SST Climatology and Analysis Inter-Comparison Task Team Report

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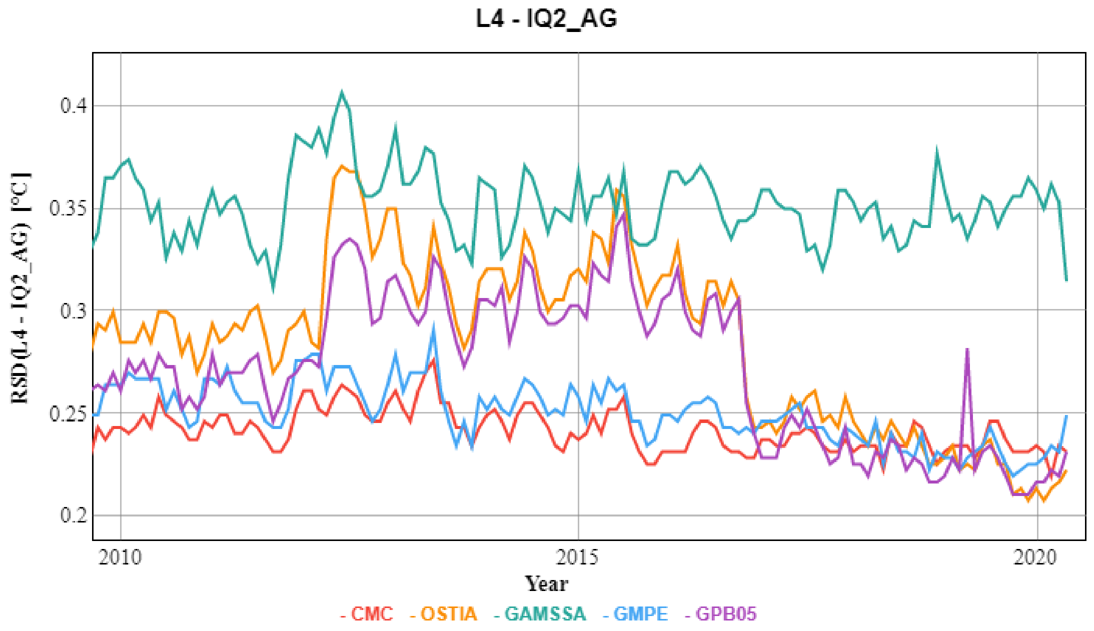
SST Climatology and Analysis IC Task Team Members

- **Task Team Co-Chairs:** Helen Beggs (BoM, Australia) and Chunxue Yang (ISMAR, CNR, Italy)
- CNR/ISMAR (Italy): Andrea Pisano, Francesca Elisa Leonelli, Bruno Buongiorno Nardelli, Rosalia Santoleri
- ENEA (Italy): Salvatore Marullo, Vincenzo De Toma, Vincenzo Artale
- NASA/JPL (USA): Toshio (Mike) Chin, Jorge Vazquez
- ECMWF: Hans Herbach
- Uni. of Reading (UK): Owen Embury, Jon Mittaz, Christopher Merchant
- Met Office (UK): John Kennedy, Simon Good, Chongyuan Mao,
- JMA (Japan): Toshiyuki Sakurai
- NOAA/NESDIS/NCEI (USA): Boyin Huang
- NOAA/NESDIS/STAR (USA): Alexander Ignatov, Eileen Maturi, Andy Harris, Tom Smith, Prasanjit Dash
- NOAA/NCEP (USA): Xu Li
- NC CICS (USA): Garrett Graham
- IOUSP (Brazil): Marouan Bouali

Background

- Gap-free SST analyses using satellite and possibly in situ data are the most widely used SST products for both operational and research applications
- Most of these analyses *do not* ingest Argo SST, reserving this data stream for L4 validation, such as in:
    - UK Met Office SST Monitor: http://ghrsst-pp.metoffice.com/pages/latest_analysis/sst_monitor/argo/
    - NOAA/NESDIS/STAR SQUAM Monitor: https://www.star.nesdis.noaa.gov/socd/sst/squam/
- But several, including MUR, RTG_HR and OISSTv2.1, do ingest Argo SST which limits its use for validation

SQUAM: RSD (L4 minus Argo SST)

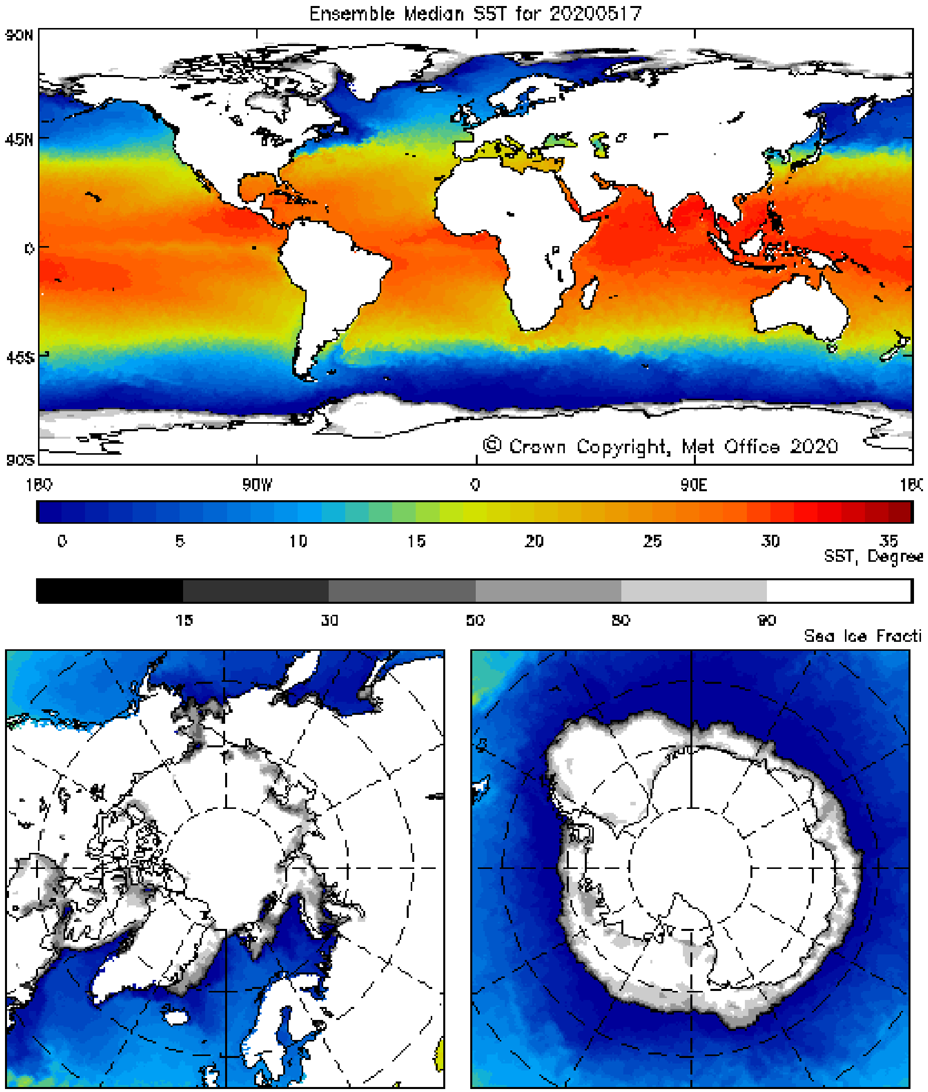


https://www.star.nesdis.noaa.gov/socd/sst/squam/analysis/l4/

Background

- Several global SST analyses are compared and validated in near real-time using the UK Met Office's GHRSST Multi-Product Ensemble, a median of up to 14 daily satellite SST analyses interpolated onto a 0.25^{o} grid
    - OSTIA, RTG, K10, MGDSST, RSS MW, RSS MW+IR, FNMOC, NOAA AVHRR OI, CMC, ODYSSEA, GAMSSA, DMI_OI, MUR 1 km and NOAA/OSPO Geo-Polar Blend
    - See http://ghrsst-pp.metoffice.com/ostia/sst_monitor/daily/ens/index.html

GMPE SST



Motivation for L4 IC Task Team

- Currently > 30 level 4 (L4) near real-time and reprocessed SST analyses are publicly available from organisations and operational agencies
- Important to compare and validate SST analyses in order to provide guidance to
  - users for their particular applications
  - producers to improve their analysis systems
- A median or mean ensemble SST analysis, like the GMPE, provides a useful comparison tool for open ocean regions, as indicated in Martin et al. (2012), Dash et al. (2012), Fiedler et al. (2019) and Rayner et al. (2019)
- But, should we also use additional metrics (such as for SST gradients or "sensitivity") to compare analyses?

Climatology Task Team Tasks

Task 1: Inter-comparison of SST analyses for climate studies (led by Chunxue Yang, CNR/ISMAR)

Task 2: Understand differences among the SST analysis products and find ways to improve these products (led by Xu Li, NOAA/NCEP)

Task 3: Feature inter-comparison of SST analyses (led by Jorge Vazquez, NASA/JPL) (New!)

Task 1: Inter-comparison of SST analyses for climate studies

(led by Chunxue Yang, CNR/ISMAR)

Aims: To perform various diagnostics on a range of publicly available, global sea surface temperature (SST) analyses, in order to provide guidance for users on the application of long-term SST analyses for climate studies and climate applications.

- A contribution to the **Independent Assessment of Essential Climate Variables (C3S_511)** for the Copernicus Climate Change Service (C3S)

Initial Feb 2020 Report to ECMWF prepared by:

- CNR/ISMAR (Italy): Andrea Pisano, Francesca Elisa Leonelli, Bruno Buongiorno Nardelli, Chunxue Yang, Rosalia Santoleri
- ENEA (Italy): Salvatore Marullo, Vincenzo De Toma, Vincenzo Artale

Report's findings presented by Chunxue Yang in GHRSST-XXI Session Analyses and Reanalyses at https://training.eumetsat.int/course/view.php?id=367 Topic 5

Contact: Chunxue Yang (chunxue.yang@artov.ismar.cnr.it) if you would like to contribute to the final report and paper (due Oct 2020).

Climate Change

SST Analysis Datasets Description

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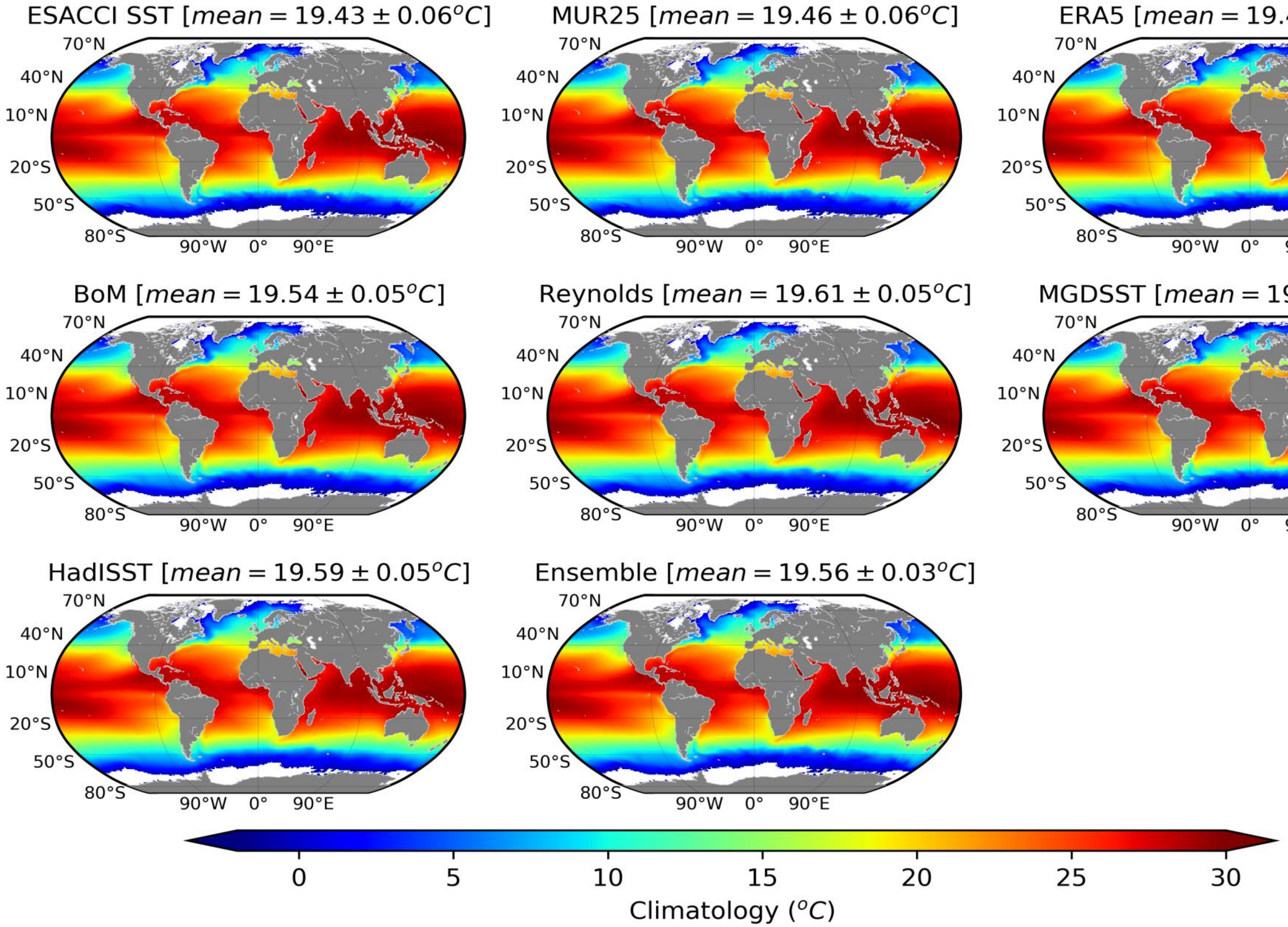
Dataset	Institution	Time Range	Observation input	Type of SST	Horizontal Grid spacing	Temporal resolution	Main Reference	Used for climate monitoring?
ESA CCI SST (v2.0)	**Met Office**	**1981-2018**	**IR**	**SST at 0.2 m**	**global 0.05°x0.05°**	**daily**	**Merchant et al. (2019)**	**Potentially**
ERA5	**ECMWF**	**1979-2018**	**IR + MW + in situ**	**---**	**global 0.25°x0.25°**	**hourly**	**Hirahara et al. (2016)**	**Yes**
HadISST1	Met Office	1870-2018	IR + in situ	---	global 1°x1°	monthly	Rayner et al. (2003)	Yes
Reynolds (v2.0)	NOAA	1981-2018	IR + in situ	SST at 0.2 m	global 1°x1°	weekly/monthly	Reynolds et al. (2002)	Yes
MUR25 (v4.2)	JPL PO.DAAC	2003-2018	IR + MW + in situ	Foundation SST	global 0.25°x0.25°	daily	Chin et al. (2017)	Potentially
MGDSST	Japanese Met. Agency (JMA)	1982-2017	IR + MW + in situ	Foundation SST	global 0.25°x0.25°	daily	Sakurai et al. (2005)	Potentially
BoM Monthly SST	Australian Bureau of Met. (BoM)	2001-2018	IR + in situ	SST at 0.2 m	global 1°x1° (weekly/monthly)	weekly/monthly	Smith et al. (1999)	Yes (BoM only)

ECMWF Copernicus Europe's eyes on Earth European Commission

Global SST climatology from 2003-2017



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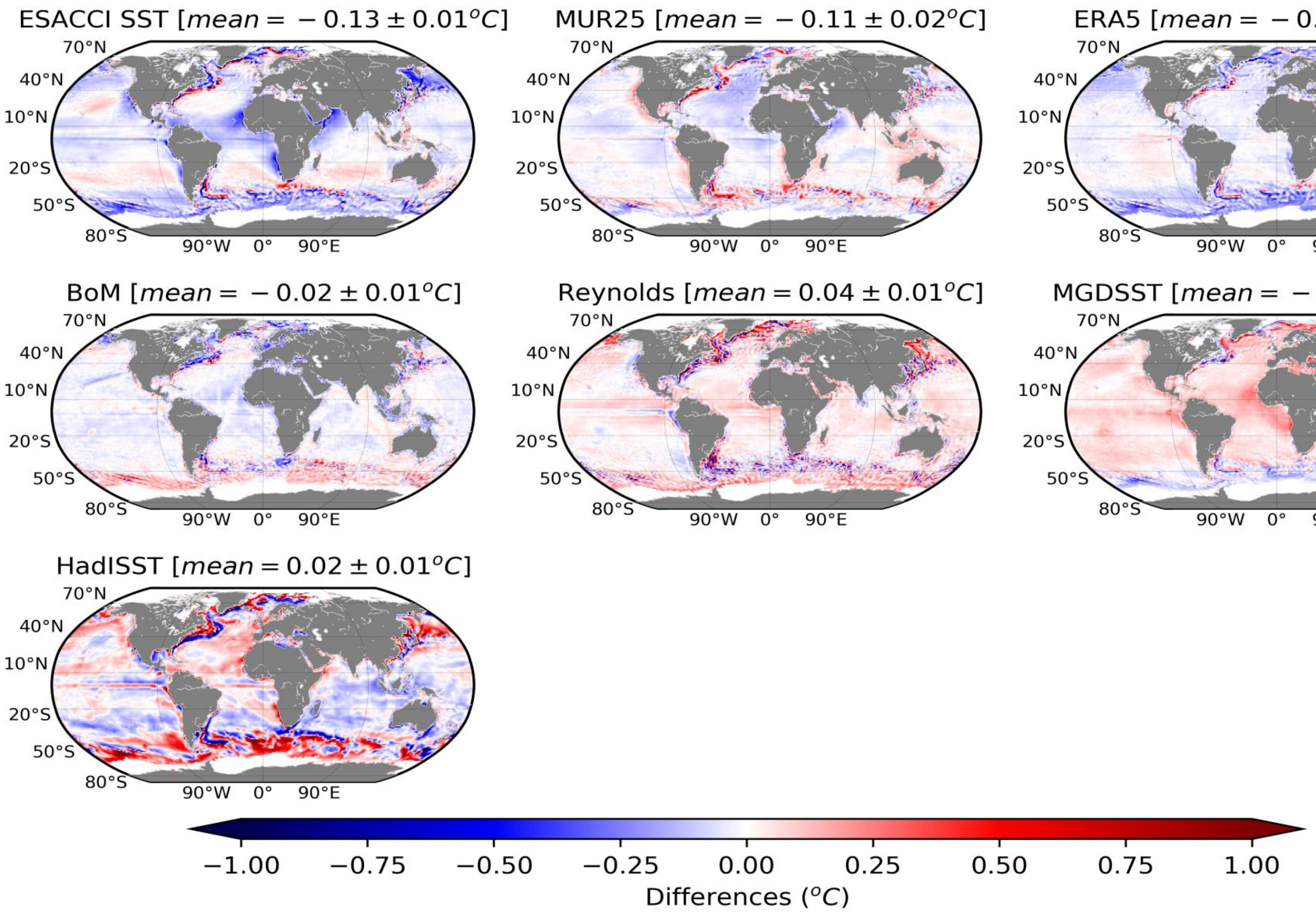
The difference between each SST data and the ensemble mean for the period of 2003-2017



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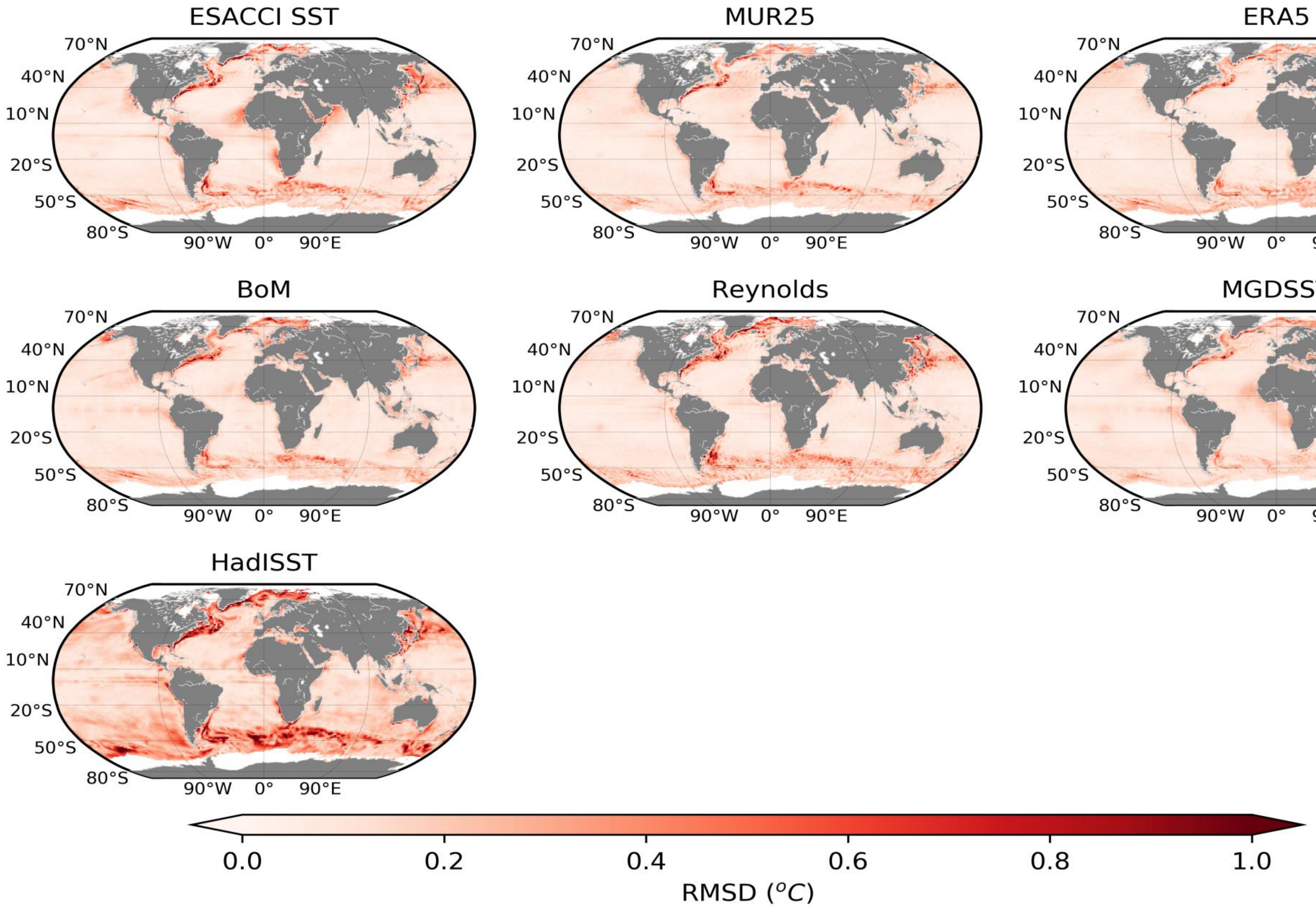
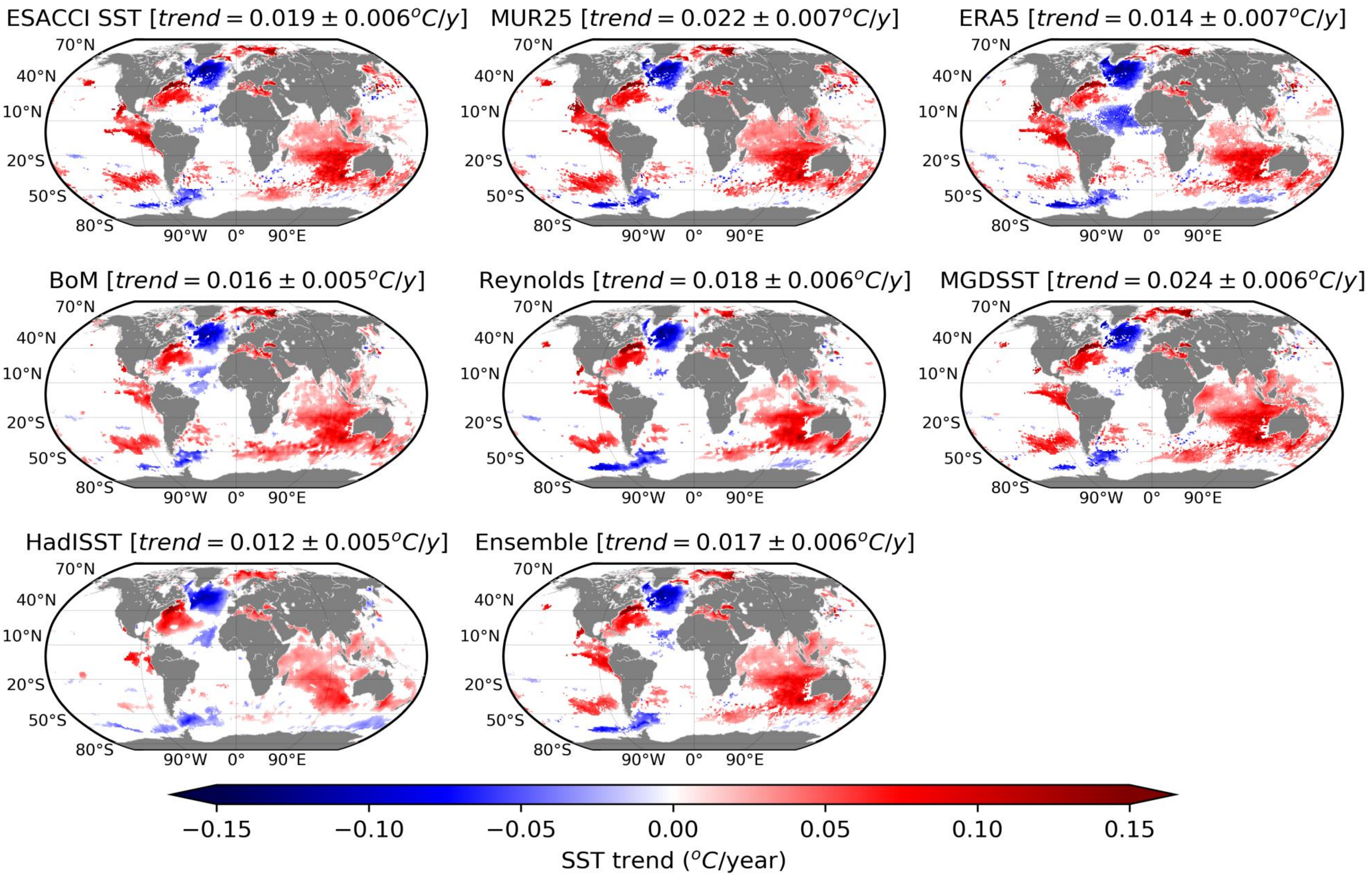
RMSD between each SST data and the ensemble mean for the period of 2003-2017



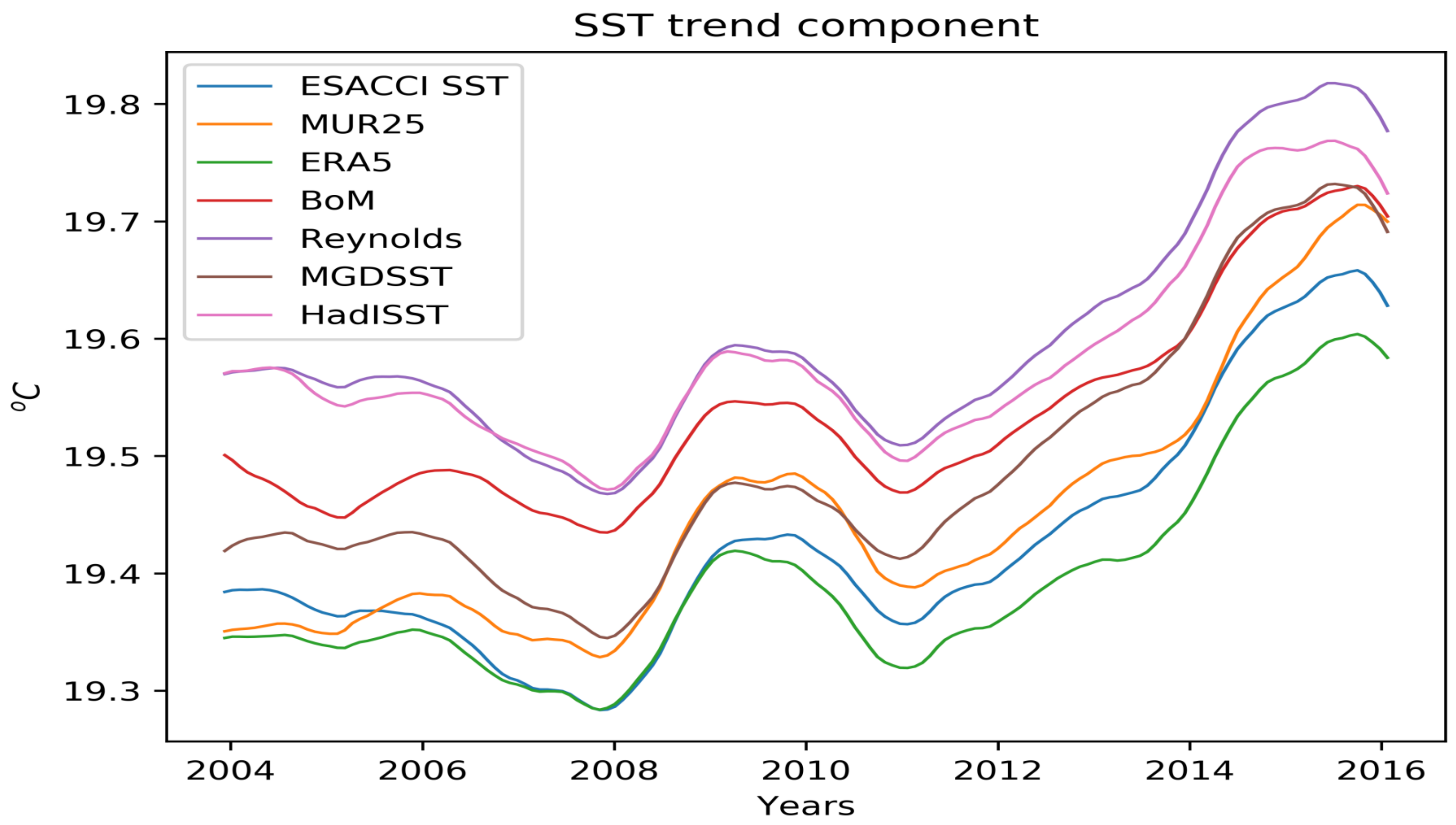
Climate Change

Linear trends of global SST for the period 2003-2017



Climate Change

Global SST trend components (2004 to 2016)



Climate Change

Summary of MPQB evaluations

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- All the SST datasets show consistent climatological spatial patterns as well as global mean time series.
- The disagreements are located at the main current systems, such as the Gulf Current, the Kuroshio Current and the Antarctic circumpolar current.
- These discrepancies could be due to the different retrieval methods, interpolation technique and related configuration (e.g. observation/background error correlation scales), interpolation grid size, input data bias-correction, etc.
- All the datasets reproduce very similar spatial patterns of global SST trends. In addition, global mean warming trends as estimated from all the datasets are consistent (within the 95% confidence interval) with the global ocean warming trend as reported in the last IPCC report, estimated at 0.011 ° C/year from 1980 to 2005.
- The PCA analysis of ENSO confirms the close similarity of all the five datasets selected and their capability to reproduce, in the same way, the main components of the tropical Pacific region space and time variability at time scales compatible with the length of the selected time series

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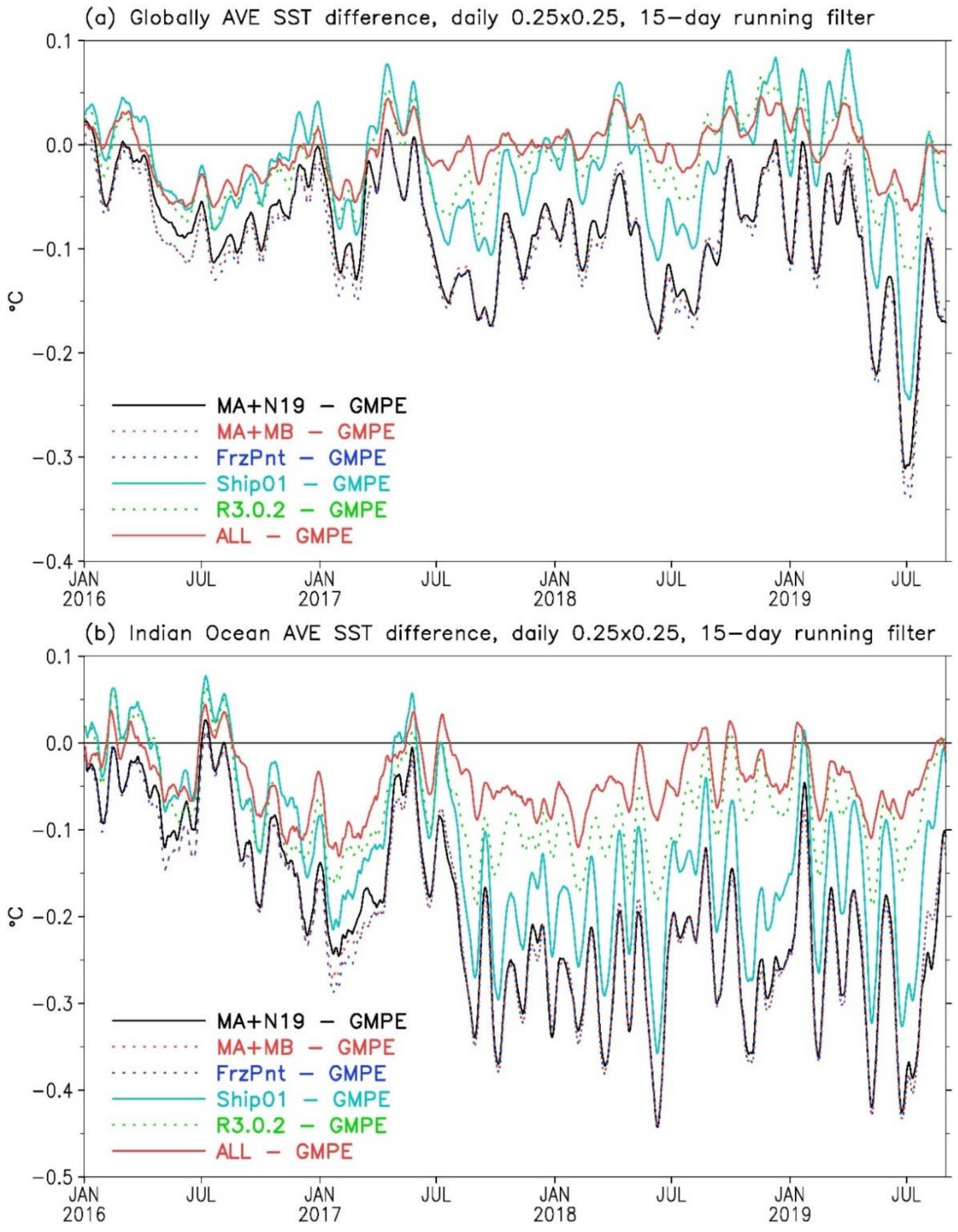
The Task 1 C3S_511 Study does not include the recently reprocessed daily SST analyses:

- NOAA/NESDIS/NCEI OISST v2.1: 2016 to present
- CMEMS OSTIA-based Reanalyses: 1981 to 2018



NOAA/NCEI OISST updated from v2.0 to v2.1 (Reprocessed back to 1 Jan 2016)

SST differences between OISST experiments and GMPE showing OISST biases are reduced over the global (upper panel) and Indian Ocean (lower panel).

See Boyin Huang's poster in GHRSST-XXI Session Analyses and Reanalyses at https://training.eumetsat.int/course/view.php?id=367

Experiments	Descriptions
(a) MA+N19	MetOp-A and NOAA-19, **v2.0**
(b) MA+MB	MetOp-A and MetOp-B
(c) FrzPnt	Freezing-point (FrzPnt) ice-SST proxy
(d) Ship01	Reducing ship bias from 0.14°C to 0.01°C
(e) R3.0.2	Ship and buoy SSTs from NCEP by ICOADS R3.0.2
(f) ALL	Including Argo temperatures at 5 m depth, **v2.1**

New OSTIA-based SST Reanalyses
(Chongyuan Mao, UK Met Office)

- CMEMS reprocessed SST analysis based on Met Office OSTIA configuration: provides foundation SST and uses the latest OSTIA configuration, covering 1 Oct 1981 to 31 Dec 2018 https://resources.marine.copernicus.eu/?option=com_csw&task=results?option=com_csw&view=details&product_id=SST_GLO_SST_L4_REP_OBSERVATIONS_010_011
  - There are plans to extend beyond 2018 but the exact dates for future releases are not clear at the moment

- ESA SST CCI and C3S reprocessed analysis: provides SST at 20 cm depth, covering 1 Sep 1981 to 31 Dec 2018 https://resources.marine.copernicus.eu/?option=com_csw&task=results?option=com_csw&view=details&product_id=SST_GLO_SST_L4_REP_OBSERVATIONS_010_024

- Both products used reprocessed satellite observations from the ESA SST CCI project.

Task 2: Understand differences among the SST analysis products and find ways to improve these products
(led by Xu Li, NOAA/NCEP)

Aims: Understand differences among the L4 products and then find out the possible ways to improve L4 products. This task will focus on specified time periods (like two or four months in different seasons).

Contributors: Xu Li (NOAA/NCEP), Helen Beggs (BoM, Australia), Chongyuan Mao (UK Met Office), Dorina Surcel-Colan (CMC)

Contact: Xu.Li@noaa.gov if you would like to join this task.

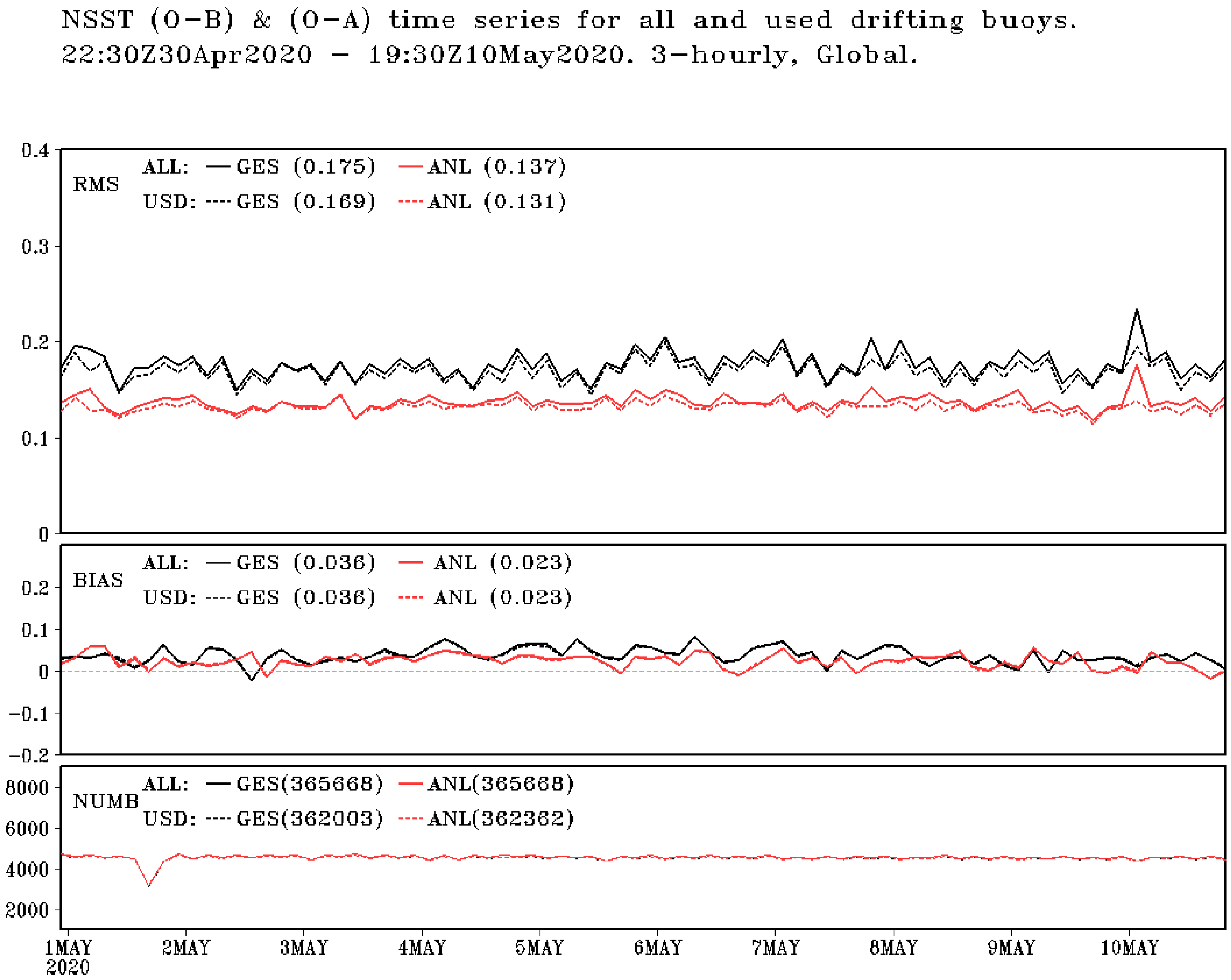
Initial Activity: For the period 1 – 10 May 2020, for various operational SST analyses (NCEP NSST, GAMSSA, OSTIA, CMC) compare the total number of available drifting buoy SST observations (Numb_All) with the number that pass the pre-processing tests before the analysis (Numb_GES) and the number that pass the tests after the analysis (Numb_ANL).

Task 2: Motivation

- There are many reasons that SST analyses are different from each other, i.e., observations used, analysis scheme, resolution ...
- The number of the observations used in a specific analysis is a fundamental issue in IC of L4 products using the traditional obs – analysis or obs – background field metrics used for assessing model/analysis performance
- Drifting buoy SST observations are ingested into most global SST analyses and are the major source of in situ SST data
- The number of drifting buoy observations used in the analysis system depends on many factors, like QC, observation error, weight relative to the background, correlation length scale
- These counts (even if the all data received by the systems are the same) are system dependent

NSST Drifting Buoy (Obs – Background) and (Obs – Analysis)

(Xu Li, NOAA/NCEP)



Task 3: Feature inter-comparison of SST analyses
(led by Jorge Vazquez, NASA/JPL)

Aims: To inter-compare SST analyses based on their feature resolution and SST gradients

Contributors: Prasanjit Dash (NOAA/NESDIS/STAR, USA), Marouan Bouali (IOUSP, Brazil), Helen Beggs (BoM, Australia), Chongyuan Mao (Met Office, UK)?

Contact: Jorge Vazquez (jorge.vazquez@jpl.nasa.gov) if you would like to join this task.

Possible Initial Activities:

(a) Validate L4 SST gradients in highly variable regions using SailDrone (and other vessel?) SST data (could also be applied to L3C/L3S)

(b) Produce an online visualisation tool for SST gradients

(c) Develop the science to calculate fronts and intercompare (selected regions?)

(d) Match with other independent but related data, e.g., altimeter derived currents and SST patterns in the Gulf stream. These will serve for independent validation

(e) Compare feature resolution of various SST analyses (using spectral density)?

3a: Validation of SST Gradients
(Jorge Vazquez, JPL)

- See Jorge Vazquez (JPL) presentation in GHRSST-XXI Calibration and Validation Session at https://training.eumetsat.int/course/view.php?id=367
- **Motivation:**
  - Important for air-sea coupling
  - Applications to coastal dynamics where mesoscale and sub-mesoscale dominate.
  - Connection to upwelling and ocean productivity
  - Recent work has shown that high correlations for SST with in-situ data does not lead to high correlations of SST gradients
- **Methodology:**
  - Argo floats and drifters are lacking in coastal regions
  - Co-location methodologies for matching up buoys and remote sensing data are not necessarily application for colocation of gradients
  - New instruments, like Saildrone, provide an opportunity for validating gradients in challenging areas, inclusive of coastal regions and high latitudes.

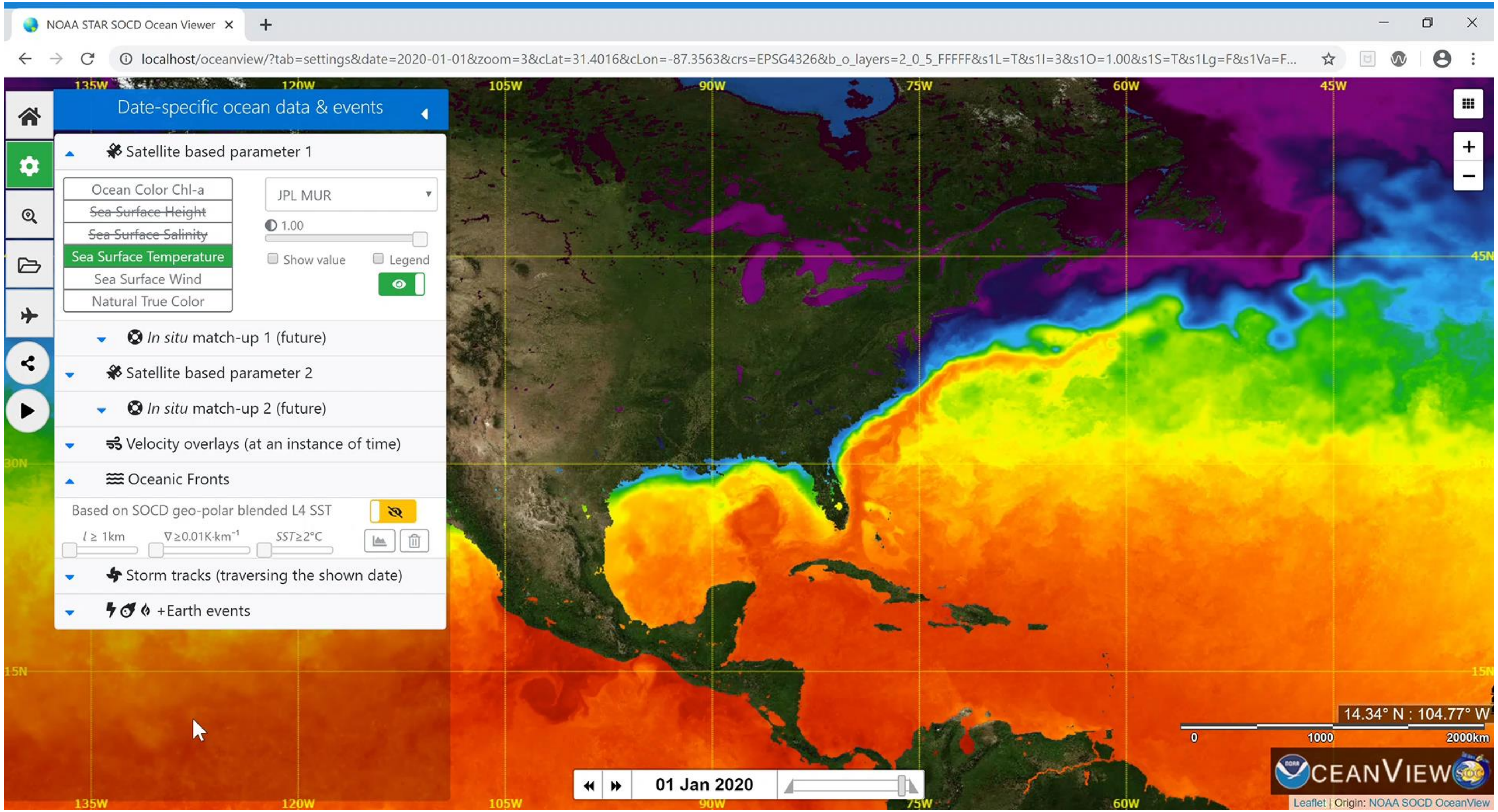
Example comparison Statistics of SST gradients from GHRSST L4 products and Saildrone Baja Deployment (10 Apr – 5 Jun 2018)

–	–	Bias	RMSE	Correlation
CMC	SST	-0.074	0.417	0.975
	$\lvert\nabla SST\rvert$	-0.009	0.022	0.315
K10	SST	0.137	0.475	0.969
	$\lvert\nabla SST\rvert$	-0.007	0.022	0.293
REMSS	SST	0.075	0.401	0.977
	$\lvert\nabla SST\rvert$	-0.007	0.023	0.243
OSTIA	SST	0.022	0.365	0.980
	$\lvert\nabla SST\rvert$	-0.008	0.022	0.306
DMI	SST	0.040	0.489	0.966
	$\lvert\nabla SST\rvert$	-0.008	0.023	0.255
MUR	SST	0.285	0.500	0.975
	$\lvert\nabla SST\rvert$	-0.003	0.021	0.395
JPLSMAP	SSS	0.141	0.414	0.429
	$\lvert\nabla SSS\rvert$	0.002	0.005	0.128
RSS v4	SSS	-0.170	0.336	0.464
	$\lvert\nabla SSS\rvert$	0.002	0.004	0.072

3b: Demo fronts overlaid on JPL MUR L4

(NOAA/STAR SOCD Ocean Viewer)

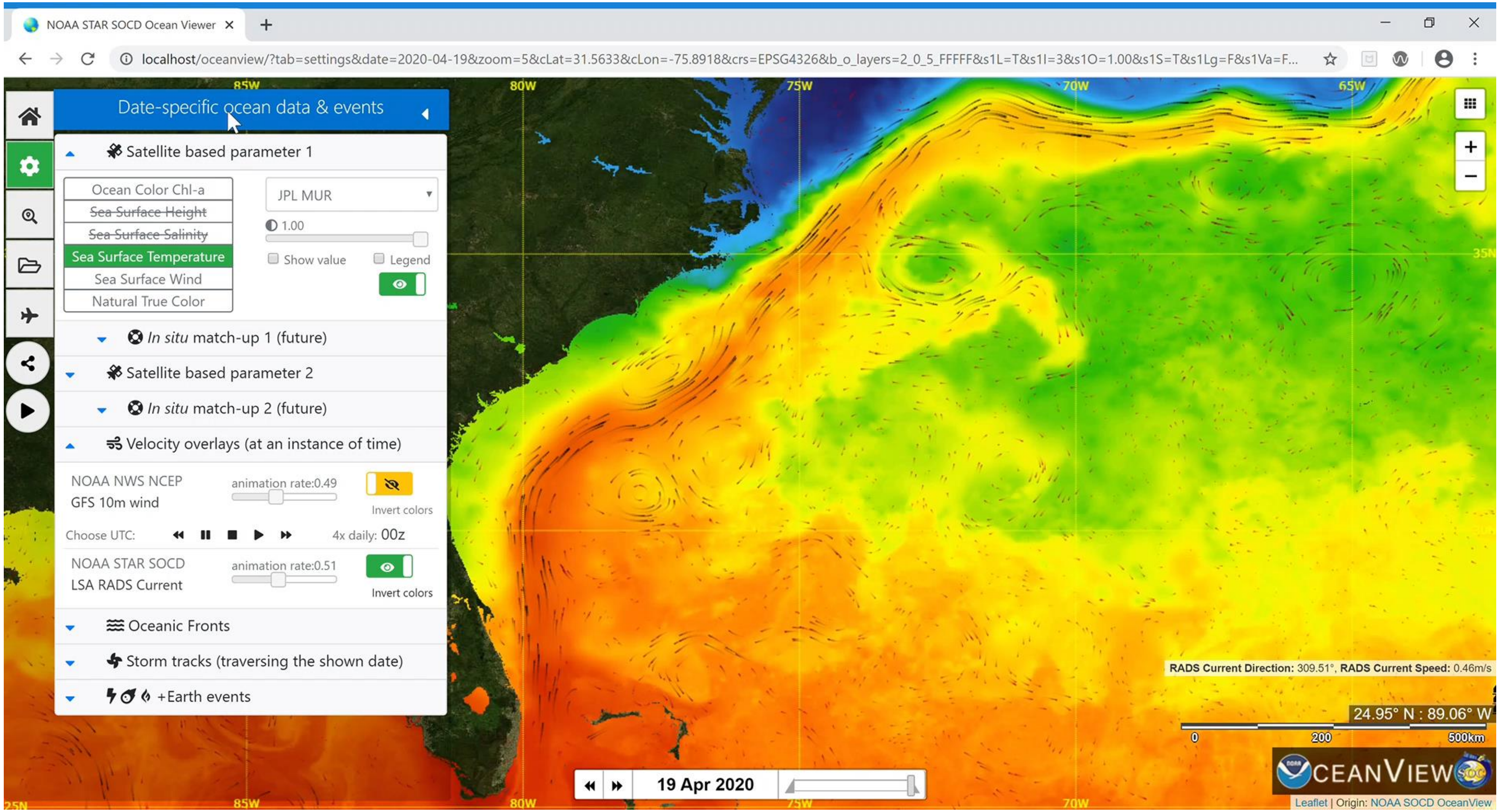
(Prasanjit Dash, NOAA/STAR)



3d: RADS Altimeter 0.25º currents overlaid on JPL MUR L4

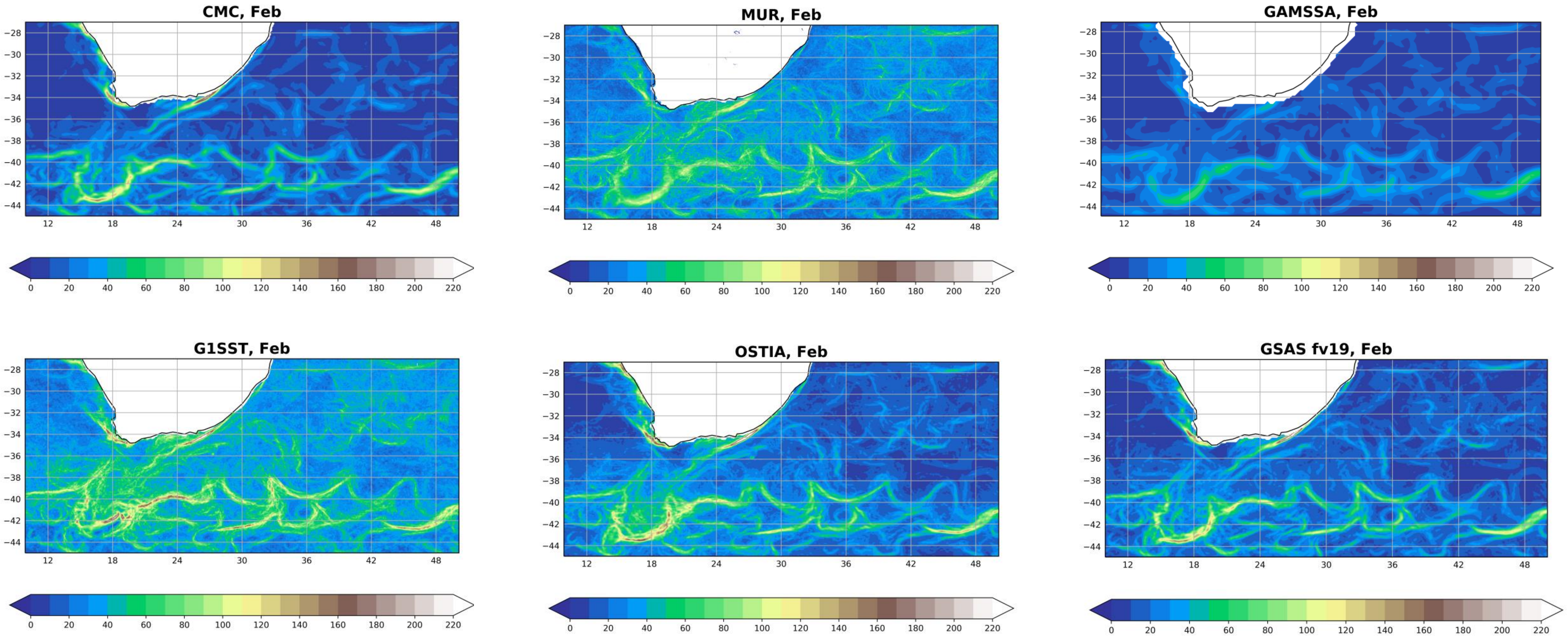
(NOAA/STAR SOCD Ocean Viewer)

(Prasanjit Dash, NOAA/STAR)

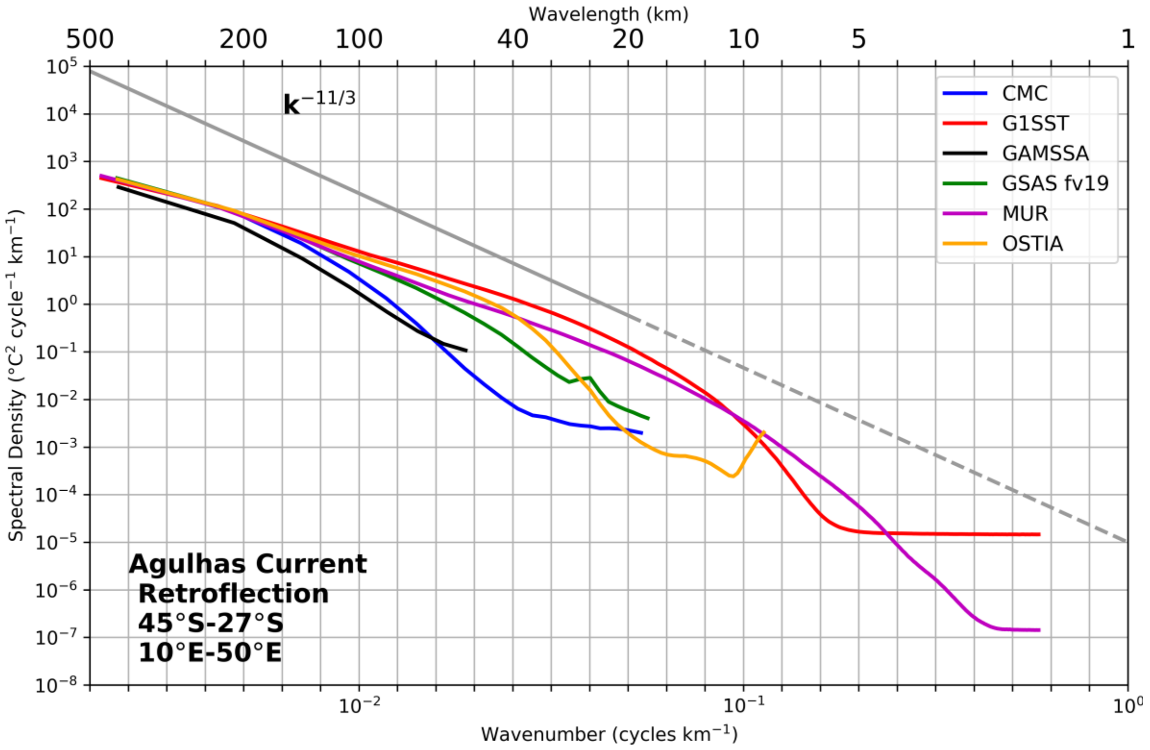


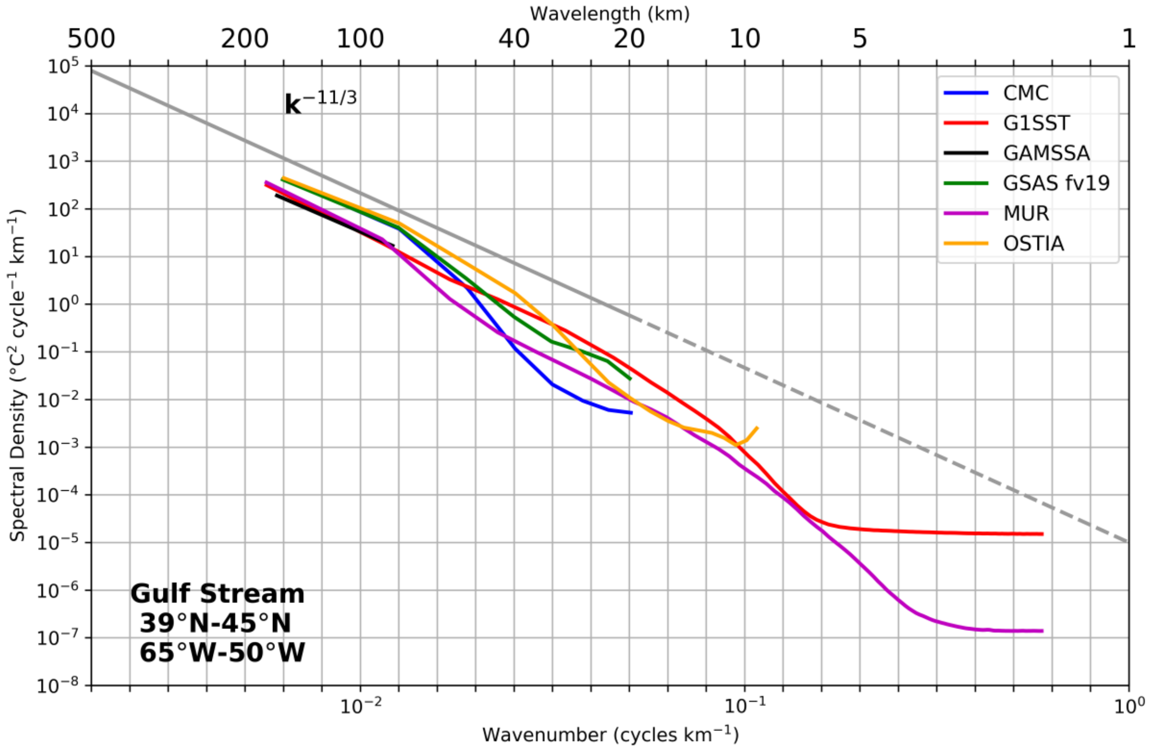
SST Gradient Maps - Feb 2019

(Simon Good, UK Met Office)



Spectral Density Plots – Feb 2019
(Simon Good, UK Met Office)





Future Work

Task 1:

- Include additional SST analyses (e.g. new CMEMS OSTIA reanalysis, OISSTv2.0+v2.1?)
- Compare L4 with *median* ensemble SST
- Complete final report and paper (Oct 2020)

Task 2: Complete initial activity with drifting buoy counts

Task 3: Develop online tool to compare SST gradients in L4 products

Collaborate with the GHRSST Climate Data Assessment Framework (CDAF) TT? – Jon Mittaz (Uni Reading)

Interested in contributing to IC Task Team activities?

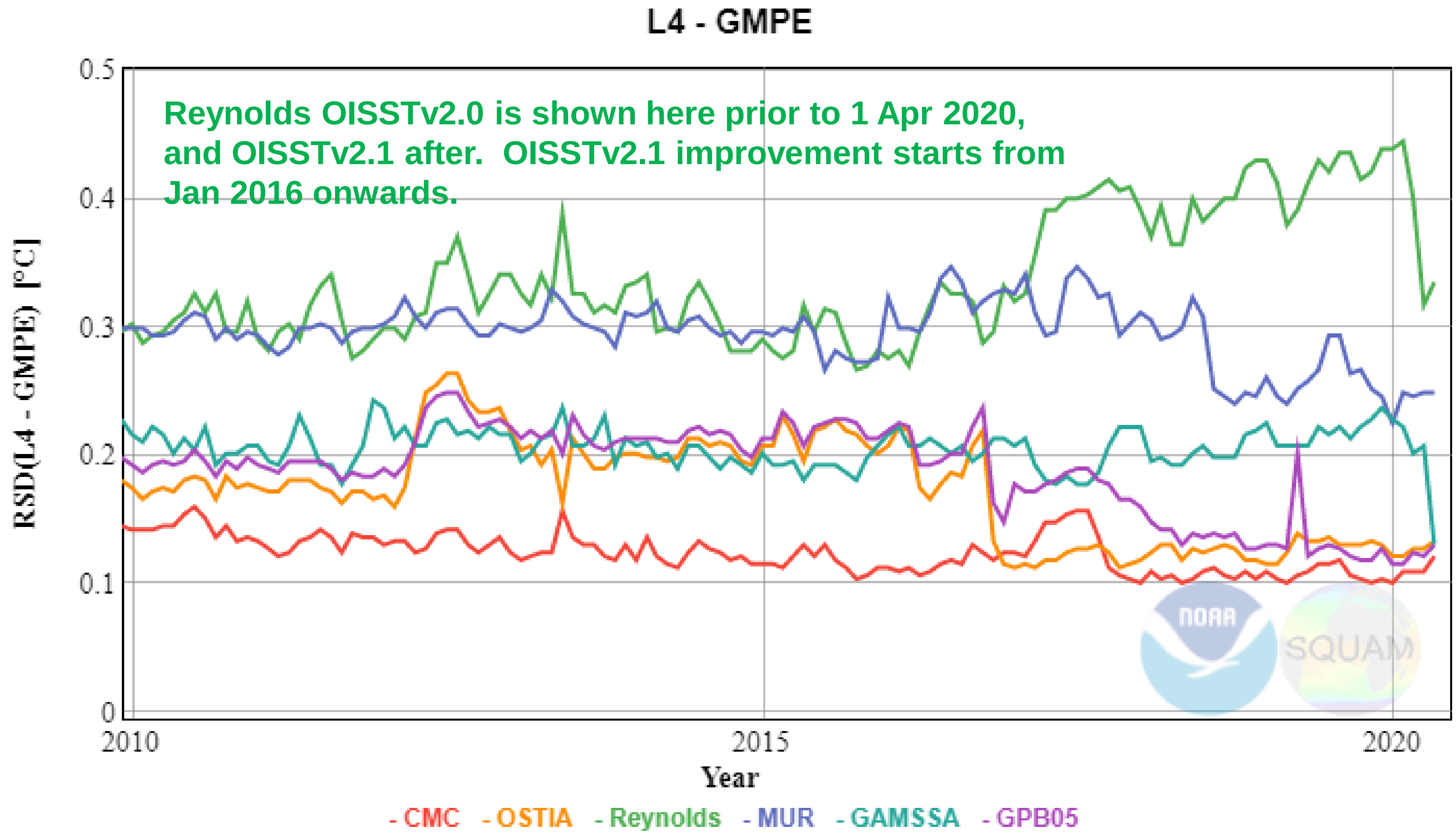
Please contact: helen.beggs@bom.gov.au and chunxue.yang@artov.ismar.cnr.it

Additional Slides for Discussion

Previous L4 Inter-comparison Studies

- There have been several SST analysis inter-comparison studies performed over the past 15 years involving GHRSST Science Team members, including:
  - https://www.nodc.noaa.gov/SatelliteData/ghrsst/intercomp.html
  - Dash *et al*., 2012. GHRSST Analysis Fields Inter-Comparisons: Part 2. Near real time web-based level 4 SST Quality Monitor (L4-SQUAM), *Deep Sea Research Part II: Topical studies in Oceanography*. (doi: 10.1016/j.dsr2.2012.04.002)
  - Martin *et al.* (2012) Group for High Resolution SST (GHRSST) Analysis Fields Intercomparisons: Part 1. A GHRSST Multi-Product Ensemble (GMPE). *Deep Sea Research II*, http://dx.doi.org/10.1016/j.dsr2.2012.04.013
  - Saha *et al.* (2012) *J.G.R. Oceans*, 117. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012JC008384
  - Fiedler *et al.* (2019) Intercomparison of long-term sea surface temperature analyses using the GHRSST Multi-Product Ensemble (GMPE) system. *Remote Sensing of Environment*, 222, 18–33. https://doi.org/10.1016/j.rse.2018.12.015
  - Rayner *et al.* (2019) *SST-CCI-Phase-II SST CCI Climate Assessment Report Issue 1*. European Space Agency, http://www.esasstcci.org/PUG/pdf/SST_CCI-CAR-UKMO-201_Issue_1-signed.pdf

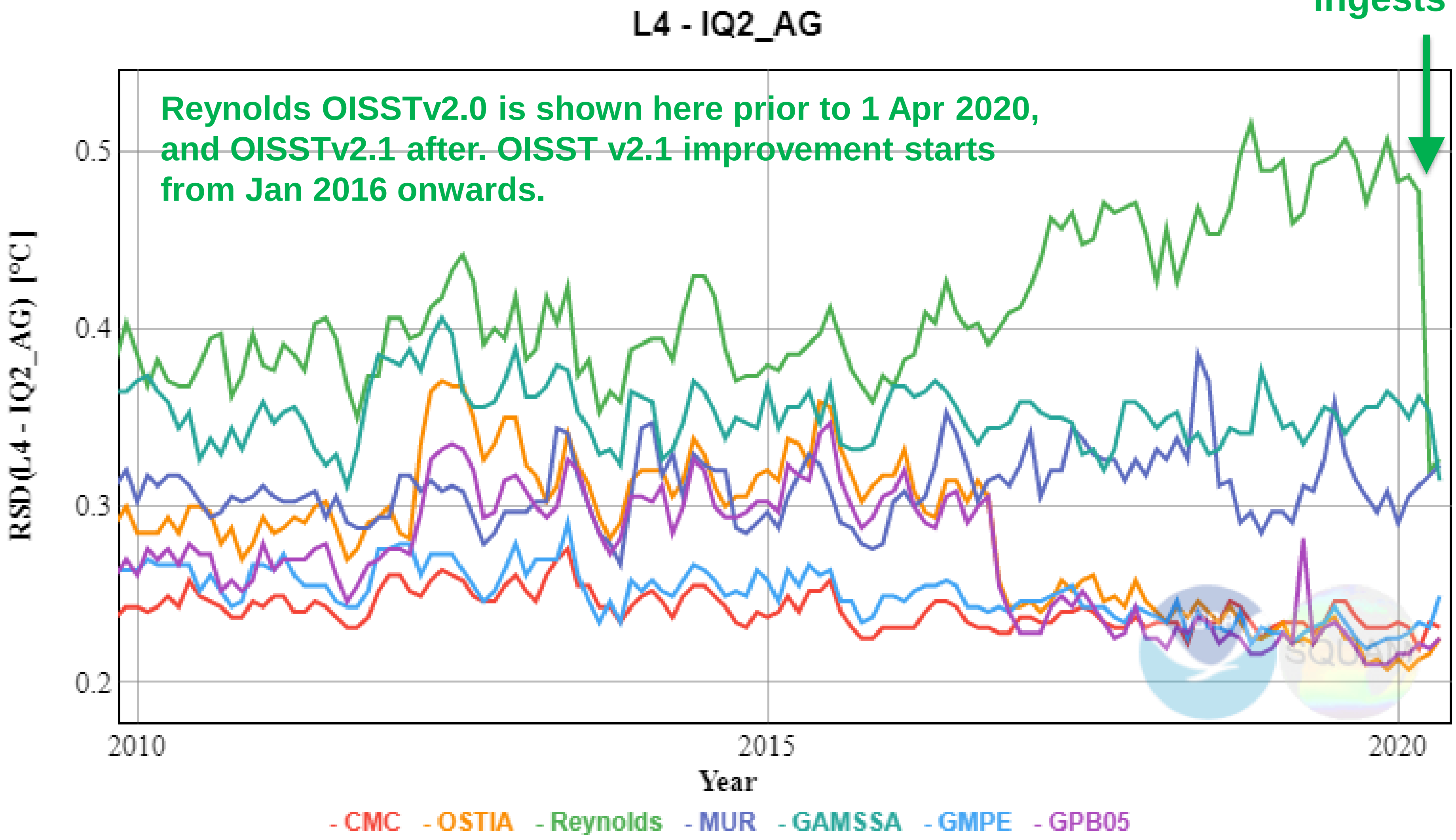
RSD (L4 minus GMPE SST)



https://www.star.nesdis.noaa.gov/socd/sst/squam/analysis/l4/

RSD (L4 minus Argo SST)

Reynolds OISSTv2.1 ingests Argo



MUR has always ingested Argo

https://www.star.nesdis.noaa.gov/socd/sst/squam/analysis/l4/