

# Workshop on snow data assimilation

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Impact of MODIS snow cover fraction on modeled SNOWGRID quantities



SNOWGRID Snow model

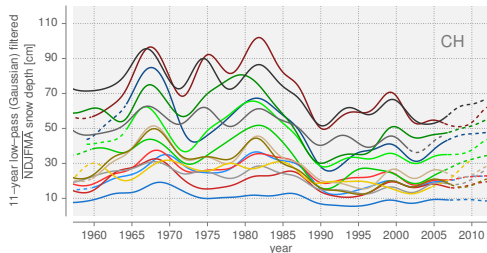
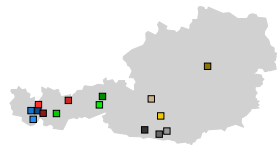
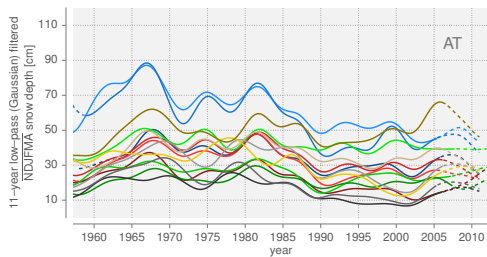
Assimilation of MODIS fractional snow cover

Impact of MODIS observation

Validation

# Snow depth variability (daily base)

Seasonal (Nov–Apr) snow depth time series of stations elevated between 800 m and 1600 m



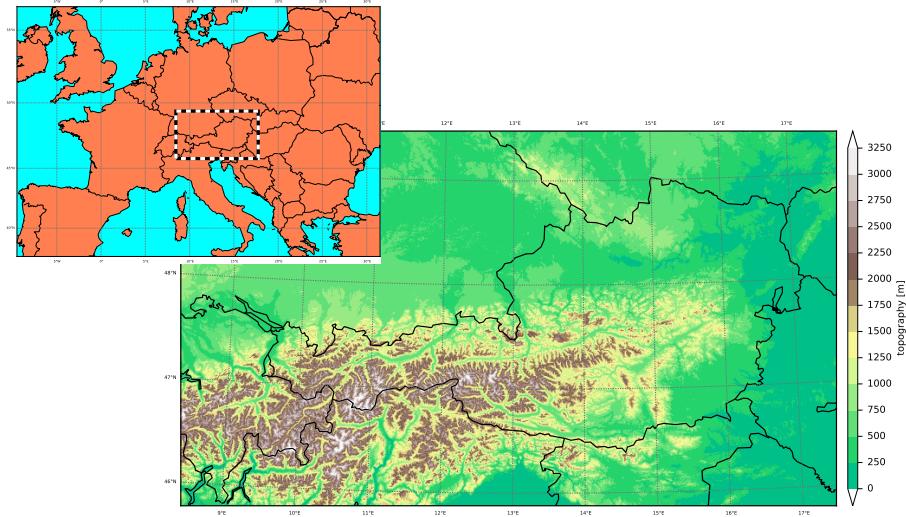
Marty, C. (2008). Regime shift of snow days in Switzerland, *Geophys. Res. Lett.*, 35, L12501, doi:10.1029/2008GL033998.

# SNOWGRID Snow model

- ▶ Operational spatially distributed snow cover model with high spatial (100 m) and temporal (15 minutes time step) resolution for INCA-L grid (Zürich-Bratislava, Nürnberg-Triest)
- ▶ Upper BC: Meteorological input from INCA (air temperature, rel. humidity, snowline (wet-bulb temp.), precipitation). Lower BC: INCA ground temperatures
- ▶ Simple degree-day scheme
- ▶ Simple 1-2 layer model
- ▶ Snow settling (rapid setting after snowfall - destructive metamorphism, density-dependant slower settling thereafter (overburden pressure, metamorphism))
- ▶ State variables are: snow depth (SD), snow water equivalent (SWE), average snow temperature (ST)

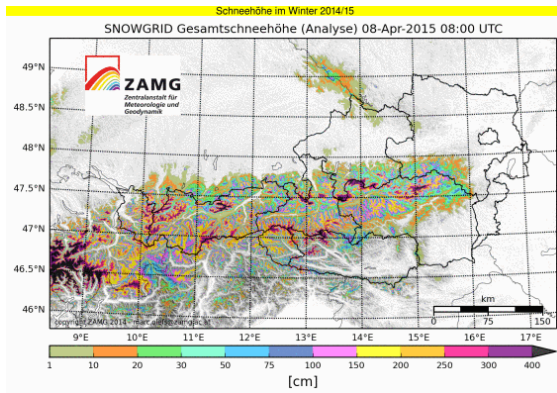
# SNOWGRID model domain and topography

Topography: 100 m DEM (corrected NASA SRTM3 + add. Data)



# SNOWGRID products

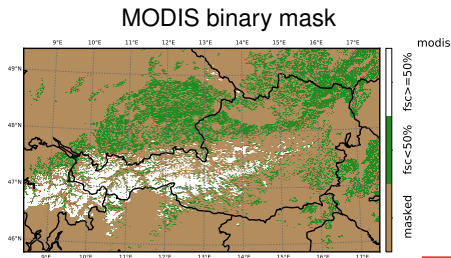
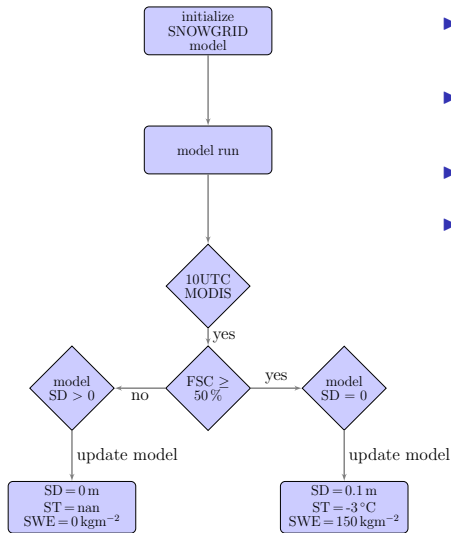
- ▶ Internal use (weather forecasts)
- ▶ road weather products
- ▶ Avalanche warning service
- ▶ Wintertourism (websites)
- ▶ snow melt runoff calculations
- ▶ ...



Olefs, M., Schöner, W., Suklitsch, M., Wittmann, C., Niedermoser, B., Neururer, A., Wurzer, A. (2013). SNOWGRID – A new operational snow cover model in Austria. International Snow Science Workshop Grenoble, 2013.

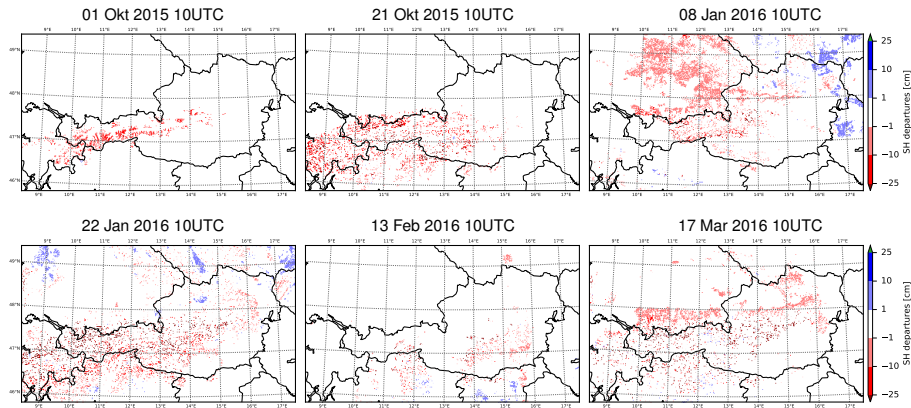
# Assimilation of MODIS fractional snow cover (FSC)

- ▶ Experiment duration:  
01 Oct 2015 to 01 May 2016
- ▶ MODIS fields are interpolated onto SNOWGRID grid (nearest neighbour)
- ▶  $N_{\max}(\text{MODIS}) = 214$
- ▶ 160 MODIS fields available



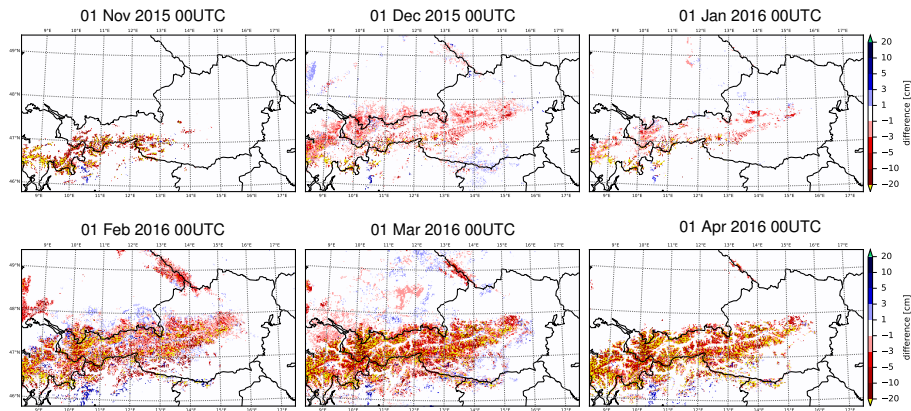
# Analysis departures (MODIS: passively assimilated)

analysis departures:  $d = M(\text{MODIS})^{pas} - M$



# Analysis differences (MODIS: actively assimilated)

analysis differences:  $a = M(\text{MODIS})^{\text{act}} - M$

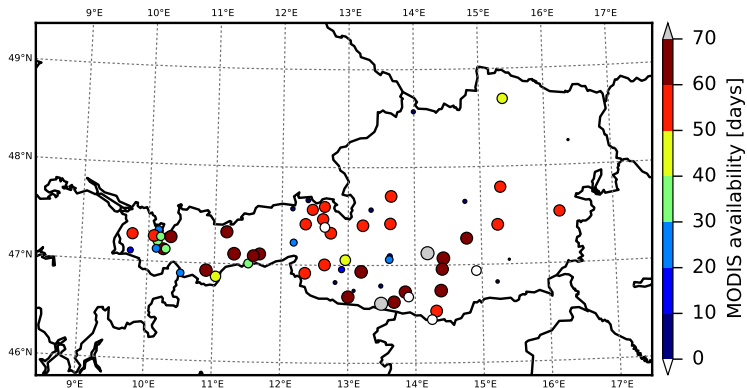


# Available valid MODIS data at station location I

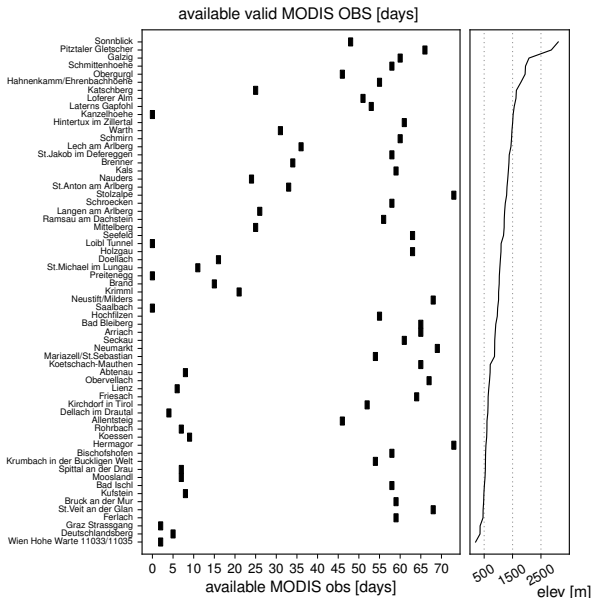
Selection of 63 TAWES stations

Station snow depth sensor: Laser distance sensor (Jenoptik SHM 30)

01 Oct 2015 to 01 May 2016



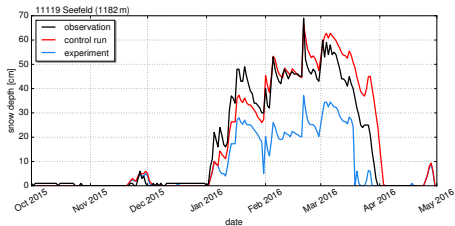
# Available valid MODIS data at station location II



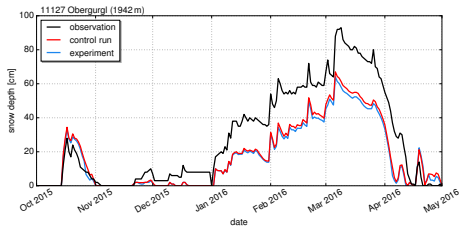
# Observations vs Control run vs. Experiment

black: observation, red: control run, blue: assimilation experiment

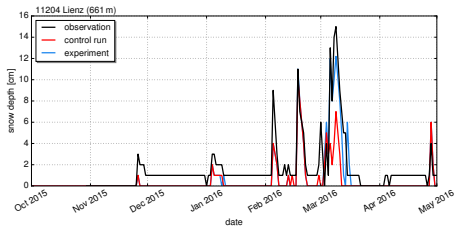
### Seefeld (1182 m)



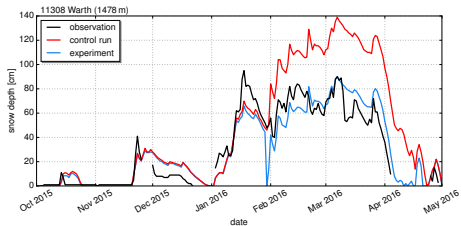
### Obergurgl (1942 m)



### Lienz (661 m)



### Warth (1478 m)



# Impact of MODIS data I

$$\left(1 - \frac{R^2_{control}}{R^2_{exper}}\right) \times 100 > 0$$

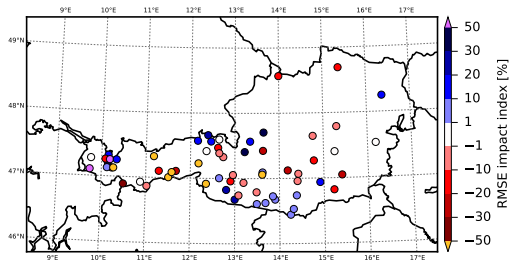
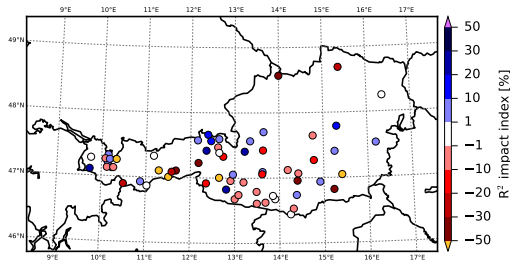
→ positive impact

blue: positive impact

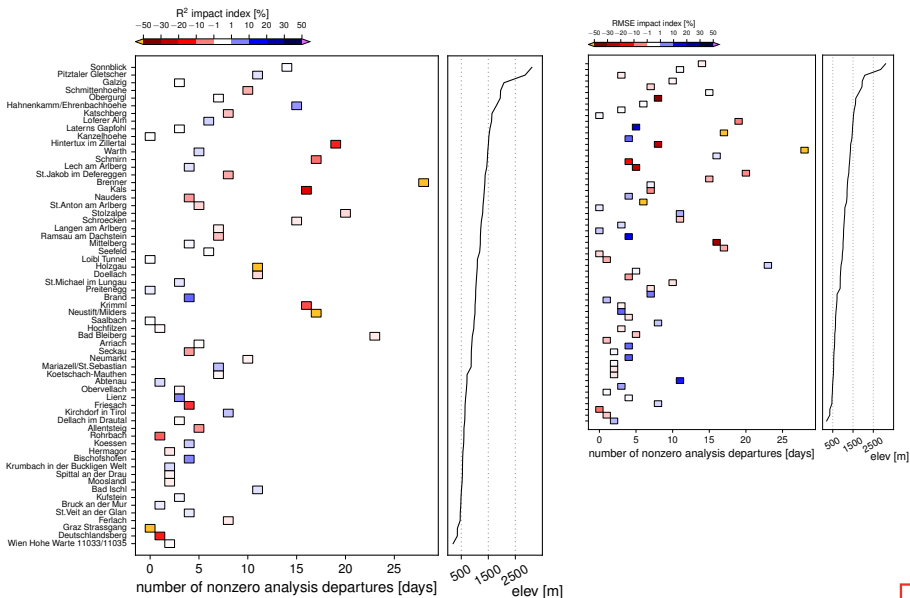
red: negative impact

$$\left(1 - \frac{RMSE_{exper}}{RMSE_{control}}\right) \times 100 > 0$$

→ positive impact



# Impact of MODIS data II



# Results and summary

## Average statistics

$N_{\text{dates}} = 149$

$N_{\text{stations}} = 63$

|           | control run | experiment |
|-----------|-------------|------------|
| $R^2$     | 0.69        | 0.64       |
| RMSE [cm] | 15.17       | 15.57      |
| MBE [cm]  | -6.01       | -8.81      |
| MAE [cm]  | 11.31       | 11.65      |

- ▶ No improvement on average
- ▶ Improper use of MODIS information?
- ▶ MODIS misclassification?
- ▶ Initial thresholds?  
FSC, snow depth, snow temperature, snow density (SWE)
- ▶ More experiments are strongly needed...

# FSC threshold

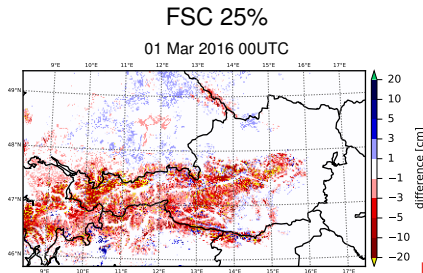
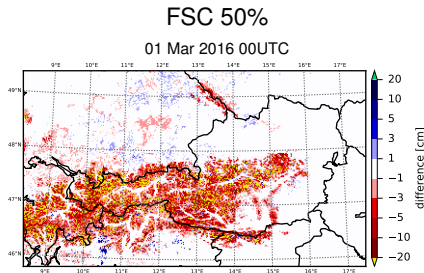
Experiments with different FSC thresholds (01 Jan to 01 Apr 2016)

## Average statistics

$N_{\text{dates}} = 91$

$N_{\text{stations}} = 63$

|           | experiment  |          |          |          |
|-----------|-------------|----------|----------|----------|
|           | control run | FSC 50 % | FSC 25 % | FSC 10 % |
| $R^2$     | 0.62        | 0.58     | 0.60     | ?        |
| RMSE [cm] | 17.54       | 18.26    | 17.63    | ?        |
| MBE [cm]  | -5.88       | -11.15   | -7.94    | ?        |
| MAE [cm]  | 14.71       | 15.43    | 14.79    | ?        |





Thank you  
for your attention!