

Model Uncertainty (SPP) in cy 46

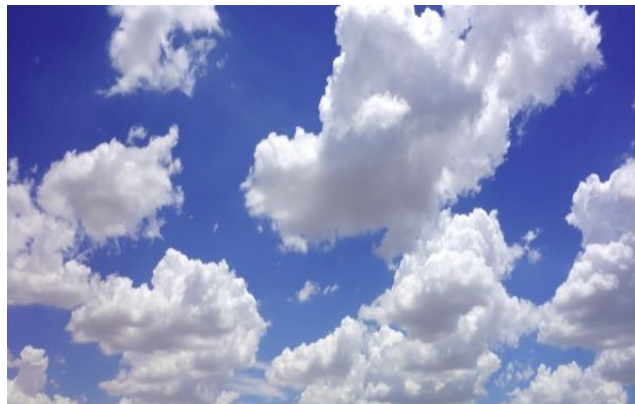
Pirkka Ollinaho and Inger-Lise Frogner

and the rest of the Hirlam SPP upper air team:

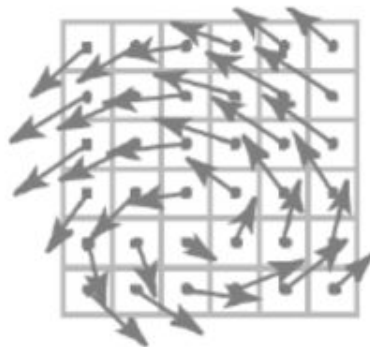
Karoliina, James, Sibbo, Janne, Xiaohui, Ulf, Ole and Alan



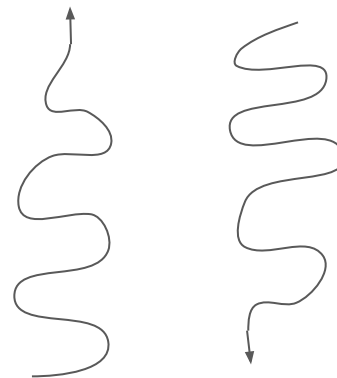
SPP - perturbing uncertain parameters



Clouds and microphysics



Dynamics



Radiation



Turbulence



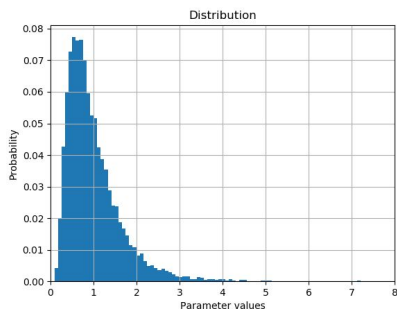
Surface



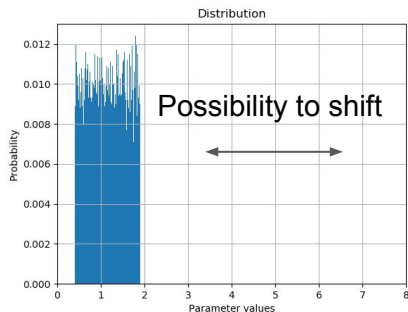
Stochastically Perturbed Parameterizations (SPP) - Upper air

Status:

- A 5 parameter version operational in MetCoOp (since August 2022) and in UWC-W - in cy43
- Many more parameters in the SPP scheme that are not in operations
- Operational versions switching to cy46
- Bias issues seen in current SPP implementation for cy46



lognormal distribution



Uniform distribution

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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(Manuscript received 30 April 2021, in final form 15 December 2021)

An extensive overhaul and extension of SPP

- Revisited the 5 parameter SPP (5SPP) scheme in cy46 and got (close to) unbiased ensemble (with respect to the control)
 - removing bias leads to loss of spread
 - while working on this we also identified compensating biases in the 5 SPP scheme
 - addition of new parameter perturbations to alleviate this
- Include uncertainty in more processes - including the dynamics
- Ongoing work by the Hirlam SPP team for the last year or so
- Work in progress

Revisit 5SPP configuration

- **P1 (PSIGQSAT)** - 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
- **P11 (RZC_H)** - Stable conditions length scale
- **P12 (RZL_INF)** - Asymptotic free atmospheric length scale

OPER

- **P1** - lognormal, CMPERT 0.6
- **P3** - lognormal, CMPERT 0.6
- **P4** - uniform, no offset, CMPERT 1.2
- **P11** - uniform, offset 0.475, CMPERT 1.05
- **P12** - lognormal, CMPERT 0.45

Exp 1b

- **P1** - lognormal, CMPERT **0.3**
- **P3** - no change
- **P4** - uniform, offset **0.475**, CMPERT **1.0**
- **P11** - uniform, **no offset**, CMPERT **0.9**
- **P12** - lognormal, CMPERT **0.35**

CMPERT is the scaling of the perturbation

Exp 1c

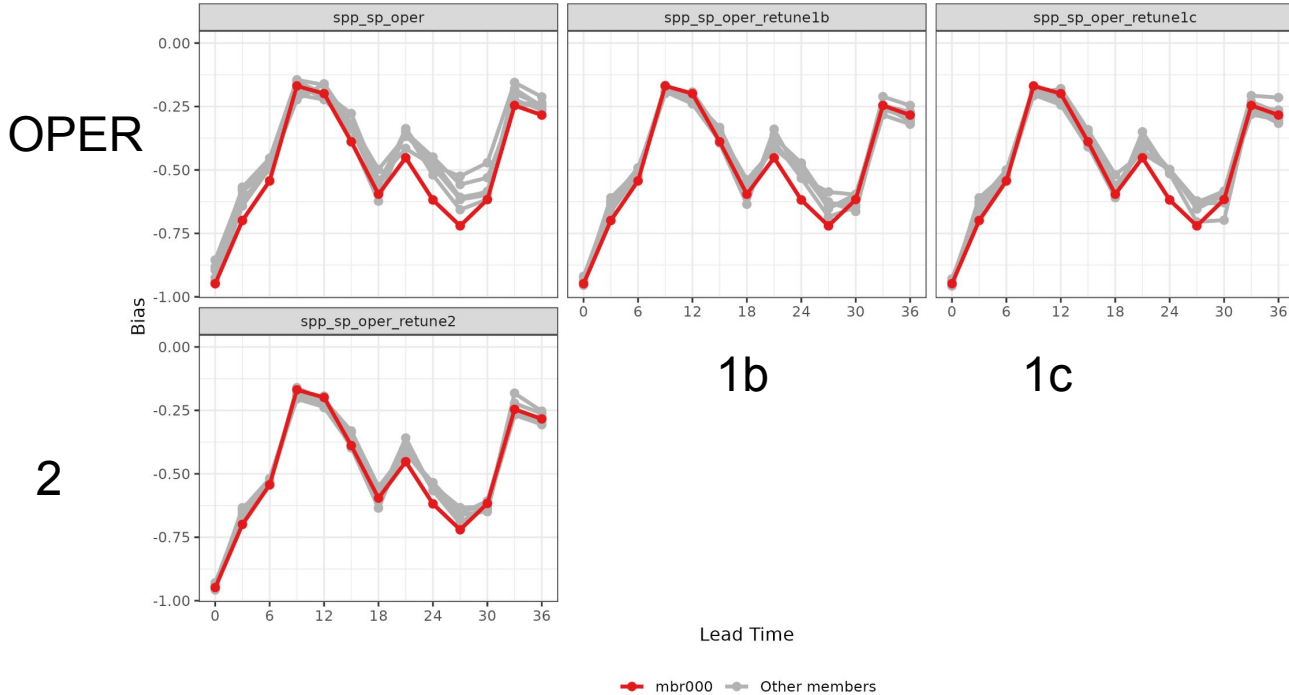
- **P1** - lognormal, CMPERT **0.25**
- **P3** - no change
- **P4** - uniform, offset **0.475**, CMPERT **1.0**
- **P11** - uniform, **no offset**, CMPERT **0.9**
- **P12** - lognormal, CMPERT **0.35**

Exp 2

- **P1** - lognormal, CMPERT **0.25**
- **P3** - **uniform**, no offset, CMPERT **1.4**
- **P4** - uniform, offset **0.475**, CMPERT **1.0**
- **P11** - uniform, **no offset**, CMPERT **0.8**
- **P12** - lognormal, CMPERT **0.35**

Effect on member bias

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

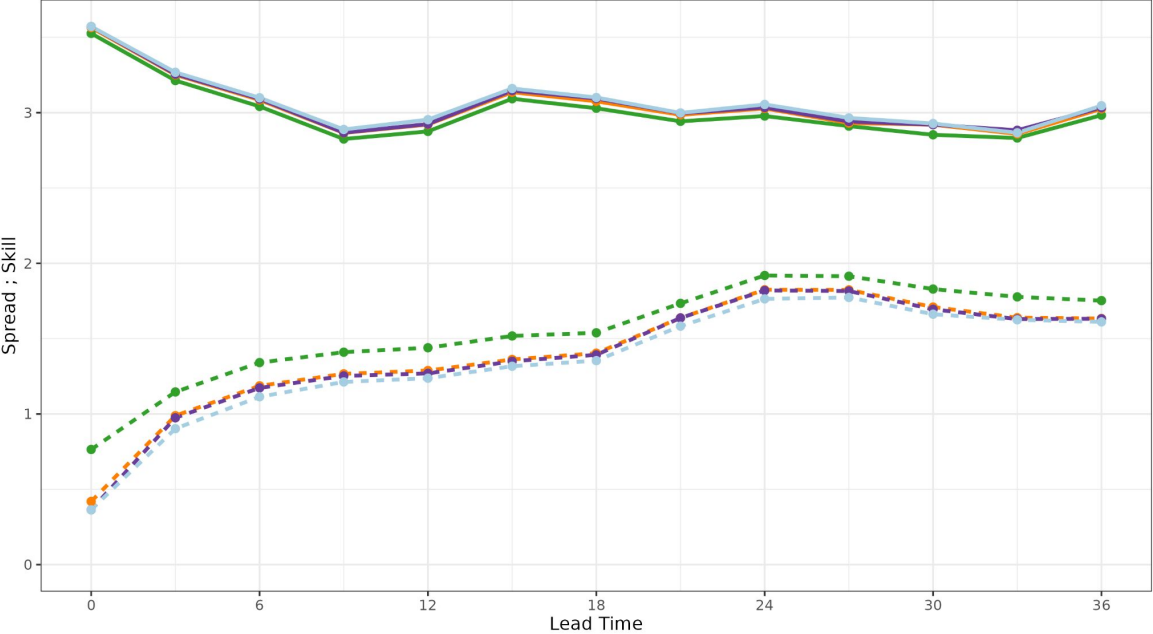


Low clouds

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

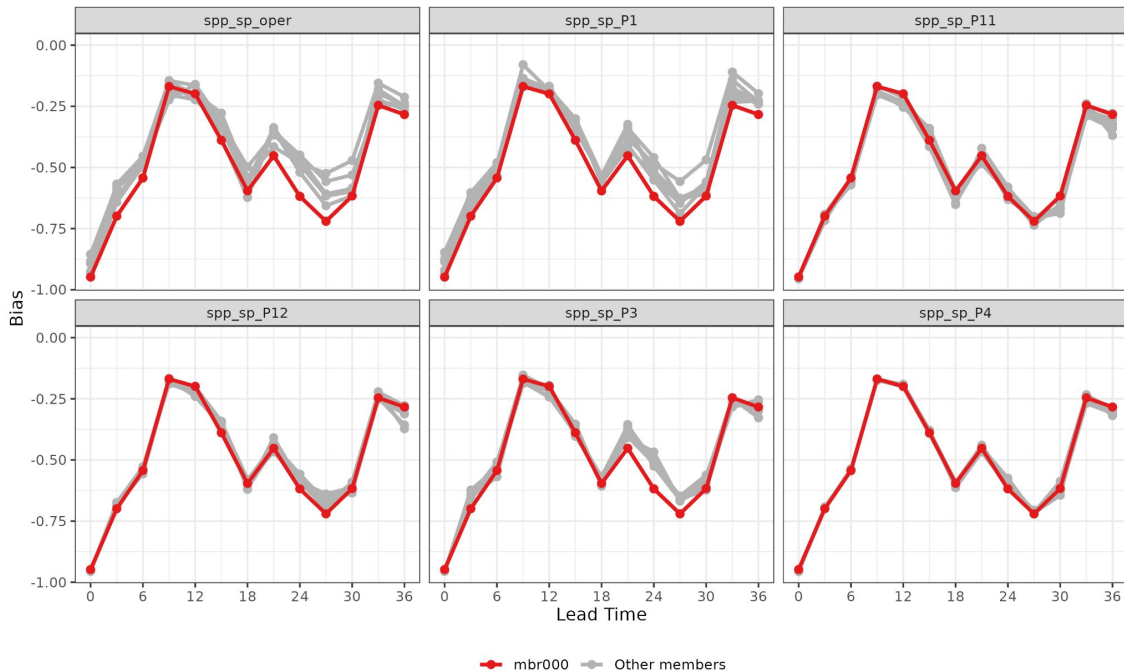
Bias of individual parameter perturbations

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

437 stations

OPER

Bias issues



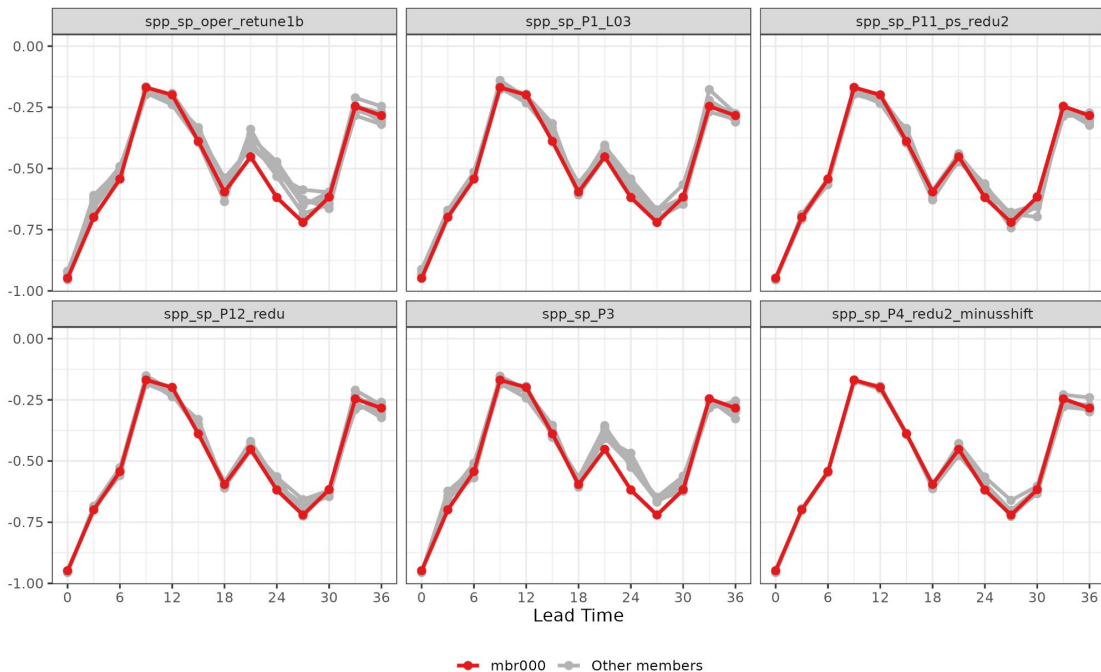
Bias of individual parameter perturbations

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

437 stations

Exp 1b

Largest impact
from P1
changes



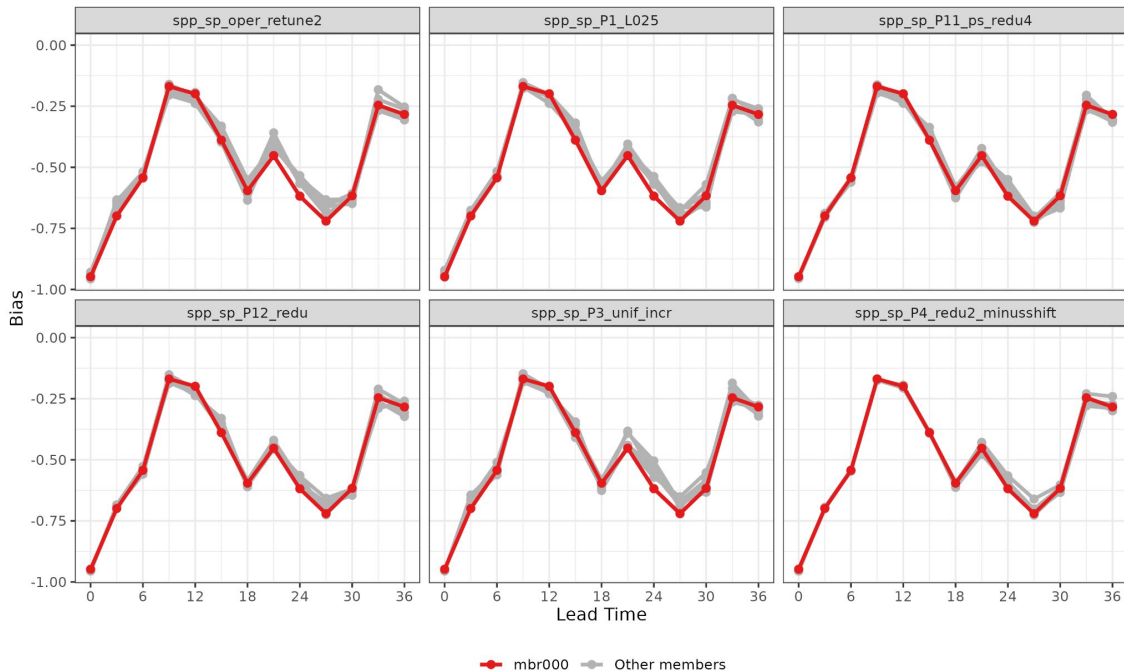
Bias of individual parameter perturbations

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

437 stations

Exp 2

A further
reduction from
P3 changes



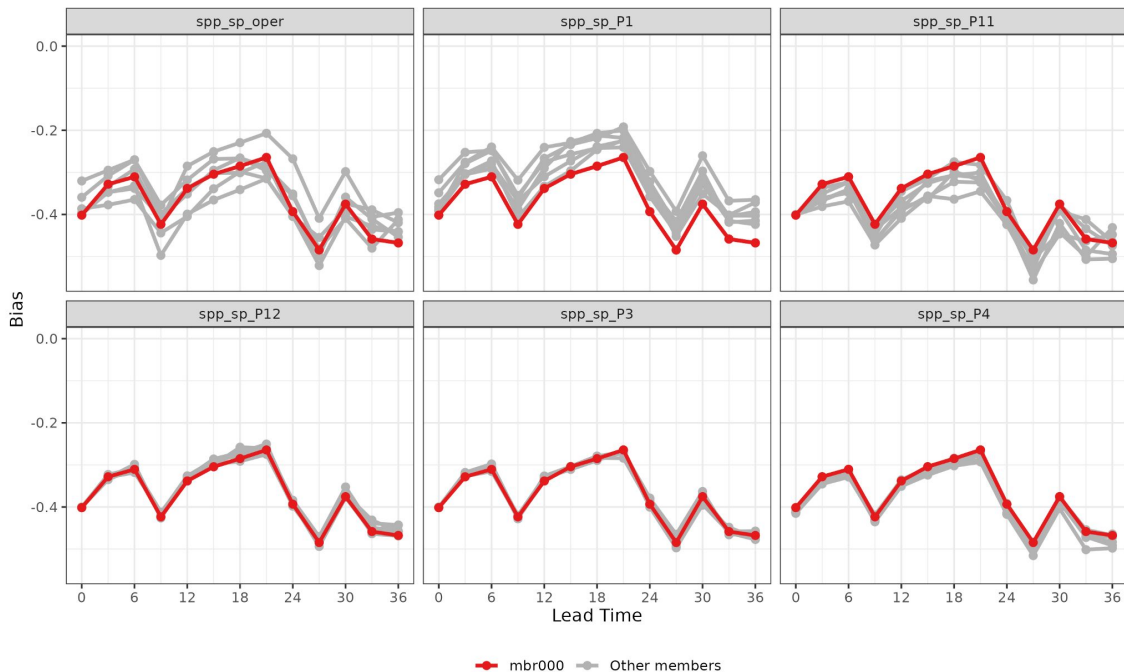
Compensating biases

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

430 stations

OPER

Overall bias
is OK but
compensating
opposite
biases for P1
and P11



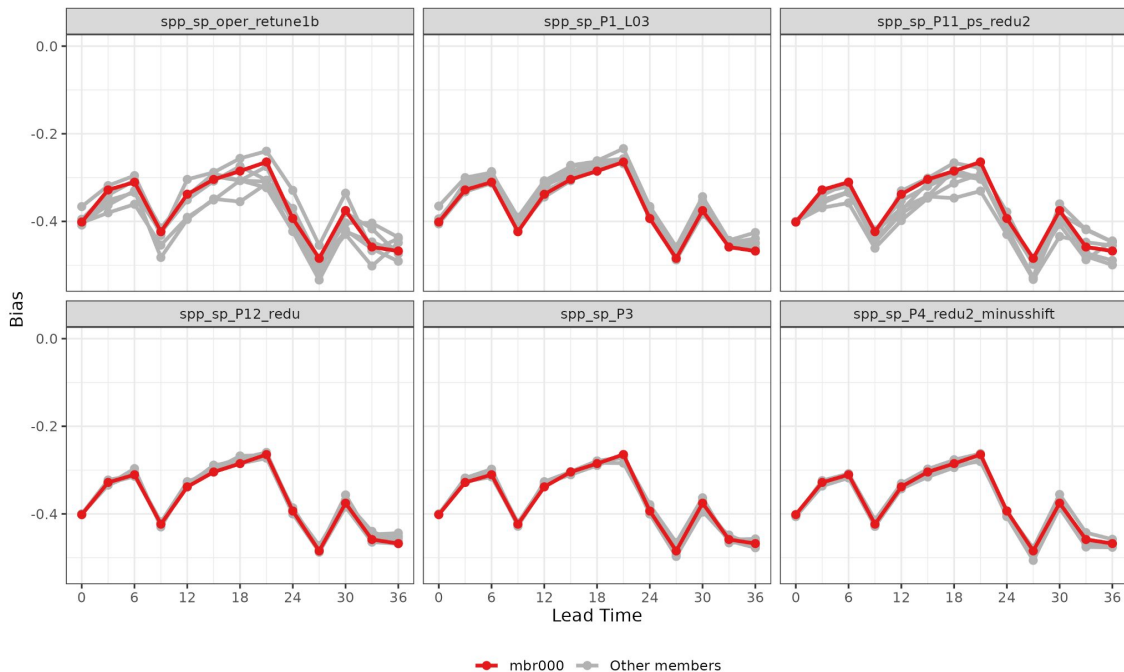
Compensating biases

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

430 stations

Exp 1b

Fixes the
worst for
P1 and P11



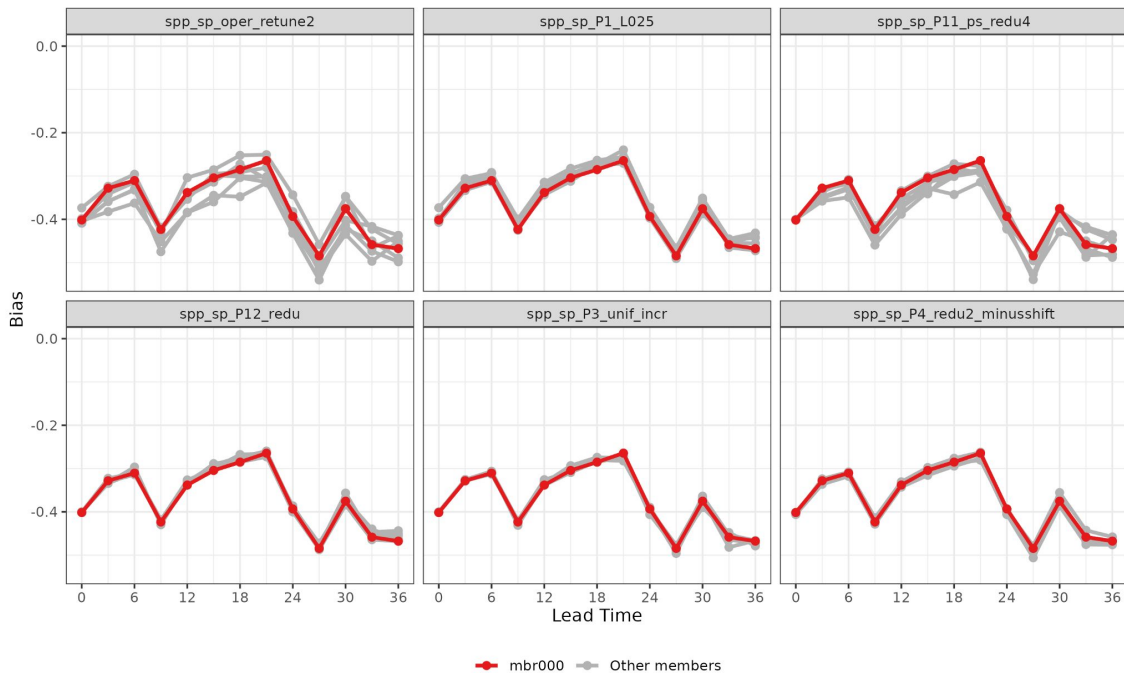
Compensating biases

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

430 stations

Exp 2

Further
improves both

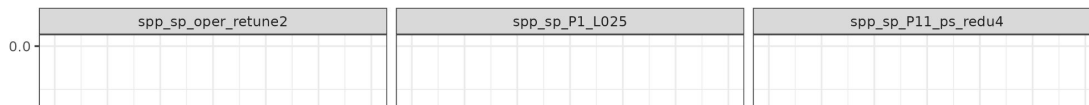


Compensating biases

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

430 stations

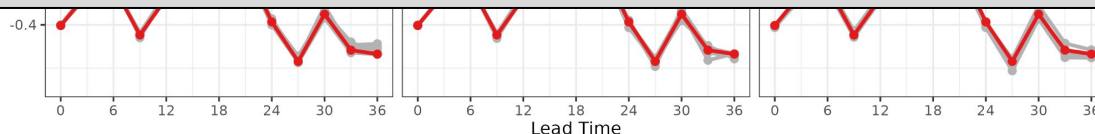
Exp 2



=> 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)

Further
impr



—•— mbr000 —•— Other members

Adding new parameters to SPP

- 2 new for shallow convection, 6 new for micro-physics, 1 new for turbulence, 1 new for dynamics and 2 new for radiation
- We are 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
- For all new parameters, example shown here is for the dynamic perturbation - slwind

-> See also presentations by Sibbo in this session!

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:

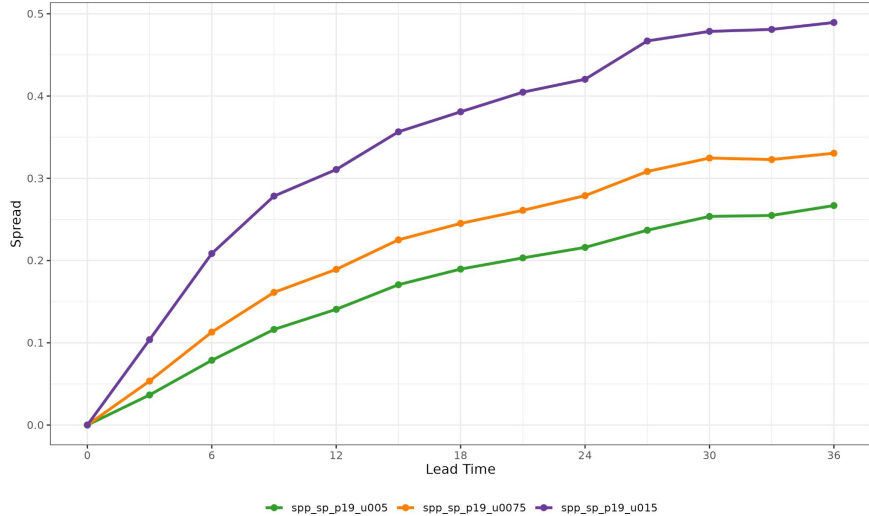
$$V = 0.5 * RW2TLFF * (V(F) + V(O)) + (1 - RW2TLFF) * \mathbf{V}(M)$$

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.

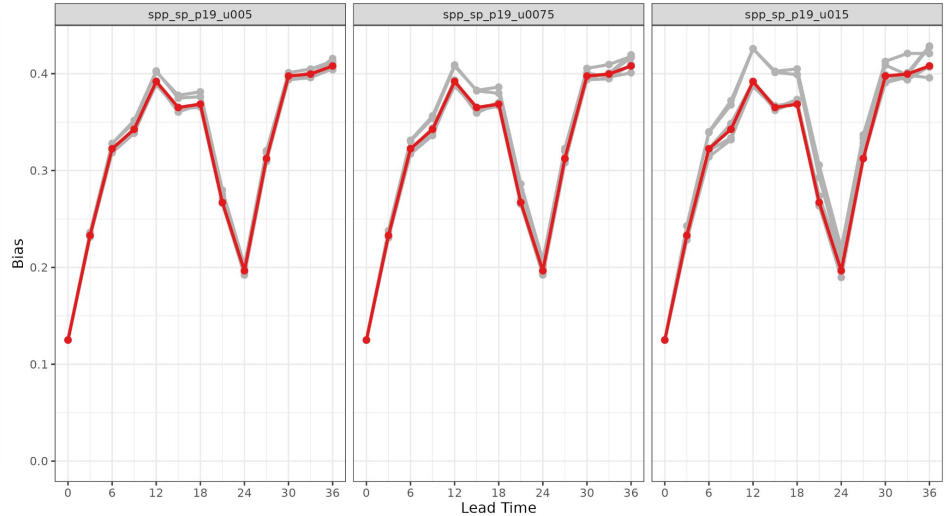
An example: Optimising SLWIND

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

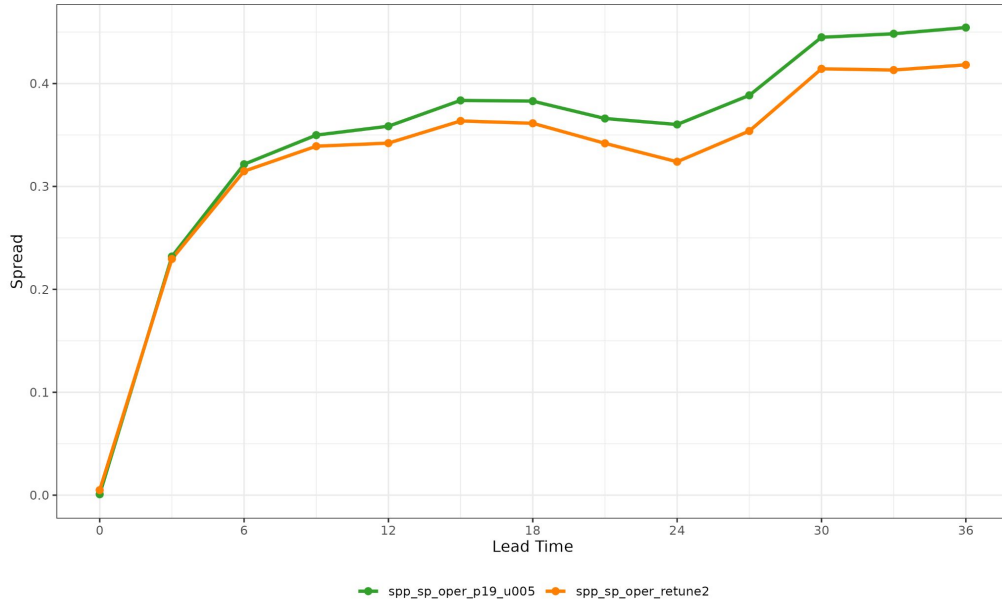
Verification for S10m

Spread 10m wind speed for three different values of CMPERT (0.05, 0.075 and 0.15)
To avoid shifting the ensemble to higher wind speeds go for CMPERT 0.15

Optimising SLWIND - adding it to 5SPP

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

782 stations



Verification for S10m

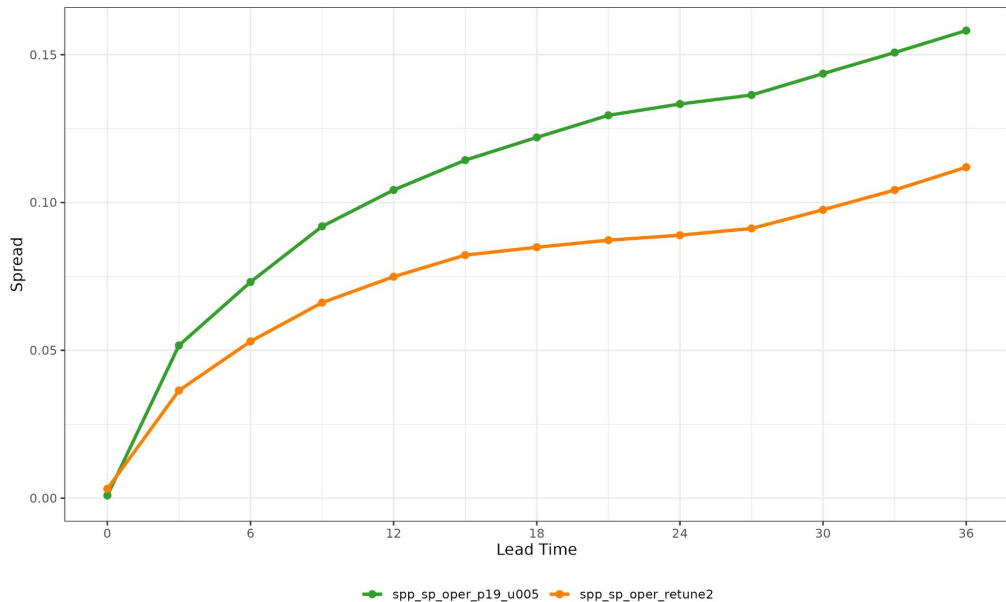
The small CMPERT value of 0.05 gives a nice increase in spread for 10m wind speed

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

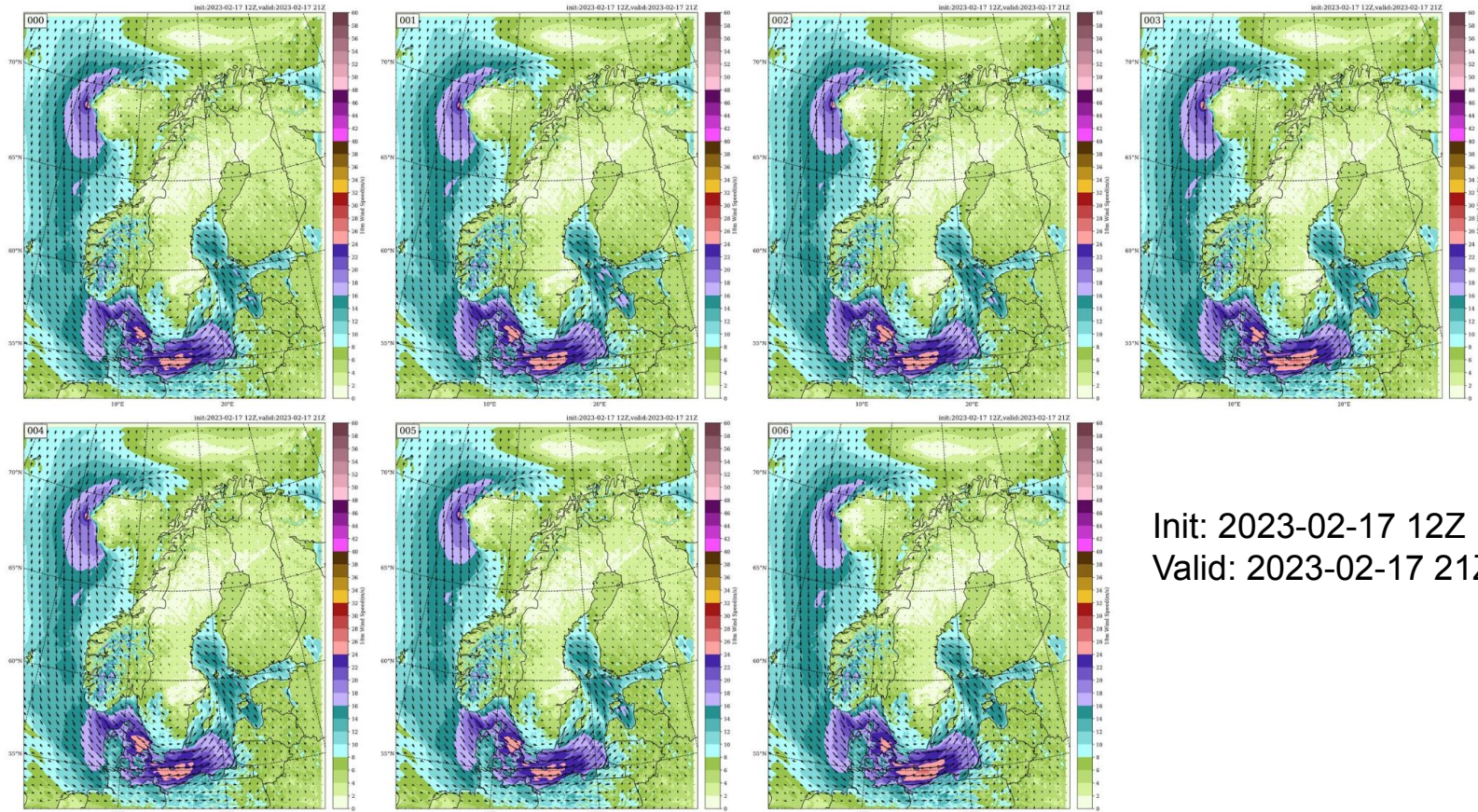


Verification for Pmsl

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

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

Spatial Distribution of S10m - a check to see if OK



Init: 2023-02-17 12Z
Valid: 2023-02-17 21Z (+09h)

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

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 -> see Endi's presentation in this session!
- Maintenance and refinements -> easier in the future? See presentation by James in this session!

Thank you for your attention

Extra

Shallow convection	Micro physics (1)	Micro physics (2)	Turbulence	Dynamics	Radiation
<p>P3 <u>CLDDPTHDE</u></p> <p>Settings:uniform, CMPERT=1.4, offset=0.5, clip at 0 in lower range to be sure not crossing zero</p>	<p>P1 <u>PSIGOSAT</u></p> <p>Settings: lognormal, CMPERT=0.3</p> <p>Checked that smaller scale did not give better spread</p>	<p>P15 ALPHA</p> <p>Settings: uniform, CMPERT=1.5,offset=0.57, corr=no</p>	<p>P10 RFAC_TWOC</p> <p>Settings:uniform, CMPERT=0.9, offset=0.45,clip at 0 in lower range to be sure not crossing zero</p>	<p>P19 SLWIND</p> <p>Settings:uniform, offset=0.5, CMPERT=0.05 is OK but we lose a lot of spread. Xiaohui will look at 2D-fields. James does not see any bias in his Uranie runs, even with large CMPERT.</p>	<p>P8 RADGR</p>
<p>P17 RZMFDRI</p> <p>Settings:uniform, offset=0.475, CMPERT=2.0,clip at 0 in lower range to be sure not crossing zero</p>	<p>P4 <u>ICE_CLD_WGT</u></p> <p>Settings:uniform, CMPERT=1.0, offset=0.475, clip at 0 in lower range to be sure not crossing zero</p>	<p>P16 RZNUC</p> <p>Settings:lognormal, CMPERT=0.3, corr=no</p>	<p>P11 RZC_H</p> <p>Settings:uniform, offset=0.5, CMPERT=0.8, *corr with RZL_INF*</p>		<p>P9 RADSN</p>
<p>P18 RZMBCLOSURE</p> <p>Settings:uniform, offset=0.5, CMPERT=1.3, clip at 0 in lower range to be sure not crossing zero</p>	<p>P5 ICENU</p> <p>Settings: lognormal, CMPERT=0.6, TAU=3h, XLCOR=50 km</p>	<p>P20 VTERM</p>	<p>P12 <u>RZL_INF</u></p> <p>Settings: lognormal, CMPERT=0.35, smaller scales (50km and 3h) *corr with RZC_H*</p>		
	<p>P6 KGN_ACON</p> <p>Settings:</p>	<p>P21 RZNUC2</p> <p>Settings:</p>			
	<p>P7 KGN_SBGR</p> <p>Settings: lognormal, CMPERT=0.3, clipping=0-1</p>	<p>P22 ALPHA2</p> <p>Settings:</p>			

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 RADSNO: 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

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