# Measuring Sea-Surface Temperature for the MAGIC Field Campaign

Victor R. Morris and Laura Riihimaki, Pacific Northwest National Laboratory
Michael T. Ritsche, Argonne National Laboratory

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## Introduction

The second ARM Mobile Facility was deployed aboard the container ship *Horizon Spirit* in September 2012 for the Marine ARM GPCI Investigation of Clouds (MAGIC). A critical measurement for this over-ocean field campaign is the up-welling infrared emission which can be determined by measuring the temperature of the sea surface. Most instruments capable of making this measurement are relatively expensive, such as the Infrared Sea-surface temperature Autonomous Radiometer (ISAR) and the Marine Atmospheric Emitted Radiance Interferometer. For MAGIC, an inexpensive and simple method of measuring sea-surface temperature (SST) was provided with two standard ARM Infrared Thermometers (IRTs).

## System Configuration

The IRTs are the same as those deployed on the ARM SKYRAD and GNDRAD platforms. The two IRTs are orthogonally-mounted at 45° from horizontal such that one is measuring the ocean surface temperature and the other is measuring the sky brightness temperature. This allows the up-welling radiance to be corrected for the reflection of the down-welling radiance. The down-welling IRT views the sky using a protected gold mirror to prevent rain or ocean spray from collecting in the lens.

## Sea-Surface Temperature Value-Added Product

To derive SST from the new IRT datastream

- Measure temperature of ocean surface $T_o$ and sky/clouds $T_s$
- Convert temperatures to radiances $L$ using Plank function $B$ and IRT spectral response function $S$

$$L_o = \int_{\nu 1}^{\nu 2} S(\nu)\, B(T_o, \nu) d\nu \qquad L_s = \int_{\nu 1}^{\nu 2} S(\nu)\, B(T_s, \nu) d\nu$$

- Compute emissivity $\varepsilon$ of ocean surface at incident angle of IRT (dependent on roll angle of ship)

$$\varepsilon = 0.986 \; at \; \theta = 45°$$

- Correct ocean surface radiance $L_o$ for reflected sky radiance $L_s$

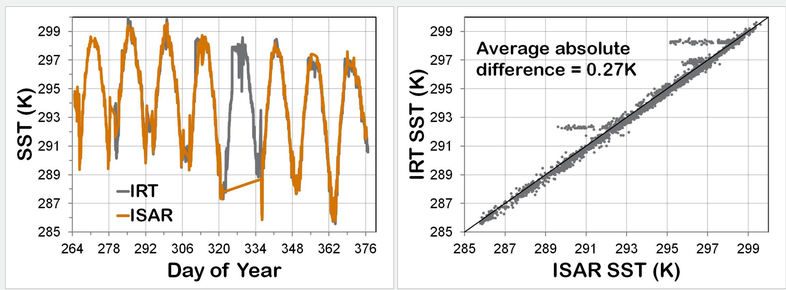
$$L_{SST} = \frac{L_o - (1 - \varepsilon) L_s}{\varepsilon}$$

- Convert sea-surface radiance $L_{SST}$ to temperature $T_{SST}$

$$L_{SST} = \int_{\nu 1}^{\nu 2} S(\nu)\, B(T_{SST}, \nu) d\nu$$

## Sea-Surface Temperature Comparison with ISAR

First Eight Transits
from Los Angeles to Honolulu
9/20/2012 - 1/10/2013




Time series and scatter plot of 30-minute average sea-surface temperature measurement from IRT and ISAR (assumes constant emissivity of 0.986).

## Summary

- A method of deriving sea-surface temperature (SST) from standard ARM Infrared Thermometers (IRT) was developed.
- IRTSST instrument was deployed with second AMF aboard a container ship for the MAGIC campaign.
- Measurements of SST, compared with ISAR, have average percent error of only 0.09%.
- Calculation of SST will be improved to account for changing incident angle of IRT due to roll of ship.
- IRTSST is now baseline ARM instrument for ship-borne operations.

## Infrared Thermometer Specifications

Provides measurements of equivalent blackbody brightness temperature of target

- **Instrument:** Heitronics KT19.85II Infrared Radiation Pyrometer
- **Spectral response:** 9.6 to 11.5 µm
- **Temperature measuring range:** 173 to 473 K
- **Temperature resolution (emissivity=1, response time=1s):** ±0.2 K at 293 K
- **Accuracy:** ±0.5 K
- **Optical field of view:**
  - down-welling 2.64° (f=120 mm)
  - up-welling 30.51° (f=20 mm)
- **Sample rate:** 1 Hz
- **Operational temperature range:** -20° to 60°C

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## References

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victor.morris@pnnl.gov, 509-372-6144
www.pnl.gov