German AMUN wind atlas

January 2023
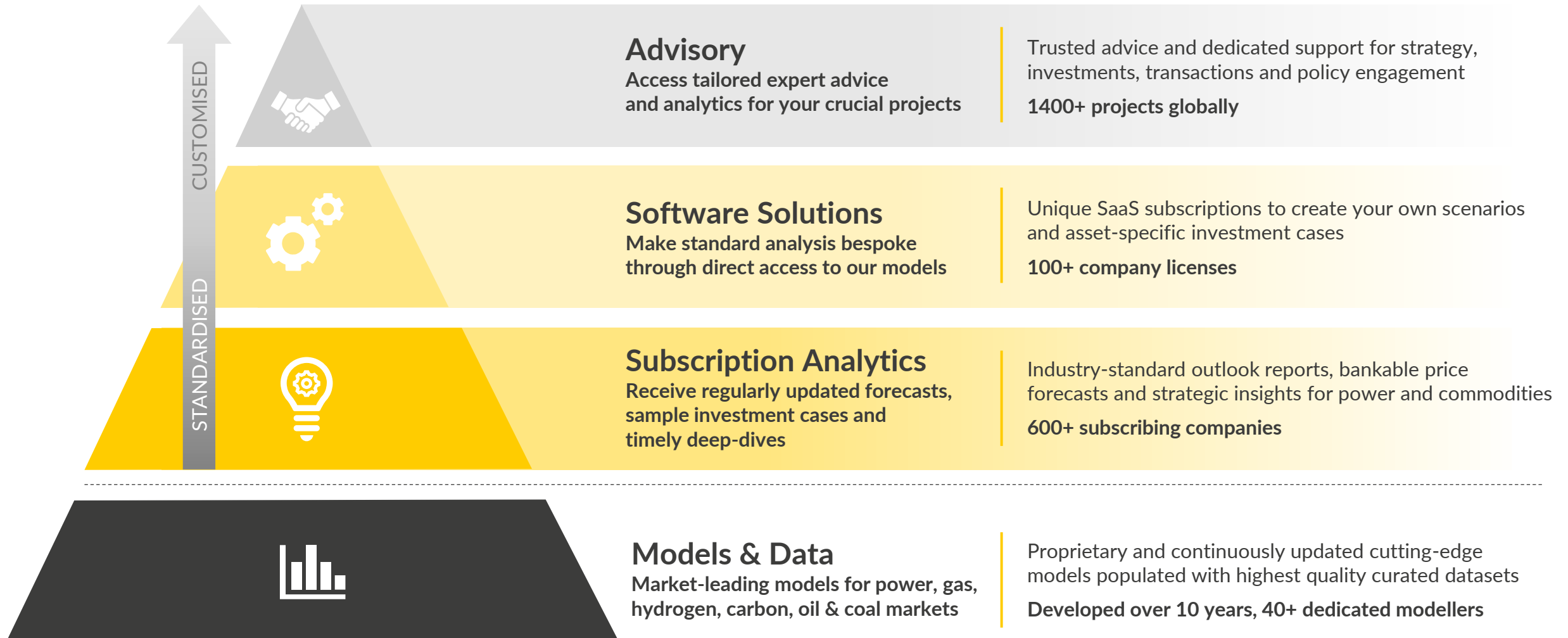
Aurora Software
Find unique value on the road to Net Zero

Aurora's integrated software suite empowers **you** to analyse power markets and assets with unprecedented sophistication and ease, helping you build an edge in the crowded market

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Proprietary and continuously updated cutting-edge models populated with highest quality curated datasets

Developed over 10 years, 40+ dedicated modellers

Seamlessly integrated suite of software products

ORIGIN

AMUN
for wind

CHRONOS
for batteries

RA
for solar

Our **market-level model** enables you to create your own market scenarios within hours and quantify market risks and upsides from policy, commodity, demand and supply changes.

Our **asset-level tools** quantify the value of your assets or sites under different configurations and market scenarios.

SEAMLESS INTEGRATION

With Origin: use your own scenarios in your valuations

With each other: value co-located assets and portfolios

Discover software solutions that suit your business needs with **Shaun Claridge, Senior Commercial Associate**

✉ **shaun.claridge@auroraer.com**

AMUN

The #1 wind valuation software

AMUN delivers bankable asset-specific revenue forecasts for wind assets in minutes

- Over 50 subscribers across 17 markets including leading banks, funds, utilities and developers

- Access an unlimited number of offshore/onshore valuations

- With greenfield and operational assets

- Backed by Aurora data and supported by experts

- Used on the largest wind deals, including Hornsea One

- Powered by the most accurate proprietary wind atlas

Transactions **Site Selection and Optimisation** **Portfolio Valuation** **PPAs**

A global benchmark trusted by industry leaders

AMUN

- 50+ subscribing companies across 17 markets
- Supports the largest transactions globally
- Values the biggest wind portfolios
- Underpins major debt financings
- Sets prices for wind PPA deals
- Used by leading developers for site selection and optimisation

High quality wind atlas can be a source of huge advantage in renewables investments

Developers rely on wind atlases to assess project feasibility before local measurements are available

Screening green field projects using a more accurate wind atlas improves the efficiency of project development

Investors rely on wind atlases to assess project attractiveness before local measurements are accessible

Screening operational projects using a wind atlas validated using production data improves the efficiency of origination

Find out more about **AMUN's features, software advantages, regional specificities, and special offers for subscribers**, contact Senior Commercial Associate, Shaun Claridge.

✉ **shaun.claridge@auroraer.com**

But conventional wind data sources can suffer from low resolution and poor validation

Reputable global data sets suffer from low resolution

- **Computing power is limited** – This requires simplified spatial representation to keep computation time reasonable

- **Low resolution data is less representative of ground reality** – local favourable wind conditions can be "averaged out" when average is taken of a large area

ERA5 grid

17km

28km

AURORA EOS

INSIGHTS AND ANALYSIS

- ⚡ Power & Renewables ▸
- 🛢 Commodities & Hydrogen ▸
- 📄 Reports Browser

SOFTWARE

- 🚀 Launcher & Tracker
  - 📊 Run Statistics
  - 🧑‍💼 Inputs Editor
- ⚙ Amun
- 📍 Origin
- 🔋 Chronos

DATA DASHBOARDS

- 📊 Historical Market Data
- 📈 Scenario Forecast Explorer

- ⚙ Settings
- ⏻ Log Out

Snow effect: ⚪

Leaflet | © Mapbox © OpenStreetMap | Search by LocationIQ
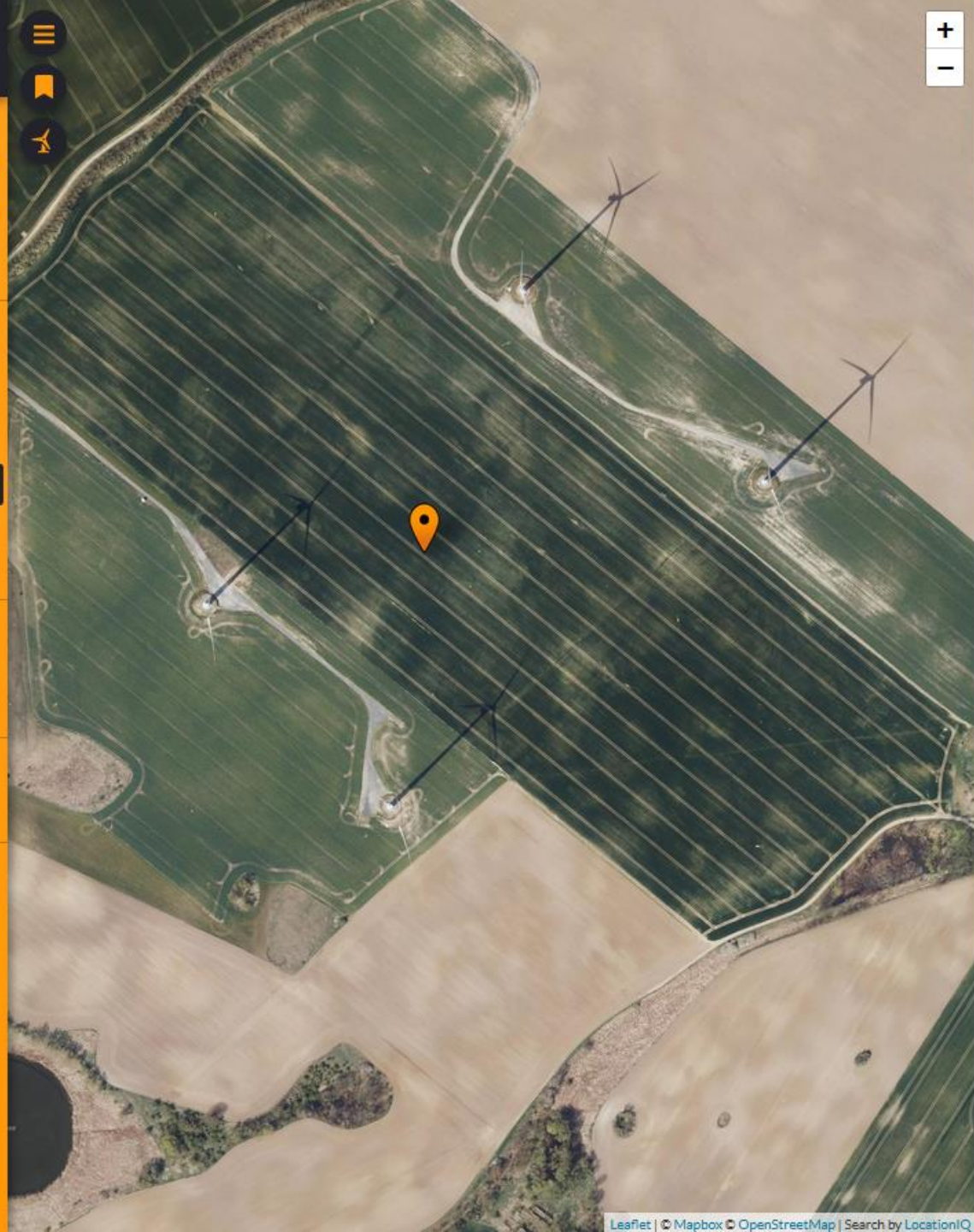
Schmölln

Valuation created from wi...

Germany (53.311374, 14.072366)   SUBSCRIBED

The selected point belongs to the Germany power price zone. Aurora's Germany power price forecasts are applicable.

1 Power Data — **2** Turbine Data — **3** Scenario Data — **4** Results
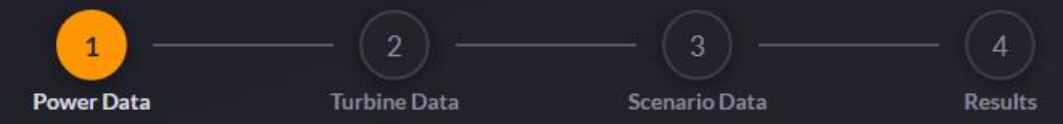
Power Data ⓘ

Choose which calibration data you have

- 🛩 Pre Calibrated Generation
- 🌬 Calibrate Generation
- 🌬 Calibrate Wind

Or select built-in wind data

- 🛰 Amun Wind Atlas

Enable additional data sets ⚪

Show Description - Built-In Wind, Amun Wind Atlas ⌄

Hide Comparison - Average Wind Speed ⌃

Built-in wind data sets are the best available views on wind resource levels before site-specific measurements are taken. Public data sets (ERA5, MERRA2, NEWA) might differ from each other due to differences in methodology. Where available, we recommend the Amun Wind Atlas, which incorporates calibration using observations available to Aurora.
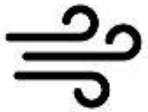
Request support ✕

Average Wind Speed [m/s] at 100m — chart:
- Amun Wind Atlas
- ERA5
- NEWA
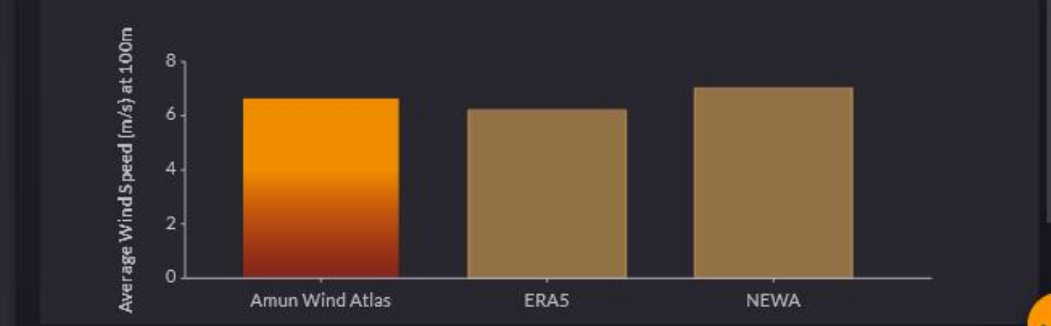
"What wind data should I use?"

If site specific data is available, use it.

If not, use the **AMUN Wind Atlas.**

The AMUN Wind Atlas is built using the best wind data and techniques

A U R O R A

We calibrate with data at **239 wind sites** using private data shared by the AMUN community and publicly available data from Betreiber-Datenbasis.

A combination of climate reanalysis data sets provides the **low bias** of ERA5 with the **high resolution** of the Global Wind Atlas.

An **ensemble of machine learning models** is used to correct bias in the downscaled atlas.

When more observational data arrives the robust data pipelines can be rerun to **incrementally improve** the AMUN Wind Atlas.

The German AMUN wind atlas

German onshore data is bias corrected

Other regions are interpolated from ERA5

Average wind speed (ms^{-1})
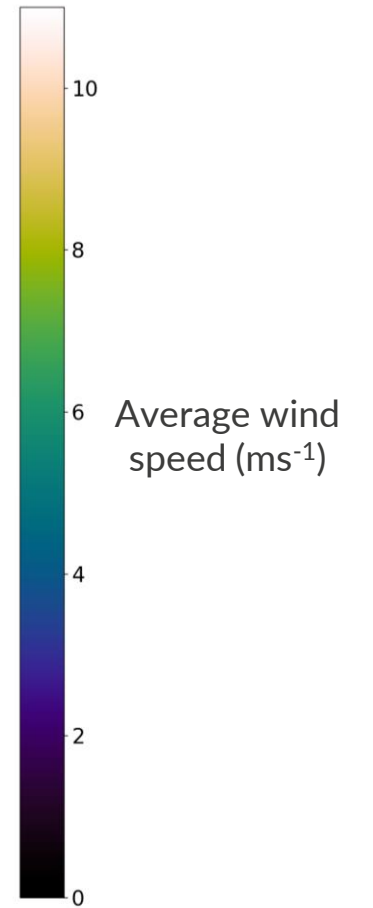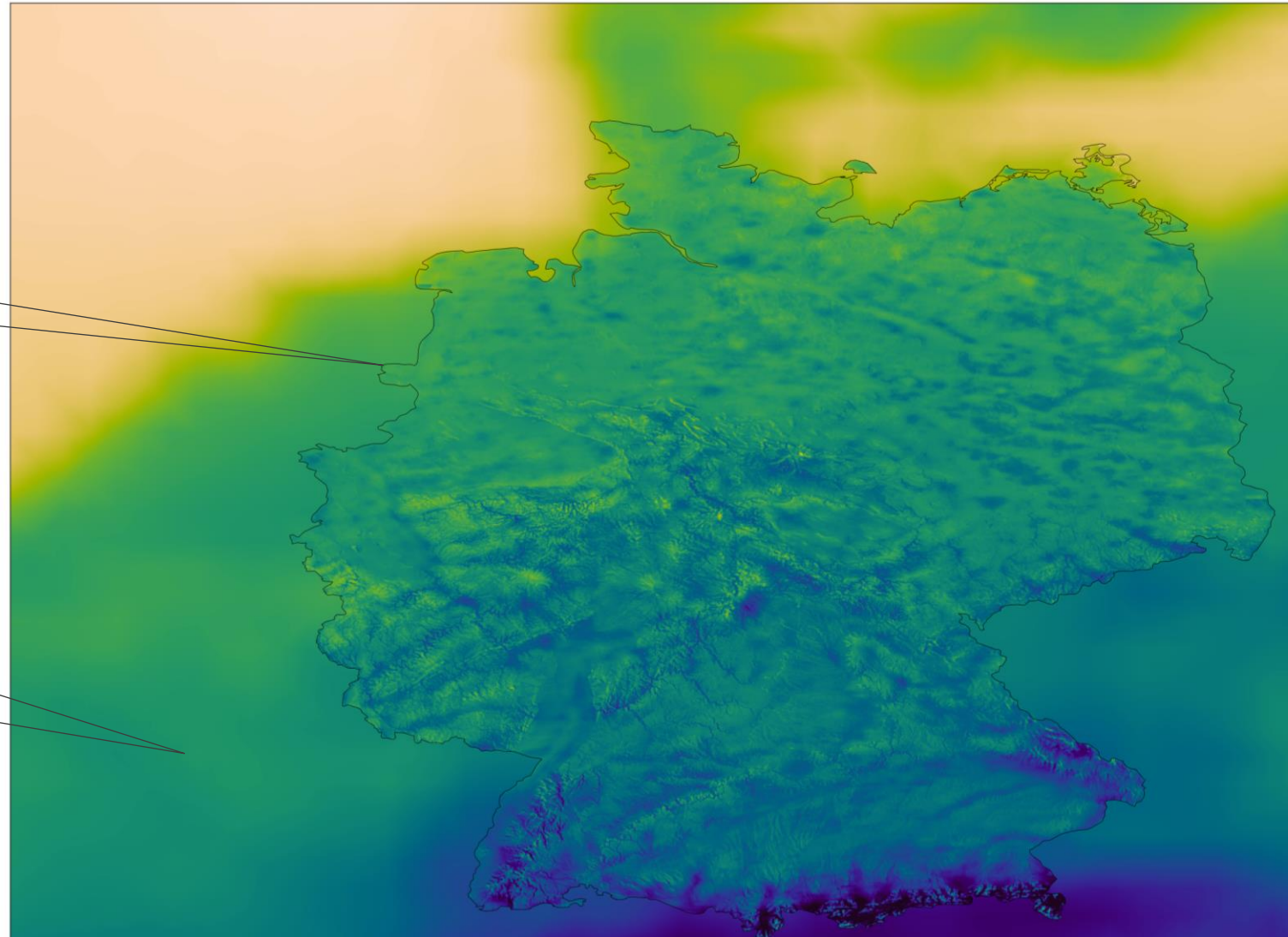
AMUN outperforms other wind atlases because it is bias corrected

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Atlas	Methodology	Distribution	Bias	Uncertainty	Resolution
Amun	Bias corrected		0.2%	3.4%	1km
ERA5[1]	Reanalysis		0.5%	6.8%	28km
GWA[2]	Microscale WAsP		24.3%	7.5%	0.25km
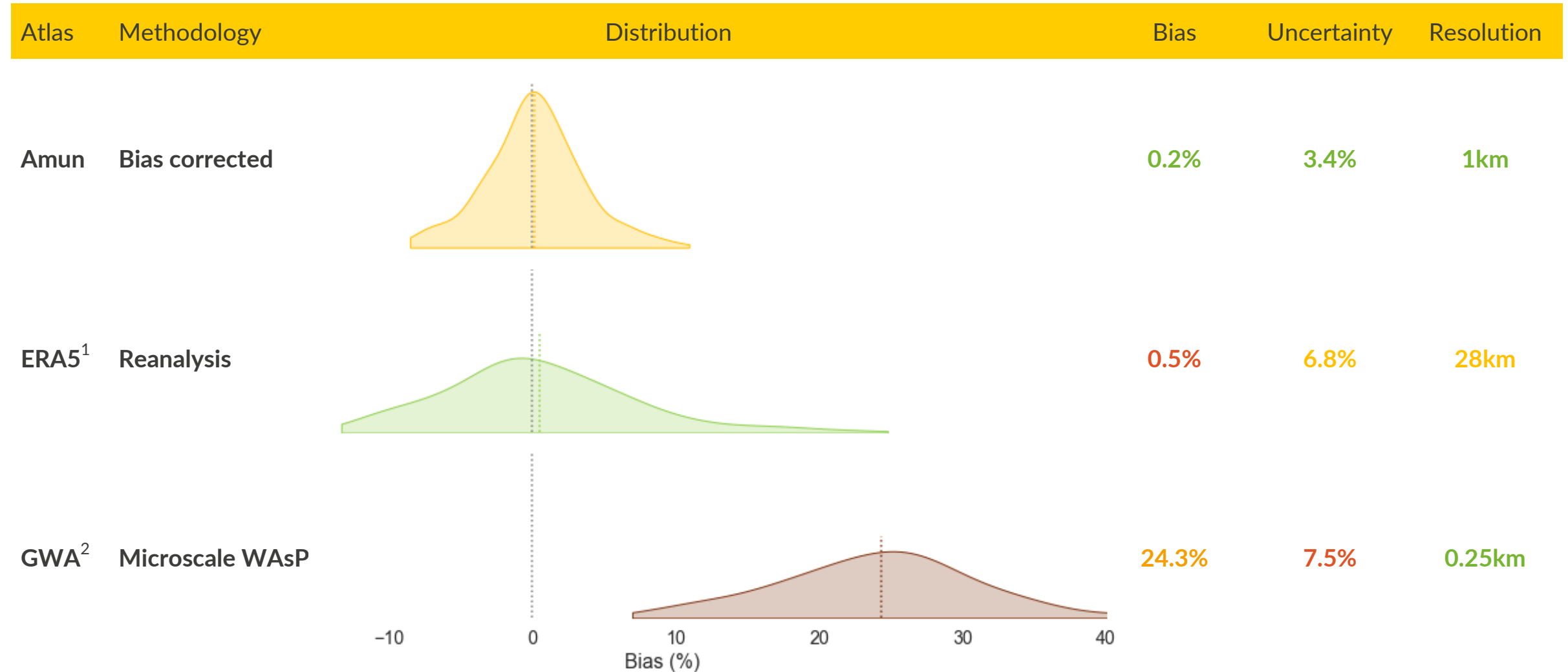
Bias (%)

1) Generated using Copernicus Atmosphere Monitoring Service information, 2022.
2) Data obtained from the Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU).

Bias corrected wind atlases offer the highest accuracy

A U R O R A

Atlas	Type of Bias Correction	Data that is Bias Corrected	Sites for training	Sites for testing[2]	Bias	Uncertainty
Amun	Statistical	Average wind speed @ 100m	239	239	0.2%	3.4%
Anemos[1]	WRF remodelling	Hourly wind speed @ hub height	26	88	0.1%	4.4%

1) Schneider et al 2022. A wind atlas for Germany and the effect of remodeling. https://doi.org/10.1127/metz/2022/1102
2) The Amun wind atlas is evaluated using 10-fold Nested Cross Validation, which ensures that model performance is always measured using data that has not been used for training or tuning.

The atlas can also be loaded into GIS systems as a .tiff file
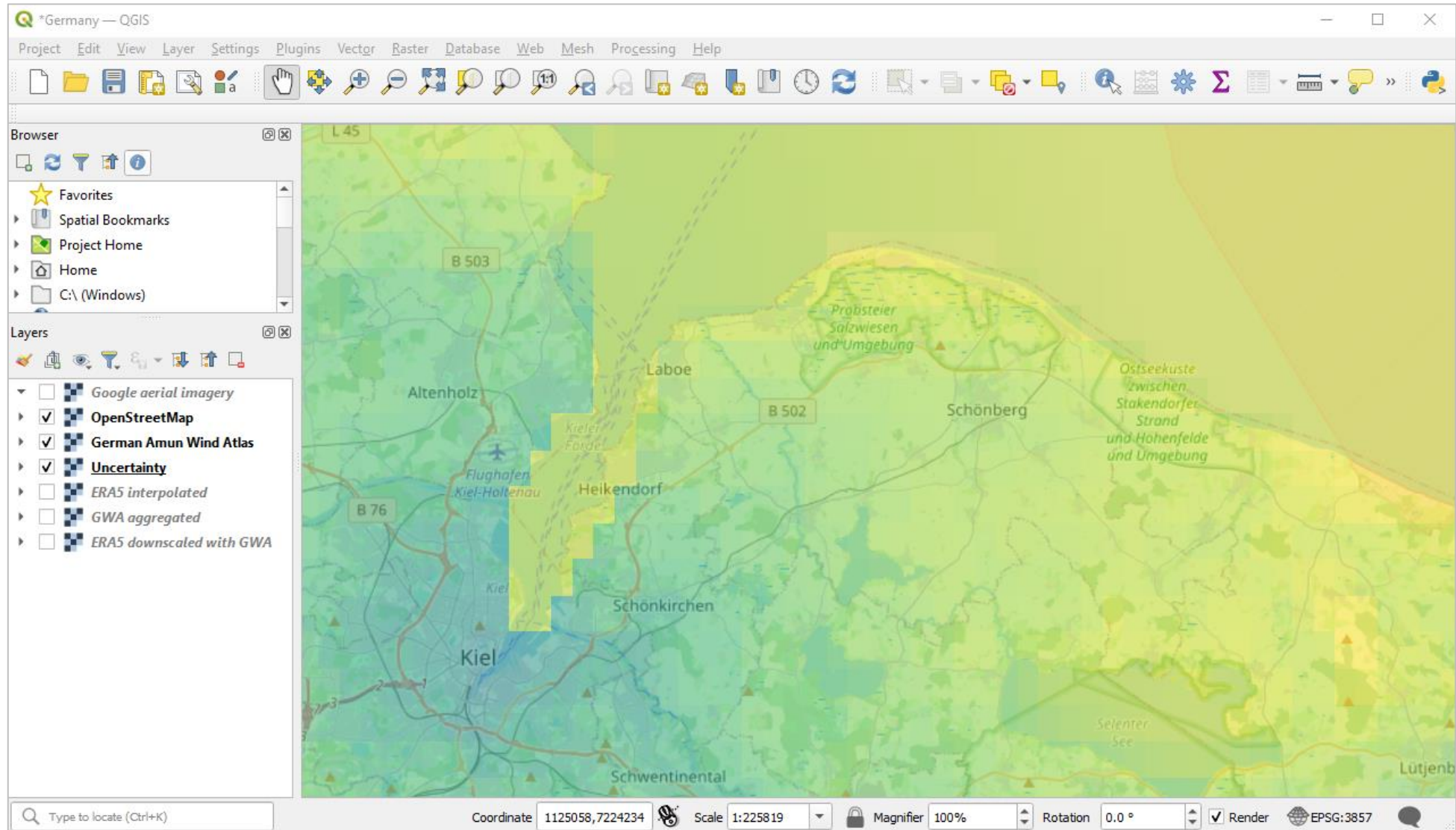
Our uncertainty map can be used to refine your assessment of the potential at each site

AUR🌅RA
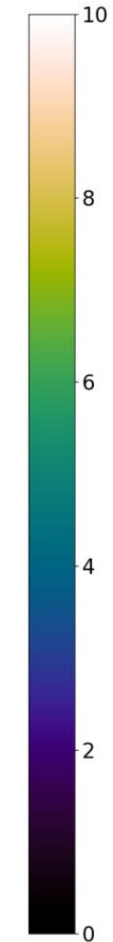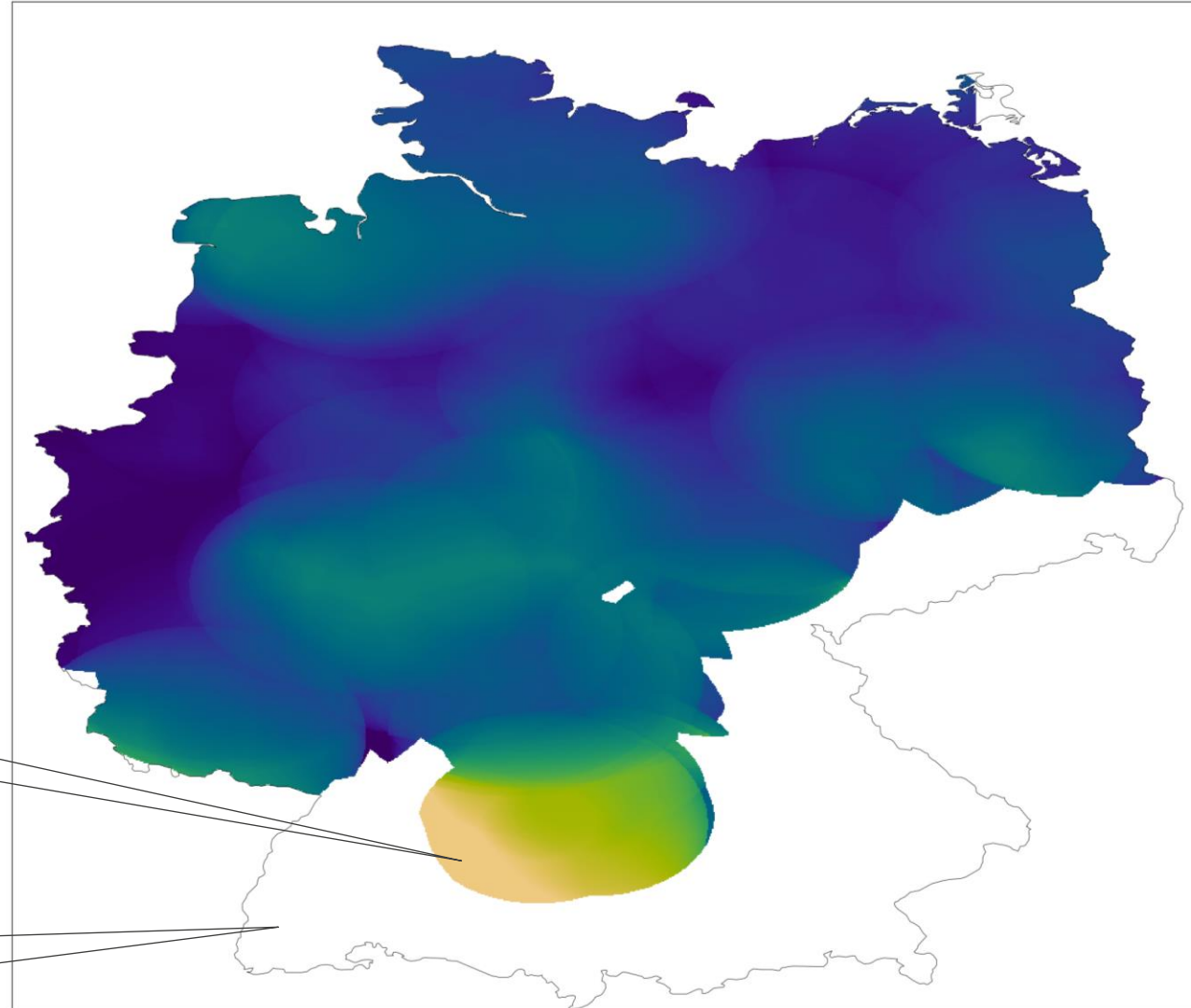
Uncertainty (%)

The uncertainty map shows the standard deviation of residual errors over a 150km radius

Uncertainty is higher in the south

Uncertainty is null where we have <4 sites within 150km

Wind speed accuracy has a large impact on estimated revenue
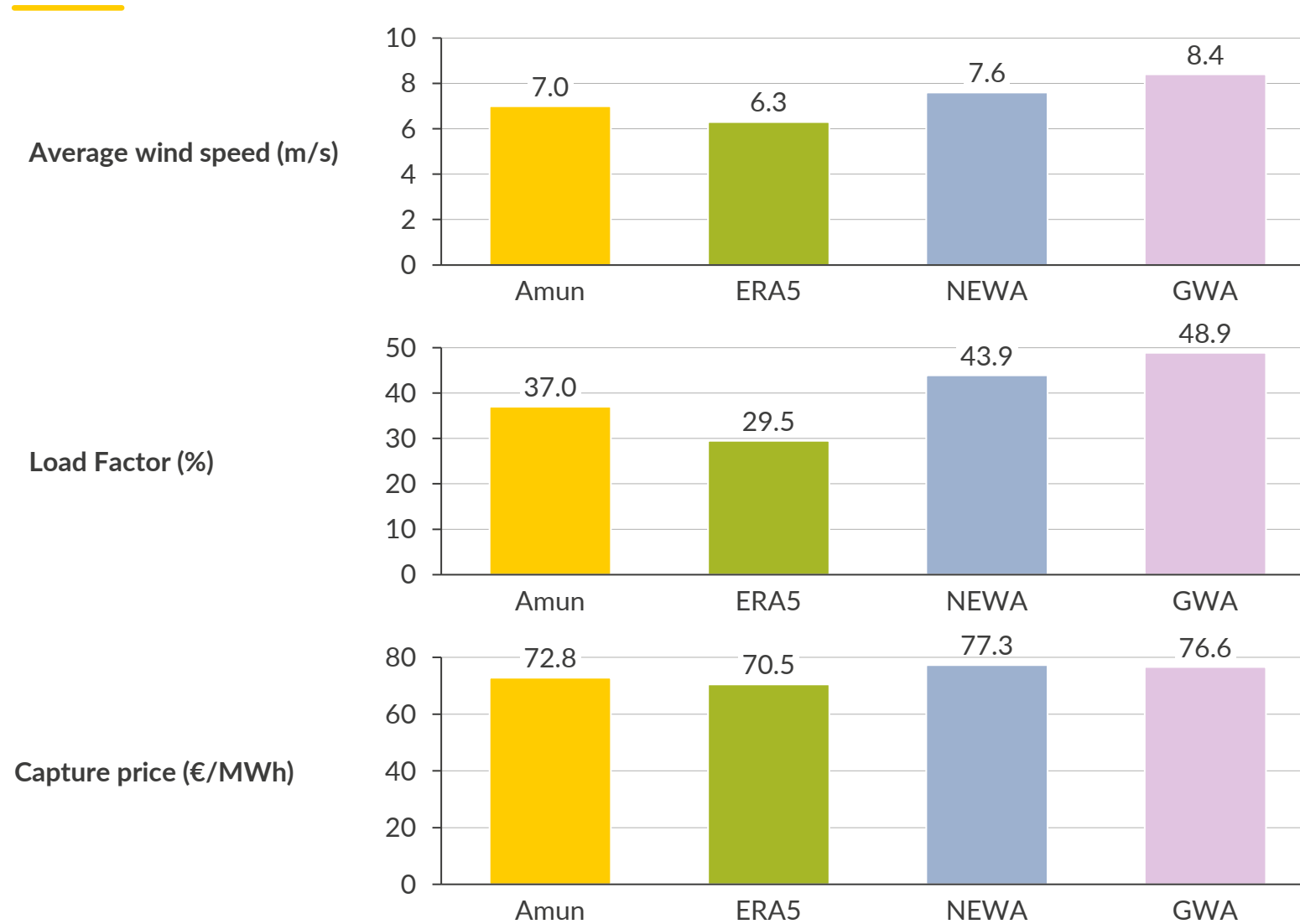
Using the AMUN Wind Atlas allows you to avoid costly mistakes

A U R O R A

Average annual revenue (million €)
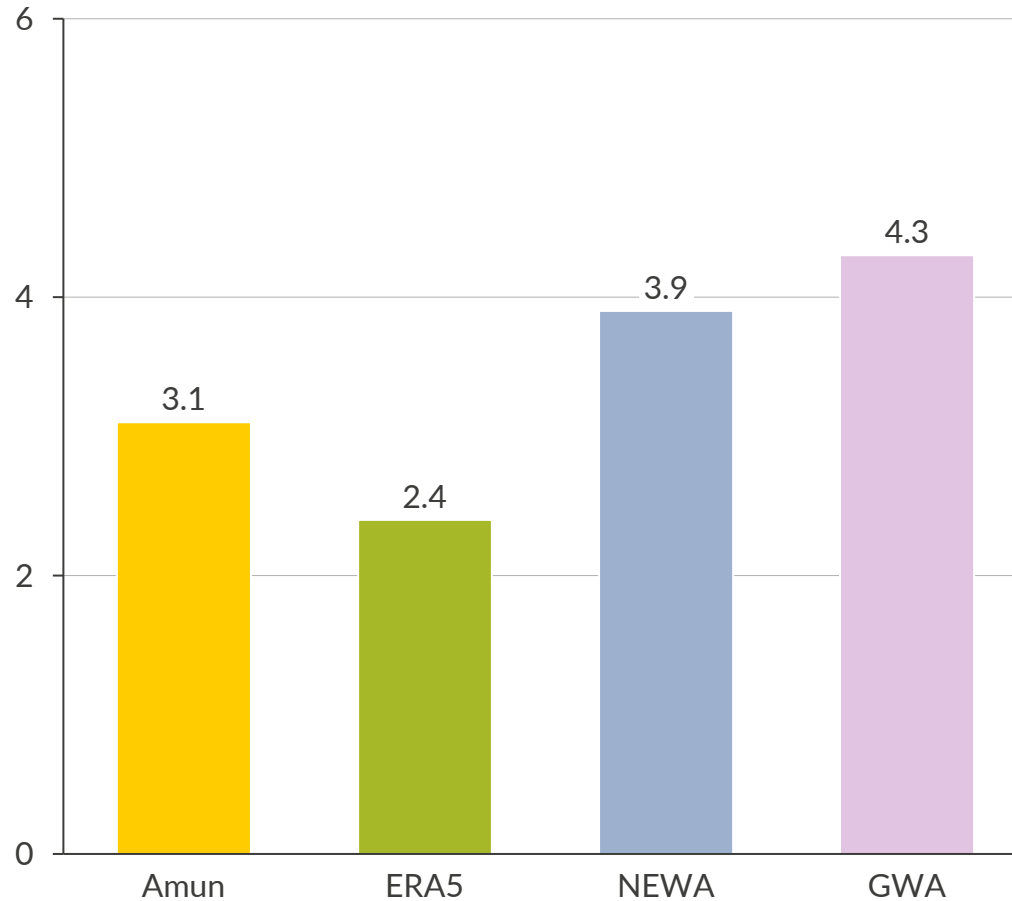
AMUN Wind Atlas benefits:

1. Decrease the number of resource-poor sites where you conduct measurements

2. Decrease the number of resource-rich sites that you reject at early stage

3. Avoid spending money and time on valuing unviable assets and projects in origination

4. Improve the precision of your competitive analysis informing your bidding strategy

5. Reduce uncertainty in your decision making

AURORA
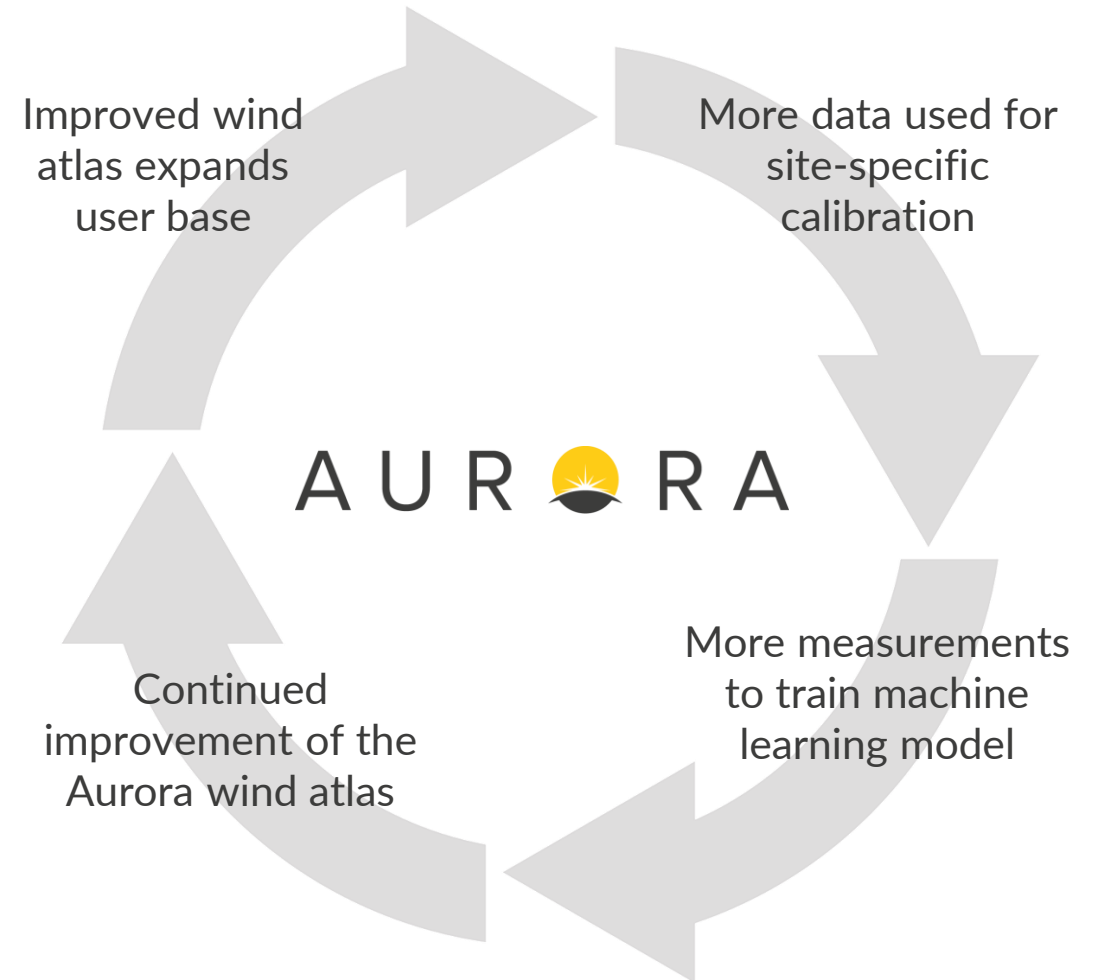
Interested in more Aurora products?

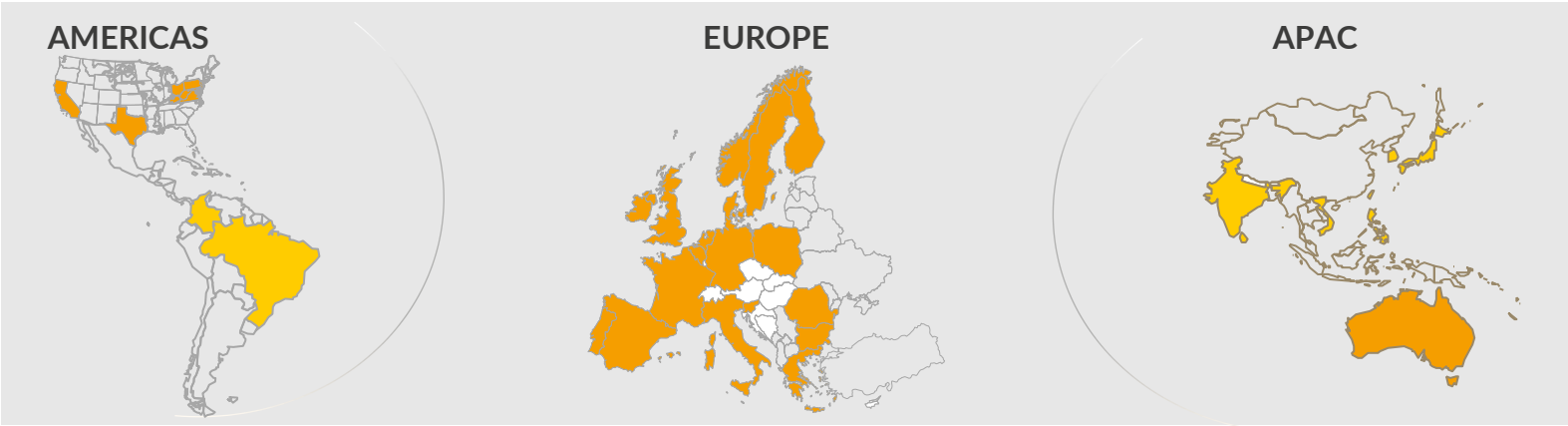Discover our **Offshore Wind Offering!**

Join the study for an opportunity for investors to access Aurora's expertise in offshore wind, with options for global or regional coverage

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Offer

- **Global Offshore Wind MCS** will focus on **three key regions**; Europe, Americas & APAC
- Participants have the option to select the region(s) of focus; discounts available for multiple region bundles

Key:
◑ Partial coverage for Asia & South America

	Market Sizing & Composition	Policy & Regulatory Environment	Technology Costs & LCOE Analysis	Project Economics & IRR Analysis	Investment Strategies
1 Europe	●	●	●	●	●
2 Americas[1]	●	●	●	◑	◑
3 APAC[2]	●	●	●	◑	◑

Deliverables

1 final Multi-Client Study report
Compiling all work and feedback from clients over the course of six months; regular updates from then on under the Investing in Global Offshore Wind service

Discounted access to Amun wind valuation software
and discounts on annual subscriptions to regular Investing in Global Offshore Wind service

3 four-hour workshops
Deep dive into the sector, in a collaborate format by Aurora's senior management

Regions

AMERICAS

EUROPE

APAC

All regions
- ✓ Market sizing & outlook
- ✓ Grid connection risks
- ✓ Regulatory overview
- ✓ Technology costs
- ✓ Auction outlooks
- ✓ Spatial levelized costs

Additional Detailed Analysis
- ✚ Analysis of value drivers
- ✚ Investment strategies
- ✚ IRR Analysis

1) CAISO, PJM, ERCOT, Brazil & Colombia 2) Australia, Japan, South Korea, Vietnam, Philippines, Taiwan & India

Join the Multi Client Study, contact
Julia Breuing, Senior Analyst
✉ **julia.breuing@auroraer.com**