



In-Flight Validation of Mid and Thermal Infrared Remotely Sensed Data from MODIS (Terra and Aqua) Using the Lake Tahoe and Salton Sea Automated Validation Sites

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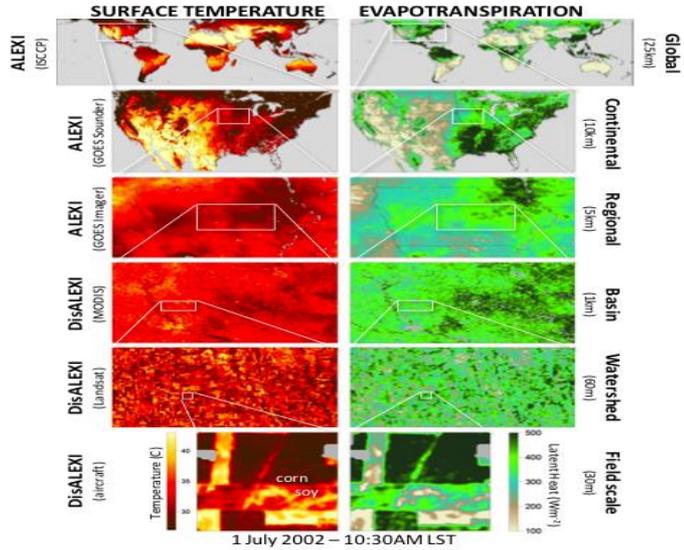
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Outline

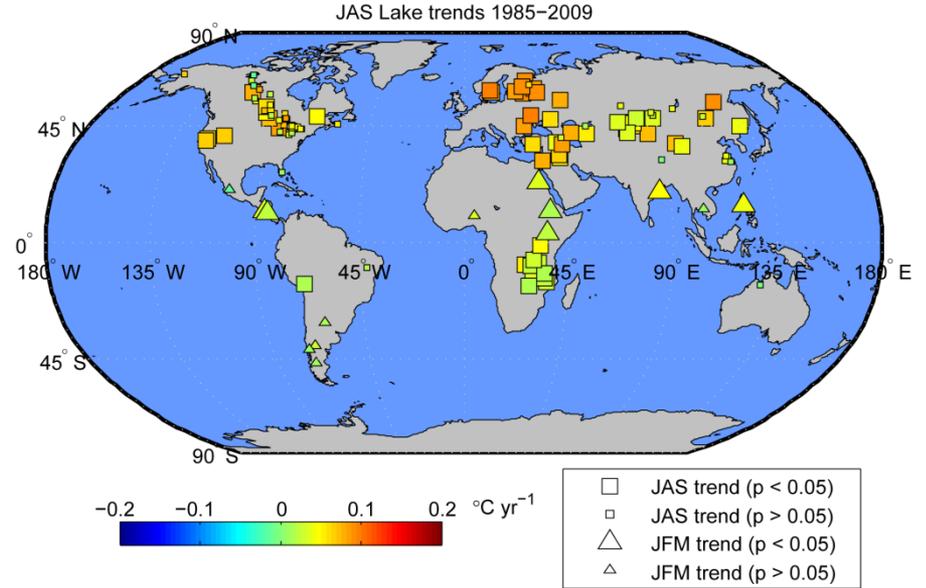
- Introduction
- Location
- Measurements and Calibration
- Data Reduction Methodology
- Results from various sensors
 - TIR MODIS and a little VIIRS
 - MIR MODIS
- Summary and Conclusions

Earth Science Use of LST&E

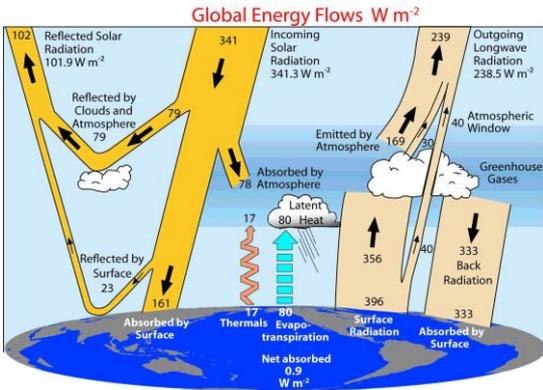
Evapotranspiration (drought monitoring)



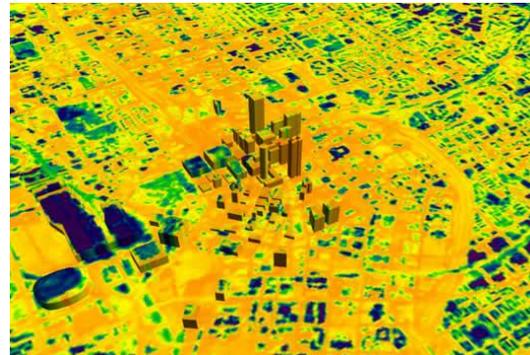
Understanding Climate Change



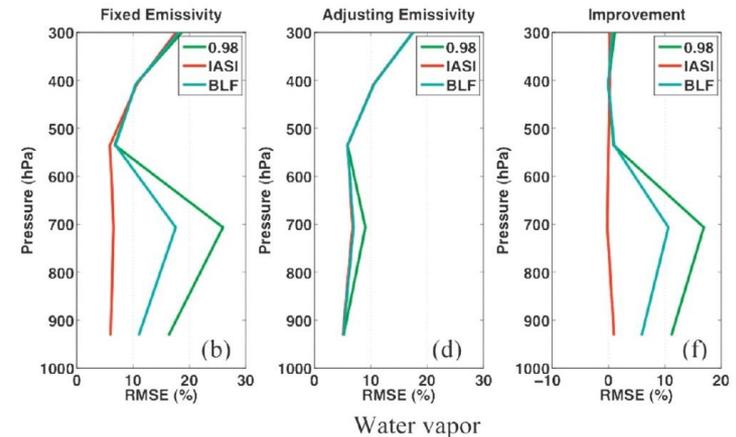
Surface Energy Balance



Urban Heat Island Studies



Atmospheric profile retrievals



N



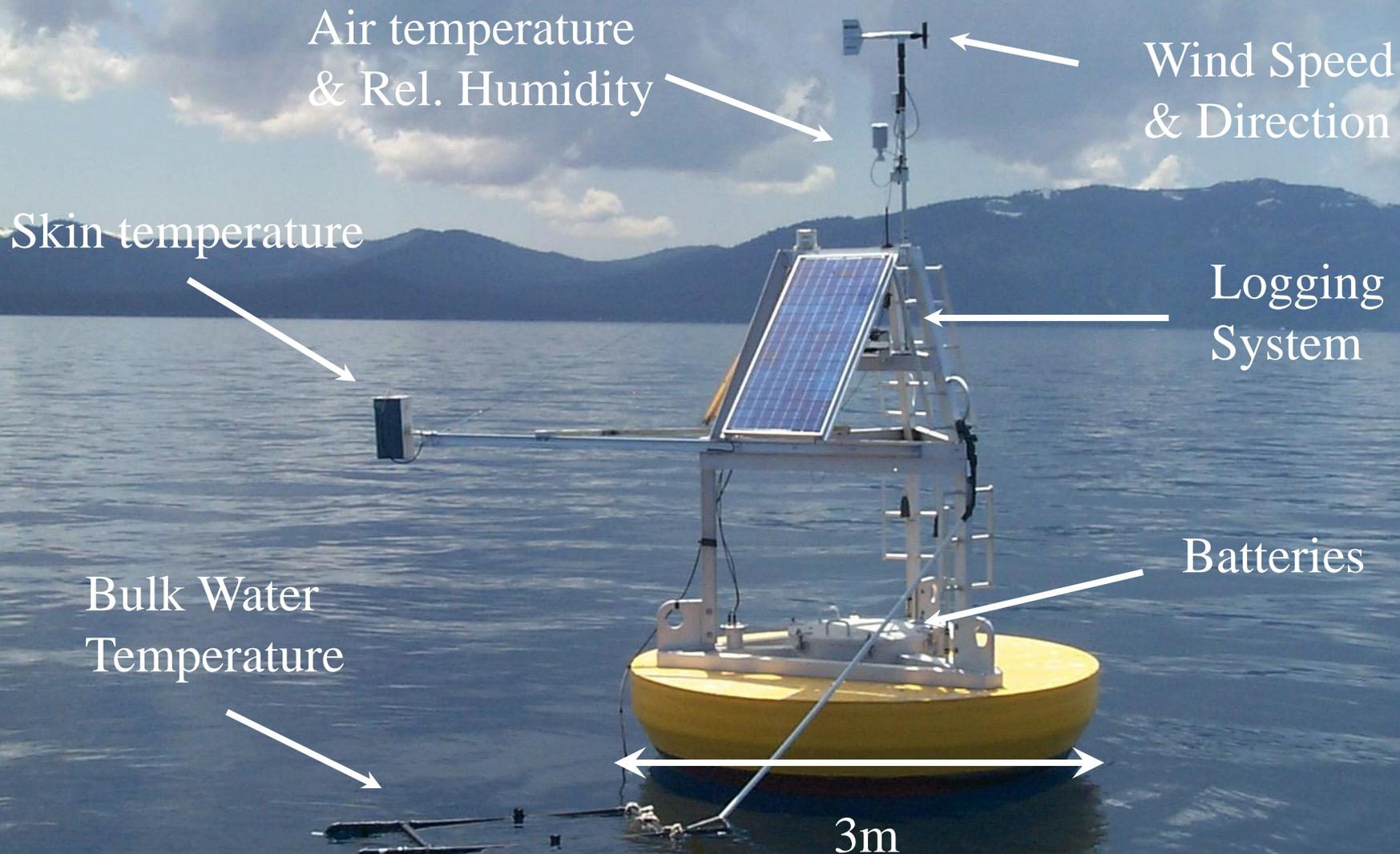
2000-09-20-D

- 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.

0 35 km



TB3 Installed 11-04-2002

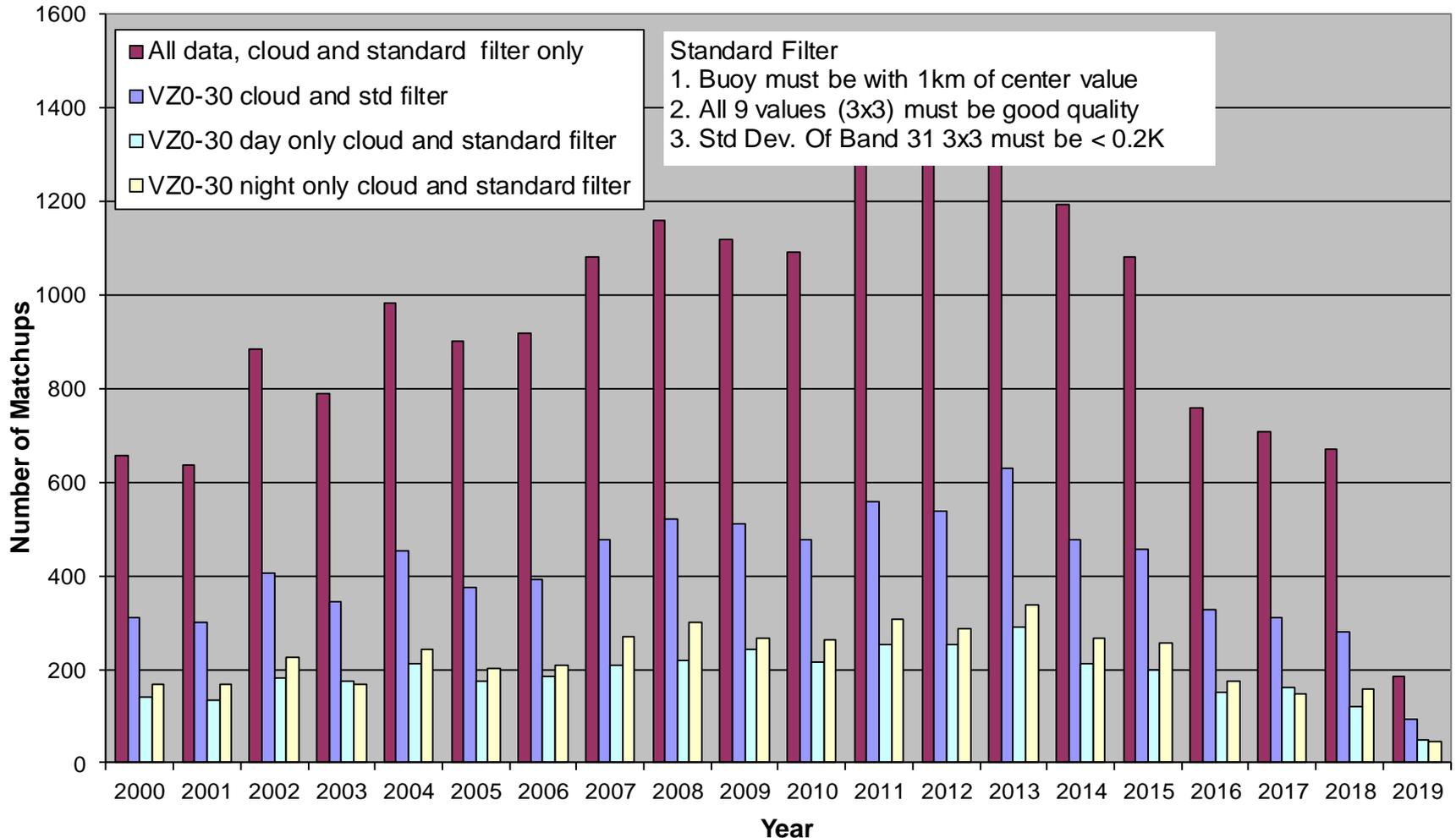


6/17/2003 1:20pm

Custom-Built Radiometers Calibrated to NIST Traceable Blackbody

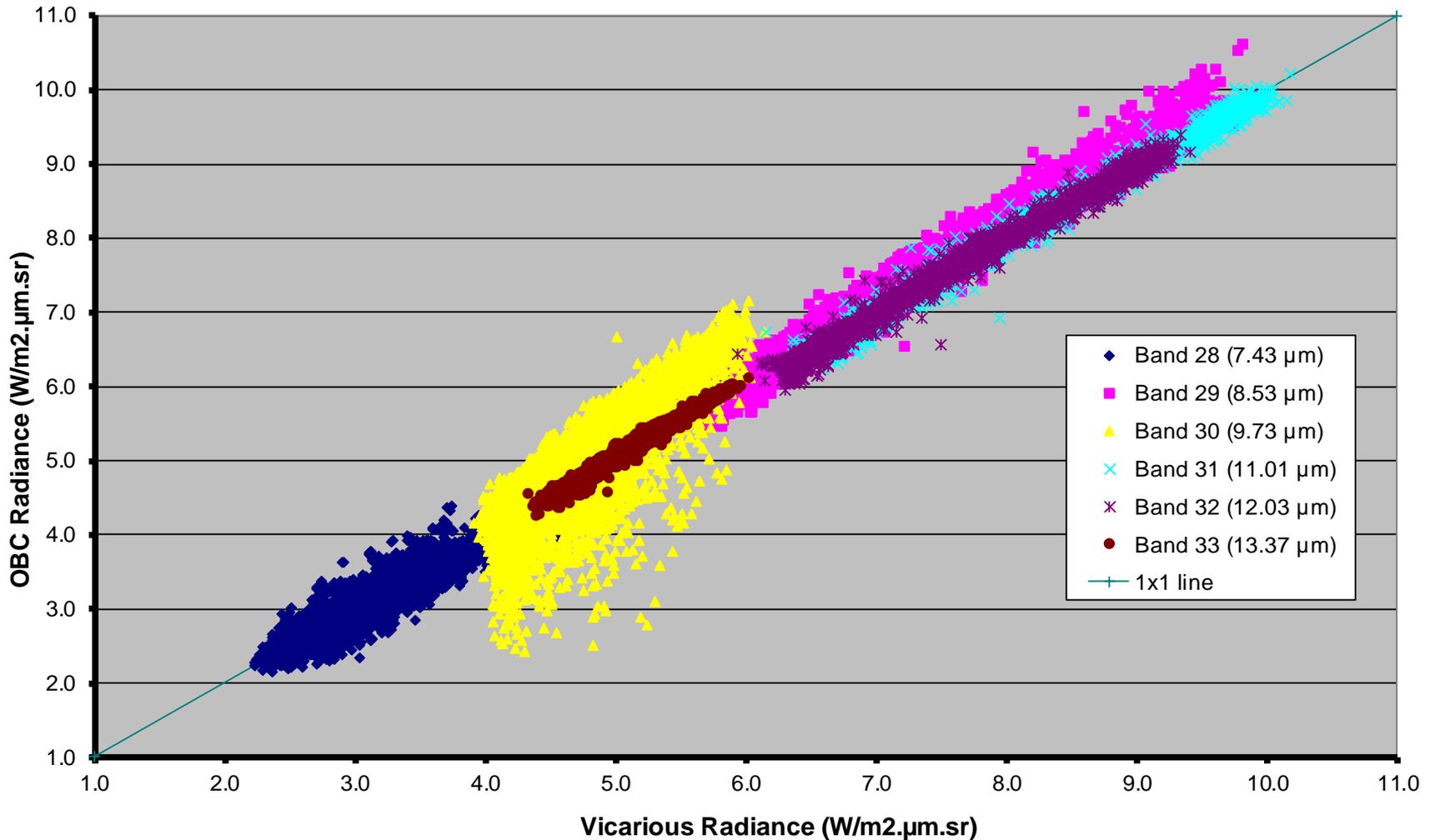


Matchup Count for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2019 v6.x



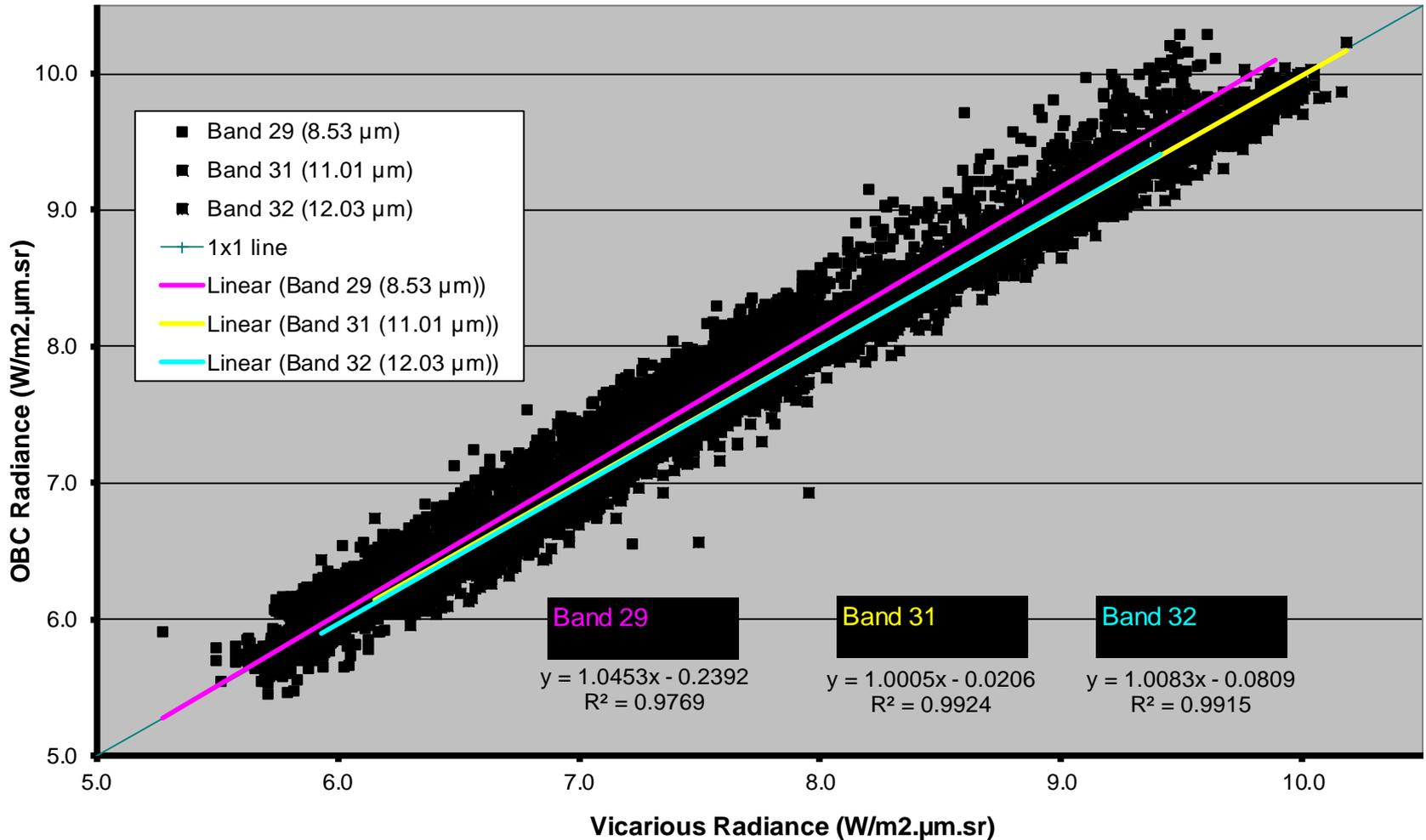
Now have large numbers of matchups – can restrict to optimum view angles

MODIS Terra Vicarious and OBC Thermal Infrared Derived Radiances at Lake Tahoe and Salton Sea CY2000-2019, v6.x



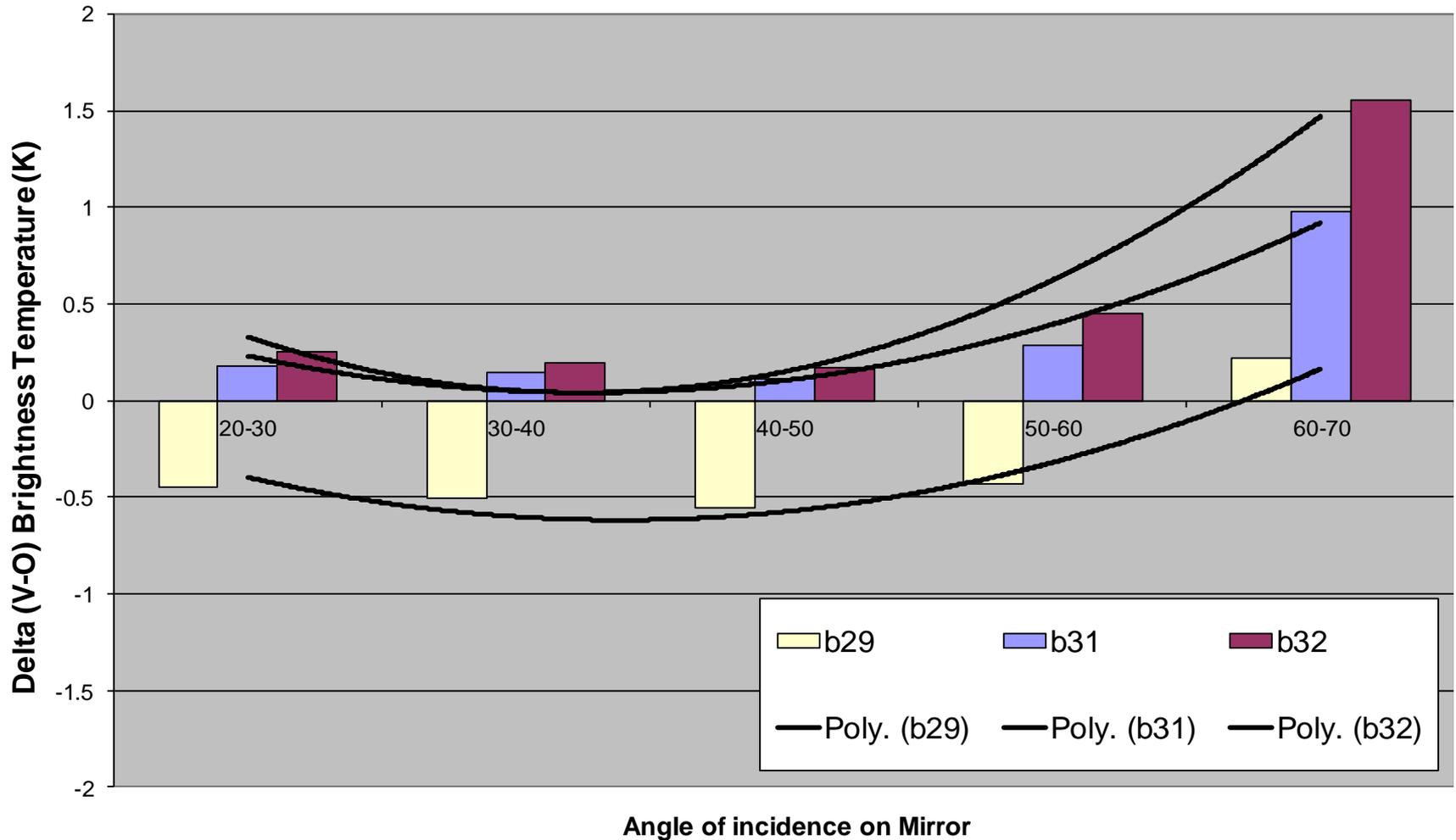
IR Window bands 31 and 32 align nicely with 1x1 line, but Band 29 does not.

MODIS Terra Vicarious and OBC Thermal Infrared Derived Radiances at Lake Tahoe and Salton Sea CY2000-2019, v6.x



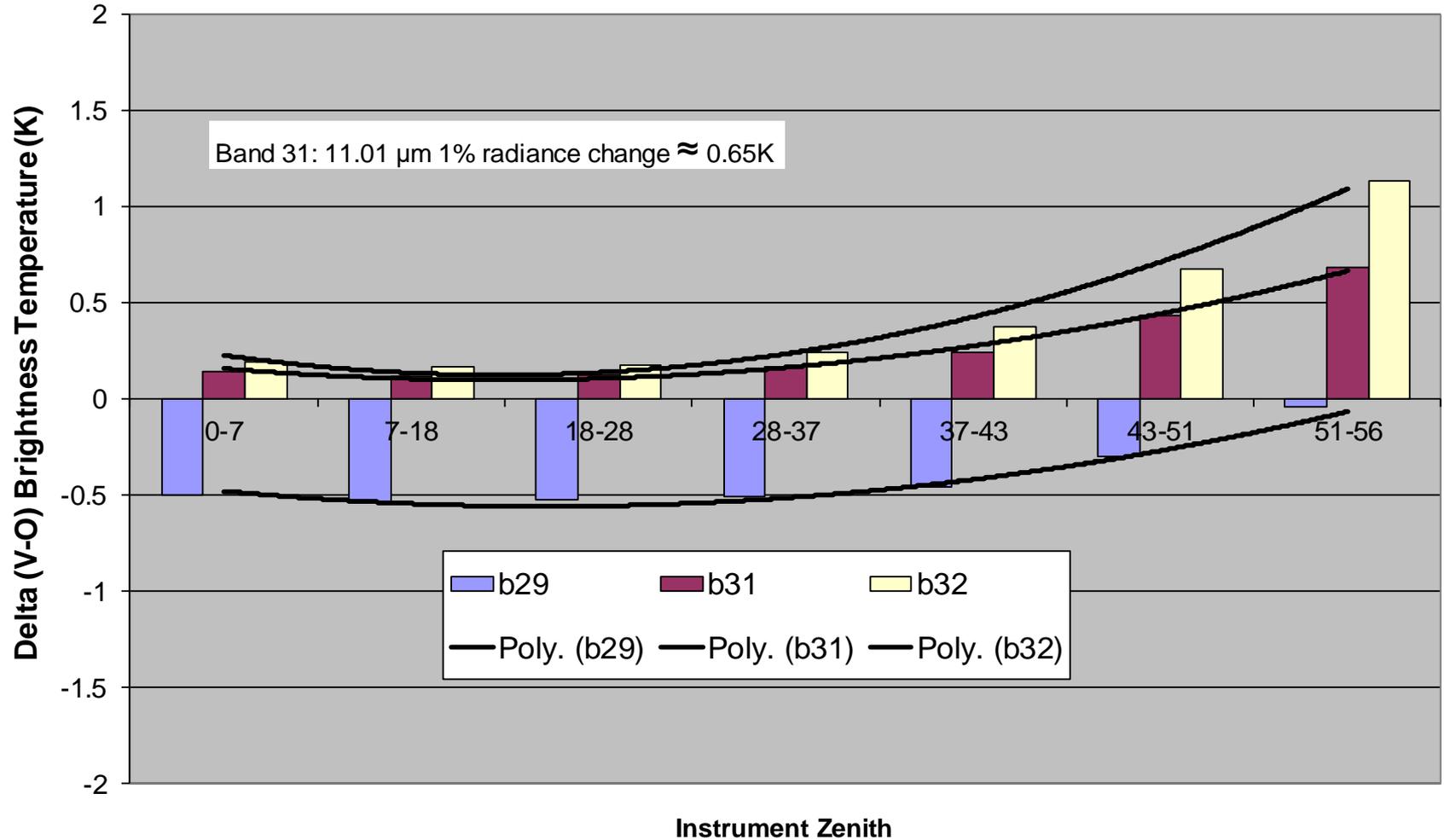
Window bands 31 and 32 closely follow 1 to 1 line, but 29 is out of family

Delta Brightness Temperature in TIR Channels for MODIS Terra with Mirror AOI at Lake Tahoe and Salton Sea CY2000-2019 v6.x



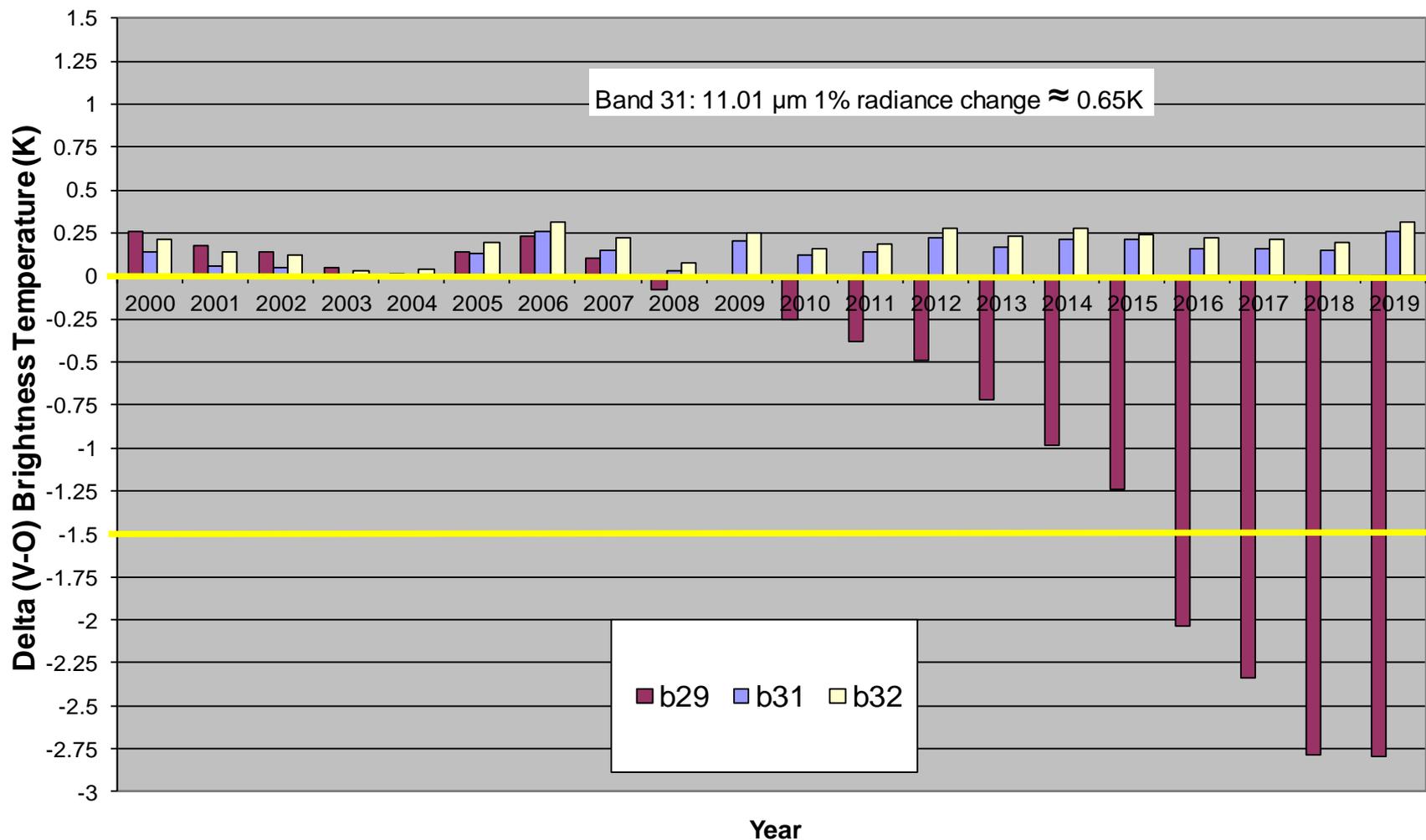
AOI relates to viewing geometry, more oblique views worse validation as expected

Delta Brightness Temperature in TIR Channels for MODIS Terra with Instrument Zenith at Lake Tahoe and Salton Sea CY2000-2019 v6.x



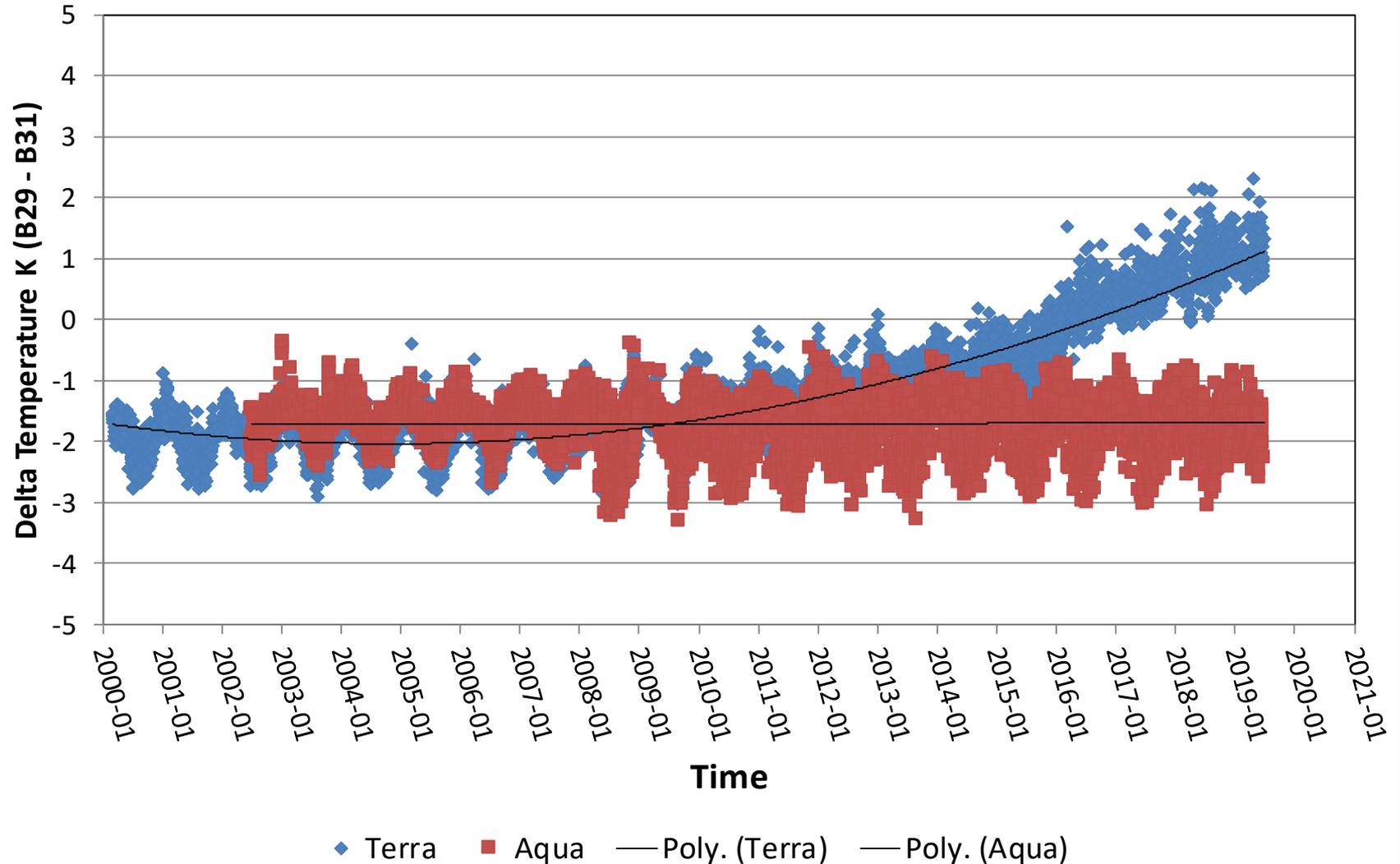
Analysis indicate get excellent results with in situ out to about 30 degrees but problem with calibration of b29

Delta Brightness Temperature in TIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2019, vz0-30 v6.x



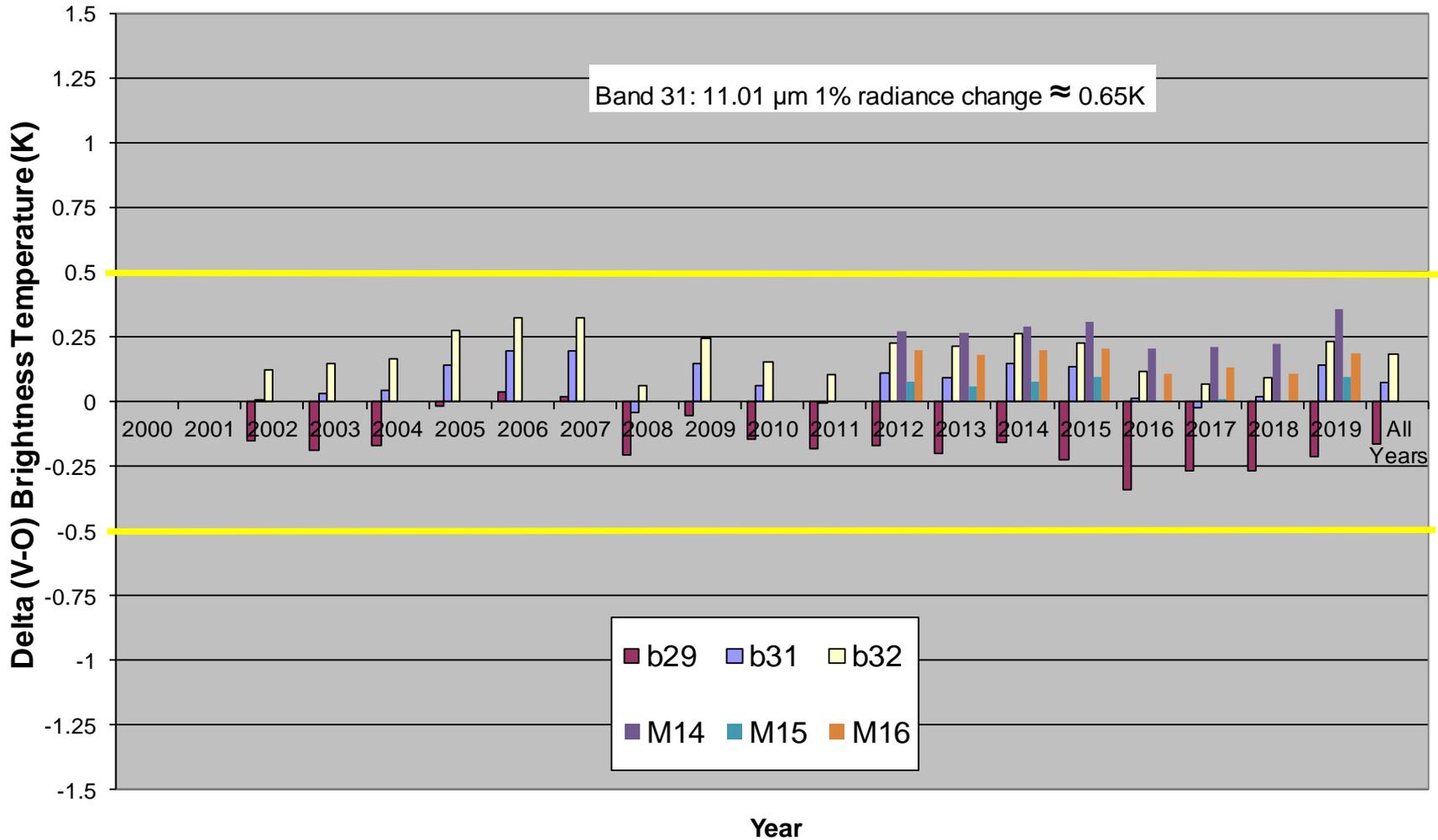
Excellent calibration until 2009. Since 2009 channel 29 calibration has degraded

Delta Temperature M29-M31 at Lake Tahoe and Salton Sea CY2000-2019, v6.x



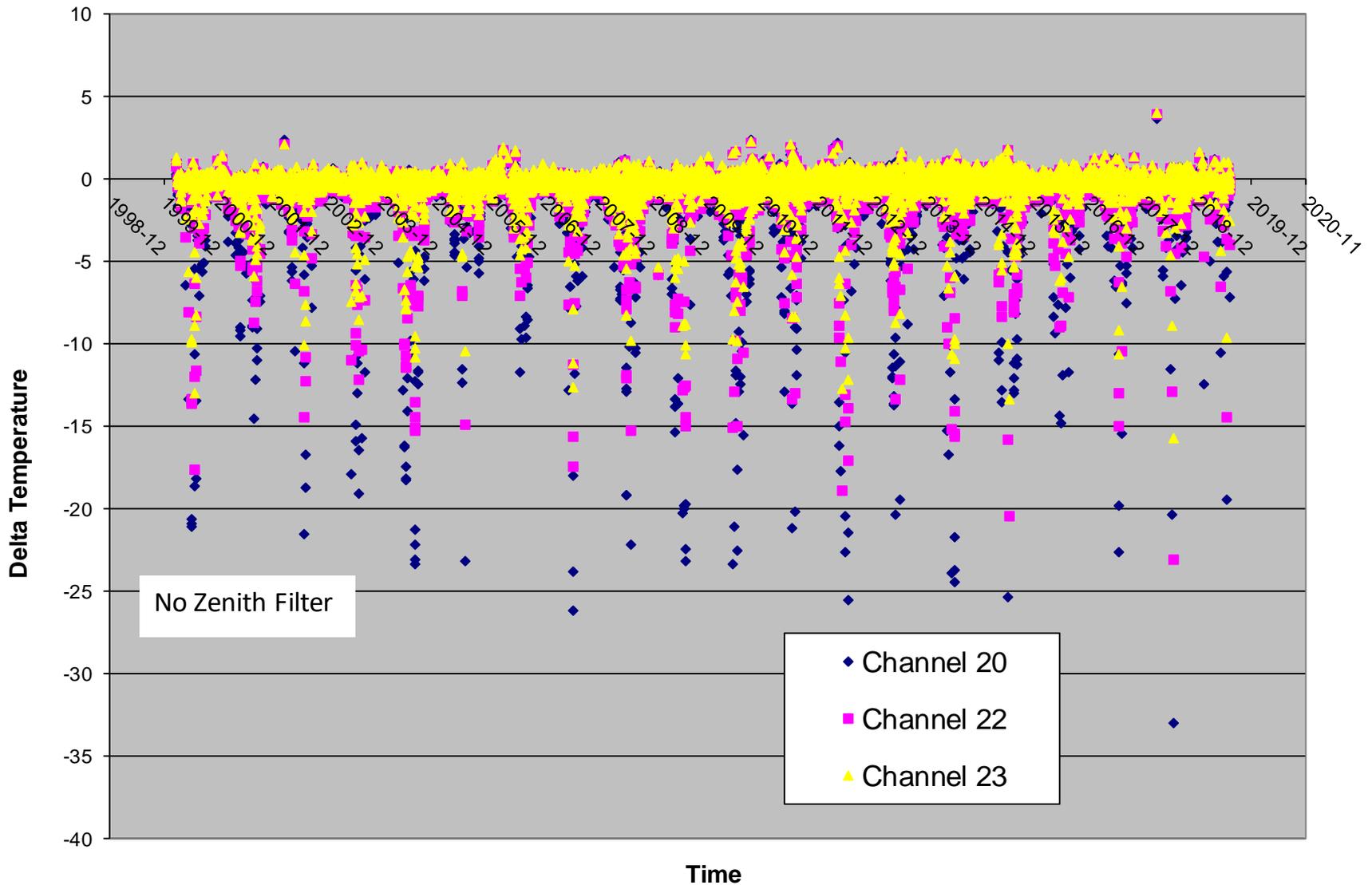
Similar analysis to previous slides but notice how range of Aqua data has increased

Delta Brightness Temperature in TIR Channels for MODIS Aqua at Lake Tahoe and Salton Sea CY2000-2019, vz0-30 v6.x



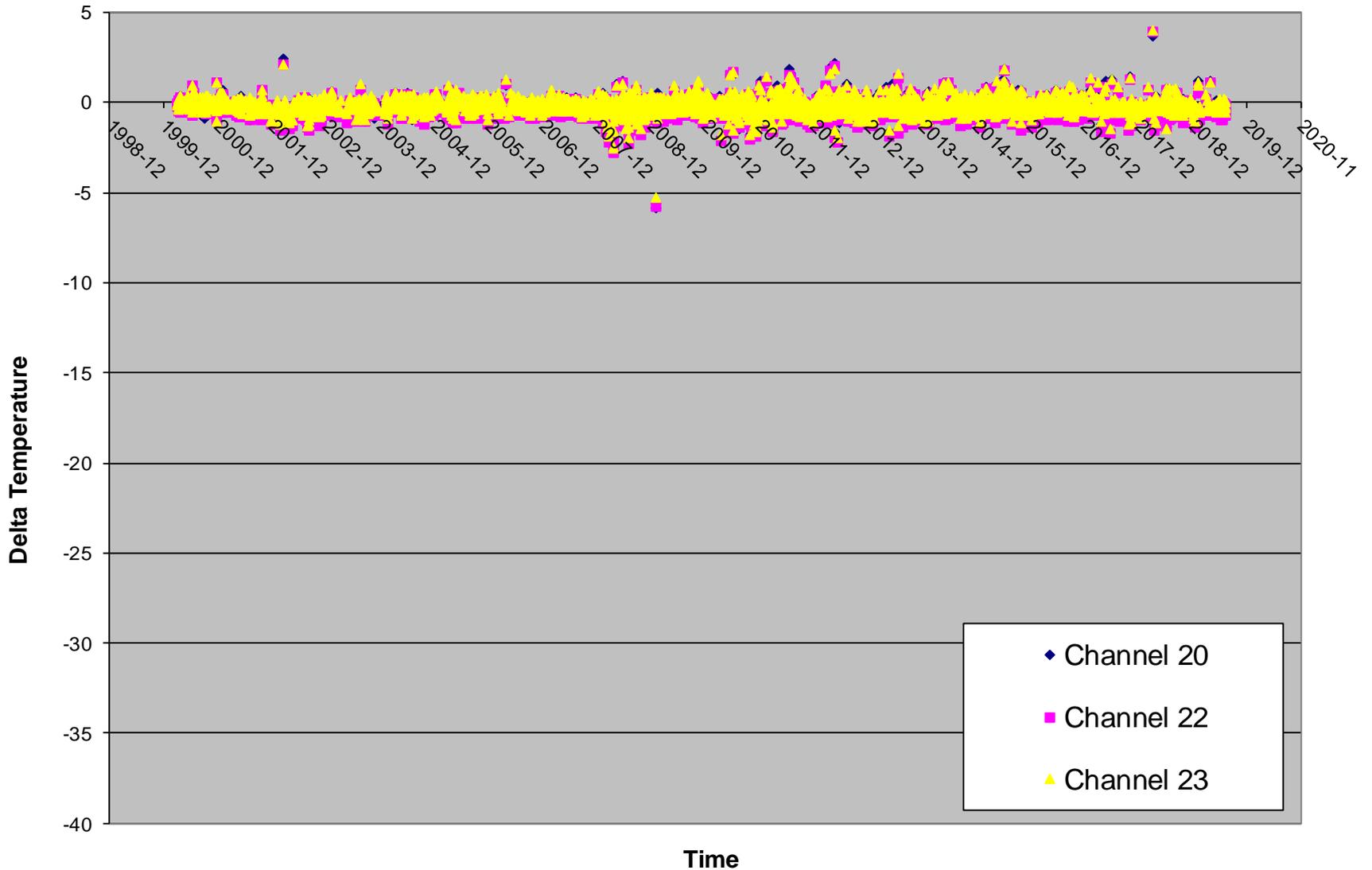
No sign of problems in channel 29 on Aqua-MODIS, VIIRS performance similar to MODIS ¹⁴

MODIS Terra Mid Infrared Channels Delta Temperature between Vicarious and OBC BT's at Lake Tahoe, 2000-2019 v6.x - DAY AND NIGHT



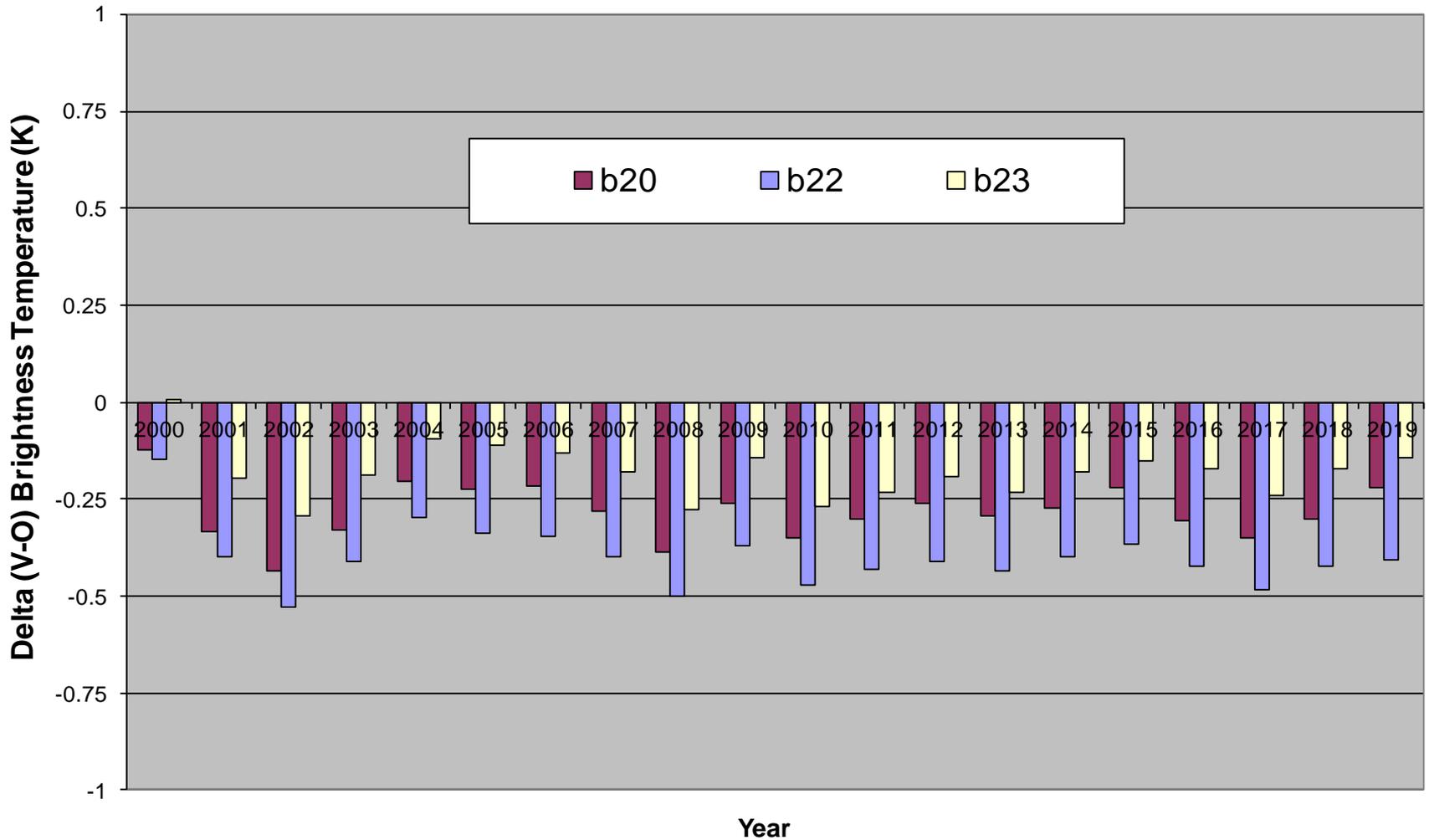
Can also use buoy data to validate MIR channels but cannot use daytime values since affected by reflected solar (as illustrated above). Since buoys operate 24x7 use just nighttime data (see next slide) 15

MODIS Terra Mid Infrared Channels Delta Temperature between Vicarious and OBC BT's at Lake Tahoe, 2000-2019, v6.x - NIGHT ONLY



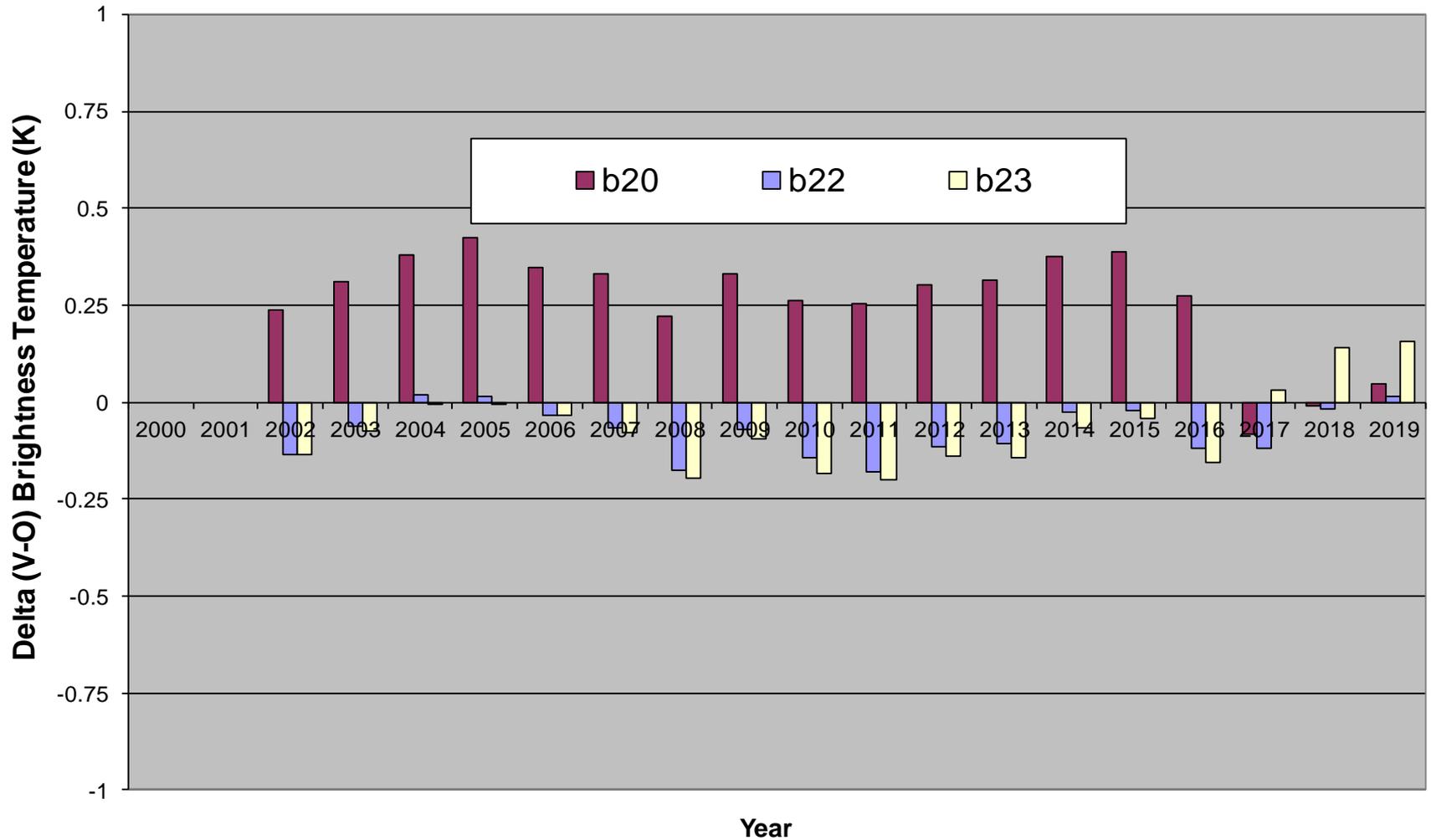
Nighttime only – no problems with reflected solar

Delta Brightness Temperature in MIR Bands for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2019, vz0-30, v6.x



When look at vicarious minus observed bias, Terra is warm.

Delta Brightness Temperature in MIR Bands for MODIS Aqua at Lake Tahoe and Salton Sea CY2000-2019, vz0-30, v6.x



No bias in MIR channels of Aqua

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, ECOSTRESS, MODIS (Terra, Aqua), VIIRS, Landsat 5, 7, 8 and MTI.
- Results so far indicate
 - MODIS-Terra at-sensor radiance: TIR 31 and 32, no bias, abs. acc. $\pm 0.5K$
 - MODIS-Terra at-sensor radiance: TIR 29, large bias, abs. acc. $\pm 2.75K$
 - MODIS-Aqua at-sensor radiance: TIR, no bias, abs. acc. $\pm 0.25K$
 - MODIS-Terra at-sensor radiance: MIR, bias 0.4 K
 - MODIS-Aqua at-sensor radiance: MIR, bias 0.3 K