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METEOROLOGISKA INSTITUTET
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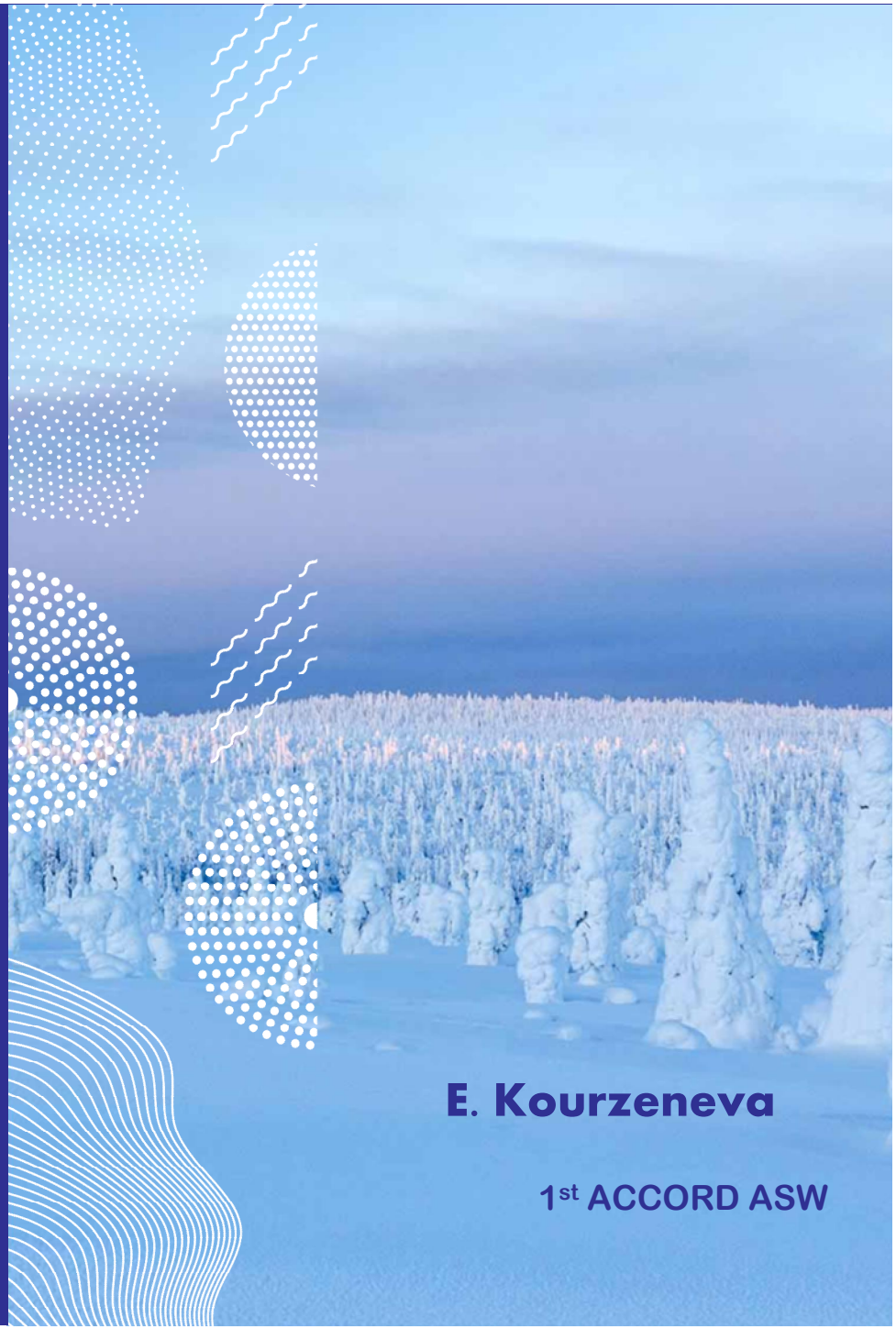
Snow analysis and physiography

12-16.04.2021



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Motivation for the presentation

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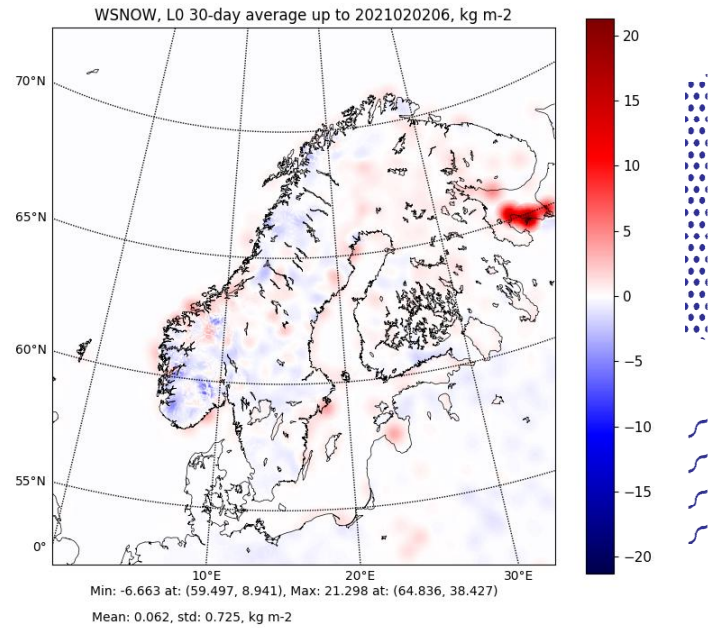
- HARMONIE-AROME CSC: problems with snow analysis over coastal areas in operational runs for MetCoOp. Blacklisting of SYNOP stations.
- AROME CSC (Météo-France): reports no problems in snow analysis associated with the coastline.
- ALARO CSC (LACE): question by Matrina about the old E923 and SURFEX (ECOCLIMAP) physiographies in relation to DA.



Monthly average inc. of SWE for Jan. 2021, kg/m**2

- Different physiographies in DA and in the model: how can it happen? Is it safe?
- Tiles and patches are in SURFEX, but not in DA: is it safe?

Snow analysis is very sensitive to physiography!

Basic physiography, tiles and patches:

<u>CANARI (all CSCs):</u>

Basic physiography: E923, 150 sec

Surface types: water and land (SHIPs and SYNOPs)

Land-water binary mask with 50% threshold

<u>Old ISBA (ALARO CSC):</u>

? The same as in CANARI ?

<u>SURFEX (AROME and HARMONIE-AROME CSCs):</u>

Basic physiography: ECOCLIMAP(SG), 30(10) sec

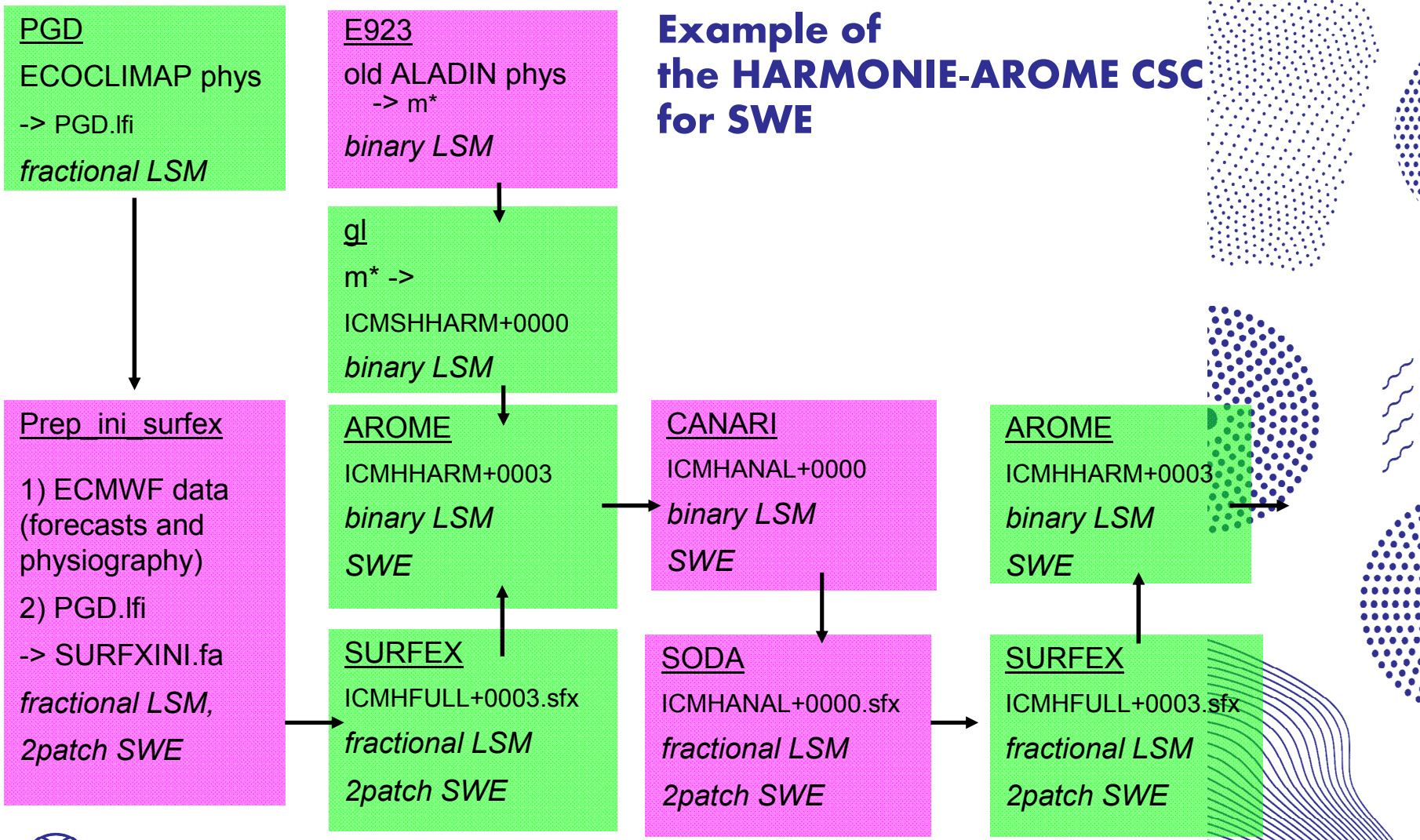
Surface types: sea, inland water, nature, urban
in nature tile: up to 20 patches

Fractions, 0.0 – 1.0

The surface type exists when its fraction is < 0.0

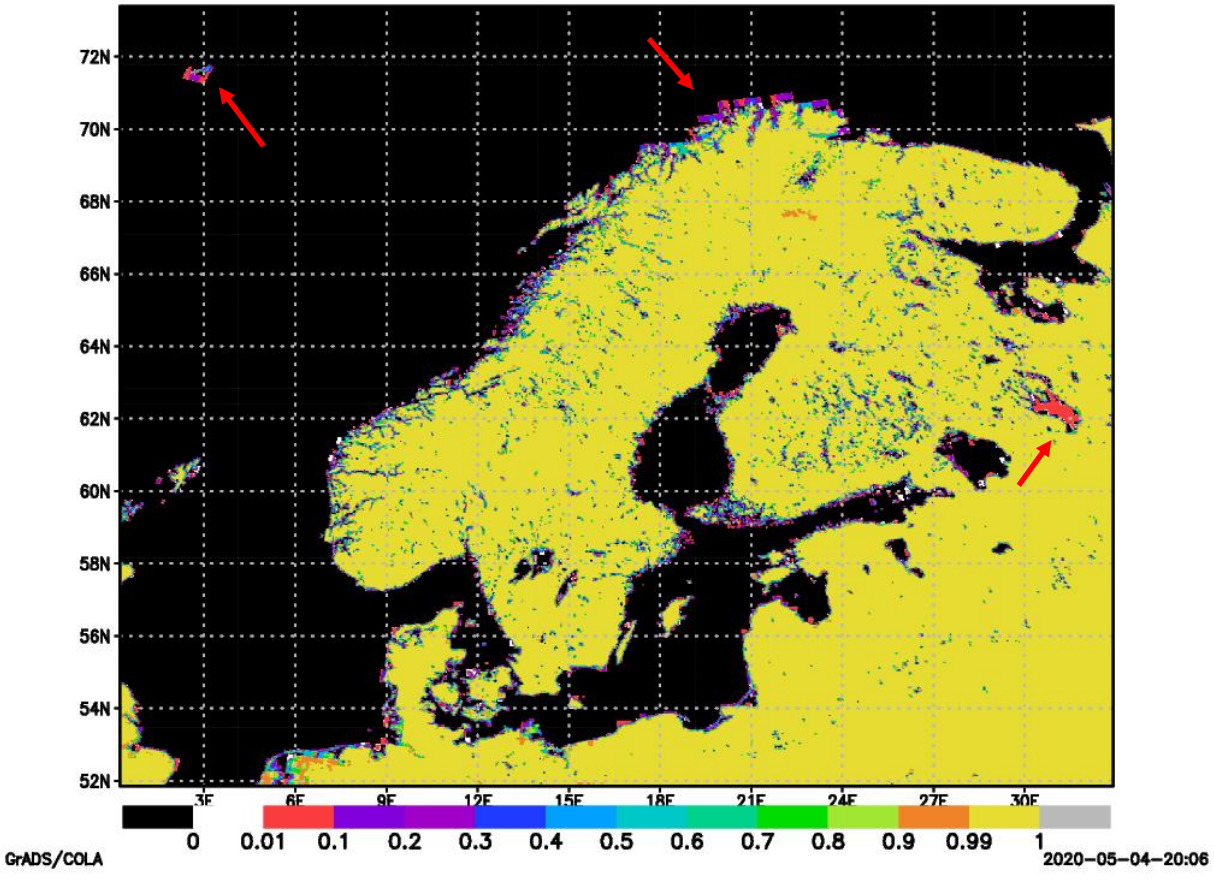
How it is done?

Example of the HARMONIE-AROME CSC for SWE



Issues in E923:

No issues in binary LSM, however in fractional LSM there are artifacts, too small values.
It is not possible to use it even for a temporary solution, to relax the problem.



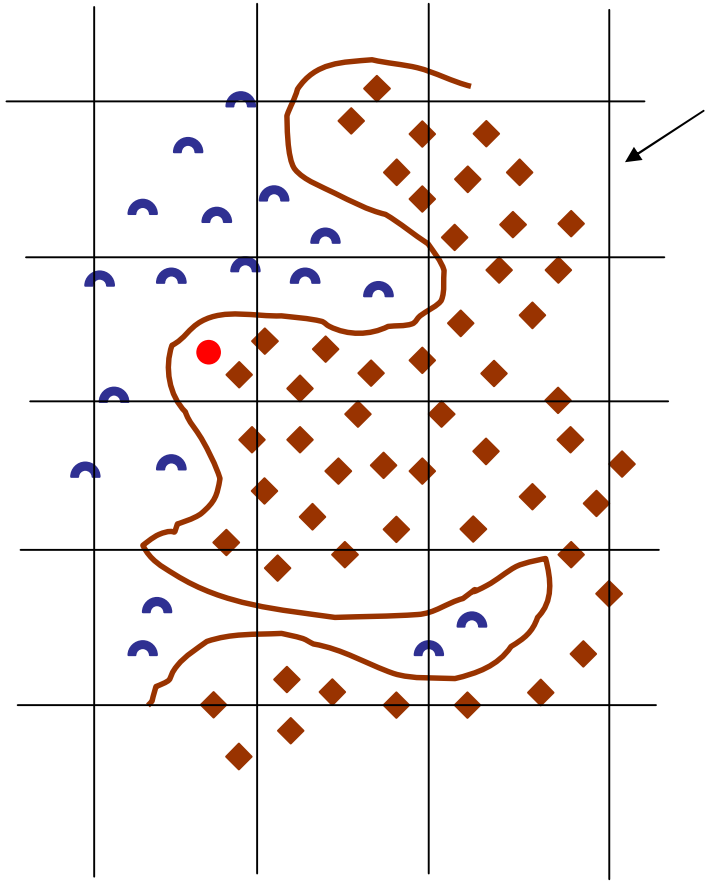
Fractional LSM from m12 file

To remove old physiography

Done

Done but not yet commited

How to apply fractions in land- surface DA?



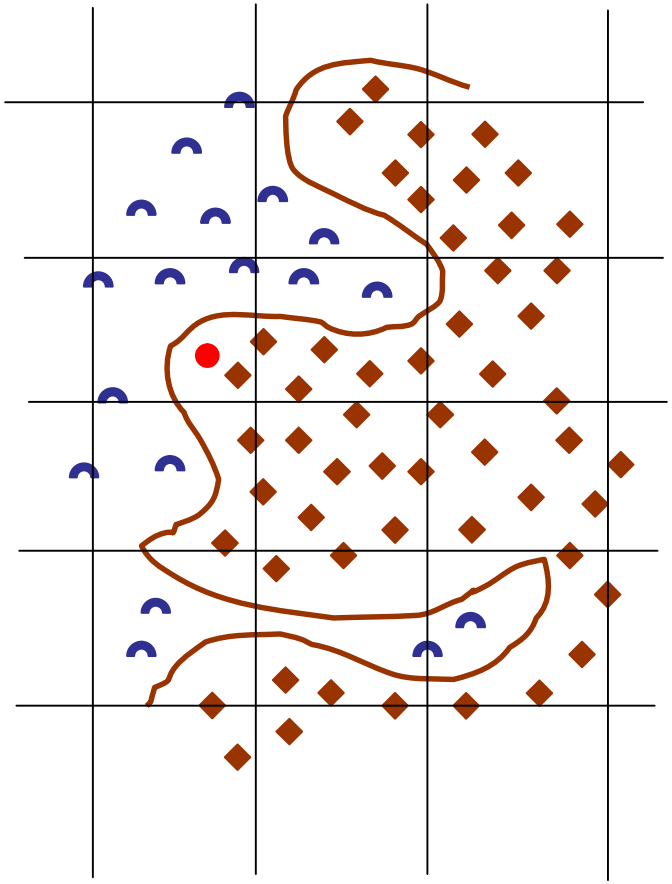
Where snow can exist on this sketch?

Masking with a threshold of 50% for Fr_land is a poor solution in complicated coastline situations.

For snow, something better is needed.

A 0% threshold is not save, due to machine accuracy.

How to apply fractions in land- surface DA?



- Solution from HIRLAM experience: to use double-masking

Fr_land < 5%: only water vars exist, no land

5% < Fr_land < 95%: both water and land vars exist

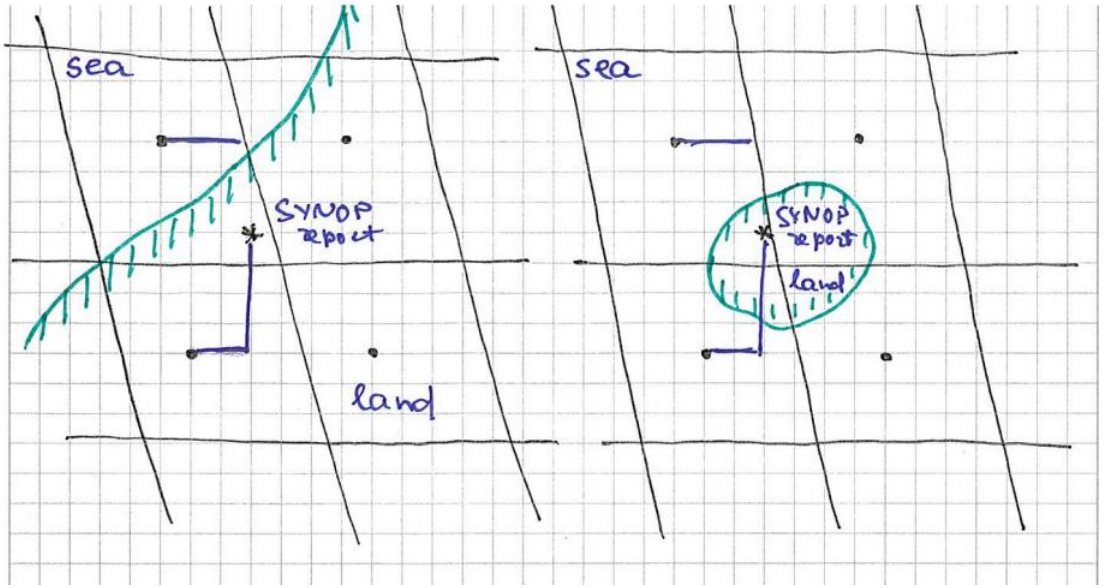
Fr_land > 95%: no water vars exist, only land

- Also, for patches …
- Apply not only for snow, but for soil vars.
- To implement in all parts of the system …

Implemented in PGD
but not yet in PREP (for patches)

Issues in obs operator (CANARI):

- Obs operator is bilinear but land-sea mask dependent interpolation
- When according to LSM there is a land SYNOP station on water or SHIP station on land, the observation should be rejected. But it does not happen in the code, because the surface layer diagnostics does not allow “missing” values
- Correction to CANARI: done, but not yes committed



Issues in ECMWF cold start data:

- HARMONIE-AROME CSC uses the ECMWF data for cold start
- Unlike a pure model, errors in a DA system can persist and even accumulate. Thereby, cold start fields should be accurate
- Due to interpolations in mars, issues appear in the ECMWF fields:

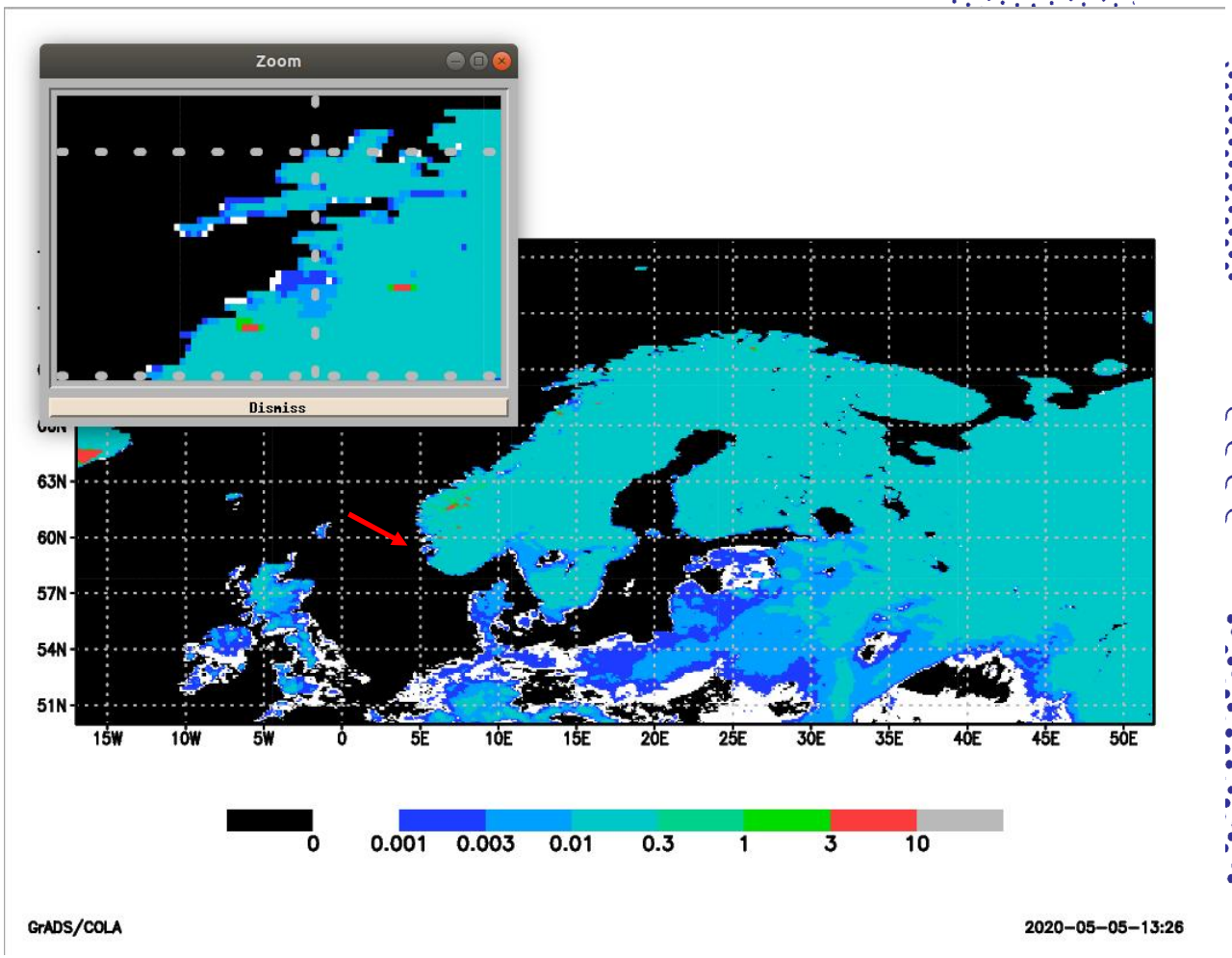
- the ECMWF land fraction is provided, but surface fields are inconsistent with it, as well as between each other;

- currently SURFEX/PREP uses the 50% threshold for masking of the ECMWF data. However, for example the *soil moisture type* var is:
for Fr_land<15% - always UNDEF,
for 15%<Fr_land<86% - can be both defined and UNDEF,
for Fr_land>86% - always defined.
This may be unsecure.

Issues in ECMWF forecasts *(fcYYYYMMDD_HH+006):*

- SWE is smoothed along the coastline
- Large areas of unrealistically small SWE values
- Note: glaciers are modeled with 10 m of SWE (*ca* 30 m of SD)

Corrections in PREP to provide agreement and remove thin snow: done

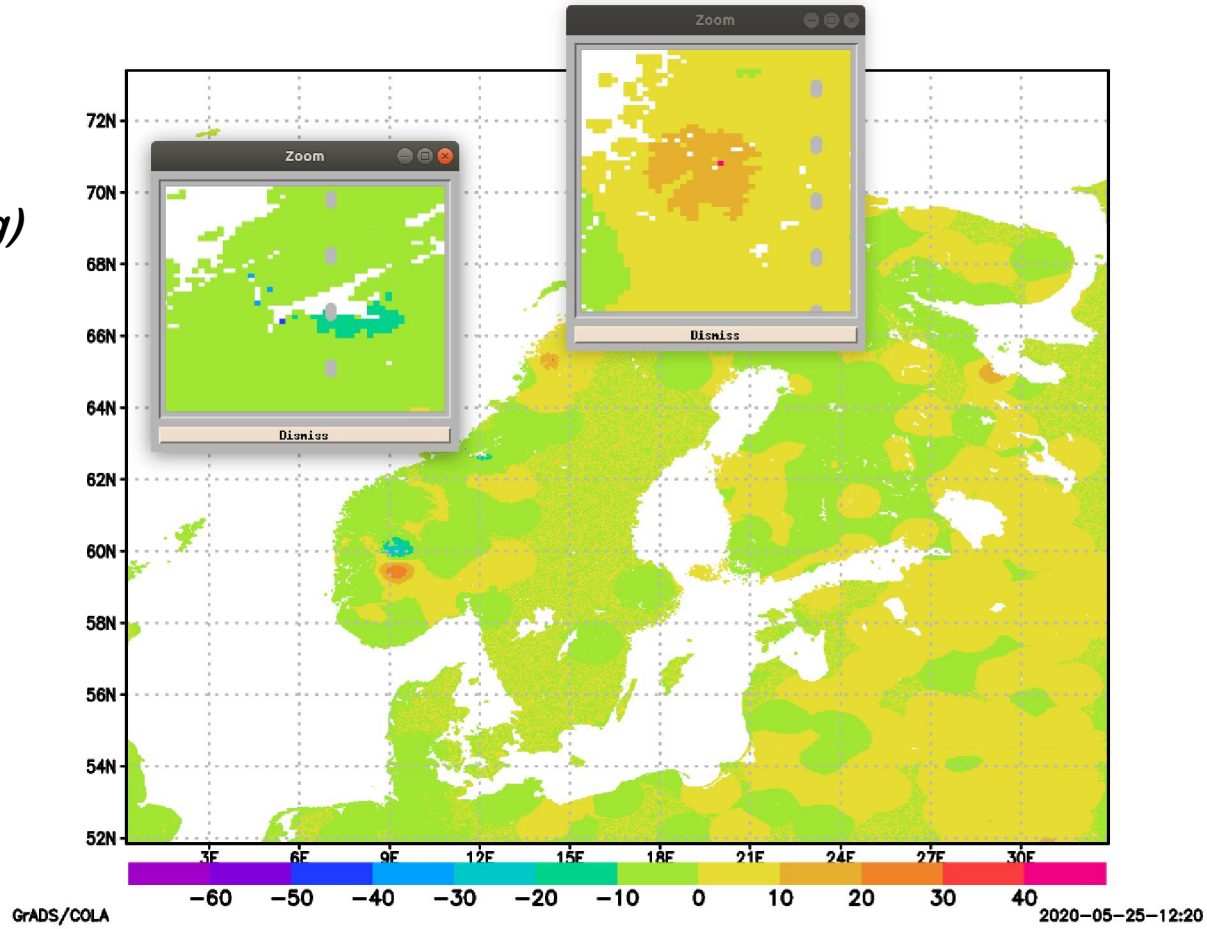


SWE, m, from fc20171214_18+006 file

Issues in SODA

Analysis increments (an-fg) for SWE,mm for 2017.12.19.06, MetCoOp

ICMSHANAL+0000.sfx – ICMSHFULL+0003.sfx Patch 1

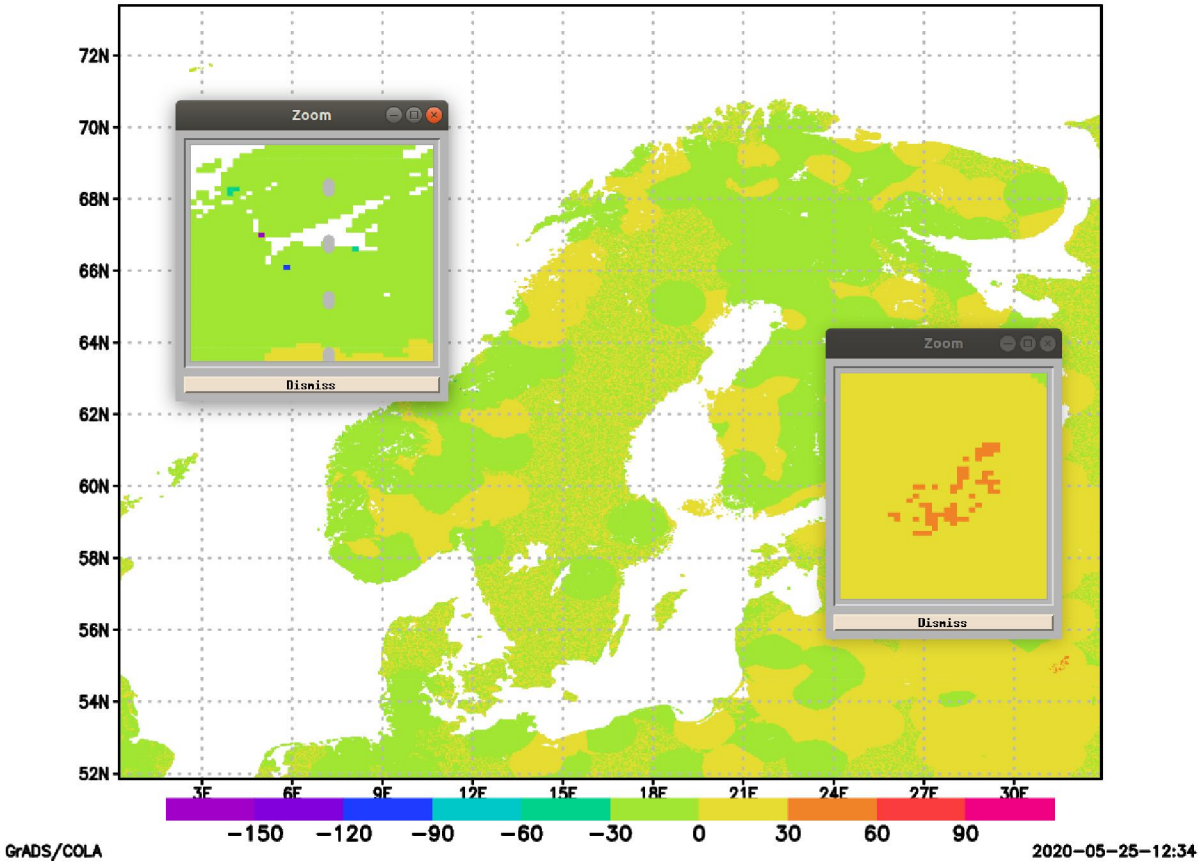


- **Unrealistic increments are associated with the coastline (including lakes) and perhaps glaciers**

Issues in SODA

Analysis increments (an-fg) for SWE,mm for 2017.12.19.06, MetCoOp

ICMSHANAL+0000.sfx – ICMSHFULL+0003.sfx Patch 2



- **Unrealistic increments are associated with the coastline (including lakes) and perhaps glaciers**

- to be studied

Summary and further steps for HARMONIE-AROME CSC:

- Fraction of land from PGD is inserted into m* files.
- Fraction of land in PGD is limited from both sides with a threshold which may be defined from the NAMELIST (currently, 5%).
- Security for the cold start is provided in PREP, by ensuring the consistency between the fraction of land and other soil fields of ECMWF and by removing unrealistically thin snow with the threshold defined from the NAMELIST (currently, 1 kg/m**2).

- Work with patches in PREP (ongoing).
- Fractions and obs operator in CANARI: transferring the code to cy43h, to make commit
- Work with SODA
- Smth. else may appear

General conclusions:

- Snow analysis is an indicator of physiography problems
- Different physiographies in DA and model parts of the system are possible with interpolations (aggregation/disaggregation) at each assimilation cycle. This solution is crude and in general unsafe. We need something better. The work is ongoing
- Tiles and patches existing in the model, should be (at least partly) taken into account also in DA. The work is ongoing
- ECMWF surface fields need pre-processing when using them for the cold start

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Thank you for your attention!

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