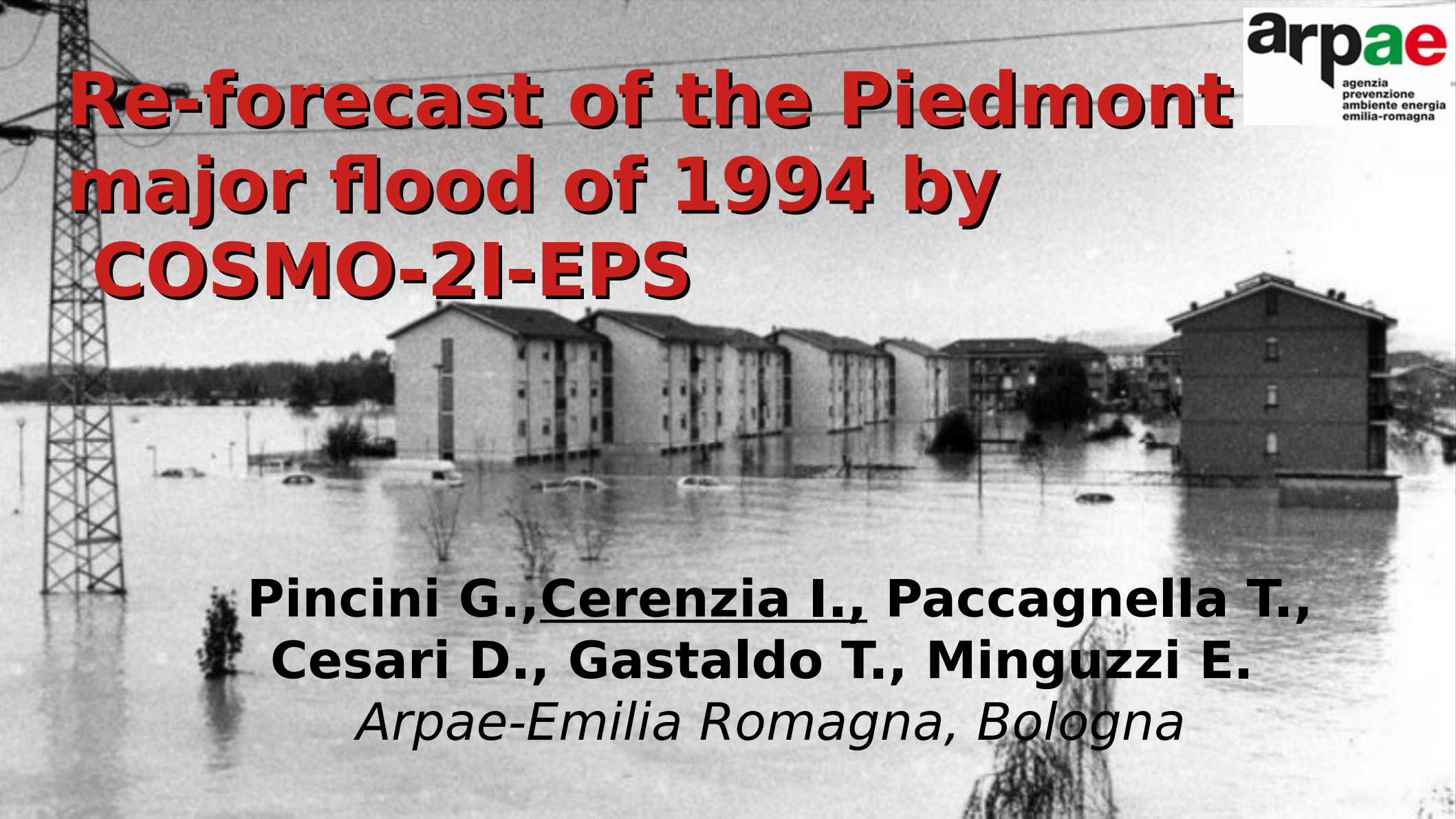
Re-forecast of the Piedmont major flood of 1994 by COSMO-2I-EPS

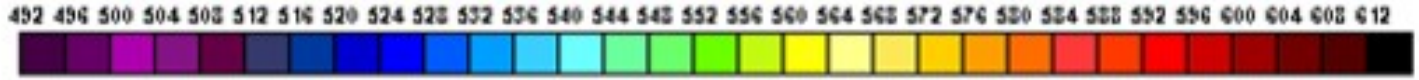


Pincini G.,Cerenzia I., Paccagnella T., Cesari D., Gastaldo T., Minguzzi E.

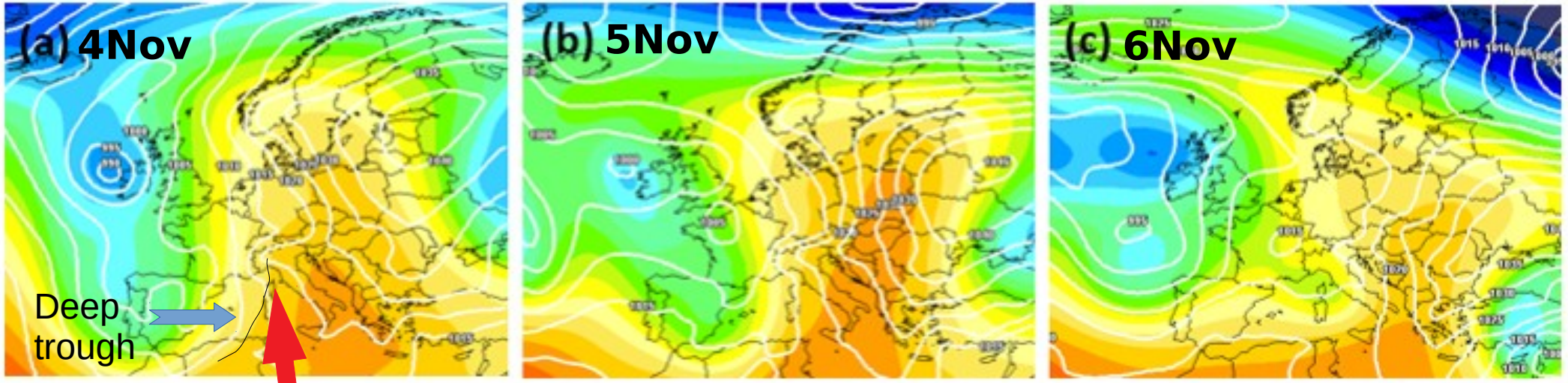
Arpae-Emilia Romagna, Bologna

Synoptic situation

Geop500hPa 04-06 November 1994



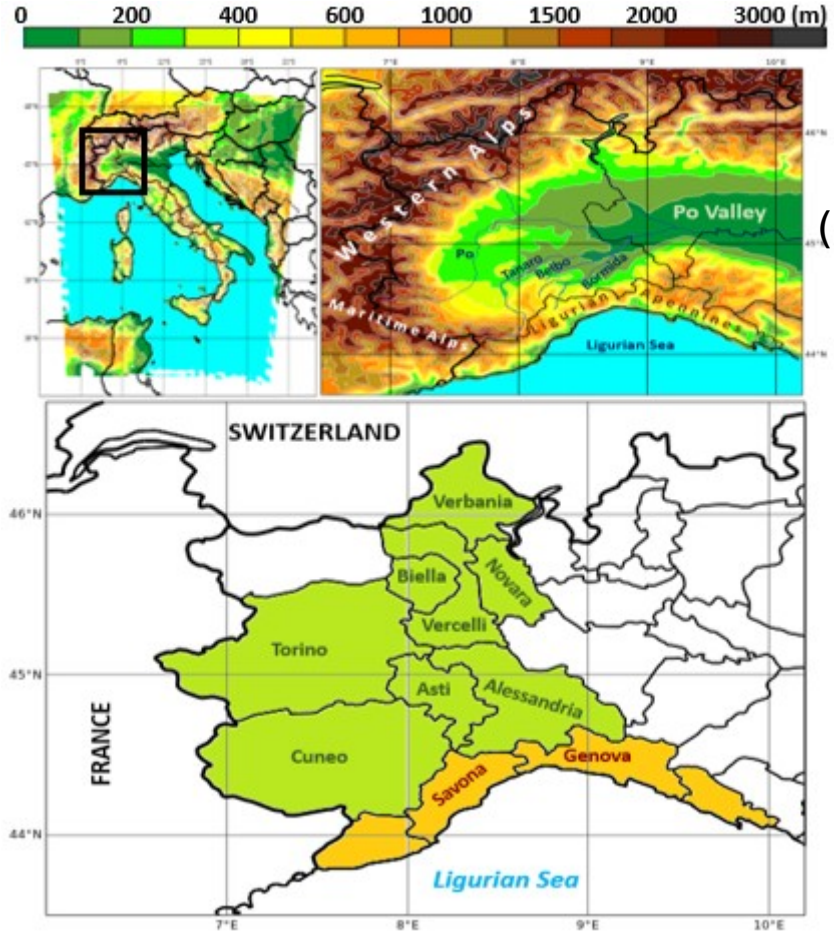
Data from ERA5



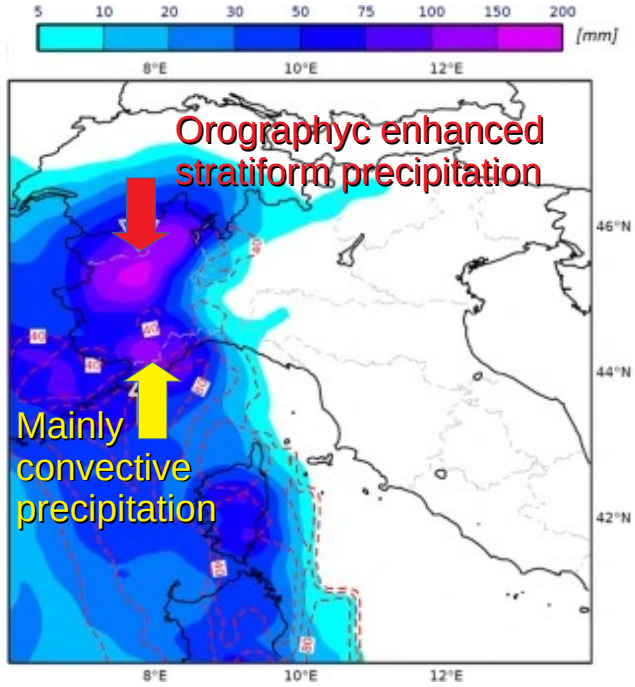
Warm moist air from Mediterranean Sea

Slowly-evolving synoptic situation
Autumnal case: high thermal contrast

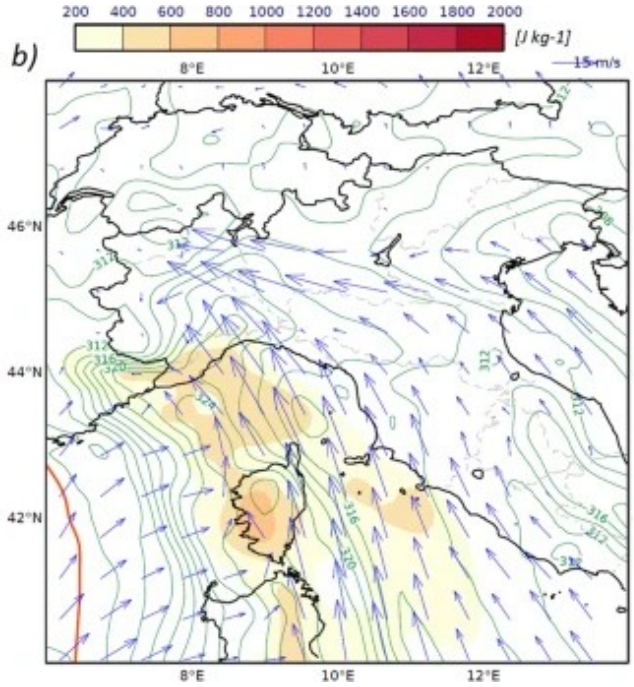
Flow interaction with the orography



Tot. Prec
(18h accumulated on 5Nov)

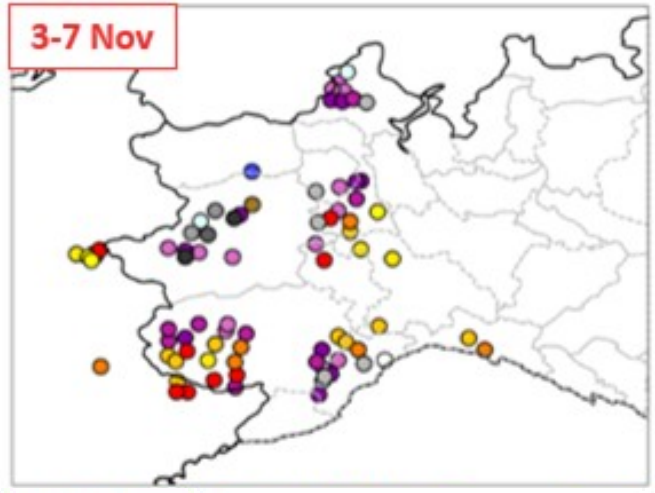


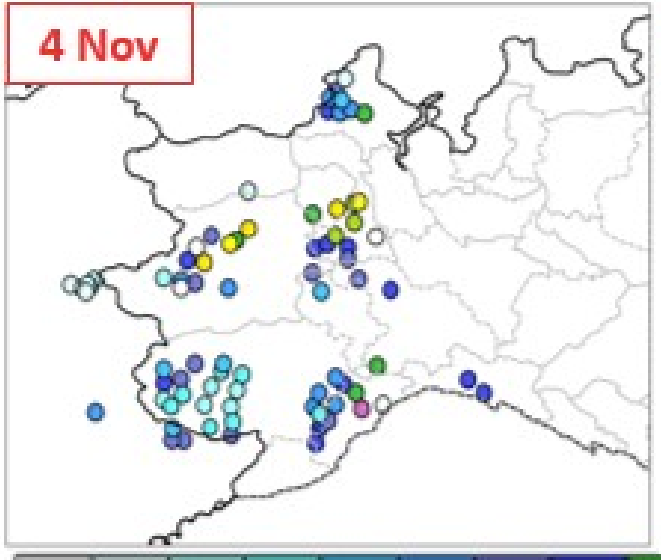
UV at 925hPa, CAPE
(at 18UTC on 5Nov)

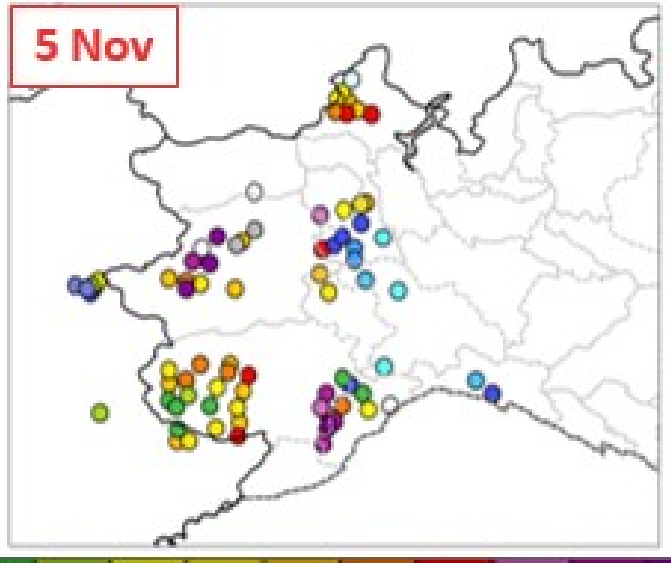


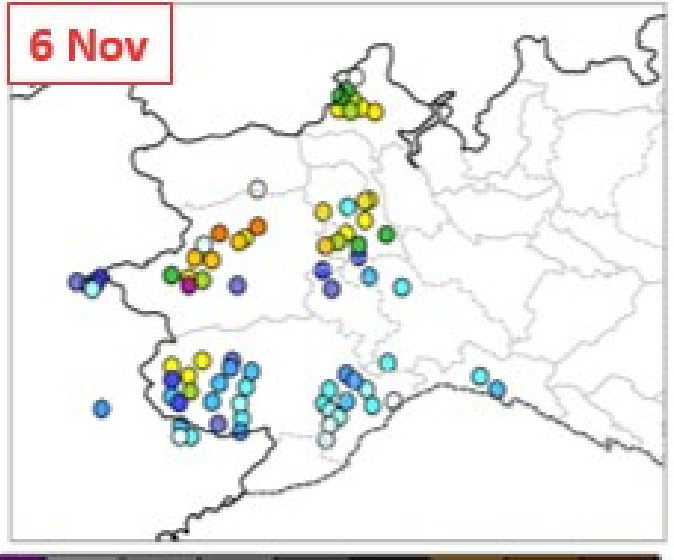
Data from ERA5, Grazzini et al. 2020

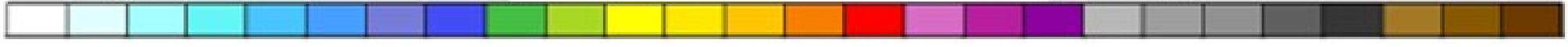
Total accumulated precipitation from surface rain gauges





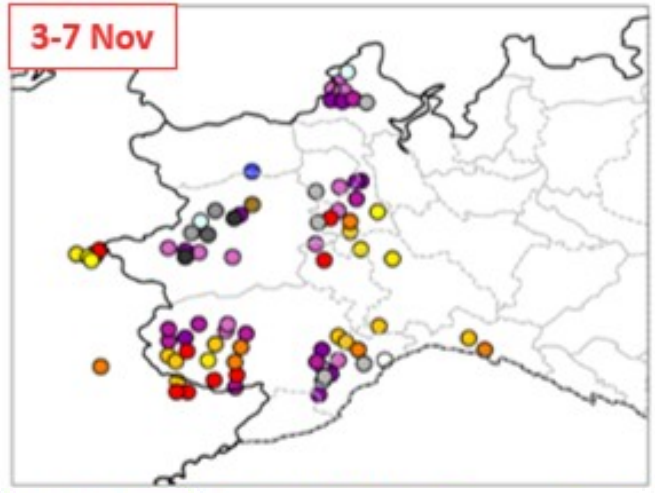


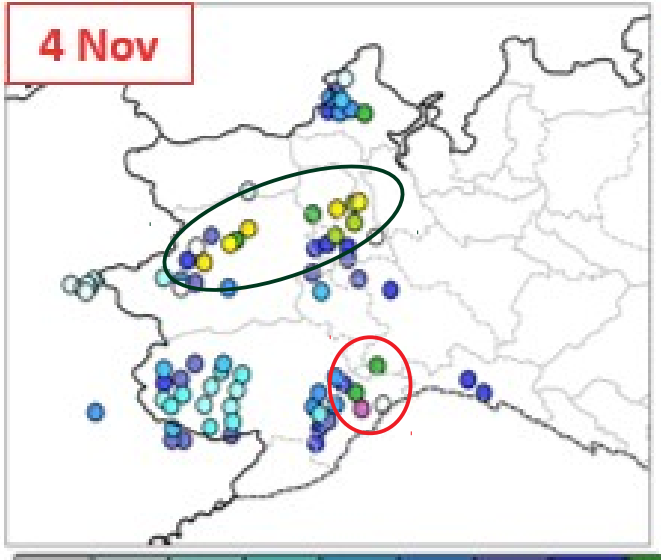


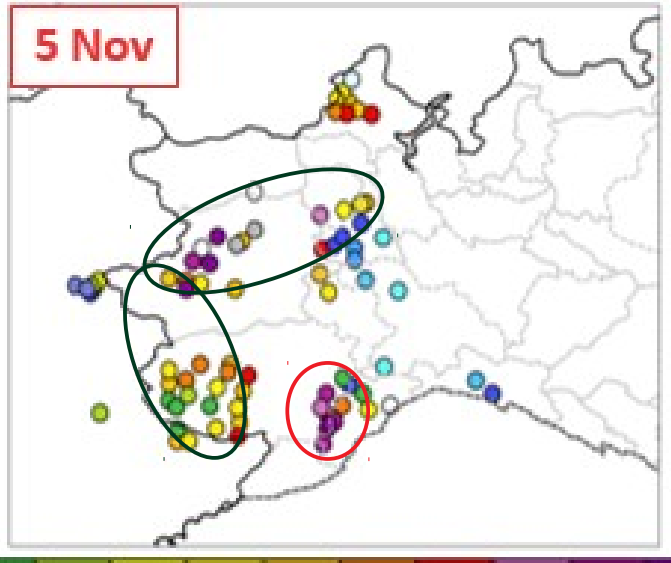


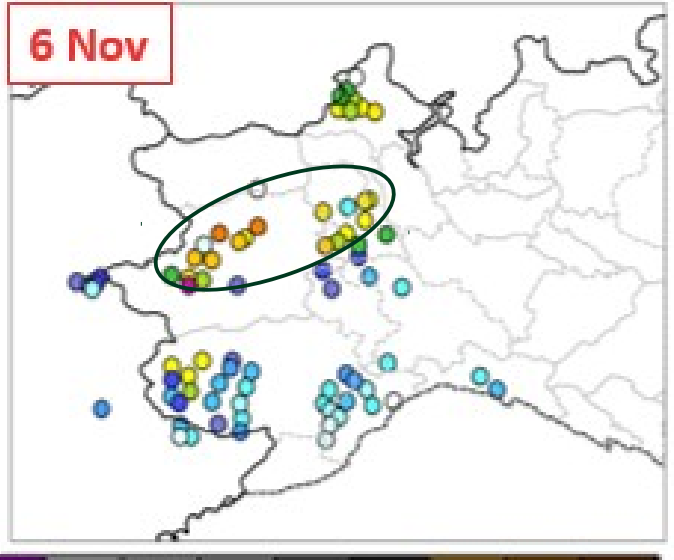
0 10 20 30 50 70 100 150 200 300 400 500 600 700mm

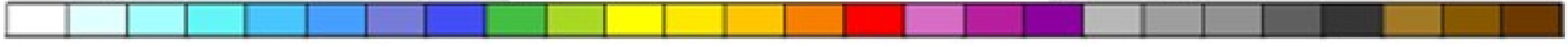
Total accumulated precipitation from surface rain gauges



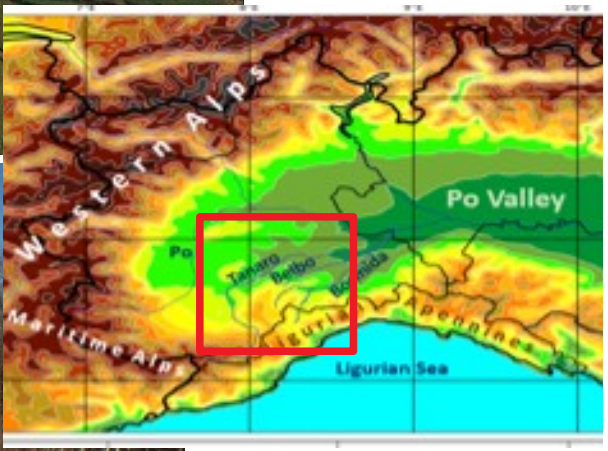








0 10 20 30 50 70 100 150 200 300 400 500 600 700mm

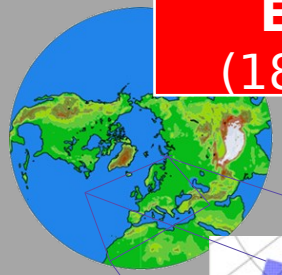


ALLUVIONE NEL PIEMONTE DEL 1994 (FONTE WWW.ARPA.PIEMONTE.IT)

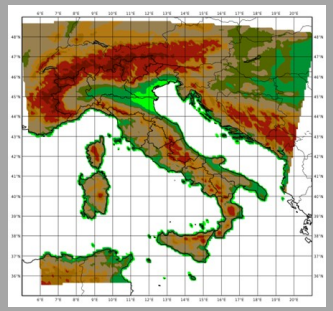
COSMO-2I-EPS

❖ Pre-operational

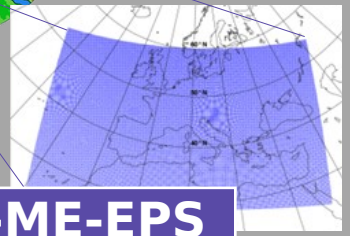
ECMWF ENS (18 km)



KENDA

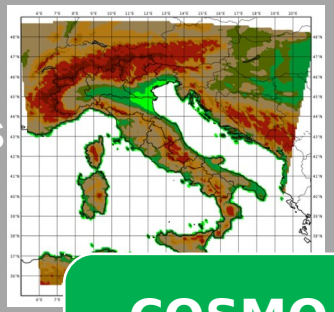


Perturbed IC



COSMO-ME-EPS by AM (7 km)

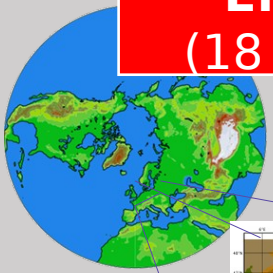
LBCs

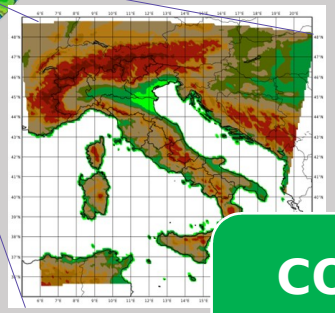


COSMO-2I-EPS (2.2 km)

❖ Re-forecast

ECMWF ENS (18 km)





COSMO-2I-EPS (2.2 km)

Starting time: 3 Nov 1994 at 00UTC
Lead time: 5 days (1 day spin-up)

Ensemble Configurations

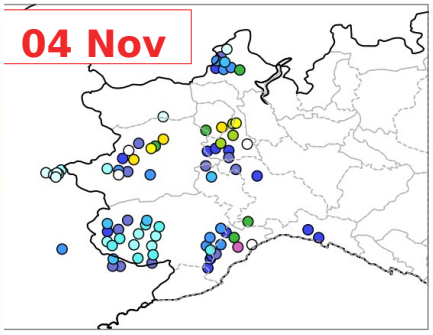
MAIN TECHNICAL FEATURE \ ENSEMBLE SYSTEM	ECMWF ENS	COSMO-2I-EPS
Mesh size	0.16°	0.02°
Horizontal resolution	18 km	2.2 km
Vertical resolution	91 lev	65 lev
Type of model	Hydrostatic	Non-hydrostatic
Type of deep convection	Parameterized (Bechtold et al. 2014)	Explicit
Initial Conditions	ERA5/EDA	ECMWF ENS members
Boundary Conditions	--	ECMWF ENS members
Model Perturbation	Stochastic scheme	--
Forecast range (hours)	120	120
Ensemble size	50	50
Starting times (UTC)	3 nov 1994 00 UTC	3 nov 1994 00 UTC

Probability of occurrence

Probability of threshold exceedence
24h-accumulated total precipitation

0 10 30 50 70 90 100%

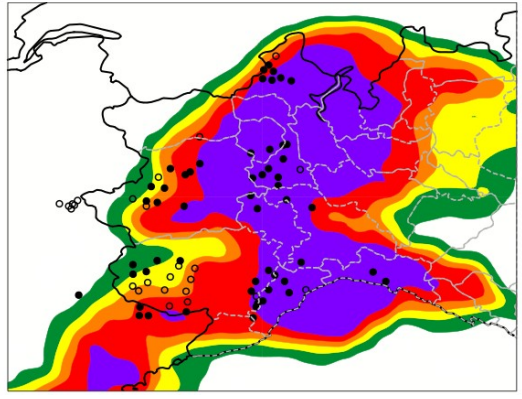
0 10 20 30 50 70 100 150 200 300 400 500 600 700 mm

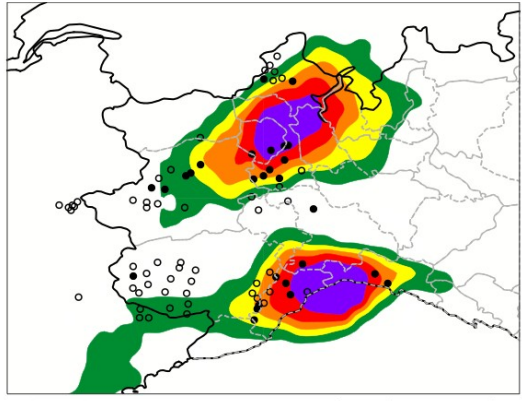


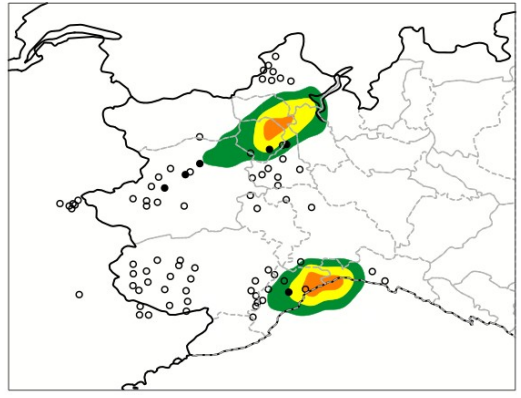
Observations:
Threshold exceeded
NO YES

TP>20mm | TP>40mm | TP>70mm

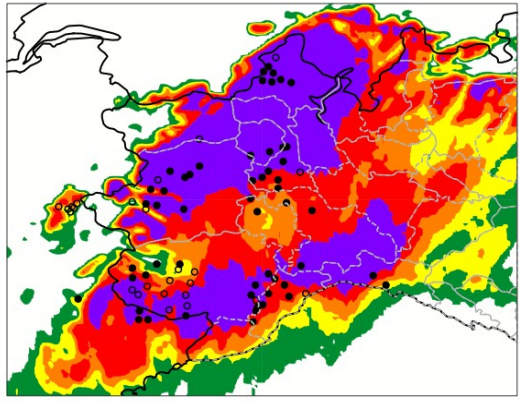
ECMWF ENS

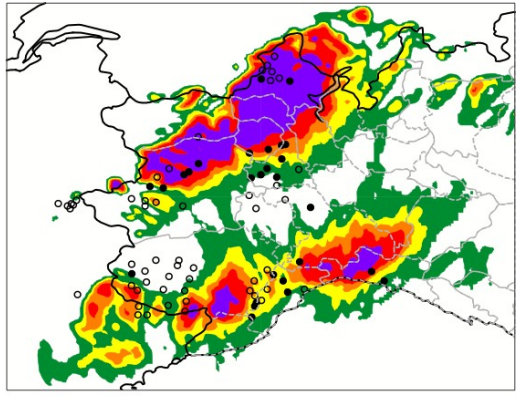


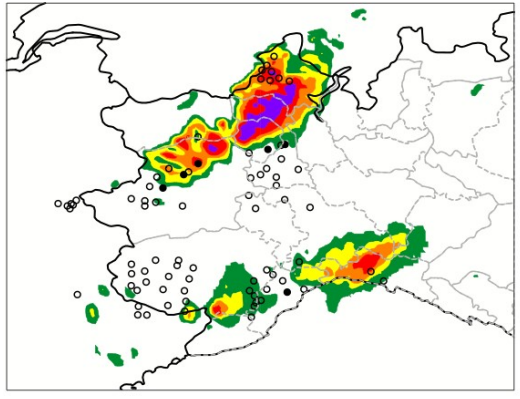




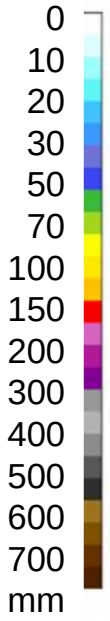
COSMO-2I-EPS

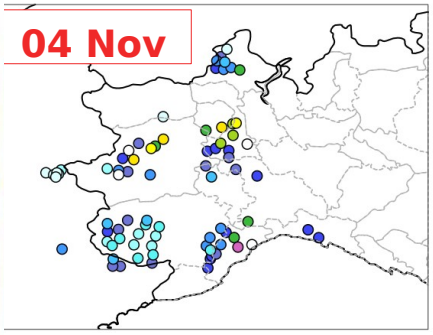






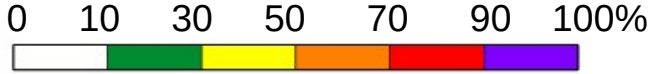
Probability of occurrence





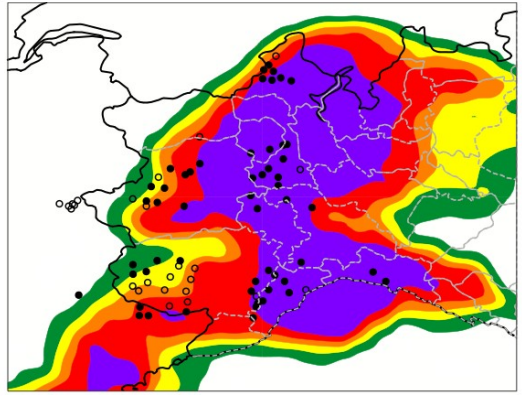
Observations:
Threshold exceeded
NO YES

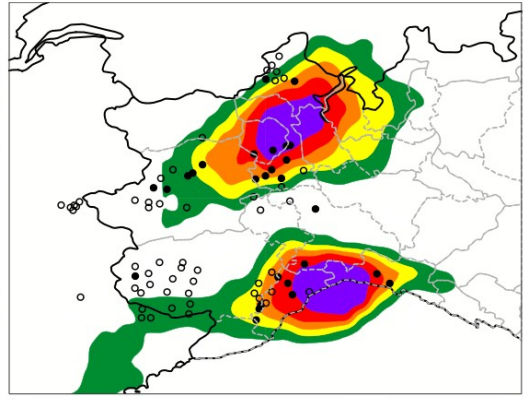
Probability of threshold exceedence
24h-accumulated total precipitation

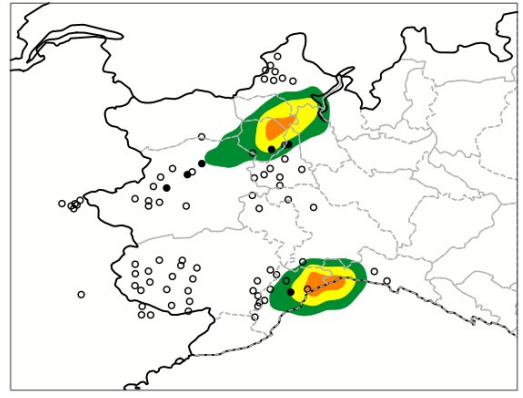


TP>20mm | TP>40mm | TP>70mm

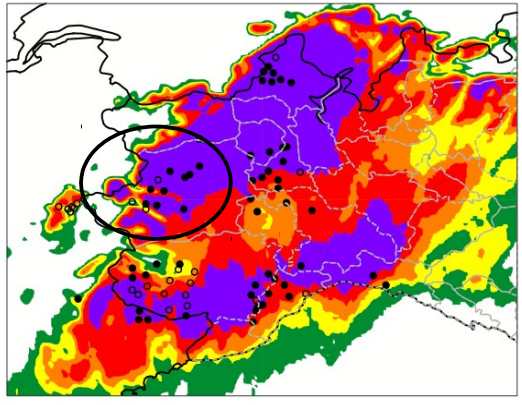
ECMWF ENS

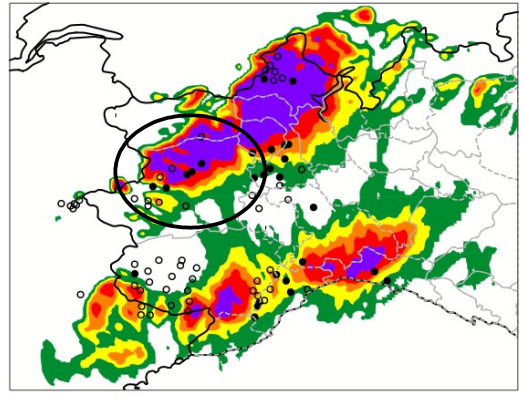


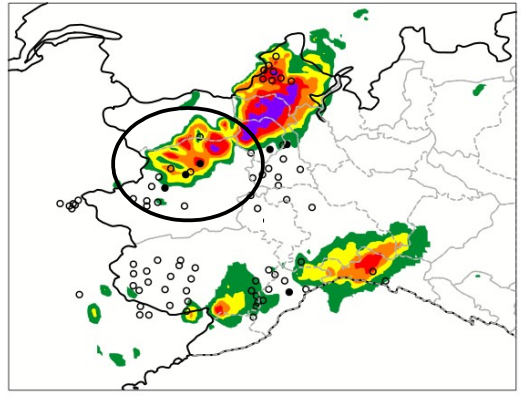




COSMO-2I-EPS



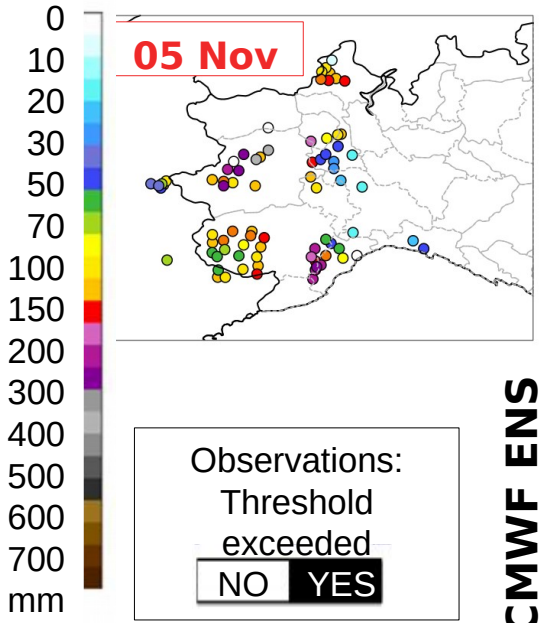




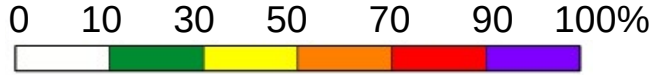
Both EPSs reproduce the two peaks of precipitation

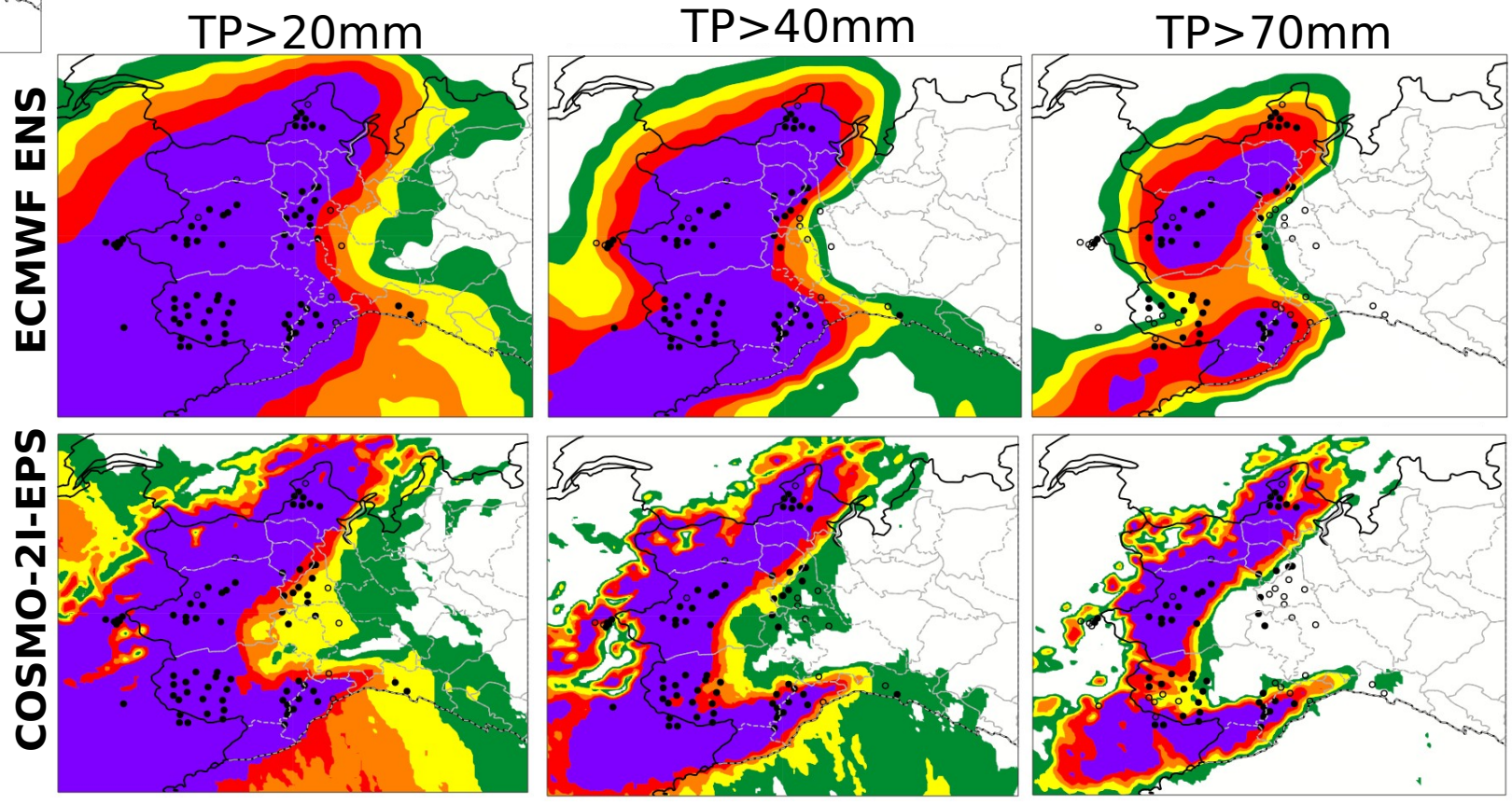
Higher capacity to displace precipitation in COSMO-2I-EPS

Probability of occurrence

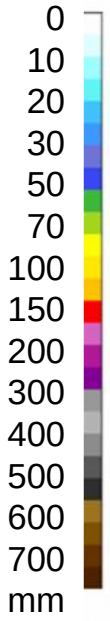


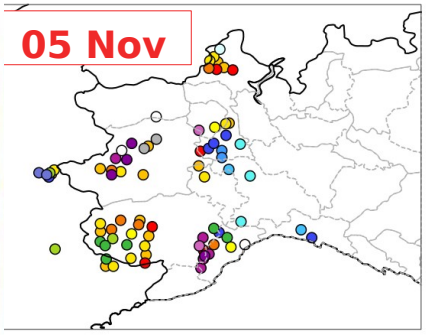
Probability of threshold exceedence
24h-accumulated total precipitation





Probability of occurrence



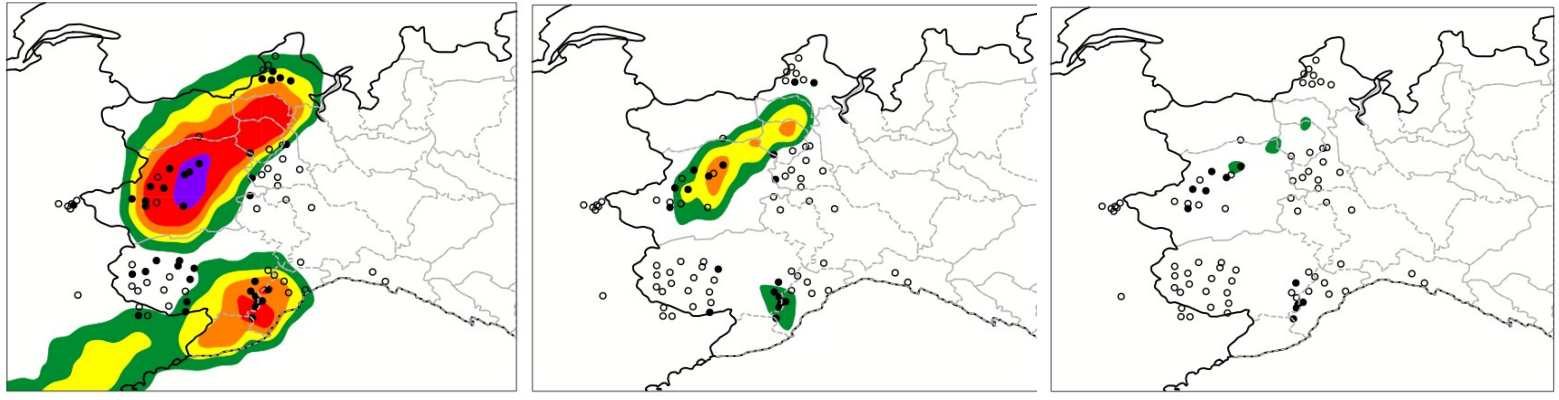


Observations:
Threshold exceeded
NO YES

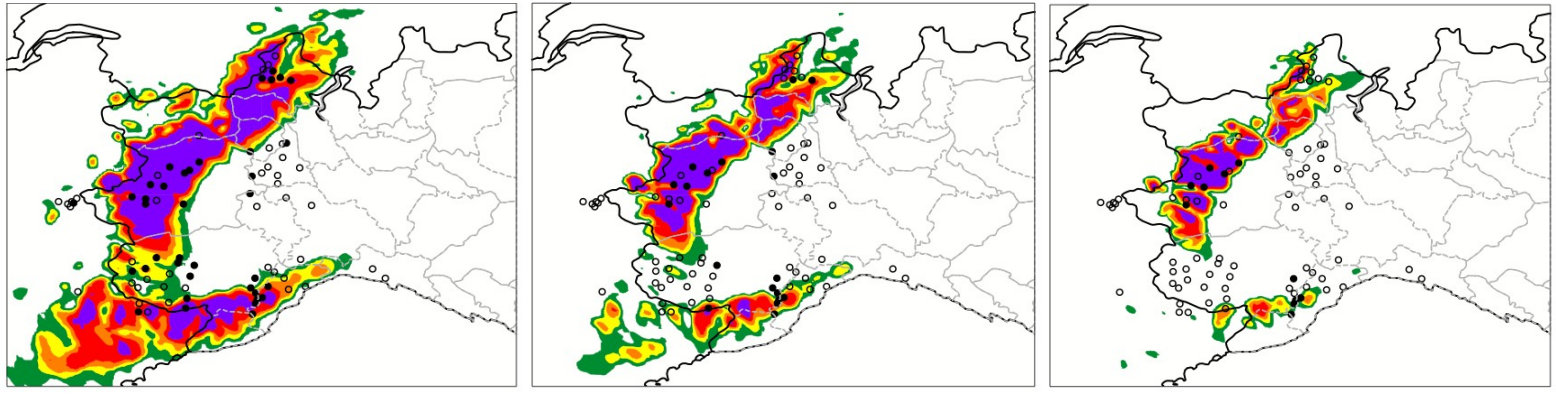
Probability of threshold exceedence
24h-accumulated total precipitation

TP>100mm | TP>150mm | TP>200mm

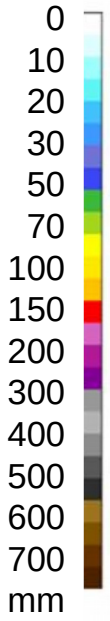
ECMWF ENS

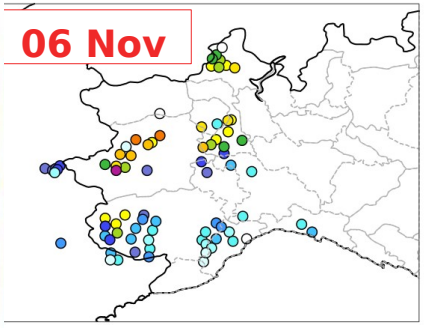


COSMO-2I-EPS



Probability of occurrence



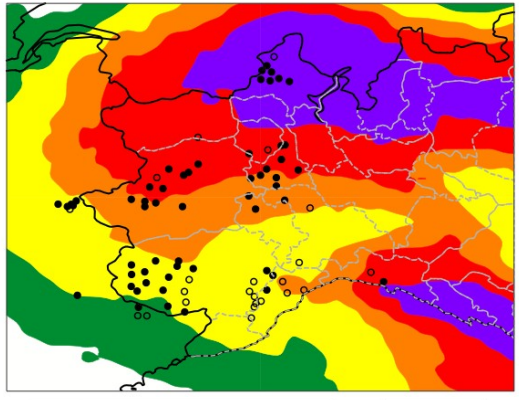


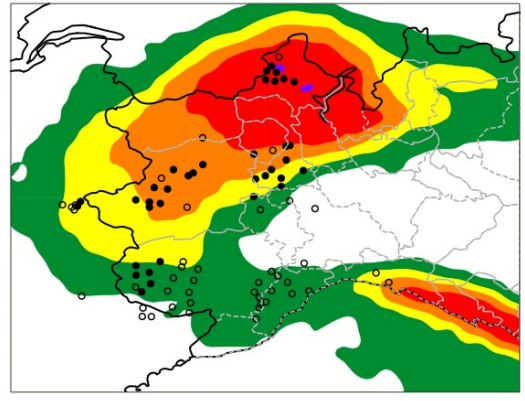
Observations:
Threshold exceeded
NO YES

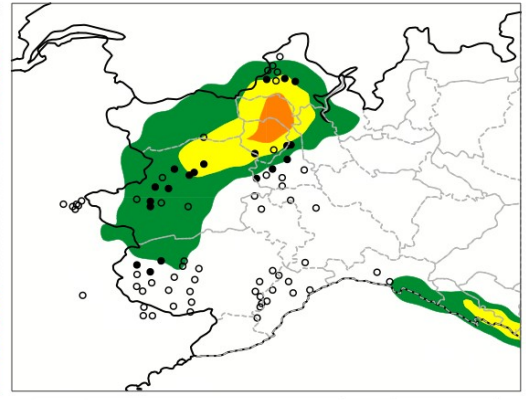
Probability of threshold exceedence
24h-accumulated total precipitation

TP>20mm | TP>40mm | TP>70mm

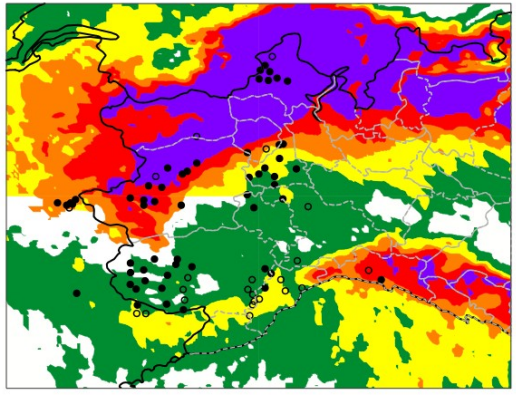
ECMWF ENS

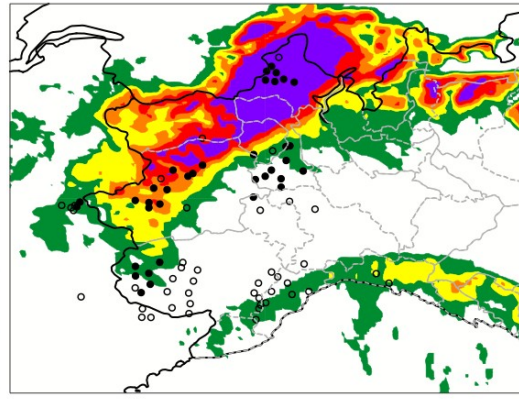


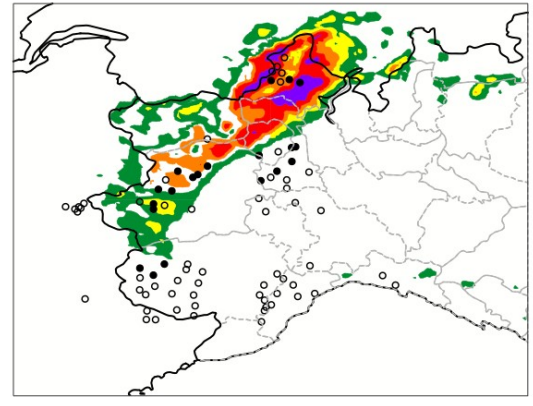


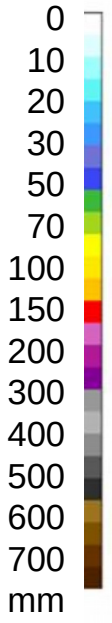


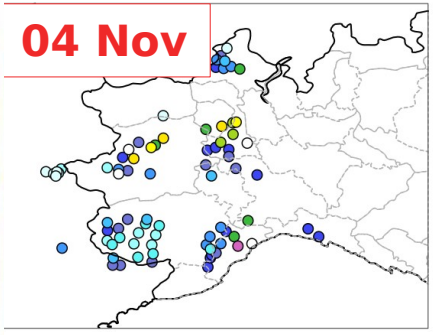
COSMO-2I-EPS











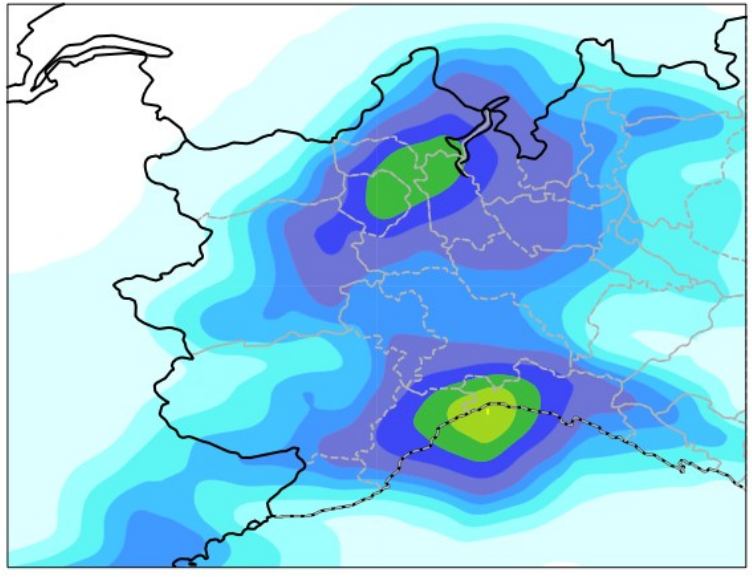
Ensemble SPREAD as an index of predictability

The spread indicates the area where the ensemble members present more different scenario

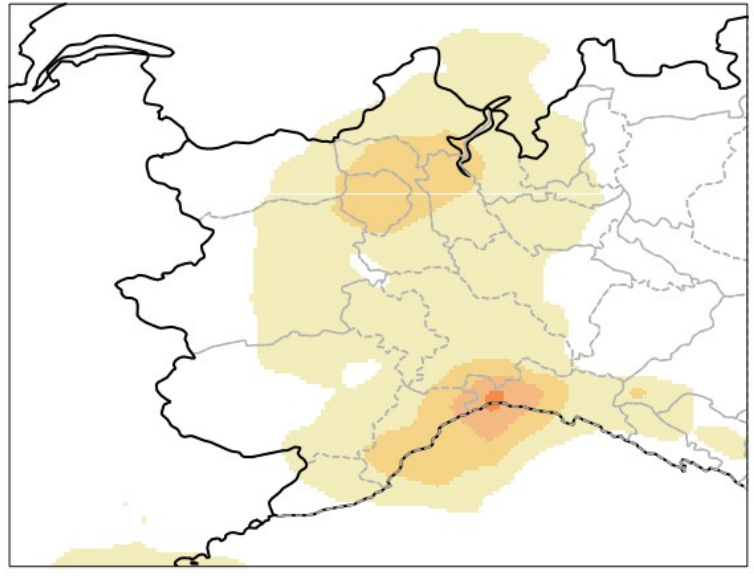
Often areas with high ensemble mean show also high ensemble spread

ECMWF ENS

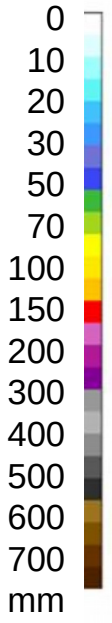
ENSEMBLE MEAN

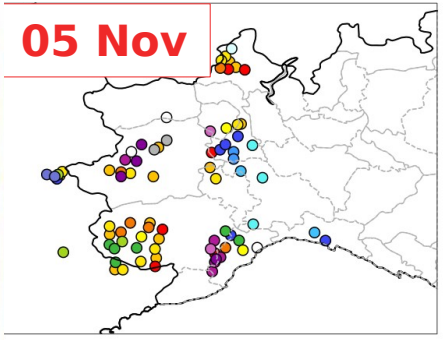


ENSEMBLE SPREAD



Ensemble SPREAD as an index of predictability



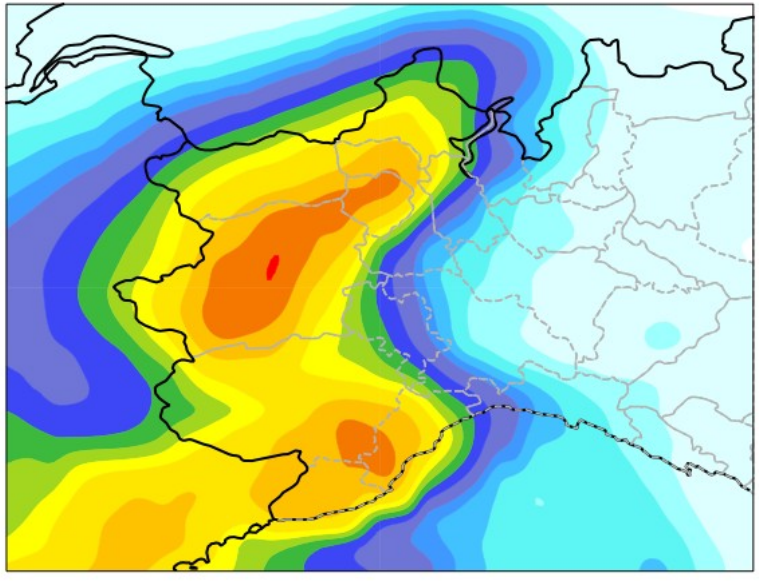


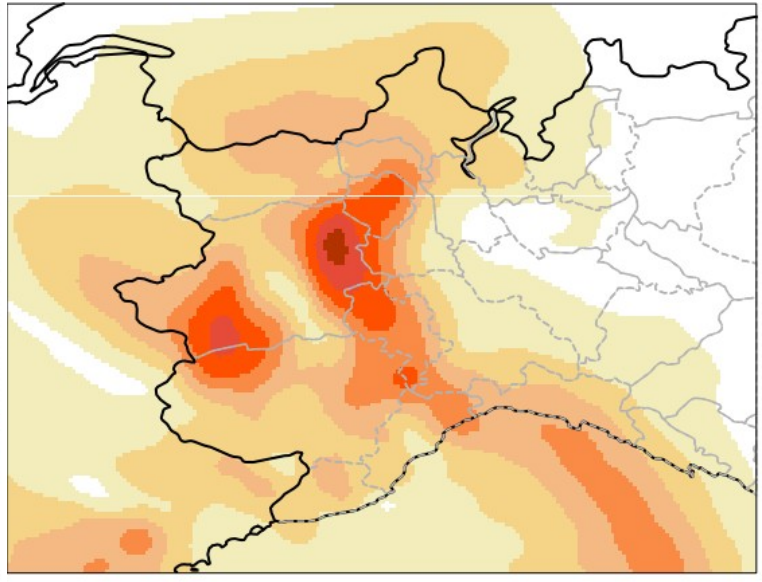
The spread indicates the area where the ensemble members present more different scenario

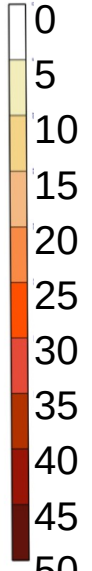
ENSEMBLE MEAN

ENSEMBLE SPREAD

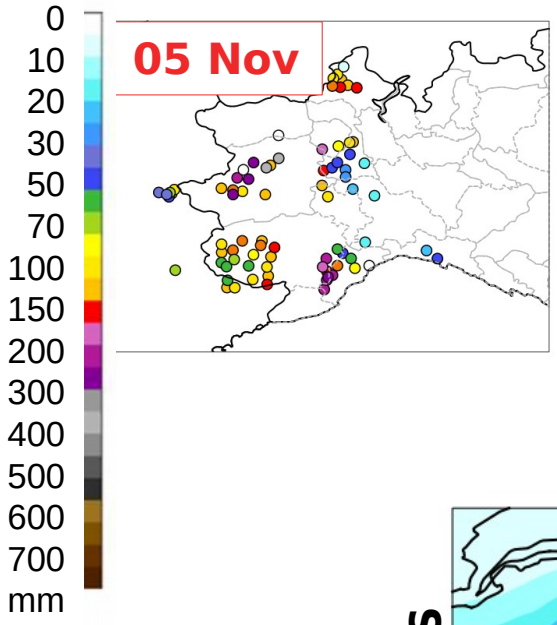
ECMWF ENS



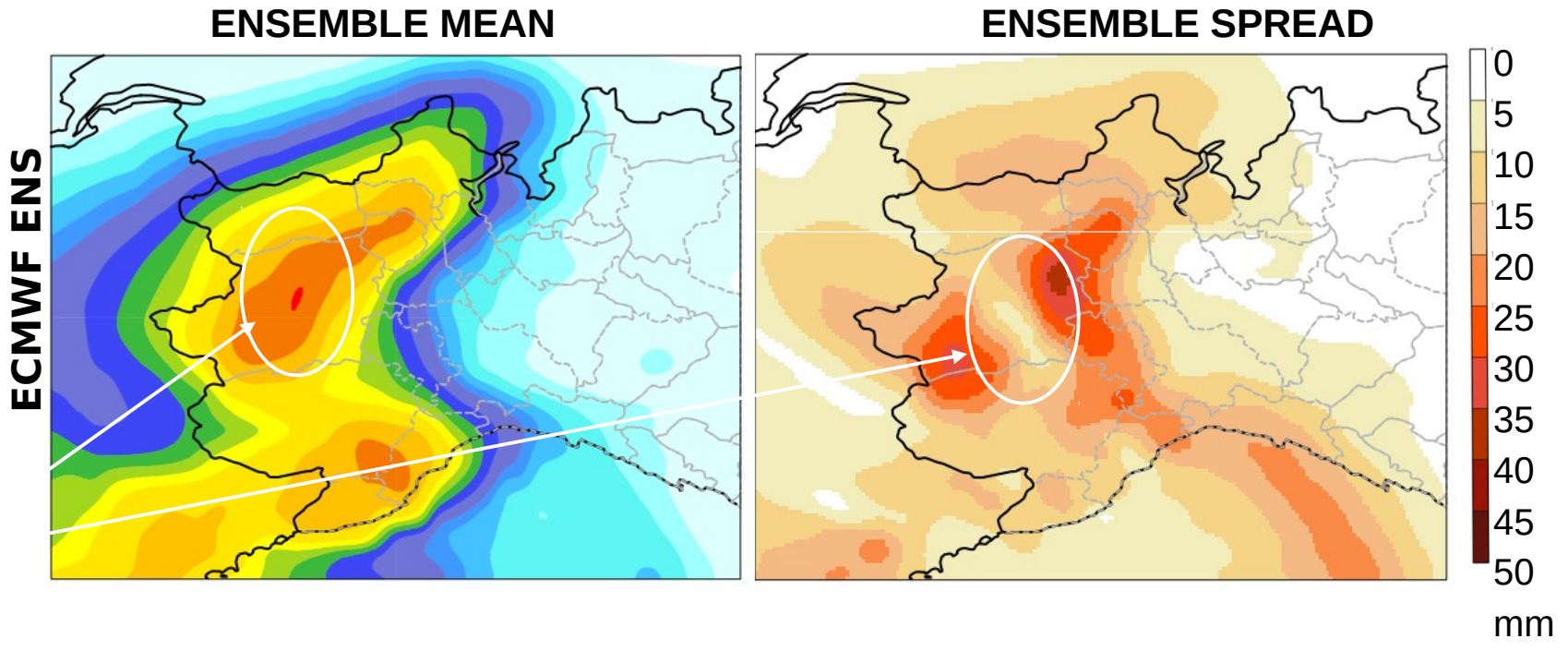




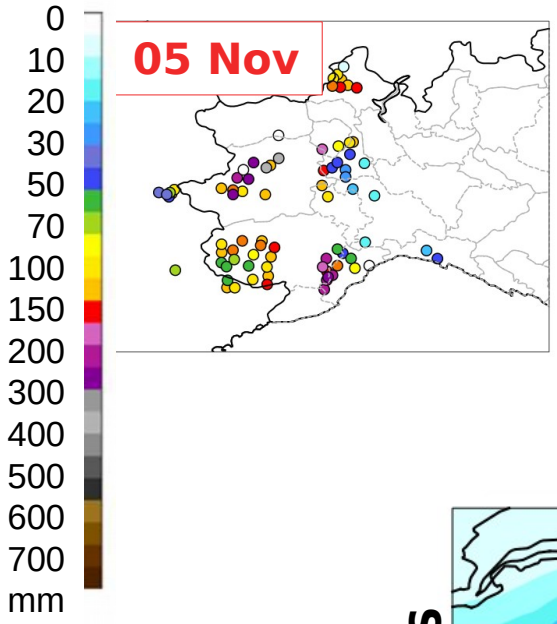
Ensemble SPREAD as an index of predictability



The spread indicates the area where the ensemble members present more different scenario



Low uncertainty on the position of nucleus of precipitation



Ensemble SPREAD as an index of predictability

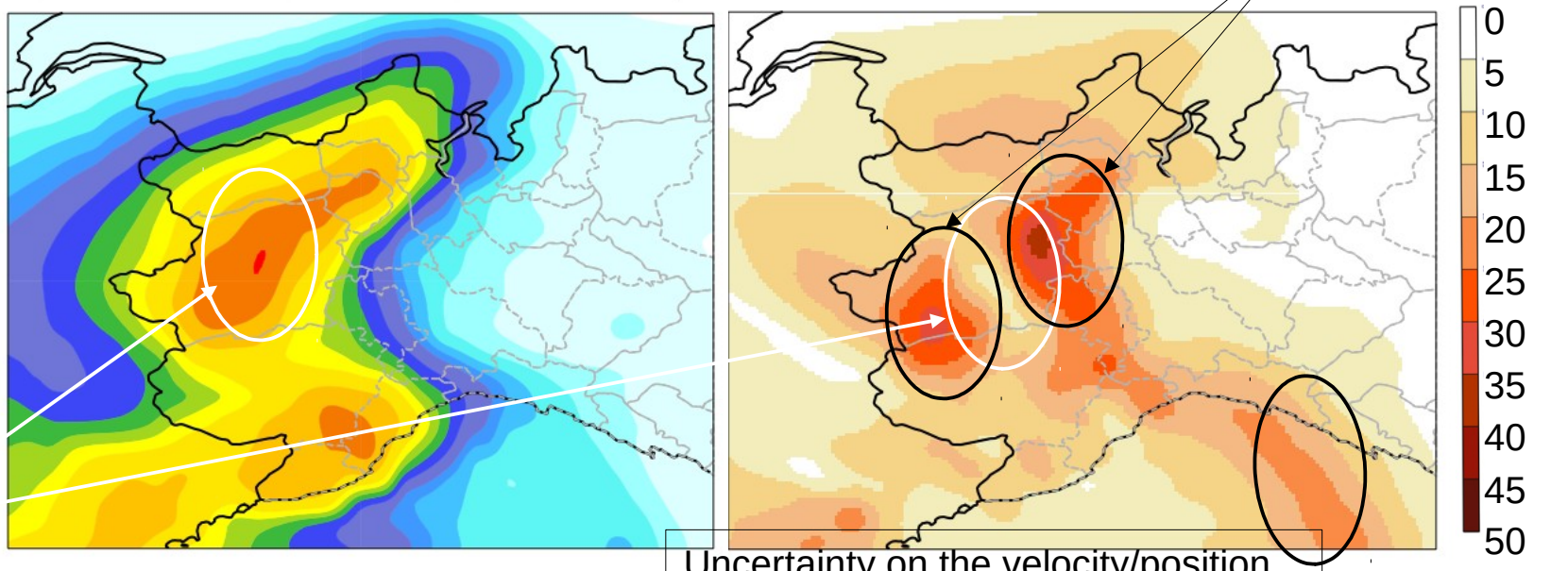
The spread indicates the area where the ensemble members present more different scenario

Uncertainty due to low level flow direction

ENSEMBLE MEAN

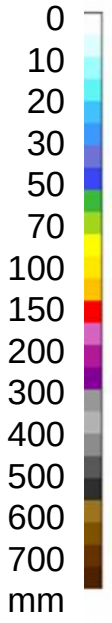
ENSEMBLE SPREAD

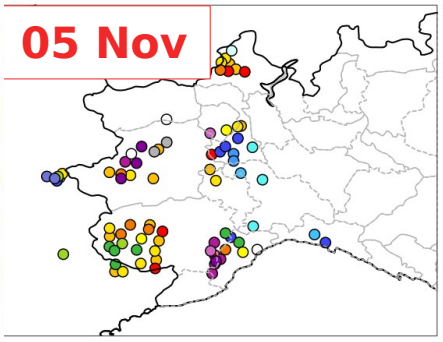
ECMWF ENS



Low uncertainty on the position of nucleus of precipitation

Uncertainty on the velocity/position of the warm conveyor belt





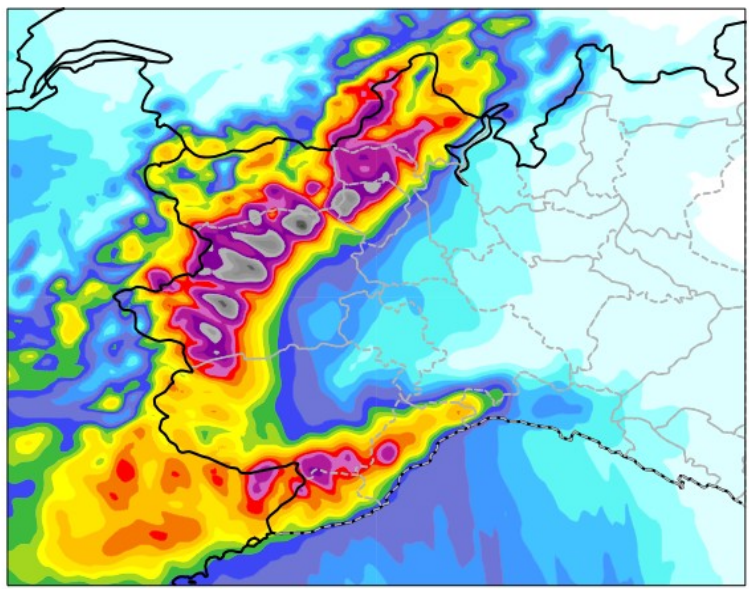
Ensemble SPREAD as an index of predictability

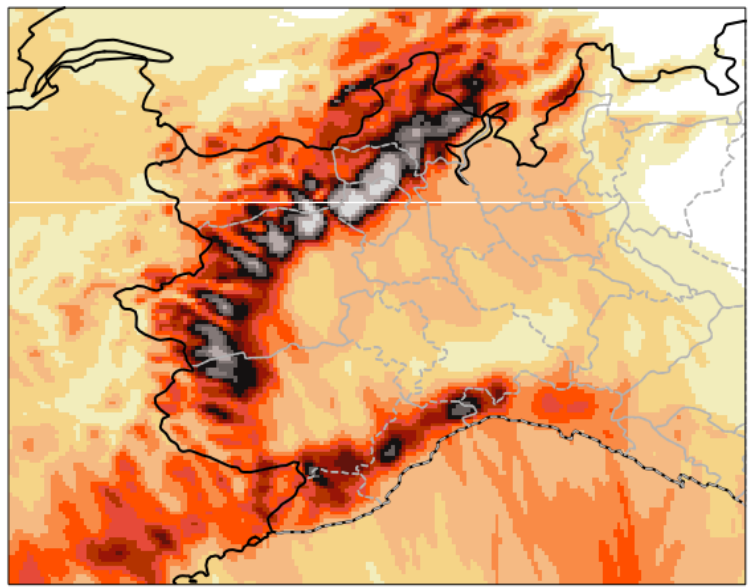
The spread indicates the area where the ensemble members present more different scenario

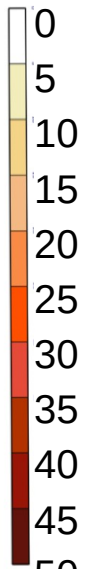
ENSEMBLE MEAN

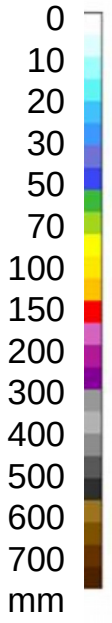
ENSEMBLE SPREAD

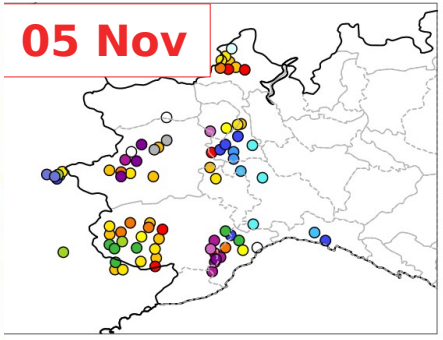
COSMO-2I-EPS











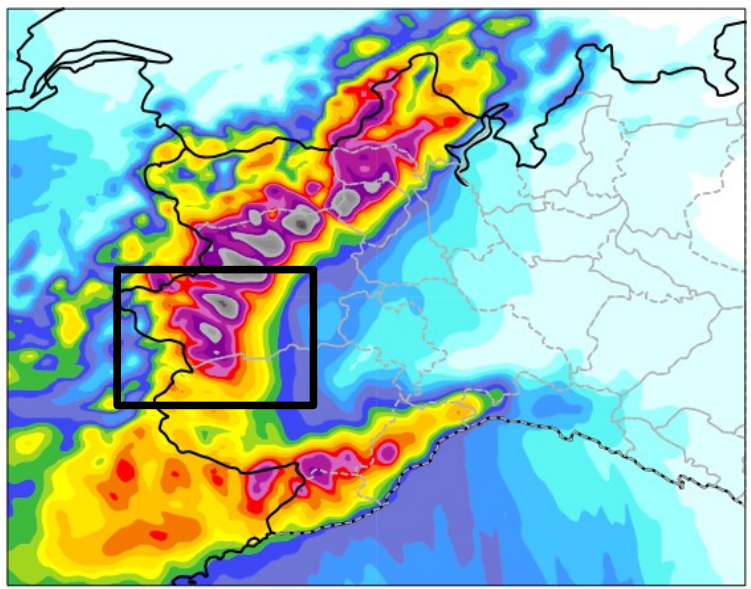
Ensemble SPREAD as an index of predictability

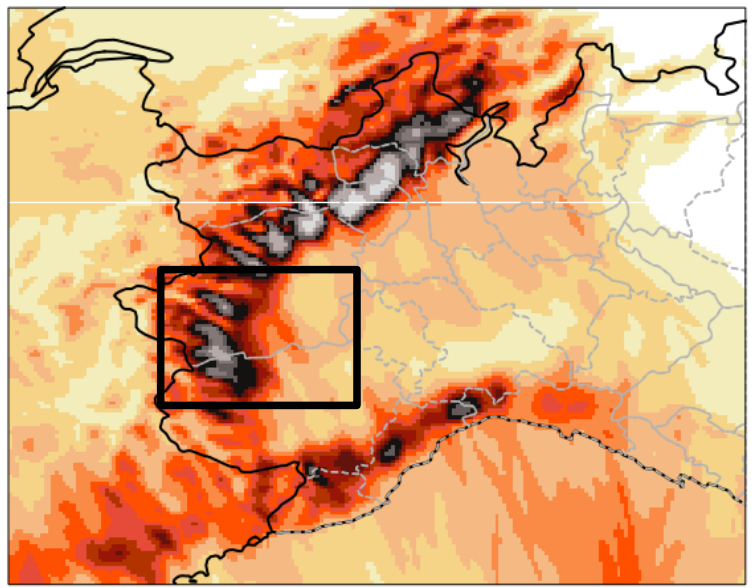
The spread indicates the area where the ensemble members present more different scenario

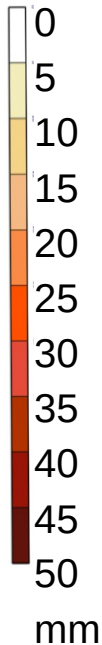
ENSEMBLE MEAN

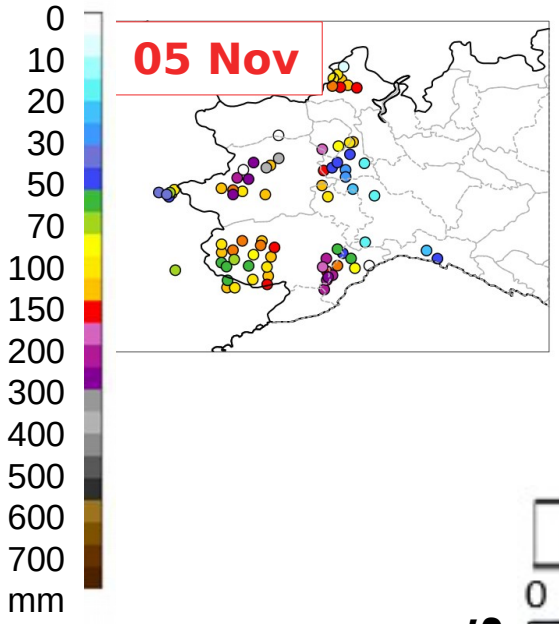
ENSEMBLE SPREAD

COSMO-2I-EPS





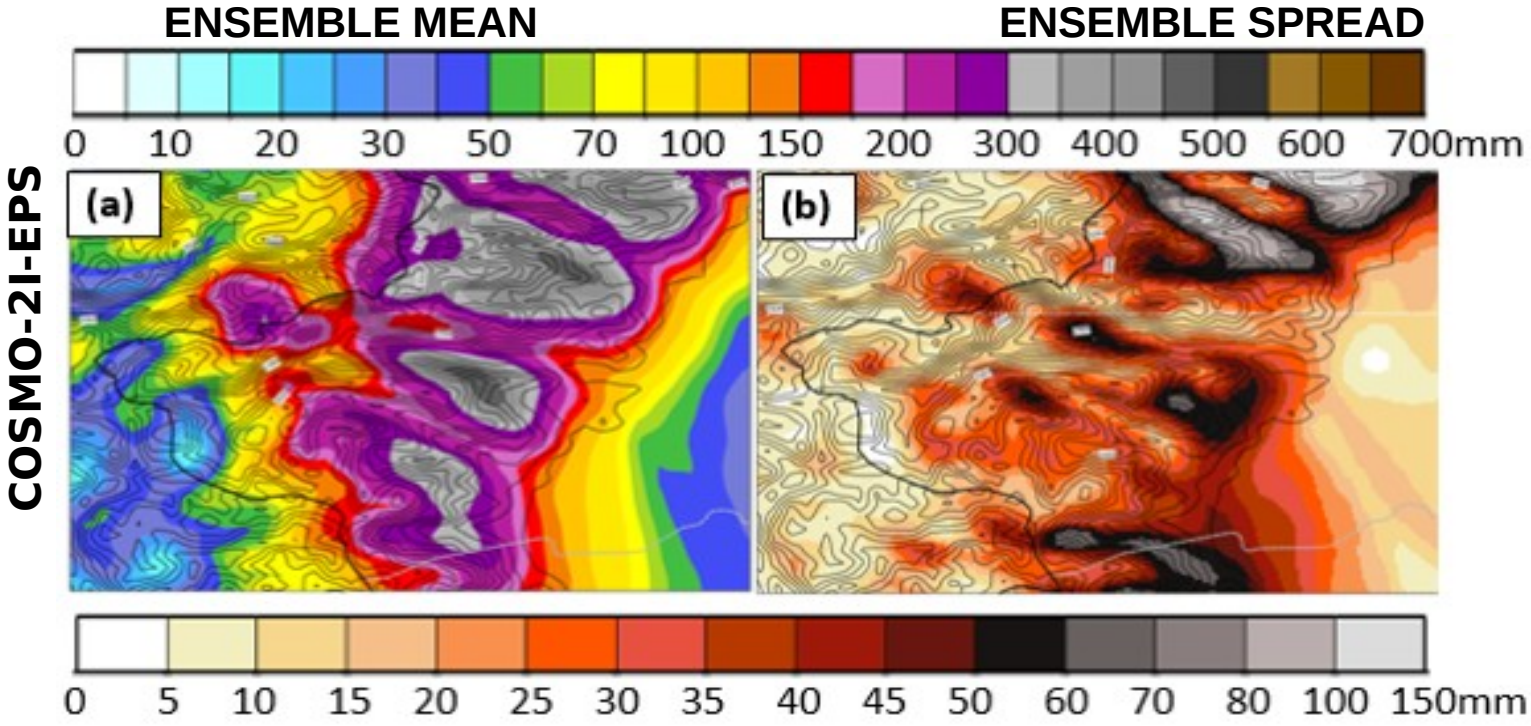


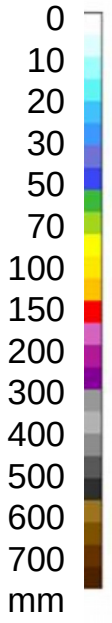


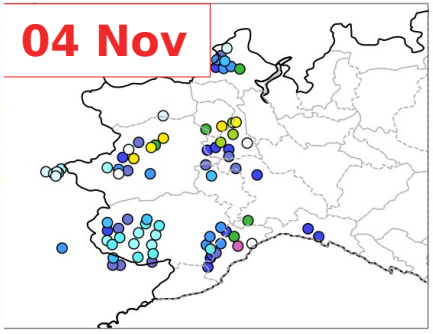
Ensemble SPREAD as an index of predictability

The spread indicates the area where the ensemble members present more different scenario

Uncertainty in the representation of the small scale interaction between orography and flow







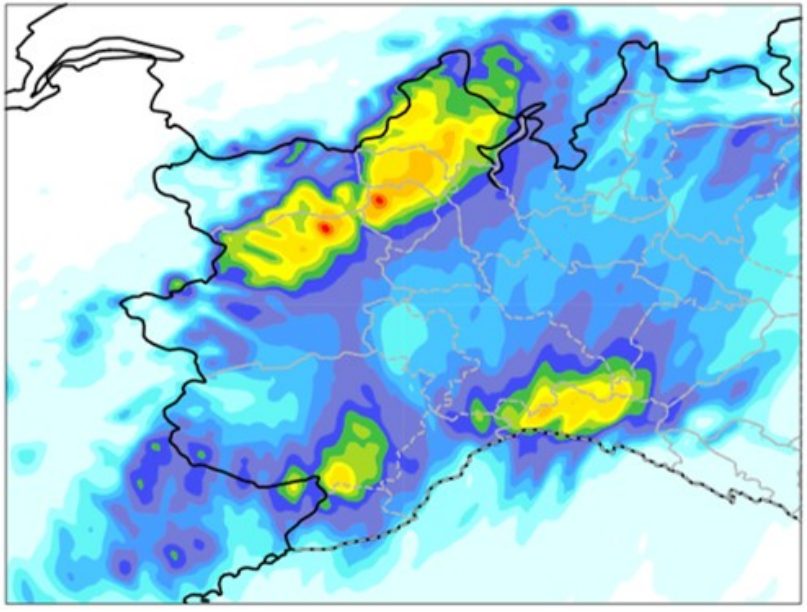
Ensemble SPREAD as an index of predictability

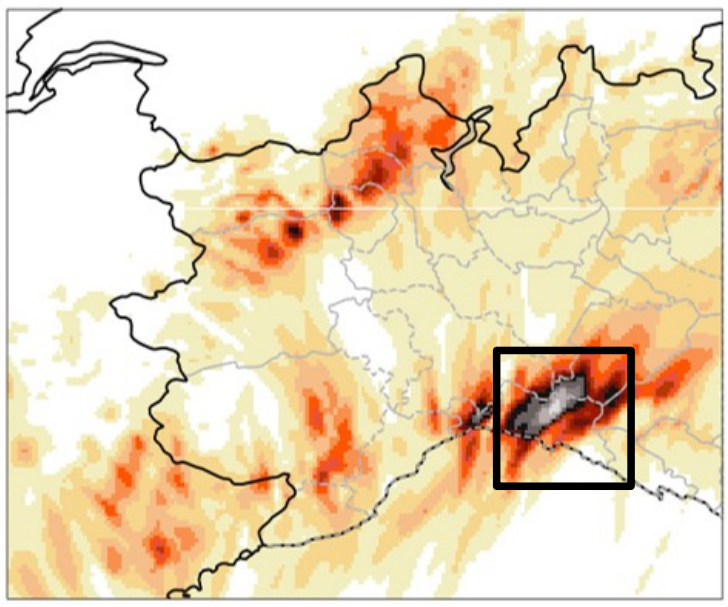
The spread indicates the area where the ensemble members present more different scenario

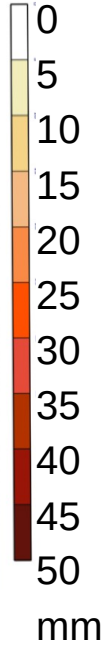
ENSEMBLE MEAN

ENSEMBLE SPREAD

COSMO-2I-EPS



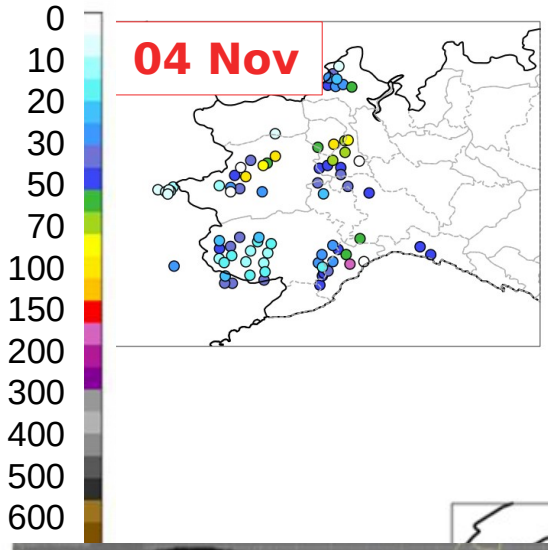


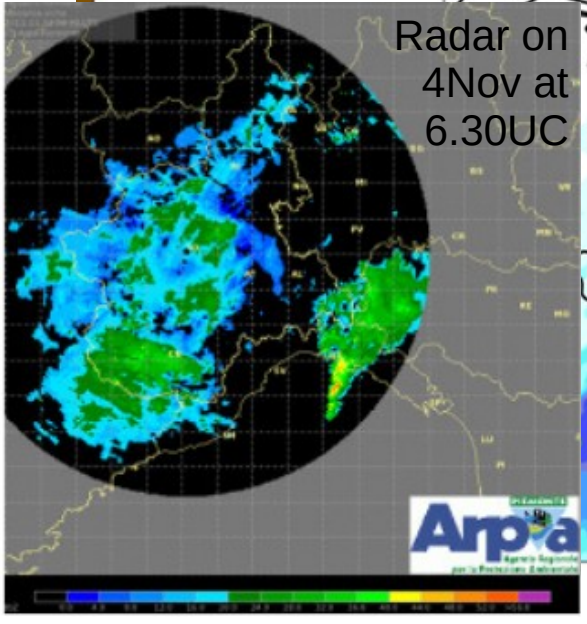


Here the ensemble spread is larger than the ensemble mean

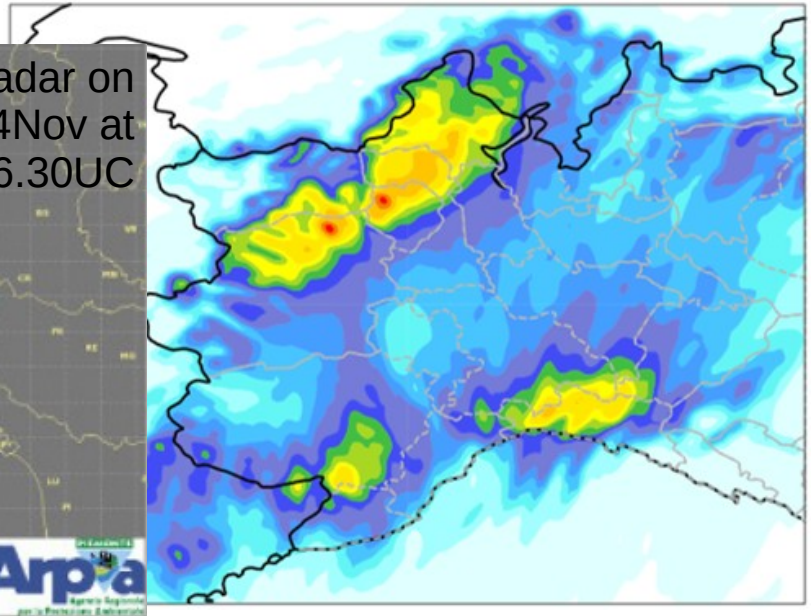
Ensemble SPREAD as an index of predictability

The spread indicates the area where the ensemble members present more different scenario

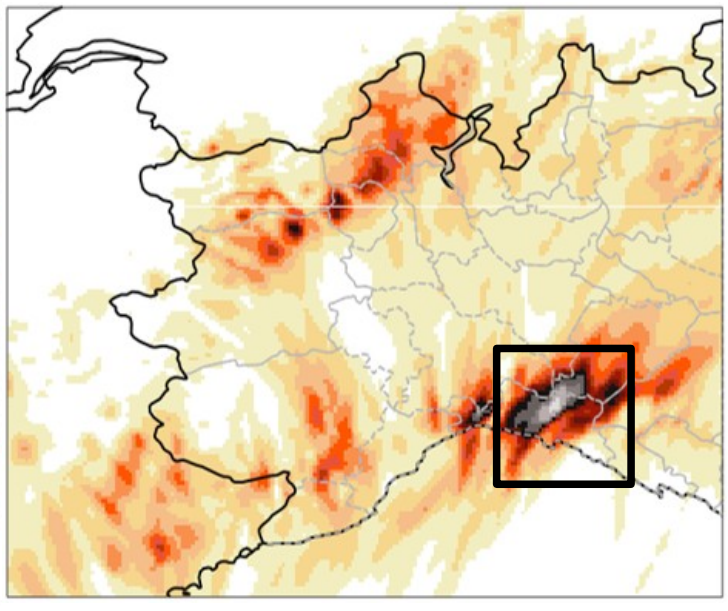


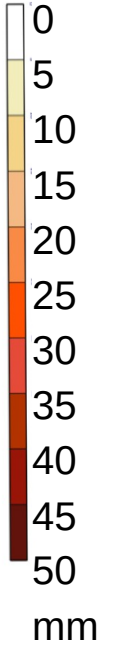


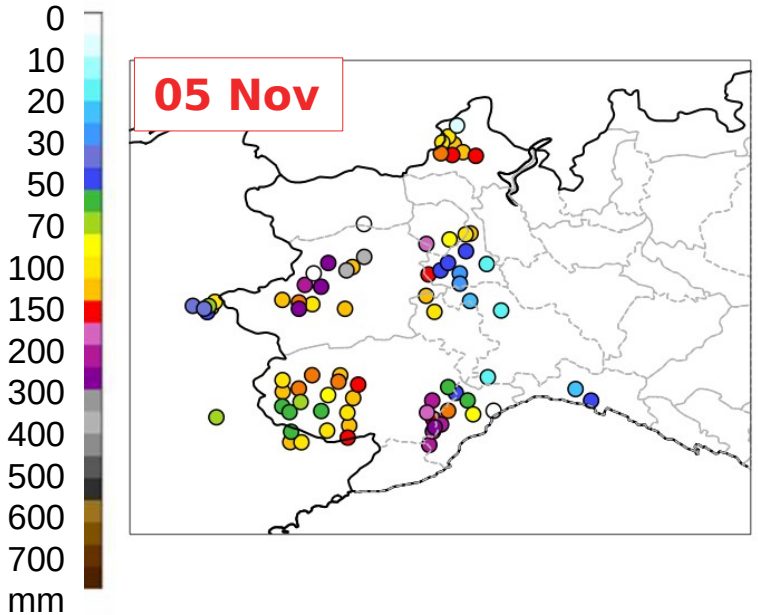
ENSEMBLE MEAN



ENSEMBLE SPREAD



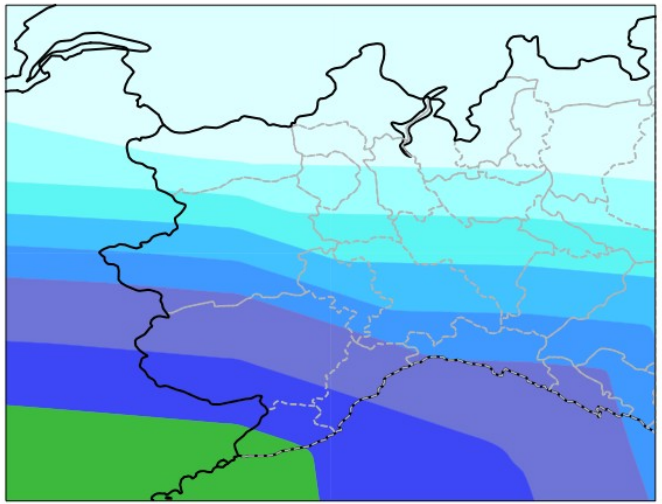




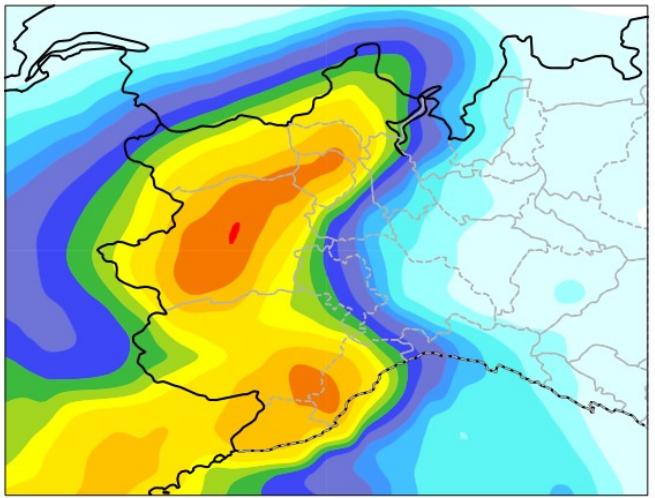
Conclusions

- Impressive improvements along the years in the ability to forecast the intensity/location in advance (resolution, physics, perturbation techniques..)

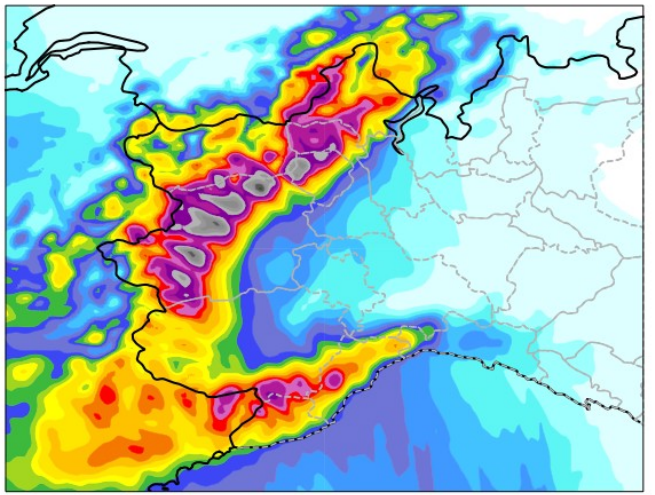
ECMWF-ENS-1994

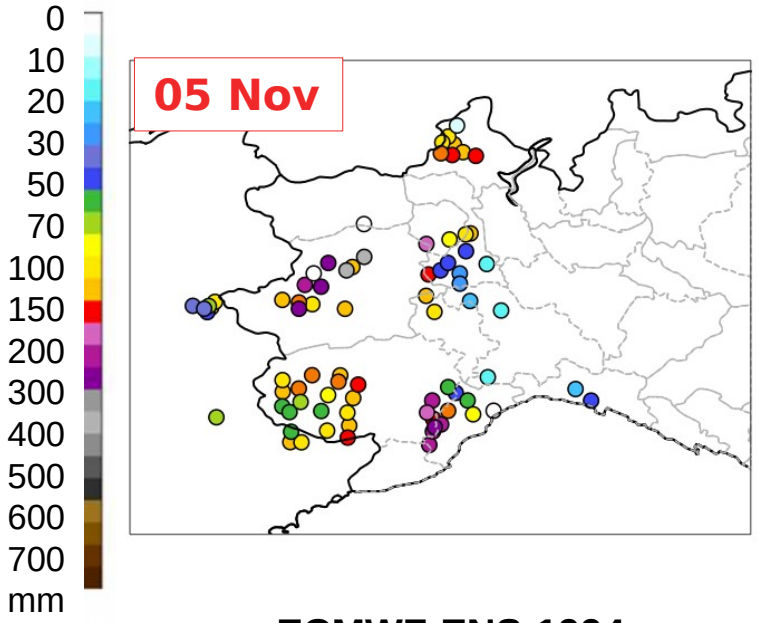


ECMWF-ENS-2019



COSMO-2I-EPS-2019

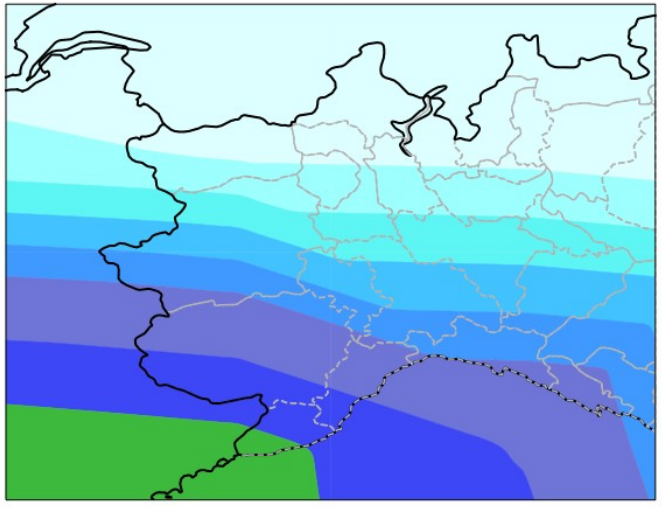




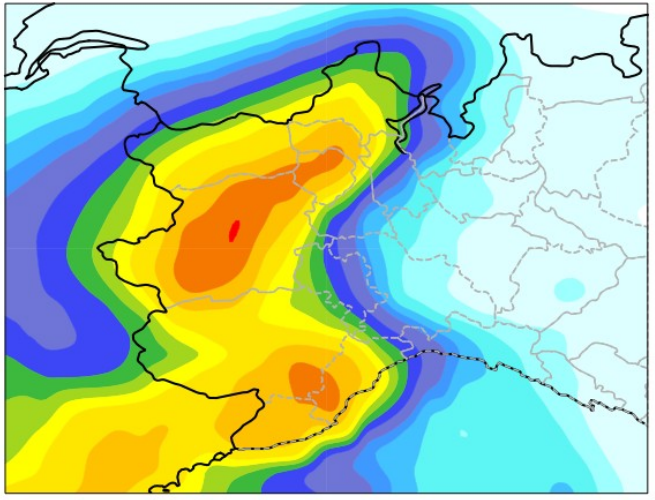
Conclusions

- Impressive improvements along the years in the ability to forecast the intensity/location in advance (resolution, physics, perturbation techniques..)
- Km-scale resolution models are pivotal for having the chance to reproduce convective events over complex orography
- Predictability issues moves to the small scale
- Ensemble spread as an index of predictability and of potential occurrence of extreme events (alternatively to 90° percentile)

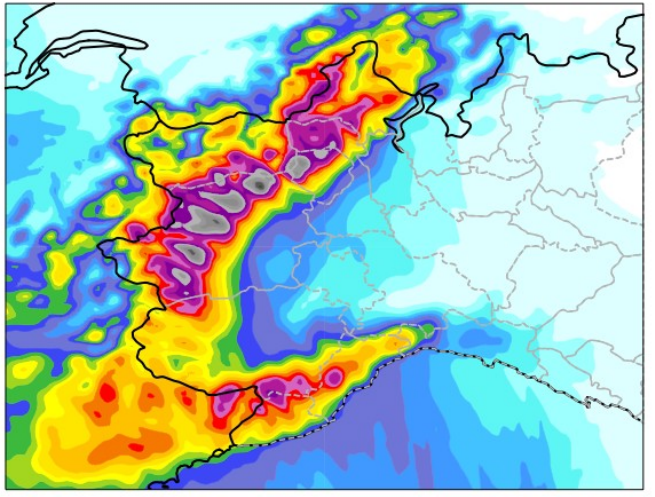
ECMWF-ENS-1994



ECMWF-ENS-2019



COSMO-2I-EPS-2019



Conclusions

- The strong synoptic scale component of the triggers for this event facilitate the EPSs in forecast it
- There is still large space of improvement for the representation of hazardous events less triggered by the large scale forcings

134mm accumulated in less than 2hours

Palermo thunderstorm
90° percentile of Tot.Prec. in 24h - 15/07/2020