The Importance of High-resolution Satellite Observations In Addition to In Situ Observations

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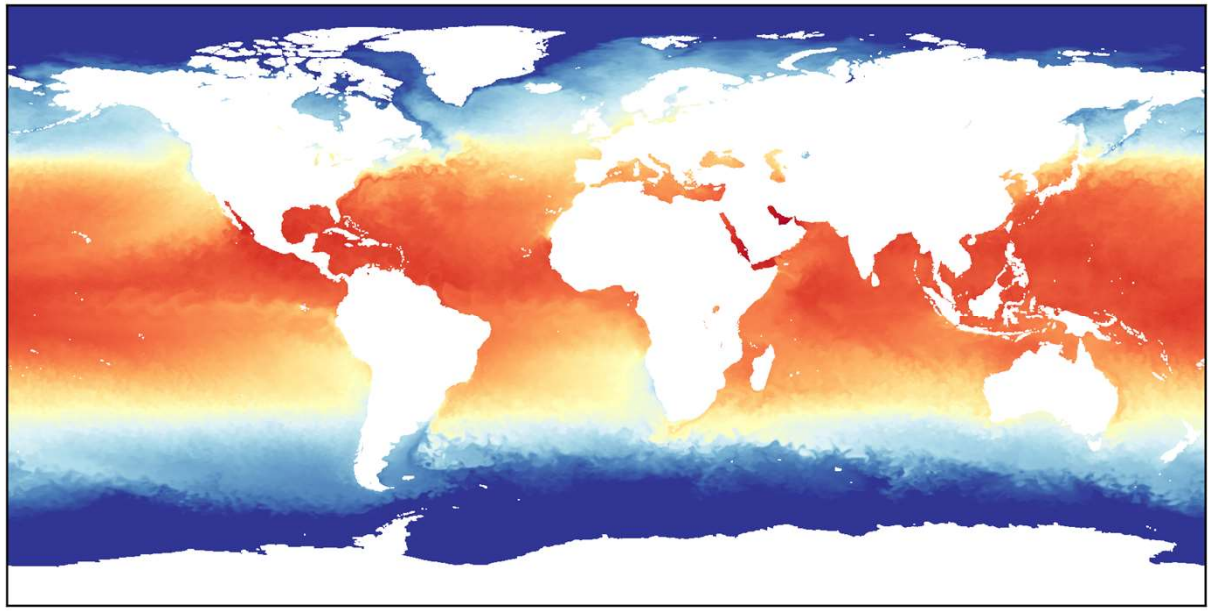


Based on presentation provided by: Anne O'Carroll (EUMETSAT)

Included training materials provided by Simon Good and Emma Fiedler (Met Office)

In situ and satellite observations are important, and…

Met Office

Copernicus Europe's eyes on Earth

EUMETSAT

In Situ

Pros:

- Only way to know the subsurface structure of the ocean
- Direct measurements of geophysical variables

Cons:

- Sparse in coverage (~thousands a day)
- Weather and ocean conditions could be prohibitive
- Always require quality control and checks for systematic errors

Satellite

Pros:

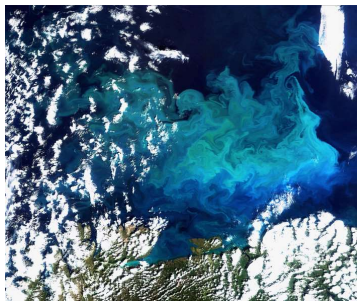
- Global coverage to provide spatial information on large scales
- Large number of daily, repeated and consistent measurements (~millions a day)

Cons:

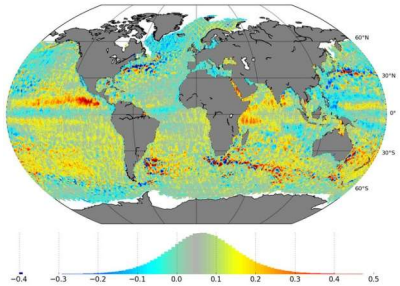
- Do not "measure" geophysical variables, instead detect electromagnetic radiation
- Impact from atmospheric processes, e.g. clouds

High-quality satellite observations provide important information about the ocean that are essential for better monitoring and forecasting of the global ocean

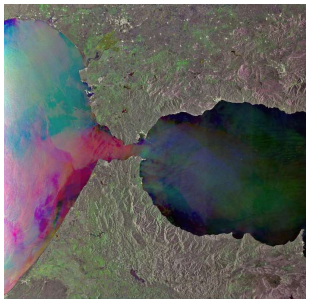
A few examples of satellite observations



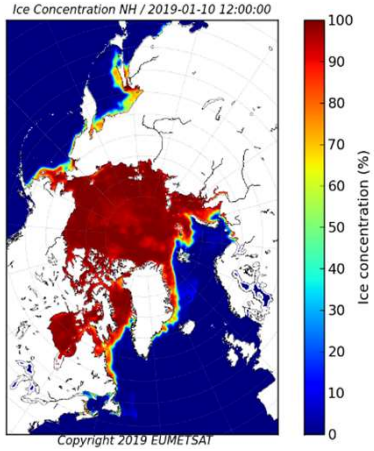
Surface Colour
(Envisat/MERIS, Barents Sea, August 2009, ESA)



Surface height
(Sentinel 3A, monthly sea level anomaly, March 2016, ESA)

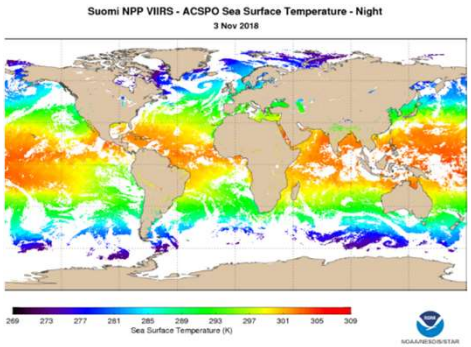


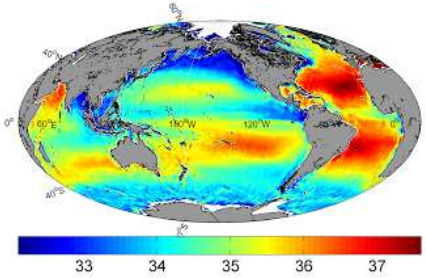
Surface Roughness
(Envisat/SAR, Gibraltar, 2010 (Composite image), ESA)



Sea ice concentration/type/ thickness
(SSMIS sea ice concentration, 10 January 2019, OSI SAF)

Surface temperature
(S-NPP VIIRS, 3 November 2018, NOAA/NESDIS/STAR)





Surface salinity
(SMOS, Annual mean 2010, Ifremer)

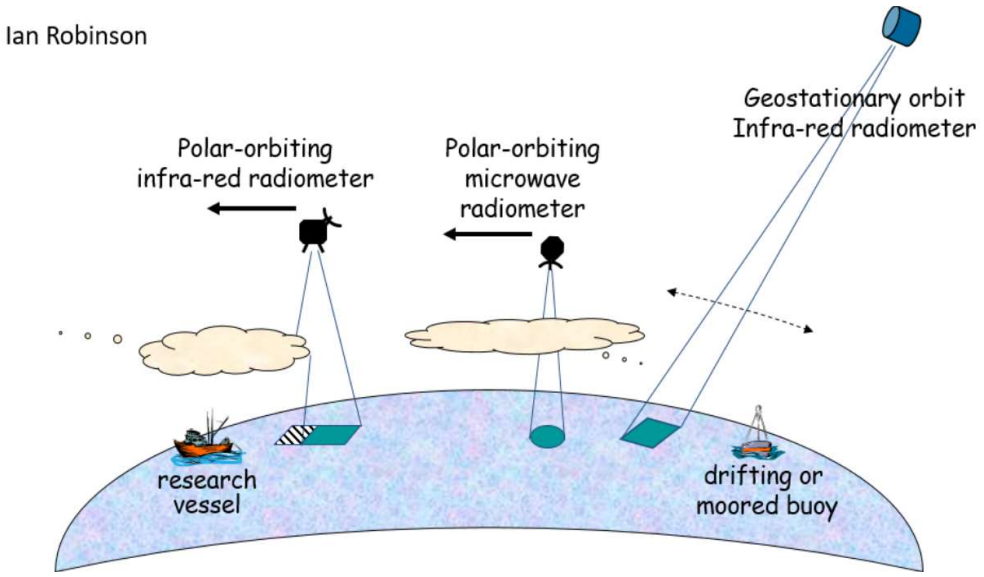
Satellite Sea-Surface Temperature (SST)

Focus on satellite SST observations, as SST products are the most mature satellite-based observations. Ocean temperature also has been used as proxy for other ocean parameters, although direct, high-quality measurements of these parameters are improving over years.

SST is crucial for understanding, monitoring and modelling the climate

Group for High Resolution Sea-Surface Temperature (GHRSST) coordinates on providing satellite-derived global SST with good estimates of uncertainty to operational users, climate / ocean monitoring / prediction and the science community:

- Providing guidance on satellite SST data quality and format standard
- Providing opportunities for exploitation of high-quality SST products and building bridges between data providers and users

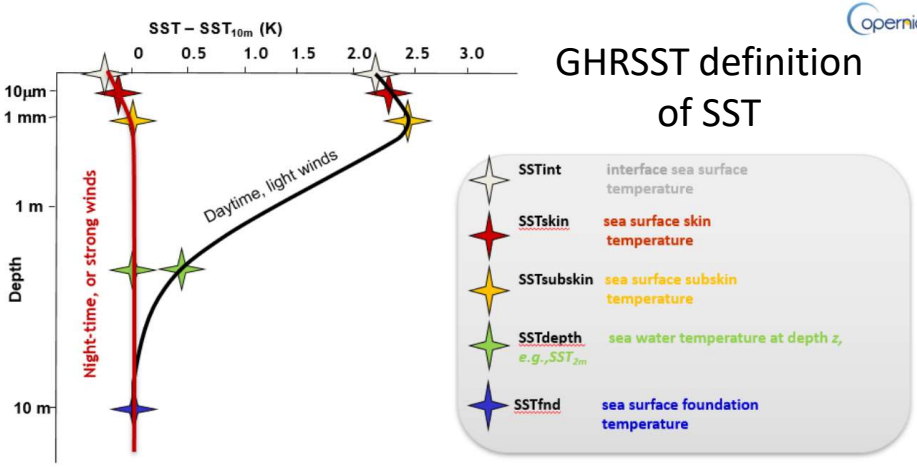


Proper retrieval algorithm, clouds detection (especially for Infra-red satellite), quality control and validation are essential to achieve high-quality satellite sea-surface temperature

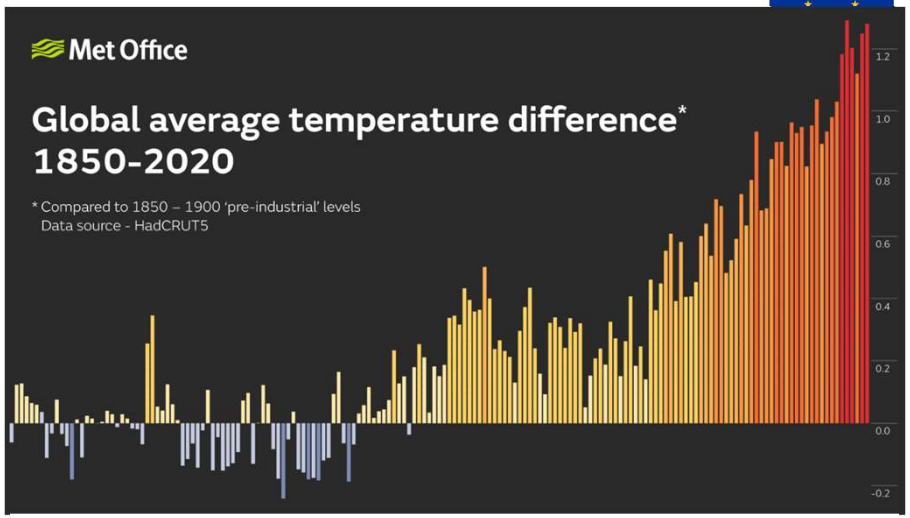
Why is Sea-Surface Temperature from satellites important?

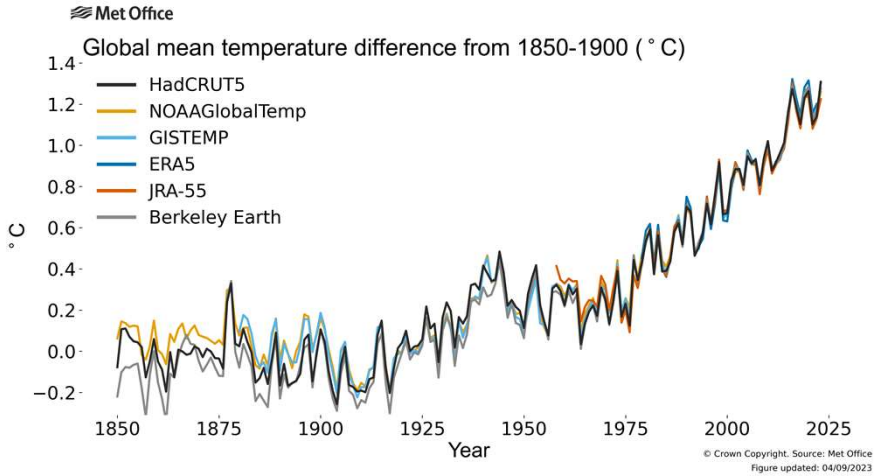
Ocean is an important component of the Earth System
Understanding ocean temperature is essential for climate monitoring, modelling and seasonal predictions:

- Improves seasonal predictions
- Influences regional and global atmospheric circulation
- Influences weather forecasting boundary condition
- Influences density and circulation of oceans
- Impacts ocean biogeochemistry and marine ecosystems



GHRSST definition of SST

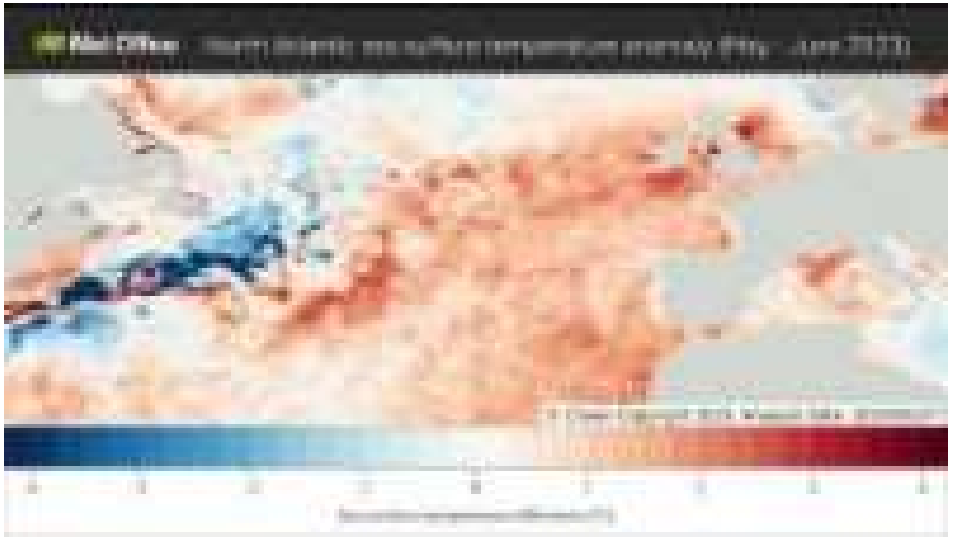




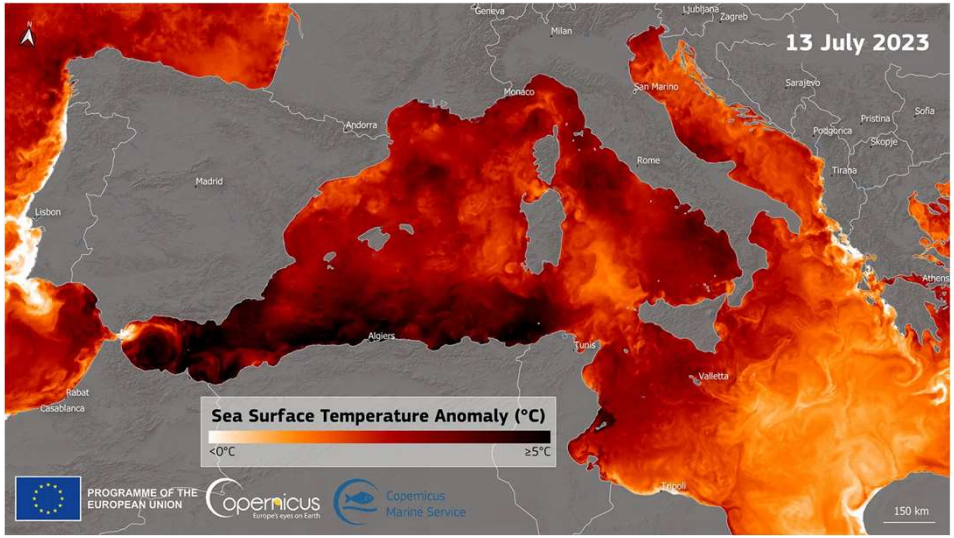
More information on https://climate.metoffice.cloud/

Applications of Satellite-based Sea-Surface Temperature Observations

Marine heat waves



Sea-Surface Temperature anomaly for May – June 2023, source: HadSST 4.0.1.0 and OSTIA

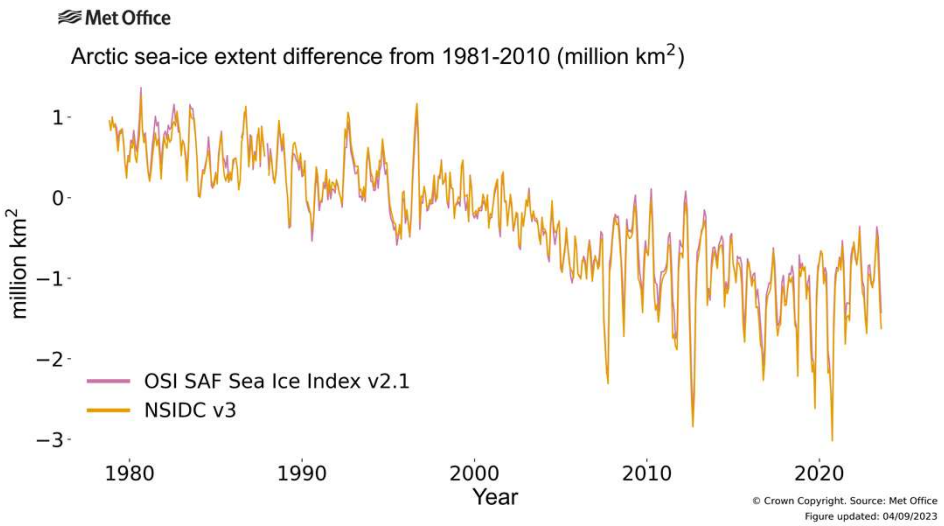


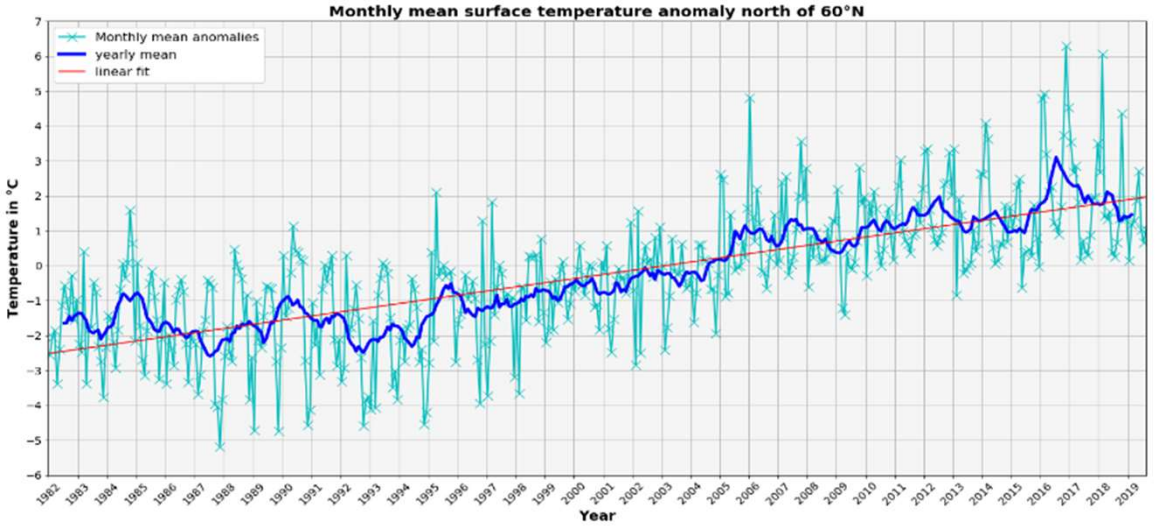
The northern Atlantic Ocean and Mediterranean Sea have experienced record-breaking sea temperatures over the past few months (Credit: European Union/Copernicus)

Ocean analyses usually combine high-quality Sea-Surface Temperature observations from satellite and in situ sensors. Satellite-based observations are essential to form the bigger picture of the changing climate.

Applications of Satellite-based Sea-Surface Temperature Observations

Improve observations in high latitudes and regions/season of rough ocean conditions





Hoeyer et al. (2021) https://www.youtube.com/watch?v=KXPBgUWLFgs

- "Direct" measurement of sea ice extent started during the satellite era and allowing us to being to understand the connection of sea-surface temperature, ice surface temperature and sea ice extent
- In situ observations could have seasonal and regional biases: more observations in summer and low-mid latitudes
- **Satellite SST observations help to achieve better understanding of the high latitudes, west boundary current regions and during winter when ocean conditions are rough for in situ observations**
- **Challenges: satellite angle for high quality observations; lack of in situ observation for validation and accurate identification of sea ice; larger uncertainty due to cloud cover or ocean roughness.**

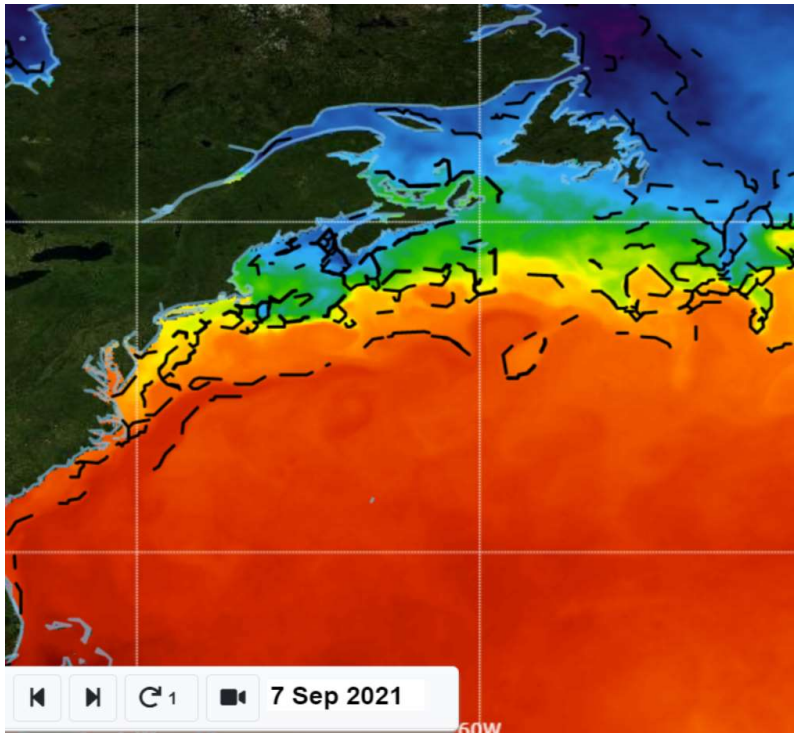
Challenges for improving Sea-Surface Temperature

Improving coastal SST data quality

- *Challenges:* greater variability in water vapour, temperature and aerosol, changes in surface emissivity and turbidity/cloud detection
- ***Requirement:*** **high spatial resolution satellite data from multiple sources.**

Improving SST feature resolution

- *Challenge*: reliance on high resolution infra-red data but limited by cloud cover
- ***Requirement*****: focus on new techniques e.g. in coastal, upwelling, polar and dynamic regions**



https://www.star.nesdis.noaa.gov/socd/ov/

Innovation and Priorities for Sea-Surface Temperature

Summary of priorities in next decade:

- Arctic and high-latitudes; coastal data quality; SST feature resolution

Observational needs of Sea-Surface Temperature:

- Continuity and redundancy of the constellation of satellite Sea-Surface Temperature observing system
- New generation of geostationary and polar-orbiting sensors has begun but innovation to translate these to higher resolution and better accuracy Sea-Surface Temperature products is still needed
- Continued investment into Fiducial Reference Measurements (FRM) with known uncertainties for traceability and long-term assessment of stability of satellite SST

O'Carroll et al, OceanObs19, https://www.frontiersin.org/articles/10.3389/fmars.2019.00420/full

Key take home messages

- Sea-Surface Temperature is essential for operational meteorology, oceanography and seasonal predictions. It is crucial for climate monitoring, modelling and predictions
- Satellite SST observations complement in situ observations by providing global coverage, large quantity of measurements and reach regions/seasons that are challenging for in situ observations
- Main challenges for improving satellite SST observations include better validation of high-latitude observations; high-quality SST observations in coastal regions and better spatial feature resolution in the product