Snowpack modelling in Central Italy: analysis and comparison of high-resolution WRF-driven Noah LSM and Alpine3D simulations

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Introduction

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- Apennines mountain range: crosses the Italian peninsula from north-west to south-east
- Highest peaks: located in Central Apennines (Central Italy)
- Mediterranean sea: important source of moisture
- Substantial snow cover during winter and high regional variability
- Goal of the study: investigate the snow cover evolution in Central Apennines, using and comparing different snowpack models

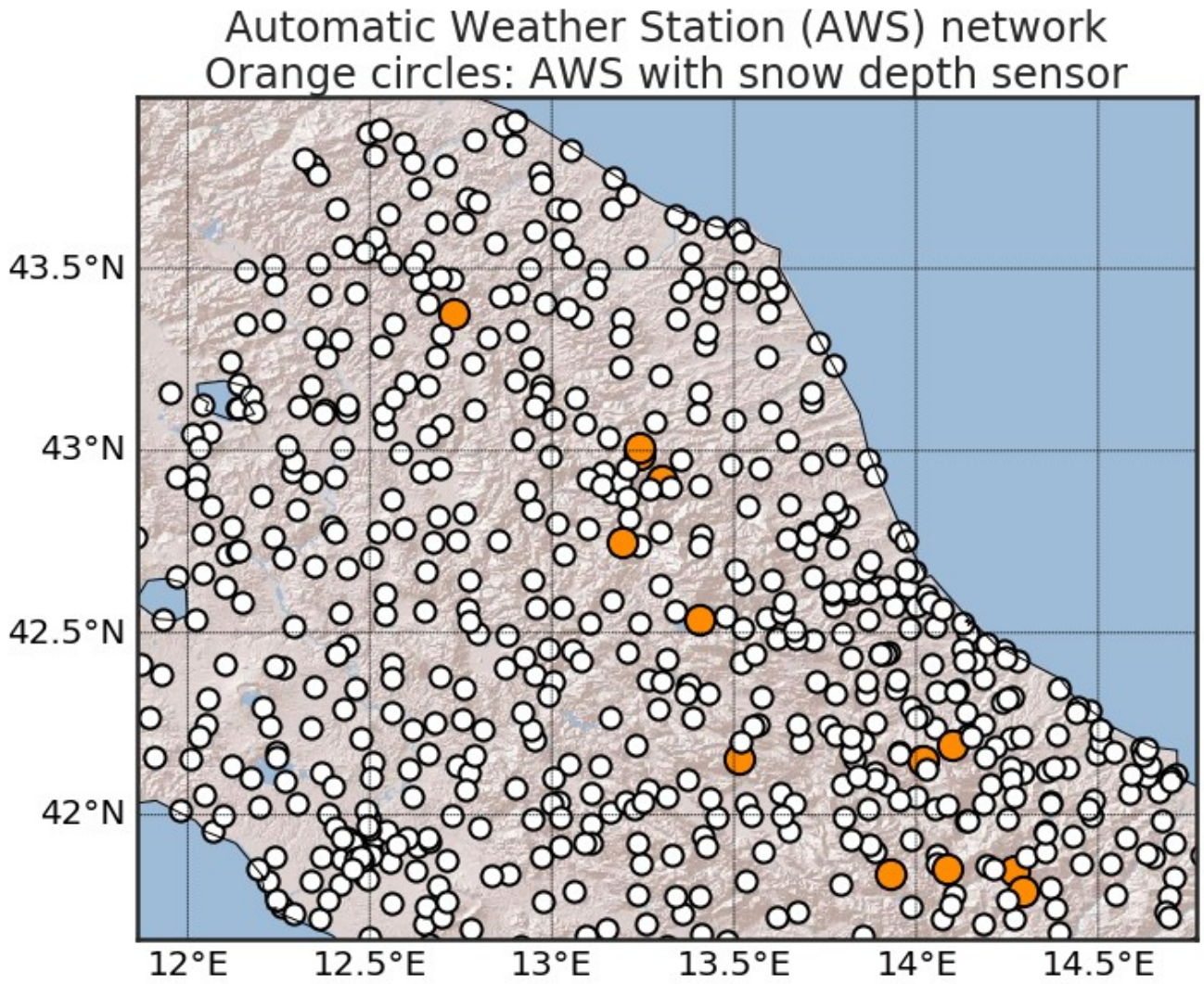
Dataset and Methods

Observational Dataset

Study domain:
Central Italy

Automatic Weather Station (AWS):

- 702 in study domain
- 13 AWS with snow depth sensor
- measure interval from 15 to 30 minutes



Weather Research and Forecasting (WRF) Model:

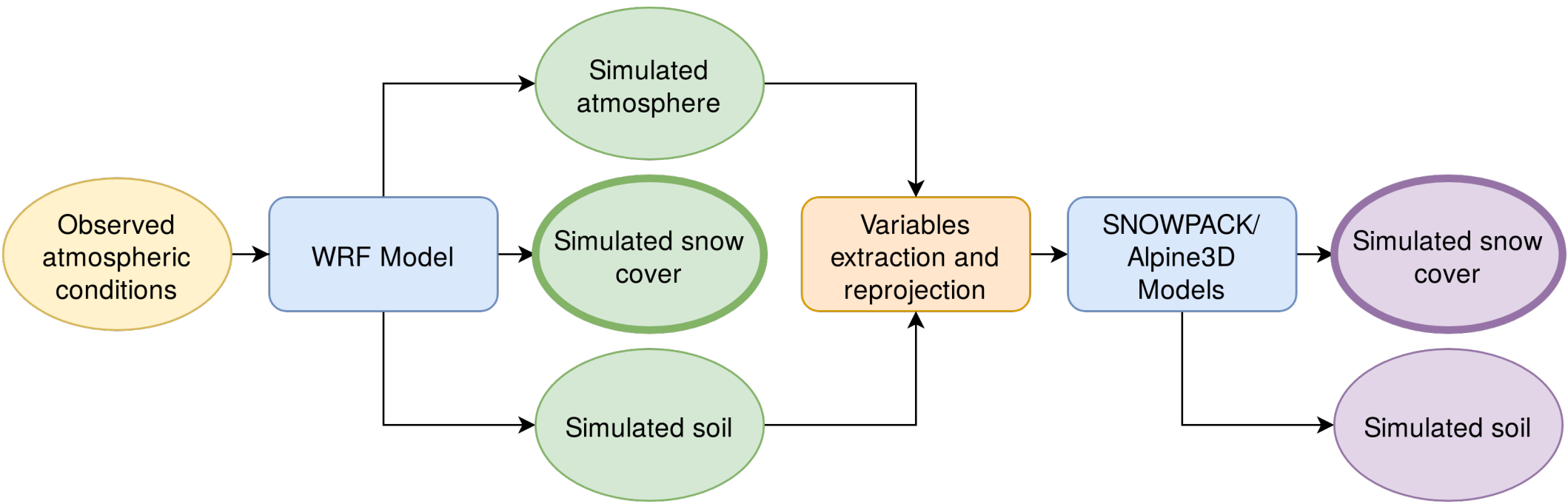
- Mesoscale numerical weather prediction system
- Simulates atmosphere and ground surface conditions
- Configuration:
  - 3 two-way nested domains of 27 km, 9 km and 3 km resolutions (continental, national and regional size)
  - 33 vertical levels with first at 10 m
  - Land Surface Model: Noah
  - 4 soil levels (2 m total thickness)
  - 45 sequential simulations of 60 hours with 12 hours of spin-up
  - atmosphere initialized with NCEP 0.25° reanalysis
  - soil initialized with previous simulations (except for first simulation)
  - 2160 hours of atmosphere and soil simulation from 2018/12/01 to 2019/02/28
  - simulated data reprojected on a regular grid

Models description

Alpine3D:

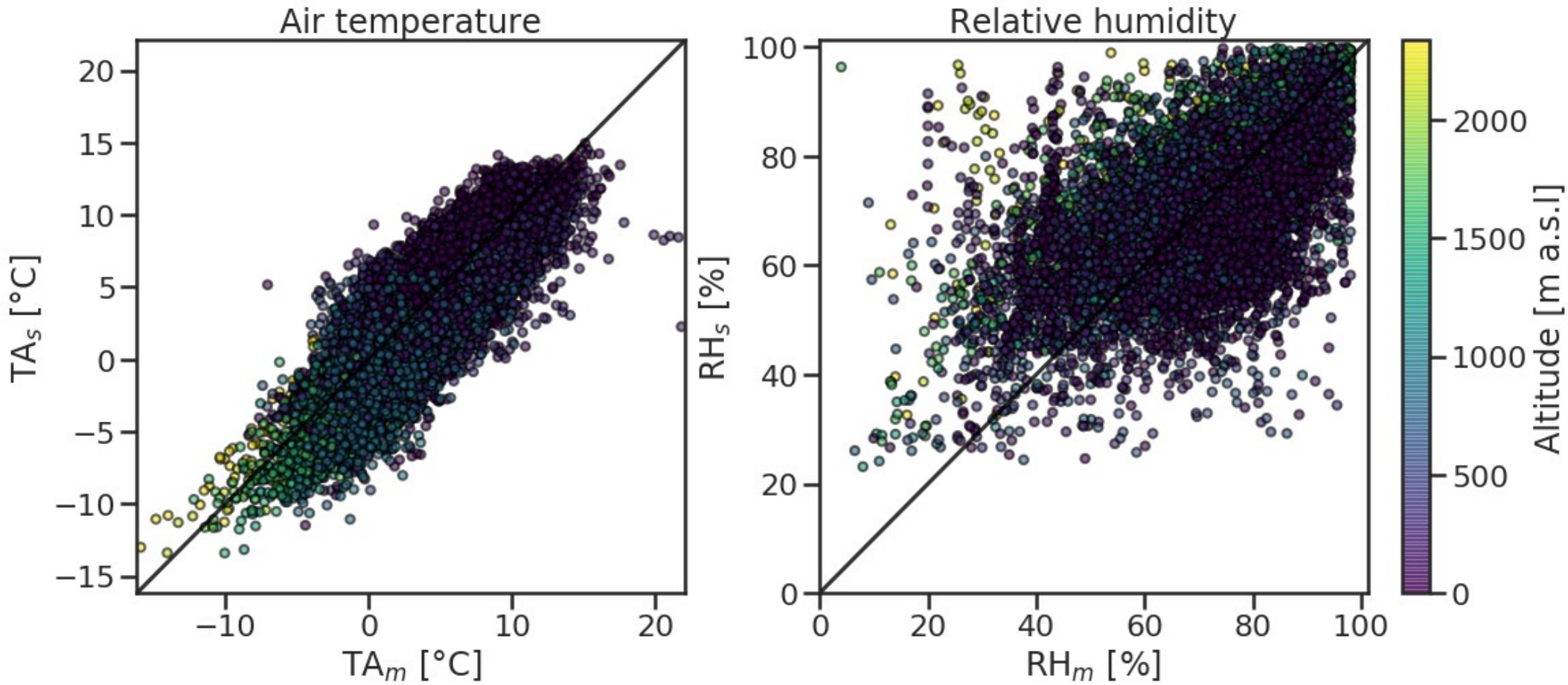
- Three-dimensional snow cover and earth surface numerical model
- Includes modules for snow transport, radiation transfer and runoff
- Configuration:
  - input variables from WRF: air temp., relative hum., wind speed, incoming shortwave and longwave rad., precipitation amount and phase, ground surface temp.
  - 4 soil levels (2 m total thickness)
  - ground elevation from WRF digital elevation model
  - background albedo, soil roughness length and canopy from WRF landuse
  - single simulation of 2160 hours of snow cover and soil properties from 2018/12/01 to 2019/02/28
  - simulated data reprojected on a regular grid

Snow cover models forcing

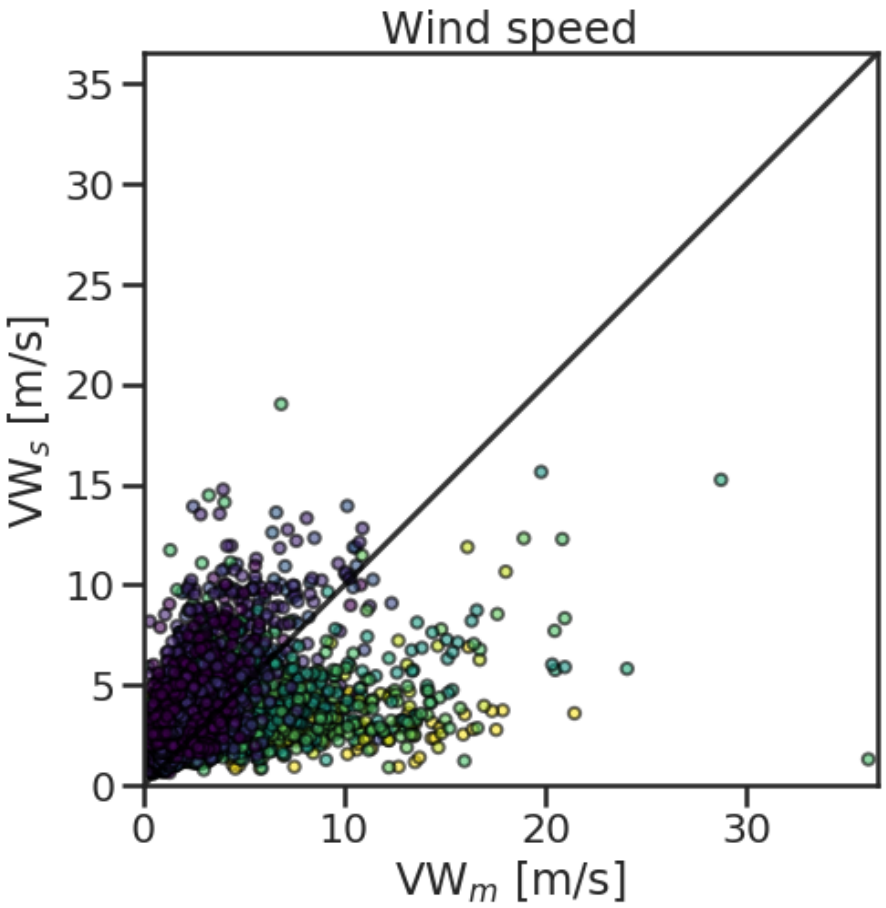


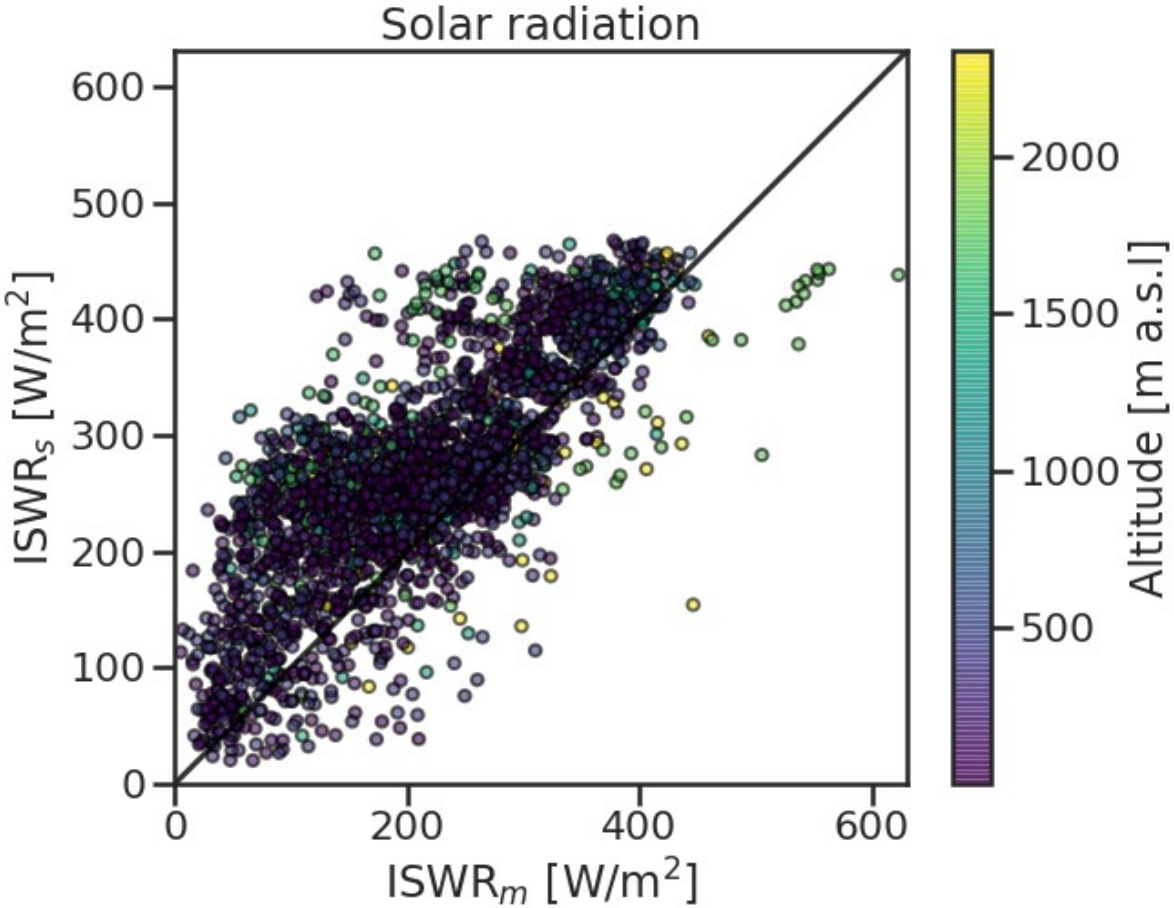
Results

Atmospheric forcing evaluation

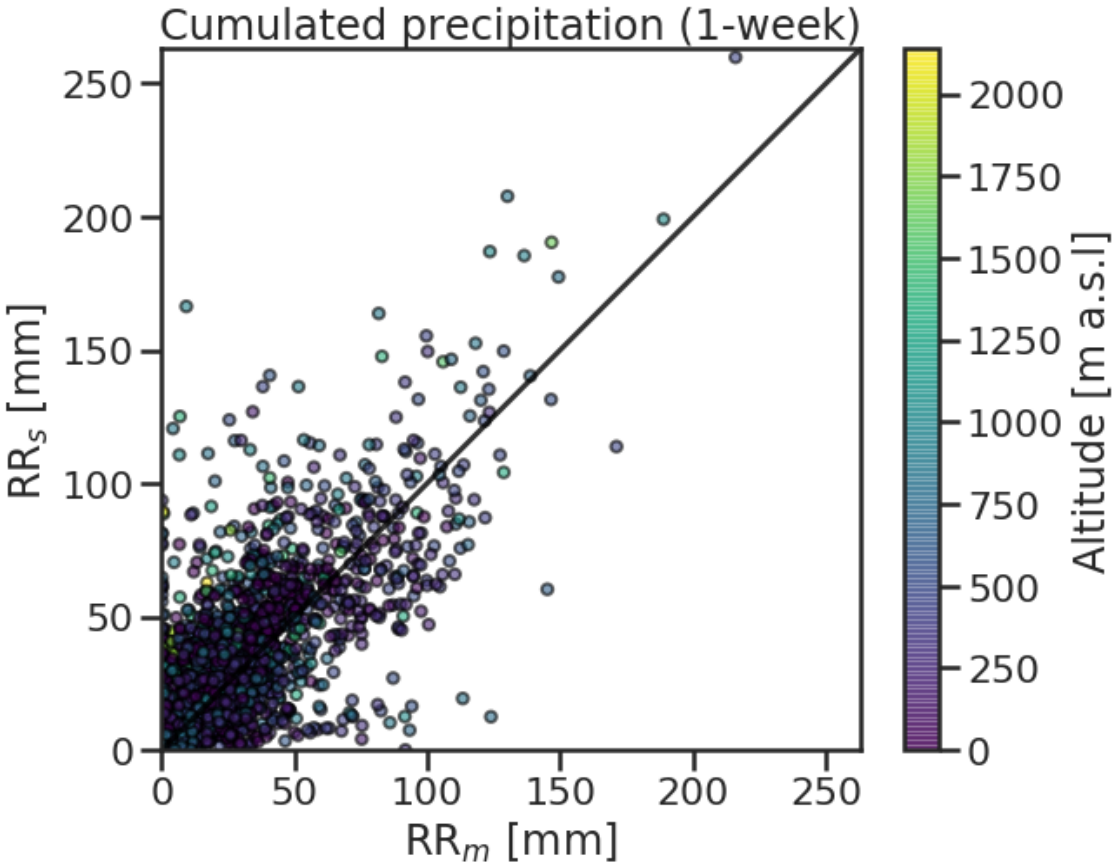


Atmospheric forcing evaluation



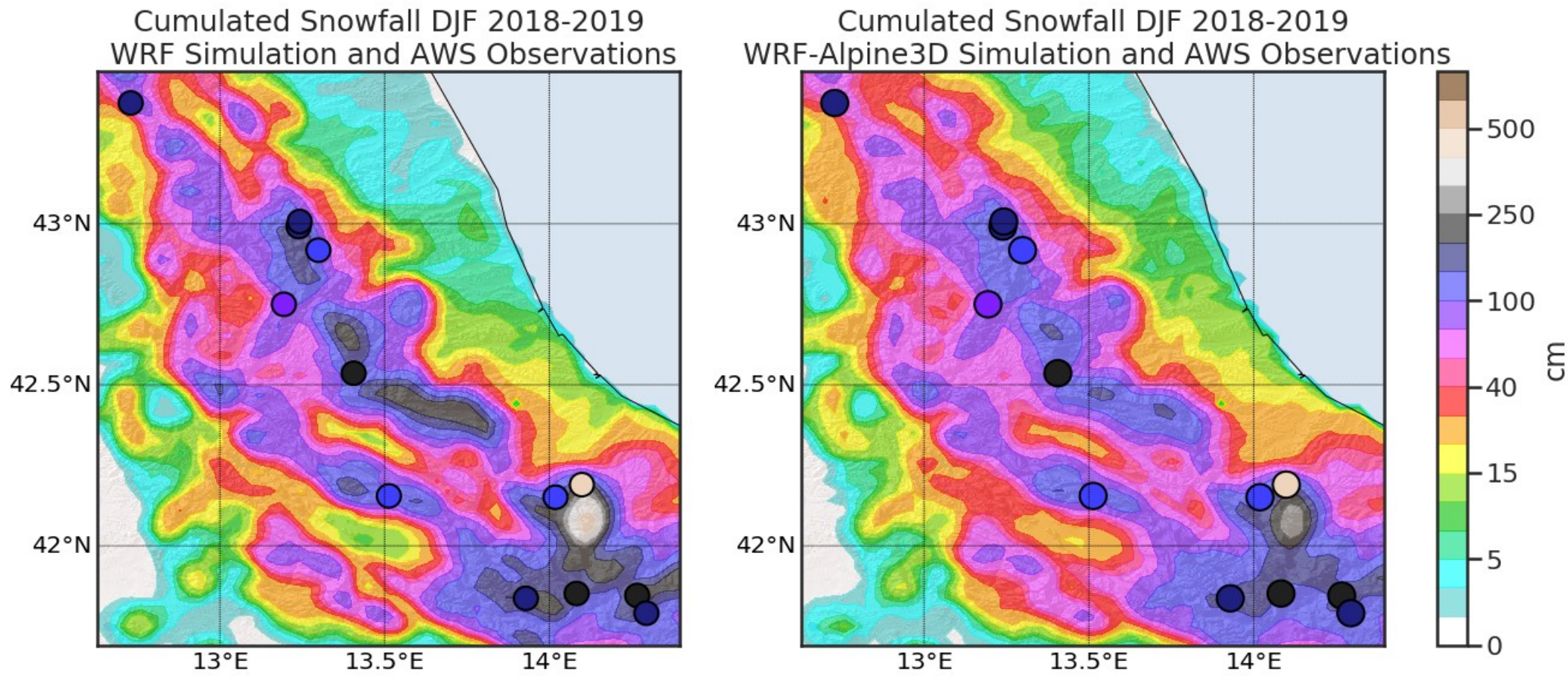


Atmospheric forcing evaluation



	STDE	Bias	R
TA [°C]	2.2	-0.76	0.84
RH [%]	14.0	1.72	0.58
VW [m/s]	2.7	0.39	0.4
ISWR [W/m^2]	67.0	0.77	0.77
RR [mm]	16.3	52.6	0.78

Snow cover models evaluation



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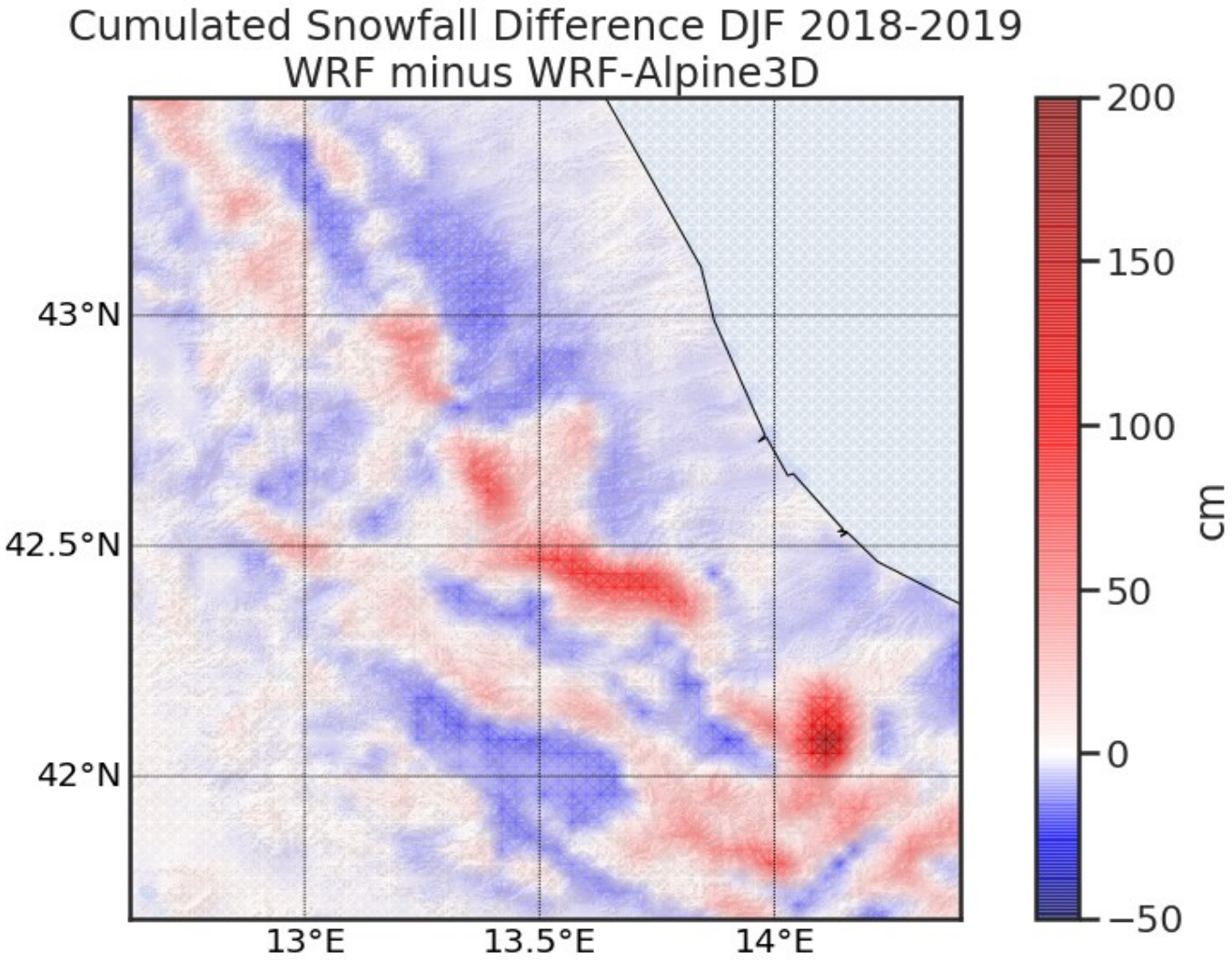

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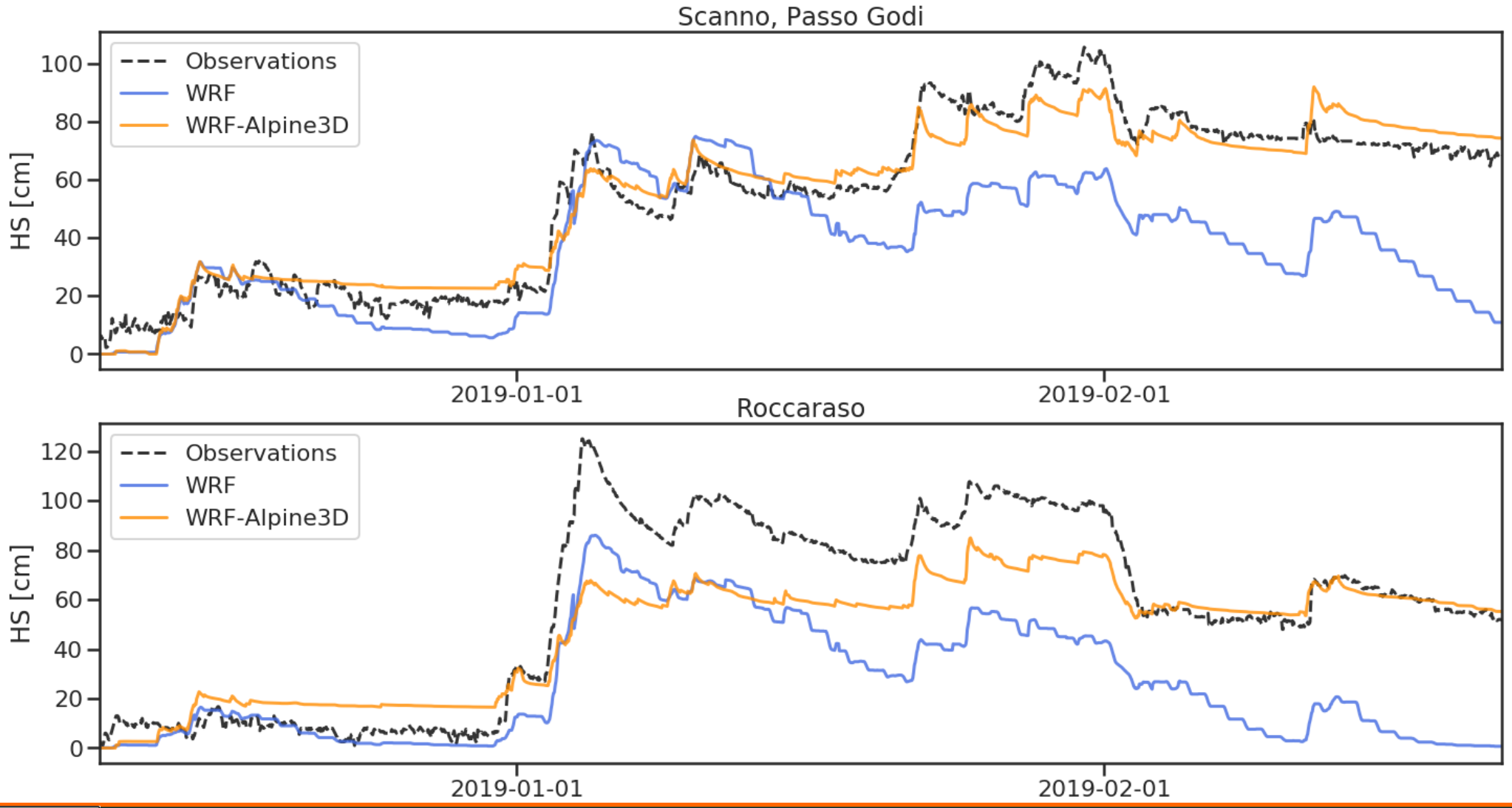

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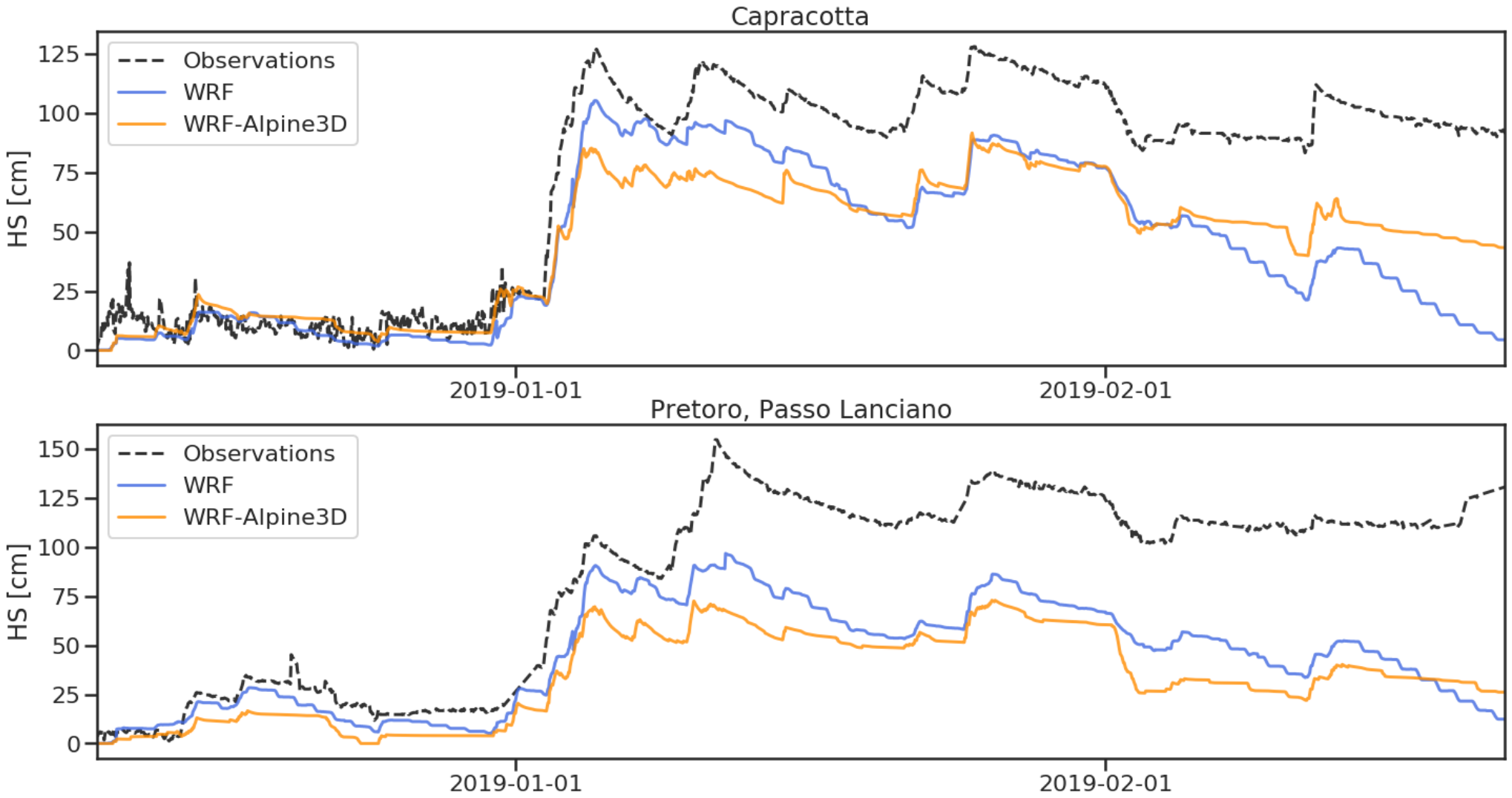

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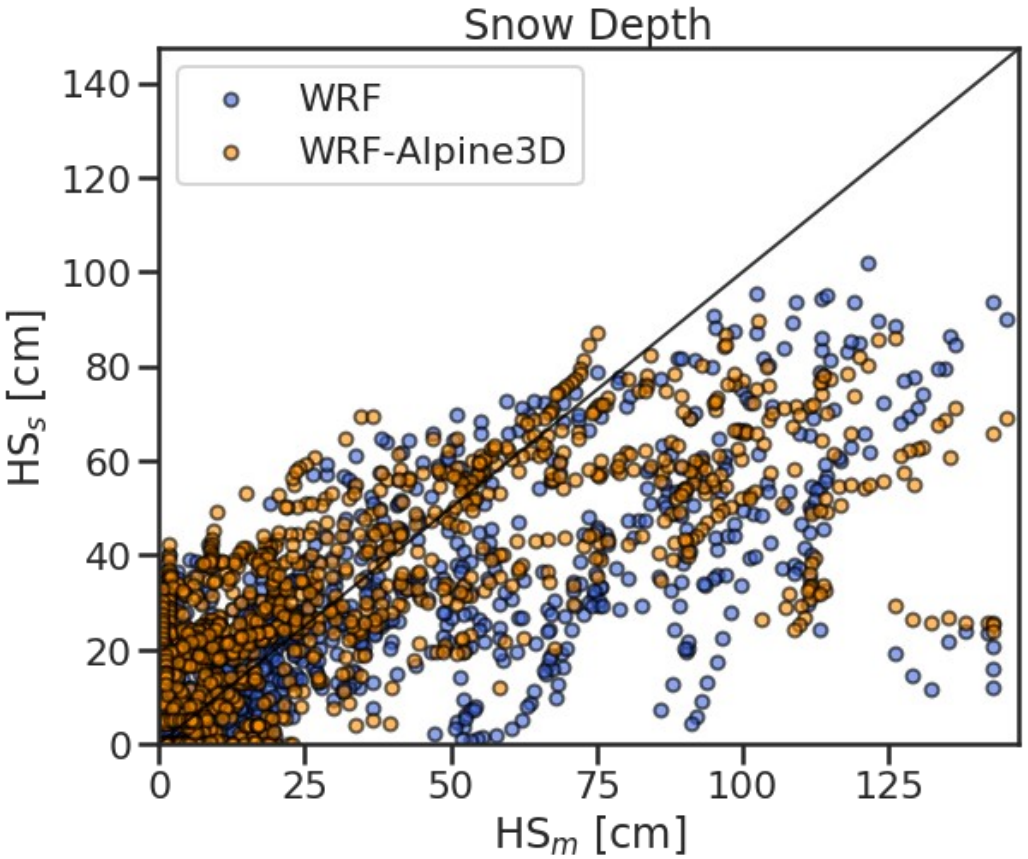

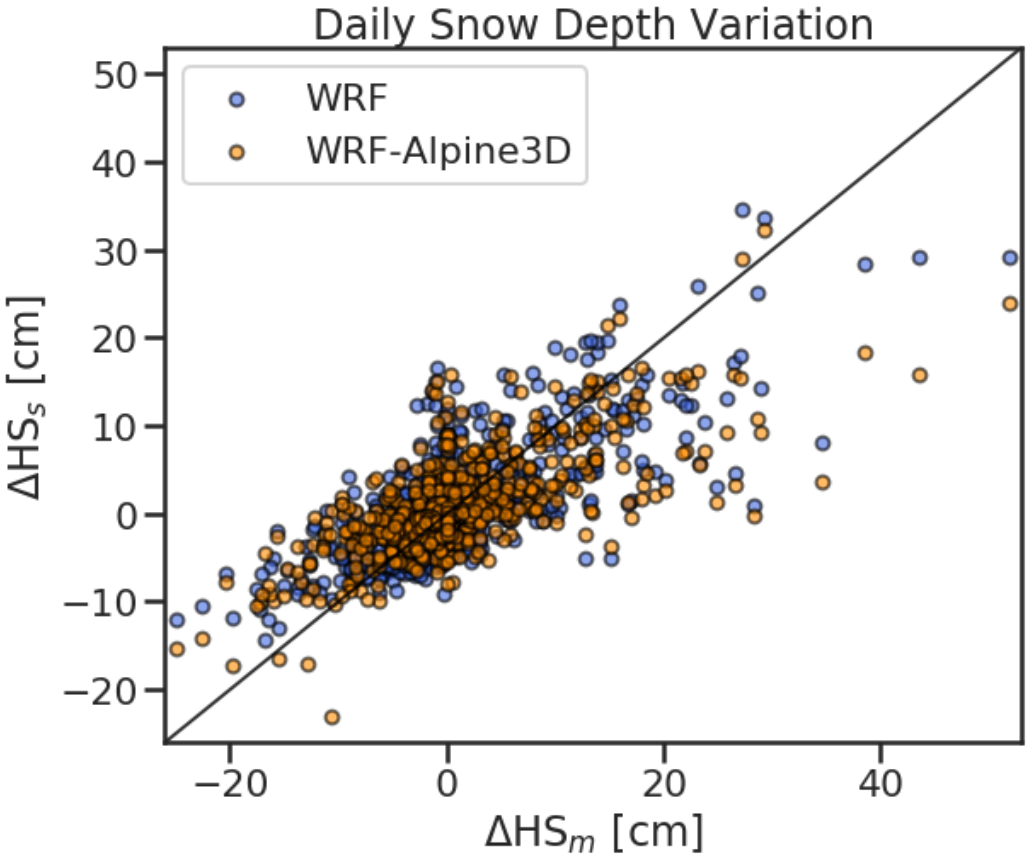

Snow cover models evaluation

	STDE		Bias		R	
	WRF	**Alpine3D**	**WRF**	**Alpine3D**	**WRF**	**Alpine3D**
HS [cm]	14.4	14.5	-10.2	-3.0	0.82	0.77
DeltaHS [cm]	4.5	4.5	-0.23	0.03	0.71	0.71

Discussion and Conclusion

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- Good WRF scores for TA, RH, ISWR and PSUM
- Underestimation of VW at high elevations
- WRF cumulated snowfall higher than Alpine3D at high elevations and smaller at lower elevations
- WRF and Alpine3D negative bias for HS
- Alpine3D better than WRF to reproduce observed daily HS variation and HS densification rate
- Underestimation of the new snow depth: negative impact on the entire simulation