Effect of Freshwater Input into the Tropical and Subtropical Ocean from Small- to Meso-Scales

Alexander Soloviev[1] and Roger Lukas[2]

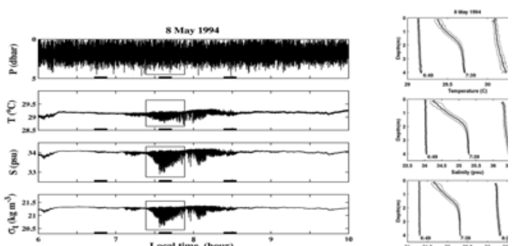
[1]*Oceanographic Center, Nova Southeastern University, Dania Beach, FL 33004 USA*

[2]*Department of Oceanography, University of Hawaii, Honolulu, HI 96822 USA*

Introduction

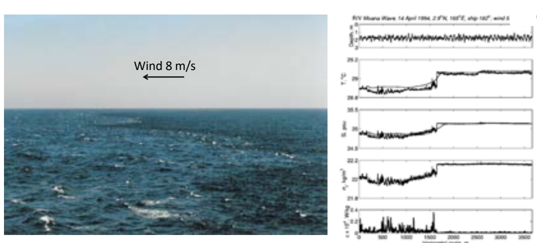
The TOGA Coupled Ocean-Atmosphere Response Experiment (Webster and Lukas, 1992) focused observations and modeling on two-way atmosphere-ocean spatial and temporal scale interactions (Meehl et al., 2001) in the western equatorial Pacific warm pool. Recently, Dong et al. (2019) showed that the warm pool plays a uniquely large role in determining the global radiative feedback to global CO2-induced surface warming, attributing this to the very deep atmospheric convection over the warm pool. Palmer and Stevens (2019) show that the bias error in seasonal mean precipitation is larger than the anthropogenic signal in many regions around the globe, arguing for a quantum leap in spatial resolution to eliminate parameterizations of unresolved processes. Carbone and Li (2015) show that the magnitudes of small-scale SST variations in the warm pool are associated with convective rainfalls within the envelope of the Madden-Julian Oscillation. Here, we show observations and model results that support the conclusion that the atmosphere and ocean are strongly coupled on the convective cell scale in the warm pool of the western Pacific Ocean.

Freshwater lenses observed during TOGA COARE



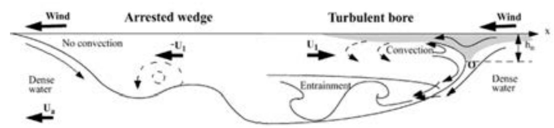
Soloviev and Lukas (1997)

Edges of freshwater lens can be sharp due to wind stres



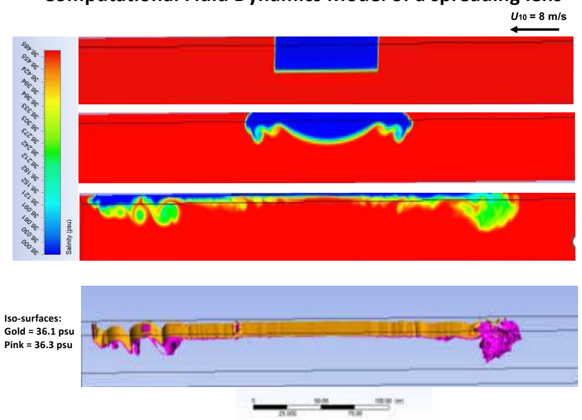
Soloviev, Matsuura, and Lukas (2002)

Freshwater lens spreading and interacting with wind

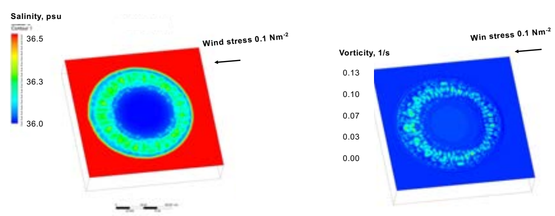


Soloviev and Lukas (2014)

Computational Fluid Dynamics Model of a spreading lens



Spreading lenses generate spatially coherent structures



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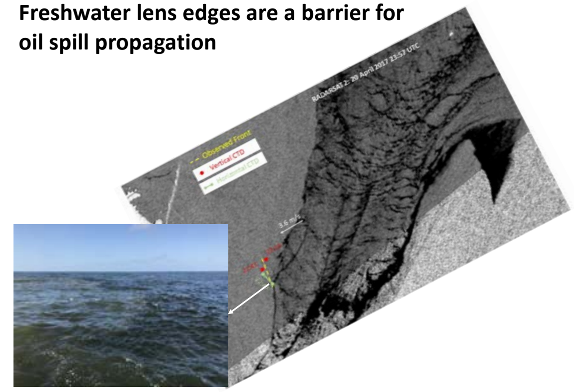
Freshwater lens edges are a barrier for oil spill propagation



Splash - UM CARTHE/GoMRI

Conclusions

- Rainfall into the tropical and subtropical ocean is often from convective cells with scales of O(10 km). Another source of freshwater input to the ocean is river runoff.
- Due to the significant density difference between fresh and seawater, near-surface lenses and fronts develop, which then spread horizontally becoming progressively thinner.
- While spreading, the freshwater lenses interact with existing ocean stratification and wind stress, as well as the diurnal cycle of solar radiation eventually mixing and merging with other lenses. Such small-scale processes are important for creating the deeper layer known as the barrier layer (BL; Lukas and Lindstrom,1991). There are numerous strongly nonlinear processes involved.
- The BL is an important component of climate, especially in the tropical and subtropical ocean (Sprintall and Tomczak, 1992) and is known to influence some tropical cyclones.
- Because of strong nonlinearity and thermal feedbacks to the atmosphere the physical connections across time and space scales need to be modeled explicitly (Carbone and Li, 2015; Palmer and Stevens, 2019).
- Incorporation of sub-mesoscale processes and small-scale parameterizations involved in freshwater input in coupled models may lead to a better understanding and modeling of tropical cyclones, oil spill propagation, and climate.

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