



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

Simon J. Hook et al.

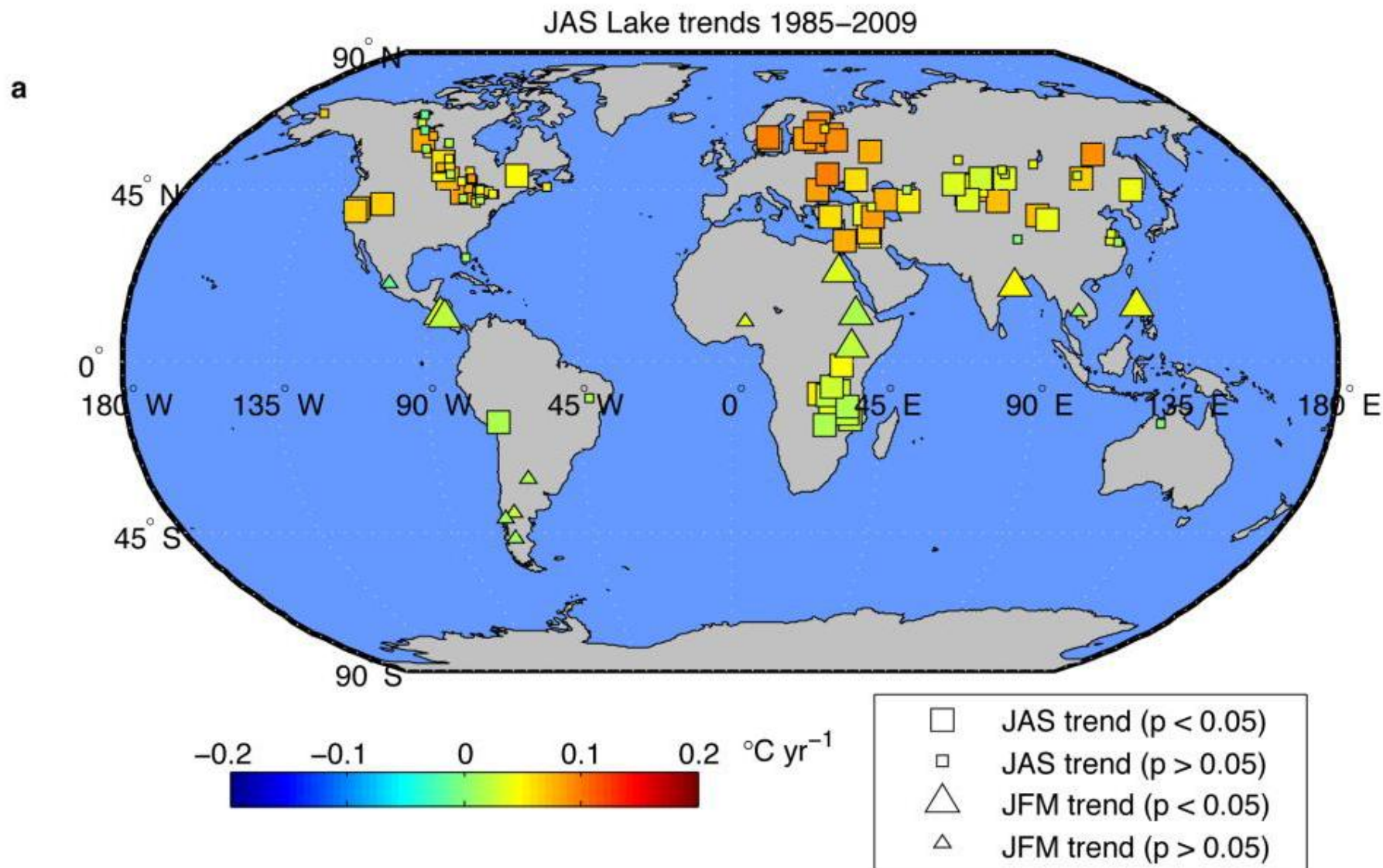
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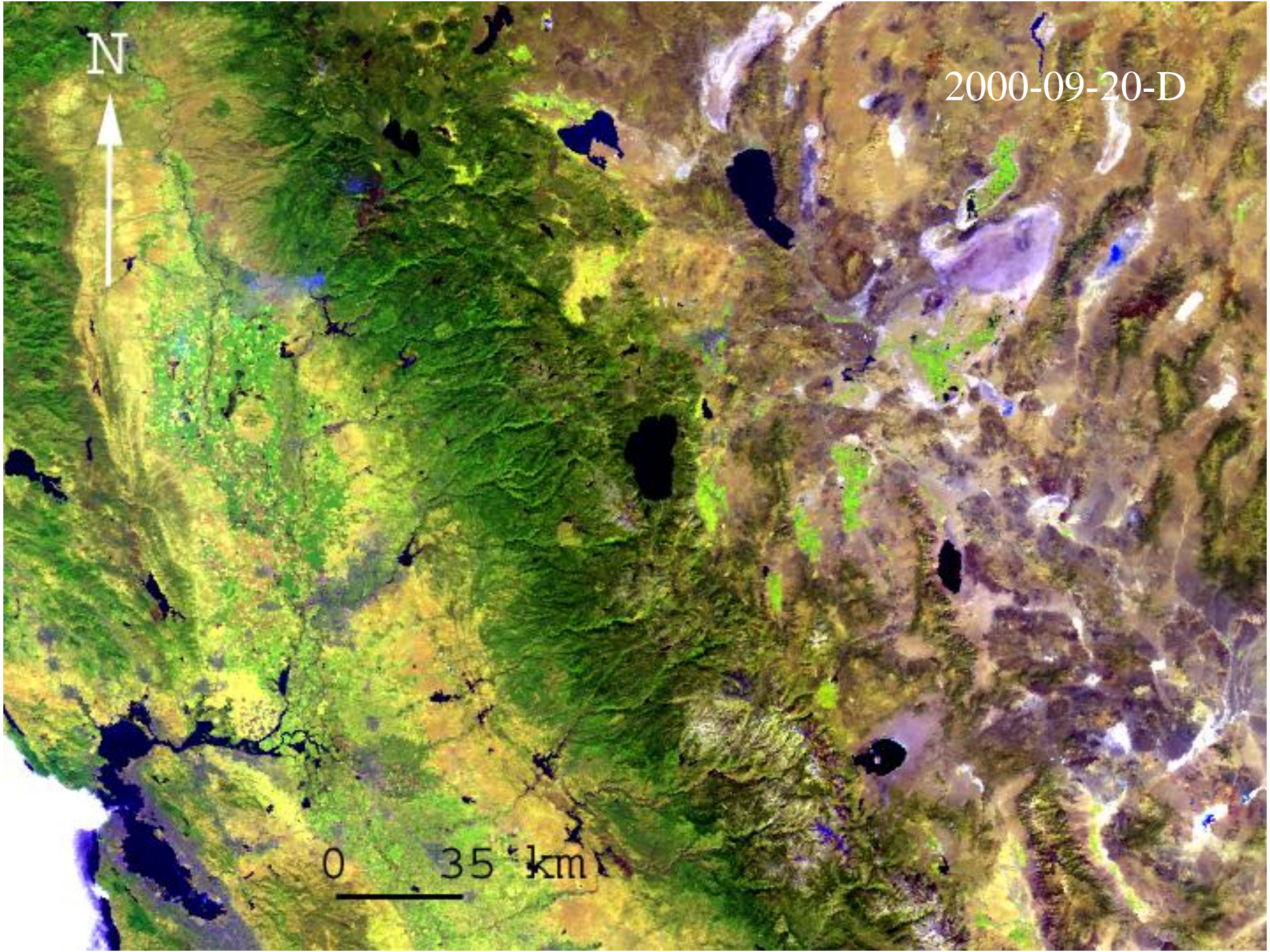
Outline

- Introduction
- Location
- Measurements and Calibration
- Data Reduction Methodology
- Results from various sensors
 - MODIS
- Summary and Conclusions
- Future Work

Global satellite-derived seasonal (July, August, September (JAS) and January, February, March (JFM)) nighttime lake surface temperature trends between 1985 and 2009



From Schneider and Hook, 2010



N

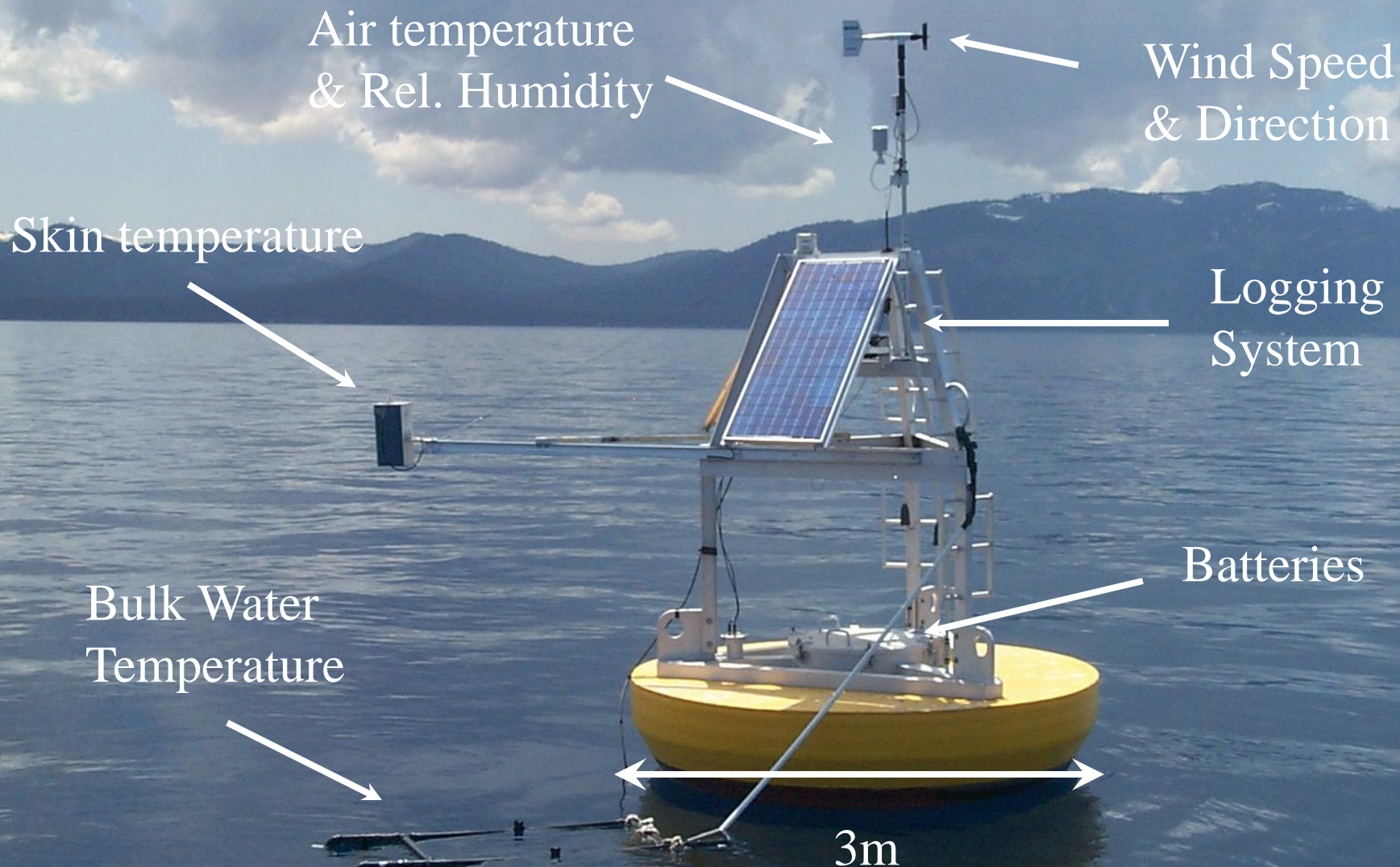


2000-09-20-D

0 35 km



TB3 Installed 11-04-2002



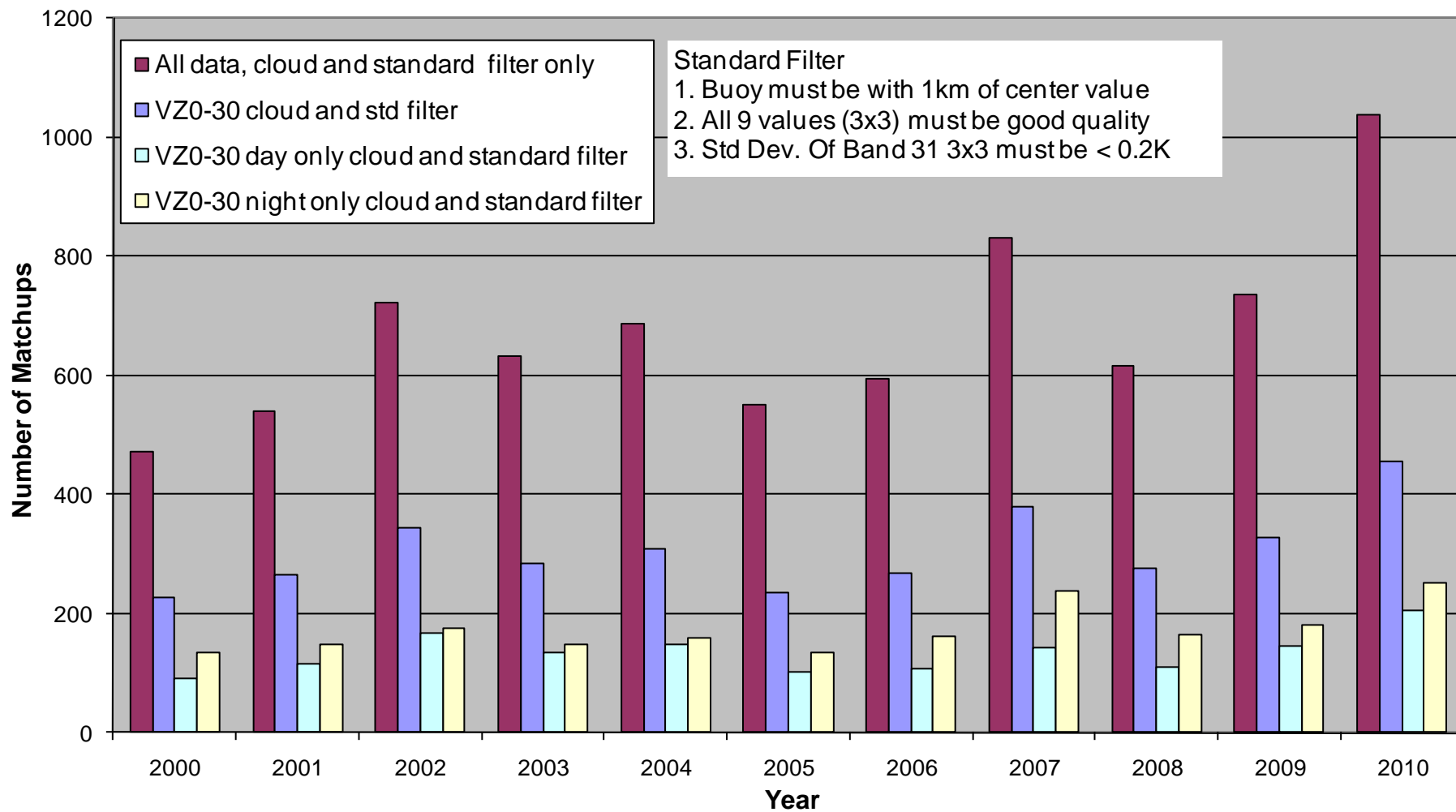
6/17/2003 1:20pm

MODERATE RESOLUTION IMAGING SPECTRORADIOMETER

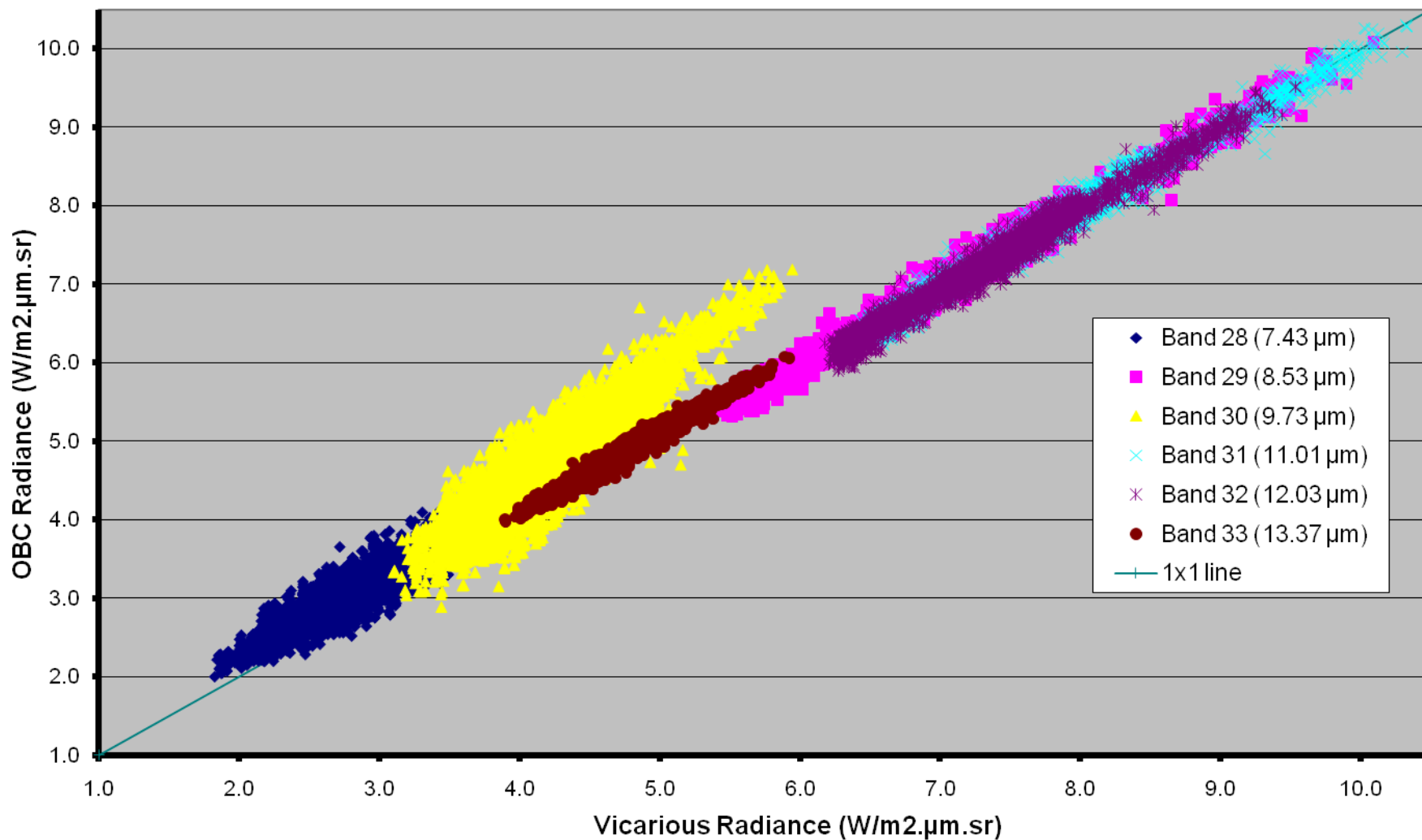
Orbit: 705 km, 10:30 a.m. descending node (AM-1) or 1:30 p.m. ascending node (PM-1), sun-synchronous, near-polar, circular.
 Swath dimensions: 2330 km (cross track) by 10 km (along track at nadir). Spatial Resolution 250 m (bands 1-2), 500 m (bands 3-7)
 1000 m (bands 8-36).

Application	Band	Bandwidth (nm)	SNR	Application	Band	Bandwith (um)	NEdT
<i>Land/Cloud Boundaries</i>	1	620-670	128	<i>Surface/Cloud Temperature</i>	20	3.660-3.840	0.05
<i>Land/Cloud Properties</i>	2	841-876	201		21	3.929-3.989	2.00
	3	459-479	243		22	3.929-3.989	0.07
	4	545-565	228	<i>Atmospheric Temperature</i>	23	4.020-4.080	0.07
	5	1230-1250	74		24	4.433-4.498	0.25
	6	1628-1652	275		25	4.482-4.549	0.25
	7	2105-2155	110	<i>Cirrus Clouds</i>	26	1.360-1.390	150 (SNR)
<i>Ocean Color/ Phytoplankton/ Biogeochemistry</i>	8	405-420	880	<i>Water Vapor</i>	27	6.535-6.895	0.25
	9	438-448	838	<i>Ozone</i>	28	7.175-7.475	0.25
	10	483-493	802		29	8.400-8.700	0.25
	11	526-536	754		30	9.580-9.880	0.25
	12	546-556	750	<i>Surface/Cloud Temperature</i>	31	10.780-11.280	0.25
	13	662-672	910		32	11.770-12.270	0.25
	14	673-683	1087	<i>Cloud Top Altitude</i>	33	13.185-13.785	0.25
	15	743-753	586		34	13.485-13.785	0.25
<i>Atmospheric Water Vapor</i>	16	862-877	516		35	13.785-14.085	0.25
	17	890-920	167		36	14.085-14.385	0.35
	18	931-941	57				
	19	915-965	250				

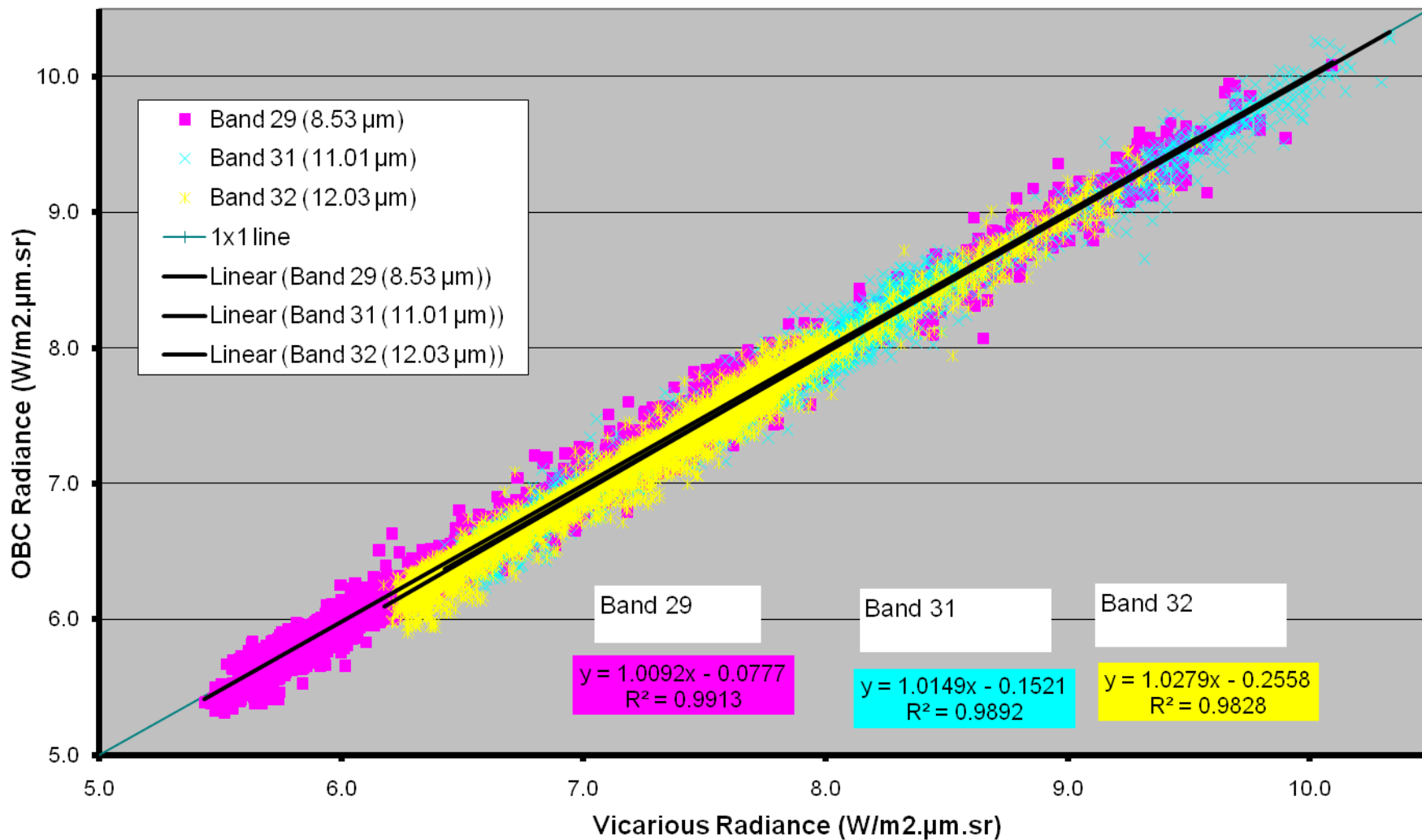
Matchup Count for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2010 v5.x



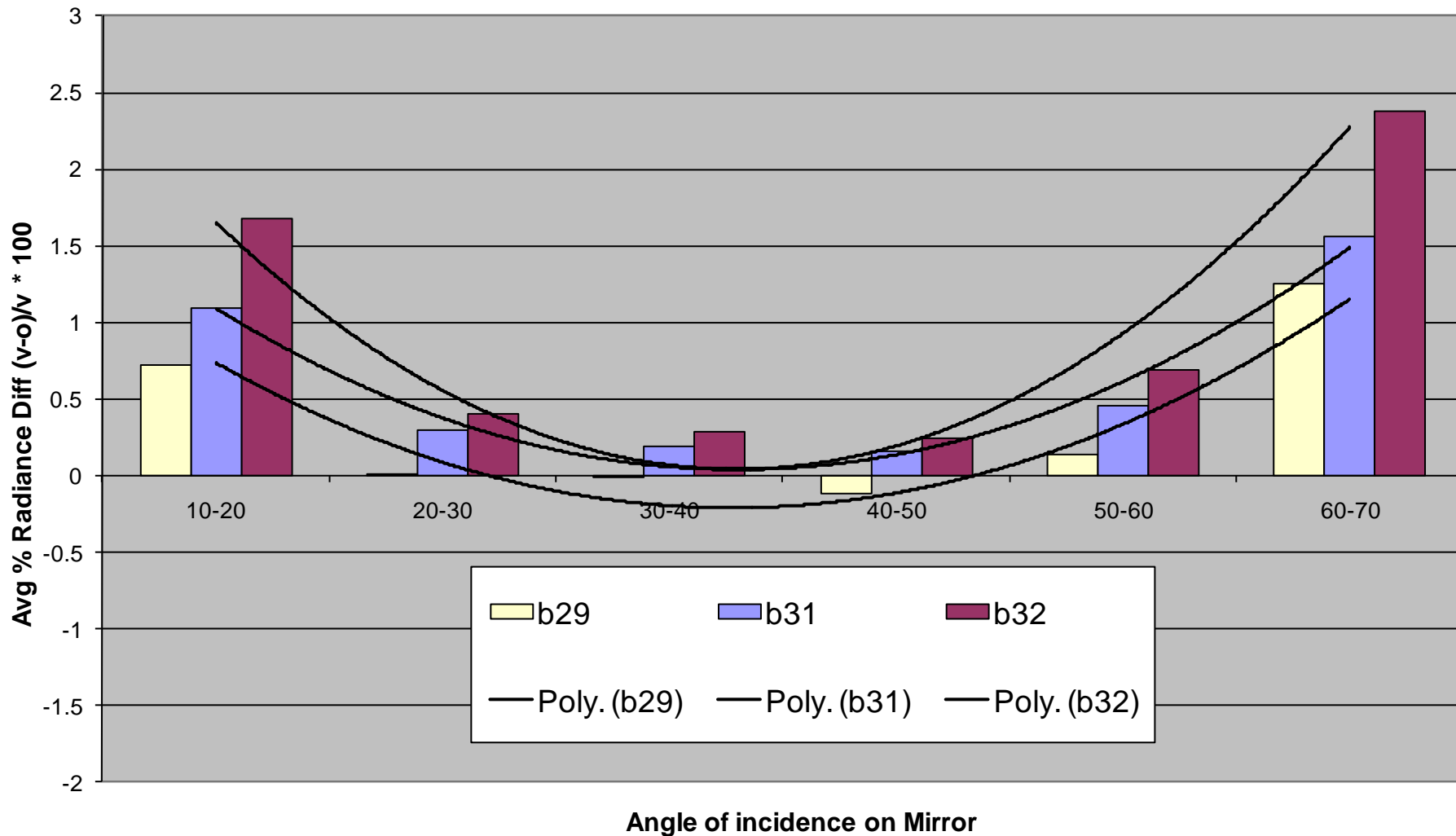
MODIS Terra Vicarious and OBC Thermal Infrared Derived Radiances at Lake Tahoe and Salton Sea CY2000-2010, v5.x



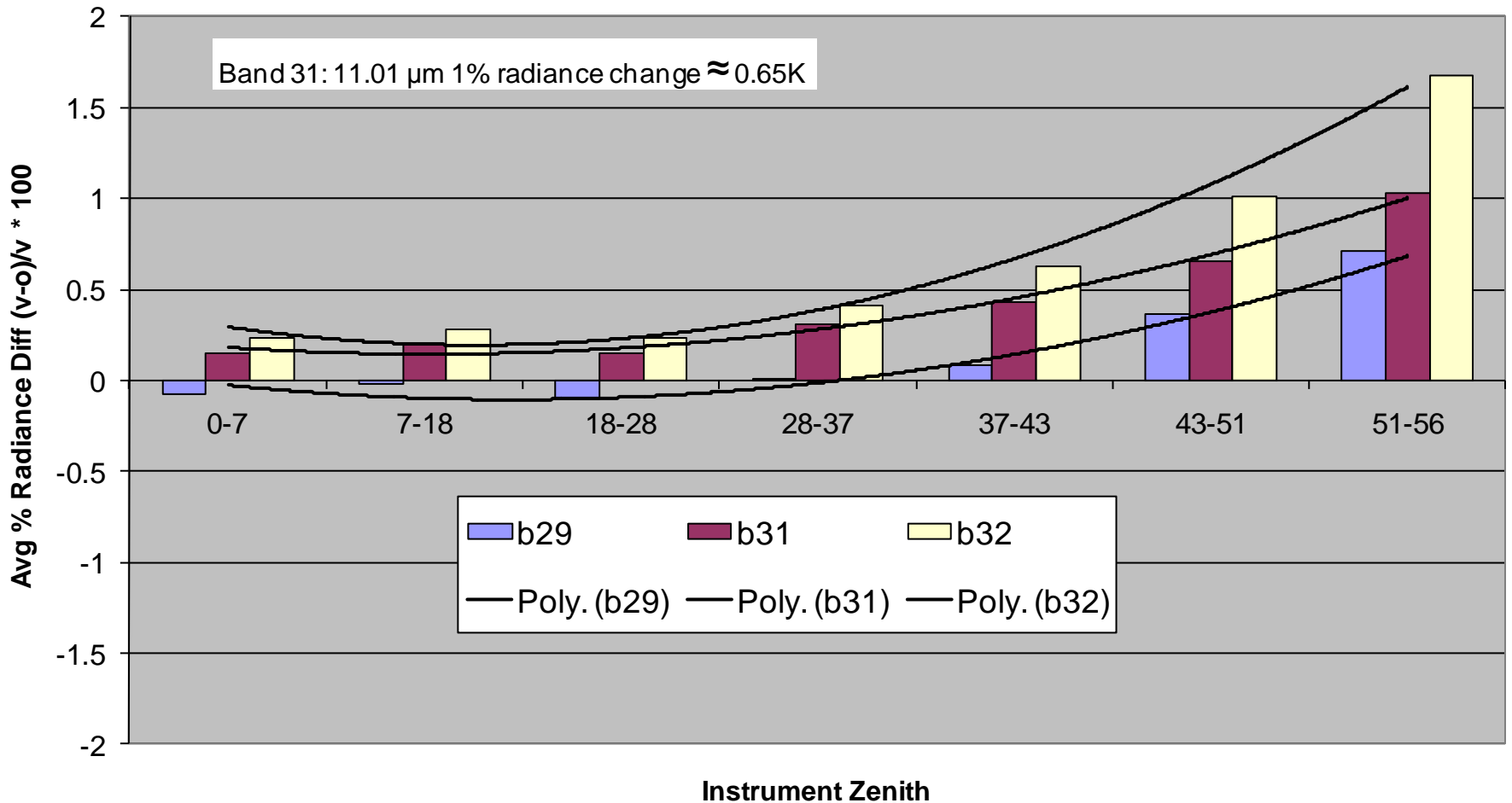
MODIS Terra Vicarious and OBC Thermal Infrared Derived Radiances at Lake Tahoe and Salton Sea CY2000-2010, v5.x



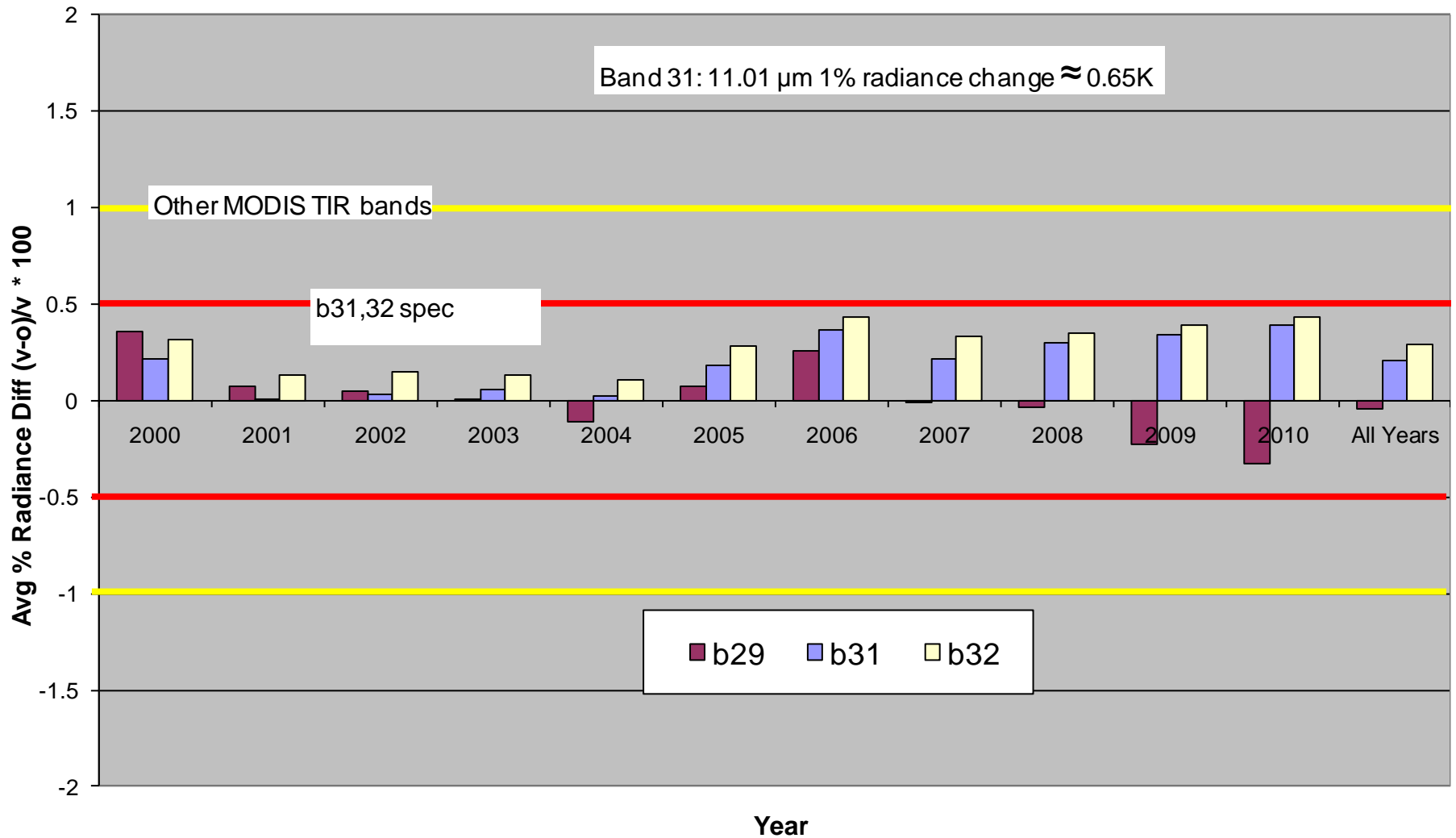
% Radiance Change in TIR Channels for MODIS Terra with Mirror AOI at Lake Tahoe and Salton Sea CY2000-2010 v5.x



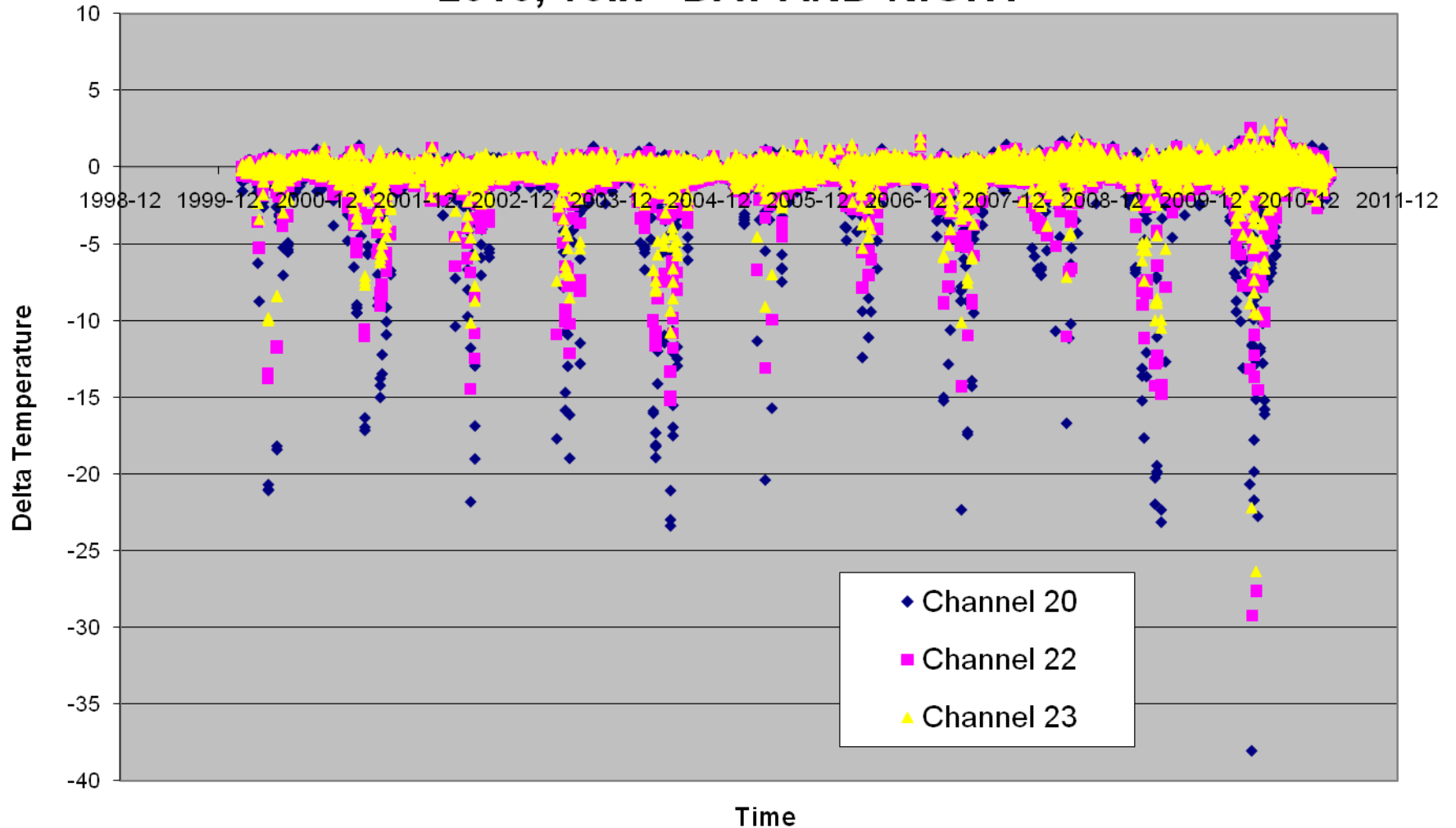
% Radiance Change in TIR Channels for MODIS Terra with Instrument Zenith at Lake Tahoe and Salton Sea CY2000-2010, v5.x



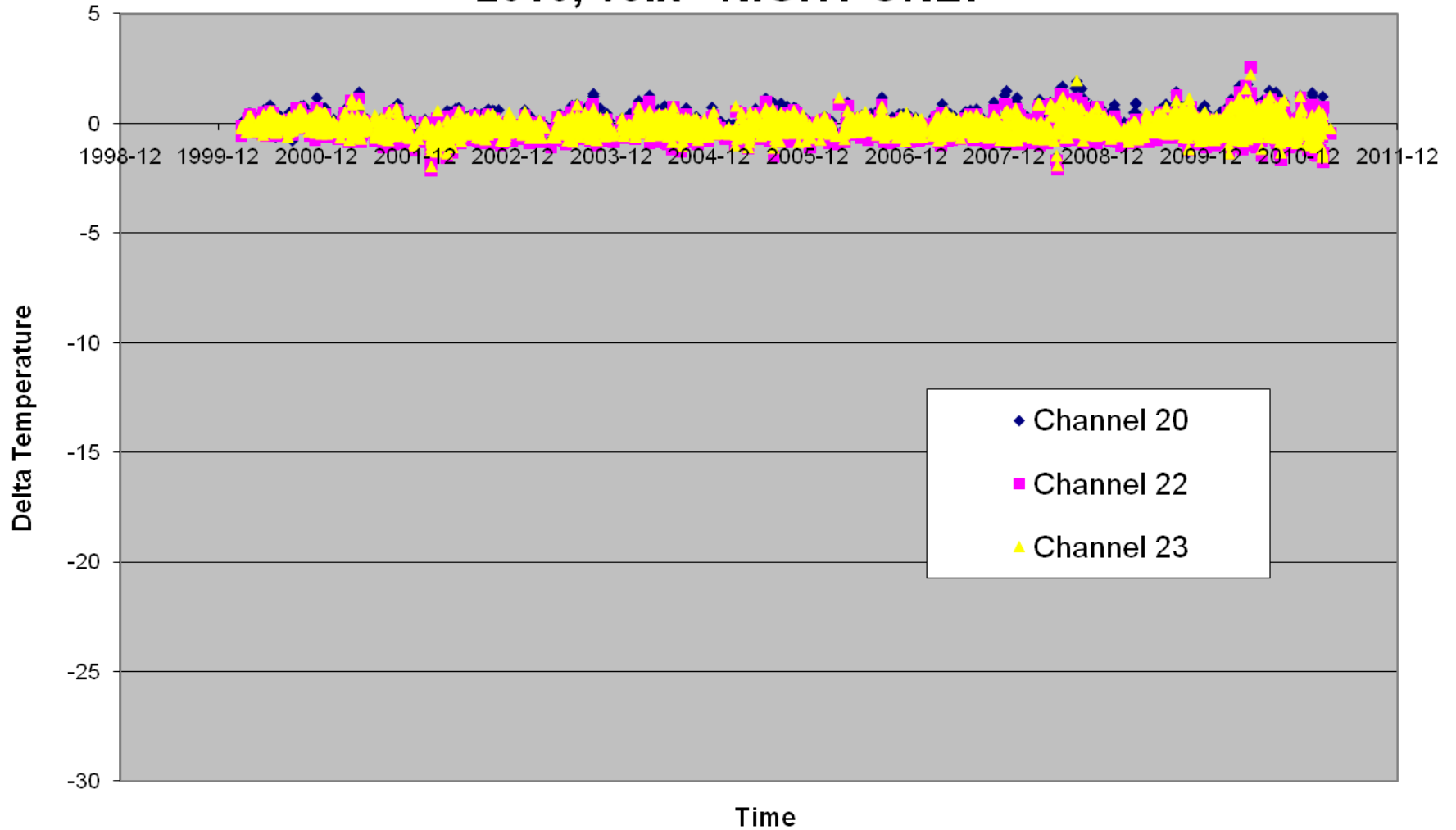
% Radiance Change in TIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2010, vz0-30 v5.x



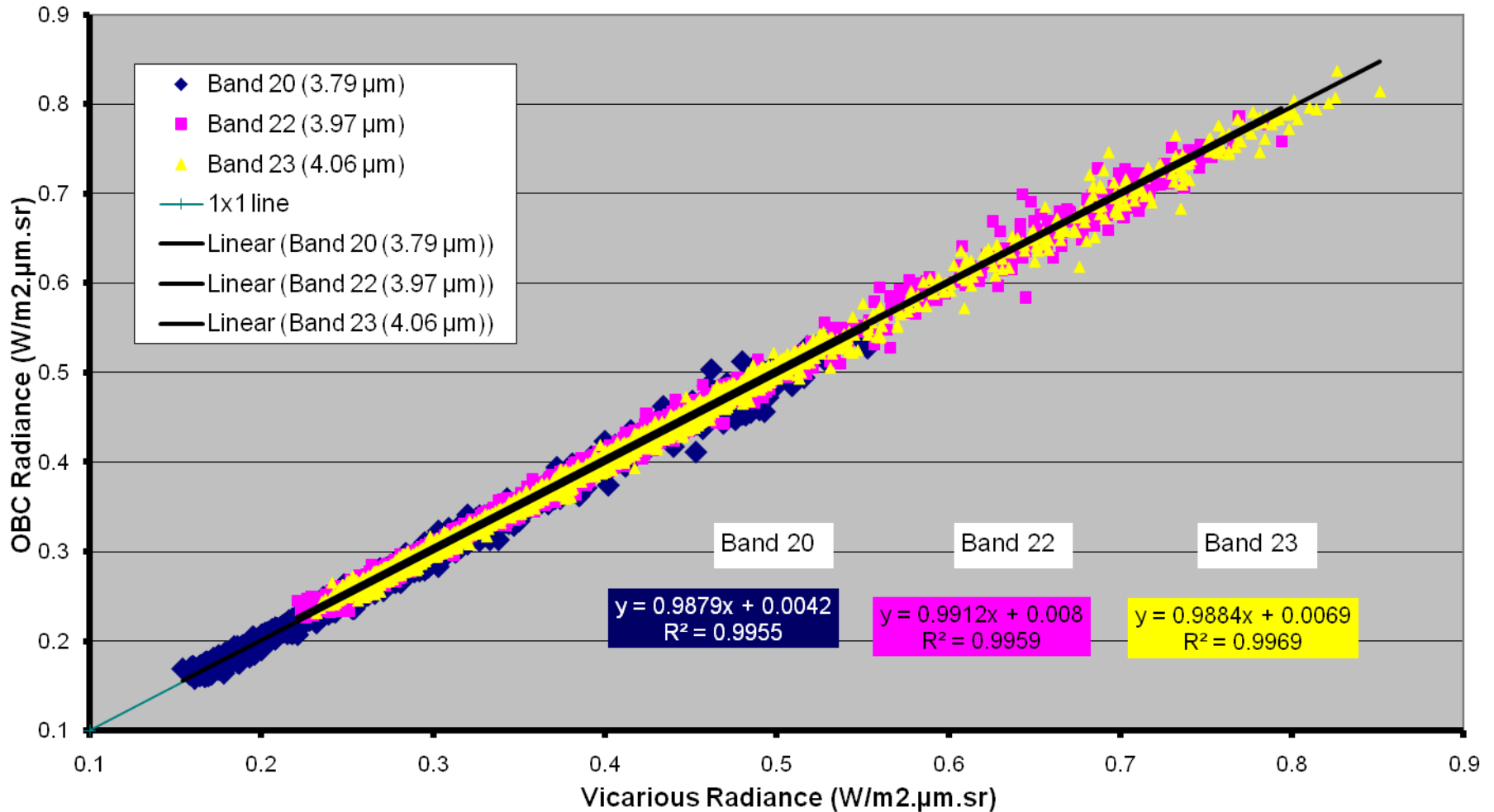
MODIS Terra Mid Infrared Channels Delta Temperature between Vicarious and OBC BT's at Lake Tahoe, 2000-2010, v5.x - DAY AND NIGHT



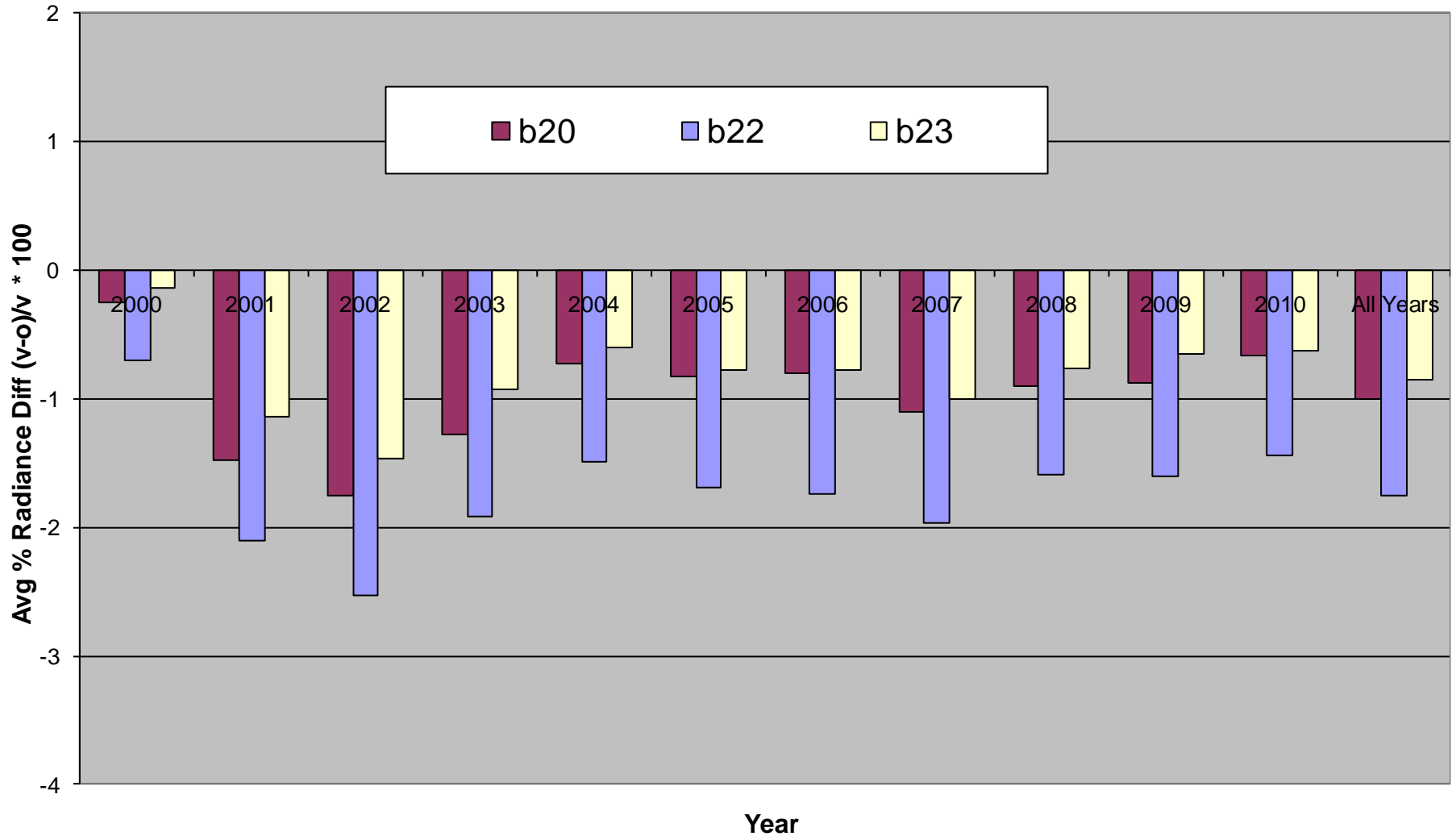
MODIS Terra Mid Infrared Channels Delta Temperature between Vicarious and OBC BT's at Lake Tahoe, 2000-2010, v5.x - NIGHT ONLY



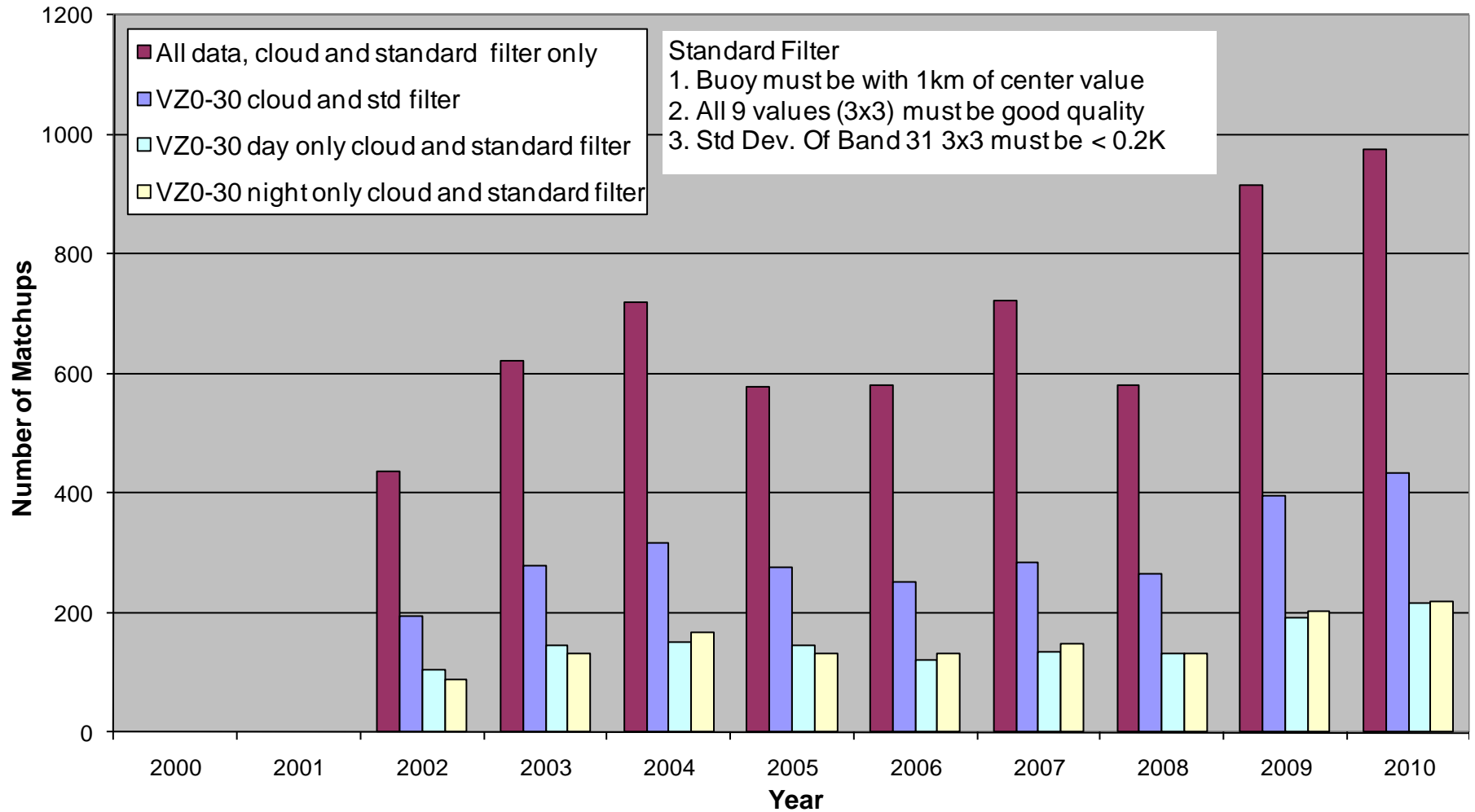
MODIS Terra Night Only Vicarious and OBC Mid Infrared Derived Radiances at Lake Tahoe and Salton Sea CY2000- 2010, VZ0-30, v5.x



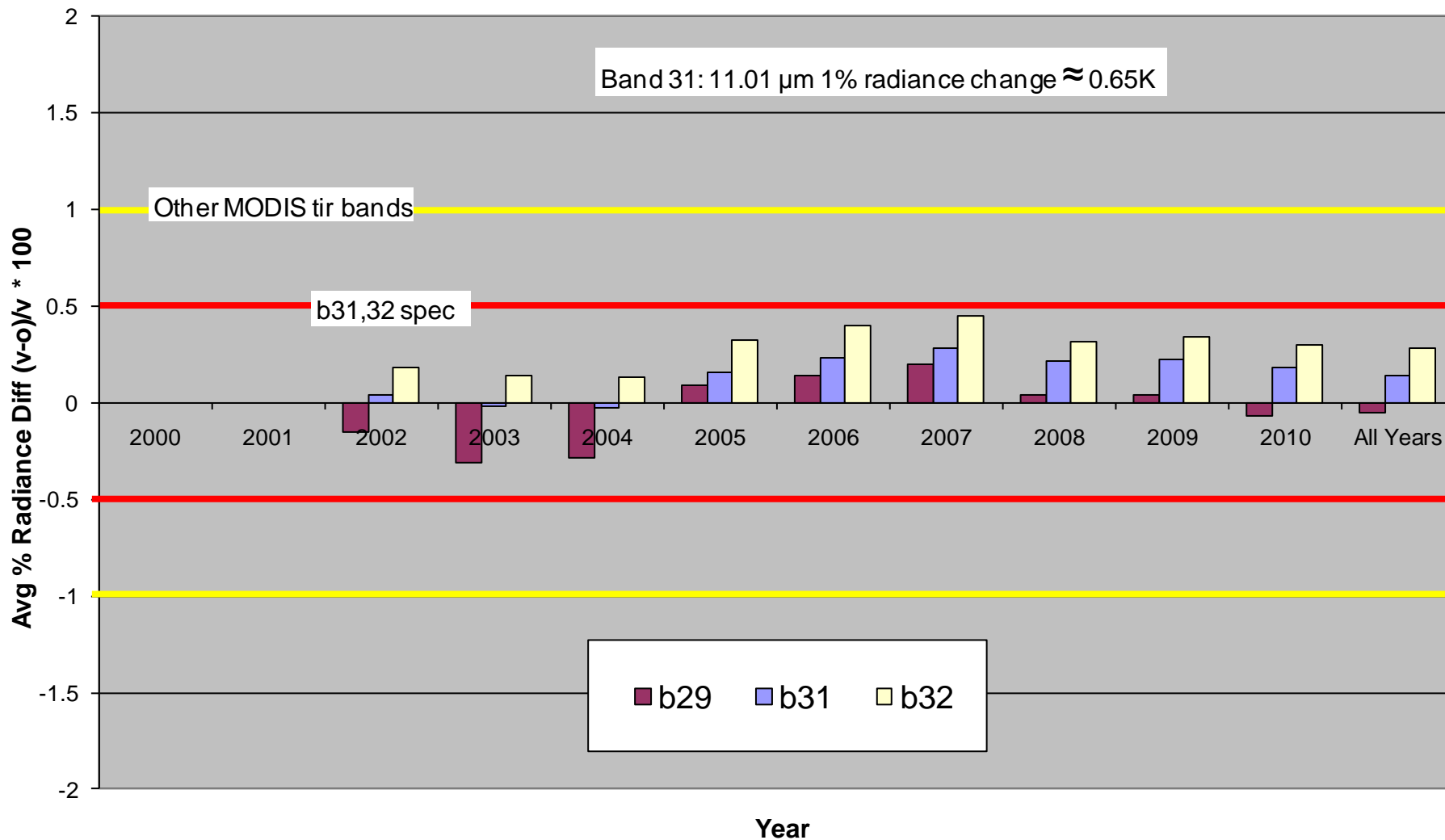
% Radiance Change in MIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2010, vz0-30, v5.x



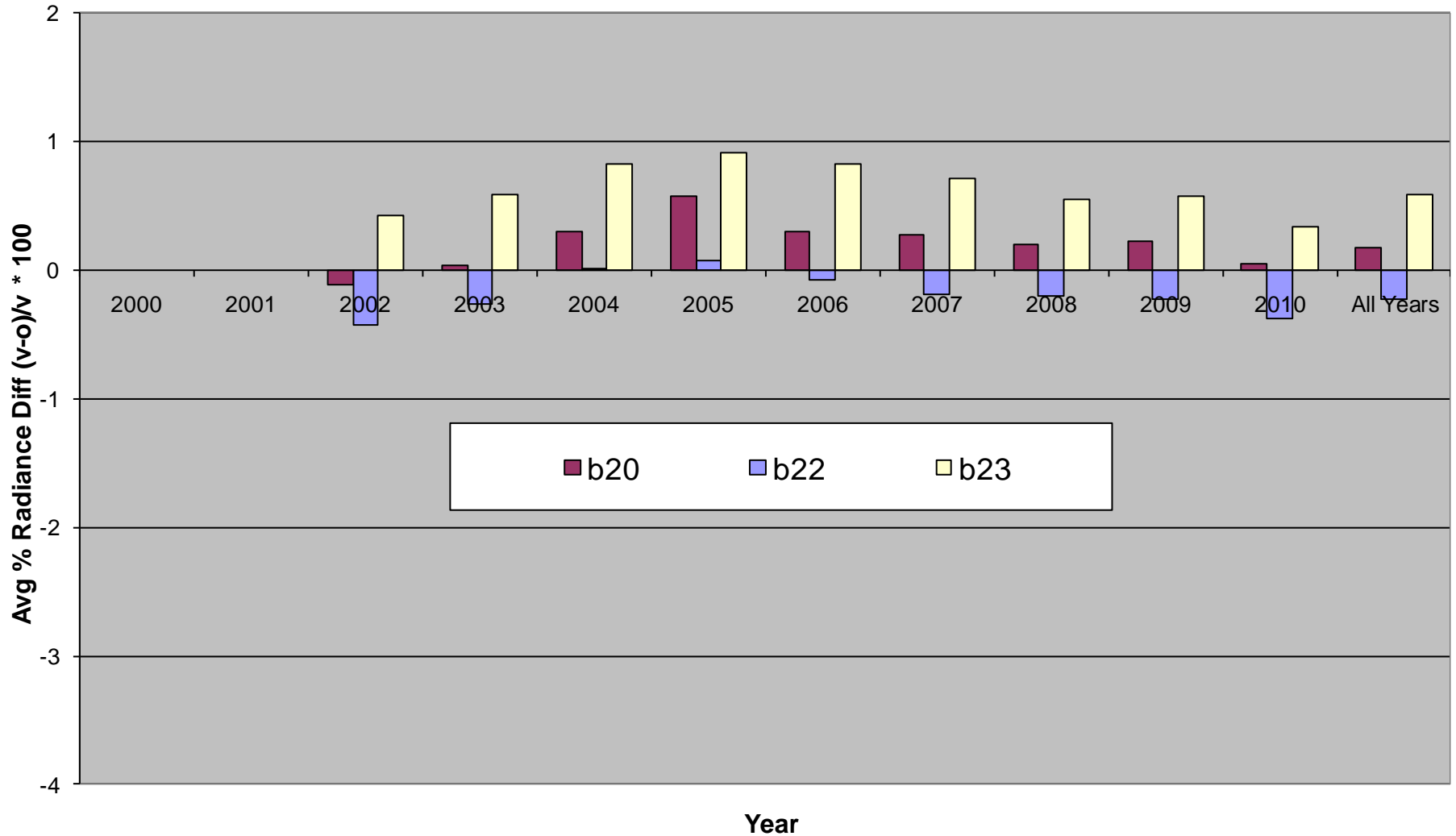
Matchup Count for MODIS Aqua at Lake Tahoe and Salton Sea CY2000-2010 v5.x



% Radiance Change in TIR Channels for MODIS Aqua at Lake Tahoe and Salton Sea CY2000-2010, vz0-30 v5.x

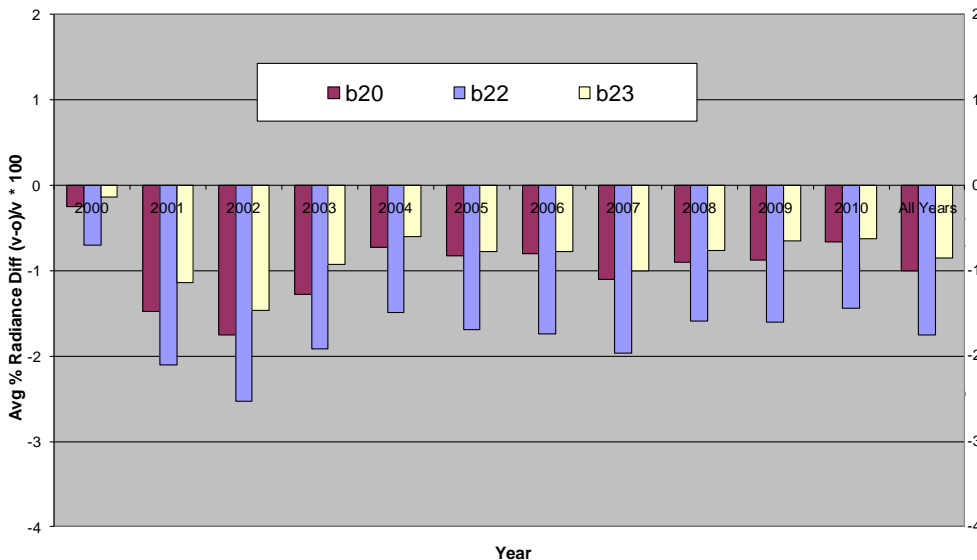


% Radiance Change in MIR Channels for MODIS Aqua at Lake Tahoe and Salton Sea CY2000-2010, vz0-30, v5.x

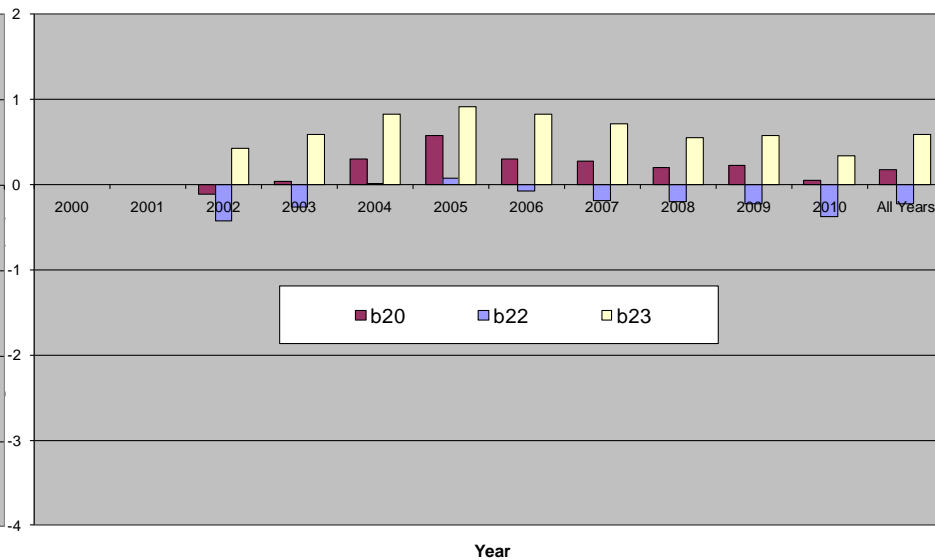


Difference in MIR bands for Terra and Aqua

% Radiance Change in MIR Channels for MODIS Terra at Lake Tahoe and Salton Sea CY2000-2010, vz0-30, v5.x



% Radiance Change in MIR Channels for MODIS Aqua at Lake Tahoe and Salton Sea CY2000-2010, vz0-30, v5.x



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.
- Results so far indicate
 - MODIS-Terra at-sensor radiance: TIR, no bias, abs. acc. 0.2K
 - Suggestion of gain change in band 29 starting in 2008
 - MODIS-Aqua at-sensor radiance: TIR, no bias, abs. acc. 0.2K
 - MODIS-Terra at-sensor radiance: MIR, small bias
 - MODIS-Aqua at-sensor radiance: MIR, no bias, abs. acc. 0.2K



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Welcome to Calibration and Validation

The calval website acts as a portal to data from certain field sites used by scientists at JPL for calibration and validation activities related to:

- [Advanced Spaceborne Thermal Emission and Reflection Radiometer \(ASTER\)](#)
- [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#)
- [Landsat \(5 and ETM+\)](#)
- [Along Track Scanning Radiometers \(ATSR, ATSR2, AATSR\)](#)
- [MODIS/ASTER Airborne Simulator \(MASTER\)](#)

These activities include the validation of the absolute radiometric calibration of the systems and surface geophysical products derived from the sensor data such as reflectance, temperature and emissivity. The goal is for all the measurements acquired at the validation sites to be made autonomously with the data regularly telemetered back to JPL and made available over the WWW. Currently there are two sites located at:

Lake Tahoe CA/NV (<http://laketahoe.jpl.nasa.gov>)

Salton Sea CA (<http://saltonsea.jpl.nasa.gov>)

The sites have been selected to provide a range of conditions. Together the Lake Tahoe and Salton Sea sites provide water temperatures ranging from 4C-35C.

September 2006						
Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

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This site conforms to the following standards:



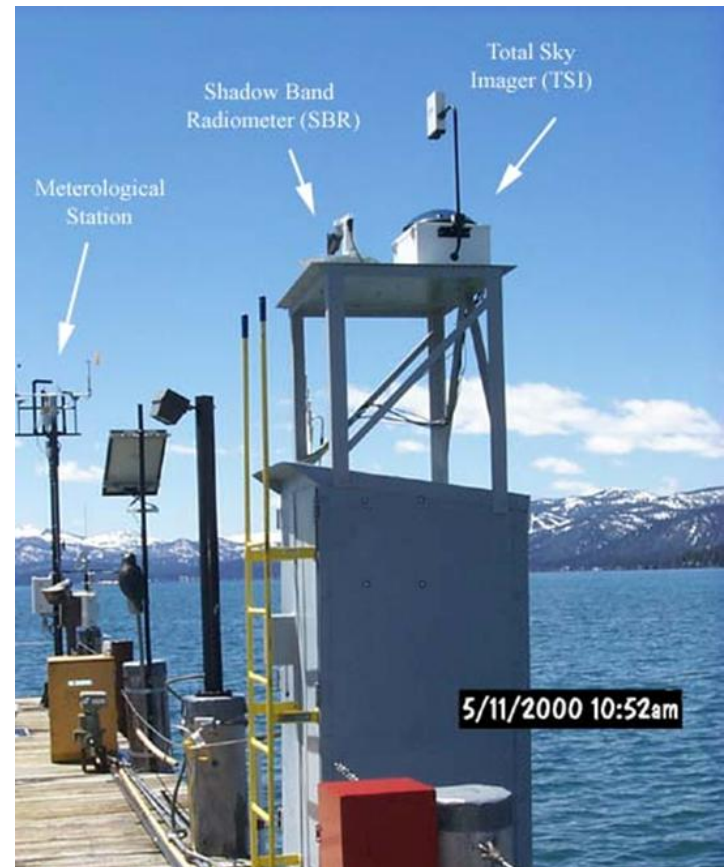
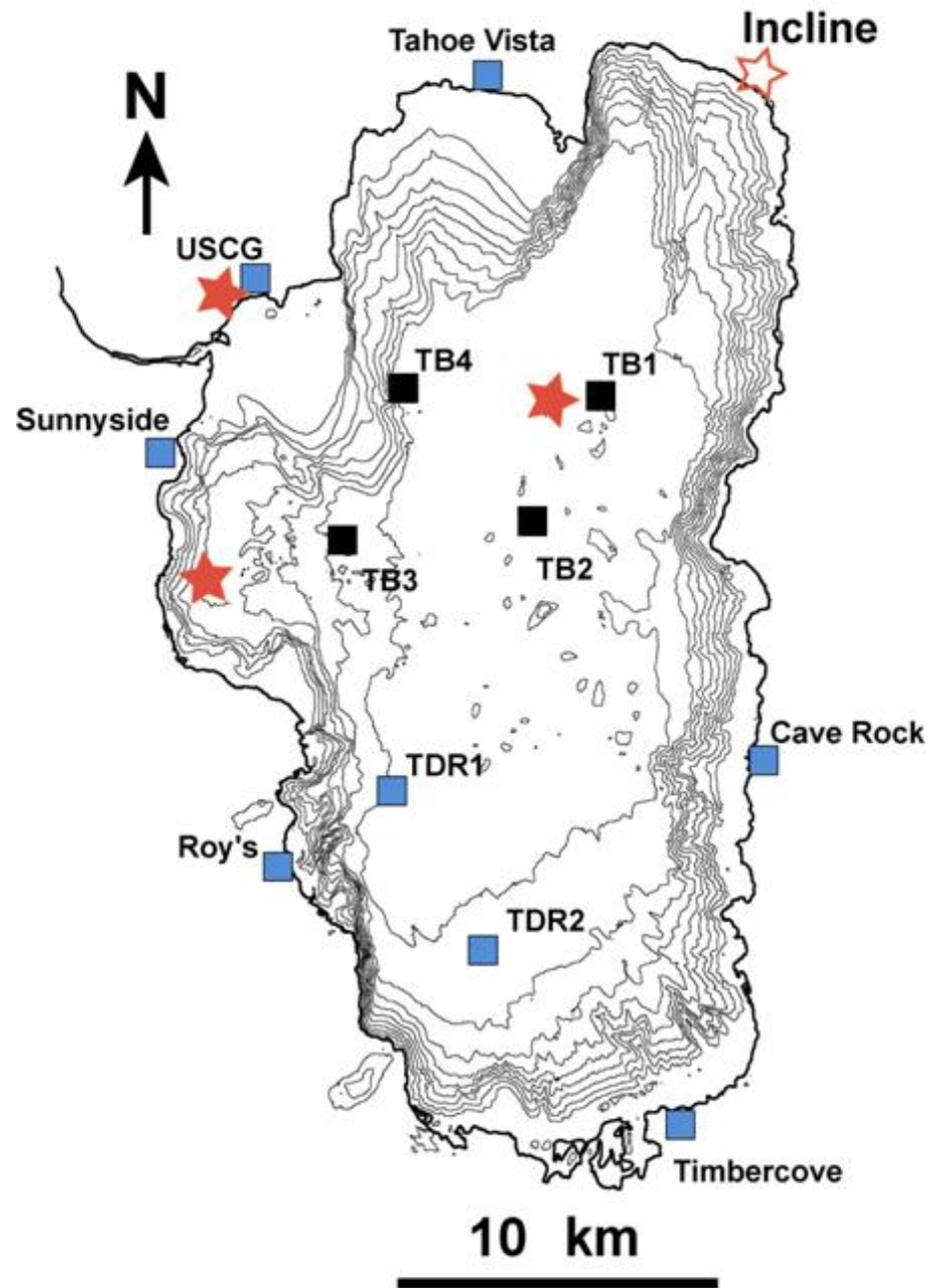
Why Lake Tahoe?

- 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.

Measurements

- Offshore
 - bulk temperature, skin temperature, air temperature, wind speed, wind direction, relative humidity, net radiation.
- Onshore
 - air temperature, wind speed, wind direction, relative humidity, short and longwave radiation (up and down), sky imager, aerosols, total column water.

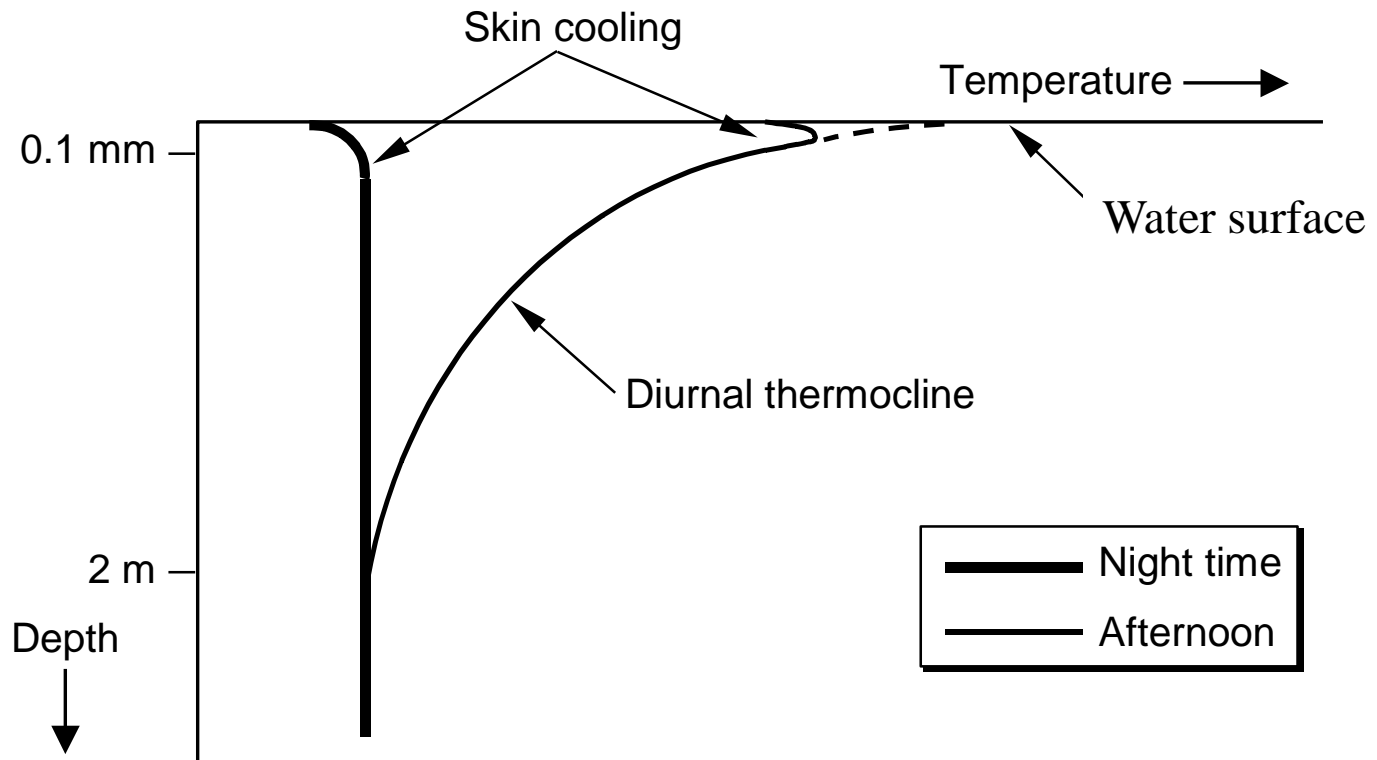
Site Layout and Measurement Stations



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.

Skin Effect



After Minnett et al. 2000