A tailored solar power forecasting system for optimized grid management in Tahiti, French Polynesia

Damien Raynaud, Pierre Besson, Elena Escudero-Ramos, Guillaume Tremoy

International Conference Energy & Meteorology, Padova 27-29 June, 2023

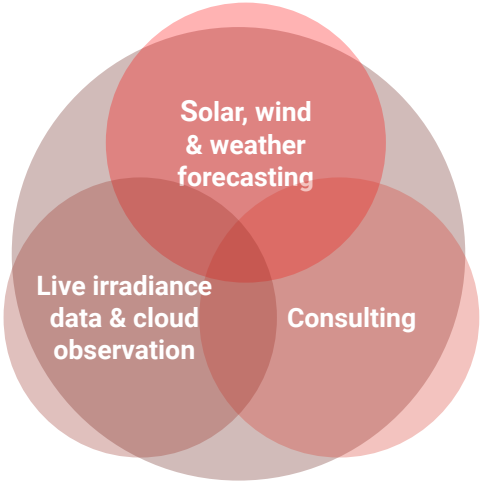
About Steadysun

Some key information

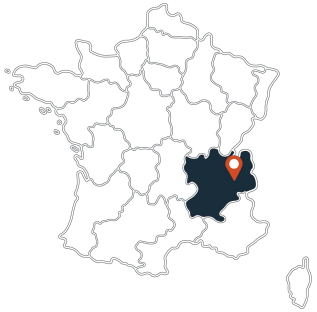
Better predictability

Less risk

More renewables



Location



Key Figures

Founded in **2013**
25 employees
6 PhD level
Turnover : ~**+25%**/year
14,000 sites covered

Our expertise

Solar & Wind Technologies,
Meteorology,
Image Processing,
Data Science, AI
IoT & Web Services.

Our partners

Spin-off from

cea

ines NATIONAL INSTITUTE OF SOLAR ENERGY

steadysun

About Steadysun

Our three main forecasting products

steadymet

“day-ahead” Forecasting

6 hours to 15 days

Based on meteorological models

steadysat

“intraday” Forecasting

30 min to 6 hours

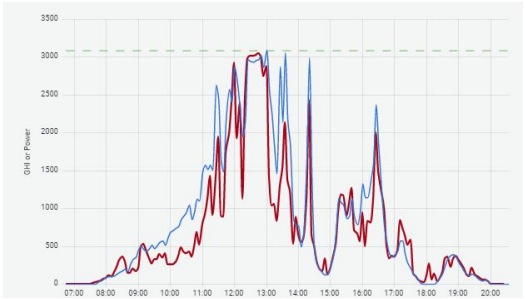
Based on satellite imagery

steadyeye

“very short-term” Forecasting

5 to 30 min

Use of a sky imager installed on site



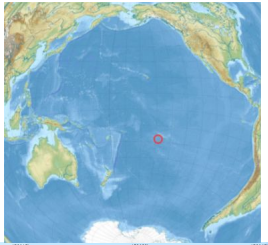
The Tahitian power grid

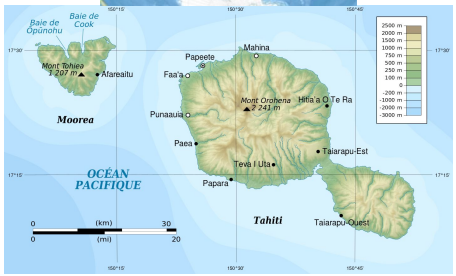
The power mix

148 MW
2 thermal plants
(8 diesel generators)

48 MW
18 hydropower plants

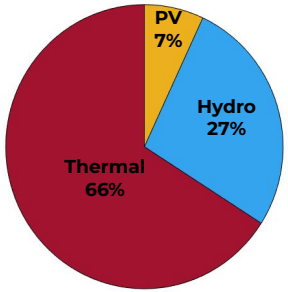
15 MW / 5 MWh
Virtual Synchronous Generator





44 MWp
>3200 rooftop PV installations

30 MWp
4 PV+storage plants
(2024)



520GWh total electricity production (2021)

(Source EDT Engie)

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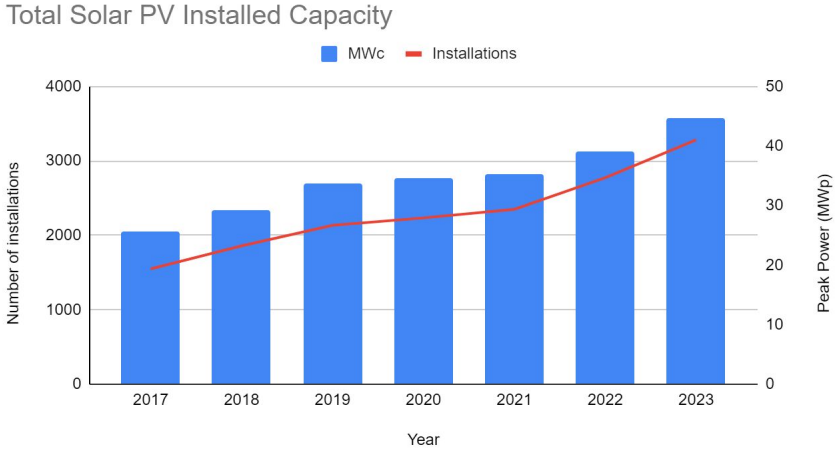
The Tahitian power grid

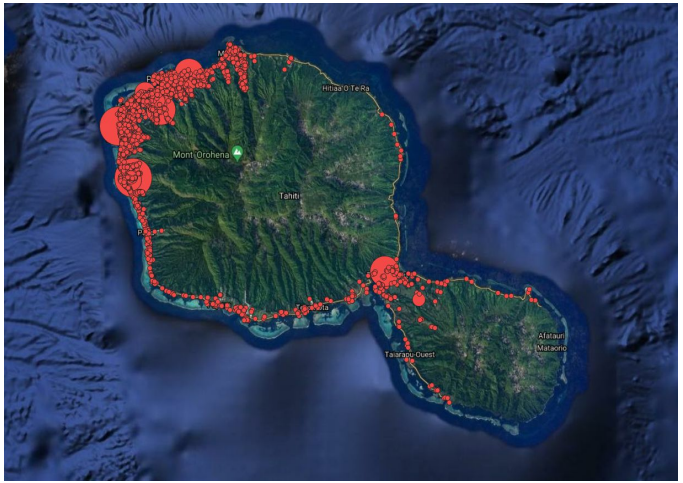
An increasing share of PV power



The PV installed capacity is increasing every year

Obj. 2020 : 50% renewable power
Obj. 2030 : 75% renewable power

Locations and sizes of the >3200 pv power plants in Tahiti



- More than 3200 real PV plants, mostly on-roof
- Distributed all around the island, mainly on the coast
- More installed capacity in the north-western coast

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The Tahitian power grid

Forecasting needs

Maximize the use of RE while ensuring power network stability

How to ensure demand/supply balancing and scheduling of the different generation units (hydropower, gensets)?

➔ **12 hours ahead** total PV production probabilistic forecasts, updated every 1 hour

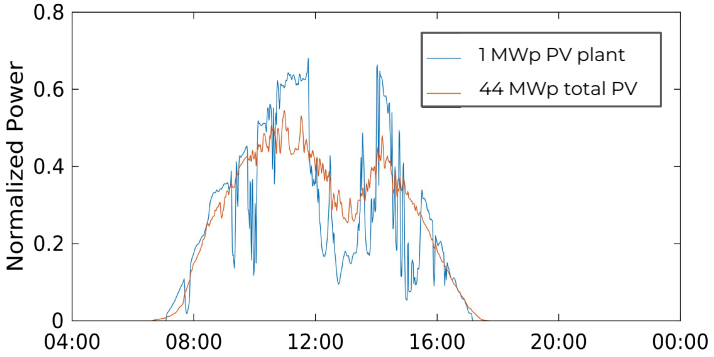
How to limit the use of spinning reserves (fuel saving, maintenance costs)?

➔ **10-30 minutes ahead** total PV production probabilistic forecasts, updated every 1 min

How to integrate PV+storage production (safe and stable operations)?

➔ **12/8/5 hours ahead** PV+storage production forecasts, updated every 6 hours (trapezoidal power profile provided by plant operators)

Typical daily PV production profile



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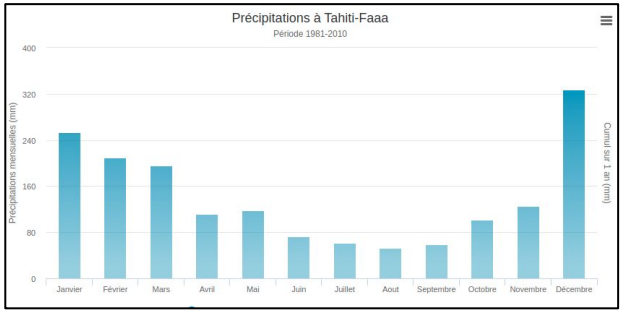
The Tahitian climate

Large scale weather patterns

Tahiti has a tropical climate with an wet season (Dec to Mar) and a dry season (Jun to Oct)

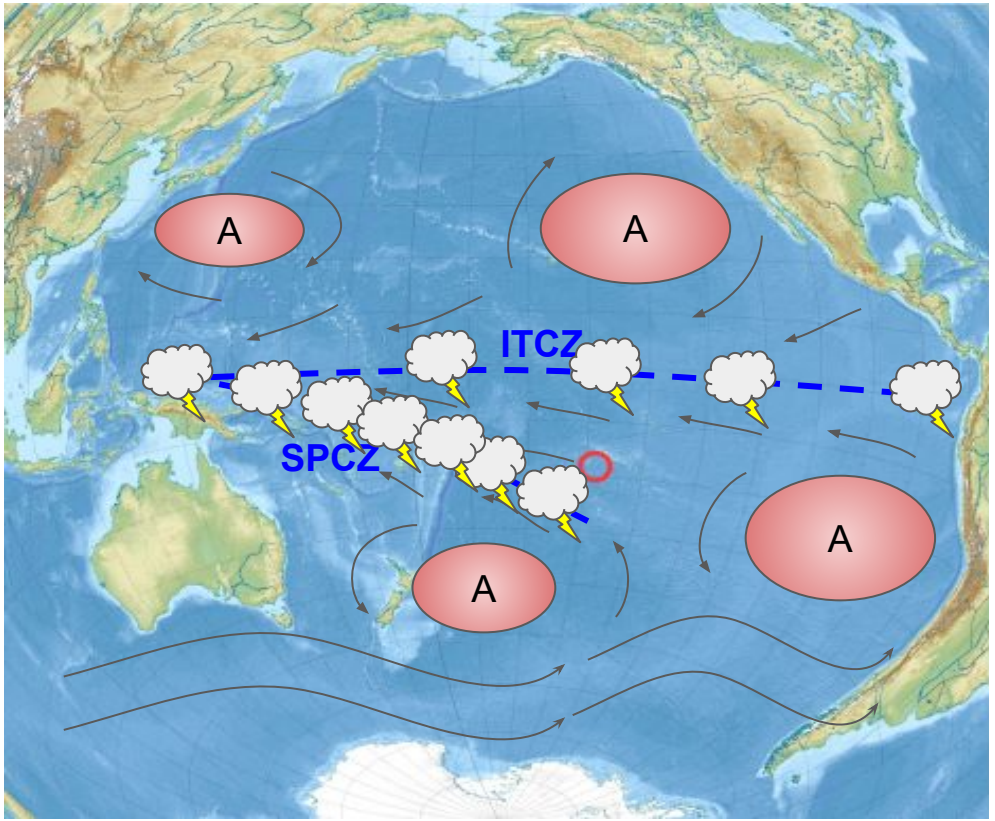


(Source Infoclimat)

Two convergence zones drive most disturbances:

⇒ Inter-Tropical Convergence Zone
⇒ South Pacific Convergence Zone

Some Subtropical disturbances coming from the South can also affect the island



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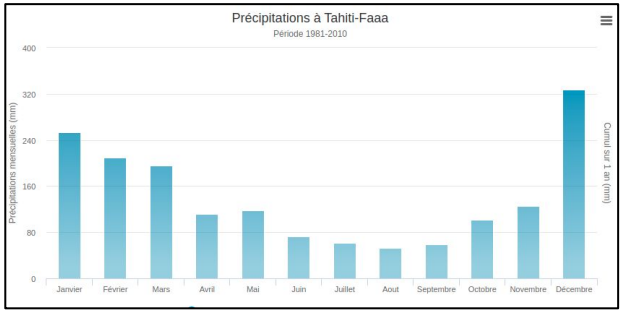

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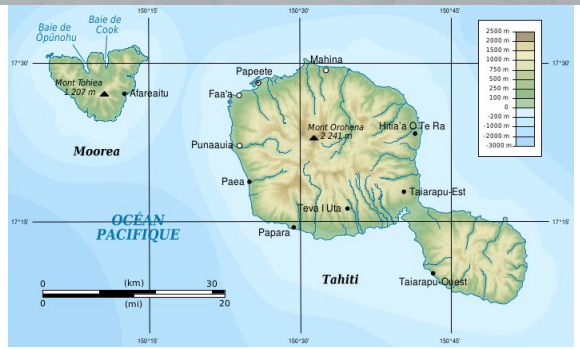
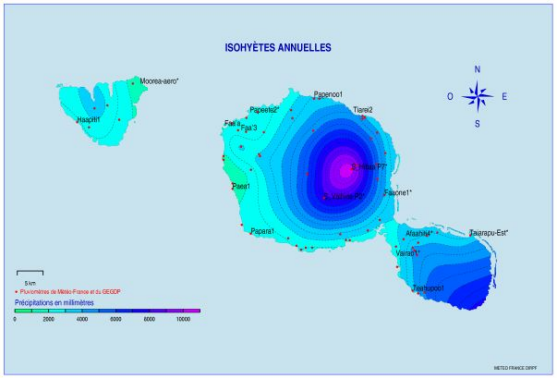
Interaction with the topography

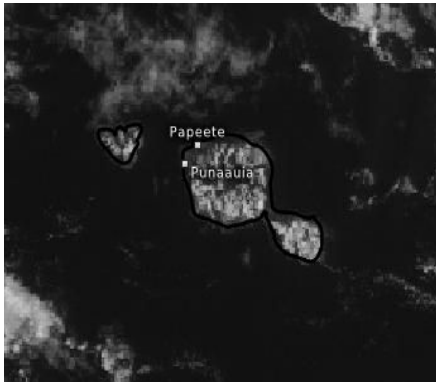


Topography

Annual precipitations
(Source Météo-France)



Satellite image



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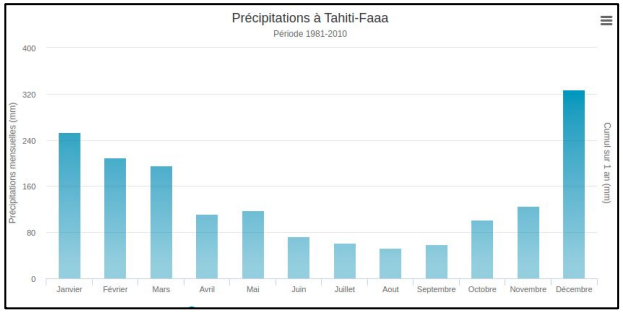

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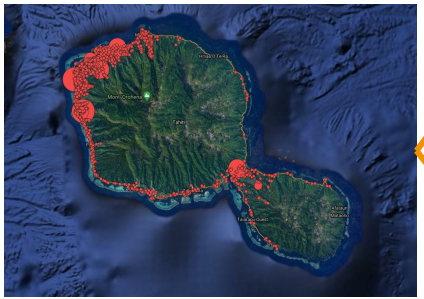
PV forecasting in Tahiti

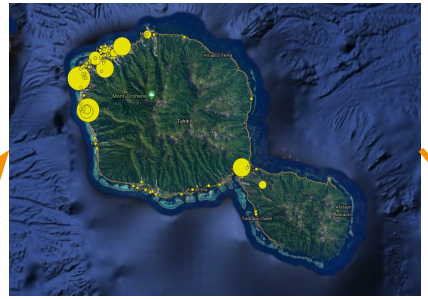
Modelling the PV park

From >3200 real PV plants to 1 aggregate

Actual distributed PV
(>3200 real plants, 44 MWp)

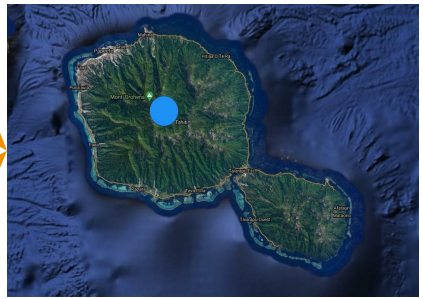


Modeled distributed PV
(38 monitored pv plants, 16 MWp)



Modeled distributed PV
(35 virtual plants, 28 MWp)

Modeled total PV
(1 aggregate, 44 MWp)



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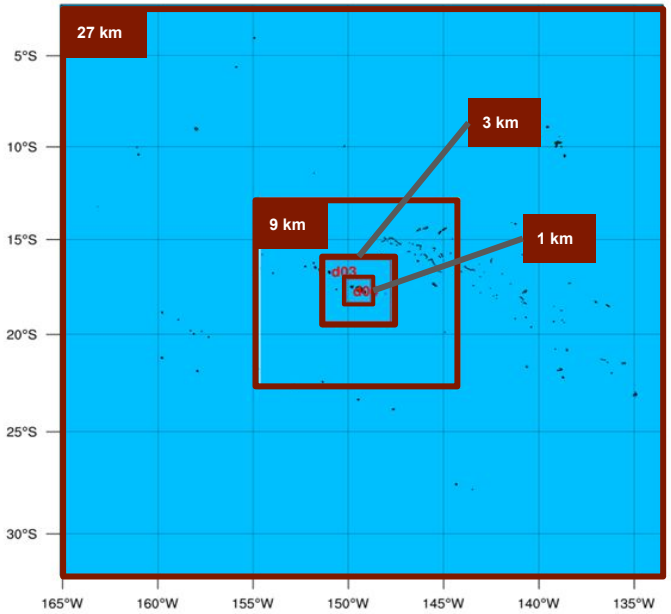
H+12 forecasts

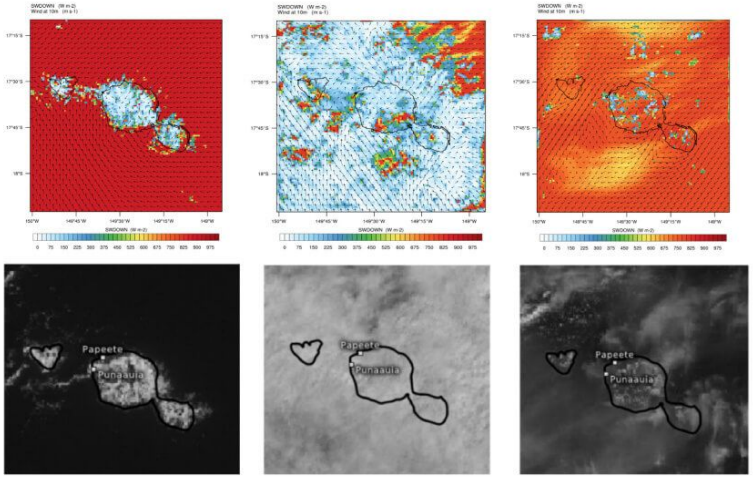
The WRF regional model

Model setup with 4 nested domains



WRF simulations

WRF is a regional model that can be implemented and calibrated anywhere in the world



Examples of WRF simulations versus satellite images

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H+12 forecasts

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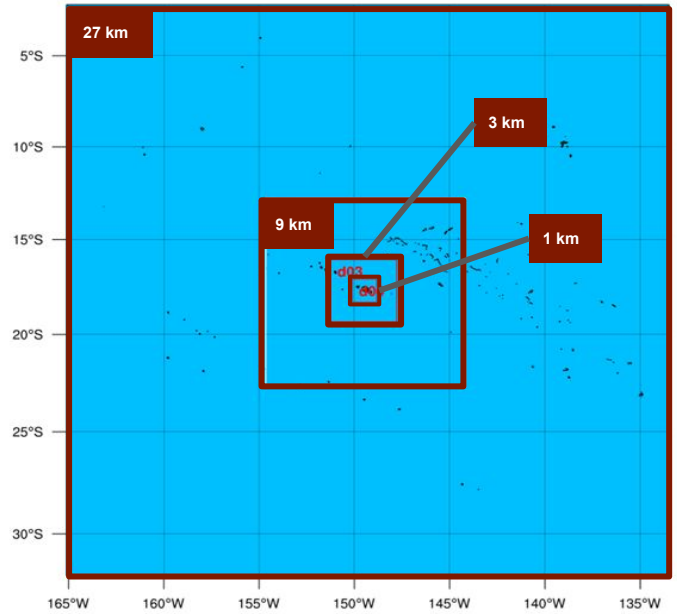

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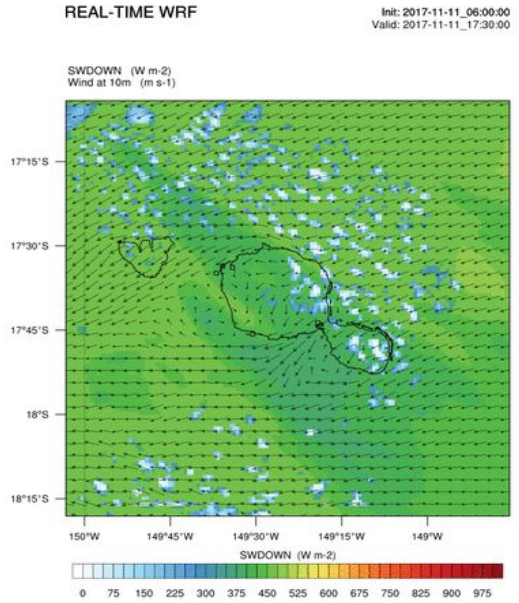

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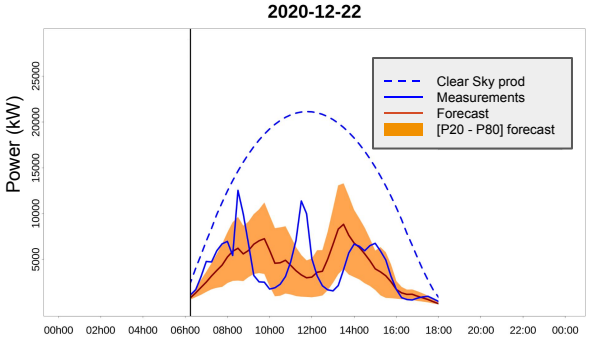
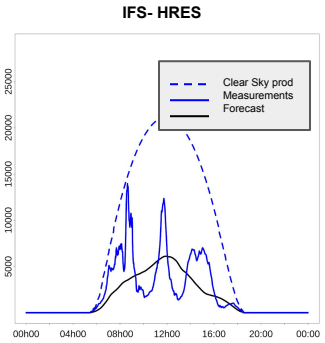
H+12 forecasts

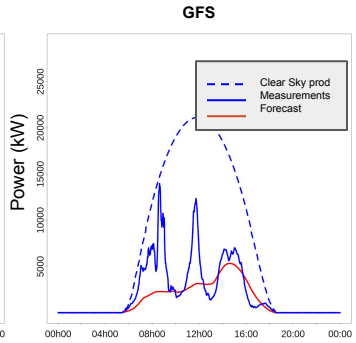
SteadyMet: a multi-model / multi-run mix

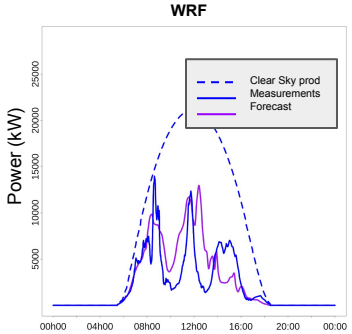
Date : 2021-03-02

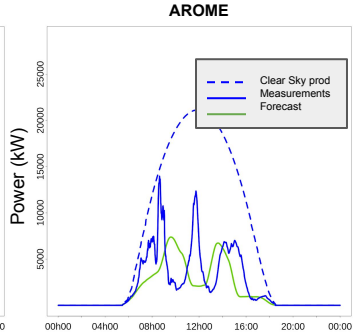
Model	Domain	Provider	Spatial Resolution	Temporal Resolution
GFS	Global	NOAA	25km	3h
IFS-HRES	Global	ECMWF	12km	3h
AROME	France	Météo France	2.5km	1h
WRF	150x150km	Steadysun	1km	10 min

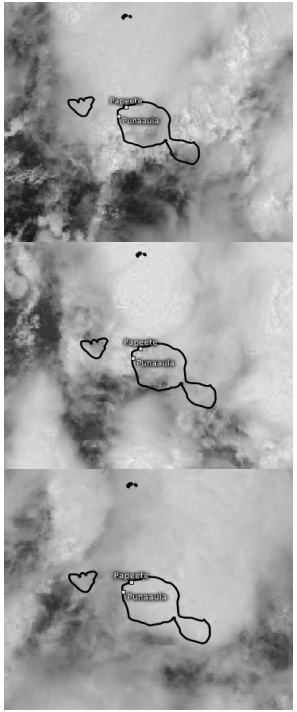












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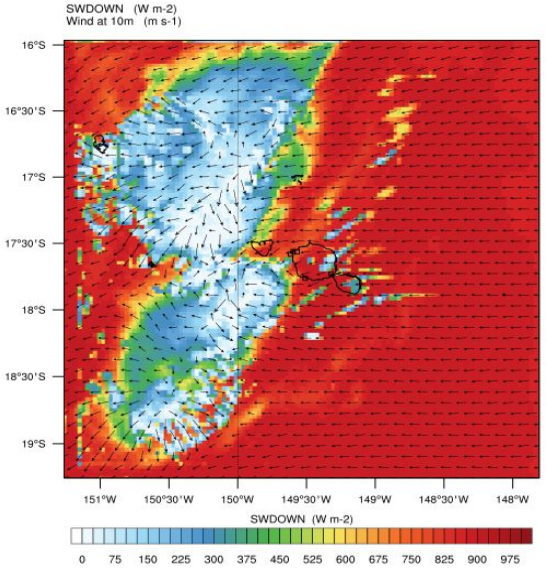
H+12 forecasts

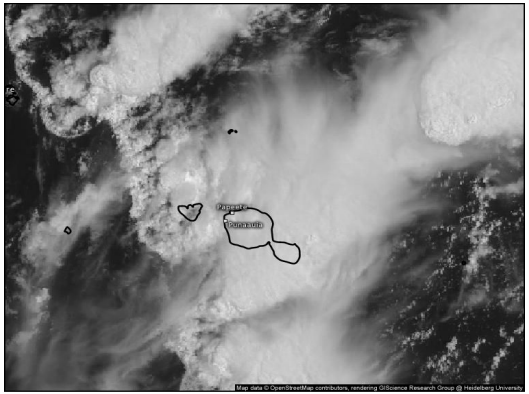
Developing a spatial confidence indicator

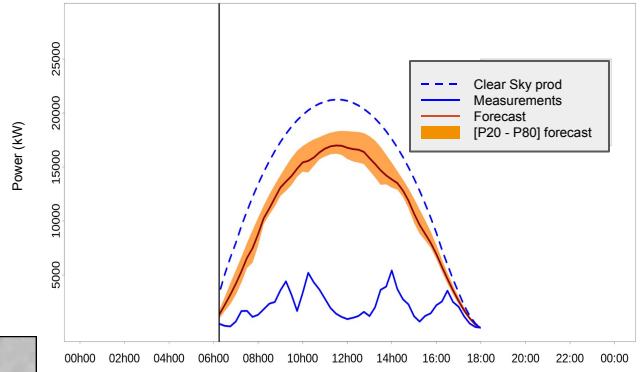
Sometimes, ensemble, multi-model and multi-run forecasting is not sufficient to estimate the uncertainty



WRF global horizontal irradiance forecast

Satellite image





PV power forecast versus measurements

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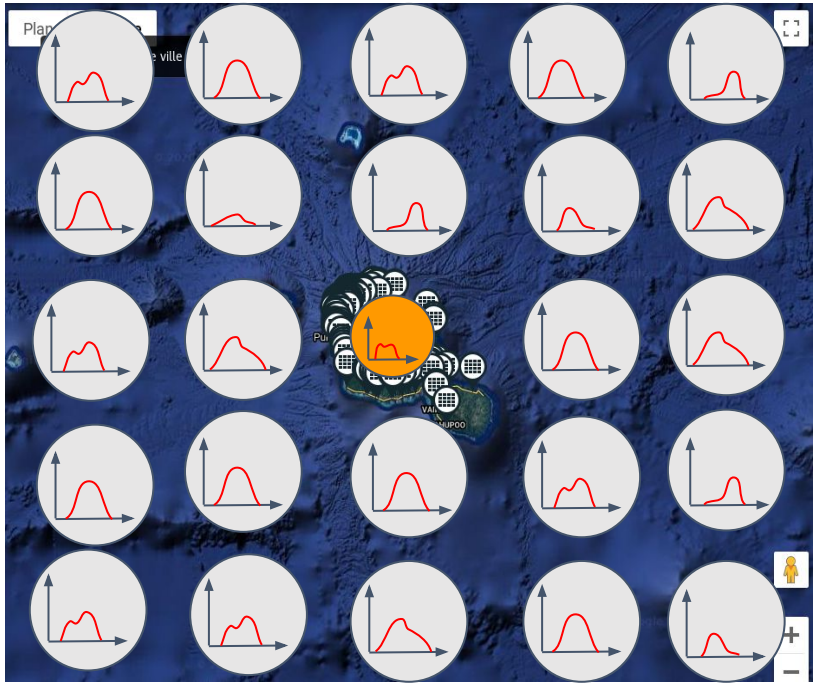
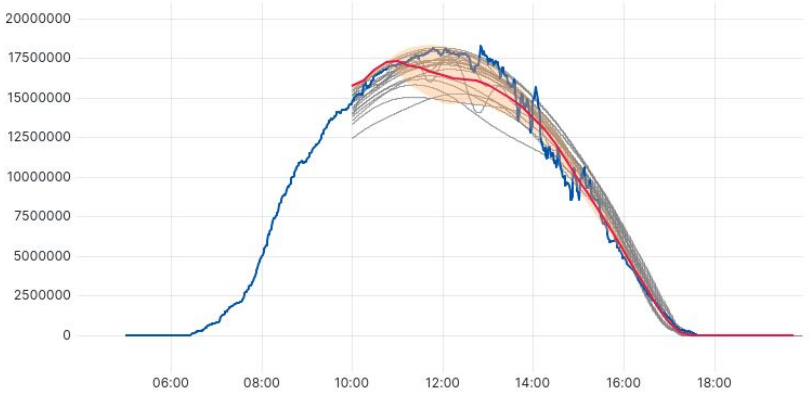
H+12 forecasts

Developing a spatial confidence indicator



24 PV power forecasts around the island

As numerical weather models have difficulties forecasting the location of thunderstorms we create an ensemble forecasts from 24 virtuals plants around the island.



Comparison between the local forecast (red line) with the surrounding ones (grey lines)

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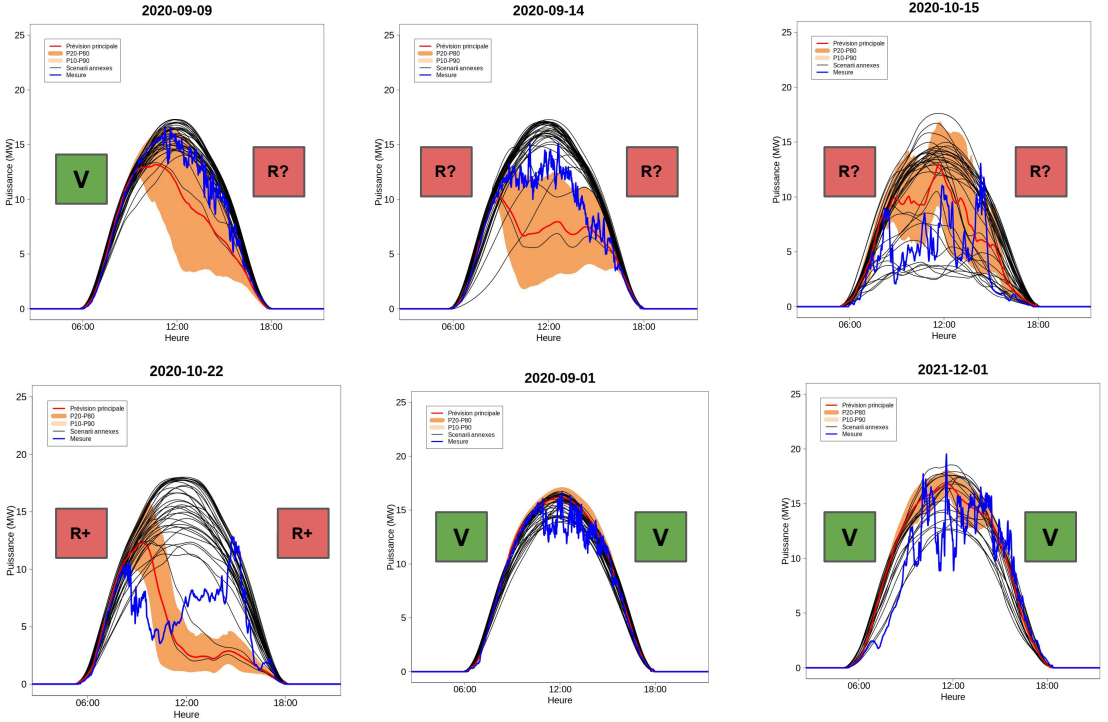
H+12 forecasts

Developing a spatial confidence indicator

The confidence indicator is provided at 4 am for both morning and afternoon with an update at 10 am.

The indicator can be:

- **V** — Good confidence in the forecast
- **R+** — Risk of much higher PV production than forecasted
- **R-** — Risk of much lower PV production than forecasted
- **R?** — Large uncertainty



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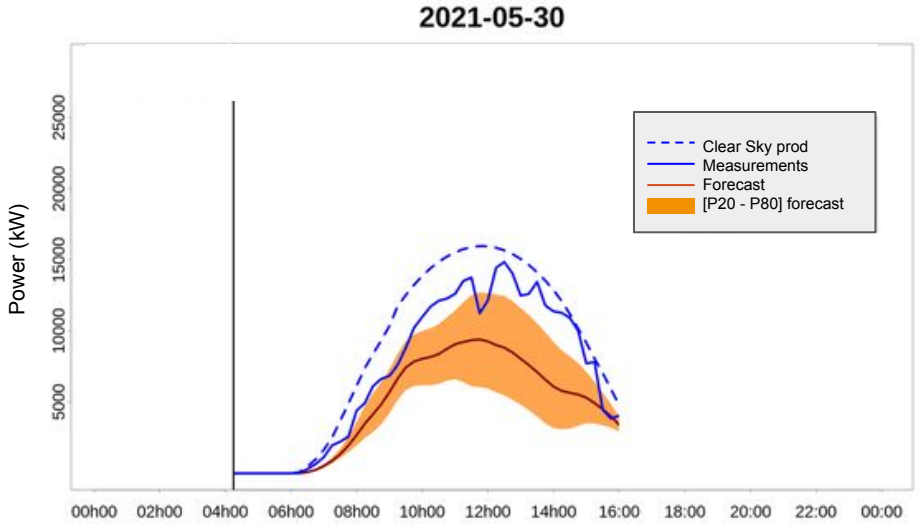
H+12 forecasts
Live correction

Correcting the forecast with power measurements reduces some of the errors made by the forecast in the first few time steps (H+4 max).

- Forecast-measurement comparison over the previous hour
- Weighting (more weight given to recent deviations than to those at H-1)
- Progressive return to the raw forecast from H+0 to H+4



H+12 forecasts

Full information visualisation

12h PV power forecast time series (average and quantiles)

12H PV forecast (average, 20% and 80% quantiles)

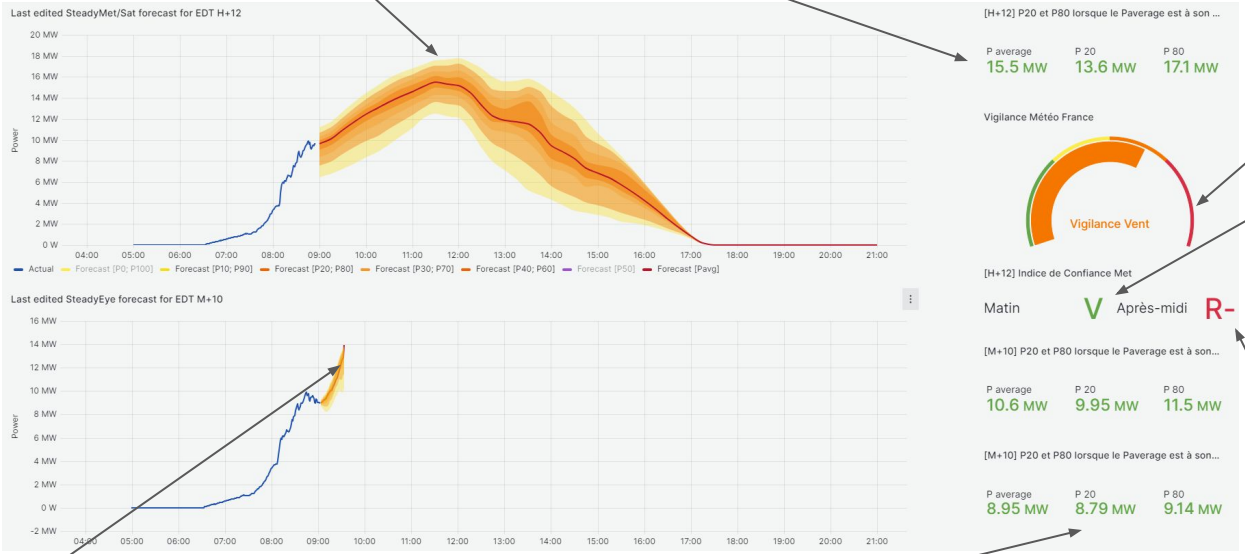
Weather warning from Météo-France

Morning confidence indicator

Afternoon confidence indicator

30min PV power forecast time series (average and quantiles)

10min PV forecast (average, 20% and 80% quantiles)



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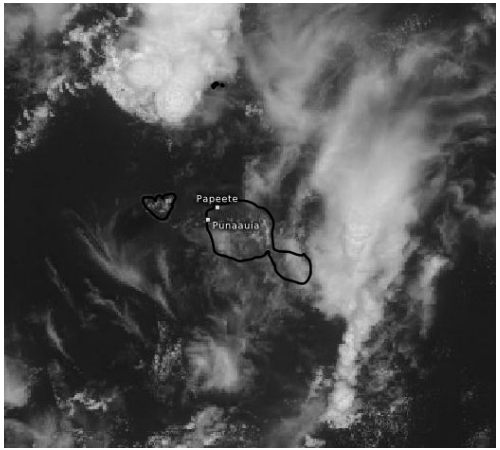
There is still room for improvement: Data assimilation in WRF, ensemble forecasting with differents forcings/parameterizations, AI...

THANK YOU



THANK YOU

More information on the tahitian power grid and all of our forecasting services delivered there for >6 years can be found on the following poster:

Solar energy assessment and forecasting in insular regions: the Tahiti case study	Guillaume Tremoy

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