

# NREL's Effort Toward Predicting Soiling

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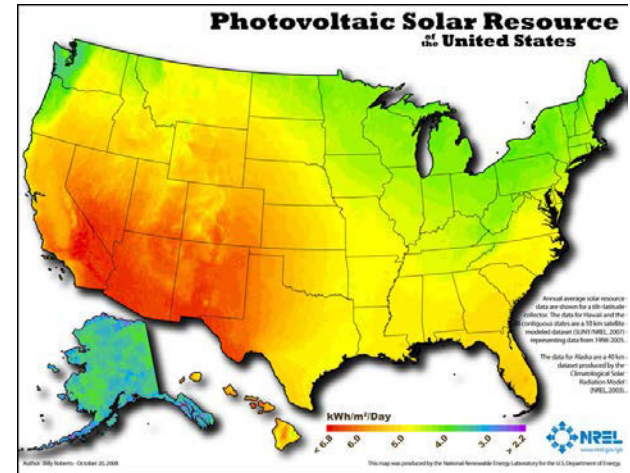
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# Streamlining soiling models and using data-driven strategies to optimize cleaning schedules

Our industry has benefited from Typical Meteorological Year data.

Can we come up with a similar tool for soiling?



## 1. Soiling map ([nrel.gov/pv/soiling.html](http://nrel.gov/pv/soiling.html))



Using data from soiling stations and PV systems, and a method to extract losses from PV performance data.

## 2. Environmental parameters

Using more widely available parameters to estimate soiling: we compare soiling registered at soiling stations with more than 100 environmental parameters.

**Particulate matter** and **average length of dry period** are the best soiling predictors in the USA.

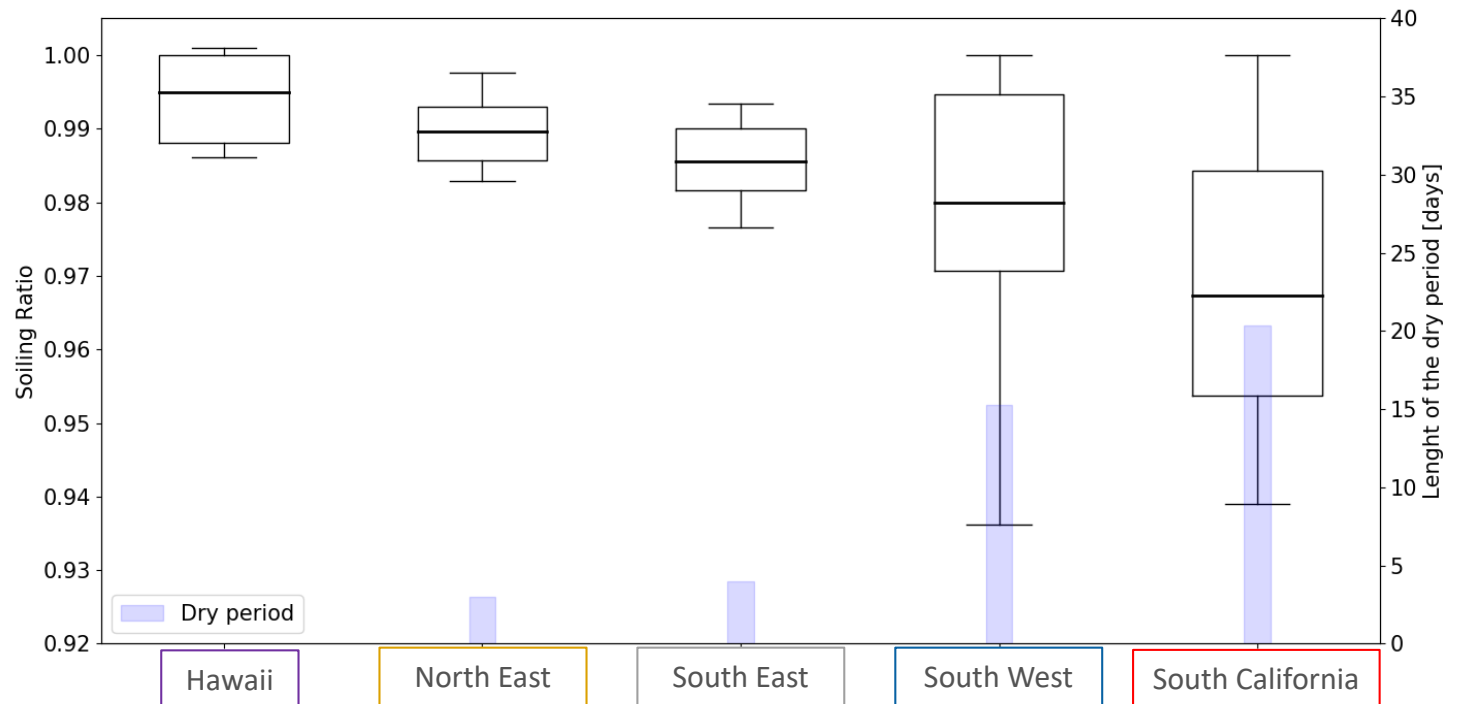
# 1. Soiling map and regional soiling distribution



**Soiling Ratio** =  
 Electrical output of  
 soiled PV module /  
 Electrical output of  
 clean PV module

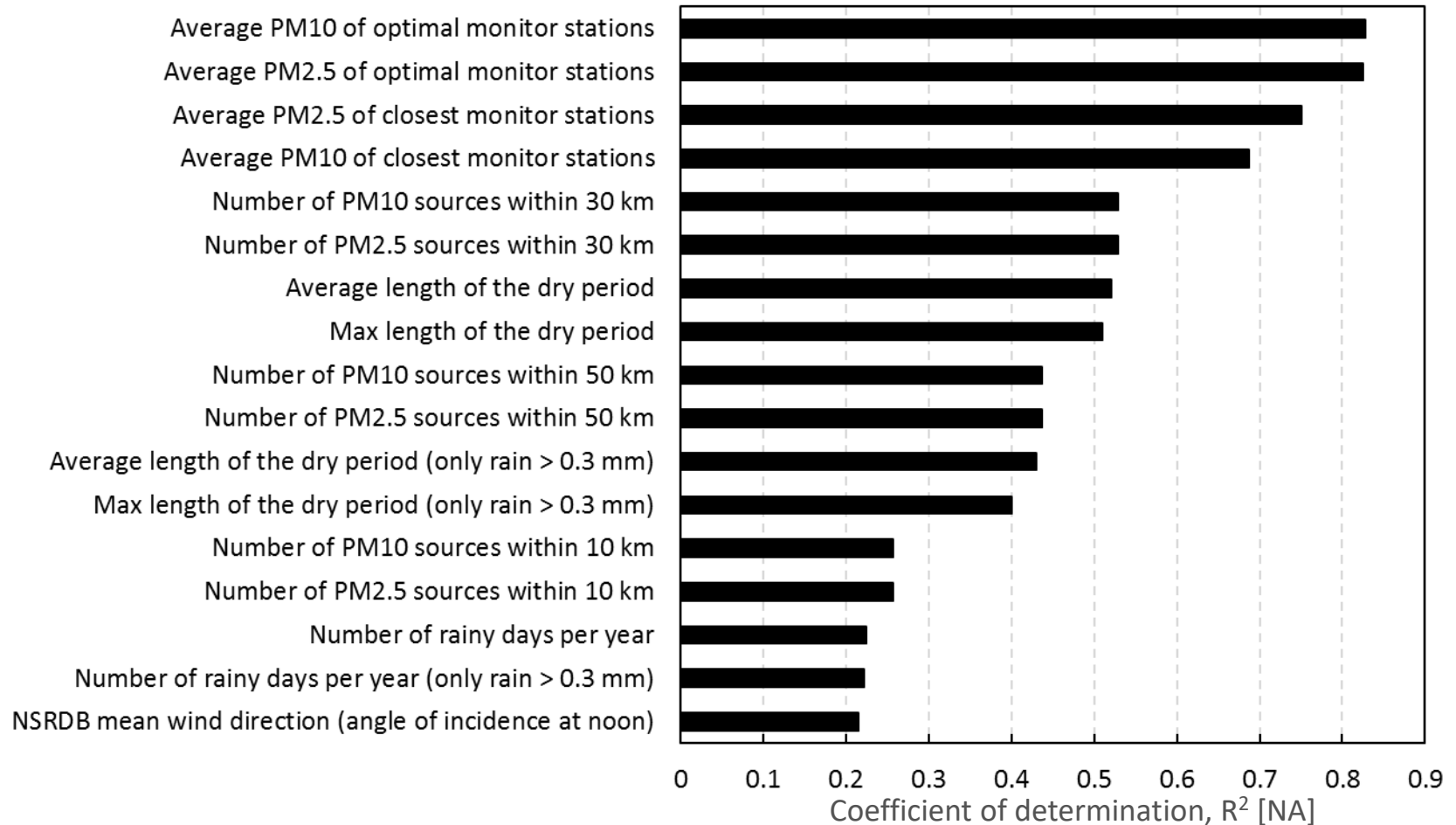
**Soiling Ratio = 1**  
 Clean condition

**Soiling Ratio < 1**  
 Soiling



## 2. Soiling Vs. Environmental Parameters

Compared soiling loss at 20 PV installations in the USA to 97 Independent variables. Pareto Chart shows results for variables with highest correlation to Soiling Ratio.



Open questions: **Nonuniformity? Seasonality? Inter-annual variability?**

# Cleaning efficacy and innovative methods

NREL is working to identify and develop the scientific basis and methods for qualifying cleaning practices. As part of this focus, a new workgroup on PV cleaning solutions (**PVQAT 12-2**) was recently launched, and a survey was conducted among the participants:

Cleaning Methods	Advantage	Disadvantage
<b>Natural rainfall</b>	No cost	May not occur when needed and may not be enough
<b>Gentle water spray</b>	Low cost (depending on water availability)	Lots of water, may not clean well enough
<b>High-pressure spray</b>	Good cleaning	Lots of water, may damage modules
<b>Hand squeegee/soap</b>	May be needed in some cases	Labor and water intensive, may damage modules
<b>Dry brush</b>	Low cost, no water	May scratch glass, may damage module / components

The efficacy of cleaning depends on type and amount of soiling, cleaning frequency, and cleaning method.

# Cleaning efficacy and innovative methods

Currently studying efficacy of various cleaning methods and anti-soiling solutions:

- **10 different glass coupon types** deployed (coated and uncoated)
- **4 cleaning/treatment methods** for the coupons:  
no clean, dry brush, sponge/squeegee/water, water spray
- Coupons returned to NREL at Years 1–5 to **quantify degradation**.



After 1 year:

- **Biological contamination** (fungi) on some coupons, can trap inorganic matter but no evidence of glass etching. Similar fungi found on fielded modules in California, Germany, and Brazil.
- Greater **surface roughness** after dry brush than after wet sponge/squeegee.
- Much contamination is left if only rinsing performed.

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Proposed an international standard on the abrasion of PV surface

# PVQAT TG12 Activities

NREL aims to conduct high-quality, impactful research for the PV community. Among the efforts, NREL is supporting the work of the “Soiling” group of the International PV Quality Assurance Task Force (**PVQAT**).

- ***Subgroup 12-1 (Sensor and the monitoring of soiling)***  
Contributed to IEC 61724-1 (Quantifying effect of soiling on PV systems)  
Contact: YuePeng DENG, [Yuepeng.Deng@FirstSolar.com](mailto:Yuepeng.Deng@FirstSolar.com)
- ***Subgroup 12-2 (Solutions for cleaning)***  
Goal: Module cleaning standard (manual and robotic methods)  
Contact: Lin SIMPSON, [Lin.Simpson@nrel.gov](mailto:Lin.Simpson@nrel.gov)
- ***Subgroup 12-3 (Antireflective and/or anti-soiling coatings)***  
Goal: Abrasion test standard, artificial soiling test standard  
Contact: David MILLER, [David.Miller@nrel.gov](mailto:David.Miller@nrel.gov)
- ***Subgroup 12-4 (Modeling/analysis of effects of soiling on PV performance)***  
Web study group to share knowledge and questions on soiling modeling  
Contact: Leo MICHELI, [Leonardo.Micheli@nrel.gov](mailto:Leonardo.Micheli@nrel.gov)

Free webinars held monthly, with references and recordings available online.

Next webinar: April 14<sup>th</sup> – **Monitoring Global Transportation of Dust from**

**Space.** Contact: Greg SMESTAD, [smestad@solideas.com](mailto:smestad@solideas.com)