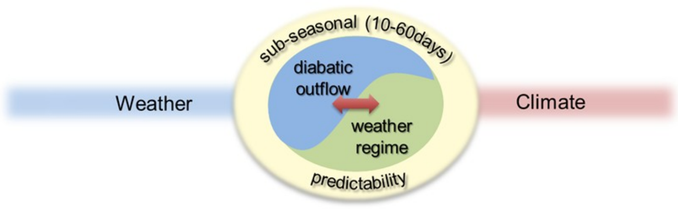
*Helmholtz Young Investigator Group VH-NG-1243: "**S**ub-seasonal **PRE**dict**A**bility: understanding the role of **D**iabatic **OUT**flow" (SPREADOUT)*



The effect of stochatically perturbed parametrisation tendencies (SPPT) on rapidly ascending air streams

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(1) Background and Motivation

Why SPPT and rapidly ascending air streams / warm conveyor belts (WCBs)

- SPPT represents model uncertainties related to physical parametrizations by randomly perturbing the net tendencies from all physical processes (Leutbecher et al., 2017)
- Physics tendencies and hence the introduced perturbations are large in regions of rapidly ascending air streams, as these are influenced by diabatic heating from cloud-condensational processes

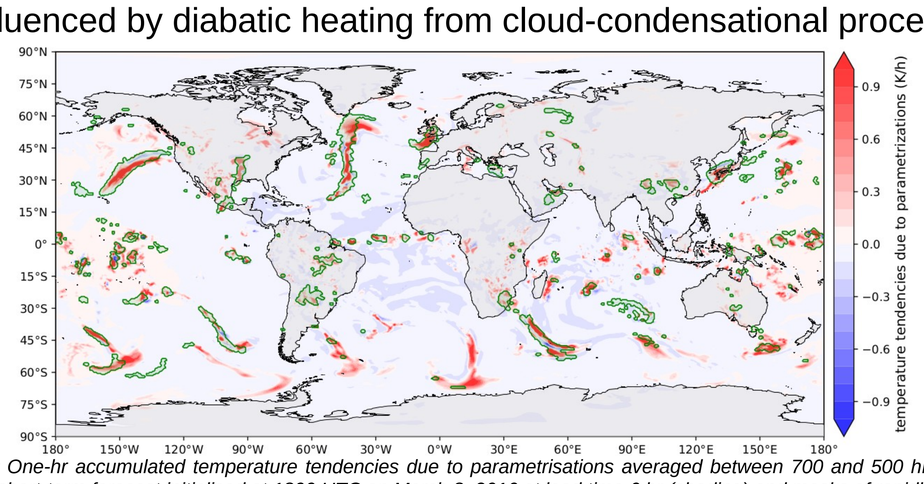

***Fig. 1**: One-hr accumulated temperature tendencies due to parametrisations averaged between 700 and 500 hPa from the ERA5 short-term forecast initialised at 1800 UTC on March 8, 2016 at lead time 6 hr (shading) and masks of rapidly ascending air streams in their ascending stage (see methods) for the sane valid time (green contours). Reprinted from Pickl et al., 2022.*

(2) Research question, Data and Methods

Are rapidly ascending air streams affected by stochastic physics perturbations through SPPT?

Experimental design

- 3 IFS ensemble experiments with CY46
  - *SPPT* (SPPT & initial condition perturbations)
  - *IC-ONLY*
  - *SPPT-ONLY*
- 32 initial times in summer/autumn 2016, 12 days lead time, 20 perturbed members

Lagrangian detection of rapidly ascending air streams / WCBs

- 48-h forward trajectories starting on a global equidistant grid below 700 hPa with Lagranto (Sprenger and Wernli, 2015)
- Consider only such trajectories that ascend by at least 600 hPa in 2 days
- Automated post-processing implemented into the IFS-suite enables the trajectory computation in the ensemble

(3) Impacts of SPPT on trajectories

Trajectory counts

- SPPT systematically increases the trajectory count
- Magnitude is more pronounced in the tropics than in the extratropics and scales with the latent heating rate along the trajectories
- Differences between experiments are independent of lead-time
- IC-perturbations do not affect the counts

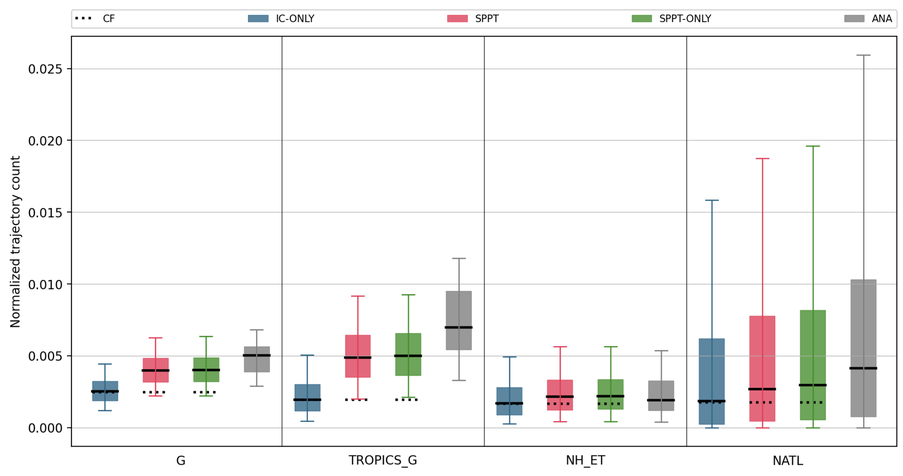

***Fig. 2** Number of trajectories starting globally (G), in the Tropics (TROPICS_G), in the northern hemisphere extratropics (NH_ET), and in the North Atlantic (NATL), per forecast initialization, member and lead time, normalized by the size of the corresponding region. Reprinted from Pickl et al., 2022.*

Trajectory characteristics

- Increase of the number of strongly heated trajectories with SPPT results from larger effect in the (sub-) tropics
- Classifying trajectories into a weakly and strongly heated regime shows that the physical characteristics remain unchanged by SPPT

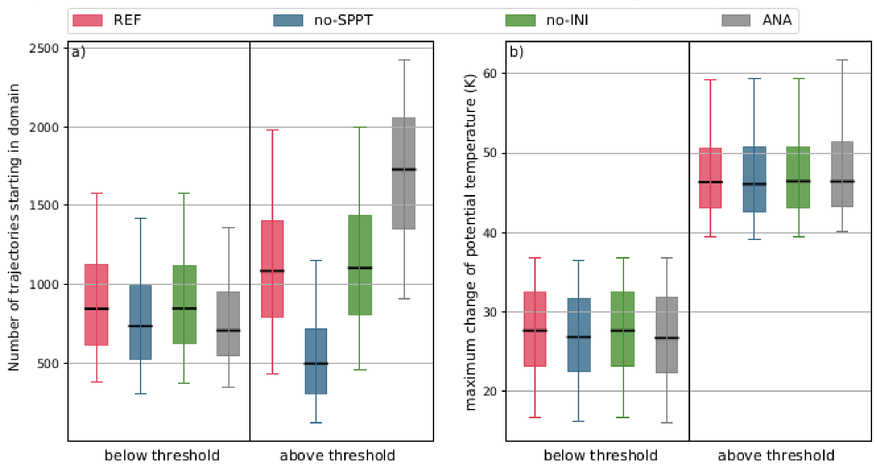

***Fig. 3** (a) Number and (b) diabatic heating rate of trajectories starting globally per forecast initialization, member and lead time, separated into weakly heated ("below") and strongly heated ("above") trajectories by the threshold of 38K. Reprinted from Pickl et al., 2022.*

(4) Eulerian perspective & Mechanism

Vertical velocities

- Increased occurrence of fast upward motions are balanced by accelerated downward motions
- Stimulation of air parcels that are at rest

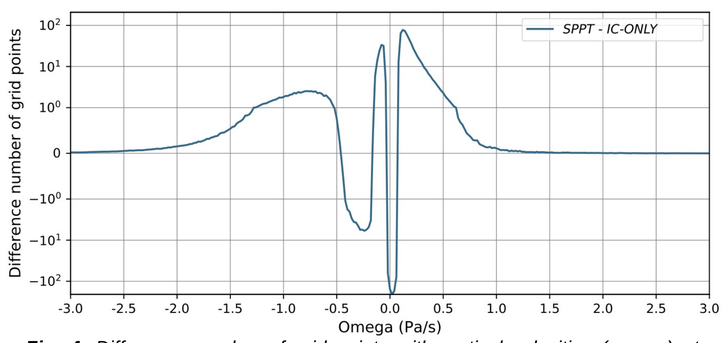

***Fig. 4**: Difference number of grid points with vertical velocities (omega) at 500hPa in bins of 0.02 Pa/s per forecast, member and lead time between the experiments SPPT and IC-ONLY. Reprinted from Pickl et al., 2022.*

Explaining the unilateral response

- Positive perturbations are more effective in triggering ascent than negative perturbations in preventing it in a non-linear system characterized by threshold behaviour (for example atmospheric convection)

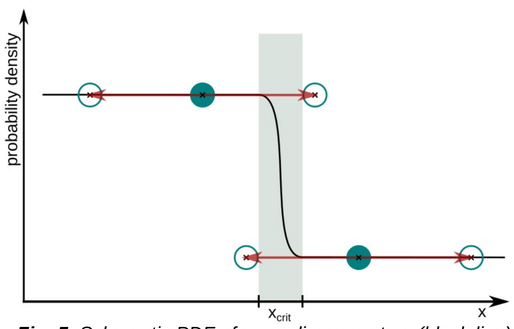

***Fig. 5**: Schematic PDF of a non-linear system (black line) and the effect of symmetric perturbations (red arrows). Reprinted from Pickl et al., 2022.*

(5) Conclusions

- SPPT systematically increases the frequency of rapidly ascending air streams / WCBs without changing their characteristics
- Acceleration of vertical motions
- Process-oriented perspective on how stochastic perturbations affect the model climate

(6) Outlook

- Do other model uncertainty schemes (e.g. SPP, STOCHDP) result in similar effects?
- Can changes to the large-scale circulation (Rossby wave amplitude, blocking) through SPPT be attributed to the modified distribution of vertical velocities?

References

Sprenger and Wernli, 2015: The LAGRANTO Lagrangian analysis tool - Version 2.0. *Geosci. Mod. Dev.* *DOI: 10.5194/gmd-8-2569-2015*

***Leutbecher et al., 2017**: Stochastic representations of model uncertainties at ECMWF: state of the art and future vision. Q. J. R. Meteorol. Soc. DOI: 10.1002/qj.3094*

***Pickl et al., 2022**: The effect of stochastically perturbed parametrisation tendencies (SPPT) on rapdily ascending air streams. Q. J. R. Meteorol. Soc.. DOI: 10.1002/qj.4257*

Acknowledgments

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