SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2021
Project Title:	Numerical studies for short-range forecast and nowcasting in complex terrain areas
Computer Project Account:	SPITGARB
Principal Investigator(s):	Valeria Garbero (mcy0), valeria.garbero@arpa.piemonte.it
Affiliation:	Arpa Piemonte
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Massimo Milelli (mcy), massimo.milelli@arpa.piemonte.it
Start date of the project:	August 2020
Expected end date:	December 2021

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	500000	36870	900000	236961
Data storage capacity	(Gbytes)	300	300	300	280

Summary of project objectives (10 lines max)

In the last years, the numerical weather prediction (NWP) models constantly improved, mostly due to major improvements in high-performance computing, which allows a finer horizontal grid resolution. Complex terrain, however, still poses a challenge for NWP models, due to not sufficient resolution and physical parameterizations. In the framework of the EU Project RISK-GEST (PITEM RISK, Interreg 2014-2020 Alcotra IT-FR), high resolution numerical modelling has been used to study flood or flash flood events occurred in the area among Liguria and Piedmont, characterized by complex orography. The COSMO meteorological model at 2 km resolution was used to study such extreme events and different tests were performed in order to find the best configuration of the model. The impact of new physical parameterizations and different data assimilation methods on the forecast quality has been investigated using classic statistical indices and the innovative fuzzy verification.

Summary of problems encountered (10 lines max)

Some problems were encountered in collecting and validating the observed data from the Italian meteorological network Dewetra, as there were some inconsistencies in the station database.

Summary of plans for the continuation of the project (10 lines max)

The project will be continued by analysing other case studies of extreme events in complex terrain and two numerical weather models will be used, ICON and COSMO. Different model configurations will be tested, and results will be evaluated by means of classic statistical indices or fuzzy technique in order to understand which configuration is the best in reproducing the event.

List of publications/reports from the project with complete references

V. Garbero, M. Milelli "Reforecast of the November 1994 flood in Piedmont using ERA5 and COSMO model: an operational point of view", Bulletin of Atmospheric Science and Technology volume 1, pages339–354 (2020)

Summary of results

The COSMO model was used at high resolution to study three different test-cases:

- the November 1994 flood in Piemonte
- the extreme event among Liguria, Emilia-Romagna and Piemonte on 12-13 December 2017
- the VAIA storm on the 29-30 October 2018

The reforecast of the November 1994 flood was performed by COSMO at 2.2 km grid spacing (COSMO-2I) over Italy from 4th November up to +48h, nested in a domain over the Mediterranean area at 5 km grid spacing (COSMO-5M). The initial and boundary conditions for COSMO-5M were provided by a new set of experiments performed by IFS HRES at grid spacing of 9 km and driven by the new climate reanalysis dataset ERA5 HRES at 31 km horizontal resolution. We tested the 2 available parametrizations for the shallow convection, Tiedtke and Bechtold scheme, since the deep convection was resolved, and finally we tested the fully explicit convection. Some results are summarized in the paper "Reforecast of the November 1994 flood in Piedmont using ERA5 and COSMO model: an operational point of view".

Different model configurations have been evaluated on the VAIA storm and the 2017 flood in Emilia, in order to highlight a possible optimal configuration in reproducing the studied events. The impact on the model performance of new physics parameterizations recently developed in COSMO, i.e. the new "icon-like" physics, and hybrid initialization, which consists in the assimilation of observations from non-GTS stations or from radar to improve the determination of the initial conditions, was evaluated.

The different tested configurations are:

1. OPE/RUN2: operational set-up and initial and boundary conditions (ICBC) provided by IFS at 9 km
2. ICON/CTRL: "icon-like" set-up and ICBC provided by IFS at 9 km
3. LHN/RUN4: "icon-like" set-up, ICBC provided by IFS at 9 km and latent heat nudging employed to assimilate precipitation rates observed by the Italian national radar composite up to +5h forecast
4. T2mN/RUN5: "icon-like" set-up, ICBC provided by IFS at 9 km and data assimilation by nudging for 2m temperature observed by non-GTS stations from Italian meteorological network up to +5h forecast
5. TR2mN/RUN6: "icon-like" set-up, ICBC provided by IFS at 9 km and data assimilation by nudging for 2m temperature and 2m relative humidity observed by non-GTS stations from Italian meteorological network up to +5h forecast

To assess which configuration is best in representing the events, the fuzzy technique (2D and 3D) has been used to verify precipitation, by comparing the simulated maps with the observed data from the national radar mosaic improved using stations, and the classic statistical indices (Mean Bias, Root Mean Square Error, correlation, etc.) have been calculated for temperature and humidity at 2m and wind speed at 10m.

Some plots are shown in Figure 1-4 for the case study of the VAIA storm as an example, but all the results will be shown in the final report and properly commented.

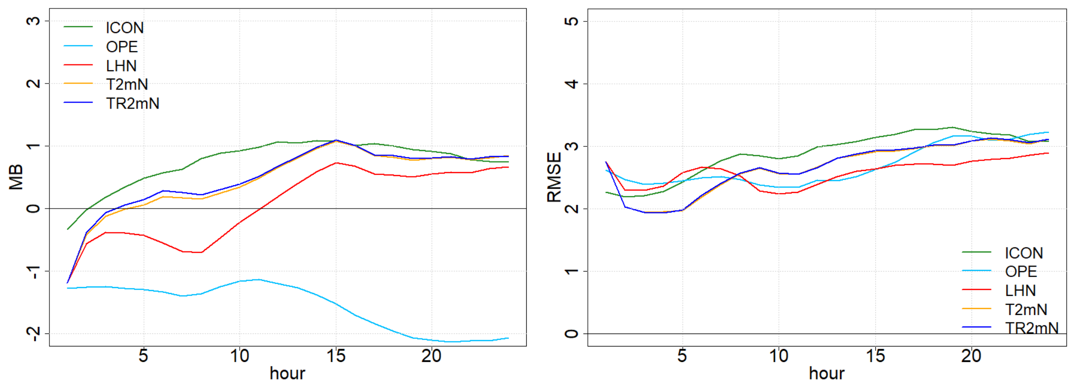

Figure 1. Evolution of 2 m temperature (T2M) mean bias (MB) and Root Mean Square Error (RMSE) as a function of lead time for the different tested configurations

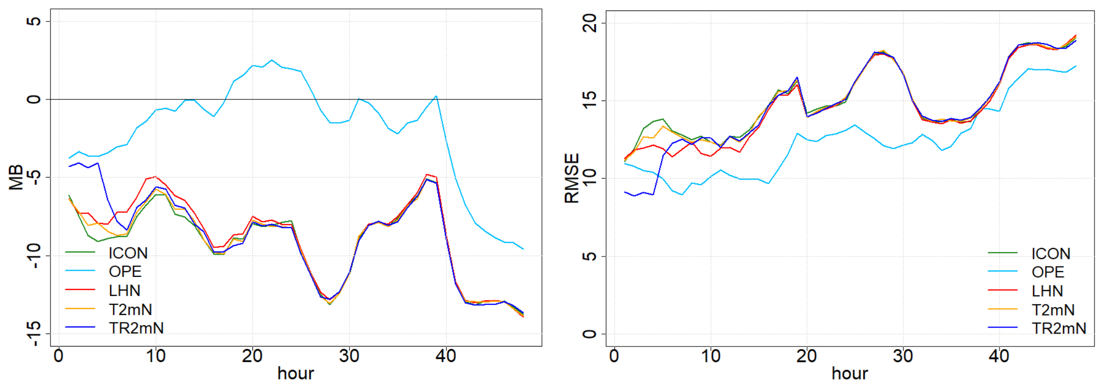

Figure 2. Evolution of 2 m relative humidity (RH2M) MB and RMSE as a function of lead time for the different tested configurations

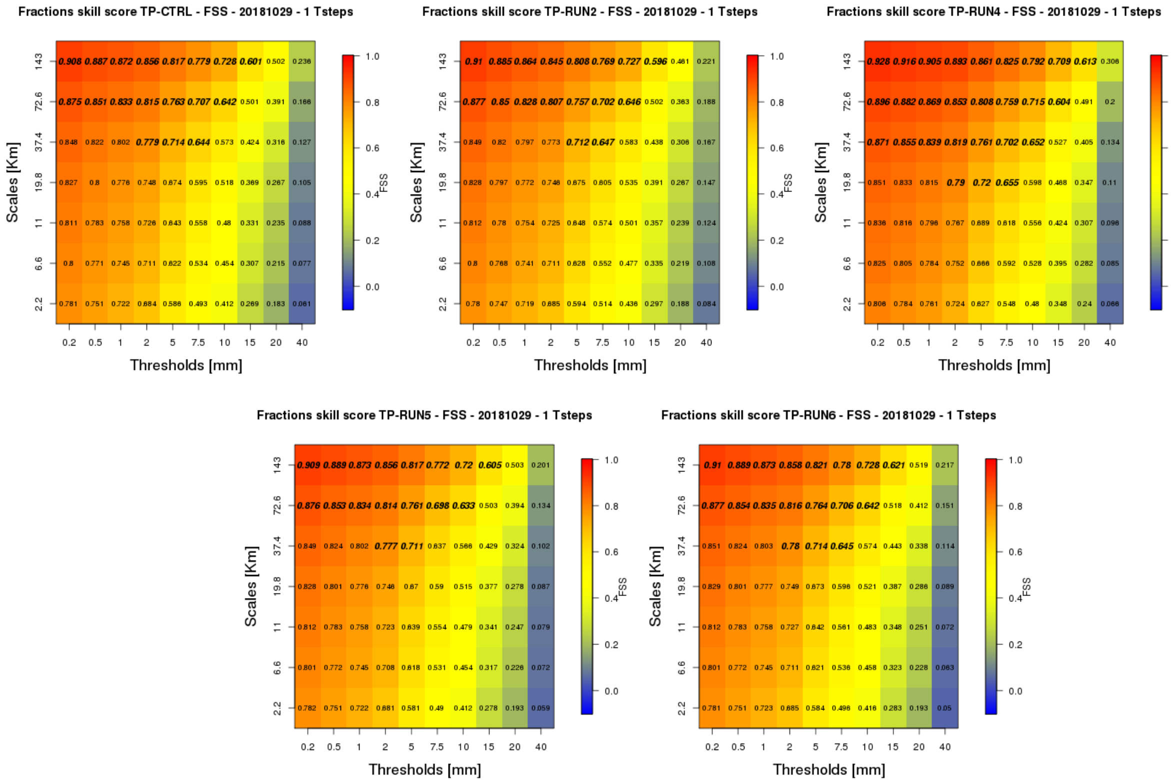

Figure 3. 2D fuzzy verification for the different tested configurations

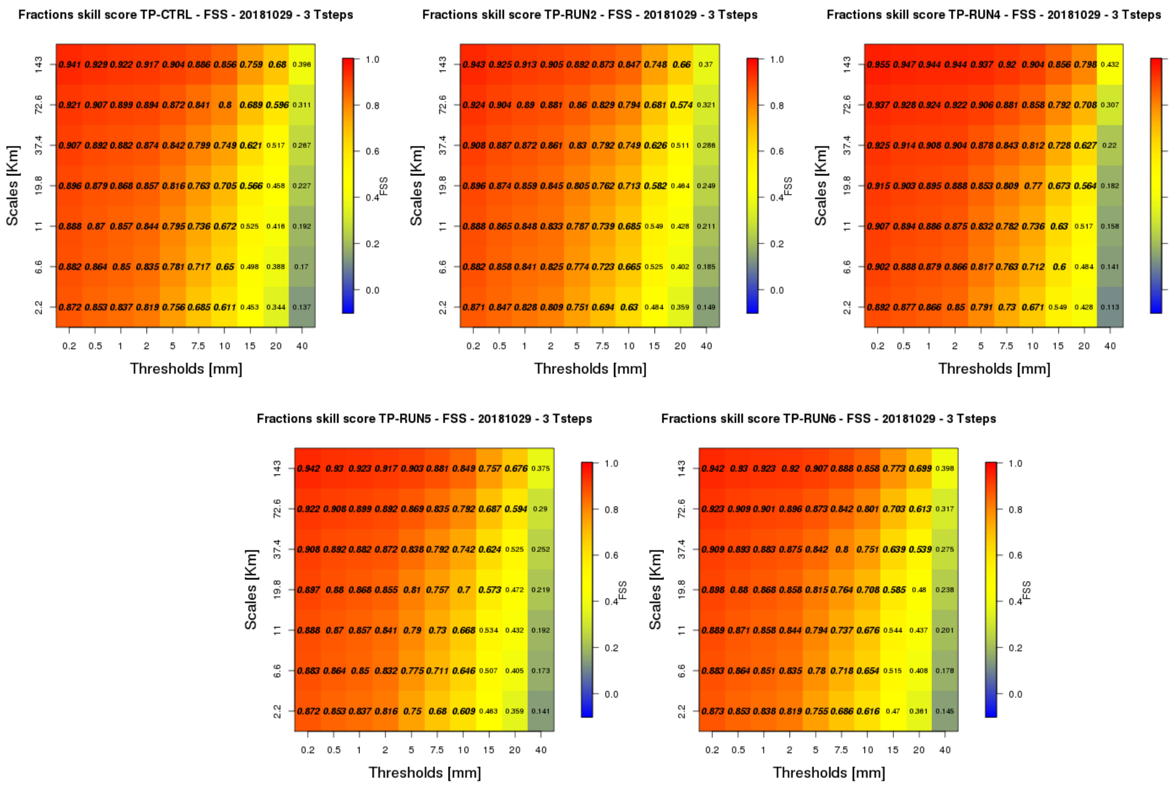

Figure 4. 3D fuzzy verification for the different tested configurations