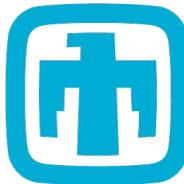


# Solar Forecast Arbiter

## An open source evaluation framework for solar forecasting



Sandia  
National  
Laboratories



ELECTRIC POWER  
RESEARCH INSTITUTE



William F. Holmgren, Clifford W. Hansen, Aidan Tuohy, Justin Sharp, Antonio T. Lorenzo, Leland J. Boeman, Adam Wigington, David P. Larson, Qin Wang, Anastasios Golnas

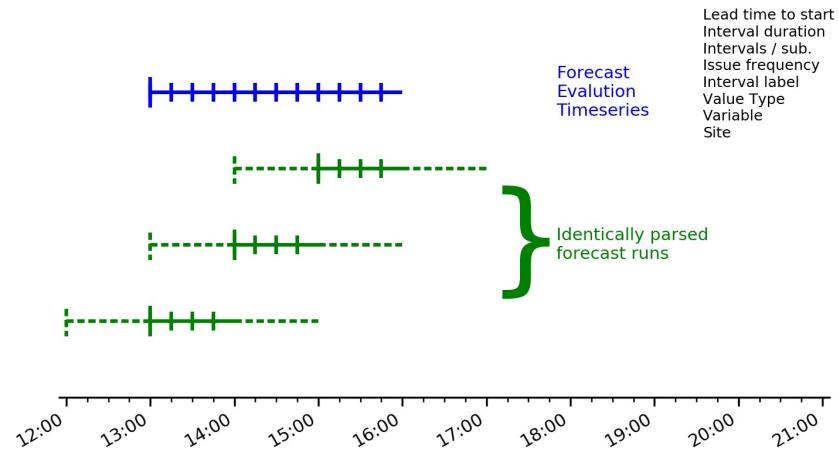


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# What is a forecast?

Consider the “Vendor A Solar Power Forecast”...

- Each forecast extends **N** hours
- New forecast every **M** minutes
- If probabilistic, **P** percentiles
- $\text{values/day} = N * (1440/M) * P \sim 10k+$
- *Underdefined evaluation problem*
- *Metrics alone will not save you!*
- *“Big data” analytics will not save you!*
- *AI definitely will not save you!*

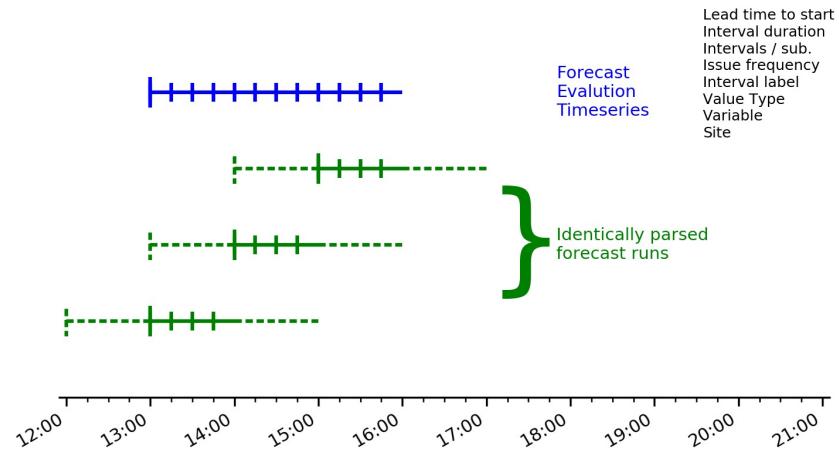


Stop and think about the problem/analysis before you start it.

# What is a forecast?

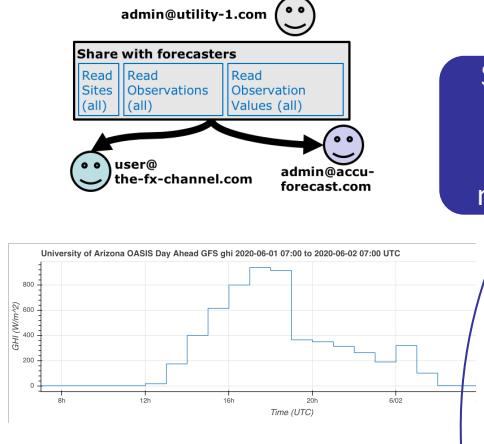
Consider the “Vendor A Solar Power Forecast”...

- Each forecast extends **N** hours
- New forecast every **M** minutes
- If probabilistic, **P** percentiles
- $\text{values/day} = N * (1440/M) * P \sim 10k+$
- *But I mostly care about Day Ahead. Especially issued early in the day. And only 3 percentiles really matter.*
- $24 * 1 * 3 < 100$



Stop and think about the problem/analysis before you start it.

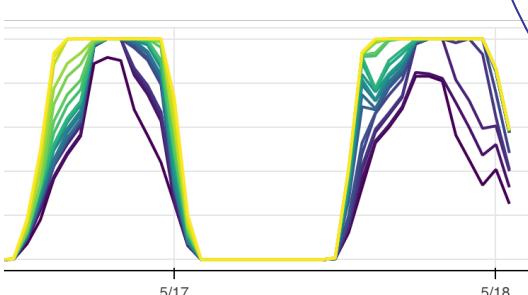
# [solarforecastarbiter.org](https://solarforecastarbiter.org)



## Solar Forecast Arbiter API

Download OpenAPI specification: [Download](#)

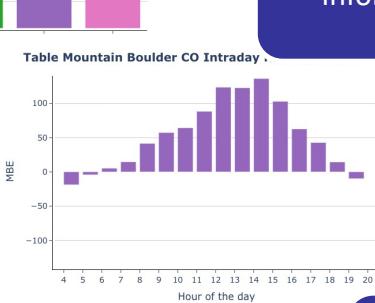
Graphical reporting  
Automated workflow



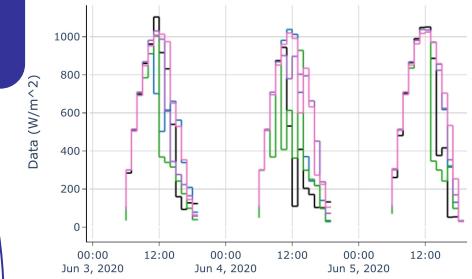
Deterministic  
Event  
Probabilistic

Standardized  
Objective  
Open source

# GitHub



Stakeholder  
Informed

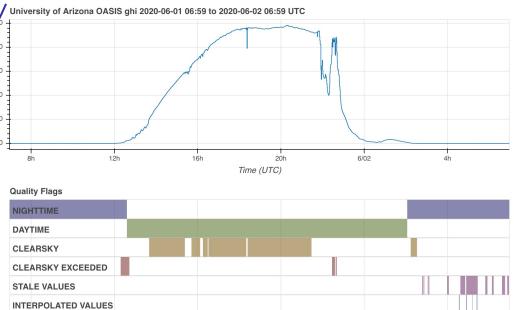


Many-vendor trial  
Anonymization  
Realtime and  
retroactive

Table Mountain Boulder CO Current Day NAM ghi MBE



Data quality  
control  
Reference data  
& forecasts



Free!  
Available now!

# How do I use the Solar Forecast Arbiter?

- 1. Define site, observation and/or forecast metadata**
- 2. Upload observation and/or forecast data**
- 3. Optional: grant another user access to your metadata/data**
- 4. Run analysis report**

## Create New CDF Forecast

### Site Metadata

Name: Boulder power plant 2

UUID: 98fb7648-e941-11e9-8ad7-0a580a820002

[Copy UUID](#)

Latitude: 40.0 (°N)

Longitude: -105.0 (°E)

Timezone: America/Denver

Elevation: 1650.0 (m)

Climate Zones:

- [Reference Region 4](#)

### Modeling parameters:

AC capacity: 10.0 (MW)

DC capacity: 14.0 (MW)

AC loss factor: 0.0 (%)

DC loss factor: 0.0 (%)

Temperature coefficient: -0.3 (%/C)

Tracking type: single axis

Axis tilt: 0.0 (°)

Axis azimuth: 0.0 (°)

Ground coverage ratio: 0.4

Backtrack: True

Max rotation angle: 45.0 (°)

### Name

### Variable

 GHI (W/m<sup>2</sup>)

### Issue time of day

 00 : 00 UTC

### Lead time to start

 Minutes

### Run length/Issue frequency

 Minutes

### Interval length

 Minutes

### Interval label

 Beginning

### Interval value type

 Mean

### Axis

variable value  percentile

### Constant values

# How do I use the Solar Forecast Arbiter?

1. Define site, observation and/or forecast metadata
2. **Upload observation and/or forecast data**
3. Optional: grant another user access to your metadata/data
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My data is formatted in:

CSV  JSON

Forecast data in CSV format should follow the formatting of the example below.

```
# optional header, ignored by Solar Forecast Arbiter  
timestamp,value  
2018-11-22T12:00:00Z,10.23  
2018-11-22T12:05:00Z,10.67
```

No file selected.

## Solar Forecast Arbiter API (1.0.2)

Download OpenAPI specification:

Solar Forecast Arbiter Team: [info@solarforecastarbiter.org](mailto:info@solarforecastarbiter.org)

URL: <https://github.com/solararbiter/solarforecastarbiter-api> | License: MIT

The backend RESTful API for Solar Forecast Arbiter.

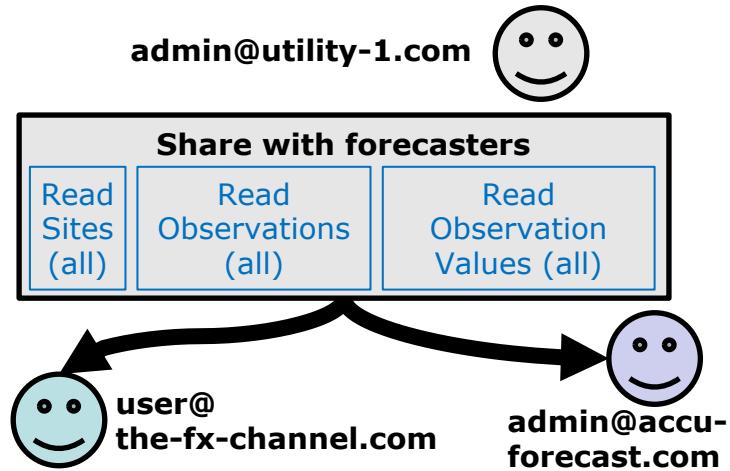


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# How do I use the Solar Forecast Arbiter?

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4. Run analysis report



# How do I use the Solar

1. Define site, observation and/or forecast metadata
2. Upload observation and/or forecast data
3. Optional: grant another user access to your metadata/data
4. Run analysis report

## Create New Report

Report type: Deterministic Event Probabilistic

Name:

Table Mountain Prob Fxs

Timezone

Infer timezone from selections

Start (UTC)

2021 - 7 - 25 0 : 0

End (UTC)

2021 - 7 - 29 0 : 0

Observation, Forecast pairs

Forecast: Table Mountain Boulder CO Day Ahead Prob Persistence ghi remove

Observation: Table Mountain Boulder CO ghi

Uncertainty: Ignore uncertainty

Distribution

Reference Forecast: Unset remove

Prob( x ) = 10 %

Reference Forecast: Unset remove

Prob( x ) = 90 %

Reference Forecast: Unset remove

Create Forecast Evaluation pairs ▾

Distribution Metrics

CRPS

CRSS

Binary Metrics

BS

BSS

REL

RES

UNC

QS

QSS

Categories

Total

Year

Season

Month of the year

Hour of the day

Date

Day of the week



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# Example Report

## Table Mountain Prob Fxs

[Recompute report](#) [Clone report parameters](#)

This report of forecast accuracy was automatically generated using the [Solar Forecast Arbiter](#).

This report can be downloaded as a [standalone HTML file](#), [standalone HTML file without timeseries](#) or [PDF file](#). The download is a ZIP archive that includes checksums for the report file and a PGP signature that can be used to verify the authenticity of the report. The Solar Forecast Arbiter PGP key ID is [0x22bd497c0930f8b0](#).

- Report Metadata
- Data
  - Observations and Forecasts
  - Data Preprocessing
    - Summary
    - Validation and Resampling
  - Summary Statistics
- Metrics
- Versions

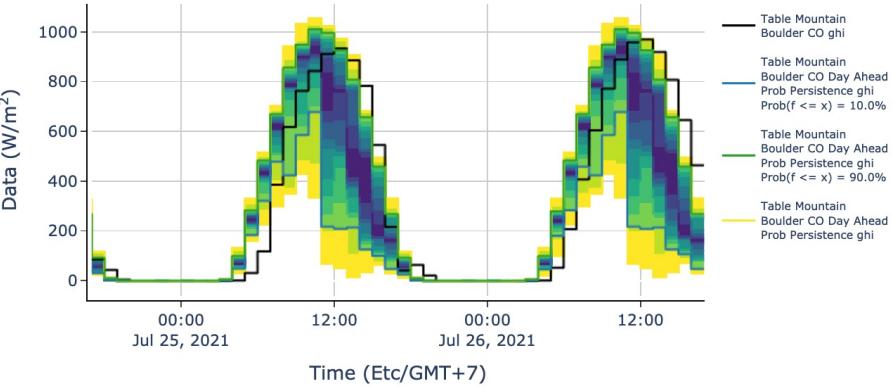
### Report Metadata

- Name: Table Mountain Prob Fxs
- Start: 2021-07-25 00:00:00+00:00
- End: 2021-07-29 00:00:00+00:00
- Generated at: 2021-07-28 20:48:12+00:00

### Data

This report includes forecast and observation data available from 2021-07-25 00:00:00+00:00 to 2021-07-29 00:00:00+00:00.

## Time series plots



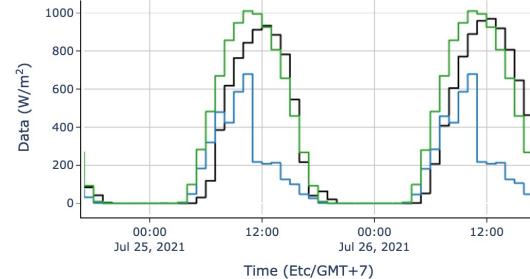
Plotly



Interactive



Downloadable



# Example Report

## Metrics Summary Table

Table of total metrics

Forecast

QS CRPS

Table Mountain Boulder CO Day Ahead Prob Persistence ghi

62.2

Table Mountain Boulder CO Day Ahead Prob Persistence ghi Prob( $f \leq x$ ) = 10.0%

160

Table Mountain Boulder CO Day Ahead Prob Persistence ghi Prob( $f \leq x$ ) = 90.0%

64.3

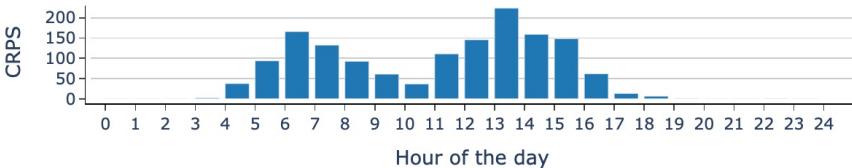
- + Forecast skill
- + Normalization
- + Deadband

# Example Report

## Plots of metrics by hour, date, etc.

### ▼ Category: Hour of the day

Table Mountain Boulder CO Day Ahead Prob Persistence ghi CRPS



### ▼ Category: Date

Table Mountain Boulder CO Day Ahead Prob Persistence ghi CRPS



### ▼ Category: Hour of the day

Table Mountain Boulder CO Day Ahead Prob Persistence ghi Prob( $f \leq x$ ) = 10.0% (

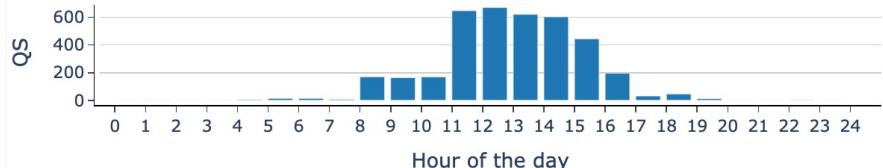
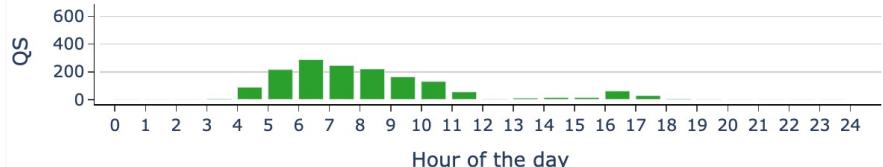


Table Mountain Boulder CO Day Ahead Prob Persistence ghi Prob( $f \leq x$ ) = 90.0% (



# Solar Forecast Arbiter Components

## Tool for analyzing accuracy of solar forecasts

- Web-based user interface
- Web-based API for scripting
- Python software package for analysis
- Scripts to redeploy entire software stack
- Detailed supporting documents
- Supported by stakeholder input, feedback

The screenshot shows the GitHub repository page for "solarforecastarbiter". It features three main repository cards:

- solarforecastarbiter-core**: Core data gathering, validation, processing, and reporting package for the Solar Forecast Arbiter. Last updated 19 hours ago.
- solarforecastarbiter-api**: HTTP API and database schema for the Solar Forecast Arbiter. Last updated 5 days ago.
- solarforecastarbiter\_dashboard**: Templates and code for rendering the Solar Forecast Arbiter dashboard. Last updated 19 days ago.

On the right side, there are sections for "Top languages" (Jupyter Notebook, Python, HTML, Dockerfile, TSQL), "People" (a grid of profile pictures), and a "Customize pins" button.

Open source. Transparently developed on GitHub

# How to get started

## 1. Make free user account

- [dashboard.solarforecastarbiter.org](https://dashboard.solarforecastarbiter.org)
- Browse reference data, forecasts

## 2. If you like it

- Sign the Use Agreement
- Experiment with a small problem, upload some test data

## 3. If you love it

- Help us test the operational forecast trial feature
- Spread the word
- Contribute to the open source code development on GitHub

## 4. Stay informed

- [solarforecastarbiter.org/emailist](https://solarforecastarbiter.org/emailist)

*Just announced:  
Operational forecast  
trial with SRP*

# Summary

- Open source, reproducible, transparent framework
- Use cases tailored to needs of forecast stakeholders
- Reference datasets
- Secure, private data upload. Sharing optional.
- Benchmark forecast capability
- Automated reports including bulk metrics, analysis filters
- Use dashboard, sign up for project updates at:

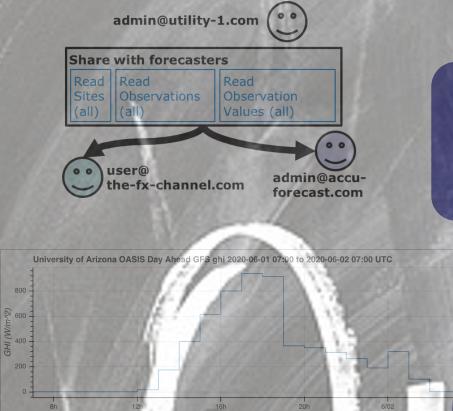
[solarforecastarbiter.org](http://solarforecastarbiter.org)



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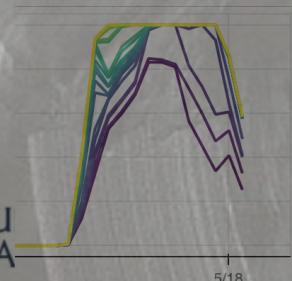
# solarforecastarbiter.org



## Solar Forecast Arbiter API

Download OpenAPI specification: [Download](#)

Graphical reporting  
Automated workflow



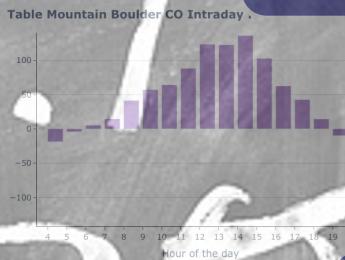
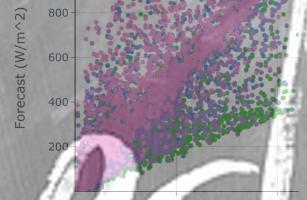
THE U  
OF A  
Sandia  
National  
Laboratories

Standardized  
Objective  
Open source

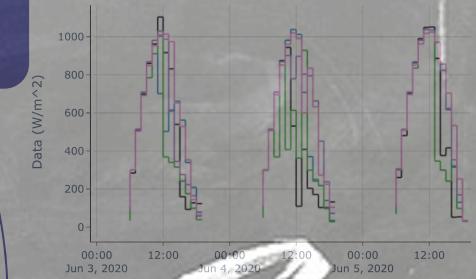
# GitHub

Free!  
Available now!

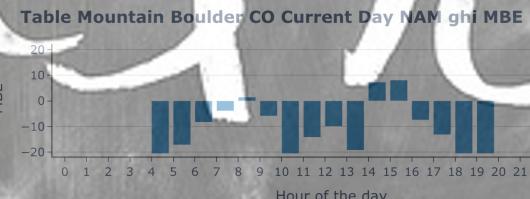
Safe, secure,  
private  
Data rights  
management



Stakeholder  
Informed



Multi-vendor  
trials  
Anonymization  
Realtime and  
Retroactive



Deterministic  
Event  
Probabilistic

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Data quality  
control  
Reference data  
& forecasts

