Validation of NASA, NOAA and ESA MID and Thermal Infrared Data and Products Using the Lake Tahoe and Salton Sea Automated Validation Sites

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Outline

• Introduction (why we need validation)
• Location (Lake Tahoe and Salton Sea)
• Field Measurements and their Calibration
• Data Reduction Methodology
• Radiance at Sensor validation results from:
  – MODIS (Terra and Aqua), VIIRS, AATSR, ECOSTRESS
• Summary and Conclusions
Earth Science Use of LST&E

Evapotranspiration (drought monitoring)

Understanding Climate Change

Surface Energy Balance

Urban Heat Island Studies

Atmospheric profile retrievals
• Large 35 km x 16 km
• High 2 km
• Available year round (does not freeze in winter).
• Homogenous compared with land.
• Large annual temperature range 5-25°C.
• Freshwater (kind to instruments!)
• Good infrastructure and easy access.
TB3 Installed 11-04-2002

- Skin temperature
- Air temperature & Rel. Humidity
- Wind Speed & Direction
- Logging System
- Bulk Water Temperature
- Batteries
- 3m
Custom-Built Radiometers Calibrated to NIST Traceable Blackbody
Data Reduction: Methodology For Radiance at Sensor Validation

- Extract the bulk temperatures.
- Extract the radiometric temperature.
- Correct the radiometric temperature to skin kinetic temperature.
- Propagate the skin temperature to the satellite using a radiative transfer model and interpolated atmospheric profile.
- Convolve the propagated at-sensor radiance to the instrument response function to obtain the Vicarious Radiance (VR).
- Extract the image radiance derived using the On Board calibrator (OBC).
- Compare and contrast the OBC and VR Radiance values.
Now have large numbers of matchups – can restrict to optimum view angles
IR Window bands 31 and 32 align nicely with 1x1 line but band 29 does not
Window bands 29, 31 and 32 closely follow 1 to 1 line, but suggestion 29 is out of family.
Analysis indicate get excellent results with in situ out to about 30 degrees
Delta Brightness Temperature in TIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2019 vz0-7 v6.x

Delta Brightness Temperature (K)

Band 31: 11.01 μm 1% radiance change ≈ 0.65K

Excellent calibration until 2009. Since 2009 channel 29 calibration started to degrade.
Similar analysis to previous slides but notice how range of Aqua data has increased
Excellent calibration until 2009. Since 2009 channel 29 calibration started to degrade.
No sign of problems in channel 29 on Aqua-MODIS, VIIRS performance similar to MODIS.
Can also use buoy data to validate MIR channels but cannot use daytime values since affected by reflected solar (as illustrated above). Since buoys operate 24x7 use just nighttime data (see next slide).
Nighttime only – no problems with reflected solar
When look at vicarious minus observed small bias, Terra is warm
Small bias in b20 in Aqua in Collection 6 but not in other bands and different behavior in last 3 years
Delta BT between Vicarious and Observed TIR Channels for NPP VIIRS at Lake Tahoe and Salton Sea All Years VZ 0-7

Excellent calibration since launch
Delta BT between Vicarious and Observed in MIR Channels for VIIRS at Lake Tahoe and Salton Sea Nighttime, vz0-30

Excellent calibration since launch
Delta Brightness Temperature in TIR Channels for AATSR at Lake Tahoe and Salton Sea CY2002-2012, vz0-30 v6.x

Band 31: 11.01 μm 1% radiance change ≈ 0.65K
Delta Brightness Temperature in MIR Channel for AATSR Lake Tahoe and Salton Sea CY2002-2012, Night Only vz0-30, v6.x

Delta (V-O) Brightness Temperature (K)

Year

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 All Years

3.7 um

Year
Radiometric accuracy and precision

Radiometric requirements:
From PLRA 4.1a) An accuracy of 1 K and a precision of 0.3K at 300K – satisfied.

Accuracy (mean difference) and precision (noise equivalent delta temperature, K) between vicarious and ECOSTRESS observed brightness temperatures at Lake Tahoe and Salton Sea from 2018-2020 (See Hook et al. 2020 for more details)

<table>
<thead>
<tr>
<th>Channels</th>
<th>Mean bias at 300 K</th>
<th>Noise Equivalent delta Temperature (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy</td>
<td>Precision</td>
</tr>
<tr>
<td>ECOSTRESS B1-B5</td>
<td>0.29 K</td>
<td>0.23 K</td>
</tr>
</tbody>
</table>
Summary and Conclusions

- Established an automated site for validating thermal infrared data at Lake Tahoe CA/NV. Site has been operating since 1999.
- Measurements made at the site include skin-, bulk-, air-temperature, wind speed, wind direction and net radiation at multiple locations every 2 minutes. Multiple locations (4 buoys) allow validation of several points within a scene.
- Second site added at Salton Sea in 2008 to enable validation at high water temperatures (~35 C).
- Validated data from multiple instruments including, AVHRR AATSR, ASTER, MODIS (Terra, Aqua), Landsat 5 and Landsat ETM+, MTI, VIIRS, ECOSTRESS.