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On the use of an explicit snow scheme in numerical weather prediction and operational snow mapping

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NWP model and SURFEX (External surface model)

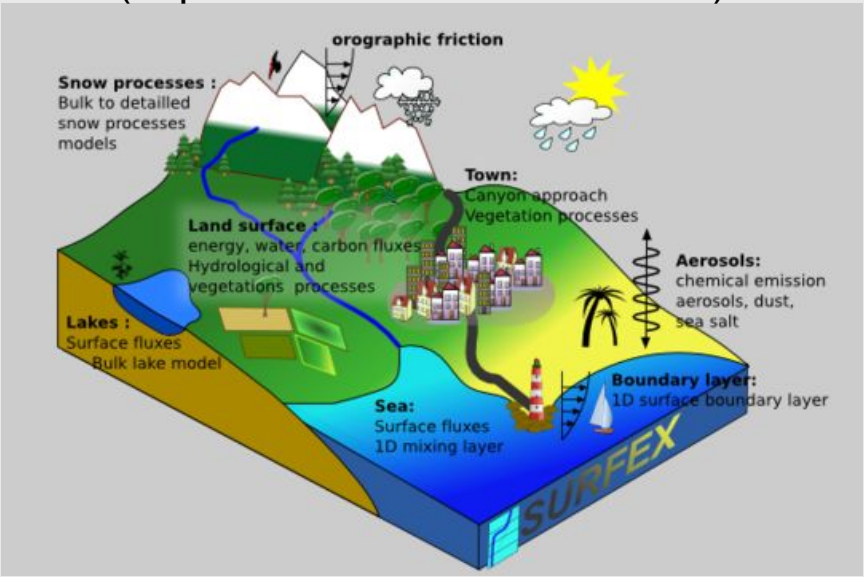
NWP:

- Atmosphere communicates with SURFEX every time step and exchange fluxes
  - Inline mode
- Used on yr.no and publically available (thredds.met.no)

Offline:

- Atmospheric forcing communicates with SURFEX at given time steps but no fluxes are returned to the forcing.

SURFEX
(http://www.umr-cnrm.fr/surfex//)



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Snow “models” and SURFEX settings

- D95 (Douville 95)
  - used operationally
  - Simple 1 layer bulk scheme, works quite well but add too much snow and melts too late
- ISBA-ES (Explicit snow scheme)
  - More advanced 12 layer snow scheme

Patches:

Nature land surface vegetation types aggregated together

- 1 patch = all vegetation types
- 2 patches:
  - patch 1 = open land (the rest)
  - Patch 2 = forest

MEB (Multi energy balance)

- e.g. separate energy budget for snow under trees

Soil: (ISBA: Interaction Soil Biosphere Atmosphere)

- ISBA-FR (force-restore 3-layer scheme)
- ISBA-DIF (14 layer diffusion scheme)

Experiments

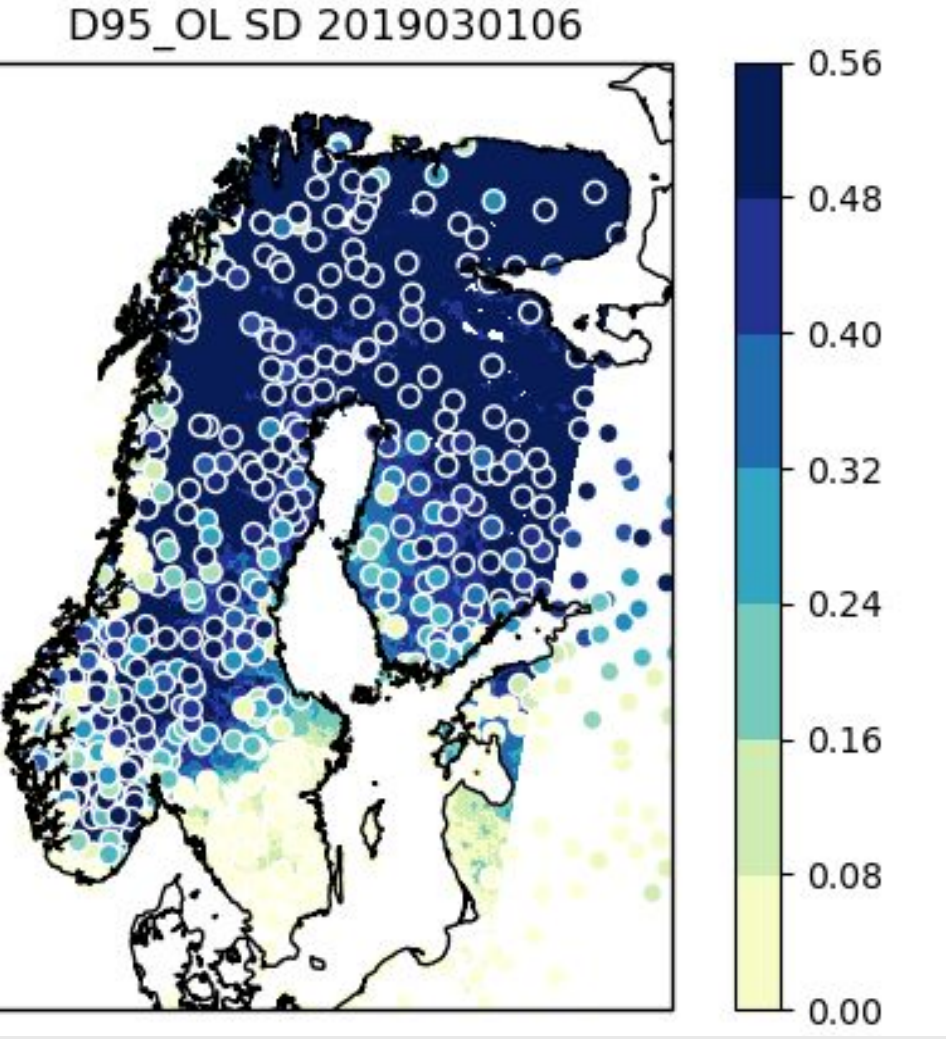
- Open loop simulations from September 1st 2018 until june 2019
- Forcing from MetCoOp EPS (MEPS) control run

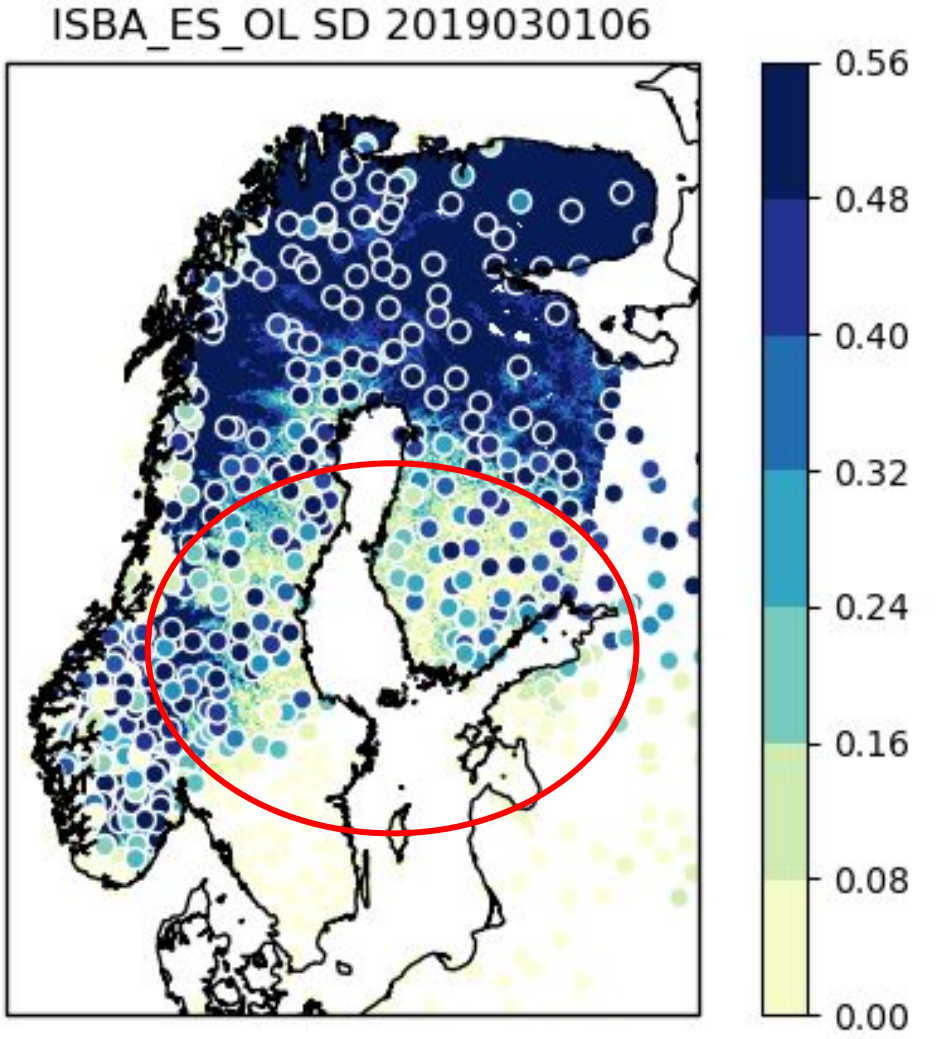
Name	**D95**	**ISBA_ES**	**ISBA_ES_DIF**	**ISBA_ES_DIF_MEB**
Snow scheme	D95	ISBA-ES	ISBA-ES	ISBA-ES
Soil scheme	ISBA-FR (3L)	ISBA-FR (3-L)	ISBA-DIF	ISBA-DIF
MEB	NO	NO	NO	YES

Open loop maps
vs
observations (circles)

Early spring:
Snow depth March 1st 2019

D95 vs ISBA-ES





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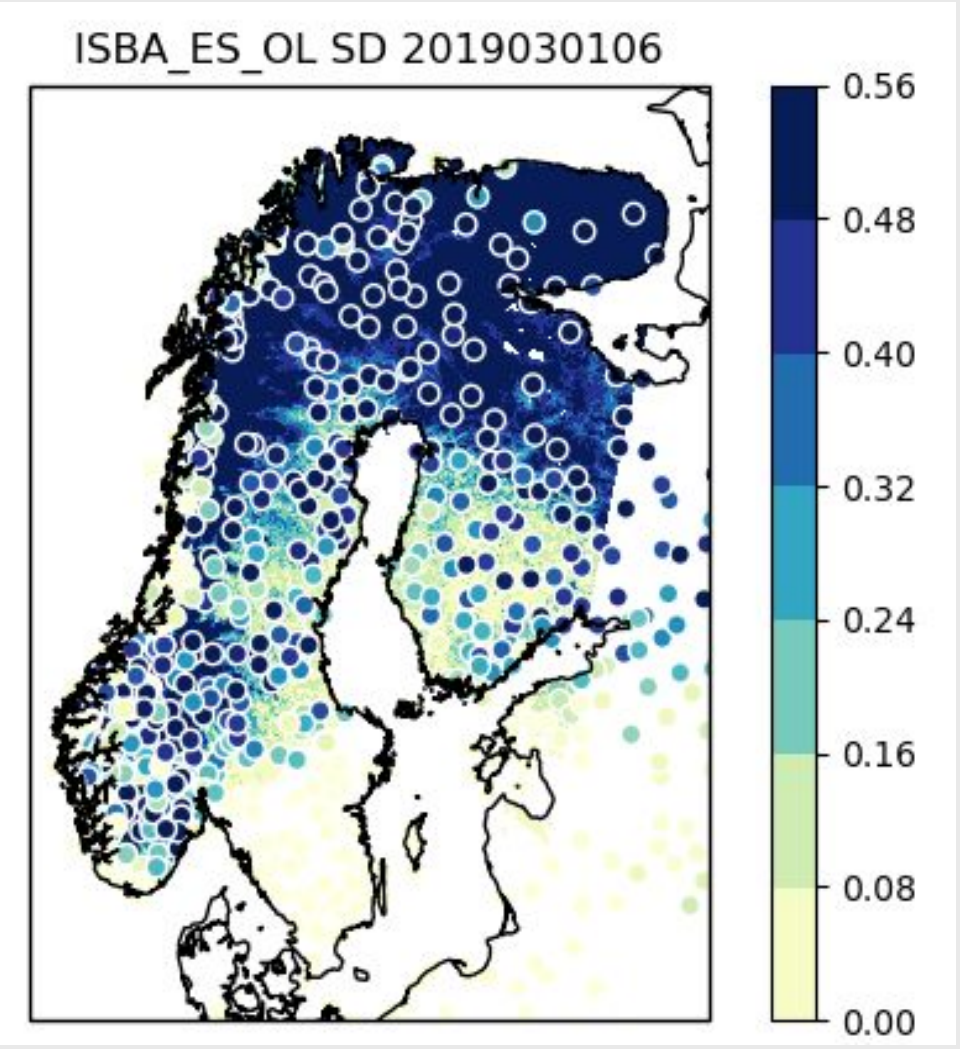
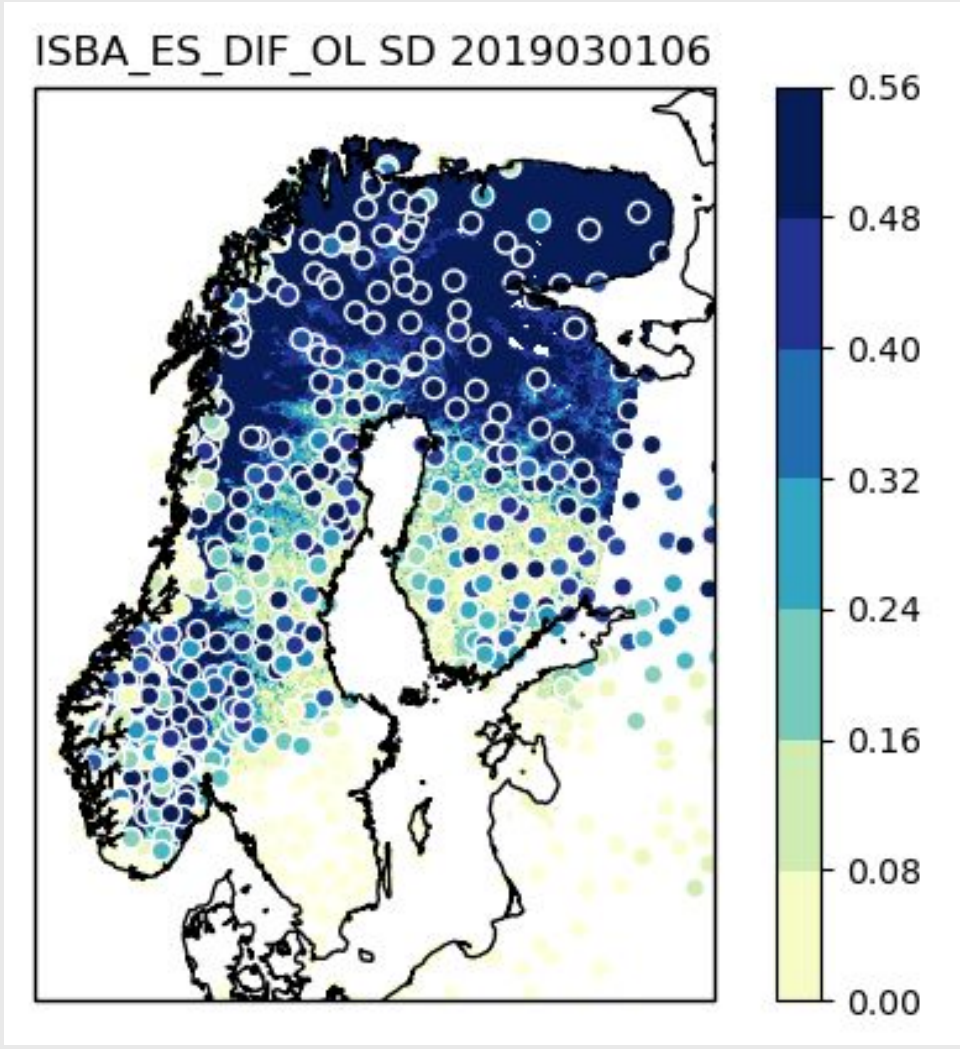
ISBA-ES: 3-L FR vs ISBA-DIF





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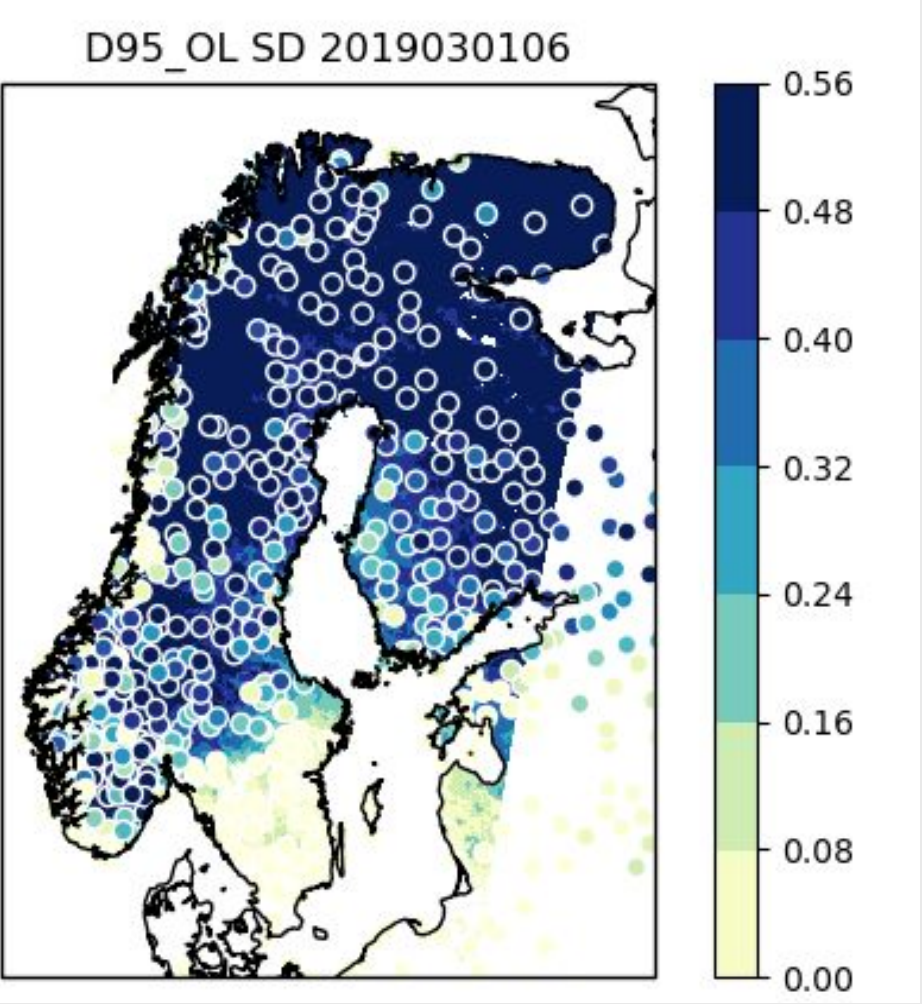
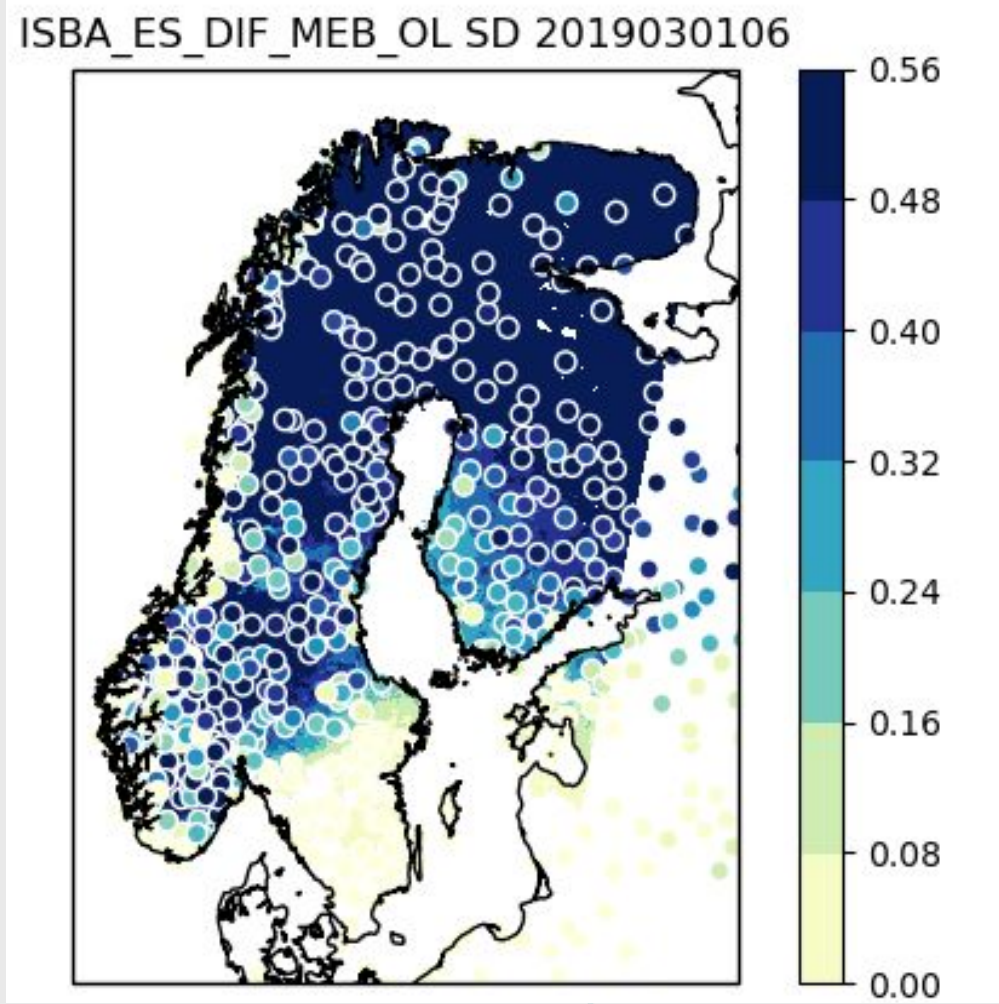
D95 vs ISBA-ES + ISBA-DIF + MEB





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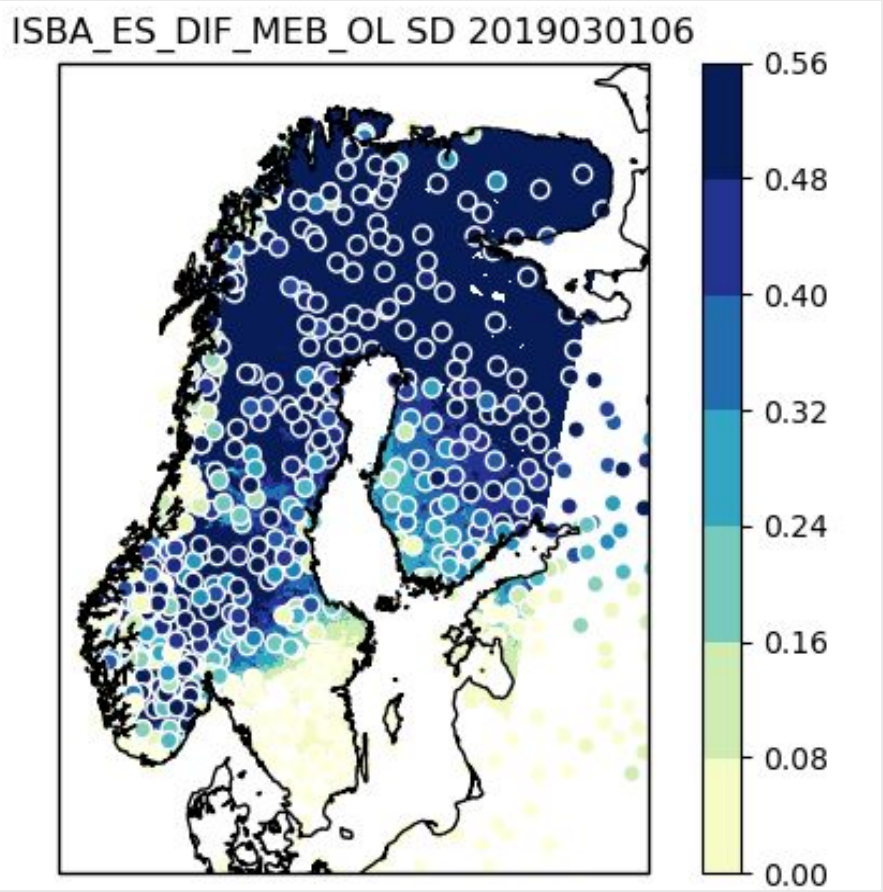
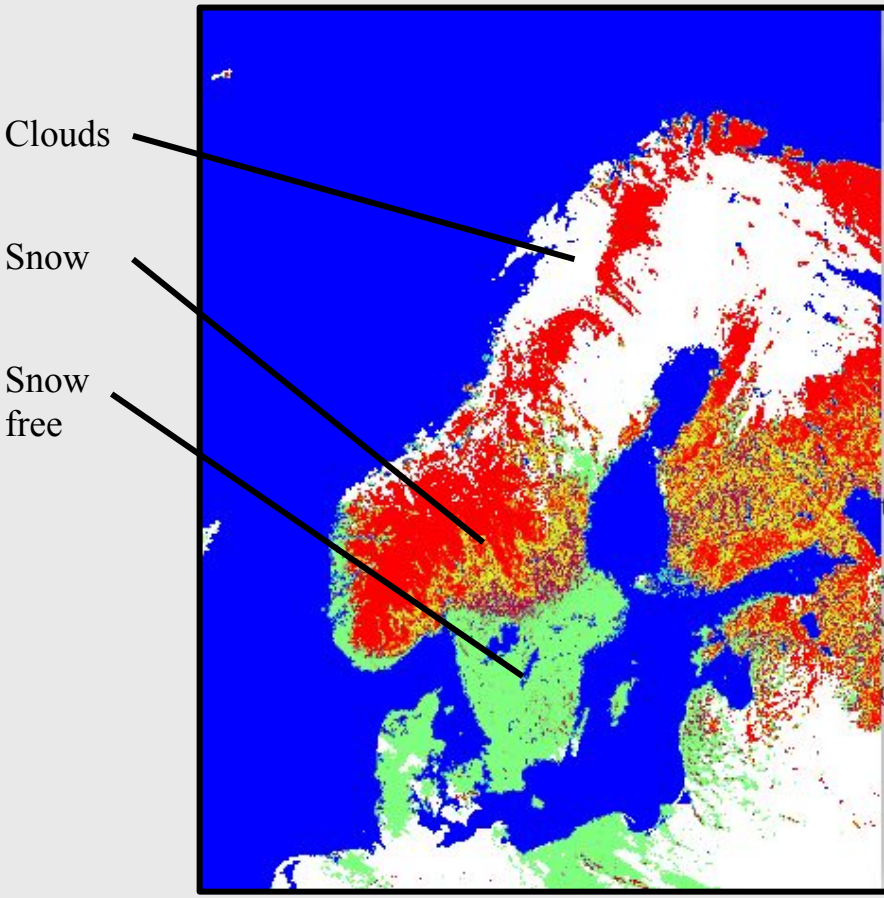
Satellite snow probability





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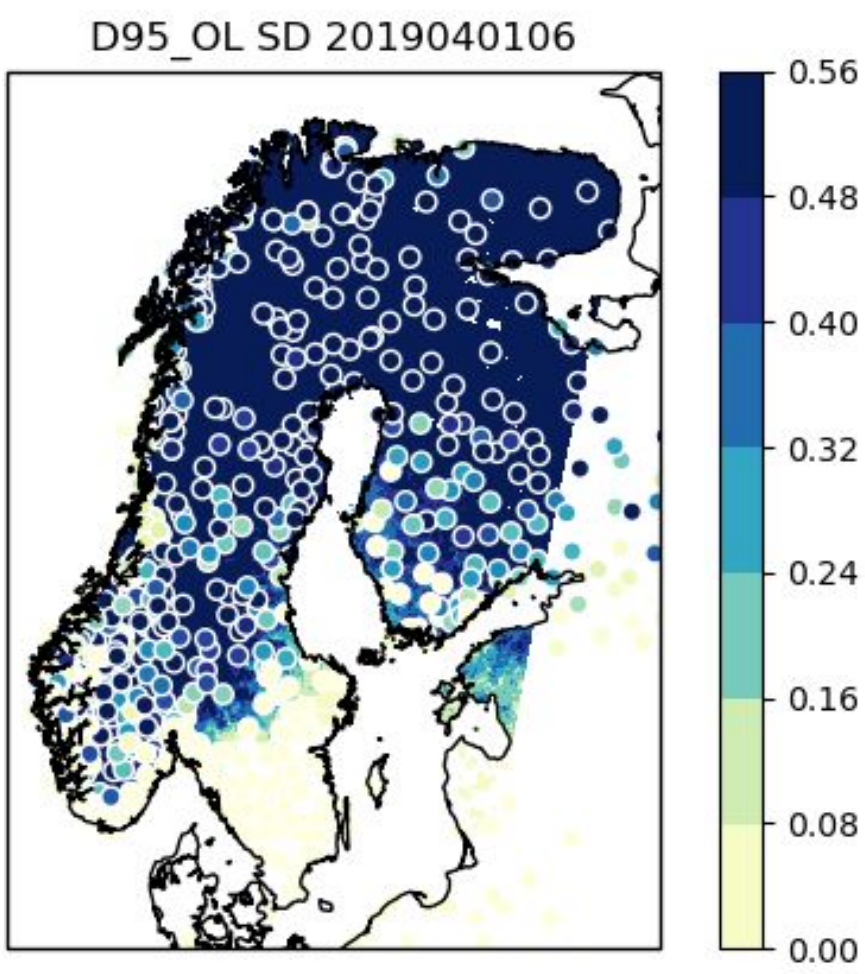
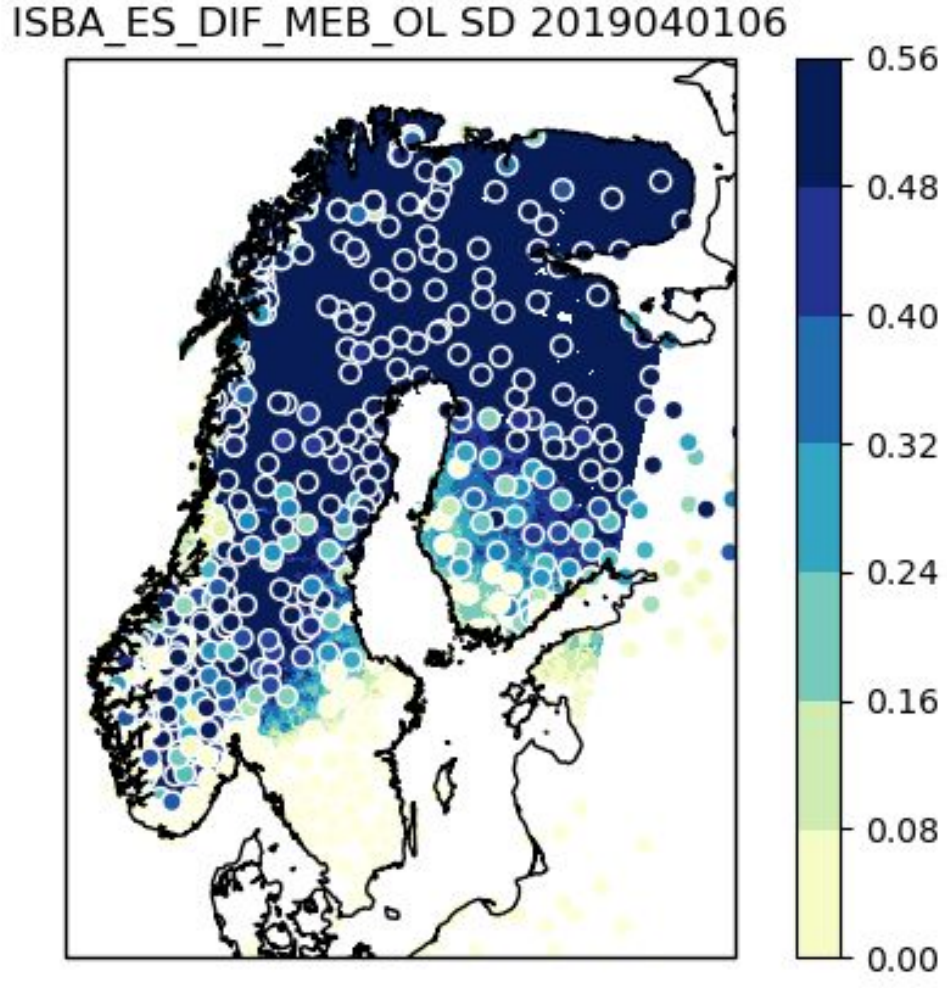
April 1st:
D95 vs ISBA-ES + ISBA-DIF + MEB





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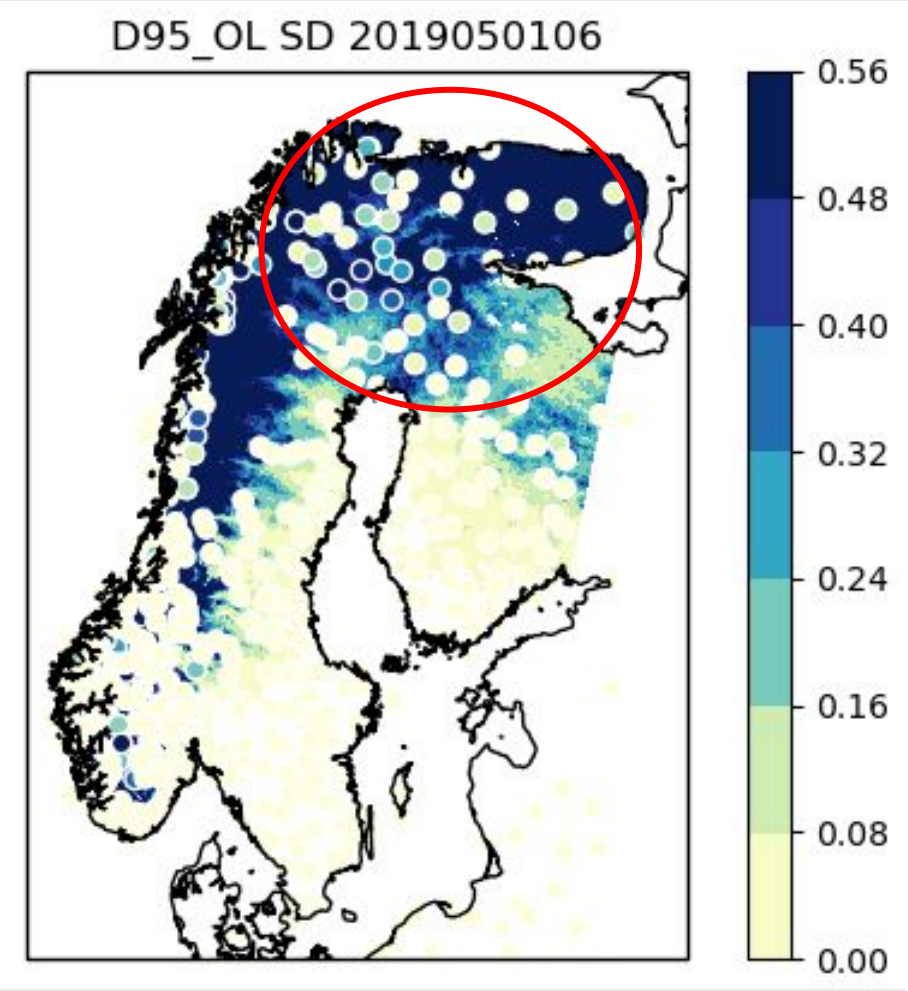
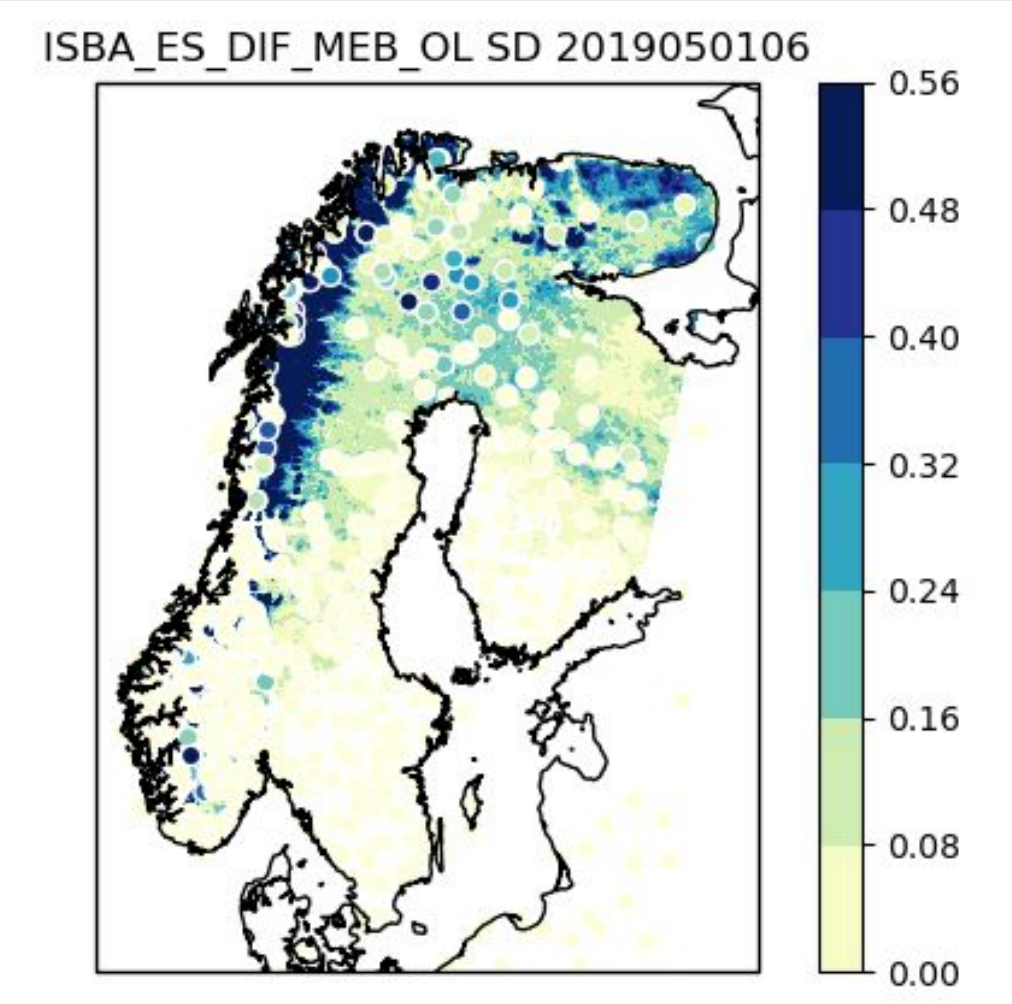
May 1st:
D95 vs ISBA-ES + ISBA-DIF + MEB





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Open loop time series….

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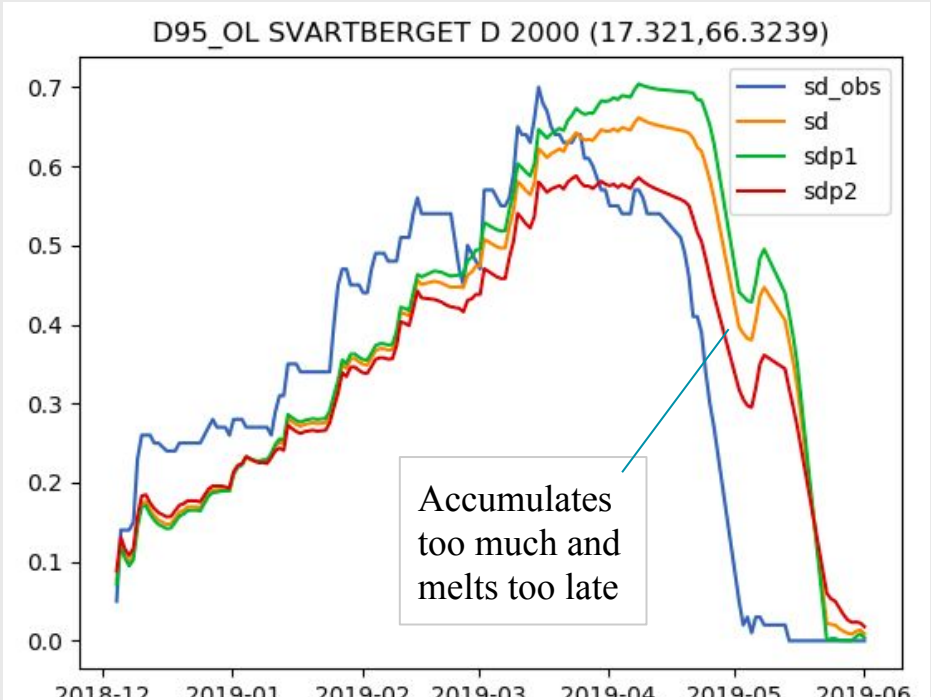
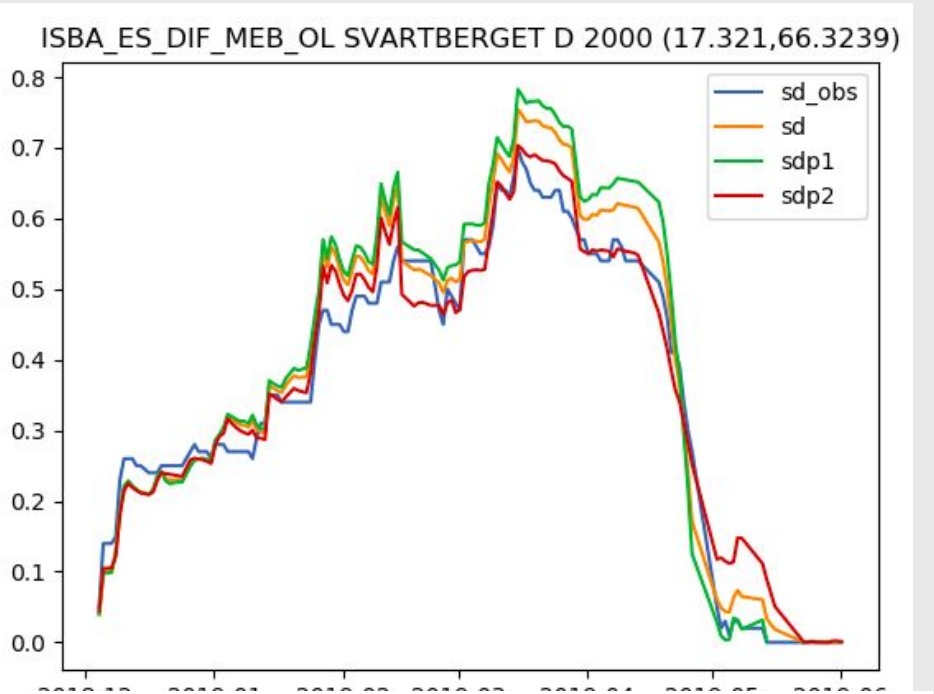
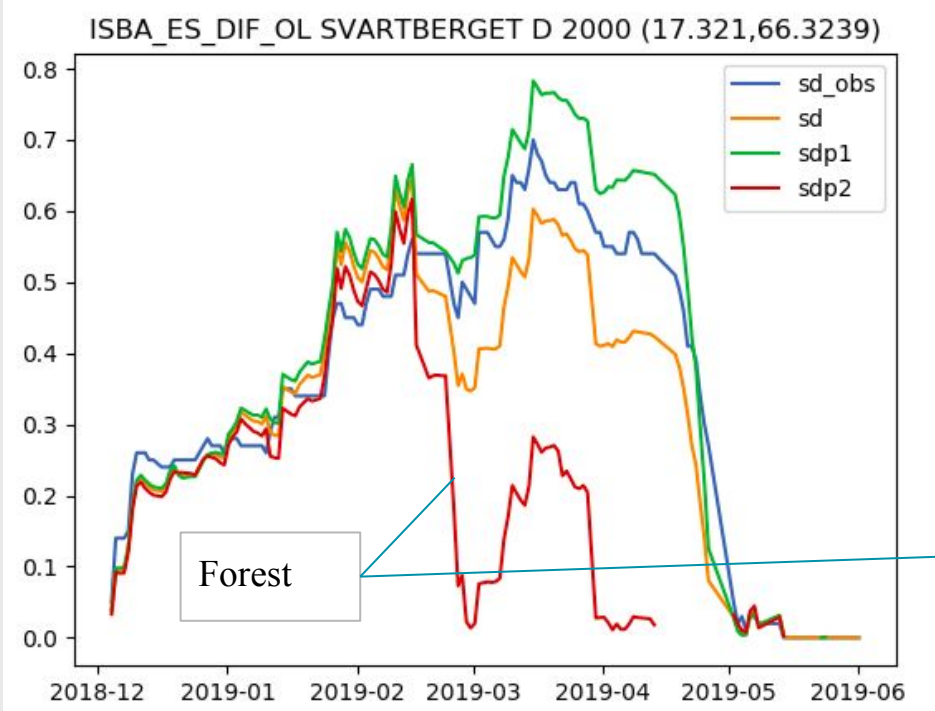
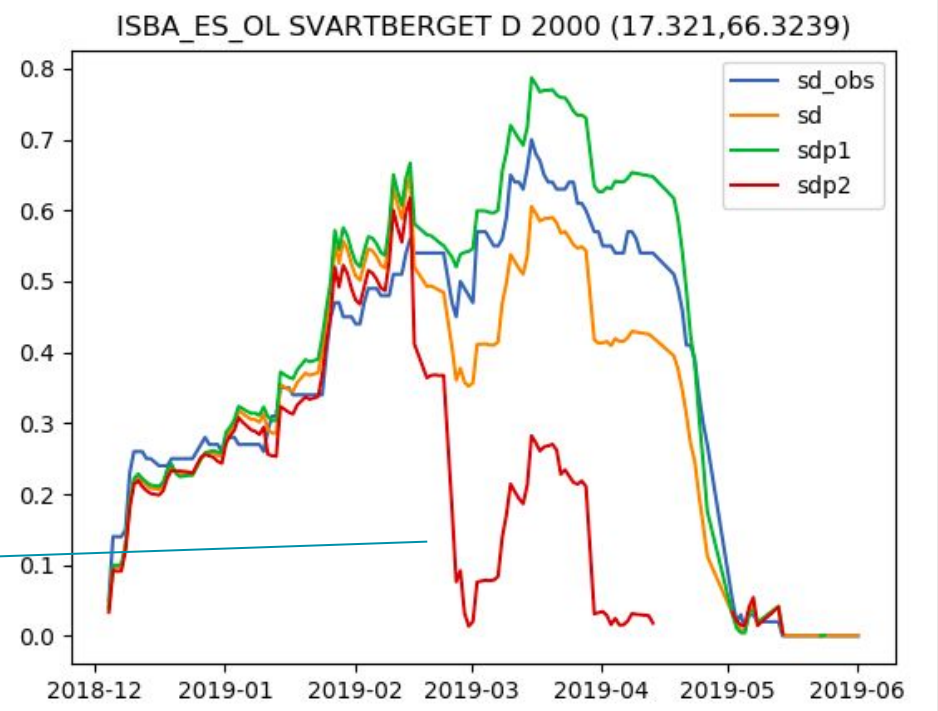

D95_OL SVARTBERGET D 2000 (17.321,66.3239)
sd_obs
sd
sdp1
sdp2
Accumulates too much and melts too late


ISBA_ES_DIF_MEB_OL SVARTBERGET D 2000 (17.321,66.3239)
sd_obs
sd
sdp1
sdp2


ISBA_ES_DIF_OL SVARTBERGET D 2000 (17.321,66.3239)
sd_obs
sd
sdp1
sdp2
Forest
2018-12
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06


ISBA_ES_OL SVARTBERGET D 2000 (17.321,66.3239)
sd_obs
sd
sdp1
sdp2
2018-12
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06

Assimilation

1. quality control of observations

(TITAN - **https://github.com/metno/TITAN**)

2. Spatial analysis of snow depth observations (gridpp)
3. Update snow water equivalent (SWE) in SURFEX

(SURFEX Offline Data Assimilation - SODA)

gridpp

Gridded post-processor

build passing coverage 62%

Gridpp is a command-line tool that post-processes weather forecasts in NetCDF format. The program performs two types of post-processing: Downscaling and calibration. Gridpp downscales forecast from a coars grid to a finer grid using a variety of interpolation methods. Gridpp then calibrates the forecasts by applying corrections to each gridpoint. Gridpp is modular, so any combination of downscaling and calibration can be selected.

For information on how to use the software, check out the wiki page: https://github.com/metno/gridpp/wiki

Variable name (in file): -v variable-name

OI calibrator: -c oi

OI options: d=X h=Z useEns=0 sigma=S elevGradient=0 minObs=0 landOnly=1 diaFile=name-of-file

Parameter file (observations): -p $param type=netcdf dimName=coefficient varName=coefficients

Quality control calibrator and options: -c qc min=0.00001 max=1

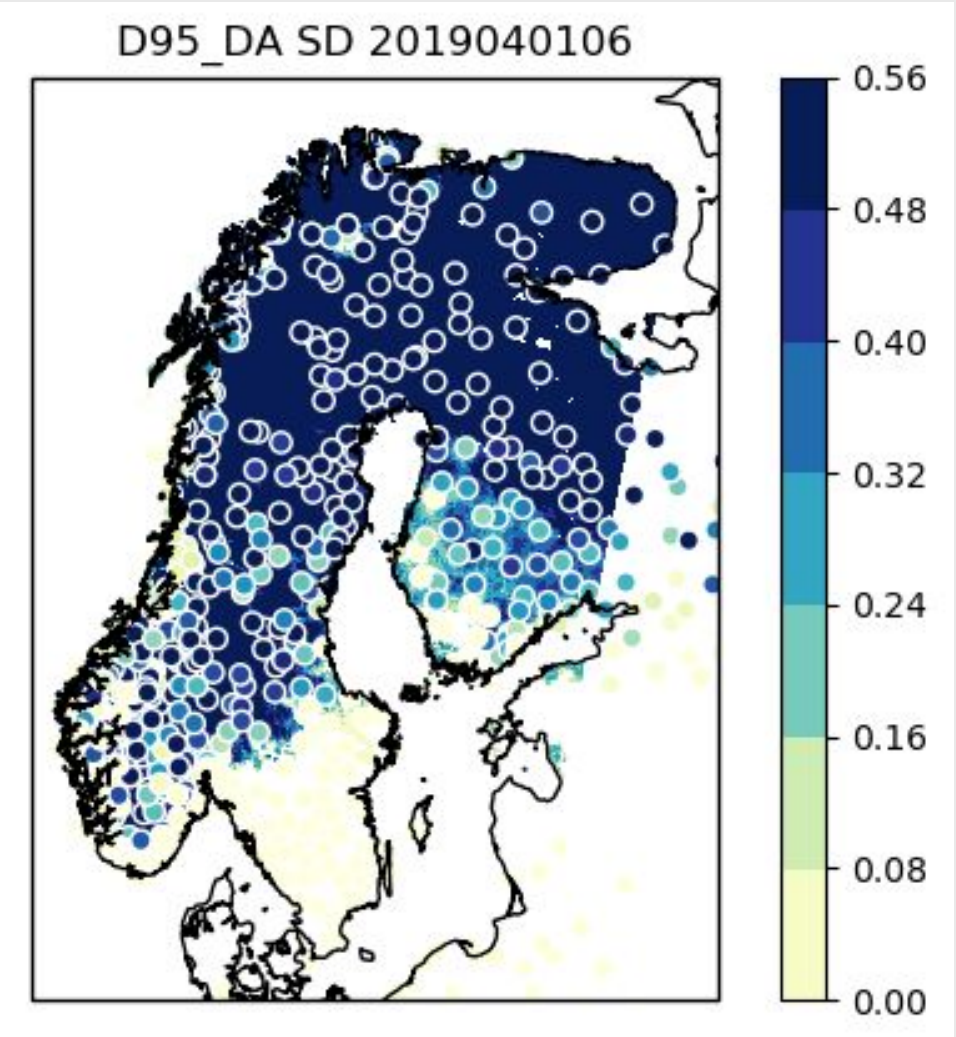
Update of SWE

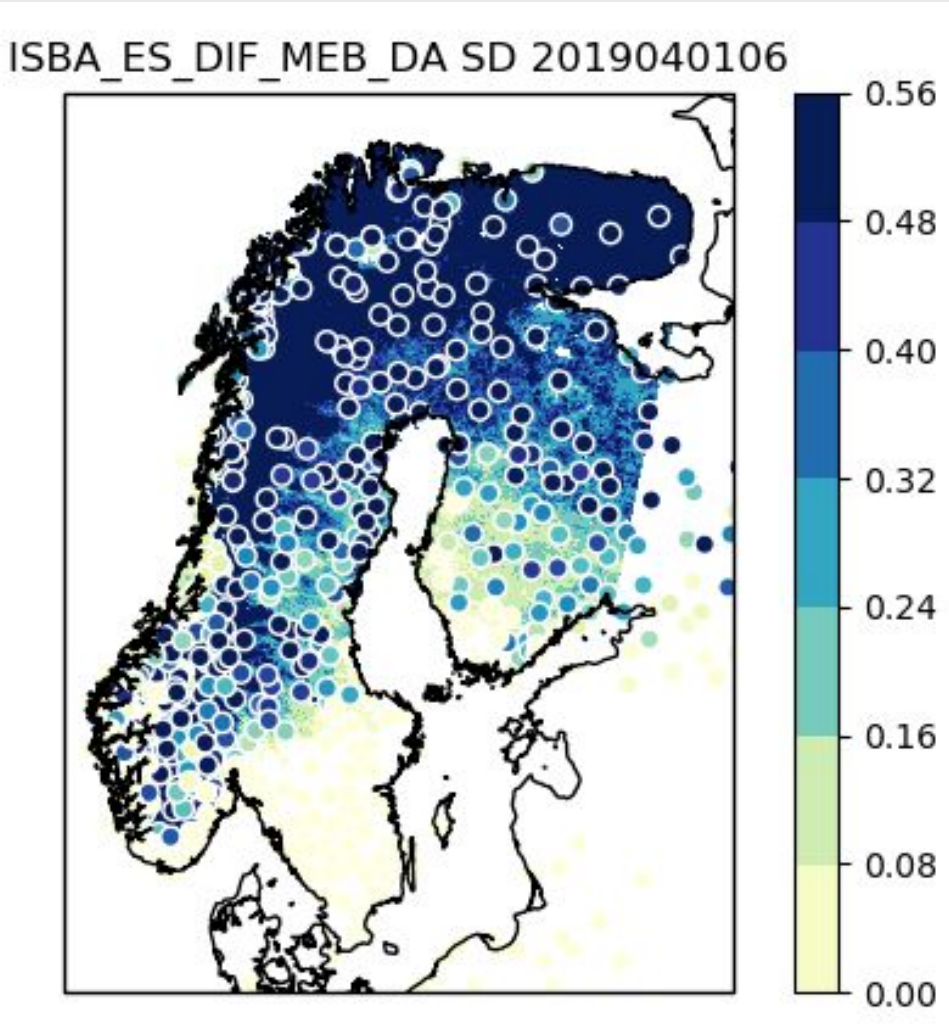
How to distribute snow depth observations taken over open-land to a model setup with separate patches for open land and forest?

- Use the SWE fractions between the first guess from the patches
- Use a uniform weight function for open land
- Use the ratio between patch 1 and 2 for patch 2 SWE within thresholds (0.8 and 1.25)

Snow depth maps April 1st 2019

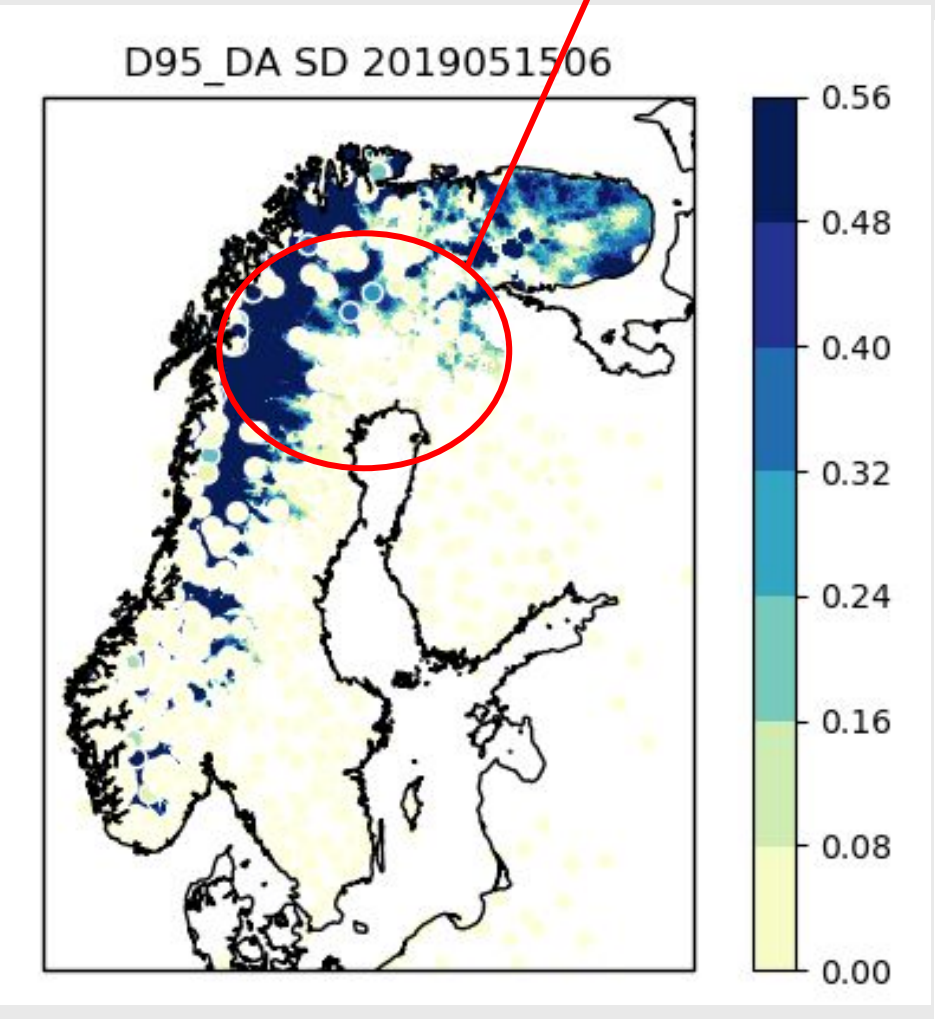
More similar

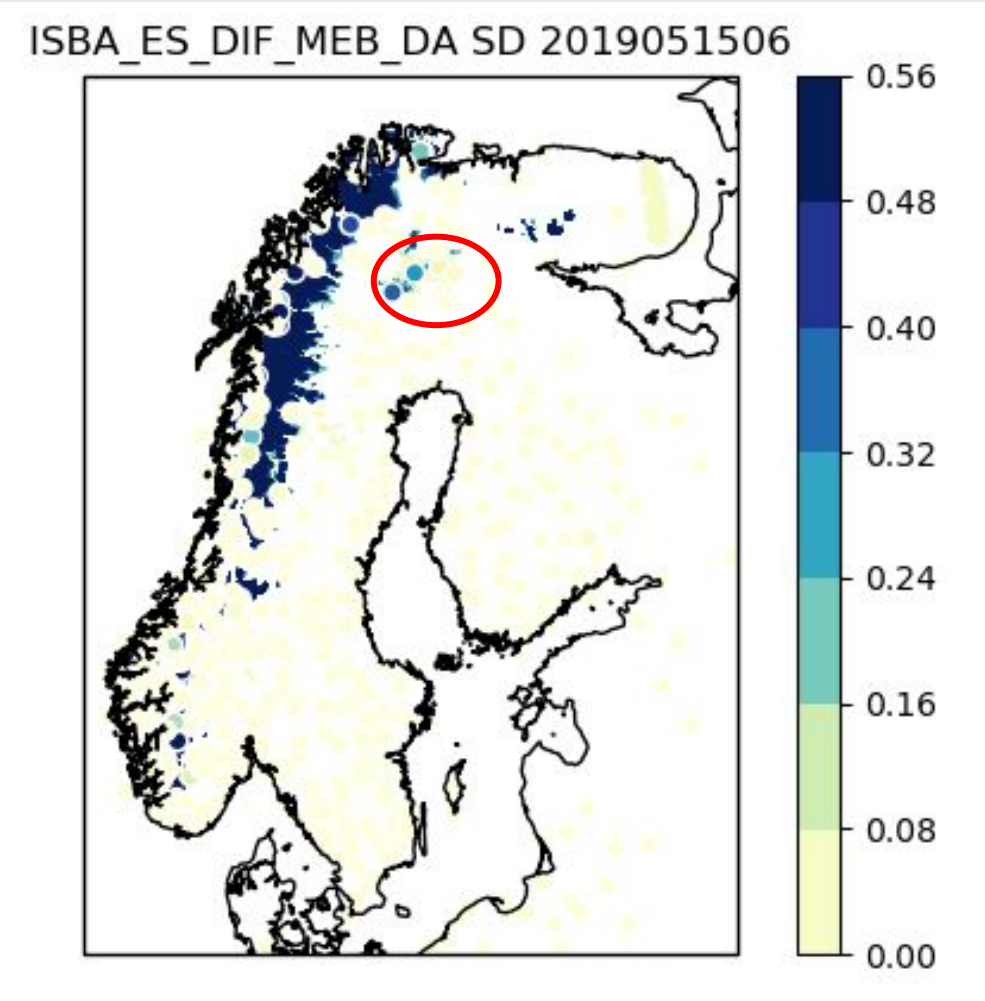




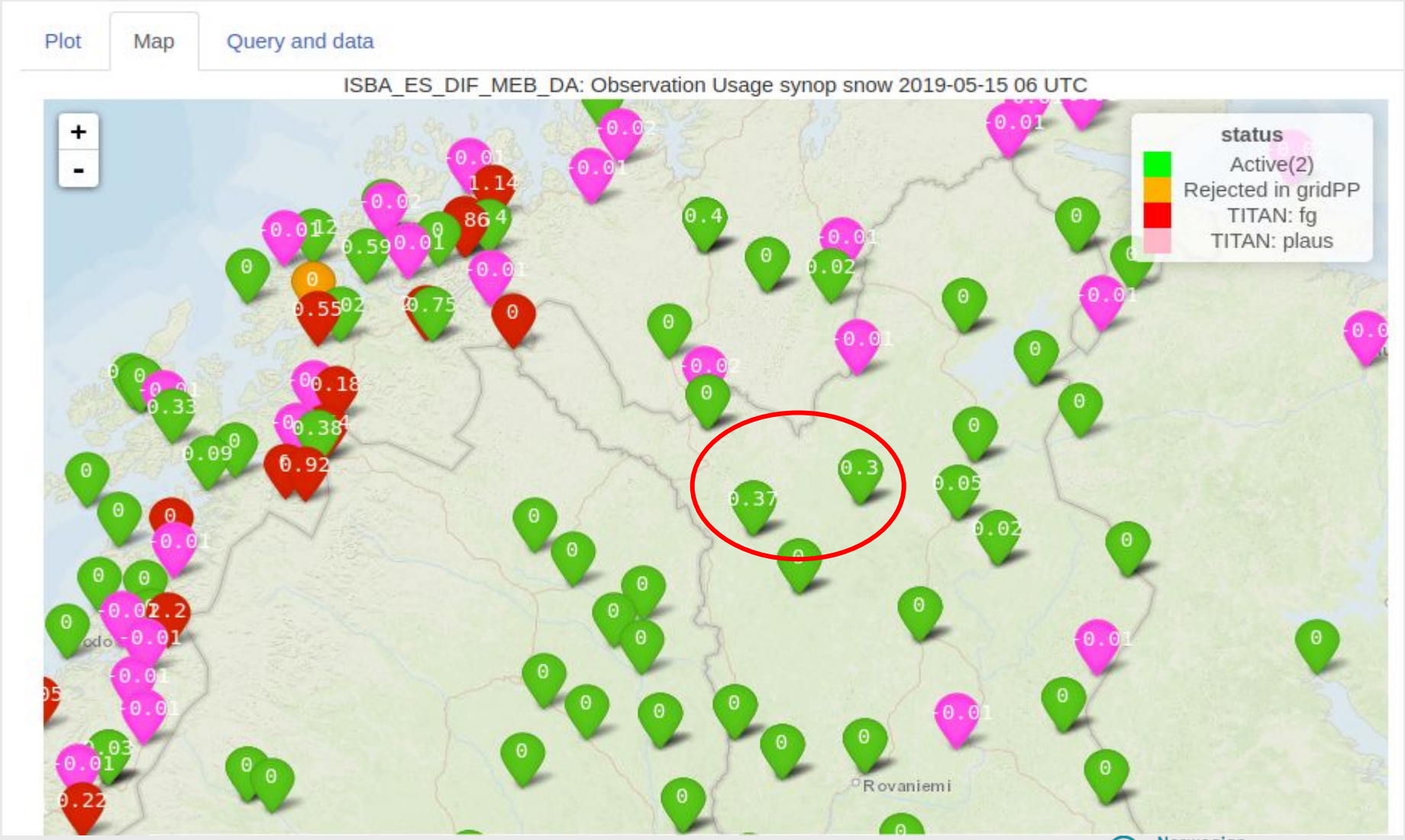
Snow depth maps May 15th 2019

Still too much snow





Observation monitoring



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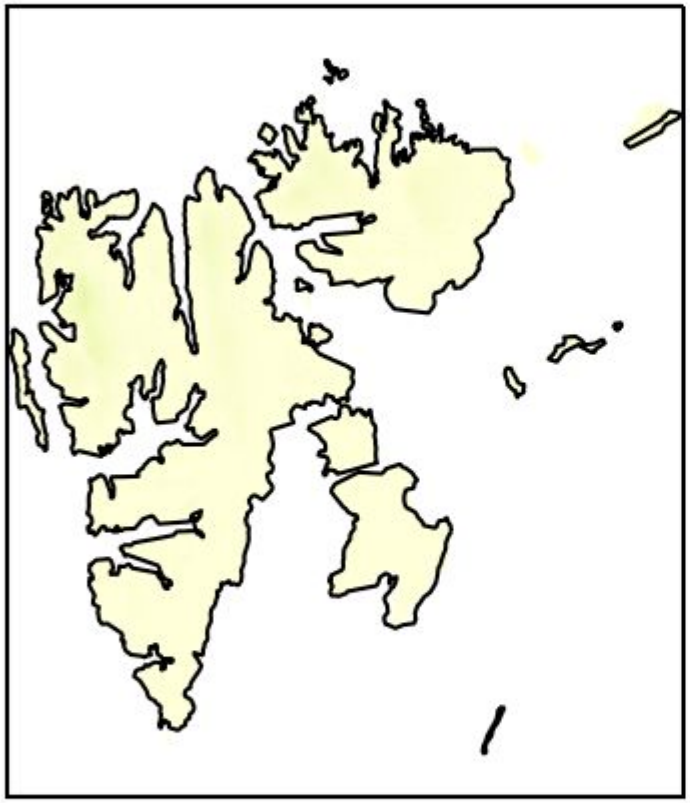
Operational map product for SVALBARD

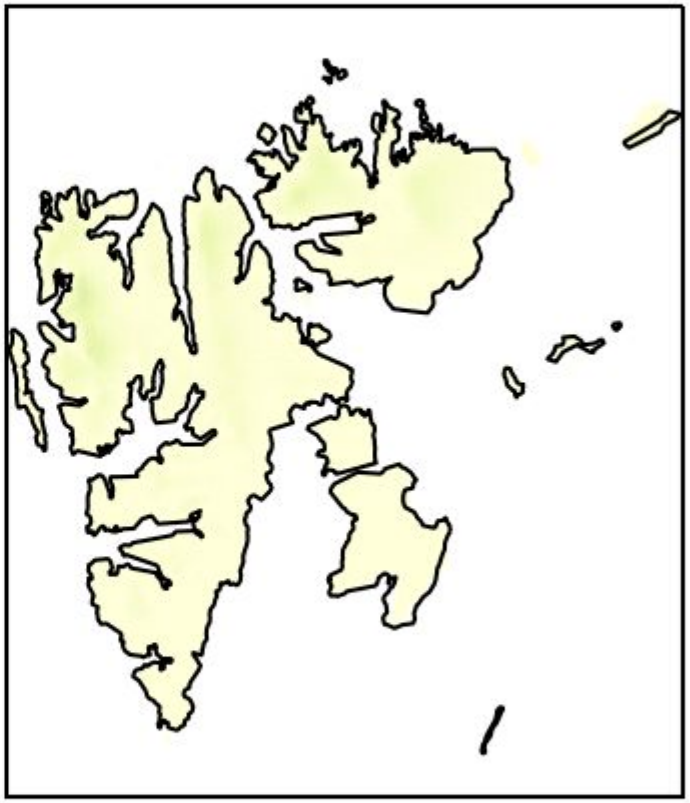
- Almost no vegetation -> 1 patch
- Few observations -> no assimilation

2018090106

ISBA-ES



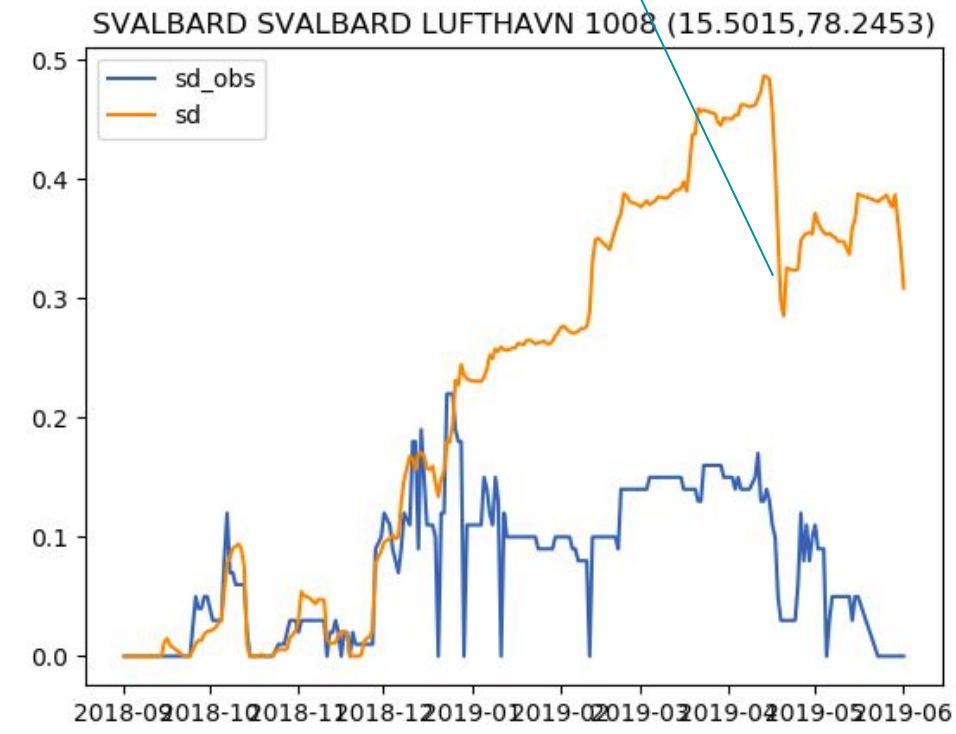
D95

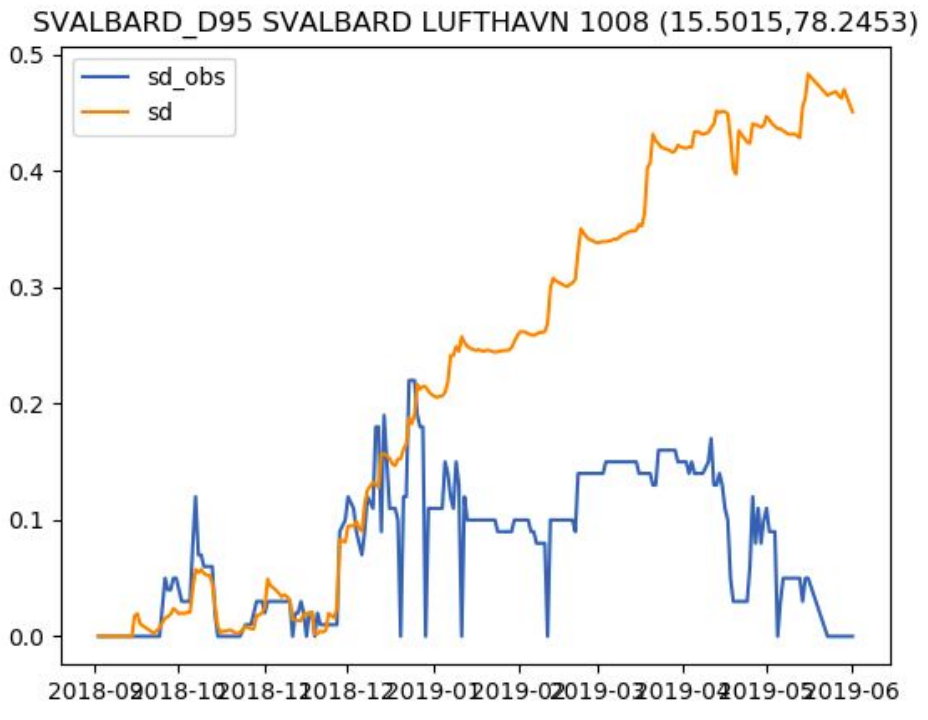


Time series Svalbard lufthavn

ISBA-ES

D95





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Conclusions

- ISBA-ES shows promising results in combination with ISBA-DIF and MEB
- Assimilation of snow now possible for ISBA-ES
  - Seems to do what it should. Need possibly still a bit tuning.
- Snow map product for Svalbard set up
  - few observations
  - problems with melting? Runs should be extended...

Bonus

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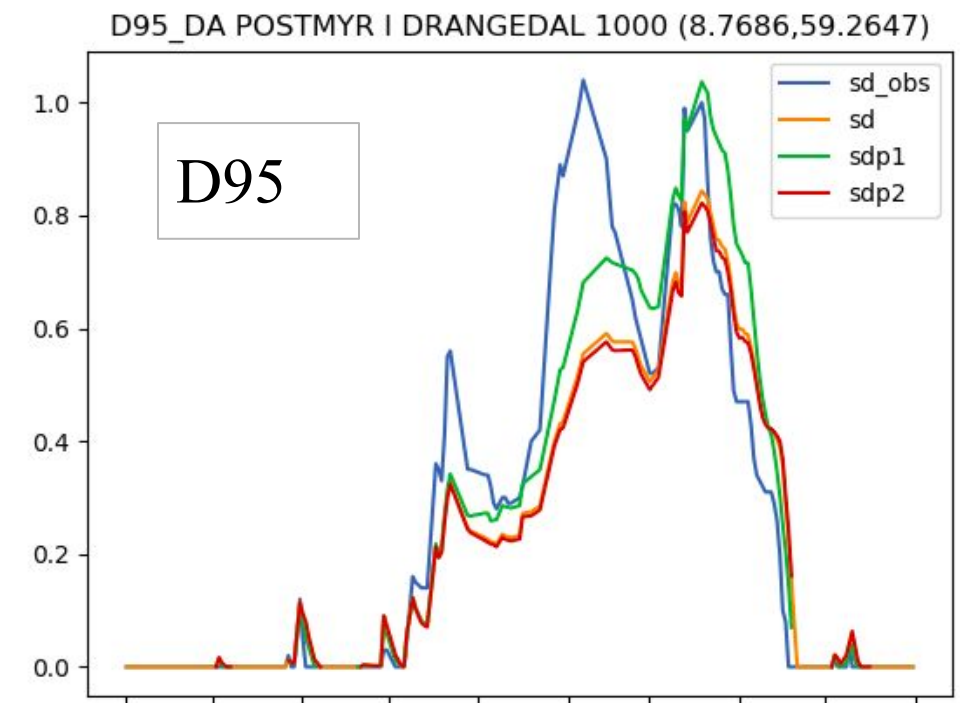
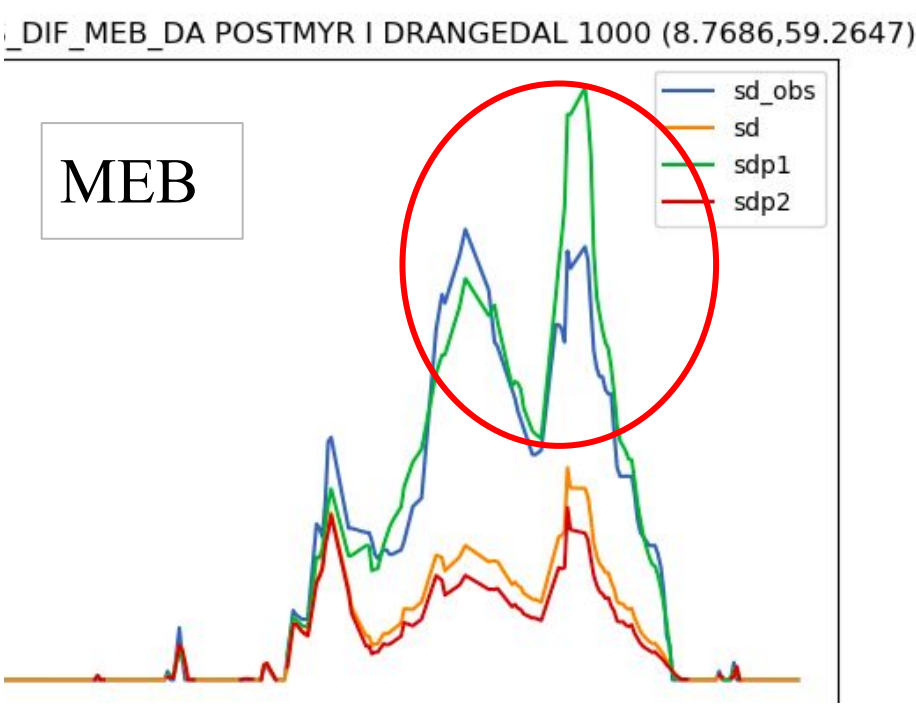
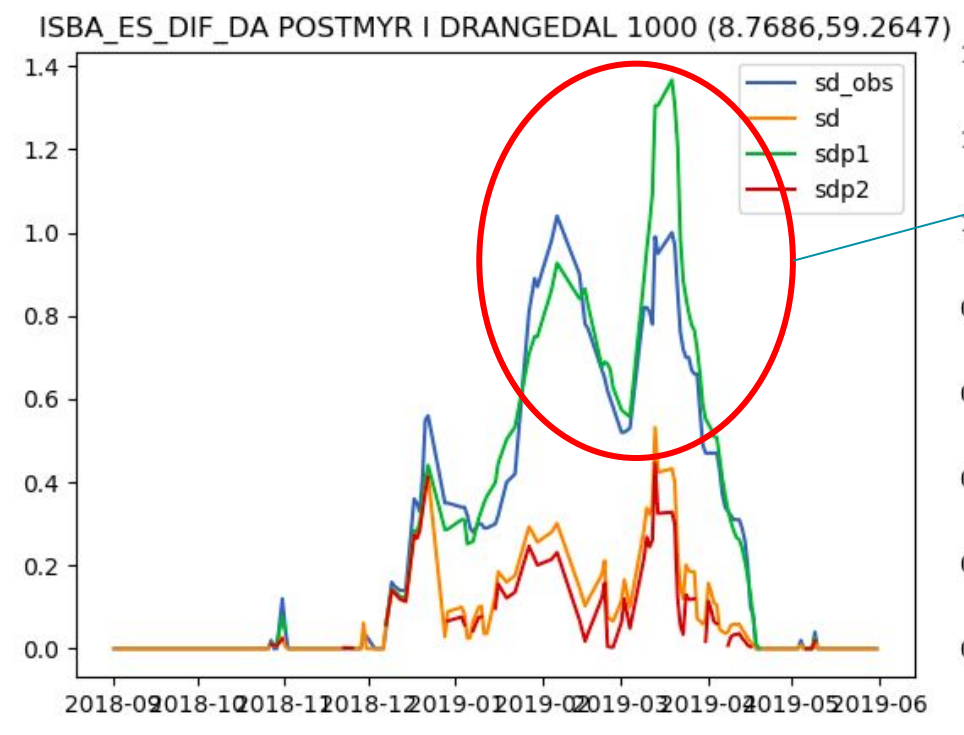
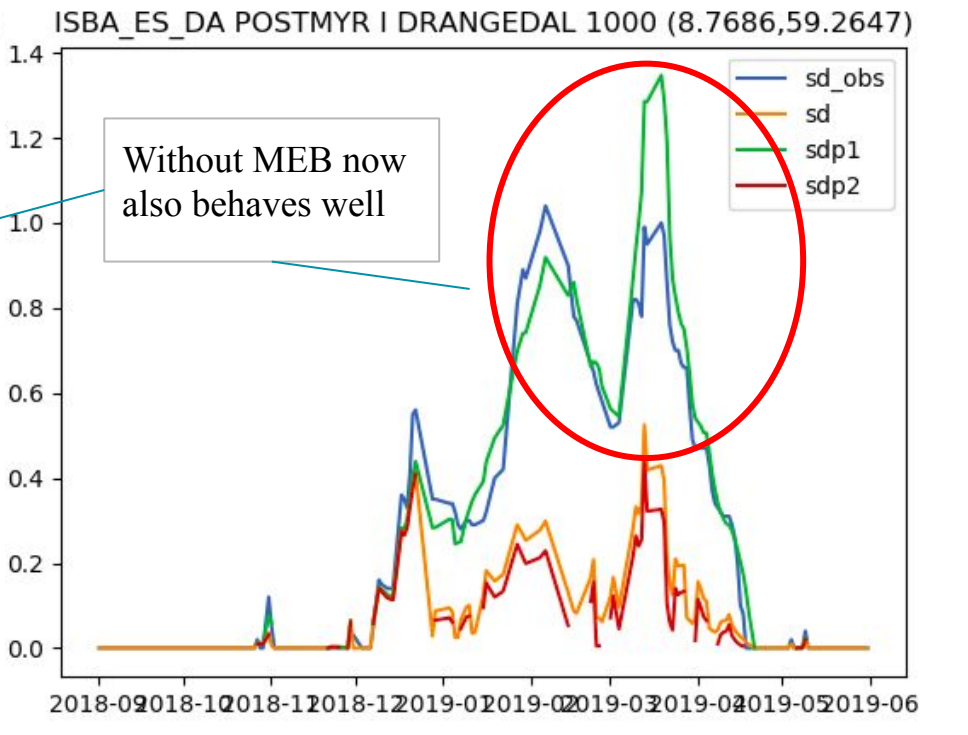
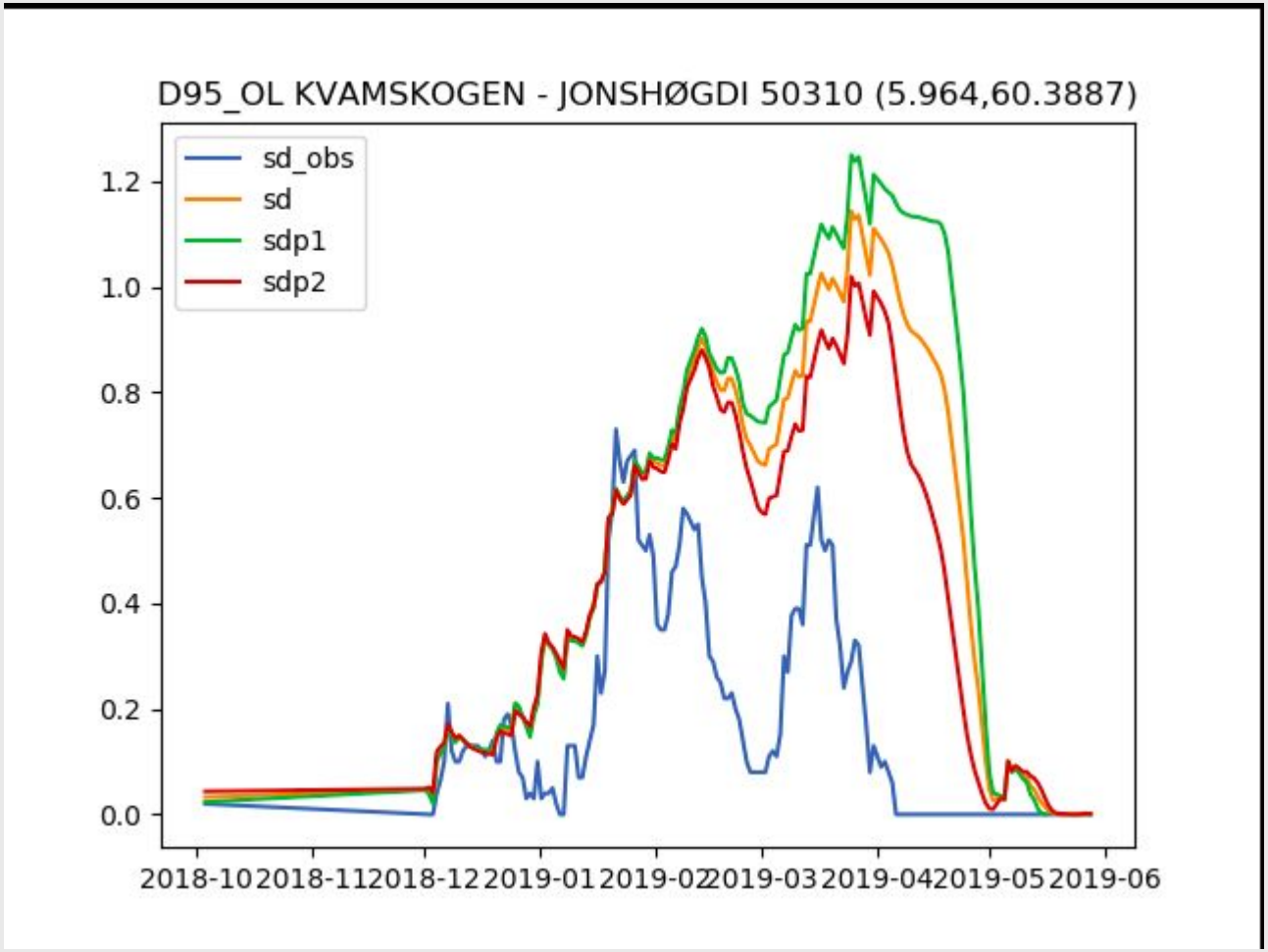
Data assimilation time series...


D95_DA POSTMYR I DRANGEDAL 1000 (8.7686,59.2647)
D95
sd_obs
sd
sdp1
sdp2
1.0
0.8
0.6
0.4
0.2
0.0


_DIF_MEB_DA POSTMYR I DRANGEDAL 1000 (8.7686,59.2647)
MEB
sd_obs
sd
sdp1
sdp2


ISBA_ES_DIF_DA POSTMYR I DRANGEDAL 1000 (8.7686,59.2647)
sd_obs
sd
sdp1
sdp2
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2018-09
2018-10
2018-11
2018-12
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06


ISBA_ES_DA POSTMYR I DRANGEDAL 1000 (8.7686,59.2647)
Without MEB now
also behaves well
sd_obs
sd
sdp1
sdp2
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2018-09
2018-10
2018-11
2018-12
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06



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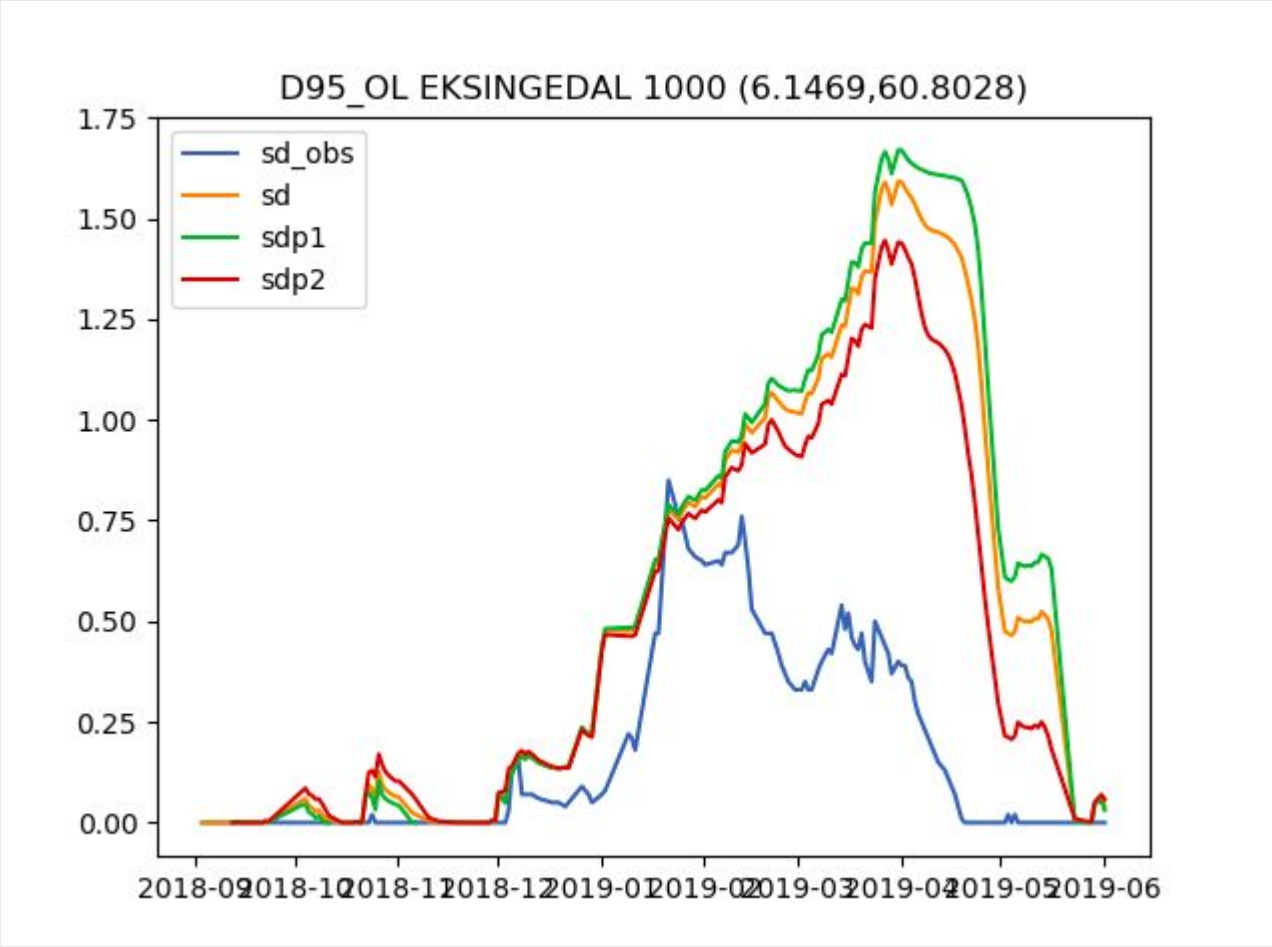

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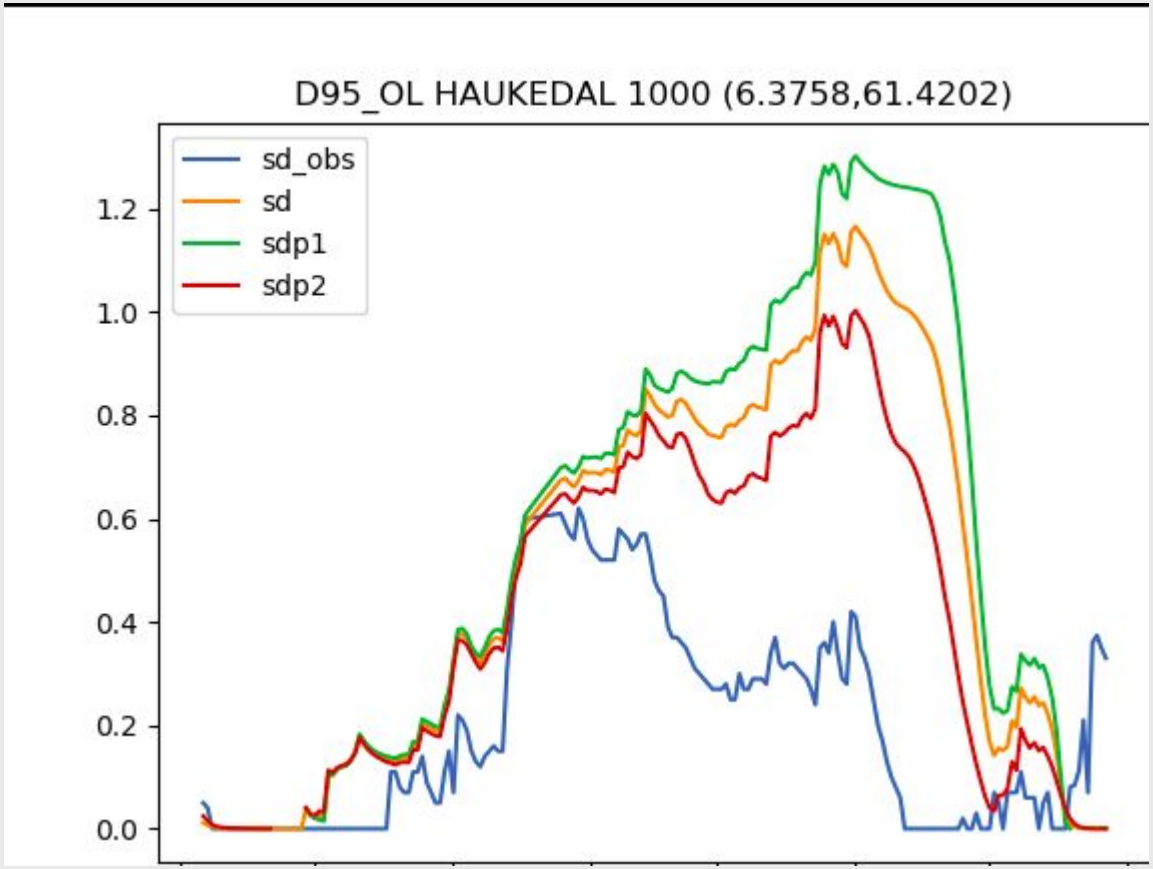

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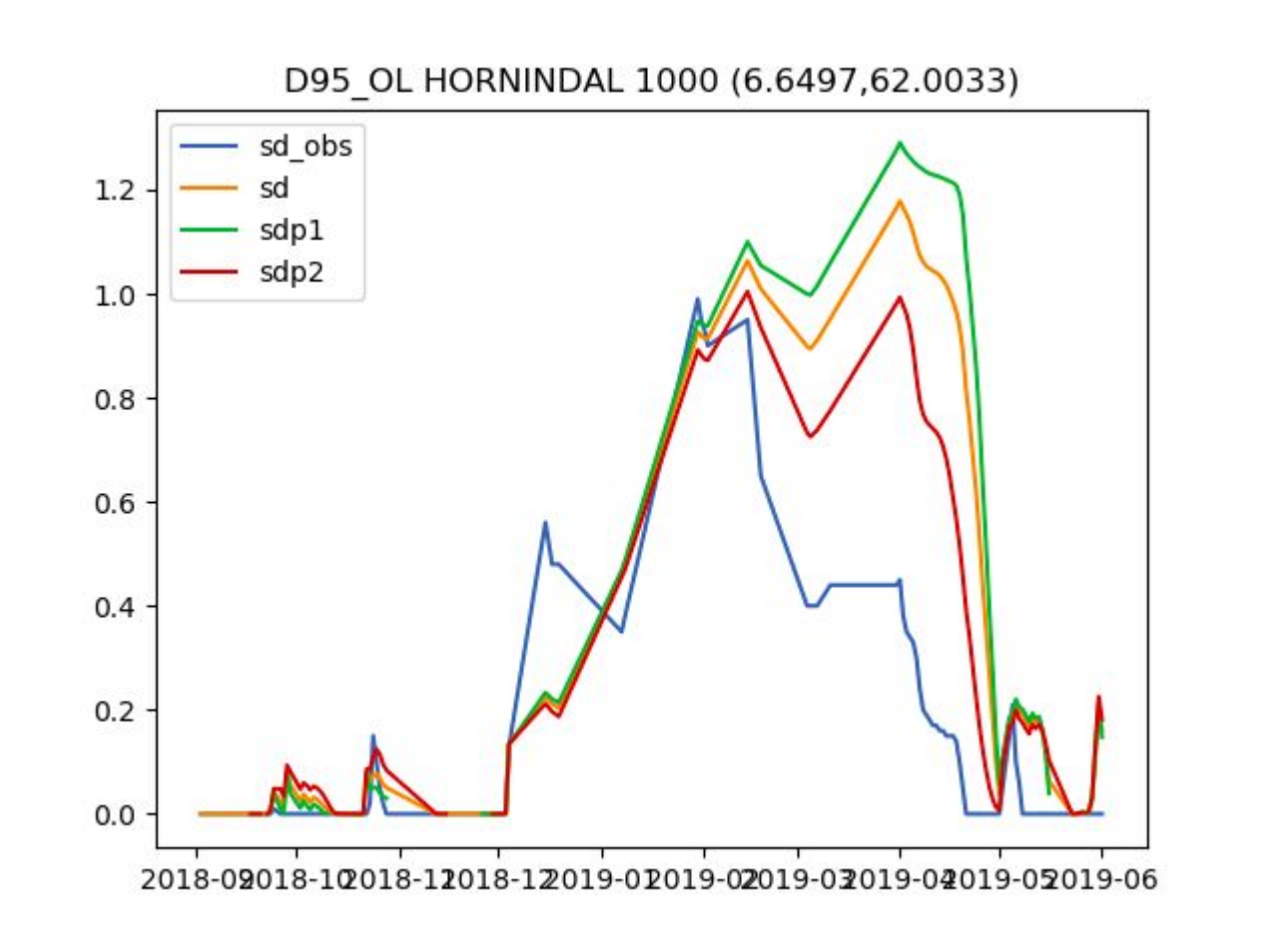

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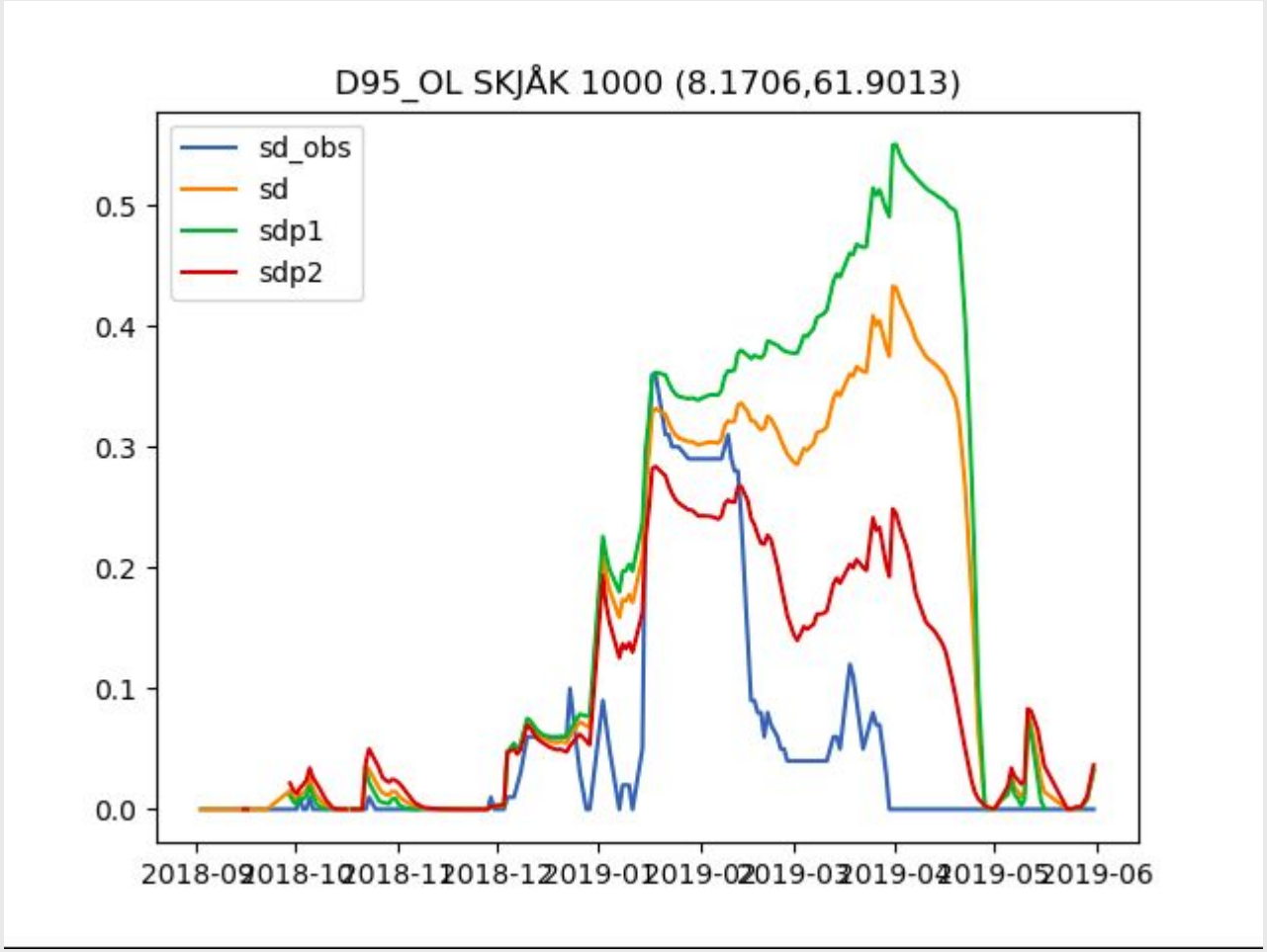

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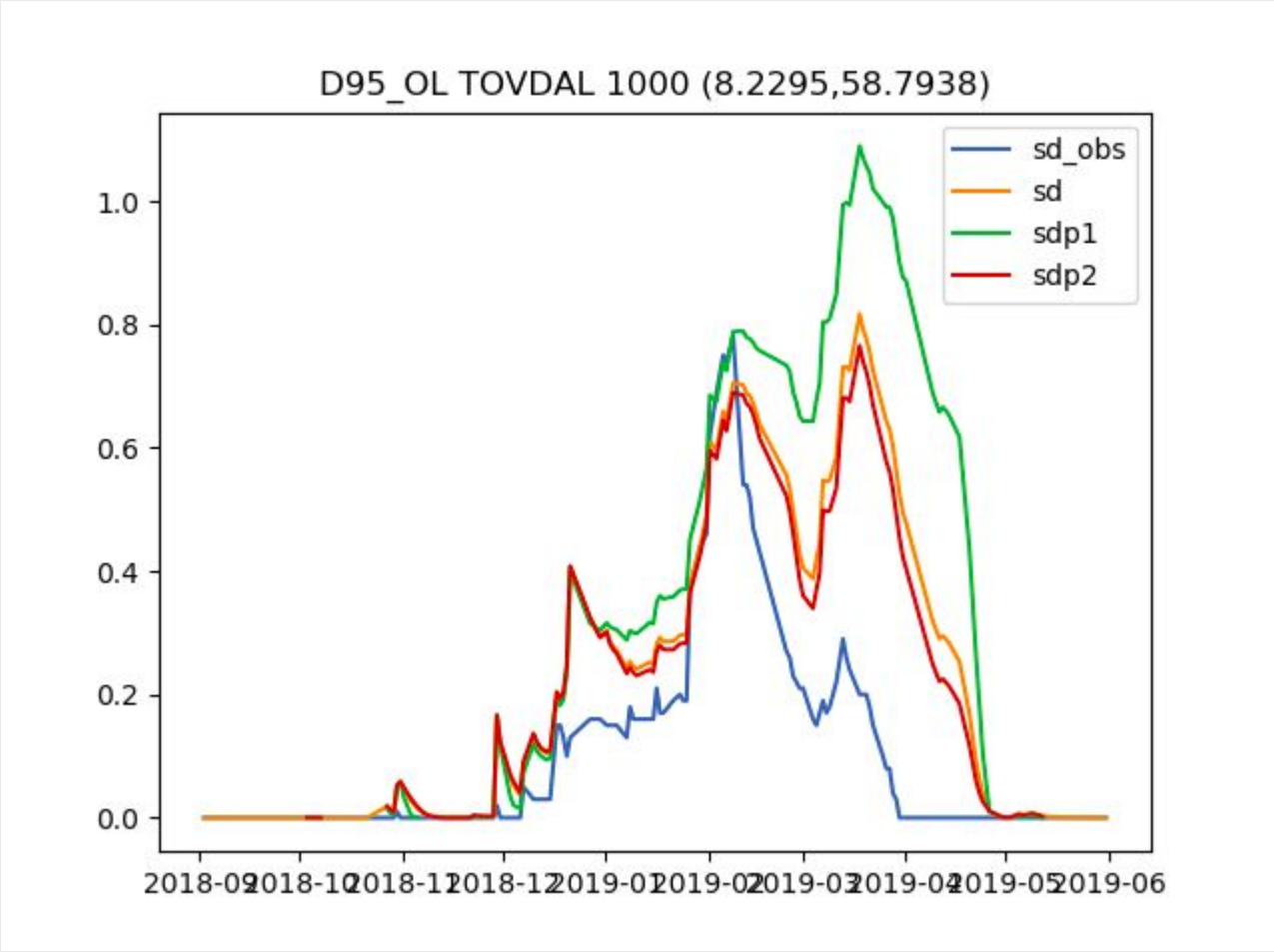

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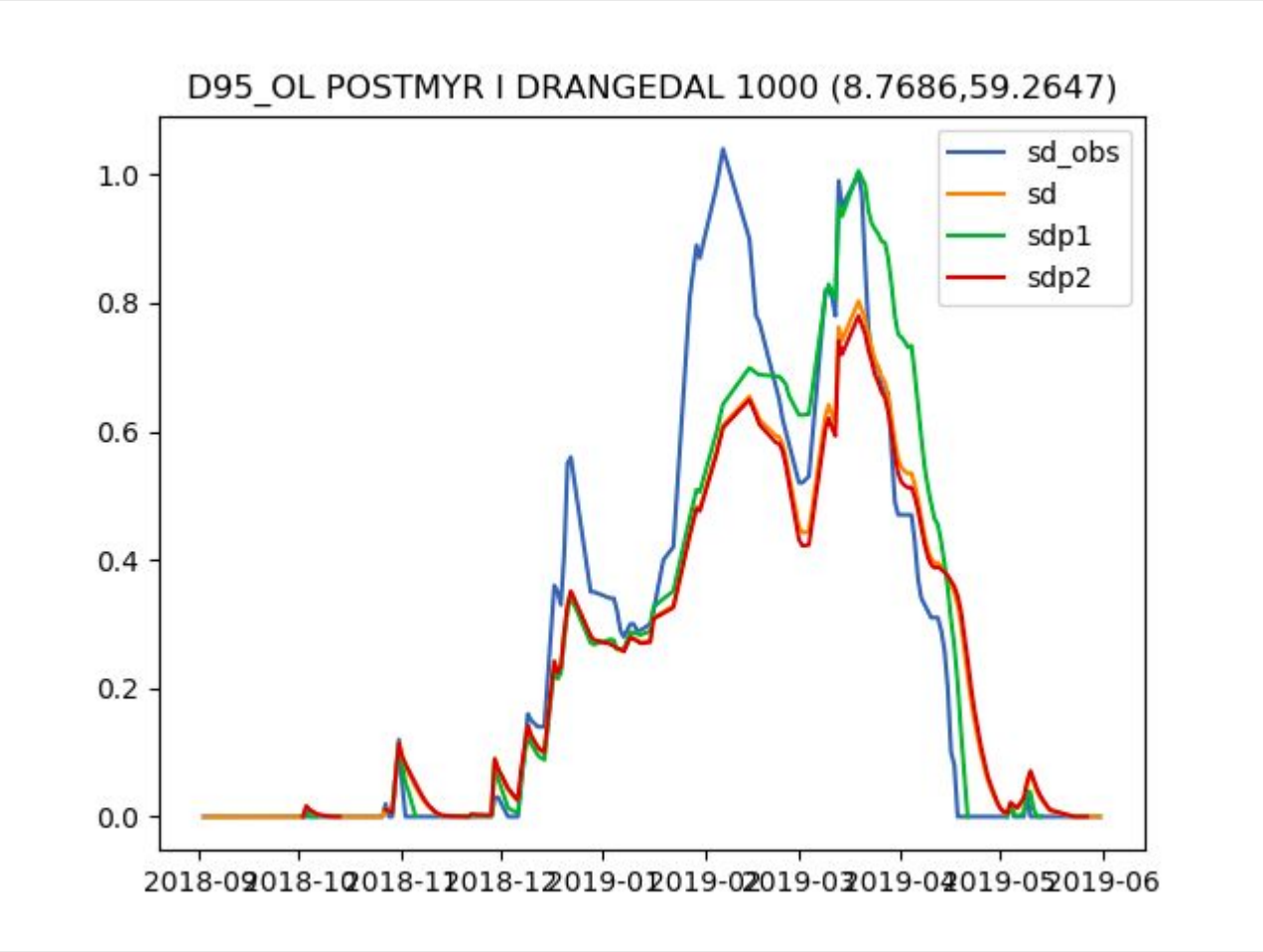

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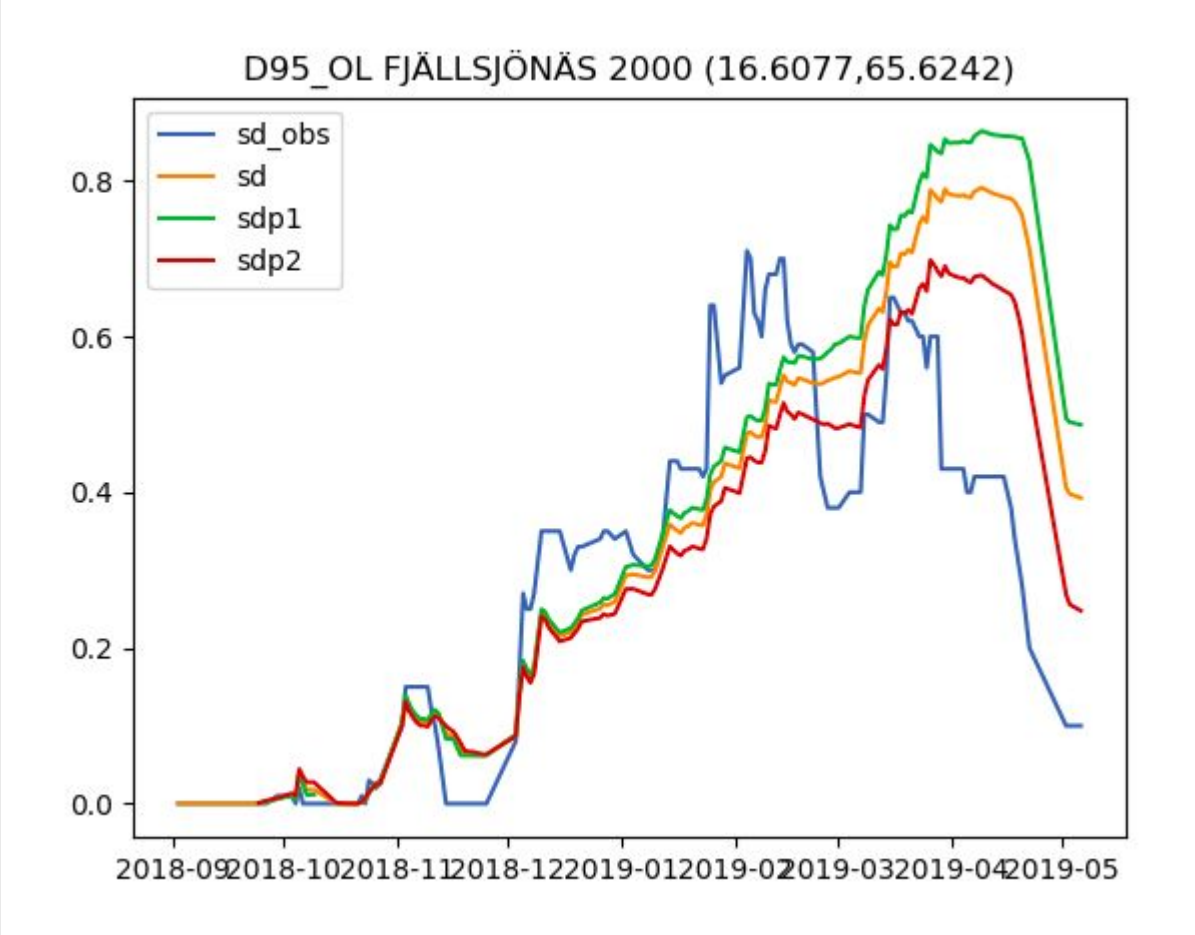

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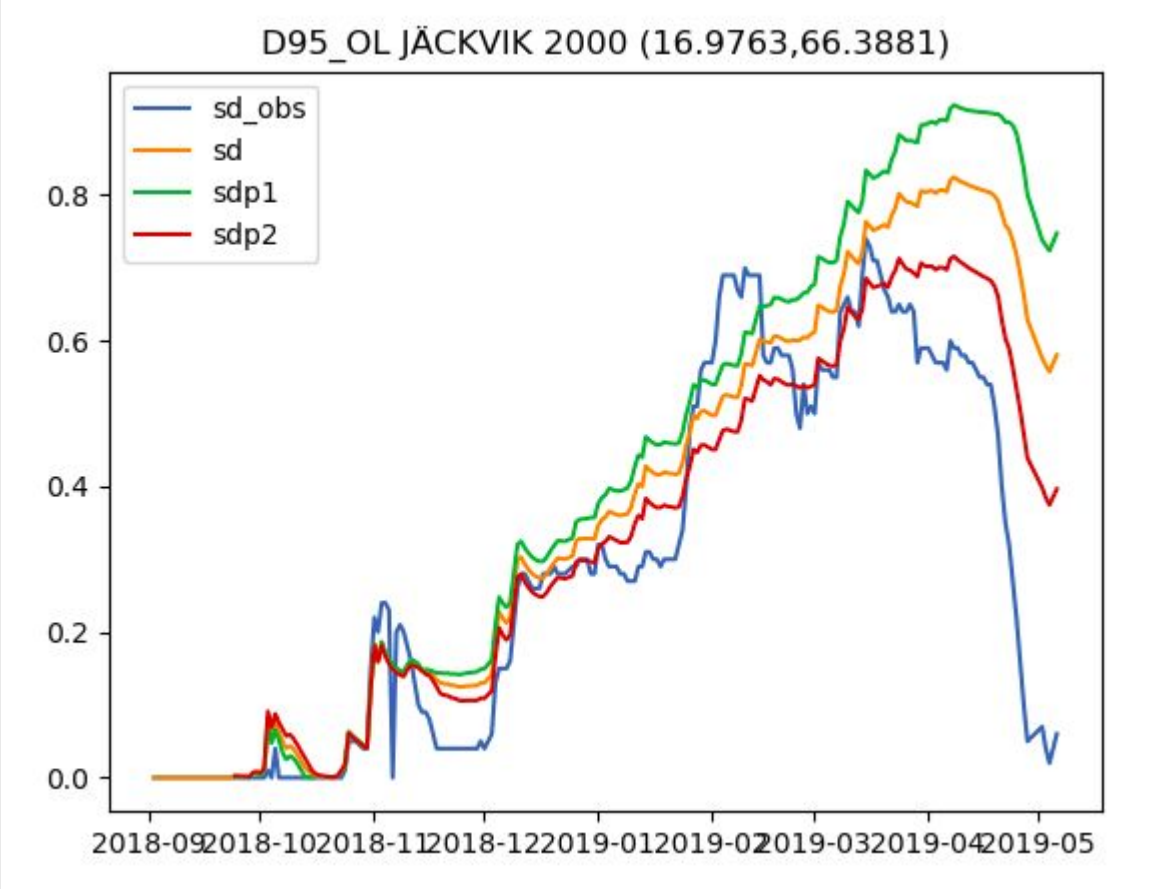

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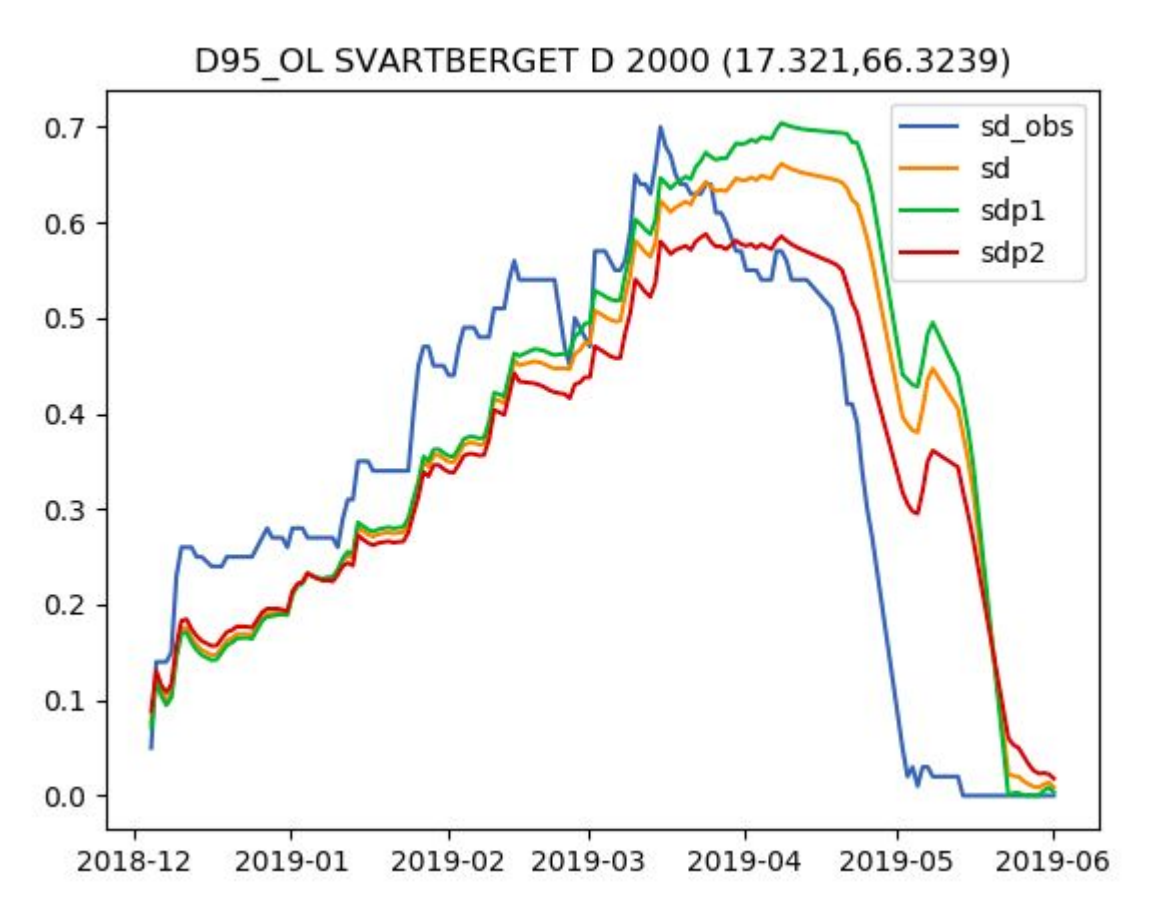

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