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

Yu Xie and Manajit Sengupta

Power Systems Engineering Center, National Renewable Energy Laboratory, Golden, CO 80401

Introduction

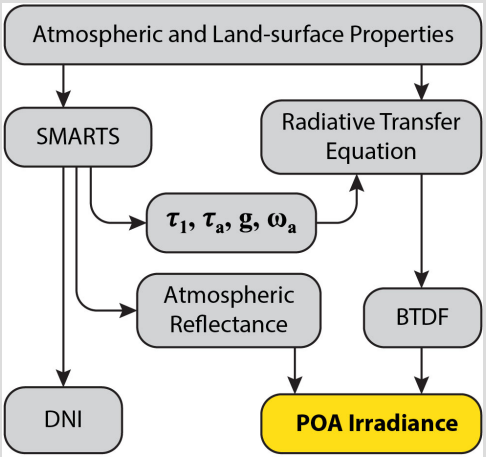
- ***Spectral models***, e.g. SMARTS, SUNSPEC and TMYSPEC, provide rapid solutions of spectral radiation for solar energy applications. High-spectral-resolution models designed for meteorological applications are often time consuming.
- ***Transposition models***, converting horizontal irradiance to the POA, simulate the contribution from diffuse radiation using empirical regression analyses. POA irradiance can be accurately computed by the spatial distribution of radiances which can be provided by physics-based models designed for meteorological propose.

Objective

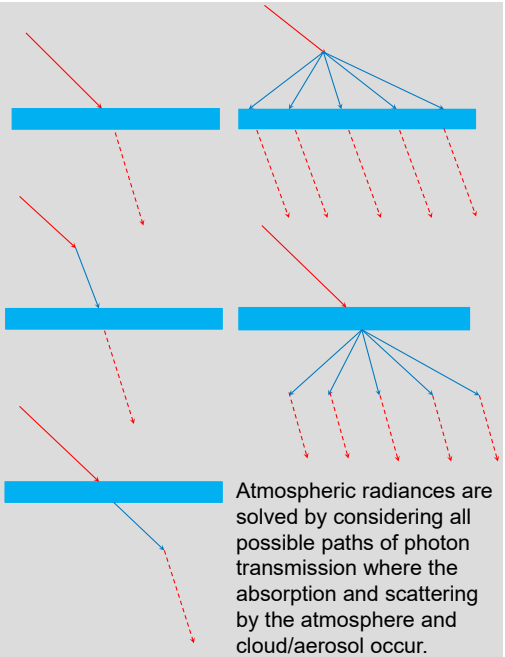
This study develops ***a new model*** that bridges the advantages in the existing models used for meteorological and solar energy proposes. This new model is based on efficient computation of spectral radiances which simultaneously leads to POA irradiances in broad and narrow wavelength bands.

Method

SMARTS is used to compute atmospheric properties, combined with the solution of radiative transfer equation and BTDF of cloud/aerosol, and compute atmospheric radiances.

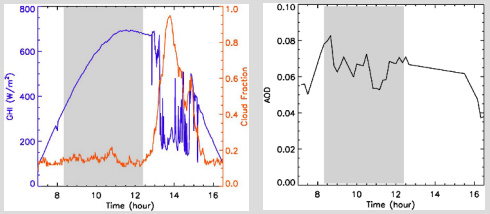


Solutions of Atmospheric Radiances

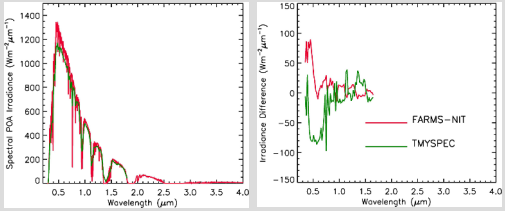


Atmospheric radiances are solved by considering all possible paths of photon transmission where the absorption and scattering by the atmosphere and cloud/aerosol occur.

Validation using Observations

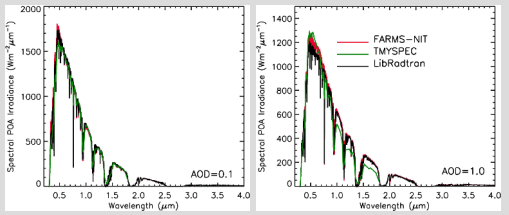


Observation of GHI, cloud fraction, and AOD at NREL on October 20, 2017.

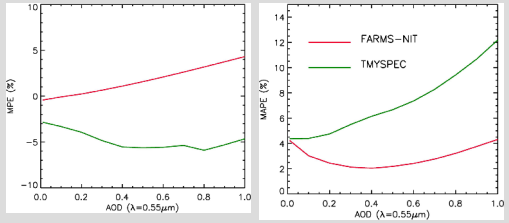


Comparison between FARMS-NIT and TMYSPEC, and their differences at 10:05 am on October 20, 2017.

Validation using LibRadtran



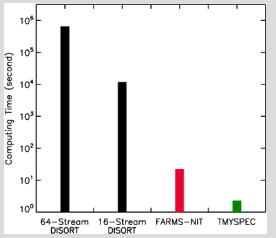
Comparison of POA irradiances computed by FARMS-NIT, TMYSPEC, and LibRadtran.



MPE and MAPE of FARMS-NIT and TMYSPEC evaluated by LibRadtran.

Computing Time

Computing time of hourly spectral POA irradiances over a day. The 64-stream DISORT, 16-stream DISORT, FARMS-NIT, and TMYSPEC consume 650880.0 seconds (180 hours 48 minutes), 11912.7 seconds (3 hours 18 minutes 32.7 seconds), 21.9 seconds, and 2.31 seconds, respectively.



Conclusions

- FARMS-NIT computes spectral radiances in the atmosphere.
- FARMS-NIT combines separate steps from spectral models and transposition models.
- FARMS-NIT is more accurate than TMYSPEC in clear-sky conditions with a large AOD.
- FARMS-NIT significantly reduces the computational time of conventional radiative transfer models.

Contacts:

- Yu Xie: yu.xie@nrel.gov
- Manajit Sengupta: manajit.sengupta@nrel.gov

This work was authored by Alliance for Sustainable Energy, LLC, the manager and operator of the National Renewable Energy Laboratory for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

NREL/PO-5D00-71722

World Conference on Photovoltaic Energy Conversion (WCPEC-7)
Waikoloa, Hawaii
June 10-15, 2018