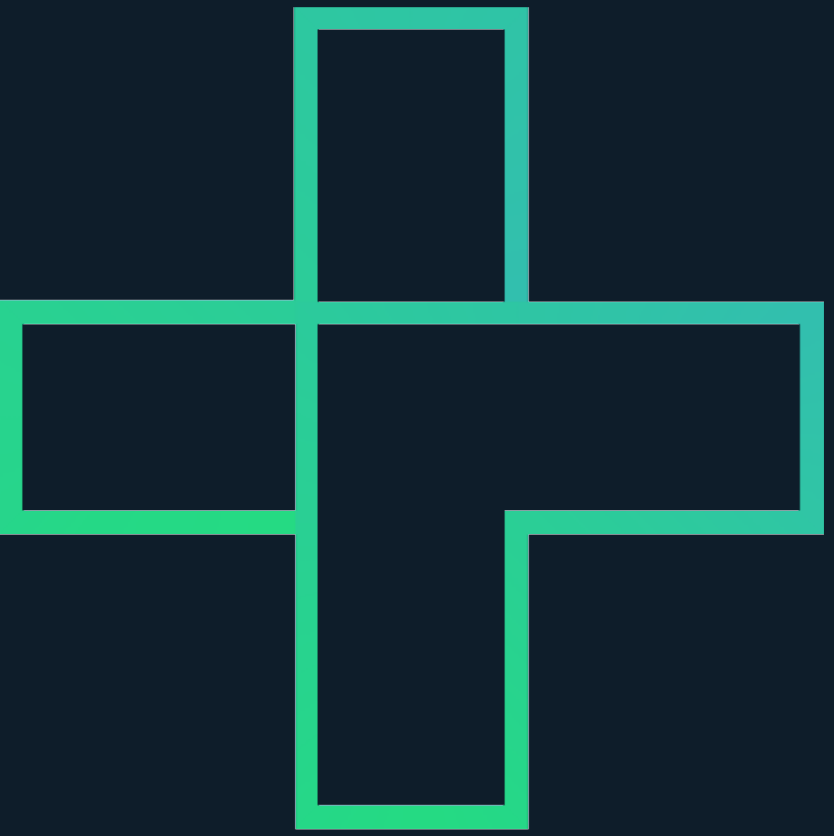


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Forecasting Wind Ramps with Scanning Lidar to Minimize Wind and Solar Park Damages and Operational Costs

Andrew Black, Laurie Pontreau, Darshan Sathiyanarayanan, Susana Jorquera

Internal

Agenda

- Wind Ramps Impact on Solar farms and Wind farms
- Solution overview
- Windcube Scan Technology
- Wind ramp example
- Solution software preview
- Processed detection example
- Results on 2 campaigns
- Call to action

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Wind Ramp Impact

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Wind Energy

- Energy trading: cause production – forecast mismatches, leading to grid imablance penalties, higher costs and revenue losses
- Wind turbine safety and insurance: increase turbine loads, raising the risk of damage and sortening equipment life
- Construction & Maintenance: Accurate short-term wind monitoring secures safer lifting and craning operations and helps optimize work windows

Solar Panels safety

- Sudden gusts can lead to catastrophic damages on solar power plants, solar trackers and heliostats
- Stowing trackers before the gust hits is critical to reduce loads and protect the assets
- Unnecessary stow can negatively impact power generation

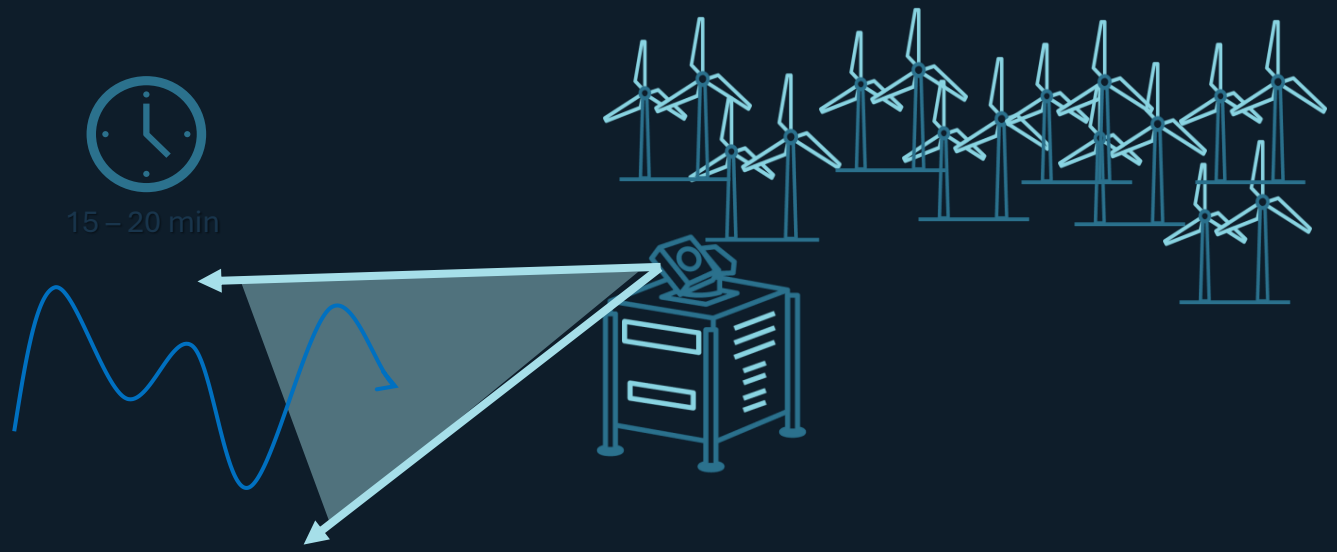




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Lidar-based short-term forecasting solutions

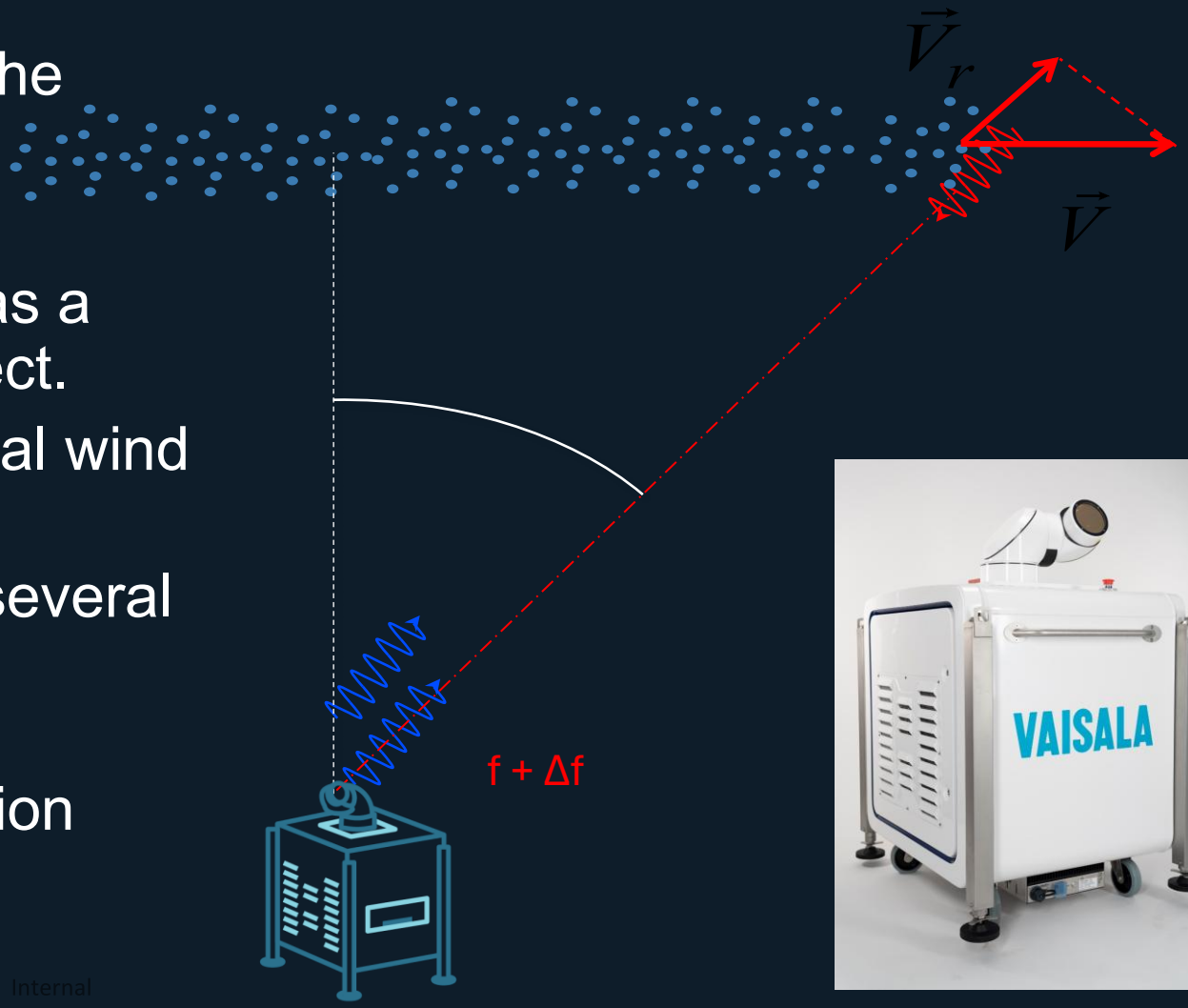


- Detect wind variations ~15-20 minutes before reaching the wind farm by measuring wind conditions 10 kms ahead a wind farm
- A long-range scanning wind lidar provides a detailed wind mapping from 200m to 10+ kms which enables to detect and track strong wind variations all around or in targeted areas

Internal

Technology: Doppler Pulsed Lidar

- Laser signal (λ=1.54μm) emitted into the atmosphere.
- Backscattered by moving aerosols
- If they are moving, the return signal has a different frequency by the Doppler effect.
- Doppler shift is proportional to the radial wind speed.
- Backscattered signal is processed at several distances simultaneously.
- Reconstructions using the full scan determine wind speed and wind direction

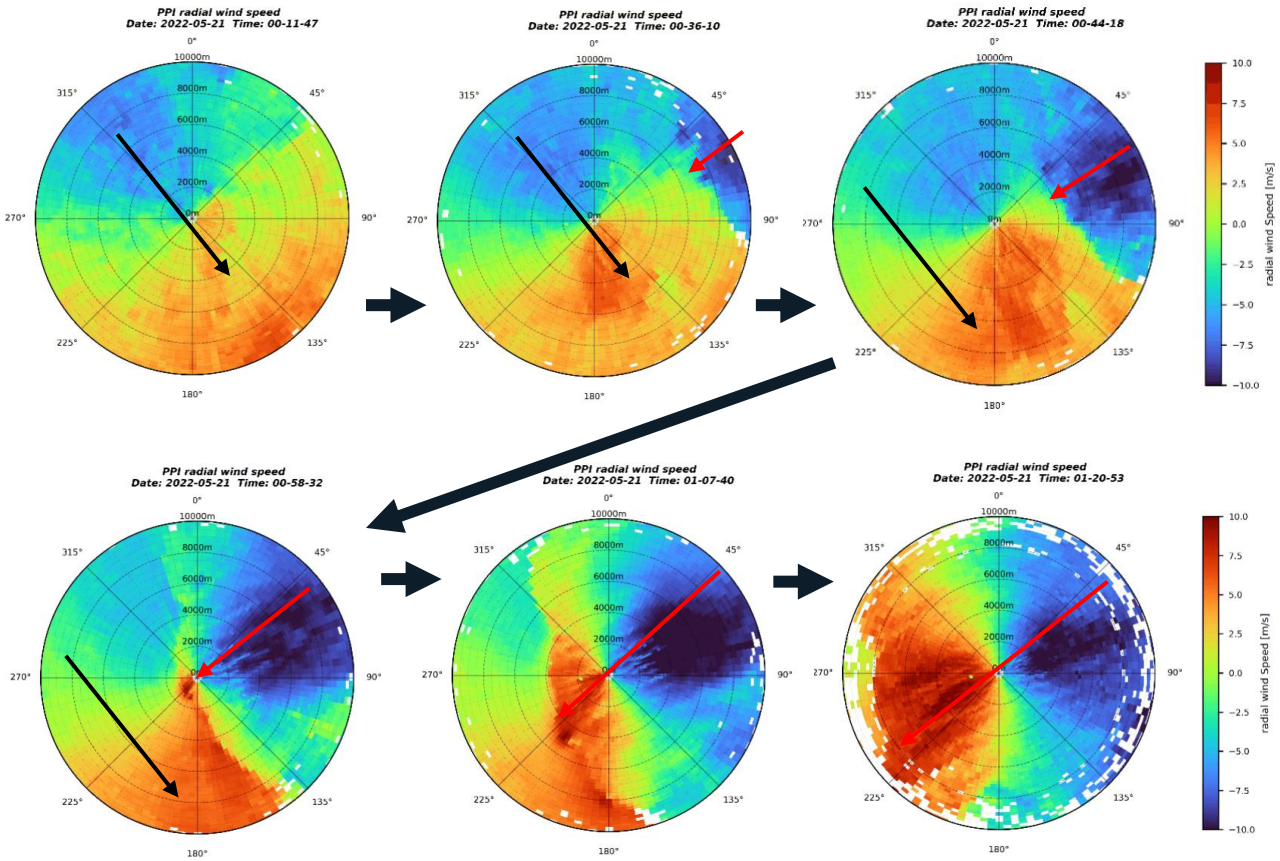


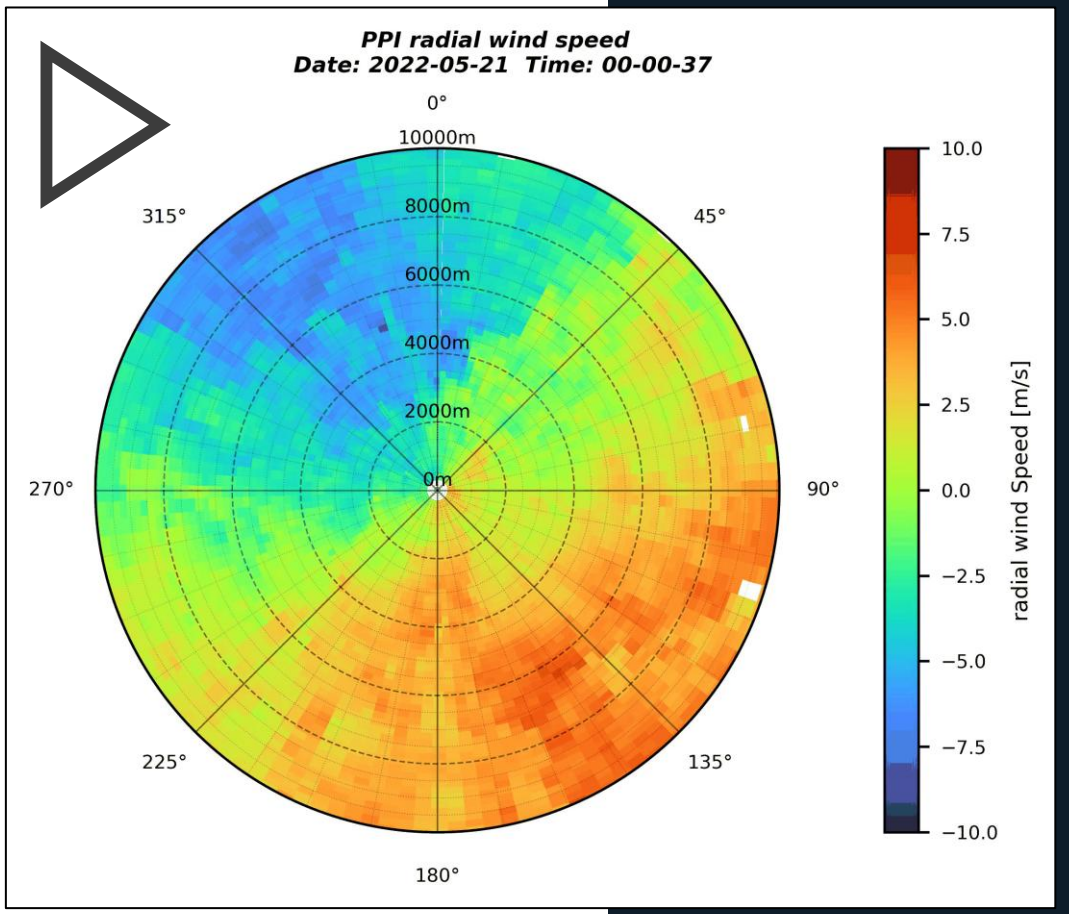
Internal

Space & time coherent variations are measured and tracked by a WindCube Scan

Black arrow: Wind direction before the weather front

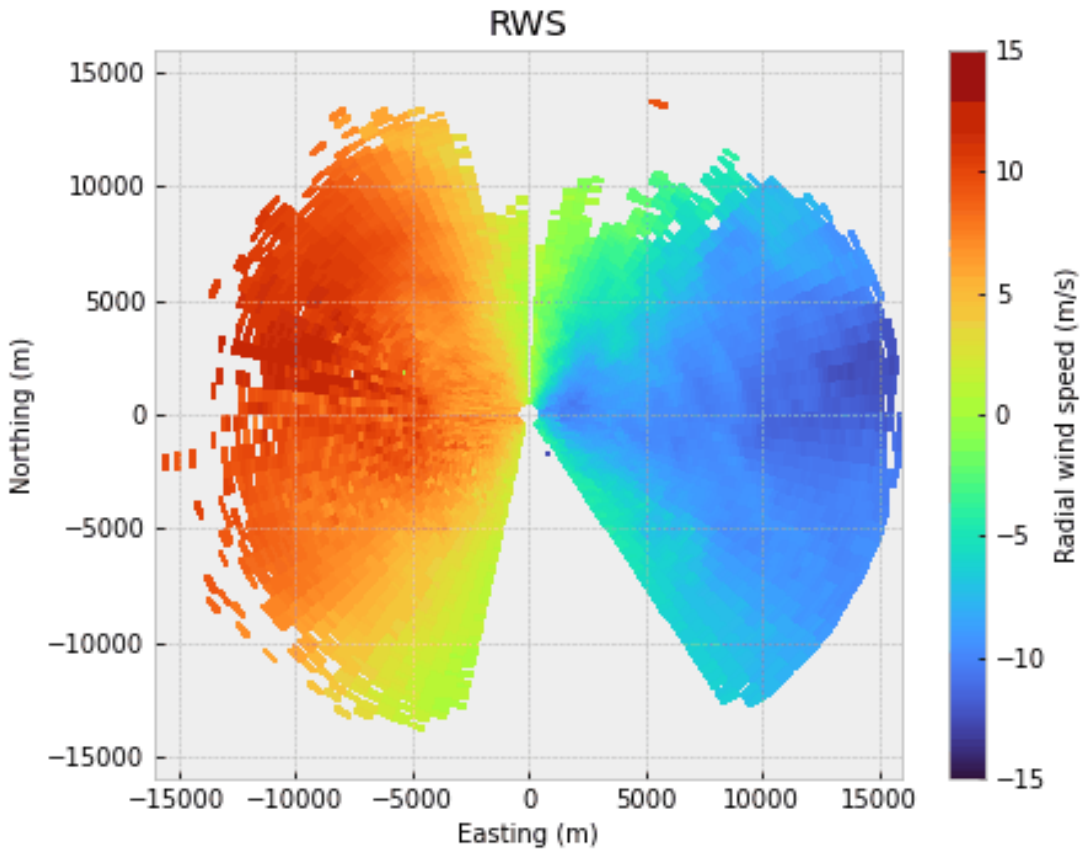
Red arrow: Wind direction after the weather front

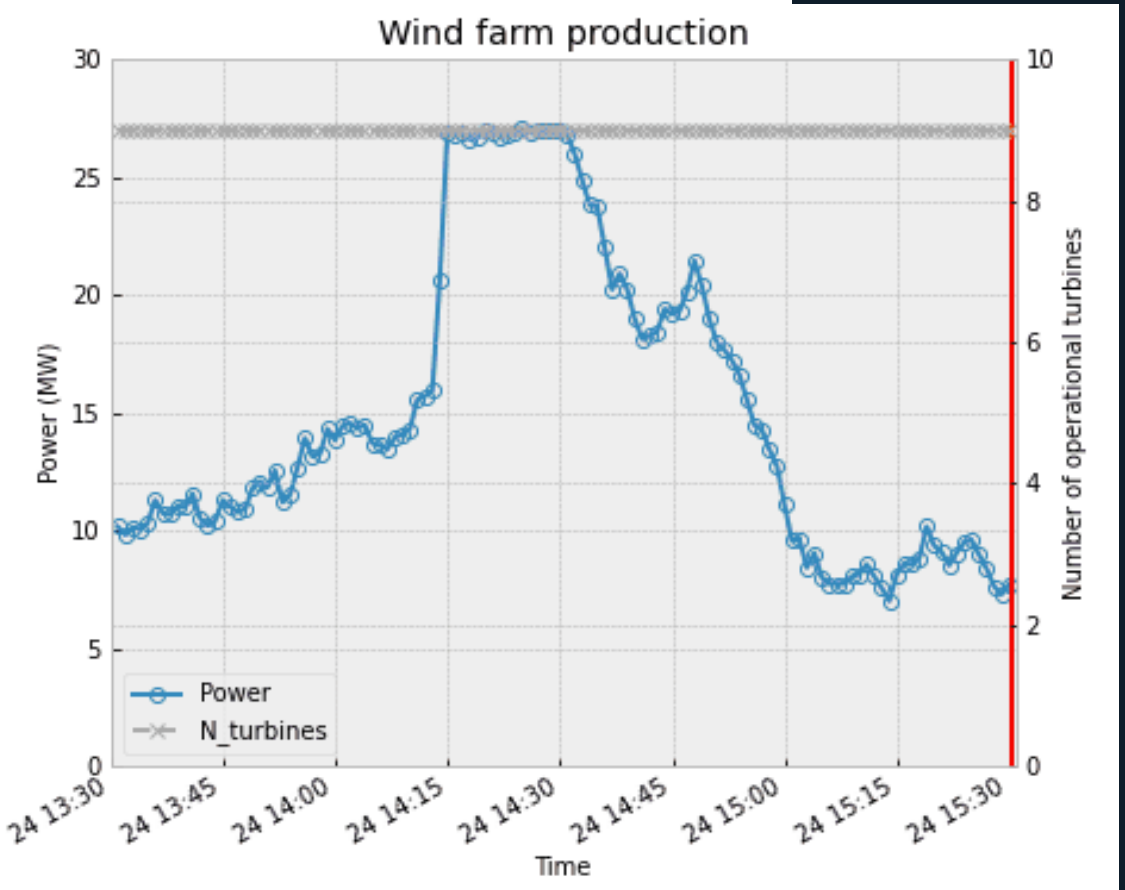




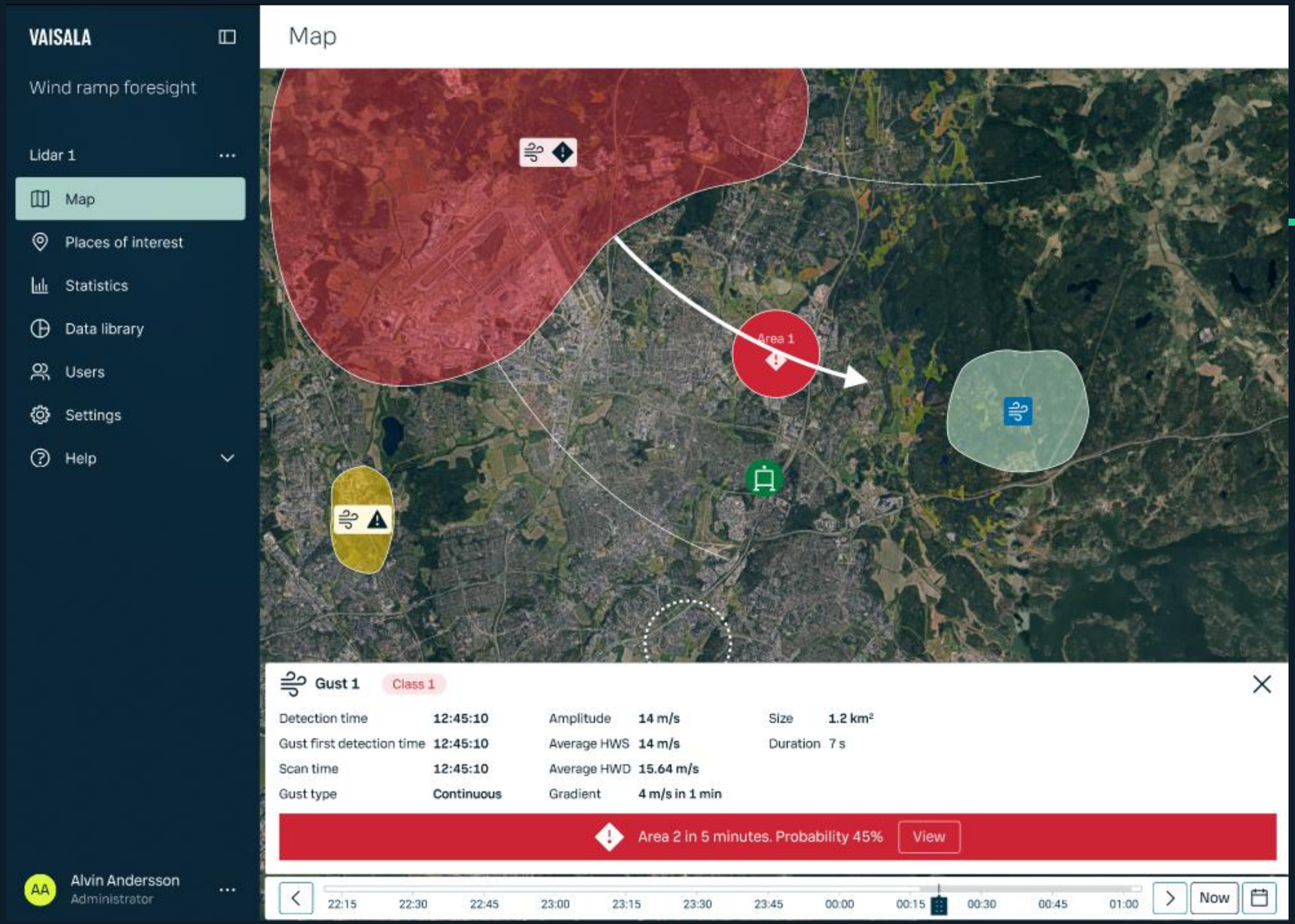
10km range wind measurement – 360°

Real-time Wind ramp detection and tracking from operational wind farm project





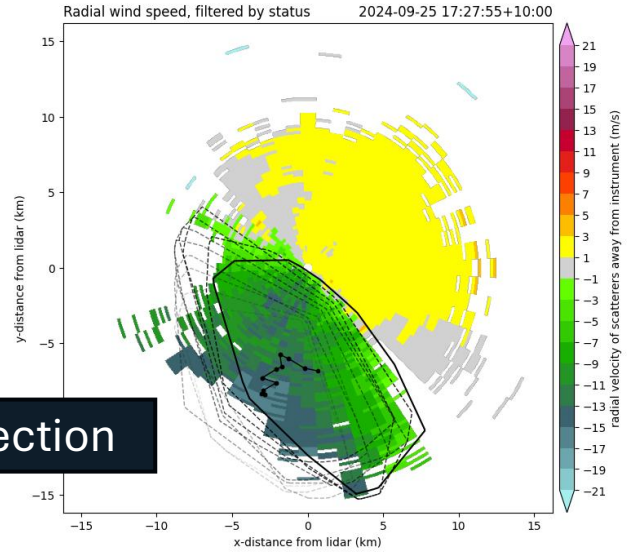
Solution software preview



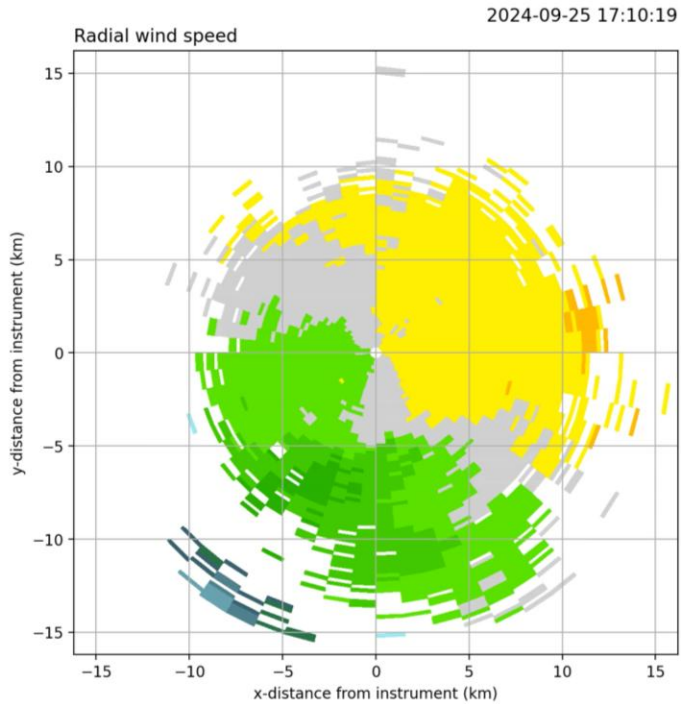
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Wind ramp feature forecast

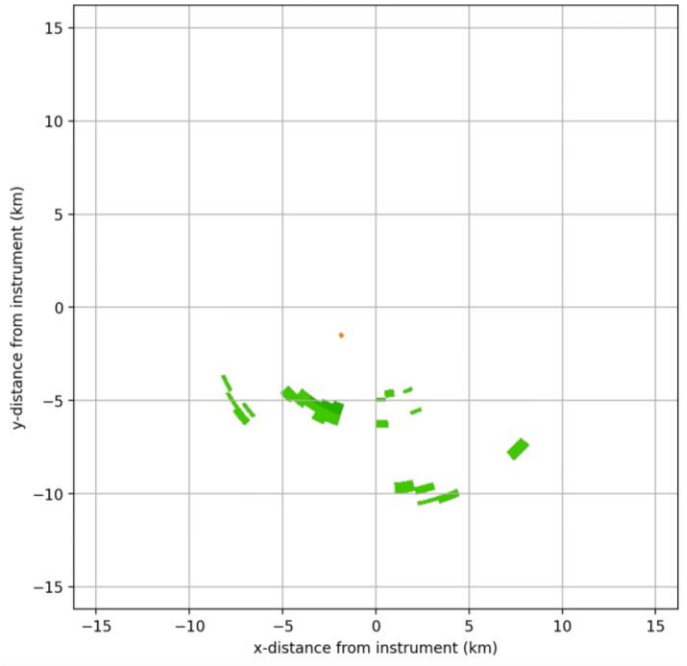
- Improve forecasting with wind ramp feature detection and forecasting
- Instead of full wind field maps, forecasting systems ingest wind ramp features and propagation information



History of detection



Wind ramp forecast



Solid black line:
actual detected gust

Solid Red line:
estimated propagation of the gust

Dashed red line:
the one really detected in the future for validation purposes

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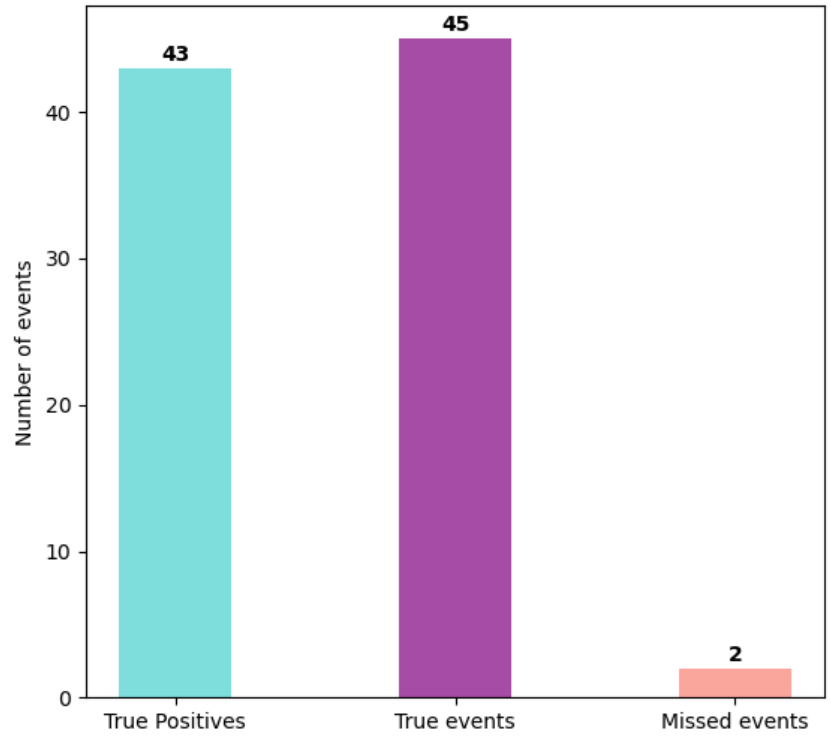
Results – Wind Energy campaign

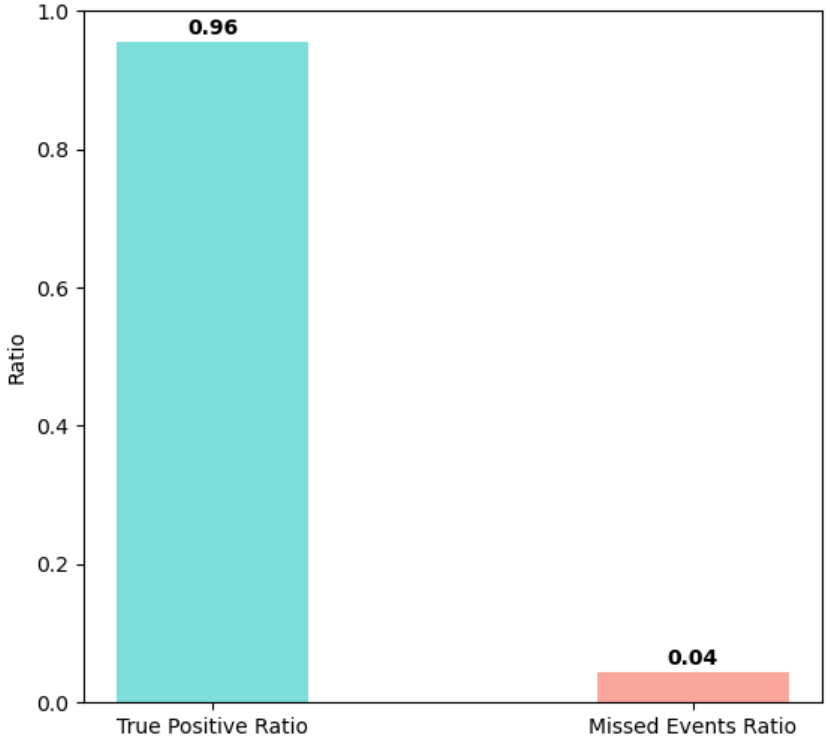
Reference data	Campaign	Results
SCADA data on site (1min) Threshold applied : • Gradient of gust ramps : **2** m/s /5min • Amplitude of Wind ramps : **5** m/s	2 years of data	True positive : **204 (TPR 96%)**
	True events : **213**	Missed events : 9 **(FNR 4%)** 9 due to data availability



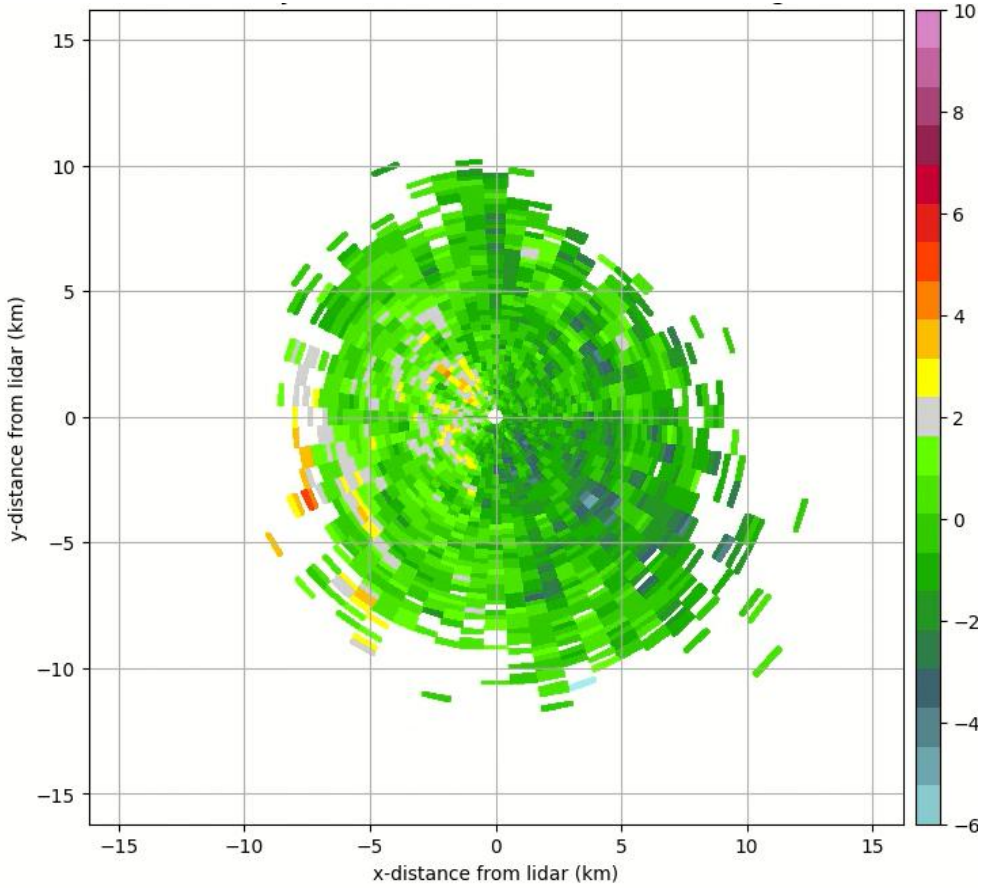
Results – Solar panel safety campaign

Reference data	Campaign	Results
Anemometer data on site (1min) Threshold applied : • Gradient of gust ramps : **3** m/s /5min • Horizontal Wind Speed : **15** m/s	9 months of data	True positive : **43 (TPR 96%)**
	True events : **45**	Missed events : **2 (FNR 4%)** 2 due to data availability





False Positive Example



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Value of mitigating wind ramp impact on the spot market

What is the monthly financial impact of wind ramps on spot market intraday 15 mins trading ?

- The average spot market imbalance price is MWh, so for a 15mins ramps period this account to around :
  - 80 € = 20 € per MW15mins
- Thus, the financial value of a single wind ramp for a 500 MW Wind farm :
  - 50 MW x 20 € = 1000 €
- At least, 50% of ramp cases cause a negative penalty following imbalance price fluctuations

	Imbalance price positive	Imbalance price negative
Positive imbalance	Payment from TSO to BRP	Payment from BRP to TSO
Negative imbalance	Payment from BRP to TSO	Payment from TSO to BRP

Wind ramp financial impact	500 MW capacity
Wind ramp of at least (Roughly 10%)	50 MW
Price per wind ramp	1000 €
Number of 10% ramps for 1 year	~ 400
Avg Yearly Financial impact of wind ramps	~ 400 000 €
Considering 50% of trades are optimized (given the imbalance price)	~ 200 000 €

Let’s first analyze your site-specific wind ramps together

Then make an informed decision on the appropriate forecasting solution

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- **Vaisala can help you characterize your site-specific :**

  - Number of wind ramps
  - Types of ramps
  - And recommend a site-specific measurement/ forecast strategy

This will help you calculate your ROI for different forecasting approaches

Do you have a 100MW site sensitive to wind ramps ?

Do you already have Scada/anemometer data on site ?

Get in touch !

We can help !

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