Breakout 4: Air-sea Interactions

Objective: To identify opportunities for integrated air sea interactions modeling and observation session

Discussion Questions:

1. What are the main progress during the past decade and remaining key gaps in observing, understanding, and modeling of tropical air sea interactions?
2. What new technological tools are available and need to be developed to further model-observation integration to advance understanding, modeling, and prediction of tropical air-sea interaction and to combine studies on tropical convection and air-sea interaction in a way that is impossible in the past?
3. Which existing coordinated activities could be leveraged to address these challenges and what new ones could be put together that will further integration of modelling and observational activities to advance understanding, modeling, and prediction of tropical air-sea interaction?
4. What are the key lessons learned from past activities regarding integration of studies on modeling and observations of tropical air-sea interaction and studies on tropical convection and air-sea interaction that could potentially benefit future activities?

Breakout 4 (G1): Air sea interactions

- Progress and remaining gaps
  - Progress: Bulk parameterizations for latent and sensible heating fluxes. But more work needed
  - Gap: Behavior in extreme conditions (high winds and precipitation).
  - Gap: The improved bulk parametrizations need to go into models
  - Gap: Consistent parallel/unified component model development
- Technological tools
  - Coupled data assimilation products (broadly used in global models)
  - CYGNUS GPS satellite fluxes under precipitation, surface wind speed, no rain contamination.
  - Flux communication frameworks (e.g., wave models)

Breakout 4 (G1): Air sea interactions

- Coordinated activities
  - Leverage Year of MC activities better for strategic problems (esp. modeling)
  - Can we cast the science in terms of tractable air-sea interaction problems?
  - New: Multi-scale process interactions (diurnal->sub-seasonal->seasonal->~mean)
  - Requires co-location of observing capabilities (atmosphere and ocean)
  - New: Locations that are key for exploiting predictability of the system (e.g., mature MJO heating location)
- Lessons learned
  - Long term, multi sensor capabilities are needed to ‘attract’ climate<->process-study interest
  - Legacy datasets need to be accessible and useful to a broad community
  - For deployments (e.g., TPOS) need to clearly communicate need for instrument and instrument combinations
  - Societal benefits must exist alongside the science questions

Breakout #4 group #2

Progress:

- Air-sea-wave coupling in numerical model
- Observations and modeling of diurnal coupling
- Improvement of stratus cloud of the eastern Pacific in GCMs
- Observations of TC cold SST trails
- Recognition of TC as a coupled phenomenon
- Recognition of the importance of SST gradient to surface fluxes across a variety of scales
- Buoy-based lidar profilers (surface – 300 m)
- Coupled models for NWP

Gaps:

- Observations and knowledge of turbulence in the PBL
- Observations of moisture variability associated with cold pools
- Observations of the vertical structure and evolution of cold pools at min resolution
- Observations of SST fronts, their processes, surface fluxes, and PBL
- Not using the most advanced surface flux algorithms in numerical models
- Flux parameterization for high wind
- Observations of coastal wind

Recommendations for progress

- Enhanced model-observation integration: ensure applications of most advanced observational products to model development.
- Surface fluxes should be used as a metric to evaluate (coupled or uncoupled) model performance over the ocean. Comparisons with satellite gridded products are encouraged, and product improvement should co.ntinue
- Modelers should not select a flux parameterization that produces the results they want. They should use a consensus flux algorithm (such as COARE) as standard surface flux scheme to reduce one tunable parameter in models
- Measurements of vertical profiles of atmospheric boundary layer key to improvements (state variables, fluxes).
  - Need continued technological development to bring down power needs and sizes
  - Note developments where other partners have interests (e.g. wind power industry)
- Measurements of a spatial domain are needed to understand air-sea interactions on various scales. Examples:
  - Observations of the vertical structure and evolution of cold pools at min resolution
  - Observations of SST fronts, their processes, surface fluxes, and PBL
- Optimal locations for continuous (≥ three years) field observations (supersites) should cover all or most scenarios of air-sea coupling (strong vs. weak winds, uniform SST vs. strong SST gradients, types of waves, etc.), convection (shallow to deep), open water vs. coast. Should provide for horizontal coverage as well as vertical
- Significant differences shown between model simulations with differing ABL vertical resolution and parameterization
  - Vertical resolution in the boundary layer of ocean has progressed, but what about vertical resolution in atmosphere models?
  - Need a focus on PBL mixing schemes and improvements

B4, G3

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- Key gaps (especially related to air-sea interaction):
    - MJO initiation, tropical cyclones, monsoon, ENSO
    - Diurnal cycle
    - Scale interactions
    - “Small” features when close to the interface: waves, bubbles, gas exchanges, aerosols,…
- New technological tools:
    - Newer in ocean: saildrones, ARGOs, drifters, wave gliders, seagliders, floats, UAVs, …
    - For atm.: observations looking at dry dynamic BL organization that feedbacks to convective processes. Tools are developing for turbulence or cloud resolving observation: buoy, aircraft,… needs contextual ~5km foot print nested with 25 km Doppler wind lidar, SAR, …

- Existing coordinated activities could be leveraged to address these challenges:
  - Supersites
  - Microwave resolution (ex: SST ~25 km) is not high enough. Problems with satellite observations of sea surface in the presence of clouds.
  - Vector winds from active satellites. Vector winds are important for air-sea interaction.
- Key lessons learned:
  - Put state-of-art coare flux parameterization in the models. Many don’t!
    - Challenges in designing observing plans for asymmetric or multidisciplinary phenomena; need to coordinate atmospheric scientists and oceanographers. (ITOP air-sea missions were well-coordinated!)
    - Need of ARGO floats which are capable of measuring air-sea interaction.
    - Better communications between scientific communities/ countries. EX: with other local partners in east and southeast Asia.
    - Create online platform or user friendly website that consolidates all the data available - map or list or … that could possibly ease the communication between scientific communities and observation initiatives.

Breakout #4: Air-sea interactions

Group #4

Key Findings

- Technological advancements have been made with regards to our ability to observe aspects of air-sea interactions (Satellites, Argo, etc), but gaps remain (retrieval of fluxes at the air-sea interface from satellites - depends upon relationship between surface fluxes and boundary layer processes).

- Our understanding has improved in certain areas (Oceanic mesoscale) but continues to lack in some (significance of sub-mesoscale dynamics, surface ocean/mixed layer processes and their role in convection, model biases in the tropics)

Future Recommendations

- Better integration of modeling and field campaigns - conduct a modeling study prior to the field campaign to help design and guide data collection (Such as TPOS and pre-VOCALS).

- Data curation and dissemination through cloud, using advanced Machine Learning techniques.