Quotations Bjorn Stevens

What does EUREC^{4}A aim at?

We test the hypothesis that fair-weather clouds are diminished with warming. If this were true it would imply that models which predict a greater temperature sensitivity to increases in CO_2, are more similar to nature than models that predicted a lessened sensitivity. On this question, that is how much Earth warms for a given input of CO_2, there is considerable uncertainty, mostly related to how clouds behave. This is what we are investigating with EUREC^{4}A.

The campaign takes place in the Tropics. There solar irradiation, which the ocean readily absorbs, is very intense. Hence, over the ocean in the tropics, the amount of sunlight that is ultimately absorbed by the surface, is very sensitive to how cloudy it is, as the clouds reflect back to space radiation that would otherwise be absorbed. Trade wind clouds are particularly interesting because there they cover such large areas over the ocean, are good at reflecting sunlight, but are not so effective at trapping terrestrial (IR) radiation. This endows them with a large effect on Earth's energy budget.

Besides five research aircrafts and four research vessels, many other platforms are used for measuring purposes during the campaign. Why?

While this wasn't planned, we certainly designed the campaign in ways that would encourage this. A key innovation of EUREC^{4}A is a new method a Sandrine Bony and I developed for measuring the average rising or sinking motion of airmasses over a large area. This gentle vertical motion greatly influences cloudiness, but could not be well quantified in the past. As a result, past experiments had a difficult time unravelling the effects of rather small changes in the environment, associated with a gently rising or subsiding large-scale environment, from other changes. Now that we can separate this effect on clouds from other effects it opens a whole new window on cloud studies, and allows us to better quantify their sensitivity to other changes. For example, there is a longstanding question as to whether the aerosol (particulate matter like dust) influences cloud amount. In the past this was very difficult to answer because one could not separate the aerosol effect from the meteorological effect. Now that we can do this, we hope to better quantify how sensitive clouds are to changing aerosol amounts. Likewise, the effect of surface heterogeneity, for instance in association with ocean eddies and fronts.

What is the task of the research vessels?

As simple as it sounds, it is quite difficult to say with some precision how cloudy it is. The answer to this question depends on how clouds are measured, but it also requires extensive sampling. One job of the Research Vessels is to provide additional sampling of clouds, and from above to complement measurements from HALO aloft. They also provide a ground truth, or a double check on the aircraft measurements.

The ships are also important for quantifying the state of the upper ocean, to better understand how this influences cloudiness, or is influenced by cloudiness. In the last few years there has been an explosion of interest in small scale ocean eddies and fronts. These

features can make the difference as to whether air currents evolve in a way that leads to cloud formation or not, and thereby may substantially influence the behaviour of the overlying atmosphere. The Research Vessels allow us to investigate these types of questions.

One of the aspects of EUREC^{4}A that we were careful to emphasize, was that we never pretended to do everything, but rather a few new things well. From this position it opened the door for other scientists to add to the experiment, to use it as a platform for doing those things that we did not do. Sometimes there is a tendency to claim that one is doing more than one is, the downside of this is that it makes it harder for others to contribute. Why would someone fund a group to investigate things we are already doing? EUREC^{4}A has become an ambitious and comprehensive study as a collective effort that only became possible by groups clearly stating what they are not doing, as that is what makes room for contributions by others.

The campaign will provide a reference data set based on the extensive measurement data. This will serve as a benchmark for the improvement of modelling and of satellite remote sensing of clouds and circulation. Which relevance has it?

The idea of using EUREC^{4}A to create a benchmark data set is the idea of Felix Ament [Universität Hamburg] – he took it as a chance for the evaluation of kilometer-scale resolution models. Does this exciting new type of models mimic nature more correctly? So far, we do not have the data to answer this question. EUREC^{4}A should change that. Likewise, for the interpretation of satellite data, which measures Earth at similar scales, but for which the ground truth is often missing.

It would be really good if EUREC^{4}A would lead to a data set that influences research for decades like BOMEX, and GATE. These were both watershed studies that took place decades ago and continue to influence thinking in the field.

As for the data. It will belong to Barbados, in that it is intended for it to be responsible for the long-term archive. That said, after it is collected data is copied and propagated around the world. Our clouds will live in the cloud

Shall the new findings improve the models?

This is the wrong question. Climate science is not about making ‘better models’ it is about understanding how the climate system functions, being able to anticipate changes and avoid surprises. Models are part of that, as they often suggest ways of thinking which one might call understanding, but which must first be tested by measurements. So, models are important for improving how we observe the system. Of course, one hopes that a deeper understanding, which requires the empiricism that comes from better and more exact observation, will also lead to improved tools (models) for predicting the weather and projecting changes in climate, but it is not a one way street.

The measurements we are making during EUREC^{4}A are exciting because they are well suited, by virtue of the scales of motion that they measure, to a new frontier of modelling. This new frontier of models, tomorrows climate models if you will, are computationally extremely intensive, but they promise to revolutionize how we think about the climate system.

Currently there is considerable discussion as to how much effort should be devoted to advancing the use of these types of models, as is discussed for instance in a recent commentary I wrote in PNAS together with Tim Palmer. I see EUREC^{4}A as going hand in hand with the other exciting new direction in climate science, as both focus on linking clouds and Earth's energy budget to its circulation systems in ways that previously was not possible.

PNAS publication:
Palmer, T., and B. Stevens (2019) The scientific challenge of understanding and estimating climate change. PNAS, www.pnas.org/cgi/doi/10.1073/pnas.1906691116.