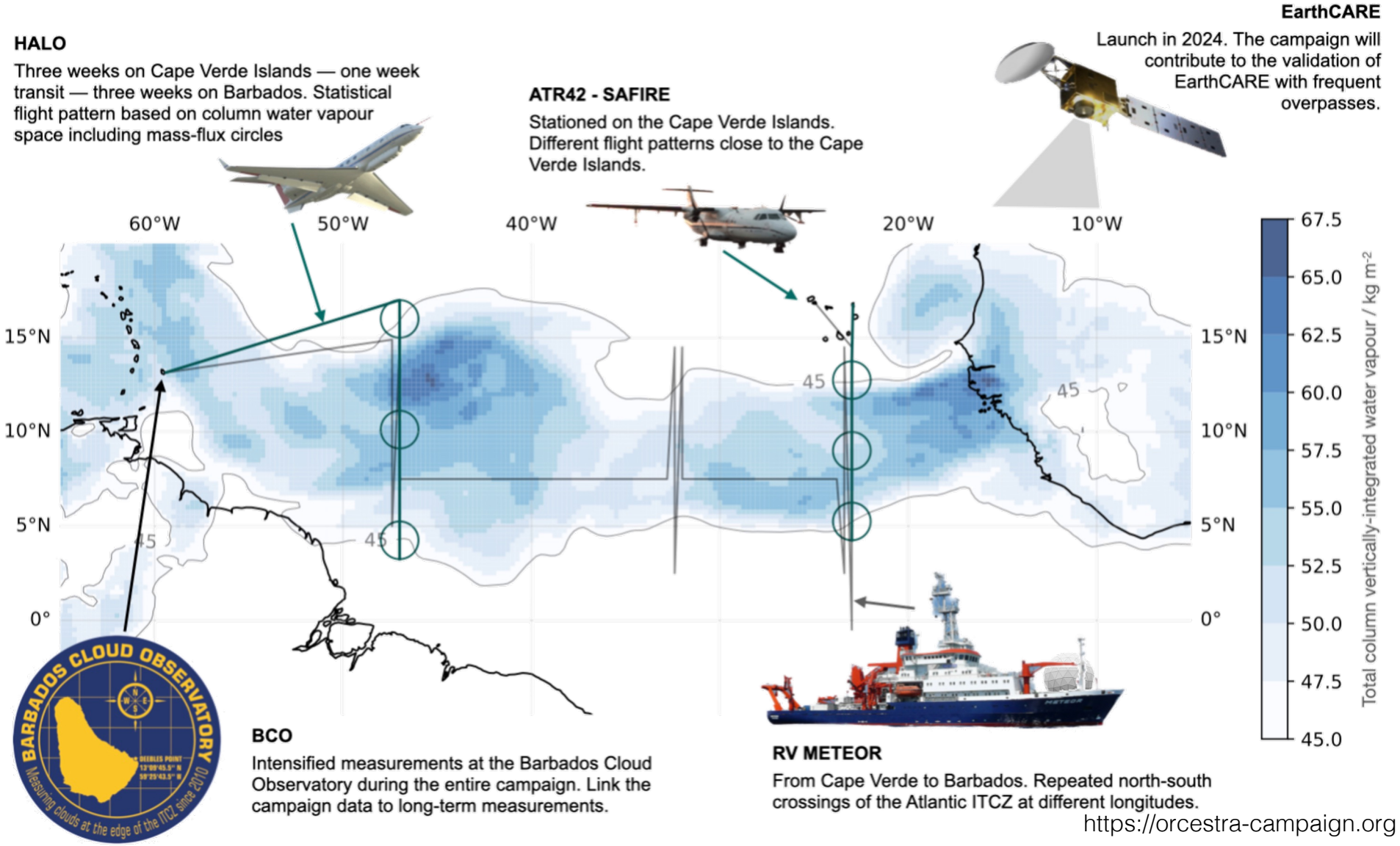
ORCESTRA : ORganized Convection and EarthCare Studies over the TRopical Atlantic



https://orcestra-campaign.org

Members of ORCESTRA

- MAESTRO
- PERCUSION
- BOW-TIE
- PICCOLO
- SCORE
- CELLO

Overarching objective:

Better understand physical mechanisms that organize tropical convection at the mesoscale, and the impact of convective organization on climate and Earth's radiation budget

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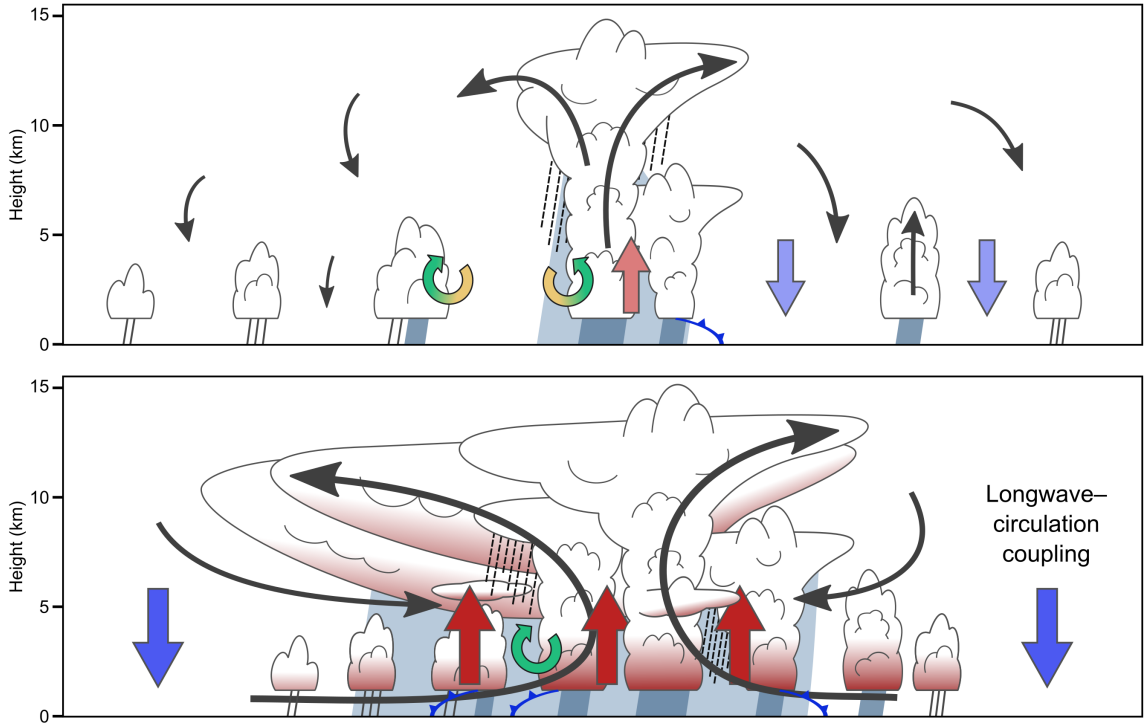
ORCESTRA-PICCOLO

Process Investigation of Clouds and Convective Organization over the atLantic Ocean



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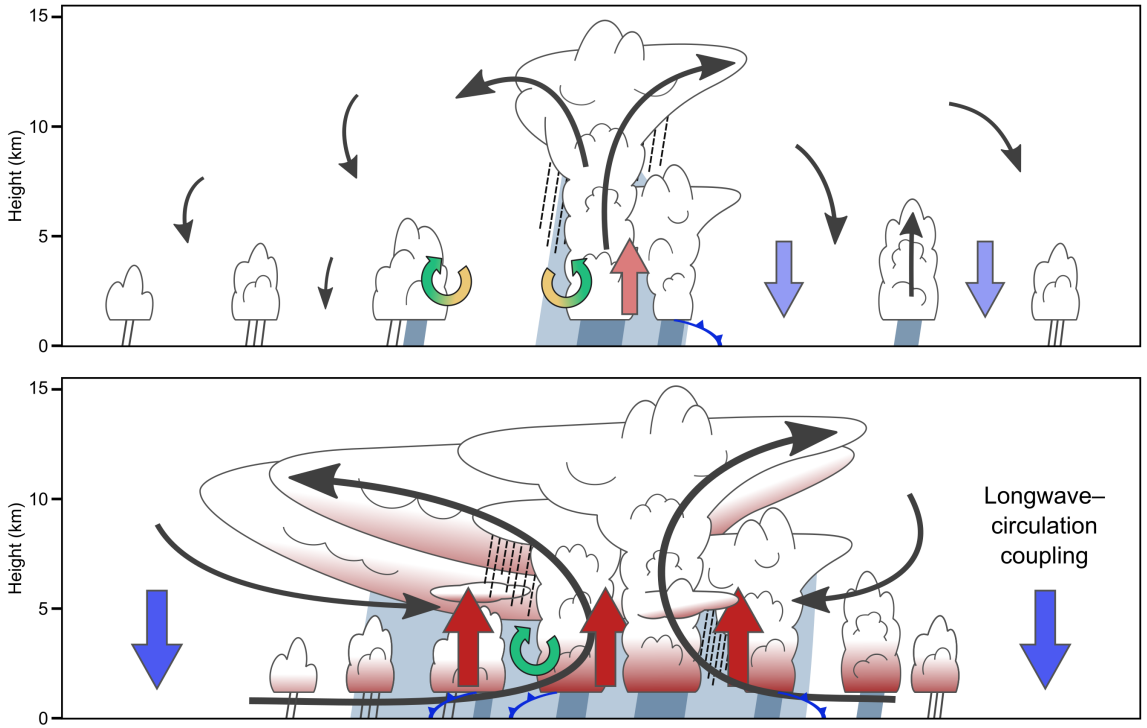
Morgan O'Neill (U. Toronto), v. Chandrasekar (CSU), Chelsea Nam (FSU)

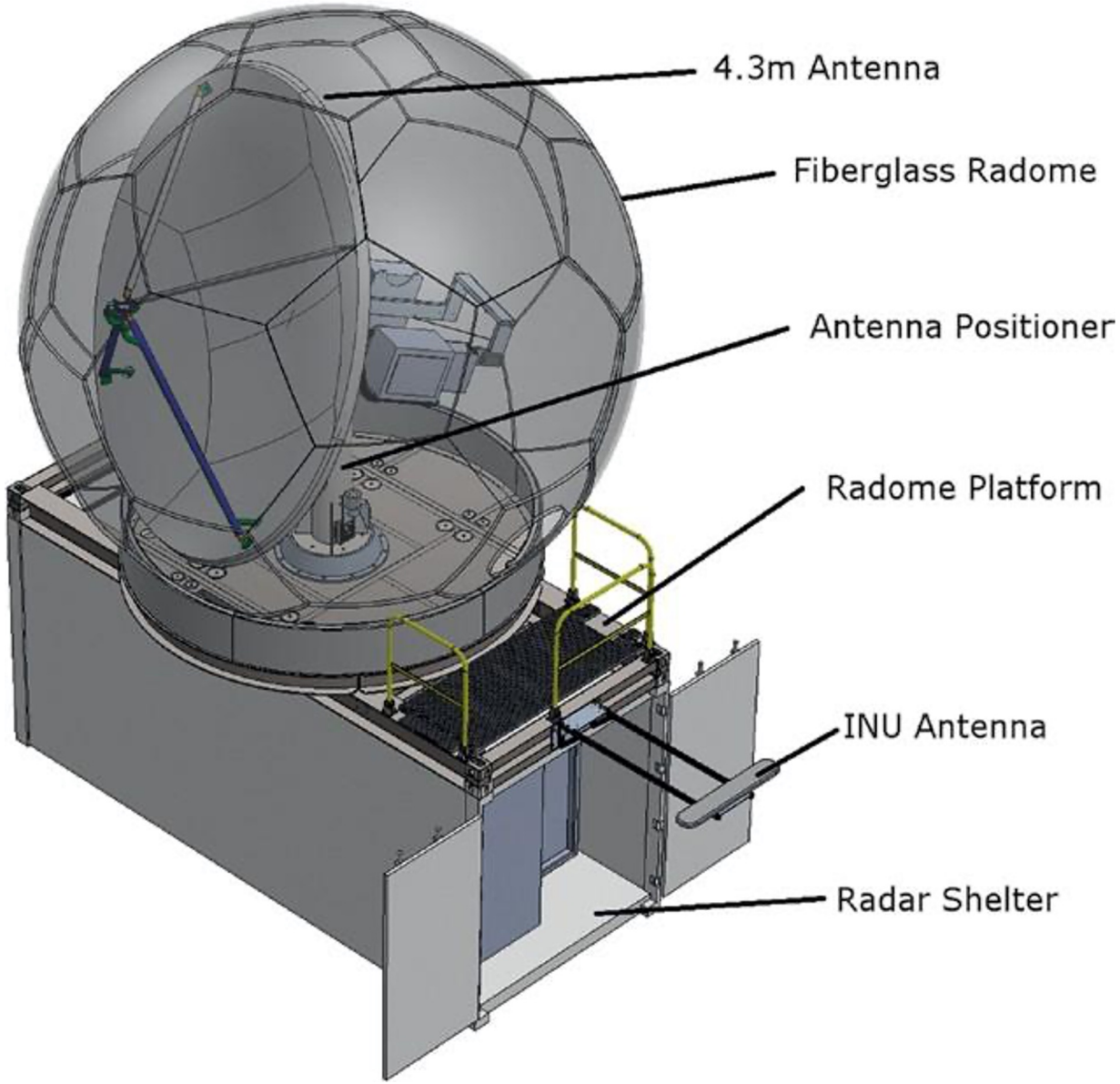
ORCESTRA-PICCOLO

- Deploy the SEA-POL radar on the RV Meteor, to characterize the properties of precipitation and its mesoscale organization
- SEA-POL is the Colorado State University (CSU) Sea-Going Polarimetric Radar, a National Science Foundation (NSF) community facility.
- 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.



PICCOLO is funded by the National Science Foundation

About SEA-POL

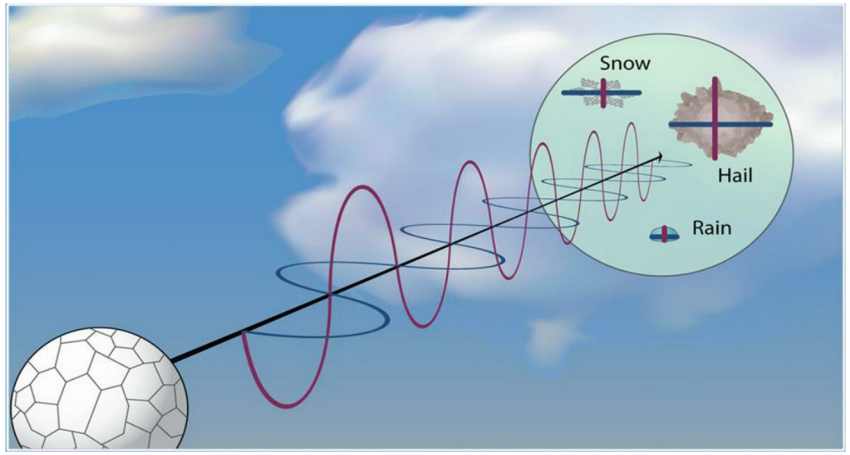


- Wavelength/Frequency: C-band (5 cm, 5.65 GHz)
- Antenna diameter: 4.3 m (5.4 m fiber glass radome)
- Measures Dual-polarization
- Built for harsh environments:
  - An inertial navigation unit (INU) measures ship motion and sends compensation commands to the antenna positioner.
  - Doppler velocity data is also corrected for ship velocity. This permits high quality data to be collected at sea, correcting for ship roll and pitch up to 7 degrees.

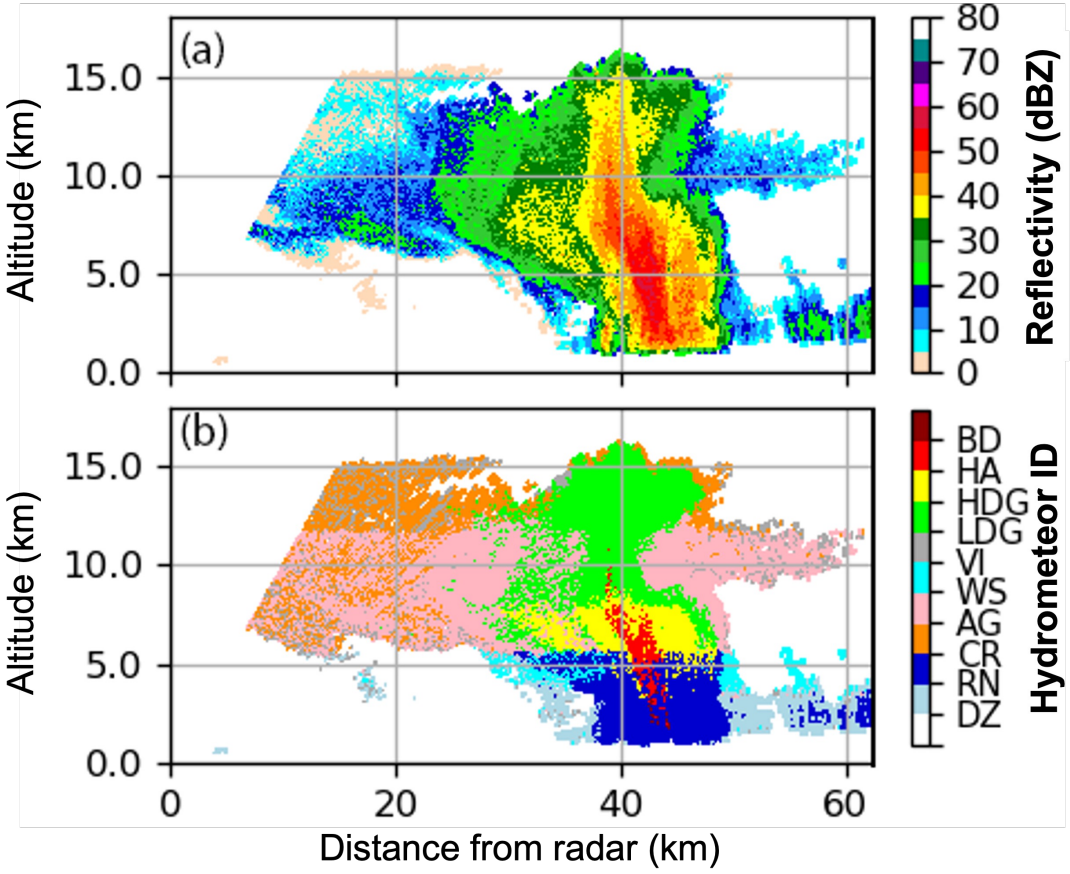
SEA-POL data

Dual-polarized data:

- Specific Differential Phase (Kdp)
- Differential Reflectivity (Zdr)
- Hydrometeor type (Level-3 product, using CSU-radar package algorithm)
- Sensitivity: -7 dBZ at 100 km
- PPI range ~150 km,
- RHI range ~100 km



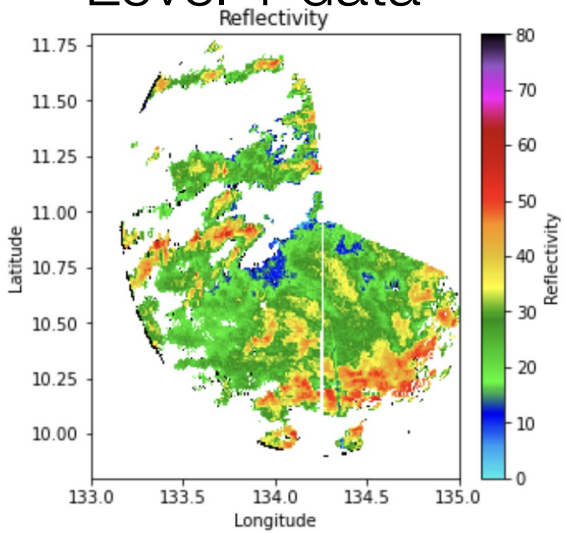
(image: NOAA)

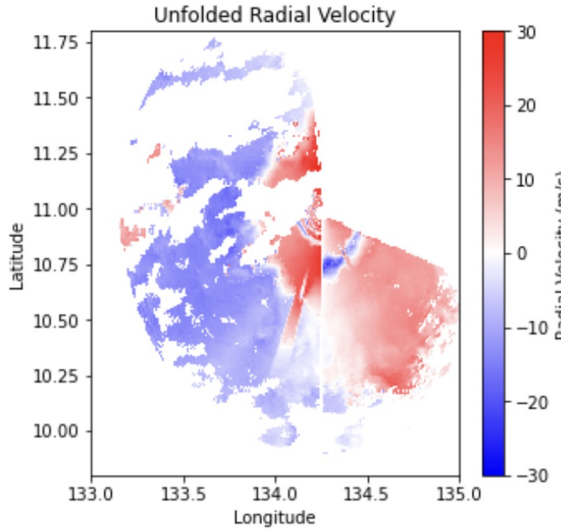


(a) Radar reflectivity and (b) polarimetric hydrometeor identification of an MCS observed by a SEA-POL radar RHI scan during PRECIP on 29 July 2022.

SEA-POL data levels

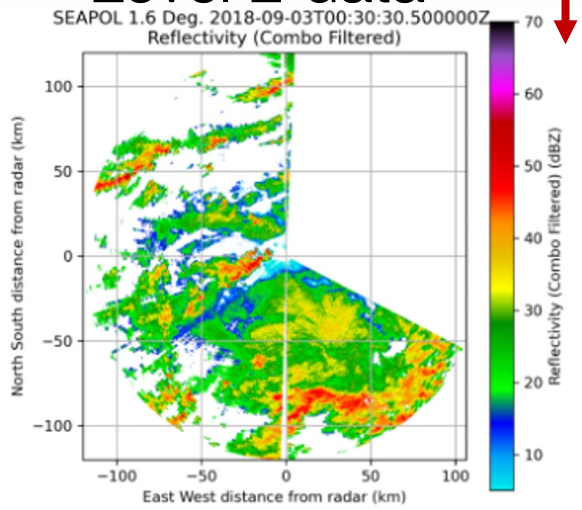
Level 1 data

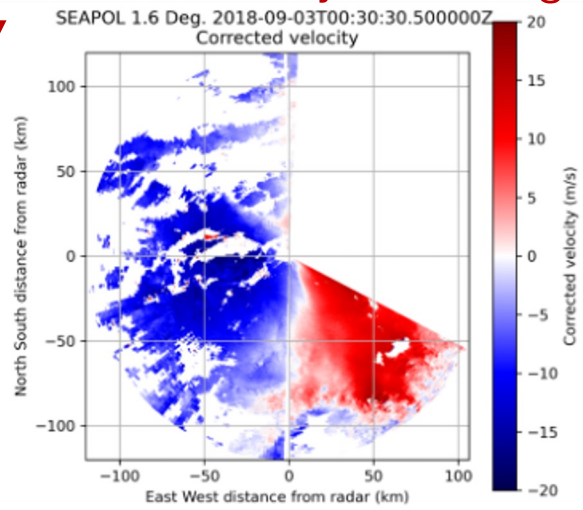




QC & Velocity unfolding

Level 2 data



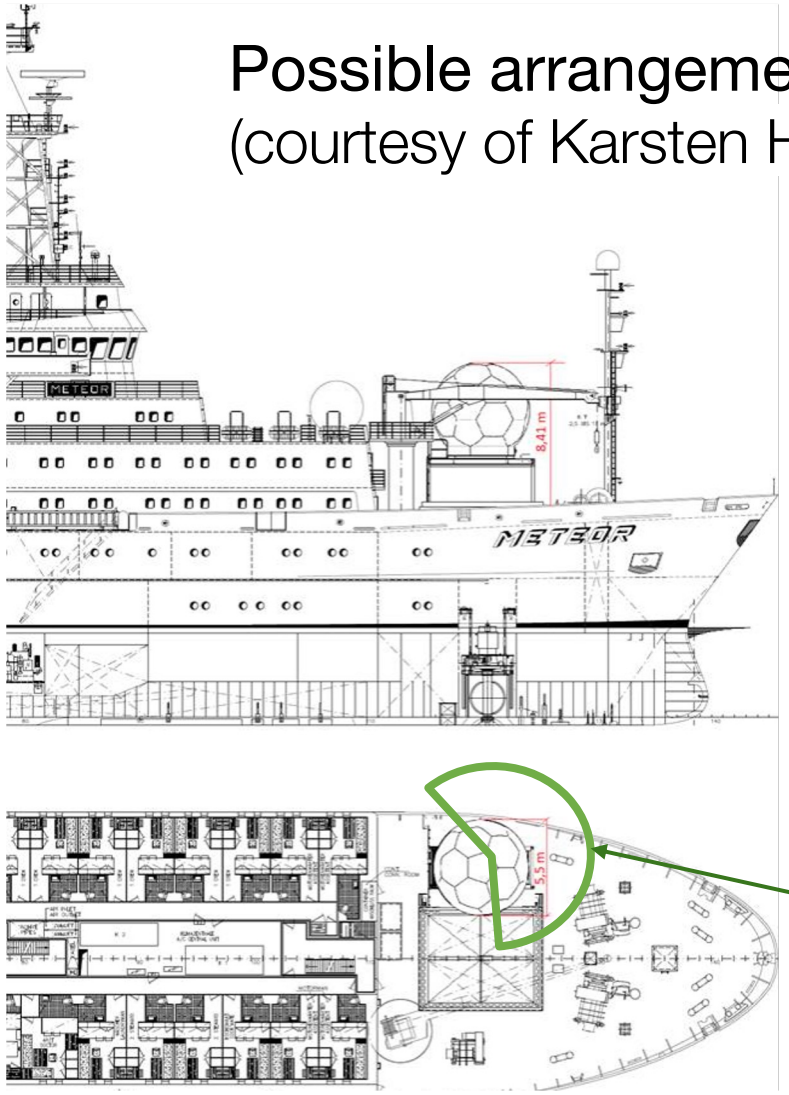


1. **Real-time imagery** will be uploaded to the SEA-POL website (almost real-time) if bandwidth allows.
2. **Level 1 data**: all the measurements as is (reflectivity, Doppler velocity, dual-pol data)
3. **Level 2 data**: format converted and QC'ed. will be delivered *no later than 3 months after the end of the deployment.*
4. **Level 3 data**: additional QC & scientific processing including
   - Removal of non-meteorological echoes
   - Cartesian gridding
   - Hydrometeor Identification

SEA-POL on R/V Meteor

Sea-Pol radome being installed on R/V Roger Revelle (2017 Spurs)

Possible arrangement of SEA-POL
(courtesy of Karsten Heikens)



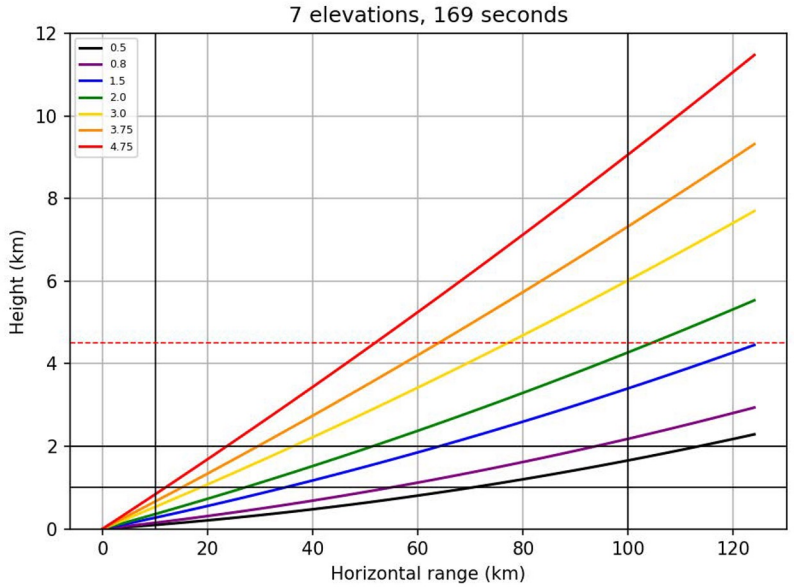
- Portion of radar coverage area blocked for bridge operation
- Exact blocking angle range is TBD

SEA-POL operation & scan strategy

Radar shelter container: operation center & radar workstation (1 or 2 engineers on board)

- Transmitter, Signal processor
- Power conversion and distribution
- Data storage
- Tools and hardware

- 24-hour continuous operation
- PPI volumes and RHI slices at pre-defined angles for unbiased statistics
- Some user-selected scans to boost RHI sampling of convective targets and coordinate retrievals with other platforms



Elevation angles used in the PISTON 2019 rain mapping PPI volumes.

PICCOLO Objectives

Investigate the nature, governing mechanisms, and impact of mesoscale organization of precipitating deep convection in the context of the Atlantic ITCZ

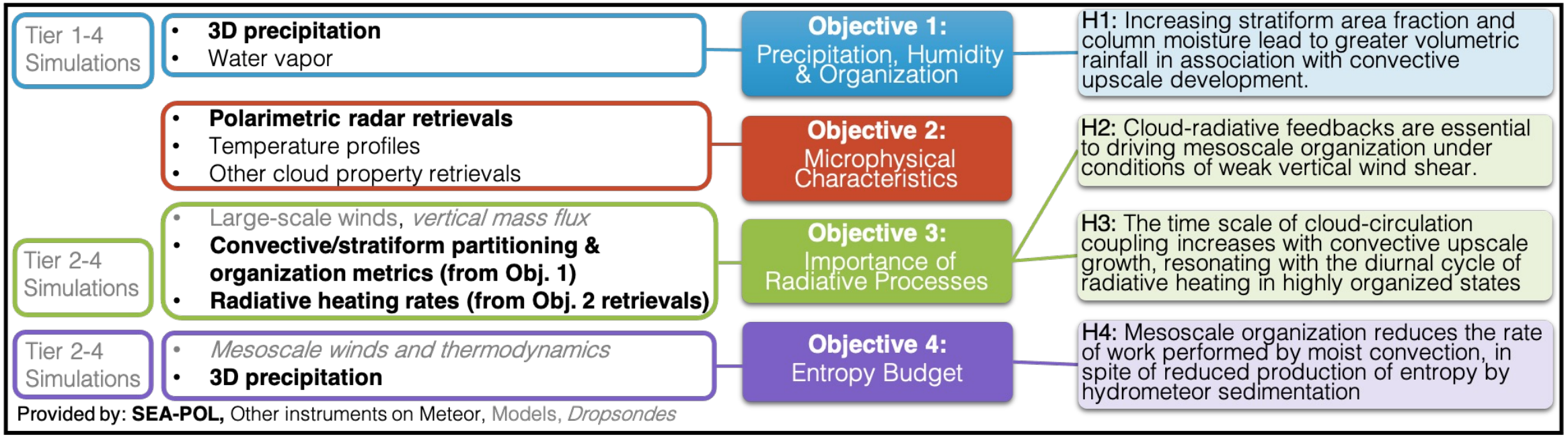
Objective 1:
Evaluate observed process relationships between precipitation, humidity, and convective organization in comparison to numerical simulations.

Objective 2:
Use advanced polarimetric radar retrievals to investigate the microphysical, dynamical, and radiative characteristics of convection in relation to mesoscale organization.

Objective 3:
Investigate the importance of radiative processes in relation to large-scale forcing in driving mesoscale convective organization using field observations

Objective 4:
Use novel observational approaches to compute the entropy budget to advance our understanding of organized convection and its impacts on the climate system

PICCOLO Science Overview



	Type	Model(s)	Configuration
Tier 1	*Idealized (H1)*	*30-member RCEMIP ensemble [159, 160]*	*GCMs (100 km grid), CRMs (6000 x 400 km^2 domain, 3 km grid)*
Tier 2	Semi-Realistic (H1–H4)	CM1 [19], SAM [61], WRF-ARW [128]	~300 x 300 km^2 domain, 300 m grid.
Tier 3	Semi-Realistic (H1–H4)	WRF-ARW [128]	~4000 x 3000 km^2 domain, 3 km grid
Tier 4	*Realistic (H1–H4)*	*ICON [48, 62]*	*Global coupled (1 km grid), Atlantic basin atmos-only (300 m grid).*

Other Instruments

BOW-TIE instrumentation — Atmosphere

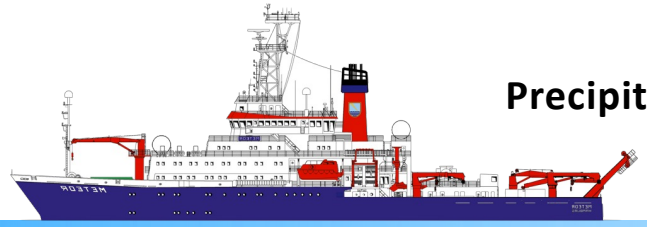
Atmospheric profiles of Humidity, Wind, Temperature, Clouds, and Aerosol

(RAMAN LiDAR - 1064, 532, 355 nm, 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)

+ Upper ocean measurements

*Funding decision still pending

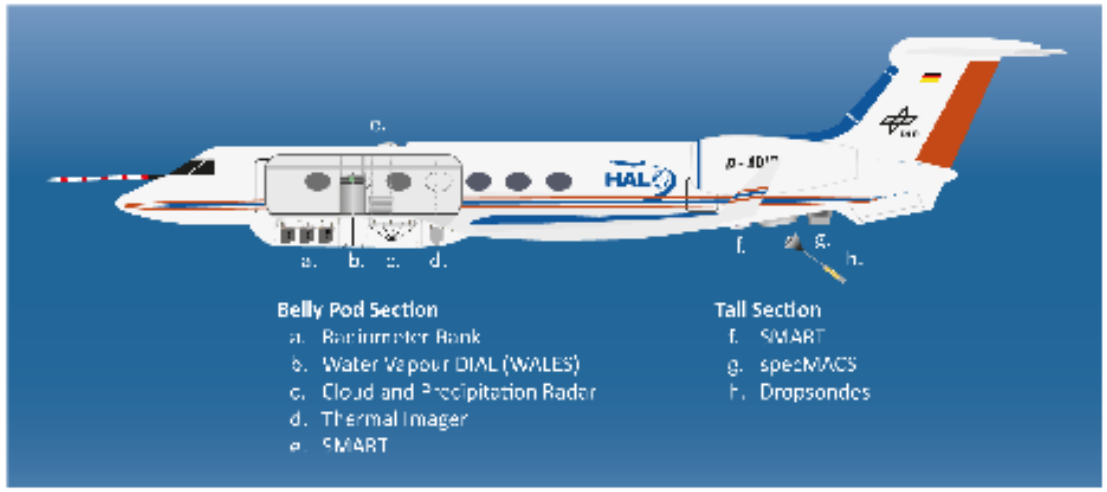
Slide from Julia Windmiller

A HIGH-ALTITUDE LONG-RANGE AIRCRAFT CONFIGURED AS A CLOUD OBSERVATORY

The NARVAL Expeditions

Bjorn Stevens, Felix Ament, Sandrine Bony, Susanne Crewell, Florian Ewald, Silke Gross, Akio Hansen, Lutz Hirsch, Marek Jacob, Tobias Kölling, Heike Konow, Bernhard Mayer, Manfred Wendisch, Martin Wirth, Kevin Wolf, Stephan Bakan, Matthias Bauer-Pfundstein, Matthias Brueck, Julien Delanoë, André Ehrlich, David Farrell, Marvin Forde, Felix Gödde, Hans Grob, Martin Hagen, Evelyn Jäkel, Friedhelm Jansen, Christian Klepp, Marcus Klingebiel, Mario Mech, Gerhard Peters, Markus Rapp, Allison A. Wing, and Tobias Zinner

Using dropsondes and advanced remote sensing instrumentation, the German High-Altitude Long-Range Research Aircraft (HALO) is configured for use as an airborne cloud observatory.



Instrument	Institution	Observable	Derived products
HAMP (HALO Microwave Package) (Mech et al., 2014)	MPI-M Hamburg, Univ. Hamburg, Univ. Cologne, DLR-IPA	• Brightness temperature at 26 selected microwave frequencies between 22 and 183 GHz • Profiles of radar reflectivity, depolarization ratio & Doppler velocity	• Integ. water vapor • temperature + humidity profiles • cloud, snow & rain water path • target classification, cloud geometry • rain rate
WALES (Wirth et al., 2009)	DLR-IPA	Profiles of • Backscatter coefficient (532 nm, 935 nm, 1064 nm), • Color ratio of backscatter, Particle linear depol. Ratio (all at 532/1064 nm), • Particle extinction coefficient (at 532 nm)	• water vapor profile (from 935 nm channels)
SMART (Wendisch et al. 2015)	Univ. Leipzig	• Spectral nadir radiance (300-2200 nm), • Spectral upward and downward irradiance (300-2200 nm), cloud top albedo	Cloud thermodynamic phase Liquid and ice water path • Cloud optical thickness, effective radius
BACCARDI Ehrlich et. al. 2021	Univ. Leipzig	• Broadband down- and upwelling solar- and thermal-infrared irradiance • Cloud Radiative Forcing (CRF)	• Cloud Radiative Forcing (CRF)
VELOX Thermal Imager	Univ. Leipzig	**brightness temperatures of upward radiance 7.7 to 12.0 micrometer (VELOX) and nadir radiance 9.6 to11.5 micrometer (VELOX KT9)**	• Cloud Mask • Cloud top temperature
specMACS (Ewald et al. 2016)	LMU Munich	Radiance imagery in VIS/NIR spectral range with 34° (spectral) and 75° (monochromatic and polarized) across-track field-of-view	• Cloud Mask • Cloud phase • Optical thickness • Effective particle size • Particle size distribution
dropsondes	DLR-IPA, MPI-M, Univ. Hamburg	Profiles of • relative humidity • temperature • horizontal wind	-
BAHAMAS	DLR-FX	In-situ observations of T, q, u, v, w, 100 Hz data, GPS	-