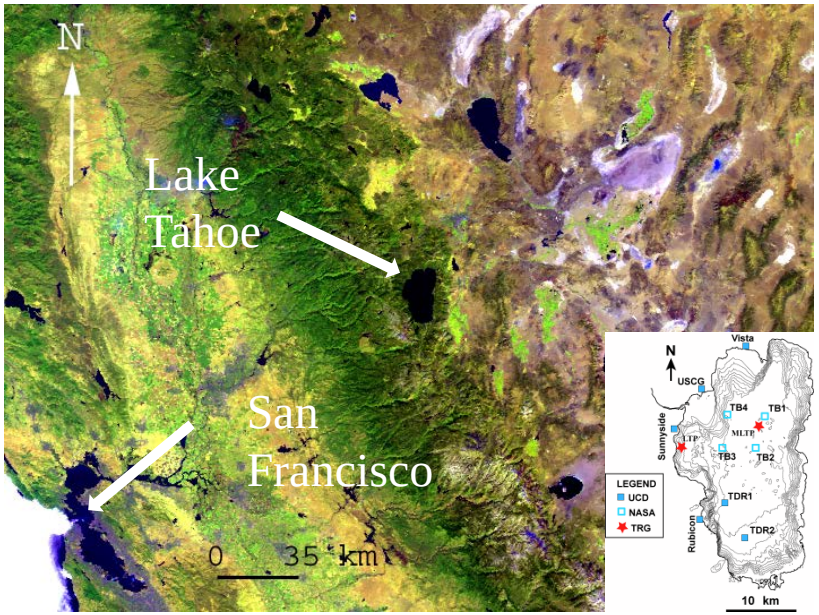
In Flight Validation of MODIS and VIIRS Mid and Thermal Infrared Emissive Bands at Lake Tahoe and Salton Sea CA/NV USA

Simon J. Hook, Kerry Cawse-Nicholson, Robert Radocinski, Glynn C. Hulley

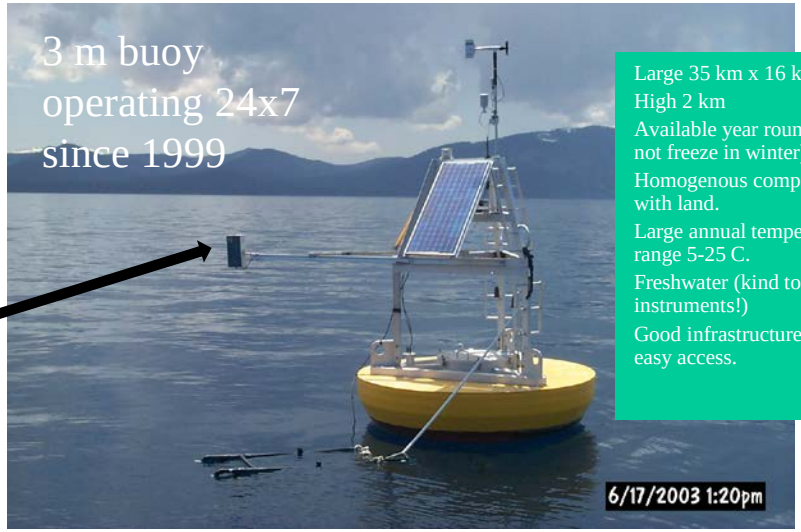
Vicarious at Lake Tahoe, CA/NV USA



Methodology:

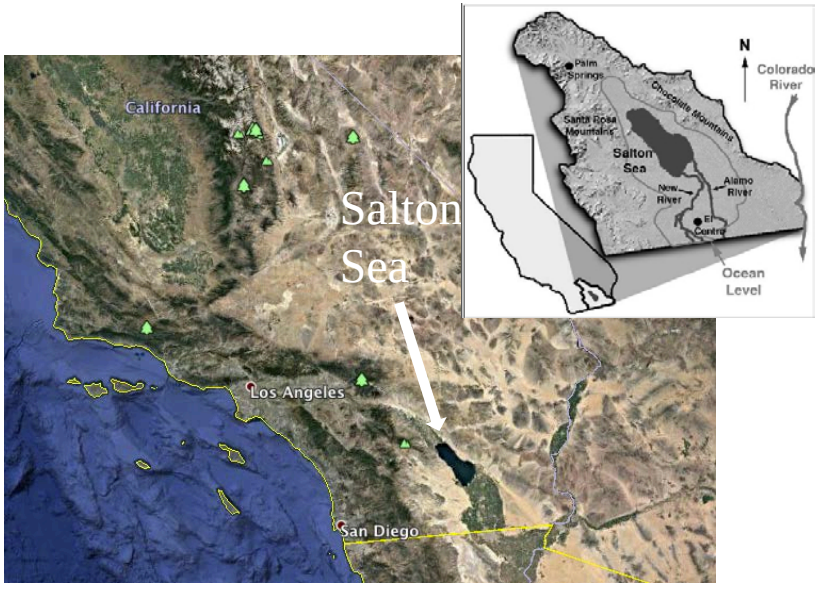
- 4 buoys on large, high lake, each buoy is 1 km from shore and nearest buoy.
- Each buoy has custom thermal infrared radiometer operating 24x7 and associated meteorological measurements.
- Extract skin temperature from radiometer at time of overpass and propagate to top of atmosphere with radiative transfer model.
- Convolve to instrument system response functions and compare to satellite instrument measured value.

Custom radiometer calibrated to NIST-traceable blackbody



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.

Vicarious at Salton Sea, CA USA



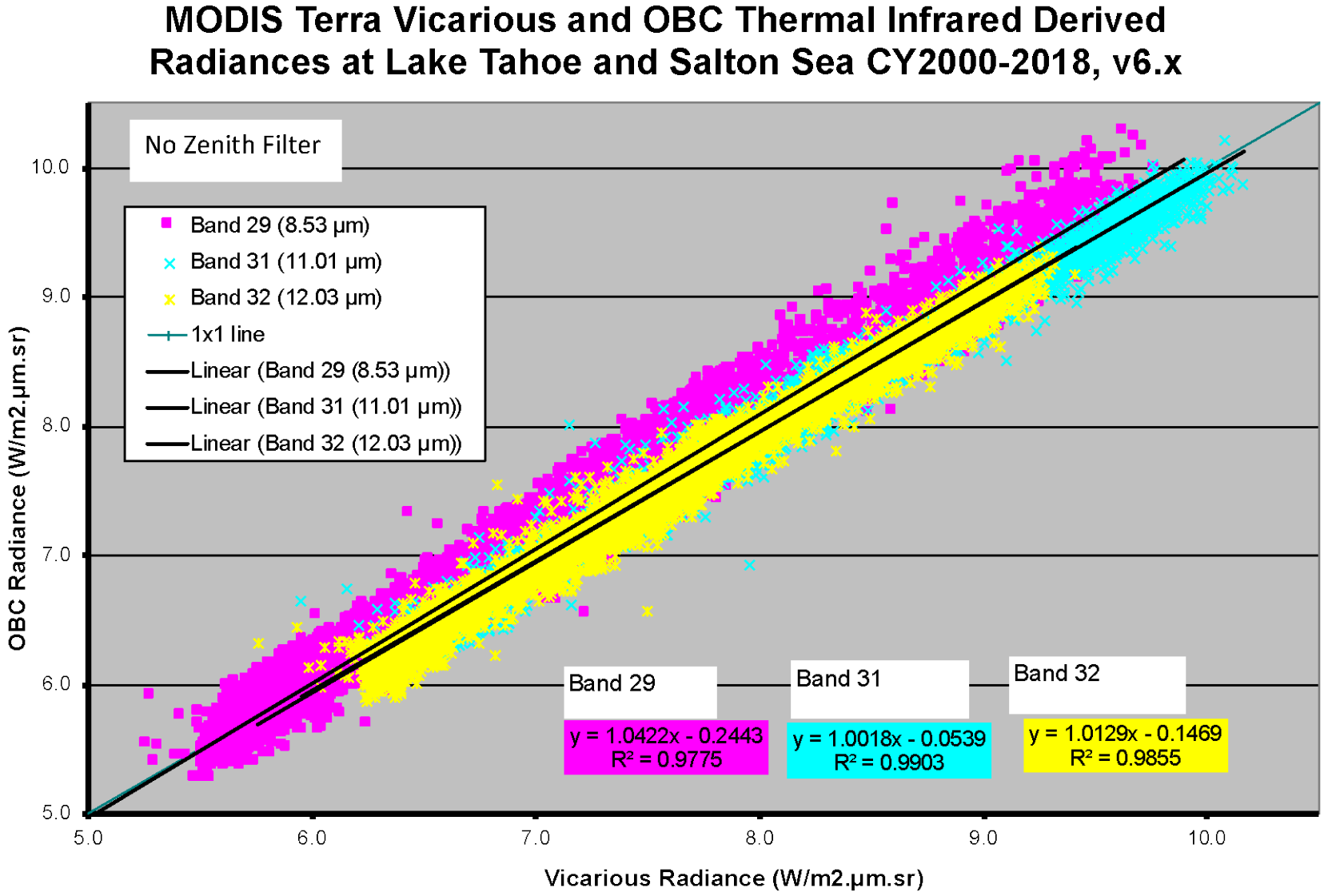
Methodology:

- A mounted platform due to high salinity.
- The site has two custom thermal infrared radiometers operating 24x7 and associated meteorological measurements.
- Extract skin temperature from radiometer at time of overpass and propagate to top of atmosphere with radiative transfer model.
- Convolve to instrument system response functions and compare to satellite instrument measured value.

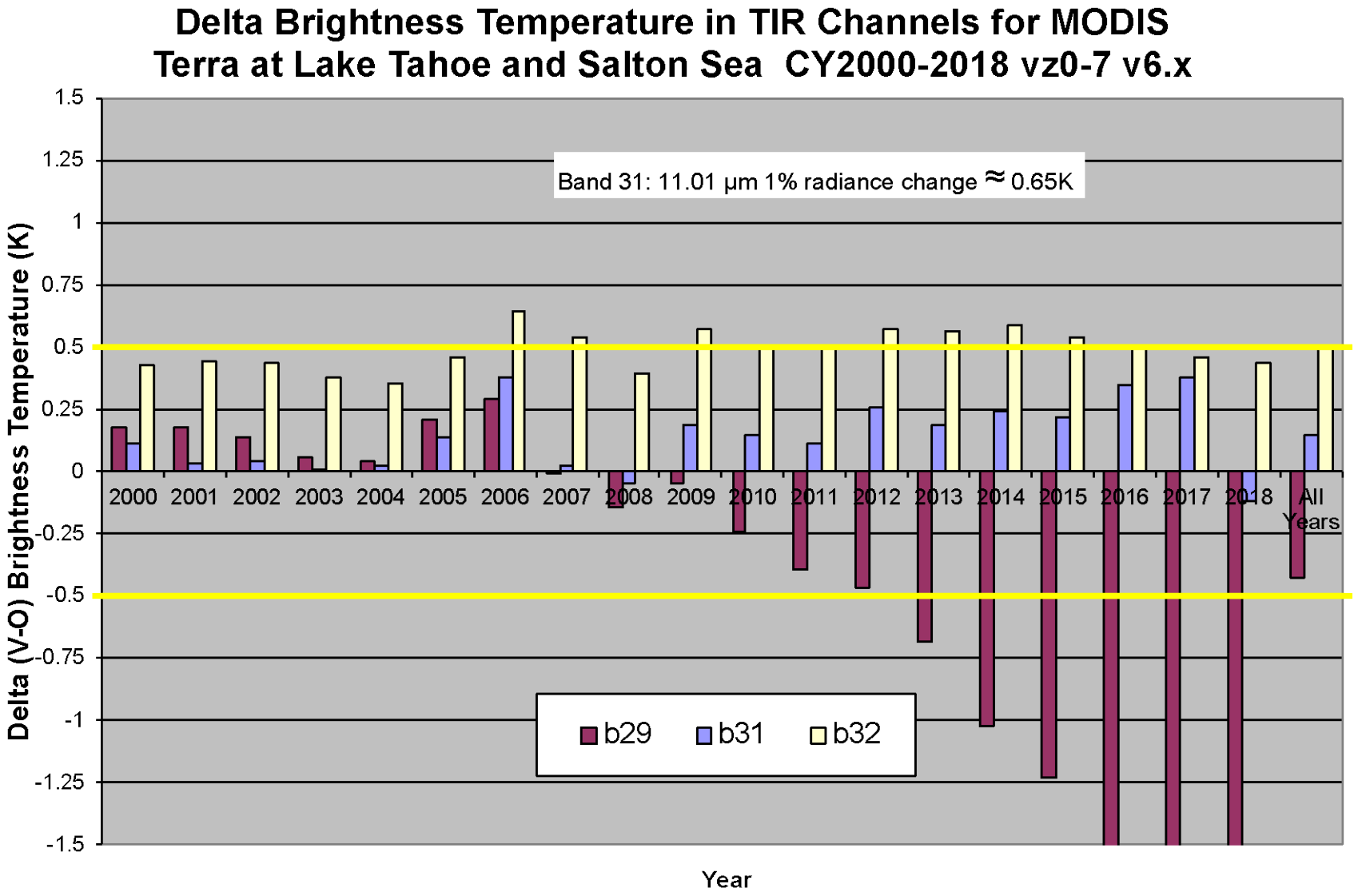
Custom radiometer calibrated to NIST-traceable blackbody

Large 60 km x 20 km
Low elevation -71 m
Available year round (does not freeze in winter).
Homogenous compared with land.
Large annual temperature range ~4-35 C.
Good infrastructure and easy access.

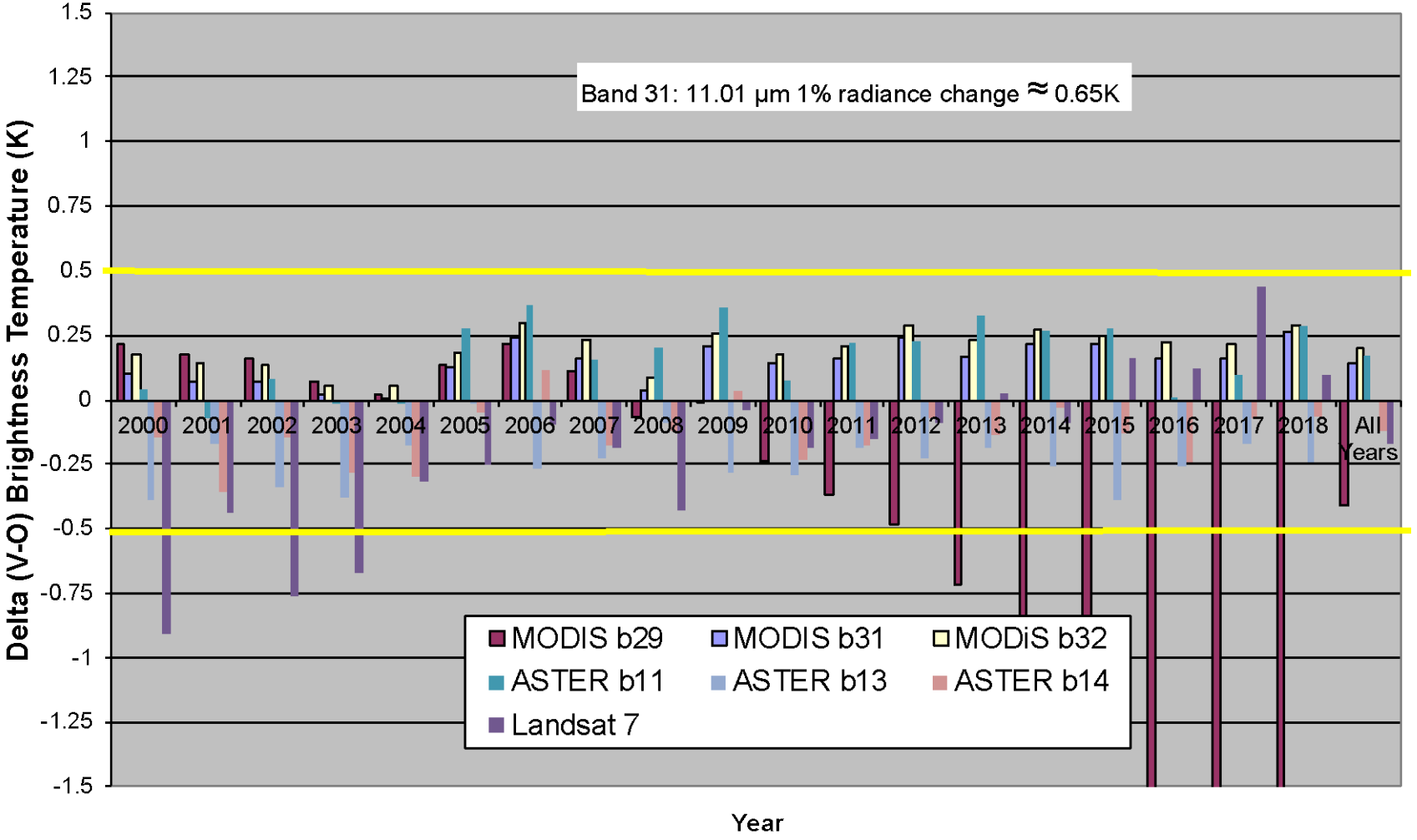
Terra-MODIS - Results

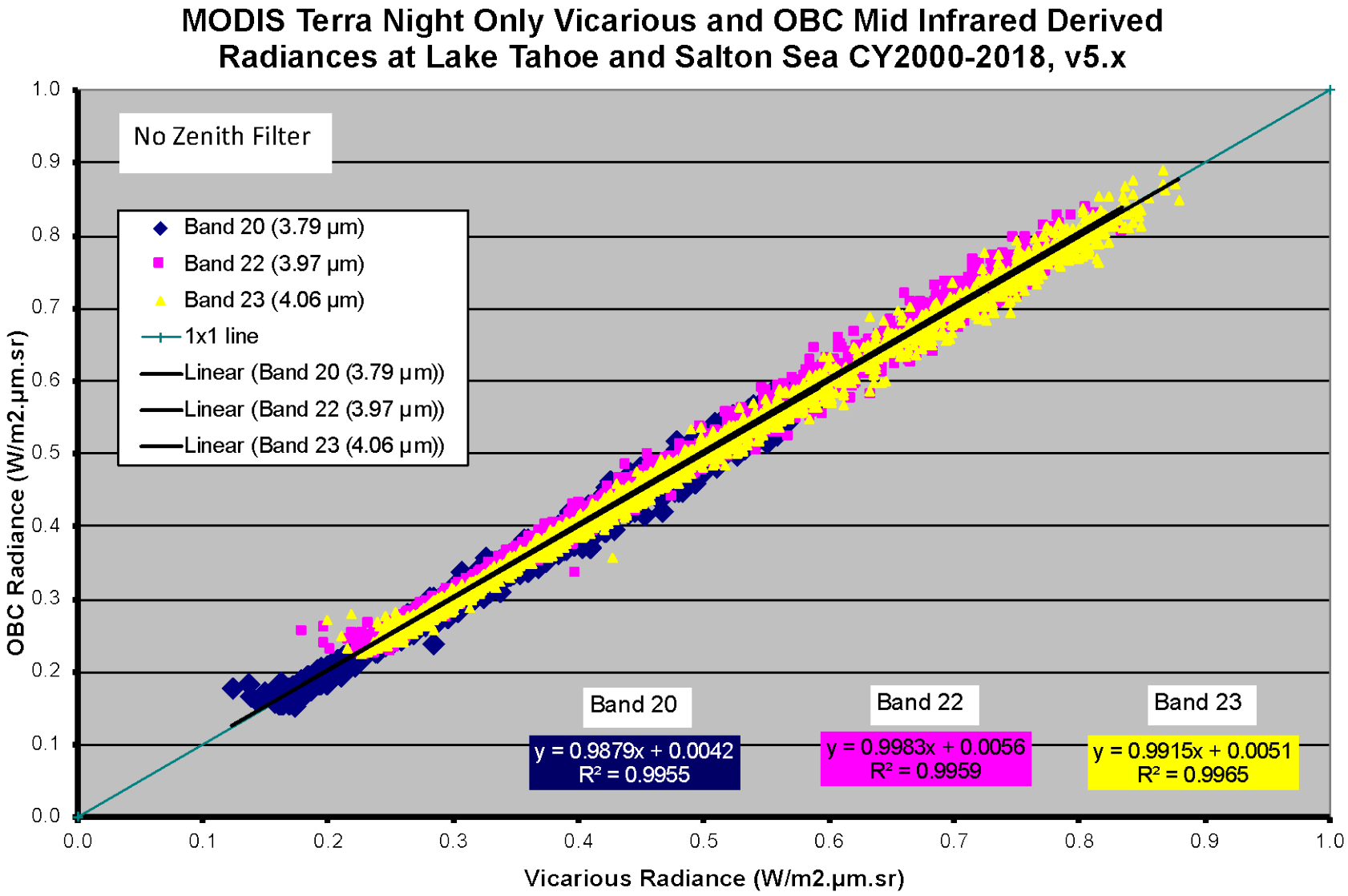


MODIS-Terra – Calibration problem with Band 29.

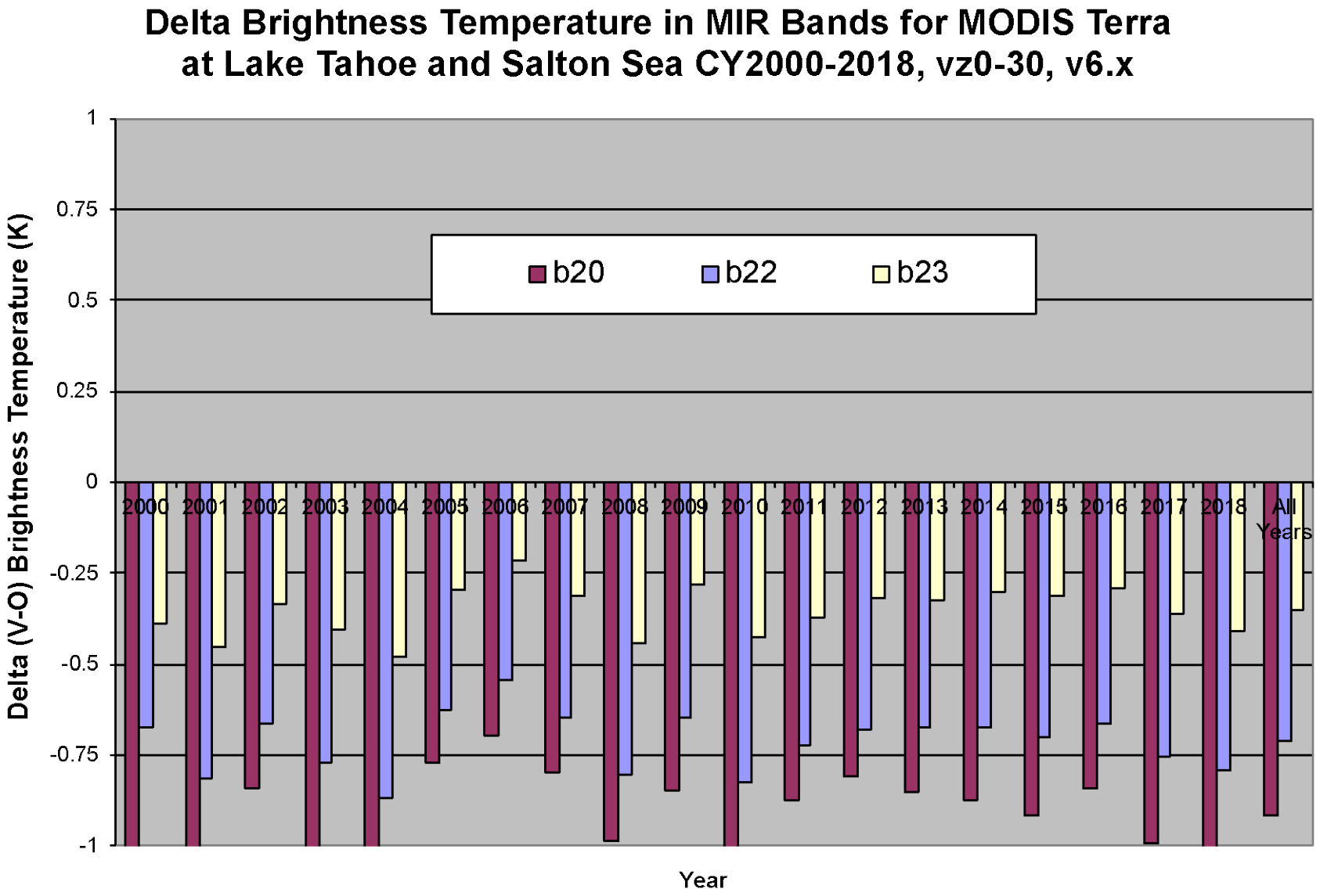

Delta Brightness Temperature in TIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2018 vz0-7 v6.x
Band 31: 11.01 µm 1% radiance change ≈ 0.65K
Delta (V-O) Brightness Temperature (K)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 All Years
b29 b31 b32
Year

Delta Brightness Temperature in TIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2018, vz0-30 v5.x



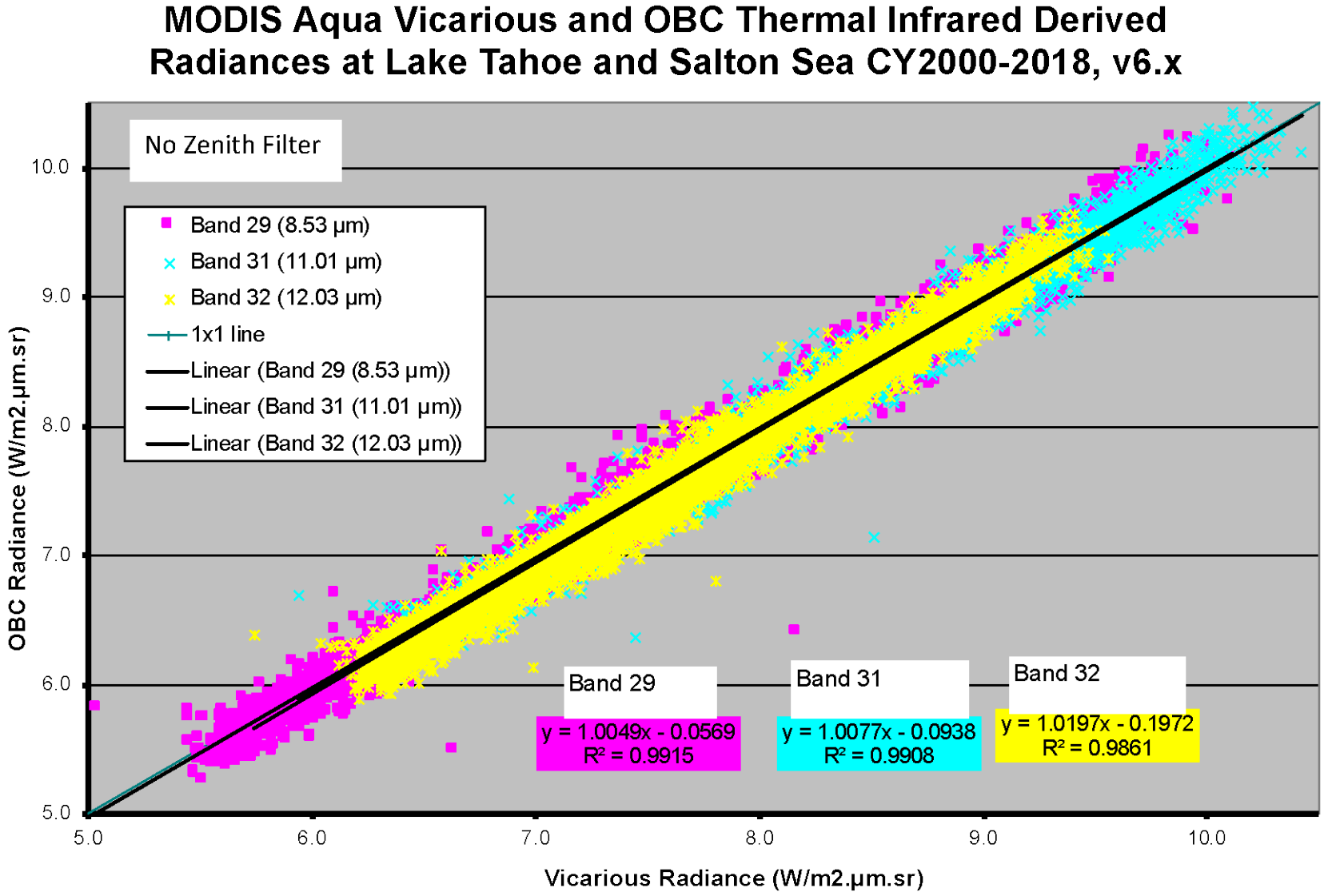


MODIS-Terra – MIR bands are consistently slightly hot.

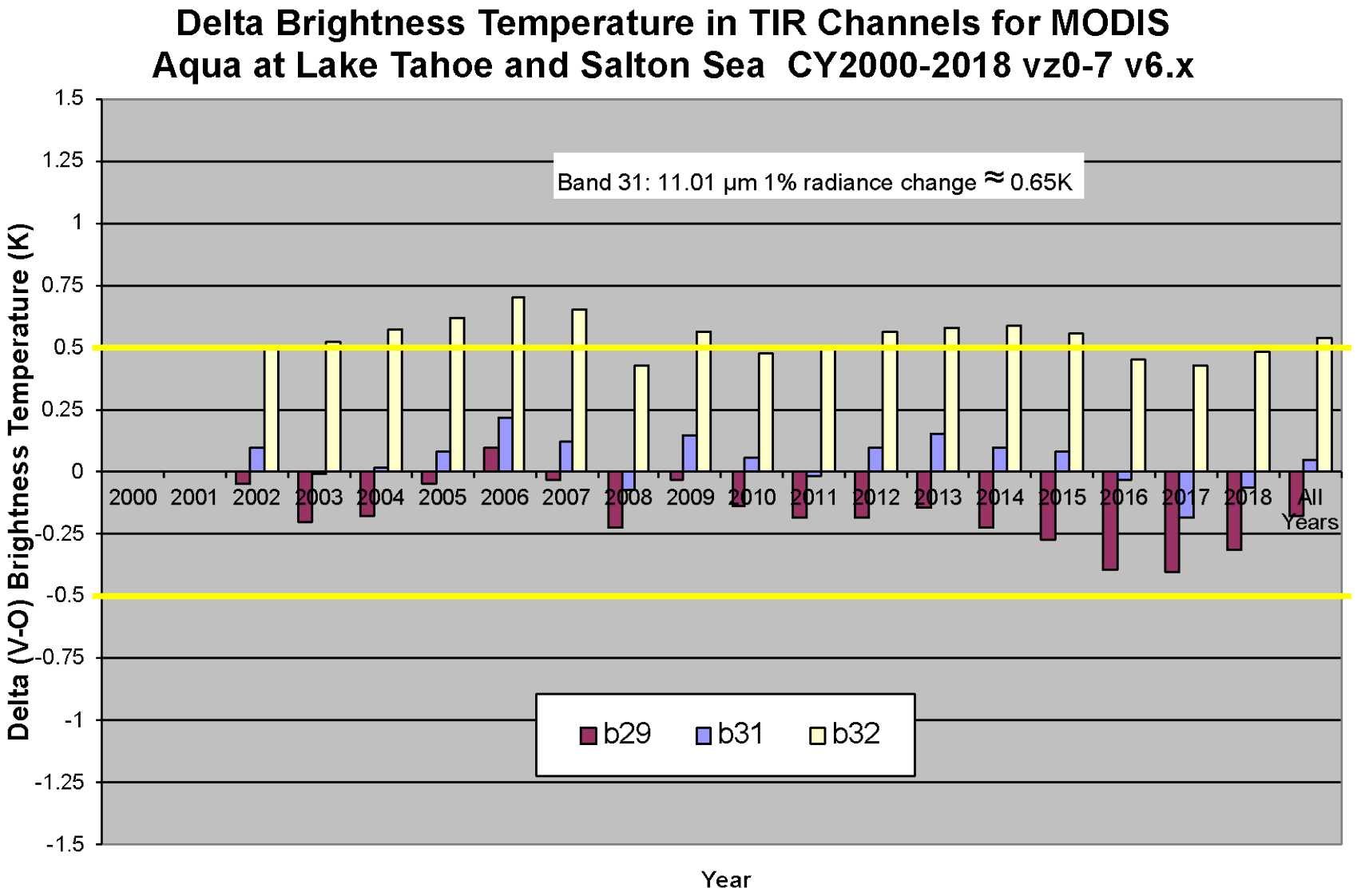


MODIS-Terra – MIR bands are consistently slightly hot.

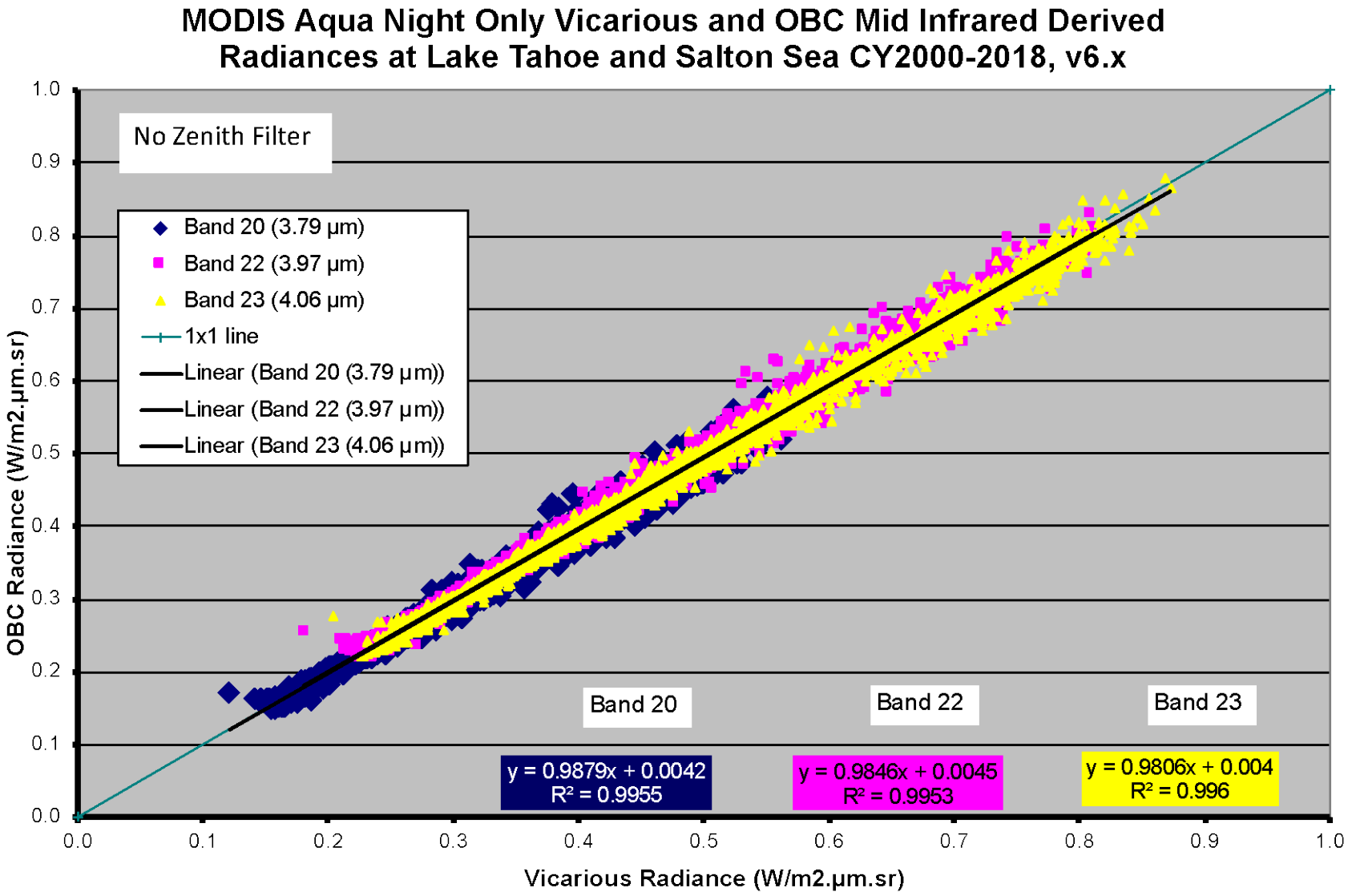
Aqua-MODIS - Results



MODIS-Aqua – Excellent calibration.



MODIS-Aqua – Band 32 is slightly hot.



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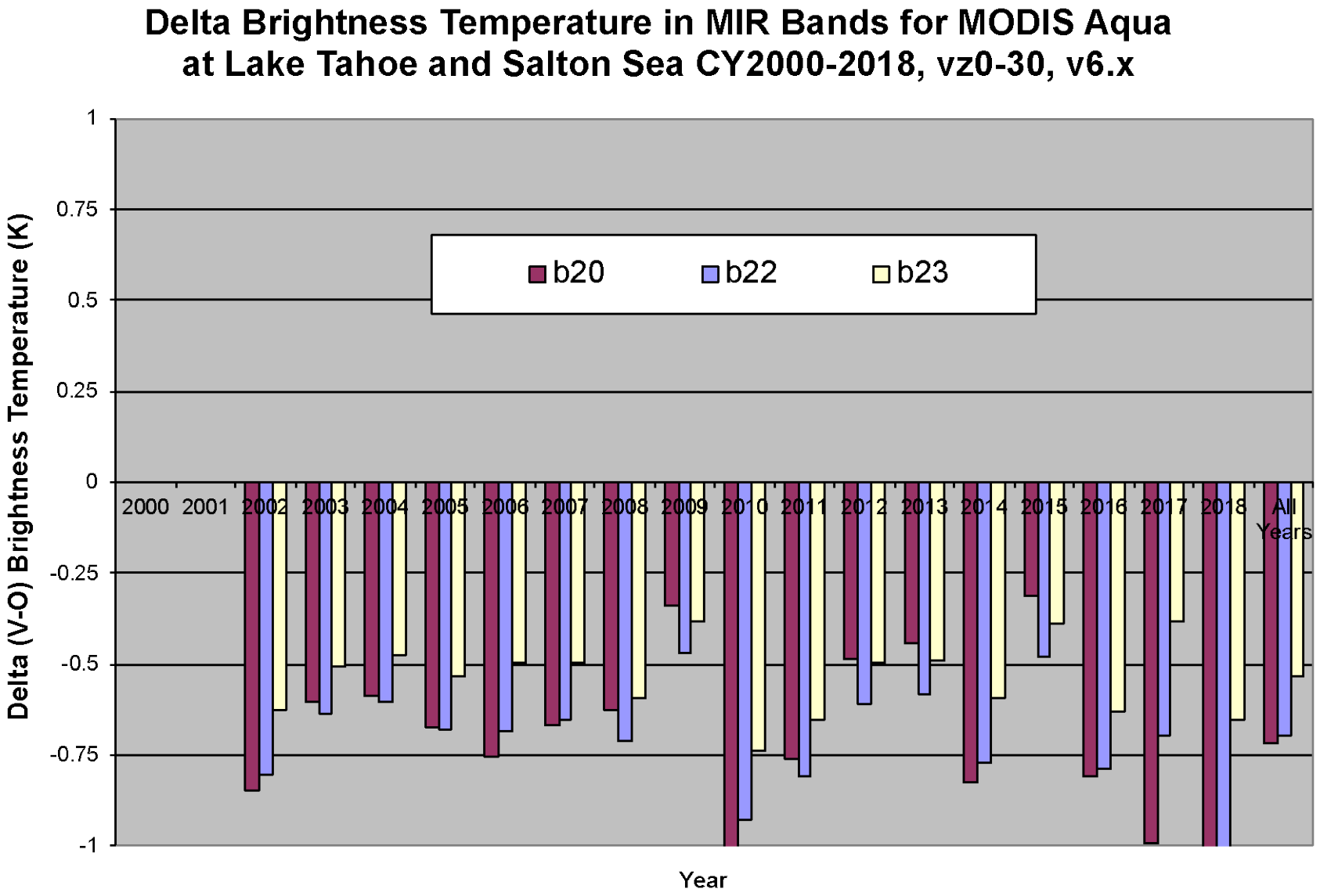
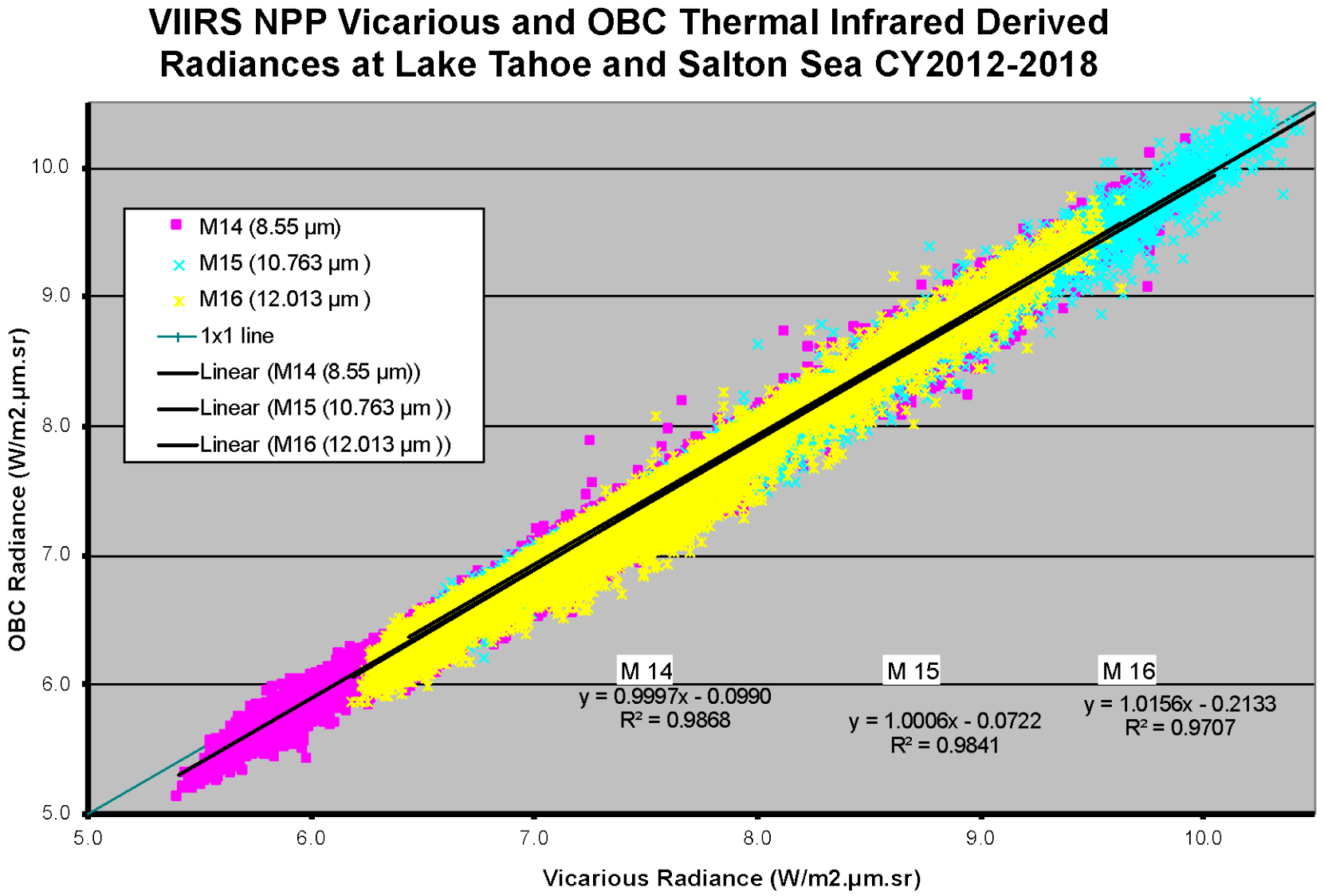
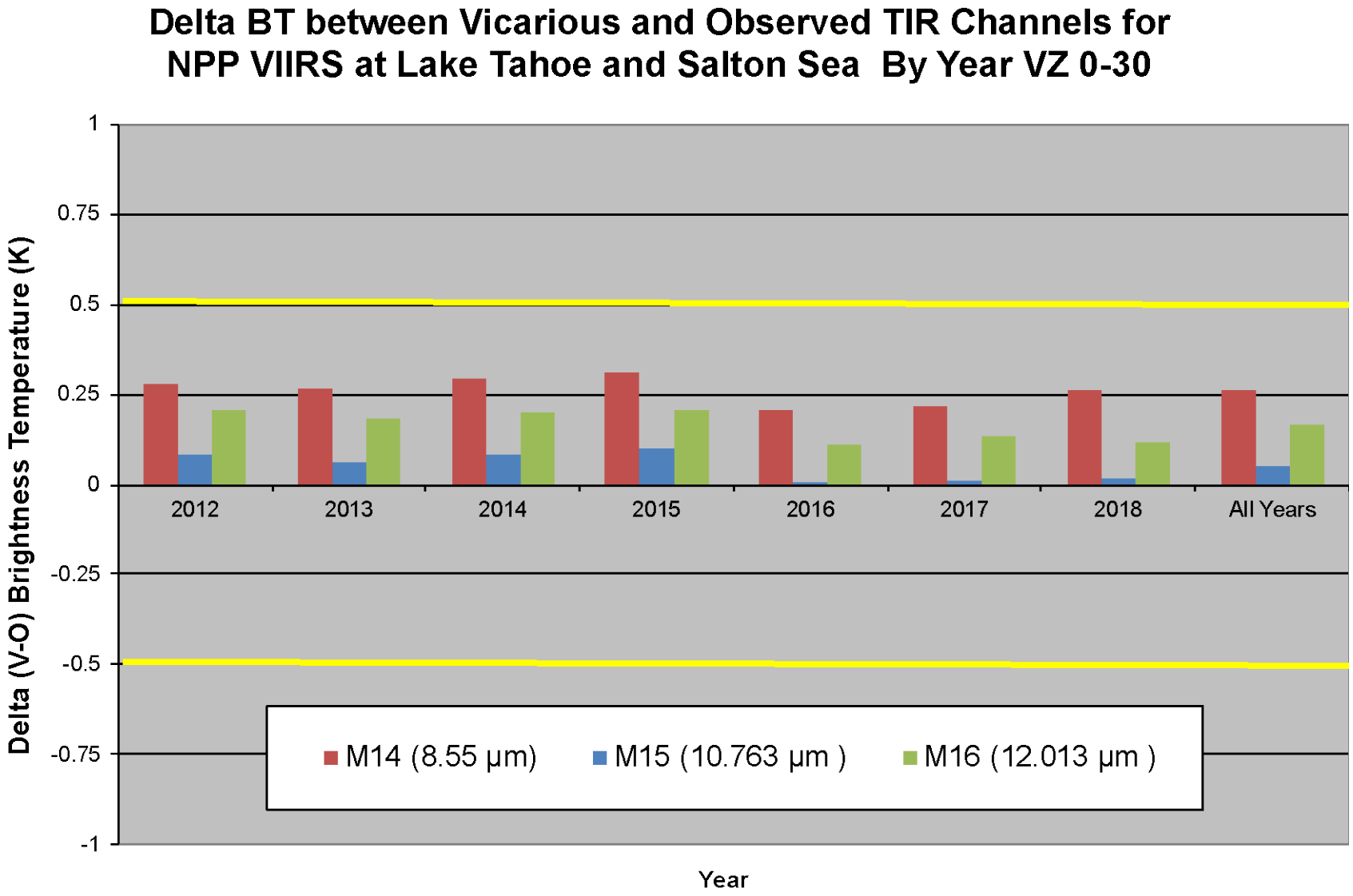


MODIS-Aqua – MIR bands are consistently slightly hot.

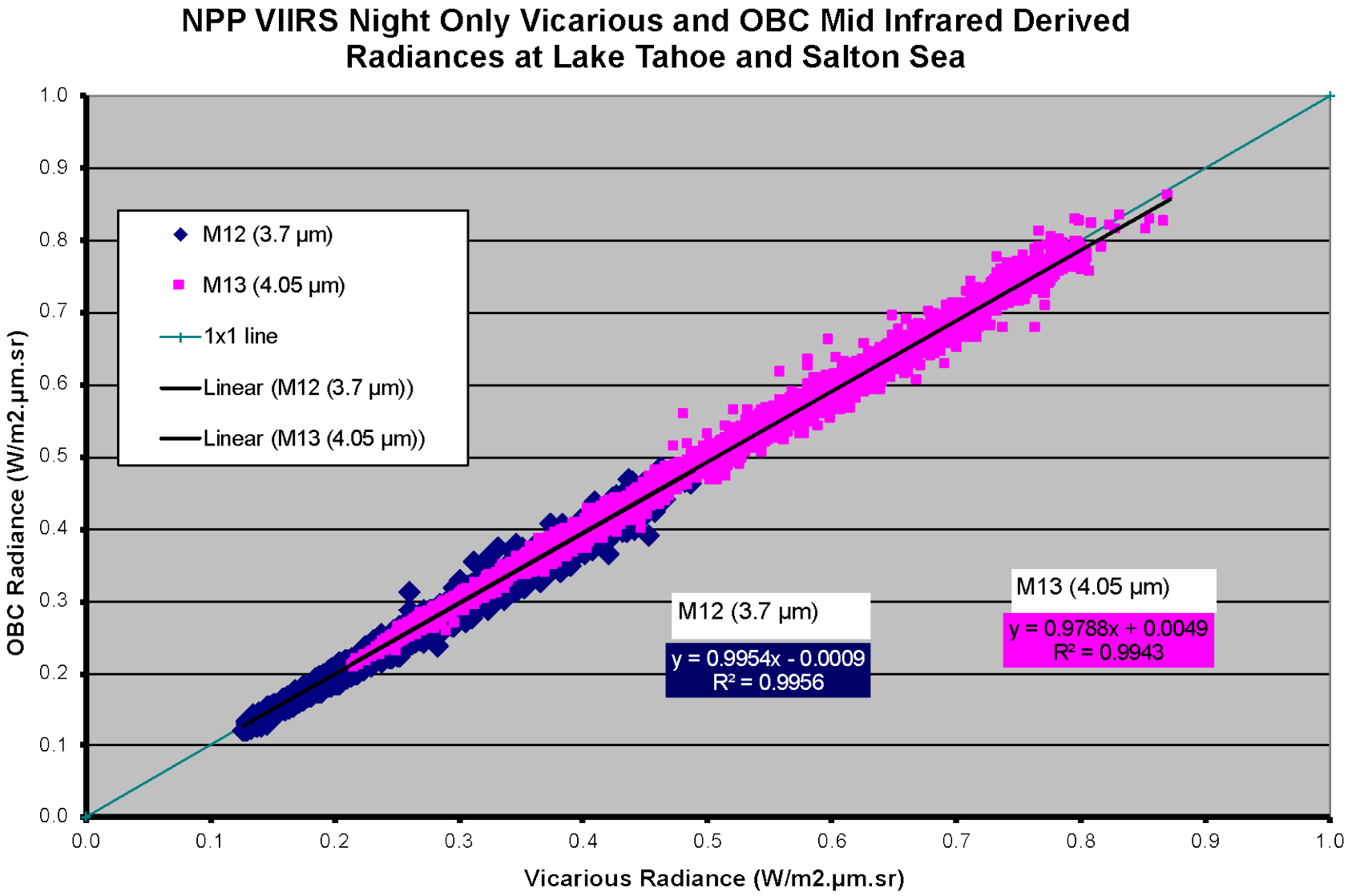
NPP-VIIRS - Results



Bands closely follow 1-1 line.

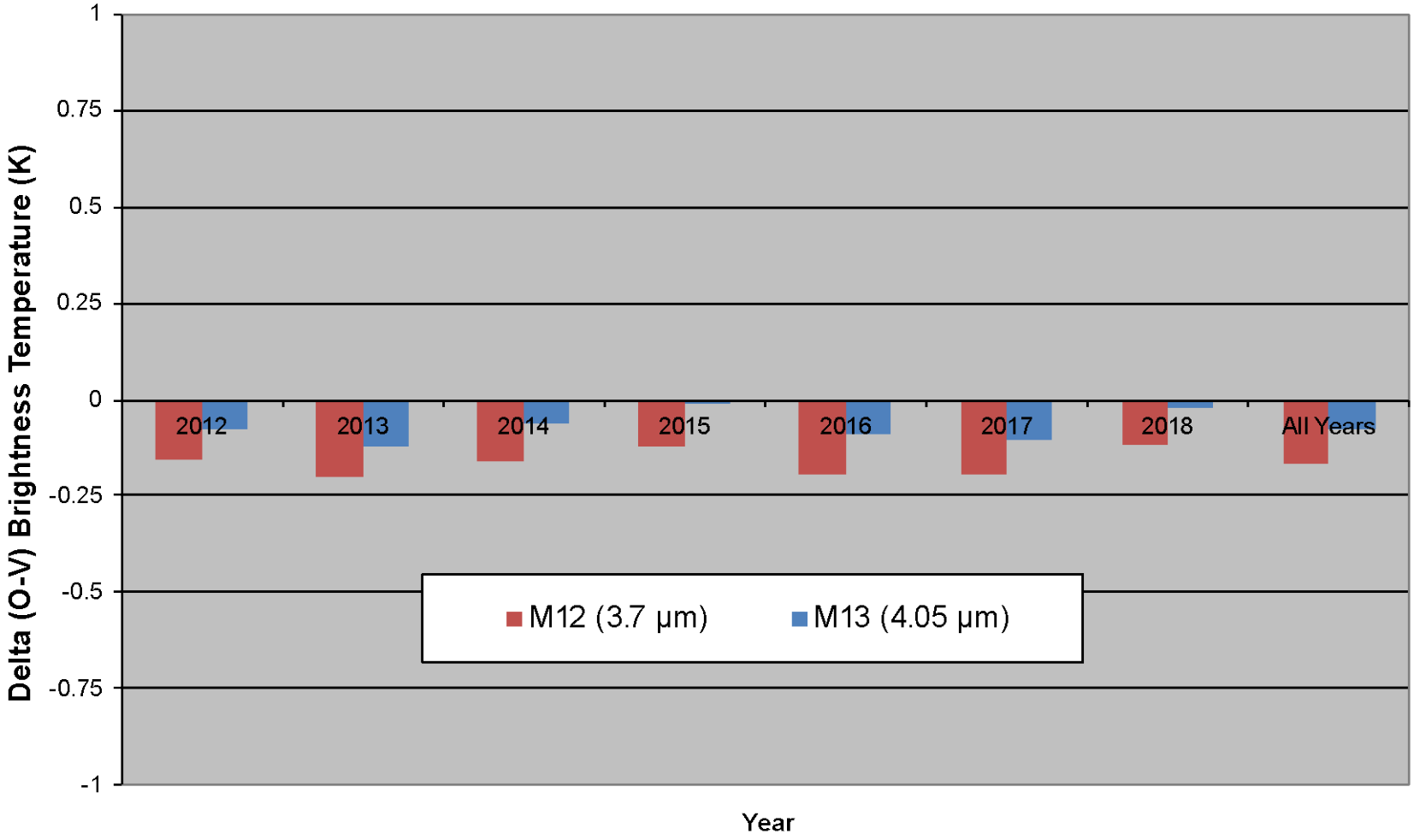


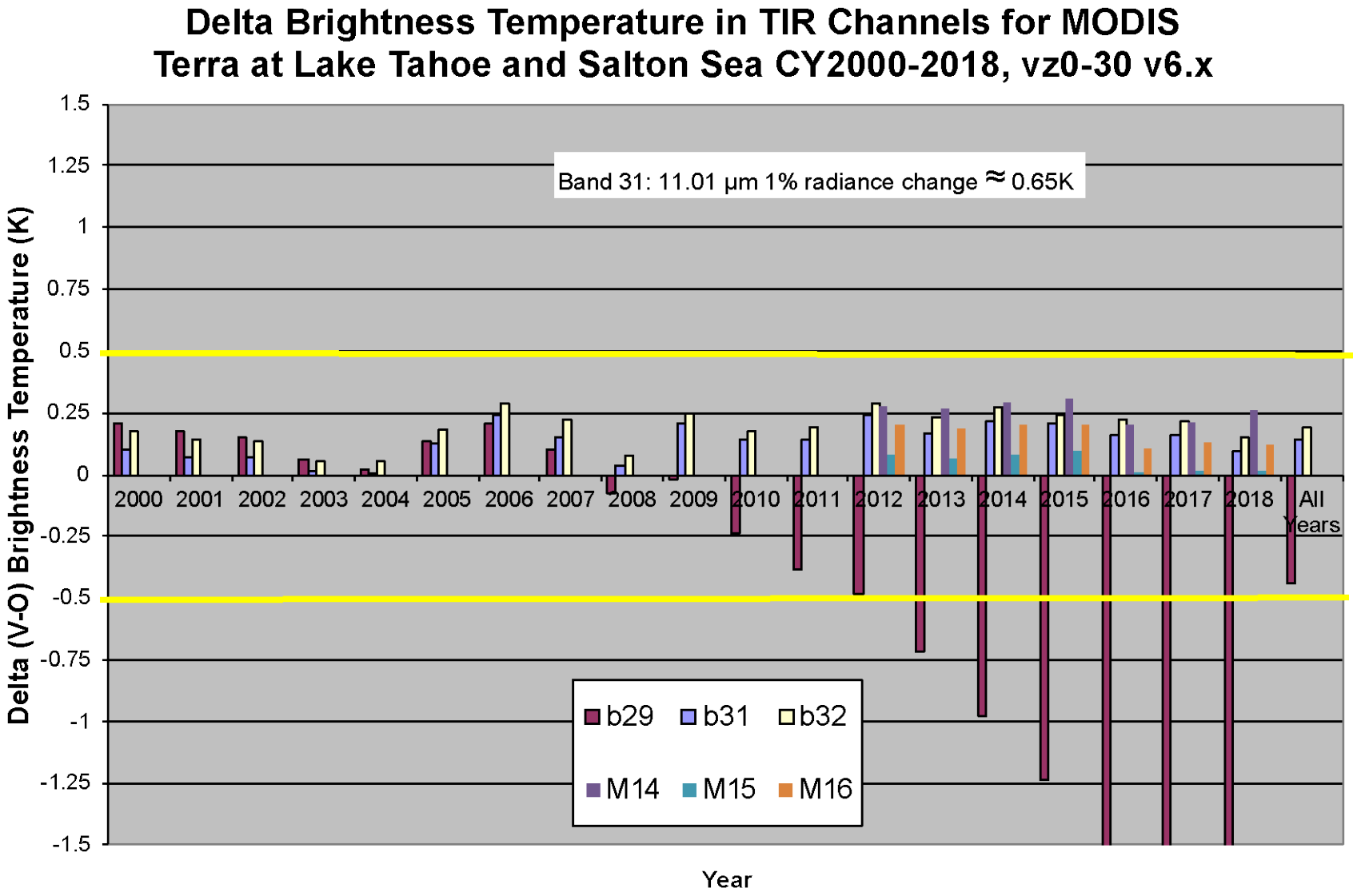
VIIRS – excellent calibration so far.



MIR bands also follow 1-1 line.

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

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-1.5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 All Years
b29 b31 b32
M14 M15 M16
Year

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, AATSR, ASTER, MODIS (Terra, Aqua), Landsat 5 and Landsat ETM+, MTI and now VIIRS
- Results:
  - MODIS-Terra at-sensor radiance: TIR bands 31 and 32 no bias, abs. acc. ± 0.3K
    - Gain change in band 29 starting in 2009
  - MODIS-Aqua at-sensor radiance: TIR, no bias, abs. acc. ± 0.3K
  - NPP-VIIRS at-sensor radiance: TIR, no bias, abs. acc. ± 0.3K
  - MODIS-Terra at-sensor radiance: MIR, small bias 0.25-0.5 K
    - MODIS Terra MIR is slightly hot!
  - MODIS-Aqua at-sensor radiance: MIR, small bias 0.25-0.5 K
    - MODIS Aqua MIR is slightly hot!
  - NPP-VIIRS at-sensor radiance: MIR, no bias abs. acc. ± 0.2K
- NPP-VIIRS compares well with Aqua-MODIS and is slightly better than Terra-MODIS.

ECOSTRESS – Preliminary results