Can MODIS reflectance assimilation improve snowpack simulations in alpine terrain ?

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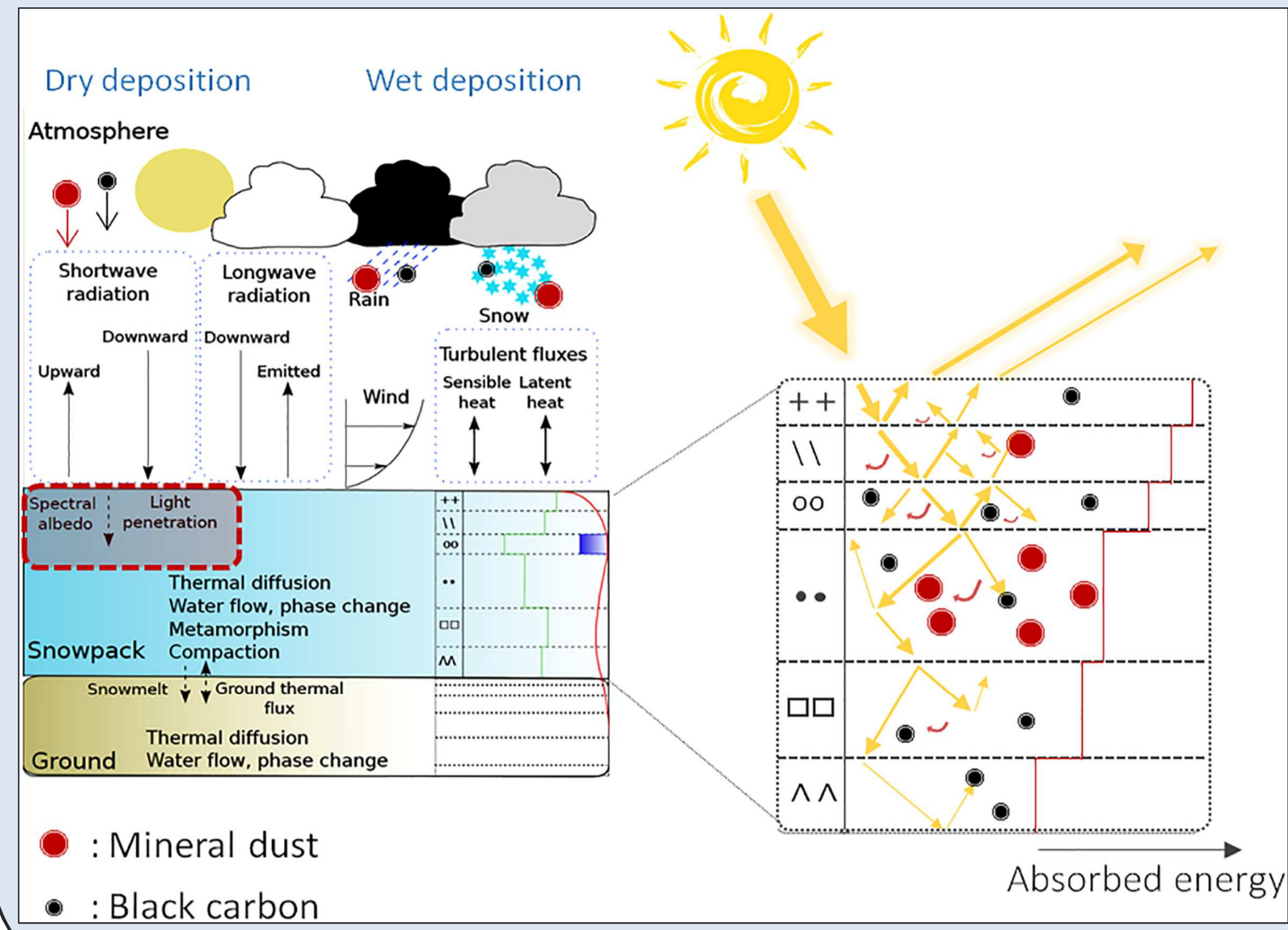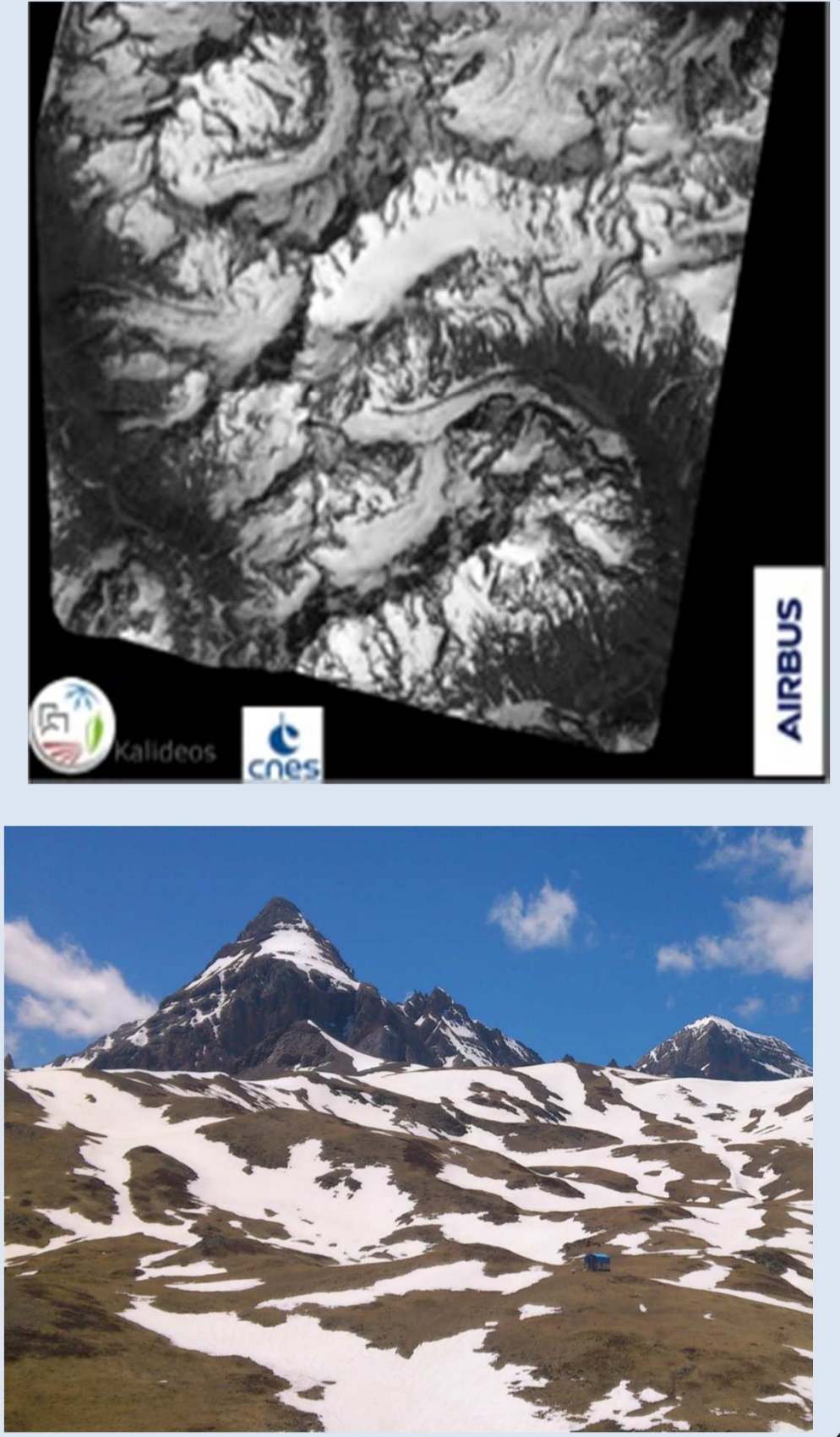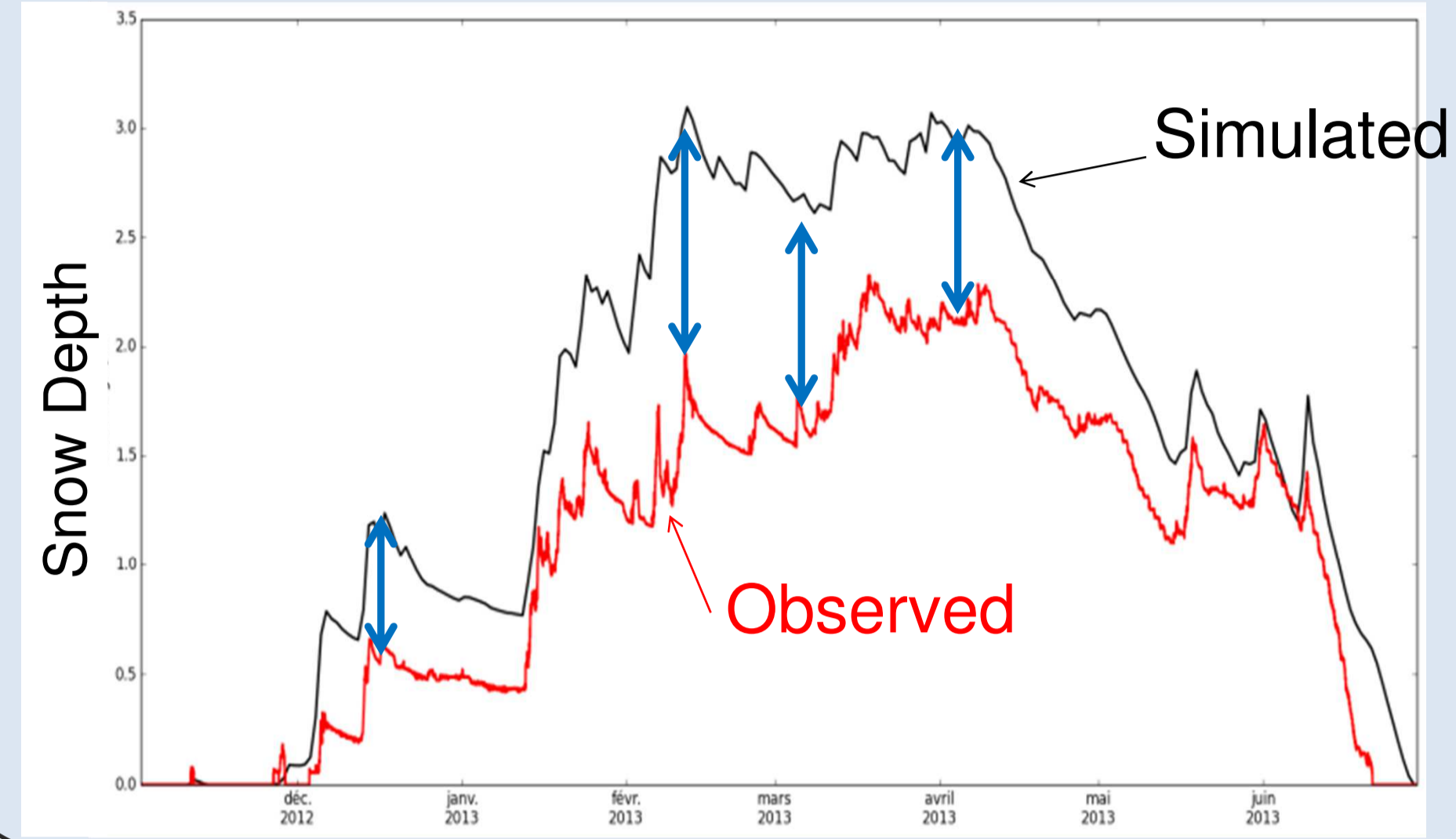
Snowpack simulation with Crocus model

- Multilayer snow model
- Tartes: Radiative transfer model
- SAFRAN forcing
- LAP (impurities) depositions from MOCAGE
- SURFEX model: ISBA+Crocus+SAFRAN

Tuzet et al., 2017
Vionnet et al., 2012
Durand et al., 2009

● : Mineral dust
● : Black carbon

Snowpack numerical modelling errors

Errors coming from:
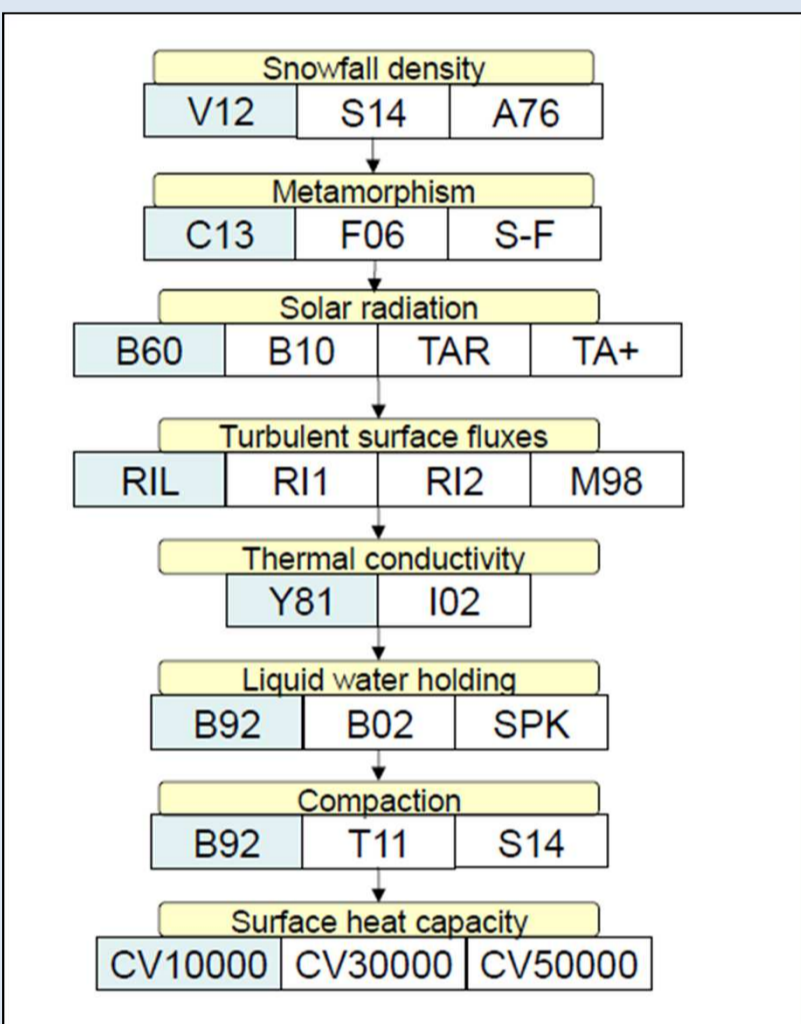- Deviations from meteorological forcing
- Aprox. and errors in snow "physics" model
- Unresolved subgrid variability (2D simul.)

Simulated
Observed

Ensamblist approach to tackle modeling errors

- Ensemble of meteorological forcing (stockastic perturbation) (Charrois et al., 2016)
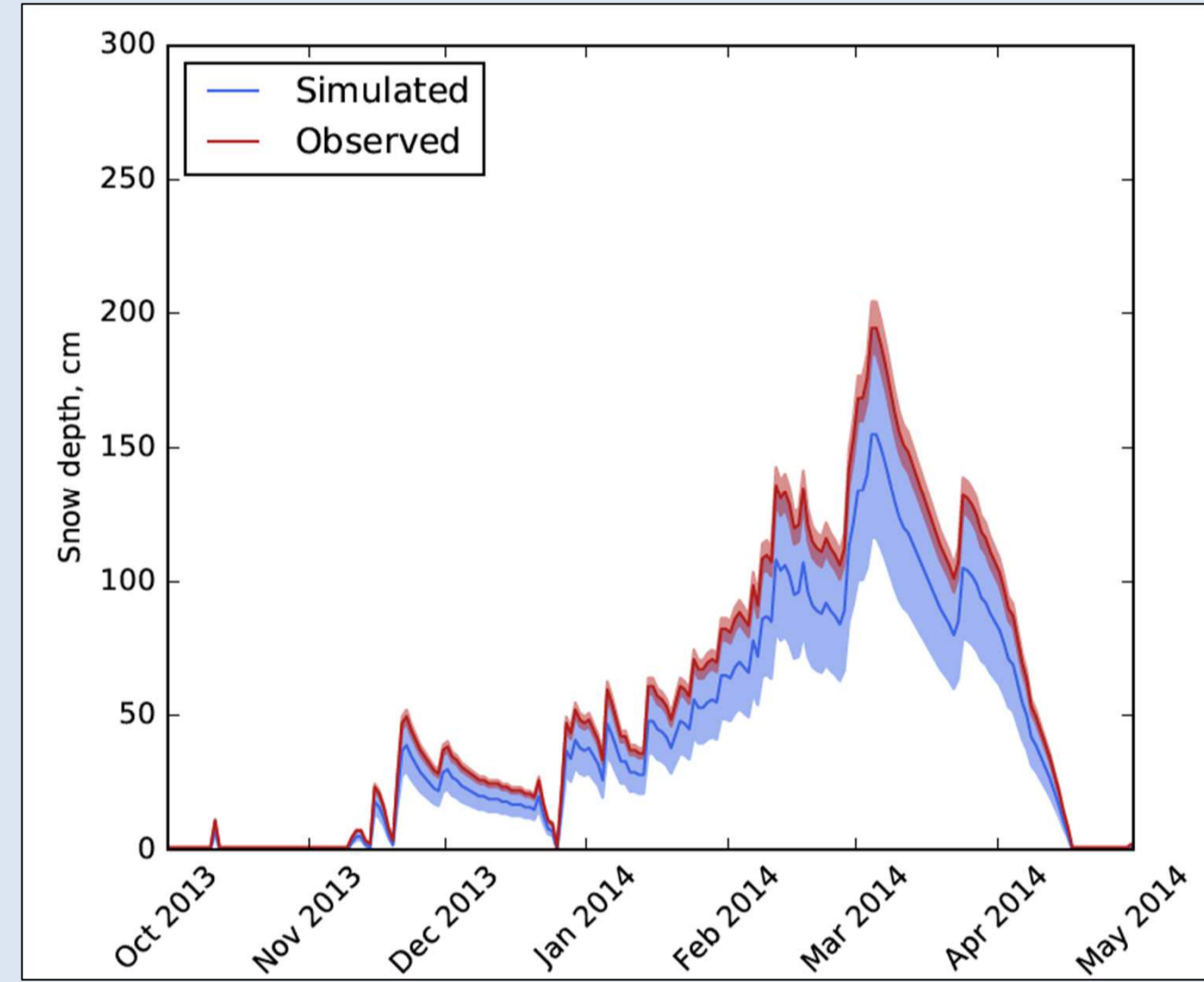- Ensemble of multiphysics snowpack simulations (ESCROC ensemble) (Lafaysse et al., 2017)

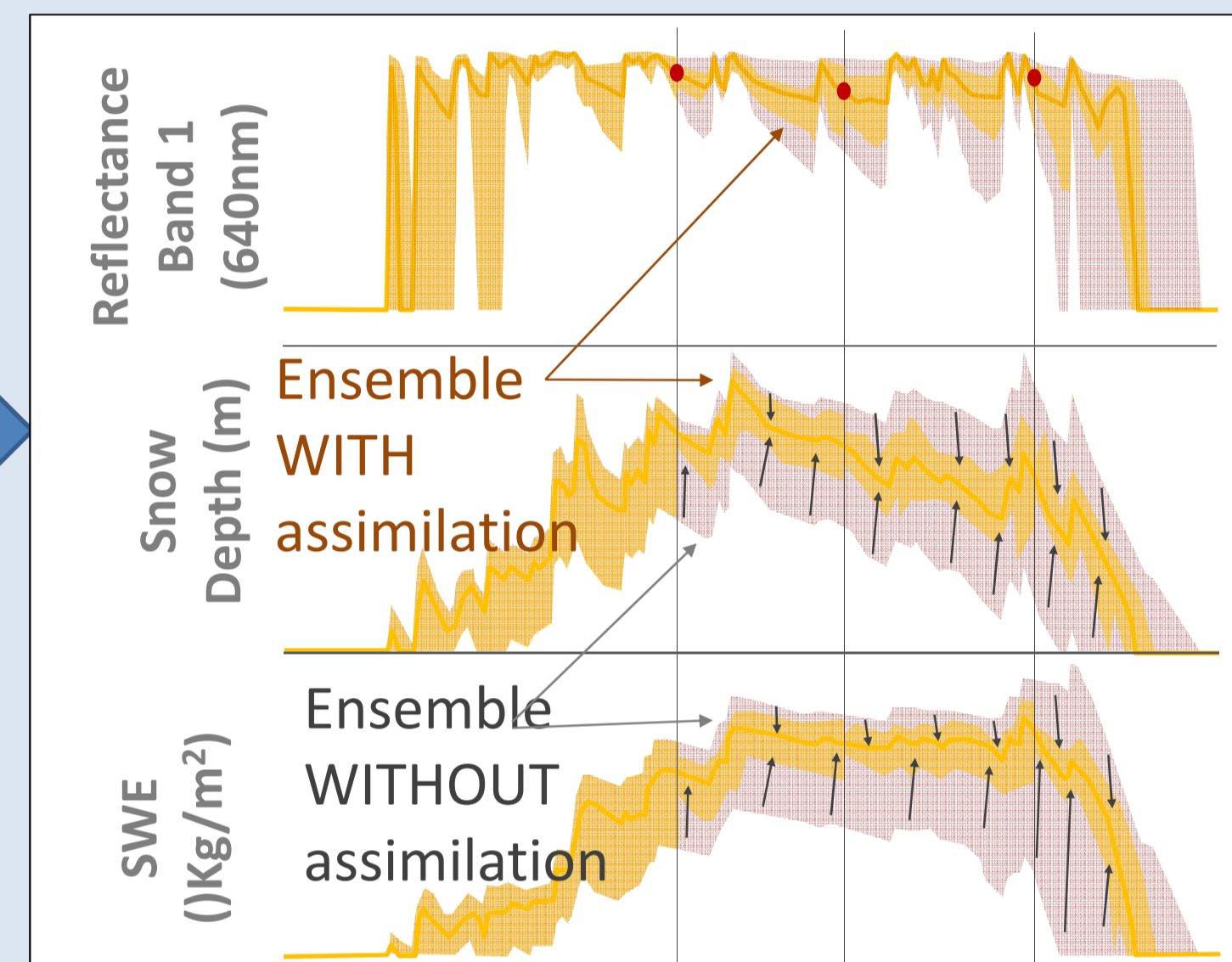**Particle Filter** to select members of the ensemble better simulating real state (Gordon 2003)
"Twin experience": synthetic reflectance assimilation

ESCROC ensemble

| Snowfall density |
| V12 | S14 | A76 |
| Metamorphism |
| C13 | F06 | S-F |
| Solar radiation |
| B60 | B10 | TAR | TA+ |
| Turbulent surface fluxes |
| RIL | RI1 | RI2 | M98 |
| Thermal conductivity |
| Y81 | I02 |
| Liquid water holding |
| B92 | B02 | SPK |
| Compaction |
| B92 | T11 | S14 |
| Surface heat capacity |
| CV10000 | CV30000 | CV50000 |

SAFRAN ensemble

Ensemble of snow simulations

Reflectance Band 1 (640nm)
Snow Depth (m)
Ensemble WITH assimilation
SWE (|Kg/m²)
Ensemble WITHOUT assimilation

- Optical data assimilation can reduce the spread on SWE and snow depth simulations by a factor of 2.
- More accurate SWE and SD are simulated.

(Charrois et al., 2016)

Experimental setup: Col du Lautaret
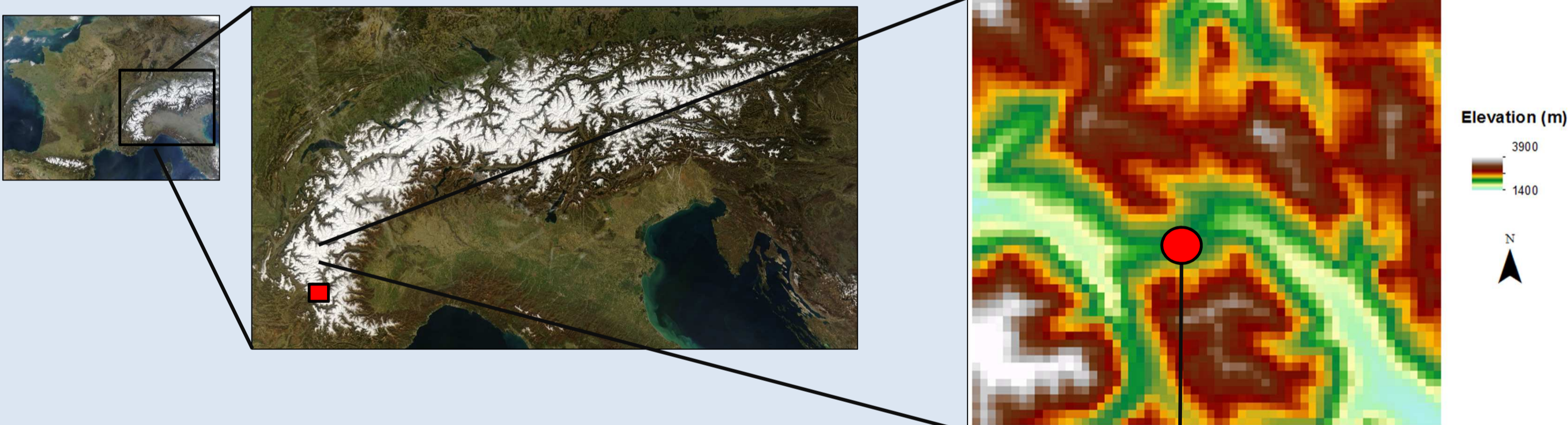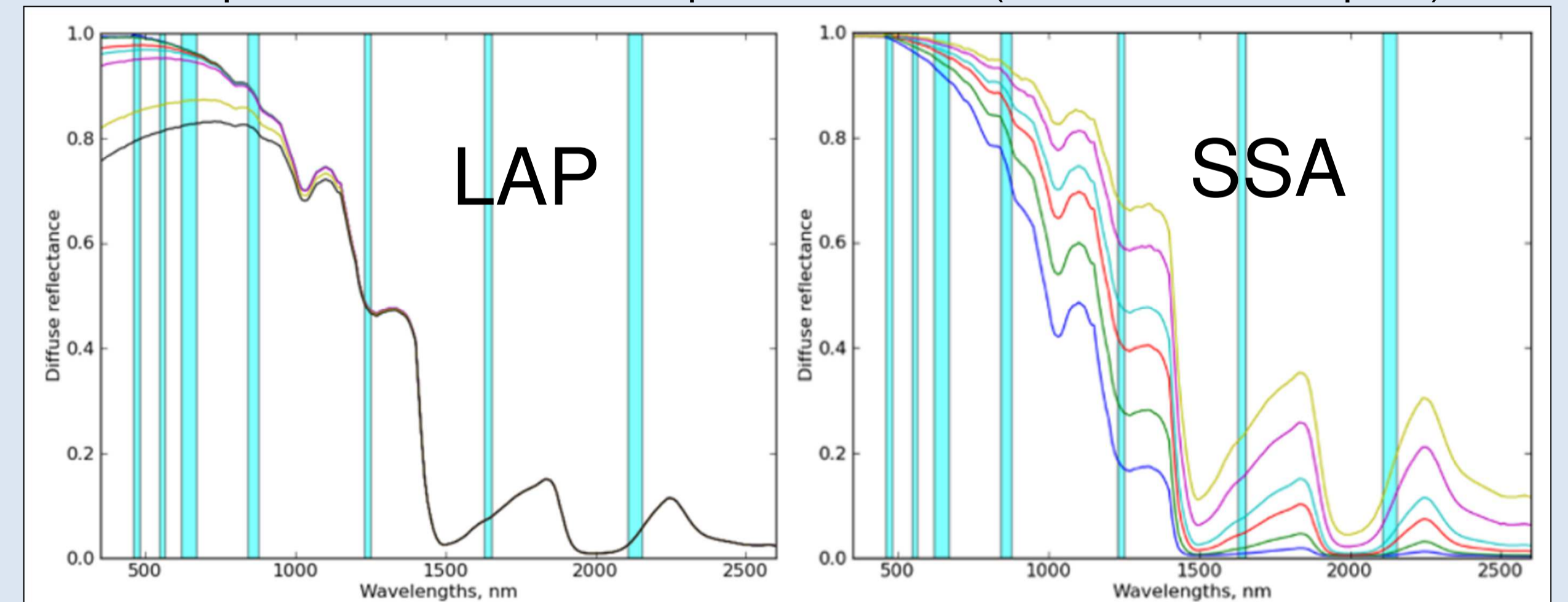
Elevation (m)

- Medium-high elevation area
- Meteorological station at 2000 m
- Highly heterogeneous topography
- Long periods with snow presence in winter-spring
- Study period: 2013-2017
- Distributed (250m spatial resolution) and semi-distributed simulations
- Particle filter: Ensemble member selection (No spatial consistency)
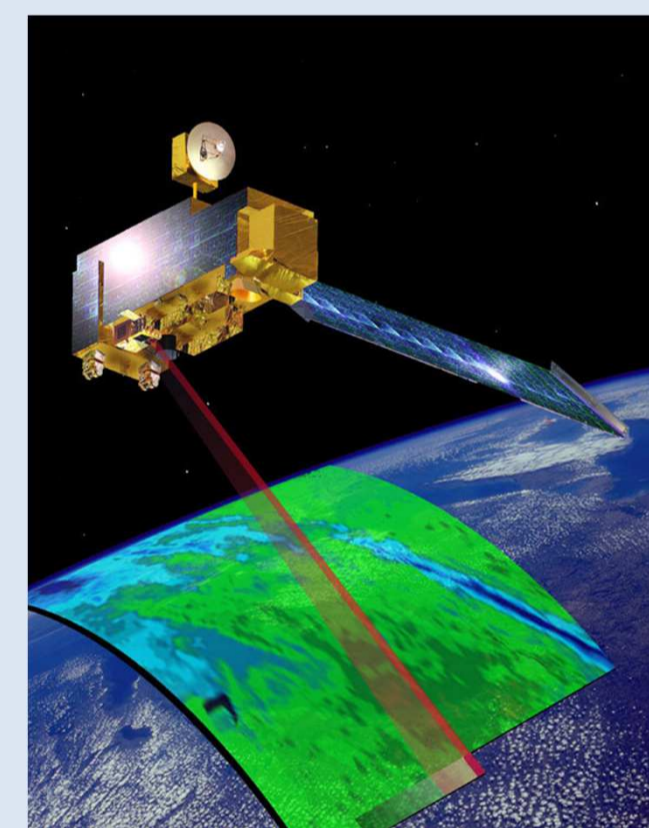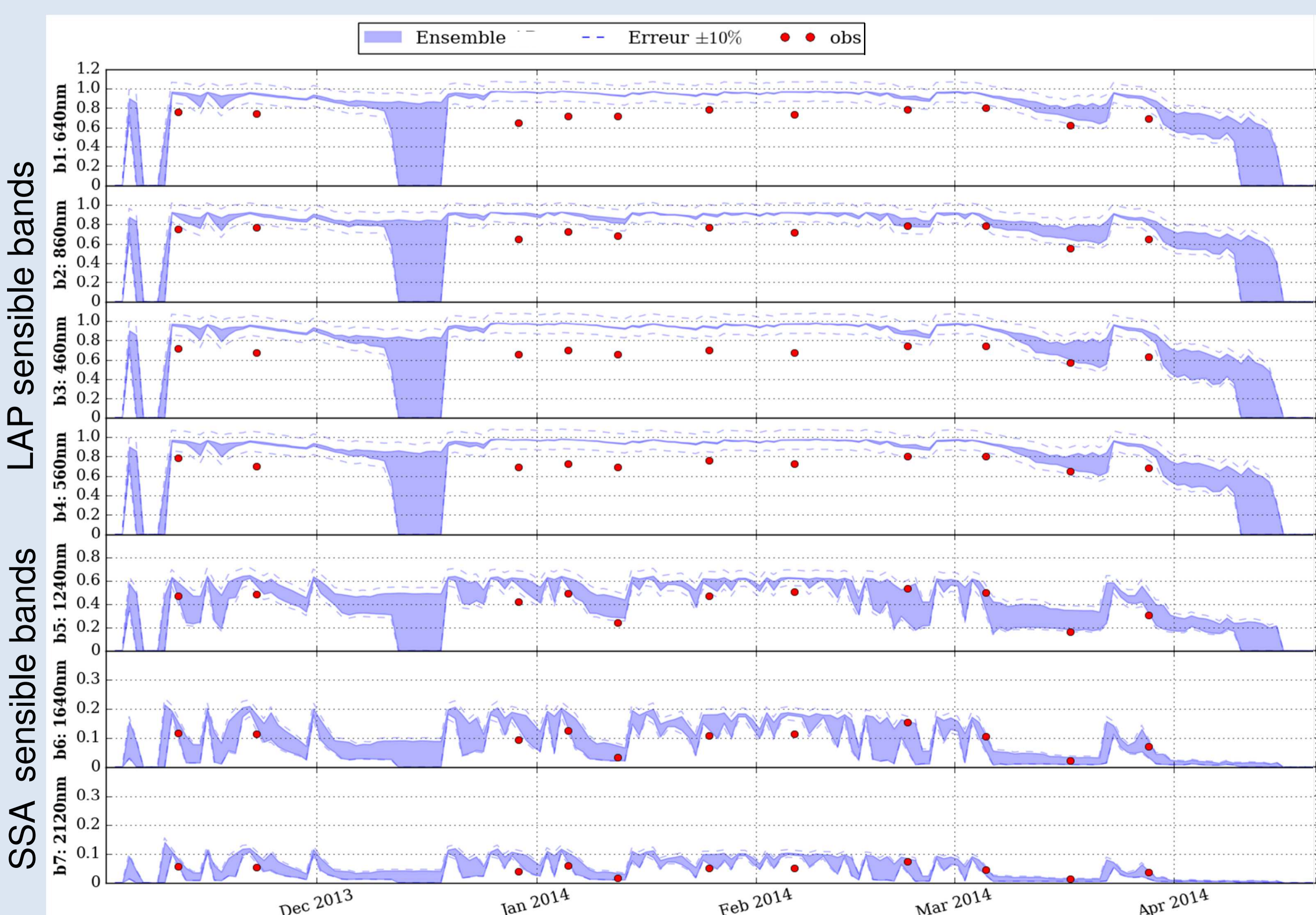
MODIS satellite sensor

- 7 visible/Near infrared
- Daily images (cloud limitation)
- 250m resolution
- MODImLab for accounting complex topography (Sirgey et al. 2009)

MODIS spectral bans vs snow spectral albedo (LAP and SSA impact)

LAP

SSA

Results

Enemble and MODIS reflectance temporal evolution

Ensemble   Erreur ±10%   obs

LAP sensible bands
b1: 640nm
b2: 860nm
b3: 460nm
b4: 560nm

SSA sensible bands
b5: 1240nm
b6: 1640nm
b7: 2120nm

> MODIS bands 1-4 : Strong bias between the ensemble and the observations
> Preliminary analysis (S2) confirm the negative bias of some MODIS bands
> MODIS assimilation show great potential to improve snowpack simulations but at present time is not possible.
> Necessity to apply higher dispersion to the ensemble for some bands: Mainly for sensible bans to LAP deposition.

Ensemble AD   Erreur ±10%   obs MODIS
b1: 640nm
b2: 860nm
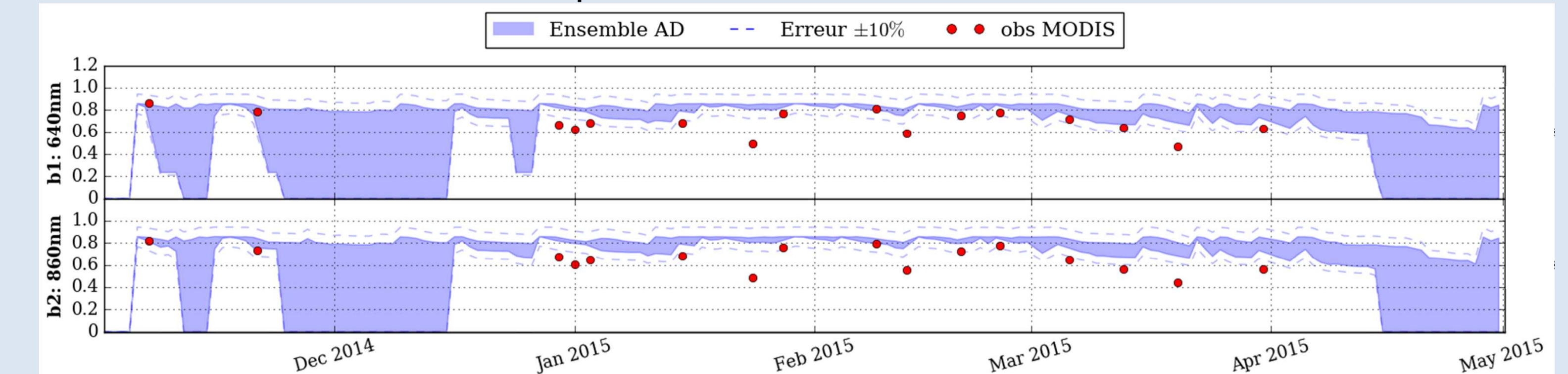
> Future research lines:
> • Determine MODIS bias and correct it?
> • Address the impact of synthetic observations on snowpack profile.

References:
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