HarmonEPS developments

2 topics chosen this year: understanding a problem and how we hope to solve it and status of the SPP development

Inger-Lise Frogner
and the HIRLAM EPS team

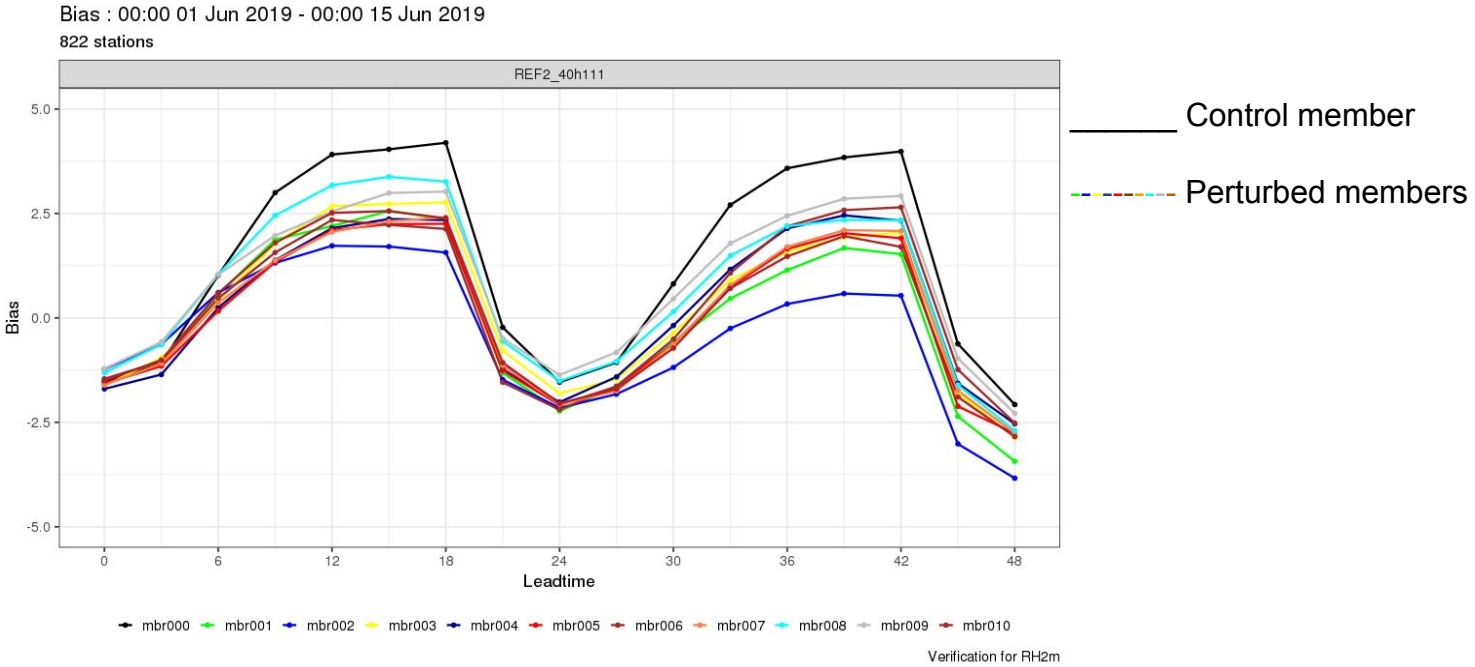
Members dryer than control

Harold McInnes and Henrik Feddersen

A problem seen in operational suites as well as in experiments - are perturbations of humidity in any form to blame?

Standard HarmonEPS experiment run for 15 days in June 2019. perturbations of humidity on in initial state, surface and LBCs

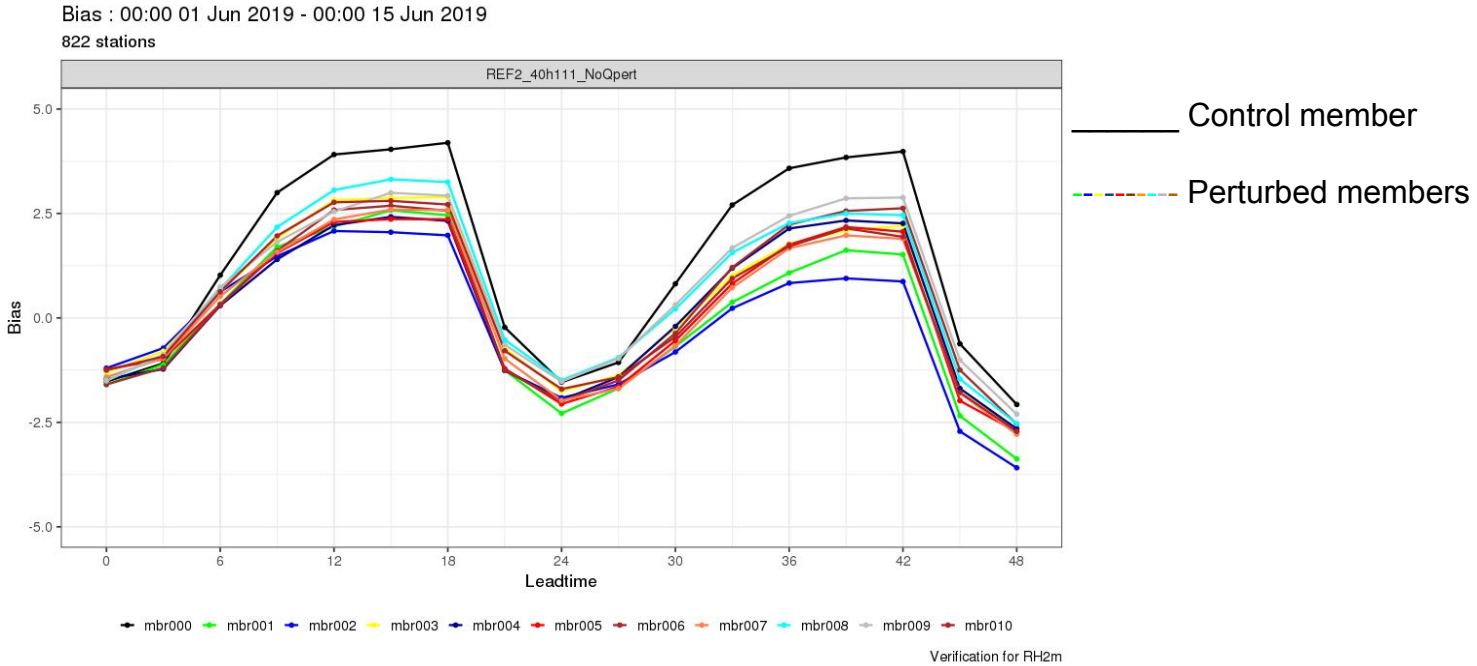
Bias all members, RH2m



Switching off humidity perturbations in initial state only

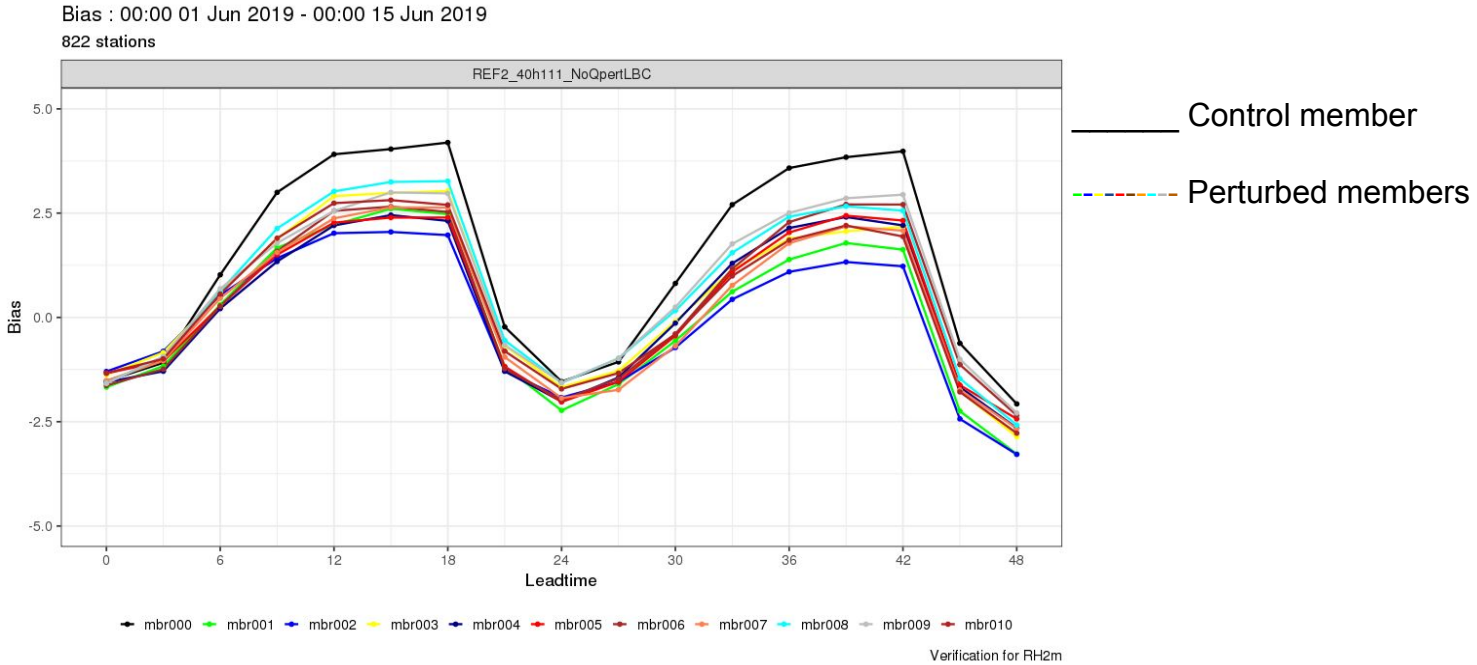
Switching off humidity perturbations in the initial state did not help much

Bias all members, RH2m



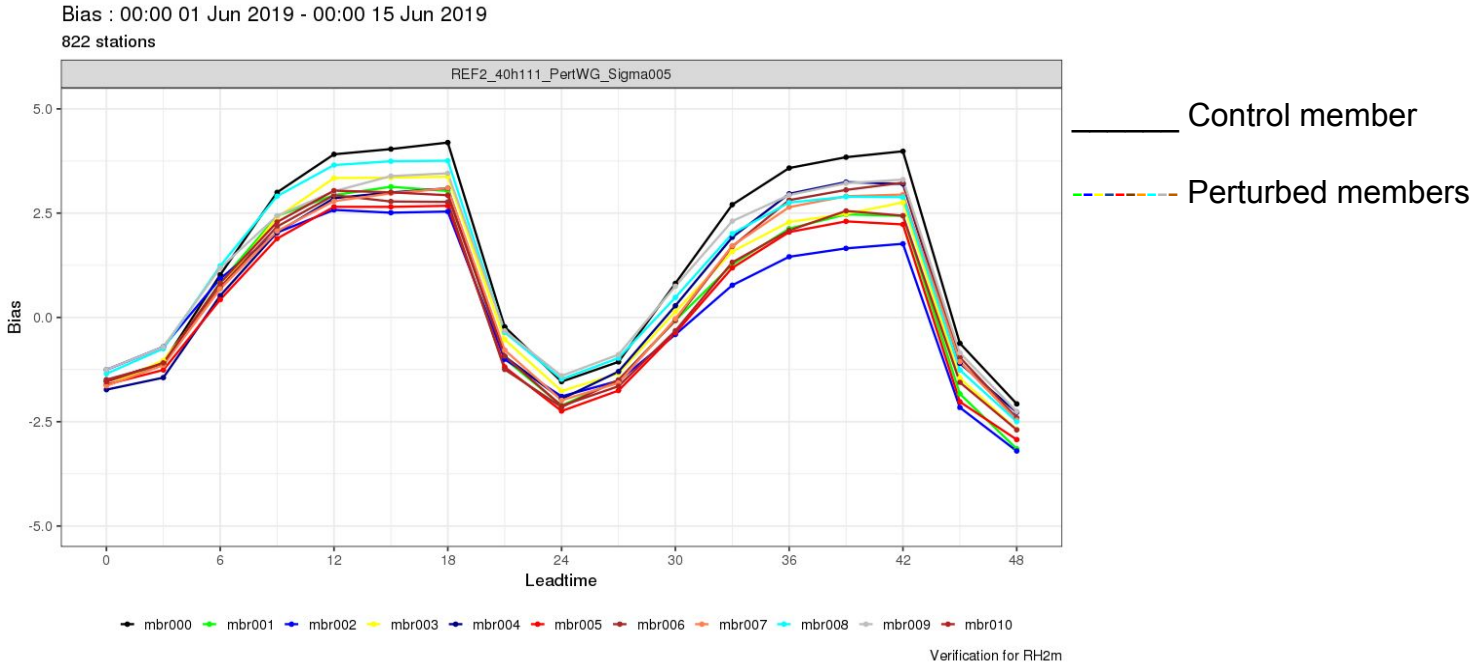
Switching off humidity perturbations in LBCs only

Switching off humidity perturbations in LBCs did not help much either



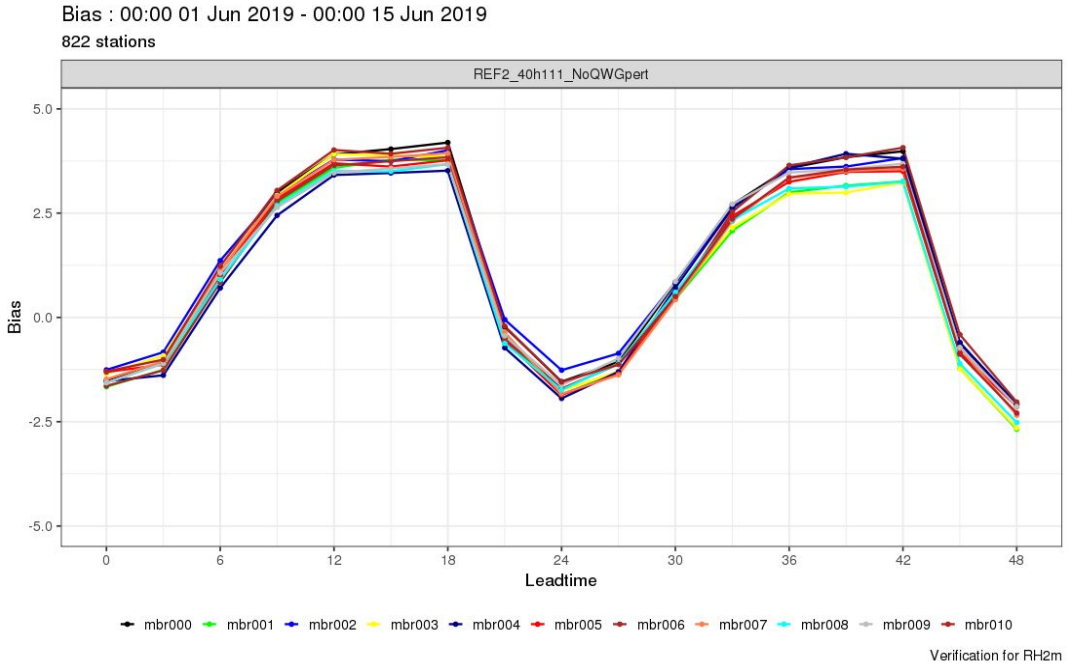
Reducing the humidity perturbations in surface scheme

Reducing the size of the humidity perturbations by 50% in surface helps a little bit.



Switching off humidity perturbations in initial state, LBCs and surface

The drying is heavily reduced when switching off all perturbations of humidity



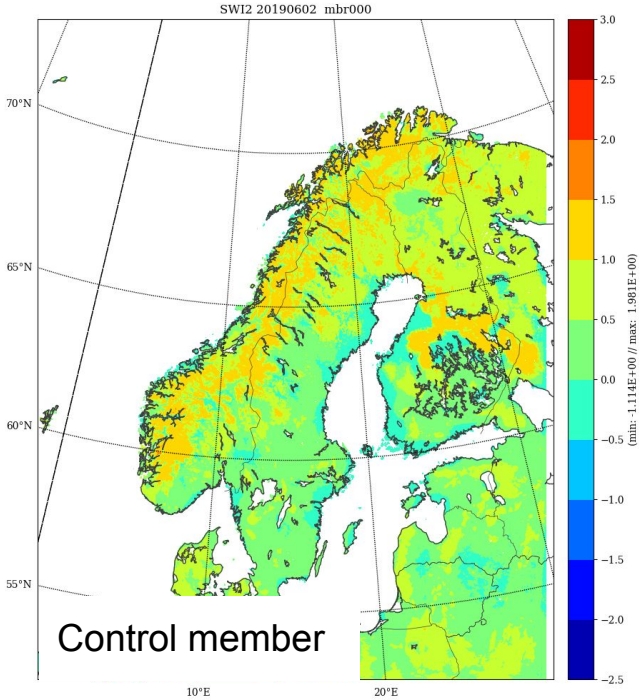
Control member

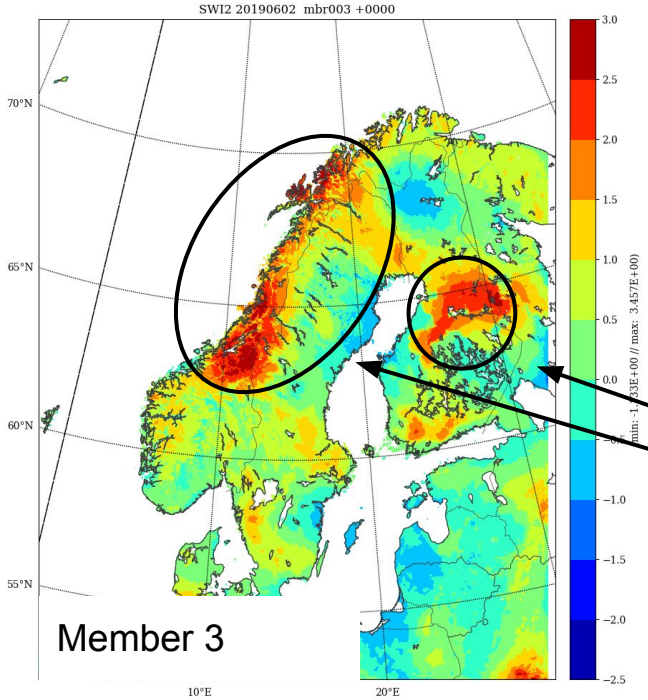
Perturbed members

Clearly the perturbations of soil moisture are leading to drying

What is causing the drying from the soil moisture perturbations?

Soil saturation: SWI=1.
Wilting point; SWI=0
MBR3: SWI between 2 and 3 in parts of the domain



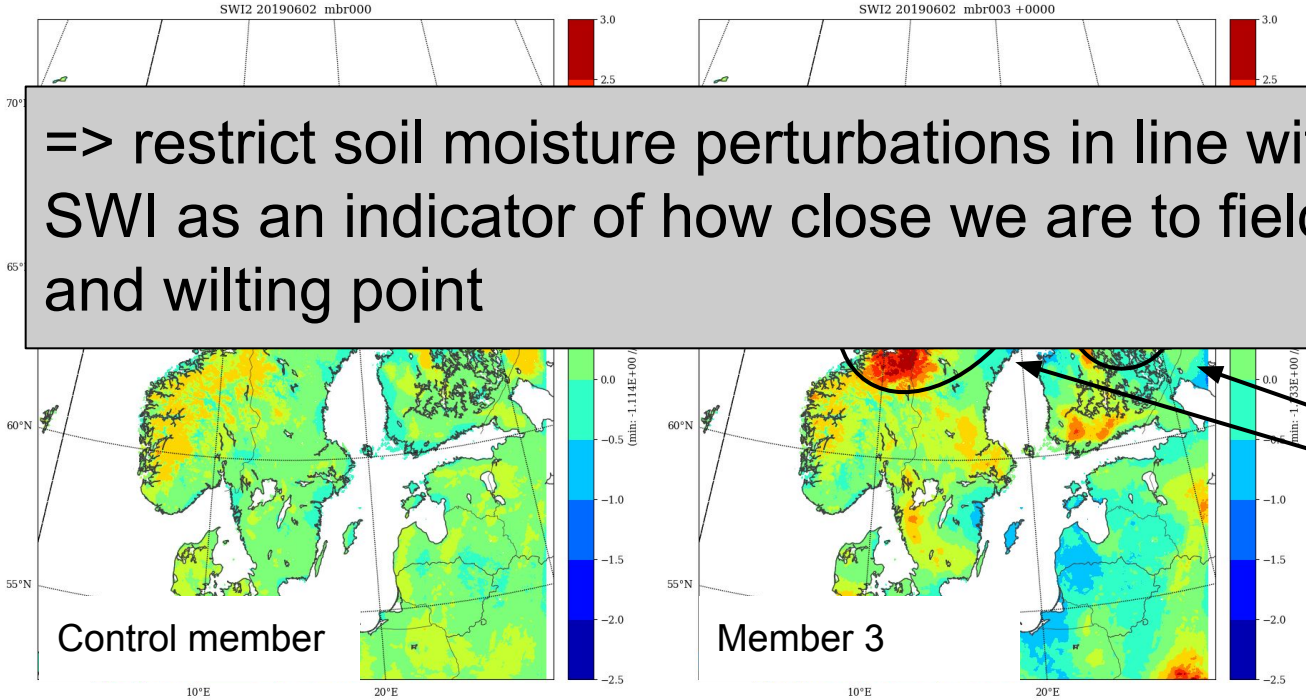


SWI in perturbed members indicates that soil moisture is perturbed far above field capacity

Large areas where SWI ~ 2-3

What is causing the drying from the soil moisture perturbations?

Soil saturation: SWI=1.
Wilting point; SWI=0
MBR3: SWI between 2 and 3 in parts of the domain

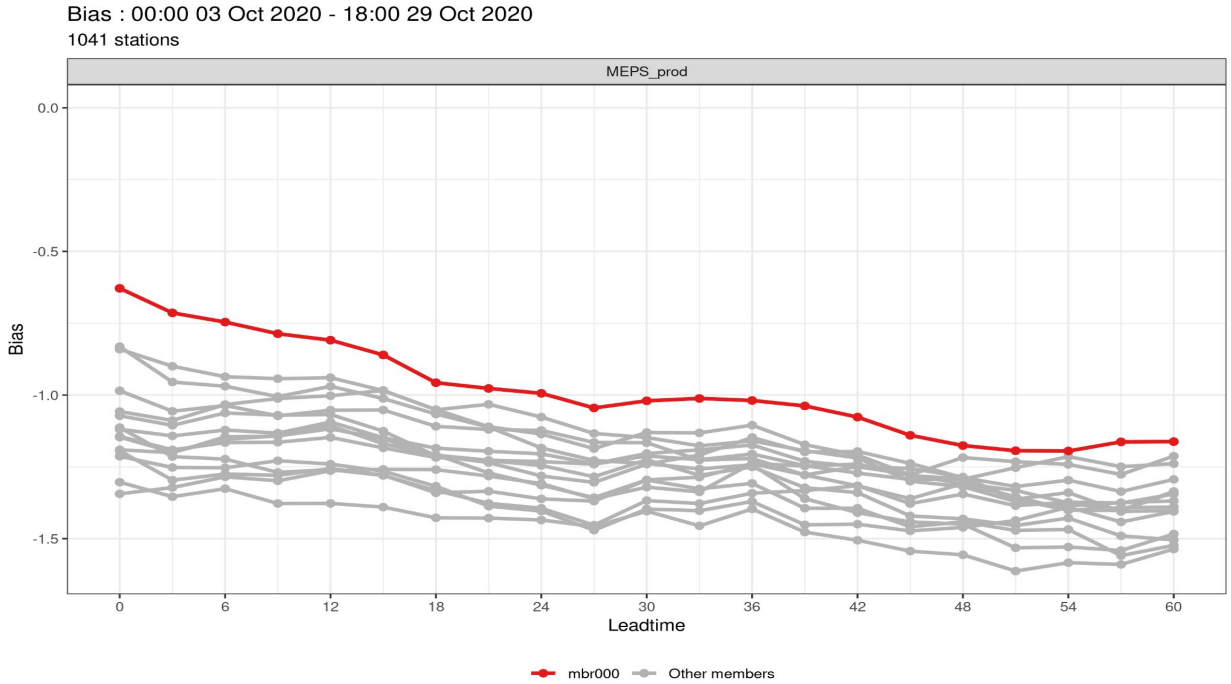


SWI in perturbed members
isture
e field

=> restrict soil moisture perturbations in line with SWI, using SWI as an indicator of how close we are to field capacity and wilting point

Large areas where SWI ~ 2-3

Soil moisture perturbations have bees switched off in operational MEPS a year a go, but problem persists:



Bias RH2m in MEPS members, October 2020

___ control
___ Members

Soil moisture perturbations are switched off by default in cy43

Verification for RH2m

Difference in operations compared to the experiments shown is that in operations EDA is used - we are now in the process of testing the effect EDA has on the drying of the ensemble members.

Status of SPP work

SPP = Stochastically Perturbed Parametrizations - a way to represent model uncertainties

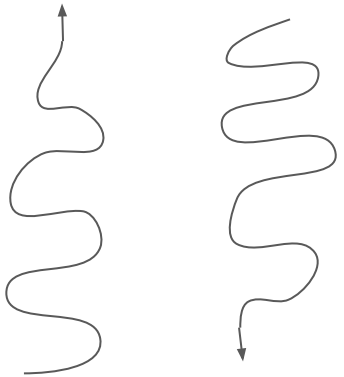
Ulf Andrae, Pirkka Ollinaho and Inger-Lise Frogner

SPP - currently 12 parameters implemented - 11 used

https://hirlam.org/trac/wiki/HarmonieSystemDocumentation/EPS/SPP

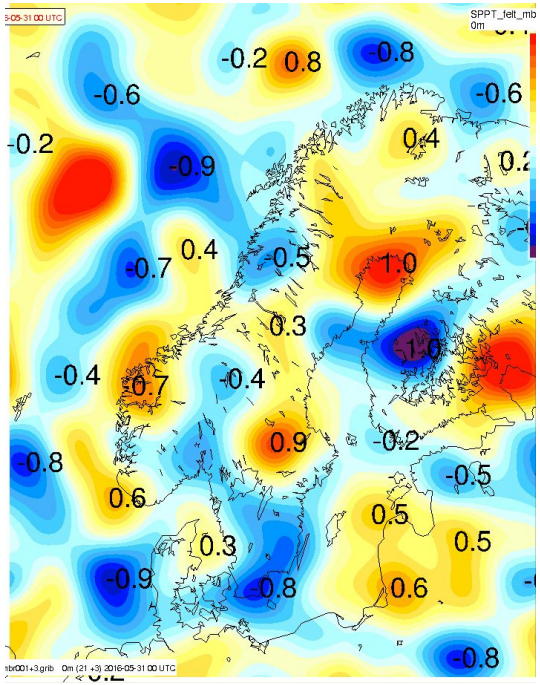
7 for clouds and microphysic
(6 used)

3 for turbulence

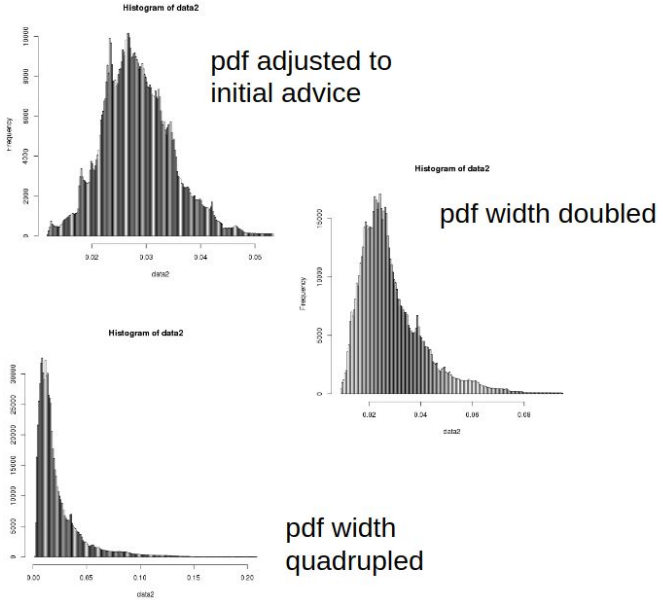


2 for radiation

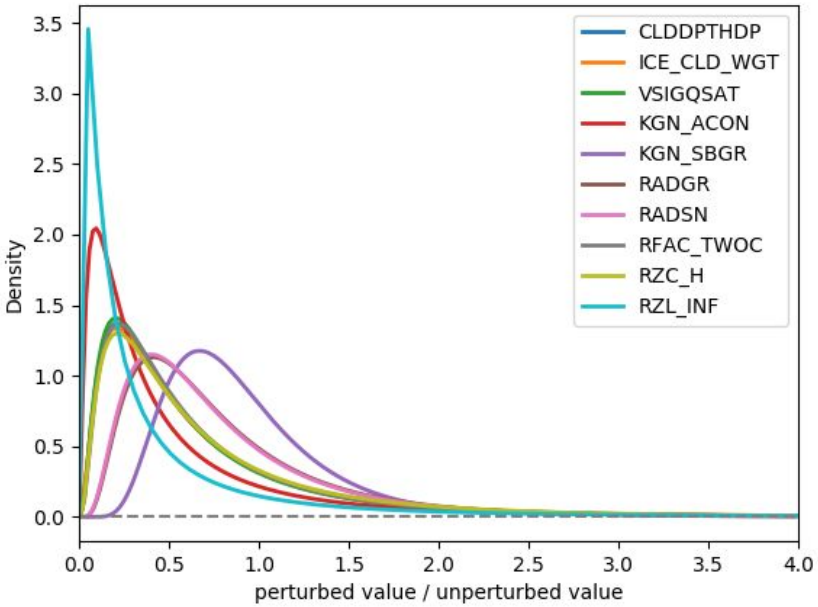
SPP basics

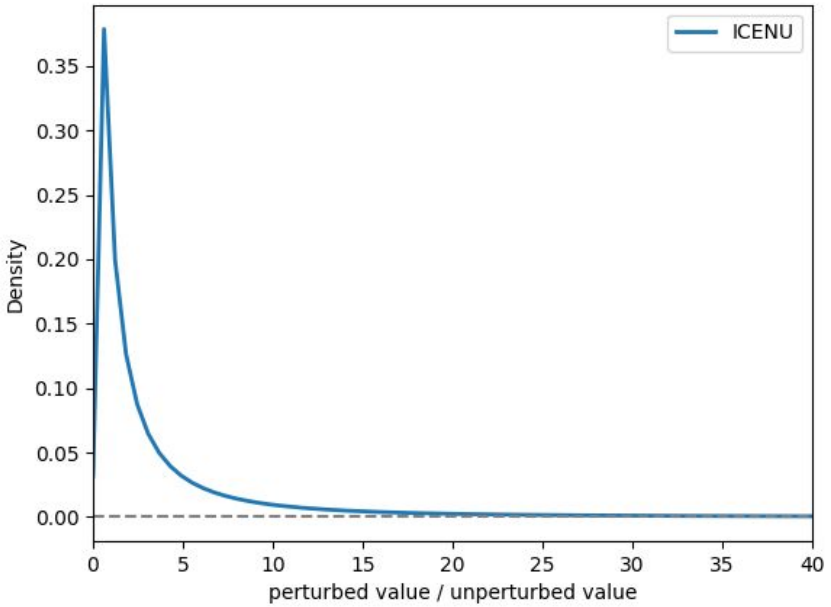


200 km / 12 h used



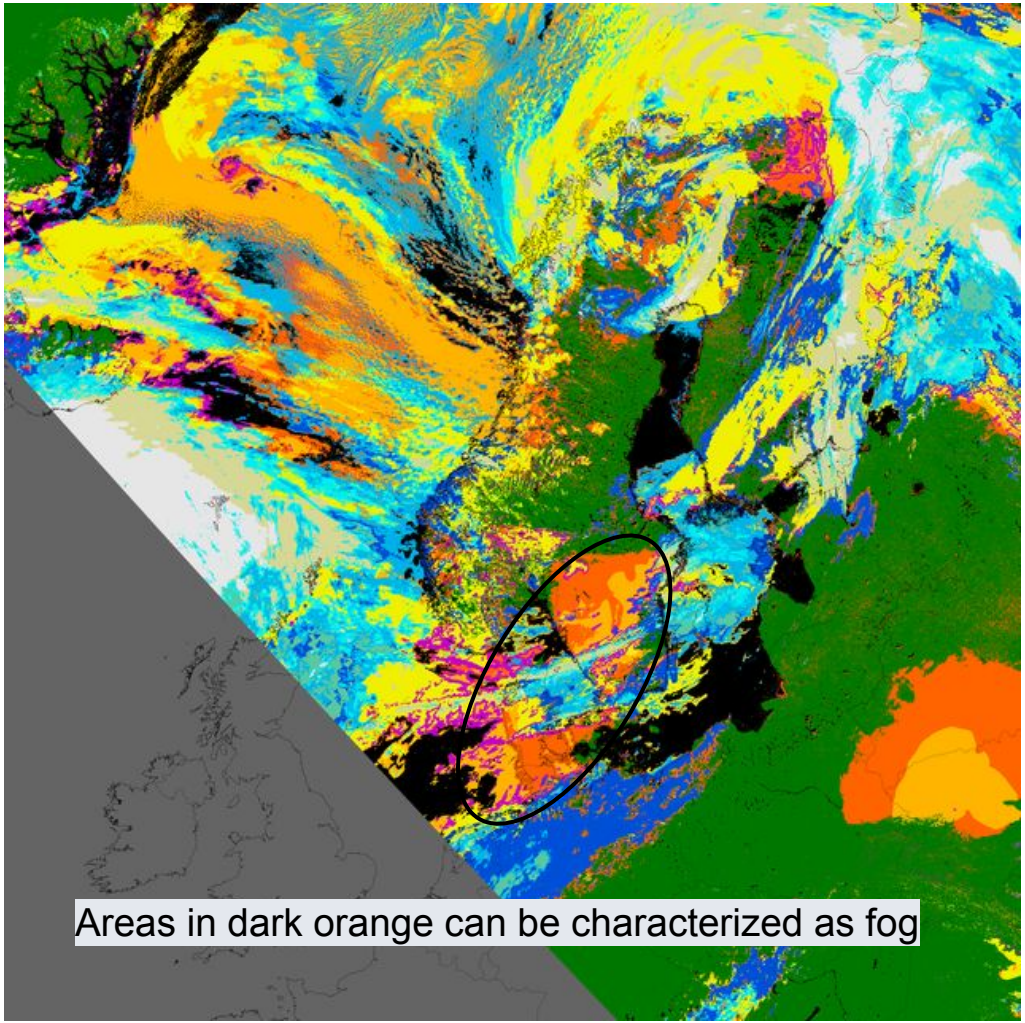
Pfd's of the perturbed parameters





The mean is correlated with the unperturbed value

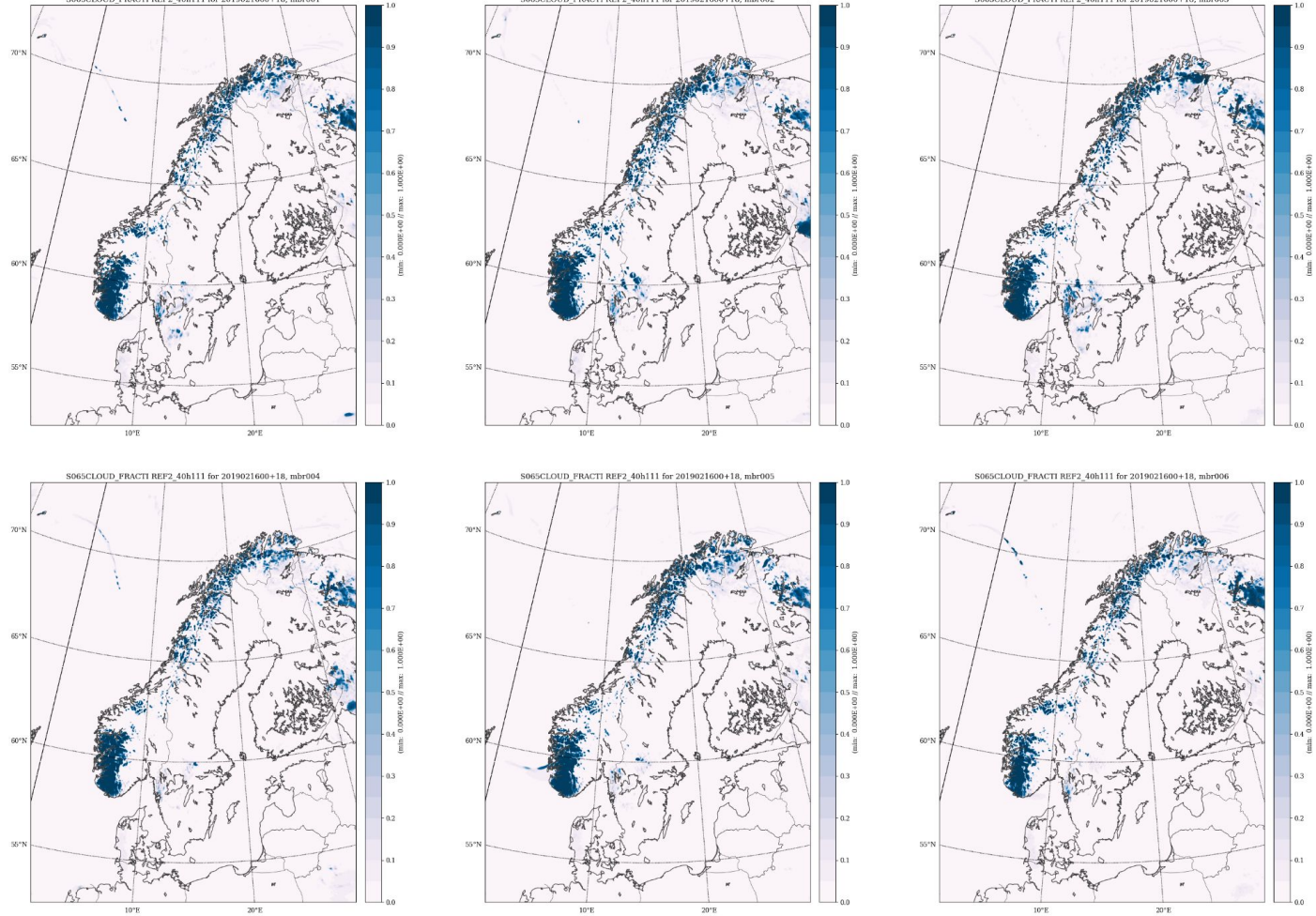
For ICENU the median is correlated with the unperturbed value



A case with poorly predicted fog

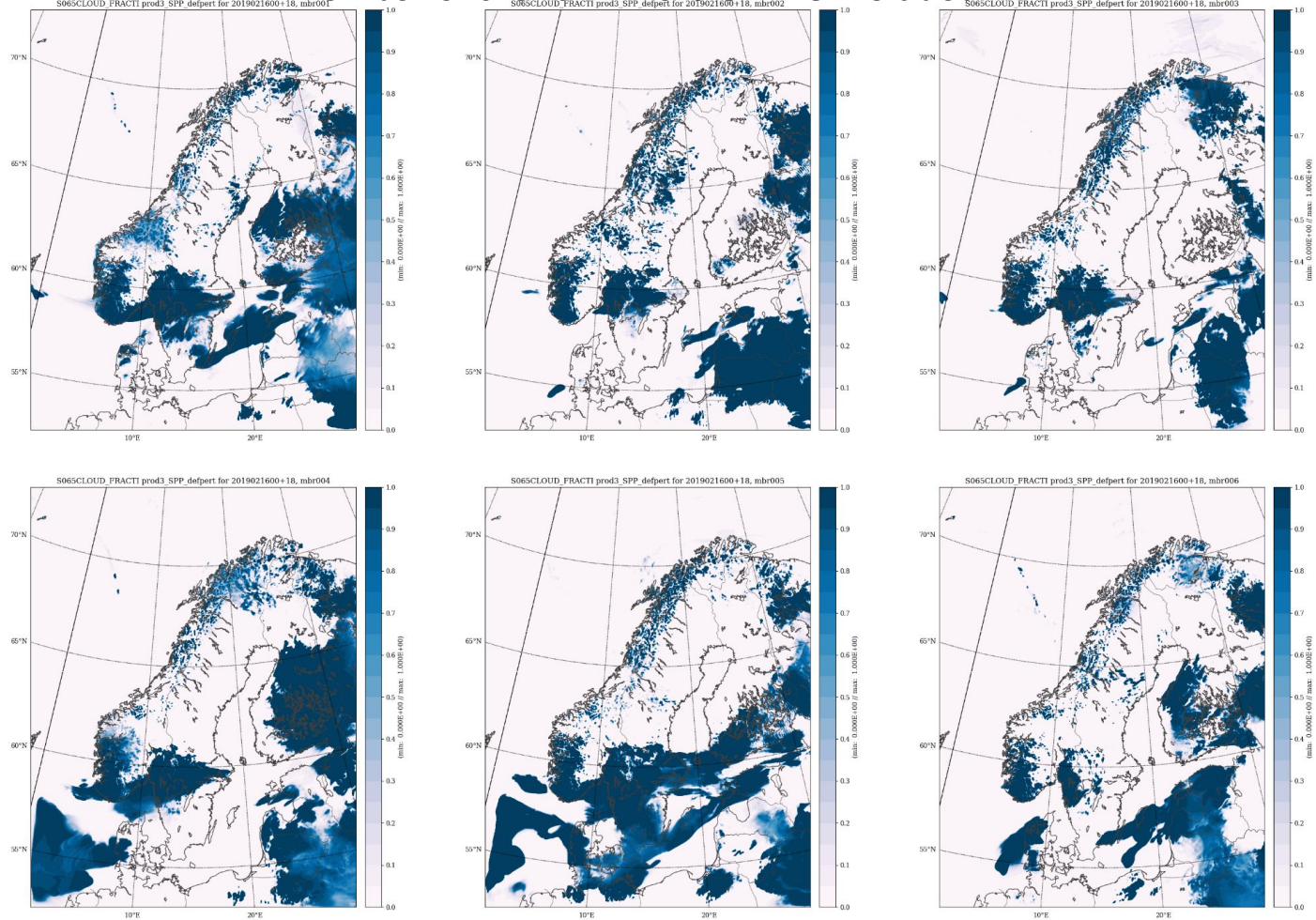
Satellite image is from 16 February 2019 showing widespread areas of fog covering southern Sweden and Denmark, and some areas with scattered fog over southwestern Norway and northeastern Finland

Member of the reference run - no SPP



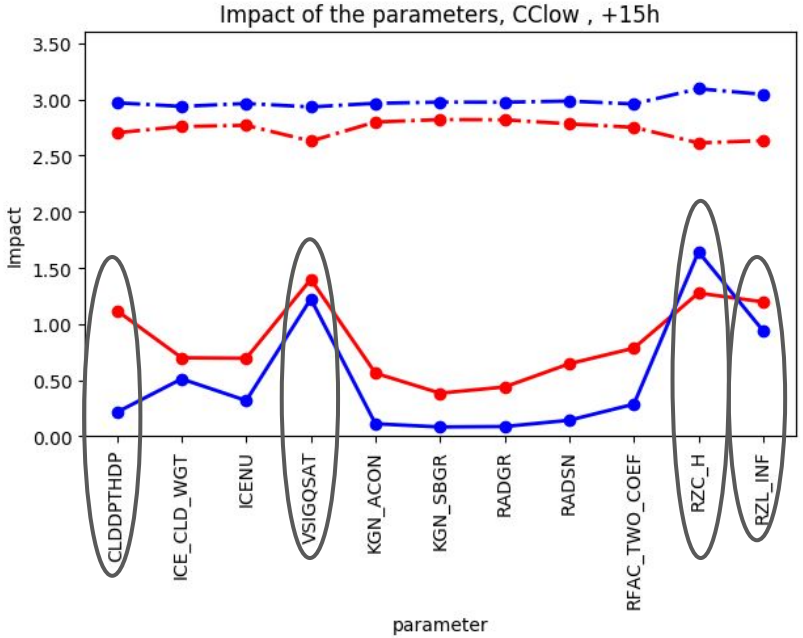
No SPP:
all the perturbed members represent the scattered fog quite well, but the larger fog covered areas in Sweden and Denmark are not present in the forecasts at all.

Member of the run where SPP is included



With SPP:
we see a *larger variability* between the ensemble members and *a tendency for more fog*. The fog predicted in the reference is still present, but in addition *we find larger areas of fog in better agreement with the satellite image.*

Impact of the perturbed parameters - two months



spread (_____)
RMSE (--------)
Summer and winter

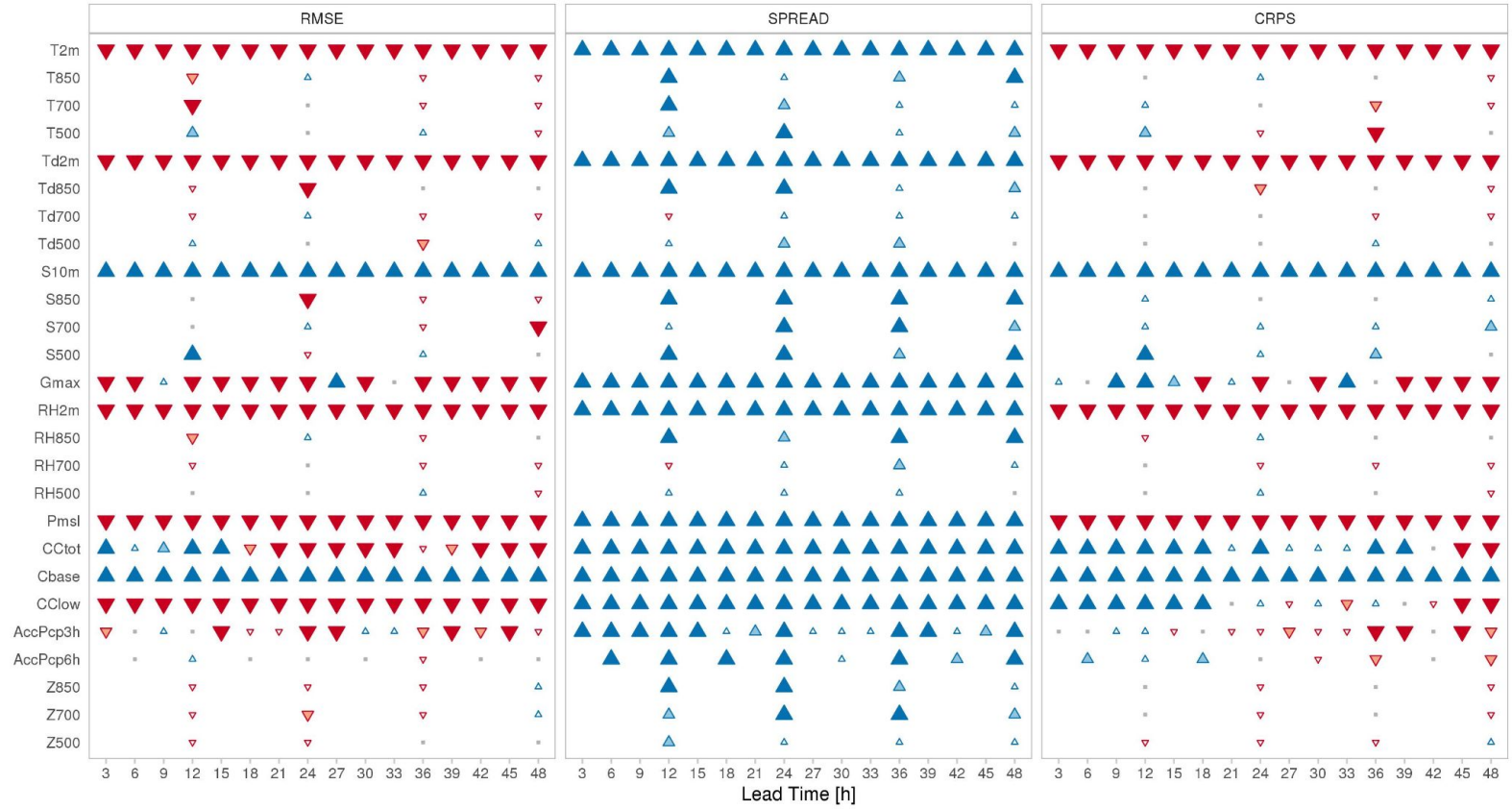
CClow, +15h

Most influential:

- The stable condition length scale (**RZC_H**)
- The saturation limit sensitivity for condensation (**VSIGQSAT**)
- The threshold cloud thickness used in shallow/deep convection decision (**CLDDPTHDP**)
- The asymptotic free atmospheric length scale (**RZL_INF**)

In winter *KGN_ACON*, *KGN_SBGR*, *RADGR* and *RADSN* have little impact.

We can also observe that the impact of the parameters varies most for the spread and very little for the ensemble mean RMSE.



Feb. 2019

With SPP worse than REF with significance > 99.7 %

With SPP worse than REF with significance > 95 %

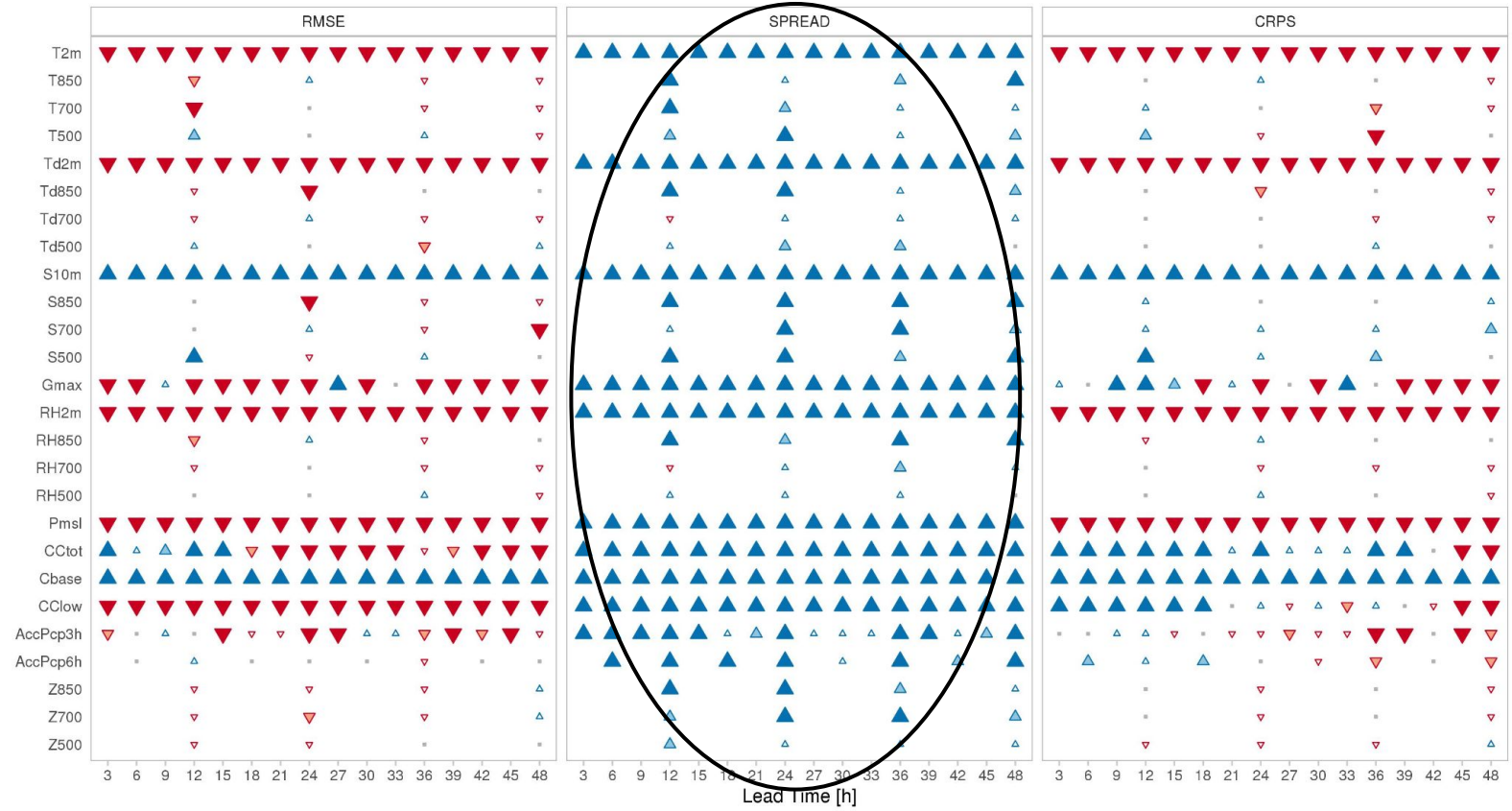
With SPP worse than REF with significance > 68 %

No significant difference between REF and with SPP

With SPP better than REF with significance > 68 %

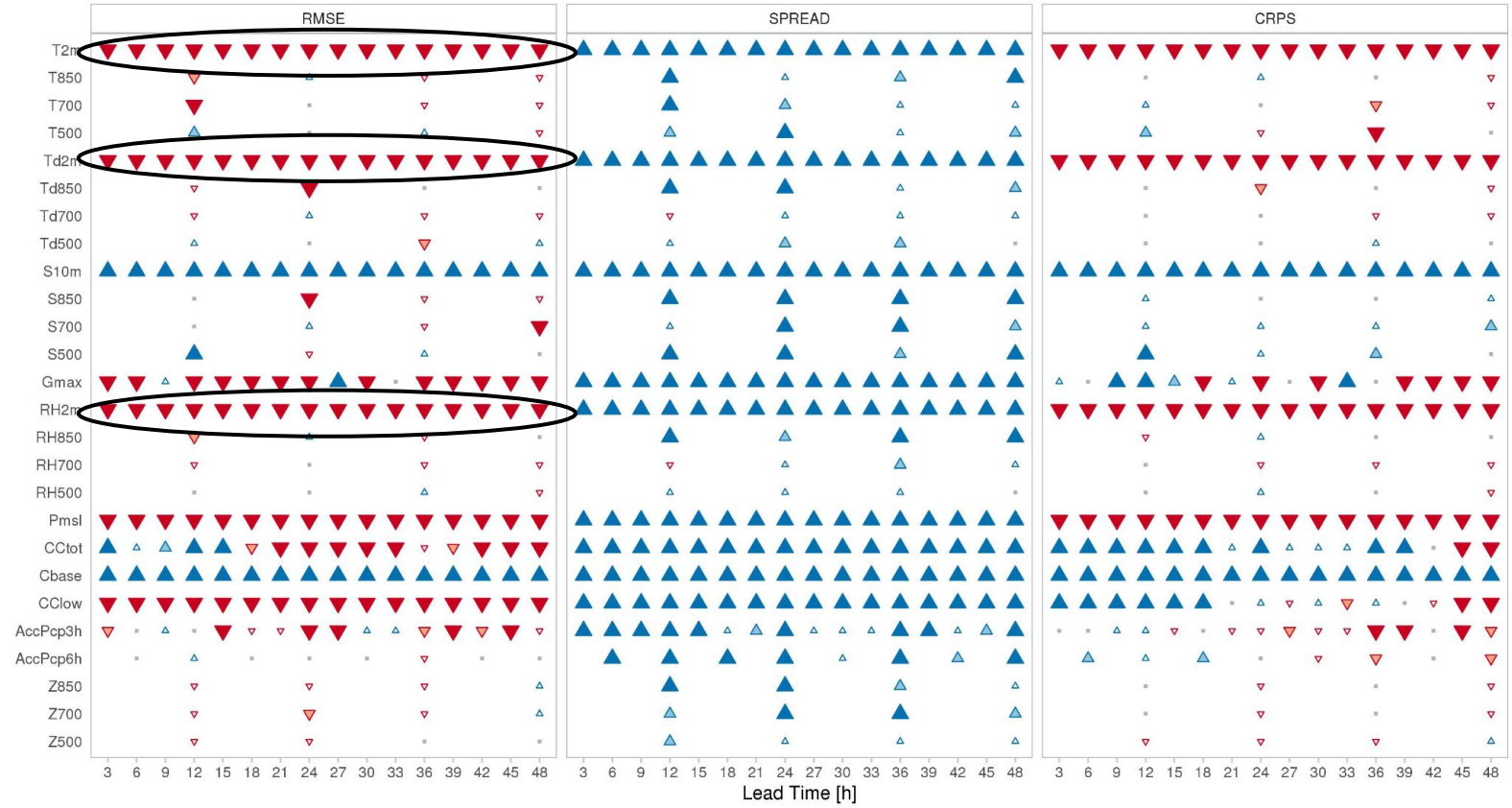
With SPP better than REF with significance > 95 %

With SPP better than REF with significance > 99.7 %



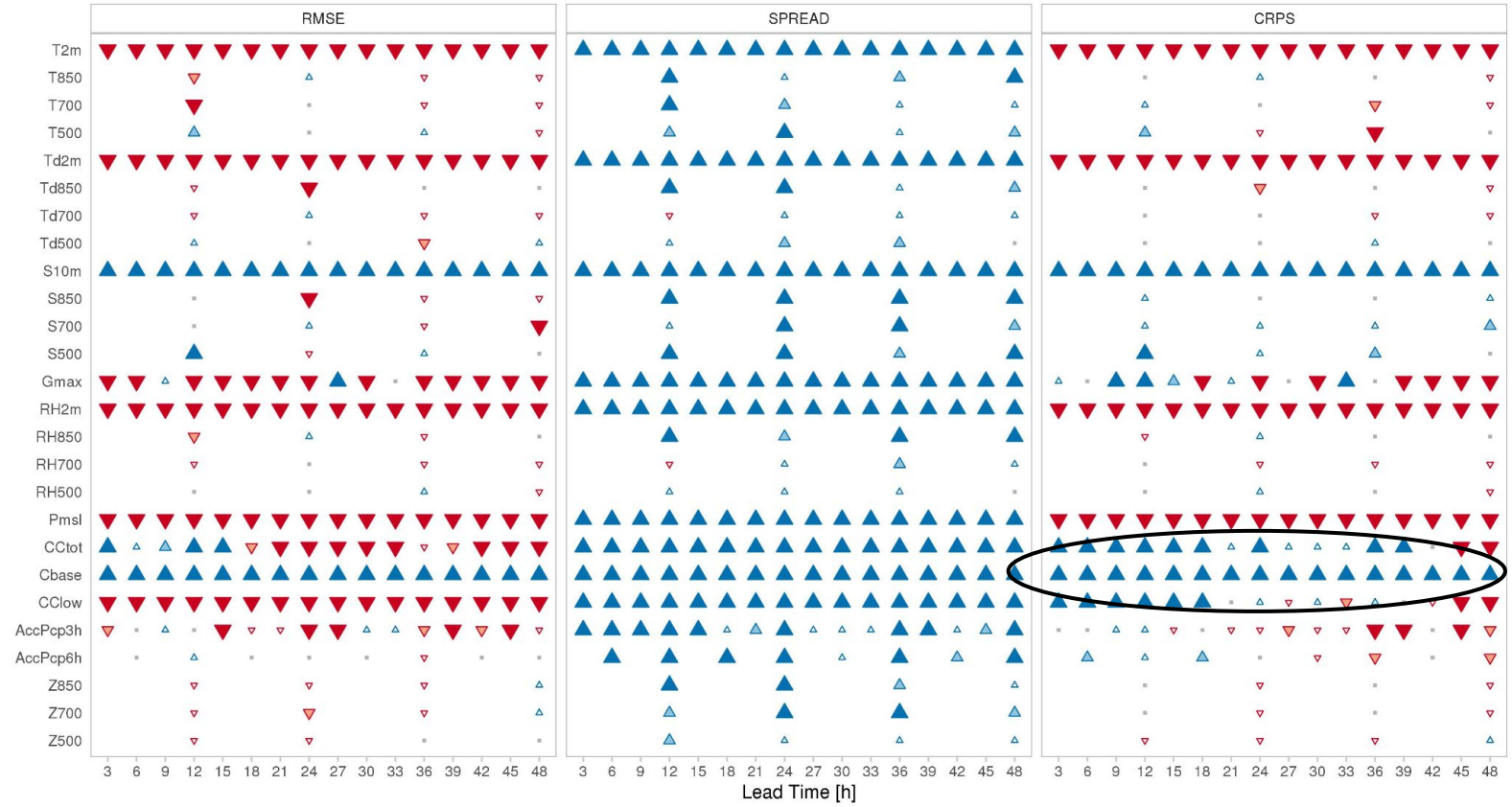
Feb. 2019

- Spread is clearly increased



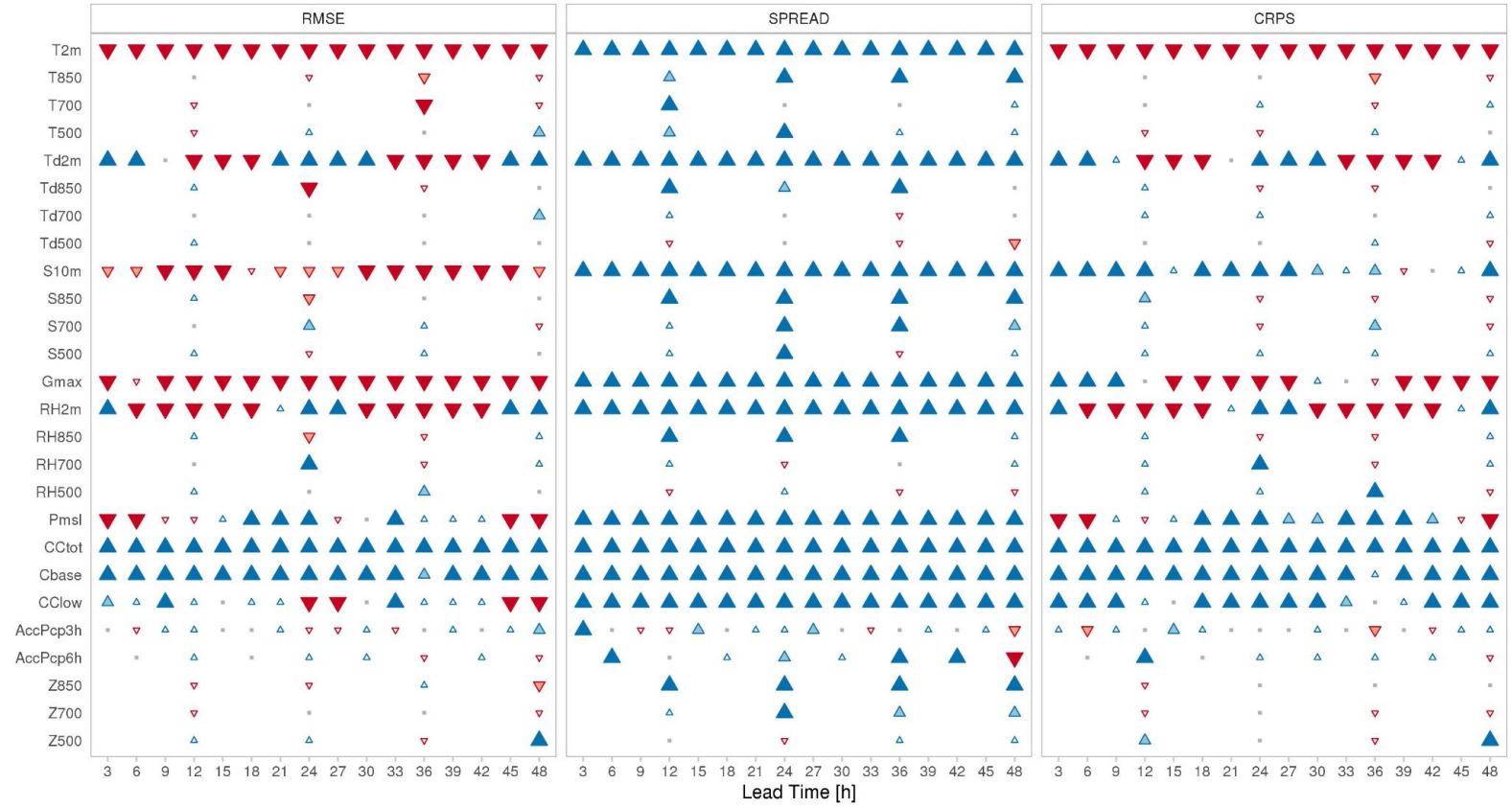
Feb. 2019

- RMSE is worse for many parameter, e.g. 2m variables



Feb. 2019

- CRPS is better for the cloud variables, worse for e.g. 2m variables



June 2019

With SPP worse than REF with significance > 99.7 %

With SPP worse than REF with significance > 95 %

With SPP worse than REF with significance > 68 %

No significant difference between REF and with SPP

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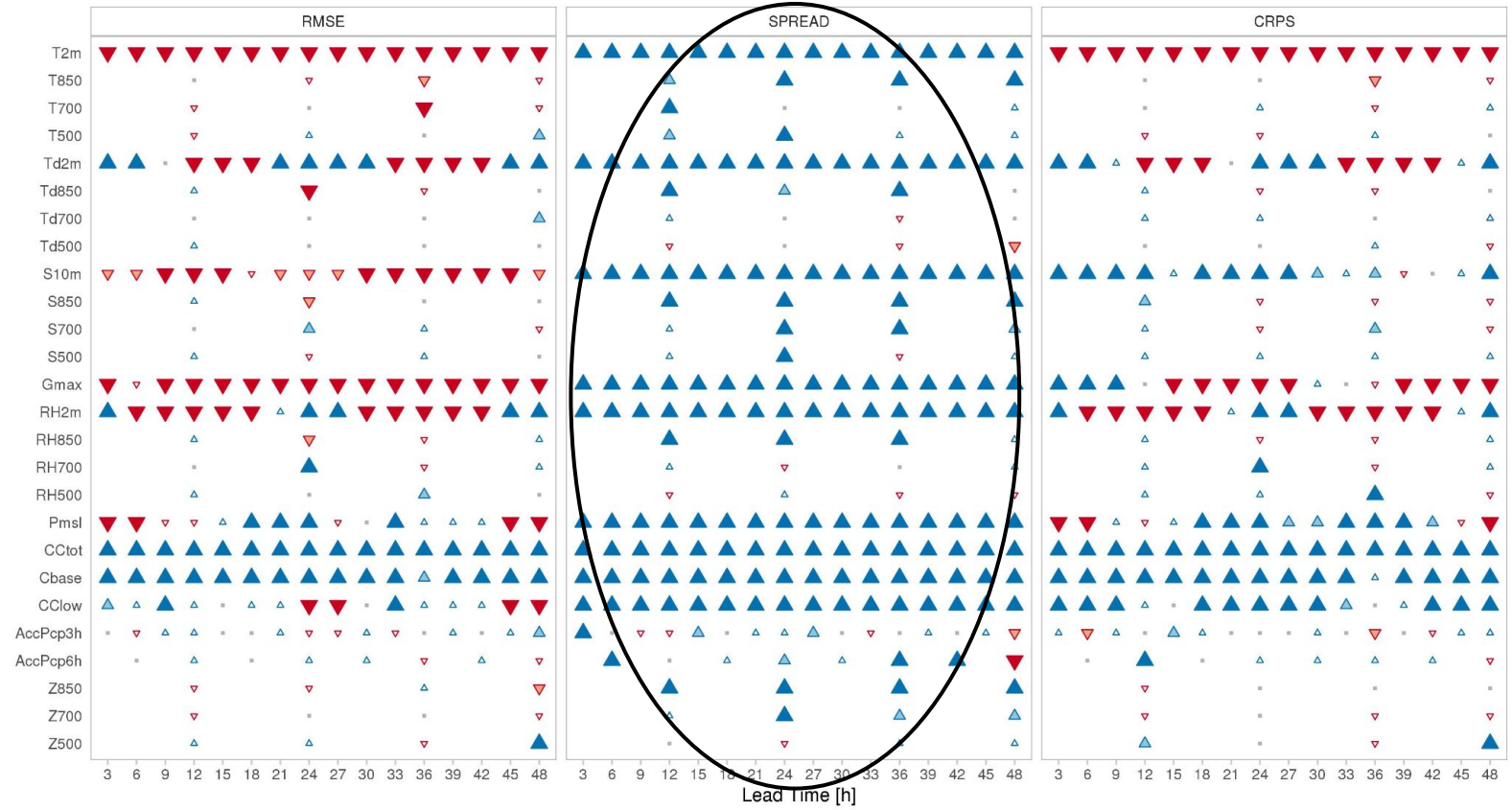
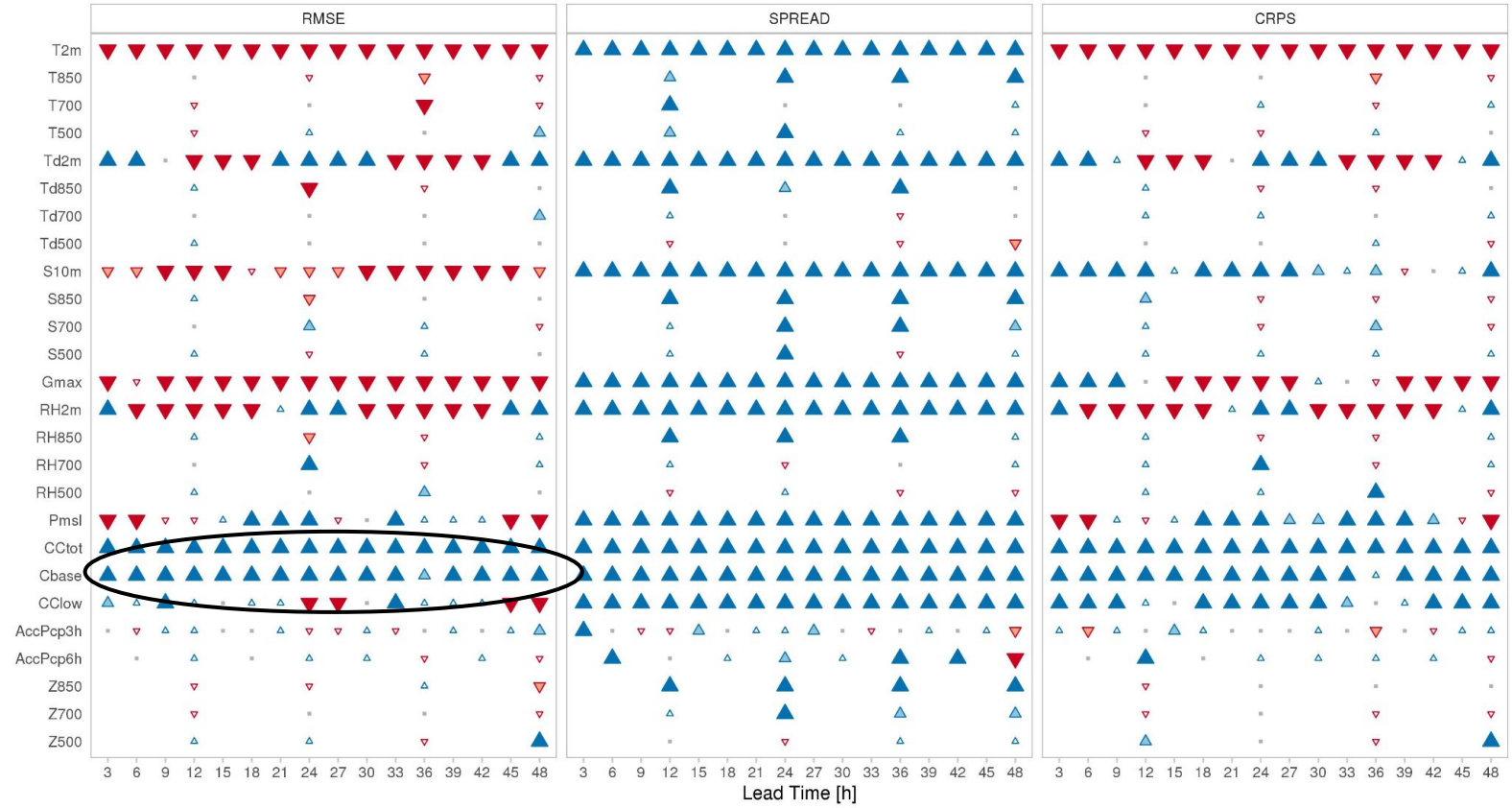
With SPP better than REF with significance > 99.7 %



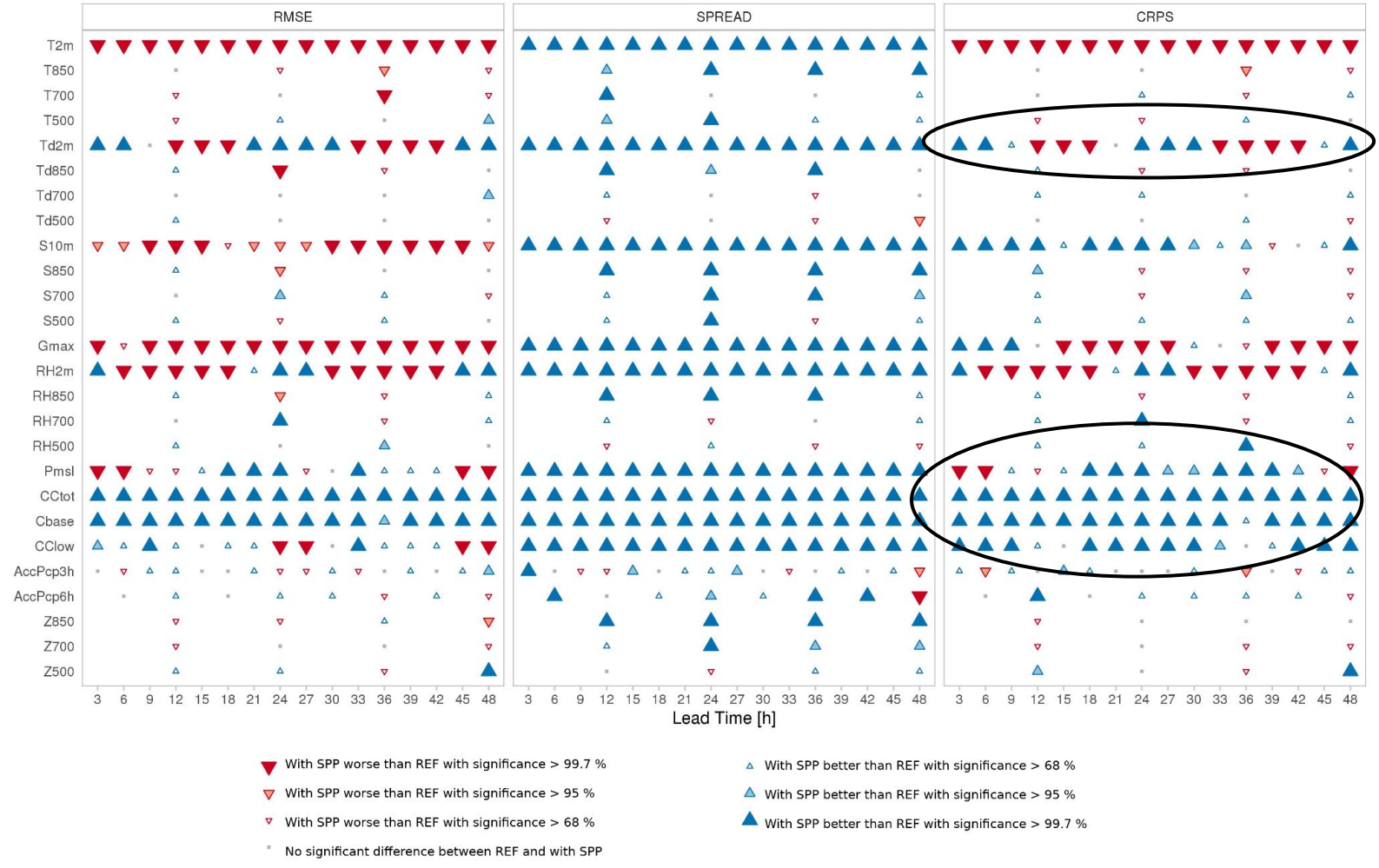
June 2019

- Spread is clearly increased also for summer period



June 2019

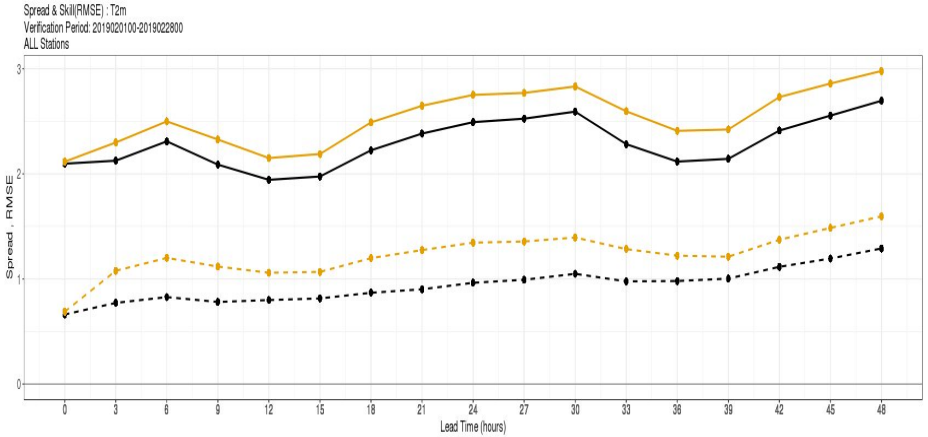
- RMSE is worse for many parameters also for summer, but now better for cloud variables



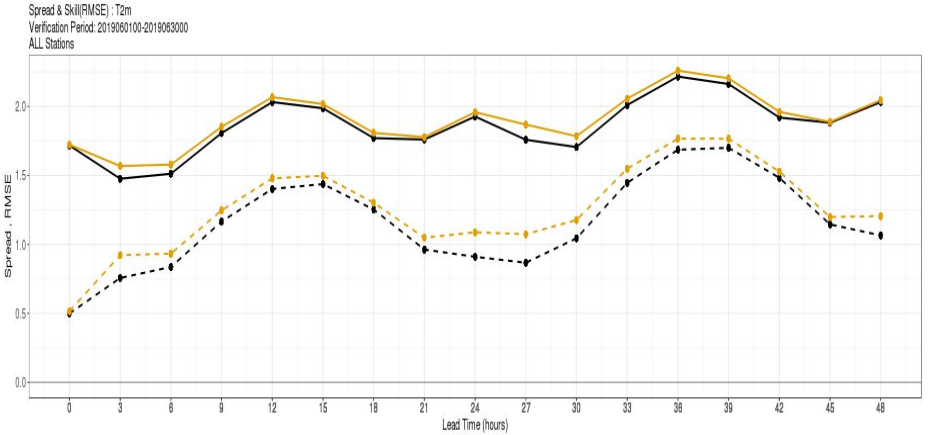
June 2019

- CRPS: still problems for the 2m variables. Better than for winter for some variables

A closer look at the spread and RMSE for T2m



Winter

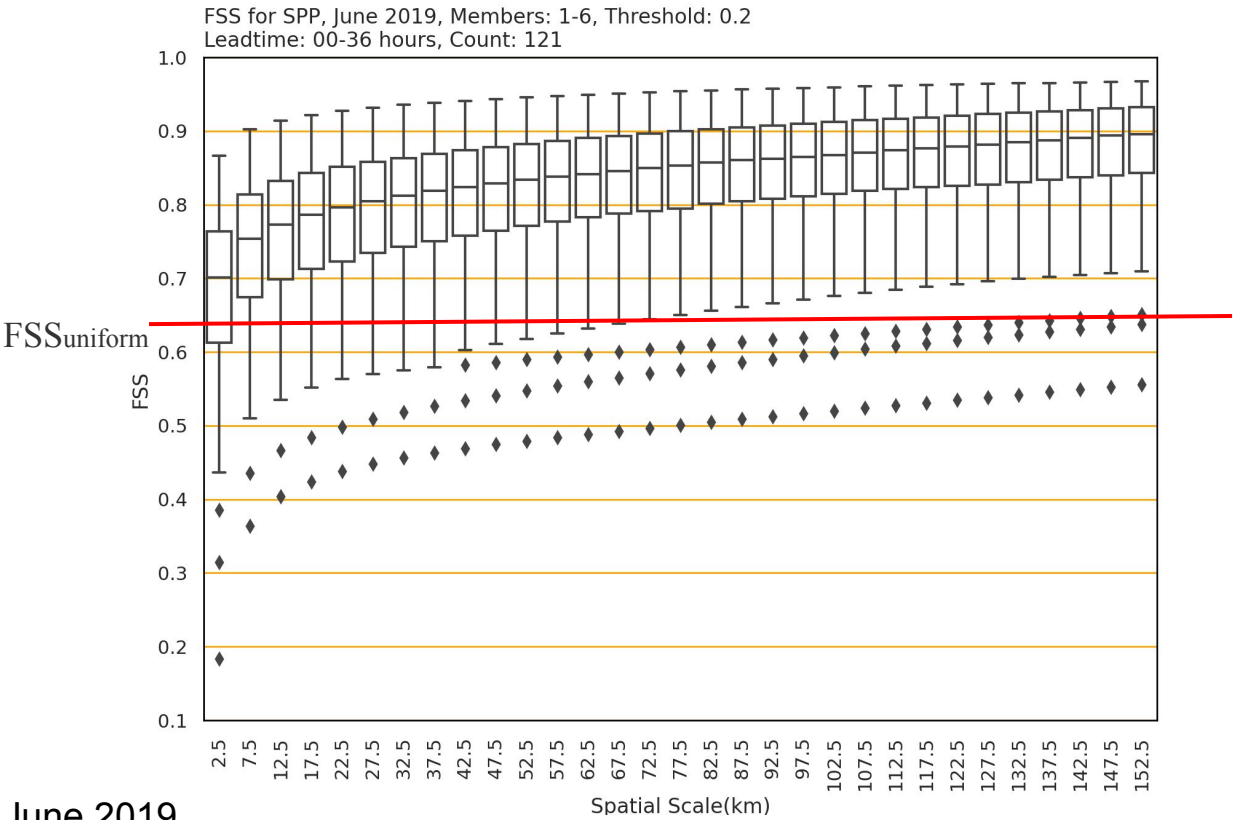


Summer

The RMSE issue is clearly worse in winter than in summer

____ REF _____ with SPP

SPP and scale - FSS for total cloud cover



Assessing skill of SPP using FSS by verifying predicted cloud mask with satellite-observed cloud mask from Polar Platform System (PPS) product from the EUMETSAT SAFNWC

Predicting clear areas

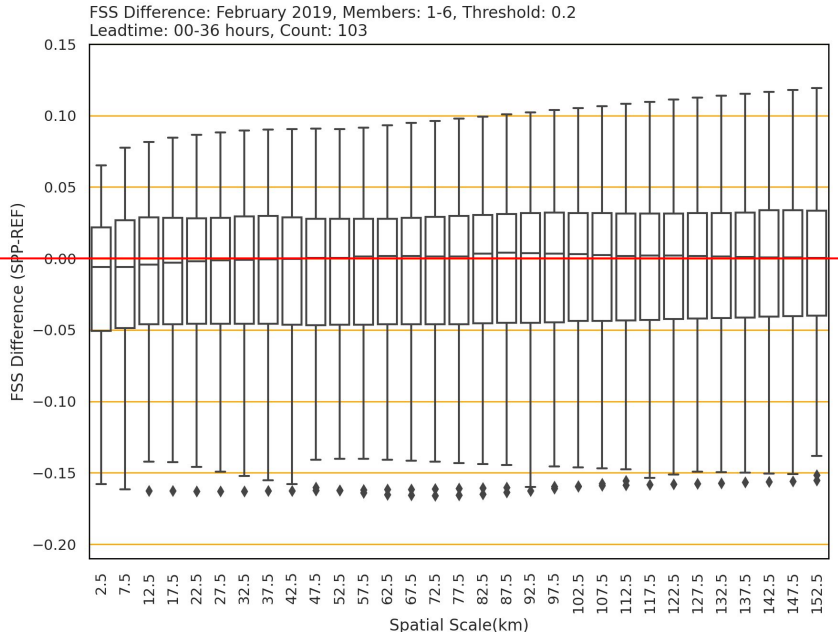
Lower threshold means more clouds and less cloud-free grid cells - here 0.2

Only dates where model domain is covered >= 80% by satellite data are considered

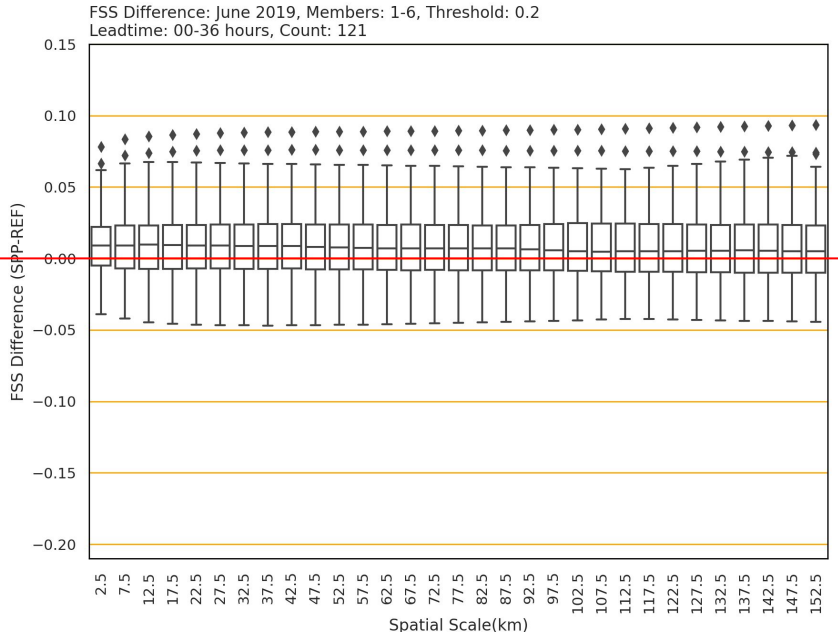
Daniel Yazgi

Effect of SPP on FSS for total cloud cover

FSS difference for the experiment with and without SPP



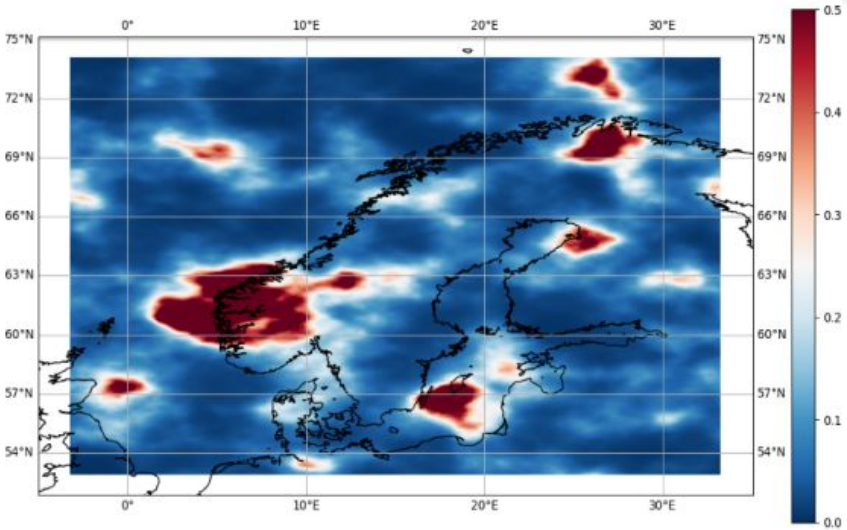
February 2019

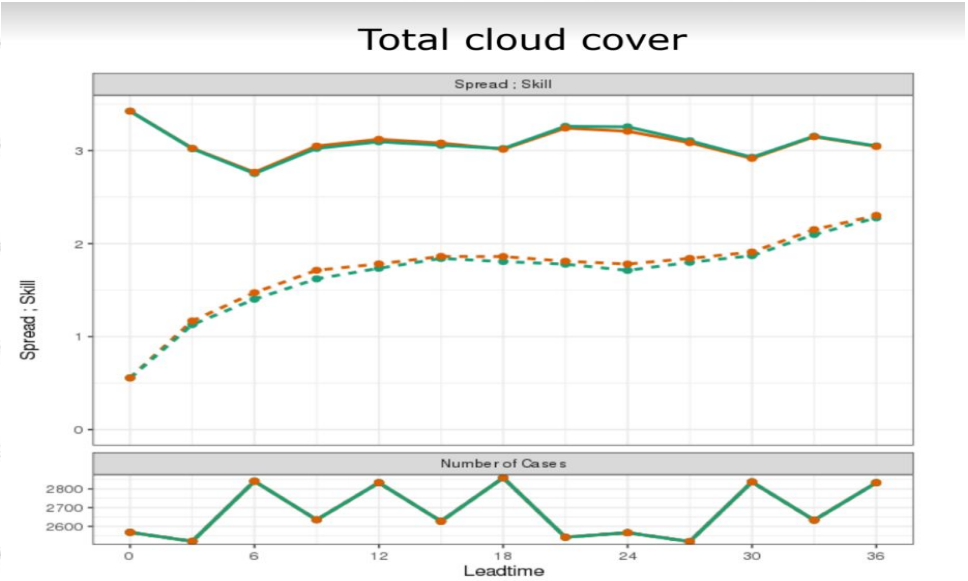


June 2019

Daniel Yazgi

Coupled parameter perturbations for RZC_H and RZL_INF





Parameters RZC_H and RZL_INF are coupled using the 2D pattern generated for RZC_H.
Small increase in spread with coupled perturbations. Likely that RZC_H dominates in this first test.

Aristofanis Tsiringakis, Jan Barkmeijer, Wim de Rooy and Sibbo van der Veen

SPP and further work

- Interest from several institutes to get SPP **operational** (KNMI, Met Eireann, MetCoOp) -> **main focus in 2021** -> need to fix 2m problems
- How to achieve this?
  - Work on the parameter pdf's - what is meaningful physically? Can we change from log-normal to some other distribution? Use mean or the median of the distribution correlated with the unperturbed closure parameter value? - **HIGH priority**
  - Work on the correlated patterns/parameters - **HIGH priority**
  - Cost reduction - **HIGH priority**
  - Include and test more parameters - **MEDIUM priority**
  - Play with the temporal and spatial scales - different for different parameters? **LOW to MEDIUM priority**

SPP is working in cy46, and the SPP framework is coordinated with ECMWF for cy48/49

SPP/SPPT paper to be submitted to MWR next week

Model uncertainty representation in a convection-permitting ensemble - SPP and SPPT in HarmonEPS

Inger-Lise Frogner*
Norwegian Meteorological Institute (Met Norway), Oslo, Norway

Ulf Andrae
Swedish Meteorological and Hydrological Institute, Norrköping, Sweden

Pirkka Ollinaho
Finnish Meteorological Institute, Helsinki, Finland

Alan Hally
Irish Meteorological Service (Met Éireann), Dublin, Ireland

Karoliina Hämäläinen and Janne Kauhanen
Finnish Meteorological Institute, Helsinki, Finland

Karl-Ivar Ivarsson and Daniel Yazgi
Swedish Meteorological and Hydrological Institute, Norrköping, Sweden

Thank you for your attention

SPP - currently 11 parameters used

https://hirlam.org/trac/wiki/HarmonieSystemDocumentation/EPS/SPP

No.	Description	PAR.	Det.	STD#1	STD#2	95 perc.	Type
1)	Threshold for cloud thickness used in shallow/deep convection decision	CLDDPTHDP	4000	0.1	0.4	2.21	CONV
2)	Cloud ice content impact on cloud thickness	ICE_CLD_WGT	1	0.1	0.4	2.23	IM
3)	Ice nuclei concentration	ICENU	1	0.35	0.7	13.48	IM
4)	Saturation limit sensitivity for condensation	VSIGQSAT	0.03	0.1	0.4	2.17	LM
5)	Kogan autoconverltsion speed	KGN_ACON	10	0.25	0.5	2.06	LM
6)	Kogan subgrid scale (cloud fraction) sensitivity	KGN_SBGR	0.5	0.1	0.2	1.77	LM
7)	Graupel impact on radiation	RADGR	0.5	0.15	0.3	1.99	RAD
8)	Snow impact on radiation	RADSN	0.5	0.15	0.3	2.03	RAD
9)	Top entrainment efficiency	RFAC_TWO_COEF	2	0.1	0.4	2.07	TURB
10)	Stable conditions length scale	RZC_H	0.15	0.1	0.4	2.38	TURB
11)	Asymptotic free atmospheric length scale	RZL_INF	100	0.15	0.6	1.87	TURB

- Det. is the deterministic value of the parameter
- STD#1 is the original standard deviation
- STD#2 is the standard deviation we ended up with
- 95 perc. is the 95 percentile of the resulting pdf for STD#2, scaled by the deterministic value
- LM = liquid micro-physics
- IM = ice micro-physics
- RAD = radiation
- CONV = convection
- TURB = turbulence

the threshold for cloud thickness for stratocumulus/cumulus transition not in use

A quick look at the relation between soil moisture and soil wetness index

F2= (WG2 - WILT) / (FC - WILT)
Rs = (Rsmin / LAI) * (F1 F2 F3 F4)$^{-1}$
Transpiration ~ 1/Rs

Thus, low WG2, gives low F2, gives high Rs, gives low transpiration

Soil Wetness Index (SWI) has same formulation as F2.
But 0 < F2 < 1, while SWI can be negative or be more than 1.

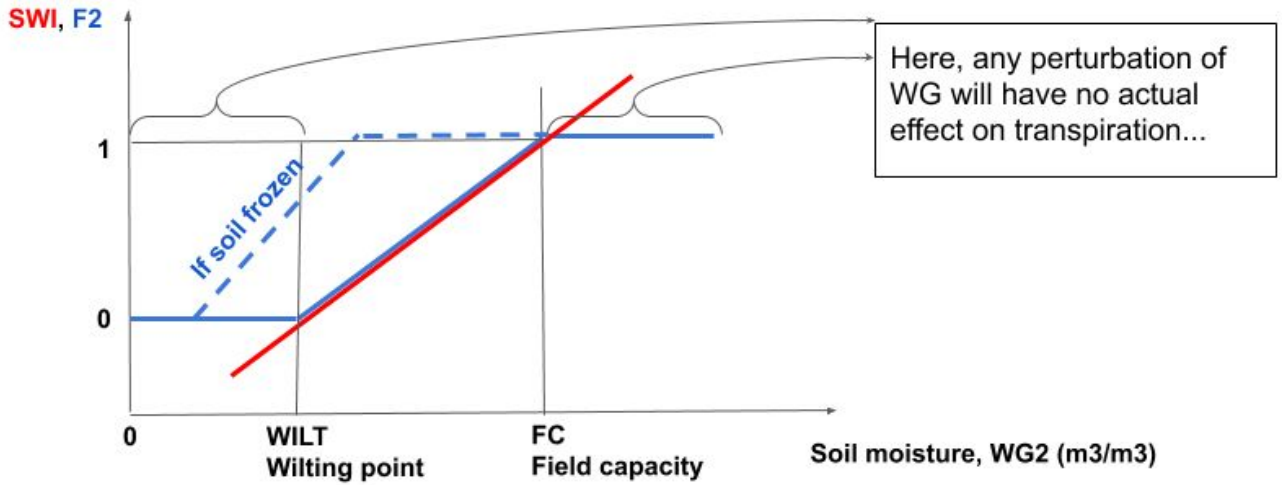
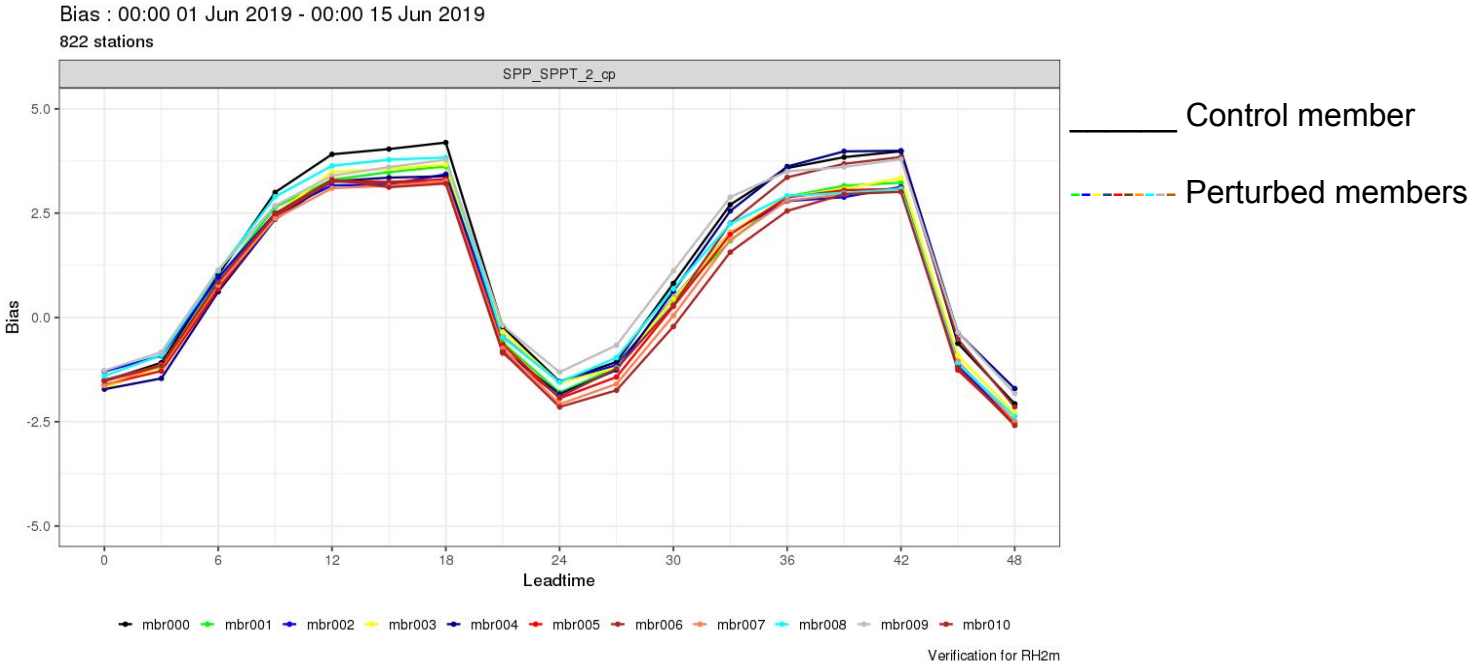


Figure: Patrick Samuelsson

Switching off surface assimilation for the members

All humidity perturbations are ON

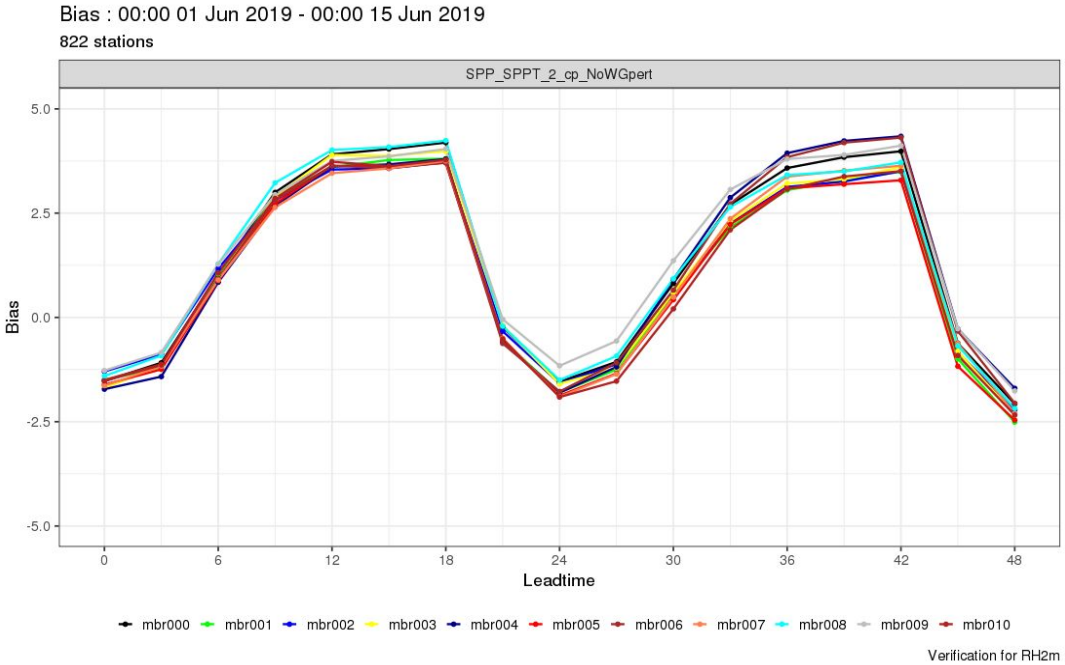
Switching off surface assimilation for the members also clearly helps somewhat



surface assimilation for members = off

Switching off humidity perturbations in surface scheme AND surface assimilation for the members

Switching off humidity perturbations in surface clearly helps - but it comes at the expense of the spread.



Control member

Perturbed members

Problem seems to be solved

surface assimilation for members = off