



# AGENDA – ‘PT SAINT’ – COSMO Snow Session

<b>Time</b>	<b>Topic</b>	<b>Who</b>
09:00 - 09:15	Welcome and Goals	Sascha
09:15 - 09:45	Snow Analysis at DWD - Status and Plans	Gernot
09:45 - 10:30	A new snow model at MCH.	Varun & Sascha
10:30 - 10:45	Tea Break	All
10:45 - 12:00	What's Next - Brainstorming	All



Schweizerische Eidgenossenschaft  
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Swiss Confederation

Federal Department of Home Affairs FDHA  
Federal Office of Meteorology and Climatology **MeteoSwiss**

# On snow cover modelling at MeteoSwiss: Current status and future plans

**Sascha Bellaire<sup>1</sup>, Varun Sharma<sup>2,3</sup>, Michael Lehning<sup>2,3</sup>, Jean-Marie Bettems<sup>1</sup>**

<sup>1</sup>MeteoSwiss, Zurich, Switzerland

<sup>2</sup>WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

<sup>3</sup>CRYOS, School of Architecture, Civil and Environmental Engineering, EPFL, Lausanne, Switzerland



# What models currently contain SNOWPOLINO?

## SNOWPOLINO<sub>stand-alone</sub>

### TERRA<sub>stand-alone</sub> (TSA)

- decoupled version of COSMO/ICON of the surface scheme TERRA
- TSA can be forced with gridded and non-gridded data
- unified code (with COSMO v6.0)
- Low computational costs

### COSMO

- part of official COSMO (v6.0) code. Already patched!
- code is GPU capable (not optimized for NEC)
- currently implemented outside of TERRA ...

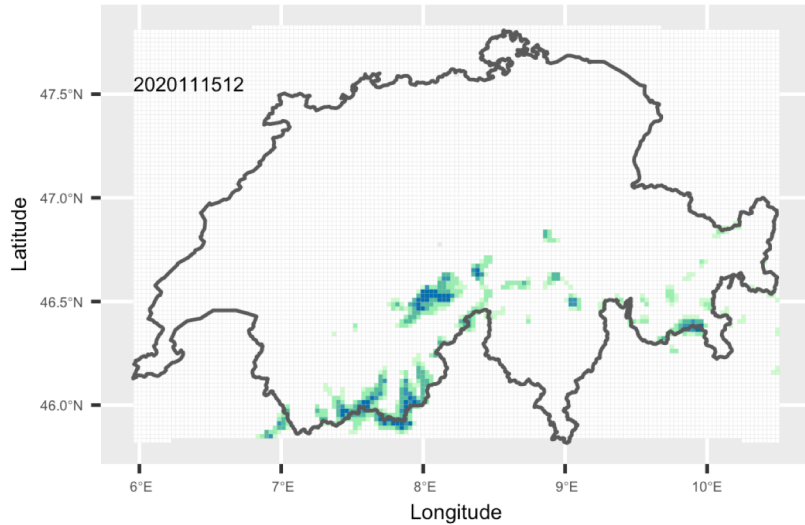
### ICON

- Initial release is implemented in ICON, but old 'buggy' code

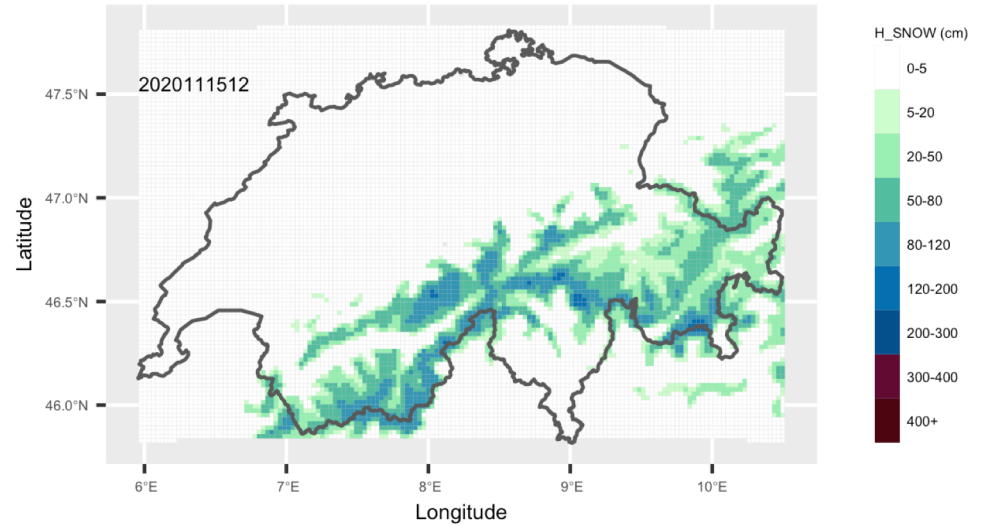


# Spatial validation – Snow height CH-Domain

## Single layer scheme



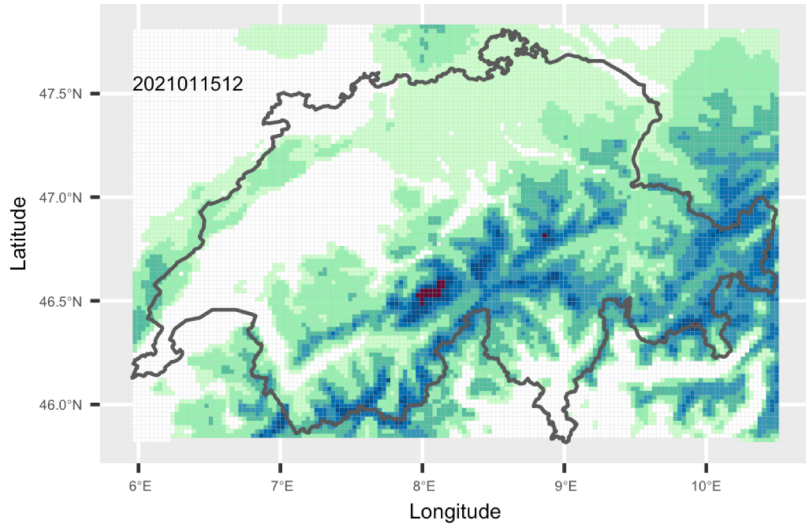
## Multi layer scheme



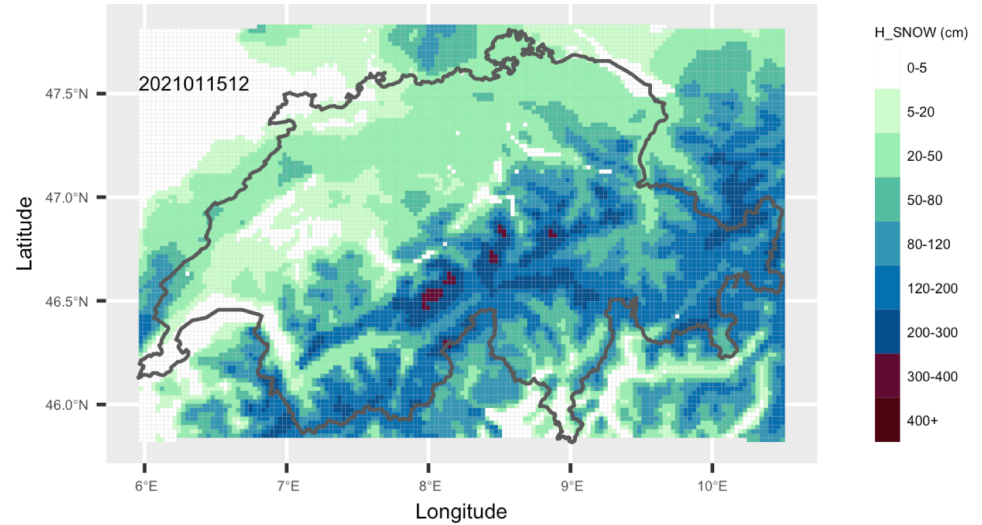


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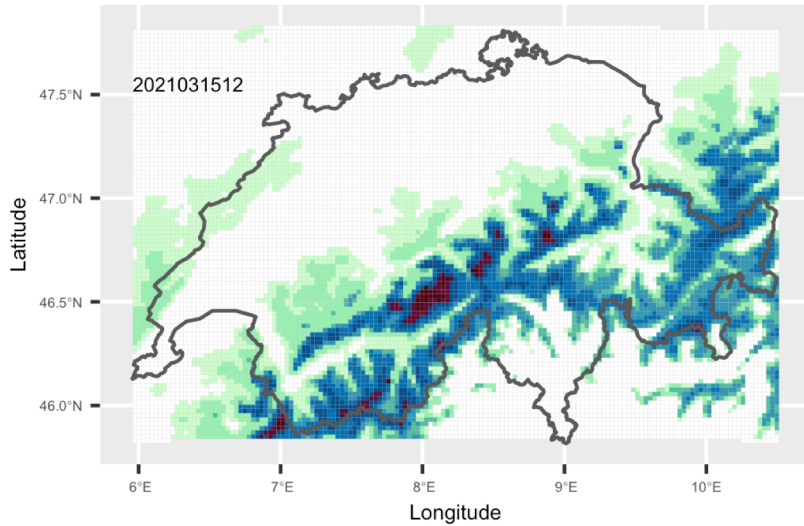
## Multi layer scheme



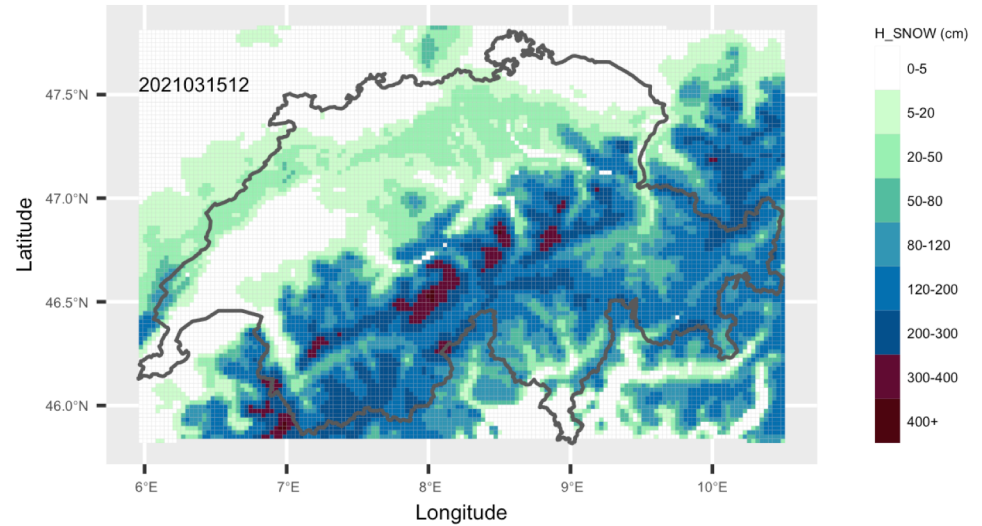


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## Single layer scheme



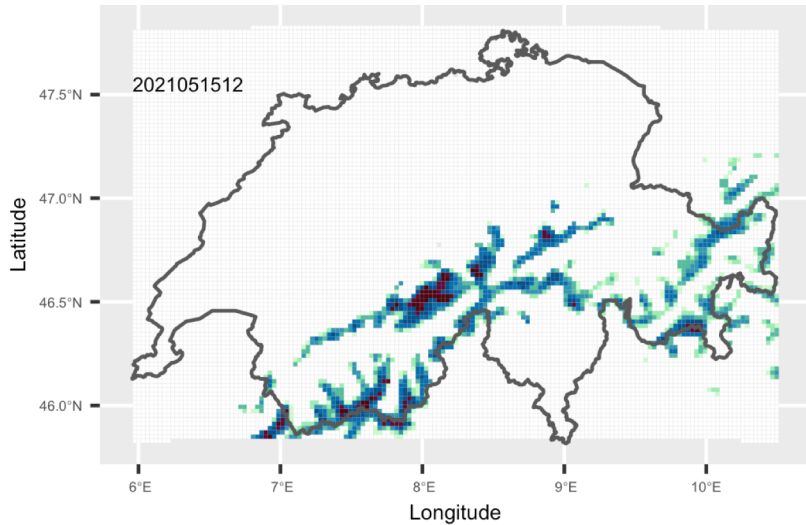
## Multi layer scheme



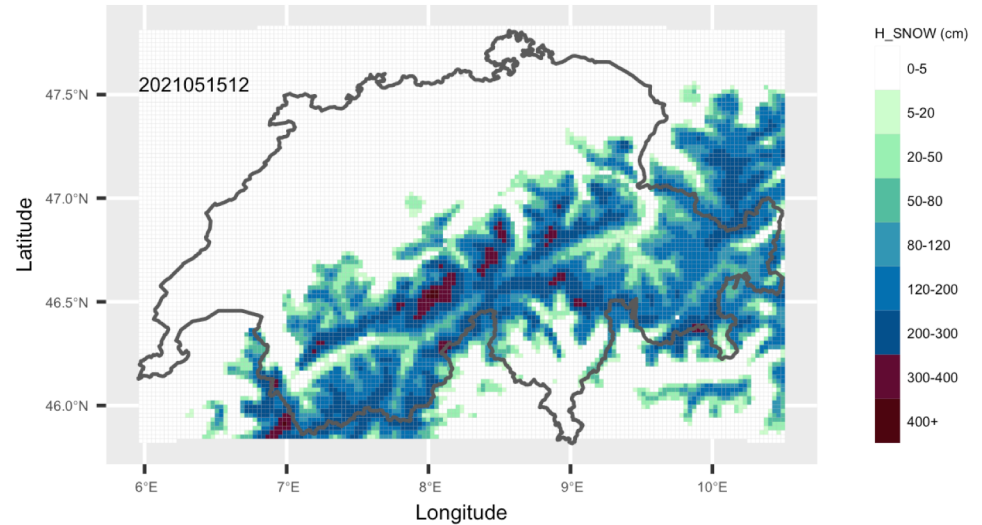


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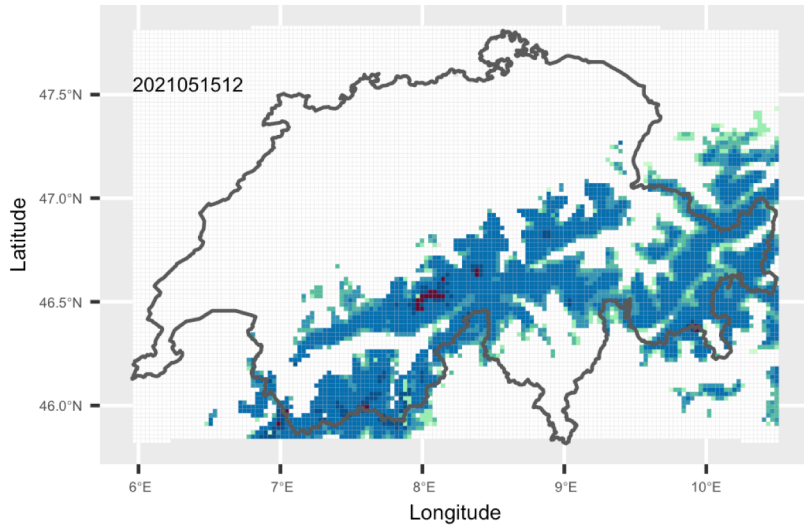
## Multi layer scheme



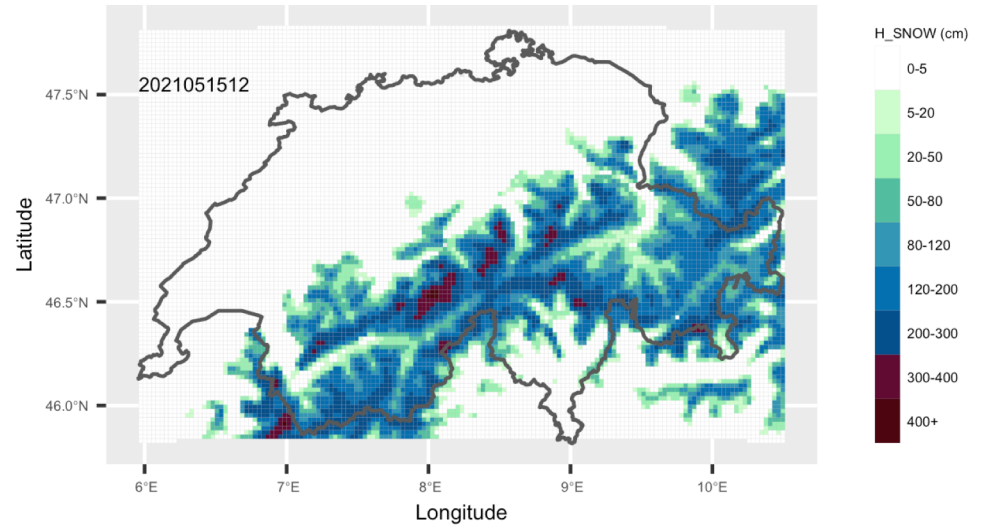


# Spatial validation – Snow height CH-Domain

## Snow analysis<sub>MCH</sub>



## Multi layer scheme

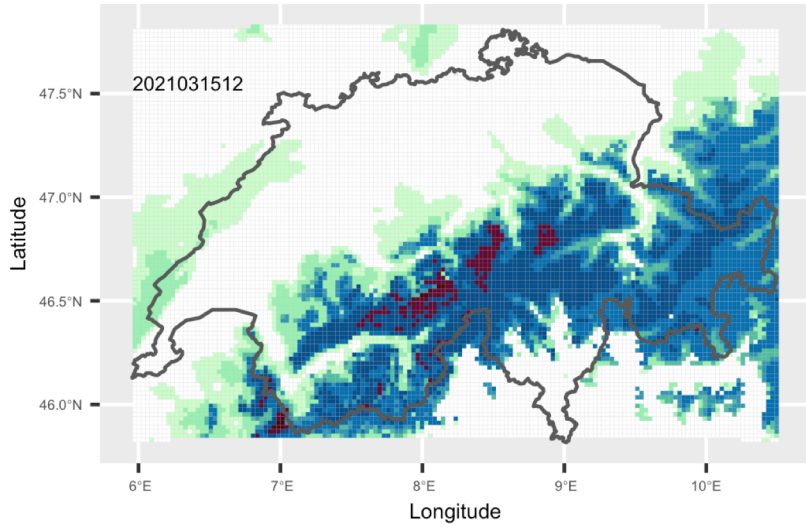




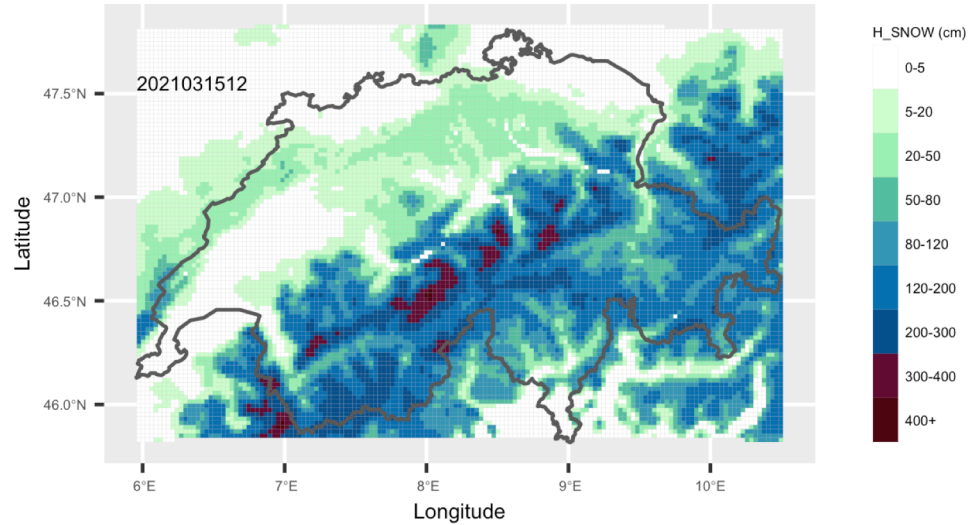


# Spatial validation – Snow height CH-Domain

## Snow analysis<sub>MCH</sub>



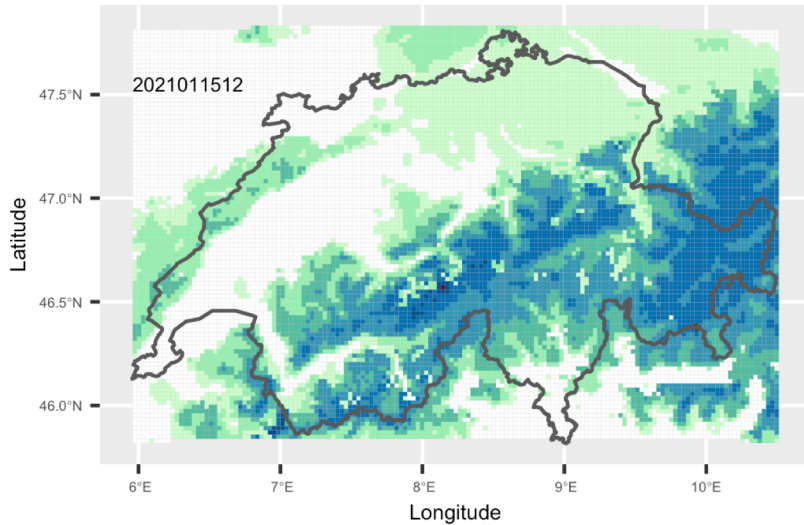
## Multi layer scheme



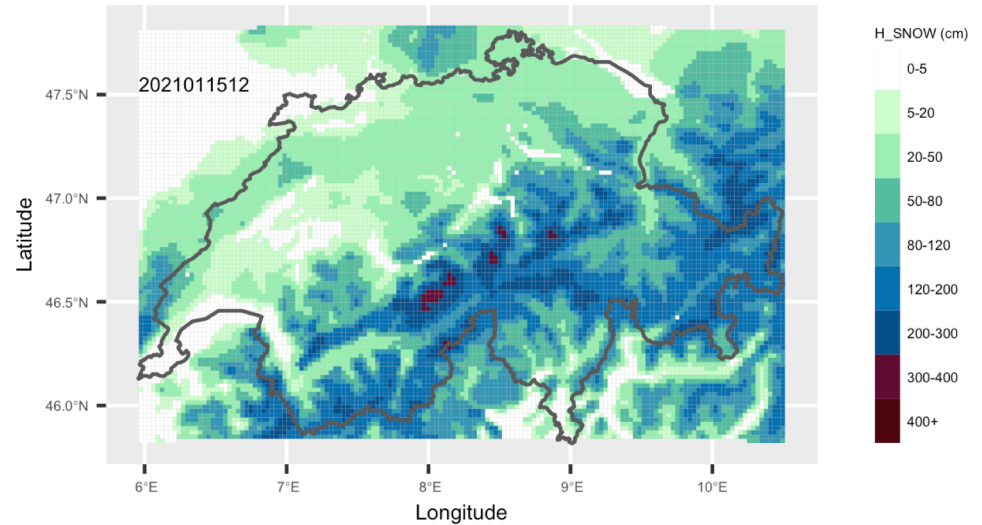


# Spatial validation – Snow height CH-Domain

## Snow analysis<sub>MCH</sub>



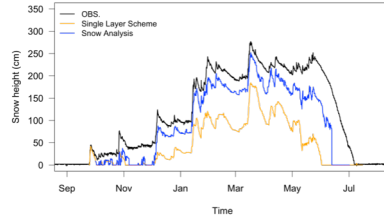
## Multi layer scheme



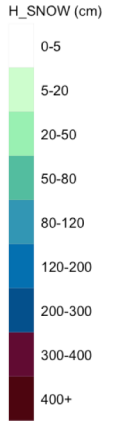
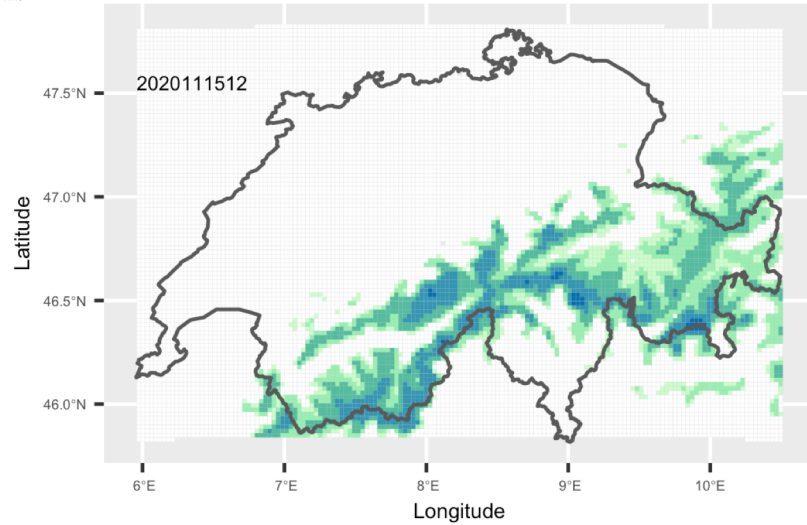
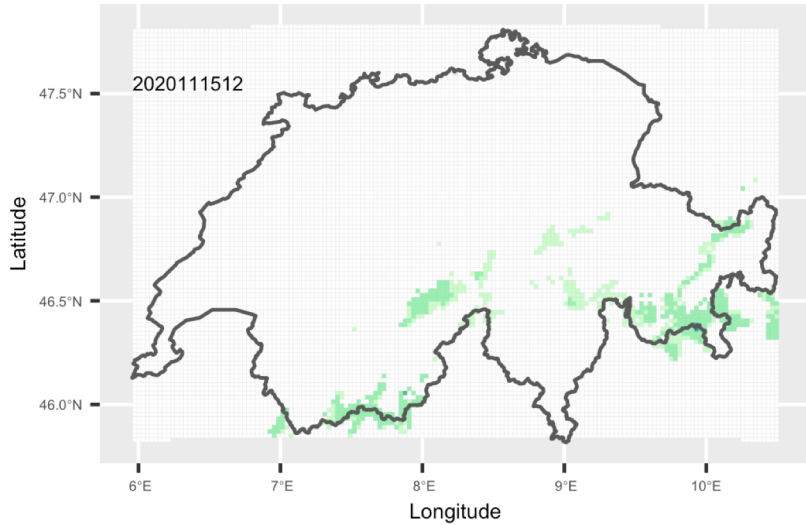


# Spatial validation – Snow height CH-Domain

Snow analysis<sub>MCH</sub>

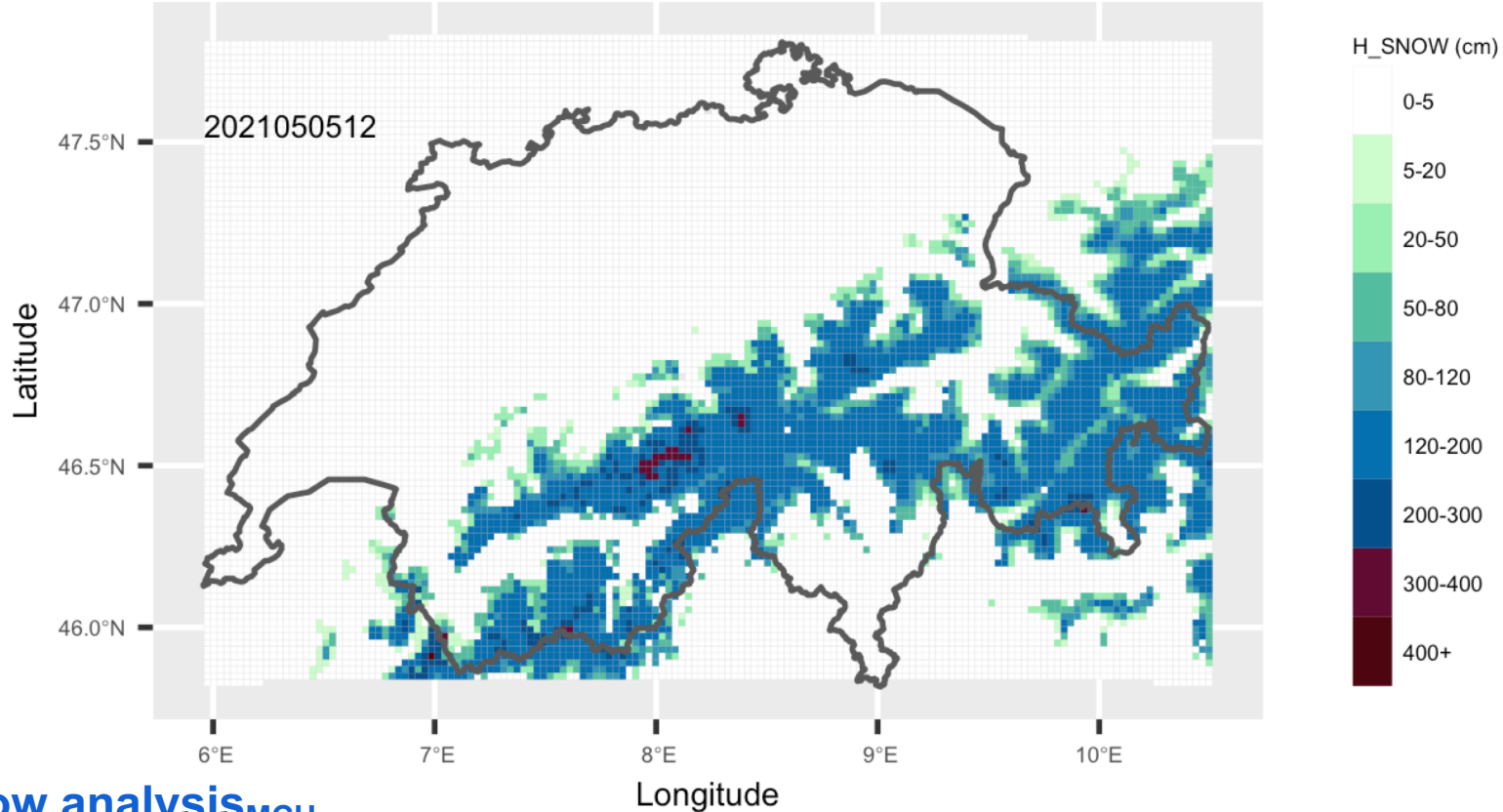


Multi layer scheme



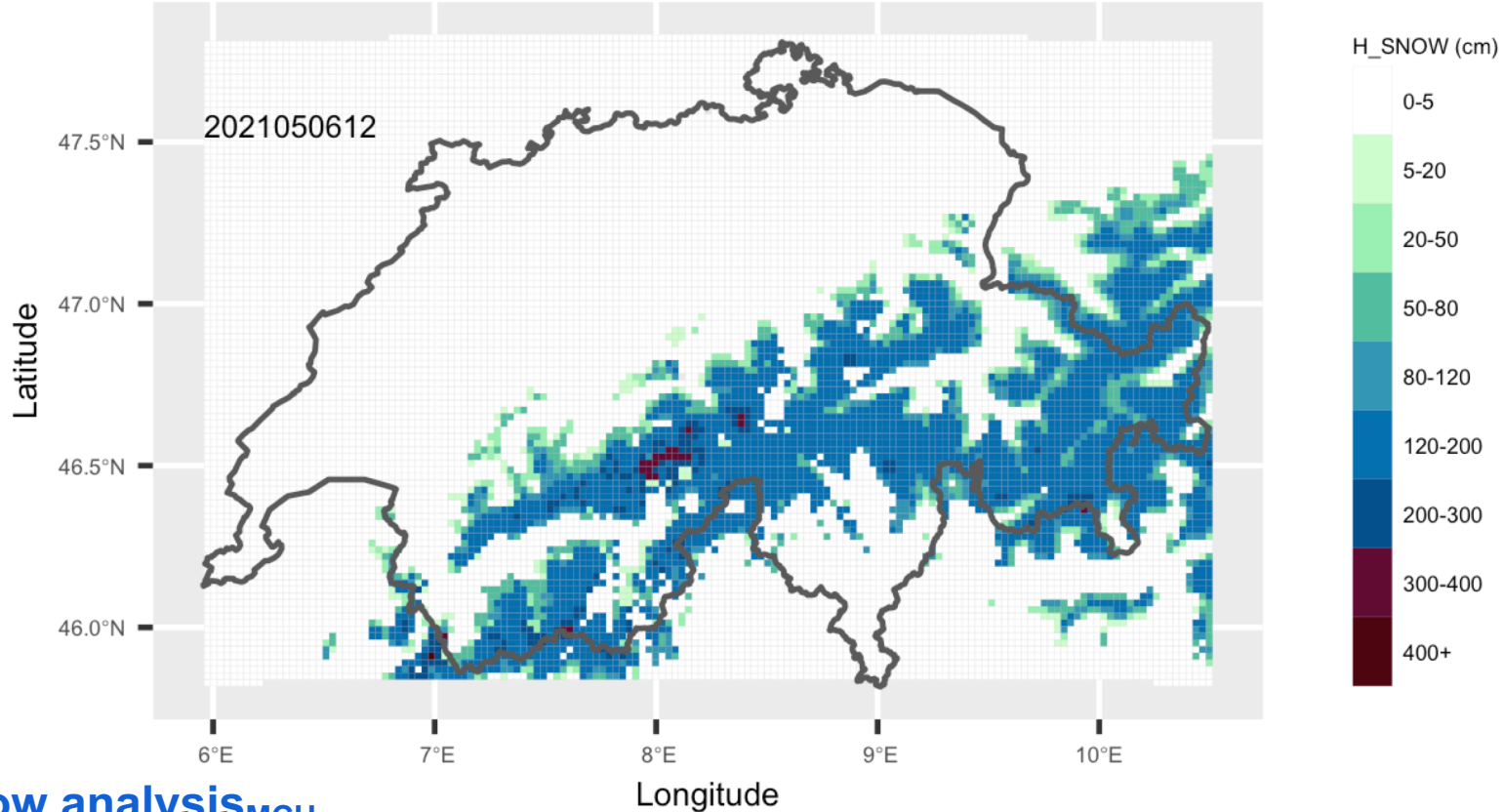


# Spatial validation – Snow height CH-Domain



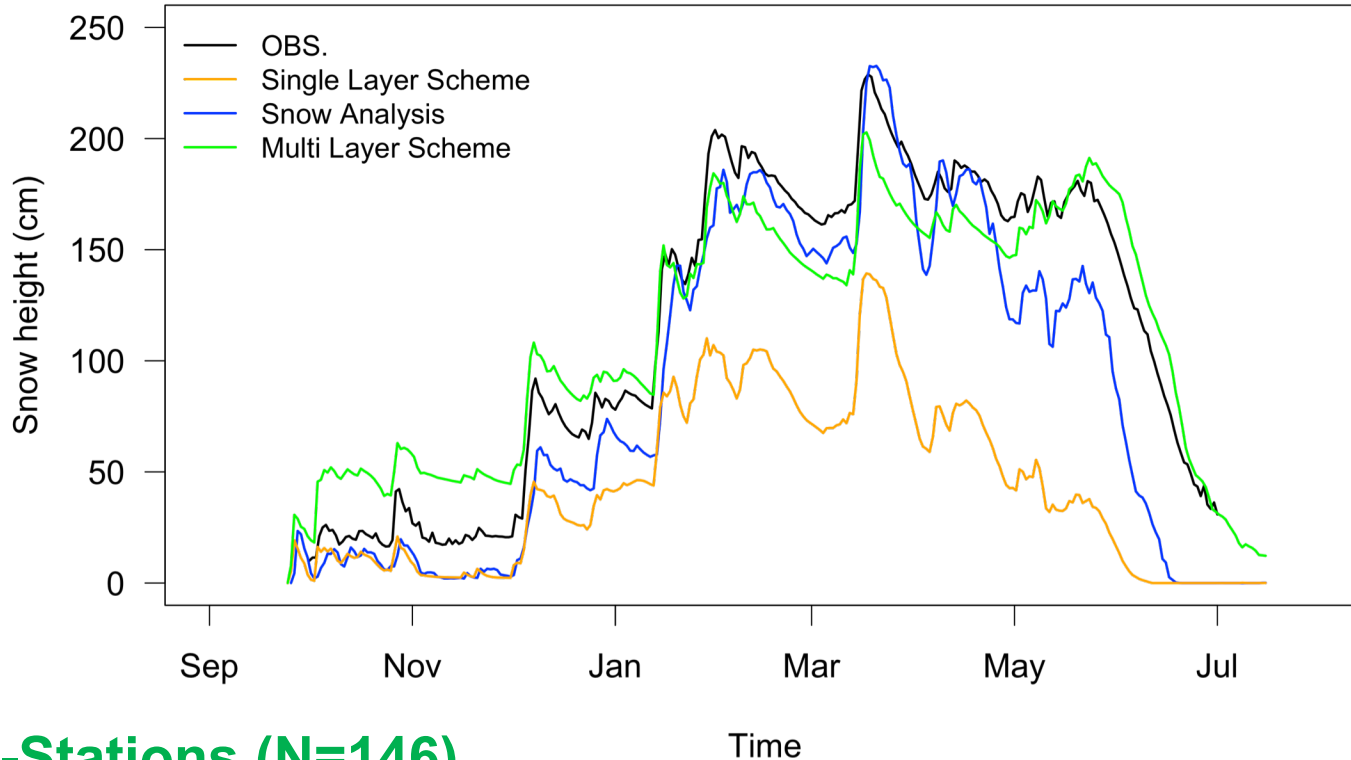


# Spatial validation – Snow height CH-Domain





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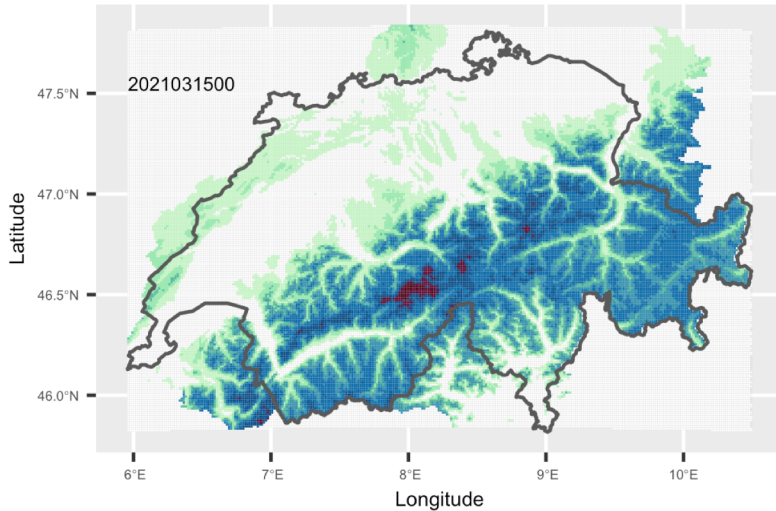


**IMIS-Stations (N=146)**



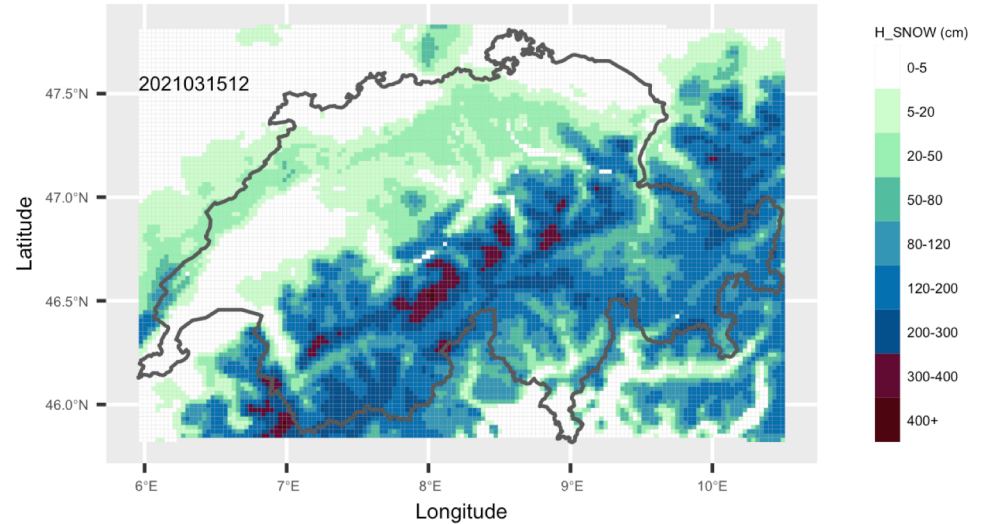
# Spatial validation – Snow height CH-Domain

OSHD<sub>data assimilation</sub>



**OSHD-1km**

Multi layer scheme



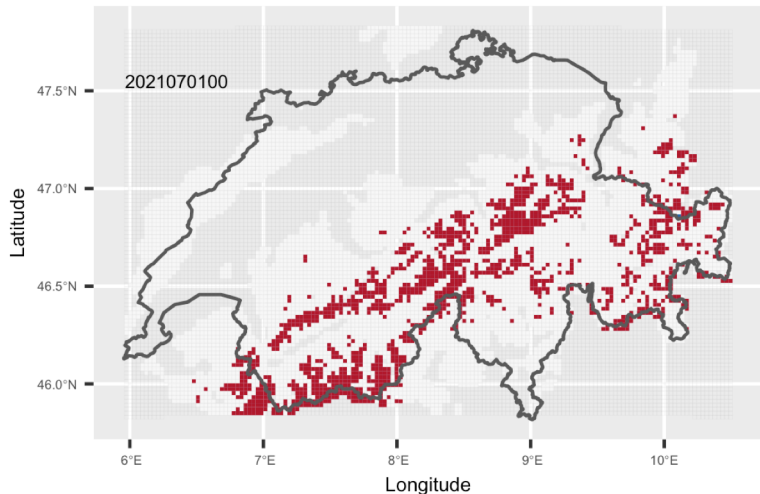
**COSMO-2**

upscaled to

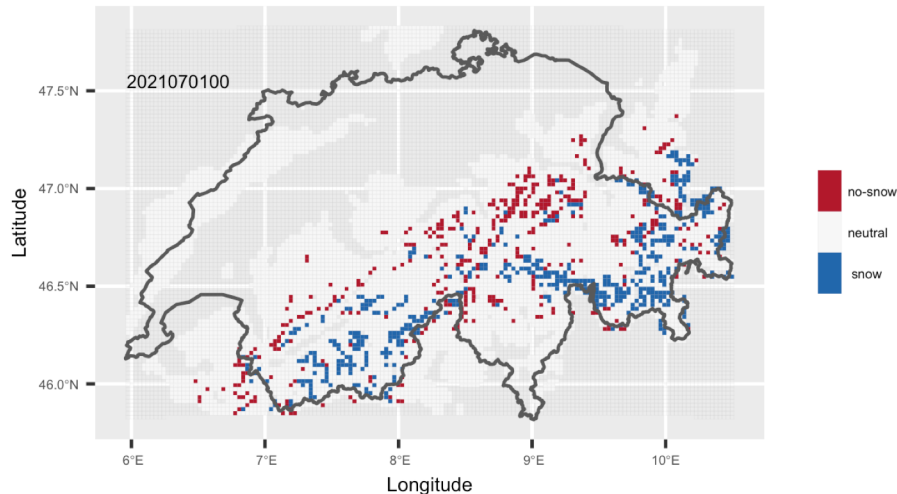


# Spatial validation – Performance measures

## Single layer scheme



## Multi layer scheme



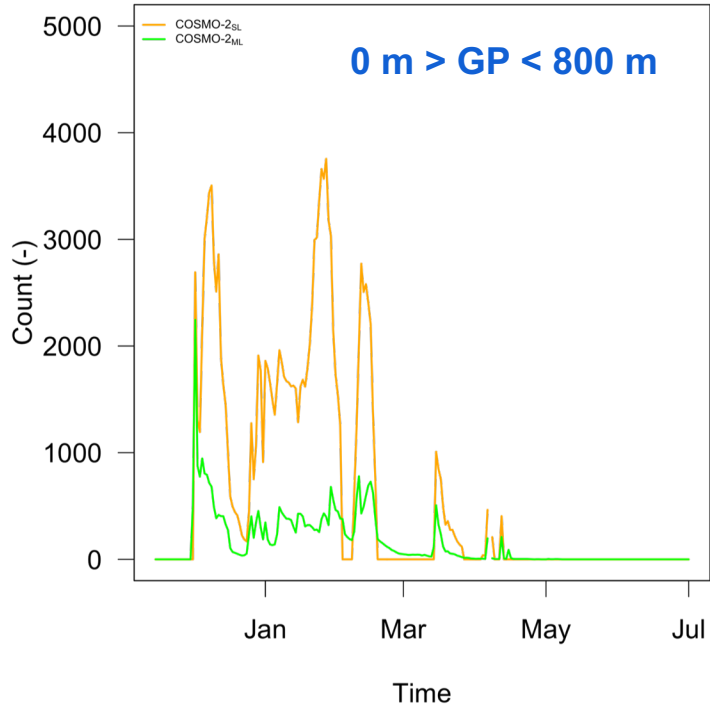
2021-07-01 00 UTC; grid points larger 800 m; threshold > 4 cm (snow)



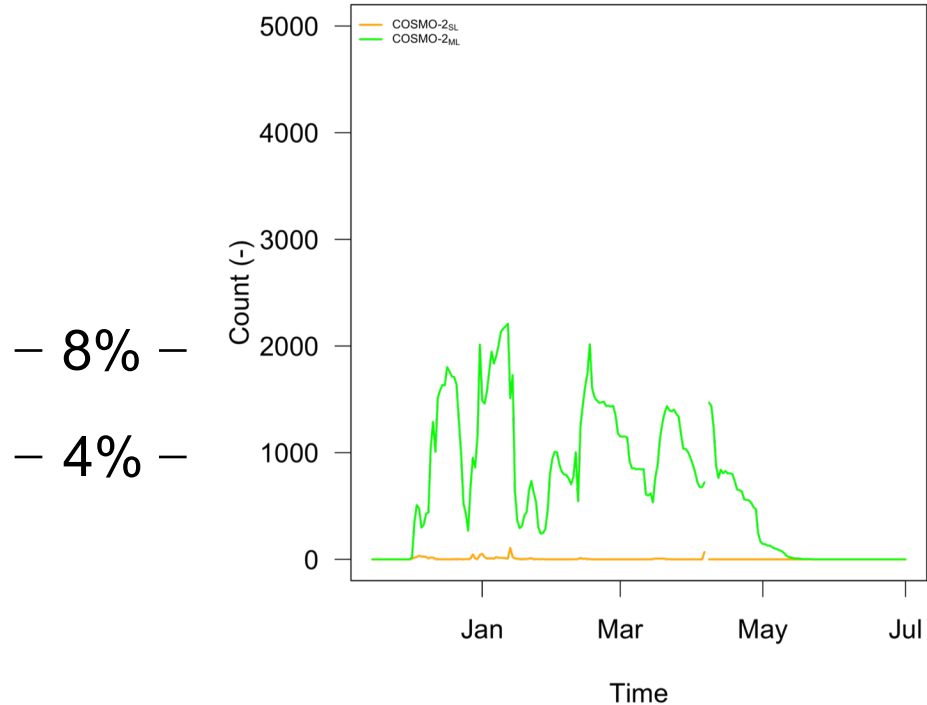


# Spatial validation – Performance measures

## False Positive - 'Red's - No Snow



## False Negative - 'Blue's - Snow

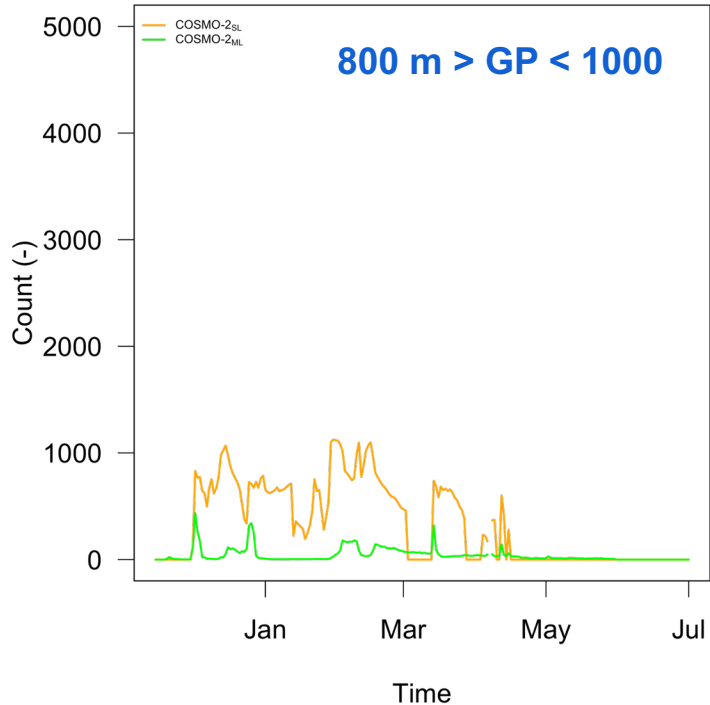


**GP = Grid Point's (N = 23876)**

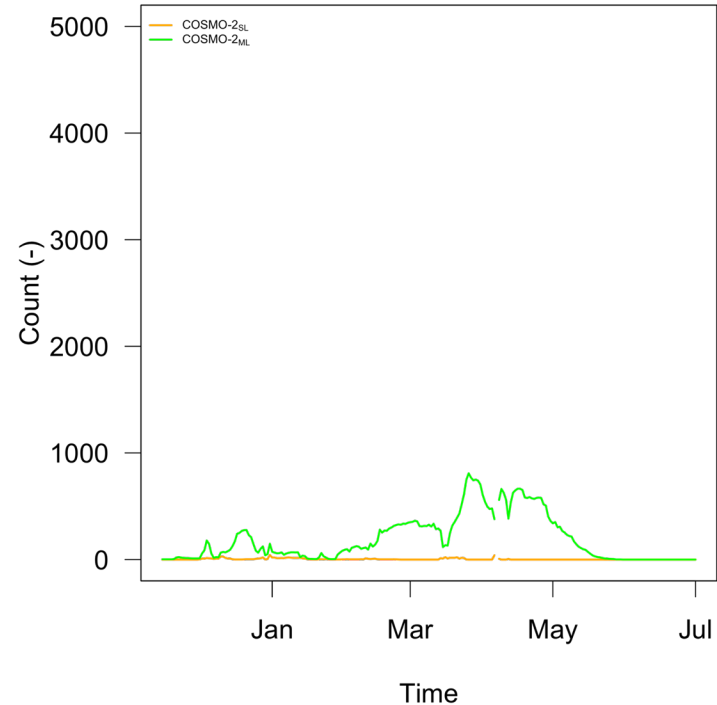


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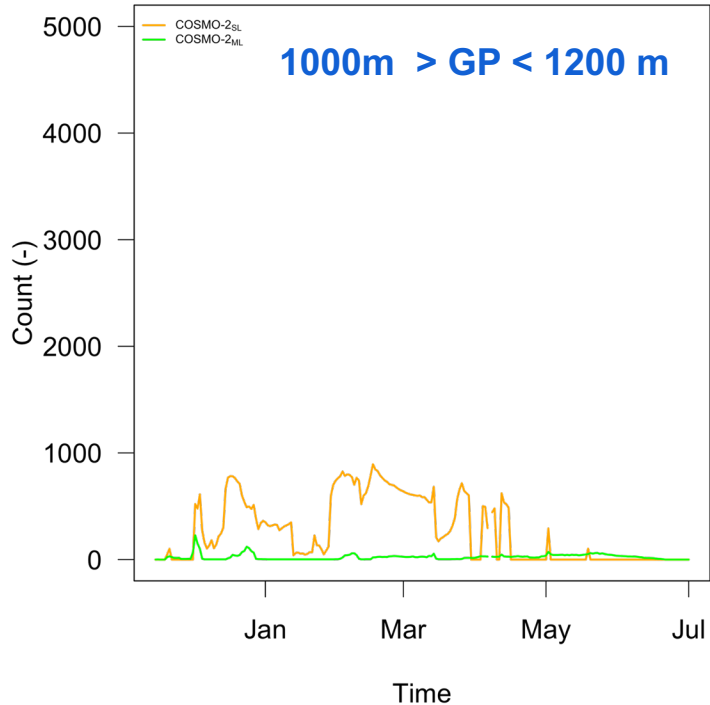


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# Spatial validation – Performance measures

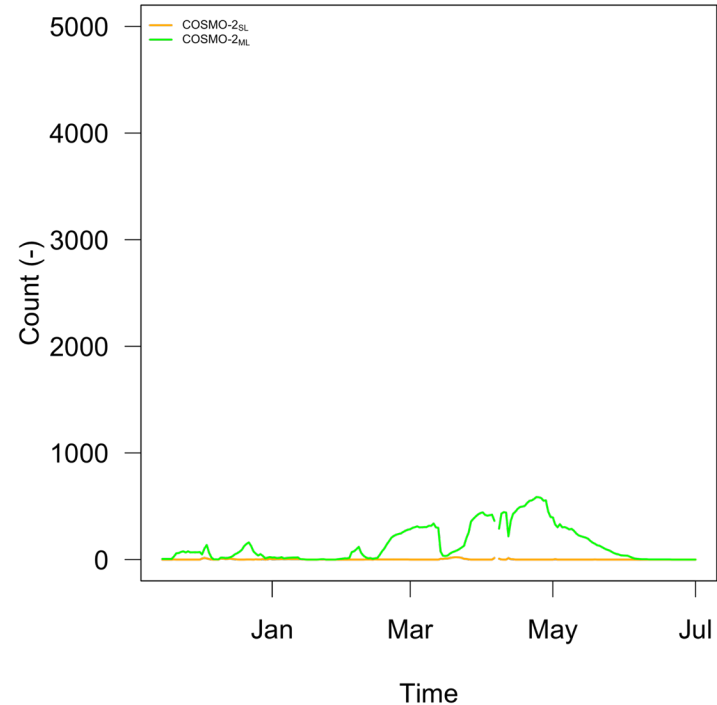
## False Positive - 'Red's - No Snow



— 8% —

— 4% —

## False Negative - 'Blue's - Snow

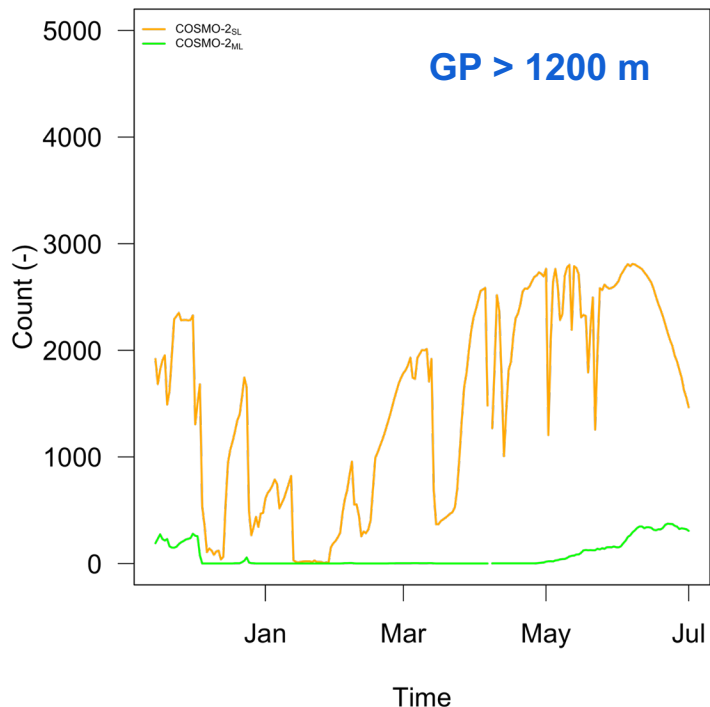


**GP = Grid Point's (N = 23876)**



# Spatial validation – Performance measures

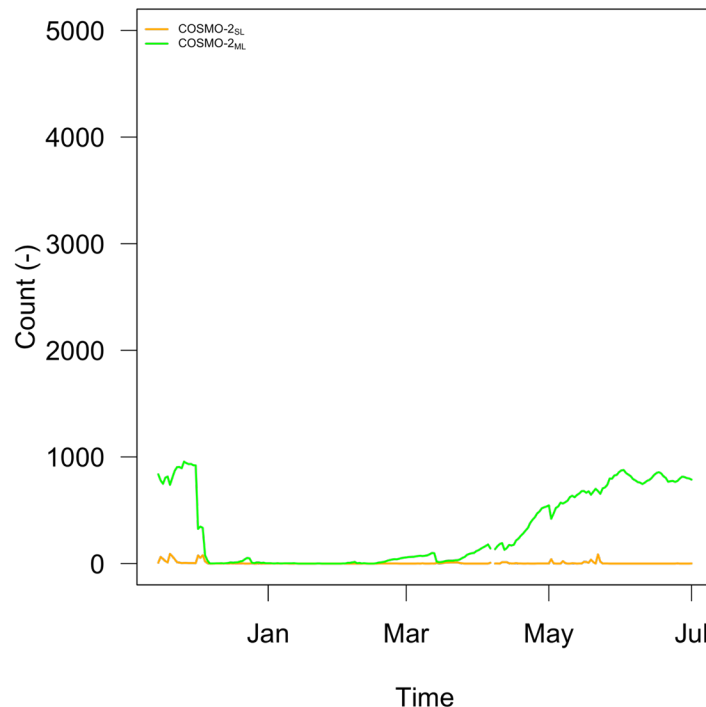
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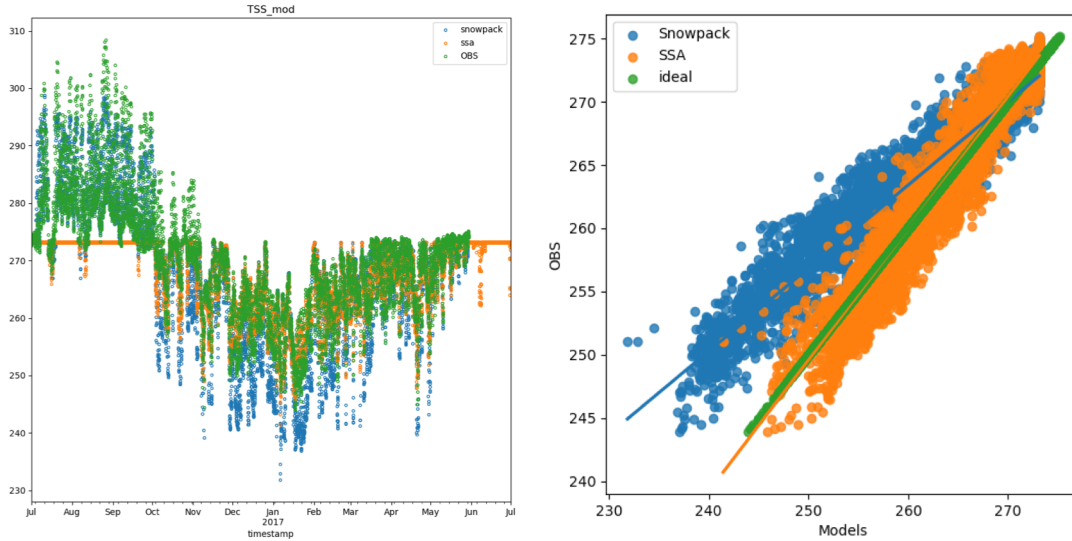


**GP = Grid Point's (N = 23876)**



# Going from standalone to a coupled model

## Surface Temperature



## Snow Height



snowpack (reference model) vs snowpolino vs observations

1. Snowpolino works well ! at WFJ and many other stations.
2. But in a standalone setting ...



# Going from standalone to a coupled model

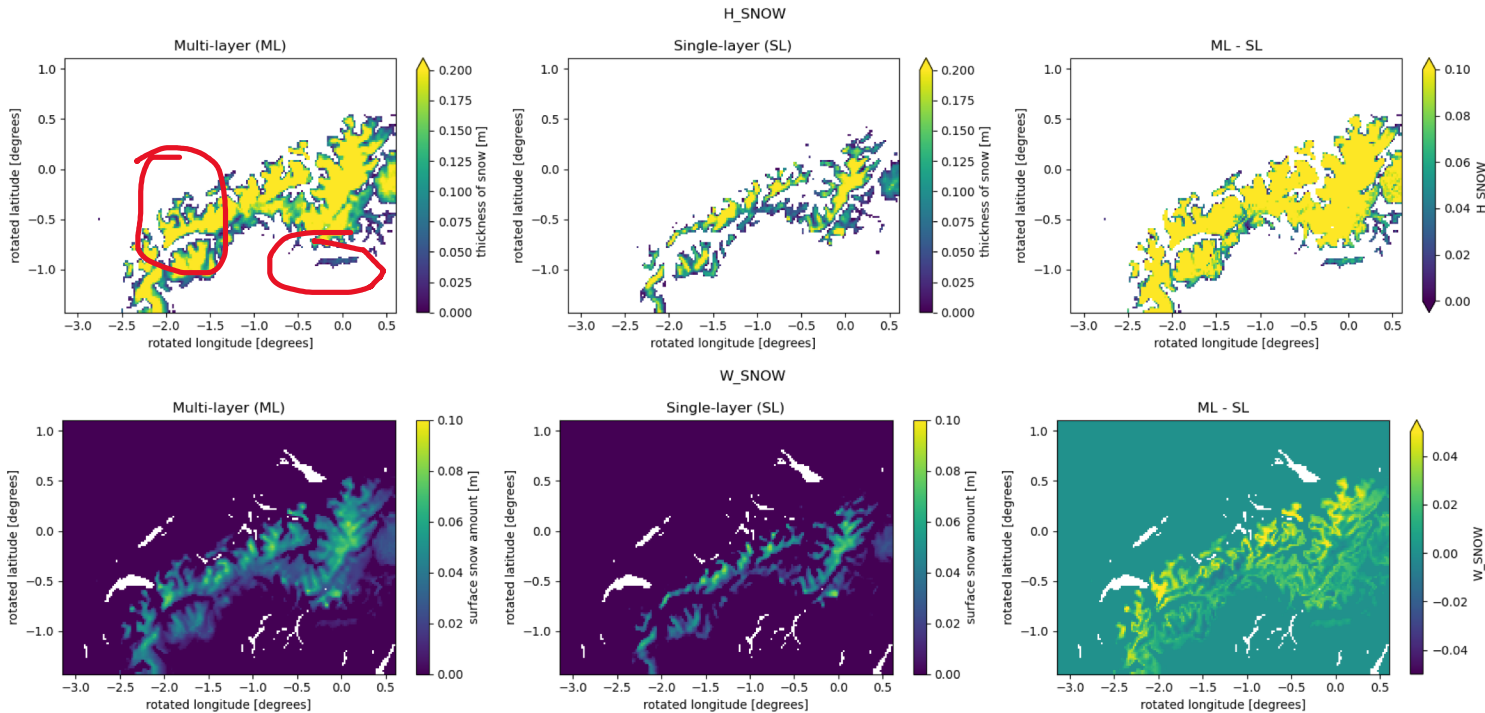
- In a coupled setting – things are getting more tricky – feedback loops !
- To investigate, we use the following setup :
  1. A small domain covering only Switzerland
  2. COSMO-2 grid
  3. One year e-suite runs
  4. One week runs at start of the season without assim ( forecast )



# Going from standalone to a coupled model

- In a coupled setting – things are getting more tricky – feedback loops !

After first snow event of the year ( end of 1 week run )



Snow / No  
snow mismatch

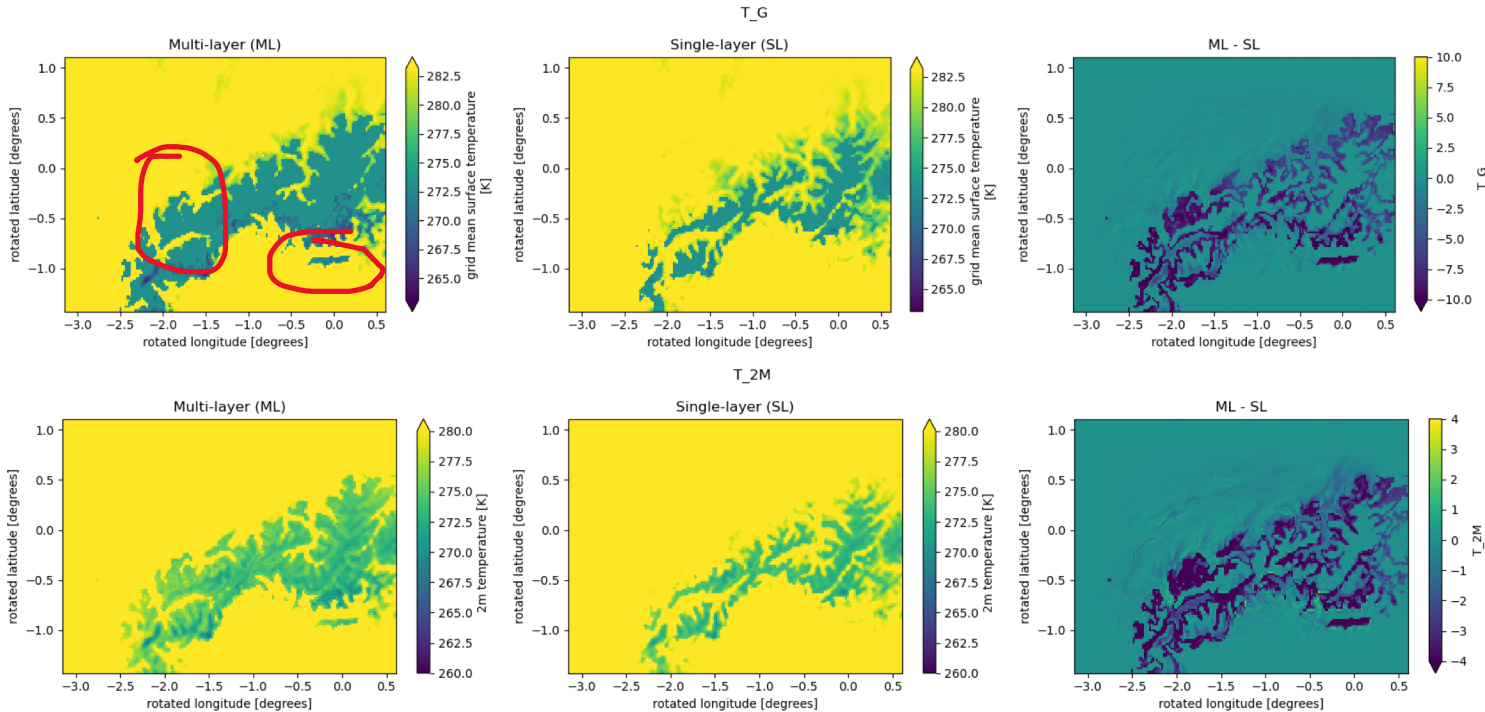
more snow on  
the ground with  
SNOWPOLINO



# Going from standalone to a coupled model

- In a coupled setting – things are getting more tricky – feedback loops !

This mis-match results in cooling the domain ..



Immediate 5 to 10 K difference SNOWPOLINO and SL scheme at many points in the domain

both  $T_G$  and  $T_{2M}$

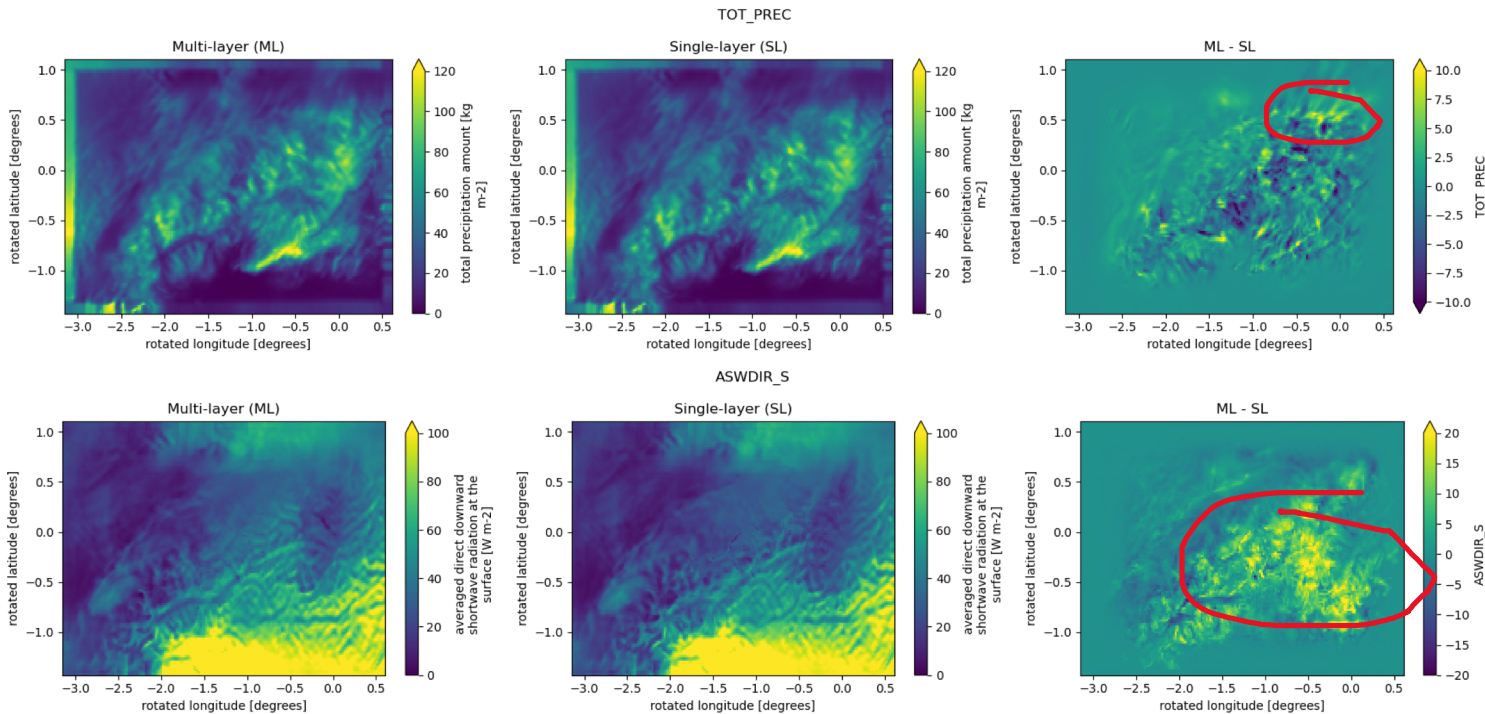




# Going from standalone to a coupled model

- In a coupled setting – things are getting more tricky – feedback loops !

And triggering further changes ( note .. all this after only ONE week )



Change in Precip ~ 20 / 30 percent or more at locations ..

Long range perturbations introduced

Cloud cover changes resulting in 20 % changes even in direct shortwave radiation.



# Going from standalone to a coupled model

In a coupled setting – things are getting more tricky – feedback loops !

## Moral of the story:

- Coupled model – any error results in feedback loops.
- untangling effects is hard.
- long-range perturbations both spatially and temporally.
- just snow / no snow mismatch is sufficient to cause a bifurcation in the state.
- playing chicken and the egg.



# Going from standalone to a coupled model

## What we have done so far:

1. Ensured that there are no 'technical' bugs ( this took a lot of time with GPU issues ) – this is guaranteed to be correct
2. Understanding COSMO at the `sfc_interface.f90` level – are there some variables we are forgetting to update ?
  - ✓ Got advice from the 'community' – adding further variables that need to be updated – more discussions to follow.
3. Getting further understanding of what terra is doing with snow as opposed to us.



# Going from standalone to a coupled model

## Questions:

1.  $qv\_s$  or  $qvfl\_s$  ( seems to change between cosmo and icon ). Updating  $qv\_s$  seems to introduce more perturbations.
2. Is there anything to learn from the seaice / lake model ?
  - We are computing our own fluxes vs seaice / lake models that seem to use fluxes already computed AND/OR only turbulent transfer coefficients are used.
  - check / check / check everything.



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# Thanks!

## Comments or Questions?

Contact: [Sascha.Bellaire@meteoswiss.ch](mailto:Sascha.Bellaire@meteoswiss.ch) & [varun.sharma@epfl.ch](mailto:varun.sharma@epfl.ch)

Sascha Bellaire<sup>1</sup>, Varun Sharma<sup>2,3</sup>, Michael Lehning<sup>2,3</sup>, Jean-Marie Bettems<sup>1</sup>

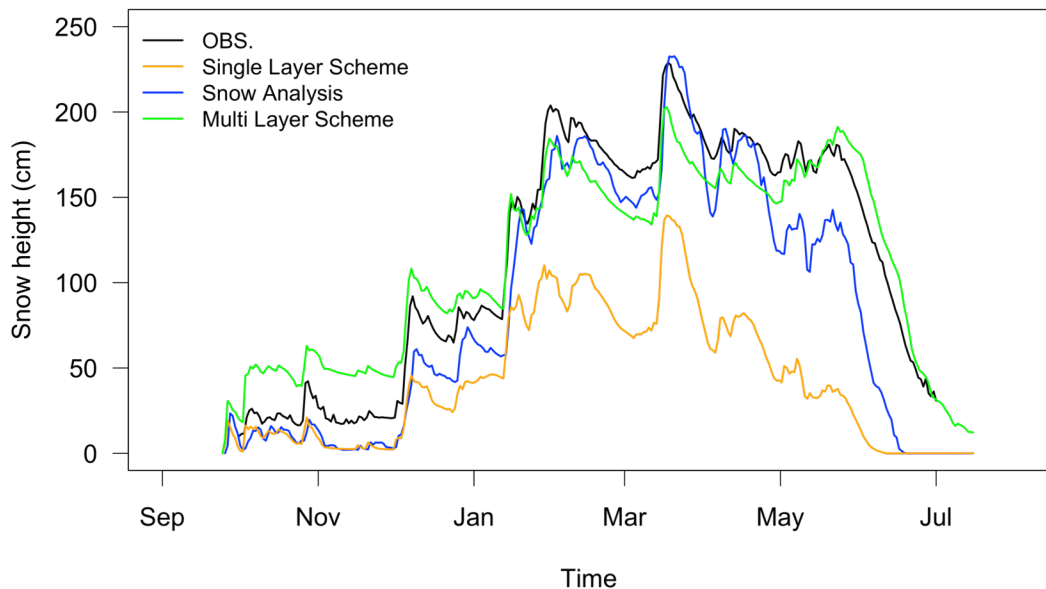
<sup>1</sup>MeteoSwiss, Zurich, Switzerland

<sup>2</sup>WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

<sup>3</sup>CRYOS, School of Architecture, Civil and Environmental Engineering, EPFL, Lausanne, Switzerland



# 'PT-SAINT' – Swiss Snow Model<sub>SNOWPOLINO</sub>



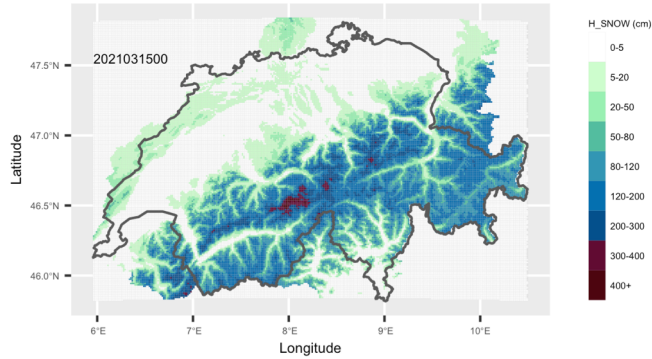
- Comparable to more sophisticated snow cover schemes (SNOWPACK), while forced with measured data.
- Reasonable good performance at point locations, i.e. automated weather stations (IMIS) while forced with forecasted data (COSMO-2E).
- Outperforms single layer scheme and currently use snow analysis at point locations.

**IMIS-Stations (N=146)**

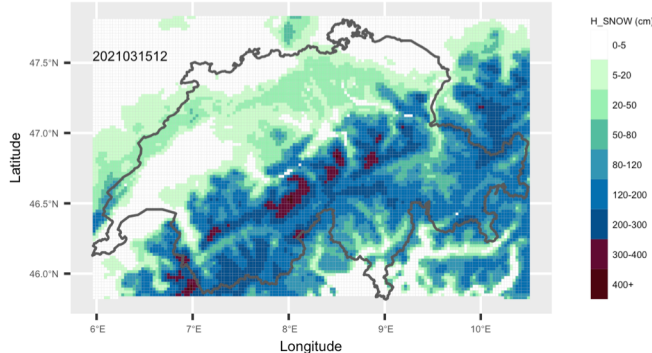


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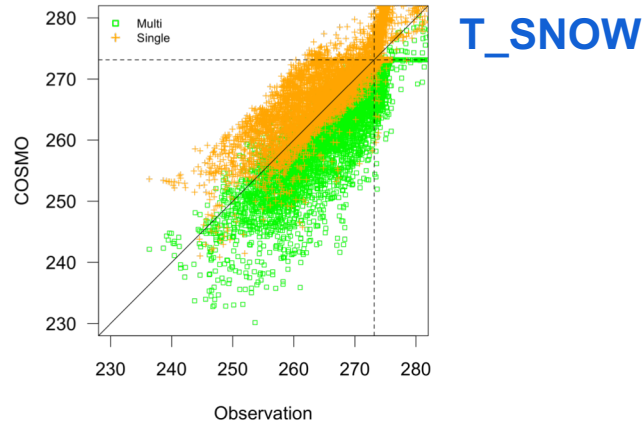
## Reference (1km)



## COSMO-2E



- Spatial validation (CH) shows also reasonable performance, however snow tends to stay too longer on the ground, i.e. too much snow.
- Currently, the surface-atmosphere coupling is too strong, i.e. a too strong feedback, which currently doesn't allow using the scheme in production. Investigation is ongoing!!!

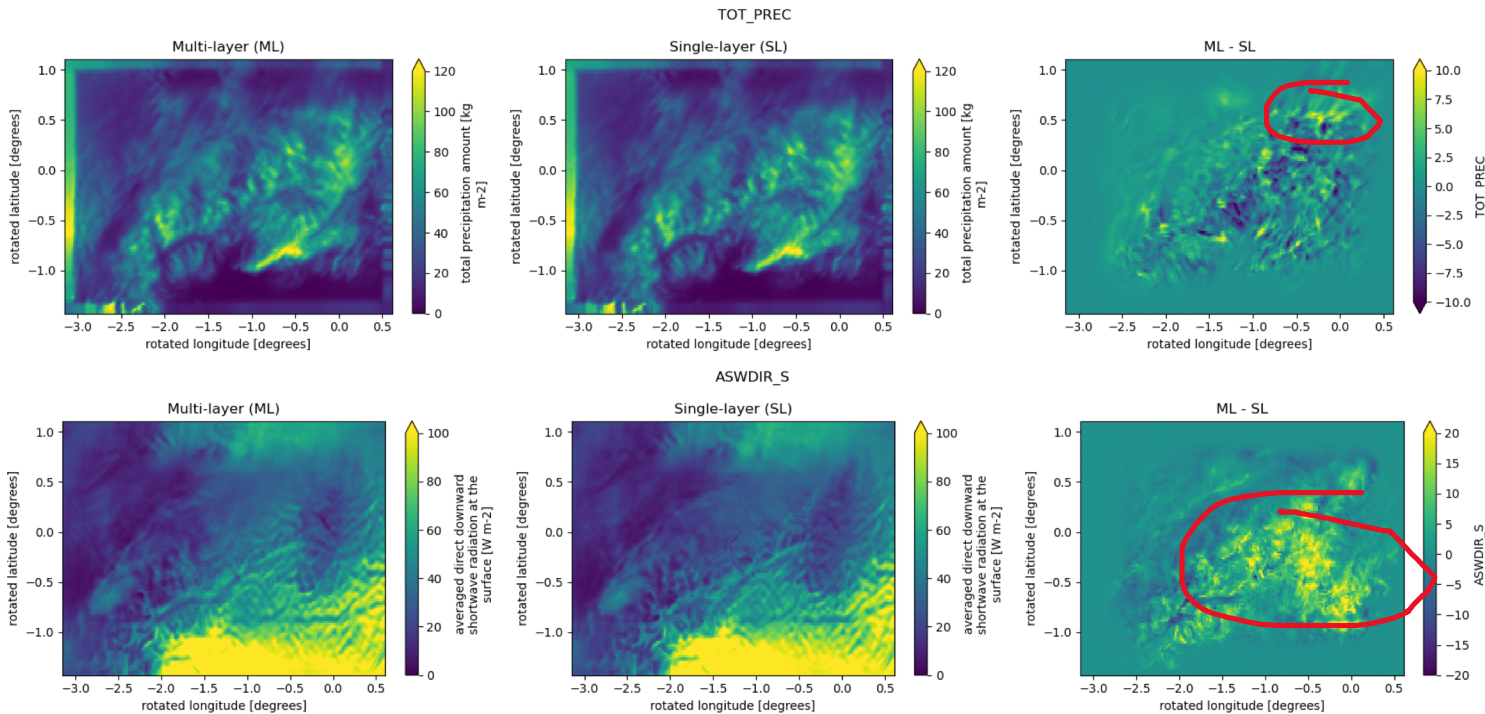




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