

WCRP Grand Challenge on *Clouds, Circulation and Climate Sensitivity*

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Clouds, Circulation and Climate Sensitivity



Four Questions:

1. What role does convection play in cloud feedbacks?
2. What controls the position, strength and variability of storm tracks?
3. What controls the position, strength and variability of the tropical rain belts?
4. What role does convective aggregation play in climate?

Workshops/conferences organized around the four questions

1. What role does convection play in cloud feedbacks?

Earth's Climate Sensitivities, Ringberg, Mar 2015

2. On the role of cloud-circulation coupling in climate

Special Session at EGU, Vienna, Apr 2015

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

Grindelwald, Aug 2015 (SPARC)

4. What controls the position, strength and variability of the tropical rain belts?

Monsoons & ITCZ: the annual cycle in the Holocene and the future, Columbia/LDEO, Sept 2015

5. Shallow clouds, convective aggregation and climate sensitivity

International Space Science Institute (ISSI), Bern, Feb 2016

6. Understanding clouds and precipitation through high-resolution models and observations

HD(CP)2, Berlin, Feb 2016

And soon:

7. Cloud Feedback Model Intercomparison Project (CFMIP)

Trieste, Jul 2016

8. Modeling hierarchies (held in conjunction with WGCM-20)

Princeton, Nov 2016

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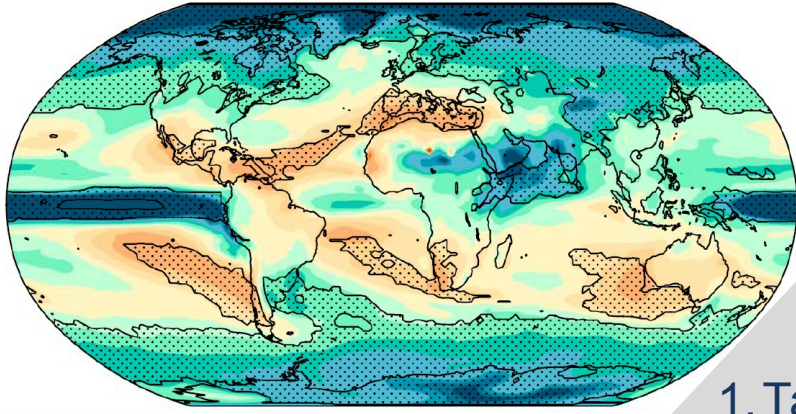
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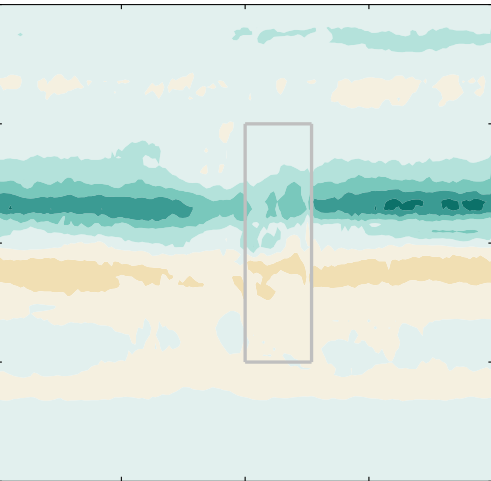
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Princeton, Nov 2016

Tropical Rain belts with an Annual cycle and Continent MIP

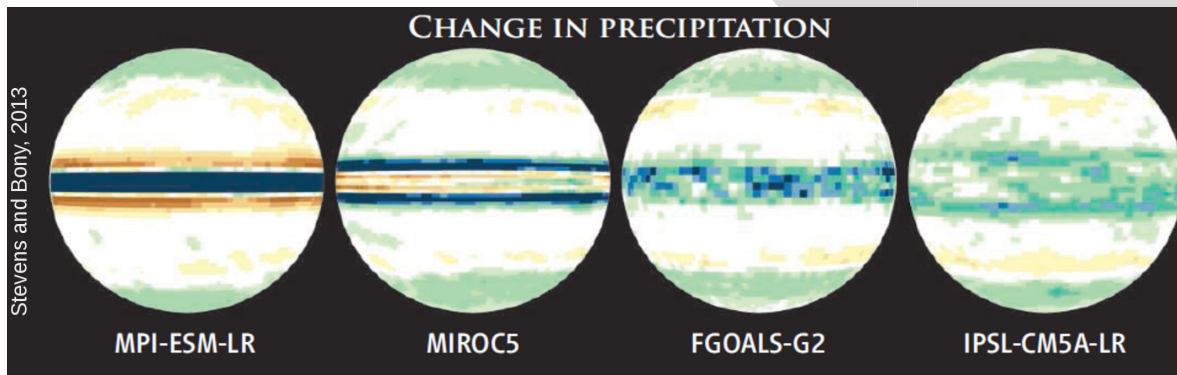


CMIP5 Abrupt4x+ paleo



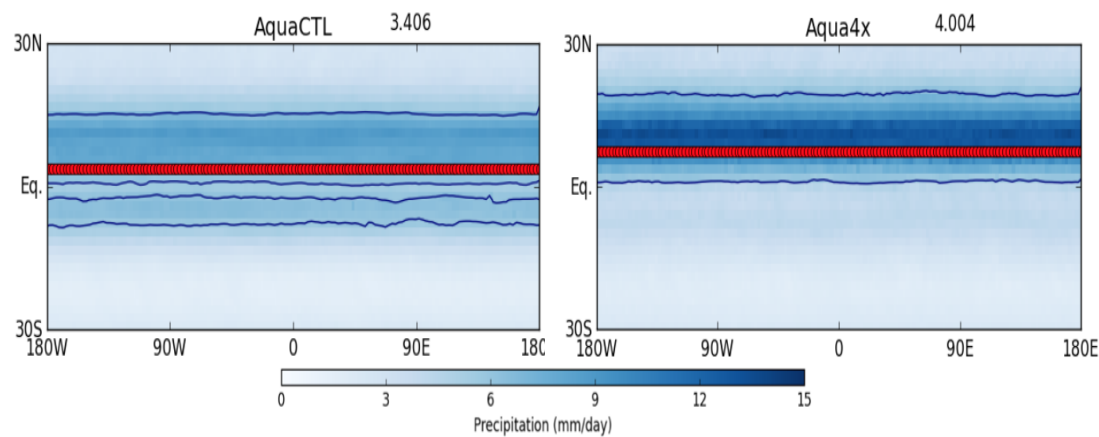
TRACMIP

1. Targets the essential dynamics of tropical rain belts with interactive SST (slab ocean)
2. Considers the main forced cycles (diurnal and annual)
3. Compares zonally symmetric (ITCZ) to zonally asymmetric (“monsoon”) case
4. Considers both future (CO_2) and past (precession) forcings

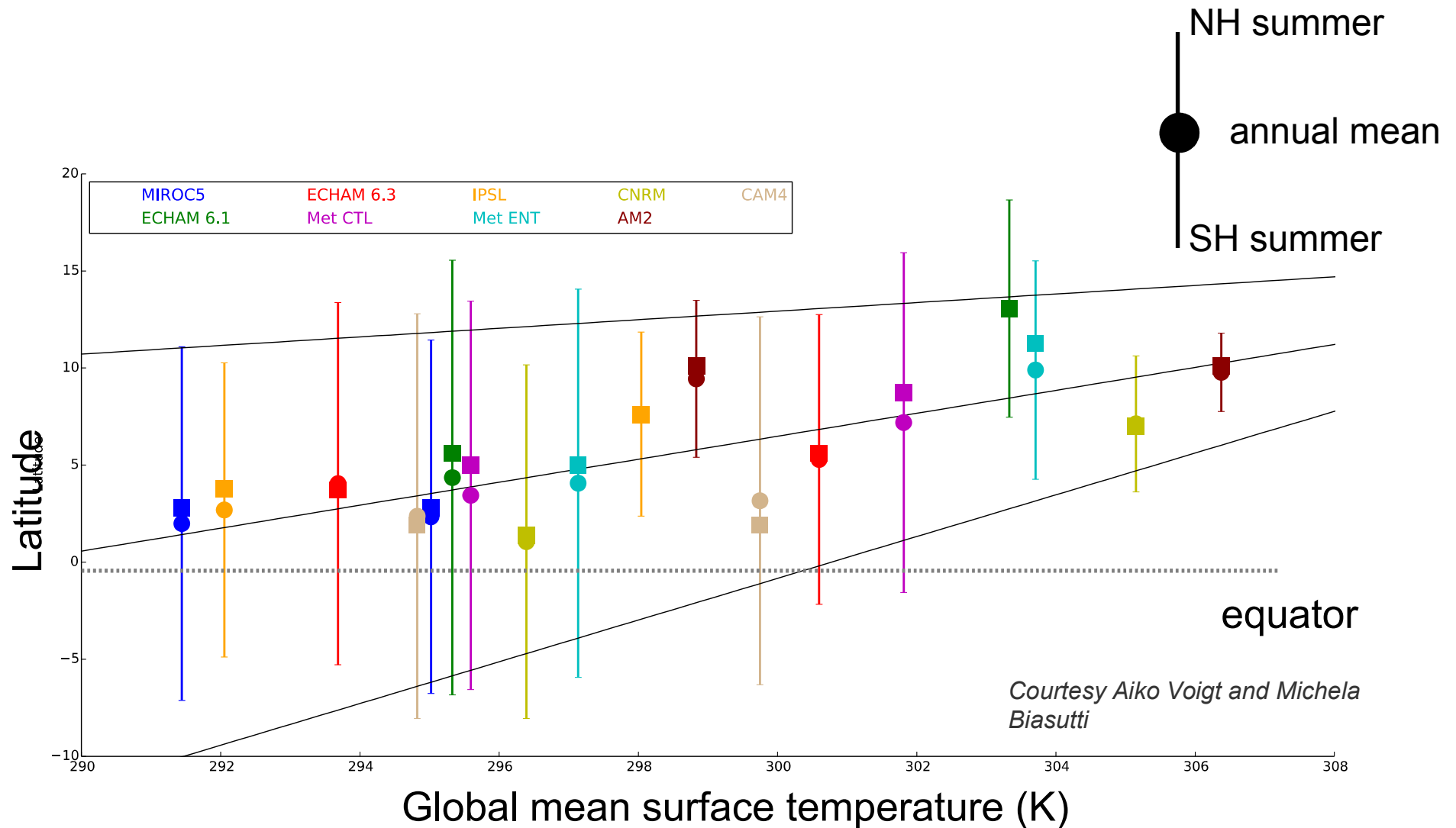


Courtesy Aiko Voigt and Michela Biasutti

CFMIP Aqua+4K



Aquaplanet Ctrl & 4xCO₂:
Seasonal range of ITCZ shrinks
in warmer climates.

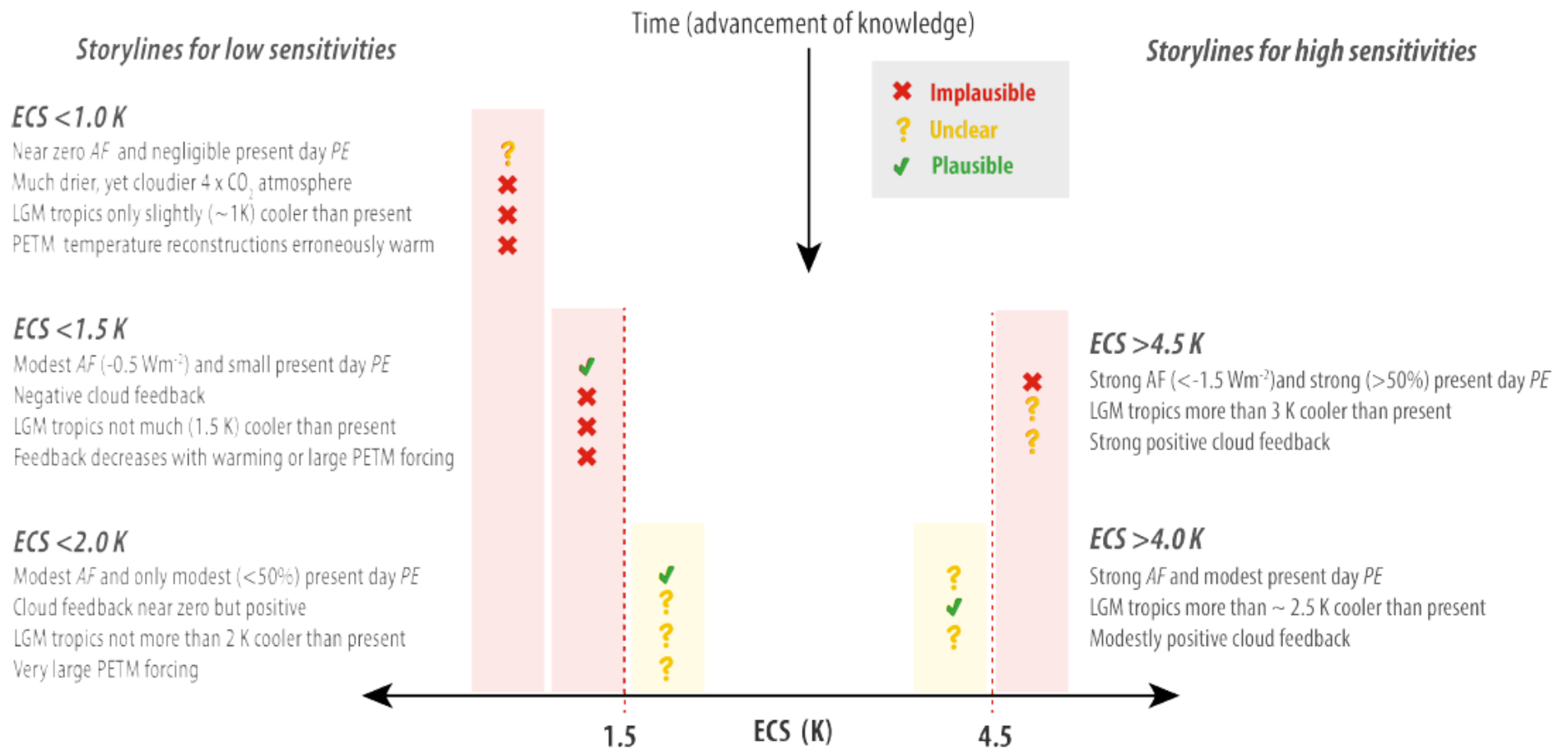


Prospects for narrowing bounds on Earth's Equilibrium Climate Sensitivity

Ringberg workshop:

- Reviewed understanding of bounds on Equilibrium Climate Sensitivity (ECS)
- Discussed possible causes of inconsistency between different estimates (instrumental, paleo, modeling, process studies, emerging constraints)
- A strategy to narrow uncertainty emerged: reasoning by refutation of storylines for low and high sensitivities

Applying reasoning by refutation to storylines for high and low sensitivities



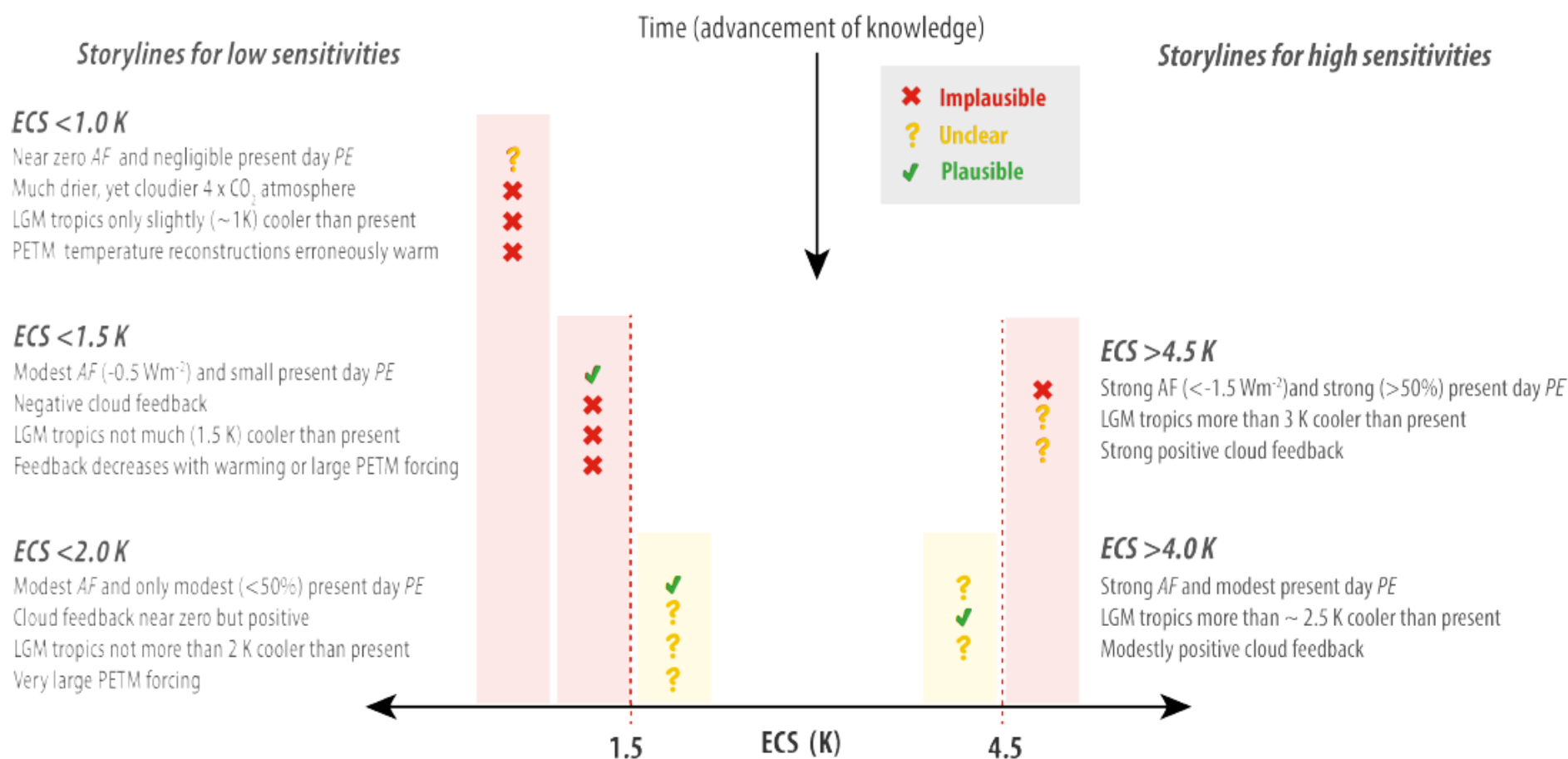
AF (Aerosol Radiative Forcing); PE (Pattern Effect); LGM (Last glacial maximum, 21 ky before present); PETM (Paleocene Eocene Thermal Maximum)

Stevens, Sherwood, Bony and Webb (submitted)

Prospects for narrowing bounds on Earth's Equilibrium Climate Sensitivity

- **Towards a GC Assessment Report on Climate Sensitivity (2018)** – will contribute to IPCC AR6
- Lead coordinators: Steve Sherwood (UNSW, Australia) and Mark Webb (MetOffice, UK)
- Will consider modeling and observational analyses of the instrumental period, paleoclimates and process studies, and will apply refutation reasoning to refine bounds on ECS.

Applying reasoning by refutation to storylines for high and low sensitivities



AF (Aerosol Radiative Forcing); PE (Pattern Effect); LGM (Last glacial maximum, 21 ky before present); PETM (Paleocene Eocene Thermal Maximum)

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Modelling activities associated with this GC (selection)

Model inter-comparison projects:

- TRAC-MIP (ITCZ and monsoons)
- Easy-Aerosols and RFMIP (robust responses of circulation and precipitation to aerosol forcing)
- CFMIP and PMIP (cloud feedbacks, climate sensitivity, past and future precipitation changes)
- DynVar (dynamical diagnostics in CMIP6 simulations), VolMIP (response to volcanoes)
- RCE-MIP in preparation (Masaki Satoh, comparison GCM/CRM/LES)

Workshops:

- Understanding CMIP results through model hierarchies
(Princeton, Nov 2016, jointly organized by WGCM & GC)
- The future of convective parameterizations
(Ringberg, 2017, organizers: Christian Jakob and Pier Siebesma)

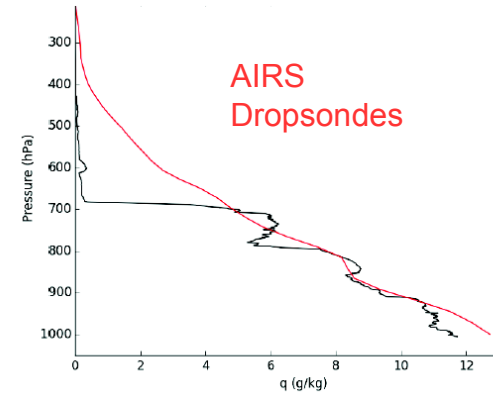
Observational needs to advance this Grand Challenge

- **Climate Symposium**, Darmstadt (Oct 2014)
 - + Asrar et al, BAMS (2015)
- **PROES workshop**, Paris (Nov 2015)
 - processes controlling high-clouds, observational datasets
 - cf Graeme Stephens' presentation
- **ISSI (International Space Science Institute) workshop**, Bern (Feb 2016)
 - satellite, in-situ, airborne instrumentation + modelling (process, climate)
 - book in preparation (+ articles published in Surveys of Geophysics)
 - a proposal for an ISSI international team has been submitted
- **GCOS conference on climate observations**, Amsterdam (Mar 2016)
 - presentation of conclusions/recommendations from ISSI workshop
- **Towards a GC Field Study: EUREC⁴A**
(Elucidating the role of clouds-circulation coupling in climate)

Recommendations to GCOS (Amsterdam, March 2016) based on ISSI workshop

Advancing the understanding and prediction of the role of clouds in climate requires improved observations of Water, Heating & Circulation:

1. Atmospheric cloud radiative effects (i.e. radiation budget + vertical cloud information)
2. Highly-vertically resolved water vapor, especially in the lower troposphere
3. Better estimates of cloud water path, particularly in scenes with small broken clouds.
4. Improved estimates of surface evaporation and vertical structure of latent heating
5. Wind vertical profiles and large-scale vertical velocity (ω)



Field experiments are opportunities to develop synergies between modelling, space observation and in-situ measurements around key science questions, to test new ideas and technological advances, thus helping to address the challenge.

EUREC⁴A (Elucidating the role of cloud-circulation coupling in climate)



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The Field Study is a French-German initiative in support of the WCRP GC on Clouds, Circulation and Climate Sensitivity.

Will take place in the Tropical Atlantic, over the shelf oceans east of Barbados (57W, 13N) in late 2019 or early 2020.

Will test hypotheses related to the interplay between shallow cumulus clouds, convection and circulation and their role in climate change.

Will involve two aircraft (French ATR42 and German HALO), will build on the Barbados Cloud Observatory and on two aircraft campaigns (NARVAL in 2013, NARVAL2 this summer) in the same area.

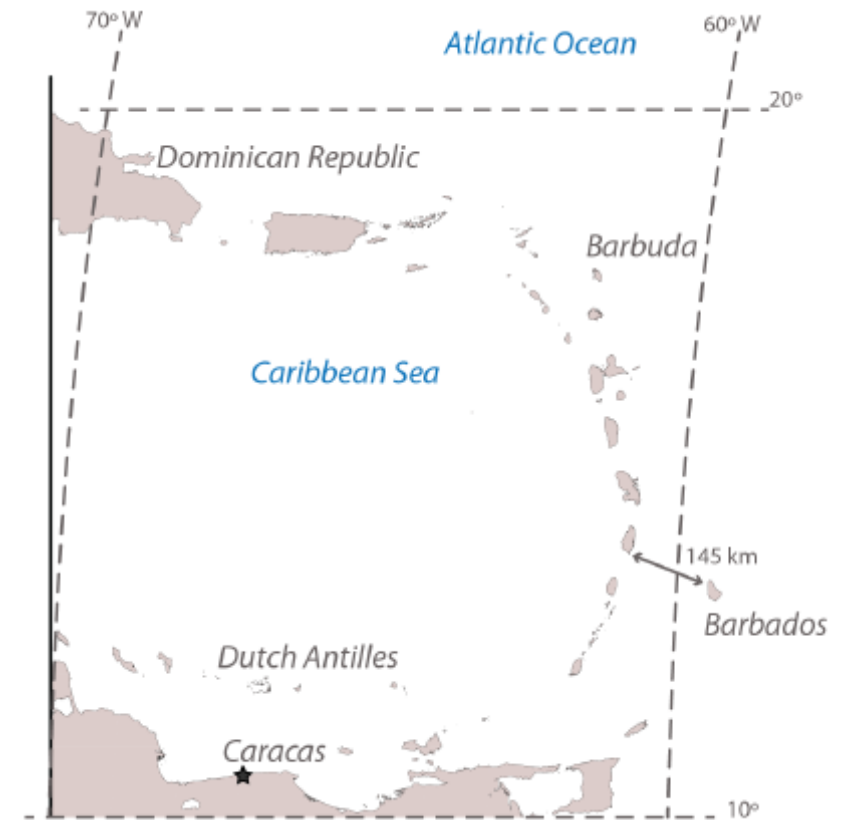
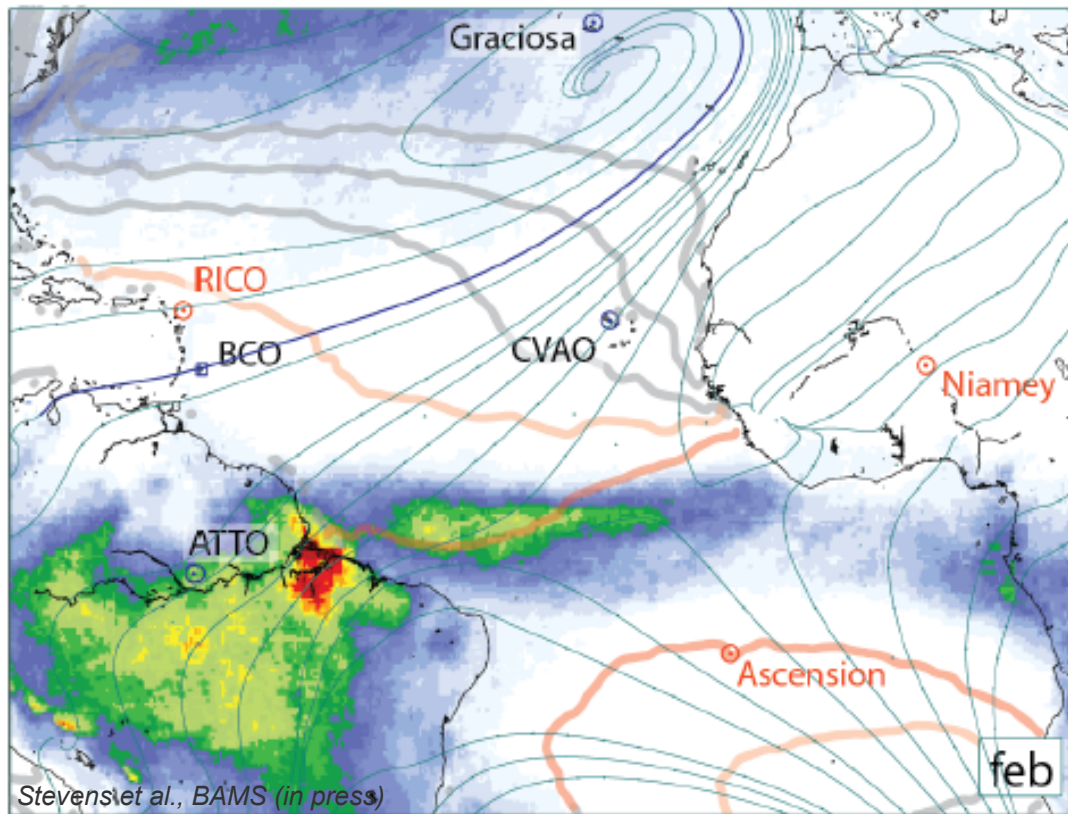
More information: <http://www.mpimet.mpg.de/en/science/the-atmosphere-in-the-earth-system/narval-eurec4a/>



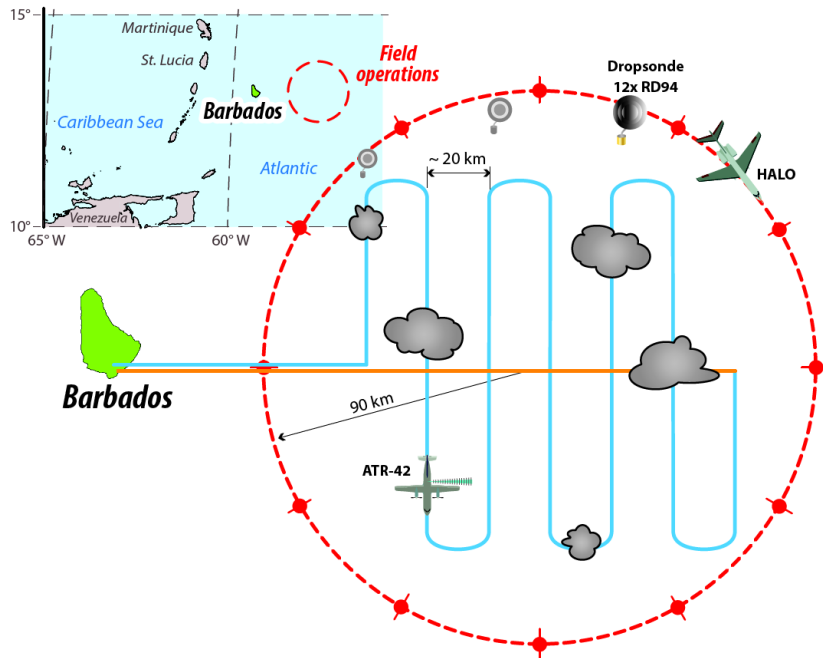
EUREC⁴A (*Elucidating the role of cloud-circulation coupling in climate*)

Field of operations:

Atlantic trades, East of Barbados (13N, 59W), late 2019 or early 2020

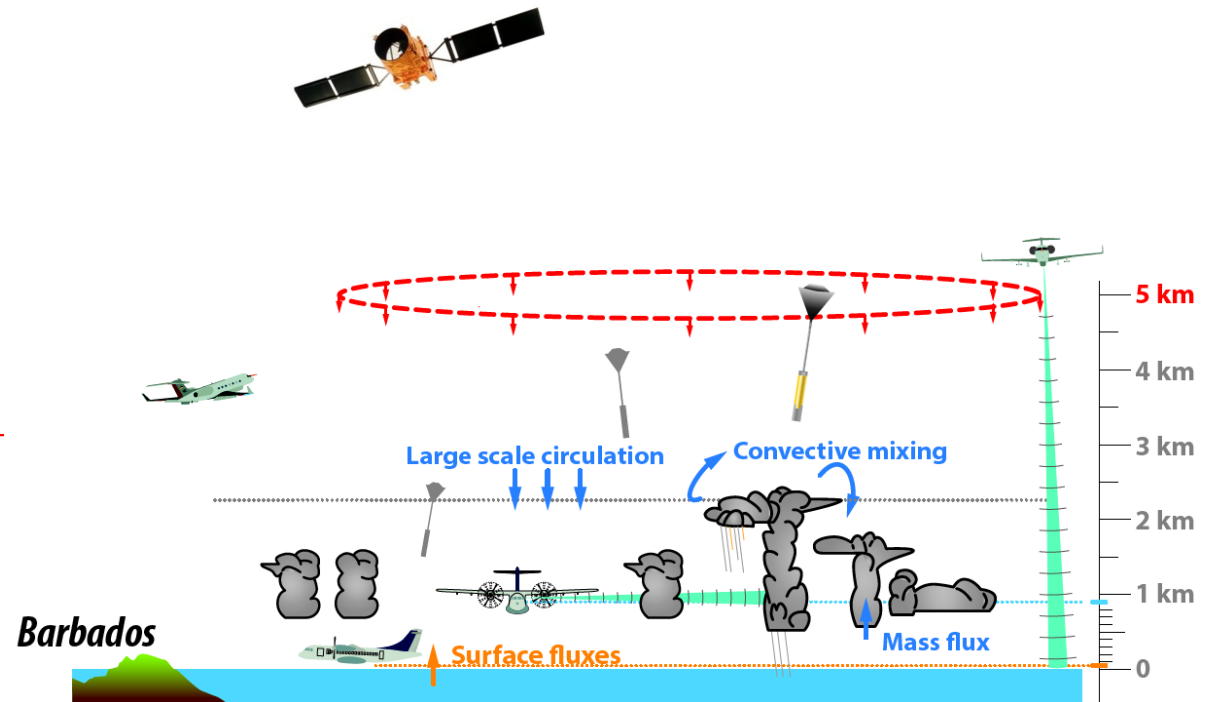


EUREC⁴A (Elucidating the role of cloud-circulation coupling in climate)



Scientific questions:

- Control of shallow cumulus clouds by large-scale environment and mesoscale organization
- Test retrievals of cloud and atmospheric properties (e.g. EarthCare, ADM-Aeolus, water vapor profiling)



Questions/requests to the JSC

1. Will WCRP formalize the GC Assessment Reports?

If so, it would be welcome if WCRP could:

- Endorse and support the GC assessment on Climate Sensitivity
- Write a letter to organizers and participants
- Help advertise the report (e.g. IPCC)

2. EUREC⁴A field study:

- Could this campaign be endorsed as a WCRP/GC initiative?
- Could WCRP promote participation of core-projects and partners (e.g. GEWEX, CLIVAR, SPARC, GCOS, NWP/WWRP) and help with the coordination and integration across the different projects/partners?

Thank you

