SAND2024-00332C

50th IEEE Photovoltaic Specialists Conference
San Juan, Puerto Rico,
11-16 June 2023

Inverter clipping and its masking effect on PV soiling: truth or myth?

Leonardo Micheli[1], Matthew Muller[2], Marios Theristis[3], Greg P. Smestad[4], Florencia Almonacid[5], Eduardo F. Fernandez[5]

* Corresponding author: **L. Micheli, leonardo.micheli@uniroma1.it**

Affiliations

[1] Dept. of Astronautical, Electrical and Energy Engineering (DIAEE), Sapienza University of Rome, Rome, Italy

[2] National Renewable Energy Laboratory, Golden, CO, USA

[3] Sandia National Laboratories, Albuquerque, NM, USA

[4] Sol Ideas Technology Development, San José, CA, USA

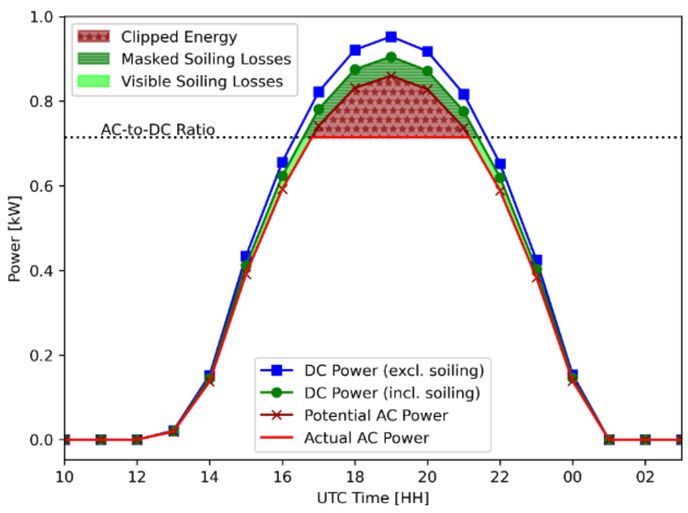
[5] Advances in Photovoltaic Technology (AdPVTech), University of Jaén, Jaén, Spain

Background and Motivation

The DC capacity in PV power plants is typically larger than the rated inverter AC capacity. Because of this, the inverter saturates on some occasions. “Clipping” leads to the conversion of only part of the DC energy generated by the PV modules into AC.

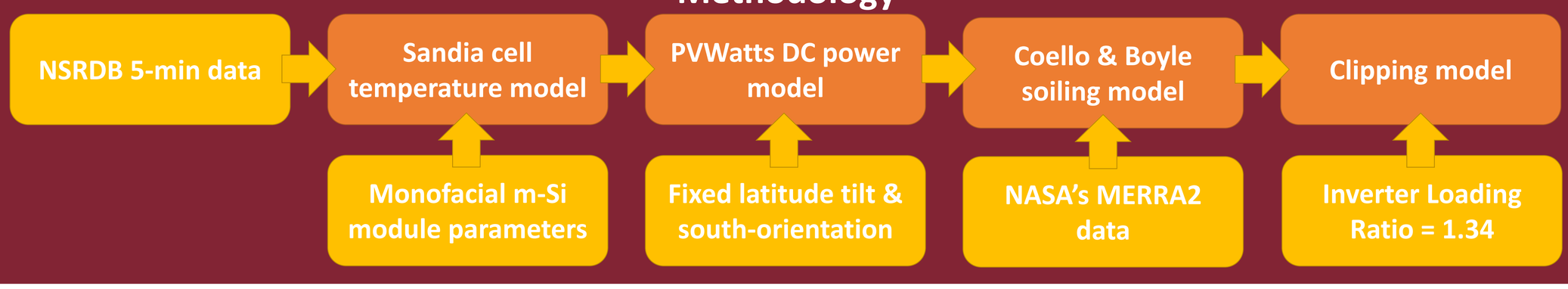
Over the years, the DC-to-AC ratio has increased up to values of 1.5 and more, making clipping events more common and more frequent [1].

Inverter undersizing is often suggested as a **practical soiling mitigation strategy**.

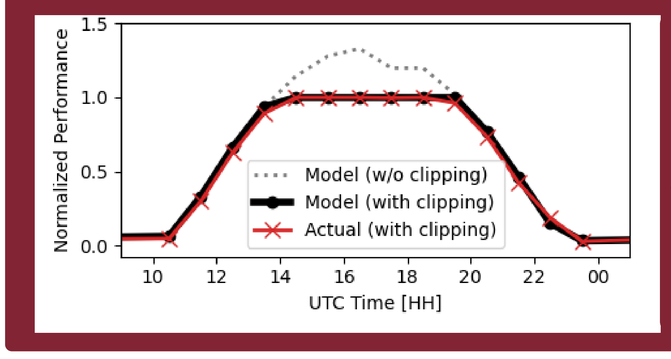


Research Question: is inverter undersizing masking enough losses to make soiling mitigation no longer needed?

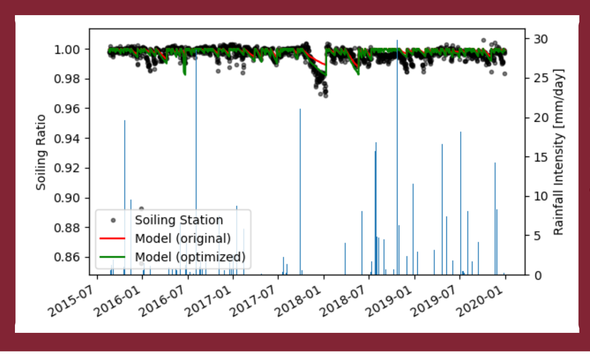
Methodology



Calibration & Validation



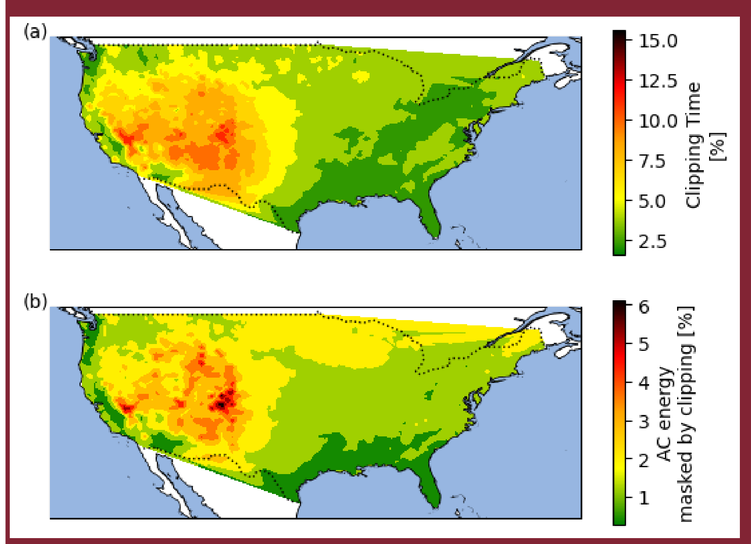
Clipping model validated against data from three sites.
The modelling error on clipping days was reduced by 50-75%.



Soiling model calibrated against one site.
The modelling error was reduced by 50%.

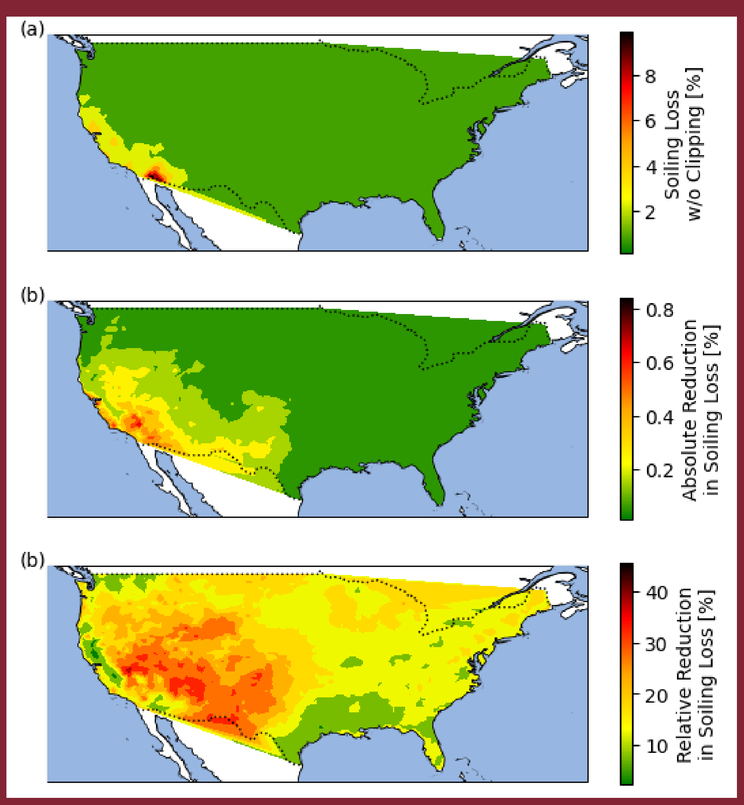
Results

Impact of clipping on energy yield



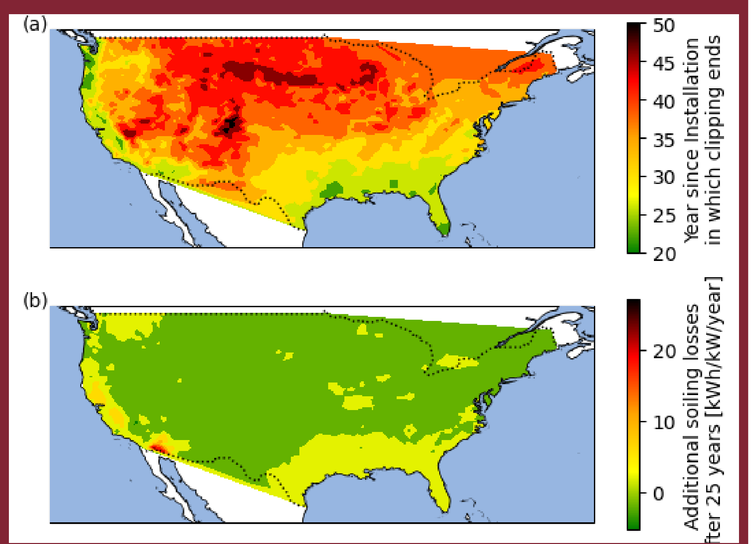
For 1.34 inverter loading ratio, systems clip on average for **4% of the time**. **1.4% of the DC energy** is clipped.
Clipping occurs mainly in the non-coastal Southwestern states, where inverters saturate **for 7-8% of the time**.

Impact of clipping on soiling



Soiling is only partly masked by clipping.

Impact of degradation on clipping



Degradation and performance loss make clipping less frequent therefore soiling losses more visible.
Clipping ends in between **20 and 50 years**. In most of the locations, clipping will stop occurring after 30 years.

No, **currently, soiling cannot be neglected because of inverter undersizing.**
DC oversizing affects the severity of soiling losses in those areas where losses are low-intermediate.
In areas where losses are significant, **the masking effect of clipping on soiling is limited**.
In addition, **soiling losses increase as the system ages**, as they become more visible as the degradation loss increases.

Acknowledgments
L. Micheli’s work was supported by Sole4PV, a project funded by the Italian Ministry of University and Research under the 2019 «Rita Levi Montalcini» Program for Young Researchers.

Part of this work was authored in part by Alliance for Sustainable Energy, LLC, the man- ager and operator of the National Renewable Energy Laboratory for the US Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding was provided by the US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under Solar Energy Technologies Office (SETO) Agreement Number 35893. This material is partially based upon work supported by the US DOE, SETO under Award Number DE SC0020012.”

The work of M. Theristis was supported by the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office Award Number 38267.

E.F. Fernández thanks the Spanish Ministry of Science, Innovation and Universities for the funds received under the “Ramón y Cajal Programme” (RYC-2017-21910).

Sole4PV (Soiling Live Estimation for Photovoltaics)

Project funded by the **Italian Ministry of University and Research** under the 2019 **«Rita Levi Montalcini» Program** for Young Researchers