A Significant In-Situ Diurnal Warming Event in the Labrador Sea Obscured to Satellite Observations

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Access abstract

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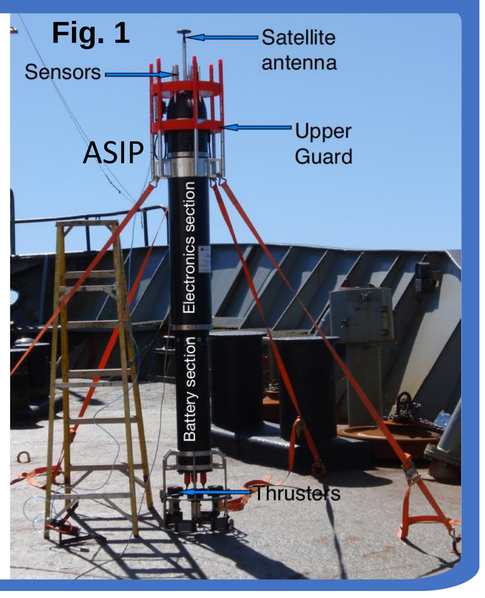
Introduction

- Under conditions of high shortwave radiation (SWR) combined with low wind speed, the sea surface temperature (SST) can increase significantly.
  → Diurnal warming (DW)
- DW has been well described using satellite and in-situ observations, but very few reports at northerly latitudes.
- Observations of a DW event of 1.5°C confined to the upper 2m in the Labrador Sea were conducted with an upwardly-rising microstructure profiler.
  → Air-Sea Interaction Profiler (ASIP, see Fig. 1)



Results: Obscured to Satellite Observations

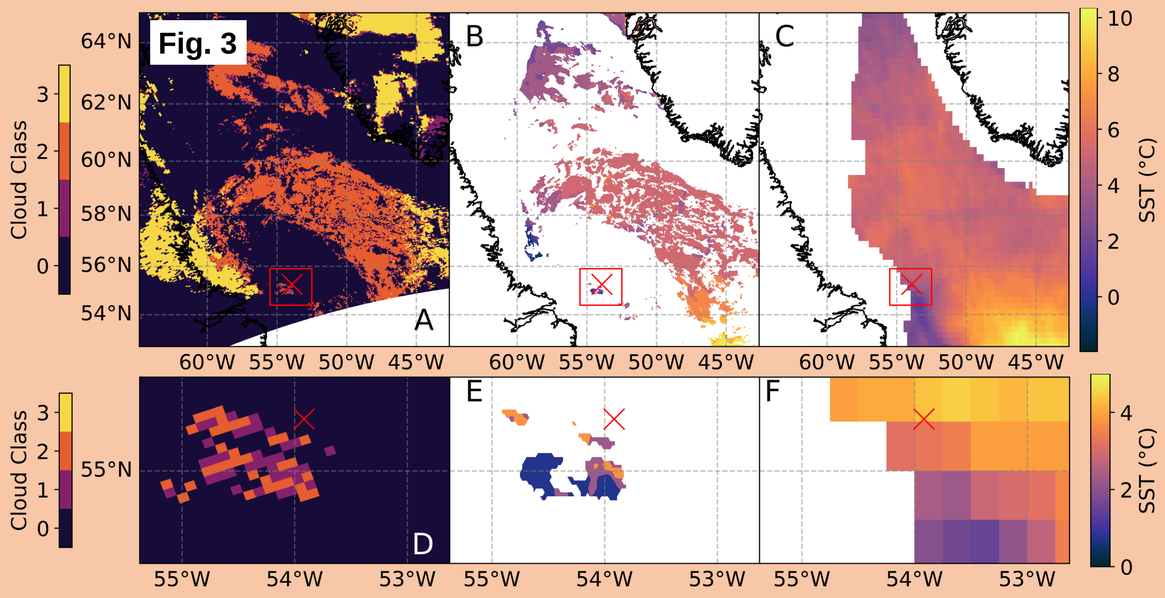
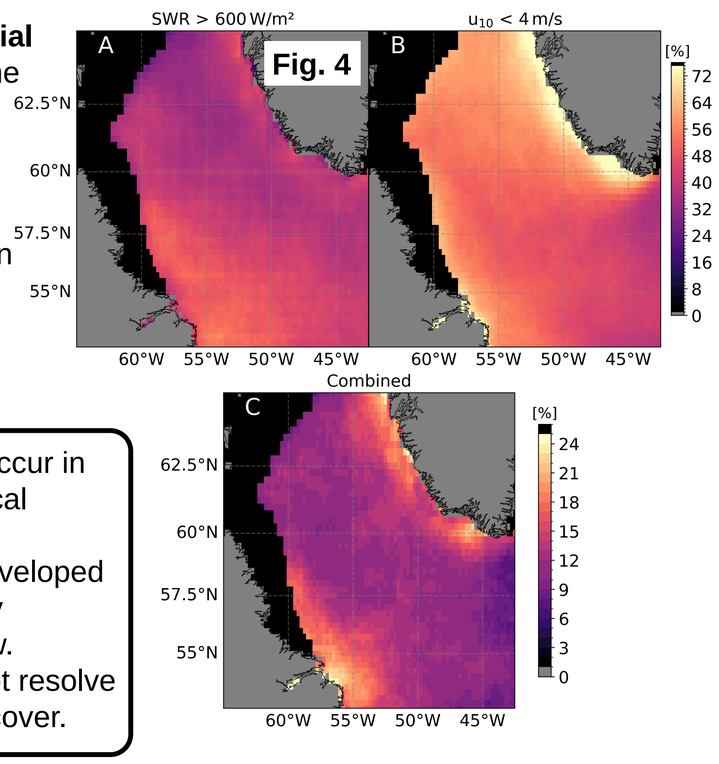


Fig. 3: Satellite Observations for the Labrador Sea on 23 May 2010
A Aqua MODIS cloud mask. The cloud classification assigns the following categories: 0-Cloudy, 1-Uncertain, 2-Probably Clear and 3-Confident Clear.
B Aqua MODIS Level-3 SST data.
C Aqua AMSR-E Level-3 SST data.
The red cross indicates the ASIP measurement position at (55.3°N, 53.9°W).
D-F Zooming into to the red rectangles around the ASIP measurement position in A-C.

- Eight instruments on polar orbiting satellites had high-quality SST data available for the Labrador Sea on 23 May 2010.
- None of them contained SST of two consecutive overpasses at the ASIP position.
- GOES-13 (geostationary) had the Labrador Sea in the field of view, but there is no SST data available for 23 May 2010.
- DW amplitude of the event cannot be estimated from satellite observations.

Conclusion

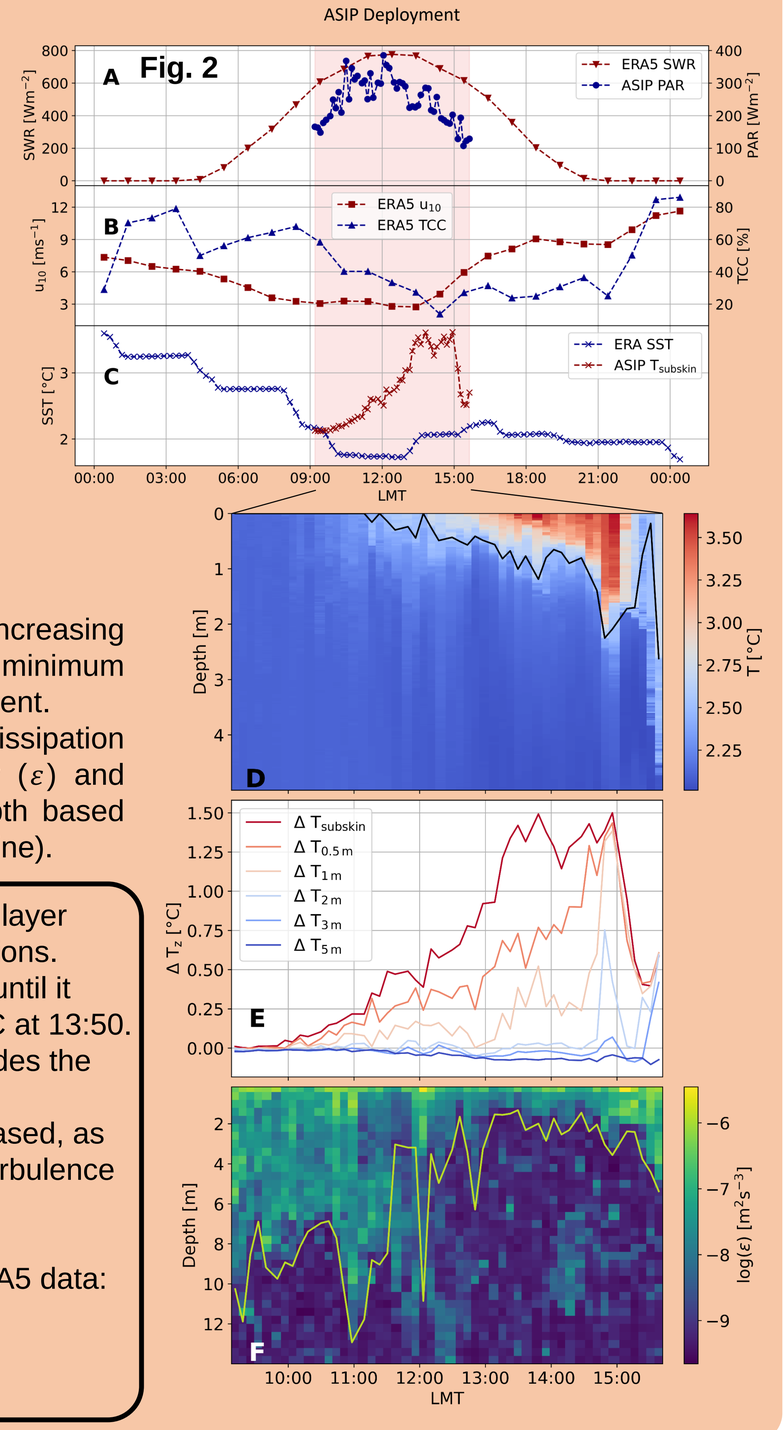
Fig. 4: Diurnal Warming Potential
Percentage of days in June for the years 1979-2019 in which at least for one hour:
A The shortwave radiation was larger than 600 W/m².
B The wind speed was lower than 4 m/s.
C Both conditions were fulfilled.
A-C are based on ERA5 data.



- Localized DW events can occur in the Labrador Sea during local summer, especially in June.
- The observed DW event developed in a spatially and temporally restricted cloud-free window.
- Satellite observations do not resolve the event due to the cloud cover.

Results: Diurnal Warming Event in the Labrador Sea

Fig. 2: Meteorological Conditions at the ASIP position on 23 May 2010
A Shortwave radiation (SWR) from ERA5 and ASIP photosynthetically active radiation (PAR).
B ERA 5 wind speed and total cloud cover (TCC).
C ERA SST and ASIP $T_{Subskin}$, which is the ASIP temperature closest to the surface.
D Temporal distribution of temperature showing the depth of the diurnal warm layer (black line, 2.5°C isotherm).
E Temperature amplitudes at increasing depth levels with respect to the minimum ASIP $T_{Subskin}$ during the deployment.
F Temporal evolution of the dissipation rate of turbulent kinetic energy (ε) and estimate of the mixed layer depth based on the dissipation profile (green line).

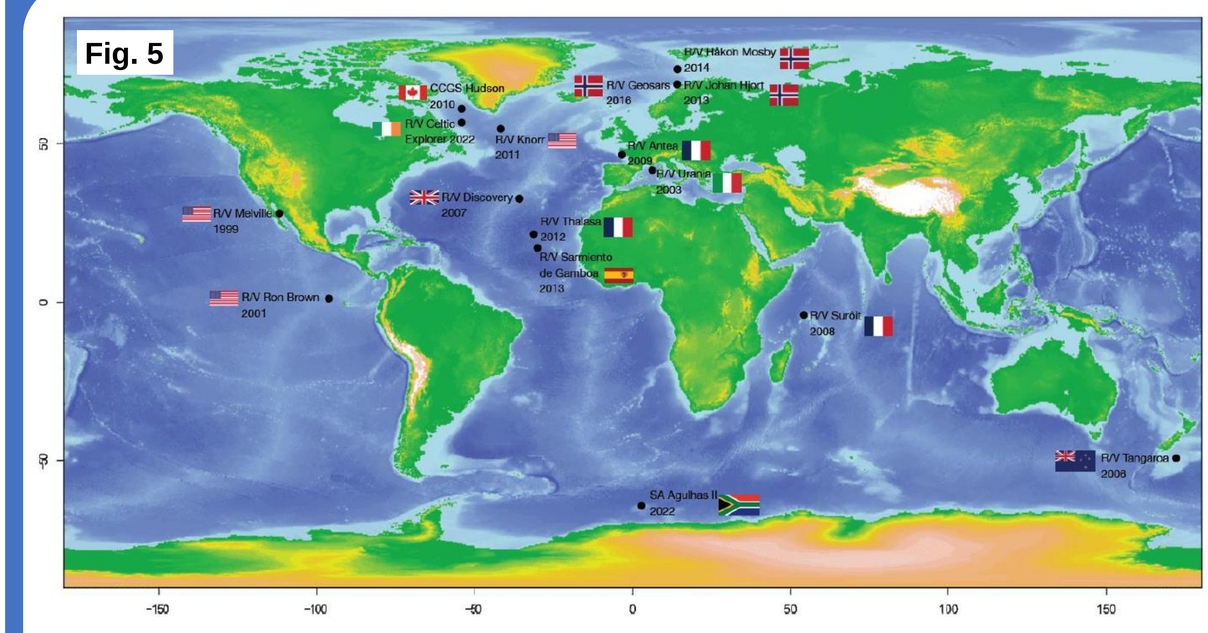


- Start: Well-mixed isothermal layer reflecting prewarming conditions.
- $\Delta T_{Subskin}$ increases steadily until it reaches a maximum of 1.5°C at 13:50.
- At 15:00, a mixing event erodes the stratification.

→ Indicates that the wind increased, as wind is the main source of turbulence in the upper ocean.

- Based on ASIP data and ERA5 data:
  (i) Wind speed < 4 m/s
  (ii) SWR > 600 W/m²
  for the DW event to form.

Outlook: Towards an ASIP Database



- Air-Sea Interaction Profiler (ASIP): Microstructure measurements of the upper 100m of the ocean.
- Equipped with sensors for temperature, conductivity, shear and photosynthetically active radiation.
- Designed to investigate small-scale ocean surface boundary layer processes.
- > 2500 individual profiles from >10 cruises (see Fig. 5).

Summary

- A strong in-situ diurnal warming event was observed in the Labrador Sea.
- This event was not detected by Earth observing satellites, which is the most prevalent detection method.
- Diurnal warming events have the potential to occur more frequently than satellites can observe.
- An Air-Sea Interaction Profiler (ASIP) database is being built.