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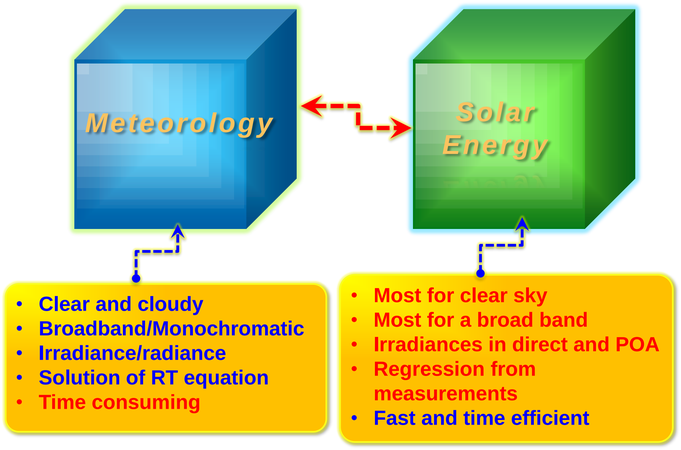
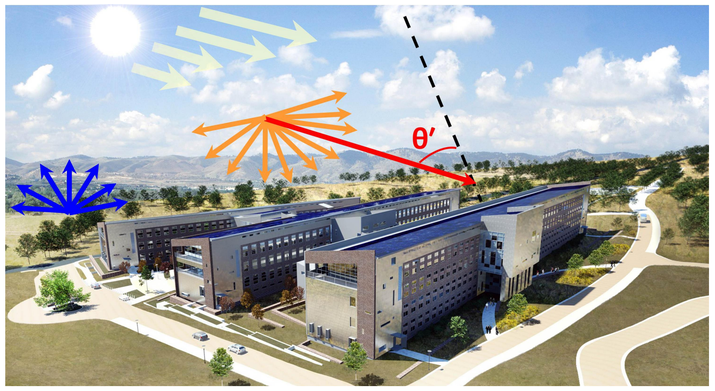
Advances in the Modeling of All-sky Radiative Transfer for Solar Energy Applications

Yu Xie, Manajit Sengupta, and Mike Dooraghi National Renewable Energy Laboratory, Golden, CO

Objectives

- Radiative transfer models simulate atmospheric radiation under all-sky conditions and can be used for a broad range of applications.
- This study introduces NREL's recent advancements in developing new radiative transfer models to meet the requirements of solar energy applications.

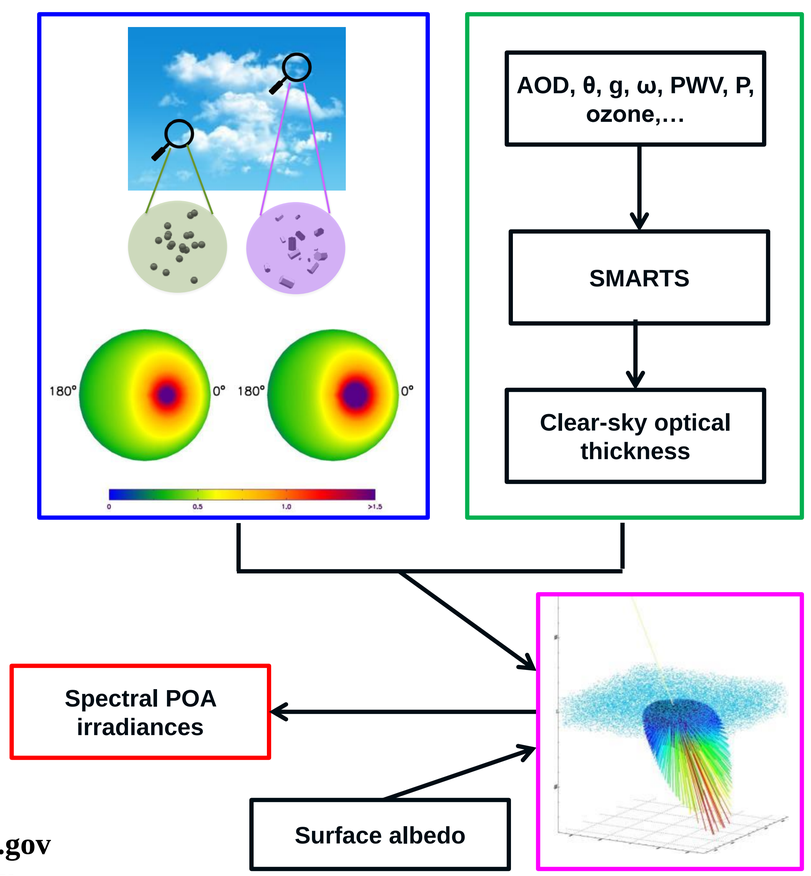




- Unlike weather and climate studies, solar energy requires irradiances over both horizontal and inclined surfaces.
- To characterize the impact of the spectral response of PV panels, solar energy industry requires irradiances in both broad- and narrowband regions.

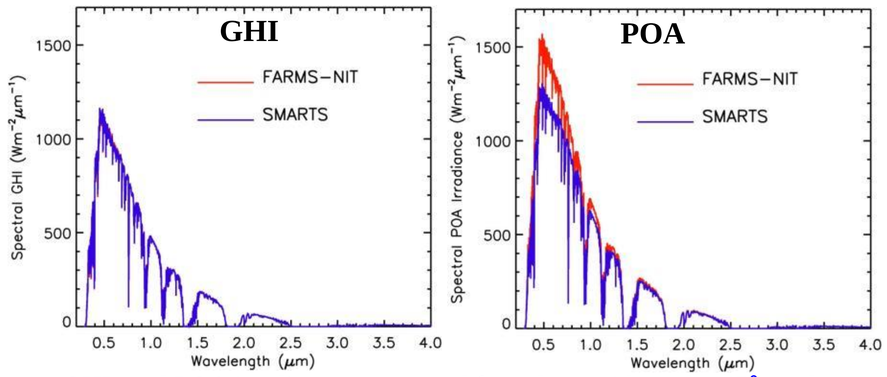
Fast All-sky Radiation Model for Solar applications: Narrowband Irradiances on Tilted surfaces (FARMS-NIT)

- A lookup table of cloud transmittances is computed for 2002 wavelengths, 39 cloud optical thicknesses, 28 cloud effective particle sizes, 50 solar zenith angles, 25 viewing zenith angles and 18 relative azimuth angles.
- The cloud transmittances are combined with a clear-sky radiative transfer model, SMARTS, to efficiently solve the radiative transfer equation.



Contact to:
Yu.xie@nrel.gov
Manajit.sengupta@nrel.gov
Mike.dooraghi@nrel.gov

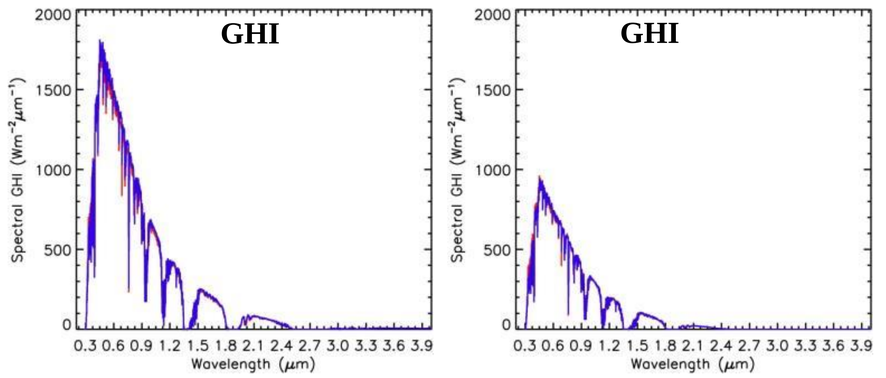
Clear-sky Comparisons



GHIs and POA irradiances computed for solar zenith angle=45° and AOD=0.5.

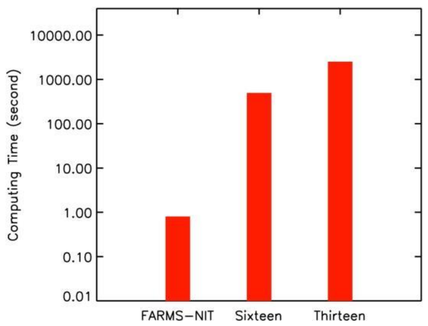
- GHIs computed by FARMS-NIT and SMARTS (industry standard clear sky spectral model) have excellent agreement.
- FARMS-NIT better represents the strong forward scattering by aerosols.

Cloudy-sky comparisons



GHIs for (left) solar zenith angle=15°, cloud optical thickness=1, and effective particle size=20 μm; and (right) solar zenith angle=30°, cloud optical thickness=10, and effective particle size=20 μm.

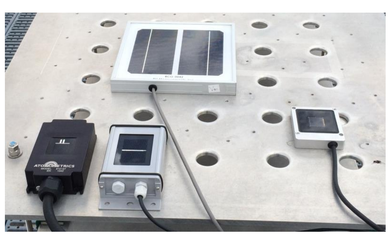
- GHIs computed by FARMS-NIT have a good agreement with LibRadtran (standard radiative transfer model).
- (left) PE=2.26% and APE=4.19%; (right) PE=-1.47% and APE=3.67%.



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

Validation data

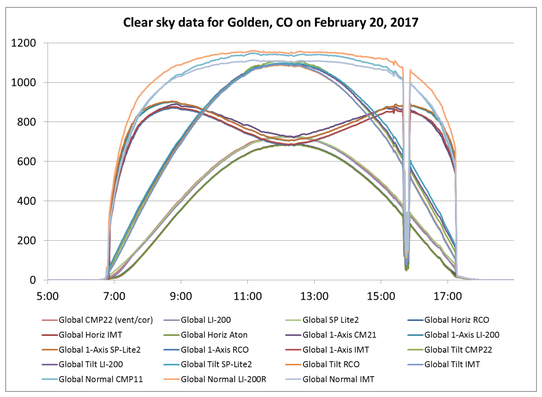
Global horizontal data



One-axis spectral data

One-axis data

40° fixed-tilt data



One-Axis, 40° fixed tilt, two axis and GHI data from one clear day in Golden, CO.

Acknowledgements

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