Breakout 2: Observations

Objective: To identify opportunities for integrated convection and air-sea interaction Observations

Discussion Questions:

1. What are the major progress during the last decade and remaining key gaps in observations of tropical convection and air-sea interactions?

2. What observational technological tools are newly available during the recent years and need to be developed to address key questions for fundamental understanding and model improvement?

3. Which existing coordinated activities could be leveraged to address these challenges, and what new activities could be formed? How should modeling activities be included, in an improved fashion, to complement these observation based activities?

4. What are the key lessons learned from past observational activities that could potentially guide/inform future activities?

Breakout 2, Group 1

Lead: Scott Ellis

Co-Chairs: Samson Hagos and Hyodae Seo

Key Scientific Challenges

- Entrainment of environmental air into convection
- Air-sea interaction under high wind, low wind and rainy conditions
- SST variability and air-sea interaction at mesoscale
- Modeling variability/noise around the mean flux relationships i.e., beyond deterministic relationships
- Develop parameterization in coupled model framework. Stochastic parameterization, Models?
- Convection and humidity cause and effect

Technological advances

- Drones, miniaturization of sensors etc , High flux towers and buoy lidars mounted on a Buoy due do wind energy interests.
- Data assimilation could be useful, but one needs to be aware of model limitations
- Model informed observational strategy, OSSE for example.
- Machine learning and stochastic physics can be used to represent variability and introduce correct variance in models
- Laboratory experiments to test flux measurements in high wind regimes – with caution!

Lessons learned from past observational activities

1. Do not shy away from innovative ideas, you will not always succeed but try..
2. Expect surprising results. Prepare to make decisions on the fly while observing. There is no single platform that can answer everyone questions. One needs multiple platforms.
3. Improvise. Prepare to modify your objectives based on realities on the ground.
4. It is important to inform the students the big picture and the scientific objectives of the campaign as they evolve.
5. It is important to know the errors and limitations of the instrumentation

Breakout 2, Group 2

Lead: Chelle Gentemann

Co-Chairs: Greg Foltz and Kevin Reed

What are the major progress during the last decade and remaining key gaps in observations of tropical convection and air-sea interactions?

We need collocated surface and atmospheric data to observe convective systems life cycle through development, evolution, and destruction

Improved humidity and surface waves in situ observations in TC

Upper ocean (T,S,vel) profiles at higher spatial and vertical resolution. We are currently unable to quantify Rossby intraseasonal effects (need vertical), improved barrier layer (spatial 3D effects).

What technological tools are newly available during the recent years and need to be developed to address key questions for fundamental understanding and model improvement?

For existing and new data/systems: A community need for characterizing the data. What are we measuring and how is it calibrated? Community needs to demand robust calibration.

Uncertainty: Characterizing uncertainty, communicating uncertainty. Useful for how we use the observations and can improve our models, especially stochastic processes.

Which existing coordinated activities could be leveraged to address these challenges, and what new activities could be formed? How should modeling activities be included, in an improved fashion, to complement these observation-based activities?

There is a gap in observations of early / shallow part of cloud formation. Dual doppler cloud radar, lidar to get 3d velocities in the boundary layer supplemented by aircraft observations all targeting a 10km box for weeks to months to get statistically robust sampling of cloud formation processes.

There is value in including modeling when designing new observational systems or program, but it can be expensive to run OSSEs. US Clivar. Ideally run models while campaign on-going to target areas of sensitivity then send in situ platforms there.

What are the key lessons learned from past activities that could potentially benefit future activities?

Collocated air-sea observations missing upper ocean and boundary layer we don't understand the spatial temporal scale, sustained observations. This is a coupled boundary layer problem with a permeable layer between them.

Open data is important, open source software is important. A common framework is important. The data archival plans should make it as easy as possible to reach the broadest audience possible to advance science. Provide both the high resolution data but also subsampled or averaged. Easy to access, easy to read, collocated data in a thoughtful manner.

Lead: Lisan Yu

Co-Chairs: Sue Chen, Chidong Zhang

Breakout 2, Group 3

(1) What are the major progress during the last decade and remaining key gaps in observations of tropical convection and air-sea interactions?

Major progresses:

- the COARE algorithm and its continuing improvements
- Satellite observations of SST diurnal cycle, SSS, Argo, ocean mesoscal eddies, Clouds and the Earth's Radiant Energy, Precipitation
- Radar observations of hydrometers and boundary-layer turbulence structures

Major gaps:

- Satellite observations of wind, temperature and humidity profiles
- Observations of the 1km that connects the ocean surface to the free troposphere through the PBL
- Observations and understanding of SST fronts and their impact,
- Observations of spatial-temporal variability of the ocean mixed layer depth
- Lack of sufficient observations of cloud microphysics from airplanes and balloons
- Inconsistency among surface fluxes of different reanalysis products and different satellite products
- GCM tropical Atlantic biases: local vs. remote effects

(2) What technological tools are newly available (and need to be developed) to address key questions for fundamental understanding and model improvement?

New and future observing technology:

- Saildrone, air drone, wave glider, cubeSats
- Phase-radar: fast electronic scanning producing high-resolution 3D images
- Submersible underwater drones: drone in the air, gliders in the water

(3) Which existing coordinated activities could be leveraged to address these challenges, and what new activities could be formed? How should modeling activities be included, in an improved fashion, to complement these observation-based activities?

Our recommendations:

- **AI-driven autonomous coordination platform:**

  communicating with each other and coordinate in changing the sampling strategy based on changes in the environment

- **Virtual field campaigns:**

  sampling numerical gridded products (reanalysis, simulations) based on known observing platforms (airplanes, ships, moorings, and other autonomous devices) to guide the design of field observation plans.

(4) What are the key lessons learned from past activities that could potentially benefit future activities?

Engage with the modeling community to achieve an optimal design of field observation plans

Breakout 2, Group 4

Lead: Angela Rowe

Co-Chairs: Antonietta Capotondi and Elizabeth Thompson

Key observational gaps

- ➢ Extreme events (high winds!)
  - Coupled dropsondes with XBT
- ➢ Origin, movement, and evolution of barrier layers (Argo insufficient, spatial variability? Need dedicated buoys over spatial scales of convection)
- ➢ What conditions affect the fluxes that are not captured in models → occurring over what spatial scales?
- ➢ Waves: presence, directional spectra, height, role in air-sea interactions (ideal surface buoy unconstrained from surface, most research buoys anchored; autonomous measurements exist, need larger support)
- ➢ El Niño onset: momentum response in ocean important for air-sea interaction
- ➢ Net effect of small-scale events (e.g., atmospheric cold pools) on larger and longer time scales (Ocean memory: spatial and temporal correlation, good way to unify models and obs!)

Technological advancements

- ➢ Ocean: Drifters, crawlers, wire walkers, autonomous platforms - link to obs!
- ➢ Atmos: Sampling in atmospheric boundary layer (drones revisiting areas recharging over buoys, UAVs from ships, TKE from lidar, cloud radars), coupled with oceanic observations (Saildrones array!)
- ➢ Satellite: IR scanning of SSTs, CUBESAT

Activities (Lessons from past, existing, new)

- ➢ Pilot studies coordinated with the current global observing system (Need co-located air-sea obs over long periods of time)
  - ○ MISO-BOB (ONR, Bay of Bengal) good example of co-located measurements but need 2D information -> Pilot for 15 N, drifting buoys, ship into the wind, over the period of a day they'd separate by a few 100 km. What is optimal spacing?
  - ○ Revisit previous area (e.g., TOGA COARE) with newer technology/understanding
- ➢ Coupled DA is needed
- ➢ AEOLUS ESA satellite mission (Doppler wind lidar - global winds!)
- ➢ Coordinated data types/synthesis of data products (support model efforts)