Sea Surface Temperature Virtual Constellation (SST-VC) Report to WGCV-36

Gary Corlett

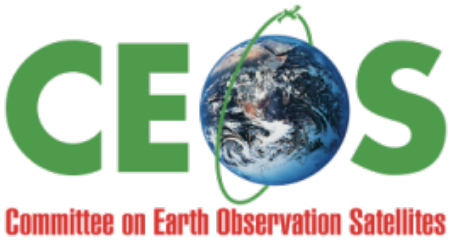
University of Leicester/ GHRSST Project Office

On behalf of the SST-VC

GHRSST
Group for High Resolution Sea Surface Temperature

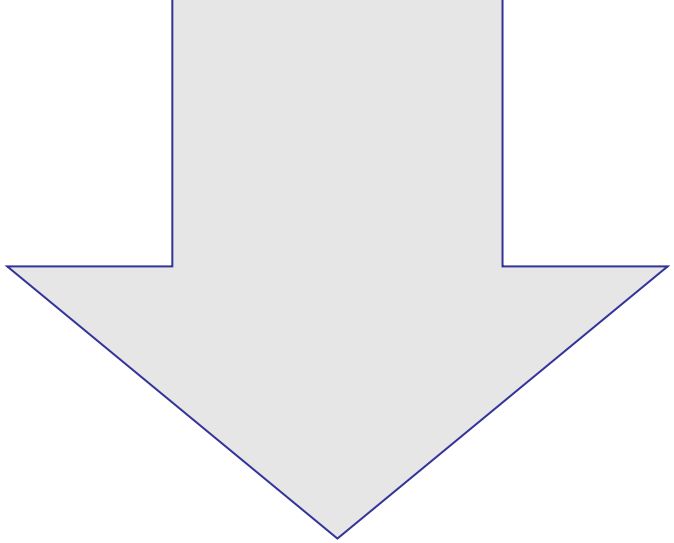
http://www.ghrsst.org

CEOS
Committee on Earth Observation Satellites

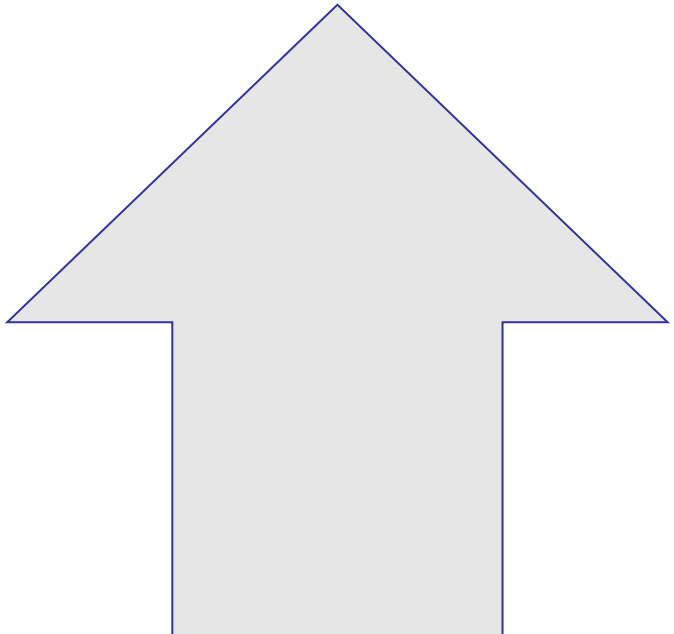


= The Committee on Earth Observing Satellites, the international coordinating group for earth-observing agencies.

= The Group for High Resolution SST, the international coordinating group for SST.



Where these two meet = the CEOS SST Virtual Constellation



GHRSST

- GHRSST, the Group for High Resolution Sea Surface Temperature grew out of a Pilot Project of the Global Ocean Data Assimilation Experiment (GODAE), 1997-2008.
- Composed of a Science Team of researchers and operational practitioners.
- Coordinates research and operational developments in satellite-derived SST.
- Organized into Working Groups and Technical Advisory Groups focused on particular problems or activities
- Data processing through Regional and Global Data Assembly Centers, combining satellite and NWP fields in common data formats for ease of access and analysis.
- Data are available in perpetuity at the GHRSST Long Term Stewardship and Reanalysis Facility at the NOAA National Oceanographic Data Center (http://ghrsst.nodc.noaa.gov).
- See https://www.ghrsst.org/

GHRSST

Group for High Resolution Sea Surface Temperature

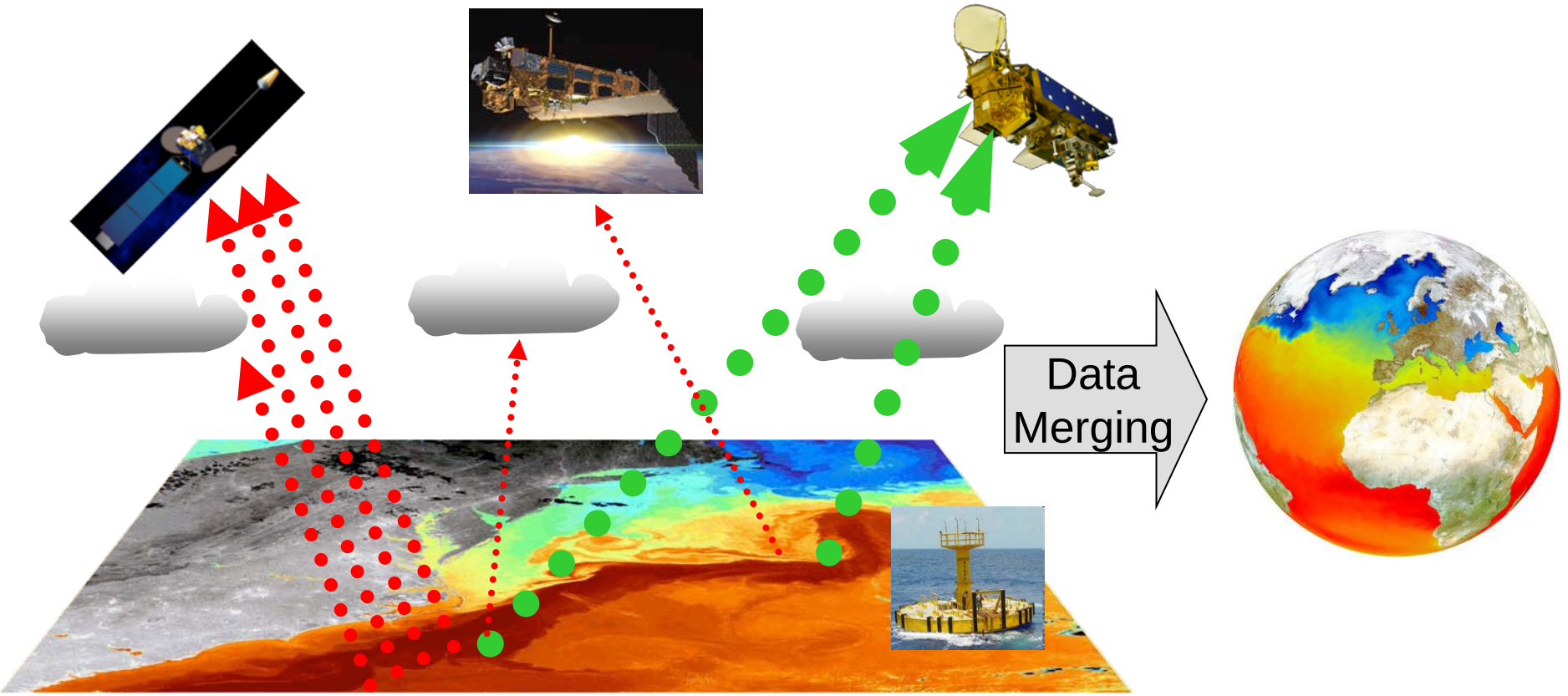
Providing a framework for SST data sharing, best practices for data processing and a forum for scientific dialog, bringing SST to the user.

Science Team

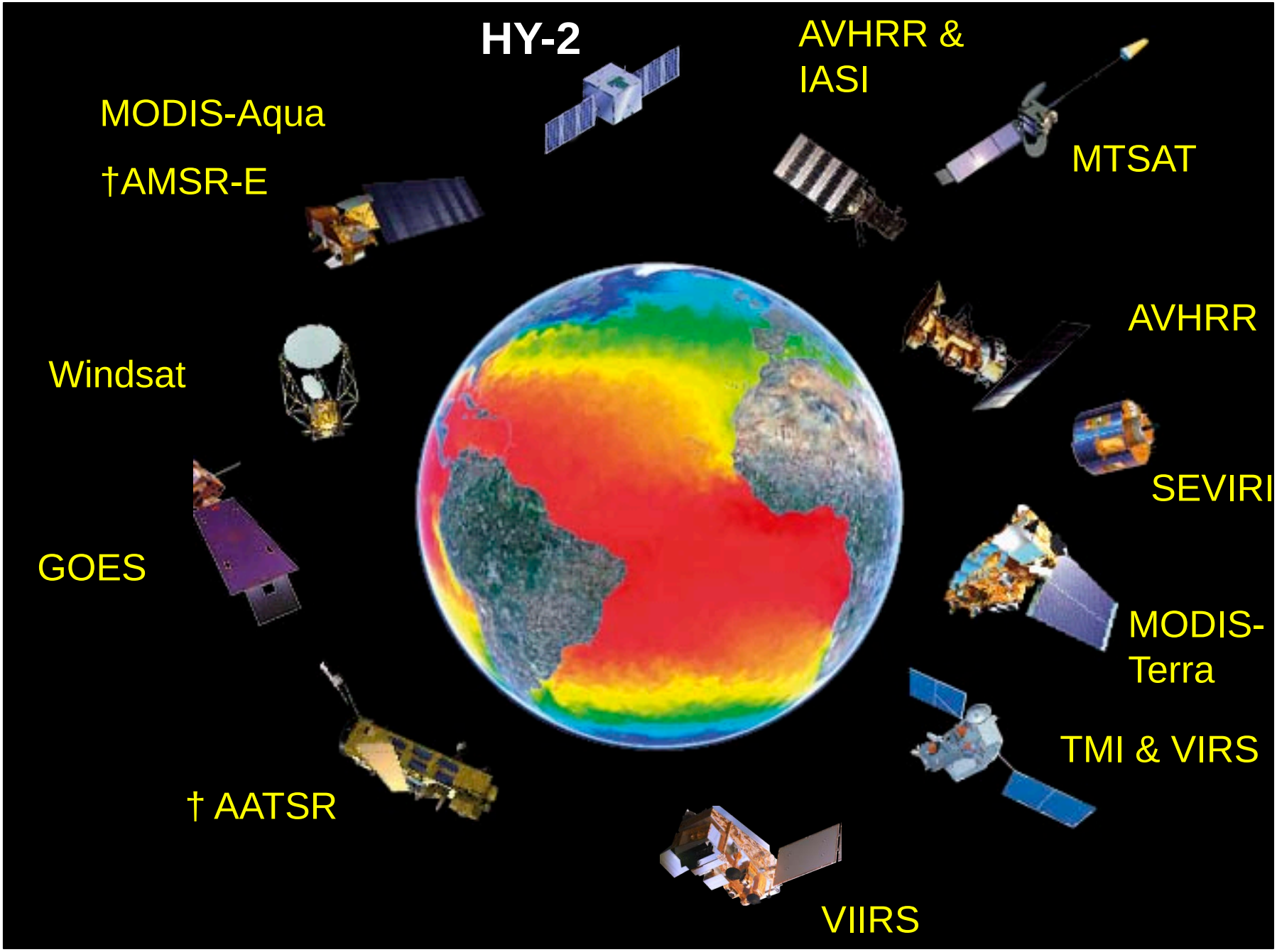
Peter Minnett (Science Team Chair), RSMAS, University of Miami, USA
Gary Corlett (Project Coordinator), University of Leicester, UK

Craig Donlon (chair 2000-2011), ESA, The Netherlands
Olivier Arino, ESA-ESRIN, Italy
Ed Armstrong, JPL PO.DAAC, USA
Viva Banzon, NOAA NCDC, USA
Ian Barton, CSIRO Marine Research, Australia
Helen Beggs, Bureau of Meteorology, Melbourne, Australia
Ken Casey, NOAA/NESDIS NODC, USA
Sandra Castro University of Colorado, USA
Mike Chin, NASA JPL, USA
Peter Cornillon, University of Rhode Island, USA
Steinar Eastwood, met.no, Norway
Bill Emery, University of Colorado, USA
Bob Evans, RSMAS, University of Miami, USA
Chelle Gentemann, Remote Sensing Systems, USA
Lei Guan, Ocean University of China, China
Ted Habermann, NOAA NGDC, USA
Andy Harris, NOAA/NESDIS ORA, USA
Jacob Høyer, Danish Meteorological Institute, Denmark
Shiro Ishizaki, JMA, Japan
Misako Kachi, JAXA, Japan
Alexey Kaplan, Columbia University, USA ,
Hiroshi Kawamura, JAXA/University of Tohoku, Japan
Pierre LeBorgne, Meteo France OSI SAF, France
Tim Liu, NASA JPL, USA
David Llewellyn-Jones, University of Leicester, UK
Matt Martin, MetOffice, UK
Doug May, Naval Oceanographic Office, USA
Chris Merchant, University of Edinburgh, UK
Jon Mittaz, NOAA, USA
Tim Nightingale, Rutherford Appleton Laboratory, UK
Anne O'Carroll, EUMETSAT, Germany
Jean-Francios Piolle, IFREMER, France
David Poulter, Pelamis Scientific Software Ltd, UK
Nick Rayner, Hadley Centre, Met Office, UK
Richard Reynolds, NOAA CDC, USA
Ian Robinson, University of Southampton, UK
Jorge Vasquez, JPL, PO.DAAC, USA
Gary Wick, NOAA ETL, USA

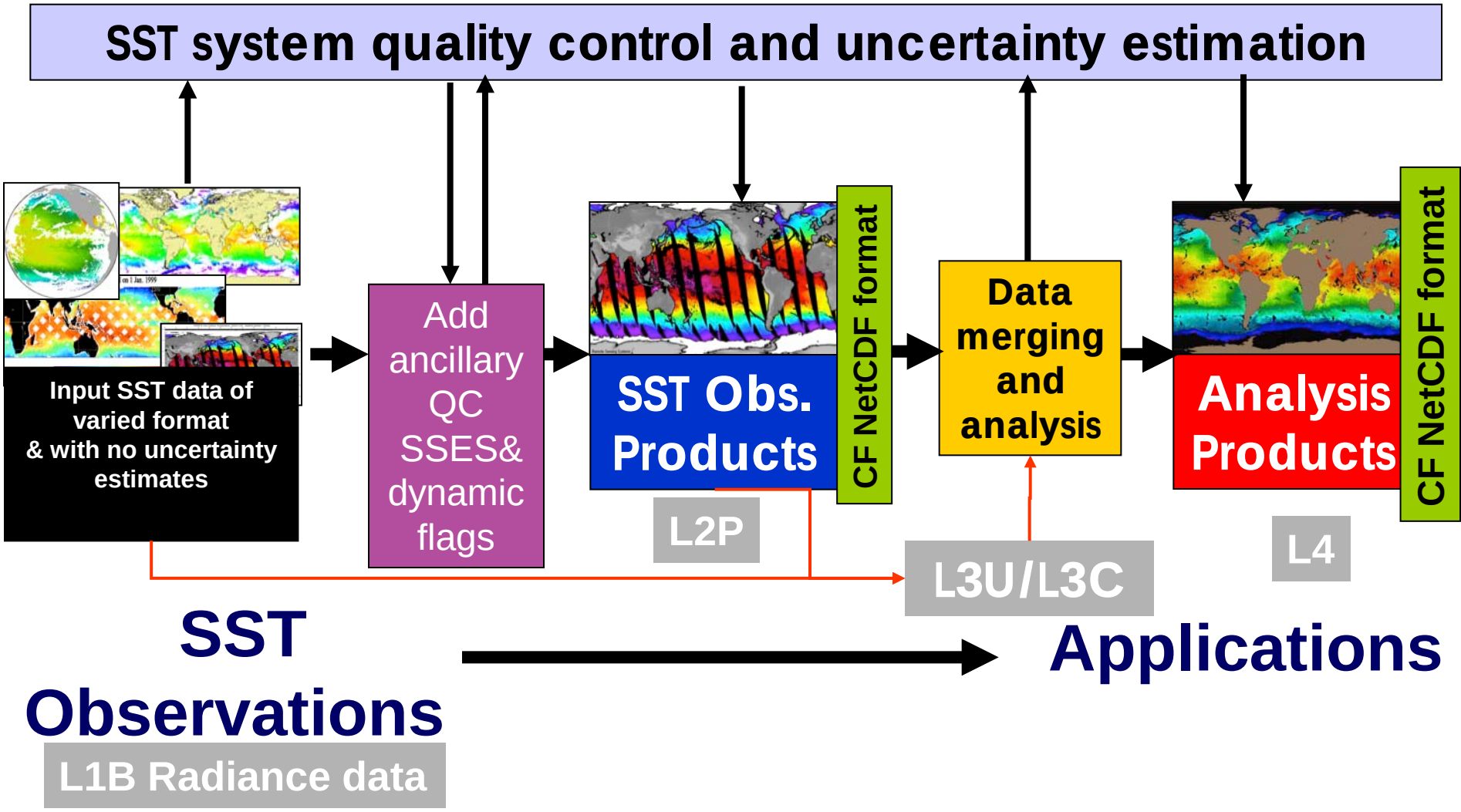
GHRSST Builds on EO complementarities



- 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***

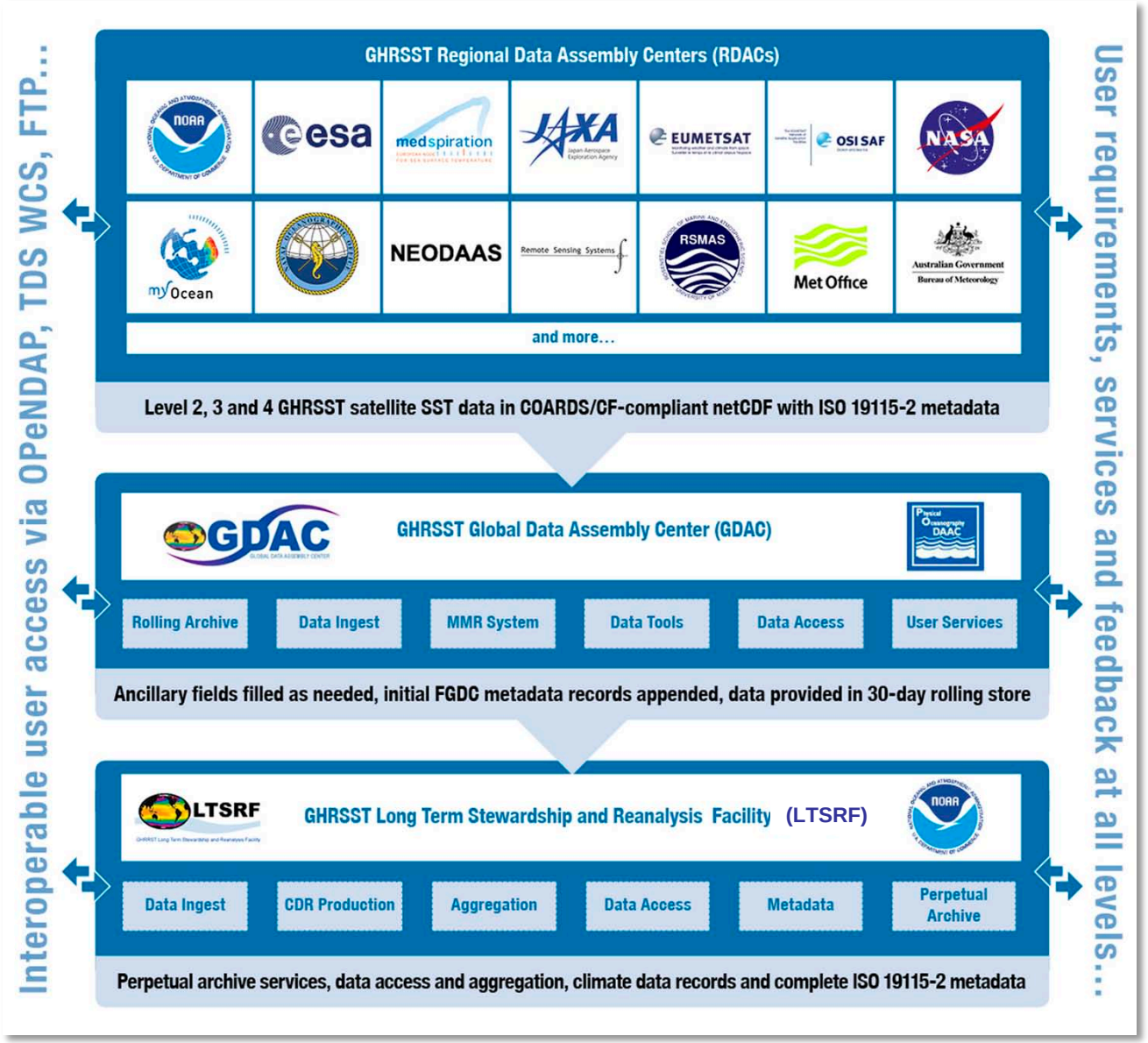

HY-2
AVHRR &
IASI
MODIS-Aqua
†AMSR-E
MTSAT
AVHRR
Windsat
SEVIRI
GOES
MODIS-
Terra
TMI & VIRS
† AATSR
VIIRS

The GHRSST Strategy



SST-VC: Implementation

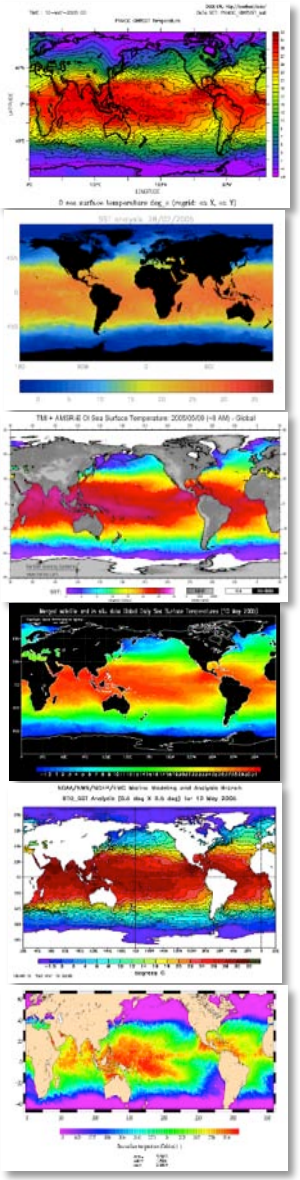
The SST-VC builds on the existing *Group for High Resolution SST* framework.

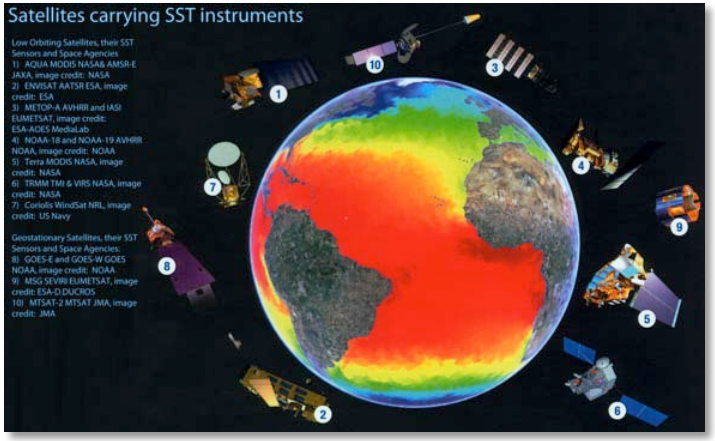


SST-VC: Implementation

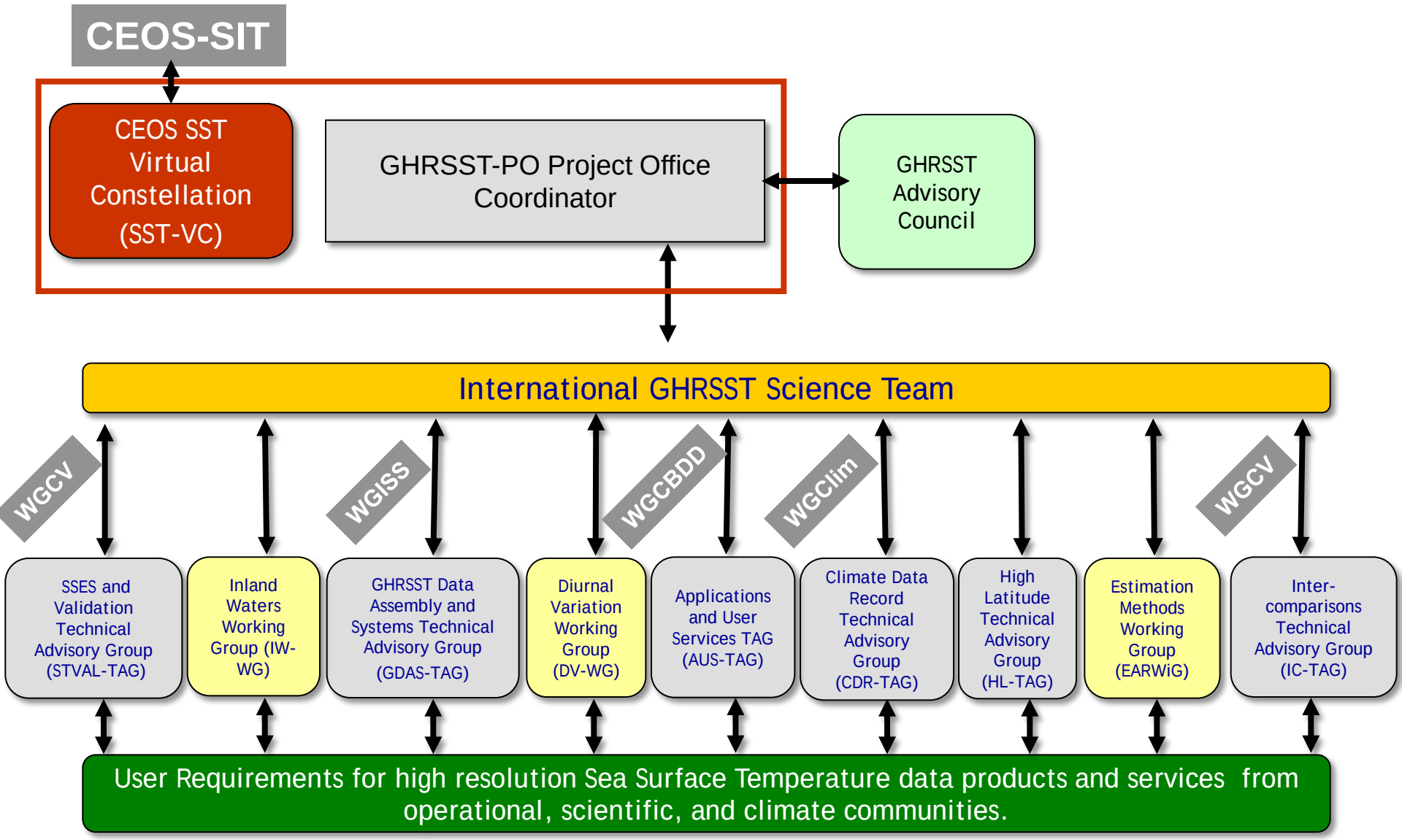
Using this approach, the CEOS SST-VC can leverage and support GHRSST's:

- **Baseline SST virtual constellation** system of systems
- **Internationally agreed SST products and services** (data access, user support services)
- **Initial consensus technical documentation** for the constellation
- **Functional coordination mechanism** active at the international level (Science Team, Advisory Council, Project Office)





CEOS Interfaces to GHRSST



SST-VC: Current Membership

SST-VC Co-leads:

- Kenneth S. Casey, National Oceanic and Atmospheric Administration (NOAA), USA
- Craig Donlon, European Space Agency (ESA), Netherlands

SST-VC Members:

- Hans Bonekamp, European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), Germany
- Andrew Bingham, Jet Propulsion Laboratory, National Aeronautics and Space Administration (NASA), USA
- Misako Kachi, Japan Aerospace Exploration Agency (JAXA), Japan
- Jane Olwoch, South African National space Agency (SANSA), S. Africa
- Chris Merchant, United Kingdom Space Agency (UKSA), UK
- Helen Beggs, Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BoM), Australia
- Gary Corlett, Group for High Resolution SST (GHRSST) International Project Office coordinator
- Peter Minnett (GHRSST Science Team Chair), University of Miami, USA

SST-VC and GHRSST: Growth

- Our aspiration is to provide a sustainable high resolution SST measurement system
- This needs to a real constellation (not just a virtual one!)
- For this we need to have all satellite SST sensors and datasets within the SST-VC/GHRSST data system
  - For example, we would like to bring in data from the Haiyang (HY) series
- To help this process the SST-VC/GHRSST would like to widen its international collaboration to countries with an interest or a capability in SST.
  - Such countries would include, but are not limited to, Argentina, Brazil, China, Korea, India and Russia.
- To participate please contact
  - SST-VC: Kenneth Casey (Kenneth.Casey@noaa.gov) or Craig Donlon (Craig.Donlon@esa.int)
  - GHRSST: Gary Corlett (gpc@ghrsst.org)

SST-VC and WGCV

- **The CEOS SST-VC has had very strong links to the CEOS WGCV for many years**
  - Ah, but how… the SST-VC is relatively new…
  - Ian Barton, David Llewellyn-Jones, Peter Minnett, amongst others, have attended previous WGCV meetings
  - Since 2008, GHRSST has actively participated in WGCV IVOS (Gary Corlett, ST-VAL Chair)
- We expect and want this to continue
- If this interaction is not clear to CEOS then we have a communication issue

SST-VC Activities

- Clear separation of calibration and validation (each one clearly defined by the CEOS WGCV)
- For calibration
  - Coordinated through CEOS WGCV IVOS and reported to SST-VC/GHRSST
  - Need input from instrument teams
  - Radiometry intercomparisons (‘Miami IV’)
- For validation
  - Coordinated through GHRSST and reported to SST-VC/CEOS WGCV IVOS
  - Established links to JCOMM DBCP and SOT, Argo and other in situ data sources

‘Miami IV’ (1)

- Ship-borne IR radiometry provides an independent SI-traceable data source for generating SST CDRs from multiple sensors
  - Maintain pre-launch SI traceability of satellite calibration
  - Independent SI traceable assessment of stability through quantified uncertainties per measurement
- Routine intercomparison of radiometers to national standards and to each other is essential

Note: ‘Miami IV’ is a working title – it does not mean it will take place in Miami

‘Miami IV’ (2)

- Timing for the next international IR radiometer workshop in 2014:
  - Close to launch of SLSTR on Sentinel 3a
  - Many new sensors, including of Suomi-NPP VIIRS, METOP-B, MSG-3, AMSR2
  - Towards the end of MODIS on Terra and Aqua?
- So timing is appropriate for a “reset” of traceability to SI standards of ship-based radiometers.

‘Miami IV’ (3)

- As with earlier workshops, field as well as laboratory measurements
- Involve groups doing land/ice surface temperatures as well
  - Link to LPV
  - Common laboratory component (led by IVOS)
  - Field components would diverge
    - At sea for SST (led by SST-VC)
    - Land areas with multiple cover types for LST (led by LPV)
- Involve atmospheric community?

SST-VC and QA4EO

- QA4EO introduced to GHRSST in 2009
  - **Interoperability** is very important within a domain
  - Agreed and implemented community best practices are essential
- Sensor Specific Error Estimates (SSES) included in L2P data
  - Development and implementation is compliant with QA4EO
  - Uses community ‘reference’ standard
  - **Quality indicators were developed in conjunction with users**
- Now transitioning to uncertainty budgets and validation of uncertainties
  - Needed for future (coupled) forecasting
  - Need for climate data records

QA4EO Guiding Principles

1) Data Quality

All data and derived products must have associated with them a **Quality Indicator (QI)** based on **documented quantitative assessment** of its **traceability to community agreed reference standards**.

2) Data Policy

Cal/Val data must be **freely and readily available / accessible / useable**. This necessitates that **all Cal/Val data and associated support information (metadata, processing methodologies, QA, etc.) is associated with the means to effectively implement a quality indicator.** In return, the provider must be consistently acknowledged.

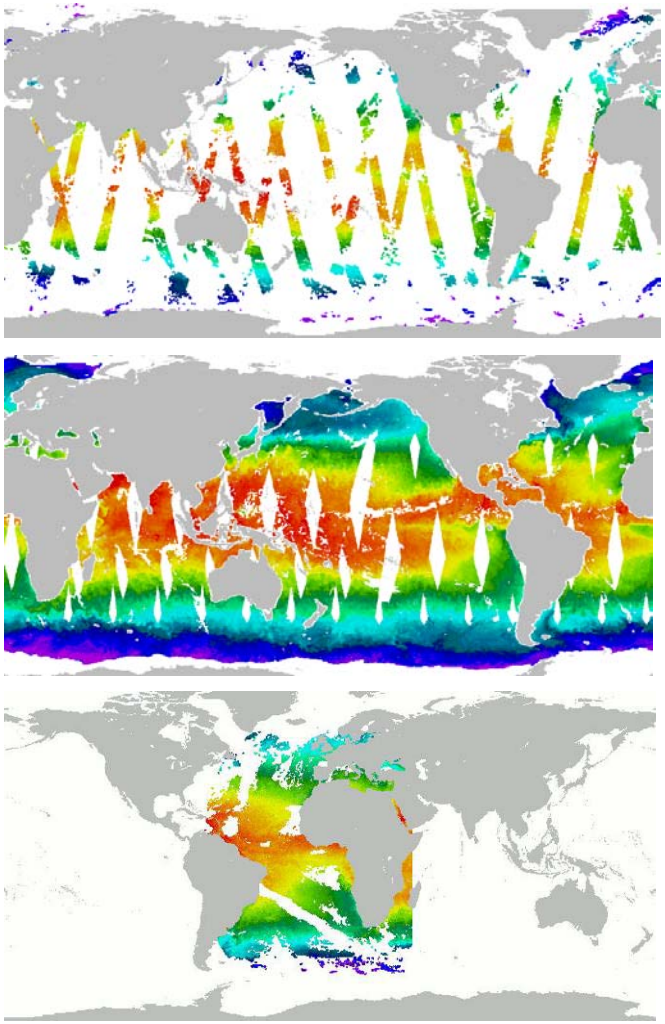
3) Communication and Education

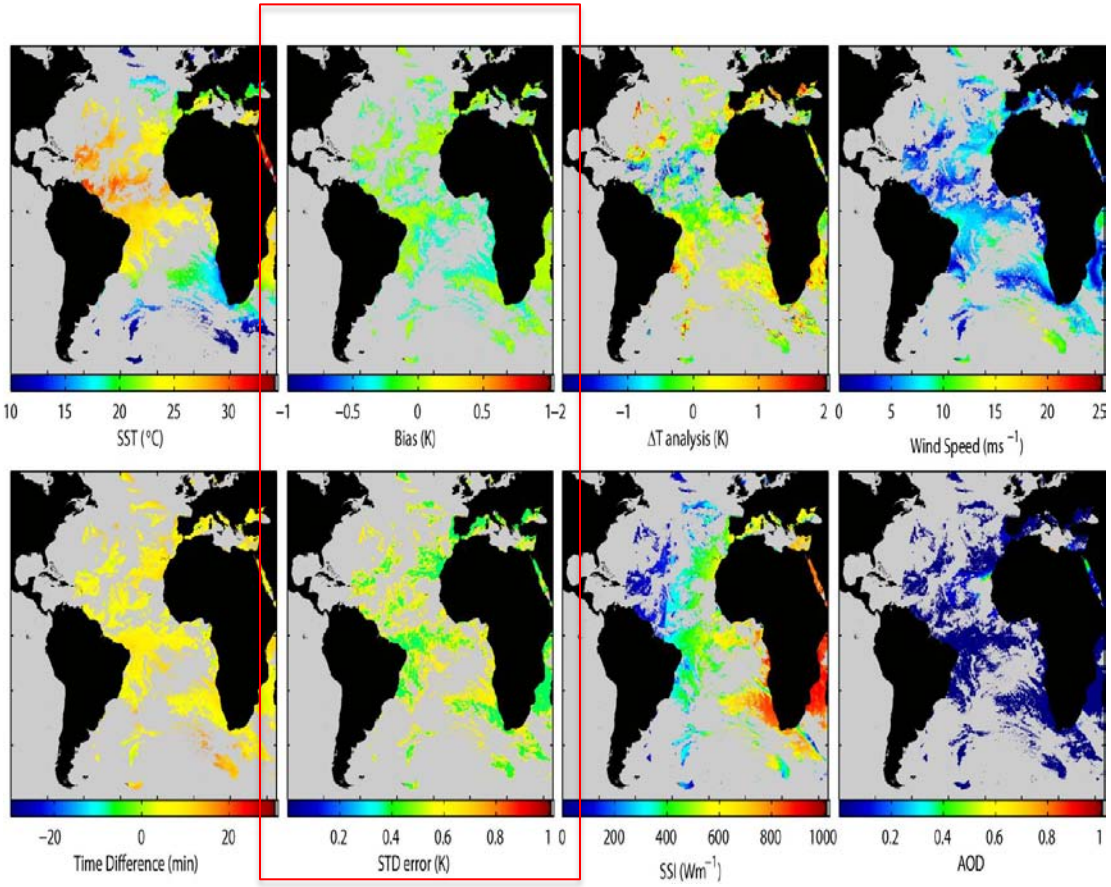
All stakeholders must have a **clear understanding** of the adequacy of the information, which should be **accessible through a single portal** and should be **fully traceable to its origins**.

… in 2009 at least….

QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

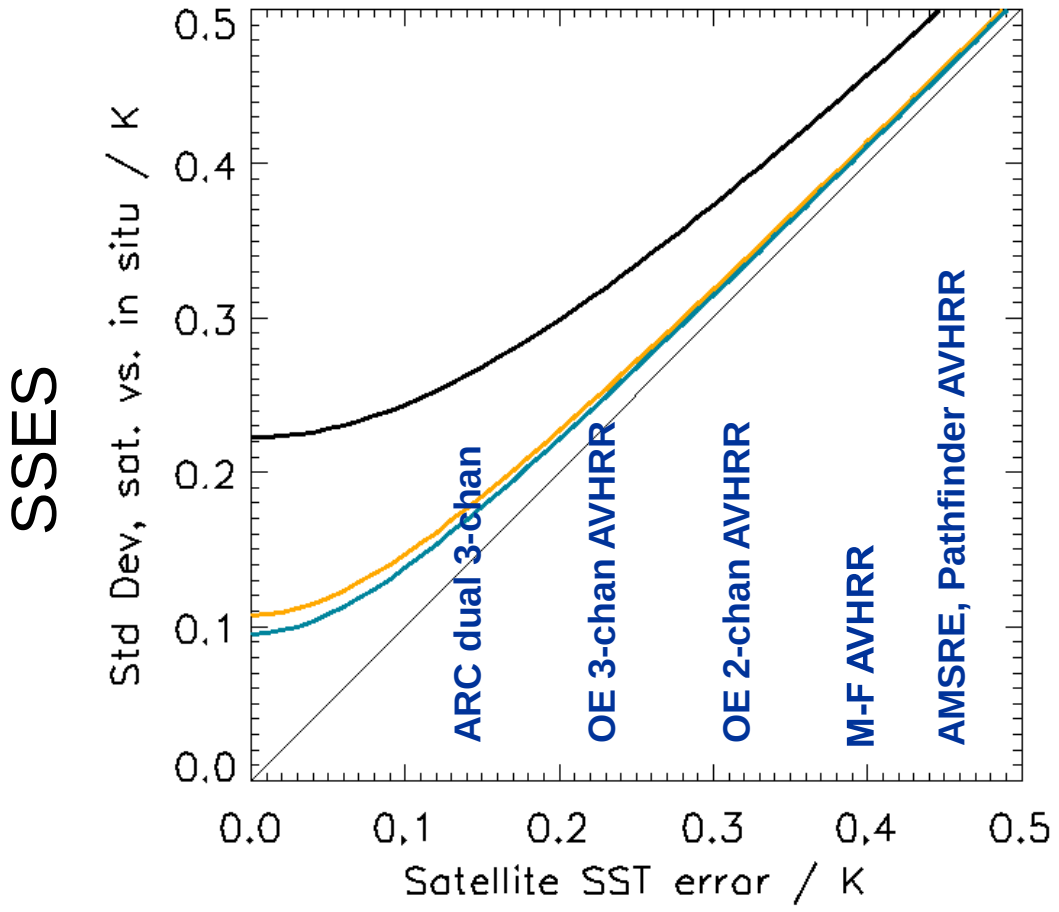
L2P: common format with uncertainty





Ancillary information in L2P products: dynamic flags

Impact of drifter uncertainty



True satellite uncertainty

Current drifters

Uncertainty ~ 0.05 K

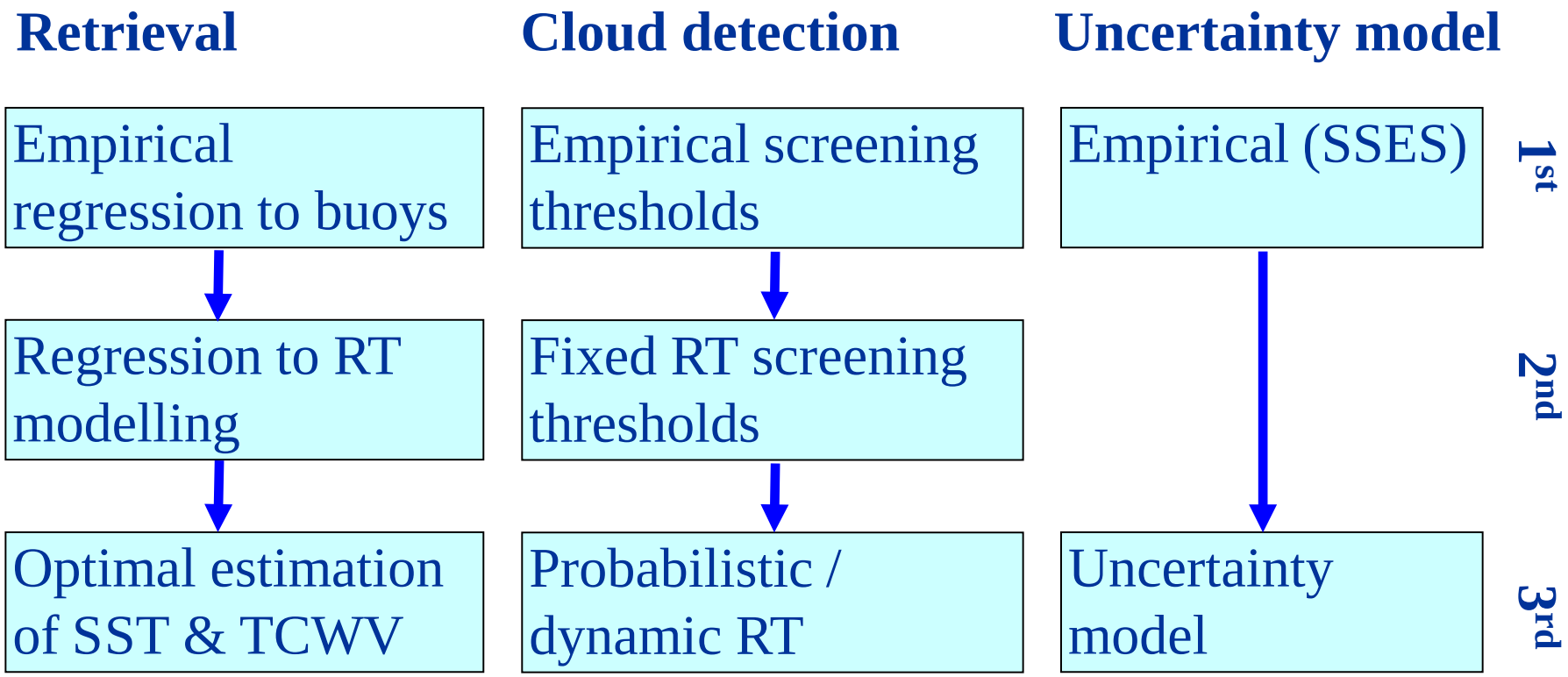
Argo

Have started pilot project with JCOMM DBCP to improve calibration of drifters

Need validated uncertainty models

- Uncertainty in an EO product is not a straightforward quantity
- A single statistic (such as SSES) is inadequate for most users
- For SST, there are four (or more) components
  - Calibration / forward model uncertainty
    - Highly correlated over time and space
  - Radiometric uncertainty
    - Uncorrelated over time and space
  - Retrieval (“algorithmic”) uncertainty
    - Partially decorrelates above synoptic time and space scales
  - Contamination uncertainty
    - Low frequency, erratic in time and space, asymmetric

Third strand of progress is needed…



Important: You must work with you users to define uncertainty information and quality indicators

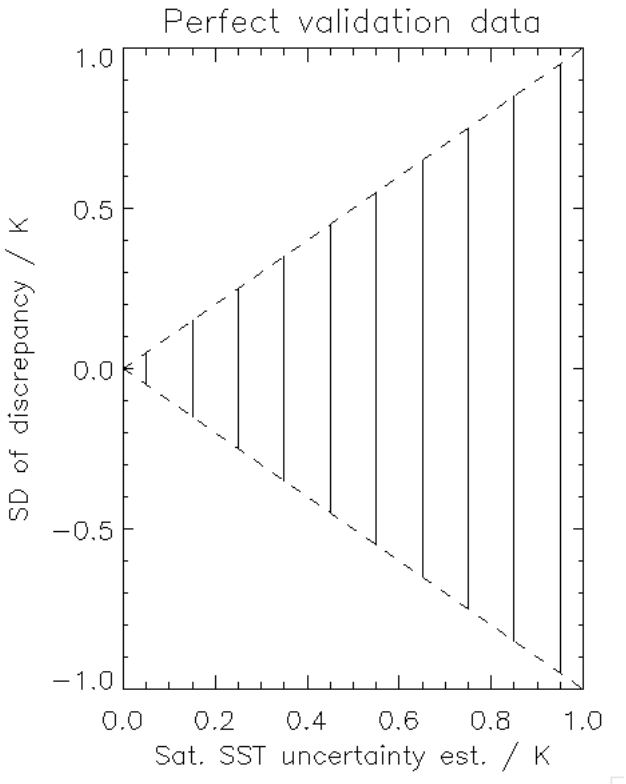
Validation of uncertainties

- Example: ARC/ESA SST_CCI v1.1 L3C 0.1 deg SST
  - This is a precursor for SST_CCI L3C at 0.05 deg
- Uncertainty model combines
  - Radiometric noise and how it averages for many pixels in cells
  - Synoptically correlated uncertainty (which doesn't average)
  - The uncertainty in the cell mean from having sub-sampled the cell

How to validate uncertainties (1)

- If we had perfect validation data (in situ), then

$$\sigma_{ARC-buoy} = SD(\hat{x}_{ARC} - x_{buoy}) = \varepsilon_{ARC}$$

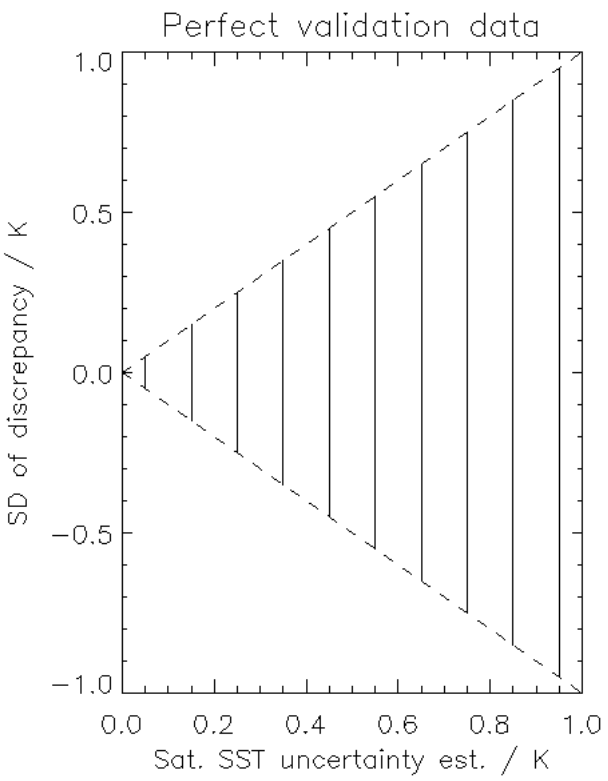


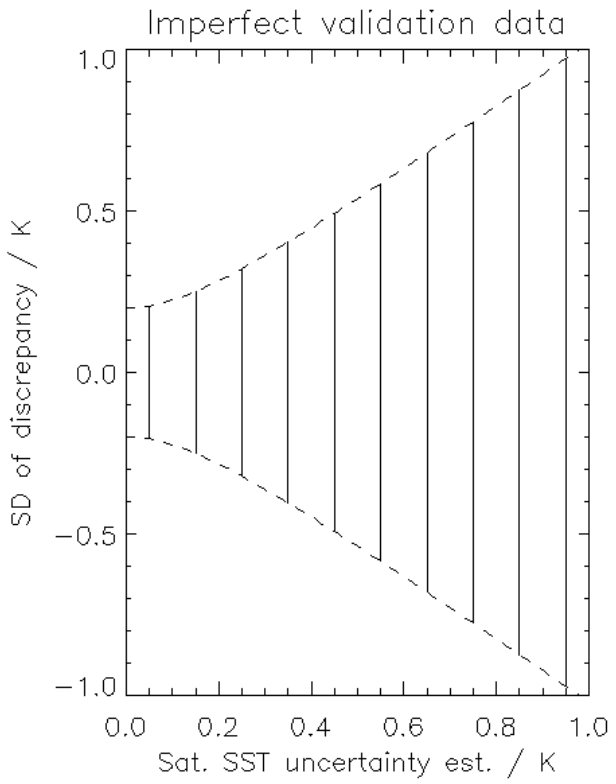
Acknowledgement: Chris Merchant, Owen Embury

How to validate uncertainties (2)

- But drifting buoys have calibration uncertainty: ~0.2 K

$$\sigma^2_{ARC-buoy} = VAR(\hat{x}_{ARC} - x_{buoy}) = \varepsilon^2_{ARC} + \varepsilon^2_{buoy}$$





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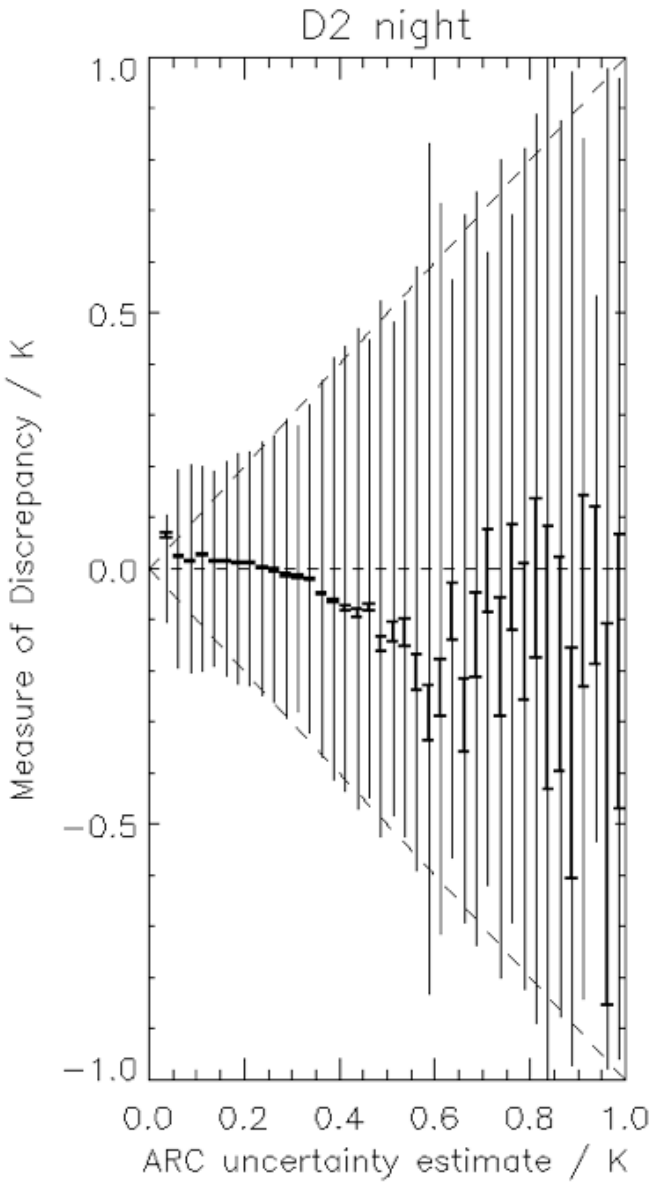
Example of uncertainty validation



- ARC v1.2, many thousands of matches of satellite and drifting buoy SSTs.
- Abscissa: uncertainty estimate attached to an individual ARC SST value (0.1 deg product)
- Ordinate: (thin) ±SD of ARC-drifter discrepancy (thick) median discrepancy

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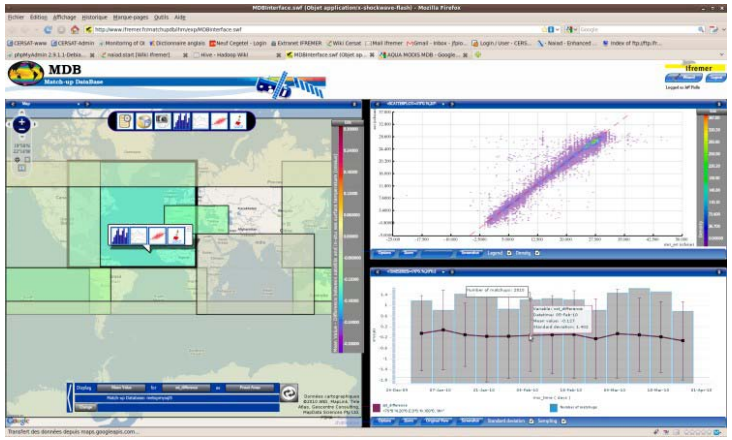
QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Match-up Database



All MDBs available
Online graphical analysis
Extraction on demand

http://www.ifremer.fr/matchupdb/ihm/exp/MDBInterface.swf

Routine FTP matchup delivery:
Daily files are created every day for ftp distribution, for each satellite & in situ pair (ex: AATSR/drifters, AATSR/moored buoys, AATSR/ships, AATSR/argo,...)

Files are in netCDF4

Two versions are produced: with (*_full.nc) and without neighbours
ftp://ftp.ifremer.fr/ifremer/cersat/projects/myocean/sst-tac/matchups/

MDB home page at:
http://cersat.ifremer.fr/Data/Quality-control/GHRSST-Match-up-Database

HR-DDS

High Resolution Diagnostic Data Set

Welcome to the HR-DDS, Craig Donlon. Log out.

Interactive SST results for site nmi051

Your location is MyDDS -> SST HR-DDS -> Interactive time series analysis for site nmi051

Site nmi051 (Metno_Weddell_Sea_South): Centered on (-70° N, -30° E), 3° by 3&deg.

National Oceanography Centre, Southampton

Met Office

esa

MERSEA

Site map:

<- 1 Year-> <- 1 Month-> <- 1 Day->

The HR-DDS system is currently being rebuilt under contract to the European Space Agency

See http://hrdds.ifremer.fr/ for further details

Please click here for a legend of observations, here for a legend of other product types and here for a detailed legend.

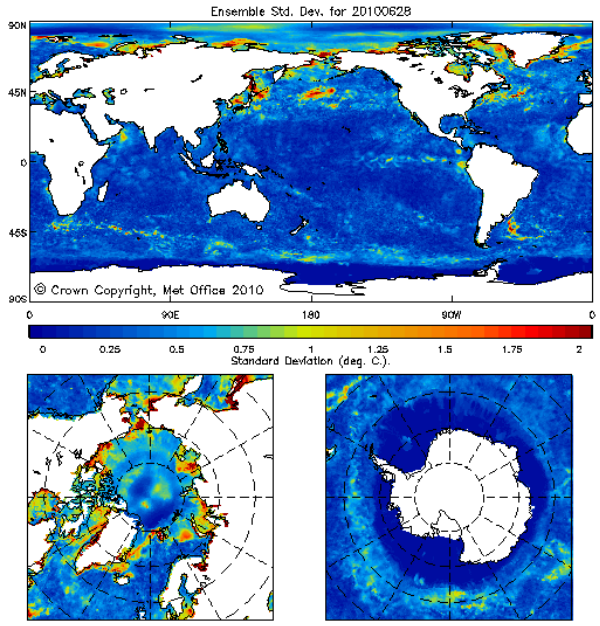
Select y-axis maximum auto, an y-axis minimum auto and a minimum valid data percentage 5

Note: Please enter no units for the above entries.

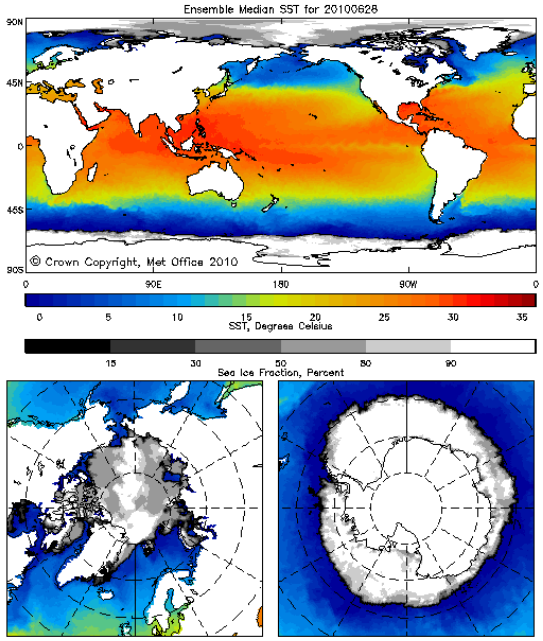
Parameter Type	Statistical Operator	Coverage and Quality
sea surface temperature	mean	centre area and best quality

The GHRSST Multi Product Ensemble (GMPE)

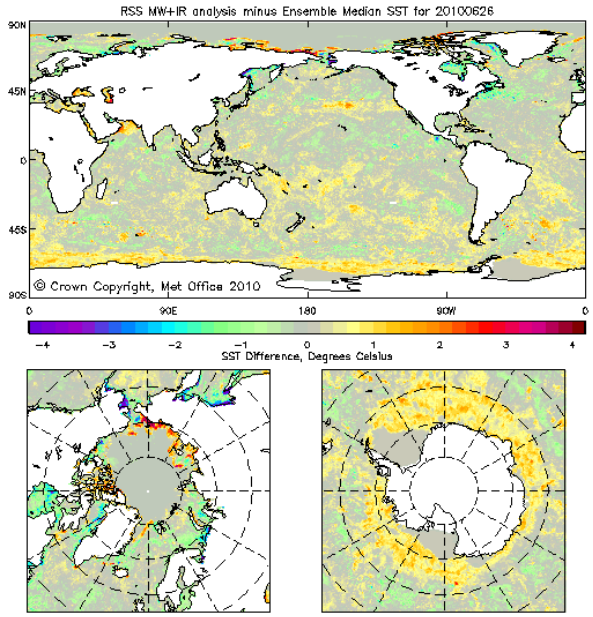
http://www.ghrsst.org/Todays-global-SST.html



STD



SST + Sea Ice concentration



Anomaly (1985-2001)

10-member Median Average ensemble

All plots are available each day in NRT

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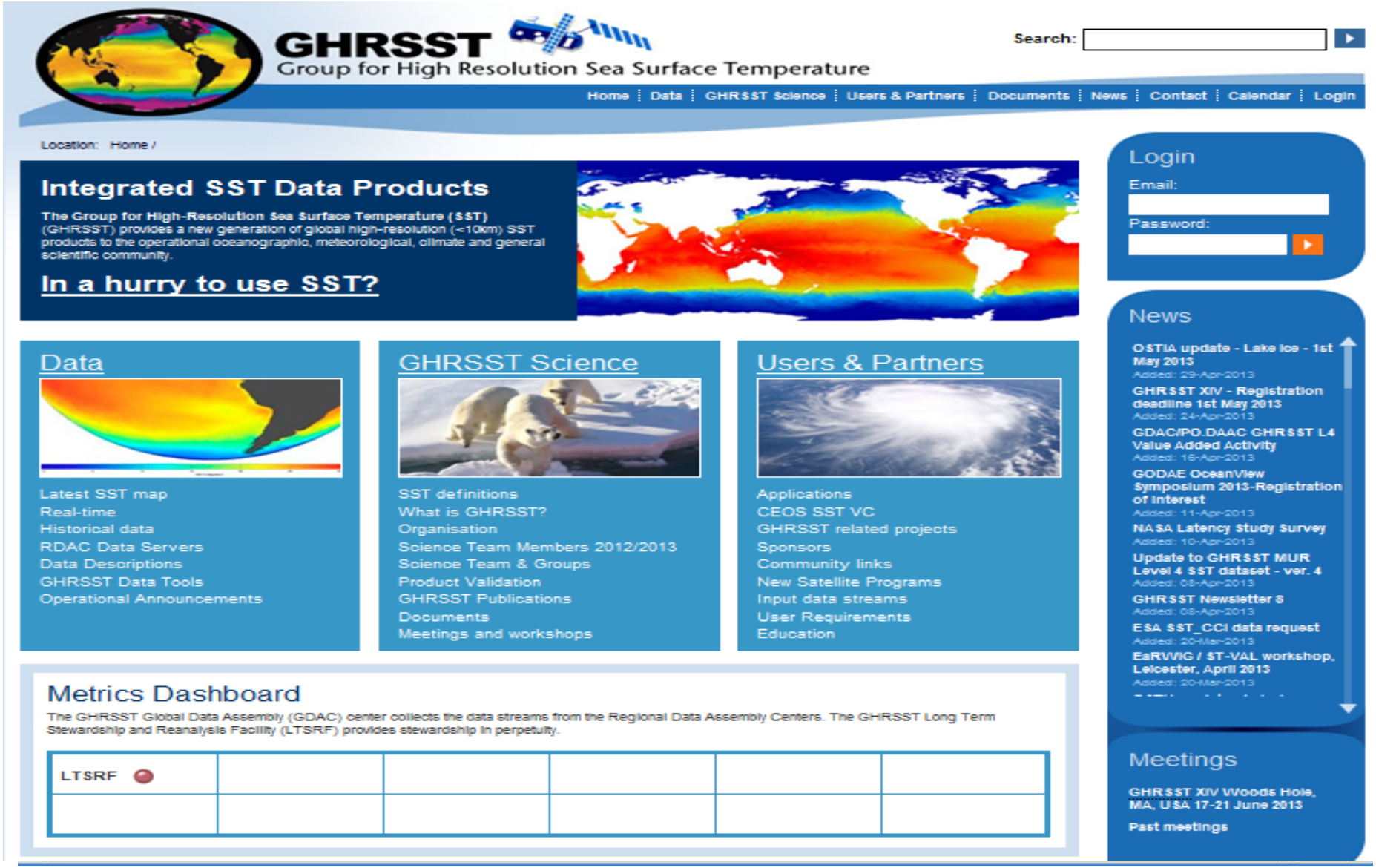
GHRSST Global Data Services: Portal and data distribution



Summary

- A CEOS SST-VC has now been developed and approved according to the CEOS VC Process Paper
- The SST-VC and GHRSST work together

- The SST-VC has had, and will continue to have, very strong links to the WGCV
- The SST-VC provides quality information in its products that is compliant with the guiding principles of QA4EO

- The SST-VC/GHRSST wishes to widen its international collaboration to countries with an interest or a capability in SST to operate a true constellation.
- The next SST-VC meeting will be held on 21 June 2013 at WHOI, Woods Hole, MA, USA

- For further information please contact
  - SST-VC: Kenneth Casey (Kenneth.Casey@noaa.gov) or Craig Donlon (Craig.Donlon@esa.int)
  - GHRSST: Gary Corlett (gpc@ghrsst.org)