WG EPS

Chiara Marsigli
Arpae-SIMC

WG EPS - ongoing work

- 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

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Classical parameter perturbation (CPP)

Each uncertain parameter is set to
- default or
- boundary value of the range

The value is kept fix during the run

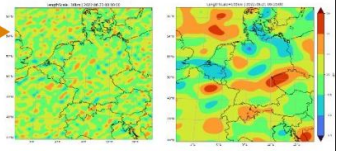
~18 parameters

Stochastic parameter perturbation(SPP):

Each uncertain parameter is perturbed by
Stochastic Pattern

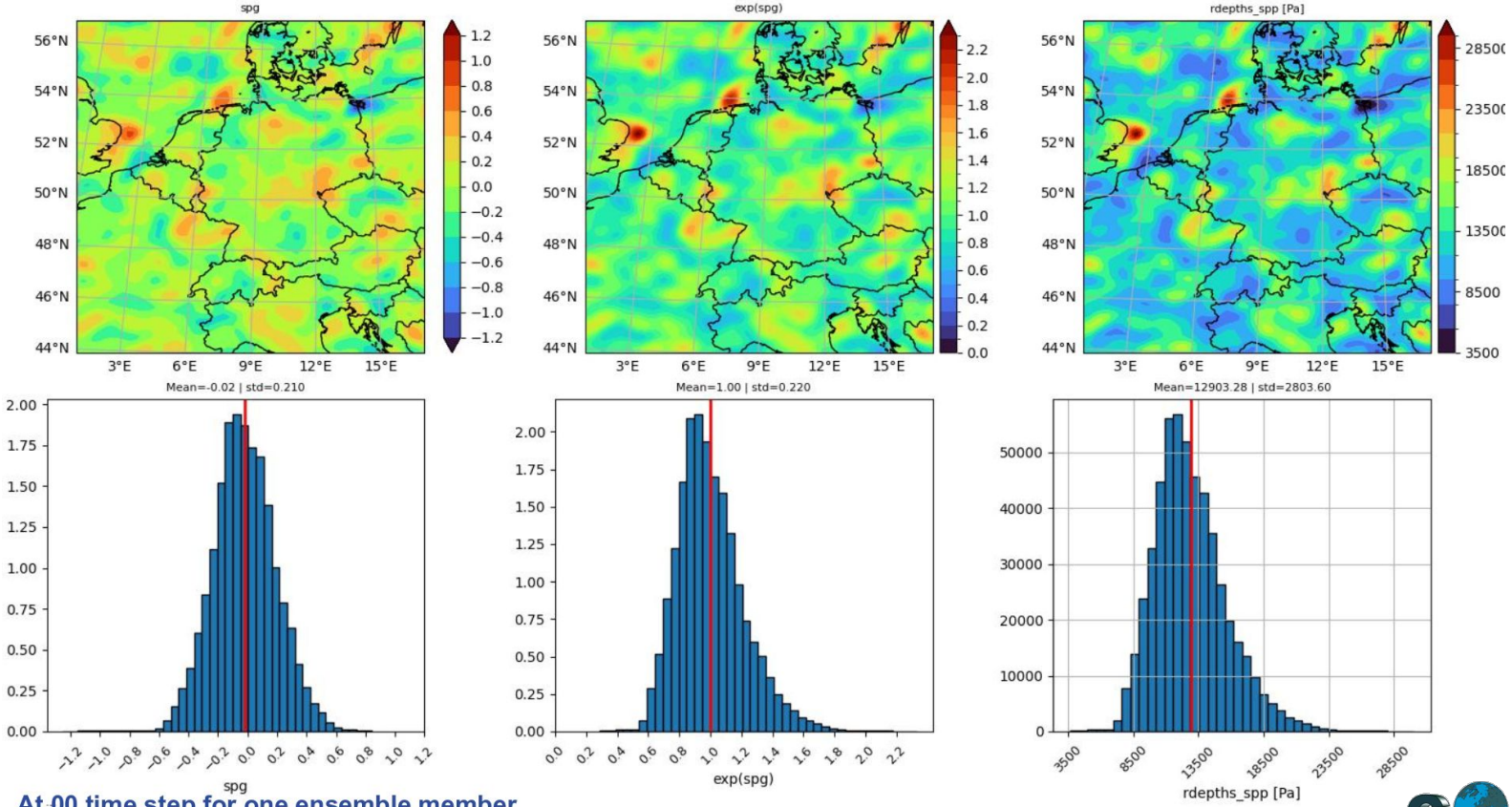
- Temporally evolving via spectral space
- Spatial and temporal correlations
- Some certain properties

Length scale
Time scale
Variance
Mode



Seed different for each:
- parameter
- ensemble member
- initialization date
- initialization time

SPP in ICON

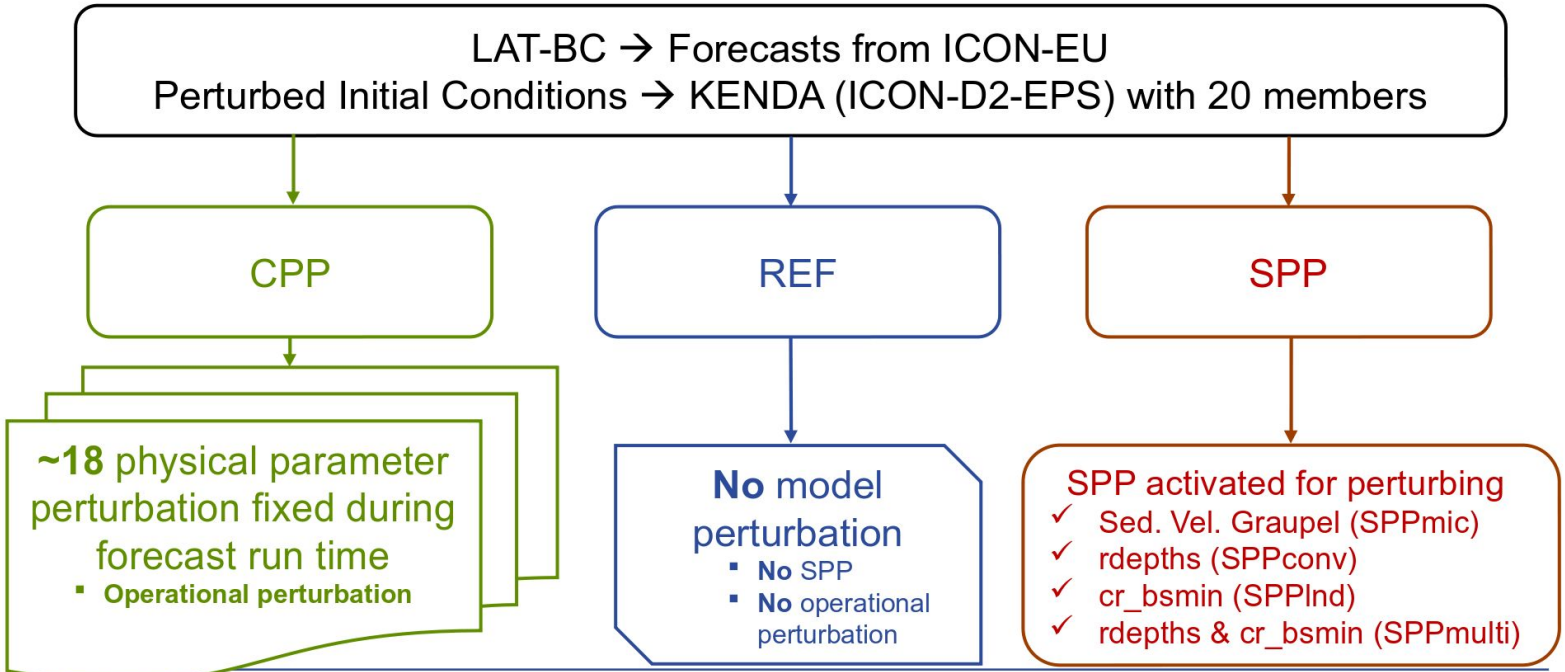


At 00 time step for one ensemble member

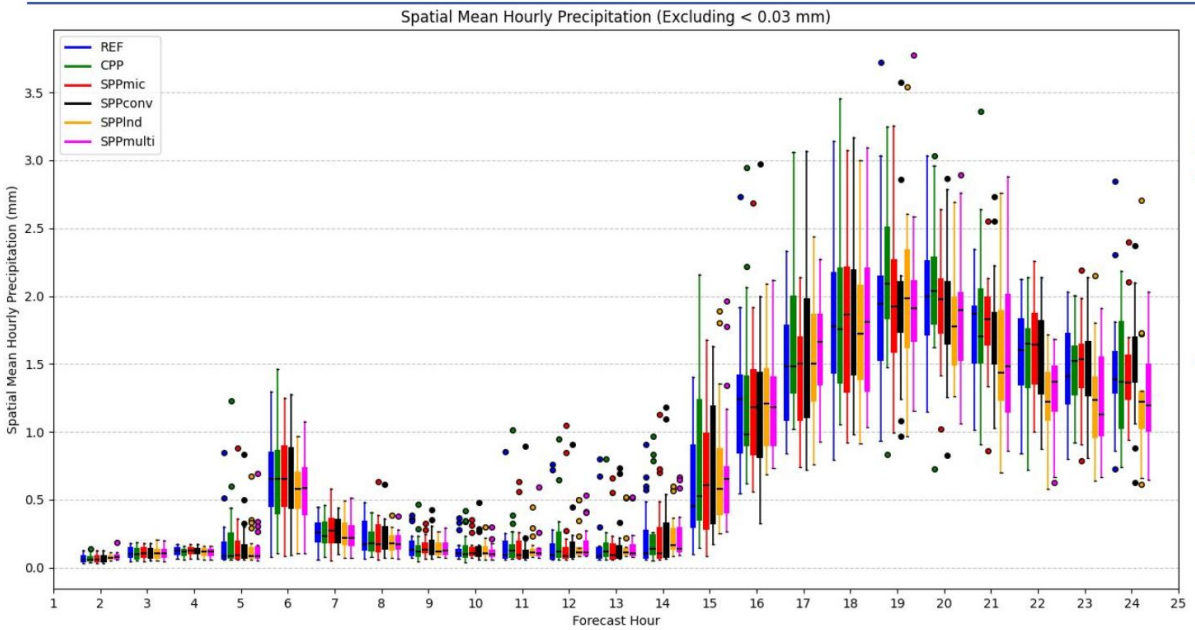
SPP in ICON

Test Setup

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



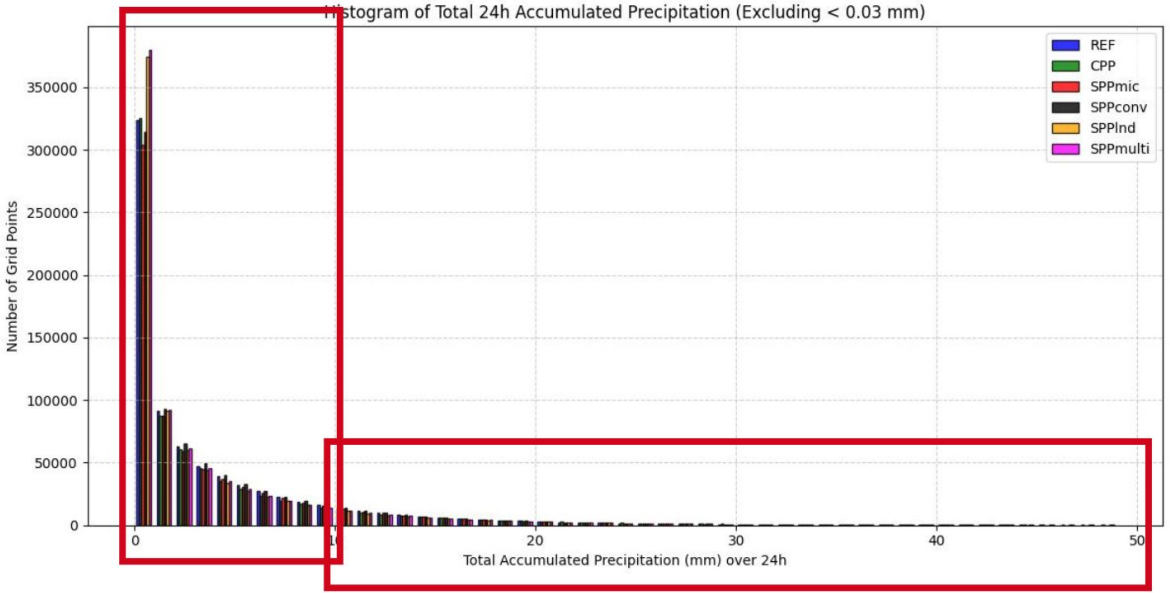
Statistical Analysis



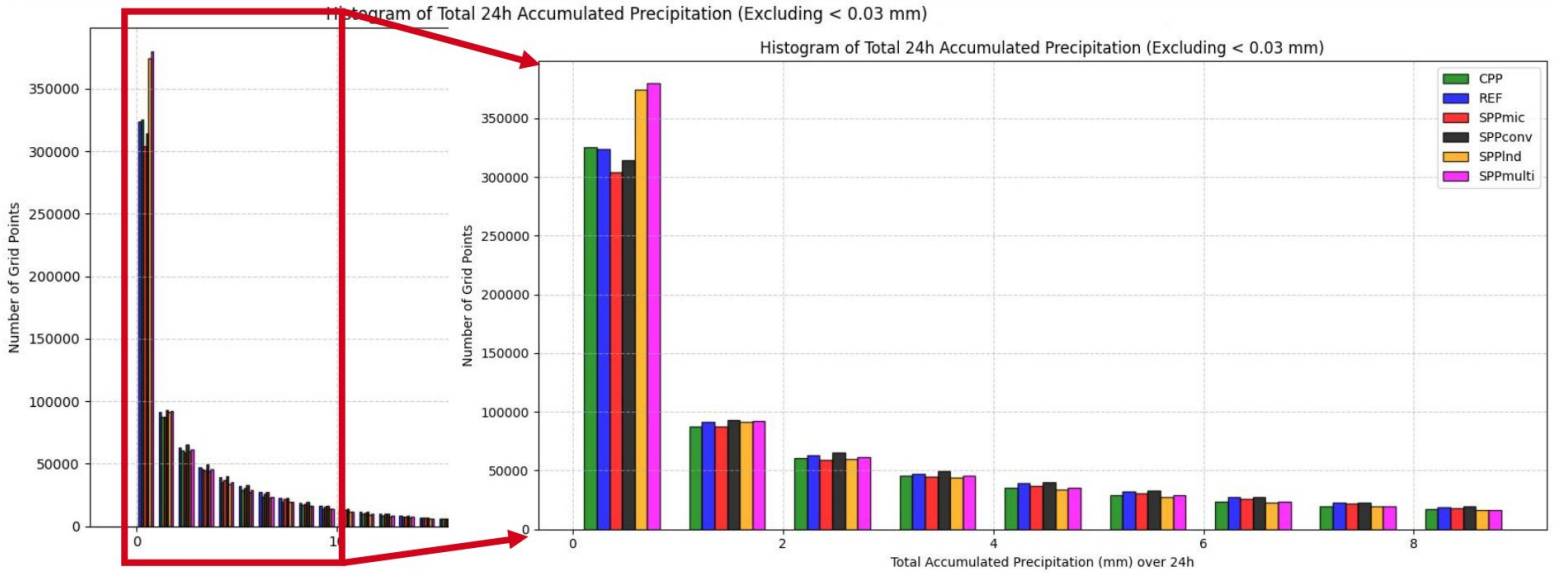
Box-Whisker plot:

- 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



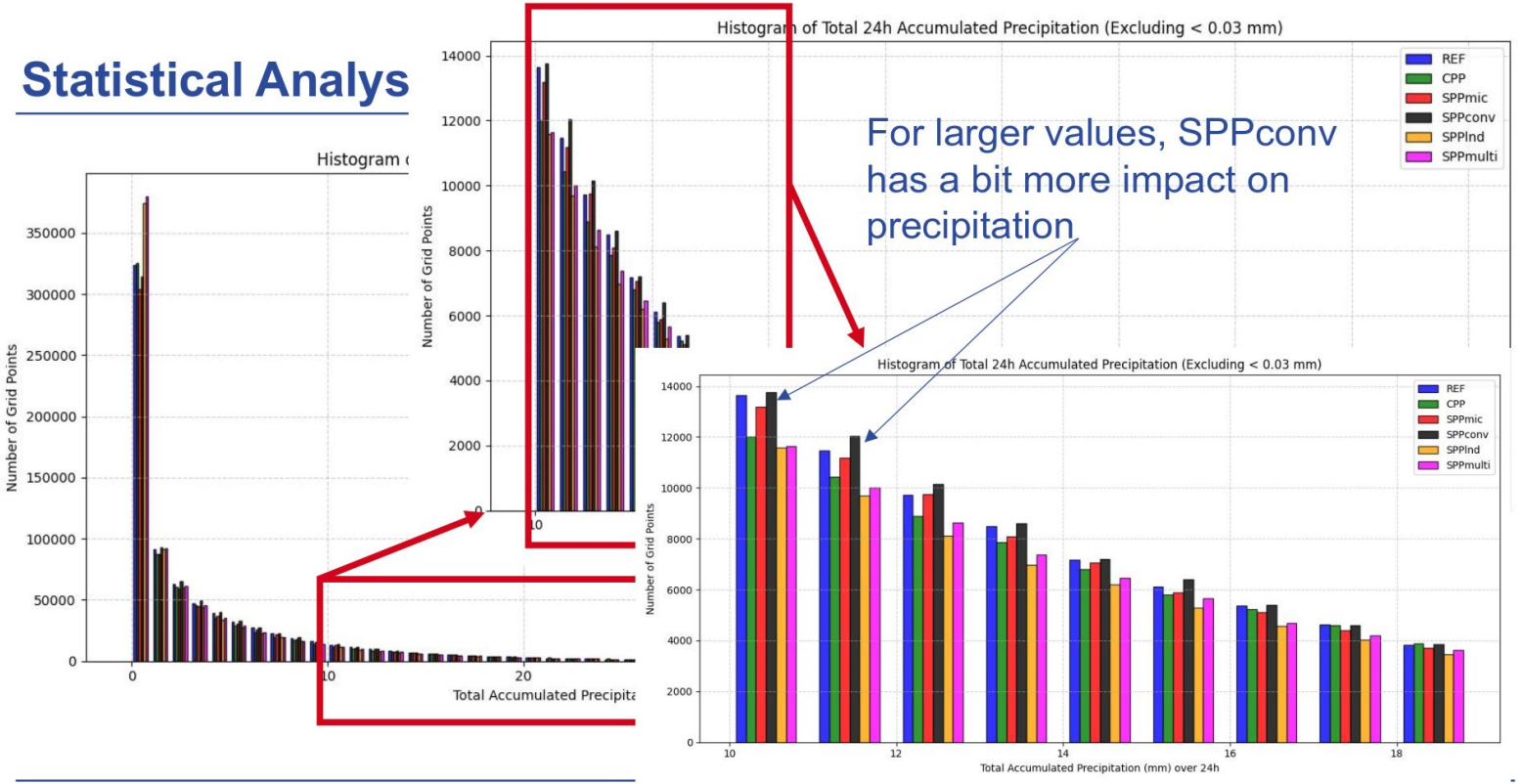
Statistical Analysis



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

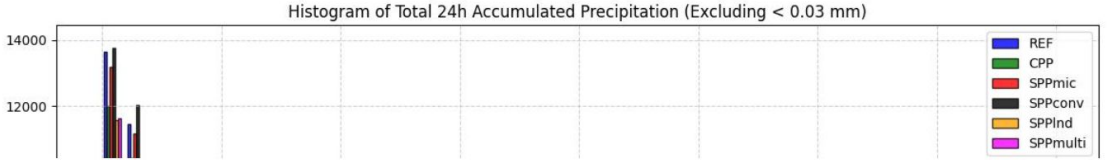
SPP in ICON

Statistical Analys

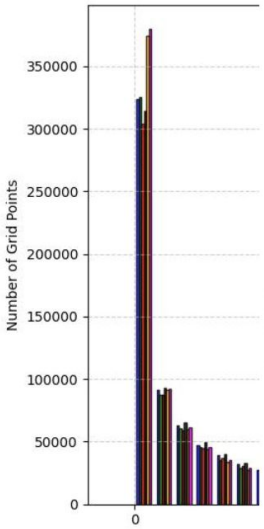


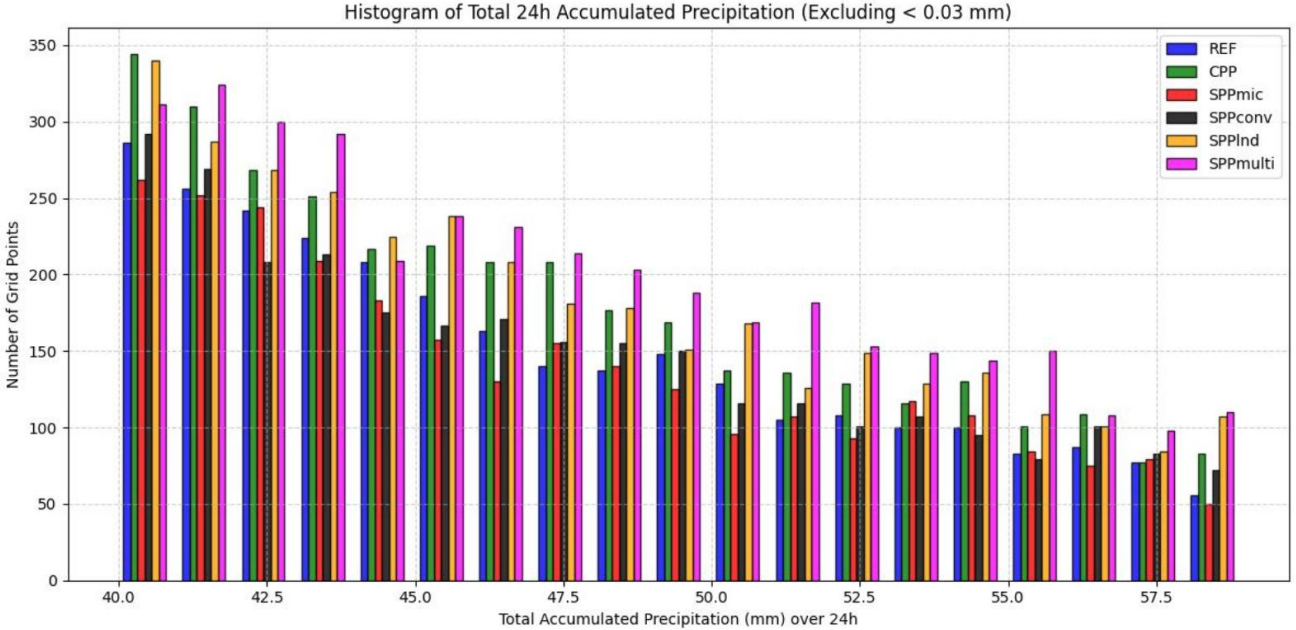
SPP in ICON

Statistical Analys

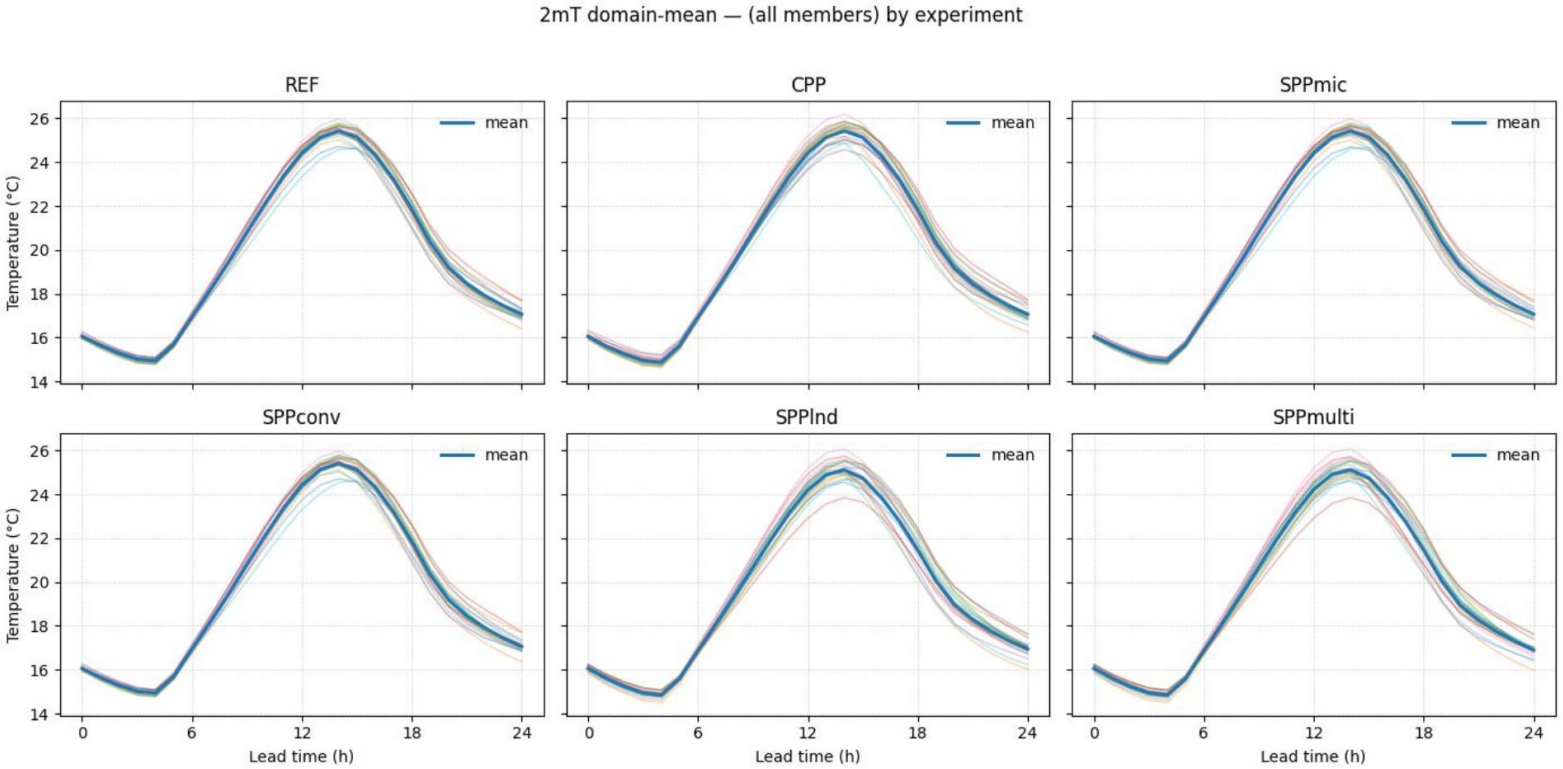


Histogram (





SPP in ICON



- Ensemble spread in 2mTemp is negligible before noon,
- Small spread for 2 m Temp when rain started!

SPP in ICON

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Summary

- SPG Implementation is done by Axel Seifert (since June2025 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

Thank you!

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.

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

Surface temperature perturbation

Influence of perturbation of surface temperature on temperature inversion at selected SYNOP stations in Poland – intro, preliminary results

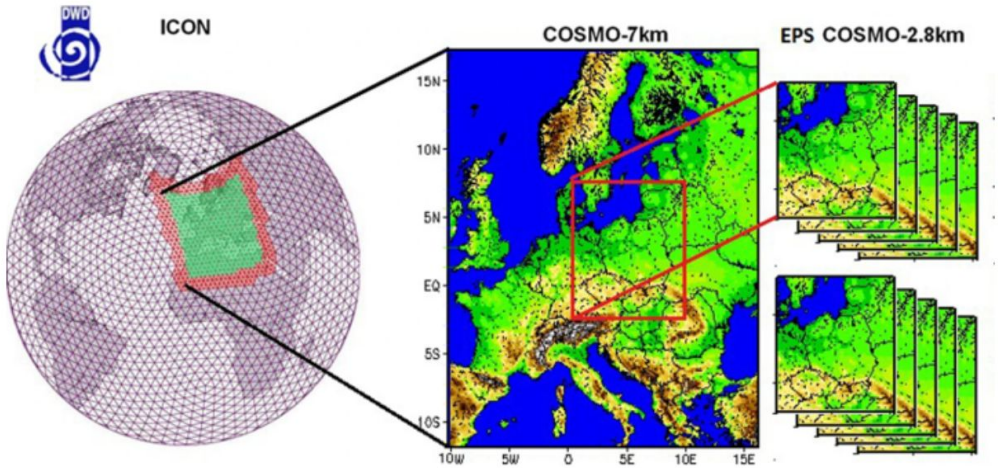
A. Mazur, T. Tabalchuk, A. Wyszogrodzki

01/09/2025, Basel

Surface temperature perturbation

METHODS

Instytut Meteorologii i Gospodarki Wodnej
Państwowy Instytut Badawczy

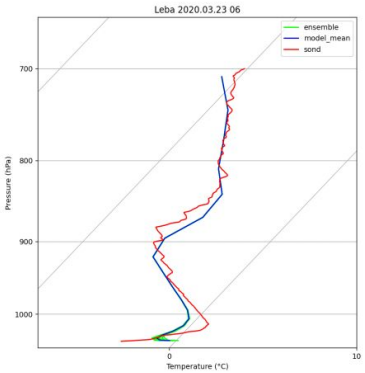


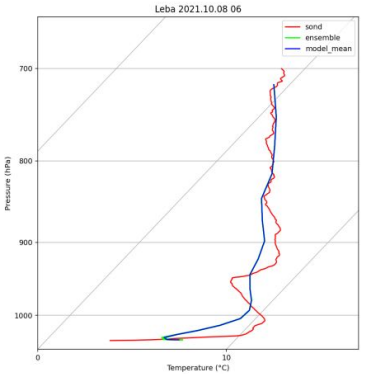
Modeling used the COSMO-2k8 ensemble with surface temperature perturbations, along with a separate deterministic run. The 20 ensemble members were split into two groups: 1–10 with perturbations in initial conditions only; 11–20 with perturbations in both initial and boundary conditions

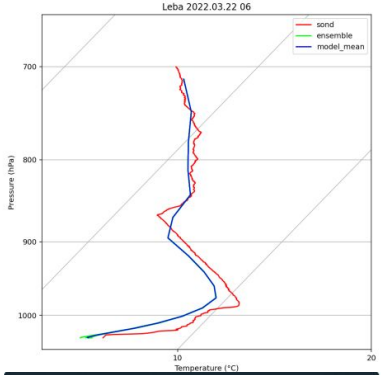
Surface temperature perturbation

ANALYSIS

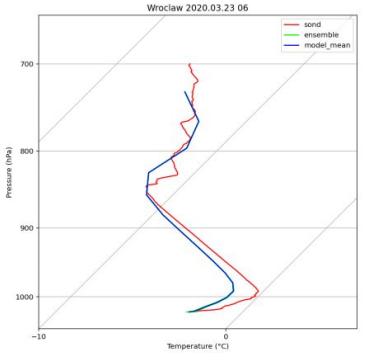
Instytut Meteorologii i Gospodarki Wodnej
Państwowy Instytut Badawczy

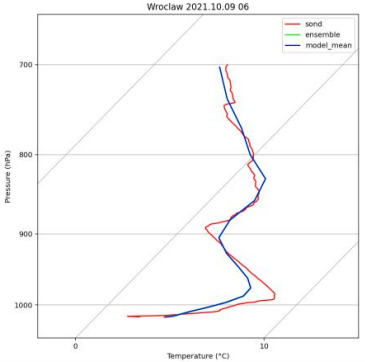


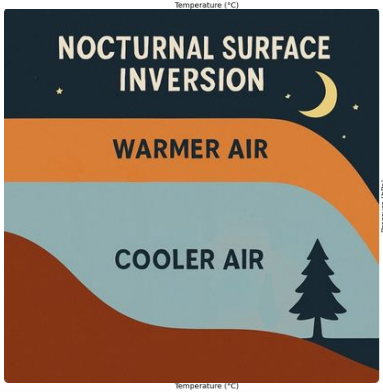


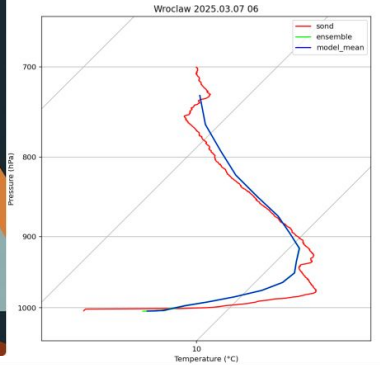


However, in the near-surface layer, most cases show significant deviations between the modeled and observed temperature profiles, both positive and negative, while at higher levels the ensemble members exhibit almost no spread in air temperature values.







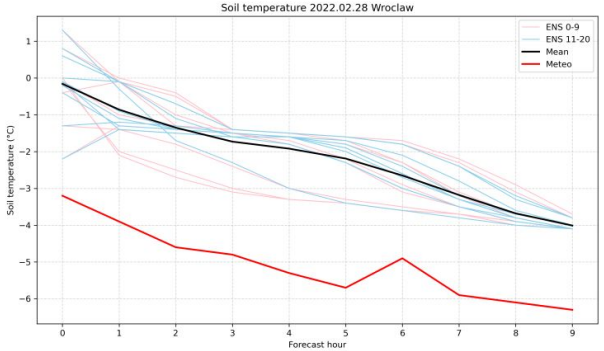


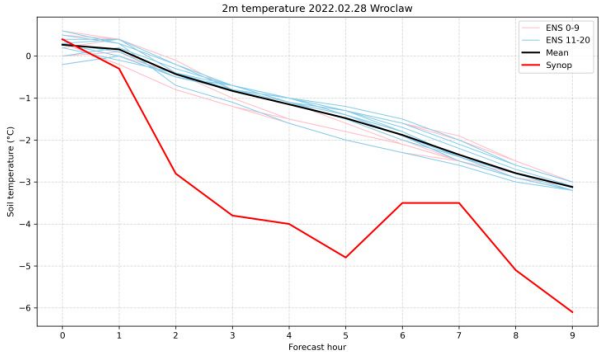
CONSORTIUM FOR SMALL SCALE MODELING
SMO

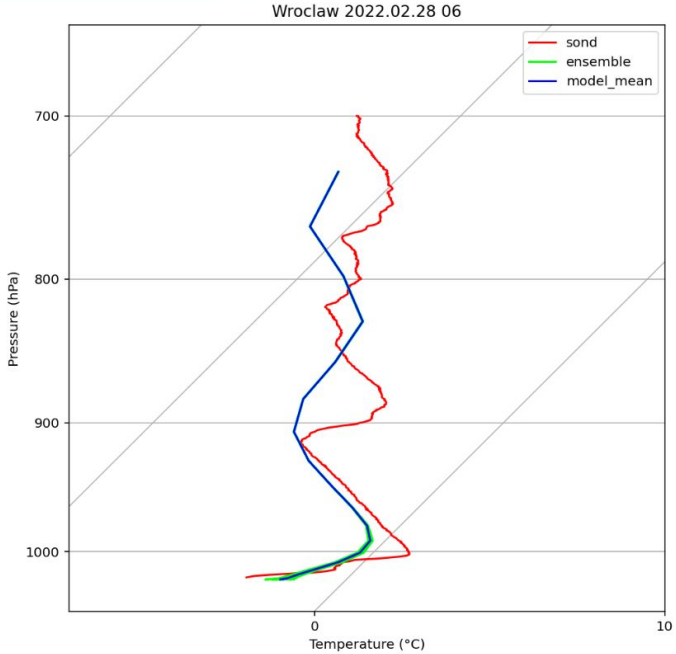
Surface temperature perturbation

ANALYSIS

Instytut Meteorologii i Gospodarki Wodnej
Państwowy Instytut Badawczy





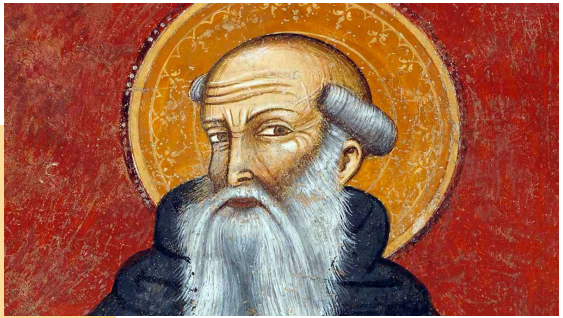


For the case of 2022.02.28, when the amplitude of surface temperature values persists throughout the modeling period, a greater spread in air temperature values is observed, leading to improved temperature forecasts.

Spread for precipitation

“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

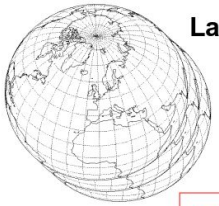
COSMO General Meeting, 01.09.2025

Spread for precipitation

recap 2024

Forecasting System based on ICON

Ensemble Data Assimilation:
LETKF
40+1 members at 1.0 km grid size
with ICON-CH1 setup (SPPT)
hourly cycling

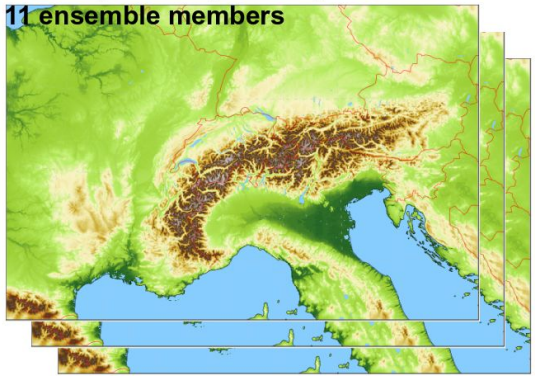


Lateral boundary conditions:
IFS ENS
9 (18) km
4x per day

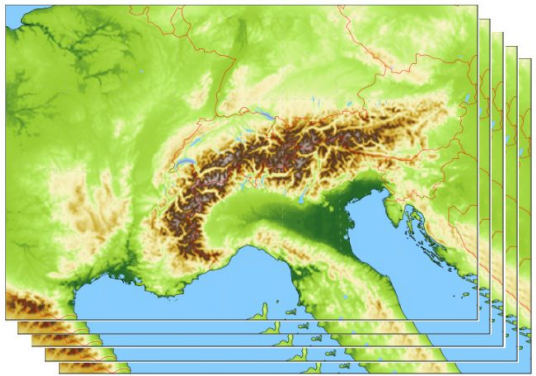
operational since 28 May 2024

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

1.0 km grid size (R19B08), 80L
11 ensemble members



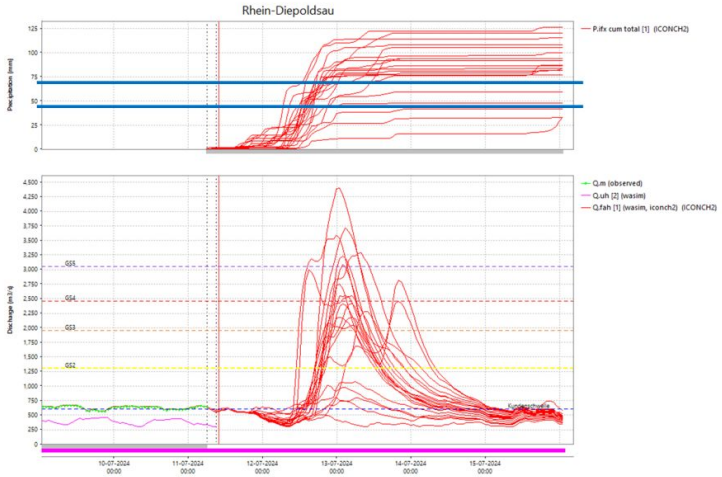
ICON-CH2-EPS: 5 day forecasts, 4x per day
2.1 km grid size (R19B07), 80L
21 ensemble members

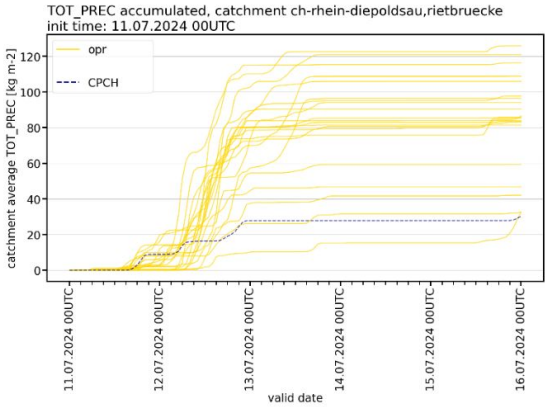


recap 2024

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





Figures: BAFU / Lukas Jansing

Spread for precipitation

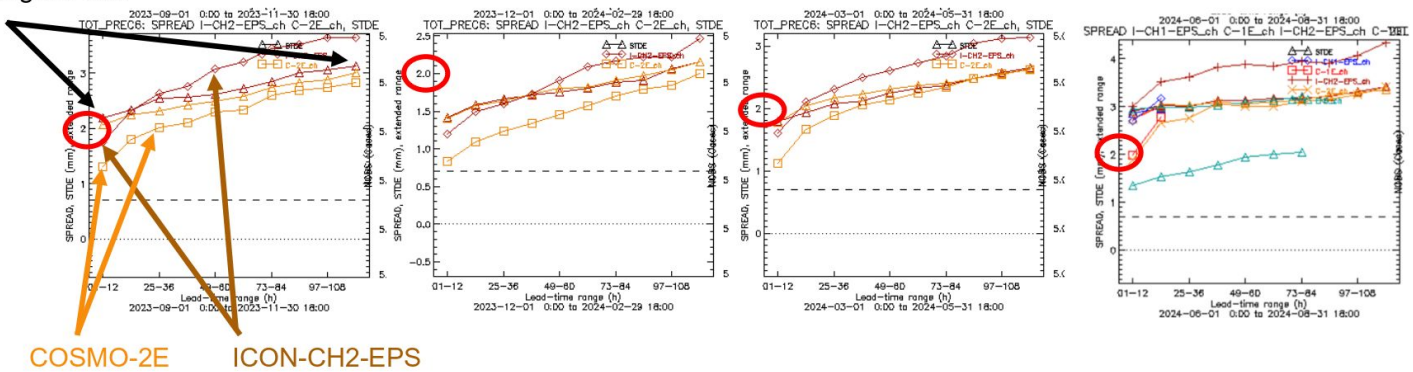
recap 2024

Precipitation, spread vs skill – ICON vs COSMO

Ensemble **spread exceeds skill** (STDE of ensemble mean) in all seasons for ICON-CH2-EPS for the large lead times

Triangles: skill

SON 2023 | **DJF 2024/25** | **MAM 2024** | **JJA 2024**



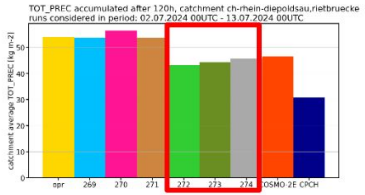
Figures: Pirmin Kaufmann

Spread for precipitation

update

Excessive spread for precipitation – Summary

Rhein



- Not a technical issue (interpolation, aggregation, workflow,..)
- **ICON-CH2-EPS produces higher precipitation amounts and larger spread than COSMO-2E**
- **Reduction of the model perturbations reduces the precipitation of the ICON-CH2-EPS members on average and the precipitation spread, and hence mitigates the excessive precipitation spread issue**
- However, the ICON-CH2-EPS uncertainty forecasts for temperature, humidity and wind speed get worse (not shown)
- Still unclear why model perturbations in ICON trigger more excessive precipitation than in COSMO → investigations ongoing
- Reduction of exaggerated convective precipitation rates / peaks does not substantially reduce the excessive spread for precipitation

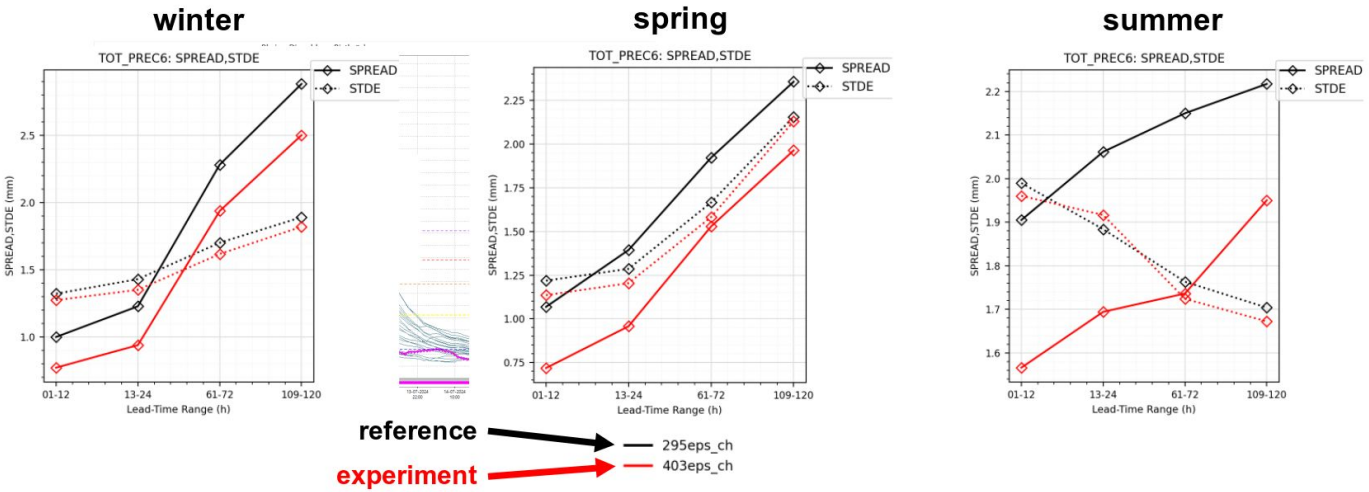
Deactivate SPPT: lsppt=.false.

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



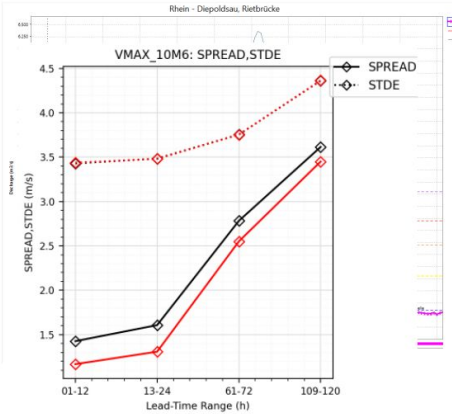
Negative effects: Decrease in spread

NEW

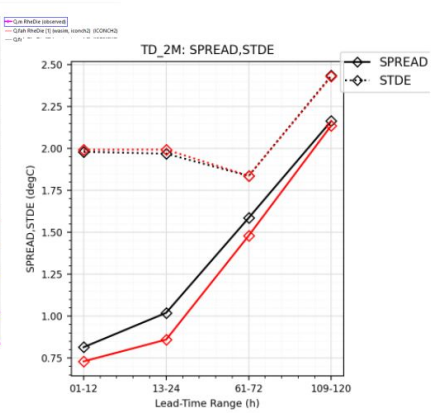
2 km ensemble

- (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

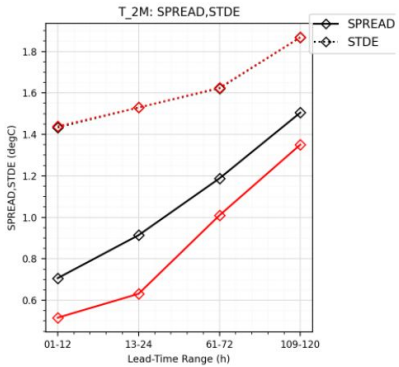
winter, e.g. VMAX_10M6



spring, e.g. TD_2M



summer, e.g. T_2M



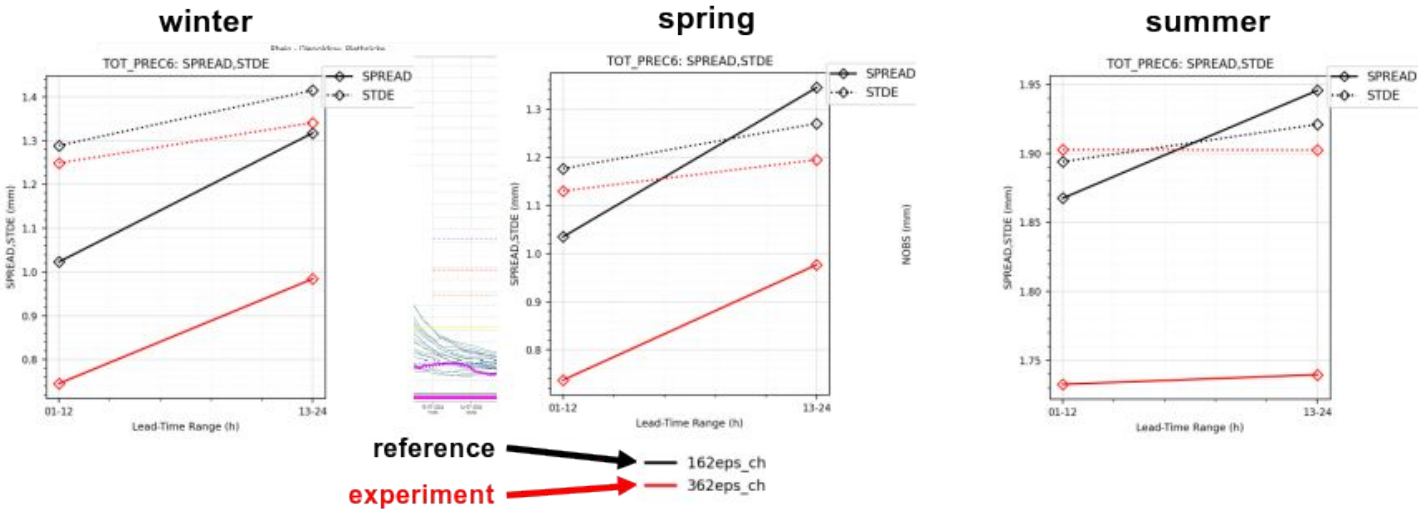
Deactivate SPPT: lsppt=.false.

Positive effects: spread of TOT_PREC

NEW

- Decrease in spread, spread is below STDE for all periods and lead times (too much reduction?)

1 km ensemble



Slide: Lukas Jansing

Deactivate SPPT: lsppt=.false.

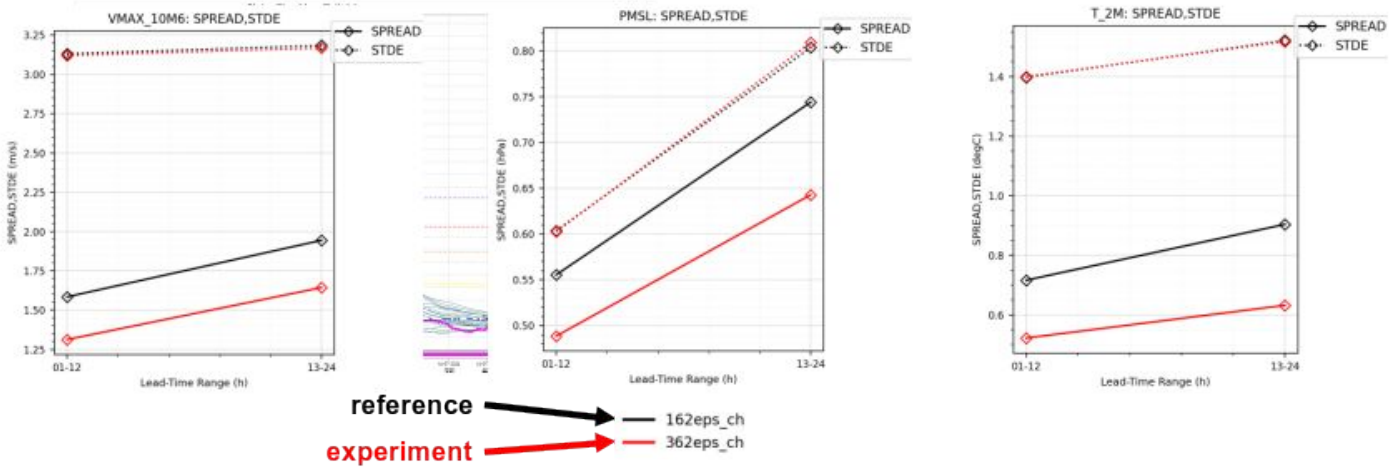
Negative effects: Decrease in spread

NEW

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

1 km ensemble

winter, e.g. VMAX_10M6 | **spring, e.g. PMSL** | **summer, e.g. T_2M**



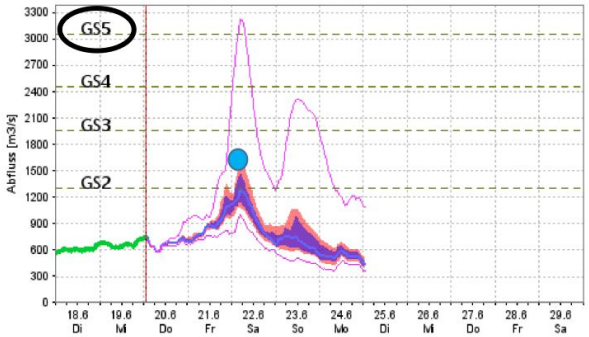
Slide: Lukas Jansing

Spread for precipitation

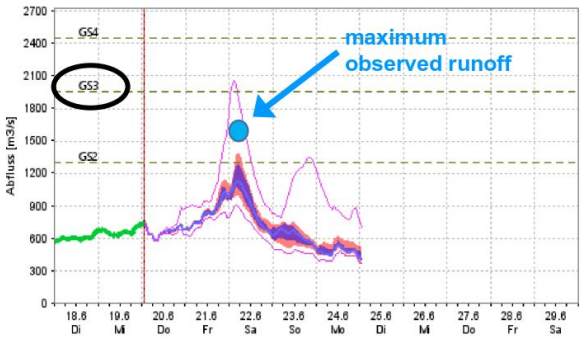
Decision (hopefully temporary …):
Deactivate SPPT in ICON-CH2-EPS,
but keep it in ICON-CH1-EPS

operational since 11 December 2024

operational



no SPPT



Figures: Karsten Jasper (BAFU)

Ensemble for Nowcasting

“Please give me just one forecast, but good!”

the mayor

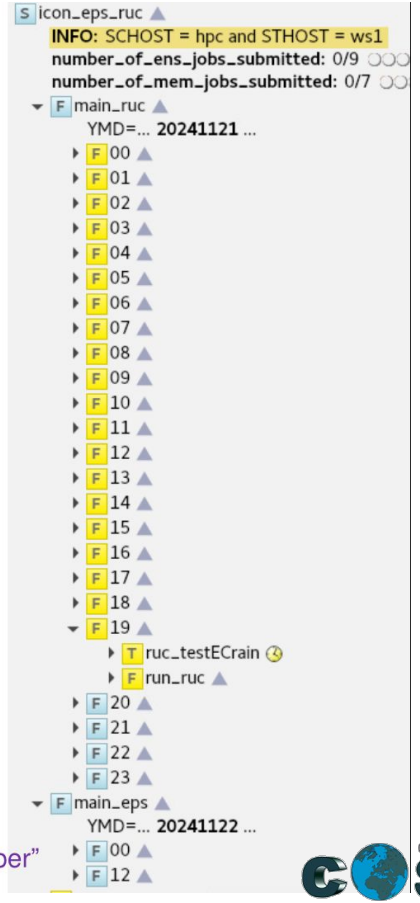
RUC at IMS: Best-member selection for nowcasting

Pavel Khain, Elyakom Vadislavsky, Anat Baharad, Yoav Levi, Amir Givati
Israel Meteorological Service

Precipitation Nowcasting

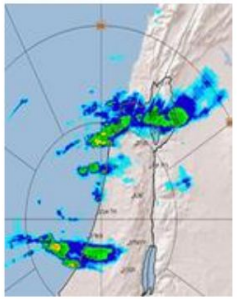
Method

- Platform: ICON-EPS runs (ecFlow suite in Bologna) for rain nowcasting
- During rainy days (defined automatically by IFS forecast) ICON-EPS is running twice daily with **50 members**, driven by EC-ENS for 30 hours
- **Every hour**, all 50 ICON-EPS members are automatically verified versus the radar data during the last hour, using FSS, and the **best member** for the current hour is defined
- This member is rerun till that hour with radar-data assimilation (LHN) and then continued as free run for additional 12 hours
- This "best" member serves as our "deterministic" precipitation nowcast (also LPI and hail diagnostics)
- Includes: Urban scheme, Convective precipitation correction
- Recently:
  - ❑ all IMS deterministic models were added as optional “best members”
  - ❑ Lightning (ground measurements+MTG) helps choosing the “best member”
  - ❑ EUMETSAT MTG FCI L2 AMV (Atmospheric Motion Vector) helps choosing the “best member”



Precipitation Nowcasting

Example: 19.11.2024


RADAR

6:00-7:00 UTC


RADAR

7:00-8:00 UTC


RADAR

8:00-9:00 UTC

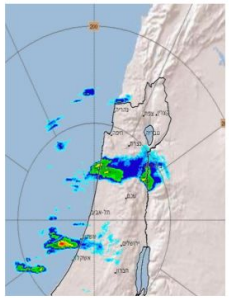
Peak of the event


RADAR

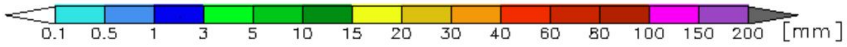
9:00-10:00 UTC


RADAR

10:00-11:00 UTC


RADAR

11:00-12:00 UTC



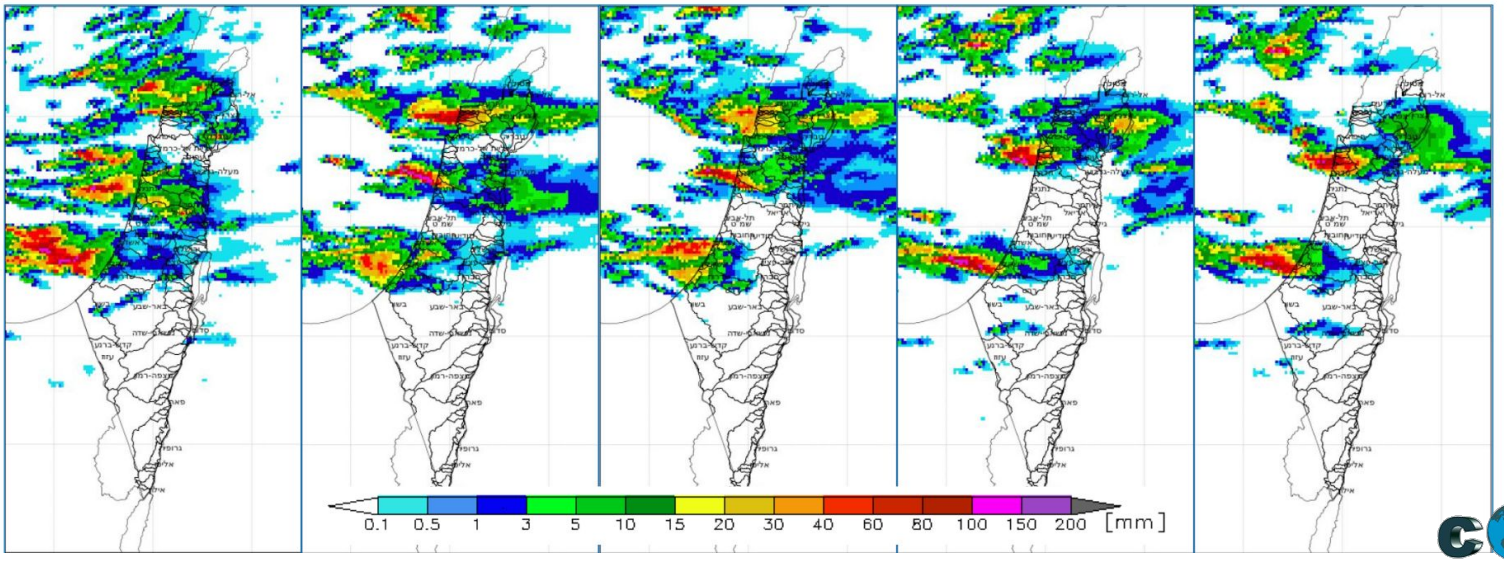
34 mm/10min, 62.4 mm/30min, 88mm/60min, 129mm/120min, 196mm/240min, 217mm/24h

Precipitation Nowcasting

Best member forecasts several hours before the event (12h accumulation)

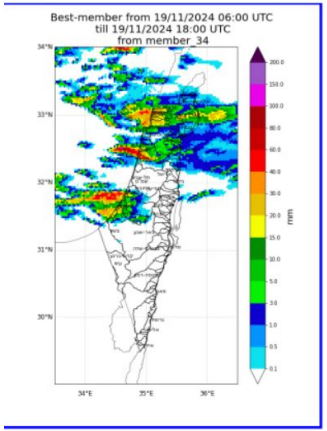
4 hours before the event | 3 hours before | 2 hours before | 1 hour before | Time of the event

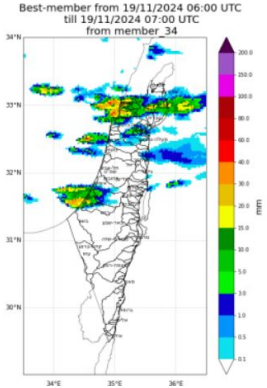
תחזית מ- UTC 04 | תחזית מ- UTC 05 | תחזית מ- UTC 06 | תחזית מ- UTC 07 | תחזית מ- UTC 08

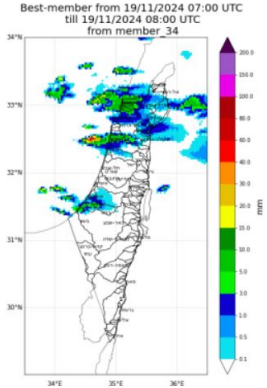


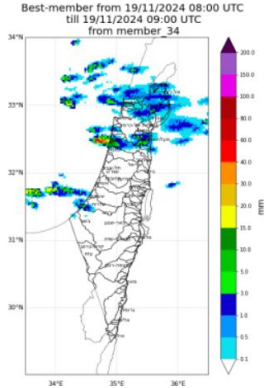
Precipitation Nowcasting

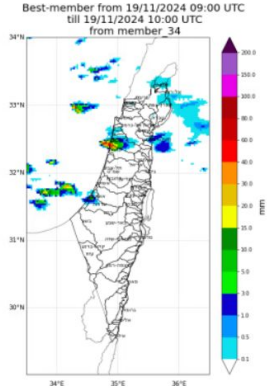
Forecast from 06 UTC: 12 accumulation (blue frame), and hourly precipitation (no frame)

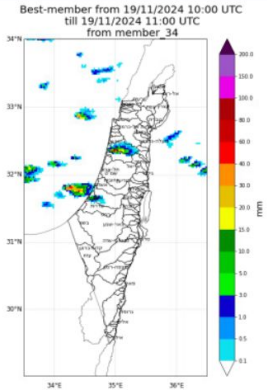


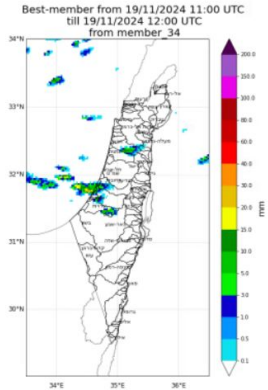


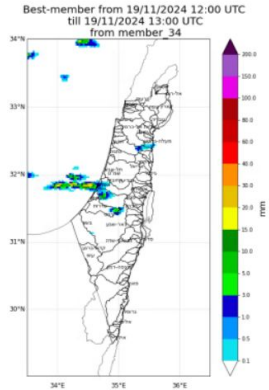


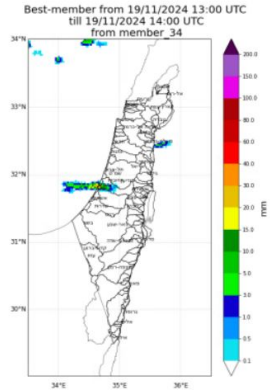


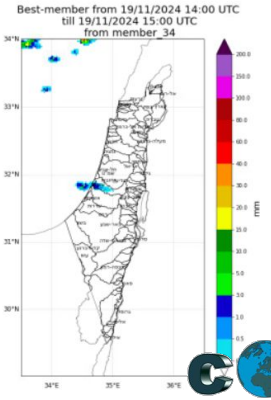






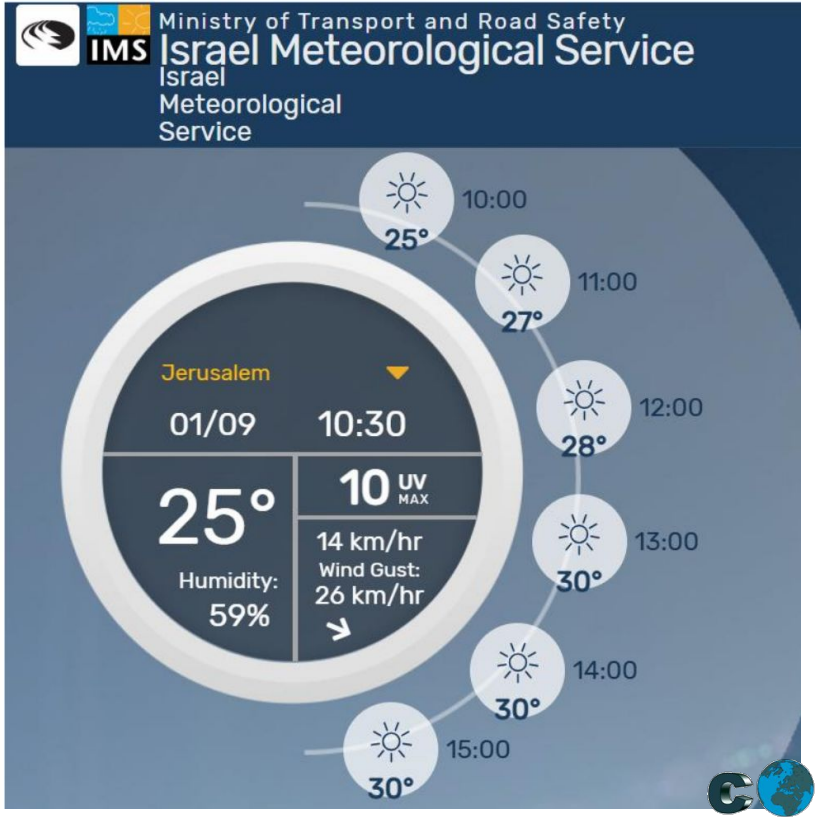






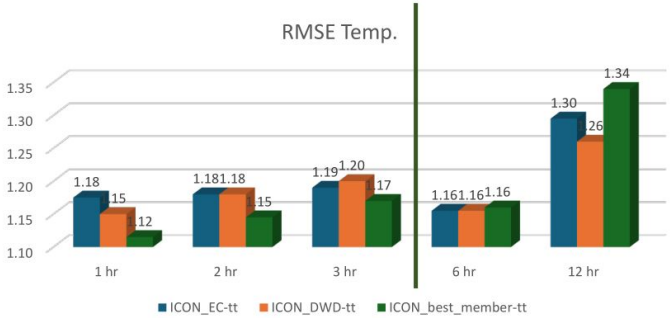
Surface fields nowcasting

- Platform: ICON-EPS runs (ecFlow suite in Bologna) for rain nowcasting
- Every day ICON-EPS is running twice daily with **20 members**, driven by EC-ENS for 120 hours
- **Every hour**, all 20 ICON-EPS members are automatically verified versus the surface observations during the last hour, and the **best member** for the current hour is defined, for each field seperatelly
- This "best" member serves as our "deterministic" T/RH/WS nowcast

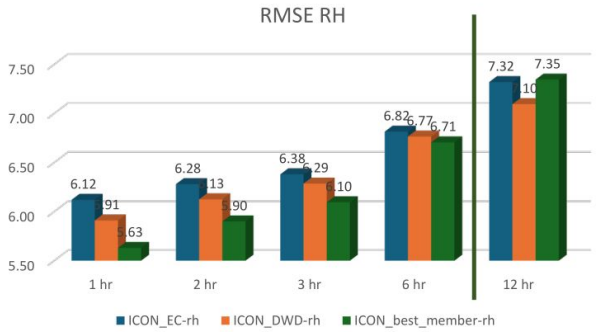


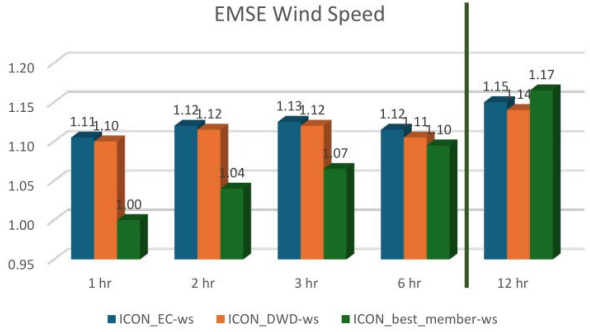
Surface fields nowcasting

Best member nowcasting
20 EPS + 3 deterministic ICONs
compared to 10 min obs. at the last hour



June July 2025





The best member approach is good for the first ~3 hours

Conclusions

- ICON best ensemble member improves “deterministic” nowcasting both for rain (based on special 50-members runs), and surface fields (based on regular 20-members runs)

- A lot of open questions related to the choice of the current best ensemble member:
  - Metric?
  - Focus on entire area or strongest cells?
  - Time span to define the best member?
  - Met. Fields to define the best member?
  - New idea: run not only the best member, but an ensemble of several winners!

WG EPS - new project proposal

- proposal for the new PP (title still uncertain)
- model perturbation
  - Stochastically Perturbed Parametrizations (SPP) (DWD, Arpae; when the implementation is more mature, others are interested in testing)
  - further work on SPPT and possible test of different schemes (MCH)
  - introduce model perturbation in ICON-LEPS (Arpae)
  - surface temperature perturbation (IMGW)
- ensemble for nowcasting (IMS)
  - precipitation nowcasting
  - surface fields nowcasting

WG EPS - new project proposal

- verification and diagnostic for ensembles:
  - homogeneous verification and evaluation of operational ensembles: WG V/A
  - use methods for homogeneous spatial verification and spread/skill evaluation -> test the DWD method by Michael Hoff (all)
  - verification for ICON-LEPS, operational and development (Arpae, DWD, HNMS)

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

WG EPS

Thank you for your attention!