GXXII VIRTUAL MEETING – 7-11 June 2021

Short Abstracts Submitted

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ID 001: Saharan dust effects on North Atlantic sea surface skin temperatures

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ABSTRACT

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. By exploiting large sets of measurements from many ship campaigns in conjunction with reanalysis products, this study characterizes the sensitivity of the SRF and skin Sea-Surface Temperature (SSTskin) to the Saharan dust aerosols using models of the atmospheric radiative transfer, diurnal heating in the ocean, and thermal skin effect. Saharan dust outbreaks can decrease the surface shortwave radiation up to 190 W/m2, and an analysis of the corresponding SSTskin 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. Greater physical insight into the radiative transfer through an aerosol-burdened atmosphere and the response thermal response will substantially improve the predictive capabilities of weather and climate studies on a regional basis.

ID 002: Presenting a new high-resolution Climate Data Record product.

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ABSTRACT

The near real time OSTIA SST production system is continuously upgraded, and therefore historical data will not be consistent with newer data. To address this, we announce a new level 4 reprocessed foundation SST product generated using the OSTIA system as part of the Copernicus Marine Environment Monitoring Service (CMEMS; https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=SST_GLO_SST_L4_REP_OBSERVATIONS_010_011). This reprocessed product aims to serve users of the near real time OSTIA data who want a consistently processed dataset going back in time.

This second version of the CMEMS OSTIA reprocessing replaces the previous version which spanned the period 1985-2007. V2.0 spans 1981-2020 and will be updated twice-yearly with 6-month delay. It also incorporates data from a wider range of instruments than previously, and uses the data recently generated by the ESA SST CCI and C3S projects.

In this poster we discuss the accuracy and feature resolution of the new product compared to the previous dataset. We also compare it to other climate data records currently available to researchers.

ID 003: Evaluation of AIRS and CrIS SST measurements relative to three globally gridded SST products between 2013 and 2019.

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ABSTRACT

Globally gridded sea surface temperatures (SSTs) provide key data for the long-term monitoring of the stability of satellite data. Despite apparent limitations, accurate hyperspectral data can provide useful independent information to critique the stability of global SST products on the annual-to-decadal time scale. We compared data from AIRS on EOS Aqua and CrIS on SNPP to the SST products from NOAA/NESDIS (RTG), the Canadian Meteorological Centre (CMC) and the UK Met Office (OSTIA). For the 2013 through 2019 period, the overall standard deviation of the difference between AIRS and the RTG was 0.55K, with an increasing trend over time. In contrast, the standard deviation of the difference between the AIRS, the CMC and the OSTIA dropped steadily to below 0.4 K, a level previously seen only in SST products relative to independent buoy data. Unexplained biases between the observed and the gridded SSTs at the 100 mK level are consistent with already existing estimates of the AIRS and CrIS absolute calibration accuracy. However, the AIRS and CrIS observations both show artifacts in all three SST products, increasing with distance from the equator, with the CMC artifacts being the smallest. Even with the CMC a trend of 4 mK per year relative to AIRS and CrIS was observed between 2013-2019 for the 30S-30N oceans. Investigation of the underlying causes of the observed discrepancies requires further work.

ID 004: Assessment and intercomparison of NOAA Daily Optimum Interpolation Sea Surface Temperature (DOISST) version 2.1

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ABSTRACT

NOAA DOISST has recently updated to v2.1 starting from January 2016. Its accuracy may impact the climate assessment, monitoring and prediction, and environment-related applications. Its performance, together with those of seven other well-known SST products, is assessed by comparing against buoy and Argo observations in the global oceans on daily 0.25º×0.25º resolution from January 2016 to June 2020. These seven SST products are NASA MUR25, GHRSST GMPE, BoM GAMSSA, UKMO OSTIA, NOAA GPB, ESA CCI, and CMC.

Our assessments indicate that biases and RMSDs in reference to all buoys and Argo floats are lower in DOISST, GMPE and MUR25 than other products. The bias and RMSD in DOISST in reference to the independent 10% of buoy SSTs remain low as those in reference to full buoy SSTs. The bias in DOISST in reference to the independent 10% of Argo SSTs also remain low as that in reference to full Argo SSTs. The RMSD in DOISST becomes higher in reference to the 10% of Argo SSTs than in reference to full Argo SSTs. Both biases and RMSDs in reference to the independent 10% of Argo observations are low in GMPE and CMC. The biases are similar in GAMSSA, OSTIA, GPB, CCI, and CMC whether they are compared against all buoy or independent Argo observations, while the RMSDs become slightly smaller. These features suggest that ingesting the Argo observations, rather than reserving purely for independent validation, is beneficial in providing expanded global and regional spatial coverage for effective bias correction of satellite data. Overall, DOISST, GMPE, and MUR25 performs better.

ID 005: Copernicus Sentinel-3 SLSTR Sea (and sea-Ice) Surface Temperature: product status, evolutions and projects

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ABSTRACT

The first Copernicus Sentinel-3 satellite was launched on 16th February 2016 and the second on 25th April 2018. One of its main objectives is to observe very accurate Sea Surface Temperature (SST) from the Sea and Land Surface Temperature Radiometer (SLSTR). These highly accurate SSTs provide a reference satellite SST dataset and time-series for other satellite SST missions and are important for climate monitoring.

Operational SLSTR SST products have been distributed from the EUMETSAT marine centre since 5th July 2017. EUMETSAT performs ongoing validation activities for SLSTR SST, together in coordination with the Sentinel-3 validation team, and real time monitoring is shown from the link to metis.eumetsat.int. Validation results show the products performing extremely well, and dual-view SSTs are recommended to be able to be used as a reference SST source.

The ongoing validation activities are important for assessing and maintaining SLSTR SST product quality. In addition to inter-comparisons with other satellite SST, key components are collocations and analyses with drifting buoy SSTs. A Copernicus-funded EUMETSAT project called 'Towards Fiducial Reference Measurements (FRM) of Sea-Surface Temperature by European Drifters' (TRUSTED) is now in its fourth year. Over 100 high-resolution drifting buoys (HRSST) with the design of SVP-BRST have so far been deployed. Activities continue to assess and validate these reference buoys as FRM for SLSTR together in coordination with the HRSST Task Team of the Group for High Resolution Sea-Surface Temperature (GHRSST). The status of these assessments, together with the outcomes from a science review workshop in March 2021 on HRSST and TRUSTED for SLSTR SST validation, will be shown.

EUMETSAT are beginning activities in 2021 towards a revised and improved algorithm for SLSTR SST with the intention of the operational implementation of SLSTR day-2 SST in early 2023. This will include improvements to the Bayesian cloud-screening in coastal zones. In addition, activities continue towards an operational implementation of sea-Ice Surface Temperature from SLSTR, and the evolutions and initial results from the prototype processor deployed in the EUMETSAT offline environment will be shown.

Further ongoing projects and evolutions relating to marine Surface Temperature at EUMETSAT will also be presented.

ID 006: Using Saildrones to Validate Sea Surface Temperatures in the Arctic

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ABSTRACT

The Arctic is one of the most challenging areas for validating remote sensing data. It is also one of the most critical areas for understanding climate change. Accurate measurements of Sea surface Temperature (SST) as an Essential Climate Variable (ECV) are critical for monitoring and forecasting changes in the Arctic.

During 2019 two NASA deployments of the Saildrone uncrewed vehicle occurred off the Alaskan Coast in the Bering Strait. Both deployments left Dutch Harbour on approximately May 13, 2019. Four different onboard instruments were used to measure SST, including two CTDs and two radiometers. Comparisons were made with eight GHRSST Level 4 products, including the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA), Canadian Meteorological Center (CMC), Danish Meteorological Institute (DMI), NASA's Multi-Scale Ultra High Resolution (MUR), Naval Oceanographic Center (NAVO), Remote Sensing Systems (REMSS), the GHRSST Median Product Ensemble (GMPE), and the NOAA National Centers for Environmental Information (NCEI) Daily Optimum Interpolation SST (DOISST) . Statistics were compared between the 4 Saildrone SSTs and each product. Overall Root Mean Square Differences (RMSD) varied between 0.7 to approximately 1.0 degrees Celsius with REMSS SSTs showing biases close to zero.

ID 007: Filtering cold outliers in NOAA AVHRR SST for ACSPO GAC RAN2

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ABSTRACT

Global long-term SST record is being created under the NOAA AVHRR GAC Reanalyses (RANs) project, by historical reprocessing 4 km GAC data of AVHRR/2 and /3 instruments flown onboard multiple NOAA satellites from 1981 – present. The original AVHRR L1b data are reprocessed with the NOAA ACSPO enterprise SST system. Processing algorithms in the latest iteration of RAN2 (Beta02) have been further modified, to mitigate two issues, intrinsic to AVHRR data, both appearing as periodic contamination of retrieved SSTs with massive cold biases. The sources of cold biases are: (1) solar impingement on the black body calibration target, when the satellite approaches the terminator from the nighttime part of the orbit (seen in all AVHRR missions); (2) contamination of the atmosphere with volcanic aerosols, following eruptions of Mt. El Chichon (1982), Mt. Pinatubo (1991) and Mt. Hudson (1991) (in NOAA-7, -11 and -12). The mitigation algorithm exploits the fact that in both cases the spatial densities of cold outliers exhibit well-expressed latitudinal dependencies. The RAN2B02 algorithm identifies 5° latitudinal bands with abnormally high density of outliers, and makes the cloud mask in those bands more conservative. This improves filtering of cold SST outliers in the contaminated areas, without increasing the false cloud detection rate in the unaffected parts of the ocean. We also discuss the future development, which involves correction of AVHRR calibration coefficients (RAN2B03). The preliminary results suggest that re-calibration of AVHRR data can eliminate nighttime cold SST biases caused by solar impingement on the black body calibration target.

ID 008: Historical and Near-real Time SST retrievals from Metop AVHRR FRAC with ACSPO

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ABSTRACT

For the first time, full-mission SST datasets have been created at NOAA from 1km AVHRR FRAC data onboard three Metop First Generation satellites: A (2006-pr), B (2012-pr) and C (2018-pr), using its enterprise ACSPO system. Historical reprocessing (RAN1) starts at the beginning of each mission and continues with near-real time (NRT) processing, using two algorithms: Global Regression (highly sensitive to "skin" SST) and Piecewise Regression (a closer proxy for "depth" SST). The effect of platform/sensor instabilities on global biases is minimized by retraining regression coefficients daily against matchups with drifting and tropical moored buoys, within moving windows (91/361 days for GR/PWR, respectively). The offsets of regression equations are additionally adjusted using matchups within 31-day windows. In RAN1, both training and offset correction windows are centered at the processed day. In NRT processing, delayed windows of the same size are used, ending ~4-10 days before the processed day (depending on matchups' availability), and the offsets are adjusted from the last 31 days in each training window. This mitigates long-term calibration trends on scales from 1-2 months in both RAN1 and NRT. Short-term variations in SST biases in NRT are higher than in RAN1 but do not exceed ~0.05 K. The presentation evaluates the performance of the ACSPO AVHRR FRAC dataset**.** Negotiations with PO.DAAC are underway to archive the full Metop-FG SST record, to set the stage for the Metop-SG series, expected to be launched in 2023 and processed by ACSPO.

ID 009: A completeness and complementarity analysis of the data sources in *i*Quam

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ABSTRACT

In situ sea surface temperatures (SSTs) are a key component in the calibration and validation (Cal/Val) of satellite SST retrievals. The NOAA *in situ* SST Quality Monitor (*i*Quam) system aims to collect and distribute, after uniform quality control, *in situ* SST observations obtained from maximally complete platforms. For each platform type, *i*Quam ingests *in situ* SSTs from 2-4 independent data sources, to ensure complete coverage, often at the cost of some redundancy. However, the relative completeness of various data sources and their mutual complementarity are often unknown, and are the focus of this study. Stratified by four platform types, five data sets are analyzed, including: (1) the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), (2) the Fleet Numerical Meteorology and Oceanography Center (FNMOC) data set, (3) the Atlantic Oceanographic and Meteorological Laboratories (AOML) buoy data set, (4) the Copernicus - Marine Environment Monitoring Service (CMEMS) products, and (5) Argo measurements from two Global Data Assembly Centers, GODAE and IFREMER. The four platform types are drifting buoys, ships, moorings, and Argo floats. Each data set provides SSTs from one or more platform types. Several key findings: FNMOC and CMEMS have more complete coverage for drifting buoys; most ship SSTs are found in FNMOC and ICOADS; ICOADS, FNMOC, and CMEMS all have nearly complete set of tropical mooring measurements, and some CMEMS reports are sampled every 10 mins compared to 1 hr sampling in other datasets. The two Argo data sets are nearly identical.

ID010: First Evaluation of the Diurnal Cycle in the ACSPO Global Super-Collated SST from Low Earth Orbiting Satellites (L3S-LEO)

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ABSTRACT

SST products from geostationary (GEO) and low-earth-orbit (LEO) satellites are provided by NOAA using the Advanced Clear Sky Processor for Ocean (ACSPO) system. Up until recently, LEO SST products have been available in L2P and L3U formats, organized into 10-minute granules. The number of high-resolution LEO satellites processed in ACSPO reached seven (2 VIIRSs aboard NPP/N20, three AVHRR FRACs aboard Metop-A/B/C, and two MODISs aboard Terra/Aqua). In conjunction with two planned launces of N21 VIIRS, and Metop-SG METimage, the numerous L2P/3U data are becoming progressively more challenging to manage by users.

In response, NOAA is developing a new suite of super-collated (L3S) products, separately from low-earth (L3S-LEO) and geostationary (L3S-GEO) satellites. The ACSPO L3S-LEO family comprises two lines: PM, from “afternoon” (currently, NPP/N20) and AM, “mid-morning” (currently, Metop-A/B/C). Both AM and PM L3S-LEO products are publicly available in near-real-time on the NOAA CoastWatch website and continuously validated in NOAA SQUAM and ARMS systems.

Both AM and PM lines are reported twice-daily, night and day, sampling the diurnal cycle at four points around 01:30, 9:30, 13:30 and 21:30 local time. Keeping the four L3S-LEO products can potentially capture the diurnal cycle. In this work we analyse this potential by comparing L3S-LEO diurnal signal to the quality-controlled *in situ* data from the NOAA iQuam system. We also discuss recent L3S-LEO algorithm improvements, which were aimed at improving spatial continuity of SST imagery and reducing impact of cloud leakages from individual sensor L3U data.

ID 011: Towards ACSPO Super-Collated Gridded SST Product from Multiple Geostationary Satellites (L3S-GEO)

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ABSTRACT

NOAA users increasingly state the need for reduced-volume, high information content SST products from multiple satellites. In response, NOAA is developing a suite of Advanced Clear Sky Processor for Ocean (ACSPO) multi-sensor 0.02º gridded super-collated (L3S) SST products, which aim to maximally preserve temporal and spatial resolution of the original satellite data, without reliance on modeled data. Two ACSPO L3S-LEO products have been produced from two Low Earth Observing families (the afternoon JPSS and mid-morning Metop) since 2020. L3S-LEO data are reported 4 times daily: L3S-PM/AM, day/night, to capture the diurnal cycle (at approximately 1:30am, 9:30am, 1:30pm, and 9:30pm local time). This presentation focuses on its geostationary counterpart, L3S-GEO, which reports 24 files per day, in 1hr UTC increments. Initial L3S-GEO implementation super-collates data from 3 GEO sensors (2 ABIs onboard G16/17, and one AHI onboard H08). Data from the future FCI onboard the EUMETSAT MTG will be added after its launch (expected in 2023). The L3S-GEO algorithm comprises 3 major steps: 1) creating satellite-based SST reference; 2) its use to debias individual-satellite products; 3) aggregating the debiased individual SSTs into L3S-GEO. We demonstrate that the debiasing makes the individual GEO products more consistent and reduces collation artifacts. Initial qualitative evaluation of the L3S-GEO SST imagery and its quantitative global validation against iQuam in situ data is performed in the NOAA monitoring systems ARMS and SQUAM. We discuss the remaining issues and potential improvements.

ID 012: SST AT 70-M SCALE FROM ECOSTRESS ON THE SPACE STATION: APPLICATION TO COMPLEX COASTS AND INTERTIDAL FLATS

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ABSTRACT

The ECOSTRESS thermal radiometer on the Space Station has a 70-m pixel scale and a subdaily to 5 day revisit interval. It resolves thermal patterns at sub-pixel scales relative to the highest resolution GHRSST products, and is especially useful in coastal regions with complex shorelines. We validated ECOSTRESS SST and at-sensor radiances with co-located cloud-free ocean pixels from VIIRS, and to NOAA in-situ SST Quality Monitor observations, to establish a bias correction for use in coastal regions. We examined spatial variation in SST at different tide stages on tidal flats in Mont Saint Michel Bay, France (tidal range 10m) and in Galicia, NW Spain (tidal range 3m). ECOSTRESS resolves the position of the water line at all stages of the tidal cycle. This allows three important determinations (1) quantification of surface temperature changes during flood and ebb, (2) quantification of the degree of tidally dependent land contamination of GHRSST product pixels, and (3) quantification of thermal stress during aerial exposure of intertidal surfaces. None of these is possible with existing operational SST products prior to ECOSTRESS. ECOSTRESS SST provides added value to GHRSST L2 data, documenting details of spatial gradients within the highest resolution GHRSST pixels.

ID 13: Ultra high-resolution SST from NASA ECOSTRESS resolves fine structure of upwelling zones

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ABSTRACT

To resolve fine scale environmental forces relevant for marine ecosystem function, new satellite derived products are required, especially along the coasts of the world. In this context, the Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) provides sea surface temperature imagery with an unprecedented 70×70m pixel size. To assess its performance, we compared processed ECOSTRESS images on the coastal upwelling systems of Western Iberia, Chile, South Africa and California with quasi-simultaneous (less than 90 minutes apart) NOAA-20 VIIRS images with a pixel size of 750×750 m. ECOSTRESS successfully quantifies sub-pixel scale physical structures like upwelling shadows, fronts and filaments that are not properly resolved with NOAA-20 VIIRS. Moreover, it also provides a much more detailed characterization of thermal gradients across fronts. The novel imagery from ECOSTRESS provides an important complement to the operational GHRSST L2 suite of products for the study of fine-scale ocean dynamics.

ID 014: Bias-aware optimal estimation for sea surface temperatures from historic AVHRRs

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ABSTRACT

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. 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. First, corrections for brightness temperature relative to radiative transfer are obtained, as piecewise linear functions of a variety of predictors. Preference is given to using predictors that have a geophysical interpretation: for example, errors in spectral response function in infrared channels may lead to the need to correct brightness temperatures as a function of atmospheric water vapour path; instrumental errors may track quantities such as the temperature of the internal calibration target, and this is also often used as a predictor. Second, the error covariance of discrepancies between simulations and observations is obtained, which characterizes uncertainty from calibration, noise and radiative transfer simulation. This reveals inter-channel error correlations that are important for optimal retrieval.

Fourth, the bias and uncertainty in prior information is also estimated, of most relevance here being the relationship between water vapour in numerical weather prediction (NWP) fields compared to clear-sky fields of view: in general, clear-sky areas appear to be drier than the all-sky NWP, which makes sense. Lastly, in situ data, adjusted to skin values, are used as an anchoring reference for the BAOE parameter estimation step, and their uncertainty is also estimated. This estimated includes effects from geophysical mismatch between satellite and in situ data types, as well as the in situ error distribution. 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.

ID 015: The intermittency of Sea Surface Temperature: a global perspective

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ABSTRACT

The observed patterns in Sea Surface Temperature (SST) are a manifestation of the direct cascade of potential energy from large scales towards small scales. The hallmark of such a turbulent cascade is the intermittency of SST. Recently, we have proposed a new approach to investigate and quantify it. The proposed approach, which has its roots in the Multifractal Theory of Turbulence, has allowed to develop new metrics to characterize the variability of SST and has underlined the importance of the strongest fronts to reproduce the statistical properties of SST variability.

Preliminary results has shown that, the investigation of intermittency using real SST observations presents two difficulties that need to be understood: the noise present in observations and the masking of strong fronts by cloud detection algorithms. A key step necessary to address these problems is the characterization of intermittency and SST variability at a global scale. To this end we have analyzed the SST issued from realistic numerical simulations of the global ocean. These simulations have spatial resolutions close to SST observations (~ 2 km) and temporal samplings of the order of 1 hour. The firsts results of this analysis will be presented and discussed and compared with some real observations.

ID 016: PODAAC milestone: GHRSST data migrating to AWS Cloud

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ABSTRACT

NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC) is the Global Data Assembly Center (GDAC) for the Group of High Resolution Sea Surface Temperature (GHRSST) project. Recently, PO.DAAC has made revolutionary changes to its data publication, access, distribution systems through NASA's Earthdata Cloud, powered by Amazon Web Service (AWS). A recent update to the PO.DAAC web-portal provides direct synchronization of dataset content via the Earthdata Search API, providing seamless integration and distribution of data distributed both in the cloud and on-premise. A growing number of PO.DAAC datasets, including GHRSST, are already available in the cloud. This is a big step forward for PO.DAAC to enhance and promote the GHRSST data discoverability, usability and services. All of the 95 GHRSST datasets currently archived at the PO.DAAC have been or will be moved to the AWS Cloud by February 2022 with the MUR, MODIS, and VIIRS SST datasets as the pioneer group. Such efforts enable the GHRSST datasets to be available to a much broader SST and interdisciplinary user community, and further promote open science and data fusion research. The traditional data access and service tools are being transitioned into the Earthdata Cloud system, but availability will vary due to the configuration steps required for cloud-based integration. An enterprise-level web service API, known as NASA Harmony, for data discovery, download, subsetting and reformatting will be described, including some Jupyter notebook recipes developed by the PO.DAAC. In parallel to the cloud-migration effort, PO.DAAC has also reformed the metadata management and archiving infrastructure by switching the local management service to NASA's Common Metadata Repository (CMR), which is an enterprise-level data and metadata management system. CMR integrates metadata from all 12 NASA DAACS, providing the capability to make data search and extraction through the cloud more efficient than ever before.

ID 017: Himawari-8 and Multi-sensor sea surface temperature products and their applications

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ABSTRACT

Sea surface temperature (SST) products within a few kilometres of coasts that can resolve fine-scale features, such as ocean upwelling, are increasingly in demand. The Australian Bureau of Meteorology (Bureau) currently produces operational, real-time SST from the Himawari-8 geostationary satellite every 10 minutes at ~2 km spatial resolution. These native resolution SST data have been composited to experimental hourly, 4-hourly and daily SST products and projected onto the rectangular Integrated Marine Observing System (IMOS) grid at 0.02 x 0.02 degrees. In response to user requirements for gap-free, highest spatial resolution and highest accuracy SST data, the Bureau is experimenting with compositing geostationary Himawari-8 data with data from the Visible Infrared Imaging Radiometer Suite (VIIRS) and Advanced Very High-Resolution Radiometer (AVHRR) satellite sensors installed on polar-orbiting satellites to construct new "Multi-sensor L3S" products. The compositing reduces data gaps due to clouds and presents an opportunity for easy-to-use, more gap-free SST data. The new Himawari-8 and Multi-sensor L3S SST products are expected to provide improved data for applications such as IMOS OceanCurrent, FISHTRACK and the Bureau's ReefTemp Coral Risk Monitoring service. The improved coverage will also provide useful insight into the study of marine heatwaves and ocean upwelling in near-coastal regions. We will discuss our method to combine data from different sensors and present validation of the Multi-sensor L3S SST against in-situ SST data.

ID 018: Optimal Estimation of SST from INSAT-3D/3DR Imagers

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ABSTRACT

The accurate estimation of sea surface temperature (SST) is very crucial for Earth’s climate monitoring. The satellite-based measurements provide a unique opportunity to estimate the global SST at frequent intervals. In this regard, 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. To evaluate the efficacy of the 1DVAR based retrieval algorithm, it has been applied on the six months of INSAT-3D/3DR observations to retrieve SST. Thereafter, the retrieved SST has been assessed against the in-situ measurements of SST. The quantitative measure of the retrieval errors in the SST was computed in terms of standard statistical parameters viz. bias and the standard deviation of the differences (SD), etc. The slightly negative bias of -0.20K with 0.6K SD were obtained in the retrieved SST when compared against the in-situ measurements. Moreover, the spatial gradients of the daily SST were also computed to observe the fine scale features of the ocean. 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). The spatial gradients are the primary inputs for generating the thermal fronts in predicting the potential fishery zones (PFZ). This methodology of SST retrieval is now operational for INSAT-3D/3DR Imager at India Meteorological Department (IMD), New Delhi, India.

ID 019: Validation of SGLI SST

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ABSTRACT

SGLI is an optical sensor onboard the GCOM-C satellite which was launched from the Tanega-shima Space Center of JAXA in December 2017. SGLI SST is retrieved from the split window data of SGLI. SGLI SSTs from January 2018 to the latest are available at the JAXA G-Portal and the JAXA GHRSST server. The latest version of SGLI SST is 2.0 which will be updated to 3.0 in 2021. Accuracy of the SGLI SST is monitored at the GCOM-C Calibration and Validation Monitor Web in near-real-time. Bias and RMSE of SGLI SSTs from January to March in 2021 are -0.150 and 0.401 which were derived by comparison with buoy data. For further information, SGLI SSTs will be validated and discussed in detail in the GHRSST XXII.

JAXA G-Portal: https://www.gportal.jaxa.jp/gp/top.html

JAXA GHRSST server: https://suzaku.eorc.jaxa.jp/GHRSST/

GCOM-C Cal-Val Monitor: https://suzaku.eorc.jaxa.jp/GCOM_C/Validation//index.html

ID 020: Observations of Infrared SST Autonomous Radiometer (ISAR) Skin Temperatures in the Seas around Korean Peninsula, Indian Ocean, and Northwest Pacific

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ABSTRACT

This study presents preliminary results on Infrared SST Autonomous Radiometer (ISAR) measurements in the seas around Korean Peninsula in recent years. ISAR observations have been also conducted in the Indian Ocean (19 March - 14 April, 2019) and the Northwest Pacific (13–26 May, 2020) using R/V ISABU in 2019 and 2020. An additional cruise for ISAR measurements has been conducted in the eastern region off the Korean Peninsula from 21 April to 6 May 2020. For understanding characteristics of skin-bulk temperature differences, the temperature differences between ISAR measurements and shipborne thermosalinograph data were analyzed. Atmospheric and oceanic variables such as air temperature, sea surface wind, currents were also measured during the cruises for the study area. The temperature differences between ISAR skin temperatures and the thermosalinograph presented well-known features of the previous literature. The observation data revealed diurnal variations of the skin-bulk temperatures, which showed a good agreement with the previous studies. In the study region, diurnal variations of the differences, cool-skin effect, daytime warm biases, and wind effects were well presented. The temperature differences showed a large range from –2 K to 5 K at low winds (<3 m/s) at 12-15h, while a small range from –1 K to 1 K at high winds of 12-15 m/s. Compared with the previous studies, the present measurements indicated relatively large amplitudes of the positive differences amounting to 5 K in daytime and to -2.2 K in night. More cruise observations need to be performed for further understanding skin-bulk temperature differences.

ID 021: VALIDATION OF SATELLITE SEA SURFACE TEMPERATURES AND LONG-TERM TRENDS IN KOREAN COASTAL REGIONS (1982–2018)

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ABSTRACT

Validation of daily Optimum Interpolation Sea Surface Temperature (OISST) data from 1982 to 2018 was performed by comparison with quality-controlled in situ water temperature data from Korea Meteorological Administration moored buoys and Korea Oceanographic Data Center observations in the coastal regions around the Korean Peninsula. In contrast to the relatively high accuracy of the SSTs in the open ocean, the SSTs of the coastal regions exhibited large root-mean-square errors (RMSE) ranging from 0.75 °C to 1.99 °C and a bias ranging from –0.51 °C to 1.27 °C, which tended to be amplified towards the coastal lines. The coastal SSTs in the Yellow Sea presented much higher RMSE and bias due to the appearance of cold water on the surface induced by vigorous tidal mixing over shallow bathymetry. The long-term trends of OISSTs were also compared with those of in situ water temperatures over decades. Although the trends of OISSTs deviated from those of in situ temperatures in coastal regions, the spatial patterns of the OISST trends revealed a similar structure to those of in situ temperature trends. The trends of SSTs using satellite data explained about 99% of the trends in in situ temperatures in offshore regions (>25 km from the shoreline). This study discusses the limitations and potential of global SSTs as well as long-term SST trends, especially in Korean coastal regions, considering diverse applications of satellite SSTs and increasing vulnerability to climate change.

ID 022: Is there a need for yet another model to account for SST diurnal variability?

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ABSTRACT

SST's day-time variability due to low enough winds and strong enough solar heating has long been of interest for the GHRSST community and beyond. Yet, no consensus on its numerical representation has been reached; thus, diurnal variability is not properly resolved in many oceanic and atmospheric models. Erroneous estimation of air-sea interactions are direct impacts of the "missing" diurnal variability of SST, which can lead to demised model accuracies. Merging of SSTs from different satellite sensors, with different overpass times, is affected by diurnal signals with a direct impact on efforts to create climate records. Misrepresentation of the diurnal variability of the upper ocean temperature may result in errors when modelling harmful algal blooms.

The "Improved Diurnal Variability Forecast Of Ocean Surface Temperature through Community Model development (DIVOST-COM)" project focused on developing the existing one-dimensional General Ocean Turbulence Model (GOTM) to a "common" tool, using the CMEMS Baltic Modelling & Forecasting Centre (MFC) 3D physical-biological HIROMB-BOOS Model (HBM) ocean and HARMONIE atmospheric component as inputs to resolve the vertical temperature structure of the upper ocean.

Simulated GOTM temperatures were compared to HBM outputs, in situ measurements, the CMEMS SST TAC Level 4 North/Baltic Sea analysis and SEVIRI SST. GOTM comparisons against L4 and SEVIRI SST are typically lower by ~0.2 degrees, compared to those for HBM, with the added benefit of a higher depth resolution. Regarding diurnal variability, GOTM better reproduced the spatial extend, amplitude and statistical properties of events identified in hourly IR SST retrievals, compared to HBM.

ID 023: Use of ESA SST CCI data in HadISST2

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[1] *Met Office, UK*

ABSTRACT

The Met Office Hadley Centre Sea Ice and Sea-Surface Temperature data set, HadISST2, combines 170+ years of in situ measurements of sea surface temperature with over 35 years of satellite data. In the latest version of HadISST2 we use SST retrievals from the ESA SST CCI AVHRR v2.1 data set together with SSTs from AATSR Reanalysis for Climate (ARC) data set. Minimal bias adjustments are required to homogenise the satellite records so that they can be combined seamlessly with the in situ SSTs. As in previous versions of HadISST2, data with near-global coverage from satellite SSTs over the past 35 years is combined with the much longer, yet sparser records from in situ data to estimate large-scale and local covariance structures in the data. These, together with SST inferred from sea ice concentration are used to produce a globally complete and consistent analysis of SST and sea ice. HadISST2 is presented as a set of ensemble members the spread of which indicates uncertainty associated with: residual bias in the data, measurement error more generally, and sparse sampling.

ID 024: Analysis Ready Data applications for GHRSST and related data

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(3) *Farallon Institute*
(4) *Development Seed*

ABSTRACT

Remote sensing data that have been processed to a set of interoperable conventions, properly documented with quality and accuracy information, and available for immediate long time series analysis are characterized as Analysis Ready Data (ARD). Understandable and available to both expert and novice users, ARDs have found growing utilization in the land community. The land remote sensing experts in the Committee on Earth Observation Satellites (CEOS) community have developed a complete ARD specification and approval workflow that is now being reviewed to see how it applies to non-land datasets including ocean data. Some of the recent collaborative work of the CEOS SST Virtual Constellation in this arena will be highlighted including an analysis of the GHRSST Aqua/Terra MODIS L2P datasets from the perspective of the CEOS CARD4L specifications. This presentation will further describe the emerging work in ocean ARDs including practical examples of existing products available in the Amazon cloud, and data services workflows to create ARDs from Level 2 data, as well as noting some of the pitfalls in the processes. Some earth observation products are tailored by users to address specific measurement challenges within their marine ecosystems and need to be delivered in an ARD format to facilitate community scrutiny. A unique solution is required to facilitate the coherent and rapid analysis of these spatially and temporally dense datasets. Progress on the development of an Open Data Cube solution for ingesting, archiving and analyzing ARDs developed for the southern Benguela Large Marine Ecosystem will also be presented.

ID 025: Status and plans for the sea-ice concentration data records from the EUMETSAT OSI SAF and ESA CCI: possibilities for polar SST products

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2: Danish Meteorological Institute

ABSTRACT

Satellite-based Sea Surface Temperature (SST) products that cover the polar oceans rely on accurate sea-ice cover information. Such information can be used e.g. for masking pixels at Level1&2, for preparing Level3&4 SST analyses, and for controlling the transition between SST and Ice Surface Temperature (IST). For climate-quality SST data, it is a key requirement that the sea-ice information does not introduce trends or jumps in the data record.

In this contribution, we present the status and plans for sea-ice concentration climate data records from the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) and from the ESA Climate Change Initiative (CCI). We show how these two European initiatives have coordinated to prepare climate-quality sea-ice cover information from the suite of passive microwave satellite missions, to achieve maximum temporal coverage, and to improve the spatial resolution and fidelity along the sea-ice edge. We describe the algorithm steps that are most relevant for the SST/IST community when using such sea-ice information in their climate products. We illustrate our presentation with examples from the Copernicus Climate Change Service (C3S) Arctic Regional ReAnalysis (CARRA), and from the Copernicus Marine Environment Monitoring Service (CMEMS) service.

We finally invite the SST/IST community to a dialogue about their needs and requirements for such sea-ice concentration products.

ID 026: The Sea Surface Temperature analysis in the NCEP GFS and the future NCEP UFS

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IMSG at EMC/NCEP/NOAA, EMC/NCEP/NOAA

ABSTRACT.v2

At National Centers for Environmental Prediction (NCEP), the Sea Surface Temperature (SST) is analyzed in the Global Forecast System (GFS), referred 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.

A few NSST updates have been developed and tested with GFSv15.2 and may be implemented in the next GFS. They are: the inclusion of VIIRS radiances, exclusion of AVHRR partly cloudy radiance, new background error correlation length scales and a new thinning scheme with smaller mesh for AVHRR and VIIRS radiances. This package of developmental upgrades is based on the evaluation of the NSST performance. It has been found that more observations should be used as is standard practice for other operational SST analysis products. Additionally, it has been noticed that small-scale spatial features are not well resolved due to the too broad background error correlation length and too large thinning box size. Experimental results have shown the NSST analysis can be improved significantly through the aforementioned modifications.

The effort to produce SST analysis in the future UFS is underway. The near surface sea water temperature simulated by the coupled model, with the 2-m top layer thickness oceanic model (MOM6), has been verified against the buoy observations. It has shown the fit to drifting buoy is encouraging, but the diurnal variability is too weak, which means an explicit diurnal warming model is still needed in the coupled system. Further, 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, will be presented.

The coupled data assimilation, which will provide the SST analysis, depends on the configuration of the coupled model with or without the NSST model.

ID 027:Developments towards a 40-year climate data record from the ESA Climate Change Initiative

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ABSTRACT

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 presentation will cover the major developments since version 2 of the CDR.

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. The quality of the AVHRR retrievals has been improved by using a new bias aware optimal estimation (BAOE) technique (described fully in the presentation by Merchant) and updated radiative transfer modelling including tropospheric dust which significantly reduces the SST biases due to dust aerosols seen in previous CDRs. Developments affecting the recent half of the record includes work to include the passive microwave AMSRE and AMSR2 sensors into the main CDR, use of full resolution MetOp data and the dual-view SLSTR sensors.

ID 028: Studying the thermal skin layer using thermofluorescnt dyes

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ABSTRACT

The thermal skin layer of the ocean is both the conduit for and barrier to the supply of heat from the ocean to the atmosphere which influences weather and climate. Of especial interest is how the internal temperature gradients in the thermal skin layer adjust to changes in the incident infrared radiation. Because of its very thin vertical extent, typically less than 100 μm and being a little thicker for low wind speeds, it is not feasible to measure the internal structure of the thermal skin layer using contact thermometers. By exploiting the wavelength dependence of the emission depth of infrared radiation emerging from the sea-surface it is in principle feasible to invert measurements of spectra of the infrared emission to derive temperature gradients in the thermal skin layer, but even measurements from the best current spectroradiometers are insufficient to provide clear representations of the signals we seek. A new measurement technique is required. Using dyes that fluoresce with a dependence on temperature provide a potential approach to studying the internal temperature structure of the thermal skin layer. We will present a summary of recent laboratory research that leads us to believe that this approach will deliver an innovative method of providing answers to questions of how the ocean and atmosphere interact, and how this will adapt to a changing climate.

ID 029: Towards Improved ACSPO Clear-Sky Mask for SST from Geostationary Satellites

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ABSTRACT

A crucial element of the NOAA Advanced Clear Sky Processor for Oceans (ACSPO) sea surface temperature (SST) system is identification of the clear-sky domain. One of the current priorities is advanced cloud detection by revisiting the existing set of cloud screening tests. Our goal is a comprehensive revision of the current status, and implementing computationally efficient and affordable algorithms for improved cloud detection, with a focus on challenging (dynamic, coastal, broken/multi layer clouds etc) scenes. New algorithms, including computationally intensive pattern recognition approaches, are tested on a diverse set of representative imageries/tiles (both where the current ACSPO Clear-Sky Mask, ACSM, performs well and where it produces false positive/negative detections). Our goal is robust clear-sky detection for SST, with minimized cloud leakages and false alarms. The initial priority is on the SST from the Advanced Baseline and Himawari Imagers (ABI/AHI) onboard NOAA GOES-16 and -17, and JMA Himawari-08 geostationary satellites, with a possible extension to data of Low Earth Observing (LEO) satellite sensors. We start with a comprehensive assessment of the current status of (ACSM), focusing on its current limitations . Using a representative set of ABI/AHI granules, we first evaluate possible algorithm improvement options. Next step will be implementation in ACSPO and comprehensive evaluation of the improvements in an experimental production pipeline, from L1b to L3C level products, in two NOAA online monitoring systems: global NOAA SST Quality Monitor (SQUAM) and image-quality oriented ACSPO Regional Monitor for SST (ARMS).

ID 030: USE of ERA-5 Sea Surface Temperature Fields as prior in Optimal Estimation retrieval of SST from MODIS

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ABSTRACT

Two ERA5 SST fields, the ‘sst’ (sea surface temperature) and the ‘skt’ (skin temperature) were considered as a prior in an Optimal Estimation (OE) of SST from MODIS measurements and the results were compared with in situ measurements from buoys and retrievals with the traditional non-linear SST retrieval (NLSST).

The ERA5 ‘sst’ is a foundation temperature which 1) lacks the diurnal signal of the skin SST, and 2) requires correction for the skin effect. The diurnal variability in skin SST can be a degree or more and not accounting for that would result in OESST missing the diurnal variability and thus being biased with respect to buoy measurements. The ERA5 ‘skt’ variable might seem a more appropriate prior SST and it should be able to be used directly without the need for corrections for the skin effect or for diurnal signals.

We found that for MODIS, using as the prior to the OE retrieval the ERA-5 ‘sst‘ with a skin effect correction of -0.17K and a simple daytime offset leads to much smaller differences between the retrieved OESST and the in-situ temperature (also corrected for skin effect when necessary) than using as prior the ‘skt’. This is perhaps not very surprising if one considers that the ERA-5 ‘skt’ is biased with respect to the in-situ measurements with mean nighttime and daytime biases of -0.1K and -0.37K which are larger than corresponding biases for the skin effect corrected ERA-5 ‘sst’.

ID 031: RECENT UPDATES OF CMC SST ANALYSIS

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ABSTRACT

As part of its operational prediction program, the Canadian Meteorological Centre (CMC) produces a daily sea surface temperature (SST) analysis on a global 0.1° latitude-longitude grid. This analysis assimilates satellite data from AVHRR, AMSR2 and VIIRS instruments, in situ observations from fixed and drifting buoys and from ships and it uses ice information from CCMEP global ice concentration analysis.

Recent updates of the system include assimilation of AVHRR data from Metop-C, VIIRS data from NOAA 20 and the addition of ships data available on GTS in BUFR format.

This study reviews the SST analysis with emphasis on the later implementations. It assesses the impact of assimilating different satellite datasets to the quality of global SST analysis. Verification against independent data and against GMPE product are also presented.

ID 032: Using Saildrone Campaigns to assess the accuracy of SST gradients in Level 2 SST datasets

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ABSTRACT

Sea Surface Temperature (SST) gradients and fronts provide pivotal information on the physical state of the ocean, its biological composition, its interaction with the atmosphere and have therefore become an important variable for the study of long term changes in ocean dynamics.

Because standard *in situ* observations derived from drifting/moored buoys and Argo floats are only representatives of one specific geographical point, they cannot be used to measure spatial gradients of ocean parameters (i.e., two-dimensional vectors). In this study, we exploit the high temporal sampling of the unmanned surface vehicle (USV) Saildrone (i.e., one measurement per minute) and describe a methodology to compare the magnitude of SST gradients derived from satellite-based Level 2 products with those captured by Saildrone.

Results based on SST derived from Terra/Aqua MODIS and SNPP/JPSS1 VIIRS using several quality flags are presented and can serve as feedback for future improvements in cloud masking and SST retrieval algorithms.

ID 033: A New Operational Mediterranean Diurnal Optimally Interpolated SST Product within the Copernicus Marine Service

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ABSTRACT

Within the Copernicus Marine Environment Monitoring Service (CMEMS), an operational diurnal Sea Surface Temperature (SST) product has been developed for the Mediterranean Sea. This product provides daily optimally interpolated (Level-4) maps of hourly mean sub-skin SST at 1/16° horizontal resolution over the CMEMS Mediterranean domain, by combining model and infrared satellite data. The diurnal SST product is built through optimal interpolation of geostationary satellite observations as available from SEVIRI collated (Level-3C) observations and the CMEMS Mediterranean forecast hourly data, the latter used as first-guess. This approach takes advantage of geostationary satellite observations as the input signal source to produce hourly gap-free SST fields using model analyses as first-guess. The resulting SST anomaly field (satellite-model) is free, or nearly free, of any diurnal cycle, thus allowing to interpolate SST anomalies using satellite data acquired at different times of the day. Preliminary validation results show that the reconstructed diurnal cycle is in good agreement with in situ data (Bias=0.033 ± 0.001 K; RMSD=0.55 ± 0.01 K). This product performs better than the CMEMS model data during the central warming hours. Further analyses will focus on the characterization of the spatial-temporal distribution of the diurnal warming events as well as their relation with atmospheric variables.

ID 034: Introducing the ISRO-CNES TRISHNA mission for high resolution SST observations in coastal ocean and continental waters

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ABSTRACT

The TRISHNA mission (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment) is a cooperation between the French (CNES) and Indian (ISRO) space agencies. It will measure the optical and thermal spectra emitted and reflected by the Earth from a low-altitude Sun synchronous orbit, over a swath with a width of 1026 km. It is intended to measure approximately twice a week the thermal infrared signal of the surface-atmosphere system at 57 m resolution for the continents and the coastal ocean, and a resolution of 1000 meters over deep ocean. The primary scientific objectives of the mission will be to provide high-quality imagery of vegetation, snow, ice and sea surface temperature and albedo. In coastal areas, the deep interactions between the ocean, the atmosphere and the land generate a strong variability in the surface temperature at very fine scales. It is therefore interesting to measure the temperature of the water at the surface with high spatial and temporal precision, as this information can have several uses. Thermal imaging with high spatial resolution and frequent observation, including night-time acquisitions will bring key information on sea surface temperatures, sub-mesoscale activity in coastal areas and in the high seas, continental waters (lakes and rivers) as well as oil spills, thermal pollutants, effluents and wastewater discharges.

ID 035: EUMETSAT SLSTR SST multi-mission matchup database: ongoing work, TRUSTED MDB and evolutions

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ABSRACT

Sea surface temperature (SST) is an essential variable for operational forecasting and global climate monitoring, and is one of the main products provided by the Copernicus Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR) instruments. As such, there is a stringent requirement on SLSTR SST product performance: Its absolute accuracy should be better than 0.3 K and its temporal stability better than 0.1 K/decade.

One of the main SST Cal/Val activities to confirm these requirements is comparison with in situ reference measurements. To perform this activity, we are generating an SST matchup database (MDB) using the felyx application, from which we then analyse differences between SLSTR SST and in situ SST measurements. Currently we are using several in situ measurement types: drifters, Argo, moorings and ship-borne radiometers. We added in situ measurements from HRSST drifters built and deployed through the EUMETSAT/Copernicus TRUSTED project and experimentally we are adding Saildrone measurements. The full SLSTR SST MDB contains variables from SLSTR Level-1 and Level-2 products, as well as the main variables from the in situ datasets. As part of our internal validation activities, we also produce SST MDBs for AVHRR-B SST, IASI-B SST and VIIRS-NPP SST (L2 variables only) against main in situ types.

This presentation will summarise ongoing SLSTR SST MDB processing activities and more detailed information on prepared HRSST TRUSTED dataset. The presentation will also give an overview of the MDB content and format, access details and expected future evolutions.

ID 036: Deep Learning of Sea Surface Temperature Patterns to Identify Ocean Extremes

J. Xavier Prochaska[1] , **Peter Cornillon**[2], **and David Reiman**[1]

(1) University of California, Santa Cruz; (2) University of Rhode Island

ABSTRACT

We report on an out of distribution analysis of ~12,000,000 semi-independent 128x128 pixel^2 SST regions from all nighttime granules in the MODIS R2019 L2 public dataset to discover the most complex or extreme phenomena at the ocean surface. Our algorithm (*ULMO*) is a probabilistic autoencoder, which combines two deep learning modules: (1) an autoencoder, trained on ~150,000 random regions from 2010, to represent any input region with a 512-dimensional latent vector akin to a (non-linear) EOF analysis; and (2) a normalizing flow, which maps the autoencoder's latent space distribution onto an isotropic Gaussian manifold. From the latter, we calculate a log-likelihood (LL) value for each region and define outliers to be those in the lowest 0.1% of the distribution. These exhibit large gradients and patterns characteristic of a highly dynamic ocean surface, and many are located within larger complexes whose unique dynamics warrant future analysis. Without guidance, *ULMO* consistently locates the outliers where the major western boundary currents separate from the continental margin. We will detail the analysis with emphasis on SST pre-processing and will highlight future directions.

ID 037: Revealing Fundamental SST Patterns with Deep Learning

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ABSTRACT

We have developed an Artificial Intelligence model termed a probabilistic autoencoder (PAE) to analyze ~12,000,000 128x128 pixel^2 regions extracted from the MODIS AQUA Level 2 SST dataset. These were restricted to nighttime and to areas with less than 5% cloud coverage. While our initial study focused on the most extreme SST patterns (i.e., outliers; Prochaska, Cornillon, Reiman 2021), the PAE latent vectors (akin to EOF coefficients) enable global analyses of the full SST distribution. Here, we will examine the fundamental SST patterns of the ocean and explore their spatial and temporal distribution to assess the underlying ocean dynamics. We will also briefly describe development of the PAE model and our plans to share the analysis products with the community for new investigations.

ID 038: Instrument Noise, Retrieval Issues or Geophysical Signal?

Peter Cornillon[(1)], Jörn Callis[(2)] and J. Xavier Prochaska[(3)]

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ABSTRACT

To better understand the categorization of images with a Probabilistic Autoencoding (PAE) algorithm (discussed in the ‘Deep Learning of SST Patterns…’ also to be presented in this meeting), we found that the large wavenumber (small wavelength) portion of the SST power spectra determined from L2 MODIS Aqua nighttime fields is a function of latitude. Specifically, the spectra level off to relatively higher energy levels at low latitudes compared to high latitudes. Another way of looking at this is that the pixel-to-pixel variance of the SST field is substantially larger at low latitudes than at high latitudes in both the along-scan and along-track directions. So, why might there be a latitudinal dependence in the small scale variability of the L2 MODIS Aqua SST fields? We examine three possibilities:

1) Instrument noise - noise in the brightness temperatures used to determine SST.

2) Issues related to the retrieval algorithm - atmospheric issues.

3) Sub-mesoscale processes, which might vary with latitude.

Unfortunately, we do not have the answer to this question at this time but - well, we’re praying that - we will by early June.

ID 039: A CMEMS level 4 SST and IST climate data set for the Arctic

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ABSTRACT

The surface temperature is one of the key variables for assessing climate change. Climate change is most pronounced in the Arctic and it is therefore crucial to accurately estimate sea surface temperatures (SST) and ice surface temperatures (IST) in this region. The availability of in situ observations is limited in the Arctic, thus, emphasizing the potential of using satellite observations to estimate surface temperatures. We present the first Arctic (>58°N) gap-free Level 4 climate data set covering the surface temperatures of the ocean, sea ice and the marginal ice zone since 1982. The SST/IST data set has been generated within the Copernicus Marine Environment Monitoring Service (CMEMS) project. The multi-satellite optimal interpolation algorithm produces daily gap-free fields, with a spatial resolution of 0.05° in latitude and longitude. In situ observations from drifting buoys, moored buoys and ships have been used to derive consistent validation statistics over the ocean and sea ice. The comparison of derived SSTs against drifting buoy measurements shows a mean bias of 0.03°C and a standard deviation of 0.66°C. Over sea ice, the derived ISTs have been compared with 2-meter air temperatures from ECMWF and CRREL drifting buoys, with resulting biases of -3.73°C and -3.40°C and standard deviations of 3.44°C and 3.40°C, respectively. The combined sea and sea ice surface temperature have risen with more than 4°C, considering the period 1982-2019. The combination of sea and sea ice surface temperature provides a consistent climate indicator, which is crucial for studying climate change and trends in the Arctic.

ID 040: Development of consistent surface temperature retrieval algorithms for the sea surface, marginal ice zone and sea ice in the polar regions.

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ABSTRACT

The Earths surface temperature is a key variable to observe to determine the global energy balance and the heat fluxes between surface and atmosphere. Where Sea Surface Temperature (SST) satellite retrievals are relatively mature, less focus has been on the development of sea Ice Surface Temperature (IST) algorithms and the consistency with the SST algorithms in the Marginal Ice Zone (MIZ). SST and IST algorithms are produced daily within the OSI-SAF and a prototype SST/IST algorithm for SLSTR instrument on Sentinel 3 has been developed within a recent Copernicus and EUMETSAT project.

In this presentation, an overview of different Level 2 SST/IST algorithms and products are presented. Result from the EUMETSAT SLSTR SST/IST project are shown regarding the development of traditional split window algorithms and dual view algorithms. The final algorithms have been selected based on data from a full year of match up data. Focus in this presentation will be on the MIZ as it is a highly variable region with mixed ocean and sea ice. In the MIZ, the consistency between the SST and IST algorithms is thus crucial and the IST algorithms and product formats have been developed aiming at a maximum synergy with SST products.

The lack of high quality in situ observations will be discussed with reference to the methodology developed in the SST Fiducial Reference Measurement projects, like the TRUSTED project. Finally, further synergy between IST and SST product development within GHRSST will be presented and discussed.

ID 041: The NOAA STAR SOCD OceanView (OV): An application for integrated visualization of satellite, in situ, and model data & ocean events – the v1.0 release

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ABSTRACT

The NOAA STAR SOCD OceanView OV (NB: OV presently the working name; may/not change) is an upcoming web-based geospatial viewer and event tracker. Its objective is to assist ocean-enthusiasts, satellite-data, and other users to view the oceans' state and associated events using products primarily from NOAA STAR SOCD and other NOAA line offices, along with some datasets from external sources. The OV undergoing a beta-testing phase will be publicly released in April 2021 and accessible from https://www.star.nesdis.noaa.gov/socd/ov/. The OV version 1.0 has several satellite/model products ingested in it: *ten* SST, *six* chlorophyll-a, *six* sea wind, *one* sea surface height anomaly, *one* true-color image, *two* atmospheric information, *i.e.*, rain rate and aerosol, *three* derived information, *i.e.*, geostrophic currents, SAR storm images, and polar flight navigation, GFS model wind, NCEI storm track, NOAA oil spill location and info, and *an experimental Level-4* thermal front. Other information to be included in the next version is marine heatwaves, polar flight images, HABs, ship tracks, and more. Along with serving the satellite remote sensing community and ocean enthusiasts, the OV will also contribute to other space-based earth science efforts (GEO Blue Planet Initiative, AquaWatch) and some of the GHRSST task teams (L4 fronts intercomparison). This presentation will introduce the current capabilities to the audience and highlight the planned expansion.

ID 042: Uncertainty validation of shipborne radiometers

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ABSTRACT

With a number of satellite sensors providing high quality sea surface temperature (SST) products, the need for validation data of a similar quantity is increasing. This is especially true for the Copernicus Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR). In order to address the need for such reference data sources ESA is building on almost 15 years of continuous Fiducial Reference Measurements (FRM) from UK-funded shipborne radiometers by establishing a service to provide historic and ongoing FRM measurements to the wider SST community through an International SST FRM Radiometer Network (ships4sst).

One of the key components of 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. However field comparison of two or more shipborne radiometers have been limited, mainly due to cost, and as a result the no at sea comparison of the uncertainty models has been conducted. 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 ISAR uncertainty model.

ID 043: UPDATES OF AMSR3 ON GOSAT-GW AND ITS OCEAN PRODUCTS

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(3) GOSAT-GW Project Team, Japan Aerospace Exploration Agency

ABSTRACT

The 3rd generation of Advanced Microwave Scanning Radiometer (AMSR) series, called AMSR3, will be carried on the Global Observation SATellite for Green-house gases and Water cycle (GOSAT-GW) and is currently under development to be launched in Japanese Fiscal Year (JFY) of 2023. The Preliminary Design Review (PDR) of satellite system including AMSR3 was completed in March 2021. Sensor characteristics and channel set of AMSR3 will be almost equivalent to that of AMSR2 except additional channels in X- and G-band and some change in Ka-band to avoid possible future risk caused by the new 5G communication. Additional channels in X-band (10.25-GHz) will have wider bandwidth with finer NEDT than original 10.65-GHz channels for more robust SST in higher resolution. New G-band channels will contribute to snowfall retrievals and numerical weather prediction. Two ocean products, multi-band SST and all-weather sea surface wind speed, was upgraded to standard product while they are research products in AMSR2. The recent status in development of AMSR3 hardware and algorithms will be introduced during the presentation.

ID 044 Science Storms the Cloud

Chelle Leigh Gentemann(1,2), Chris Holdgraf(3,4), Ryan Abernathey(3,5), Daniel Crichton(6), James Colliander(3,7,8), Edward Joseph Kearns(9), Yuvi Panda(3), Richard P. Signell(10)

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ABSTRACT

The core tools of science (data, software, and computers) are undergoing a rapid and historic evolution, changing what questions scientists ask and how they find answers. Earth science data are being transformed into new formats optimized for cloud storage that enable rapid analysis of multi-petabyte datasets. Datasets are moving from archive centers to vast cloud data storage, adjacent to massive server farms. Open source cloud-based data science platforms, accessed through a web-browser window, are enabling advanced, collaborative, interdisciplinary science to be performed wherever scientists can connect to the internet. Specialized software and hardware for machine learning and artificial intelligence (AI/ML) are being integrated into data science platforms, making them more accessible to average scientists. Increasing amounts of data and computational power in the cloud are unlocking new approaches for data-driven discovery. For the first time, it is truly feasible for scientists to bring their analysis to data in the cloud without specialized cloud computing knowledge. This shift in paradigm has the potential to lower the threshold for entry, expand the science community, and increase opportunities for collaboration while promoting scientific innovation, transparency, and reproducibility. Yet, we have all witnessed promising new tools which seem harmless and beneficial at the outset become damaging or limiting. What do we need to consider as this new way of doing science is evolving?

ID 045: Open source algorithms for AMSR3

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ABSTRACT

To date, algorithm development for PMW retrievals has been ‘siloed’ – mostly restricted to a few select groups. This is partly due to the difficulty of moving research that involves working with the large orbital and ancillary datasets, and software developed for specific computational environments. Advances in cloud computing and open source software have created an ecosystem perfect for open collaboration and science through easily shared coding environments that can be deployed adjacent to cloud-stored datasets. Utilizing new shared tools that reduce redundant coding efforts has the potential to advance PMW algorithm development, opening it to collaborations with data scientists in addition to the remote-sensing specialists. These tools will be directly applicable to PMW sensors and will encourage open science as the new, more efficient, ‘norm’.

ID 046: Detection and Characterisation of Marine Heat Waves in the Mediterrenean Sea in the past 40 years

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(3) Dipartimento di Matematica, Sapienza Università di Roma

ABSTRACT

Marine Heat Waves (MHW) are anomalously warm events which cause significant impacts on marine ecosystems, and their mean intensity and duration have globally increased in the last century. A systematic study and a hierarchical characterisation of MHWs has only recently been proposed in literature. We focus on detection of MHWs in the Mediterrenean Sea by analysing SST provided by the ESA Copernicus Climate Initiative (CCI) product, which consists in daily average data at 0.05° x 0.05° regular grid from September 1981 to present. Since it is well known that the Mediterrenean Sea has experienced positive SST trends in the last 40 years, we accomplish the detection of MHWs on the detrended SST data, which do not suffer from the trend bias, therefore more coherently represent the variability of anomalously warm events themselves.

Lastly we create a catalogue of the main MHWs occurring in the Mediterrenean Sea over the period under analysis by defining both a spatial and temporal minimum threshold on the overall pixel-wise events detected. We consider only events impacting at least 15% of the basin and lasting at a minimum of 30 days, highlighting the large scale and long lasting MHWs which reasonably have major impacts. With this methodology we evidence about 20 main events and give an overview of their main characteristics.

These events will be analysed in more detail, as e.g. examining the subsurface temperature also, and compared one with the other in order to understand the spatio-temporal scales and their impacts on the ecosystem.

ID 047: Bayesian Cloud Detection Scheme improvements for the SLSTR instrument

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ABSTRACT

The SLSTR instrument onboard Sentinel-3 provides Land Surface Temperature (LST) and Sea Surface Temperature (SST) data for the climate data records. In order to provide accurate SST retrievals, clouds are screened operationally using the Bayesian Cloud Detection Scheme (BCDS). The BCDS returns a probability of clear sky given the observations compared to on-the-fly simulations based on the prior meteorological information embedded with SLSTR products. We have investigated cloud-screening failures with the BCDS in coastal regions using a wide selection of test case studies. Failures mostly consist of false flagging, including false flagging of optically active, turbid waters, of blocks or haloes along the coastline, and of high SST gradients or coastal variability. Another class of failures (both false flagging and failures to detect) are attributable to simplistic use of the reflectance image grid with the infrared image grid (on which the probability of cloud is calculated). In order to establish an improved screening algorithm, we have tested modifications to the BCDS with reference to a set of varied training images and assessed outcomes on a diagnostic set. Modifications tested include a pre-processor to optimise the visible imagery for joint use with the infrared grid, use of full resolution reflectance variability, modified channel selections and changes to the definitions of prior information used for clear-sky simulations. Results for the selected set of modifications will be presented.

ID 048: USE OF ESA CCI SST ANALYSIS TO VALIDATE SAMPLING AND MEASUREMENT ERROR MODELS FOR SST FROM SHIPS

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ABSTRACT

Taking advantage of high resolution, reliable uncertainty estimates, and in situ data independence of daily fields of the European Space Agency (ESA) Climate Change Initiative (CCI) SST Analysis product (hereinafter, CCI SST), versions 1&2, errors in $1^o x 1^o$ monthly bin averages of ship SST observations from International Comprehensive Ocean-Atmosphere Data Set (ICOADS), Release 3.0, were modelled as a sum of random effects, once their systematic biases were approximately removed by subtracting their climatologically-averaged differences from similarly binned CCI SST, and error estimates were split into sampling and random measurement error components. For 1992-2010 period, in more than 66%(50%) of locations with temporal coverage of $1^o x 1^o$ monthly bins that contain more than a single observation exceeding 50%(66%), the error magnitude agrees within 20%(10%) with the estimates, based on the random error model. The agreement is worse for $1^o x 1^o$ monthly bins with a single ship SST observations that constitute a surprisingly large portion (31.8%) of all bins of this size that contain any SST observations from ships. Seasonal variations in the error magnitude were traced to the sampling error component, which reflects seasonal changes in the intra-bin SST variability, while the seasonality of measurement error estimates appears less significant. Random measurement error estimates for different measurement methods used on ICOADS ships in 1981-2016 period were compared with previously published estimates. Improved error estimates are constructed by recombining the measurement error estimates with sampling error estimates that are based on the full data sample of the CCI SST data set.