GHRSST
GROUP FOR HIGH RESOLUTION
SEA SURFACE TEMPERATURE

Annual Report 2021

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Foreword

The goal of this annual report is to provide a review on the key activities and results of the GHRSST community in 2021.

In 2021, the provision of high quality Sea-Surface Temperature (SST) data from a broad satellite constellation has continued, with particular advances towards the continuity of microwave SST with AMSR-3 planned for launch by JAXA in 2023/2024 on the Global Observation Satellite for Greenhouse gases and water cycle. There are exciting times ahead with further launches of several Sea Surface Temperature capable and specific missions coming up in the next few years, all adding valuable observations to the constellation. These include GOES-T, JPSS-2, MTG I1, Metop-SG A1, Sentinel-3C/D, FY-3E, FY-4B, plus others.

At our annual meeting in summer 2021, the 22nd International Science Team meeting (GHRSST XXII), five science sessions were held to present inputs on the following topics:

- Challenging Regions – The Coast and The Arctic
- Applying The Data: Spatio-Temporal Variation; Extreme Events
- Calibration, Validation and Product Assessment
- Algorithms
- Computing and Products

Highlights from the sessions included the progress on high-latitude SST, the retrieval of SST from INSAT 3D/3DR, the validation and trends in Korean coastal waters, the progress towards climate records of SST, analysis ready data applications, and the new release of NOAA STAR OceanView.

An online meeting addressing Science to Operations was held for the Copernicus Imaging Microwave Radiometer (CIMR) mission planned for 2029, with contributions on bridging the gap between the scientific measurements made by the CIMR mission and preparation to operational services and scientific applications.

In July 2021, GHRSST Project Office, funded by the European Union's Copernicus programme, successfully transitioned to a new hosting organisation, the Danish Meteorological Institute.

In the second half of 2021 GHRSST reached out to international stakeholders by participating in events organised under the framework of COP26 and the United Nations Ocean Decade for Sustainable Development.

Last but not least, the GHRSST website www.ghrsst.org has been restyled and all presentations and report have been transferred to an open access repository in Zenodo https://zenodo.org/communities/ghrsst to allow easier re-use by the scientific community.

The GHRSST Project Office

What is GHRSST?

The Group for High Resolution Sea Surface Temperature (GHRSST) is an **open international science group** that coordinates research and operational developments in satellite-derived SST, and promotes the application of satellites for monitoring sea surface temperature (SST) by enabling SST data producers, users and scientists to collaborate within an agreed framework of best practice,

Governance: GHRSST is composed of a Science Team of researchers and operational practitioners, and it is organised into Technical Advisory Groups focused on particular challenges and activities (https://www.ghrsst.org/about-ghrsst/organisation). Specific Task Team's are initiated to address and work on identified issues and projects.

International collaboration: GHRSST comprises researchers and operational practitioners of SST from a number of worldwide institutes and agencies.These bodies are represented by the set of logos shown below. Participation in GHRSST is always increasing as new groups join the GHRSST community.

Figure 1: GHRSST members are worldwide institutes and agencies

CEOS SST Virtual Constellation: GHRSST also acts as the science team of **the Committee on Earth Observation Satellites (CEOS) Virtual Constellationfor SST (CEOS SST-VC).** The CEOS SST-VC serves as the formal link between GHRSST and the broader CEOS community (https://ceos.org/). The committee coordinates space-based, ground-based, and/or data delivery systems to meet a common set of requirements within a specific domain. CEOS SST-VC leverages inter-agency collaboration and partnerships to address observation gaps, sustain the routine collection of critical observations, and minimize duplication/overlaps, while maintaining the independence of individual CEOS Agency contributions.

GHRSST services

The Group for High Resolution Sea Surface Temperature (GHRSST) provides:

- A framework for sea surface temperature (SST) knowledge and data sharing
- Best practices for data processing, assessing uncertainties in the satellite SSTs
- A forum for scientific dialogue including how best to provide SSTs for climate studies, bringing SST to the operational users and scientific researchers.

GHRSST offers:

- Data processing through Regional and Global Data Assembly Centres, combining satellite and NWP fields in common data formats for ease of access and analysis
- A variety of tailored methods for downloading and access full products or subsets
- Online visualisation of data quality through diagnostic comparisons.

Major GHRSST components and services

GHRSST Global Data Archiving Centre GDAC

You can download real-time data from the respective data producers (RDACs), or as collected by the GHRSST Global Data Archiving Centre (GDAC), which is provided and hosted by NASA at their Physical Oceanography Distributed Active Archive Center (PO.DACC).

For further details of the GDAC and instructions on how to download data please go to the GDAC website at http://podaac.jpl.nasa.gov/

GHRSST Long-Term Steward-ship and Reanalysis Facility LTSRF

Historical SST products (older than 30 days) are available from the GHRSST Long-Term Stewardship and Reanalysis Facility, which is provided and hosted by NOAA at the National Oceanographic Data Center (NODC).

For further details of the LTSRF and instructions on how to download data please go to the LTSRF website at http://data.nodc.noaa.gov/ghrsst/

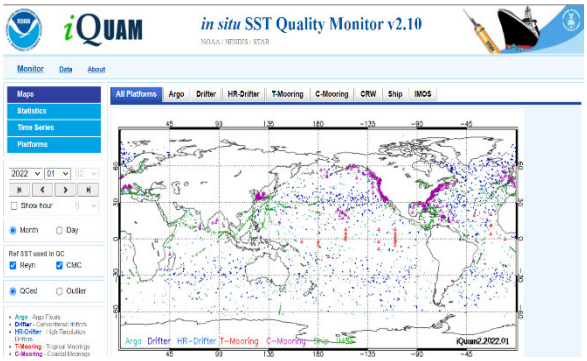
Felyx

The aim of the Felyx project was to provide an open-source, flexible and reusable software system that can be used to research and monitor the quality and performance of Earth observation (EO) data streams. Felyx was developed by IFREMER, PML and Pelamis and funded by the European Space Agency. Further activities on a multi-matchup dataset (MMDB) have been funded by Copernicus, and activities continued with the GHRSST Task Team on MMDBs, with further information here: https://www.ghrsst.org/about-ghrsst/task-teams/task-team-on-matchup-database-standards-mdb-tt

iQUAM and SQUAM

The in situ data quality monitor, iQUAM, and SST summary quality monitor, SQUAM, systems are provided and hosted by NOAA.

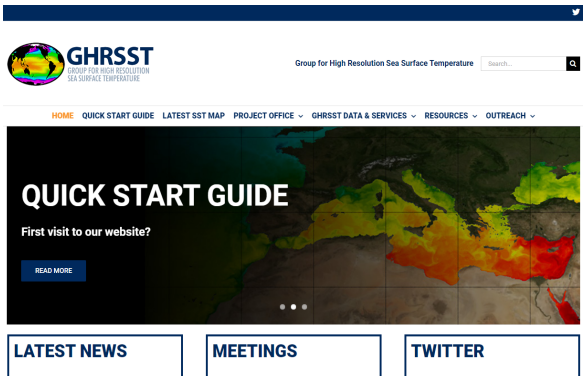
For further details, please see
http://www.star.nesdis.noaa.gov/sod/sst/iquam/
and
http://www.star.nesdis.noaa.gov/sod/sst/squam/
respectively.



GHRSST products, services and tools

In the GHRSST website, we have published information on how to access GHRSST products, services and tools to exploit GHRSST data.

For further details, please see
https://www.ghrsst.org/ghrsst-data-services/



Major GHRSST achievements in 2021

A New Framework for GHRSST Data Provision

GHRSST pioneered a Regional/Global Task Sharing Framework (R/GTS) https://www.ghrsst.org/about-ghrsst/task-teams/task-team-on-evolution-of-the-regional-global-task-sharing-r-g-ts-tt/ which uses a scientifically sound and technically feasible strategy to acquire existing SST data products, add additional information and output a new generation of products in a common format.

The first products were made available in 2005. Under the R/GTS, data produced by Regional Data Assembly Centres (RDACs) were ingested by a Global Data Assembly Centre (GDAC) and publically distributed via various services; final archiving and further distribution were performed by the Long-term Stewardship and Reanalysis Facility (LTSRF). The original system has grown more complex with the addition of more DACs and data producers.

A new system, with decentralisation of data ingestion and distribution, will better prepare GHRSST for future growth andfacilitate the participation of new data producers. The new framework is illustrated below and is reported in "GHRSST R/G TS System Architecture" document, available from https://zenodo.org/record/4926440

There are two entities: data producers (GDP) and distributing centres (DAC). Each DAC implements a minimum set of services for granule data access, search and discovery, production/distribution metrics and long-term archiving. The GHRSST-PO portal provides and maintains a central catalogueof all GHRSST datasets with collection level metadata, and federated search and discovery services. The portal allows theuser to discover and search all GHRSST products and granules with no need to know the data producer or distributor.

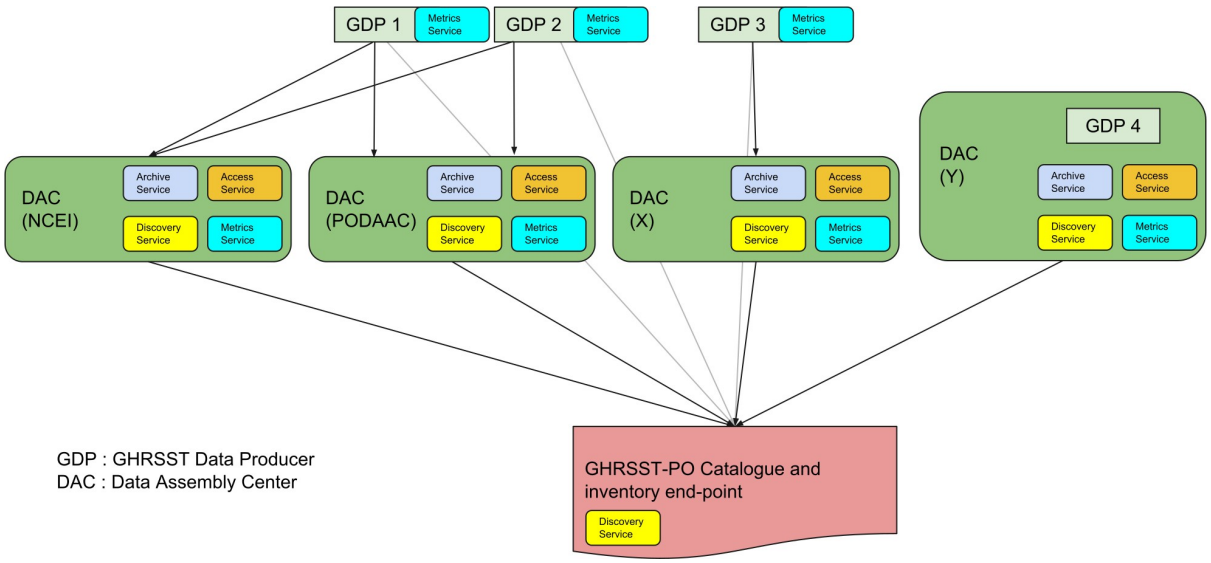


Figure 2: GHRSST R/G TS System Architecture new framework of implementation.

The implementation of the new framework is underway. All DACs have agreed to provide metadata to the central catalogue and implementation of the catalogue, supported by EUMETSAT and Copernicus, will be completed in 2022. The DACs' level of readiness to provide data access (HTTP(S), FTP, THREDDS, and OpeNDAP) and granule search (OpenSearch) services has been established. Most are able to provide HTTP(S) and OpenSearch services. Mitigation for those that cannotwill be in place by 2023.

The implementation of the new framework will be completed by the Science Team Meeting to be held in summer 2023 (GHRSST XXIV Meeting).

GHRSST has been extremely successful in revolutionising the way satellite SST data sets are developed, shared, and applied in mod- ern oceanography, meteorology, and climate centres. Success is achieved by solving scientific, operational, and technical problems and also by co-operation at an international level to agree data product definitions and standards that are acceptable to users, pro-ducers, and data managers. GHRSST coordinates and conducts research, establishes procedures and protocols, provides near real- time data access portals and user services, and implements near real-time quality control monitoring services. Large volumes of data and data services are harnessed together to deliver the new generation of global coverage high resolution SST data thereby meeting GHRSST User Requirements.

Sea surface temperature Inter-comparison in the Framework of the Copernicus Climate Change Service (C3S)

The Task Team on Climatology and L4 Inter-comparison (short IC-TT) inter-compares and validates gap free SST analyses of satellite, including in situ data, providing information to producers to enable them to improve their analysis systems and guidance to users for their particular applications. The Task Team is led by Helen Beggs and Chunxue Yang and authored an open access paper published in Journal of Climate.

Yang, C., Leonelli, F.E., Marullo, S., Artale, V., Beggs, H., Nardelli, B.B., Chin, T.M., De Toma, V., Good, S., Huang, B., Merchant, C.J., Sakurai, T., Santoleri, R., Vazquez-Cuervo, J., Zhang, H.M., & Pisano, A. (2021). ***Sea surface temperature Intercomparison in the Framework of the Copernicus Climate Change Service*** *(C3S). Journal of Climate, 34, 5257-5283, doi: https://doi.org/10.1175/JCLI-D-20-0793.1*

A joint effort between the Copernicus Climate Change Service (C3S) and the Group for High Resolution Sea Surface Temperature (GHRSST) has been dedicated to an intercomparison study of eight global gap-free sea surface temperature (SST) products to assess their accurate representation of the SST relevant to climate analysis. In general, all SST products show consistent spatial patterns and temporal variability during the overlapping time period (2003–18). The main differences between each product are located in the western boundary current and Antarctic Circumpolar Current regions. Linear trends display consistent SST spatial patterns among all products and exhibit a strong warming trend from 2012 to 2018 with the Pacific Ocean basin as the main contributor. The SST discrepancy between all SST products is very small compared to the significant warming trend. Spatial power spectral density shows that the interpolation into 1° spatial resolution has negligible impacts on our results. The global mean SST time series reveals larger differences among all SST products during the early period of the satellite era (1982–2002) when there were fewer observations, indicating that the observation frequency is the main constraint of the SST climatology. The maturity matrix scores, which present the maturity of each product in terms of documentation, storage, and dissemination but not the scientific quality, demonstrate that ESA-CCI and OSTIA SST are well documented for users' convenience. Improvements could be made for MGDSST and BoM SST. Finally, we have recommended that these SST products can be used for fundamental climate applications and climate studies (e.g., El Niño).

Discover the work of this Task Team: https://www.ghrsst.org/about-ghrsst/task-teams/ghrsst-climatology-and-l4-inter-comparison-task-team-ic-tt/

Coral Heat Stress: The SST User Requirements Report 2021

The GHRSST Task Team on Coral Heat Stress User SST Requirements was set up at GHRSST XX Science Team Meeting in 2019 and published their first report in 2020. This year the Task Team updated the report to include other uses of SST regarding coral reef science and management beyond the quantification of heat stress.

To requirements for stability, geo-location accuracy, SST accuracy (including high SSTs), SST uncertainty, and timeliness, the update adds requirements for diurnal variation, increased spatial resolution, preservation of oceanographic features such as upwelling, and a measure of effective spatial resolution.

The Coral Heat Stress User SST Requirements Report can be downloaded from Zenodo: https://zenodo.org/record/5795570

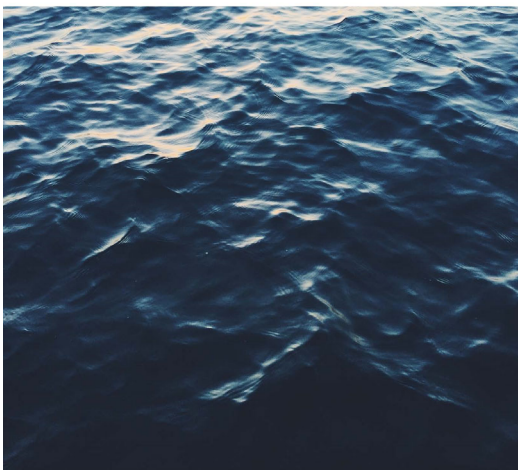
Figure 3: Coral Reef (Courtesy of Joakant, via Pixabay)

Discover the work of this Task Team: https://www.ghrsst.org/about-ghrsst/task-teams/task-team-on-coral-heat-stress-user-sst-requirements/

Outcomes of the GHRSST XXII Science Team Meeting (2021)

The 22nd International GHRSST Science Team Meeting was held on 7th-11th June 2021 and, for the second year running, online due to continuing travel restrictions caused by the COVID-19 pandemic. The meeting was hosted on the EUMETSAT platform. The GHRSST Project Office is grateful to the EUMETSAT Training Team for help in running and setting up the online meeting!

The meeting was well received with participants enjoying the online format and video conference discussions.



The meeting was structured in five science sessions:

- Challenging Regions – The Coast and The Arctic
- Applying The Data: Spatio-Temporal Variation; Extreme Events
- Calibration, Validation and Product Assessment
- Algorithms
- Computing and Products

Additionally, a discussion on the "Priorities for GHRSST" was held considering contributions on the following topics:

- What progress is GHRSST making with regard to the user priorities on Observational Needs for SST as set out in the Ocean Obs 19 white paper https://doi.org/10.3389/fmars.2019.00420 e.g. Arctic, coastal, feature resolution? What still needs to be done?
- What are the needs of coupled ocean atmosphere NWP for satellite SST and how can GHRSST contribute to this?
- What progress has been made in GHRSST to consider Artificial Intelligence / Machine Learning techniques and applications, and what more can be done? How can GHRSST better promote open science and open data not only in the SST community but also for related ocean and atmospheric measurements? Are there things we can do in our community to improve the sharing of results besides publications?

Read more:

- The Science Team Meeting 2021 proceedings can be accessed at the following link: https://zenodo.org/record/5750123 Highlights of some of the extended abstracts of the Science Team Meeting 2021 are reported in the next pages.
- Additional resources can be found on the GHRSST webpage: https://www.ghrsst.org/meetings/22nd-ghrsst-international-science-team-meeting-g-xxii

Highlights of the Science Team Meeting 2021: Extended abstracts of the talks

Abstract 1

Development of consistent surface temperature retrieval algorithms for sea surface, marginal ice zone and sea ice in the polar regions

by Jacob L. Høyer (1), Gorm Dybkjær (1), Anne O'Carroll (2), Wiebke Kolbe (1) and Pia Nielsen-Englyst (1)

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(2) EUMETSAT, Eumetsat Allee 1, D-64295 Darmstadt, Germany

A new gap-free reprocessed SST/IST product from the Copernicus Marine System (CMEMS) is presented. This product is the first of its kind and allows for the first time to perform an assessment of the Arctic Ocean (sea and ice) surface temperature variability since 1982.

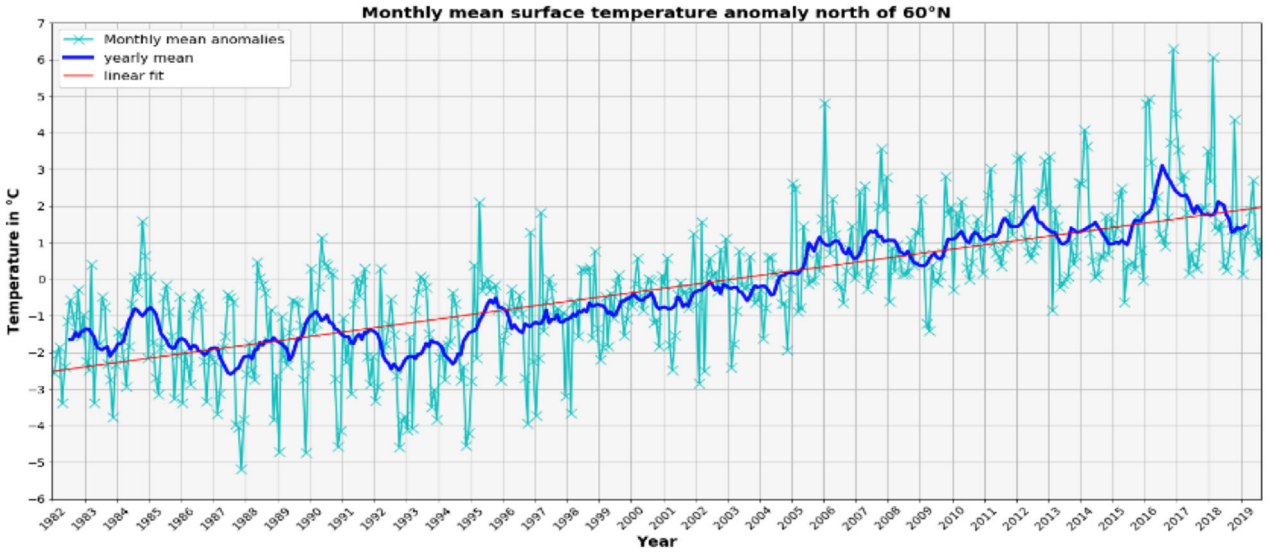

Figure 4: Temperature anomalies above 60°N from the new L4 combined SST/IST analysis (1982-2019).

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 27: https://zenodo.org/record/5750123

Abstract 2:
Uncertainty Validation of Shipborne Radiometers

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Email: w.wimmer@soton.ac.uk

One of the key components of Fiducial Reference Measurements (FRM) are the uncertainty models and per measurement uncertainty. These uncertainty models have only been validated in the laboratory during inter-comparison and their theoretical basis has been verified. This paper will first show the data from side by side of shipborne radiometers comparison in 2015, 2018, 2019 and 2020 and second the validity of the uncertainty models in the at sea conditions. Furthermore, the possible improvements to the shipborne radiometer models will be shown on the example of the Infrared Sea-surface temperature Autonomous Radiometer (ISAR) uncertainty model.

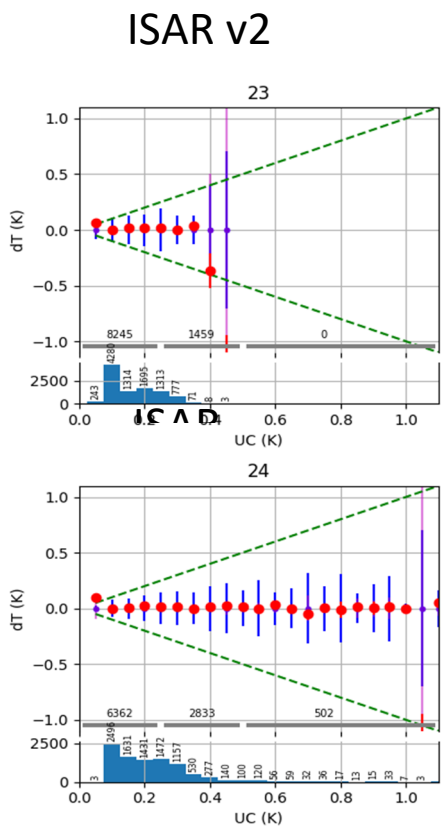

Figure 5: ISAR - SISTeR uncertainty comparison, new ISAR uncertainty model V2 (top) and V3 (bottom). Blue lines show the standard deviation in each uncertainty bin, Magenta lines show the mean in each uncertainty bin, Red dots show the median and the error bar shows the standard error around the median, green dashes show the theoretical limit the uncertainty should follow.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 72: https://zenodo.org/record/5750123

Abstract 3: A completeness and complementarity analysis of the data sources in iQUAM

Haifeng Zhang (1), Alexander Ignatov (2), Dean Hinshaw (3)
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& Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, Colorado, USA. Email: haifeng.zhang@noaa.gov
(2) STAR, NOAA Center for Weather and Climate Prediction (NCWCP), College Park, Maryland, USA.
Email: alex.ignatov@noaa.gov
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& Global Science and Technology, Inc., College Park, Maryland, USA. Email: dean.hinshaw@noaa.gov

In situ sea surface temperature (SST) measurements play a critical role in the calibration and validation (Cal/Val) of satellite SST retrievals . To facilitate this task, the in situ SST Quality Monitor (iQuam) system was developed at the National Oceanic and Atmospheric Administration (NOAA) in 2009. The iQuam strives to provide the most authoritative Cal/Val standard for the satellite SST community, which is both maximally complete and uniformly quality controlled using a flexible, community consensus QC algorithm . In the

current iQuam version 2.10, in situ SST from the following platforms are reported: drifting buoys (including heritage and high-resolution, HR, drifters), ships (including vessels of opportunity, VOS, research vessels, R/V, commercial ships, and the Integrated Marine Observing System, IMOS, ships), coastal and tropical moorings, Argo floats and Coral Reef Watch (CRW) buoys. Whenever possible, SST data are collected from more than one data source, to provide back-up (in case of occasional outages in individual feeds) and to take advantage of their complementarity, hence ensuring a more complete coverage. The relative completeness and complementarity of different data sets are often unknown and are the focus of this study.

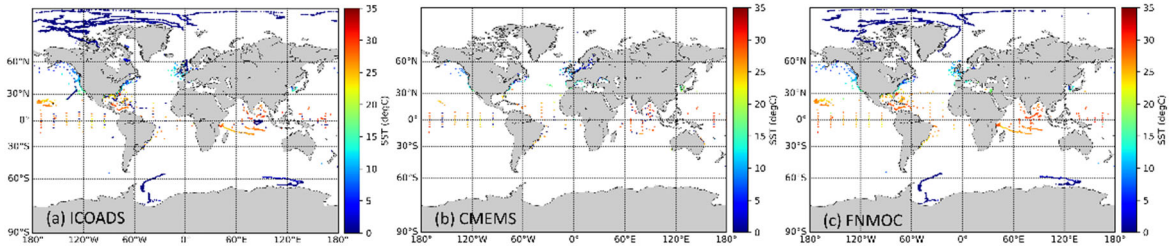

Figure 6: Spatial distributions of all moorings (coastal + tropical) from:
(a) ICOADS, (b) CMEMS, and (c) FNMOC. The colour bar represents SST.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 83:
https://zenodo.org/record/5750123

Abstract 4:
Saharan dust effects on North Atlantic sea surface skin temperatures

Bingkun Luo (1), Peter J. Minnett (1), Paquita Zuidema (1), Nicholas R. Nalli (2), Santha Akella (3)
(1) Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL 33149
(2) IMSG, Inc. at National Oceanic and Atmospheric Administration (NOAA) NESDIS/STAR, College Park, MD 20740
(3) NASA Goddard Space Flight Center, Global Modeling and Assimilation Office (GMAO), Greenbelt, MD 20771

Saharan dust outbreaks frequently propagate westward over the Atlantic Ocean; accurate quantification of the dust aerosol radiative effects on the surface radiative fluxes (SRF) is fundamental to understanding the sea surface radiation budget. This study characterizes the sensitivity of the SRF and skin Sea-Surface Temperature (SST skin) to the Saharan dust aerosols. Saharan dust outbreaks can decrease the surface shortwave radiation up to 190 W/m2, and an analysis of the corresponding SST skin changes suggests dust induced cooling effects as large as -0.24 K during daytime and a warming effect of up of 0.06 K during daytime and nighttime respectively.

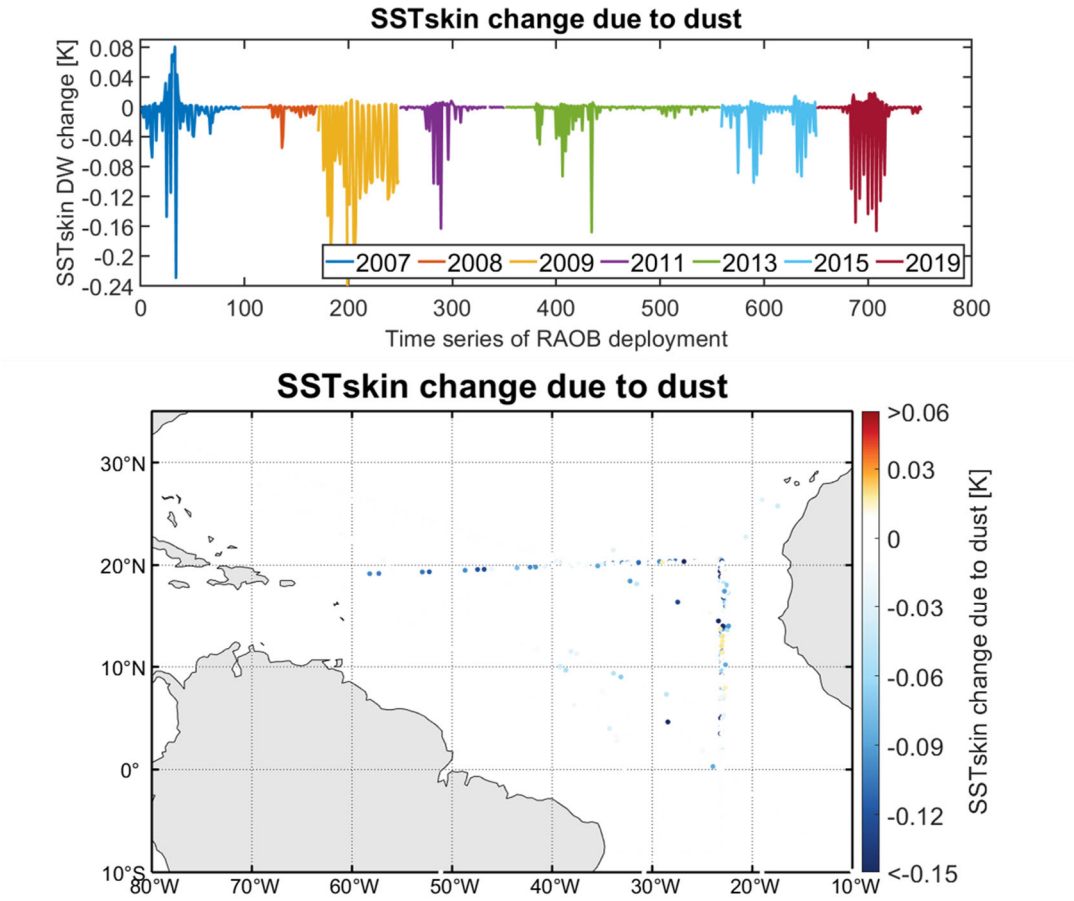

Figure 7: Top: Time series of the SST_{skin} changes due to dust. The x-axis is the radiosonde deployment number, and the y-axis shows the simulated SST_{skin} changes, which are calculated as the difference between the SST_{skin} with and without dust. The unit is K. The colors indicate the deployment year. Bottom: Geographic distributions of the calculated SST_{skin} changes due to dust. The colors indicate the SST_{skin} change due to dust, as shown on the right with the unit of K. Note there are many points which have almost zero SST_{skin} change.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 89: https://zenodo.org/record/5750123

Abstract 5:
Optimal estimation of SST from INSAT-3DR Imagers

Rishi Kumar Gangwar (1), Pradeep Kumar Thapliyal (2)

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We have exploited optimal estimation (OE) or one-dimensional Variational (1DVAR) technique for developing a retrieval algorithm for SST from thermal infrared observations of Imagers flown on-board the Indian geostationary satellites INSAT-3D & 3DR. The slightly negative bias of -0.20K with 0.6K SD were obtained in the retrieved SST when compared against the in-situ measurements. The spatial gradients in the retrieved SST from INSAT-3D/3DR show the similar pattern as observed in the daily Multiscale Ultrahigh Resolution (MUR) level-4 analysis SST acquired from Group for High-Resolution Sea Surface Temperature (GHRSST).

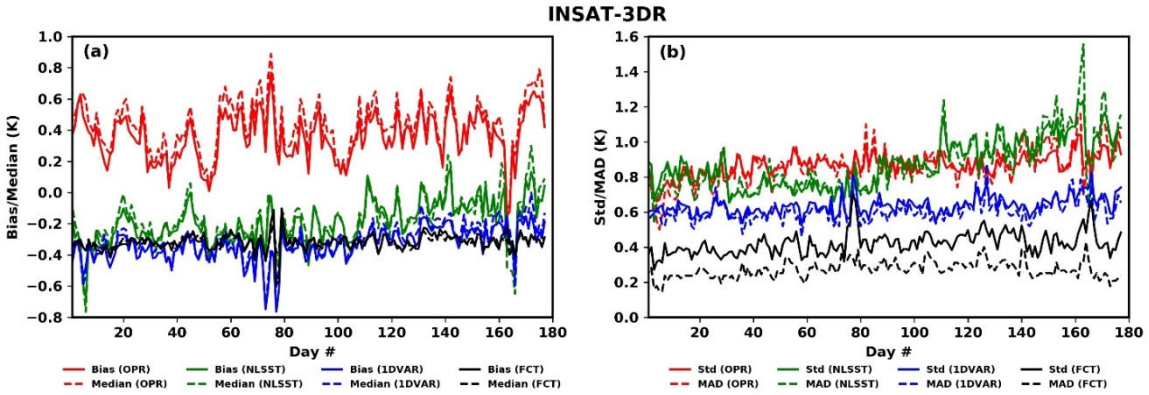

Figure 8: Validation statistics generated on a daily scale for retrieved SST from INSAT-3D observation against iQuam SST, (a) Bias/Median, and (b) Std/MAD.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 121: https://zenodo.org/record/5750123

Abstract 6:

A new operational Mediterranean diurnal optimally interpolated SST product within the COPERNICUS Marine Service

Andrea Pisano (1), Salvatore Marullo (2), Rosalia Santoleri (1), Daniele Ciani (1), Bruno Buongiorno Nardelli (3)

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(2) ENEA, Frascati, Italy, Email: salvatore.marullo@enea.it

(3) CNR-ISMAR, Napoli, Rome, Italy, Email: bruno.buongiornonardelli@cnr.it

Within the Copernicus Marine Environment Monitoring Service (CMEMS, Le Traon et al., 2019), the Sea Surface Temperature Thematic Assembly Centre (SST-TAC) is in charge of the near real-time and reprocessed production of satellite-based SST products.

For the Mediterranean Sea (MED), the SST-TAC provides daily mean (night-time) L3S and L4 foundation SST fields at high (1/16°) and ultra-high spatial resolution (1/100°) covering the period from 2008 to present (Buongiorno Nardelli et al., 2013). All these data are built by using L2P data derived from different infrared satellite sensors, which also include the new generation SLSTR sensor on board the ESA Sentinel-3A/3B satellites. In May 2021, a new Mediterranean diurnal optimally interpolated SST (MED DOISST) product was released (SST_MED_PHY_SUBSKIN_L4_NRT_010_036). This product provides hourly mean L4 maps of subskin SST at 1/16° grid resolution covering the period from 1st January 2019 up to near real time. .

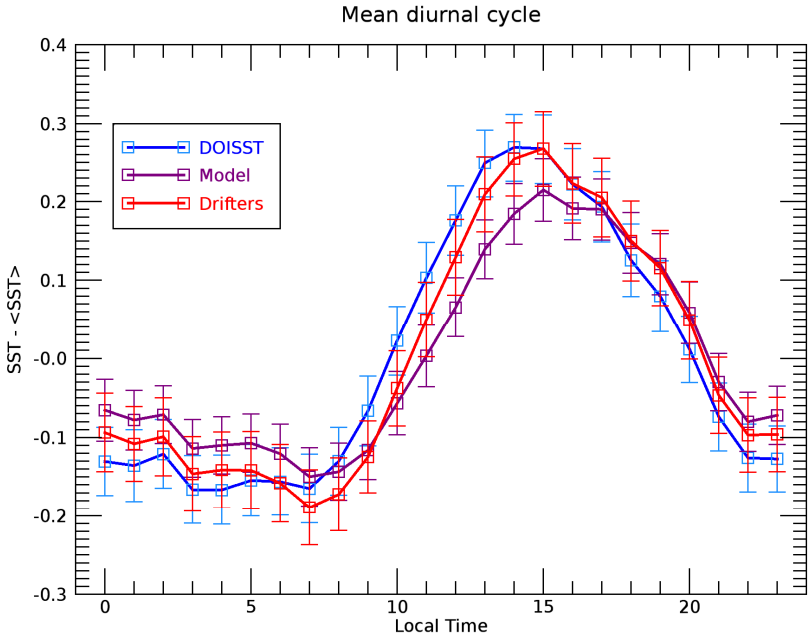

Figure 9: Mean diurnal cycle computed for MED DOISST (blue line), model (purple line) and drifters' data (red line) anomalies over the matchups for the period 2019-2020. Anomalies are computed by subtracting from each SST time series their average (<SST>) in order to remove eventual biases and better evidence the diurnal cycle amplitude.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 126: https://zenodo.org/record/5750123

Abstract 7:
Bias-aware optimal estimation for sea surface temperatures from historic AVHRRS

Christopher J. Merchant (1,2) and Owen Embury (1, 2)
(1) University of Reading and National Centre for Earth Observation
(2) Met Office, UK

Bias aware optimal estimation (BAOE) is a technique to estimate bias adjustment and error covariance parameters that bring retrievals using classical optimal estimation closer to their theoretical performance (Merchant et al. 2020a; Merchant et al. 2020b). We have applied BAOE to Advanced Very High Resolution Radiometers (AVHRRs) from NOAA 6 to Metop B. BAOE leads to estimates of the following quantities. Nonetheless, when using drifting buoy sea surface temperatures as a reference, there is a clear tendency for the estimated uncertainty in the in situ data to improve over several decades. After the bias and covariance parameters are evaluated, they are used within the optimal estimation of sea surface temperature, and the error covariance information is also exploited within Bayesian cloud detection, along with bias correction. These techniques are being applied for the v3 climate data record from the SST climate change initiative, and results suggest improved bias and stability properties, including when validated against data not included in the BAOE of parameters.

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Element	x		x		x		x		x	x		x	x
Sat. Zen.		x		x		x		x			x		
Sol. Zen.							x	x	x		x	x	x
ICT	x	x	x	x	x		x	x	x	x	x*	x	x
TCWV	x			x			x			x			
Latitude			x		x	x							
Time		x		x	x	x		x	x	x		x	x

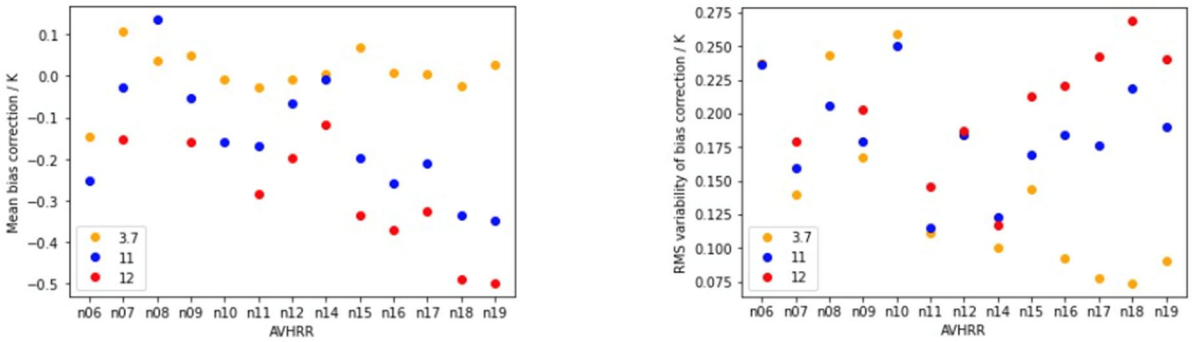

Figure 10: Summary of bias correction results for AVHRR BTs.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 129: https://zenodo.org/record/5750123

Abstract 8:
Developments towards a 40 year climate data record from the ESA Climate Change Initiative

Owen Embury (1), Christopher J. Merchant (2), S. A. Good (3), Jacob L. Høyer (4)
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(2) University of Reading, UK, Email: c.j.merchant@reading.ac.uk
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Long-term, stable observational records of sea surface temperature (SST) and other essential climate variables (ECVs) are needed to understand the state of the climate. The ESA Sea Surface Temperature Climate Change Initiative (SST-CCI) is now developing a third version of our Climate Data Record (CDR) which will cover a 40-year period using data from Advanced Very High Resolution Radiometer (AVHRR), Along Track Scanning Radiometer (ATSR), Sea and Land Surface Temperature Radiometer (SLSTR) instruments, Advanced Microwave Scanning Radiometer (AMSR)-E and AMSR2. This will be the first version of the SST CCI CDR to make use of data from AVHRR/1 instruments carried on board NOAA-6, -8, and -10 platforms. This will increase the data coverage in the 1980s and allow the dataset to extend back to late 1979.

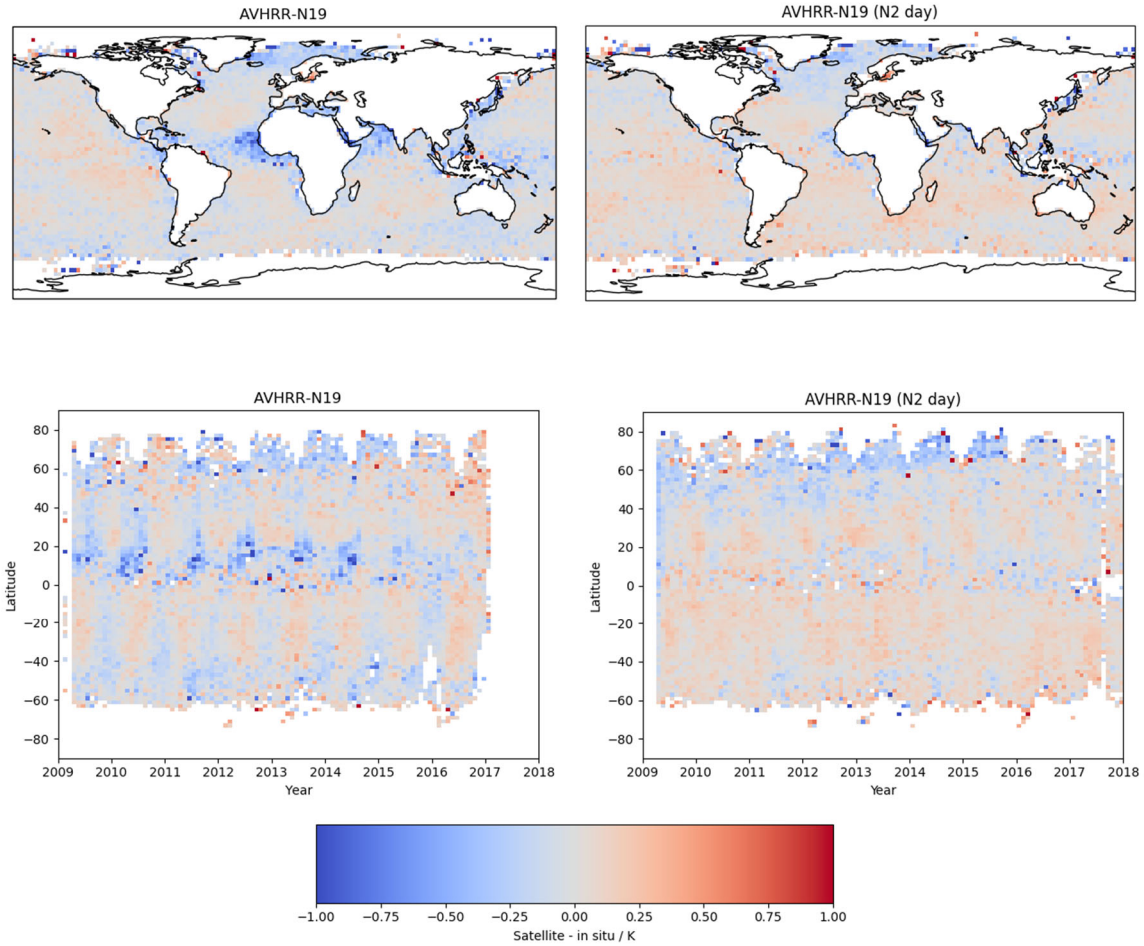

Figure 11: NOAA-19 daytime retrieval bias (satellite – in situ) for CDRv2.1 (left) and CDRv3.0 (right). In CDRv3 the new forward modelling and BAOE retrieval has significantly reduced regional dust biases and seasonal signal.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 132: https://zenodo.org/record/5750123

Abstract 9:
Analysis ready data applications for GHRSST data and applications

Edward M. Armstrong (1), Christo Whittle (2), Chelle Gentemann (3), Chris Lynnes (4), Steve Labahn (5), Adam Lewis (6), Amie Baciauskas (7)

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(7) Development Seed, Email: aimee@developmentseed.org

The Committee on Earth Observation Satellites (CEOS) has taken a pioneering role in providing a foundational definition and specification for Analysis Ready Data (ARD), a broad term to describe the readiness of data for

scientific analysis, for remote sensing products. This has resulted in a formal CEOS approved governance structure (known as the CEOS ARD Framework) for evaluating data for ARD status and adoption. In the context of this CEOS ARD Framework, the GHRSST data model was evaluated from the perspective of the MODIS L2P Aqua SST dataset. In this evolving landscape of ARD, other perspectives on ARD are also presented with regard to data containers, data services, environmental applications and community interests.

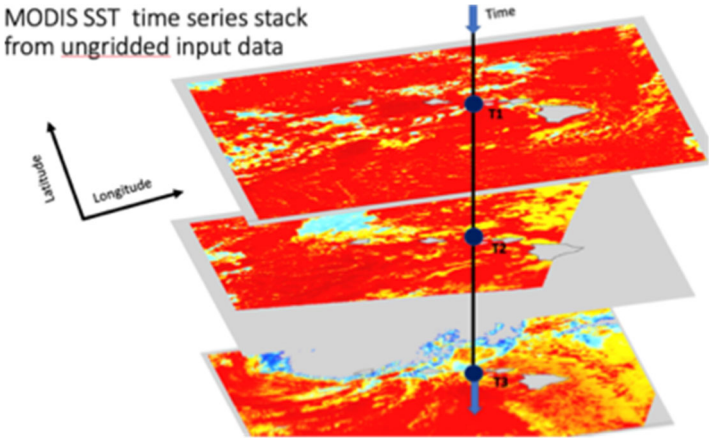

Figure 12: "Data cube" of gridded co-located 1 km MODIS Aqua SST subsets over the Hawaiian Islands region. Created "on demand" via web services and scripts. Only first three time steps shown with no cloud masking applied.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 161: https://zenodo.org/record/5750123

Abstract 10:
The sea surface temperature analysis in the NCEP GFS and the future NCEP UFS

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(1) IMSG at EMC/NCEP/NOAA, USA

(2) EMC/NCEP/NOAA, USA

At National Centers for Environmental Prediction (NCEP), the Sea Surface Temperature (SST) is analyzed in the Global Forecast System (GFS), referred to as NSST (Near-Surface Sea Temperature), and will be in the Unified Forecast System (UFS), Medium-Range Weather and Subseasonal to Seasonal Application, a coupled data assimilation and weather prediction system.

The NSST has undergone several upgrades since becoming operational in the NCEP GFS in 2017. The evaluation results of an NSST update package developed recently is reported here.

The results to evaluate the impact of the NSST model, including a diurnal warming and a skin-layer cooling parameterization, on the coupled model performance, with a scheme to determine the foundation temperature with the NSST and MOM6 T-Profiles, is presented as well.

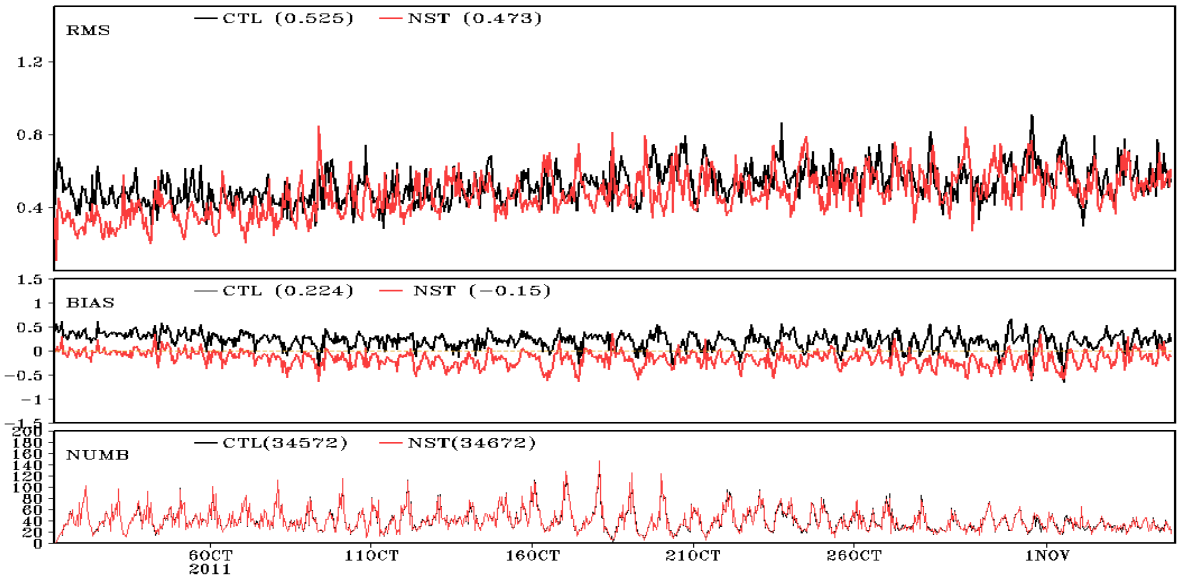

Figure 13: Observation minus Forecasting (O-F) time series of RMS, BIAS and the number of used data, Global, 35-day coupled model run starting from 10/01/2011. For Drifting buoys with dTw: [0.25, 0.50), 3.8% of the total count.

Read more in the extended abstract in the Science Team Meeting 2021 Proceedings, on page 166: https://zenodo.org/record/5750123

GHRSST XXII Science Team Meeting 2021 Poster Presentations

A variety of posters was presented at Science Team Meeting 2021 on Padlets for each science session. The posters are available on the Padlets, follow the links in the table below. In addition to the padlets, some of the extended abstracts have been made available in the proceedings of the meeting https://zenodo.org/record/5750123, see in particular the titles in bold in the table on the next page.

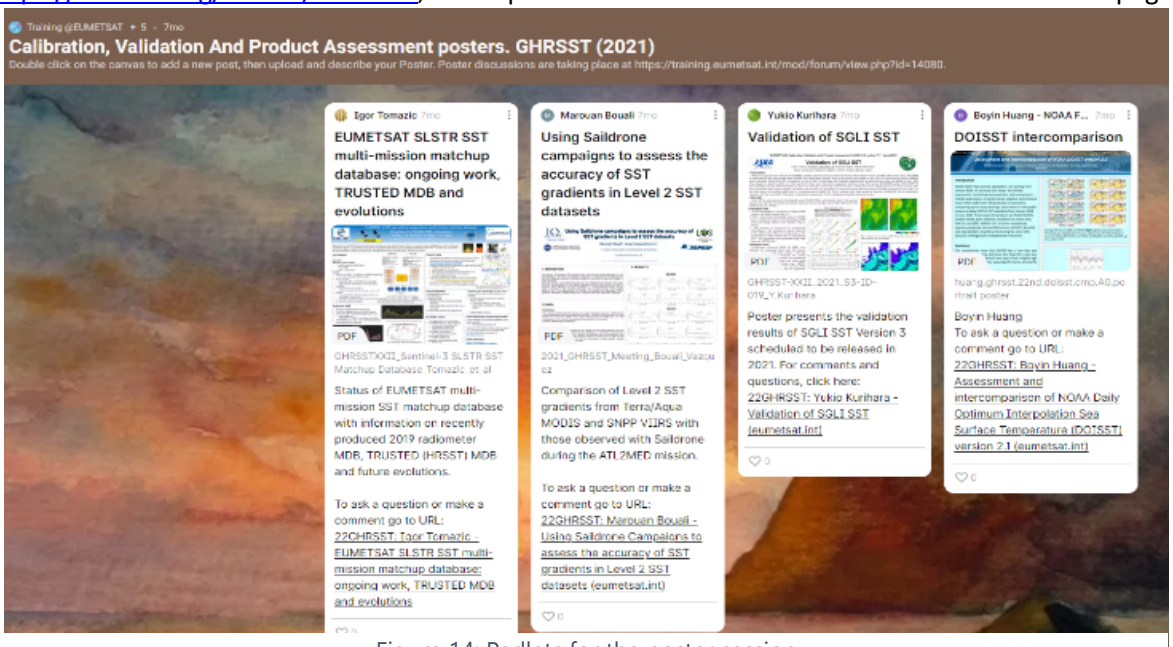

Figure 14: Padlets for the poster session

Science Session	Posters *(For the titles **in bold**, extended abstracts are available in the Proceedings)*
Science Session 1 - Challenging Regions: The Coastal Margin and The Arctic	• **Ultra high-resolution SST from NASA ECOSTRESS resolves fine structure of upwelling zones** • Validation of satellite sea surface temperatures and long-term trends in Korean coastal regions (1982–2018) • **A CMEMS level 4 SST and IST climate data set for the Arctic** • **Using Saildrones to Validate Sea Surface Temperatures in the Arctic**
Access the Padlet of the Science Session 1 Challenging Regions – The Coast and The Arctic https://padlet.com/TrainingEUMETSAT/el4plfma88e4a1t	
Science Session 2 - Applying The Data: Spatio-temporal Variation, Extreme Events	• **The NOAA STAR SOCD OceanView (OV): An application for integrated visualization of satellite, in situ, and model data & ocean events – the v1.0 release** • The intermittency of Sea Surface Temperature: a global perspective • **Is there a need for yet another model to account for SST diurnal variability?** • Observations of Infrared SST Autonomous Radiometer (ISAR) Skin Temperatures in the Seas around Korean Peninsula, Indian Ocean, and Northwest Pacific • Revealing Fundamental SST Patterns with Deep Learning
Access the Padlet of the Science Session 2 Applying The Data: Spatio-Temporal Variation; Extreme Events https://padlet.com/TrainingEUMETSAT/2dltnpeni8e9mzed	
Science Session 3 - Calibration, Validation and Product Assessment	• **Evaluation of AIRS and CrIS SST measurements relative to three globally gridded SST products between 2013 and 2019** • Assessment and intercomparison of NOAA Daily Optimum Interpolation Sea Surface Temperature (DOISST), version 2.1 • **Using SAILDRONE Campaigns to assess the accuracy of SST gradients in Level 2 SST datasets** • **EUMETSAT SLSTR SST multi-mission matchup database: ongoing work, TRUSTED MDB and evolutions** • **Validation of Second-generation Global Imager SST**
Access the Padlet of the Science Session 3 Calibration, Validation and Product Assessment https://padlet.com/TrainingEUMETSAT/klmswuubrmqcj0pg	

Science Session	**Posters** *(For the titles **in bold**, extended abstracts are available in the Proceedings)*
Science Session 4 - Algorithms	• Open source algorithms for AMSR3 • **Historical and Near-real Time SST retrievals from Metop AVHRR FRAC with ACSPO 1** • **USE of ERA-5 Sea Surface Temperature Fields as prior in Optimal Estimation retrieval of SST from MODIS** • Towards Improved ACSPO Clear-Sky Mask for SST from Geostationary Satellites • **Bayesian Cloud Detection Scheme improvements for the SLSTR instrument**
Access the Padlet of the Science Session 4 Algorithms https://padlet.com/TrainingEUMETSAT/37erohxscv59r8dy	

Science Session 5 - Computing and Products	• Towards ACSPO Super-Collated Gridded SST Product from Multiple Geostationary Satellites (L3S-GEO) • **Use of ESA SST CCI data in HadISST2** • Himawari-8 and Multi-sensor sea surface temperature products and their applications • Recent Updates Of CMC SST Analysis • **Copernicus Sentinel-3 SLSTR Sea (and sea-Ice) Surface Temperature: product status, evolutions and projects** • **Updates of AMSR3 on GOSAT-GW and its Ocean Products** • **Presenting a new high-resolution Climate Data Record product** • **S5-P8-ID-007 - Filtering cold outliers in NOAA AVHRR SST for ACSPO GAC RAN2**
Access the Padlet of the Science Session 5 Computing and Products https://padlet.com/TrainingEUMETSAT/46oseukzvpio7s0m	

Disseminating knowledge

One of the GHRSST tasks is to share knowledge with the scientific community but also to engage with stakeholders interested in climate and climate change. For this reason, GHRSST has been involved in the co-organisation of the following online workshops.

Webinar on Ocean Predictions and Observations In Response to the Climate Emergency, 16 September 2021

This 90 minutes webinar was a satellite event to the Ocean Decade Laboratories Laboratory 2:
"A predicted Ocean" UN Decade of Ocean Science for Sustainable Development 2021-2030".

The main goal was to showcase the link between ocean observations, climate models and climate services, highlighting their importance for decision-making and for responding to the climate emergency.
Forecasts of future ocean conditions, of weather trends, of climate, covering months to 10 years are made all the time. *But are they coming soon to the decision making process?*

This webinar has offered a unique opportunity to the target audience to access researchers representing the state of the art. How do we get from a measurement taken at sea, a measurement taken from space, to a forecast, to an interpretation that is going to make a difference to the way people plan?
It also offered insight into how the integration of different ocean and climate disciplines contributes to the vision of a predicted ocean, empowering all stakeholders, from decision-makers to local communities, to make meaningful decisions on the best available information.

Target audience: Stakeholders from across the world, particularly from industry, policy, NGOs and science.

Speakers: Marilena Oltmanns (National Oceanography Centre /Blue-Action), Pablo Ortega (Barcelona Supercomputing Center /INTAROS), Noel Keenlyside (University Bergen/Nansen Environmental Research Center/ TRIATLAS/ Blue-Action), Anne O'Carroll (European Organisation for the Exploitation of Meteorological Satellites EUMETSAT /GHRSST), Mark Payne (Danish Meteorological institute /Blue-Action), Barbara Berx (Marine Scotland Science/ Blue-Action). Moderator: Martin Coath (Danish Meteorological Institute/Blue-Action).

Resources: Presentation https://zenodo.org/record/5512694#.YdMvcGj0lnI
A collaboration of Blue-Action, GHRSST, TRIATLAS, INTAROS projects. Blue-Action, INTAROS and TRIATLAS projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements no. 727852, 727890 and 817578 respectively. The GHRSST project office is funded by the European Union Copernicus programme.

Workshop: Ocean Connections from the Arctic across the Globe at COP26, 4 November 2021

GHRSST co-organised a 1 hour workshop on "Ocean Connections from the Arctic across the globe" at COP26 on 4th November 2021 in Glasgow & virtual, together with the Marine Science Scotland, the Horizon 2020 project Blue-Action and many other contributors. This workshop explored the importance of the ocean in the global and North West European climate, the need to ensure we are measuring the strength of ocean currents and the ocean's properties, and how this information can be incorporated into climate models, climate services and decision-making at national and international level.

Speakers: Bee Berx (Scottish Government), Mark Payne (Danish Meteorological Institute), Jacob Høyer (Danish Meteorological Institute, GHRSST Group for High Resolution Sea Surface Temperature), Noel Keenlyside (Bjerknes Centre for Climate Research, University of Bergen), Marit Reigstad (UiT the Arctic University of Norway), Siân Henley (University of Edinburgh)

Resources: Webrecording on Youtube: https://youtu.be/fJ31QC4uIcw and presentation https://zenodo.org/record/5729404

In collaboration with: This workshop is a collaboration of a number of projects funded by Copernicus and Horizon 2020, Blue-Action, Arctic Passion, TRIATLAS, AMOC-ASAP. Blue-Action and TRIATLAS projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements no. 727852 and 817578 respectively. The GHRSST project office is funded by the European Union Copernicus programme.

Interested in joining GHRSST?

We are open for collaborations!

If you are interested, please get in touch with the chairs/co-chairs of the task teams: https://www.ghrsst.org/about-ghrsst/task-teams/

Follow us on Twitter: https://twitter.com/ghrsst

Subscribe to our newsletter: https://www.ghrsst.org/outreach/newsletter

Figure 15: Participants of the GHRSST international science team meeting June 2021.

GHRSST Project Office

The GHRSST Project Office (GPO) provides the secretariat for the GHRSST Project. It provides secretarial support to the GHRSST Science Team Chair, Anne O'Carroll (EUMETSAT), and coordinates and manages the GHRSST Science Team https://www.ghrsst.org/about-ghrsst/science-team/. It provides an interface to the CEOS SST-VC, and provides logistical coordination and technical support to the Advisory Council.

Together with the GHRSST Science Team Chair, the GPO coordinates, enables and facilitates, on behalf of the GHRSST Science Team, the open exchange of relevant satellite and in situ data streams for use within GHRSST. It provides direct logistical coordination and technical support to coordinate, enable and facilitate the GHRSST Science Team and all subsidiary TAG and TT and the GHRSST Advisory Council.

The GPO also maintains the primary GHRSST documentation:

- GHRSST Strategy and Implementation Plan (GDIP)
- https://zenodo.org/record/4700521
- GHRSST Data Specification (GDS) https://zenodo.org/record/4700466
- User Requirements Document (URD)
- Validation Protocol Document (VPD)
- Climate Data Assessment Framework (CDAF) https://zenodo.org/record/4700356

The GPO is funded by the European Union as part of the Copernicus Programme.
The GPO is hosted by the Danish Meteorological Institute.

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