

# Comparing Derived and Actual Upwelling Longwave Measurements at the CERES Ocean Validation Experiment (COVE)

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COVE website: <http://cove.larc.nasa.gov>

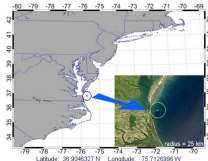


## Introduction:

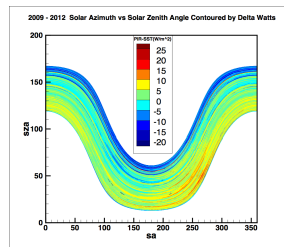
- The Clouds and the Earth's Radiant Energy System (CERES) Ocean Validation Experiment, or COVE, was established at Chesapeake Light Station as a validation site for CERES and other satellites in 2000.
- Pictures of COVE and the upwelling instrument locations are displayed.
- The upwell LW "tower radiating effect" issue shows an extra heat signal measured in the afternoon, due to this undesired heat signal, an emphasis is presented on "deep" night measurements when solar insolation is not an issue.
- Analysis of Infrared Radiation Thermometer (IRT) data (which was used to measure sea surface temperature, or SST) and upwell Precision Infrared Radiometer (PIR) measurements are displayed and will strive to make a case for using both measurements for a new derived upwell PIR reading to account for the tower radiating effect.
- A source term is introduced as another means to attempt to explain the tower radiating effect.



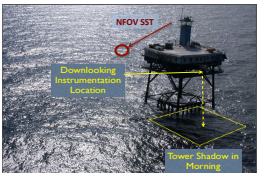
COVE is ~25km off the coast of Southeast Virginia, USA. Depth of water is ~12m.



Map of COVE's location.



Solar Azimuth vs. Solar Zenith Angle. Note the enhanced heating signature in the afternoon being picked up by the upwelling PIR. We posit this extra heat is coming from the tower.



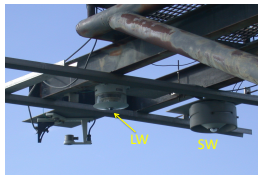
Notice the shaded area beneath the upwell instruments. This occurs primarily in the morning and will affect SW measurements. However, this shading should not affect LW measurements measured with the PIR.



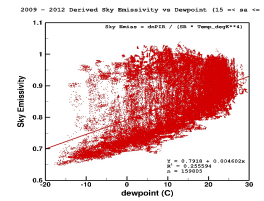
The "tower radiating effect". A fish-eye lens picture shows the structure in the field of view of the upwelling instruments. The signal from the tower is an undesired quantity. As shown in the photo to the left, the narrow field of view (FOV) IRT does not have the tower in its view. IRT specifications: 2.8° FOV, 9.6-11.5µm range.



Upwelling instruments are at the end of the 8m catwalk on the west side of the structure.



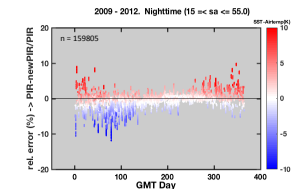
Upwelling broadband SW (Kipp and Zonen) pyranometer and LW pyrgeometer (Eppley PIR). Instrument elevation: 21m.



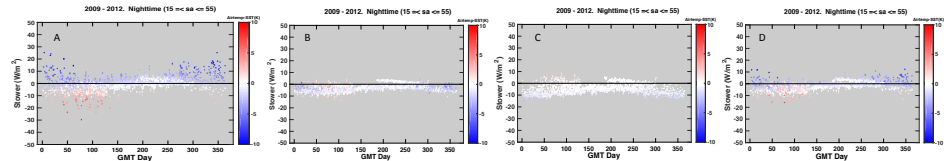
Derived Upwelling Longwave Equation:

$$E_{wT} = E_{wT} \sigma (1 - E_a) + E_a T_a^4$$

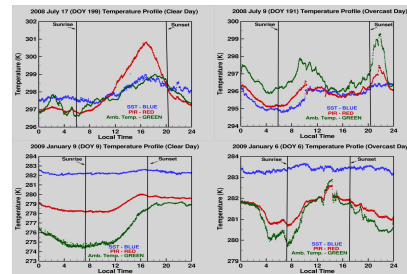
where,  
 $E_w$  = Emissivity of water  
 $\sigma$  = Stefan-Boltzmann constant  
 $T_w$  = Water temperature  
 $E_a$  = Emissivity of air  
 $T_a$  = Air temperature



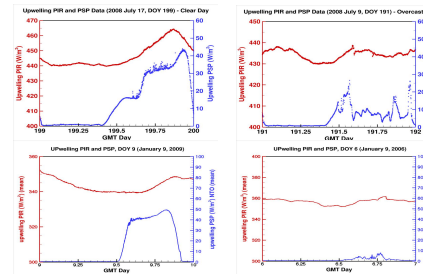
Left: Determining sky emissivity from the "deep night" dataset. Center: The derived upwelling longwave equation. Results from this equation are used to compare to the actual upwell longwave measurements made by the pyrgeometer. Right: Using data only from the "deep night" period, the mean, median, standard deviation and standard error is -0.378, -0.14, 1.906 and 0.005 respectively. The relative error is larger in the colder months and smaller in the warmer months. This result has led to the plots below to attempt to understand tower effects that may be occurring in the nighttime.



Left to Right: A source term for the tower (Stower) is added to the derived upwelling longwave equation. The 4 Stower graphs are different depending on where the air temperature measurements are made. A) Air temperature at instrument height (23 meters). B) Air temperature derived at a height (11.5 meters) halfway between the ocean surface and the air temperature instrument location. C) Air temperature at 6 meters above the ocean surface. D) Air temperature at 17 meters above the ocean surface. There appears to be a seasonal dependence on all 4 results. Another noticeable event is when the air temperature is interpolated to halfway between the ocean surface and instrument height, the data had the lowest range compared to the other scenarios.



Left: Upwelling LW measurements (PIR, red lines) are affected by the SST (IRT, blue lines), ambient air temps (green lines), and the tower temp. The red line should be in between the green and blue lines and this is usually the case. The influence of the tower signal is the most obvious on a sunny, summer day (upper left plot). This is less of a problem on overcast days, and the PIR tends to track the ambient air temps. On a clear winter day (lower left plot), the closing of the gap between the PIR and ambient temp (red and green lines) seems to indicate that the tower is heating up more slowly than the ambient air. Right: The radiant energy results for the 4 different days depicted by the 4 plots on the left. Each quadrant on the right corresponds to the quadrants on the left.



## Summary:

- Upwelling radiation measurements in this research were from 2009-2012.
- There is an afternoon bias, particularly noticeable on clear, sunny days which we believe is the tower heating up and re-radiating the extra heat that the upwell PIR is obtaining.
- Using "deep night" periods (15 <= sa <= 55), to remove any solar insolation effects, a new derived upwell longwave term may be achieved combining upwelling PIR, IRT, and the emissivity of air and water, but there is a seasonal dependence that still needs to be addressed.
- Another attempt to understand the tower radiating effect is adding a source term to our radiation budget equation. Determining where the air temperature is measured can affect your derived results.

## Acknowledgements:

• We thank the United States Coast Guard and the Department of Energy for allowing atmospheric and oceanic research at COVE.