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Marine ARM GPCI Investigation of Clouds Infrared Sea Surface Temperature Autonomous Radiometer (ISAR) Field Campaign Report

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ARM CLIMATE RESEARCH FACILITY

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Acronyms and Abbreviations

Aqua	NASA satellite mission studying Earth's water cycle
ARM	Atmospheric Radiation Measurement Climate Research Facility
BB	black body
BNL	Brookhaven National Laboratory
C	Celsius
DOE	U.S. Department of Energy
ENVSAT	ESA earth observation satellite (now inactive)
ESA	European Space Agency
GEWEX	Global Energy and Water Experiment
GPCI	GEWEX Pacific Cross-Section Intercomparison
GPS	Global Positioning System
IOP	intensive operational period
ISAR	Infrared Sea Surface Temperature Autonomous Radiometer
MAERI	marine atmospheric emitted radiance interferometer
MAGIC	Marine ARM GPCI Investigation of Clouds
Mm	milimeter
MODIS	moderate-resolution imaging spectroradiometer, flown on NASA's Terra and Aqua satellites
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
NOCS	National Oceanography Centre, Southampton (UK)
RMSE	root mean squared error
ROSR	remote ocean surface radiometer
SBD	short-burst data
SSST	sea surface (skin) temperature
SST	sea surface temperature

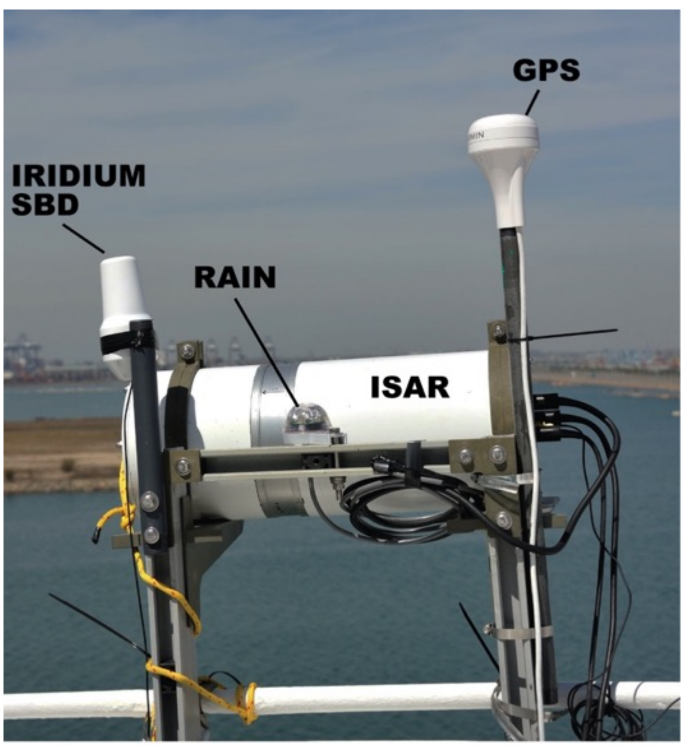
Contents

Figures

1.0 Summary

Infrared Sea Surface Temperature Autonomous Radiometer (ISAR) IOPR
2012-6539 http://www.arm.gov/campaigns/amf2012isar
Co-Investigator: Peter Minnett, University of Miami
Data is in the ARM Data Center.

Sea surface temperature (SST) is one of the most appropriate and important climate parameters: a widespread increase is an indicator of global warming and modifications of the geographical distribution of SST are an extremely sensitive indicator of climate change. There is high demand for accurate, reliable, high-spatial-and-temporal-resolution SST measurements for the parameterization of ocean-atmosphere heat, momentum, and gas (SST is therefore critical to understanding the processes controlling the global carbon dioxide budget) fluxes, for detailed diagnostic and process-orientated studies to better understand the behavior of the climate system, as model boundary conditions, for assimilation into climate models, and for the rigorous validation of climate model output. In order to achieve an overall net flux uncertainty < 10 W/m^2 (Bradley and Fairall, 2006), the sea surface (skin) temperature (SSST) must be measured to an error < 0.1 C and a precision of 0.05 C. Anyone experienced in shipboard meteorological measurements will recognize this is a tough specification. These demands require complete confidence in the content, interpretation, accuracy, reliability, and continuity of observational SST data—criteria that can only be fulfilled by the successful implementation of an ongoing data product validation strategy.



MAGIC_ISAR

Figure 1. The Infrared Sea Surface Temperature Autonomous Radiometer (ISAR) aims a narrow-field-of-view infrared radiometer at the sea and then the sky and computes SSST each 10 minutes.

The Infrared Sea Surface Temperature Autonomous Radiometer (ISAR) system has been developed to collect high-quality in situ observations of the radiative SSST that can be used to validate the SSST observations made by several satellite systems (ENVSAT, MODIS, Aqua). The ISAR is carefully calibrated against National Institute of Standards and Technology (NIST) transfer standards and one goal of this intensive operational period (IOP) is to ensure that satellite retrievals of SSST have characterized uncertainties and that the validation procedure provides traceability to NIST standards and therefore can be legitimately considered a Climate Data Record. Traceability to NIST standards is retained by careful maintenance of the laboratory calibration equipment at the University of Miami and the University of Washington, and periodic recalibration of the reference thermometers.

The ISAR is a compact (570 x 220 mm) precision, self-calibrating, infrared radiometer capable of measuring in situ SSST accurate to ±0.1 C rmse that has been developed in collaboration with scientists at the National Oceanography Centre, Southampton (NOCS), UK, Brookhaven National Laboratory (BNL), USA, and the European Commission, Italy. The ISAR uses two precision calibration black body (BB) cavities to maintain the radiance calibration of a solid-state infrared detector having a spectral window of 9.6-11.5µm. All ISAR target views are made using a single-route optical path via a protective scan drum arrangement that may be programmed to any target view over a range of 160°. In this way, views of the atmosphere can be made at regular intervals, providing the necessary measurements required to correct sea view radiance data for sky radiance reflection due to the non-unity value of sea water emissivity.

The ISAR system on the Horizon container ship *Spirit* has an external Global Positioning System (GPS) and a pitch-and-roll sensor. These provide important information for estimating the precise SSST. In addition, it incorporates an iridium short-burst data (SBD) modem so SSST measurements can be transmitted to shore on a regular (half hour) schedule. During the cruises, SSST data are given quality assurance by comparisons with SST maps and with co-located data buoys.

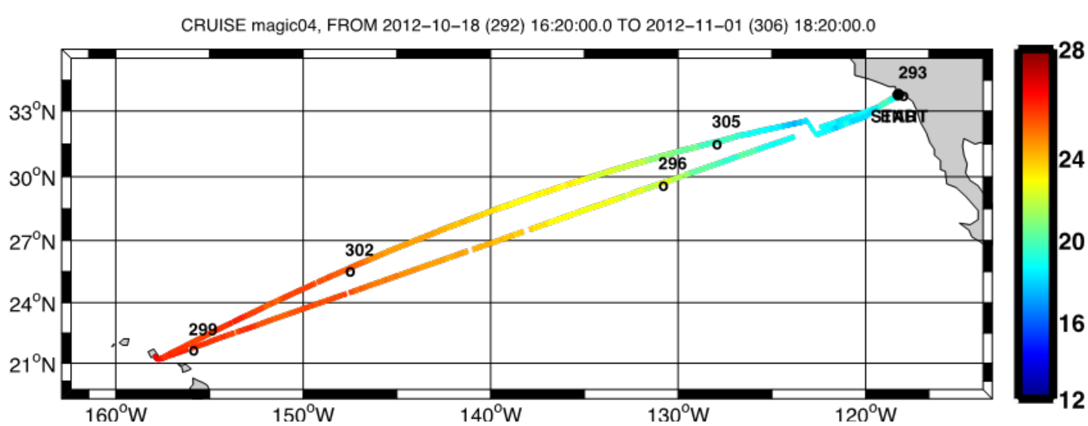


Figure 2. The iridium SBD telemetry sends SSST data each 30 minutes. Records of the ship track line are useful for day-to-day operation.

2.0 Results

ISAR was operating for Legs 2-19 and collected 28163 quality-checked 10-minute SSST data points. These data provided the base for the air-sea flux calculations.

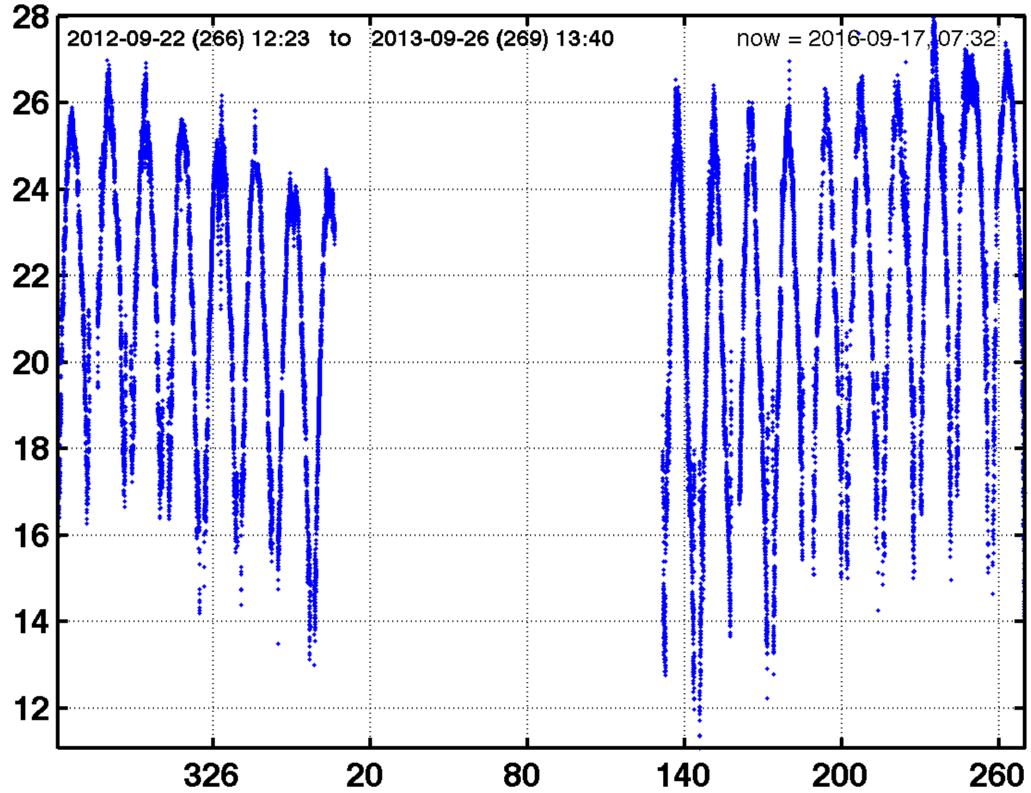


Figure 3. All ISAR sea surface skin temperature for the MAGIC legs. The legs start in Long Beach, California (cooler temperatures) and end in Honolulu, Hawaii (warmer temperatures). The gap from year day 10, approximately, to 130 were when the ship was away for dry-dock service.

3.0 Publications and References

Donlon, C, IS Robinson, M Reynolds, W Wimmer, G Fisher, R Edwards, and TJ Nightingale. 2008. “An Infrared Sea Surface Temperature Autonomous Radiometer (ISAR) for Deployment aboard Volunteer Observing Ships (VOS).” *Journal of Atmospheric and Oceanic Technology 25*: 93-113, doi:10.1175/2007JTECH0505.1.

Bradley, Frank and Chris Fairall, 2006. *A Guide to Making Climate Quality Meteorological and Flux Measurements at Sea.*

NOAA Tech Memo OAR PSD-311, Boulder, CO.
Available at http://rmrco.com/prod/samos/doc/ bradley06_shipbpardmeasurements.pdf

Description of the MAGIC Experiment: https://www.bnl.gov/envsci/cloud/campaigns/MAGIC/index.php

Review of MAGIC data processing for flux computation:
http://rmrco.com/docs/ m1402_MAGIC_OnDataProcessing/index.html

Overview of the MAGIC met instrumentation including ISAR:
http://rmrco.com/docs/m1212_MagicMet.pdf

4.0 Lessons Learned

Every ship program must include IR SSST measurements. If the marine atmospheric emitted radiance interferometer (M-AERI) is not available, then an ISAR (or the new remote ocean surface radiometer [ROSR]) must be used.

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