

EPS developments with Harmonie

Inger-Lise Frogner
and the rest of the Hirlam EPS team



An extensive update of the model uncertainty scheme - SPP

Inger-Lise Frogner
and the rest of the Hirlam EPS team

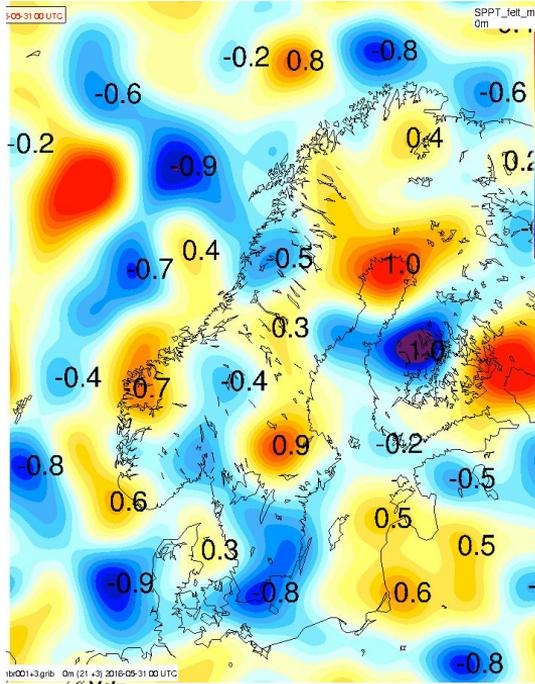


SPP = Stochastically perturbed parameterizations

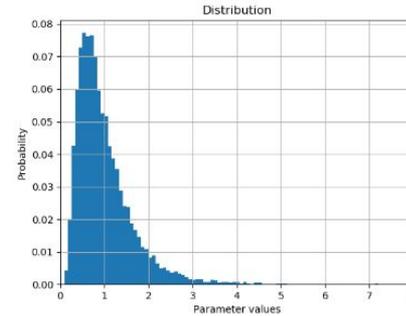
Some basics:

Pattern
evolving in
space and
time

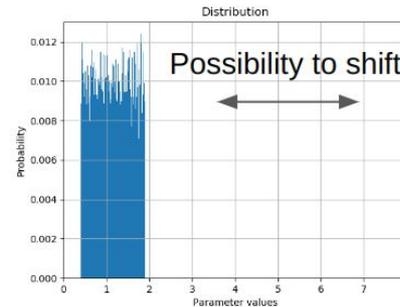
Patterns
can be
correlated
between
parameters



50 or 200 km / 3h or 12 h used,
depending on parameter



lognormal distribution



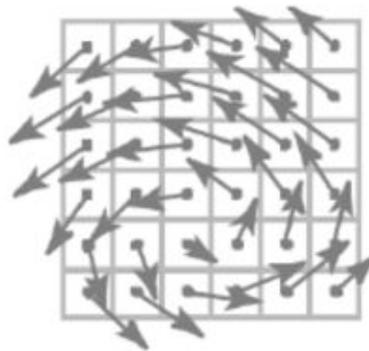
Uniform distribution

We can clip to
ensure the
parameters
stay within
physical
bounds

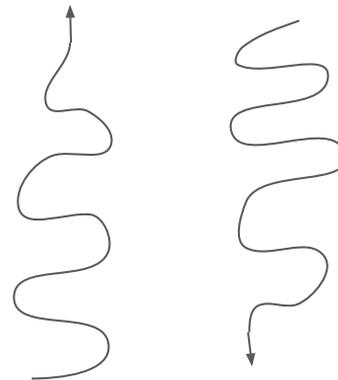
Extensive update of the SPP scheme



Clouds and microphysics: **from 3 to 11**



Dynamics: **from 0 to 1**



Radiation: **from 0 to 2**



Turbulence: **from 2 to 3**



Surface: **from 0 to 2**

Extensive update of the SPP scheme



Clouds and mic



In total: extending from
5 parameters to 19



Turbulence: **from 2 to 3**



Surface: **from 0 to 2**

Radiation: **from 0 to 2**

Revisit 5SPP configuration

A bias issue was found in the current 5SPP implementation when testing in cy46
-> first task was revisiting and adjusting this

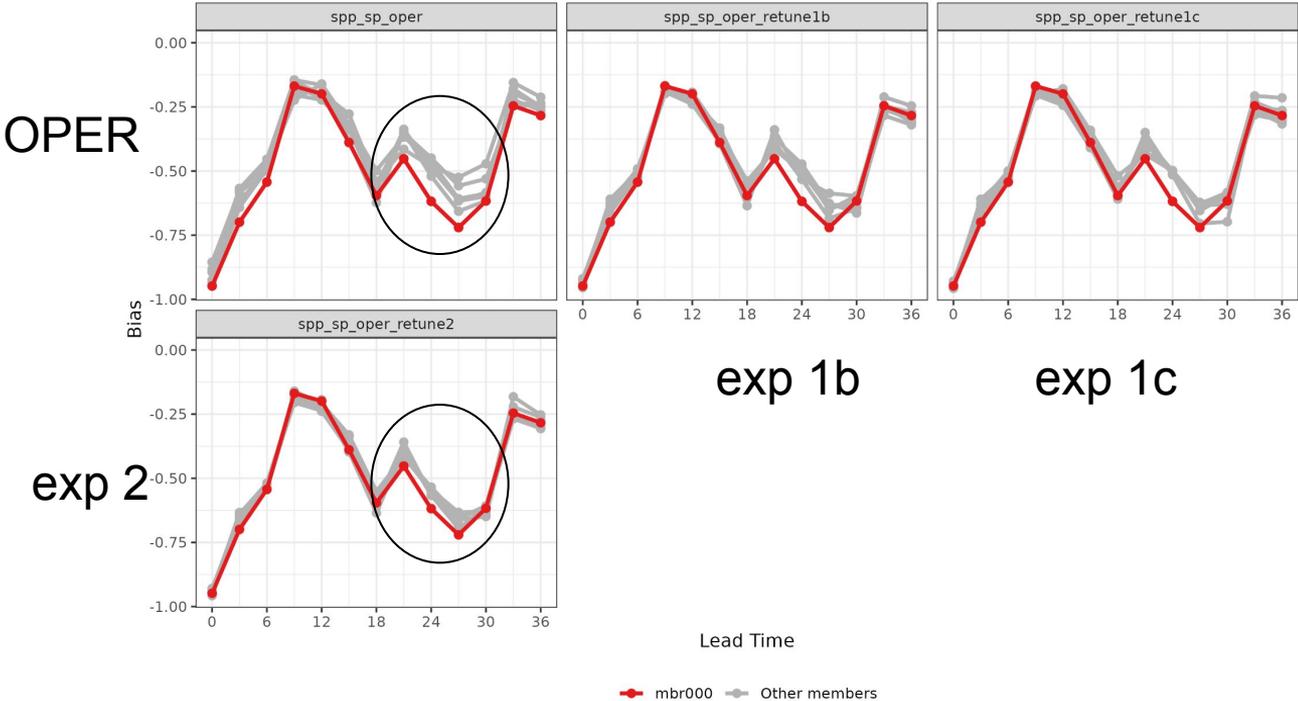
Bias issue in this context refers to all members being pushed away from the control in one direction

5SPP

- **PSIGQSAT** - Saturation limit sensitivity for condensation
- **CLDDPTHDP** - Threshold for cloud thickness used in shallow/deep convection decision
- **ICE_CLD_WGT** - Cloud ice content impact on cloud thickness
- **RZC_H** - Stable conditions length scale
- **RZL_INF** - Asymptotic free atmospheric length scale

Effect on member bias

Bias :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
437 stations

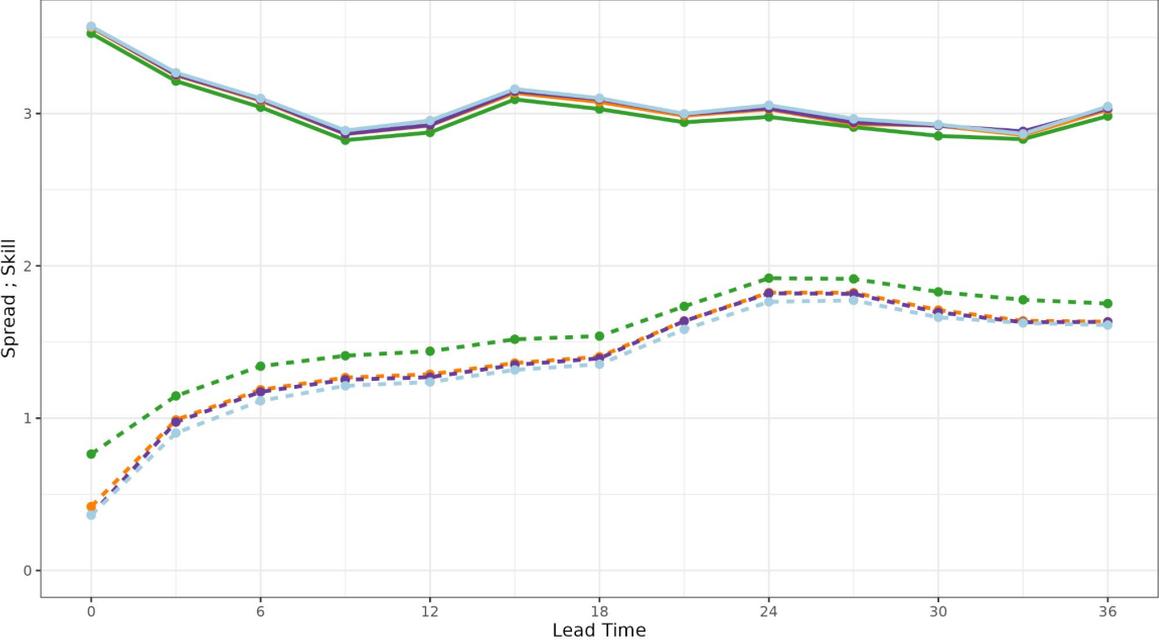


Low clouds

Effect on spread - skill

Spread Skill :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022

437 stations



Low clouds

- OPER
- Exp 1b
- Exp 1c
- Exp 2

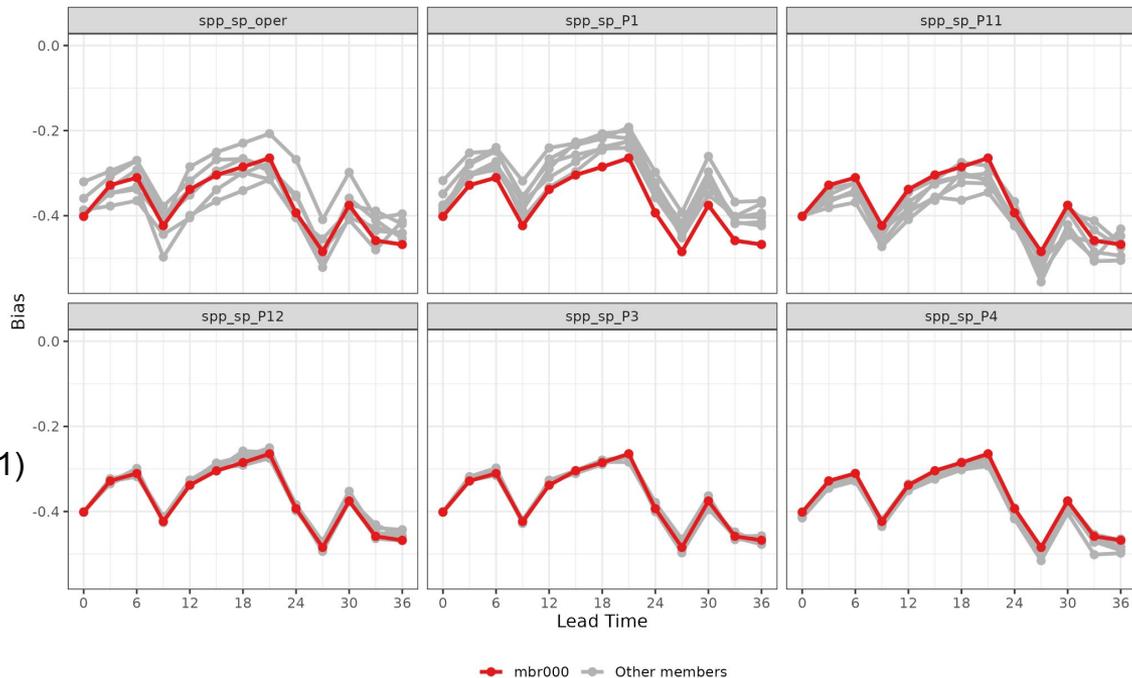
Compensating biases

Bias :: 12:00 14 Feb 2023 - 12:00 28 Feb 2023

430 stations

OPERATIONAL
5SPP

Overall bias
is OK but
compensating
opposite
biases for VSIGQSAT (P1)
and RZC_H (P11)

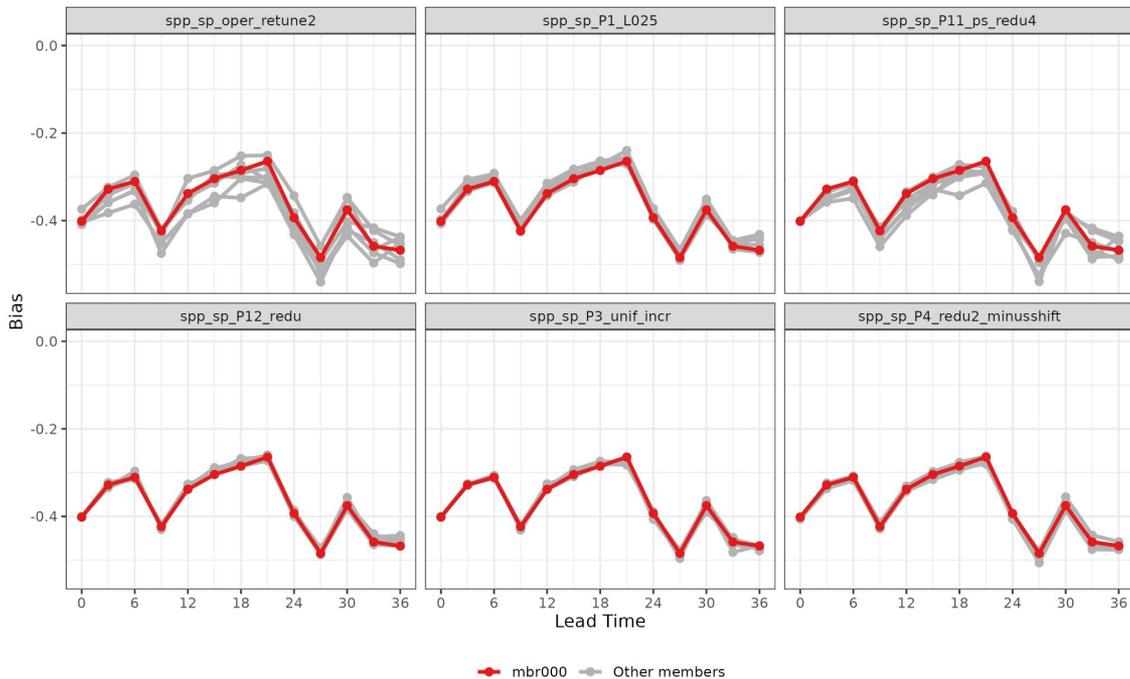


Compensating biases

Bias :: 12:00 14 Feb 2023 - 12:00 28 Feb 2023

430 stations

Exp 2



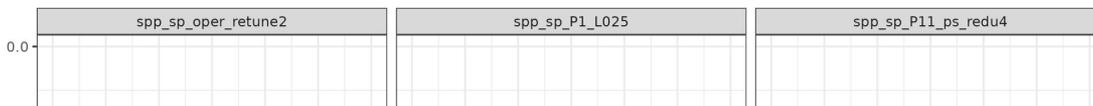
Improves

Compensating biases

Bias :: 12:00 14 Feb 2023 - 12:00 28 Feb 2023

430 stations

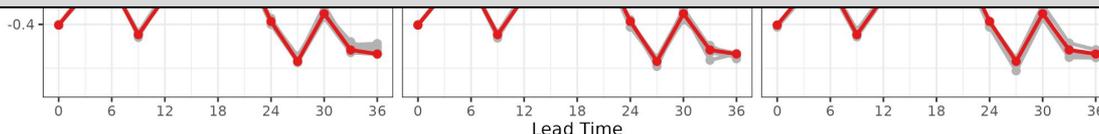
Exp 2



=> New settings for 5SPP as in Exp 2

- Happy with the overall bias behaviour
- Happy with the individual bias behaviour from the different parameters
- resulted in reduced spread (but for the right reason)

Impr



—•— mbr000 —•— Other members

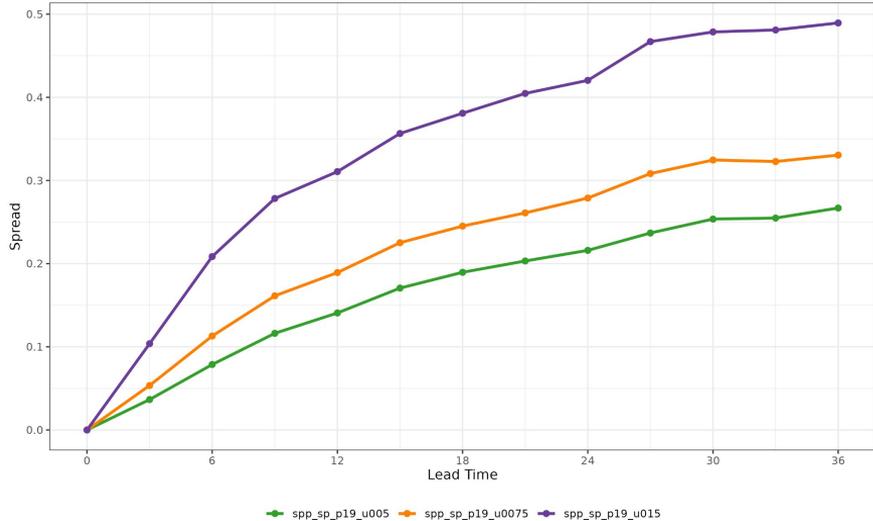
Adding the new parameters to SPP

- We aim at maximising the spread without creating bias issues (also looking at other scores), then we add them to the new 5SPP
- In-depth investigation for some of the parameters - focusing on the involved processes
- Example shown here is for the dynamic perturbation - slwind
 - Perturbing the midpoint wind $V(M)$ in the semi-Lagrangian advection scheme by adding a random rotation with uniform distribution and zero mean angle

An example: Optimising SLWIND

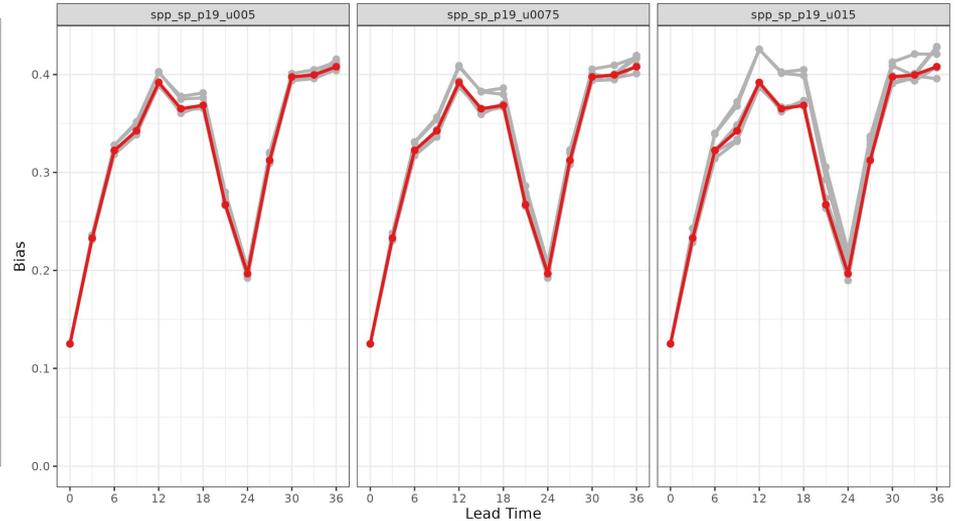
S10m

Spread :: 12:00 14 feb 2023 - 12:00 28 feb 2023
782 stations



Verification for S10m

Bias :: 12:00 14 feb 2023 - 12:00 28 feb 2023
782 stations



mbr000 Other members

Verification for S10m

Spread 10m wind speed for three different values of $CMPERT$ = standard deviation/width of the parameter distribution (0.05, 0.075 and 0.15) - Less spread with 0.05

What about a severe storm like Eowyn?

- Storm Éowyn was a powerful extratropical cyclone that caused widespread disruption and even fatalities across Ireland and the UK
- Hit the west coast of Ireland 24 January 2025
- Record-breaking winds and extensive power outages.
- Underwent explosive cyclogenesis as it approached Ireland.



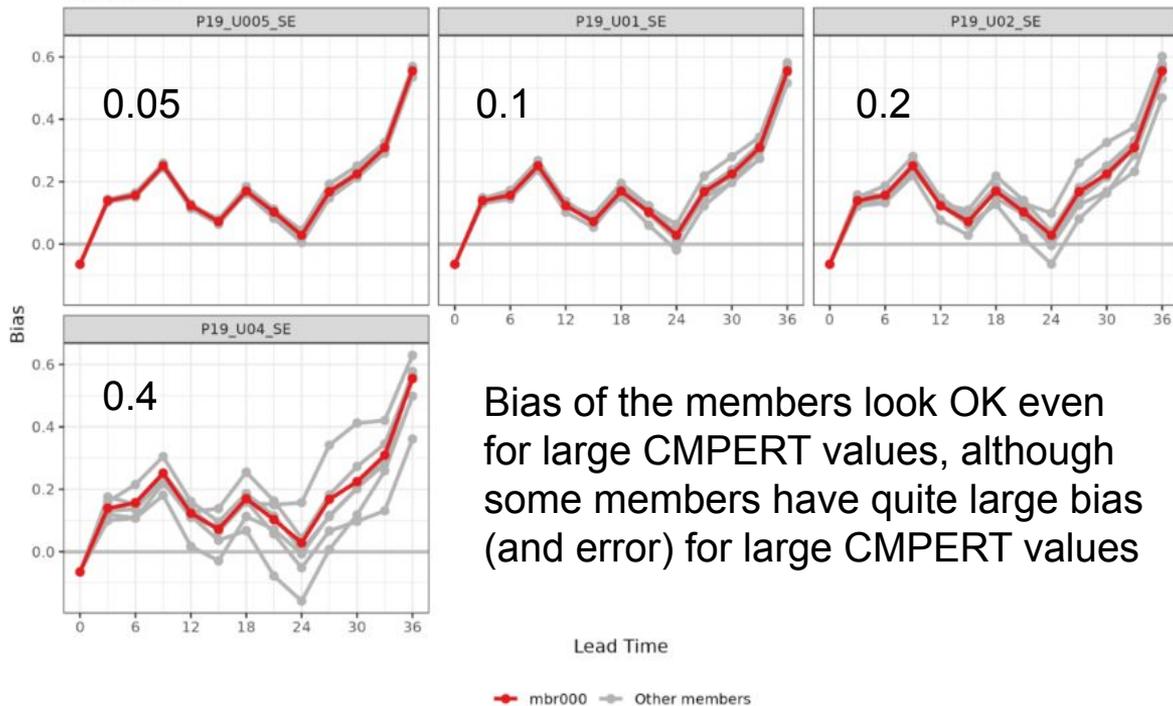
What about a severe storm like Eowyn?

PMSL

For period 17 - 31 January 2025

Bias :: 12:00 17 Jan 2025 - 12:00 31 Jan 2025

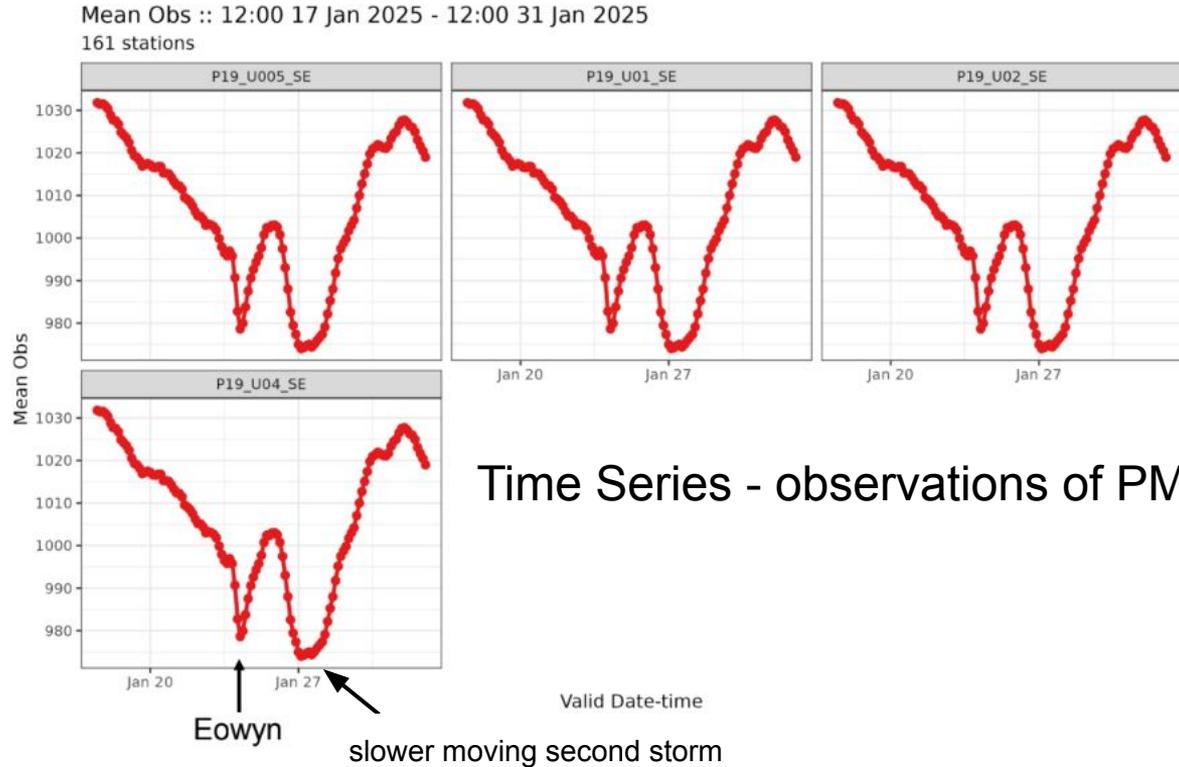
161 stations



Bias of the members look OK even for large CMPERT values, although some members have quite large bias (and error) for large CMPERT values

What about a severe storm like Eowyn?

PMSL

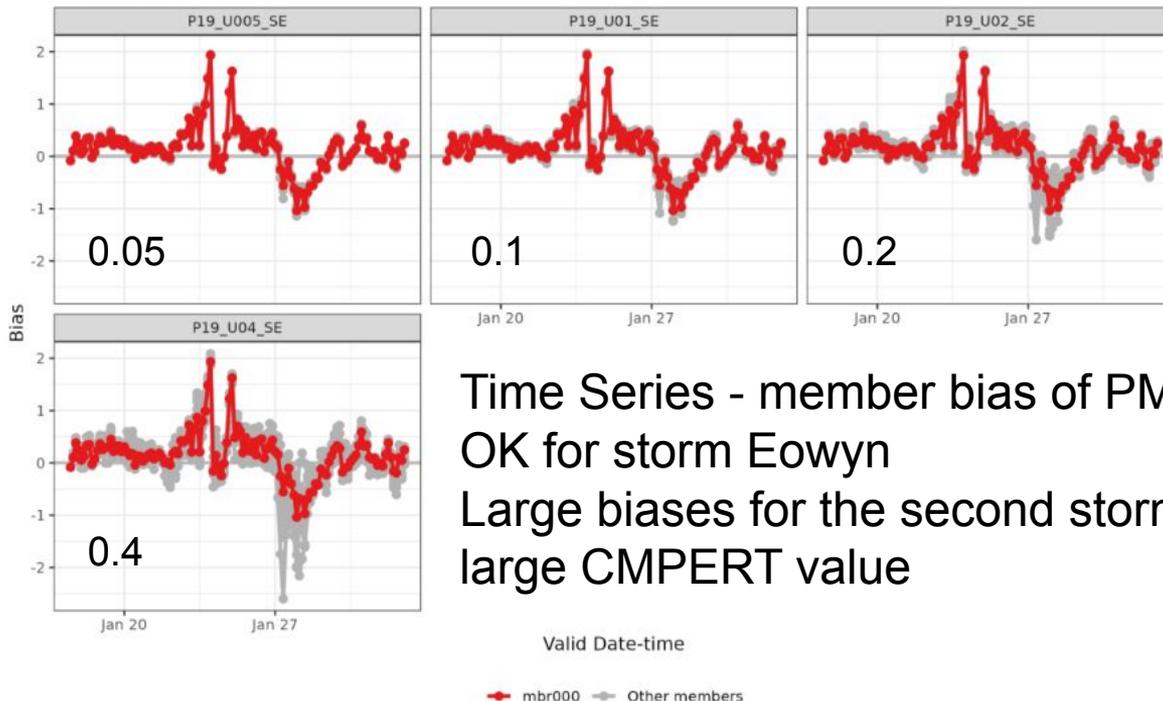


What about a severe storm like Eowyn?

PMSL

Bias :: 12:00 17 Jan 2025 - 12:00 31 Jan 2025

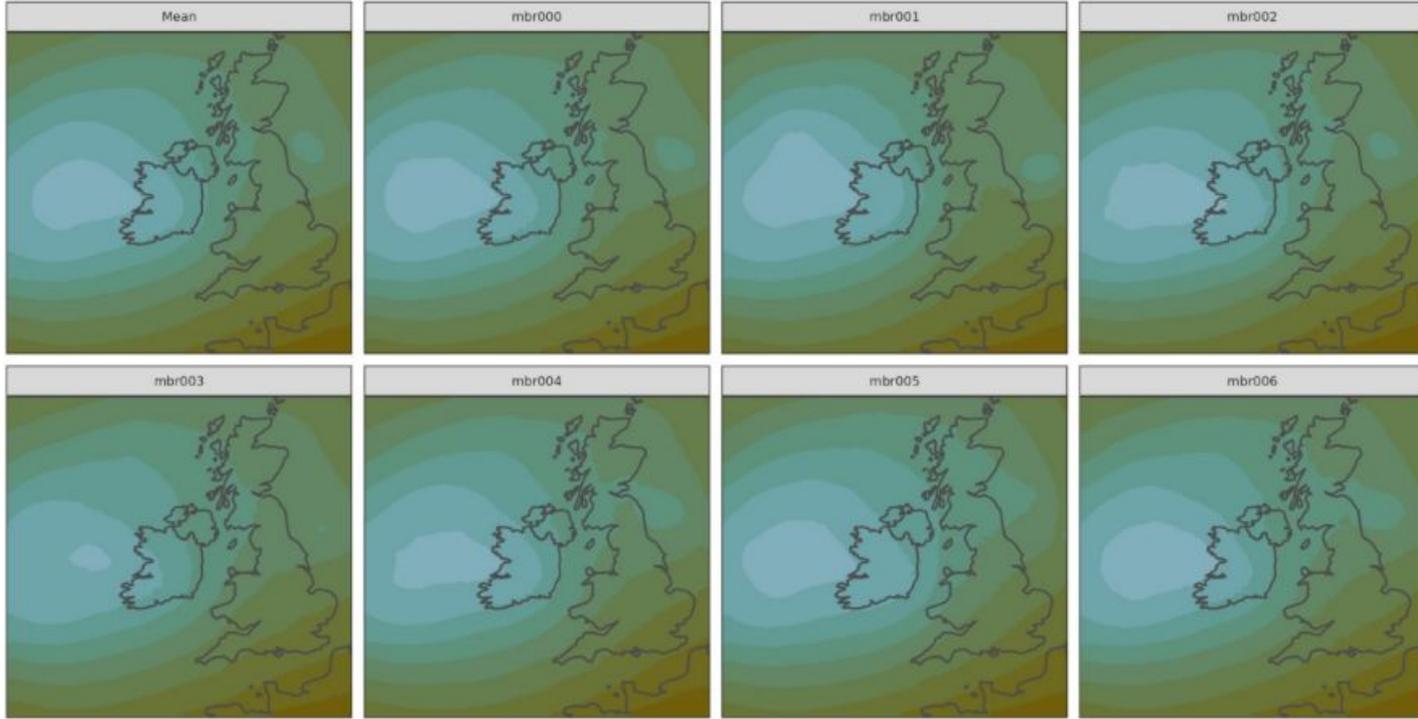
161 stations



Time Series - member bias of PMSL
OK for storm Eowyn
Large biases for the second storm for
large CMPERT value

PMSL CMPERT=0.4

P19_U04_SE : 2025/01/26/12+18 (valid at 2025-01-27 06:00:00) : Pres



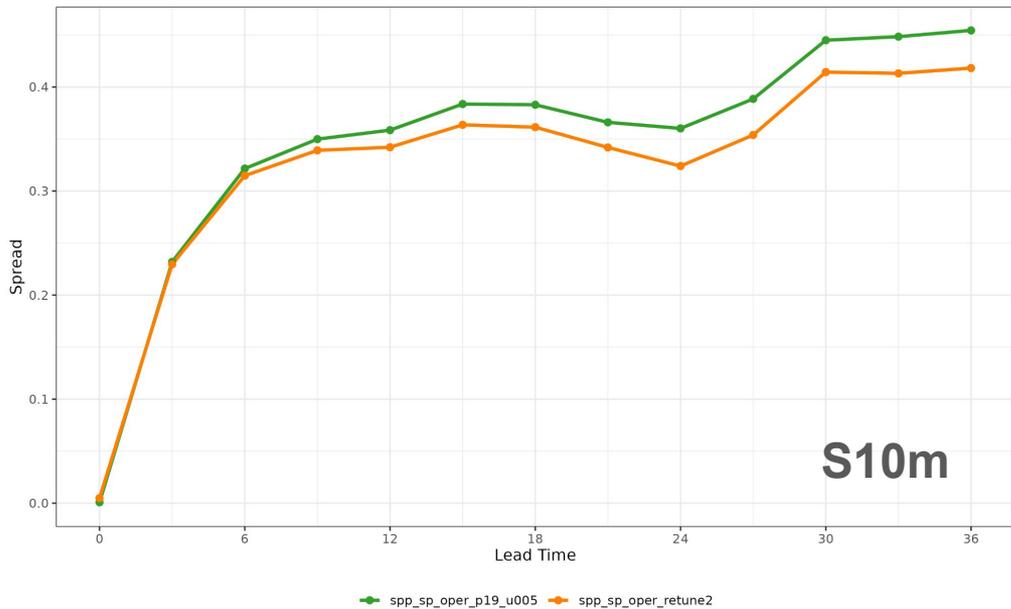
Fields look reasonable

Increased amplitude with increasing CMPERT, not changing the location of system

Optimising SLWIND - adding it to 5SPP

Spread :: 12:00 14 feb 2023 - 12:00 28 feb 2023

782 stations



Verification for S10m

Although OK with large CMPERT for Eowyn, second storm gave large biases

We go for CMPERT=0.05

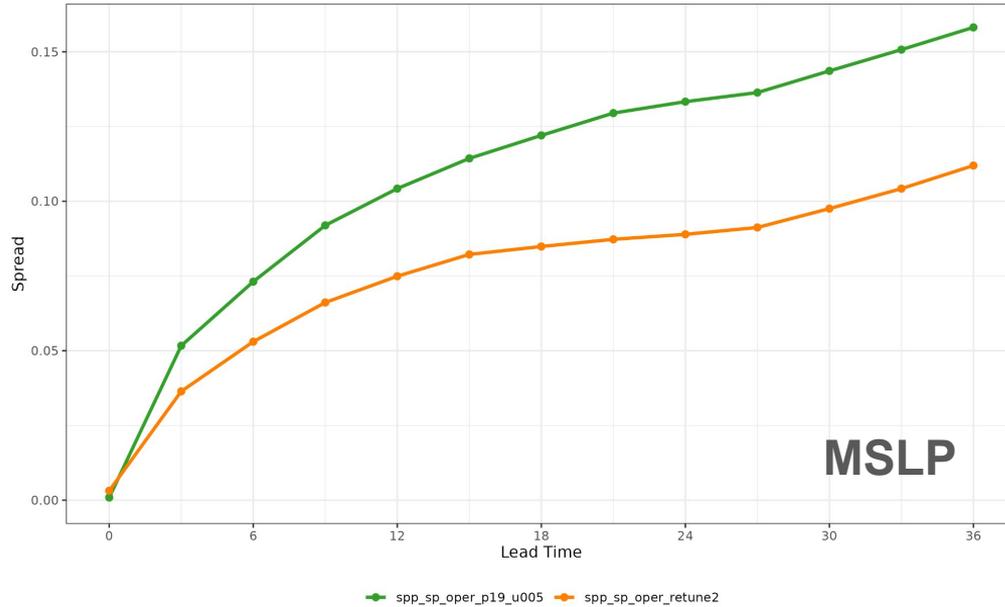
The small CMPERT value of 0.05 gives a nice increase in spread for 10m wind speed

Spread 10m wind speed **5SPP** **5SPP + SLWIND (0.05)**

Optimising SLWIND - adding it to 5SPP

Spread :: 12:00 14 feb 2023 - 12:00 28 feb 2023

649 stations



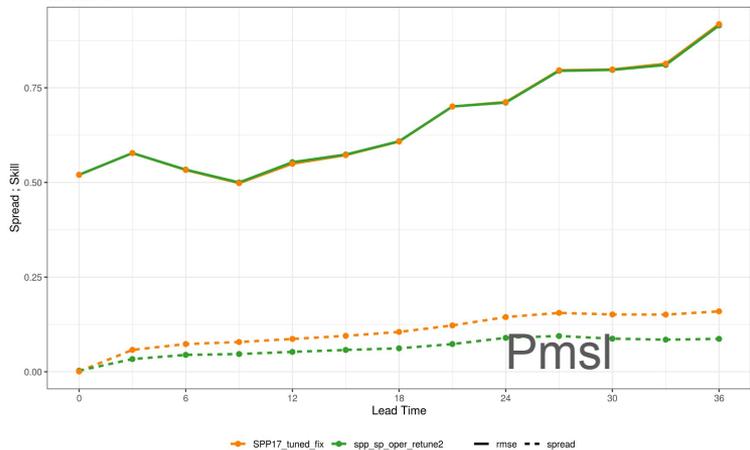
Verification for Pmsl

We get a nice increase in spread also in other weather parameters

Spread MSLP **5SPP** **5SPP + SLWIND (0.05)**

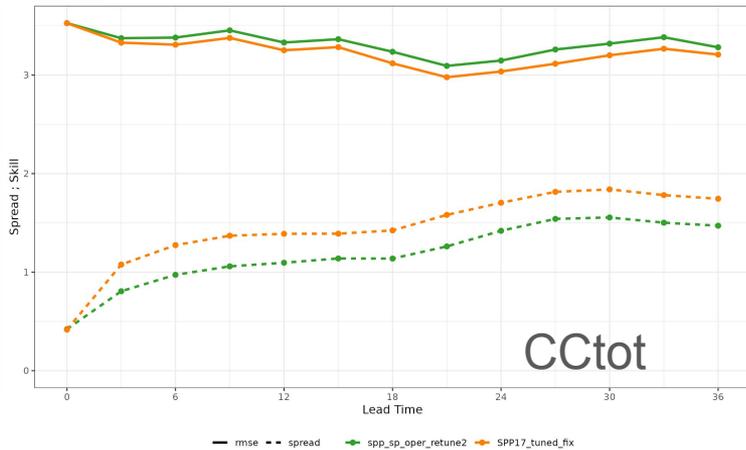
All 17 SPP upper air parameters together - summer

Spread Skill :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
655 stations



Verification for Pmsl

Spread Skill :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
421 stations

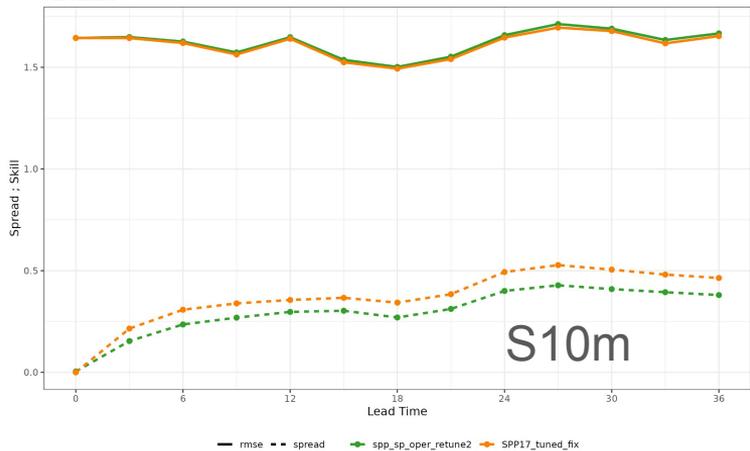


Verification for CCtot

New 5SPP

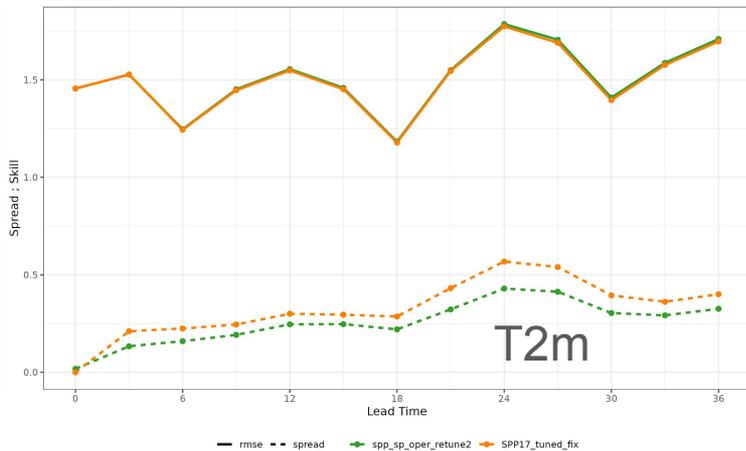
17SPP

Spread Skill :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
792 stations



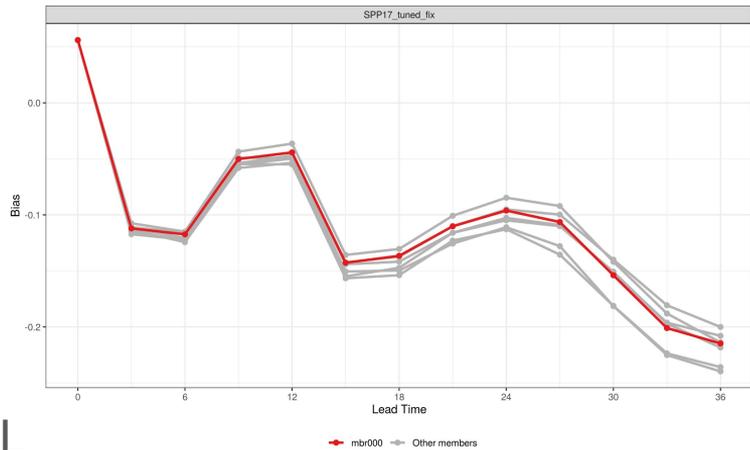
Verification for S10m

Spread Skill :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
852 stations



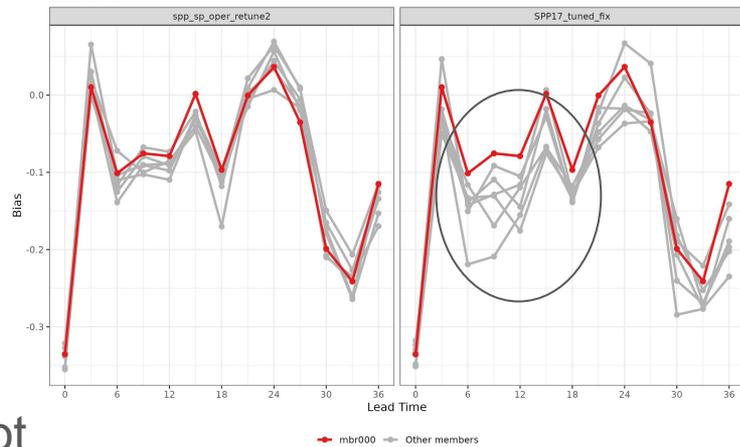
Verification for T2m

Bias :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
655 stations



Verification for Pmsl

Bias :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
421 stations

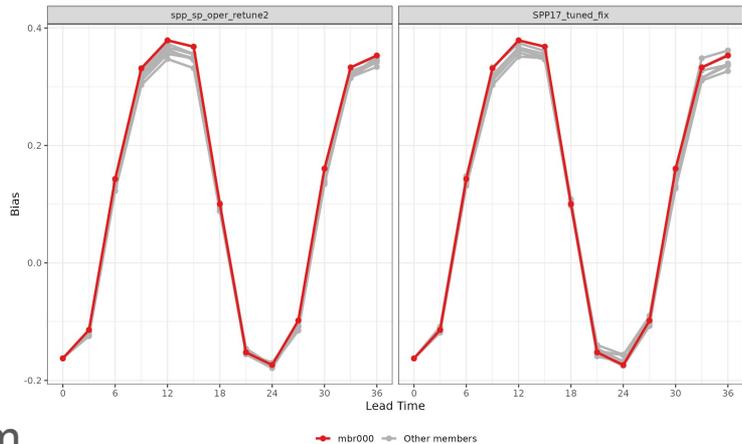


Verification for CCtot

PMSL

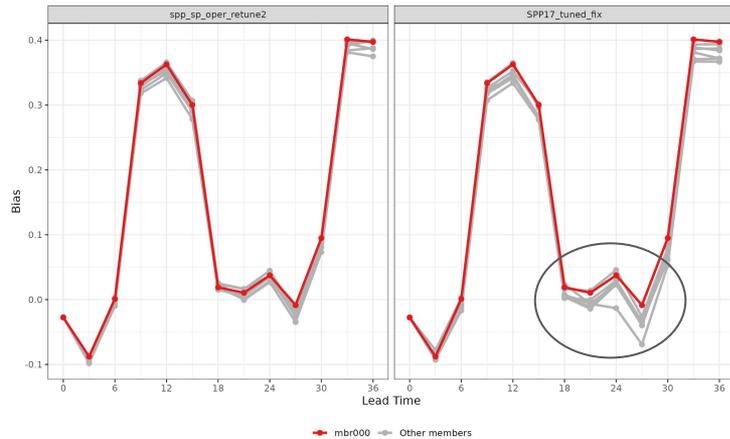
CCtot

Bias :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
792 stations



Verification for S10m

Bias :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022
852 stations



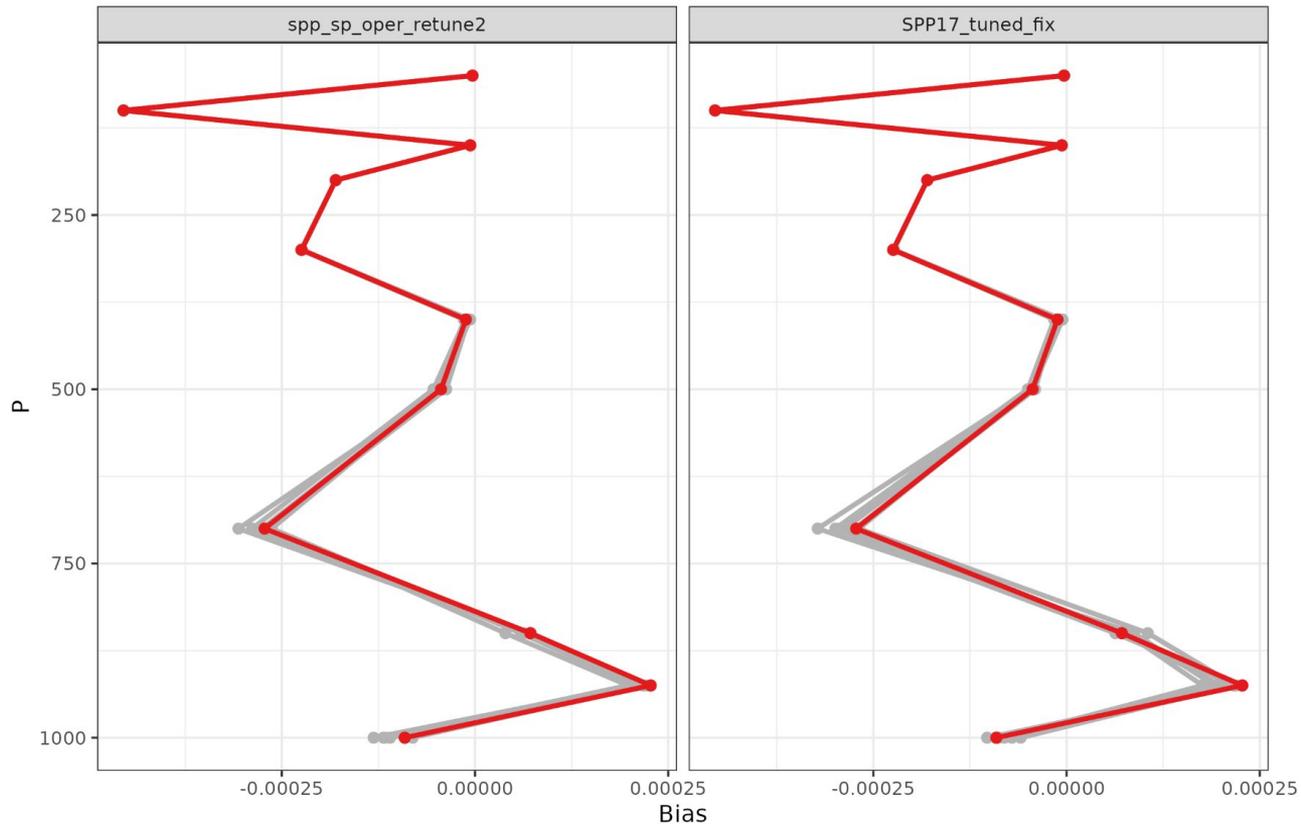
Verification for T2m

S10m

T2m

Bias :: 12:00 07 Jul 2022 - 12:00 21 Jul 2022

19 stations



● mbr000 ● Other members Q

Verification for Q

Outlook SPP

- Finish the extension of SPP from 5 to 17 parameters -> end up with a recommendation for operational use in cy46
- Continue the work on extending SPP to surface
- Continue the work on adding flow dependence in line with what is done in Arome/Lace
- Maintenance and refinements -> easier in the future? Uranie work

Thank you for your attention

Extra

A note on the cost

Exp	NSPP_PAR	NPATFR(s)	SPGMAXS UBSTEPS	Total cost(s)	Step cost(s)	Total Cost relative ref
ref	0	0	0	3254	2.670	1.0
spp_4	5	21600	300	3271	2.670	1.005
spp_ref	5	3600	150	3294	2.683	1.012
spp_1	17	3600	50	3344	2.693	1.028
spp_3	17	10800	150	3354	2.717	1.031
spp_2	17	75	50	4286	3.487	1.317

The cost stays < 3% even for 17 parameters and is in line with experiences from ECMWF

List of parameters:

- P1 VSIGQSAT: Saturation limit sensitivity for condensation
- P3 CLDDPTHDP: Threshold for cloud thickness used in shallow/deep convection decision
- P4 ICE_CLD_WGT: Cloud ice content impact on cloud thickness
- P5 ICENU: Ice nuclei
- P6 KGN_ACON: Kogan autoconversion speed
- P7 KGN_SBGR: Kogan subgrid scale (cloud fraction) sensitivity
- P8 RADGR: Graupel impact on radiation
- P9 RADSN: Snow impact on radiation
- P10 RFAC_TWOC: Top entrainment
- P11 RZC_H: Stable conditions length scale
- P12 RZL_INF: Asymptotic free atmospheric length scale
- P15 ALPHA: Cloud droplet gamma distribution parameter alpha (over sea)
- P16 NU: Cloud droplet gamma distribution parameter NU (over land)
- P17 RZMFDY: Dry mass flux
- P18 RZMBCLOSURE: Closure parameter for moist mass flux
- P19: SLWIND: Perturbing V(M) in the semi-Lagrangian advection scheme
- P20 VTERM: Fallspeed
- CV: Thermal inertia coefficient
- RSMIN: Minimum stomatal resistance

SPG

Stochastic pattern generator (SPG; Tsyrlunikov and Gayfulin 2017) is employed for the generation of the random perturbation fields.

This pattern generator has the advantage of accounting for 'proportionality of scales', meaning it takes into account the fact that longer spatial scales live longer than shorter spatial scales, which die out quicker, a widespread feature in geophysics.

In SPG, the perturbations vary spatially and temporally, and are correlated through a third-order in time stochastic differential equation with a pseudo-differential spatial operator defined on a limited area.

The implementation in HarmonEPS interfaces the code provided by Tsyrlunikov and Gayfulin (2017) and is solely defined by the spatial (XLCOR) and temporal (TAU) correlation length scales, and the standard deviation, SDEV

New developments - perturbing the dynamics

- First dynamics perturbation in SPP
- Perturbing $V(M)$ in the semi-Lagrangian advection scheme
- Used to compute a refined position for the origin point of the trajectory (only for the Coriolis term)

- Formula for the wind used:

$$V = 0.5 * RW2TLFF * (V(F) + V(O)) + (1 - RW2TLFF) * \mathbf{V}(M)$$

where F is final, O is origin and M is midpoint along trajectory

- The option sets $RW2TLFF=0.5$ (is 1 in unperturbed) and adds a random rotation with uniform distribution and zero mean angle to the $V(M)$ wind.

SPP status

Operations:

- A 5 parameter version operational in MetCoOp (since August 2022) and in UWC-W - in cy43
- SPP update to be ready before the operational versions switching to cy46

AUGUST 2024

TSIRINGAKIS ET AL.

1923

An Update to the Stochastically Perturbed Parameterization Scheme of HarmonEPS[®]

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APRIL 2022

FROGNER ET AL.

775

Model Uncertainty Representation in a Convection-Permitting Ensemble—SPP and SPPT in HarmonEPS

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