ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
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Increasing solar radiation under Arctic sea ice – Seasonality and spatial distribution

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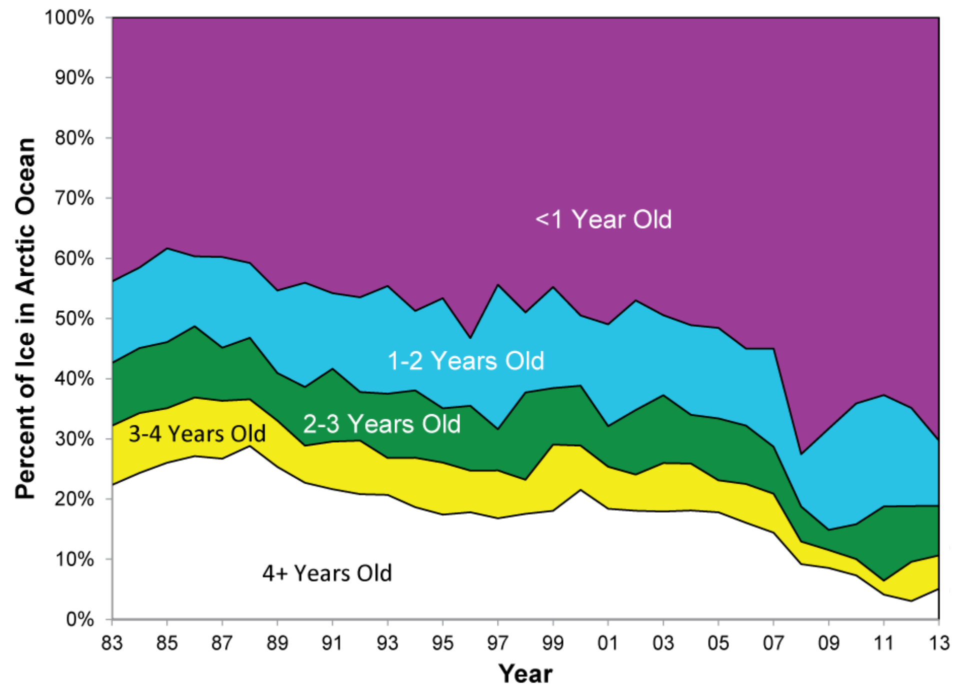
Motivation

- Arctic sea ice is getting **thinner**, younger, and **more seasonal**
- Observed **decrease** in **surface albedo** *[Perovich et al., 2011]*, **earlier melt onset**, and **longer melt season** *[Markus et al., 2009]*

> **Increase** in sea ice/snow **melt**, and light **absorption** and **transmission**

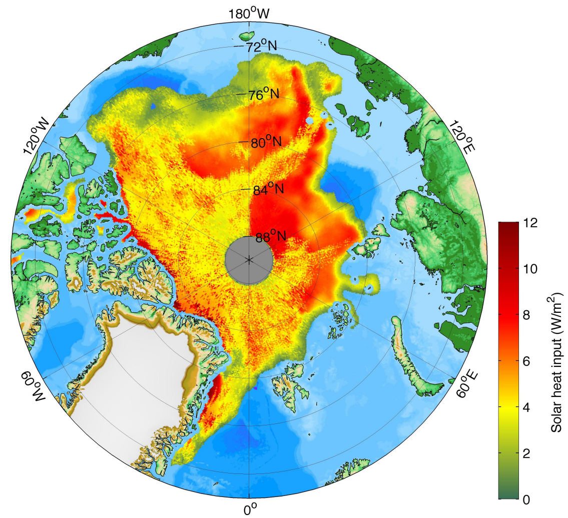
> Changes affect the ice-associated ecosystem



NSIDC courtesy J. Maslanik and M. Tschudi, University of Colorado

Motivation

- First **up-scaling** of transmitted heat fluxes through Arctic sea ice in summer by *Nicolaus et al. [2012,2013]*



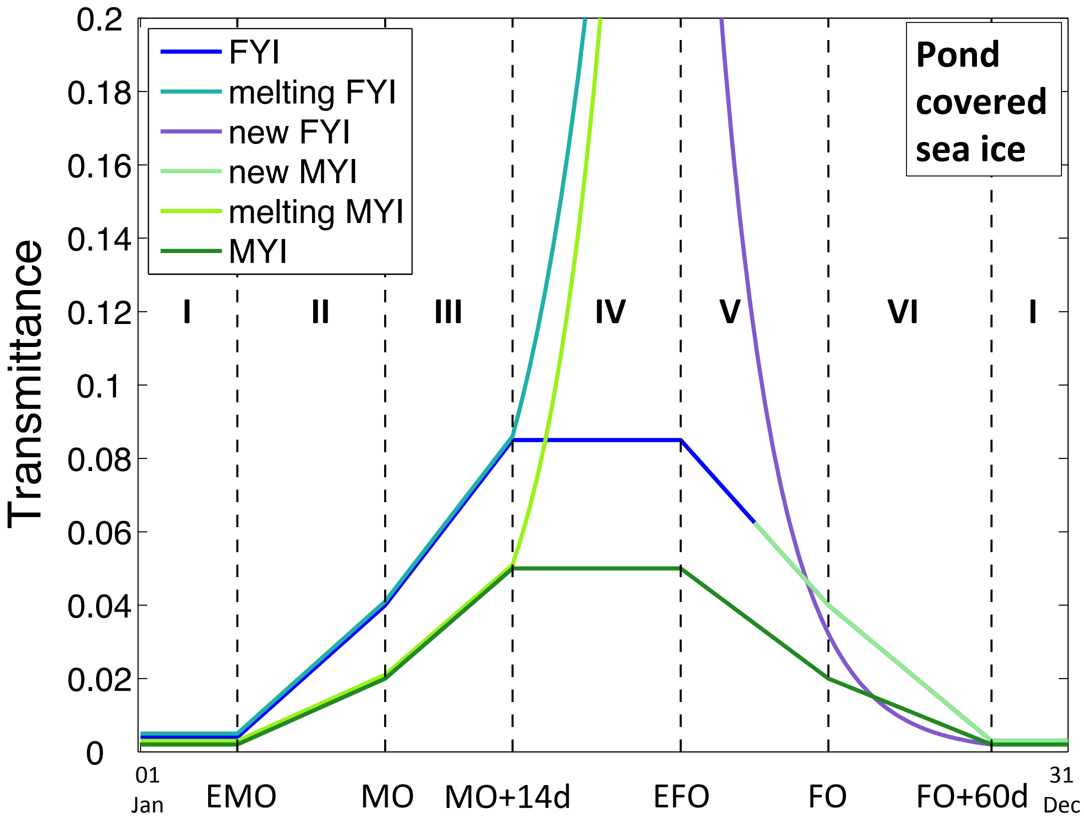
Solar heat input into the Arctic Ocean through sea ice in August 2011 [Nicolaus et al., 2013].

> Extending and generalizing the method by new a parameterization to quantify
> **large-scale,**
> **multi-seasonal, and**
> **interannual changes**
> in the radiation transfer through Arctic sea ice *[Arndt&Nicolaus, subm. in JGR]*

Method

New up-scaling method for calculation of under-ice radiation

Parameterization



I Winter
II Early melt
III Continuous melt
IV Summer
V Fall freeze-up
VI Continuous freeze

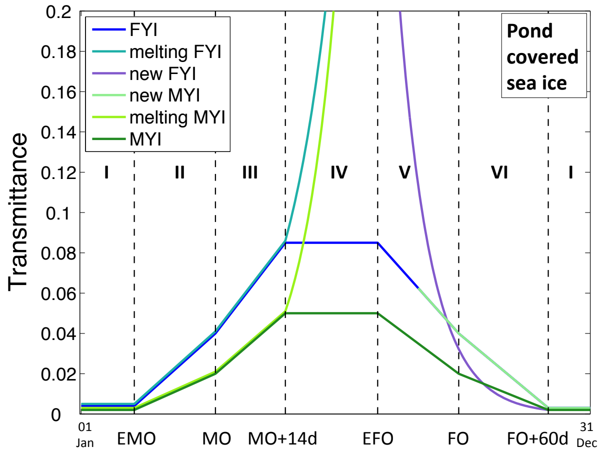
Total transmittance of pond covered sea ice.

[Arndt&Nicolaus, subm. in JGR]

Method

New up-scaling method for calculation of under-ice radiation

Parameterization



I Winter
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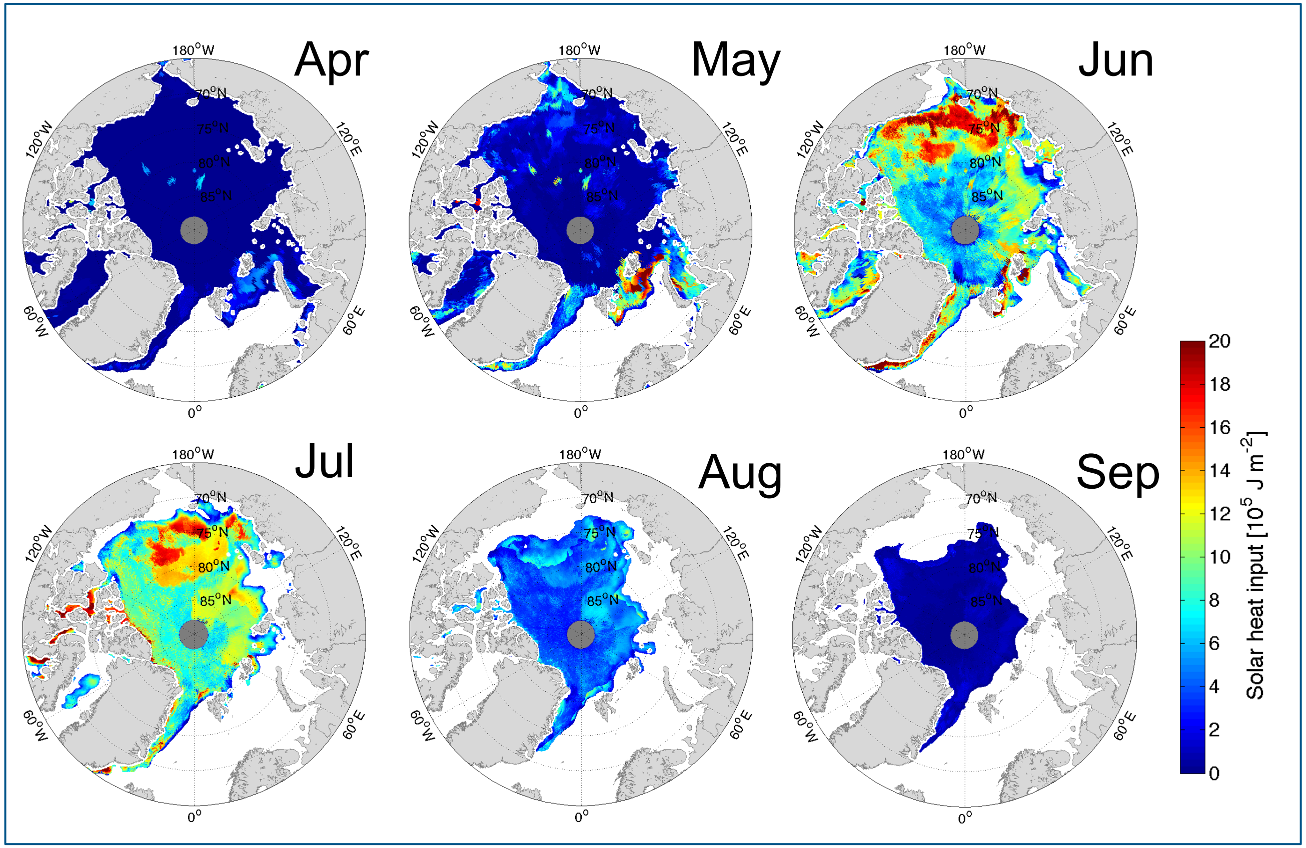
Total transmittance of pond covered sea ice.

Data sets

- Sea ice concentration *[OSI SAF]*
- Sea ice age *[Maslanik et al., 2007, 2011]*
- Downward surface solar radiation [ECMWF]
- Melt/ Freeze onset dates *[Markus et al., 2009]*
- Melt pond fraction *[Rösel et al., 2012]*

Seasonality of transmitted heat fluxes



Monthly mean of transmitted heat fluxes through Arctic sea ice in 2011.

- **96 %** of the annual under-ice radiation are transmitted in only 4 months (May to August)

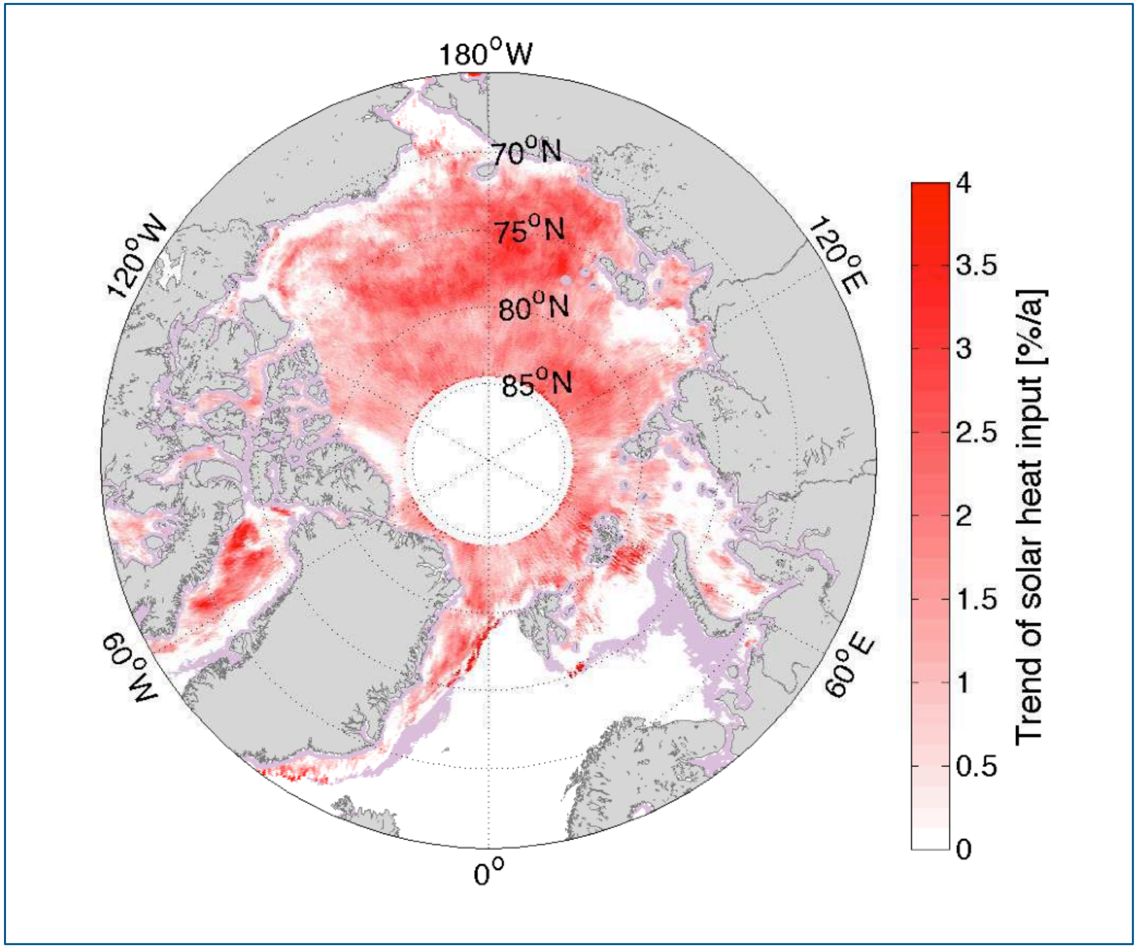
  ≙ **51.2×10^{19} J**

- Highest fluxes in **June** (20.9×10^{19} J)

[Arndt&Nicolaus, subm. in JGR]

Annual and monthly trends

Annual trends



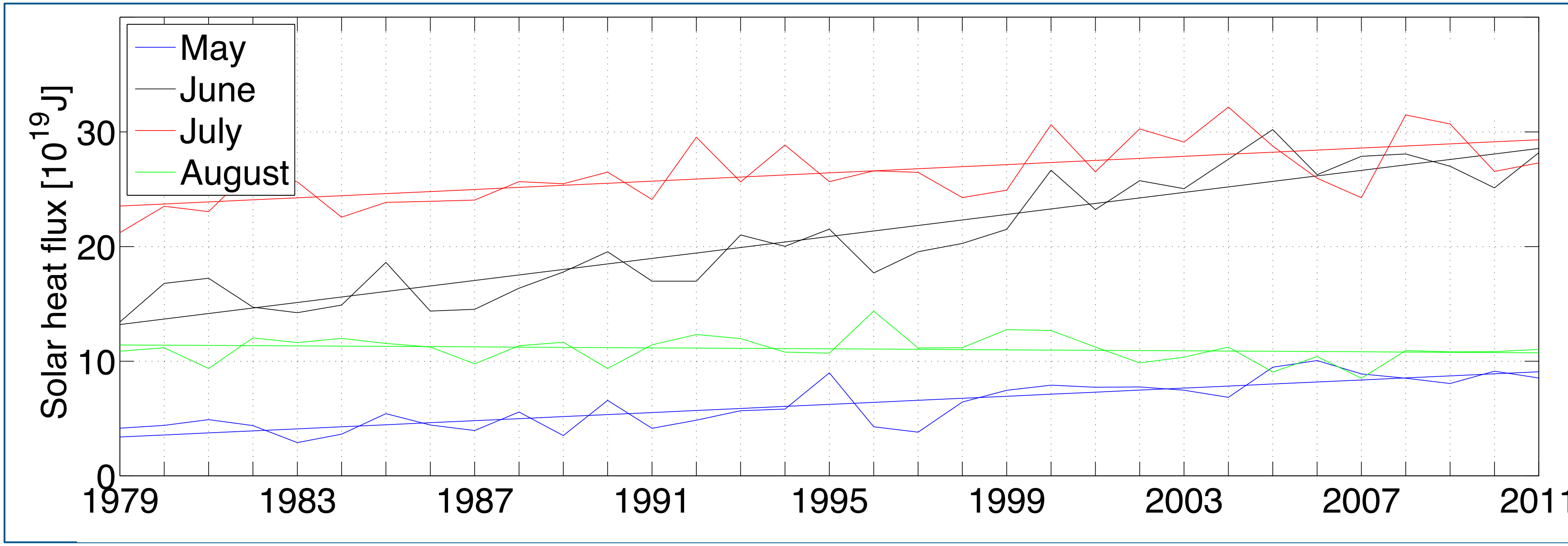
- Light transmission increases by **1.5% per year** Arctic-wide since 1979

Trend in annual total solar heat input through Arctic sea ice from 1979 to 2011.

[Arndt&Nicolaus, subm. in JGR]

Annual and monthly trends

Monthly trends



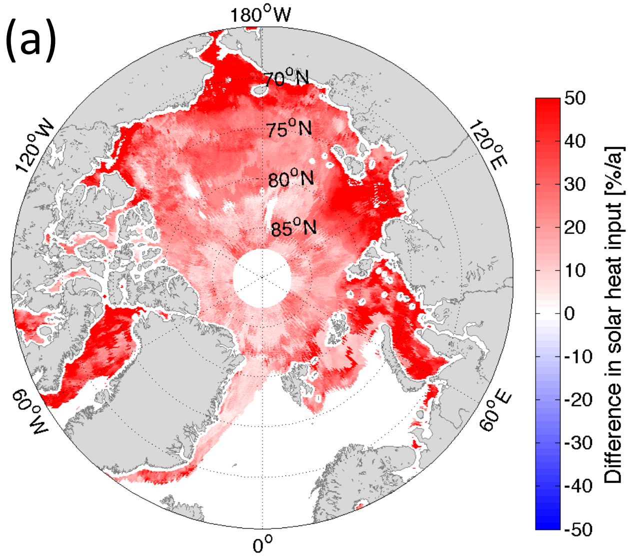
Monthly Arctic-wide solar heat input through Arctic sea ice from 1979 to 2011.

- Strongest increase in **June by 2.3% per year**

[Arndt&Nicolaus, subm. in JGR]

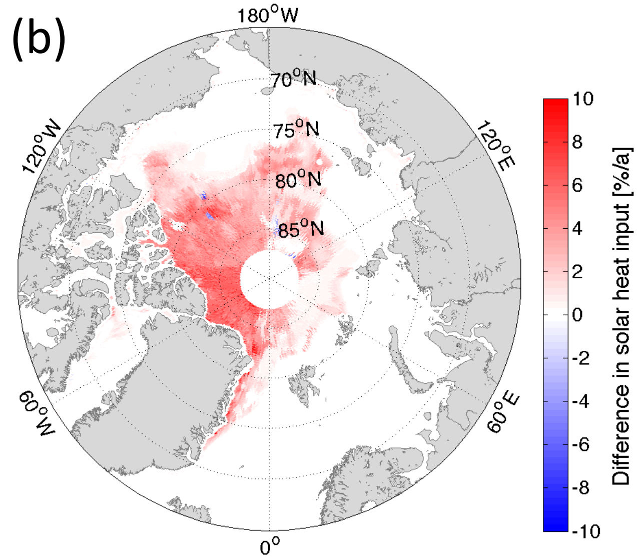
Sensitivity studies

<u>Melt onset – 14 days</u>



Increase of **24 %** of transmitted under-ice radiation

<u>Freeze onset + 14 days</u>



Increase of **1 %** of transmitted under-ice radiation

Changes in total solar heat input through sea ice in 2011.

(c) Assuming **only FYI** in the entire Arctic in 2011, transmitted under-ice radiation increases by another **18 %**.

[Arndt&Nicolaus, subm. in JGR]

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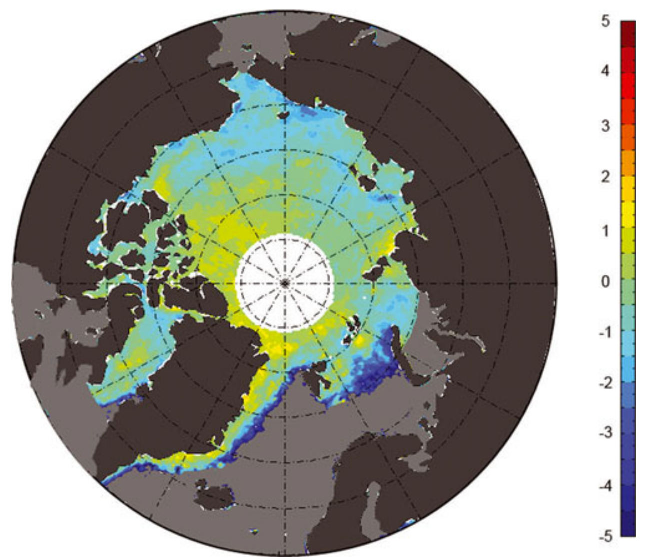
Conclusions

- Changes in **sea ice properties** have a large impact on the **energy budget**
- The additional energy input into the sea ice and upper ocean impacts e.g.
  - **Heat storage** in the ocean mixed layer
  - **Melt season** duration/ timing
  - **Melting** processes
  - **Bio-geo-chemical** processes

- Comparison with **surface radiation** trends *[Perovich et al., 2011]*:
  - Larger trend in light transmission than absorption

  > Additional **transmittance-melt feedback mechanism**



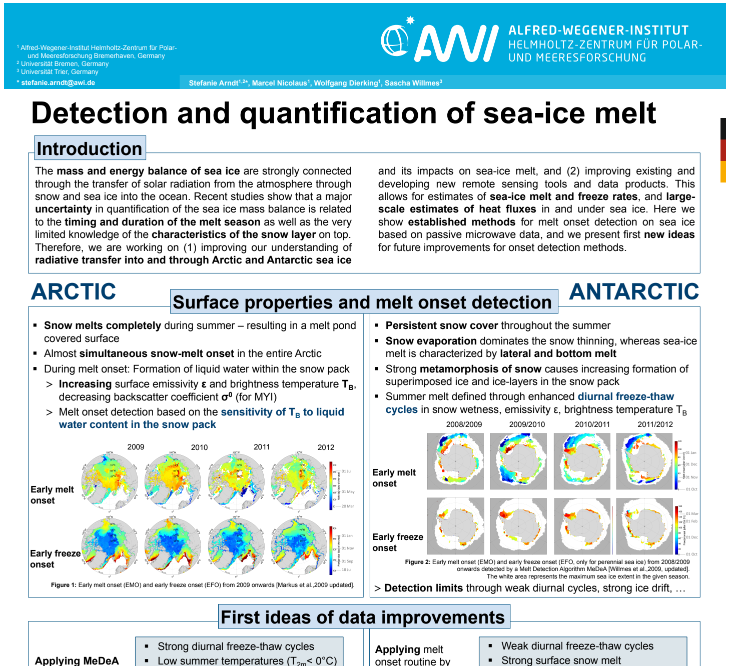
Trend in total annual solar heat input to the ice [% a^{-1}] by Perovich et al. [2011].

Outlook

- **How big** are the effects of a changing physical environment on the ecosystem and **coupled climate system** exactly?
  (*paper in prep. by Fernandez et al.*)

- How does the data product change with an improved Arctic-wide **snow depth and sea ice thickness** data product?

- How can the developed Arctic-based method be transferred to **Antarctic surface processes**?
  (*see Poster Session A, location number 008*)



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Thanks for your attention!

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