The role of wind gusts in upper ocean diurnal variability

Giglio, Donata

Sarah T. Gille, Aneesh C. Subramanian and San Nugyen
The **diurnal warm layer** has a nonlinear rectification effect on longer timescales (mean SST, MJO, monsoons, …).

*Bernie et al. [2007], Bernie et al. [2008], Weller et al. [2014], Seo et al. [2014], Large and Caron [2015], …*

Air-sea coupling resolving the diurnal cycle or not: difference in 50 year mean SST

*Bernie et al. [2008]*
How to account for the diurnal warm layer in a climate model?

\[
T_w = T_{5 \text{ cm}} - T_{10 \text{ m}}
\]

\[
T_{\text{skin}} = T_{10 \text{ m}} + \Delta T
\]

\[
\Delta T = T_w + T_c
\]

- obs
- 1D process model
- diurnal cycling scheme by Large and Caron [2015]
Observed $T_w$ diurnal peak in the Indian Ocean from RAMA moorings

$T_w$ from R/V Revelle = $T_{5 \text{ cm}} - T_{10 \text{ m}}$

$T_w$ from RAMA = $T_{1 \text{ m}} - T_{10 \text{ m}}$

- 11-22 October 2011
- 13-23 November 2011
1D process model

Diurnal Cycling Scheme
Large and Caron 2015

- $\Delta t = 5$ minute
- $\Delta z = 10$ cm

$T(z) = T_{5\text{ cm}} - f(z,d,p) T_{W}$
1D process model experiments

obs at Eq, 80.5°E
G1, GOTM
G2, 24-hour smoothed wind
G3, G2 + diurnal wind
G4, G2 + random wind gusts
G5, G2 with non-solar heat fluxes from smoothed wind

Solar radiation, W m\(^{-2}\)
Non-Solar heating, W m\(^{-2}\)

Wind stress amplitude, kg m\(^{-1}\) s\(^{-2}\)
Diurnal wind: CCMP

October climatology

October minus January
Wind gusts regulate downward mixing of surface water warmed by solar radiation.

Random wind gusts in input to GOTM yield a good comparison with observed $T_W$

$$T_W = T_{5\,\text{cm}} - T_{10\,\text{m}}$$

**Obs at Eq, 80.5°E**
- $G_1$, 1D process model
- $G_2$, 24-hour smoothed wind
- $G_3$, $G_2$ + diurnal wind
- $G_4$, $G_2$ + random wind gusts
- $G_5$, $G_2$ with non-solar heat fluxes from smoothed wind

**NOV2011**
A variant version of the Large and Caron [2015] diurnal cycling scheme provides a good estimate of the observed $T_W$

\[ T_W = T_{5\text{ cm}} - T_{10\text{ m}} \]
Summary

• What is the role of wind gusts versus diurnal wind on the evolution of the diurnal warm layer? **Wind gusts regulate downward mixing of surface water warmed by solar radiation. Diurnal winds are weak and play a minor role.**

• Can a 1D process model simulate the observed upper ocean diurnal warming? **Yes, even when random wind gusts are used as forcing.**

• Does the Large and Caron [2015] diurnal cycling scheme provide a good estimate of the upper ocean diurnal warming? **A variant version of the Large and Caron [2015] diurnal cycling scheme does provide a good estimate, but it is not sensitive to wind gusts.**

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