ORGANIZATION OF SHALLOW CONVECTION

ISSI TEAM ON SHALLOW CONVECTION
(BLYTH, BONY, BROGNIEZ, DELANOË, L'ECUYER, FLAMANT, HENTGEN, HOHENEGGER, KIEMLE, NAUMANN, SCHÄR, STEVENS, VIAL, WINKER, ZUIDEMA)

Questions

Shallow clouds in the trades exhibit rich forms of organization. Satellite and surface based observations show large mesoscale clusters with scales of tens to hundreds of kilometers, often crowned by a think stratiform cloud and capped by a pronounced hydrolapse. At other times networks of clouds, linked and regenerated by what appear to be colliding cold pools, can cover areas with a similarly large, or even larger linear dimension. On smaller scales individual cumulus are organized in wind-aligned rows or streets. To the extent clear patterns of organization emerges this seems to have less to do with the lack of organization and more to do with the overlapping of different patterns of organization. The question arises as to whether this organization matters. Does the organizational form of the clouds determines their radiative properties, or their efficiency in kinematic enthalpy transfer. And if it does, do the clouds or cloud processes actively contribute to the observed form of organization, or are they merely along for the ride, illuminating organized patterns of motion within the flow that arise as a result of instabilities quite unrelated to clouds and cloud processes?

To address these questions we initially propose to organize our thoughts around the following questions:

(1) Overview of cloudiness in study area.
(2) How can we characterize the form or degree of organization?
(3) How is the form of organization selected?
(4) To what extent do models capture these properties of cloud systems?
(5) Can our ideas suggest tests via new observational strategies, or new observations?

These are briefly expanded upon below, along with planned contributions of different team members. At the very end we summarize what everyone articulated as their proposed contributions. Contributions from those who could not attend the meeting are still very welcome.

Proposed Study Area

We agreed that our analysis would focus on the following study area:

- Between 20°W - 60°W and 10°W - 30°W. For geographic analysis we would look at grid boxes of $5^\circ \times 5^\circ$.

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- The three month periods of December-February, starting with December 2006 and concluding at the end of February 2017 for a total of 33 months. We recognize that some products are only available for a portion of this time, but then we would take whatever overlap exists.

1. Broad scale patterns of cloudiness and co-variability or representation in other meteorological fields

We will look at the statistics of CloudSAT (l'Ecuyer) and CALIOPI (Winker) objects in 5×5 degree boxes over the study area. This summary view will be complemented by an analysis of the SAPHIR (Brogniez) humidity data, and also flight level data from NARVAL-1 (Kiemle). Also GERB climatology (Keller-Schär). Particularly interesting would be if we could identify specific cases of apparent forms of organization using a combination of the satellite and flight level data. This could also serve some of the planned microphysical analyses.

Another question in this context is to what extent the cloud forms seen in the study area are also evident near Ascension Island over the south Atlantic, or perhaps in flights data from the North Pacific, as part of a study Paquita was involved with.

2. How can we characterize the form or degree of organization?

Here we will develop or apply different measures of convective organization. Different approaches will be explored. For instance Pier will use geometric approaches, and Sandrine will look at SCAI measures. Here some coordination and communication is important. Links to Cathy Hohenegger's project as part of HD(CP)^2 also would be worth exploring. We discussed different datasets to work with. Suggestions include: (i) MODIS cloud mask; (ii) MODIS shortwave reflectances; (iii) GERB data. For the second point their was some concern that this might be too influenced by sun angle effects but focusing on the Dec-Feb period minimizes the effect of sun-glint and when combined with the fact that the overpass times are fixed this also simplifies the analysis and makes it worth looking directly at MODIS shortwave reflectance. For the third point there was some concern that the GERB pixesl might be too large, but after checking it appears that the GERB product is at 10 km resolution and would be useful.

3. How is the form of organization selected?

Ann Kristin proposed to look in the ICON simulations to see if she could identify dynamic signatures of different forms of organization, not unlike what has been done for radiative-convective equilibirum. We also discussed perhaps considering to what extent the importance of cloud-scale dynamics, cold pools could be identified based on model simulations that Alan proposed to analyze. Another open question was to what extent precipitation helps select certain forms of organization, for instance the open networks as compared to more pancake cloud forms. Alternatively some of Helene's analysis could contribute to better understanding the large-scale context for organization. Compositing on organizational indexes as being developed by Pier and Sandrine might also help answer this question.

4. What do the models say?

Initially Bjorn will focus on an analysis of the ICON simulations to see if forms of organization can be identified in these, pehraps in coordination with the HErZ group led by Cathy. This will be compared to larger-scale simulations performed with ICON and ECHAM. Christoph and Laureline will prepare first simulations with COSMO and coordinate with Hamburg regarding the analysis of the simulations. Alan's work may also contribute to understanding to what extent we can explain particular features seen possible case studies identified from the flight data.

5. Developing testable ideas?

One goal of the analysis would be to develop ideas that we can test with existing observations, or which might guide new observations, particularly those being planned for EUREC^{4}A. This is something for us all to keep in the back of our mind.

6. Sentences

6.1. **Blyth:** will have a first shot at reproducing the life cycle of the clouds, with microphysics details included. In other words, the production of rain and the detrainment layer(s), the downdraft, the spreading cold pool with front, and the new clouds. I would look at the drop size distribution in the cloud and detrainment layers and also the raindrop size distribution, etc. Compare all that to the lidar, radar and satellite observations.

6.2. **Bony:** Characterize the mesoscale organization of shallow convection in different ways (e.g. using geostationary or MODIS data) and investigate the influence of organization on the large-scale cloud fraction and albedo. And maybe: investigate the dependence of organization on large-scale environmental conditions.

6.3. **Brogniez:** Will look at the diurnal cycle of wv associated to the formation of the Sc. My idea is to composite the data according to the time (UT) of obs of SAPHIR within the NARVAL domain, but also the Sc associated to the Benguela current in the Southern Atlantic. And I will look at the whole SAPHIR profile (top to bottom layer).

6.4. **L'Ecuyer:** Short-term: (1) We'll generate basic climatologies of cloud macrophysical characteristics (fraction, height, vertical structure), rain fraction, cloud forcing, vertically-resolved heating/cooling rates, etc. for each 5x5 degree box from 10-30 N and 20-60W from the A-Train data products; (2) We'll generate some characteristic cross-sections/imagery for some sample aggregated and disorganized scenes. Longer-term: We'll repeat (1) but stratified by three instantaneous measures of shallow convective aggregation in each 5x5 grid box supplied by Sandrine adding vertical profiles of cloud impacts on radiative heating and radiative cooling in surrounding clear-sky regions.

6.5. **Kiemle:** Will: (a) for different cloud cluster and cloud gap morphology, investigate statistics of lidar obs (cloud fraction, top height, moisture environment); (b) sort wv lidar profiles after occurrence of height of topmost cloud to ease comparisons with models; (c) lidar analyses of A-Train underf-lights to see how well Calipso and CloudSat see the trades.

6.6. **Naumann:** Will look at the ICON NARVAL simulations in terms of shallow circulations, possibly in connection to radiative cooling and convective organisation. Can we find situations (case studies) where convective organisation is supported by a shallow circulation? Do the radiative cooling rates in these areas match those expected from our conceptual model?

6.7. **Schär:** 1) We will set-up a modeling domain and conduct first simulations over the tropical Atlantic, initially at 12 km resolution, then at 2.2 km resolution. We will start with simulations for December 2013. The 12 km domain should cover the NARVAL domain (or larger). Ma be Laureline could visit MPI later this year if we get anything interesting, with the intent to work on an intercomparison with the MPI simulations. We intend to involve Michael Keller (currently working as a post doc in our group) for the analysis of MSG images, with the intent to create a climatology of GERB products. We have some experience over the Alpine and European domain. The climatology should give an idea of the mean diurnal and seasonal cycles as well as interannual variations for about a 10 to 15 year period. Whether we can do this work depends upon the career plans of Michael. The work would be restricted to MSG and not address detailed cloud structure. We would be happy to provide results to groups working at high resolution on cloud organization.

6.8. **Siebesma:** I will try to have a go with analysing the MODIS images during the NARVAL I period on their geometrical properties. I have to think about the precise details but it probably will include cloud fraction, cloud size distribution for different effective resolutions. I also would like to have a look on how to characterize "organisation" for these structures. Probably this will be done using the cloud fraction since that is easiest, but preferably with something that has a more meaningful weight on top of this such as optical depth or reflectivity or albedo. As a follow up it would be nice to use MSG/GERM (or GOES in a later stage) to look at time-development to see how these (statically) observed structured develop.

6.9. **Stevens.** Will analyze ICON simulated cloud fields, focusing on December simulations. Do clouds qualitatively capture features seen in satellite climatologies, and do they exhibit similar forms of organization For context will compare with Transpose AMIP simulations using ICON/ECHAM and possibley other models.

6.10. **Winker:** Will Initially look at statistics on 5x5 degree boxes from CALIPSO Level 3 cloud product. Also, Identify vertical structure of shallow clouds: LCL, trade inversion ... When are the cloud shields transparent/opaque? Can CALIPSO tell us about microphysics, radiation?

6.11. **Zuidema:** Plans to compare and contrast thermodynamic and large-scale conditions between Barbados (as a proxy for the NARVAL campaigns) and Ascension. Can include the NARVAL dropsondes also.