CONSORTIUM FOR SMALL SCALE MODELING

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Model perturbations for the COSMO ensembles

Chiara Marsigli

Deutscher Wetterdienst

Outline

- The COSMO ensembles
- Recent developments:
  - Sensitivity of ICON to physics parameters
  - Combination of SPPT and PP and in COSMO
  - More stochastic physics!
- Use of ensembles
- Final remarks

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COSMO

The COSMO ensembles

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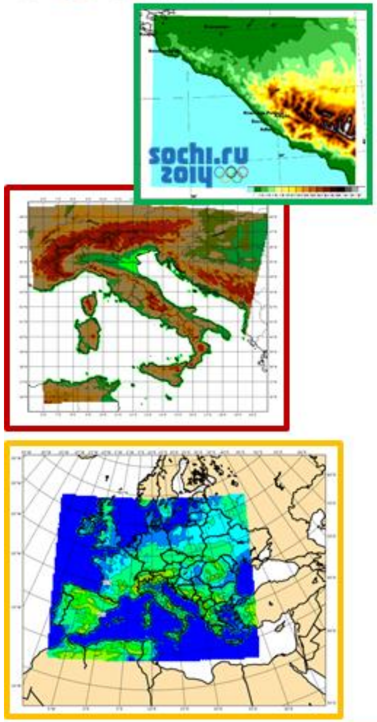
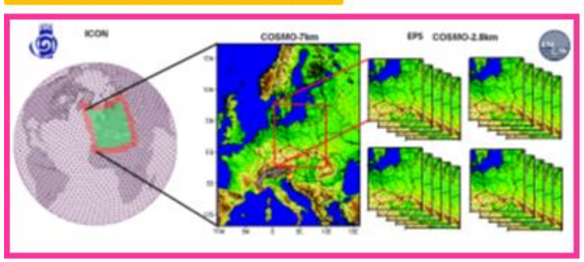
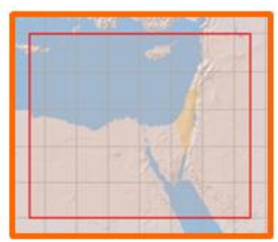
DWD

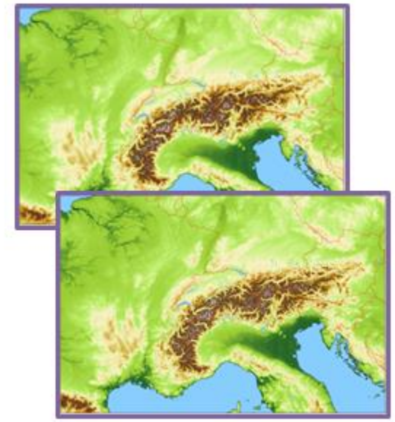


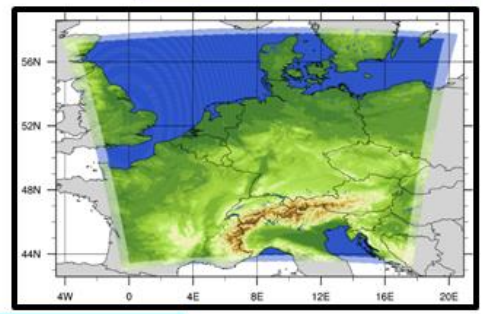


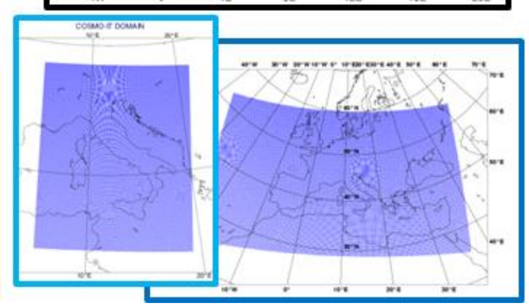


Ensemble systems

- ICON-D2-EPS
- COSMO-2E
  COSMO-1E
- TLE-MVE
- COSMO-2I-EPS
- COSMO-IT-EPS
- COSMO-Ru2-EPS
- COSMO-IL-ENS
- COSMO-LEPS
- COSMO-ME-EPS







http://www.cosmo-model.org/content/tasks/workGroups/wg7

Model perturbation

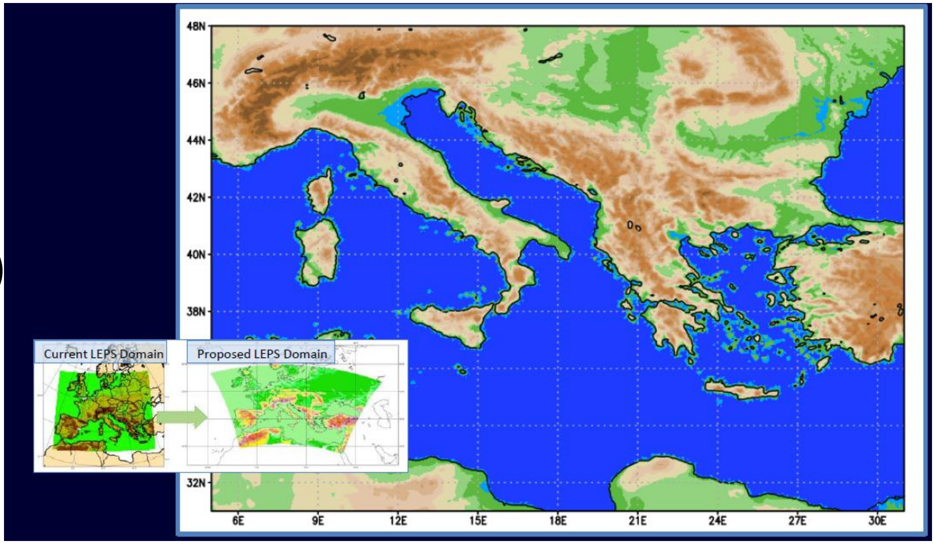
- Methods currently operational:
  - SPPT - Stochastically Perturbed Parametrization Tendency
  - PP – Perturbed Parameters
- Methods currently under development:
  - SMME – Stochastic Model for the Model Error
  - AMPT – Additive Model-error perturbations scaled by Physical Tendencies
- New (external) developments currently under test:
  - SSC - Stochastic shallow convection
  - PSP2 - Physically based stochastic perturbations for boundary layer turbulence

Status of the experiments on parameter perturbations towards ICON-LEPS

Euripides N. Avgoustoglou
Hellenic National Meteorological Service

- Goal: study the sensitivity of the ICON model to a large set of parameters over a Mediterranean area

  => implementation of the Parameter Perturbation in ICON-LEPS (transition of COSMO-LEPS)



E. Augoustoglou, HNMS

Status of the experiments on parameter perturbations towards ICON-LEPS

Euripides N. Avgoustoglou
Hellenic National Meteorological Service

24 parameters were considerd.

⊗

3 values/parameter including default.

⊗

The evaluation period consisted of 62 days from year 2020 i.e.: January 1-31, July1-31

3000 runs based on ICON-IMS (Gratis IMS):

- Horizontal grid size: R3B08 (~6.5km).
- 417x273 grid points (wider area of Greece and Italy), 65 levels.
- Integration time-step: 60 secs.
- Integration period: 132 hs.
- Boundary conditions : 3hr IFS Forecast.
- Computational Cost ~ $5x10^6$ b.u. on Cray X C40 of ECMWF (Gratis HNMS).

E. Augoustoglou, HNMS

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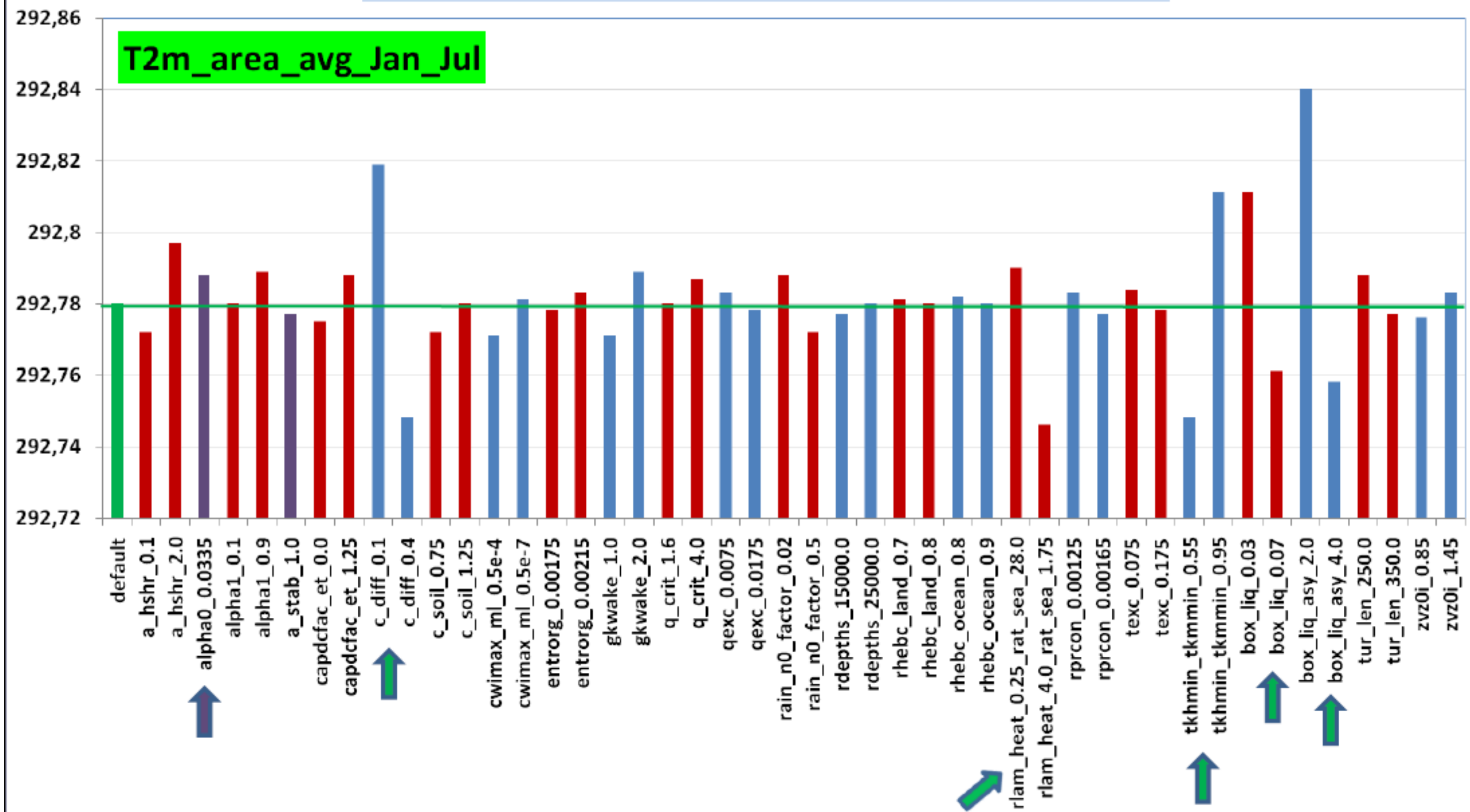
ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

Areal <2m temperature> [K] (132nd hr)



Euripides Avgoustoglou, Hellenic National Meteotological Service, 23rd COSMO GM , September 13th 2021 07

Dominating parameters table for the considered meteorological fields

		1	2	3
T2m	2 m Temperature [K]	box_liq_asy	c_diff	tkhmin_tkmmin
Tmax2m	2 m max Temperature [K]	box_liq_asy	c_diff	tkhmin_tkmmin
Tmin2m	2 m min Temperature [K]	tkhmin_tkmmin	rlam_heat_0.25_rat_sea_28.0	c_diff
Td2m	2 m max dew point Temperature [K]	c_diff	box_liq	alpha1
tot_prec	accumulatedPrecipitation [kg/m^2]	box_liq_asy	rain_n0_factor	rprcon
pmsl	mean sea level Presure [Pa]	box_liq	gkwake	c_diff
u10m	10 m wind speed u component [m/s]	box_liq	box_liq_asy	tur_len
v10m	10 m wind speed v component [m/s]	gkwake	tkhmin_tkmmin	box_liq_asy
gust10m	wind gust 10 m above ground [m/s]	gkwake	box_liq	a_hshr
clcl	low cloud cover [1-100]	box_liq_asy	box_liq	alpha0
clcm	medium cloud cover [1-100]	box_liq	box_liq_asy	rdepths
clch	high cloud cover [1-100]	zvz0i	entrorg	rprcon
clct	total cloud cover [1-100]	box_liq_asy	box_liq	zvz0i
tqv	column integrated water vapour [kg/m2]	alpha1	a_stab	box_liq
tqi	total column integrated cloud ice [kg/m2]	zvz0i	rprcon	box_liq_asy
tqc	total column integrated cloud water [kg/m2]	rdepths	tur_len	q_crit

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COSMO-IL-ENS

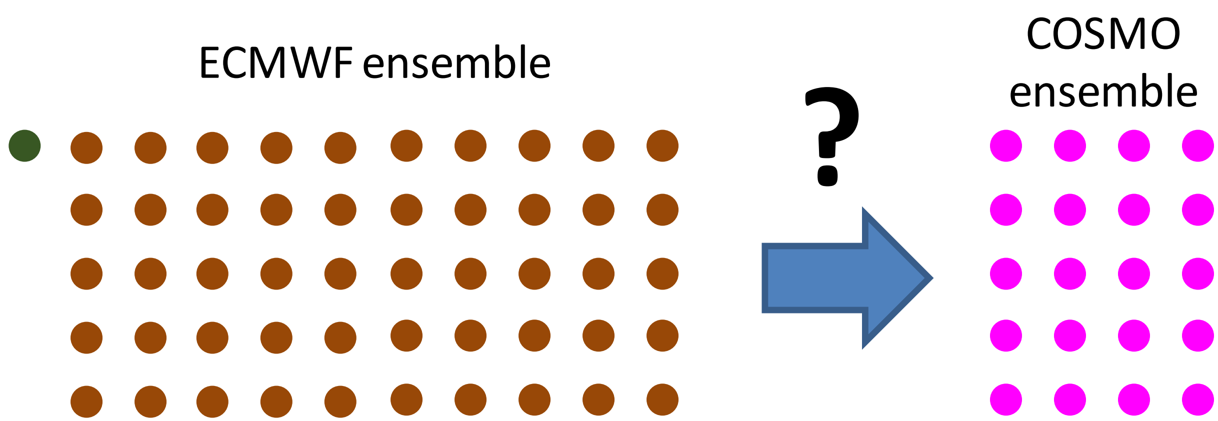
Sources of forecast uncertainty:

- Uncertainty in boundary conditions → use of driving ensemble (**EC-ENS**)
- Uncertainty in model physics → Stoch. Pert. of Param. Tendencies (**SPPT**), parameter perturbations (**PP**)

Questions?

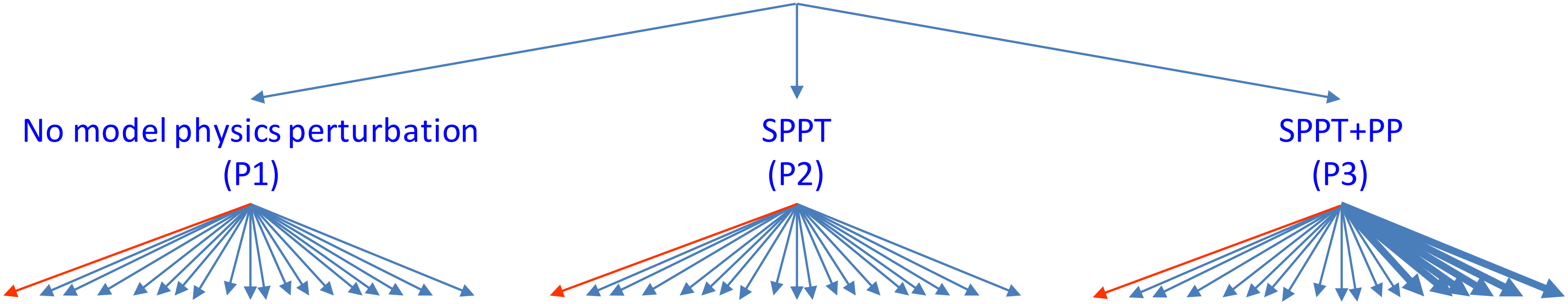
1. Which 20 EC-ENS members to choose?

2. Do model physics perturbations benefit?

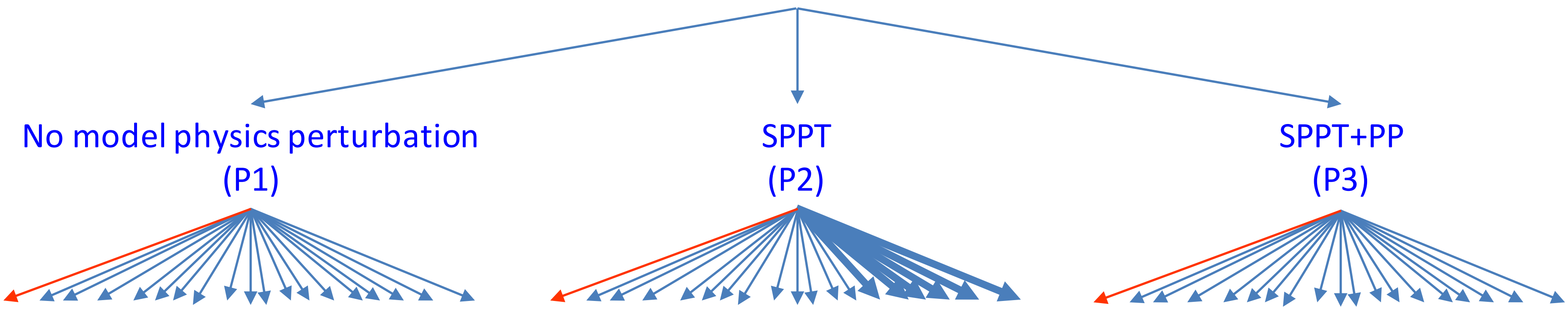


Khain et al., IMS

Which option of ensemble structure is better for near surface variables?



Which option of ensemble structure is better for precipitation?

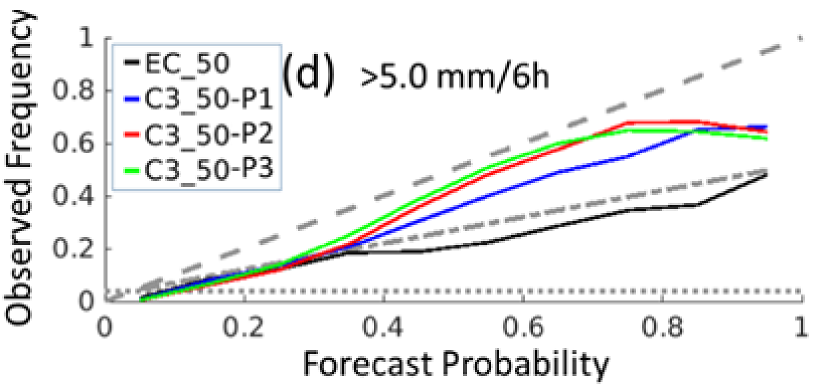


Khain et al., IMS

Which option of ensemble structure is better for precipitation?

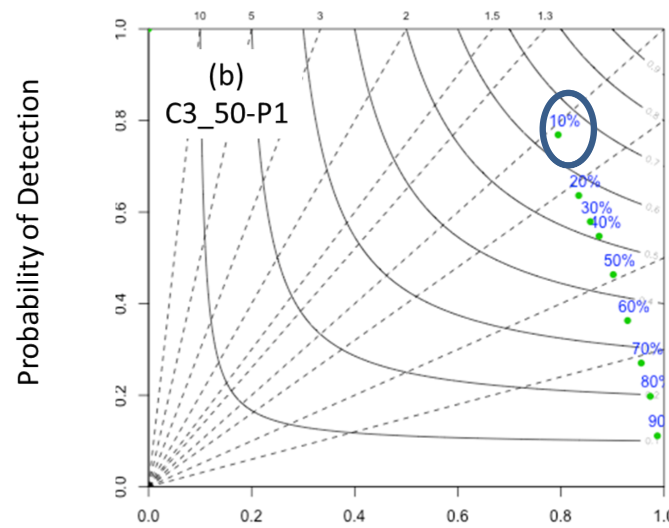
Reliability: P3 (SPPT+PP), Resolution: P1 (no phys pert), ROC and TS: P2 (SPPT)

Reliability diagram



C3_50-P3 has better reliability

Performance diagram



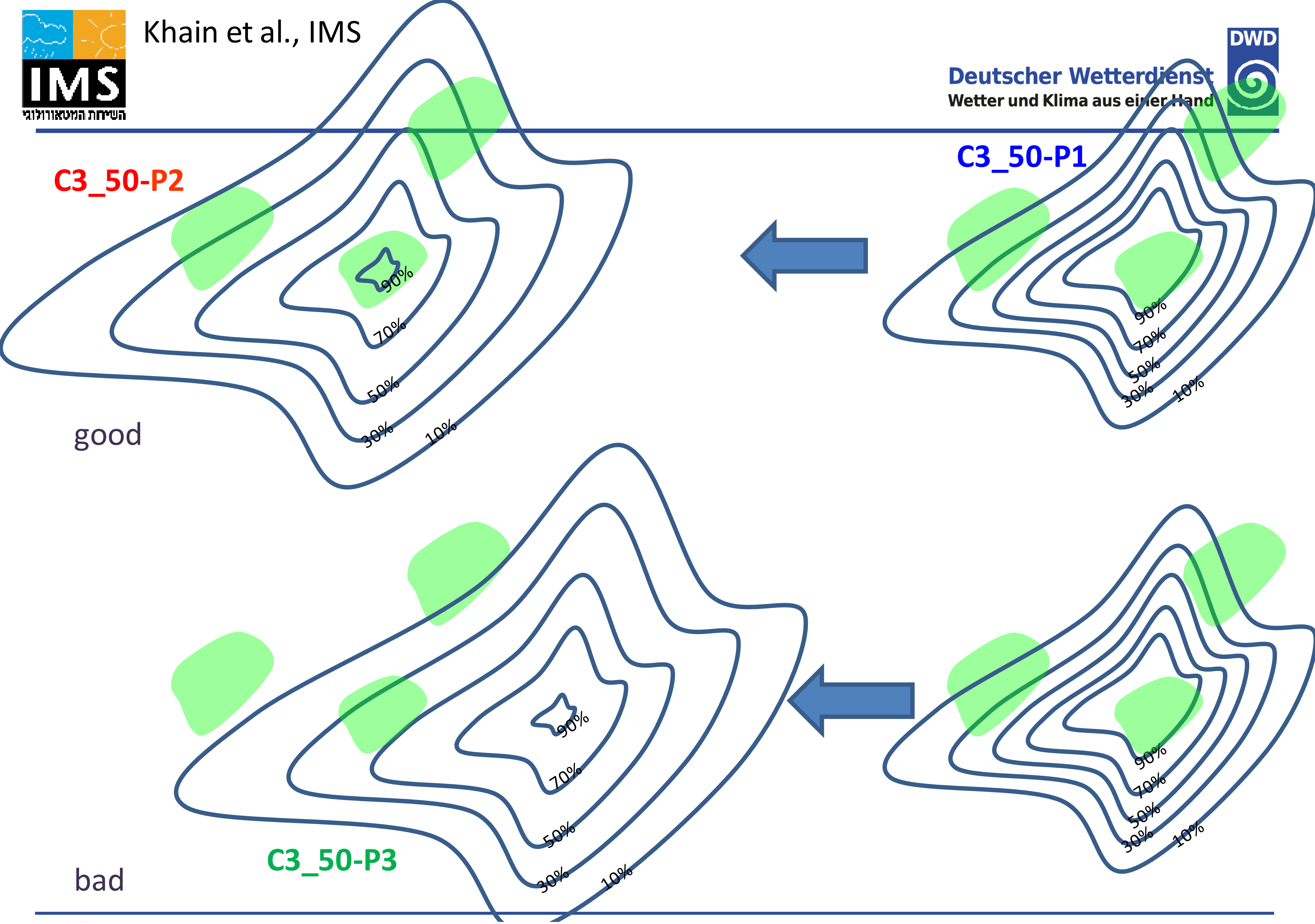
Success Ratio =1-FAR

Problem: The ensemble is biased. One should forecast the event (>5mm/6h) already when 10% of members “agree” with that.

C3_50-P1 has a bit higher TSmax

Khain et al., IMS

Khain et al., IMS



Increasing spread is good if it does not destruct the model (precipitation locations etc.)

Stochastic Workshop

- 2nd and 3rd of March 2021
- Purpose: to make the point about the activities on-going in the COSMO Consortium and in the other European Consortia in the field of "stochastic physics", in particular intrinsically stochastic parametrisations, in view of their usage in ensembles
- 40-50 participants, from COSMO members, LMU (University of Munich), ECMWF, Meteo France, Met Office, Met Eireann, KNMI, SMHI, Met No, Met Hu, AEMET, NCAR, KIT
- Presentations and minutes (of a very interesting discussion) are online at: http://www.cosmo-model.org/content/tasks/workGroups/wg7/default.htm

Physically based stochastic perturbations for boundary layer turbulence :

PSP (Kober and Craig, 2016) PSP2 (Hirt et al., 2019, MWR)

It reintroduces the influence of the lost small-scale variability by adding perturbations to the tendencies of T, q_{υ}, w on the smallest effectively resolved scale ($5\Delta x$)

$$\left(\frac{\partial \phi}{\partial t}\right)_{all} = \frac{\partial \phi}{\partial t} + \underbrace{\alpha \cdot \eta \cdot \sqrt{\overline{\phi'^2}}}_{\text{Stochastic perturbations}}$$

ϕ ={T, q, w}

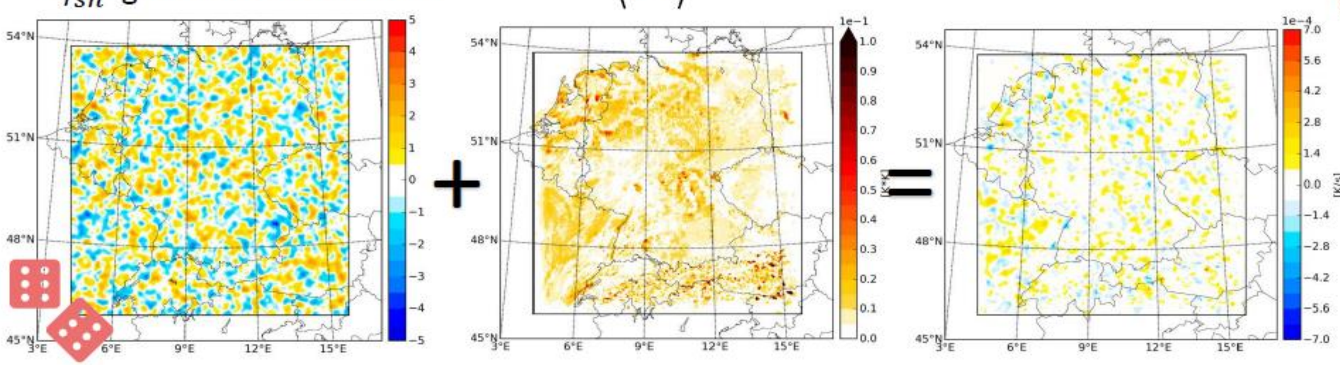
$\boldsymbol{\eta(t, \sigma)}$: Random field , regenerated every 10 min with spatial correlation σ

$\boldsymbol{\alpha}$: perturbation ampl., scaling factors

$\boldsymbol{\phi'}$: physical scaling/subgrid-scale variance of variable ϕ

η_{sh}: gaussian random field

$\langle T^2 \rangle^{0.5}$



(Kober and Craig, 2016)

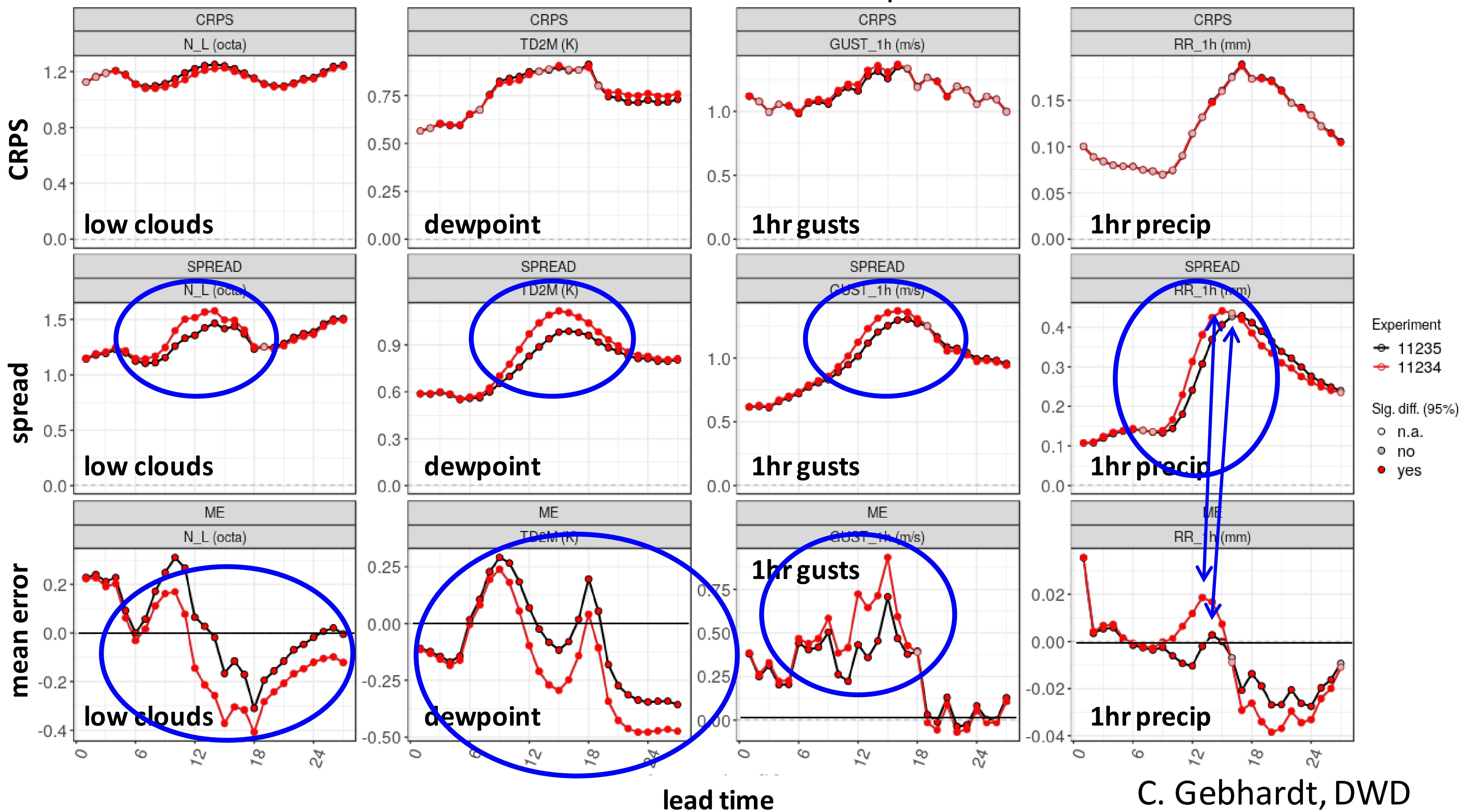
Physically based stochastic perturbations for boundary layer turbulence (PSP2)

- cooperation with Ludwigs-Maximilian-Universität in Munich (LMU)
- first promising tests at LMU
- PSP2 implemented in ICON by LMU
- test run of ICON-D2-EPS from May 26th to August 1st 2021 at DWD
- ICON-D2-EPS with PSP2 vs. operational set up
- verification against synop observations

C. Gebhardt, C. Marsigli, DWD

2021/05/26 22UTC - 2021/08/01 21UTC
INI: 00 UTC, DOM: ALL

PSP2 oper. 00 UTC runs



C. Gebhardt, DWD

Forecaster feedbacks 2021

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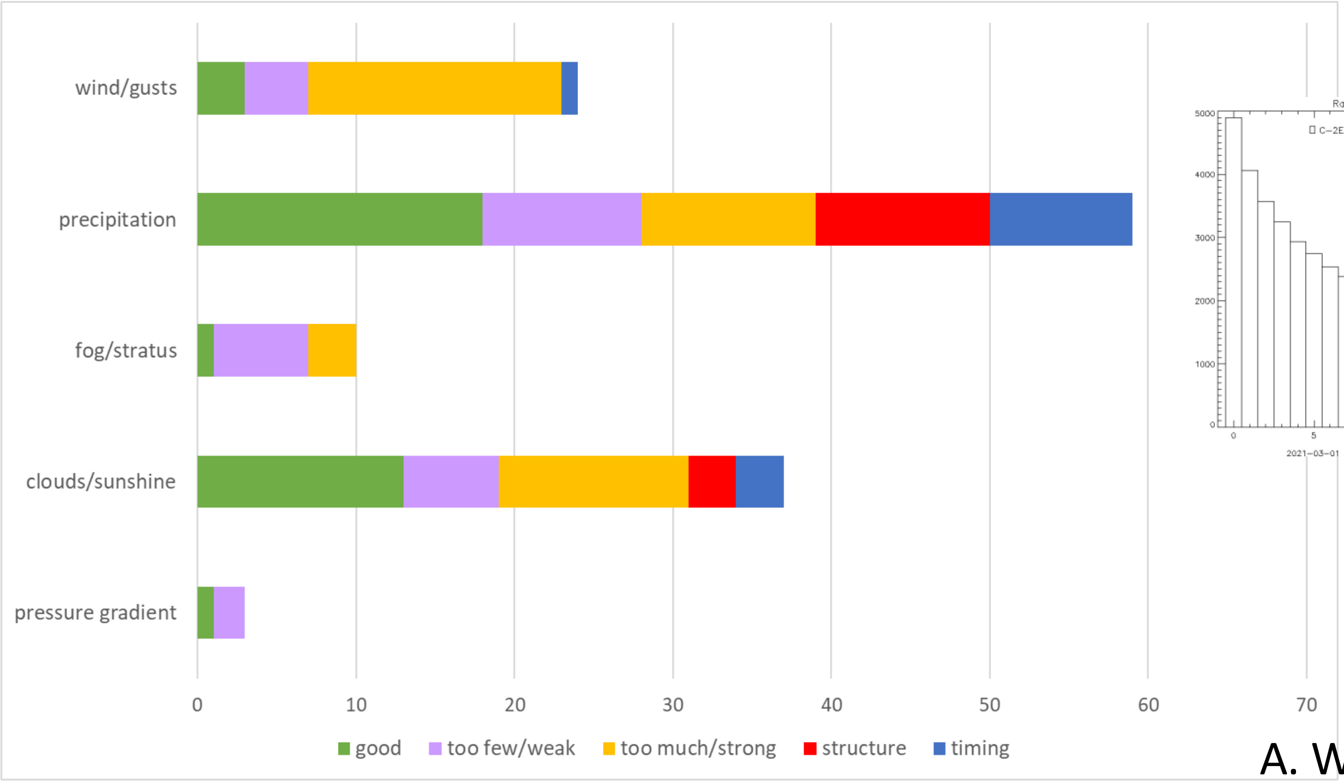
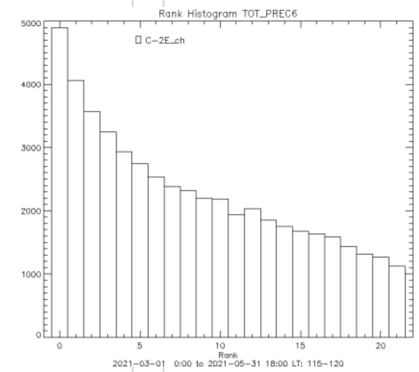
- model feedbacks from forecaster on duty every day (scheduled, up to 15 min)
- increased use of ensemble information also in the short range
- probabilities are translated to keywords in forecast bulletins (possible, likely, ...)
- …but control run still get (too) much attention

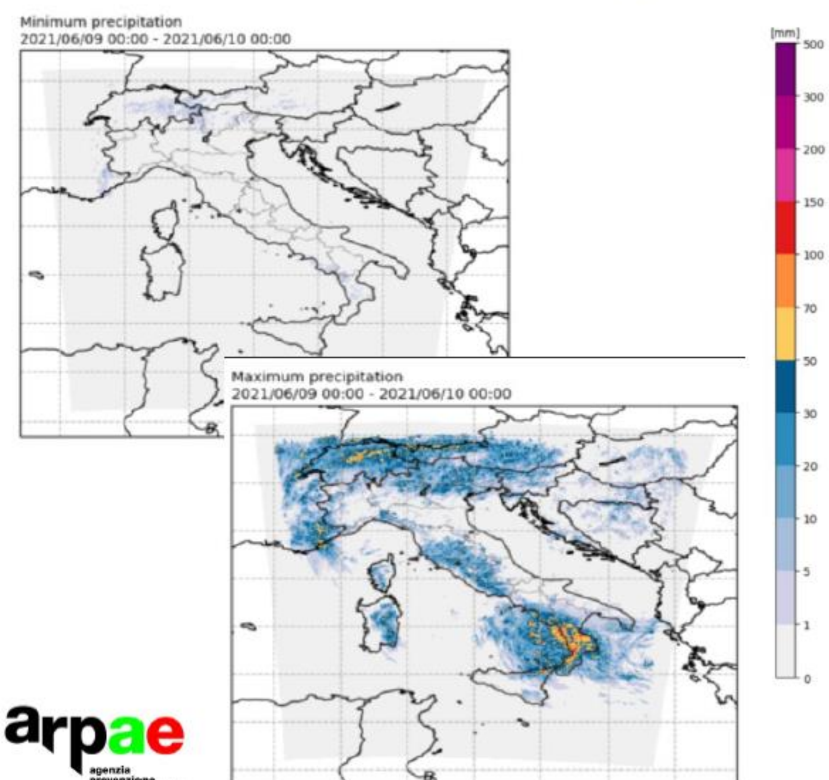


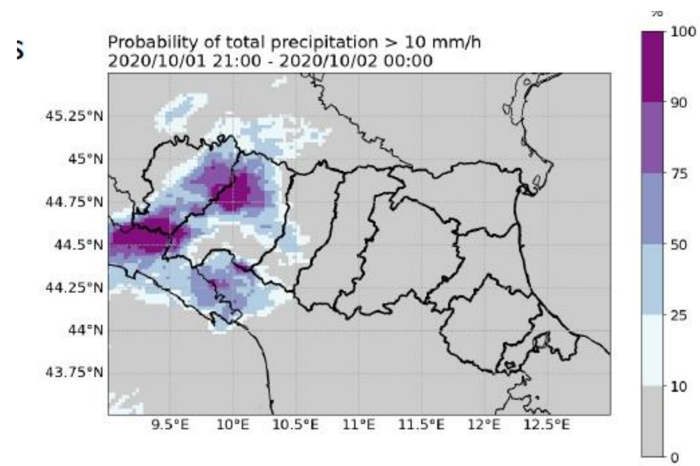


A. Walser, MCH

COSMO-2I-EPS

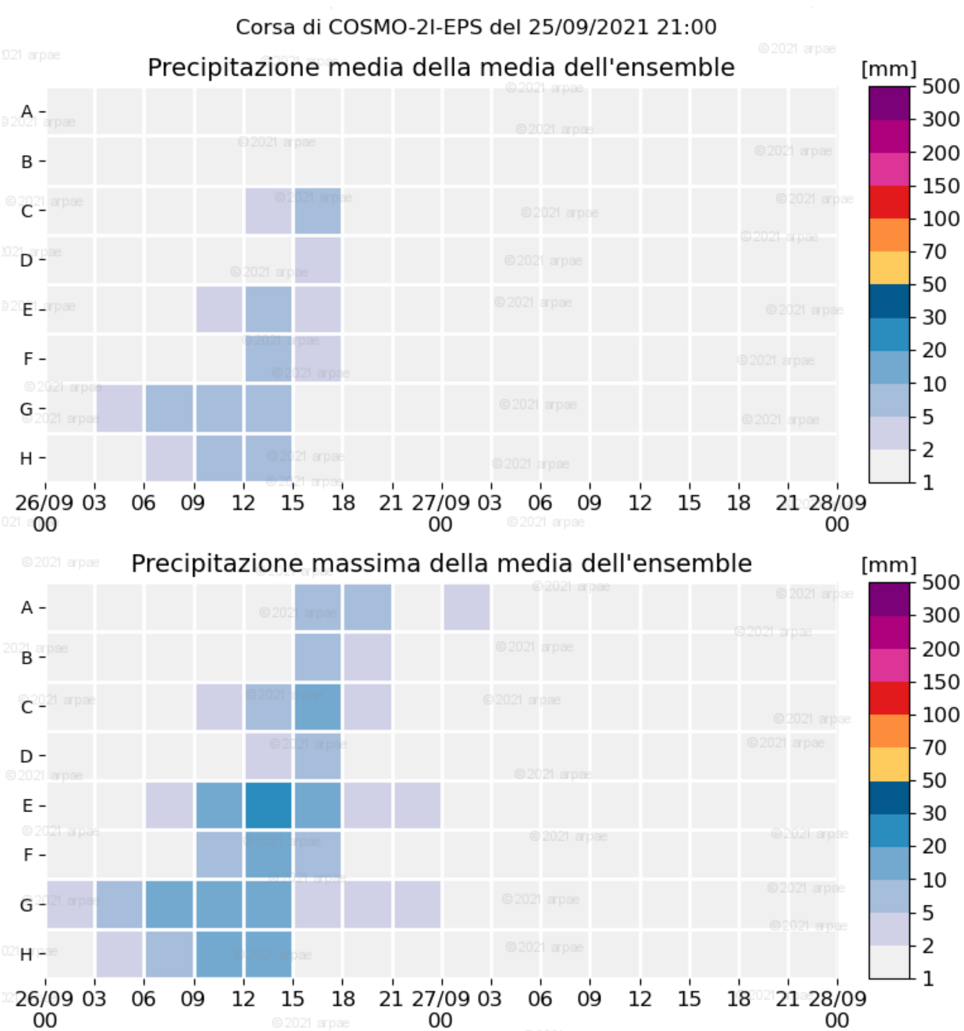
- Most likely scenario (mean)
- Extreme scenarios (min max)
- Probability maps
- Percentiles

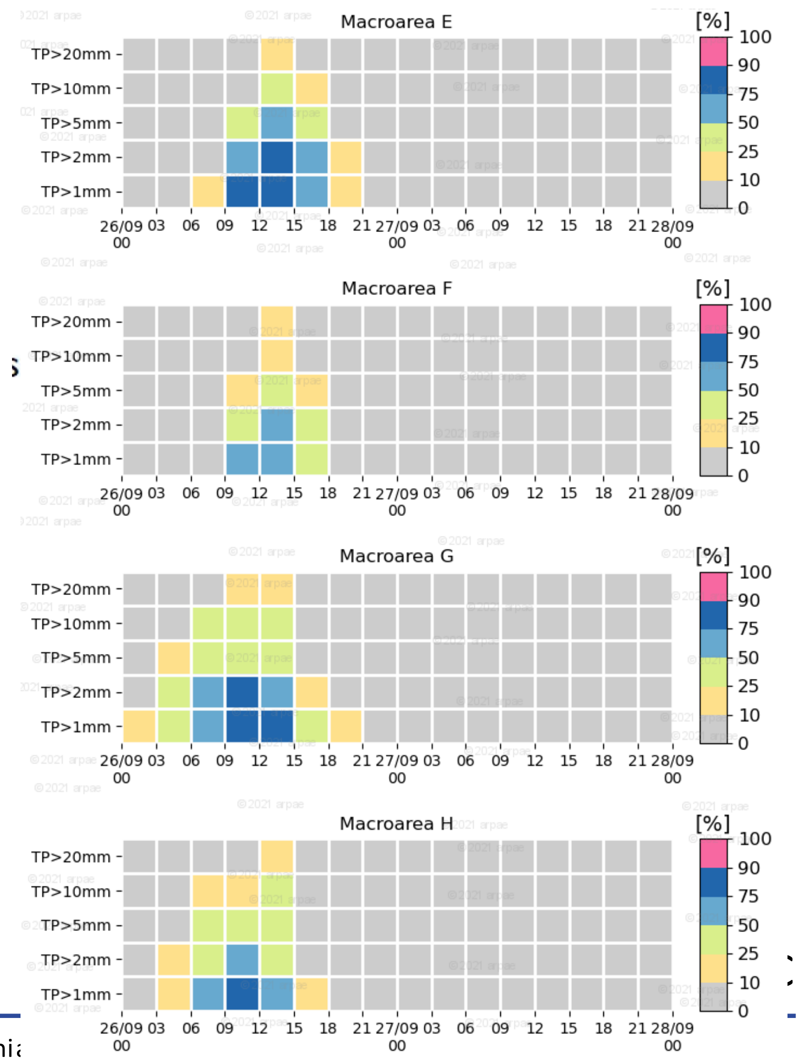




C. Marsigli, V. Poli et al., Arpae-SIMC

COSMO-2I-EPS





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Final remarks

- The transition of the ensembles to ICON is on-going
- Model perturbation schemes are further studied / developed /tested
- The ensemble development is becoming more and more part of the numerical modelling development
- It is needed to invest more in ensemble interpretation, in order to increase its usability and usage

Thank you for your attention!