Improving Land Surface Model Simulations

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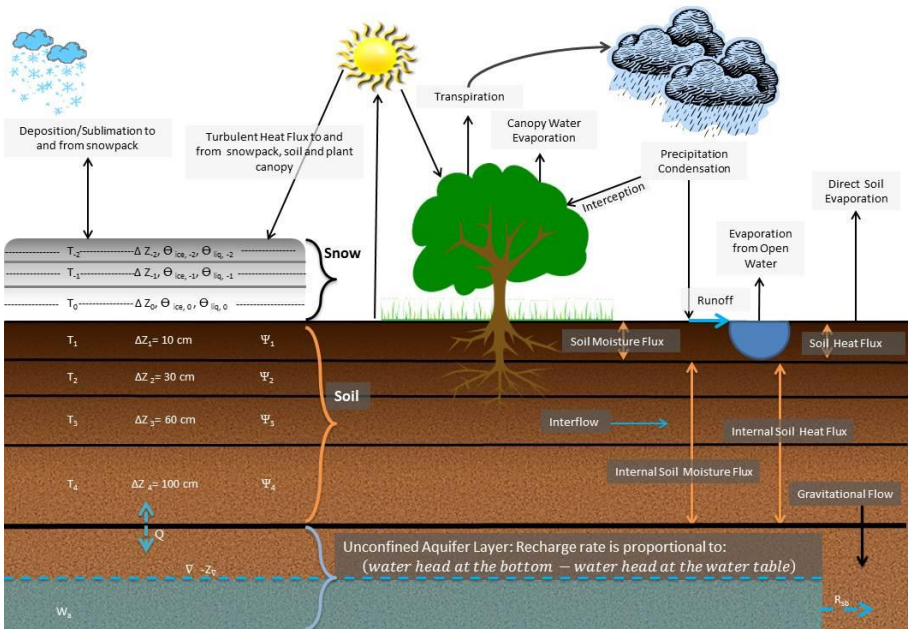
Land Surface Model (LSM)



- LSMs compute the energy, water (and sometimes carbon) balance at the land surface
- Based on first principles: conservation of energy and mass

$$R_n = \lambda E + SH + G$$

$$\frac{dS}{dt} = P - E - R_s - R_g$$

Important snow variables

Snowpack metamorphose due to near-surface atmospheric forcings

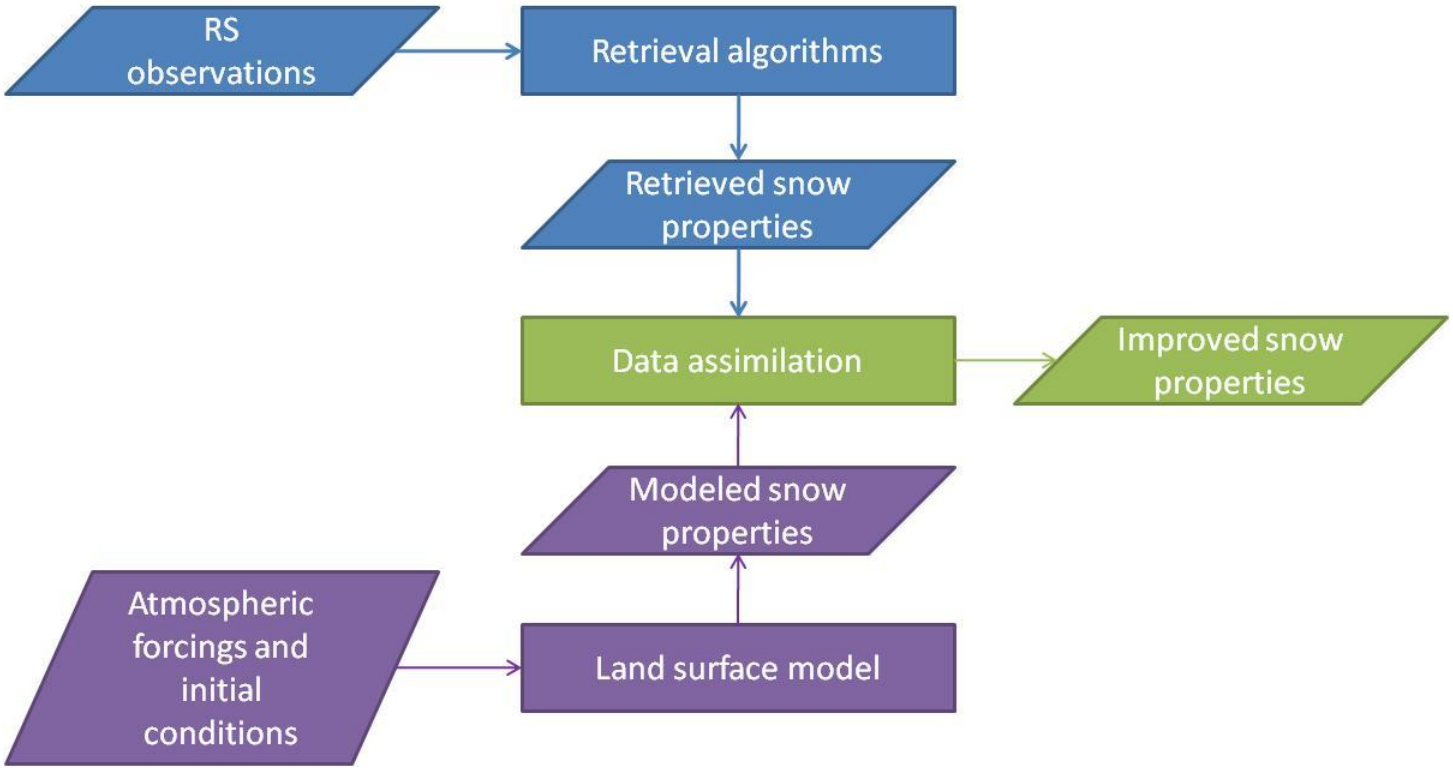
- **Snow albedo + Snow Coverage:** Controls partitioning of energy fluxes and magnitude of water fluxes
- **Snow water equivalent (SWE) + Snow Coverage:** defines liquid water quantity

Snow affects world's climate, weather and hydrological systems

Objective

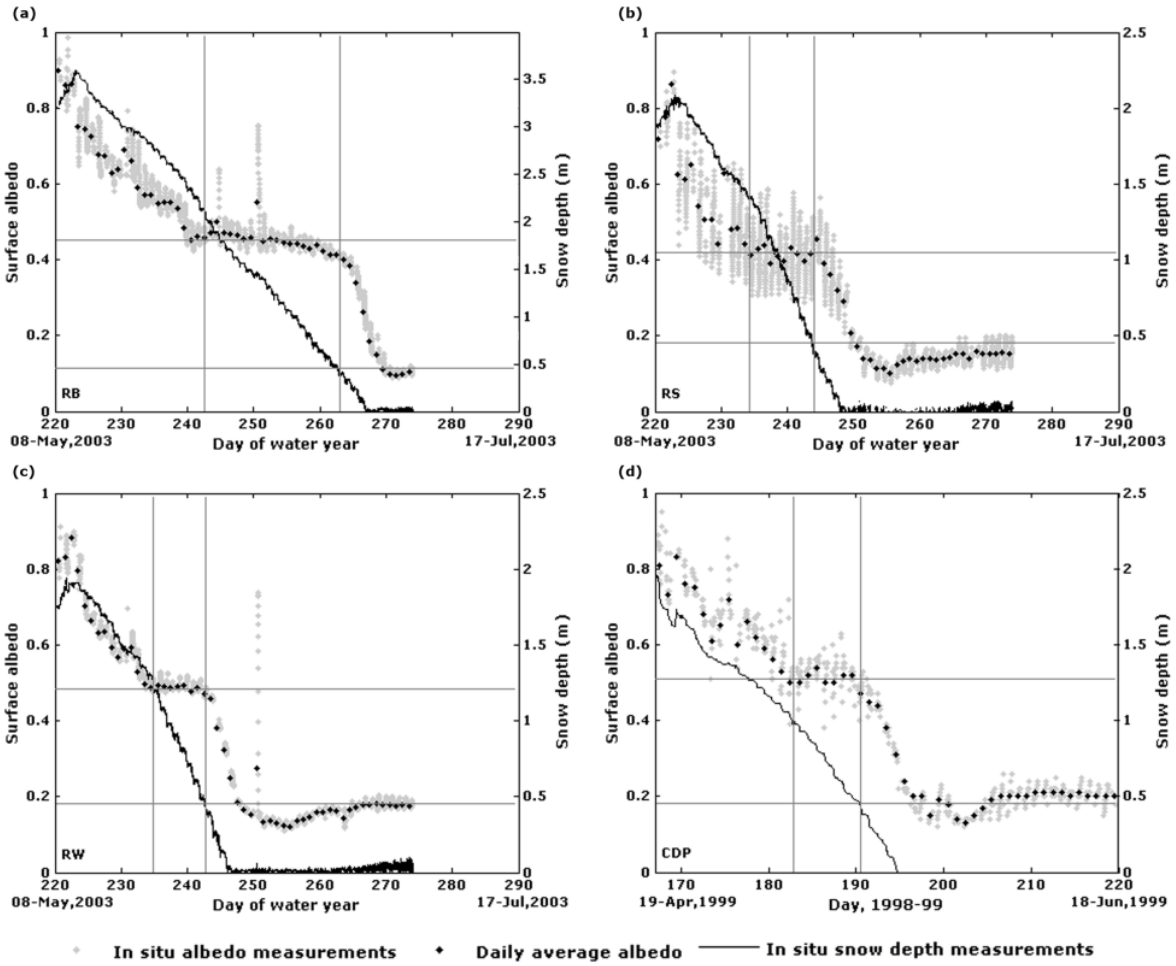
The presentation aims to improve the simulation of snow processes by LSMs, which ultimately improve energy and water fluxes simulations.

Research flowchart

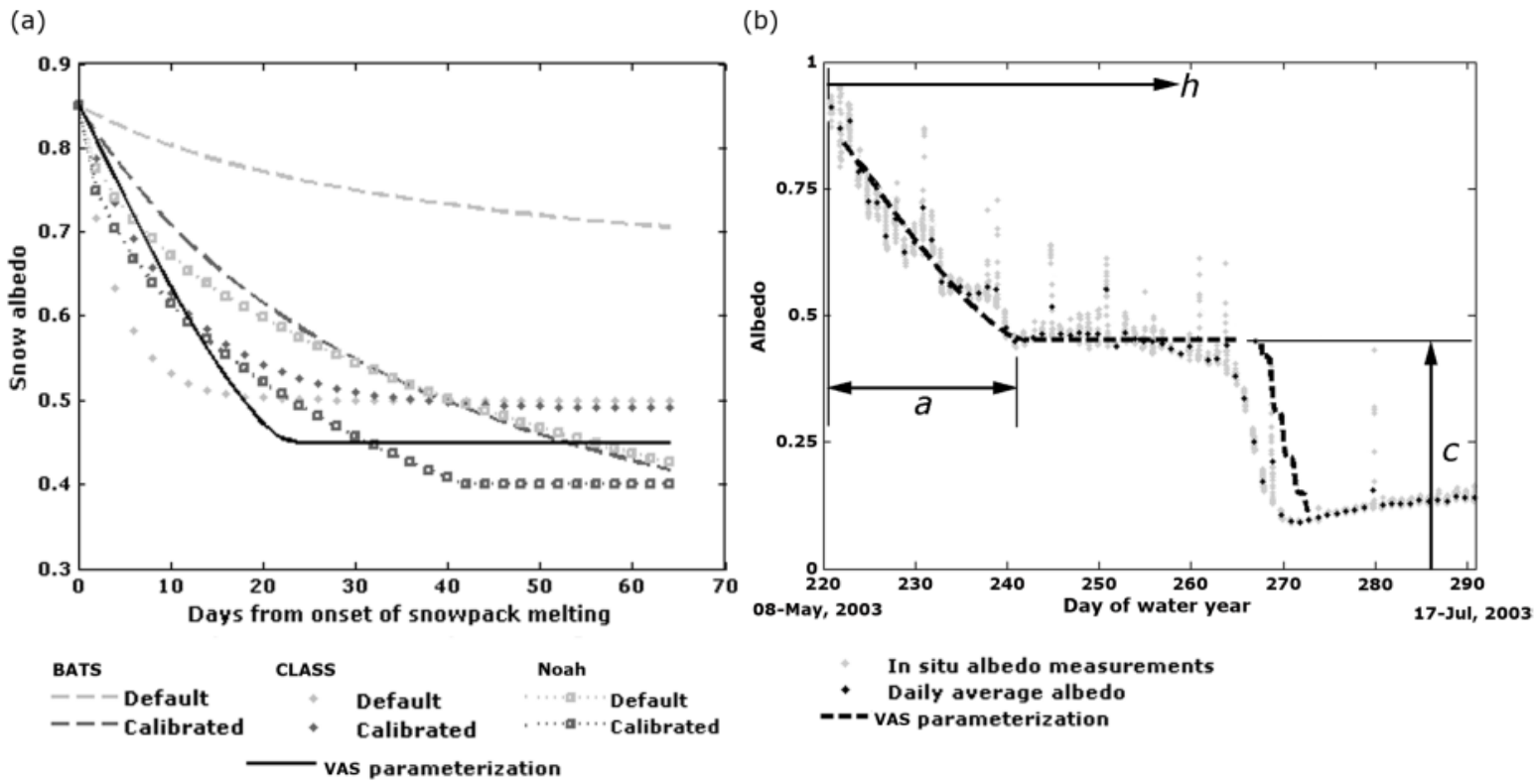


Measured snow albedo evolution

- The albedo:
  - drops to the minimum value of 0.45 - 0.5
  - stays around this value till the snowpack remains optically thick
  - decreases again when snowpack becomes optically thin
- We proposed VAriogram-Shaped (VAS) parameterization to characterize the snow albedo decay



Snow albedo parameterization

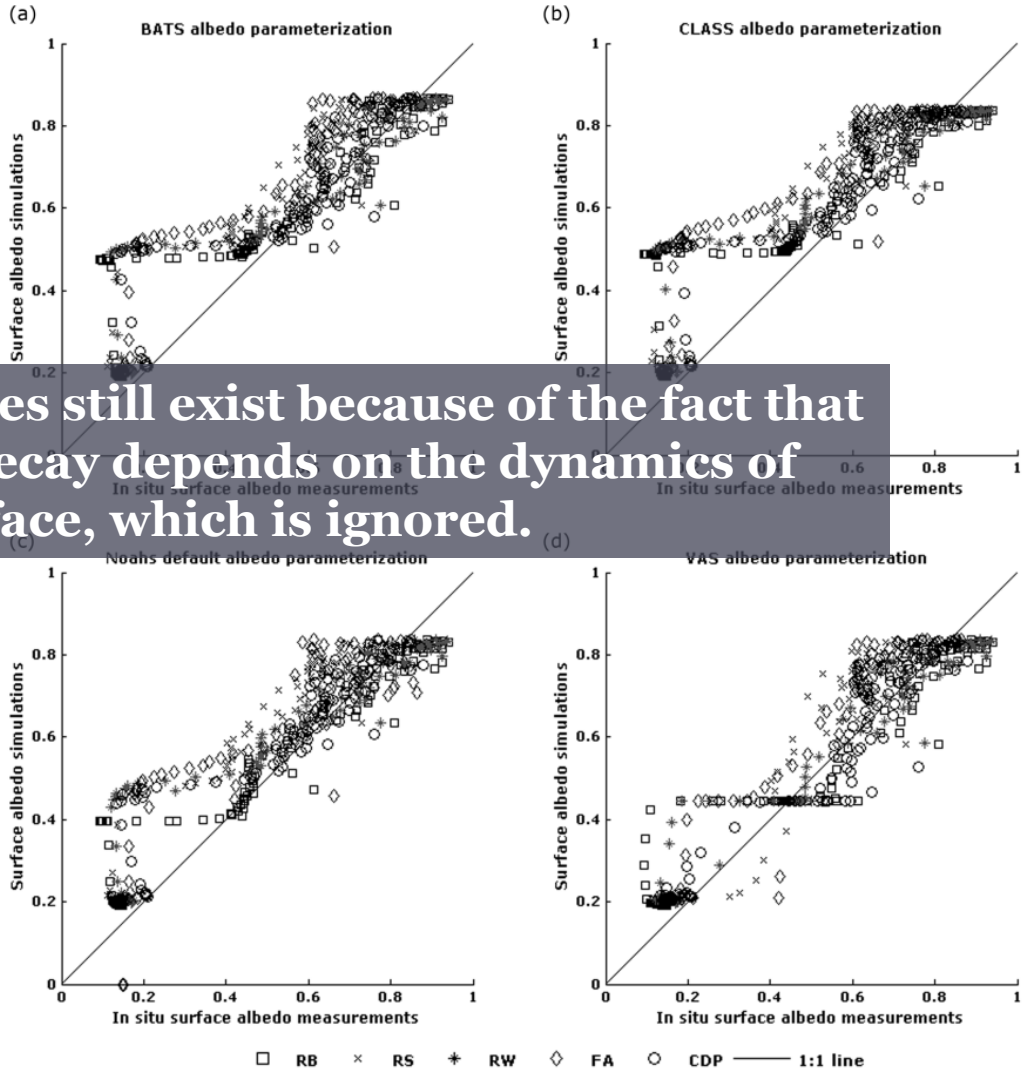


All parameterizations differ in **rate** of snow albedo evolution and **range** of snow albedo values

Comparison of simulated snow albedo

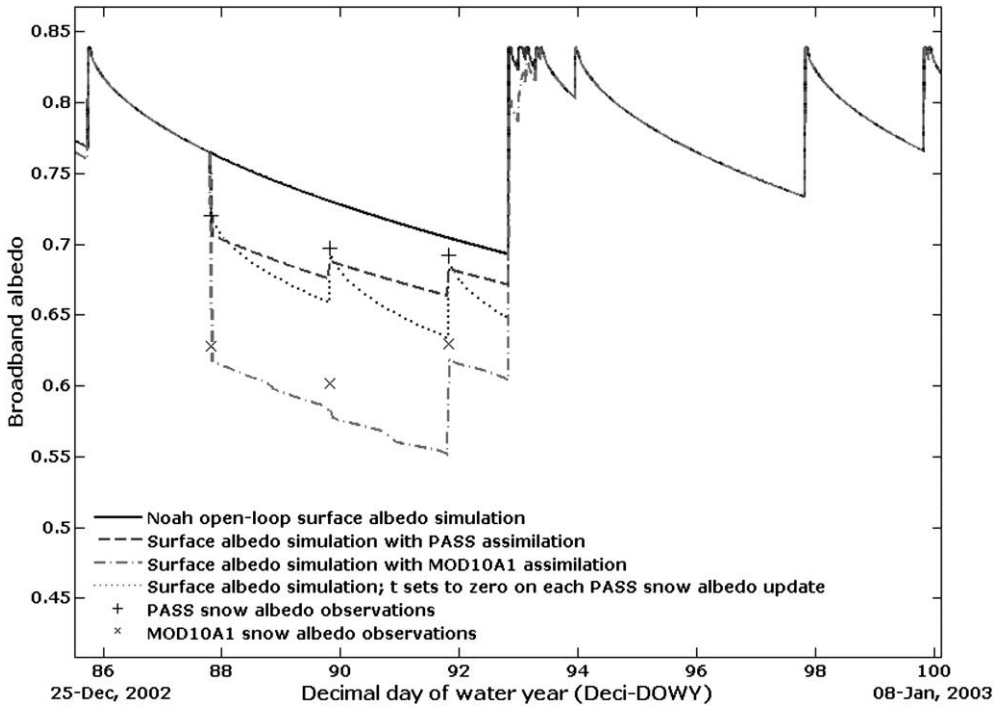
- The three parameterizations overestimate snow albedo during springtime
- The results with the VAS parameterization are significantly better than the BATS and CLASS snow albedo parameterizations

Nevertheless, uncertainties still exist because of the fact that the rate of snow albedo decay depends on the dynamics of atmosphere near the surface, which is ignored.



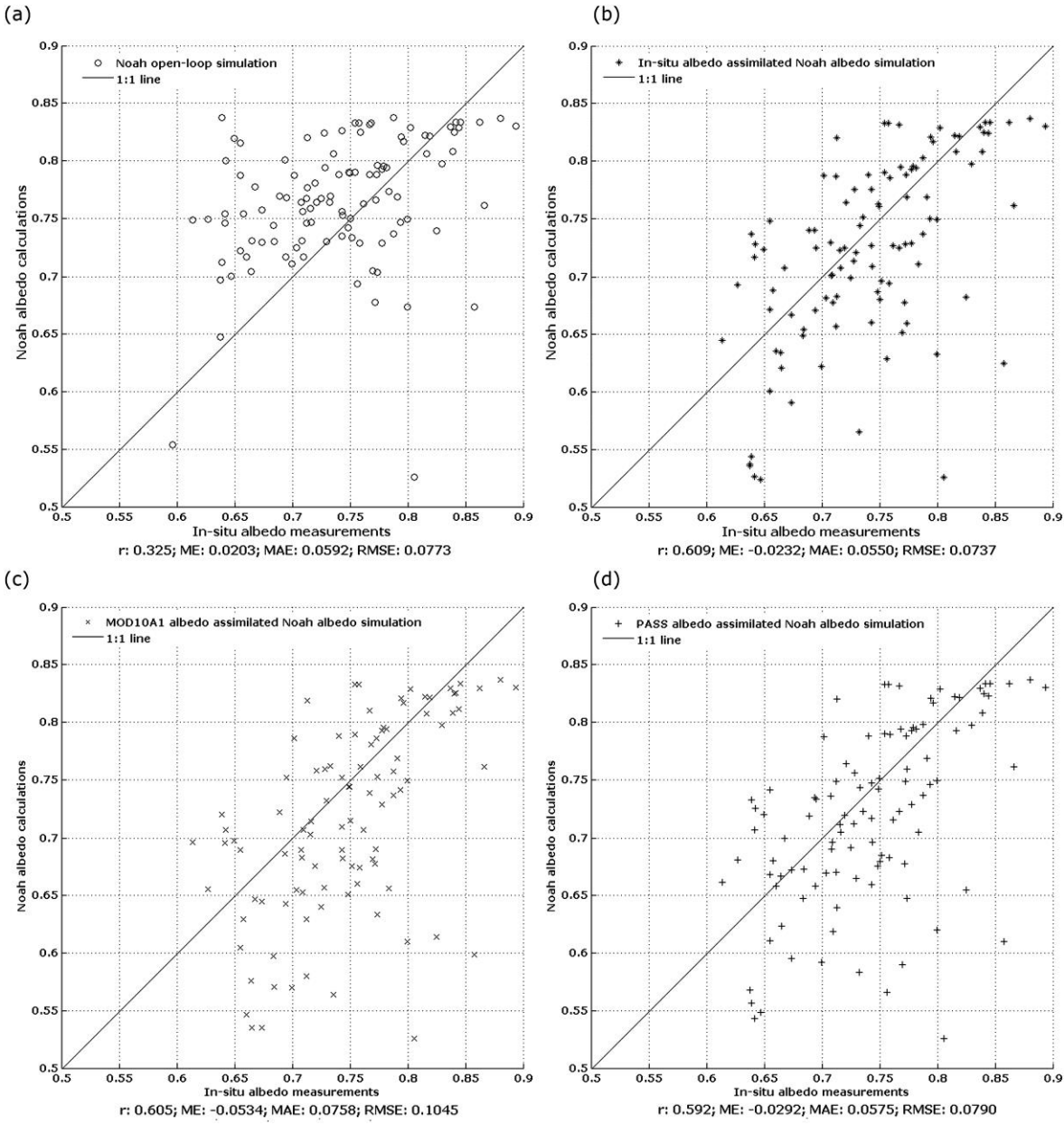
Data Assimilation

- Data Assimilation optimally integrates observed and modeled estimates to improve model simulations
- The developed assimilation approach is based upon a Direct Insertion (DI) scheme



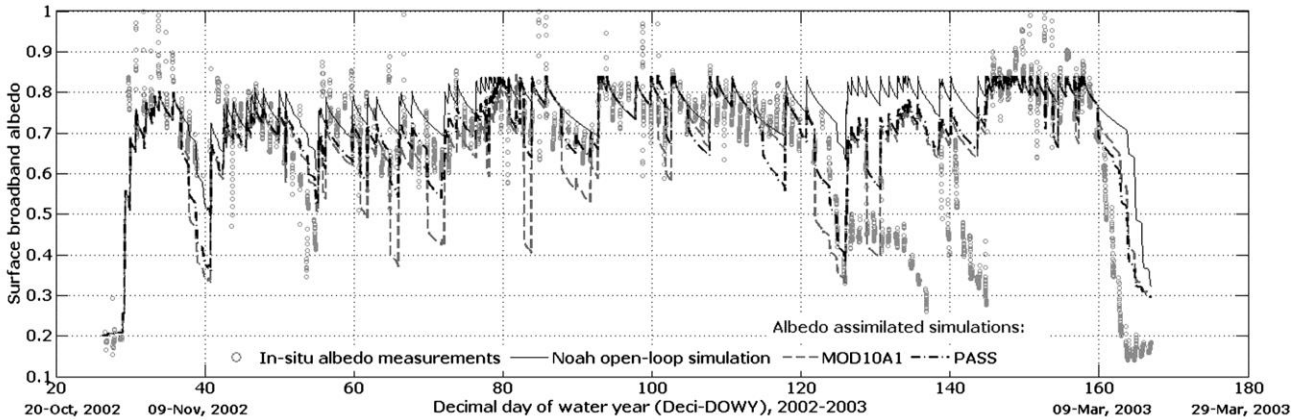
Assimilated albedo simulations

- The assimilation improves the simulations
- The simulation improves with the quality of measurements used for assimilation

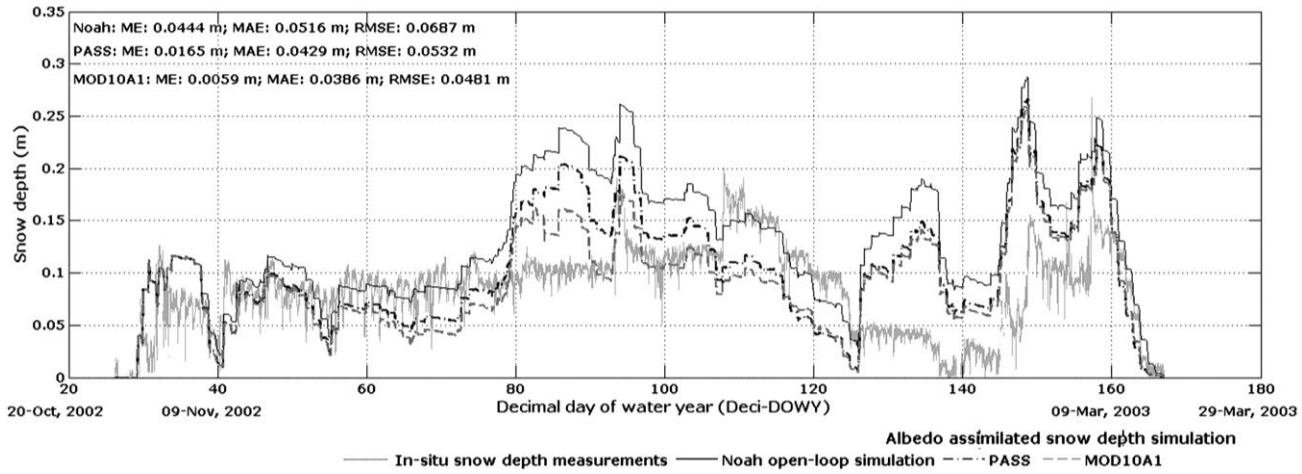


Simulations of snow properties

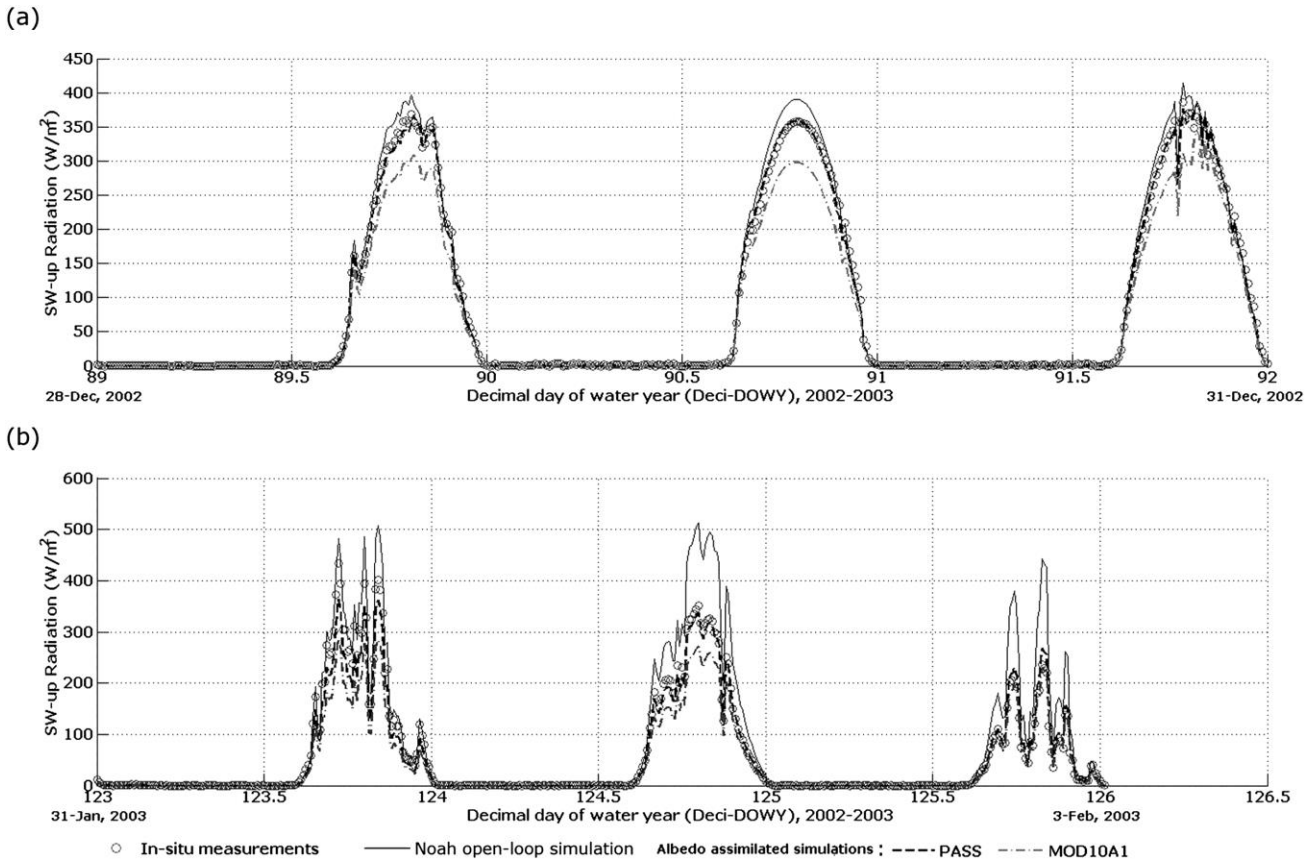
Snow albedo



Snow depth



Simulations of upward shortwave radiation

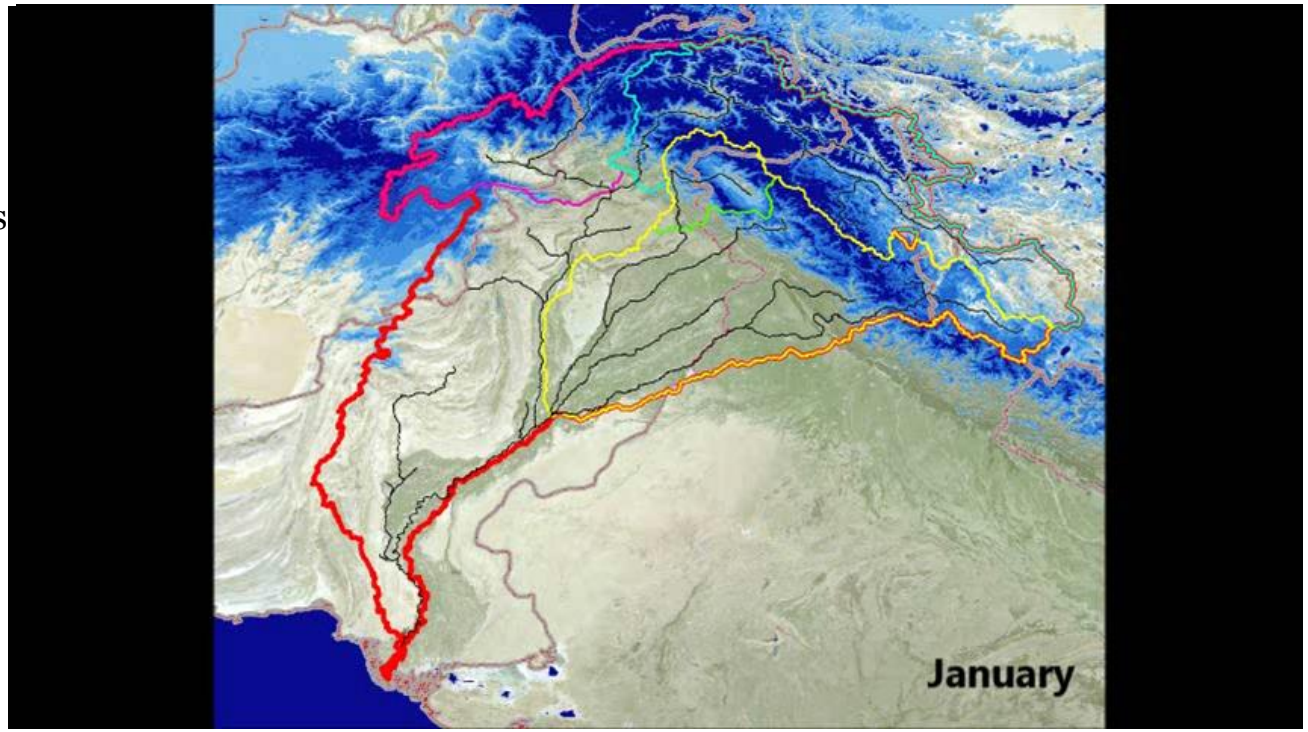


Satellite-derived snow cover climatology of Indus Basin

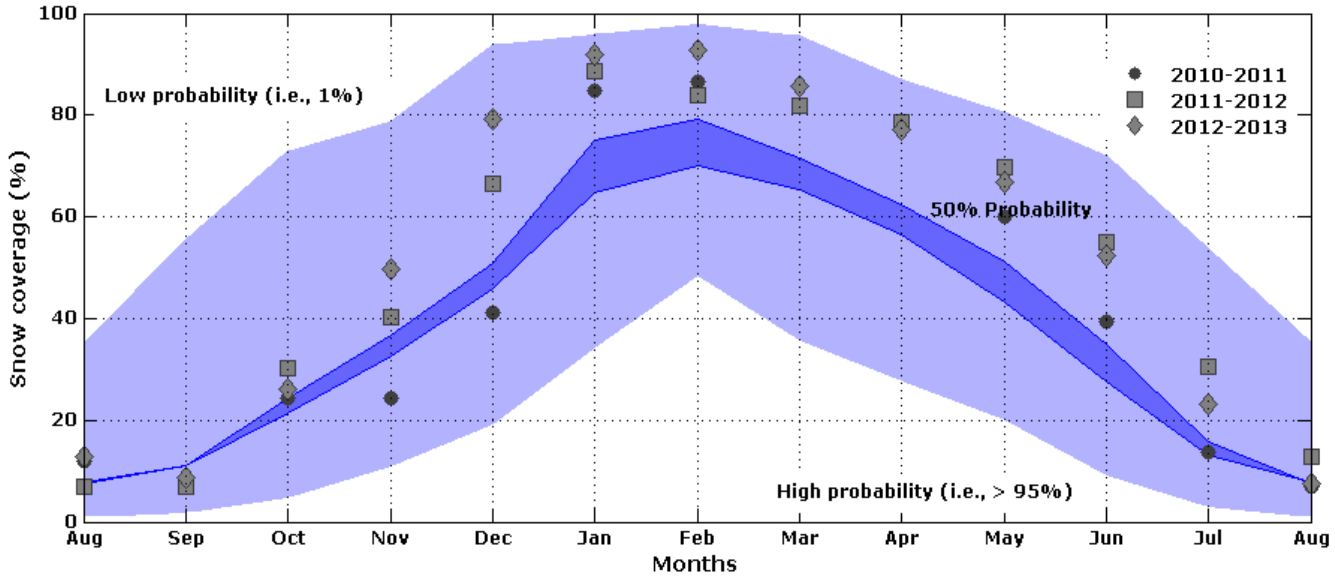
Snow cover climatology is derived:

1. Using time series of satellite observations from 2000 to 2014.

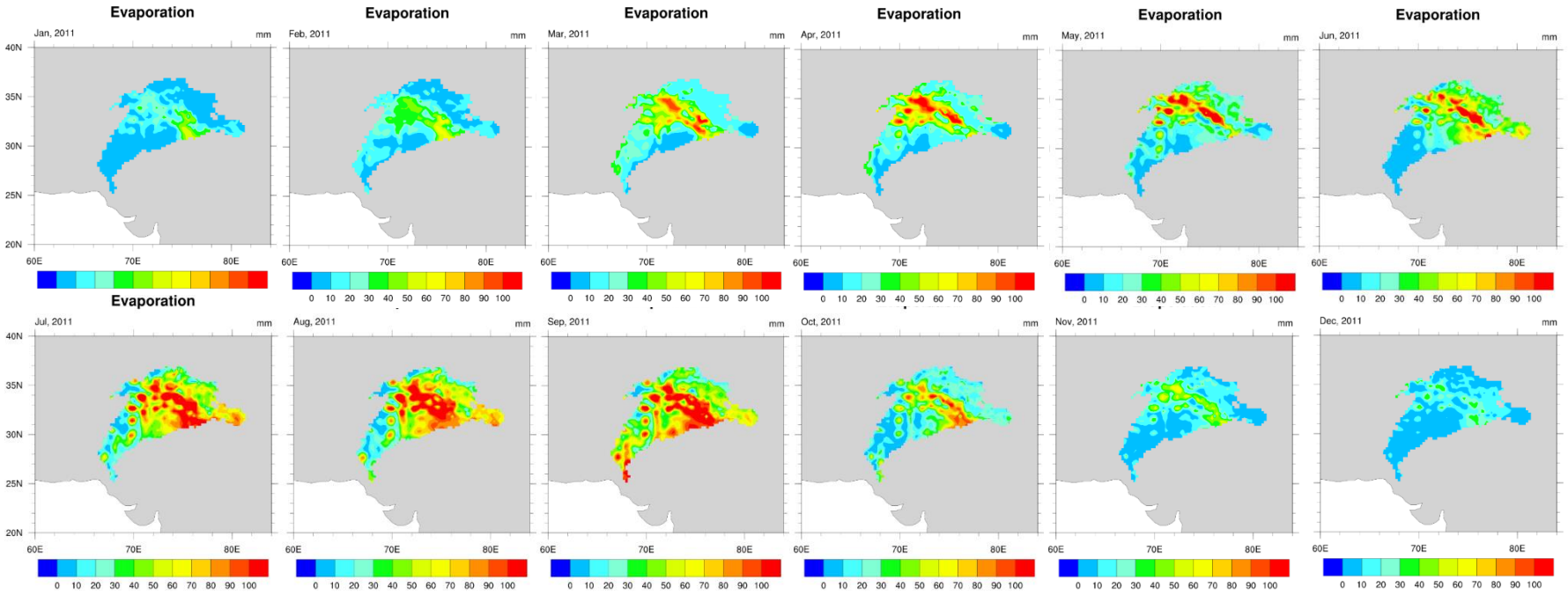
2. Following satellite sensors are employed:
   - ✓ METEOSAT
   - ✓ AVHRR
   - ✓ MODIS
   - ✓ SSMI



Simulated snow coverage for the Upper Indus River Basin

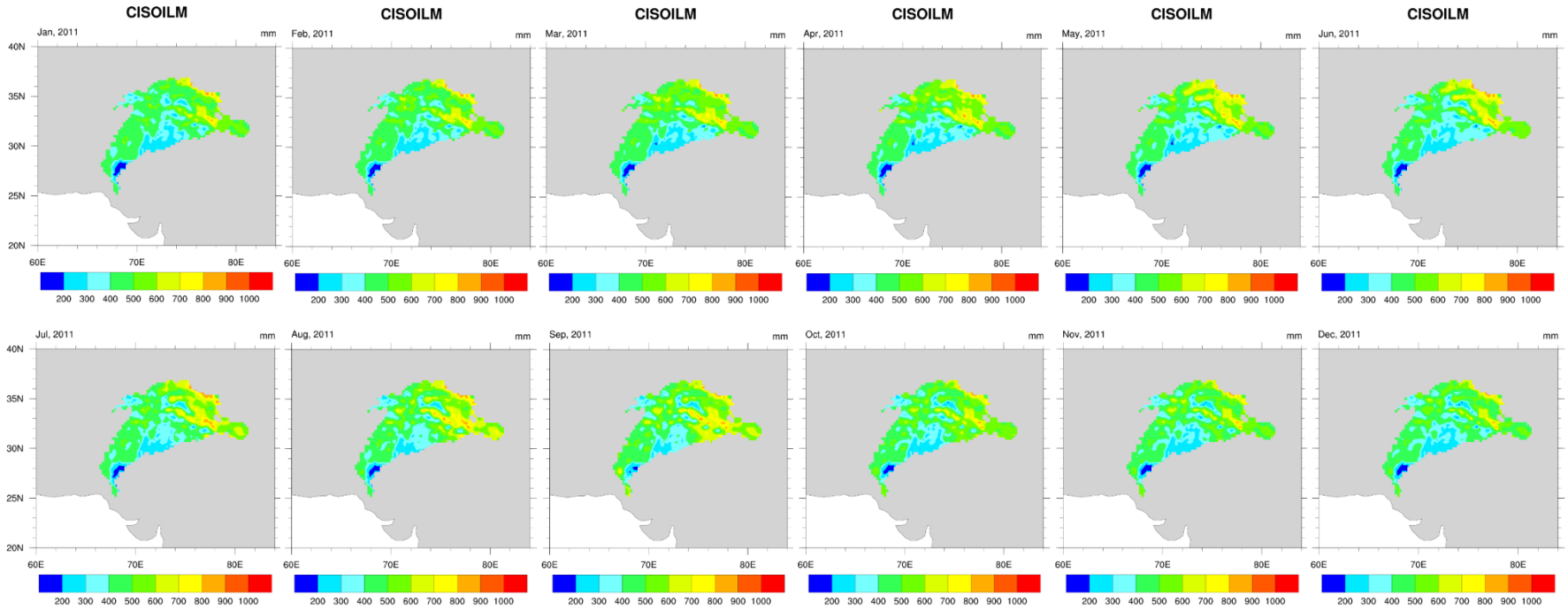


Simulated Evapotranspiration



Indus Basin

Simulated soil moisture



Indus Basin

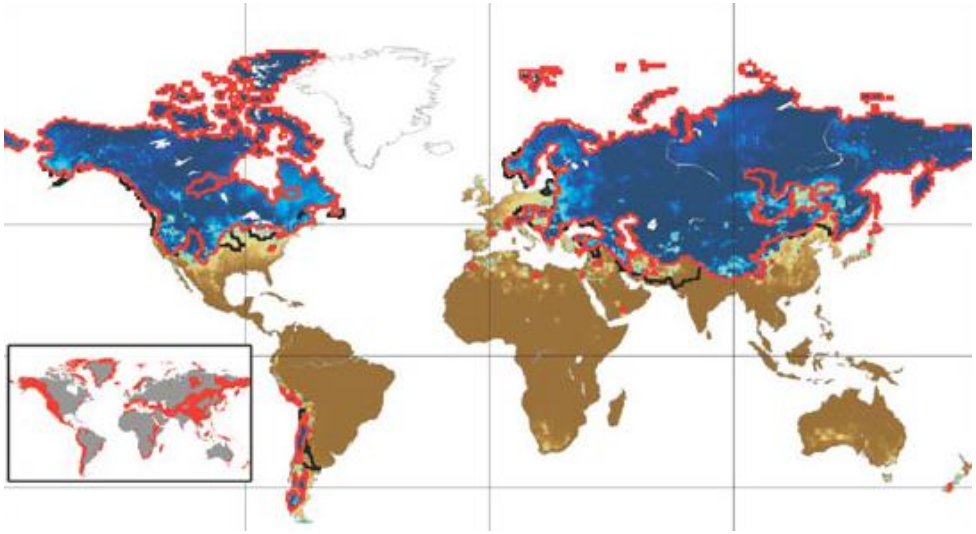
Conclusions

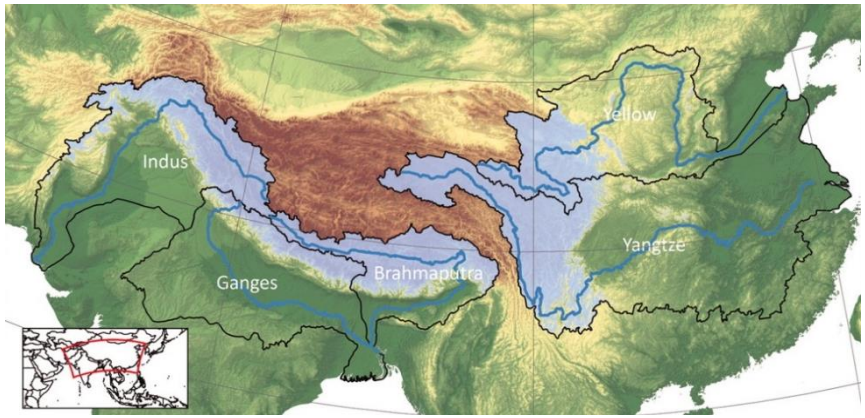
- LSM simulates well the common hydrologic features of the Indus basin (e.g., soil moisture, evapotranspiration, runoffs).
- Seasonal snow cover simulations are consistent with satellite-derived climatology of snow cover for the basin.
- Assimilation of MODIS-retrieved snow cover with simulation improves snow cover simulation.

- Thanks

Why to study snow…?

- More than one-sixth of the Earth's population relies on glaciers and seasonal snowpacks
- All climate models predict a near-surface warming trend
- The consequences of this on future water availability are likely to be severe





Barnett, T. P., et al. (2005). Potential impacts of a warming climate on water availability in snow-dominated regions. Nature 438(7066): 303-309.