Results from a cross-calibration experiment

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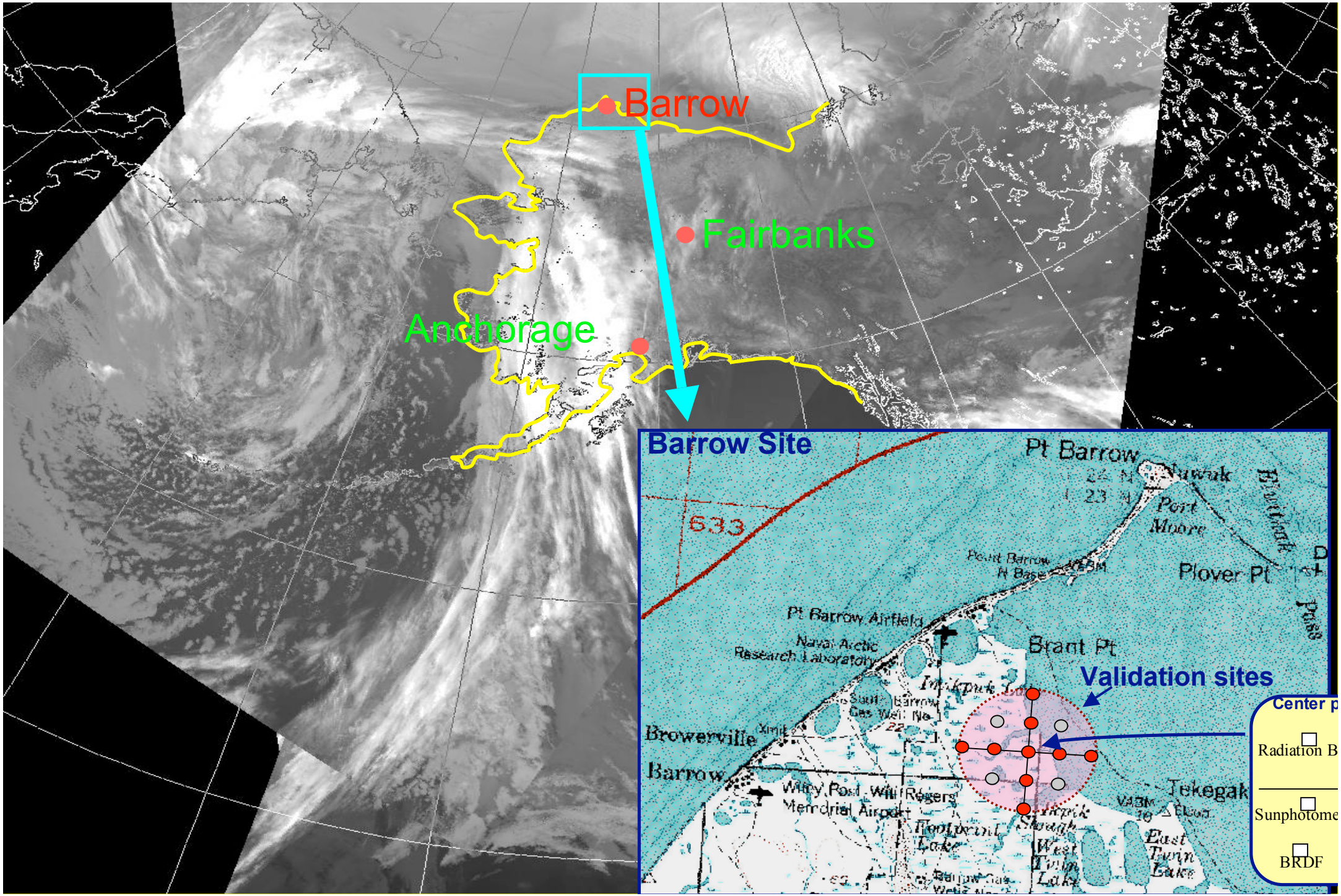
General Approach

1. CalVal site 2 x 2 km^2 located near Barrow, Alaska
2. Ground-truth data: aerosol optical thickness (AOT), snow reflectance measurements etc.
3. Macro site (6 x 6 km^2) was used for uniformity check
4. GLI, MERIS, AATSR, SeaWiFS, MODIS (terra, aqua) and AVHRR (N16/17) TOA radiance/reflectance data were taken
5. Sensor TOA radiance/reflectance were compared to Radiative Transfer Code 6S* calculations

Advantages of snow fields in the polar region

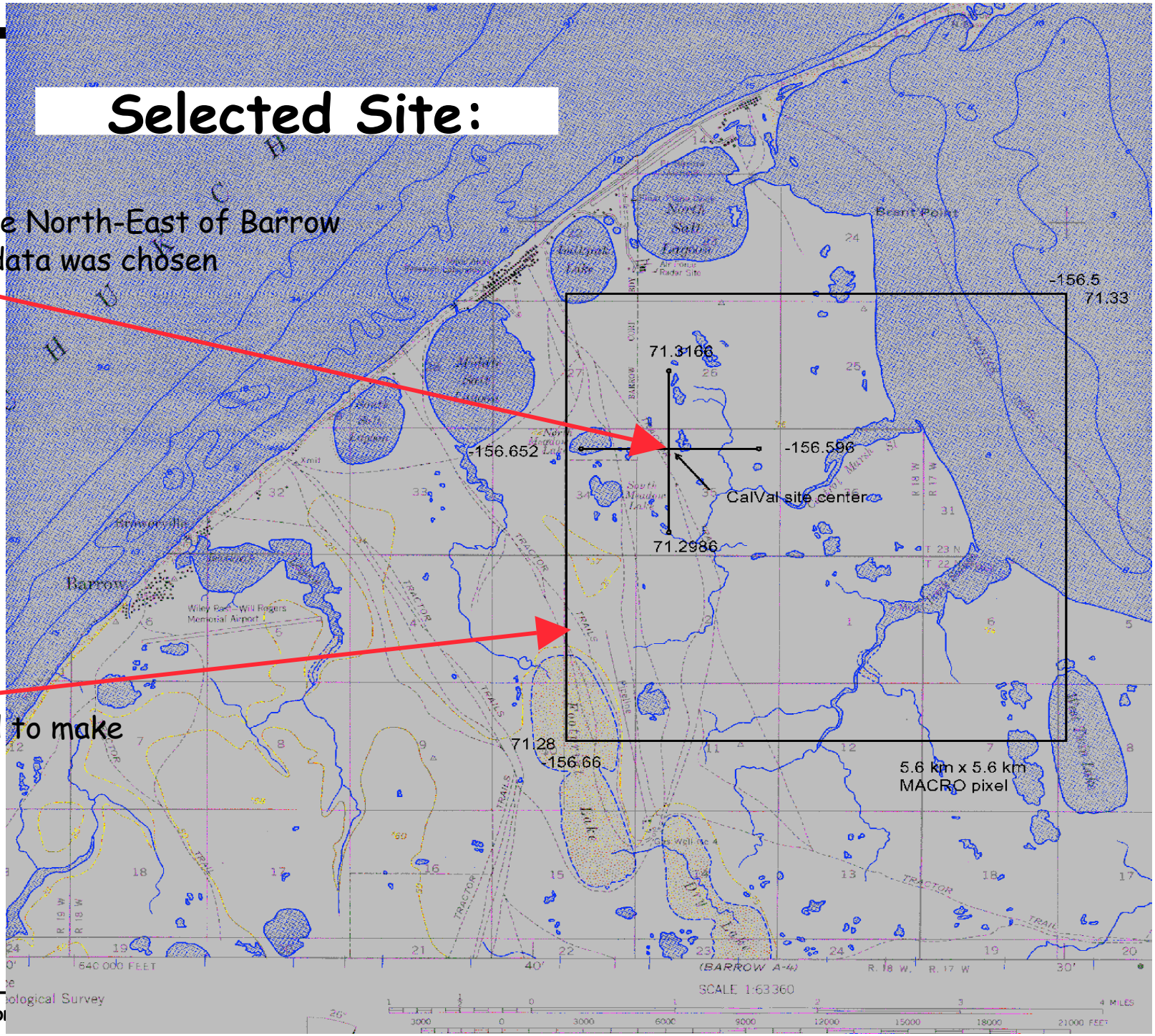
- Semi-Simultaneous measurements of polar orbiting satellites
- Minimum correction for atmospheric effects
- Near Lambertian properties of New-Snow
- Same reflectance properties over a large region
- Dry and sunny condition periods in Spring/Autumn
- New-Snow conditions over longer period


Barrow
Fairbanks
Anchorage
Barrow Site
Pt Barrow
Point Barrow N Base
Plover Pt
Pt Barrow Airfield
Naval Arctic Research Laboratory
Brant Pt
Validation sites
Browerville
Barrow
Wiley Post - Will Rogers Memorial Airport
Tekegak
Center p
Radiation B
Sunphotome
BRDF

Selected Site:

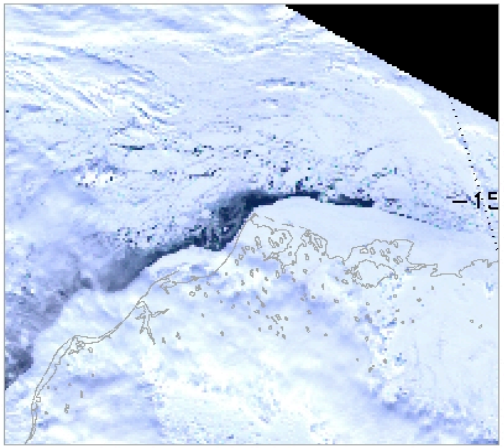
CalVal site is located in the North-East of Barrow
CalVal site's TOA sensor data was chosen

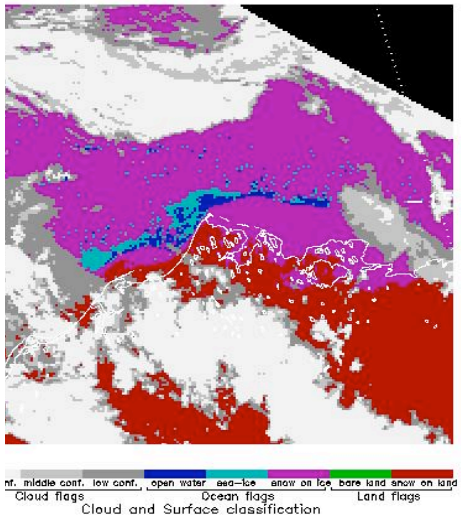
Macro site signal was used to make uniformity check

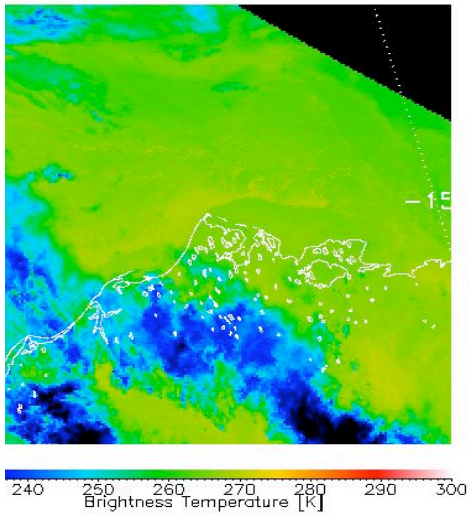


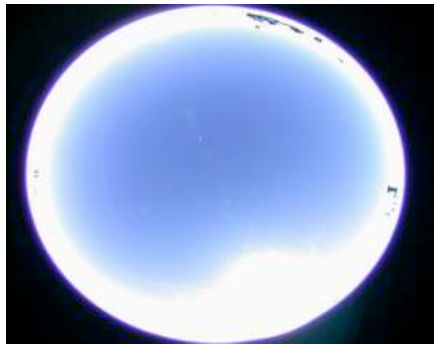
GLI Snow products around Barrow

Date: April 14



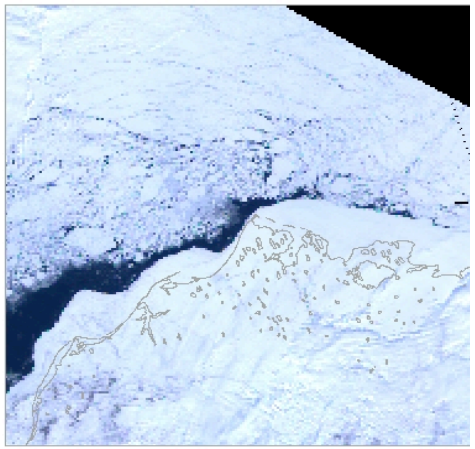


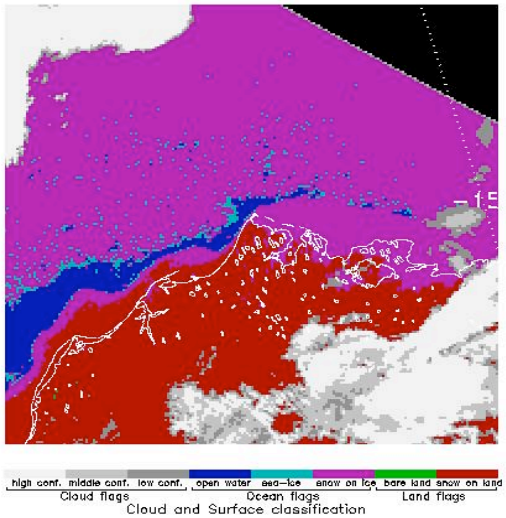


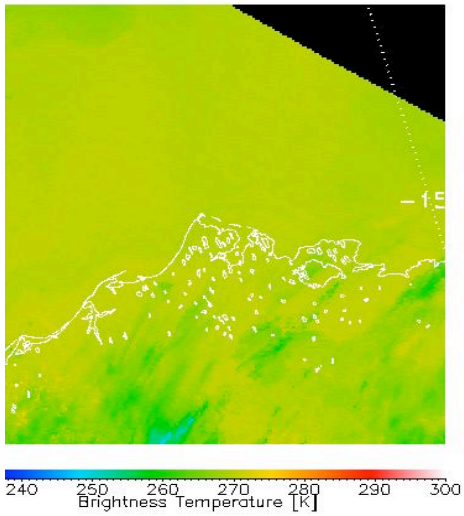


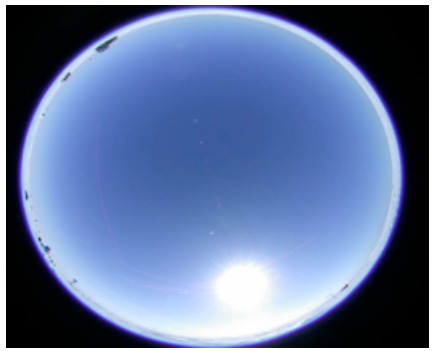
RGB | Cloud flag | BT 11μm | Skycamera

April 26









Barrow observatory (CMDL/NOAA):

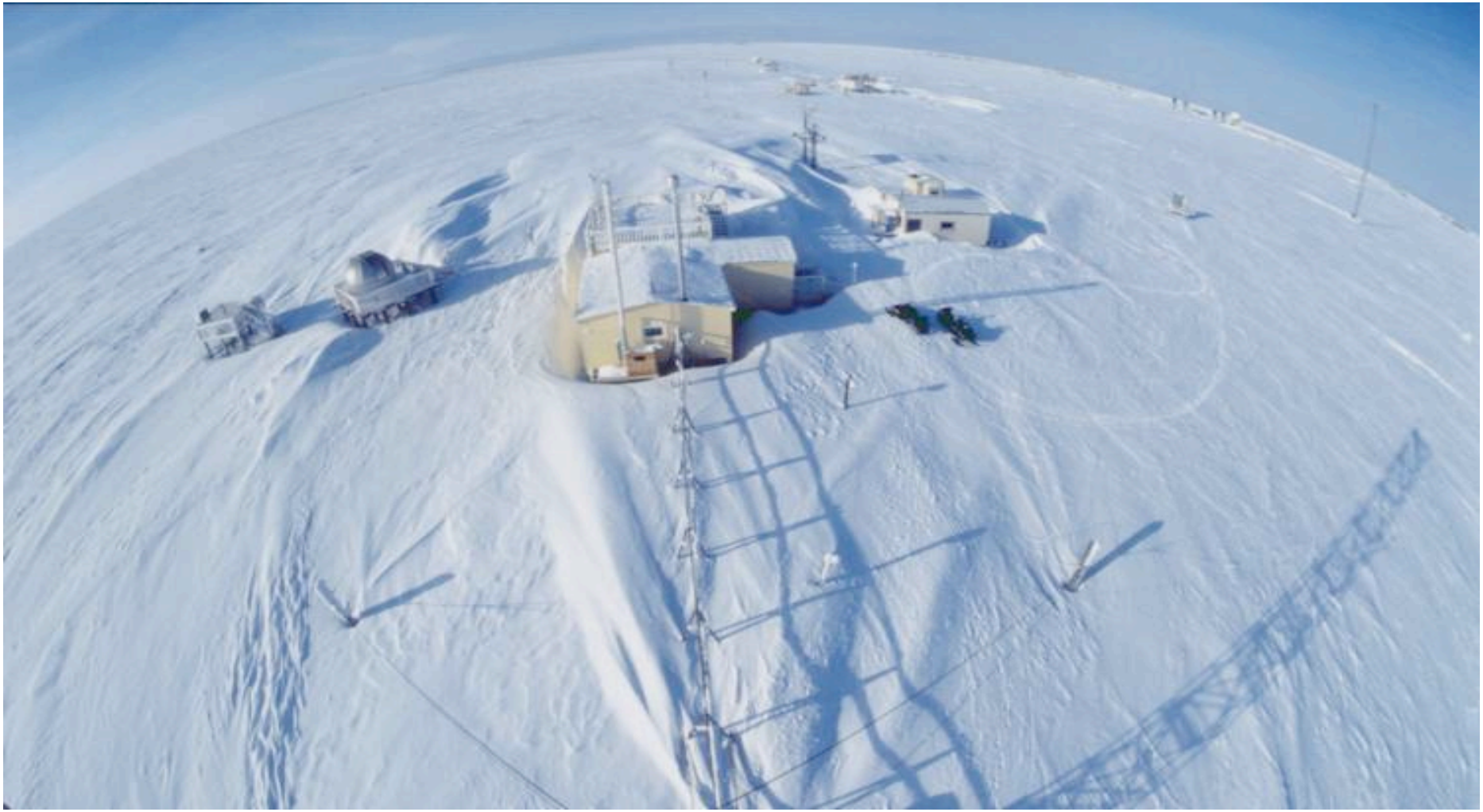
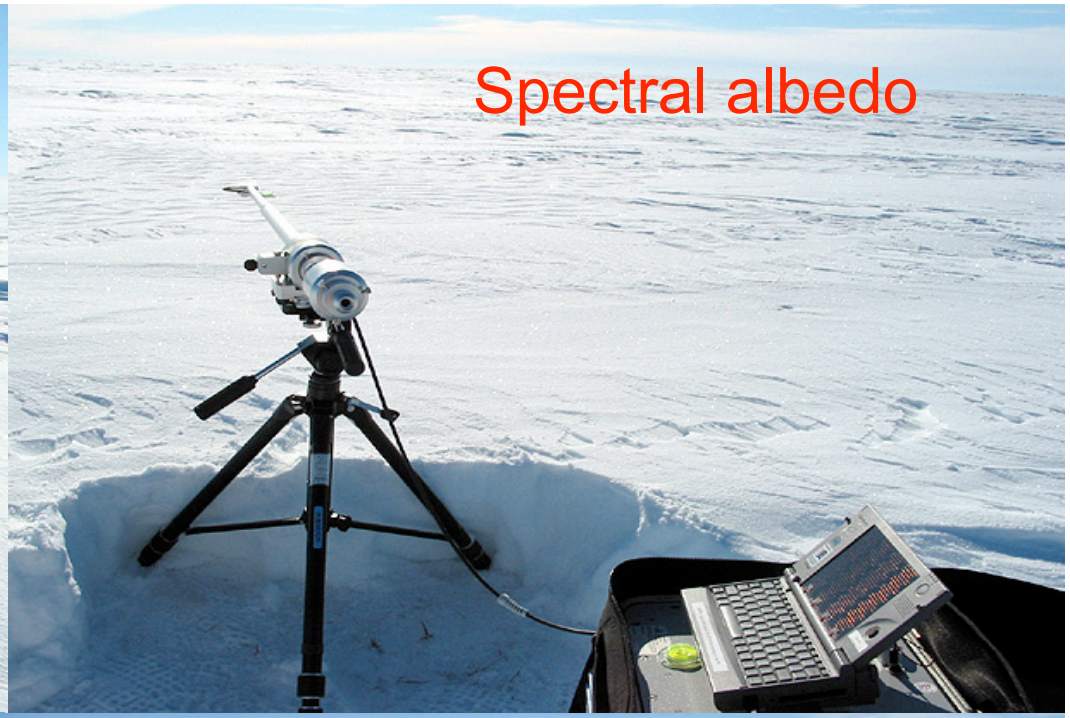


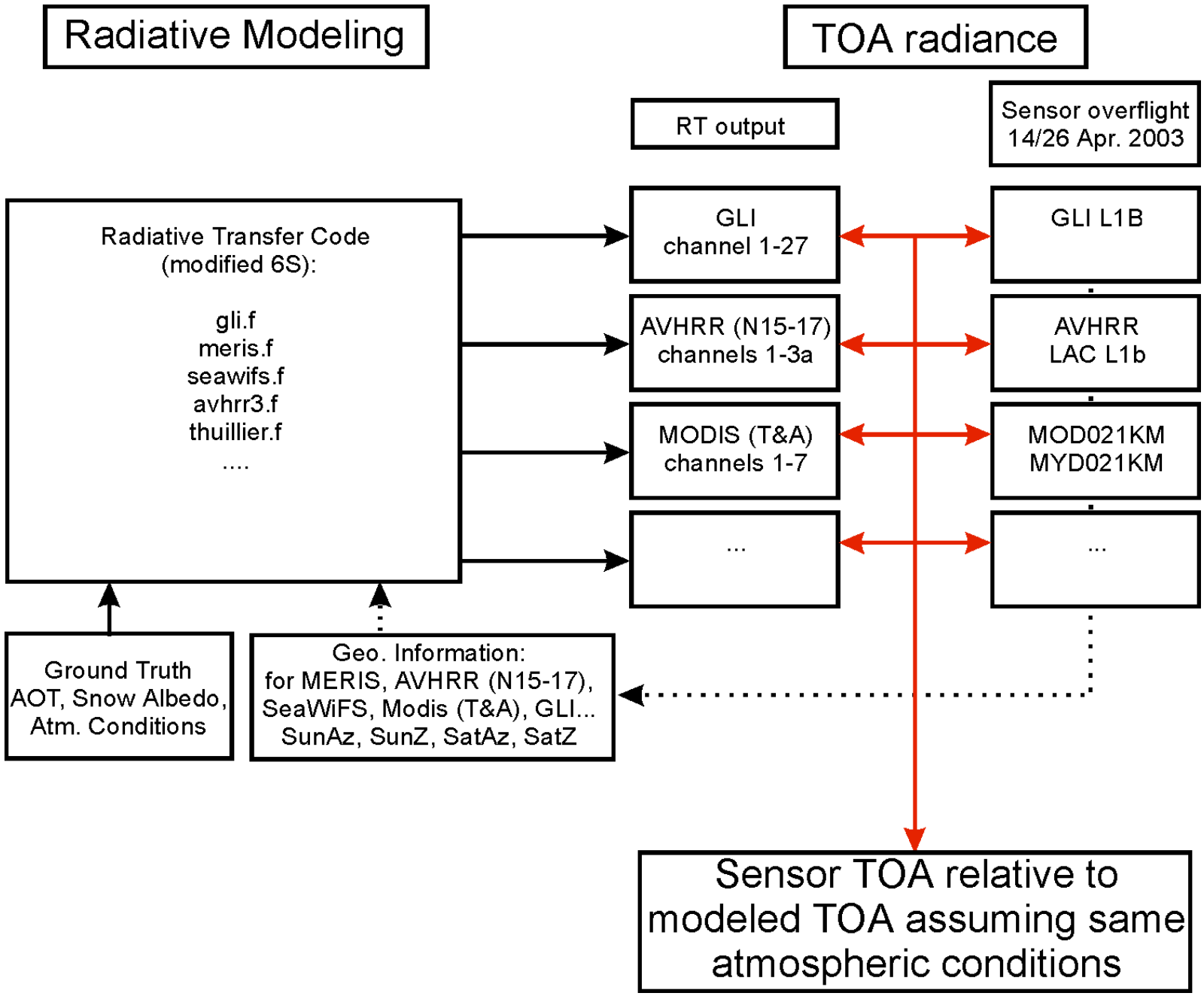
Photo from a different day, taken by Bob Stone, Climate Monitoring & Diagnostics Laboratory /NOAA


Spectral BRDF


Spectral albedo


FTIR


Whole sky image


Radiative Modeling
TOA radiance
RT output
Sensor overflight
14/26 Apr. 2003
Radiative Transfer Code
(modified 6S):
gli.f
meris.f
seawifs.f
avhrr3.f
thuillier.f
....
GLI
channel 1-27
AVHRR (N15-17)
channels 1-3a
MODIS (T&A)
channels 1-7
...
GLI L1B
AVHRR
LAC L1b
MOD021KM
MYD021KM
...
Ground Truth
AOT, Snow Albedo,
Atm. Conditions
Geo. Information:
for MERIS, AVHRR (N15-17),
SeaWiFS, Modis (T&A), GLI...
SunAz, SunZ, SatAz, SatZ
Sensor TOA relative to
modeled TOA assuming same
atmospheric conditions

The following satellite data sets were used:

Satellite Data:	from 2003 April	14th	26th
• GLI	(cha. 1-19)	✓	✓
• MERIS	(cha. 1-15)	✓	✓
• AATSR	(cha. 1-3)		✓
• SeaWiFS	(cha. 1-8)	✓	
• AVHRR N16,N17	(cha. 1,2) ✓	✓	
• MODIS terra	(cha. 1-4)		2x
• MODIS aqua	(cha. 1-4)	✓	✓

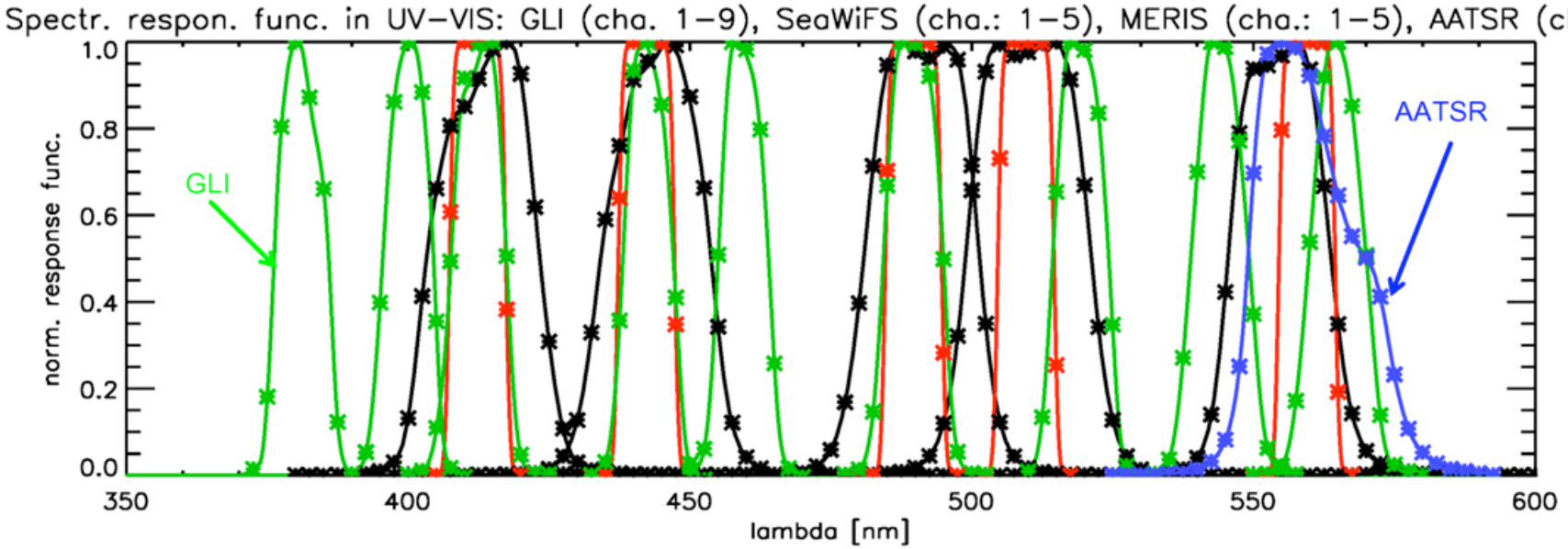
April 14

N16	NSS.HRPT.NL.D03104.S2227.E2241..B1319797.GC
GLI	A2GL10304145709OD2_PV1B0000000.00
SeaWiFS	S2003104225757.L1A_HUAF
MERIS	MER_RR__20030414_230804_000001972015_00302_05867_0855.N1
MODIS_A	GSUB1.A2003104.2250.2003160044556168303 3
AHVRR	NSS.HRPT.NM.D03104.S2327.E2340.B0418585.GC

April 26

MODIS_T	GSUB1.A2003116.2140.2003154181643125012 5
MERIS	MER_RR__1POLRA20030426_215033_000001972015_00473_06038_0513.N1
AATSR	ATS_TOA_1COLRA20030426_215130_000000862015_00472_06037_0444.N1
MODIS_A	GSUB1.A2003116.2155.2003154181652125012 5
GLI	A2GL10304265709OD2_PV1B0000000.00
MODIS_T	GSUB1.A2003116.2315.2003154181639125012 5

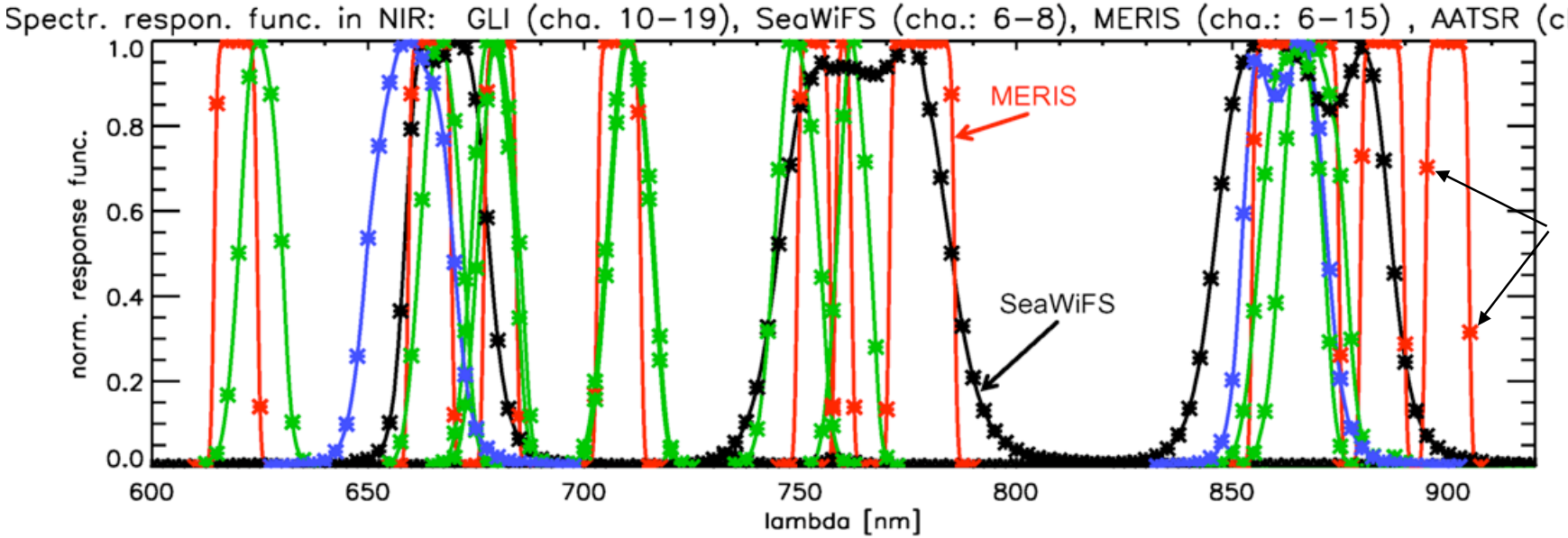
Spectral Response Functions



GLI (green)

MERIS (red)

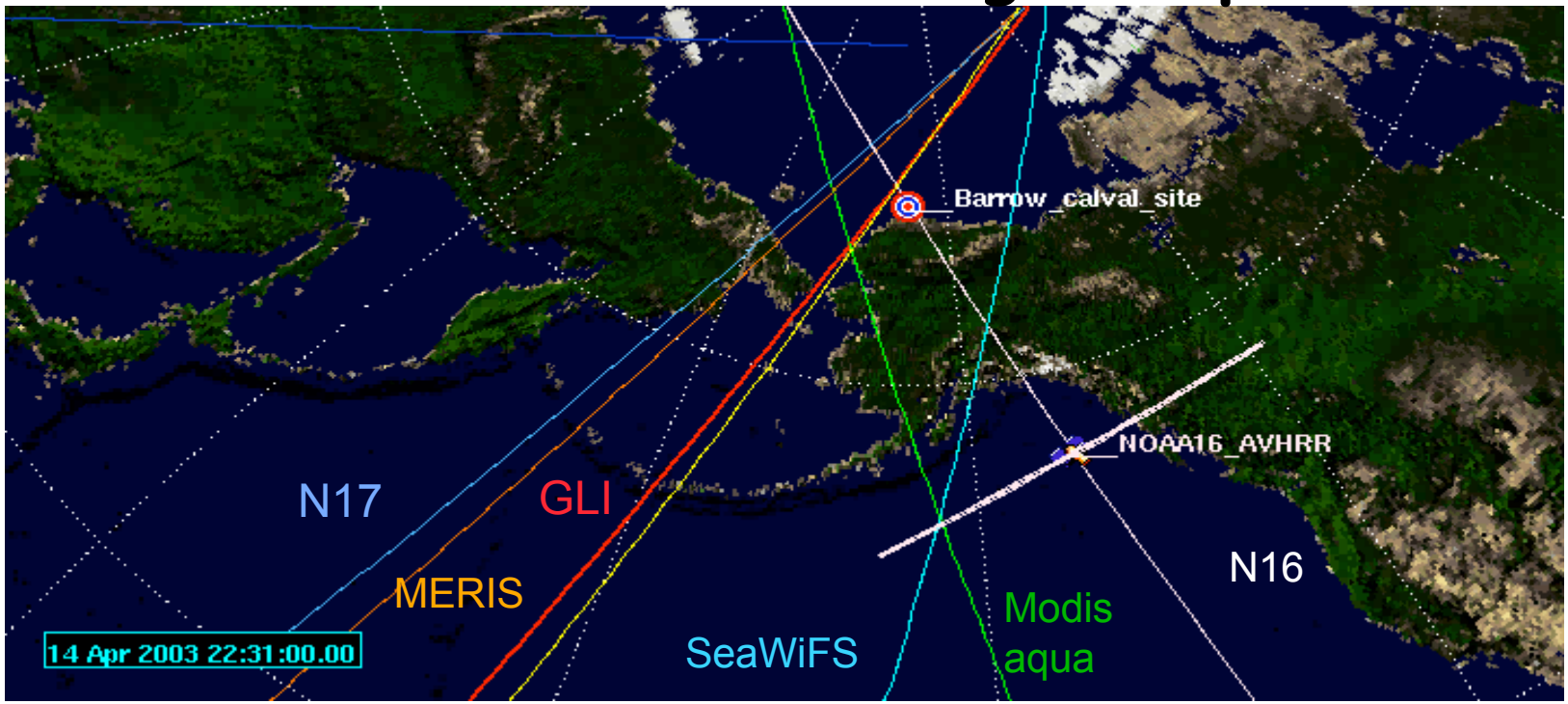
SeaWiFS (black)



RSP interpolated to 6S

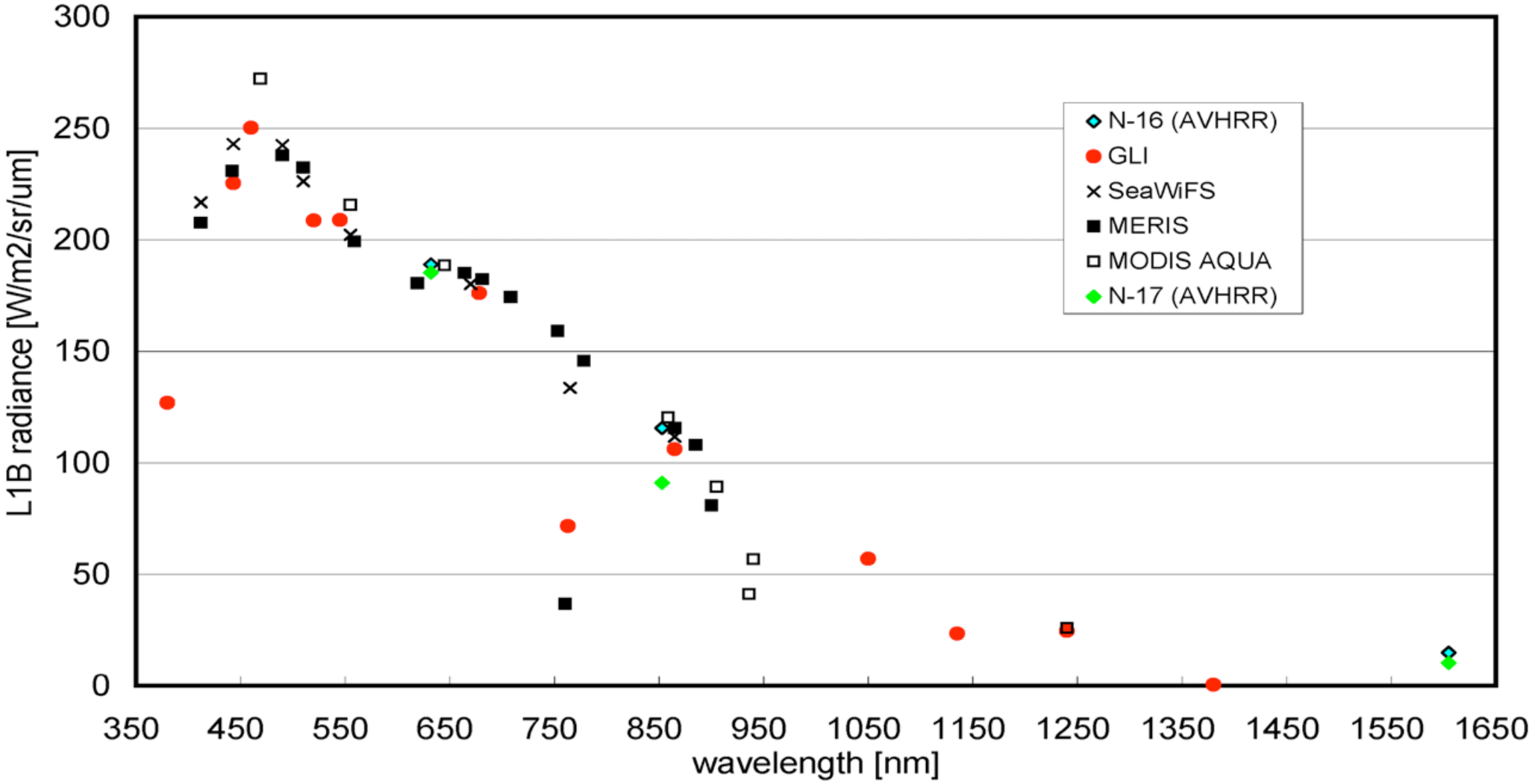
2.5-nm-spectral intervals

Selected Overflights April 14th 2003

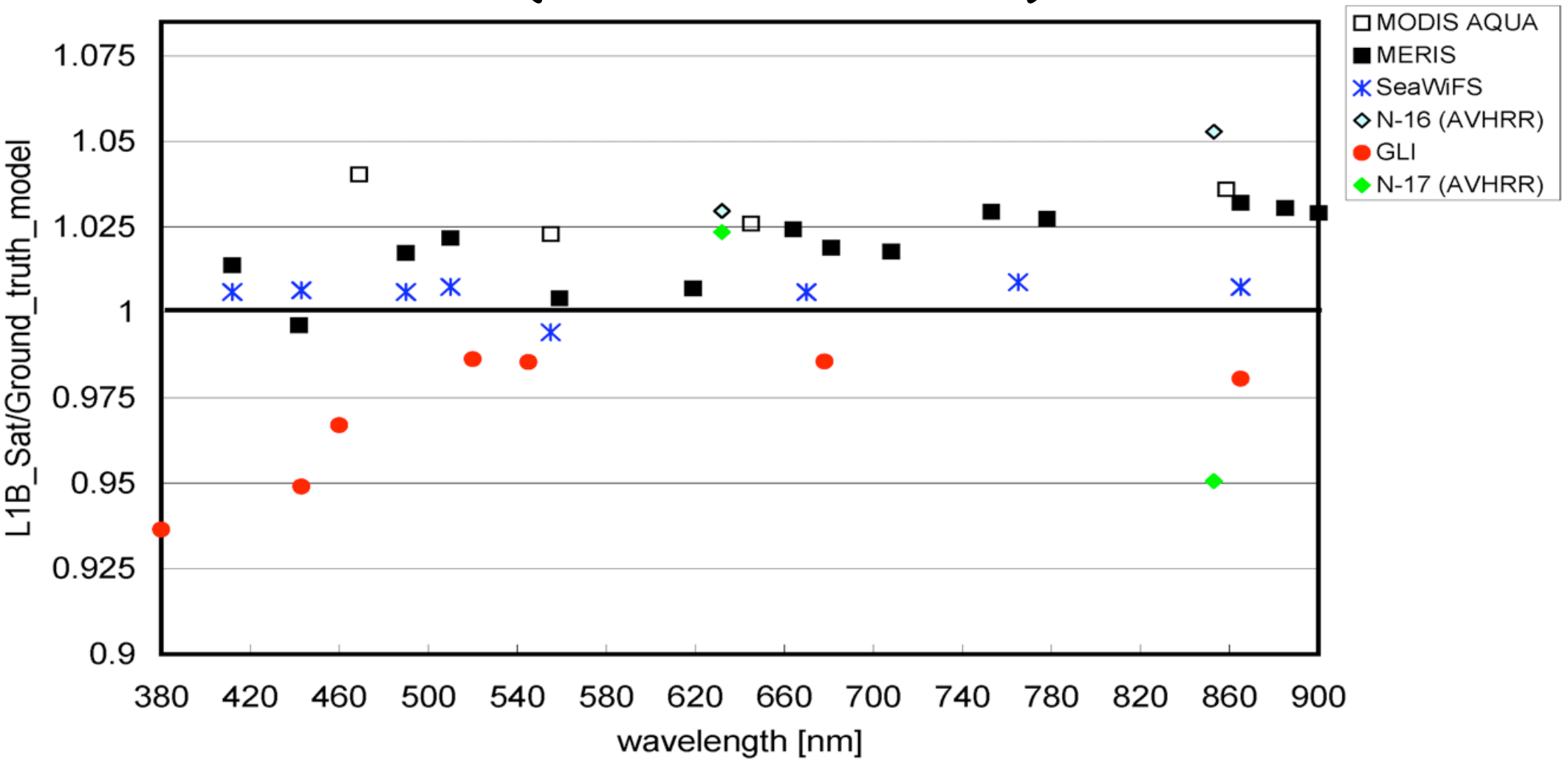


GMT	Satellite	sensors	SunAZ	SatAZ	SunZ	SatZ
22:35:46	N16	AHVRR	182.59	152.96	61.80	0.78
22:54:11	Terra	MODIS	X	X	X	X
22:57:46	ADEOS-2	GLI	188.68	242.36	61.97	24.09
23:01:00	Orbview	SeaWiFS	189.89	122.42	62.03	49.47
23:08:00	ENVISAT	MERIS	191.76	312.13	62.13	31.37
23:09:00	Aqua	MODIS	192.02	255.86	62.14	34.58
23:33:00	N17	AHVRR	198.66	314.07	62.61	33.62

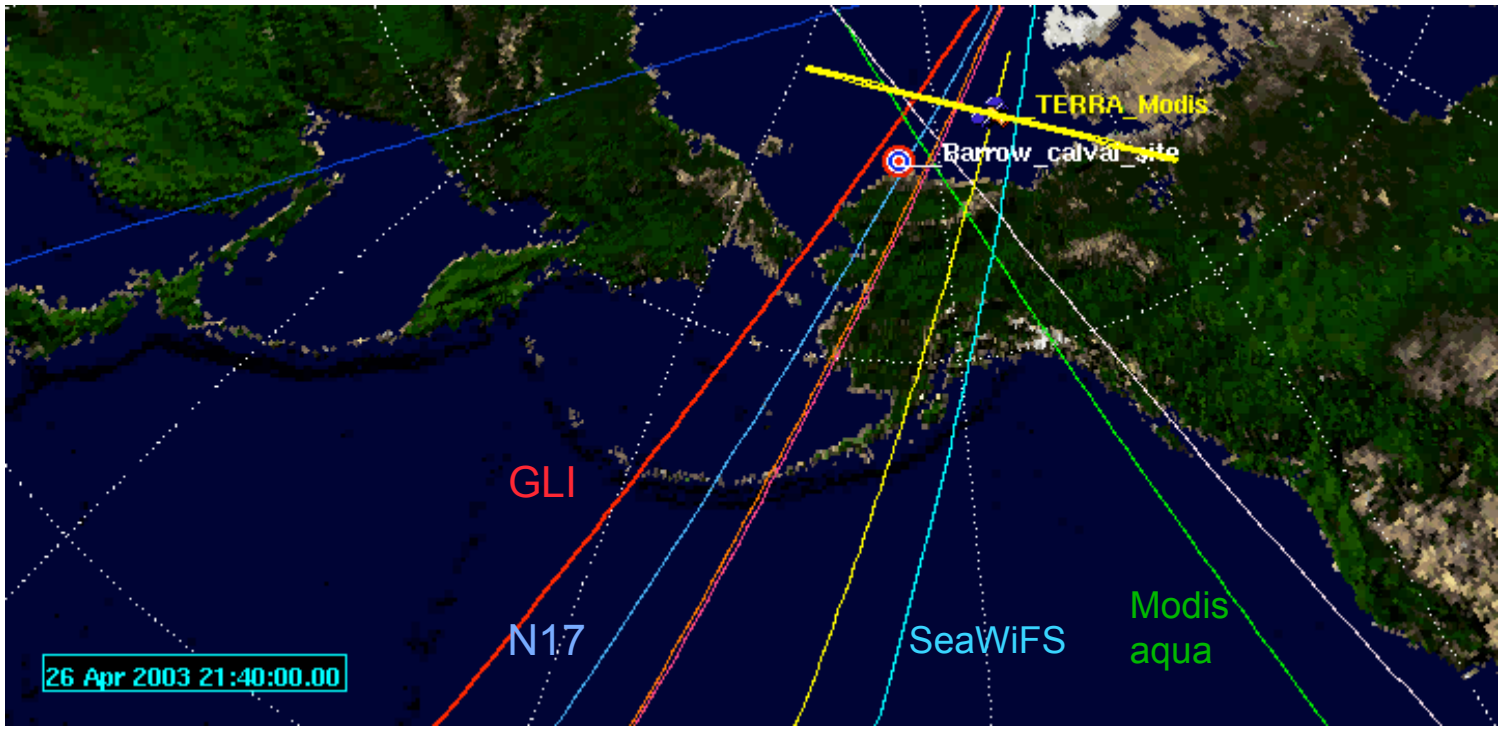
TOA radiance (L1B data) April 14th



Deviation for the April 14th (L1B/Ground-truth)

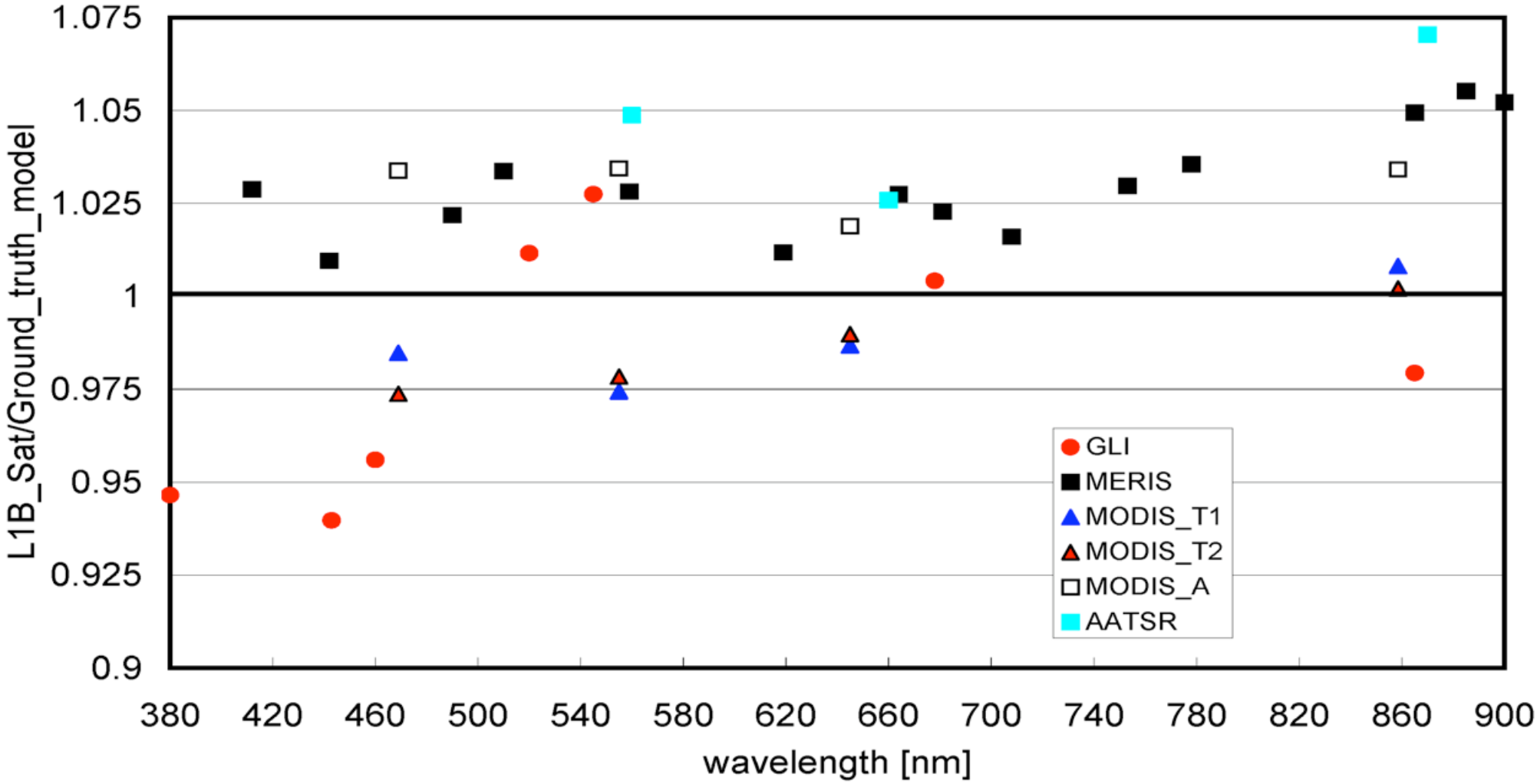


Selected Overflights 26 April 2003



GMT	Satellite	sensors	SunAZ	SatAZ	SunZ	SatZ
21:41:00	Terra	MODIS	167.68	103.16	58.08	36.75
21:52:00	ENVISAT	MERIS AATSR	170.79	114.12	57.91	12.42
21:56:00	Aqua	MODIS	171.93	59.63	57.86	15.00
22:57:38	ADEOS-2	GLI	189.78	242.52	57.92	24.13
23:00:00	Orbview	SeaWiFS	X	X	X	X
23:19:00	Terra	MODIS	195.83	305.94	58.29	27.17

Deviation for the April 26th 2003 (L1B/Ground_truth)

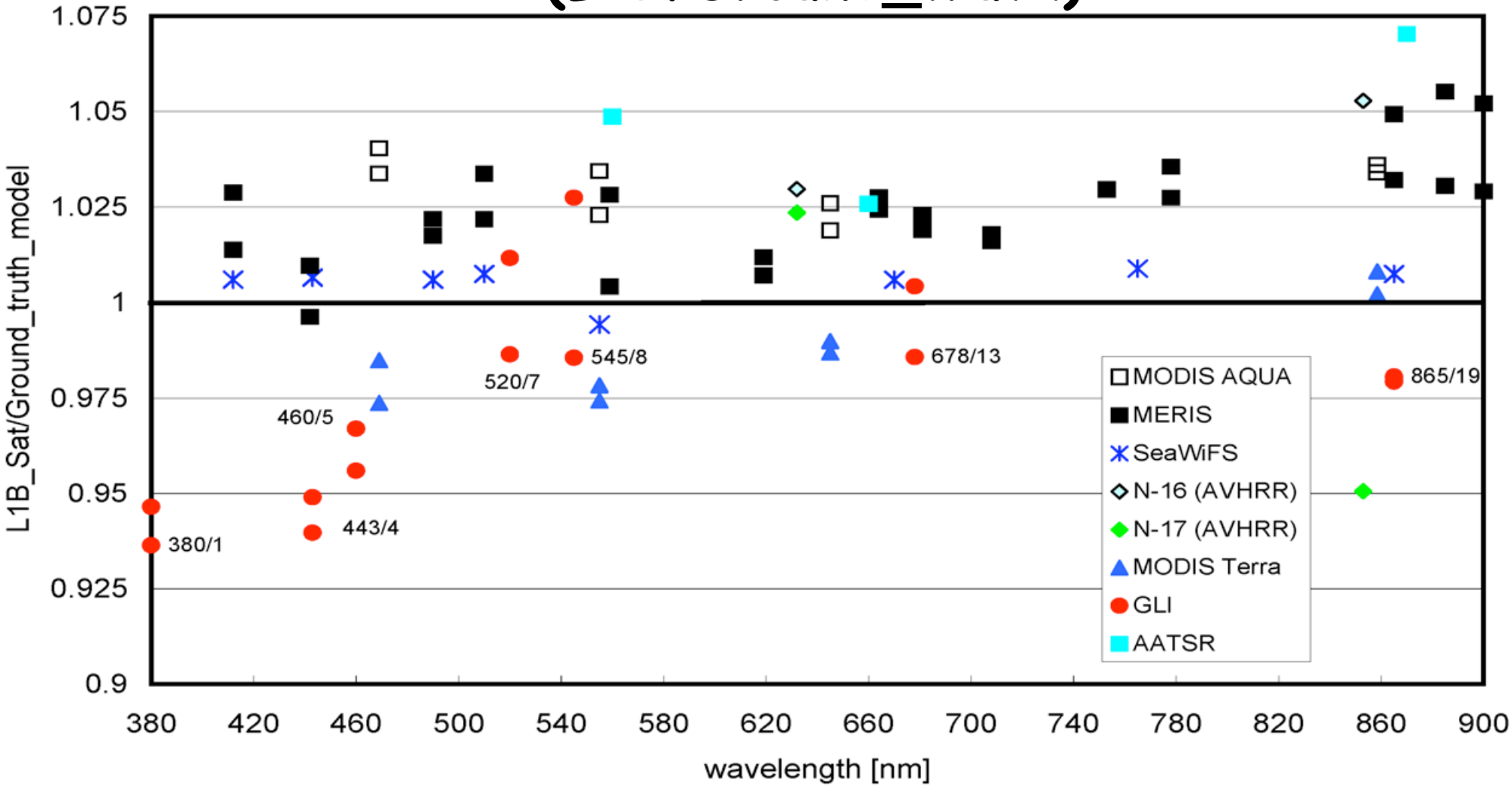


Error analysis for a single inter-comparison

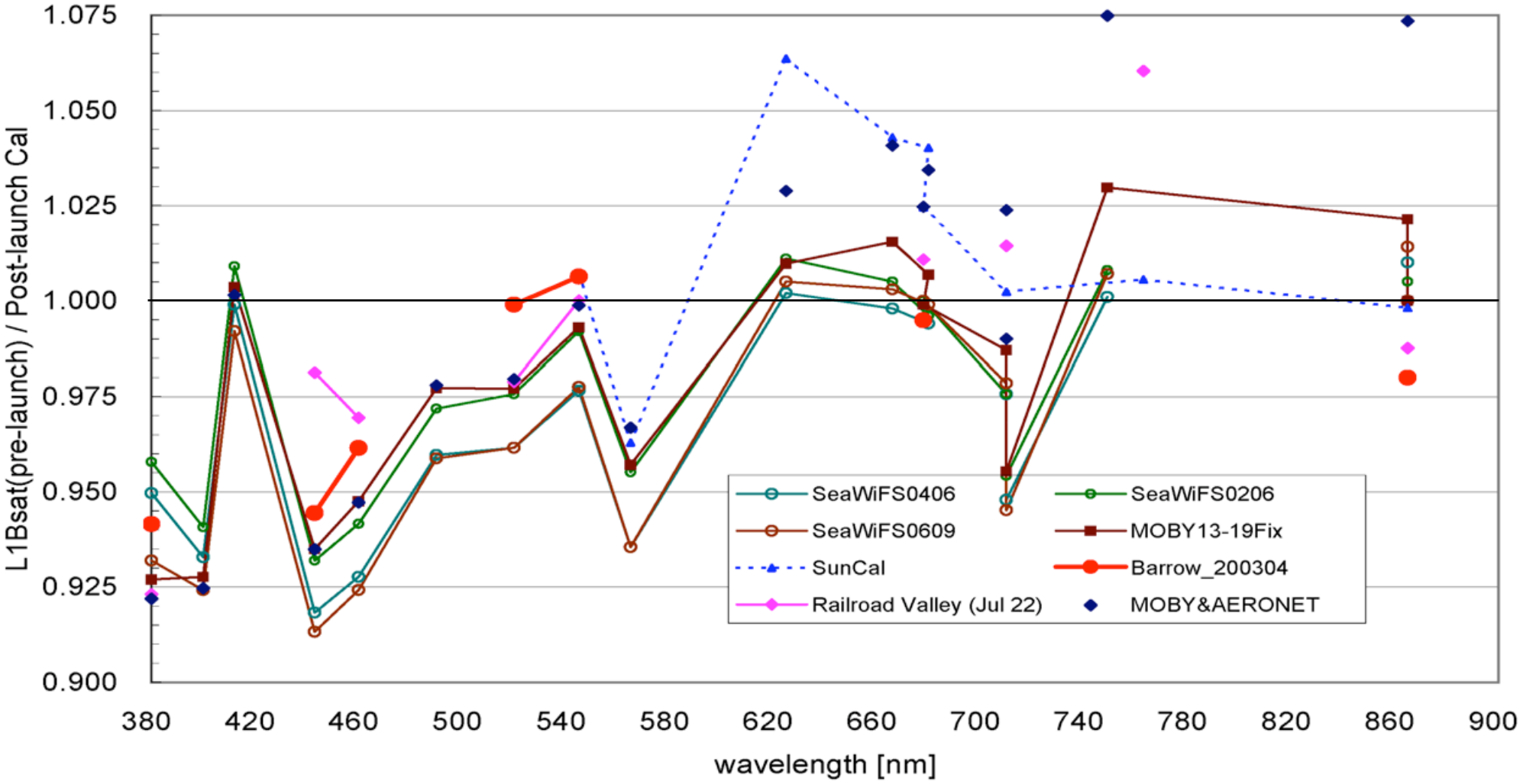
Sources	Error
Satellite sensor absolute calibration	5
Measurement accuracy – uniformity of the site – positioning accuracy, georef accuracy	1–3
Atmospheric modeling – change of atmospheric conditions – atmospheric characterisation – correction for viewing angle differences – differences in spectr. response funct.	3
Total error (RMS)	5–6.6

The error budget of single event comparison is high at about 5-7%, however, the following tendency becomes "interesting"

Deviation for April 14 and 26th 2003 (L1B/Ground_truth)



Results agree well with other GLI cal-methods!



Conclusion

- All analyzed space sensors have similar radiometric performance within 6-7%.
- GLI pre-launch calibration agrees well with cross-cal. results in the VNIR.
- however GLI seems to underestimate the snow target in the UV/blue.
- Comparison results for GLI fit well with other GLI calibration methods.

We would like to **acknowledge**

NASA (DAAC, SeaWiFS project), NOAA (SAA), ESA & Brockmann, Aeronet/ARM site, C.R. McClain (SeaDAS code) and E. Vermote (6S code)

for the **production** and **distribution** of **data** and **codes** used in this investigation.

6S input data

	14th	26th	
• AOT data			
• AOT @ 550 nm	0.0263	0.235	
• Atmosphere profile:			
• H2O:	0.6	0.68	cm
• O3:	450	400	DU
• Aerosol type (typical):			
• dust-like components:	2.85	2.85	%
• water-soluble components:	70	70	%
• oceanic components:	12.85	12.85	%
• soot components:	14.3	14.3	%

- Snow site reflectance

- Assumptions:
  - Atmosphere (AOT, type, H_2O, O_3) and snow reflectance are constant, each period
  - Cirrus layer (non-visible) at TOA for April 26th (2000m from ARM MPL)
  - Aerosol component for both days is "typical polar aerosol type" at Barrow