Estimation of wind resource assessment at high-resolution using SAR observations, validated with lidar measurements

Guillaume Vervout / METEODYN

Speaker

Guillaume Vervout

I am a **Business Development Engineer** and the **SARWind technology manager at Meteodyn, leading company in wind engineering, climatology, and meteorology**.

Founded in 2003 and has since established itself as **an expert in the wind energy field**. The company is now part of the **CLS Group, an offshore expert**, and a subsidiary of the CNES agency.

With over a year of experience at Meteodyn, I have worked on the development of SARWind in collaboration with CLS, and together we continue to push the boundaries of innovation in the offshore wind energy sector.

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Summary

1. Wind assessment: State of the Art
2. SARWind methodology: To de-risk offshore projects
3. SAR observations
4. Methodology
5. Performance of SARWind technology
6. SARWind for offshore wind assessment

Wind assessment: State of the Art

Wind assessment: State of the Art

FLOATING LIDARS

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- High precision
- High frequency
- 40-250 meters

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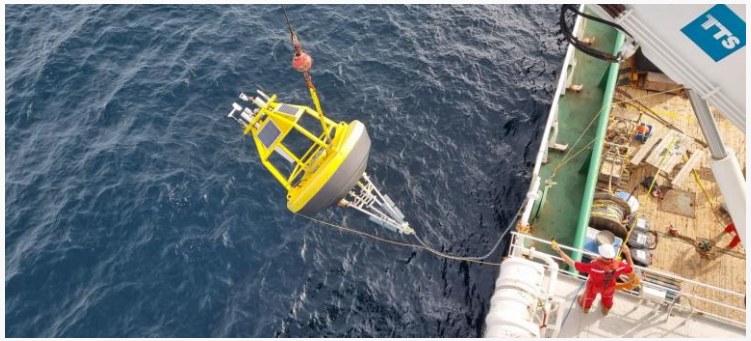
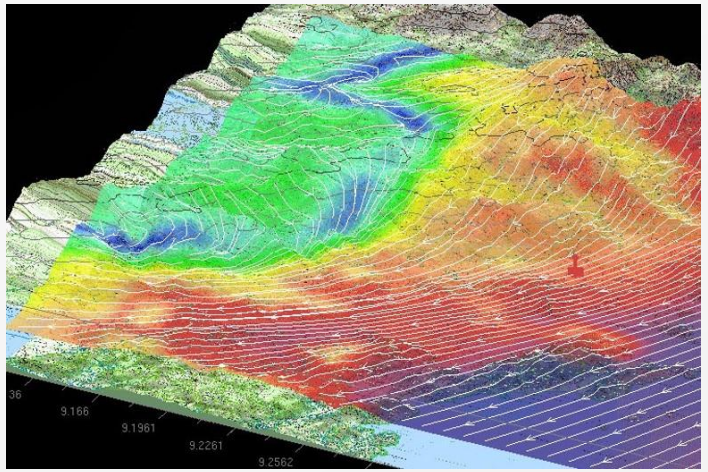
- Single point
- One- to two-year database

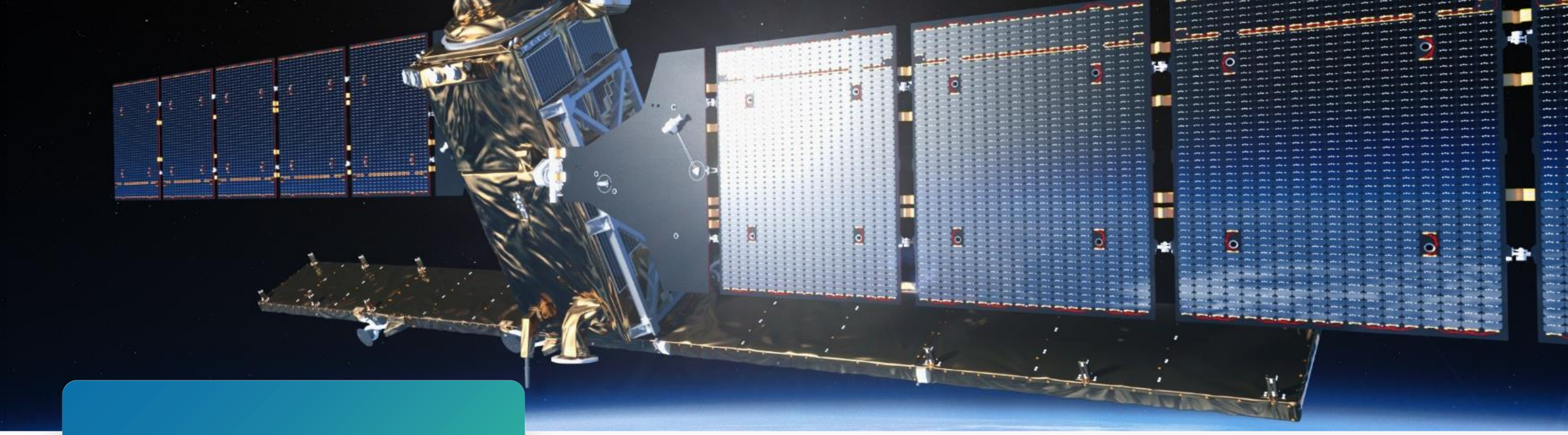


ATMOSPHERIC MODELS

- Spatial and temporal coverage

- Strong dependency on the numerical parameterization
- Flatten extremes
- Poor coast to offshore gradient representation



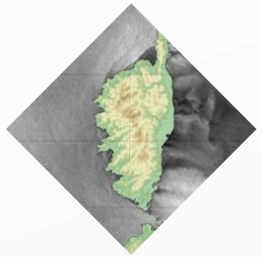


SARWind methodology: to de-risk offshore projects

SARWind methodology: to de-risk offshore projects

Synergy between:

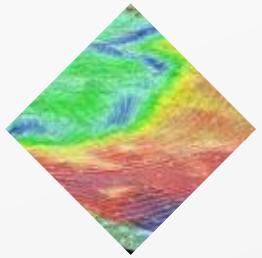
- In-situ data
- Satellite and machine learning
  CLS (CLS Group), official provider of processed satellite data
- Atmospheric modeling
  Meteodyn (CLS Group), developer of Meteodyn Universe software (WT)



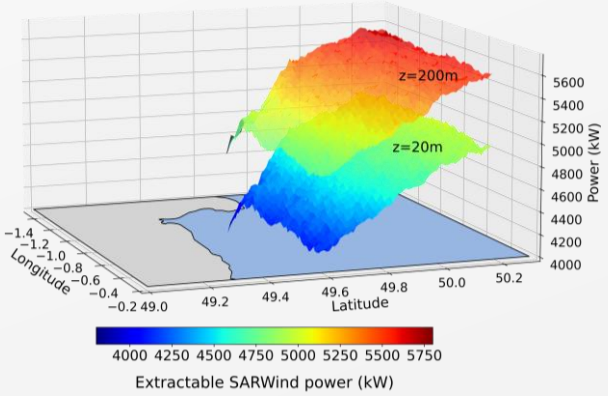
SAR IMAGERY

INSITU DATA

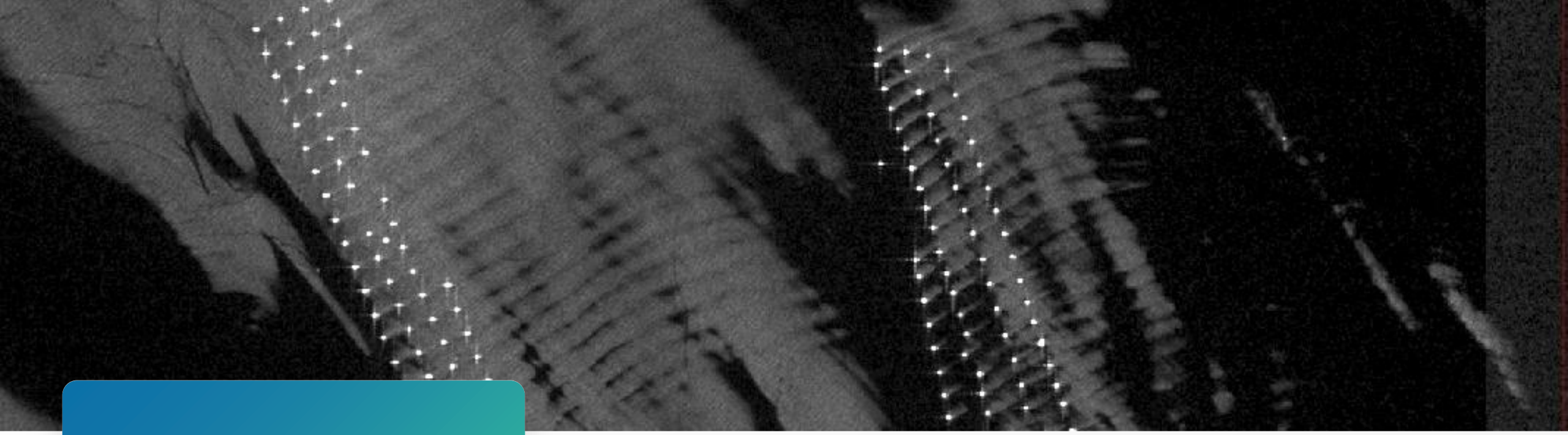
MACHINE LEARNING



HIGH-RESOLUTION ATMOSPHERIC MODEL

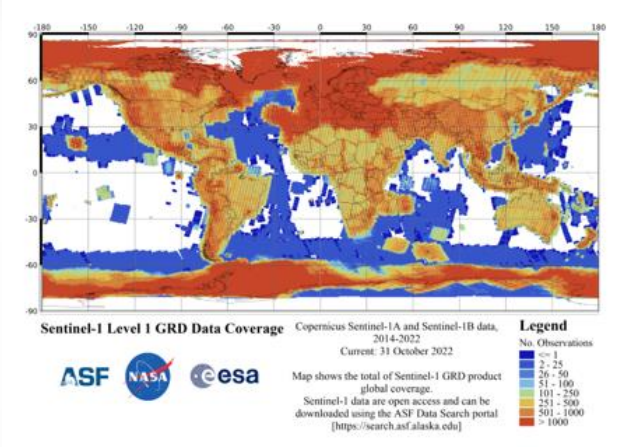


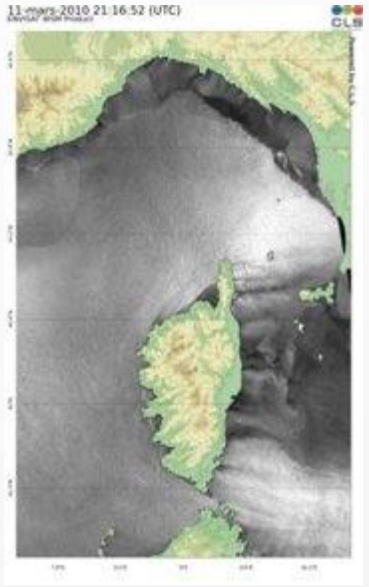
OFFSHORE WIND RESOURCE ASSESSMENT



SAR observations

SAR observations





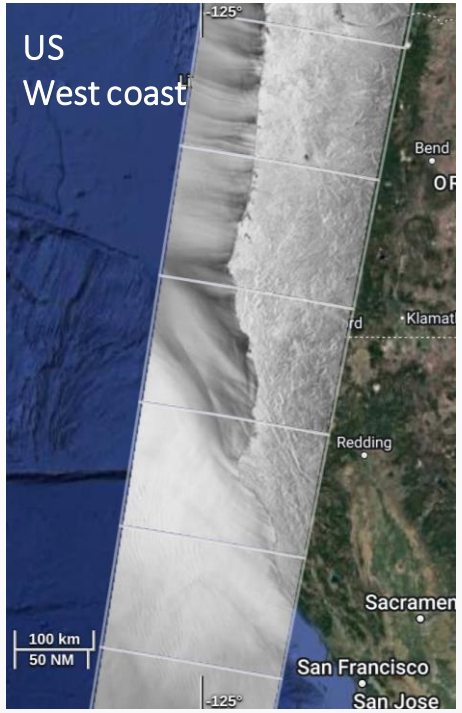
SAR: Synthetic Aperture Radar

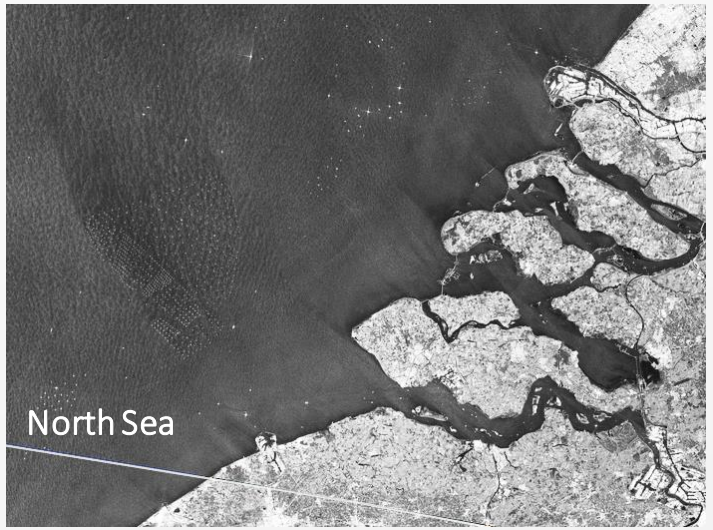
- Emissions/reception of electromagnetic waves
- Interaction with sea surface ripples (centimeter-scale)
- Day and night
- Wide coverage (250 to 400 km)

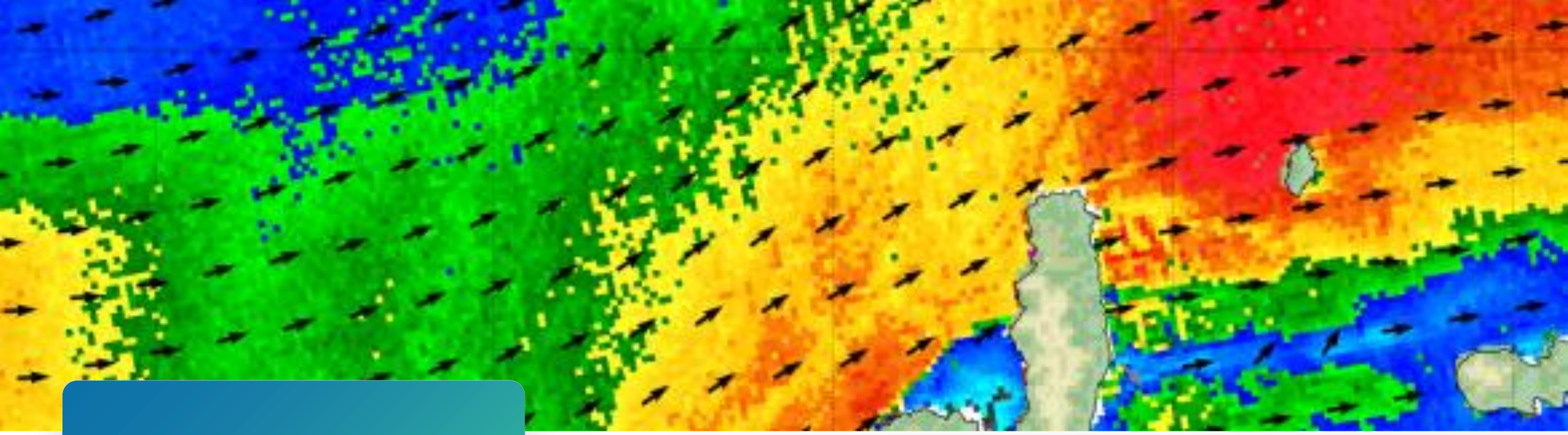
Space-born system

- 18-year database
  - ENVISAT
  - Sentinel-1A (2014-ongoing) & Sentinel 1-B (2016-2021)
  - Others
- Quasi worldwide coverage
- One passage every two days, always at the same time

SAR observations







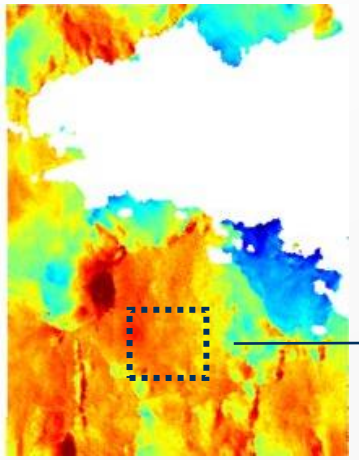
Methodology

Methodology

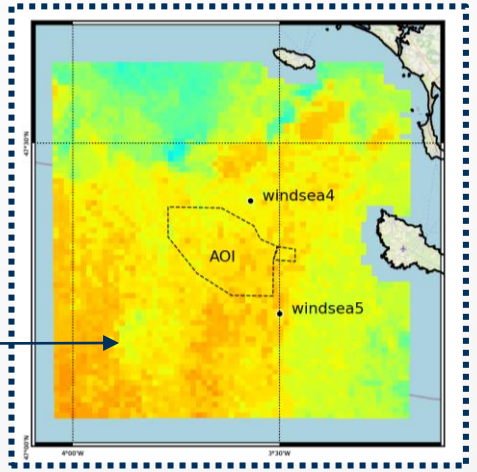
SAR observation (2021-12-08 at 06:23 UTC, Brittany, France).

SAR Level-1 product

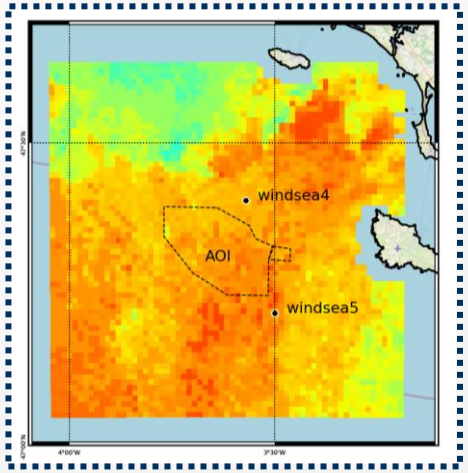
SAR Level-2 product



SARWind at 10 m
10-min wind speed at 1 km resolution



SARWind at 140 m
10-min wind speed at 1 km resolution



Step 1.
Surface wind speed retrieval

Improved performance at low wind speeds (vs. CMOD5.N)

Step 2.
Correction of systematic biases

Reduced bias and standard deviation
Bias: from -0.57 m/s to -0.06 m/s
Standard deviation: from -1.24 m/s to 0.86 m/s

Step 3.
Vertical extrapolation

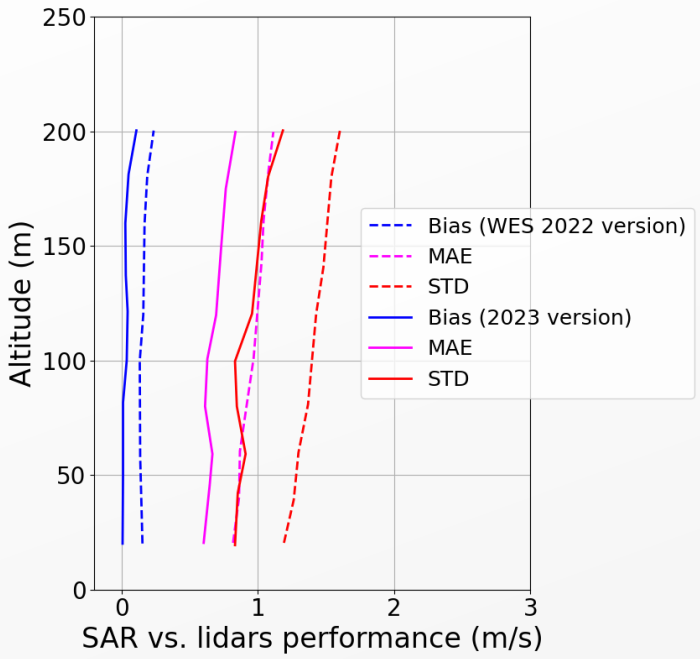
Corrected SAR surface wind speed from Step 2. Input parameters from high-resolution atmospheric model (related to atmospheric stability)

Performance of SARWind technology

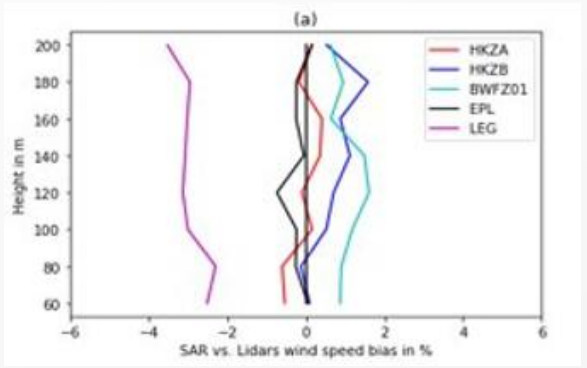
Performance of SARWind technology

Validation of the extrapolation method in North Sea

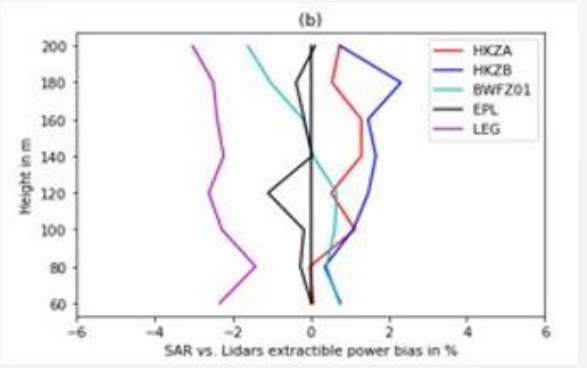
- Lidar dataset: 80% for training, 20% for validation
- Comparison to Lidars



- Mean wind speed error < 2%



- AEP error < 3%

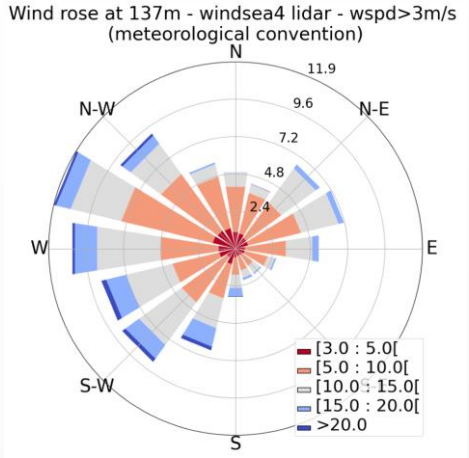


- Except for LEG Lidar (not enough co-locations)

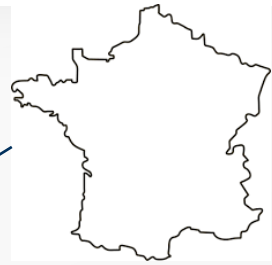
Validation against lidars in France

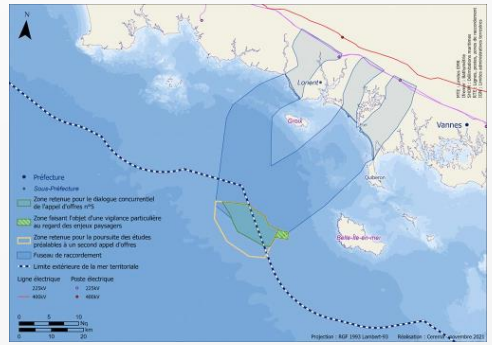
Data kindly provided by the French Directorate General for Energy and Climate from the Ministry of Energetical Transition.

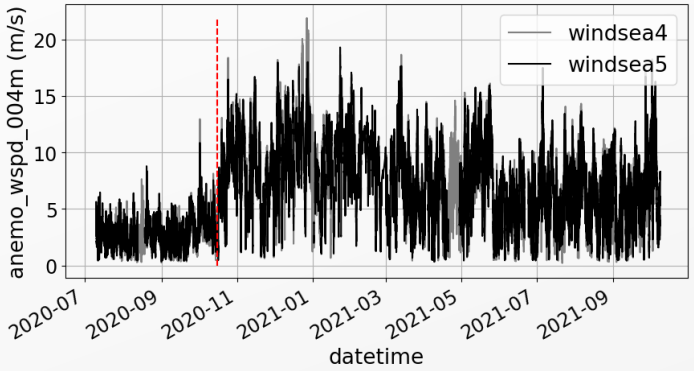
Call for tenders “Bretagne Sud” (250 MW)



- 2 floating lidars
  - Windsea4 and 5
  - Every 10 min
  - Altitudes 40 → 197m

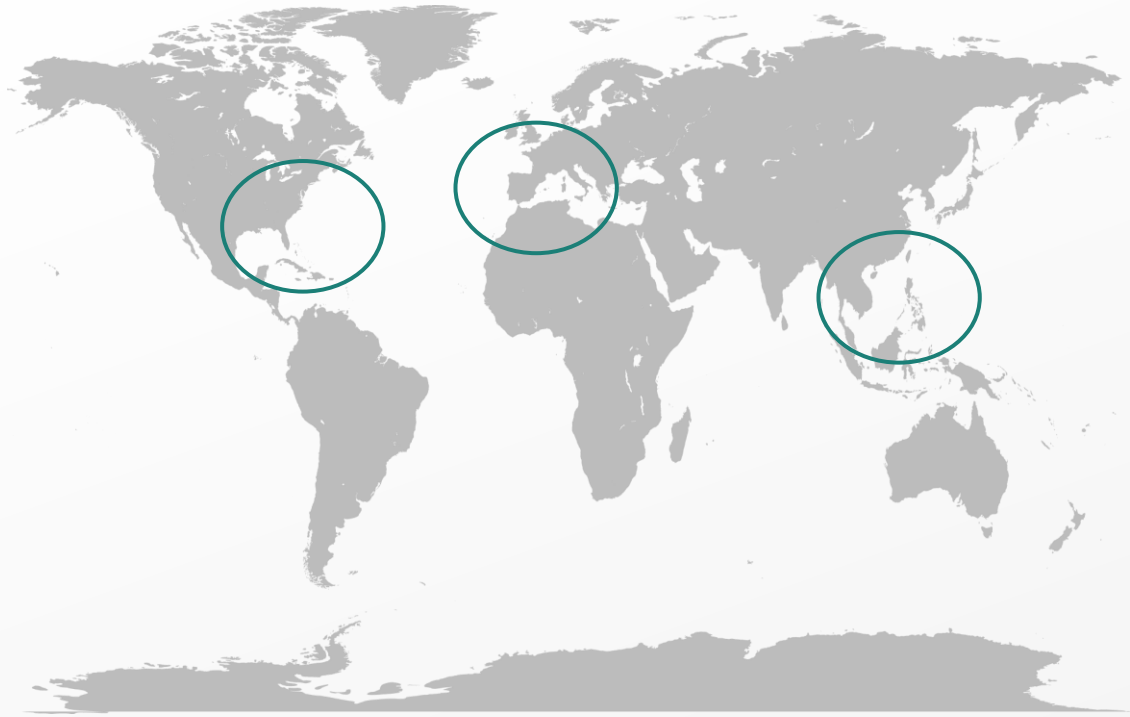






- 2 anemometers at ~4m
  - Every 10 min
  - Sheltering effect due to solar panels before 16/10/2020

SARWind performance vs. lidars



Projects in Europe, North America, Asia

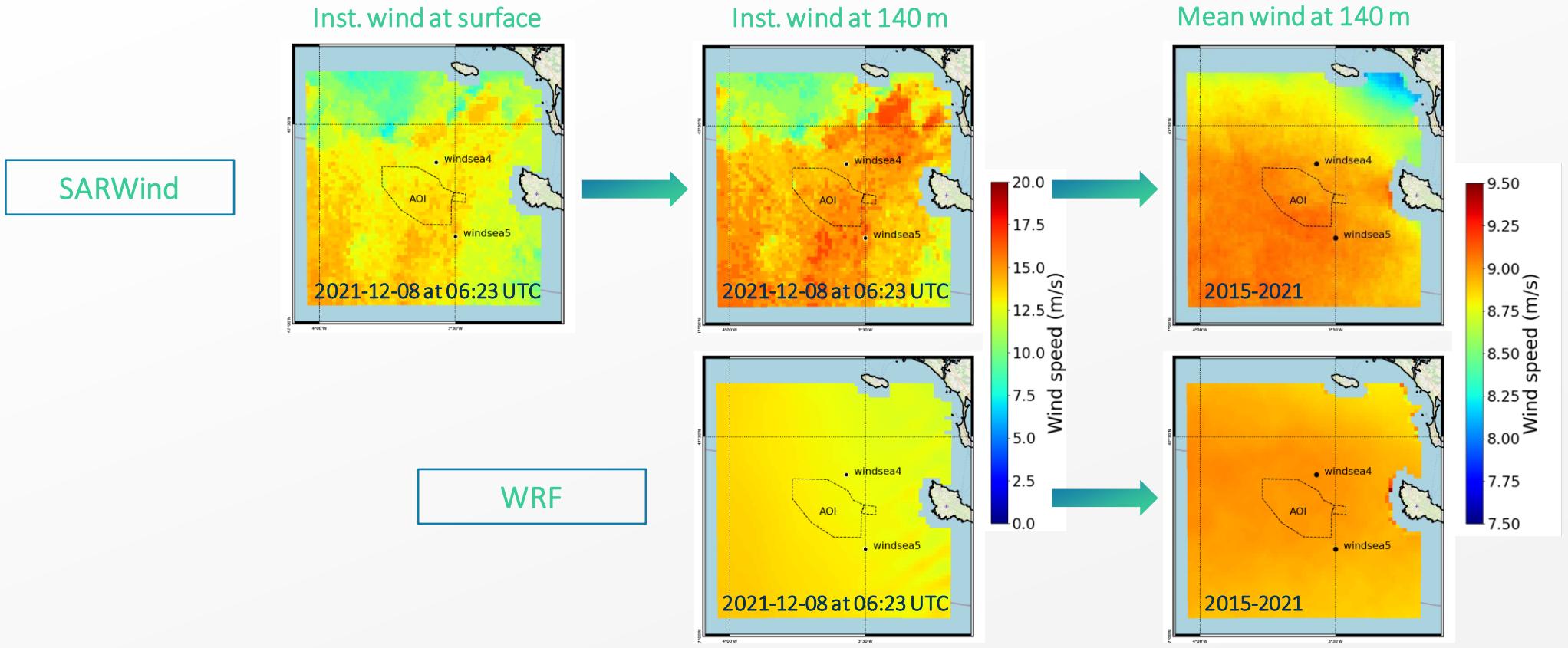
Examples of WRA :

	Measurement	WRF	SARWind
Bias (m/s)	2 lidars	-0.10	0.05
MAE (m/s)		1.15	0.98
STD (m/s)		1.40	1.27

	Measurement	WRF	SARWind
Bias (m/s)	5 lidars	-0.08	0.03
MAE (m/s)		1.27	0.68
STD (m/s)		1.68	0.94

Coastal effects: comparison with WRF

SAR measures sea roughness related to wind stress. It captures: orography effects (e.g. costal gradient), thermal effects (e.g. land-sea breeze), air-sea interactions, wake effects, etc.



SARWind captures spatial heterogeneities (here an atmospheric front).

WRF flattens the wind field due to filtering and dampening of numerical schemes.

SARWind for OFFSHORE wind assessment

SARWind for offshore wind assessment

SARWind in short

- Provides wind atlas, Weibull parameters, AEP over a 1-km resolution grid (lon/lat) up to 250 m
- More precision in terms of wind characterization at high resolution
  - From air-sea interactions to large-scale gravity waves, but also wind farm wakes
- A wide spatial coverage
  - A spaceborne system with a 250-km swath
- Fast
  - A 10-year wind study in less than a month over a 40,000-km² area

→ Less O&M, less costs

SARWind, a dedicated tool for:

- Early planning and large area screening
- Lidar campaign design
- Wind emulator
- Large-scale study in nearshore locations

Thank you

Any questions?

For more information, visit us at booth **J30**.

https://meteodyn.com