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Impact of stochastic shallow convection scheme on ensemble forecast spread

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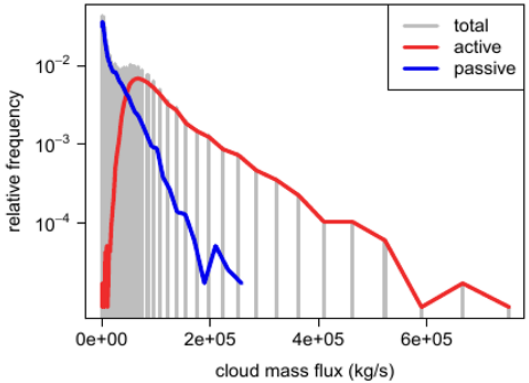
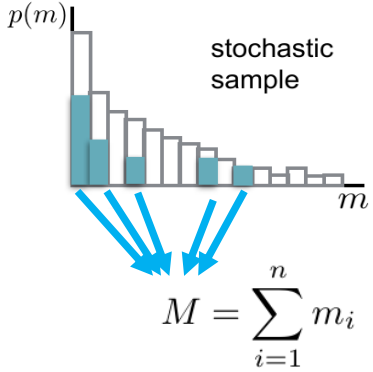
Basic concept of the stochastic convection scheme

- In each grid box with active convection, **construct a mass flux distribution** of the entire (shallow or deep) cloud ensemble (based on the large-scale forcing)
- **Randomly draw** from this mass flux distribution for each new cloud, and **add up all clouds' mass flux** within the grid box to get a representative value
- All else being equal (forcing), **each realization** will produce a **slightly different mass flux** for the grid box, but on average (mean over many realisations) **the mass flux will converge back to the mean** of the originally constructed mass flux distribution.



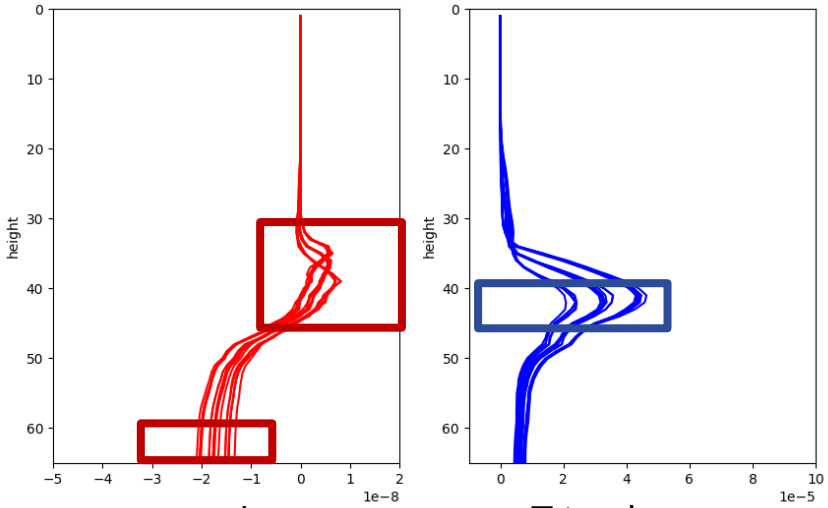


Question: How much spread does the stochastic scheme generate? … and how do we best measure it?

- First step: Consider spread of ensemble forecast only
- BACY LAM ENS forecast experiments:
  - Identical initialisation of 20 members
  - Spread **only** from stoch conv, or convection parameter perturbations (PPconv)
    - PP: +/- sigma (additive/multiplicative) – constant in time and space
  - Analyse tendencies of qv, T from convection parameterization from 10-12UTC (when parameterised convective activity peaks)
  - Analyse precip spread
- BACY global ENS forecast experiments (deep SDE)

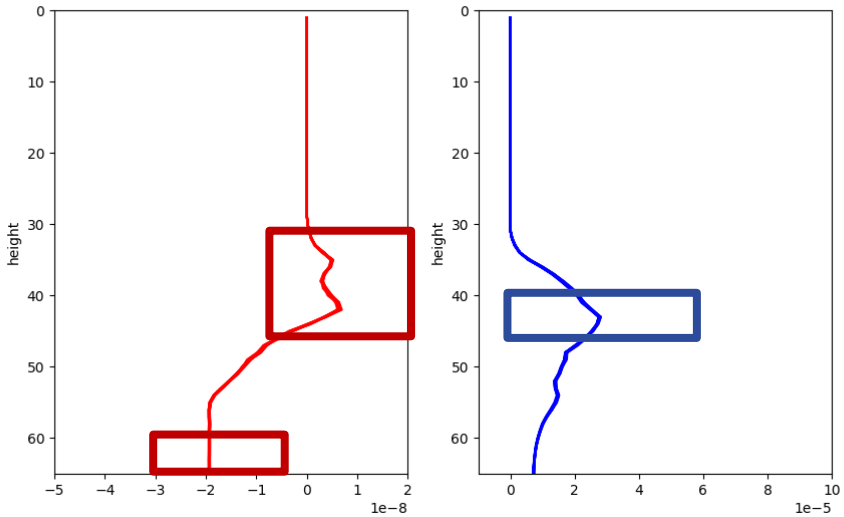
T and qv tendencies from convection (domain average)

Oper (grayzone tuning off) + PPconv



qv tendency T tendency

Stochastic scheme



qv Tendeny T Tendency

- Domain average from the stochastic scheme is very similar for all members
- PPconv together with the stochastic scheme mainly influences the cloud top height (rdepths)

T and qv tendencies from convection (domain average)

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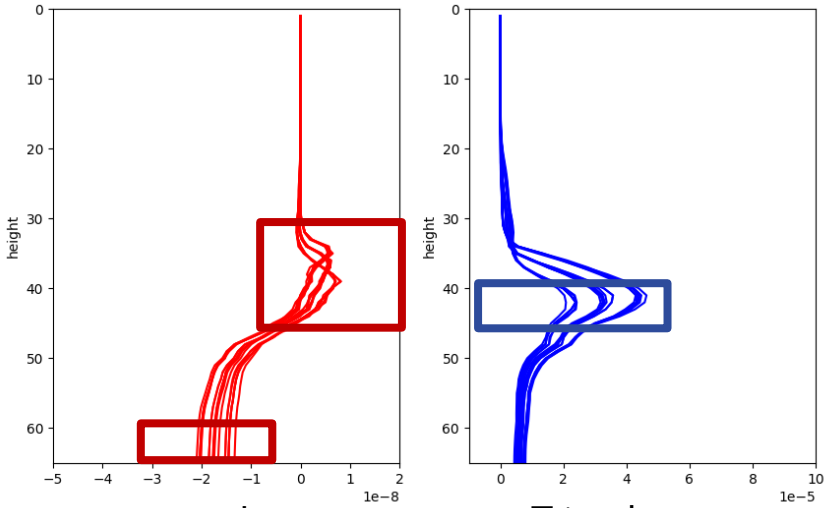
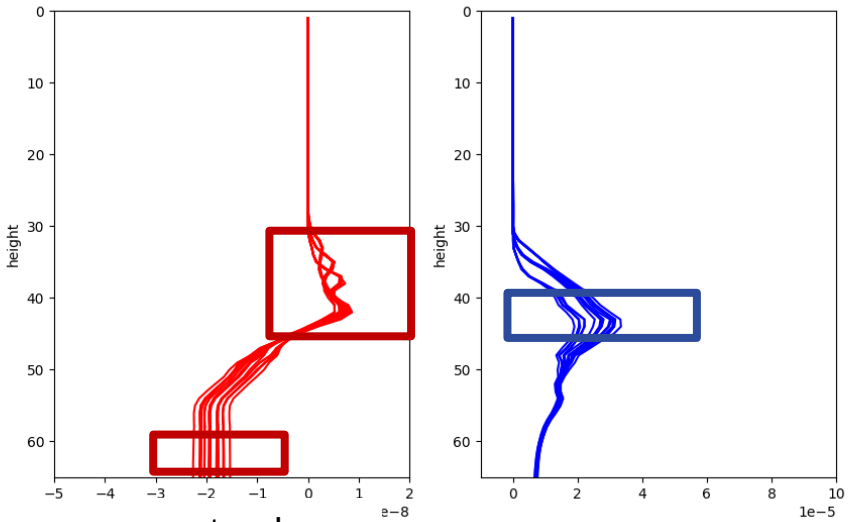


qv tendency T tendency

Stochastic schema + PPconv



qv tendency T tendency

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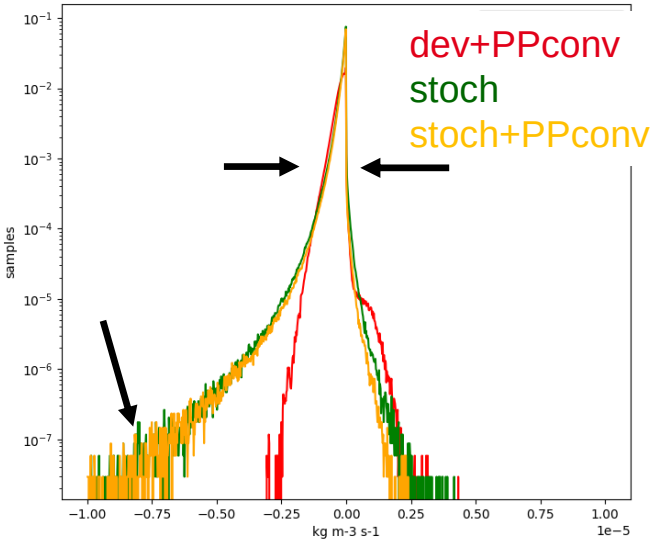
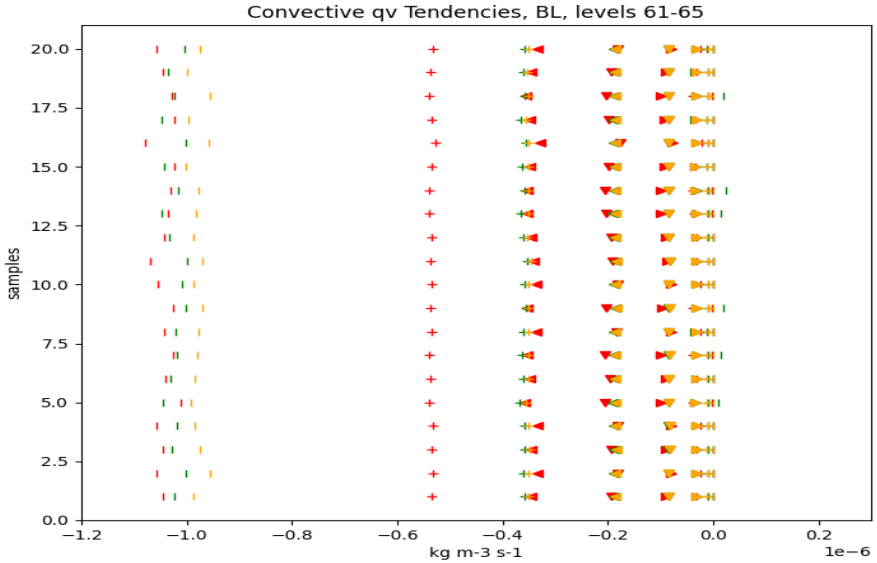
Distribution of tendencies

- Stochastic scheme: more (rare) extremes, but distribution peak narrower (percentiles)
- PPconv: fewer extreme values, but broader distribution peak

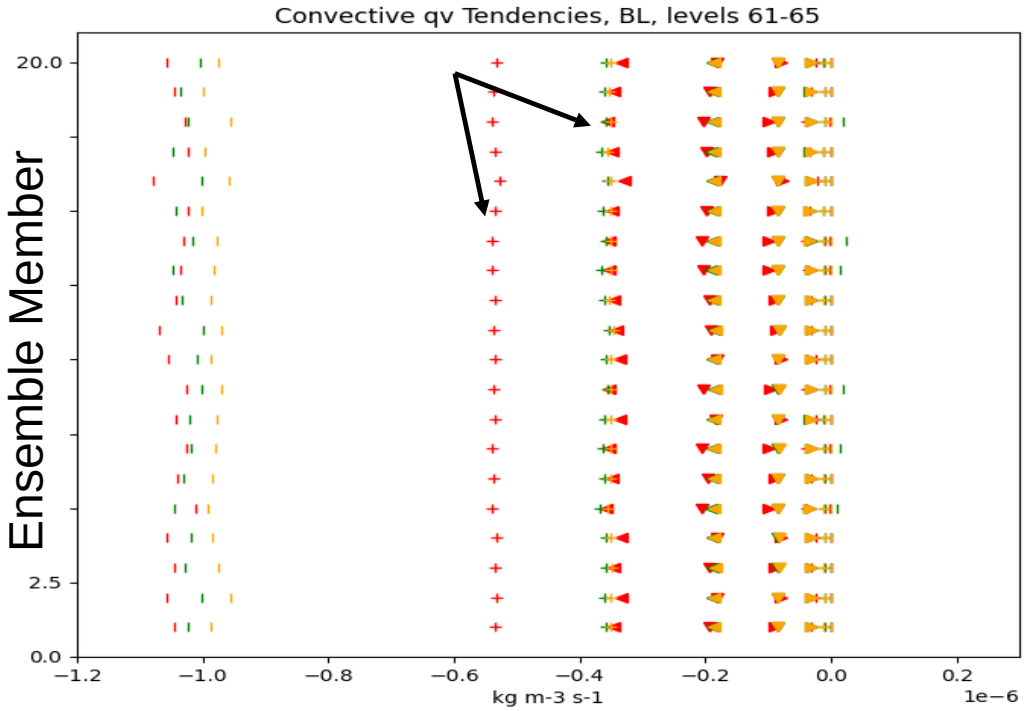
qv tendencies in the boundary layer





Distribution percentiles

qv tendencies in the boundary layer



oper
oper+PPconv
stoch
stoch+PPconv

Symbols mark percentiles

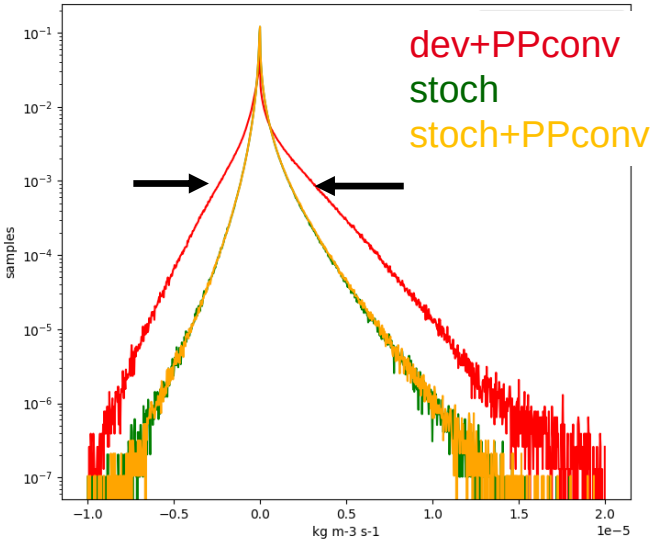
| + < v > + |

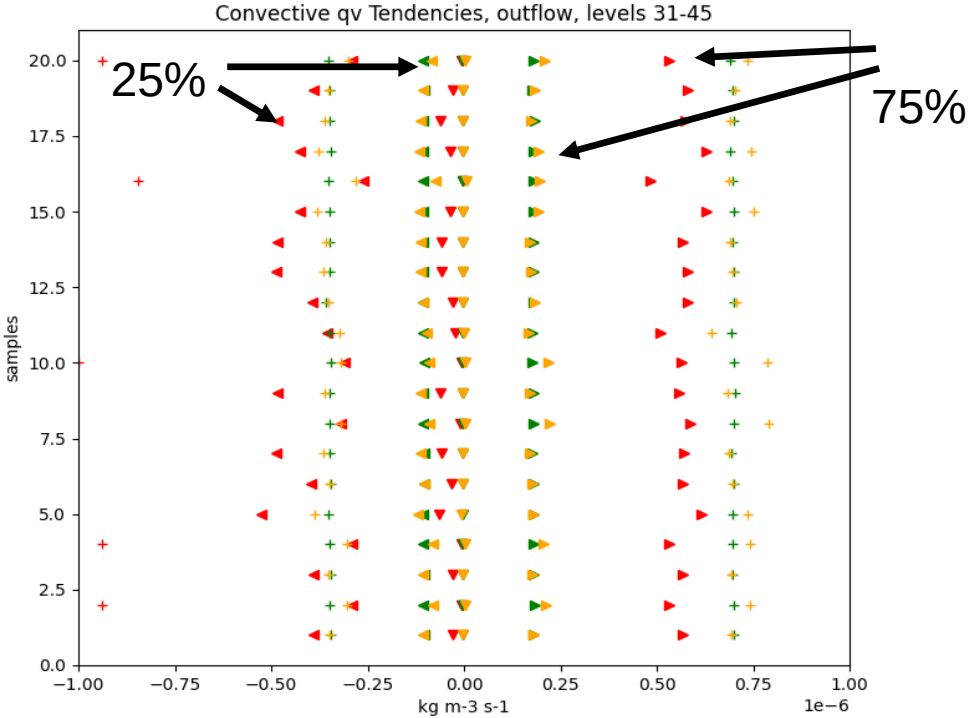
1, 10, 25, 50, 75, 90, 99%

Results depend on quantity and vertical level
Example: qv outflow

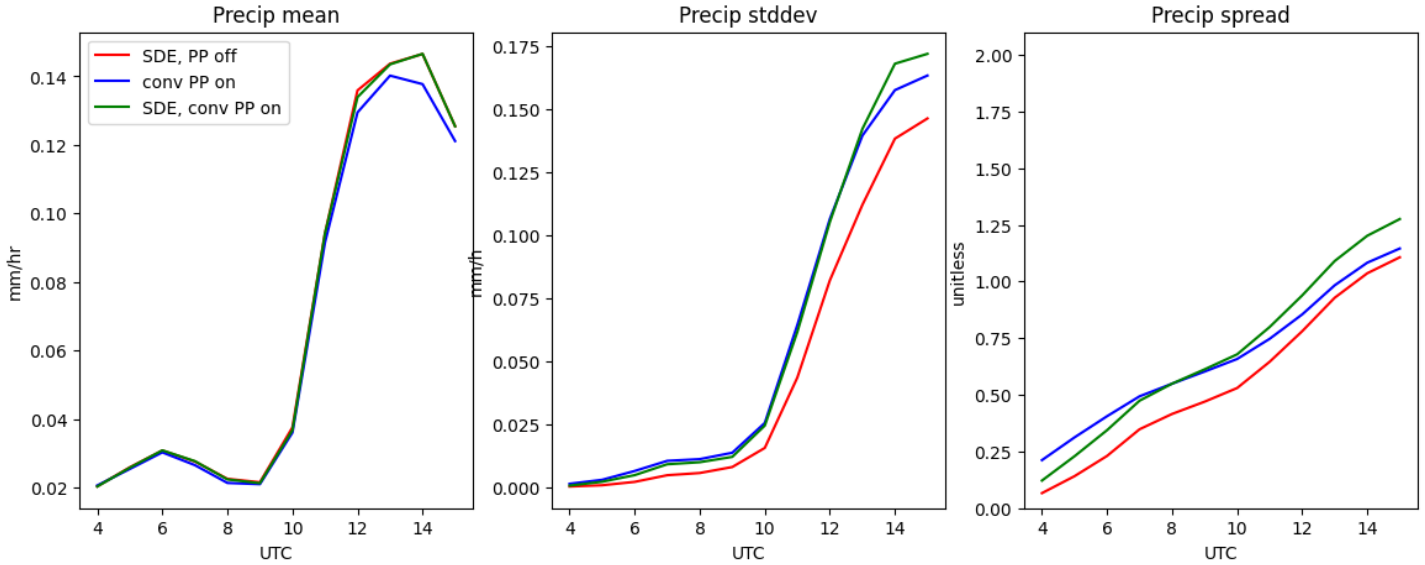
➔ Stochastic has broader peak, but not necessarily more extreme values

qv tendency, outflow layer



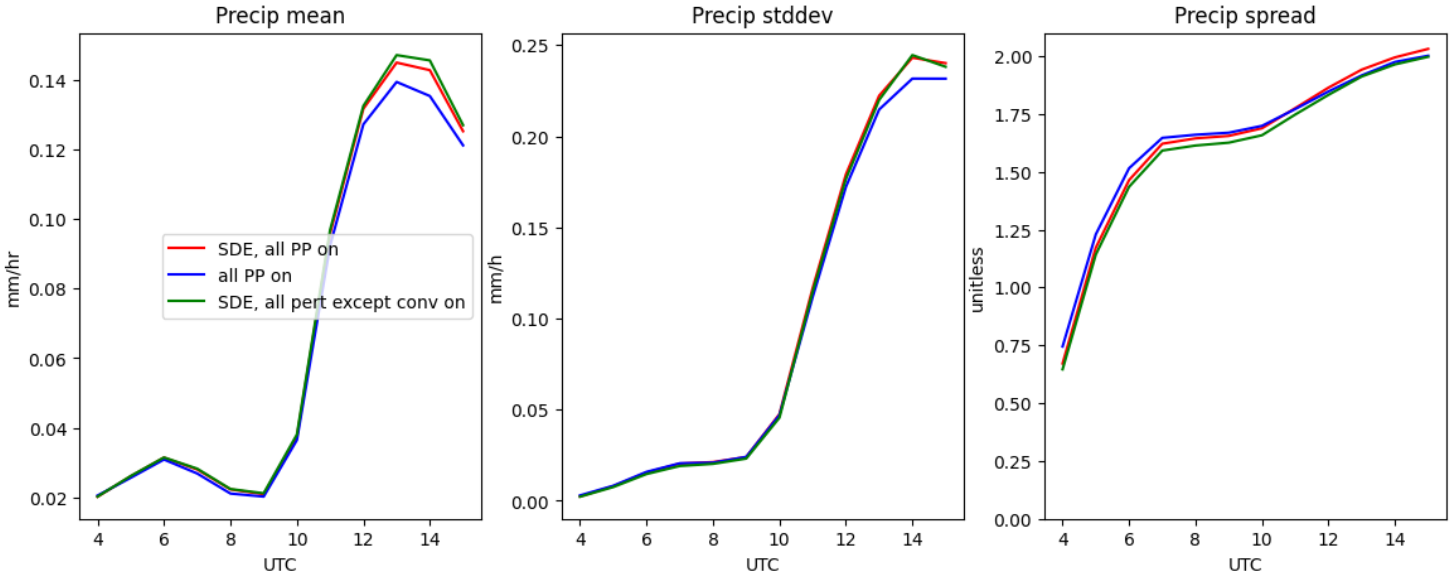


Domain-average spread for total precip



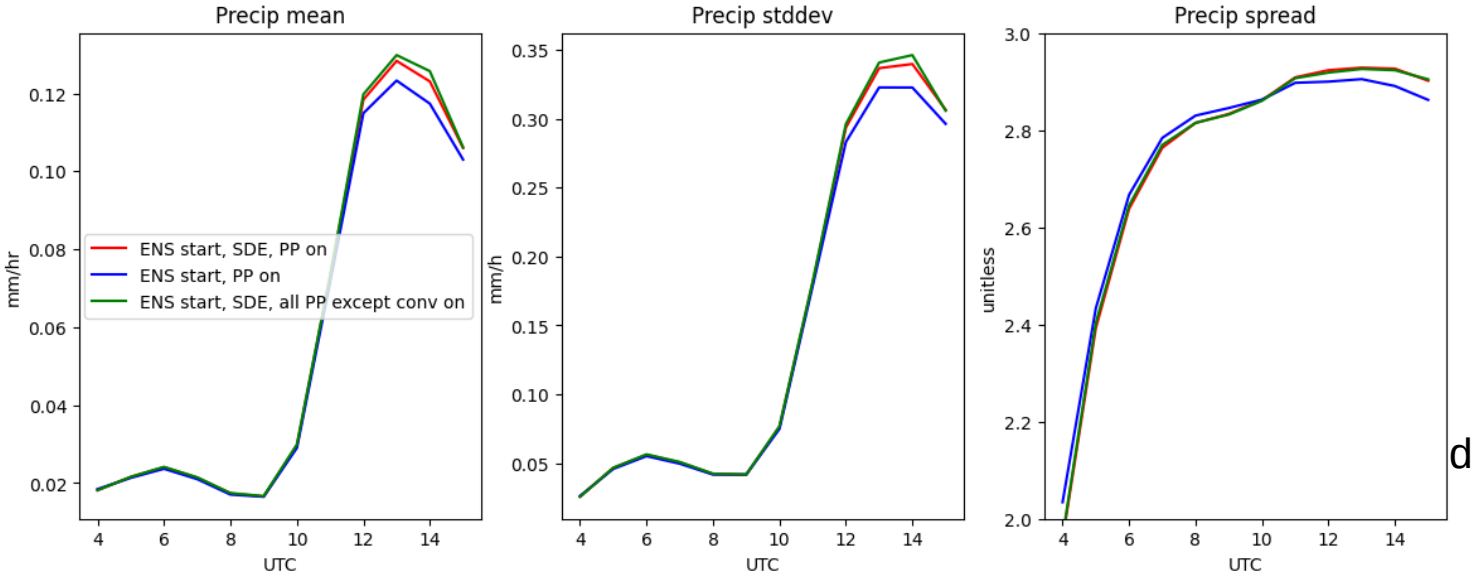
- Spread generated by SDE alone is less effective than PP applied to convective parameters only.
- SDE plus PP applied to convection parameters adds spread later in the day.

PP active for all parameters



- Sensitivity related to convection perturbations generally fairly small.
- Adding SDE on top of the operational PP increases spread slightly.
- Replacing convective PP with SDE (while keeping other PP unchanged) leads to similar spread from about 11UTC onwards, less previously.

Initialise FC from 20 different members



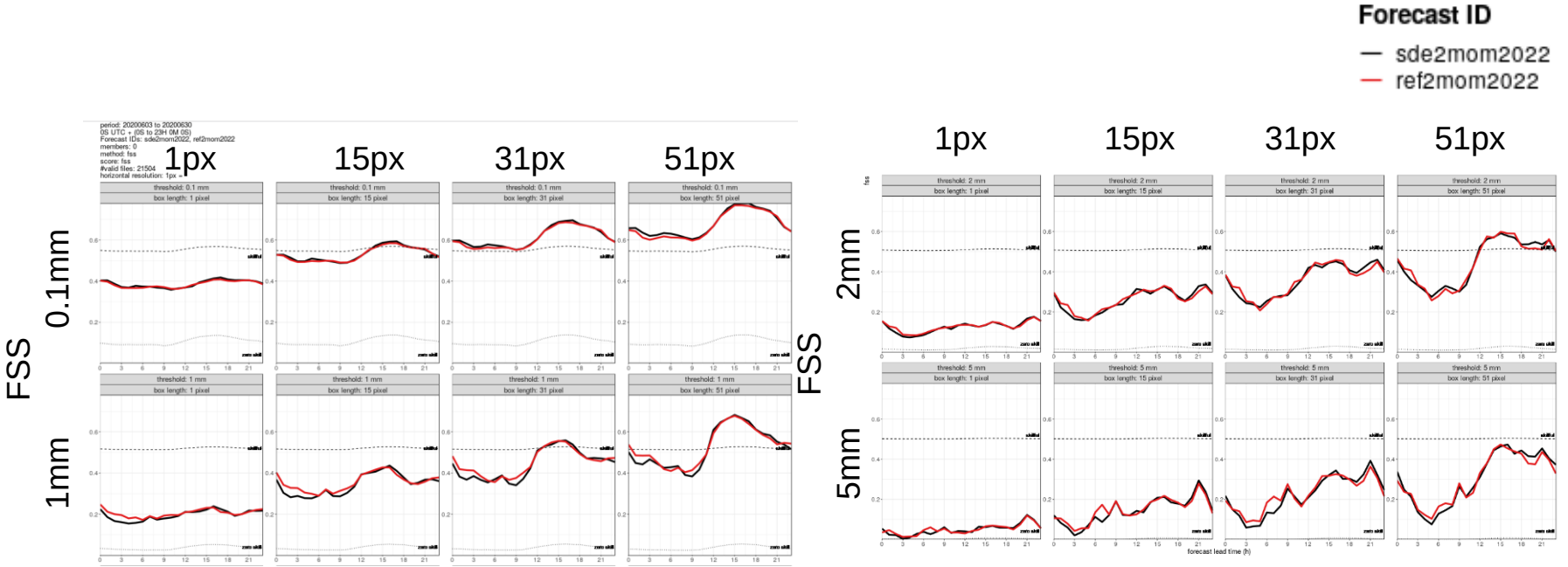
different scale!

- SDE still adds extra spread after 10UTC, regardless of whether conv PP is on/off

How does SDE affect forecast skill?

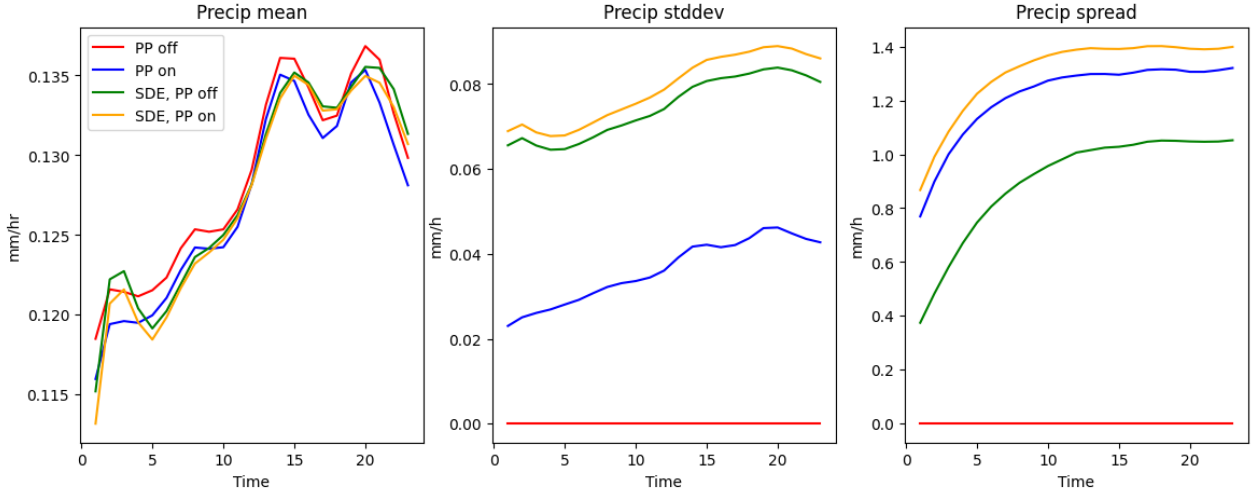
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Hot off the press: month-long hindcast of SDE+2mom scheme (RUC-setup) is largely neutral in precip neighbourhood verification, surface/upper air RMSE, slight improvements related to cloud cover (vs. satellite obs)



Deep SDE: global ensemble forecast

- No separate switching of convective PP parameters
- Single day, 20 members
- About 10 hours of spinup



Deep SDE alone produces a lot of spread (though less than PP)
Deep SDE plus PP adds more spread than in LAM setting.

Global hindcast performance (Günther):
More frequent, high intensity precip events
Warm bias in upper troposphere

Summary:

- Shallow SDE has similar impact as PP* (precip, later in the day – diurnal dependence, non-linear growth?), but convection overall adds little to overall spread
- Deep SDE appears to have a more noticeable impact
- Stochastic scheme does not produce the same kind of spread as PP
  - How important is it have an “offset’ between members, vs. spread at a single grid point?
  - How important are rare extreme values vs. a broader peak?
- More robust statistics
- Relative relevance of spread in init state vs. forecast spread
- Open question: Assimilation cycle