Grand Science Challenge on Clouds, Circulation, and Climate Sensitivity

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2021-06-30 Report to JSC-42

Some basic reminders about the Grand Challenge:

Activities organised around 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?

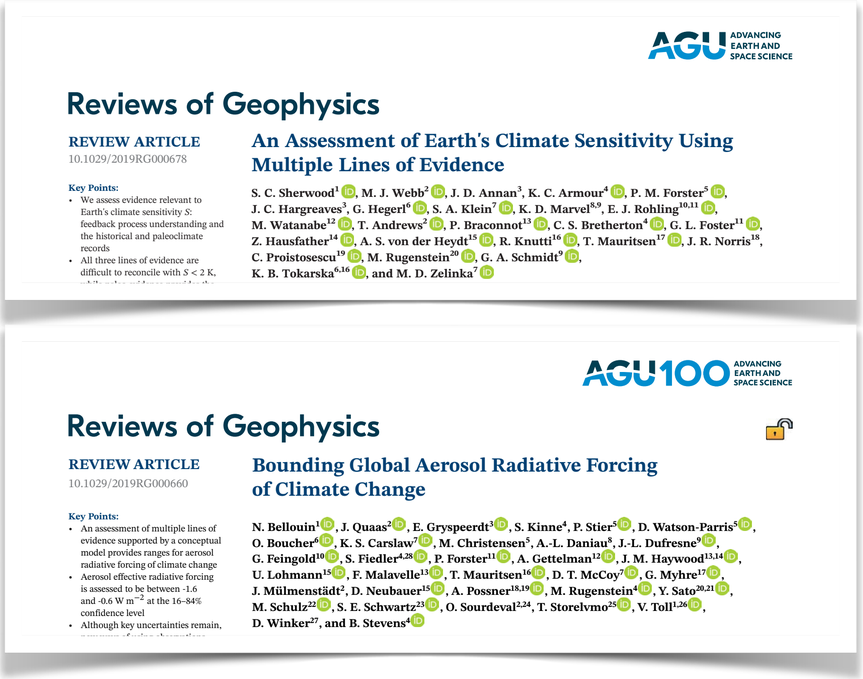
In addition to the key question of the climate sensitivity, which we addressed through two community assessments: (i) Climate Sensitivity; (ii) Aerosol Forcing.

Organised in three phases:

1. 2012-2015: Definitional
2. 2016-2020: Mature
3. 2021-2022: Wrap-up — we're wrapping up.

Bony, Sandrine; Stevens, Bjorn; Frierson, Dargan M.W.; Jakob, Christian; Kageyama, Masa; Pincus, Robert; Shepherd, Theodore G.; Sherwood, Steven C.; Siebesma, A. Pier; Sobel, Adam H.; Watanabe, Masahiro; Webb, Mark J., cited 377 times.

Our “lighthouses”



AGU ADVANCING EARTH AND SPACE SCIENCE

Reviews of Geophysics

REVIEW ARTICLE
10.1029/2019RG000678

An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence

Key Points:
- We assess evidence relevant to Earth's climate sensitivity *S*: feedback process understanding and the historical and paleoclimate records
- All three lines of evidence are difficult to reconcile with $S < 2$ K,

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AGU100 ADVANCING EARTH AND SPACE SCIENCE

Reviews of Geophysics

REVIEW ARTICLE
10.1029/2019RG000660

Bounding Global Aerosol Radiative Forcing of Climate Change

Key Points:
- An assessment of multiple lines of evidence supported by a conceptual model provides ranges for aerosol radiative forcing of climate change
- Aerosol effective radiative forcing is assessed to be between -1.6 and -0.6 W m^{-2} at the 16–84% confidence level
- Although key uncertainties remain,

N. Bellouin[1], J. Quaas[2], E. Gryspeerdt[3], S. Kinne[4], P. Stier[5], D. Watson-Parris[5], O. Boucher[6], K. S. Carslaw[7], M. Christensen[5], A.-L. Daniau[8], J.-L. Dufresne[9], G. Feingold[10], S. Fiedler[4,28], P. Forster[11], A. Gettelman[12], J. M. Haywood[13,14], U. Lohmann[15], F. Malavelle[13], T. Mauritsen[16], D. T. McCoy[7], G. Myhre[17], J. Mülmenstädt[2], D. Neubauer[15], A. Possner[18,19], M. Rugenstein[4], Y. Sato[20,21], M. Schulz[22], S. E. Schwartz[23], O. Sourdeval[2,24], T. Storelvmo[25], V. Toll[1,26], D. Winker[27], and B. Stevens[4]

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Open Access Earth System Science Data

EUREC⁴A

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- The assessments brought together multiple lines of evidence around new approaches to meaningfully, and for the first time, narrow the uncertainty surrounding central quantities of climate science.
- EUREC⁴A (see the film) developed and exploited new techniques and experimental strategies to quantify how clouds couple to circulation in ways that were previously not possible, and is guiding the development a new generation of earth-system models and observations.

What about the four questions?

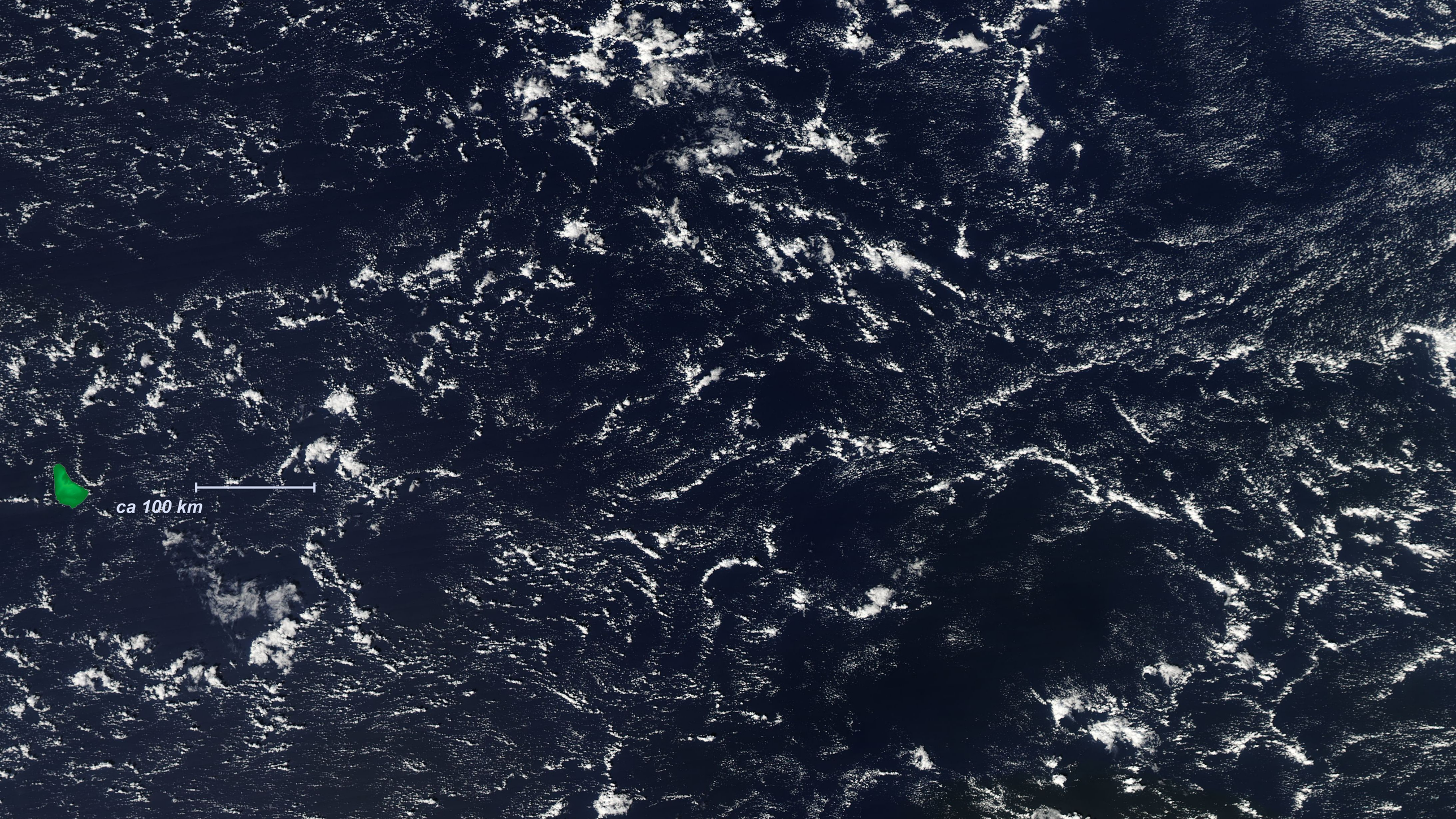
Question 1: What role does convection play in cloud feedbacks?

Question 2: What controls the position, strength and variability of storm tracks?

Question 3: What controls the position, strength and variability of the tropical rain belts?

Question 4: What role does convective aggregation play in climate?

- Communities (from workshops, conference sessions, schools, etc) have developed around each of these, supporting and initiating model intercomparison activities, field studies, research programmes, and individual research.
- Some definitive answers (EUREC^{4}A, but also from modelling) are emerging for Q1.
- Understanding Q4 is seen as central to further progress on Q1 & Q3, is a major motivation for new approaches to modelling (SR-ESMs), and is motivating a new generation of field studies (e.g., TOOC).
- Due to the pandemic, and given the previous point, we have decided to forgo a stock taking in favor of a transition which pivots about the question of convective aggregation (Q4), as it appears best poised to animate diverse WCRP activities (Lighthouses on Digital Earth's, GEWEX).


ca 100 km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Why Q4 (convective aggregation) is interesting for WCRP

- Convection organization (not just for shallow convection) strongly influences Earth's energy budget.
- Precipitation doesn't form in clouds, but cloud clusters.
- Hydrological extremes are often expressions of convective clustering (deep and shallow alike).
- Convective aggregation determines how effectively clouds coupled to circulation.
- Convection aggregates less over land than over the ocean.
- CMIP (like) models are built on the assumption that it doesn't matter.

Q4 could serve as a lightning rod for activities in GEWEX

Why WCRP is interesting for efforts to understand convective aggregation

- Its name.
- Its ability to bring people together.
- Its international cachet (particularly in countries with less scientific infrastructure).
- Its organizational support.

Mich Rixen: a hidden hero of our grand challenge …

How could WCRP have been more helpful for our grand challenge?

Issues

1. *WCRP is requested to endorse and adopt the Aerosol Forcing Assessment as an official WCRP activity, with report, similar to what it is doing for the Climate Sensitivty Assessment*
2. *Support from the core projects in the form of coordinated activities in support of EUREC⁴A will increase its impact (ESA, EUMETNET).*
3. *WCRP is requested to become more active, also with national governments, to create funding mechanisms, around the use of space-borne infrastructure in Europe*
4. *WCRP, and the take up of what we are doing after our GSC comes to an end, will be more effective if it is more question and idea, and less activity, driven … here we see untapped possibilities on questions pertaining to Palaeo Climate*

Slide from JSC-39

WCRP's blessings (and Mich's efforts) proved very beneficial for the success of our grand challenge.


Blessings are fine ...
but people need stories.