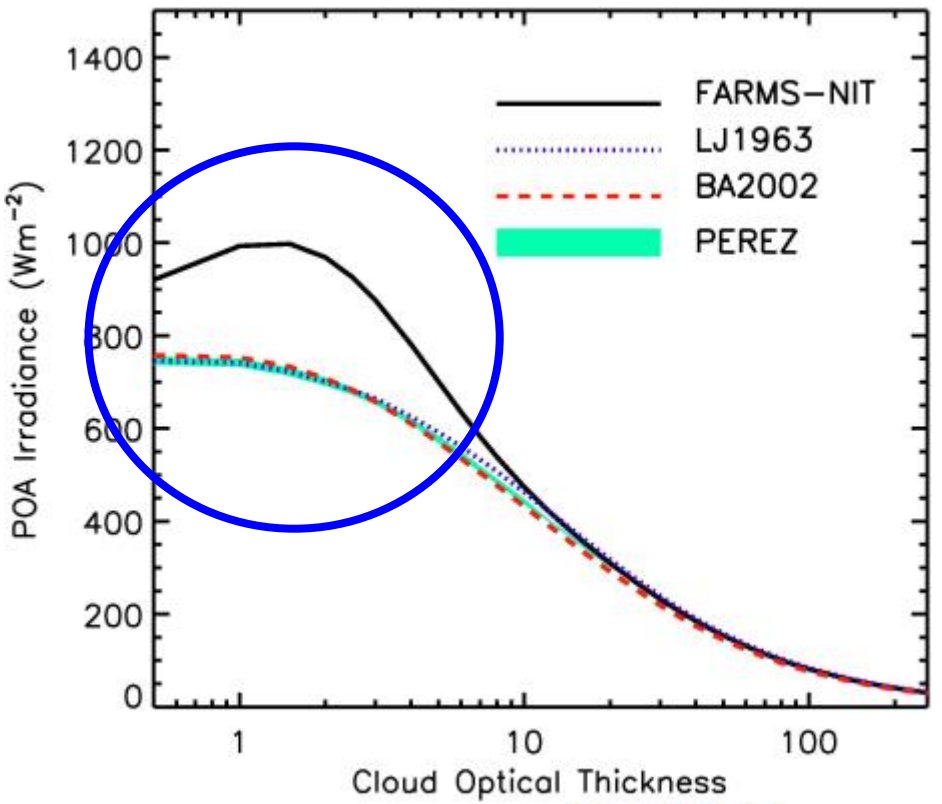


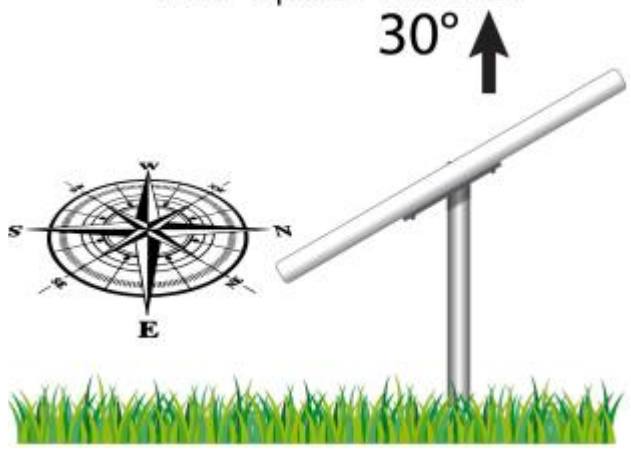
FARMS-NIT: 0.8 second.
LibRadtran (16 stream): 492 seconds.
LibRadtran (32 stream): 2493 seconds.

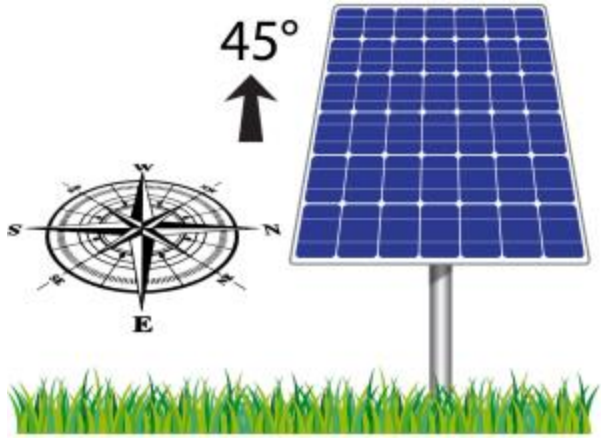


FARMS-NIT is more accurate than transposition models







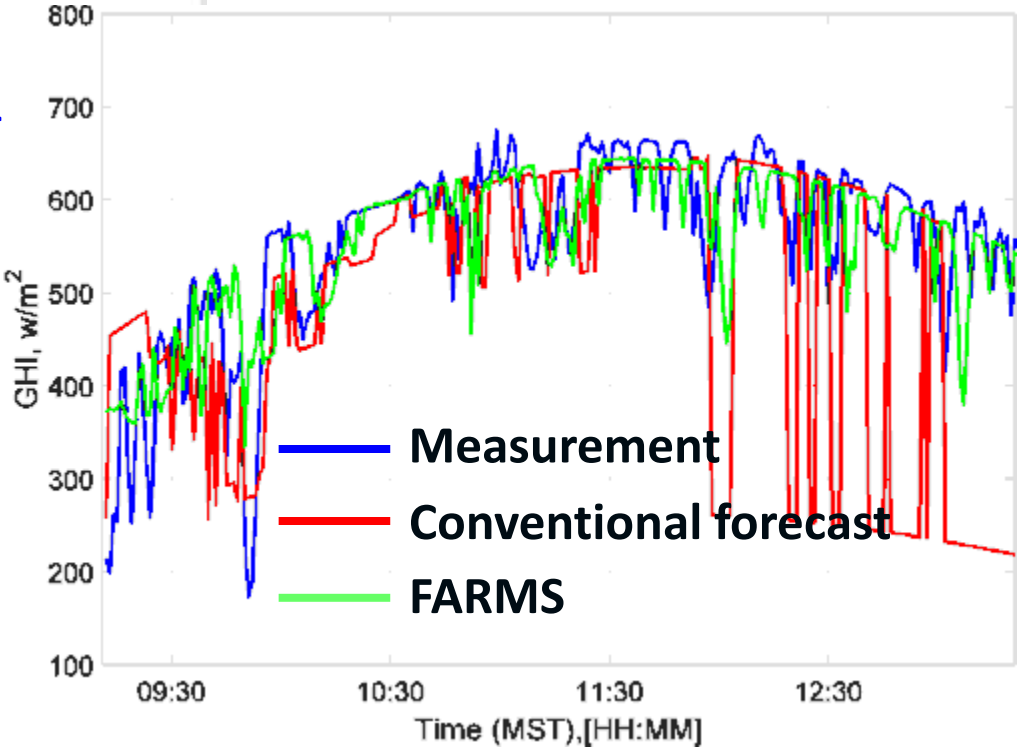


Applications and Future Work

https://ral.ucar.edu/projects/wrf-solar

FARMS provides WRF-Solar an option to rapidly forecast GHI and DNI.

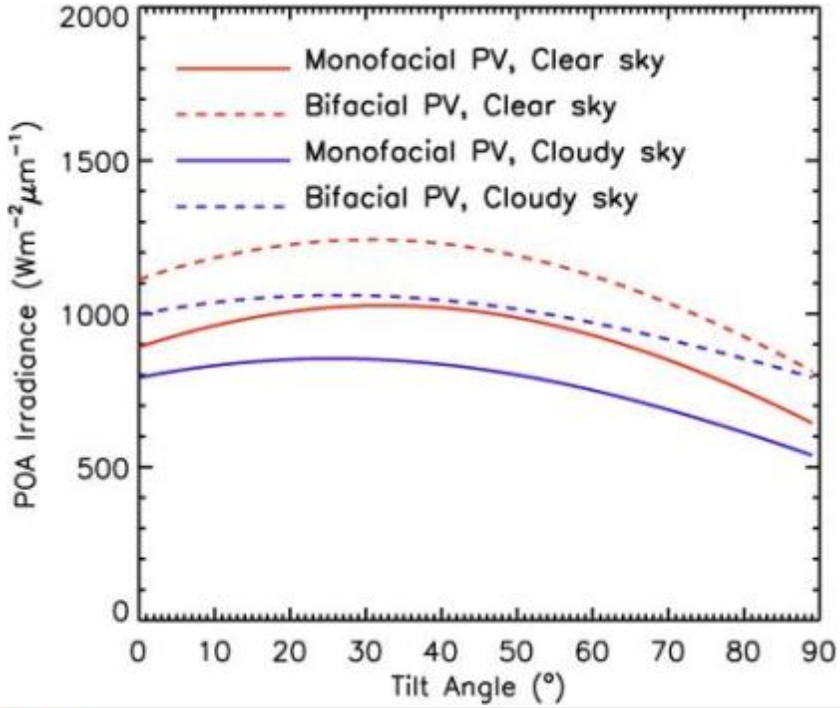
FARMS is used to promote short-term solar forecast from satellite or surface measurements.

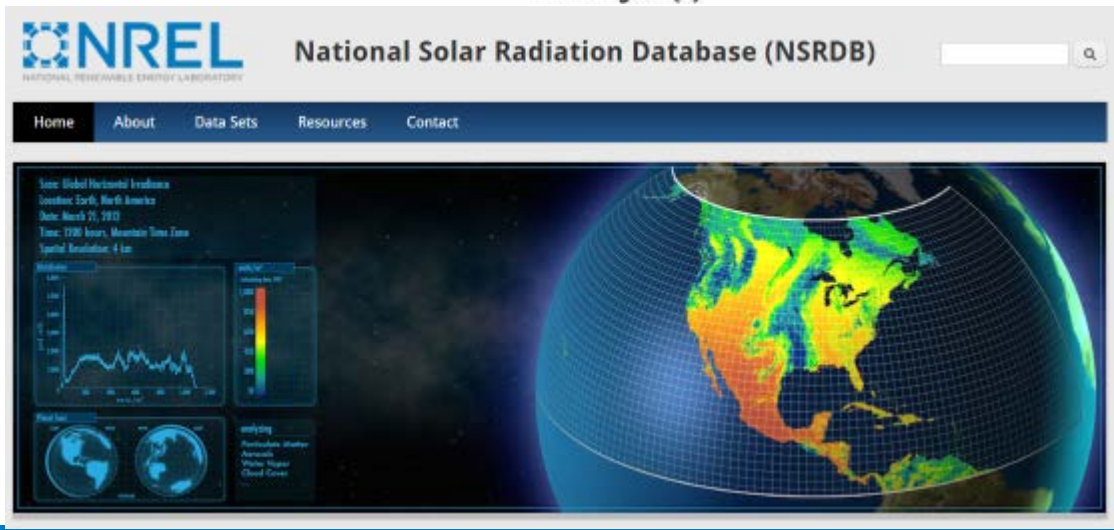


Applications and Future Work

Photo by Thomas Kelsey, NREL 38319.

FARMS-NIT will upgrade NSRDB with spectral irradiances in the POA.





Q&A or Thank you

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