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

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Timing and regional patterns of snowmelt on Antarctic sea ice from passive microwave satellite observations

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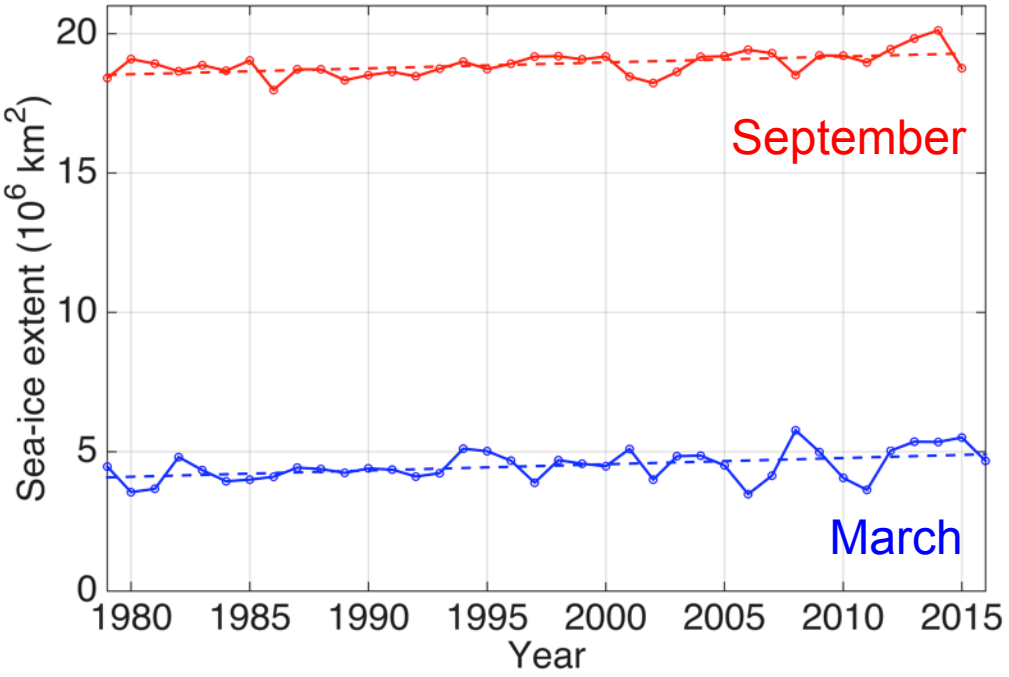
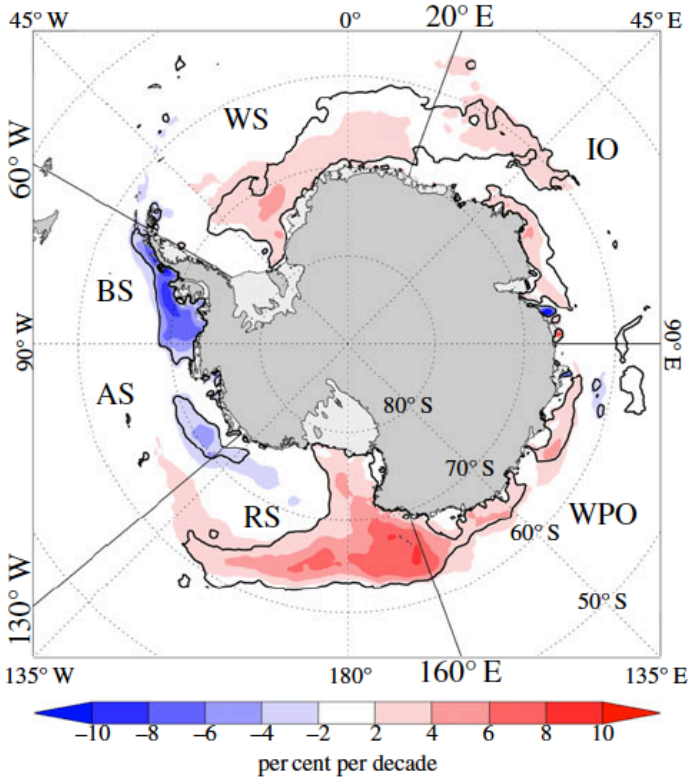
Antarctic sea ice

Sea-ice extent



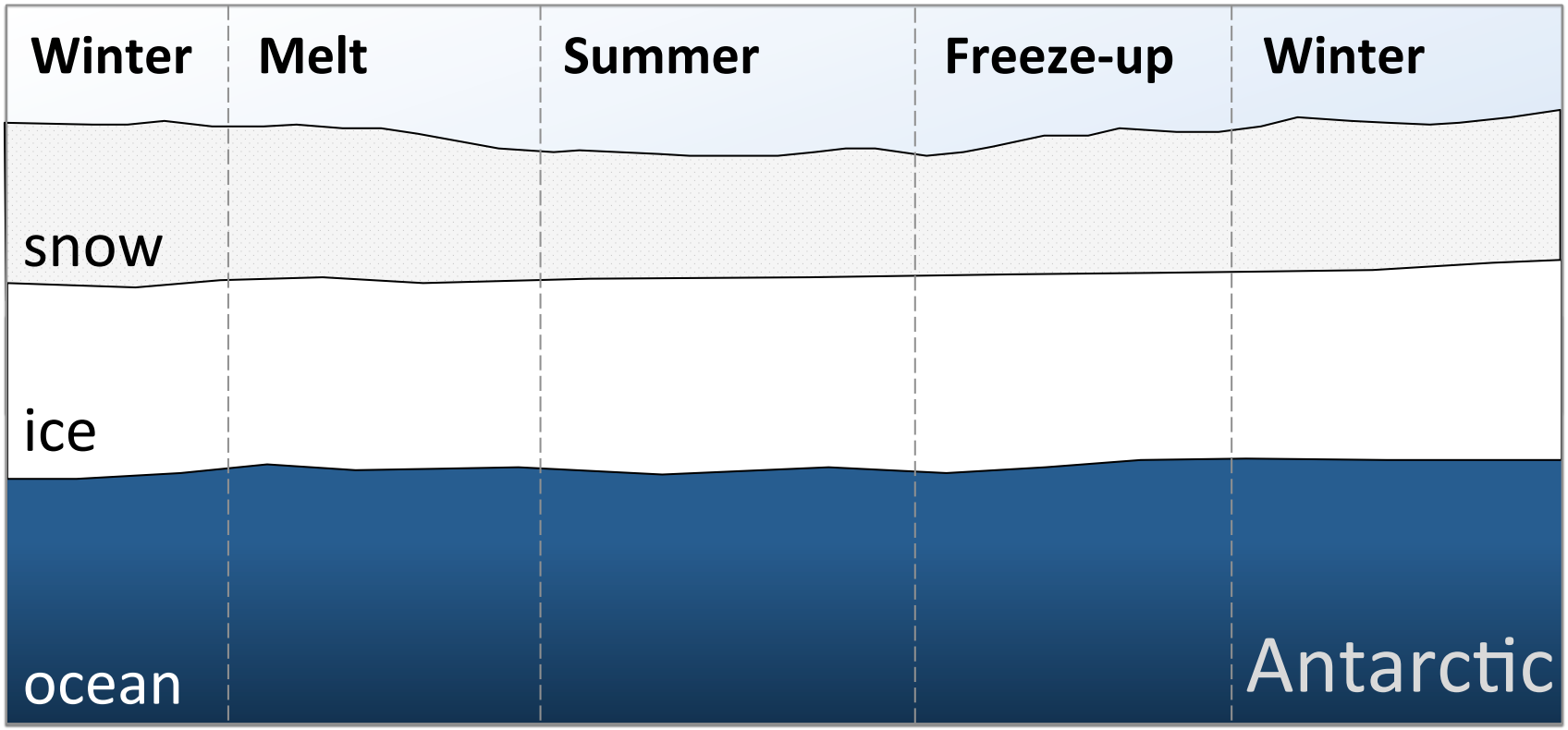
Mean Antarctic sea-ice extent for March and September. Data provided by the NSIDC (Fetterer, 2002).

Sea-ice concentration



Trend in mean sea-ice concentration from 1979 to 2013 (Turner et al., 2015).

Seasonal Cycle of Surface Properties

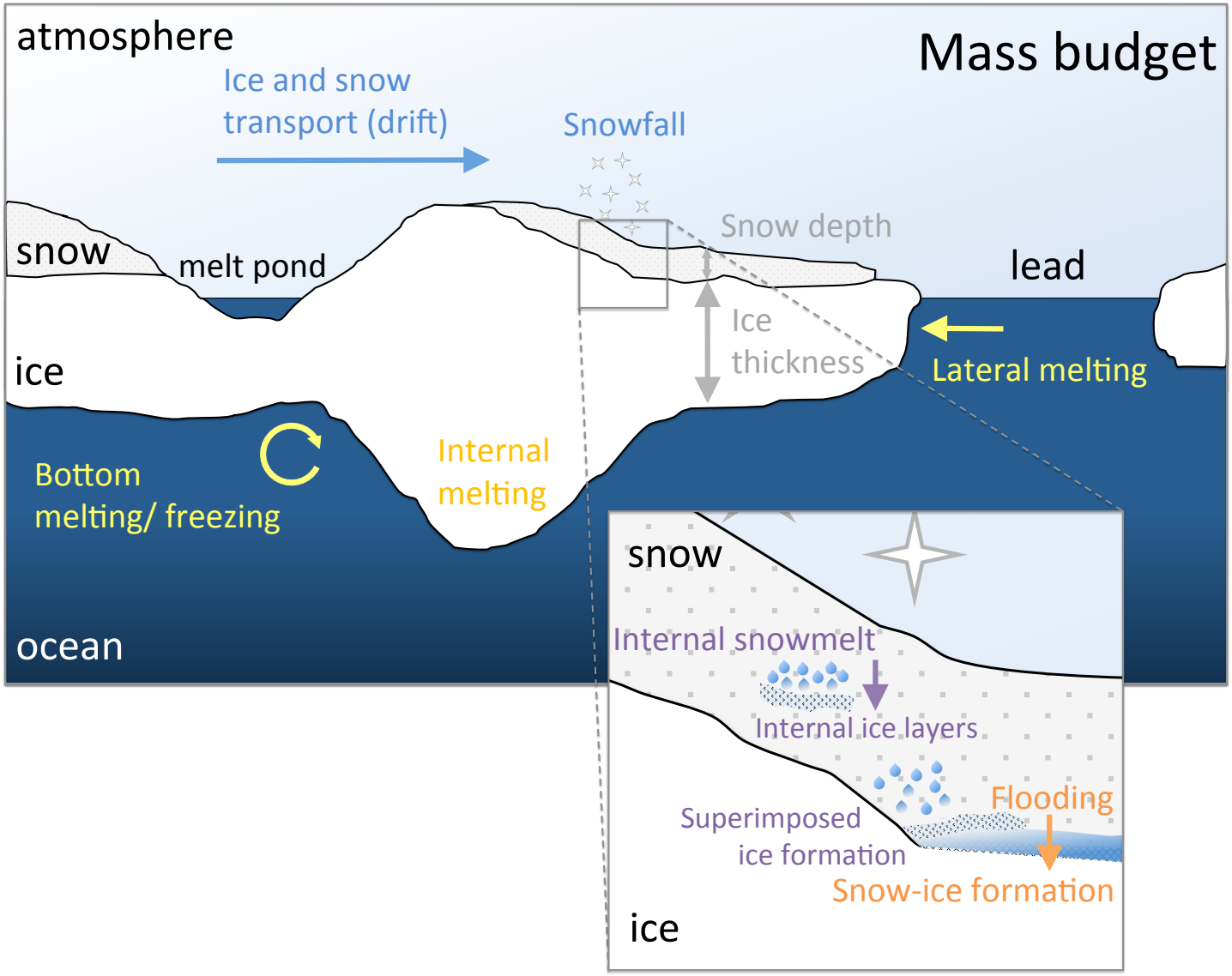


Snow on Antarctic sea ice persists generally **year-round**

Seasonal changes in **snow properties** dominated by e.g.

- Diurnal freeze-thaw cycles
- Internal snowmelt

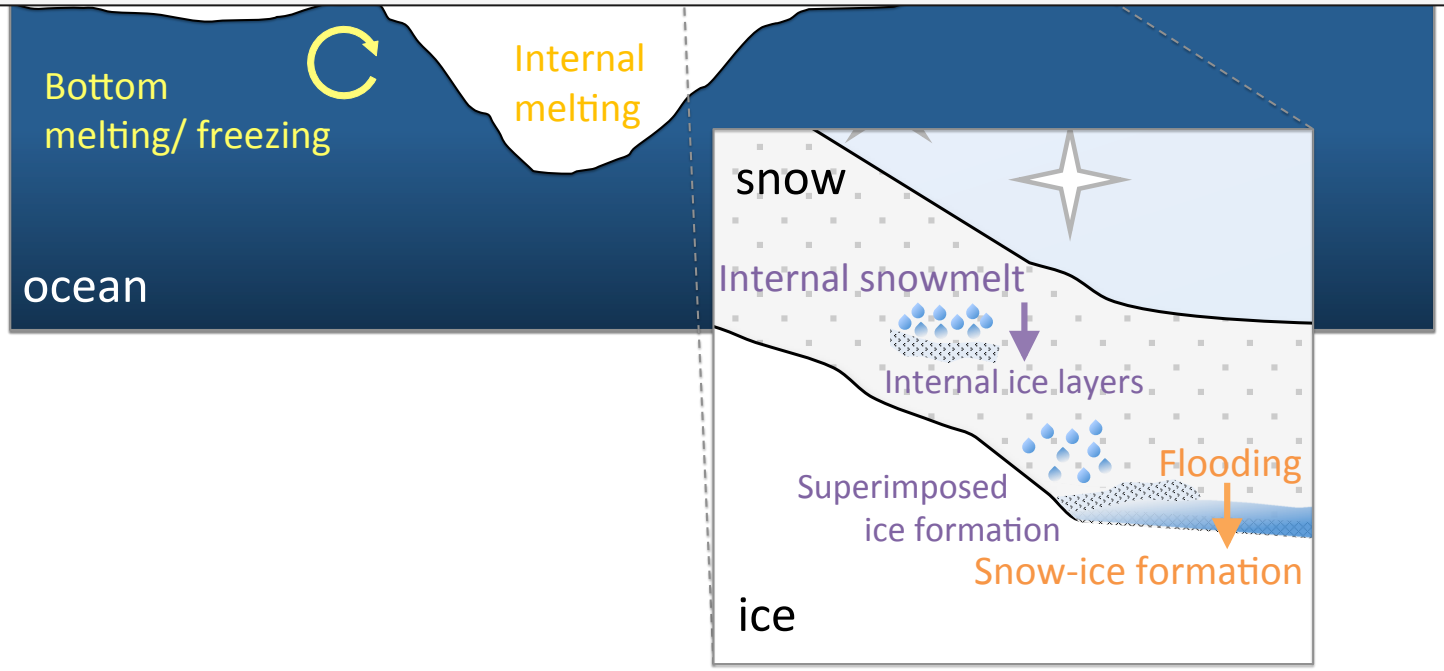
Sea-Ice Mass Budget



Sea-Ice Mass Budget

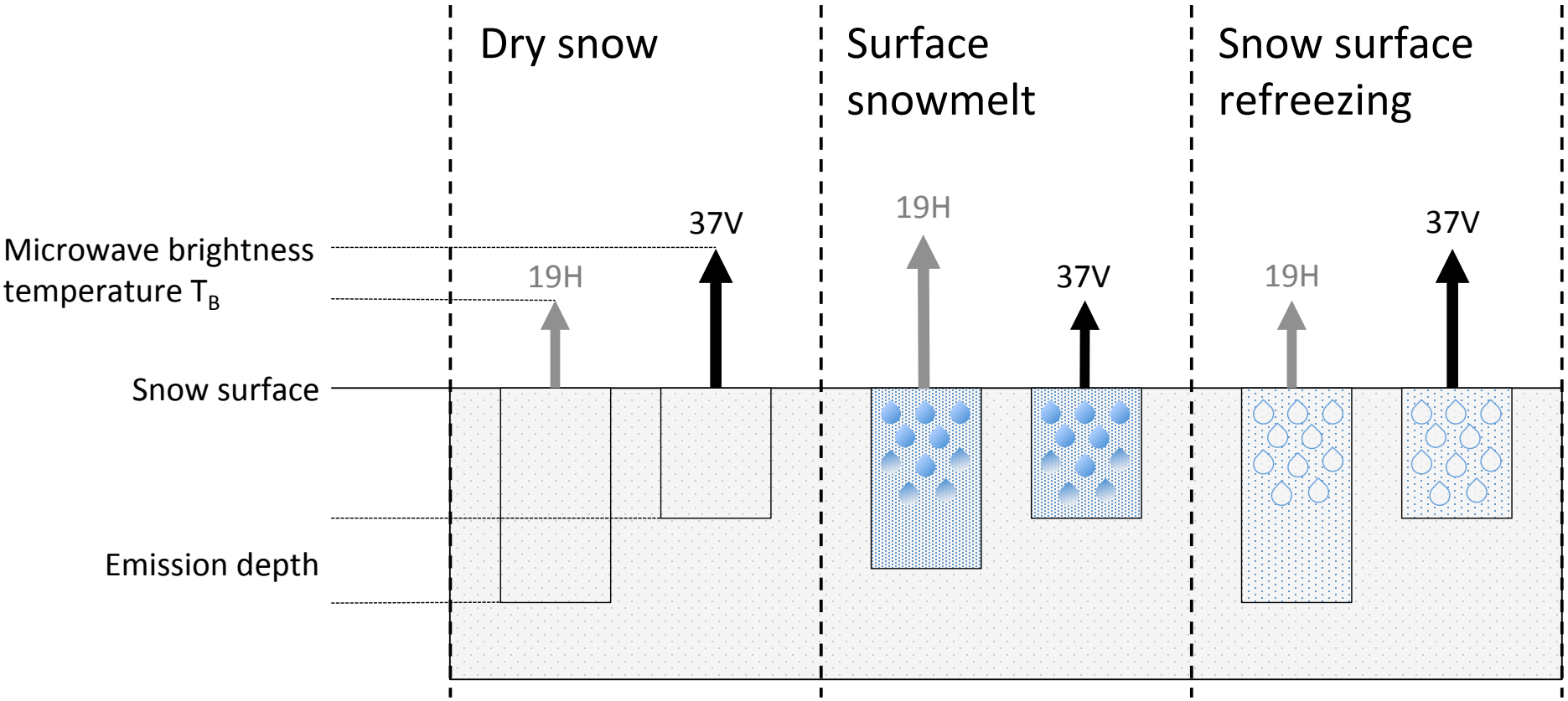
Which processes and mechanisms drive the temporal variability and spatial distribution of snowmelt on Antarctic sea ice?

How can we derive these snowmelt processes on Antarctic sea ice?



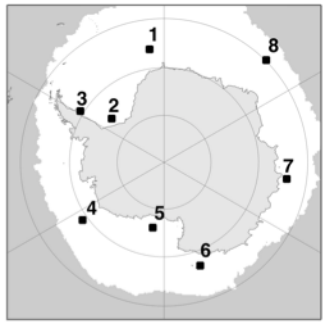
Passive Microwave Observations

Brightness temperature: $T_B(f,p) = \varepsilon(f,p) \times T_S$



Modified after Willmes, 2007

Method: Derived Variables

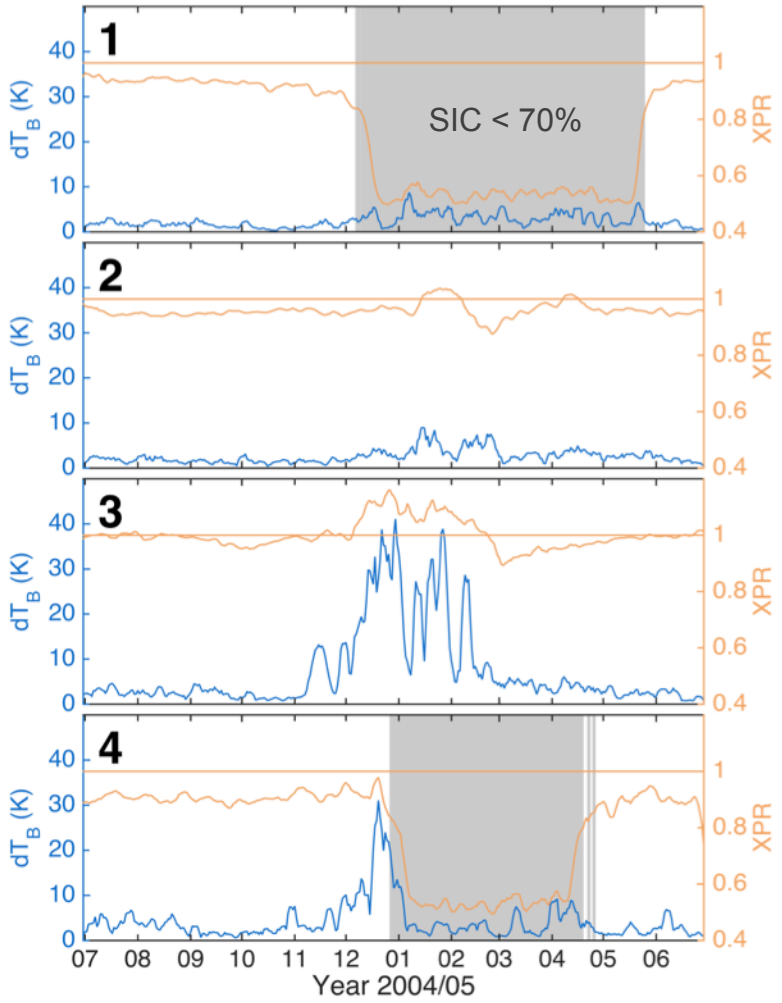


- **Diurnal variation in brightness temperatures, dT_B**
  EASE-Grid brightness temperature data (NSIDC), 37 GHz, vertically polarized

- **Cross-polarized ratio, XPR**

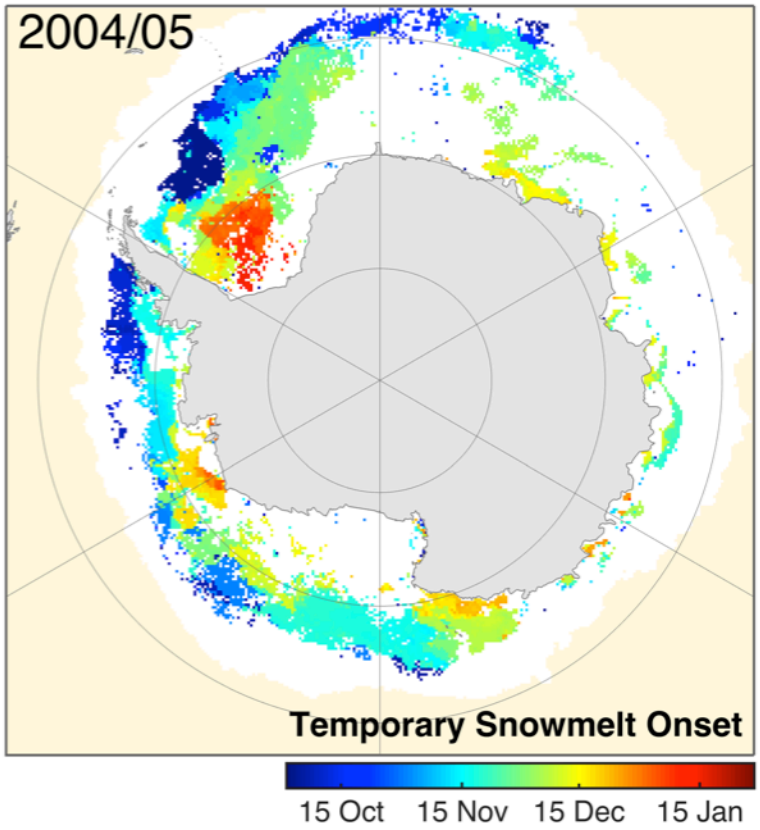
$$XPR = \frac{T_B(19GHz,H)}{T_B(37GHz,V)}$$

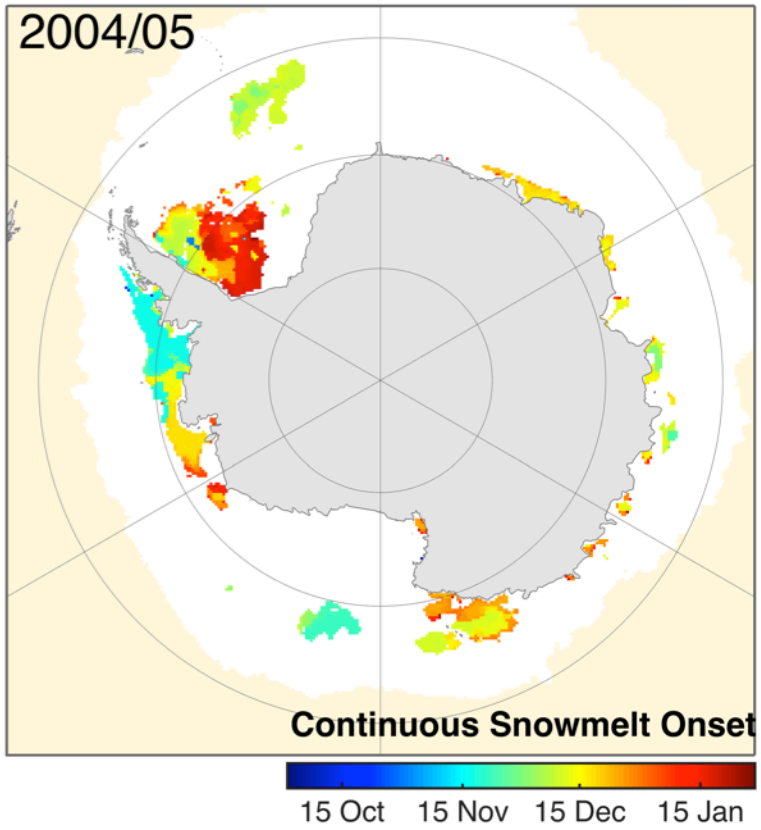
- **Further data set:**
  Sea-ice concentration, SIC
  Bootstrap data (SSM/I)



Arndt et al., 2016 (JGR)

Spatial Variability of Snowmelt Patterns

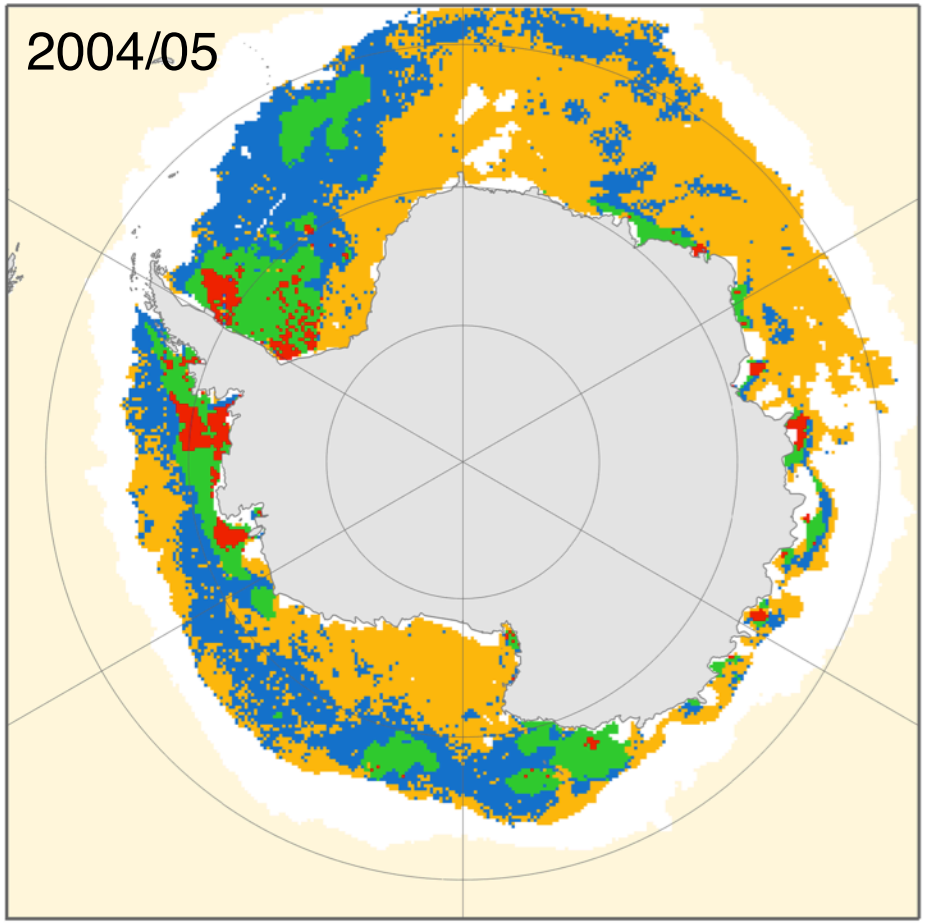


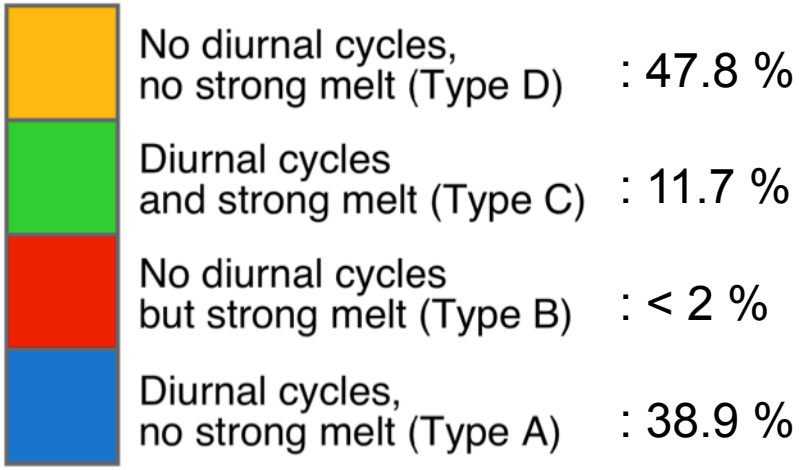


Temporary snowmelt shows a **latitudinal dependence**

Continuous snowmelt is usually **17 days after** temporary snowmelt onset observed

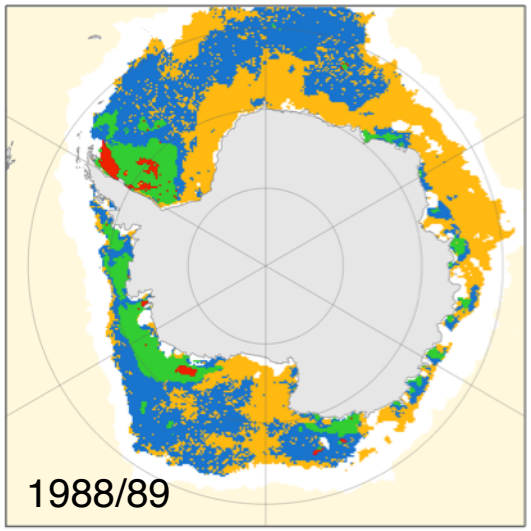
Characteristic Surface Melt Types

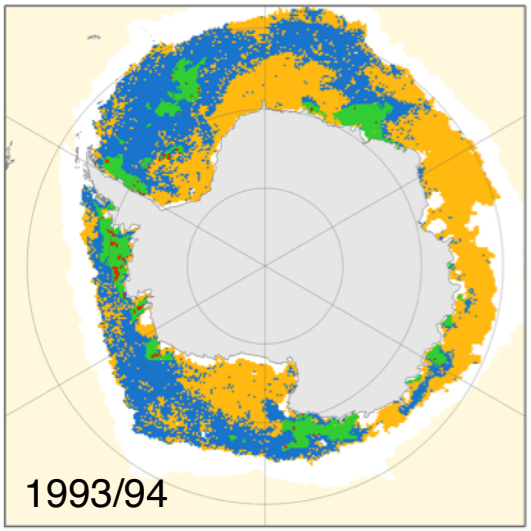


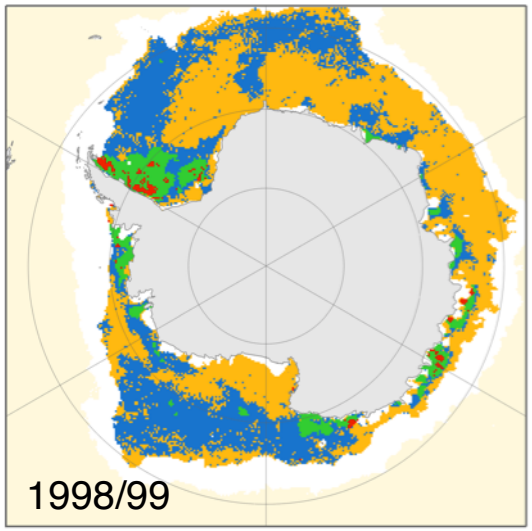


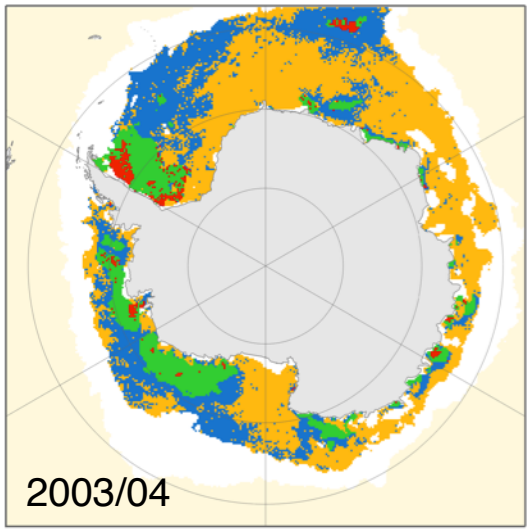
Results indicate **four characteristic melt types**

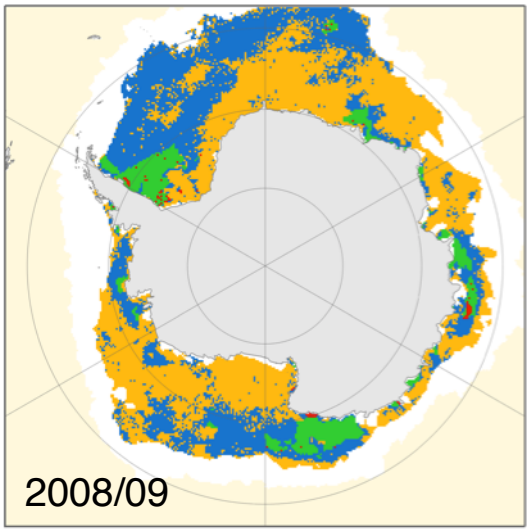
Characteristic Surface Melt Types

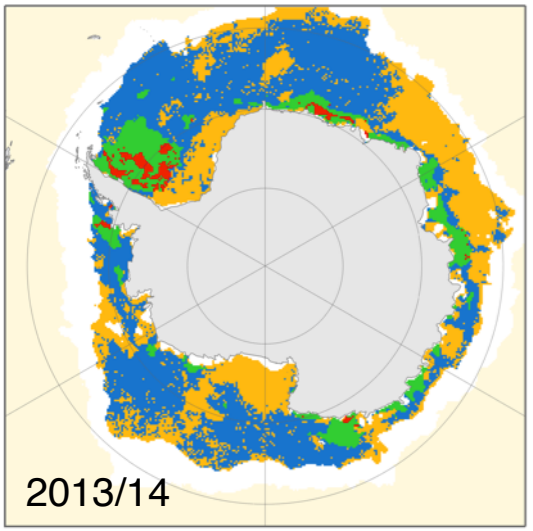












Diurnal cycles, no strong melt (Type A)

No diurnal cycles but strong melt (Type B)

Diurnal cycles and strong melt (Type C)

No diurnal cycles, no strong melt (Type D)

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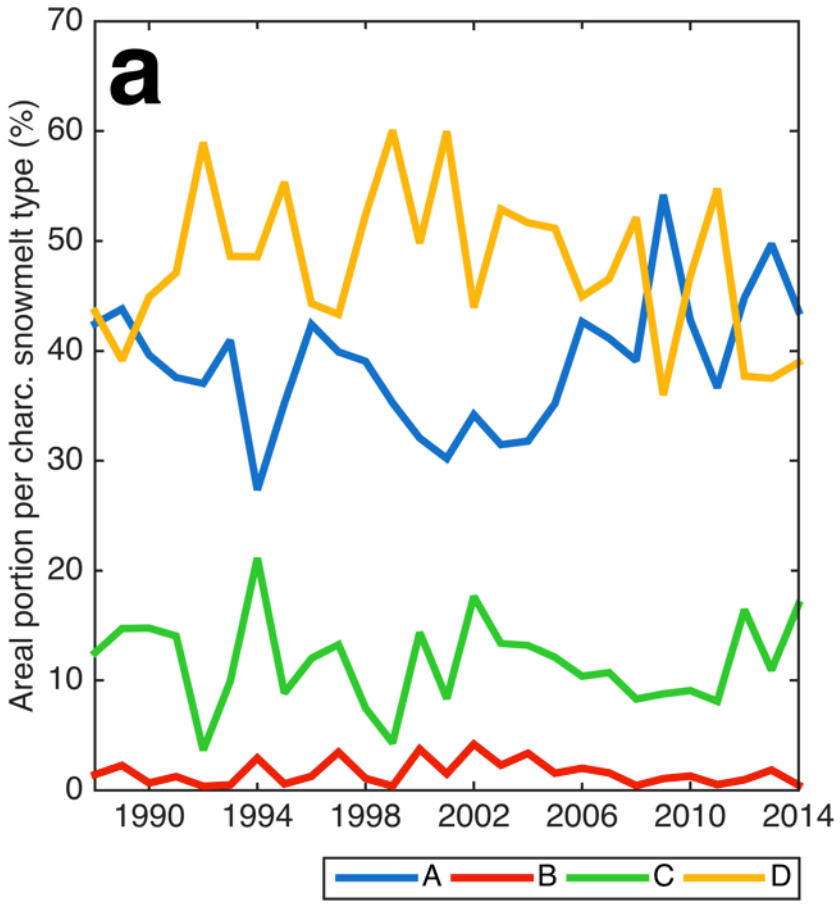
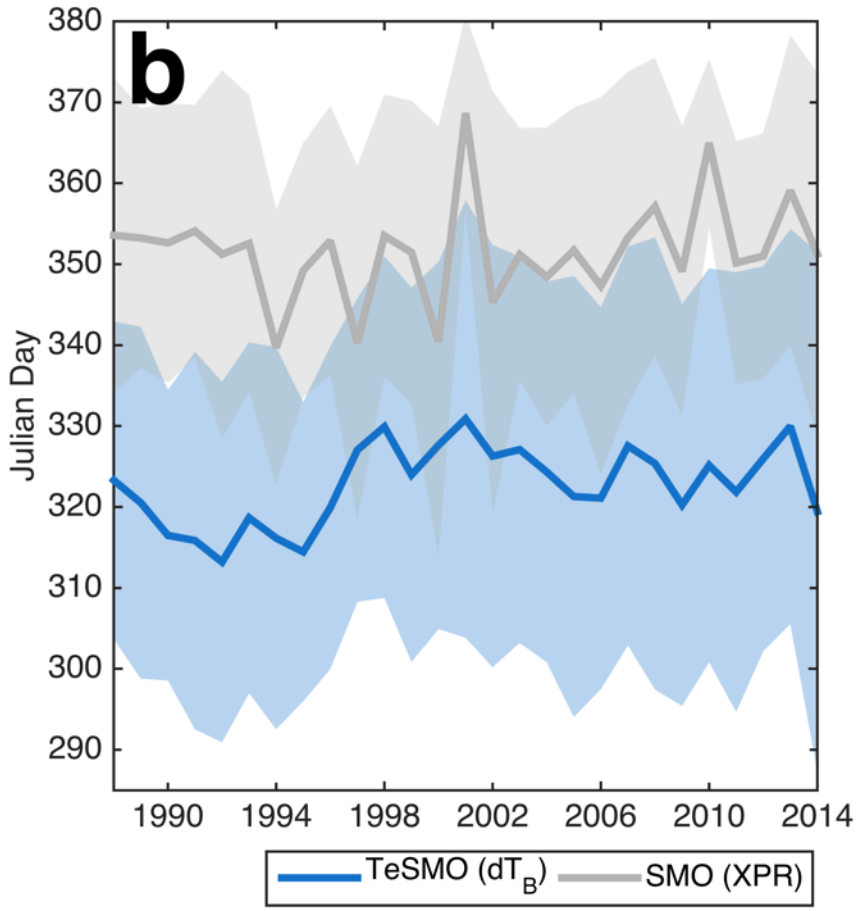
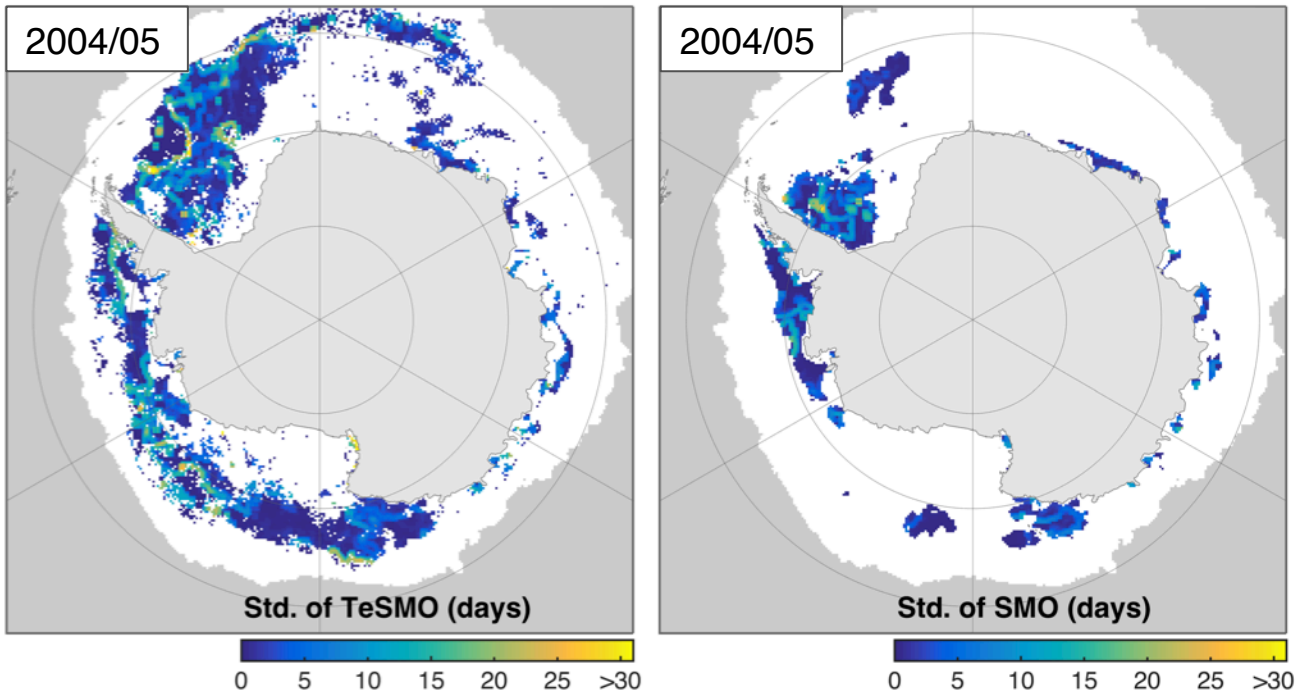
Decadal Variability of Snowmelt Patterns





No significant over-all trend in timing of snowmelt processes but strong **inter-annual variations**

Spatial Homogeneity

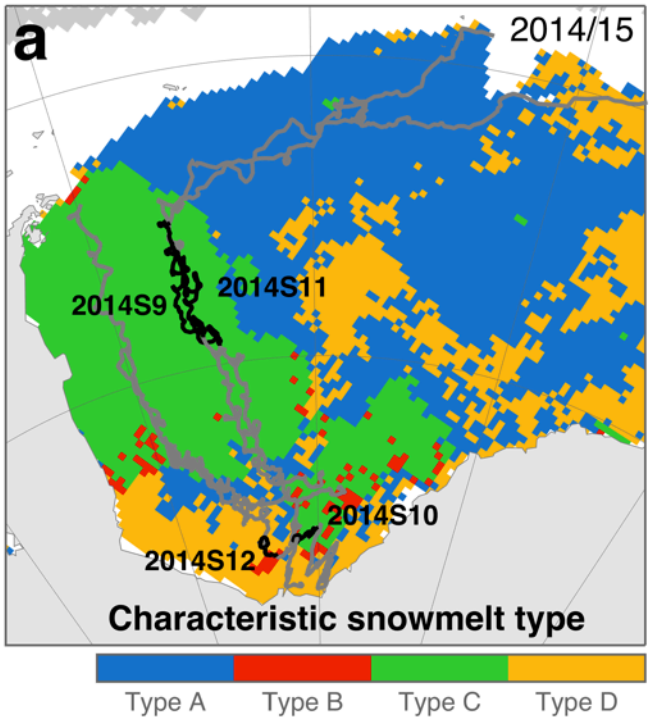


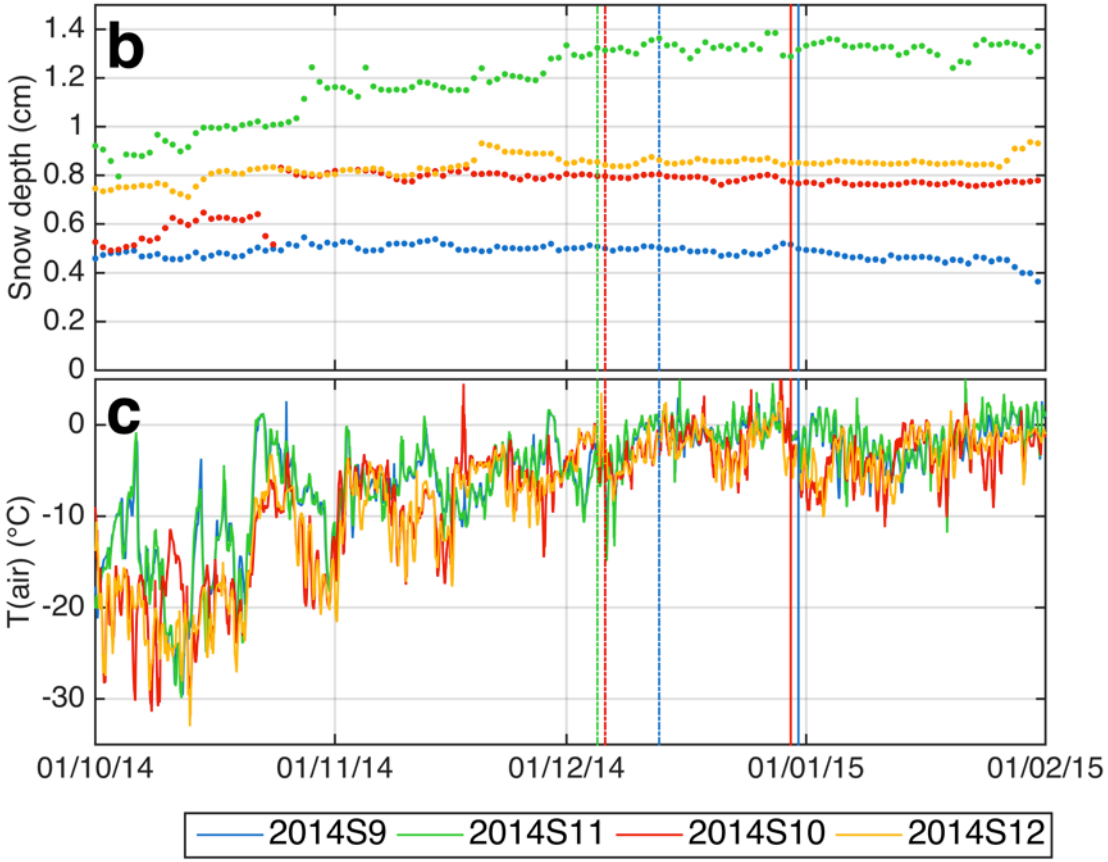
Standard deviations (Std.) derived from overlapping windows of 3-by-3 grid cells.

More heterogeneous distribution of temporary snowmelt:
Strongly affected by localized processes on snow surface (e.g. snow drift)

More homogeneous distribution of continuous snowmelt:
Triggered by atmospheric circulation patterns (e.g. solar radiation, clouds)

Comparison with Snow Depth Buoys





Continuous snowmelt does **not necessarily** translate into **snow depth changes**

Uncertainties in local point-to-point measurements due to, e.g., **snow drift**

Conclusions

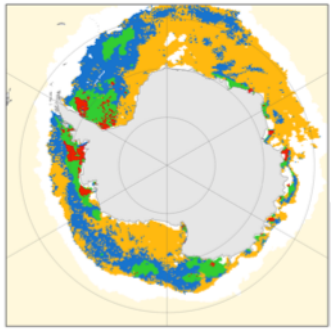
Results reveal **four regimes with substantial differences** in their surface characteristics

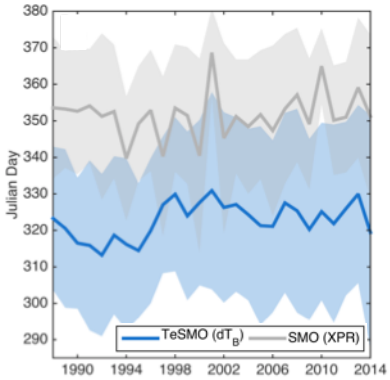
Snowmelt **processes on a broad-scale can be described** whereas local phenomena as, e.g., snow drift events and snow metamorphism lead to **local uncertainties**

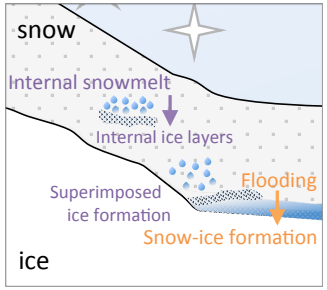
Ongoing **Antarctic sea-ice advance is triggered less by snowmelt**

As **temporary snowmelt** causes changing physical properties of snow grains, it might **influence the energy budget** of Antarctic sea ice

As **continuous snowmelt** enhances snow metamorphism and internal melt leading to formation of superimposed ice, it might **help to detect sea-ice mass budget changes**







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