Evaporative cold pools enhance air-sea fluxes in DYNAMO

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2011-Oct-13 NOAA HRDL plan images
80E, equator *Revelle* ship observations

**Surface heat balance**

- **SST**
- $T_{\text{air}}$
- **Net sensible longwave**
- **Solar**
- **Evaporation**

2011 date UTC
air temperature

PSD surface temperature (C)

November 2012
12-minute Haar filter finds slope $< -0.4 \, \text{C/min}$

229 events in legs 2 and 3
composite cold pool front

![Graph showing temperature and wind speed changes over time from front.](image-url)
composite cold pool front

- Temperature (°C)
- Wind speed (m/s)
- Sensible heat flux (W/m²)
- Latent heat flux (W/m²)
- Solar down (W/m²)
- Longwave down (W/m²)

Graph showing changes over time from front (minute).
composite cold pool front

graph showing temperature (°C), wind speed (m/s), sensible heat flux (W/m²), latent heat flux (W/m²), solar down (W/m²), and longwave down (W/m²) over time from front (minute).
Cold front turbulence method

• Using **229 unique cold pools** from 1-min temperature time series:

  12-minute Haar gradient filter $\leq 0.4 \, \text{C/min}$

• Composite turbulence ±2 hours from front
  – $u, v, w, T_s$
  – covariance $<w'u'>, <w'v'>, <w'Ts'>$
stream-wise stress

streamwise kinematic stress $\langle w'u' \rangle$ (m$^2$/s$^2$)

across wind

along wind

time after cold pool front (minute)
stream-wise stress

COARE 3 bulk fluxes

mean

median

median turbulent

time after cold pool front (minute)
zonal and meridional stress

kinematic wind stress $\langle w'u' \rangle$, $\langle w'v' \rangle$ (m$^2$/s$^2$)

time after cold pool front (minute)
zonal and meridional stress

wind stress $\rho \langle w'u' \rangle$ (Pa)

time after cold pool front (minute)

meridional

zonal

COARE 3 bulk fluxes
heat flux

heat flux $<w'T_s>$ (K m/s)

time after cold pool front (minute)
heat flux

sensible heat flux $\rho C_p \langle w'T' \rangle$ (W/m$^2$)

time after cold pool front (minute)

COARE 3 bulk flux
Effect of cold-pool gusts: summary

- Median cold pool front doubles stress and sensible heat flux for 20 minutes.
- 12-24 minute windows capture more covariance than shorter windows.
- COARE bulk fluxes are consistent with turbulence fluxes.
  - Near cold pool fronts, anomalously strong wind gusts are disproportionately responsible for mean stress/flux.
  - Sea swell could reduce along-wind stress.
large-scale setting

- Hovmoller
- time series
- Distinct structures at multiple scales in atm. and ocean:
  - MJO
  - wind bursts (Kelvin waves)
  - convective complexes
  - evaporative cold pools
  - turbulence
  - waves, fluxes, air-sea interaction
  - stratification and mixing
  - Wyrtki/Yoshida jet acceleration
  - Equatorial undercurrent
    (BAMS proposal, Moum et al.)
MJO, Kelvin wind bursts, rain showers

[Diagram showing OLR [W m$^{-2}$] over November and December, with Kelvin wave 1 and Kelvin wave 2 indicated, and MJO envelope]
MJO, Kelvin wind bursts, rain showers

OLR [W m$^{-2}$]

Kelvin wave 1

Kelvin wave 2

MJO envelope

daily OLR [W m$^{-2}$] and Revelle hourly precipitation [mm hr$^{-1}$]

2 wind bursts
Development of 1st Westerly Wind Burst

METEOSAT water vapor path, COAMPS 850 hPa wind

COAMPS model wind courtesy Sue Chen
Large-eddy simulation
lowest model level

potential temperature

vertical velocity

cold

warm
model potential temperature at lowest level (150 m)
$w'\theta'$ at 150 m
Outflow boundary in TOGA radar

October 24 5:10 UTC

Angela Rowe, Colorado State U.
Effect of convection on surface fluxes
Clouds on the density current, 2011 October 24, 10 local
NOAA W-band cloud radar

[Image of radar data with height, reflectivity, and Doppler velocity plots]

- Height (km)
- Reflectivity (dBZ)
- Doppler velocity (m s\(^{-1}\))