DATA ASSIMILATION OF GNSS ZTD
Operational and reanalyses

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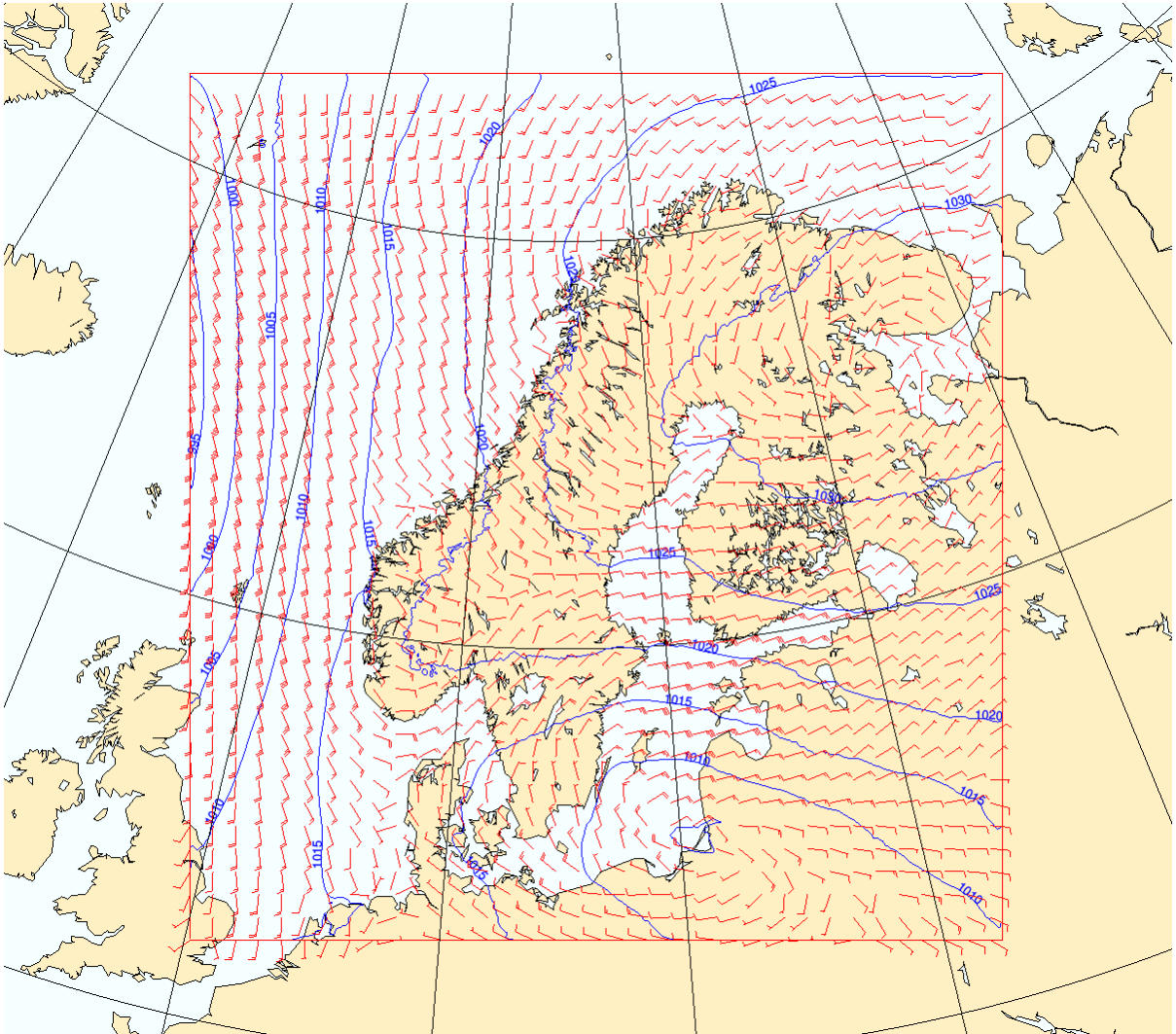
MetCoOp (MEPS)

An operational cooperation between Sweden, Norway and Finland.
Estonia, Latvia and Lithuania will join the cooperation by 2022.

- Domain is 900x960 points
- 2.5km grid spacing
- linear grid
- 65 vertical levels.
- 3 hour cycling



MetCoOp (MEPS)

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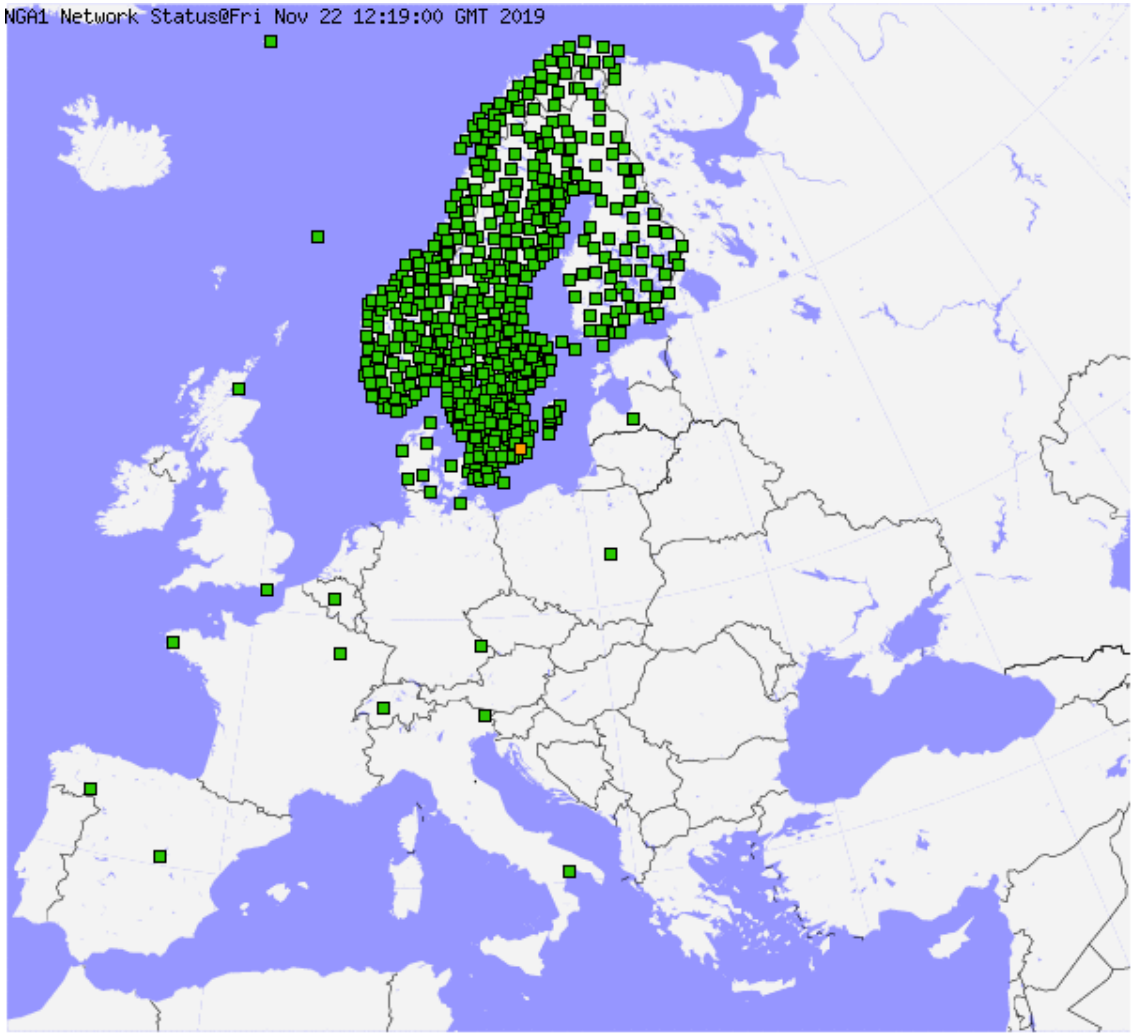
- MEPS currently consists of 1+9 members
- Observations used are (3Dvar):
  - Conventional observations
  - Satellite radiances (AMSU-A, MHS, IASI)
  - Scatterometer
  - Radar reflectivity)
  - GNSS ZTD
- EDA derived structure functions
- SLAF (Scaled Lagged Average Forecast) as boundaries

- From February:
  - CMEPS – 4-6 members every hour, i.e. up to 30 members
  - ECMWF-ENS at the boundaries

- Observations to come
  - MODE-S
  - GNSS slant delays

Available NGA1 at E-GVAP

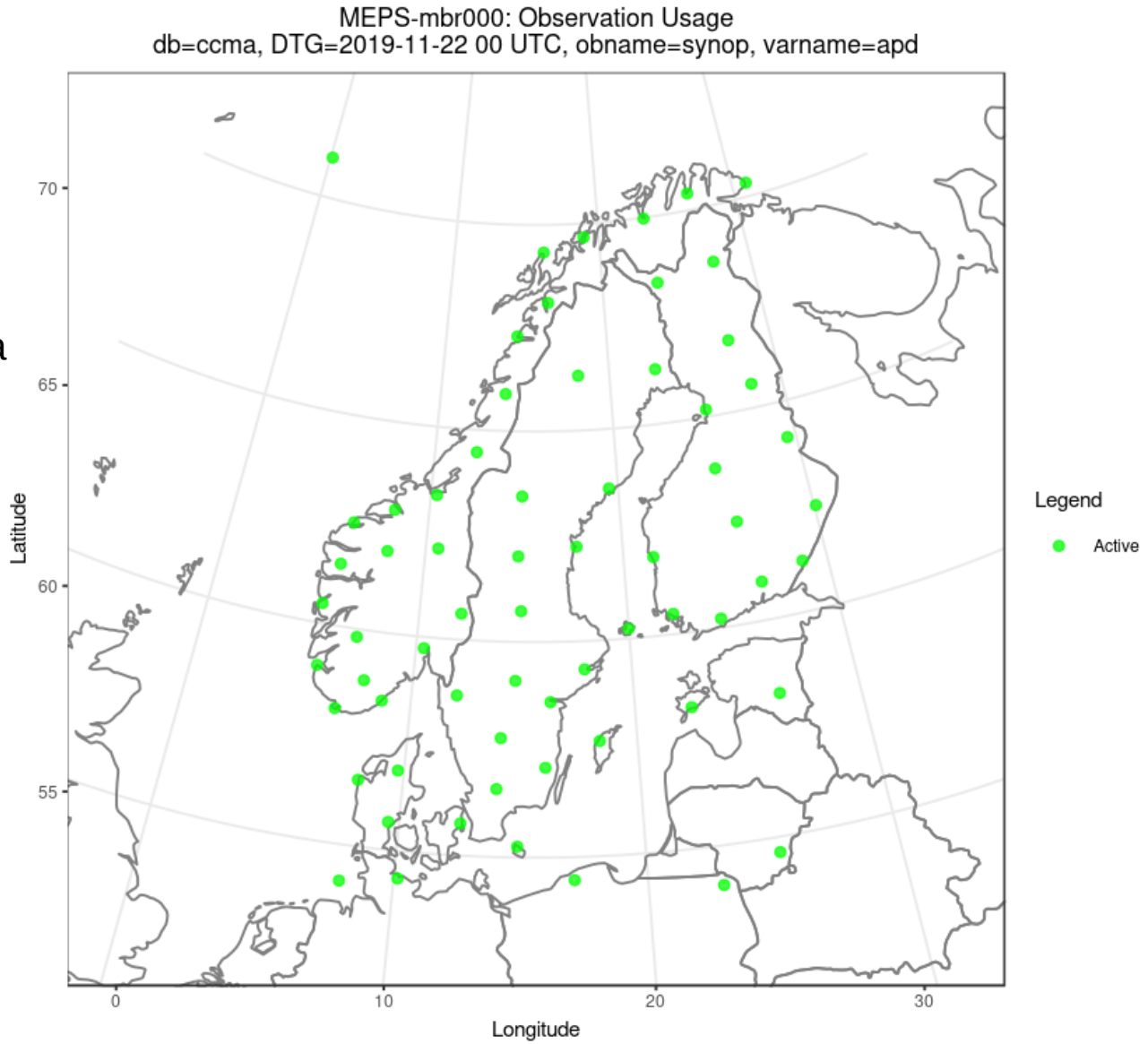
Operational since June 2018
Still indicated as ”test” at egvap.dmi.dk



Operational use in MetCoOp

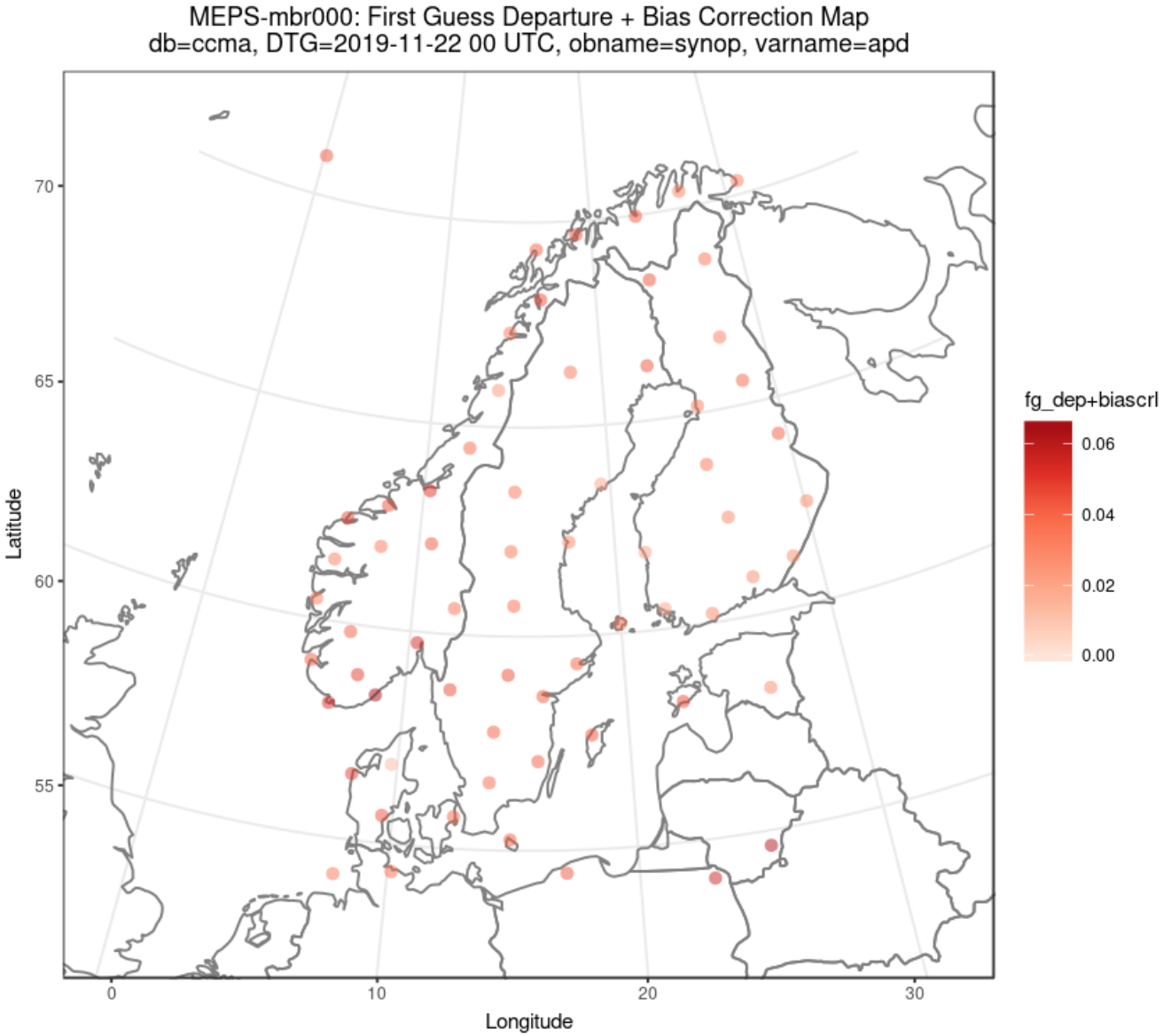
Included are:
NGA1
METO
ROBH

Hourly data
Stations selected through a white list



Operational use in MetCoOp

Observation – first guess



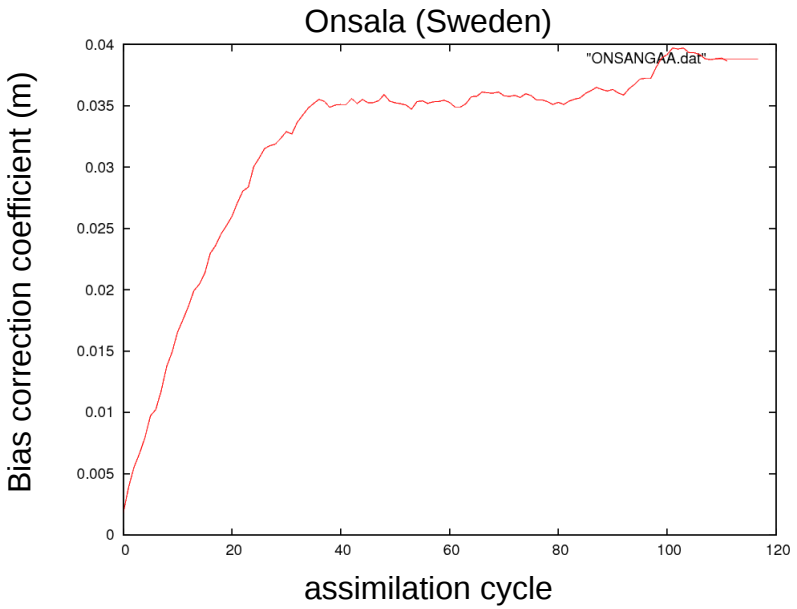
Variational Bias Correction

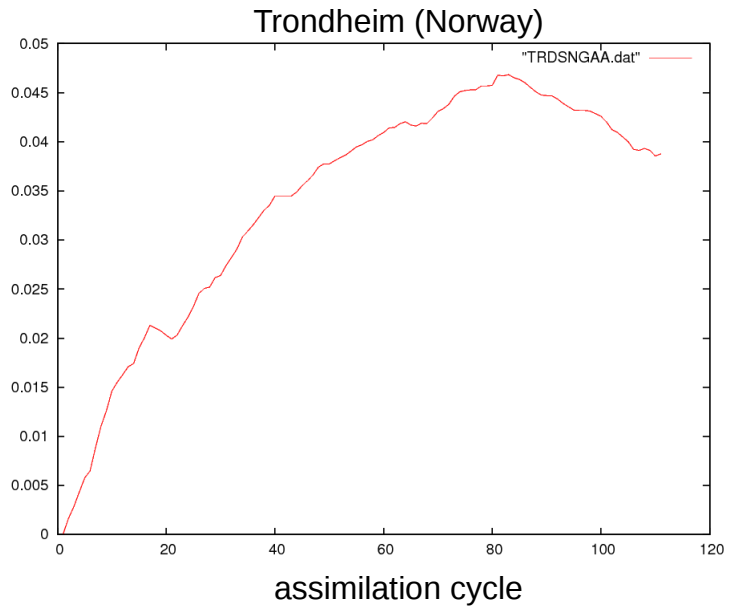
Linear predictor model:

$$b(x,\beta) = \sum_{i=0}^{Np} \beta_i p_i(x)$$

Modified cost function:

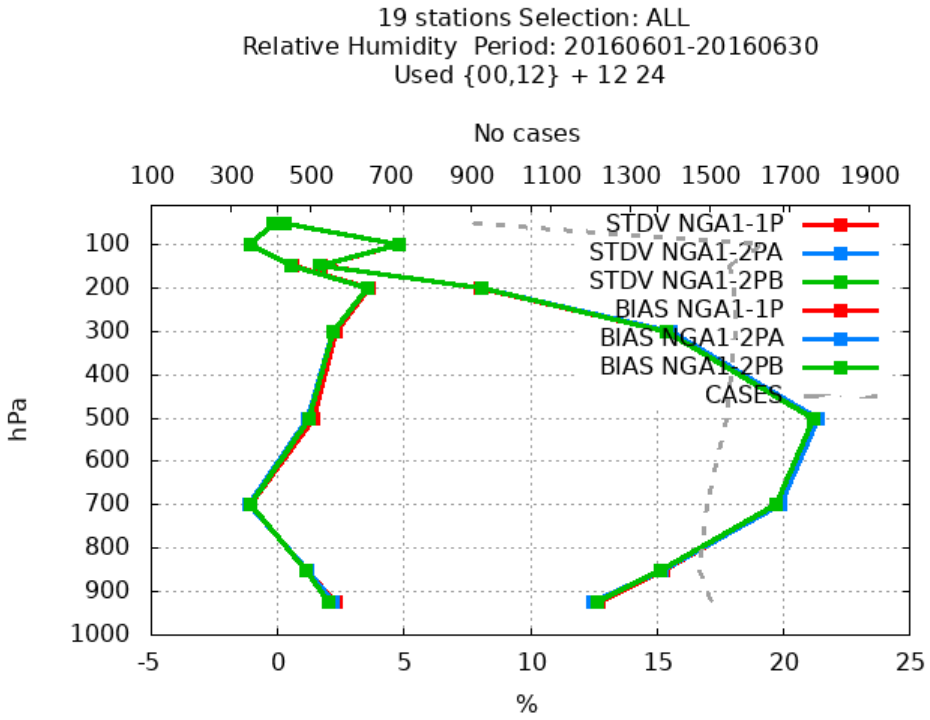
$$J(x,\beta) = \frac{1}{2}(x - x^B)^T B^{-1}(x - x^B) + \frac{1}{2}(\beta - \beta^B)^T B_\beta^{-1}(\beta - \beta^B) + \frac{1}{2}(Hx + b(x,\beta) - y)^T R^{-1}(Hx + b(x,\beta - y))$$





Impact of different VARBC predictor choices – 3 hour cycling

Bias and RMSE for +12,24 hour relative humidity forecasts

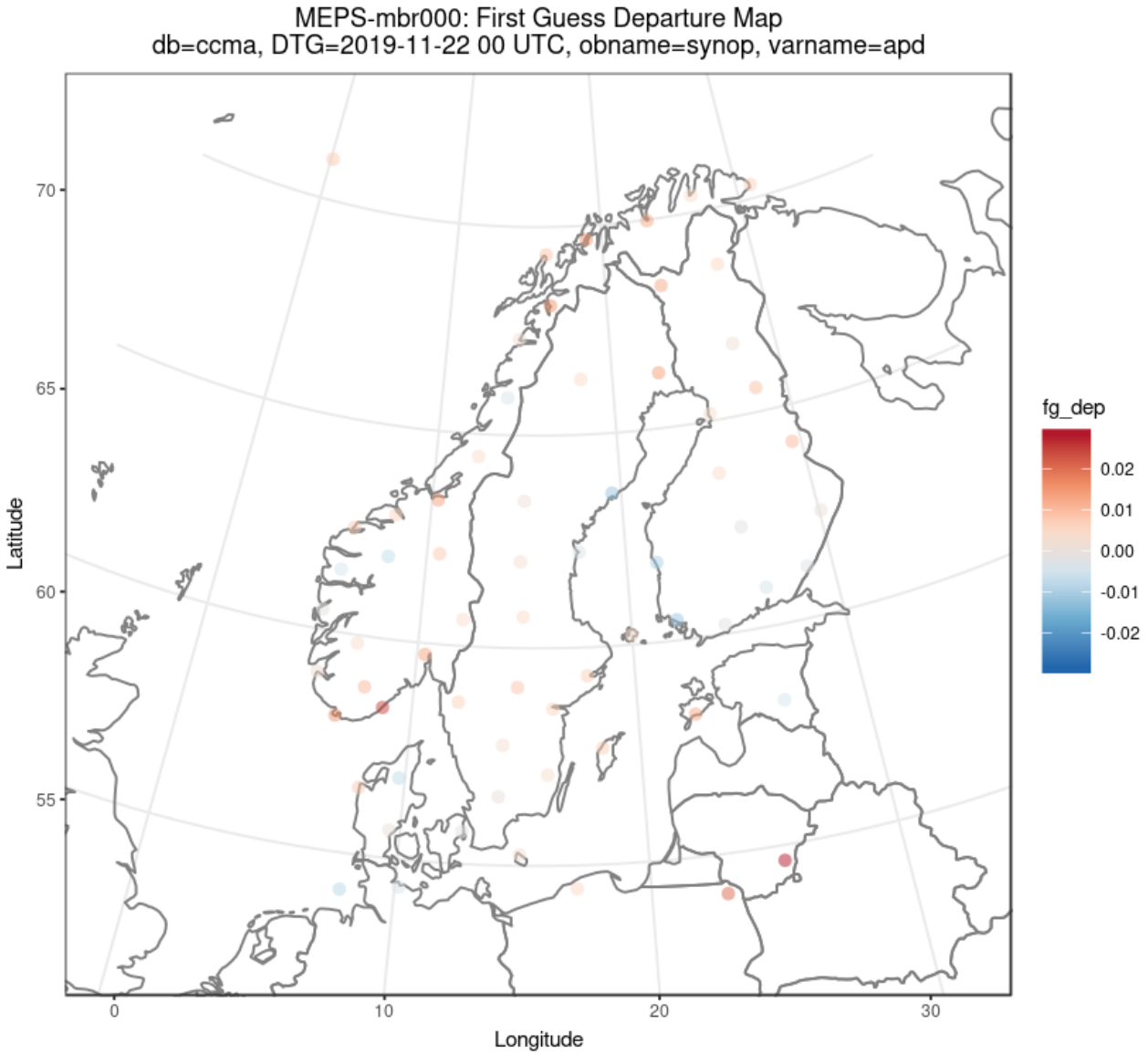


— Offset
— Offset + 1000-300 hPa
— Offset + TCWV

Small impact of introducing one more predictor in GNSS VARBC.

Operational use in MetCoOp

Observation – first guess



HARMONIE 4Dvar (still in development)

SMHI

- 3 hourly cycling
- 3 hour assimilation window, 1.5 hour before analysis time and 1.5 after
- Sub hourly GNSS ZTD data need some work
- GNSS ZTD introduced successfully (technically) every 30 minutes
- VARBC does not work properly
- To be continued…

MetCoOp nowcasting (still in development)

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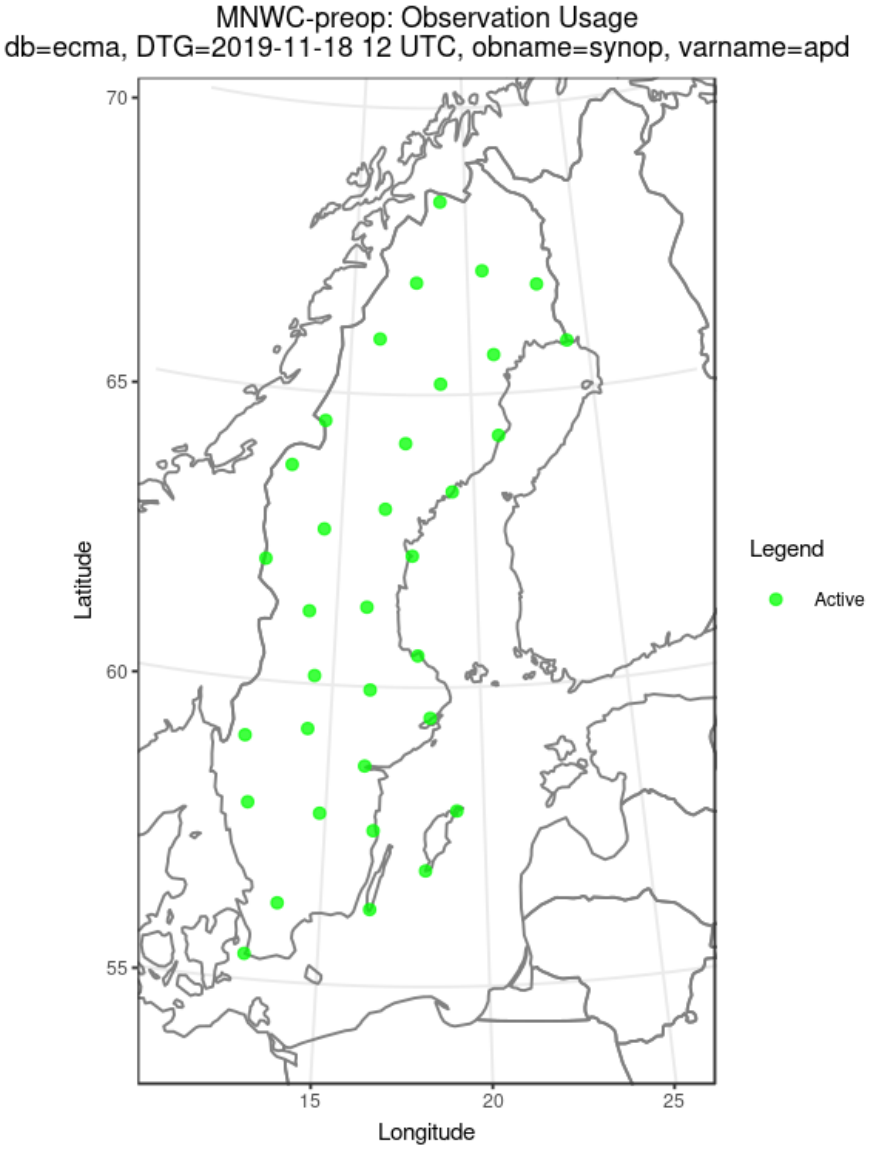
- Same domain/resolution/levels as the operational runs
- Updates every hour with 15 minutes cut off time
- Up to 9 hour forecasts with output every 15 minutes
- Rapid refresh, i.e. the first guess for upper air is operational forecast (3-6 hours)
- Surface is cycled
- Same observations as operational runs EXCEPT GNSS ZTD and ASCAT

- Sub-hourly GNSS data is used
- Observations from XX:45 from the previous hour is used
- Stations are selected through a white list
- Only Swedish stations

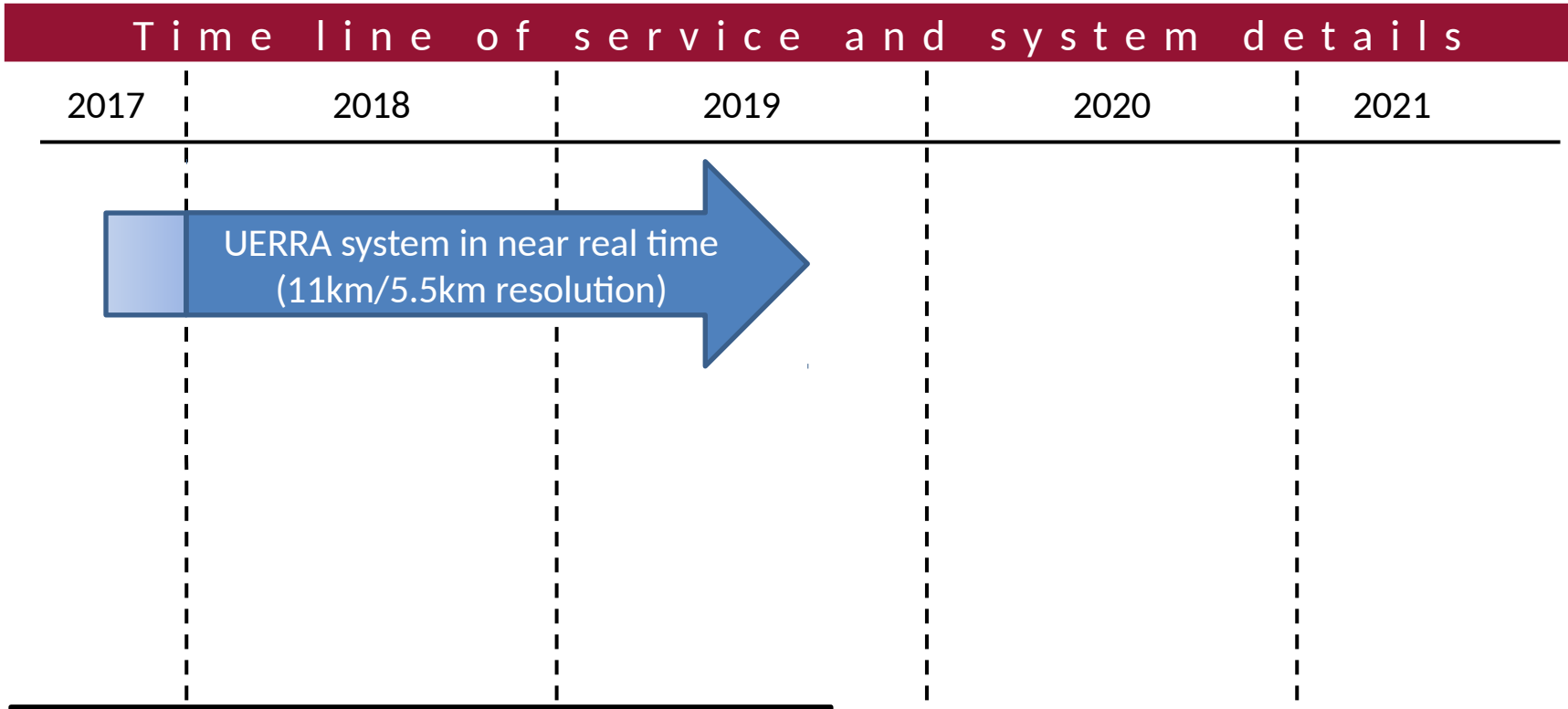
MetCoOp nowcasting (still in development)



Regional Reanalysis over Europe

SMHI

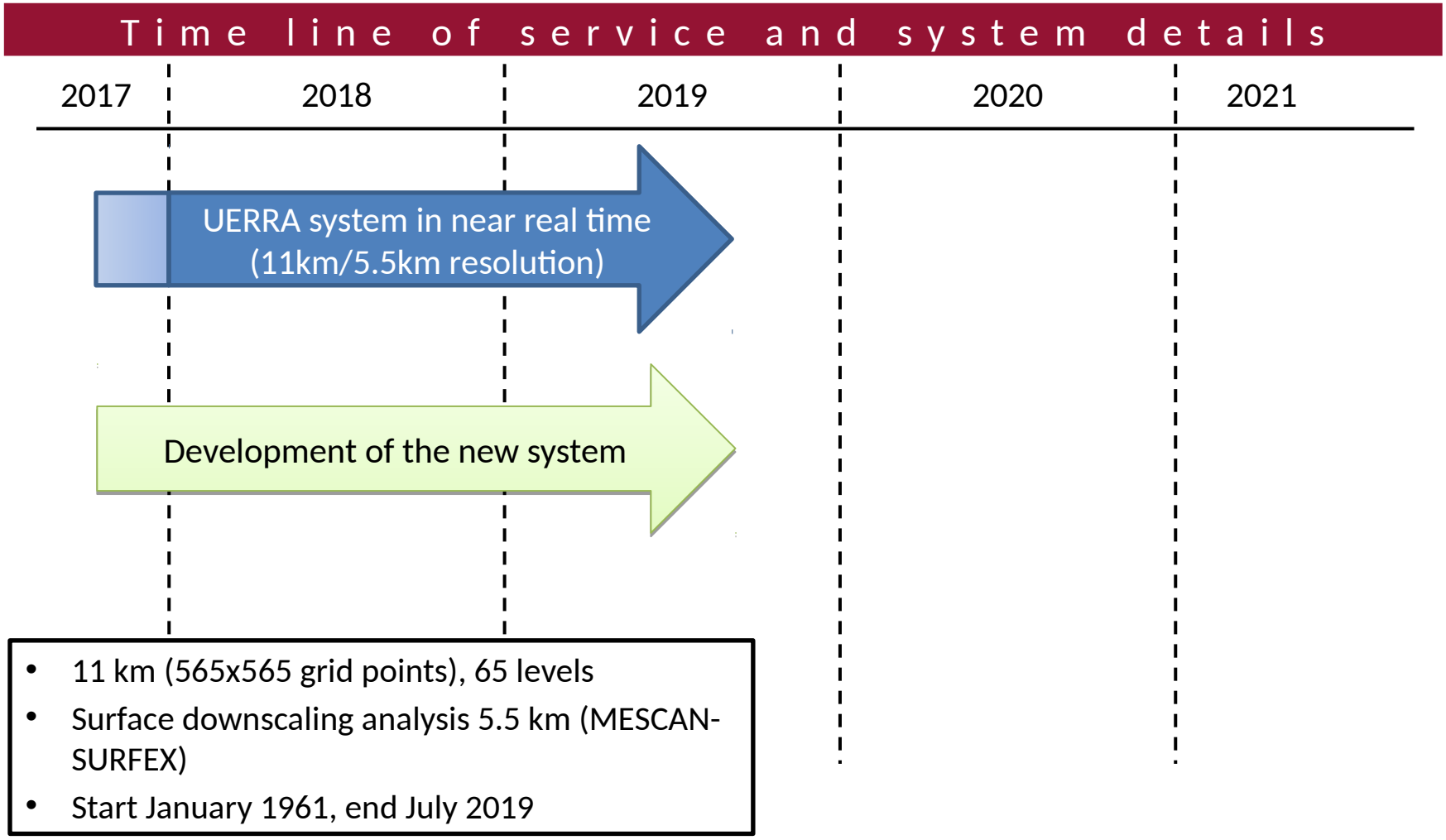
Time line of service and system details



- 11 km (565x565 grid points), 65 levels
- Surface downscaling analysis 5.5 km (MESCAN-SURFEX)
- Start January 1961, end July 2019

Regional Reanalysis over Europe

SMHI



Regional Reanalysis over Europe

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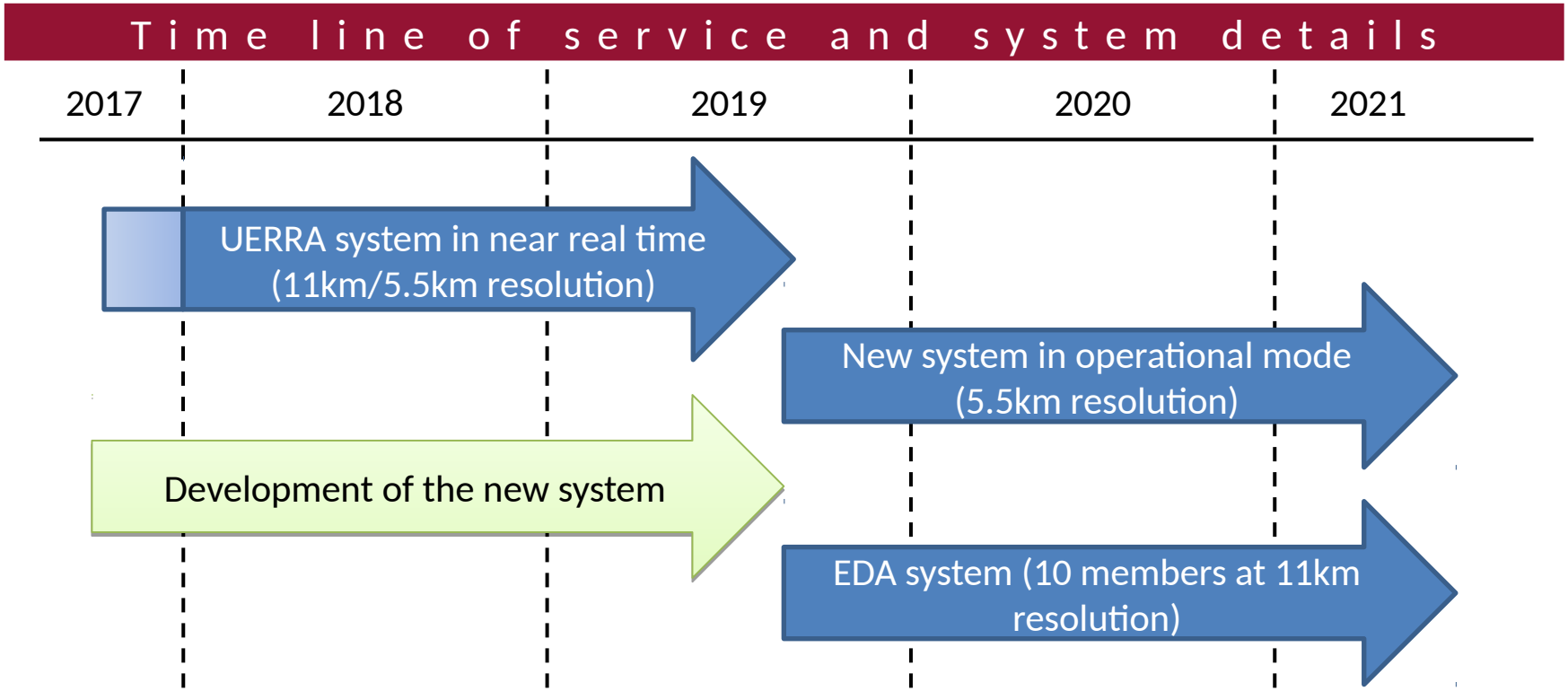
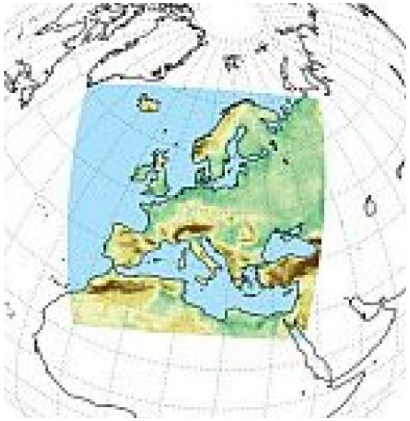


- 11 km (565x565 grid points), 65 levels
- Surface downscaling analysis 5.5 km (MESCAN-SURFEX)
- Start January 1961, end July 2019

- 5.5 km (1069x1069 grid points), 106 levels
- Surface analysis at 5.5 km
- Plus 10 ensemble members at 11km
- Will start from 1981

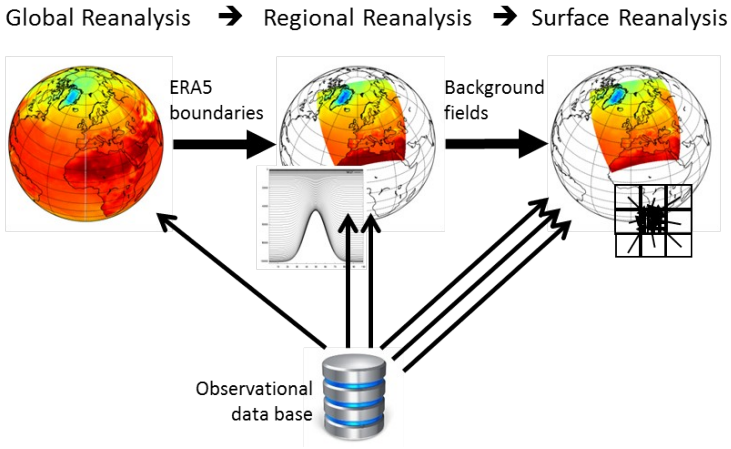
Regional Reanalysis over Europe

C3S_322_Lot1 Copernicus Climate Change Service - Regional Reanalysis for Europe



- 5.5 km (1080x1080 grid points)
- 106 vertical levels
- MESCAN surface analysis 5.5 km

- Continue the RRA from the FP7 UERRA project in near real time
- Deliver a RRA for Europe with an enhanced system from the early 80's (available via CDS)
- A small ensemble with 10 members at lower resolution
- A comprehensive set of output parameters, ECVs, upper air, surface and soil
- Collaboration and coordination with other reanalysis activities (e.g. Lot2 and ERA5)
- User guidance and support



Regional Reanalysis over Europe

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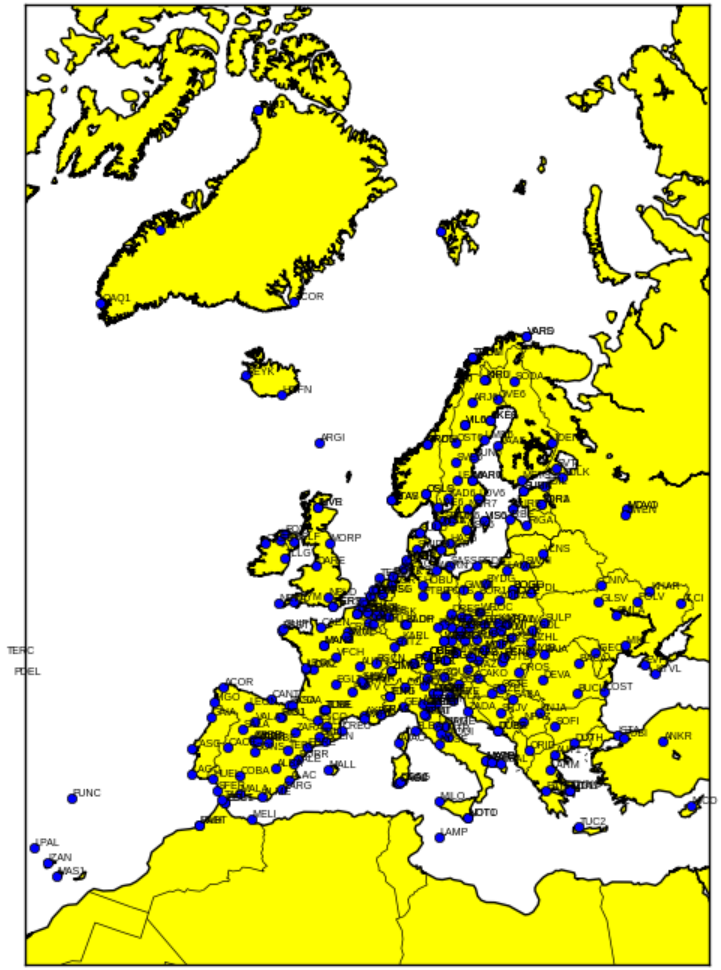
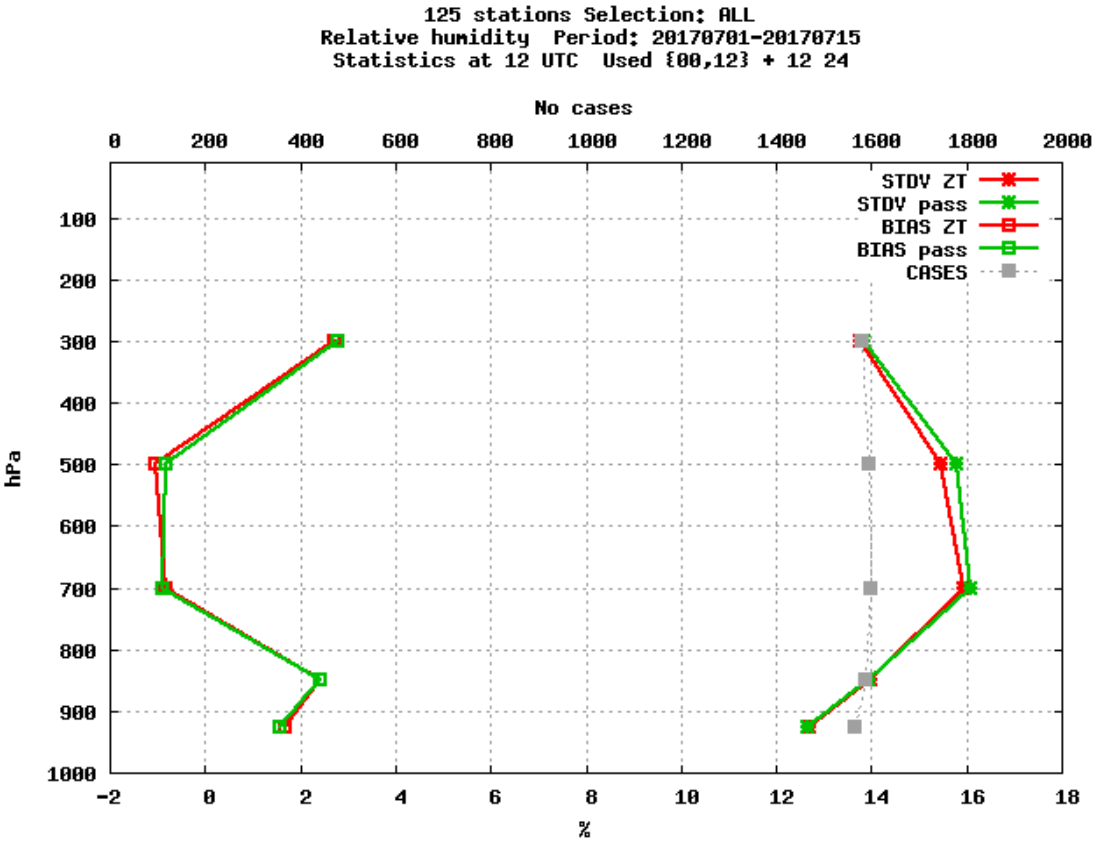
- GNSS ZTD will be included
- Re-processed data from the EPN EUREF Permanent Network will be used
- Data covers the period 1997–2014.
- Operational data 2015–
- 94 station in a white list



Regional Reanalysis over Europe

Verification of relative humidity
July 2017



GBGNSS + AMSU
GBGNSS passive + AMSU

Summary

GNSS ZTD from the NGAA processing centre is used in the MetCoOp operational data assimilation.

- **Wish/plan:**
- **Increase the station density**
- **Introduce slant delays**

Introduce GNSS ZTD in HARMONIE 4D-Var data assimilation.

- **Wish/plan:**
- **Some code cleaning**
- **Get VARBC in shape**

Sub-hourly GNSS ZTD from Swedish stations is used in the preoperational MetCoOp nowcasting.

- **Wish/plan:**
- **Get access to subhourly ZTD from all Nordic countries**

Reprocessed GNSS ZTD is used in the Copernicus regional re-analysis over Europe

- **Wish/plan:**
- **Everything is perfect!**