EUREC^{4}A

Elucidating the role of cloud-circulation coupling in climate

EUREC^{4}A: A field campaign to elucidate the couplings between clouds, convection and circulation

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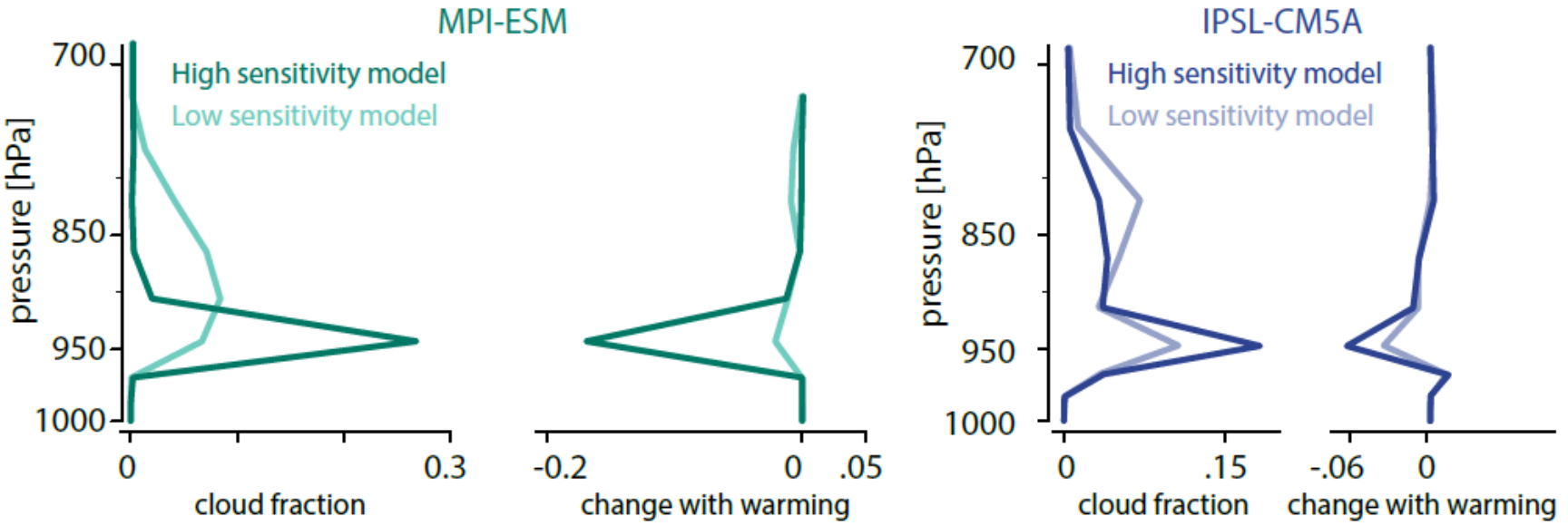
Bony, Stevens et al., Surveys in Geophys. (2017)


The original motivation:
What controls the shallow cumulus cloud amount?

High-sensitivity climate models predict a dessication of clouds at their base



→ How sensitive is the cloud-base cloud amount to changes in environmental conditions?

→ How does the shallow cumulus cloud amount depend on the strength of convective mixing in the lower troposphere, large-scale vertical motions, surface turbulent fluxes, radiative effects?

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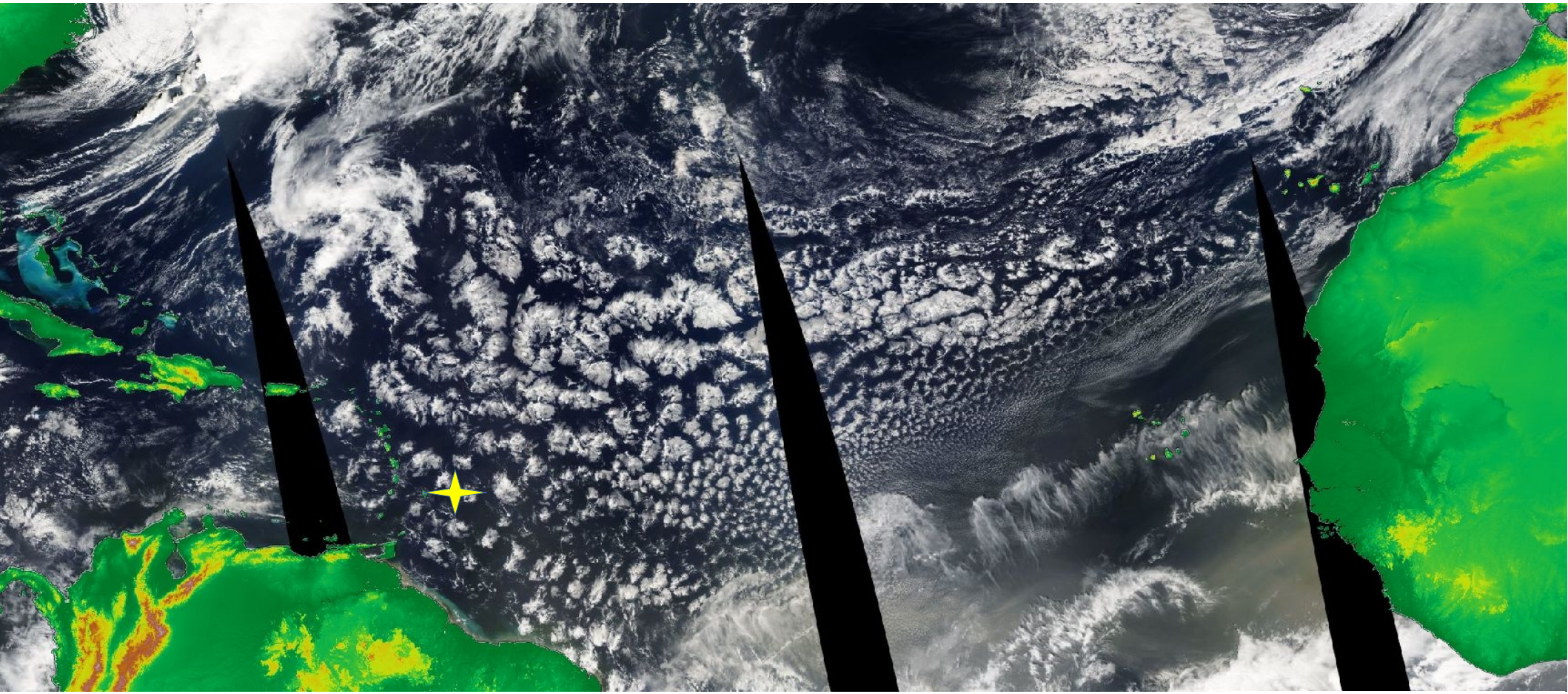

- A French-German initiative in support of the WCRP Grand Challenge on *Clouds, Circulation and Climate sensitivity*
- Will take place near Barbados (13N, 59W) from 20 Jan to 20 Feb 2020

WCRP
World Climate Research Programme

eurec4a.eu

EUREC⁴A

Elucidating the role of cloud circulation coupling in climate

EUREC⁴A has been designed to answer the questions:
What controls the trade-wind cloud amount and radiative properties?

More specifically: how do the shallow Cu properties (e.g. cloud base cloud fraction) depend on:

- boundary-layer turbulence
- strength of lower-tropospheric mixing (convective mass flux)
- large-scale circulation
- mesoscale organization

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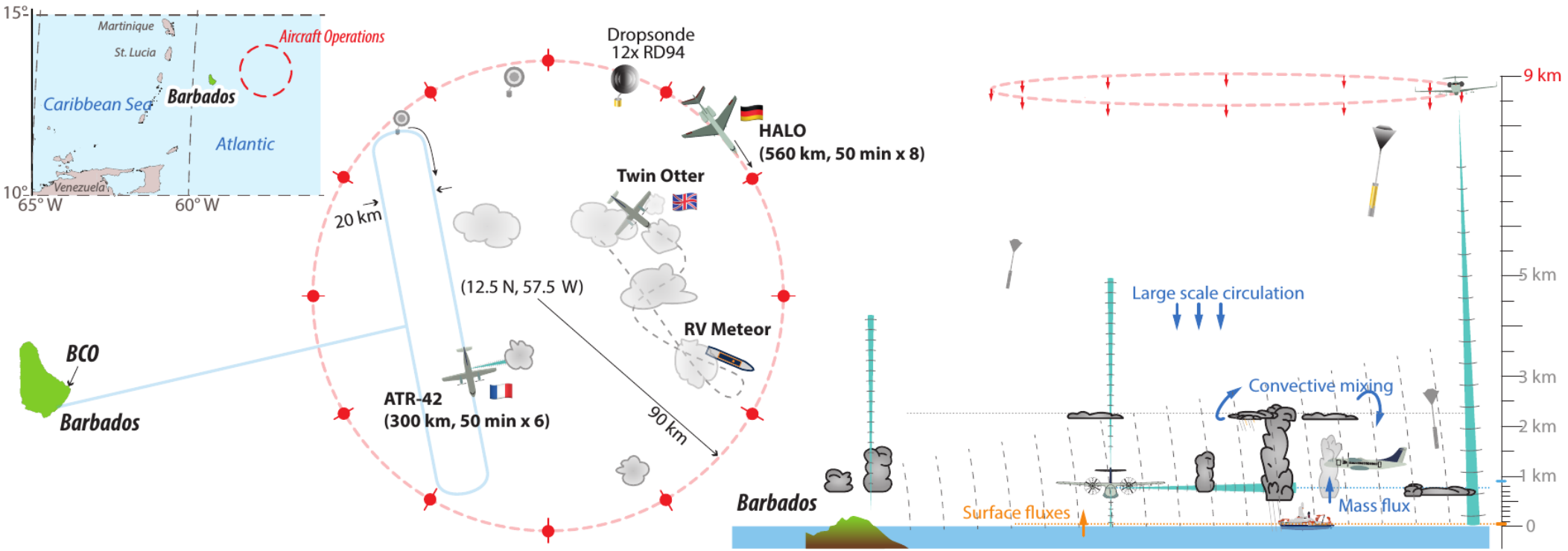
Approx. 200 flight hours (100h HALO + 100h ATR)

EUREC⁴A flight strategy

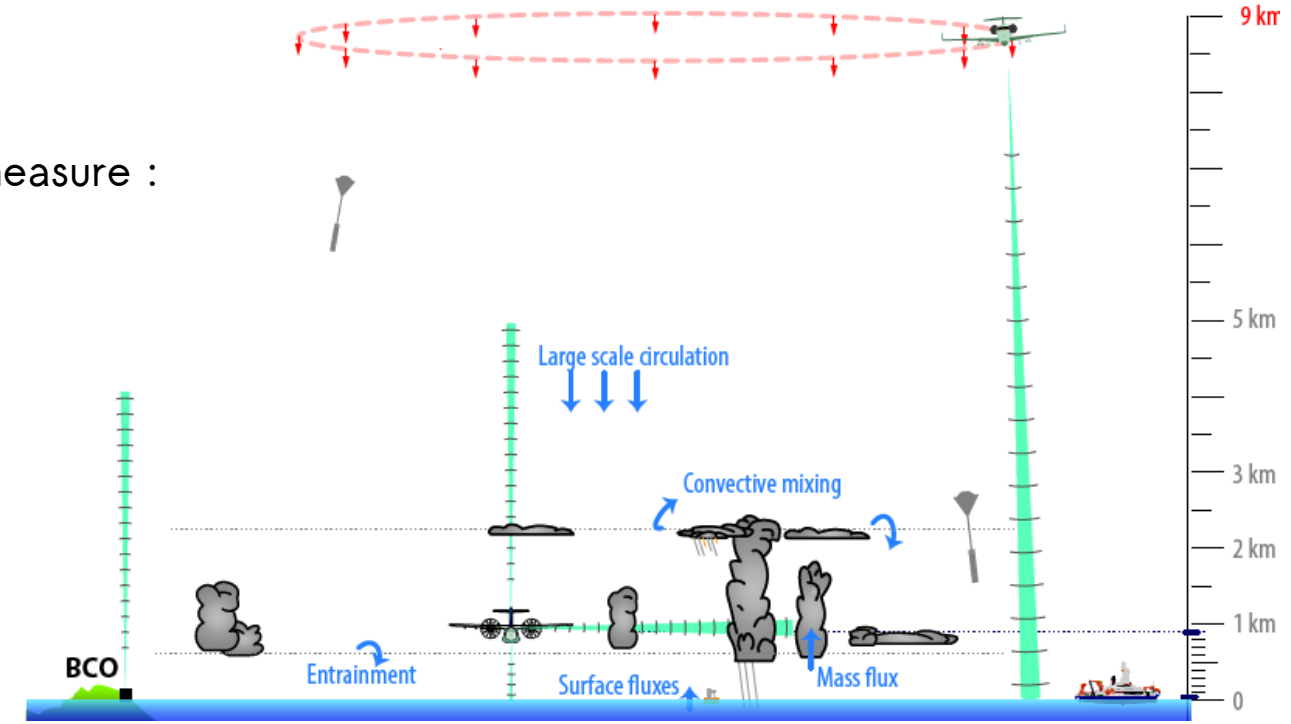


- HALO will fly in the upper troposphere: launch dropsondes, characterize cloud macroscopic conditions and remotely sense microphysical properties (lidar, radar, radiometers)
- The ATR-42 will fly in the lower troposphere: subcloud-layer and cloud properties (cloud-base cloud fraction, cloud water, microphysics, precipitation, isotopic composition), turbulence, radiative fluxes and SST
- Surface measurements (Barbados Cloud Observatory) will provide complementary remote sensing (water isotopes, microphysics) and will constrain the surface energy budget

New methodologies

The experimental strategy rests on the premises that it is possible to measure :

- Large-scale vertical motion
- Cumulus mass flux
- Cloud fraction at cloud base



These premises have been, or are currently being tested using past field campaigns (NARVAL2), LES simulations, instrument simulators and experimentation with an ultralight aircraft.

Can we measure the large-scale vertical motion?

NARVAL2 airborne field campaign (Stevens et al., BAMS, 2019)

- 8-28 Aug 2016, near Barbados

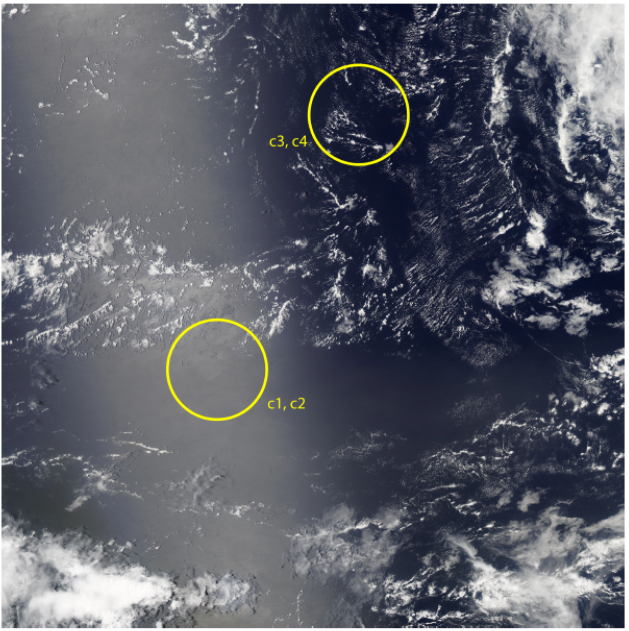
Test the possibility to measure divergence profiles by using dropsondes (Bony & Stevens, JAS, in press)

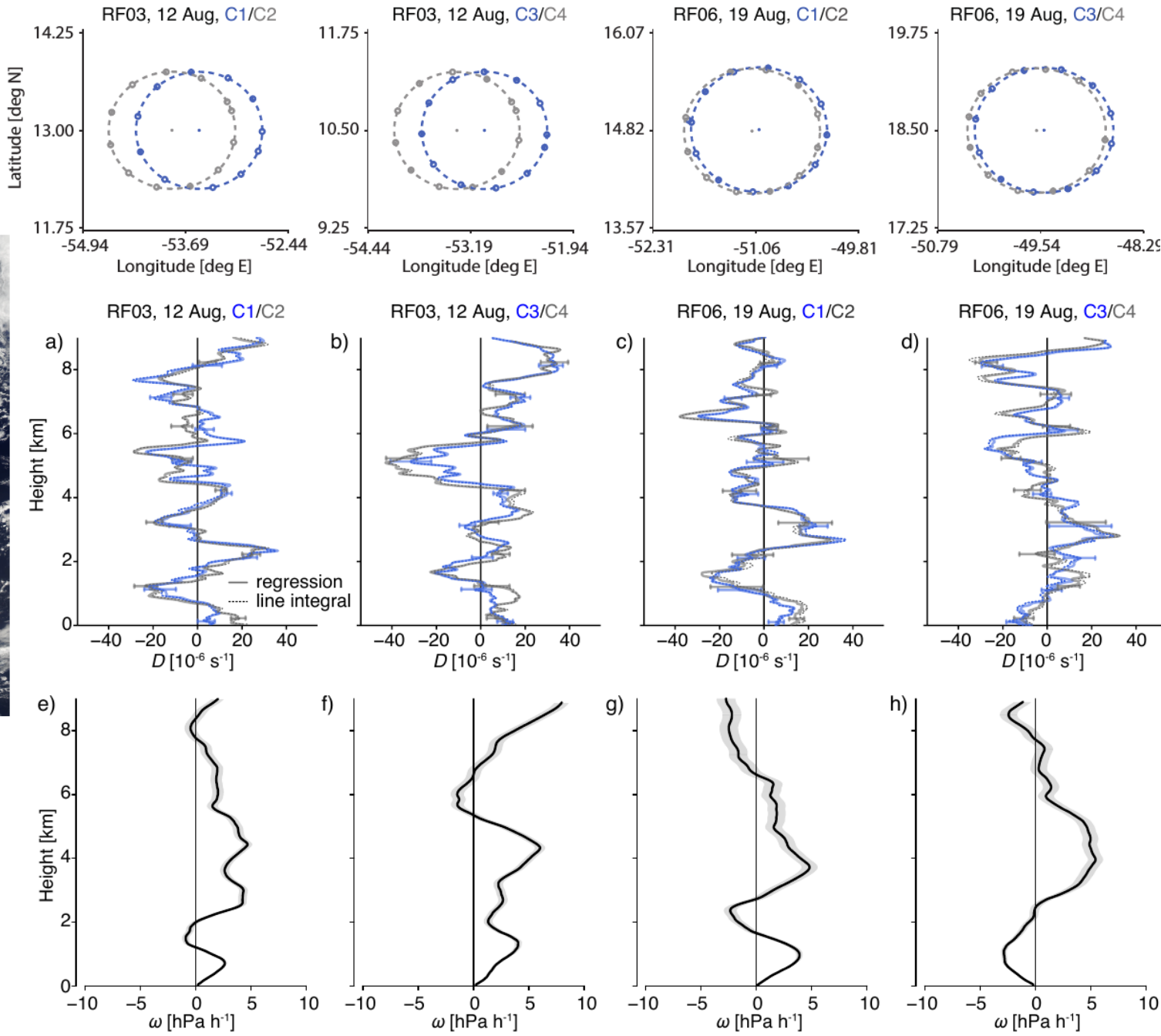
- HALO aircraft, circular flights, radius ~80-90 km, 45-50 min
- 12 dropsondes along each circle (i.e. one every 4 min)
- Wind profiles measured by GPS dropsondes

NARVAL
next-generation aircraft
remote-sensing for
validation studies

Divergence and area-averaged vertical velocity measurements

RF06, 19 Aug 2016





Bony and Stevens, JAS (in press)

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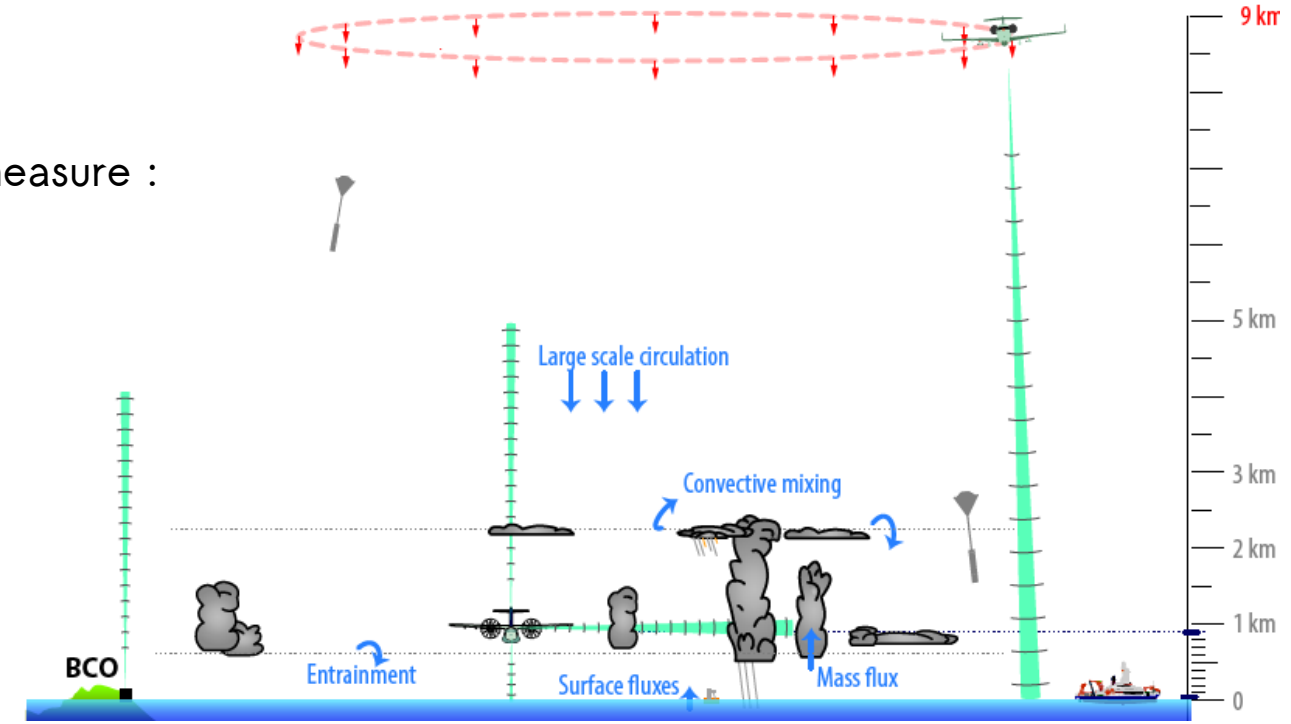

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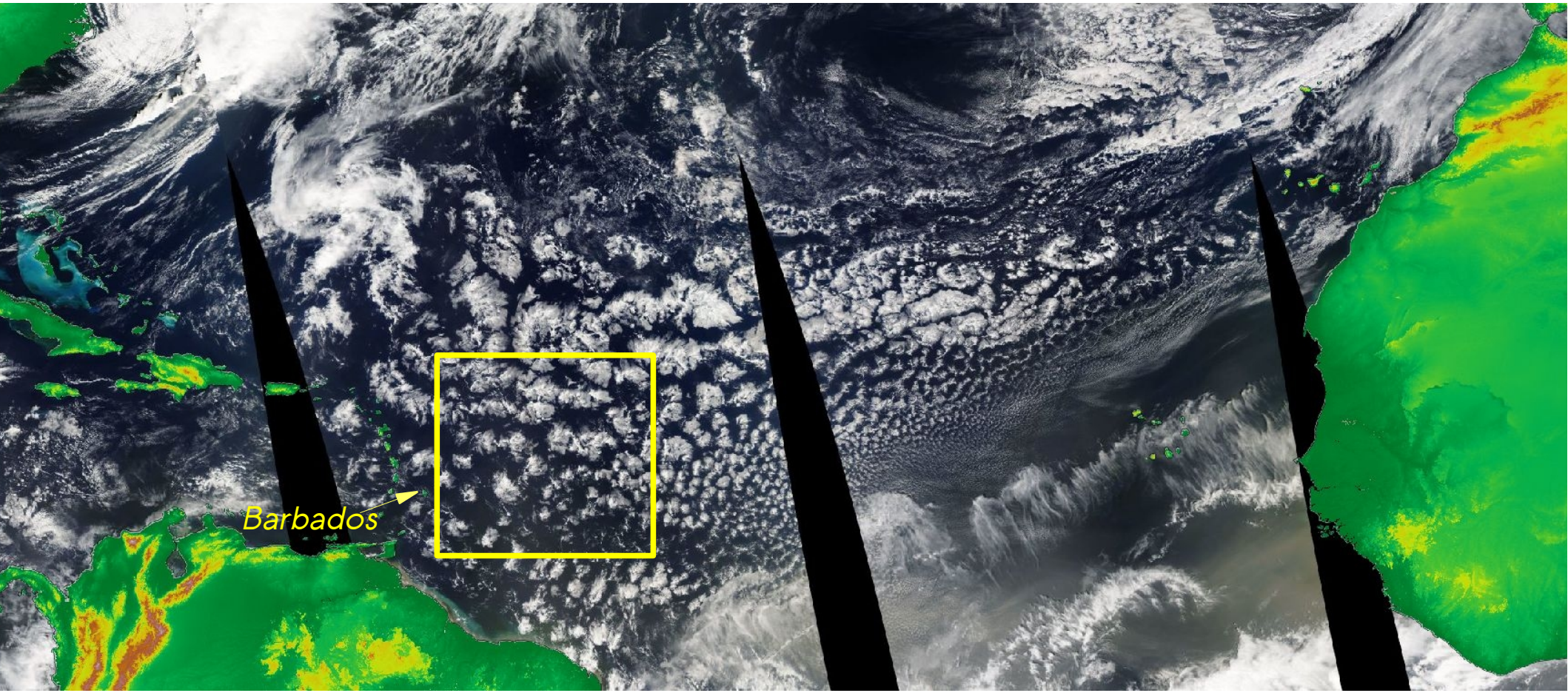
Mesoscale organization of shallow clouds in the winter trades



MODIS Aqua 10 Feb 2017 (NASA Worldview)

Does it matter for radiation? Could it matter for cloud feedbacks?

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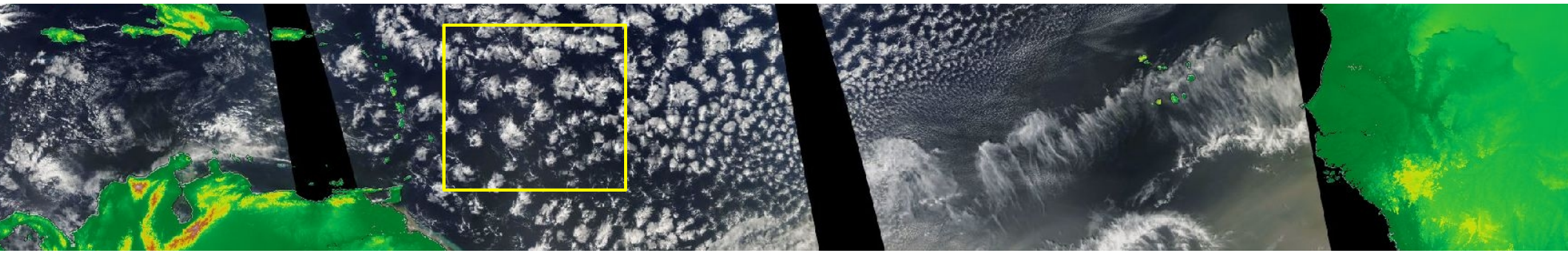

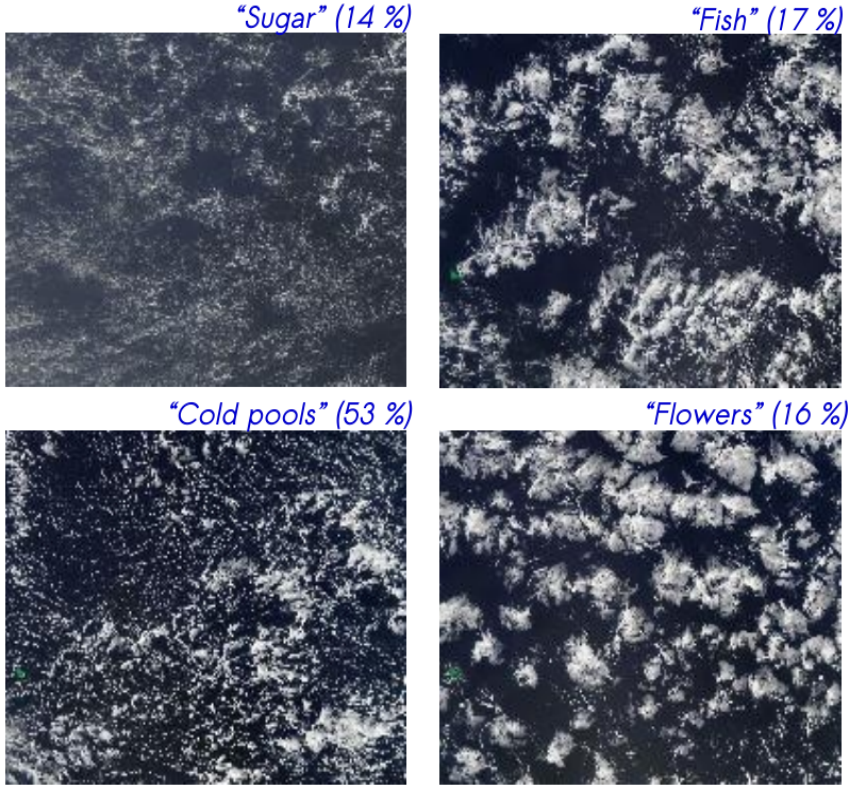

- 4 main patterns of convective organization
- Large variability at daily and interannual time scales

Stevens et al. (in preparation)

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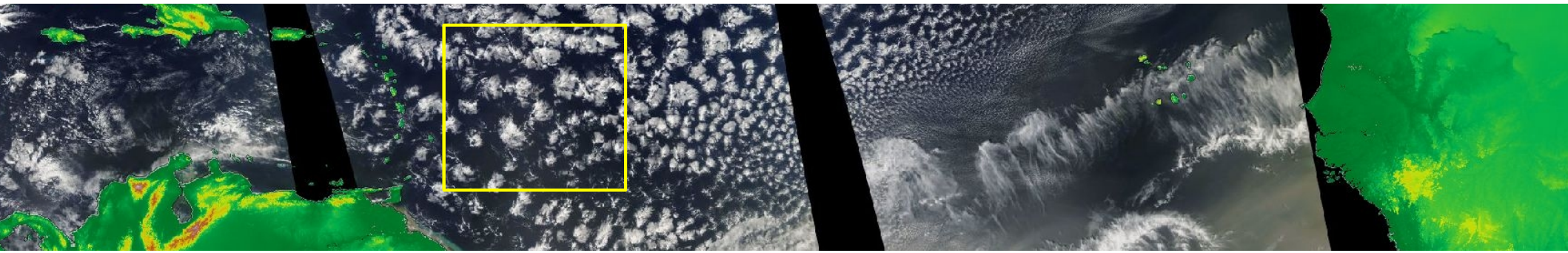

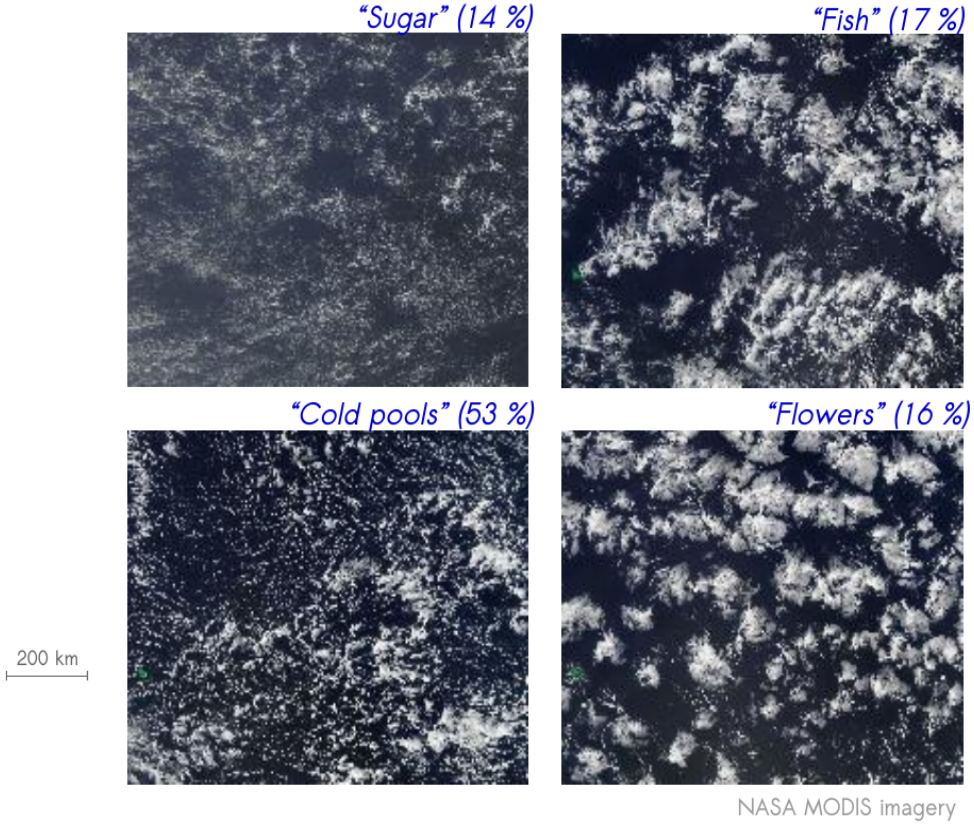

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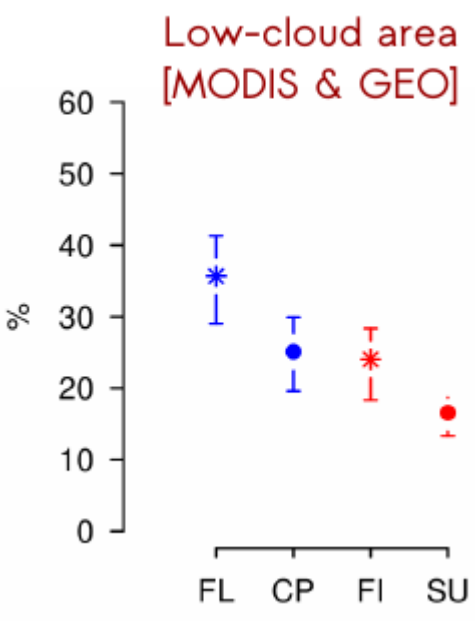

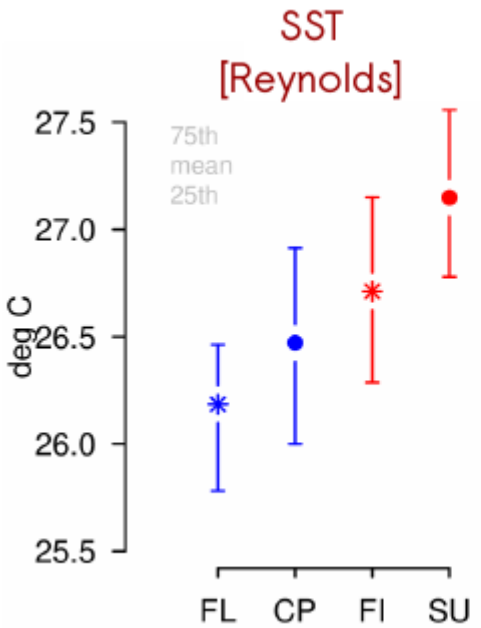

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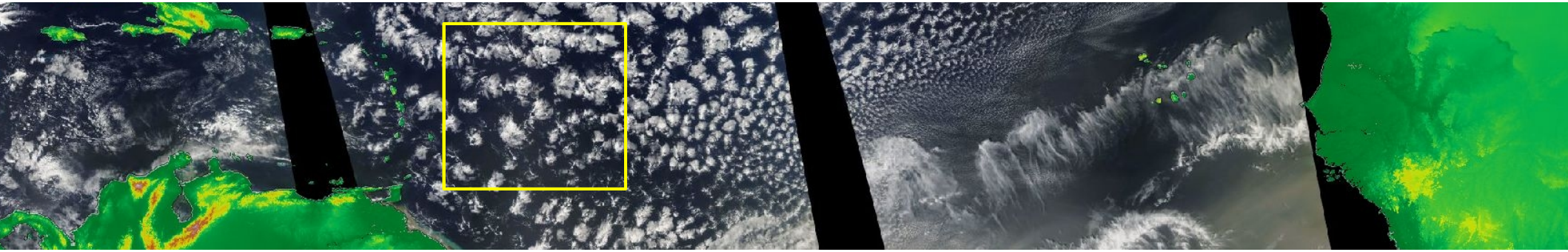
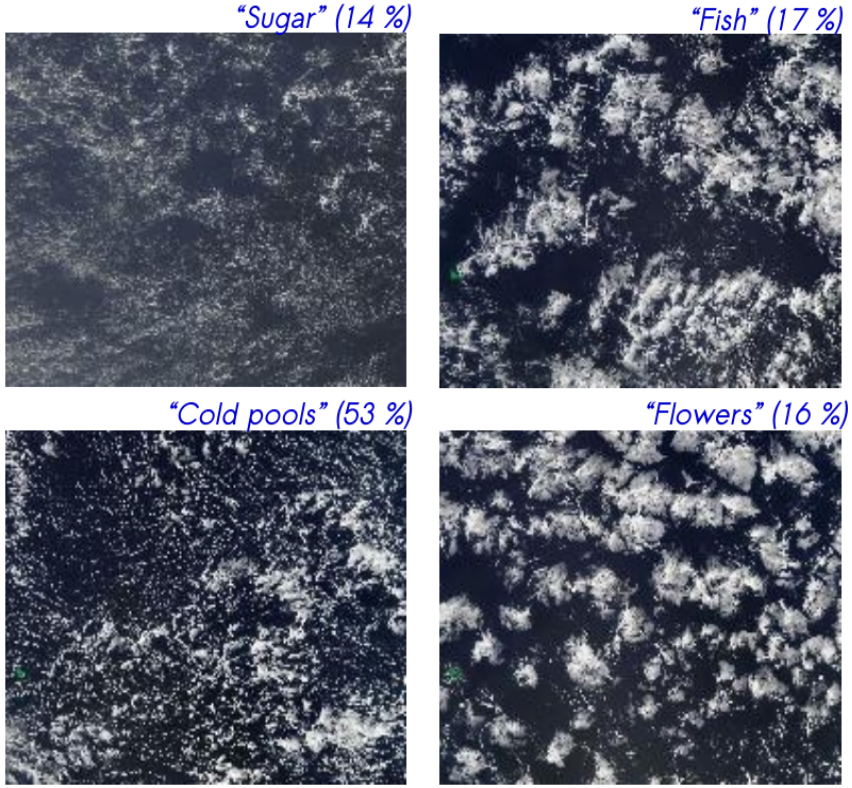




NASA MODIS imagery

- 4 main patterns of convective organization
- Large variability at daily and interannual time scales

Additional EUREC4A objectives:

→ controls of the mesoscale patterns of cloudiness?

→ surface vs atmospheric processes?

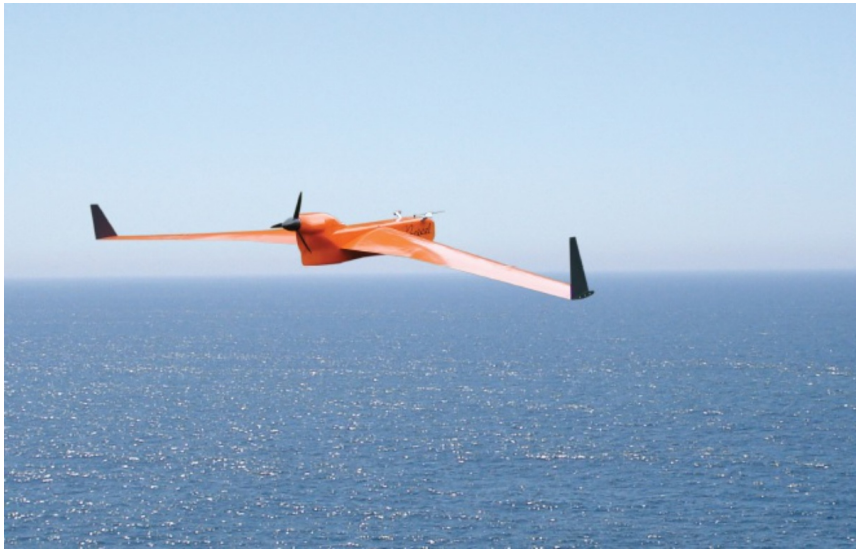
→ sub-surface, surface and near-surface measurements

→ fine-scale modeling

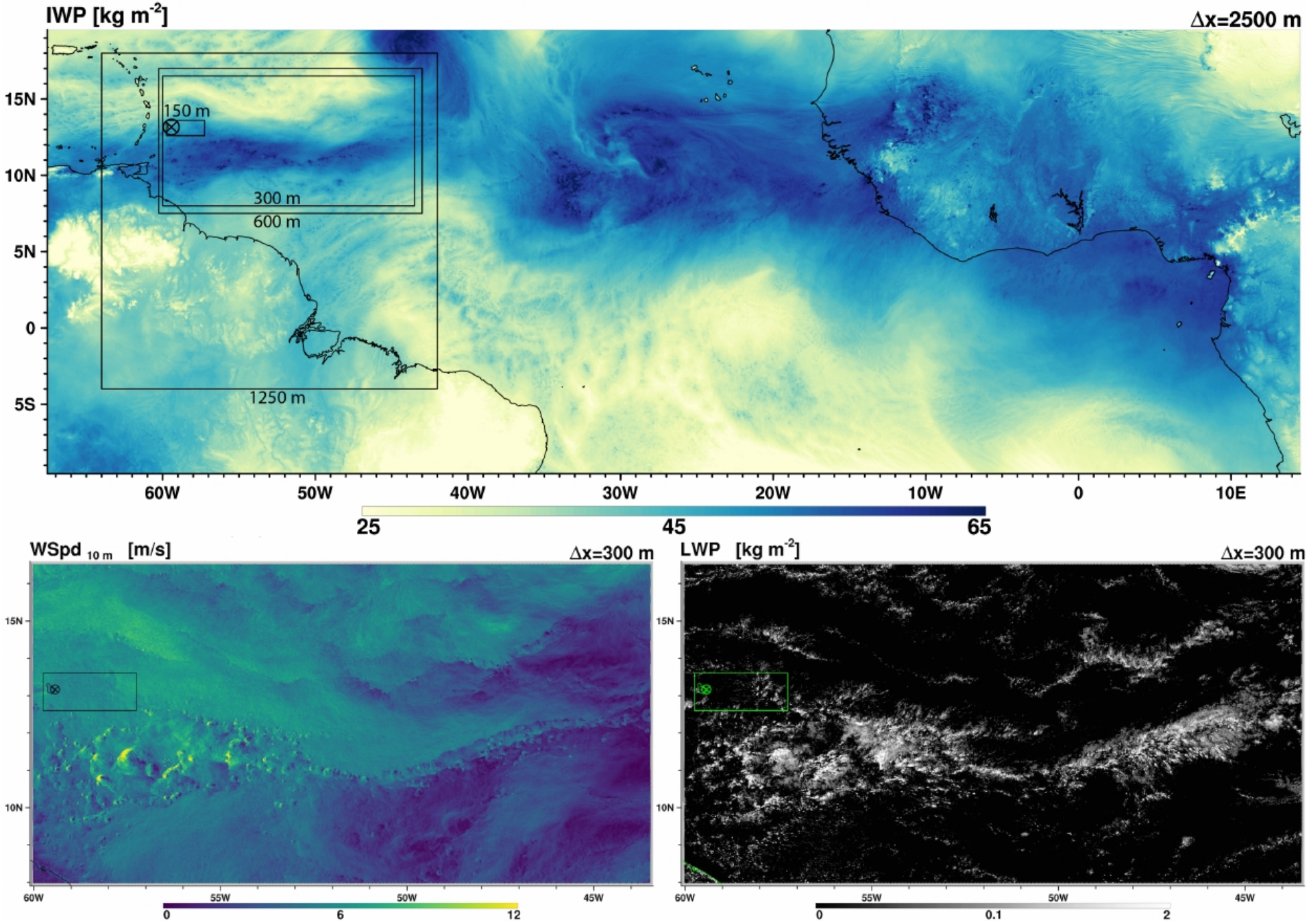
Mesoscale variability of T, q, turbulence, radiation in the subcloud layer

- aircraft data (HALO dropsondes, ATR in-situ)

- Boreal UAV (CNRM)



High-resolution atmospheric modeling (CRM, LES)



Stevens et al., BAMS (in press)

EUREC⁴A

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If successful, EUREC⁴A will:

- help assess the shallow Cu cloud feedback, which remains one of the main sources of uncertainties in model estimates of climate sensitivity
- provide a benchmark data set for a new generation of high-resolution models and satellite remote sensing designed to resolve clouds.
- quantify the role of the mesoscale in determining cloud properties

Together with EUREC⁴A-OA/ATOMIC, it might become the first framework to explore the role of the mesoscale on the atmosphere, the ocean and air-sea interactions.