living planet symposium 2016

Intercalibration of two polar satellite instruments without simultaneous nadir observations

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European Space Agency

Motivation

- Established method: Simultaneous Nadir Observations (SNO)
- What if SNOs do not exist or their number is too small to be statistically representative?
- How much is it possible to reduce the requirements?
  - Not simultaneous observations? 
  - Other viewing angles than nadir?
  - Not overlapping areas?
  - Not overlapping time period?
  - …

Material

- TOA reflectance values
  - Sun zenith angle <=70°, Satellite zenith angle <=60°
- MODIS Terra and Aqua
- AVHRR NOAA-15, NOAA-18, NOAA-19 and METOP-A/2, data from NOAA
- 0°N - 75°N
- -130°E - 45°E
- June 29 – July 19, 2010

Simulation of AVHRR vs. MODIS

87 individual reflectance spectra of diverse land cover types from the USGS Spectroscopy Lab data base

Red: 620…670 nm (MODIS), 580…680 nm (AVHRR)

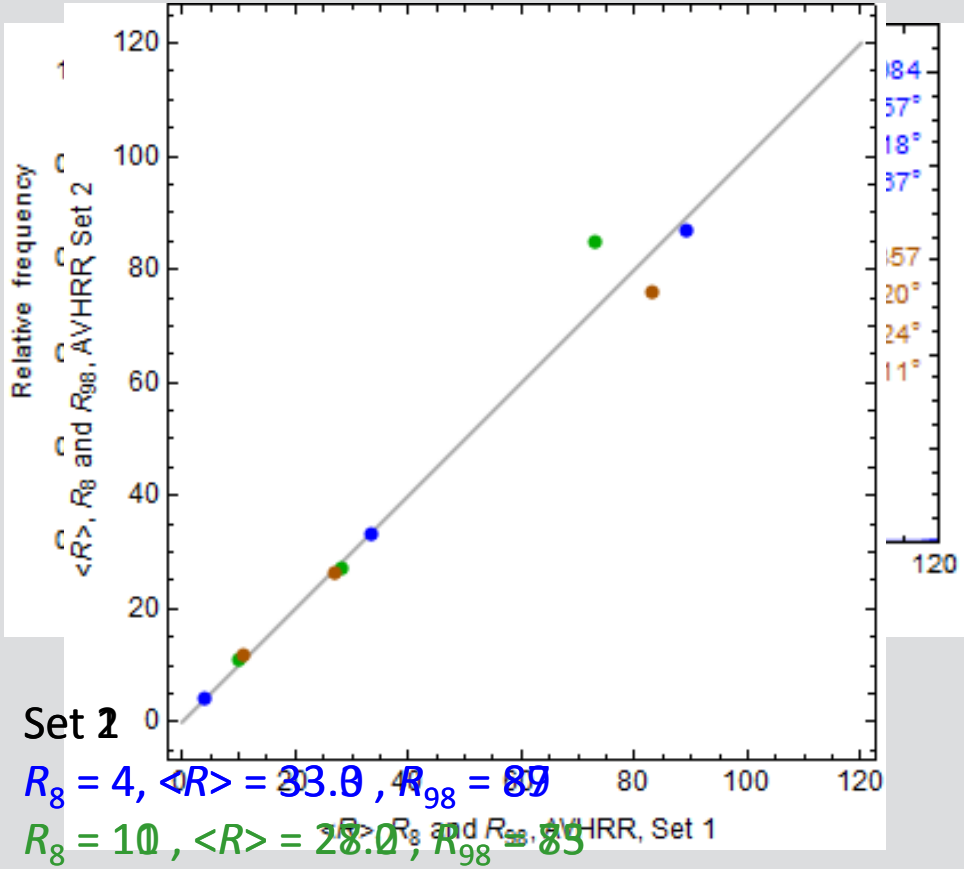
NIR: 841…876 nm (MODIS), 725…1100/1000 nm (AVHRR)

AVHRR vs. MODIS

Channel	Target	n	b_0	b_1	R^2
Red	Snow/water	11	0.002	0.987	1.000
	Mixtures	13	-0.000	0.985	1.000
	Man-made	18	-0.001	0.977	0.999
	Vegetation	40	0.014	0.924	0.988
NIR	Snow/water	12	0.001	0.907	0.961
	Mixtures	13	-0.001	0.914	0.990
	Man-made	18	0.003	0.961	1.000
	Vegetation	40	0.010	0.925	0.997

Method

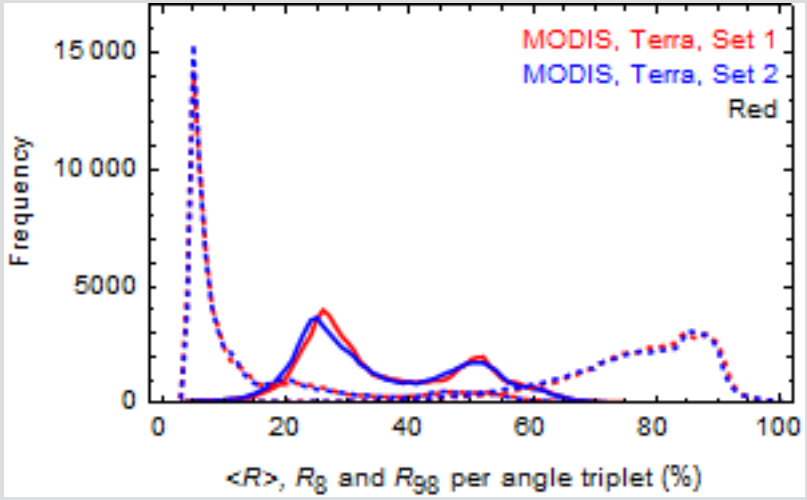
- Each image is split in subsets according to the sun zenith angle θ_s, satellite zenith angle θ_v and the azimuth difference angle ϕ
- For each subset distribution the average value <*R*> and 8% (ocean) and 98% (snow) quantiles, R_8 and R_{98} respectively, are derived
- The <*R*> , R_8 and R_{98} values of two independent data sets are regressed to obtain their intercalibration parameter values (b_0 and b_1)
- Deming regression is used with iterated weights

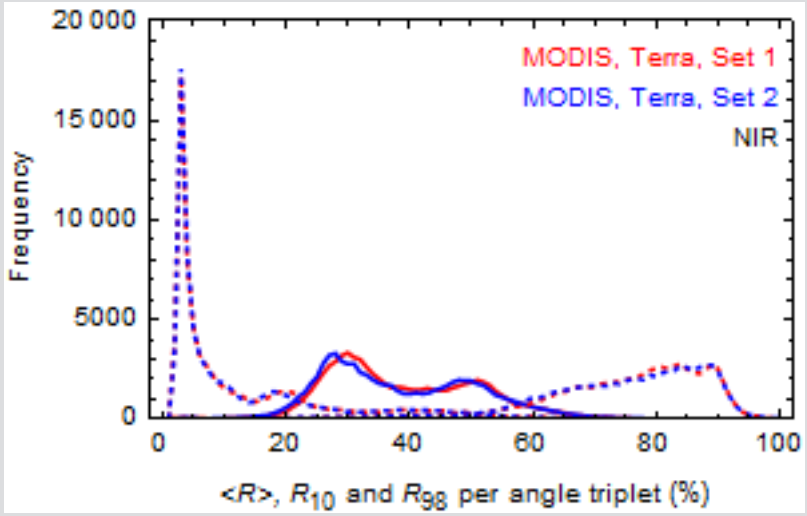


MODIS Terra vs. MODIS Terra

One instrument on one satellite

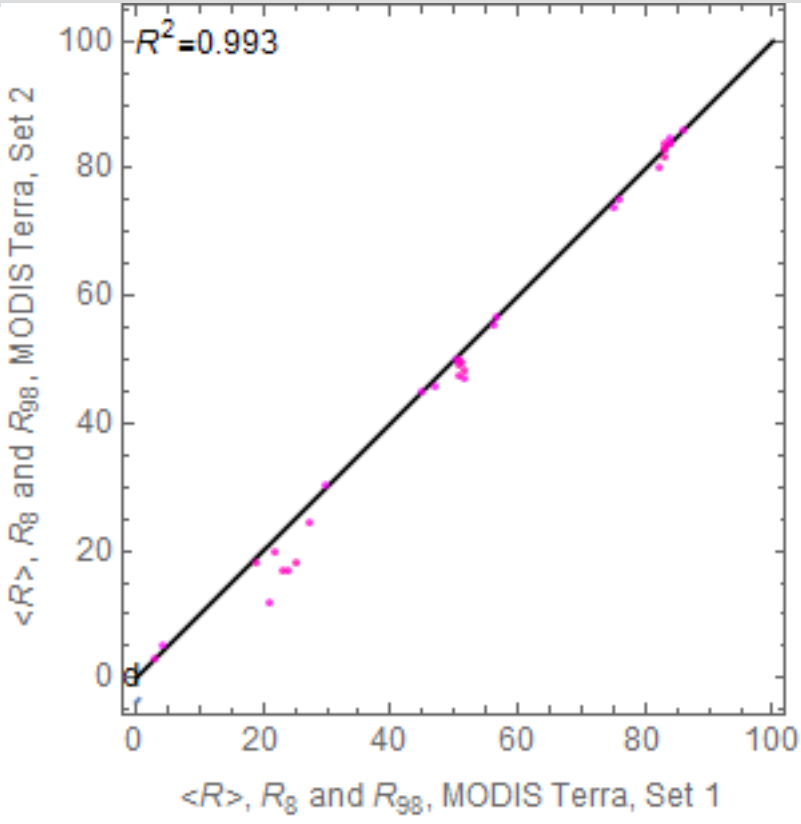
Every second image of the chronologically arranged MODIS Terra data set is taken in Set 1 and the rest in Set 2





MODIS Terra, Set 2 vs. Set 1

Effect of the minimum number of points in the distributions



n_{min} = 1

n_{min} = 500

n_{min} = 1000

n_{min} = 1500

n_{min} = 2000

n_{min} = 2500

n_{min} = 3000

n_{min} = 3500

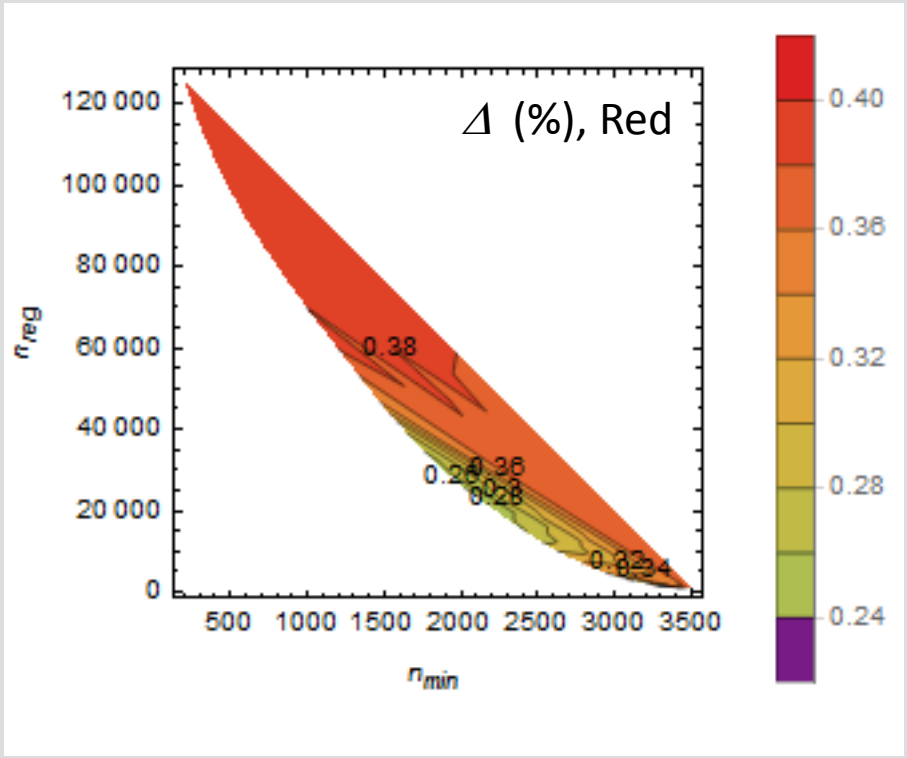
n_{min} = 4000

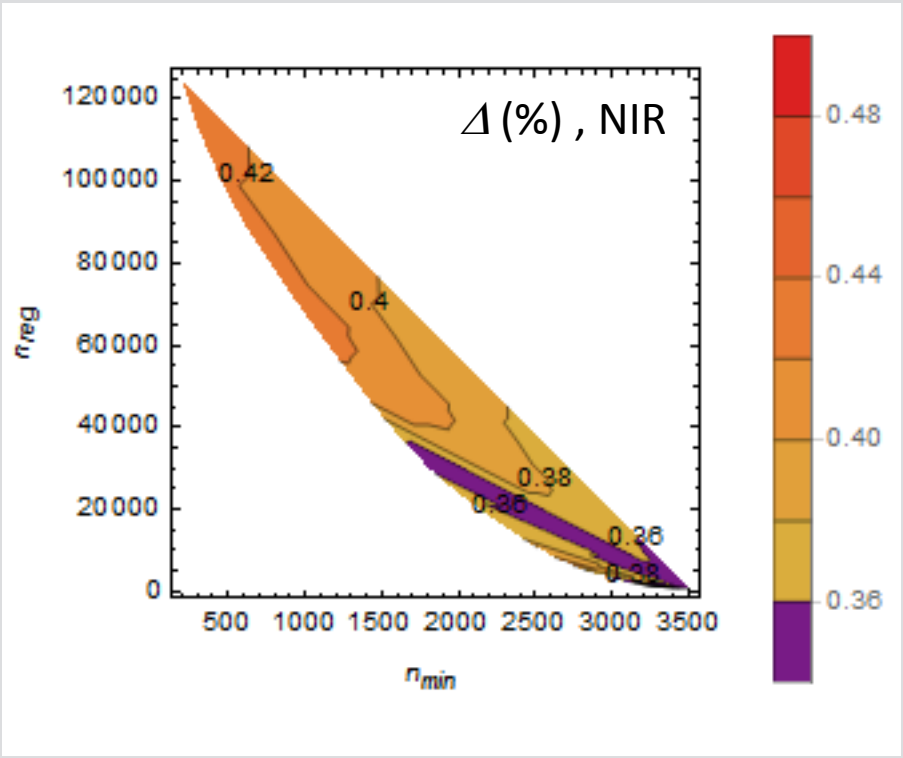
n_{min} = 4500

n_{min} = 5000

MODIS Set 1 vs. Set 2, goodness of fit

$$\Delta = \frac{1}{100}\int_0^{100} \left| b_0 + b_1 x - x \right| dx$$

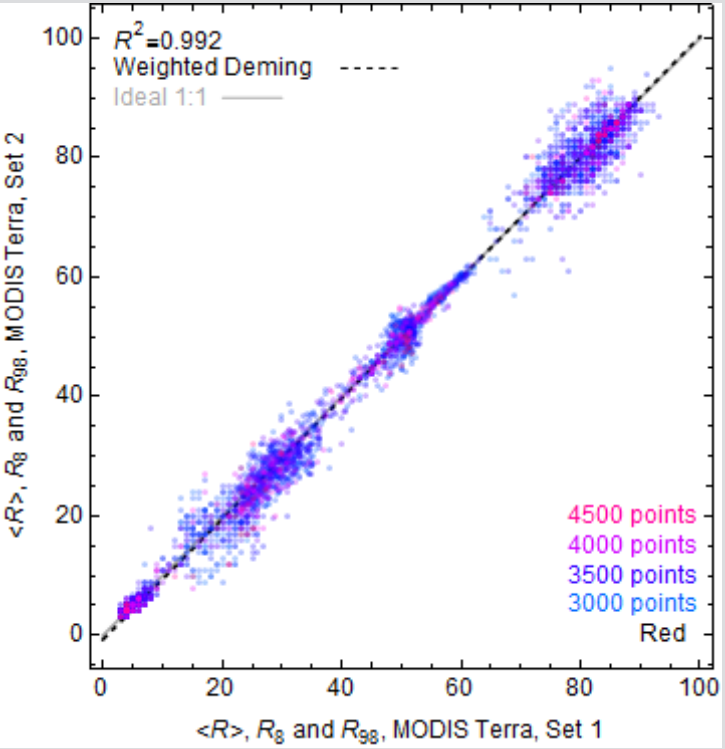


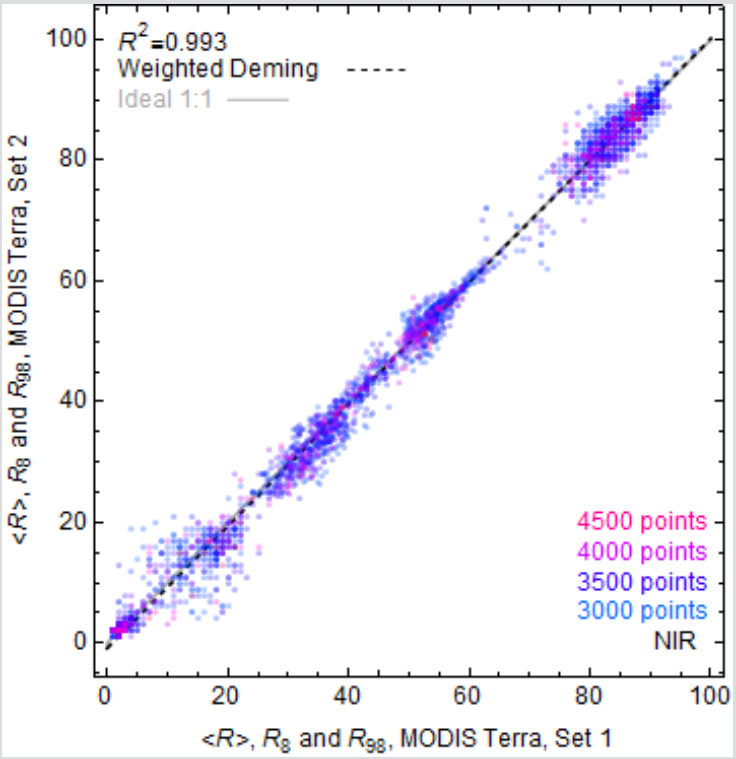


MODIS Set 2 vs Set 1, fit parameters

MODIS	Channel	b_0	b_1	Δ (%)
Terra Set 2 vs. Set 1	Red	-0.551	1.007	0.241
	NIR	-0.525	1.003	0.361

$$\Delta = \frac{1}{100}\int_0^{100} \left| b_0 + b_1 x - x \right| dx$$

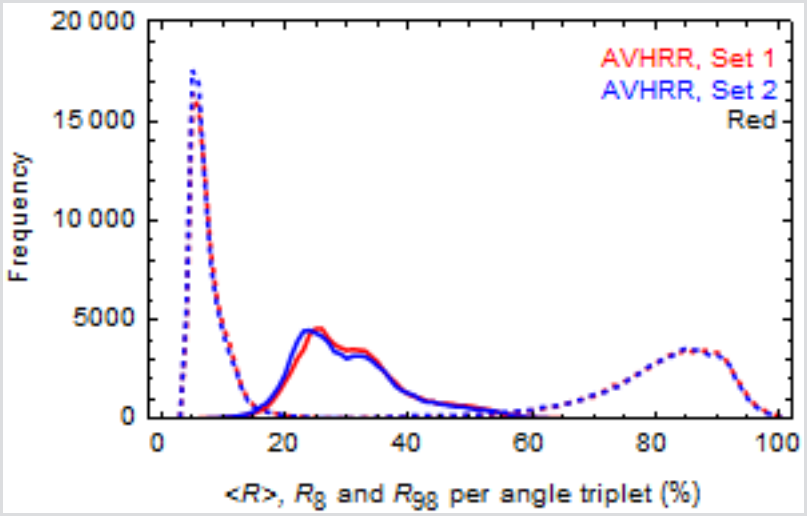


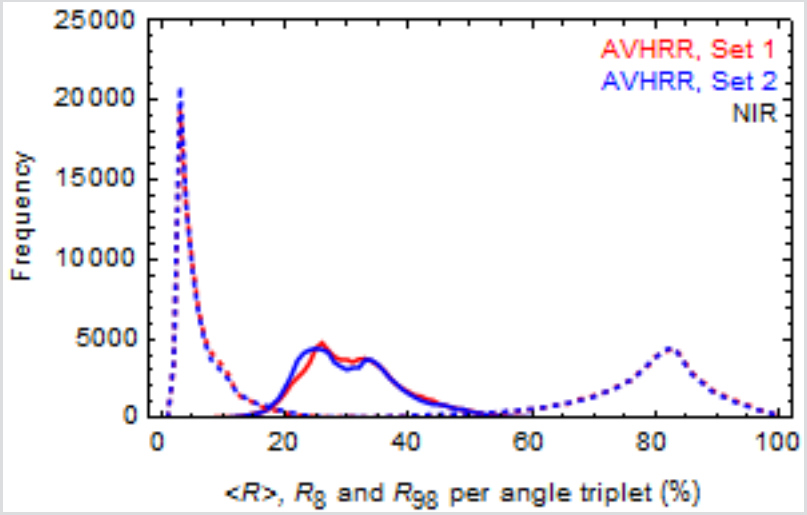


AVHRR vs. AVHRR

One instrument type on four satellites

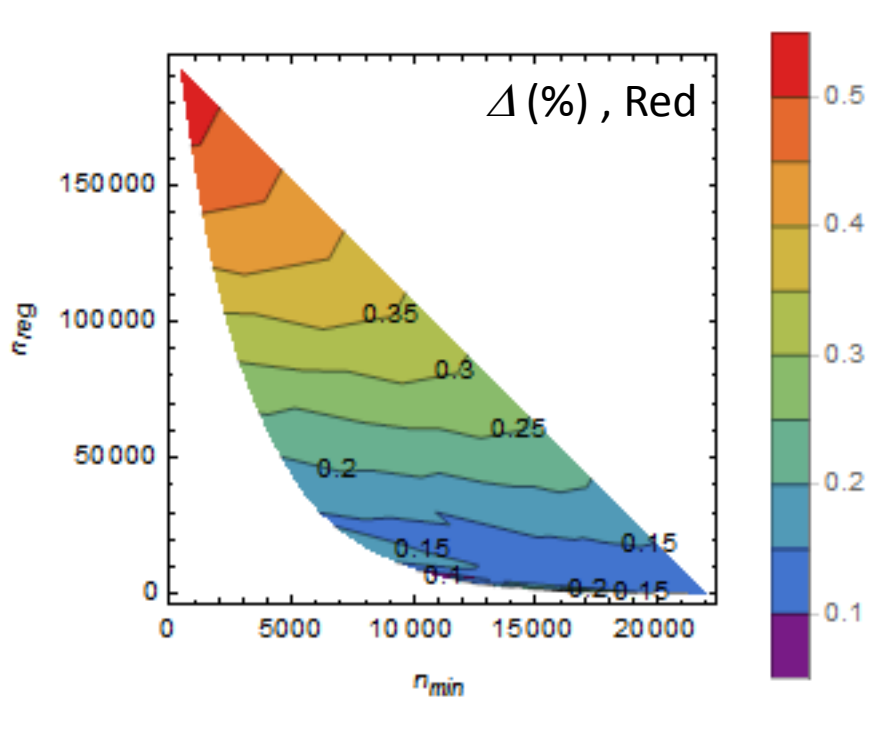
Every second image of the chronologically arranged data set of all AVHRR images is taken in Set 1 and the rest in Set 2

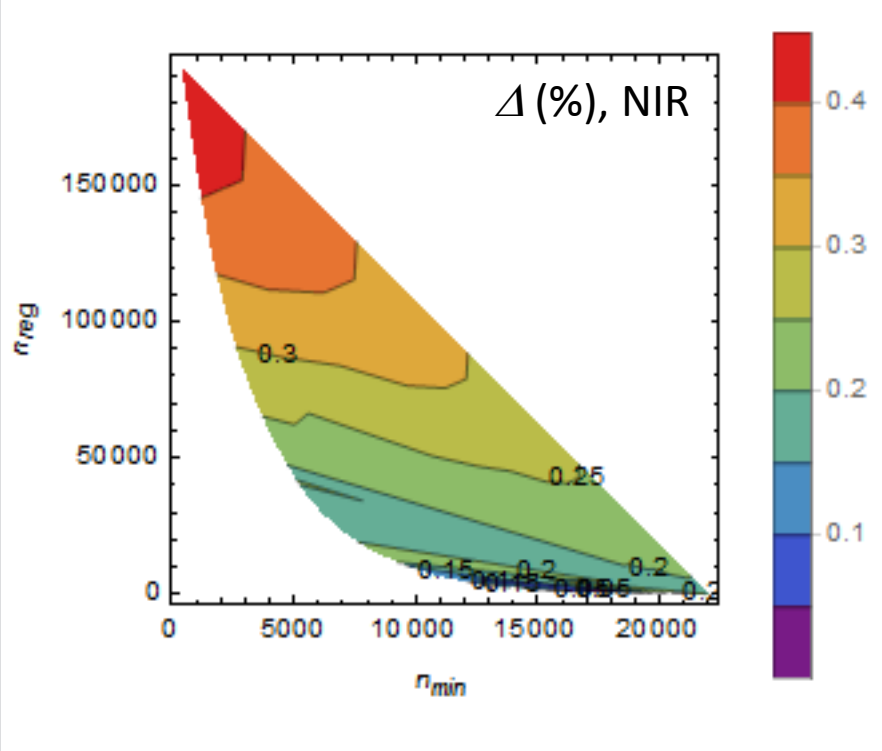




AVHRR vs. AVHRR, goodness of fit

$$\Delta = \frac{1}{100}\int_0^{100} \left| b_0 + b_1 x - x \right| dx$$

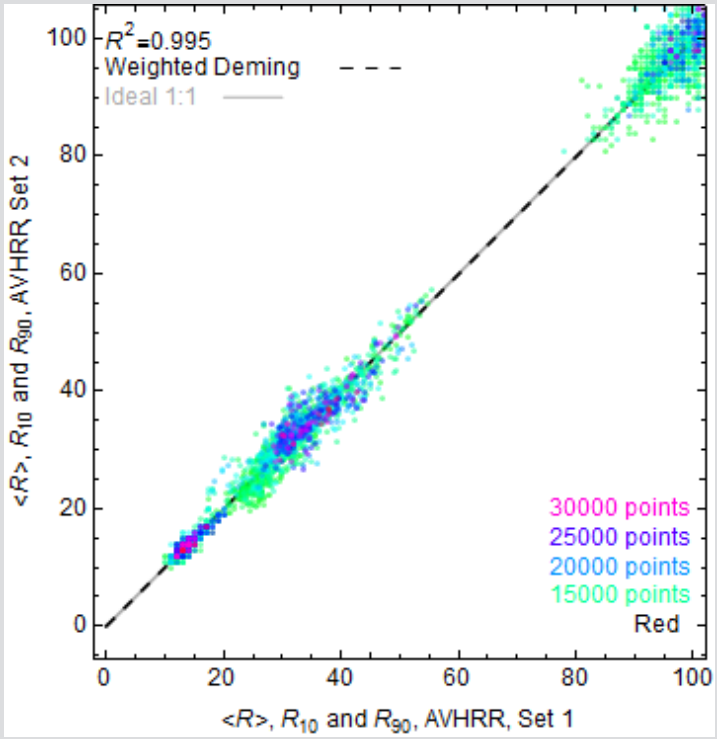


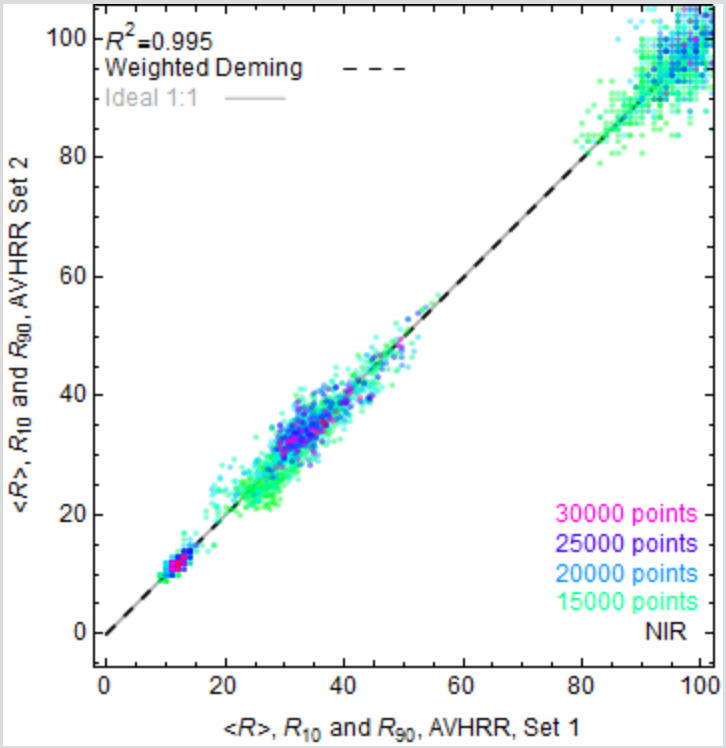


AVHRR vs. AVHRR, fit parameters

	Channel	b_0	b_1	Δ (%)
Set 2 vs. Set 1	Red	0.009	0.999	0.063
	NIR	-0.013	0.999	0.073

$$\Delta = \frac{1}{100}\int_0^{100} \left| b_0 + b_1 x - x \right| dx$$

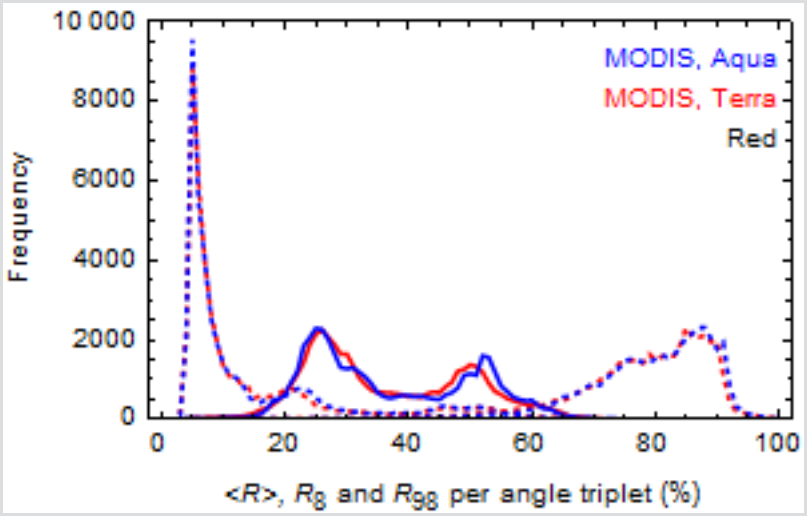


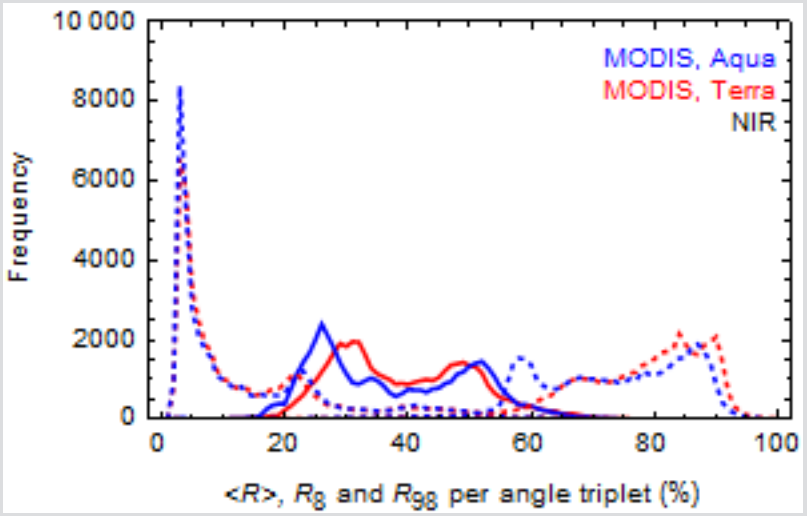


MODIS Aqua vs. MODIS Terra

One instrument type in different orbits

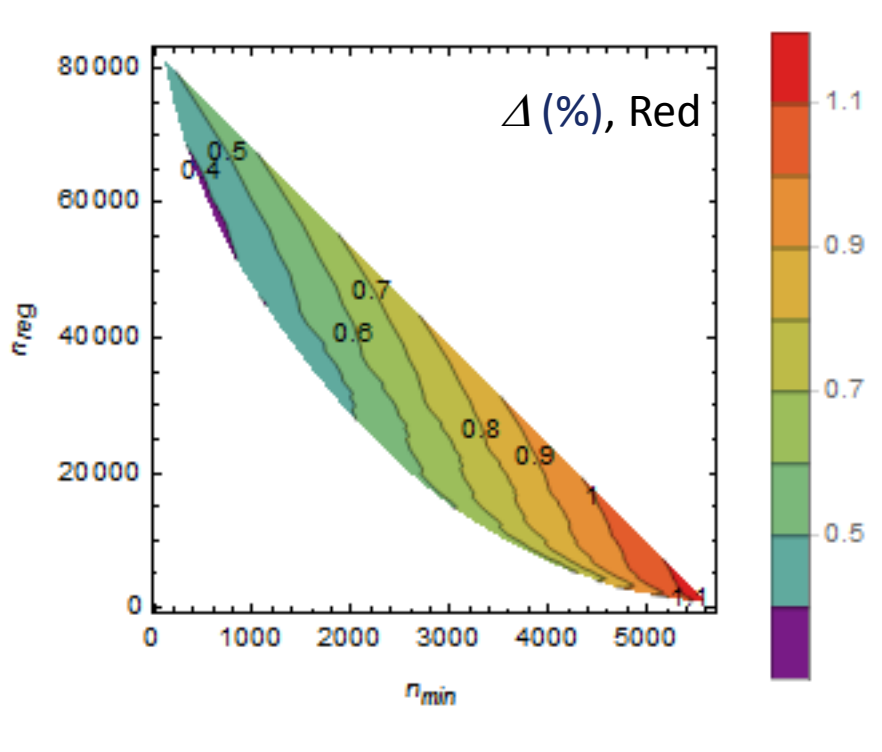
All MODIS Terra data and all MODIS Aqua data included

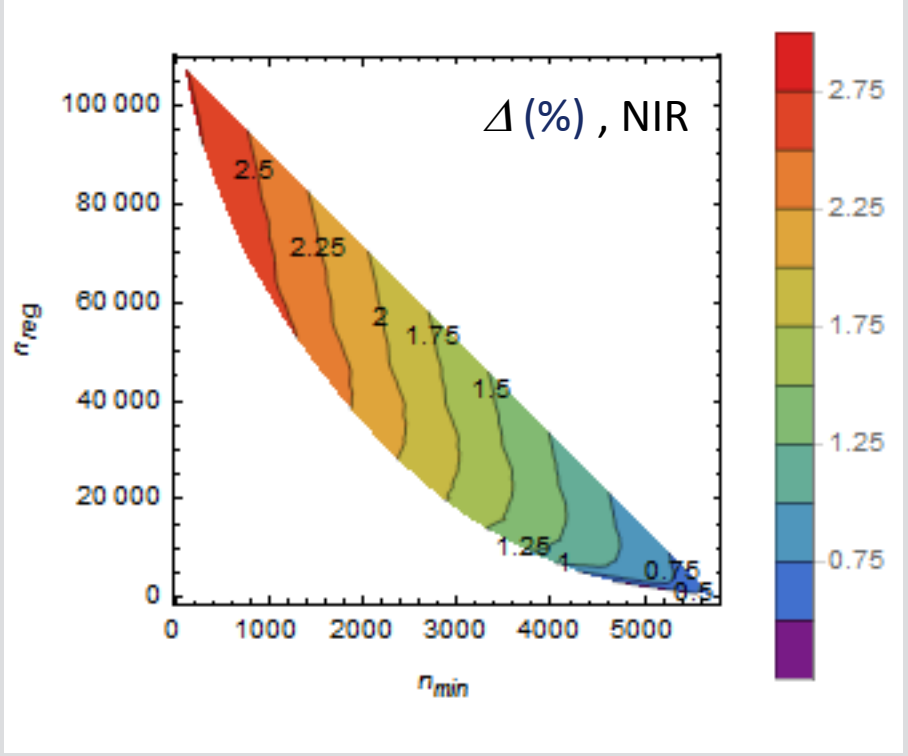




MODIS Aqua vs. Terra, goodness of fit

$$\Delta = \frac{1}{100}\int_0^{100} \left| b_0 + b_1 x - x \right| dx$$

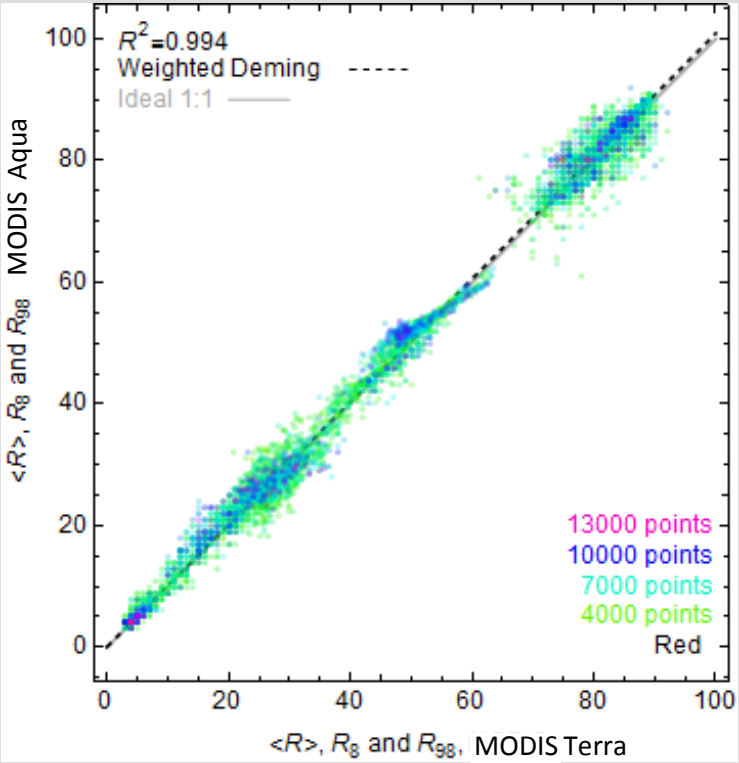


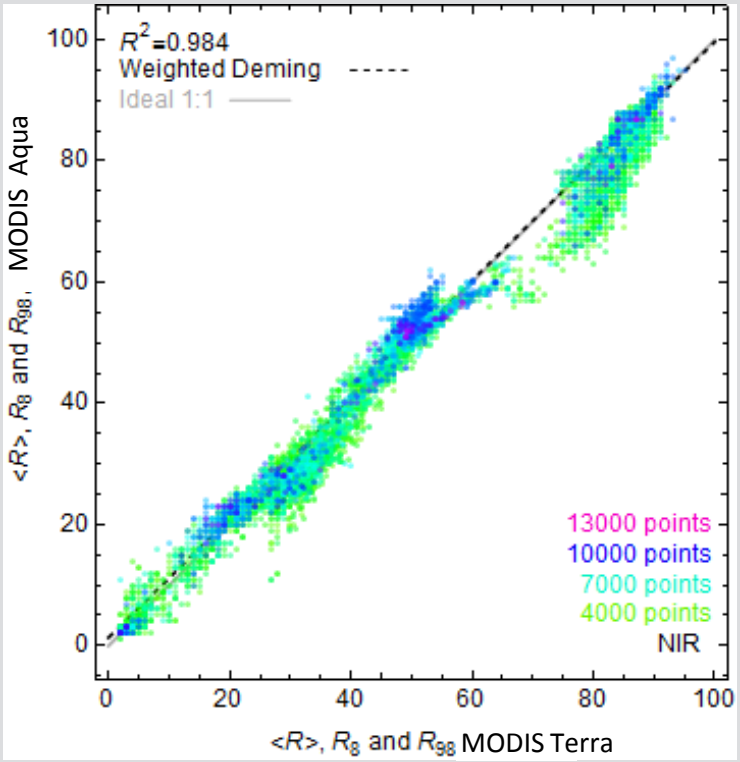


MODIS Aqua vs. Terra, fit parameters

MODIS	Channel	b_0	b_1	Δ (%)
Aqua vs. Terra	Red	0.164	1.006	0.478
	NIR	1.356	0.983	0.577

$$\Delta = \frac{1}{100}\int_0^{100} \left| b_0 + b_1 x - x \right| dx$$

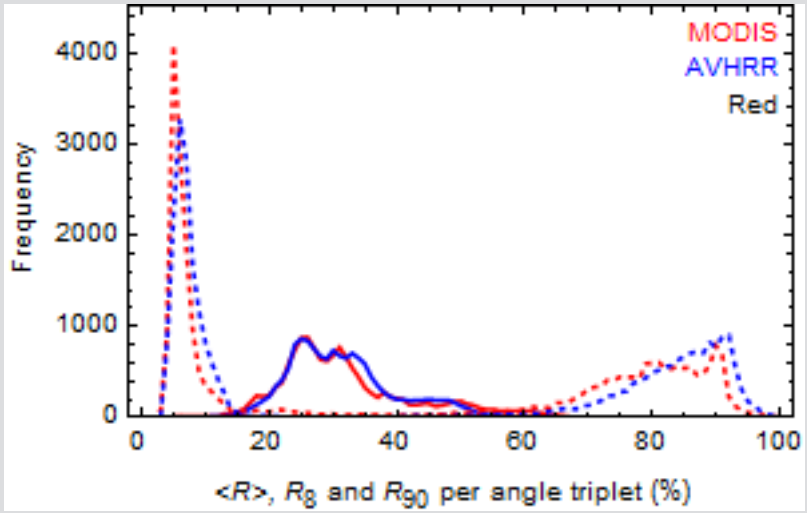


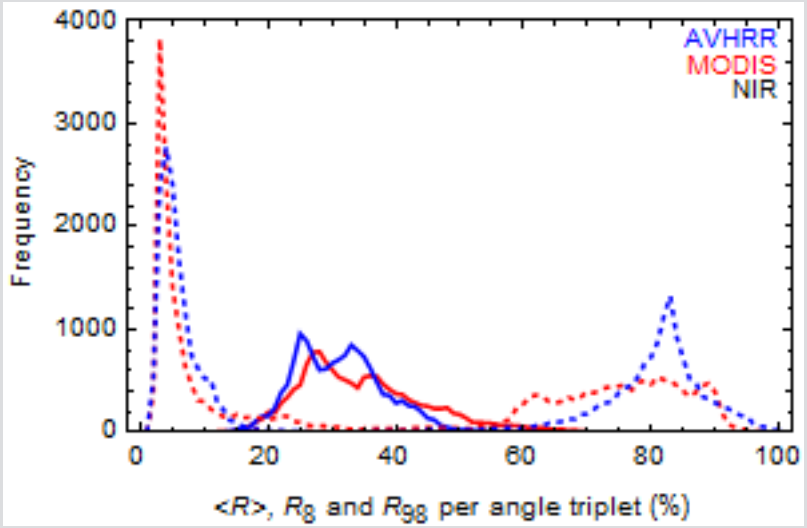


AVHRR vs. MODIS

Two instrument types on different satellites

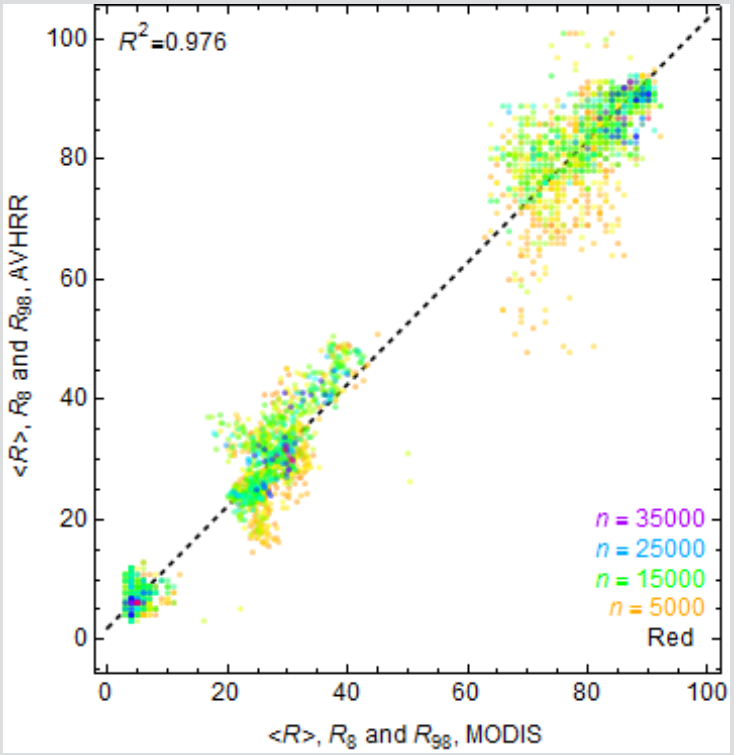
All AVHRR images and all MODIS Terra and Aqua data are included

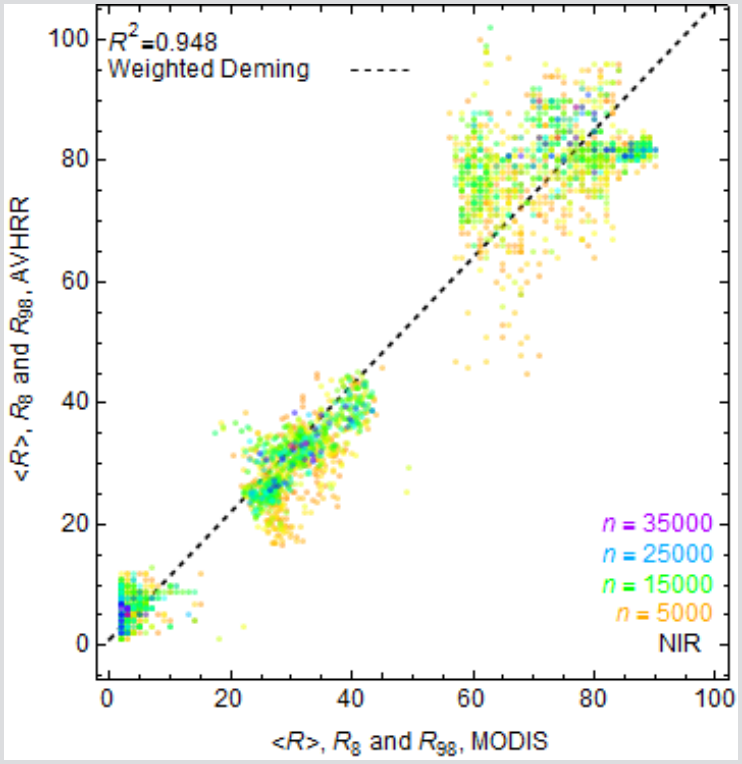




AVHRR vs. MODIS, fit parameters

	Channel	b_0	b_1
AVHRR vs. MODIS	Red	1.866	1.018
	NIR	0.873	1.056





Conclusions

- The statistical intercalibration approach presented produces good ($\lesssim$0.5%) intercalibration results for data sets split in two subset (MODIS vs. MODIS and AVHRR vs. AVHRR)
- The ratio of the achieved intercalibration accuracy of AVHRR and MODIS roughly equaled the ratio of the number of points in the distributions of AVHRR and MODIS (~6.5)
- The intercalibration of an afternoon satellite vs. a morning satellite (MODIS Aqua vs. MODIS Terra) seemed to suffer from the diurnal variation of cloud cover, but the calibration was still within the instrument accuracy limit. Larger amount of data would probably have improved the result.
- AVHRR reflectance values were higher than those of MODIS, the difference being larger in the NIR channel (~6%) than in the red channel (~2%).