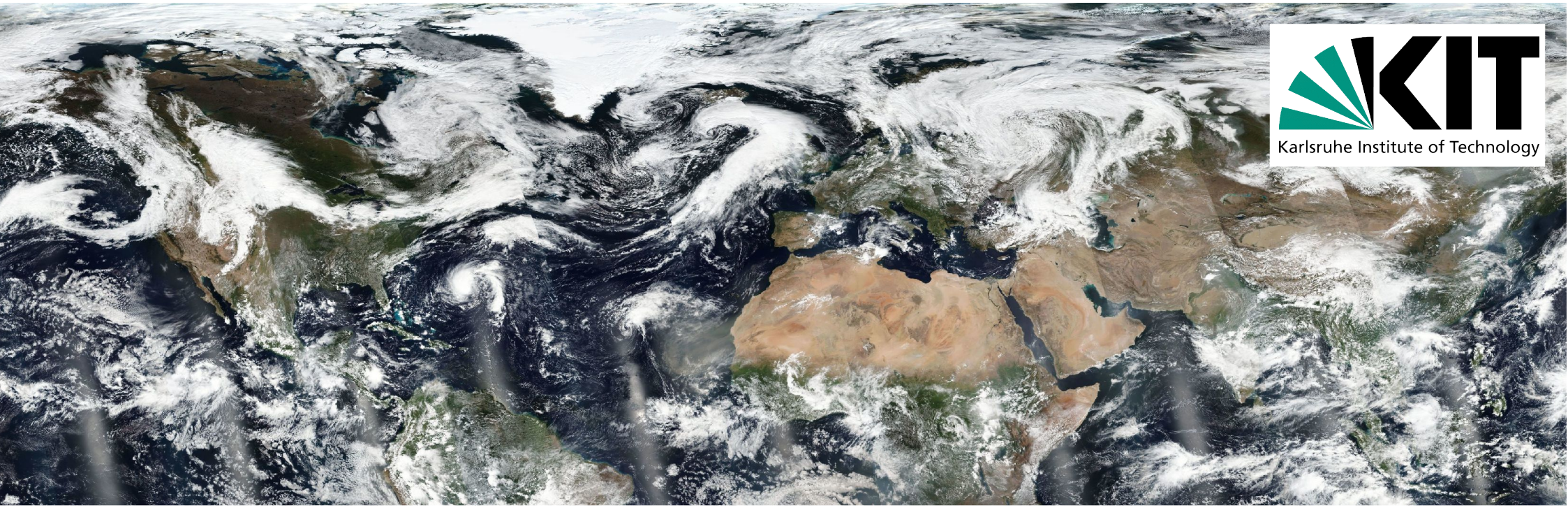


Clouds, radiation, weather and climate

Aiko Voigt

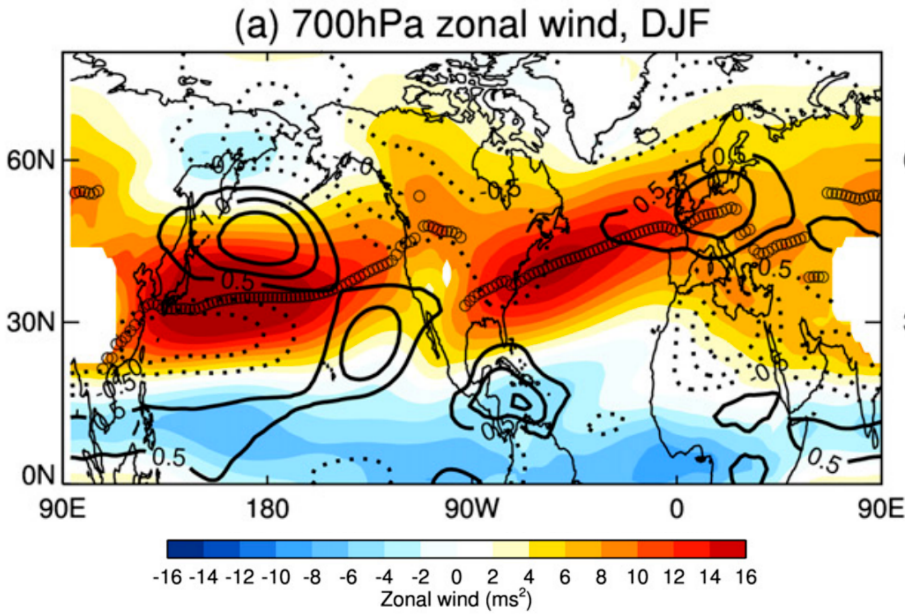
Karlsruhe Institute of Technology; Columbia University, New York

With contributions from Tiffany Shaw, Sophia Schäfer, Nicole Albern and George Papavasileiou

Funded by the German Ministry for Education and Research and FONA: Research for Sustainable Development.

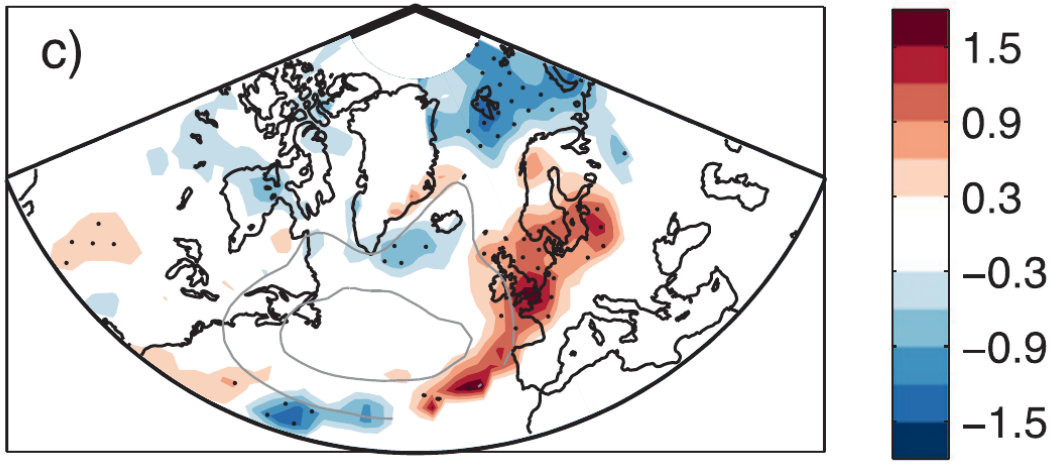
The circulation response to warming shapes regional climate change

Climate change



weather change

wind intensity strong cyclones DJF



Simpson et al., 2014, J. Climate
Zappa et al., 2013, J. Climate

A Grand Challenge

nature geoscience

PERSPECTIVE

PUBLISHED ONLINE: 31 MARCH 2015 | DOI: 10.1038/NGEO2398

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What controls the position, strength and variability of storm tracks?

My take home message

Clouds and their radiative interactions have a fundamental impact on the extratropical circulation and its response to global warming.

The cloud impact involves local as well as remote clouds.

What I will talk about

1. Cloud impact on the present-day circulation

2. Cloud impact on future circulation changes

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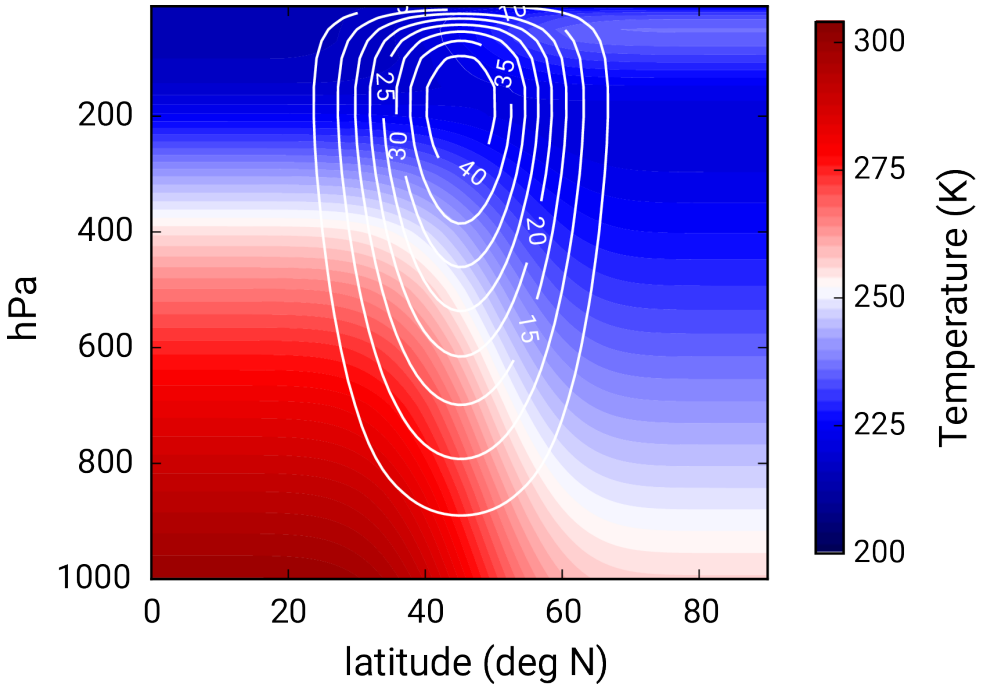
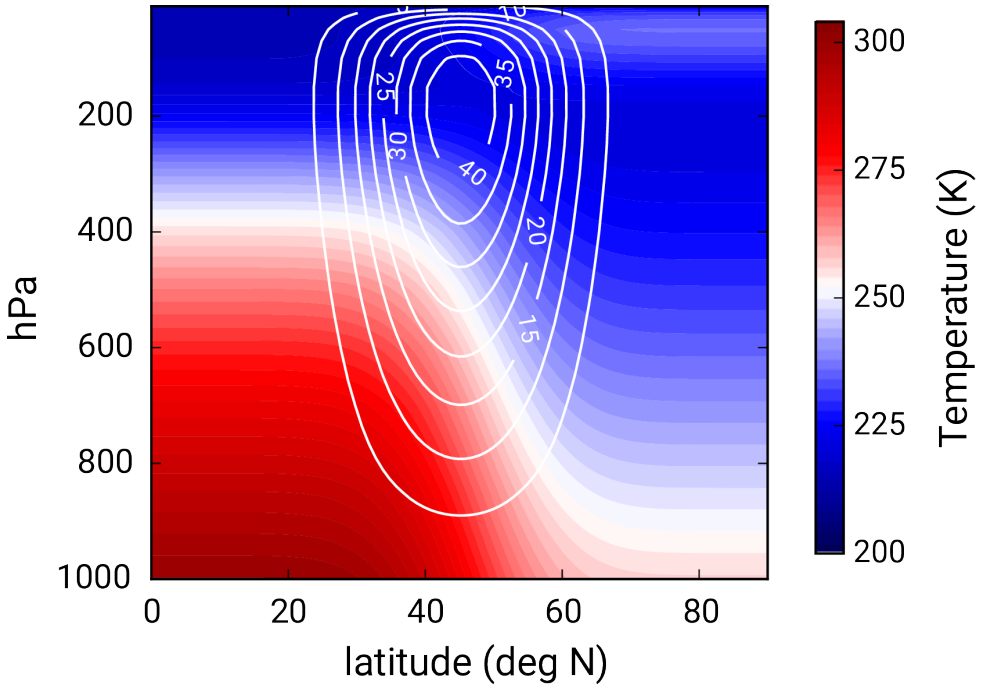
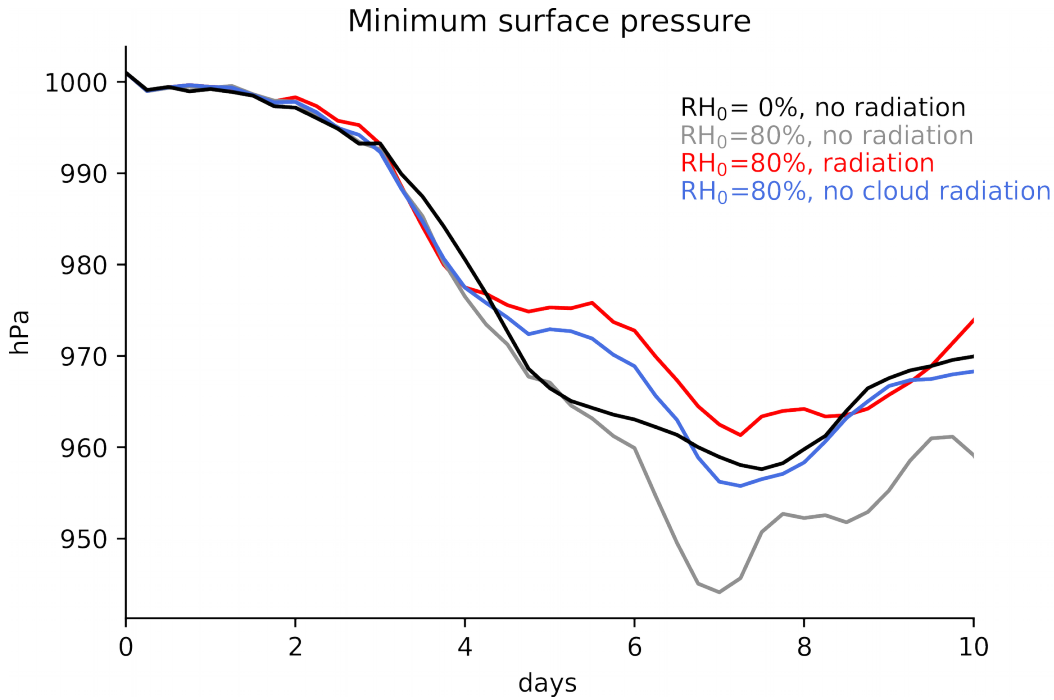
Baroclinic life cycles



Schäfer and Voigt, GRL, 2018

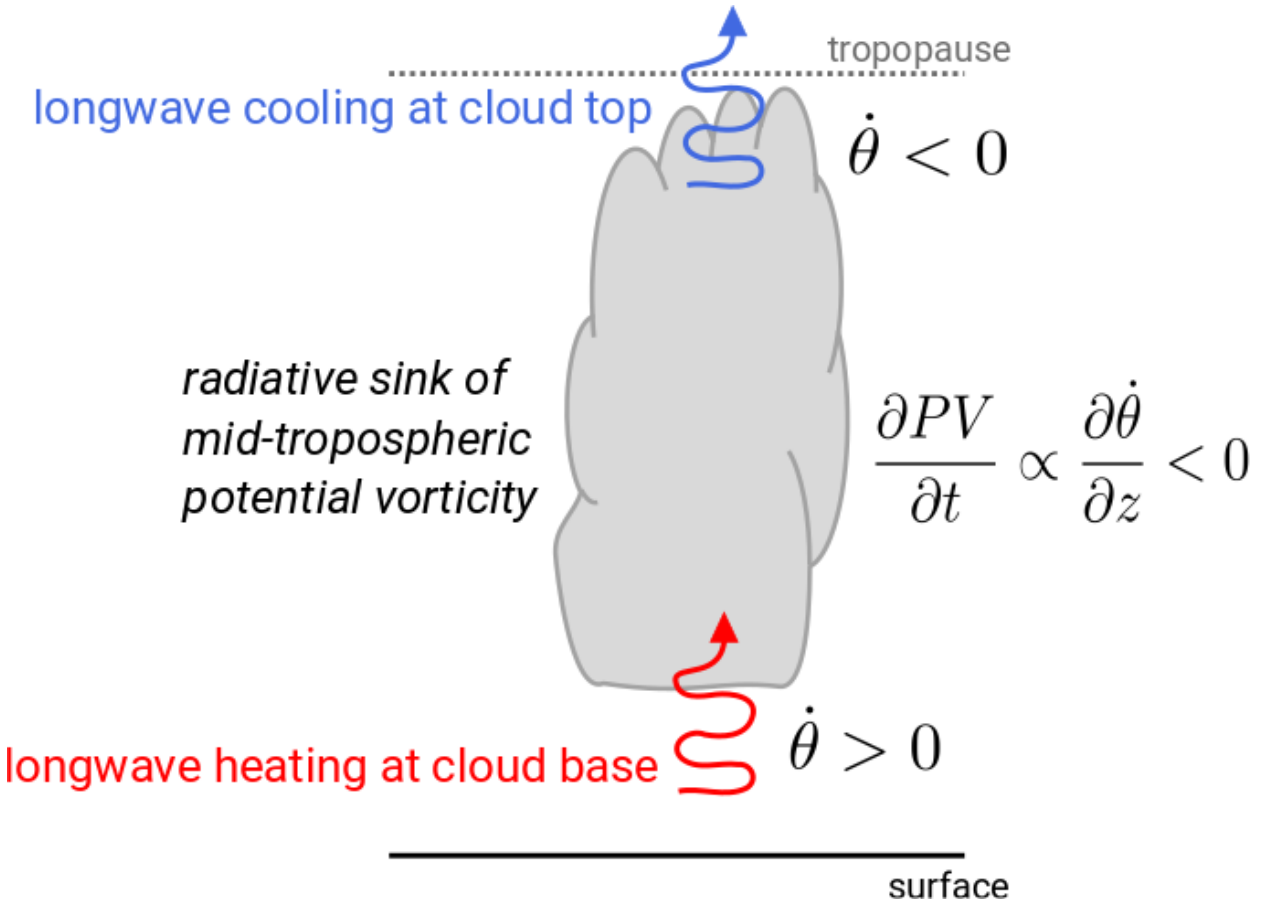
Baroclinic life cycles: Radiation weakens idealized cyclones





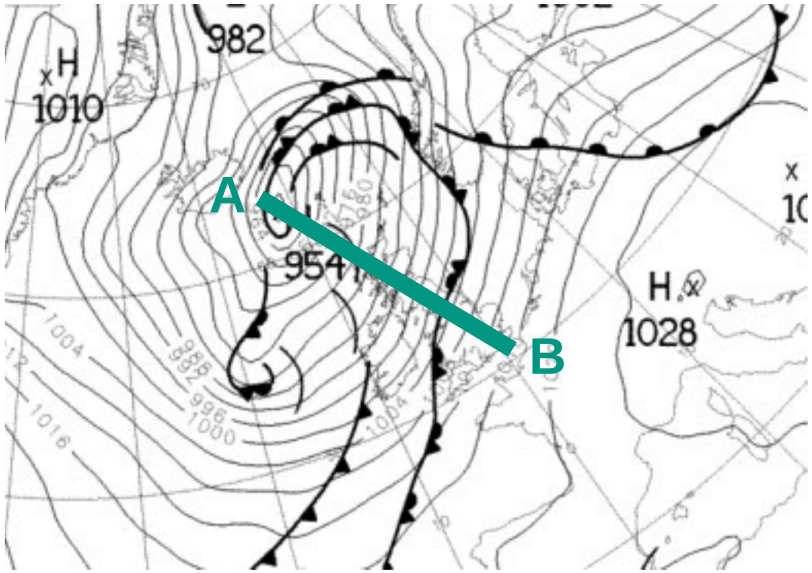
Schäfer and Voigt, GRL, 2018

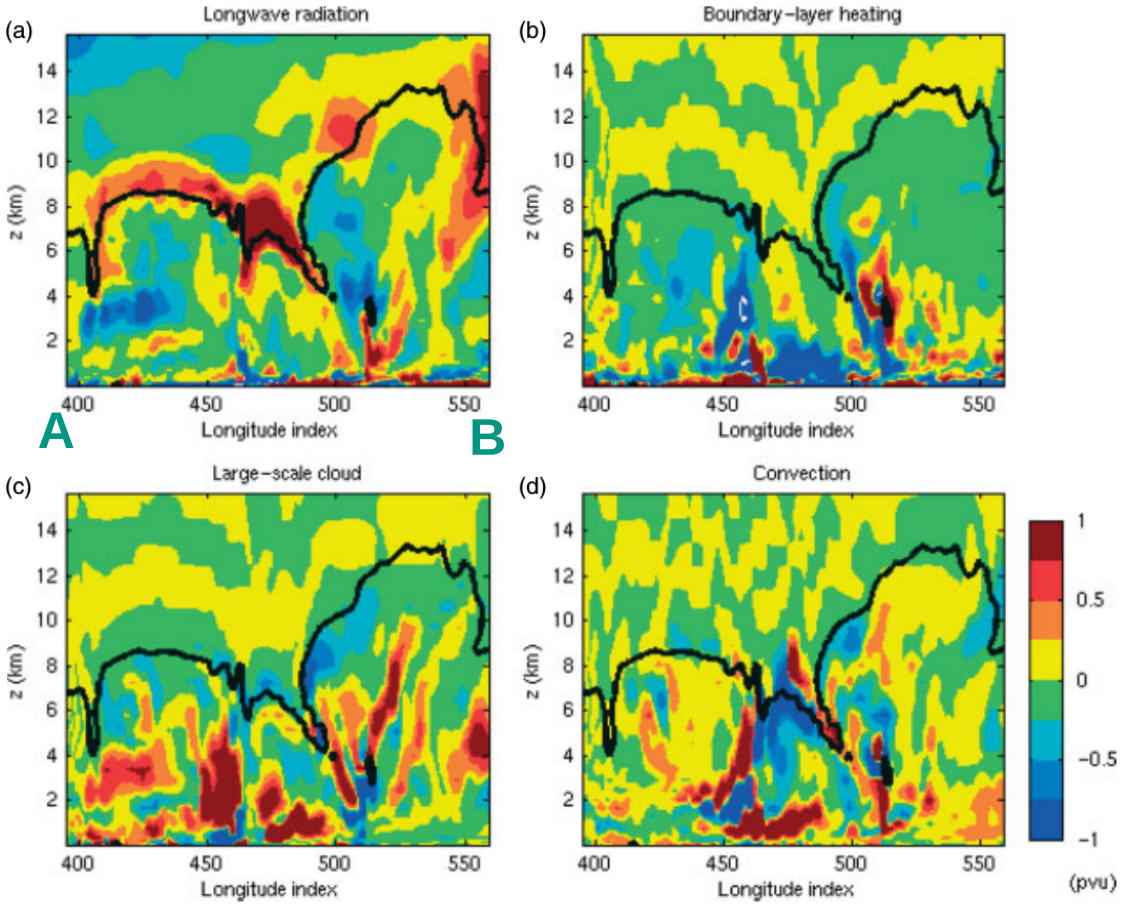
We believe that cloud-radiative dipole in ascent region weakens the cyclone by destroying potential vorticity



Schäfer and Voigt, GRL, 2018

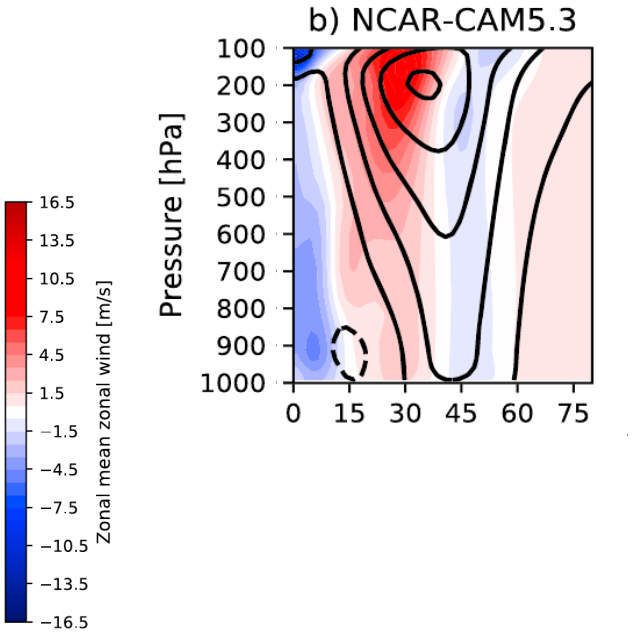
Radiation modifies PV also in actual North Atlantic cyclones





Chagnon and Gray, 2013, QJRMS

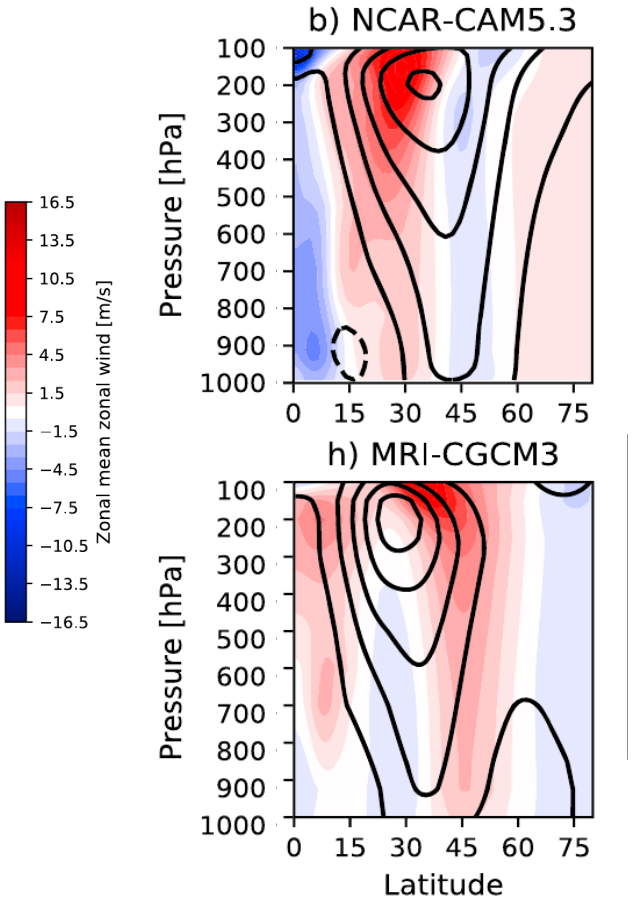
COOKIE: Clouds-On/Off Klimate Intercomparison Experiment



- NCAR model: clouds lead to *equatorward* jet shift

Stevens et al., 2012
Watt-Meyer and Frierson, 2017, GRL

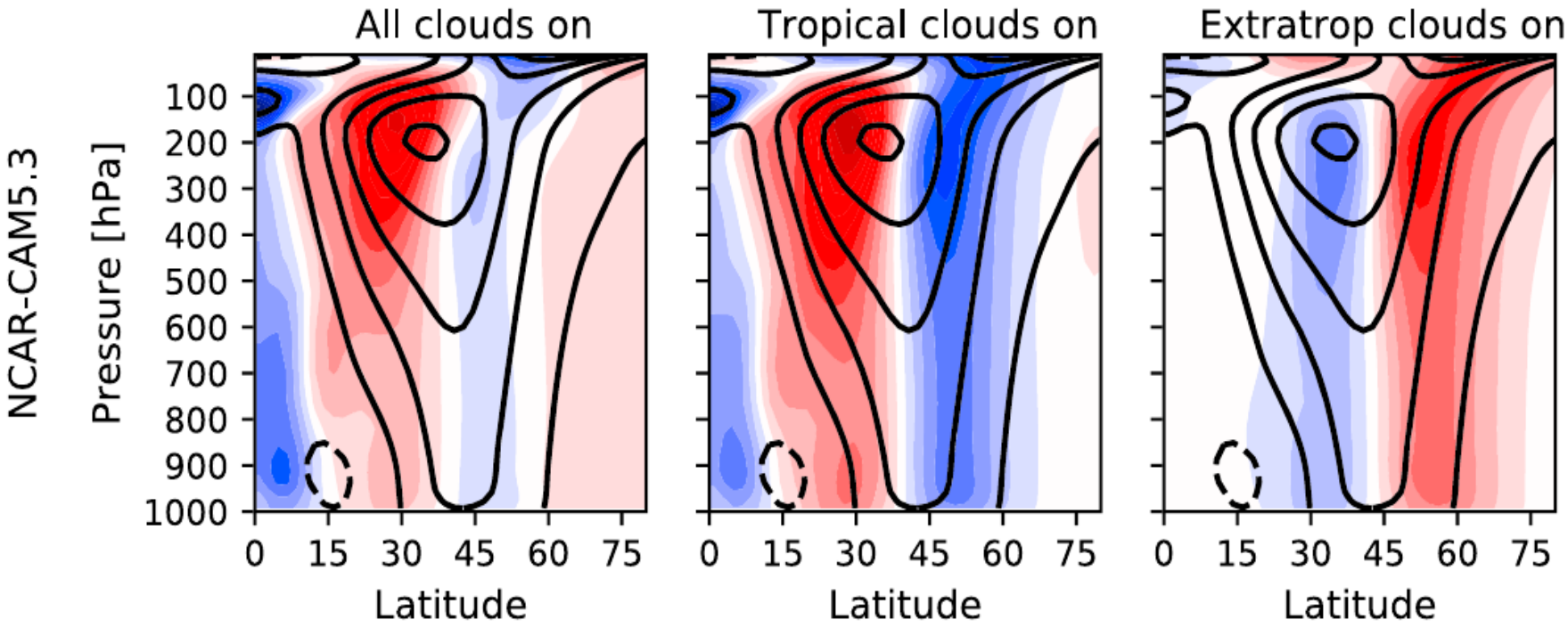
COOKIE: Clouds-On/Off Klimate Intercomparison Experiment



- NCAR model: clouds lead to *equatorward* jet shift
- MRI model: clouds lead to *poleward* jet shift

Stevens et al., 2012
Watt-Meyer and Frierson, 2017, GRL

Tug of war between tropical and extratropical cloud impacts on jet



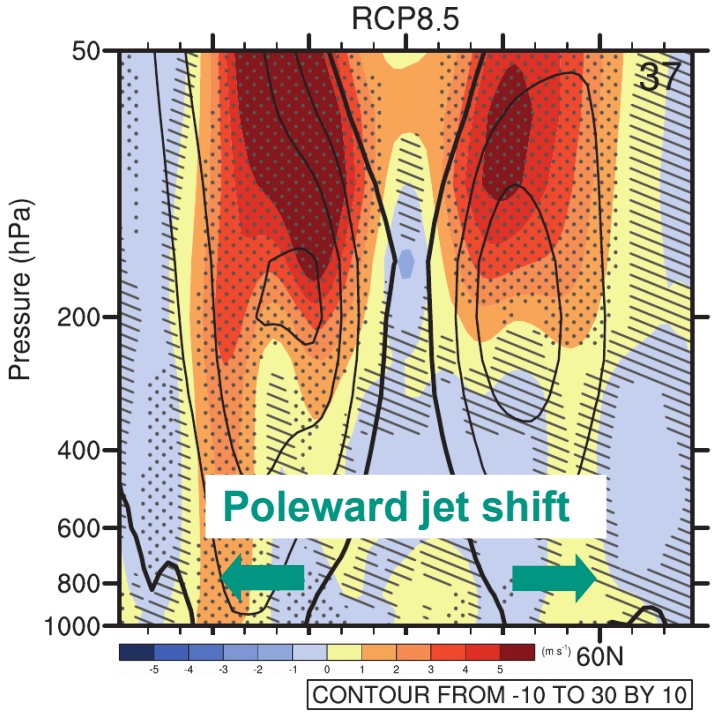
Stevens et al., 2012
Watt-Meyer and Frierson, 2017, GRL

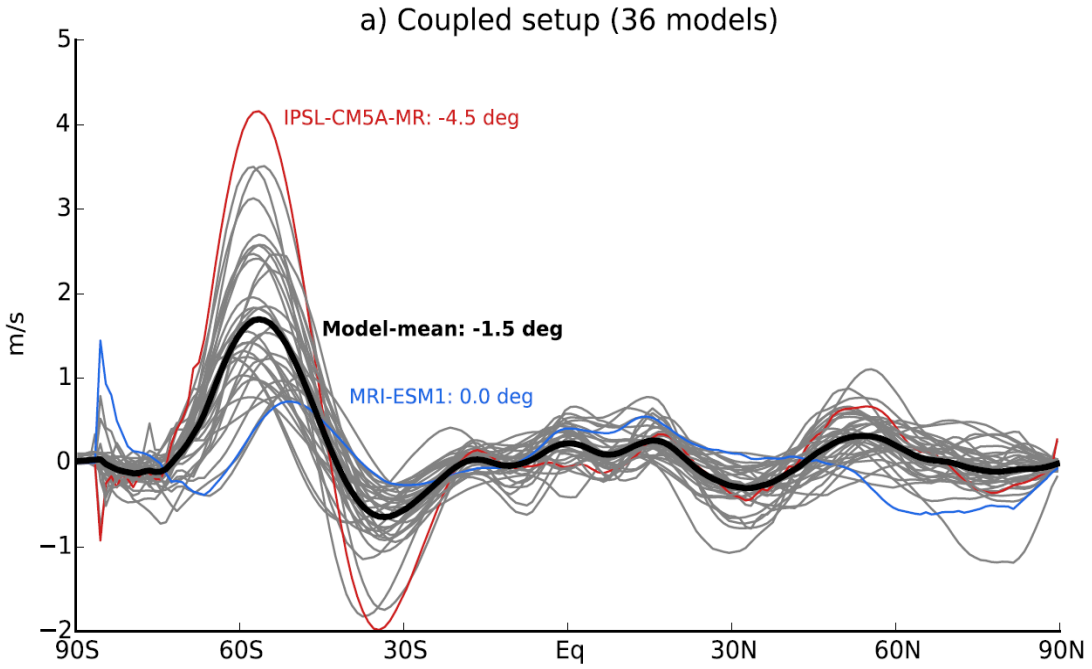
What I will talk about

1. Cloud impact on the present-day circulation

2. Cloud impact on future circulation changes

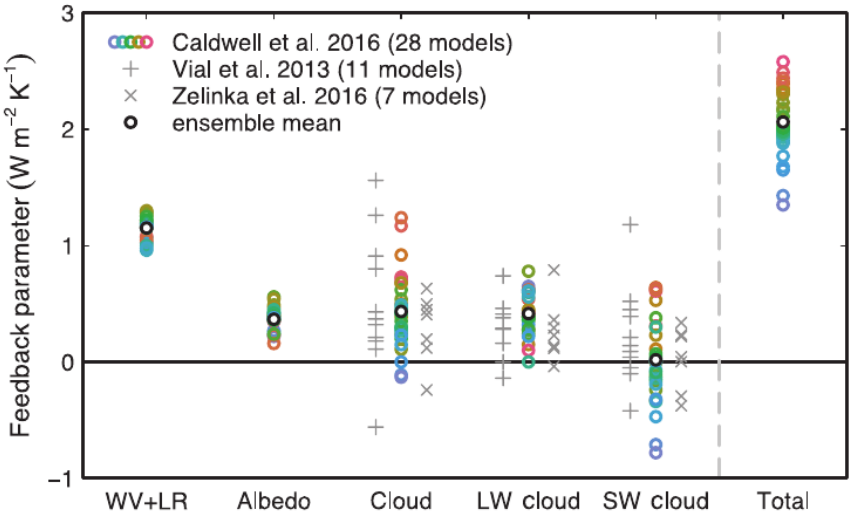
Circulation will expand poleward under global warming, but by how much remains uncertain.





IPCC AR 5, Fig. 12.19
Voigt and Shaw, J. Climate, 2016

Clouds are the largest source of model uncertainty in future projection



Grise and Polvani, 2014, GRL
Ceppi et al., 2017. WIREs Climate Change

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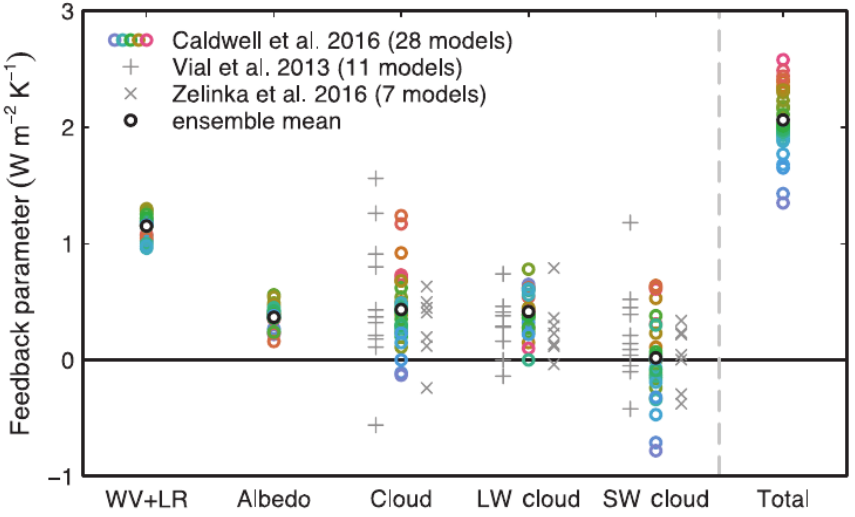

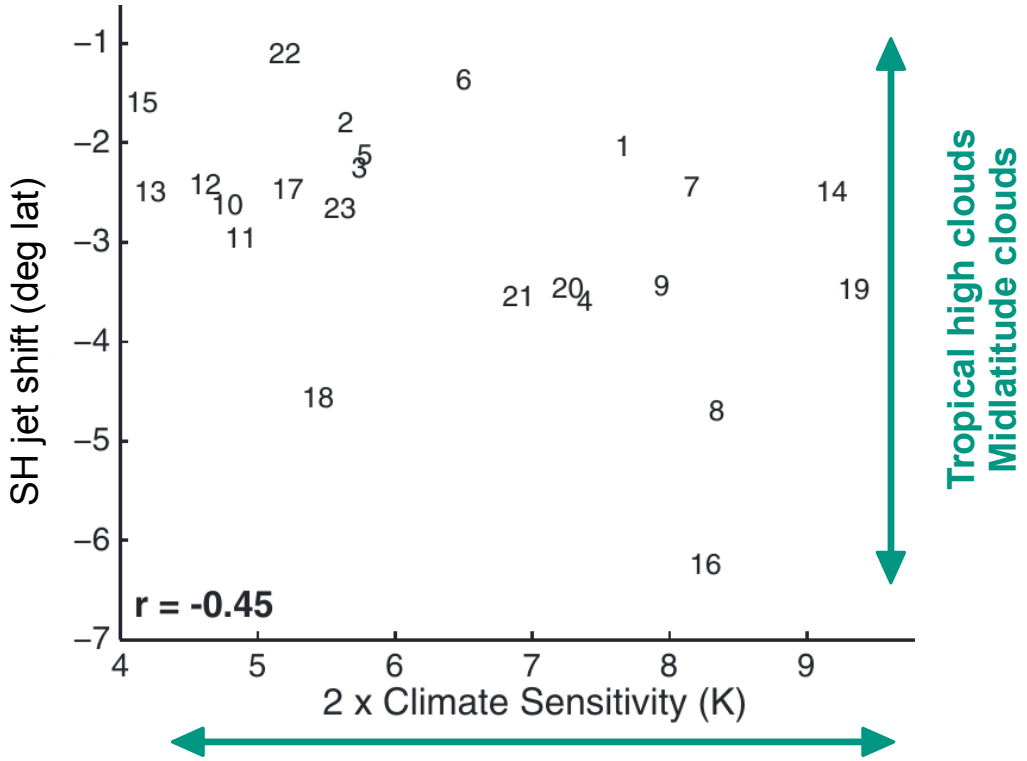

Grise and Polvani, 2014, GRL
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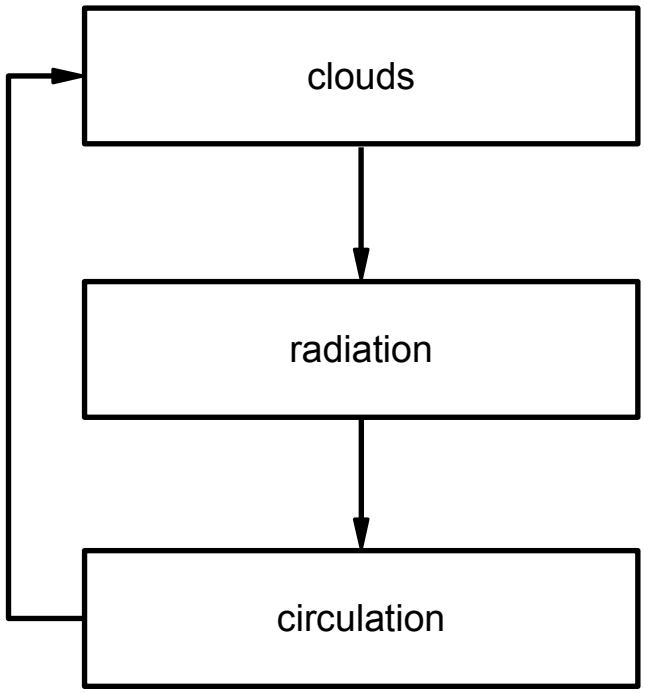
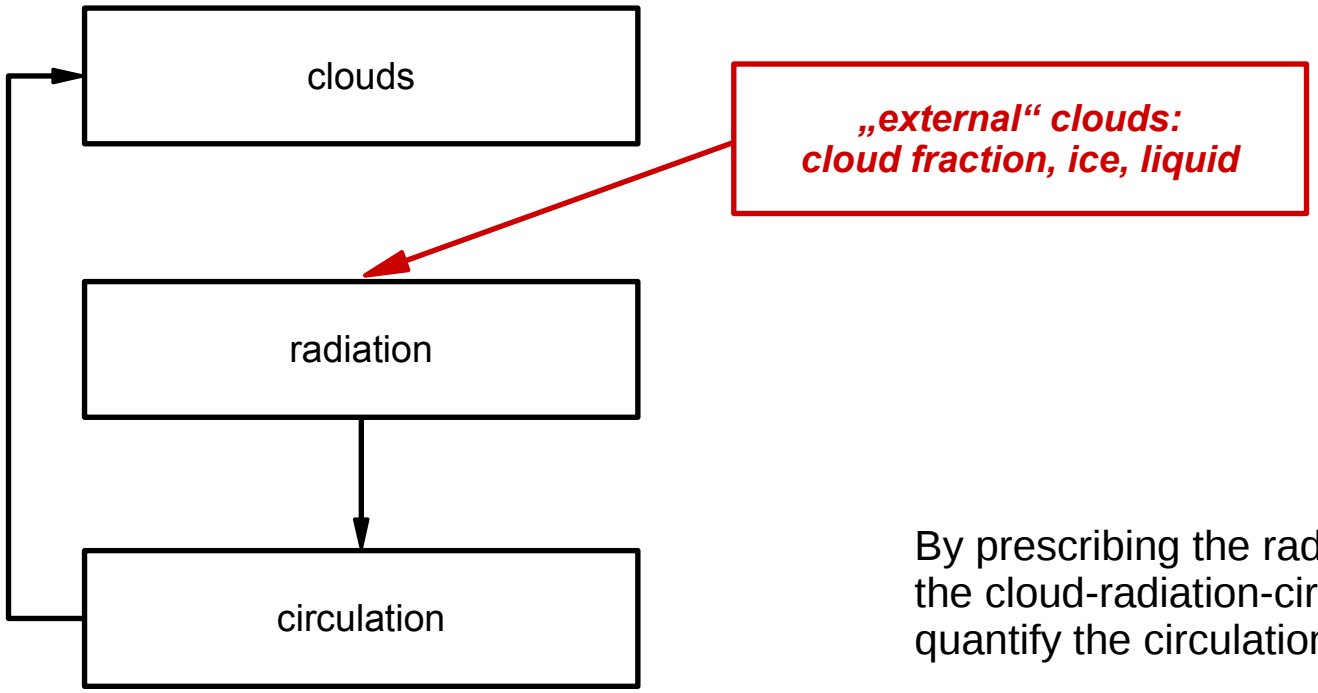
Understanding the cloud impact on circulation changes by “cloud locking”



Mauritsen et al., Climate Dynamics, 2013
Voigt et al, Nat. Geoscience, 2015

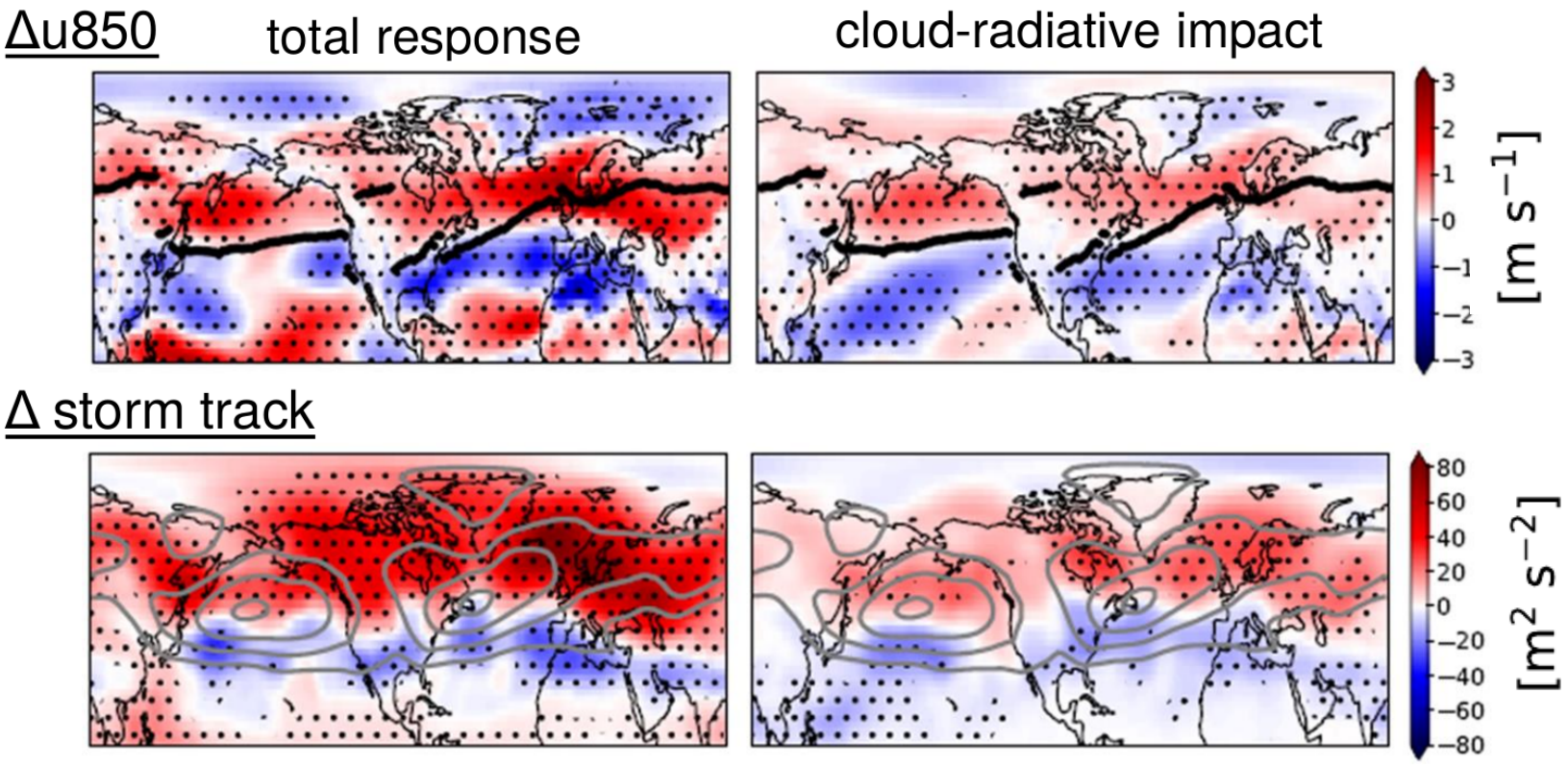
Understanding the cloud impact on circulation changes by “cloud locking”



By prescribing the radiative properties of clouds, we break the cloud-radiation-circulation coupling. This allows us to quantify the circulation impact of cloud-radiative changes.

Mauritsen et al., Climate Dynamics, 2013
Voigt et al, Nat. Geoscience, 2015

Cloud-radiative impact important for North-Atlantic storm track response



See poster of Nicole Albern today!

Albern, Voigt, and Pinto, in preparation

My take home message

Cloud-radiative interactions are a key factor for the extratropical circulation.

The cloud-radiative impact involves local as well as remote clouds.

The cloud-radiative impact is important both for today's weather and climate, and for their response to global warming.