Impact of snow drift on snow cover in the central Apennines simulated with the WRF/Noah-MP model

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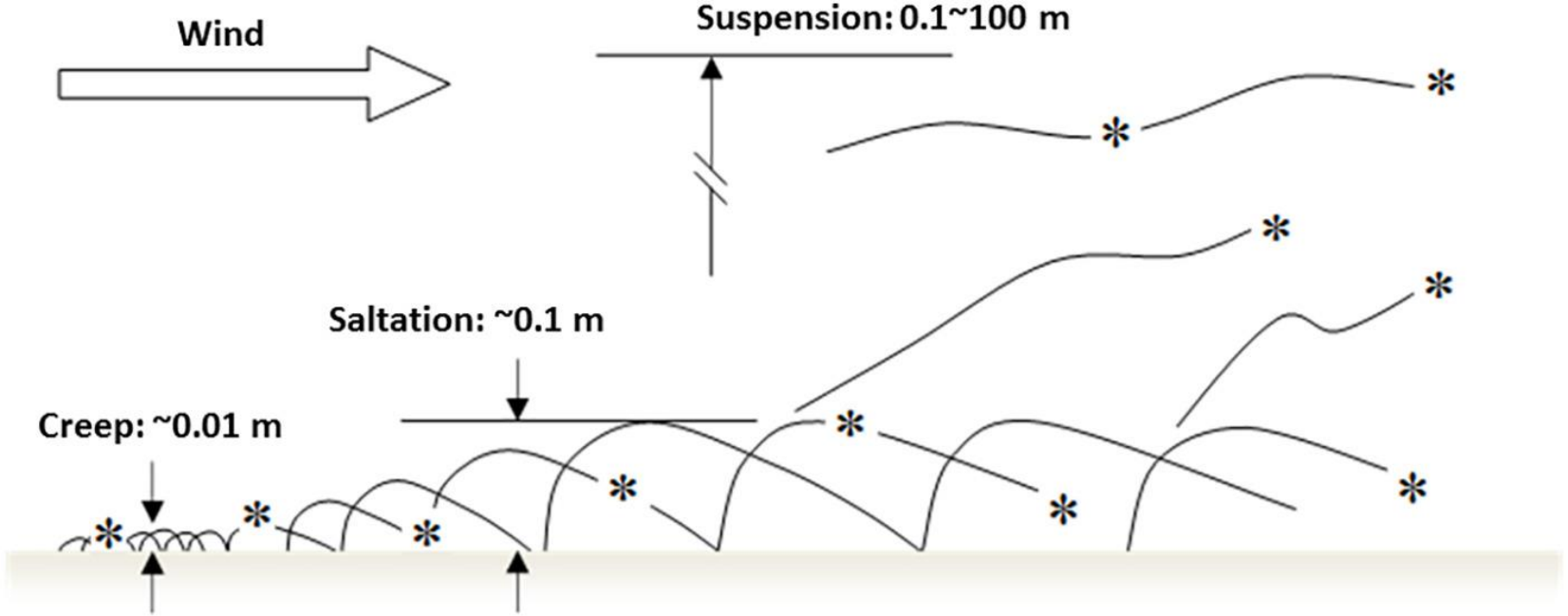
Snow Drift

- It causes inhomogeneous snow height
- Snow eroded from wind exposed surfaces and deposited on wind sheltered surfaces

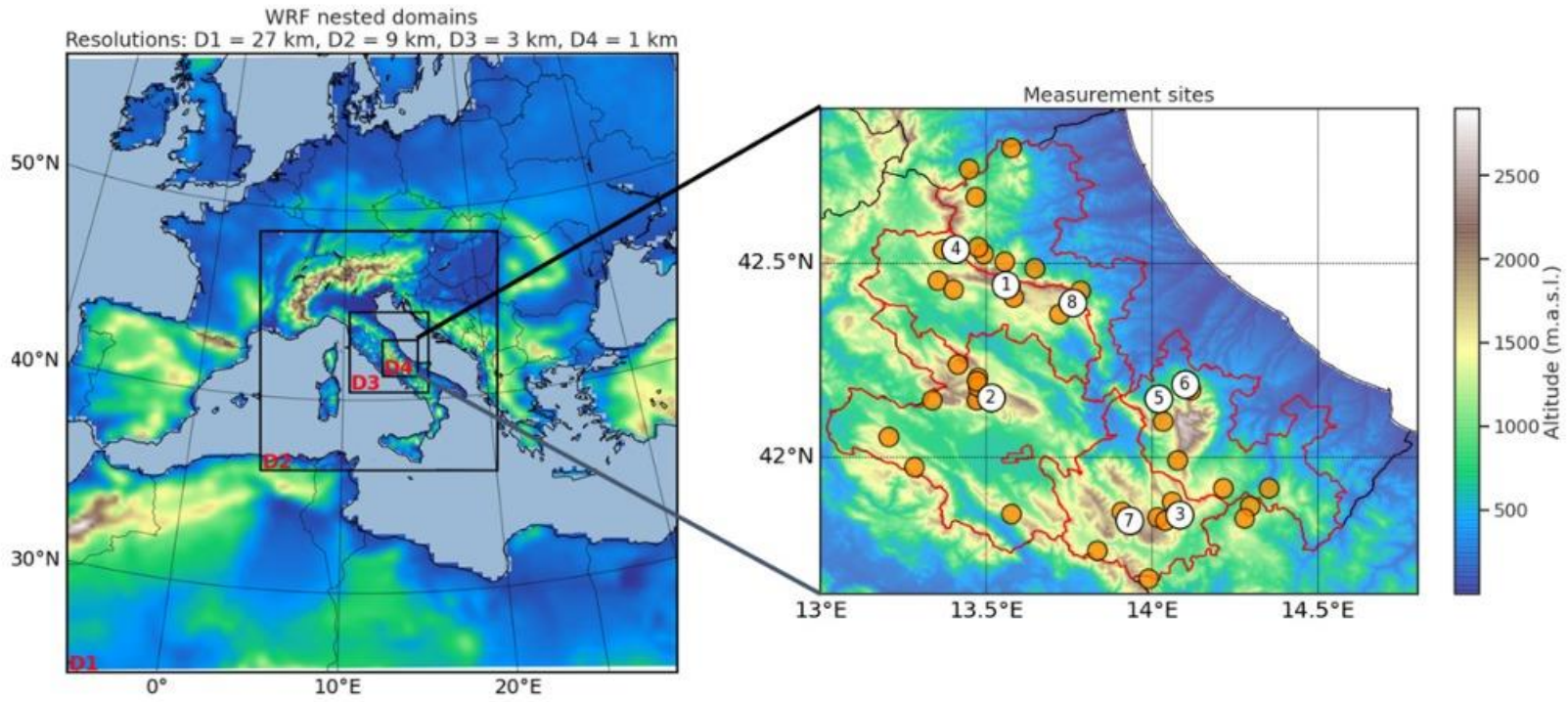


Taken from Yoshihide Tominaga, 2018

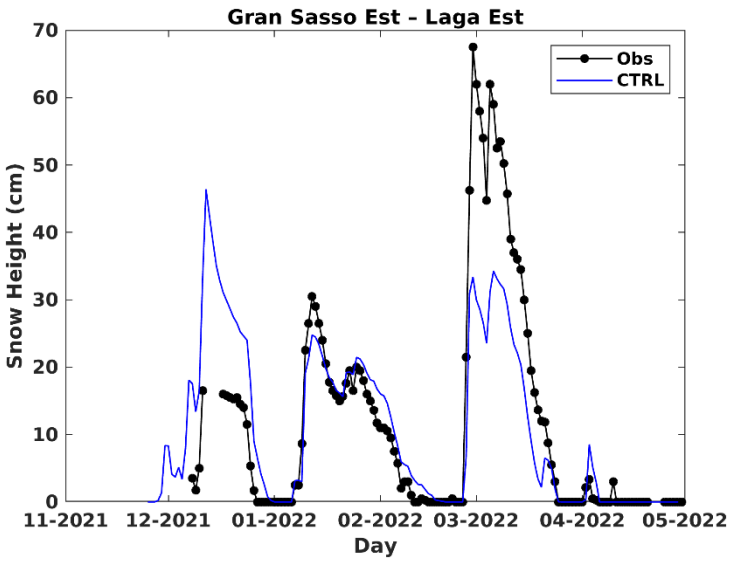
- Wind-induced snow transport occurs when the wind speed exceeds a threshold value, which depends on the snow type at the surface
- Three modes of snow transport: reptation, saltation and turbulent suspension
  - Reptation: the rolling of particles over the surface of the snowpack (negligible)
  - Saltation:
    - particles follow ballistic trajectories close to the ground
    - returning to the surface they may rebound and/or eject new grains
  - Turbulent suspension:
    - occurs above the saltation layer
    - snow grains are transported by turbulent eddies.
- Distances of transport limited by the sedimentation and sublimation of snow grains
- Sublimation modifies the vertical profiles of temperature and humidity near the surface

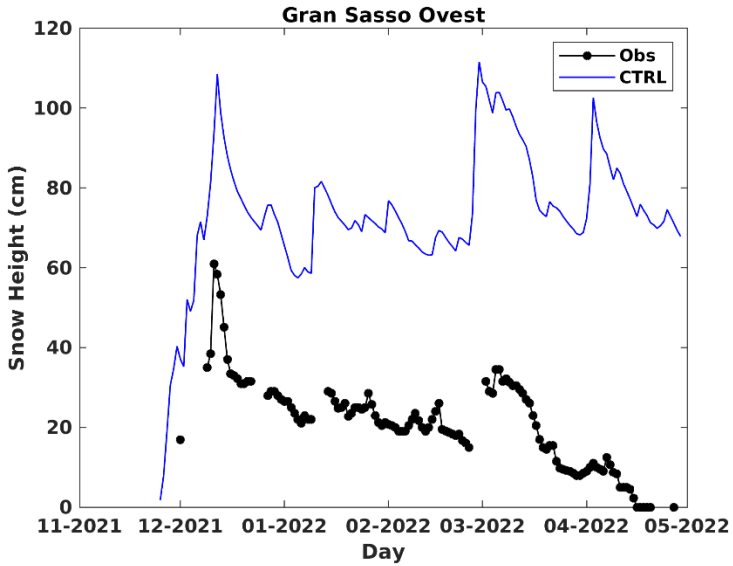
WRF-NOAH-MP model configuration and evaluation

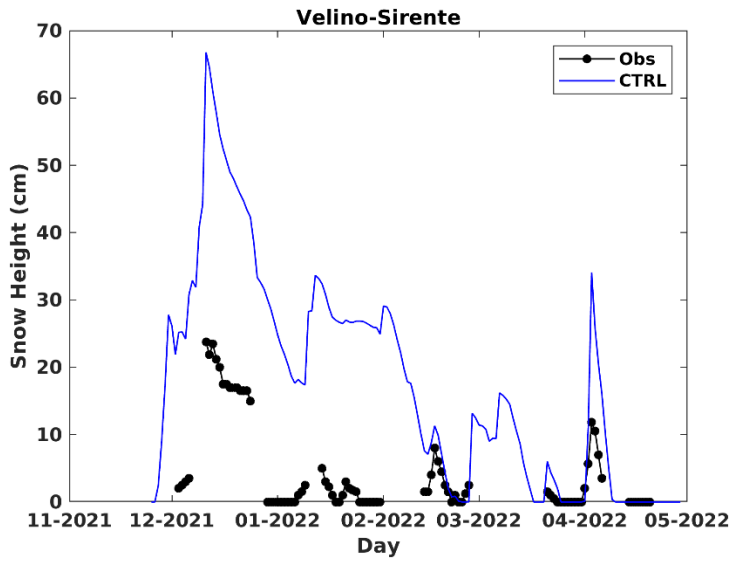
- Central Italy is a region characterized by complex terrain, it is crossed by Apennines mountain chain and is surrounded by the Adriatic and Thyrrenian seas. These features result in a high micro-climate variability.
- WRF has been configured with four nested domains. The innermost domain has a resolution of 1 km and is centered on the Abruzzo region, where the Apennine chain reaches its highest elevation (2912).
- NOAH-MP is used in the online configuration embedded in WRF.
- Snow height predicted by WRF-NOAH-MP is evalauted with data from manual stations maintained by the MeteoMont service.
- Model evaluation has been performed dividing the Abruzzo in 5 «meteo-nivological alert area», which are geographical areas that are homogeneous in terms of climate and snow conditions and are characterized by a uniform response during the occurrence of avalanche phenomena.

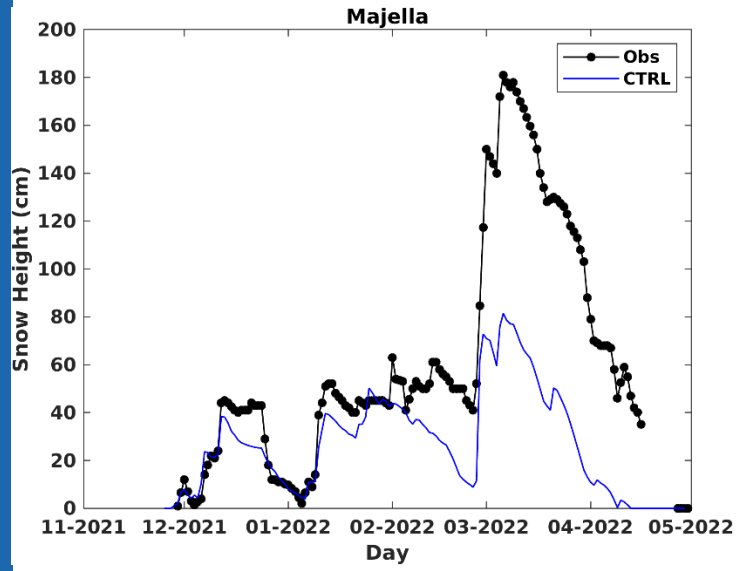


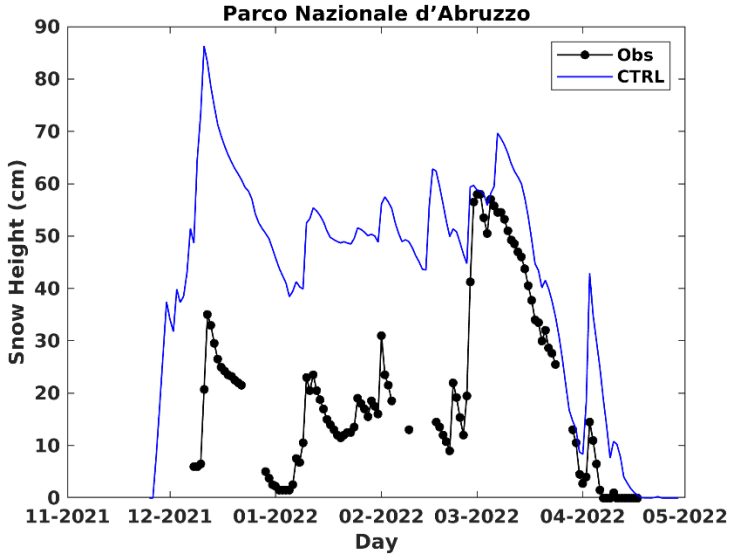
Model Evaluation











r = 0.77

MB = 11 cm

RMSE = 16 cm

STDE = 13 cm

Snow Drift Parameterization

Flux in the saltation layer:

$$F_{salt} = e\left(u_*^2 - u_{*,th}^2\right)$$ [Naaim et al., 1998] TEST-1

$$F_{salt} = 0.0014\rho_a u_*\left(u_* - u_{*,th}\right)\left(u_* + 7.6u_{*,th} + 205\right)$$ [Lehning and Fierz, 2008] TEST-2

$$u_{*,th} = 0.0195 + \sqrt{0.021\rho_s}$$

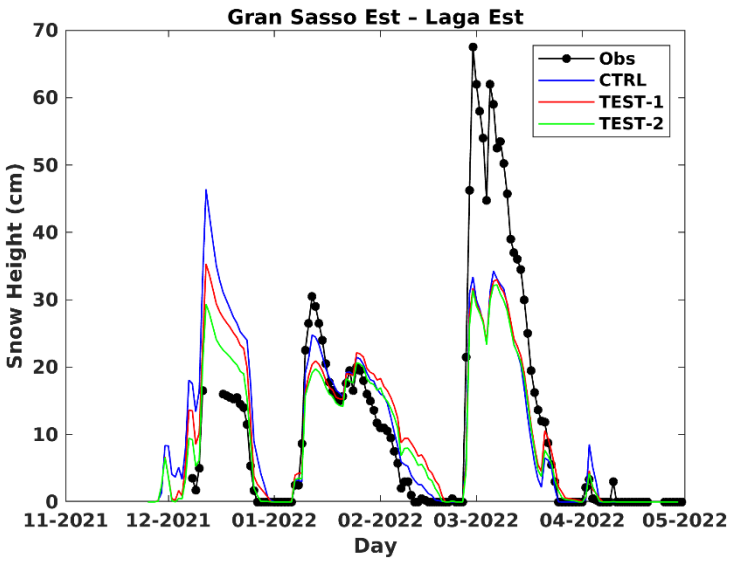
Suspension snow flux:

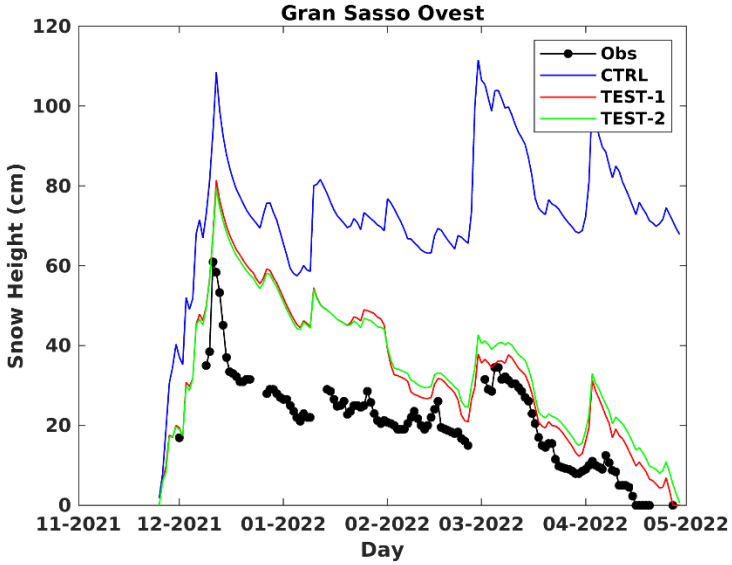
$$F_{bc} = C_D u_{10}\left(c_{salt} - c_{surf}\right)$$

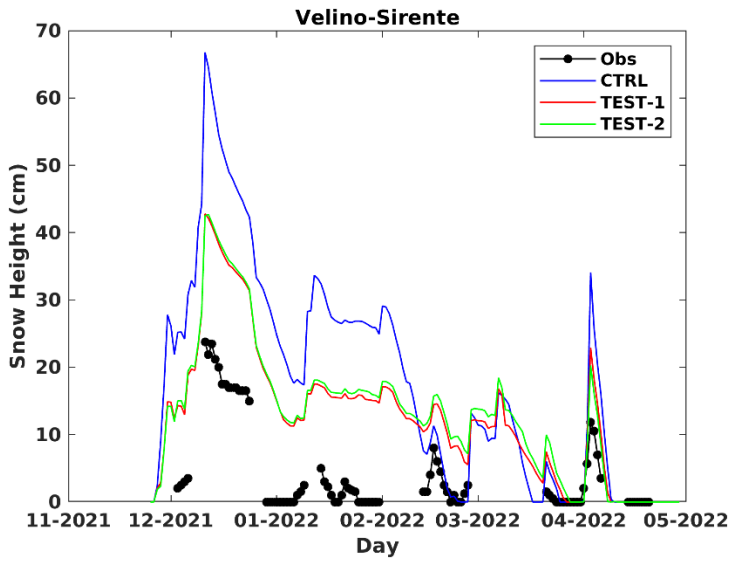
Blowing snow is transported as a tracer using the transport scheme of WRF.

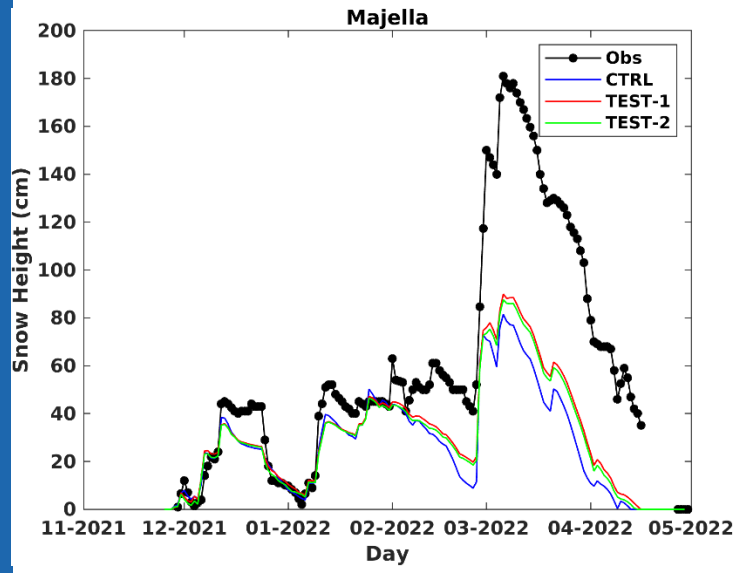
Blowing snow sublimates according to the simulated atmospheric conditions and deposites with an assumed settling velocity.

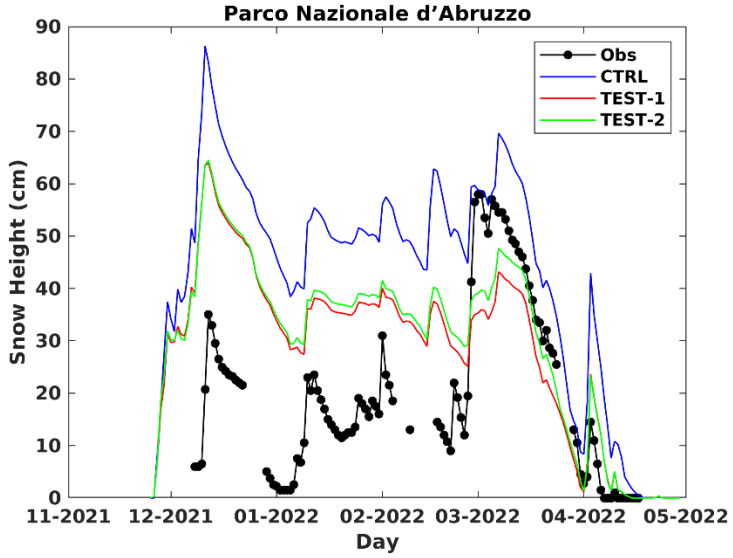
Results





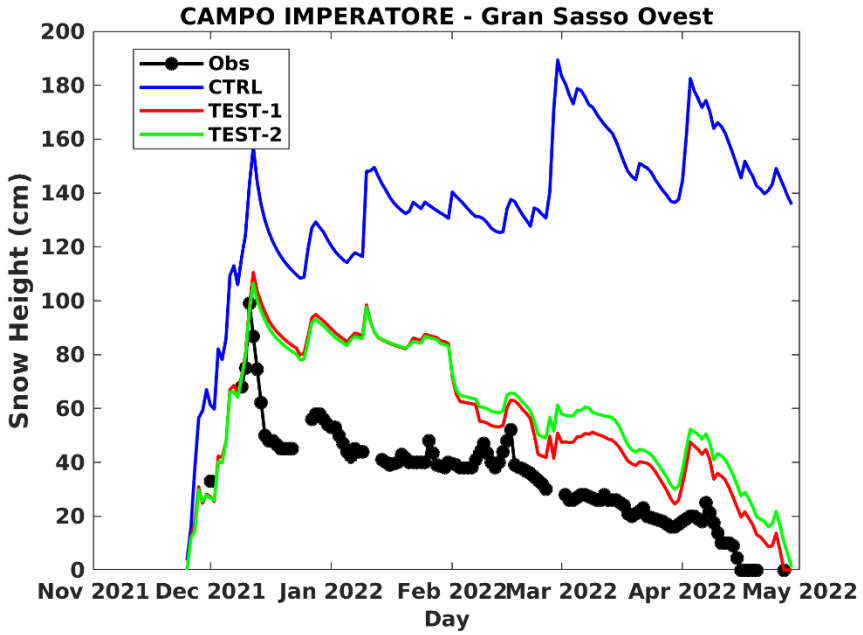


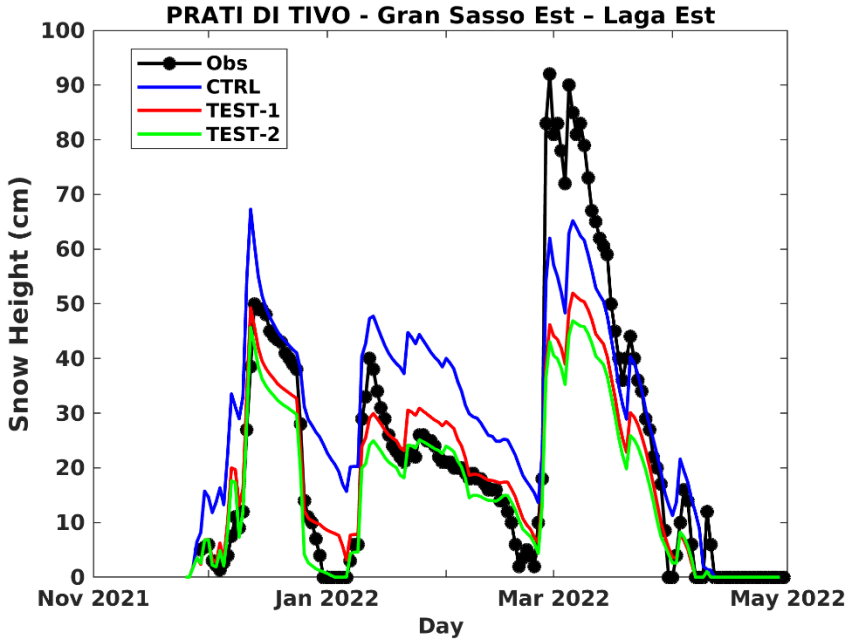


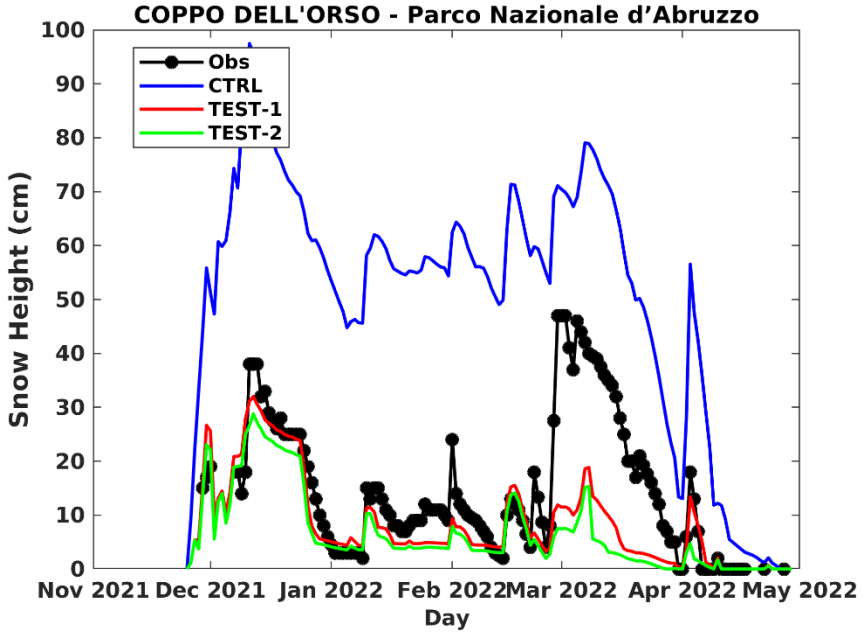


	r	MB	RMSE	STDE
CTRL	0.77	11	16	13
TEST-1	0.73	9	13	12
TEST-2	0.73	10	13	11

Results


CAMPO IMPERATORE - Gran Sasso Ovest
Obs
CTRL
TEST-1
TEST-2
Snow Height (cm)
0
20
40
60
80
100
120
140
160
180
200
Nov 2021
Dec 2021
Jan 2022
Feb 2022
Mar 2022
Apr 2022
May 2022
Day


PRATI DI TIVO - Gran Sasso Est – Laga Est
Obs
CTRL
TEST-1
TEST-2
Snow Height (cm)
0
10
20
30
40
50
60
70
80
90
100
Nov 2021
Jan 2022
Mar 2022
May 2022
Day


COPPO DELL'ORSO - Parco Nazionale d'Abruzzo
Obs
CTRL
TEST-1
TEST-2
Snow Height (cm)
0
10
20
30
40
50
60
70
80
90
100
Nov 2021
Dec 2021
Jan 2022
Feb 2022
Mar 2022
Apr 2022
May 2022
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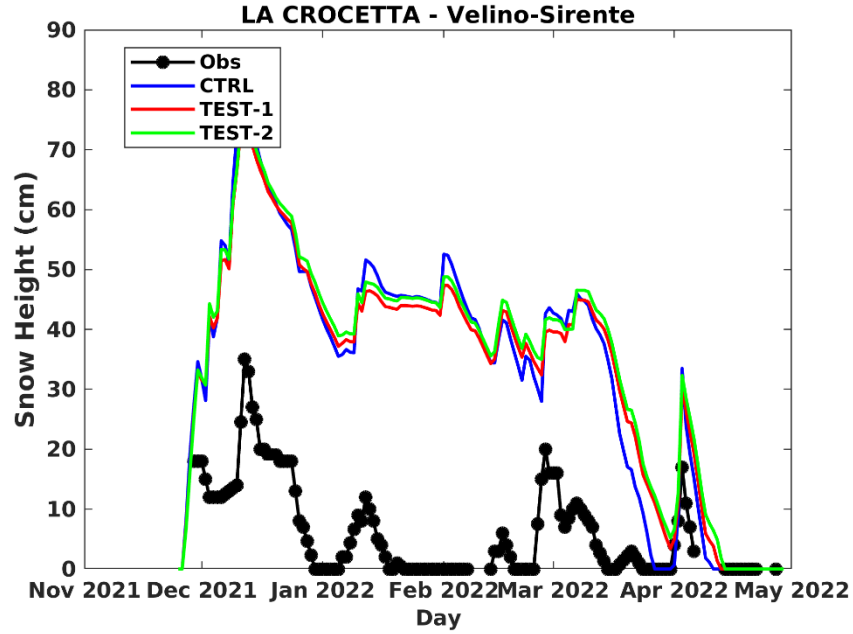
LA CROCETTA - Velino-Sirente
Obs
CTRL
TEST-1
TEST-2
Snow Height (cm)
0
10
20
30
40
50
60
70
80
90
Nov 2021
Dec 2021
Jan 2022
Feb 2022
Mar 2022
Apr 2022
May 2022
Day