CASE STUDY

The art & science of soiling sensor placement

Introduction: How many soiling stations does my site need?

The Fracsun team is often asked the question: how many soiling stations are needed for a particular site? While there are several factors that drive our recommendation for sensor quantity and placement, the most important is the variability of soiling across the array. Local site conditions can lead to uneven soiling throughout an array field, so proper sensor quantity and placement is key to understanding the full range of soiling at a site. Here we will discuss the following:

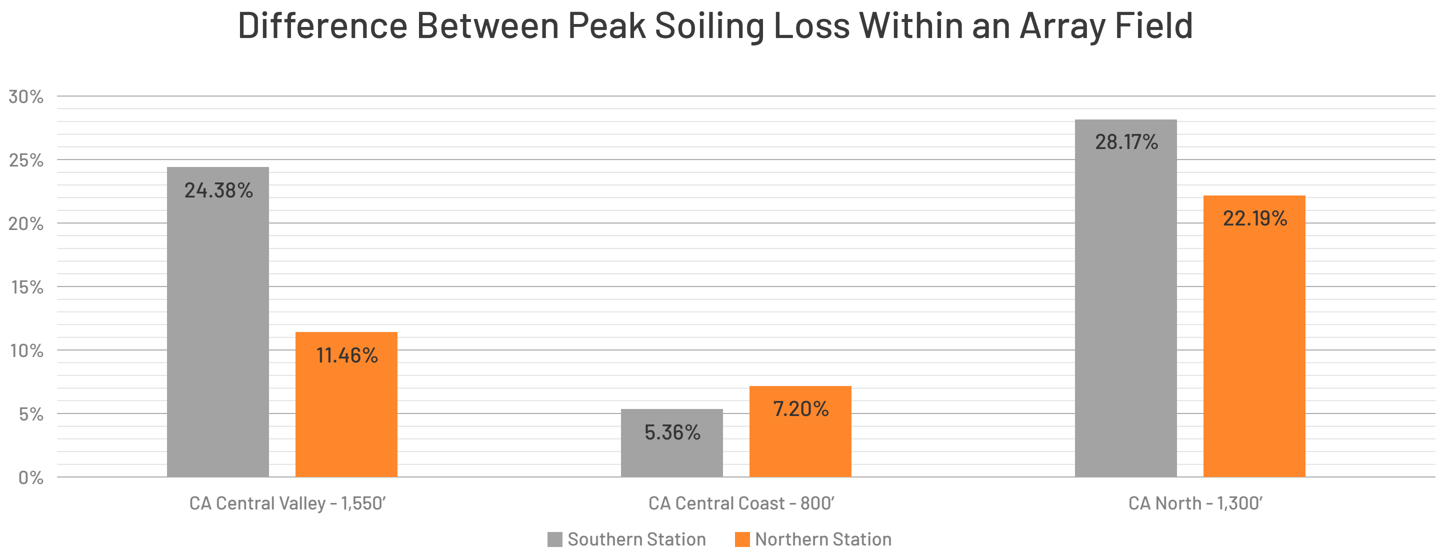
- General factors creating variability of soiling
- Soiling variability across a specific example site in California
- Other considerations driving sensor placement

Soiling sensor placement within an array

Determining correct soiling sensor placement is both an art and a science, but this case study should provide a good overview of the various factors we examine with each new project. We are happy to provide a specific recommendation or help your team perform this analysis.

Soiling variation within an array - general factors

The graph below shows the range of recorded soiling loss at three example California sites. For this example, 3 sites were chosen which have soiling stations placed between 800 and 1,550 feet apart. The two bars shown are peak soiling values during the dry season from the same day. Not included are days impacted by wildfires, which we will discuss further down.



The sites shown often exhibit 20 - 50% differences in soiling loss levels, during dry periods, across fairly short distances. These differences are most pronounced at sites with discrete anthropogenic (man-made) soiling sources. Knowing which areas of a site are impacted the most can give operators a leg-up by prioritizing their cleaning efforts on regions of higher soiling, which will generate the greatest rate of return.

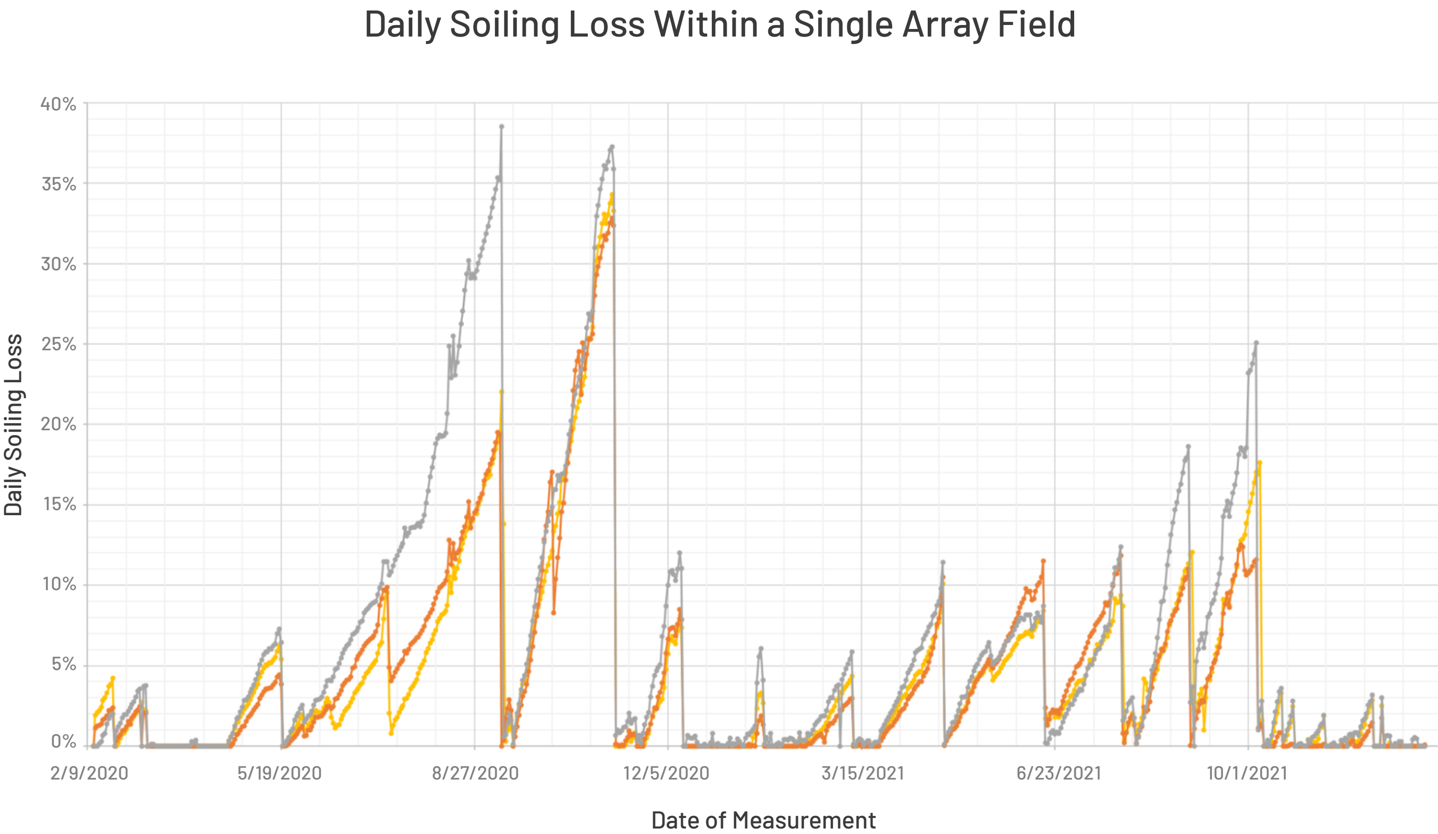
In general, solar plant soiling is driven by both regional and hyper-localized factors that can lead to a wide range of soiling impact across a given array, including:

- Agricultural activity
- Adjacent dirt roads
- Industrial emissions
- Highway proximity
- Regular on-site activity
- Pollen producing trees
- Prevailing winds

In more urban environments, soiling material accumulation is generally caused by atmospheric particulate matter (PM10, PM2.5 and PM0.1) with a uniform distribution. However, in more rural settings, human activity on the ground can kick up dust that severely impacts the nearest panels.

Project Case Study - CA Central Valley

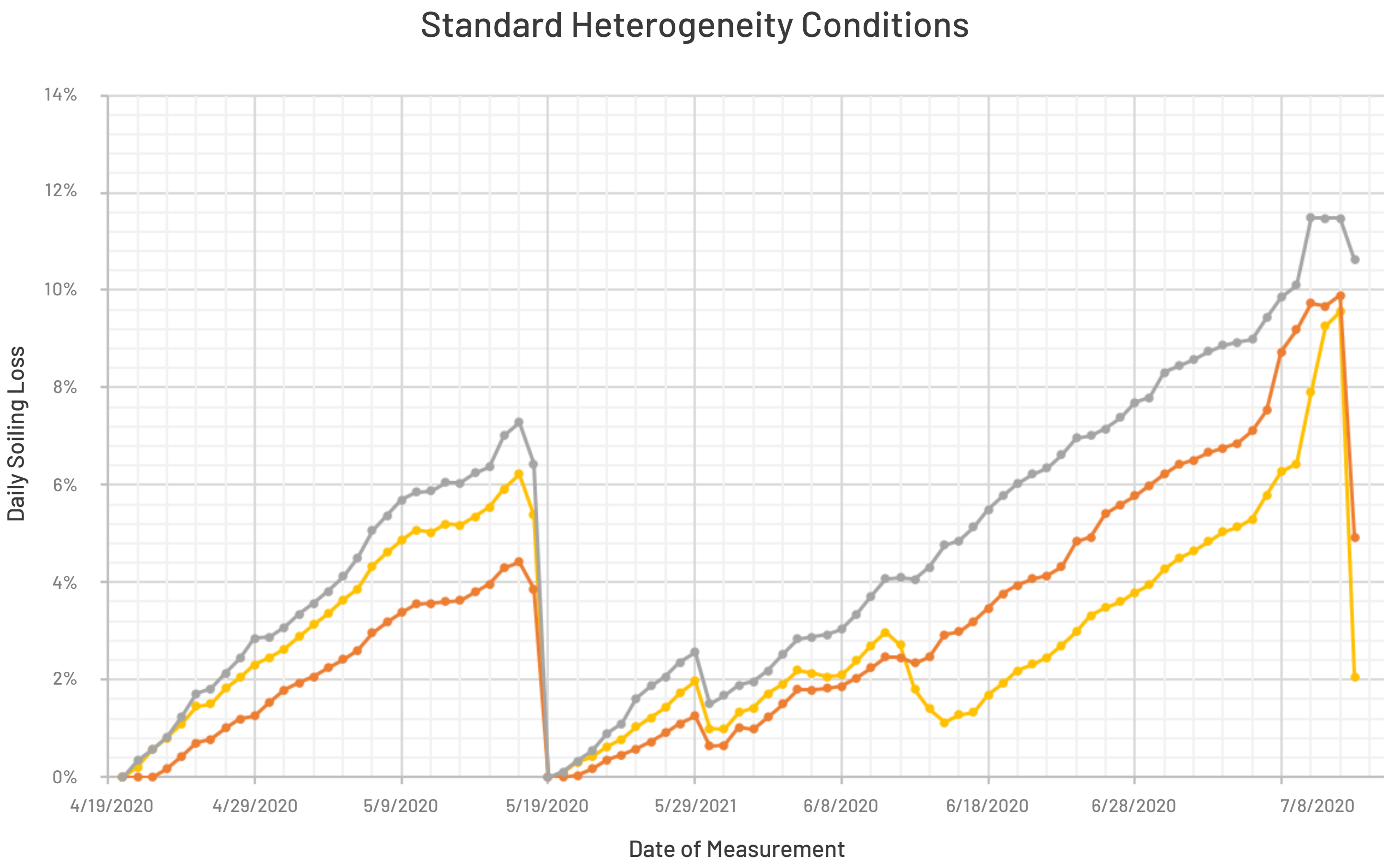
Looking more closely at the 27 MWdc example site in the California Central Valley, we can further show how soiling loss accumulation varies across the array throughout the year. This site features three soiling stations, with each sensor covering approximately 9 MWdc of PV. The chart below shows the recorded soiling loss values over nearly two calendar years.



There are several points along this chart that help to understand the true impact of soiling across the array. It is worth noting that drops to zero in this chart are either caused by cleaning or rain events.

We will not discuss those here but feel free to reach out to the Fracsun team for more information on the efficacy of rain to clean a given array.

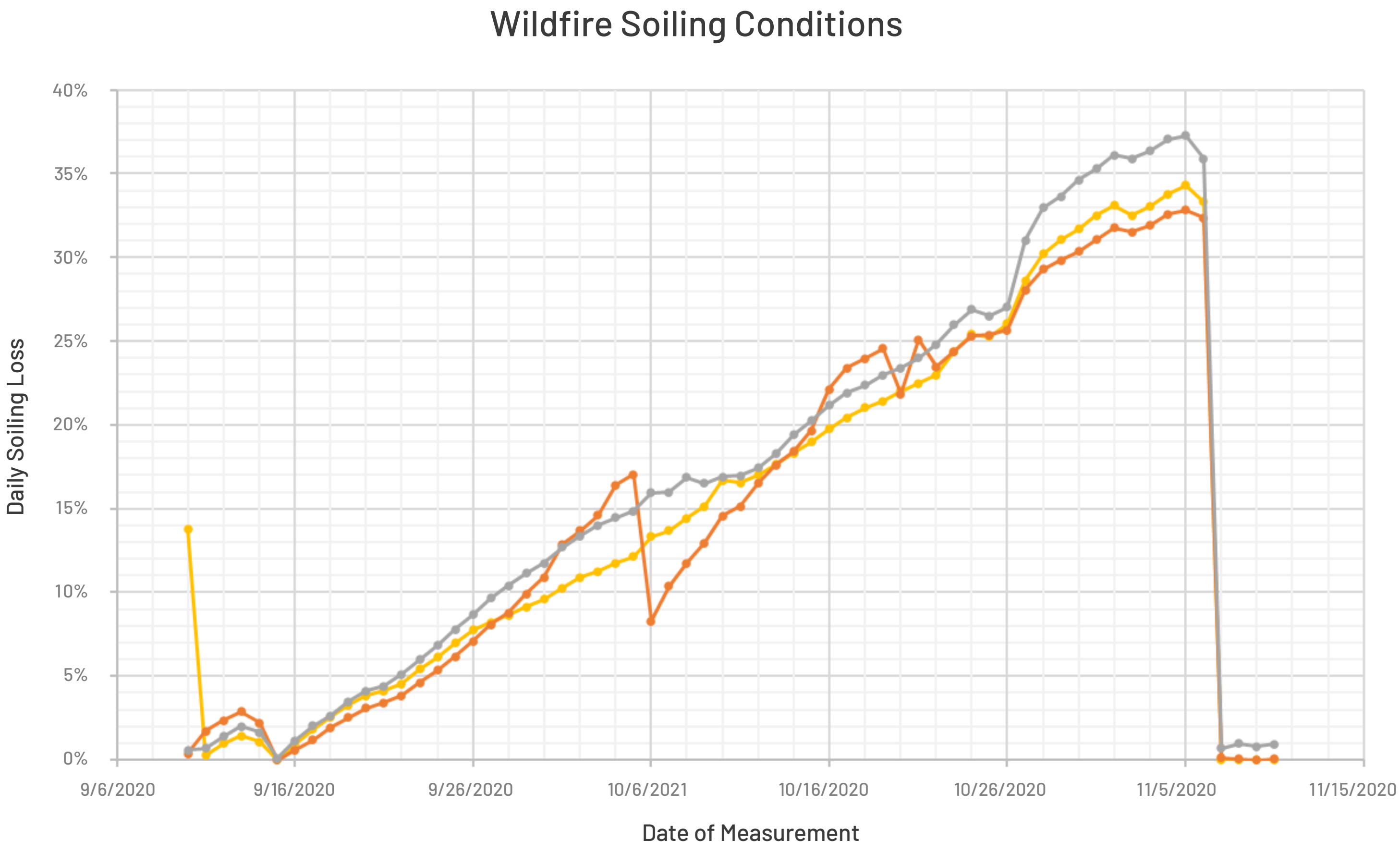
The chart below, focused on the period from 4/20/2020 to 7/14/2020, is early enough in the dry period that local effects are noticeable but not yet extreme. As shown during this time period, there are notable differences between the slope of these lines which correlates to varying rates of soiling material accumulation.



As we look further into this data we will notice the gray line generally outpaces the others. The soiling station represented by the gray line is situated in the north-west corner of the array, along the leading edge for prevailing winds, and receives the brunt of the dust kicked up by an adjacent farm. This area of the array often exhibits well over 60% more soiling loss than the other sections.

This heterogeneity effect will be magnified when an array is an irregular shape or consists of many array segments broken up over a specific region. With this in mind, it is helpful to include multiple measurement points throughout an array to capture the full range of high, medium, and low soiling so we can leverage this data when making cleaning decisions.

Another interesting phenomenon to consider is the impact of wildfires on soiling loss accumulation. While adjacent activities will have a much more localized effect within the array field, wildfire ash tends to cause extremely high soiling rates in a fairly uniform manner. Below is the effect of the 2020 wildfire season on the Central Valley of California. Daily soiling accumulation during this time period reaches a staggering 0.9%/day over a 3-week average. On November 6, a major precipitation event comes to the rescue for both firefighters and solar asset owners.



Other considerations

Sources of soiling material are a major deciding factor when determining how many soiling stations to deploy. However, other site factors also play a large role. These factors are largely economic or logistical. The three factors below will drive much of the economic decision on soiling station deployment:

- **System Size & Shape** — Larger sites typically require more sensors to accurately gauge soiling. Disparate arrays broken into multiple sections will require more sensors than a densely packaged rectangle.

- **Value of Solar** — Dollars generated by every kWh of a given solar asset is a key driver in determining how closely soiling loss should be monitored. More annual cleanings are justified when the value of solar is higher, so having intelligent soiling data is paramount to capturing the greatest return.
- **Cost to Wash** — Utilizing soiling data generally drives an important discussion pertaining to this expense. Often, assumptions are made about the economic benefit of array cleaning without fully understanding cleaning costs. This makes it difficult to determine which cleaning method is the most cost effective.
- **Array Cleaning Velocity** — In larger utility-scale plants, it may take several weeks or even months to clean the entire array. By the time one section of the plant has been cleaned, the soiling loss at opposite sections of the array may have changed drastically. Instituting a soiling monitoring program that considers the time required to clean an array segment can help fine-tune production and true-up models.

Conclusion

Examining the many factors that impact soiling at a given site produces a much deeper understanding of the true impact of soiling across an array. Determining how these factors will impact a future plant or how they are affecting an operating plant are key to developing the best possible soiling management and measurement solution.

We typically recommend one soiling station for every 5-10 MWdc of installed solar capacity, but each site is unique. We are happy to conduct virtual site evaluations for both operating and development assets. Reach out to our team today to see how intelligent soiling loss management can unlock the full potential of your solar plants.

About Fracsun

LOCAL MEASUREMENTS

At Fracsun we specialize in on-site soiling loss measurement using our *patented* ARES soiling station. By directly measuring soiling with local instrumentation, we eliminate uncertainty and enable your team to confidently manage soiling loss with ease.

INTELLIGENT ANALYSIS

Our software enables your team to access key soiling metrics from anywhere. View or download soiling station data, forecast the best wash dates, and calculate accurate costs and savings.

PROJECT DEVELOPMENT DATA

Fracsun's unique soiling dataset is the largest in North America. Our soiling sensors are currently deployed on more than 2 GW of solar assets. Utilizing historical soiling data is extremely useful during the project development phase, reducing financial risk.

FRACSUN.COM

Fracsun, Inc.
San Luis Obispo, California
info@fracsun.com
(805) 242-3722