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15th EUMETNET Data management workshop
06.11.2025

# Advancements in Precipitation Observations Preprocessing for MET Nordic Version 4

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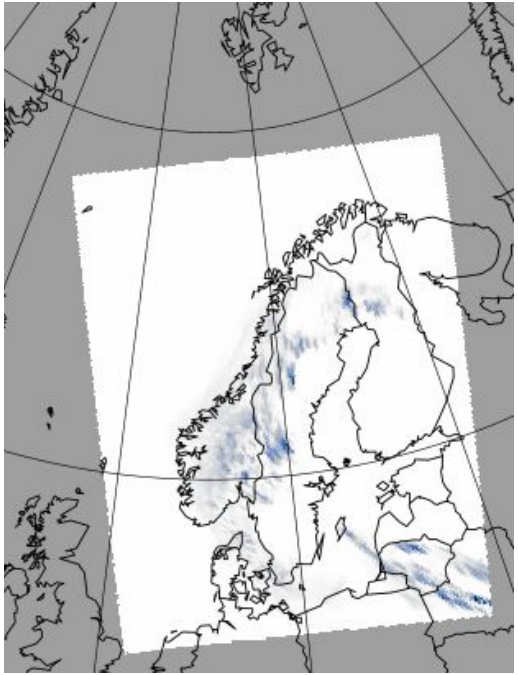
# What is MET Nordic analysis dataset ?



| met_analysis_1_0km_nordic_20240823T1... | met_analysis_1_0km_nordic_20240823T15Z.nc |
|---|---|
| air_pressure_at_sea_level | air pressure at sea level |
| air_temperature_2m | air temperature |
| altitude | surface altitude |
| cloud_area_fraction | cloud area fraction |
| forecast_reference_time | forecast reference time |
| integral_of_surface_downwelling_lo... | integral of surface downwelling longwave flux in air ... |
| integral_of_surface_downwelling_sh... | integral of surface downwelling shortwave flux in ai... |
| land_area_fraction | land area fraction |
| latitude | latitude |
| longitude | longitude |
| precipitation_amount | precipitation amount |
| projection_lcc | projection lcc |
| relative_humidity_2m | relative humidity |
| time | time |
| wind_direction_10m | wind from direction |
| wind_speed_10m | wind speed |

Covers Scandinavia, 1 km grid
Data since September 2012

https://github.com/metno/NWPdocs/wiki/MET-Nordic-dataset

# Workflow for precipitation / temperature

Observations measured by traditional weather stations


Observations measured by citizen weather stations (Netatmo, Cordulus,...)

Corrections

Quality control

MEPS
NWP model
2.5 km
downscaled to 1 km

Statistical interpolation

MET Nordic Analysis (1 km)

# Versions of the datasets

**Real Time (RT) :**

- every hour (ca 15 minute delay)
- from 2018
- methods can change along the time
- not all observations available at the time of the run

**Archive datasets :**

- consistent rerun over a long time
- from 2012
- more observations

# RT Dataset applications

- Used in “current conditions” on Yr
- Used to post-process forecasts
- Used during weather-related emergencies

  *Ex: MET Nordic Dataset can be coupled to hydrological models so we get flood warnings*

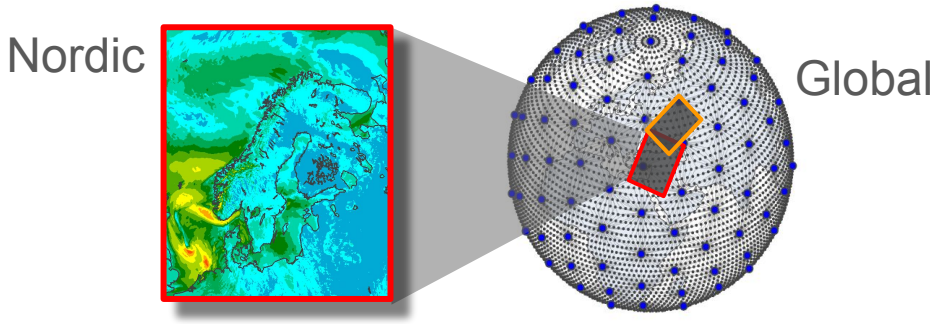


**Real Time Dataset :**

- every hour (ca 15 minute delay)
- from 2018
- methods can change along the time
- not all observations available at the time of the run

# Archive Dataset applications

- Used for case studies (hydrology, building new infrastructure… )
- Used to train the Bris machine learning weather forecasting model




**Archive datasets :**

- consistent rerun over a long time
- Previous version **V3** from 1. september 2012 to January 2023
- *New version* ***V4*** *from 1. september 2012 to August 2025*

# What is new in V4 ?

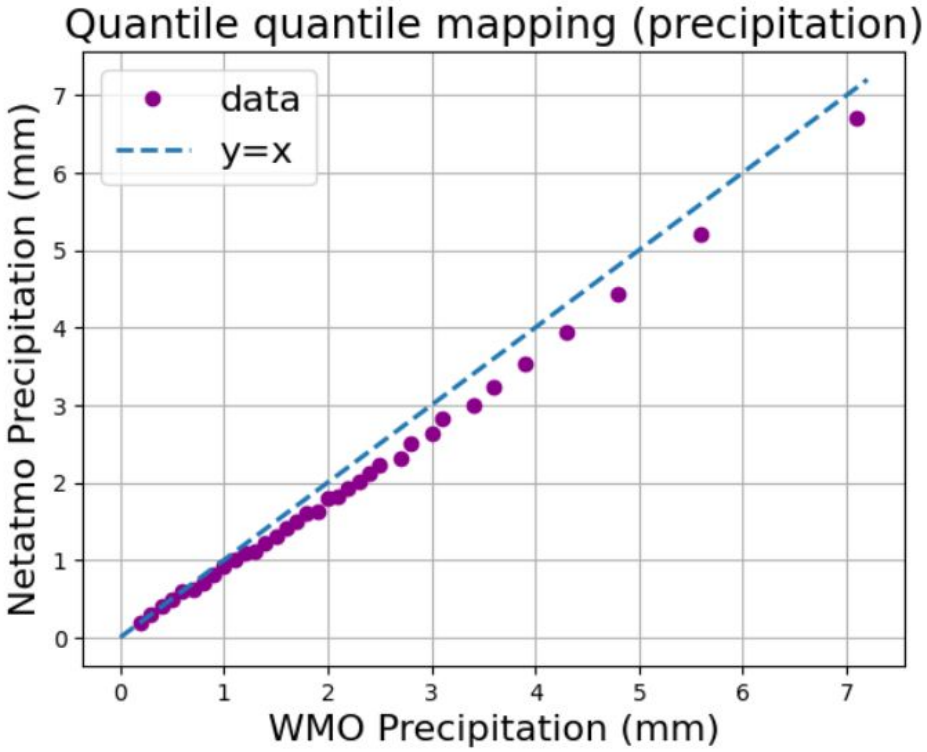
**V4**: updated with **focus on improving precipitation** compared to **V3**

- Precipitation observation corrections :
  - bias adjustment
  - wind undercatch
- Upgraded statistical interpolation method
  to be closer to the precipitation observations
- More observations (especially over Finland and Sweden)
- Better quality control
- Longer time coverage : from 1. september 2012 to August 2025

# Bias corrections for crowdsourced precipitations

Instrument bias :

Netatmo precipitations are underestimated compared to WMO stations




C. Lussana et al: Exploratory analysis of citizen observations of hourly precipitation over Scandinavia, ASR, 20, 35–48, 2023 https://doi.org/10.5194/asr-20-35-2023



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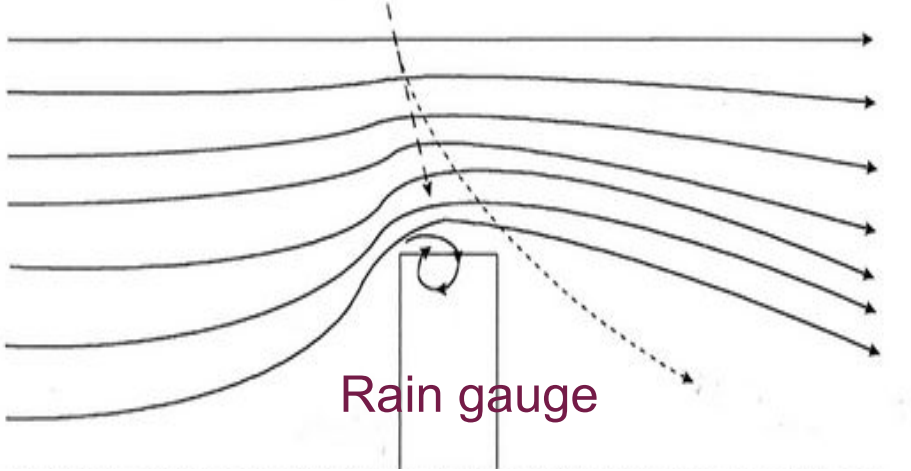
# Wind induced undercatch (all stations)




**Strangeways, Weather 75(10)** https://doi.org/10.1002/wea.3686

"Airflow over a rain gauge showing the deflected path of raindrops. The problem is much greater with snowflakes."

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# Correction for the wind-undercatch

Multiplicative correction factor : $k(T, Wind)$

Wolff formula for snow

Wolff et al: Derivation of a new continuous adjustment function for correcting wind-induced loss of solid precipitation: results of a Norwegian field study, Hydrol. Earth Syst. Sci., 19, 951–967, 2015, doi:10.5194/hess-19-951-2015

Førland formula for rain

Førland et al: Manual for operational correction of nordic precipitation data, DNMI report, 24, 96/96, 1996

Smooth transition for 1C < T < 3C

MEPS Model inputs:

- Wind at gauge level, derived from the 10m wind
- Temperature at 2m

C. Lussana: MET report

No. 05/2024 ISSN 2387-4201

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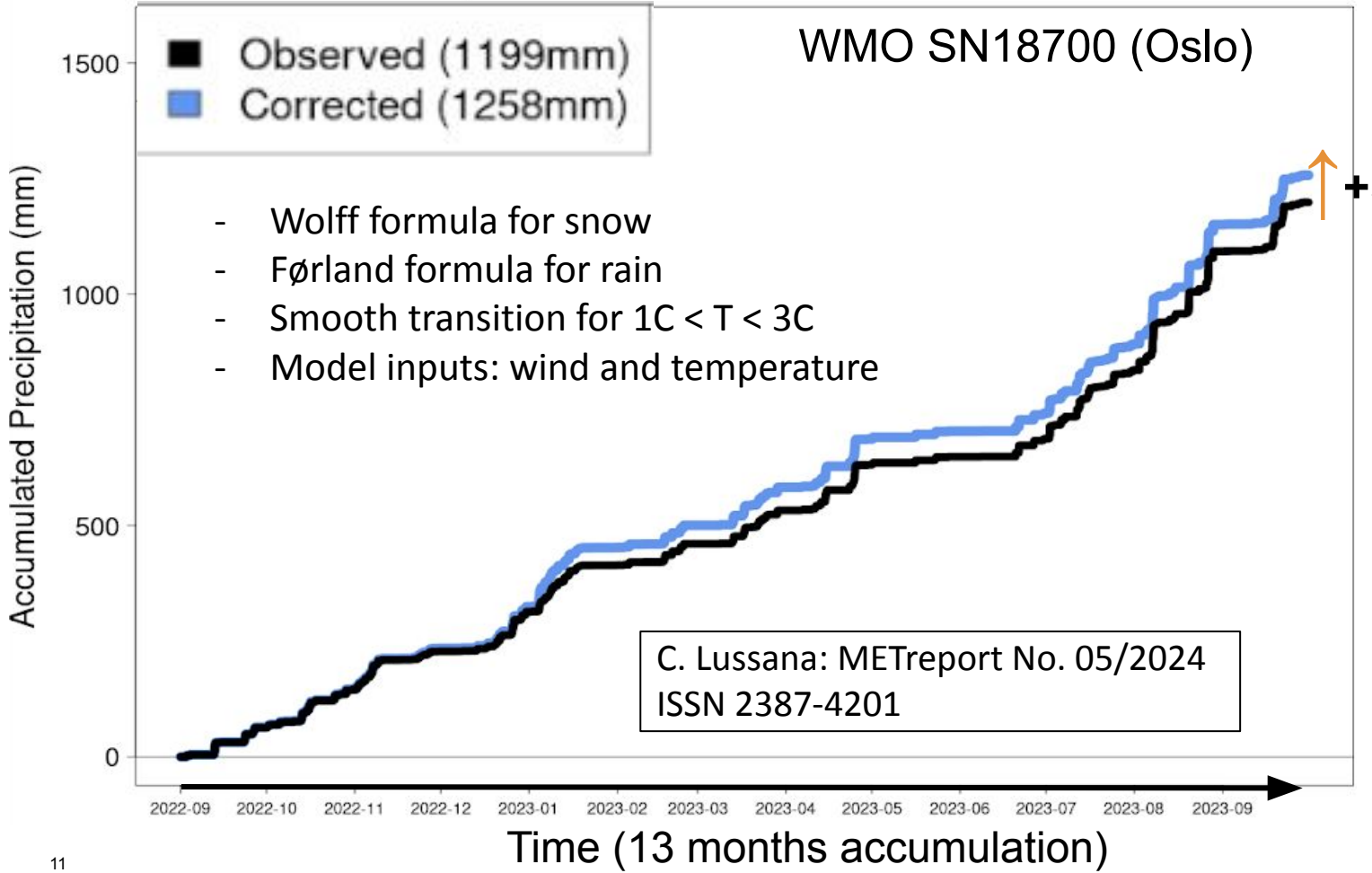
# Correction for the wind-undercatch

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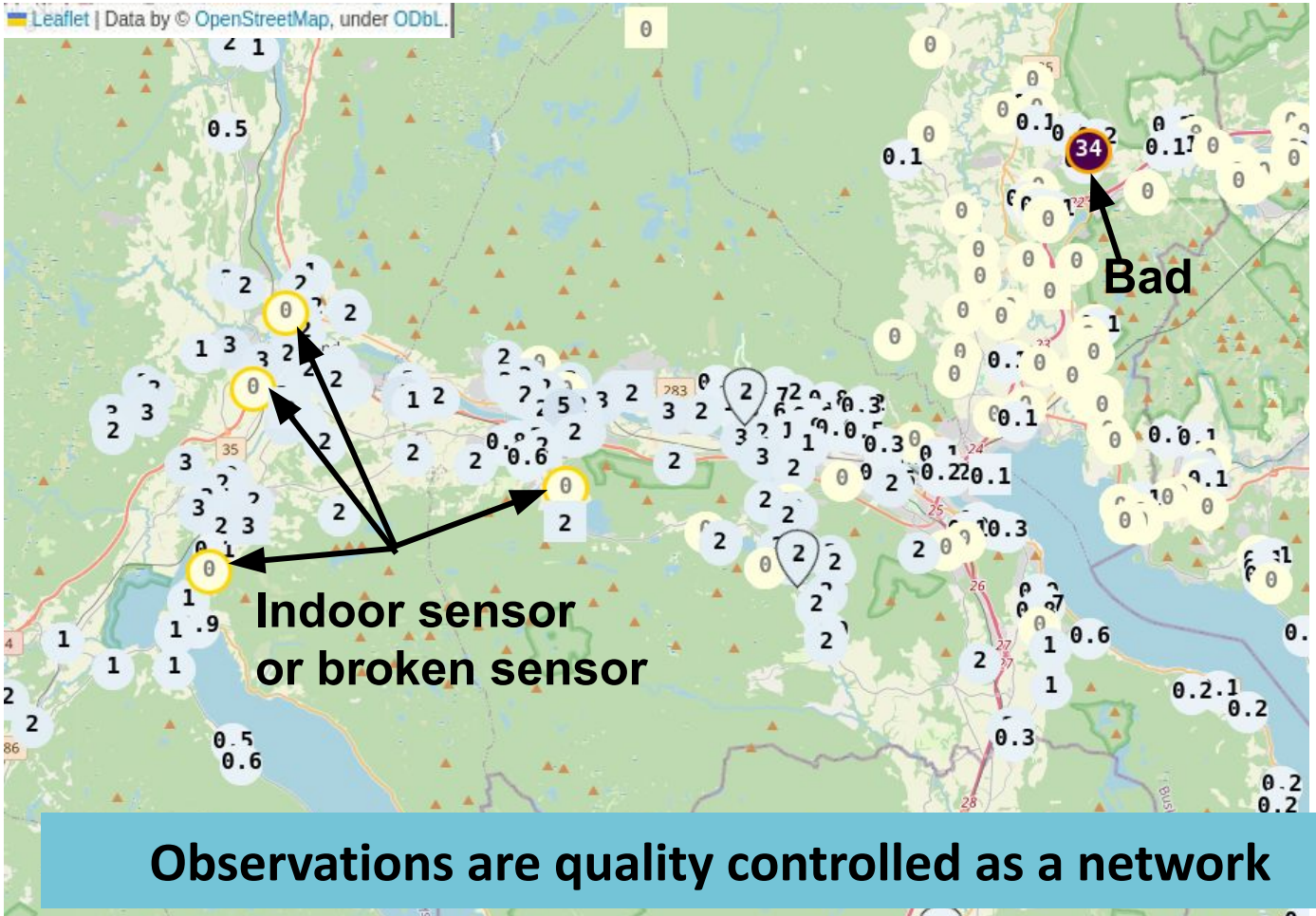
# Automatic spatial QC for hourly precipitations




Flagged stations

QC methods available on https://github.com/metno/titanlib/

**Observations are quality controlled as a network**

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# Library used to QC

https://github.com/metno/TITANLIB

## Titanlib

release v0.3.3 | C/C++ CI passing

Titanlib is a library of **automatic quality control** routines for weather observations. It emphases **spatial checks** and is suitable for use with dense observation networks, such as citizen weather observations. It is written in C++ and has bindings for python and R. The library consists of a set of functions that perform tests on data.

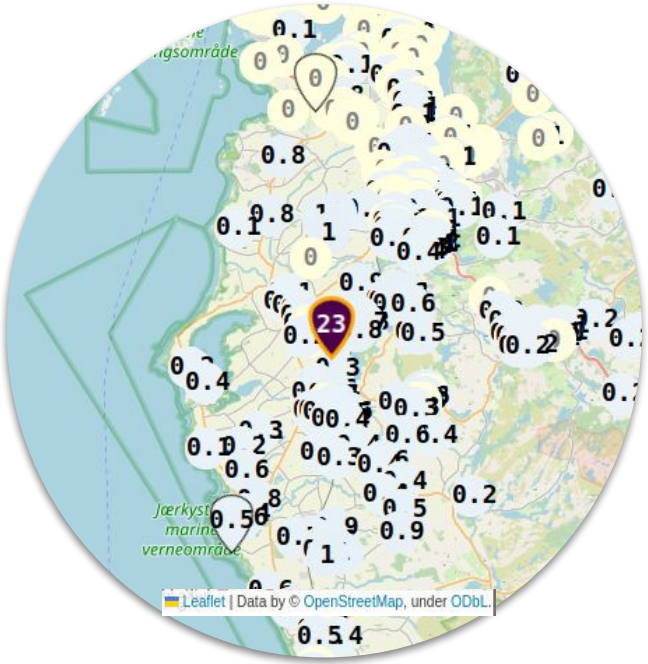
Many tests available:

- Metadata check
- Range check / climatology check
- Buddy event check
- Buddy check
- Spatial consistency check dual
- Spatial consistency check
- First guess check
- Isolation test
- …

Used in research and operationally (runs fast enough) at MET Norway

L. Båserud et al: TITAN automatic spatial quality control of meteorological in-situ observations, Adv. Sci. Res., 17, 153–163, 2020 https://doi.org/10.5194/asr-17-153-2020

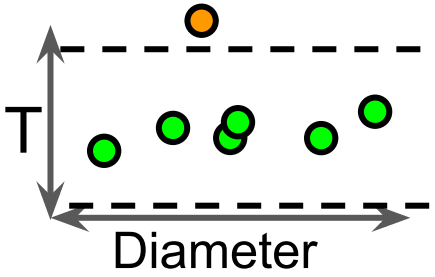
# Spatial quality control of observations




The quality assessment of an observation is based on nearby observations

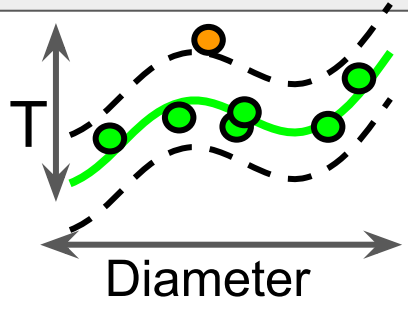
**Buddy check**

± 5 STDEV of neighbouring observations




**Spatial consistency check**

Close to the cross-validated field

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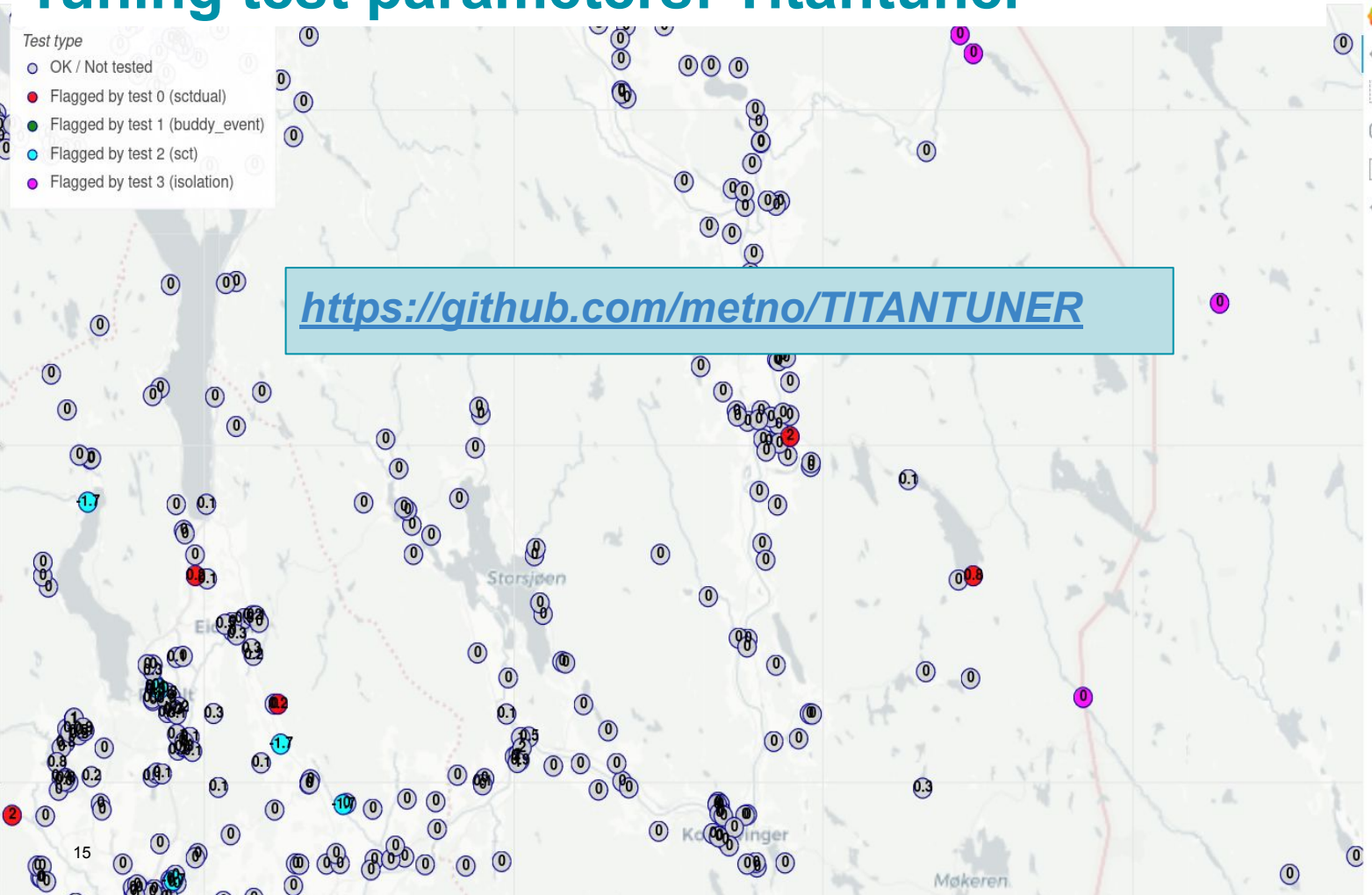
# Tuning test parameters: Titantuner




Dataset

obs_rr1_20240804T10Z.txt

Type of test

sct

- sctdual
- buddy_event
- buddy
- sct
- isolation
- sctres
- fgt

s to use [%]: **100**

3 .. 72

4 .. 32

Minimum obs in box: **5**

Maximum obs in box: **20**

Inner radius [m]: **4000**

Outer radius [m]: **10000**

Number of iterations: **1**

Minimum obs to fit profile: **100**

T2pos: **4**

T2neg: **4**

eps2: **0.50**

Min elev range to fit profile [m]: **30**

# Statistical interpolation

Quarterly Journal of the Royal Meteorological Society

RESEARCH ARTICLE | Open Access

## Ensemble-based statistical interpolation of atmospheric variables near the surface

Cristian Lussana, Thomas N. Nipen, Benjamin Menetrier, Ivar A. Seierstad

First published: 30 July 2025 | https://doi.org/10.1002/qj.5046

### Abstract

This study presents a sequential implementation of ensemble optimal interpolation (EnOI) applied to the spatial analysis of near-surface atmospheric variables. The proposed scheme, ensemble-based statistical interpolation (EnSI), combines numerical model output with observations, as commonly done using optimal interpolation (OI) in some national meteorological services. However, EnSI extends OI by incorporating a multi-scale loop, consecutive observation times, and cross-correlations between

Statistical interpolation methods available on https://github.com/metno/gridpp

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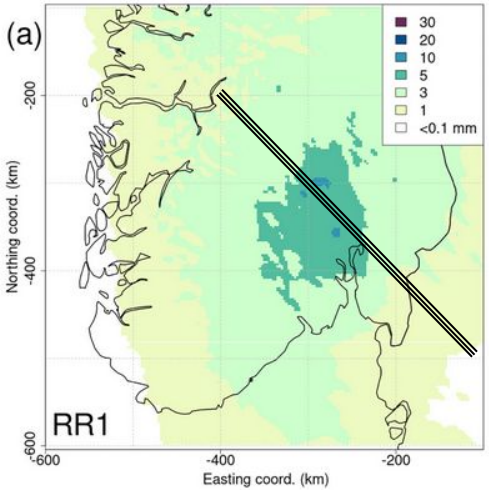
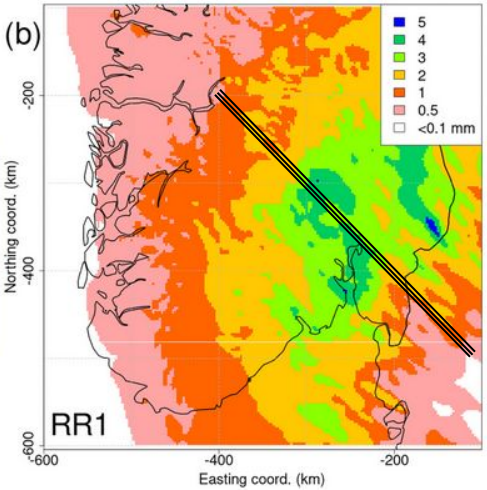
# Statistical interpolation

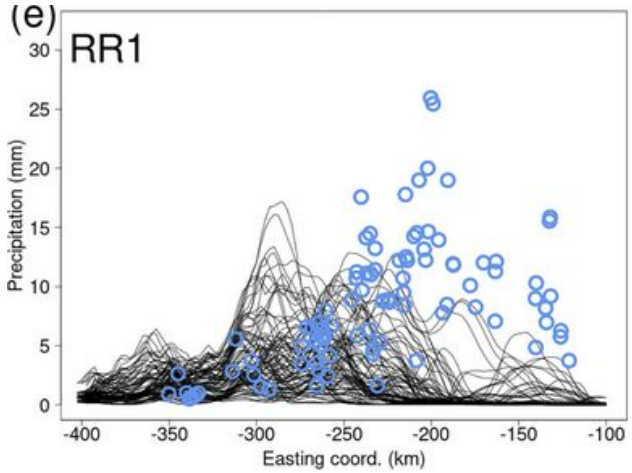
Hans event, 7th August 2023 T10Z

Mean




Spread




Before post processing (model)

Misalignment between observations and model outputs

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# Statistical interpolation

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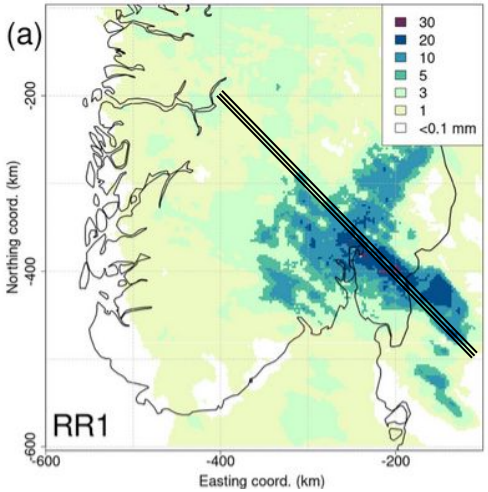
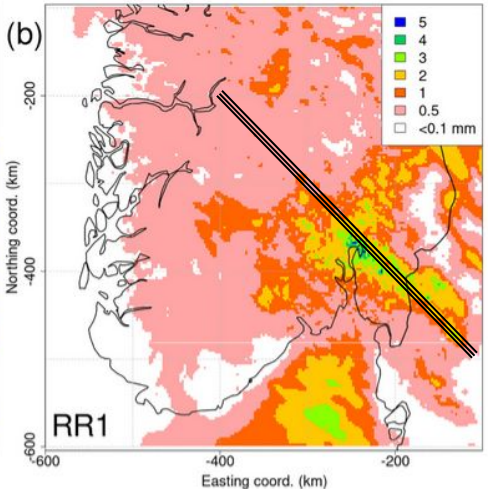
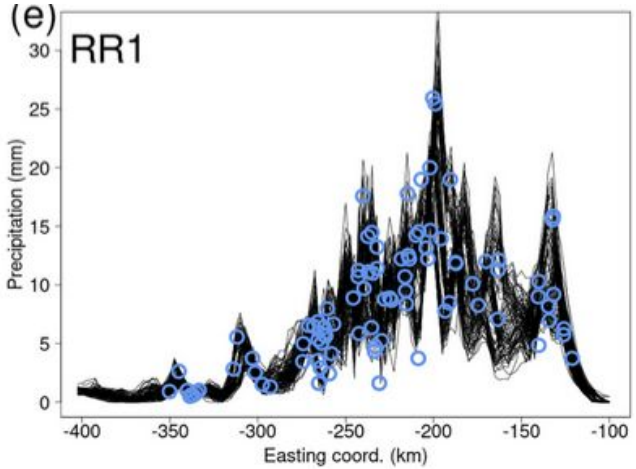



Spread




After post processing (model + obs)
Better agreement between observations and model outputs

Multiscale method based on optimal interpolation
with successive spatial scales: Dh = [10 km, 8 km, 6 km, 4 km, 2 km]

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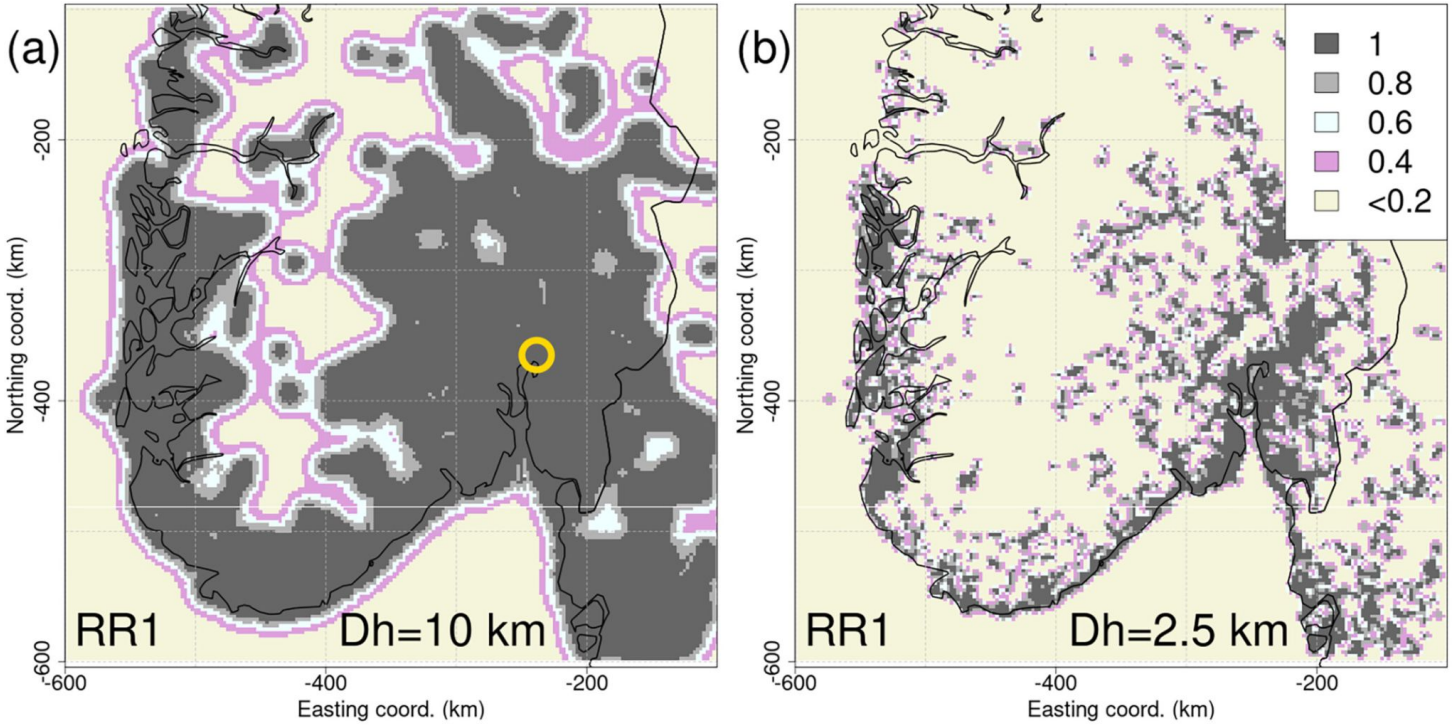
# Where do we modify the model ?

Integral data influence (IDI) for precipitation for different scales used in the interpolation

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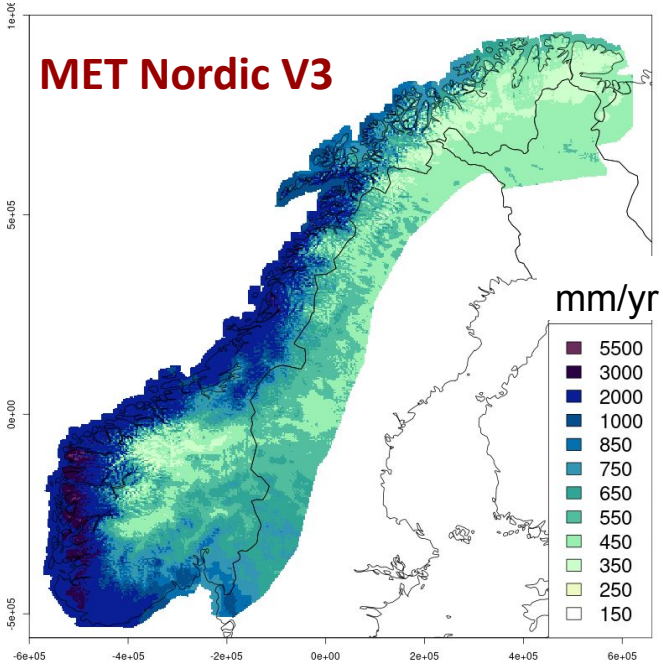
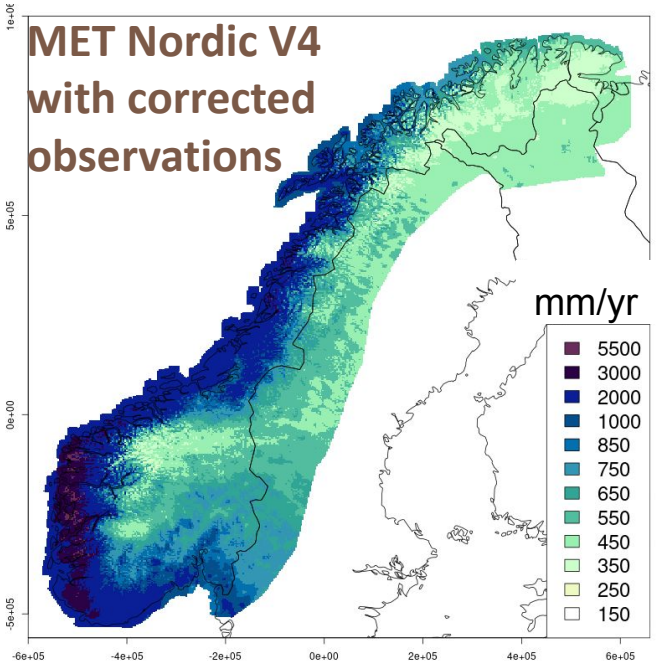
# Mean annual rain from 2013 to 2022

Rain = Total precipitation amount accumulated in the period considered when daily mean temperature is greater or equal to 0.5 °C




mm/yr

| q10 | q50 | q90 | Max |
|---|---|---|---|
| 369 | 557 | 1308 | 4369 |

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|---|---|---|---|
| 371 | 587 | 1483 | 4486 |

*Preliminary results*

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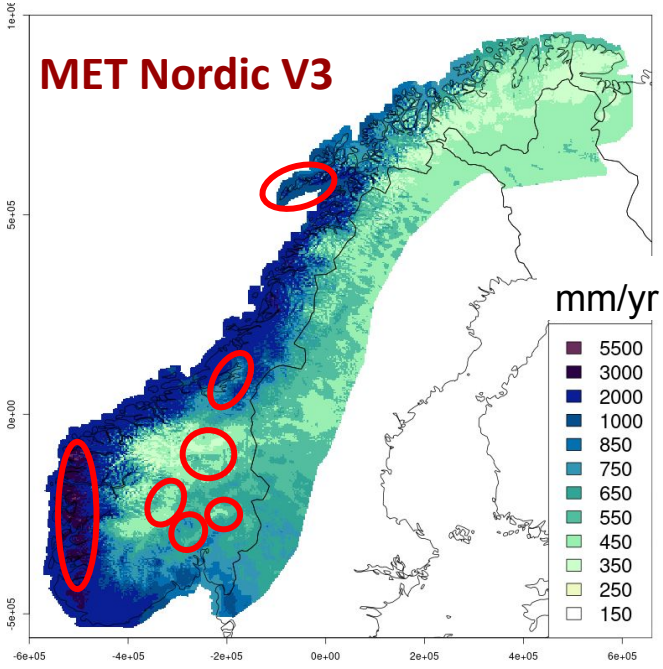


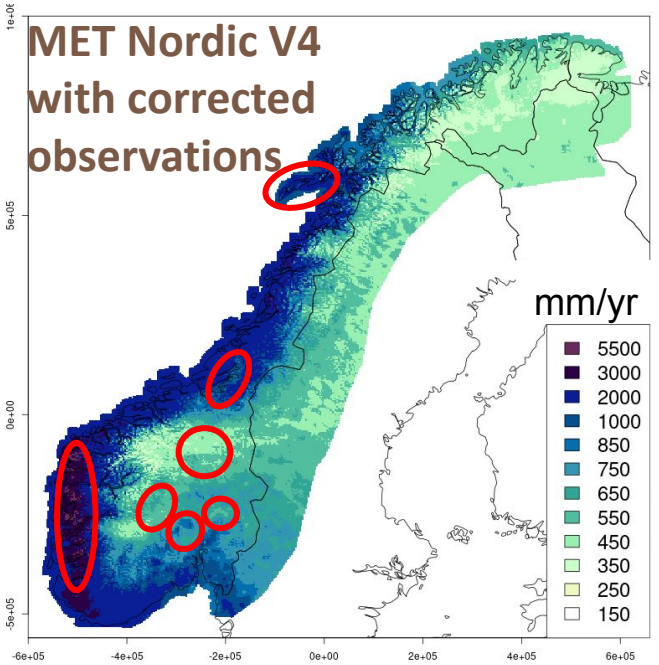


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|---|---|---|---|---|
| | 369 | 557 | 1308 | 4369 |

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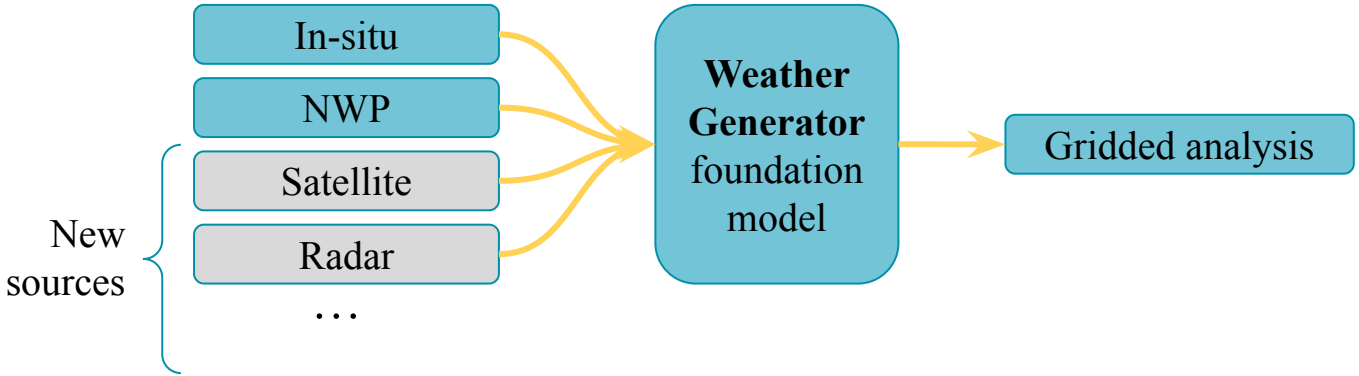
|---|---|---|---|
| 371 | 587 | 1483 | 4486 |

*Preliminary results*

# Future versions of MET Nordic ?

- Using the WeatherGenerator foundation model to develop analyses
  - Ability to integrate further data sources
  - Better handling of data sources that are intermittent or changing over time




- Using the WeatherGenerator for quality control of the observations



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# Conclusion

MET Nordic analysis v4 2012-2025
*https://github.com/metno/NWPdocs/wiki/MET-Nordic-dataset*

Bias correction for crowdsourced observations
Wind induced undercatch
Spatial QC with Titanlib
*https://github.com/metno/titanlib/*
Statistical interpolation: multiscale method
*https://github.com/metno/gridpp*
*https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/qj.5046*

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Ivar Seierstad
Cristian Lussana

## Future plans:

Funded by the European Union
Coordinated by ECMWF
Weather Generator
www. weathergenerator.eu

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