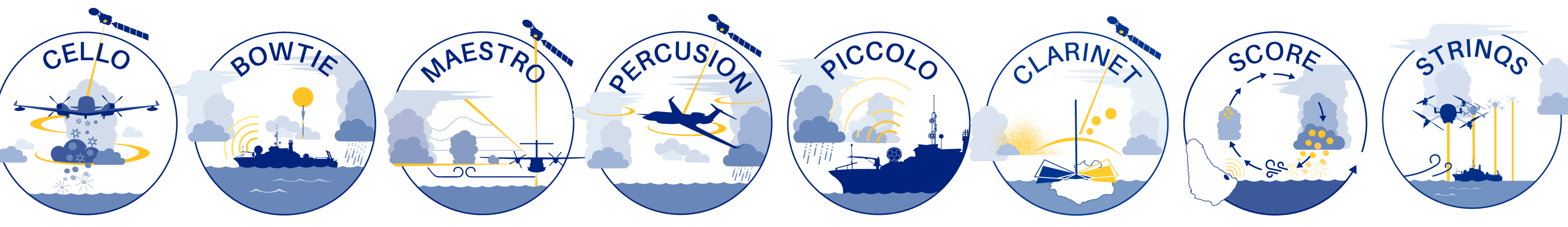


ORCESTRA

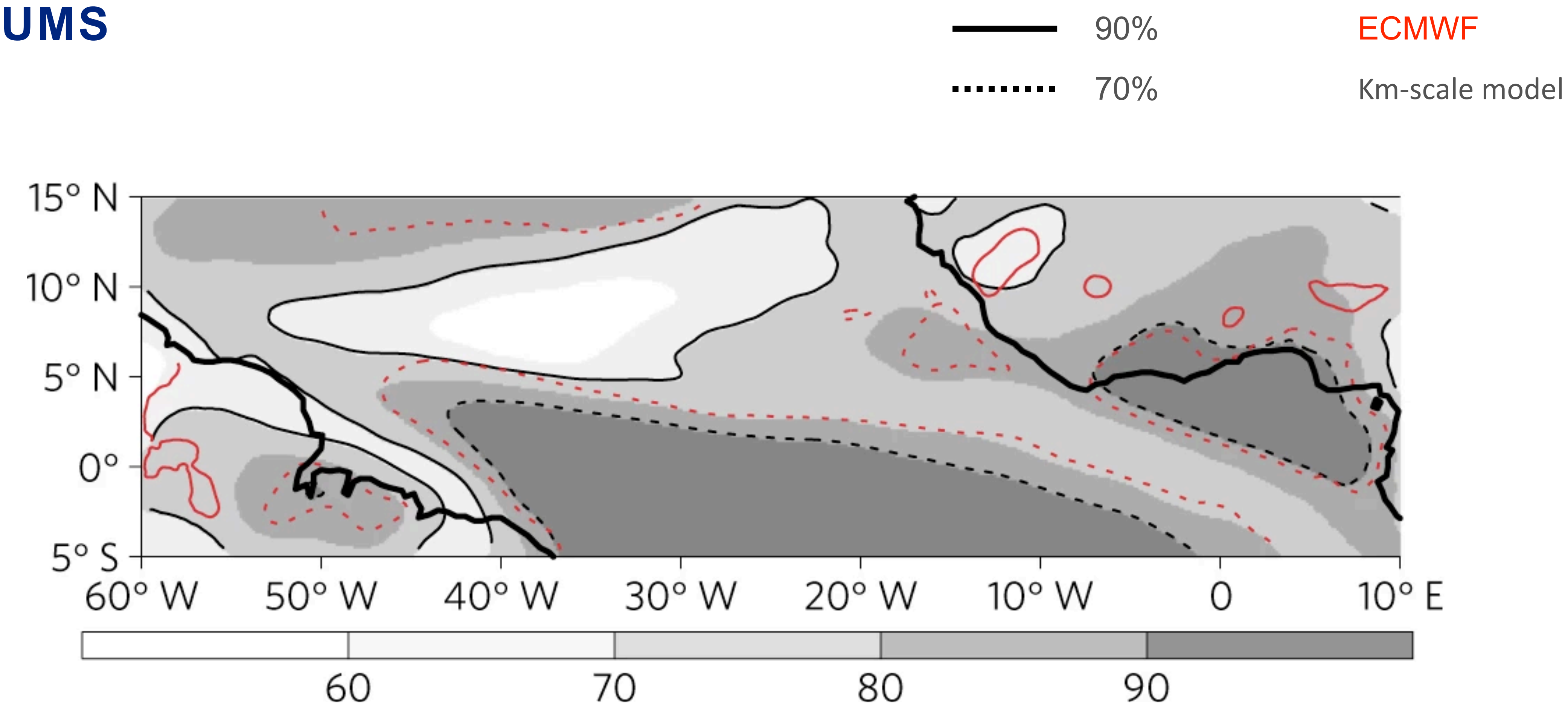
ORGANISED CONVECTION AND EARTHCARE STUDIES OVER THE TROPICAL ATLANTIC

Daniel Klocke, Julia Windmiller, Bjorn Stevens, Sandrine Bony, Silke Gross, Allison Wing, Raphaela Vogel, Julien Delanoë, Hans Segura, Tim Carlsen, Robert David, Geet George

The inner life of the ITCZ is unknown

- Classic picture: A line of surface convergence with clouds and precipitation centred on it
- Convection organises along the edges with scattered convection in-between
- Surface interactions are driven by meso-scale systems (energy and carbon)

DOLDRUMS



Percentage of time, the wind is blowing in the mean wind direction (August 2016)

Klocke et al. 2017

MODELING — COUPLED GLOBAL STORM-RESOLVING

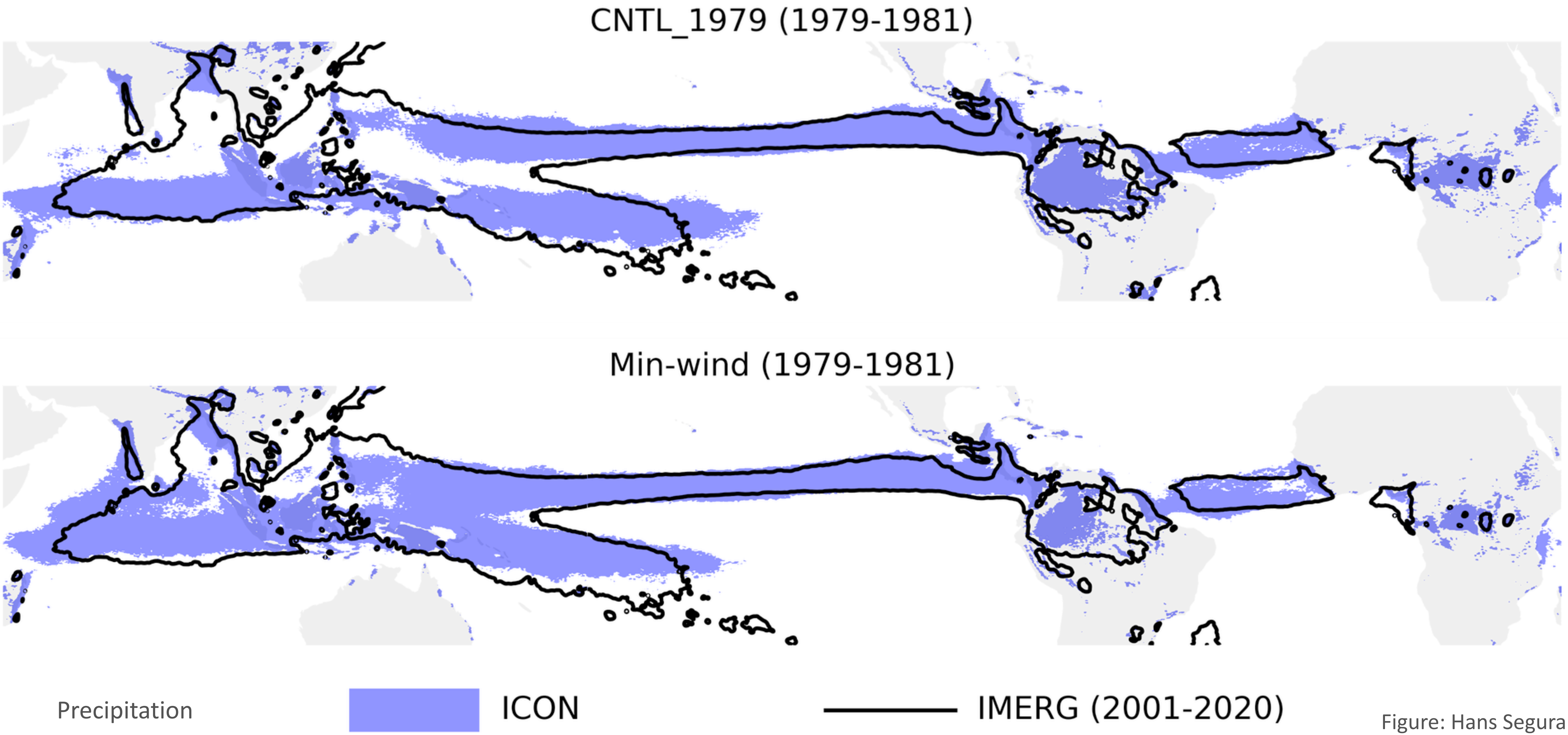


Figure: Hans Segura

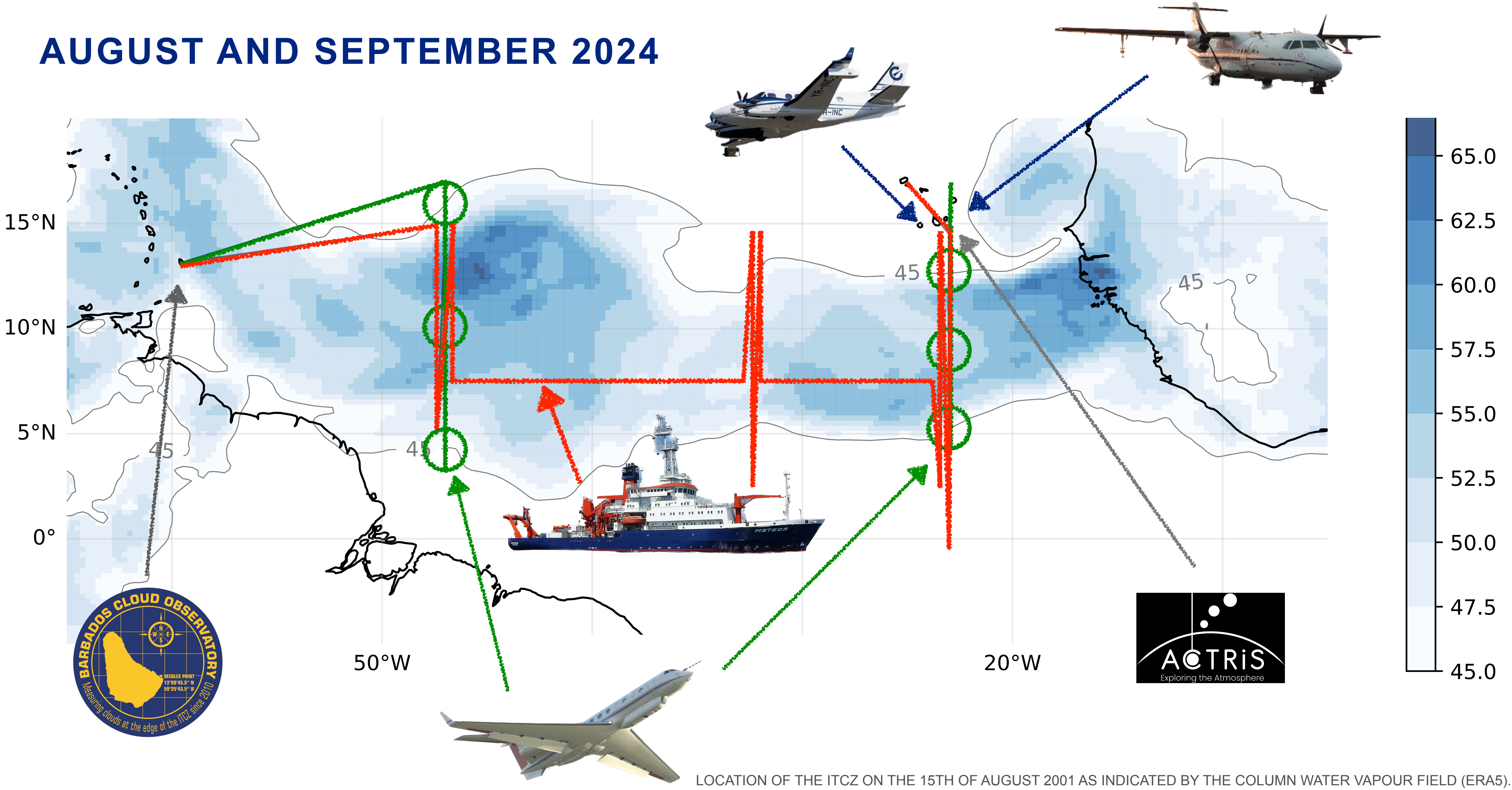
AUGUST AND SEPTEMBER 2024

ORCESTRA — Organised Convection and EarthCare Studies over the Tropical Atlantic

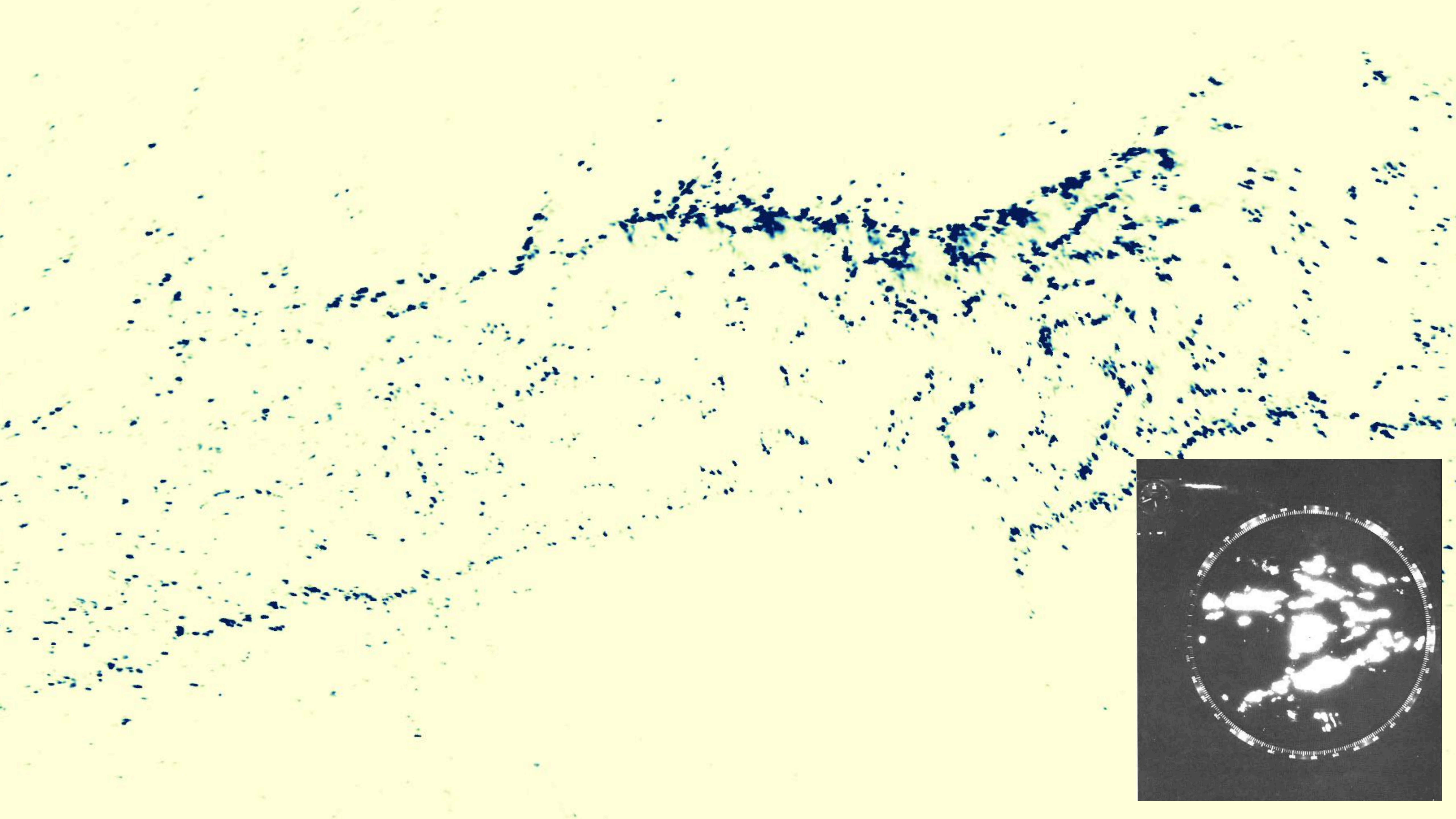
OBJECTIVES:

- What organises tropical convection at the mesoscale?
- How important is this organisation for the tropical circulation, the general circulation and climate?
- Calibrate and validate satellite remote sensing (EarthCARE)
- Serve as a benchmark for a new generation of high resolution storm resolving climate models

AUGUST AND SEPTEMBER 2024



LOCATION OF THE ITCZ ON THE 15TH OF AUGUST 2001 AS INDICATED BY THE COLUMN WATER VAPOUR FIELD (ERA5).



JUNE TO SEPTEMBER 1974

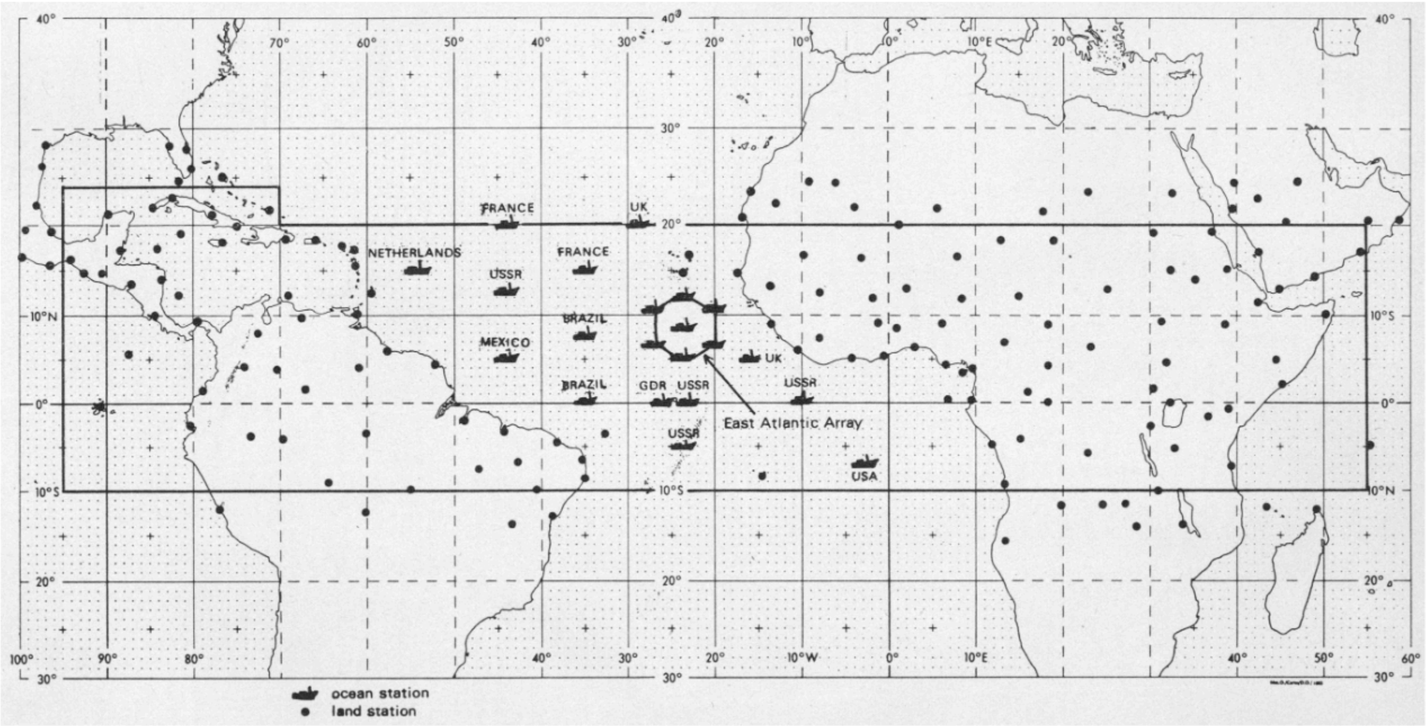


FIG. 1. Ship and land observing network during GATE. Note: the ship distribution changes slightly from phase to phase. For the 17 ships of the East Atlantic array refer to Fig. 6.

Kuettner (1974)

GATE — **G**lobal Atmospheric Research Program's (GARP) **A**tlantic **T**ropical **E**xperiment, the largest atmospheric field program of all time (Zhang et al., 2022).

JUNE TO SEPTEMBER 1974

GATE — **G**lobal Atmospheric Research Program's (GARP) **A**tlantic **T**ropical **E**xperiment, the largest atmospheric field program of all time (Zhang et al., 2022).

G A T E   C E N T R A L   P R O G R A M M E

OBJECTIVES: 1. Provide a means of estimating the effects of smaller scale tropical weather systems on the larger scale (synoptic-scale) circulations

2. Facilitate the development of numerical modelling and prediction methods.

Kuettner (1974)

results of GATE show that to simulate the effects of tropical convection in large-scale numerical models of the atmosphere a variety of phenomena must be accounted for, including not only convective-scale updrafts and downdrafts but anvil clouds with mesoscale updrafts and downdrafts, downdraft-induced boundary layer transformations, and mesoscale convergence patterns.

Houze and Betts (1981)

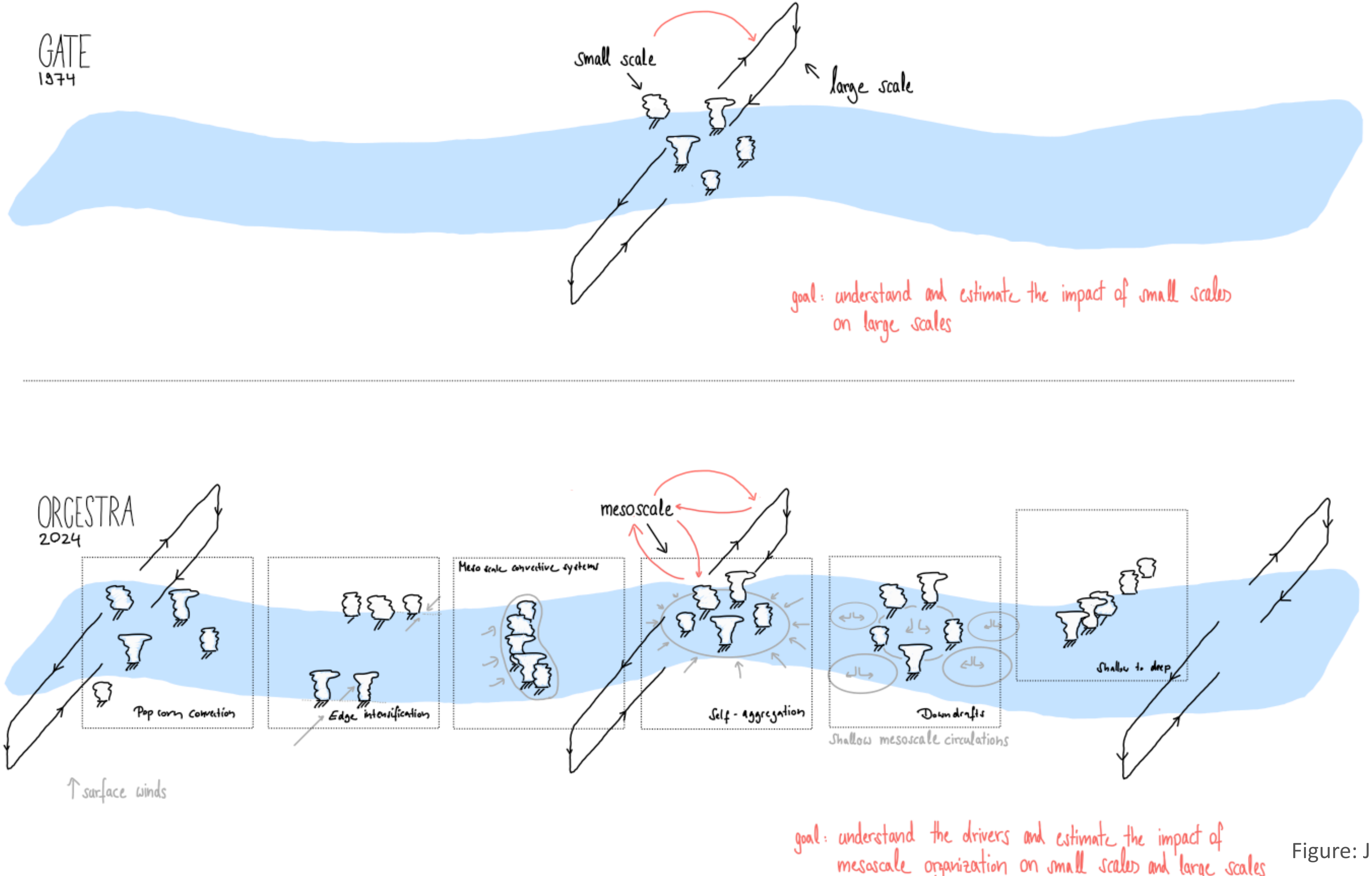
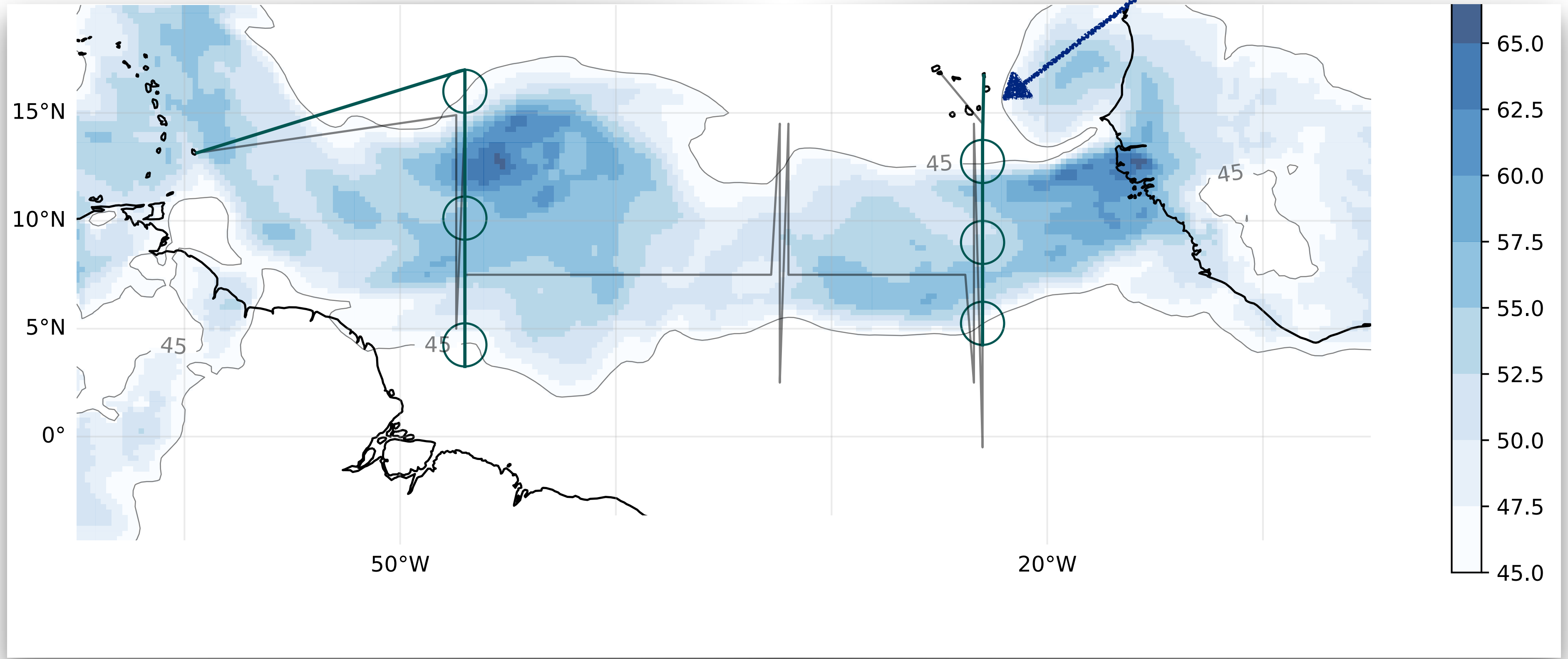


Figure: Julia Windmiller

MAESTRO — MESOSCALE ORGANISATION OF TROPICAL CONVECTION



Lead PIs: Sandrine Bony (LMD), Julien Delanoë (LATMOS), Jean-Christophe Canonici (SAFIRE)
Contact: Sandrine Bony (https://maestro.aeris.data.fr)

MAESTRO — MESOSCALE ORGANISATION OF TROPICAL CONVECTION

OBJECTIVES:

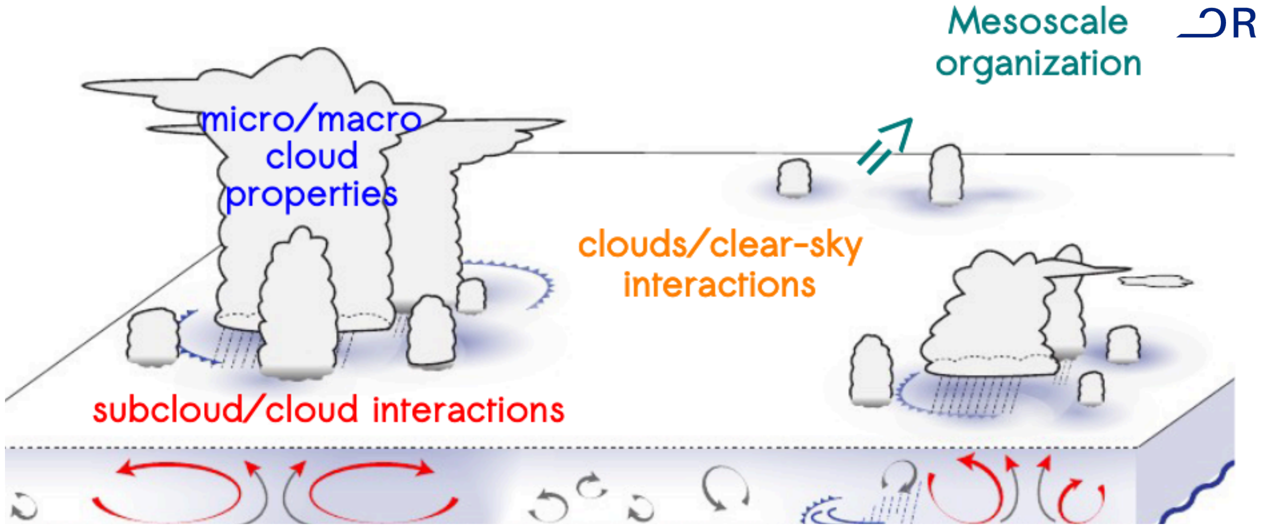
- Unravel the physical mechanisms that control the mesoscale organisation of convection
- Understand how the mesoscale organisation of convection affects the Earth's radiation budget
- Contribute to the EarthCARE CalVal

Airborne field campaign near Cape Verde

→ SAFIRE ATR-42 equipped with an exceptional instrumentation

→ in-situ probes and sensors (turbulence, microphysics, radiation)

→ Doppler cloud radars and lidars probing the atmosphere in multiple directions



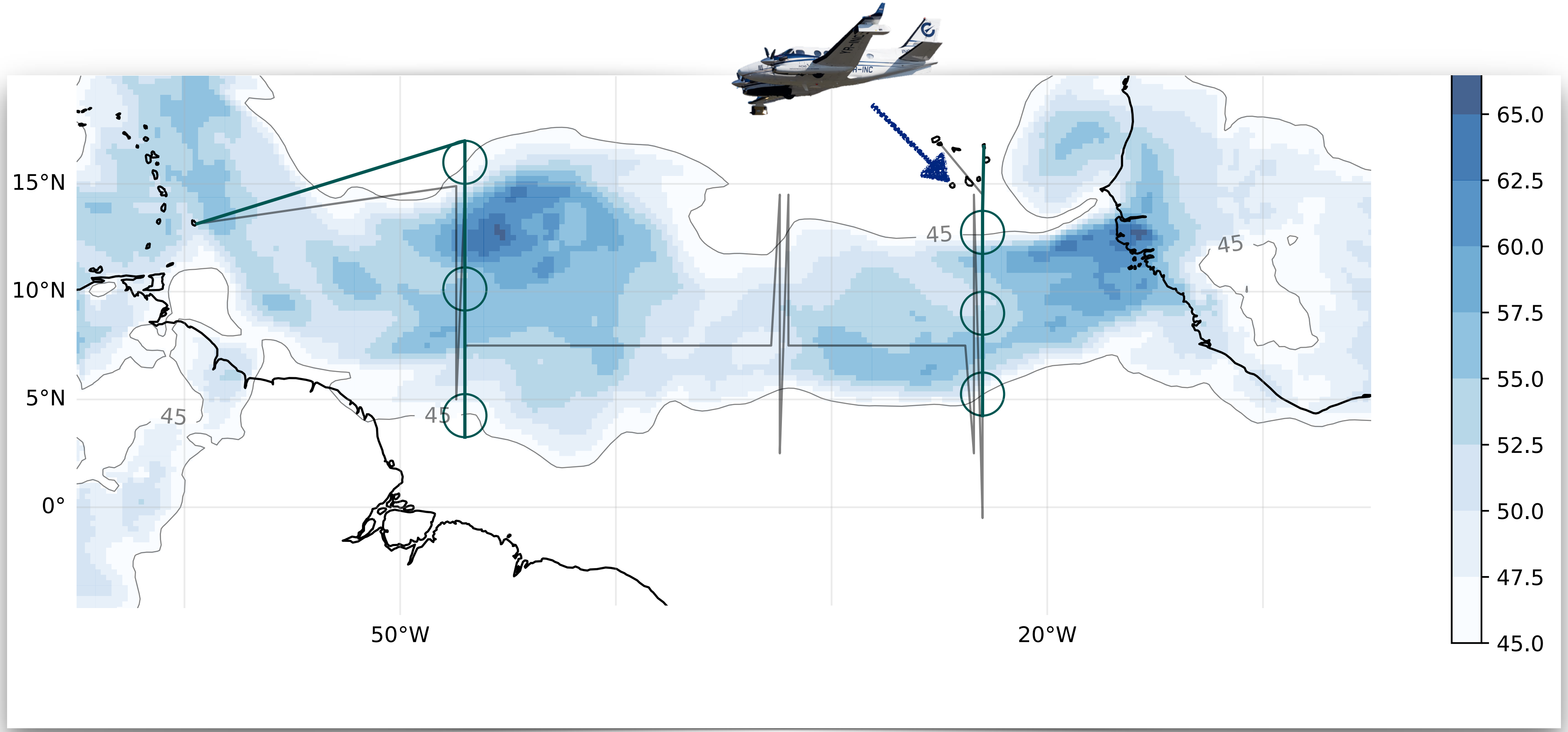
How do the interactions between clouds and their environment control the mesoscale organization of convection?

→ role of the interplay between sub-cloud coherent structures, clouds, water vapor and mesoscale vertical motions?

→ test theories and models with observations

Lead PIs: Sandrine Bony (LMD), Julien Delanoë (LATMOS), Jean-Christophe Canonici (SAFIRE)
Contact: Sandrine Bony (https://maestro.aeris.data.fr)

CELLO — CLOUD AND EARTHCARE CAL/VAL OBSERVATIONS



Lead PIs: Robert O. David, Tim Carlsen, (University of Oslo, Norway), Sorin Vajaiac (INCAS, Bucharest, Romania)

CELLO — CLOUD AND EARTHCARE CAL/VAL OBSERVATIONS

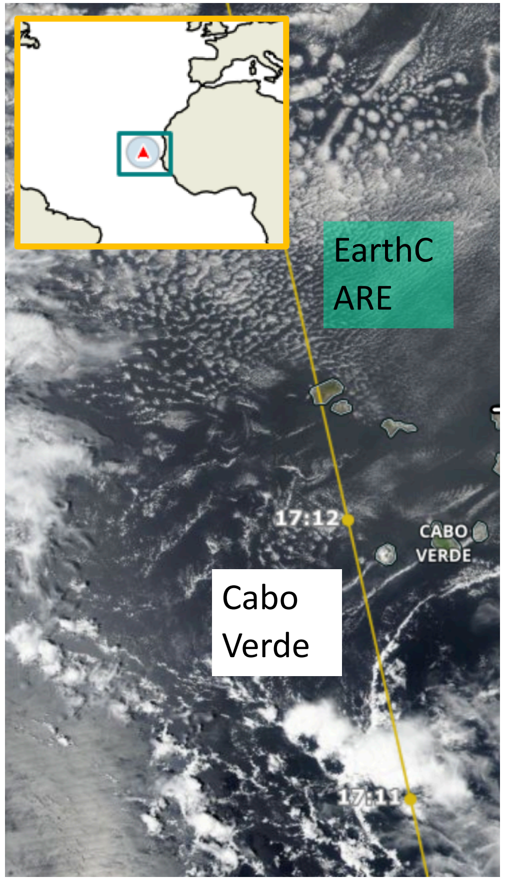
CELLO ORCESTRA

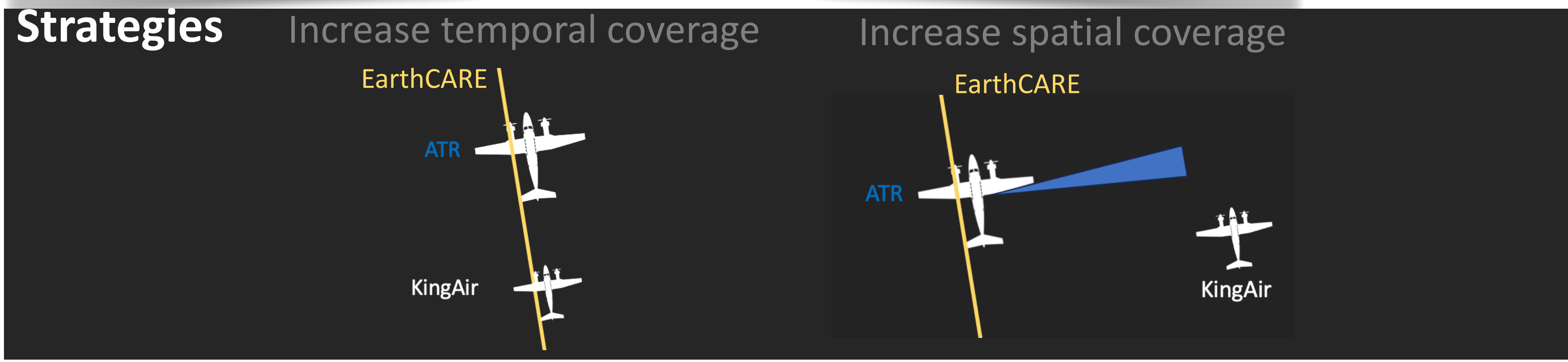
OBJECTIVES:

- In-situ cloud observations for direct EarthCARE cal/val
- Synergies with remote sensing aircraft SAFIRE ATR-42 and DLR-HALO

Airborne field campaign near Cape Verde

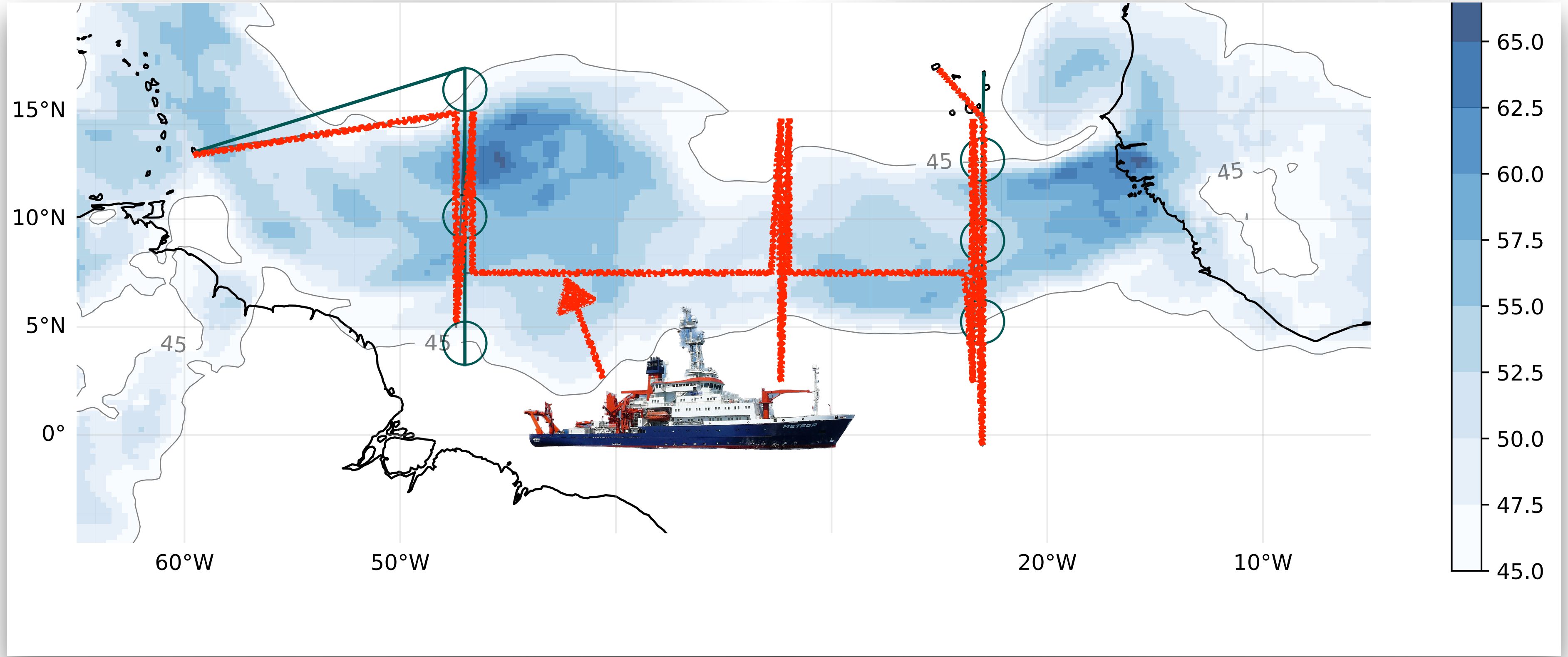
- INCAS King Air C90 GTx, range: 2000 km
- Instruments: SPEC Hawkeye, DMT CAPS
- Measurements: Cloud phase, Cloud top height Ice water content, Liquid water content Droplet/ Crystal effective radius





Lead PIs: Robert O. David, Tim Carlsen, (University of Oslo, Norway), Sorin Vajaiac (INCAS, Bucharest, Romania)

BOW-TIE — BEOBACHTUNG VON OZEAN UND WOLKEN – DAS TRANS ITCZ EXPERIMENT



Lead PIs: Daniel Klocke, Julia Windmiller, Bjorn Stevens (MPI-M), Marcus Dengler (GEOMAR)

BOW-TIE — BEOBACHTUNG VON OZEAN UND WOLKEN – DAS TRANS ITCZ EXPERIMENT

OBJECTIVES:

- obtain vertically resolved cross-sections of the ITCZ, through the upper ocean, and the surrounding thermodynamic and dynamic conditions.
- Investigate the impact of storm scale processes on the mesoscale structure of the ITCZ
- EarthCARE validation
- link to upper ocean and bio-geochemistry

Lead PIs: Daniel Klocke, Julia Windmiller, Bjorn Stevens (MPI-M), Marcus Dengler (GEOMAR)

BOW-TIE — Beobachtung von Ozean und Wolken – Das Trans ITCZ Experiment

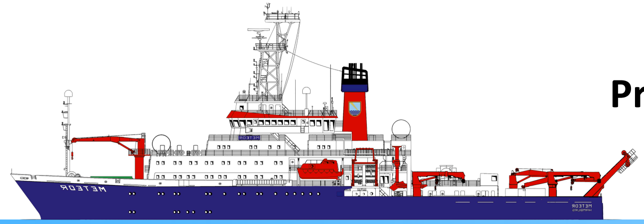
Atmospheric profiles of Humidity, Wind, Temperature, Clouds, and Aerosol

(RAMAN LiDAR - 1064, 532, 355 nm, 388+60 Radiosondes, Wind LiDAR, W-band cloud radar, Drones)

3D Precipitation field (**PICCOLO:** CSU Sea-Pol C-band scanning Rain Radar)

Cloud base height, Cloud Water and Water Content

(Ceilometer, Microwave radiometer, GPS Met.)



Precipitation, Surface Wind Speed and Direction, Sea-Surface Temperature, Surface fluxes, Aerosols

(Disdrometer, Infrared Thermometer, Sea snakes, Onboard Weather Station, Ultra-Sonic Anemometer/Thermometer, Open-path gas analyser, Aerosol Spectrometer)

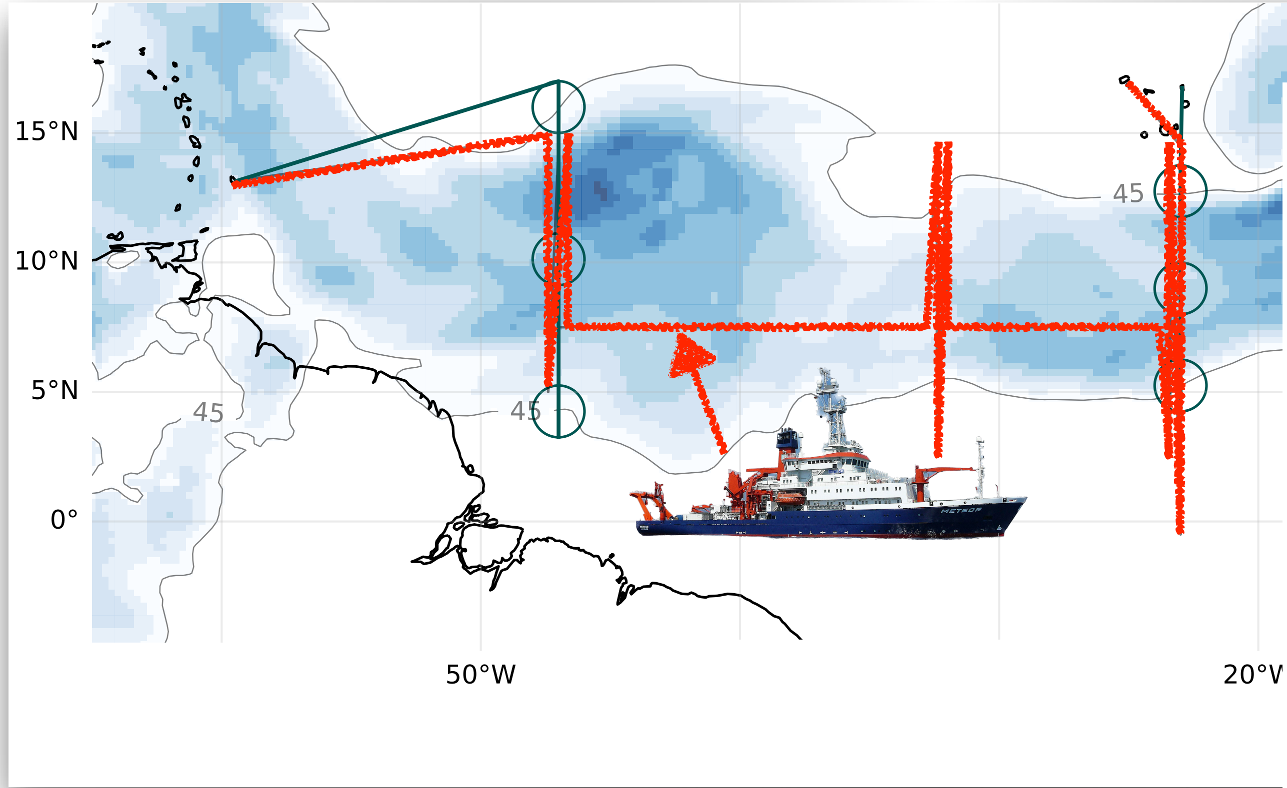
Hydrography, Currents, Ocean mixing

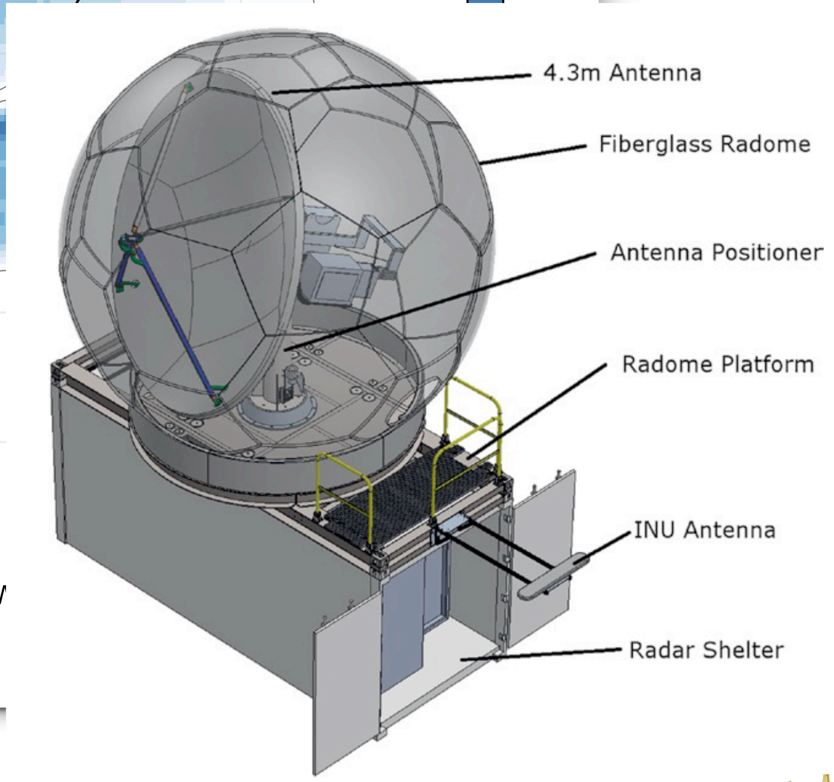
(CTD, underwayCTD, upper ocean velocity measurements, drifting buoy, glider, shipboard micro-structure system)

Marine Biology

(Plankton and particle camera, chlorophyll and oxygen sensor on wire-walker, vision profiler on CTD, incubations)

PICCOLO — PROCESS INVESTIGATION OF CLOUDS AND CONVECTIVE ORGANIZATION OVER THE ATLANTIC OCEAN





Lead PIs: Allison Wing (Florida State University), James Ruppert (University of Oklahoma), Michael Bell (Colorado State University), and Morgan O'Neill (University of Toronto)

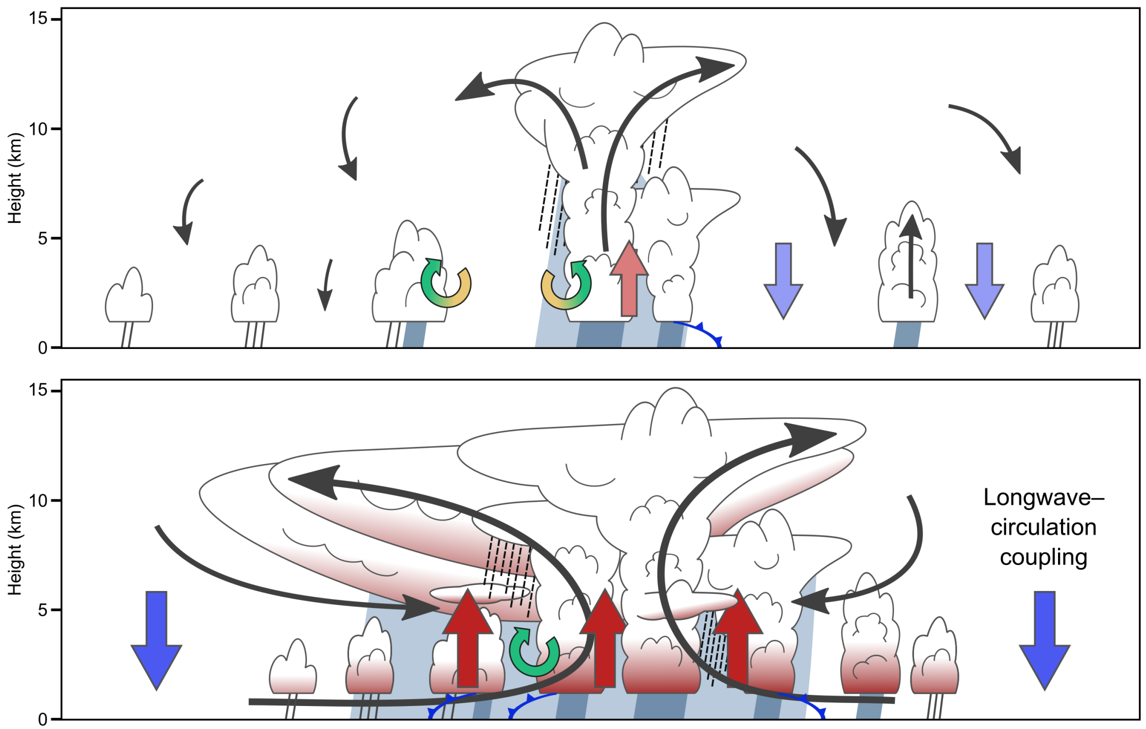
PICCOLO — PROCESS INVESTIGATION OF CLOUDS AND CONVECTIVE ORGANIZATION OVER THE ATLANTIC OCEAN

Deploy the CSU SEA-POL (Sea-Going Polarimetric) radar on the RV Meteor, to characterize the properties of precipitation and its mesoscale organization

- Wavelength/Frequency: C-band (5 cm, 5.65 GHz)
- Antenna diameter: 4.3 m (5.4 m radome)
- Doppler scanning radar measures dual-polarization

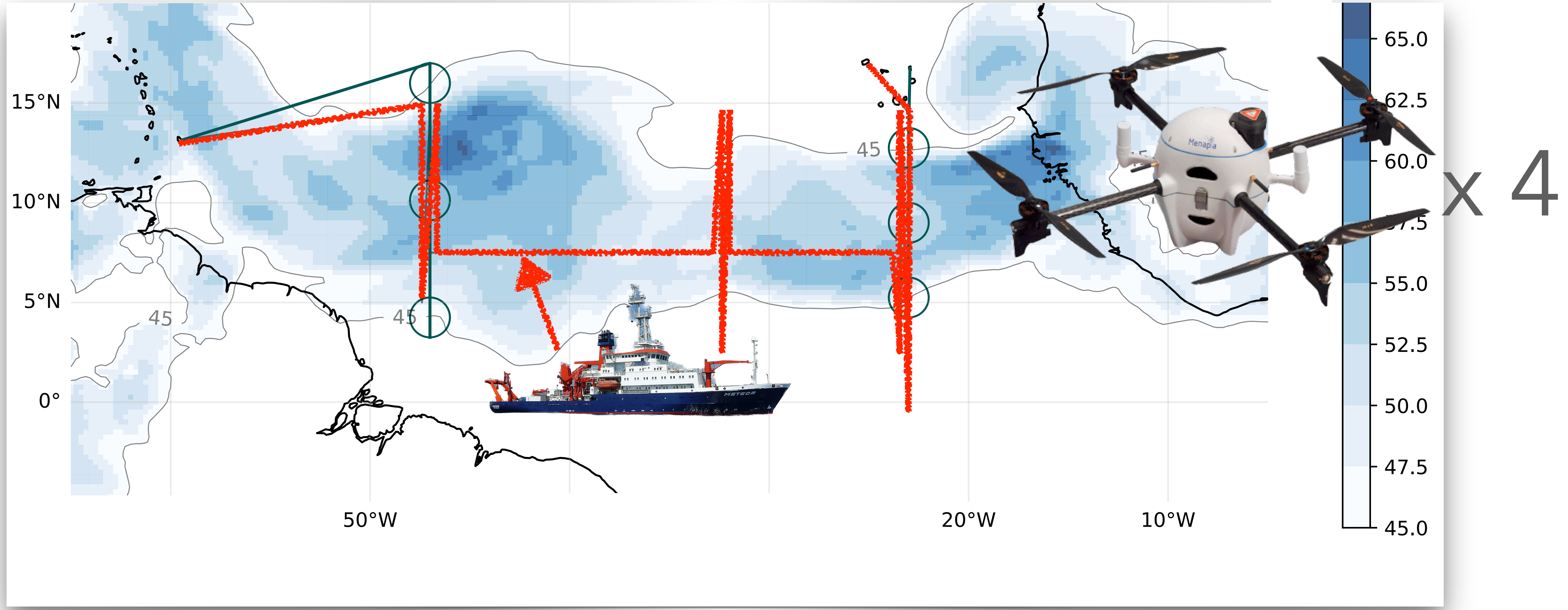
Goals:

- Investigate the nature, governing mechanisms, and impact of mesoscale organization of precipitating deep convection in the context of the Atlantic ITCZ
- Characterize the importance of localized internal feedbacks in relation to large-scale external forcing in the control of convective upscale growth and mesoscale organization.



Lead PIs: Allison Wing (Florida State University), James Ruppert (University of Oklahoma), Michael Bell (Colorado State University), and Morgan O'Neill (University of Toronto)

STRINQS — SOUNDINGS & TURBULENT EDDY MEASUREMENTS IN THE ITCZ WITH A NETWORK OF QUADCOPTERS



Lead PI: Geet George (TU Delft)

STRINQS — SOUNDINGS & TURBULENT EDDY MEASUREMENTS IN THE ITCZ WITH A NETWORK OF QUADCOPTERS

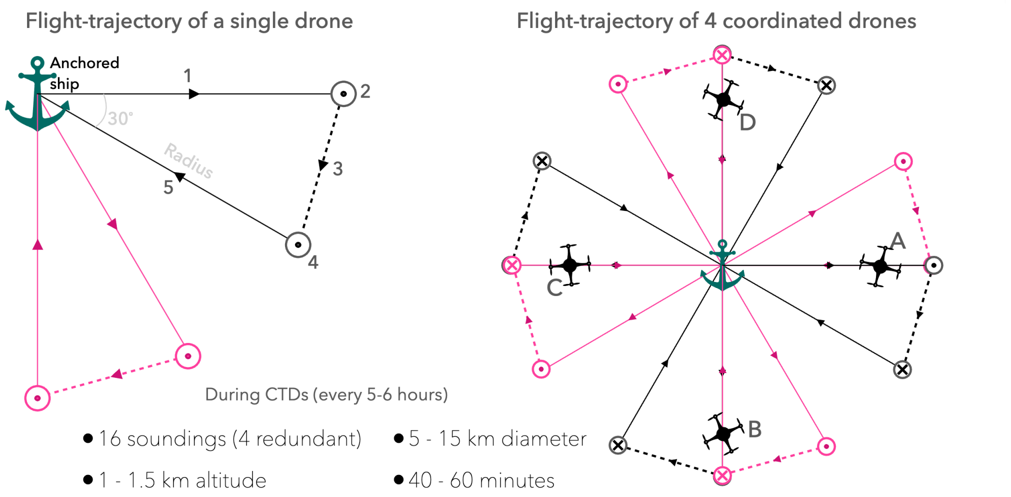
ORCESTRA

Measurments of vertical and horizontal gradients of:

- Temperature (10 Hz)
- Humidity (10 Hz)
- Pressure (10 Hz)
- 3D winds (40 Hz)

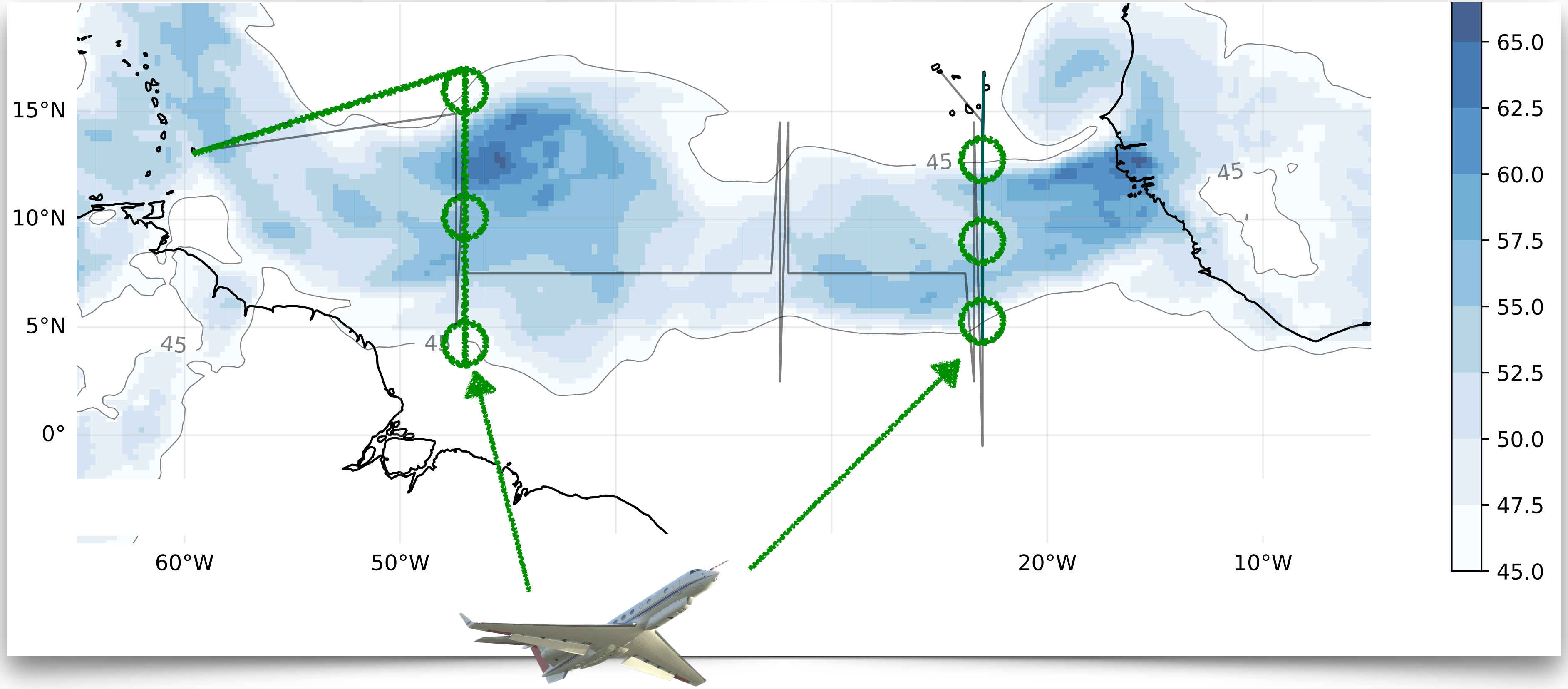
Goals:

- Distinguish boundary-layer features between edges & doldrums
- Can we get small-scale vertical velocity?
- How do the up/downdrafts relate to BL features?



Lead PI: Geet George (TU Delft)

PERCUSION — PERSISTENT EARTHCARE UNDERFLIGHT STUDIES OF THE ITCZ AND ORGANISED CONVECTION



Lead PIs: Bjorn Stevens, Julia Windmiller, Lutz Hirsch (MPI-M), Felix Ament, Ann-Kristin Naumann (UHH), Susanne Crewell, Claudia Acquistapace, Sabrina Schnitt (U Cologne), Bernhard Mayer (LMU), Manfred Wendisch, André Ehrlich (U Leipzig), Silke Gross (DLR)

PERCUSION — PERSISTENT EARTHCARE UNDERFLIGHT STUDIES OF THE ITCZ AND ORGANISED CONVECTION

Involves flights with the German G550, HALO (“cloud observatory” configuration)

- 9 flights planned out of Cabo Verde (August– September 2024)

- 9 flights planned out of Barbados (September 2024)

Goals:

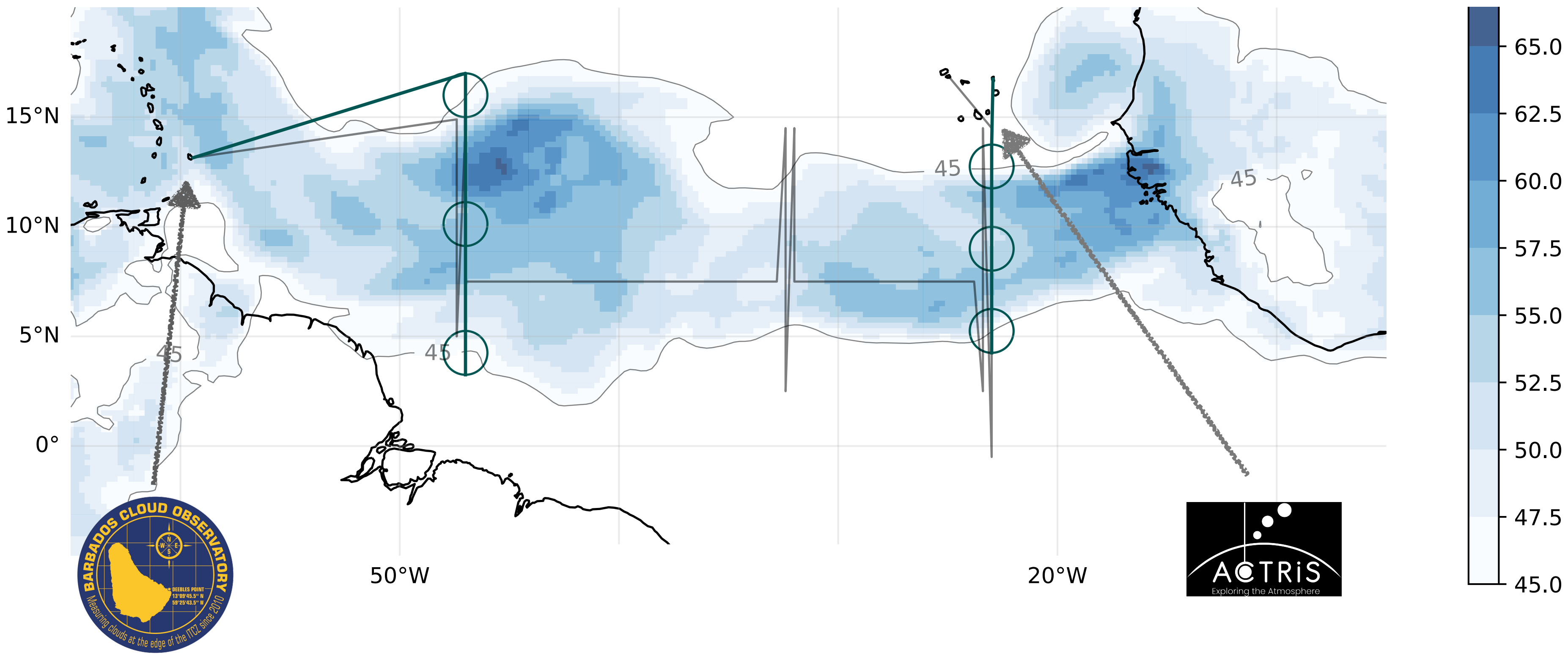
- Validation of EarthCare satellite measurements across different cloud regimes

- Seeks to understand how air-mass properties and mesoscale processes influence the structure and dynamics of the ITCZ

Lead PIs: Bjorn Stevens, Julia Windmiller, Lutz Hirsch (MPI-M), Felix Ament, Ann-Kristin Naumann (UHH), Susanne Crewell, Claudia Acquistapace, Sabrina Schnitt (U Cologne), Bernhard Mayer (LMU), Manfred Wendisch, André Ehrlich (U Leipzig), Silke Gross (DLR)

SCORE — SUB-CLOUD OBSERVATIONS OF RAIN EVAPORATION

CLARINET — CLOUD AND AEROSOL REMOTE SENSING FOR EARTHCARE



Lead PI: Raphaela Vogel (UHH)

Lead PI: Annett Skupin and Holger Baars (Tropos)

SCORE — SUB-CLOUD OBSERVATIONS OF RAIN EVAPORATION

CLARINET — CLOUD AND AEROSOL REMOTE SENSING FOR EARTHCARE

SCORE
ORCESTRA

CLARINET
ORCESTRA

OBJECTIVES SCORE:

- Assess robustness of rain evaporation and downdraft retrieval methods for trade cumulus clouds
- Test retrieval techniques for deep convective clouds
- Constrain how much it rains at Barbados Cloud Observatory (BCO)
- Link campaign data to longterm measurements at BCO

Instrumentation on Barbados

- Recycled X-band rain radar @Poldirad site
- Regular and targeted radiosondes from BCO
- Core BCO instrumentation

OBJECTIVES CLARINET:

- Complete aerosol and cloud remote sensing
- validate EarthCARE measurements.

Instrumentation on Cape Verde

- multiwavelength Raman polarization lidar for measuring aerosol, cloud and water vapour profile
- AERONET sun-sky-lunar photometer (CIMEL)
- RPG HATRPO G5 microwave radiometer
- Cloud profiling radar
- HALO photonics streamline XR scanning Doppler lidar and radiation station

Lead PI: Raphaela Vogel (UHH)

Lead PI: Annett Skupin and Holger Baars (Tropos)

SUMMARY — ORCESTRA

We will spend August and September in the tropical Atlantic, sampling the inner life of the ITCZ with:

- Many instruments
- On several platform
- Funded through eight projects

- **We will learn about what organizes convection at the meso-scale and how the meso-scale shapes the large scale tropical circulation.**
- **Calibrate and validate EarthCare measurements.**
- **Have a new benchmark data set for the evaluation of storm resolving climate models.**