SST Intercomparison in the framework of Copernicus Climate Change Service (C3S)

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Independent Assessment of Essential Climate Variables (C3S_511)

Copernicus Climate Change Service (C3S)

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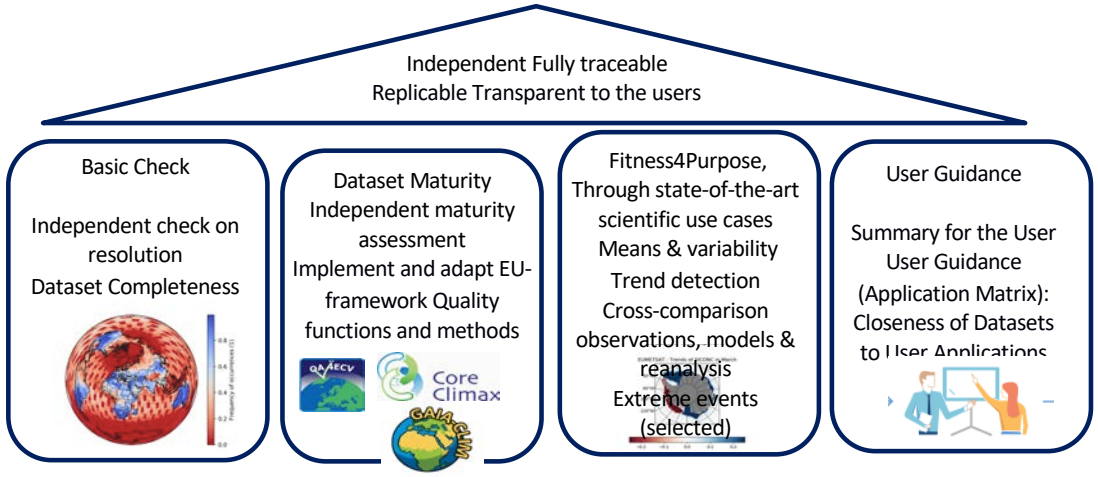
Objective: To evaluate the consistency of the climate signals observed in the different climate variables (atmosphere, ocean and sea ice, land, glaciers) and capability of the data available in the Climate Data Store (CDS) for climate scientific community and private sectors.

TABLE 1. The essential climate variables (for qualifying details, see GCOS 2010a).

Atmospheric	Surface:[a]	Air temperature, wind speed and direction, water vapor, pressure, precipitation, surface radiation budget
	Upper air:[b]	Temperature, wind speed and direction, water vapor, cloud properties, Earth radiation budget (including solar irradiance)
	Composition:	Carbon dioxide, methane, other long-lived greenhouse gases,[c] ozone and aerosol supported by their precursors[d]
Oceanic	Surface:[e]	Sea surface temperature, sea surface salinity, sea level, sea state, sea ice, surface current, ocean color, carbon dioxide partial pressure, ocean acidity, phytoplankton
	Subsurface:	Temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers
Terrestrial		River discharge, water use, groundwater, lakes, snow cover, glaciers and ice caps, ice sheets, permafrost, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation, leaf area index, above-ground biomass, soil carbon, fire disturbance, soil moisture



- Single Product Quality Assessment - *Single Variable from Single Source.*
- **Multi Product Quality Assessment -** *Single Variable from Multi-Sources*
- Thematic Assessment (e.g. energy budget, water cycle) - *Multi-Variables from Multi-Sources*

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Multi Product (multi source) Quality Brief motivation

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(1) better access to robust product specific documentation of user guidelines/support;
(2) openly available technical information and product descriptions (e.g. algorithms, product resolution, temporal and spatial coverages);
(3) information about uncertainty, quality control and stewardship maturity assessments;
(4) the description of well-known issues and level of compliance with Global Climate Observing System requirements;
(5) possibility to search, discover and access Fundamental Climate Data Records (FCDR), CDRs, Thematic Climate Data Records (TCDRs) and Interim Climate Data Records (ICDRs) (if these are available) from the same Essential Climate Variable (ECV) and data provider;
(6) better documentation on the FCDRs, CDRs, TCDRs and ICDRs;
(7) better information on the provenance of the data records all along their data cycle
(8) user feedback information

Are the ECV products from different sources measuring the same signal?

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MPQB on Sea Surface Temperature

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- SST is a key parameter to monitor global climate change at different time scales
- Serves as boundary conditions in atmospheric models
- Intercomparisons will help to understand the discrepancy and consistency between different products to help the data providers to improve the products
- It will serve to provide guidance for users for their applications

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Datasets Description

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Dataset	Institution	Type of product	Time Range	Observation input	Type of SST	Horizontal Grid spacing	Vertical resolution	Temporal resolution	Main Reference
ESA CCI SST (v.2.0)	**Met Office**	**SST analysis**	**1981-2018**	**IR**	**SST at 0.2 m**	**global 0.05°x0.05°**	**surface**	**daily**	**Merchant et al. (2019)**
ERA5	**ECMWF**	**SST analysis**	**1979-2018**	**IR + MW + in situ**	**---**	**global 0.25°x0.25°**	**surface**	**hourly**	**Hirahara et al. (2016)**
HadISST1	Met Office	SST analysis	1870-2018	IR + in situ	---	global 1°x1°	surface	monthly	Rayner et al. (2003)
Reynolds (v.2.0)	NOAA	SST analysis	1981-2018	IR + in situ	SST at 0.2 m	global 1°x1°	surface	weekly/monthly	Reynolds et al. (2002)
MUR25 (v.4.2)	PODACC	SST analysis	2003-2018	IR + MW + in situ	Foundation SST	global 0.25°x0.25°	surface	daily	Chin et al. (2017)
MGDSST	Japanese Met. Agency (JMA)	SST analysis	1982-2017	IR + MW + in situ	Foundation SST	global 0.25°x0.25°	surface	daily	Sakurai et al. (2005)
BoM Monthly SST	Australian Bureau of Met. (BoM)	SST analysis	2002-2018	IR + in situ	SST at 0.2 m	global 1°x1° (weekly/monthly)	surface	weekly/monthly	Smith et al. (1999)

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Temporal Coverage of all SST datasets

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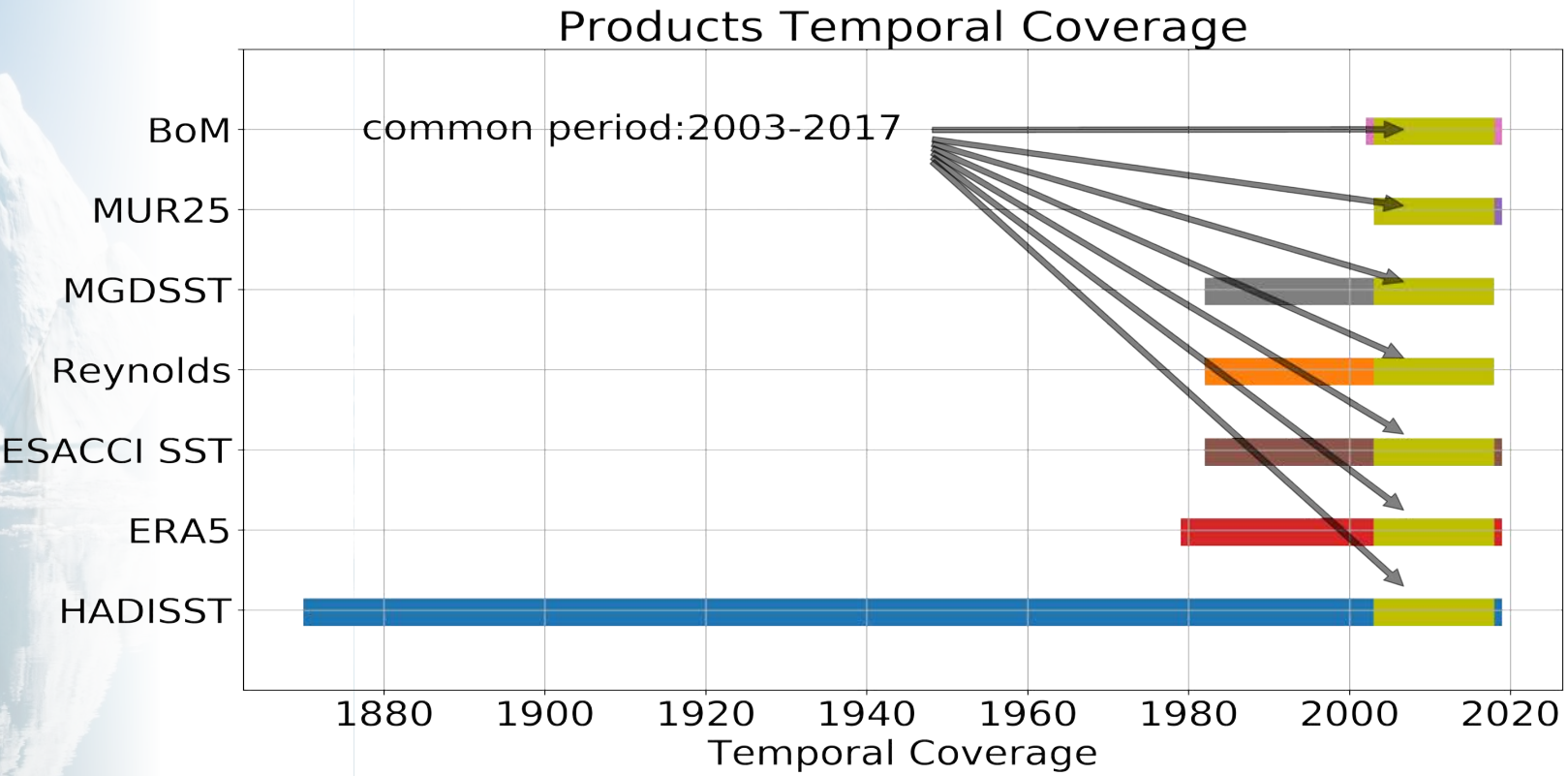

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Global SST climatology from 2003-2017

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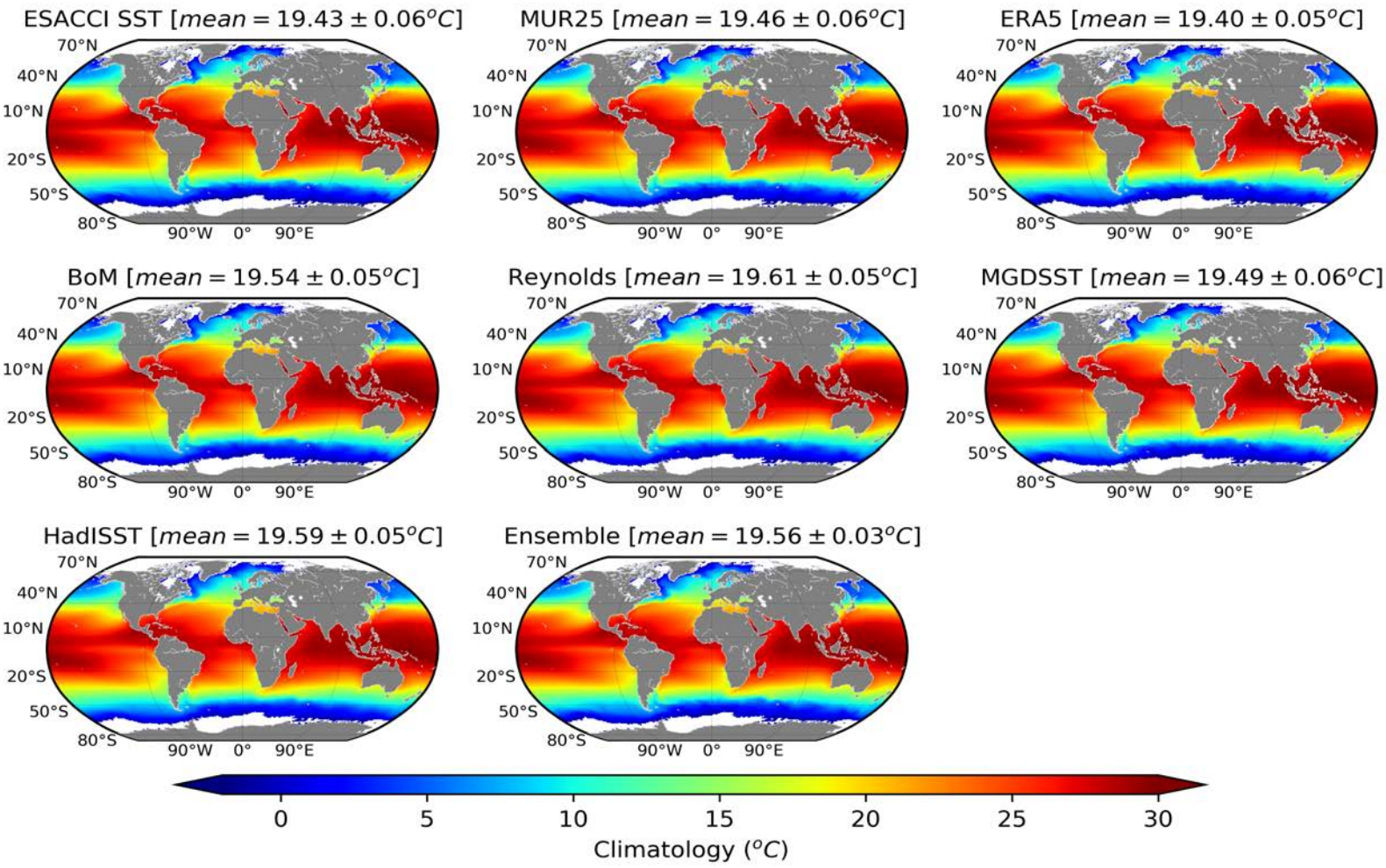

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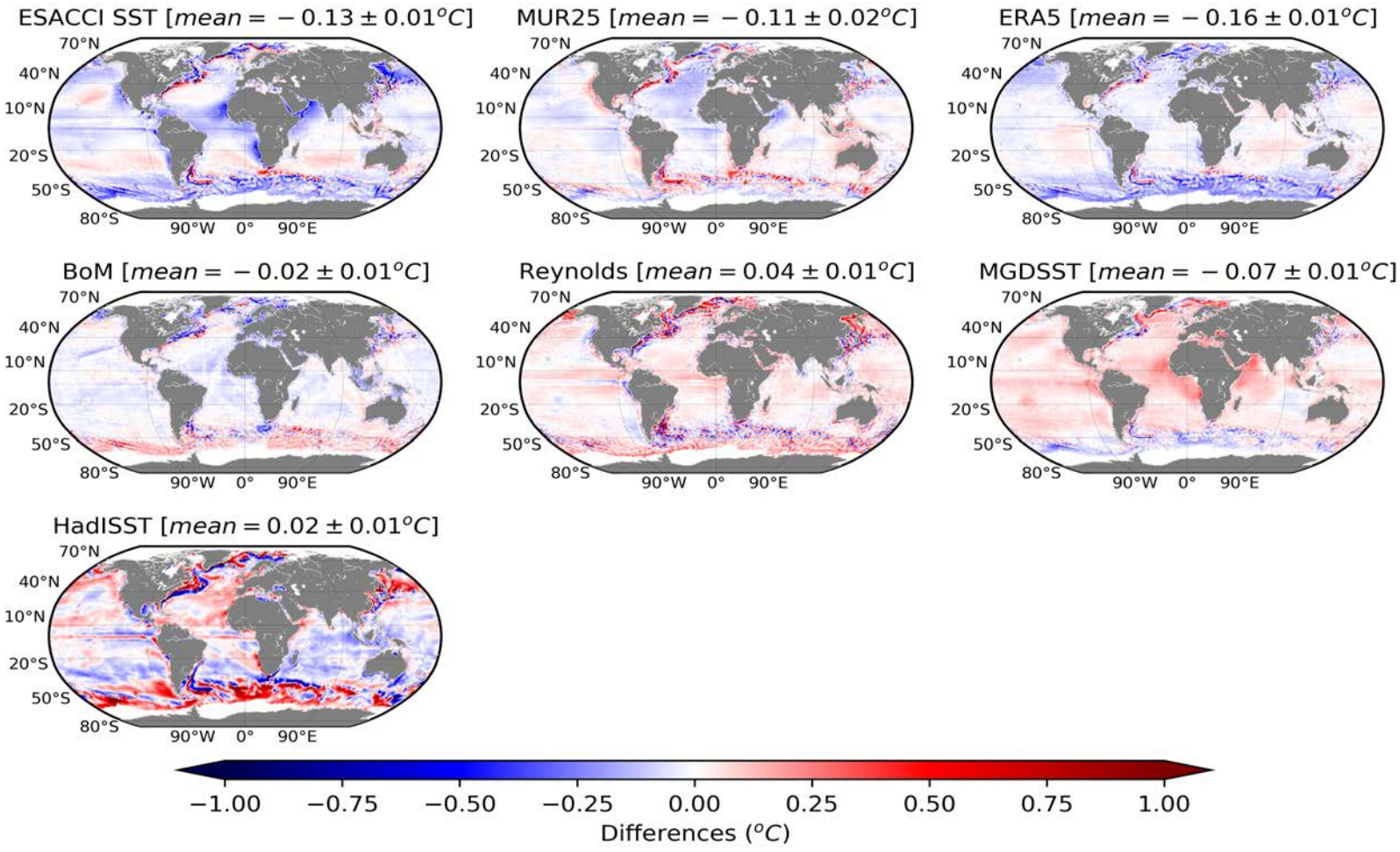
The difference between each SST data and the ensemble mean for the period of 2003-2017



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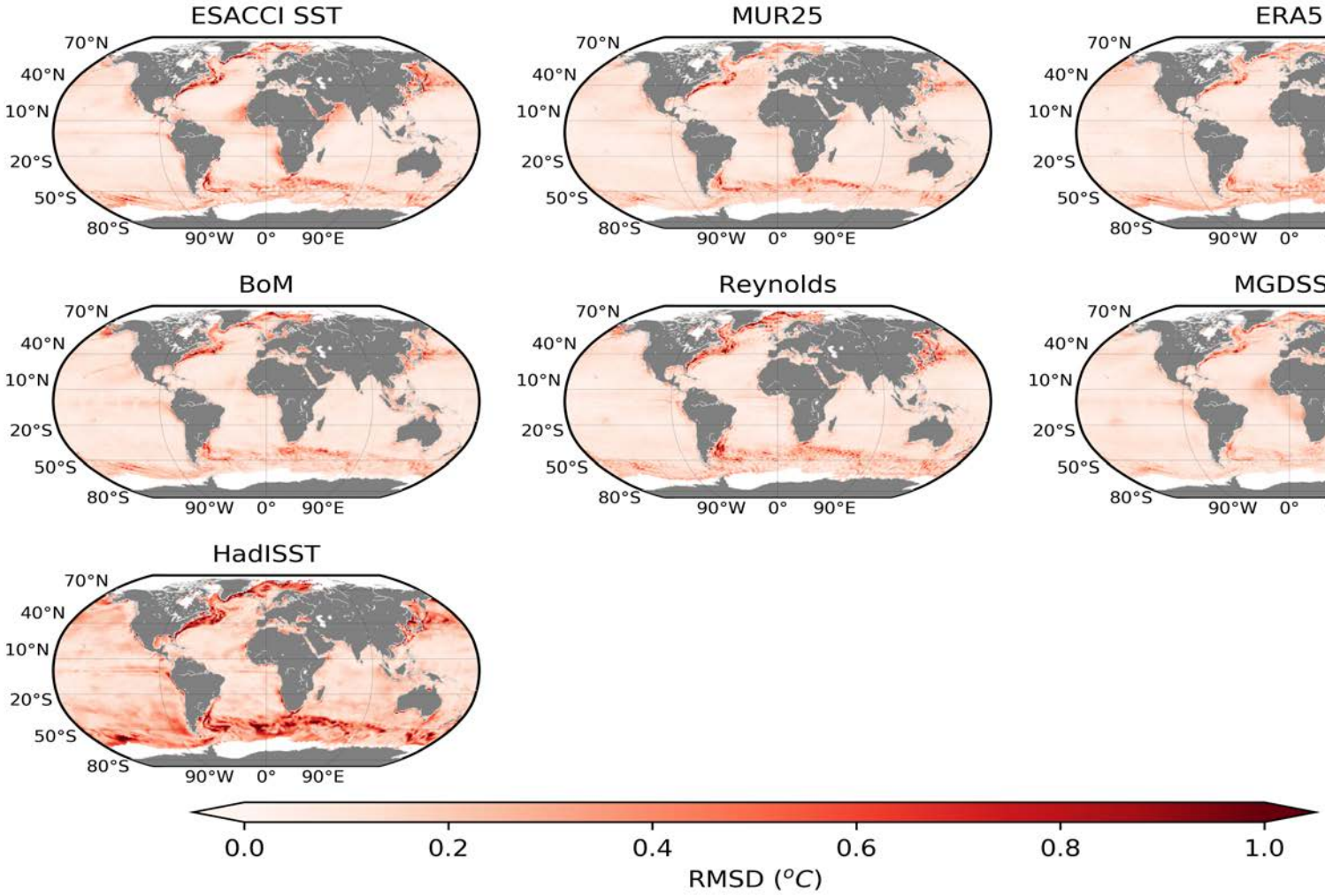
RMSD between each SST data and the ensemble mean for the period of 2003-2017



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The Pearson correlation difference between each SST data and the ensemble mean

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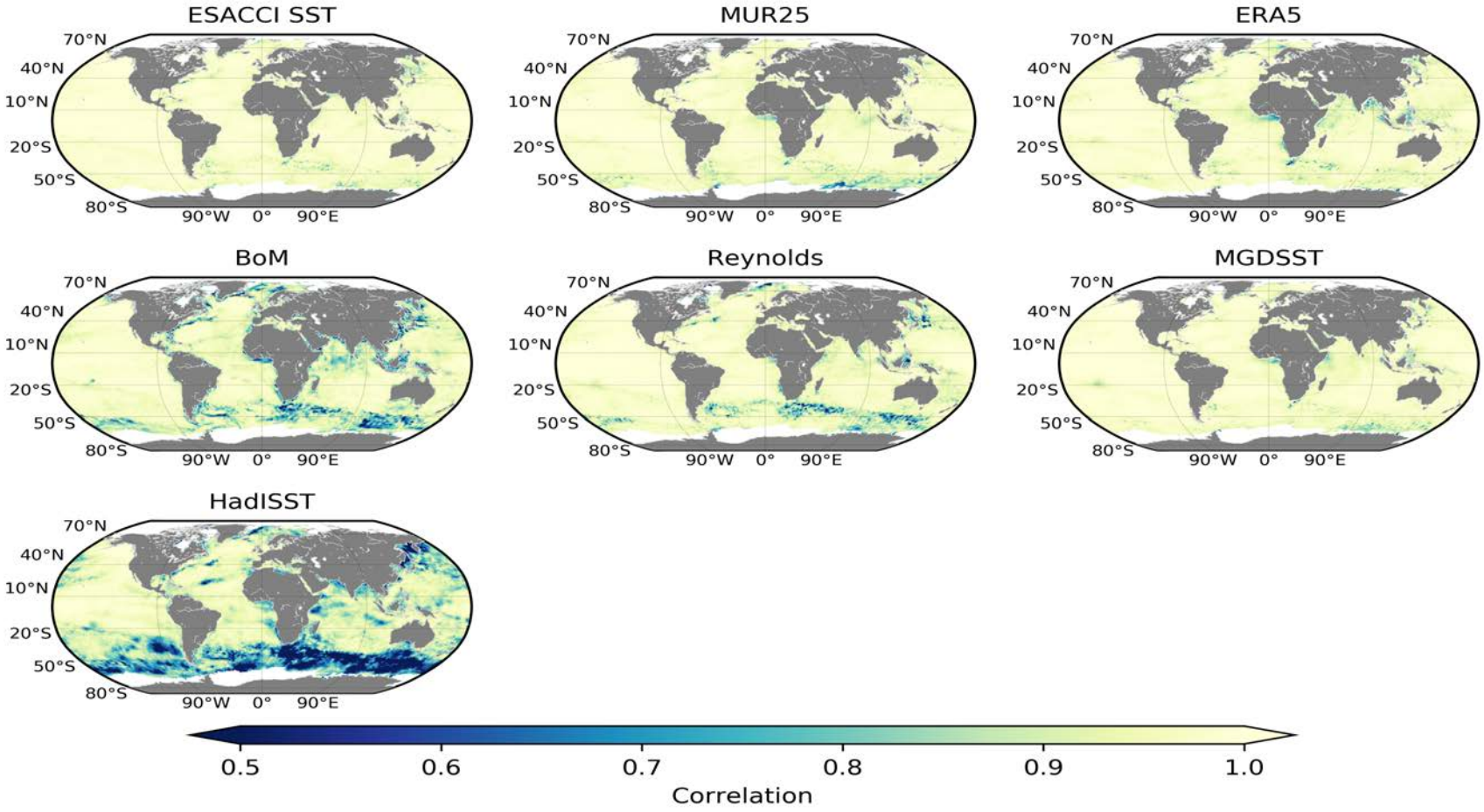

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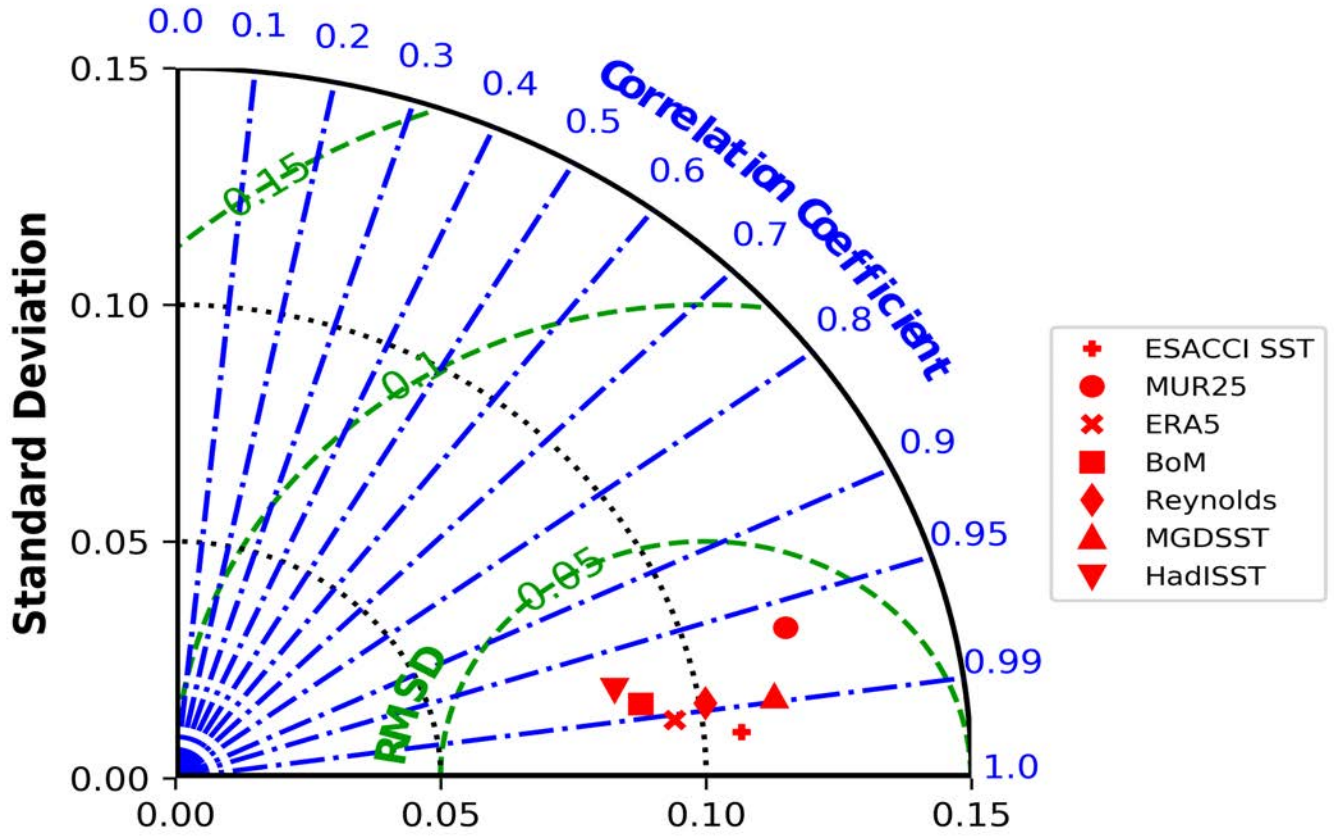
Taylor diagram of the seven SST datasets with respect to the Ensemble mean



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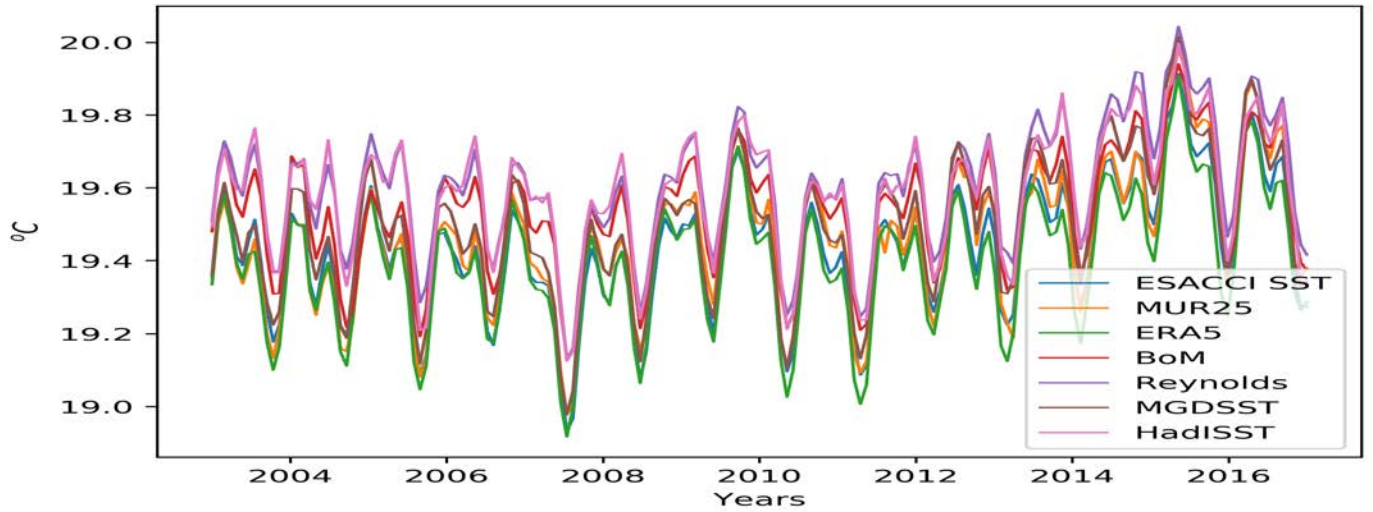
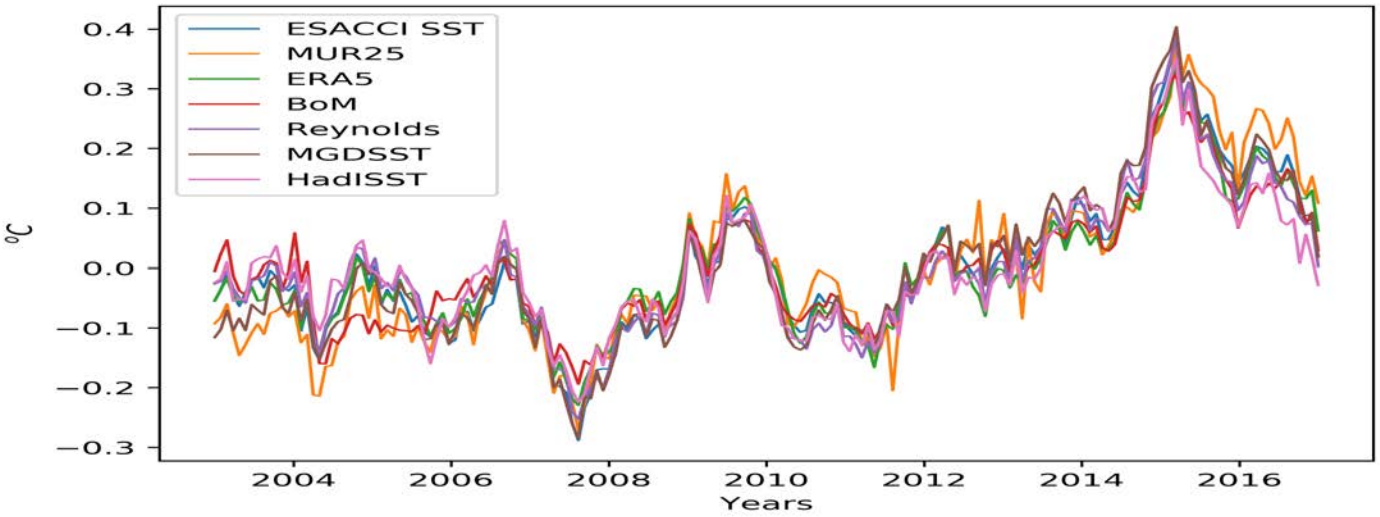
Global mean SST and anomalies time series from 2003-2017





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Linear trends of global SST

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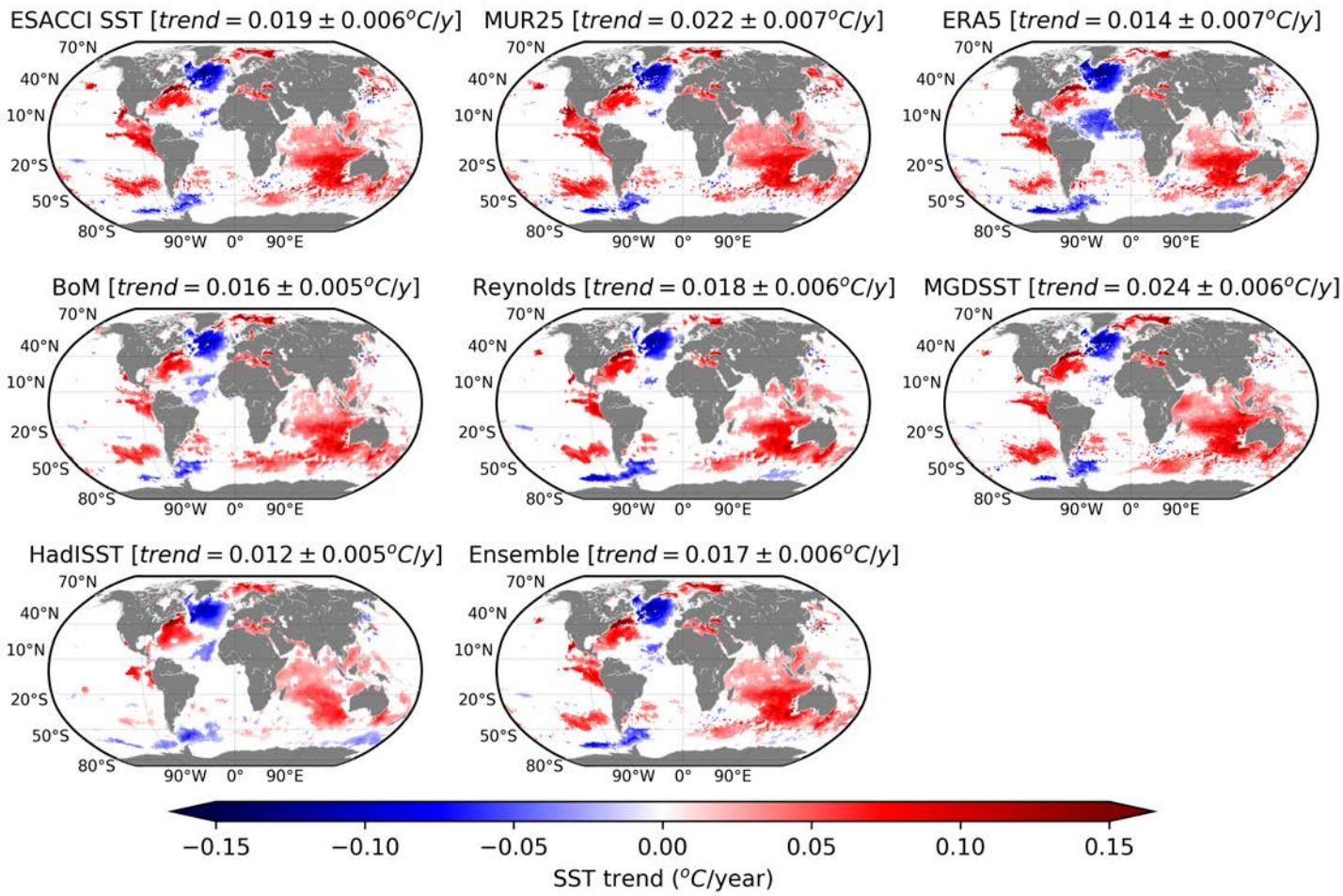

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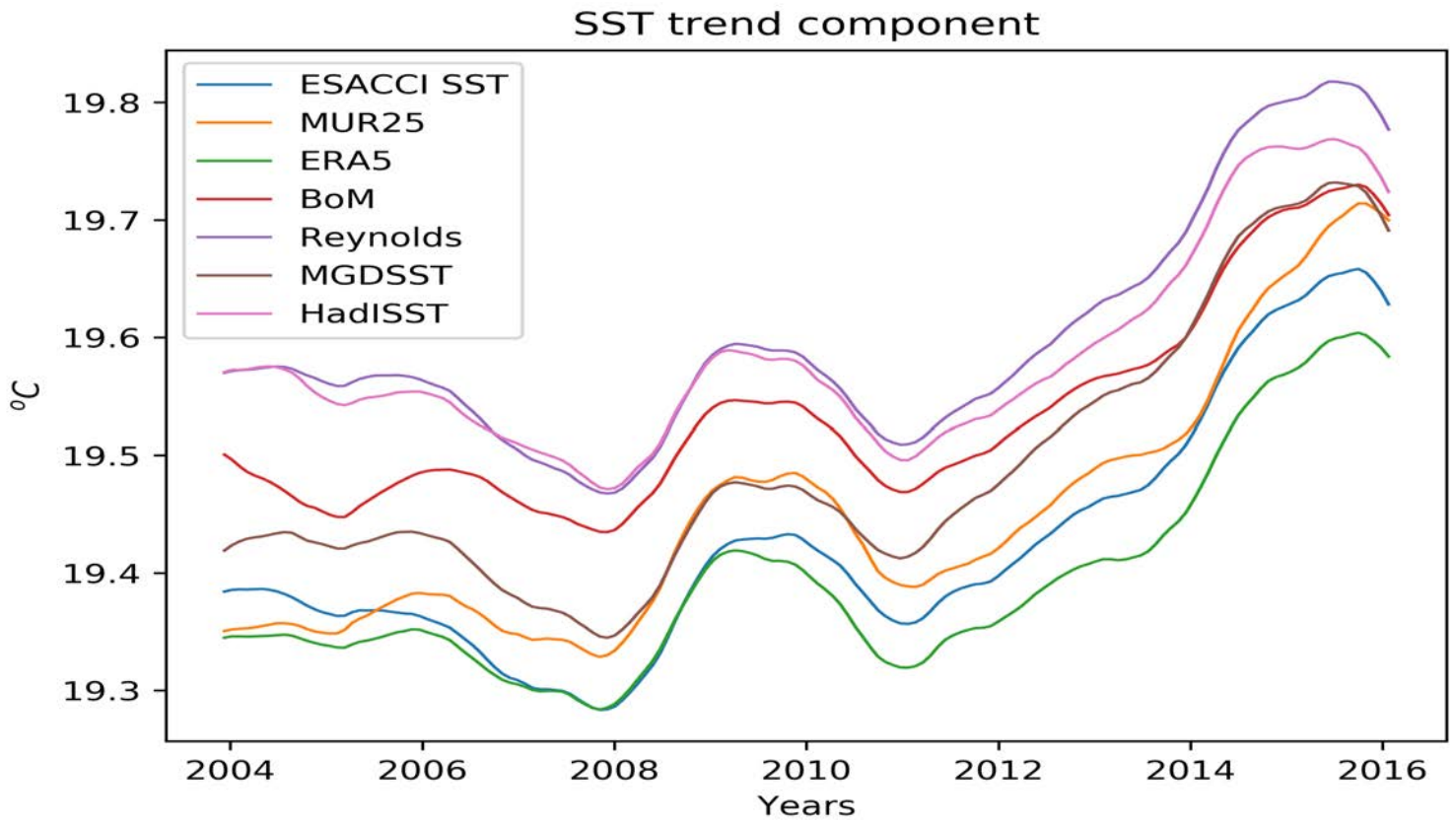
Global SST trend components



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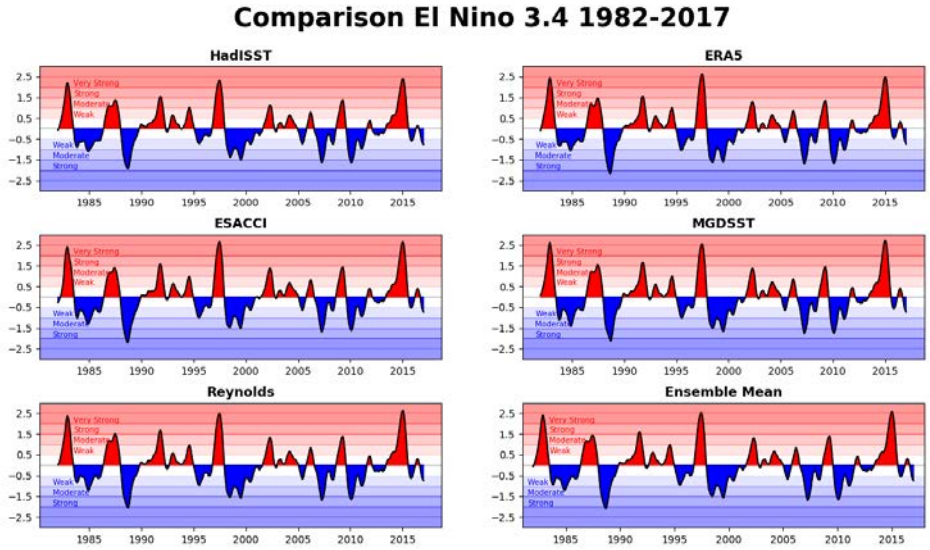
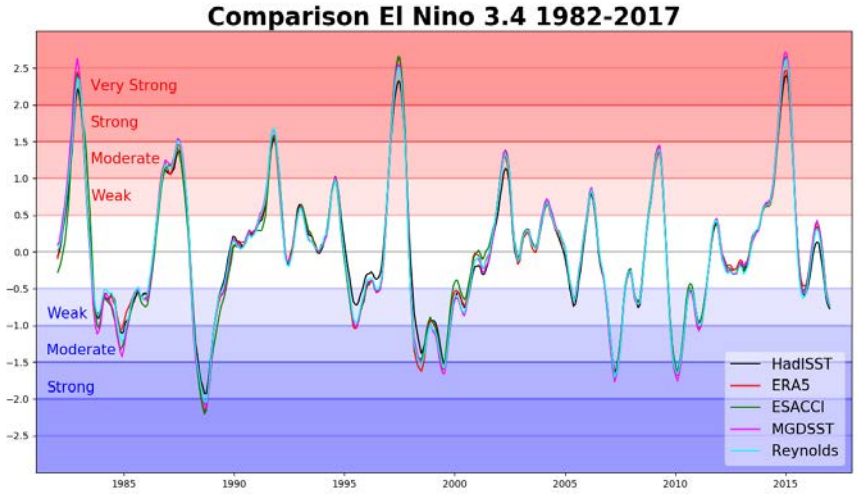
El Nino 3.4 Index





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Pricinple Component Analysis (PCA) of SST in the tropical Pacific Ocean

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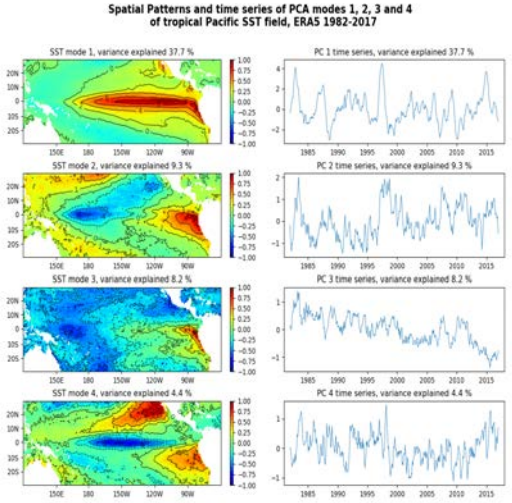

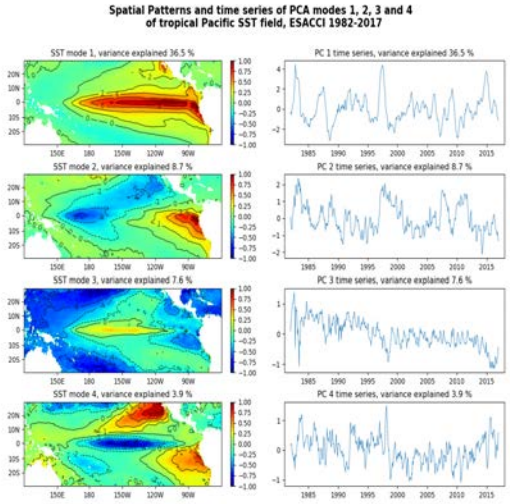

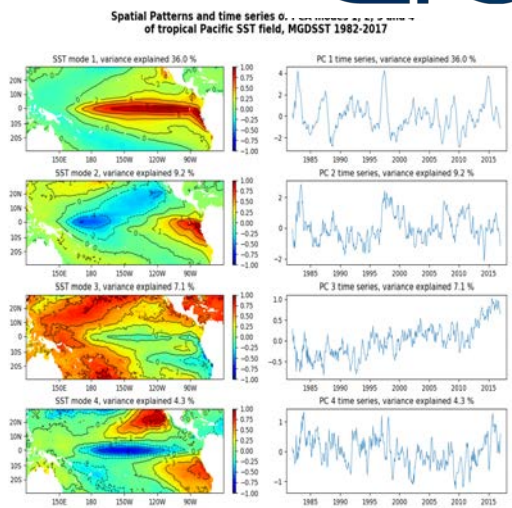

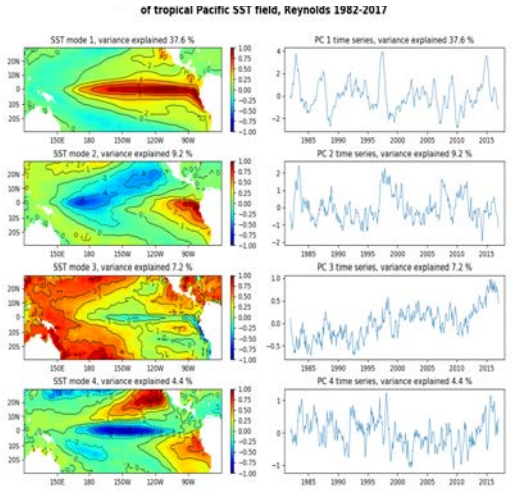

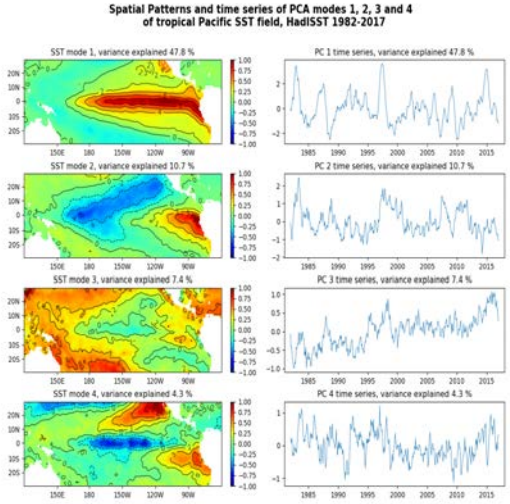

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Data Maturity Matrix

Name C3S_511 SMM Category	ESA CCI SST	ERA5 SST
Metadata		
Standards	6	6
Collection level	6	6
User Documentation		
Formal description of scientific methodology	6	4
Formal validation report	6	2
Formal product user guide	6	5
Uncertainty Characterisation		
Standards	6	1
Validation	6	1
Uncertainty quantification	6	1
Automated quality monitoring	6	1
Public Access, feedback, and update		
Public Access/Archive	6	5
Version	6	5
User feedback mechanism	6	6
Updates to record	6	6
Usage		
Research	6	3
Decision support system	2	3

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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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Recommendations to Users

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- All the datasets presented here provide state-of-the-art spatially-complete SST products at global scale. These datasets are characterized by different spatial and temporal resolutions and temporal coverage that can fulfil the requirements of a large variety of users.
- Intercomparison results and test case analysis suggest these datasets provide an accurate representation of SST spatial-temporal variability.
- These datasets can then be used for fundamental climate applications compatible with the length of each time series, such as long-term monitoring of SST changes (e.g., trends) and comparison to or initialization of numerical models.
- User are strongly encouraged to consider also the type of SST offered by each producer, distinguish between, e.g., skin SST, subskin or 20 cm SST, and foundation SST according to the specific application for which the data are meant to be used.

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