

Ensemble activities in COSMO

Chiara Marsigli
Arpae-SIMC

- implementation, tuning and testing of SPP in ICON (DWD)
 - task of GLORI, focus on Alpine domain
- perturbation of soil temperature (IMGW)
- study of the excessive ensemble spread for precipitation (MeteoSwiss)
 - (an ensemble of headaches)
- ensemble for Nowcasting (IMS)
- transition to ICON-LEPS
 - verification to be performed
 - once the transition is completed, activate also model perturbation

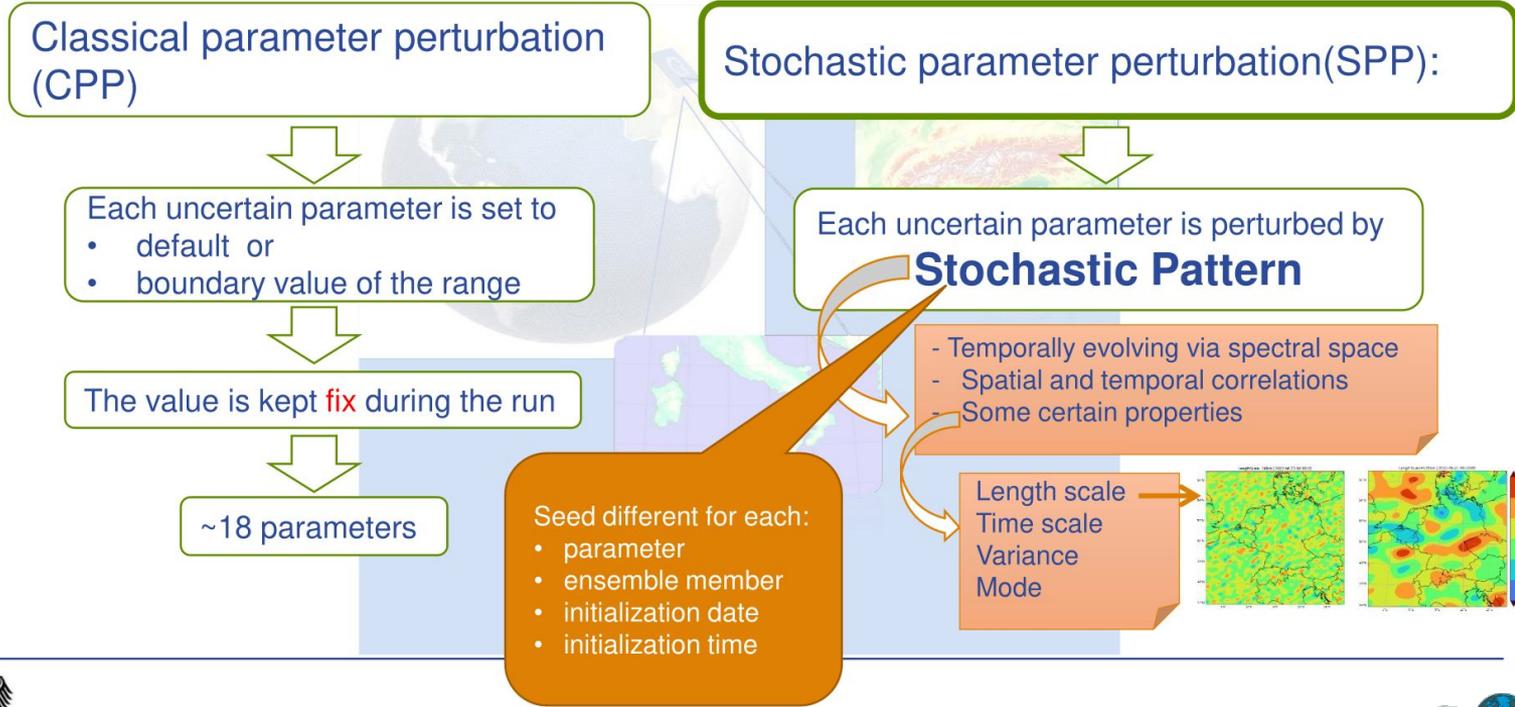
Implementation of the SPP scheme in ICON and first results



Zahra Parsakhoo, Chiara Marsigli, Christoph Gebhardt

With special thanks to Axel Seifert and Daniel Reinert

CPP vs. SPP: Key Differences



SPG implementation in ICON

Stochastic Pattern Generator (SPG)

By Axel Seifert and Maleen Hanst

Deterministic forecast
Coupled with microphysics

$$\text{perturbed} = \text{unperturbed} \times \exp(\text{SPG})$$

- Sensitivity tests on SPG variance: ≤ 0.4 model is numerically stable
- Test for ICON-LAM: real case study on 21.06.22 coupled to 2mom microphysics
→ For perturbing sedimentation velocity of graupel
- Further development for EPS
- Coupled to convection → rdepths (Maximum allowed shallow convection depth)
- Coupled to land → cr_bsmin (Minimum bare soil evapotranspiration resistance)



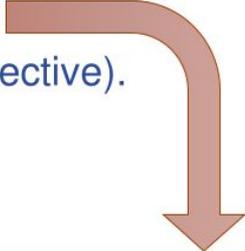
SPP in ICON : Technical & Theoretical Test

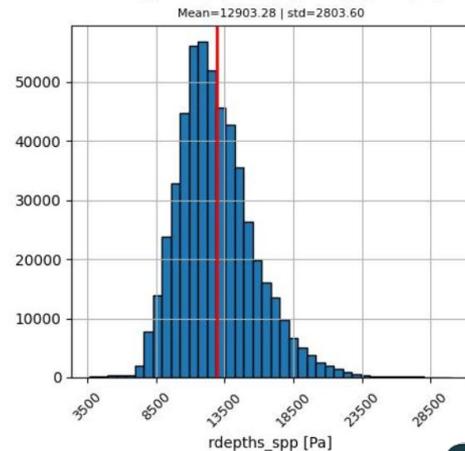
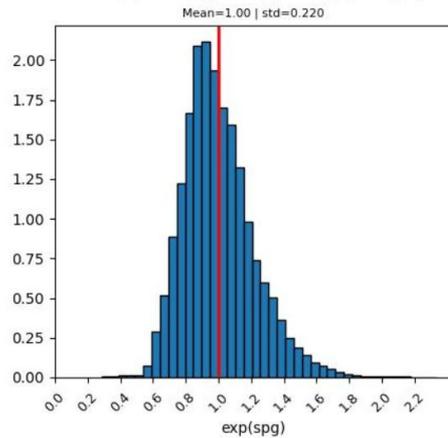
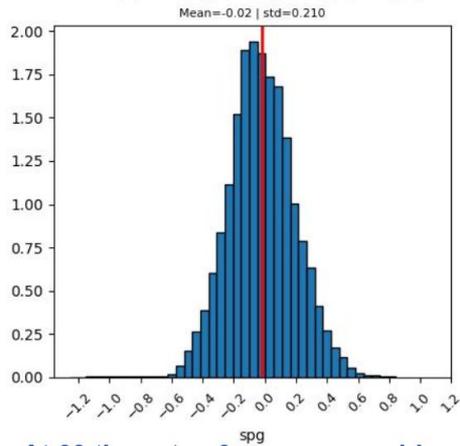
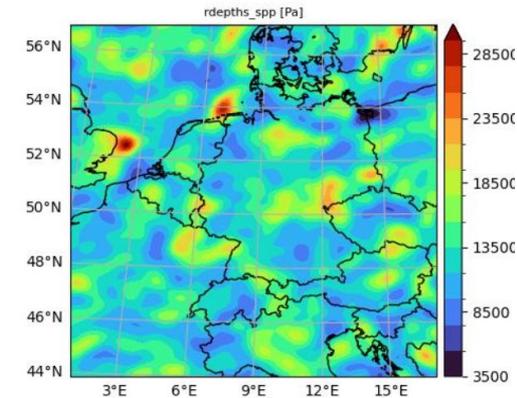
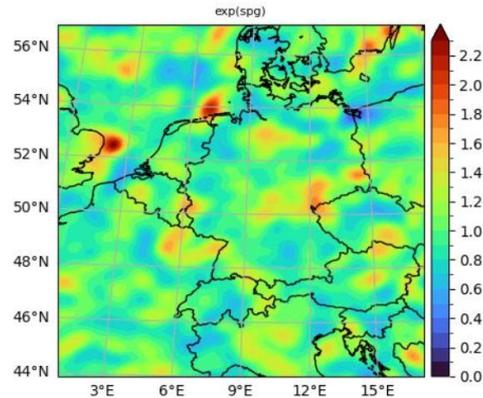
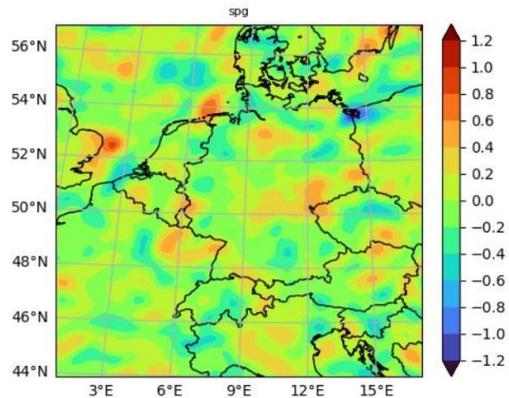
To evaluate

- stochastic patterns and
- parameter behavior before and after SPP (both from a technical and theoretical perspective).

SPG properties (namelist):

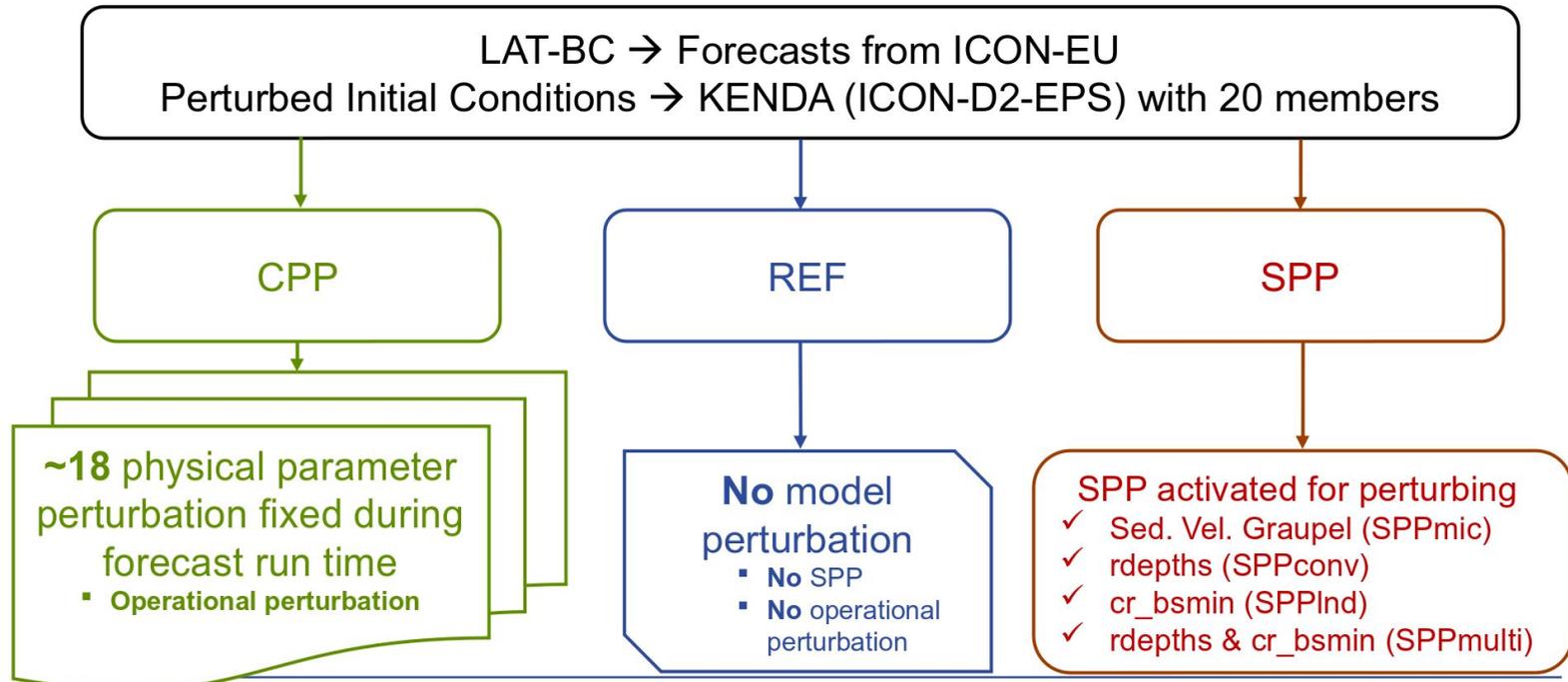
```
spg_fourier_modes = .true.  
spg_length_scale = 50e3 [m]  
spg_time_scale = 3600 [s]  
spg_spec_modes = 50  
spg_variance = 0.2
```


$$\text{perturbed} = \text{unperturbed} \times \exp(\text{SPG})$$

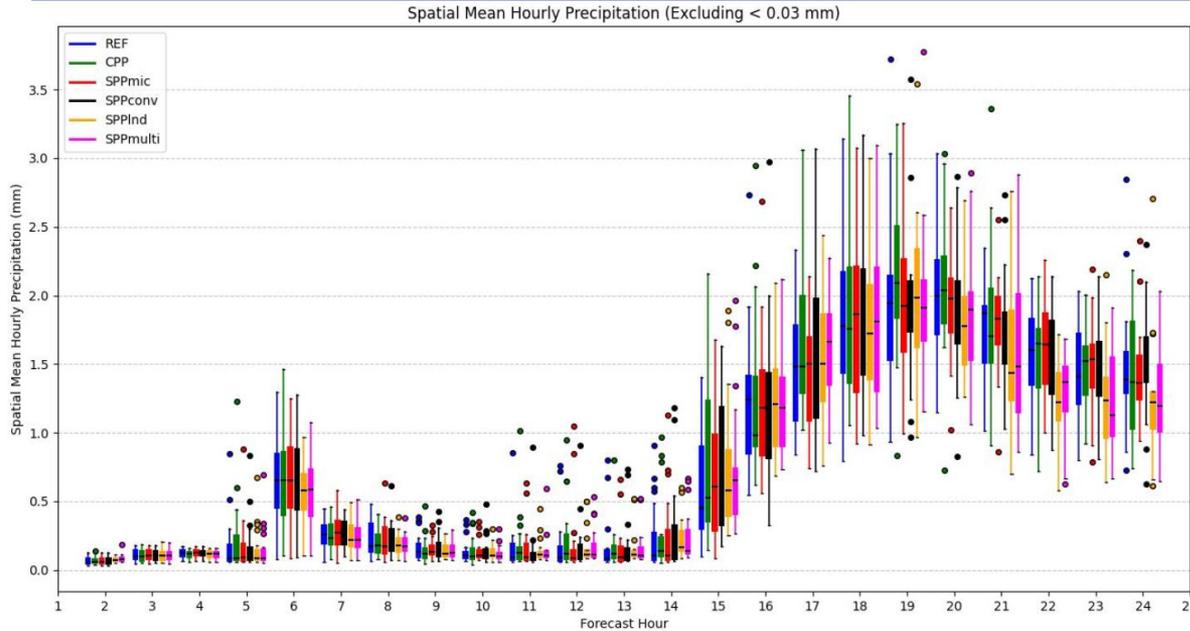


At 00 time step for one ensemble member

Test Setup



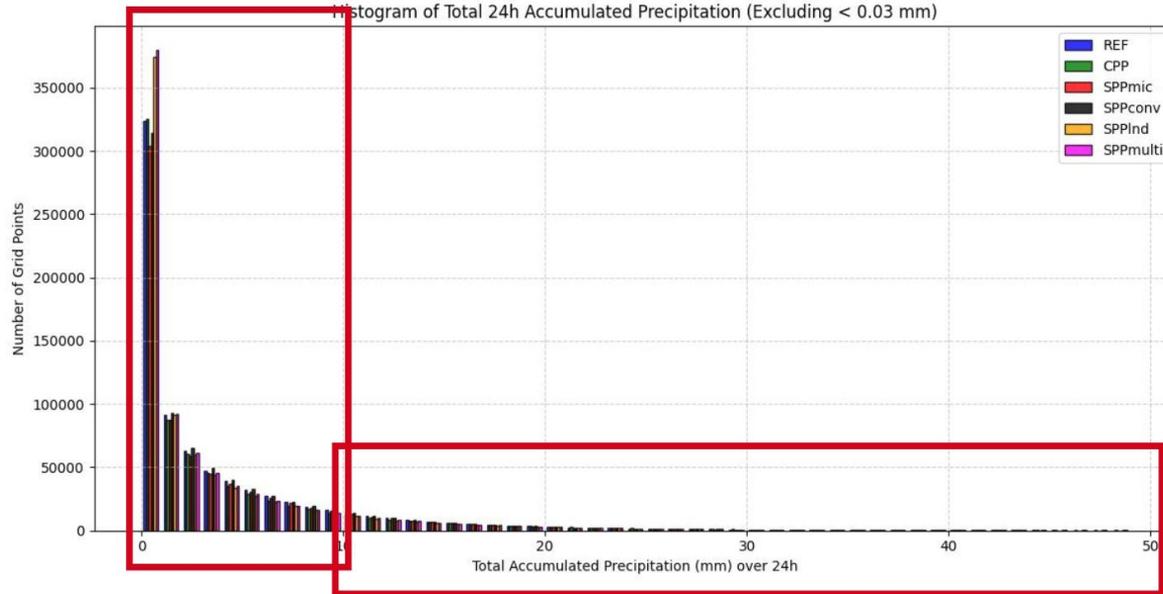
Statistical Analysis



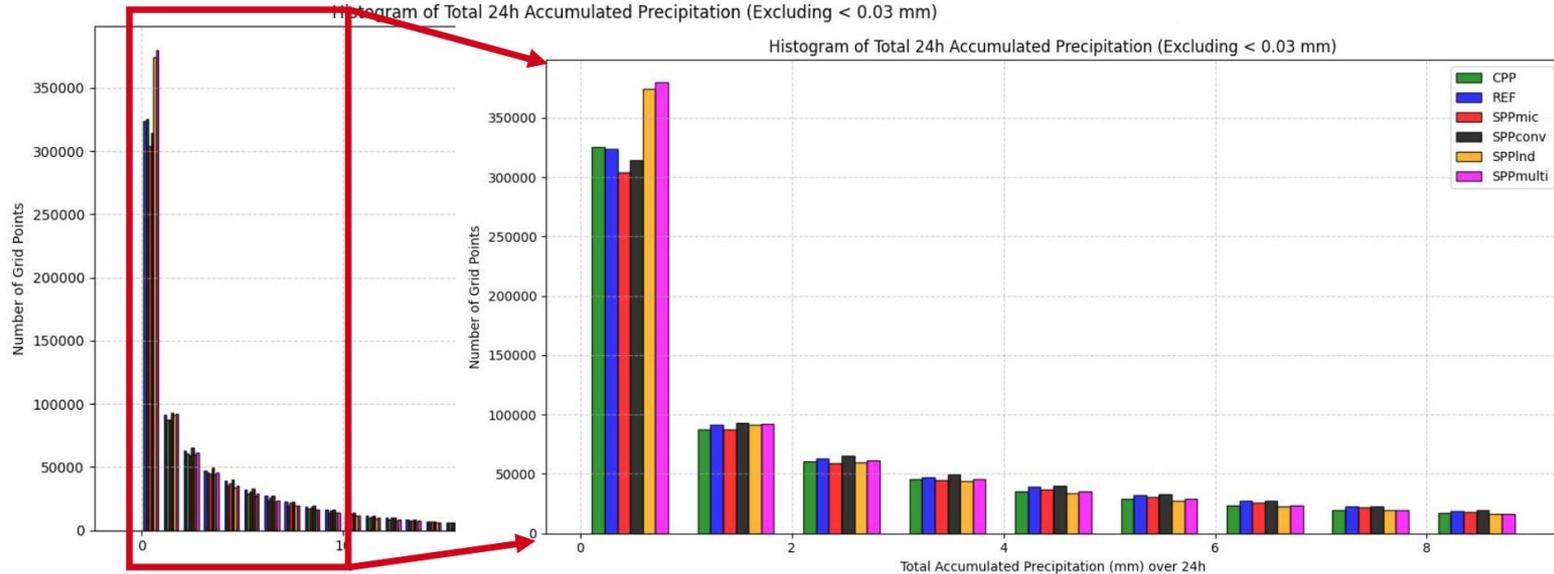
Box-Whisker plot:

- The larger distribution (wider min-max range) observed in CPP indicates a higher level of perturbations.
- The medians across the different experiments are very similar, showing consistency.

Statistical Analysis

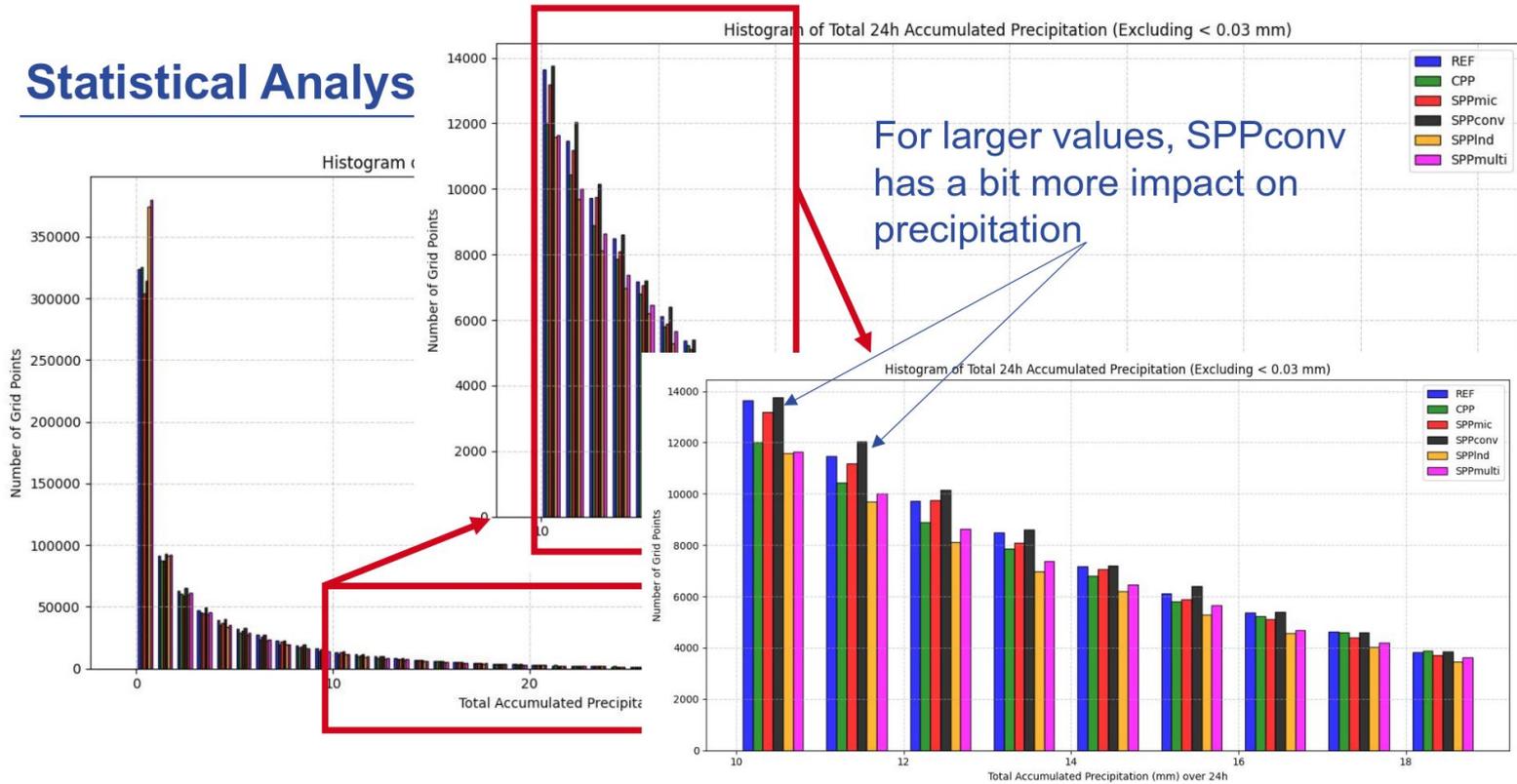


Statistical Analysis

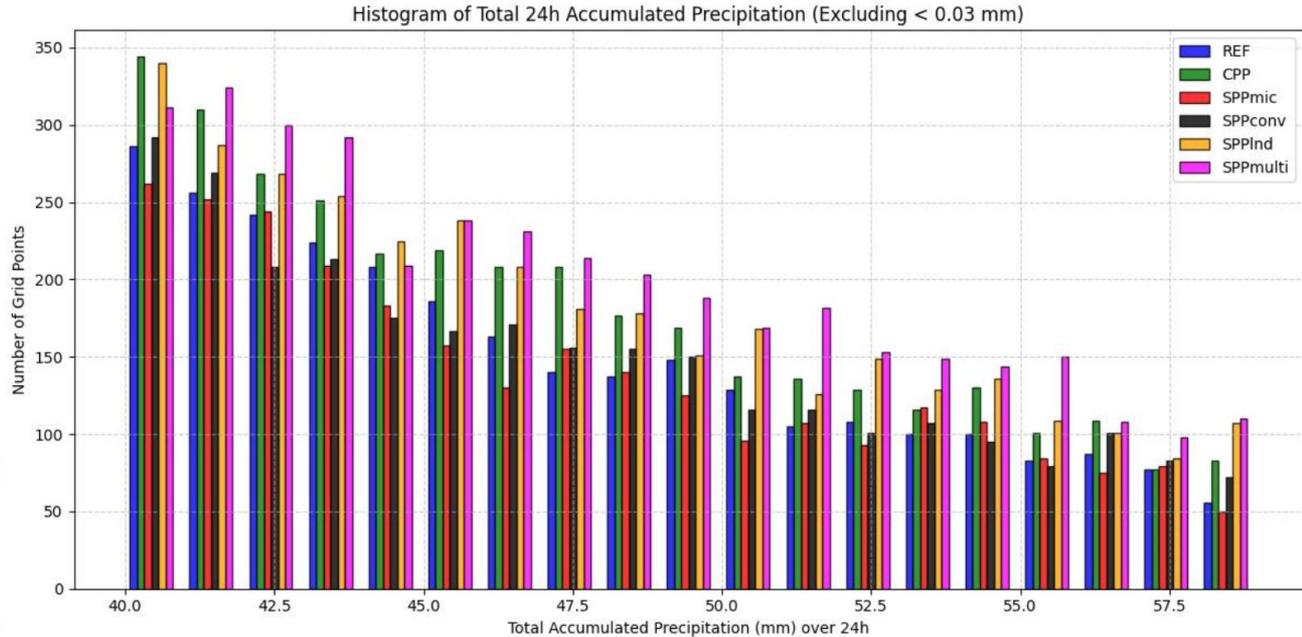
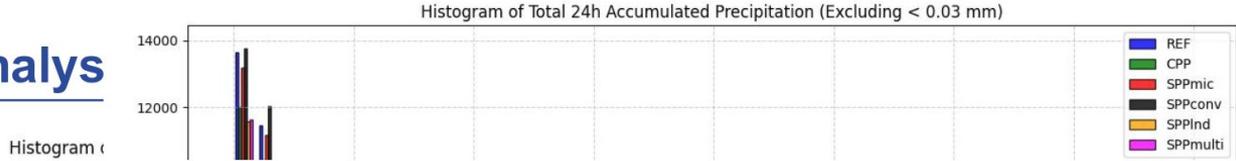
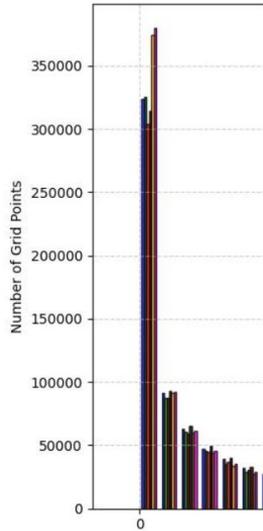


The difference is too small. However, for small values, SPPInd has larger impact on rain

Statistical Analysis



Statistical Analysis



SPP in ICON

Summary

- SPG Implementation is done by Axel Seifert (since June 2025 is merged in ICON-Master),
- SPP Implementation has been tested for 3 parameters (sed. vel. graupel, rdepths and cr_bsmin) and multiSPP (rdepths & cr_bsmin) successfully with ICON-LAM.
 - Initial tests confirm expected behavior of the SPP scheme
 - Findings motivate the need for additional cases to ensure robustness

Outlook

- **Implementation:**
 - More case studies
 - Test other physical uncertain parameters
 - Multi-parameter perturbation
 - Nest: First test uncoupled at 500 m resolution, then fully coupled with SPP.
- **Benchmarking:**
 - Tuning SPG in ICON-LAM-D2: Optimize values for SPG parameters (e.g., length scale, wave mode, temporal scale) for perturbing physical parameters.

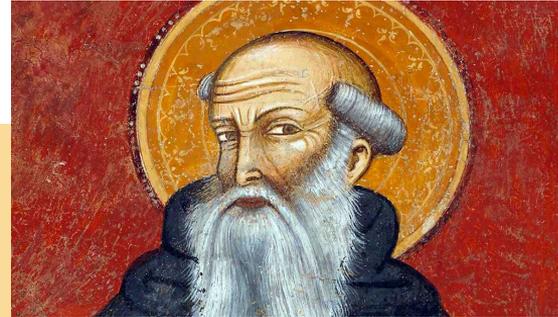
Thank you!

Refining SPP for Higher Resolution: Focus on 1 km resolution for the GLORI Alpine region.



“Be careful what you wish for, lest it come true”

Aesop's Fables





Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

Update from MeteoSwiss concerning excessive ensemble spread for precipitation

Marco Arpagaus for the MeteoSwiss team

COSMO General Meeting, 01.09.2025



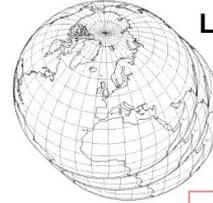
Forecasting System based on ICON

recap
2024

Ensemble Data Assimilation:

LETKF

40+1 members at 1.0 km grid size
with ICON-CH1 setup (SPPT)
hourly cycling



Lateral boundary conditions:

IFS ENS

9 (18) km

4x per day

operational since 28 May 2024

ICON-CH1-EPS: 33 hour forecasts, 8x per day

1.0 km grid size (R19B08), 80L

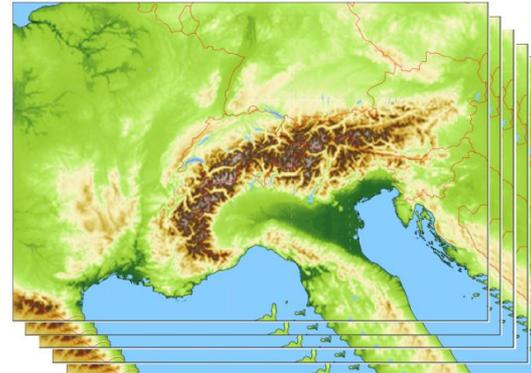
11 ensemble members



ICON-CH2-EPS: 5 day forecasts, 4x per day

2.1 km grid size (R19B07), 80L

21 ensemble members

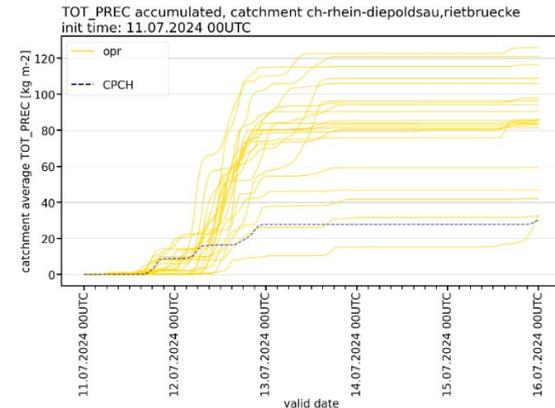
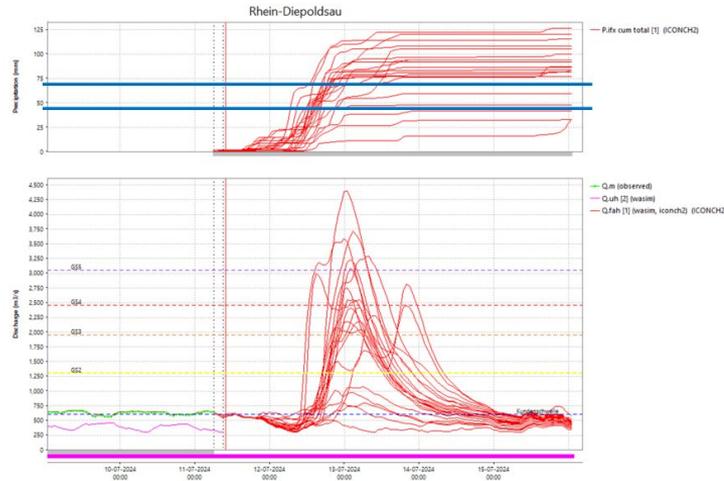




recap
2024

Excessive ensemble spread for precipitation

Hydrologists: “excessive spread and frequent overestimation in the runoff forecasts”
→ multiple events in early summer 2024 (May-Jul); large convective contributions



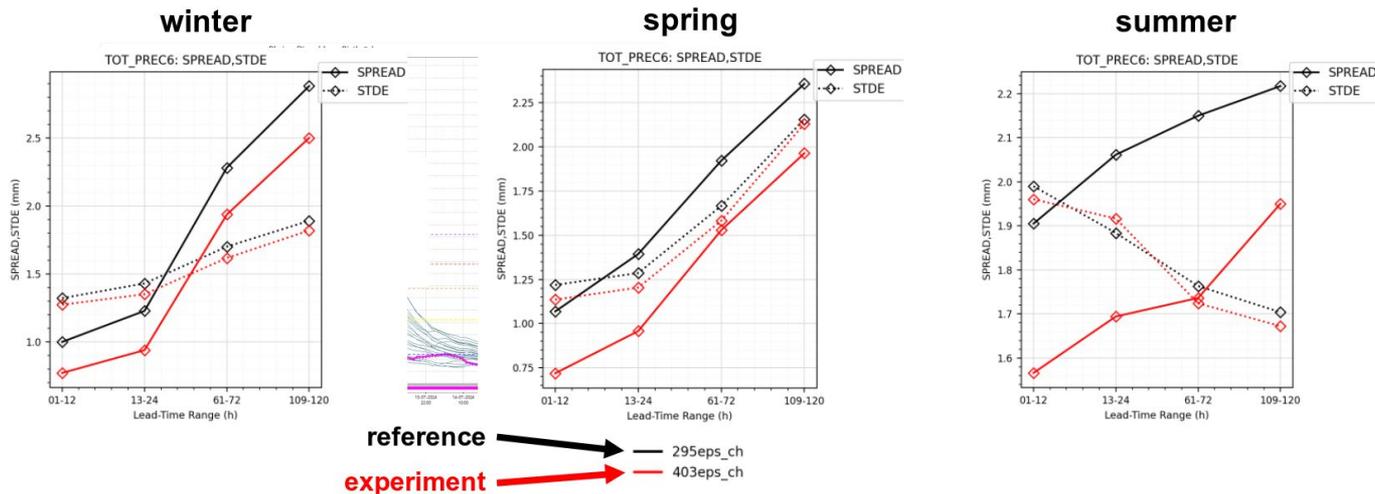


Positive effects: spread of TOT_PREC

NEW

- Decrease in spread, spread is below STDE for the majority of periods and lead times

2 km ensemble





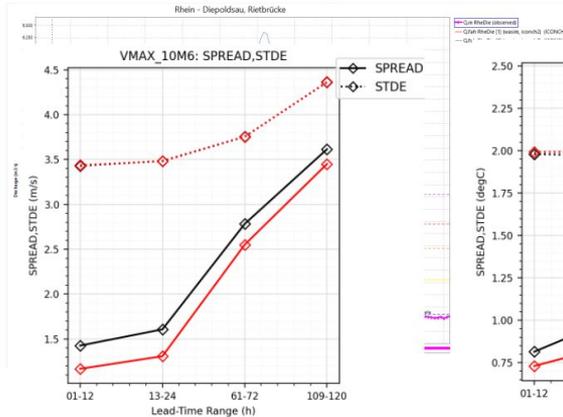
Negative effects: Decrease in spread

NEW

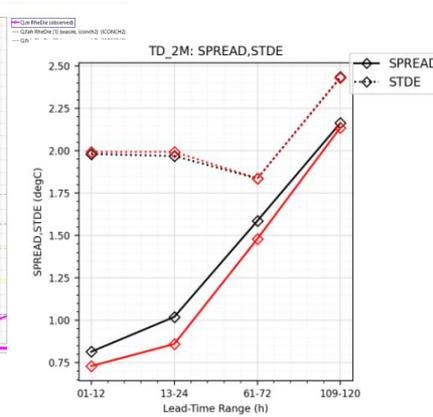
- (Slight) decrease in spread for many of the other variables: T_2M, TD_2M, FF_10M, VMAX_10M6 (less so for CLCT, PS and PMSL) → SPREAD/STDE gets worse

2 km ensemble

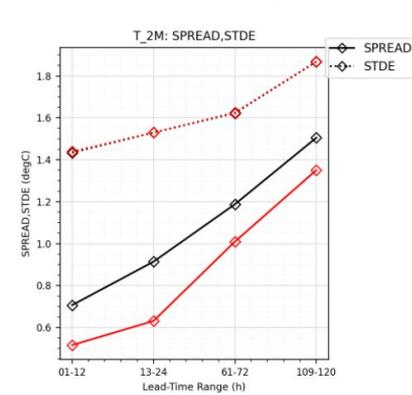
winter, e.g. VMAX_10M6



spring, e.g. TD_2M



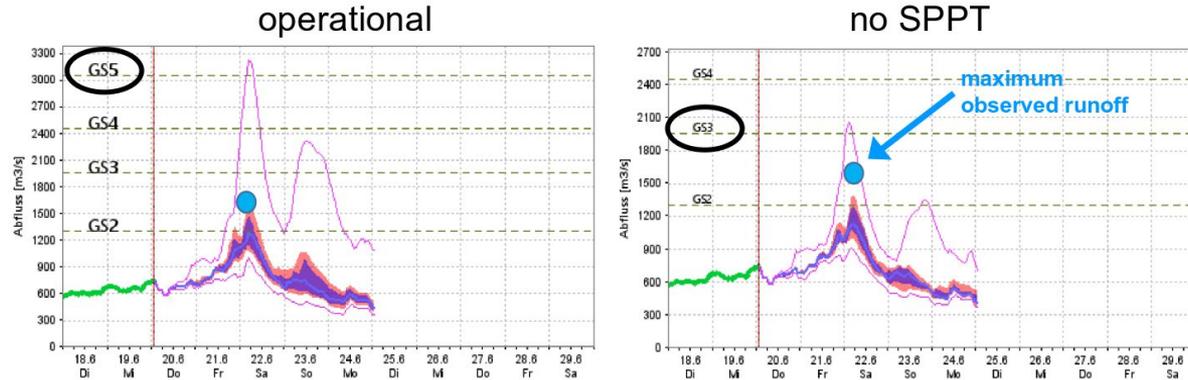
summer, e.g. T_2M





Decision (hopefully temporary ...): Deactivate SPPT in ICON-CH2-EPS, but keep it in ICON-CH1-EPS

operational since 11 December 2024



Bonus track - test of an hectometric scale ICON ensemble

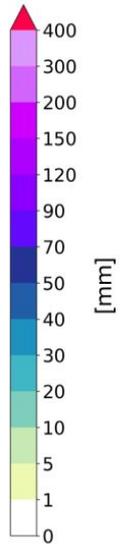
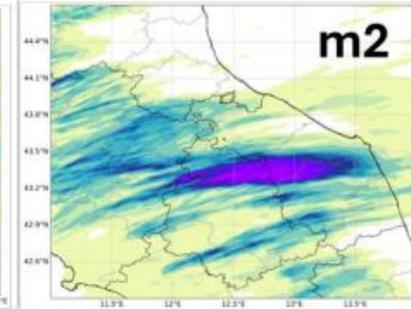
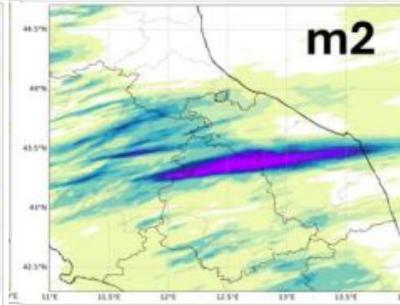
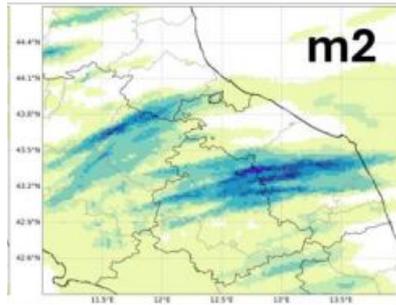
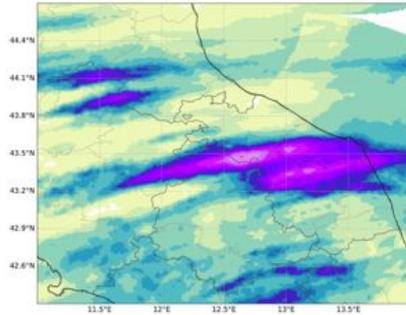
- test of an ICON ensemble at 500 m, with “standard” set-up and with hectometric scale set-up

(a) Radar observed

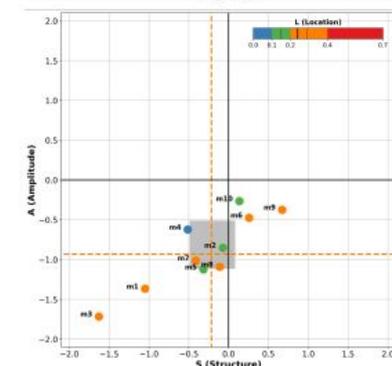
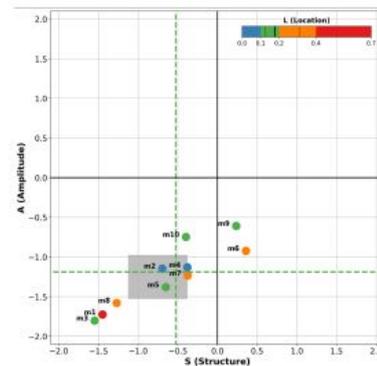
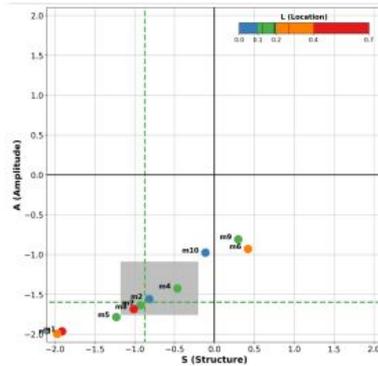
ICON 2 km

ICON 500 m

ICON 500 m 3d turb



SAL 20 mm



- SPP in ICON
 - comparison with existing methods
- homogeneous verification and evaluation of operational ensembles
 - spread/skill evaluation
- transition to ICON-LEPS

- SRNWP-EPS (EUMETNET) Meeting in Bologna,
25-27 November 2025
on Model Perturbation and Use of Ensembles



WG EPS

Thank you for your attention!