AATSR Mission Highlights

Philippe Goryl & AATSR team

Envisat IOP Closure Meeting, 11 October 2012

Outline

- INTRODUCTION
- PROCESSOR, ALGORITHM, REPROCESSING HISTORY
- APPLICATIONS
- ISSUES and OPEN POINTS
- TOWARDS SENTINEL-3
- CONCLUSION

Introduction

(A)ATSR series are AO instruments (UK, with Australia) on board ESA platforms initially designed to measure the SST

AATSR is the follow-on of ATSR-1 (1991), ATSR-2 (1995)
→ 21 years of measurements of very high accuracy
→ Homogenous and consistent data set

(A)ATSR is the precursor of SLSTR (ATSR-4!)
→ Could lead to 41 years of consistent and highly accurate data
→ Unique record data set for climate applications

THE TEAM

AATSR management - DECC, ESA

AATSR Science Team led by David Llewellyn-Jones (AATSR PI from UoL) with support from many other scientists in AATSR Science Advisory Group

AATSR Validation Team led by Gary Corlett (UoL) with support from SST validation – ISAR (Werenfrid Wimmer , UoS), M-AERI (Peter Minnett, RSMAS), SiSTeR (Tim Nightingale, RAL) and others

AATSR QWG
Andy Chalmers, Anne O'Carroll, Andrew Birks, Brian Maddison, Cathy Johnson, Chris Sear, Chris Mutlow, Craig Donlon, Dave Smith, David Llewellyn-Jones, Gareth Davies, Gary Corlett, Hannah Clarke, Jack Abolins, John Remedios, Karen Veal, Nigel Houghton, Pauline Cocevar, Chris Merchant, Philippe Goryl , Stefano Casadio, Tim Nightingale, Caroline Cox, Siân O'Hara, Hugh Kelliher

AATSR IDEAS led by VEGA (Telespazio) UK

+ all others not mentioned….

Introduction

→ **Lesson learnt: PEOPLE and teams are the most important and are the key to the success !**

→ **Lesson learnt: Organisation and communication**

- **4 Pillars**
  - **Calibration Scientist** *(Dave Smith)*
  - **Validation Scientist** *(Gary Corlett)*
  - **Routine QC** *(Sian O'Hara)*
  - **Algorithm Development**

Processors History

IPF Changes – Main Updates		
Feb 2002	5.01	Launch version
Jun 2002	5.02	Scan jitter error corrected Browse algorithm improved
Jan 2003	5.55	Modifications to Viscal algorithm
Mar 2004	5.58	New LST algorithm for NR product Further Viscal algorithm modifications
Jan 2007	5.60	AST confidence word correction Cloud flagging errors corrected
Mar 2007	6.0	Cloud-clearing over land improved Improvements to LST algorithm
Jul 2007	6.01	Correction for wrong ANX calculation
Jun 2010	6.03	Preparations for Envisat 2010+ AST 17km cell confidence word fixed
2012	*6.05*	*Improved viscal algorithm*

A reprocessing is currently planned with IPF v6.05 and updated aux files (in *blue*)

- Two previous reprocessings have been done, in 2004 (v5.58) and 2007 (v6.01)

ADF Changes – Main Updates		
ATS_VC1_AX	Sep 2002 Nov 2005 Dec 2006 Feb 2007 *2012*	Corrected scaling errors; replaced by daily files To account for Viscal drift Viscal drift correction update Orbital files delivery started *Complete set of orbital files reproduced for reprocessing, including measured drift correction*
ATS_CH1_AX	Nov 2002 *2012*	Colocation correction *Colocation and geolocation correction*
ATS_PC1_AX	Jan 2003 Aug 2004 *2012*	To support IPF v5.55 update Updated solar irradiance data *To support IPF v6.05 update*
ATS_GC1_AX	Dec 2004	1.6µm non-linearity correction
ATS_SST_AX	Dec 2005 *2012*	Revised SST coefficients *Updated SST coefficients (using ARC)*
ATS_CL1_AX	Mar 2007 *2012*	Cloud test changes (for IPF v6.0) *1.6µm & gross cloud tests corrections*

- All AATSR IPF and ADF changes are detailed at: http://earth.eo.esa.int/pcs/envisat/aatsr/events/

Processors History

- **AATSR L2P**:

In December 2008 ESA took over the responsibility for producing L2P products in netCDF format as part of AATSR operations

  - Had been initiated by the DUE Project Medspiration, as part of the European contribution to GHRSST
  - This was essentially a repackaging of the L2 NR products

L2P Processor Changes – Main Updates		
Dec 2008	1.1	Initial version (NRT only)
(Feb 2009)	-	(Format of xml description files updated)
May 2009	1.5	• Addition of Aerosol Optical Depth • Addition of satellite minus SST analysis • Lat/lon coords provided for pixel centre • Header time fields include UTC keyword • View difference only provided for SST pixels
Nov 2009	1.5.	Order of two metadata file parameters swapped
2012	***N/A***	***NEW PROCESSOR***

- Archive L2P products were produced with v1.5. for all three ATSRs

- A **new processor**, based on the ARC (ATSR Reprocessing for Climate) processor, has been developed (yet to be installed) to produce L2P and L3U data products as part of the planned reprocessing
  - SSTs will be calculated directly from L1B data
  - Will be GHRSST Data Specification v2.0 format netCDF products

Processors History

→ **Lesson learnt:** Modelling of Visible Calibration can be complex. Need for good communication and consistency (Dave's presentation).

→ **Lesson learnt:** ATSR-2 and AATSR behaved differently. SLSTR A and B could be very different.

→ **Lesson learnt:** ENVISAT format was a limitation. Too rigid, impact on all the GS. Need more flexibility. NETCDF 4 is envisaged for SLSTR and future ATSR reprocessing – TBC.

Processors History

→**Lesson learnt:** **Data quality and Cal/Val over the full mission lifetime and across similar missions requires a sustainable and long term effort**

- Instrument ageing (and instrument anomalies)
- State-of-the-art processing algorithms, including new products:
  - in response to evolving user expectations
  - in response to large programmes such as ESA Climate Change Initiative or GMES services

→ **Lesson learnt:** **Reprocessing every 2 to 3 years is probably necessary**

→ **Lesson learnt:** **Processor version for reprocessing is confusing. We need to adopt another convention (e.g. 'collection' as for MODIS)**

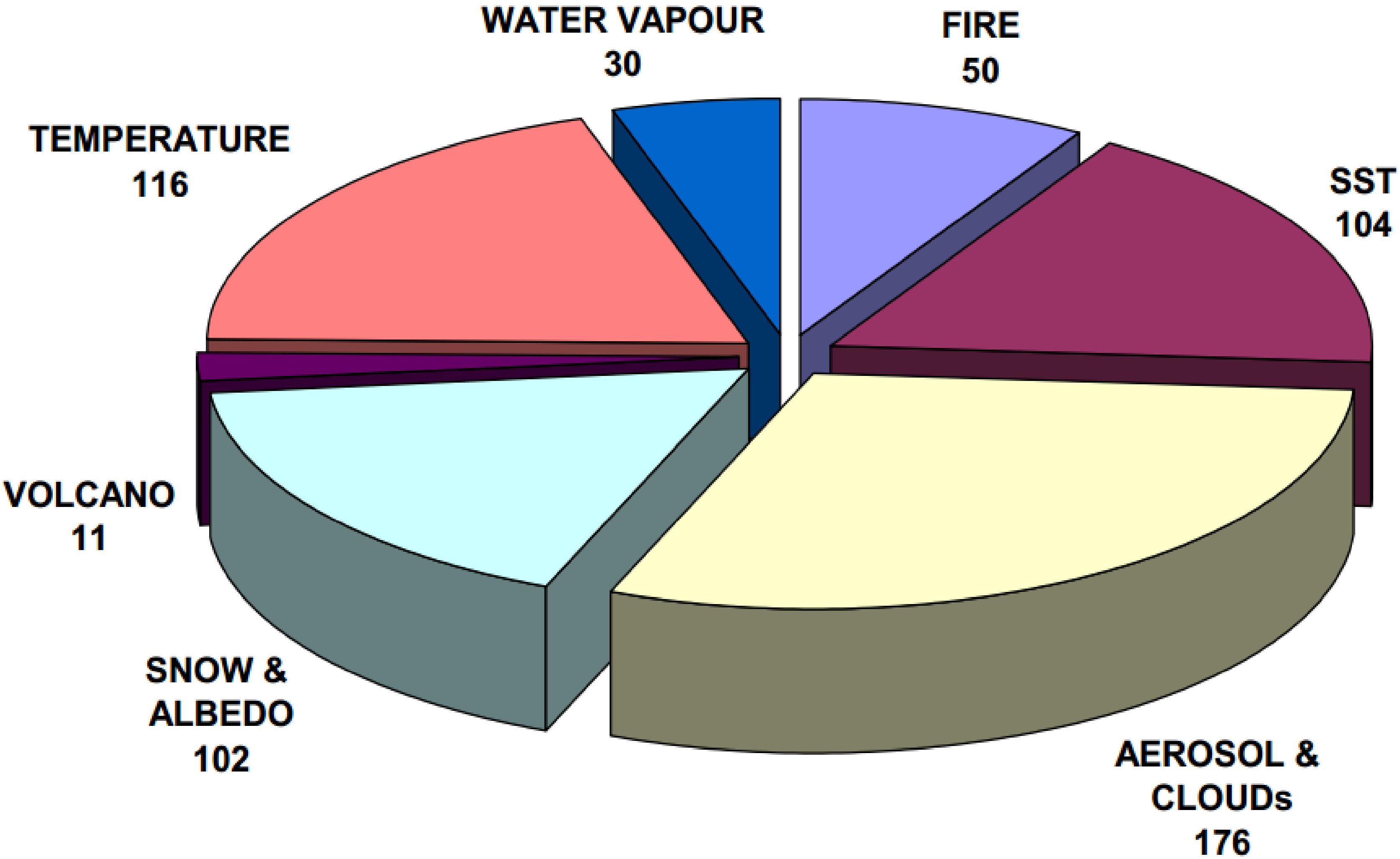
AATSR products accuracy

Products	Specification	Accuracy	Comments
AATSR Radiometry	Thermal < 0.2 K	< 0.1 K	From SST validation and algorithm sensitivity study
	Visible < 5 %	< 3 %	Vicarious calibration using stable sites (Desert, Greenland) and cross-sensor with MERIS
AATSR Geolocation	Absolute NAD	< 1 pixel	Absolute geolocation assessed using comparisons to Globcover and other ground targets
	Collocation of NAD and FWD views	<< 1 pixel	Collocation between Nadir and Forward views evaluated using BT comparisons and SST match-ups to drifting buoys.

Products	Specification	Accuracy	Precision	Comments
SST day (1 km)	< 0.3 K (1 σ)	< 0.04 K	< 0.20 K	***Based on ARC comparisons to SISTeR, M-AERI, ISAR and drifting buoys***
SST night (1 km)	< 0.3 K (1 σ)	< 0.02 K	< 0.15 K	***Based on ARC comparisons to SISTeR, M-AERI, ISAR and drifting buoys***
LST day (1 km)	< 2.5 K	0.2 → 3.8# K	0.9 → 1.4 K	***Based on results from many site including Valencia, Niger, Oklahoma and Cardington.***
LST night (1 km)	< 1.0 K	0.0 → 2.0# K	0.5 → 1.5 K	***Based on results from many site including Valencia, Niger, Oklahoma and Cardington.***

AATSR - Multi Applications

589 CAT-1 Projects exploiting



Applications - SST

MEDSPIRATION – *Arino, Donlon, Robinson.*

Pioneer project with huge benefit for:

- MyOcean and GMES
- Climate Change (CCI)
- GHRSST – general SST community

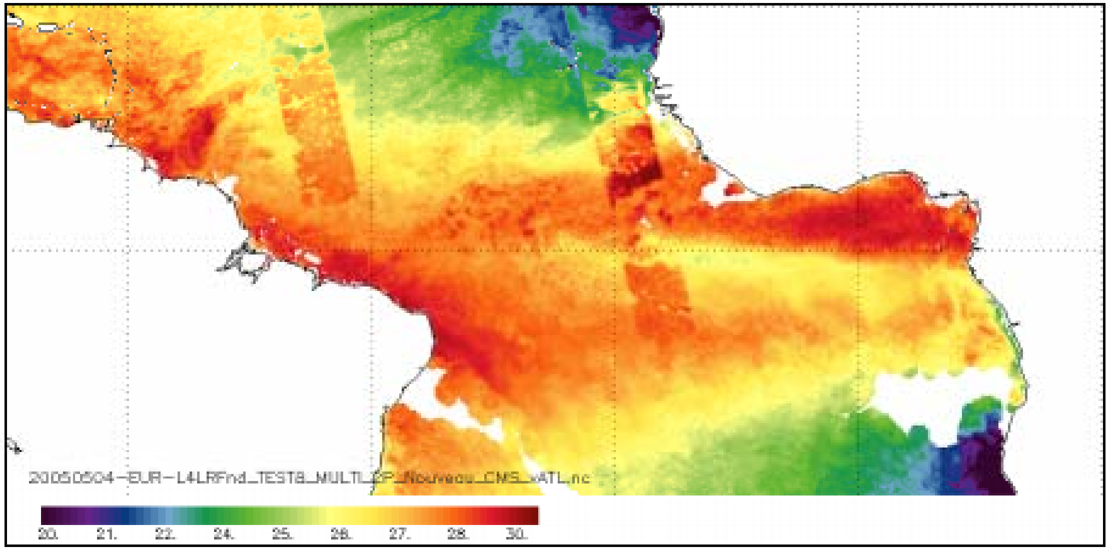
 There is evidence of its impact in:

- Its data products are now used in operational systems
- The superior quality of AATSR data is now widely agreed
- Its limited geographical coverage is no longer a problem
- It was needed as a reference standard
- There is international demand for its continuity → SLSTR
- Medspiration used as model for data format and Quality Indicator (SSES)

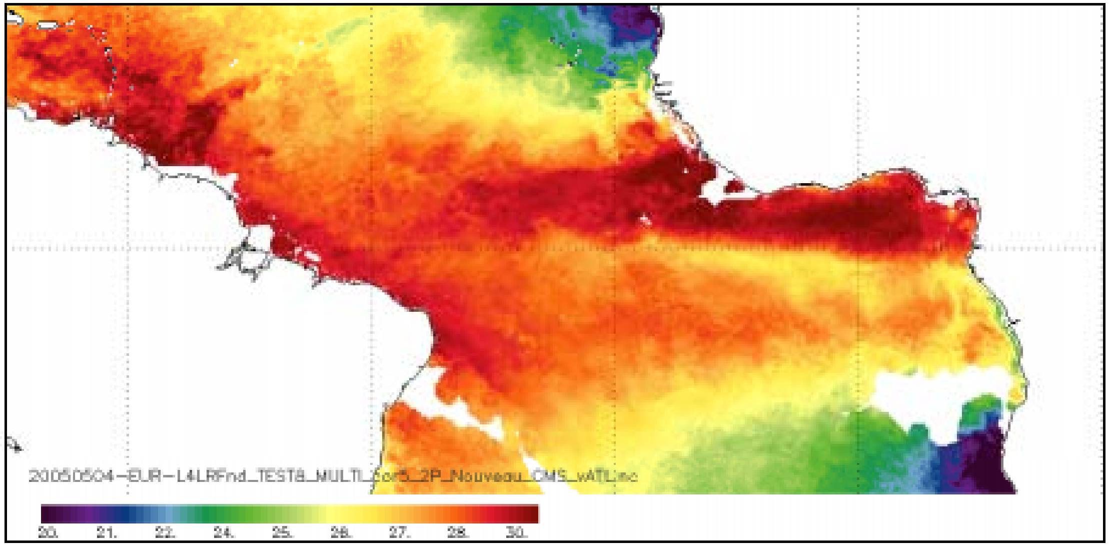
KEY to the success → Data Access, Quality, Quality Indicator

Applications - SST

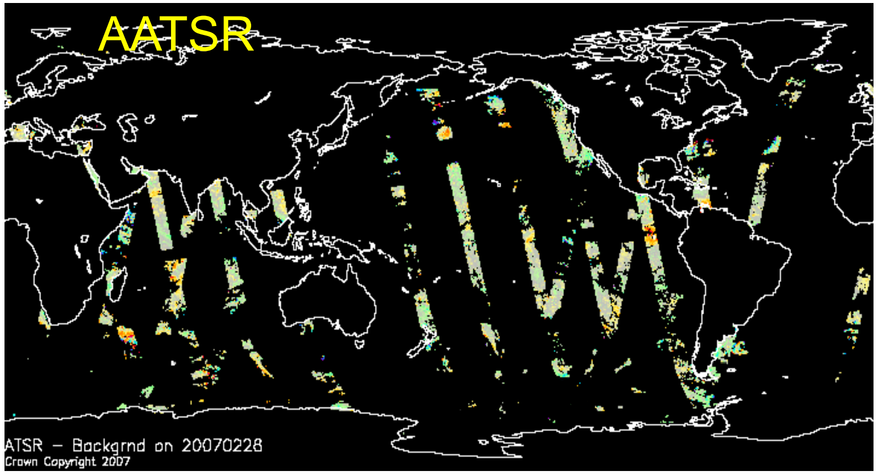
No bias correction is applied (upper panel)

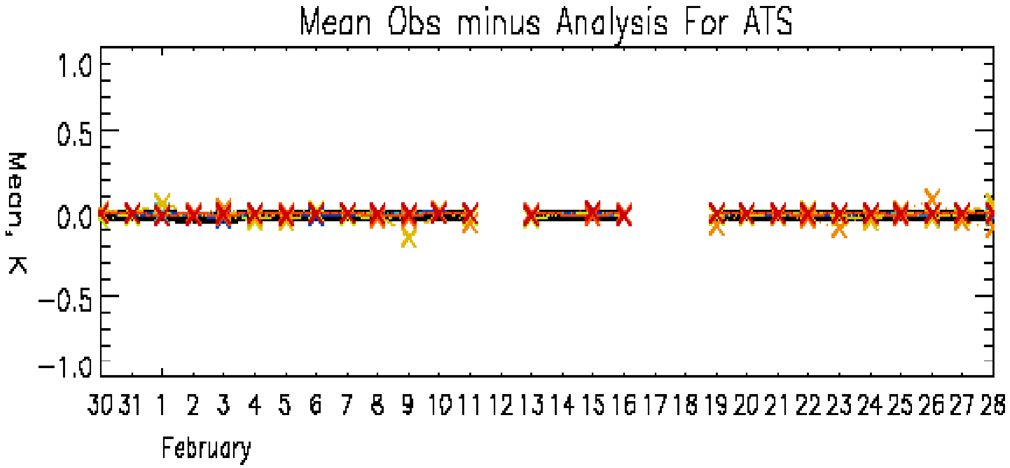


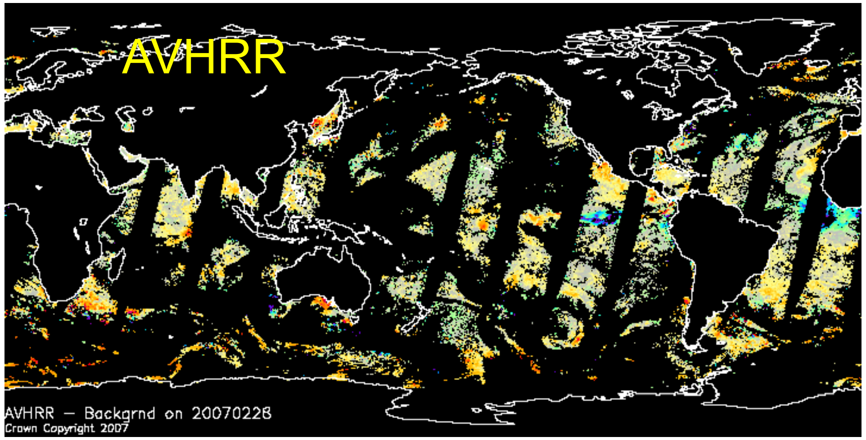
Bias correction to AATSR as a reference standard is applied over a 5-day window (lower panel)

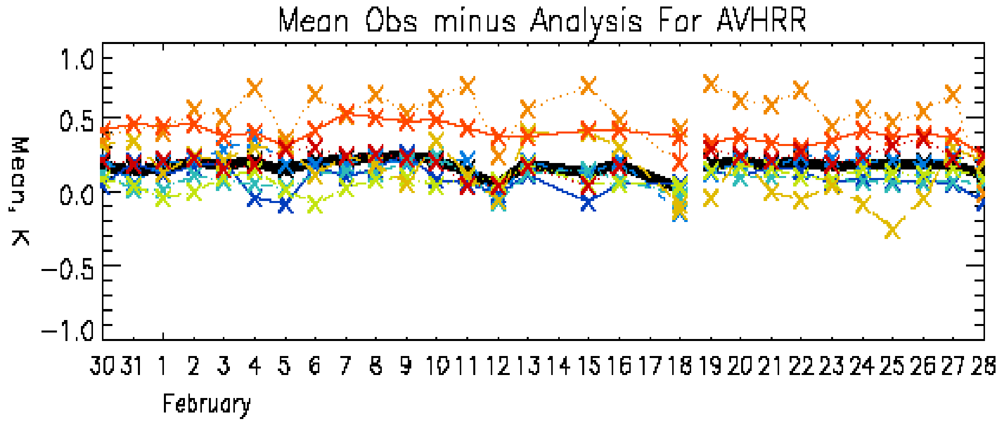


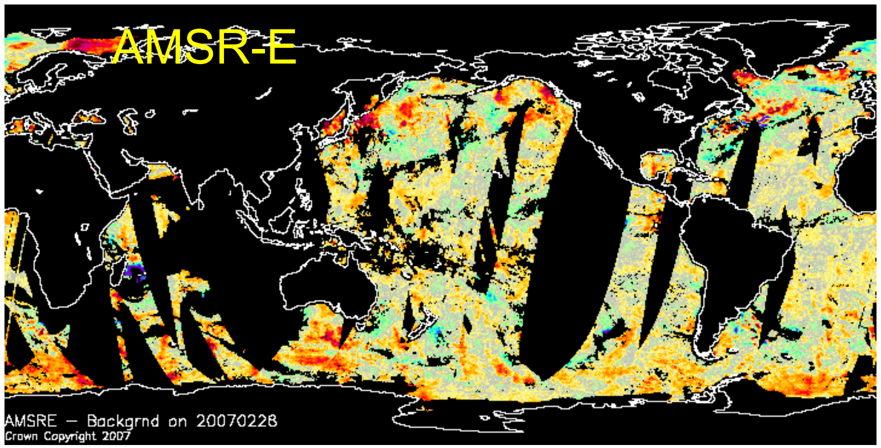
Ref. Widening the application of AATSR SST data to operational tasks through the Medspiration Service. I.Robinson et al, RSE 2012

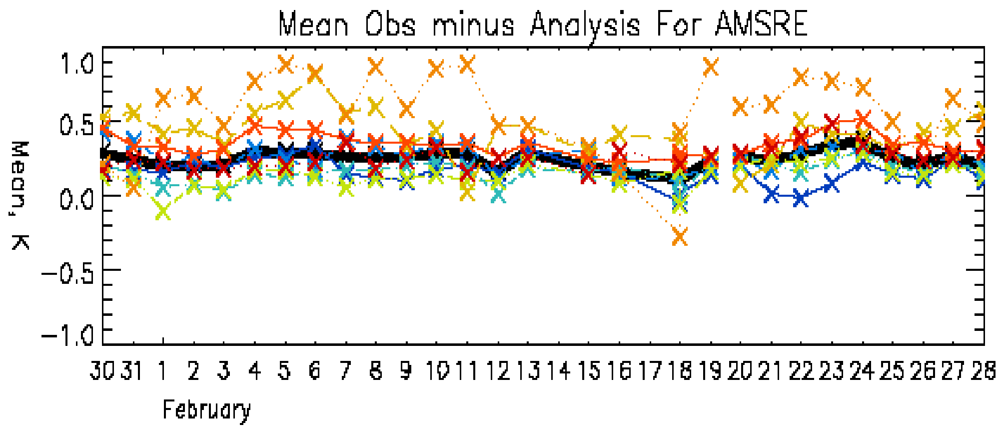

AATSR
ATSR – Backgrnd on 20070228
Crown Copyright 2007


Mean Obs minus Analysis For ATS
1.0
0.5
0.0
−0.5
−1.0
Mean, K
30 31 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
February

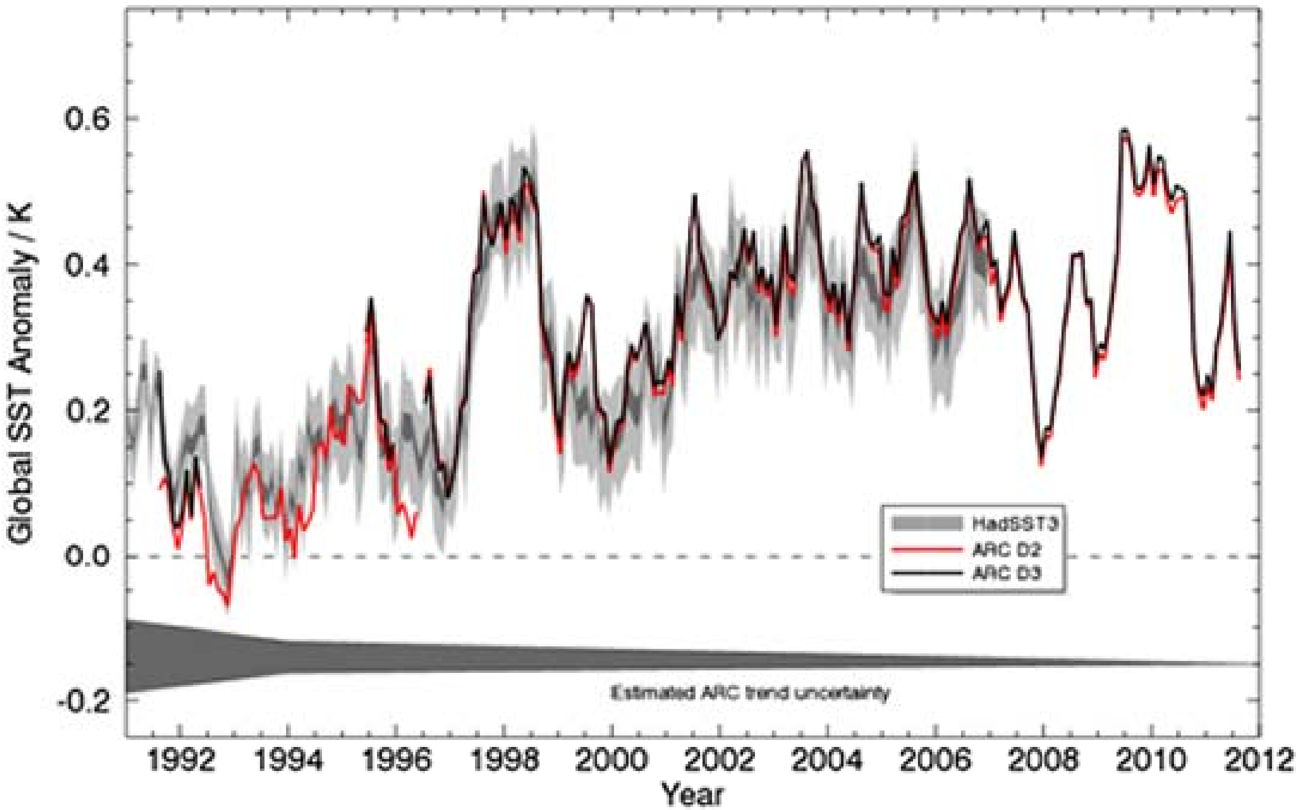

AVHRR
AVHRR – Backgrnd on 20070228
Crown Copyright 2007


Mean Obs minus Analysis For AVHRR
1.0
0.5
0.0
−0.5
−1.0
Mean, K
30 31 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
February


AMSR-E
AMSRE – Backgrnd on 20070228
Crown Copyright 2007

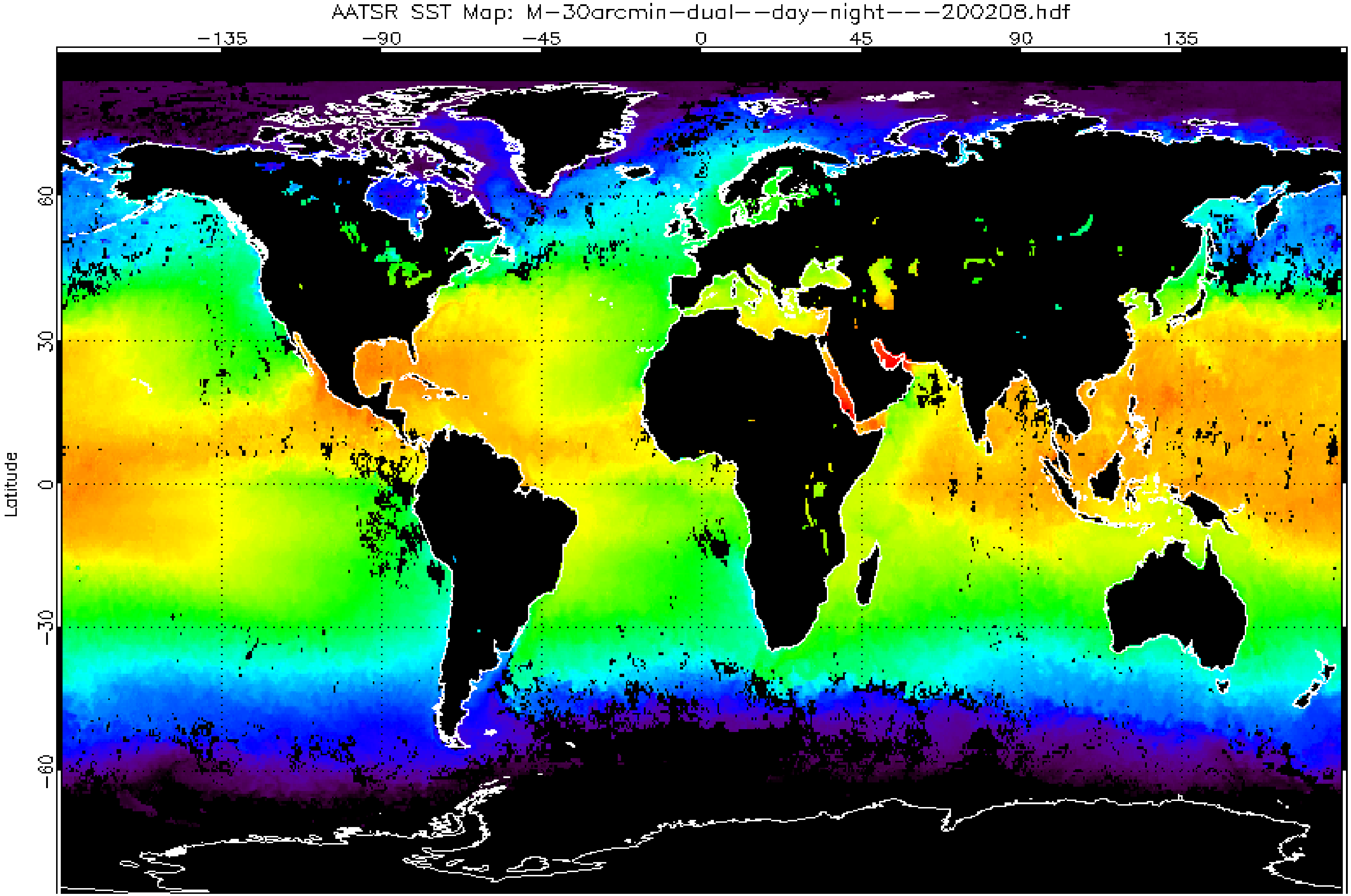

Mean Obs minus Analysis For AMSRE
1.0
0.5
0.0
−0.5
−1.0
Mean, K
30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
February

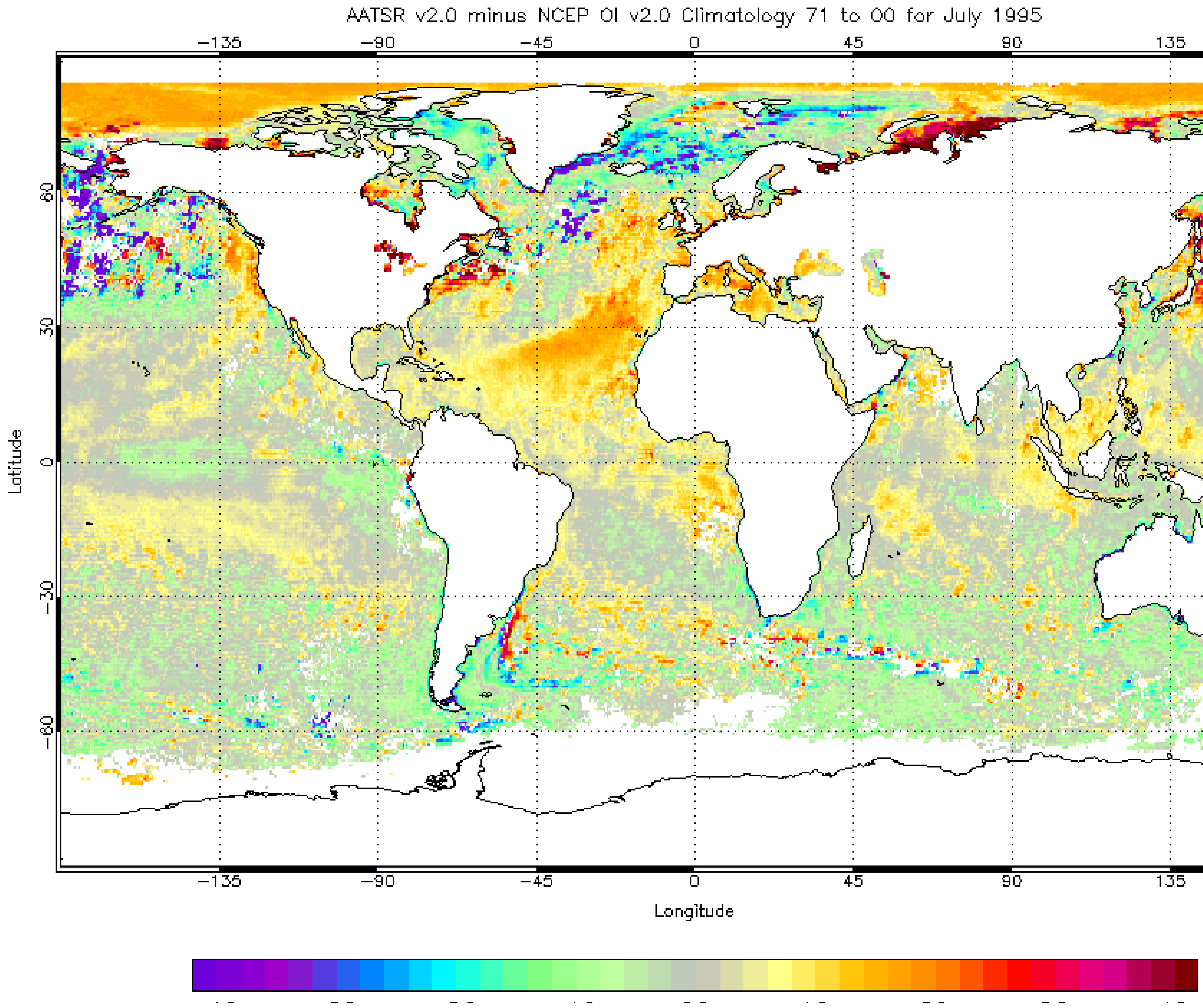
Applications – SST for climate

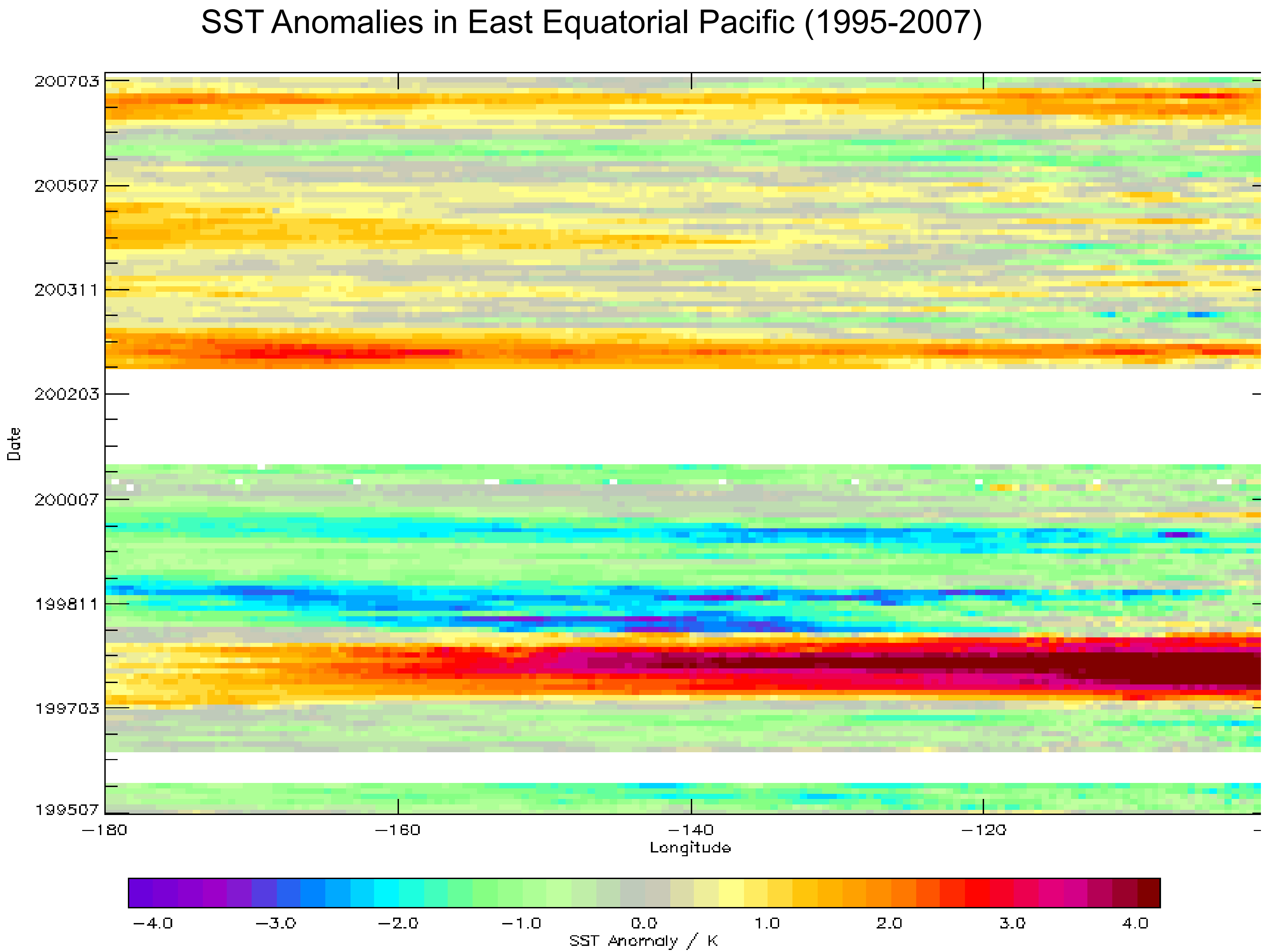


SST anomaly time series reported by ARC

Applications - SST

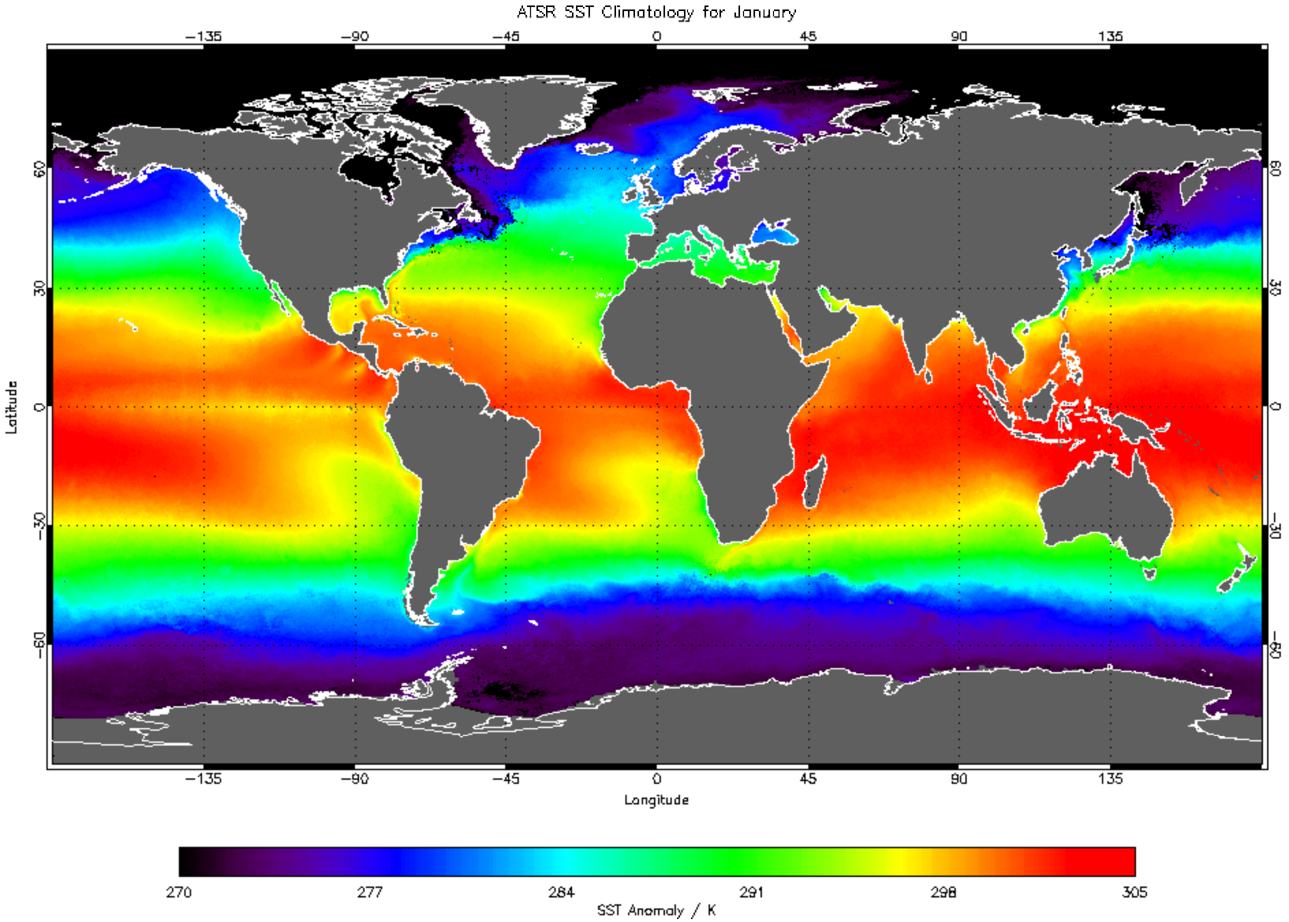



AATSR v2.0 minus NCEP OI v2.0 Climatology 71 to 00 for July 1995
−135
−90
−45
0
45
90
135
60
30
0
−30
−60
Latitude
Longitude

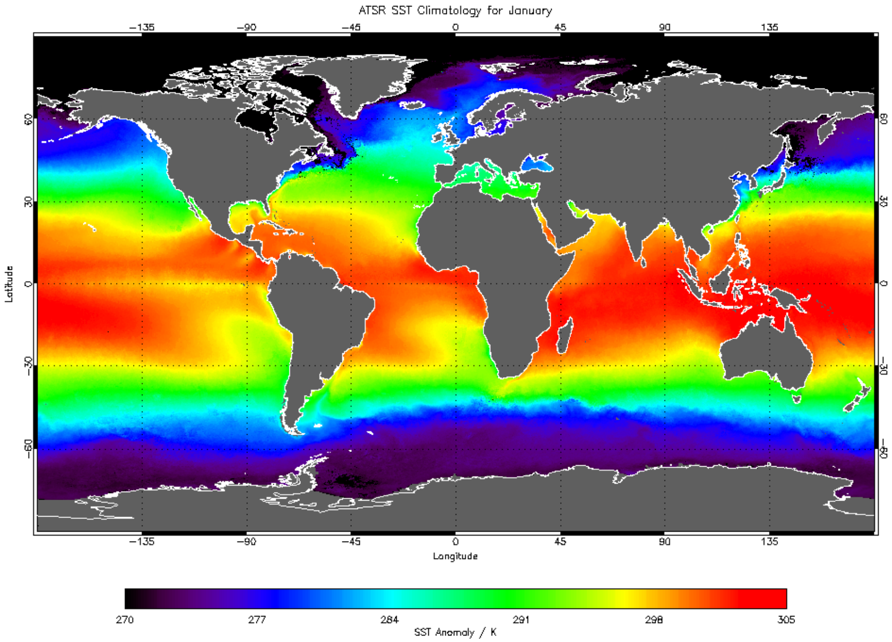


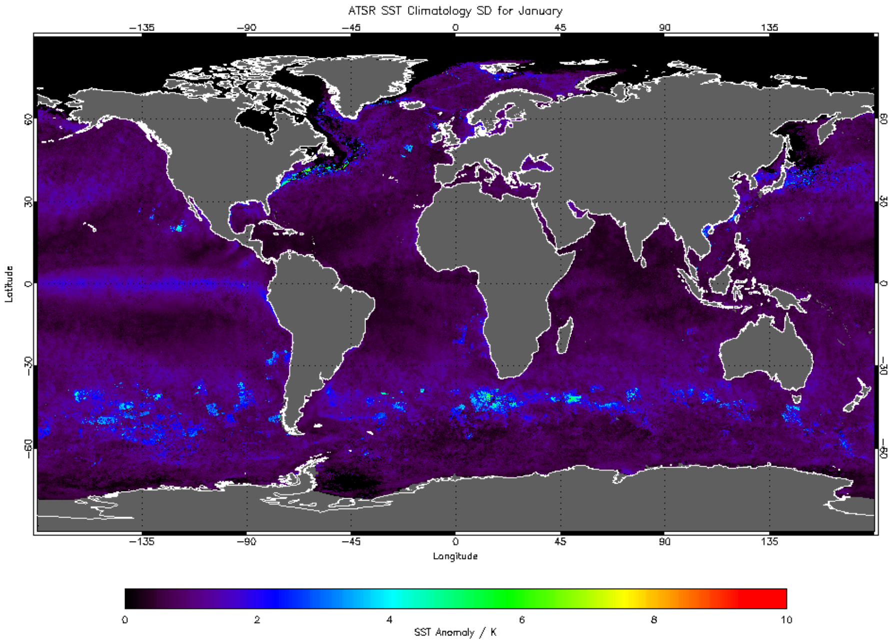
SST Anomalies in East Equatorial Pacific (1995-2007)
200703
200507
200311
200203
200007
199811
199703
199507
Date
−180
−160
−140
−120
Longitude
−4.0
−3.0
−2.0
−1.0
0.0
1.0
2.0
3.0
4.0
SST Anomaly / K

ATSR V2.0 18 Year SST Climatology (1)

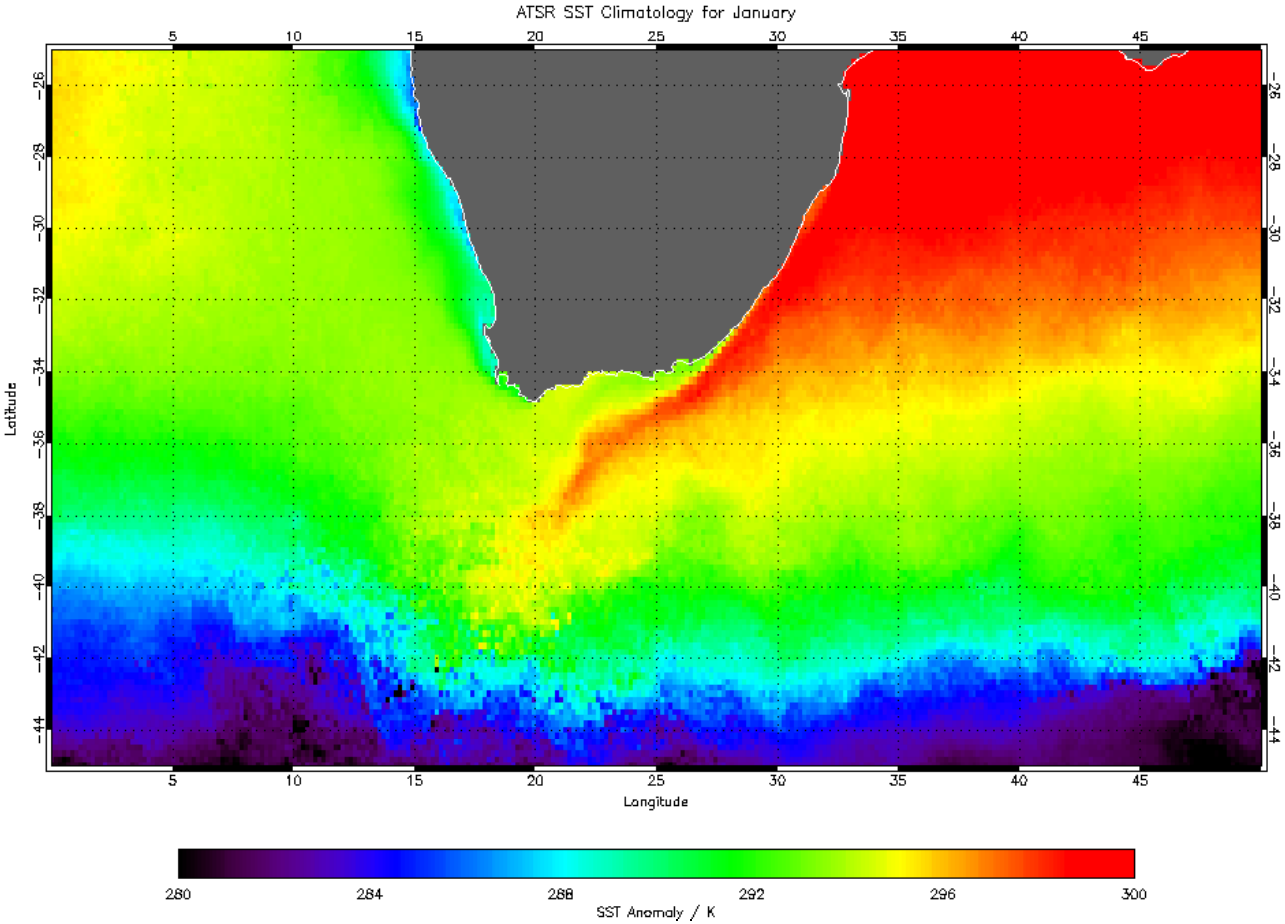


ATSR V2.0 18 Year SST Climatology (2)

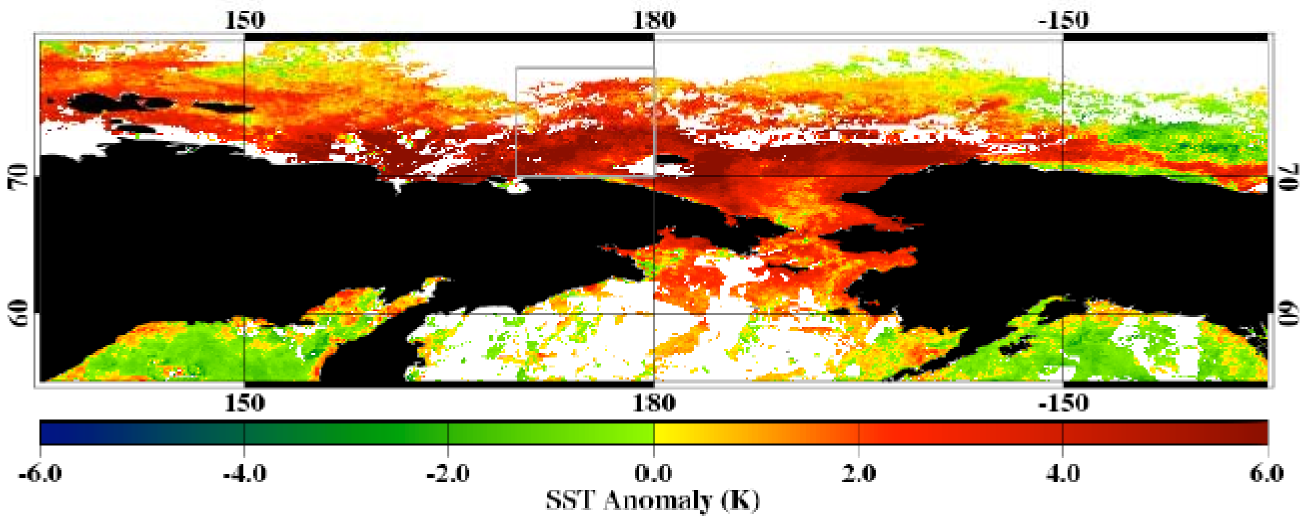




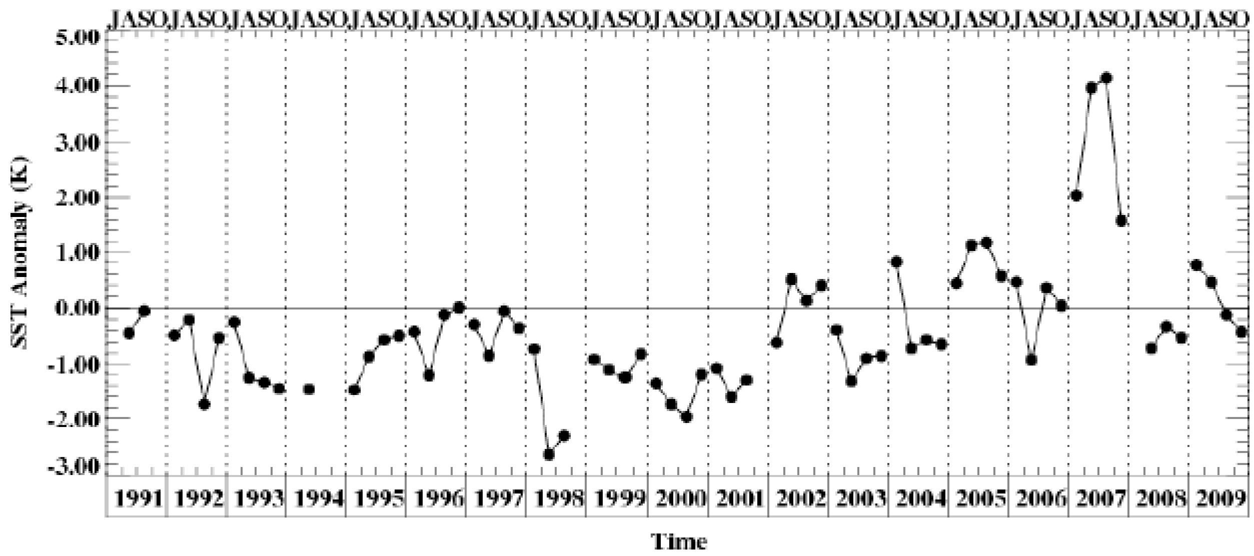
ATSR V2.0 18 Year SST Climatology (3)



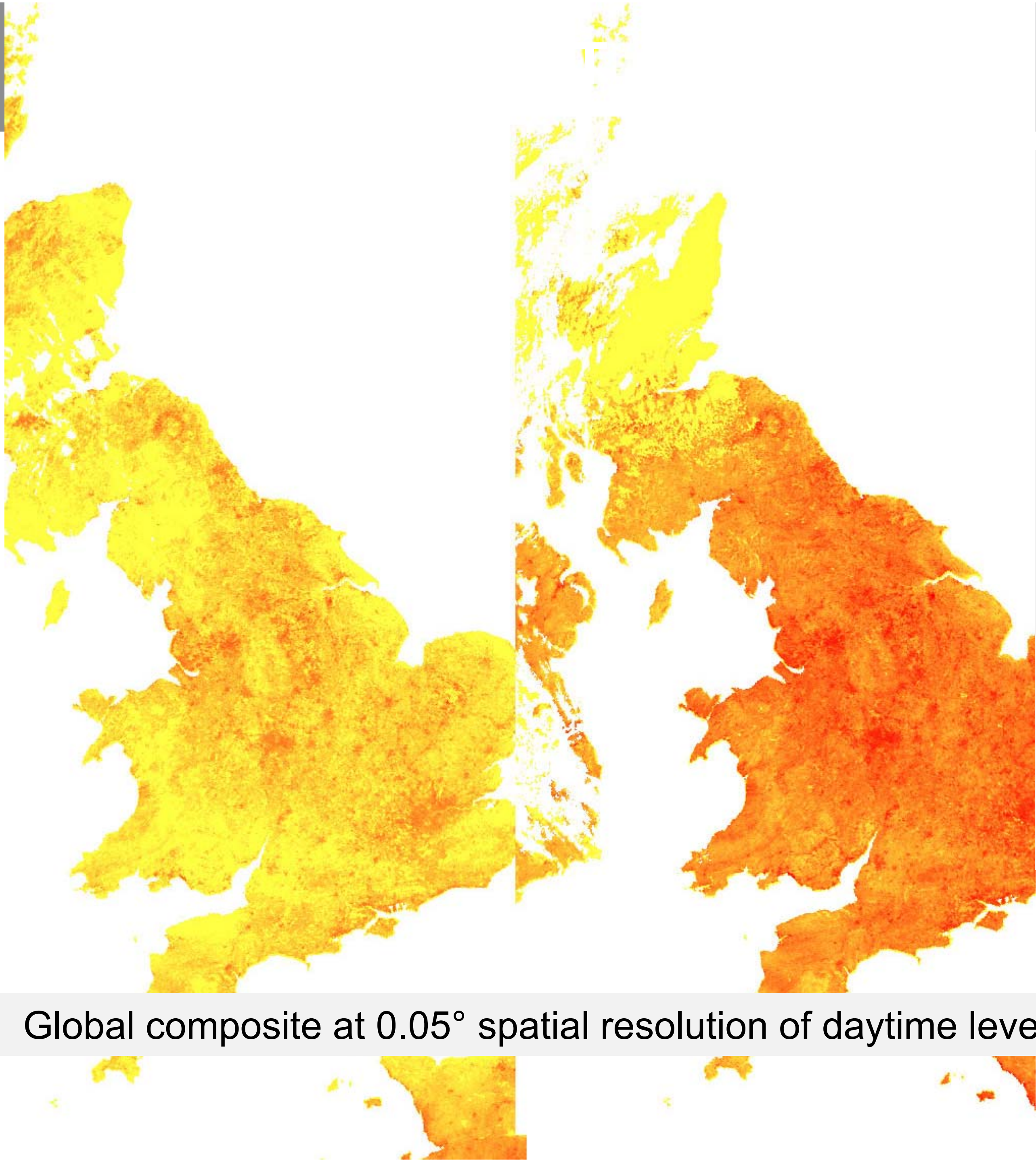
Polar SST Anomalies: Chukchi Sea



SST anomaly data for August 2007 in cylindrical map projection, over the regions north of Siberia and Alaska. The sample box identifies the Chukchi Sea box for the time series.



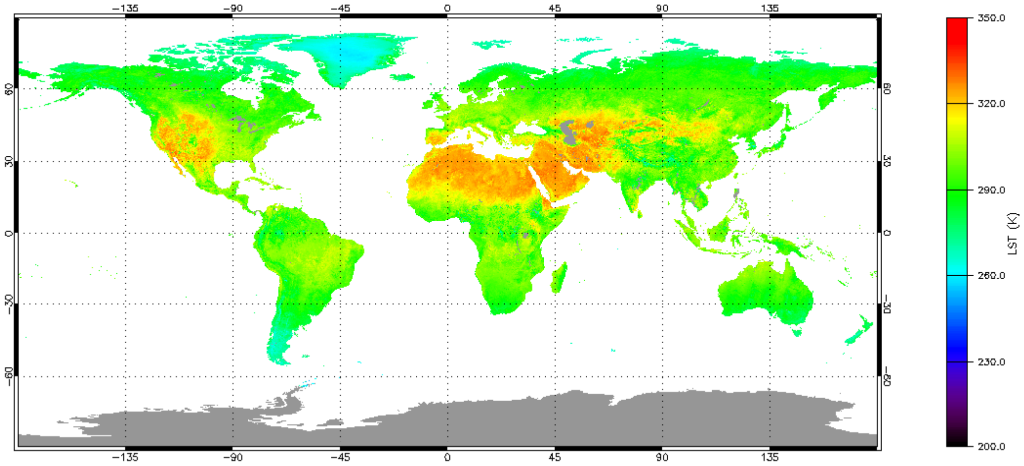
Monthly mean SST anomalies in the sample box for the Chukchi sea (entire ARC ATSR SST record).



This image shows the AATSR-derived LST over the United Kingdom for two days during a heat wave in July 2006. The left panel shows 15th July 2006, whereas the right panel shows the 18th July 2006. The color scale ranges from yellow to red, with red indicating warmer temperatures. A significant increase in LST can be observed between the two days

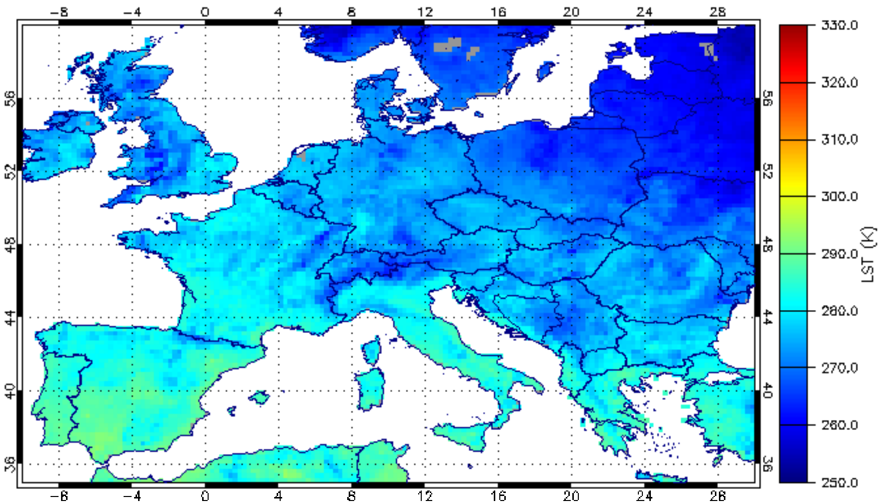
Global composite at 0.05° spatial resolution of daytime level-3 AATSR LST for July 2006

AATSR Level-3 product at user-defined spatial resolution

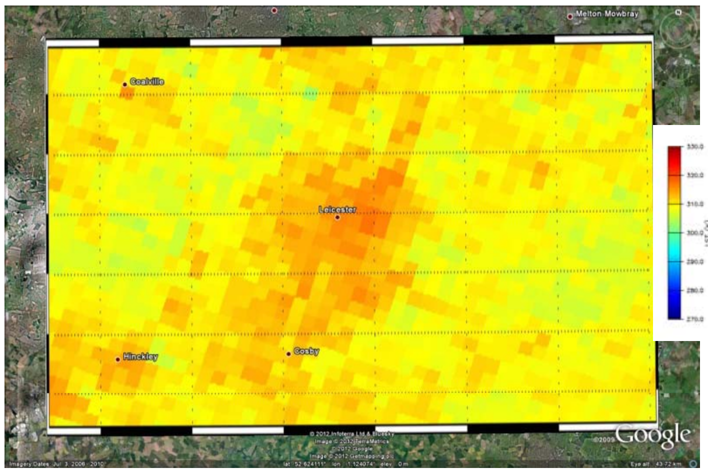


Global daytime July 2007 at 0.05°

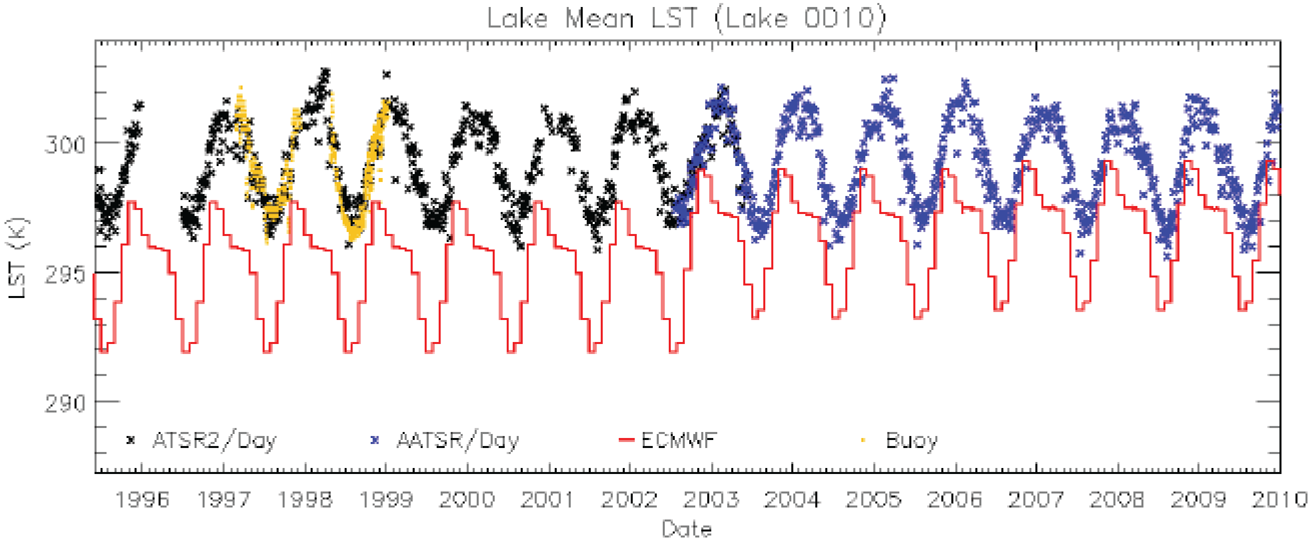
Europe daytime Feb 2011 at 0.25°



AATSR urban heat map of Leicester



Applications – Lake ST



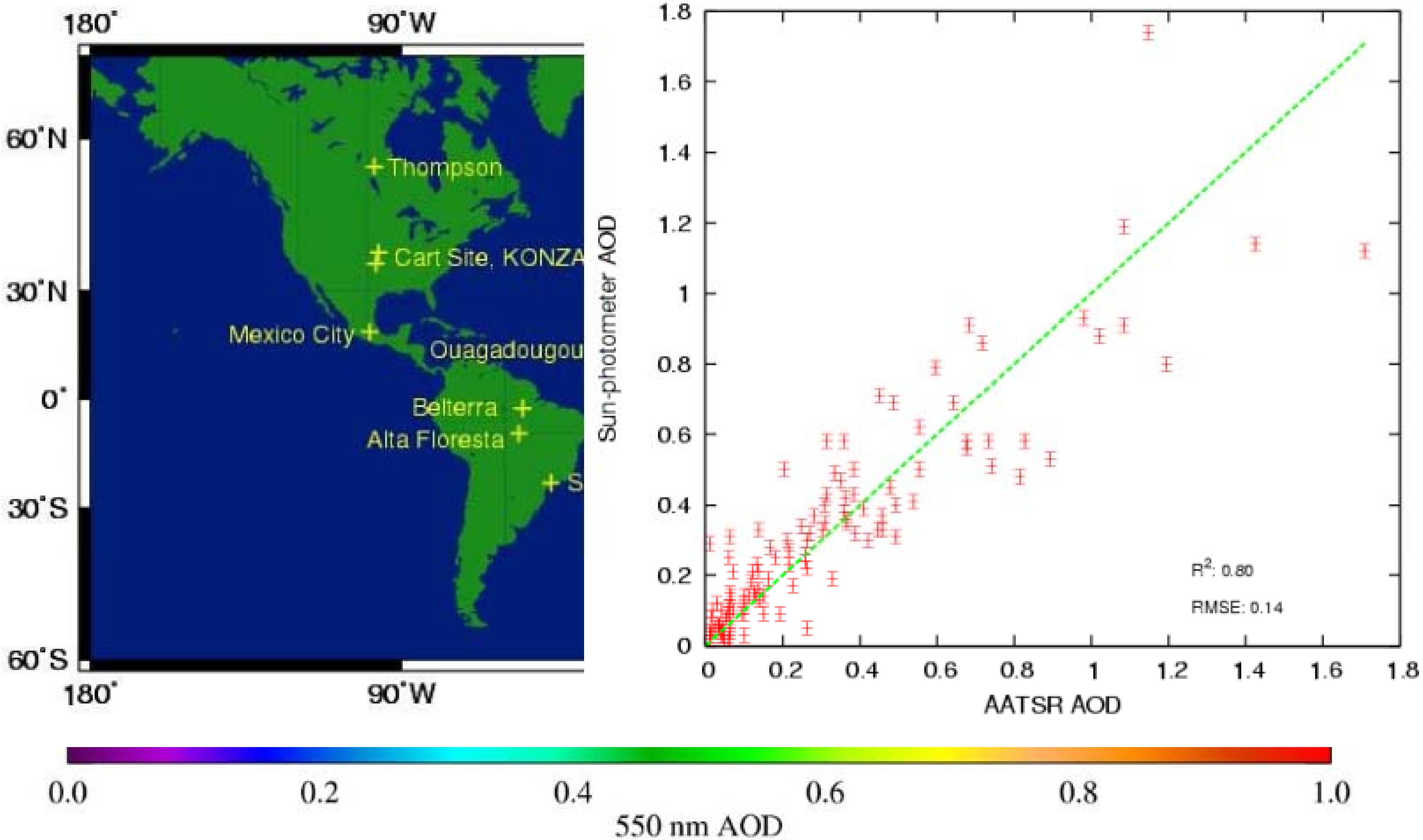
Comparison of surface temperatures from NWP and ARC-Lake observations for Lake Nyasa.

NWP data are ECMWF ERA-40 from 1995-2002 and ECMWF operational from 2002-2012. In situ observations are shown in orange.

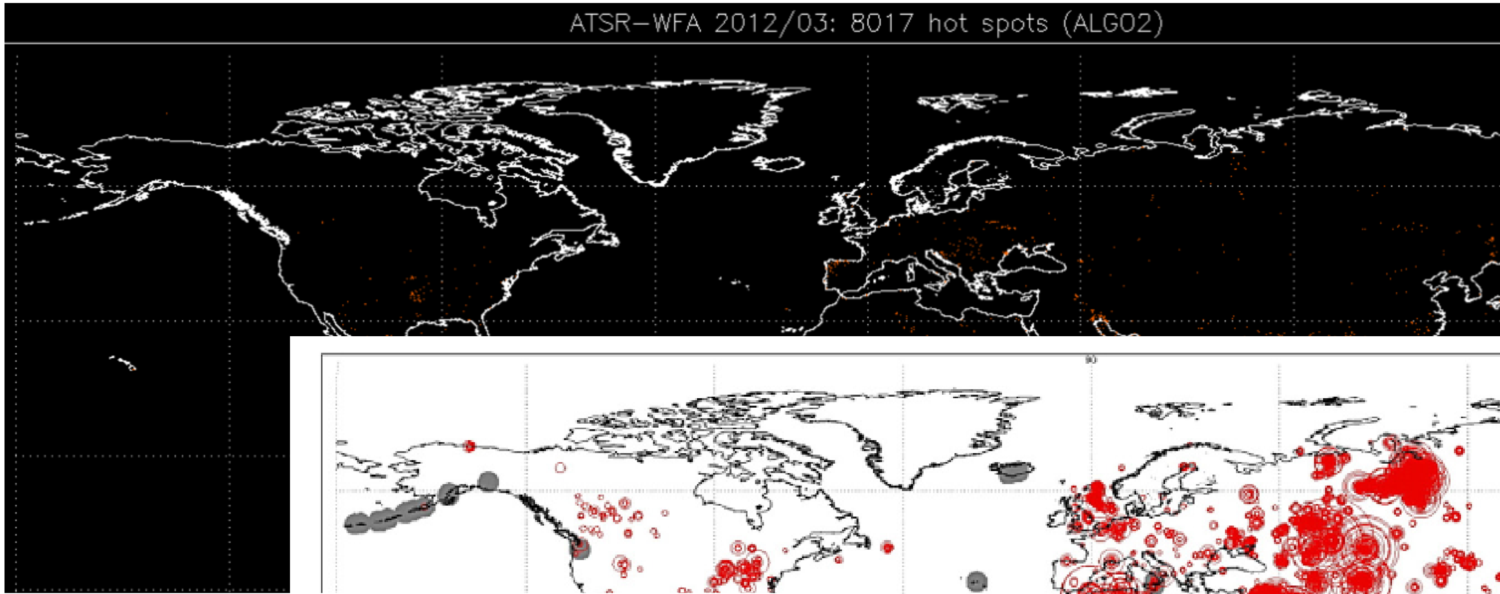
Lakes are a vital component of the Earth's fresh water resources, and are of fundamental importance for terrestrial life. Lake water temperature is one of the key parameters determining ecological conditions within a lake. Lake water temperatures determine air-water heat and moisture exchanges, and are therefore vital for understanding the hydrological cycle. Lake surface temperature (Lake ST) and lake ice cover (LIC) observations therefore have potential environmental and meteorological applications for inland water management and numerical weather prediction (NWP).

Applications - Aerosol

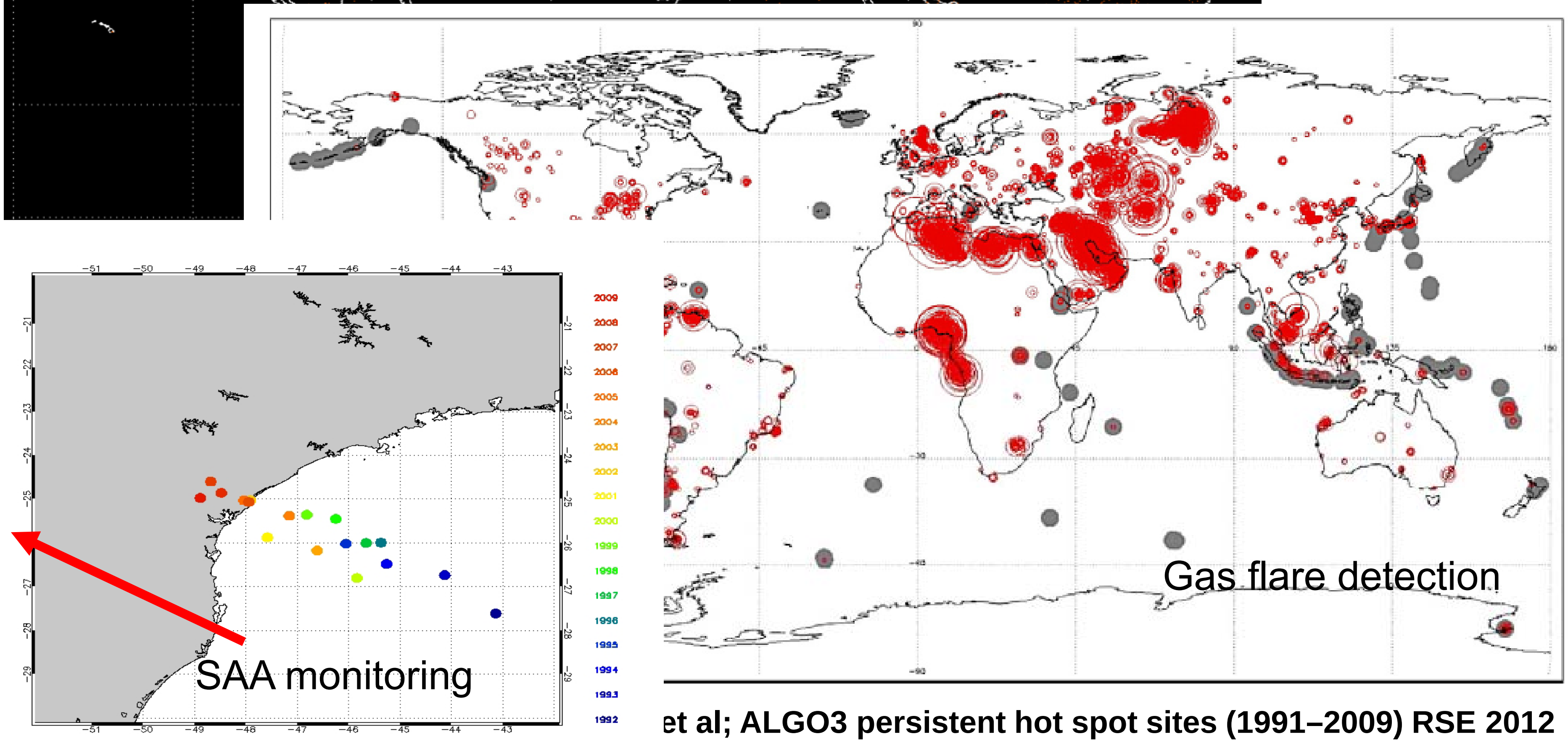
AERONET versus AATSR Aerosol Optical Depth



Applications – Fires and SAA



(A)ATSR
World Fire Atlas



et al; ALGO3 persistent hot spot sites (1991–2009) RSE 2012

Issues and Open points

From the instrument point of view → almost PERFECT (see Dave's presentation).

All the applications are possible thanks to good data quality BUT:

- Cloud masking is still poor in the standard product.
  - Need to adapt the CCI approach over sea
  - Need more research over land

- Geolocation and collocation has been perceived as a limitation by some applications
  - Improvement in 3rd reprocessing. Effort for improvement needs to continue.

- LST needs better auxiliary files

- L0 Consolidation is still an issue → ANX to ANX

- Continuity with SLSTR is at risk
  - Gap bridging plan is prepared BUT there is still a funding issue with the *in situ* data continuity (ISAR, SISTeR).
  - Need more effort and probably a dedicated budget

Toward Sentinel-3

SLSTR on board Sentinel-3 will benefit from (A)ATSR experience

- L1B ortho-geolocated (geolocation and collocation should be good)
- L2 SST – direct benefit from GHRSST with L2P production and SST coefficients. Cloud masking is still an issue.
- L2 LST direct benefit from AATSR with highly improved AUXILIARY files
- AEROSOL over land produced from synergy between OLCI and SLSTR (It is a direct output of AATSR algorithm (Peter North))
- Format is netCDF4
- All products come with uncertainty estimate per pixel.

BUT so far, no lake product, no global continuous aerosol product, no fire product yet (fire radiative power possible for first time), no sea ice temperatures.

Conclusion

- AATSR instrument performed extremely well.
  - The products have been demonstrated to be very accurate – fully in spec - and useful for science and operational services.
- Viscal monitoring is difficult to predict. “Identical” instruments can behave differently in space. This is a lesson for S3.
- The best instrument in the world can produce good data only if the right effort is dedicated to Cal/Val and algorithm evolution.
  - Cal/Val is a long term and continuous effort.
  - Continuity in the Cal/Val programme is needed. This is an issue today.
  - Proper budgets shall need to be dedicated to Cal/Val and algorithm development.
- Success is not only about systems and processes. People, teams and organisation are also important.
- There will be a continuity with Sentinel-3.

Simply

AATSR

the BEST!!