AIRE project overview & specific activities

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CENER | NATIONAL RENEWABLE ENERGY CENTRE

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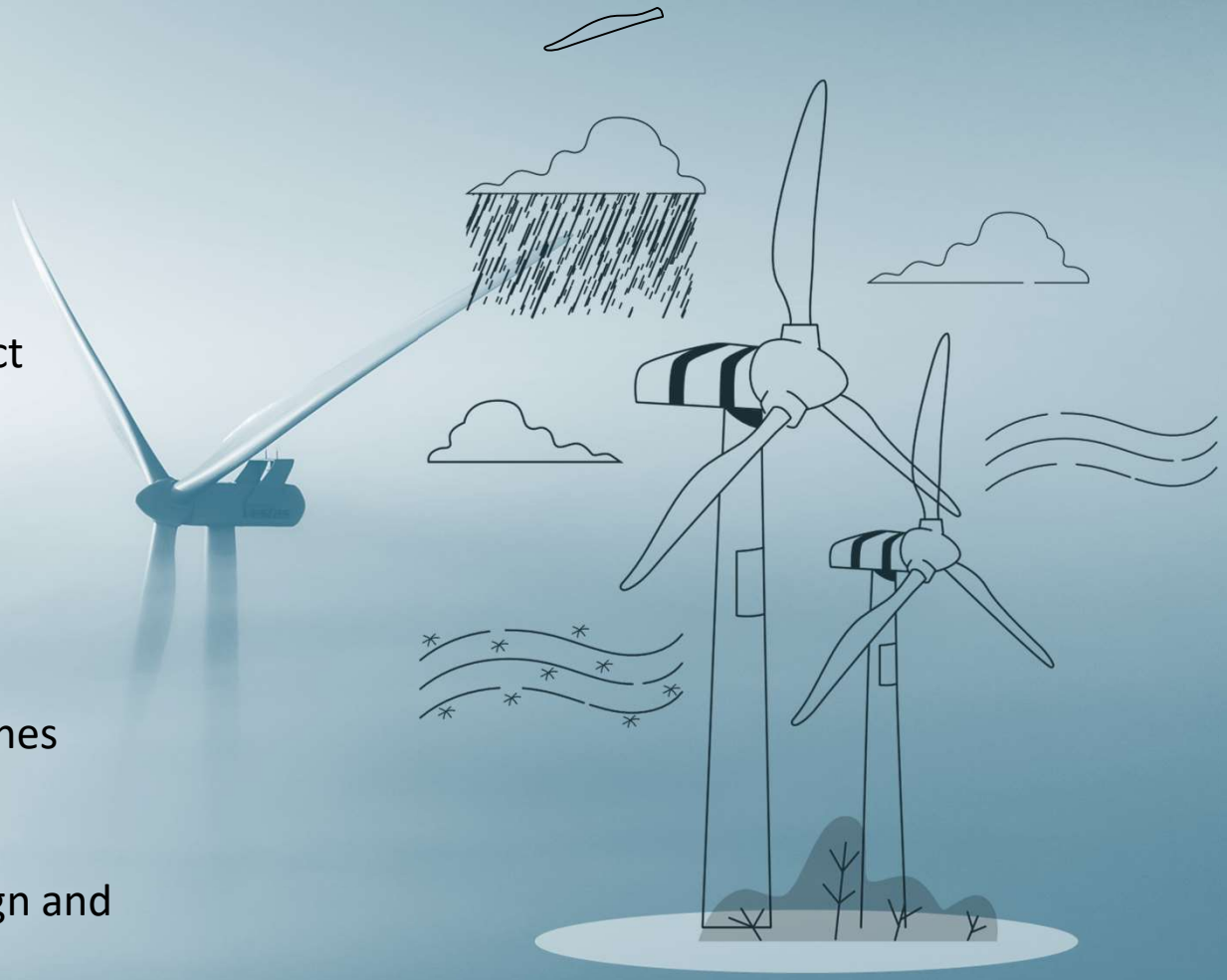
AIRE

Horizon Europe Project (2023-2026)

How **site location** and **climate conditions** affect wind turbine and wind farm operation and design?

AIRE makes a **holistic approach** to:

- Study the effect that variables such as **precipitation** and **dust** have on wind turbines and wind farms operation.
- Improve wind turbine and wind farm design and control.
- **Increase** wind energy efficiency.



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Wind turbine blade erosion

Precipitation

Blade damage

Impact on wind turbine performance

Wind farm operation and control effect

Data and knowledge collection

Components design

Models

Case Studies

Tools

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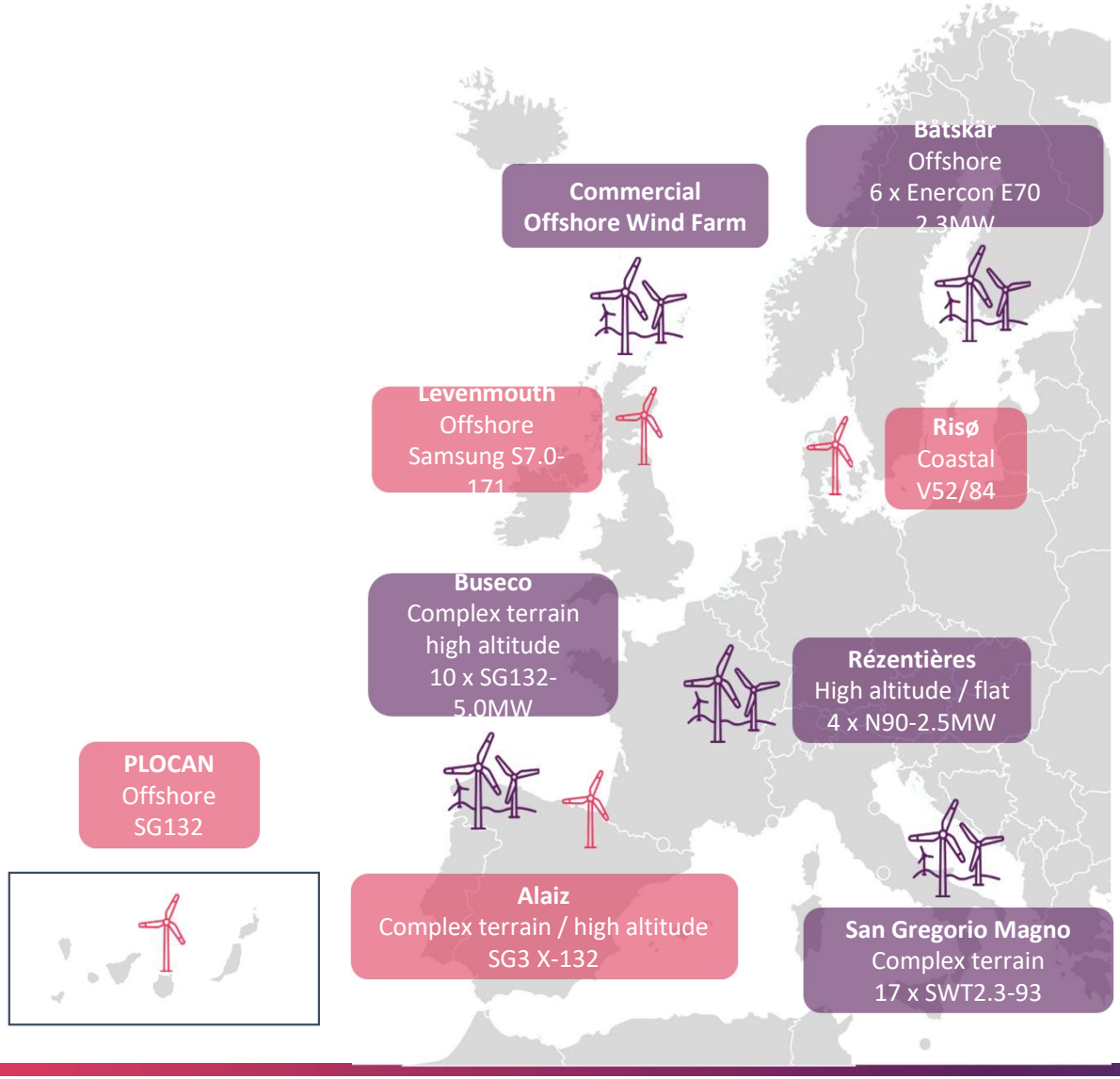
Sites & Partners



Experimental wind turbine

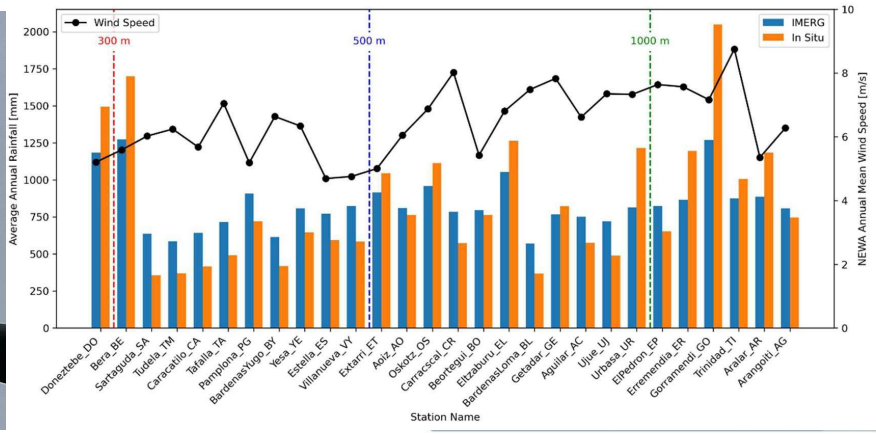
Wind farm

Knowledge hub

Wind + precipitation + sand
Different sites (onshore/offshore/altitude effect/complex terrain)
Satellite data analysis

Equipment & Data:

- Micro Rain Radar, Disdrometers, Lidar
- Radiometer, Particle aerosols (with high volume collector), Meteorological stations
- Solar radiation sensor
- Blade Status & Wind Turbine Scada
- Satellite data calibration



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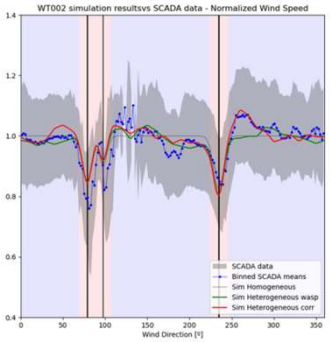
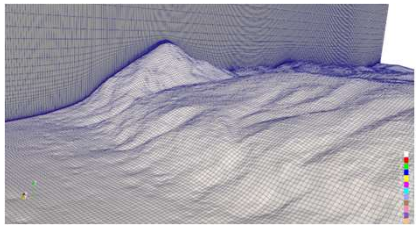
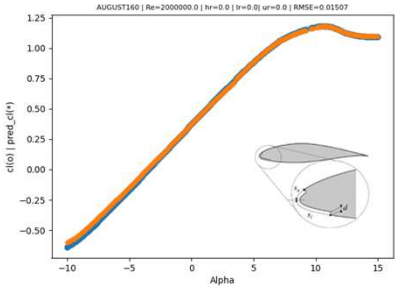
Numerical models

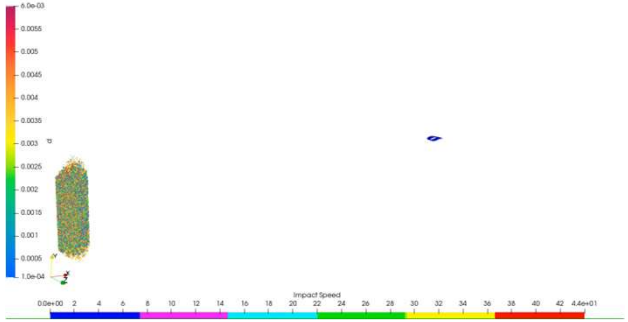
Evaluate how atmospheric wind flow affects power production and loads

Model 1: Mesoscale model
Model 2: Wake and wind farm models
Model 3: Blade Damage model
Model 4: Airfoil performance model
Model 5: 3D model of precipitation impigment









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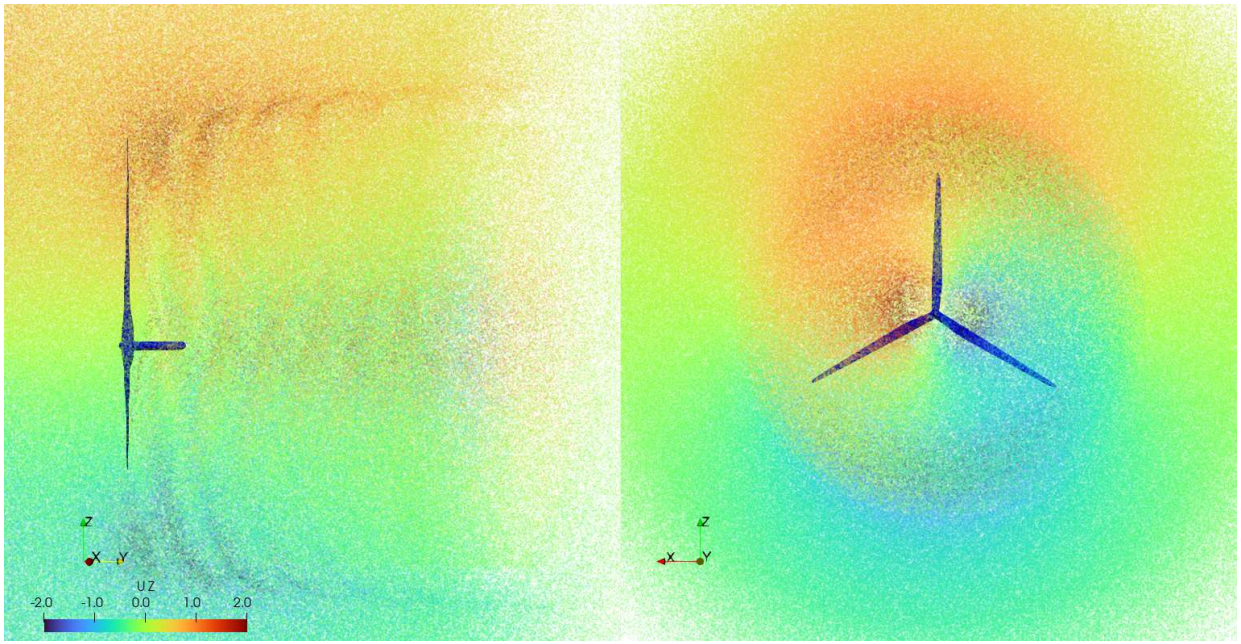
3D full IEA 15MW rotor



- 85 seconds simulated for the full rotor
- Both, particles and fluid domain are solved simultaneously
- Particles adjust trajectory towards flow field
- Wake rotation visible via normal velocity component

AIRE Toolbox

Tool 1. Erosion risk atlas: accumulated annual precipitation above (typical) rated speed and accumulated annual damage based on a reference wind turbine and the impingement damage model

Tool 2. Wind farm operation and control: blade damage effect over wakes and erosion safe model introduction

Tool 3. Wind turbine AEP prediction: depending on the blade status and wind turbine operational conditions

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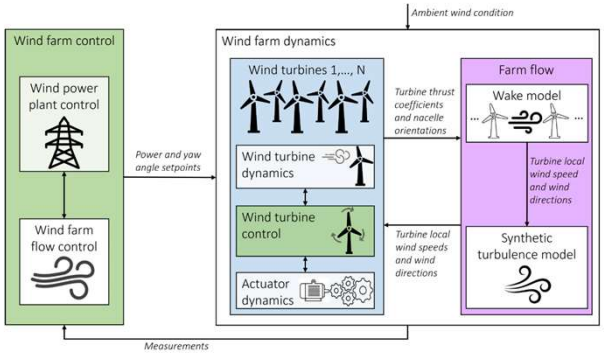
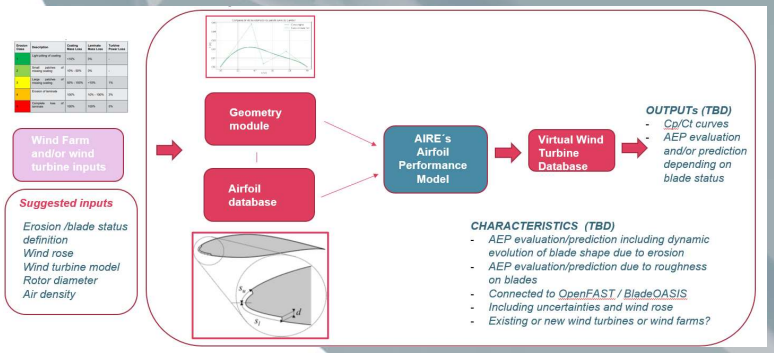
Tool 4. Erosion safe mode operation: erosion curtailment will be improved and extended to wind farm control and accounting for wake interaction.





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Toolbox application to case studies.

5 Case studies to apply the AIRE toolbox:

1) Offshore
2) Onshore complex terrain
3) High altitude
4) Blind test to compare the different tools
5) Re-evaluation of offshore case with new airfoils, improved rotor design and leading edge protection..

The objective is to stimate the **LCOE reduction** due to the use of the AIRE tools

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Wind turbine components durability

2 New Airfoils design: more resistant to erosion and blade surface status.

Study of aerodynamic effect of leading protections.

New rotor design using the new airfoils.

Advanced testing methodologies in wind tunnel and rain erosion test

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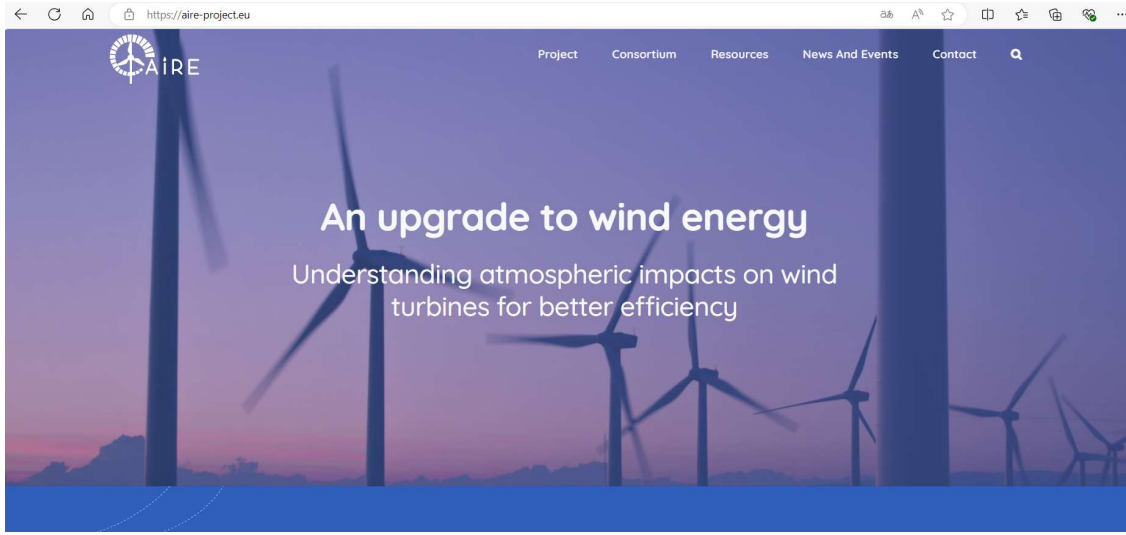
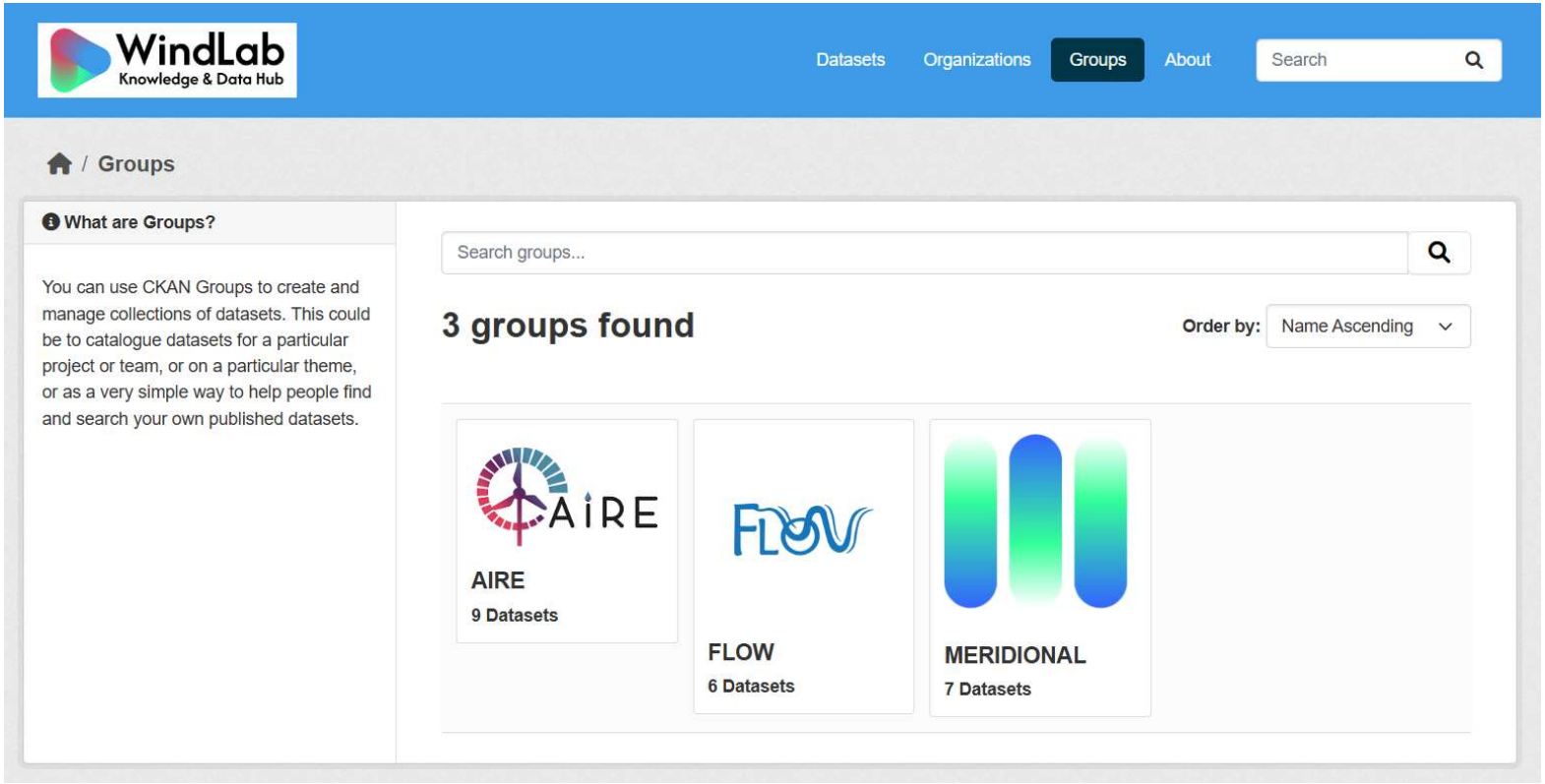
AIRE: the Newsletter & the Webpage

aire-project.eu



WindLab
Knowledge & Data Hub

https://windlab.hlrs.de/



Thank you.

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