[1] Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Bremerhaven, Germany
[2] Universität Bremen, Germany
[3] Universität Trier, Germany
* stefanie.arndt@awi.de

Stefanie Arndt[1,2*], Sascha Willmes[3], Wolfgang Dierking[1], Marcel Nicolaus[1]

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Regional patterns of snowmelt on Antarctic sea ice based on passive microwave data

Introduction

The better understanding of temporal variability and regional distribution of surface melt on **Antarctic sea ice** is crucial for the understanding of atmosphere-ocean interactions and the determination of **mass and energy budgets** of sea ice. Since large regions of Antarctic sea ice are **covered with snow during most of the year**, observed inter-annual and regional variations of surface melt mainly represent melt processes in the snow. In this study we combine two approaches for observing both **surface and volume snowmelt** by means of passive microwave satellite data. The former is achieved by analyzing diurnal differences of the brightness temperature T_B at 37 GHz, the latter by analyzing the ratio $T_B(19GHz)/T_B(37GHz)$. Moreover, we use both melt onset proxies to divide the Antarctic sea ice cover into regions of **characteristic surface melt patterns**.

(left) Penguins and (right) autonomous snow depth buoys drifting with Antarctic sea ice.

Melt transition retrieval

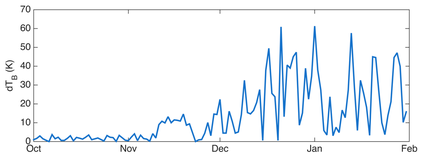
Sea-ice concentration SIC > 70%

less

Continuous time series of SIC > 70% during melt season, 01 Oct to 31 Jan

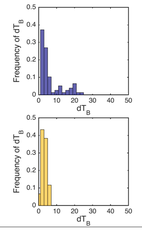
> 30/33 days

Diurnal variations dT_B in brightness temperature $T_{B,37V}$



Diurnal variations of 37 GHz vertical polarized brightness temperature (dT_B) for one exemplary grid cell.

Classification of dT_B histograms into



Multi-modal

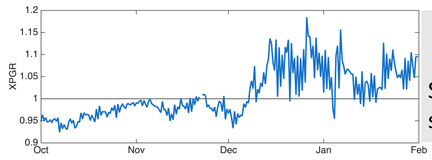
Uni-modal

Threshold criteria

Determination of individual transition threshold as local minimum between first two modes

No significant diurnal surface variations

Cross-polarized gradient ratio XPGR



$$XPGR = \frac{T_B(19GHz, H)}{T_B(37GHz, V)}$$

Sensitive to deeper snow melt

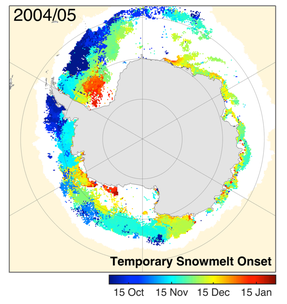
Cross-polarized gradient ratio (XPGR) for one exemplary grid cell.

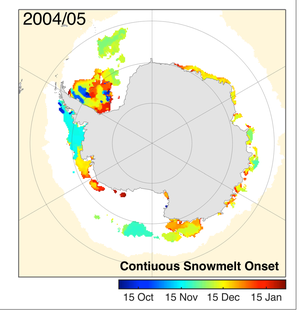
Threshold criteria

XPGR ≥ 1

Melt onset detection

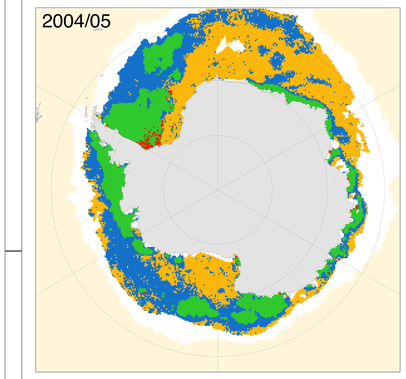
The date of melt onset is the first day of dT_B/ XPGR exceeding the respective threshold for at least three consecutive days





(upper) Temporary and (lower) continuous snowmelt onset detected from microwave brightness temperature for the melt transition 2004/05. White areas indicate the maximal sea-ice-covered area of the previous year.

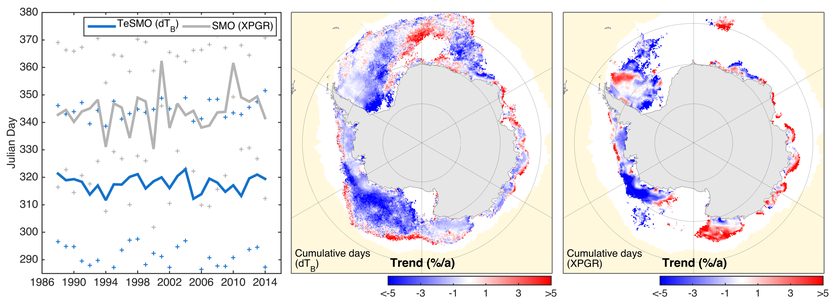
Characteristic surface types



Classification of Antarctic sea ice into four characteristic surface types from dT_B and XPGR.

- No diurnal cycles, no strong melt (Type D)
- Diurnal cycles with subsequent strong melt (Type C)
- No diurnal cycles but strong melt (Type B)
- Diurnal cycles but no strong melt (Type A)

Spatial and decadal variability of snowmelt patterns



(a) Spatial mean (solid line) and its standard deviation (crosses) of the Temporary (TeSMO) and Continuous Snowmelt Onset (SMO), and (b) trend of accumulated days indicating temporary and (c) continuous melt from 1988/89 to 2014/15.

- **No significant trend** in snowmelt onset from 1988/89 to 2014/15
- Increase in accumulated days indicating continuous snowmelt in areas of increasing sea-ice extent and vice versa

Conclusion and Summary

- Results reveal **four regimes with substantial differences** in their surface characteristics
- **Improvement of existing snowmelt onset algorithms** by
  - Individual dT_B-thresholds
  - Combination of **different frequencies and polarizations** of T_B to allow for additional description of subsurface melt
- Ongoing Antarctic **sea-ice advance triggered less by surface melt** but rather by lateral/bottom melt and dynamical atmospheric variations

Outlook

The regional patterns of dominant snow processes and melt onset dates may be applied to improve:

- Estimates of Antarctic-wide **mass and energy budgets** in the seasonal cycle
- Seasonal analysis of **habitat conditions** for ice-associated organism
- Retrieval of **sea-ice thickness** and associated ice volume from radar altimetry

Reference
Arndt, S.; Willmes, S.; Dierking, W.; Nicolaus, N. (submitted, JGR): Timing and regional patterns of snowmelt on Antarctic sea ice from passive microwave satellite observations.

Universität Trier · Helmholtz Association, Remote Sensing and Earth System Dynamics Alliance · Universität Bremen · POLMAR Helmholtz Graduate School for Polar and Marine Research

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG
BREMERHAVEN
Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
www.awi.de

HELMHOLTZ GEMEINSCHAFT