EURO1k: Accuracy Redefined

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Executive Summary

Granular weather data is the basis for reliable forecasts. These in turn are crucial for the planning of operational processes and extreme weather responses. The basis for highly precise forecasts is our unique European weather model EURO1k. Due to its remarkable resolution of 1 km in combination with frequent model updates (hourly updates), you receive fine-scale datasets for your industry throughout Europe.

Thanks to the unique 1 km resolution and hourly model updates, EURO1k customers receive the most accurate and up-to-date weather forecasts for all of Europe. Due to the high local accuracy, EURO1k delivers a high added value in terms of planning reliability and resource utilization, especially for industries whose operations are strongly influenced by short-term weather changes (such as energy in general and renewable energy in particular, but also for aviation and logistics). In weather-dependent trading (e.g. trading of renewable energies), clear competitive advantages can be realized thanks to better weather forecasts.

EURO1k to realize competitive advantages: Thanks to its uniqueness, customers will experience unique benefits that can only be achieved with EURO1k. As a result, operational efficiency can be increased, resources are used efficiently, and planning reliability and forecast quality are also enhanced. In addition to greatly improved and optimized processes, this also leads to significant cost savings and can ultimately result in strong competitive advantages.

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Introduction to Weather Models

Numerical Weather Models

A numerical weather model calculates the current and future states of the atmosphere with the help of computers and on the basis of measured data, both locally measured and remotely sensed. Complex physical equations are used, which are calculated by high-performance computers with enormous power and processed into high-resolution weather forecasts.

To obtain weather forecasts, a numerical weather model covers the earth with a three-dimensional grid. For each grid point, relevant parameters are calculated for different heights in fixed time steps. Depending on the weather model, the grid points are located at different distances from each other, and the resolution of the models varies correspondingly.

Resolution of Weather Models

When using weather models, a distinction is made between spatial and temporal resolution. A high spatial resolution in weather models means, for example, that all data points are no more than 1 km away from each other. With a high spatial resolution of 1 km or less, many local and dynamic effects can be mapped, greatly refining and thus improving weather forecasts at the local level. A high temporal resolution, on the other hand, means that changes in weather are detected by the model over short time time intervals, such as every 20 minutes.

Global Weather Models

In global weather models, a mesh size of 10 to 50 km is common. This is usually sufficient to optimally predict conditions in the upper atmosphere, but the topography below the horizontal resolution (10-50 km) cannot be captured by models, and finer-scale events, such as thunderstorms, cannot be modelled as a result. Thus, forecasts of parameters near the earth's surface, such as wind, maximum or minimum temperature, can be inaccurate at a local level. Higher resolution global models are required to close these data gaps.

Examples of global weather models are, among many others: the American Global Forecast System (GFS) with about 25 km resolution and the forecast model of the European Centre for Medium-Range Weather Forecasts (ECMWF) with about 10 km resolution.

Local Weather Models

In contrast to the global weather models, the grid points of local weather models are much closer together. The usual range is 1 - 15 km. The rule is: the closer, the better the resolution of the individual models. This requires a lot more computational capacity and is therefore only calculated for a period of one to three days.

The DWD-ICON EU, with about 5 km resolution, is an example of a local weather model.

Limitations of Current Weather Models

There are usually limits to the forecast quality of weather models. Here, fundamental sources of error can occur, such as:

- **Insufficient model resolution (horizontal and vertical):** Processes that take place below the model resolution cannot be optimally predicted.
- **Inaccuracy in the initial conditions:** The less observation data is included in the model at the initial time-step, the less realistic the initial state of the model is and the less accurate the subsequent prediction will be.
- **Poor model parameterisation:** Errors in the model equations (in the program code) can lead to incorrect predictions.
- **Numerical prediction error:** The solution of the equations contains numerical rounding errors that can accumulate to larger errors during the model runtime.

EURO1k – The Fine-Scale Weather Model for Europe

EURO1k is an extremely high-resolution weather model for **all of Europe**. It's calculated by our team of experts to a resolution of **1 km**. This resolution is **unique** for a weather model, as the standard for global weather models is a resolution of 20 km.

With a high temporal resolution, we succeed in greatly improving the weather forecasts with respect to the temporal occurrence of the weather events. Our weather data are provided by the model calculations in a resolution of **20 minutes** (other models may only offer data every 1 to 6 hours). By means of data interpolation, the data can be output at a resolution of as little as **1 minute**. The model is recalculated **hourly** with the latest weather data.

How EURO1k Works

A weather model is only as good as its initial conditions. Therefore, qualitative conditions are crucial for the calculation. For the boundary conditions, the EURO1k needs values outside Europe. The ECMWF-IFS model is used here since it is considered the global leader in terms of forecast quality. The native representation of the model is normally 9 - 14 km.

All existing measurement data are assimilated into our EURO1k model and calculated with a resolution of 1 km. Highly complex data assimilation and downscaling technologies are used to produce even more precise forecasts.

Boundary condition: ECMWF-IFS

- Spatial resolution: 0.1° (~9 km)
- Time resolution: up to 1 hour
- Lead time: 10 days (6 and 18 UTC up to 90 hours)
- Updates per day: 4

Downscaling

The results of the model calculations are post-processed using downscaling. The 1 km-resolution data are downscaled to an even finer resolution, in this case to 90 m. This is made possible by the NASA terrain model, which we include in the calculation. In this way, we can make use of high-resolution land use data, soil, terrain data, astronomical calculations, and other sources. In the final step, the most recent observations are calibrated into the predictions.

Geographical Coverage of EURO1k

EURO1k covers all of Europe plus North Africa and extension to the East.

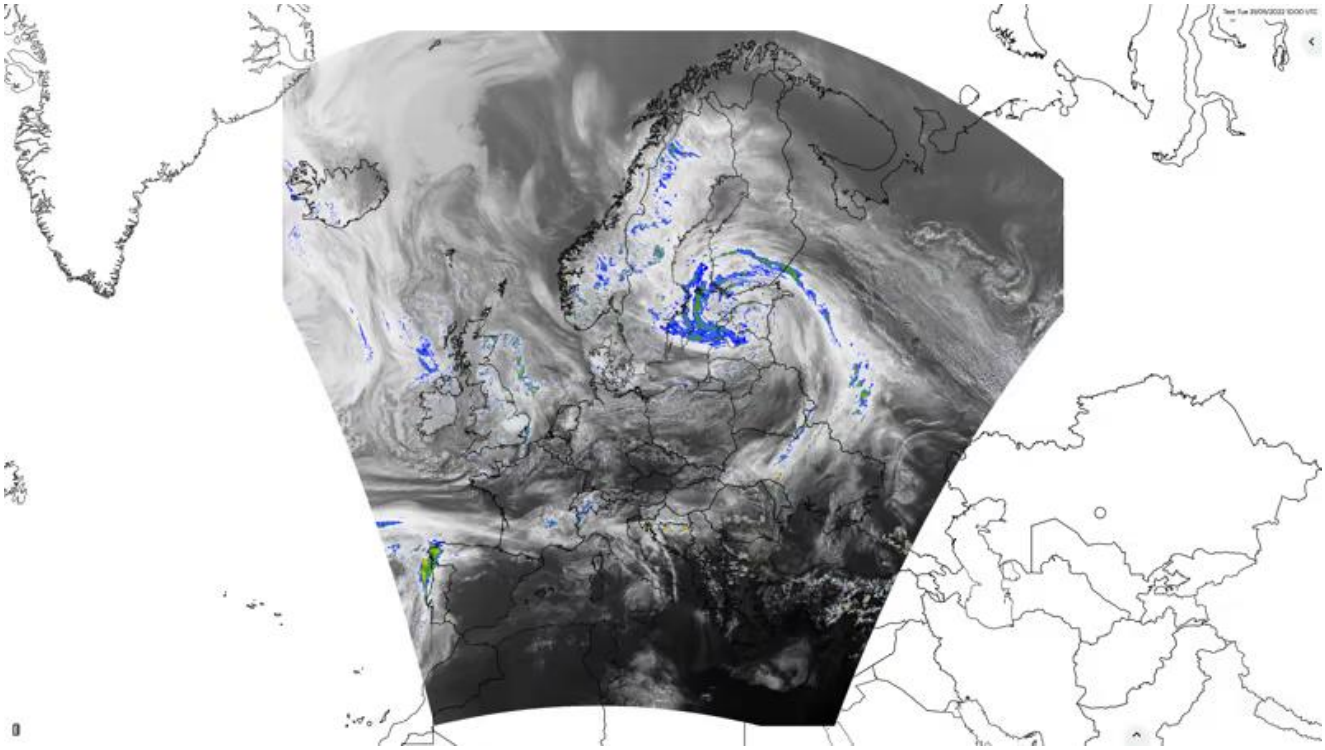


Figure 1 Coverage of EURO1K: all of Europe (plus North Africa and extension to the East)

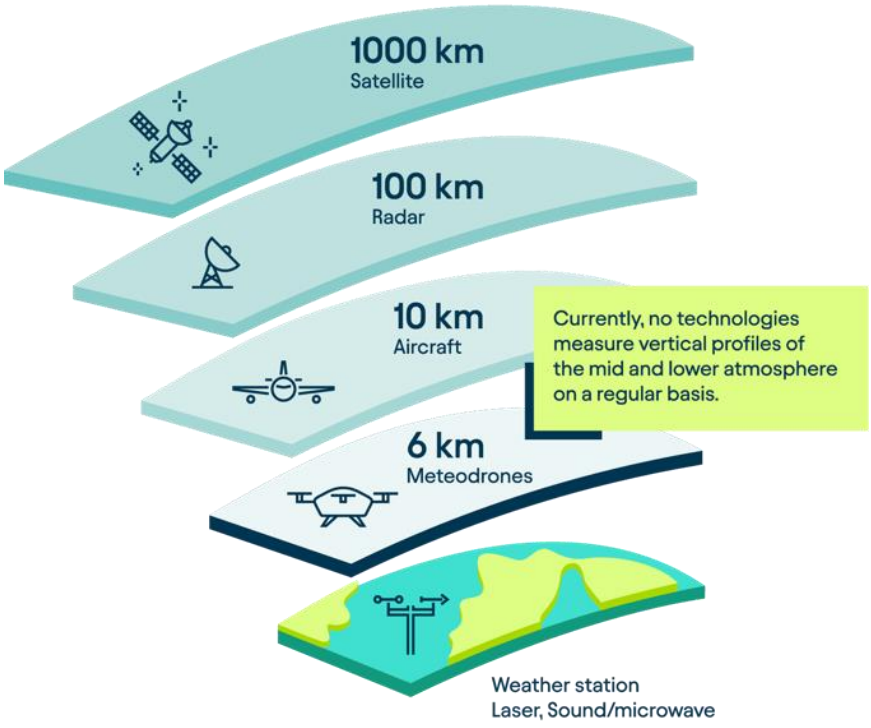
Technical Specifications of EURO1k

Since the model is calculated at high-resolution, it needs a lot of computing power. To be precise, 36000 CPUs (processors) are needed. High-performance computers in a fail-safe infrastructure provide the optimal basis for this, and make all data available in real time.

- Computing effort: ~40000 CPUs needed, 300 HPC VMs(nodes)
- Data storage capacity: ~20 GB per file => 1.5 TB per run (one model computation of EURO1k for 24h) => approx. 1000 TB per month
- Data source: ECMWF (mandatory data source as ECMWF is acknowledged to be best practice for global weather modeling)
- Model coverage in grid points: ~4600 (north/south) x ~4300 (east/west) => ~20 million grid points
- 80 vertical levels in 10 - 100 metre steps/intervals

Exclusive Use of Meteodrones

To make weather forecasts even more accurate in the future, we are the only company in the world to collect atmospheric data with our self-developed weather drone system "Meteodrones".



The European weather model can be refined with drone data at specific locations. If desired, we place our weather drones where there are data gaps. In the event that a verified model has problems measuring fog, a drone station is placed at this location and relevant measurement data is collected. These are then fed into the European weather model, which further refines and improves the forecast in the vicinity of the drone.

What Makes EURO1K So Special

- A resolution of 1 km
- Lead time of 48 hours
- Geographical coverage of all of Europe
- Hourly update of the weather model with integration of all measurement and observation data available in Europe
- Exclusive use of weather drones
- Downscaling enables resolution of up to 90 m
- Over 1800 available weather parameters
- Real-time data availability
- Boundary condition: ECMWF-IFS

EURO1k Compared to ECMWF and ICON EU

Visual Comparison

EURO1k by Meteomatics: 1 km resolution

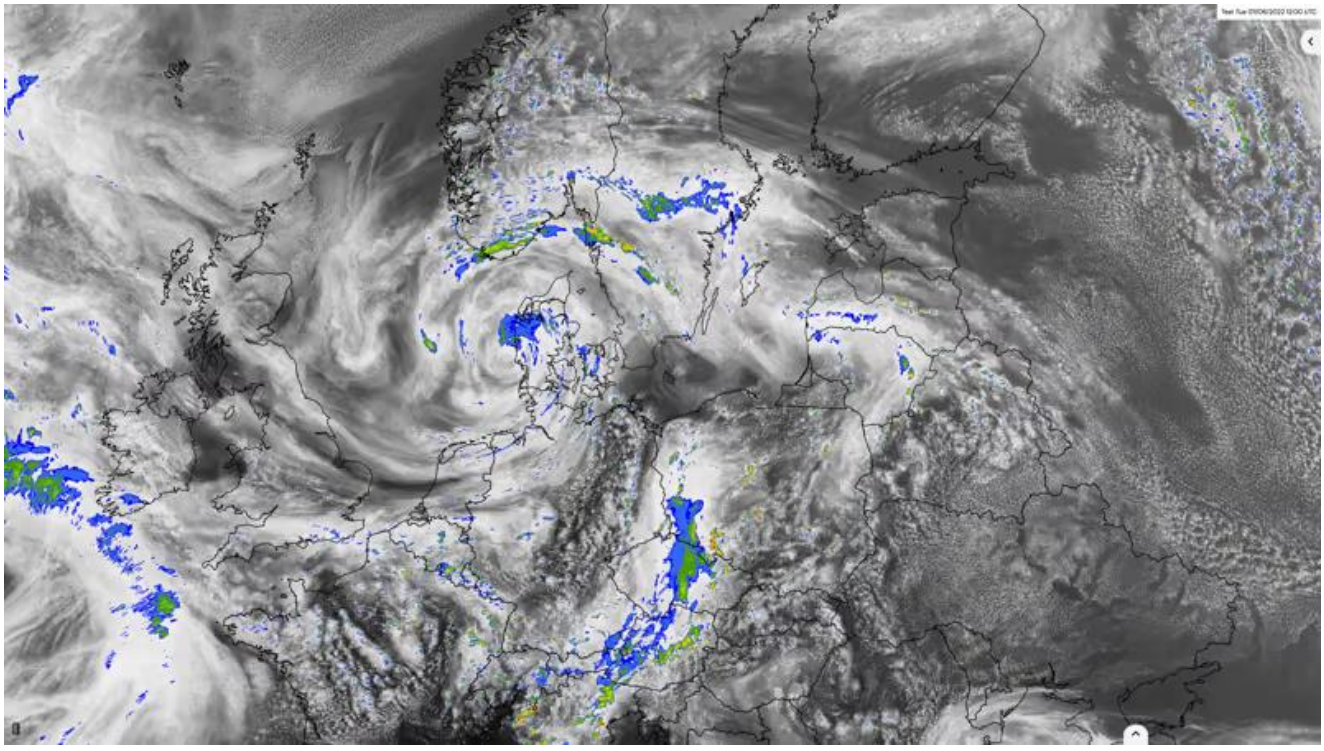


Figure 2 EURO1k: Precipitation and global radiation

ECMWF: 9–10 km resolution

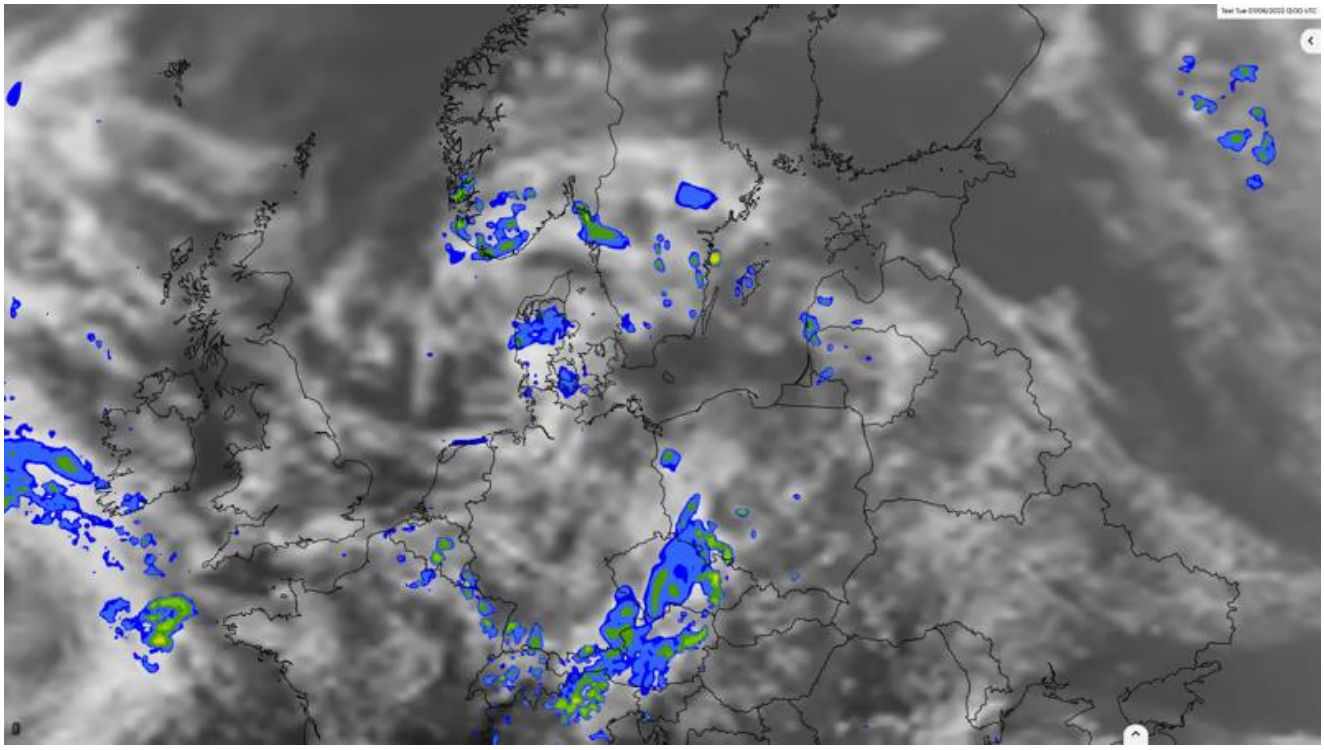


Figure 3 ECMWF: Precipitation and global radiation

ICON EU: 5–6 km resolution

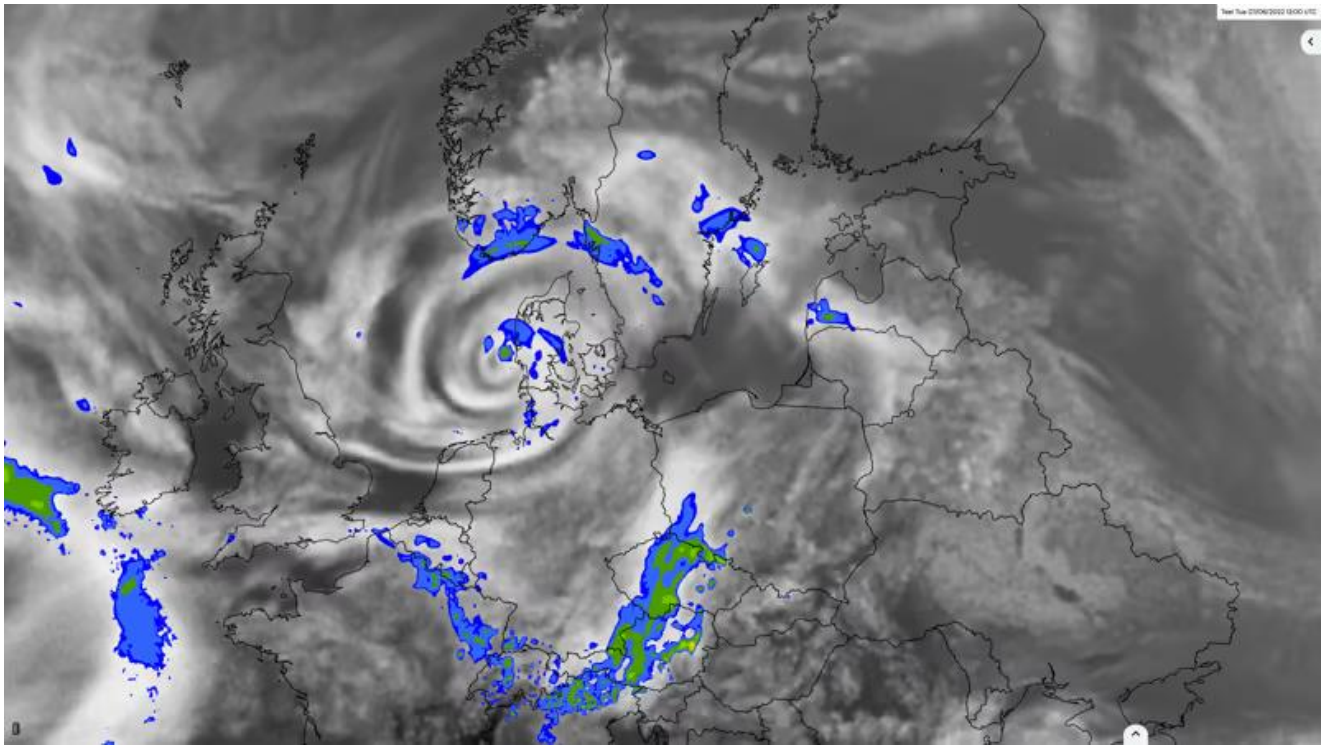


Figure 4 ICON EU: Precipitation and global radiation

Features Comparison

Features	EURO1k	ECMWF	ICON EU
Spatial Resolution	1 km	9-10 km	5-6 km
Time Resolution	20 min	Hourly	Hourly
Downscaling	90 m	90 m	90 m
Lead Time	48 hours	10 days	5 days
Daily Updates	24	4	8
Model Coverage in Grid Points	~4600 (north/south) x ~4300 (east/west) => ~20 mio. grid points	~1800 (north/south) x ~3600 (east/west) => ~6.48 mio. grid points	~656 (north/south) x ~1,069 (east/west) => ~701,200 grid points
Vertical Levels	80 in 10 - 100 m steps/intervals	137 in 20 - 5,800 m steps/intervals	60 in 10 - 2,600 m steps/intervals

Measured and Model Data Comparison: Examples

The measurements shown on all the following charts were initiated at midnight and forecast the next 24 hours. These are only a few examples of the performance of EURO1k. For more, please get in touch with our team of experts.

Solar Power in North of Germany

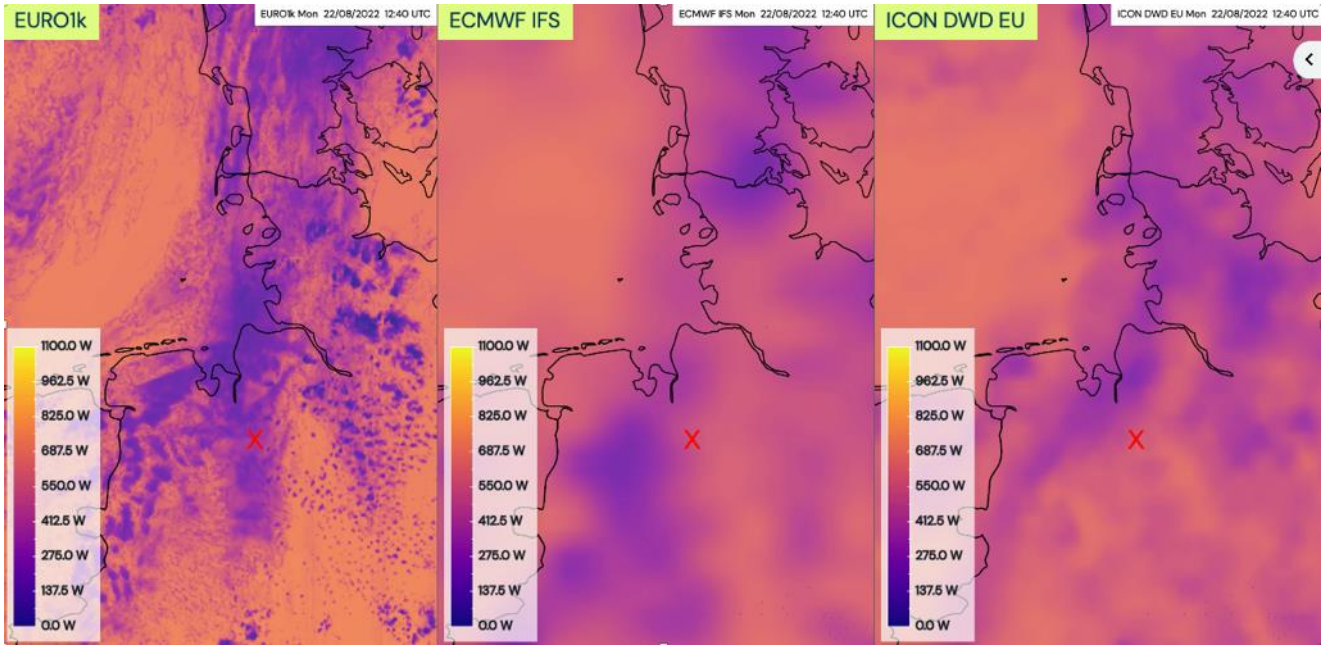


Figure 5

Figure 6

The red X on figure 5 marks the location of a solar power plant in the north of Germany. The difference between the forecast of EURO1k and the other models is clear: EURO1k was capable of capturing radiation in much more detail. As figure 6 shows, between 11:30 and 14:30, EURO1k was the model that got closer to the station's measured data, thus providing the most accurate forecast of energy production capacity for that time.

Wind Power Site at North Sea (GER)

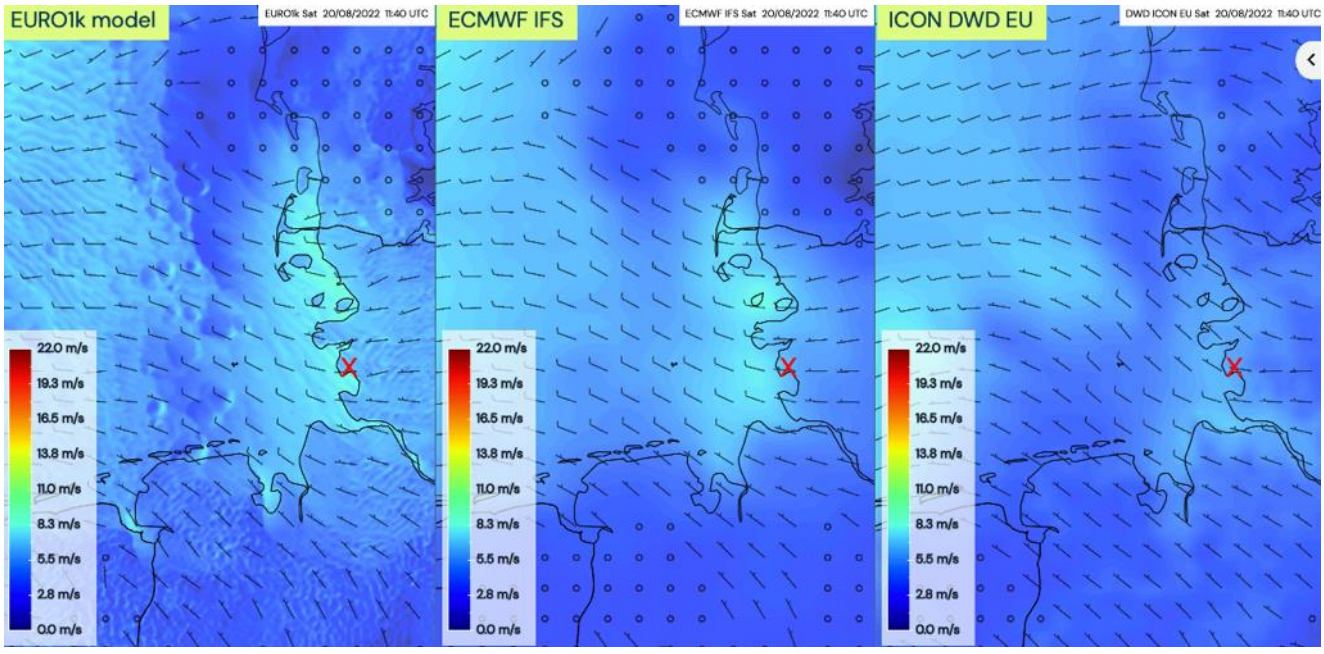


Figure 7

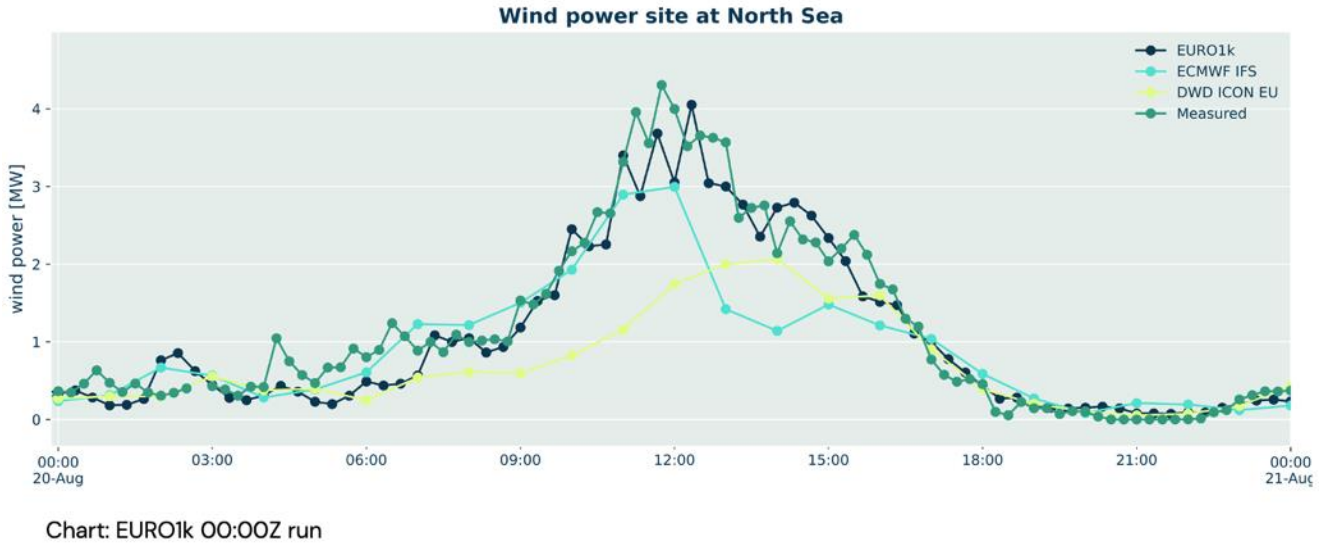


Figure 8

The red X on figure 7 marks the location of a wind power plant at the North Sea. Here, once again, the difference between the forecast of EURO1k and the other models is clear: EURO1k was capable of capturing wind speed in much more detail. As figure 8 shows, between 12:00 and 16:30, EURO1k was the model that got closer to the station's measured data, thus providing the most accurate forecast of energy production capacity for that time.

Wind Speed (channeling effect) at Sariyer (Turkey)

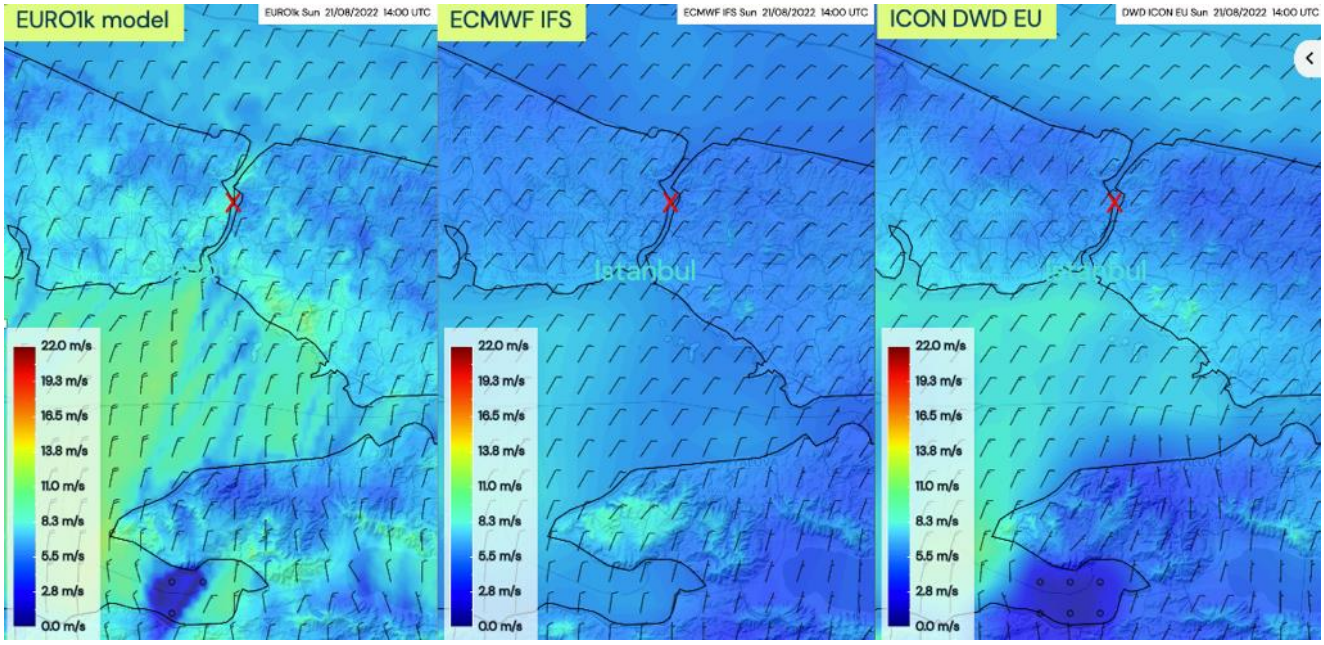


Figure 9

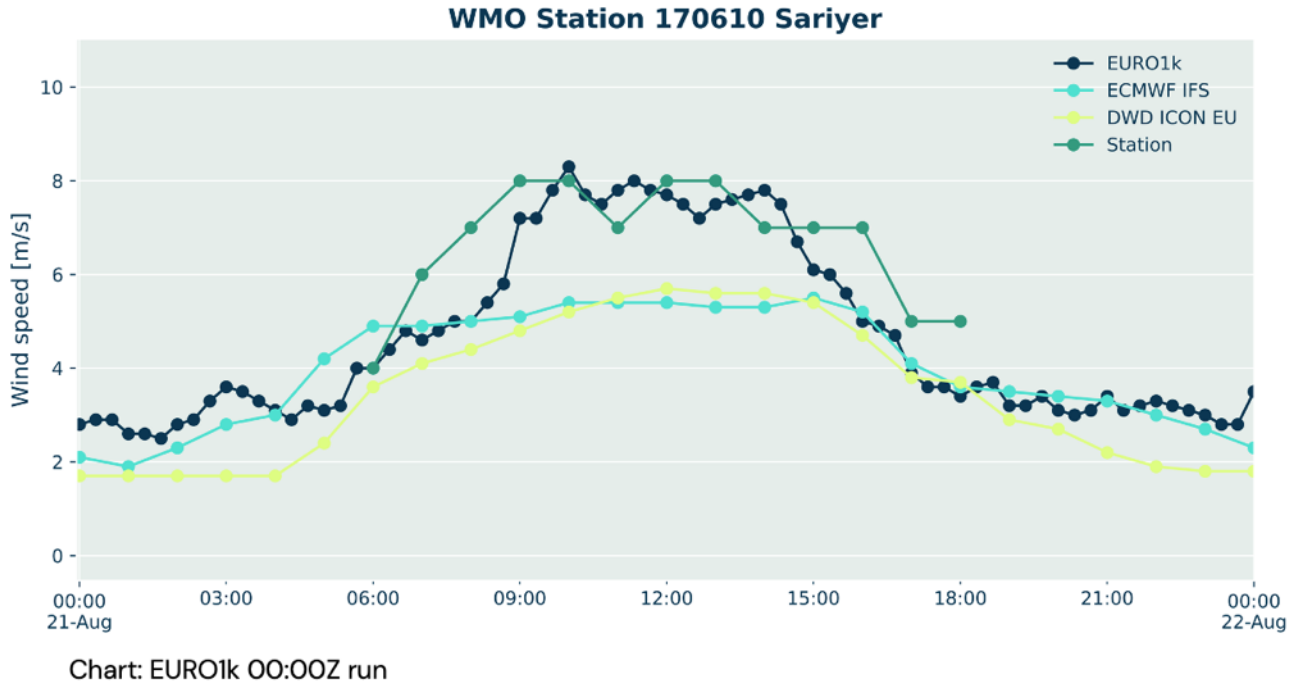


Figure 10

The red X on figure 9 marks the location of a weather station. The difference between the forecast of EURO1k and the other models is outstanding. As figure 10 shows, between 9:00 and 15:00, EURO1k was the model that got closer to the station's measured data, thus providing the most accurate forecast of wind speed for that time.

Warm-front Over Europe (Precipitation)

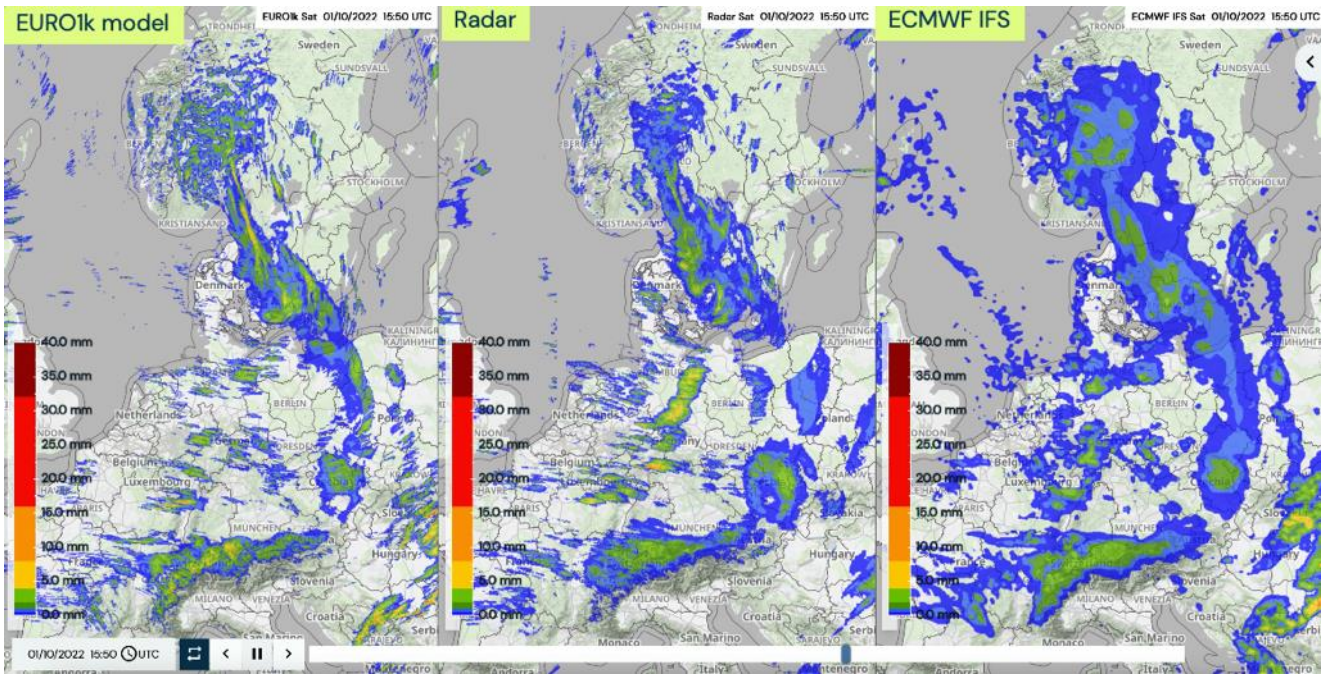


Figure 11

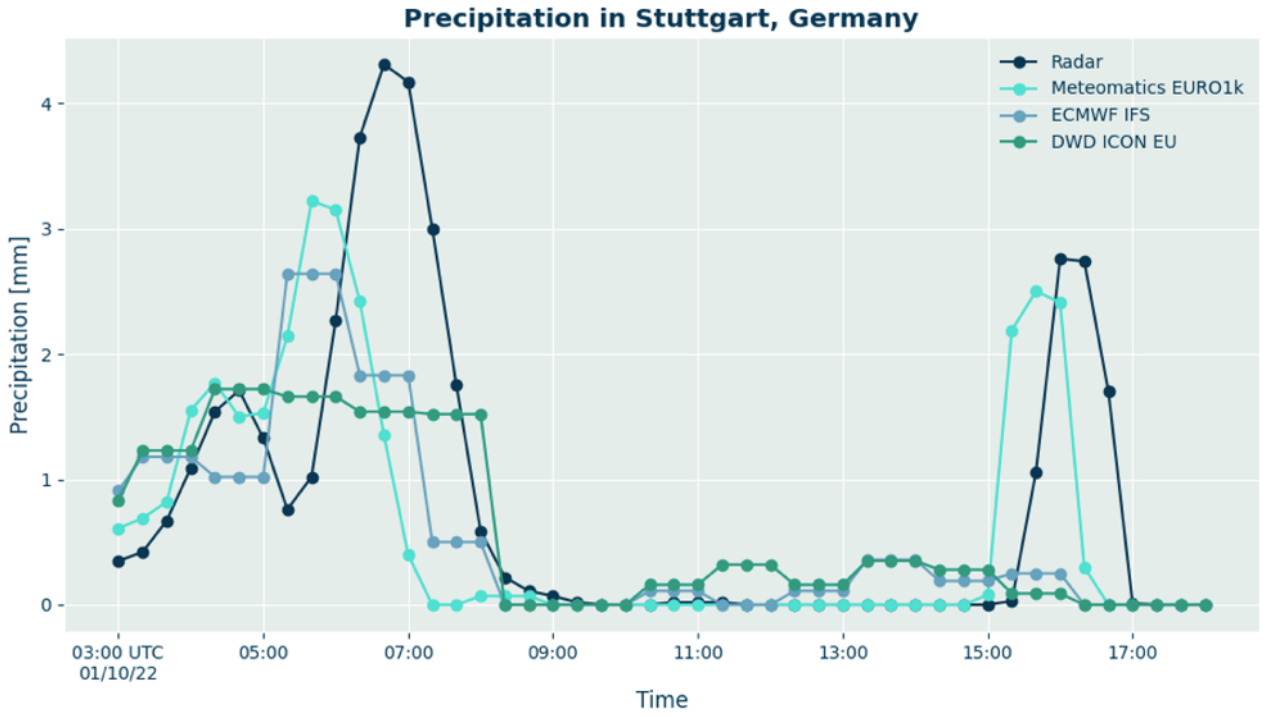
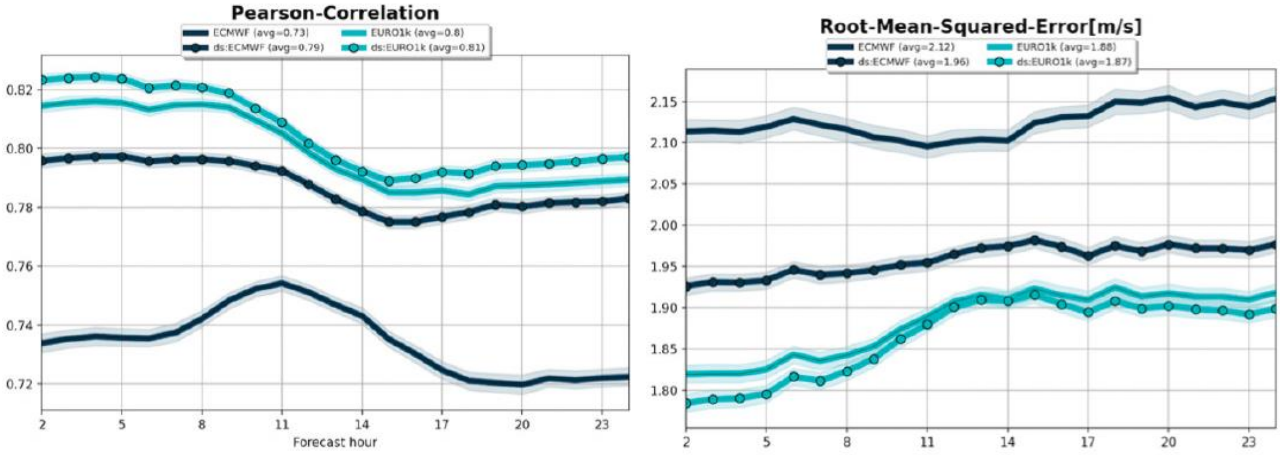


Figure 12

On figure 11, the difference between the data modeled by EURO1k and ECMWF IFS compared to the radar measured data is impressive. As figure 12 shows, EURO1k was the model that calculated the closest precipitation numbers for most of the day in Stuttgart, especially from 08:30 to 17:00.

Verifications

Verification of 10-Meter Wind Speed Across Europe

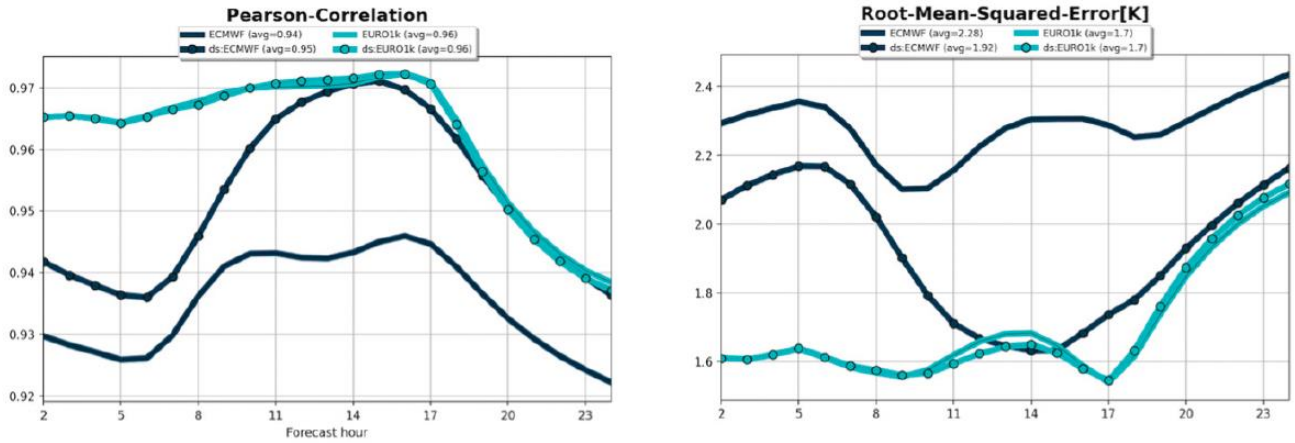


Time period: 01.01.23 — 31.03.23. Number of weather stations: 4,869 across Europe

Among the outputs, the downscaled EURO1k data (blue-dotted line) exhibited the highest correlation value of 0.81 and the lowest RMSE value of 1.87, demonstrating superior overall performance. The original EURO1k data (blue line) closely followed with a correlation value of 0.8

and an RMSE value of 1.88. The downscaled ECMFW (black-dotted line) model performed slightly worse with a correlation value of 0.79 and an RMSE value of 1.96. The original ECMFW data (black line) displayed the lowest correlation value of 0.73 and the highest RMSE value of 2.12, indicating relatively weaker performance in predicting 10m wind speed across Europe.

Verification of 2-Meter Temperature Across Europe



Time period: 01.01.23 — 31.03.23. Number of weather stations: 4,869 across Europe

Both the downscaled EURO1k data (blue-dotted line) and the original EURO1k data (blue line) demonstrated strong correlations of 0.96, indicating a robust relationship between their predicted and observed 2m temperatures. Additionally, both models achieved low RMSE values of 1.7, indicating accurate predictions. The downscaled ECMFW data (black-dotted line) also performed well with a correlation value of 0.95 and an RMSE value of 1.92. However, the original ECMFW data (black line) exhibited a slightly lower correlation value of 0.94 and the highest RMSE value of 2.28, suggesting a relatively weaker performance in predicting the 2m temperature across Europe.

Industry Applications

By refining various measurement data through downscaling, we are able to achieve unprecedented accuracy, especially at the local level. In particular, customers who are dependent on local weather experience great added value from high-resolution data.

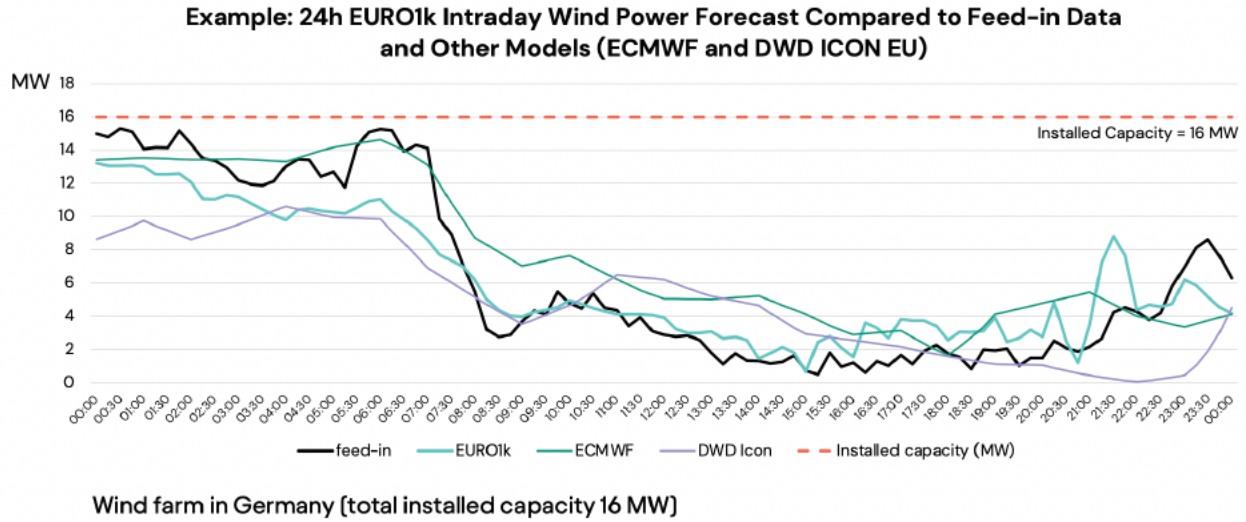
Renewable Energies

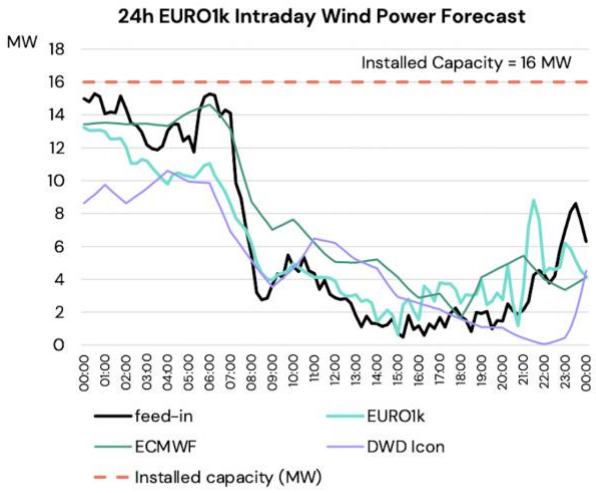
In times of global uncertainty regarding the supply of energy coming from fossil fuels, it's on the renewable energy sector to absorb the high demand of the winter season. Efficiently planning the energy production, storage, and transmission to ensure energy security is a challenge that can only be met with precise hyperlocal weather forecasts, such as the ones provided by EURO1k.

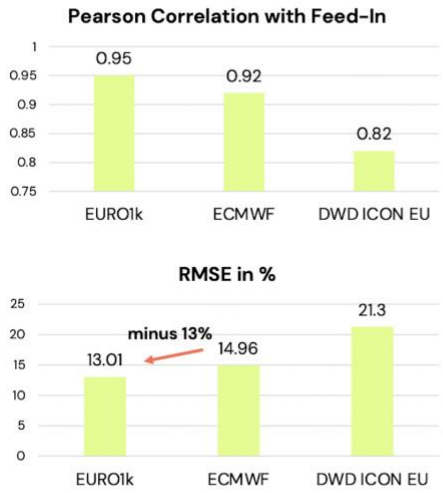
Energy Trading

Highly accurate local weather data helps guarantee successful trading results for the sector. For energy traders, the next 24 and 48 hours are critical, and granular weather data is crucial for intraday and day-ahead energy trading. With lead times of 24 and 48 hours, EURO1k is the perfect weather model for intraday and day-ahead trading, as well as hyper-local short-term weather forecasts with a high level of accuracy.

Below, the comparison between EURO1k and ECMWF/DWD Icon wind power forecasts, using actual feed-in data from the wind farm, indicates that EURO1k demonstrated the highest forecast accuracy for wind power. EURO1k's forecast of 588 MWh closely matched the observed feed-in value of 617 MWh, while the ECMWF overestimated with a forecast of 739 MWh, and the DWD ICON EU model underestimated with a forecast of 484 MWh.







EURO1k reduces RMSE by 13% compared to ECMWF

Utilities and Energy Infrastructure

Utilities' round-the-clock provision of essential services require large amounts of energy to keep the facilities running. The energy needed for cooling and heating the infrastructure is directly related to the outside temperature, humidity, and wind. Properly managing ambient temperature ensures the correct functioning of equipment and leads to energy savings. Furthermore, utilities must be aware of severe weather events that can damage infrastructure to be able to prepare and react fast.

Highly accurate weather forecasts help utilities to plan accordingly, ultimately leading to energy consumption optimization, financial savings, and efficient service provision.

Aviation

The weather in airport locations or along a flight route has a major impact on aviation operations. Severe weather conditions are responsible for most flight delays and play a large role in accidents and incidents during takeoff, landing, and in the air.

Fuel consumption is also influenced by weather conditions. By varying the altitude slightly, or by deviating laterally by a few kilometers along the flight path, a pilot can take advantage of smoother wind conditions and thus contribute to an efficient and equally more environmentally friendly flight.

With a resolution of 1 km, EURO1k's forecasts support airport operators and pilots in planning for weather-related risks, saving operating and maintenance costs, as well as ensuring the safety of passengers.

Logistics and Shipping

The safety of workforce and cargo, delivery punctuality, loading and unloading, and fuel consumption are directly impacted by the effects of extreme events. Extreme weather events can disturb traffic and damage railroad tracks, roadways, ports, piers, bridges and other transportation infrastructure, causing accidents, timetable disruptions, loss of goods, and elevated costs.

Highly precise weather forecasts help logistics and shipping companies adjust timetables and routes, increase punctuality, have more efficient fuel consumption, and prevent accidents.

Governments and Defense

Weather conditions can affect the outcome of many government and military operations. Having granular weather data can give strategic advantages in conflicts, support search and rescue operations in the aftermath of accidents or natural disasters, and inform decision-making processes regarding how to tackle climate change.

Furthermore, the military is increasingly employing remotely piloted aircraft (RPA). The capacity to "see and avoid" and "remain-well-clear" from obstacles and dangerous weather conditions is impaired for remote pilots. Hyperlocal weather forecasts with high spatial and temporal resolution help them fly more safely.

Insurance

The safety of lives, property and assets is directly impacted by the effects of extreme events. With EURO1k's fine-scale weather data, insurers can better assess near-term claims, as well as better predict near-term risk.

This comprehensive data allows the insurance sector to better plan their policies, consider weather-related cancellations, and warn their clients about dangerous events during their time abroad. The real-time data can even be used to facilitate automatic claim payment in a parametric insurance policy.

Media

Be it via weather apps or traditional TV, media outlets provide daily weather updates and issue severe weather warnings.

As leading sources of weather information that help people organize their days and keep safe, news media must have access to the most accurate local weather data. EURO1k's granular temporal and spatial resolution allows them to diffuse precise forecasts to the population and indicate to reporters where exactly they need to go to cover weather events.

More

The above are only a few examples of industries to which EURO1k will bring great value. In fact, every sector that uses weather data to optimize operations or protect lives will benefit from our weather model's highly precise forecasts with 1 km resolution.

Our team of meteorologists and sales managers are always happy to discuss different use cases and would love to hear from you. Just drop a message to one of our experts listed below and we'll get back to you shortly.

Conclusion and Unique Benefits

EURO1k is the **first and only model** in Europe that covers a resolution that can model even the smallest meteorological phenomena (thunderstorms, hail, storms, etc.), producing **highly precise forecasts spatially and temporally.** And this completely individually for relevant sectors.

What Makes EURO1K So Special

- **A resolution of 1 km**
- **Lead time of 48 hours**
- **Geographical coverage of all of Europe**
- **Hourly update of the weather model with integration of all measurement and observation data available in Europe**
- **Exclusive use of weather drones**
- **Downscaling enables resolution of up to 90 m**
- **Over 1800 available weather parameters**
- **Real-time data availability**
- **Boundary condition: ECMWF-IFS**

FAQ

How often is the European weather model calculated?
The EURO1k model is updated hourly with the integration of all measurement and observation data available in Europe.

What makes the predictions so accurate?
The European weather model is accurate due to the calculated resolution of 1 km across Europe. This resolution allows countless weather details to be incorporated, as data points are available after every km. In this way, the accuracy of the forecasts within Europe increases greatly.

In addition, assimilation increases the accuracy of the predictions because the model is repeatedly brought closer to the actual state of the atmosphere and errors can thus be minimised.

Over what period of time can accurate weather forecasts be made with EURO1k?
Due to the hourly updates and the high resolution, the model error is extremely low in the first 6 - 12 h after each initialisation. Even beyond that, high accuracy can be expected compared to other models, thanks to the higher resolution. Since the EURO1k is a high-resolution weather model, it can be used by default for short-term forecasts up to 48 h.

Get Access

Request Access to EURO1k

EURO1k is not included in the regular API access. However, EURO1k can be unlocked in case of a specific request via the API. Through our Weather API you get permanent access to the European weather model EURO1k. Use the full range of relevant weather data with the EURO1k package or request our time-limited test package.

Talk to Our Experts

If you are interested in accessing the new EURO1k please get in touch with our experts.

Our team of meteorologists, engineers and sales managers are happy to help you with any questions you may have.

Dr. Martin Fengler
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Melanie Luther
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mluther@meteomatics.com

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bguay@meteomatics.com

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More Products and Services

Weather API

With our weather API you get continuous access to worldwide high-resolution weather, ocean, environment and climate data as well as historical data, real-time data, forecasts and climate scenarios up to 2100.

Please note that EURO1k is not included in the regular API access.

Weather API

Weather Visualization – MetX

Visualise all weather events in a high-resolution map view - with our web-based weather map tool MetX based on the Weather API.

MetX

Weather Data Shop

If you only need one-time access to certain weather data, you can directly download individual weather data sets from our weather data shop. You will find a comprehensive selection of current and historical weather data as well as sector-specific weather parameters.

Data Shop

Weather Drones – Meteodrones

Our Meteodrones offer the possibility to collect weather data from the lower and middle atmosphere. With Meteodrones, it is possible to carry out high-resolution and direct measurements of temperature, humidity, air pressure and wind, to incorporate these into weather model calculations and thus demonstrably improve weather forecasts.

Meteodrones