PROPOSAL FOR AN ISSI (BERN) INTERNATIONAL TEAM

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Abstract

The aim of the International Team will be to advance understanding of what controls the cloud amount in the trades and patterns of convection in the broader tropics. Our Study Project will link existing and forthcoming satellite measurements to past, ongoing and planned field and simulation studies of clouds and mesoscale circulations in the broader tropics. Our project is motivated by the WCRP Grand Science Challenge *Clouds, Circulation and Climate Sensitivity,* the 2014 EUMETSAT Climate Symposium, and an ISSI Workshop in early 2016 on *Shallow clouds and water vapor, circulation and climate sensitivity.* With increasing specificity each of these activities pointed out the need to better understand, model and observe how water and circulations interact in the lower troposphere.

Our Team's Study Project will focus on how meso-scale radiative-convective and dynamical processes control clouds and convection within the trades, thereby complementing (and profiting from) earlier work (also by International Teams) which emphasized aerosol-cloud interactions. The Study Project will advance the use of present measurements and of a new generation of satellite remote sensing, particularly in light of the forthcoming ADM-AEOLUS and EarthCare missions. The expected outcomes will be: (i) a review paper on the topic of the Study Project; (ii) a shorter and higher profile perspective article on the importance of lower tropospheric water vapor, clouds and the mesoscale and our present capacity to observed these processes from space; and (iii) the refinement of the experimental plan, and the potential expansion of scope, of what is anticipated to be a major (generational) international field study in the tropical Atlantic sometime in 2019 or in early 2020.

We propose to meet in Bern for two weeks over a 9-15 month period between early 2017 and mid 2018. Our core Team will be comprised of eleven mid and senior level scientists, from six countries. Expertise of team members spans all aspects of the proposed project, from process understanding to modeling, from field work to the analysis and development of satellite-borne, surface and airborne remote sensing instrumentation. Senior team members have an international standing that will help bring visibility to the proposed activity. Two early-career researchers who were supported to participate in the recent ISSI Workshop would be asked to continue working with the International Team. In addition, our (own) institutional resources will be committed to fund an additional two mid-career participants with targeted expertise.

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1. Background

Two questions raised by the World Climate Research Programmes Grand Science Challenge on Clouds, Circulation and Climate Sensitivity pose particular challenges and opportunity for contributions from space-borne observing platforms. The first question, *What role does convection play in cloud feedbacks?* focuses primarily on shallow clouds. Here the question is to what extent their properties are governed by shallow and deep circulations, and hence lower-tropospheric mixing, and to what extent shallow precipitating convective systems organize the flow on the meso-β scale (20-200 km) and the influence thereof on the cloud coverage. The second question turns out to be unexpectedly complementary: *What role does convective aggregation play in climate?* asks to what extent radiatively driven circulations in shallow convection regions away from deep convection, help support the concentration and aggregation of convective regions on the one hand, and to what extent the processes underlying convective aggregation also operate in the formation of mesoscale shallow cloud clusters in the tropics. Being over the tropical ocean, and involving the interplay of small and shallow cloud systems with lower-tropospheric water vapor and smaller scale circulation systems, empiricism is largely limited to what can be deduced from remote sensing (both active and passive) on satellite platform, sporadically augmented by data from field campaigns and a few long-term measurement facilities.

With an eye on these two questions a contribution to the recent (October 2014) Climate Symposium organized by EUMETSAT, with support from ESA, NASA, JAXA and other agencies, was to emphasize the role of better measurements of circulation and lower tropopospheric water vapor. As it's foremost finding, the symposium stated that:

> The role of atmospheric water and circulation, and their coupling, emerges as a common uncertainty across several of the Grand Science Challenges. Progress on Grand Science Challenges will require improved understanding of underlying processes based on observations of water vapor, clouds, and winds, especially in the lower troposphere, and at a higher vertical resolution than is available from the current sensors.

This symposium motivated a successful application for an ISSI Workshop focusing on the present state of understanding of the two questions mentioned above, and the capabilities of the present observing system, and opportunities for new technologies. A book is in preparation summarizing the contributions of the workshop. The sharpening of the questions during the workshop and its ability to identify diverse expertise that could contribute to answering the two grand challenge questions, combined with the coincidence of ongoing and planned field studies in the region of interest motivate the proposal for a more specific study project to be carried out by the proposed International Team.

Since 2010 the Max Planck Institute for Meteorology has been maintaining a field observatory on Barbados, the Barbados Cloud Observatory. Research since its establishment suggests that it samples weather regimes characteristic of the broader trades. A programme of airborne field studies was initiated in support of the ground based observations. This included two weeks of flights over the North Atlantic trades in December of 2013 (NARVAL) and a follow up mission (NARVAL-II) which will take place in August 2016, both involving (or planning to involve) extensive dropsonde launches

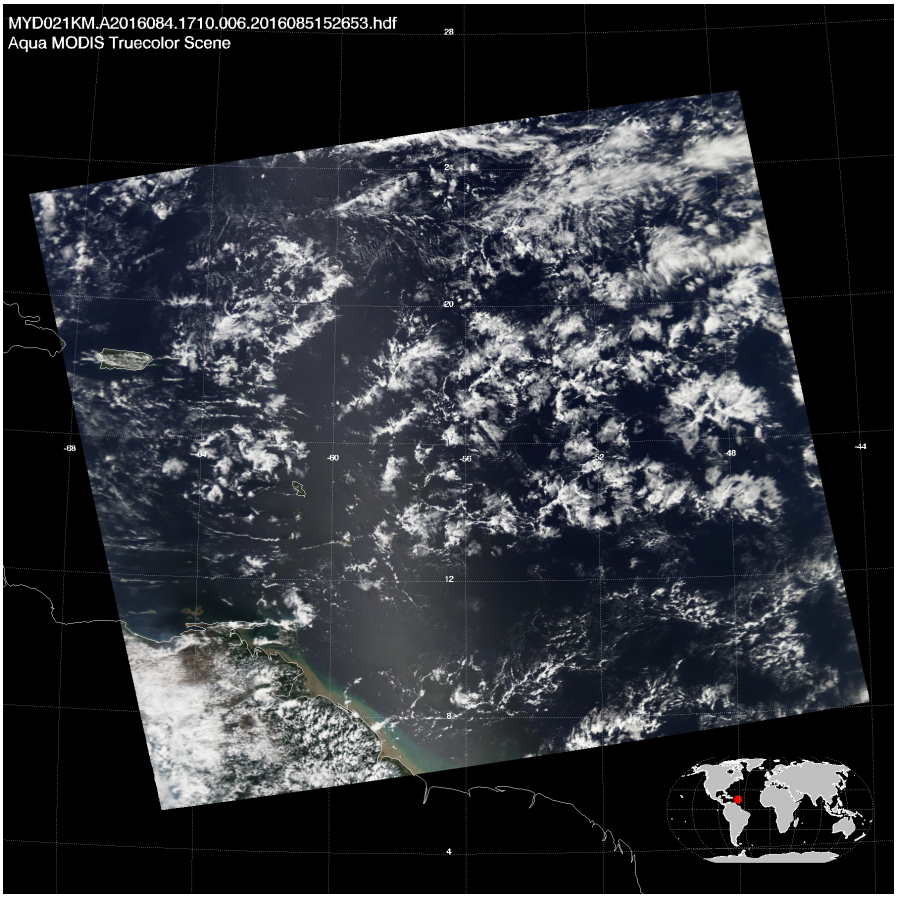

FIGURE 1. MODIS true color granule showing how shallow cloud systems are organized on the meso-scale. Image taken from porposed study area East of Barbados (59 W, 13 N), on 24 March 2016. Cluster sizes range from tens to hundreds of kilometers.

and advanced airborne remote sensing designed to mimic the capabilities of upcoming or proposed satellite missions. A further mission, EUREC^{4}A has been funded through an ERC advanced grant and will take place in either 2019 or 2020, and is anticipated to be much larger in scope. Simultaneously a German national project has developed the capacity to simulate atmospheric flows on the meso-α scale (200-2000 km) with very fine grid spacing (100 m). This simulation capacity will be combined with punctuated airborne field studies and ongoing ground based measurements over Barbados, to investigate the role of the mesoscale, and in particular mesoscale circulations, in determining the properties and coverage of shallow convection, its relation to convective activity, and its influence on the tendency to support organized convective systems (aggregation) on even larger scales. The goal of the ISSI International Team will be to put these efforts in the context of existing, pending, and proposed satellite measurements so as to more fully use the existing satellite record, and better design future satellite missions, to better understand our driving questions.

2. Proposal

We propose to organize an eleven-person ISSI International team, drawn up of experts from six countries with expertise in space-borne remote sensing, particularly of water vapor and clouds in the lower troposphere, or in clouds, cloud processes extending to the mesoscale. The Team will address three questions in the context of the Grand Science Challenge on *Clouds, Circulation and Climate Sensitivity*:

(1) What is the role of meso-β scale circulations in determining cloud amount in the trades, for instance as illustrated in Fig. 1?
(2) Can we observe processes hypothesized to be responsible for the self-aggregation of convection, for instance radiatively-driven circulations in regions where the vertical gradients of water vapor between the boundary layer and the free troposphere are particularly strong?"
(3) How can the simulations and field studies be used to identify strengths and gaps in the satellite observing systems as relates to the distribution of water vapor and condensate in the lower troposphere, and how can satellite measurements be used to evaluate the representativeness of insights extracted from field measurements?

In answering the last question we hope to use experiences from NARVAL-II, which will take place prior to our first Team meeting, to guide and refine strategies for EUREC^{4}A which will take place after the International Team has been officially disbanded.

The team will meet twice, each time for one week, in Bern, with ISSI requested to provide meeting space, and cover lodging and daily expenses while in Bern. It is proposed that the first meeting will take place in Early (Jan-Mar) 2017 and the second meeting will take place roughly a year later. It is proposed to involve younger scientists drawn from the participants of the ISSI Workshop (Ann Kristin Naumann and Jessica Vial), building on the continuity of community established at that meeting. Support for at least two additional (mid career) members to the team will also be provided by funds from the Team-Leader's institute and an ERC Advanced Grant of one of the Team members (EUREC^{4}A, Bony). Tentatively we anticipate these participants to be Cathy Hohenegger (Germany) and Julien Delanoë from (France).

The team will distinguish itself through its emphasis of radiative, thermodynamic and dynamic processes responsible for patterns of cloudiness and convection, in contrast to much previous work which has emphasized the role of aerosol-cloud interactions. Expertise of several team members (Blyth, Stevens, Winker and Zuidema) will ensure that the team is well positioned to profit from and incorporate this earlier work.

3. Team Members

Team members were chosen for their expertise and enthusiasm for the Study Project. The additional factors in shaping the team was the desire to have a diverse expertise. Specifically: experience in field measurements and a connection to national measurement facilities that could strengthen international participation in EUREC^{4}A (Blyth, Flamant, Stevens, Zuidema); deep understanding of cloud processes on all scales (Blyth, Bony, Schär, Siebesma, Stevens, Zuidema); expertise related to remote sensing of clouds and water vapor (Bony, Brogniez, L'Ecuyer, Flamant, Kiemle, Winker, Zuidema). The team comprises a healthy mix of participants from the recent ISSI Workshop with additional

Person	Country	Expertise
Blyth, A.	UK	Microphysics, Mixing Processes, Field Studies
Bony, S.	FR	Clouds & Climate, Modelling, Satellite (analysis)
Brogniez, H.	FR	Water Vapor, Satellite (microwave)
L'Ecuyer, T.	USA	Clouds, Precipitation, Satellite (radar)
Flamant, C	FR	Boundary Layer, Lidar, Field Studies
Kiemle, C.	DE	Water Vapor, Lidar, Field Studies
Schär, C.	CH	Meoscale Dynamics, Precipitation, Modelling
Siebesma, P.	NE	Clouds, Modelling, Parameterization
Stevens, B.	DE	Clouds, Field Studies, Modelling
Winker, D.	USA	Aerosol, Clouds, Satellite (lidar)
Zuidema, P.	USA	Clouds, Field Studies, Remote Sensing

TABLE 1. Synopsis of core team members.

expertise chosen to fill specific gaps. All team members are mid-career or senior scientists and many have a high international profile which will help ensure that the outcomes of the Study Project will be widely influential. Finally the team members are drawn from six countries, five within Europe and one within North America, hence the choice of Bern as the meeting place. In preparation for this proposal team members were drawn from a slightly larger group and whittled to eleven members based on the ability and interest of potential team members to commit the time required to attend the meeting and contribute amply to the expected outcomes. As such all team members have committed to participate fully in the meetings.

4. Expected Outcomes

The team will address its guiding questions through three activities which cut across the three questions. The first will be to write a review paper on the role of meso-β scale organization in determining patterns of tropical cloudiness and convection (self-aggregation). This will be targeted for publication in *Reviews of Geophysics* a highly rated journal of the American Geophysical Union. The second will be a shorter paper for a high-visibility journal such as *Nature* and *Science* which provides a perspective on observational needs and challenges pertaining to our understanding of clouds and circulation over tropical oceans. The third will be a refined experimental plan for EUREC^{4}A to optimize its ability to contribute to the evaluation of a new generation of space borne remote sensing, both the ADM-AEOLUS and EarthCare missions, and as a platform for prototyping new observational technologies that can be put in space. These specific activities will be taken up in parallel, i.e., each proposed outcome will be worked on at each meeting, and some will build on cooperations already developed in the preparation of the ISSI special issue arising from the 2016 ISSI Workshop.

Given the prominence of the Team members within their fields, and the importance of the topics being addressed (also for improved numerical weather predictions) we expect these outcomes to have substantial impact and to influence both the course of future experimental activities and space-borne measurements.