Combining satellite data and model simulations to enhance operational snow melt flood forecasting

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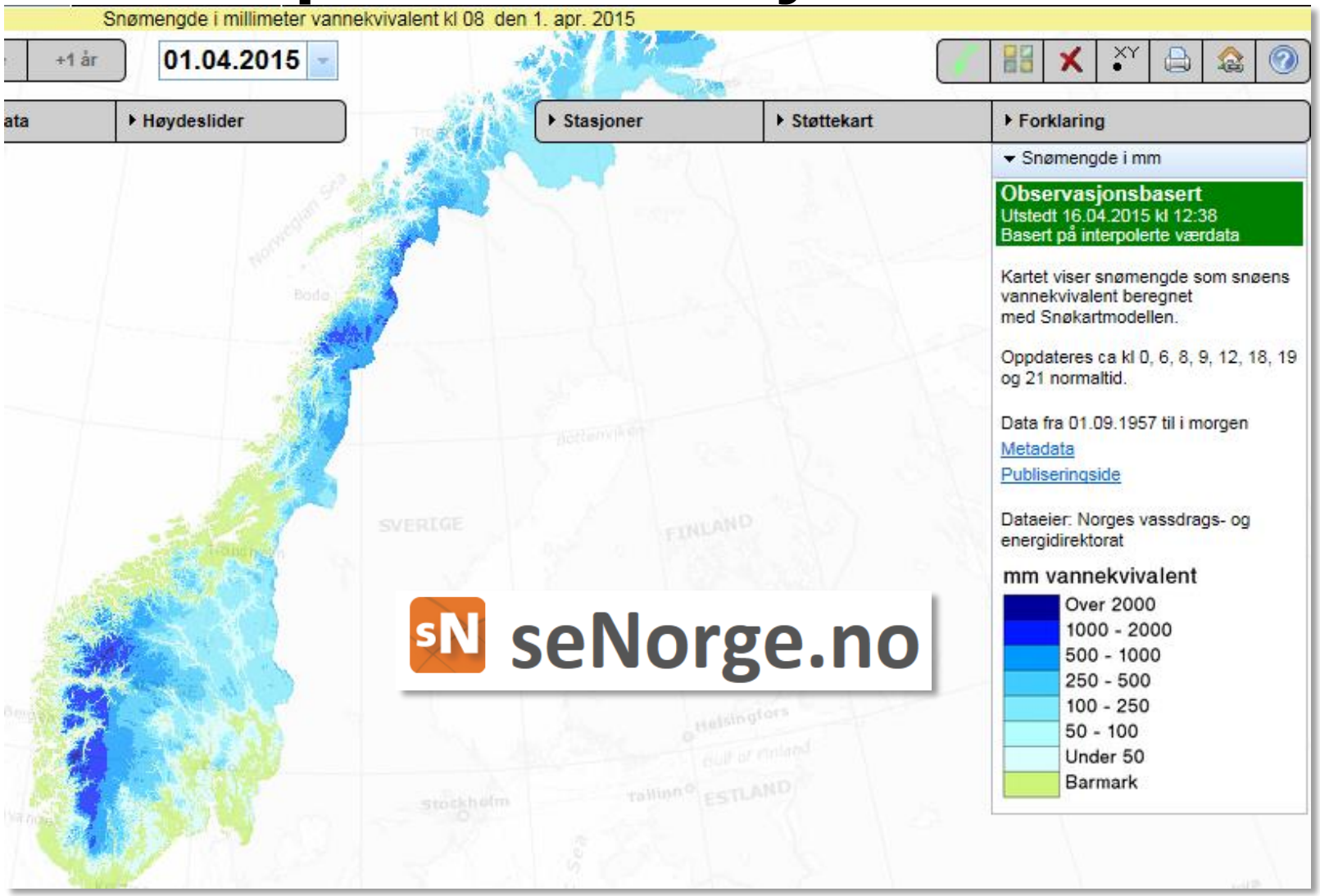
Motivation

- Seasonal snow cover is an important source of melt water
  - irrigation
  - hydropower production
  - human use

  - snow melt floods
  - slush flows
  - etc.

Snow maps for Norway



Aim

- To map the snow amounts in high-mountain regions in near real-time.
  - Main focus on the snow water equivalent, *SWE*

Challenges

- ***SWE*** *(snow water equivalent)*
  - Generally sparse observations
  - Main variable of interest
  - The melt water-giving potential of the seasonal snow cover

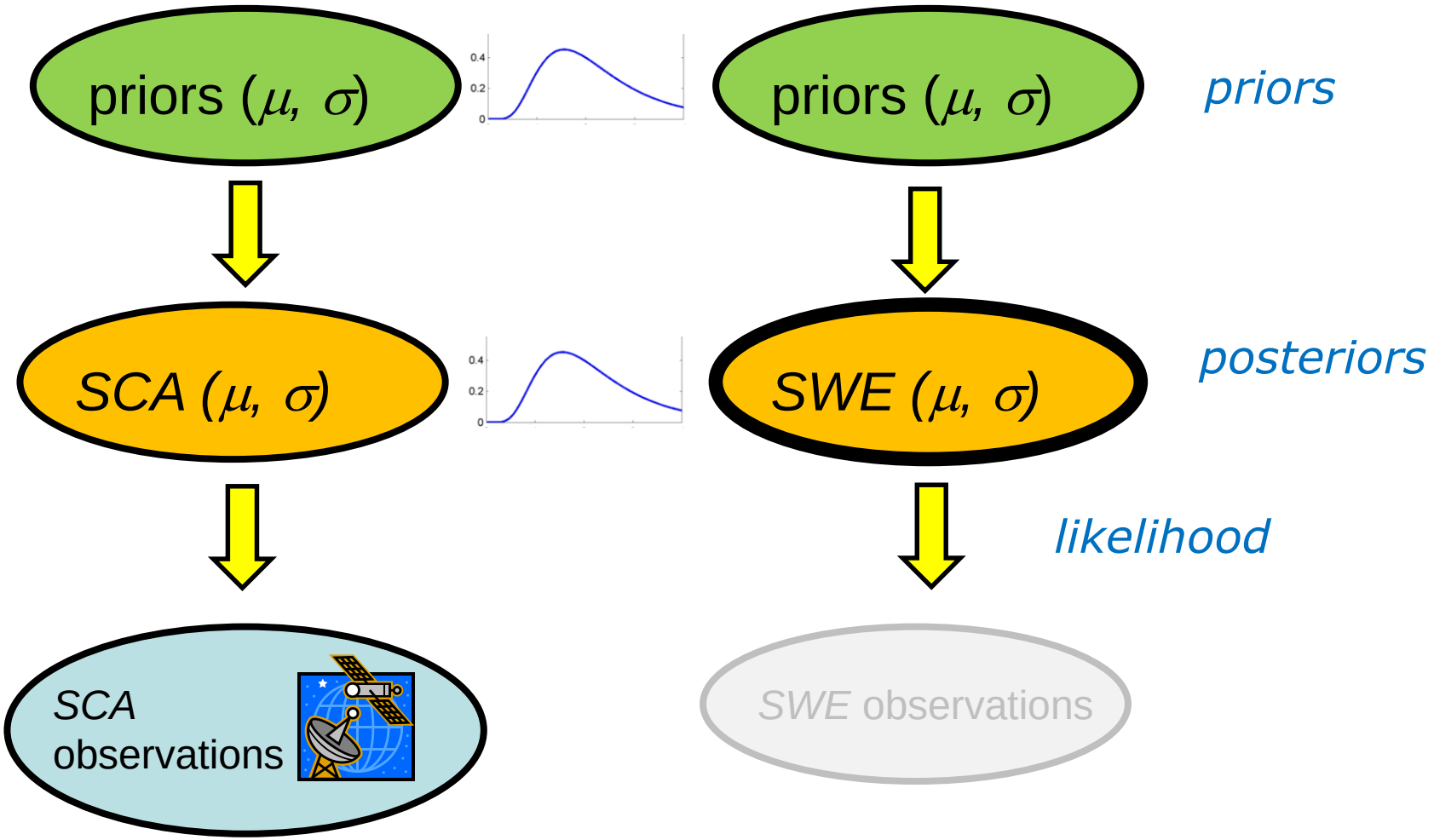
- ***SCA*** *(snow-covered area)*
  - A lot of data available
  - SCA can be estimated from cloudless satellite images (e.g. MODIS)
- However, the *SCA*-images cannot directly give information on *SWE*

Suggested solution

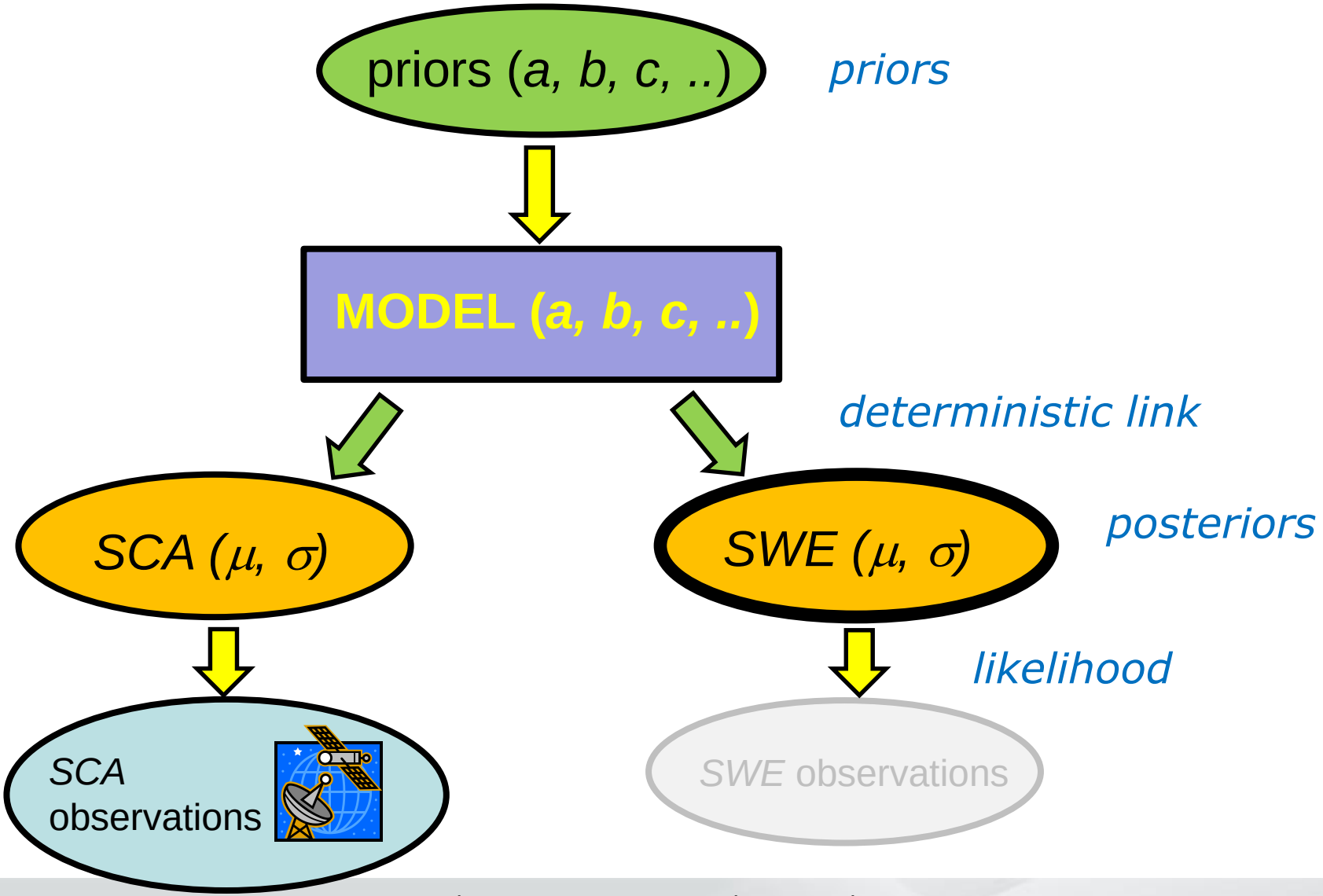
- (1) Use a **numerical model** as a deterministic link to convert between *SCA* and *SWE*
  - Our model choise: the ***seNorge*** snow model (with temperature and precipitation as input forcing).

- (2) Apply a **simple data-assimilation** method to minimize the discrepancy between observed and simulated *SCA* in near real-time.

Bayesian model (1)



Bayesian model (2)



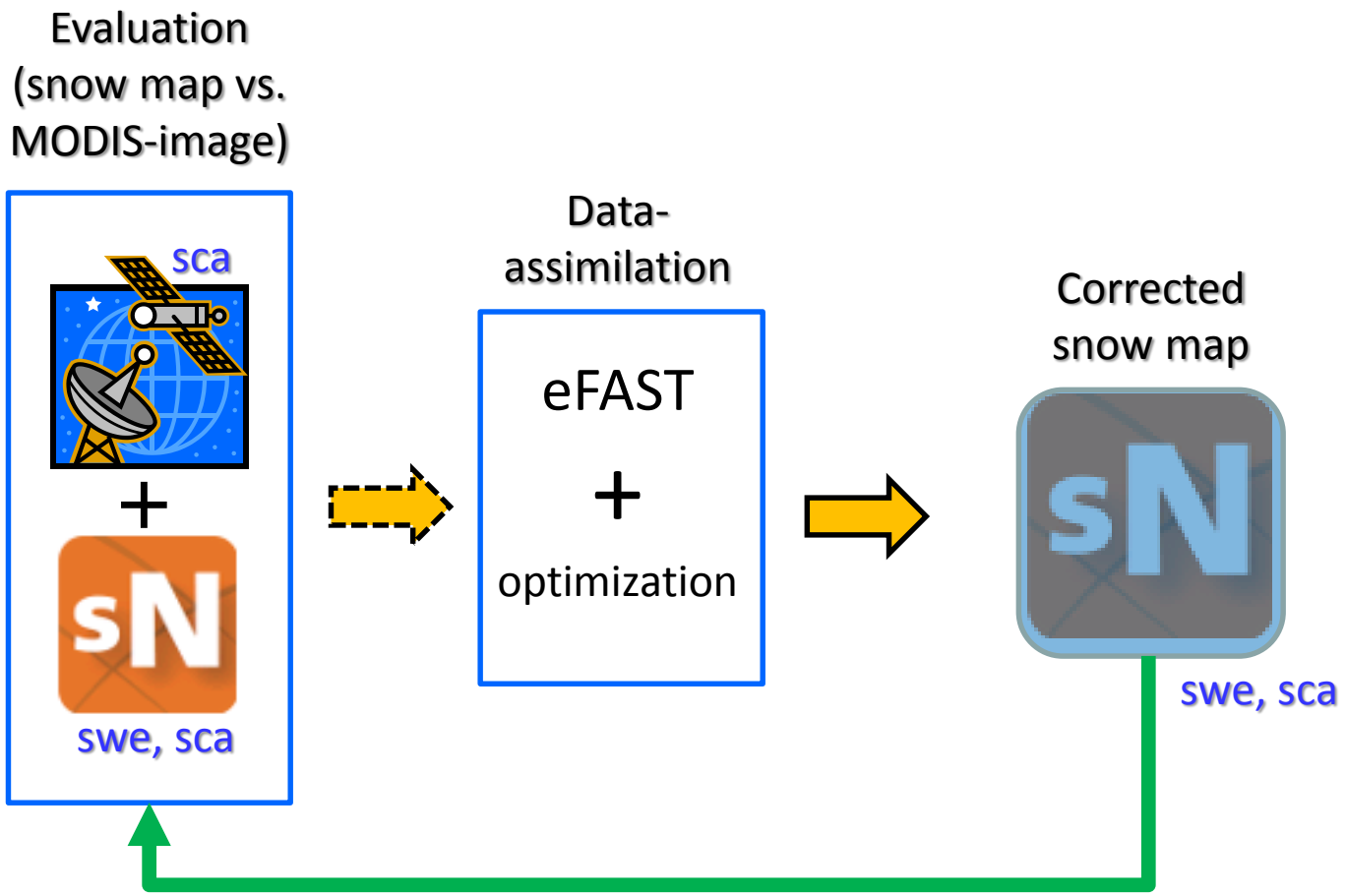
The data-assimilation procedure

- ***STEP 1:*** *Evaluation between simulated and observed SCA*

- ***STEP 2:*** *A detected discrepancy in SCA can be corrected in near real-time by simple data-assimilation*
  - *featuring Extended FAST (eFAST) sensitivity analysis to identify key model parameters for the detected discrepancy.*

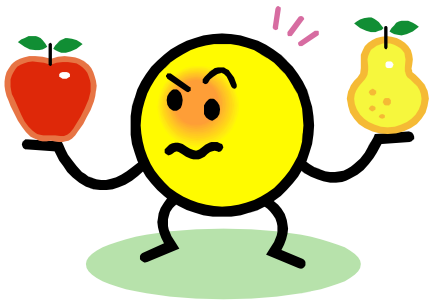
- ***STEP 3:*** *Optimization of key parameters to produce corrected snow maps.*

The data-assimilation procedure

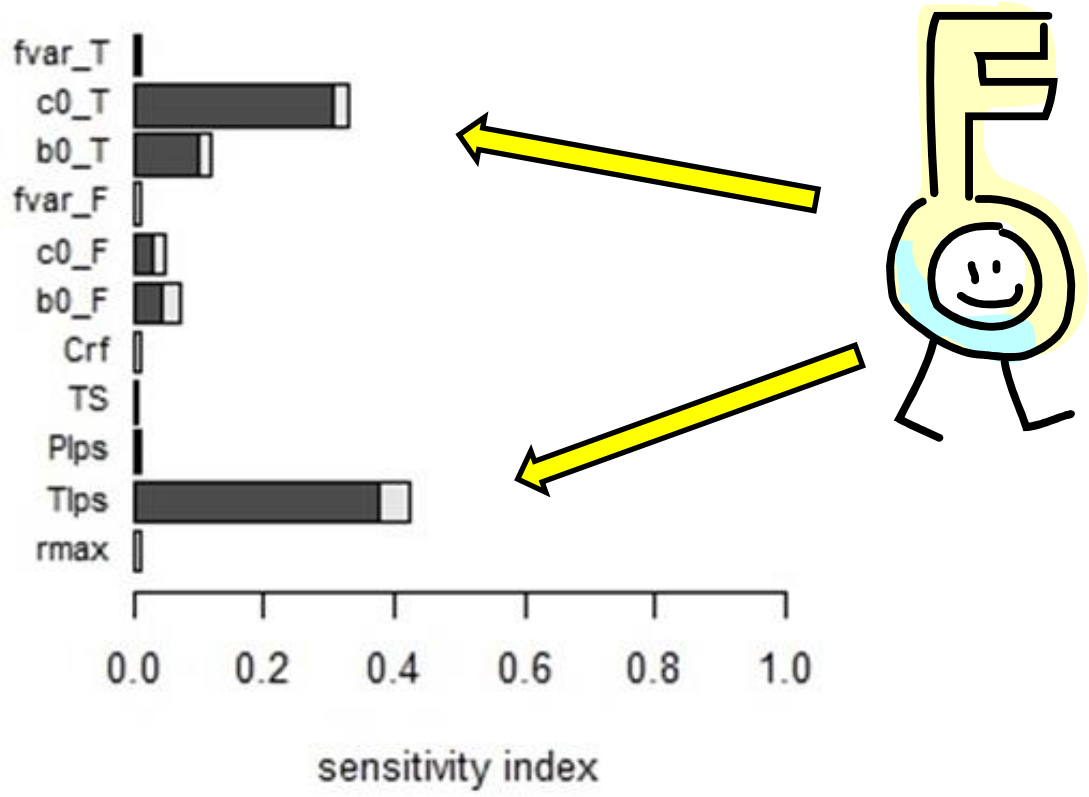


Sensitivity analysis

Which model parameters to optimize?



eFAST indices

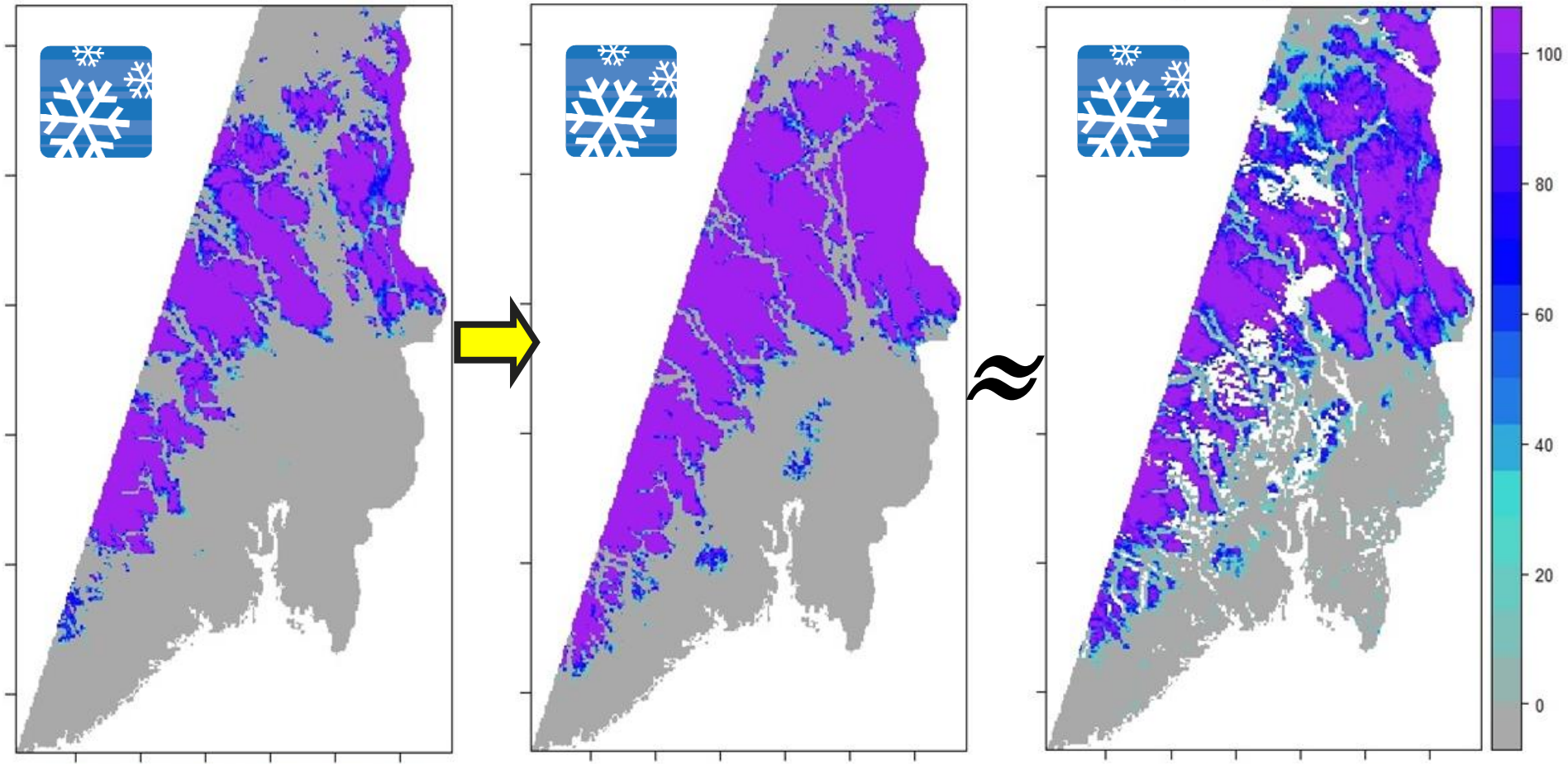


Example case

Simulated *SCA*

After data-assimilation

Observed (MODIS)



15 % underest.
1 % overest.

3 % underest.
3 % overest.

A case study in a Himalayan watershed

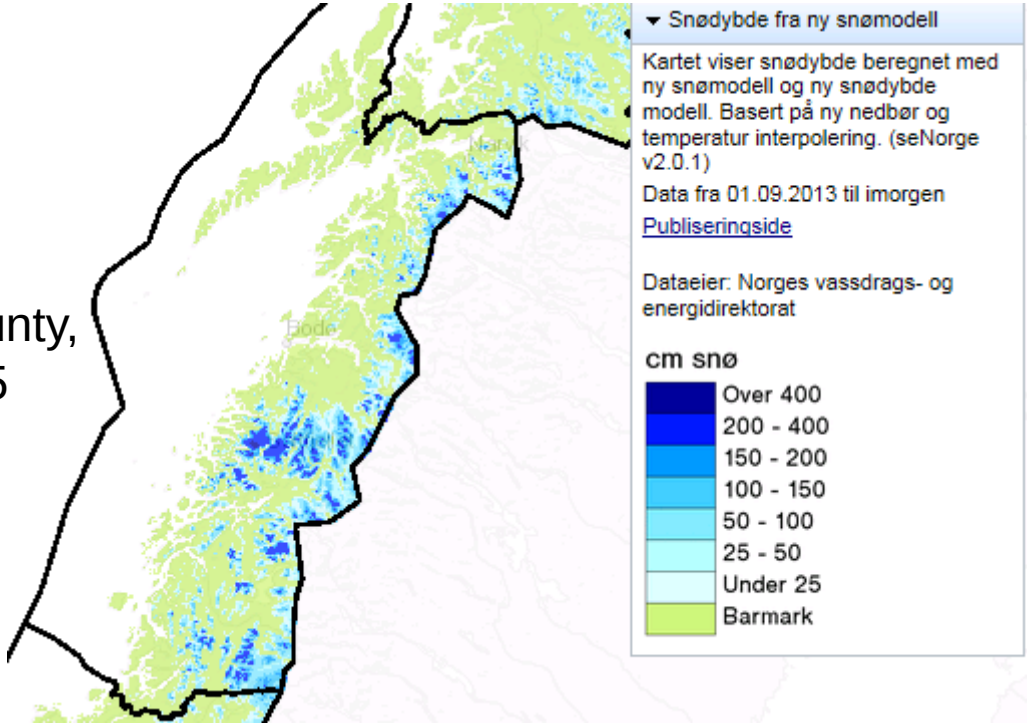
- The performance of the method will be tested in Langtang valley (Nepal) during the «***snowAMP***» project (2014-17).
  - part of ICIMOD's «HKH Cryosphere Monitoring Project» supported by the *Norwegian Ministry of Foreign Affairs*.

Extra: «Snøblikk» - snow summaries

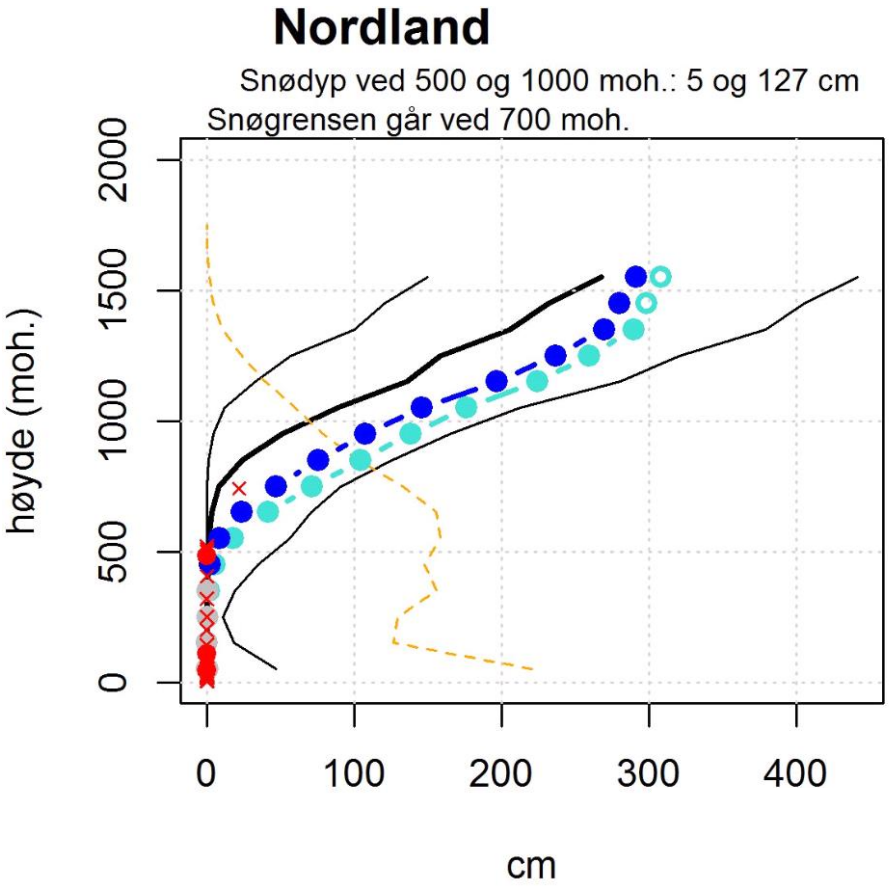
- The idea of «Snøblikk»:
  - simulated and observed snow information is gathered from an area (county, catchment), summarized, and plotted against elevation.
- Simulated values (seNorge snow model):
  - Snow depth, water equivalent, wetness, snow-covered area & snow line elevation.
- Observations (MET, NASA):
  - Snow depth, snow-covered area & snow line elevation.

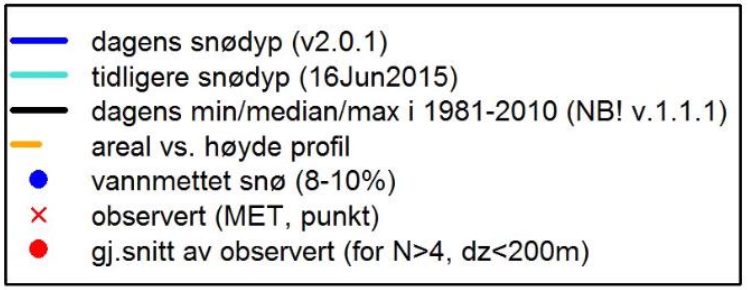
«Snøblikk» - snow summaries

Snow depth,
Nordland county,
23 June 2015



«Snøblikk» - snow summaries





23 June 2015

Summary

- **Main question:**

  How to best utilize satellite images of snow-covered area (*SCA*) to map snow amounts (*SWE*) in high-mountain regions in near real-time?

- **Suggested solution:**

  (1) Use a simple snow model as deterministic link between *SCA* and *SWE*.

  (2) Optimize the simulated *SCA quickly* by simple data-assimilation of satellite-based *SCA*-data to the snow model

This method can provide useful, near real-time, first-order estimates of *SWE* .