ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

MetCoOp-Nowcasting (MNWC)

Status and developments

30 March 2023
Tallinn, Estonia

Erik Gregow
Finnish Meteorological Institute (FMI)

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Outline of presentation

Operational status:

- Metcoop-NoWCasting (MNWC)

Developments, on-going and planned:

- Own-cycling and NetAtmo
- High-resolution

	MEPS_prod	MNWC_prod
Model version	Harmonie-Arome cy43h2.1.1	Harmonie-Arome cy43h2.1.1
Operational status	Prod	Prod (04 Oct 2022)
Resolution (horizontal)	2.5 km	2.5 km
Domain	METCOOP25D	METCOOP25D
Forecast cycles	00, 03, 06,… 21 Every 3'rd hour	**00, 01, 02,…. 23** **Every hour**
Use of own-cycling	Yes, first-guess from prev. fc.	**No. First-guess from MEPS fc. (Rapid-refresh, +3..+5h old fc.)**
Forecast length & frequency	+66h lead-time, hourly output	**+12h lead-time, 15 min output**
Output format	Grib2 (Grib1 for SFC hourly)	Grib2 (Grib1 for SFC hourly)
Cut-off observations	1 h 15 min	**25 min**
Available to end-user	~2,5h	**~1h**
Cloud-ingest method	No	**Yes**
GNSS usage	Yes, whole domain hourly	**Yes, Sweden sub-hourly data**
Upper-air assimilation (T2m & RH2m)	No	**Yes**
SFC analysis	Canari	**pySURFEX**

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Main differences between MNWC and MEPS

Shorter cut-off time of observations:

Less observations available as input

Impact on the quality of forecasts

	MEPS (approximate)	**MNWC** (approximate)	**MNWC/MEPS** (approximate)
Soundings	20'000	0	**0-10%**
Surface obs	17'000	6'000	**30-50%**
Drifting bouys	250	90	**30-50%**
Aircraft/ModeS	1'600'000	1'100'000	**60-80%**
Satellite	4'200'000	3’400'000	**60-80%**
Radar	3'600'000	3'500'000	**95-100%**

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Main differences between MNWC and MEPS

<u>Use of pySURFEX (instead of Canari) for the surface analysis and data-assimilation</u>

Use of different Python-tools to process observations and create the surface analysis
- TITAN for quality control
- GridPP to do the optimal interpolation

Verification scores for surface are improved

pySURFEX have the capability to use NetAtmo observations

Expert knowledge within MetCoOp
- pySURFEX developed at the Norwegian Meteorological Institute (Trygve Aspelien)

Main differences between MNWC and MEPS

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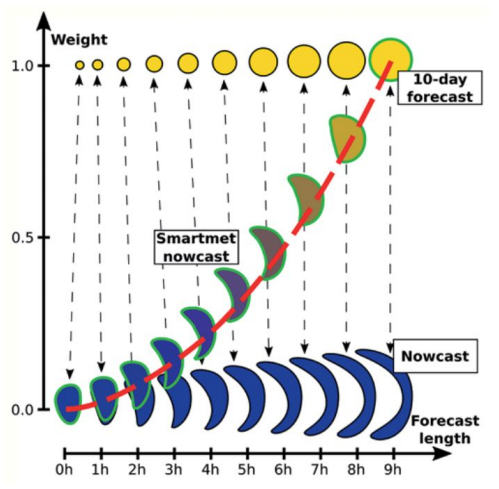
Use of cloud-ingest method

Seamless forecast



Motivation:

Low clouds, fog and precipitation are major problems in forecast models

Aviation, NMHS's and renewable energy sector benefit from better forecasts

Development of seamless forecasts (obs, short-range fc, medium-range fc)

Cloud-ingest method in MNWC model:

Modification to the 3D-humidity of the analyzed fields:

Affects the cloud and precipitation pattern to become more realistic

Cloud-ingest process uses:

Satellite products (NWCSAF); cloud-fraction and cloud-top temperature

Cloud-base from Synop observations and first-guess field from previous MNWC forecast (GridPP)

Cloud-ingest method in MNWC

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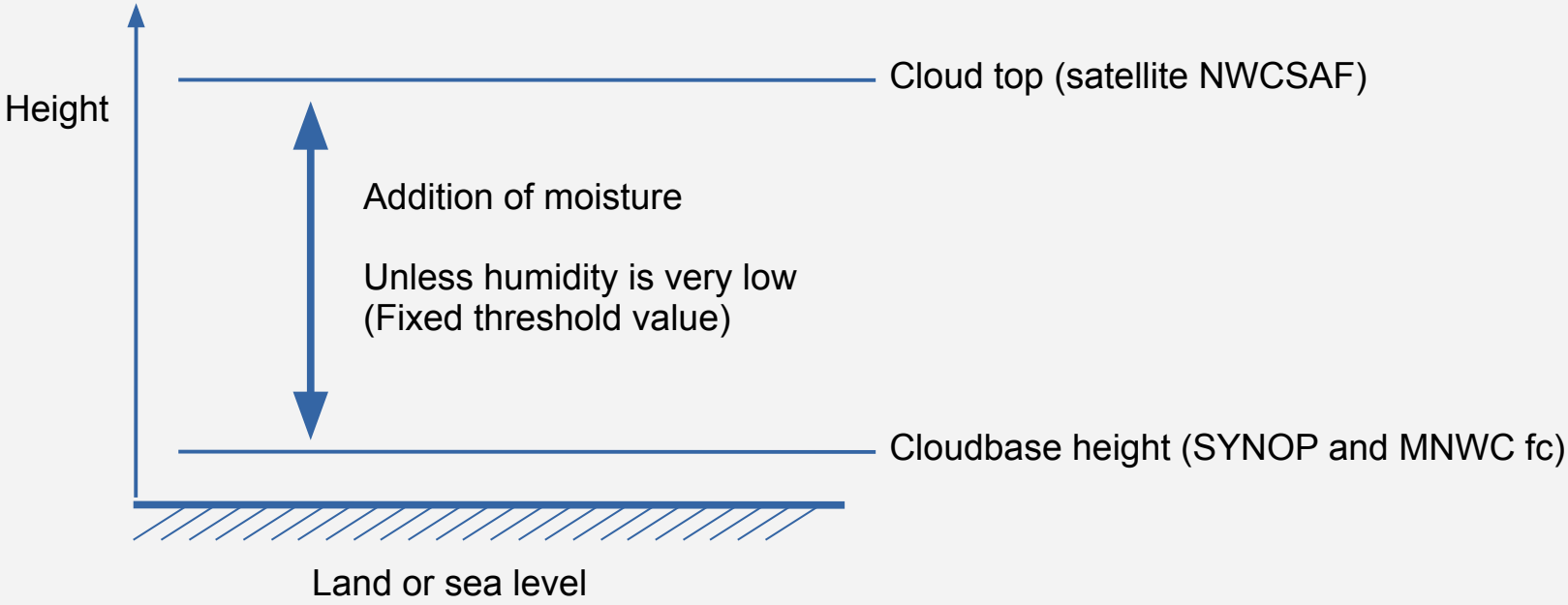
1. Satellite observe clouds but the model has no clouds



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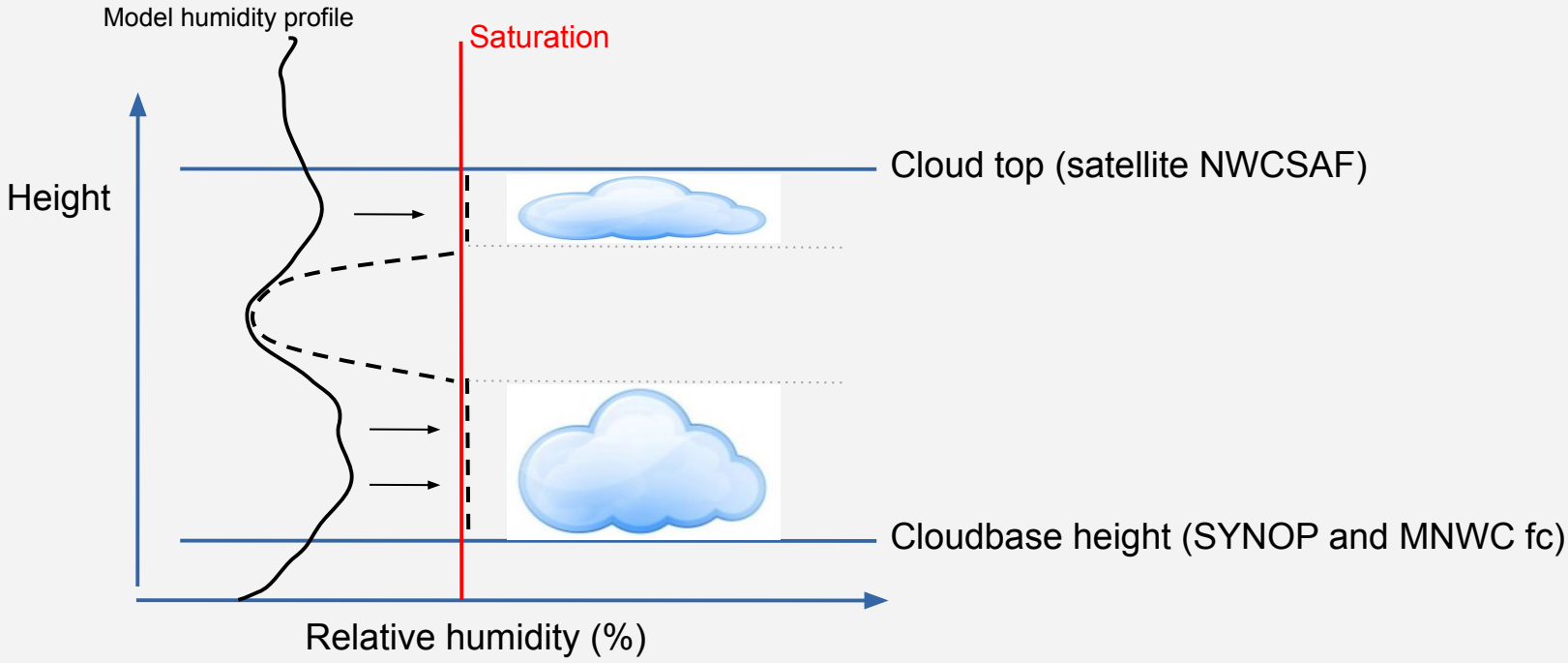

Cloud-ingest method in MNWC

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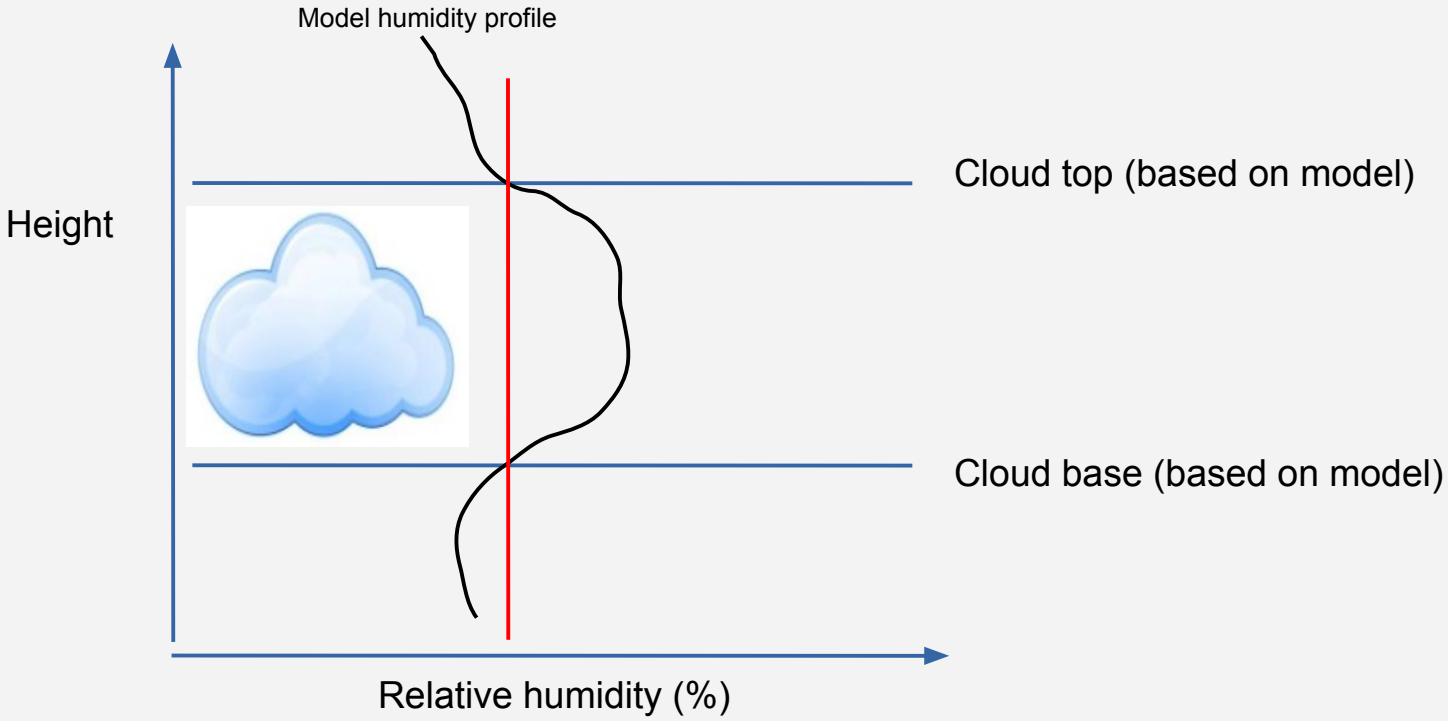
2. Satellite observe clear sky but model has clouds



Cloud-ingest method in MNWC

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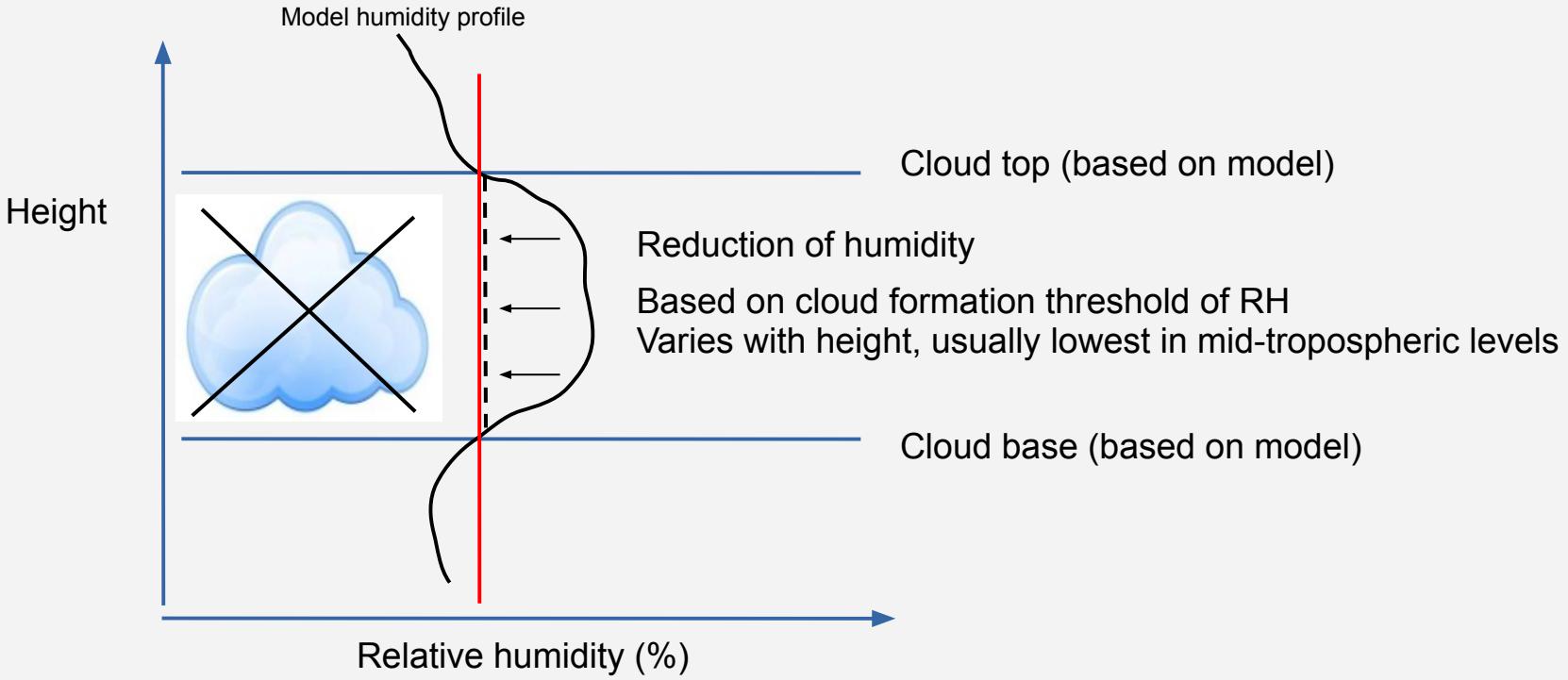

Verification of MNWC vs MEPS

Forecast scores using “same cycles” from models
MNWC_prod is better than **MEPS_prod** for most variables, not all

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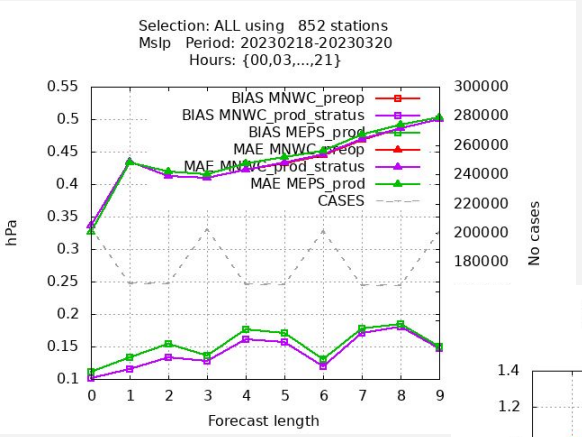
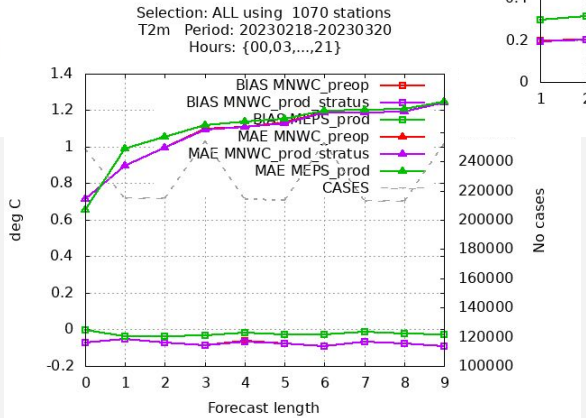
Period: 1 month
18 Feb - 20 Mar 2023

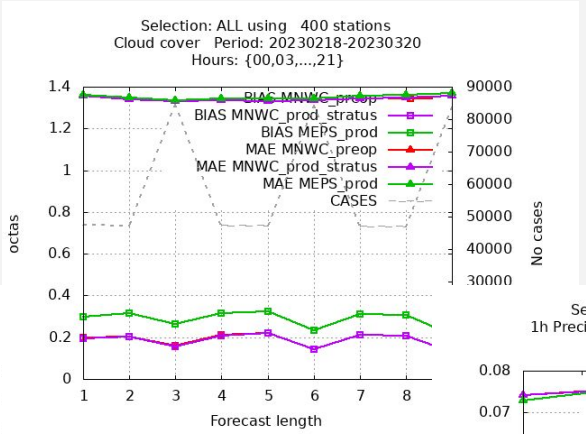
Mean sea-level pressure



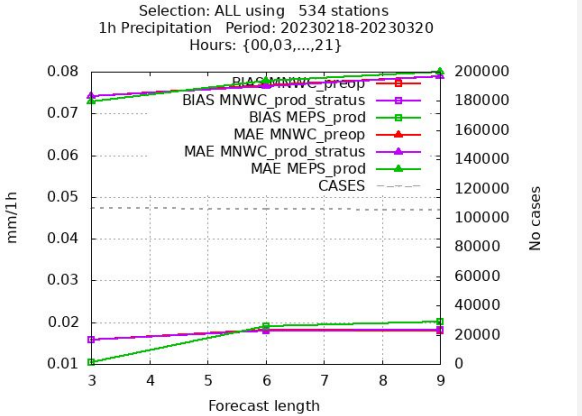
Temperature 2m



Cloud cover



1h-Precipitation

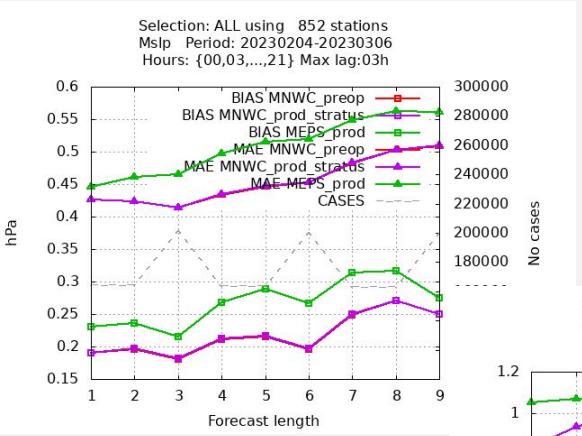


Verification of MNWC vs MEPS

For “lagged” verification MNWC show even better scores
Here **MNWC_prod** is better than **MEPS_prod** for all variables

Period: 1 month
18 Feb - 20 Mar 2023

Mean sea-level pressure



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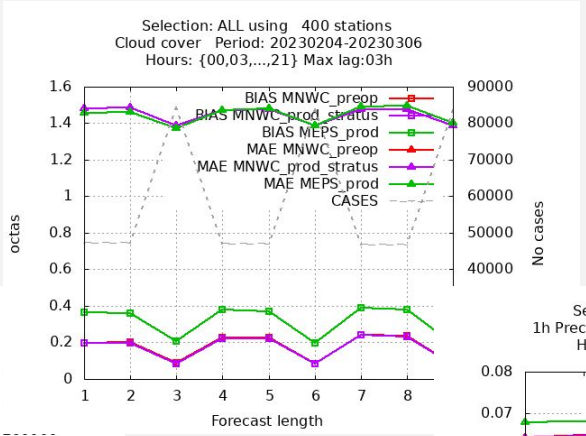

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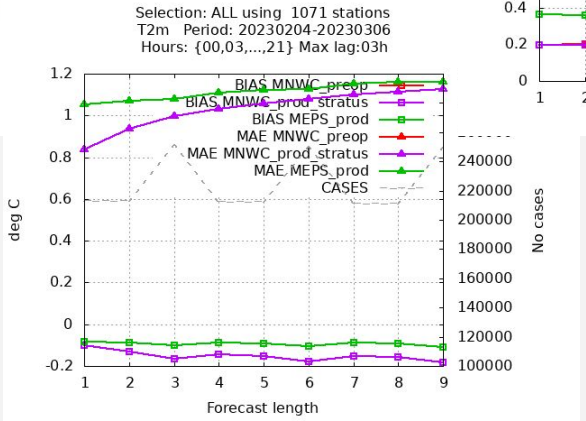

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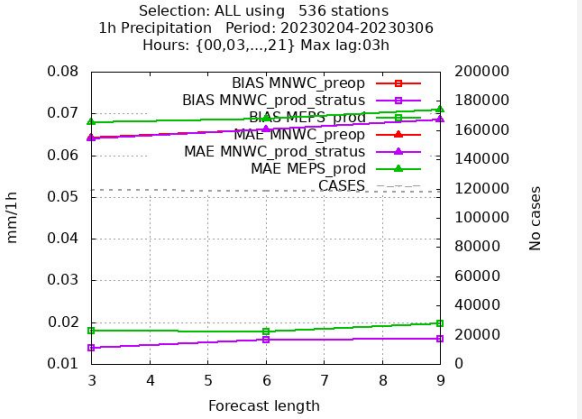

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- High-resolution

MNWC setup with own cycling, both SFC and UA, and use of NetAtmo

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Period: 16-31 Aug 2022 (2 weeks)

Ref1 - MNWC_preop with FG from MEPS

Exp2 - Cycling +1h forecast from previous run. Warm-start

Exp3 - Cycling +3h forecast from previous run. Warm-start

Exp4 - Cycling +3h forecast from previous run. Warm-start. Use NetAtmo: RH2m

Exp5 - Cycling +3h forecast from previous run. Warm-start. Use NetAtmo: RH2m and T2m

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Crash beg of Forecast after 4 days!
SIGFPE; Floating point exception error [**)]
SURFEX soil temperature related input?

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) **In file: src/surfex/SURFEX/mode_thermos.F90 #Line: 182

PPSAT(JJ) = EXP(ZALP(JJ) - ZBETA(JJ)/PT(JJ) - ZGAM(JJ)*LOG(PT(JJ)))

MNWC setup with own cycling, both SFC and UA

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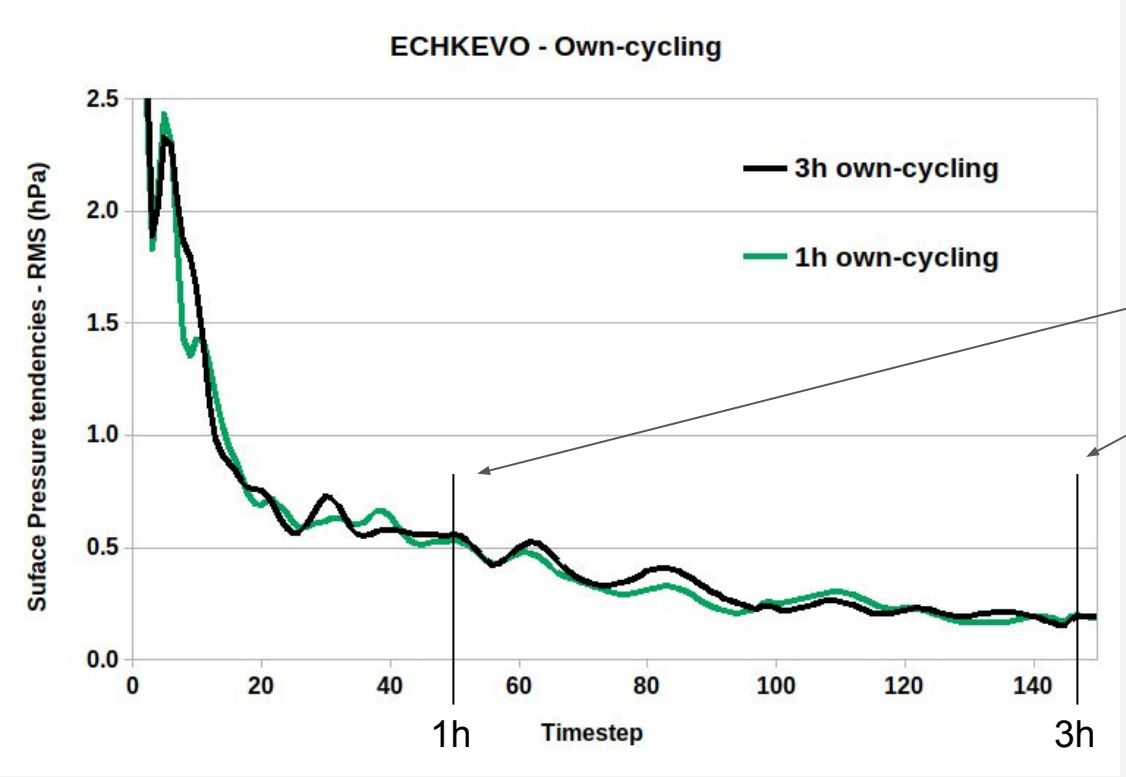
Crash in 1h own-cycling setup, after 4 days

Use **ECHKEVO** tool for 1h and 3h cycling

"ECHKEVO provides diagnostics of the gridpoint evolution during model integration (imbalances in initial state)"



At 1h RMS = **0.5 hPa**

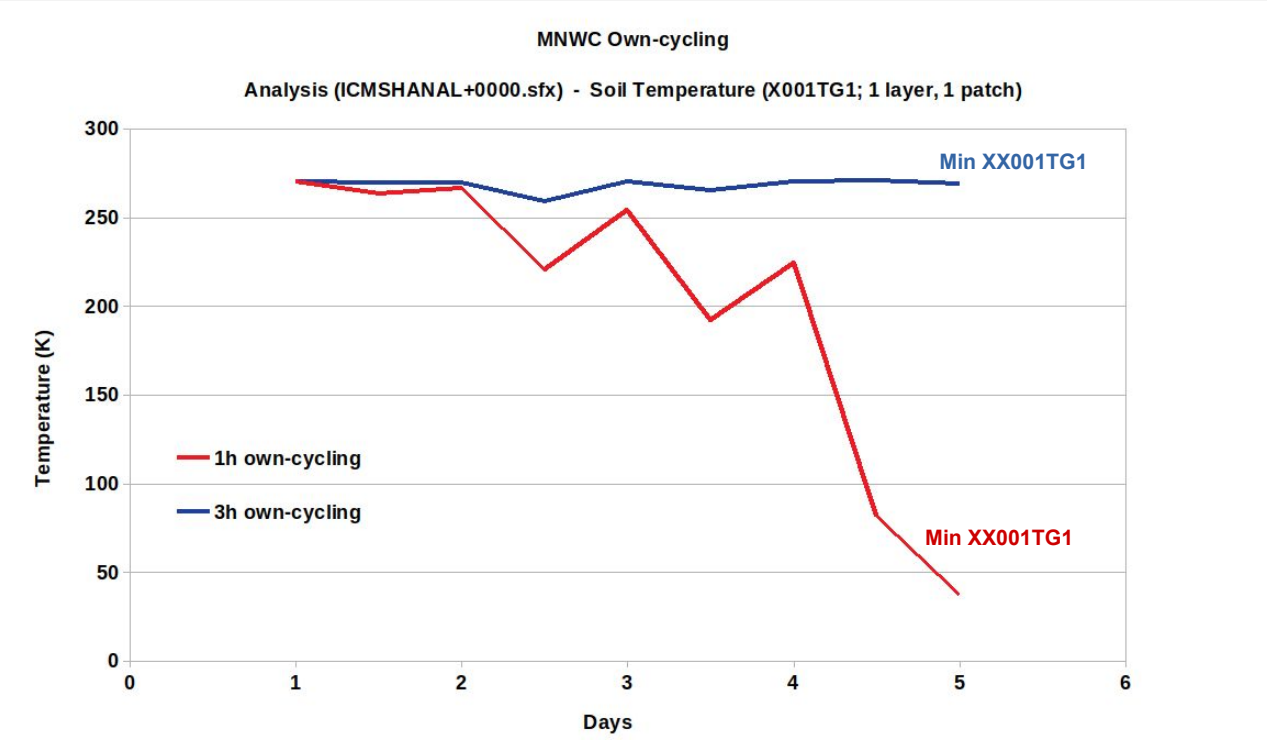
At 3h RMS = **0.25 hPa**

MNWC setup with own cycling, both SFC and UA

Crash in 1h own-cycling setup

Drift in the soil temperature, shown here from analysis file and time-serie

Period: 16 Aug 2022 - 20 Aug 2022 (2 weeks)



Courtesy:
Ekaterina Kurzeneva
David Schönach

MNWC setup with own cycling, both SFC and UA

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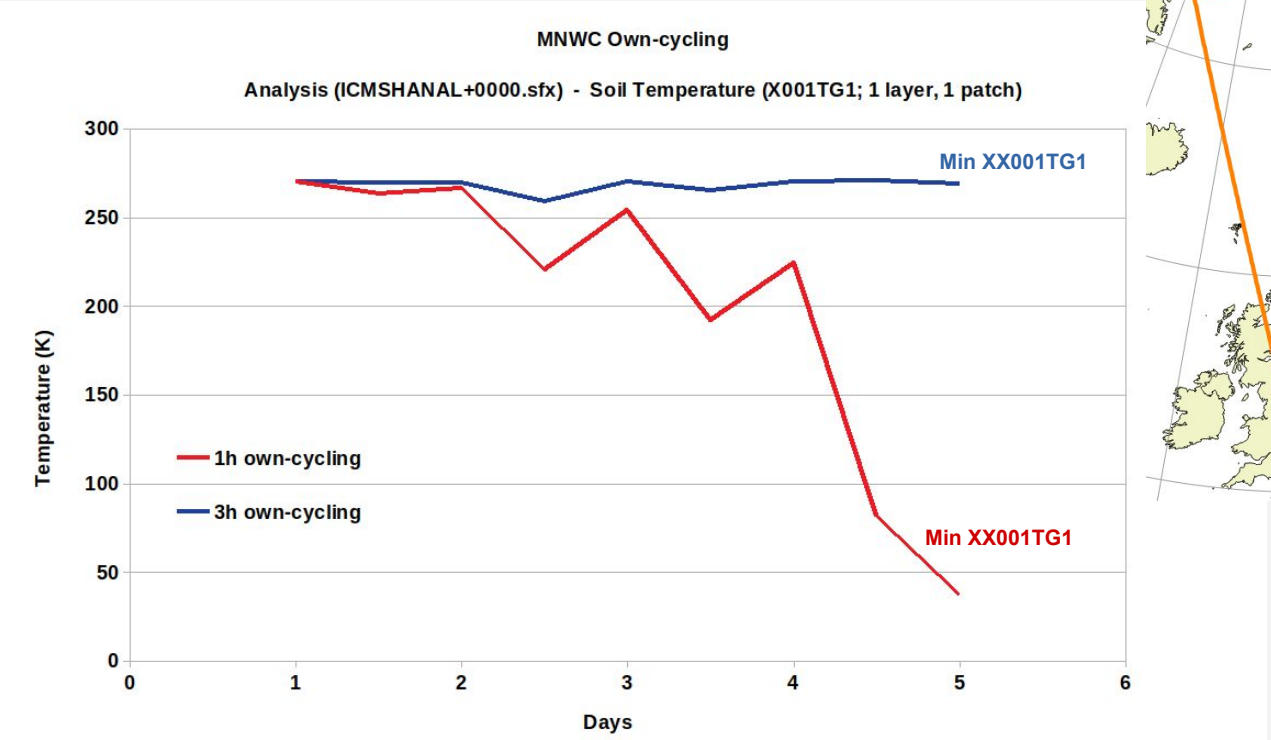

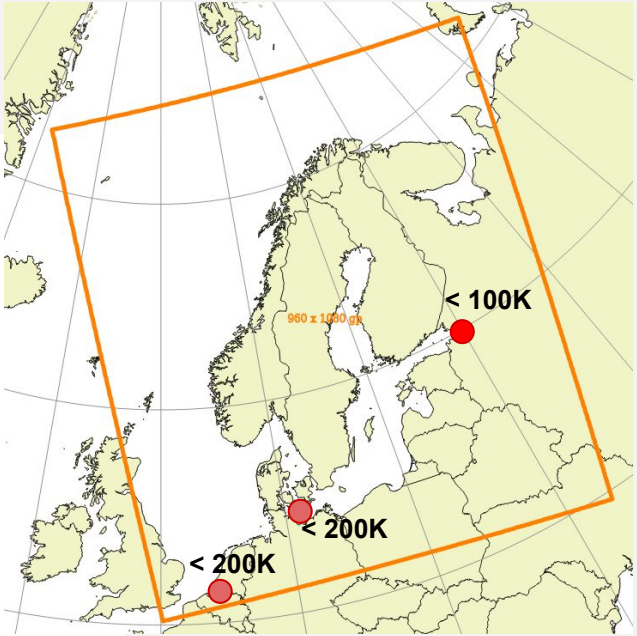

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OK!

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MNWC setup with own cycling, both SFC and UA

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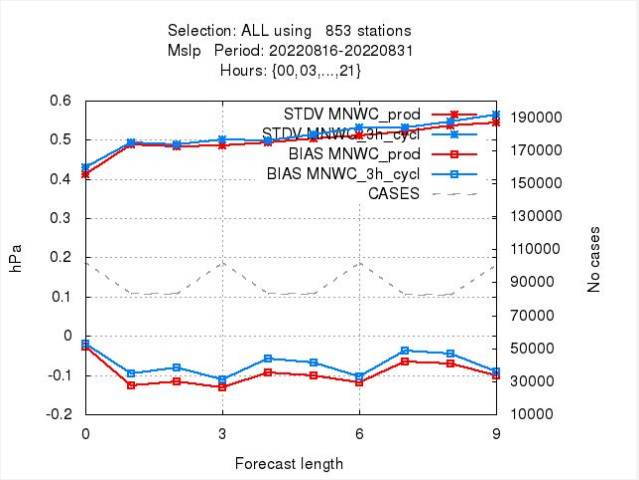
Period: 16-31 Aug 2022 (2 weeks)

MONITOR verification results

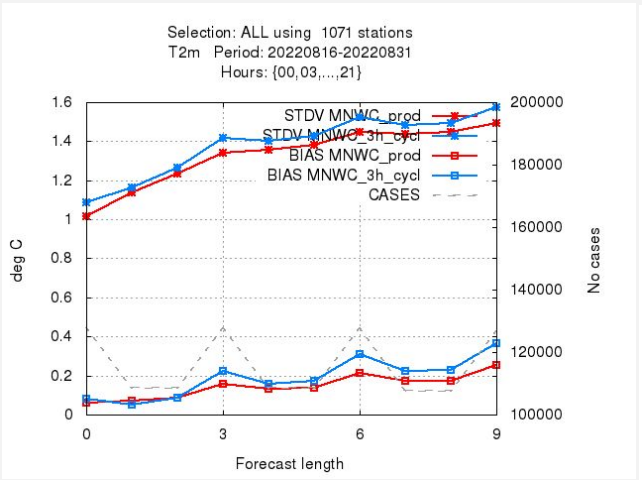
Use of own 3h-cycling gives slightly worse results compared to use of MEPS FirstGuess

Mean sea-level pressure



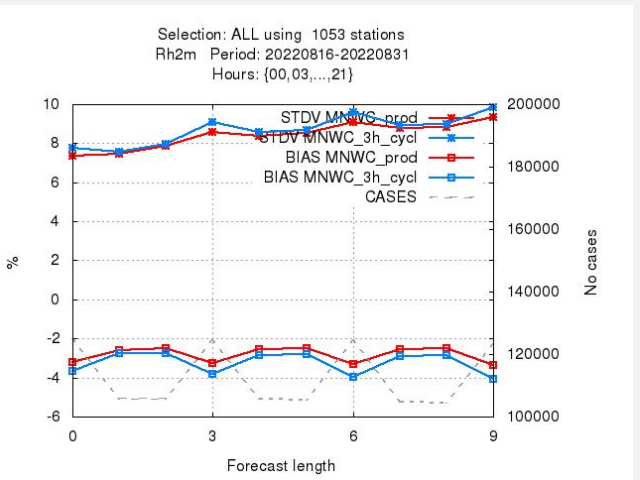
3h-cycling little worse STDV
But slightly better BIAS

Temperature 2m



3h-cycling worse BIAS and STDV

Relative humidity 2m



3h-cycling worse BIAS and STDV

MNWC setup with own cycling, both SFC and UA, and use of NetAtmo

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Conclusions:

- Own-cycling, both UA and SFC:
  - 1h cycling crashes after ~4 days due to spinup (?) in soil temperature
  - ECHKEVO, model dynamics: Less instabilities with 3h own-cycling
  - DDH, model physics: No conclusions yet, TBD
  - Verification scores not improved using 3h own-cycling

- Use of NetAtmo does not improve the scores

Further tests are needed:

- Investigate 1h own-cycling crash
- Impact of cycling SFC and UA fields, individually
- How to improve using NetAtmo

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Mesoscale Convective System (MCS) thunderstorm passing over south of Finland: 12 August 2017

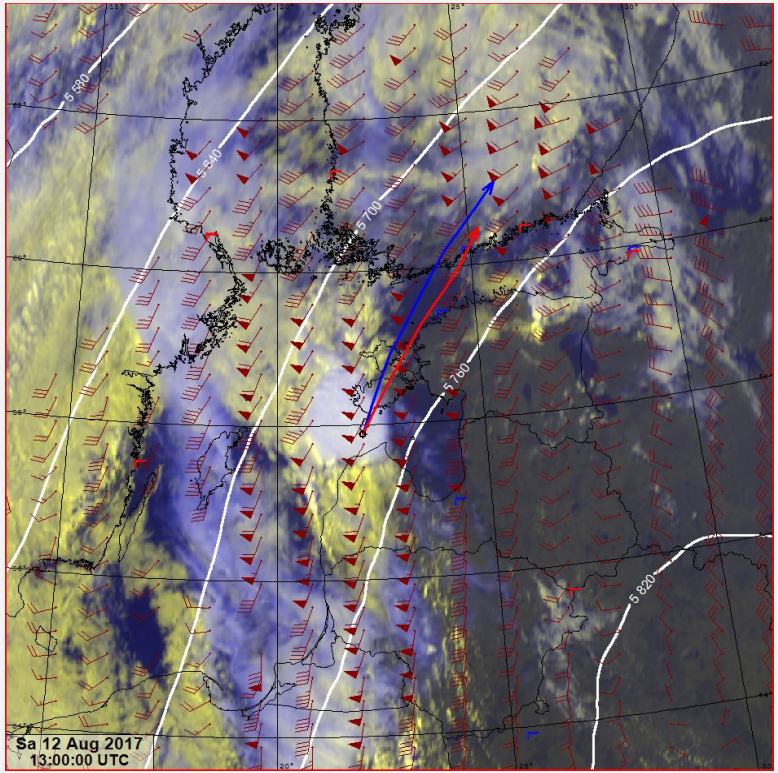
1 000 weather-related tasks for civil protection

50 000 households suffering from electricity disruptions

3 M€ forest damage

33 m/s highest measured wind speed

Several outdoor events interrupted



Storm “Kiira”

Mesoscale Convective System (MCS) thunderstorm passing over south of Fin

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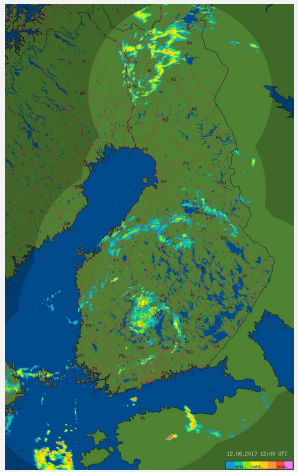
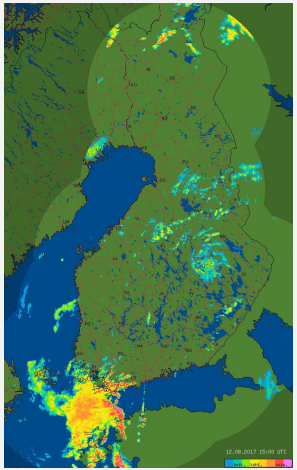
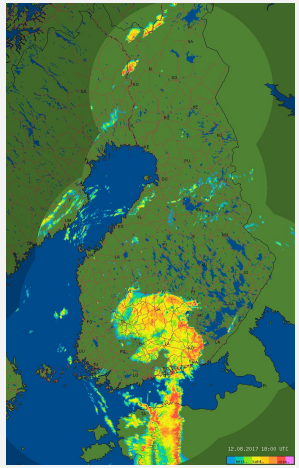
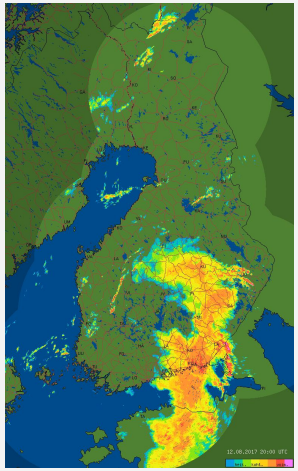
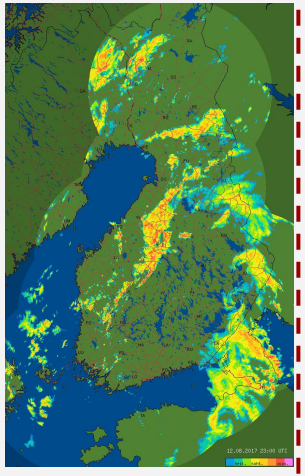
- Radar images, reflectivity (dBz)
- Main event, severe weather, took place **between 15-21Z** on the 12’t of Aug 2017
- Some time-steps of radar imaginary are missing in this section


12 Aug 2017, **12Z**


12 Aug 2017, **15Z**


12 Aug 2017, **18Z**


12 Aug 2017, **20Z**


12 Aug 2017, **23Z**

12h Precipitation accumulation period

Model configurations

HAR* - HARMONIE MetCoOp domain
HAR** - HARMONIE High-resolution domain

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Config	Coupling	Model version	Grid points (Inner nest)	Resolution	TSTEP	BDINT	UA DA	GRID_TYPE	Spinup	Levels
1 Nest	IFS-HAR*	cy43	960x1080	2.5 km	75	1	3DVAR	LINEAR	1 month	65
1 Nest	IFS-HAR*	cy46	960x1080	2.5 km	75	1	3DVAR	LINEAR	1 month	65
1 Nest	IFS-HAR**	cy46	800x720	750 m	30	6	None	CUBIC	10-0 days	90
2 Nest	IFS-HAR* HAR*-HAR**	cy46	500x500, 1500x1500	750 m	20, 30, 40	1, 3, 6	None	CUBIC	5-0 days	90
2 Nest	IFS-HAR* HAR*-HAR**	cy46	500x500, 1500x1500	500 m	30	1, 6	None	CUBIC	0 days	90
3 Nest	IFS-HAR* HAR*-HAR** HAR*-HAR**		1500x1500	200 m	15	1	None	CUBIC	0 days	90

High-resolution: Domains and resolutions

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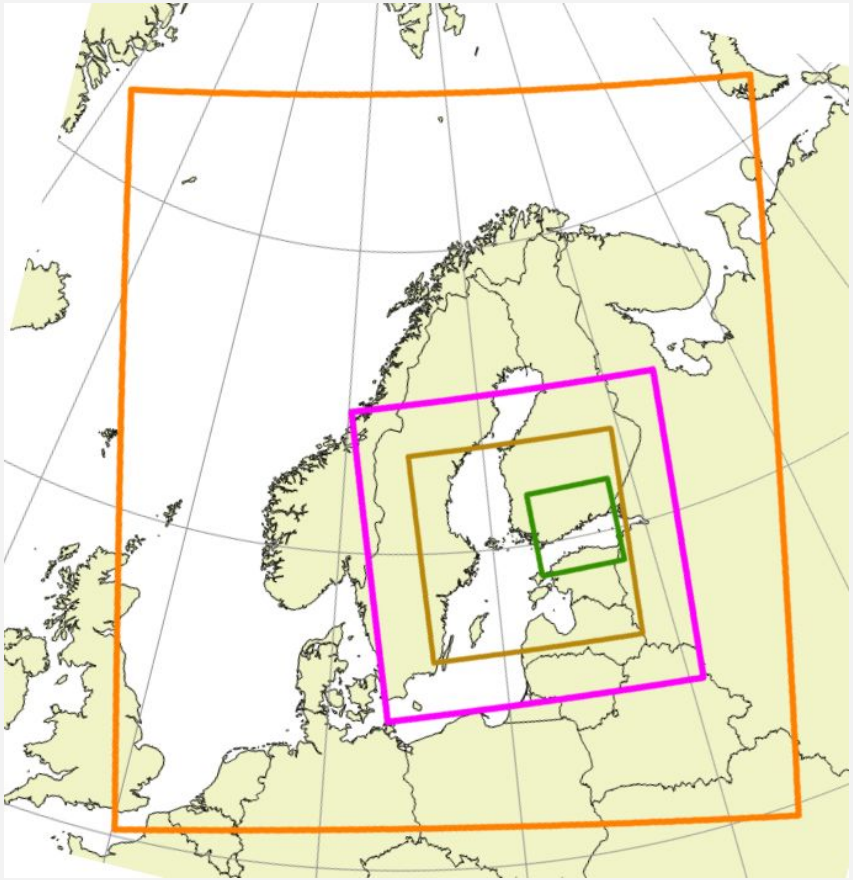

MetCoOp-MEPS domain:
2'500 m, 960x1080 gp

High-res domain 1:
750 m, 1500x1500 gp

High-res domain 2:
500 m, 1500x1500 gp

High-res domain 3:
200 m, 1500x1500 gp

High-resolution: Resolution: 2'500m vs 750m

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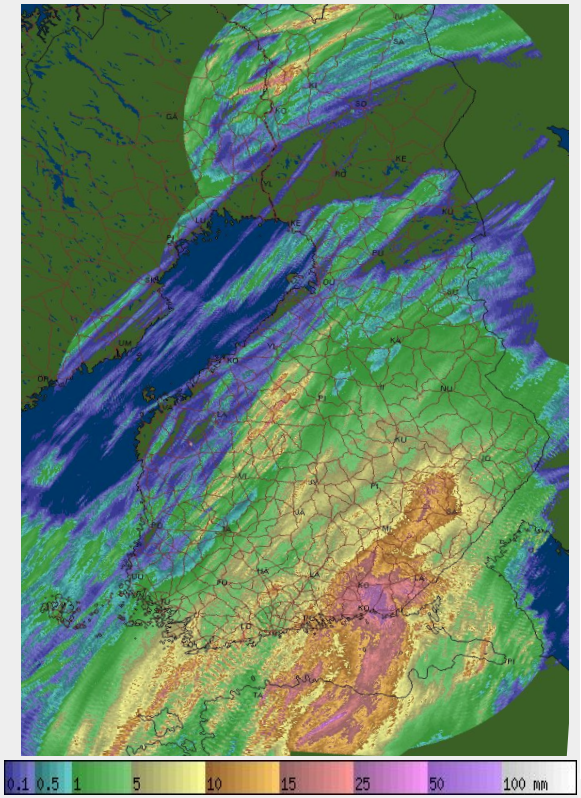
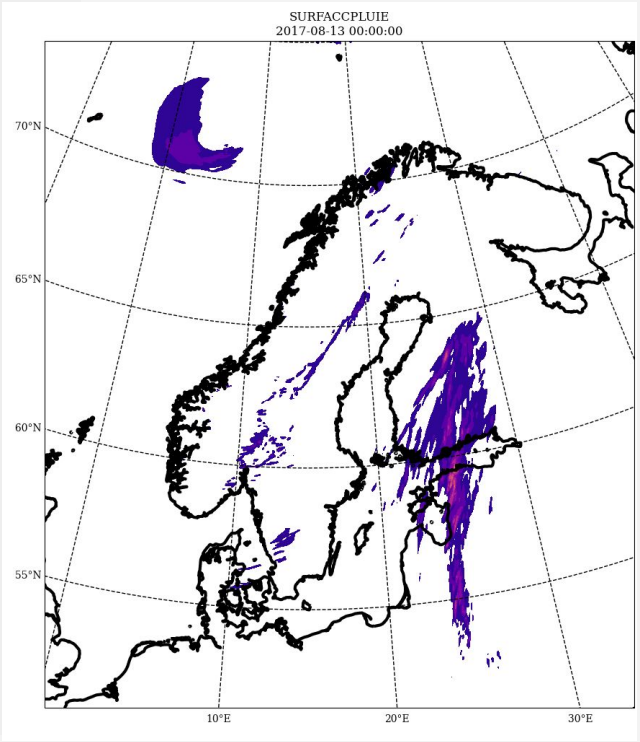
12h accumulation output

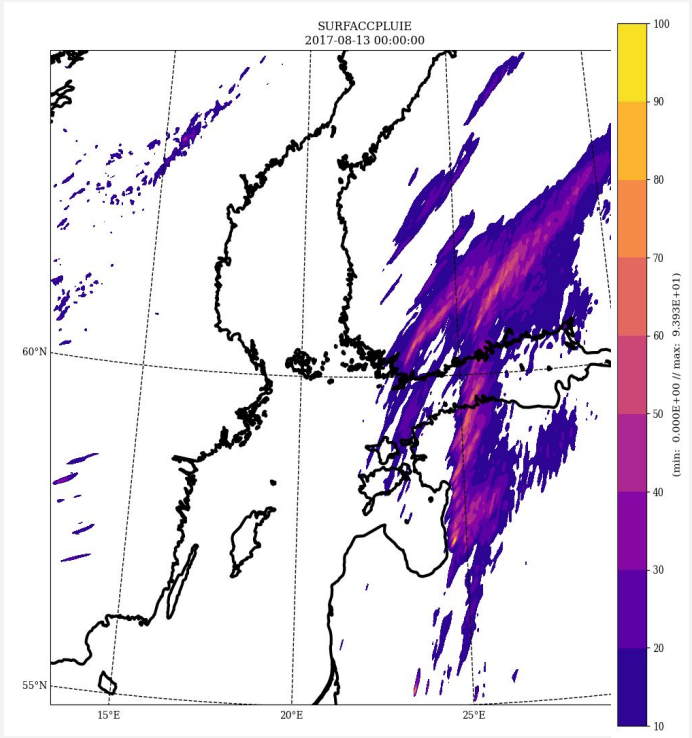
High-resolution improves the precipitation
Though, placement is not optimal



Radar 12h precip accum



2'500 m, 960x1080 gp



750 m, 1500x1500 gp

High-resolution: Cross-section of Temperature with height (m)

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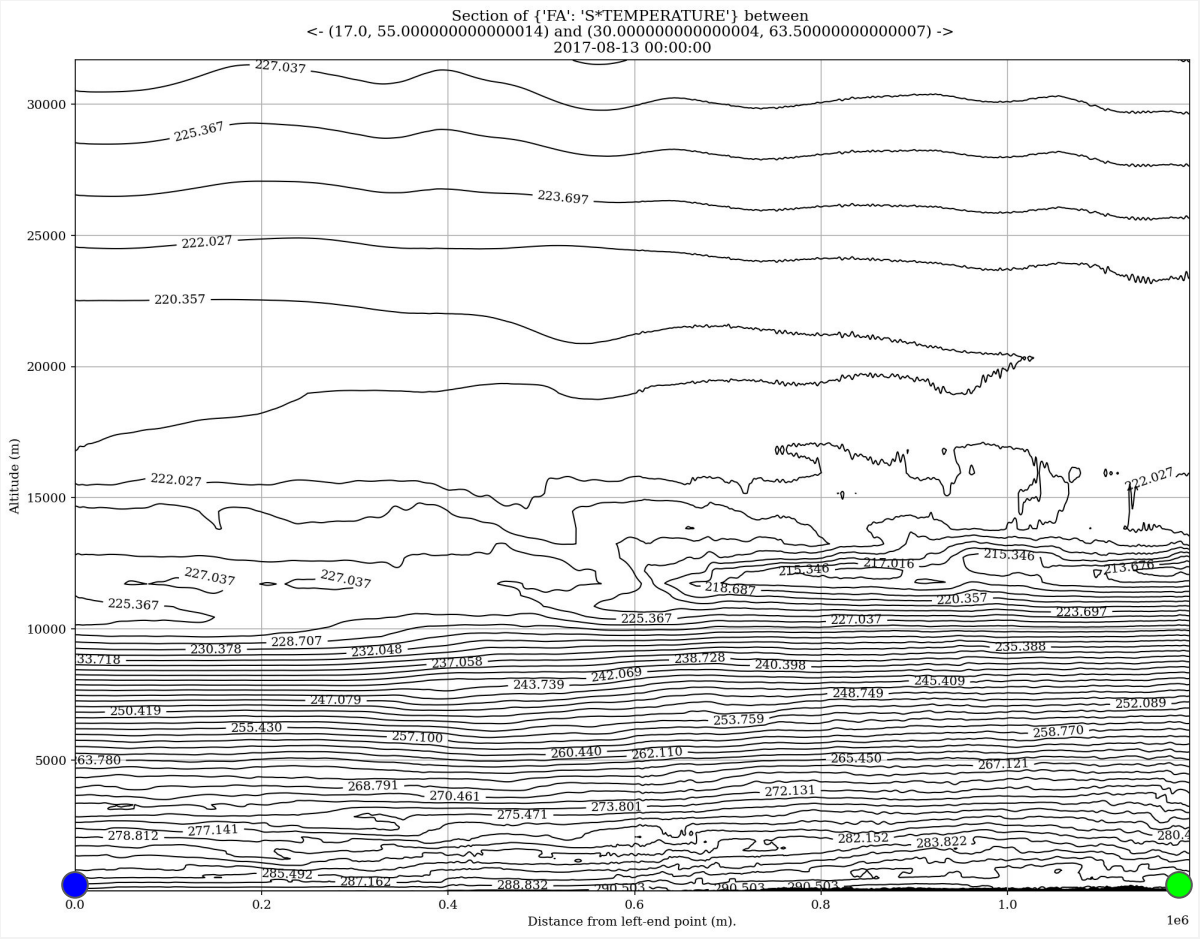
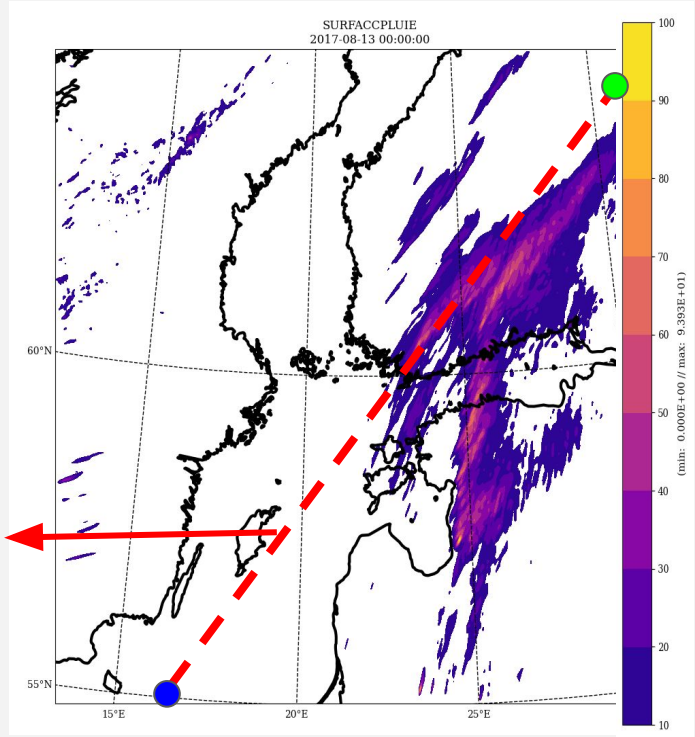


Cross-section along red line



750 m, 1500x1500 gp

High-resolution: Cross-section of Temperature with height (m)

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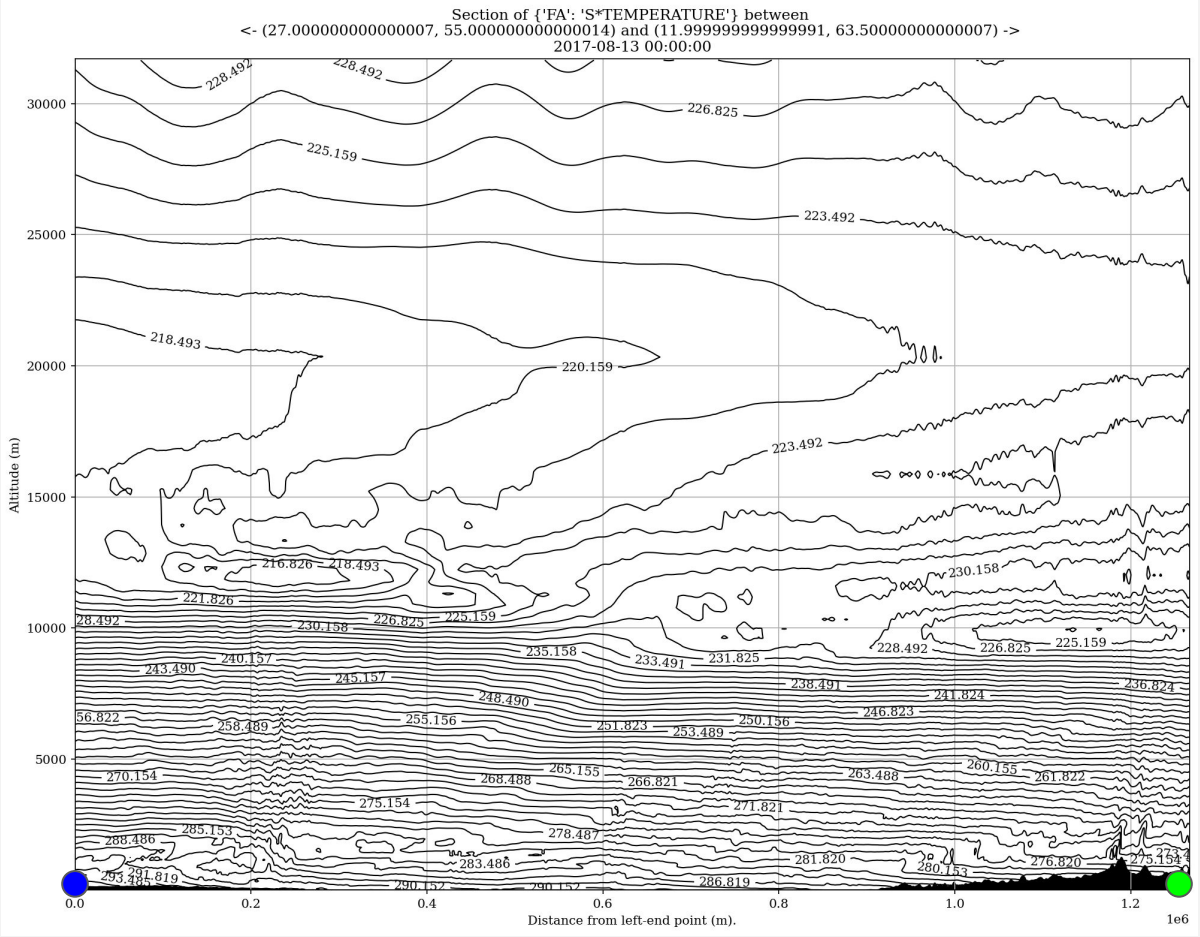
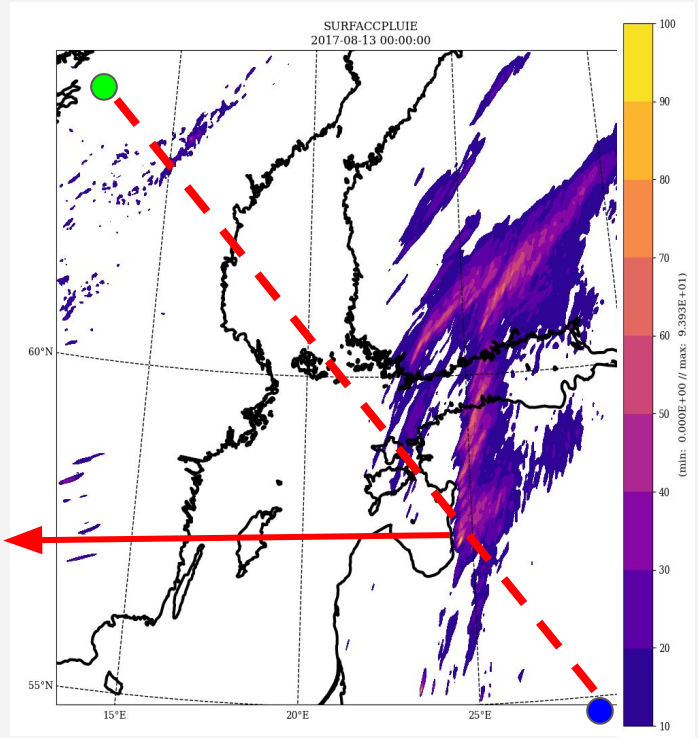


Cross-section along red line

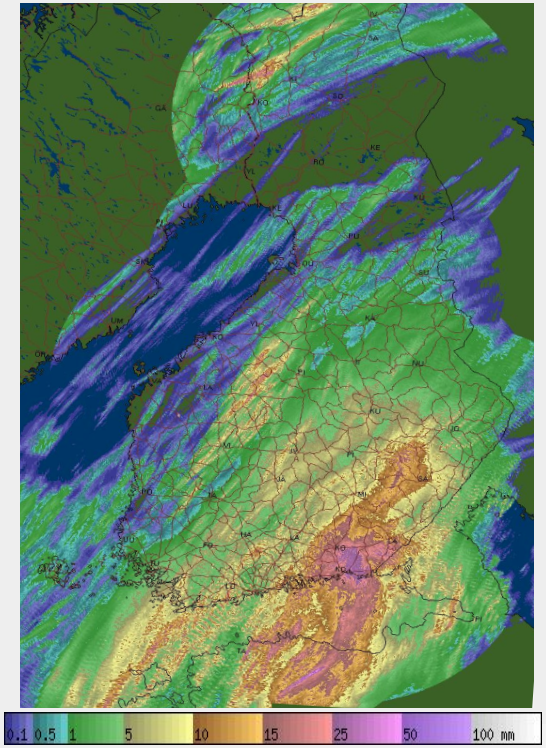


750 m, 1500x1500 gp

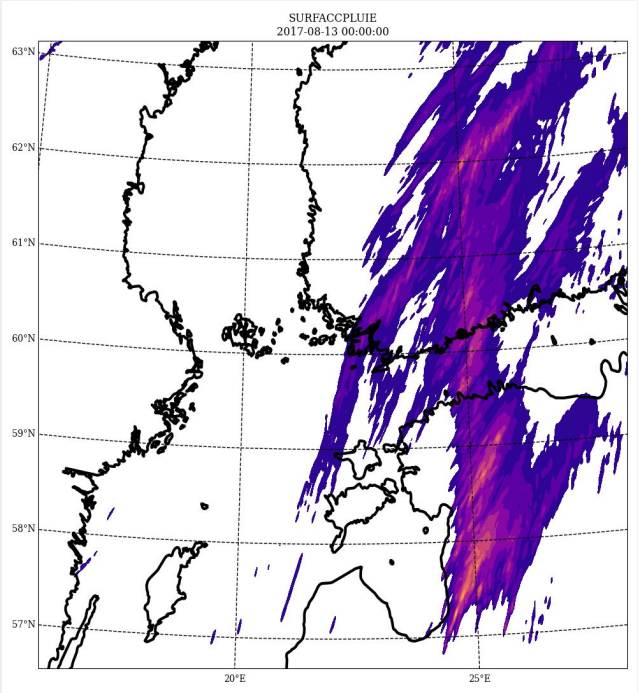
High-resolution: Resolution: 500m vs 200m

12h accumulation output

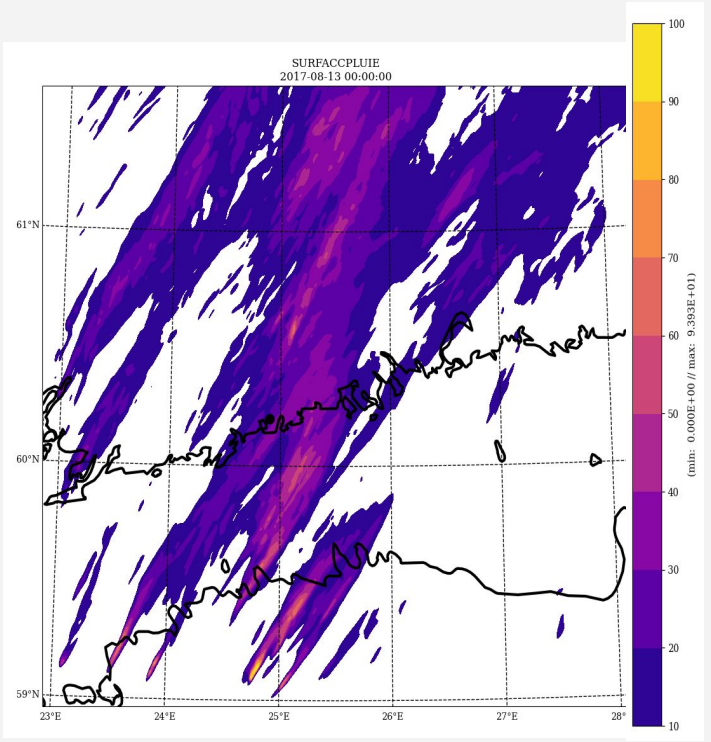
Important to have large enough domain, number of grid-points
Several nested domains better to reach high resolution



Radar 12h precip accum



500 m, 1500x1500 gp



200 m, 1500x1500 gp

High-resolution: Cross-section of Temperature (Kelvin)

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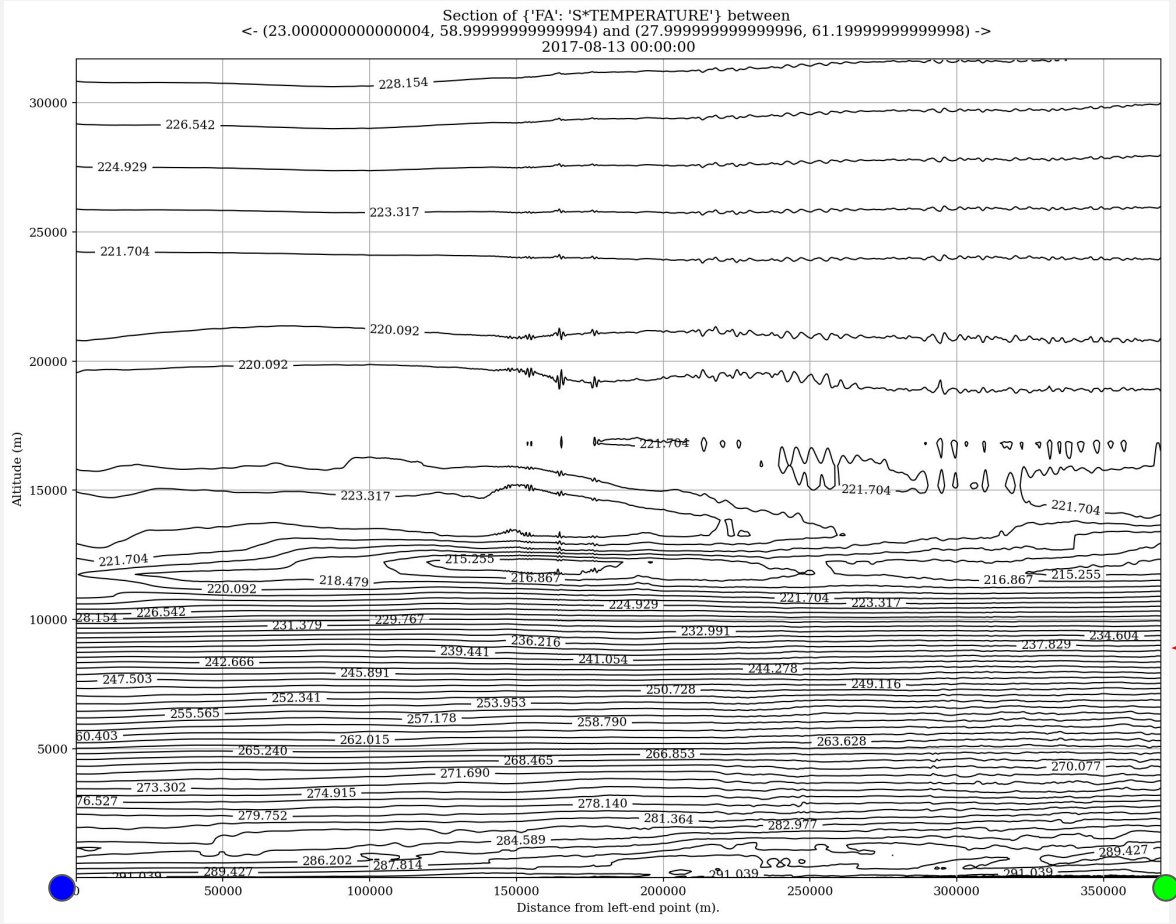
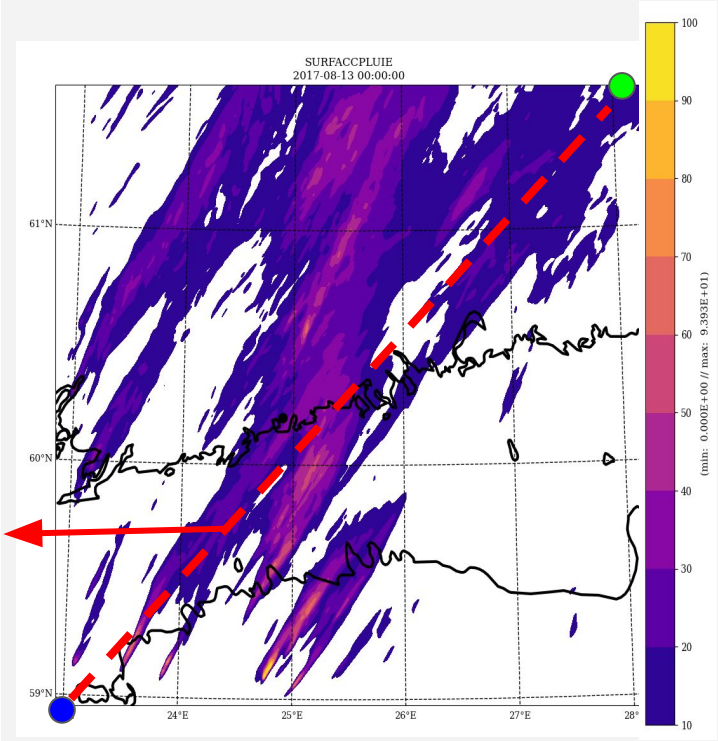


Cross-section along red line
Some noise above troposphere (?)



200 m, 1500x1500 gp

High-resolution: Resolution

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Conclusions:

Nesting within Harmonie (“same forecast”) better option, compared to nesting directly from IFS
- Using “same forecast” potential problem with excessive precipitation accumulation
- The placement of MSC is still controlled by the “host-model”

High resolution (200-750m) improves the accumulation near coastline
- Accumulation pattern also better
- High resolution need a sufficient large domain (grid points)

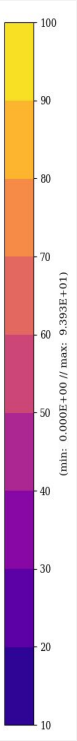
Use of cloud condensates in LBC does improve the precipitation forecast

Use of some days spinup (5-days) does improve the forecast, compared to no spinup (0 days)

TSTEP ranging from 20-40 seconds gave similar outcome (hor. res. 500m)

BDINT=1 gives clearly better result compared to BDINT=3 and 6

No “noise” in upper-air temperature, for high resolution <u>in our domain</u>



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Thank you!