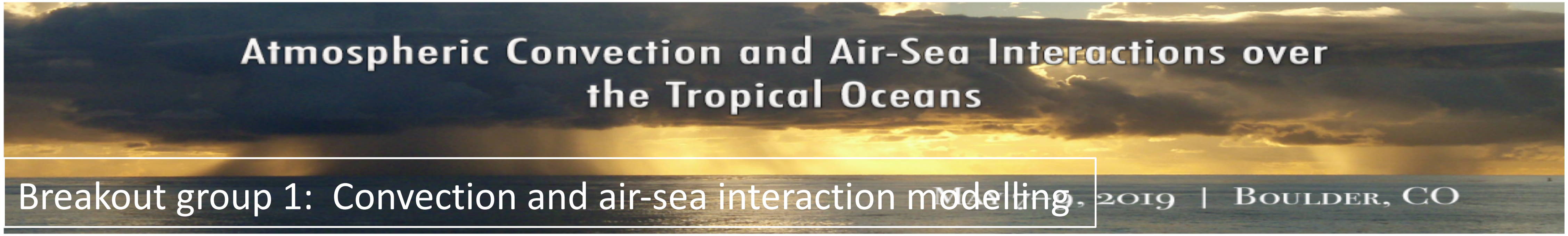
Breakout 1: Modeling

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

Discussion Questions:

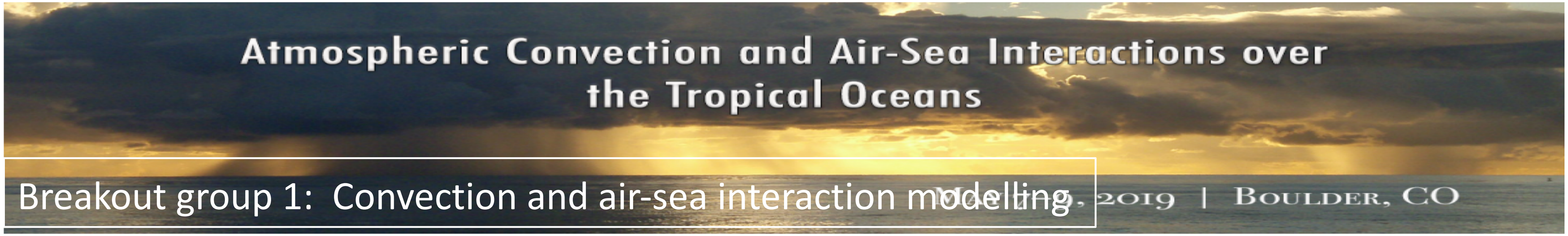
- What are the key gaps in modeling and model validation of tropical convection and air-sea interactions?
- What new technological tools and methodologies are available, or are need to be developed, for advancement of greater fundamental understanding and improved prediction?)
- Which existing coordinated activities could be leveraged to address these challenges, and what new activities could be formed? How can existing and future observations be used in a complementary fashion to achieve these goals?
- What are the key lessons learned from the past that could potentially benefit future activities?
- What are the possible implications of future changes and improvements in modeling (increasing spatial resolution, coupling frequency, data assimilation, combining primitive equations and traditional parameterizations with statistical techniques and machine learning) for the design of future process studies?
- What are the dream observations (regardless of whether they are possible based on existing technologies) needed to advance modeling/prediction in the coming decades? Can we come up with a priority list?



Breakout group 1: Convection and air-sea interaction modelling

Modelling

- Component models are too simplified and tuned separately.
- No observations, or DA can help, if processes are fundamentally not represented in model, e.g:
  - Wave model for representing surface waves (exchange of momentum and heat, important for aerosols, gas exchange)
  - Even LES has limitations
- For simulating multi-scale processes new high-resolution Earth system models should be build from scratch with an emphasis on coupling from the very beginning
  - Important to include model-error representation (e.g. stochastic parameterization possibly, machine leaning)



Breakout group 1: Convection and air-sea interaction modelling

Observations:

- PBL over ocean often uses parameters obtained from data over land (“Kansas”) New field campaign to collect data in marine PBL

➢ Co-located ocean & PBL measurements

  - Tower with instruments in PBL and sub-surface measuring for long-time continuous measurements (> 1 year)
  - Consider alternative platforms and collaborations with industry, e.g. offshore wind farms

Summary from Breakout #1, Group #2

Key gaps in modeling and model validation?

Representation of cold pools, the role of fluxes in the dissipation of cold pools, surface observations of fluxes under different conditions, PBL scheme parameterizations, convective parameterizations, LES models need validation.

New technological tools and methodologies available or need to be developed?

A need for long-term coupled air-sea measurements to grasp multiple realizations of temporal and spatial scales to be able to develop better physical understanding and parameterizations (i.e. scale-aware parameterizations). Continuous coupled observations are needed to implement machine learning.

Existing coordinated activities could be leveraged and new activities to be formed?

Ideas for “supersites” which contain instruments to measure both oceanic and atmospheric boundary layer but still undecided as to where to place it. Possible moving the platform every so often. Small field studies with supplemental observations (aircraft, drone) to complement these sites. Drones docking on moored platforms

Key lessons learned from the past and insights for the future?

A lack of progress still exists for modeling convection but need to identify the causes as to why. With long-standing coupled observations its possible to leverage both basic physic processes studies and new methodologies (machine learning, statistics, etc). Perhaps we need new-thinking paradigms for long-standing modeling issues.

Possible implications of future changes and improvements in modeling for the design of future process studies?

The inclusion of high-resolution of data assimilation would require collaborations with DA experts and identifying best observations (i.e. satellite radiances) for DA purposes. Machine learning needs continuous coupled observations of long-time scales to train off of. Similar observations needed to improve varying scale parameterizations.

B1, G3

Emily Riley Dellaripa

Key gaps:

Scales: What temporal and spatial scales of the ocean (SST, surface fluxes, waves) matter for convection? what are the *physical mechanisms* by which these ocean-based processes is communicated to convection? and at what scales? what is it about those fluxes that influences convection? What sets the scales of w in a developing system.

Target regime changes that involve multiple scales: such as seasonal transitions, non-precipitating to precipitating, non-organized to organized atm. Convection.

Coupled data assimilation: Ocean data assimilated, but some is not available within enough time for forecasting.

What is the role of ocean dynamics in NWP, S2S predictive skills or sources of predictably through delayed effects: memory, equatorial ocean waves, eddies, advection, OHC, barrier layers; At what point is 1D or 2- 3-D ocean dynamics necessary? 1-D = thermodynamic coupling and fluxes.

Dream observations:

Obs needed for model validation (long term, repeated): w and Q for development and evaluation of models

Any obs inside a TC, or other targeted high impact events (not just one though!)

More obs of air-sea fluxes, ocean mixed layer depth, barrier layer depth, OHC, *mixing* depth

Multi-satellite, vertically resolved convective properties: clouds that are validated with collocated ground based obs.

Lessons learned; How to organize ourselves for success and progress

<u>Coordinated model exercises before field experiment:</u> NSSL/SPC Hazardous Weather Testbed, Pro-VOCAL experiment, EURECA, PISTON. How do do this with enough time to inform field experiment?

Start new projects off with integrated, synthesized data legacy plan so that it can be organized for future work

B1, G4

Adam Rydbeck

Key Gaps:

Convective parameterizations are likely masking microphysical problems that we don’t yet completely understand

Output of assimilation related diagnostics is not standard practice by most modeling centers. These include analysis increments, error covariances, and other sources of model adjustments that result in large residuals when computing budgets.

Ocean model (under)representation of barrier layers

Underutilization of ocean observations that are rich in wavenumber/frequency variability for model validation/comparison

New Tools:

Collocated observations for coupled reanalysis and strongly coupled data assimilation

Wind profiler in the lower boundary. Some consider this a low utility instrument because we can use the similarity theory. However, there are cases (such as cold pools) where such instrumentation would be highly useful.

TPOS2020 - discussed the possibility of supersite island stations equipped with instrumentation to resolve atmospheric boundary layer processes

Recommendation to resume TAO cruise radiosonde launches