Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Ensemble developments in COSMO

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Deutscher Wetterdienst

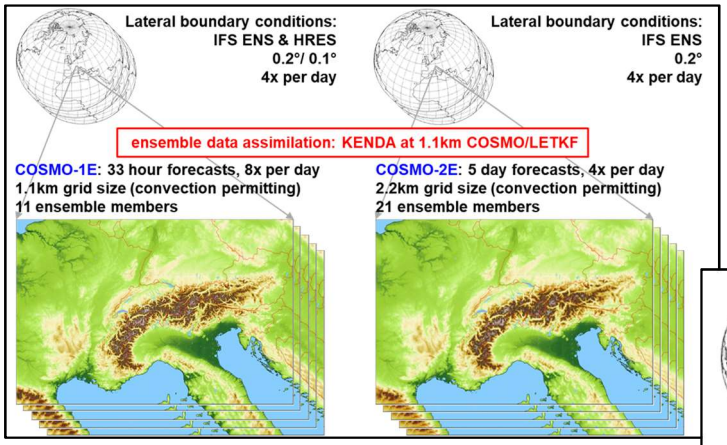
Arpae-SIMC

Outline

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

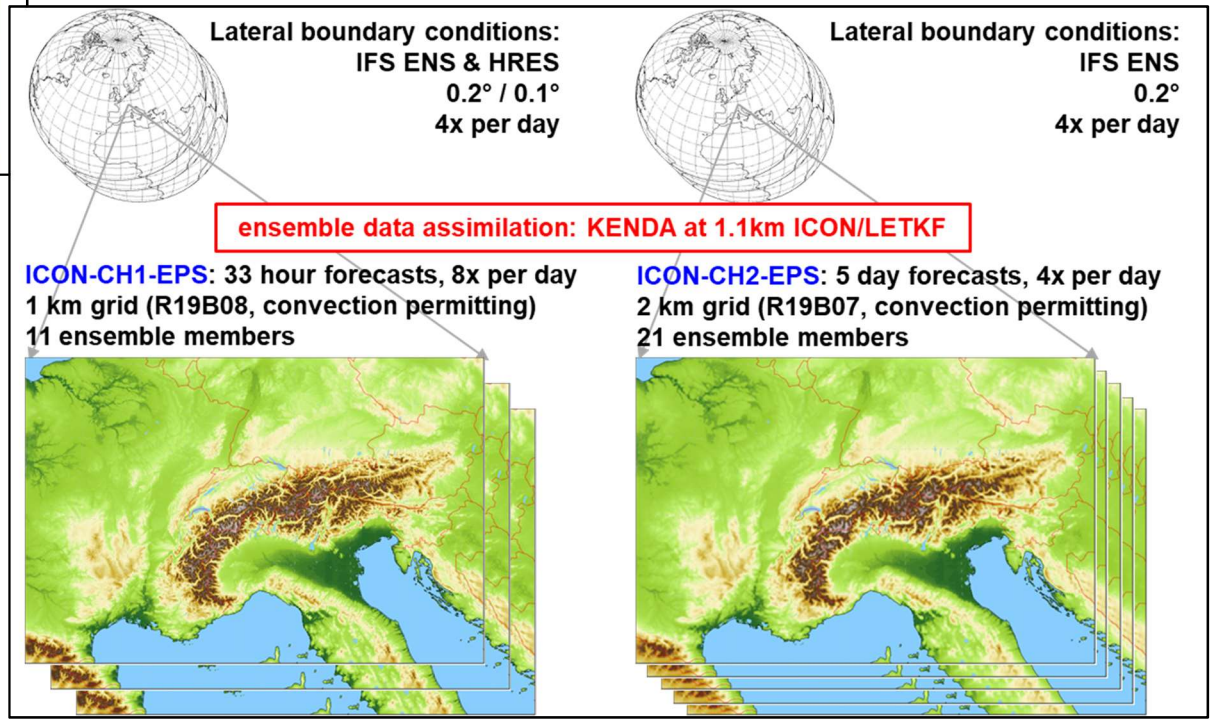
- Developments in the COSMO (Consortium) ensembles
- Model perturbation:
  - SPPT
  - Care in verification!
  - SPPT and PP
- Research on process-based perturbation:
  - PSP2: Physically based stochastic perturbations for subgrid turbulence

ICON-22 project: COSMO to ICON



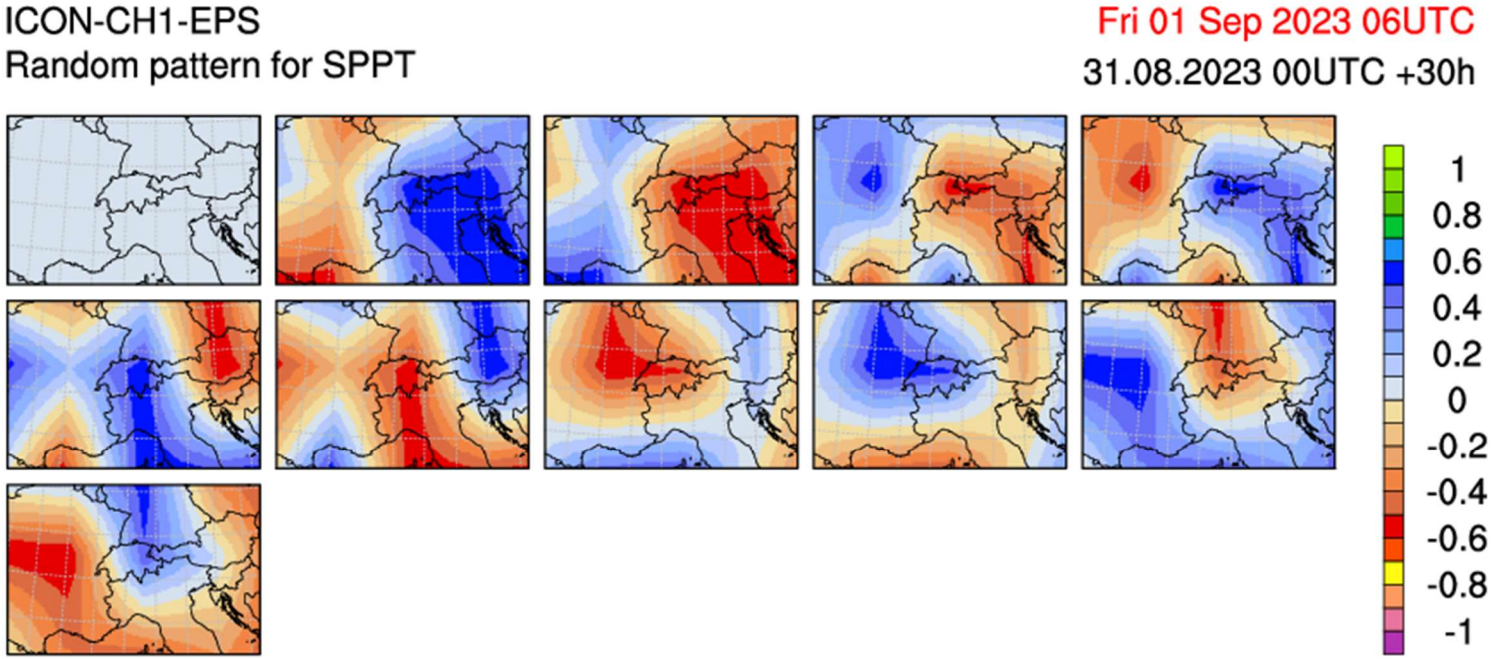
«1:1-replacement with ICON»

ICON-CHx-EPS test forecasts run twice a day coupled with KENDA-CH1 in real-time (since 15.5)



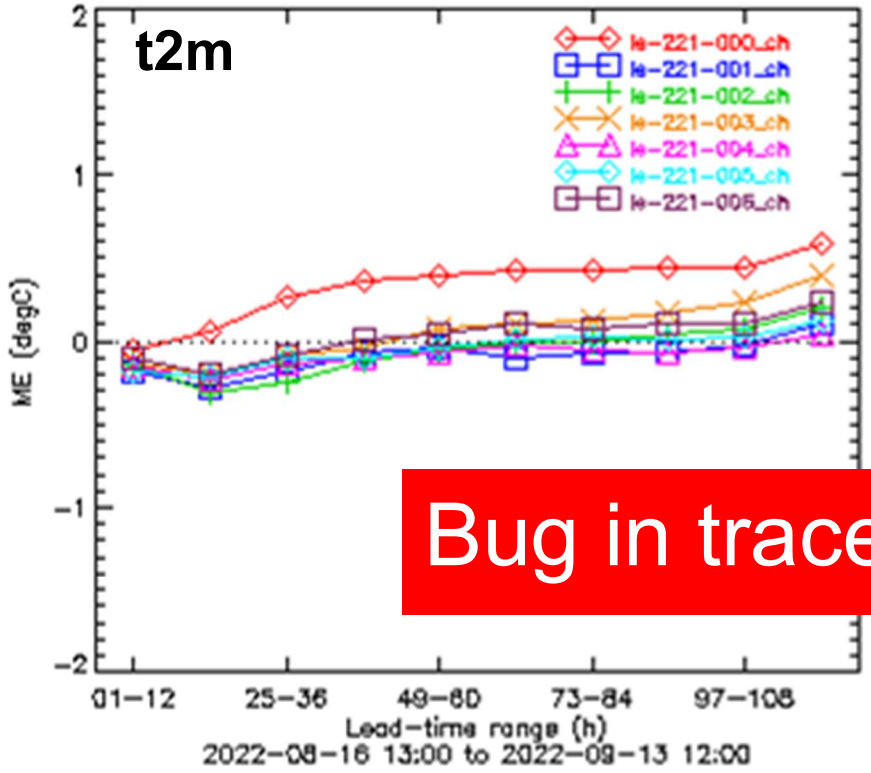
SPPT in ICON

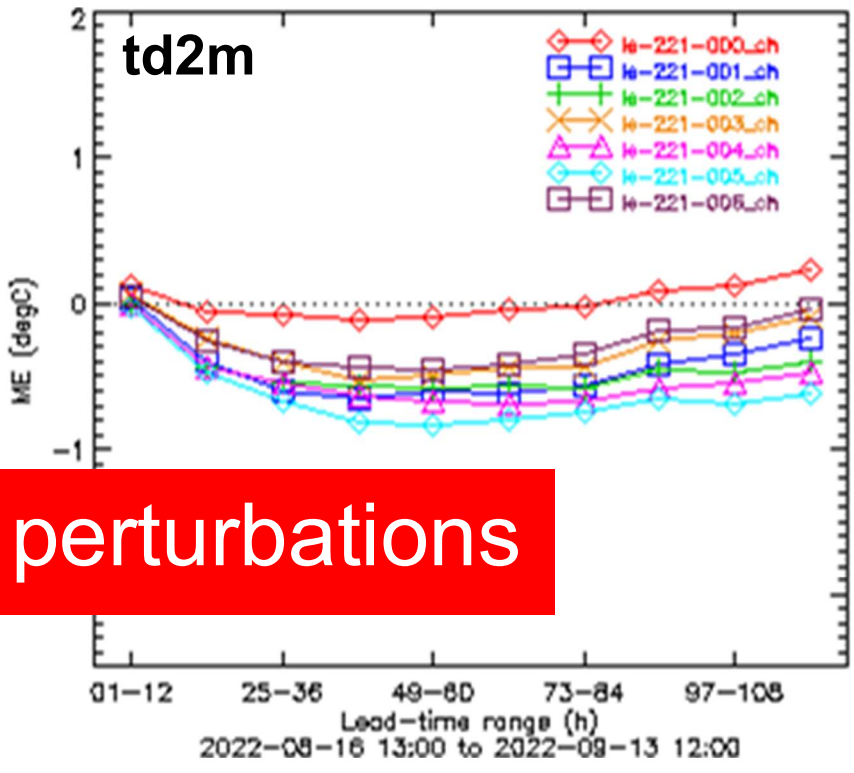
- SPPT implemented in ICON (S. Bellaire)
- new approach uses for every second member the opposed pattern from the previous one
- to better sample the PDF with small ensembles (Daniel Hupp)



control and mem 1-6 with SPPT

SPPT makes member colder and drier:

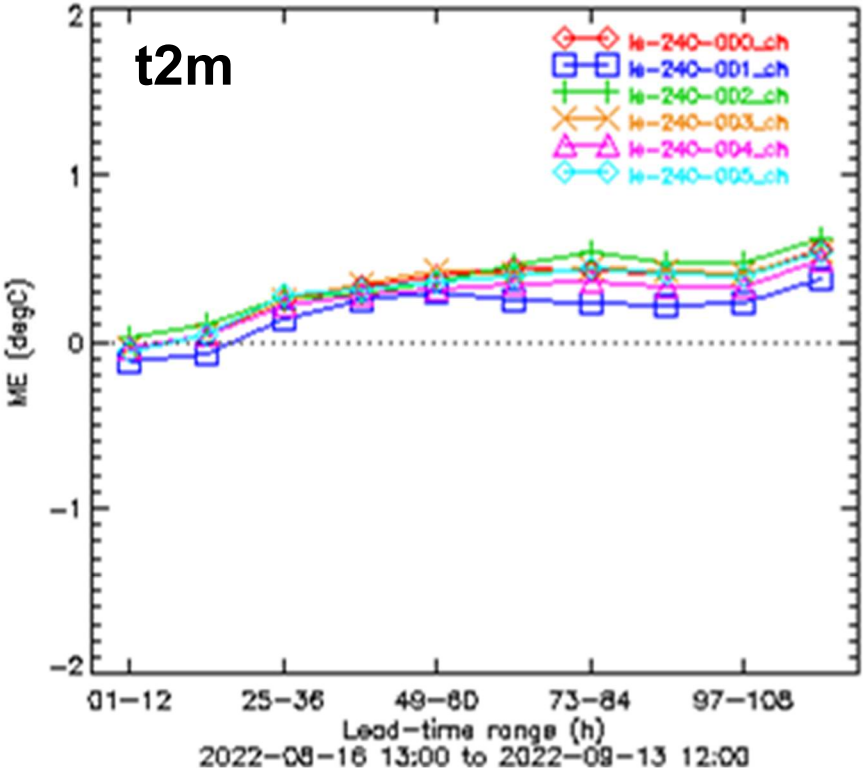


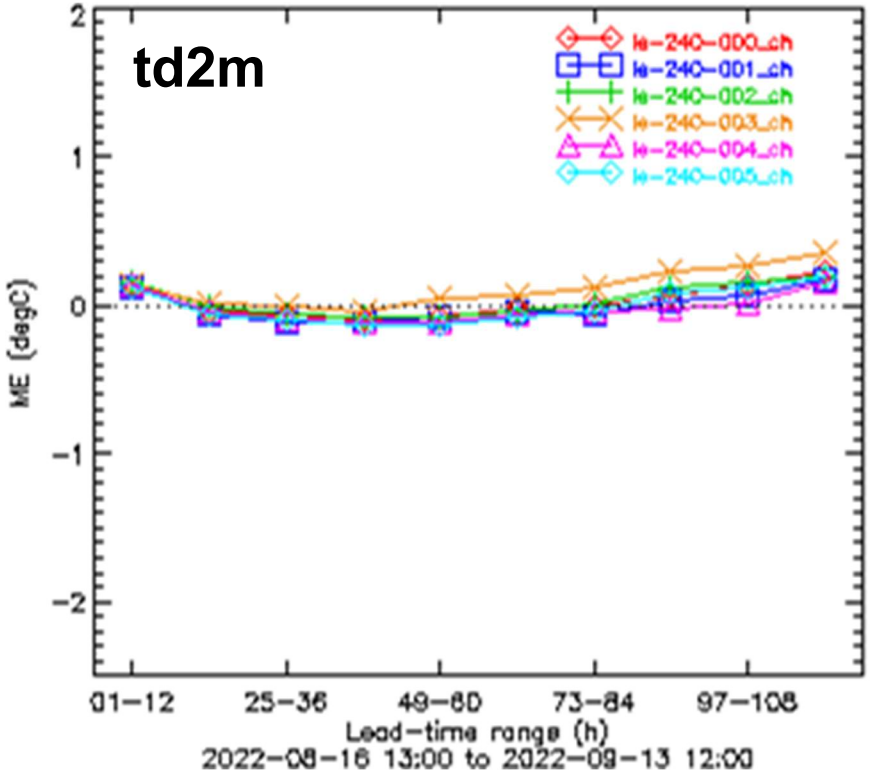


Bug in tracer perturbations

control and mem 1-6 with SPPT

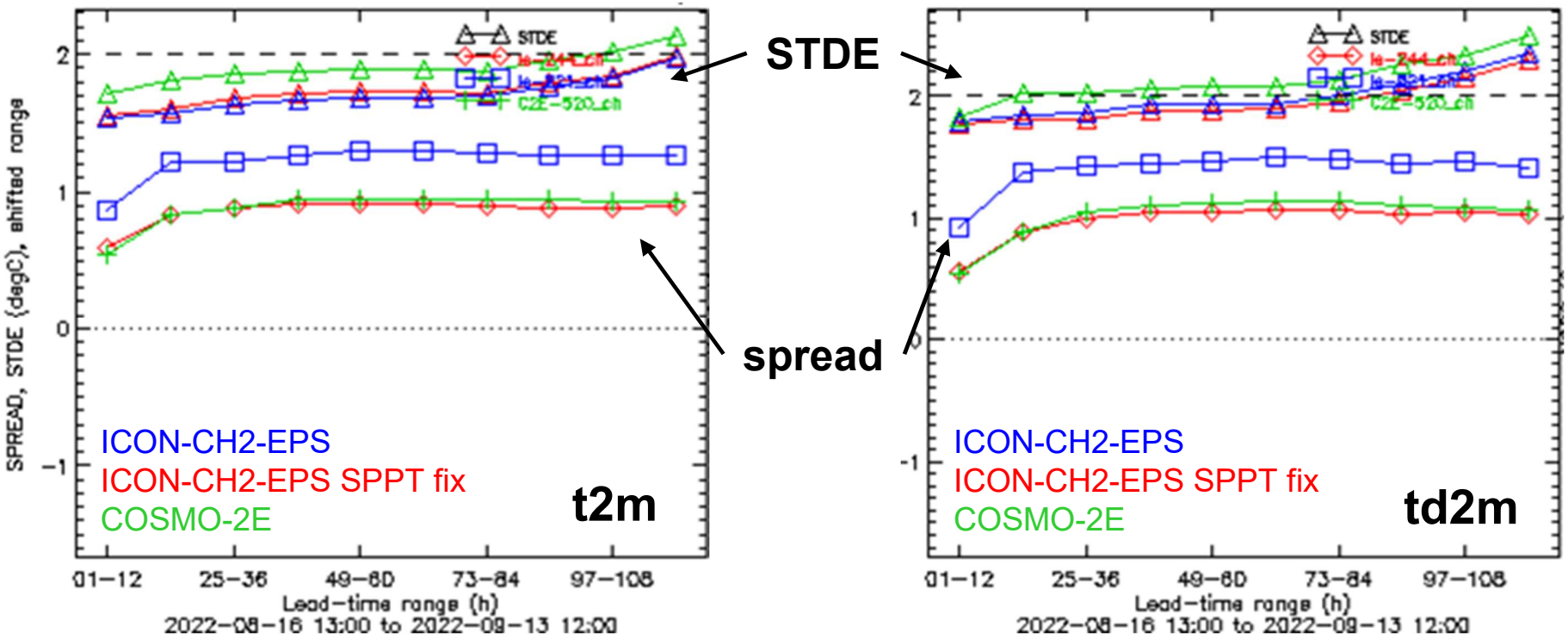
Fix removed the changes in the biases surprisingly!!





Impact of fix on ensemble spread

- spread decrease (!) with fix but is very similar to COSMO-2E
- STDE of ens mean error only slightly changed with fix



SPPT mystery in ICON…

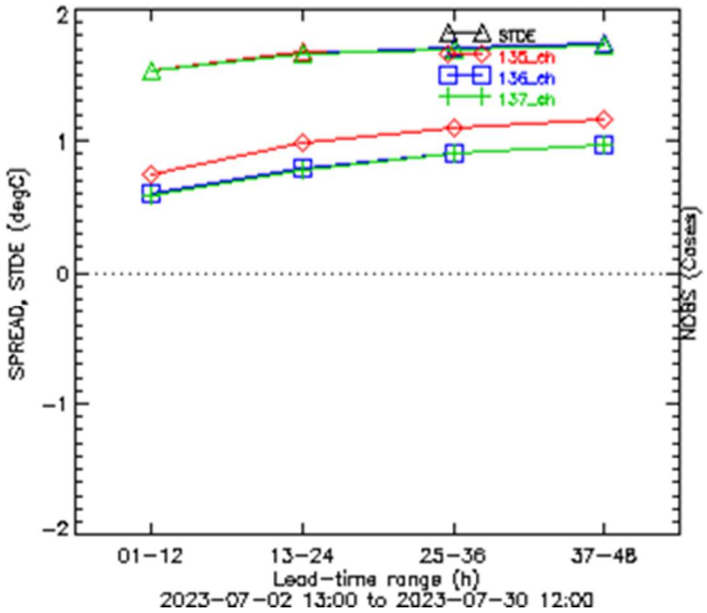
- SPPT bug fix for the amplitude of the perturbations for the water tracers, i.e. applying significant water tracer perturbations at all
  - eliminates the cold and dry bias of members with SPPT
  - reduces the ensemble spread significantly

- high non-linear interactions between temperature and missing corresponding water tracer perturbations, e.g. from microphysics, satad…?

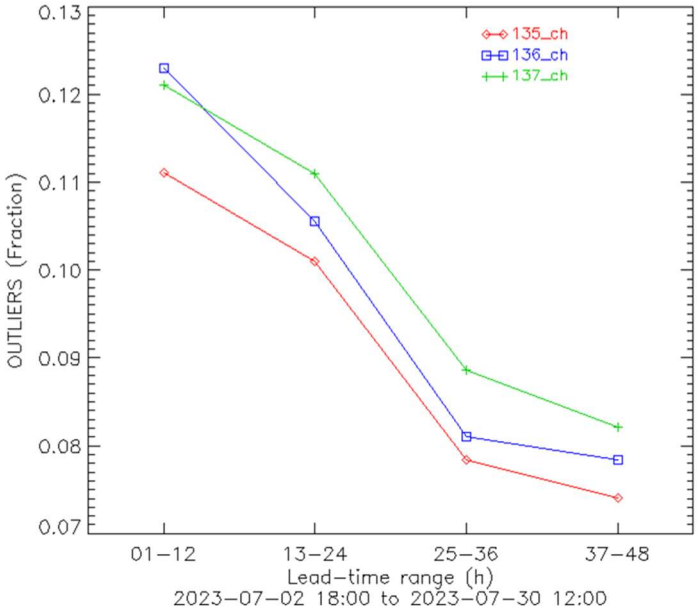
SPPT vs PP

SPPT
Parameter Perturbations
no model perturbations

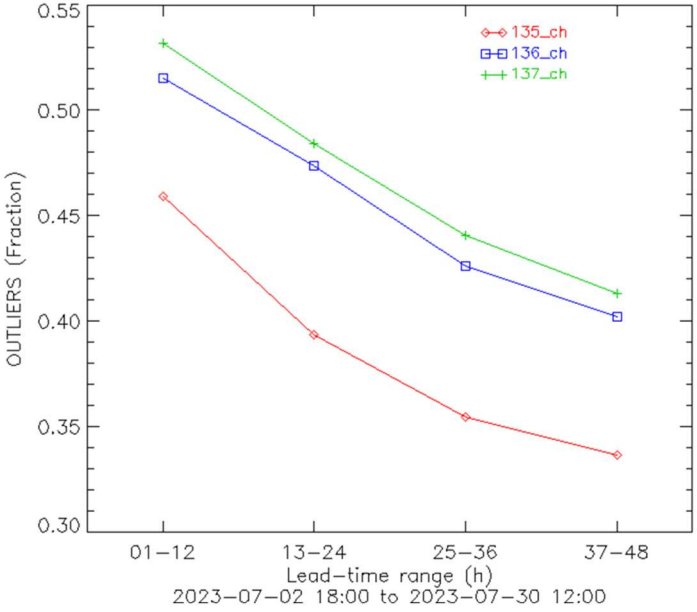
2m T



6h precip



6h vmax@10m



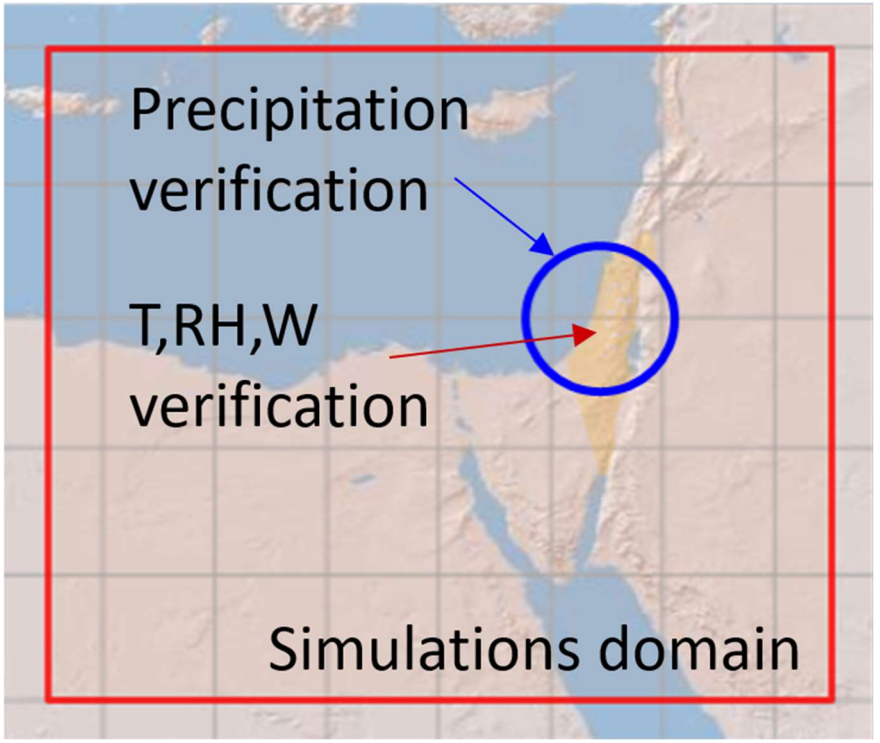
ICON ensemble (including SPPT) at IMS

ICON 20-members (2.5km resolution) driven by randomly selected ECMWF ensemble (EC-ENS) members over the Eastern Mediterranean using different perturbation methods.

- EC_ENS_51 - full ECMWF ensemble (EC-ENS)
- COSMO_SPPT_20 - Stochastic Perturbation of Physics Tendencies (SPPT)

New:

- ICON_20 - unperturbed
- ICON_PP_20 - Parameter Perturbation (PP)
- ICON_SPPT_20 - Stochastic Perturbation of Physics Tendencies (SPPT)
- ICON_SPPT4_20 – as previous but after precipitation calibration

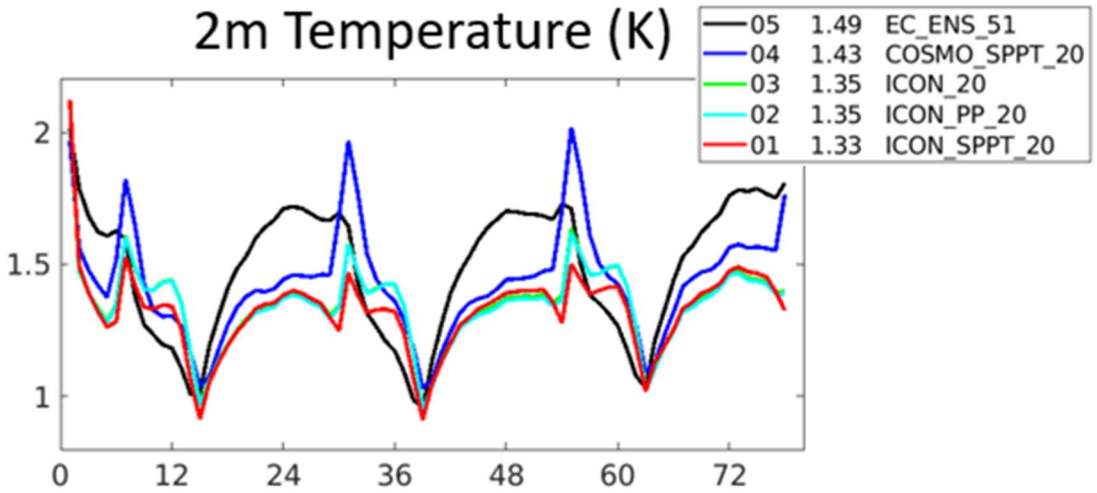


P. Khain, S. Bellaire, A. Shtivelman

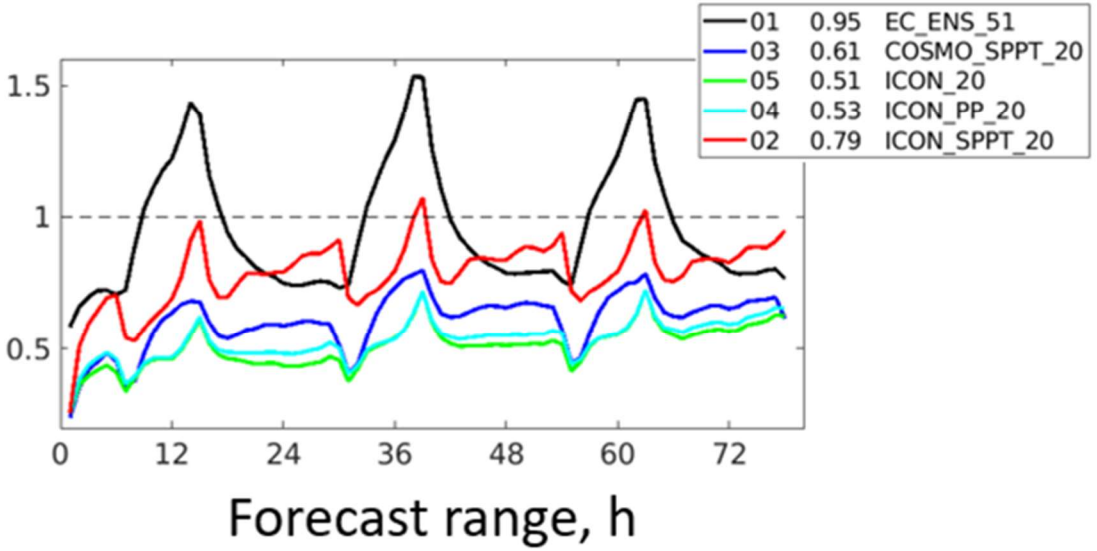
reminder

Spread Skill verification

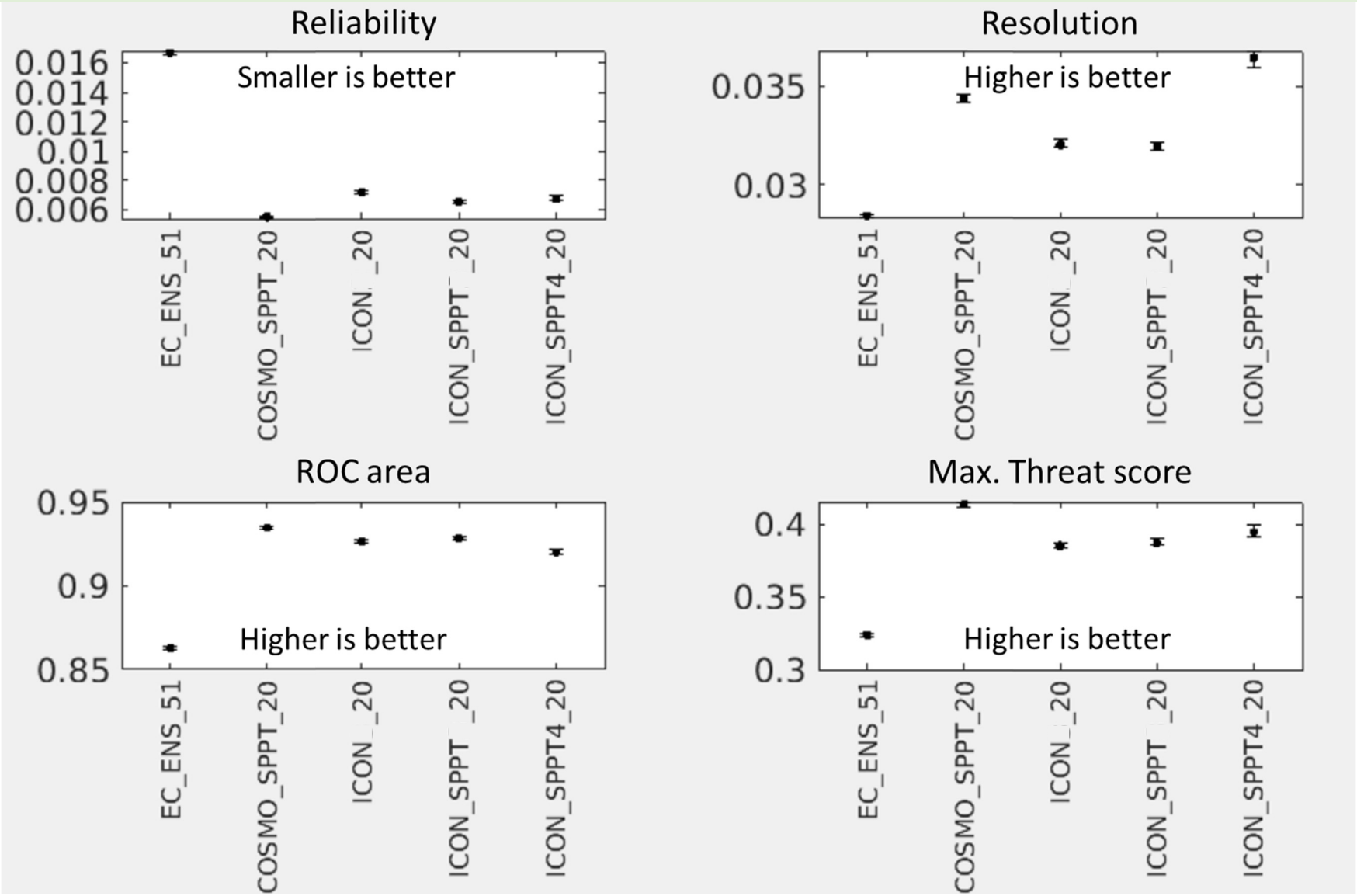
Unbiased RMSE of ensemble mean ($RMSE_e$)



Spread-skill ratio: ensemble spread*/$RMSE_e$



Precipitation verification



Physically based model perturbation: PSP2

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WAVES TO WEATHER

Physically based stochastic perturbations for boundary layer turbulence :

PSP (Kober and Craig, 2016)

PSP2 Hirt et al., 2019

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

ϕ ={T, q, w}

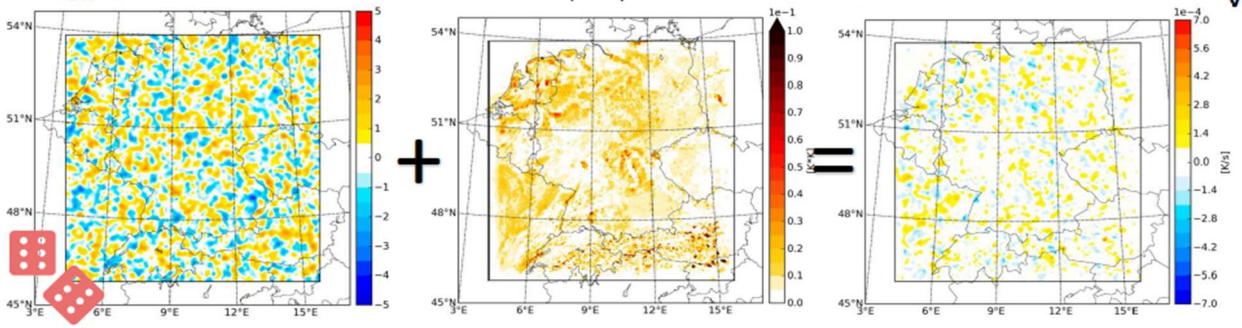
$\eta(t, \sigma)$: Random field , regenerated every 10 min with spatial correlation σ

α: perturbation ampl., scaling factors

ϕ': physical scaling/subgrid-scale variance of variable ϕ

η_{sh}: gaussian random field

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



(Kober and Craig, 2016)

PSP2: impact on convection initiation

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RESEARCH ARTICLE

Physically based stochastic perturbations improve a high-resolution forecast of convection

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Abstract

A physically based stochastic perturbation (PSP) scheme has been implemented in the convection-permitting ICON-D2 ensemble prediction system at Deutscher Wetterdienst (DWD) and run for a three-month trial experiment in summer

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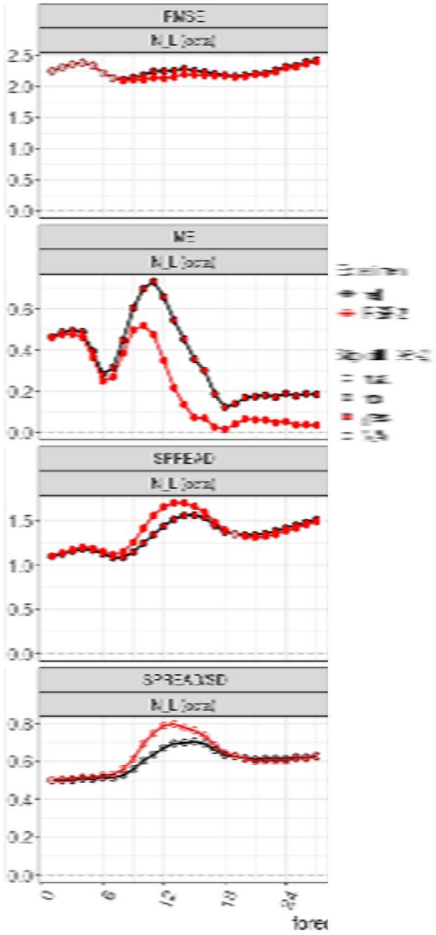
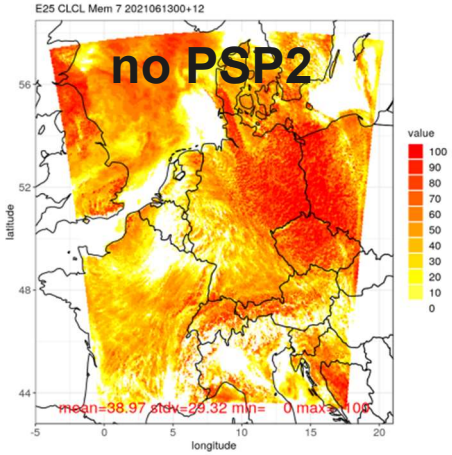
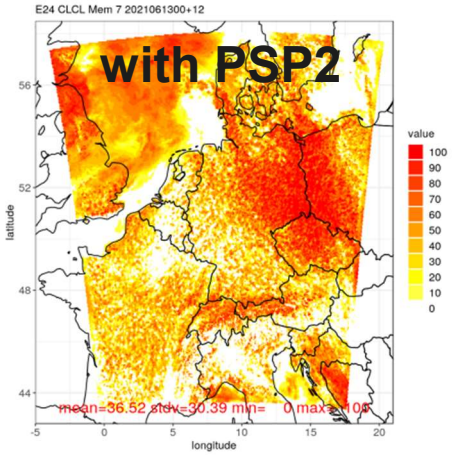
C. Gebhardt, C. Marsigli (DWD)

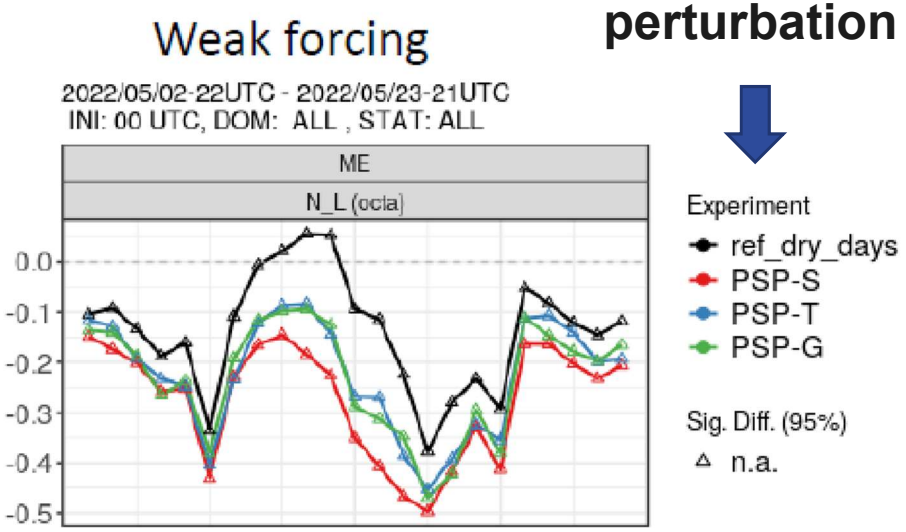
PSP2: testing different vertical profiles







different vertical profiles of the perturbation



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S. Löber, A. de Lozar (DWD)
C. Gebhardt, C. Marsigli (DWD)

PSP2: impact on convection initiation

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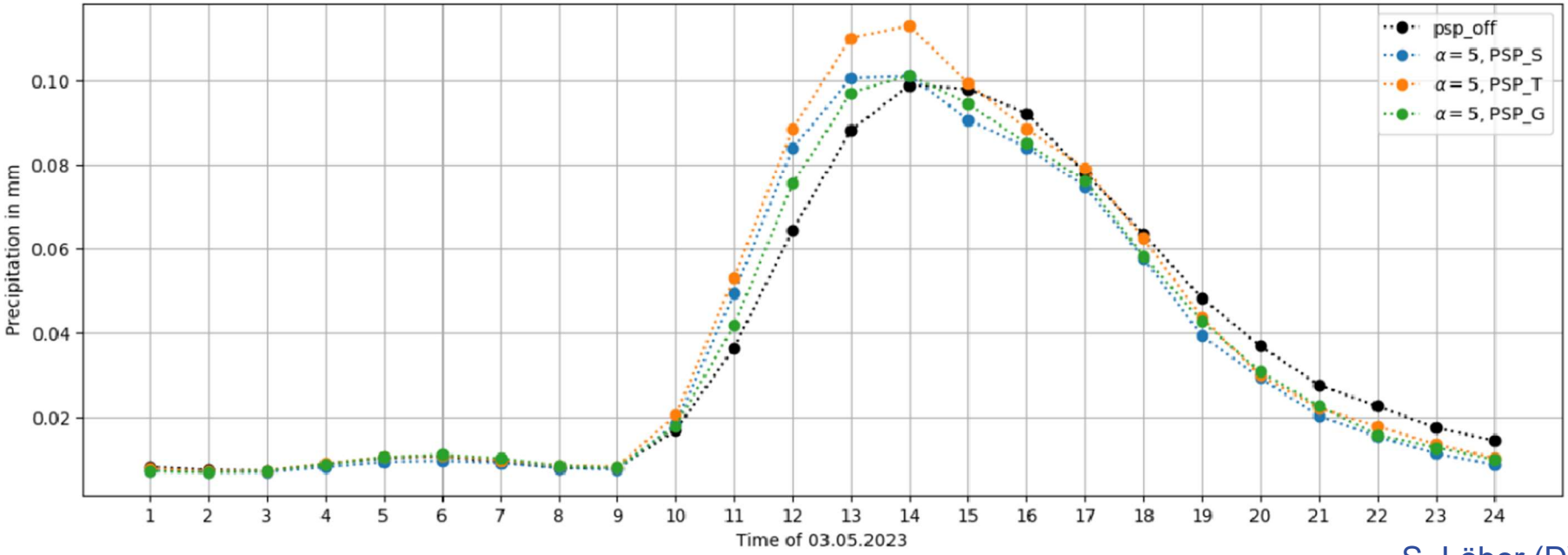
- Typical course of a day with weak convective forcing
- Earlier start of the precipitation for all vertical profiles
  -> with tanh also a greater amount



S. Löber (DWD)

Concluding remarks

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DWD

- SPPT implemented in ICON, with a Stochastic Pattern Generator
  - Good results at MeteoSwiss and IMS, but difficult to prove a benefit for precipitation
  - Small effect of Parameter Perturbations
- Research on process-based perturbations continues
- Start the implementation of SPP (for the GLORI DT)

Thank you for your attention!

SPPT namelist switches in ICON (sppt_nml)

switch	default	ICON-CHx-EPS exp.	description	remarks
lsppt	.false.	.true.		
hinc_rn	21600	21600	time increment (s) for drawing a new field of random numbers	
dlat_rn	0.1	5.0	random number coarse grid point distance in meridional direction (deg)	
dlon_rn	0.1	5.0	random number coarse grid point distance in zonal direction (deg)	
range_rn	0.8	0.6 / 0.8	max magnitude of random numbers	
stdv_rn	1	1	standard deviation of the gaussian distribution of random numbers	is still ignored

Model setup

- setup for ICON-CHx-EPS and KENDA-CH1 basically copied from ICON-D2

- main differences:
  - lgrayzone_deepconv = .false.
  - no adaptive tuning (yet)
  - HWSD soil type (higher resolution)
  - model perturbations: SPPT instead of PP, however…

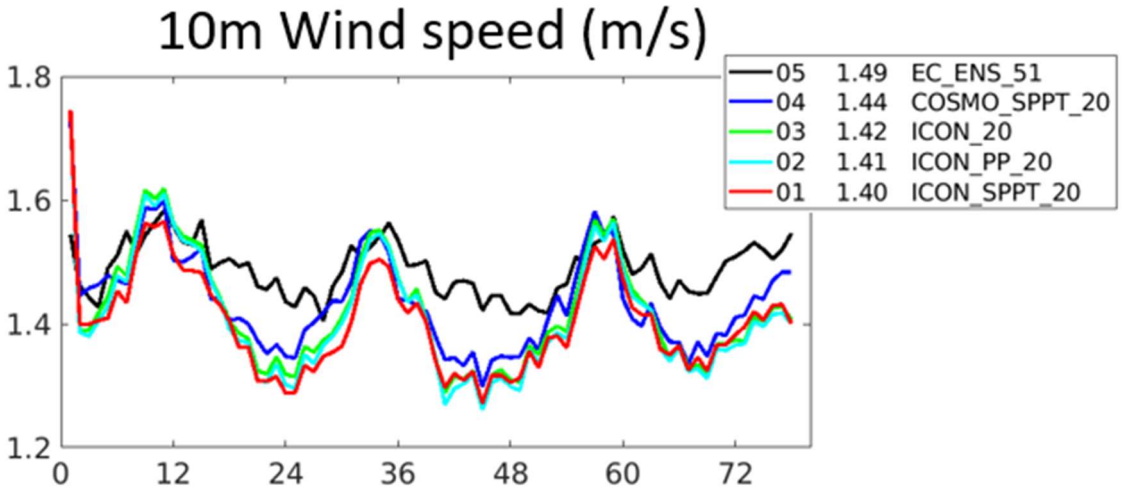
SPPT / PP tests with ICON-CH1-EPS

- 4 weeks period: 2023-07-01 to 2023-07-28
- 00 and 12 UTC forecasts
- up to +48h
- IC perturbations: KENDA-CH1 (real-time suite)
- LBCs perturbations: IFS-ENS
- exp 135: SPPT, range_rn=0.6
- exp 136: Parameter Perturbations (PP) as ICON-D2-EPS
- exp 137: no model perturbations
- surface verification for CH, verification with radio-sounding for entire domain

reminder

Spread Skill verification

Unbiased RMSE of ensemble mean ($RMSE_e$)



Spread-skill ratio: ensemble spread*/$RMSE_e$