Sea surface temperature measured by the \textit{MODerate resolution Imaging Spectroradiometer} (MODIS).


Meteorology and Physical Oceanography
Rosenstiel School of Marine and Atmospheric Science
University of Miami

MODIS Team Meeting
23 July 2002
SST Status

• Focus areas -
  – L1b versions -> calibration, validation
    • Terra Reprocessing - Version 3 L1b
      – Collection 4 coefficients, validated
    • Terra Forward processing - Version 4.0.5 L1b
      – Collection 4 coefficients, validation comparison in progress
    • Aqua Forward processing - prelaunch LUT - V3
      – Collection 3 preliminary coefficients
    • Aqua Forward processing - first on-orbit LUT - V4
      – Repeat calculations based on LUT (should be available this week)
Approach

- Radiative transfer based pre-launch SST retrieval equation derivation
- Regression based (AVHRR) based operational retrieval equation derivation
- Validation based on comparison to contemporaneous, co-located (MAERI) radiometric SST
- Auxiliary validation provided by buoy observations to extend space, time, in situ conditions
Aqua, Terra L2 track and scan SST, SST4

Along scan

Aqua, Terra tracks not co-registered

Pixel-pixel noise ~0.03C along scan

Along track order 2x along scan

SST-Terra
SST4-Terra
SST-Aqua
SST4-Aqua
MODIS SST comparison to AVHRR Pathfinder
Aqua-Terra SST comparison

Curvature in A-T likely due to use of pre-launch LUT where $a_0, a_2=0$

Increase in A-T for day due to diurnal warming, day field SST merge difficult
Time-series of M-AERI measurements on *Explorer of the Seas*

The *Explorer of the Seas* is a Royal Caribbean Cruise Liner, operating a bi-weekly schedule out of Miami. It is outfitted as an oceanographic and atmospheric research vessel, very suitable for satellite validation. For more details see [http://www.rsmas.miami.edu/rccl/](http://www.rsmas.miami.edu/rccl/)
M-AERI data from
Explorer of the Seas

Explorer of the Seas MAERI-1. Skin SST.

Temperature (°C)

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

N = 29477
Validation of MODIS SSTs

• M-AERI cruises:
  – ‘Hand-picked’ manually processed clear sky conditions for four cruises
  – Routine processing, January-May 2002

• Buoy matchups:
  – Routine processing, January-May 2002
MODIS : M-AERI Matchups

Hand-picked set – Pathfinder derived coefficients

Blue = Mediterranean – April 2000; Red = Pacific – March, April 2001;
Pink = Pacific – March, April 2001; Green = Atlantic - Explorer of the Seas.

All data

M = 0.20K
std= 0.26K
N  = 242

Explorer of the Seas

M = 0.15K
std= 0.21K
N  = 50
Explorer of the Seas MODIS : M-AERI Matchups, Jan-May 2002

MODIS M-AERI Matchups

MODIS Matchups - AVHRR Pathfinder derived coefficients

Quality flag = 0
Mean = -0.072
St.dev. = 0.391
N = 92

MODIS Matchups - RT derived coefficients

Quality flag = 0
Mean = 0.623
St.dev. = 0.447
N = 92
MODIS: Buoy Matchups, Jan-May 2002.

MODIS Matchups - AVHRR Pathfinder derived coefficients

Quality flag = 0
Mean = 0.268
St.dev. = 0.970
N = 2405

MODIS Matchups - RT derived coefficients

Quality flag = 0
Mean = 0.181
St.dev. = 1.059
N = 2405

MODIS SST error K

Clip at 2K:
Mean = -0.117
St.dev. = 0.554
N = 2295

MODIS SST error K

Clip at 2K:
Mean = 0.287
St.dev. = 0.625
N = 2304

In situ SST °C
Near surface temperature gradients – reality

Profile measured at 12:51 local time on 4 October 1999. Off Baja California, R/V *Melville* MOCE-5 cruise.

- **Blue line** = SkinDeEP* profile
- **Blue circle** = M-AERI skin temp.
- **Red cross** = Float bulk SST at ~0.05m
- **Green star** = Ship thermosalinograph at ~3m

Time evolution of near-surface thermal gradients


The need for validation

The **infrared bands** of MODIS form **self-calibrating radiometers**. The retrieved SST fields are validated to confirm the procedures used to generate them from the radiometer data are performing as believed, *i.e.* it is the **atmospheric correction algorithm** that is being **validated**.

This requires **instrumental imperfections** to be **known** and the data **corrected**.

The validation exercise provides a determination of the **accuracy characteristics** of the derived fields.
Wind speed dependence of the skin effect

Note collapse of envelope at moderate to high wind speeds.
Wind speed dependence of diurnal & skin effects

Terra and Aqua overpass times.
Merged Terra-Aqua SST night 25jun02
Merged T-A North Atlantic 25jun02
SST4
Conclusions

- Collection 4, Version 3L1b (Reprocessing) validated
- MAERI radiometric comparison, better than 0.25C
- Buoy comparison supports MAERI validation, extends to wider range of space, time, in situ conditions
- Collection 4, Version 4.0.5 (Forward Processing) validation in progress
- Aqua pre-launch equation coefficient test completed, night Terra-Aqua merged image provides near complete global coverage (not counting persistent cloud presence)
- Collection x, Aqua waiting for delivery of on-orbit LUT
- Outstanding Aqua issues: verify brightness temperatures, non-linear behavior for bands 31,32

- Manuscript with complete details near completion
Conclusions

• M-AERI provides a critical validation tool for MODIS SST
• Buoys provide a valuable secondary validation, numbers allow sampling a wider selection of environmental variability
• Preliminary SST validation shows *Terra* MODIS comparable to best AVHRR
• Need to establish lack of seasonal and regional biases
• Need to validate experimental SST₄ fields
• Look forward to *Aqua* MODIS data.
Ocean Color Radiances measured by the MODerate resolution Imaging Spectroradiometer (MODIS).

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K. Voss, D. Clark
&
Warner Baringer, Jim Brown, Kay Kilpatrick, Sue Walsh.

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Ocean Color Status

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      – Collection 4 coefficients, validation comparison in progress
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Calibration Approach

• Use at surface nLw, atmospheric and surface reflectance corrected
• Validation site for in situ reference is MOBY @ Hawaii, more extensive validation for other regions will require completion of reprocessing (use of SIMBIOS reference data)
• Cross-scan: Referenced to pixel 500, minimum of sun glint
• Detector Balance: Referenced to detector 5, low noise, center of detector array
• Mirror side Balance: reference to side 1
• Remove time trends: Compare modal peak for area surrounding MOBY to MOBY, high temporal density, not dependent on cloud free conditions
• Calibration: Adjust MOBY-MODIS single pixel match-ups to remove bias
Terra Mirror Side Cross-scan vs time gain, no cal

412 nm
Terra Mirror Side Cross-scan vs time gain, corrected

551 nm
nLw412 Modal Terra-Moby Time Series

Reprocessing
Col 4, V3 L1b

Moby

Terra
Overall bias must be removed with MOBY matchups

New Forward
Col 4, V4 L1b
nLw551 Modal Terra-Moby Time Series

Reprocessing
Col 4, V3 L1b

Moby
Overall bias must be removed with MOBY matchups

Terra

New Forward
Col 4, V4 L1b
MODIS - MOBY nLw 412nm Calibration Matchups

Reprocessing
Col 4, V3 L1b

New Forward
Col 4, V4 L1b
MODIS - MOBY nLw 551nm Calibration Matchups

Reprocessing
Col 4, V3 L1b

New Forward
Col 4, V4 L1b
Cross-scan MODIS-Moby Comparison

412 nm

Reprocessing
Calibration
Coll 4, V3L1b

551 nm
Cross-scan MODIS-Moby Comparison

412 nm

New Forward Calibration
Coll 4, V4L

551 nm
412 nm Detector gain variation time-scan

Reprocessing, Coll4, V3 L1b
551 nm Detector gain variation time-scan

Reprocessing, Coll4, V3 L1b
412 nm Detector gain variation time-scan

Time

Scan

New Forward, Coll4, V4 L1b
551 nm Detector gain variation time-scan

Time

Scan

New Forward, Coll4, V4 L1b
# Calibration Statistics

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<th>Wavelength</th>
<th>Reprocessing</th>
<th>New Forward</th>
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<td>Bias</td>
<td>Std. Dev.</td>
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<tr>
<td>678*</td>
<td>1.312</td>
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</tbody>
</table>

* MOBY measurements marginal at these wavelengths
25jun02 Chlmod Terra-up, Aqua down
25jun02 ChlMod Merge Terra-Aqua
Pre-launch calibration
Conclusions

• Terra: Uncorrected mirror side, cross-scan, detector-detector and time variations can each exceed 30% in nLw
• Collection 4, Version 3L1b (Reprocessing) nLw validated
• Caveats: variations of ± 5% in nLw expected for cross-scan, detector-detector, mirror side and time
• Collection 4, Version 4.0.5 (Forward Processing) correction, validation tests in progress and nearing completion

• Aqua detector, mirror, cross-scan preliminary corrections in test, need to verify polarization correction factors
• Collection x, Aqua, waiting for delivery of on-orbit LUT

• Manuscript with complete details near completion