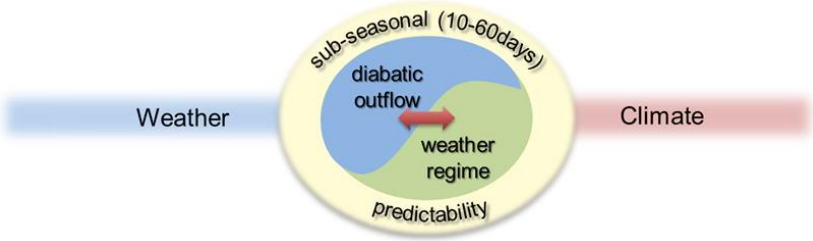
Karlsruhe Institute of Technology

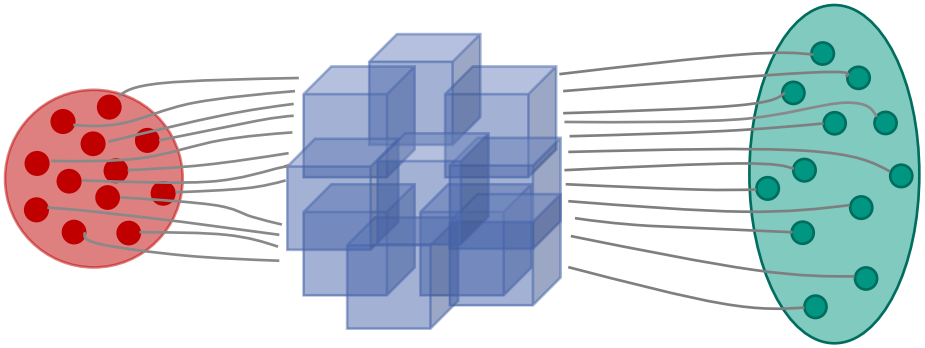


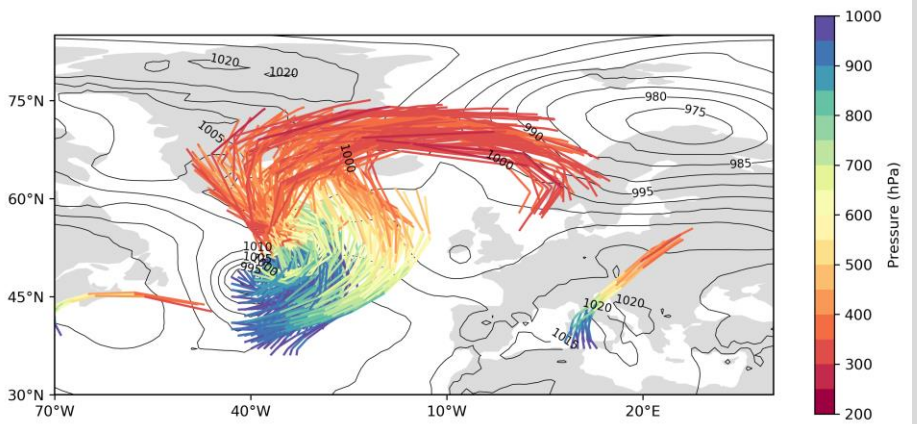
HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

A process-oriented perspective on stochastic physics, with a focus on the effect of SPPT on warm conveyor belts in the IFS

Moritz Pickl, Christian M. Grams, Simon Lang and Martin Leutbecher (ECMWF)

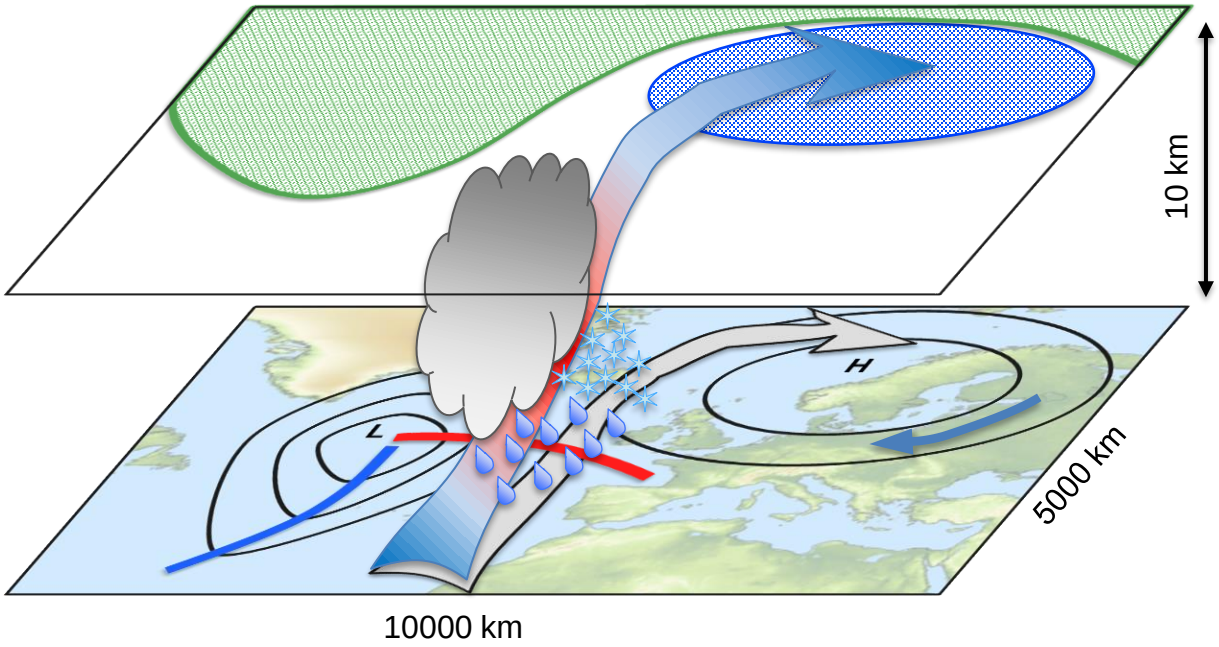
Institute of Meteorology and Climate Research, Department Troposphere Research





Warm Conveyor Belts (WCBs)

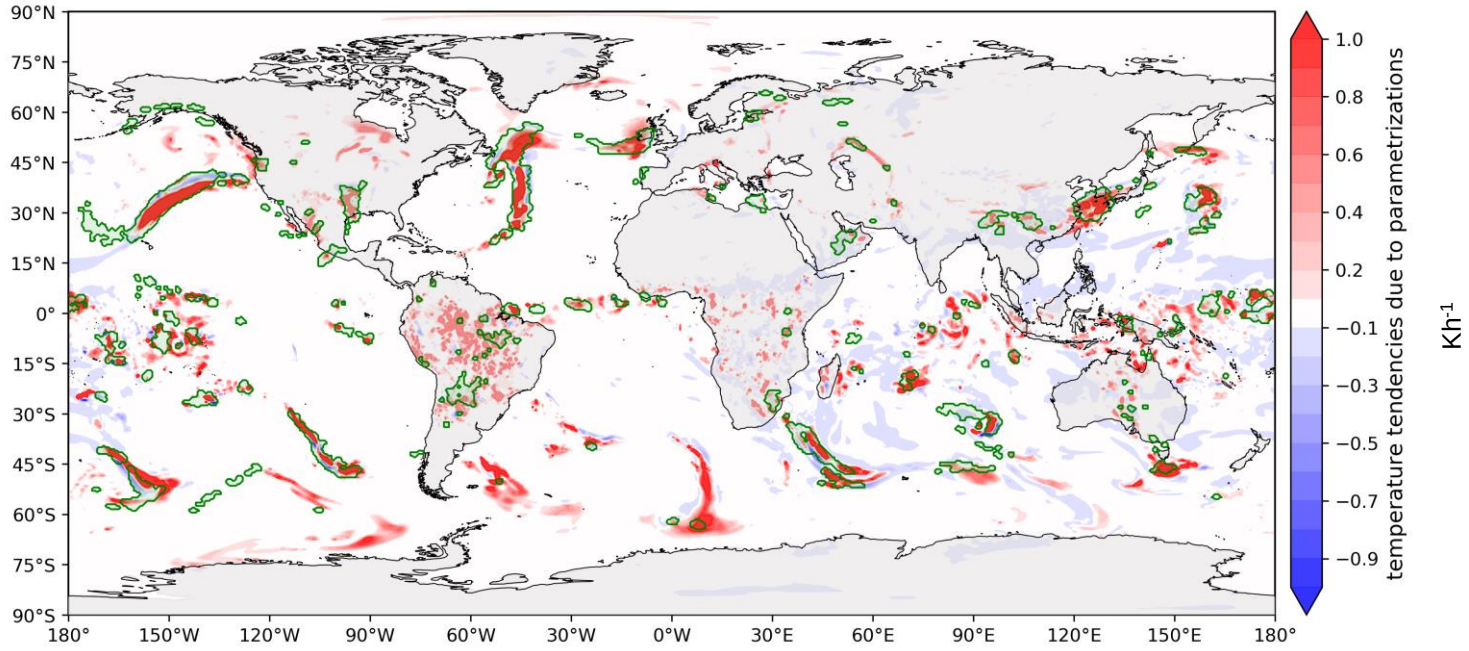
- Strongly ascending air streams in extra-tropical cyclones *(e.g. Carlson, 1980)*
- Ascent mainly driven by cloud-condensational processes *(Wernli and Davies, 1997)*
- Modification of the upper-level waveguide *(e.g. Grams et al., 2011)*



adapted from Quinting and Grams, 2021

Stochastically Perturbed Parametrization Tendencies (SPPT) (Buizza et al., 1999; Leutbecher and Palmer, 2008)

- Accounts for uncertainties in physics parametrizations
- Net physics tendencies are multiplied with a 2D random field
  - Amplitude of perturbation scales with the magnitude of the net tendencies
  - Symmetric zero-mean perturbations



Averaged over model levels 105-96

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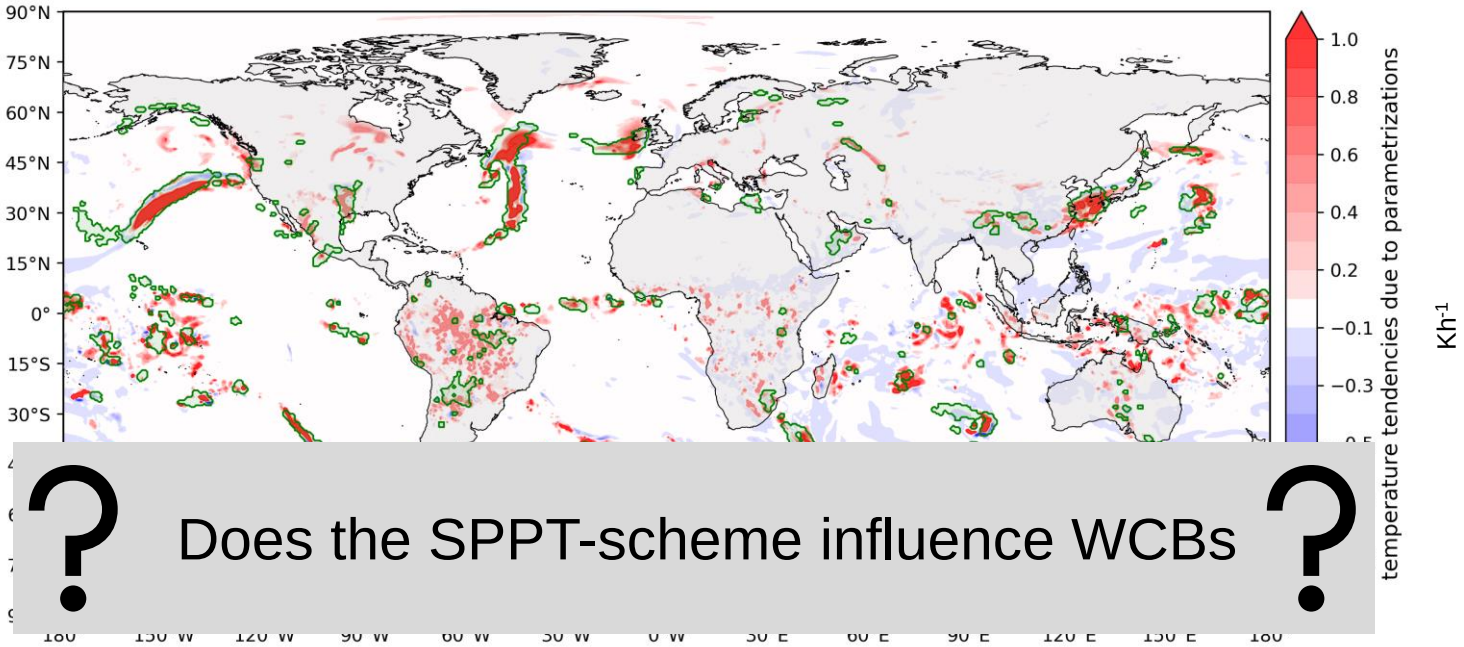
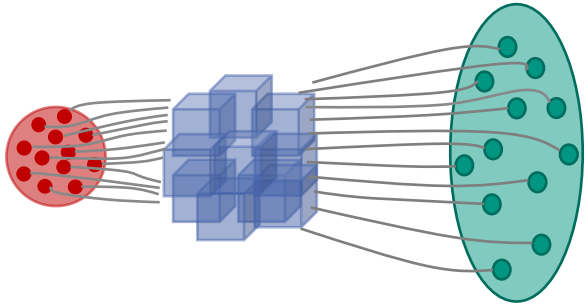


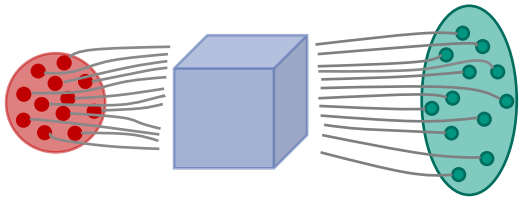
Averaged over model levels 105-96

Experimental Setup

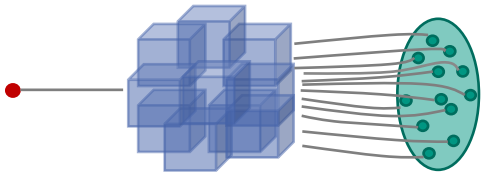
Model	ECMWF IFS CY46R1
Resolution	TCo399 (~ 36km) with 91 levels
Ensemble size	20 perturbed + 1 unperturbed control member
Simulated period	Aug. 15th - Oct. 15th 2016 ; restarted every other day (32 forecasts)
Lead time	288h (12 days)



CTRL



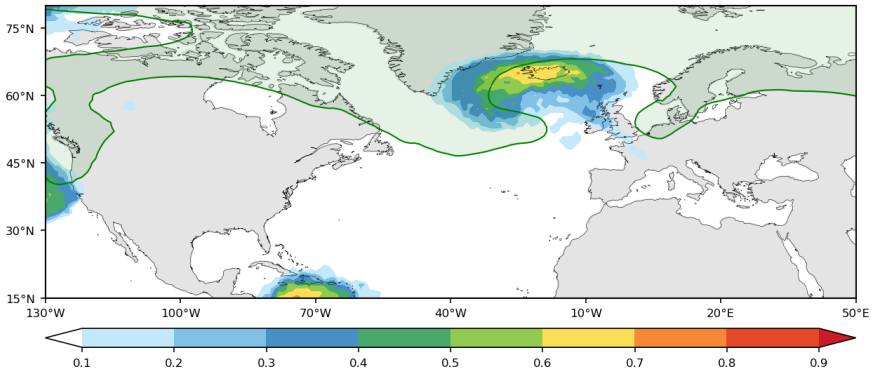
no-SPPT



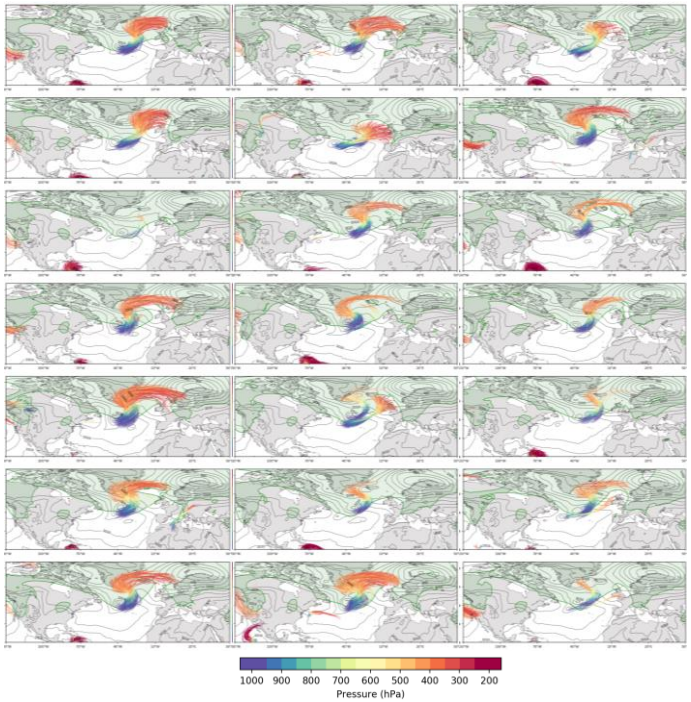
no-INI

Detection of WCBs / rapidly ascending air streams

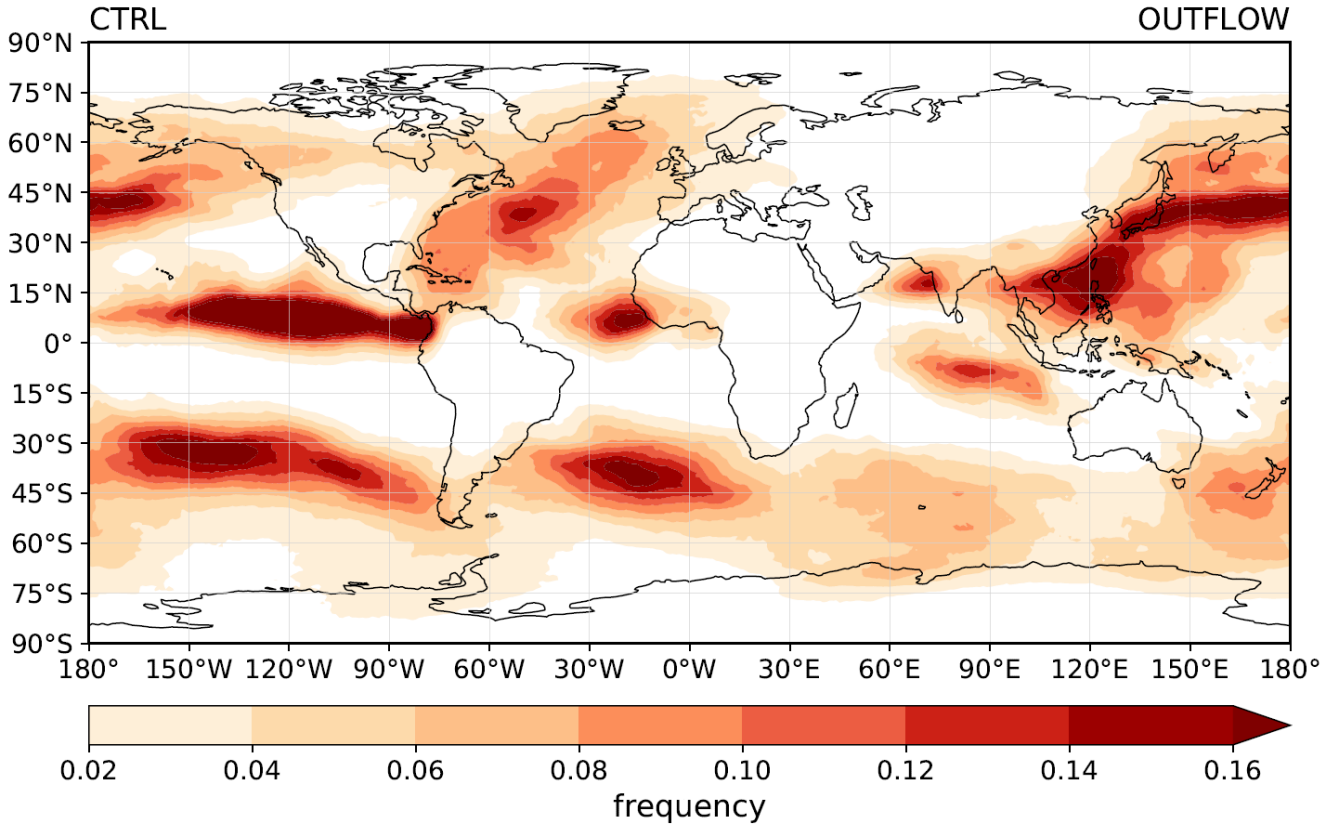
- Lagranto - **Lag**rangian **An**alysis **To**ol *(Wernli and Davies, 1997; Sprenger and Wernli, 2015)*
  - 48h-forward trajectories
  - Starting between 1000 and 750 hPa on global 100km grid
- Selection criterion: ascent of 600 hPa in 48h *(Madonna et al., 2014)*
- Detection in all ensemble members
  (~ 50M WCB-trajectories per experiment)
- Efficient “online“ implementation



WCB outflow probability

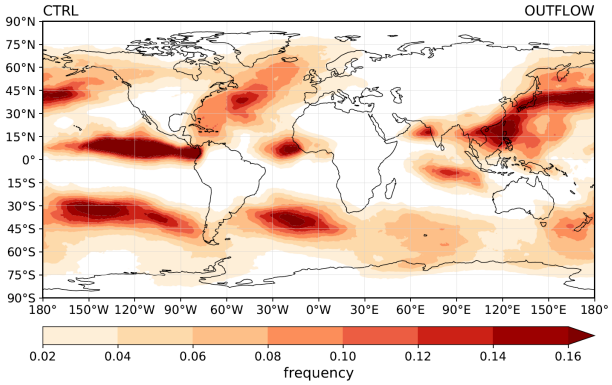


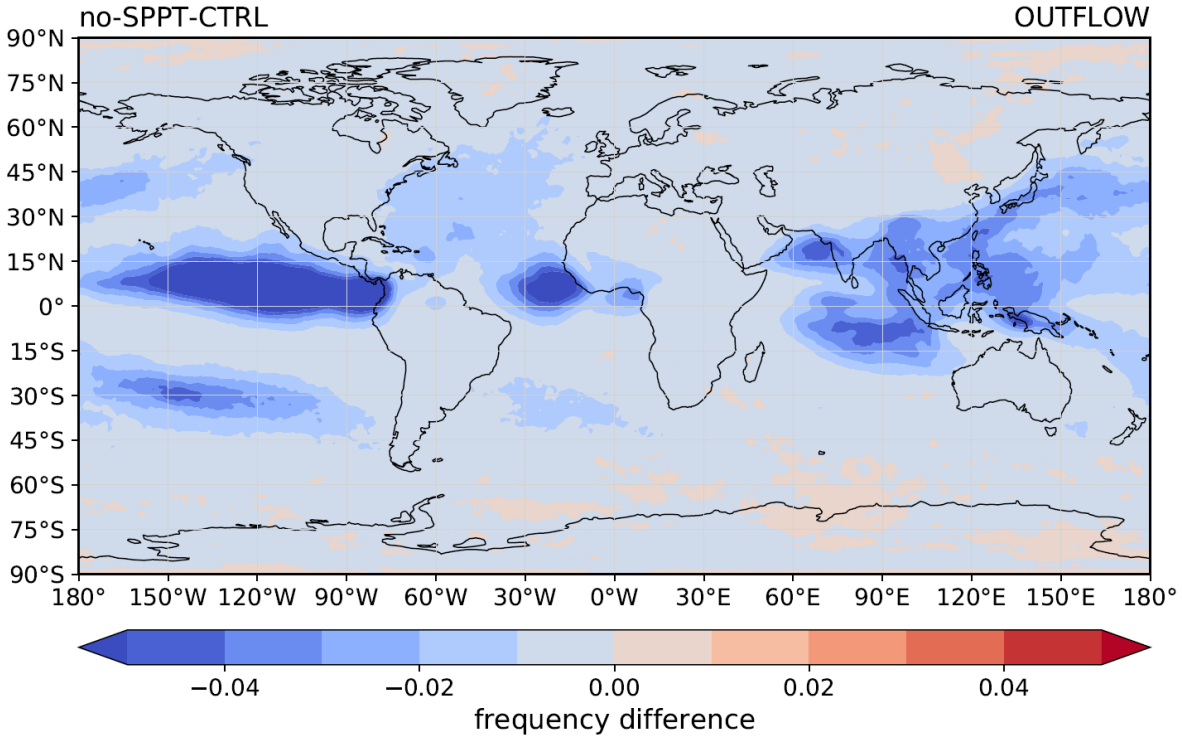
Results – frequencies



Computed over all forecasts, lead times and members

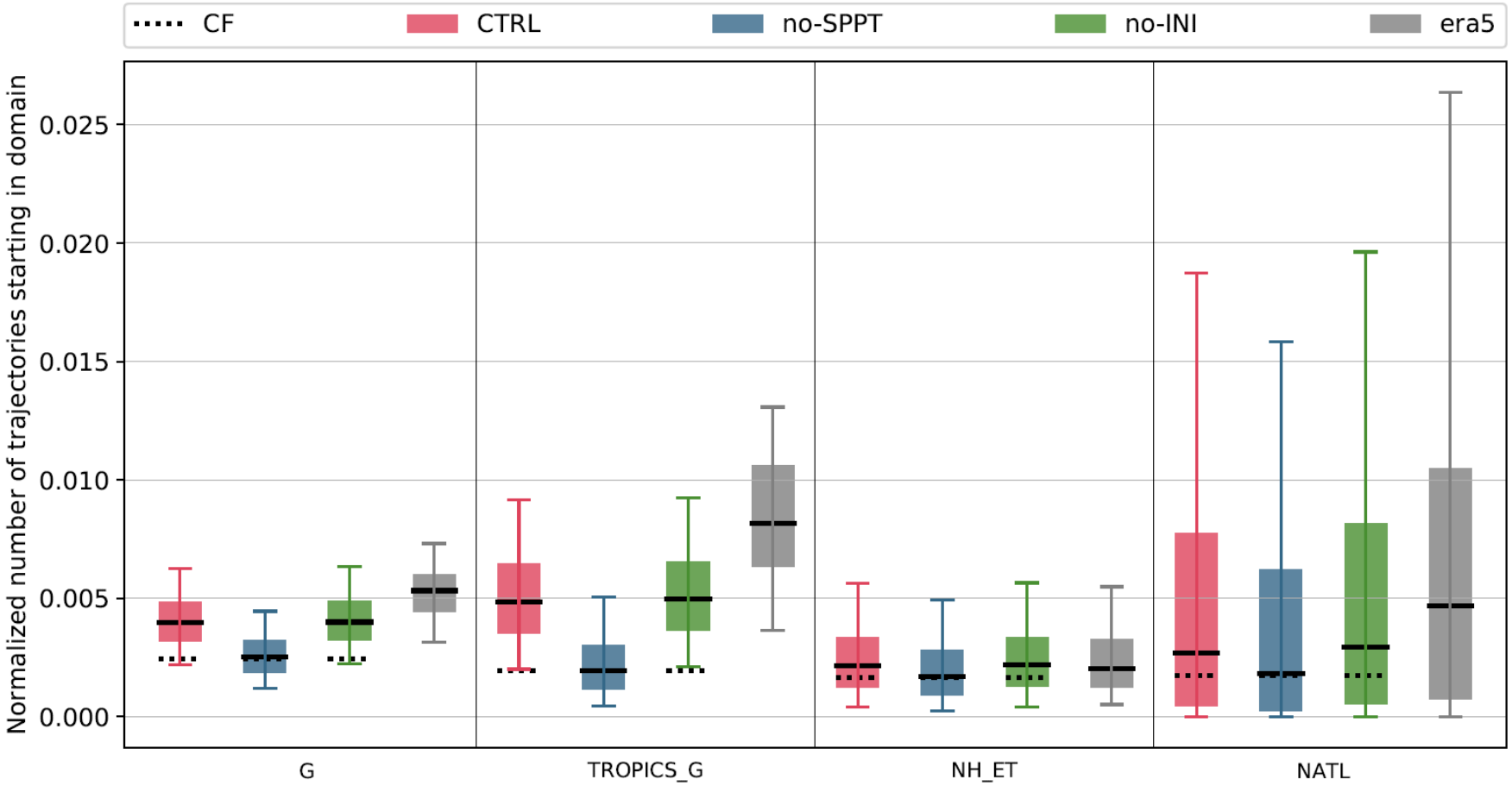
Results – frequencies



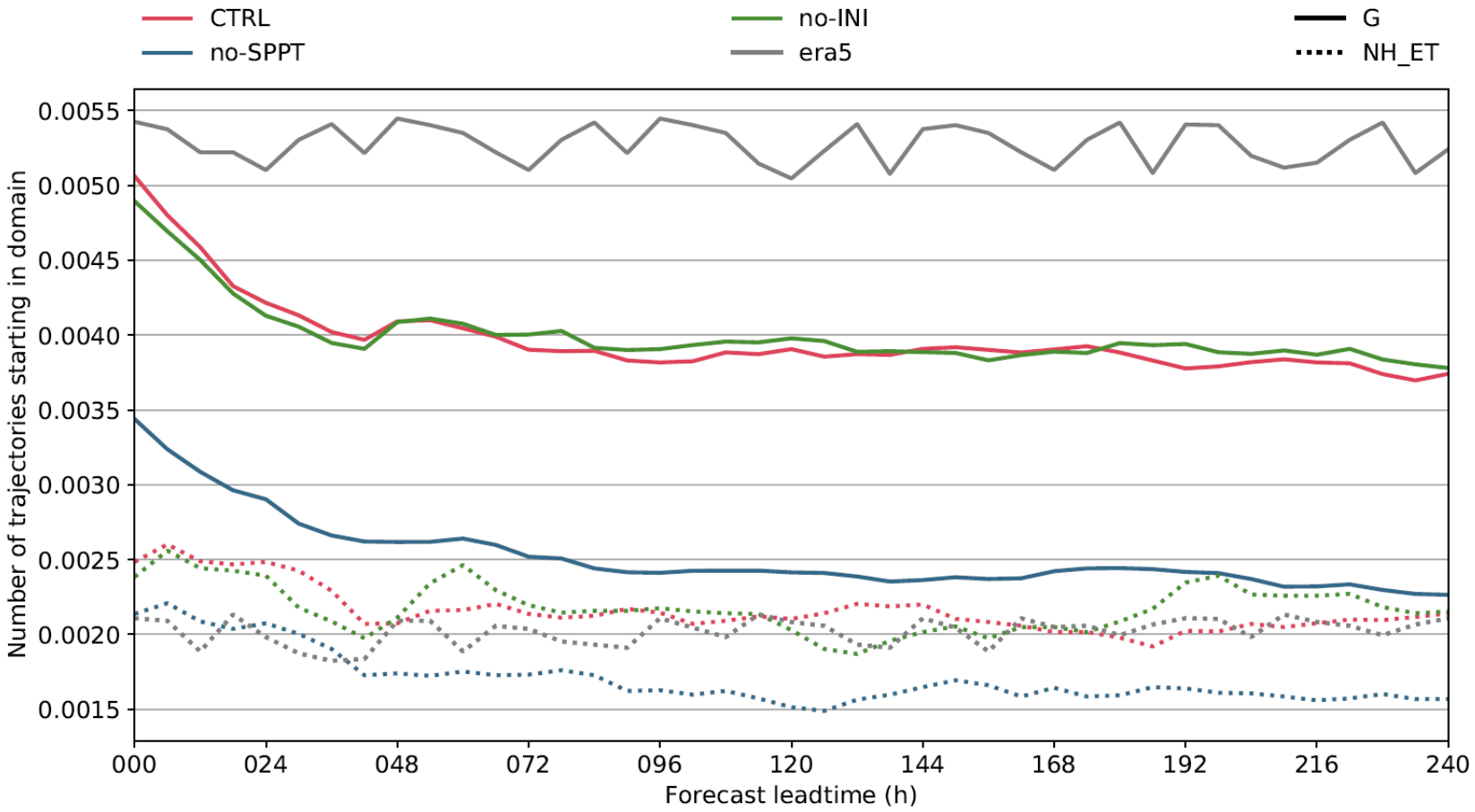


Computed over all forecasts, lead times and members

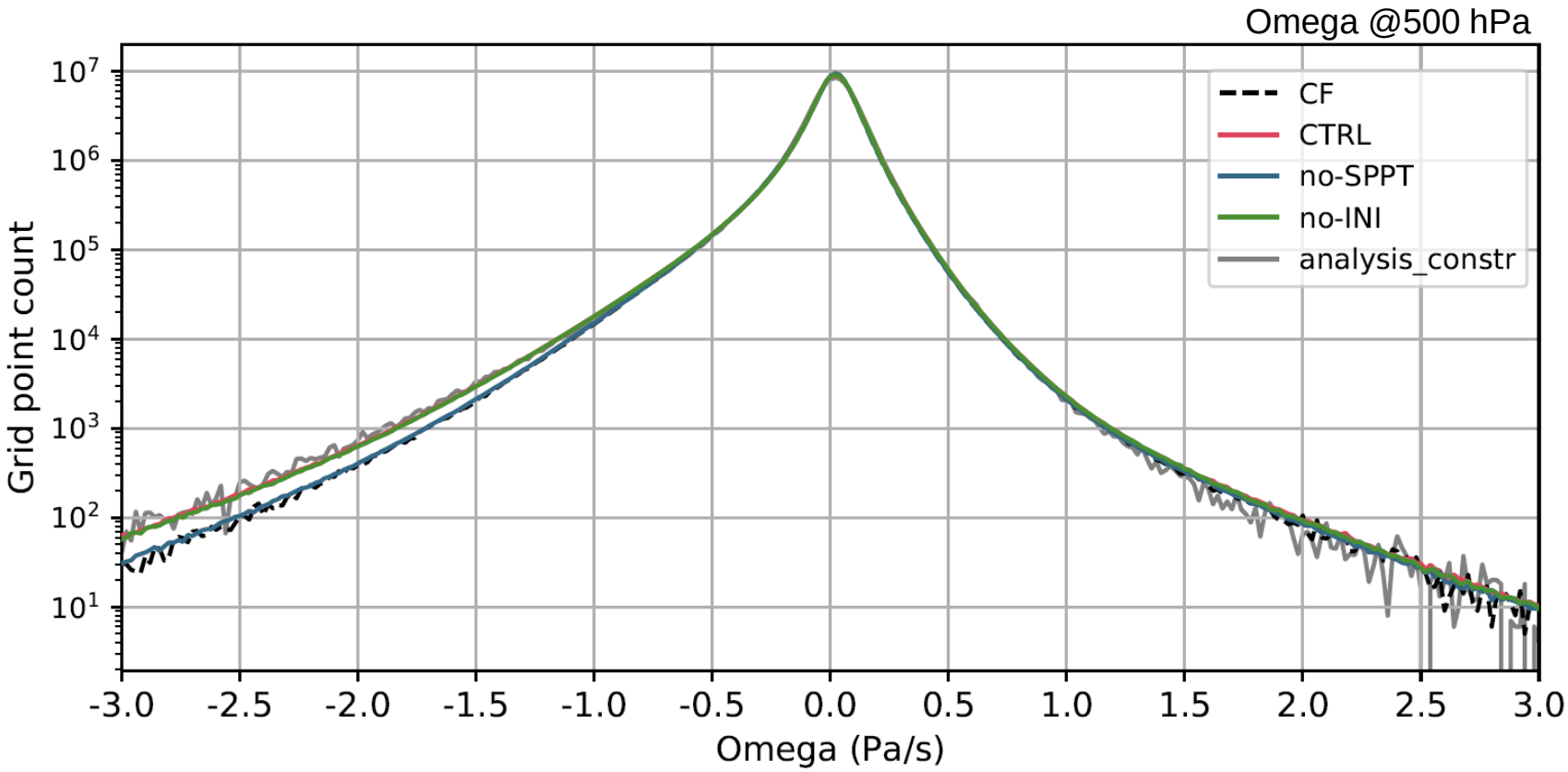
Results – trajectory counts



Results – trajectory counts with leadtime



Results – distribution of vertical velocities



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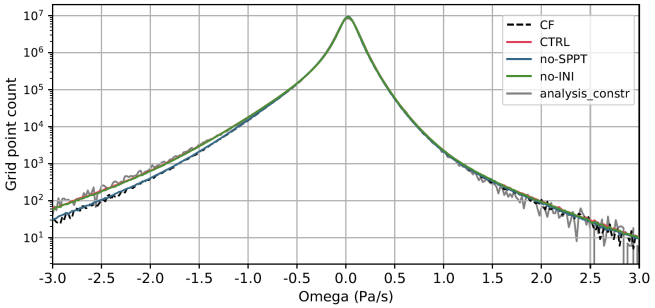
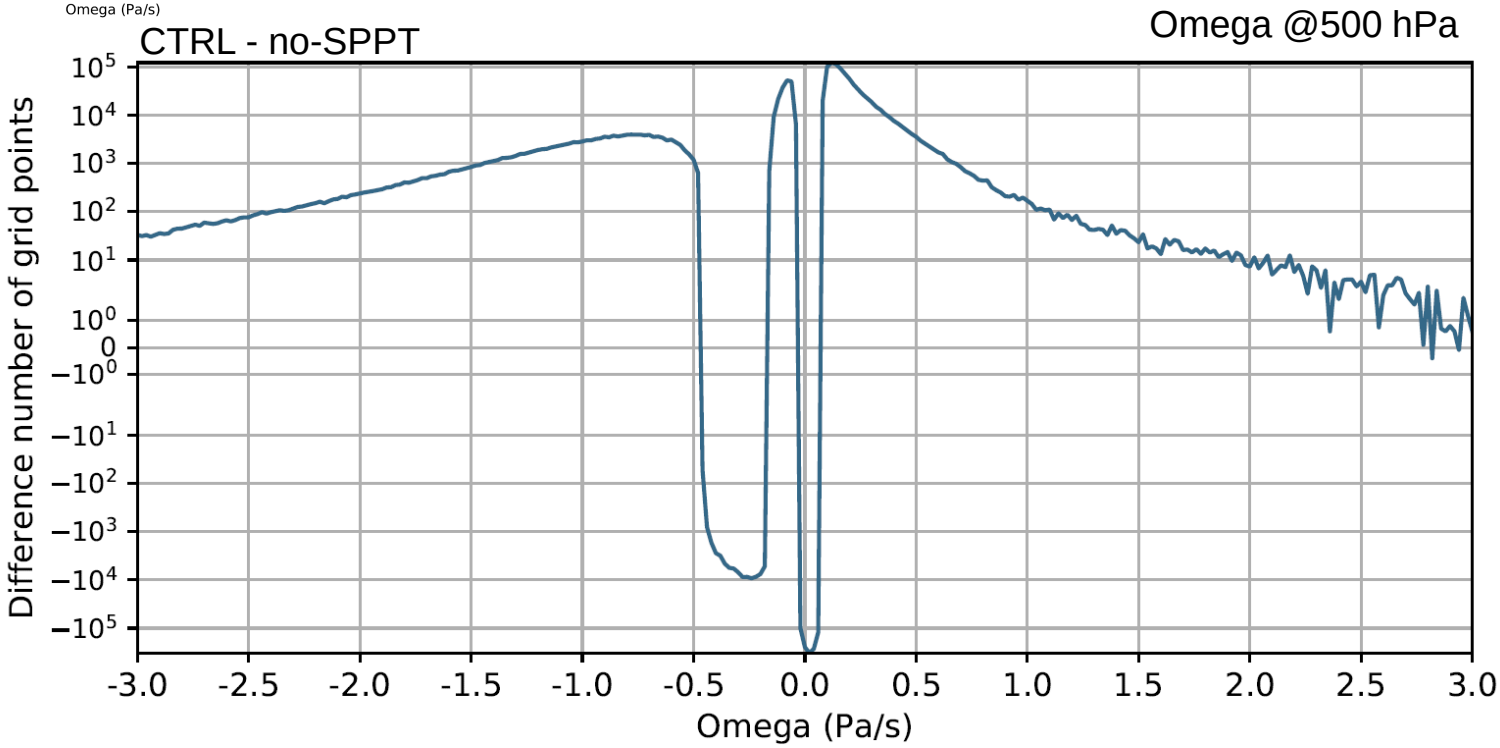
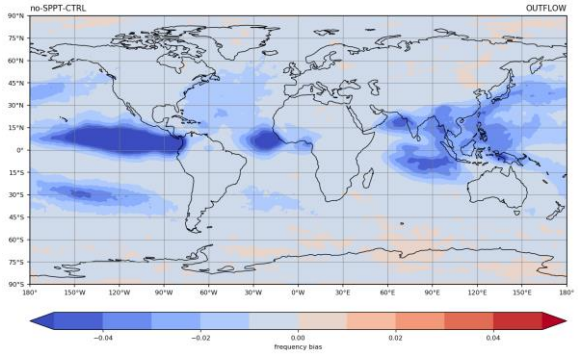


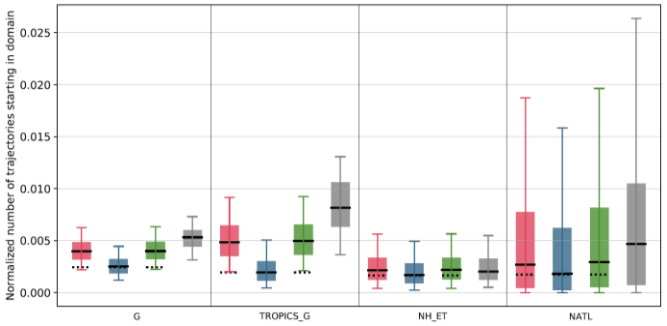


Conclusions

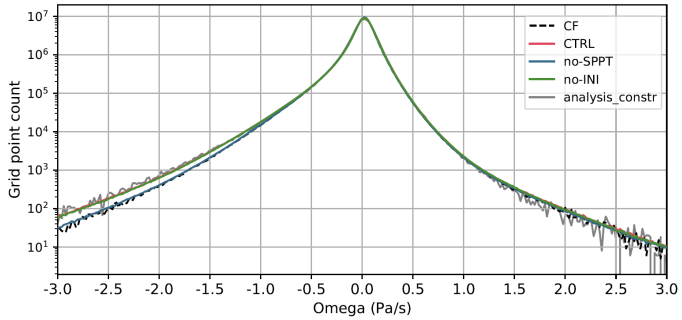
- SPPT systematically increases the frequency of rapidly ascending air streams



- SPPT makes the WCB frequencies in perturbed forecasts more consistent with analyses



- Effects also visible in global omega distribution

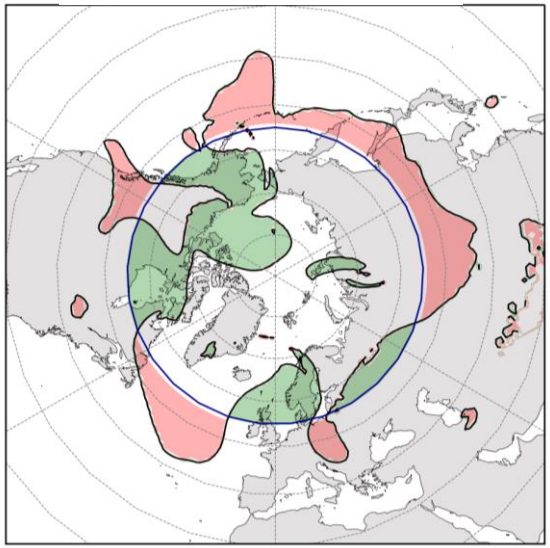


Outlook

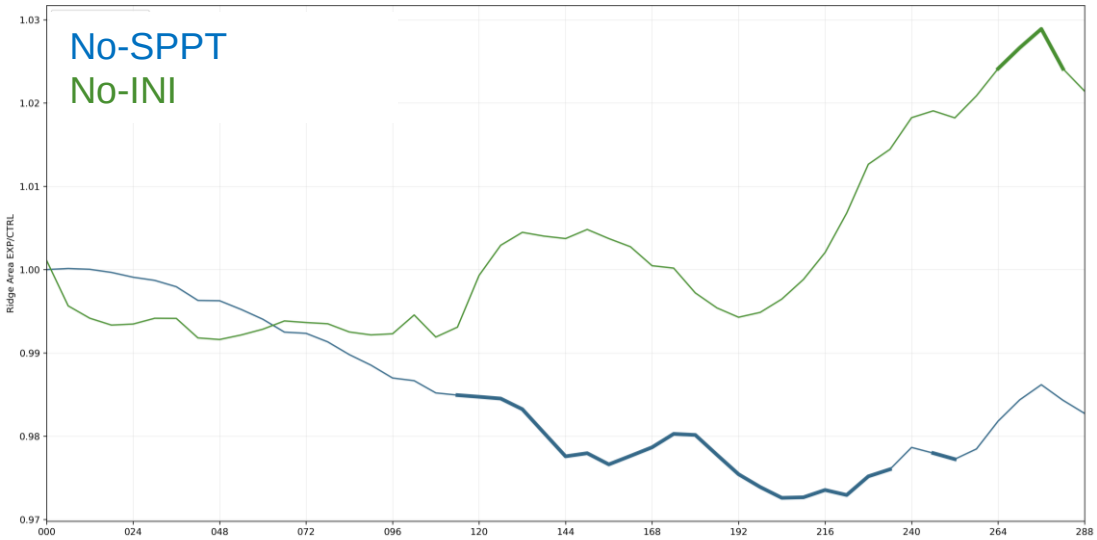
- Sensitivities in other model uncertainty schemes: **S**tochastically **p**erturbed **p**arameters (SPP) *(Ollinaho et al., 2017; Lang et al., 2021)*

- Does the observed effect have an impact on the representation of the large-scale circulation?

Ridge detection algorithm



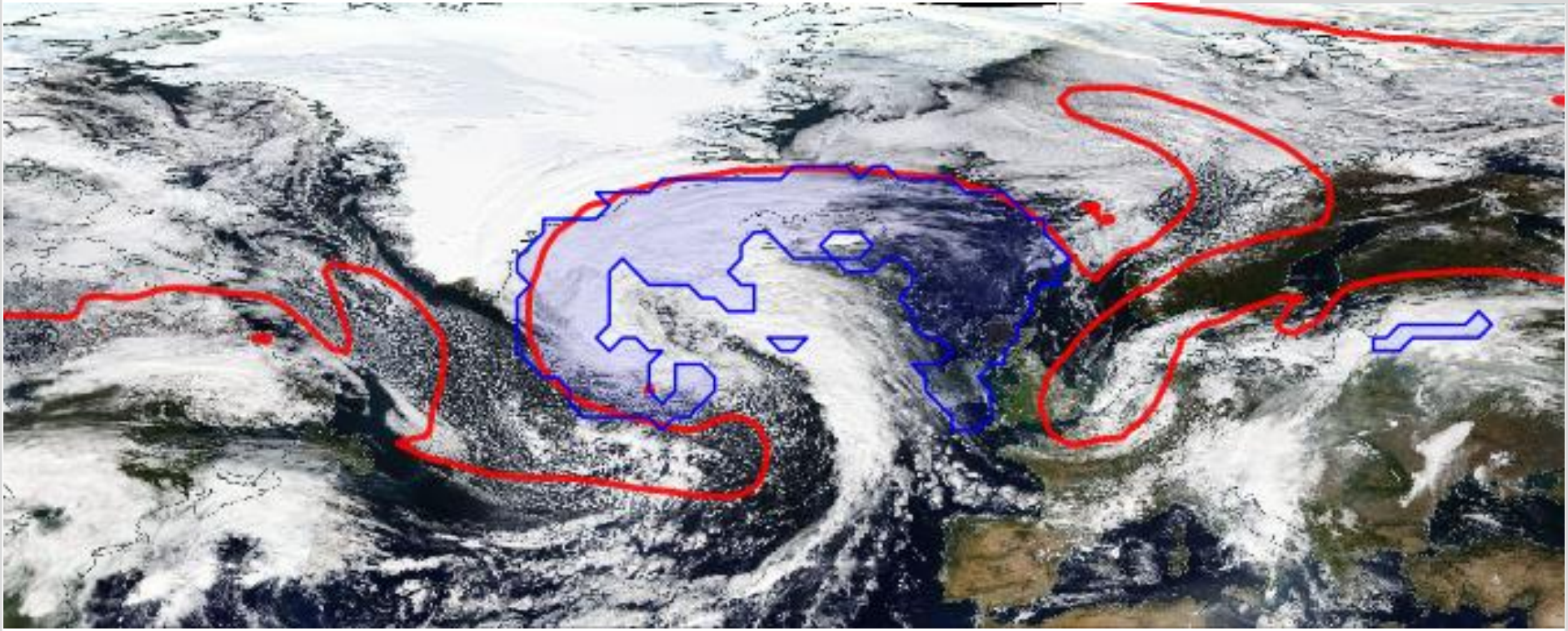
Ridge area relative to **CTRL**



Forecast lead time

Thank you for your attention!

October 2nd, 2016



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https://worldview.earthdata.nasa.gov/