A NEW METHODOLOGY FOR THE IDENTIFICATION OF WET-SNOW CONDITIONS FOR SNOW SLEEVES FORECAST ON THE OVERHEAD POWER LINES

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RSE SpA – Ricerca sul Sistema Energetico

Outline

- Introduction
- Wet-snow and snow sleeve formation
- Wet-snow ***modelling*** – Makkonen Model
- Wet-snow ***monitoring*** – WILD
- Meteorological Input - WRF-ARW domain
- New methodology for identification of wet-snow conditions
- Case studies:
  - February 27th-28th 2016
  - December 1st 2019
- Conclusions

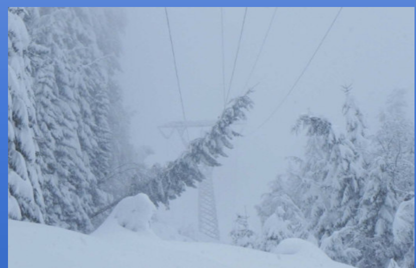
Introduction

Wet Snow and power networks: effects and costs

Snow Sleeve formation over conductors → Direct impacts

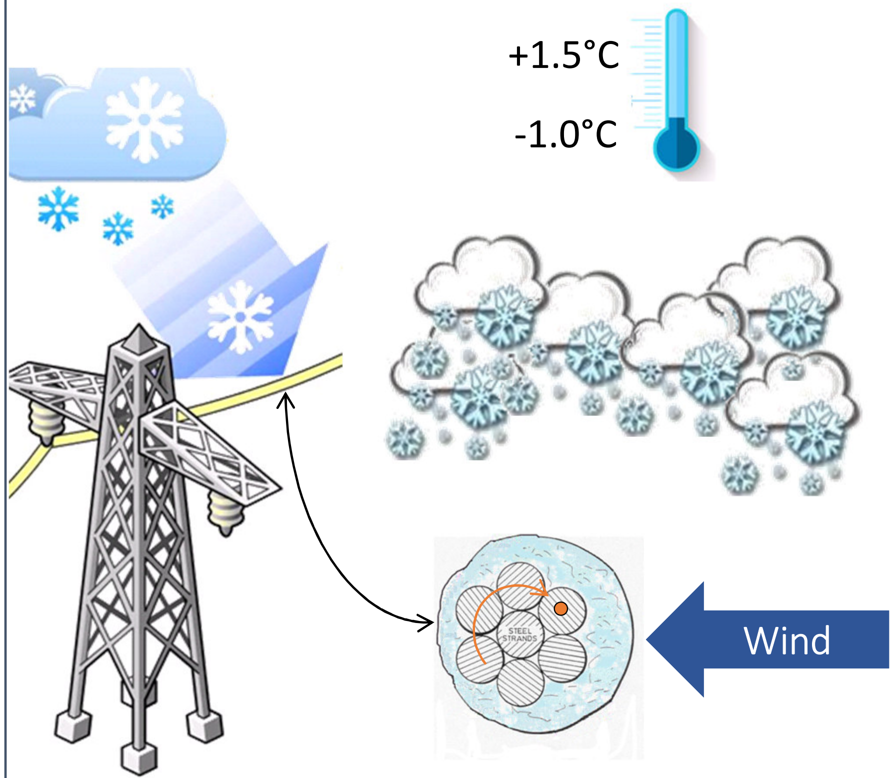



Snow accumulation over trees → Indirect impacts



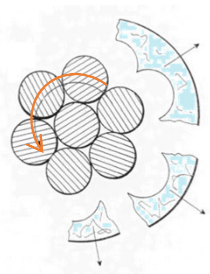
Damage costs:
up to 33M€/year

Wet Snow and Snow Sleeves formation



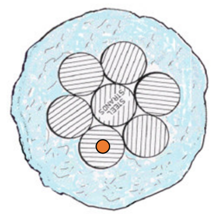
T ≥ +2°C

Rain and high temperature break the snow sleeves



-1.0°C<T<+1.5°C

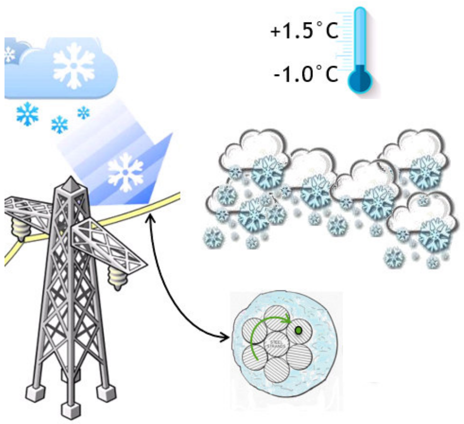
Snow, rotation of conductor and low temperatures generate the snow sleeve

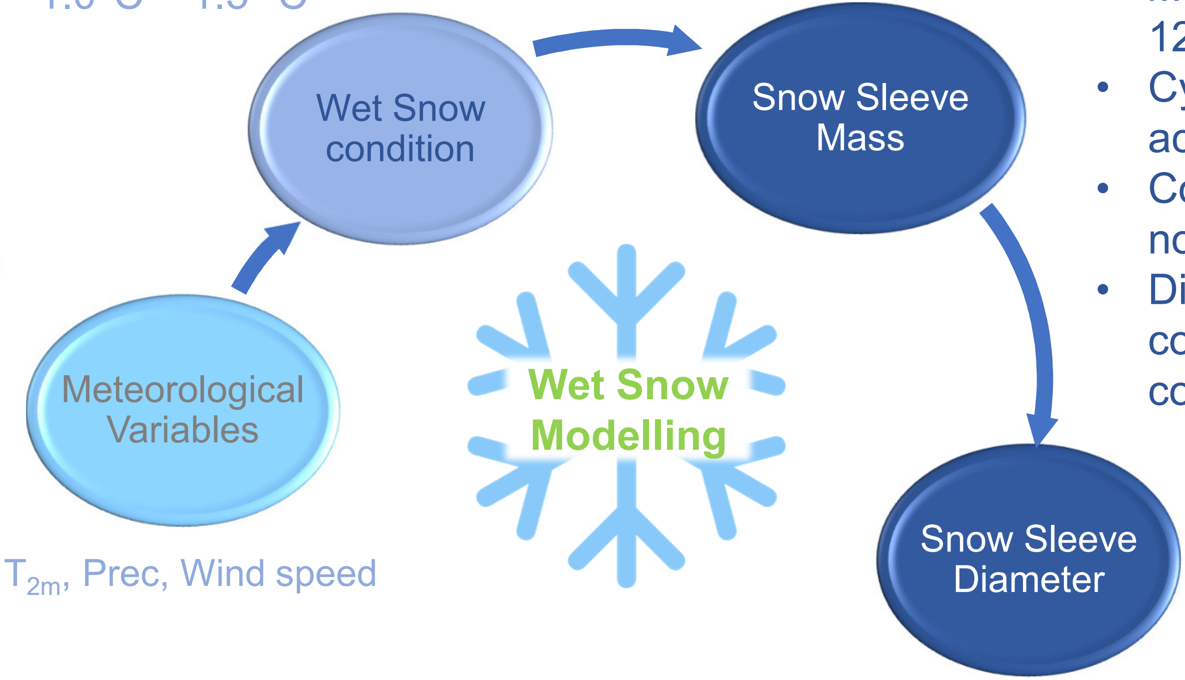


Wet Snow Modelling

Current methodology based on Thermal Window TW method

- Thermal Window TW
  -1.0°C – 1.5 °C





T_{2m}, Prec, Wind speed

- *Makkonen Model* (ISO 12494-2017)
- Cylindrical wet-snow accretion on conductor
- Conservative Model → no shedding
- Different sticking coefficient in wet/dry conditions

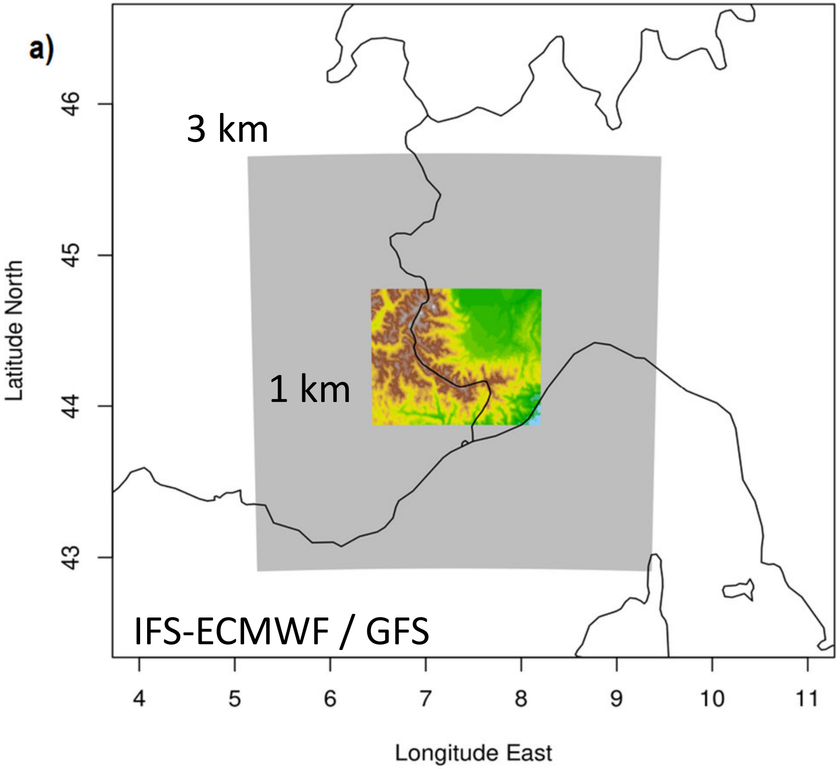
Wet snow monitoring - WILD

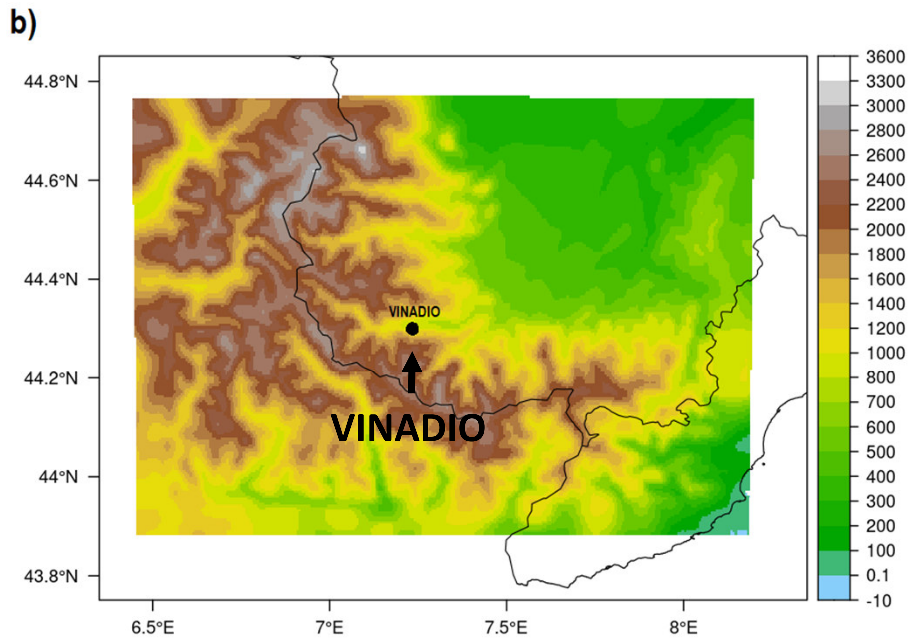
Wet-snow Ice Laboratory Detection

- Weather measurements to validate forecast models
- Measurement of snow sleeve diameter and mass to validate Makkonen model
- Monitoring of slow sleeves with webcams during wet snow events.

Meteorological Input - WRF-ARW

NW Italy Domain





Initial / Boundary Conditions:

1. IFS ECMWF
2. GFS

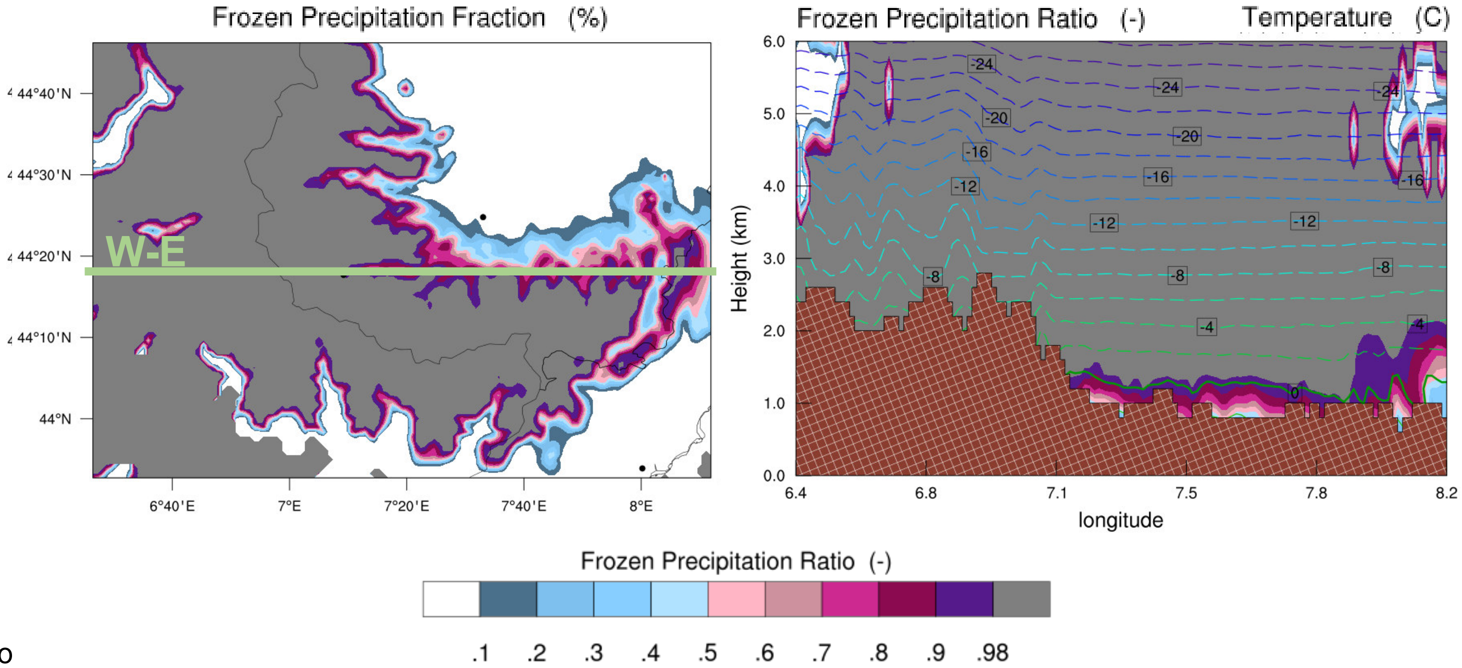
New methodology for identification of wet-snow conditions

Snow Ratio SR (or Frozen Precipitation Fraction)

$$SR = \frac{Q_{graup} + Q_{snow}}{Q_{graup} + Q_{snow} + Q_{rain}}$$

Q_{graup} : *graupel mixing ratio* (kg kg-1)
Q_{snow} : *snow mixing ratio* (kg kg-1)
Q_{rain} : *rain mixing ratio* (kg kg-1)

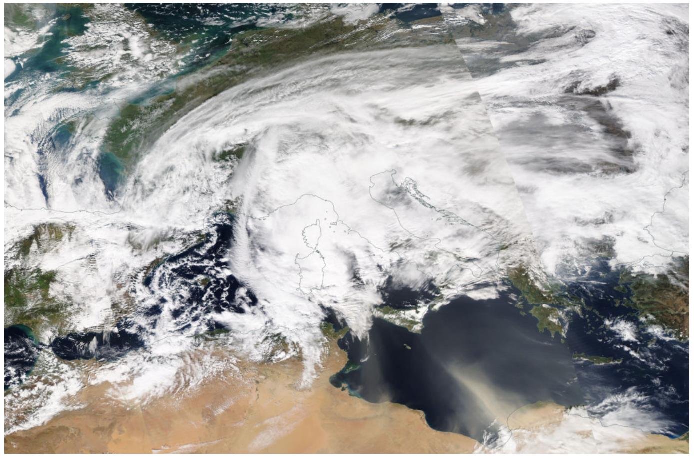
Dry-snow	SR > 0.98
Wet-snow	0.5 ≤ SR ≤ 0.98
Maintenance	0.1≤ SR < 0.5
Shedding (Rain)	SR<0.1



Sakamoto, «Snow accretion on overhead wires,»
Philos. Trans. Roy. Soc. London, p. 2941–2970, 2000

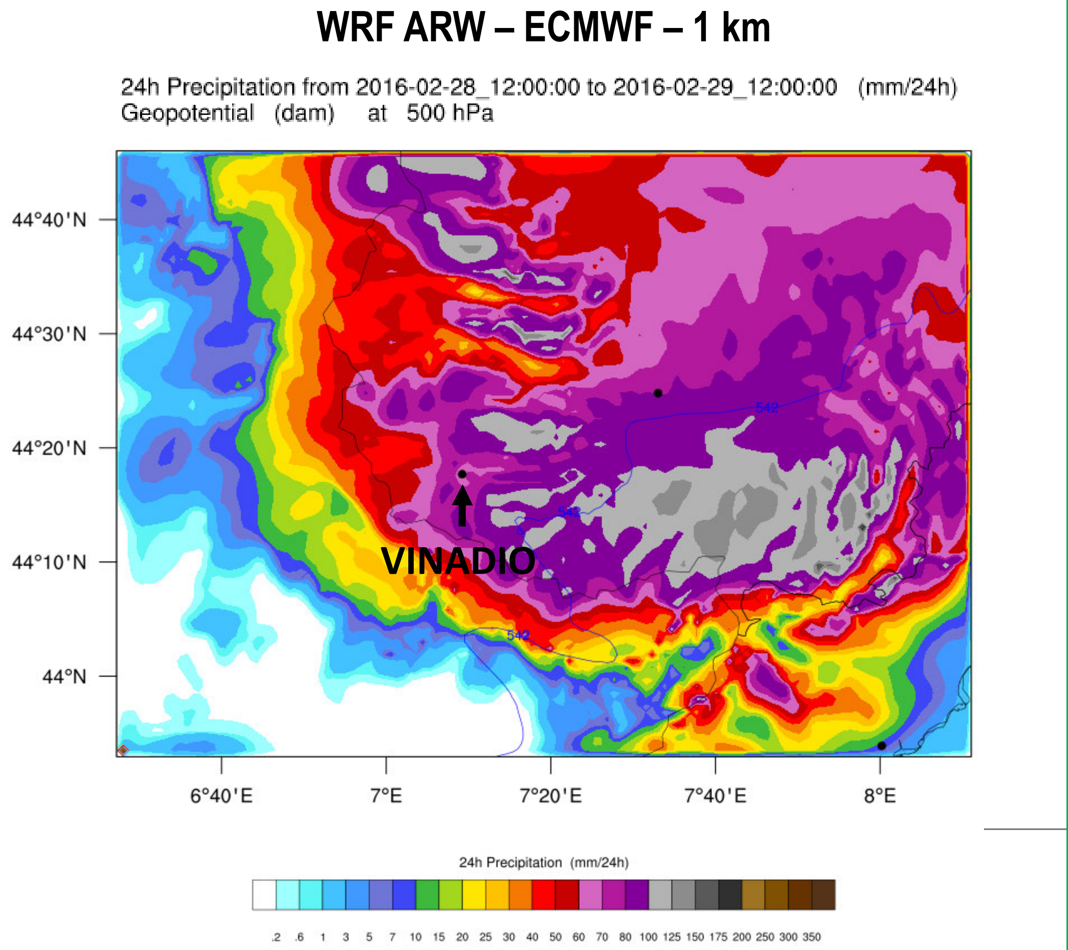
Case study February 27th-28th 2016

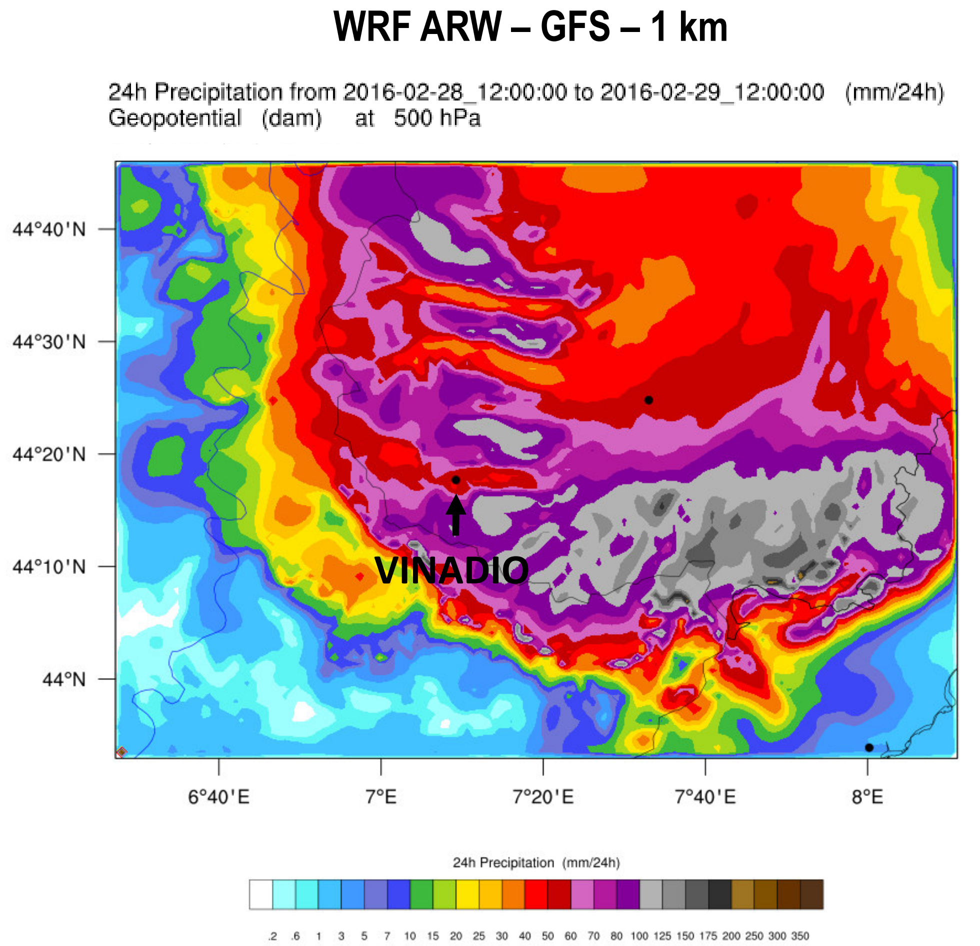
- Classic wet snow event with significant precipitation accumulations
- Snow Mass of about 8 kg/m and snow sleeve density of about 200 kg/m^3
- About 80 mm of precipitation between Febr. 28th 12UTC and Febr. 29th 12UTC



https://worldview.earthdata.nasa.gov/

24hr Accumulated precipitation





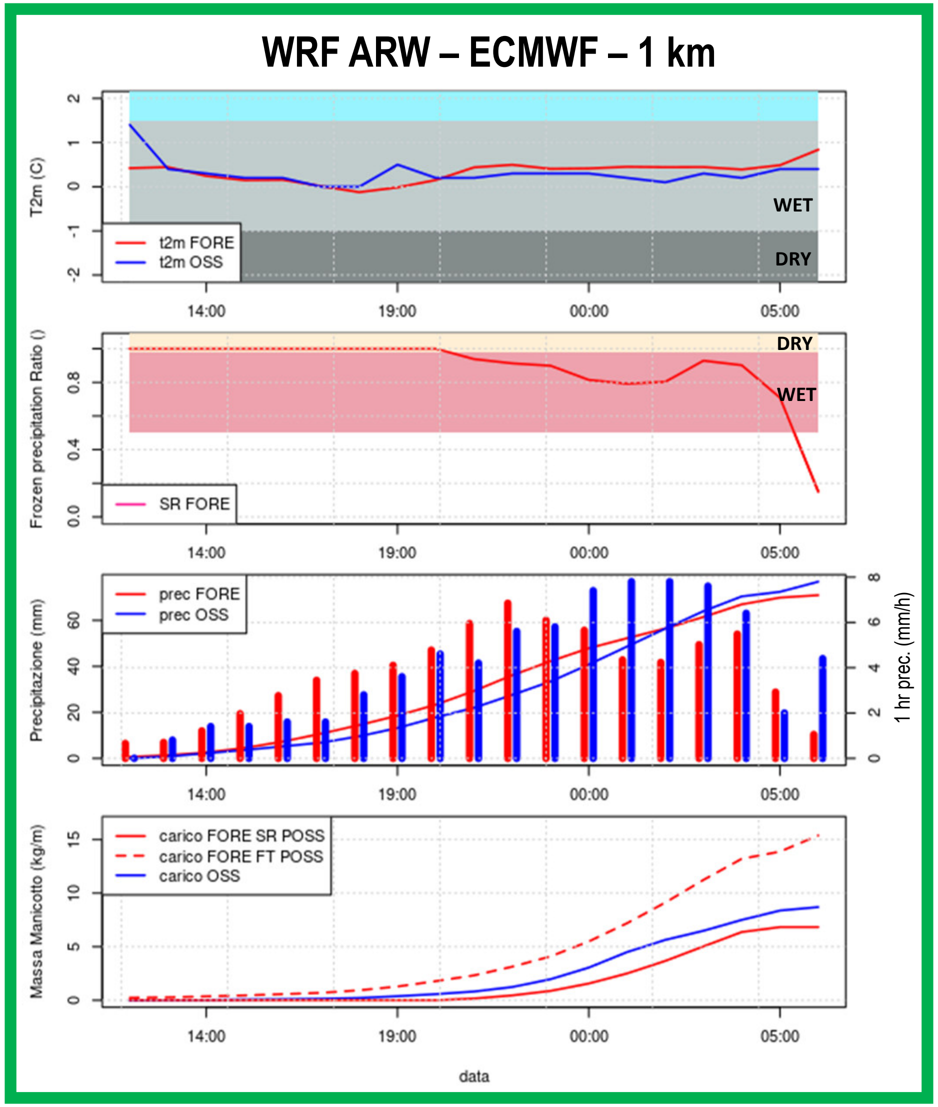
Estimated Snow Mass - Makkonen model

T2m (°C)

SR

1hr prec (mm/h)
Prec Accum. (mm)

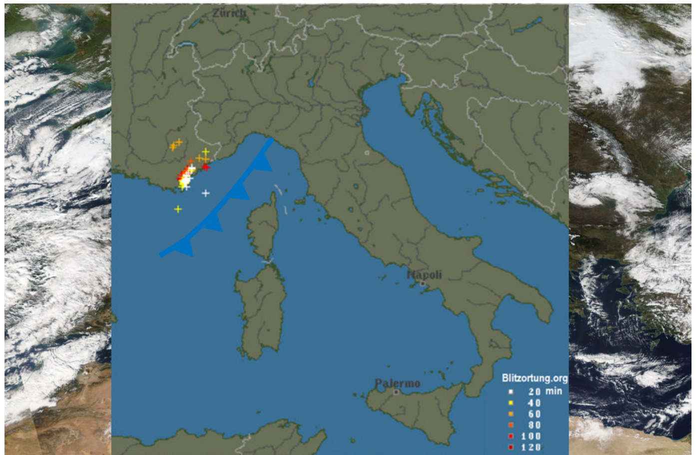
Snow Mass
Observed Prec. (kg/m)



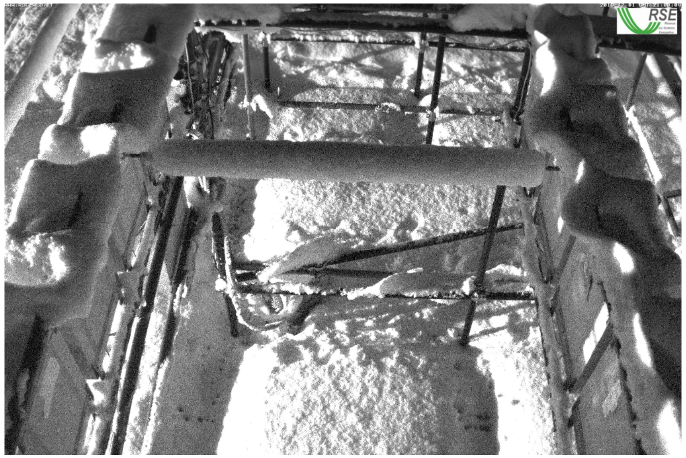
- Strong overestimation TW due to incorrect timing in the beginning of wet snow event (too early)
- Slight underestimation of SR method due to incorrect timing in the beginning of wet snow event (slight delay)

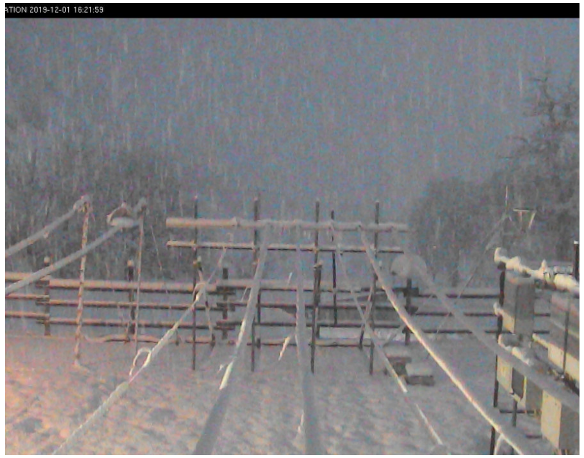
Case study December 1th 2019

- Wet snow event partly **convective**
- Snow Mass of about 3 kg/m and snow sleeve density of about 230 kg/m^3
- About 40 mm of precipitation on December 1st



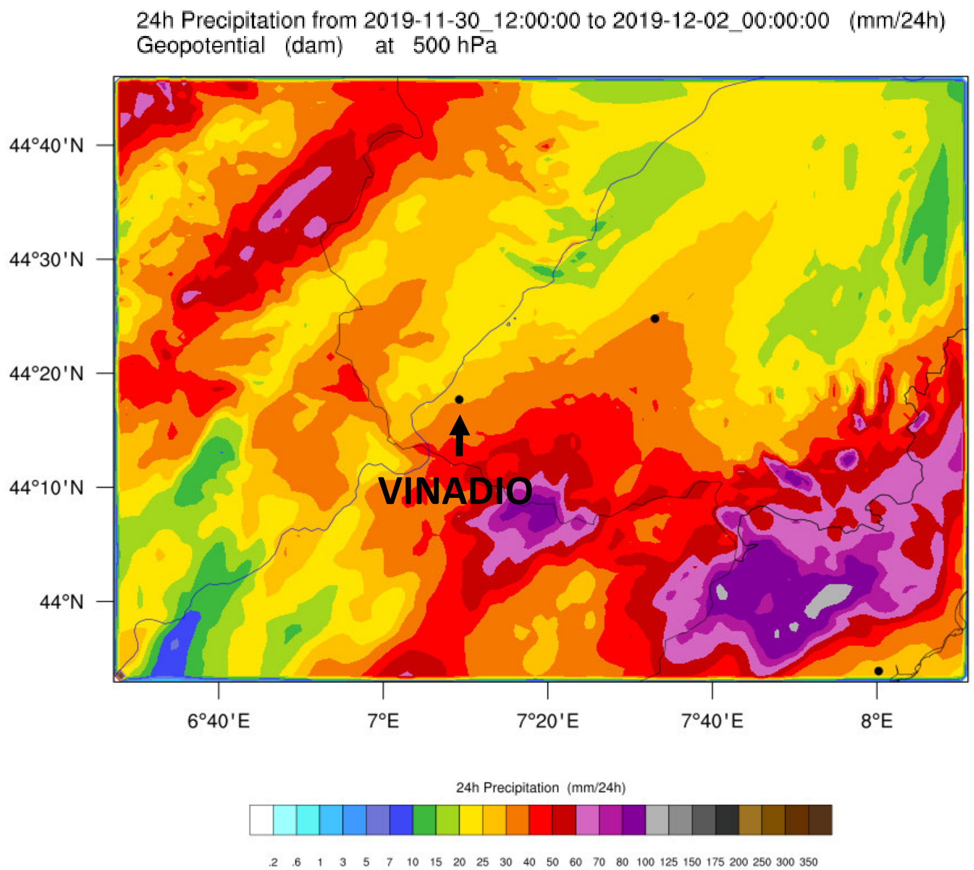
https://worldview.earthdata.nasa.gov/
www.blitzortung.org



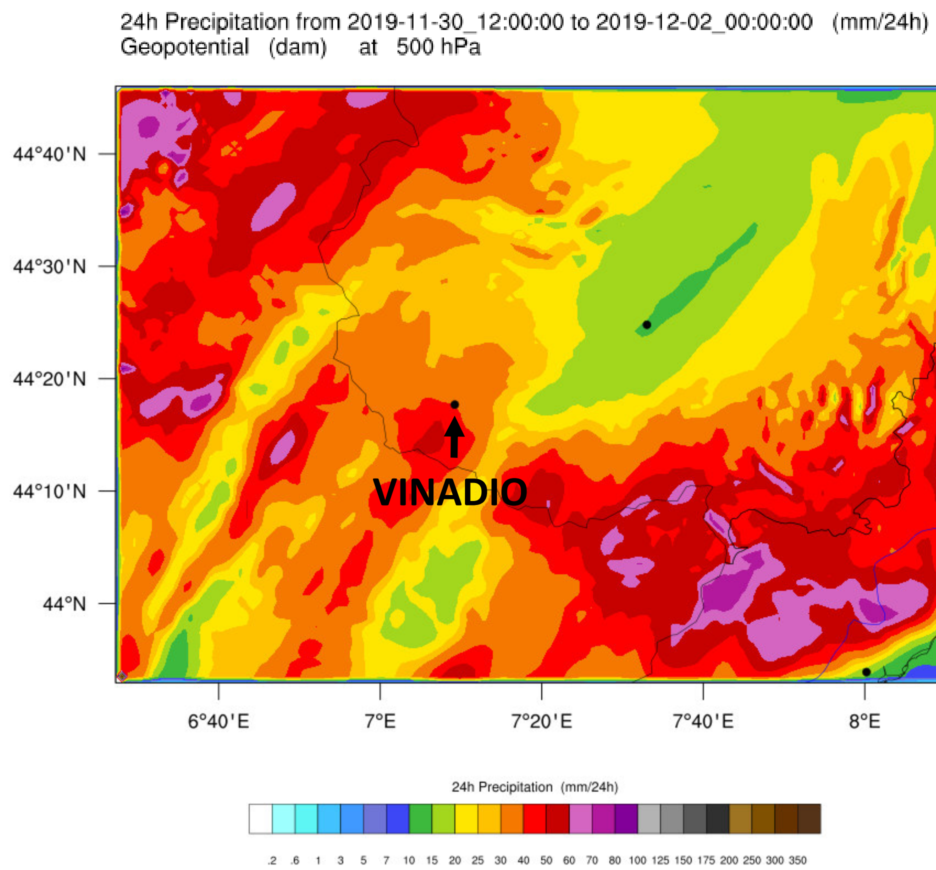


24hr Accumulated precipitation

WRF ARW – ECMWF – 1 km



WRF ARW – GFS – 1 km



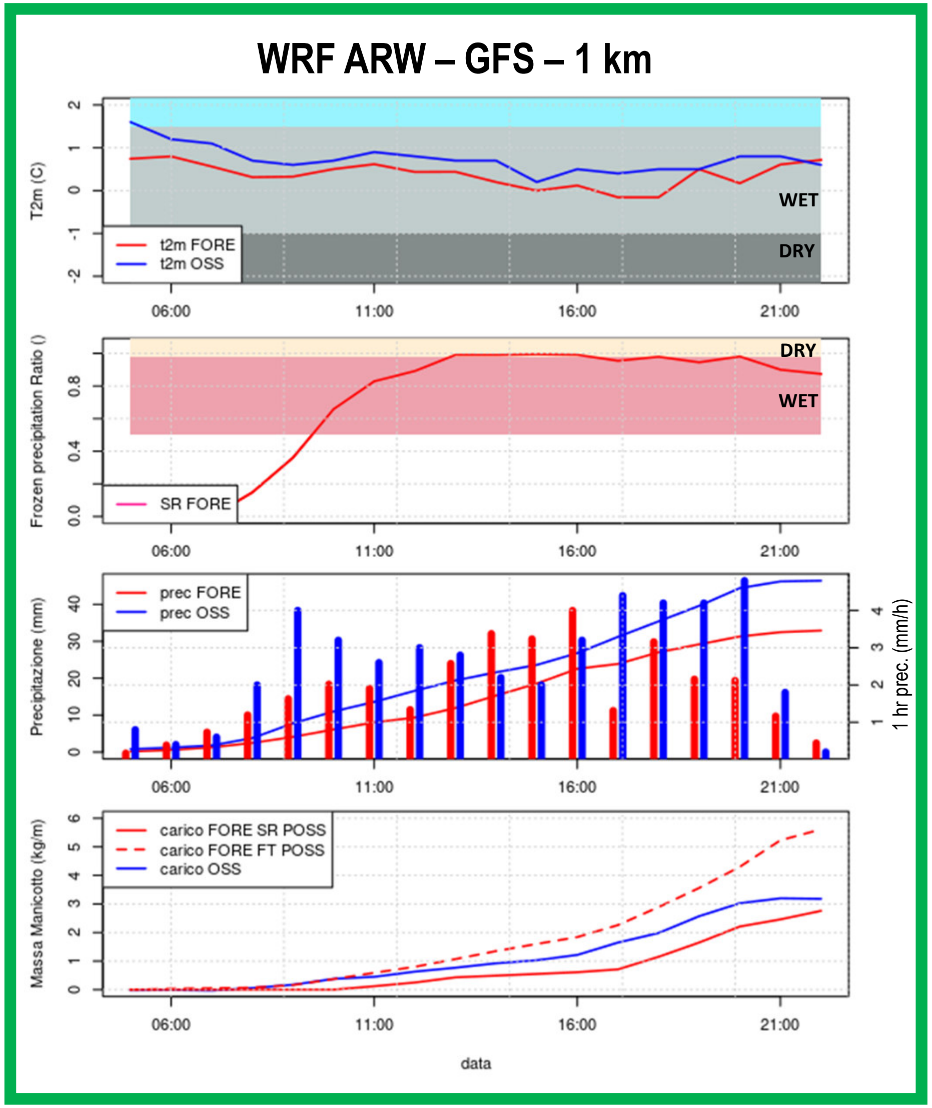
Estimated Snow Mass - Makkonen model

T2m (°C)

SR

1hr prec (mm/h)
Prec Accum.
(mm)

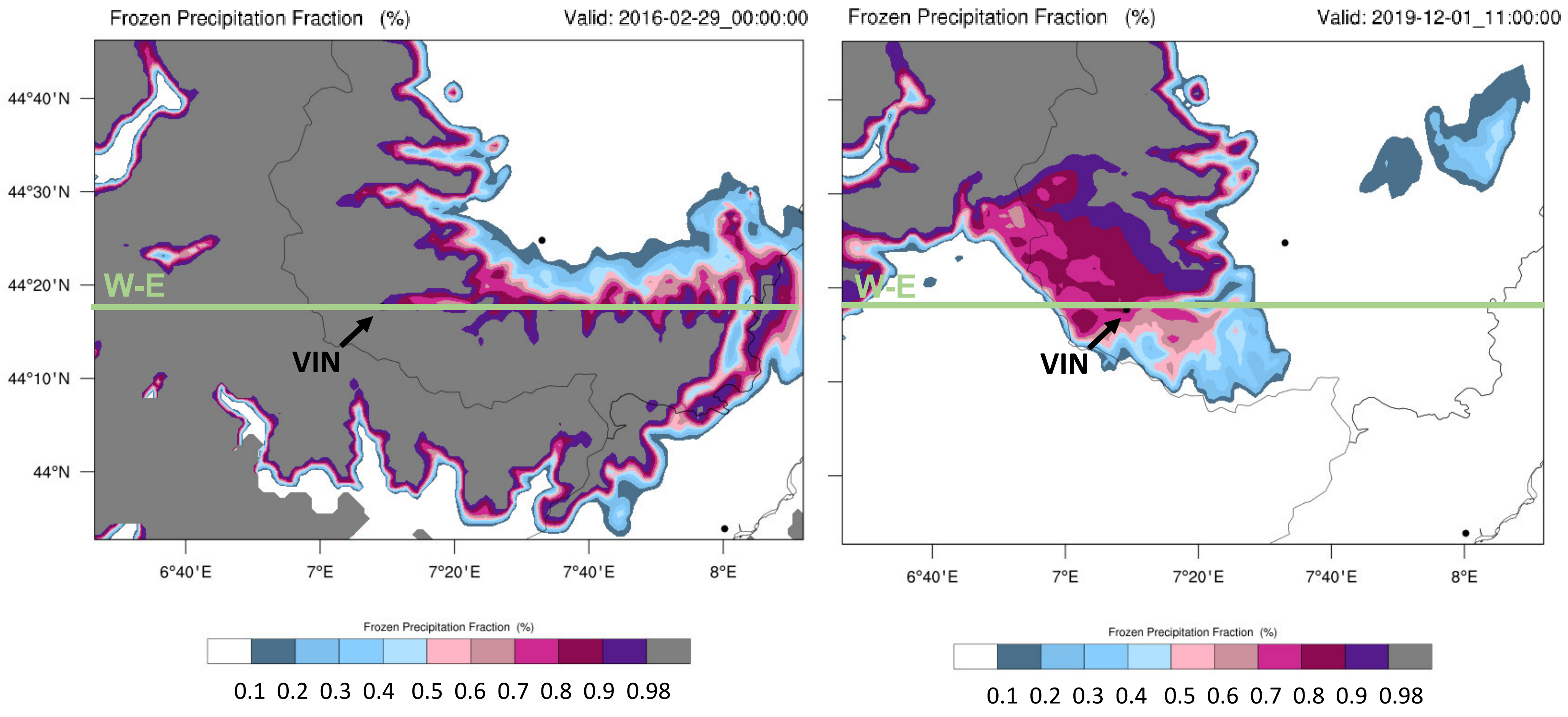
Snow Mass
Observed Prec.
(kg/m)



- Overestimation TW due to lack of dry snow conditions
- Slight underestimation of SR method due to incorrect timing in the beginning of wet snow event
- Dry condition phases correctly seen by SR method

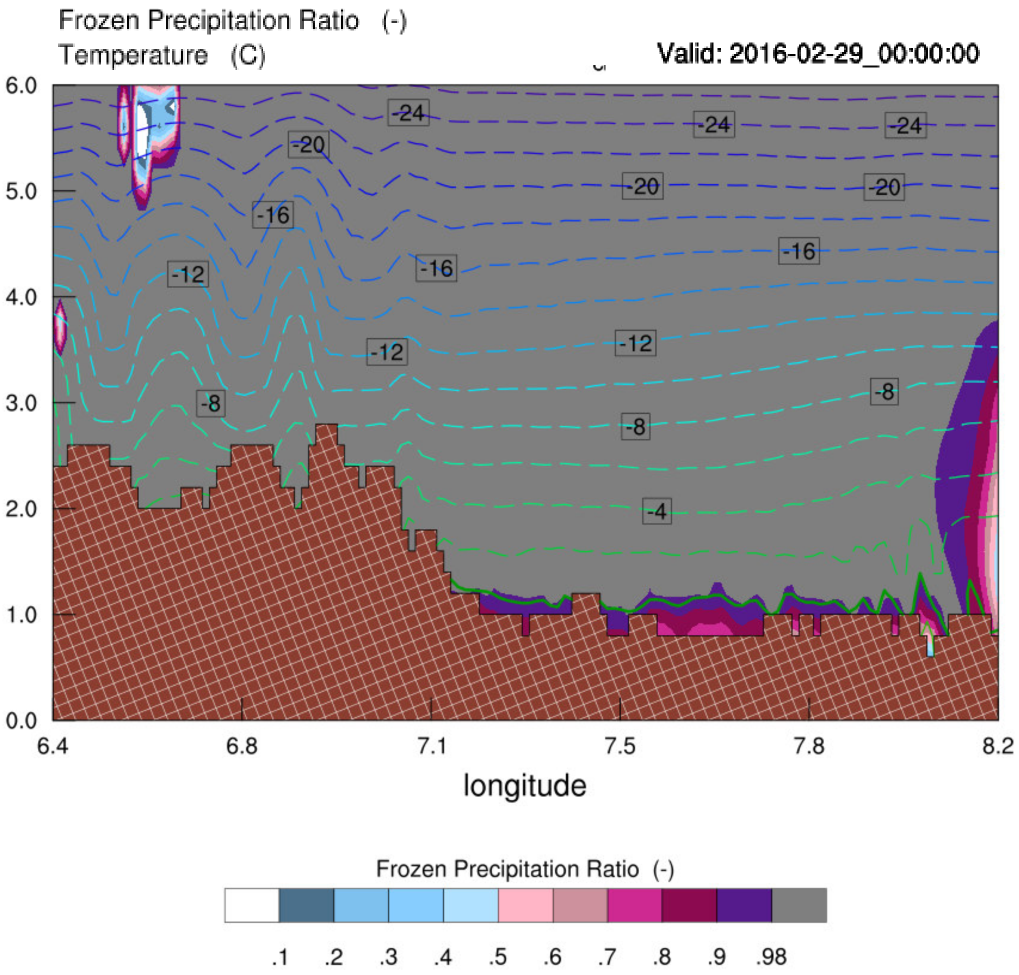
SR spatial distribution

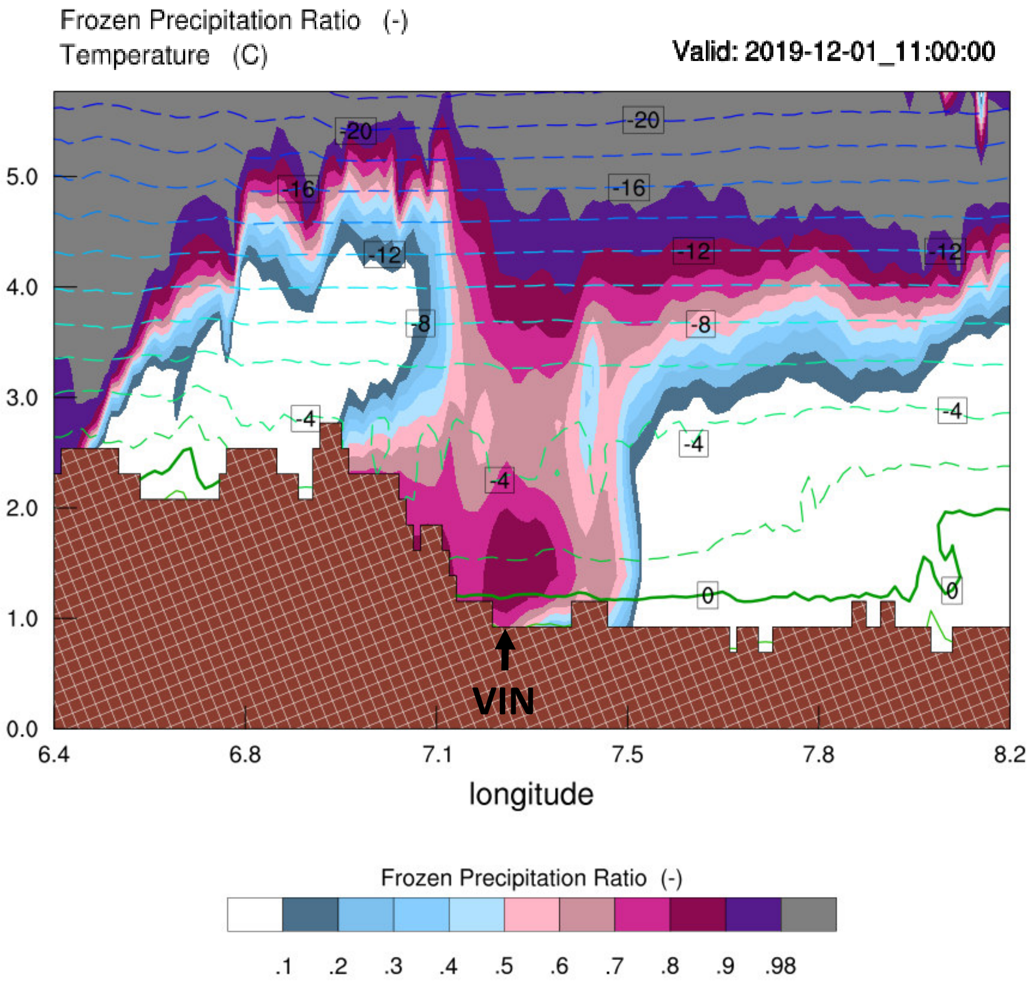
Case study 1 vs. Case study 2



SR – Cross Section – WE

Case study 1 vs. Case study 2





Conclusions

- Snow ratio SR is an alternative methodology to determine wet/dry snow conditions with respect to traditional TW method.

- In the two case studies analyzed in Vinadio monitoring station SR method show a better estimation of snow mass and a better discrimination between wet and dry snow phases.

- Wet snow condition may occur with 2m temperature far lower than 0°C as far as dry snow condition may occur also with 2m temperature close to 0°C (microphysics drive better the discrimination between wet and dry snow condition).

- Performances of the driver global model for the high-resolution forecasts may vary depending on case studies. Further case study should be analysed to have a more robust statistic of the performances with different driver models.

THANK YOU FOR THE ATTENTION!

Estimated Snow Mass - Makkonen model

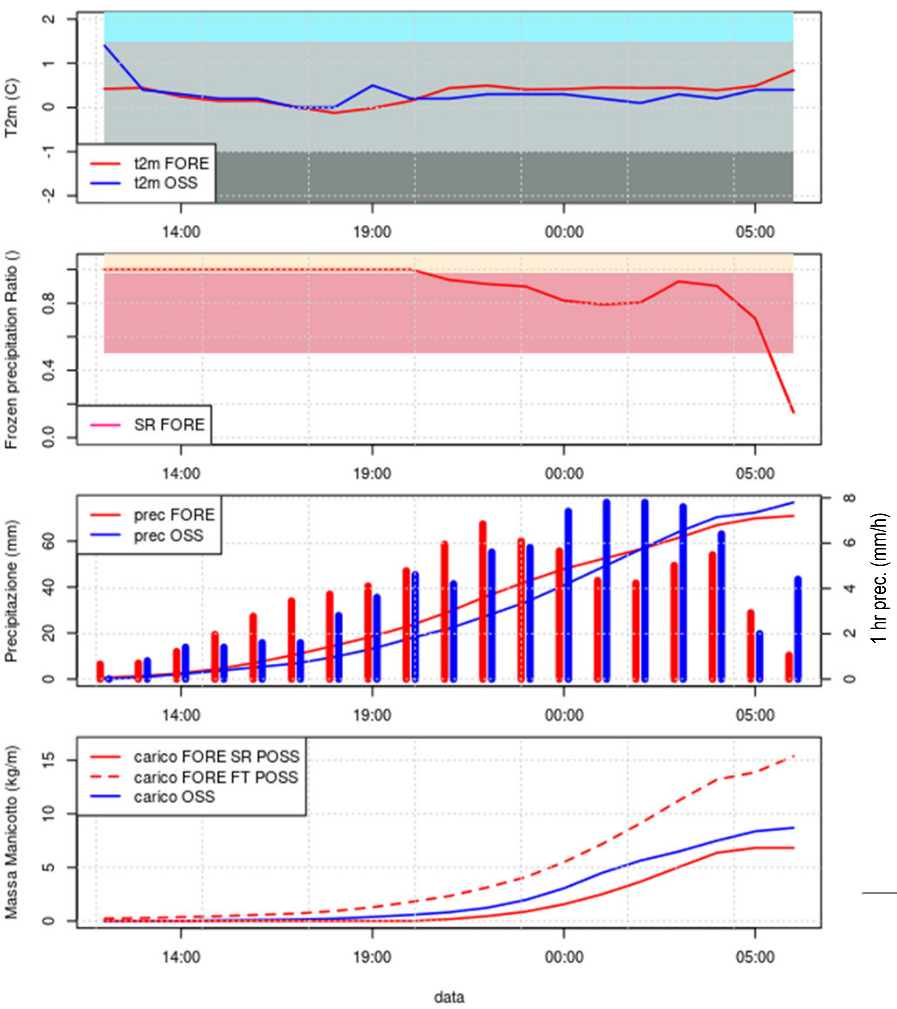
T2m (°C)

SR

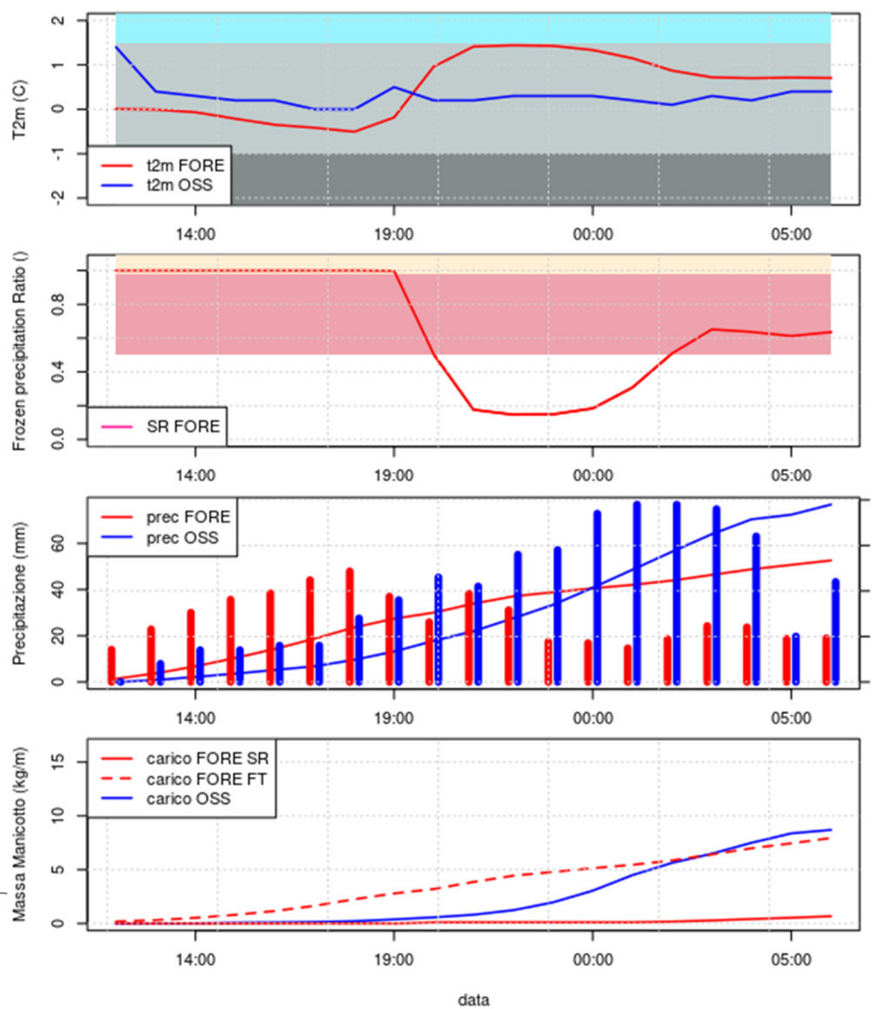
1hr prec (mm/h)
Prec Accum.
(mm)

Snow Mass
Observed Prec.
(kg/m)

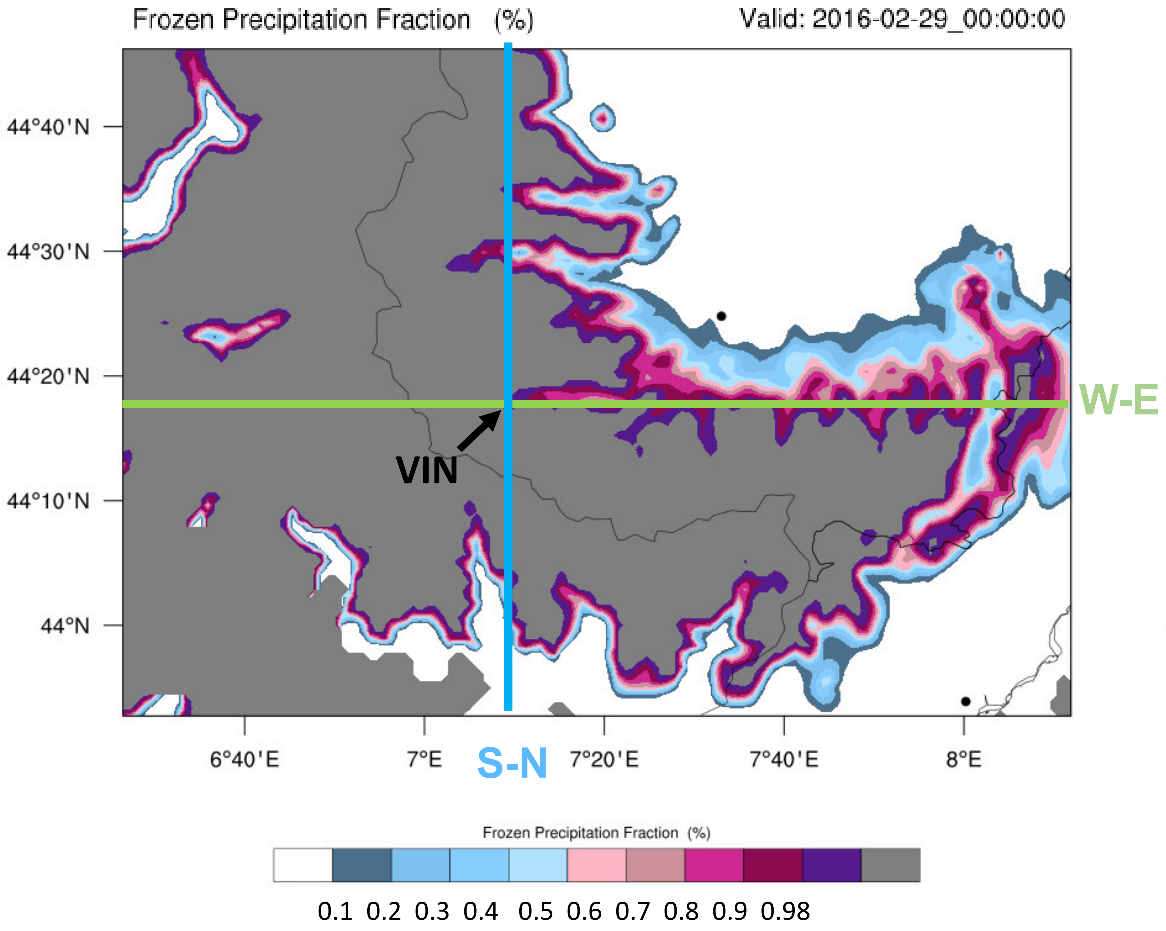
WRF ARW – ECMWF – 1 km

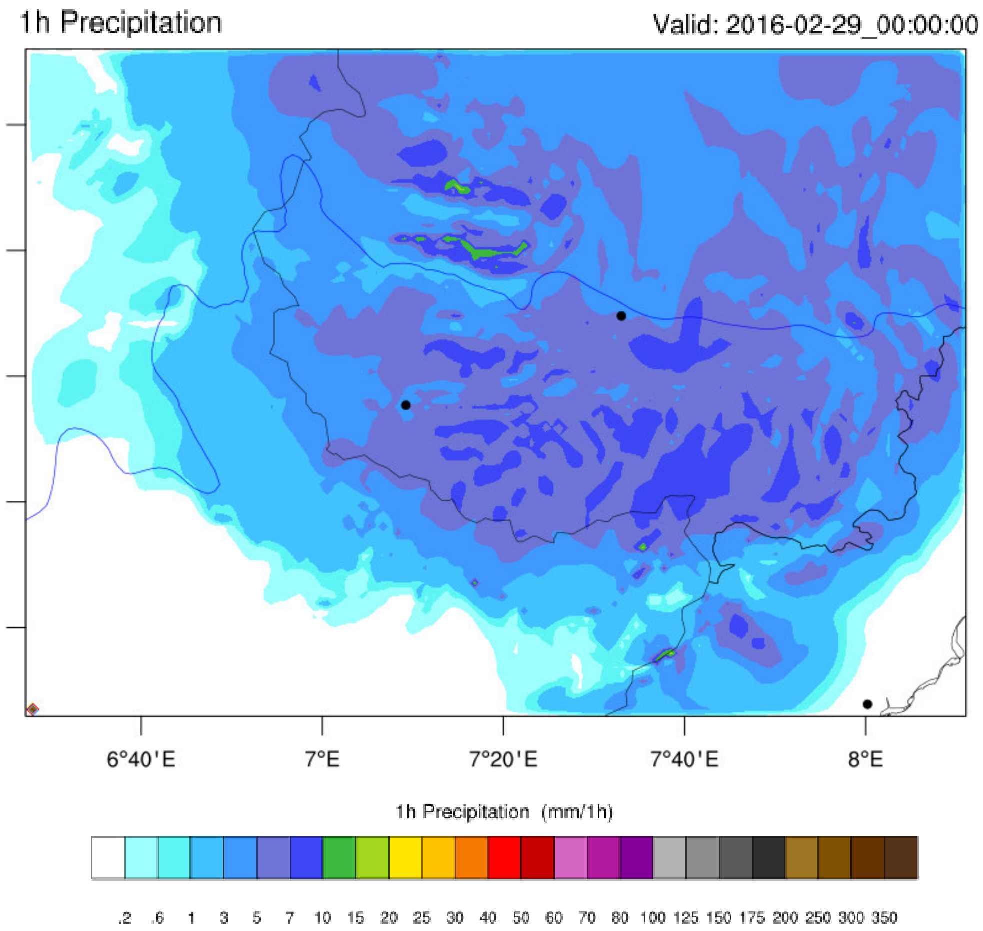


WRF ARW – GFS – 1 km



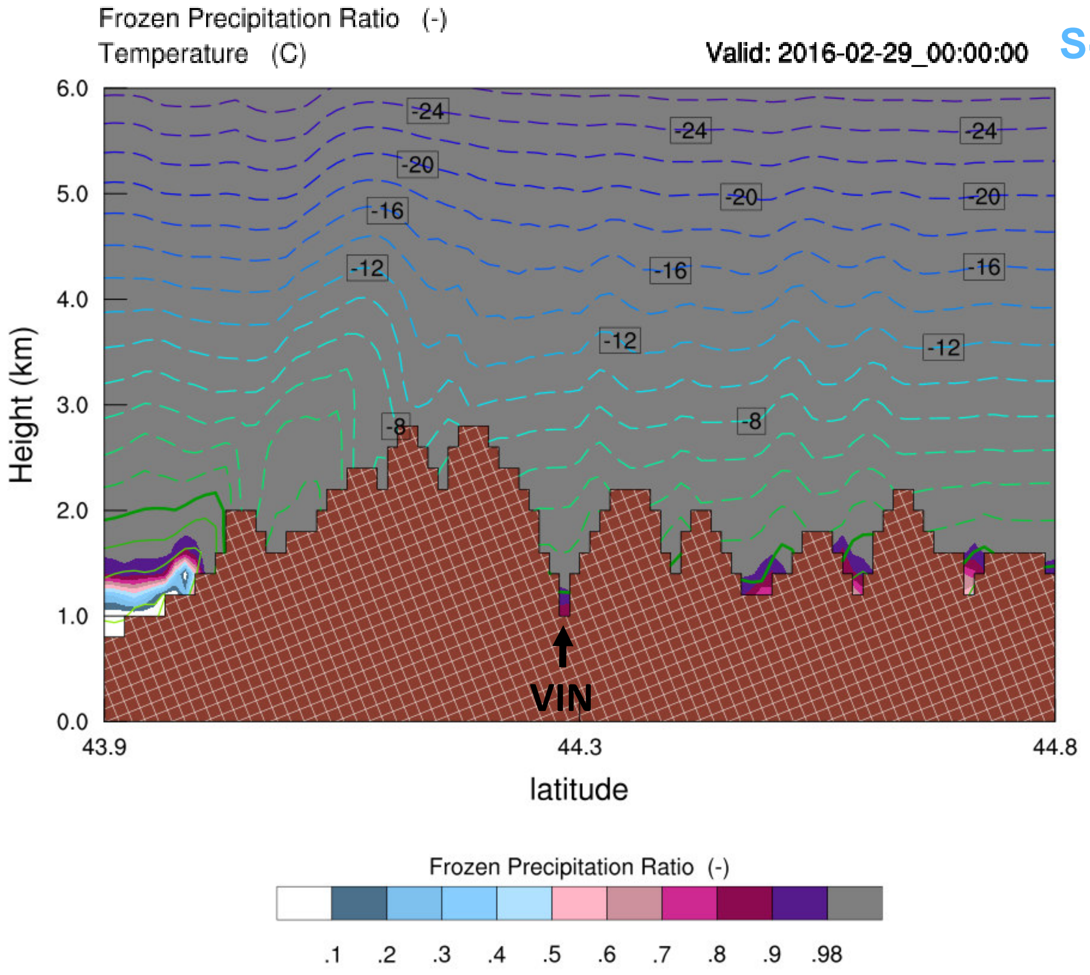
SR vs 1hr Precipitation – WRF IFS

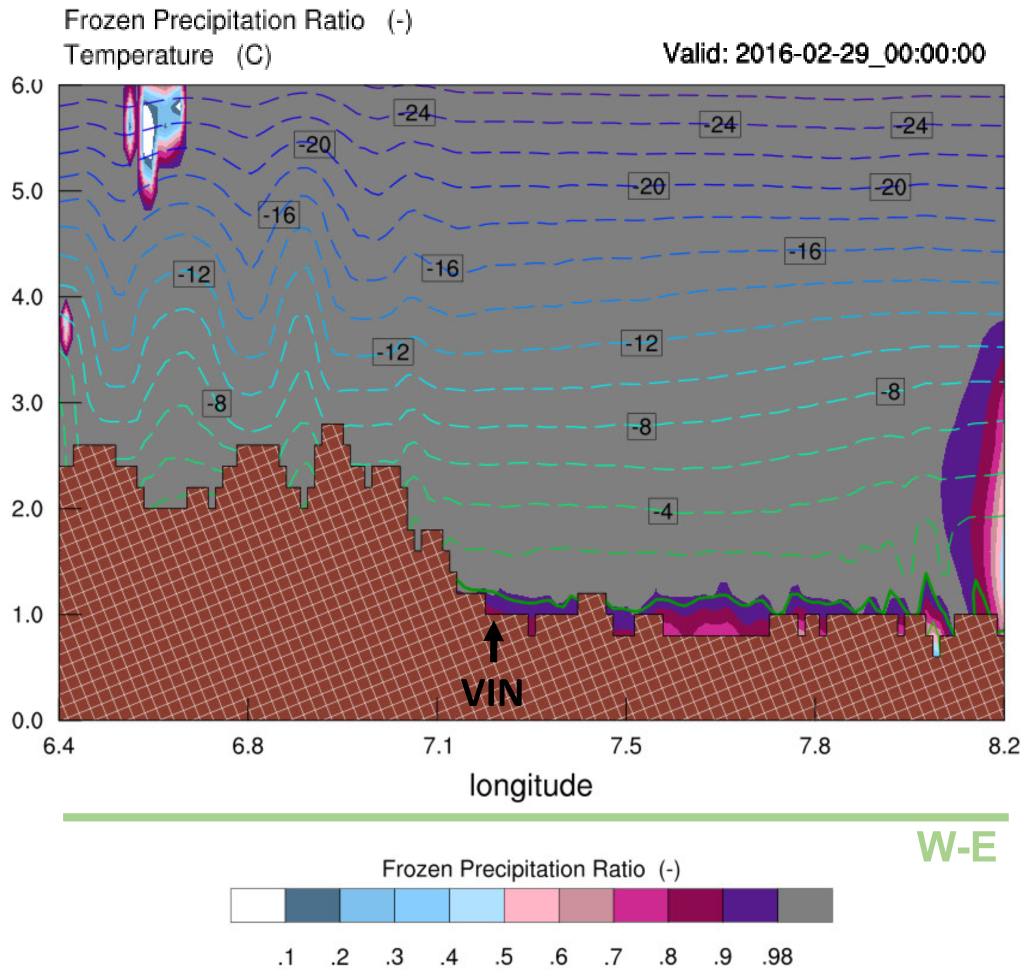




SR – Cross Section – WRF IFS

S-N





W-E

Estimated Snow Mass - Makkonen model

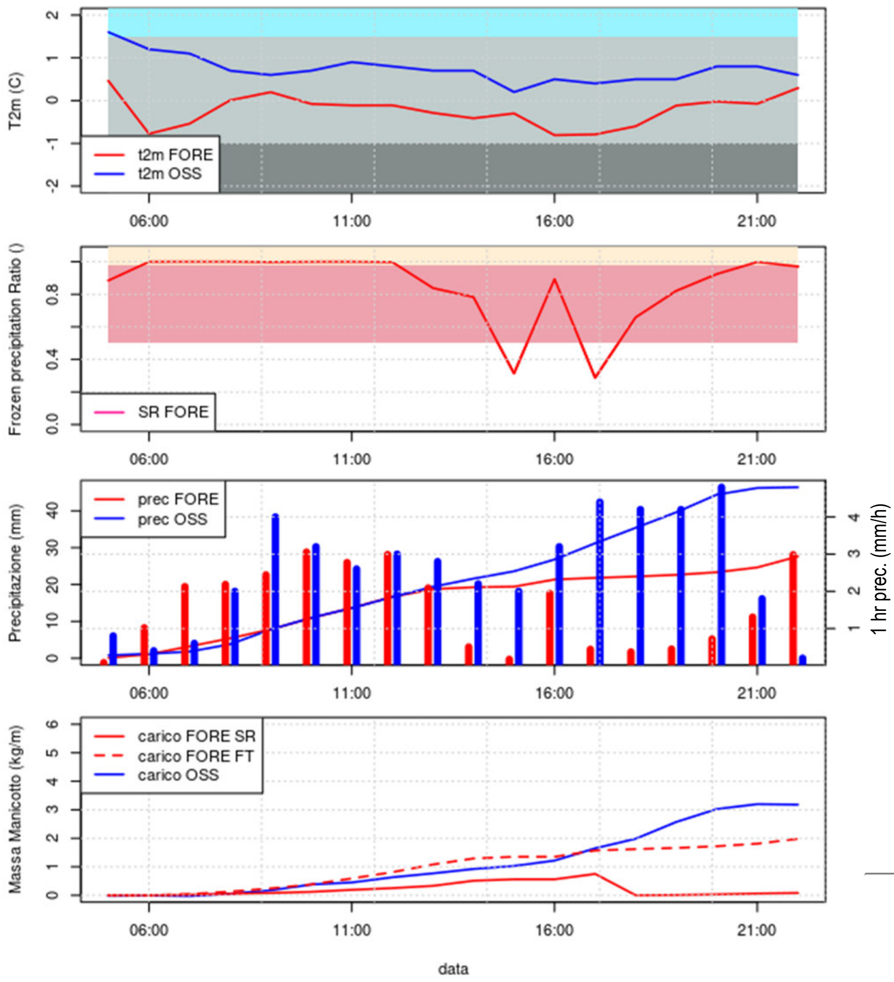
T2m (°C)

SR

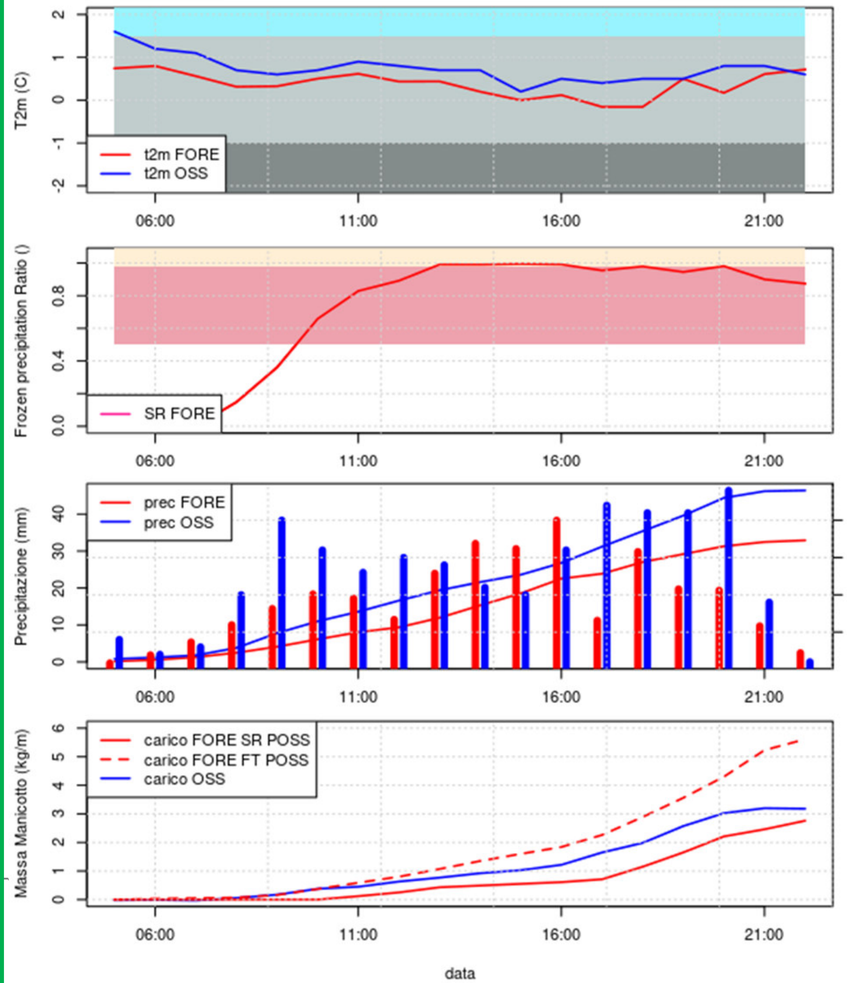
1hr prec (mm/h)
Prec Accum.
(mm)

Snow Mass
Observed Prec.
(kg/m)

WRF ARW – ECMWF – 1 km



WRF ARW – GFS – 1 km



SR vs 1hr Precipitation – WRF GFS