SEASONAL PREDICTION OF MOUNTAIN SNOW RESOURCES: AN APPLICATION IN THE ALPS

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MOTIVATION AND AIMS

- MOUNTAIN SNOW DEPTH AND SNOW WATER EQUIVALENT IN LATE SPRING ARE INDICATORS OF THE AMOUNT OF WATER RESOURCES STORED IN THE SNOWPACK THAT WILL BE AVAILABLE FOR HYDROPOWER PRODUCTION AND DOWNSTREAM NEEDS.
- FORECASTING MOUNTAIN SNOW ABUNDANCE SEVERAL MONTHS AHEAD WOULD BE KEY FOR WATER MANAGEMENT AND ENERGY SECTORS.

- WITHIN THE MEDSCOPE PROJECT WE HAVE DEVELOPED A MODELING CHAIN AIMING AT PROVIDING SEASONAL FORECASTS OF THE SNOW DEPTH AT SELECTED MOUNTAIN SITES CLOSE TO ALPINE GLACIERS IN NORTH-WESTERN ITALIAN ALPS.
- WE PRESENT THE CURRENT VERSION OF THE PROTOTYPE AND A FIRST EVALUATION OF THE RESULTS

MEDSCOPE

MODELING CHAIN

Pre-processing CSTools v3.0.0 R package

Seasonal Forecasts of meteorological variables (1°, 6-hourly or daily)

Air-temperature, total precipitation, atmospheric pressure, dew-point temperature, SW and LW incoming radiation, wind speed and ground temperature from ECMWFS5 and MFS6 models (Climate Data Store)

Bias Correction, Spatial and temporal downscaling

Spatial downscaling of precipitation and temperature, simple linear interpolation to the target coordinates for all other variables

SNOWPACK model 1D simulations

Snow depth & snow water equivalent forecasts

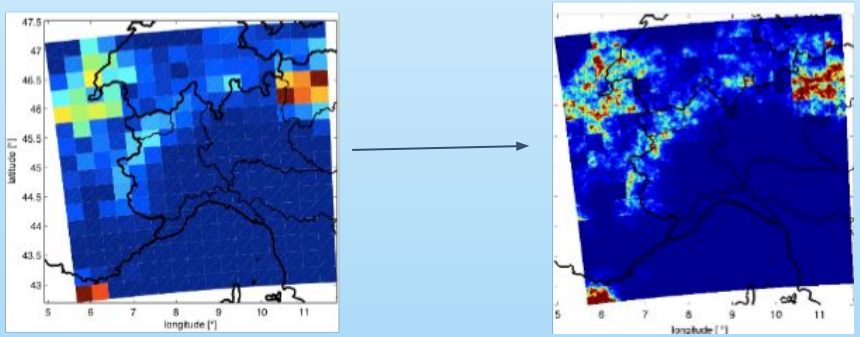
Forecast evaluation with AWS data

CSTools v3.0.0 (Perez-Zanon et al., 2020)
SNOWPACK model (Bartelt & Lehning, 2002)

STOCHASTIC DOWNSCALING OF PRECIPITATION: RAINFARM

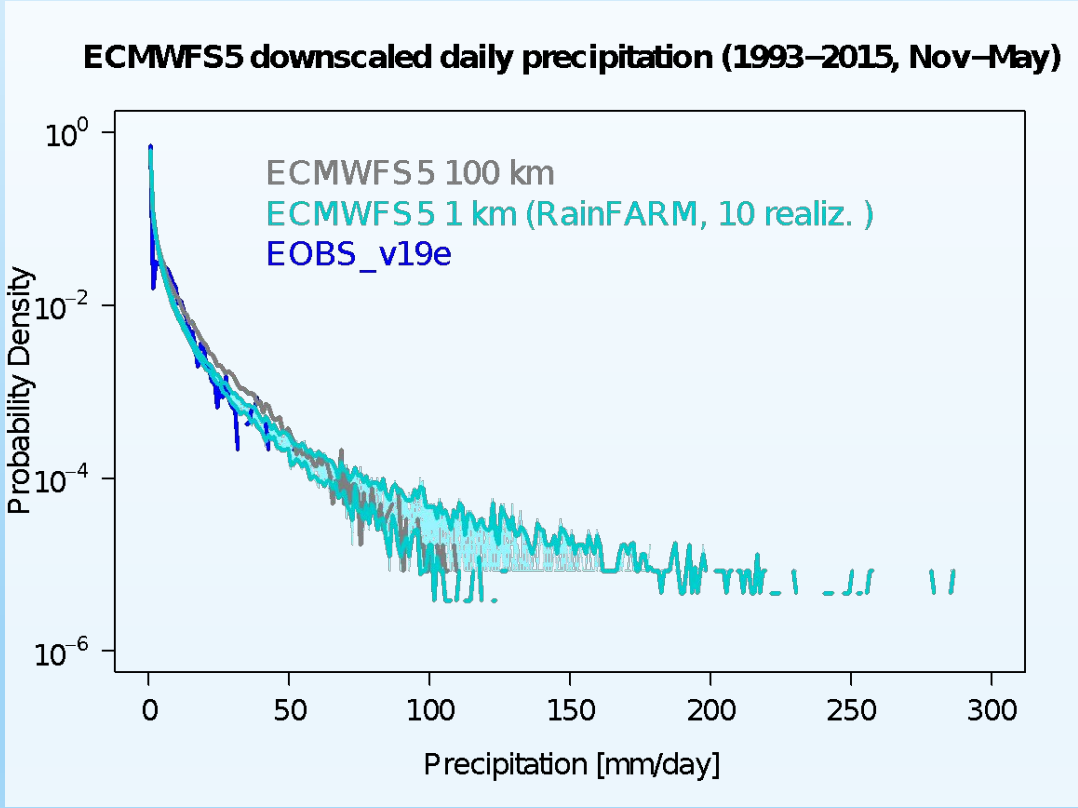
Large scale field to downscale

One possible realization of the downscaled field



CST_RainFARM function from CSTools R Package

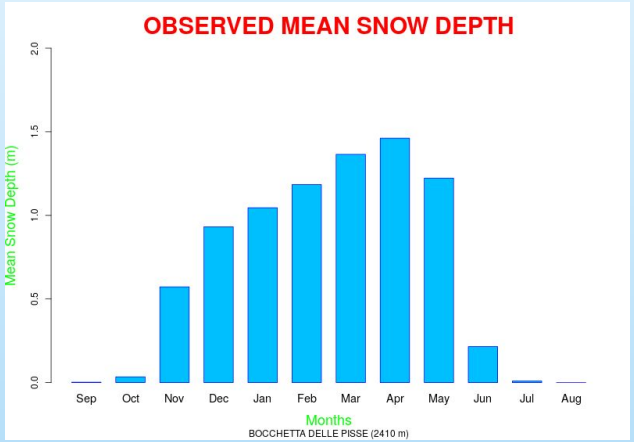
Ensemble of 10 RainFARM downscaling realizations to evaluate the uncertainty associated with the downscaling method.



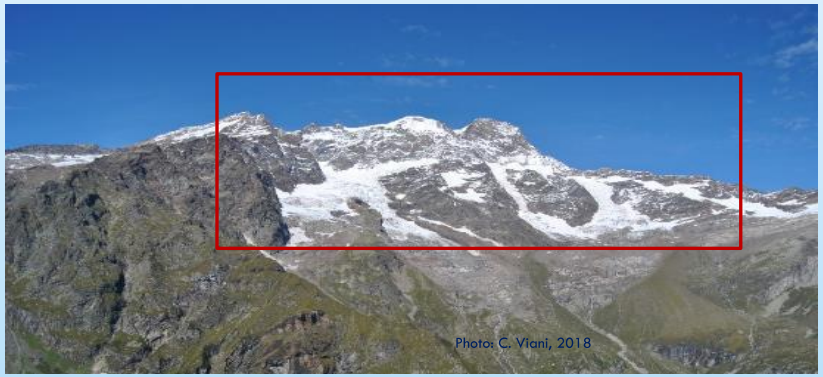
RainFARM:
D'Onofrio et al. (2014) Journal of Hydrometeorology
Terzago et al. (2018) Natural Hazards and Earth System Sciences

CSTools v3.0.0
Perez-Zanon et al. (2020) https://CRAN.R-project.org/package=CSTools

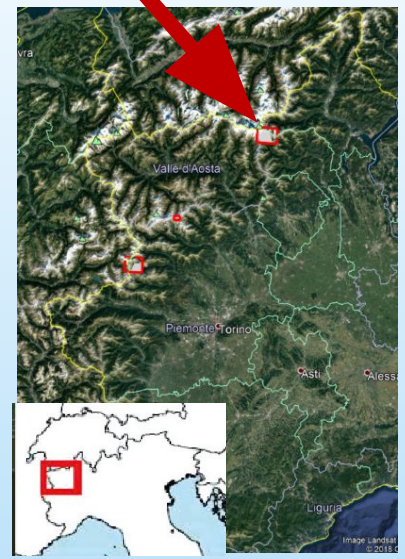
STUDY SITE: BOCCHETTA DELLE PISSE (2410 M.A.S.L)

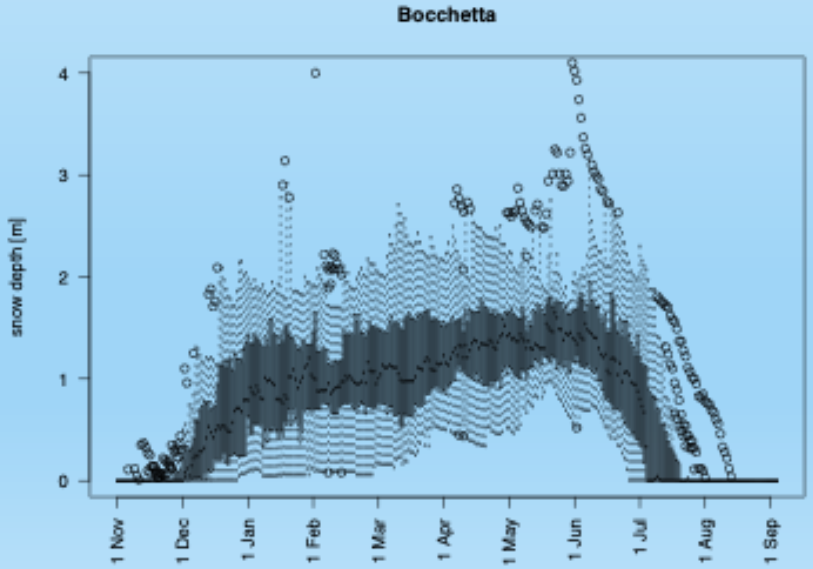


Upper Sesia Valley

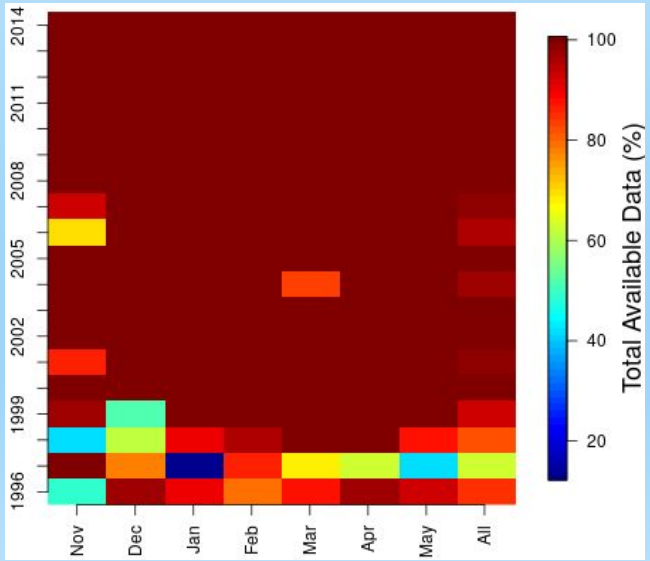


Upper Sesia Valley

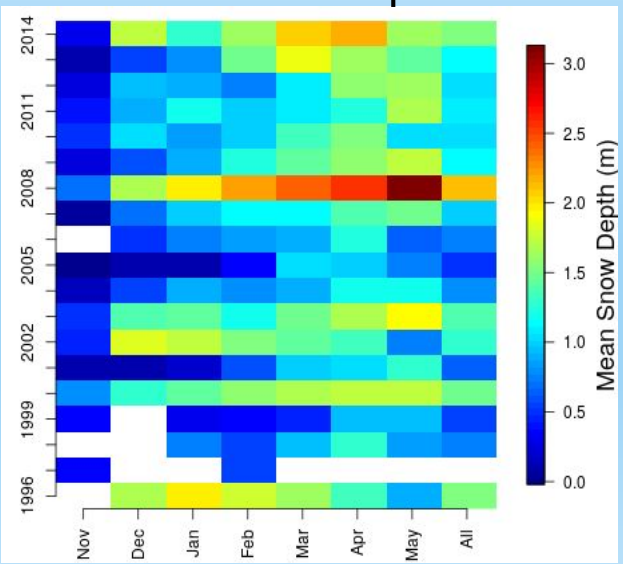




% data availability



Mean snow depth*



*calculated if at least 80% daily data are available

SNOW DEPTH FORECASTS

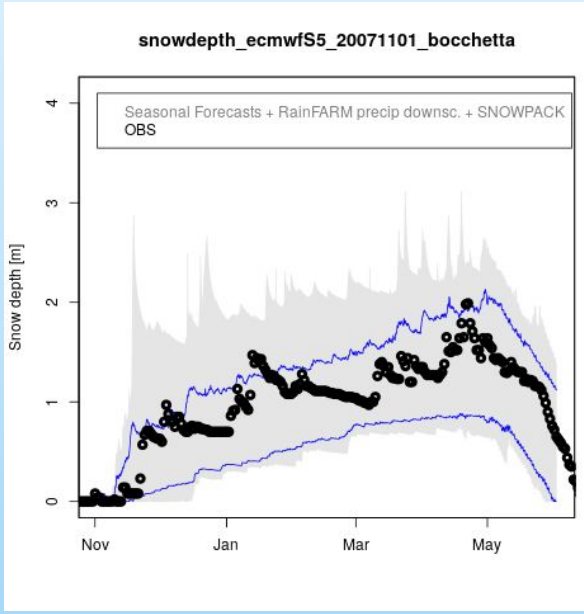
Model: ECMWFS5

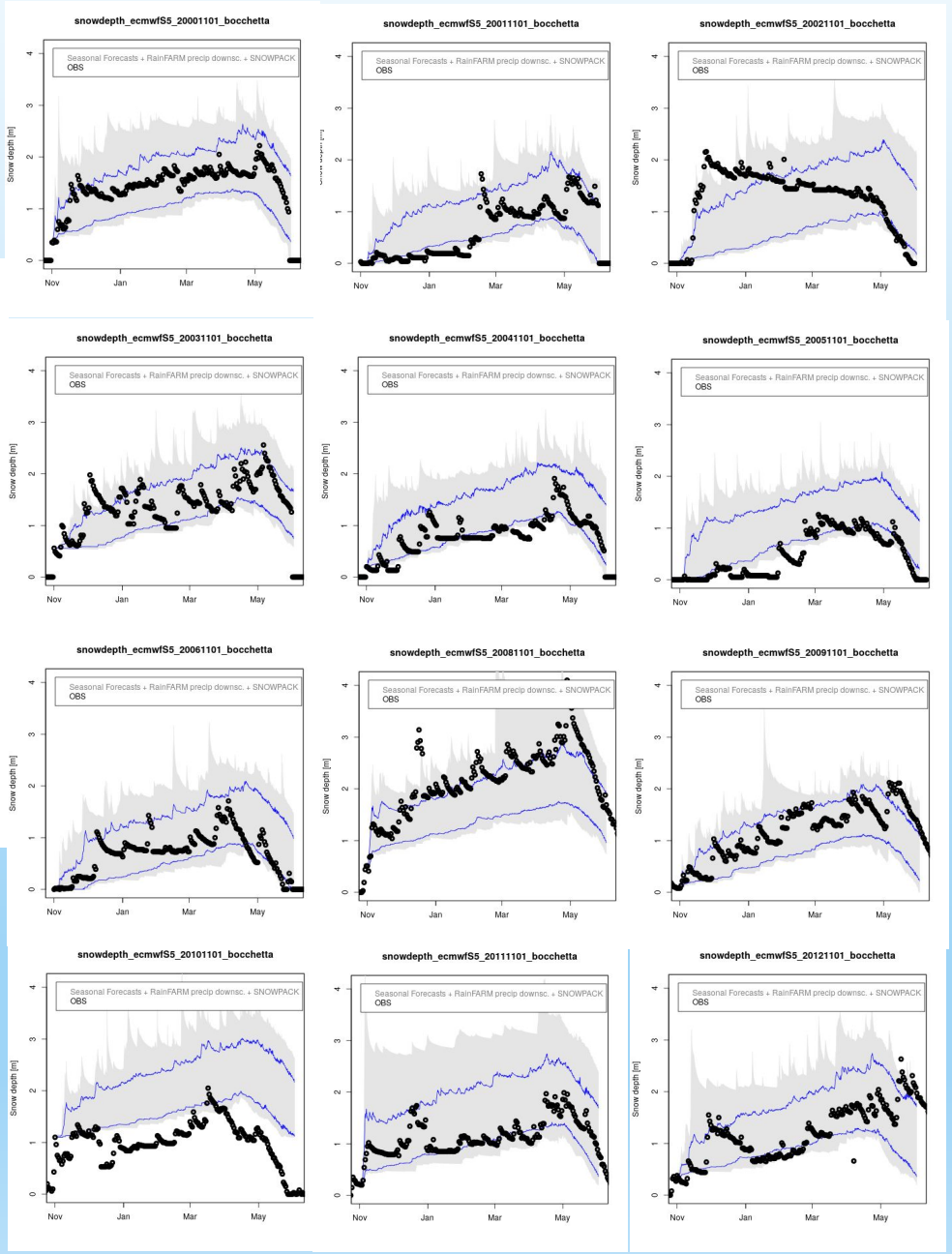
Starting date:

November 1st

Hindcast period:

1996-2014



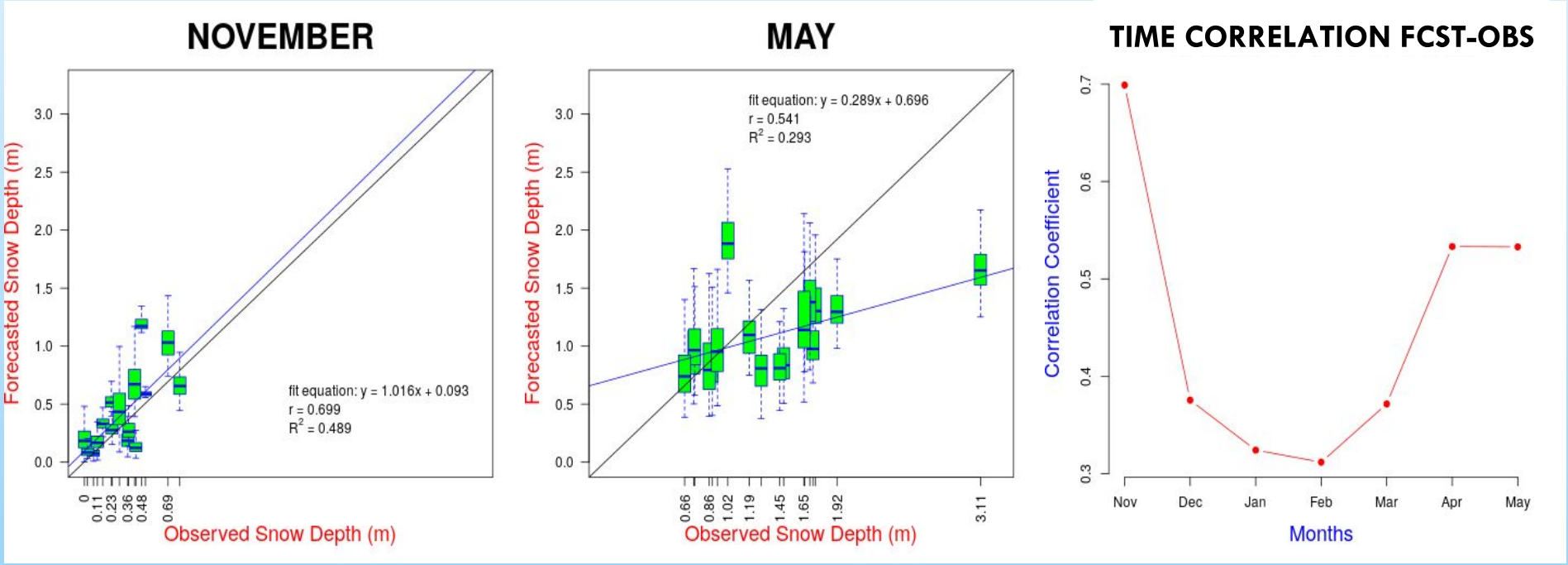


For each model forecast we obtain an ensemble of

250 SNOW DEPTH simulations

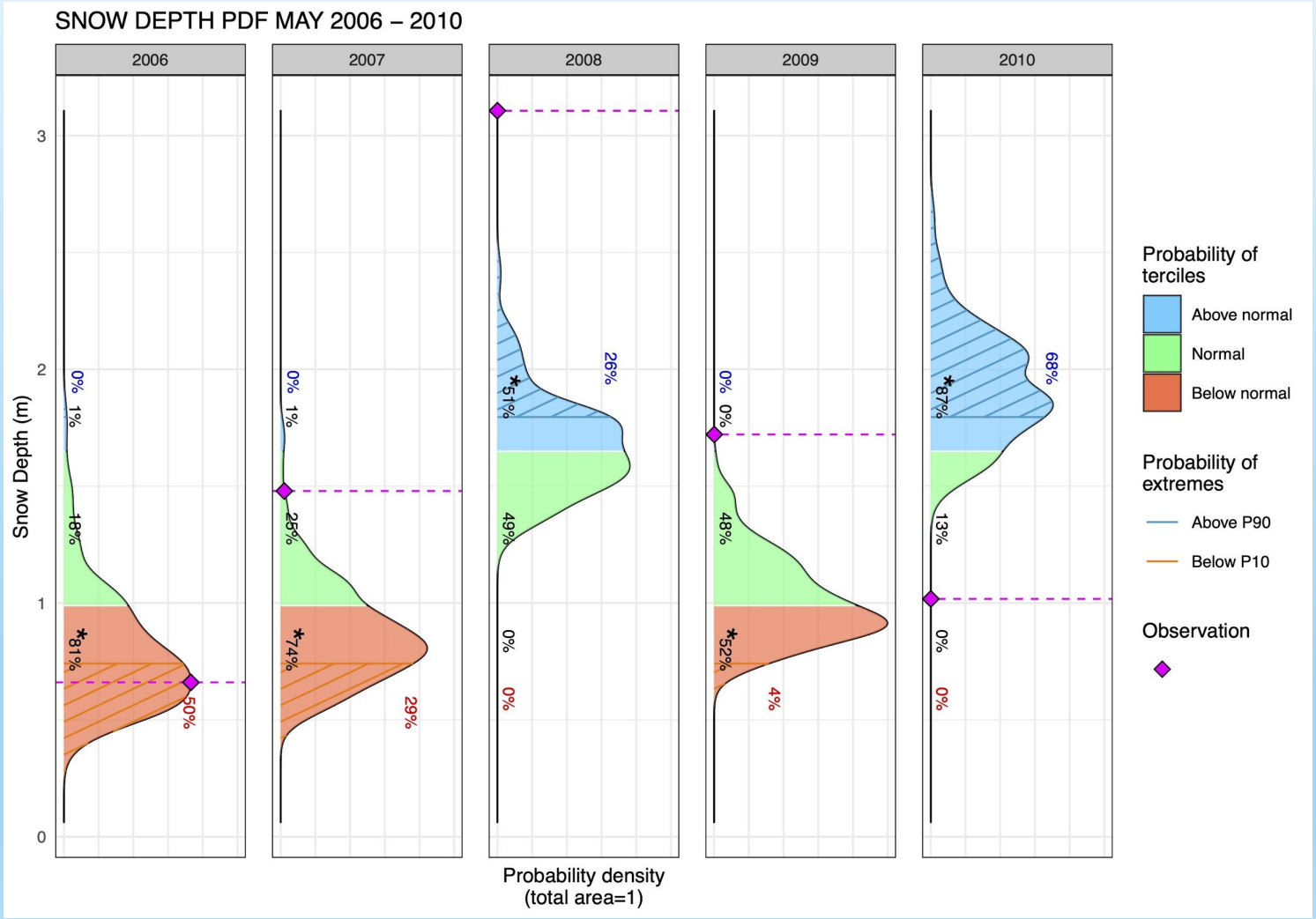
(25 FORECAST MODEL ENSEMBLE MEMBERS) x (10 DOWNSCALING REALIZATIONS FOR PRECIPITATION)

EVALUATION OF SNOW DEPTH FORECASTS

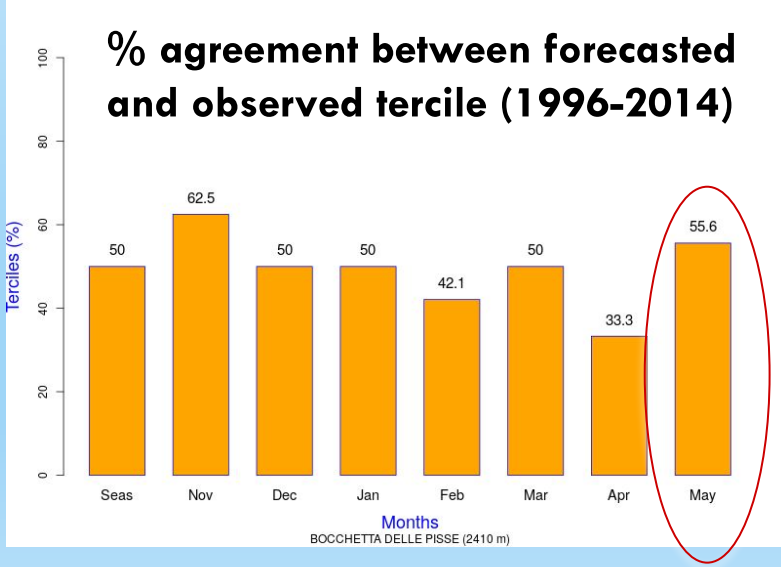


Scatterplot of Forecast vs. Observed monthly-averaged snow depth (each box represents a 250-member forecast in the period 1996-2014). Time correlation highest in November (likely an effect of initial conditions), followed by April and May, suggesting some model skills at forecasting spring snow depth

Tercile-Based seasonal forecasts

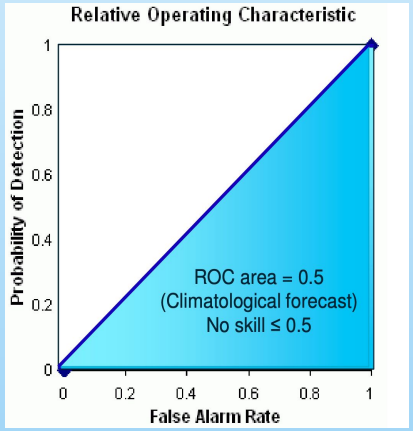


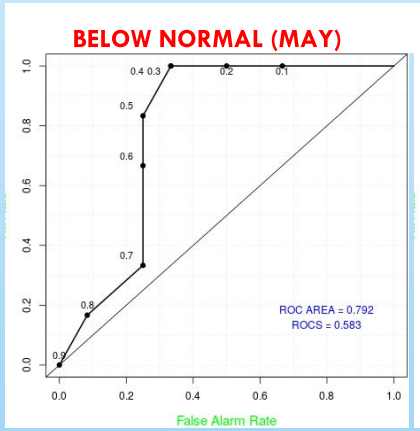
Tercile-based seasonal forecasts (left panel) indicate forecast probabilities for three categories:
below normal, **near normal** and **above normal** snow depth.
Observations are reported in **purple diamonds**

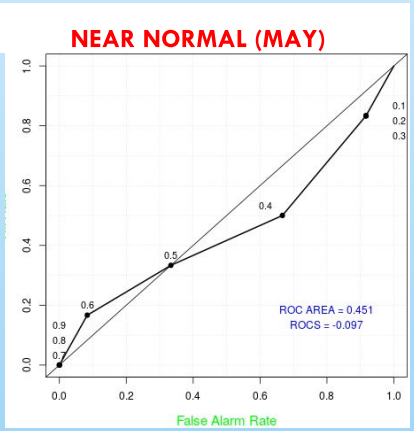


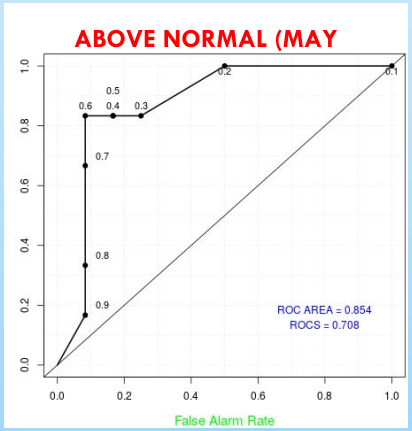
Relative operating characteristics (ROC) curve

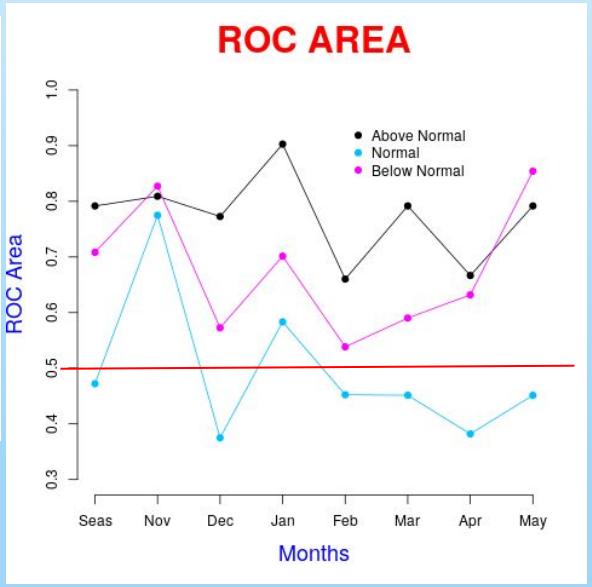
The area under the ROC curve describes the forecast system's ability to anticipate correctly the occurrence or non-occurrence of predefined 'events', i.e. snow depth below normal, near normal and above normal.
The forecast system has higher skill than the climatological forecast if ROC area > 0.5











ROC area in the range [0.54-0.85] for below normal snow depth
ROC area in the range [0.38-0-78] for near normal snow depth
ROC area in the range [0.66-0.90] for above normal snow depth
-> **the forecast system shows good skills in anticipating snow depth above and below normal for the months of April and May**

Conclusions

- A first attempt to set up an application using seasonal forecast system outputs to predict mountain snow depth at the local scale has been made
- The modeling chain employs bias-adjustment and downscaling techniques to improve the quality of the meteorological data used to drive the SNOWPACK model
- The modeling chain has proven to be effective at forecasting monthly snow depth values above and below normal, not only at lead time 1 month (an effect of initial conditions) but quite surprisingly also at lead time 6 months (April) and 7 months (May)

Perspectives

- To further improve the modelling chain we will implement the Quantile Mapping method to adjust the distribution of precipitation seasonal forecasts at a monthly scale

- The modelling chain, currently implemented in bash and R, will be adapted to run in R exploiting functions included in the CSTools package developed in the MEDSCOPE project

- So far, the application has been tested for 1 model (ECMWFS5) and one test-site (Bocchetta delle Pisse). The work will be extended to other forecast systems (MFS6, GLOSEA5, DWD, CMCC) of the Climate Data Store and to other sites in the Alps.