

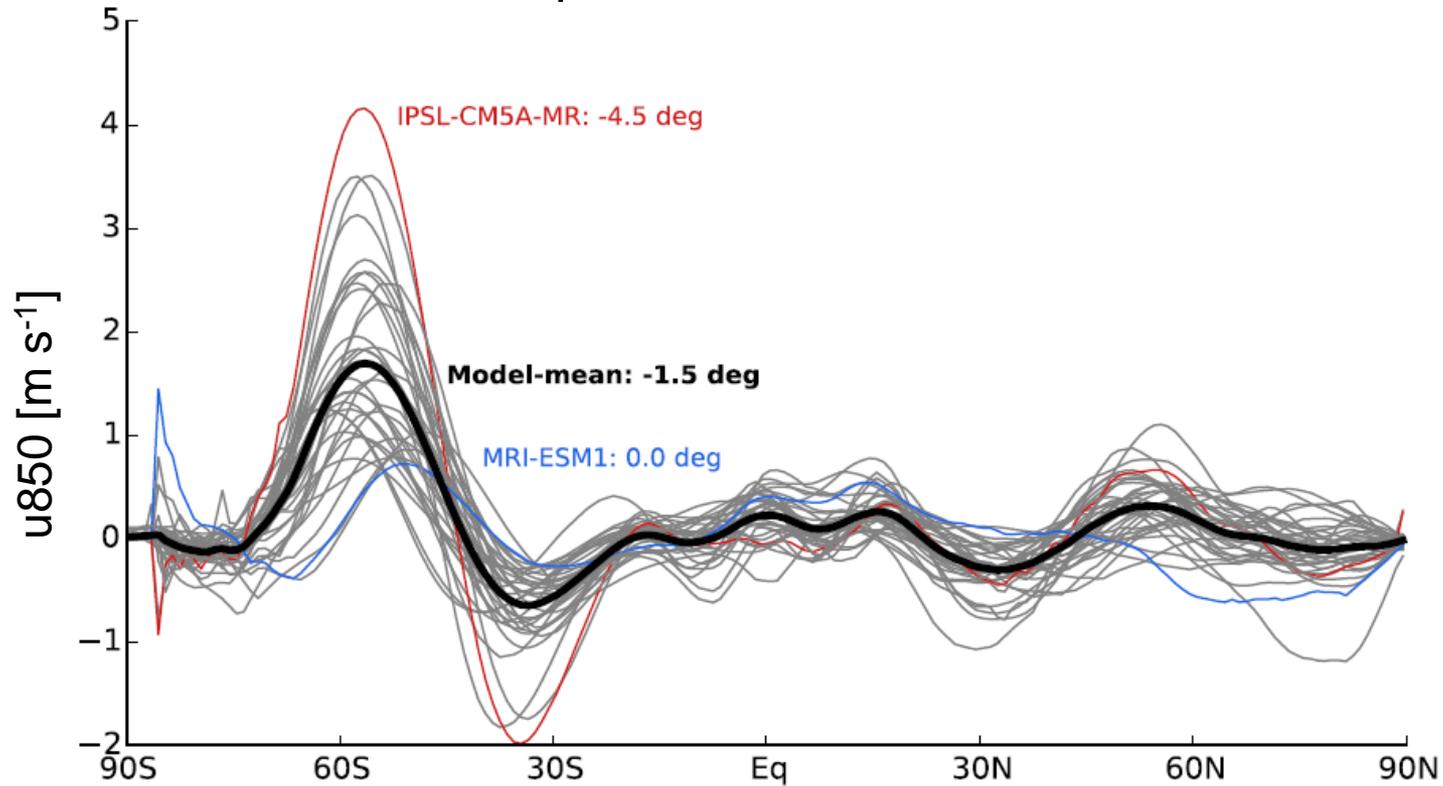
Radiative impact of clouds on the global warming response of the eddy-driven jet streams

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Extratropical circulation response to global warming uncertain

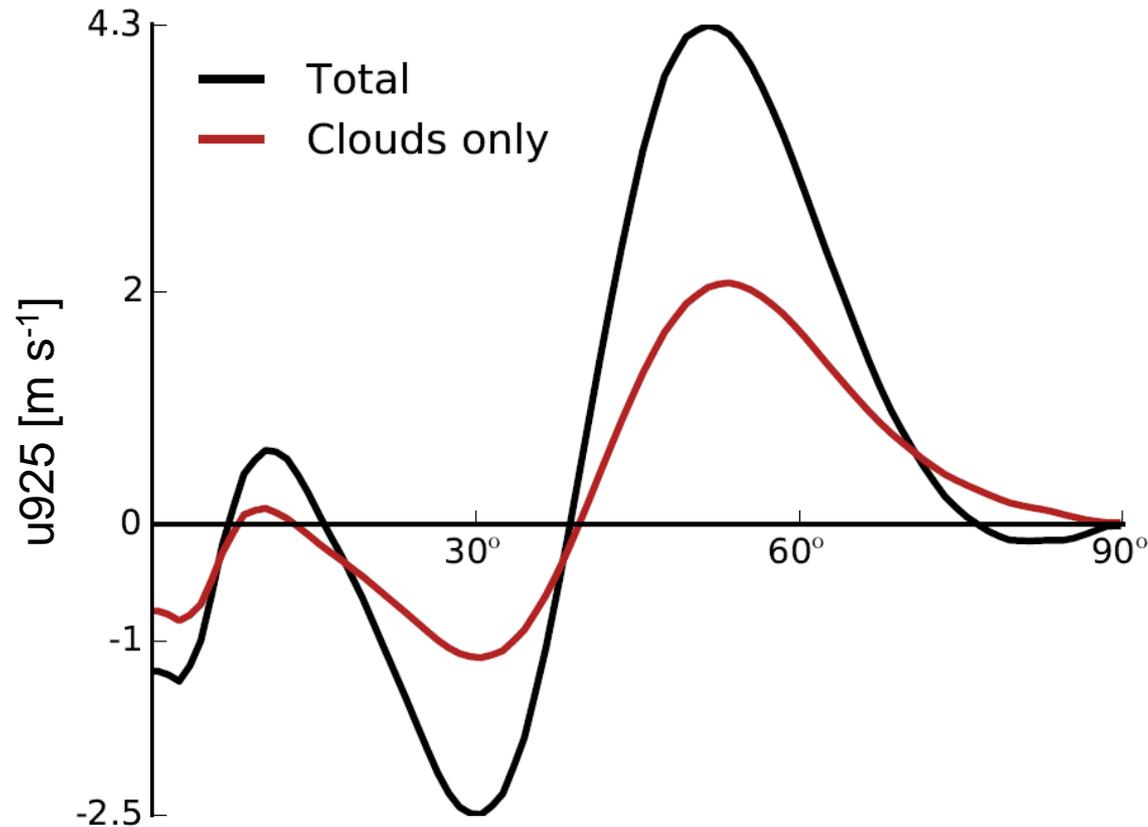
Coupled CMIP5 models



(Voigt and Shaw, 2016)

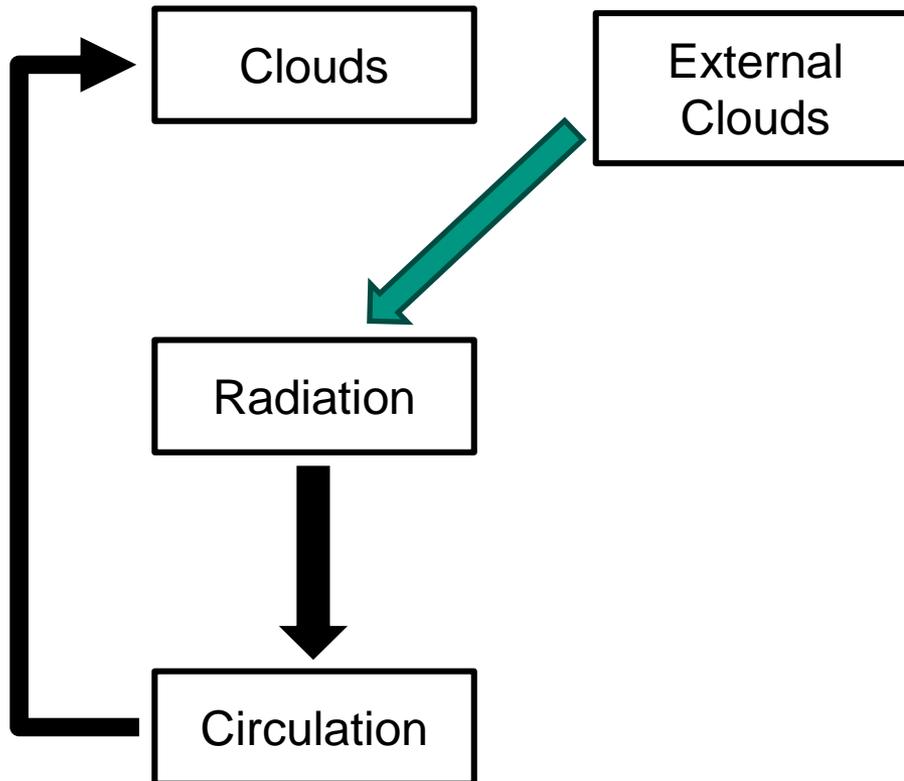
Clouds as a source for model uncertainty?

MPI-ESM aquaplanet simulations



(adapted from Voigt and Shaw, 2015)

Cloud-locking method to quantify cloud impact



Save cloud radiative properties at every radiation timestep (36 min)

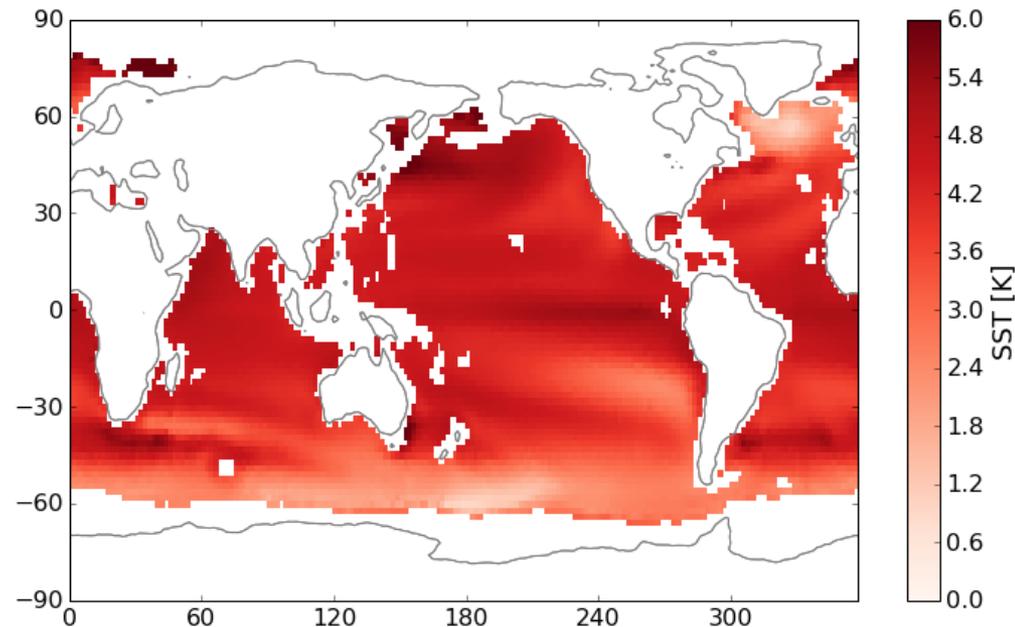
- Cloud water
- Cloud ice
- Cloud fraction

Break cloud-radiation-circulation coupling

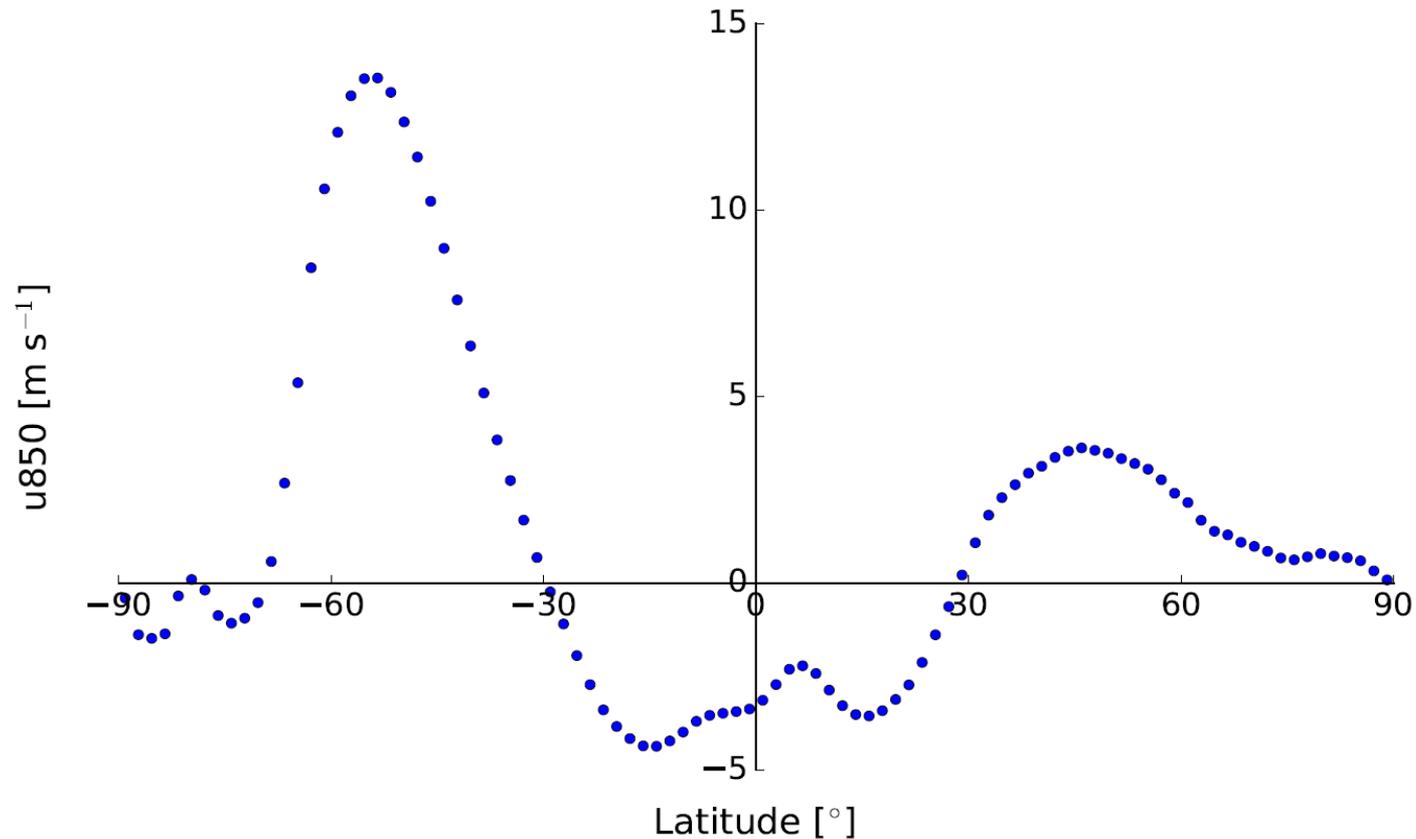
Quantify cloud impact on circulation response

ICON simulations

- ICON-NWP (version 2.1.00)
- R2B04 (~160 km), 47 vertical levels (up to 75 km), 720 s time step
- Present-day-like setup with prescribed SSTs (following Amip Protocol)
- Two sets of **global warming simulations**
 - Uniform SST increase by 4K
 - Patterned SST increase
- Simulate 30 years, 1 year spin-up



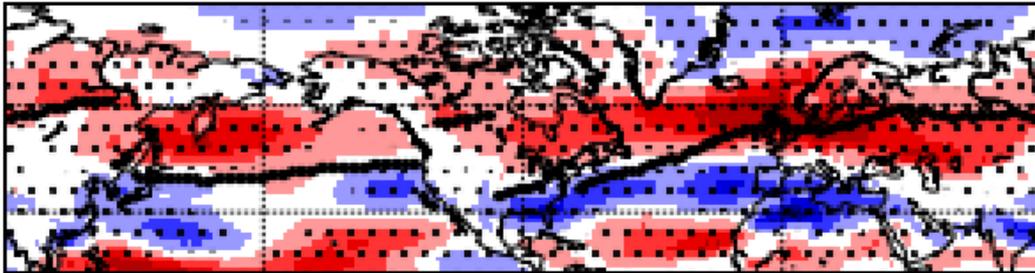
Jet stream metrics: jet latitude and jet strength



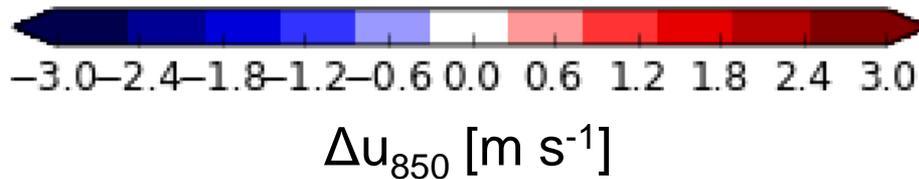
Methodology based on
Barnes and Polvani (2013)

Substantial changes in jet latitude under global warming

total

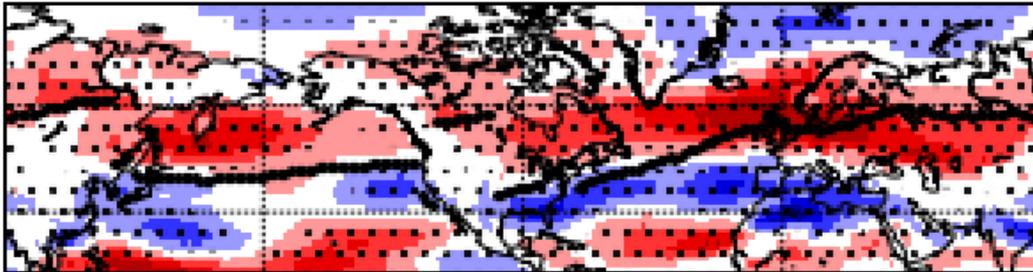


- Total poleward jet shift
- North Pacific: 2.4°
 - North Atlantic: 4°



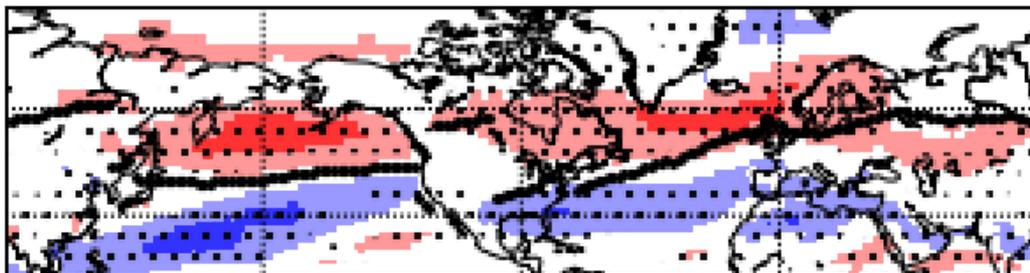
We attribute half of jet shift to clouds

total

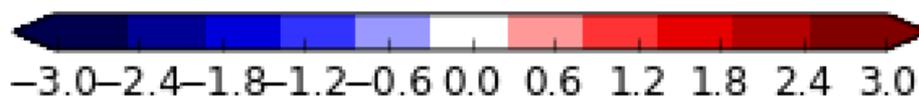


- Total poleward jet shift
- North Pacific: 2.4°
 - North Atlantic: 4°

cloud



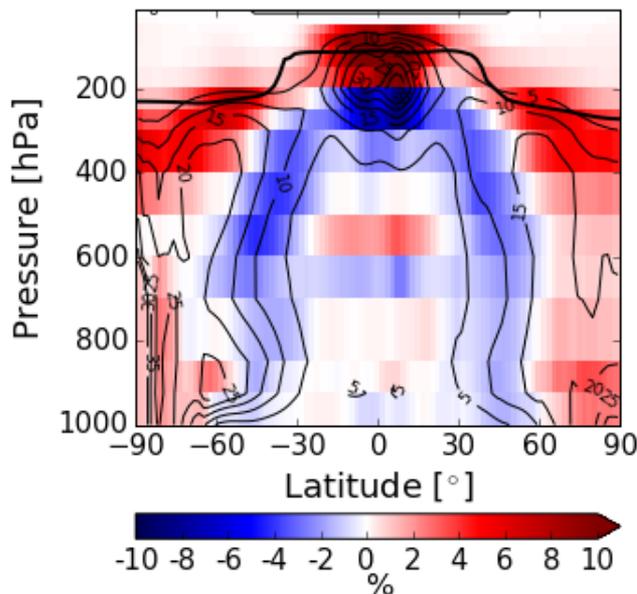
- Cloud-induced jet shift
- North Pacific: 1.4°
 - North Atlantic: 1.9°



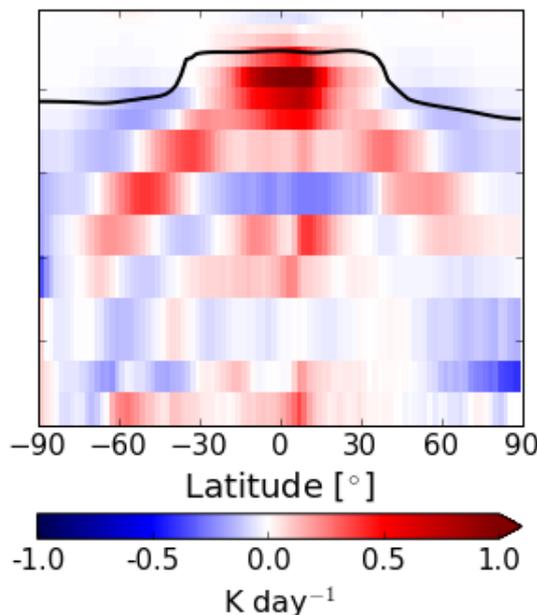
Δu_{850} [m s⁻¹]

Zonally symmetric cloud forcing, consistent with zonal cloud impact on jet

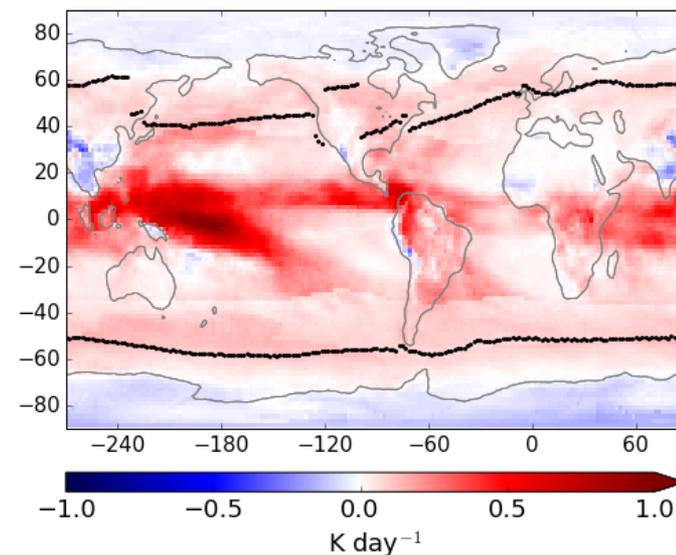
Cloud cover changes



Cloud radiative forcing

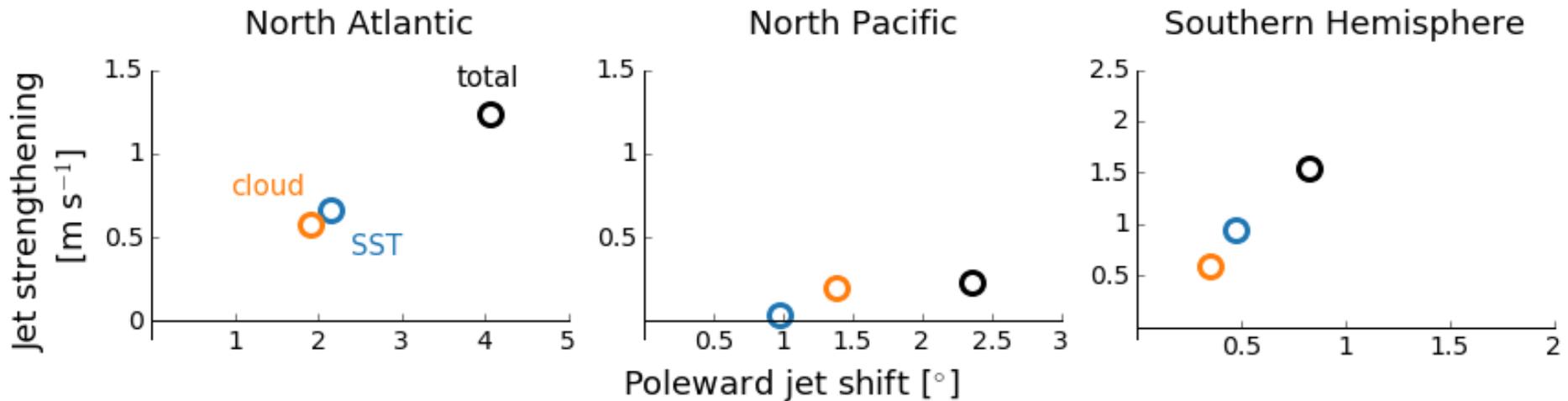


Cloud radiative forcing below tropopause



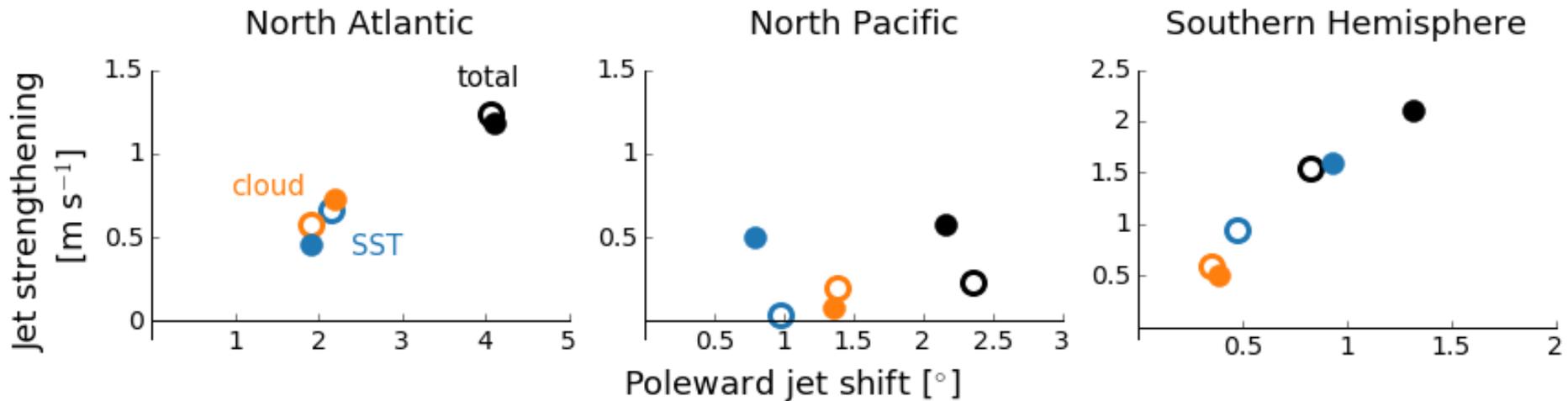
$$\left. \frac{\partial T(\varphi, \vartheta, p)}{\partial t} \right|_{PRP} = R(T_{ctrl}, q_{ctrl}, c_{4K}) - R(T_{ctrl}, q_{ctrl}, c_{ctrl})$$

Half of jet changes in NH attributed to clouds



● uniform SST increase

Cloud impact on jet independent of SST pattern



Conclusions

- Cloud-locking method in ICON-NWP used to quantify cloud-radiative impact on extratropical circulation response to global warming
- Clouds have substantial impact on jet response
- Zonally symmetric cloud impact consistent with zonally symmetric cloud forcing
- Cloud impact on jet response is largely independent of SST pattern