D5.1 - Report detailing each application

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1 Executive Summary

In this report, we define the 22 applications that will test the WeatherGenerator. These applications span a range of use-cases, covering weather and climate, renewable energy, water, and the biosphere. Applications have global and regional coverage, cover timescales from nowcasting through seasonal forecasting, and include forecasting, downscaling, and data-fusion tasks.

We have generated summaries of every application and made them available to the public through the WeatherGenerator project website. Additionally, we have collected extensive metadata on every application, providing core modellers with important information that can help the design of the model. This includes what datasets are used, what output parameters are of interest, desirable properties of the predictions, and what the existing solutions are that the WeatherGenerator will improve upon.

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2   Introduction

2.1   Background

Climate change brings huge risks for the wellbeing and prosperity of society in Europe and world-wide. Earth system models that provide a numerical representation of the various components of the Earth system with atmosphere, ocean, land surface, land ice, sea ice, lakes and atmospheric chemistry are currently the best available tools to understand and prepare for climate change and the associated weather extremes.

The WeatherGenerator project will build the world's best generative Foundation Model of the Earth system – that will serve as a new Digital Twin for Destination Earth (DestinE). The WeatherGenerator will be based on representation learning and create a general and versatile tool that models the dynamics of the Earth system based on a large variety of Earth system data. At the same time, it will integrate observations and simulations at a previously unseen level and scale.

This project brings together Europe's leading scientific groups and research institutes, Small and Medium-sized Enterprises (SMEs), and industry partners in the area of Earth system modelling, high-performance computing (HPC) and machine learning to build the WeatherGenerator as a new Digital Twin of DestinE. Once trained, the WeatherGenerator will be applied for selected high-impact applications in the energy, food, water and health sectors.

The WeatherGenerator will lead to key innovations in weather and climate science and machine learning to enable Europe to establish and defend leadership with respect to machine-learning based Earth system modelling. The WeatherGenerator will define a new state-of-the-art in both machine learning and weather and climate sciences. Through its vastly improved efficiency and flexibility compared to current Earth system models, the WeatherGenerator will create new opportunities for fast DestinE services that allow testing of many different management options and can include new levels of interactivity for a large user base including, for example, city planners, regional and national authorities, architects, and engineering companies.

2.2   Scope of this deliverable

2.2.1   Objectives of this deliverable

The objective of this deliverable is to describe the 22 applications that will, throughout the project, use the WeatherGenerator to build custom machine learning solutions.

2.2.2   Work performed in this deliverable

This deliverable is the result of the work done as planned in Tasks 5.1 to 5.8. Each task focused on a specific set of applications within one thematic area (e.g. Weather, renewable energy, etc), but the work performed was similar for all tasks.

This work has been split into two parts. The first consists of creating short descriptions of each application (Section 3) that is suitable to be posted publicly on the project's website (Section 4). We also created tables where we stored extensive metadata on every application (Section 5).

2.2.3   Deviations and counter measures

No deviations have been encountered.

2.2.4 WeatherGenerator Project Partners:

ECMWF	EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS
FZJ	FORSCHUNGSZENTRUM JUELICH
MetNor	NORWEGIAN METEOROLOGICAL INSTITUTE
MPG	MAX-PLANCK-GESELLSCHAFT ZUR FÖRDERUNG DER WISSENSCHAFTEN E.V.
KNMI	ROYAL NETHERLANDS METEOROLOGICAL INSTITUTE
MetFrance	MÉTÉO-FRANCE
SMHI	SWEDISH METEOROLOGICAL AND HYDROLOGICAL INSTITUTE
UKMO	UK METOFFICE
CMCC	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI
eScience	NETHERLANDS ESCIENCE CENTER
Buluttan	BULUTTAN
KAJO	KAJO SERVICES
LT	LATEST THINKING
Statkraft	STATKRAFT
ETHZ	EIDGENÖSSISCHE TECHNISCHE HOCHSCHULE
MetSwiss	METEOSWISS

2.2.4 WeatherGenerator Project Partners:

3 Application summaries

This section defines the 22 WeatherGenerator applications, including a short description and key points.

AP1: Global medium-range forecasting

In this application, ECMWF will use the WeatherGenerator to generate global medium-range weather forecasts. Forecasts will be produced either directly in a zero-shot setting or by fine-tuning the forecasting decoder for medium-range predictions. The quality of predictions will be evaluated against IFS, AIFS, and other machine-learned forecasting systems using standard diagnostics and forecast scores. Experimental daily forecasts will be made publicly available via ecCharts, allowing transparent comparison between the WeatherGenerator, conventional IFS forecasts, and AIFS, and providing an important check on the model's robustness.

Key features:

- Main developer: ECMWF
- Time horizon: 3-10 days ahead
- Coverage: Global

AP2: Global extended-range forecasting

In this application, ECMWF will use the WeatherGenerator to produce extended-range forecasts using a fine-tuned forecasting decoder. As an exploratory study, the model will also be run for several years following the AMIP protocol to assess its potential in climate applications. Forecasts will be coupled with sea surface temperature fields from the DestinE Climate Twin to test the robustness of the model when extrapolating into previously unseen climate states.

Key features:

- Main developer: ECMWF
- Time horizon: Up to 7 weeks ahead
- Coverage: Global

AP3: Global subseasonal to seasonal probabilistic forecasts

ECMWF will use the WeatherGenerator to produce probabilistic S2S forecasts globally. These forecasts aim to improve skill on multi-week timescales, particularly for extreme events, by leveraging the multi-resolution core of the WeatherGenerator for multi-week rollouts. The application addresses the generally low skill of current S2S predictions and provides information relevant for climate-sensitive decision-making worldwide.

Key features:

- Main developer: ECMWF
- Time horizon: weeks to months ahead
- Coverage: Global

AP4: Seasonal forecasts for Western Europe

KNMI will focus on subseasonal to seasonal forecasts for Western Europe, using a WeatherGenerator tail network to improve skill for extreme events such as cold spells,

heat waves, and droughts. By providing early-stage predictions of high-impact events, the forecasts will support decision-making for multiple societal sectors. The multi-resolution structure of the WeatherGenerator will allow multi-week rollout training for enhanced predictability.

Key features:

- Main developer: KNMI
- Time horizon: weeks to months ahead
- Coverage: Western Europe

AP5: High-resolution ensemble weather forecasts for Western Europe

National Meteorological Services translate complex weather and climate information into actionable insights for stakeholders, a mission that critically depends on accurate forecasts of extreme events. Extreme events are inherently rare, making them difficult to capture with conventional machine learning, but the WeatherGenerator can leverage global data to improve modelling of such events. In this application, KNMI will use the WeatherGenerator to generate high-resolution probabilistic forecasts of extreme weather for Western Europe, by training on regional NWP data, in-situ observations, and gauge-adjusted radar precipitation. The application will monitor forecast skill for extremes and apply corrective measures as necessary, including importance sampling of extreme events in other datasets, such as output from hectometric simulations from DestinE's On-Demand Extremes Digital Twin. Different tail-network architectures and loss functions will be explored to maximize predictive skill.

Key features:

- Main developer: KNMI
- Time horizon: Up to 2 days ahead
- Coverage: Western Europe
- Spatial resolution: 2 km

AP6: Extreme weather forecasting for France

Accurate forecasts of high-impact weather events, such as heavy rainfall, thunderstorms, and tropical cyclones, are critical to safeguard lives and property. In this application, Météo-France will fine-tune the WeatherGenerator to produce high-resolution, short-range ensemble forecasts over Western Europe, including French overseas territories, with a focus on extreme events. Both full emulation from initial conditions and downscaling from coarse models will be explored, with attention to lateral boundary conditions and the role of physical constraints in improving forecast consistency. Forecasts will be evaluated against the operational Arome model and a task-specific regional machine learning emulator, using innovative metrics to assess realism and physical consistency.

Key features:

- Main developer: Météo-France
- Time horizon: Up to 2 days ahead
- Coverage: Western Europe and French overseas territories
- Spatial resolution: 2.5 km and 1 km

AP7: 21-day forecasts for the Nordics

Accurately forecasting weather in the Nordics is challenging due to wintertime inversions, complex topography, and intricate coastlines. This application will combine a high-density network of crowdsourced weather stations with satellite and radar data to improve existing operational forecasts, producing hourly surface parameter predictions at 1 km resolution. Forecasts will be evaluated against measurements from high-quality weather stations. The goal is to provide more accurate and reliable weather forecasts for the general public.

Key features:

- Main developer: MetNor
- Time horizon: Up to 21 days
- Coverage: The Nordic region
- Spatial resolution: 1 km

AP8: High-resolution forecasts for the Alps

Accurate weather forecasting in mountainous regions is challenging due to complex terrain, wintertime inversions, and systematic model errors in cloud cover. In this application, Meteo Swiss will fine-tune the WeatherGenerator to produce high-resolution (up to 1 km) forecasts for the Alps from full initial conditions. The resulting forecasts will be compared with a task-specific regional machine learning emulator, using in-situ observations to validate inversions and satellite data to evaluate cloud predictions. This approach aims to improve forecast accuracy in complex alpine terrain.

Key features:

- Main developer: Meteo Swiss
- Time horizon: Up to 10 days
- Coverage: Central Europe, centred on Switzerland
- Spatial resolution: 1 km

AP9: Nowcasts and short forecasts of cloud and precipitation using satellite and radar data

High-resolution real-time observations are essential for nowcasting high-impact weather events, but radar, satellite, and ground data are often incomplete or inconsistent. In this application, SMHI will use the WeatherGenerator to produce fused nowcasts and short-term forecasts of cloud and precipitation, combining radar (OPERA) and satellite (NWCSAF) data. Tail networks will generate outputs at the same spatial and temporal resolution as the original products, creating seamlessly blended datasets. The application will assess whether the WeatherGenerator can replace current NWCSAF and OPERA production workflows, potentially transforming operational processing of radar and satellite observations.

Key features:

- Main developer: SMHI
- Time horizon: Current conditions and 12-hour forecasts
- Coverage: Europe

AP10: Extreme precipitation nowcasts in sub-Saharan Africa

Accurate nowcasting of extreme convective rainfall is crucial in regions with limited radar and ground station coverage. In this application, eScience will use the WeatherGenerator to enhance high-intensity precipitation nowcasts across sub-Saharan Africa. By combining WeatherGenerator forecasts at convection-permitting scales with existing satellite-based SEVIRI observations, the application aims to improve the localization and estimation of extreme rainfall. The WeatherGenerator will be fine-tuned with (i) the MSG-CPP precipitation product based on daytime SEVIRI cloud property observations and, additionally, investigate the added value of improving retrieval by finetuning on Euradclim data over the Europe, which fuses radar and rain gauge data in a single gridded product. The resulting nowcasting methods will be compared against TAHMO rain gauge data over the target region. This task will happen in collaboration with the Dutch water management and consultancy firm HKV. Finally, the potential of diffusion-based ensemble techniques to further enhance forecast reliability could be explored.

Key features:

- Main developer: eScience
- Time horizon: Up to 4 hours
- Coverage: Senegal/Burkina Faso/Ghana
- Spatial resolution: 3 km

AP11: 40-year analyses for the Nordics

Consistent historical weather time series are essential for assessing regional climate signals, but existing archives are often limited in length or costly to produce. In this application, MetNor will use the WeatherGenerator's data fusion capabilities to create a 40-year, high-resolution reanalysis of standard surface parameters for the Nordic region. By leveraging the WeatherGenerator's ability to model complex relationships between observation sources and global reanalyses, the application will generate a time-consistent dataset without additional training. The dataset will be evaluated against out-of-sample measurements from weather stations.

Key features:

- Main developer: MetNor
- Time horizon: past 40 years
- Coverage: The Nordic region

AP12: High-resolution reanalysis and climatology for the Alps

Accurate weather information in mountainous regions is limited by coarse model resolution and complex topography. In this application, the WeatherGenerator will be used to downscale conventional model output over the Alpine region, with a particular focus on topographic effects such as valley winds. This will be used to generate a high resolution climatological regional dataset from the existing ERA5 reanalysis. Such a dataset will be very valuable for applications for renewable energy and will be compared to conventional downscaling approaches.

Key features:

WeatherGenerator

- Main developer: Meteo Swiss
- Time horizon: Current conditions
- Coverage: Central Europe, centred on Switzerland
- Spatial resolution: 1 km

AP13: Spatio-temporal downscaling of climate extremes

Accurately representing climate extremes at regional scales remains a major challenge for coarse-resolution climate models. In this application, CMCC will use the WeatherGenerator as a spatio-temporal downscaling tool to produce ensembles of high-resolution decadal forecasts with more realistic extremes. Historical simulations and initialised daily decadal predictions will serve as input, and the added value of downscaling will be assessed by evaluating temperature and precipitation extremes against observations at the weekly timescale. The use of ensembles will allow for more robust statistics of extreme events, while the increased resolution and the WeatherGenerator implicit physics are expected to improve the realism of the events.

Key features:

- Main developer: CMCC
- Task: Downscaling
- Time horizon: Up to 7 days
- Coverage: Europe

AP14: Forecasting Arctic sea-ice

Understanding and predicting Arctic sea ice is essential for climate monitoring and polar operations, but is challenged by complex interactions between atmospheric, oceanic and cryospheric processes. In this application, the WeatherGenerator will use satellite and model-based data to forecast Arctic sea ice. The approach will integrate key drivers of ice dynamics, such as surface temperature, snow depth, salinity and large-scale climate indicators. The application aims to enhance ice prediction accuracy, while also strengthening process understanding through the identification of previously unrecognized relationships governing Arctic sea ice variability.

Key features:

- Main developer: CMCC
- Time horizon: Up to 7 days
- Coverage: Arctic Ocean sector
- Spatial resolution: ~10 km

AP15: Solar and wind production forecasting

Accurate short-term forecasts of wind and solar power production are essential for efficient participation in electricity markets, where forecast errors lead to balancing costs. In this application, Buluttan will use the WeatherGenerator to forecast hourly wind and solar power production at farm and regional scales, with a focus on the Turkish energy market. Real-time weather observations will be integrated through specialised tail networks to improve short-term predictions for day-ahead and intra-day trading. The application will assess the financial value of WeatherGenerator-based forecasts

compared to existing approaches, supporting more cost-effective renewable energy operations.

Key features:

- Main developer: Buluttan
- Time horizon: 12-36 hours
- Coverage: Selected sites in Turkey

AP16: Power consumption forecasting

Reliable forecasts of electricity demand are crucial for efficient energy market operation and balancing and are strongly influenced by weather variability. In this application, Buluttan will use the WeatherGenerator to forecast regional power consumption in Turkey. By combining WeatherGenerator-based weather forecasts with historical consumption data through tailored tail networks, the application aims to improve short-term demand predictions and assess their value for energy trading and system operation.

Key features:

- Main developer: Buluttan
- Time horizon: 12-36 hours
- Coverage: Selected regions in Turkey

AP17: Inflow river predictions

Hydrological models are used to map weather input data to hydropower production forecasts. As river runoff is the result of a complex accumulation of weather over long time periods, hydrological models typically need decades of training data to ensure robust predictions for all possible sequences of weather events. These long records must also be consistent over time and show similar characteristics to data that is available in real-time for operational prediction. In this application, Statkraft will use the WeatherGenerator to train a tail-network that directly predicts river inflow for Nordic catchments.

Key features:

- Main developer: Statkraft
- Time horizon: Up to 5 years ahead
- Coverage: Selected catchments in the Nordic region

AP18a: Multi-year weather scenarios for energy market modelling

Long-term energy system planning requires realistic weather scenarios that capture both short-term variability and long-term climate statistics, as well as rare but high-impact events. In AP18a, Statkraft will use the WeatherGenerator as a simulation engine to generate ensembles of daily weather scenarios (solar, wind and consumption temperature) spanning one to five years. These scenarios will be used to drive existing energy optimisation and market models at Statkraft and evaluated against current operational methods. By preserving spatial and inter-variable correlations, the application supports robust multi-year energy market modelling in systems with large reservoir storage capacities (input from AP17), such as the Nordic power market.

WeatherGenerator

Key features:

- Main developer: Statkraft
- Time horizon: Up to 5 years ahead
- Coverage: Sites in Europe

AP18b: Energy market modelling using tail models

Energy market modelling. This application takes AP18a one step further and builds an end-to-end energy market model that uses the WeatherGenerator to directly simulate the complete energy market. The model will take weather related datasets as well as market constraints as input and produce short-term price and production scenarios.

Key features:

- Main developer: Statkraft
- Time horizon: Short-term (21 days)
- Coverage: Sites in Europe

AP19: Flood prediction

Accurate flood forecasting is essential for reducing impacts on people, infrastructure and ecosystems, but remains challenging due to uncertainties in hydrological modelling and weather forcing, especially during extreme events. AP19 will use the WeatherGenerator to benchmark and potentially improve the Global Flood Awareness System (GloFAS) of the Copernicus Emergency Management Services. WeatherGenerator reanalyses and forecasts will be used to calibrate and drive the Lisflood hydrological model and compared with current operational approaches. In addition, tail networks will be developed to improve flood extent estimates by exploiting Sentinel-1 satellite data and citizen science observations.

Key features:

- Main developer: KAJO
- Time horizon: 2 weeks and 7 months
- Coverage: Global
- Spatial resolution: 0.05 degrees

AP20: Vegetation modelling for food security

Reliable forecasts of vegetation conditions are critical for food security and early warning systems, especially in drought-prone regions, but are limited by data gaps and the difficulty of predicting ecosystem responses to climate extremes. AP20 will use WeatherGen-Land, driven by WeatherGen-Atmo, to forecast vegetation greenness on subseasonal to seasonal time scales. The project will generate high-resolution forecasts of vegetation indices and leaf area index by predicting Sentinel-2 observations and explore additional tailored outputs relevant for food security. The forecasts will be evaluated in a drought and pastoralist anticipatory action scenario in Somalia in collaboration with humanitarian partners, while developing a globally applicable model that supports food security monitoring and early warning efforts.

WeatherGenerator

Key features:

- Main developer: MPG
- Time horizon: Up to 3 months
- Coverage: Global (focus on East Africa)
- Spatial resolution: 20 m

AP21: Temperature forecasting for health

Accurate forecasting of land surface temperature is crucial for understanding heat stress, especially in urban environments, but is challenged by cloud cover, surface heterogeneity and the complex relationship between skin and air temperature. AP21 will use WeatherGen-Land, driven by WeatherGen-Atmo, to produce short-term forecasts of land surface temperature as well as sensible and latent heat fluxes. The model provides hourly forecasts at very high spatial resolution and is trained using satellite data (Landsat 8+ and ECOSTRESS) and ground observations from ICOS and FLUXNET. The forecasts will be evaluated in an urban health scenario in Thuringia, Germany, in collaboration with medical and municipal stakeholders, with the goal of improving heat-related health assessments.

Key features:

- Main developer: MPG
- Time horizon: Up to 7 days
- Coverage: Global (focus on Germany)
- Spatial resolution: 70-100 m

AP22: Biosphere Fluxes

Quantifying exchanges of carbon, water and energy between the land surface and the atmosphere is essential for understanding the Earth system but remains challenging due to sparse observations and model uncertainties. AP22 will use WeatherGen-Land, driven by WeatherGen-Atmo, to diagnose land–atmosphere fluxes of CO_2, water and sensible heat. Building on the established FLUXCOM approach at MPG, the project will generate global, hourly flux estimates at moderate spatial resolution by fusing satellite, reanalysis and in situ data. The resulting flux products will be evaluated against state-of-the-art bottom-up and top-down approaches within the FLUXCOM-X framework, contributing to improved assessments of climate, water and food security.

Key features:

- Main developer: MPG
- Time horizon: Past 20 years
- Coverage: Global
- Spatial resolution: 5 km

4   Website development

To highlight and explain the WeatherGenerator's applications for the public, a new section on the project's public website (weathergenerator.eu) was developed. This section was conceptually designed, visually developed and technically implemented to ensure clear communication of the applications' main features. This includes a short

description for each application as well as descriptive bullet points and a link for further information (Figure 4.1). The information provided is based on the descriptions from Section 3 of this report.

The applications are structured into three dedicated sections covering the areas of "Weather & Climate Prediction", "Renewable Energy & Water" and "Food Security, Health and Biosphere". The structure is flexible and can be extended in the future to include additional areas e.g. for external applications.

As machine-learning solutions are developed and results become available over the course of the project, key outcomes will be integrated into the website accordingly. In particular, Task 6.3 will develop application prototypes that will be made accessible through the website. The website will also provide links to any verification reports produced by the applications.
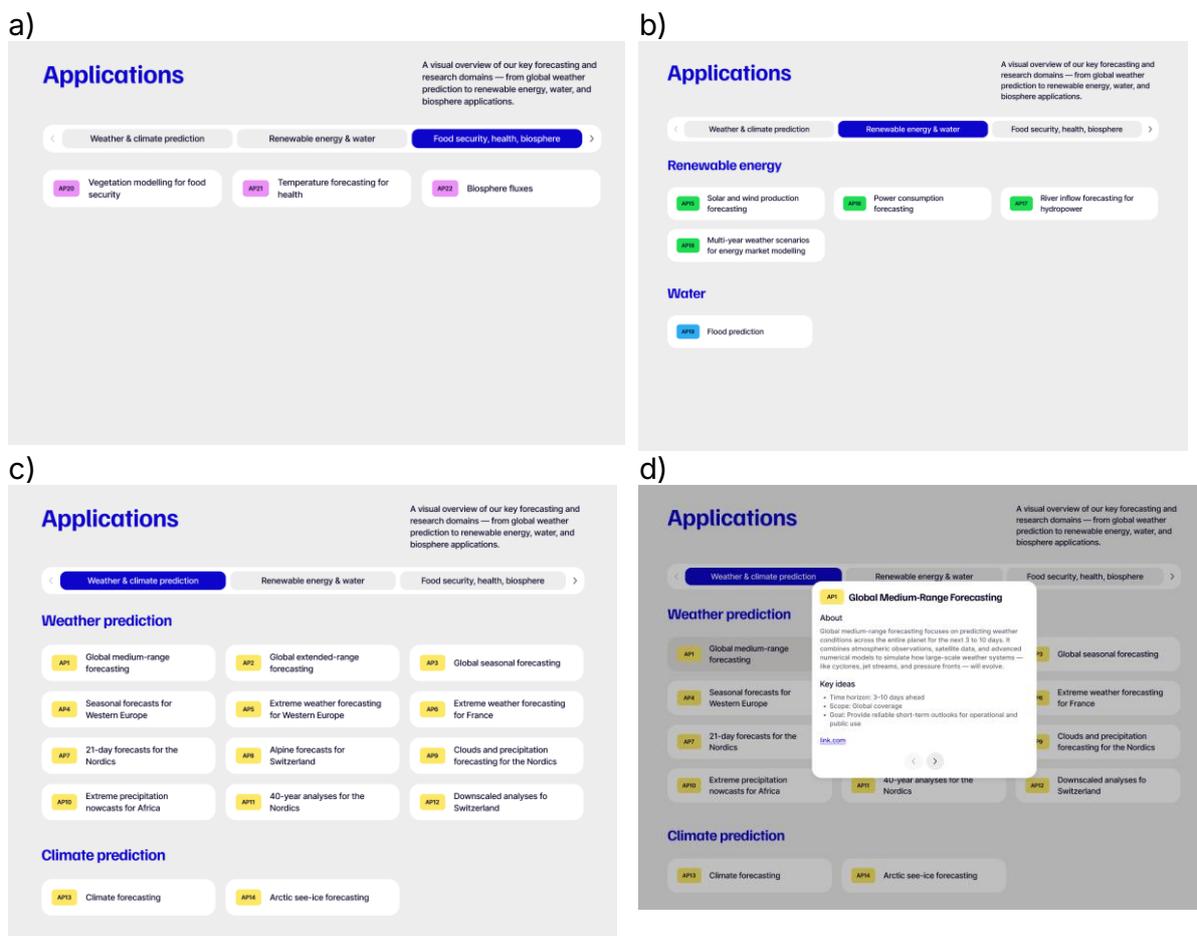

Figure 4.1: Screenshots of the applications portal on the website, showing food security, health, and biosphere applications (a); renewable energy and water applications (b); weather and climate applications (c); and a pop-up displaying detailed information when a specific application is selected (d).

5 Application tables

In the proposal, each application should "*specify required input and target datasets collected in Task 1.1, list clearly defined diagnostics and quality measures, and define a problem description. The applications should also define their benchmarking strategy*

to evaluate the WeatherGenerator. Application information will be posted publicly on the project's website."

We defined a table of metadata for each application to fill out. These tables contain 18 key characteristics of the application. The goal of these tables is to aid core development of the model. As some of these tables contain proprietary information, we do not include them in this report. They are available in the project's shared drive, under "WeatherGenerator Applications", and we provide a summary of the 22 responses below. The tables contain 18 characteristics, which have been grouped into 4 subsections.

5.1 General application characteristics

Main contact person lists the main developers of the application, enabling core model developers to know who to reach out to, if more information is needed about the application.

Forecast horizon specifies how far into the future the applications aim to forecast. We have applications to enhance the analysis data in the past, downscaling the current conditions, nowcasting (0-12h), short-range (2-3 days), medium-range (10 days), extended range (weeks), subseasonal (2 months), seasonal (several months) to multi-year scenarios.

Decoder specified what type of task the application does, such as forecasting, downscaling, or data fusion.

Ensemble specifies if an application needs ensemble output from the WeatherGenerator. A large majority of applications need ensemble scenarios from the WeatherGenerator, and some are interested in exploring large ensembles (50+ members).

Applications have specified an Output file format, which helps developers know if there are formats that can be supported collectively. Based on the survey, NetCDF and GRIB are the most common, but several partners use CSV or Zarr.

Domain specifies what area of the world the application is for. We have global applications as well as regional ones covering various parts of Europe and Africa.

We asked for Compute requirements going forward, but this was more to coordinate compute proposals.

5.2 Datasets

Input dataset training lists which datasets are to be used as input while training the model. This included global and regional reanalyses, IFS initial conditions, radar, satellite, in-situ measurements. This may be different from Input datasets inference, which for most applications were datasets that are available in real-time, however, they reanalyses are still used during inference for applications generating historical analyses.

The Target dataset refers to the datasets used to train the model towards. This included IFS, ERA5, regional reanalyses, in-situ measurements (including crowdsourced observations), radar-derived precipitation, lightning strikes, Meteorological Terminal Aviation Routine Weather Report (METAR), power plant production data, power consumption data, inflow measurements, energy market prices, river discharge reanalyses and flood extent data, ECOSTRESS, FLUXNET, and ICOS data.

Key output variables: This lists the predictands and are typically available in one or more of the target datasets. This varies a lot across applications, but includes surface and atmosphere parameters (temperature, winds, precipitation, pressure, humidity),

sea-surface temperature, precipitation at several time aggregations (e.g. hourly, daily) and split into rain and snow; chance of lightning, short/longwave radiation; clouds at varying heights (e.g. fog, low, middle, high level clouds, cloud base height); winds (speed, direction, gust); Sea ice thermodynamical variables (such as concentration and thickness).

It also includes variables related to renewable energy applications, such as power production (wind, hydro and solar), river inflow, power consumption (regional, household, and temperature-dependent consumption), spot power prices. For the flooding application, this includes river discharge, flood extent, flood damages. Normalized Difference Vegetation Index, land surface temperature, net ecosystem exchange, latent heat flux, and net radiation.

Date range training specifies what training period the model will be trained on and is typically based on what time period the target dataset is available for.

5.3   Output properties

The next section aims to gather information on what makes a successful prediction. This includes the Loss, which was optional. More importantly, we asked each application to list a set of Diagnostics. These are metrics that are frequently used to assess the quality of the predictions. This included standard point-based metrics, but also spatial consistency metrics (e.g. wavelet analysis, power spectra). Metrics on time-aggregated fields is also common as are metrics that assess inter-variable relationships. Metrics that assess trends in biases over long lead times for those applications requiring long rollouts or span long time periods (reanalysis applications).

Finally, Key properties of output are general aspects that we want the predictions to have, and the characteristic repeated a lot was ensemble members that are realistic in space, time and across variables. It also included the requirement that scenarios have a stable climatology for long rollouts. Reliable probabilities from ensembles was also an important aspect for many.

5.4   Existing solutions

The last section includes information about existing solutions. Today's solution specifies what is currently used by the application developer and includes existing NWP models (global and regional), existing ML models, or combinations of both.

There is also a field that lists the Challenges with today's solution, and included (among others) drift in NWP models over time, uncalibrated ensembles, systematic errors in NWP, winter-time cold pool inversions, complex topography and coastlines, inconsistent temporal and spatial coverage of available products, fidelity of extremes, phenomena at small spatio-temporal resolution not adequate represented, inhomogeneous input data sources.

Also, the applications listed what Data that can help address challenges. In addition to NWP reanalyses, the main sources were in-situ observations (especially at high temporal and spatial resolution), satellite, radar, and application specific data (such as power production and market prices).

6   Conclusion

This document has outlined the 22 applications that will be used to test and evaluate the WeatherGenerator. Together, these applications represent a broad and diverse set of use cases, spanning weather and climate, renewable energy, water, and biosphere domains. They cover both global and regional scales, a wide range of temporal

horizons—from nowcasting to seasonal forecasting—and a variety of tasks, including forecasting, downscaling, and data fusion.

To support transparency and collaboration, concise summaries of all applications have been made publicly available through the WeatherGenerator project website. In addition, extensive metadata have been compiled for each application, providing guidance for core model development. This information includes the datasets involved, the forecast variables of interest, and the key properties and characteristics required of the predictions.

Document History

Version	Author(s)	Date	Changes
1.0	Thomas Nipen	19/01/2026	First version
1.1	Thomas Nipen	29/01/2026	Integrated revisions

Internal Review History

Internal Reviewers	Date	Comments
Italo Epicoco	24/01/2026	Inline comments
Jelena Bojarova	26/01/2026	Inline comments