Response of physical processes in atmospheric blocking to climate change

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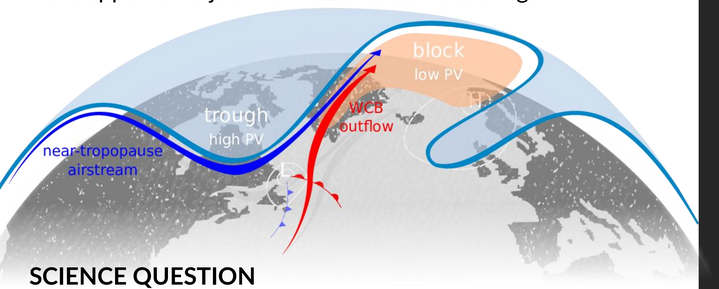
BACKGROUND

Recent research* has indicated that **dry** and **moist** processes are **equally important** for the formation and maintenance of atmospheric blocking.

Air masses with anomalously low potential vorticity (PV) are transported into the upper-level block either
- in ascending **Warm conveyor belt (WCB)** airstreams with strong latent heat release
- or quasi-adiabatically in **near-tropopause airstreams** along the upper-level jet with weak radiative cooling.



SCIENCE QUESTION

With respect to climate change, how will the relative roles of physical processes in atmospheric blocking change in a warmer and moister atmosphere?

METHODS

Compare physical processes (changes in pot. temperature θ and PV) along 3-day backward trajectories in 100 years historical (**HIST**; 1991–2000) and future climate (**RCP8.5**; 2091–2100) of the CESM1 Large Ensemble simulations (**CESM-LENS**; 10 members)*. Restarted at ETH with high temporal (6-hourly) and spatial (1° and 30 vertical levels) resolution.

Reference: ERA-Interim (**ERA-I**; 1979–2016) reanalysis*

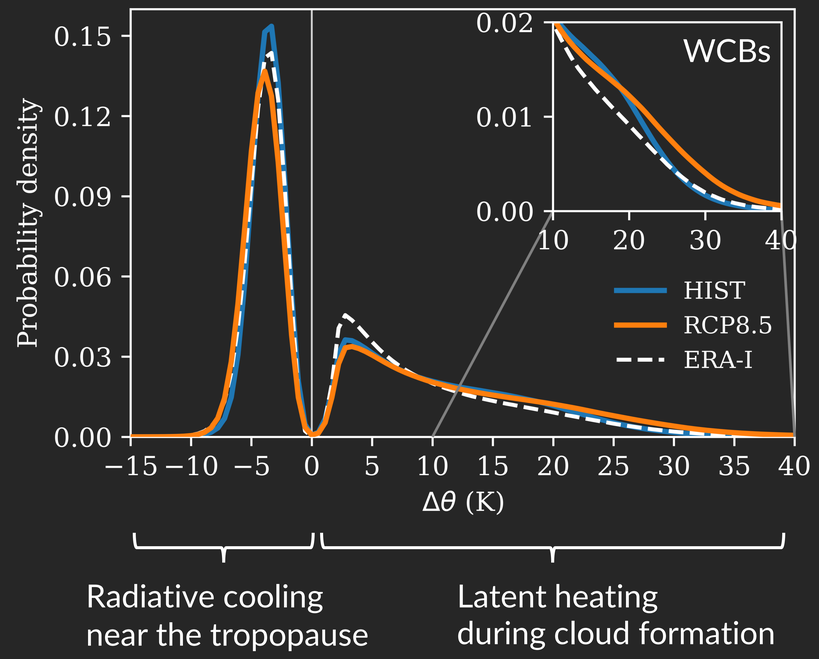
Atmospheric blocking
Persistent and quasi-stationary upper-level negative PV anomaly following the Schwierz Index*

Trajectories
3-day backward trajectories started from the upper-level blocking region using LAGRANTO*

*Reference
Pfahl et al., 2016
Steinfeld and Pfahl, 2019
Steinfeld et al., 2019
Steinfeld et al., 2020
Yamazaki and Itoh, 2013
Kay et al., 2015
Dee et al., 2011
Schwierz et al., 2004
Sprenger and Wernli, 2015

Latent heating in Warm conveyor belts becomes **more important** for atmospheric blocking in a **warmer climate**.

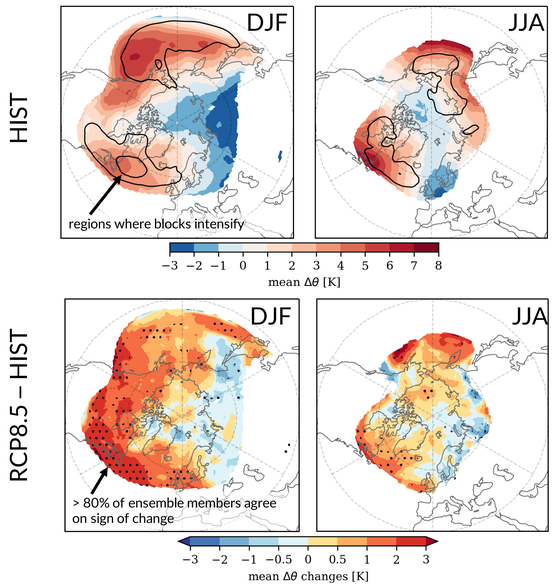
Air masses involved in blocking



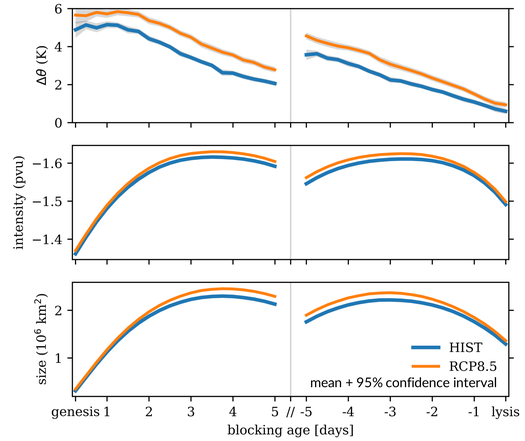
WCBs produce more intense negative PV anomalies in the upper troposphere than near-tropopause airstreams.*

KEY RESULTS

HIST: 5893 blocks and 56.6 million trajectories
RCP8.5: 5507 blocks and 60 million trajectories
ERA-I: 2558 blocks and 18 million trajectories



Different processes (heating vs cooling) dominate in different regions and seasons (strong land-sea contrast). Increase in latent heating is strongest over the storm tracks in RCP8.5.



Heating is most important during onset/intensification phase and increases (+1K) along the entire blocking life cycle in RCP8.5. Blocks become slightly larger (+7%) and more intense (+0.8%).

TAKE-AWAY

- Physical processes along trajectories are represented reasonably well in CESM-LENS compared to ERA-I
- Increased importance of latent heating in RCP8.5 with larger fraction (+50%) of WCBs
- Pronounced regional and seasonal differences in the changes of physical processes
- Blocks become slightly larger and more intense