1st INIOAS Training Course on Ocean Remote Sensing, 2023

INIOAS

17-21 Jun 2023 | Iranian National Institute for Oceanography and Atmospheric Science | Tehran, IRAN

https://www.inio.ac.ir/ORSA

Sea Surface Temperature from Space

Masoud Moradi

Iranian National Institute for Oceanography and Atmospheric Science

moradi_msd@yahoo.com

Outlines

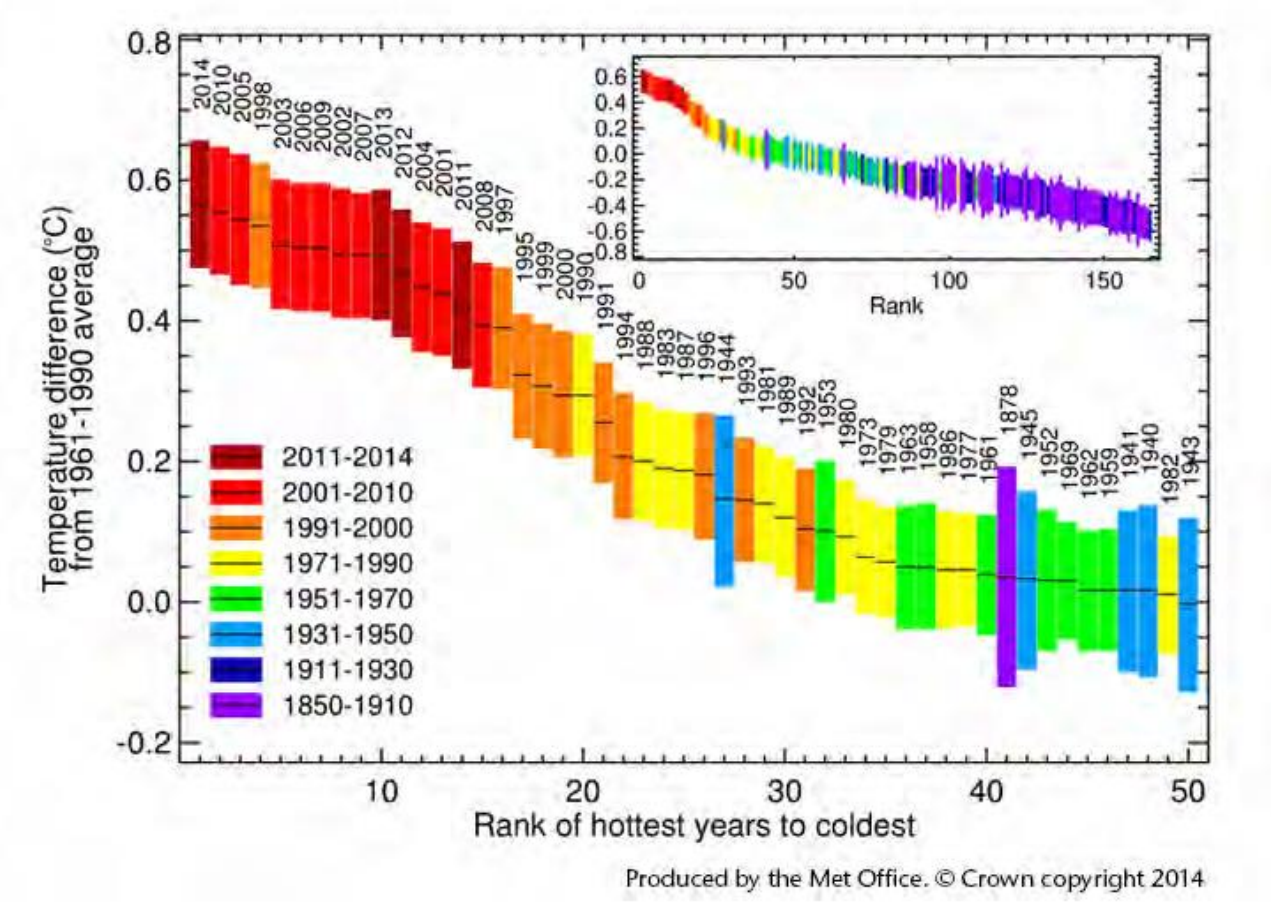
Why Measure SST from Space?

How do we measure SST from Space?

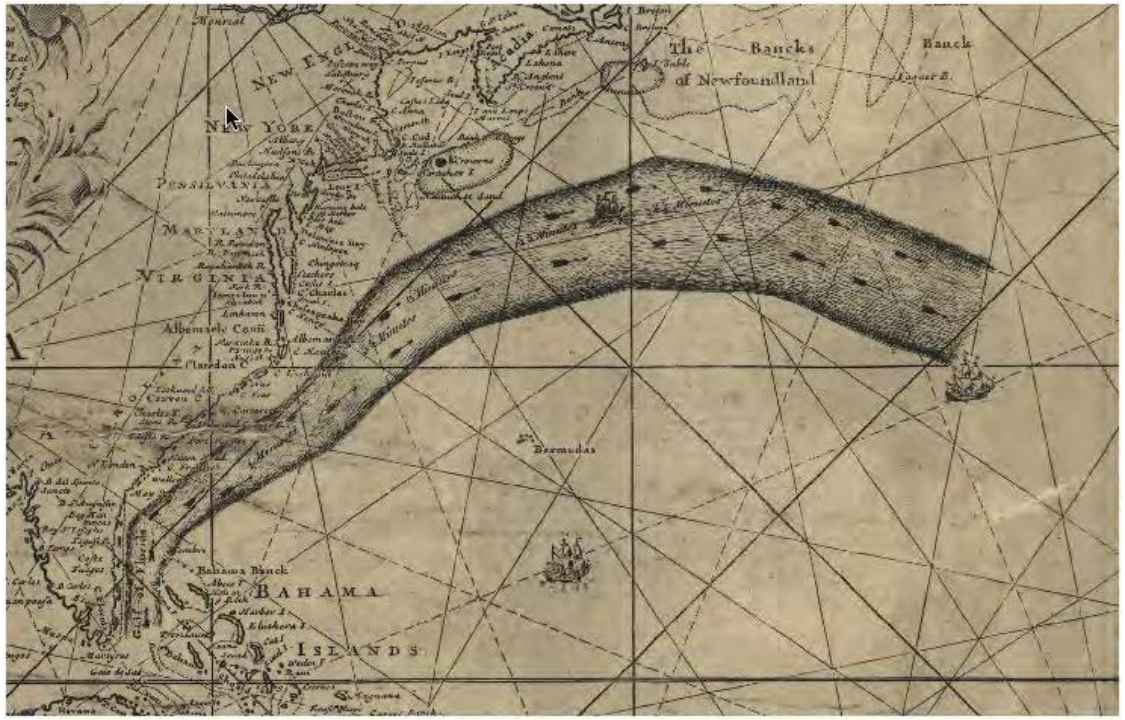
What can we find by measuring SST from Space?

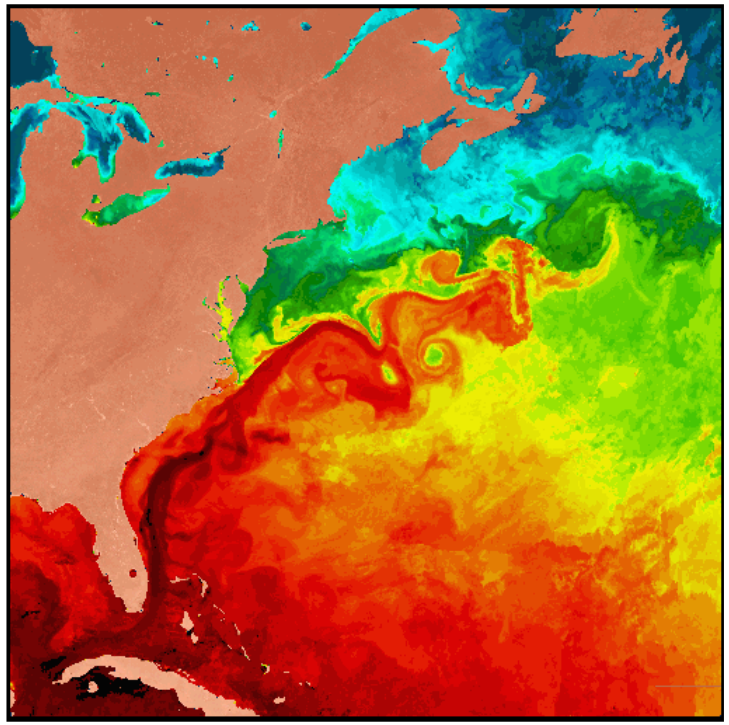
Why measure SST?

- SST influences atmospheric circulation
  - Atmospheric Model boundary condition
- SST influences density and circulation of oceans
  - Operational oceanography
- SST changes can impact ocean biogeochemistry
  - Impact on fishing
- SST is an indicator of climate change
  - Improving seasonal prediction



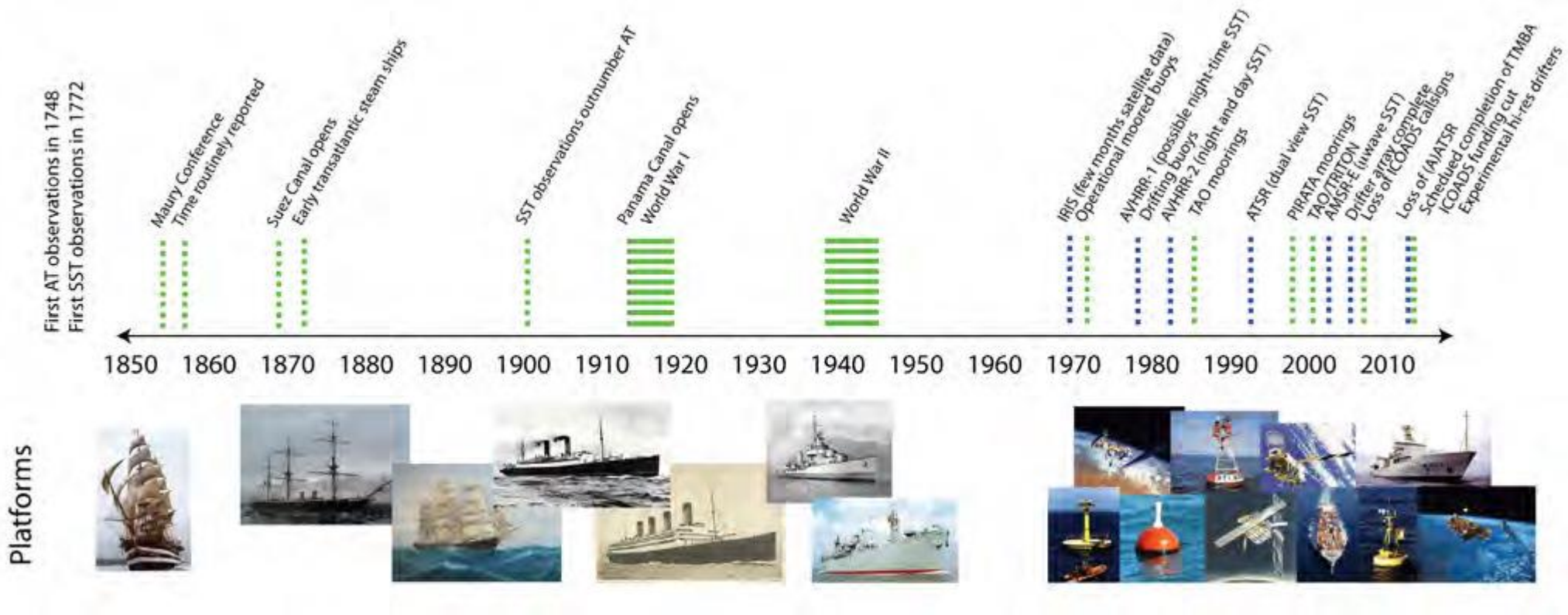
Why measure SST?





Benjamin Franklin and Timothy Folger-chart of North Atlantic Currents -1770

The evolving marine surface temperature observing system



- The quantity, quality and location of observations over time depends on:
- Technology
- Platforms –from sailing ships to drifting buoys and satellites
- Civil engineering –the Suez and Panama Canals
- Conflict and economics –Wars, available platforms, budgets and priorities

High quality observations require committed observers/analysts

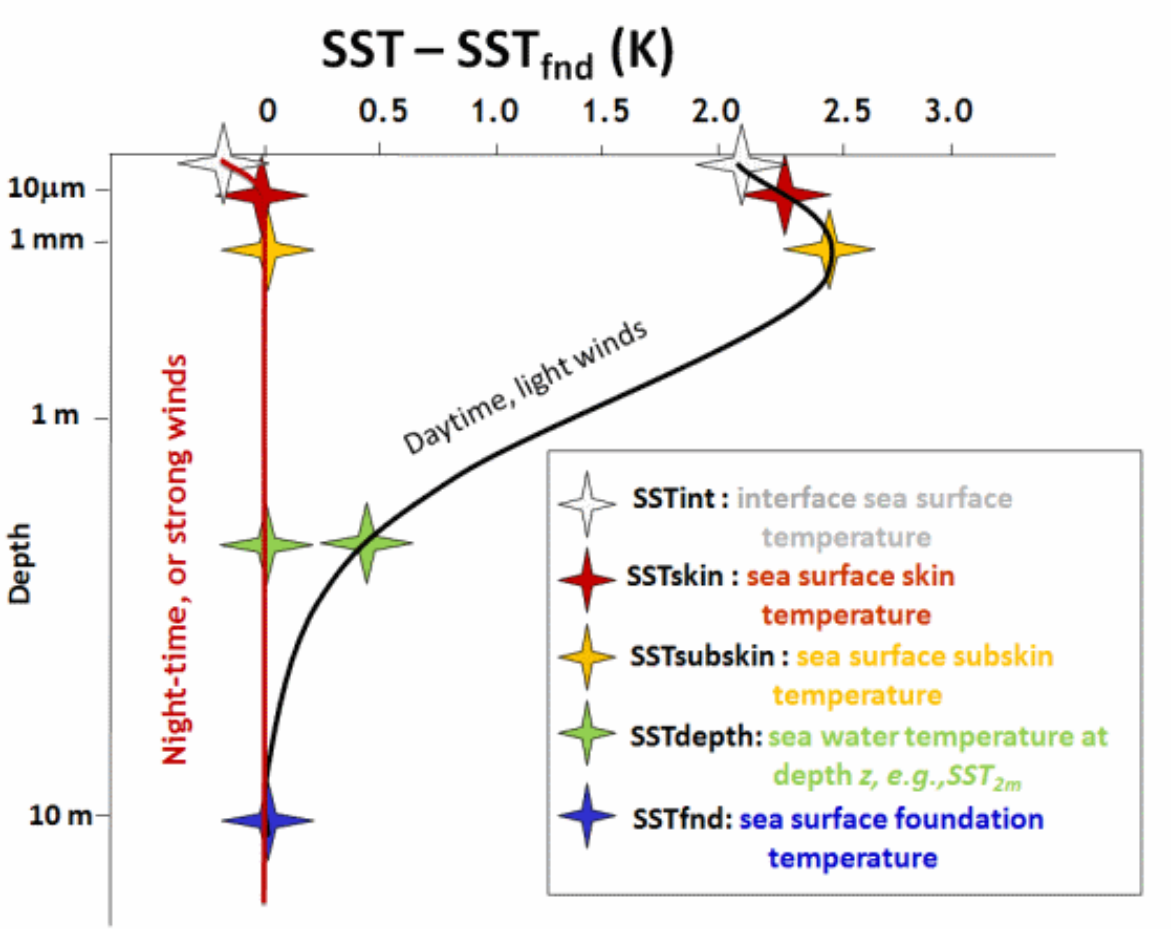
What is SST?

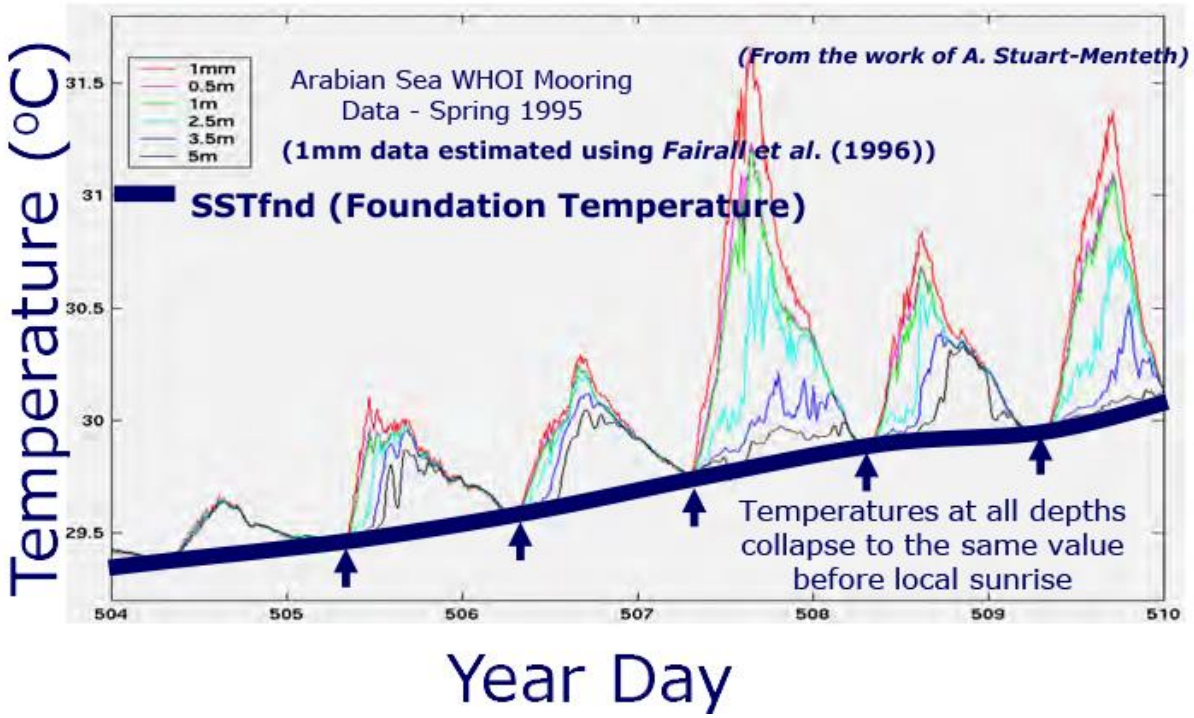
SST is a variable function of time and space, determined by integrated fluxes (including insolation), turbulent mixing, and advection (including upwelling).

"SST" depends on how and where measured:

- Heat flux between ocean and atmosphere leads to a skin layer at the ocean surface
- Absorption of insolation can lead to surface gradients, especially in low winds

Schematic Temperature Profiles



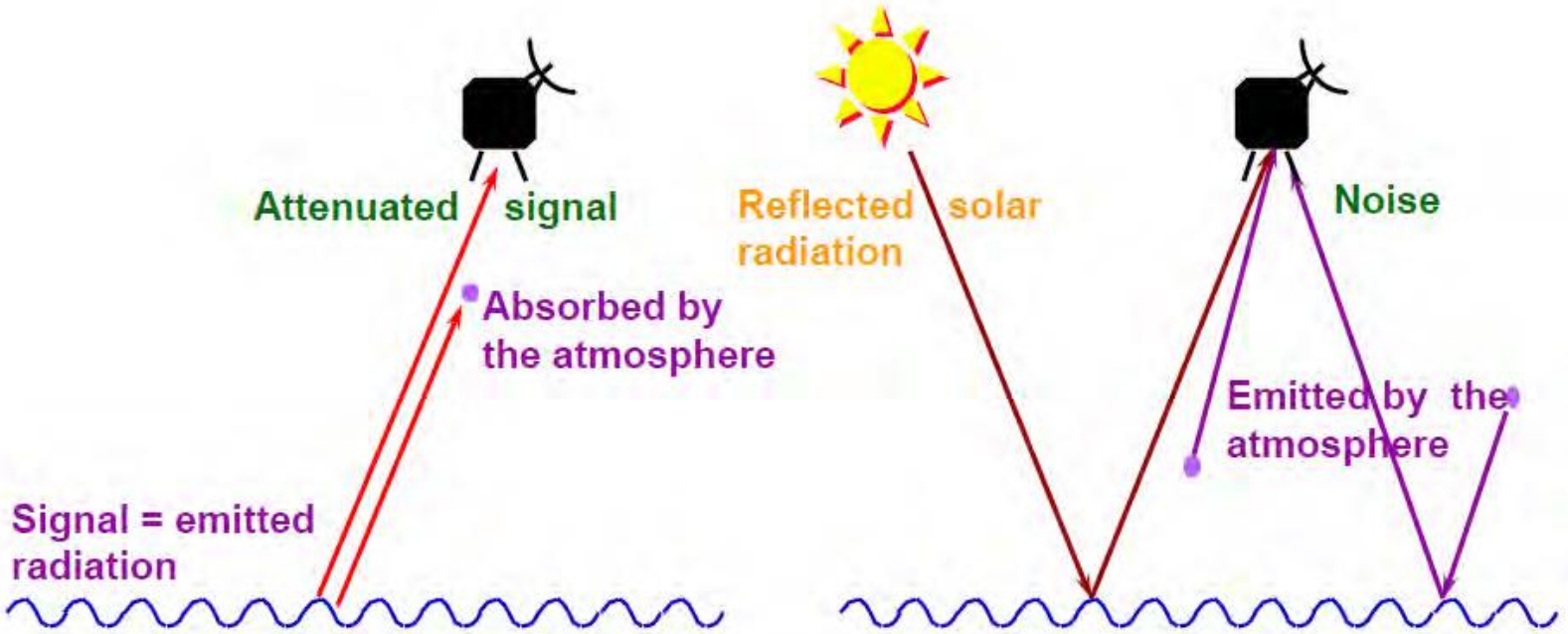


How do we measure SST from Space?

We need two things:

- **A high-performance radiometer in Space**
- **An effective Atmospheric Correction**

Atmospheric interactions with radiation



ε for sea water is about 0.99 so the water-leaving signal is almost the black body radiation.

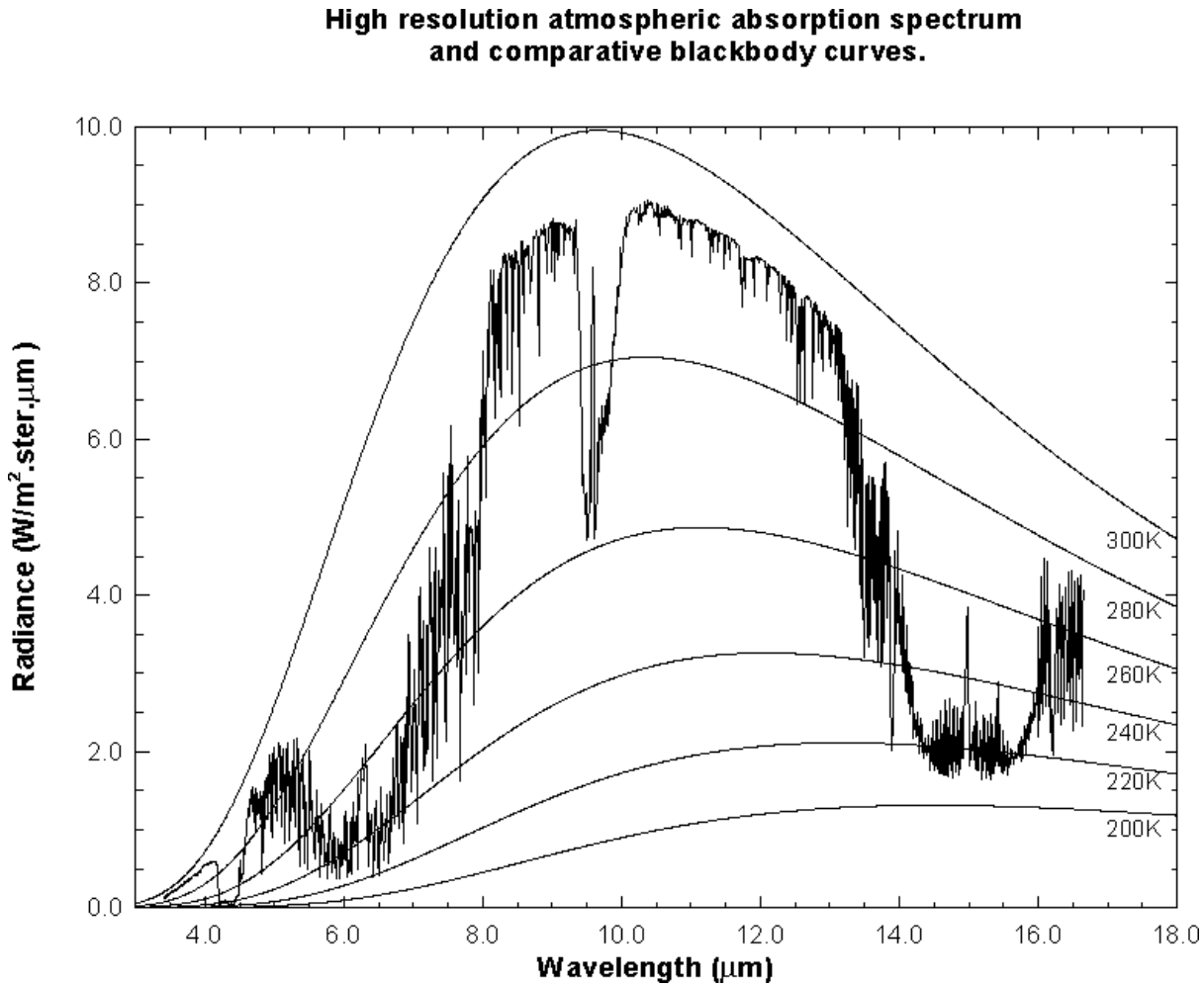
Thermal emission is approximately Lambertian, but it may be affected by surface foam and films.

Reflectance is (1 -ε) which is very small, so solar reflection is negligible at 11 microns.

Thermal emission by the atmosphere is the greatest source of atmospheric noise.

Atmospheric effects

Earth emitted spectra overlaid on Planck function envelopes



Overview of satellite SSTs

Infra-red observations

Spatial resolution: 1 to 10 km

Single pixel precision: 0.15 to 0.5 °C

Accuracy (bias): <0.1 °C to few tenths

Limitations: cloud cover

Temporal resolution per sensor (not accounting for clouds): sub-hourly (geo), ~ twice-daily (polar)

Linear Radiometric Sensitivity

Since 1981

Passive microwave observations

Spatial resolution: 50 to 100 km

Single pixel precision: 0.5 °C

Accuracy (bias): few tenths

Limitations: rain, 50 km margin around land and ice, radio frequency interference

Temporal resolution per sensor (not accounting for contaminants): ~ twice daily

High Radiometric Sensitivity (T5–T15)

Since 1997

Copernicus Sentinel 3: SLSTR

The first Sea and Land Surface Temperature Radiometer (SLSTR) was launched on Sentinel 3A on 16thFebruary 2016.

S3B launched on 26 April 2018

Dual-view self-calibrating radiometer following the **Copernicus Sentinel 3: SLSTR**

Products

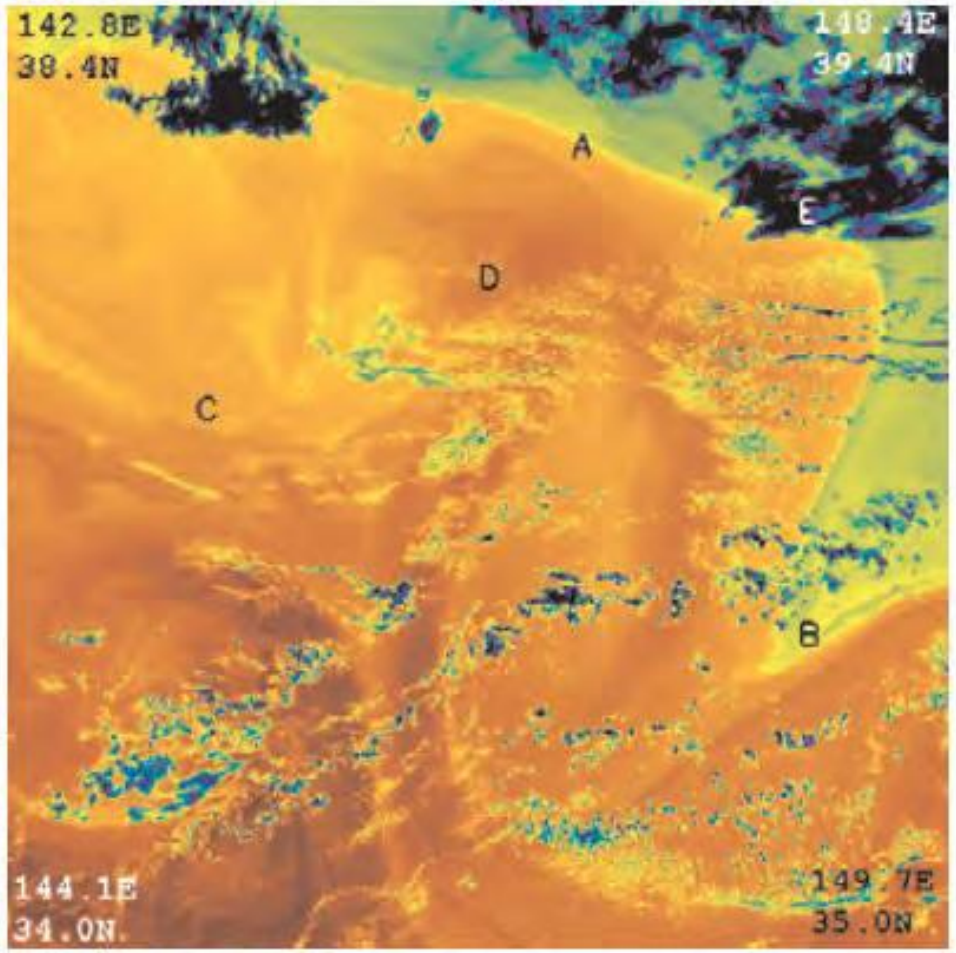
RBT: This product provides TOA radiance and brightness temperatures.
Available to all via ODA (FTP), EUMETCAST (DVB), CODA (http) and Data Centre (Archive)

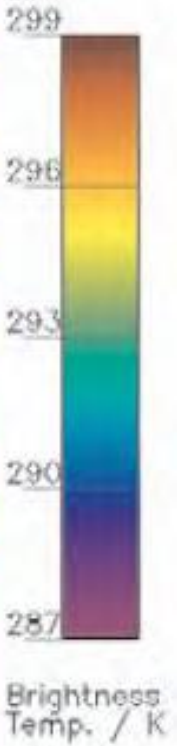
WCT: This product provides sea surface temperature for all offered retrieval algorithms.
Only available to Cal/Val users via ODA (FTP) and Data Centre (Archive)

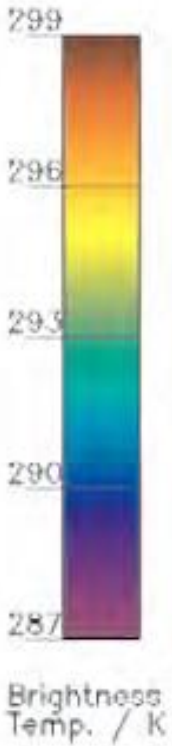
WST: This product provides the best SST at each SLSTR location in GHRSST L2P format.
Available to all via ODA (FTP), EUMETCAST (DVB), CODA (http) and Data Centre (Archive)

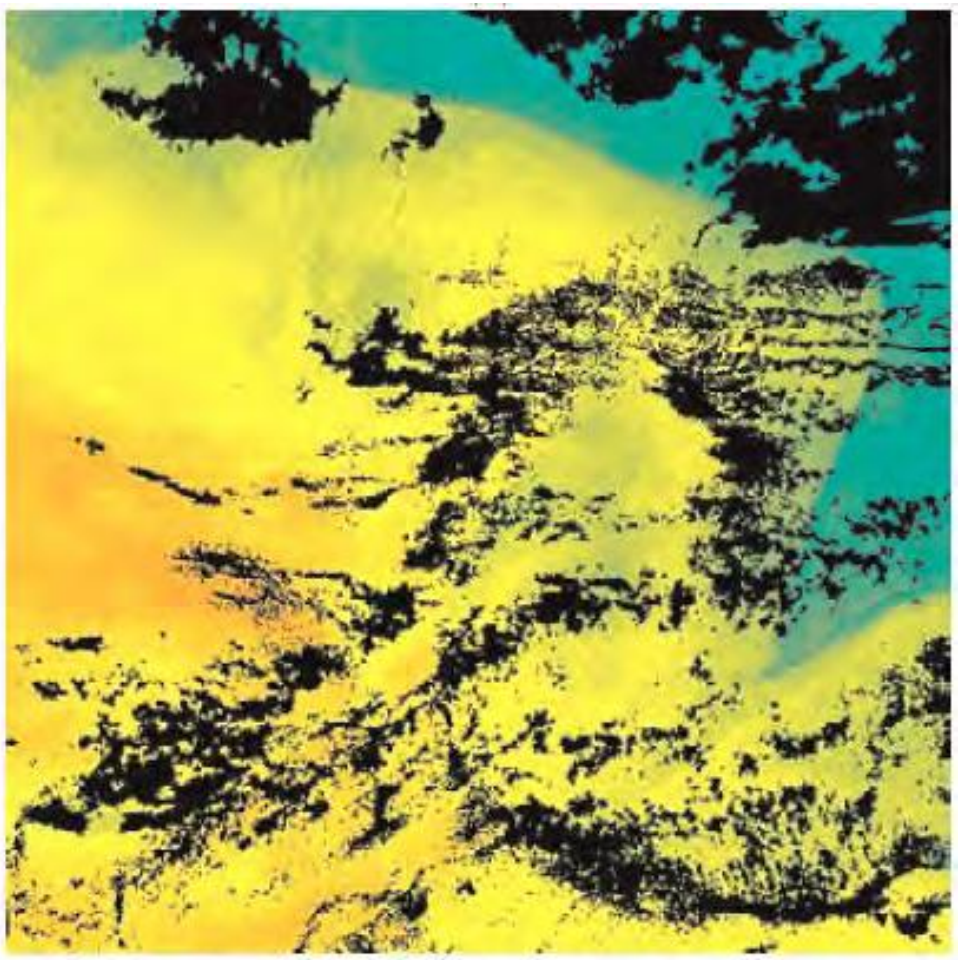
CLOUD MASKING

Example of the 1 km imagery, with SST thermal features and atmospheric effects



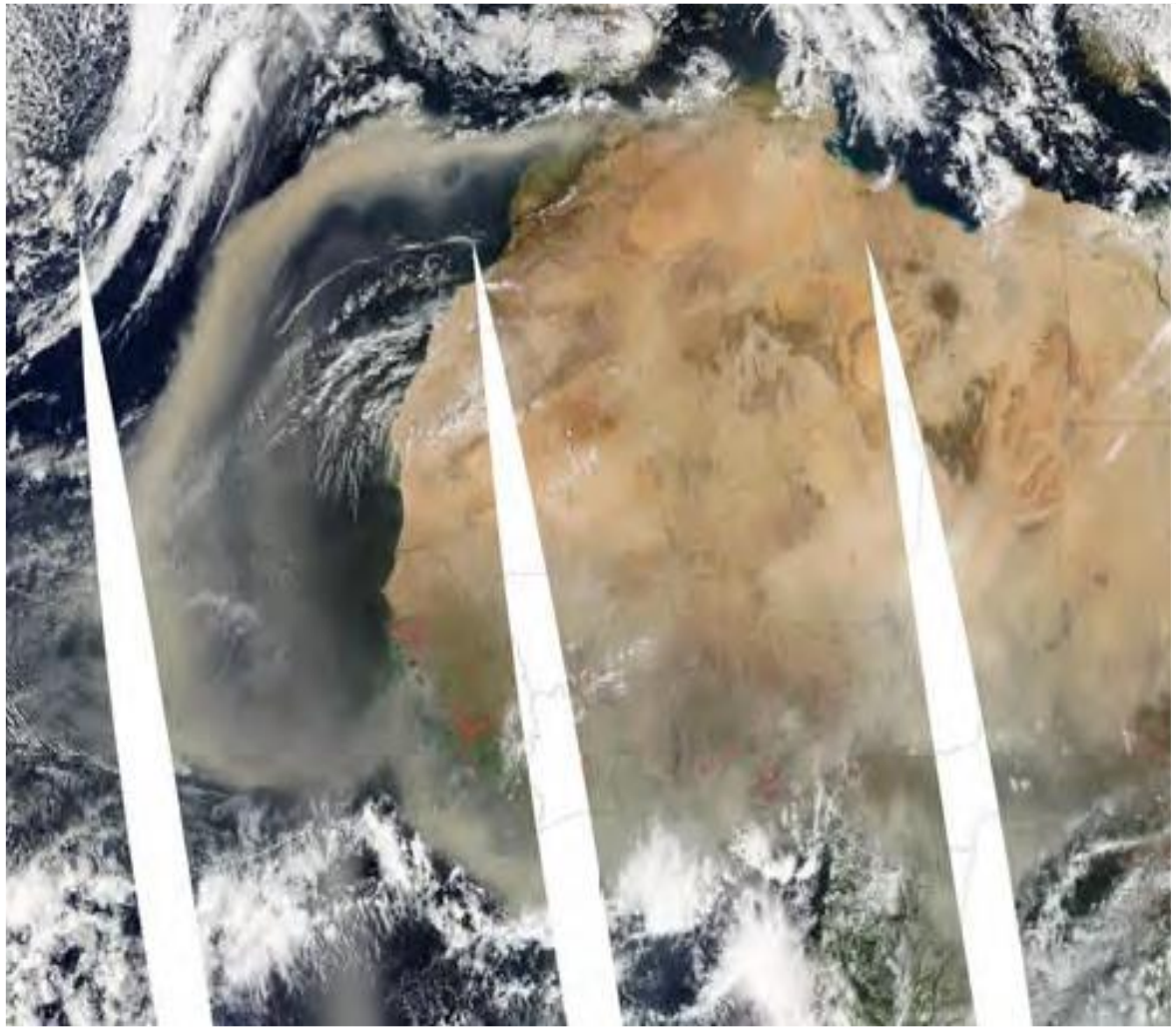


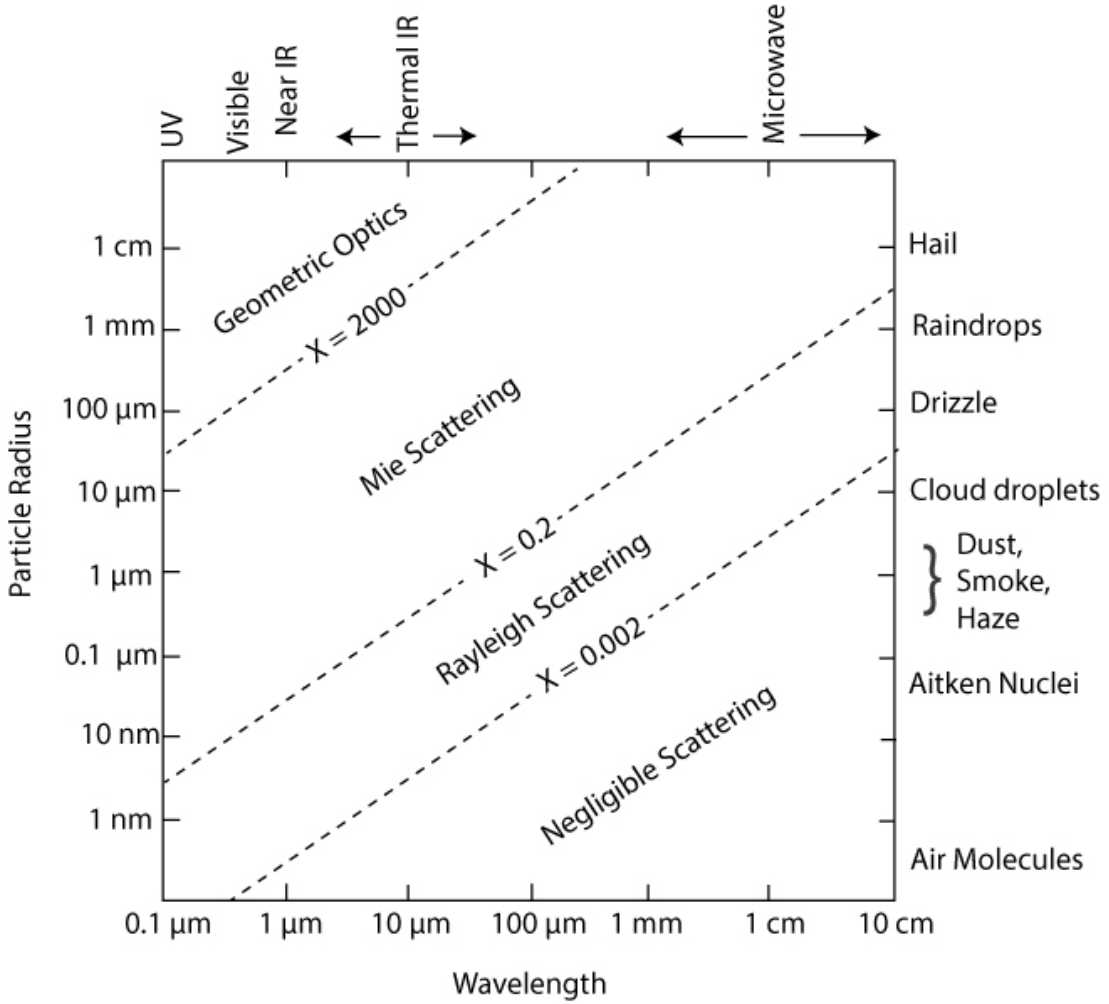




Cloud Detection –very important!

Effect of Aerosols on SST





SST Retrieval

Split window SST equation

$$SST = T_{11} + m(T_{11} - T_{12}) + c$$

Landsat 8

SST = BT10 + (2.946*(BT10 - BT11)) - 0.038

BT10 is the brightness temperature value (°C) Band 10
BT11 is the brightness temperature value (°C) Band 11

SST Retrieval

Copernicus Sentinel 3 SST

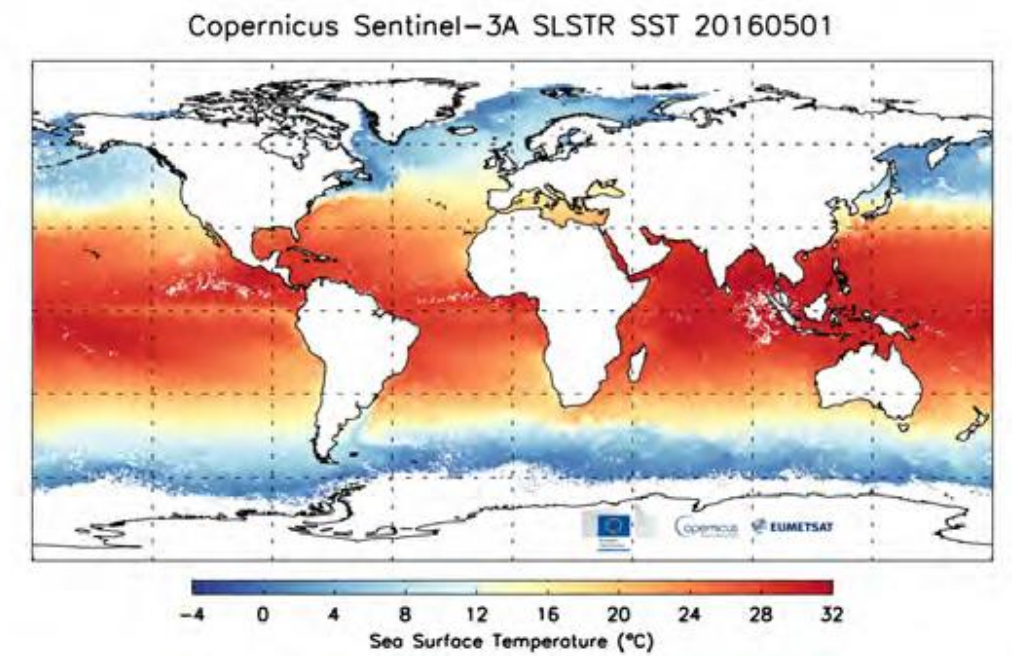
SST Retrievals by radiative transfer modelling of the form:

$$a_0 + \sum_{1}^{n} a_n BT_n$$

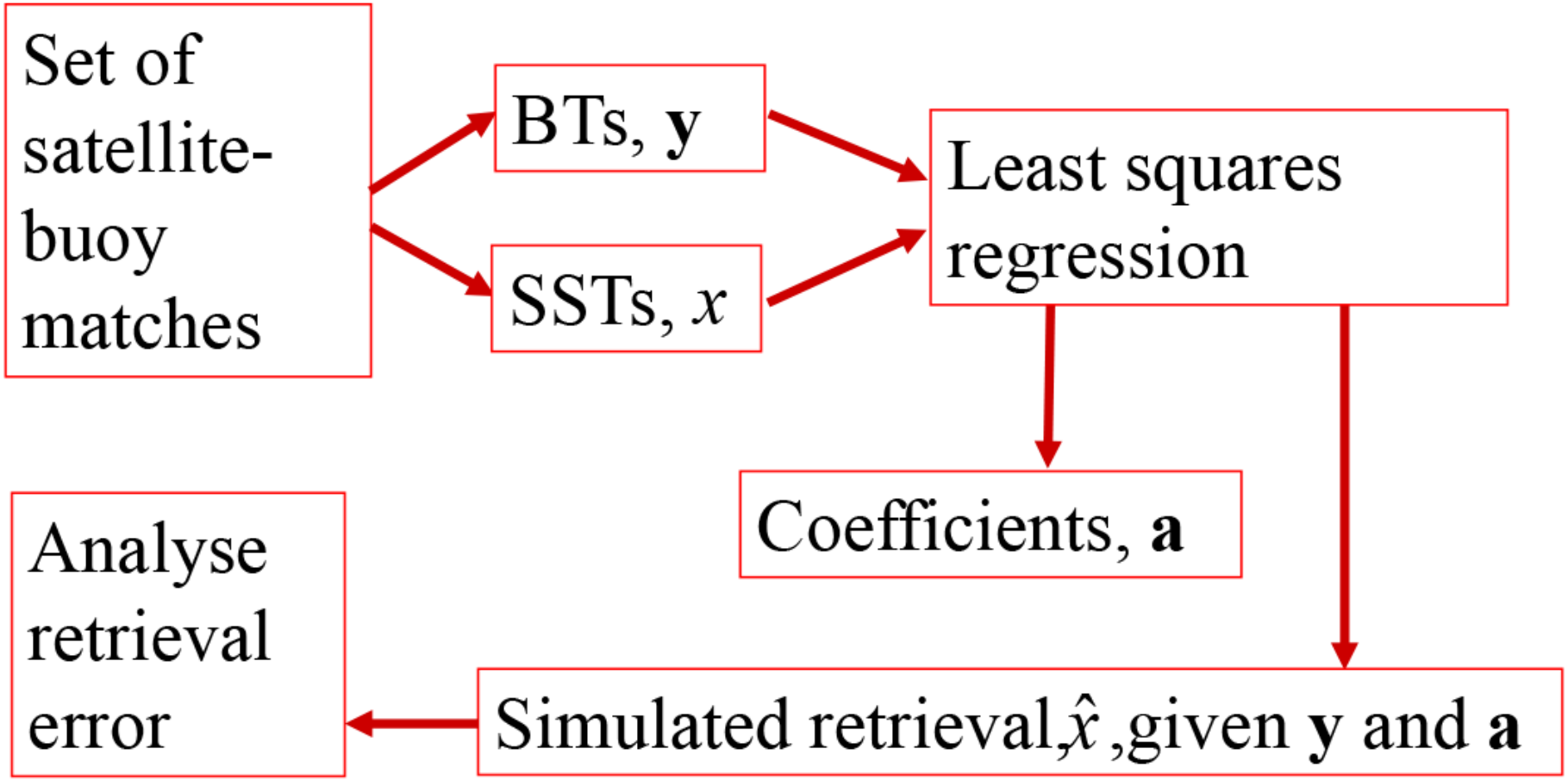
where n is the number of channels
For SLSTR:

- 2 channels during day
- 3 during night

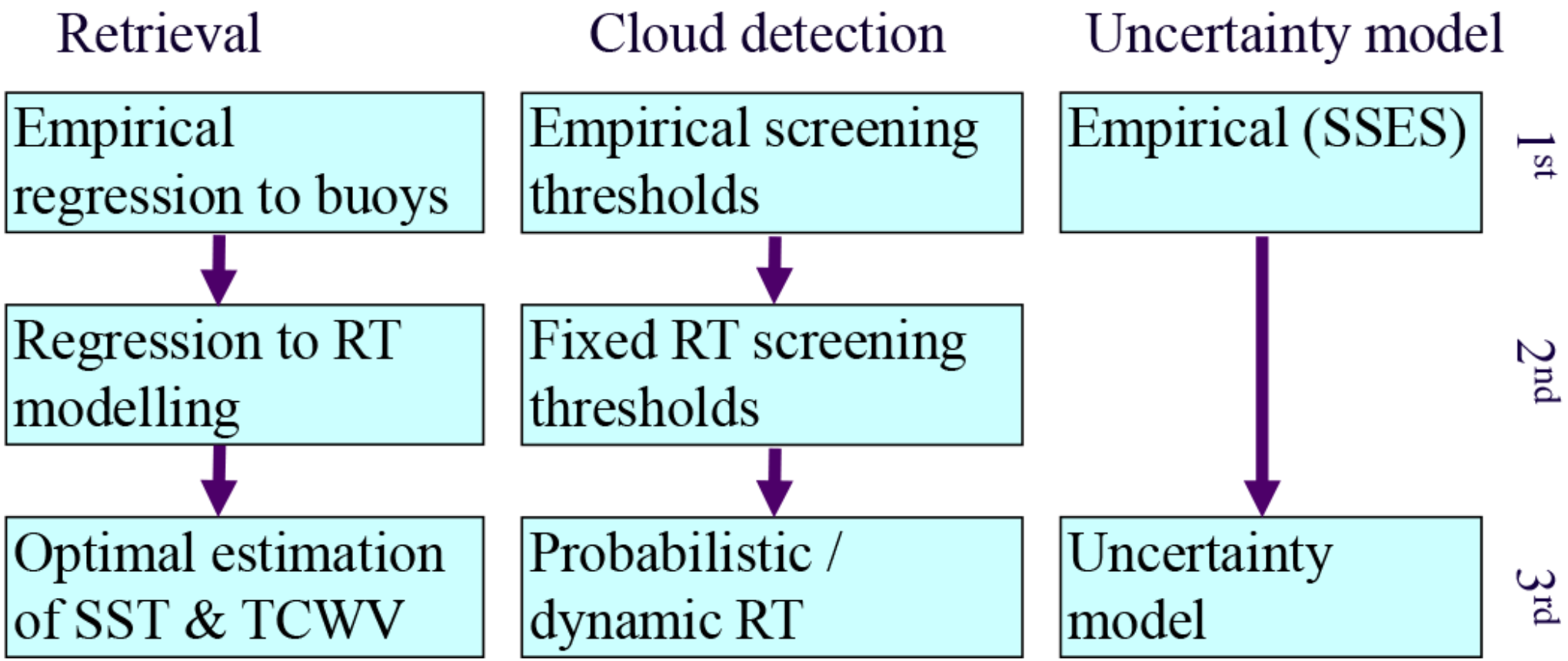
3.7 μm not used during day owing to solar contamination
so there are four SST retrievals in total



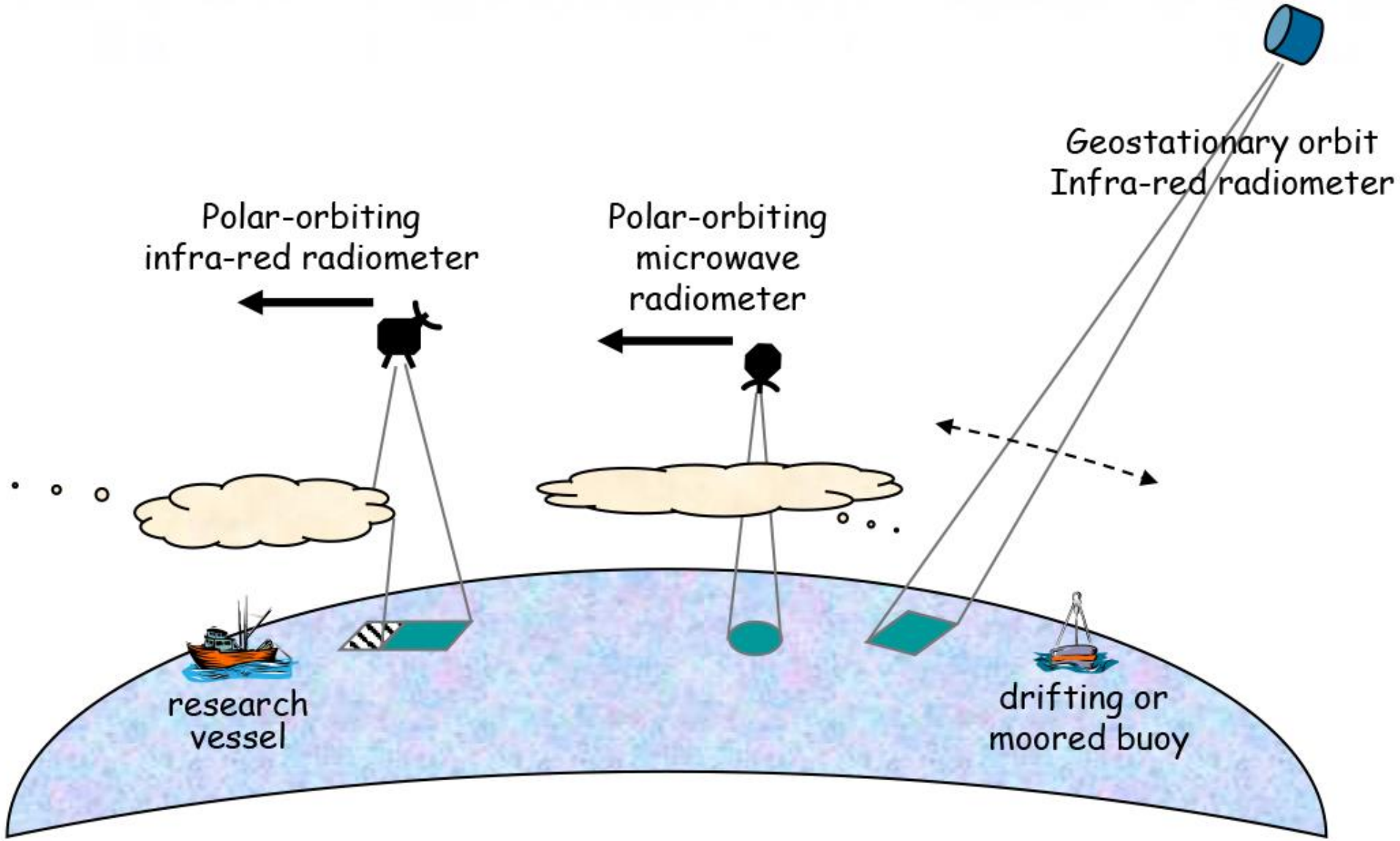
SLSTR SST retrieval



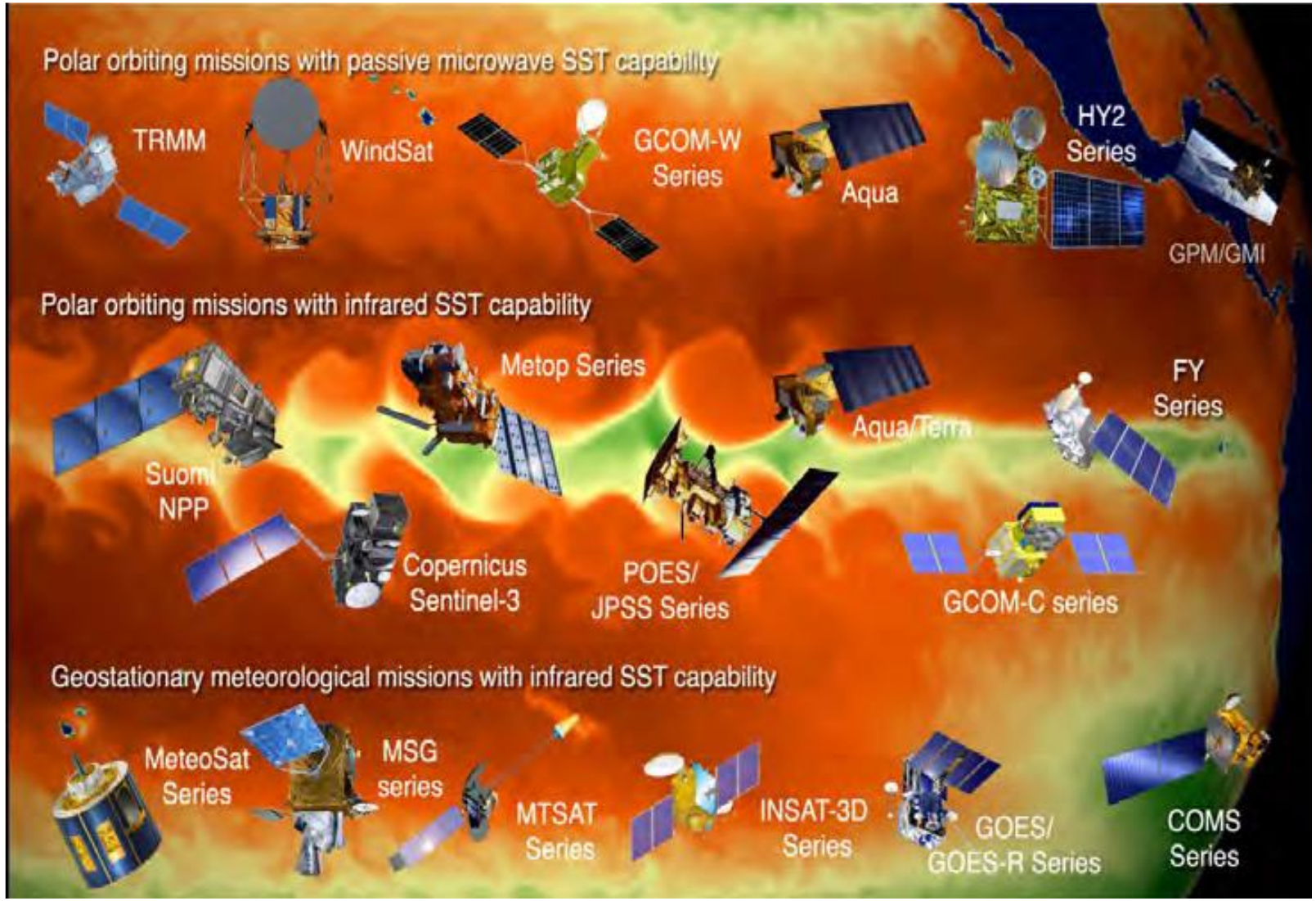
SST Retrieval



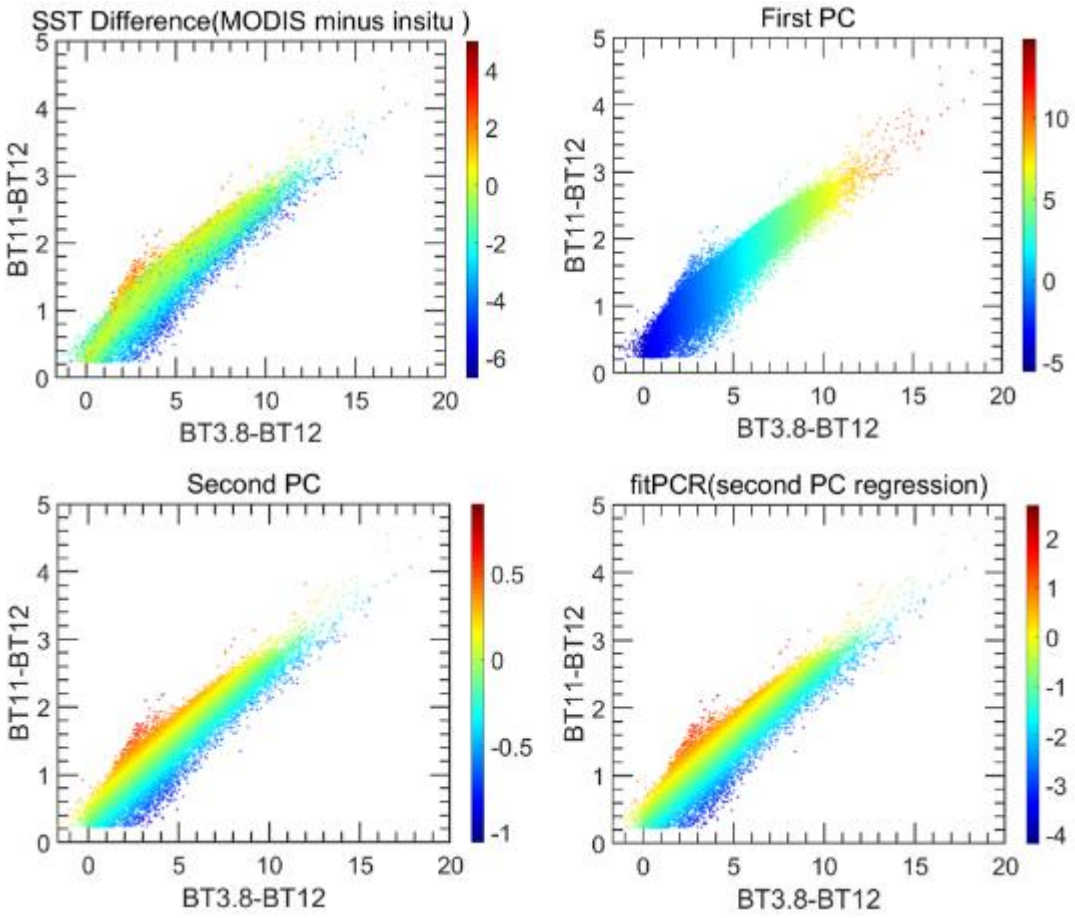
Platforms for measuring SST

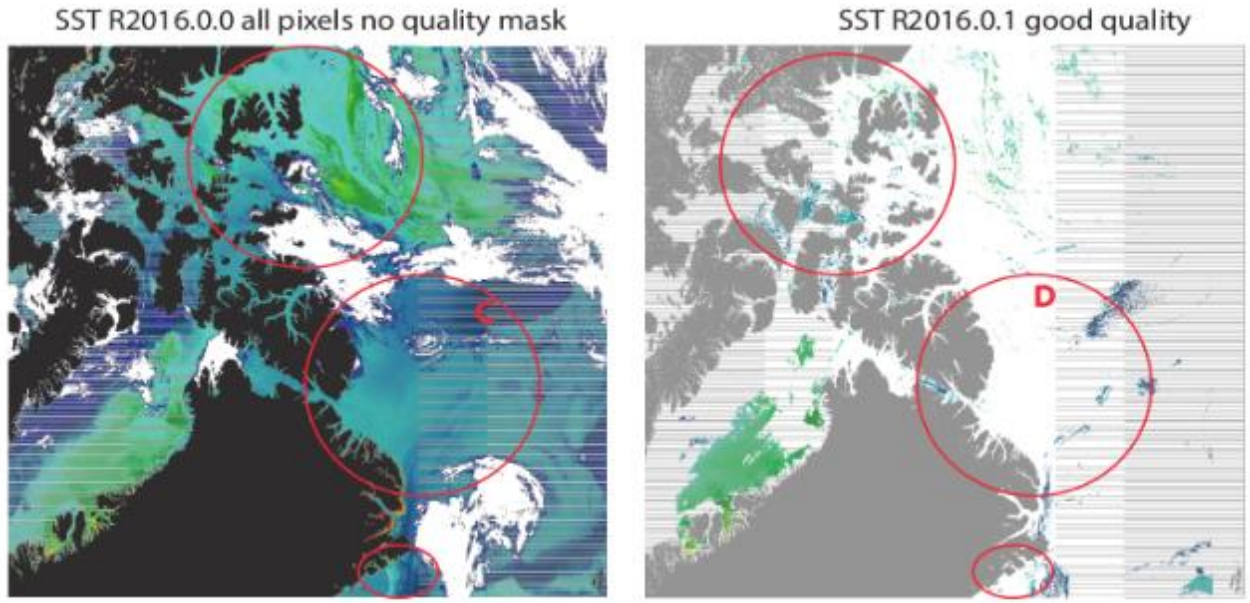


Platforms for measuring SST



NASA Standard SST Products





https://oceancolor.gsfc.nasa.gov/atbd/sst/

Thank You