MuSA: The Multiscale Snow Data Assimilation System

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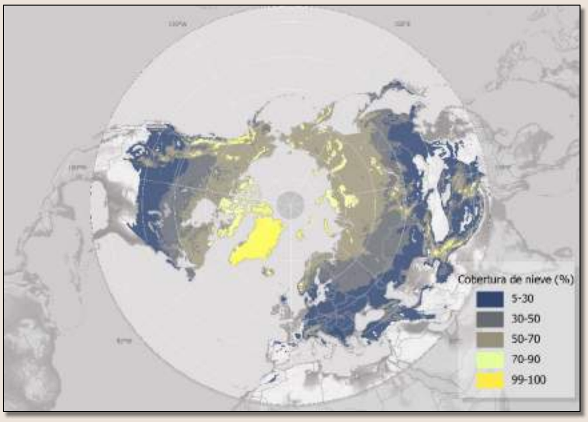
Motivation

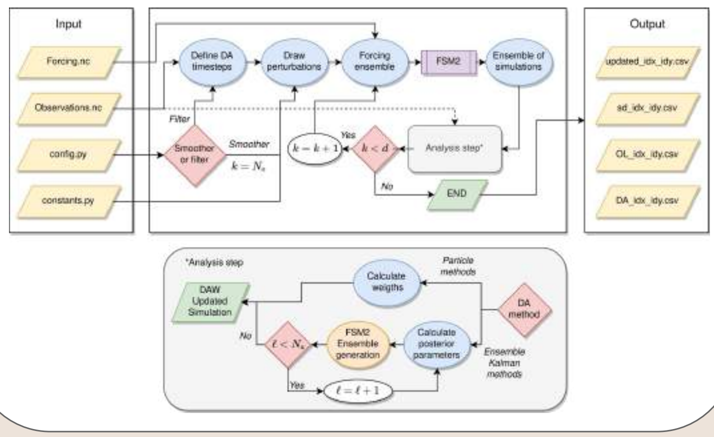


- Monitoring of the snowpack is challenging due to its spatio-temporal variability, particularly over complex terrain. In situ observations of the snowpack in mountains are limited, and very rare when it comes to snow water equivalent (SWE). Numerical modeling of snowpack has proved to be a powerful tool to simulate the SWE. However, snowpack models need accurate high resolution meteorological forcings, which are currently difficult to obtain
- The key is to integrate remote sensing and numerical simulations through data assimilation techniques, i.e. by an optimal combination of the data (given their uncertainties) and snowpack simulations to bridge the gap between remote sensing observations and the water managers needs.
- More research is needed to merge already available and emerging spatial products with numerical models for a better understanding of mountain freshwater resources.
- There are only a few standalone snow data assimilation frameworks. The existing ones are not open source, rarely include different assimilation algorithms and are complex to extend in capabilities.

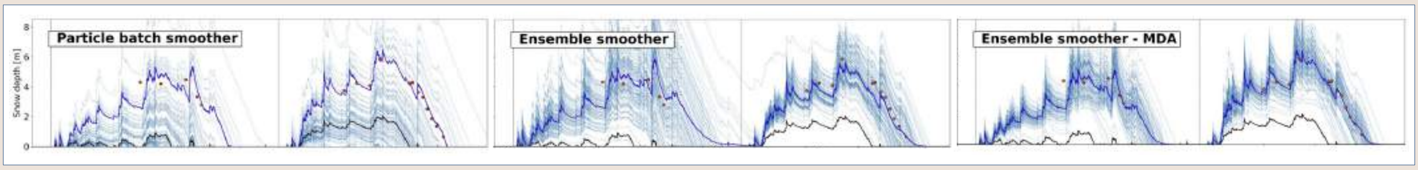
MuSA: Overview

Core: Flexible Snow Model (FSM2)

- **Language:** Python
- **Setup:** Simple configuration file
- **Compatible observations:**
  - SWE, snow depth, land surface temperature, fractional snow cover area, albedo, sensible/latent/heat fluxes...
  - Joint Assimilation (more than one variable at the same time))
- **Algorithms:**
  - Well tested: PF (5 resampling strategies), PBS, ES, IES, EnKF, I-EnKF.
  - Experimental: MCMC using a ML emulator, hybrid methods, I-PF and I-PBS.
  - Spatial propagation of the information from observed cells to gaps (Kalman methods)

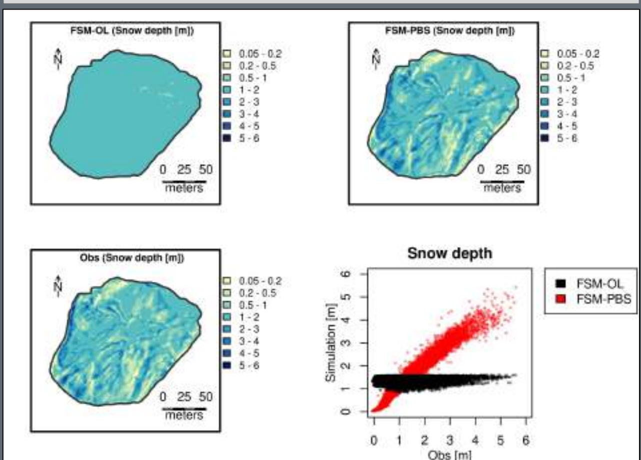


Intercomparison of algorithm performances

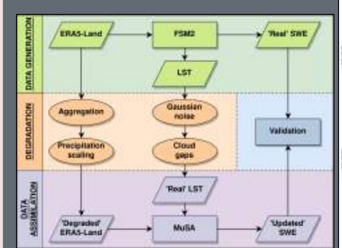


Assimilation of Hyper-resolution and land surface temperatures

- Assimilation snow depth retrievals obtained from a fixed wing drone 5m spatial resolution: 18500 cells
- Simulation ensemble was composed of 100 particles (PBS)
- MuSA scaled ~linearly up to 1000 computational units



- Exploring the potential of inferring the SWE from TRISHNA LST.
- Synthetic experiments show a significant improvement compared to Landsat due to higher temporal resolution.
- TRSHNA will significantly improve the uncertainty of snow simulations.



- Observing System Simulation Experiment (Synthetic experiment, OSSE)
- 2 different revisiting times: 3 & 16 days
- 4 different cloud cover scenarios: 0, 25, 50 & 75 %
  - LST-DA may potentially improve the snow mass estimations
    - LST-DA at low temporal resolutions, may lead to uncertain results