Clouds, radiation, weather and climate

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The circulation response to warming shapes regional climate change

**Climate change**

(a) 700hPa zonal wind, DJF

**weather change**

wind intensity strong cyclones DJF

Simpson et al., 2014, J. Climate
Zappa et al., 2013, J. Climate
Clouds, circulation and climate sensitivity

Sandrine Bony\textsuperscript{1*}, Bjorn Stevens\textsuperscript{2}, Dargan M. W. Frierson\textsuperscript{3}, Christian Jakob\textsuperscript{4}, Masa Kageyama\textsuperscript{5}, Robert Pincus\textsuperscript{6,7}, Theodore G. Shepherd\textsuperscript{8}, Steven C. Sherwood\textsuperscript{9}, A. Pier Siebesma\textsuperscript{10}, Adam H. Sobel\textsuperscript{11}, Masahiro Watanabe\textsuperscript{12} and Mark J. Webb\textsuperscript{13}
A Grand Challenge

Clouds, circulation and climate sensitivity

Sandrine Bony1*, Bjorn Stevens2, Dargan M. W. Frierson3, Christian Jakob4, Masa Kageyama5, Robert Pincus6,7, Theodore G. Shepherd8, Steven C. Sherwood9, A. Pier Siebesma10, Adam H. Sobel11, Masahiro Watanabe12 and Mark J. Webb13

What controls the position, strength and variability of storm tracks?
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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1. Cloud impact on the present-day circulation

2. Cloud impact on future circulation changes
Baroclinic life cycles
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.
Radiation modifies PV also in actual North Atlantic cyclones
• NCAR model: clouds lead to *equatorward* jet shift
COOKIE: Clouds-On/Off Kclimate Intercomparison Experiment

- NCAR model: clouds lead to *equatorward* jet shift
- MRI model: clouds lead to *poleward* jet shift
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.
Clouds are the largest source of model uncertainty in future projection.
Clouds are the largest source of model uncertainty in future projection.
Understanding the cloud impact on circulation changes by “cloud locking”

- Clouds
- Radiation
- Circulation

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

$\Delta u_{850}$ total response  cloud-radiative impact

$\Delta$ storm track

See poster of Nicole Albern today!
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.