Intercomparisons of IASI and AATSR calibrated radiances

John Remedios[1]

Jonathan Mittaz[2], Manik Bali[2], David Moore[1] and Chris Whyte[1]

1. EOS-SRC/NCEO, Physics and Astronomy, University of Leicester, UK
2. CICS/NOAA, Univ. of Maryland, USA

Radiometric inter-calibration

- **Important!**
- **Operational radiance bias correction – GSICs**
- **Calibrated level 1 radiance time series for climate**
- **Confidence in satellite climate records – give rise directly to delta(SST). Typically want 0.1 K accuracy, <0.04 K/decade stability (Ohring, 2005; WMO 2011)**
- **Could inform on radiometer spectral filter functions.**

Acknowledgements:

David Llewellyn-Jones , Gary Corlett , Darren Ghent (Leicester) and Dave Smith (RAL)

The ATSR team in the UK

Funding: **Eumetsat and NOAA;** Also DECC and NERC in UK

IASI and AATSR Comparison

AATSR

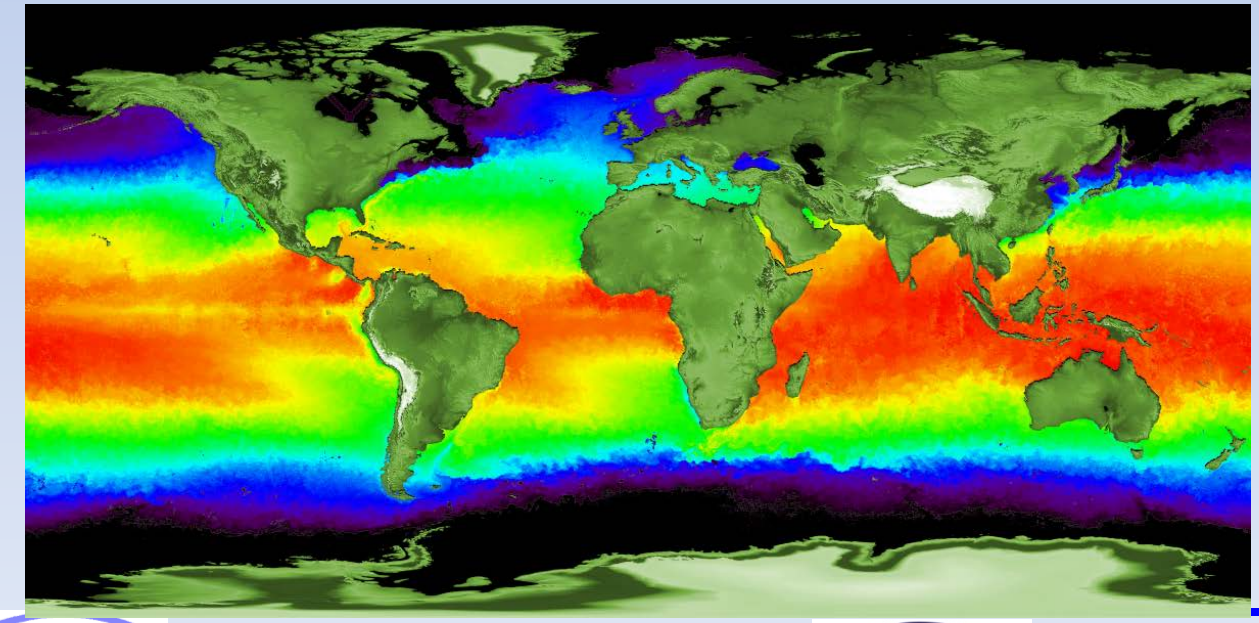
- Polar, sun-synchronous orbit
- Mean altitude ~ 800 km
- Local equator crossing at 10:00
- Repeat period of 35 days
- Radiometer
- 3 thermal channels
  - 3.7 µm, 10.8 µm, and 12 µm
- 4 reflectance channels
  - 0.555 µm, 0.659 µm, 0.865 µm, and 1.61 µm

IASI

- Polar, sun-synchronous orbit
- Mean altitude ~ 817 km
- Local equator crossing at 09:30
- Repeat period of 29 days
- High-resolution spectrometer
- 3 overlapping bands
  - 645-1240 cm^{-1} (8-15.5 µm)
  - 1200-2040 cm^{-1} (4.9-8.3 µm)
  - 1960-2760 cm^{-1} (3.6-5.1 µm)

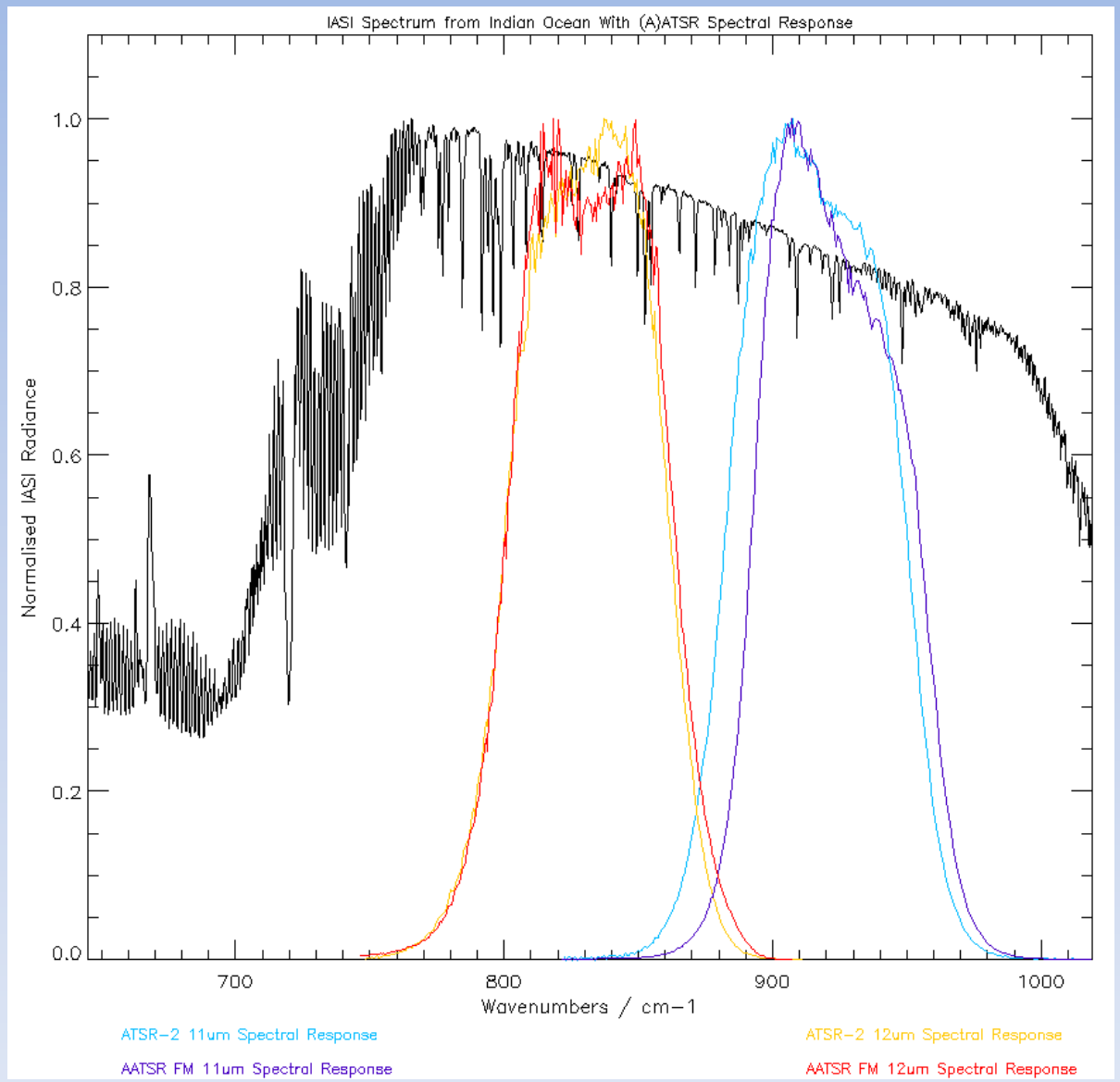
The ATSR Mission

- The Along Track Scanning Radiometer (ATSR) Mission
- Primary objective to measure Sea Surface Temperature (SST) with an accuracy of 0.3 K (1-sigma limit)
- Thermal and visible data for land studies (e.g. temperature, vegetation):
    - Secondary objective is to measure Land ST (LST) with an accuracy of 1.0 K at night and 2.5 K during the day (1σ limit)
- Provision of a long-term dataset for global climate change studies



- ATSR-1 (ERS-1) 09/1991 - 03/00
- ATSR-2 (ERS-2) 04/95 - now
- AATSR (Envisat) 03/02 – 04/12
- SLSTR (Sentinel-3) to follow

ATSR Spectral Response Functions



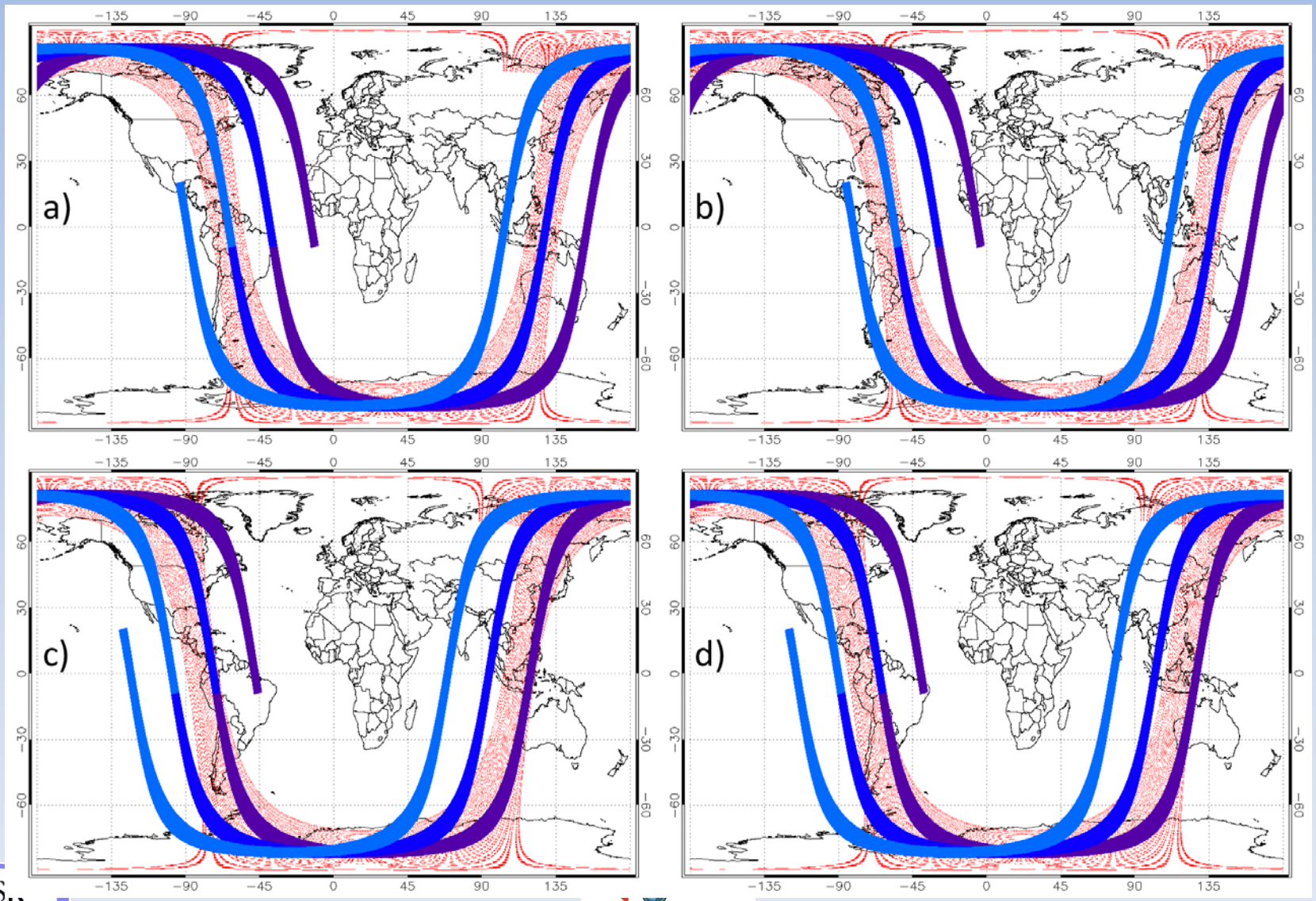
ATSR spectral functions overlaid on typical IASI spectrum.

AATSR spectral filters are "pre-flight"

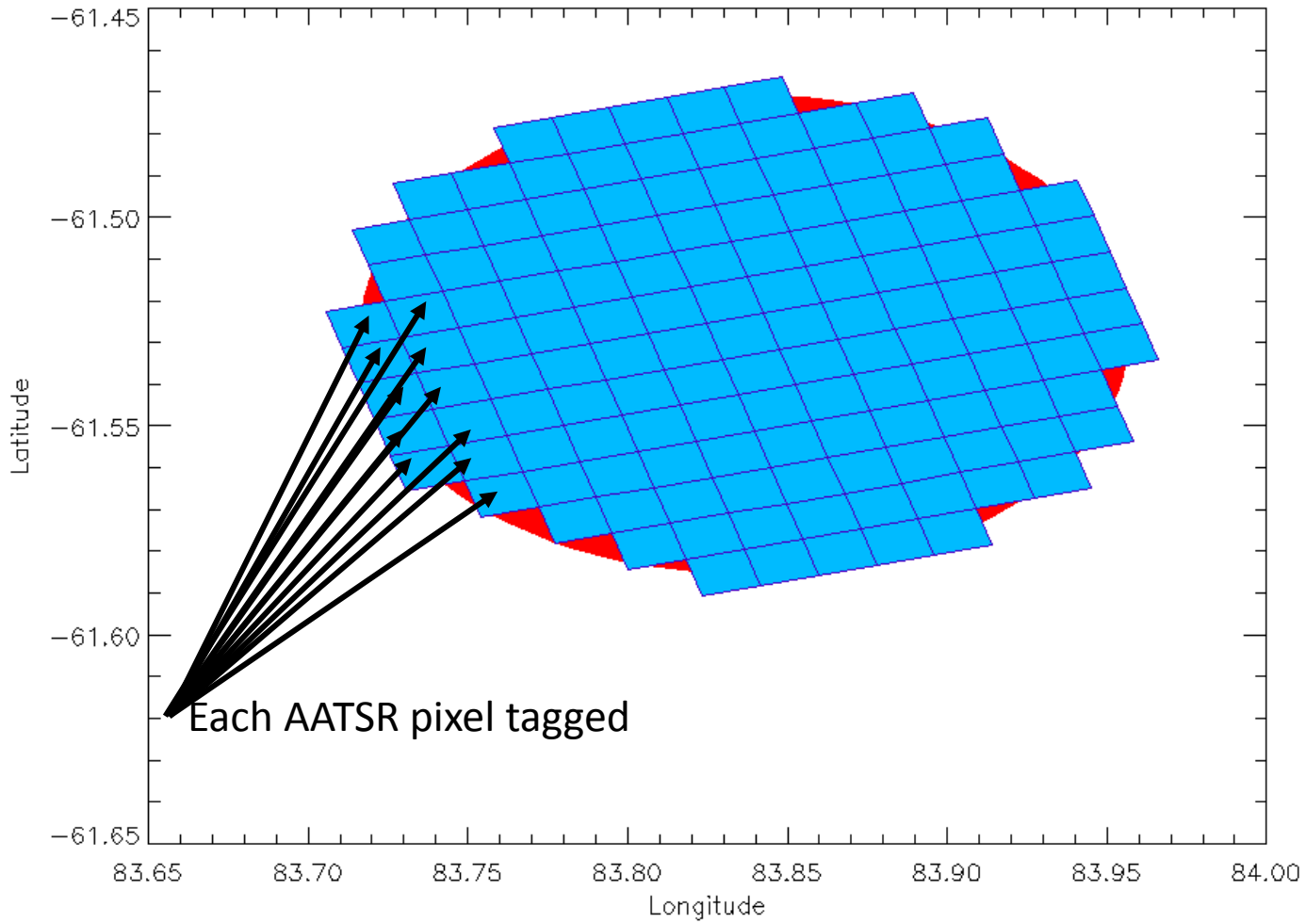
Both ATSR-2 and AATSR filter functions are shown

Progression IASI/ATSR orbit tracks

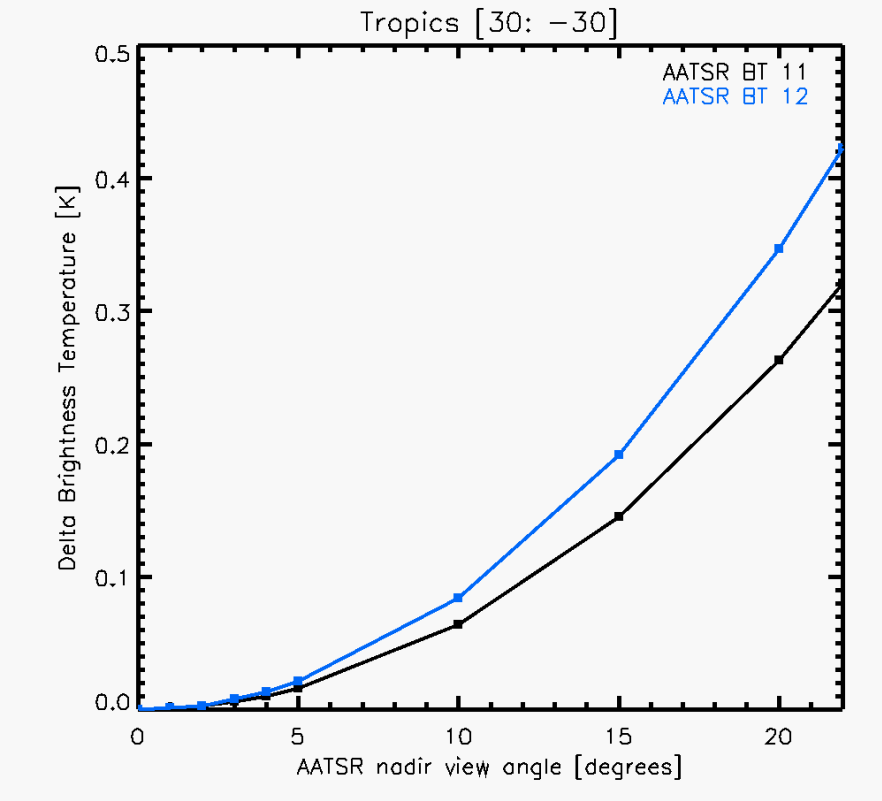
Sept 1 2007 – Sept 4 2007

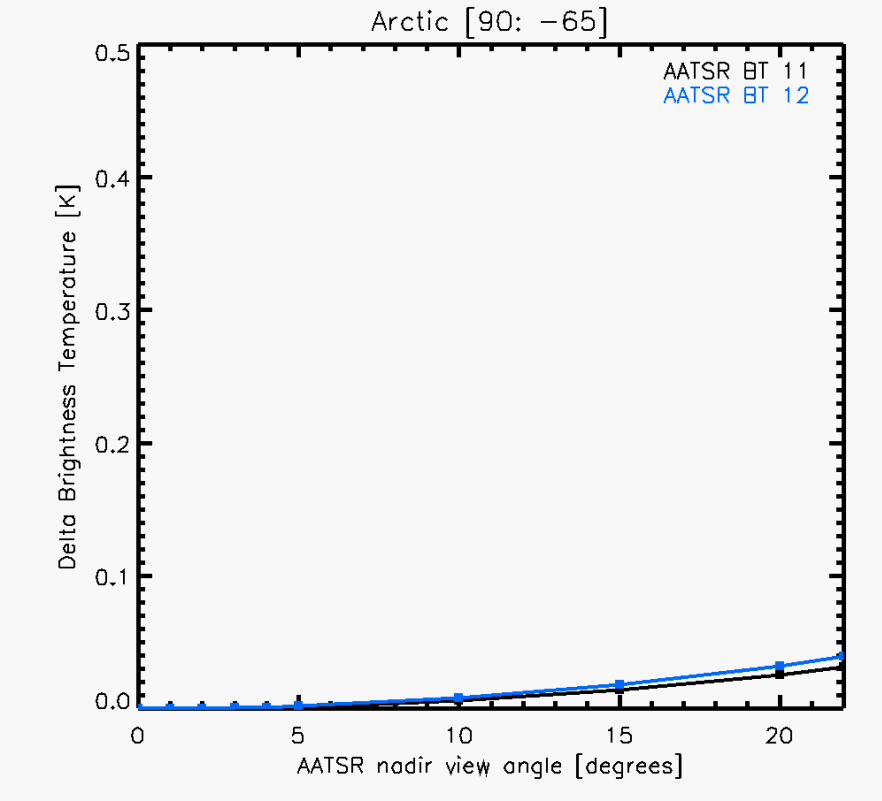


Example IASI/AATSR pixel coincidence



Sensitivity of BTs to view angle differences





- Simulated ΔBT as a function of view angle using RTTOVs and RAMSTAN climatologies.

Co-locations

Criteria (M=long time series; L = Sept 2007):

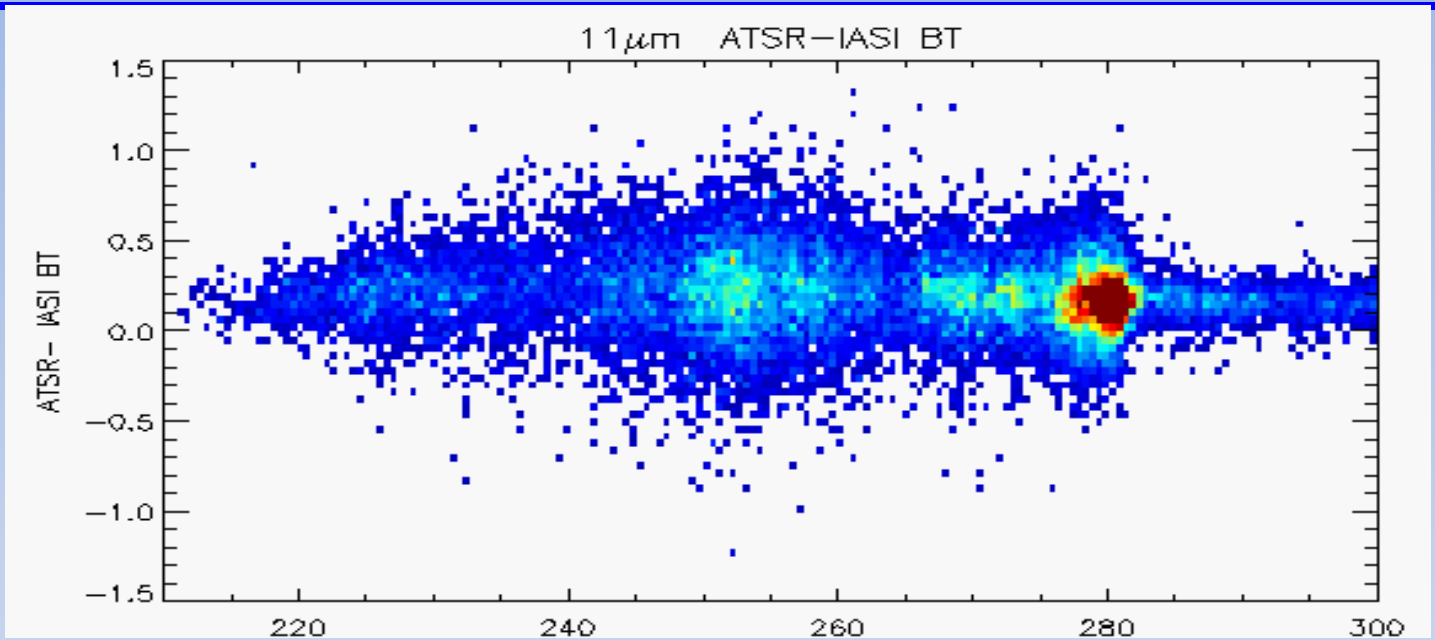
- Time difference < 15 min (M); variable (L)
- SD of collated pixels < 0.5 K (M); fully clear+0.4 K cloudy (L)
- SD Perimeter < 1 K (M)
- Maximum satellite zenith angle difference of 1° (M); 1% in sec(angle) (L) [similar]

M – preflight spectral filter profiles

L – smoothed spectral filter profiles.

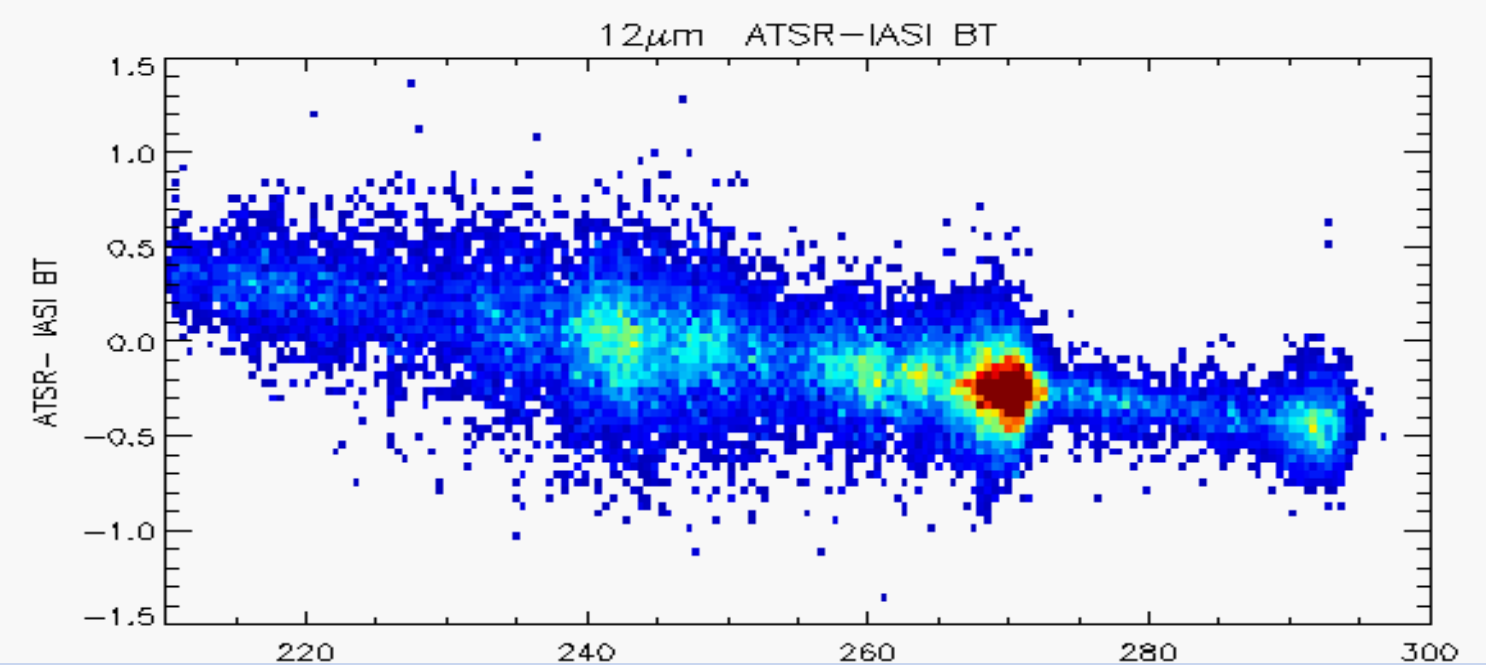
[Very small differences]

Results: 11 µm



- 2009-10 summer months+Jan./Feb. 20011
- Results at 11 µm show an approximately constant offset between IASI and AATSR of 0.06 K
- Consistent with 0.04 K reported in D.5
- Could be IASI or AATSR bias (note pre-launch calibration shows small AATSR bias at 11 µm)

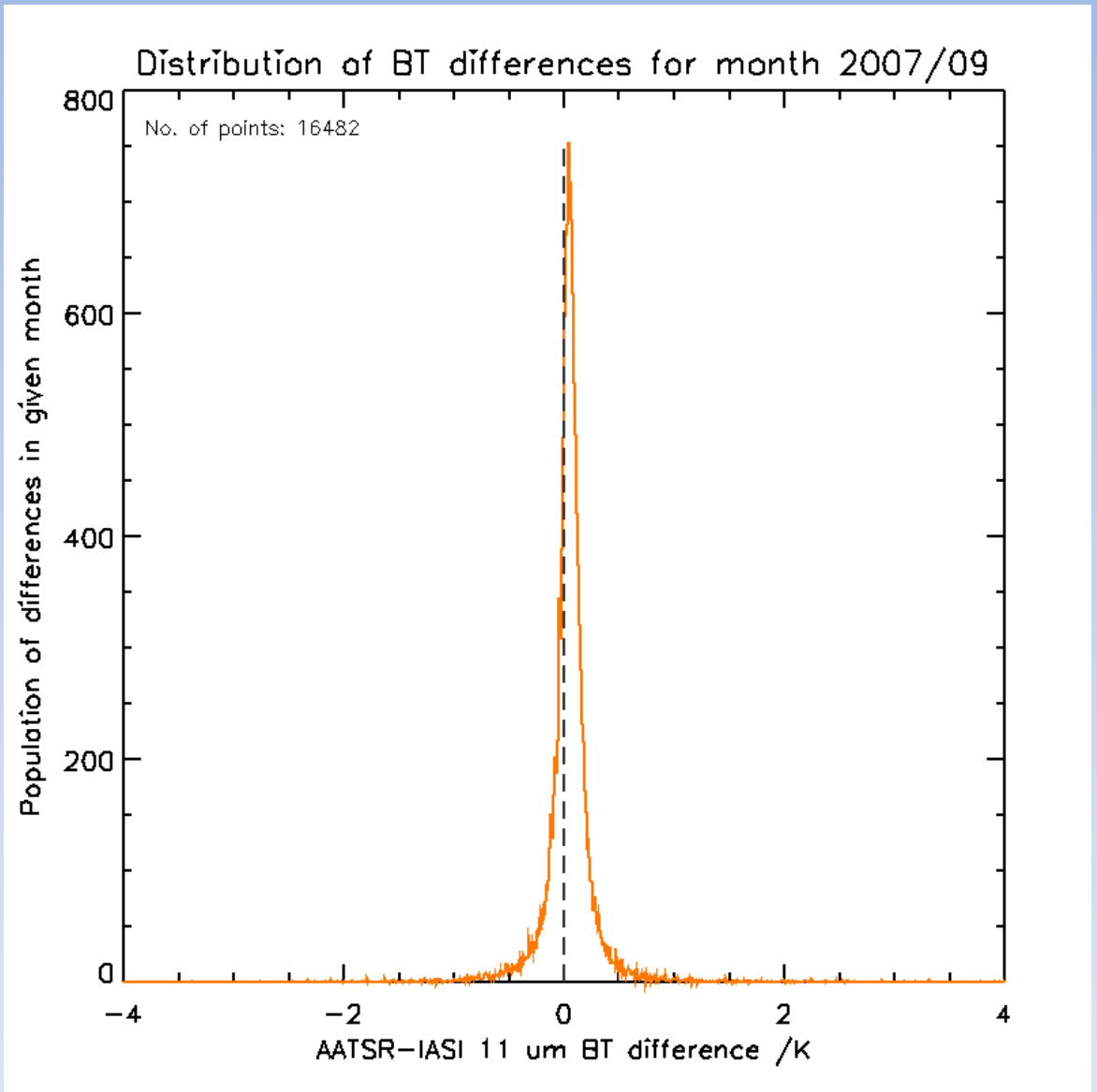
Results: 12 µm



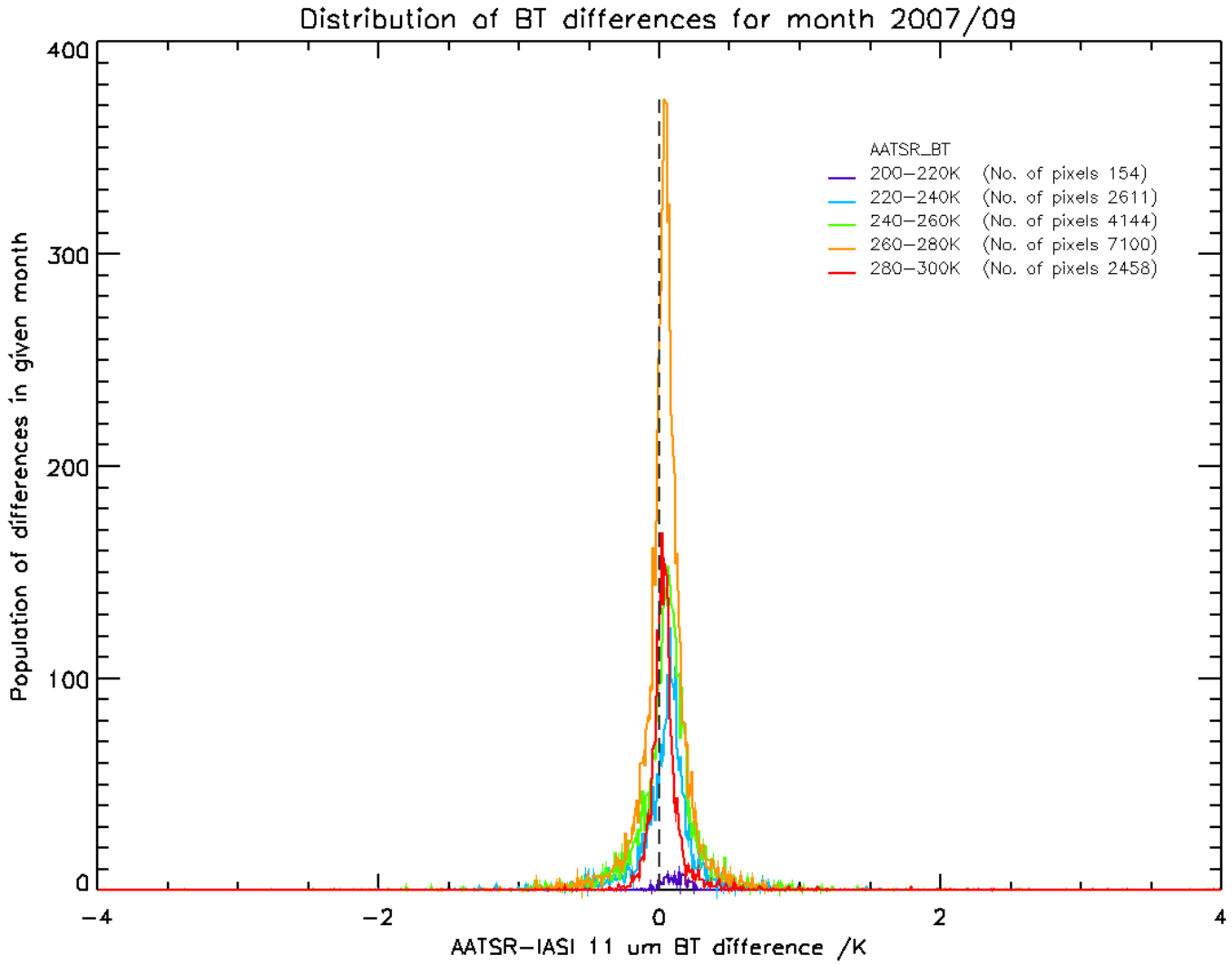
- Results at 12 µm show a systematic dependence on temperature. At 270 K, the bias is consistent with other studies but is more negative at warmer temperatures and reverses sign at colder temperatures, becoming a positive bias of up to 0.4 K.

Sea

11 µm, 20 min, day/night

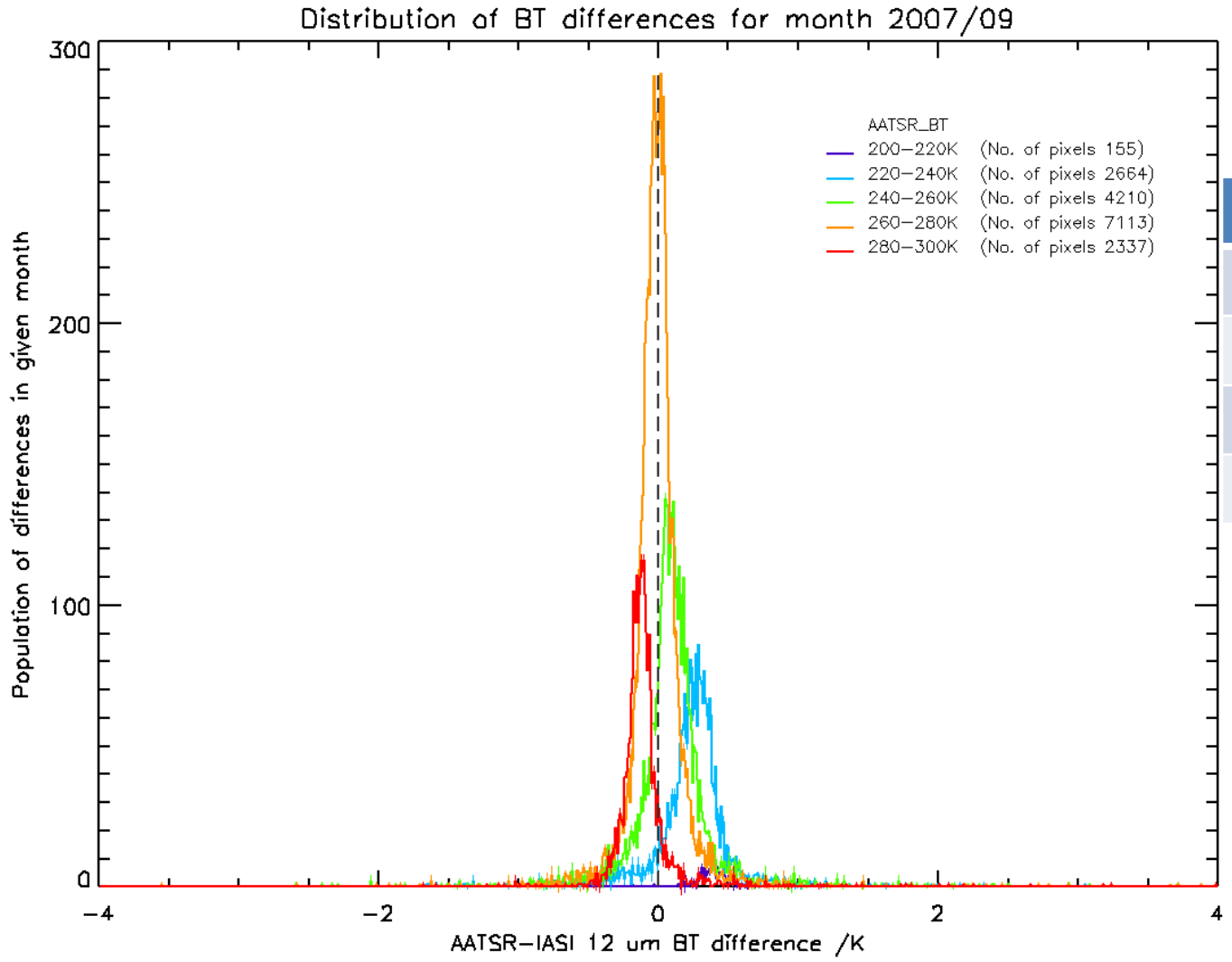


11 µm, 20 min, sea and night



200-220 K	**0.135**
220-240 K	0.075
240-260 K	0.065
260-280 K	0.015
280-300 K	0.015

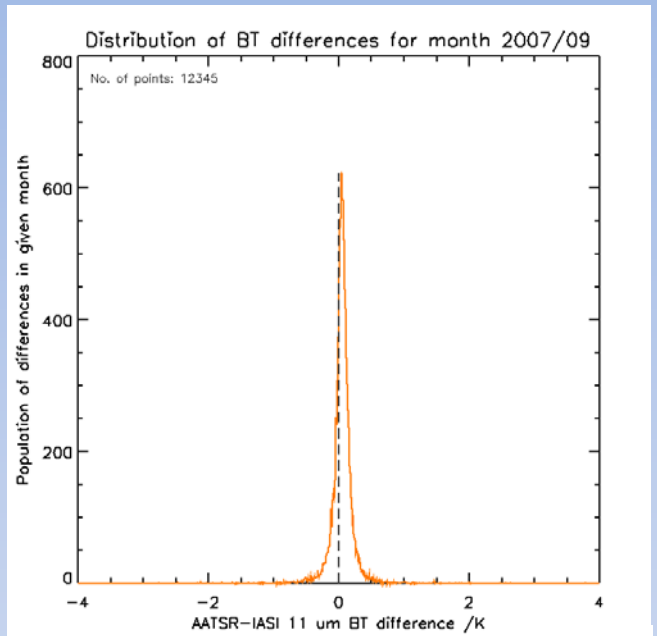
12 µm, 20 min, sea and night



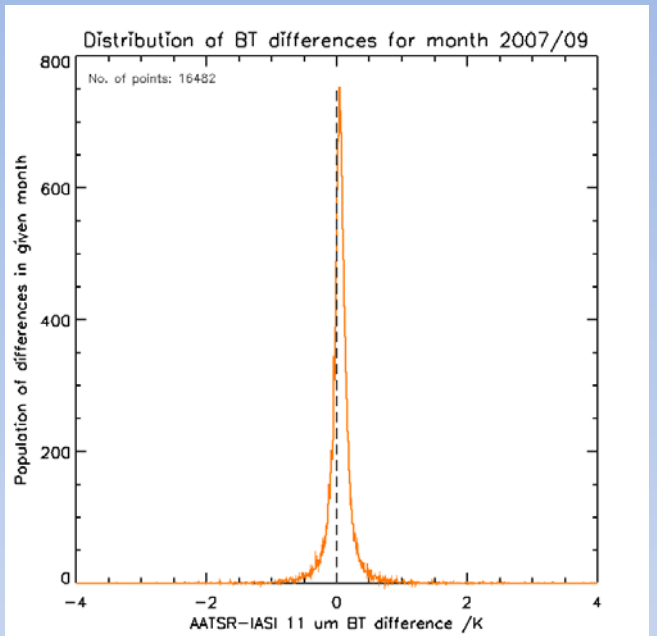
200-220 K	0375
220-240 K	0.265
240-260 K	0.145
260-280 K	-0.035
280-300 K	-0.155

Sea / All day / 1% angle difference 11 µm

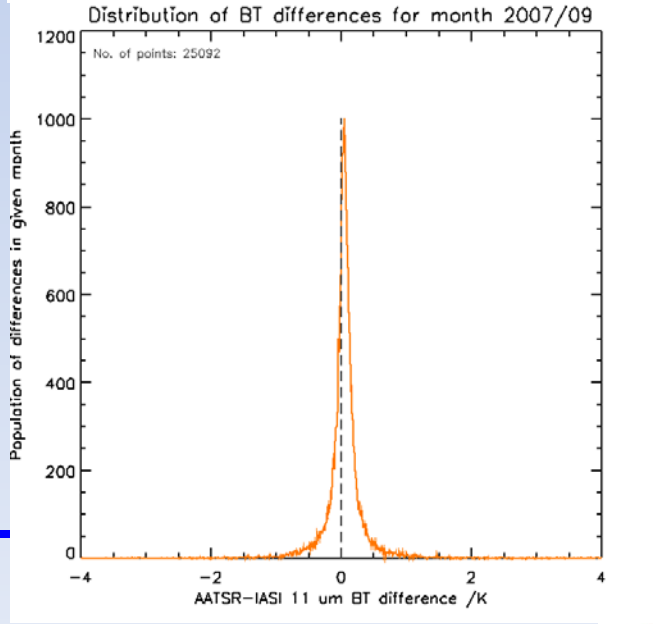
15 minutes



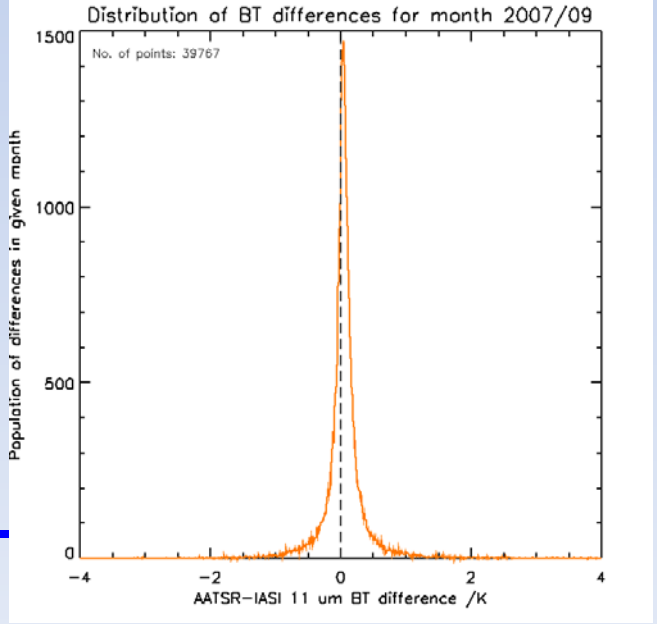
20 minutes



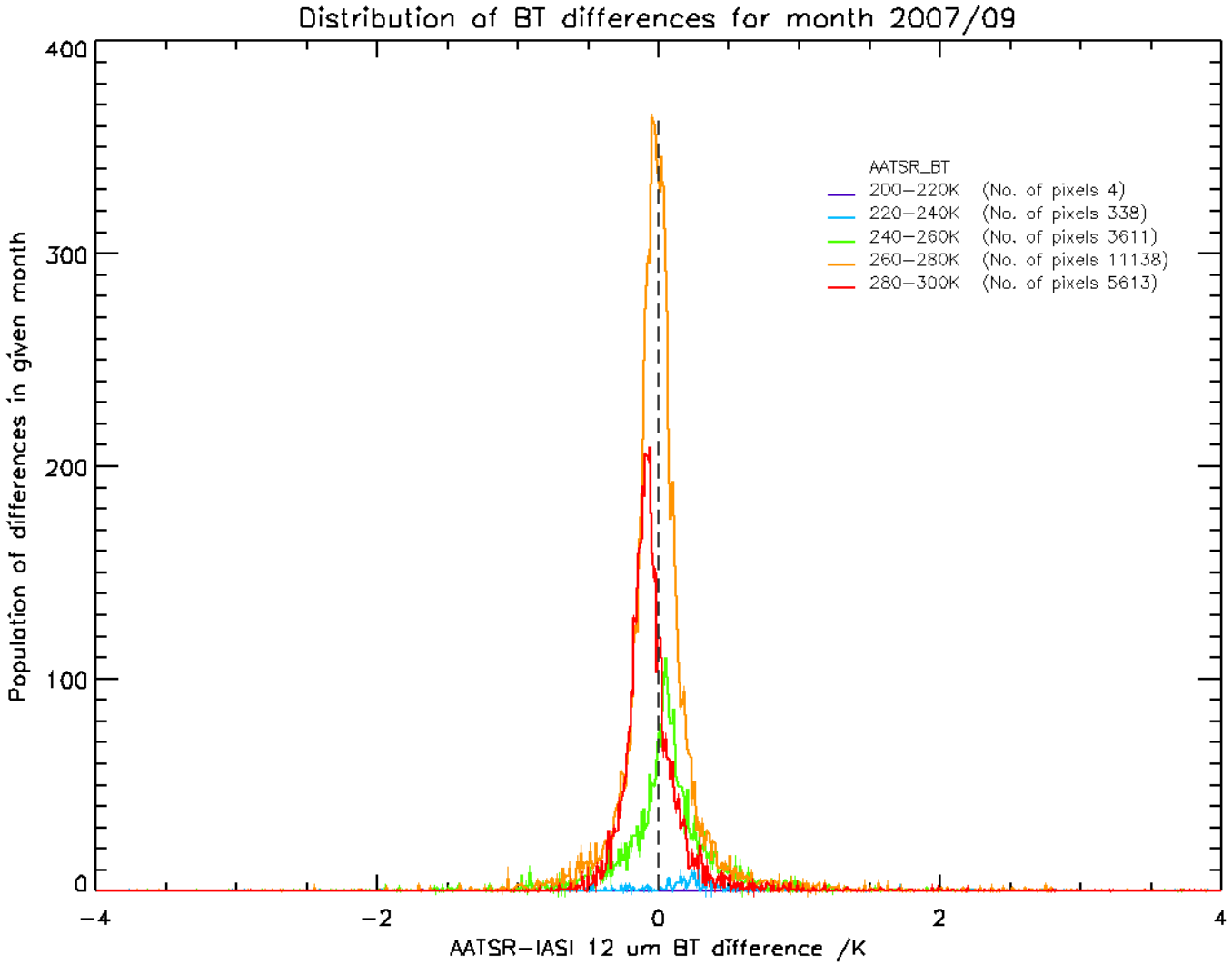
25 minutes



30 minutes



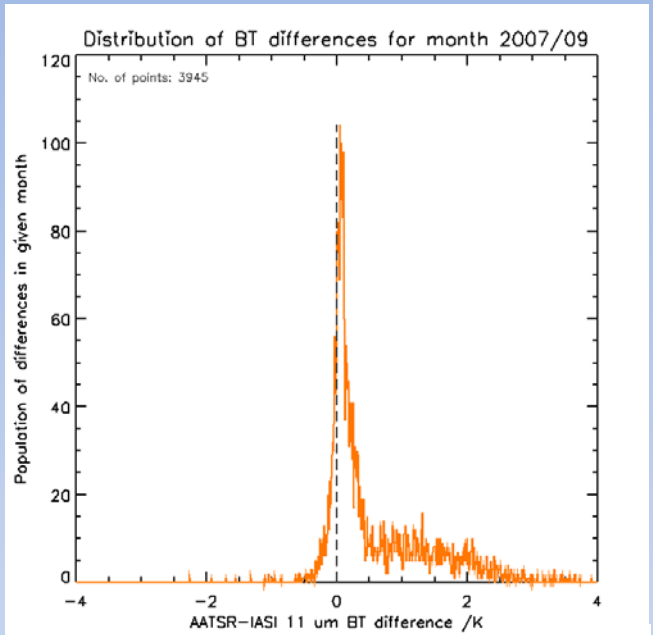
12 µm, 30 min


Distribution of BT differences for month 2007/09
Population of differences in given month
AATSR–IASI 12 um BT difference /K
AATSR_BT
200–220K (No. of pixels 4)
220–240K (No. of pixels 338)
240–260K (No. of pixels 3611)
260–280K (No. of pixels 11138)
280–300K (No. of pixels 5613)
400
300
200
100
0
−4
−2
0
2
4

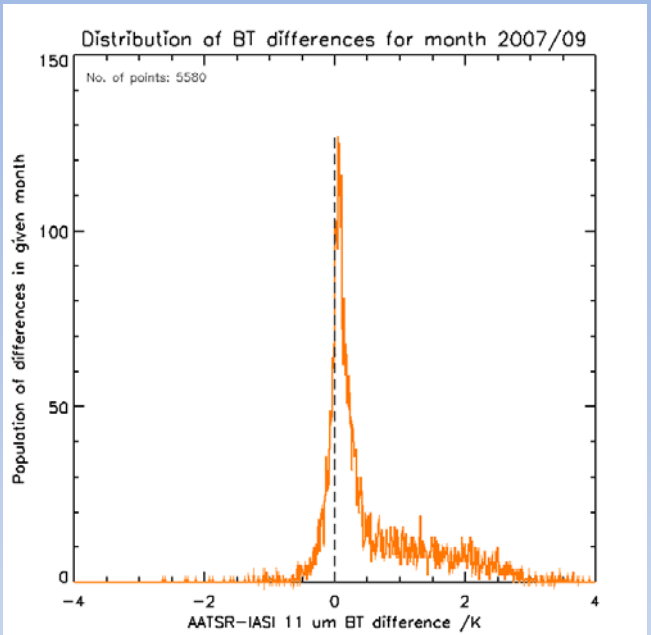
Land

Land / Day / 1% angle difference 11 µm

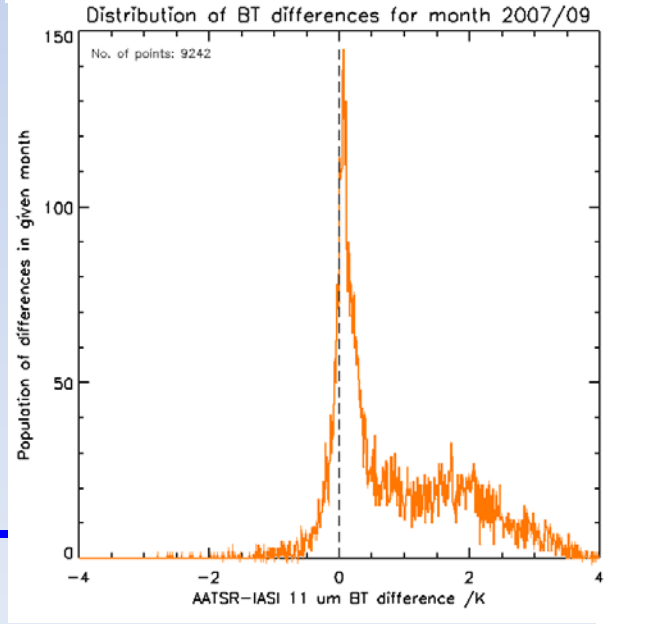
15 minutes



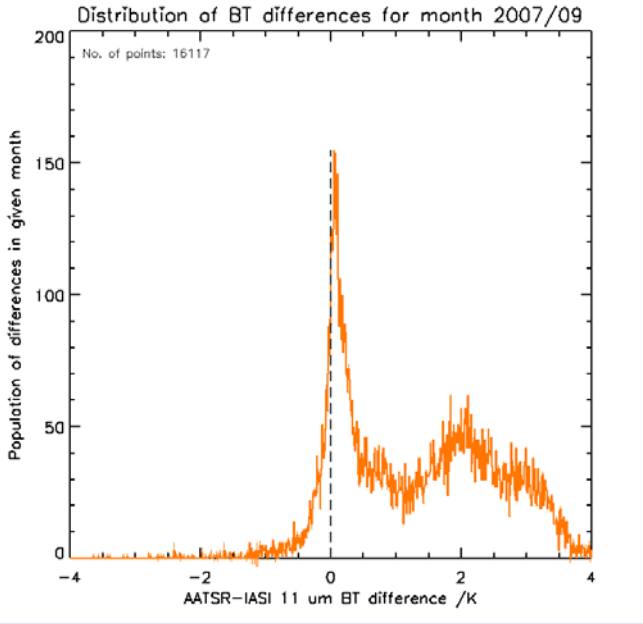
20 minutes



25 minutes

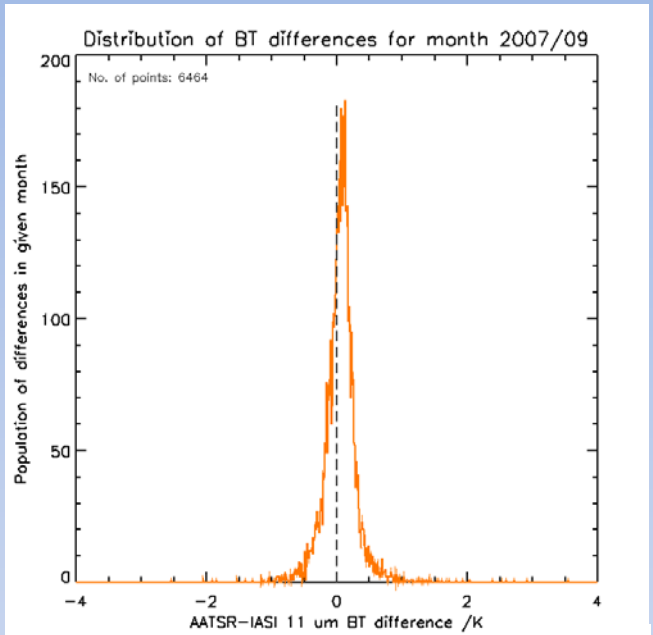


30 minutes

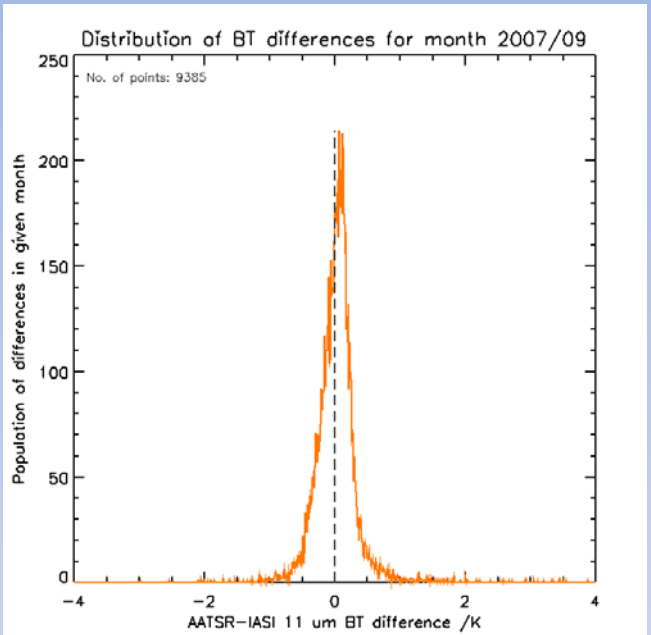


Land / Night / 1% angle difference 11 µm

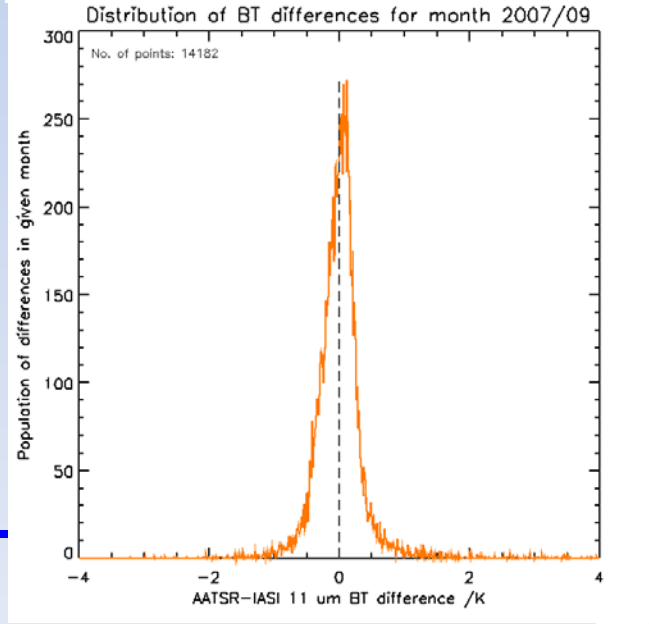
15 minutes



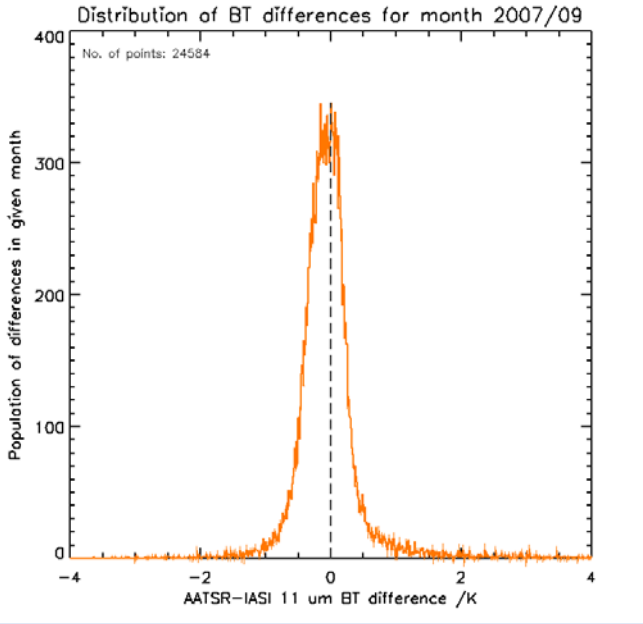
20 minutes



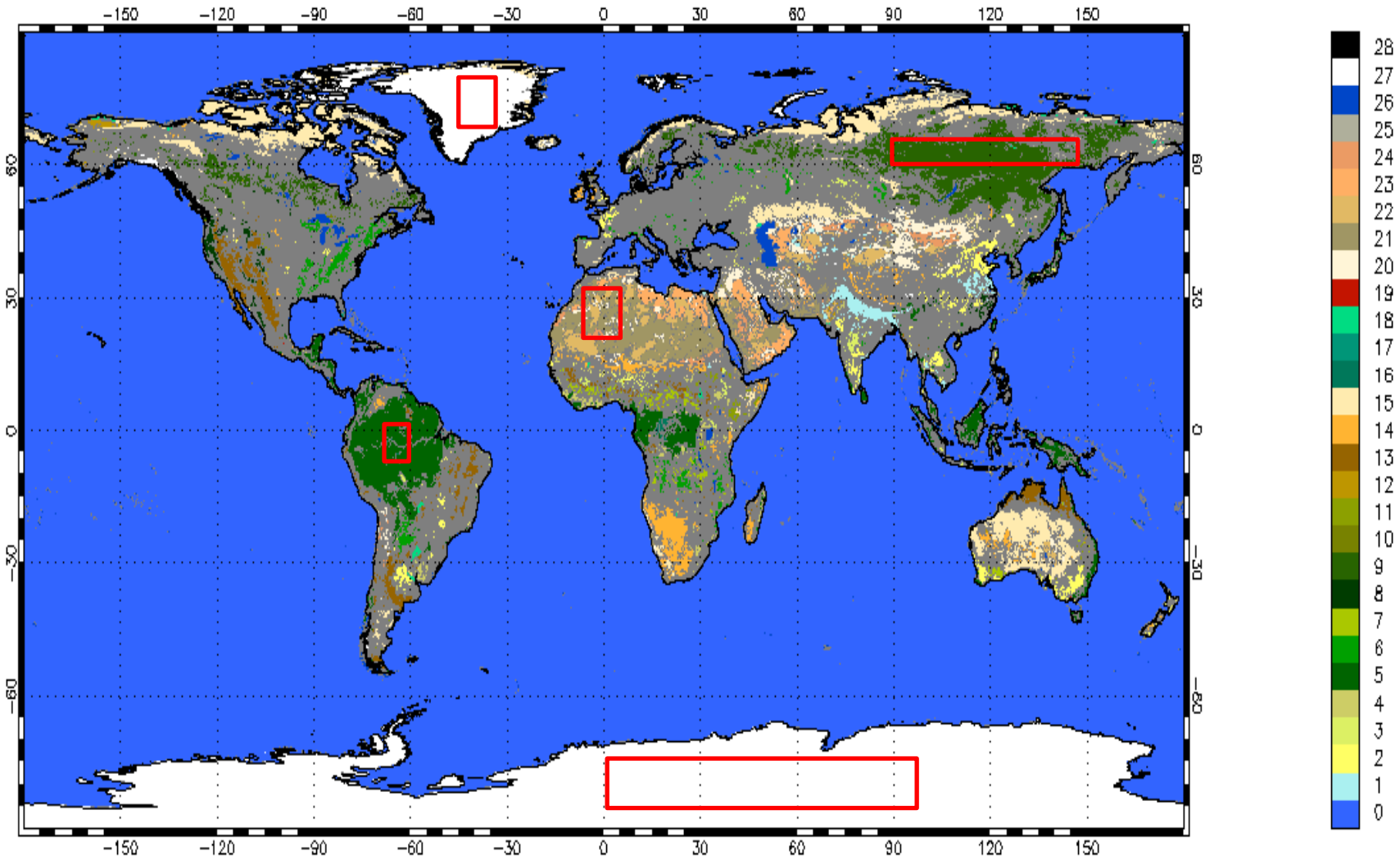
25 minutes



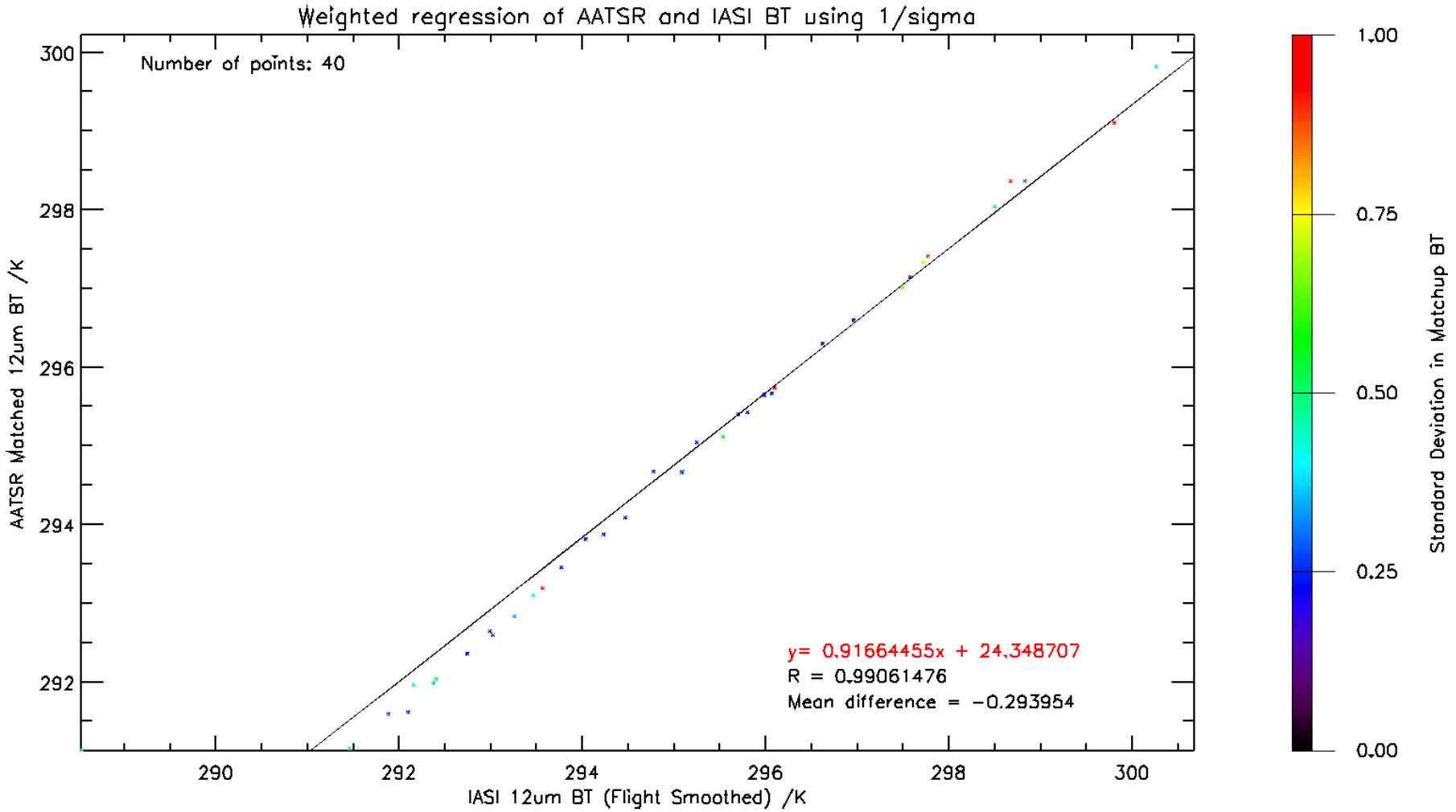
30 minutes



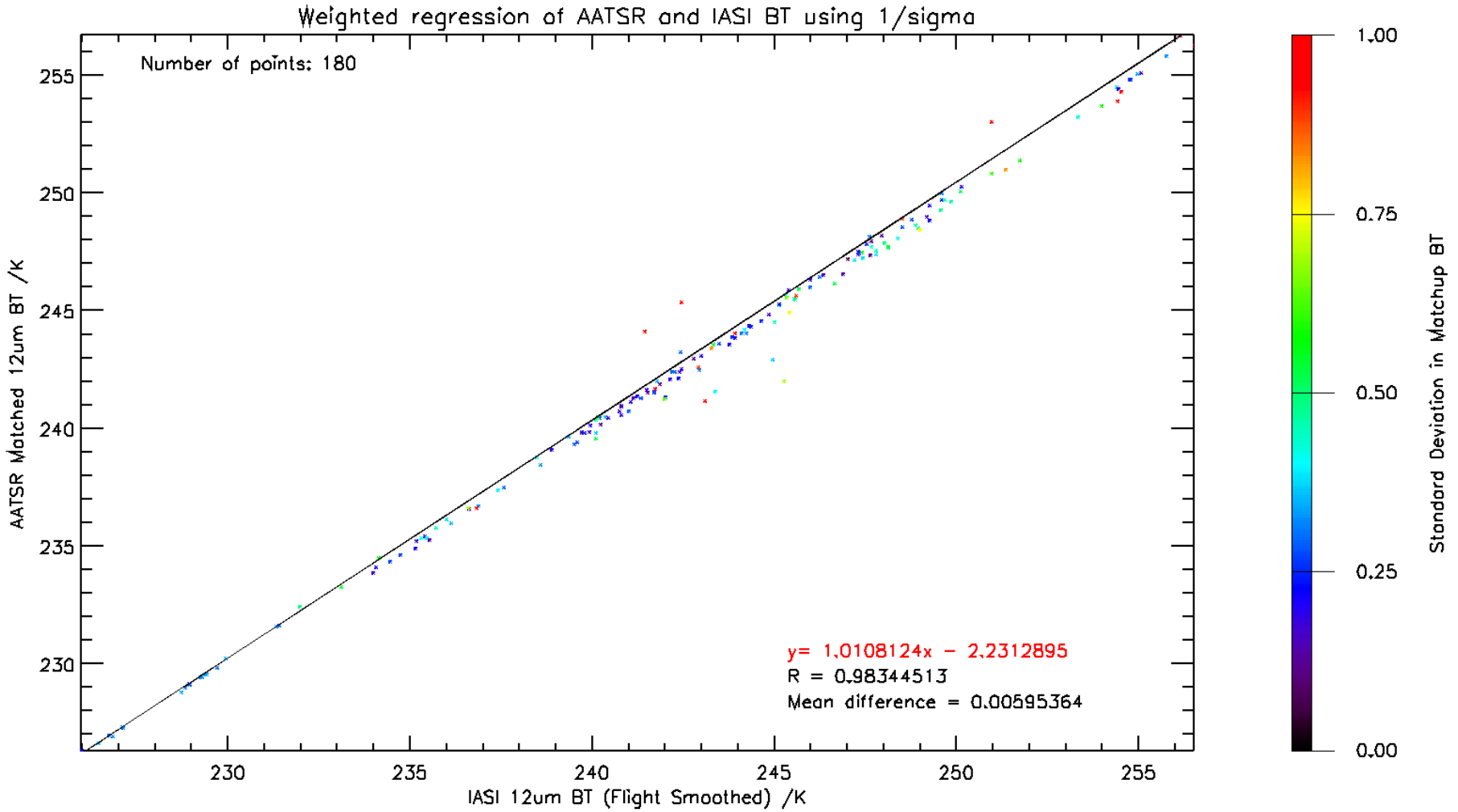
Biome Map


-150
-120
-90
-60
-30
0
30
60
90
120
150
60
30
0
-30
-60
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

Algeria / Night /1% angle difference/30 min time difference 12 µm

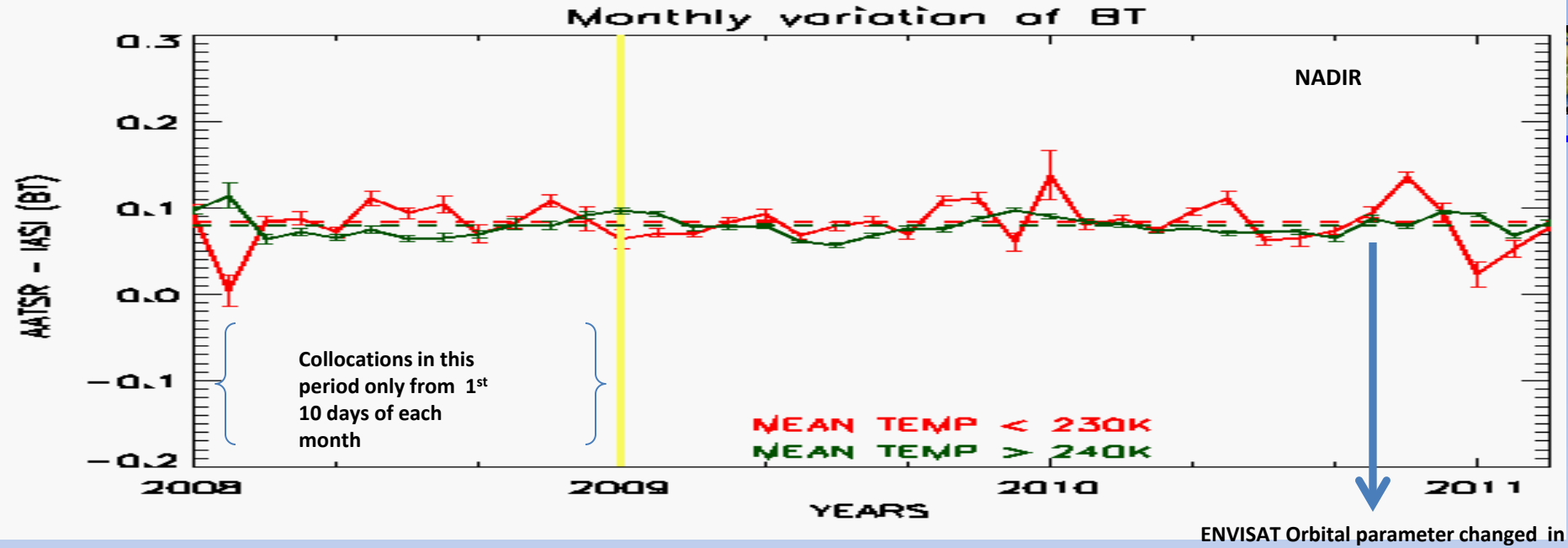


Greenland / Night/1% angle difference/20 min time difference 12 µm



Back to Time Series

(complete 2008-2010 + 1st 3 months 2011)

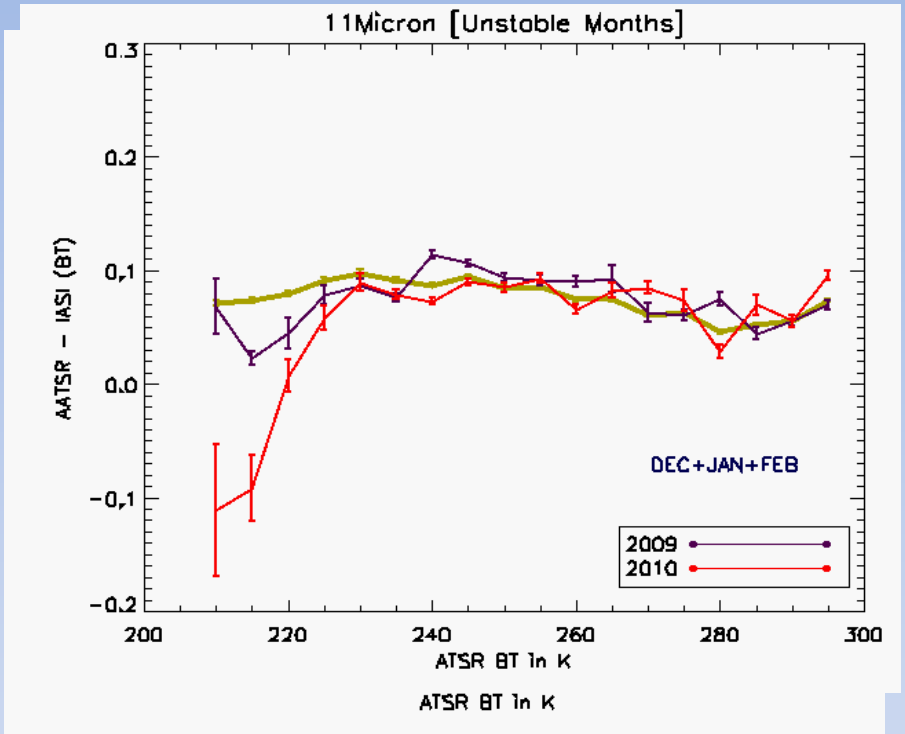


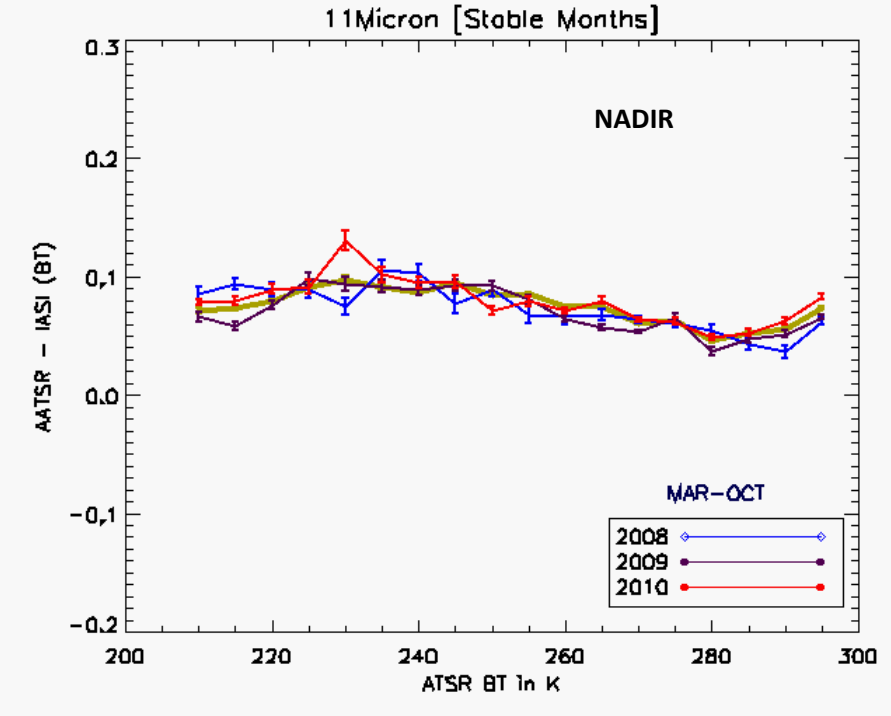
ENVISAT Orbital parameter changed in 10/2010.

MEAN Temp < 230 K			
	2008	01/2009 -10/2010 Before orbit maneuvering	11/2010 -03/2011 After maneuvering
SD of bias	0.028	0.022	0.031
Mean bias	0.083	0.086	0.062

MEAN Temp > 240 K			
	2008	01/2009 -10/2010 Before orbit maneuvering	11/2010 -03/2011 After maneuvering
SD of bias	0.015	0.010	0.012
Mean bias	0.078	0.078	0.084

- For Temp < 230 K, the Jan., Feb. , and Dec. appear more biased than rest of the months (detailed in next slide)
- For Temp > 240 K shows stability of bias in all the months.(*Plot Above*)
- Bias appears more unstable immediately after orbital parameters were changed in Oct. 2010 but recovers in March 2011(*See Tables on left*).



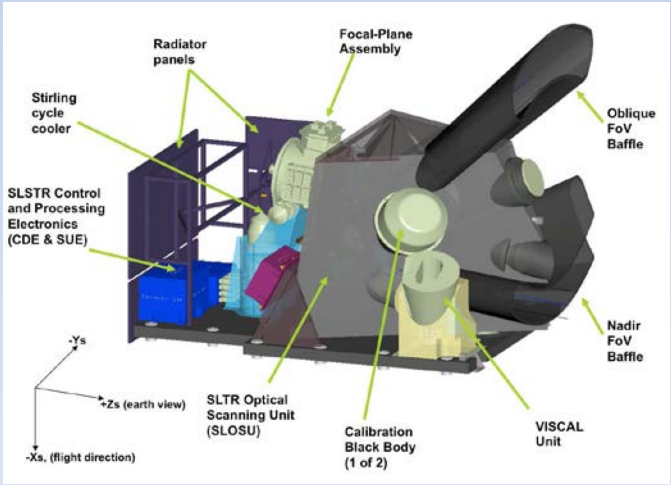


Plots show the variation with temperature for unstable months and stable months. The thick green line is the mean bias variation over all the years. In the unstable months plot, Year 2008 has Jan. & Feb. of 2008 only, rest of the years have Dec. of that year along with Jan. and Feb. of year+1, in order to club unstable months together.

- The instability in bias is mainly confined to T < 230K .
- The 2010-2011 bias stands out as it increases much more rapidly with decreasing temp.

SLSTR/Sentinel-3 characteristics

- Equivalent baseline performance to AATSR (ATSR-4!)
- Recognition of LST (land) as being important in addition to SST (sea)
- Backwards oblique view + double scanner
- Wider swath (improved re-visit) – 1420 km
- Extra SWIR (cloud) channels
- Improved fire channels
- Visible channels at 0.5 km resolution
- Launch April 2014



Coppo et al., J. Mod. Opt, 2010
Donlon et al., RSE, 2012

Summary

- IASI and the ATSR series are both great instruments for climate
- Difference at 11 µm is less than 0.1 K (function of BT)
- Difference at 12 µm is function of BT and is larger. Suspected to be due to AATSR spectral filter change.
- Land at night and Greenland promising for inter-calibration so far.
- There will be challenges with the launch of the SLSTR instrument: complexity; radiometric calibration;
- IASIs on MetOp-A and MetOp-B will be vital. Need traceable calibration from IASI-A. Ideal is direct inter-calibration of SLSTR with IASI-A. Necessary for bridging of data gap.