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Diurnal heating at the ocean surface

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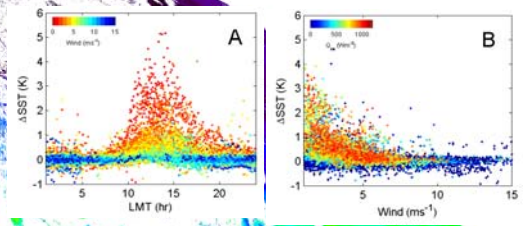
Introduction

Under conditions of low wind speed and high insolation (*i.e.* cloud-free conditions) the heat generated in the upper ocean by the absorption of solar radiation remains trapped in the uppermost few meters of the ocean. The near-surface vertical temperature gradients are called the diurnal thermocline. The cloud-free conditions that are favorable to the infrared remote sensing of the sea surface are also conducive to the generation of the diurnal thermocline.

The amplitude of the diurnal signatures in temperature are often greater than the uncertainties in the satellite-derived sea-surface temperatures (SSTs) and the merging of SST fields from satellites with different overpass times, such as from the MODISs on Terra and Aqua, requires the diurnal heating effects to be taken into account. The SST before the onset of diurnal heating is called the *Foundation Temperature.*

Here we present examples of diurnal heating as revealed as the difference in the surface skin SST, measured by the M-AERI, and a collocated, coincident subsurface temperature by an in situ thermometer (Gentemann, 2007; Gentemann & Minnett, 2008). A new model of surface heating is also introduced.

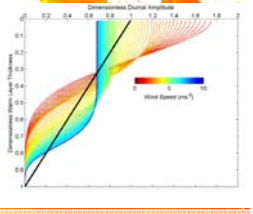


Measurements of diurnal warming as functions of

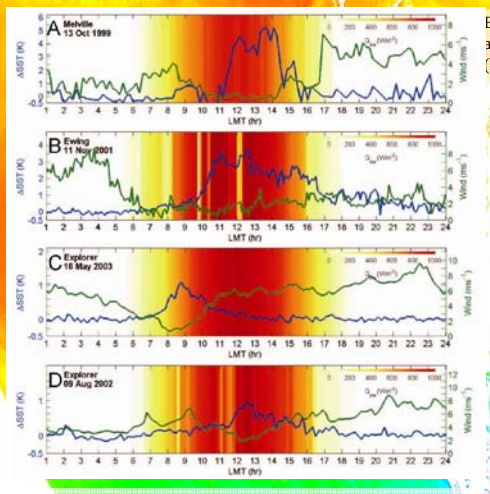
A) local time

B) wind speed

C) insolation



Normalized profiles of diurnal temperature profiles as a function of wind speed, used in the new POSH model (Gentemann, 2007). The black line is the equivalent profile in the Fairall *et al*., model (1996).

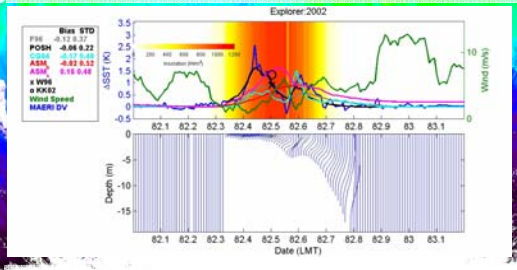


Examples of measurements of diurnal heating (blue line, left scale) as a function of wind speed (green line , right scale) and insolation (background colors, inset scale).

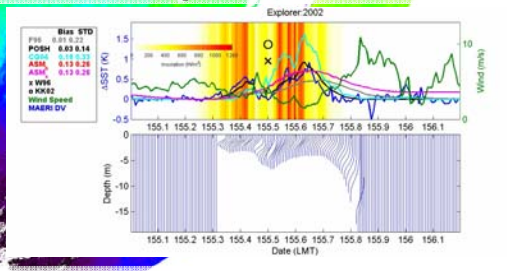
The POSH (Profiles of Surface Heating) Model

A new model of the upper ocean heating is based on a one-dimension model of the upper ocean (Price *et al*. 1986) with significant improvements, including: improved spectral representation of solar energy absorption, dissipation of momentum and heat, and parameterized profiles of temperature (Gentemann, 2007; Gentemann *et al*. 2008).

Below are two case studies of diurnal heating and cooling measured from the *Explorer of the Seas*. The predictions of other diurnal heating models from the literature are also shown. The codes in the key are: F96 – Fairall et al., 1996; CG04 – Gentemann et al., 2004; ASM - Stuart-Menteth et al., 2005, bulk and skin SSTs; KK02 – Kawai and Kawamura, 2002; W96 – Webster et al., 1996. Only the POSH model predicts the temperature profiles, shown in the lower panels.



Two peaks during the same day. Both peaks are captured only by CG04 and POSH models. The ASM models have a single peak in the middle of both peaks. The KK02 and W96 models are not coincident with either peak but the amplitude matches the second peak well, both models are unable to reflect the variability measured during this day. The F96, POSH, and CG04 models all have two distinct peaks but are too small compared to the M-AERI data. The warm layer is initially shallow, deepening with the increase in wind speed, and then decreasing in depth again as the wind decreases for the second diurnal peak.



Late afternoon peak and variable cloud cover. Here the CG04 model over estimates warming while the POSH correctly estimates the shape and magnitude. F96 under-estimates the peak, places it later than observed, and over-estimates warming in the afternoon. The ASM model correctly estimates the magnitude but not the shape and misses the early morning peak. The POSH model correctly simulates two peaks, but underestimates the amplitude of the first peak. The warm layer shallows, deepens with increasing wind, then decreases again with decreasing wind.

Summary

• Recent radiometric measurements of the SST show that large amplitude diurnal heating of the upper ocean is more common than previously thought.

• The amplitudes are often much greater than uncertainties in satellite retrievals f SST, and cannot be neglected in schemes that merge data from satellites with different overpass times.

• The amplitude of the diurnal SST is strongly dependent on wind speed.

• The new POSH model is generally more accurate than those in the literature.

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