Unmanned, automated marine SST validation measurements utilizing a Marine-Atmospheric Emitted Radiance Interferometer

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ABSTRACT

From 2002 through 2007, a Marine-Atmospheric Emitted Radiance Interferometer (M-AERI) measured open ocean surface skin temperature aboard the Royal Caribbean Cruises, Ltd. cruise vessel, Explorer of the Seas. This data set had been successfully utilized to validate ocean surface temperature from MODIS instruments and was especially valuable due to the repetitive nature of the cruise ship tracks over a wide geographic area. During this period the cruise ship was staffed 24/7 and monitored by a trained marine technician who maintained multiple instrument suites, in addition to the M-AERI, through the support of a unique private business, government, and academic partnership. At the end of 2007, the manned research laboratory program ceased to exist and a number of the instrument suites were selected to be transitioned into an innovative and technically challenging automated system that would be manned remotely from shore-side laboratories.

Automated meteorological and oceanographic measurements are not a new concept for volunteer observing ships, however the equipment is limited to the scope of what can be maintained, updated and run without interactive two-way communications and infrequent technician visits while a ship is in port. The ongoing cruise ship partnership and support has allowed the re-designed program to leverage two-way communications to the laboratory instrumentation via satellites which is normally both bandwidth and cost prohibitive for ocean going research. Through a combination of secure VPN tunnels, an onboard laboratory network, IP addressable power supplies and KVM switches, remote control software, a home port radio modem link and a staged part-time technician in the most frequent port of call for the cruise ship, the M-AERI system can run unmanned over extended lengths of time.

BACKGROUND

The three Marine-Atmospheric Emitted Radiance Interferometers (M-AERI) were developed between 1995 to 1998 by University of Wisconsin-Madison and Rosenstiel School of Marine and Atmospheric Science. These are Fourier-Transform Michelson-Moldy interferometers that measure the spectra of the infrared radiation emitted by the sea surface and atmosphere in the wavelength range of 3-13 μm. From these spectra we can derive the skin SST, the near surface air temperature, and profiles of atmospheric temperature to a height of ~500m. Calibration is traceable to NIST standards.

M-AERI data collected on the Explorer of the Seas and other ships provide validation data for satellite-derived SST. Earlier studies had used subsurface thermometers on busy ocean-going ships, and the effects of the near-surface temperature variability were incorrectly assumed to be present in the satellite retrievals. The demonstrated level of accuracy should permit the detection of climate-change signals using validated satellite data sets over a decade or two.

Previous Explorer of the Seas Operations

In 2002, a M-AERI was installed on the Explorer of the Seas, operated by Royal Caribbean Cruises, Ltd. The ship cruised two alternating tracks in the western and eastern Caribbean. The deployment was part of a larger research and public outreach program run by the University of Miami in cooperation with Royal Caribbean and the National Oceanic and Atmospheric Administration’s Atlantic Oceanographic and Meteorological Laboratory (NOAA/AOML).

The M-AERI measurements provide very accurate measurements of skin SST through the installation on a cruise ship with a fixed itinerary provided multi-year continuous geographic coverage along a repetitive cruise track which could not be obtained by any other means. Data were collected until the manned program was terminated in December 2007.

PROOF OF CONCEPT

Typical manned M-AERI deployments are 4-6 weeks in duration requiring at least one full-time person to monitor the systems.

In February 2010, an M-AERI was re-deployed on the Explorer of the Seas, for the first time in an unmanned operational mode.

The M-AERI was run remotely from shore from February 2010 until an instrument failure on 8 May 2010. Visits to the ship by technicians did not correct the problems and the M-AERI will be replaced in November 2020.

The ship-to-shore network is a critical component in operating a M-AERI remotely from shore and the capacity for two way communications allows not only for transferring data files to monitor data quality and instrument health, but also to control the M-AERI with the same facility as if you were on the ship.

Royal Caribbean Cruises, Ltd. through our continuing partnership, provides the satellite link to the ship, a site-to-site VPN connected to a server at our laboratory and web-based VPN connections to a dedicated laboratory network on the Explorer of the Seas, which allows multiple scientists two-way access to their individual computers and instruments via a remote desktop and other internet-based software.

LESSONS LEARNED

- Instrumentation and computer operating systems from the mid-90’s can be integrated into modern computer networks utilizing recent network tools.
- IP-addressable KVM switches can be utilized to give older operating systems a presence on modern computer networks. In this instance to access the M-AERI display and control screen on an OS/2 computer.
- IP-addressable power strips can be utilized to give additional control over computers and instruments which require a hard reboot to resolve some system failures.
- Two-way monitoring and control of computer and instruments over a satellite link are not only possible, but robust.
- Unmanned operations require additional UPS backup systems in the event of failure of a shipboard UPS.
- Experience from the previous long-term deployment indicates a maintenance interval of four months should be implemented.
- M-AERI components continuously operating in the tropics are vulnerable to high temperature and humidity, which leads to shorter mean time between failures.

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