# Air-Sea Fluxes in Hurricane Models

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A Challenging Physics Problem

Sea spray due to wave breaking is omnipresent under hurricane strength wind conditions. The NOAA/ESRL bulk parameterization scheme of sea spray due to wave breaking has recently been upgraded to include the feedback effect of spray droplets on the air-sea momentum transfer. Although the scheme has been undergoing testing in NCEP's GFDL and HWRF models, how to dynamically take into account sea spray effects in coupled atmosphere-wave-ocean hurricane prediction models has not been well investigated.
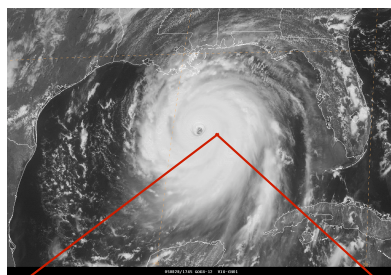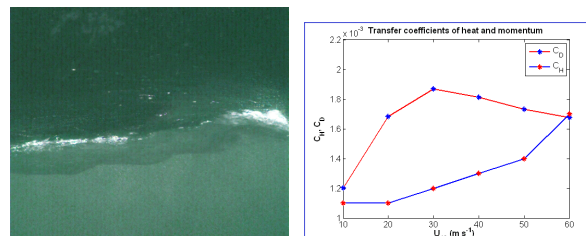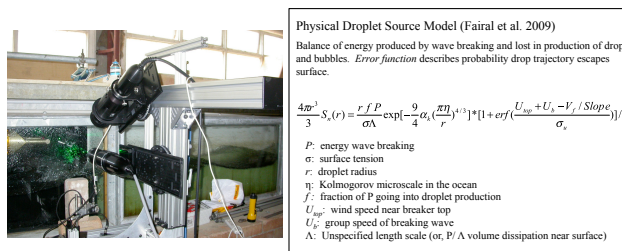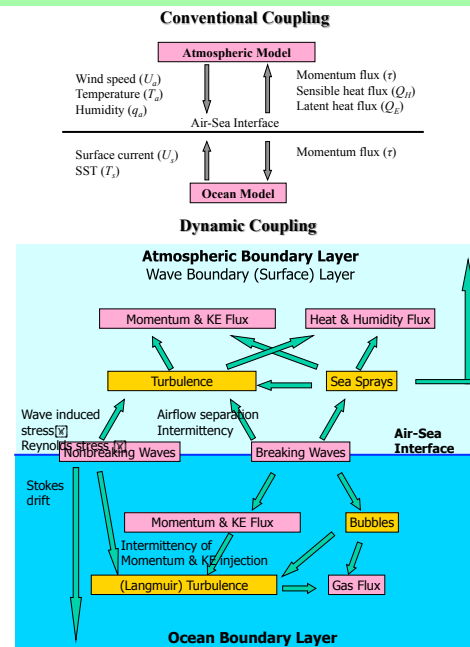
~200 m

A Gap to Fill
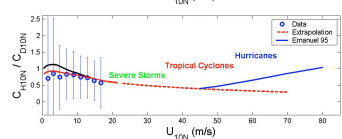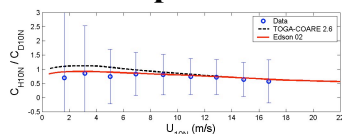
Modeling Sea Spray Effects

• A physical model of sea-spray generation function consistent with wave breaking dynamics that is formulated to depend on wind or wave state

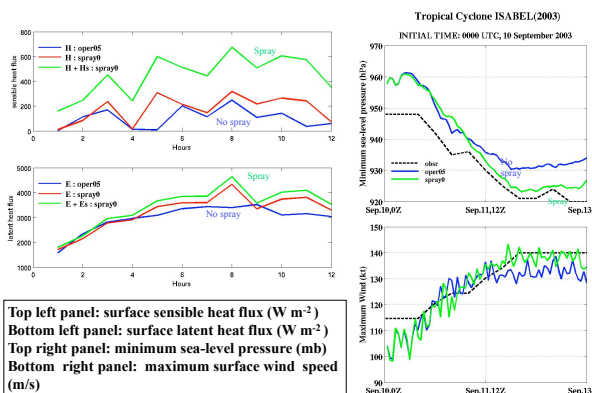• An extension of the Monin-Obukhov similarity framework to take into account the feedback effects

Physical Droplet Source Model (Fairal et al. 2009)

Balance of energy produced by wave breaking and lost in production of drops and bubbles. *Error function* describes probability drop trajectory escapes surface.

$$\frac{4\pi r^3}{3} S_v(r) = \frac{r\,f\,P}{\sigma \Lambda} \exp[-\frac{9}{4}\alpha_s(\frac{\pi\eta}{r})^{4/3}]*[1+erf(\frac{U_{top}+U_b-V_f/Slope}{\sigma_v})]/2$$

P: energy wave breaking
σ: surface tension
r: droplet radius
η: Kolmogorov microscale in the ocean
f: fraction of P going into droplet production
U_{top}: wind speed near breaker top
U_b: group speed of breaking wave
Λ: Unspecified length scale (or, P/Λ volume dissipation near surface)

Sensitivity Experiments

Output from the NCEP operational GFDL hurricane model as of 2007 with and without spray parameterization

Top left panel: surface sensible heat flux (W m^{-2})
Bottom left panel: surface latent heat flux (W m^{-2})
Top right panel: minimum sea-level pressure (mb)
Bottom right panel: maximum surface wind speed (m/s)

Research Challenge
Toward a dynamical coupling between Atmospheric and Oceanic models

Ongoing Activities

We are currently testing and evaluating the NOAA/ESRL air-sea heat flux parameterization scheme in the operational hurricane model (HWRF). The goals of the ongoing research with the operational model are (1) to determine the sensitivity of the sea-spray mediated air-sea heat flux calculation to the uncertainties in the wave dynamics and the kinematic and thermodynamic feedbacks of sea spray, and (2) to make the scheme more general by including both the spray evaporation feedback and stress reduction effects. We are also closely collaborating with researchers from NOAA and universities to evaluate the impact of the improved air-sea flux scheme on the marine boundary layer dynamics under hurricane conditions.