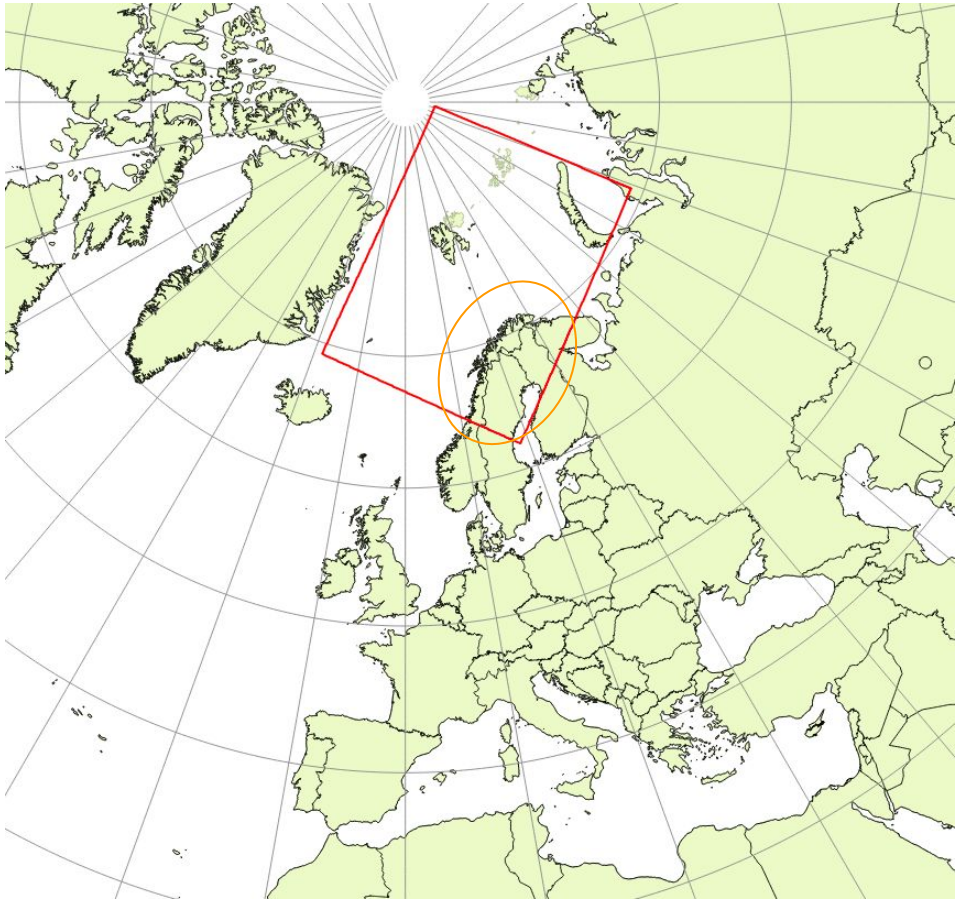
Representation of land surface physics in AROME-Arctic: Utilizing the multi-layer soil, snow and vegetation options

Å. Bakketun, J. Blyverket, P. Samuelsson, M. Müller

AROME-Arctic domain (red rectangle)



- Mainly sea

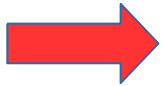
Land surface processes at high latitudes are challenging because of

- snow cover
- snow interacting with vegetation
- polar night with strong inversions
- freeze/thaw of soil water

Multi-Layer surface physics

Force-restore (operational AROME-Arctic setup)

- **ISBA-3L** 3 layer soil (top, root, deep)
- **D95** bulk snow scheme
- **OI** surface analysis



Multi-layer physics

- **ISBA-DIF** 14 layer soil (0.01m, ..., 12m)
- **ISBA-ES** 12 layer explicit snow scheme
- **MEB** Multi Energy Balance for vegetation
- **SEKF** Simplified Extended Kalman Filter for surface analysis (constant **B**)

Model setup

code: git@hirlam.org:users/metno/Harmonie arome_arctic_cy43

multi-layer physics:

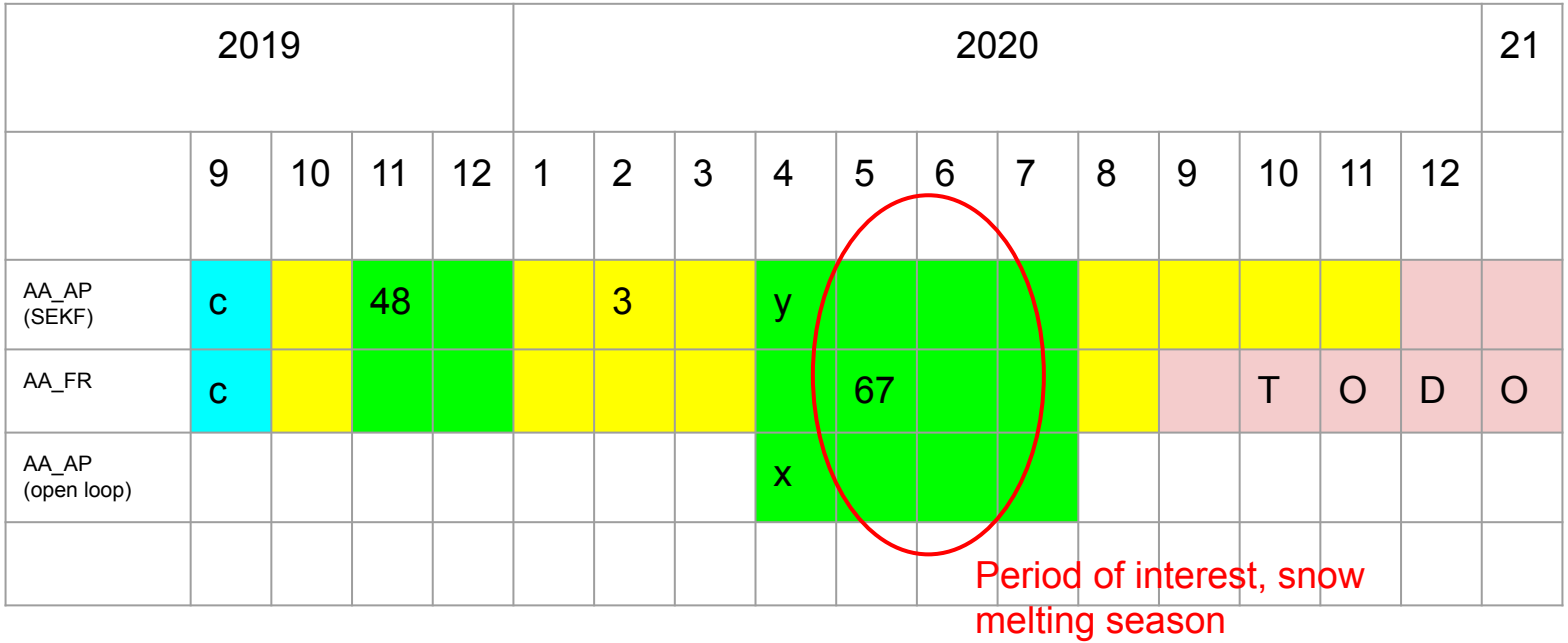
- **ISBA-DIF** (Decharme et al. 2011)
- **ISBA-ES** (Decharme et al. 2016)
- **MEB** (Boone et al. 2017)

surface analysis: SEKF (Bakketun in prep.) (t2m,rh2m -> wg6, ..., wg2, tg2, tg1)

experiment: start at 2019-09-01, 3h cycling for one year. 48-67 hour forecast in validation periods, Dec 2019, April - June 2020 and Dec 2020.

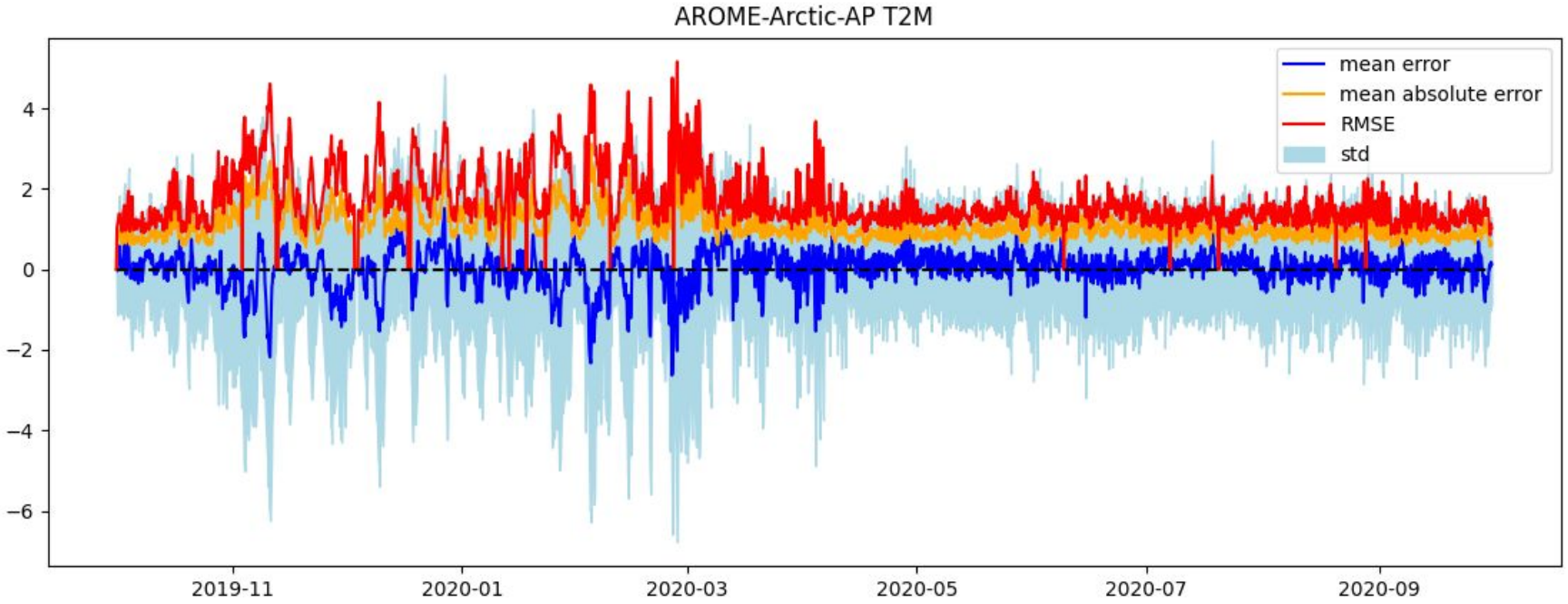
reference: Similar experiment with ISBA-Force Restore (FR), D95, MEB deactivated and OI surface analysis (CANARI)

Experiment timeline

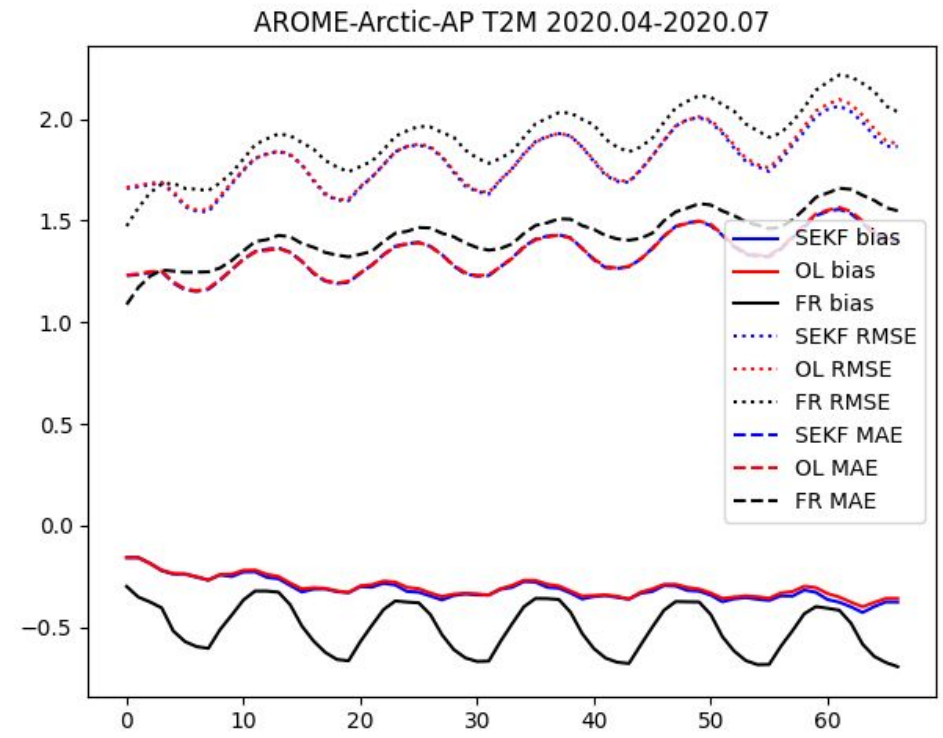


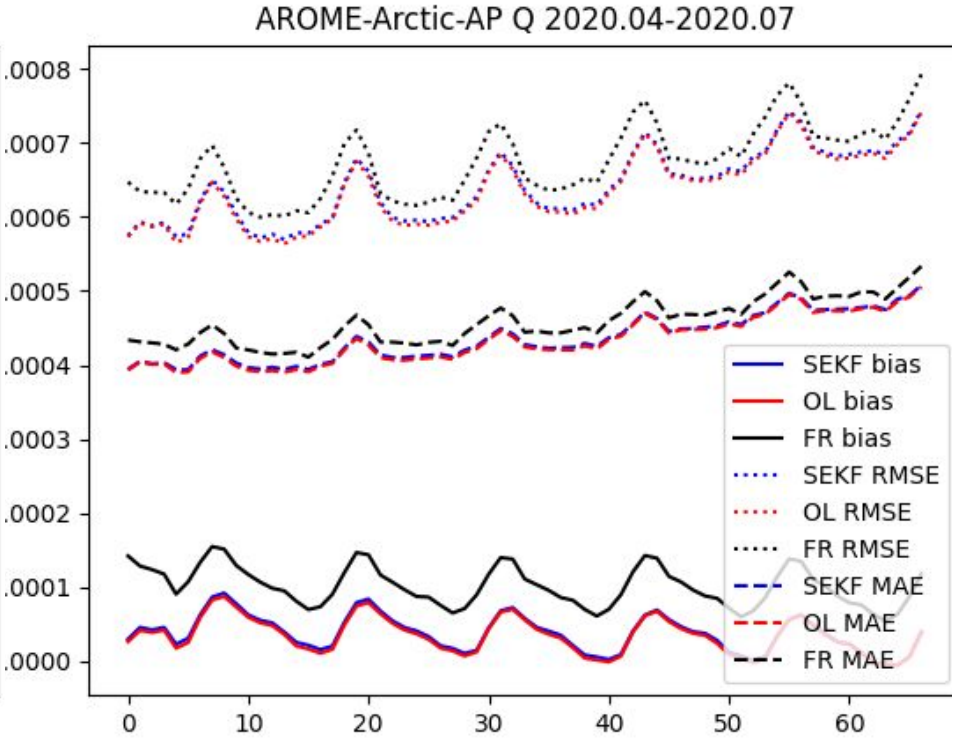
Cold start from IFS, 3h cycling, long forecasts for validation, X initialised from y

All station summary time series +00

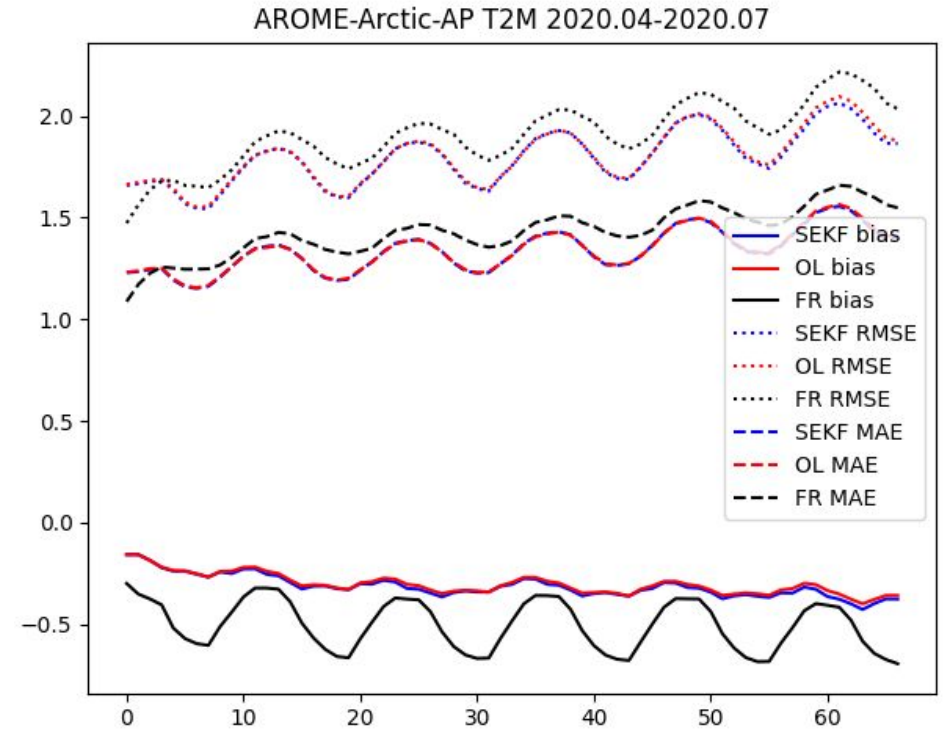


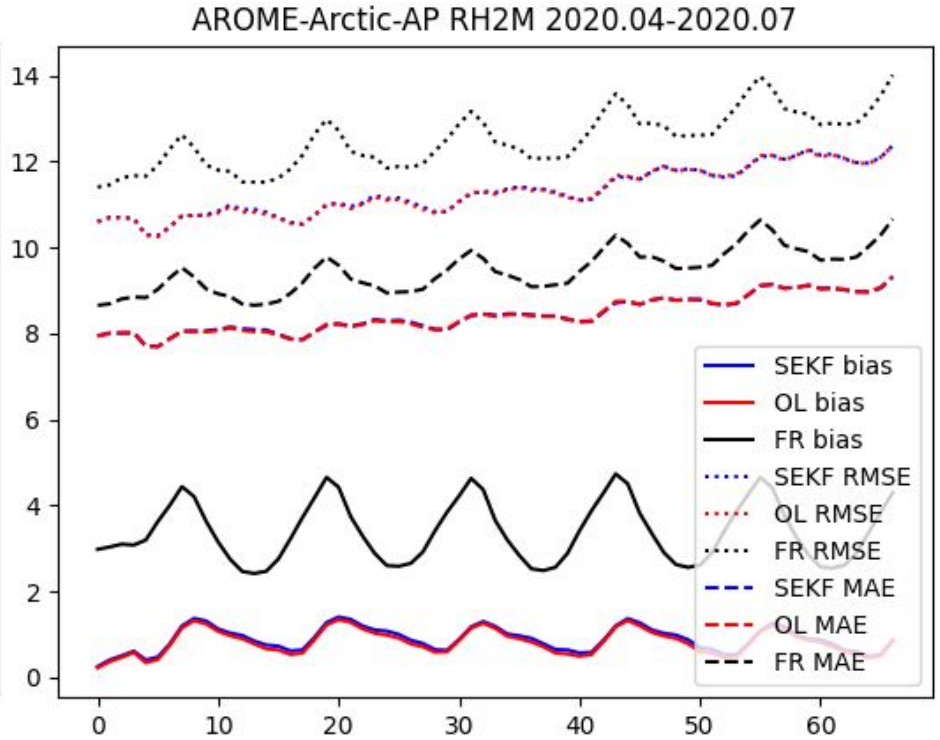
Spring validation period April - July 2020





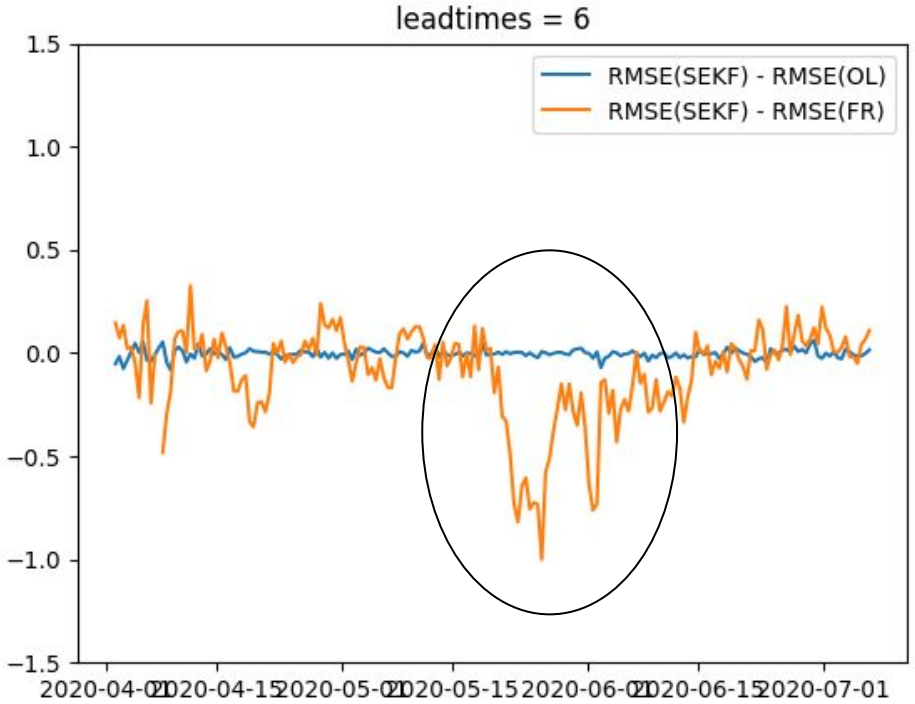
Spring validation period April - July 2020





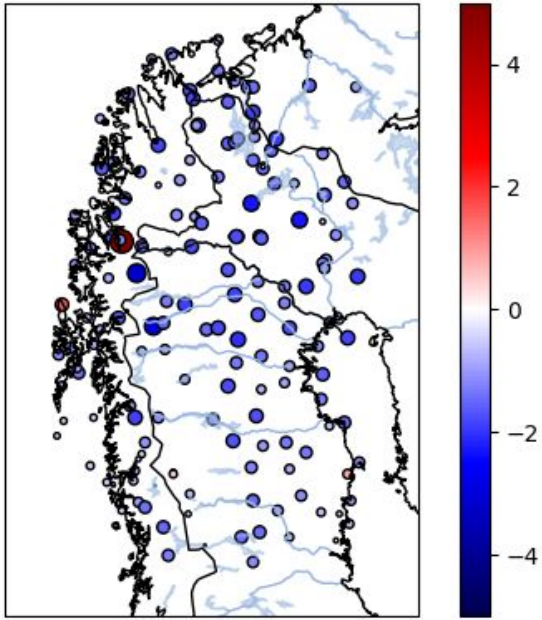
Spring validation period April - July 2020

T2M

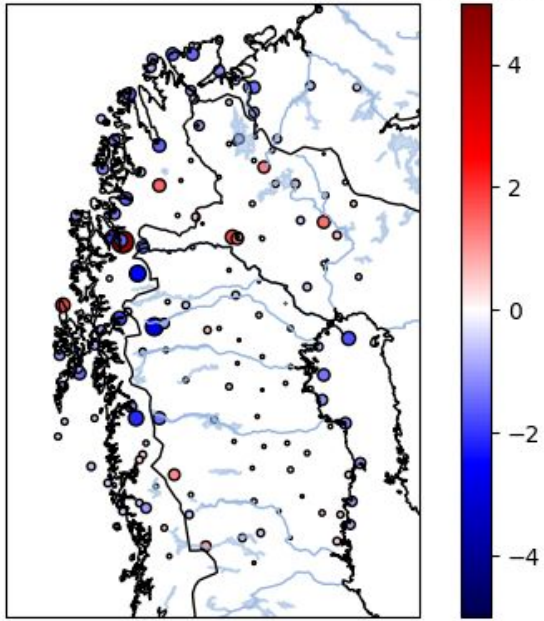


Reference has cold bias at inland stations

AROME-Arctic_FR T2M error 2020.05.16 - 2020.06.06

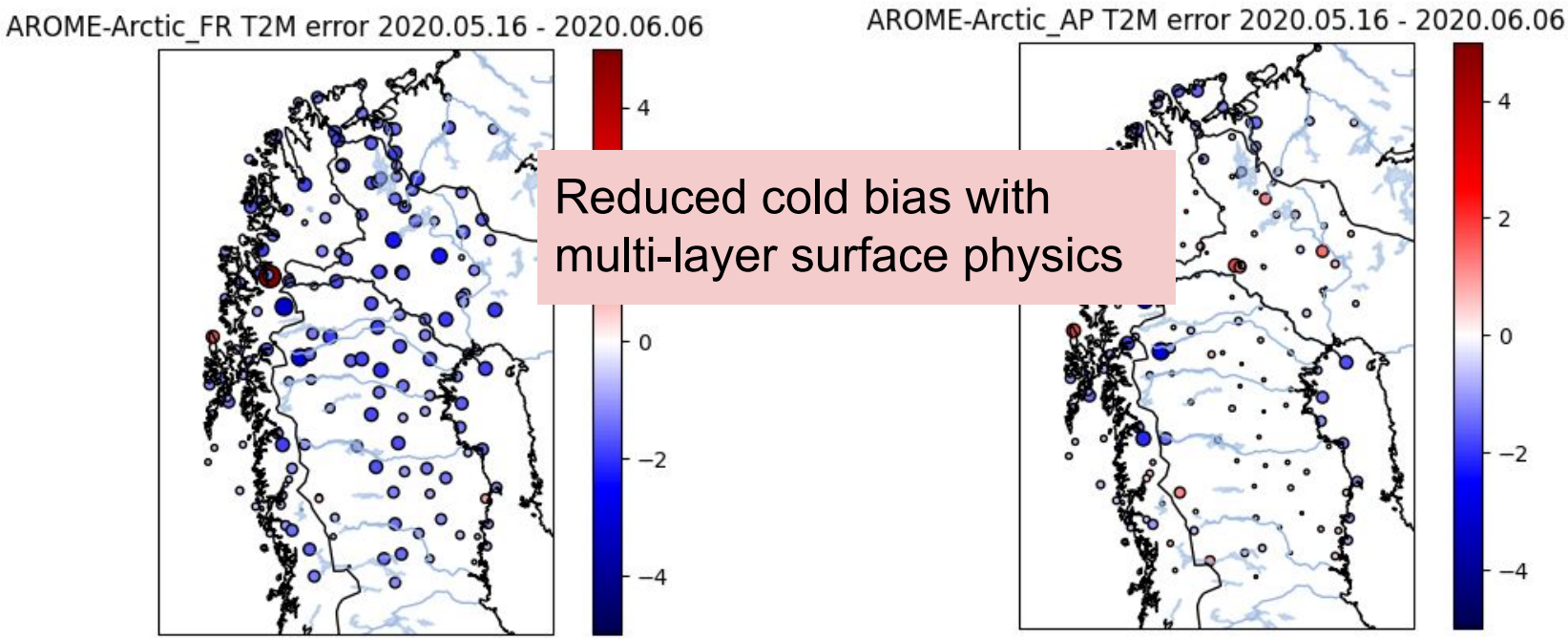


AROME-Arctic_AP T2M error 2020.05.16 - 2020.06.06



Dot size and colour indicate MAE and bias in T2M respectively

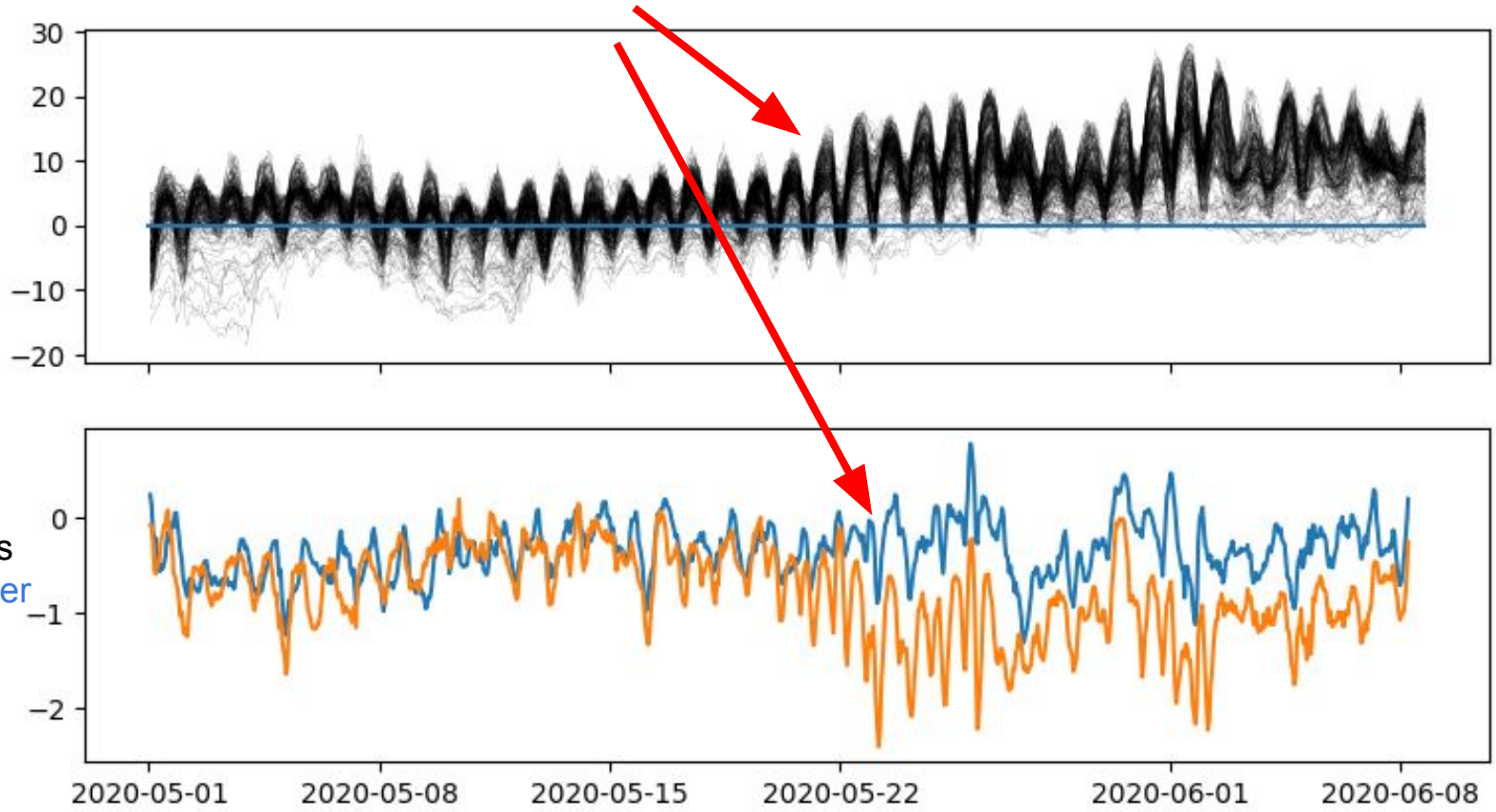
Reference has cold bias at inland stations



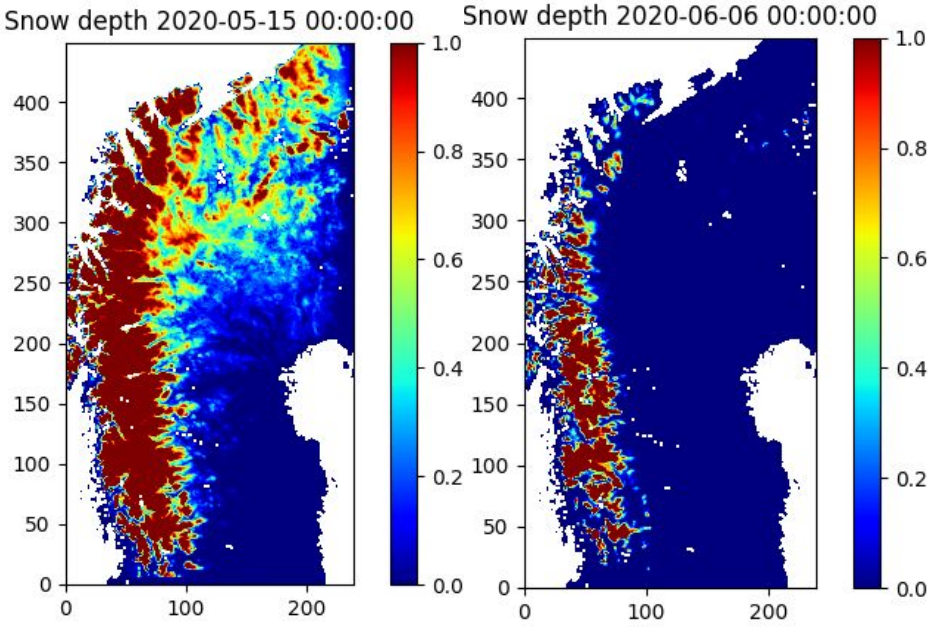
Reduced cold bias with multi-layer surface physics

Dot size and colour indicate MAE and bias in T2M respectively

Reference struggles with warming event

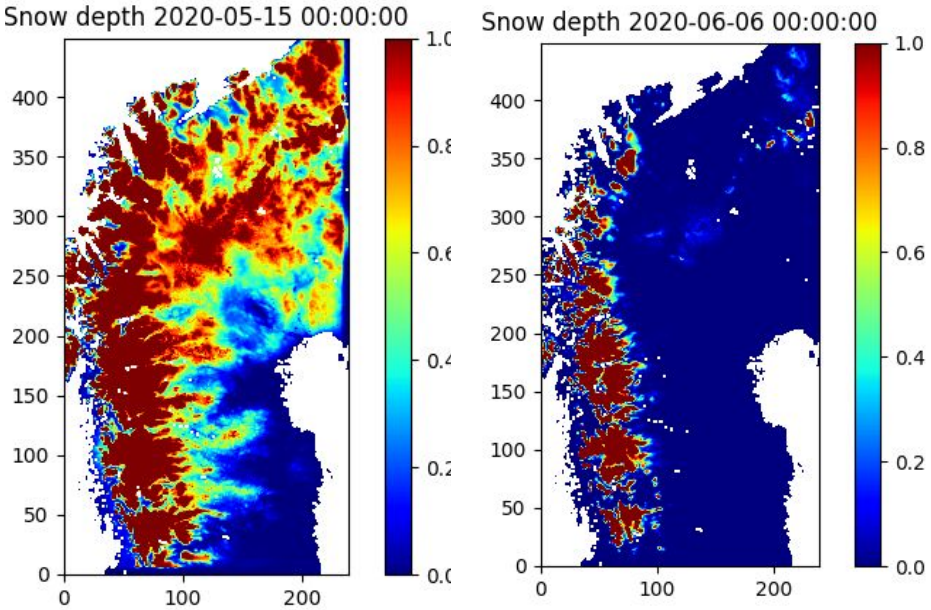


Snow depth



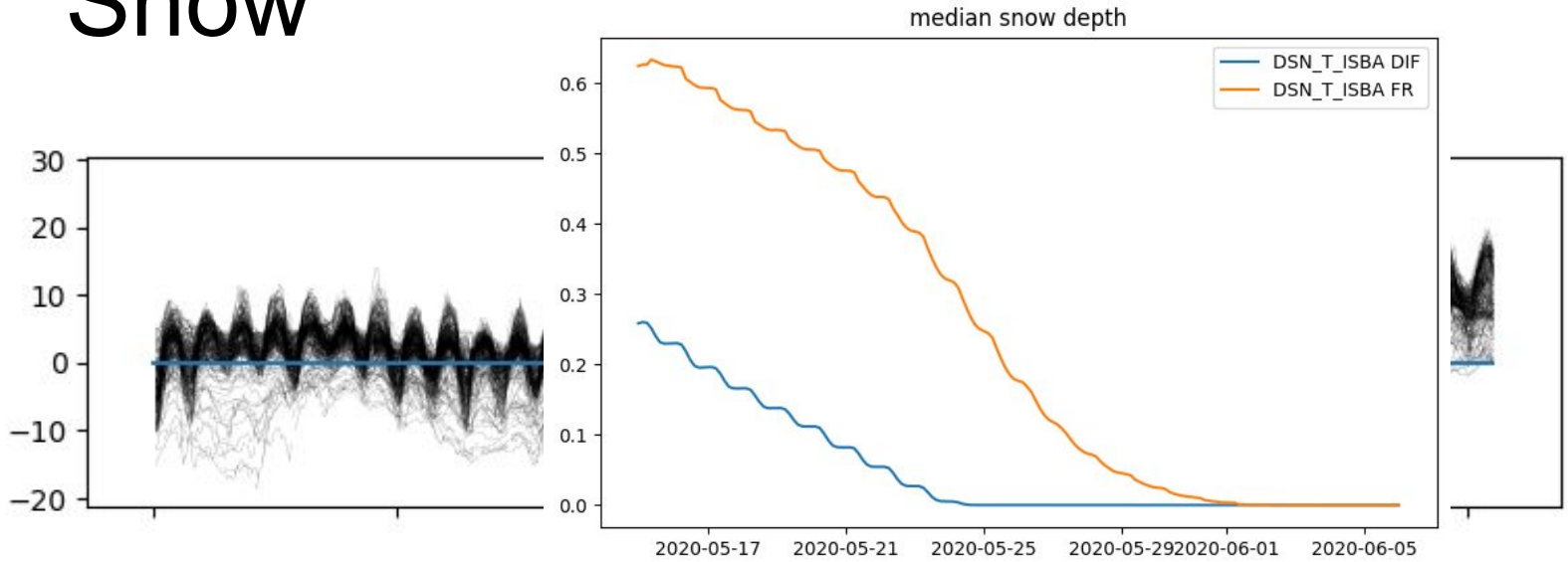
Multi-layer physics

reference

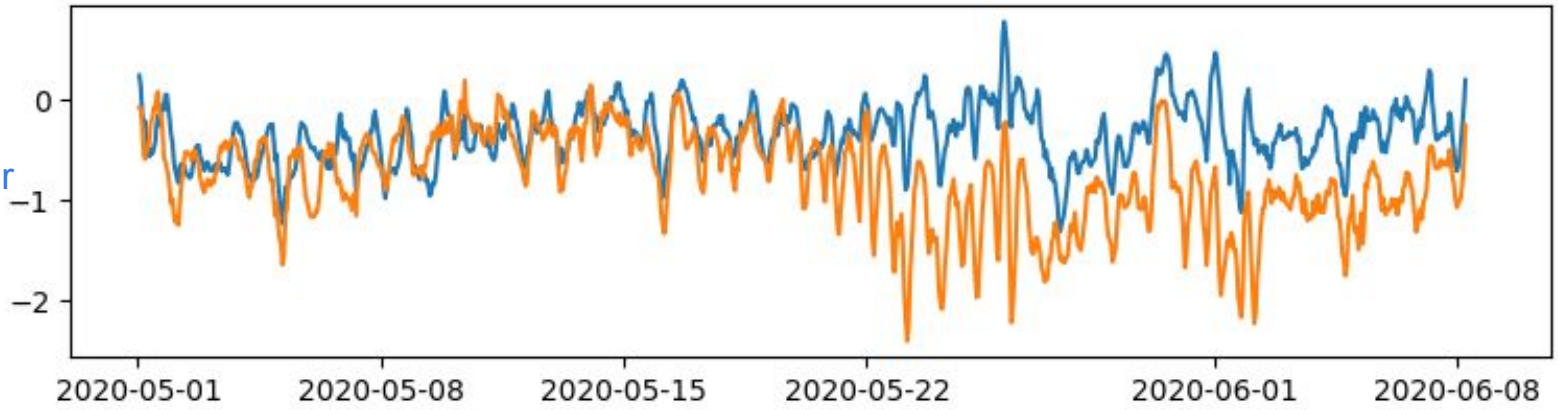


Snow

T2M obs

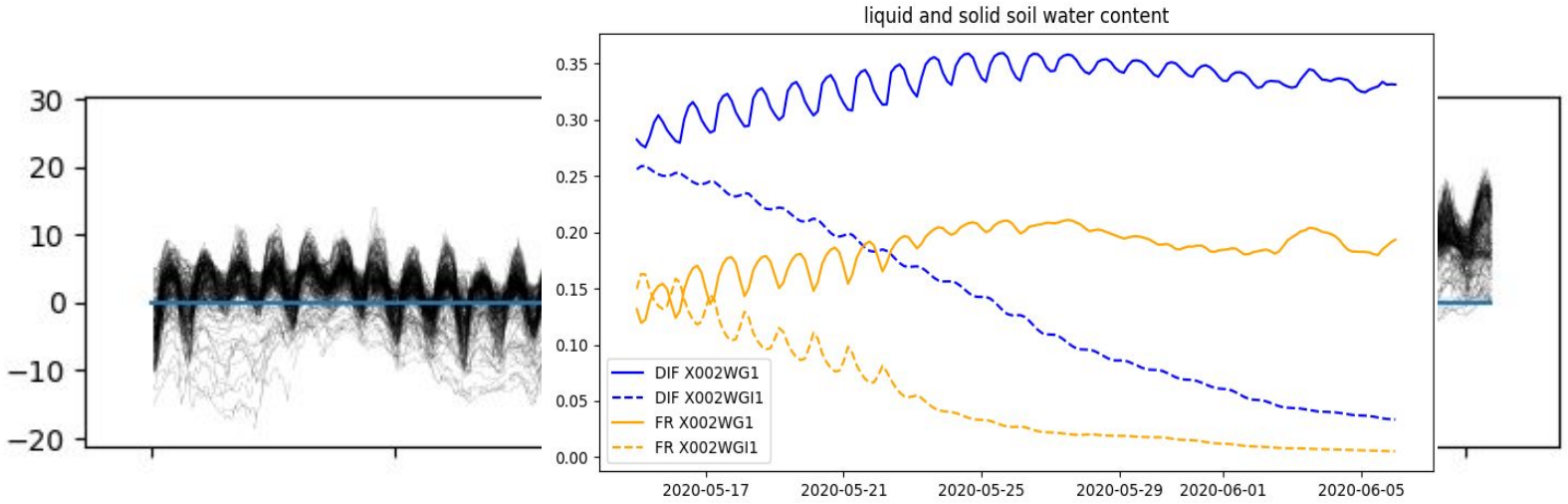


T2M bias
Multi-layer
Ref

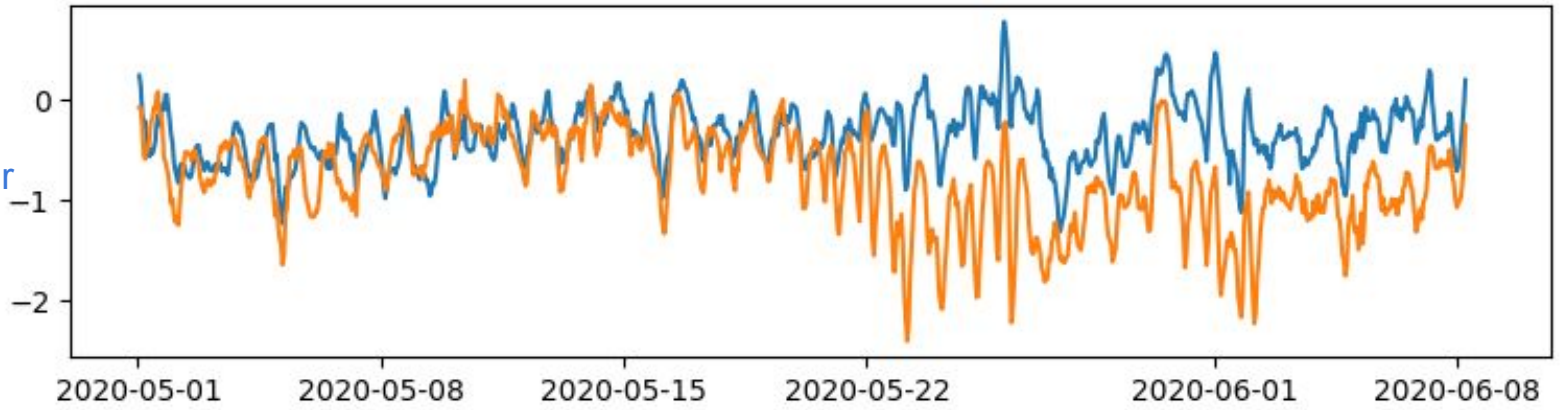


Soil Water

T2M obs



T2M bias
Multi-layer
Ref



Challenges

- Dramatic changes to model system -> difficult to isolate impact of each scheme
- Compensating errors could show up, retuning of the system required
- The current operational system has a very effective surface analysis, acts as a sink for errors in the atmospheric model. Such large increments should be avoided for the multi-layer models.
- A realistic model should be provided realistic input data.