Sensitivity of snow cover spatio-temporal dynamics to the spatial distribution of meteorological forcings in a mid altitude alpine catchment: model analysis

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Station alpine Joseph Fourier — UMS 3370 UJF CNRS — Grenoble - Col du Lautaret [2100 m]

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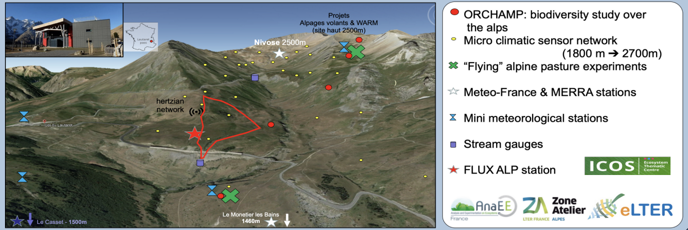
I. INTRODUCTION:

- Mountainous catchments store water along winter time and release it when snow melts several months after precipitation.
- Shorter insolation period due to mountain shadow and surface orientation with respect to solar angle affects the snowmelt regime.
- Early snowmelt due to rise in temperature affects the water and energy flux and favours the early vegetation dynamics **[1]**.

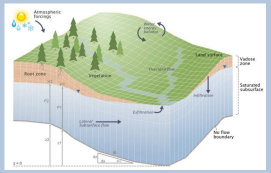
SITE DESCRIPTION

- Subalpine watershed, mean altitude of ~2100 meter **(study area figure)**.
- 1531 mm/year precipitation, out of which 970 mm as snow fall.
- Site average temperature 4°C and strong wind conditions.
- Large winter and summer solar radiation difference.
- Vegetation: subalpine meadows (C4 grassland), 5% of woody coverage.

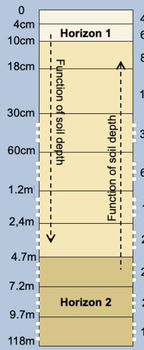
II. STUDY AREA (Col du Lautaret, French Alps):



III. ParFLOW-CLM HYDROLOGICAL MODEL:



A fully integrated coupled surface sub-surface hydrological model, solves the Richards equation in 3D **[2]**. CLM 3.5 as a land surface model.

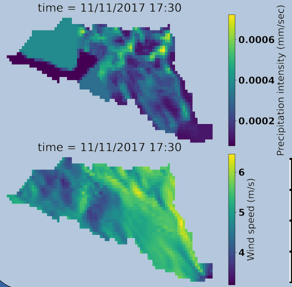


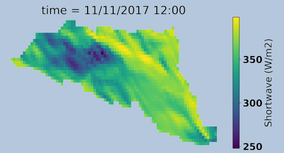
DISCRETIZATION AND MODEL SETUP:

- 10 x 10 m horizontal resolution; 11 levels (0 - 118m) with variable dz. 84 X 42 domain grids.
- DEM extracted from a 2m Lidar survey, processed with PriorityFlow **[3]**. 10 years of spin-up.
- Kinematic wave equation for sub-surface solvers.

IV. FORCING DISTRIBUTION:

Rain distribution using in-situ snow map. Radiation and wind distribution based on solar insolation and terrain effect **[4]**.



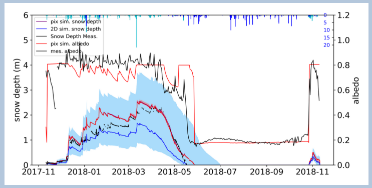


	Distributed	Non-distributed
Precipitation sum (mm)	1443.7	1531.9
Average wind speed (m³/sec)	3.5	3.6
Average shortwave (W/m²)	152.1	190.8

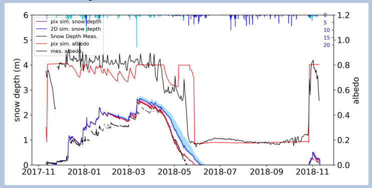
V. RESULTS:

- Rain distribution plays an important role in simulating snow depth.
- Distributed forcings plays an important role in snow stay variability (more than a month) in simulation and confirmed from sentinel image.
- Shortwave distribution helps in differential melting however wind distribution causes the re-distribution of snow over catchment.
- Slope, aspect and curvature are important terrain feature in our distribution algorithm. It specially associated with longer snow stay.

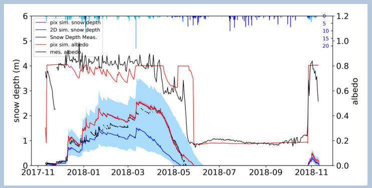
All distributed



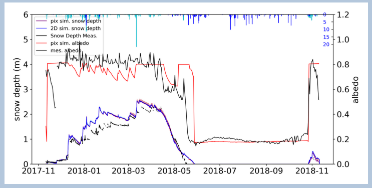
Only shortwave distributed

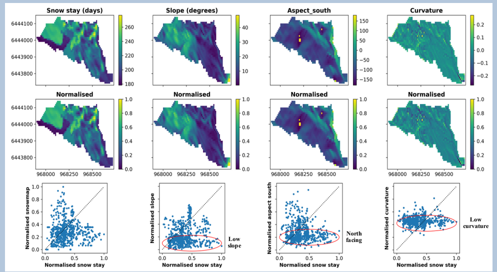


Only rain distributed

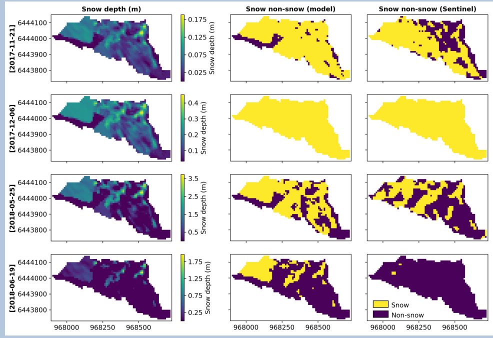


Only wind distributed





Terrain effect on snow distribution



Model snow simulation comparison with Sentinel image

VI. CONCLUSION AND PERSPECTIVE:

- ParFLOW-CLM is efficient in simulating the snow dynamics at hyper resolution scale in mountainous catchment.
- Our point forcing distribution algorithm efficiently catches the snow patch and differential melting in hillslope catchment.
- Longer snow stays affects the water, vegetation and and energy dynamics.

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[1] Beria et al. (2018) Understanding snow hydrological processes through lens of stable water isotopes.
[2] Maxwell et al. (2015). A high-resolution simulation of groundwater and surface water over most of the continental US with the integrated hydrologic model ParFlow v3.
[3] Condon & Maxwell (2019). Modified priority flood and global slope enforcement algorithm for topographic processing in physically based hydrologic modeling applications.
[4] Liston & Elder (2006) A meteorological distribution system for high-resolution terrestrial modeling.