Ice Surface Temperature activities at MET Norway and DMI

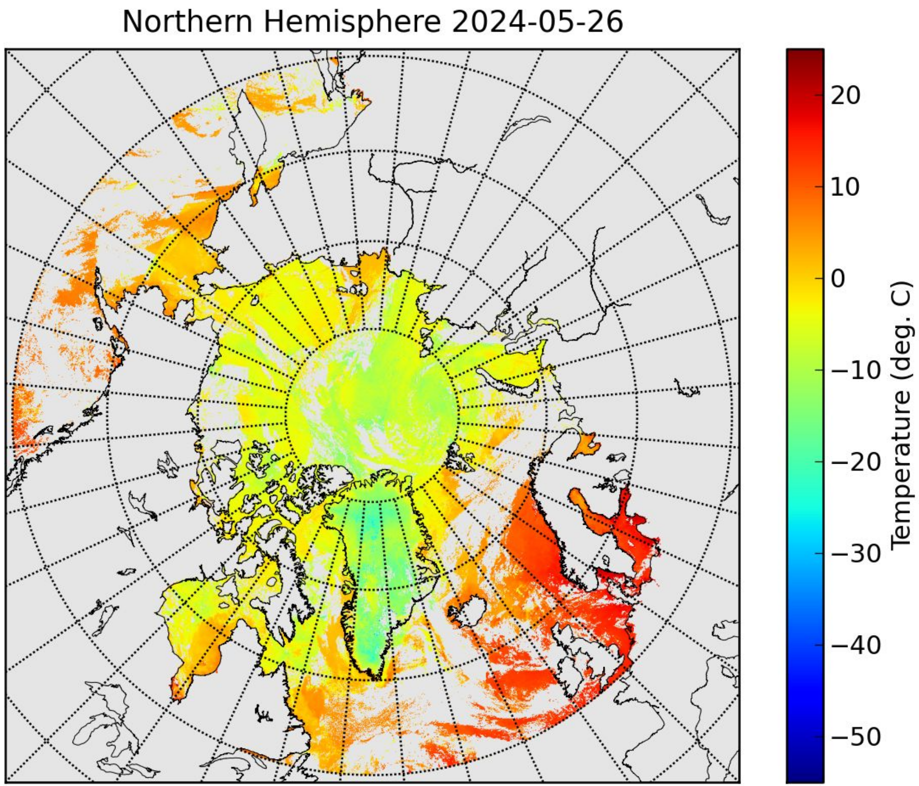
Steinar Eastwood, MET Norway
Gorm Dybkjær, DMI

Overview

- Range of IST-SST products at DMI and MET Norway
- Latest advances in IST retrieval:
- Cloud masking
- Temperature algorithm
- Validation of IST
- IST monitoring and climate perspective - decay of polar sea ice extent

Range of IST-SST products

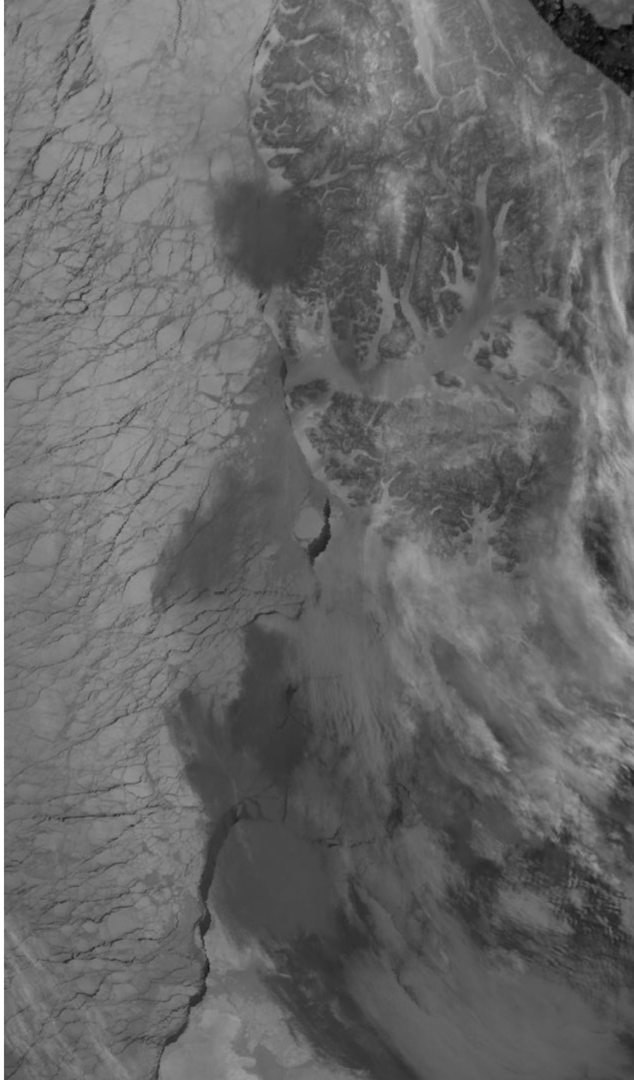
- Both IST and SST delivered to provide seamless surface temperature field
- NRT L2 and L3 from OSI SAF using AVHRR and VIIRS
- NRT L2 and L3 from EUMETSAT using Sentinel-3
- AASTI CDR + ICDR L3 (and L2 on request) from DMI/MET and Copernicus C3S using AVHRR GAC (1982-present)
- L3/L4 NRT/reprocessed from Copernicus Marine



2024-05-26 METOP-B IST+SST 24h of L2

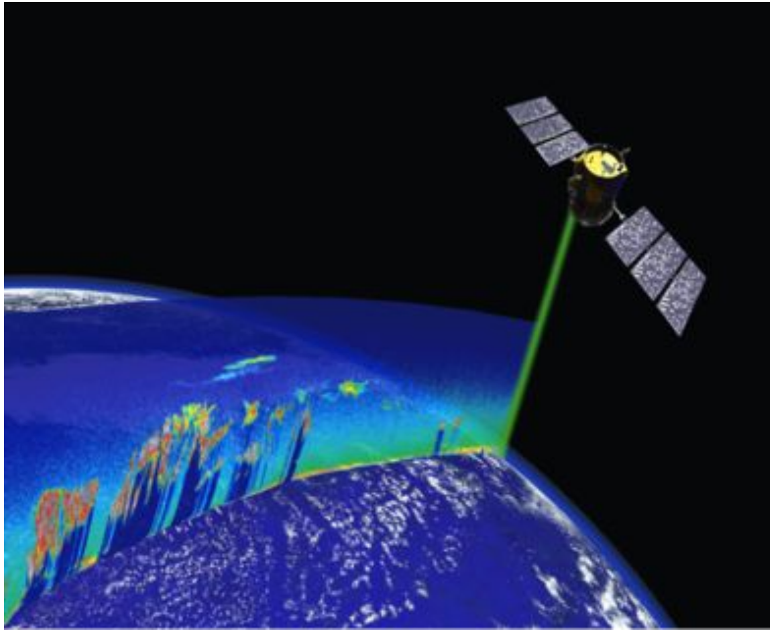
Cloud masking

- SST: usually good contrast both in visible and infrared between surface and cloud
- IST: ice surface is similar as clouds in visible brightness and for infrared the surface can even be colder than overlying clouds
- Hence cloud masking is more challenging over ice, especially at night



How good is the cloud mask?

- Cloud mask: PPSv2021 from EUMETSAT NWC SAF, including cloud probability
- Use Caliop cloud lidar from Calipso satellite to validate these cloud products
- Caliop detects presence of clouds and aerosols in multiple levels
- Have validated cloud products for Sentinel-3 in Sci4MaST project over the Arctic
- Future: Calipso -> EarthCare (ESA)



How good is the cloud mask?

Validation scores for SLSTR, VIIRS and AVHRR over polar sea (ice+water)

AVHRR+VIIRS from NWC SAF, SLSTR from Sci4MaST project

CALIOP against CMa + CMaProb	BIAS %	HR	K	POD-cloudy %	POD-cloudy Filt 0.2	FAR-cloudy %	POD-clear %	FAR-clear %	N
SLSTR-A + SLSTR-B nadir									
sea_day	5.41	0.87	0.74	95.7	97.3	7.29	78.2	13.8	58209
sea_night	3.44	0.70	0.42	80.7	83.6	18.9	61.5	39.1	42981
sea_twilight	10	0.79	0.39	92.5	93.4	16.2	46.4	32.7	48829
S-NPP VIIRS (from PPS v2021 validation report)									
sea_polar_day	1.1	0.94	0.81	97.0	97.6	4.3	84.3	11.1	22598
sea_polar_night	-4.6	0.78	0.45	83.0	84.8	11.7	61.5	49.1	23913
sea_polar_twil	2.3	0.86	0.50	92.4	93.1	10.1	57.7	34.8	19761
NOAA-18 GAC AVHRR (from PPS v2021 validation report)									
sea_polar_day	-5.8	0.87	0.71	87.9	93	5	83.4	34.1	16866
sea_polar_night	-10.3	0.76	0.49	77.3	82.8	10.5	71.8	49.5	19990
sea_polar_twil	-3	0.83	0.48	87.6	91.1	9	60.8	47.9	11427

What does the cloud probability add?

Validation scores for SLSTR over sea ice and polar water

Binned in cloud probability ranges (0-5%, 6-10%, …)

From Sci4MaST project

CALIOP against CMa+CMaProb for different subset	Day			Night			Twilight		
	POD-clear	FAR-clear	N	POD-clear	FAR-clear	N	POD-clear	FAR-clear	N
ice_prob_5	97.3	10.5	6881	99.5	35.6	1341	96.5	27.5	1231
ice_prob_10	90.4	27.3	443	99.7	36.2	2418	99.4	41.6	1193
ice_prob_15	87.9	35.9	286	99.5	36.6	2067	99.5	36.3	973
ice_prob_25	87.6	45.6	322	98.0	39.9	3309	97.2	32.3	1643
ice_prob_50	74.8	42.2	749	96.0	43.8	5415	91.1	38.6	3235
ice_prob_100	29.4	57.1	17826	75.9	51.3	23090	67.5	44.6	20542
water_prob_5	97.2	8.6	5046	100.0	0.0	74	98.1	2.9	319
water_prob_10	73.6	35.0	187	100.0	2.0	50	98.6	8.8	164
water_prob_15	82.1	45.8	89	93.2	2.4	46	80.2	8.3	118
water_prob_25	54.7	60.3	135	85.4	14.6	66	79.5	20.5	175
water_prob_50	56.7	50.5	231	62.5	21.9	197	71.3	17.7	450

IST algorithm

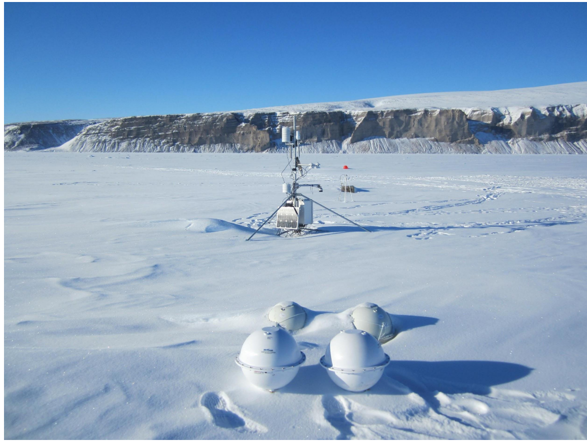
- Using classical split window algorithm:

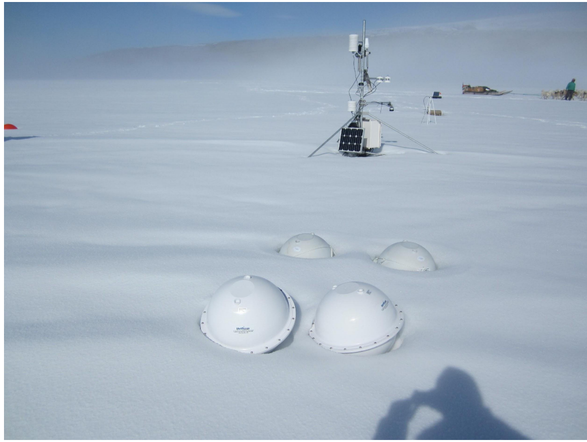
$$IST = a_0 + a_1 TB_{11} + a_2 TB_{12} + a_3((TB_{11} - TB_{12})(\sec\Theta - 1))$$

- Since IST covers a large range of temperatures, the algorithm was first set up with coefficients for 3 temperature intervals
- Now we are planning to replace this with only set of coefficients since validation shows that 1-range algorithm perform as good as 3-range

Validation of IST

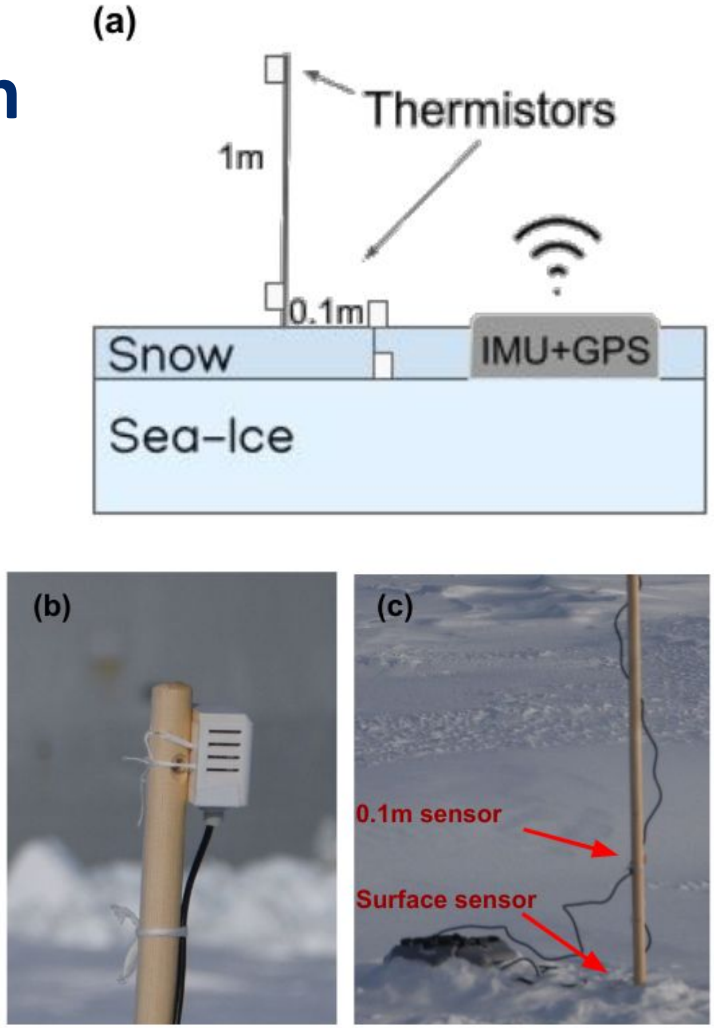
- Difficult to get good in situ validation data from sea ice
- Need observation of the skin, as the subskin/snow temp can be very different from skin





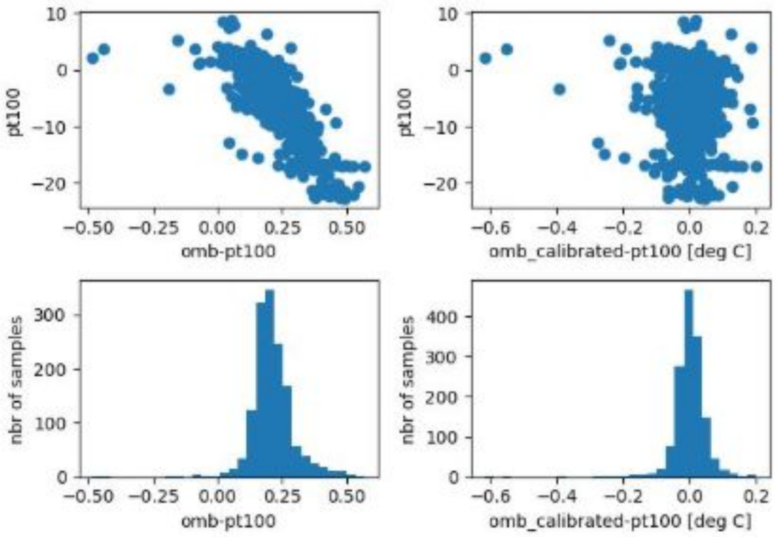
Svalbard MIZ April 2024 Campaign

- Campaign to observe and better understand the complex interplay between atmosphere, waves, and sea-ice in the winter Marginal Ice Zone
- Observations included OpenMetBuoy with four thermistors
- 34 of these buoys were deployed on the ice flows from a coast guard ship



Svalbard MIZ 2024 Campaign

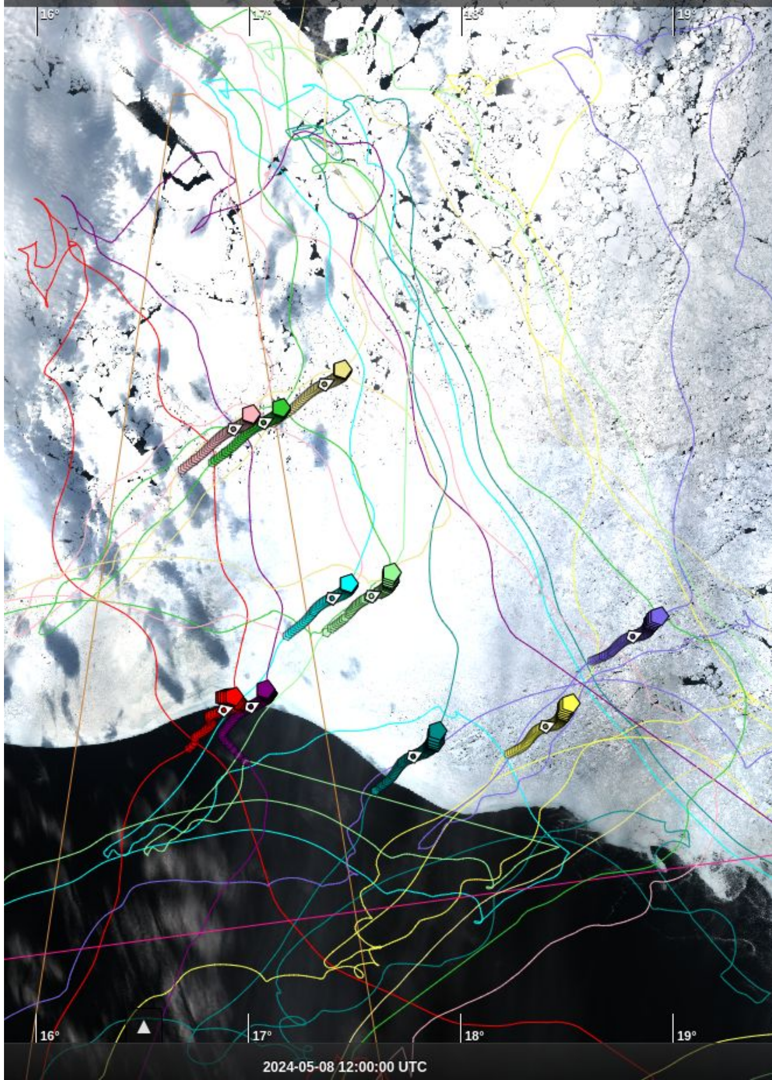
- All thermistors were calibrated before the campaign against a reference sensor (PT100)
- Calibration after campaign is difficult, as instruments disappear in the ice
- Accuracy for calibrated thermistors are typically slightly below +/- 0.1 C



Svalbard MIZ 2024 Campaign

- Very dynamic region with ice breaking up and drifting
- Some buoys did not stay long on the ice before they ended up in the water
- But some buoys provided more than one month of data
- Next step is to collocate these observations with the satellite IST products for validation
- To be continued…

Sentinel-2 + buoy trajectories

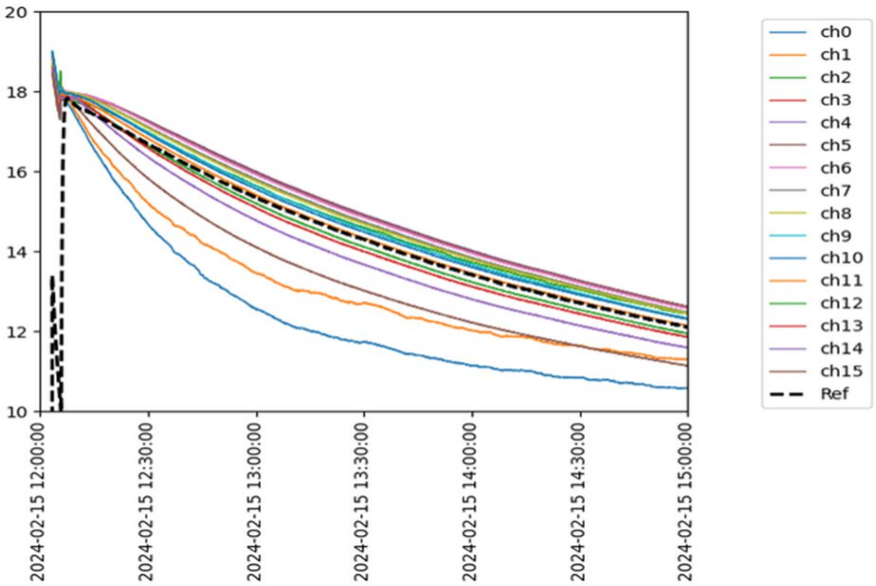


TRUSTED - in situ IST instrument

- Development of a high quality sea ice buoy for surface temperature measurements
- Cost efficient and easy to deploy design
- Specifications and requirements defined by DMI, SHOM and NKE
- Prototype has been developed (NKE, January 2024)
- Testing and CalVal activities on-going in cold calibration rooms (SHOM and DMI)

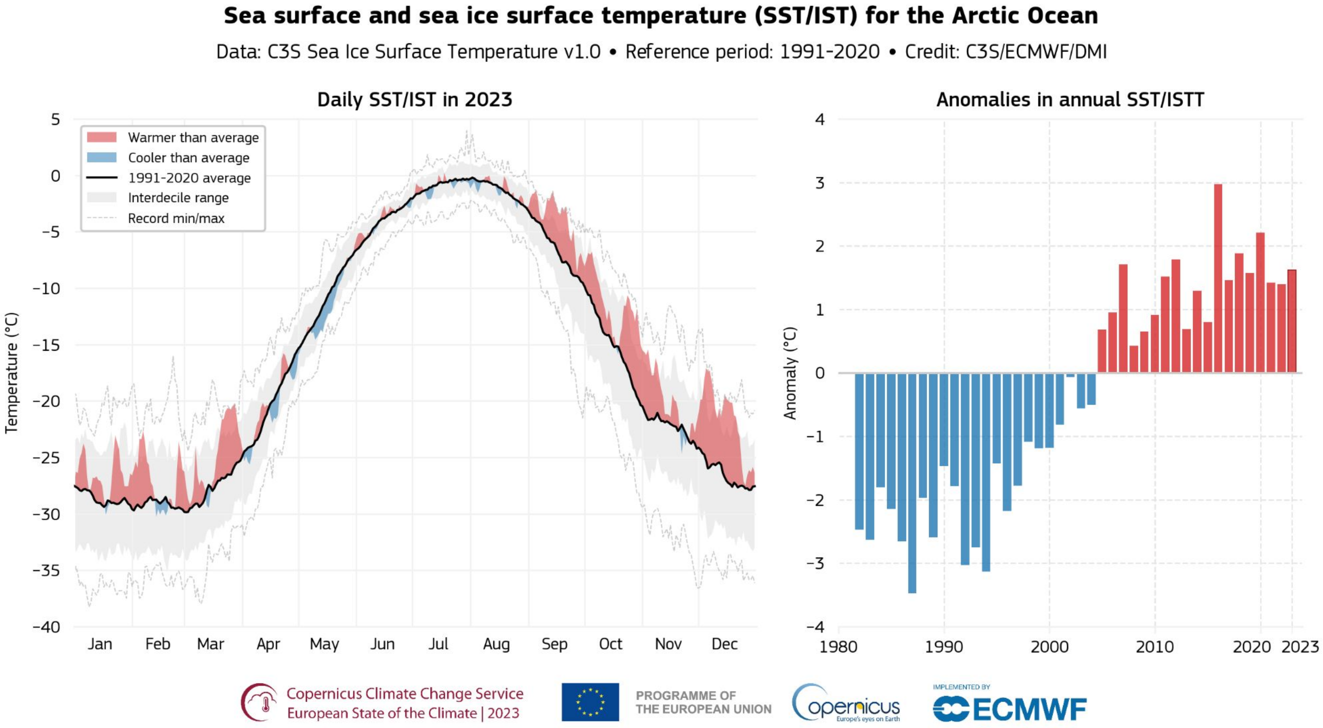
TRUSTED - in situ IST instrument

- 16 thermistors on a pole with 3 cm separation
- Calibration is ongoing



Climate Indicators

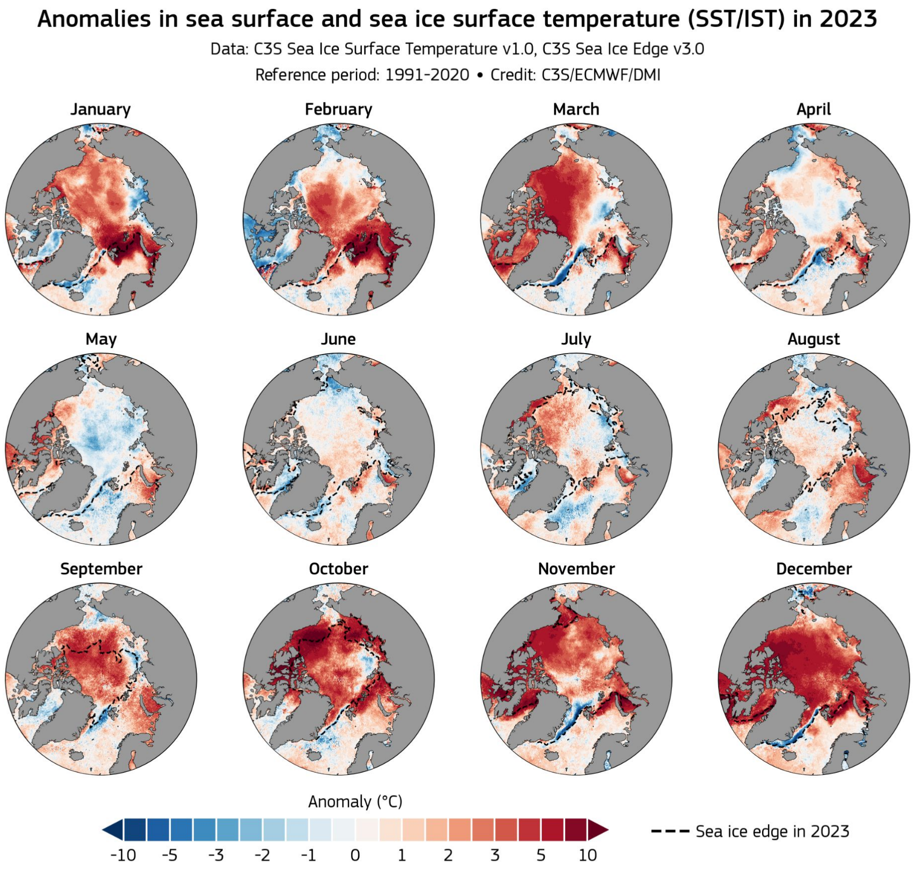
Mean temperature anomaly 2023 and trend above the Arctic circle



Climate Indicators

Geographically distributed surface temperature anomaly 2023

All available from the European State of the Climate reports
https://climate.copernicus.eu/ESOTC



Summary

IST activities:

cloud masking, algorithm, validation and climate indicators

Thank you for your attention

Extra slides

Climate Indicators

Coupled indicators

Sea ice surface temperature vs sea ice extent