Vertical snow structures on Antarctic sea ice
from in-situ and remote sensing measurements
Temporal evolution of surface properties

Year-round snow cover

Seasonal changes in snow properties dominated by
- Diurnal thawing and refreezing
- Internal snowmelt

<table>
<thead>
<tr>
<th>winter</th>
<th>spring</th>
<th>summer</th>
<th>autumn</th>
<th>winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>snow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ocean</td>
<td></td>
<td></td>
<td></td>
<td>Antarctic</td>
</tr>
</tbody>
</table>
Objective: The challenge of scales

Investigating seasonal variability of snow properties on different spatial scales

- **Large scale** (Antarctic-wide)
- **Regional scale** (Weddell Sea)
- **Floe-size scale** (< 2 km)
Vertical snow profiling: Local scale

Snow pits

- Detailed characterization of the snowpack
  - Temperature
  - Density
  - Salinity
  - Stratigraphy
  - Liquid water content

SnowMicroPen (SMP)

- High-resolution snow penetrometer retrieving essential snow structural parameters by measuring the bonding force between snow grains
  - Density
  - SSA
Variability on small scales - SMP transects

PS111_SIP_3
11 February 2018, seasonal sea ice

- Transect length: 23 m
- Measurements: twice every 0.5 m

© R. Winkelmann
Variability on medium scales - Weddell Sea

Expected strong regional variability between seasonal and perennial sea ice

Perennial sea ice

ANT-29/6: 08 June - 12 August 2013

Seasonal sea ice
Variability on medium scales - Weddell Sea

Expected strong regional variability between seasonal and perennial sea ice

ANT-29/6: 08 June - 12 August 2013

Perennial sea ice

Increased grain sizes and layering indicate strong seasonality associated with snow metamorphosis and thaw-freeze cycles
Snowmelt patterns from passive microwave observations - A pan-Antarctic approach

**Method:** Analysis of diurnal variations in brightness temperature (passive microwave, 37 GHz, vert. pol.)

**Key points**
- Temporary snowmelt shows a **latitudinal dependence**
- Continuous snowmelt is usually 17 days after temporary snowmelt onset observed
- Results indicate **four characteristic melt types**

Arndt et al., 2016 (JGR)
Snowmelt patterns from active microwave observations - A perennial sea ice approach

Method:

Analysis of seasonal cycle in radar backscatter (Ku-band at 13.4 GHz, C-band at 5.6 GHz)

Arndt & Haas, in prep.
Snowmelt patterns from active microwave observations - A perennial sea ice approach

Mean snowmelt onset dates.

Latitudinal gradient in snowmelt onset dates
- **north**: warm-air advection
- **south**: diminished warm-air advection and stronger heat loss at the snow surface

<table>
<thead>
<tr>
<th>Region</th>
<th>Pre-melt Onset</th>
<th>Snowmelt Onset</th>
<th>Diurnal thawing-refreezing Onset</th>
<th>Temporary Snowmelt Onset (TeSMO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Weddell Sea</td>
<td>27 Nov ± 25 days</td>
<td>16 Dec ± 19 days</td>
<td>19 Dec ± 13 days</td>
<td>21 Dec ± 11 days</td>
</tr>
<tr>
<td>Northern Weddell Sea</td>
<td>24 Nov ± 16 days</td>
<td>06 Dec ± 16 days</td>
<td>09 Dec ± 9 days</td>
<td>13 Dec ± 11 days</td>
</tr>
<tr>
<td>Bellingshausen Sea</td>
<td>01 Dec ± 29 days</td>
<td>04 Dec ± 27 days</td>
<td>19 Oct ± 20 days</td>
<td>19 Oct ± 28 days</td>
</tr>
<tr>
<td>Amundsen Sea</td>
<td>24 Nov ± 23 days</td>
<td>06 Dec ± 18 days</td>
<td>02 Dec ± 10 days</td>
<td>05 Dec ± 16 days</td>
</tr>
<tr>
<td>Ross Sea</td>
<td>11 Dec ± 18 days</td>
<td>15 Dec ± 17 days</td>
<td>13 Dec ± 8 days</td>
<td>16 Dec ± 10 days</td>
</tr>
<tr>
<td><strong>All regions</strong></td>
<td><strong>29 Nov ± 10 days</strong></td>
<td><strong>10 Dec ± 12 days</strong></td>
<td><strong>09 Dec ± 5 days</strong></td>
<td><strong>12 Dec ± 8 days</strong></td>
</tr>
</tbody>
</table>

Arndt & Haas, in prep.
Hypothesis:
Different sensors respond to snow melt processes in different depths within the snow cover.

- Pre-melt from scatterometers
- Snowmelt from Ku-band
- Snowmelt from Ku- and C-band
- Snowmelt from scatterometer and PMW observations
Hypothesis:
Different sensors respond to snow melt processes in different depths within the snow cover.

Using satellite remote sensing sensors with **different signal frequencies** might allow to describe **snowmelt processes in different layers** ( = vertical structures).
Again: The challenge of scales

Local scale

Global scale
Again: The challenge of scales

Local scale

Regional/ Temporal scale

Modeled snow-ice formation from Snow Buoys
[L. Rossmann et al., DFG SPP 1158 project: SCASI]

Global scale

Autonomous ice-tethered platforms to study seasonal and regional variabilities of key parameters

Seasonal snow temperature profiles
[L. Tiemann et al., SPICES, EU project]