Woods Hole Oceanographic Institution

Upper Ocean Processes Group

Technical Note

Surface Radiation Observations in the Open Ocean

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Overview

1) The ocean research community needs to use surface shortwave and longwave radiation together with latent and sensible heat flux to quantify the surface heat flux that couples the ocean and atmosphere. The accuracy goal is 10W m^{-2} in net heat flux at daily and longer time scales.

2) Surface buoys moored to the sea floor are to be located in characteristic climate regimes (e.g., stratus clouds, trade winds, tropical convection) and where ocean-atmosphere process studies are to be conducted. A number of buoys are in place now; more are planned.

3) Spatial sampling along repeat, cross-basin ship tracks is done by instrumenting Volunteer Observing Ships (VOS).

4) One goal is to use these in-situ surface radiation observations together with satellite or model-based surface radiation fields to develop ocean surface flux fields gridded at 1°x1° with daily resolution.

5) A second goal is to build up sustained ocean surface radiation time series at key locations for use in calibrating/validating model or remote-sensing based surface radiation fields and to provide local ocean surface forcing to process studies and ocean modelers.

Sensors

The WHOI Upper Ocean Processes Group has developed low power meteorological systems for use on ships and buoys. More about the Air-Sea Interaction Meteorological System (ASIMET) can be found at http://uop.whoi.edu/asimet/asimet.htm. The ASIMET radiation observations are collected using Eppley PSP and PIR and Kipp and Zonen radiometers. The material of the radiometer bodies is stainless steel to improve corrosion resistance. The sensors are set up as modules that include analog and digital electronics and flash card memory. The modules can be communicated with using RS485 or RS232. One-minute boxcar averages (thermopile voltage, body/dome temperature, and computed shortwave/longwave in engineering units) are recorded internally. Batteries can be placed in the modules, allowing their use as stand-alone sensors, or the modules can be linked to a common data logger and power supply.

VOS Coverage

The fixed point, high time resolution sampling by the buoys is complemented by sampling from VOS equipped with the same sensors as deployed on the buoys. The figure to the right is masthead installation of ASIMET shortwave and longwave radiometers, rain gauge, and air temperature / humidity sensor on a VOS.

Buoy Observations

Surface buoys anchored to the sea floor are instrumented with meteorological instruments, including the radiometer modules. Hourly-averaged surface meteorological data are telemetered via satellite, while the one-minute data are recorded internally.

Pictured to the right is a 3-meter discus buoy moored at 20°S, 85°W under stratus clouds off northern Chile. On station since October 2000, it is equipped with two Eppley PIR and two Eppley PSP.

Calibration/Comparison

The module electronics are calibrated with known voltage inputs. Longwave is then checked with a black body and next by comparison with a standard on the roof. Shortwave is also checked against a standard on the roof. We examine possible degradation due to exposure by two methods. First, before recovering a buoy, we station the ship close to the buoy, bow into the wind, and obtain one or more days of comparison between radiation sensors on the ship and those on the buoy. Second, without cleaning, the sensors are returned to WHOI and another lab/rooftop calibration is performed (pictured on next page). To check our calibration procedures, we

have deployed shortwave sensors on the Chesapeake Bay light tower, a BSRN site. This deployment will be followed by a deployment there of our longwave sensors. We have also performed comparisons with the sensors on NOAA PMEL and JAMSTEC surface buoys by collecting data with the WHOI, NOAA PMEL, and JAMSTEC buoys mounted on stands at a beach site with onshore flow.

The following tables summarize our present understanding of the accuracies in our surface radiation observations based on these laboratory and field calibrations and comparisons.

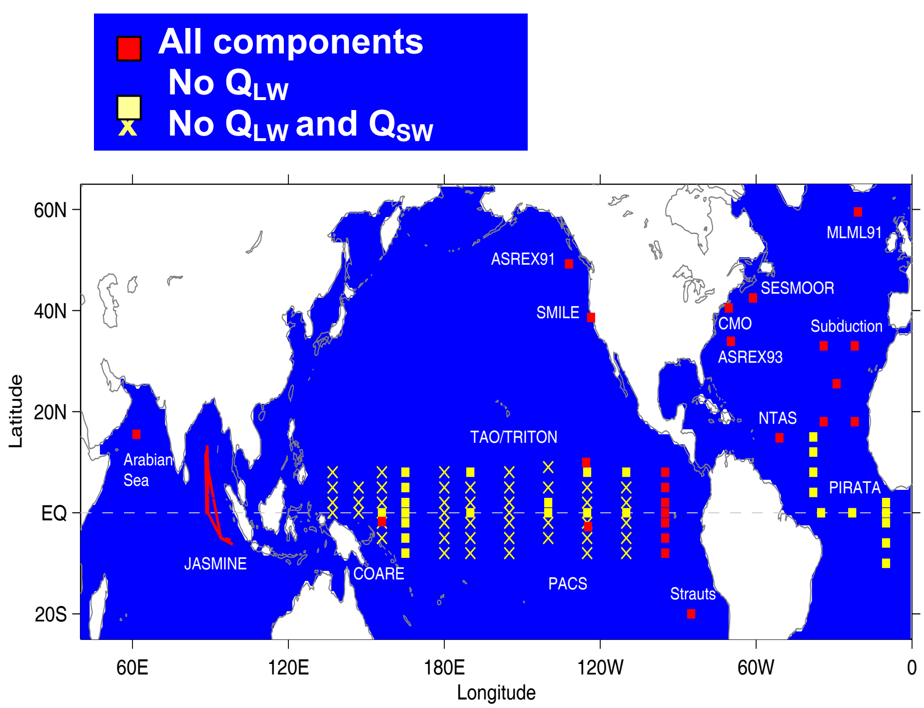
Precision	Lab Calibration	Drift	Field Errors	Total
0.1 W/m^2	2 W/m^2	<2 W/m^2	Tilt: < 2% T Gradients: 1-2 W/m^2 Salt Spray: < 1 W/m^2	Instant: 20 W/m^2 (more in broken cloud) Daily: 6 W/m^2 Annual: 5 W/m^2

Table 1: (above): The estimated components of the instantaneous error for shortwave sensors, and the expected total error for the one-minute measurements, daily averages and annual averages. **Table 2: (below):** The estimated components of the instantaneous error for longwave sensors, and the expected total error for the one-minute measurements, daily averages and annual averages. From Colbo and Weller, 2006. The accuracy of the IMET package, *Jrnl. ATmos. Oceanic. Tech*., submitted.

Precision	Lab Calibration	Drift	Field Errors	Total
Dome Temp: 0.1°C Case Temp: 0.1°C Thermopile: 10μV	Coefficient:1.5 W/m^2 Noise: 0.5 W/m^2	2 W/m^2	Tilt: < 2 W/m^2 T Gradients: 4 W/m^2 Salt Spray: < 1 W/m^2 Solar: < 1% ↓SW	Instant: 7.5 W/m^2 Daily: 4 W/m^2 Annual: 4 W/m^2

Challenges to Developing Ocean Surface Radiation Fields

In working to develop surface radiation fields over the ocean, we have compared the buoy and ship data to gridded products, including ISCCP surface radiation and the surface radiation from the NCEP and ECMWF re-analyses. These fields have significant biases. The challenge remains of developing gridded surface radiation fields over the ocean that have the accuracy required to allow us to meet the accuracy of 10W m^{-2} in net heat flux. The map below shows the location of shortwave and longwave radiation data available from buoys and research ships used to assess errors in existing surface radiation fields.



Conclusion: A global array of moored buoys and VOS with cross-basin tracks are being instrumented to collect incoming shortwave and longwave radiation. Future buoys may provide more stable, powered platforms. The ocean community needs accurate surface radiation fields. We seek advice and collaboration on in-situ radiation observations and on developing gridded surface heat flux fields for the global ocean. **Contributed by: R. Weller**

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