GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

The present and future era Satellite SST Climate Data Record

Craig Donlon, Kenneth S. Casey and John Stark

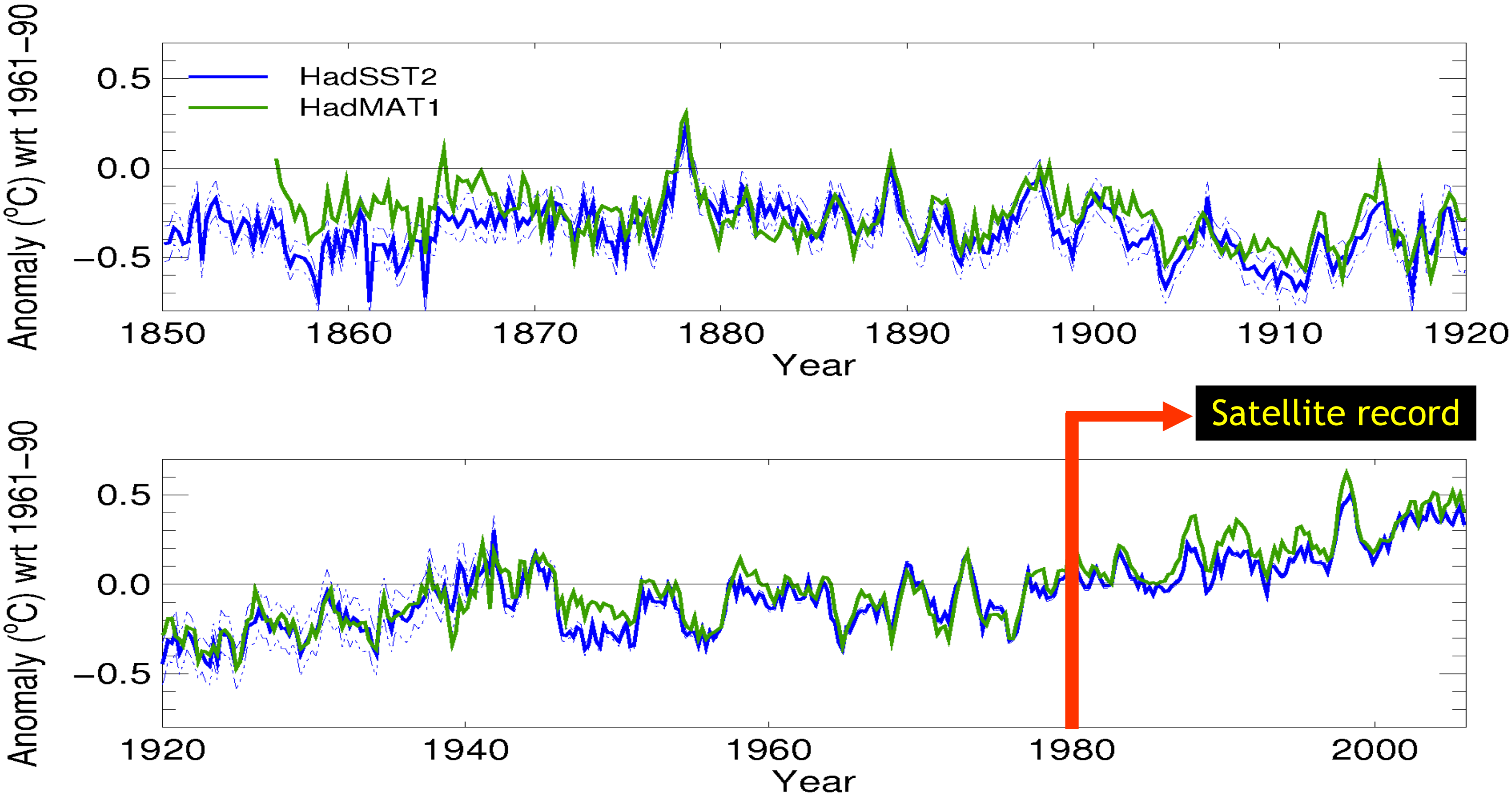
(P. LeBorgne, J. Kennedy, C. Gentemann, C. Folland)

CLIMAR-III, Gdynia, Poland, 6-9th May 2008

Overview

- The power of satellite SST data
- The challenges for satellite SST CDR
- GHRSST activities for satellite SST CDR
- The future for satellite SST CDR
- Recommendations and conclusions

SST: The ***First and longest*** global marine instrumental climate data record.



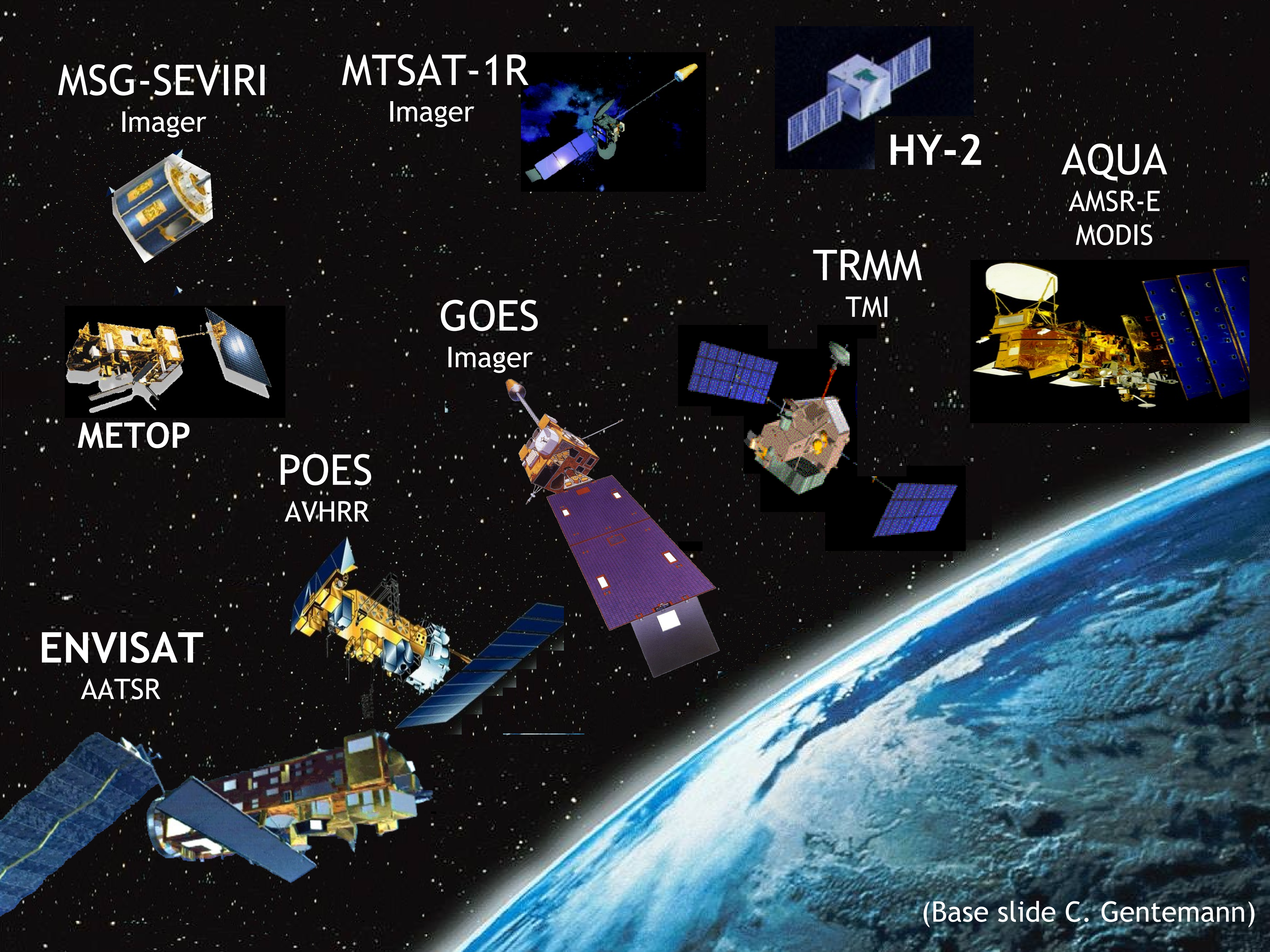
HadSST2 data used in IPCC Fourth Assessment Report, ***Rayner et al, 2006, JGR (Atmos). (anomalies from 1961-90)***

Satellite observations…

The first picture of Earth from a weather satellite, taken by the TIROS-1 satellite on April 1, 1960. Although primitive in comparison with the images we now receive from satellites, this first picture was a major advance.

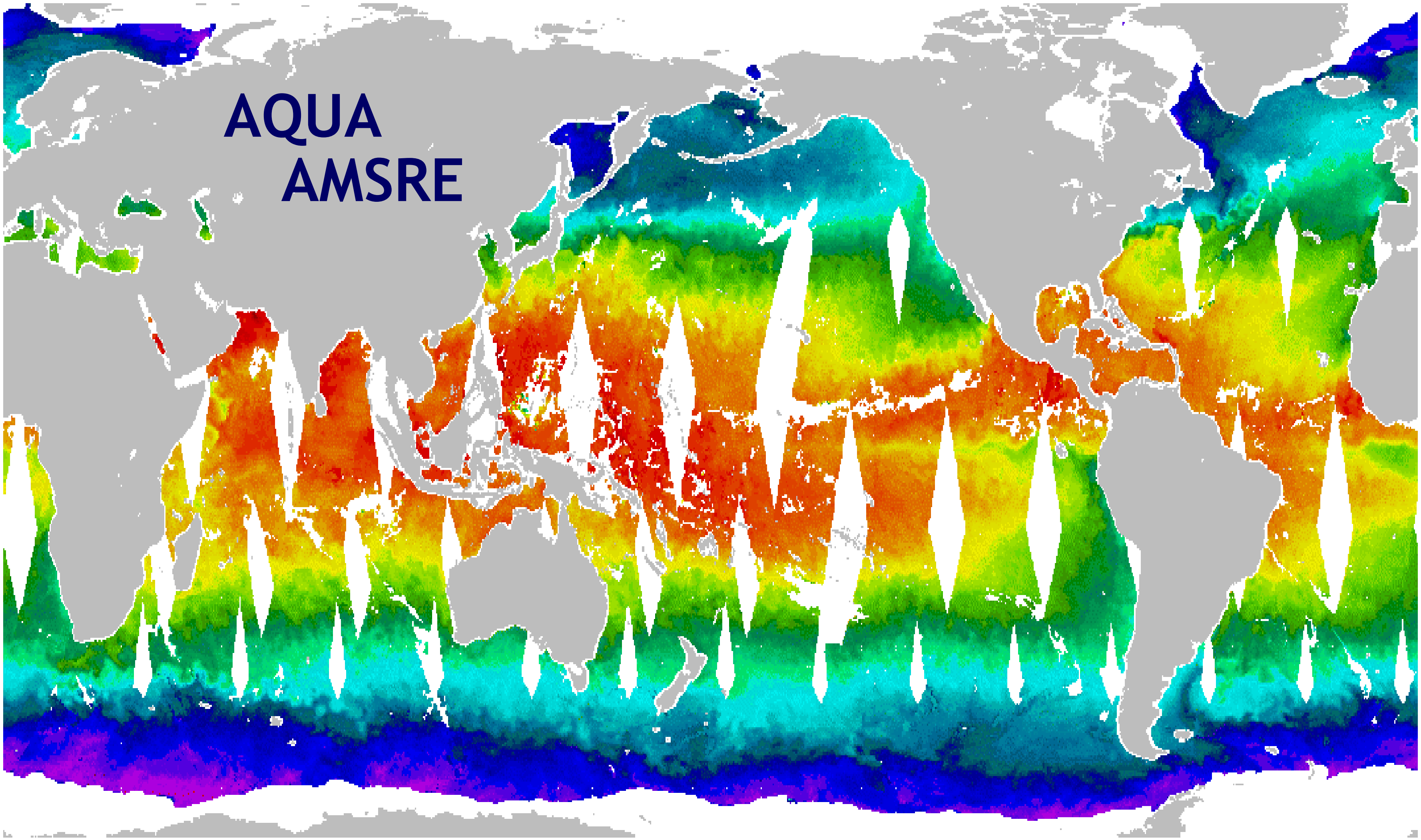
Although the spacecraft operated for only 78 days, meteorologists worldwide were ecstatic over the pictures of the Earth and its cloud cover that TIROS relayed back to the ground.

(Slide content: ECMWF)



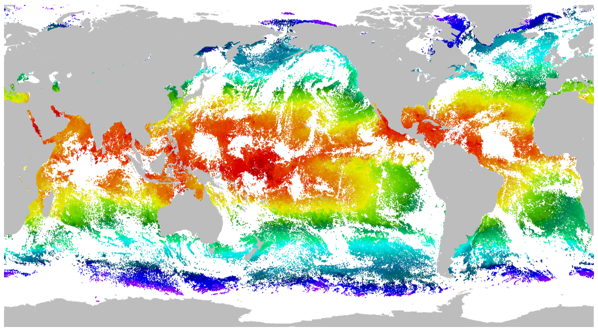
MSG-SEVIRI
Imager
MTSAT-1R
Imager
HY-2
AQUA
AMSR-E
MODIS
TRMM
TMI
GOES
Imager
METOP
POES
AVHRR
ENVISAT
AATSR
(Base slide C. Gentemann)

Measuring the ocean SST…

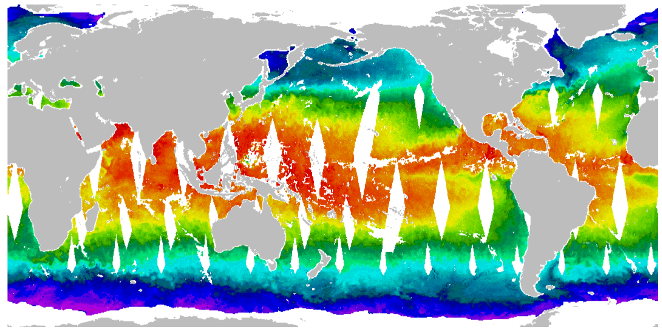


1 day of SST data coverage…

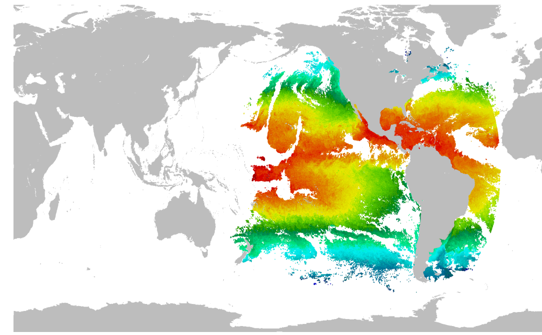
N-17/18 AVHRR GAC (9km)

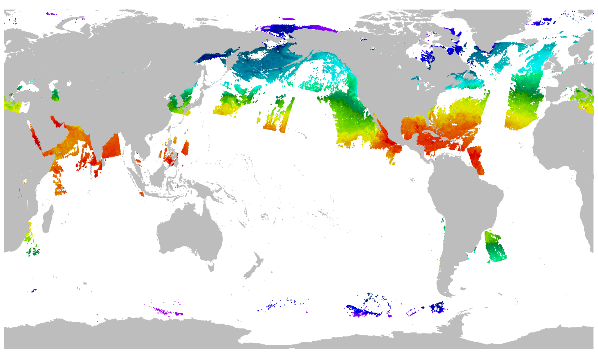


AMSRE (25/12km)

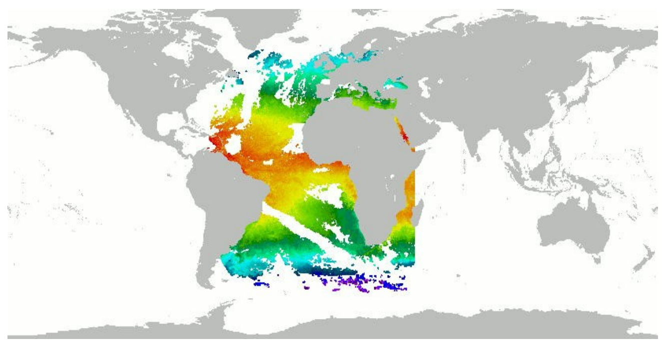


GOES-E/W (5km)

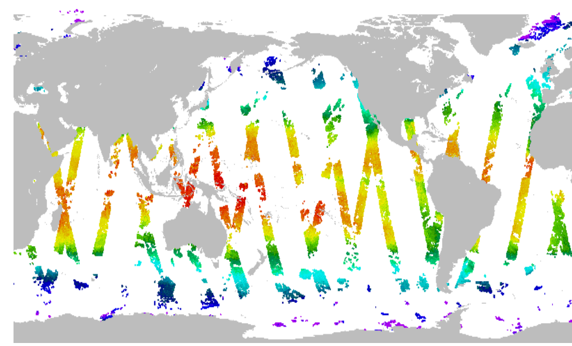




N-17/18 AVHRR LAC (1km)

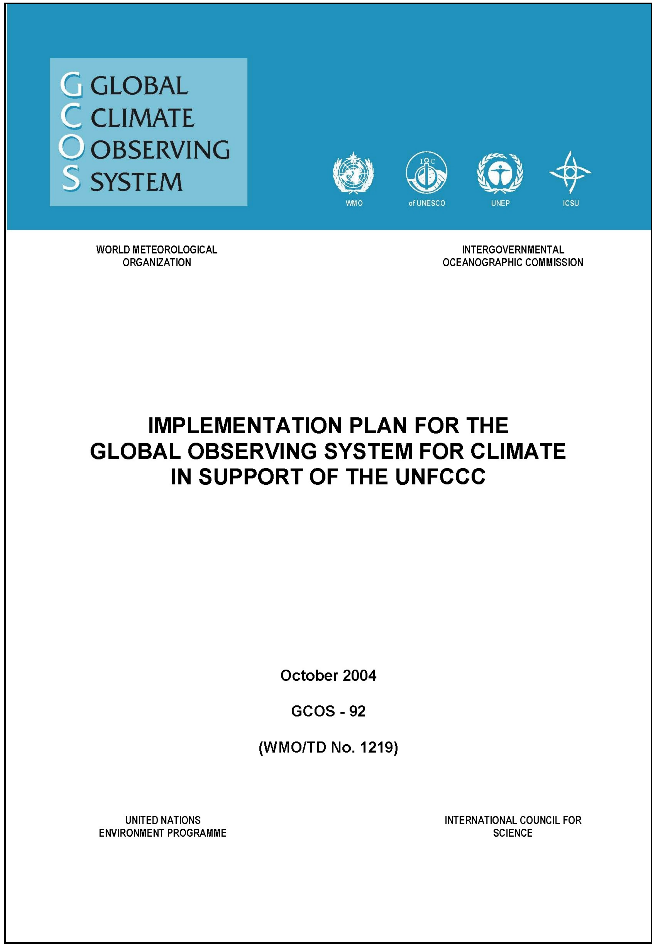


MSG (5/10km)



AATSR (1km)

GCOS Climate Monitoring Principles


GLOBAL
CLIMATE
OBSERVING
SYSTEM

WMO
of UNESCO
UNEP
ICSU

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

IMPLEMENTATION PLAN FOR THE GLOBAL OBSERVING SYSTEM FOR CLIMATE IN SUPPORT OF THE UNFCCC

October 2004

GCOS - 92

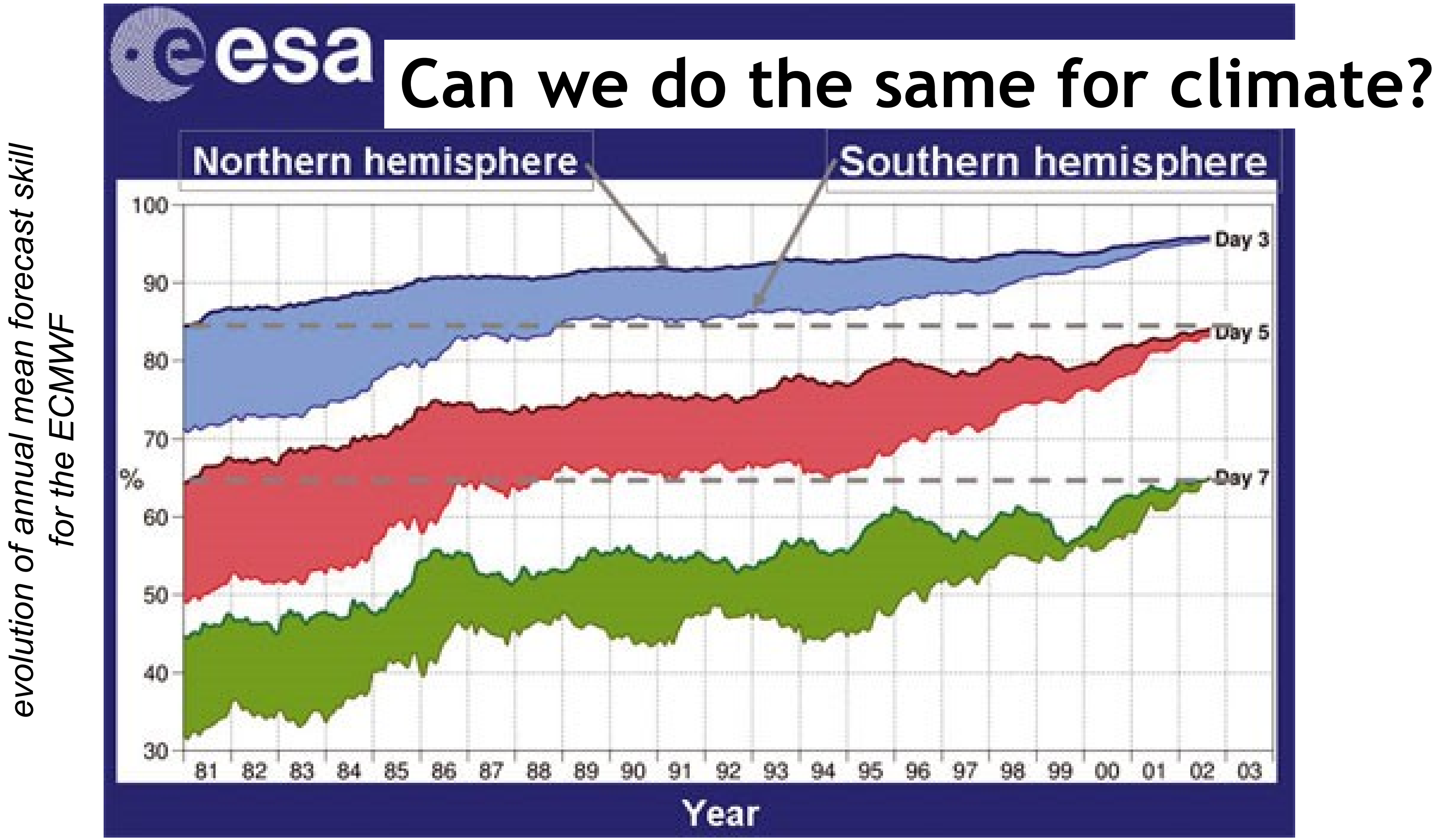
(WMO/TD No. 1219)

UNITED NATIONS ENVIRONMENT PROGRAMME

INTERNATIONAL COUNCIL FOR SCIENCE

- 10 Climate Monitoring Principles
  - End to end , from measuring instruments and observational practices to data management, access, use and interpretation
- Additional set of 10, orientated to satellite climate change assessment issues summarised as:
  - (a) Take steps to **make radiance calibration, calibration-monitoring and satellite - to satellite cross-calibration** of the full operational constellation a part of the operational satellite system
  - (b) Take steps to **sample the Earth system in such a way that climate-relevant (diurnal, seasonal and long term interannual) changes can be resolved**

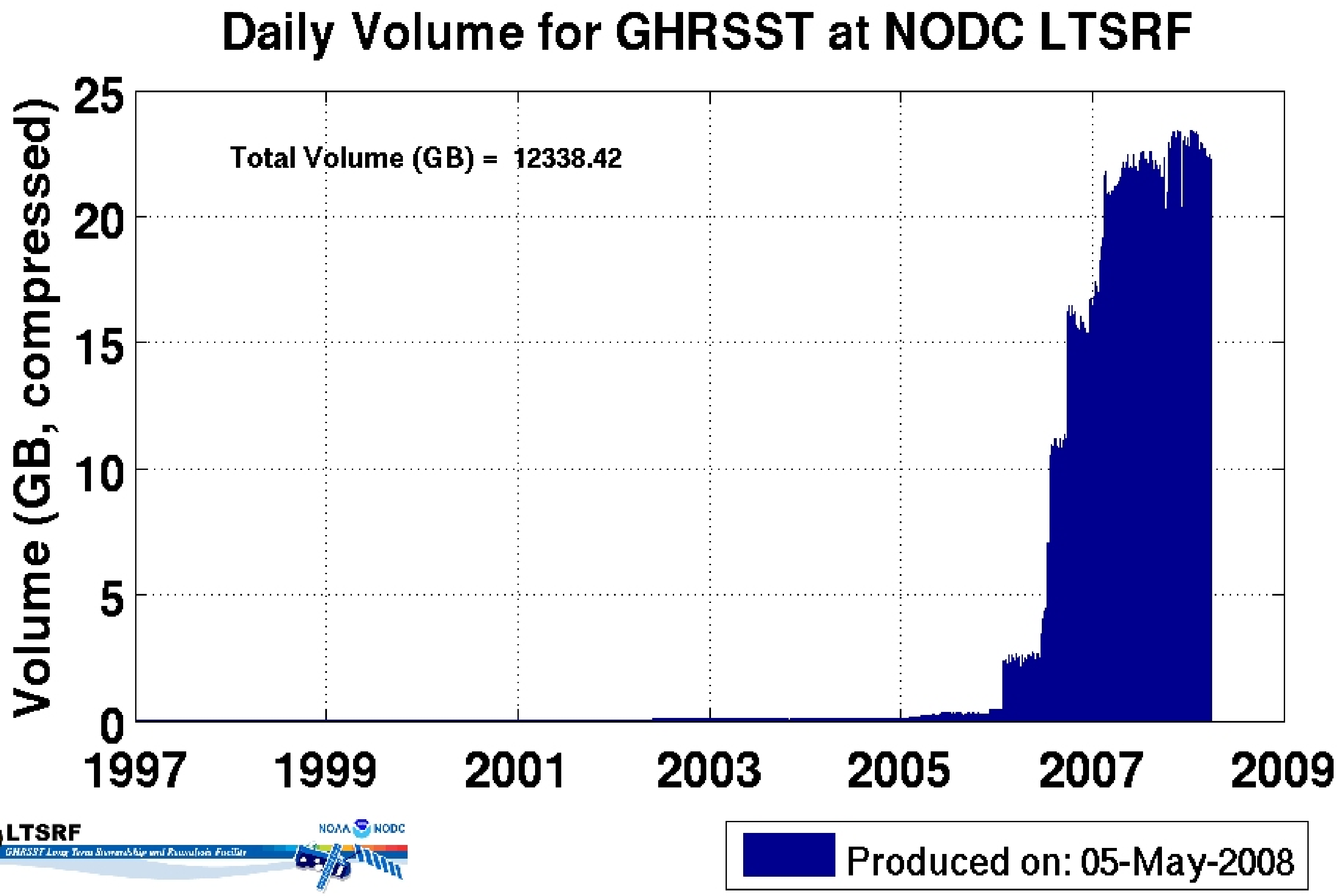
Impact of satellite observations on NWP…



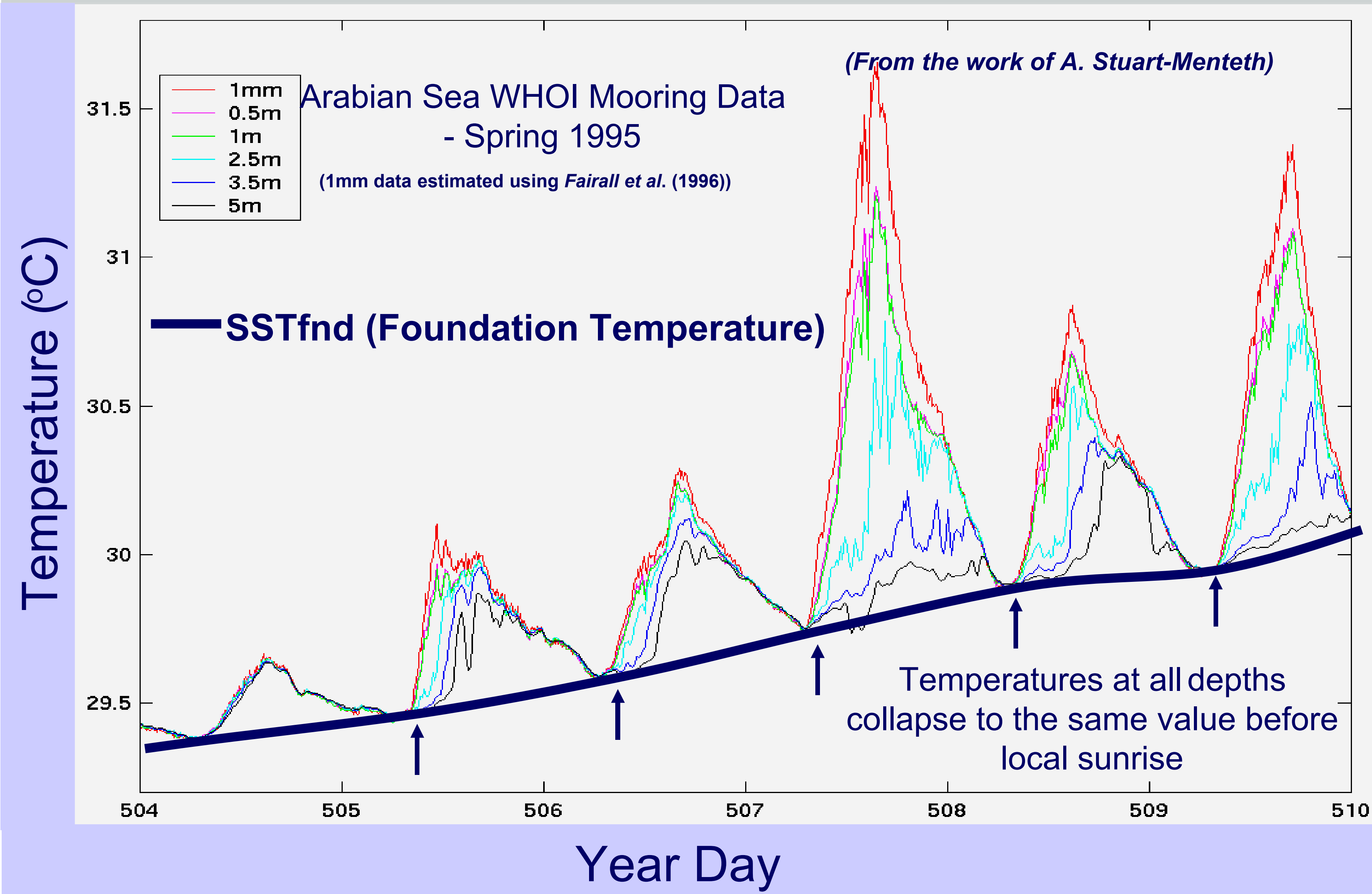
Challenges…

…not problems!

Data volume…



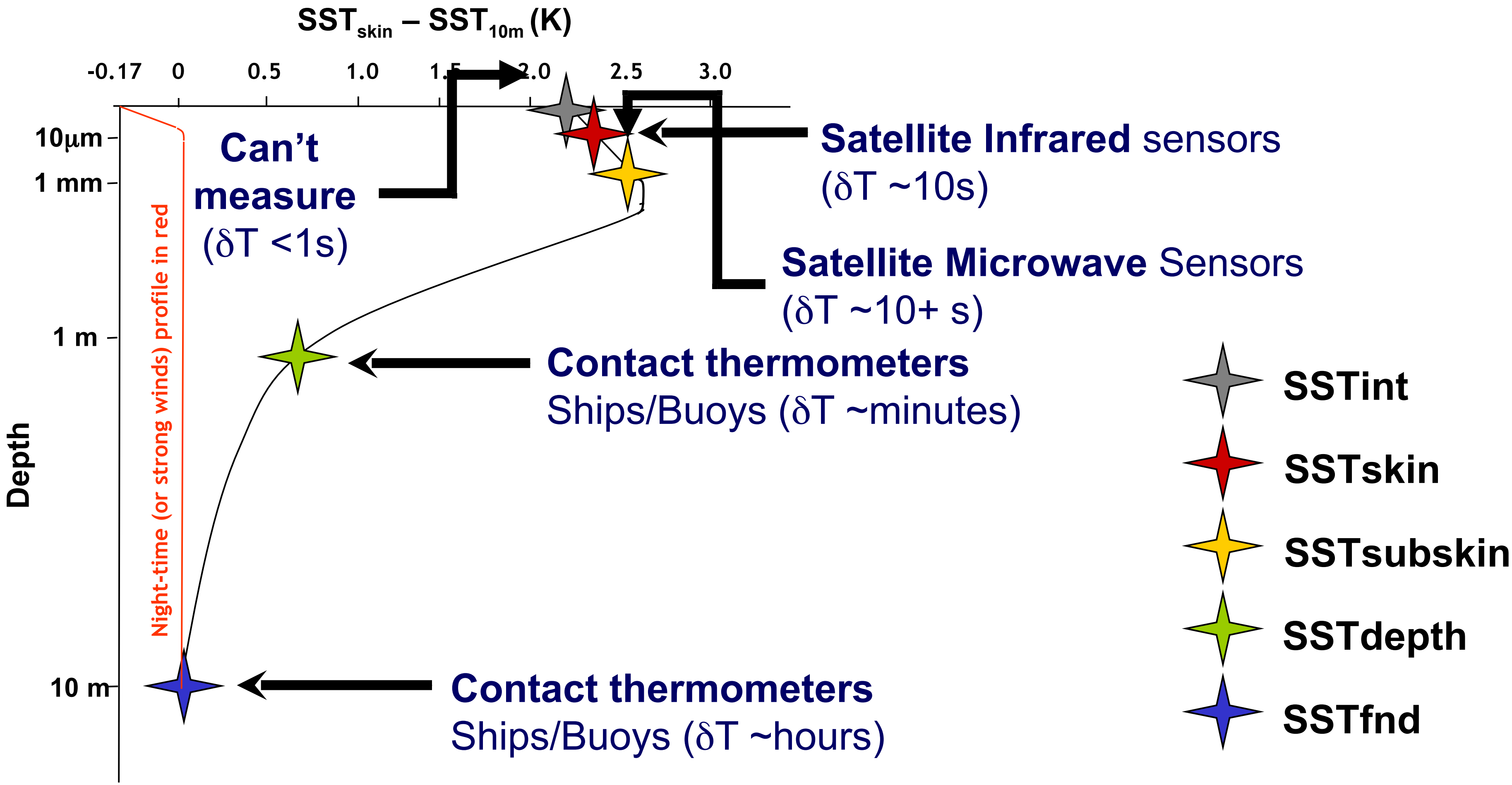
Daily Volume for GHRSST at NODC LTSRF
Volume (GB, compressed)
Total Volume (GB) = 12338.42
25
20
15
10
5
0
1997
1999
2001
2003
2005
2007
2009
Produced on: 05-May-2008



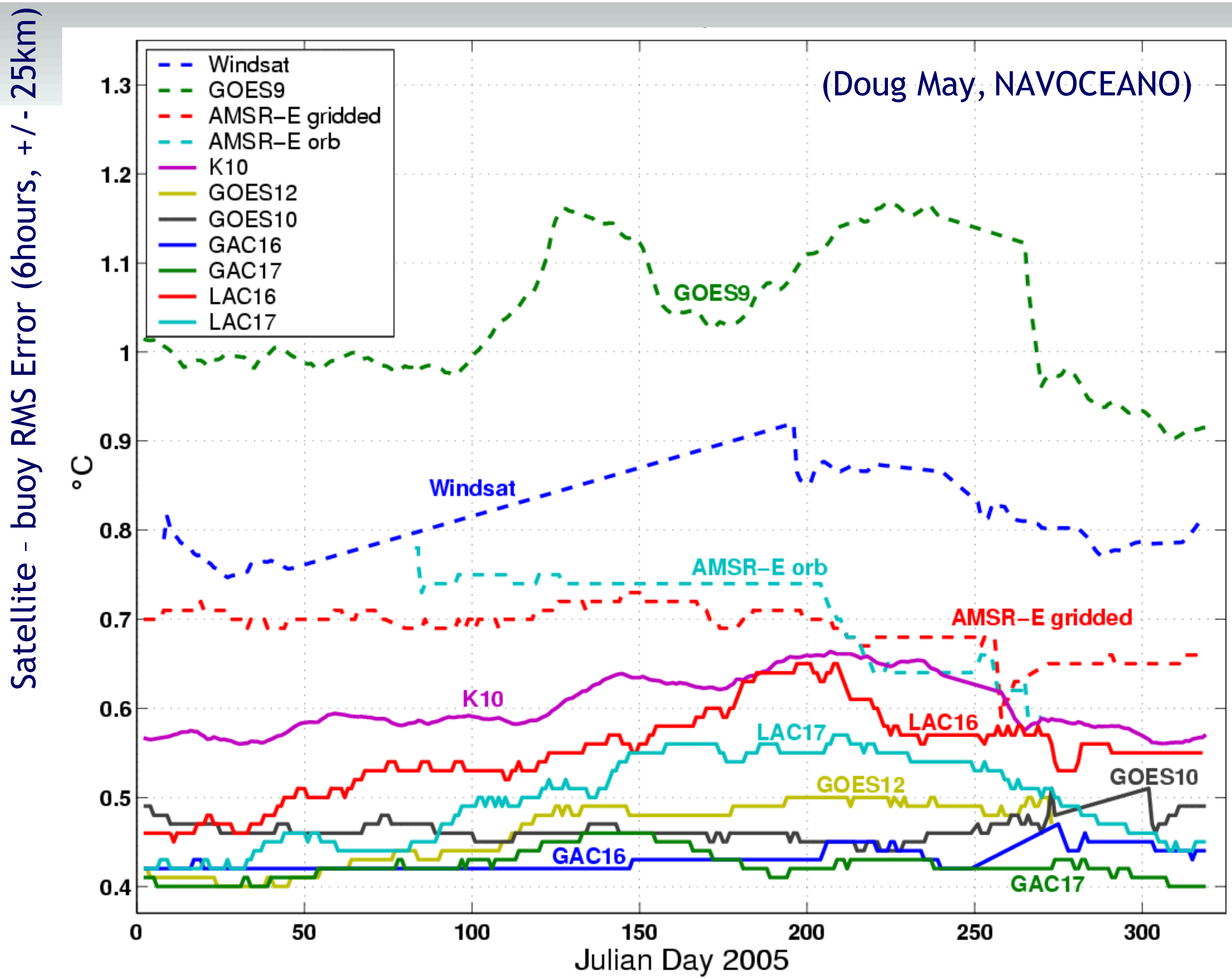
GHRSST-PP
GODAE High Resolution Sea Surface Temperature Pilot Project

http://www.ghrsst-pp.org

Measurements of SST

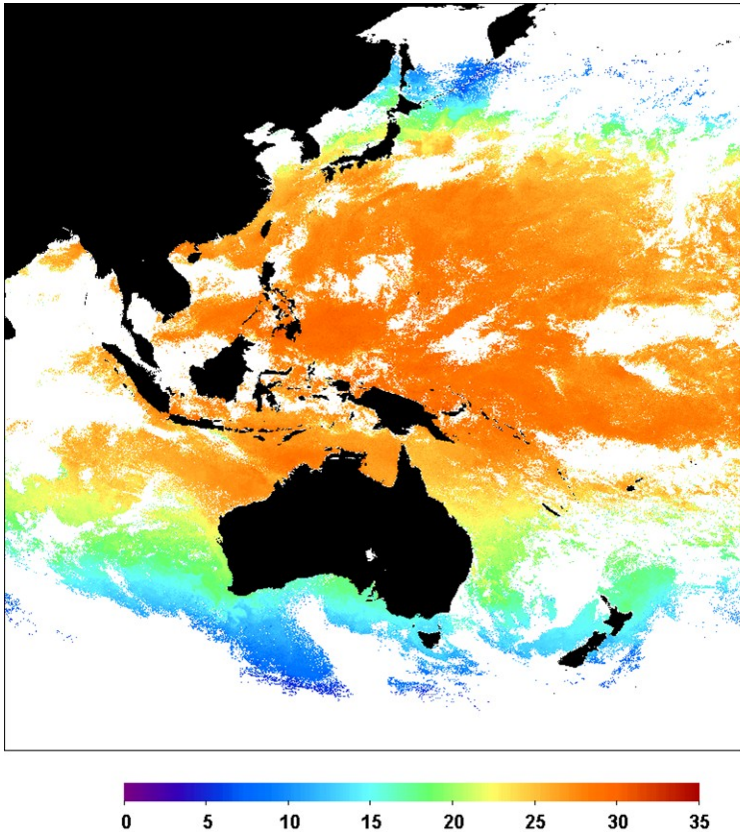


1. Night-time (or strong winds) profile in red
2. Day time situation, strong solar radiation and light winds

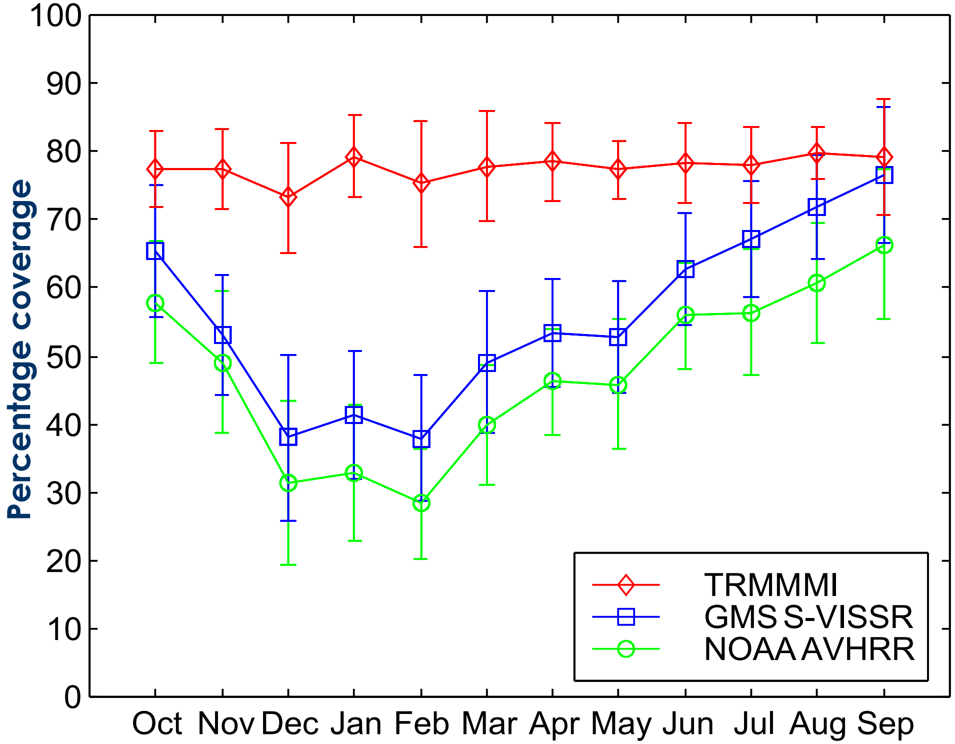


Doug May, NAVOCEANO)

Temporal sampling bias



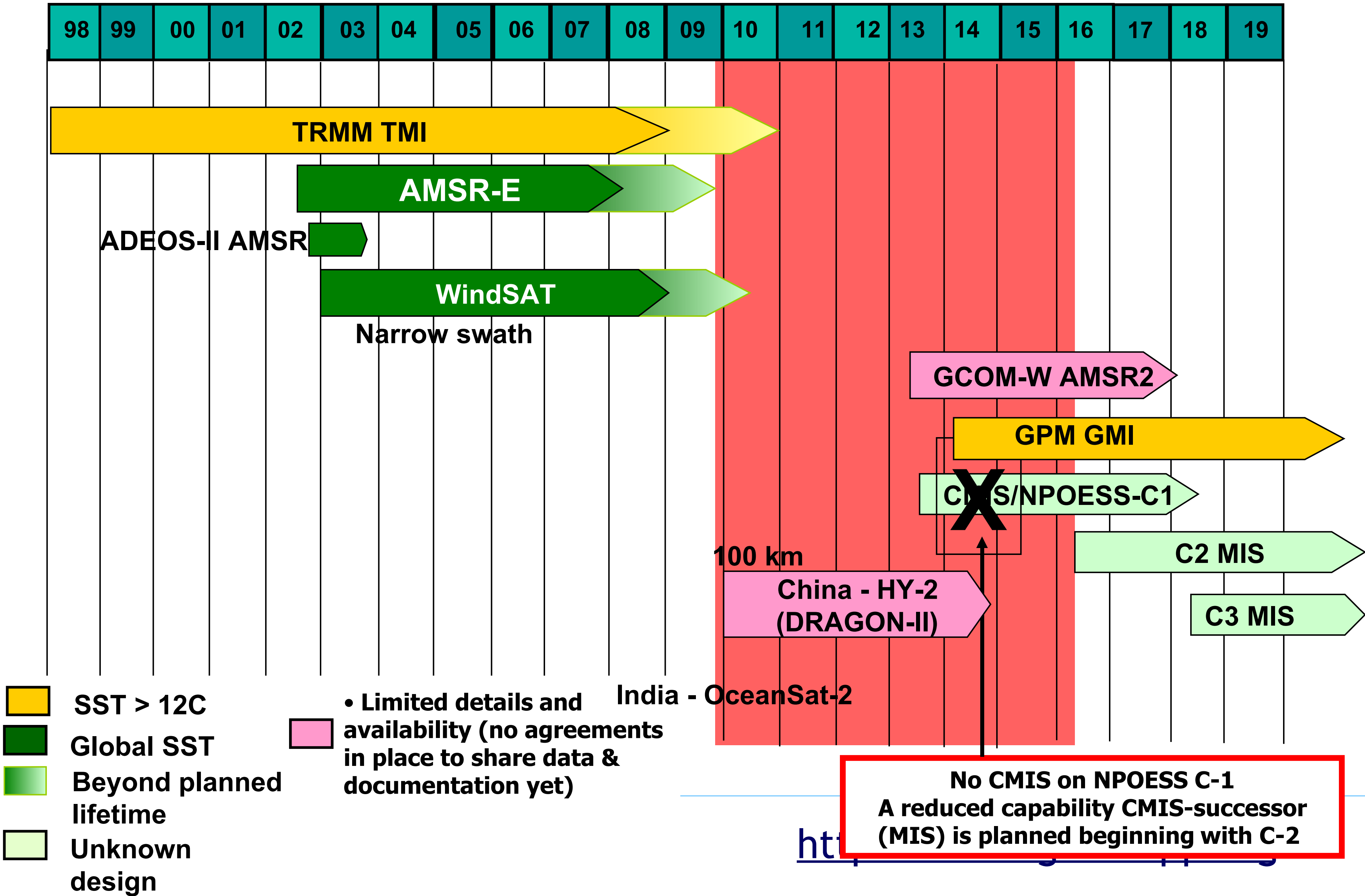
GMS VISSR SST Japan (H. Kawamura)



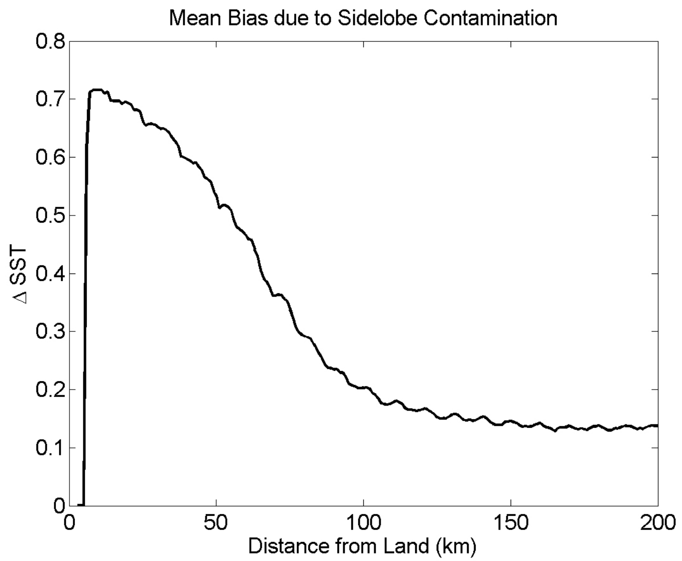
(Figure: L. Guan)

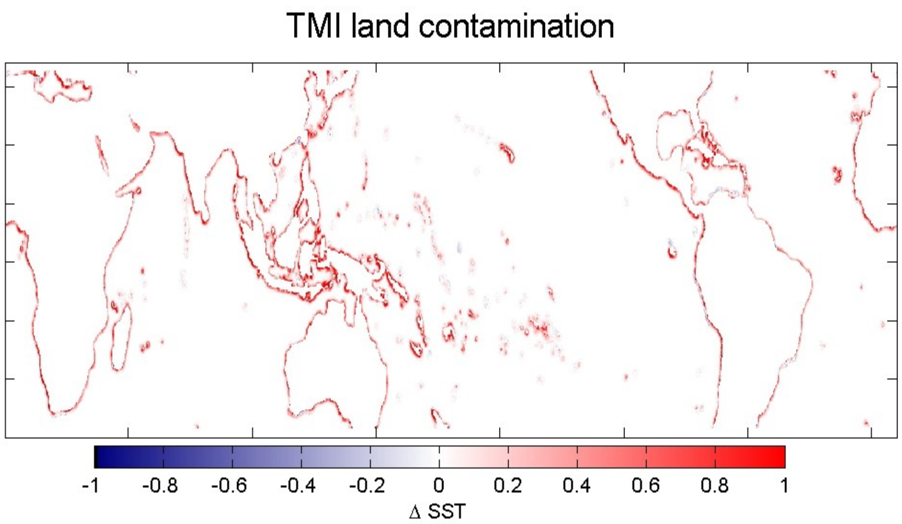
- Only Microwave SST provides temporally unbiased sample as the IR data are obscured by seasonal clouds

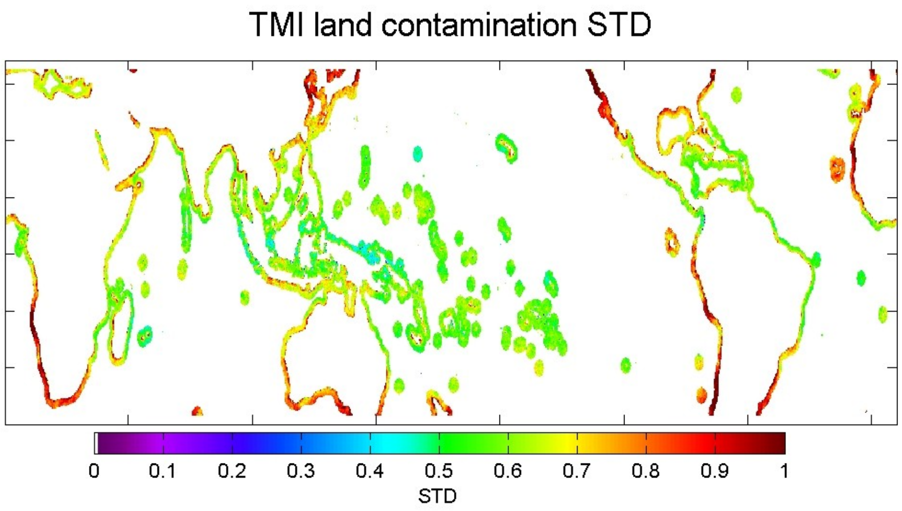
Current & Future through-cloud SST Missions



MW SST Error maps (C. Gentemann)

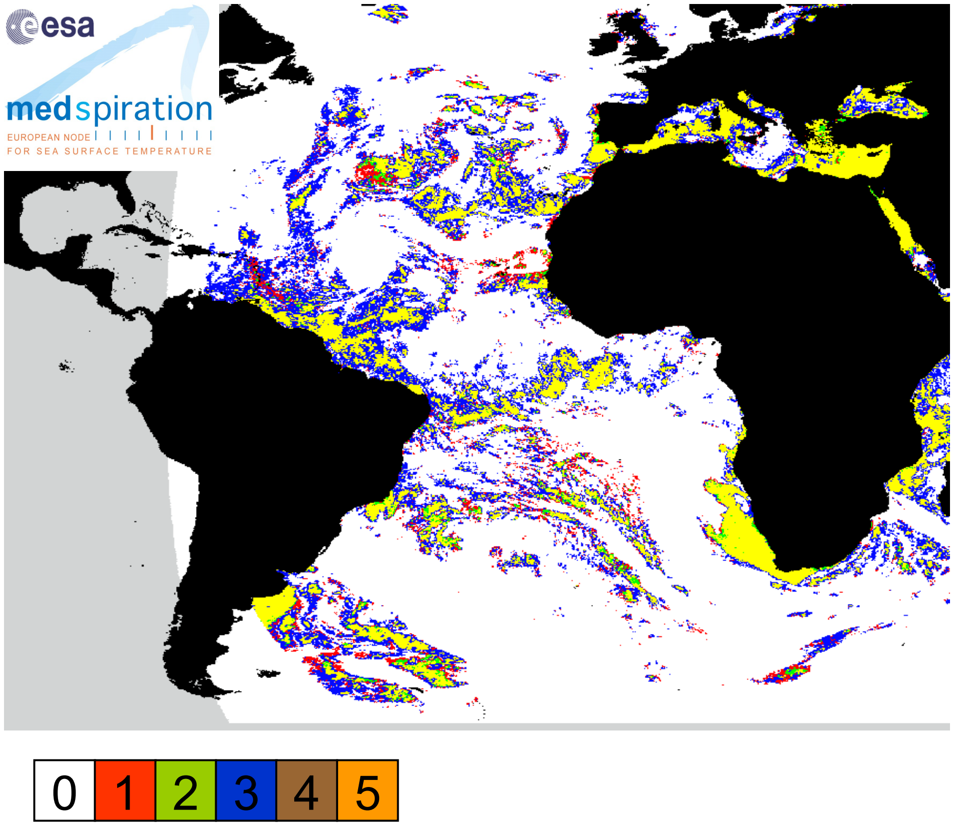






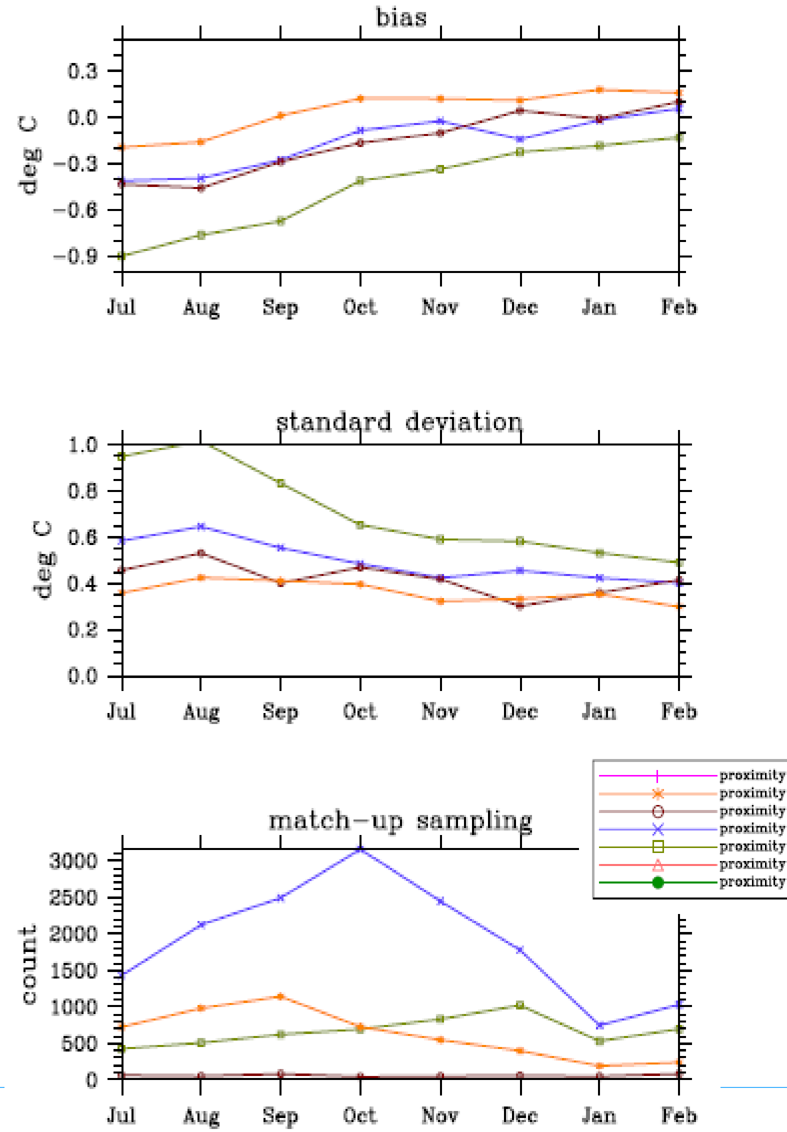
- Derived using TRMM TMI-VIRS
- 8-bit bias/distance maps are now available from REMSS to RDAC systems for TMI and AMSR-E

Single Sensor Error Statistics (SSES)

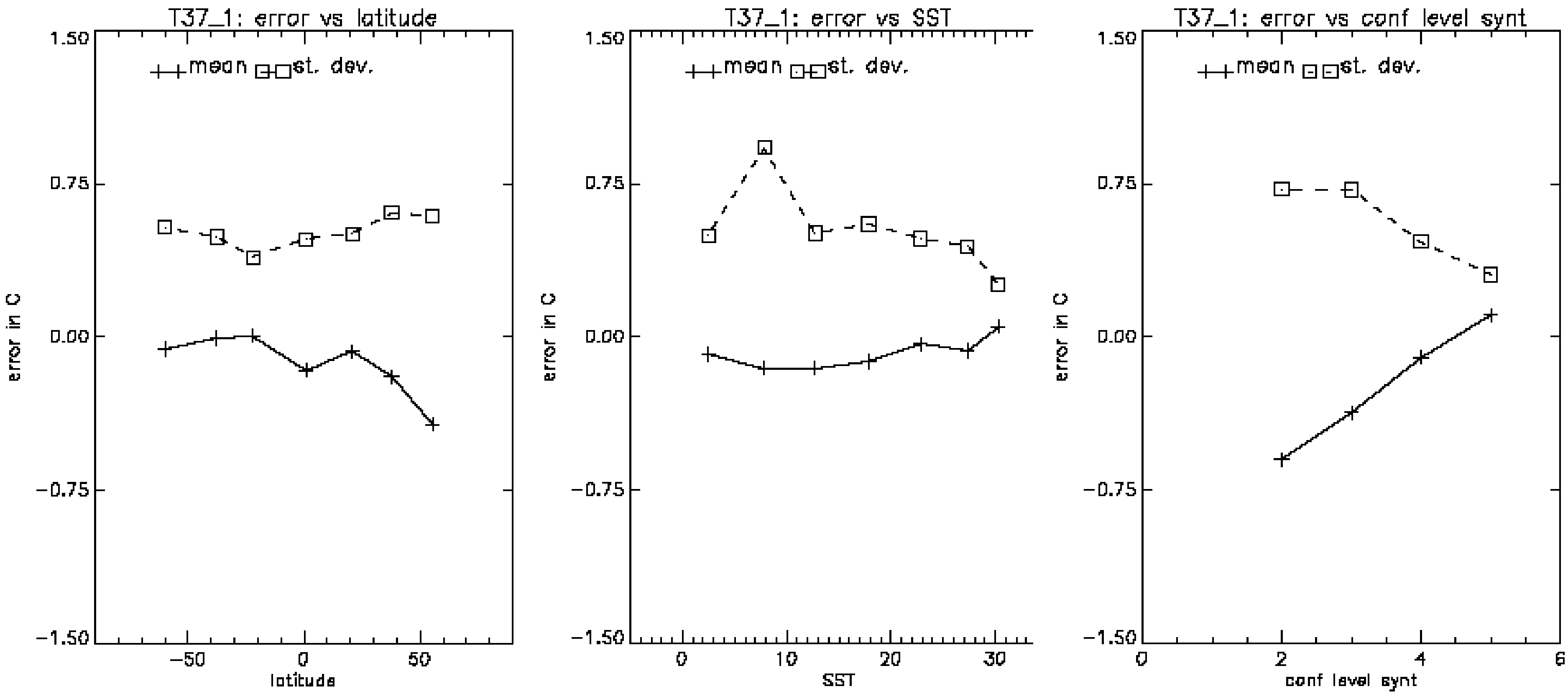


Confidence level

20040920-SEVIRI_SST-EUR-L2P-sst3mlml_20040920_1000.tar-01.nc



SST from METOP: Validation Methods MDB(2): nighttime results



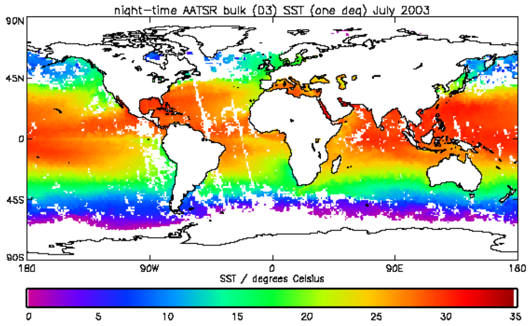
Nighttime validation results from 2007/03/10 till 2007/04/20

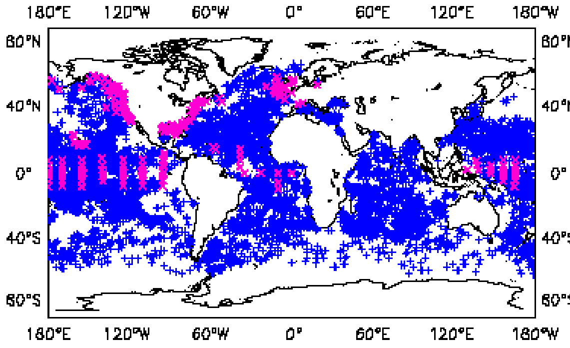
All cases:	N=17869	δ=-0.08K	σ=0.51K
Excellent:	N=6631	δ= 0.01K	σ=0.31K

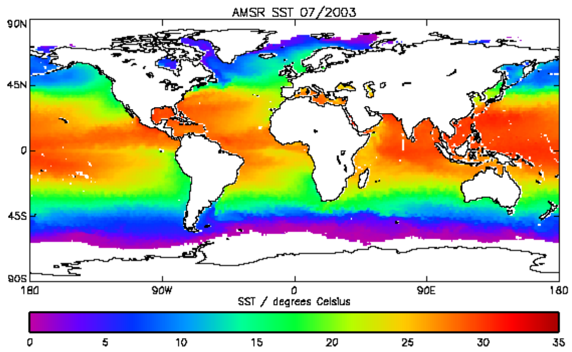
What is the absolute accuracy of AATSR?

(Anne O'Carroll)

- Using co-locations of three independent SST observation types we can estimate the standard deviation of error on each observation type.
- SST observations: AATSR (1/6 deg); in situ (point); AMSR-E (1/4 deg)
- Assume errors are not correlated. Valid attempts have been made to validate this assumption.







AATSR Errors calculated from 3-point analysis

- Calculated error for each observation type

  AATSR bulk D3 SST= 0.16K

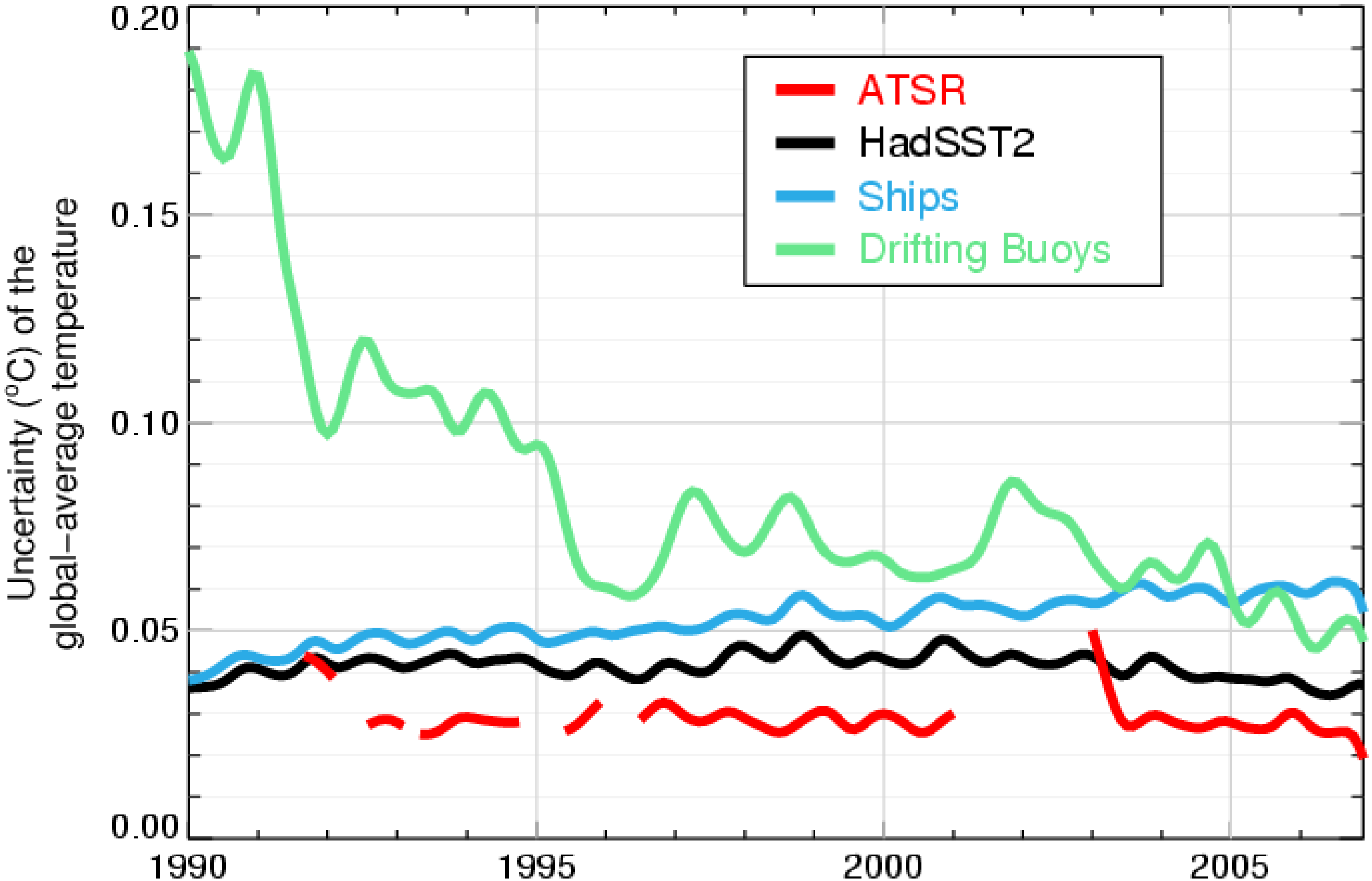
  Buoy SST = 0.23K

  AMSR-E SST= 0.42K

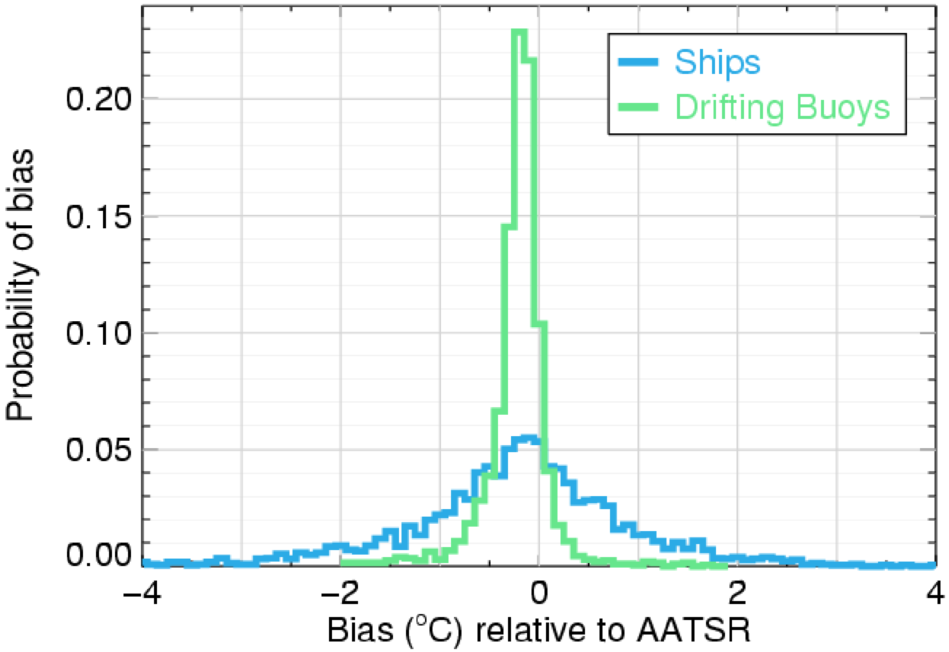
- Similar trends are seen for 8 other experiments, ranging:
  - 0.12K <= error in AATSR SST <= 0.16K
  - 0.22K <= error in buoy SST <= 0.27K
  - 0.42K <= error in AMSR-E SST <= 0.51K

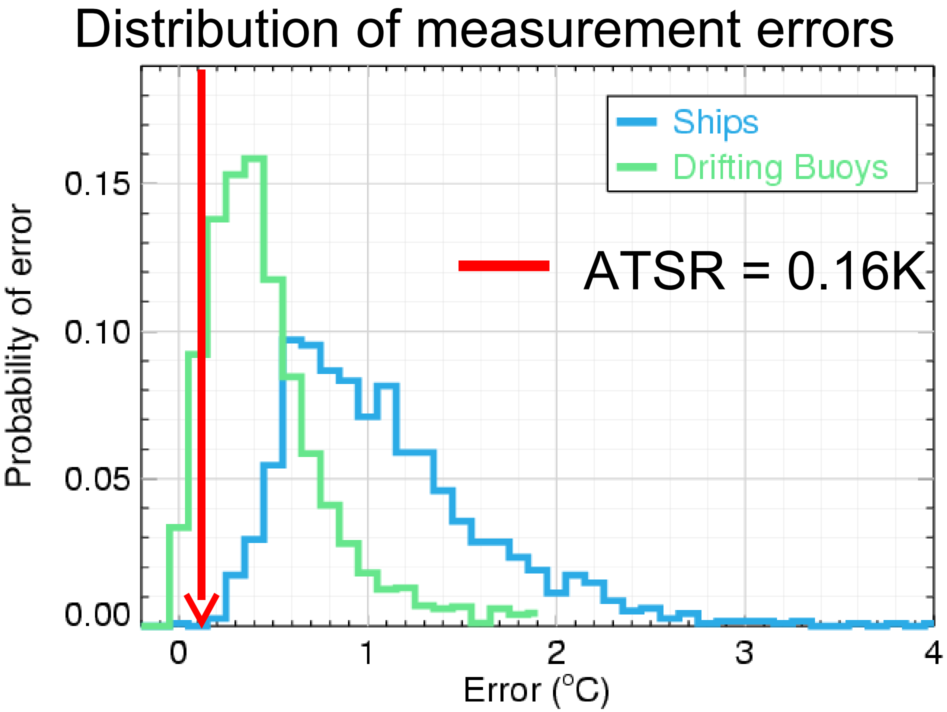
(A)ATSR reduces uncertainty in global average SST

(John Kennedy, Nick Rayner)



High accuracy AATSR used to quality control *in situ* data (John Kennedy, Nick Rayner)

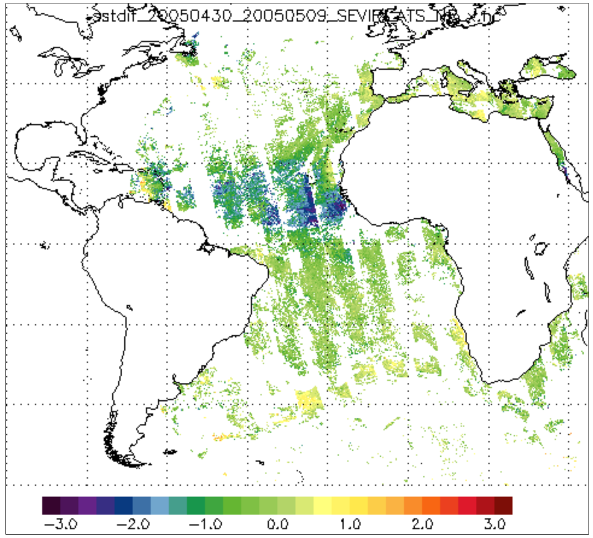




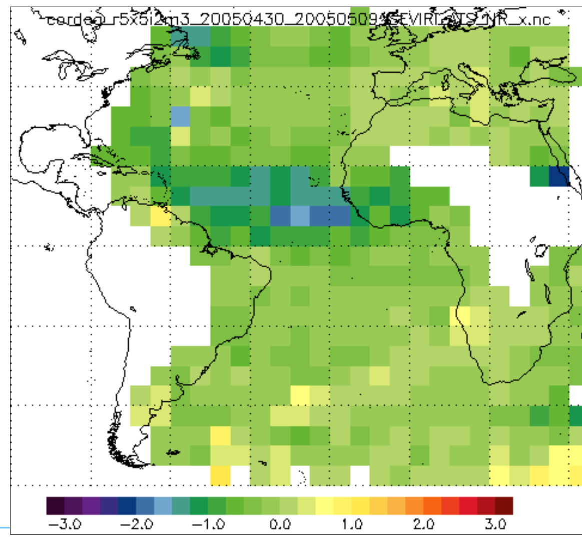
- (A)ATSR provides an accurate and consistent base line against which *in situ* data can be characterised.
- May even help us understand pre-ATSR *in situ* data.

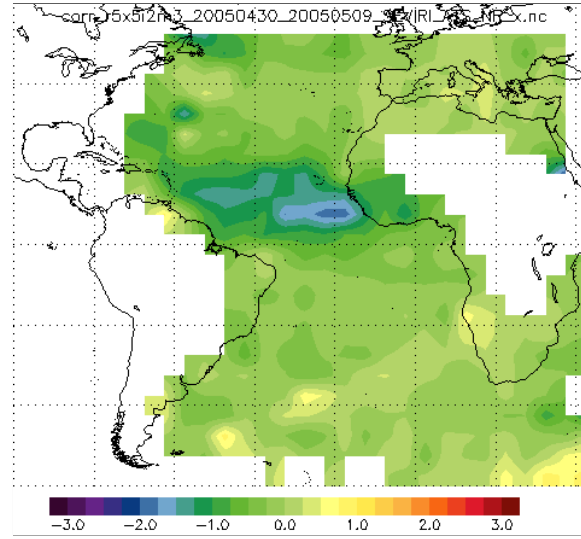
Using AATSR as a reference for SEVIRI

1) Sensor-AATSR
Over the last
~10 days



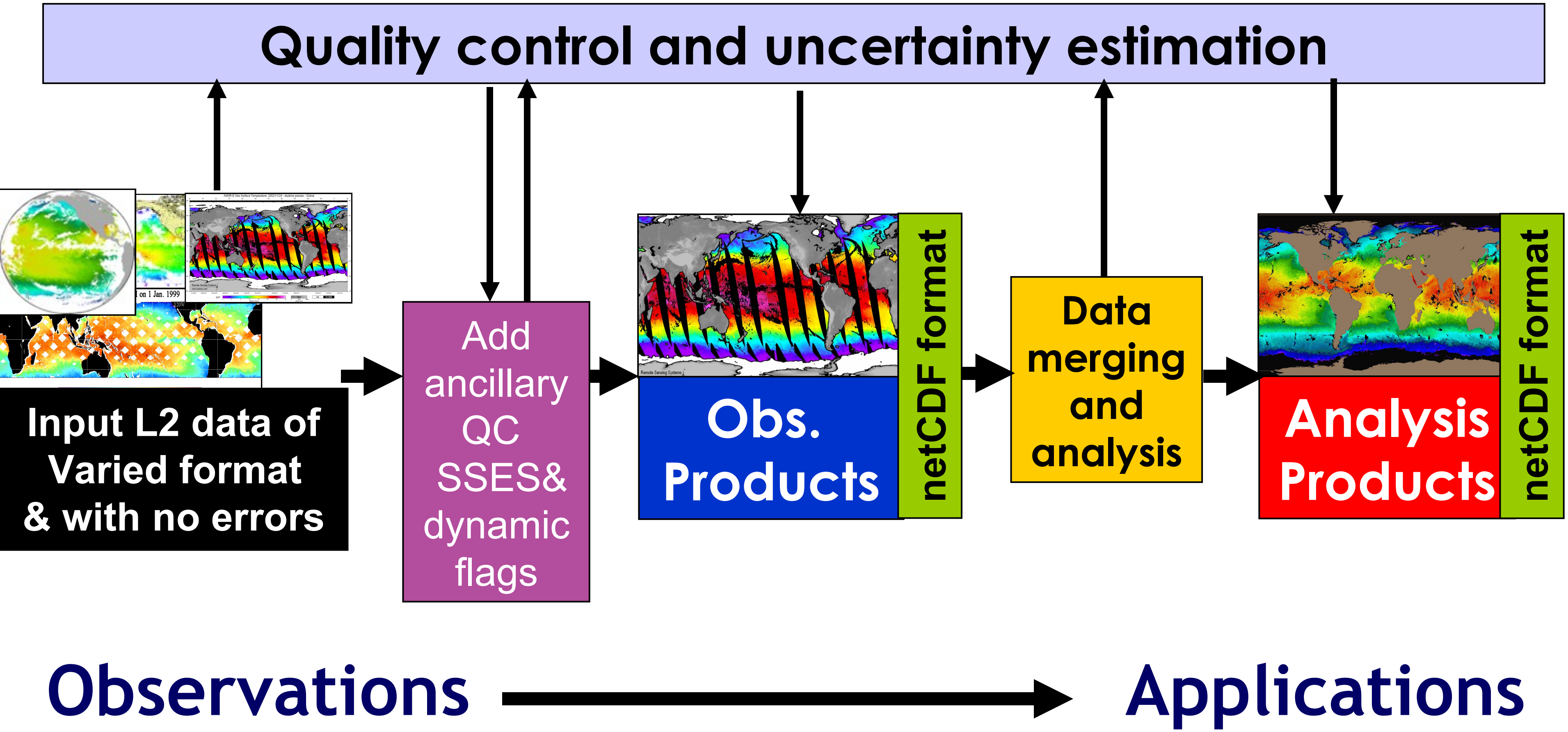
2) Alalysis of
the differences
On a 5° grid



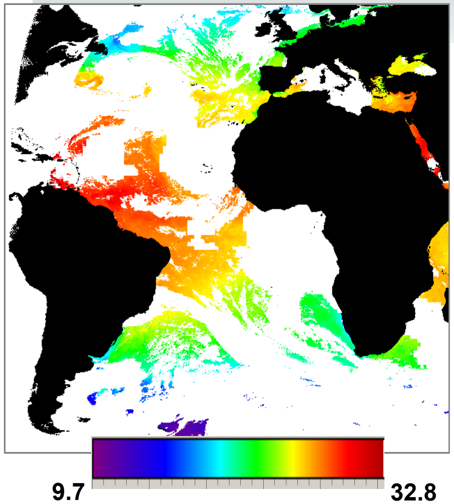


3) Interpolation
To fine resolution:
Correction of the day

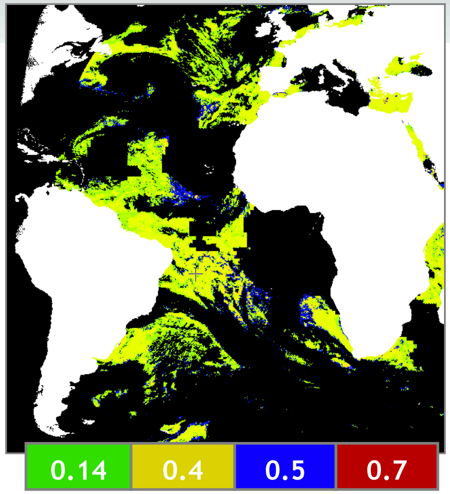
The GHRSST-PP EDR-> CDR Strategy



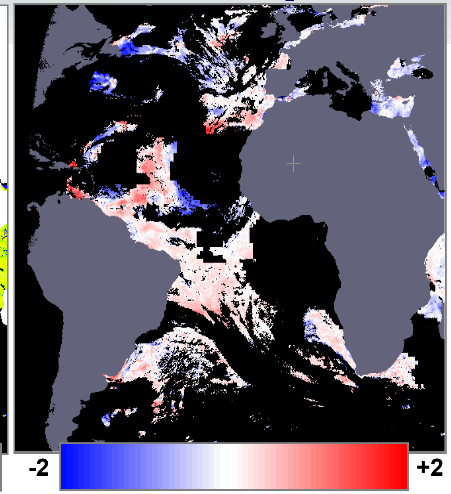
Ancillary data for interpretation



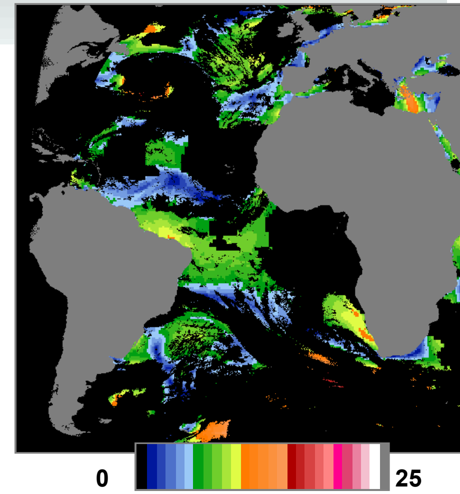
SST (K)



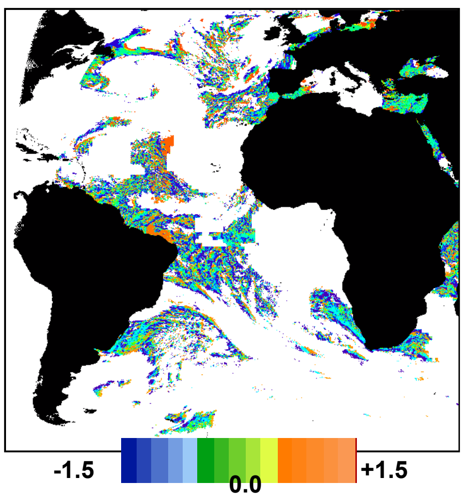
Bias error (K)



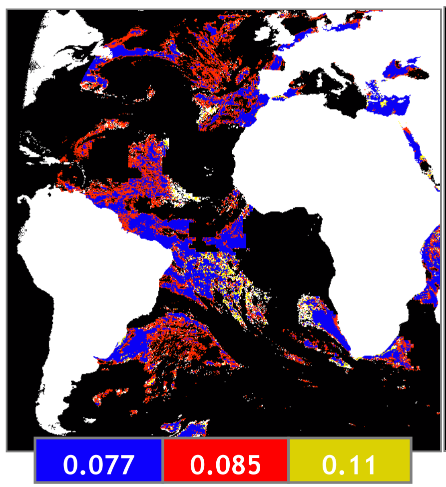
ΔT_analysis_T-1 (K)



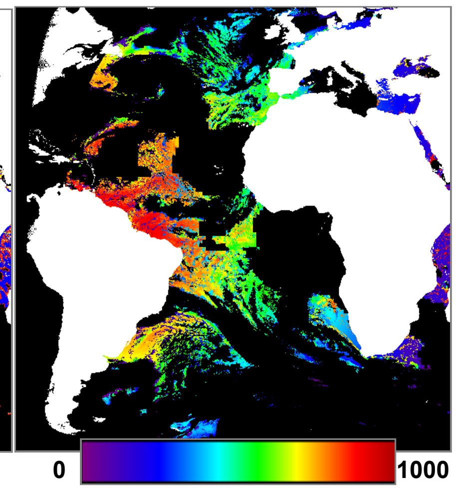
Wind Speed (ms^{-1})



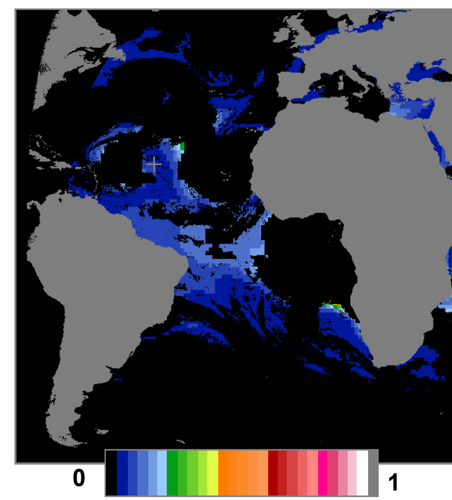
Time difference (Hours)



STD error (K)

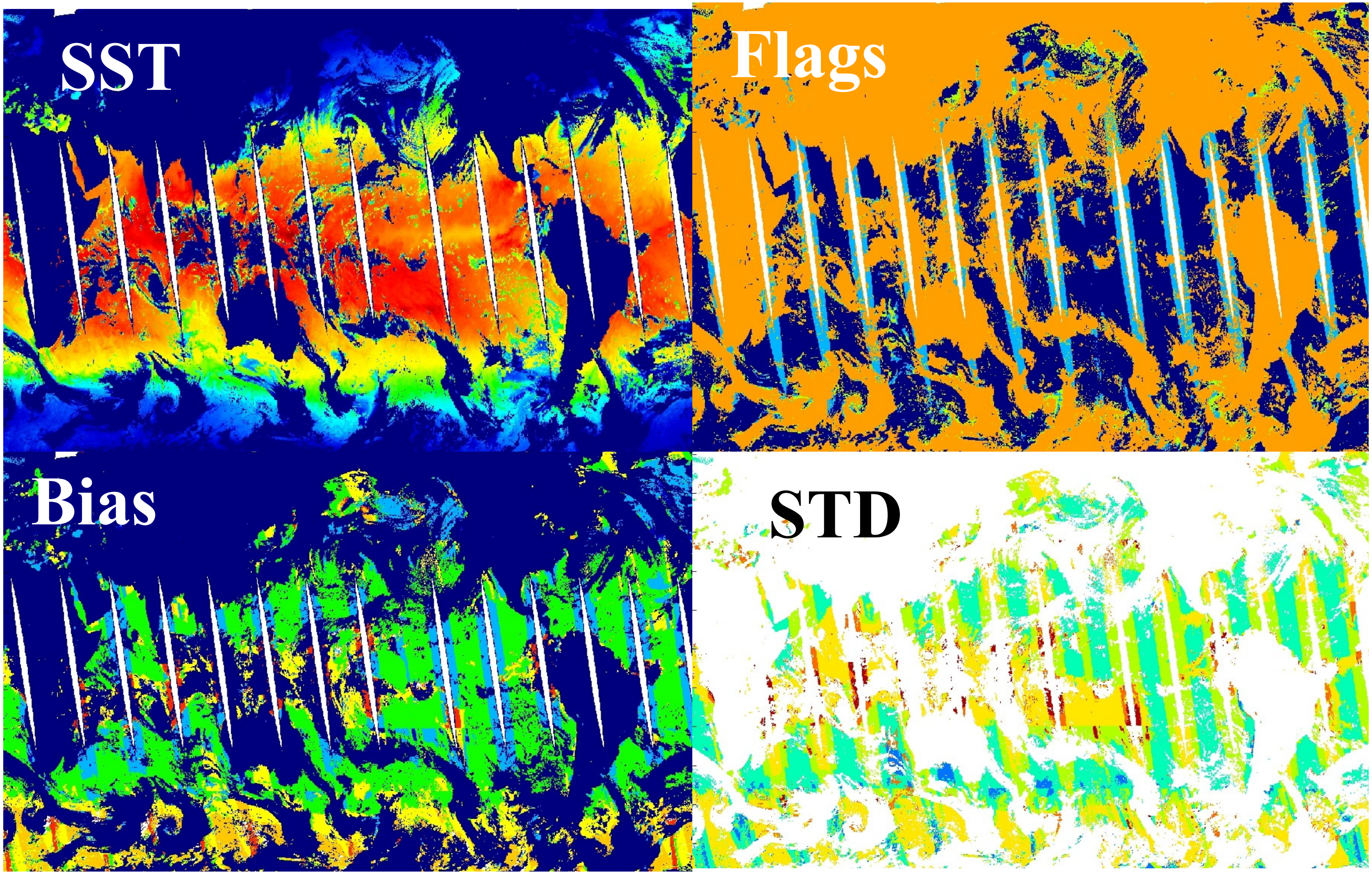


SSI (Wm^{-1})



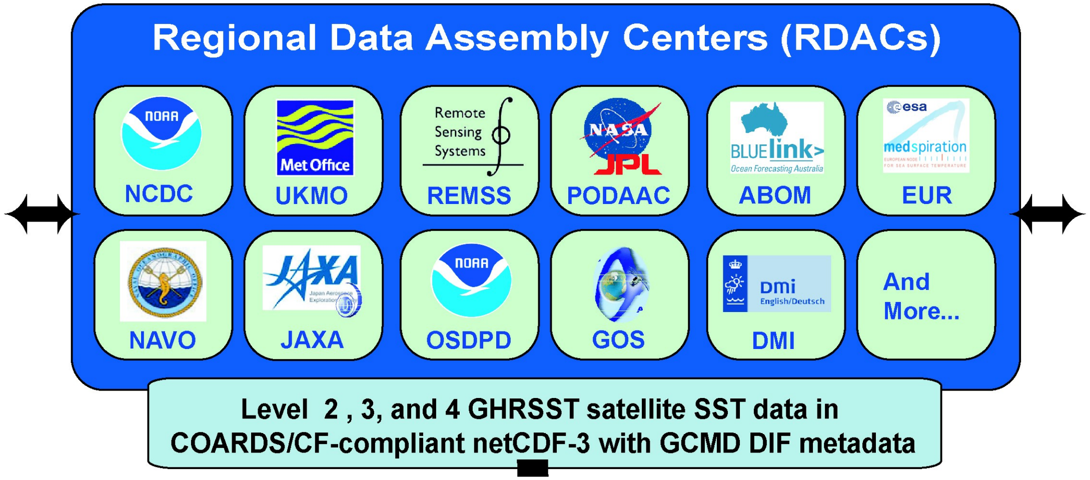
AOD

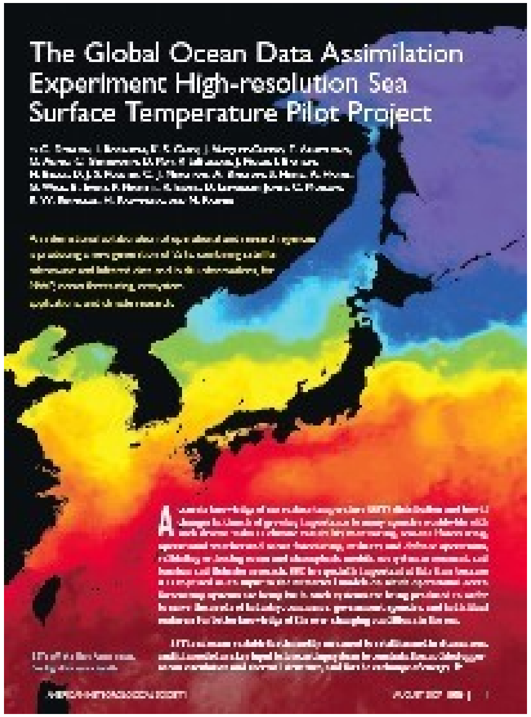
MODIS L2P uncertainties



GHRSST-PP Regional/Global Task Sharing Framework

GODAE High Resolution Sea Surface Temperature Pilot Project

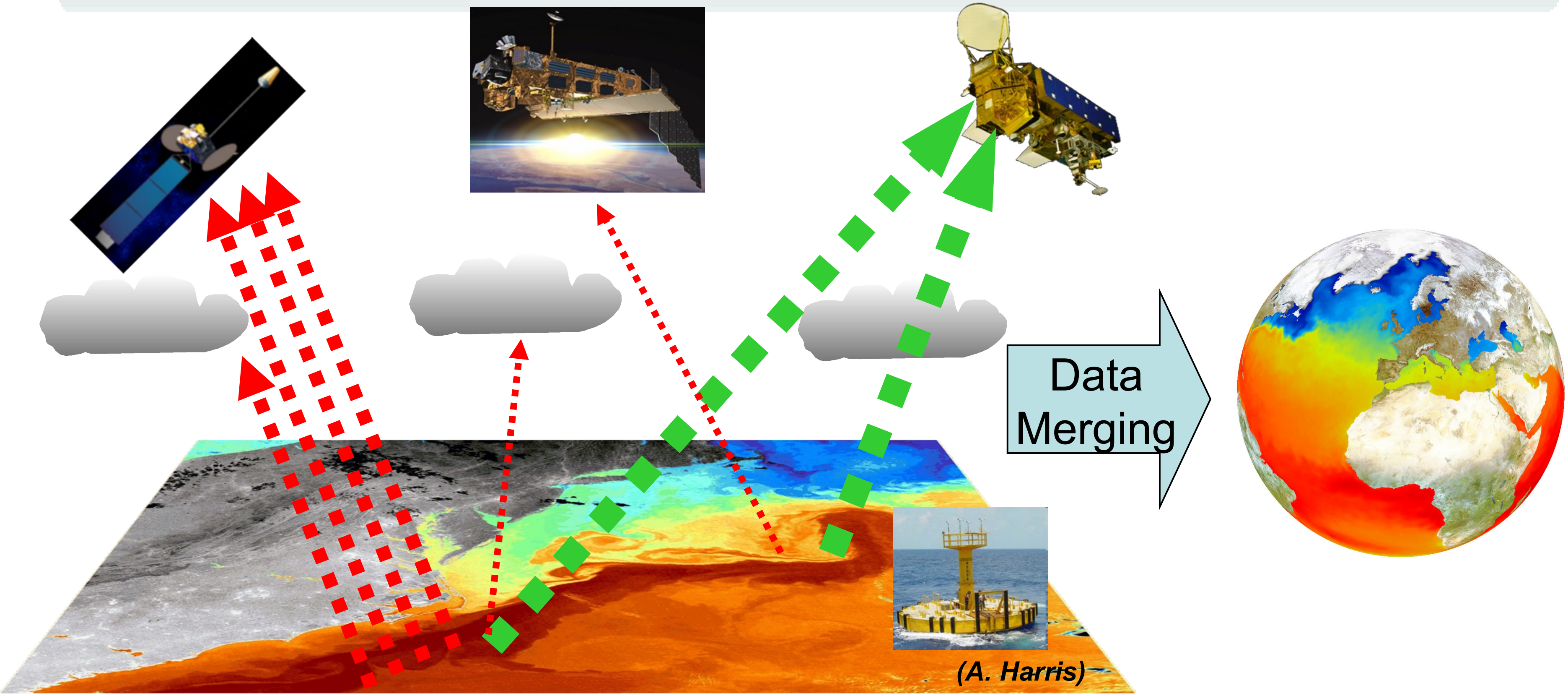




Donlon *et al*, 2007, BAMS, **88**, 1197–1213.

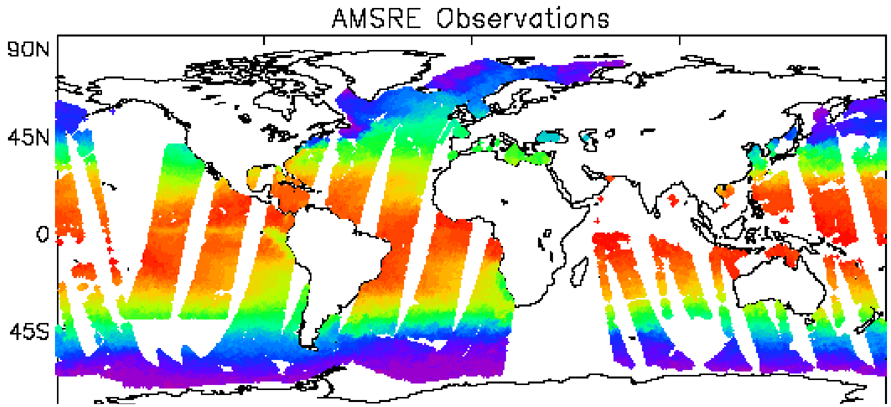
vw.ghrsst-pp.org

GHRSST-PP Builds on EO complementarities

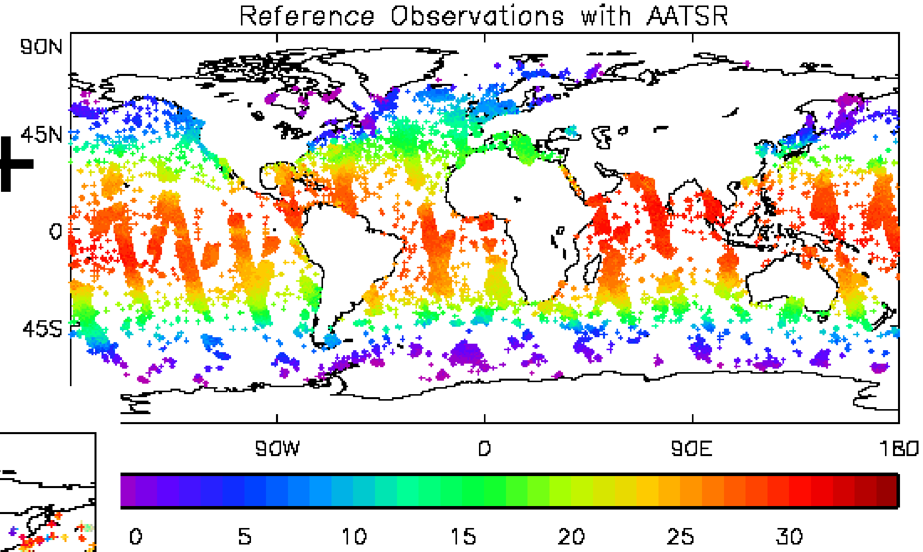


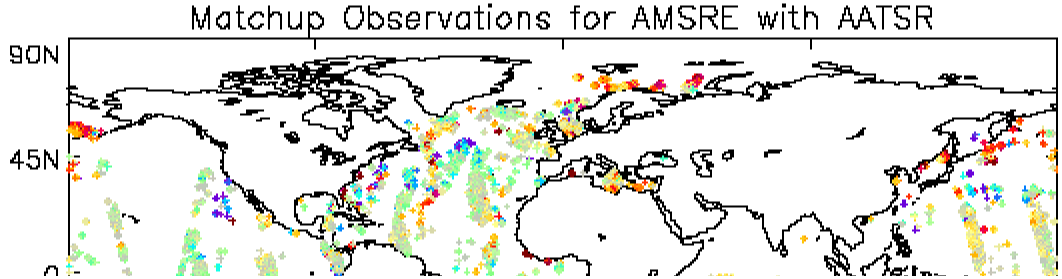
- Polar Orbiting infrared has ***high accuracy & spatial resolution***
- Geostationary infrared has ***high temporal resolution***
- Microwave Polar orbiting has ***all-weather capability***
- In situ data provide ***reality in all weather conditions***

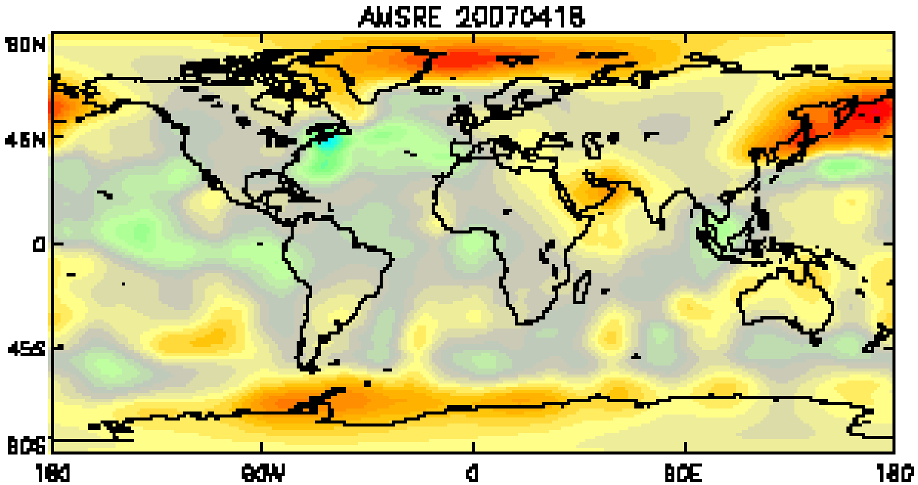
AATSR as an operational SST reference: OSTIA bias adjustment scheme



+







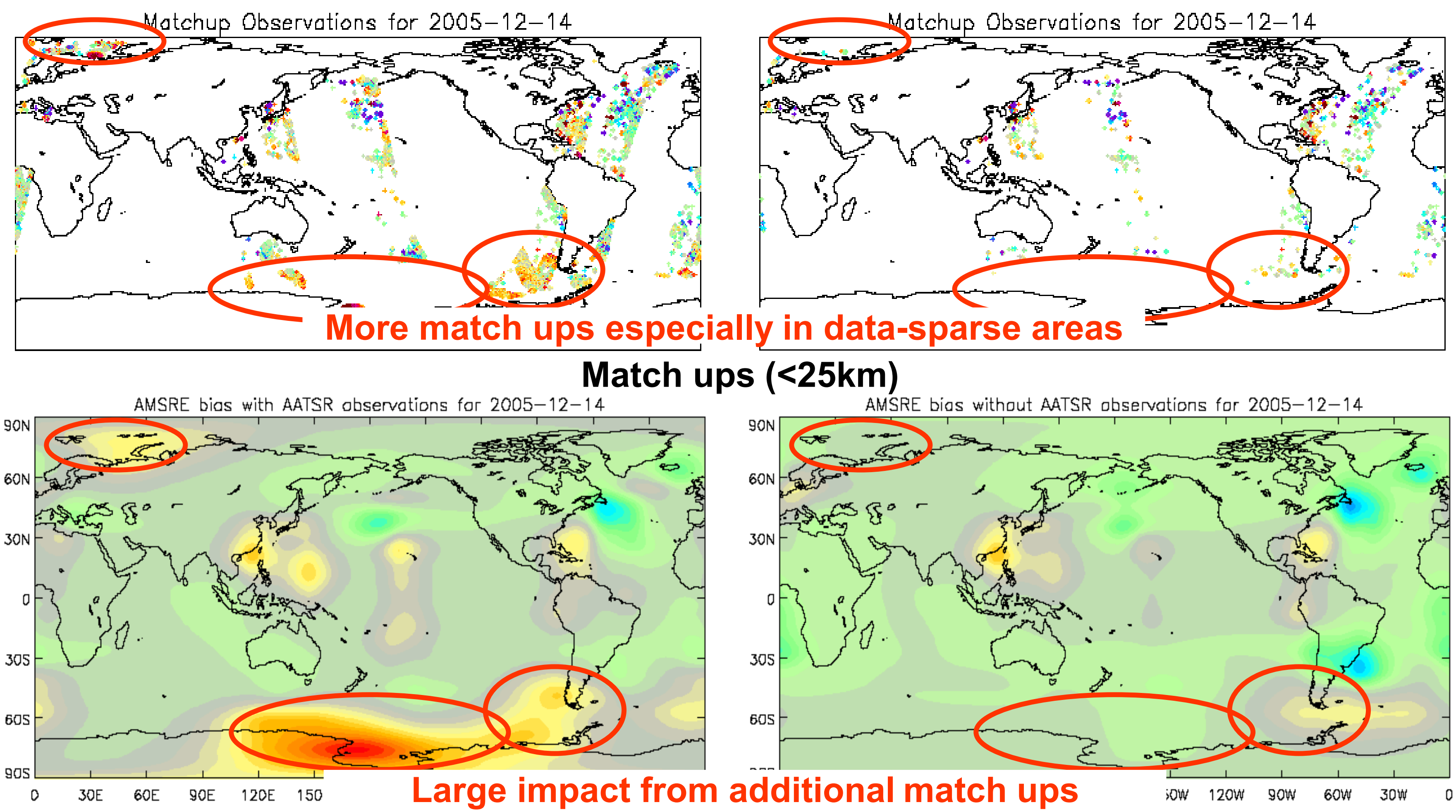
Sample data from 18 April

Find matchups (<25km, 12 hours)

Create bias analysis, and remove bias from observations for use in SST analysis.

http://www.ghrsst-pp.org

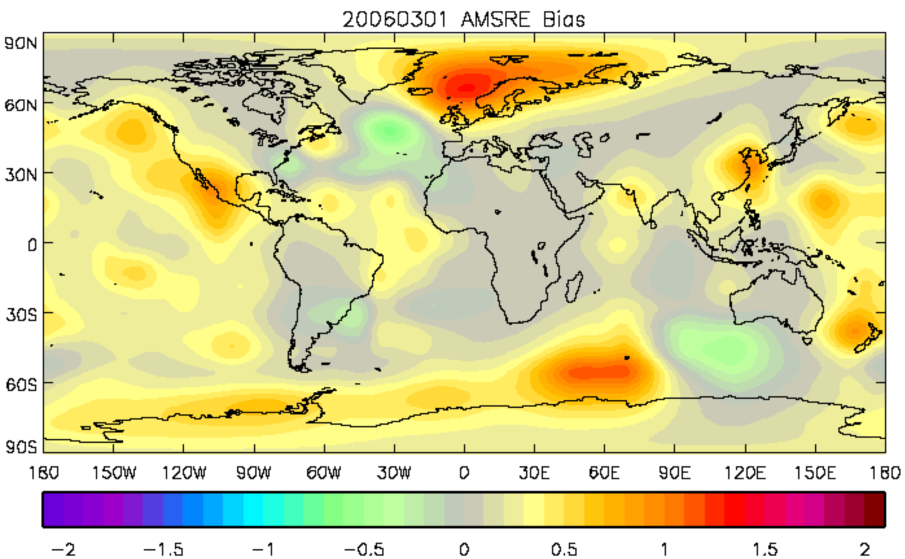
Bias correction (ATSR + in situ)

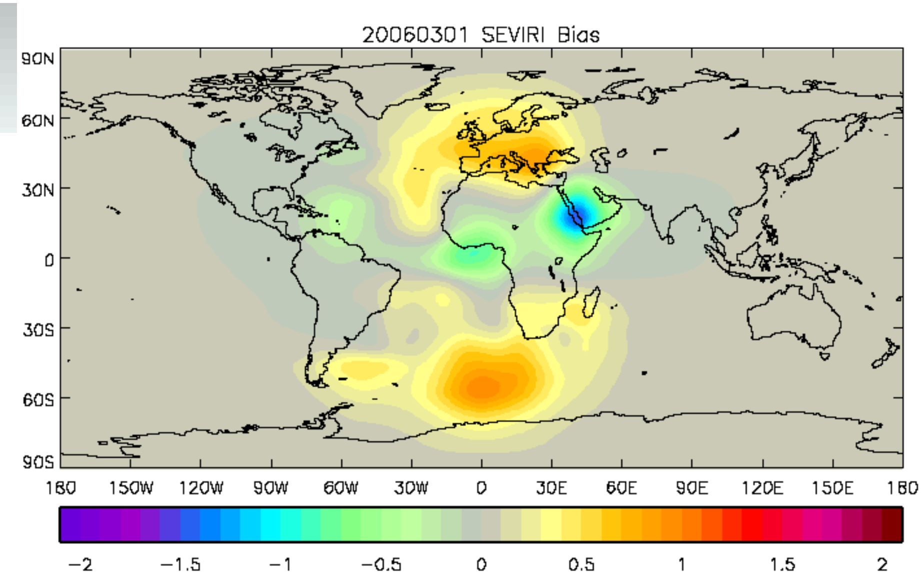


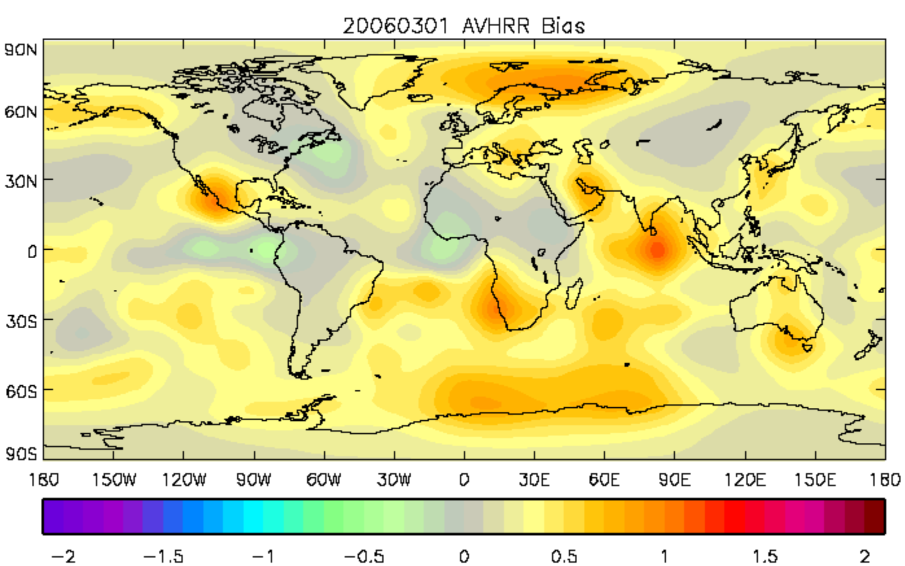
Analysed AMSRE bias for 14 Dec.

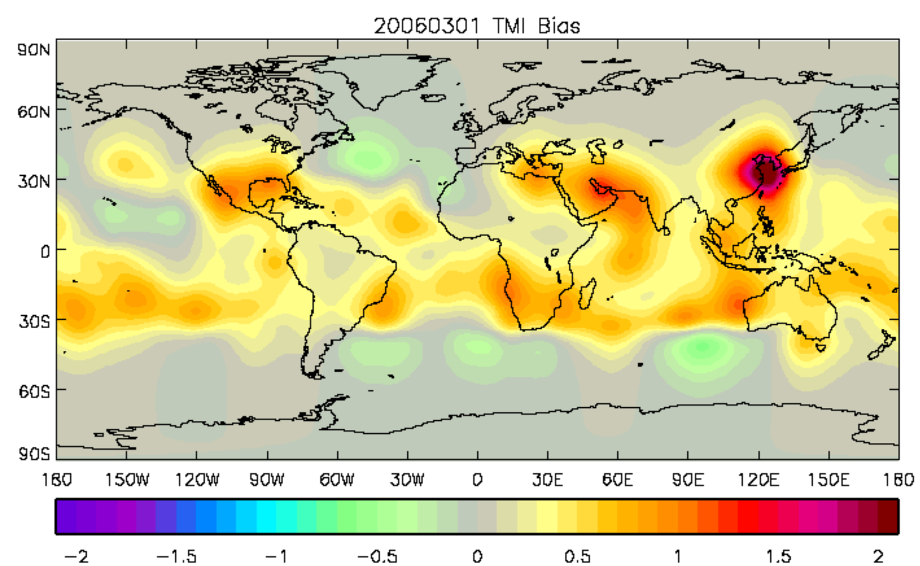
GHRSST-PP
GODAE High Resolution Sea Surface Temperature Pilot Project

http://www.ghrsst-pp.org

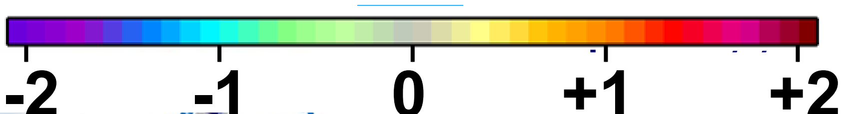








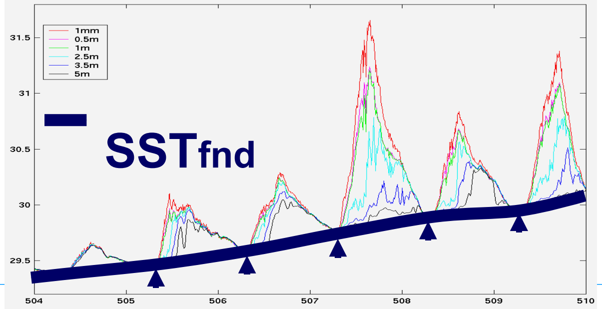
GODAE High Resolution Sea Surface Te



.ghrsst-pp.org

GHRSST Re-analysis program

- Spatial: Goal 4-5 km globally with 1-2 km regional products
- Temporal: Once per day
- Types: L4 SSTfnd (plus 4 diurnal offsets)
- Error Stats: Bias and Standard Deviation at each output grid point
- Data Format: netCDF with CF metadata



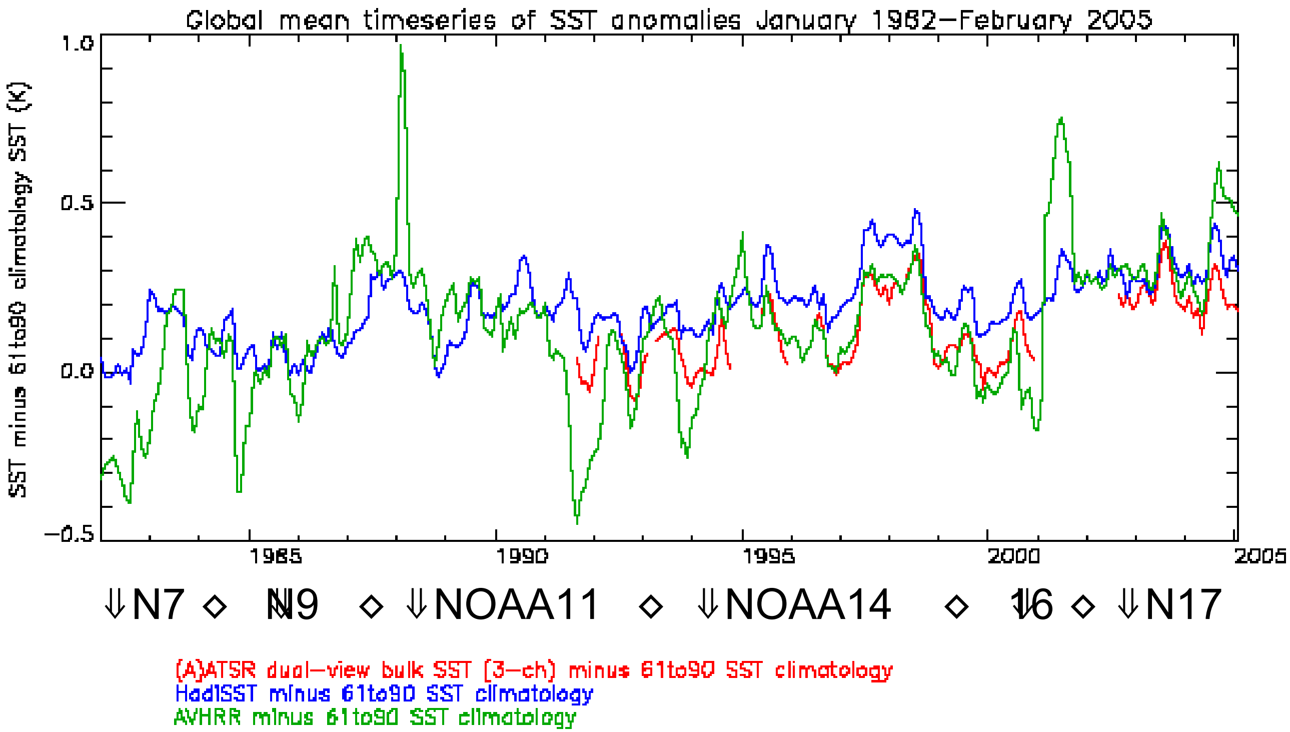
(Modified from A. Stuart-Menteth)

GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

http://www.ghrsst-pp.org

SST anomalies: (A)ATSR, AVHRR, HadISST1



ATSR-1 more robust to effects of Pinatubo than AVHRR

Possible trends of ~0.1-0.2K/decade

AVHRR cooler than HadISST1 1995-2002

(A)ATSR, here converted to "foundation" SST has the potential to be a quasi-reference instrument and provide CDRs in its own right (after *O' Carroll et al, J Climate*)

Future Role of Satellites in SST CDRs

- Satellites play an increasing role in climate research
- Have global coverage, often high resolution and
- sometimes greater accuracy possible than in situ data
- Future state of the satellite and in situ observing network is unsure – always dynamic
- Continue to combine strengths of IR and microwave satellite data with better in situ data – integrated data sets
- Need more in situ observations - and these need to be climate reference stations
- Continue to evolve and maintain uncertainty estimates for all data
- We should use the modern satellite era to understand the limitations of the historical record

Future Role of Satellites in SST CDRs

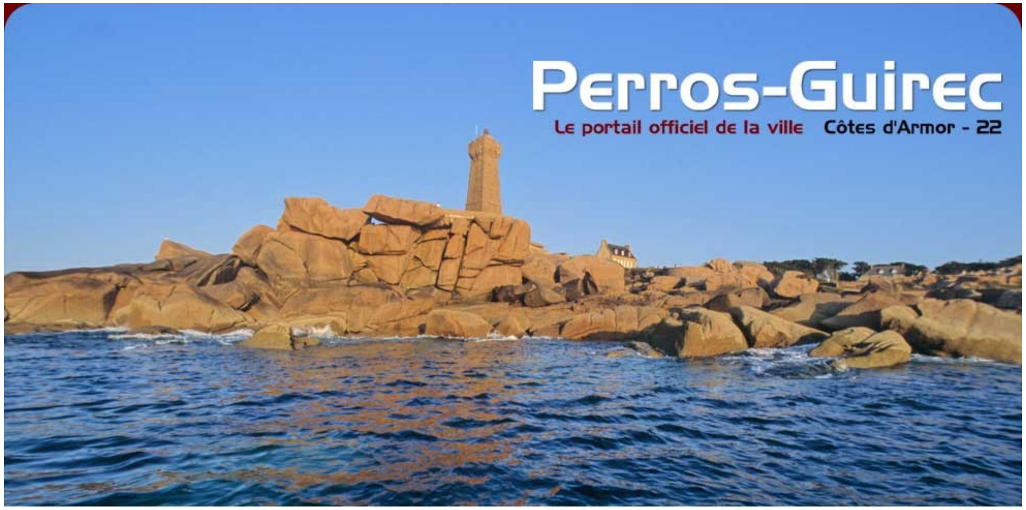
- Combination with in situ data is essential for the construction of long climate records of SST needed to detect climate change
- Need to think about the future now
- Essential to apply satellite GCOS climate monitoring principles to provide a reliable climate change monitoring capability
- Need better integration of in situ and satellite data

Specific Recommendations

- Satellite data should be fully exploited in synergy with in situ data within JCOMM ETMC
  - Start with SST and link to GHRSST/GCOS SST&SI WG reanalysis activities
  - Coordinate with the CCl OPAG 2 ET 2.2 on climate monitoring including the use of satellite and marine data and products
- Current (and potential future) satellite SST observations are sufficiently accurate and robust to be used as part of the operational QC procedures for in situ SST observations
  - ETMC/I-COADS should fully exploit this potential
- The JCOMM Data Management Program Area should assist the community in the regulation and operation of satellite oceanographic data sets
  - Particularly for observations that are unique or well suited to satellite systems (SST, Sea Surface Height, Ocean Colour, surface roughness, waves and winds)
- JCOMM should take steps to implement and maintain the GCOS satellite climate monitoring principles to ensure a robust climate data record from space based systems

9th GHRSST-PP Science Team Meeting 2008

- **The 9th GHRSST ST meeting** will be held at the Palais des Congrès in Perros-Guirec, France
- 9th-13th June 2008 - Please join us!
- Registration at http://www.ghrsst-pp.org



International GHRSST-PP Project Office

Met Office,
Fitzroy Road
Exeter,
EX1 3PB
United Kingdom
Web: http://www.ghrsst-pp.org
E-mail: craig.donlon@metoffice.gov.uk