

The value of optical and SAR based snow products for reconstructing SWE in a snow dominated headwater basin

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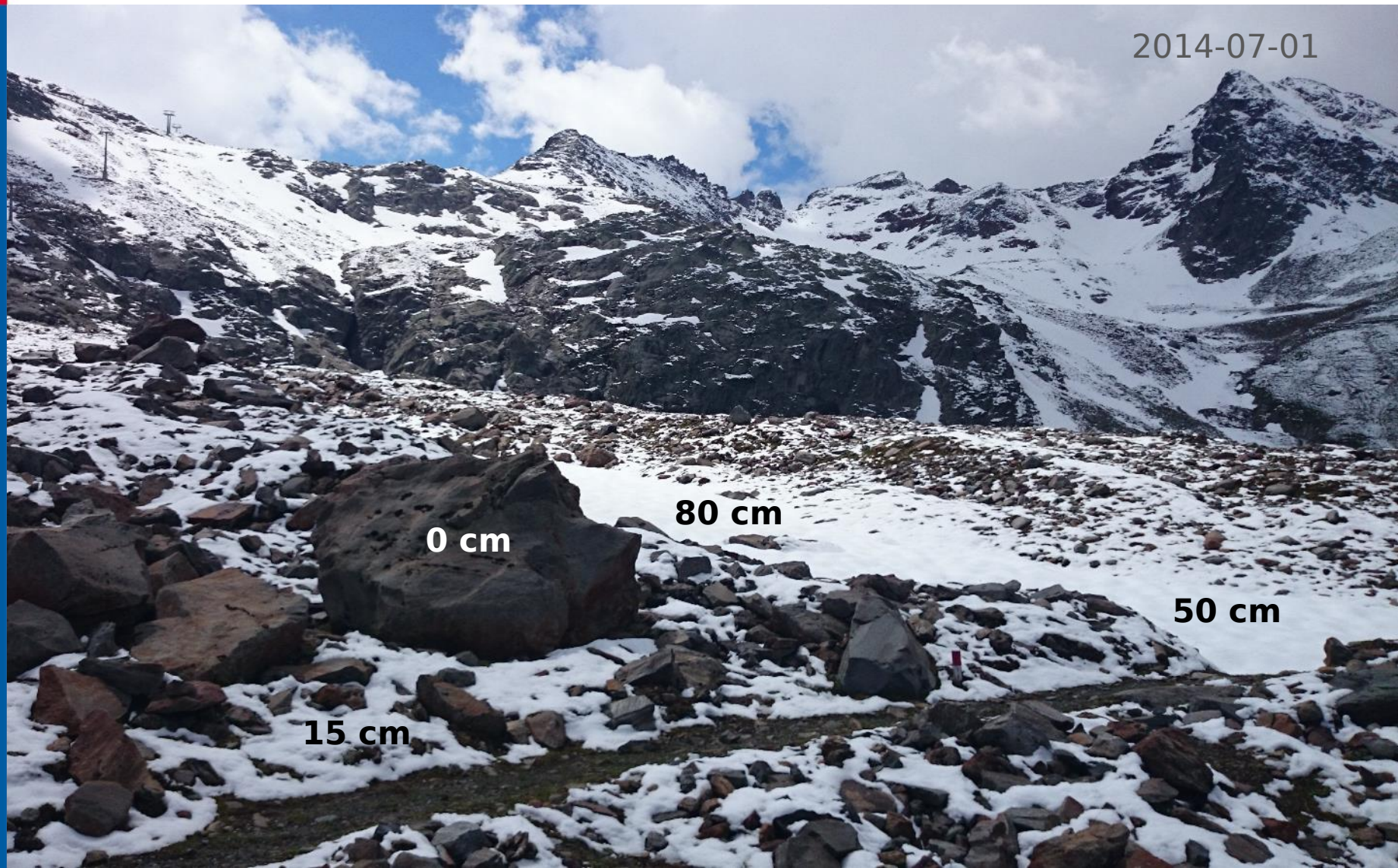
Snow Water Resources in Alpine Environments

2015-04-09

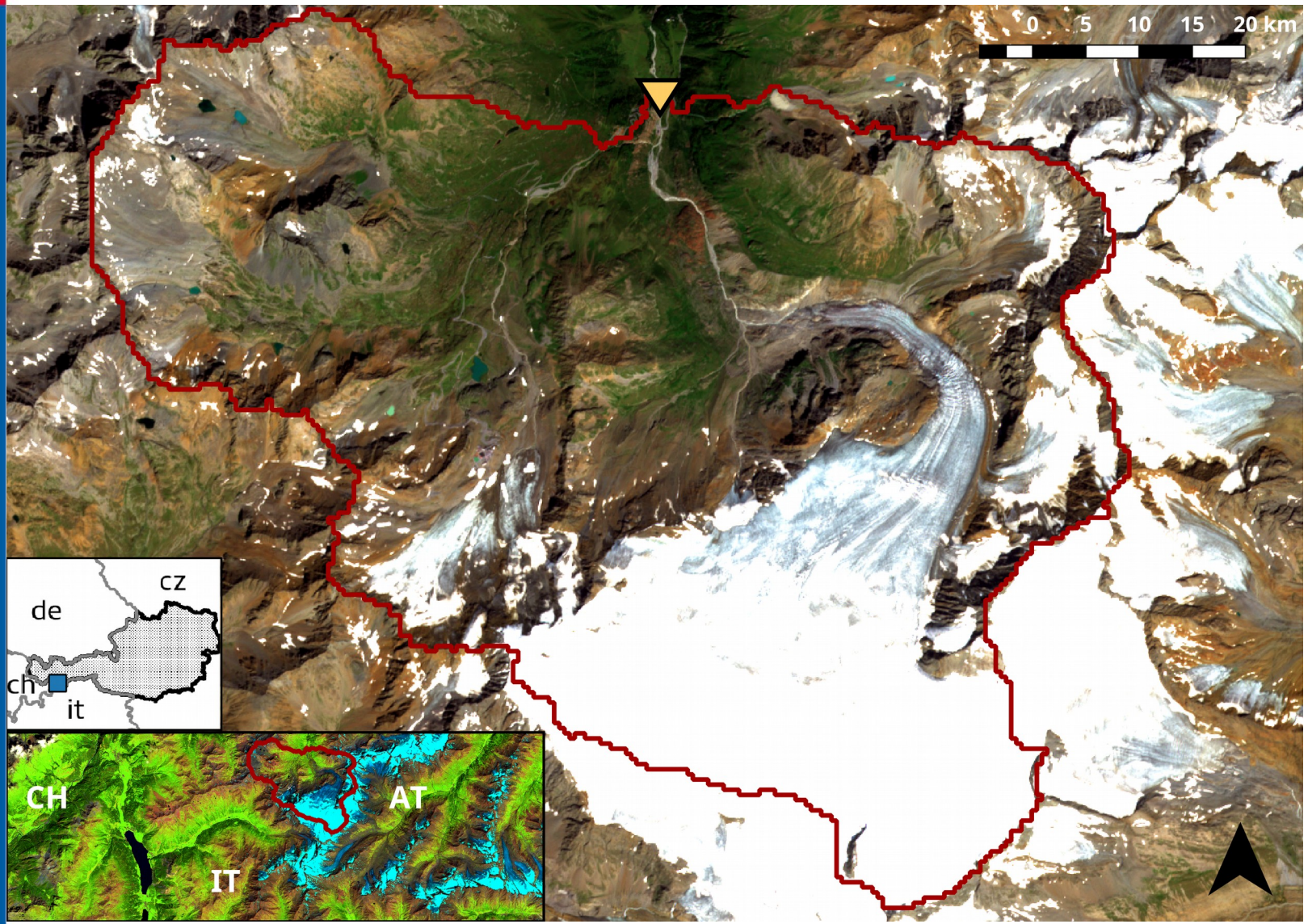
How much SWE is in the basin?



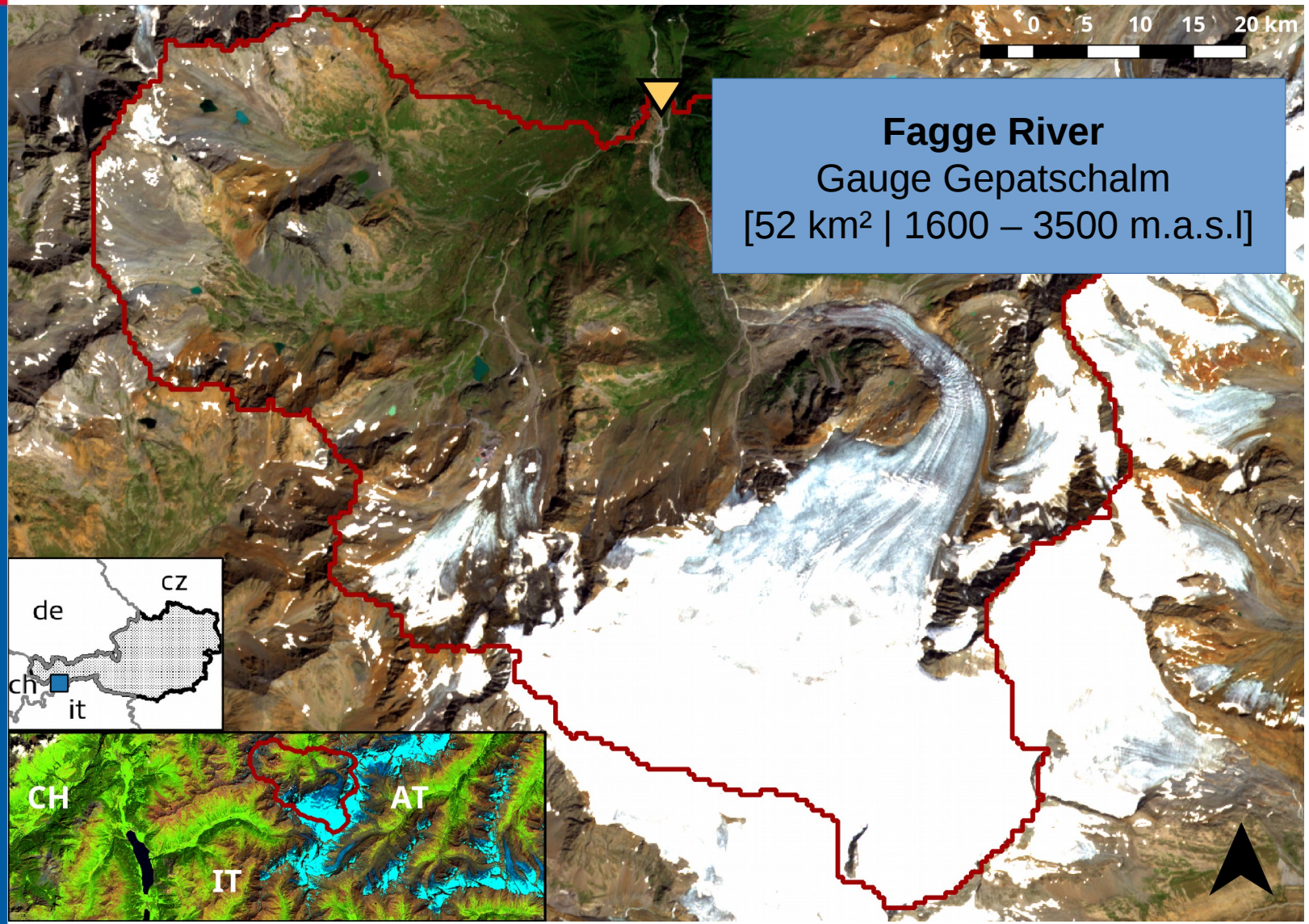
Extreme Variability



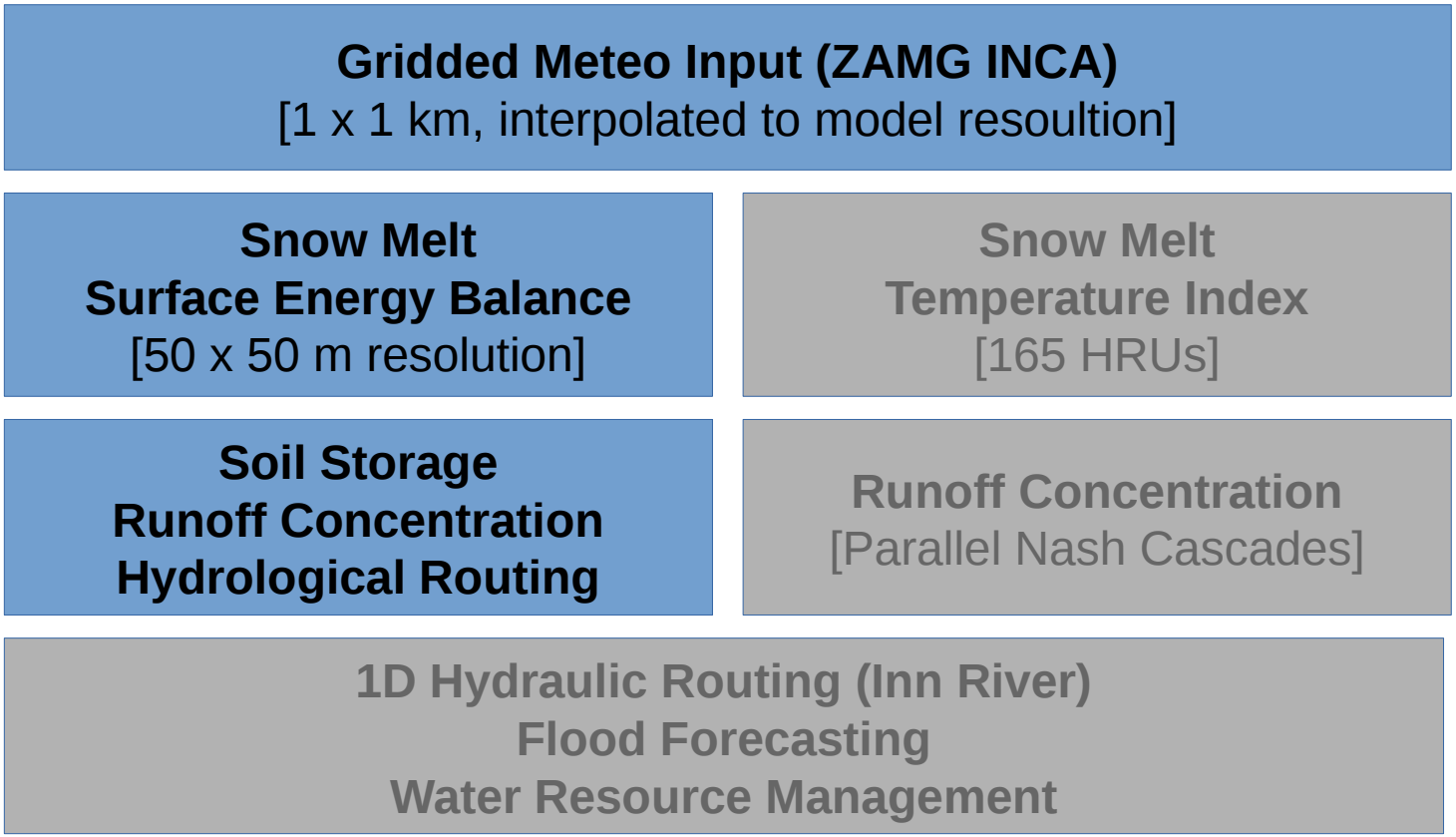
Study Area



Study Area


0 5 10 15 20 km
Fagge River
Gauge Gepatschalm
[52 km² | 1600 – 3500 m.a.s.l]
cz
de
ch
it
CH
AT
IT

Modular Model Setup



Remote Sensing Data

- **Medium Resolution Snow Cover (Cryoland)**
  - 250 x 250 m
  - Daily resolution
  - FSCA converted to binary data
- **Wet Snow Cover (Cryoland)**
  - 100 x 100 m
  - Several scenes
  - FSCA converted to binary data
- **High Resolution Snow Cover (Enveo)**
  - 50 x 50 m
  - Several scenes
  - FSCA converted to binary data

In-Situ Data

- **Point-Scale Snow Data**
  - Snow Pack Analyzer
  - Rho, SD, SWE
  - Hourly resolution
- **LiDAR (TLS)**
  - 1 x 1 m
  - SD, SWE (derived)
  - Several scenes
- **Cosmic-Ray Neutron Sensor (CRNS)**
  - Footprint ca. 230 m
  - SWE, SD
  - Hourly resolution, processed to 12 hourly data

Field Campaign 2014/16

Point-scale, LiDAR and CRNS



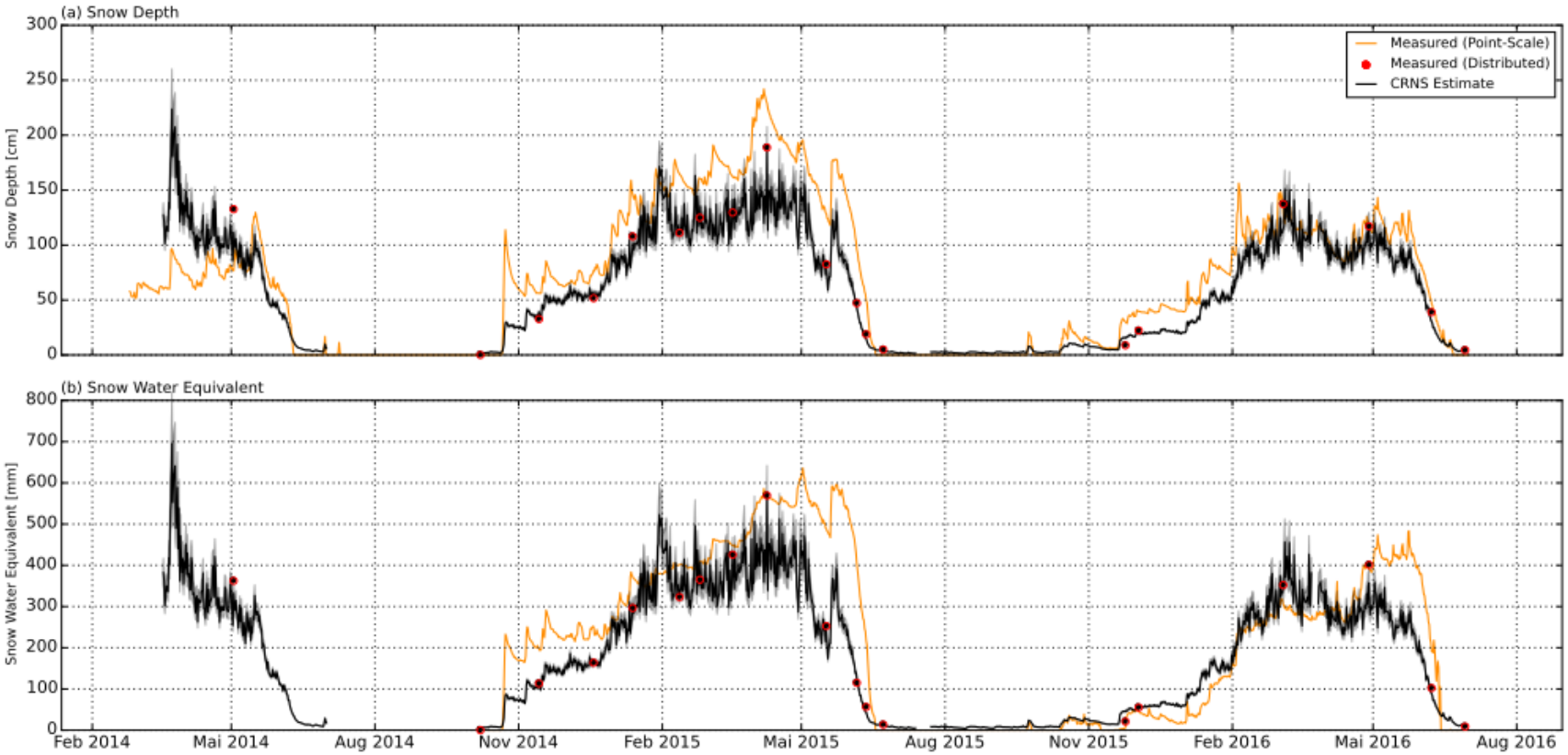






Field Campaign 2014/16

Point-scale, LiDAR and CRNS



Schattan, et al (2017, in review)

Multi-Objective Optimization

- **Simulated Annealing Algorithm**
- **Objective Function**
  - Using *n* Goodness of Fit (GoF) values
  - $1-\sqrt{\sum_{i}^{n}\left(1-GoF_{i}\right)^{2}}$
  - Dominated by lowest GoF value
- **1500 Realizations each**
  - KGE runoff + KGE runoff August (baseline)
  - Baseline + Accuracy SCA-daily
  - Baseline + Accuracy SCA high res
  - Baseline + Accuracy SCA wet snow

Multi-Objective Optimization

- **Modelling periods**
  - 10/2012 to 09/2013 (1 year, warm up)
  - 10/2013 to 09/2015 (2 years, calibration period)
  - 10/2015 to 09/2016 (1 year, validation period)

- **Validation against (Q99 subset)**
  - KGE runoff
  - Accuracy SCA high res
  - KGE SWE CRNS

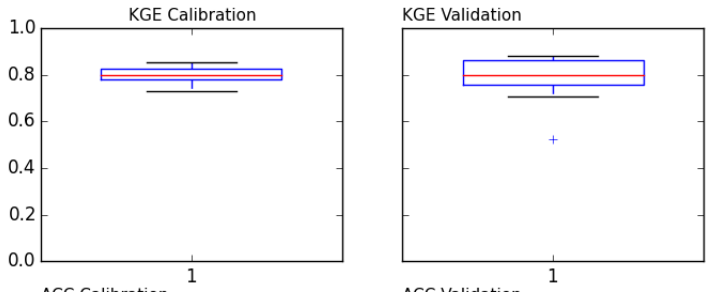
First Results
Runoff and SCA

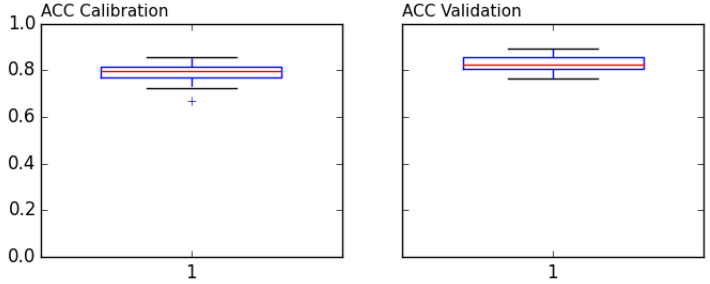
Baseline

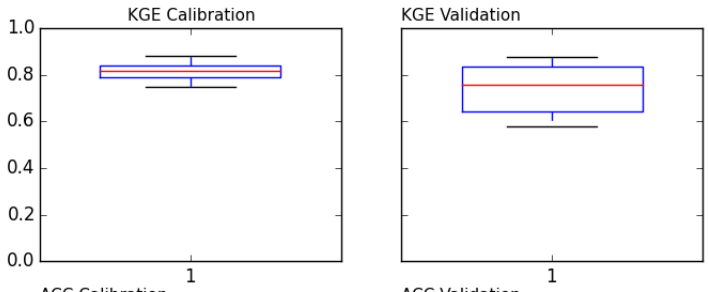
Wet snow

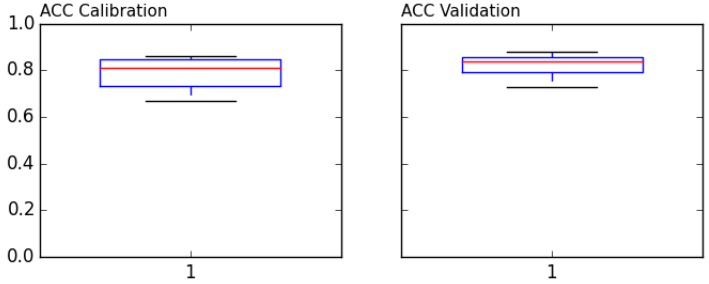
Runoff

SCA









First Results
Runoff and SCA

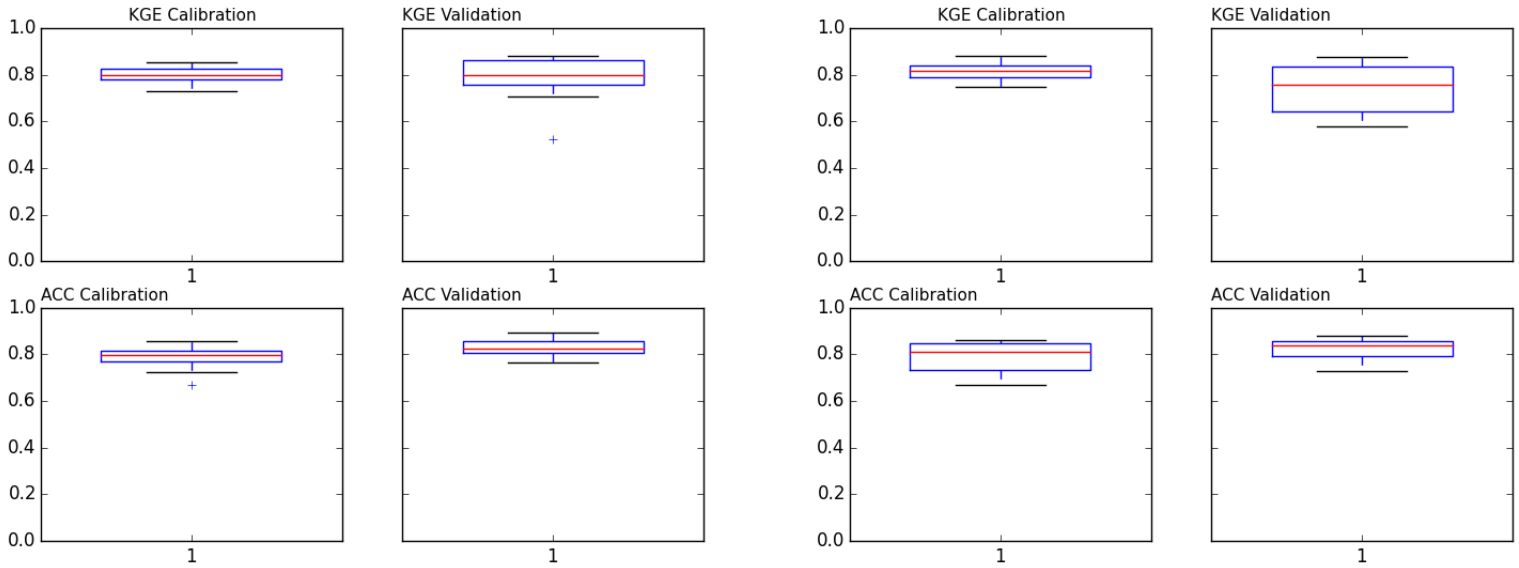
Baseline

Wet snow

?

Runoff

SCA



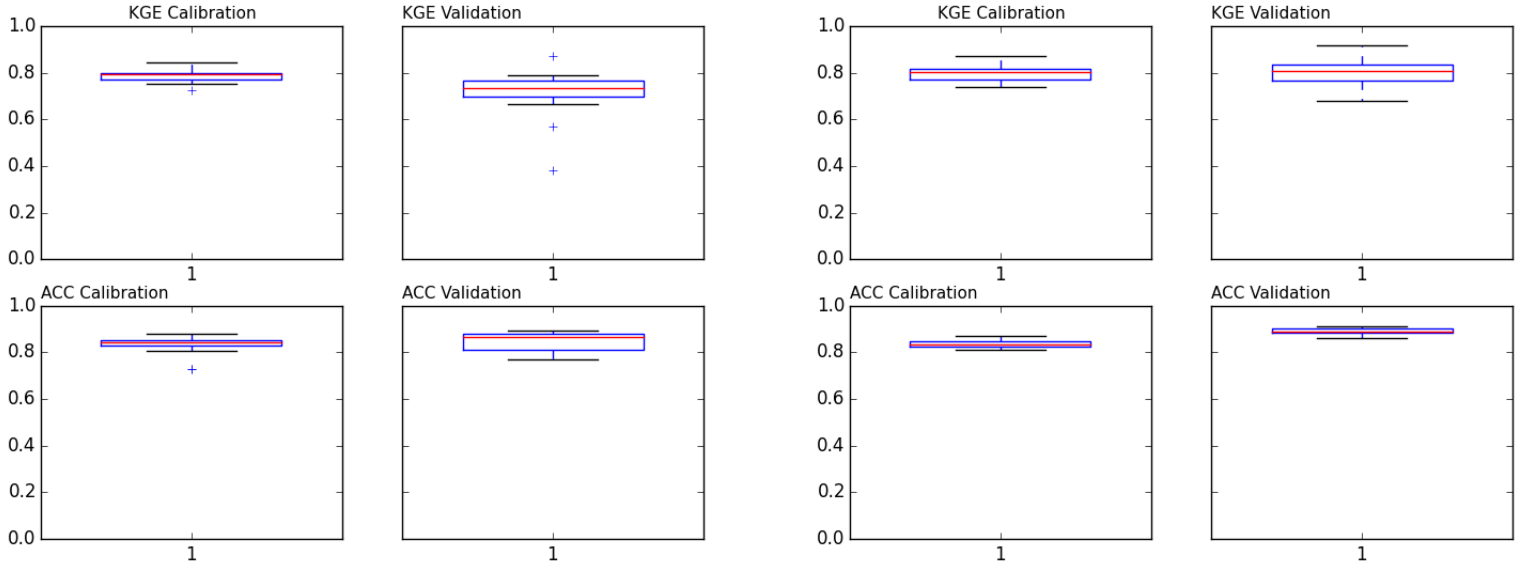
First Results
Runoff and SCA

High res

Daily

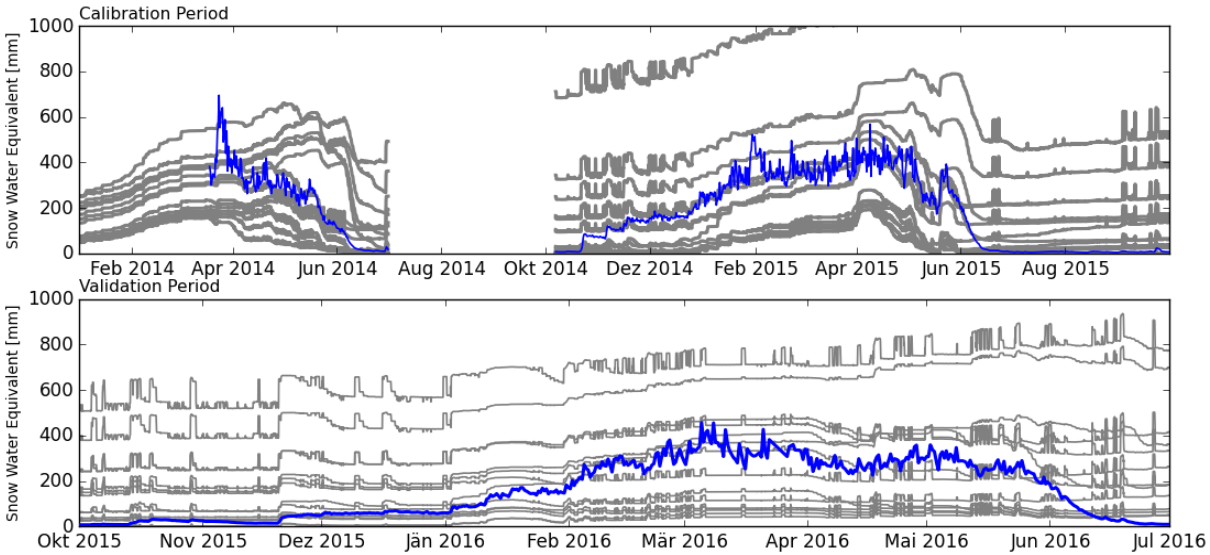
Runoff

SCA

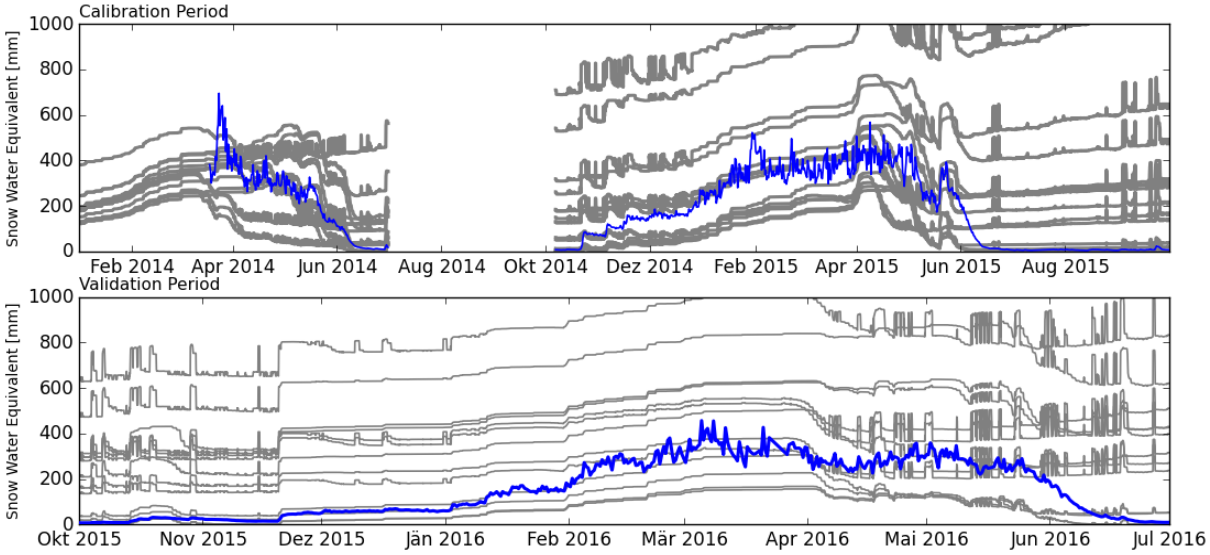


First Results
SWE CRNS

Baseline

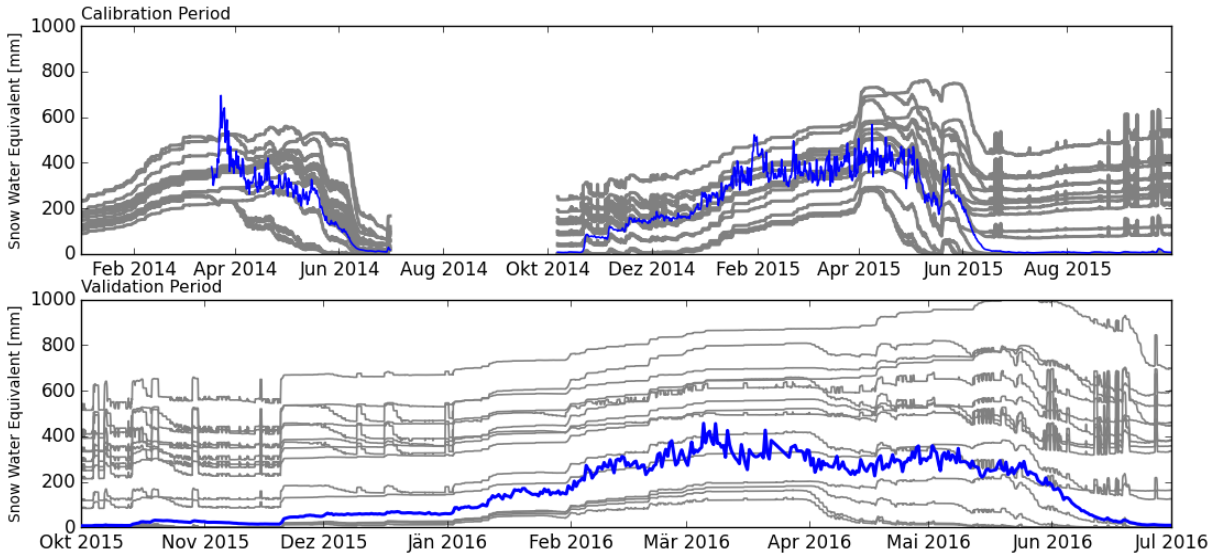


Wet snow

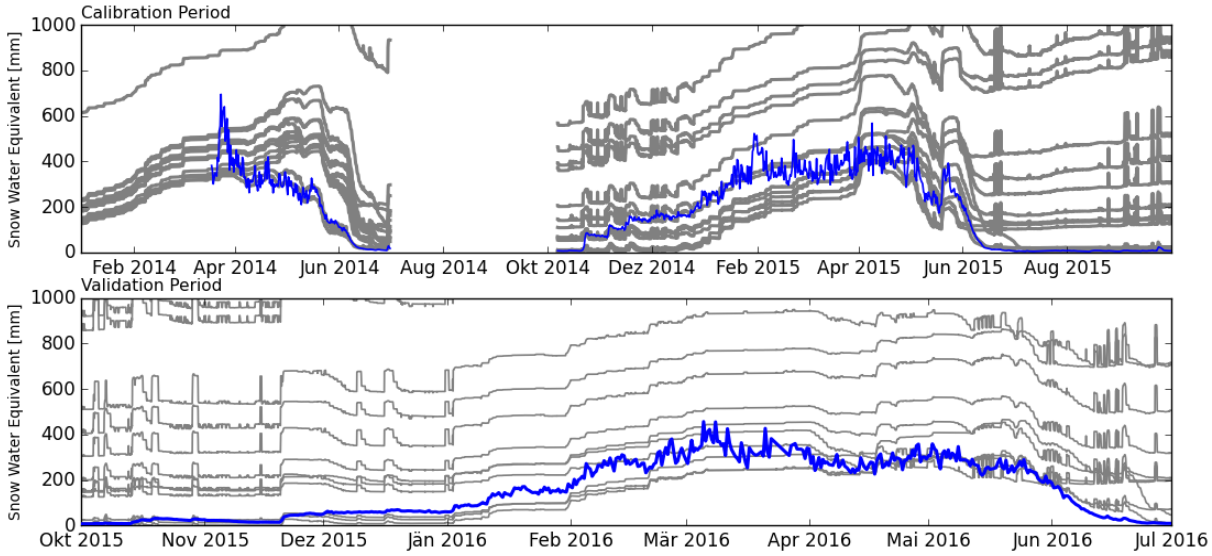


First Results
SWE CRNS

High res



Daily



Conclusions

- **Calibration with runoff only**
  - Good KGE and ACC
  - Poor SWE reconstruction
  - Good runoff prediction for the wrong reasons

- **Calibration with SCA wet snow**
  - Not sensitive for energy balance snow module
  - Increased parameter uncertainty
  - Good runoff prediction for the wrong reasons

Conclusions

- **Calibration with SCA daily**
  - Best results for KGE and ACC
  - Better SWE reconstruction
  - Physically more meaningful model
- **Calibration with SCA high res**
  - Slightly worse for KGE and ACC
  - Best SWE reconstruction
  - Best overall performance
  - Physically most meaningful model

Outlook

- **Other model setups**
  - Temperature index
  - Simpler runoff concentration
- **Basins with contrasting chracteristics**
  - Topography
  - Dryer (e.g. Engadin)
  - Wetter (e.g. Achensee region)
- **Including in-situ data into objective function**
  - TLS snow campaigns
  - Point-scale SWE
  - CRNS SWE
- **Improved method**
  - Using fractional information
  - More samples, optimized parameter space
  - Weighting scenes for data gaps

Thank you



Backup slides

Roughness and Exposure



Roughness and Exposure



Wind (Re-)distribution



Complex Energy Balance

