Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Recent modifications in global Snow observation network

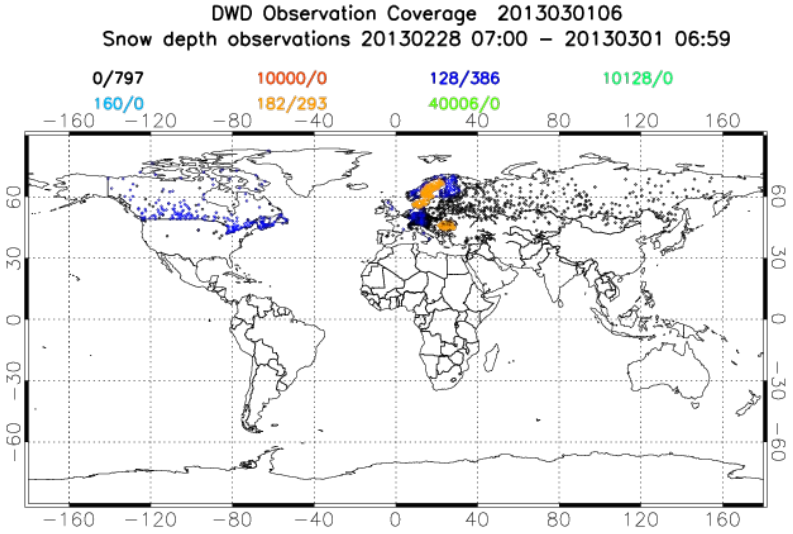
Martin Lange DWD

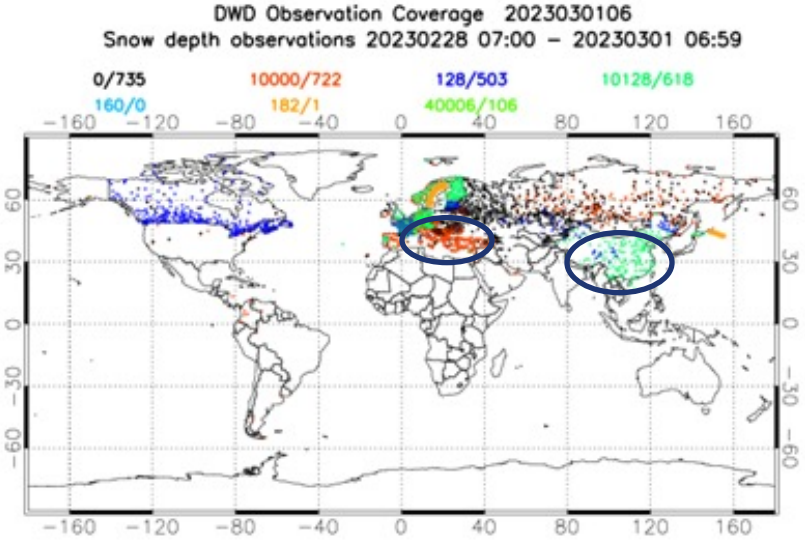
Outline

- Introduction to recent development of snow depth reporting
- First delivery of Snotel snow data
- Snotel Model-Observation Statistics
- Validation of last winter using NOAA Madis archive data
- Use of the data
- Summary

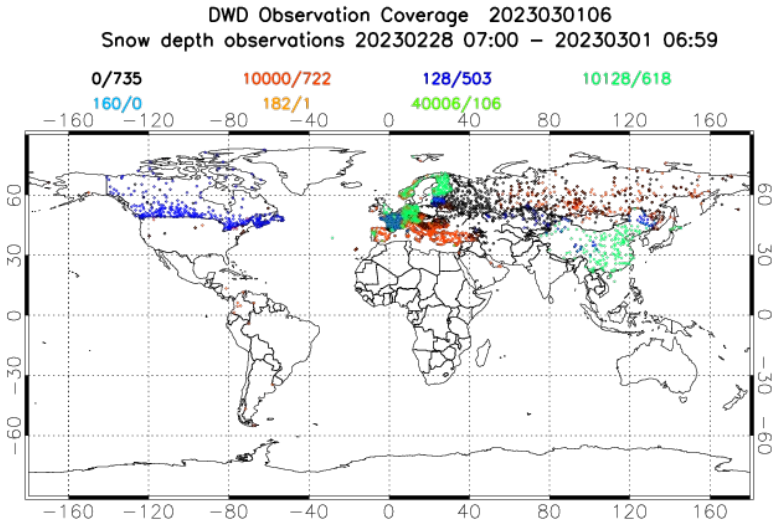
Snow depth reports in GTS March 1, 2013 vs. 2023

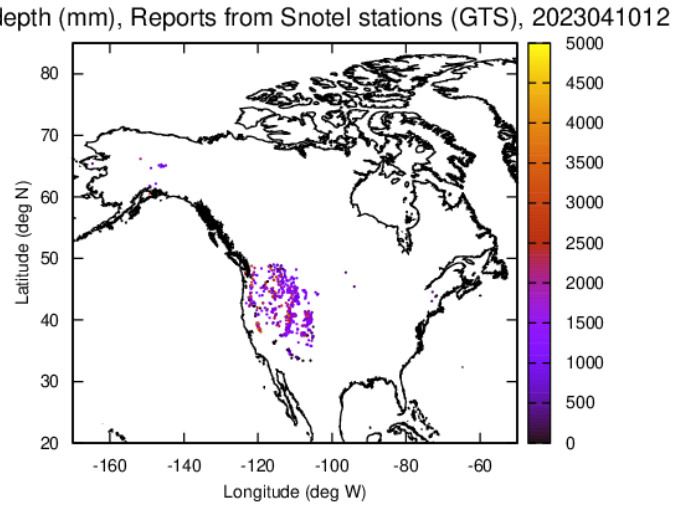
Improvement of snow reporting practice in several European countries in particular in the southern east and Kasachstan. Success from activities of GlobalCryosphereWatch Initiative and ECMWF





Around 1000 new observations in western US from Snotel network reported in GTS



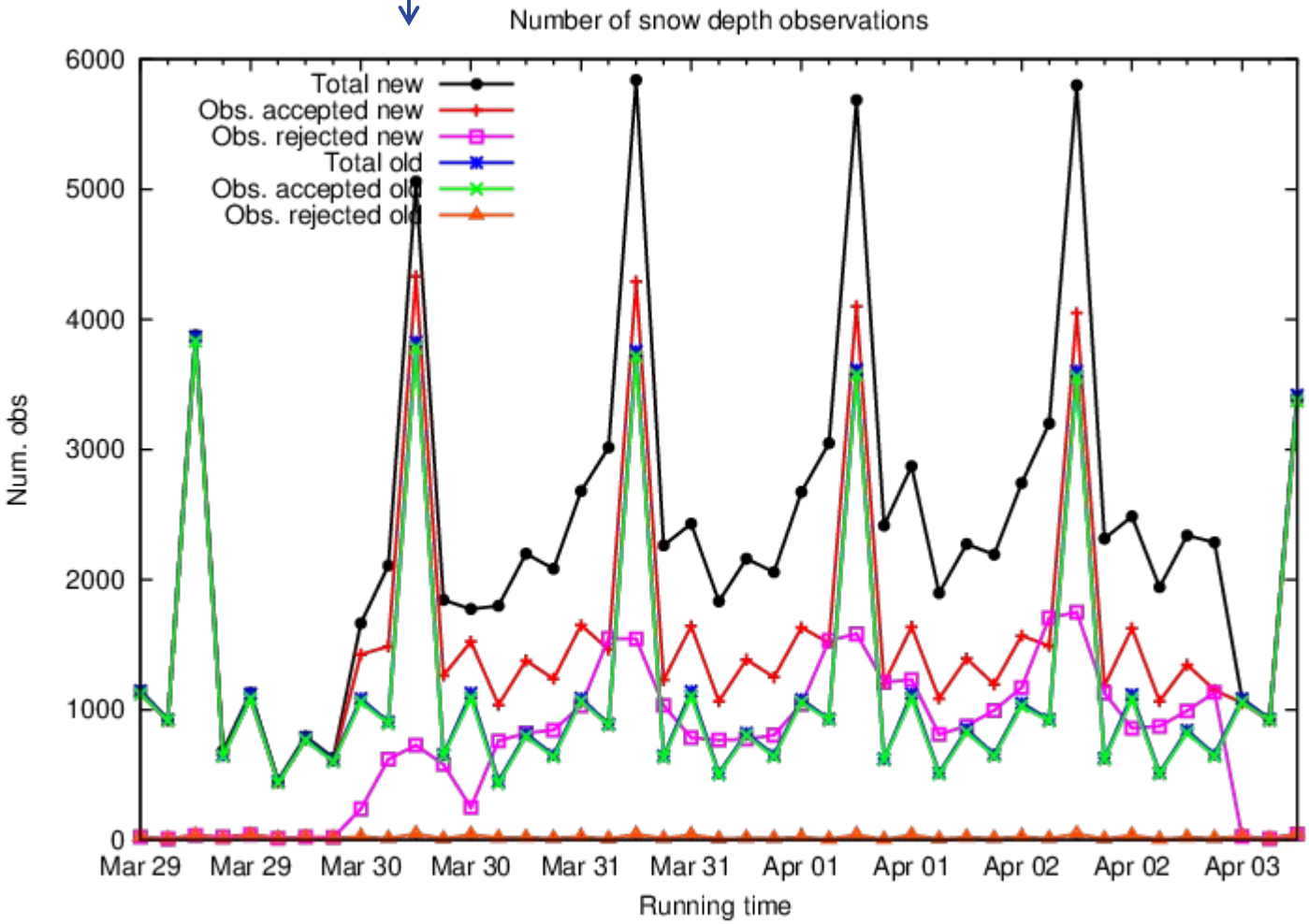


Snotel data delivery started with crash of snow analysis in operational cycle

Snow analysis failed for 03:00 UTC assimilation cycle from March 30, 2023

- New snow depth observations from SNOTEL network in western US und Alaska
- Data were anounced for march, 29, 15UTC
- Data flow started with gradually rising number of data in growing subsets.
- At 30.03. around 09:00 snow depth from 8000 subsets were delivered.
- The size lead to crash in bufr decoding part with memory error.

More than
1000 new obs



Action in operations

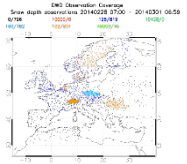
- Source of Error was identified as the data were very well announced before, and discussion with IT section took place in advance (attention flag was set).
- Action: Observations are rejected in database retrieve
  - Use of identifier internal ID (type 182) and Originating Center (8).
  - Skip use of data until problem solved and data are tested.
- No delay in production ☺.

Why ?

Reason for fail in 3:00 UTC analysis at March, 30

Combination of different bad facts

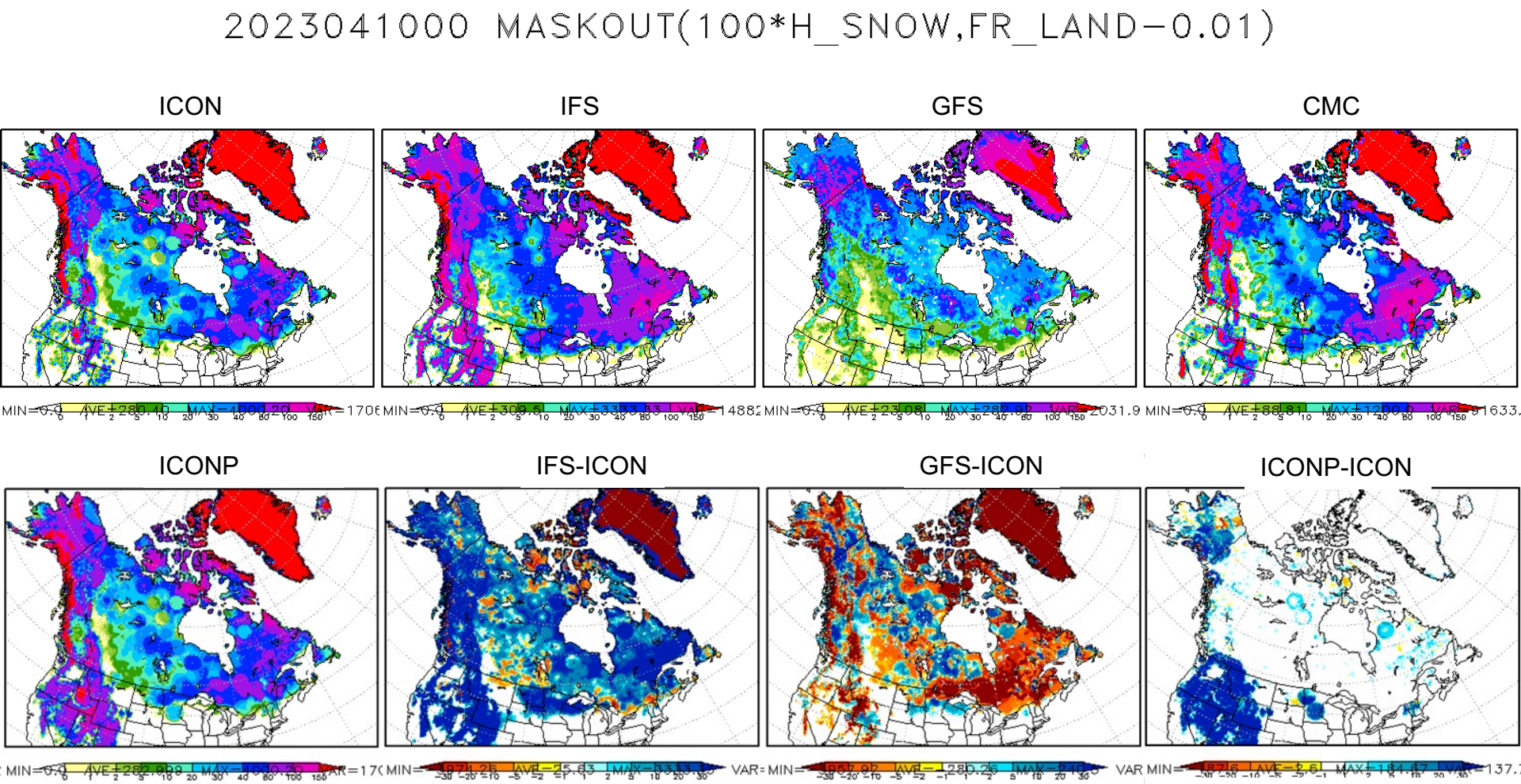
- Bufr are combined as Subsets and lead to fail due to big size, normally single reports are no problem.
- Synop reports which consist of multiple subsets are generally split into single reports before use. US data are coded as upper air, indicator „ius“ and are not split.
- Bug in dwdlib, generally the processing should not be a problem.
- The snow bufr template from ECMWF is commonly used for snow reports from other centers. Therefore no precautions were taken.



Corrections to use the data

- Split data into single reports solves the failure in dwdlib.
- Bugfix in dwdlib was shortly introduced, no split further required.
- Start using the data in parallel routine with plan to introduce them into operations after one or two weeks testing („New snow depth observations should improve the system“).

Very strong impact on analysis in ICON-Parallel Routine (more snow than IFS which shows highest values)



Courtesy Helmut Frank, DWD

Reduce impact of Snotel obs

- Strong impact pulls ICON off from own state
- ICON sd exceeds all other analysis
- Measurements are dense leading to overweighting
- Not desired, reduction of observation impact desired
  - ➢ Investigate Snotel data more detailed before further use

Model orography in Snotel domain ~1000–3000 m

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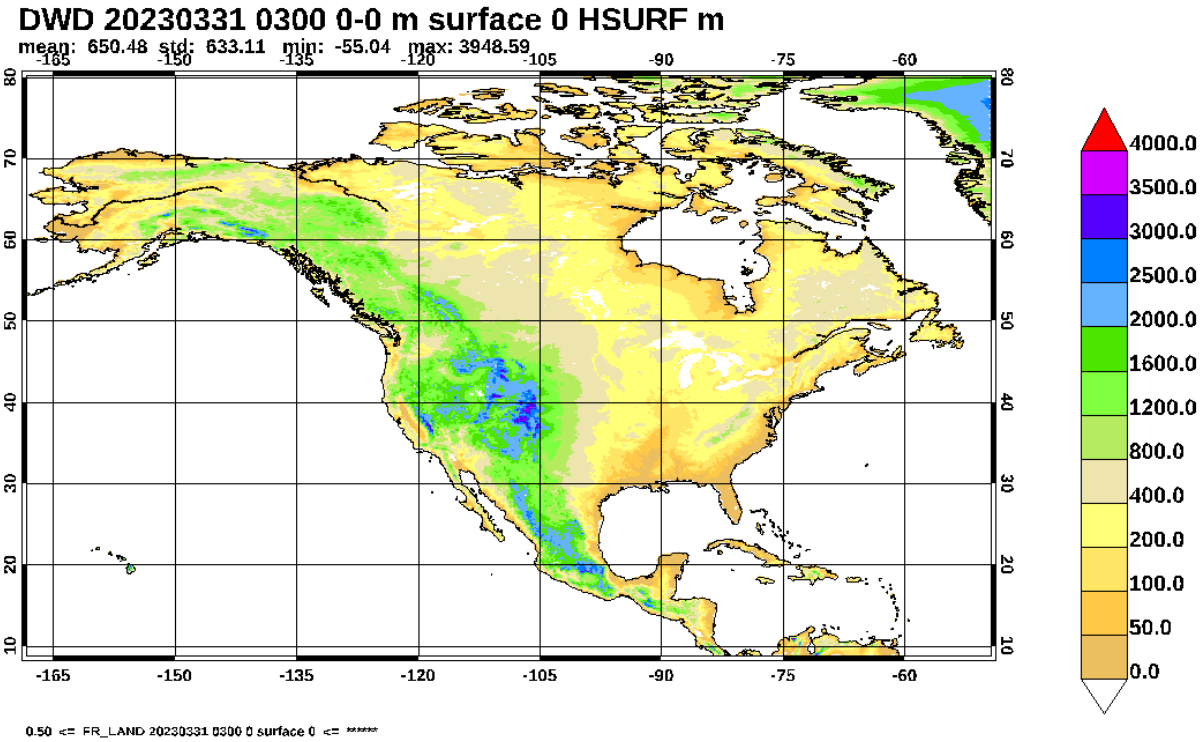
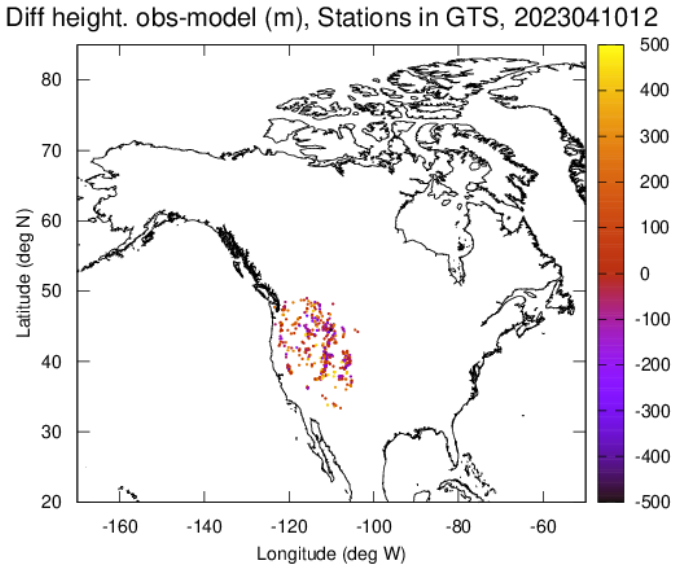
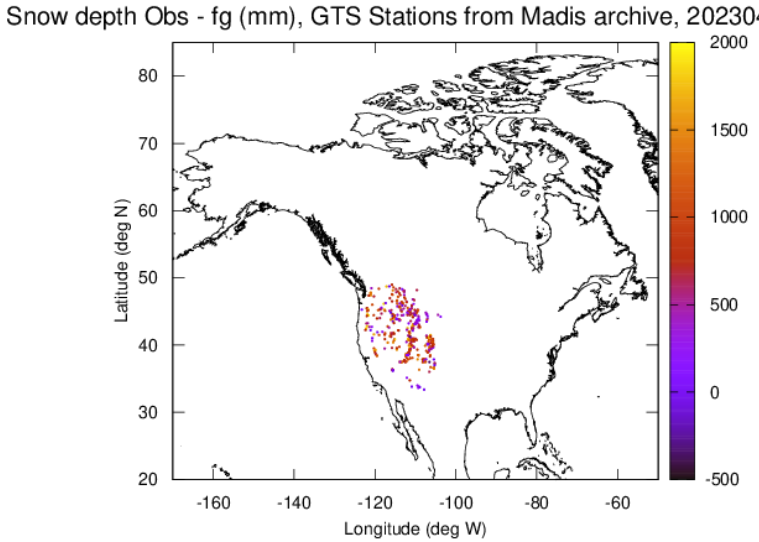
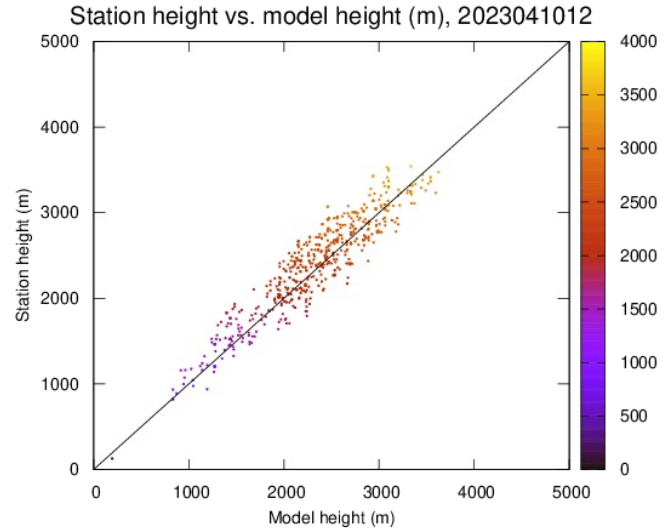
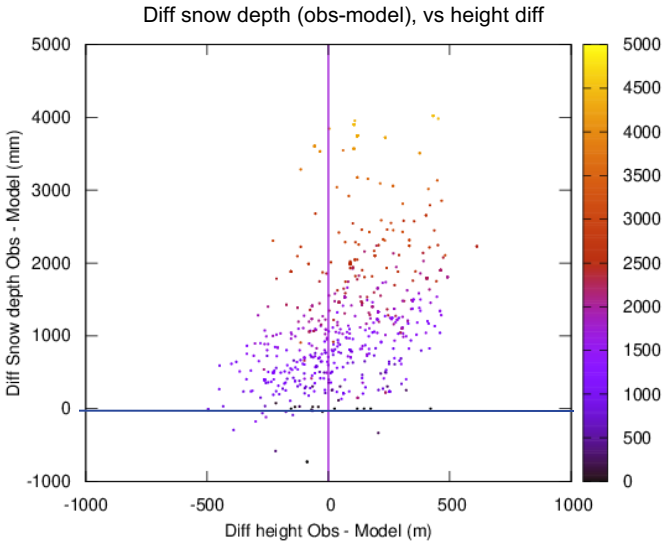


Station height almost > model height
Model generally underestimates Obs









Where does the overestimation end of march come from?

- Due to some strong snow events which were missed in the model
- Continuous underestimation of snow fall through the winter season

To investigate archive data from Madis archive were used.

Access through NOAA MADIS web site.

https://madis.ncep.noaa.gov (see /faq_historicaldata.shtml)

-> Animation of o-f timeseries

Snotel observations are subset of Madis data

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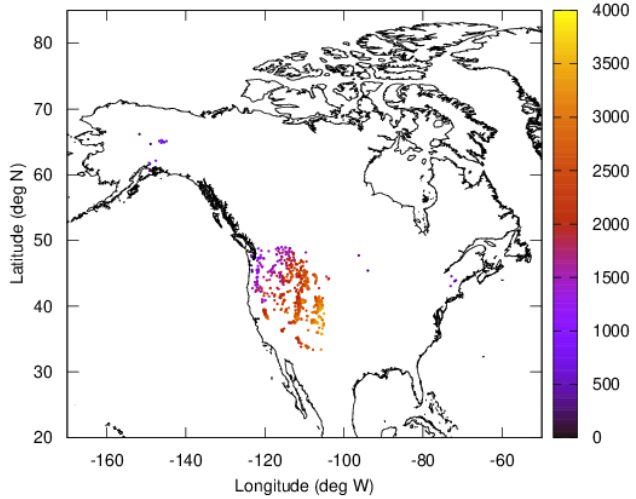
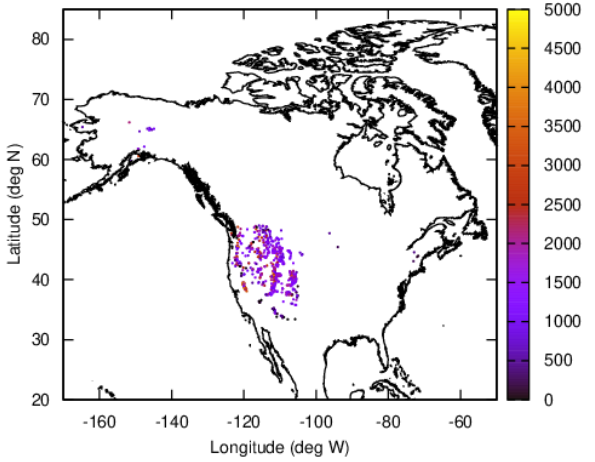
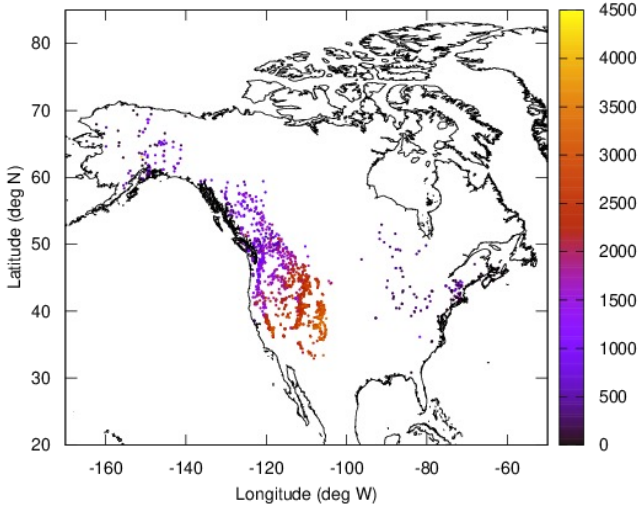
Station height (m), Reports from Snotel stations (GTS), 2023041012



Snow depth (mm), Reports from Snotel stations (GTS), 2023041012



Station height (m), Reports from Madis archive, 2023041012



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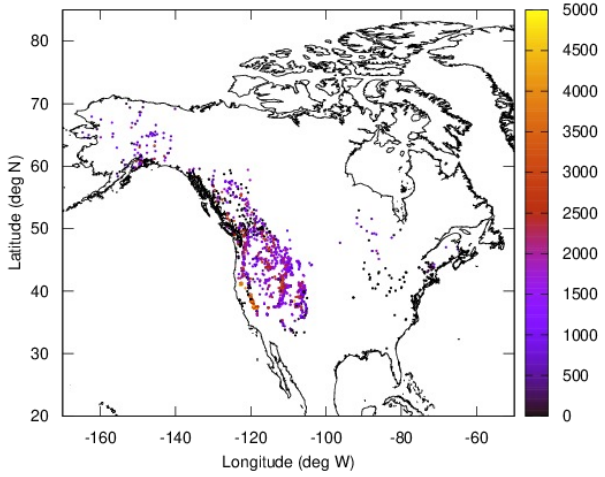

Animation obs – model over Snotel stations

Reduce impact of Snotel obs

- Pragmatic solution, compromise between using the observations and not putting too much effort in old fashioned Cressman type analysis.
- Data thinning by limiting vertical obs-model displacement.
- Artificial reduction of snow depth applying factor increasing with station height and vertical displacement obs-model height.
  (higher snow depth is beneficial for skiing resorts ;-).

Snow depth reduction factor decreases with increasing vertical displacement (obs-model)

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$$sd(ass) = f_{red} \times sd(obs)$$

$$f_{red} = Min\left[exp\left(\frac{Min(-zdh, 0)}{z_{scale}}\right), 0.7\right]$$

$$zdh = z_{obs} - z_{model}$$

$$z_{scale} = Max\left(h_{min}, Min(h_{min} + 0.2 \times (h_{stn} - 1500.), h_{max}\right)$$

$$h_{min} = 200\,m$$

$$h_{max} = 500\,m$$

$$if(zdh > 1.5 \times z_{scale})\, w = 0;\ w = obs - weight$$

No weight given to obs if
dz(obs-fg) >1.5 x zscale [300 m, 750 m]

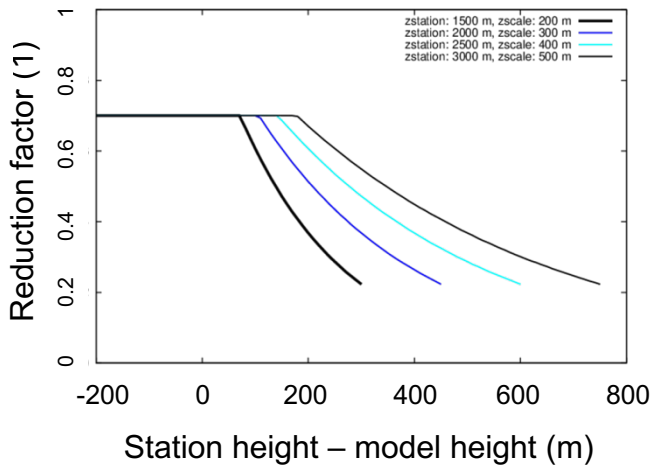
Modification of assimilated snow depth

Reduction factor

Vertical displacement obs-model

Scale changes between 200-500 m
for station height from 1500-3000 m

Reduction of snow depth at Snotel sites



Snow depth correction for zobs-zmodel > 0

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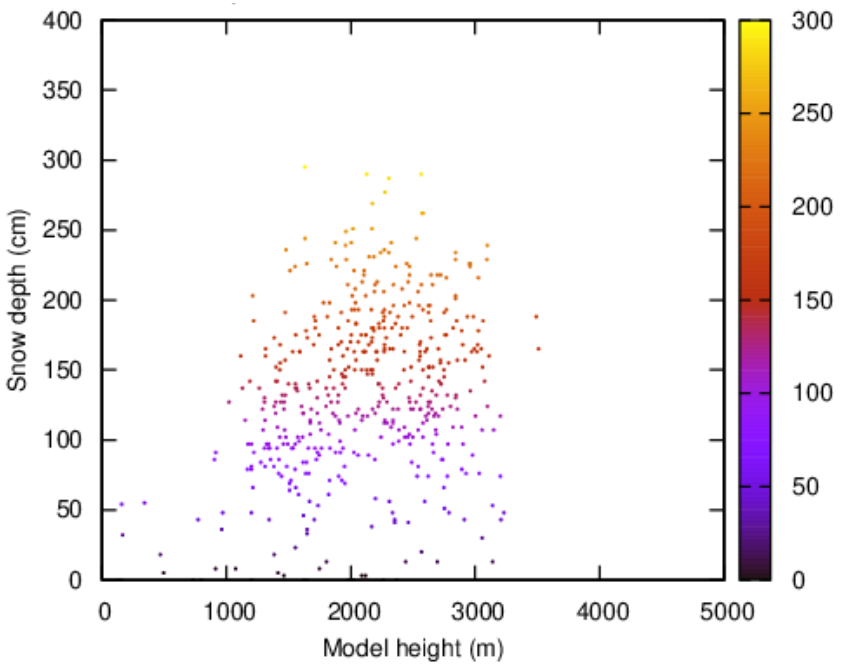
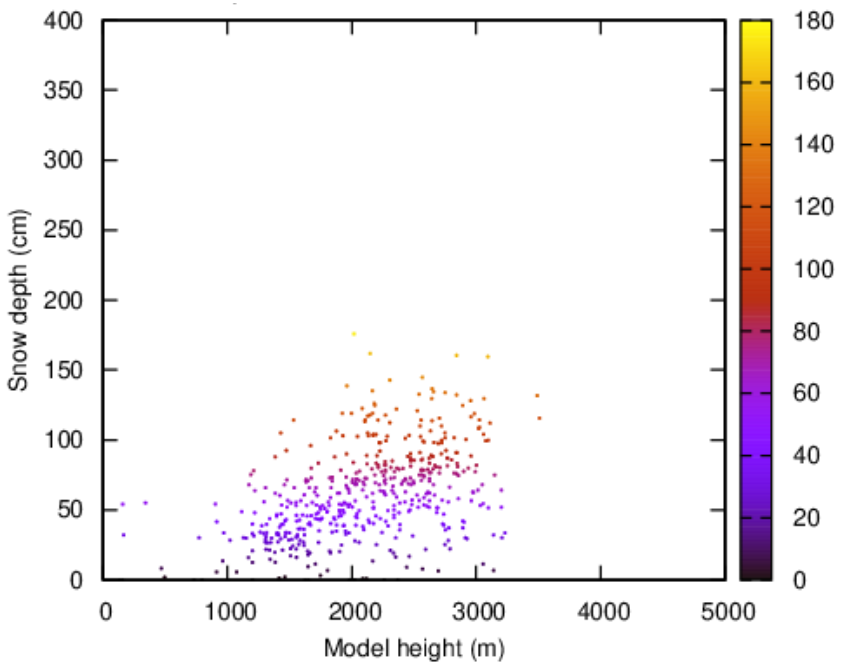
Snow depth, West US, 2023033106, old



Snow depth, West US, 2023033106, new



Impact Snotel obs on the analysis

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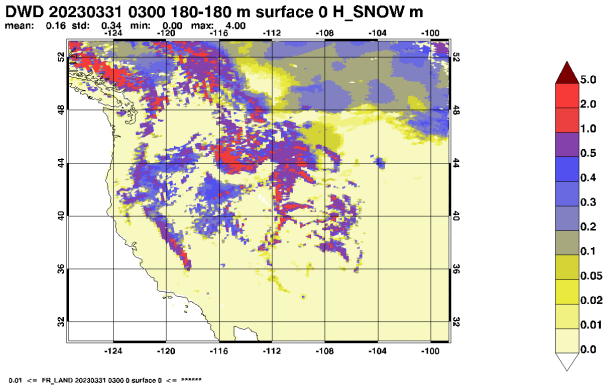
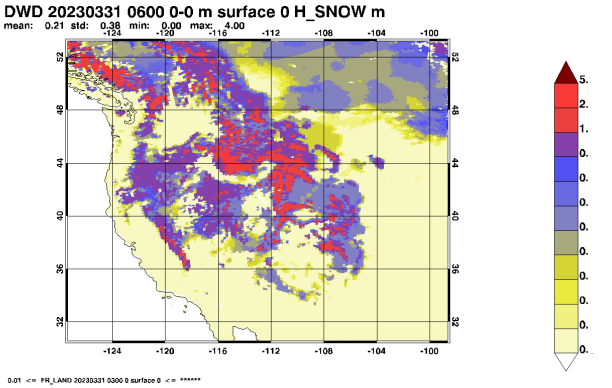
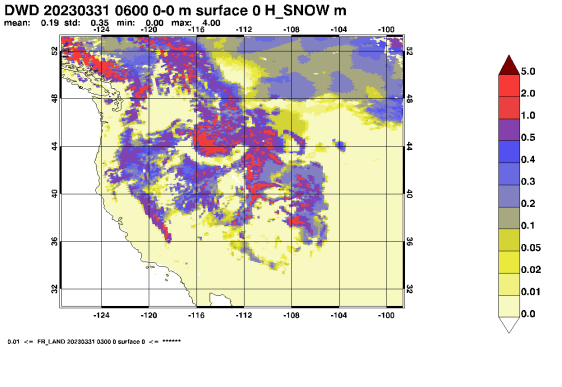
First guess (no snotel)



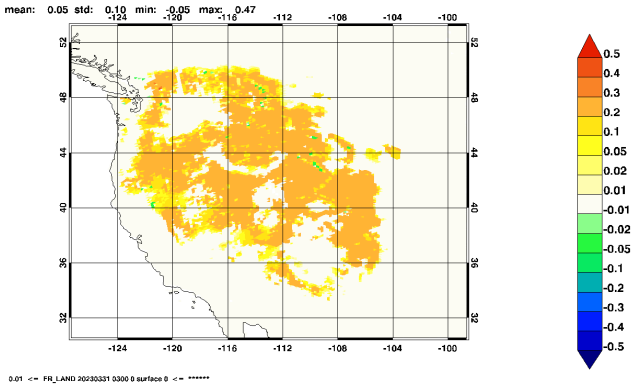
Old scheme



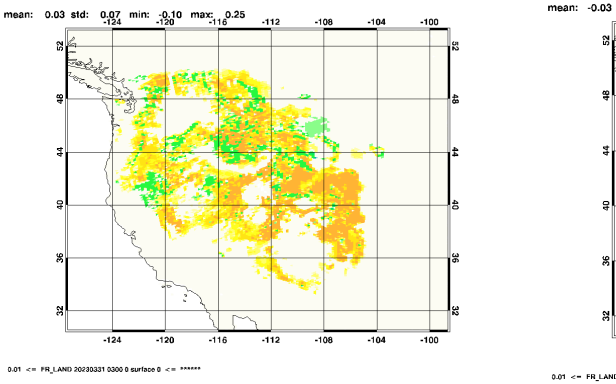
New snow correction



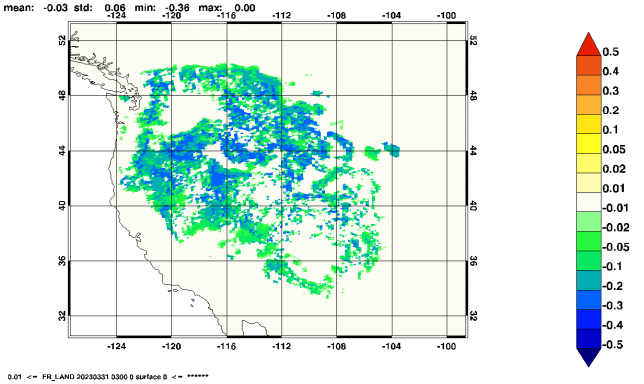
Ana-Fg old



Ana-FG new



New-old



Reduce impact of Snotel obs

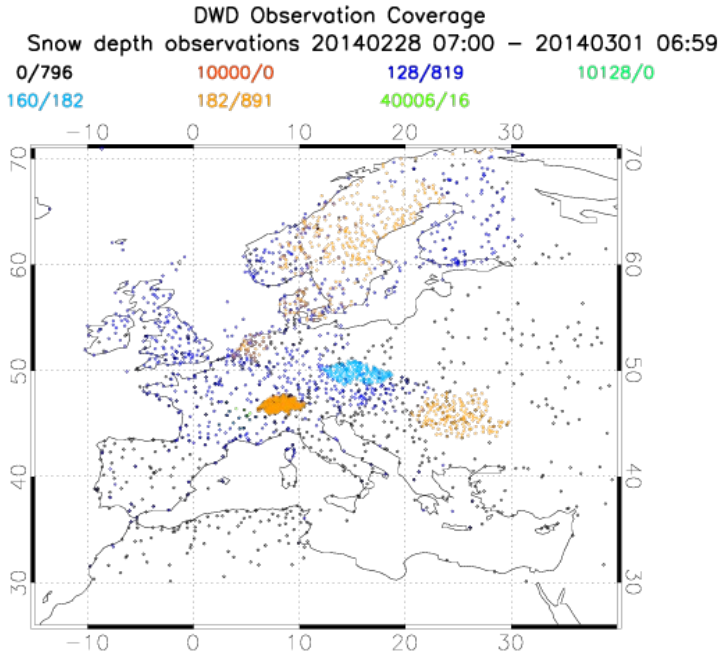
- Experiment outlined using reduced impact pulls results closer to observations
- Scores for the 4 week period mixed
- Plan: Further testing for the upcoming winter before introduction.

Summary

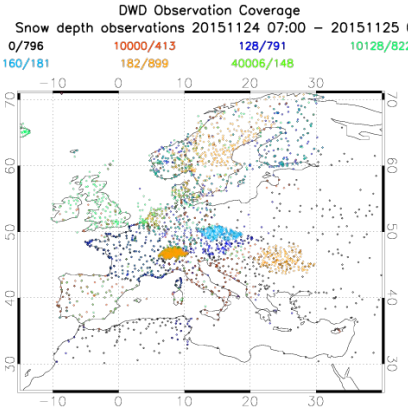
- New conventional snow depth observations in data sparse regions discover impressively model deficits.
- Thanks to continuous work of GCW and activities at ECMWF Snotel network is now available in GTS.
- High elevation data need careful handling. Pragmatic solution might help to accelerate usage of the data.
- Large domain covered by Snotel network and long dataset available via Madis data service offers excellent base for model evaluation, but also
- for evaluation of microwave derived snow water equivalent from satellites. This product has high potential to discover model deficiencies in data sparse regions. Better representation might very much improve snow mass estimation in earth system modelling which is also important for temporal availability of water resources in mountaineous regions.

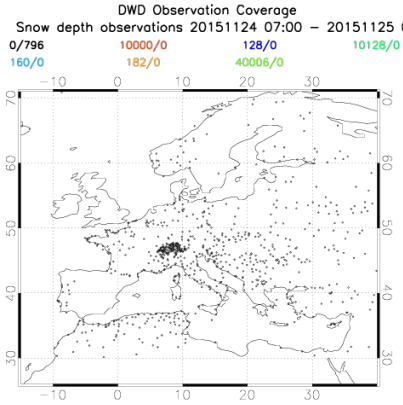
➢ Evaluation and improvement of mw-derived SWE with long-term Snotel data, model studies assimilating the data.
➢ If positive impact can be shown, recommendation of microwave missions is supported.

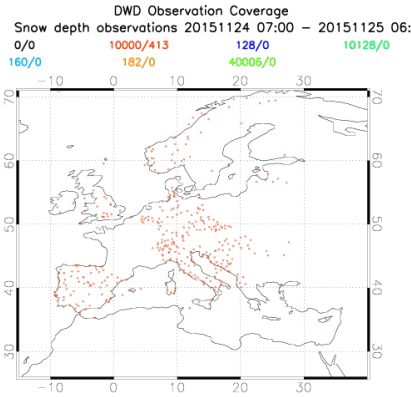
- The snow bufr template from ECMWF which is used is common for snow reports from other centers. Therefore no precautions were taken.

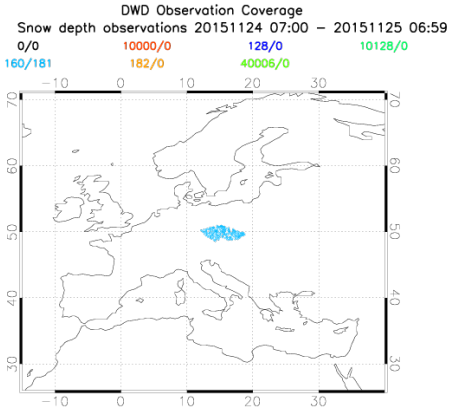


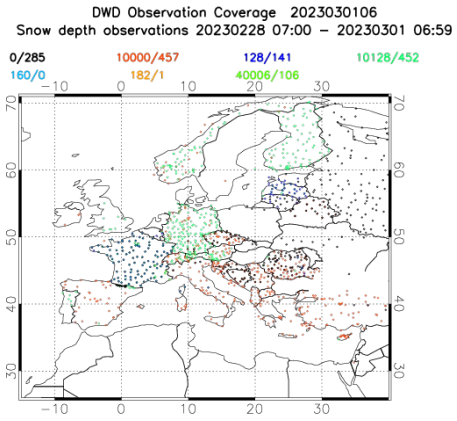
Snow depth reports in GTS End 2015 vs. Mar 2023

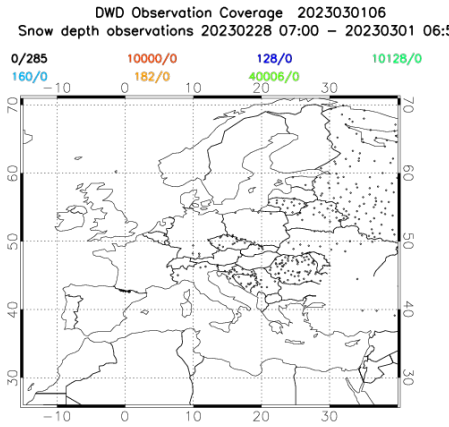


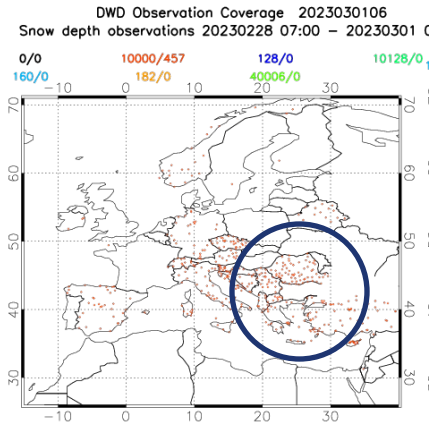


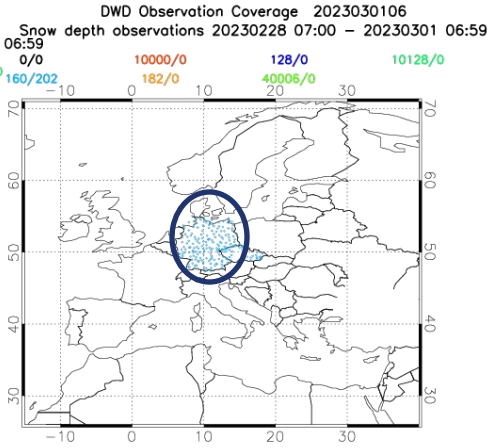












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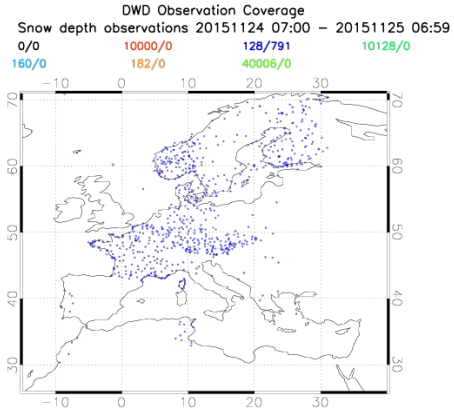
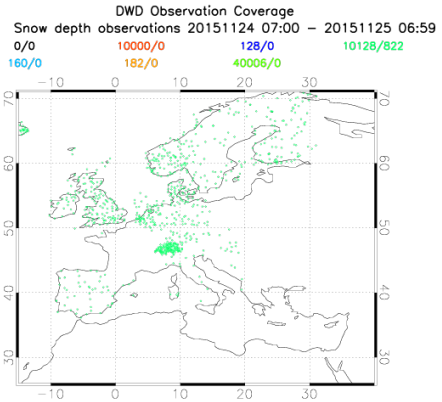
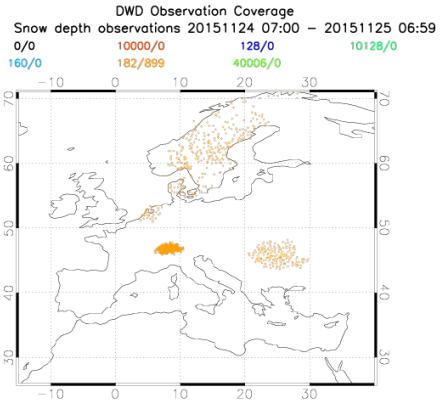
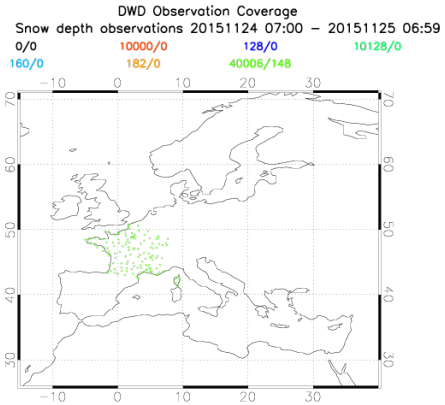
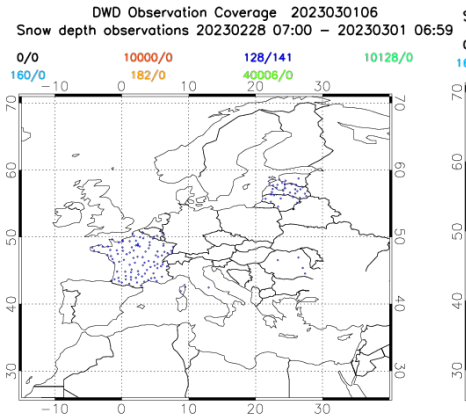
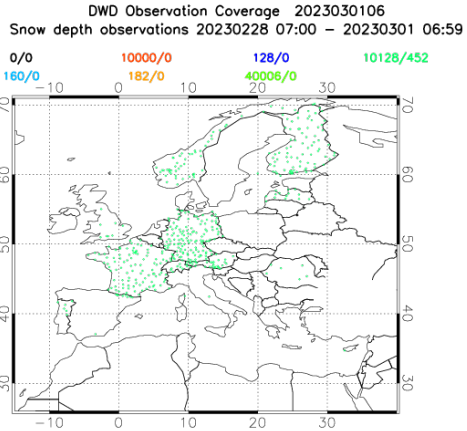


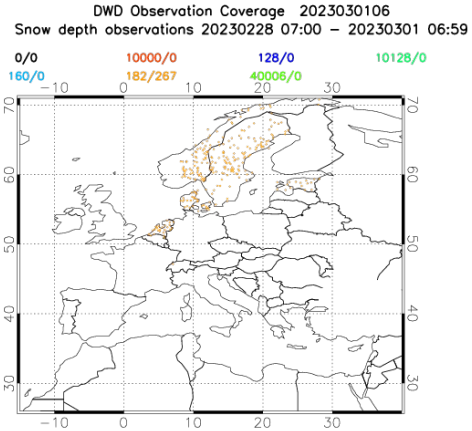


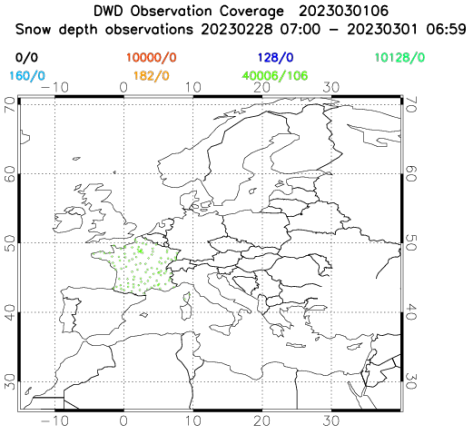






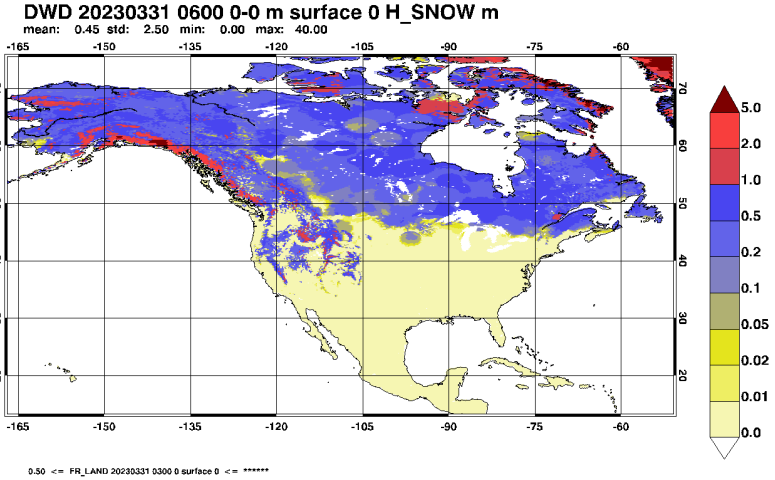




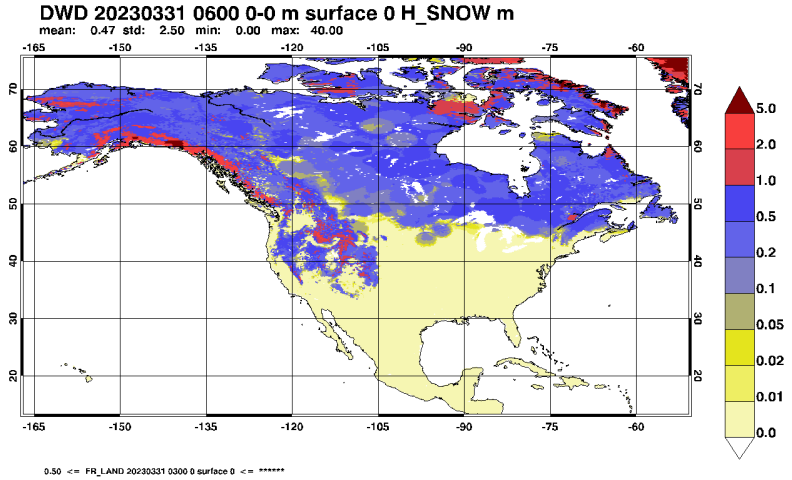


Impact on the analysis

No Snotel Obs



Snotel Obs from skyt



Diff obs – no obs