Who's the winner? A comparison of different perturbations using tendency diagnostics

Inger-Lise Frogner
Alan Hally
Ulf Andrae
Karoliina Hämäläinen
Janne Kauhanen
Pirkka Ollinaho

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In HarmonEPS you have the possibility to perturb:

Default perturbations in current cycle in blue:

- Initial conditions using nesting model and/or observation perturbations (EDA)
- Surface initial conditions
- LBCs using nesting model

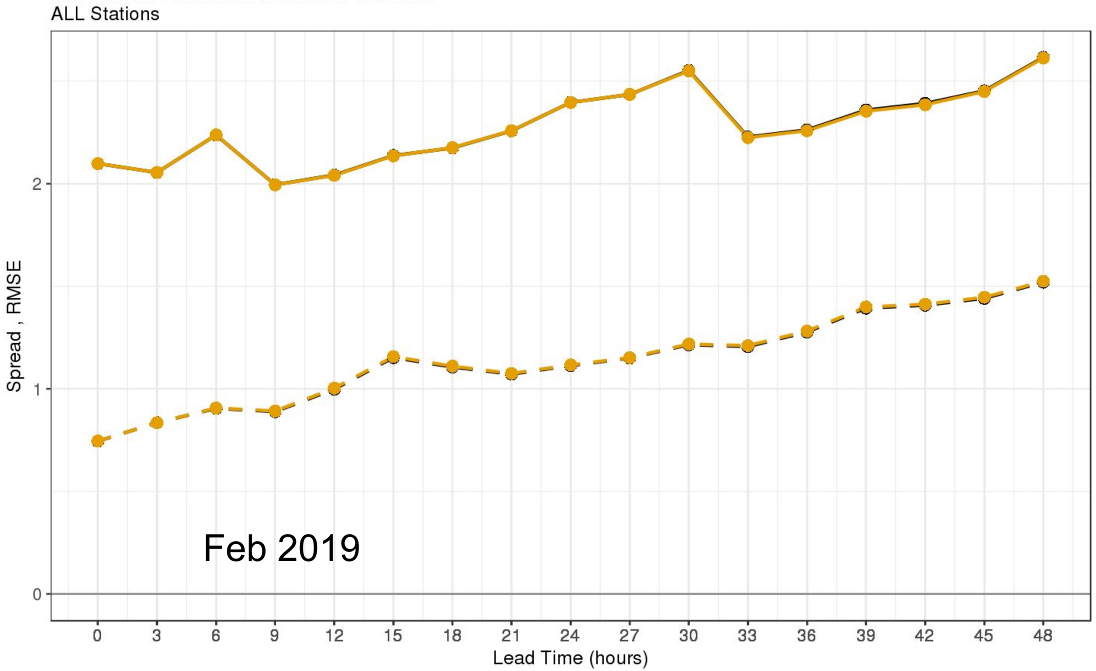
For representing model uncertainty we have

- multi-physics - with its pros and cons
- SPPT
- SPP under development (presented last year)

=> We wanted to have SPPT default, it was implemented and used elsewhere, switched it on to have model uncertainty represented while developing SPP

=> We have developed a tendency diagnostics to get deeper insight into the effect of the different perturbations

Effect of adding SPPT in HarmonEPS



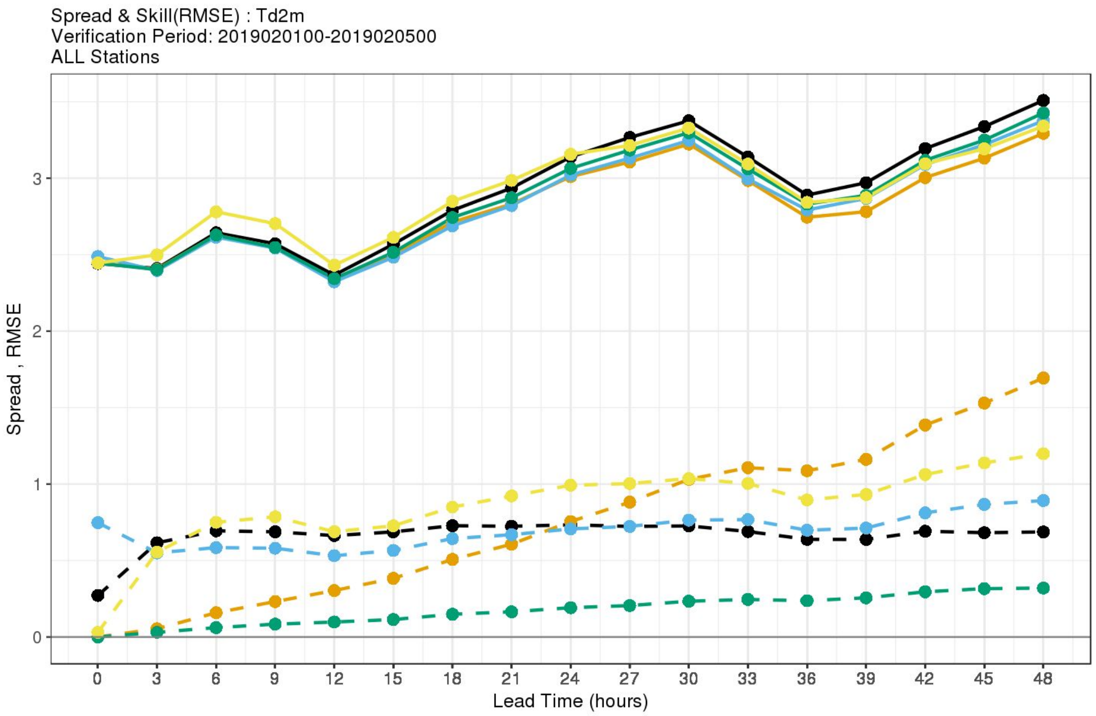
Spread/Skill
Td2m

- SPPT
+ SPPT

No additional spread by SPPT. Note: one month period!

Let’s take a closer look at SPPT and the interactions with the other perturbations

One perturbation at a time:

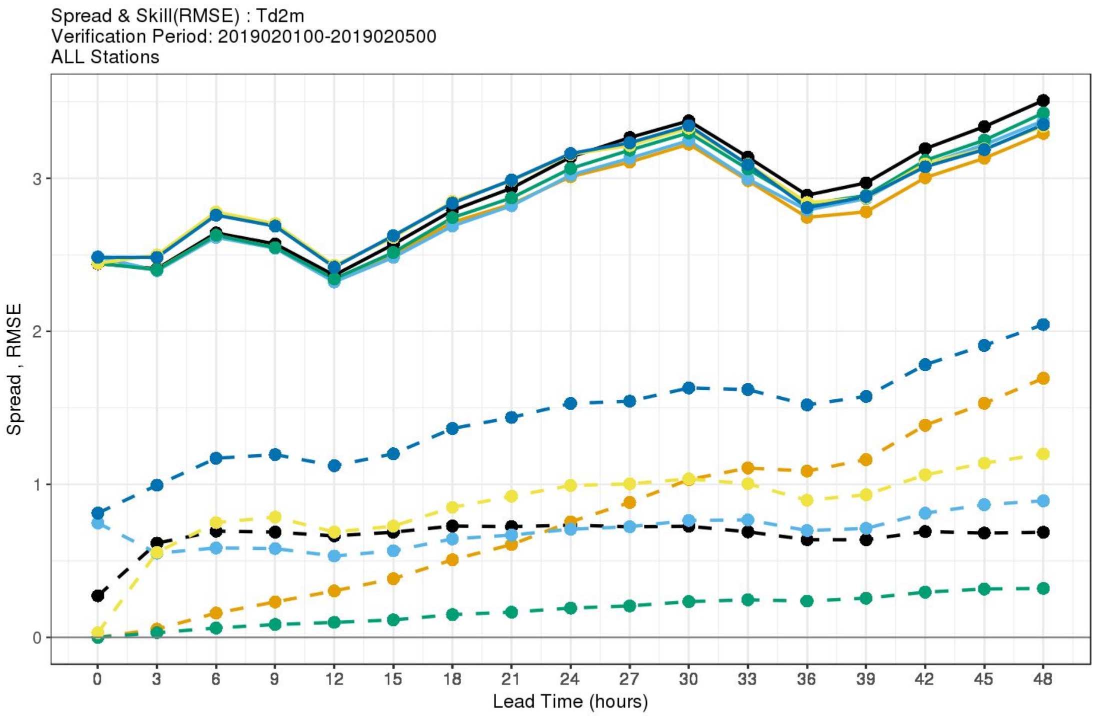


Spread/Skill
Td2m

SPPT
Boundary perturbations
Initial perturbations
Surface perturbations
SPP

All perturbations give spread to the ensemble when acting alone, also SPPT

One perturbation at a time:

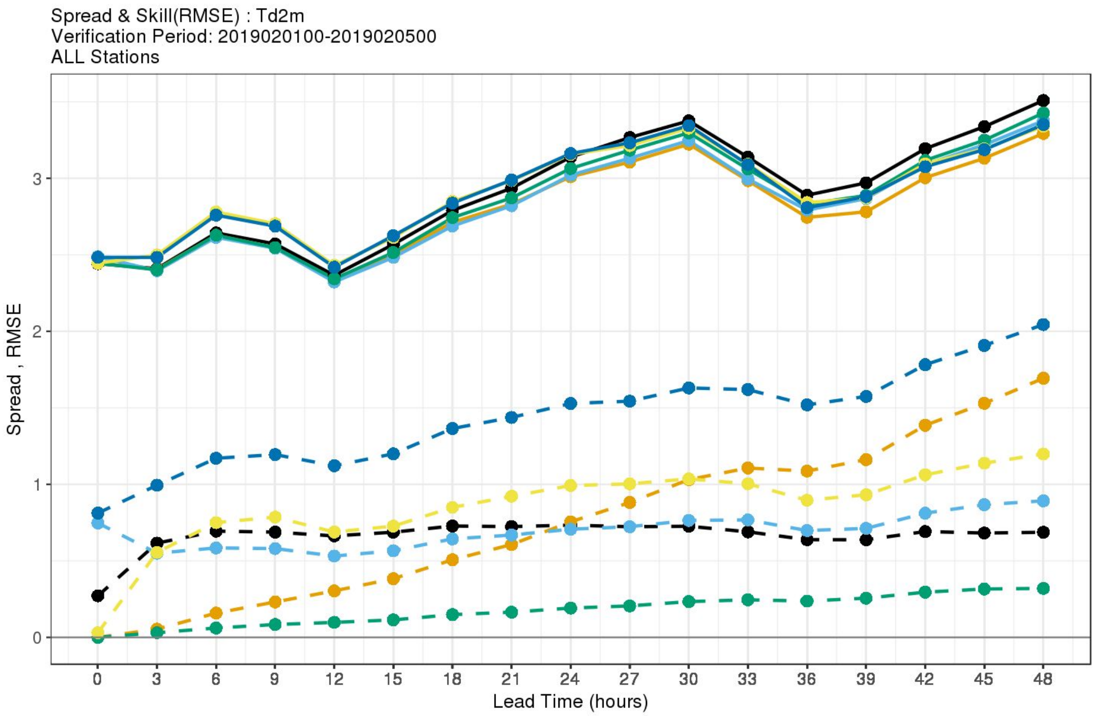


Spread/Skill
Td2m

SPPT
Boundary perturbations
Initial perturbations
Surface perturbations
SPP
All combined

The combination of all gives the highest spread

One perturbation at a time:

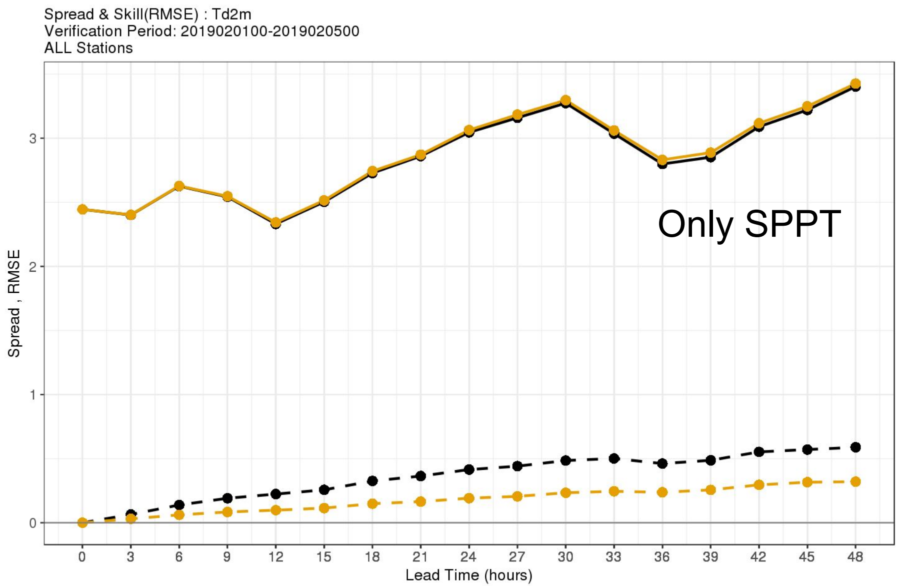


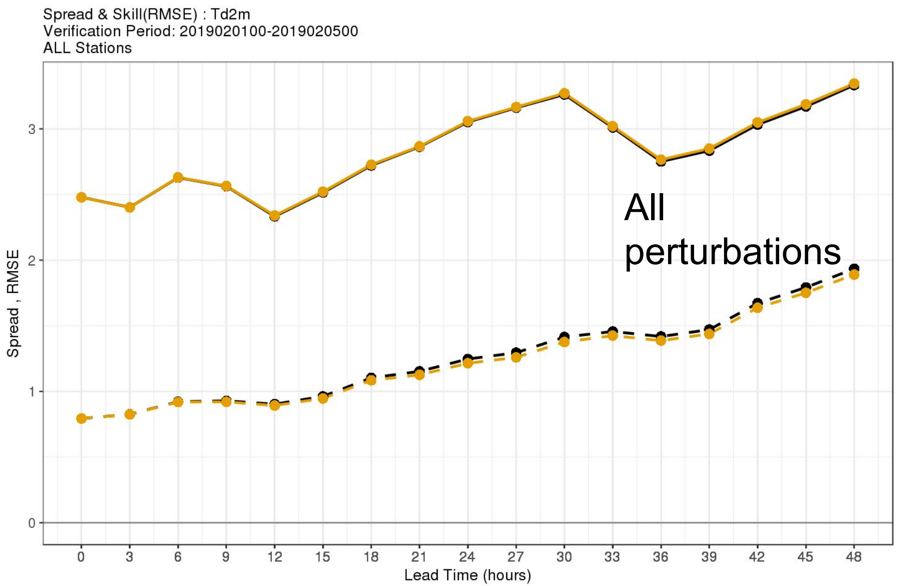
Spread/Skill
Td2m

SPPT
Boundary perturbations
Initial perturbations
Surface perturbations
SPP
All combined

So far so good

Was the SPPT perturbations simply too small?





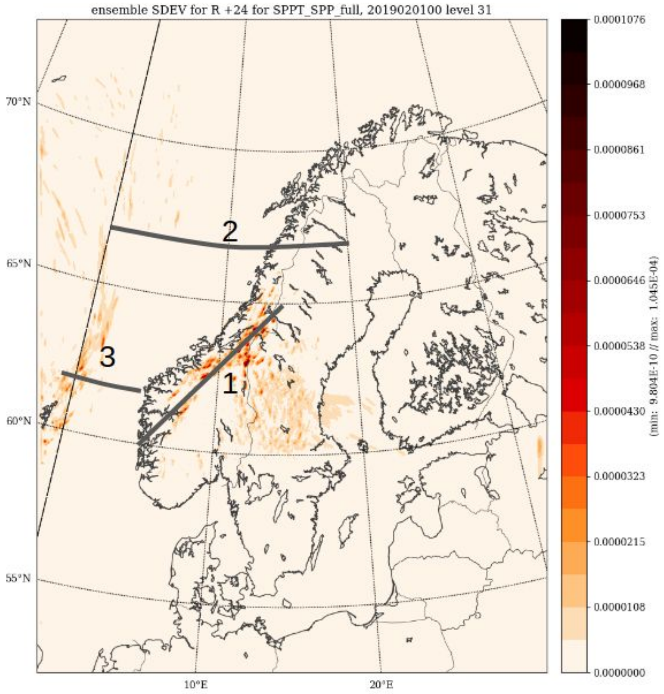
Default standard deviation for SPPT (0.3)

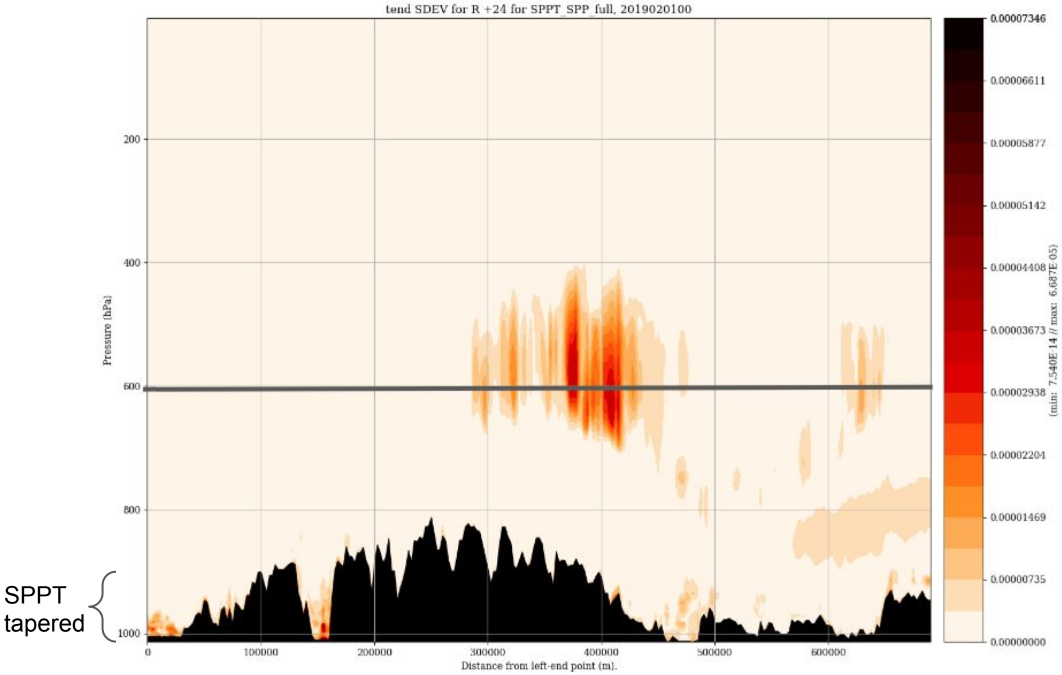
Increased standard deviation for SPPT (0.9)

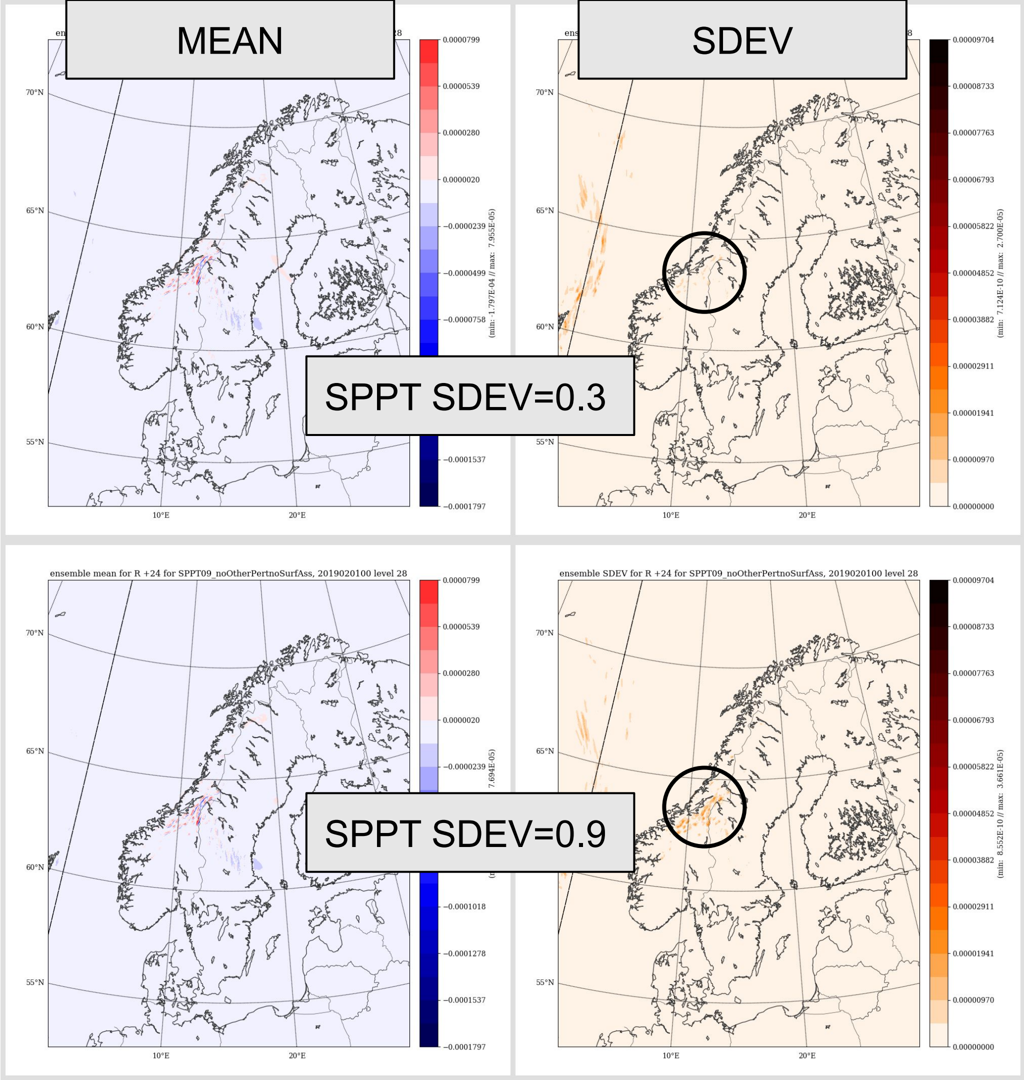
We see clear effect on the spread of increasing the SDEV when SPPT acts alone.
This effect is almost completely wiped out when combined with the other perturbations

What's happening? Looking at tendencies

In the following looking at 3h accumulated humidity tendencies for cross sections nr 1 and two levels 61 (~1000 hPa) and 28 (~600 hPa). Levels and cross sections chosen based on where the accumulated tendencies are "large".







ONLY SPPT - level 28

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h

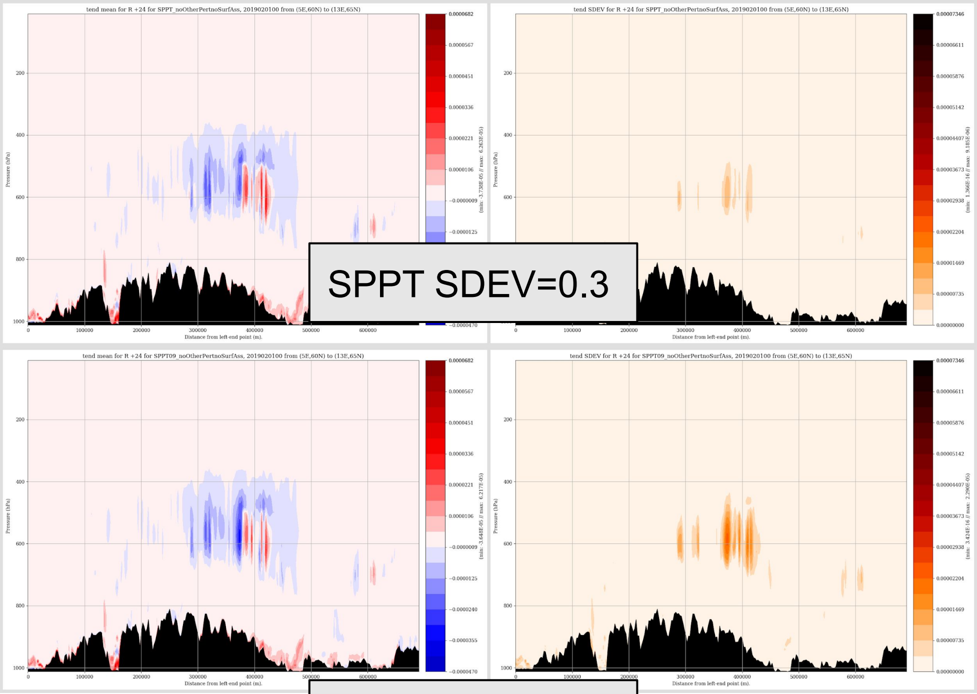
In line with the spread curves shown previously, we see increased variability when SPPT SDEV is increased, especially in the middle part of Norway

ONLY SPPT - cross section 1

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h

MEAN

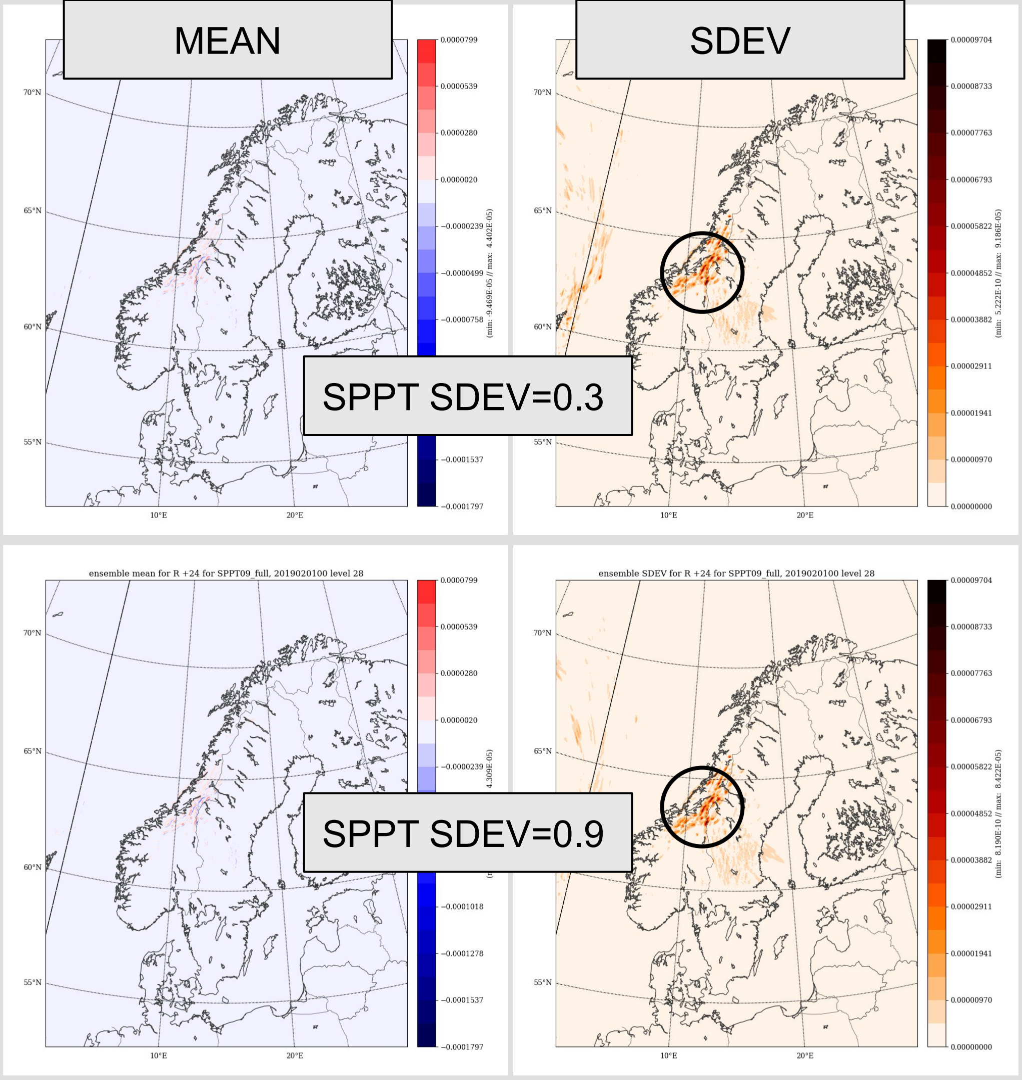
SDEV



SPPT SDEV=0.3

SPPT SDEV=0.9

In line with the spread curves shown previously, we see increased variability when SPPT SDEV is increased.



All pert. + SPPT - level 28

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h

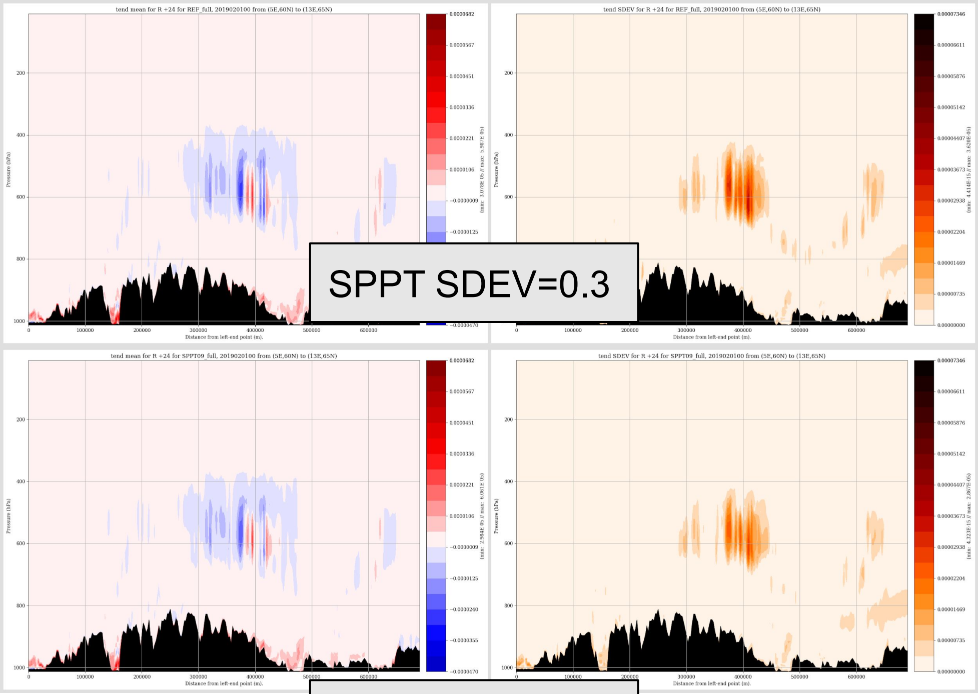
Now there is hardly any effect seen of increasing the SPPT SDEV

All pert. + SPPT - cross section 1

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h

MEAN

SDEV



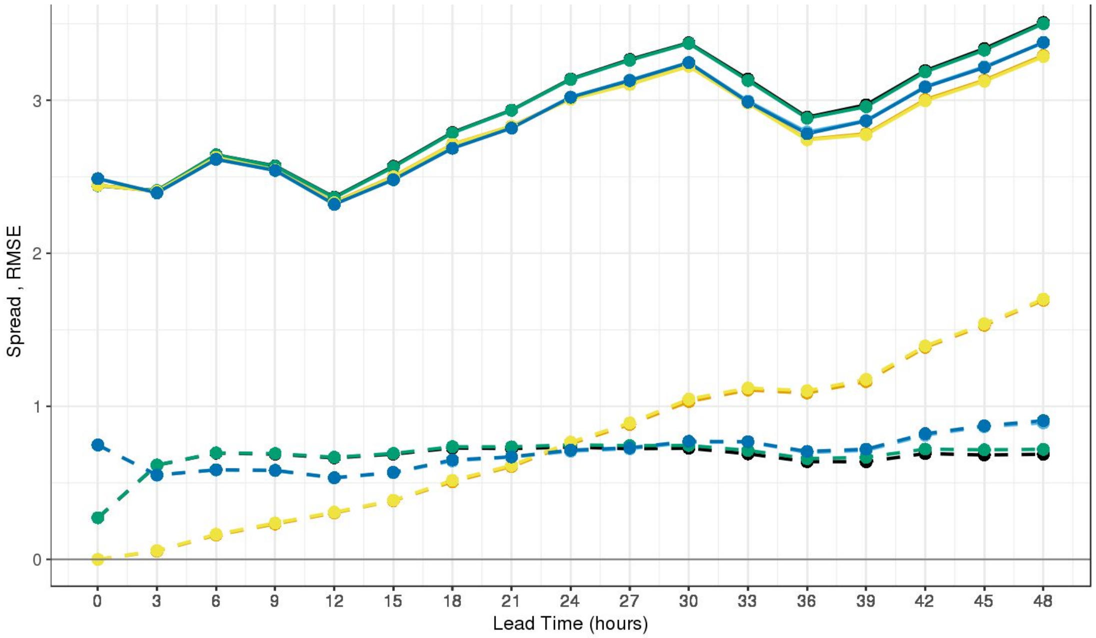
SPPT SDEV=0.3

SPPT SDEV=0.9

Confirmed also by looking at cross sections: When combined with the other perturbations, increasing the SPPT SDEV does not help. SPPT creates variability in the tendencies at same locations as the other perturbations!

What other perturbations mask the effect of SPPT?

Effect of SPPT combined with other perturbations separately

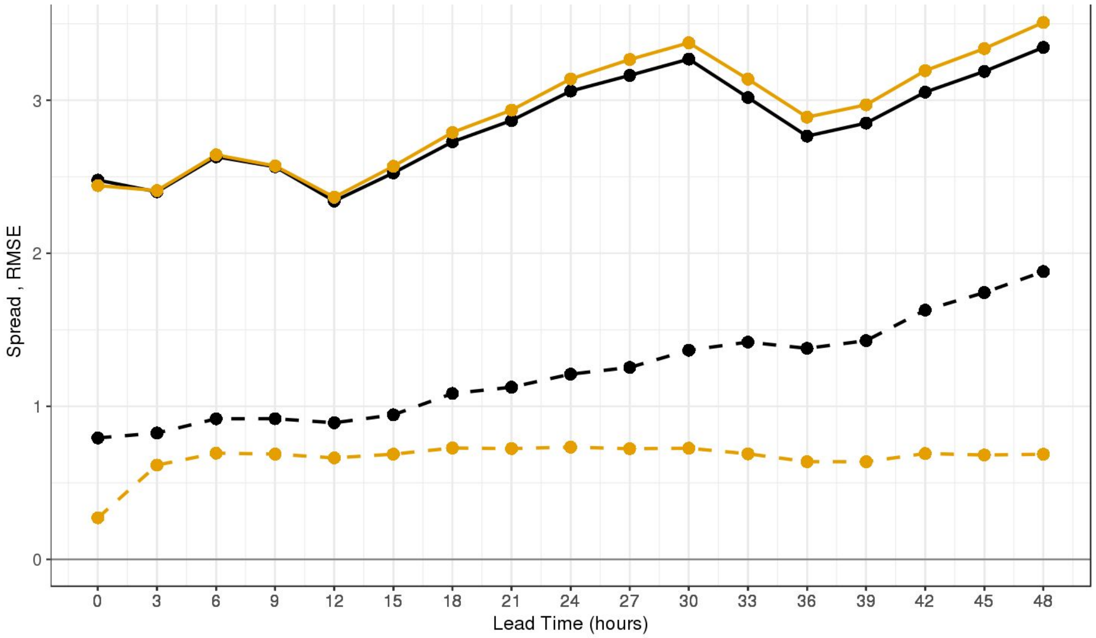


Spread/Skill
Td2m

Initial perturbations
Initial perturbations + SPPT
Lateral bnd perturbations
Lateral bnd perturbations + SPPT
Surface perturbations
Surface perturbations + SPPT

A little extra spread on top of the surface perturbations, otherwise none

For comparison: effect of surface perturbations on top of ini+bnd



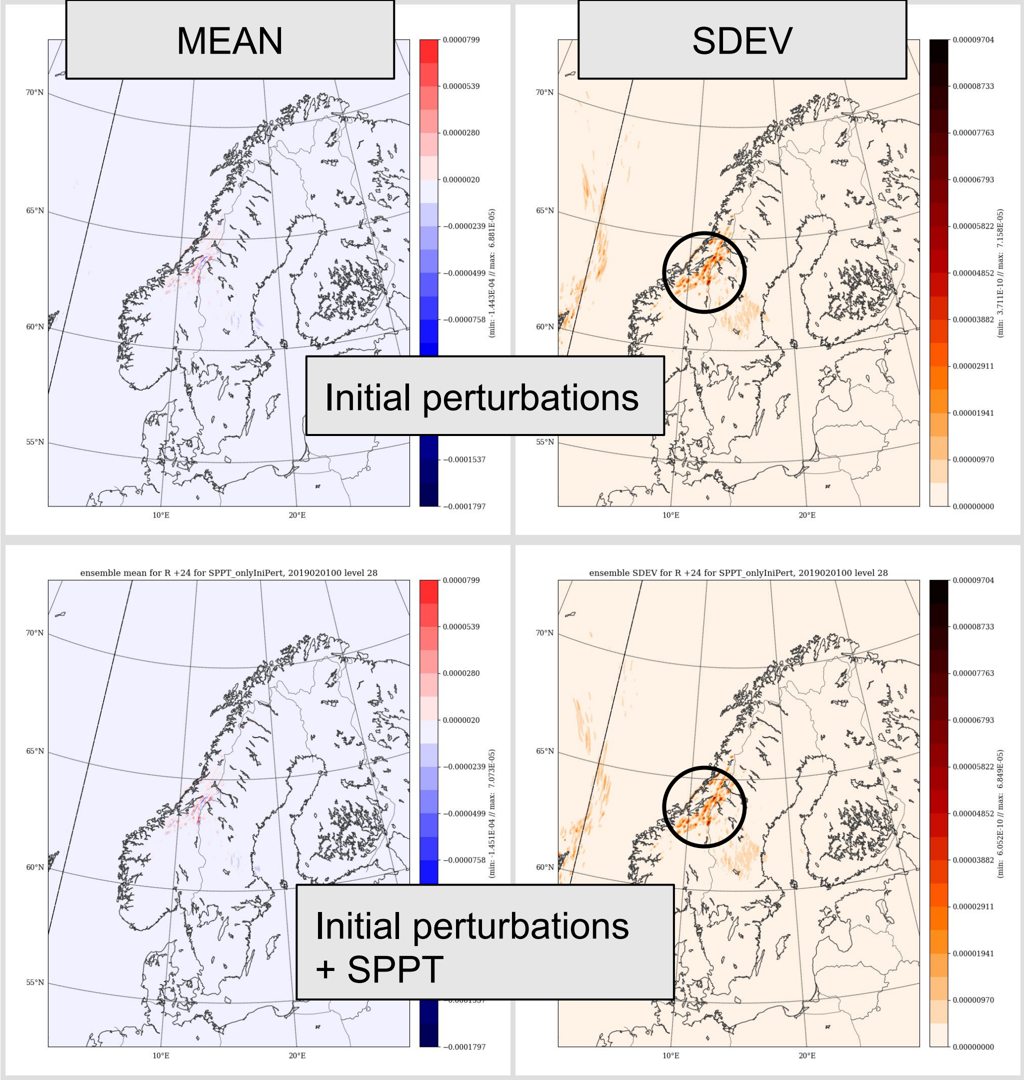
Spread/Skill
Td2m

Surface perturbations
Surface perturbation + ini and bnd perturbations

It is only for SPPT that we don’t see any effect when combined with other perturbations - why?

initial pert. + SPPT - level 28

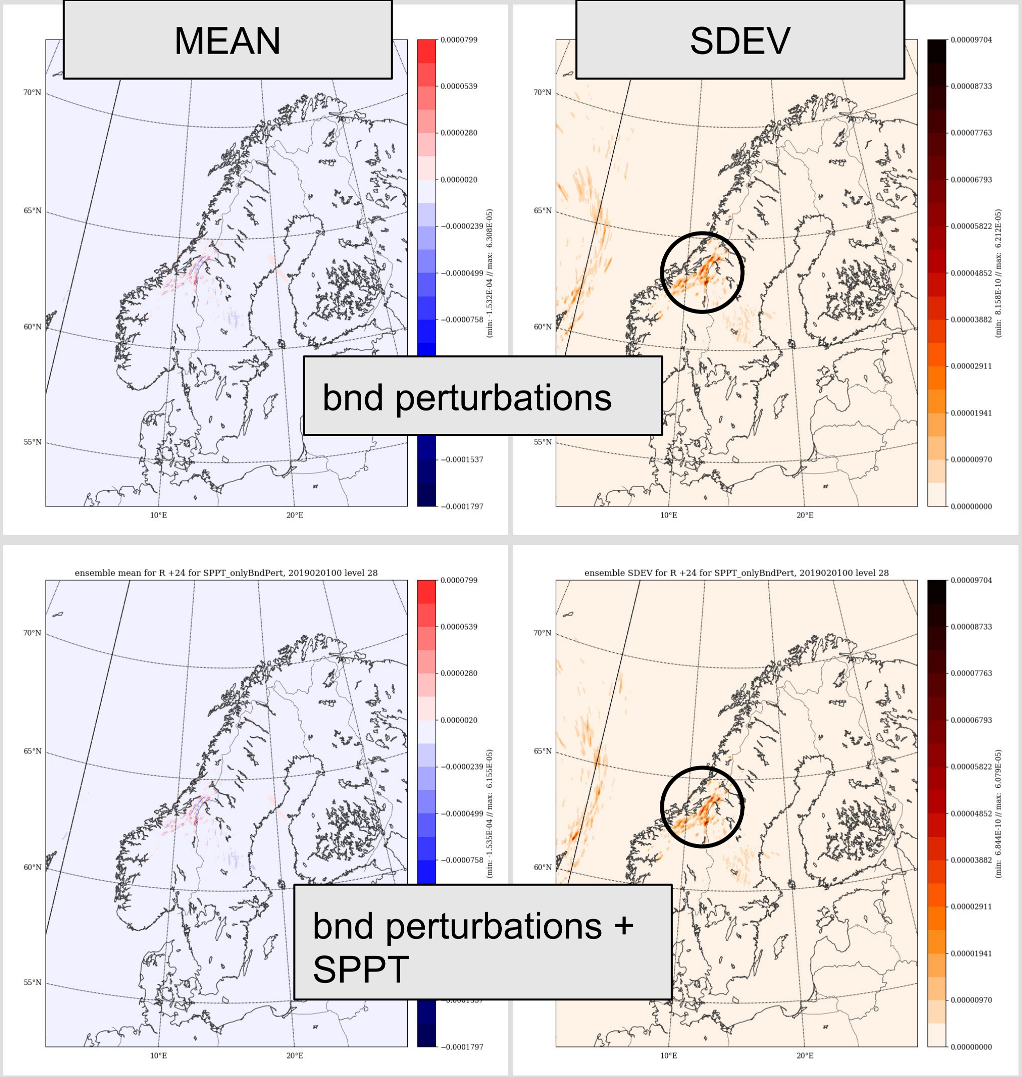
Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h



SPPT gives variability in the tendencies in the same places as the initial perturbations

boundary pert. + SPPT - level 28

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h



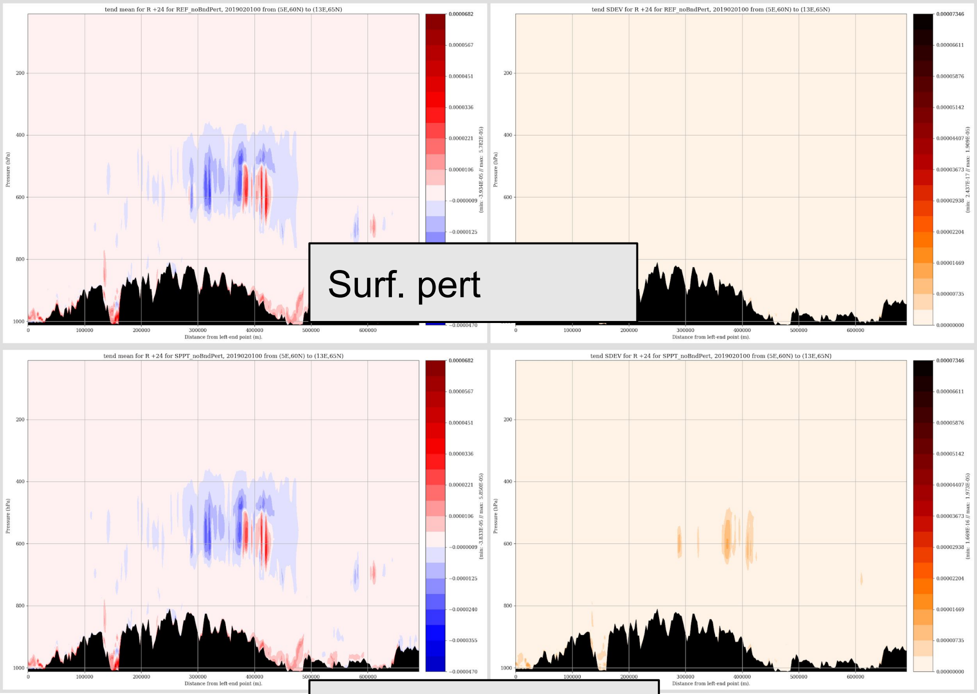
SPPT gives variability in the tendencies in the same places as the lateral boundary perturbations

Surf pert. + SPPT - cross section 1

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h

MEAN

SDEV



Surf. pert

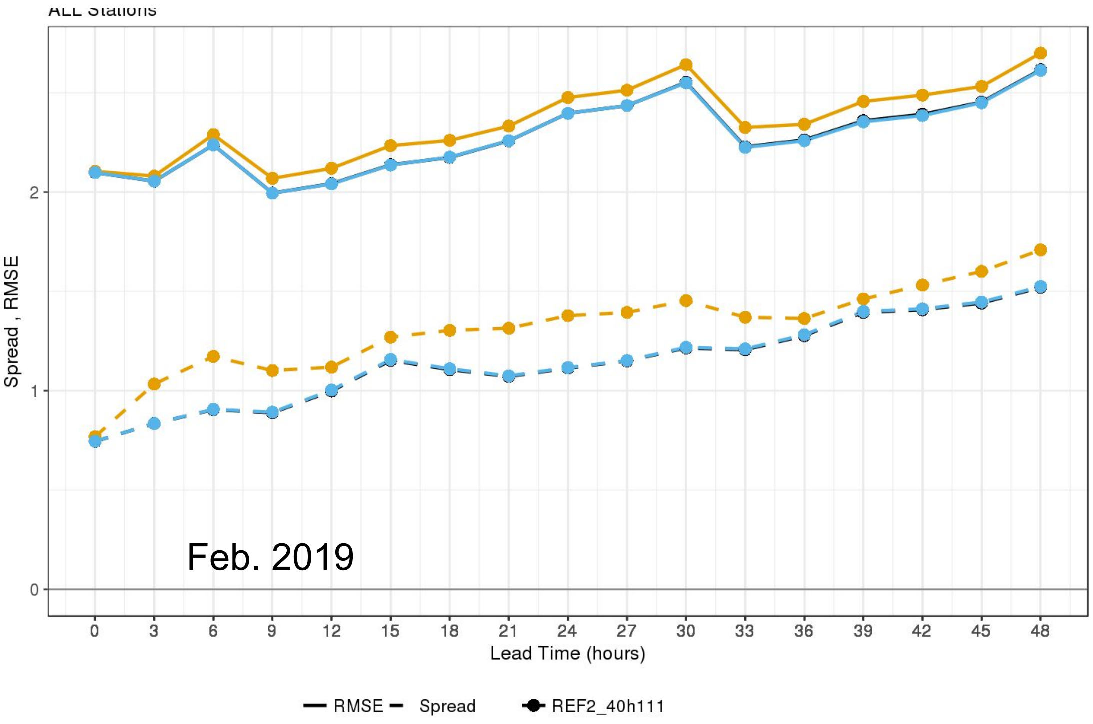
Surf. pert + SPPT

SPPT adds a little on top of the surface perturbations

SPPT in (current setup) does not give much benefit in HarmonEPS, despite a big effort to find optimal settings (time scale, length scale, standard deviation)

What about SPP, does it have the same problem?

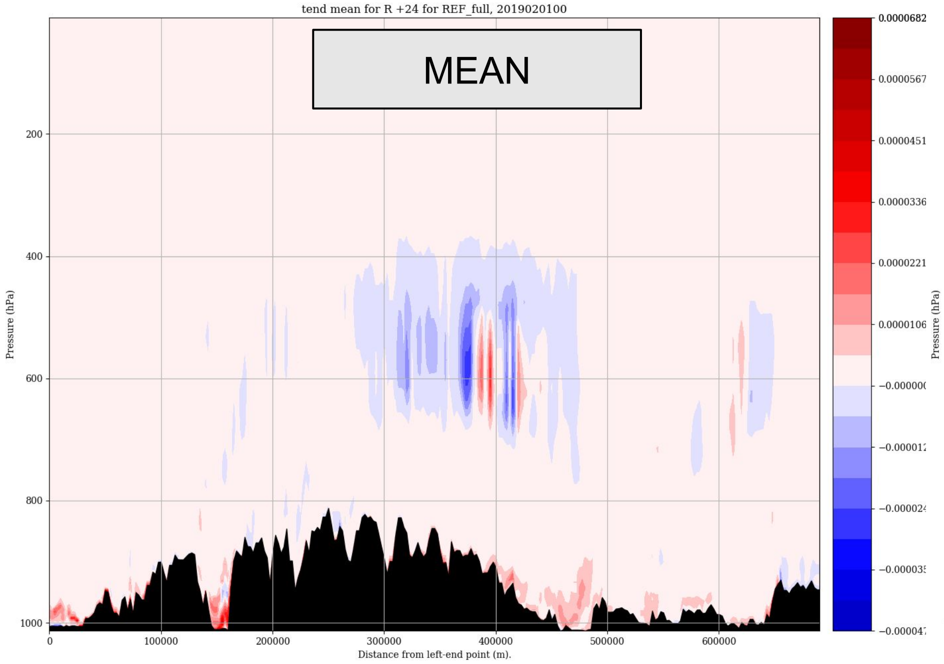
No, SPP adds variability

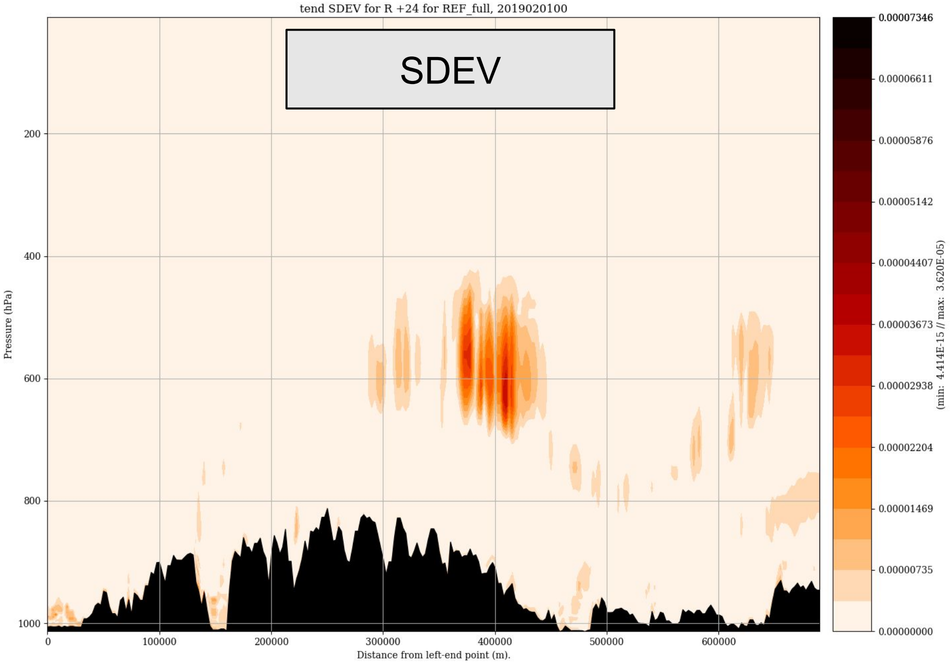


- Default pert.
+ SPPT
+ SPP

Default perturbations - cross section 1

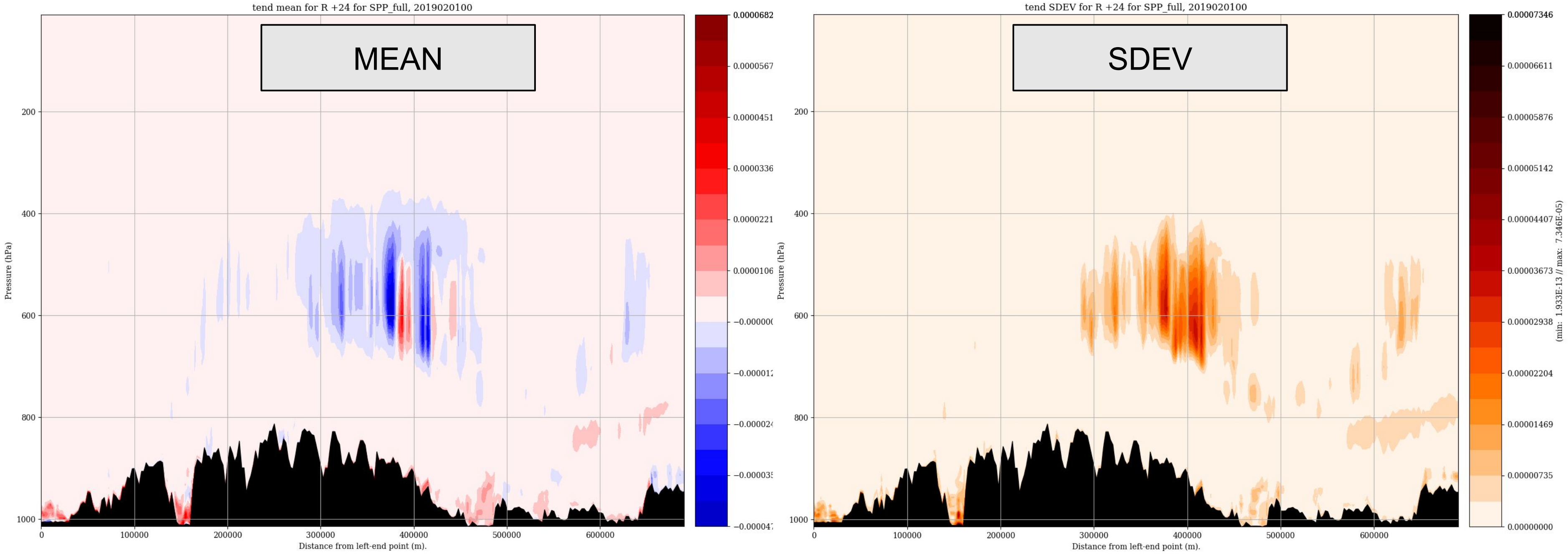
Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h





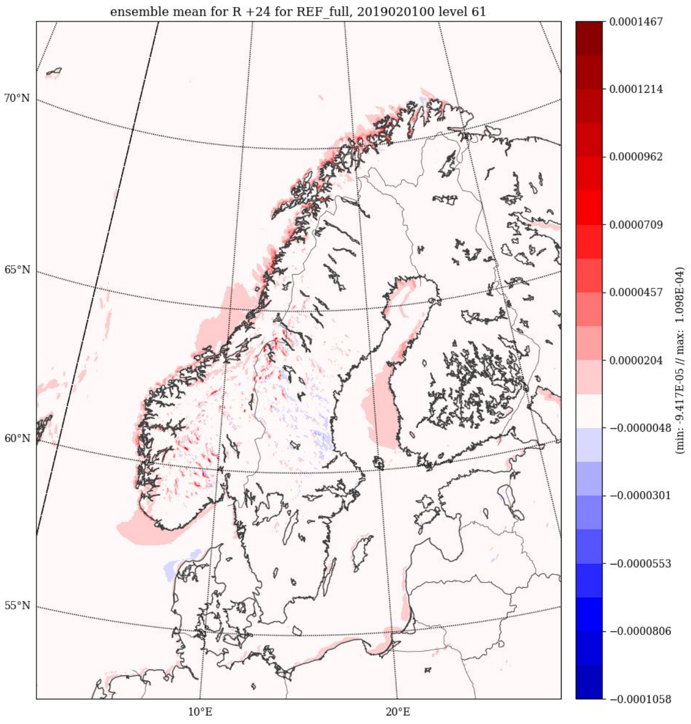
Adding SPP - cross section 1

Mean and SDEV for 3h acc. humidity tendencies for 2019020100 +24h

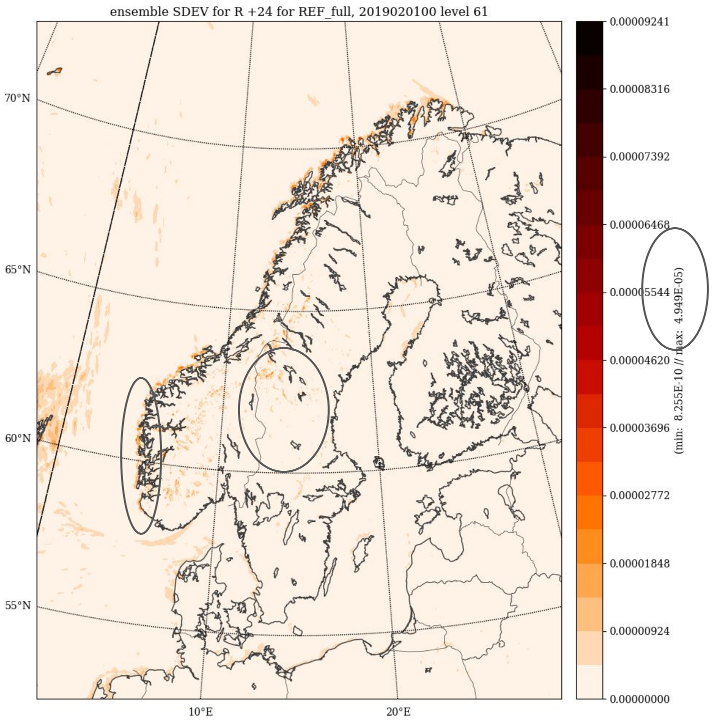


Level 61: Default perturbations
2019020100 +24

MEAN

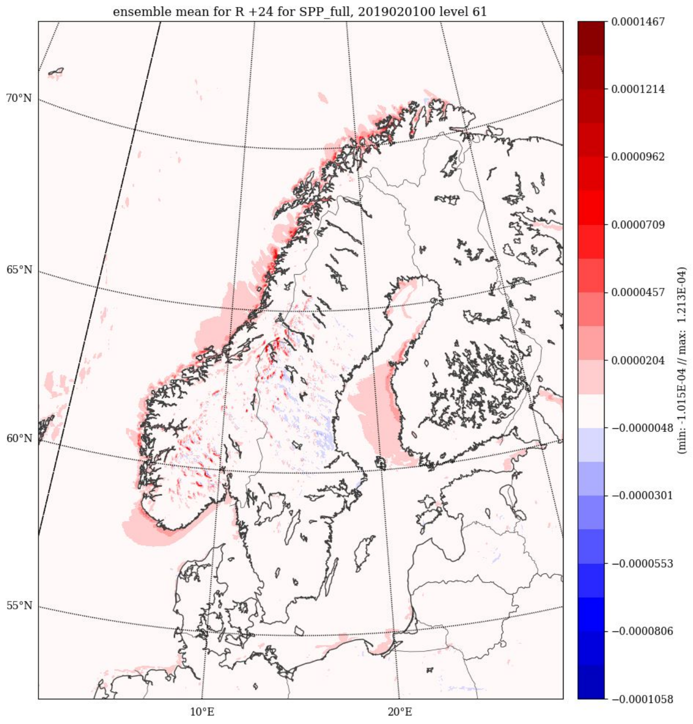


SDEV



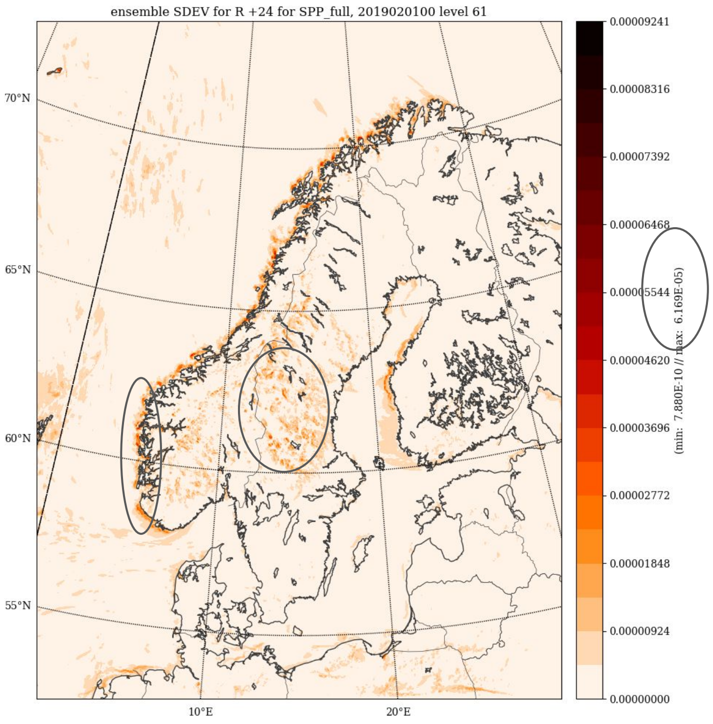
Level 61: Adding SPP
2019020100 +24

MEAN



We get more spread, AND increase in global max.

SDEV

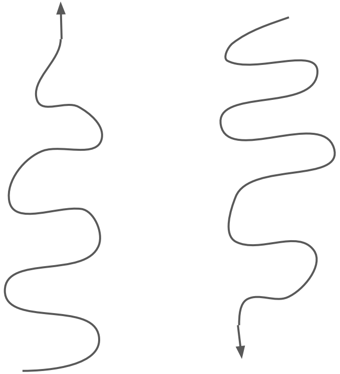


SPP - currently 14 parameters implemented

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

7 for clouds and microphysic

3 for turbulence



4 for radiation (2 tested)

So - who's the winner?

- Can not say … but we have a clear looser...
- The initial, lateral boundary and surface perturbations are all important
- SPPT (in current setup) is clearly not worth the cost of running it
- SPP is promising, giving variability in places/situations where the other perturbations are not

Further work on SPPT and SPP

SPPT:	**SPP:**
● Perturb independently each parameterisation - this way we can hopefully switch off the boundary layer tapering by removing SPPT for turbulence	● Include and test more parameters ● Correlated patterns for some parameters? ● Perturb SLHD ● Using different distribution, spatial and temporal scales for different parameters

Thank you for your attention!