Use of satellite imagery in wind resource assessment for offshore applications

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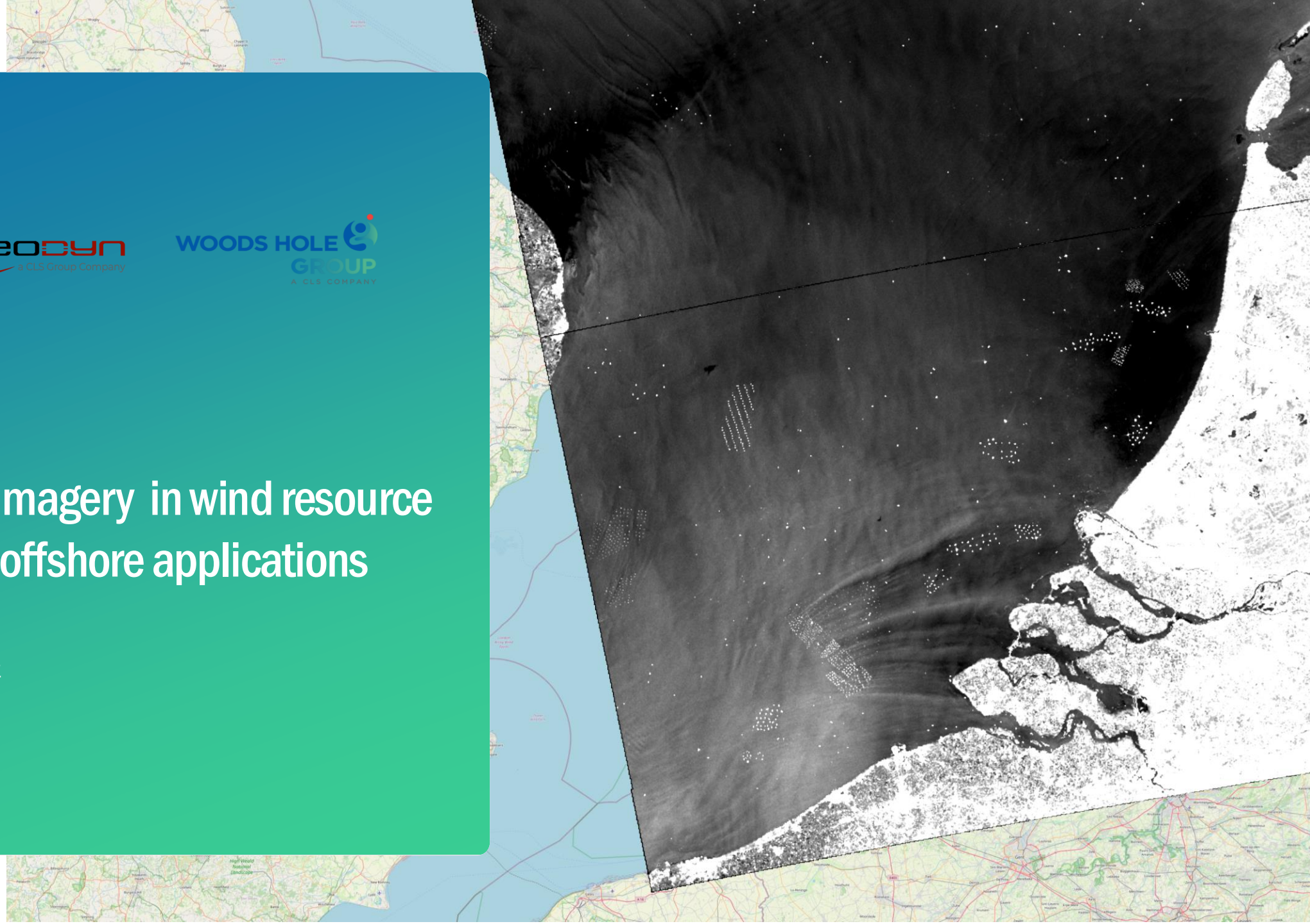


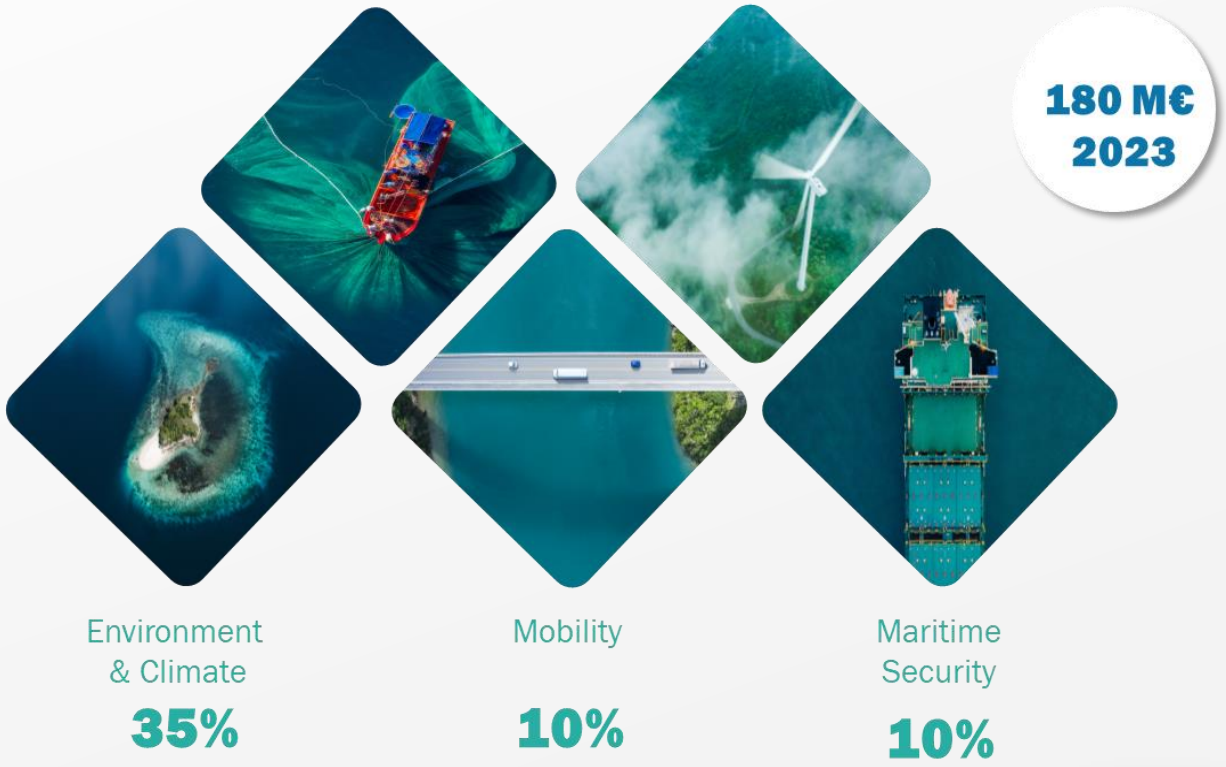
CLS, a mission-driven committed company

CLS, 12 years of expertise for the European Space Agency

- Subsidiary of the **French Space Agency** CNES and CNP.
- Worldwide company with 34 locations and 1,000 employees.
- Pioneer provider of monitoring and surveillance solutions for the Earth since 1986.
- Our mission:

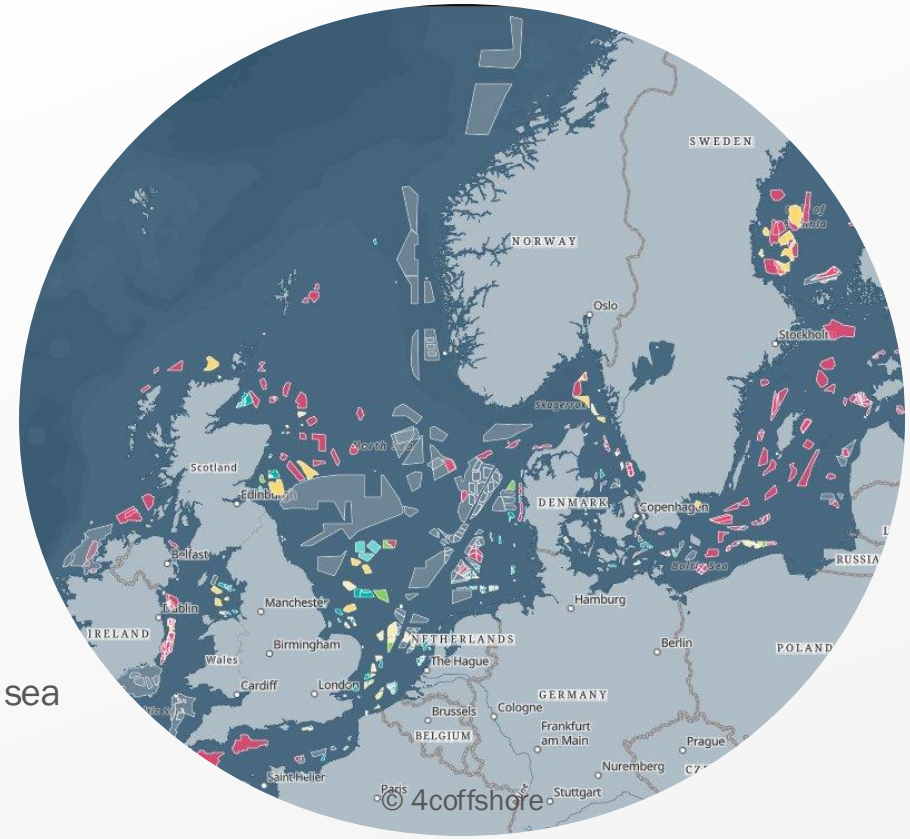
  Deploy innovative space-based solutions to understand and protect our planet, and to manage its resources sustainably
- CLS is a member of **the United Nations Global Compact** and became a **Mission Driven Company** in 2021.
- CLS contributes to **all 17** UN goals.

WE SUPPORT UN GLOBAL COMPACT



Offshore wind energy

+33 GW a year
to meet EU 2030 **climate and energy targets**



Site characterisation

with offshore wind resource assessment especially in coastal areas

- Mean wind speed and fluctuations
- Wind direction
- Local atmospheric effects with spatial heterogeneities

Maritime spatial planning

to balance sectoral activities
for a sustainable development at sea

Turbines and farms clustering

with wind speed deficit in wakes

⇨ Impact on annual energy production

with increase in turbulence intensity

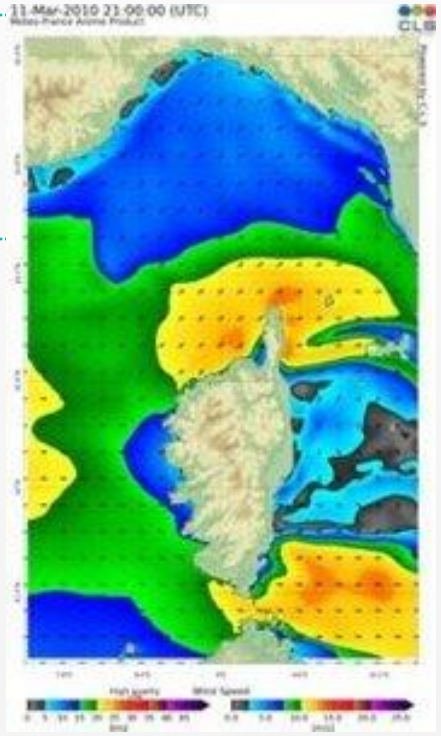
⇨ Impact on turbine lifetime

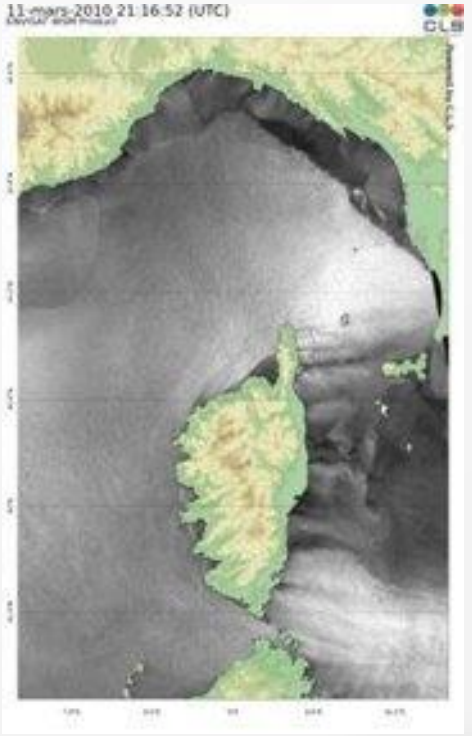
Wind assessment: state-of-the-art

*"**1%** exceeding probability of wind speed can indeed contribute to significant errors on the production leading to **millions of dollars** in gain or losses for operators"*
EDF, TEM IEA Wind

Direct observations at 10-m resolution with **satellite imagery**

	(FLOATING) LiDARs	ATMOSPHERIC MODELS
+	• High precision • High frequency • 40-250 m	• Spatial and temporal coverage
−	• Single point • One- to two-year database	• Strong dependency on numerical parametrisation • Flatten extremes • Poor coast-to-offshore gradient representation

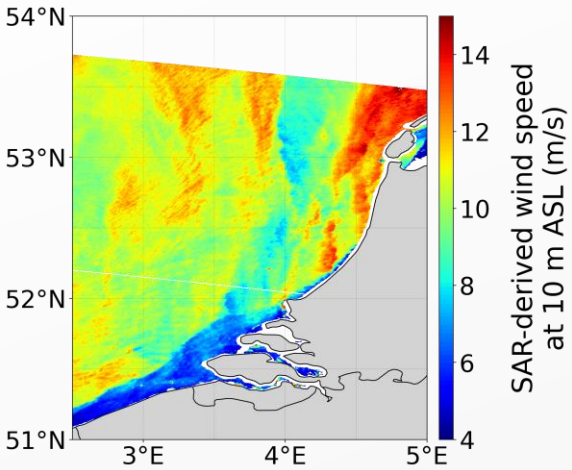




Dedicated nearshore observations

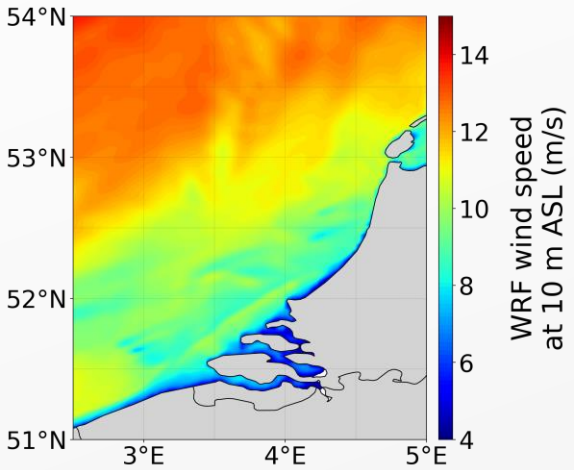
High-resolution observations with spatial heterogeneities

Processed satellite observation
(2019-09-11 at 05:57)

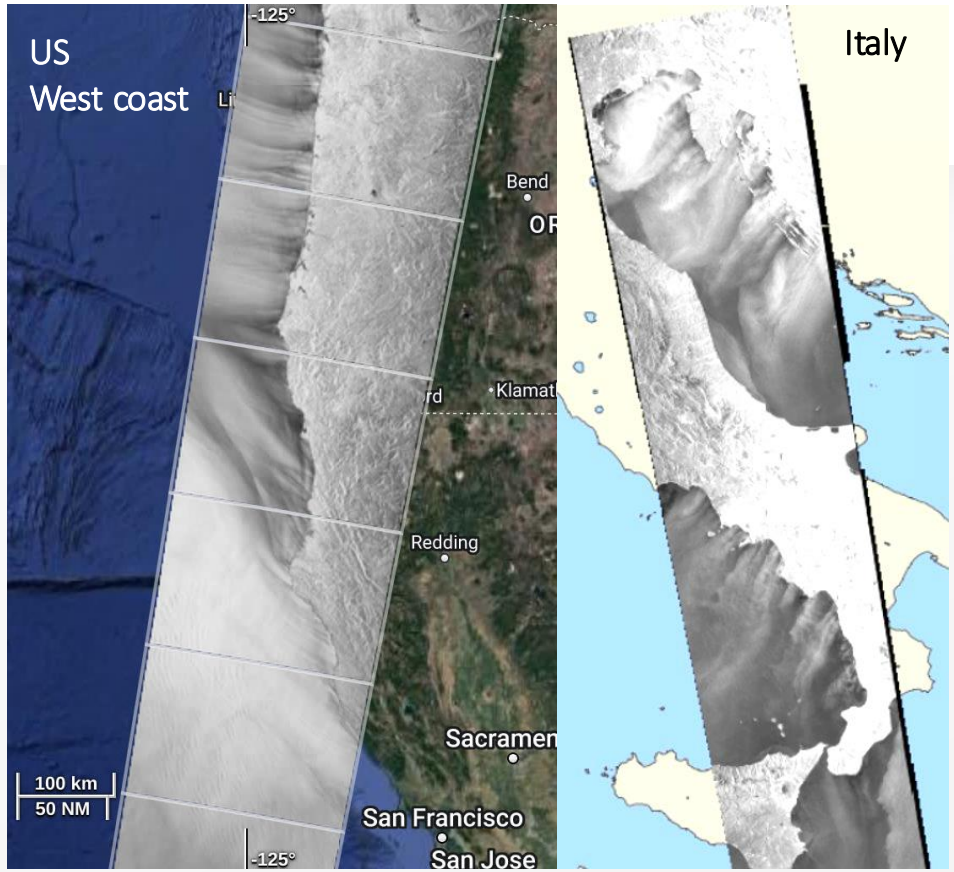


Very detailed flow, strongly heterogeneous, coastal effects

Atmospheric model
(2019-09-11 at 06:00)



Smoother flow, limited coastal effects



Observations of coastal effects

- Orography effects
- Land-sea transition, air-sea interactions
- Wakes of existing wind farms

Synthetic-Aperture Radar (SAR) imagery for offshore wind

SARWind: advanced synergy of high-resolution observations

SAR processing dedicated to offshore wind

Vertical extrapolation up to 300m

SAR SURFACE IMAGERY*

MACHINE LEARNING

METOCEAN BUOYS**

EXISTING LIDARS***

HIGH-RESOLUTION ATMOSPHERIC MODEL

MACHINE LEARNING

*2 European satellites

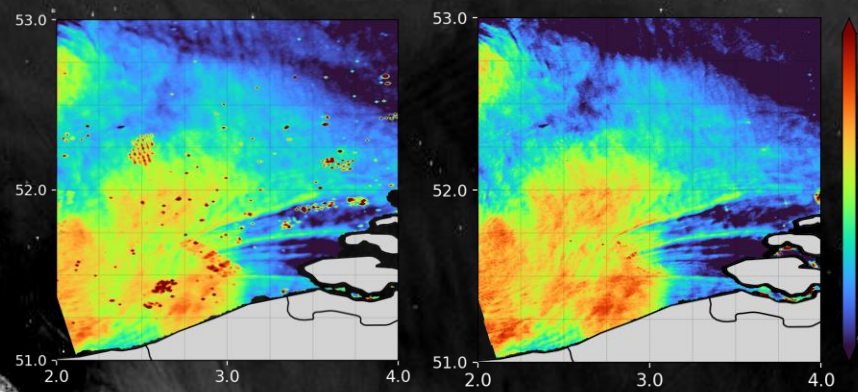
**22,000 co-locations US ocean buoys

***+30 years 12 lidars in North Sea

Direct observation of air-sea interactions and land-sea transition impacting offshore wind projects

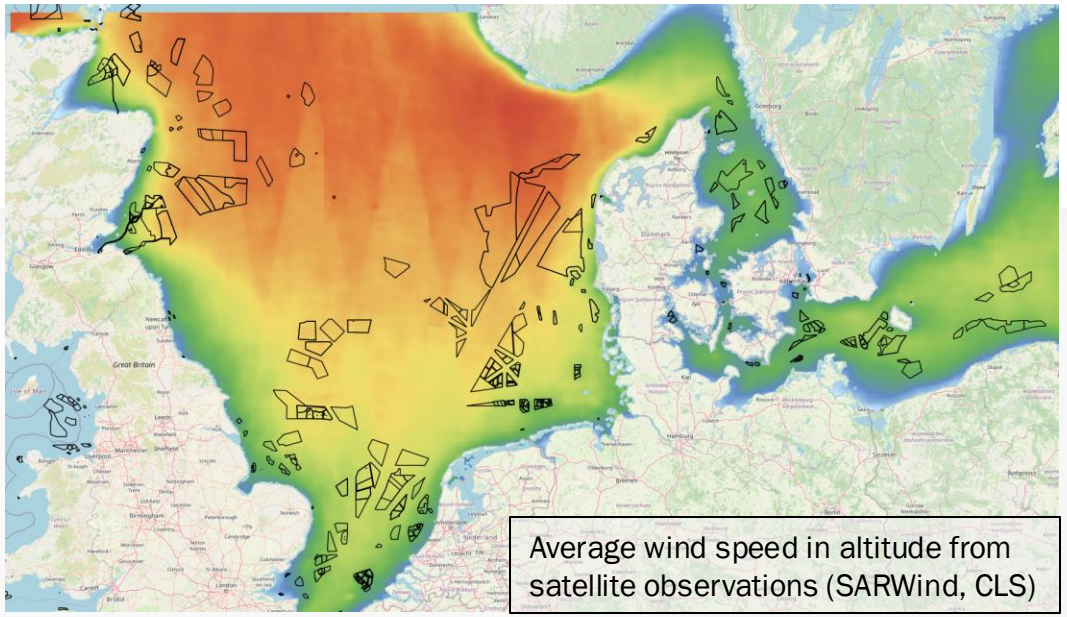
- High resolution of wind flow patterns
- Worldwide availability thanks to satellite coverage
- **Validation over 28 offshore lidars** (Europe, US, Asia-Pacific)
- **Publication** in peer-reviewed scientific journals

CLS, 12 years of expertise for the European Space Agency



Standard processing vs. *CLS processing*

SARWind for offshore wind assessment



Average wind speed in altitude from satellite observations (SARWind, CLS)

- Massive processing of satellite images: >160,000 worldwide
- SARWind, a dedicated tool for all the stages of offshore projects
  - Provides high-definition data, all over a selected zone
  - Allows to significantly reduce cost of offshore assessment: ~ 4% error reduction
- Our team:

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