ships4sst

shipborne radiometers for sea surface temperature

A next generation in-situ radiometer

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Space ConneXions

Outline

- Background
- User consultation
- Design drivers
- Survey of existing designs
- Design choices
- Outline design

Background

- Most in-situ radiometers currently in service are still from the first generation of effective, reliable instruments
  - Obsolescence increasingly an issue
  - Greater flexibility desirable
  - Next generation of satellite radiometers under development (CIMR, ASLSTR, LSTM, …)
  - Opportunity to revisit design choices made 20+ years ago

From left to right: SISTeR, ISAR, CIRIMS, M-AERI and DAR011 on the R/V *F.G. Walton Smith* in 2001

Background

- CCN to current FRM4SST contract: “WP80: Case study for a next generation radiometer”
- Were tasked to:
  - Consolidate instrument requirements
  - Survey different measurement approaches
  - Review existing instruments
  - Propose an outline design for a new instrument

User consultation

- User consultation in October 2020 to discuss key drivers and design choices
  - SST validation is the primary activity
    - Main requirement is for traceable SSTs with total uncertainties of 100 mK or better (includes SST retrieval, auxiliary data, model uncertainties, …)
  - Other applications and measurements important too: air-sea fluxes, skin vertical temperature profiles, air temperature, humidity, ice surface temperature, …
  - Cost and ease of use / flexibility and complexity
    - Moderate price, some flexibility
  - Thermal infrared or microwave?
    - TIR
  - Spectro-radiometer or filter radiometer?
    - Filter
  - Imaging / non-imaging?
    - Non-imaging

Other considerations

- Ease of manufacture and alignment
- Ease of use, including:
  - Maintenance (modular subsystems, …)
  - Deployment (portability, mounting, …)
  - Documentation
  - Training
- Calibration scheme

Spectral selection (spectrometers)

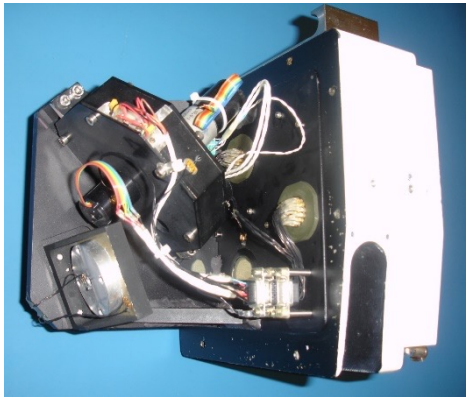
- Grating
  - Flexible
  - Poor light grasp
  - Sensitive to environment
- “Classic” Fourier (Michelson, Mach-Zehnder, …)
  - Extremely flexible
  - Excellent spectral registration
  - Very good spectral resolution possible
  - Expensive and demanding (cooled detectors, sensitive to environment)
- Static Fourier
  - Simplest and cheapest (no moving parts)
  - Lower resolution
  - May be some difficulties with calibration

Spectral selection (filters)

- Single band
  - Simplest
  - Fine for SST, IST
  - Not suitable for other applications
- Multiple bands (filter wheel)
  - Simpler. Just requires an additional mechanism
  - Easy to update band selection
  - Can’t take simultaneous measurements in different bands
- Multiple bands (dichroic beamsplitters)
  - Complex
  - Simultaneous measurements in different bands
  - Multiple detector chains
  - May not be able to update bands without replacing beamsplitters too

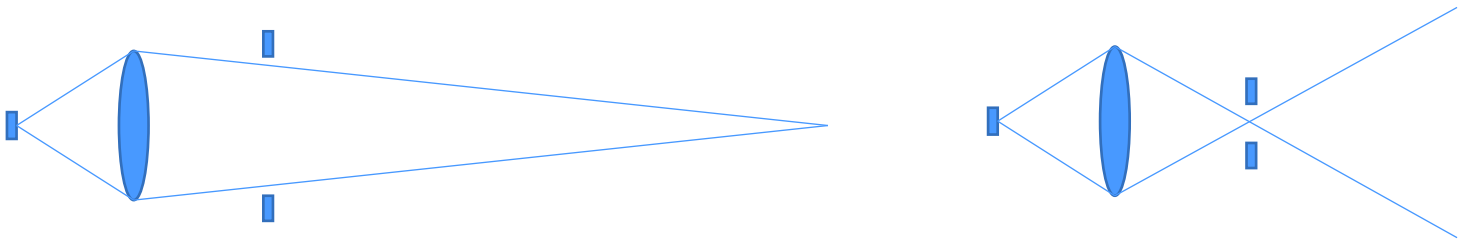
Calibration scheme

- Self-calibrating radiometer
  - Robust, frequent end-to-end calibration of optical chain
  - Possibility for self-traceability through on-board calibration targets
  - Easily adapted for multiple viewing angles if equipped with scan mirror
- Nulling radiometer
  - Black body compromises, as servo-ed to scene temperature
  - Not ideal for sky measurements



Imaging / non-imaging

- Imaging
  - Large exit aperture near to aperture plane (distant image plane)
  - Fast sampling to avoid along-track smearing (poor noise performance)
  - Small detector sizes to resolve image (poor noise performance)
  - Likely to need cooled detectors for TIR
- Non-imaging
  - Small exit aperture if placed at image plane (but divergent beam)
  - Simple detector chain – chopping and synchronous detection possible
  - Limited spatial resolution (t_{int} * v_{ship})
  - Uncooled detector will give decent noise performance (25 mK @ 1 s)



Other design choices

- “Buried” scan mirror mechanism with baffles, labyrinths, BB ports (SISTeR, ISAR)
- Chopped, uncooled detector + ellipsoid mirror (SISTeR)
- Compact small-aperture black bodies (SISTeR, ISAR)
- Modular subsystems (new)
  - Integrated electronics for BBs, mechanisms, detector
  - “Plug and play”
- Serial bus to subsystems (new)
- Synchronous control of instrument (SISTeR)
  - Embedded programming environment
  - Wrapper for ISAR-like configuration files if needed
- PoE / USB-C / other combined power and data protocol (new)
- Internal UPS (ISAR)

Other design choices

- Compact (~ 20 kg, 20 cm x 20cm x 50 cm – SISTeR, ISAR)
- Integral tethering point (new)
- Integral or demountable carry handle

TBC

- Instrument mount
- Scan mirror drive
- Scan mirror materials and coatings
- Weather door mechanism

Summary

- Baseline design is a self-calibrating thermal infrared filter radiometer
- Will be an evolution of current designs (ISAR, SISTeR), rather than a radical change
- Multiple spectral bands possible (selected by filter wheel)
- Emphasis on ease of manufacture and ease of use