Karlsruhe Institute of Technology

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HD(CP)² High definition clouds and precipitation for advancing climate prediction

Cloud-Radiative Impact on the Global Warming Responses of the Mid-latitude Storm Tracks and Eddy-driven Jet Streams

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1. Motivation

- Substantial part of uncertainties in climate change response of extratropical circulation are due to cloud-radiative impact
- Previous studies focused on aquaplanet simulations

→ We quantify the cloud-radiative impact for the Northern Hemisphere in a present-day-like model setup

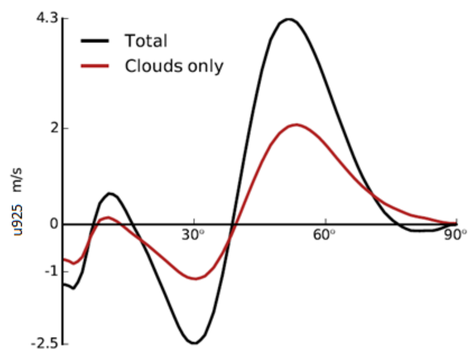


Fig.1: Zonal wind response to global warming in MPI-ESM aquaplanet simulations (adapted from Voigt and Shaw 2015).

2. ICON simulations

- Atmospheric component of ICON-NWP (version 2.1.00)
- R2B04 (~160 km), 47 levels
- Present-day-like setup with prescribed AMIP SSTs
- Two sets of **global warming simulations**
  - Uniform +4K SST increase
  - Patterned SST increase
- 30 years, 1 year spin-up

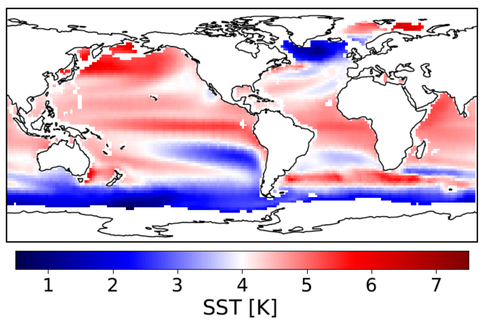
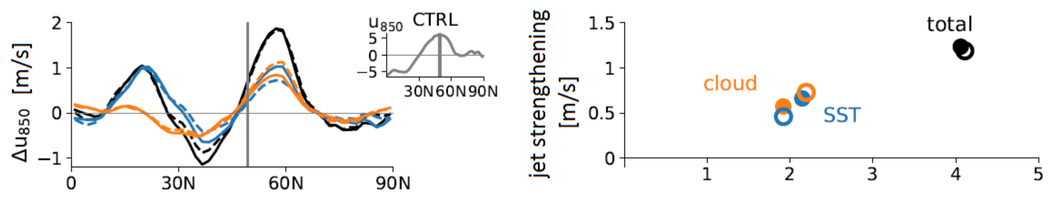


Fig. 2: Patterned SST increase derived from ensemble average of CMIP3 coupled models.

3. Annual-mean ocean basin mean jet stream response

North Atlantic



North Pacific

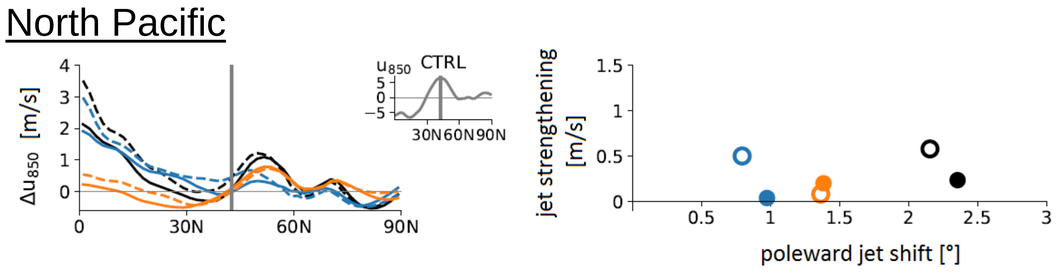


Fig. 3: Ocean basin zonal-mean zonal wind response to uniform (straight line) and patterned (dashed line) SST increase (left). Poleward jet shift versus jet strengthening (right). The **total response** is decomposed into **cloud-radiative impact** and **SST impact**.

Tab. 1: Cloud-radiative impact on jet stream response.

	North Atlantic	North Pacific
Poleward jet shift	Half	Half to two-thirds
Jet strengthening	Half to two-thirds	Dominates (uniform SST) Small (patterned SST)

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4. Annual-mean Northern Hemisphere jet stream and storm track responses

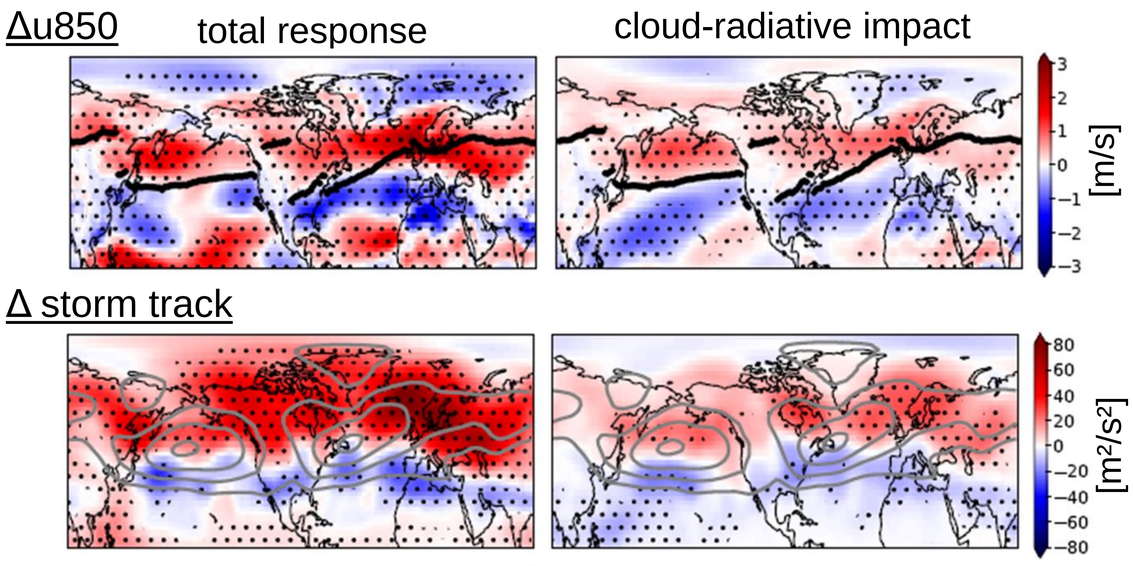

Fig. 4: Zonal wind (top) and storm track (bottom) response to uniform SST increase. Shown are the total response (left) and the cloud-radiative impact (right).

- Poleward storm track and jet stream shift, strengthening over Europe
- Half of response can be attributed to cloud-radiative impact
- Cloud-radiative impact is almost zonally symmetric, consistent with zonal cloud-radiative forcing

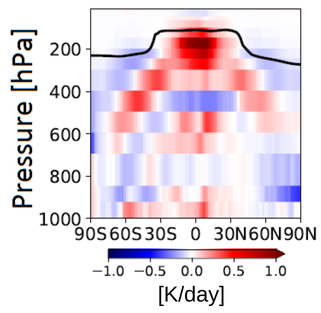

Fig. 5: Zonal-mean cloud-radiative forcing.

5. North Atlantic: seasonal-mean jet stream response

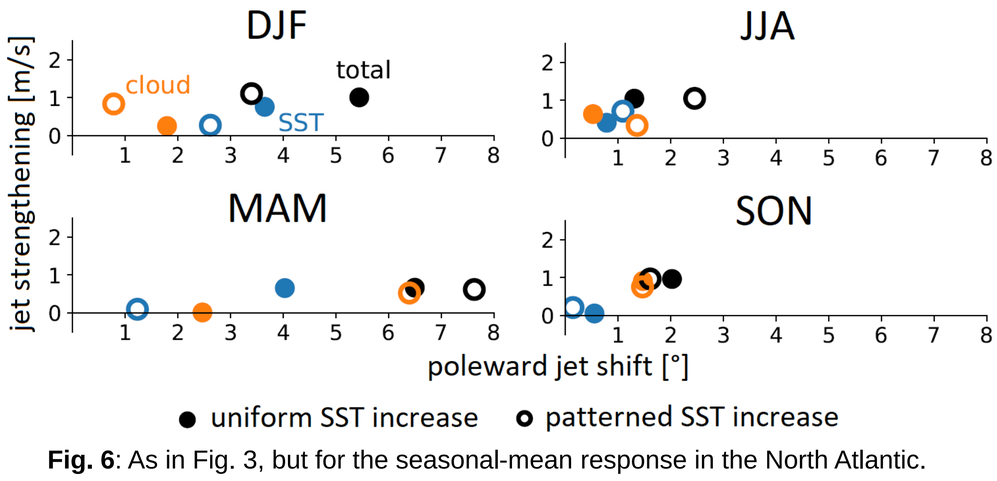

Fig. 6: As in Fig. 3, but for the seasonal-mean response in the North Atlantic.

- Poleward jet shift and jet strenthening in all seasons
- Cloud-radiative impact exhibits small seasonal cycle and is largely independent of SST pattern (except MAM)
- Relative role of cloud-radiative impact depends on season

6. Conclusions

- Clouds have substantial impact on storm track and jet stream responses to global warming
- Cloud-radiative impact
  - is almost zonally symmetric
  - exhibits a small seasonal cycle
  - is mostly independent of the SST pattern
- Similar conclusions can be drawn for the Southern Hemisphere jet stream and storm track (not shown)