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On the use of amateur weather observations in an operational nowcasting and NWP framework

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The use of amateur weather observations

- Many people and devices have online sensors measuring weather parameters
  - Pros:
    - Large amount and covering areas having a sparse GTS observation network today
    - Sensor quality normally quite good
  - Cons:
    - Misplaced or having biases from usage
    - Only where people live
    - Need several observations to “trust” them

Used in nowcasting and correction of forecasts in MET-Norway’s public API since March 19th (i.e also on yr.no)

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TITAN

https://github.com/metno/TITAN
https://github.com/metno/TITAN/wiki

TITAN - data quality control

Automatic quality control of in-situ observations with an emphasis on spatial controls.

TITAN is designed to test all the observations referring to the same observation time simultaneously. Currently, the statistics of the individual station time series is not considered.

Available checks are (applied sequentially as in this list):

- Plausibility check
- Climatological check, predefined range for each month (optional)
- Buddy-check
- Isolated event test (STEVE) both over and under multiple thresholds (optional)
- Check against a deterministic first-guess field (optional)
- Check against an ensemble of first-guess fields (optional)
- Spatial Consistency Test (SCT)
- Check elevations against digital elevation model (optional)
- Isolated event test (STEVE) both over and under multiple thresholds, 2nd application (optional)
- Detect isolated observations

Possibility to have observation black-list and keep(-it-no-matter-what)-list.

Variables considered (so far):

- temperature
- total precipitation
- relative humidity
- snow depth

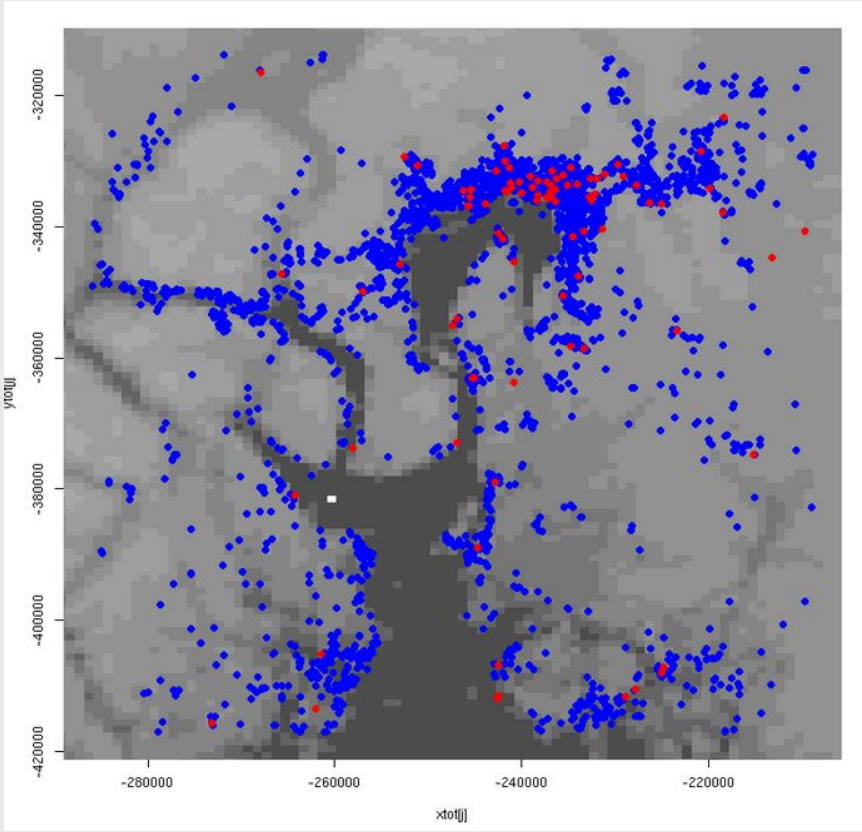
The DQC parameters depend on the observation provider (e.g., “strict” DQC for Netatmo; “tolerant” DQC for WMO-stations)

still under development!

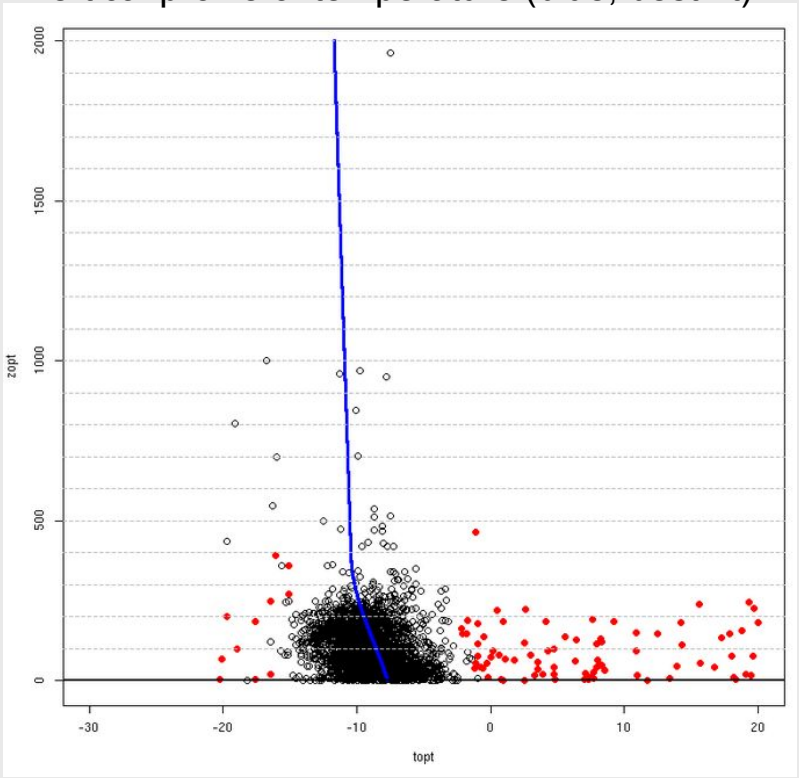
Far from having the best DQC setup for each variable! (More advanced for Temp, less for Snow depth)

SCT example, Temperature

2017/12/12 22:00 UTC. Observation locations are marked with dots and the red dots mark the observations that are flagged as suspect by the SCT iteration.



vertical profile of temperature (blue, best-fit)



References

- Frei, C., 2014. Interpolation of temperature in a mountainous region using nonlinear profiles and non-Euclidean distances. International Journal of Climatology, 34(5), pp.1585-1605.
- Lussana, C., Uboldi, F. and Salvati, M.R., 2010. A spatial consistency test for surface observations from mesoscale meteorological networks. Quarterly Journal of the Royal Meteorological Society, 136(649), pp.1075-1088.

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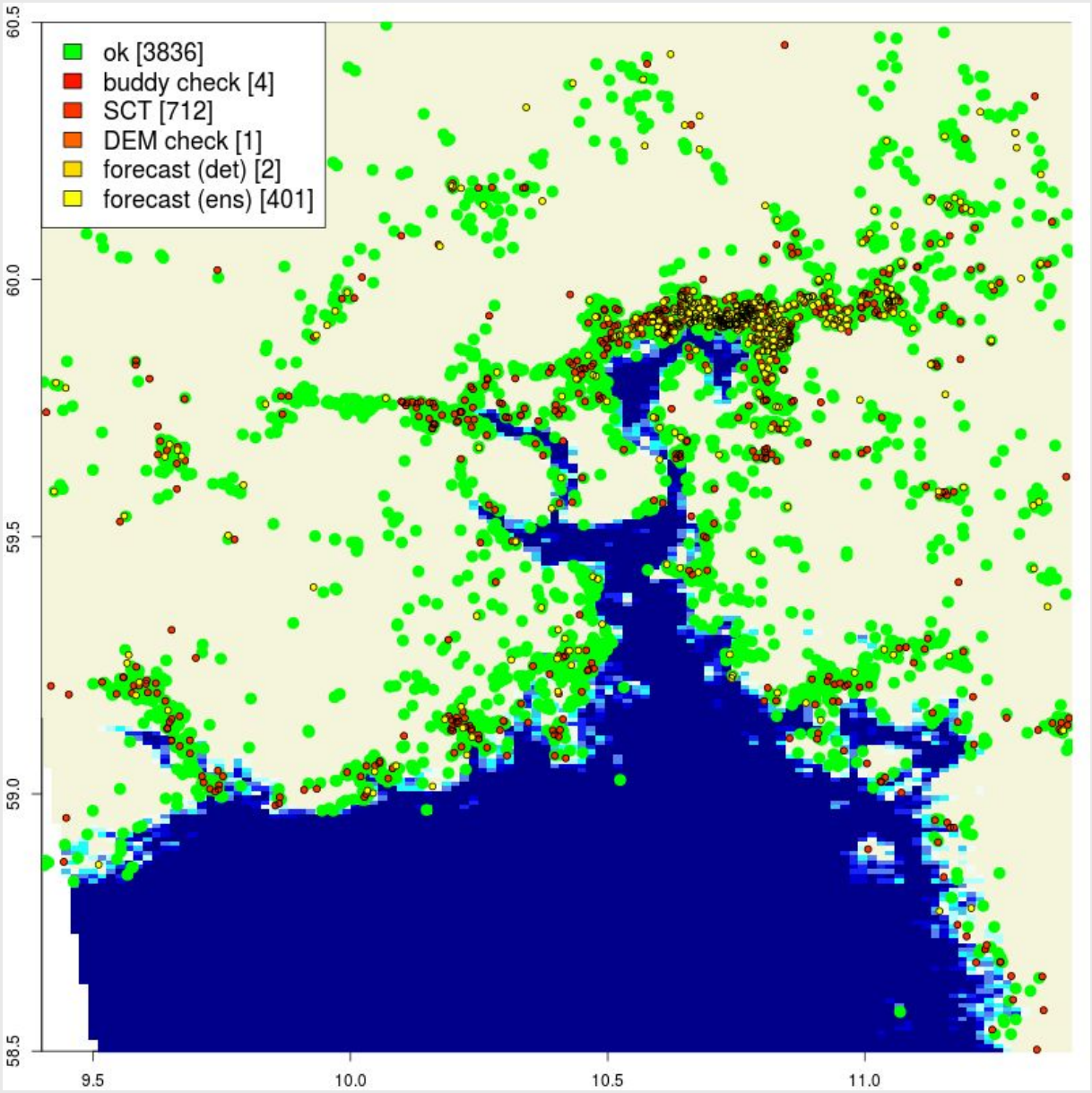
Example Mar 26, 2018 08:00 UTC



Temperature

Thousand of observations used over relatively small but densely populated area

SCT, spatial consistency test

DEM, digital elevation model

forecast test. The observations are compared against the NWP model fields. It is possible to consider deterministic and ensemble NWP outcomes.

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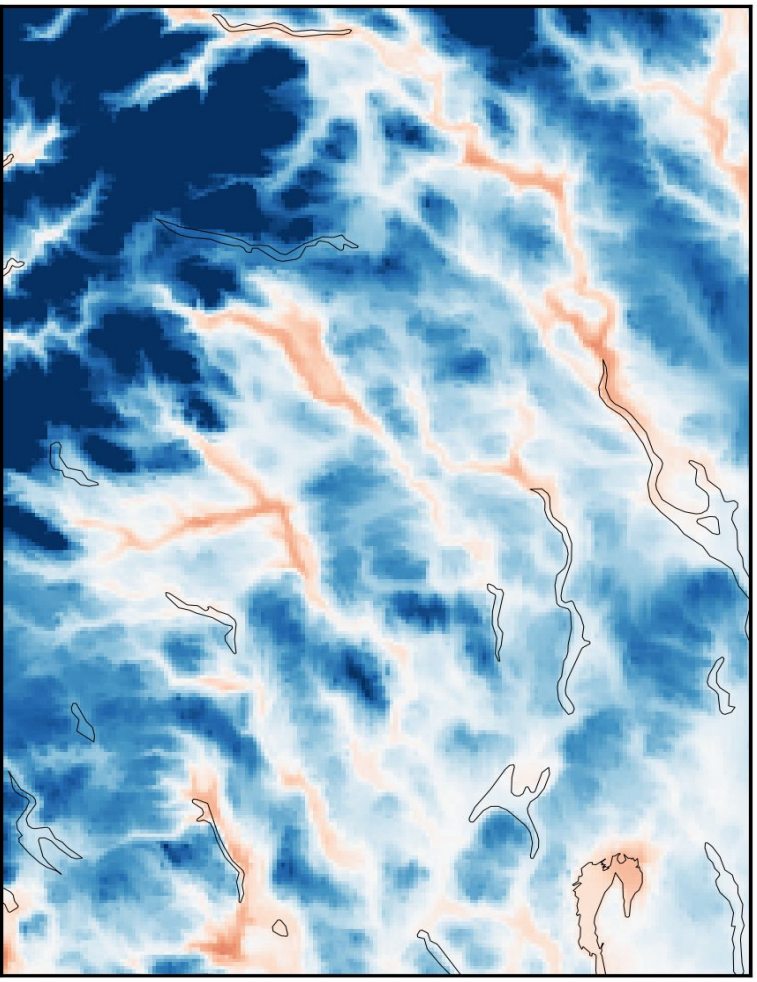
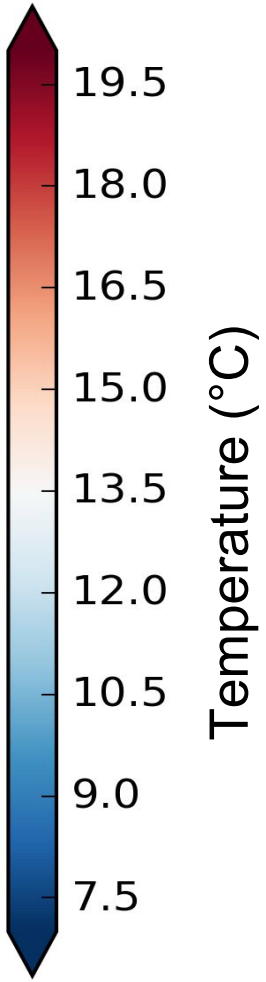
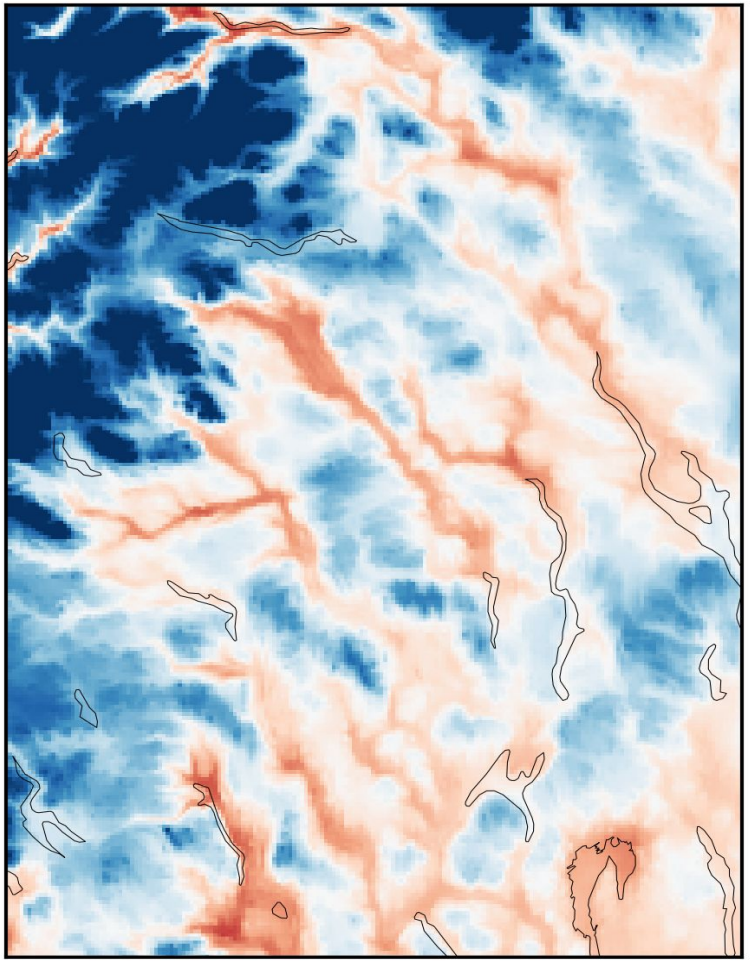
Example on added information (1km grid)





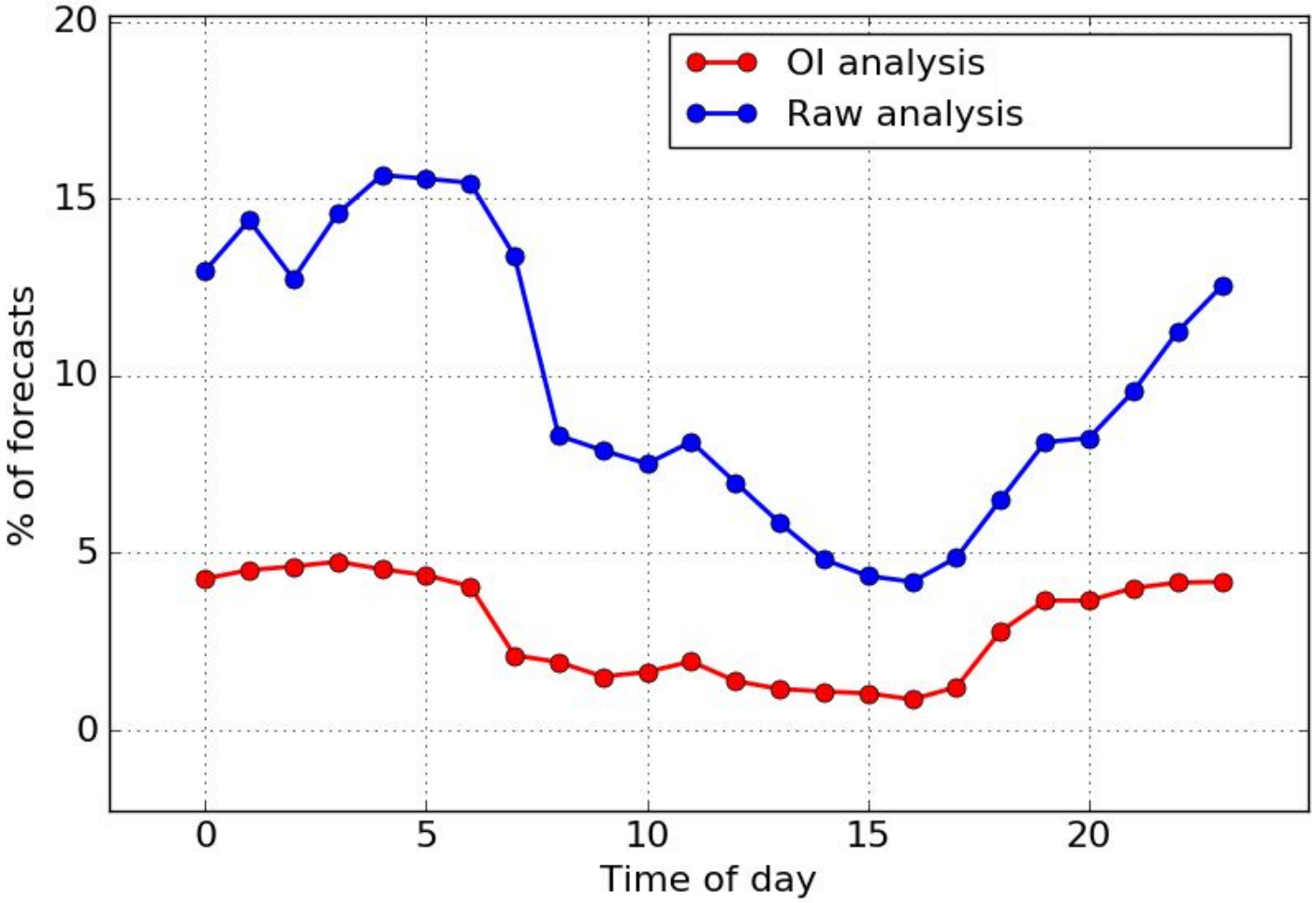


Model

Model + amateur weather observations

OI analysis using amateur T2M observations

Percentage of forecasts having an error larger than 3 degrees



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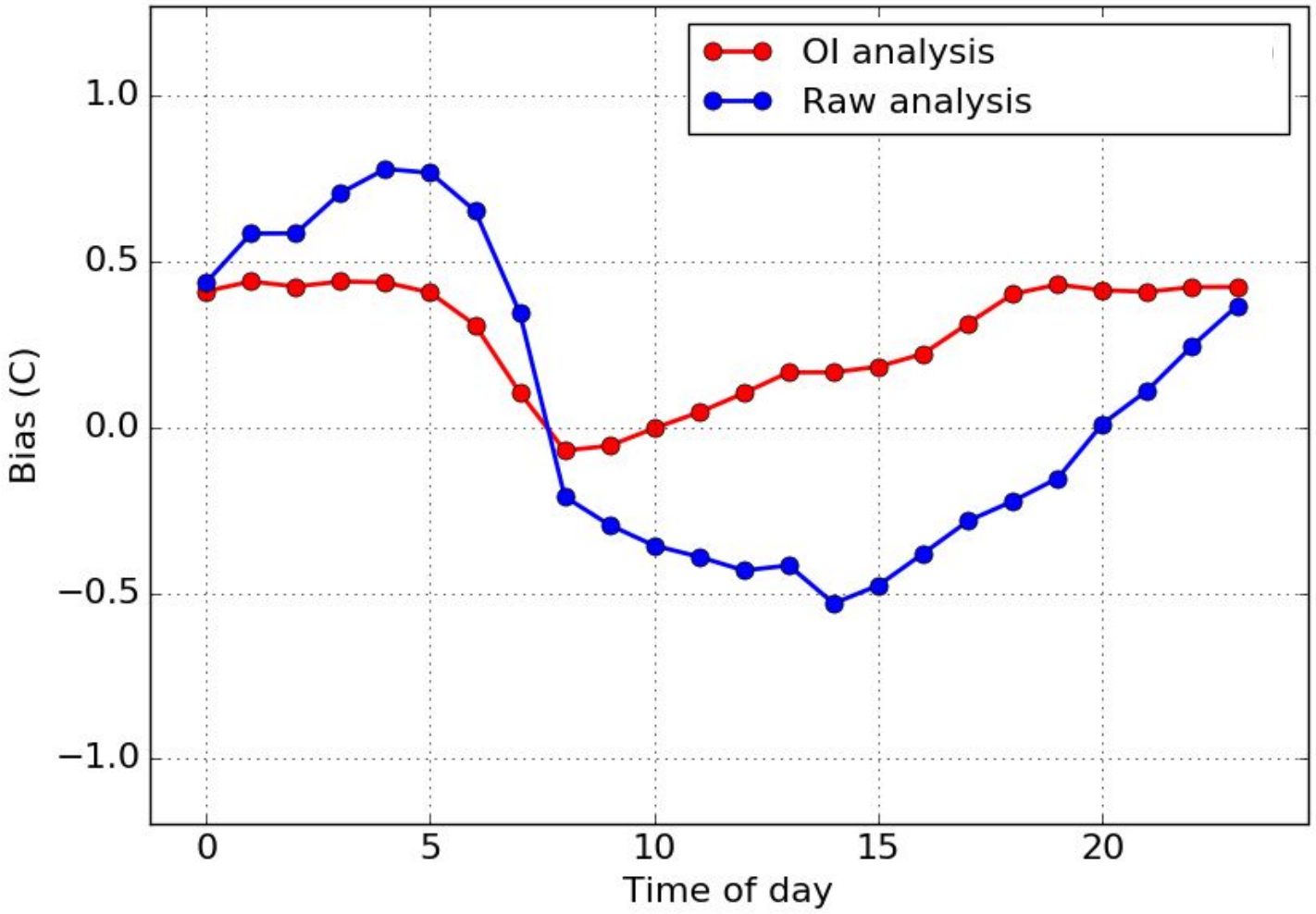
Bias after using amateur T2M observations



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Products to be ready this year

Dailly analysis products on 1x1 km grid

- Temperature
- Precipitation
- Cloud cover
- Humidity
- Wind speed
- Snow depth

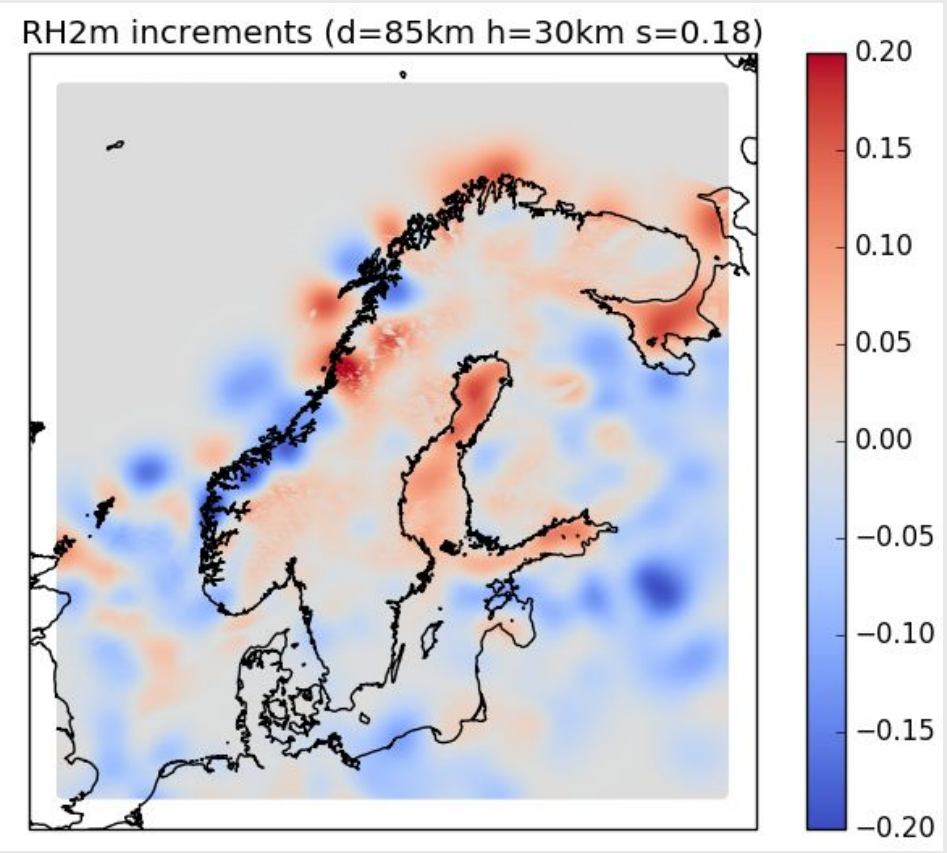
Surface/soil assimilation in NWP

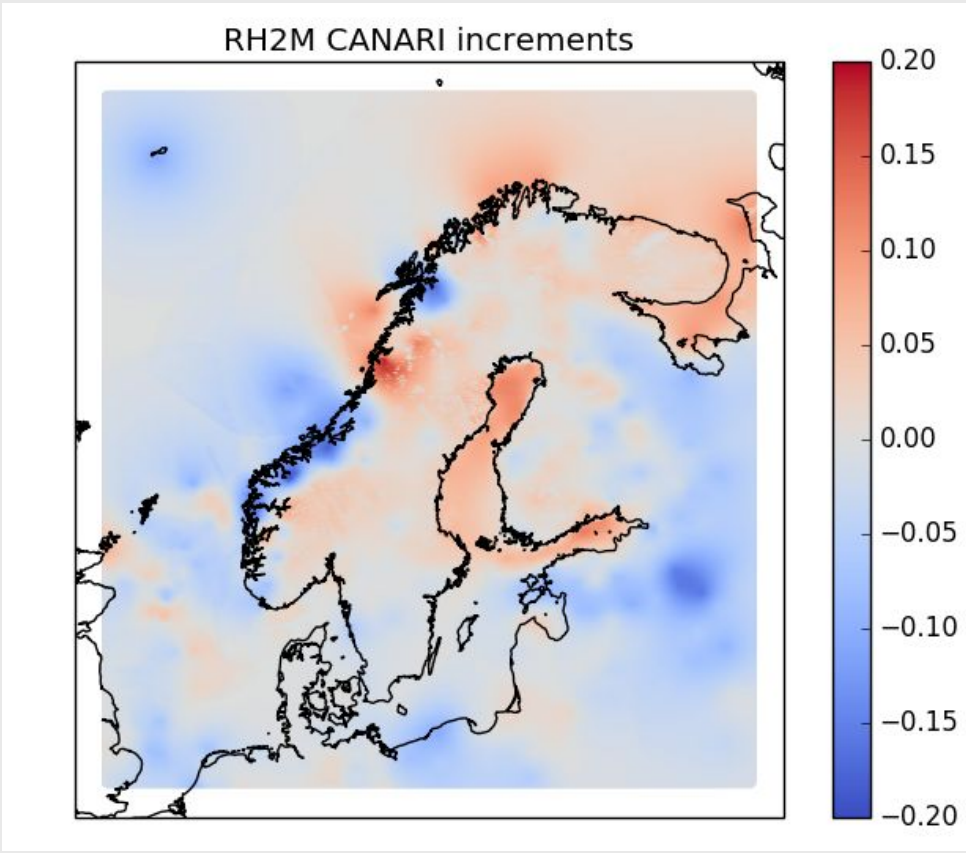
- Using an OI method for screen level variables (T2M/RH2M,SWE)
  - Using the tool **CANARI**
    - Deeply integrated in the NWP code
      - Benefits from the upper air assimilation
      - Changes affect both the forecast and upper air assimilation
      - Need the model code and can only be used with license
      - Difficult to use in the offline SURFEX community
      -
- For the inclusion of amateur weather stations in nowcasting at MET-Norway, the open source tool **gridpp** is used.
  - - Same tool could be used NWP analysis and nowcasting/re-analysis
  - - More flexible first guess information
  - - Observations are pre-processed with the open source tool TITAN

Can we do the same as CANARI?

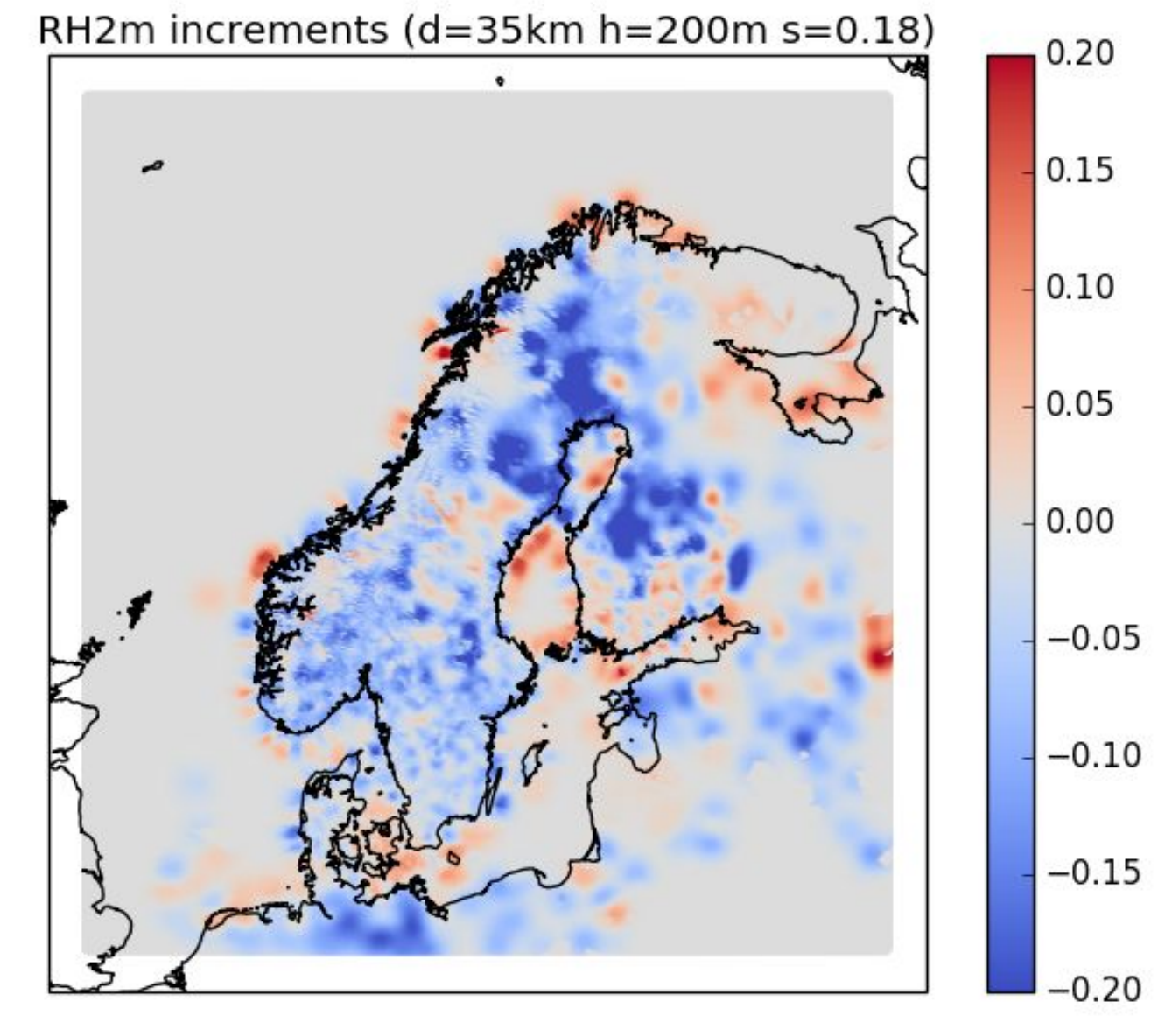
gridpp
d=85km h=30km s=0.18

CANARI
MetCoOp settings





Amateur relative humidity observations



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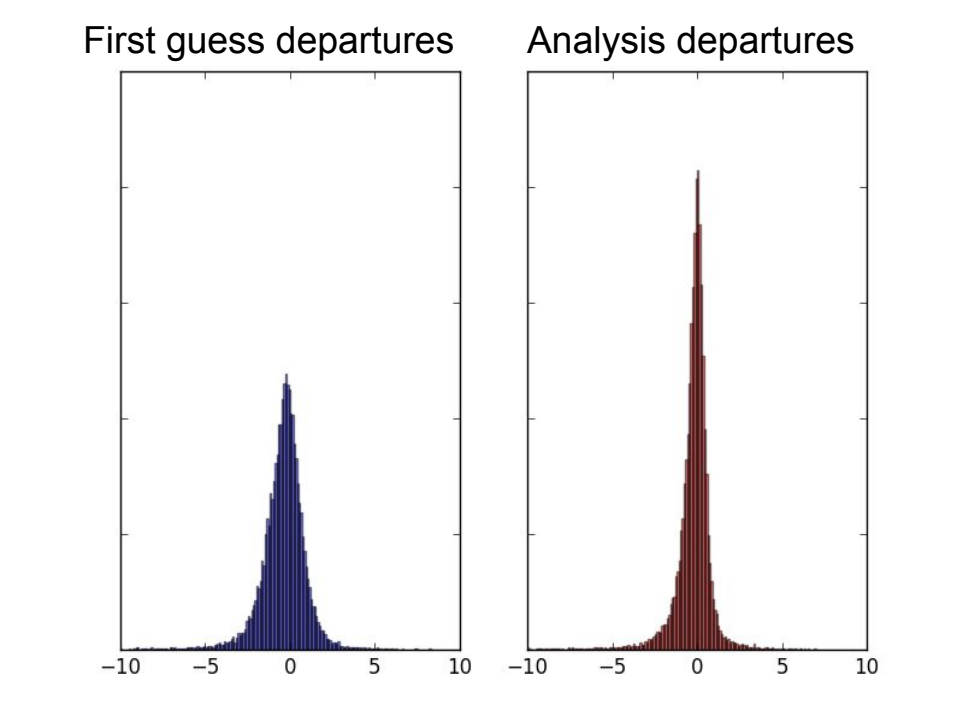
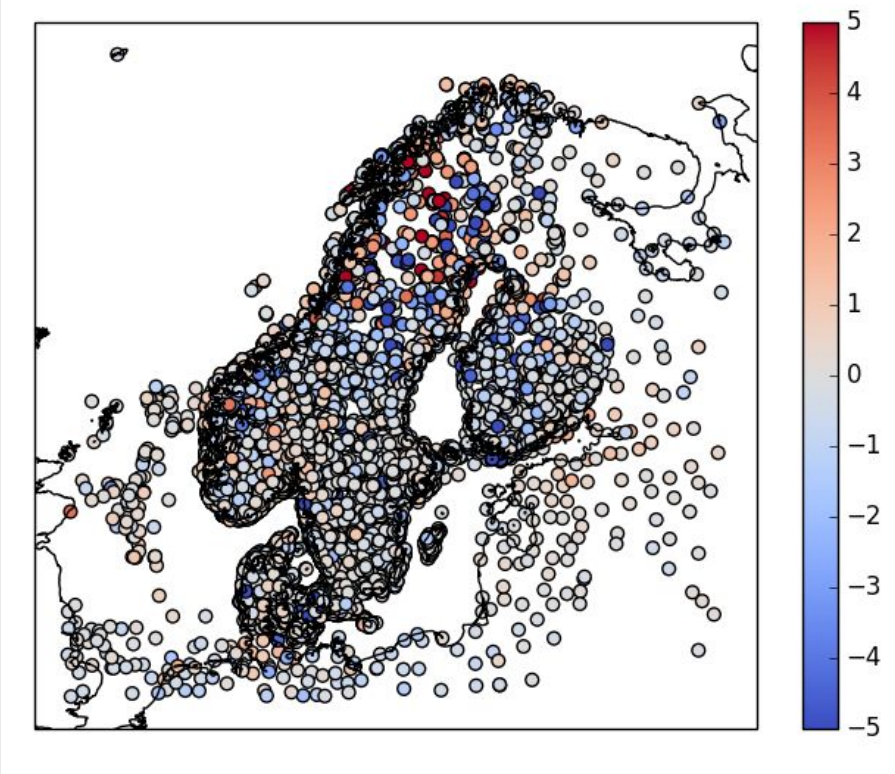
T2M departures

- Possible monitoring examples...



Histogram

Location of departures



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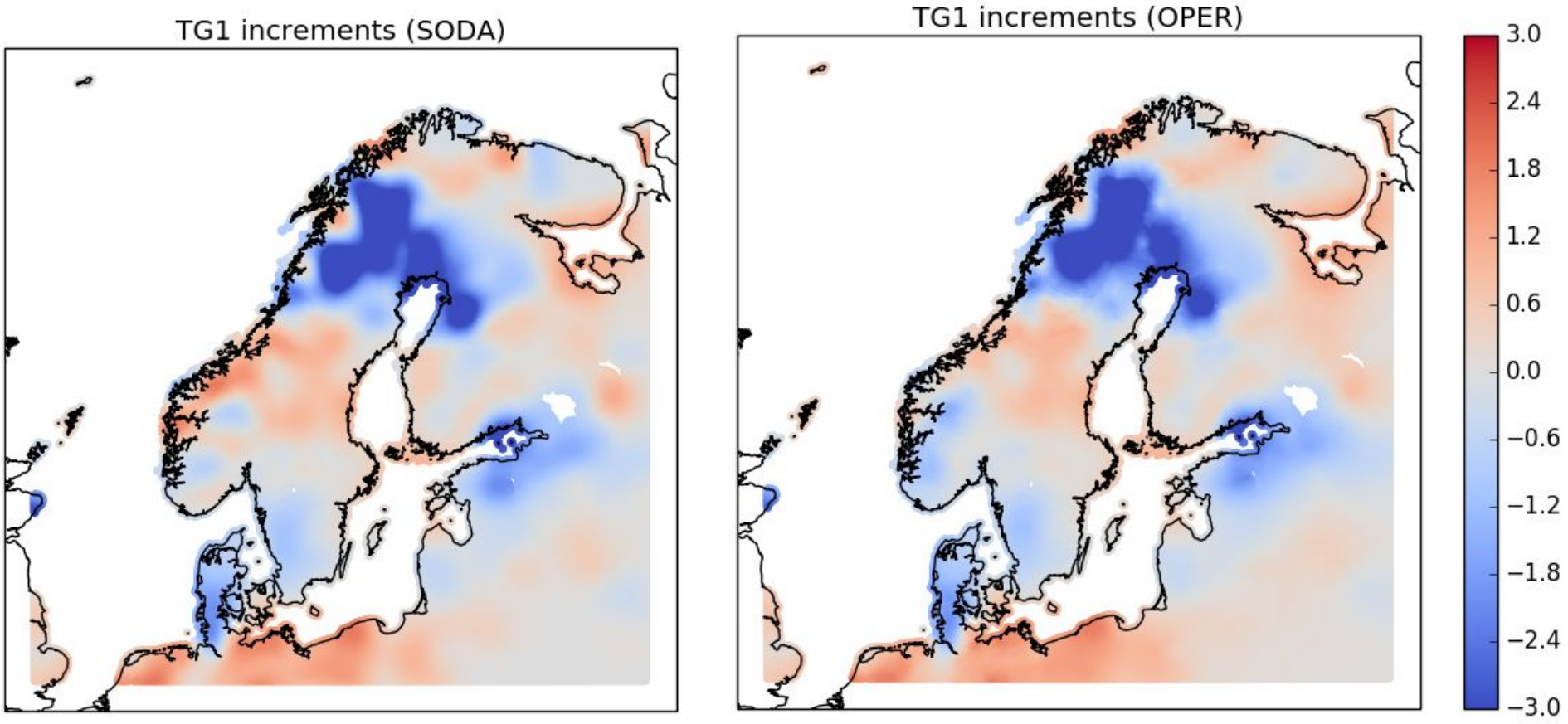
Soil assimilation (TG1)

Offline SODA

Operational:
Inline CANARI



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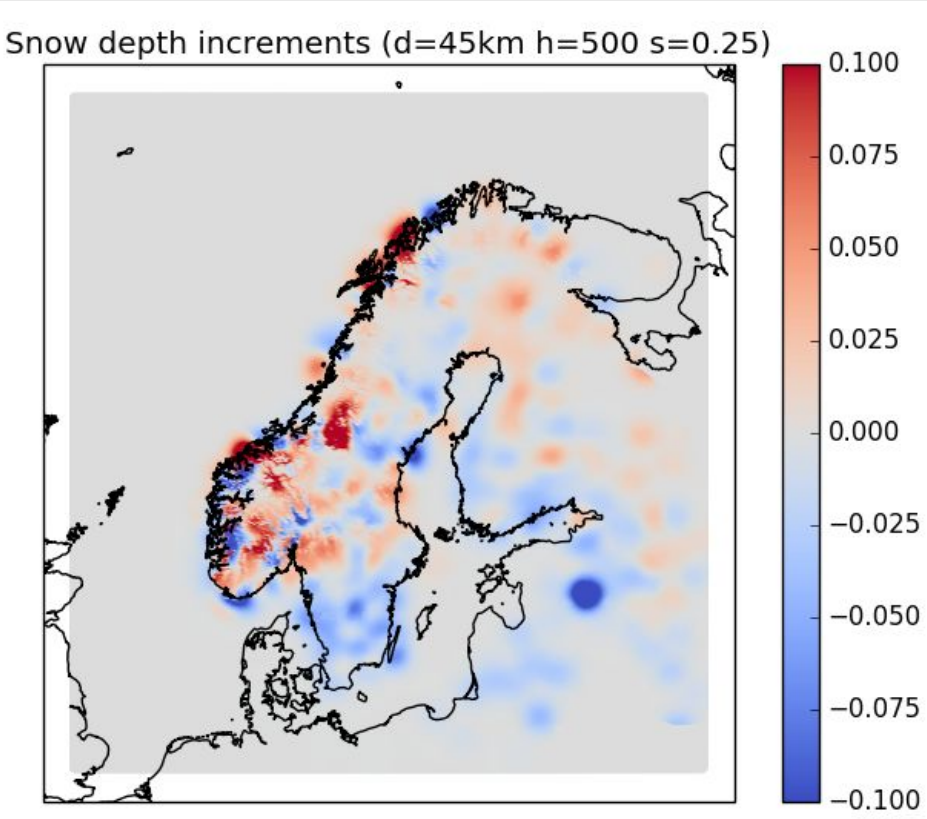
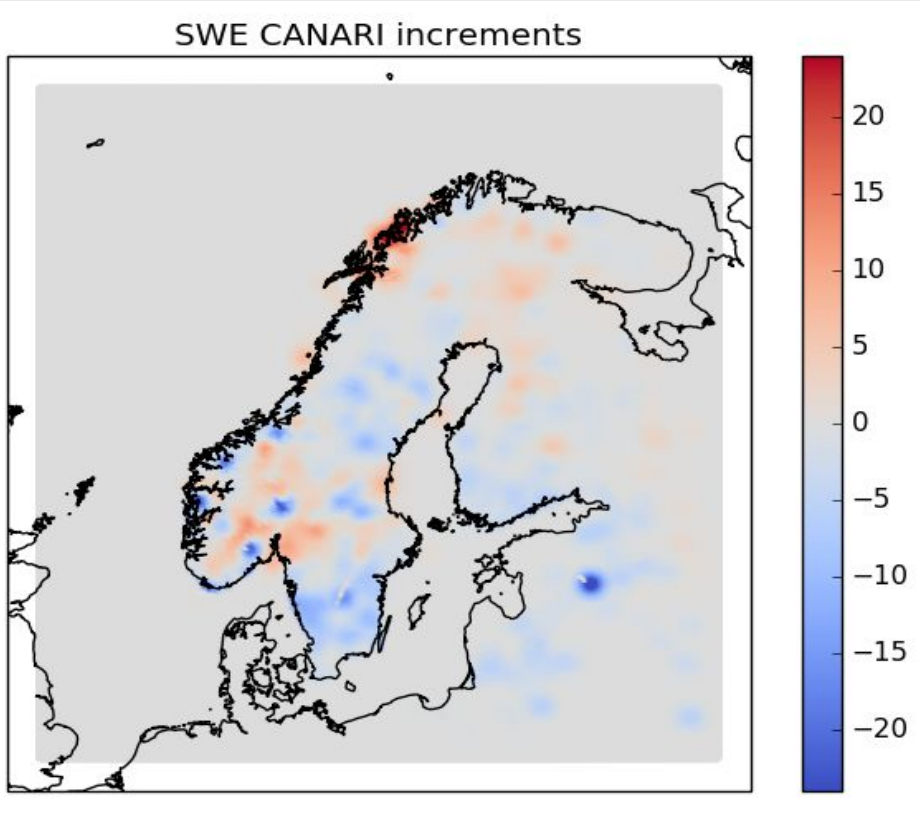
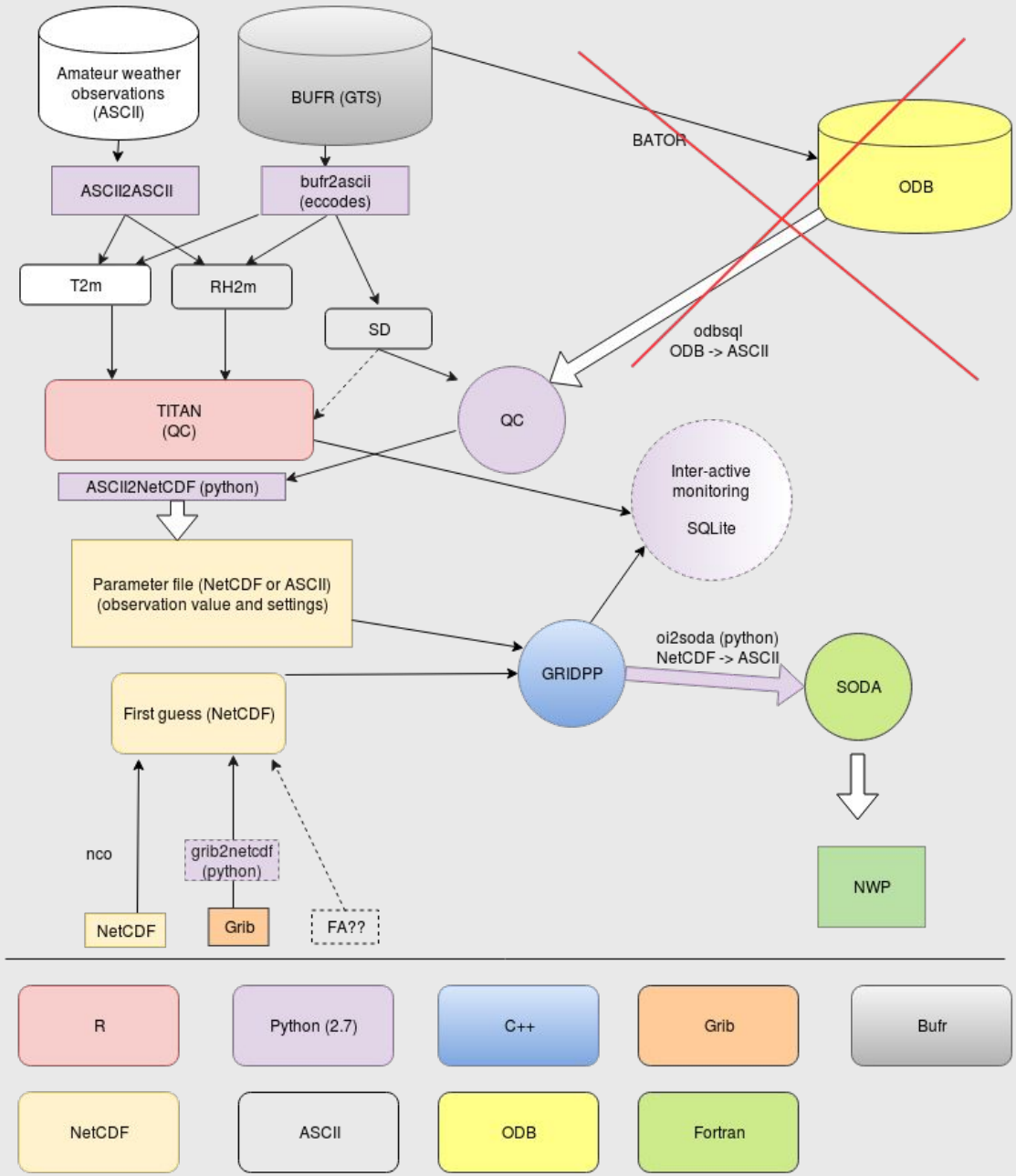
Snow depth/Snow water equivalent (SWE)

- Some challenges:
  - SWE vs Snow depth
  - Land area fraction
    - Observation operator (nearest grid point) should be a land point





gridpp in NWP



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Conclusions

- Technical tests show that using gridpp for screen level analysis is feasible for NWP
  - Can reproduce similar results as CANARI and MESCAN similar to operational settings today
    - Need information about land area fraction
- Soil assimilation seems feasible
    - SODA tested in offline surfex cy40h1 EKF branch
    - TODO: Inline tests
  -

Outlook:

- Will be implemented in the MetCoOp nowcasting suite if tests are successful
    - Amateur weather observations have high temporal resolution
- Will be implemented in the MET-Norway re-analysis suite
    - project delivery

Merci!

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Bonus tracks….

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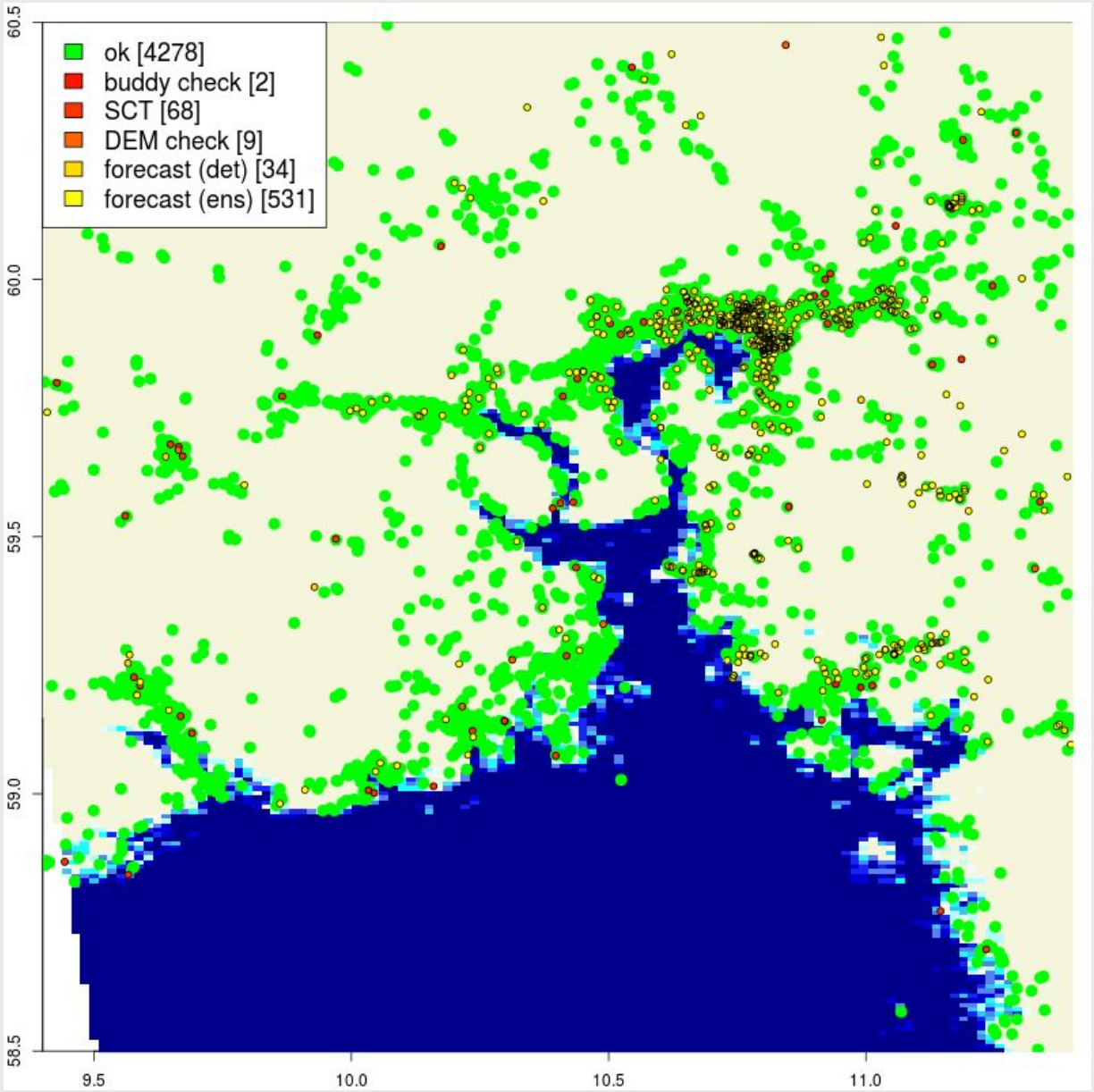
Example Mar 26, 2018 08:00 UTC



Relative humidity

Dense network, comparable to temperature.

Important variable for the closure of the water balance.

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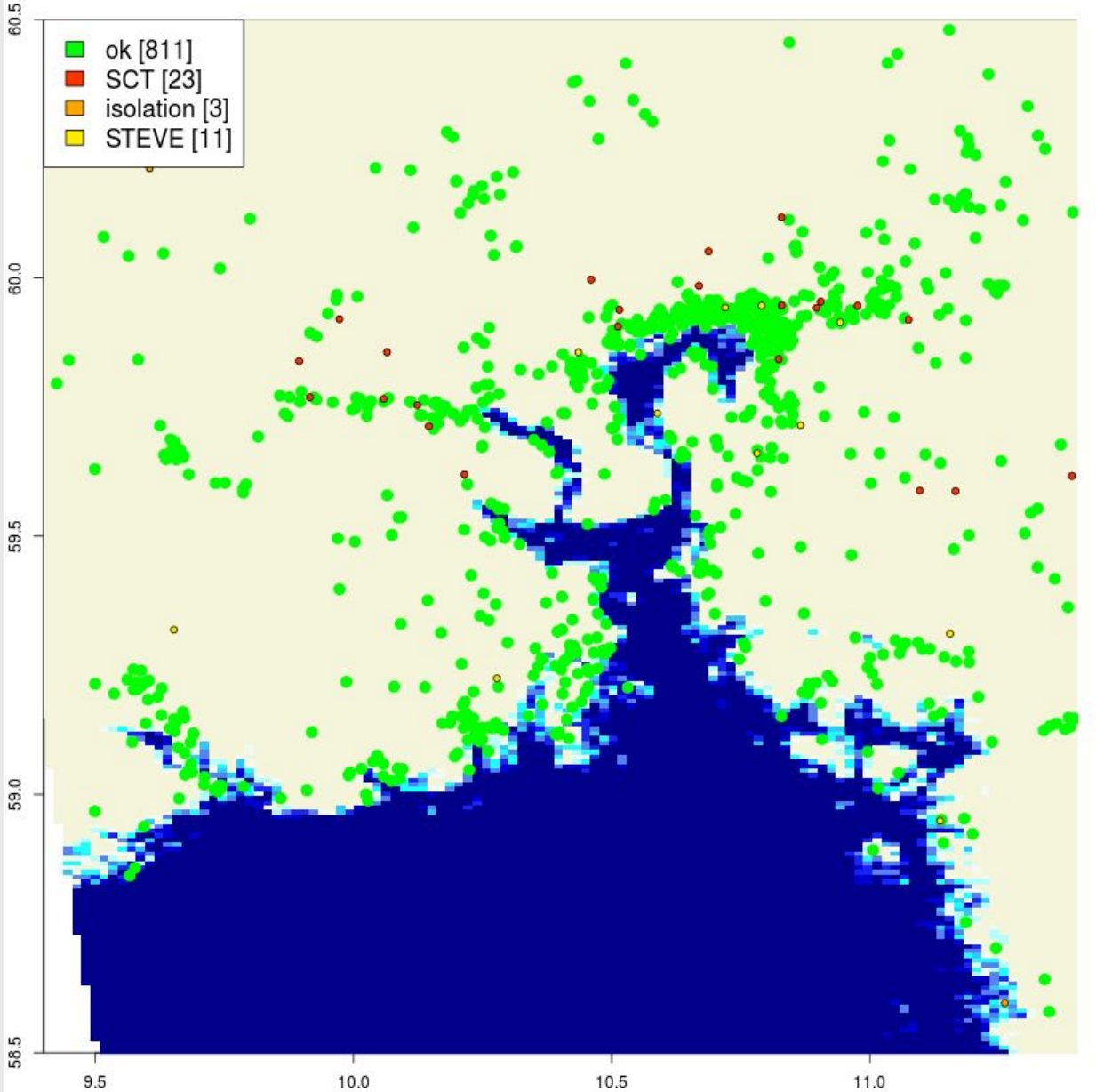
Example Mar 26, 2018 08:00 UTC



Precipitation

If compared to temperature, less observations are available.

STEVE, isolated event test, such as an observation not measuring precipitation surrounded only by observations that measure precipitation (or vice versa).

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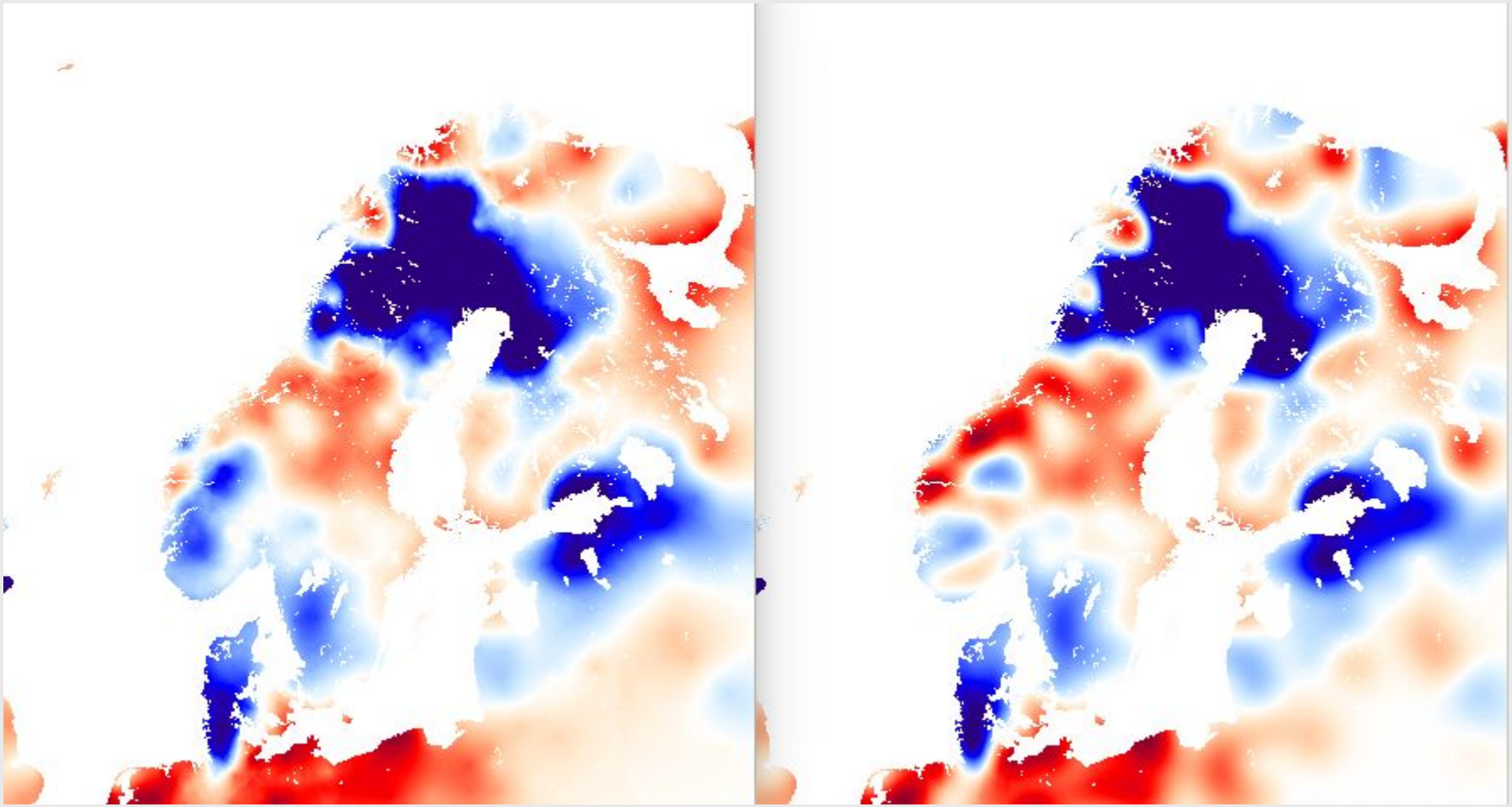
TG1 (soil assimilation)

CANARI

GRIDPP



d=85 km
Turn off height dependency
Same observation set (ODB from CANARI)

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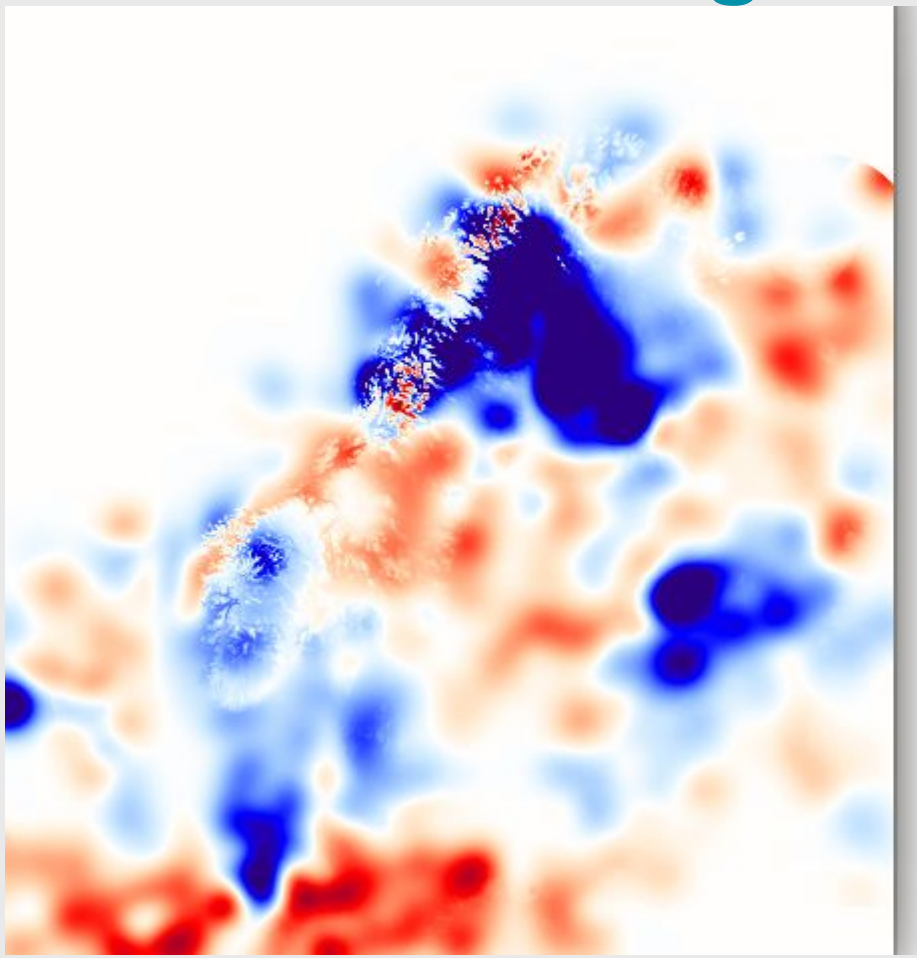
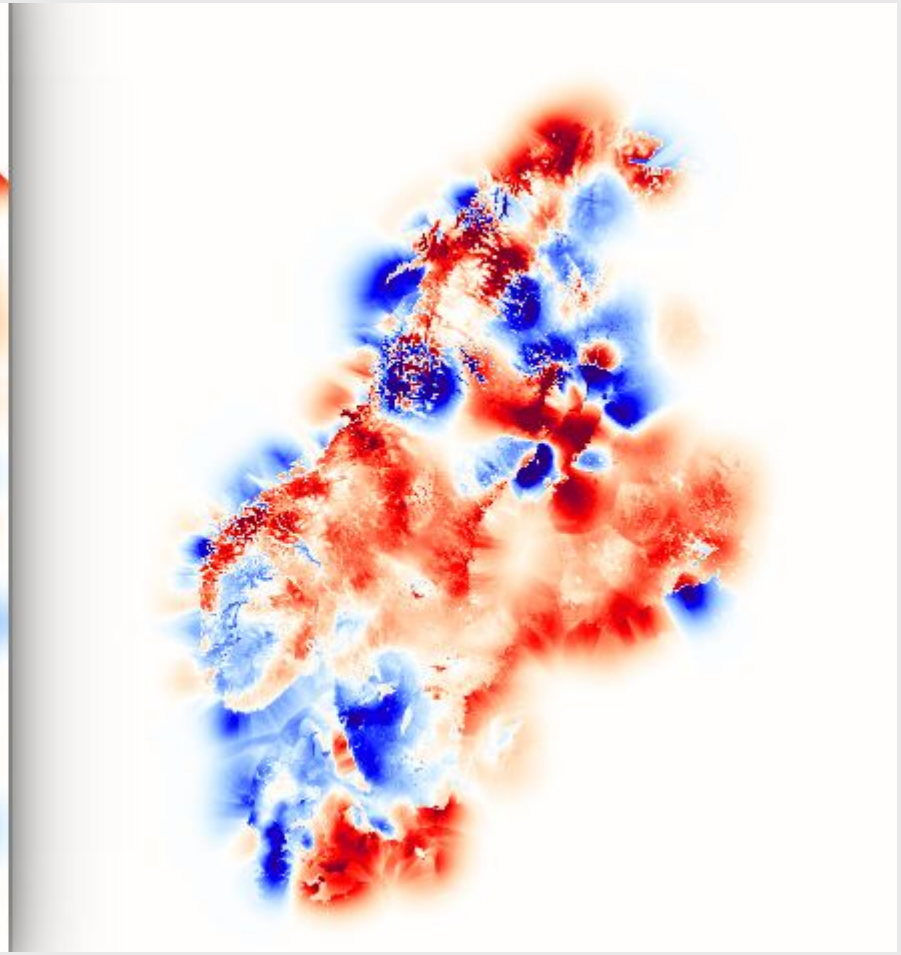
T2M
OPER + height



d=60km h=300m
gradient=0.065 sigma=0.6

Amateur T2M



d=60km h=300m
gradient=0.065 sigma=0.6

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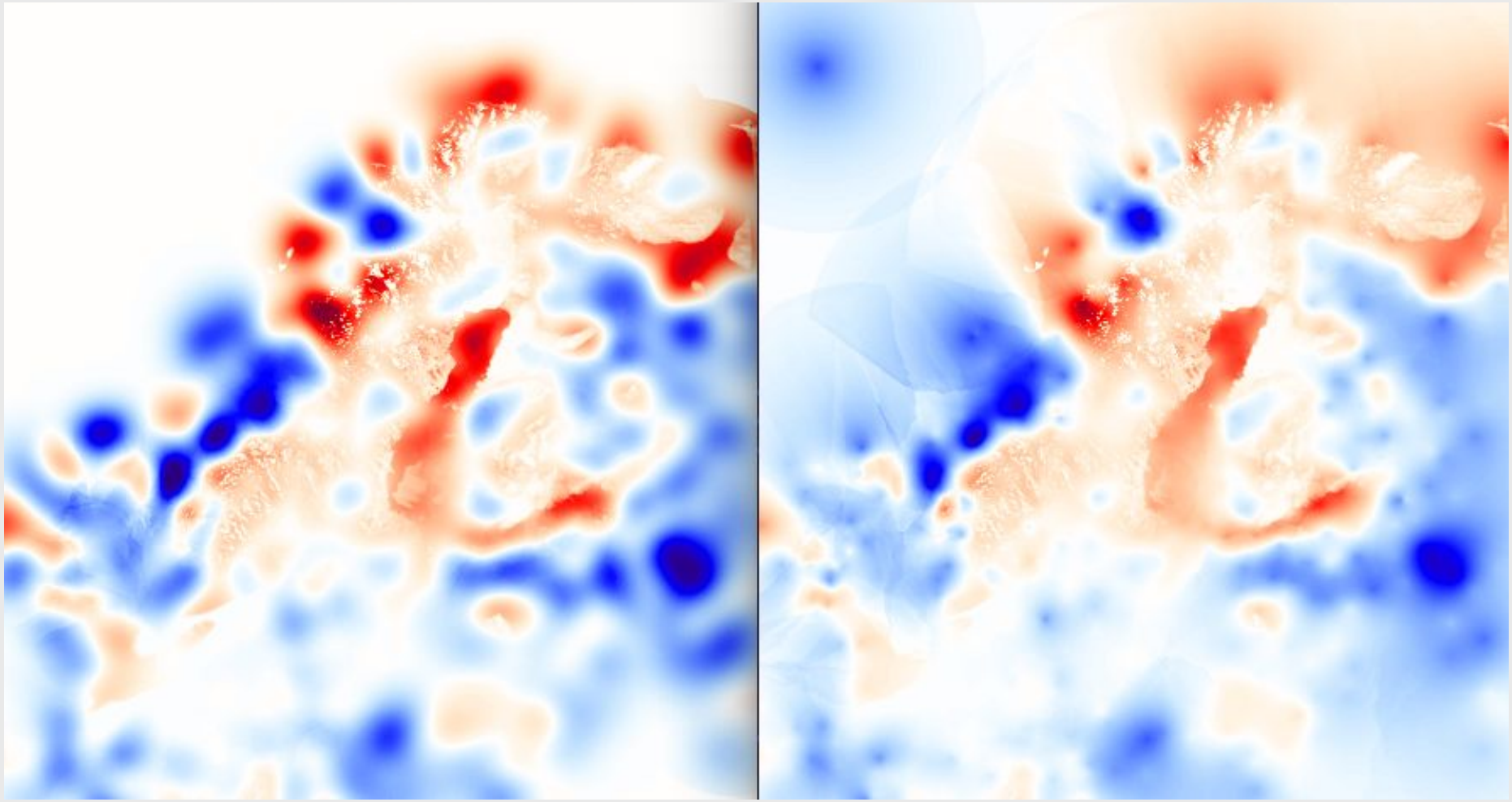
RH2M
GRIDPP

CANARI



h=85 km
sigma=0.1

Tested also with amateur weather stations

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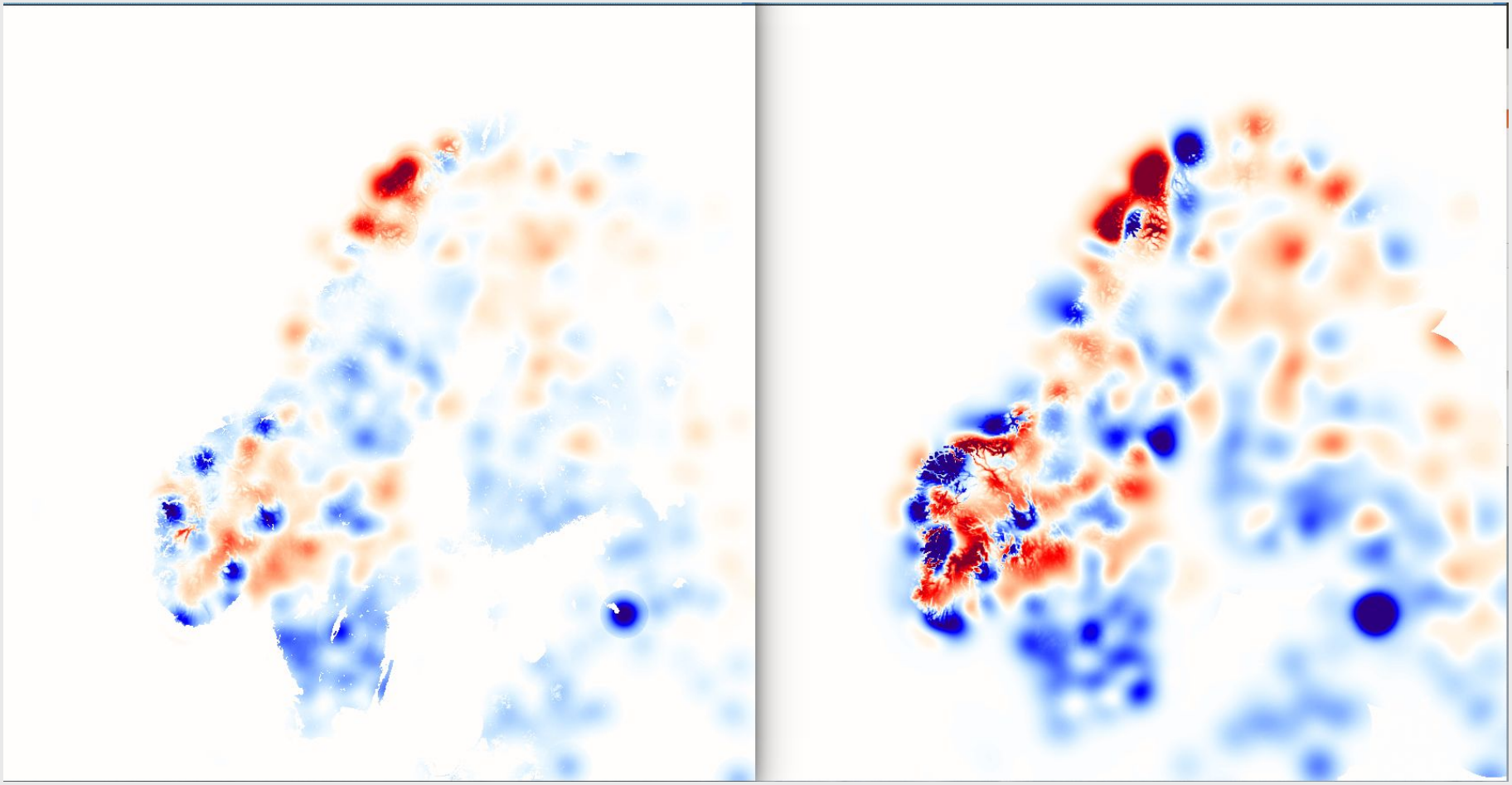
CANARI

GRIDPP



d=45km h=500m
sigma=0.25

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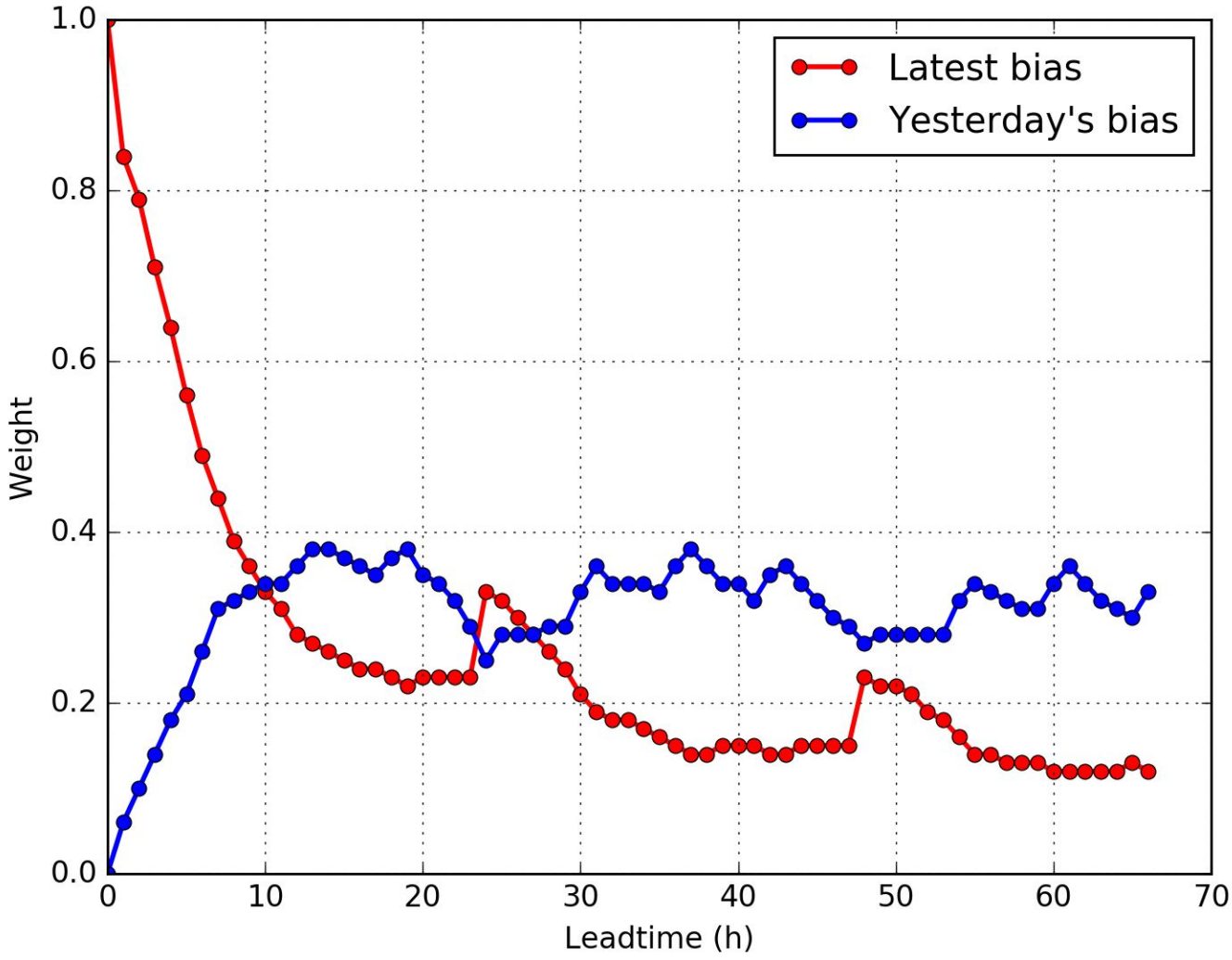
How long are corrections applied?



How does the weighting work?