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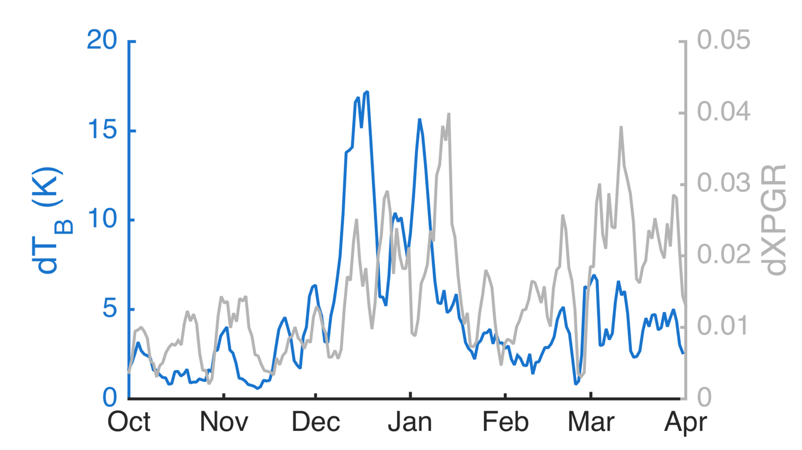
Snowmelt detection on Antarctic sea ice based on passive microwave data

Introduction

The **timing and regional distribution of surface properties** of Antarctic sea ice is crucial for the atmosphere-ocean interaction and characterizes the **mass and energy budgets** of sea ice. Therefore, it is important to map and analyze changes and trends of the related processes and parameters. Since Antarctic sea ice is **covered with snow during most of the year**, inter-annual and regional variations in summer surface melt can be described through the **timing of snowmelt onset**. **So far**, the melt onset was described through the amplitude of diurnal freeze-thaw cycles detected by microwave brightness temperatures using a **fixed threshold**. However, other studies reveal that the **strength of the diurnal variations is differing** between the perennial snowpack characterized by strong snow metamorphism and the thinner and less complex seasonal snow cover.

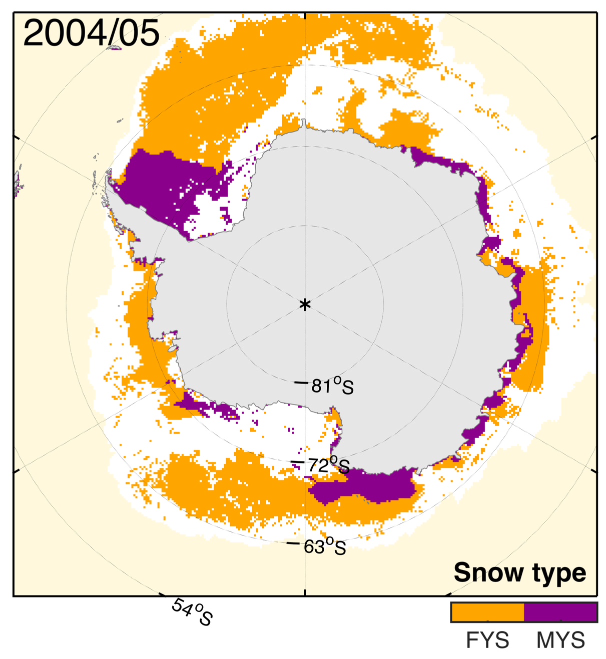
To allow for these **regional and vertical variations** in the snowpack, we present here two complementary approaches to improve the existing melt onset algorithms. Thus, we describe not only **surface melt** but also **subsurface melt processes**.

Melt transition retrieval



Diurnal variations of 37 GHz vertical polarized brightness temperature (dT_B, blue) and cross-polarized gradient ratio (dXPGR, gray) for one exemplary grid cell.

Diurnal variations in brightness temperature $T_{B,37V}$ and cross-polarized gradient ratio XPGR

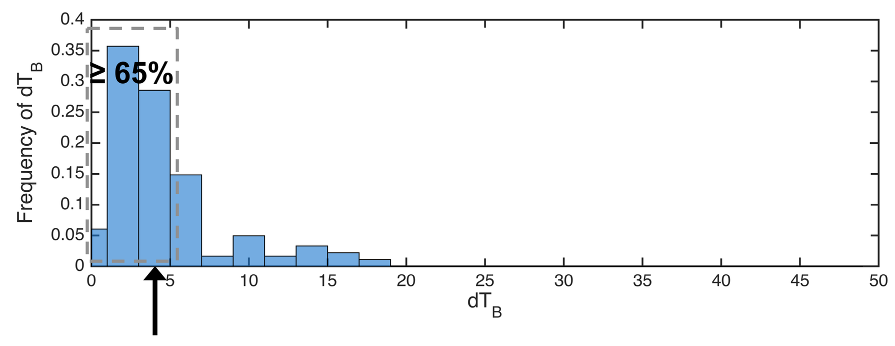


Snow type for austral summer 2004/05 (FYS: first-year snow, MYS: multi-year snow).

Snow type classification

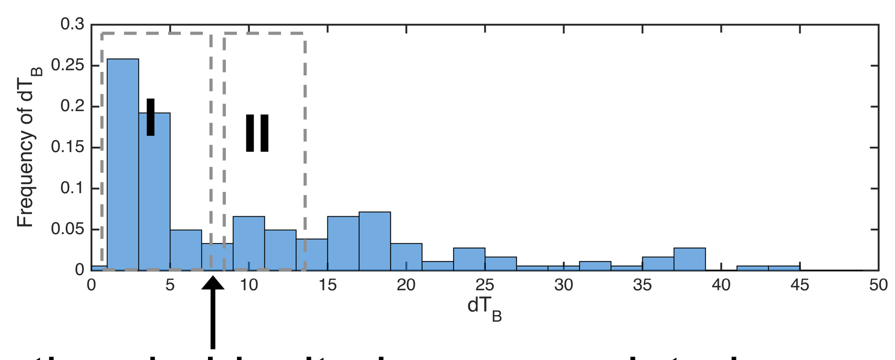
No significant diurnal variations associated with surface melt

Melt characterized by lateral and basal melt, snow evaporation, …



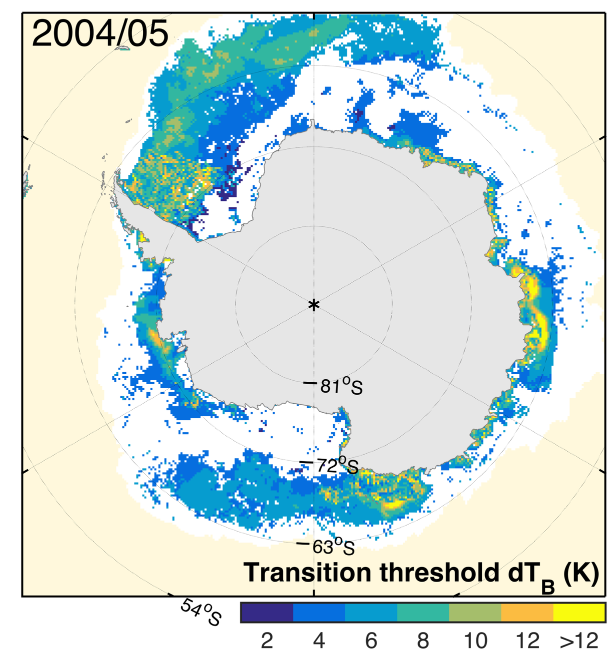
threshold criteria: detection of the first transition between two modes

Seasonal snowpack



threshold criteria: accumulated frequency must be at least 65%

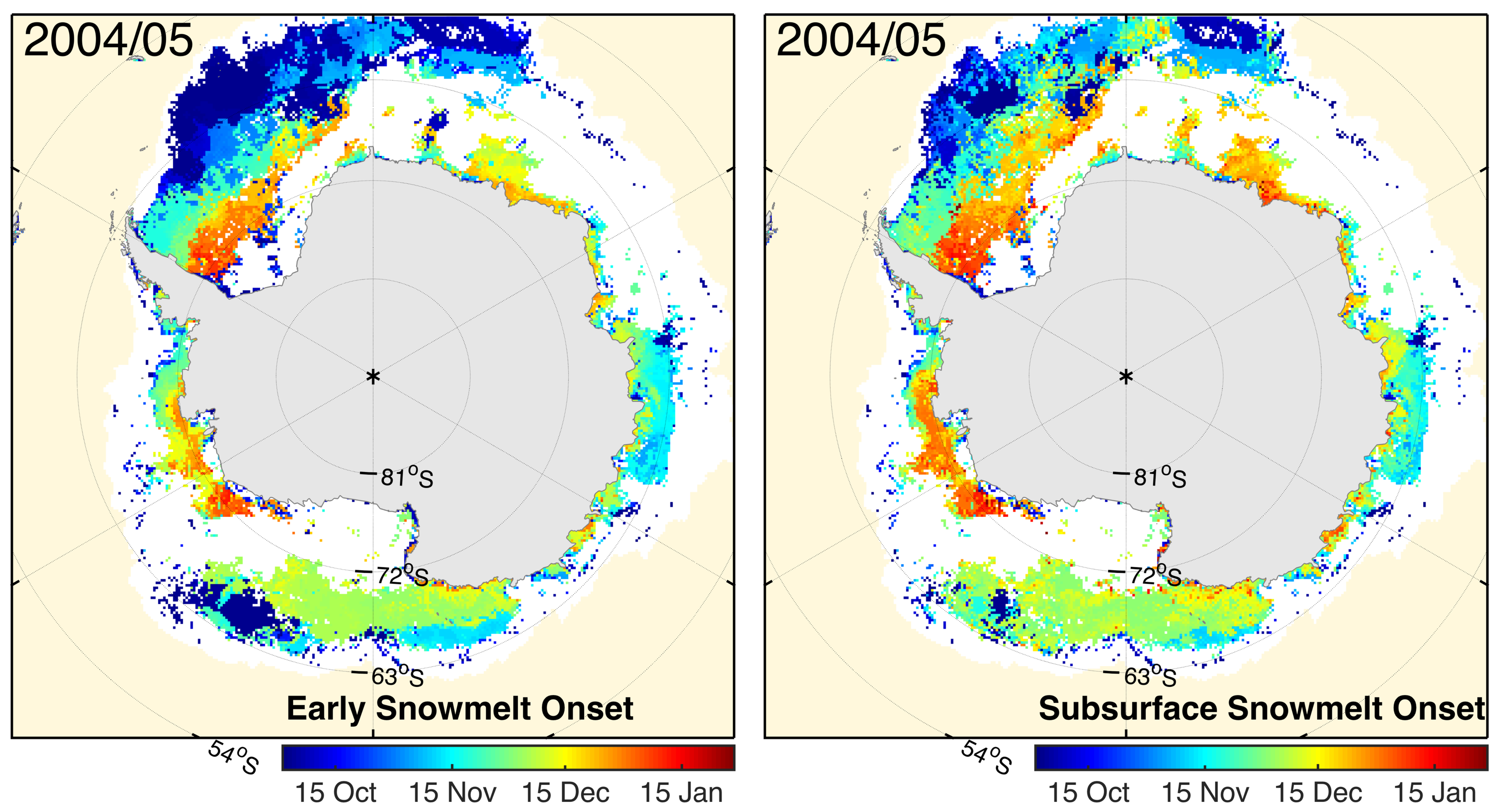
Perennial snowpack



Transition threshold for austral summer 2004/05.

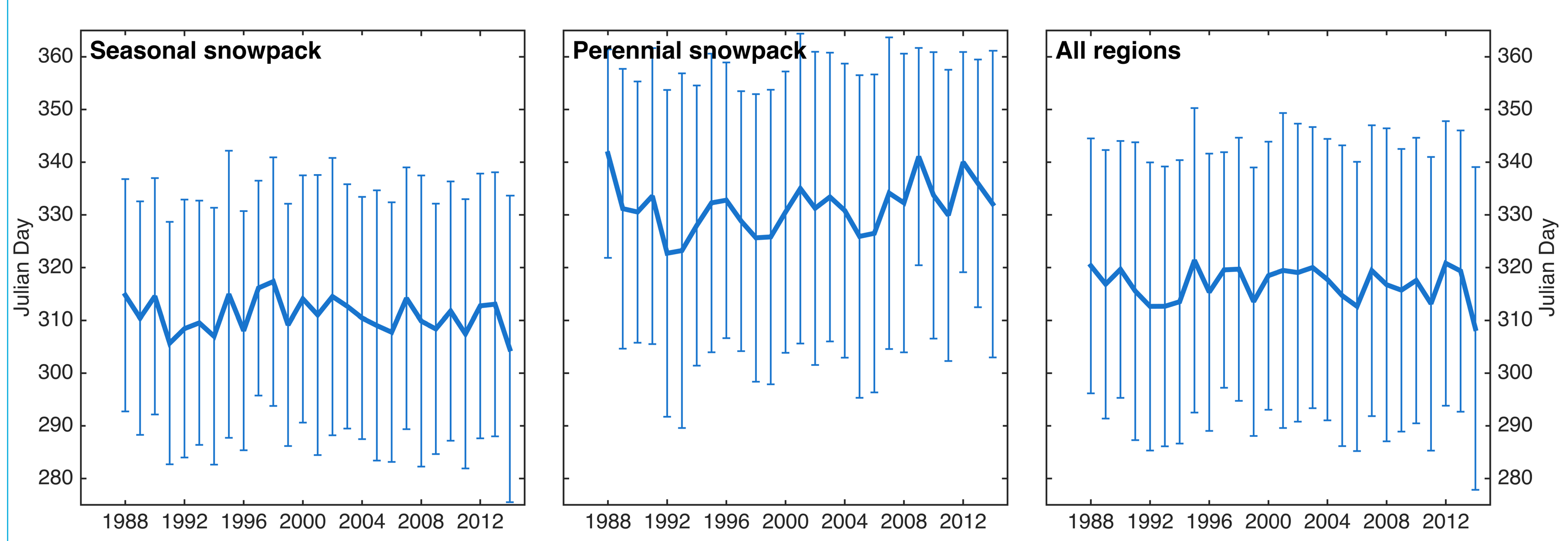
Individual transition threshold

Spatial and decadal variability of snowmelt onset



(left) Early Snowmelt Onset and (right) Subsurface Snowmelt Onset detected from microwave brightness temperature for austral summer 2004/05.

- **One third** of the Antarctic sea ice is characterized by **surface melt**
- Distinct **latitudinal dependence** of surface and subsurface melt



Annual averaged Early Snowmelt Onset and its standard deviation for the time period from 1988/89 to 2014/15.

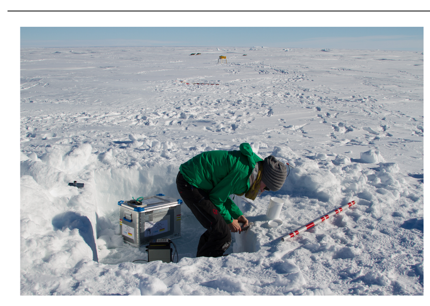
- **No significant trend** from 1988/89 to 2014/15 in snowmelt onset time series

Conclusion and Summary

- **Improvement of existing snowmelt onset algorithms** by
  - Including **snow-age dependence** for dT_B-threshold determination
  - Combination of **different frequencies and polarizations** of T_B to allow for additional description of subsurface melt
- Improved understanding of **temporal and vertical melt evolution**
- Ongoing Antarctic **sea-ice advance triggered less by thermodynamical sea-ice surface** processes but rather by thermodynamical ice-underside and **dynamical effects** (atmosphere, ocean)

Applications of new data set

- **Up-scaling** of Antarctic-wide **mass and energy budgets** in the seasonal cycle
- Seasonal analysis of **habitat conditions** in ice-associated organism
- Application to radar penetration issues to retrieve **sea-ice thickness** and associated ice volume



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