Is the Arctic temperature inversion regulated by sea ice?

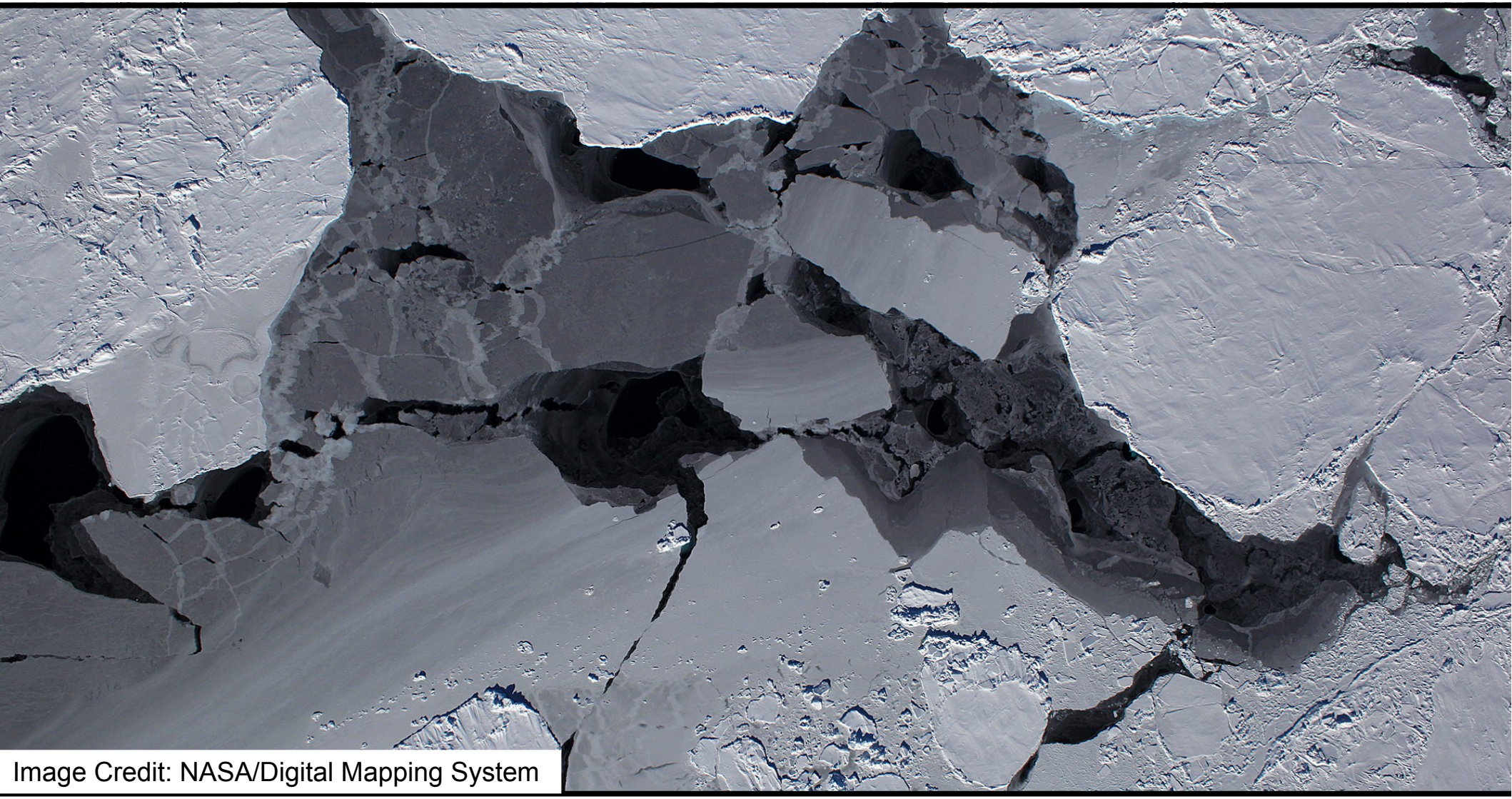


Image Credit: NASA/Digital Mapping System

NSERC CRSNG

Line Bourdages
PhD Candidate, McGill U.
February 2015

OURANOS

Background

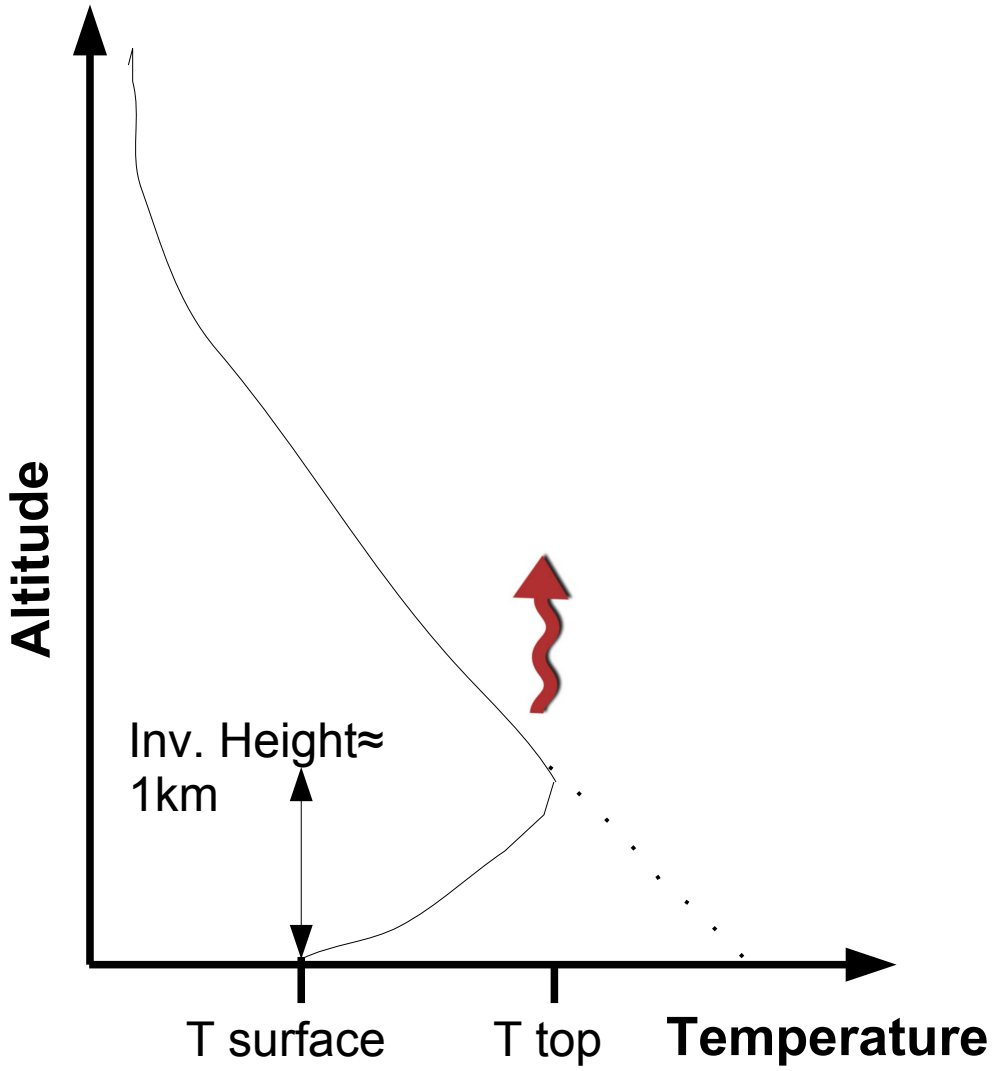
Wintertime inversion

Surface

- **LW deficit: equilibrium at low temperature**
- **Reduced mixing**
- **Presence of absorbing particles** (Curry, 1983)
- **Turbulent fluxes and Winds can destroy inversions**

Inversion Layer

- **Upper layer cooling to space**
- **Heat input to maintain inversion** (Overland & Guest, 1991)
- **Subsidence: warming and drying** (Curry, 1983)



Background

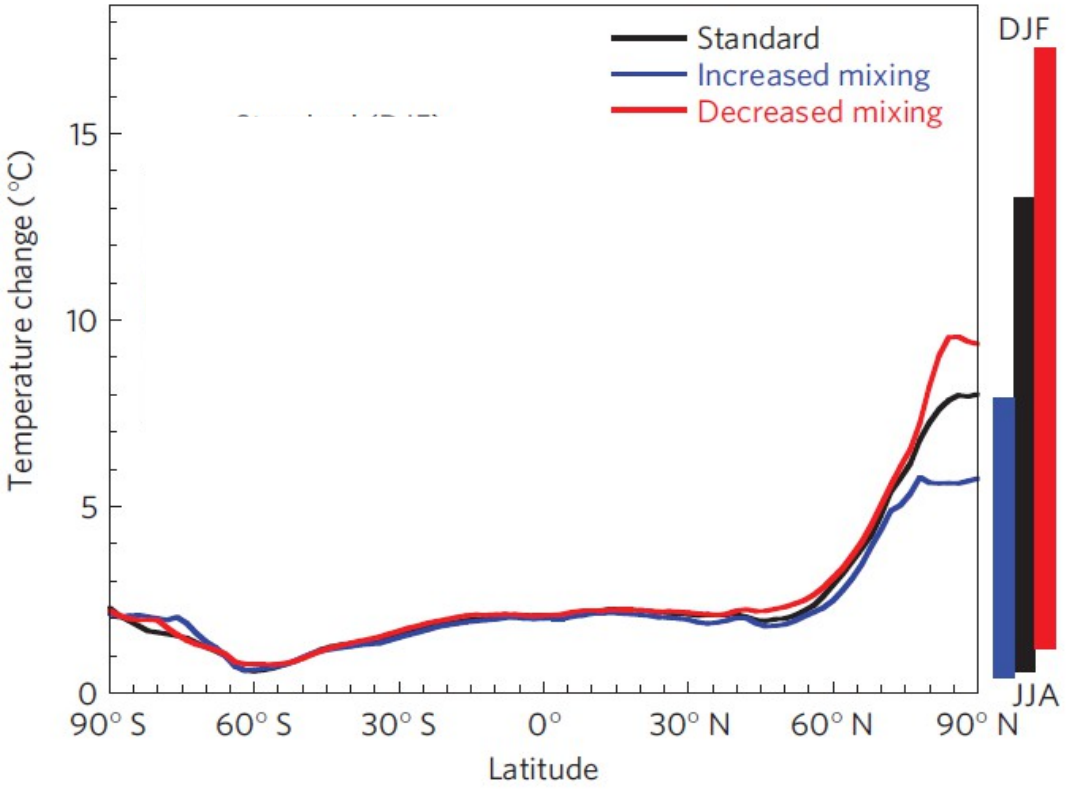
Wintertime inversion

Inversion long recognized as a pervasive feature of Arctic climate, especially in winter

Recent studies:

- Inversion linked to Arctic amplification [e.g. Boé et al.(2009), Bintanja et al.(2011)]

Temperature change for 2 x CO2



Using EC-Earth Global coupled model

Source: Bintanja, 2011: Arctic winter warming amplified by the thermal inversion [...]

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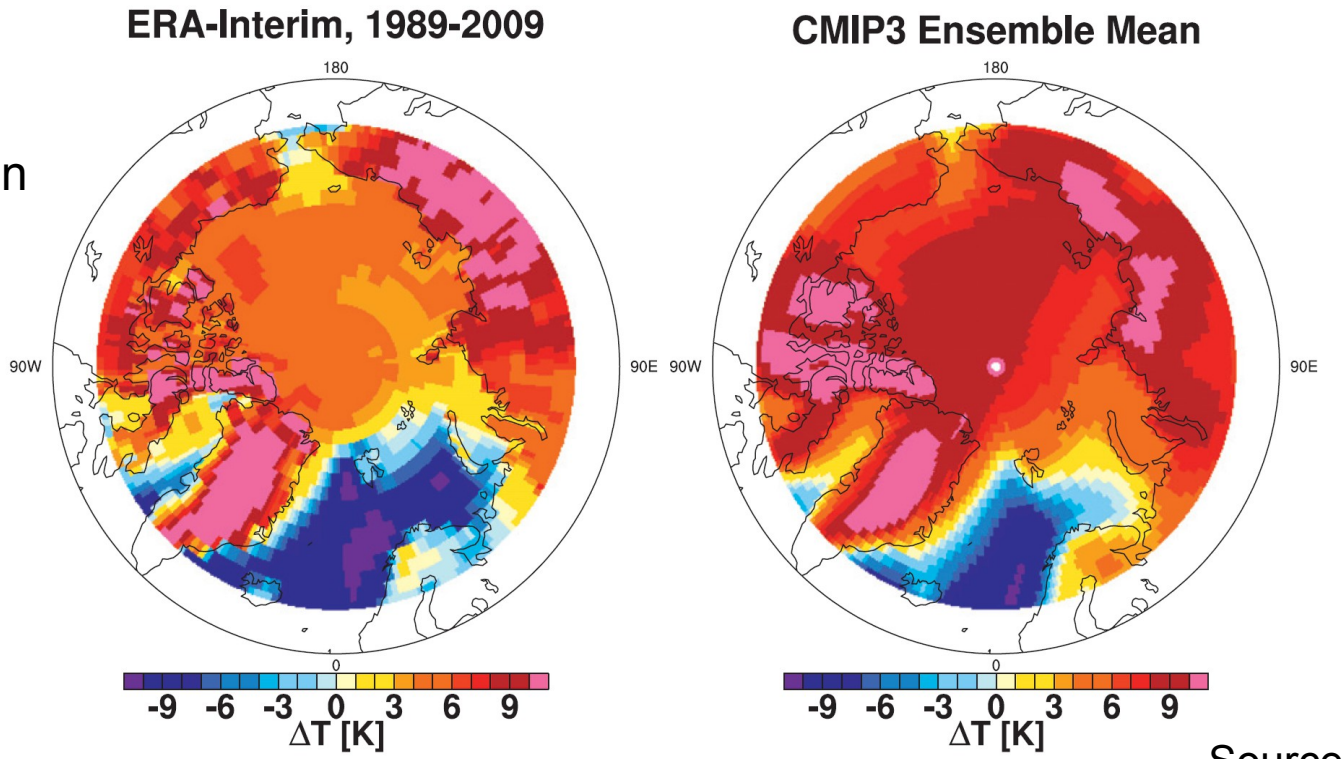
- Sensitivity of GCMs linked to stability [Boé et al. (2009), Medeiros et al. (2011)]

NDJF mean



Source:
Medeiros et al. 2011

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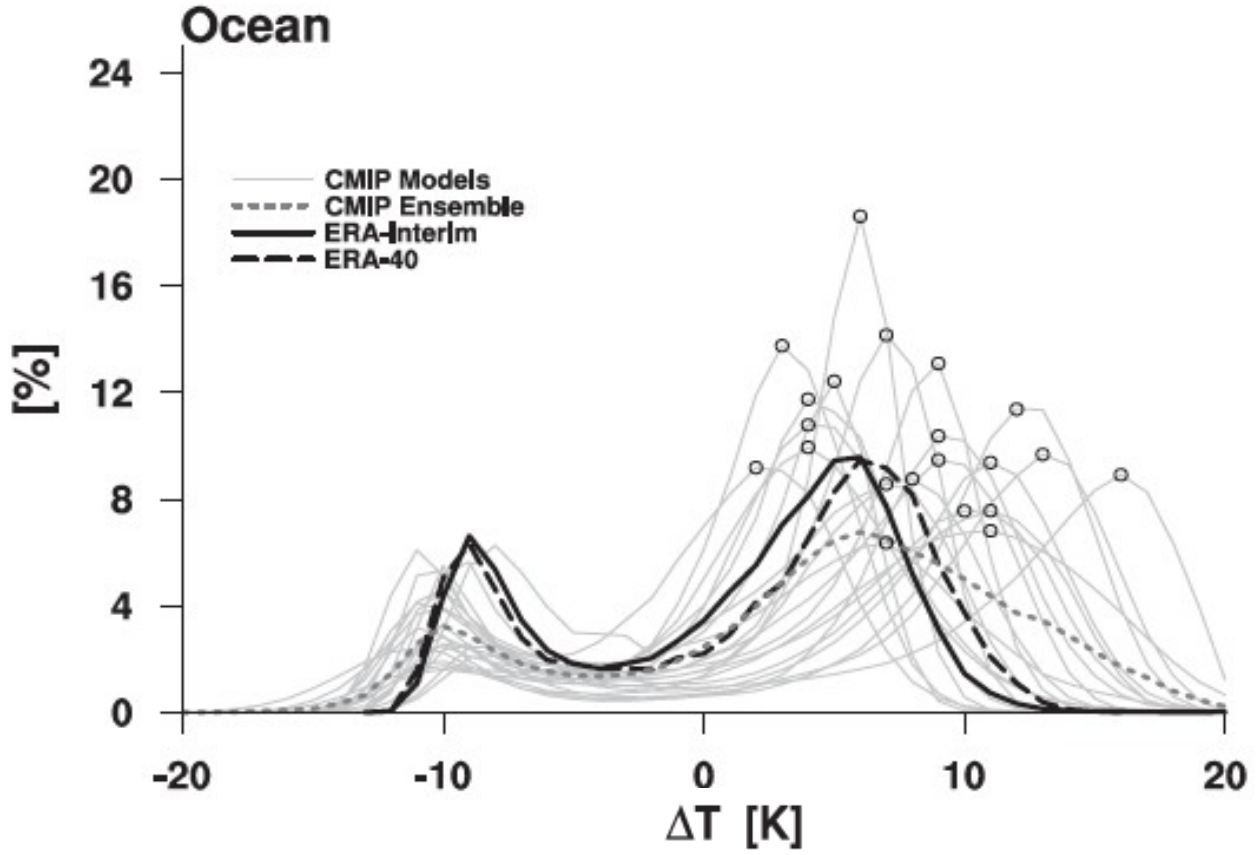

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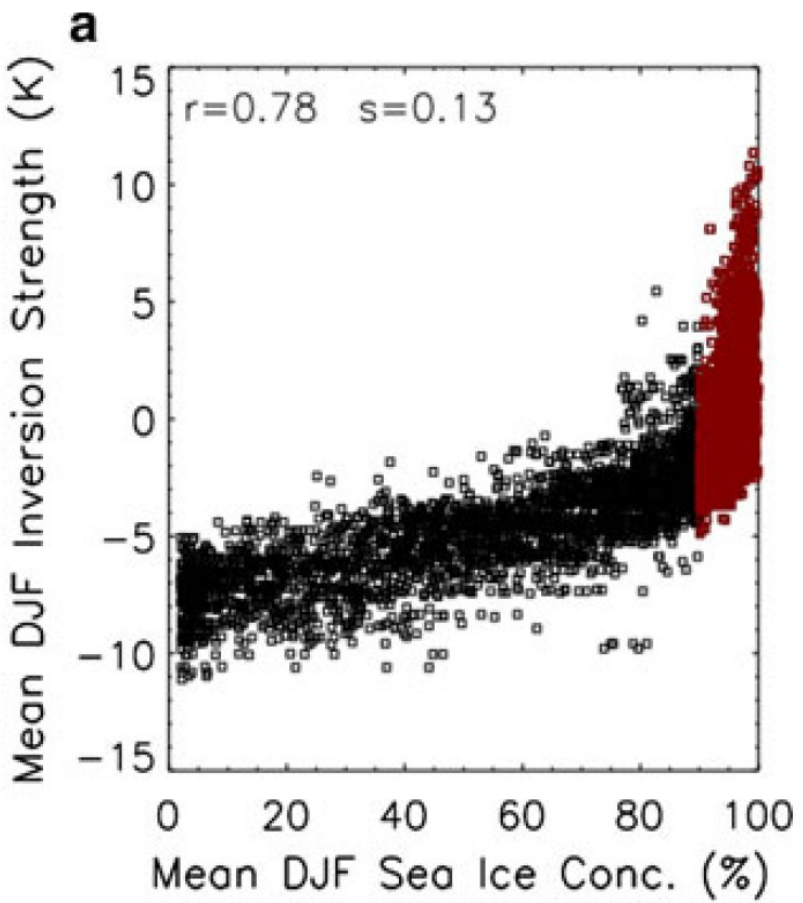
- Sensitivity of GCMs linked to stability
- Inversion regulated by sea ice

  [Pavelsky et al. (2011)]



Source: Pavelsky et al. (2011)
Inversion over polar oceans regulated by sea ice

Background

Wintertime inversion

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Recent studies:
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- Sensitivity of GCMs linked to stability
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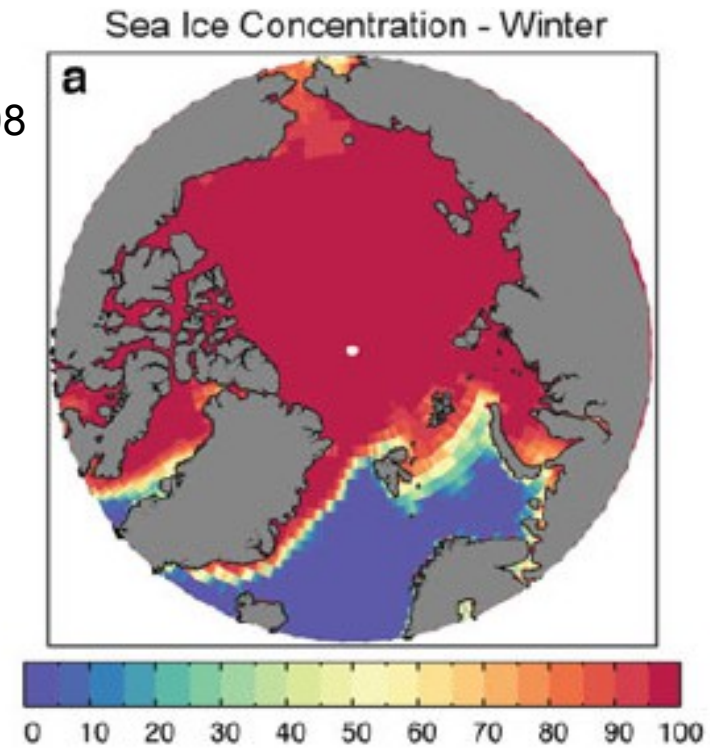
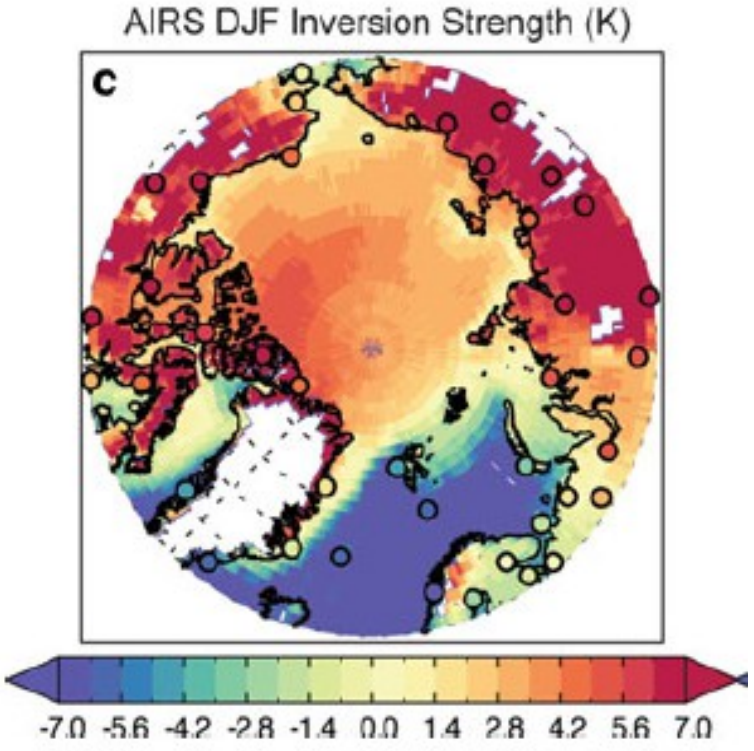
SSM/I
2002-2008





Source: Pavelsky et al. (2011)
Inversion over polar oceans regulated by sea ice

Research Objectives

Main Goal:

Understand the role of the temperature inversion on the surface radiative balance, as well as how this role will be modified in response to sea ice changes.

1) Inversion processes

- Identify main inversion formation and strengthening processes
- Quantify importance of each process - regionally

2) Link to climate changes

- Develop climate scenarios of inversion change
- Quantify changes in related processes
- Bias analysis

Arctic System Reanalysis

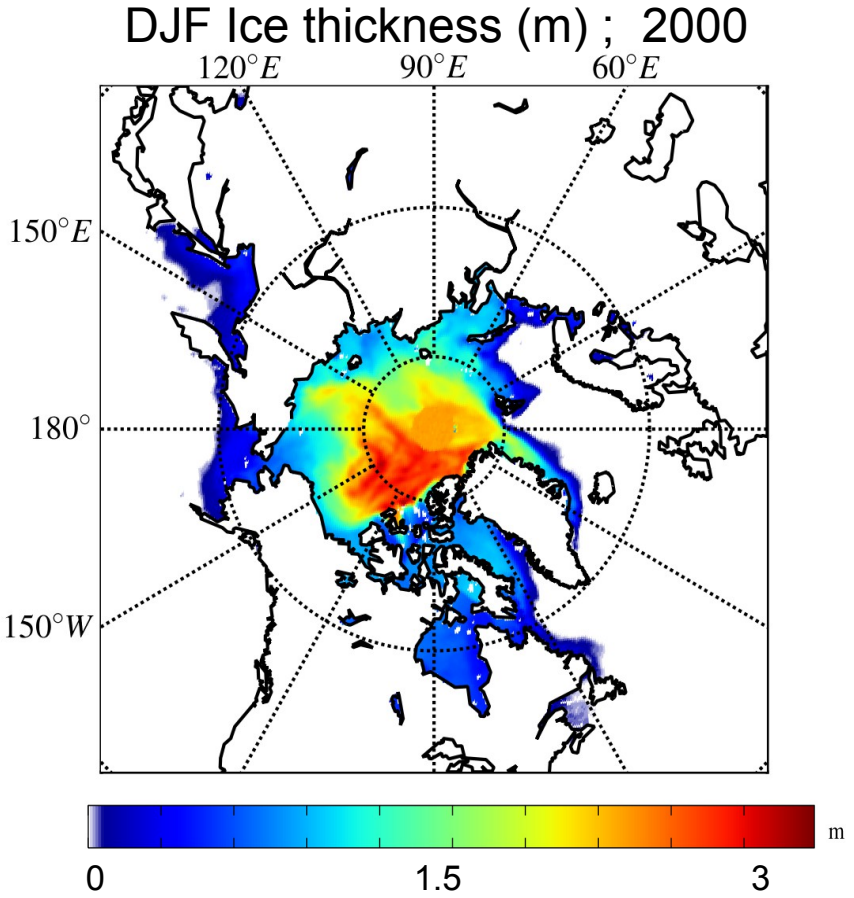
[Bromwich et al. (2015) ; Ohio State U.]

Description:

- 30km resolution
- 2000 to 2010
- Boundary cond: Era-interim

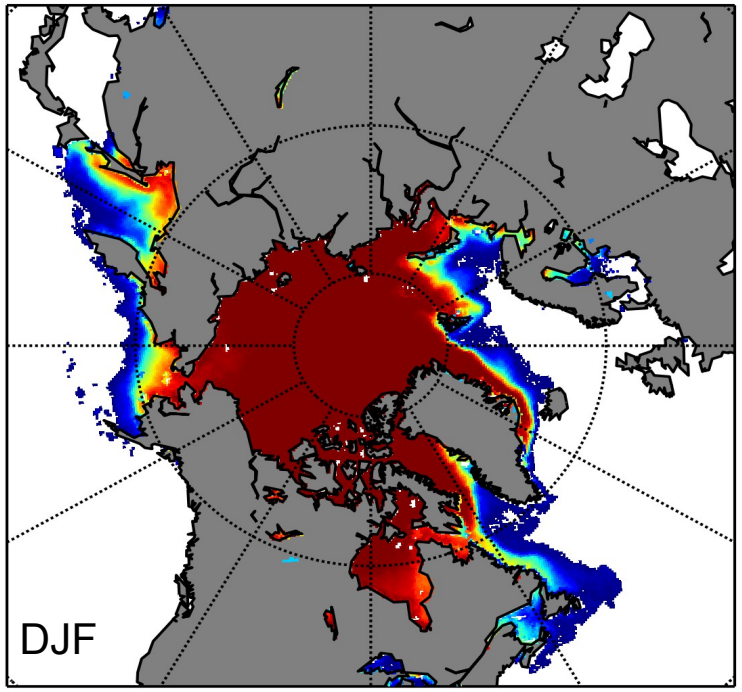
Based on Polar version of WRF

Improved sea ice treatment :
Partial cover, area, concentration, thickness, albedo and snow cover

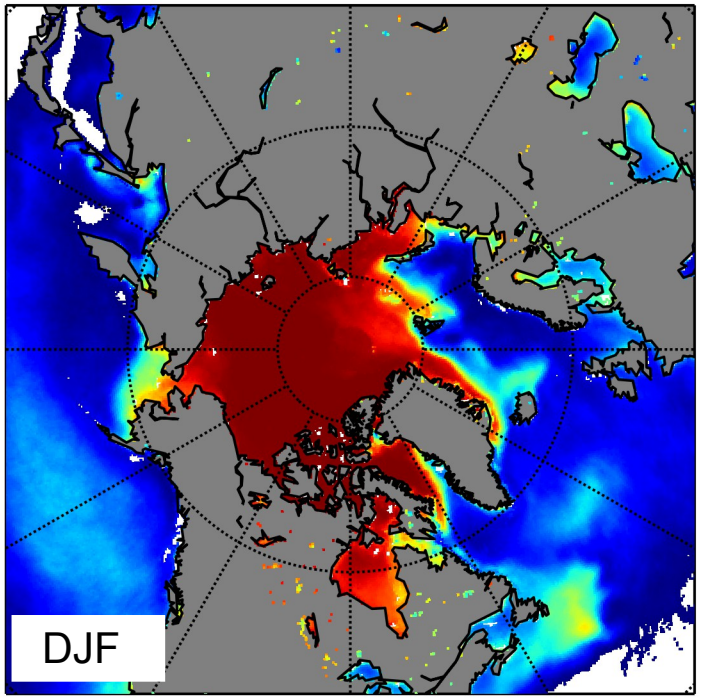


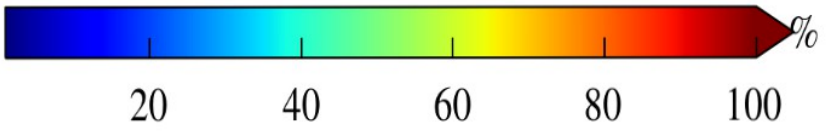
Preliminary Results

Freq. occurrence sea ice



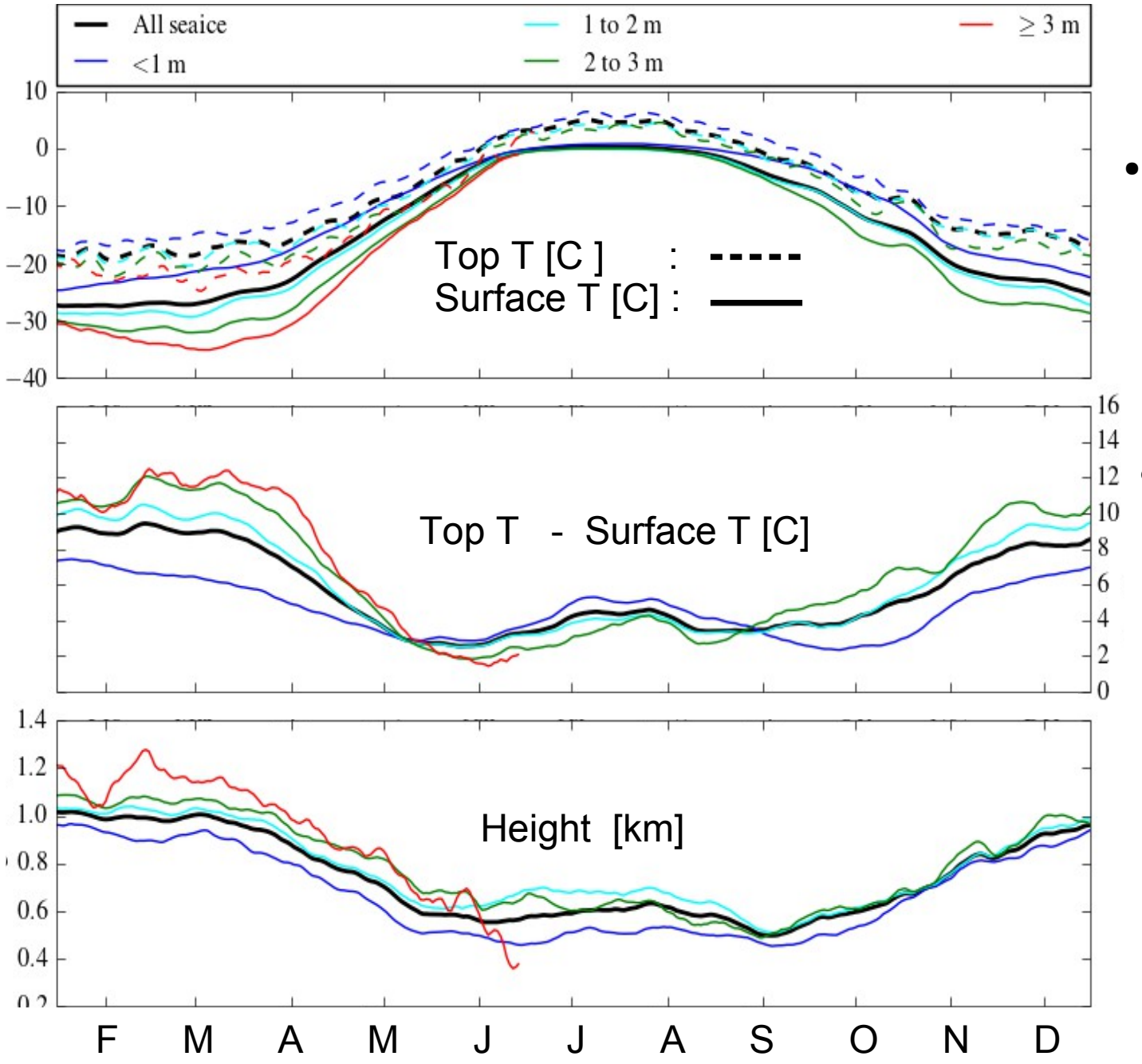
Freq. occurrence inversions





Data source: ASR, 2000-2007

Preliminary Results

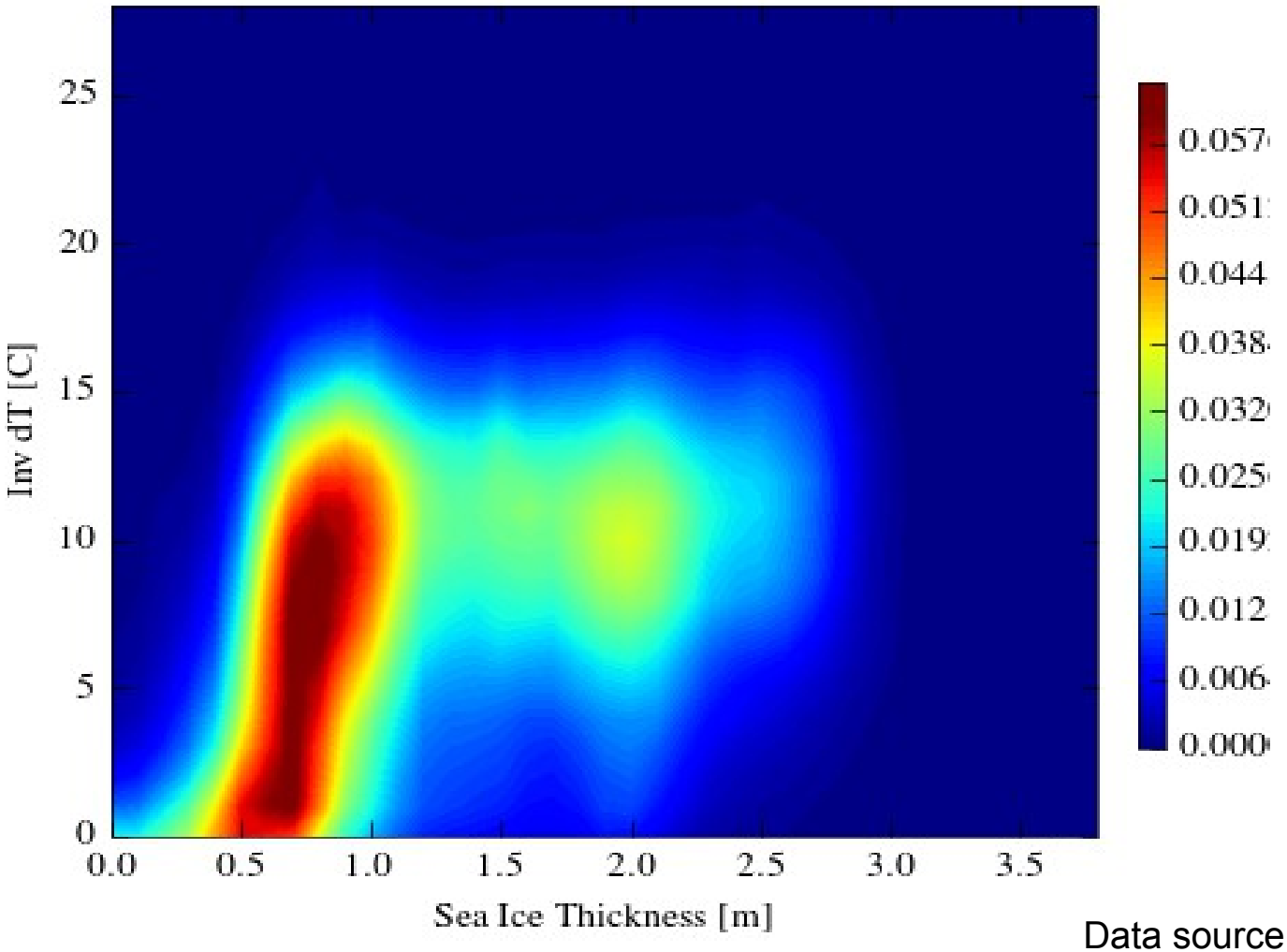


- Associated with **colder temperatures** (both top and surface)
- **Stronger** and **taller** inversions over thicker ice

Data source: ASR, 2000-2007

Preliminary Results

Histogram:
DJF inversion grid boxes over sea ice



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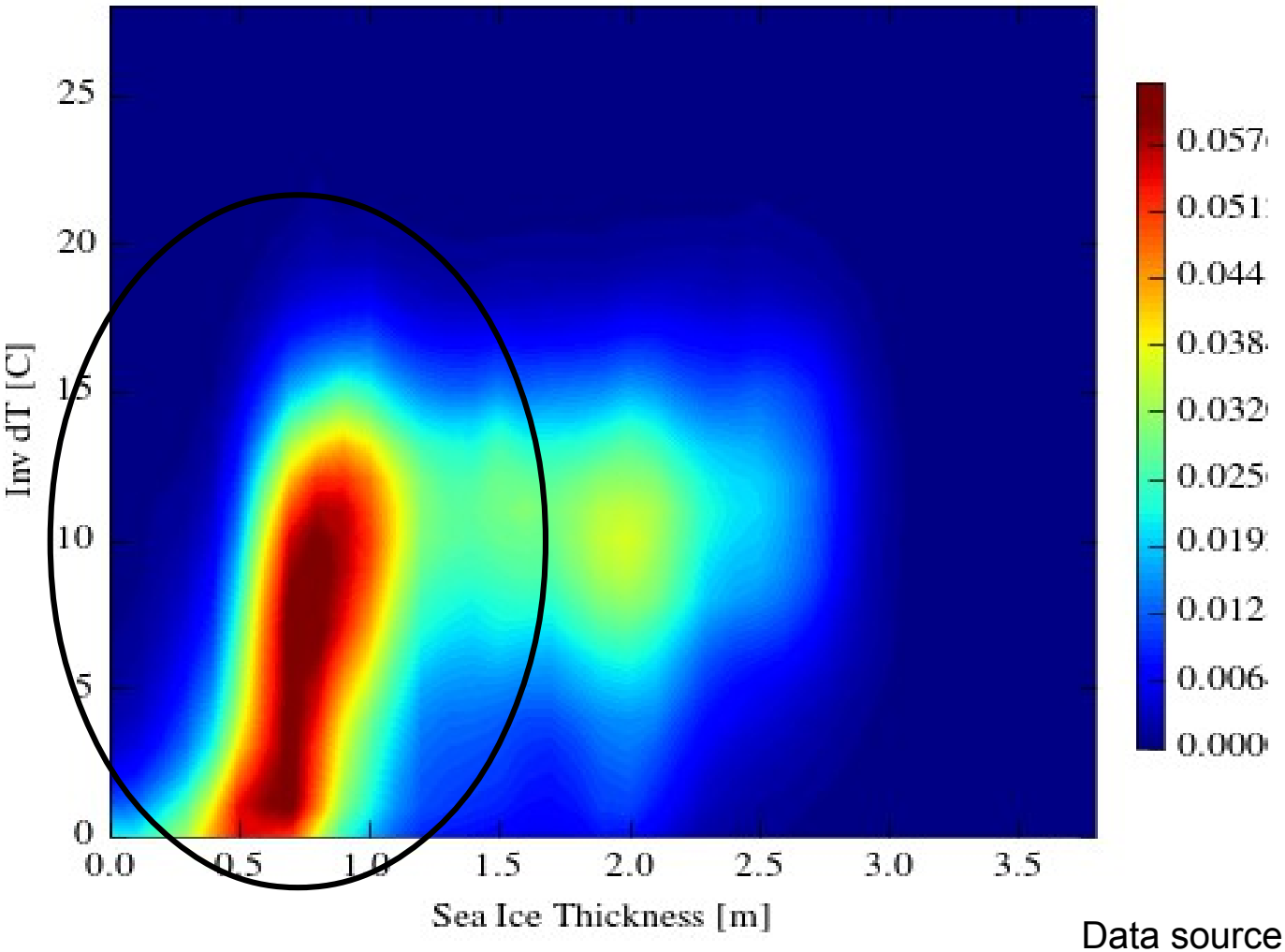

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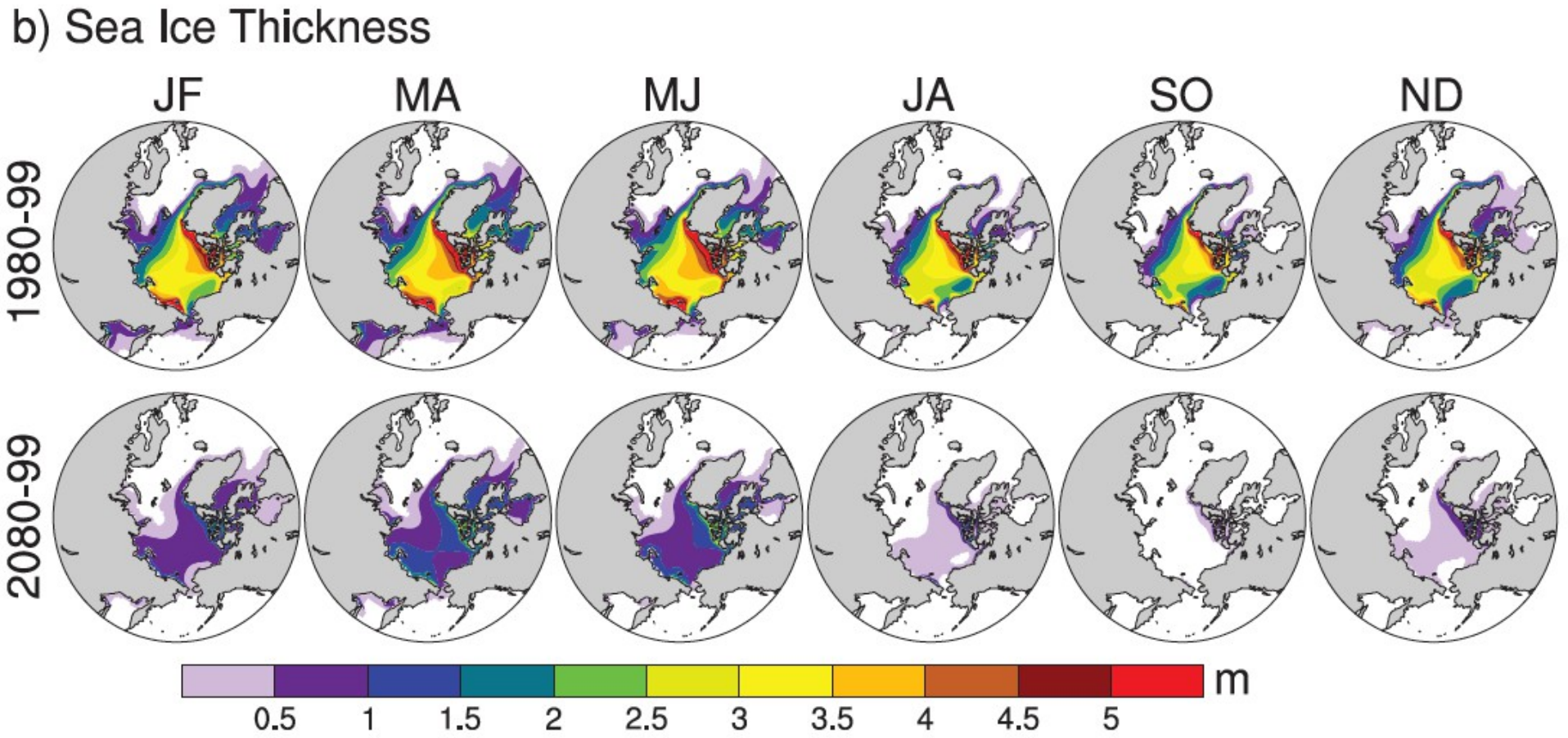
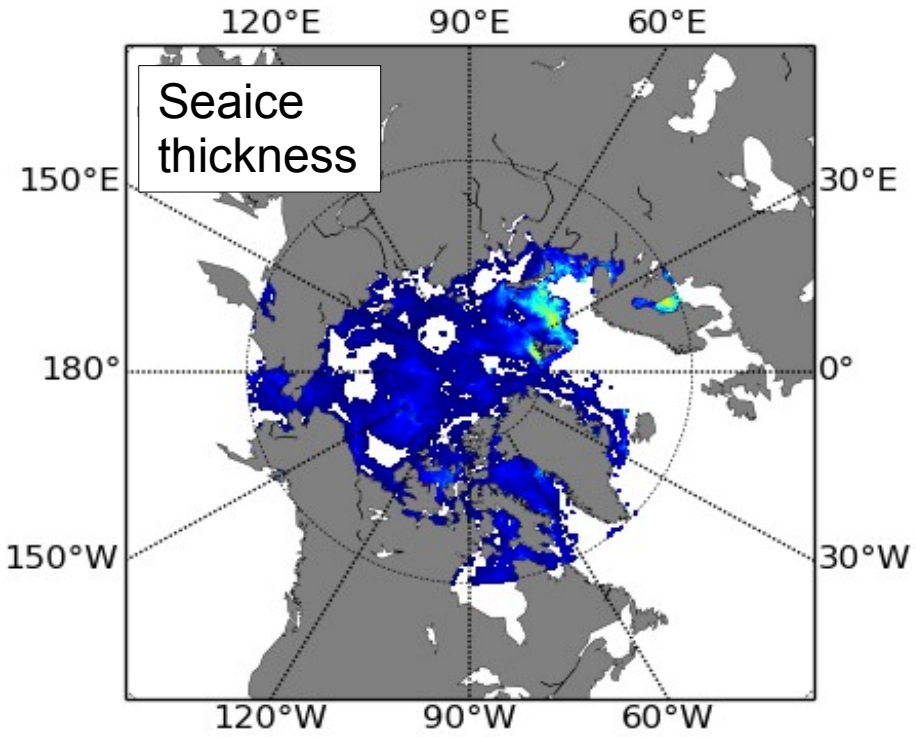


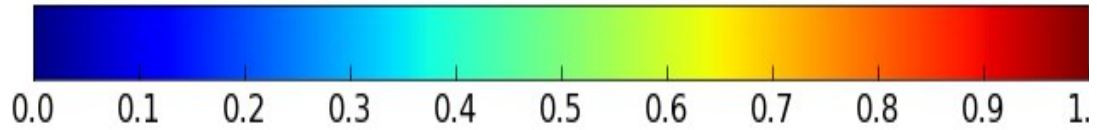
FIG. 1. Bimonthly distributions of Arctic (a) sea ice concentration (%) and (b) sea ice thickness (m) during 1980–99 and 2080–99 from CCSM3.

Deser et al. 2010.

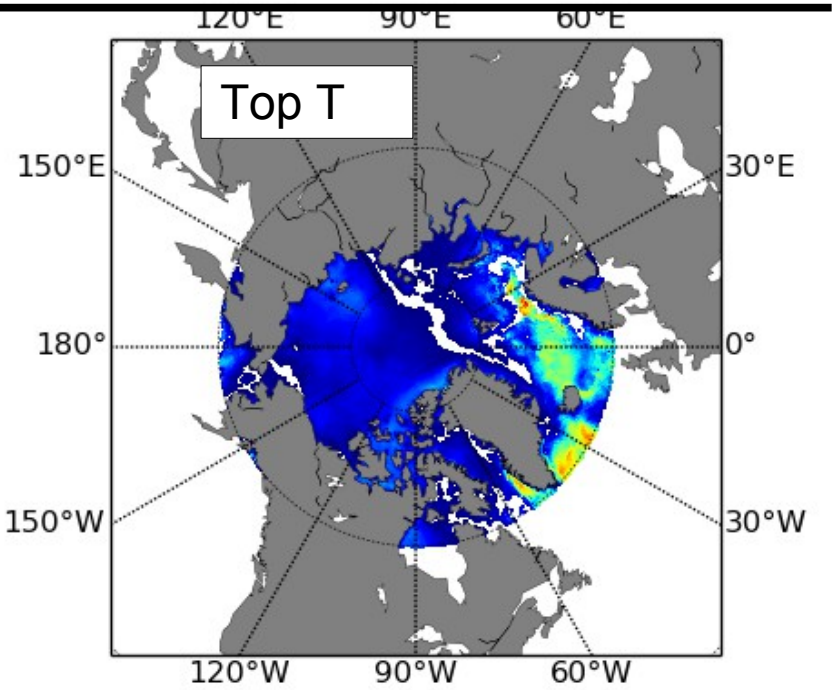
Preliminary Results

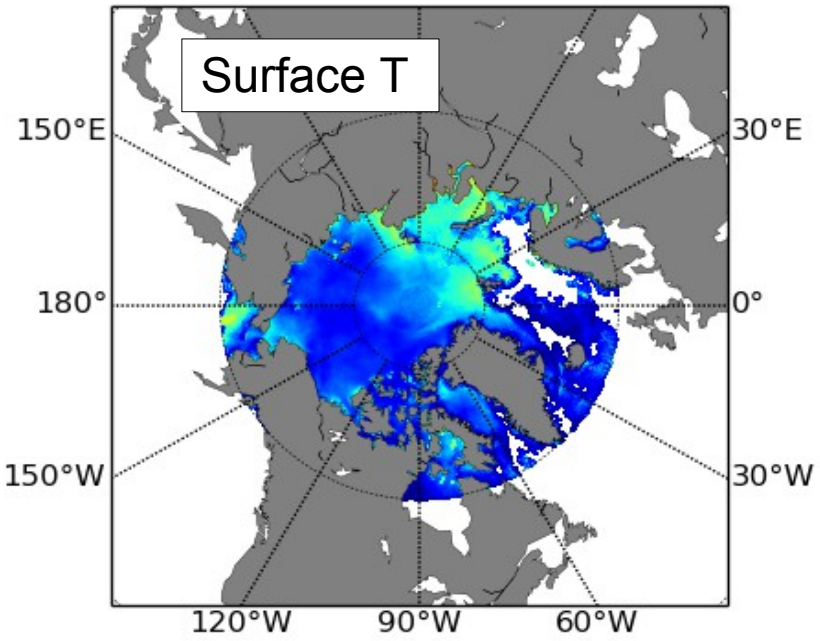
Correlations : DJF inversion ΔT





R-squared statistic





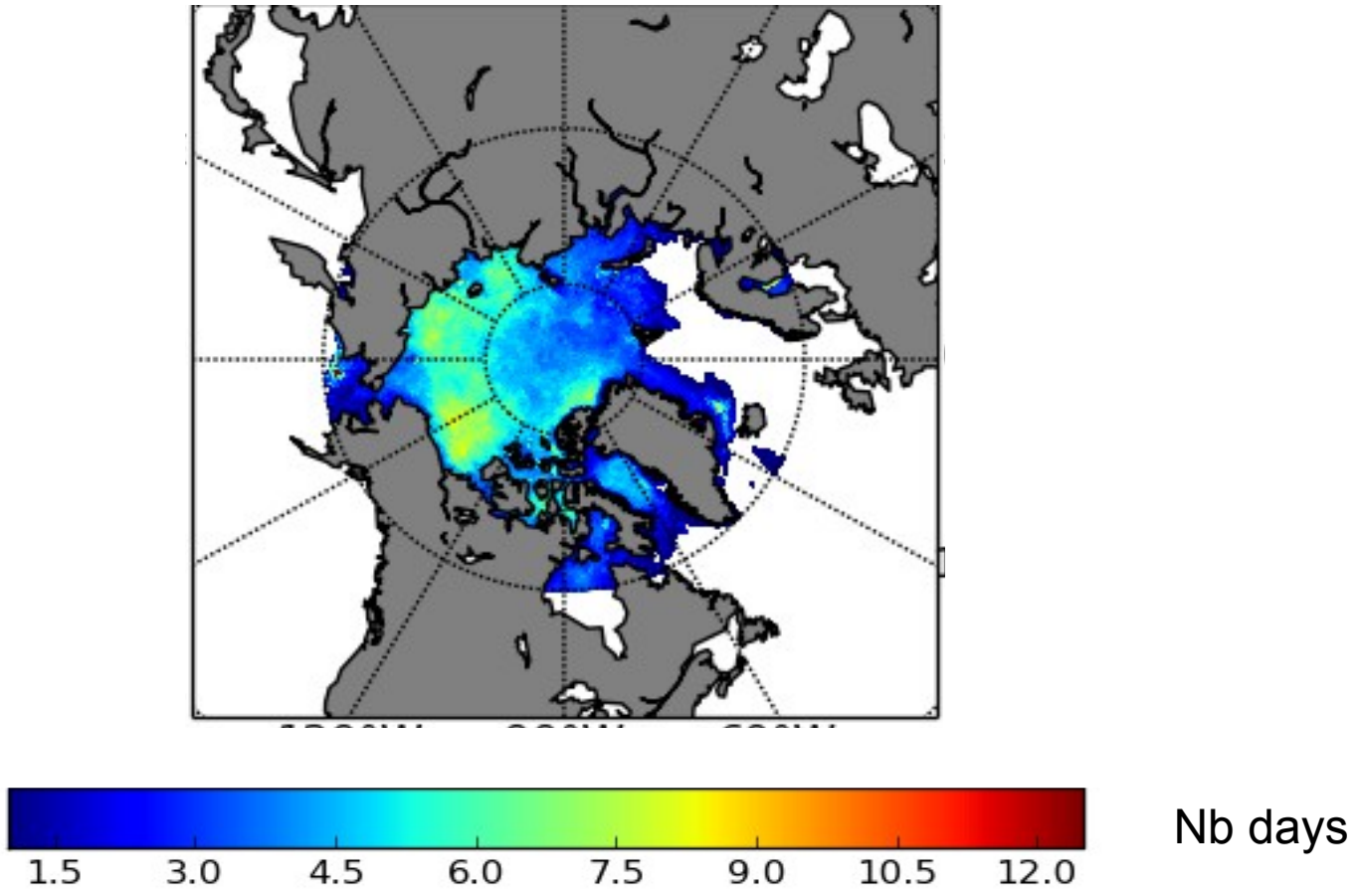
Data source: ASR, 2000-2007

Preliminary Results

Timescale analysis

DJF

Mean timescale
ΔT>10C

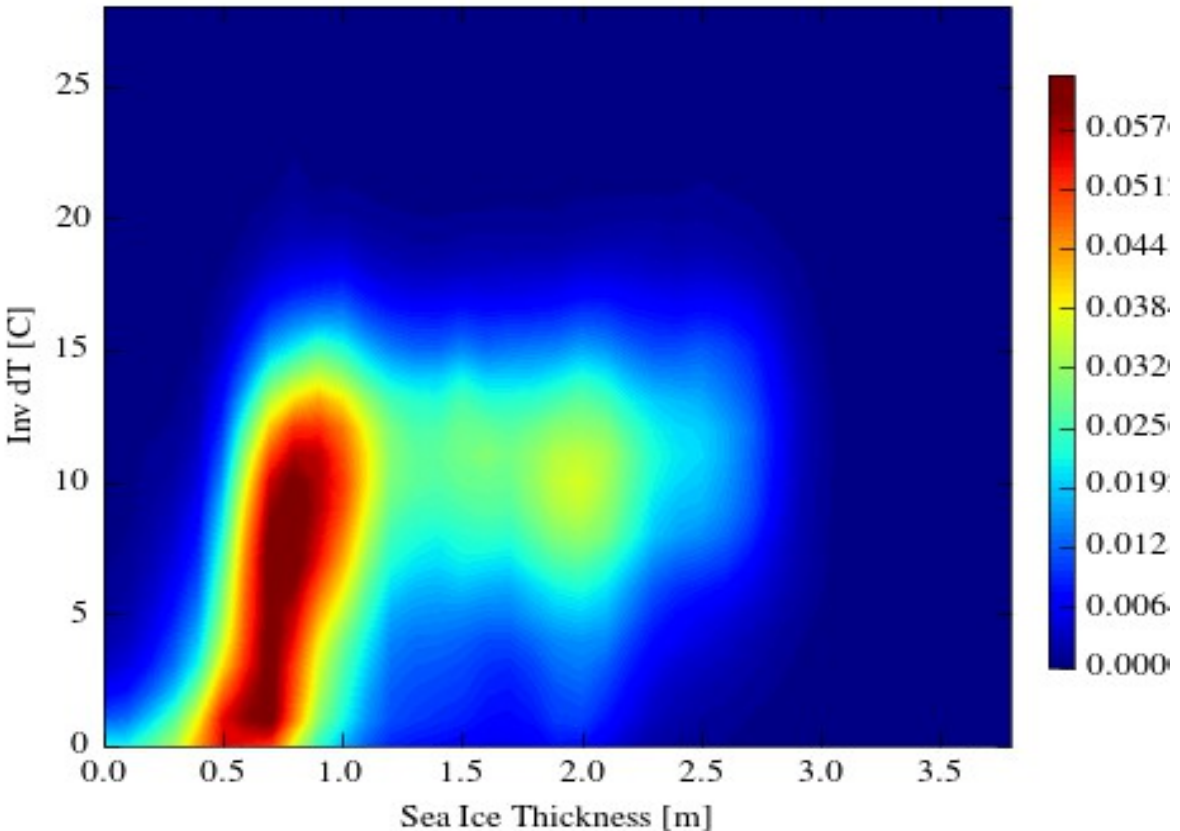


Summary / Future Work

1) Relationship between inversion strength and
sea ice concentration has been noted in Pavelsky et al. (2011)

2) Most of Arctic has high sea ice concentration in winter
- What other factors of variability?

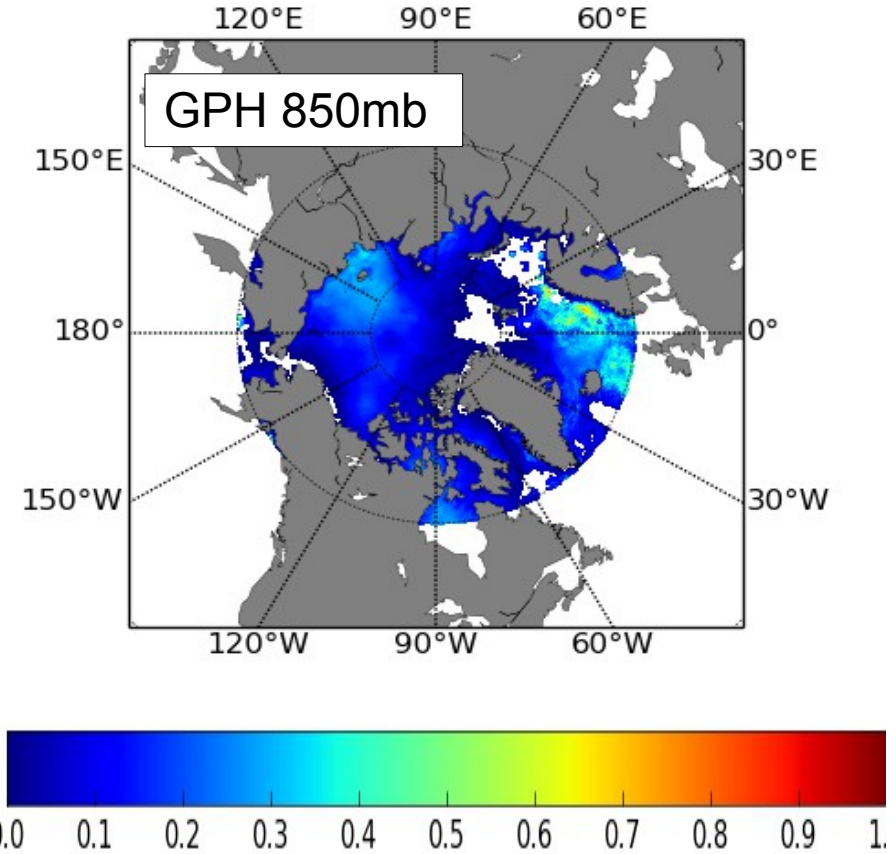
3) Sea ice thickness related to
spatial variability, not so much temporal
(similar to Pavelsky et al. study)



Summary / Future Work

Other factors:

- High pressure/ subsidence
- Meridional transport of heat and moisture
- Mixing by cyclonic systems
- Sustained conditions



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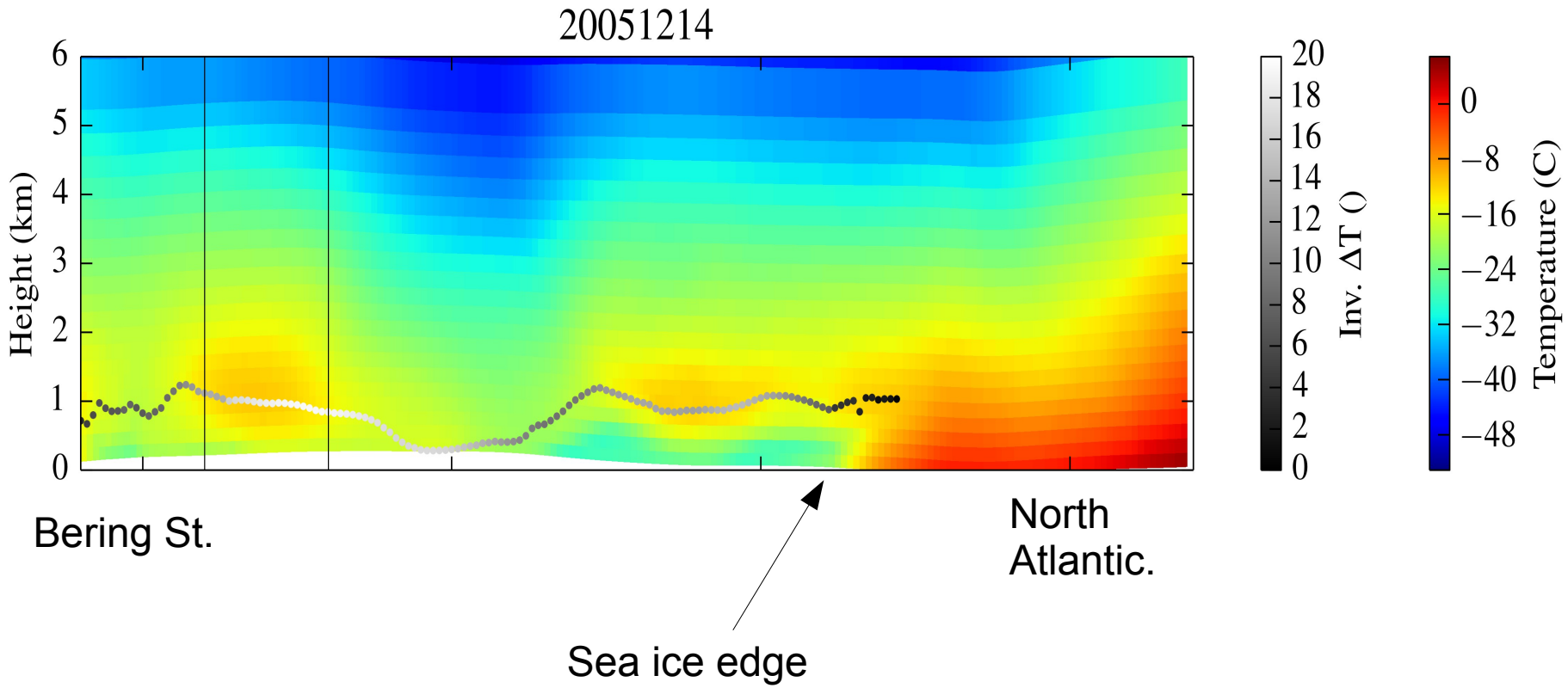

Summary / Future Work

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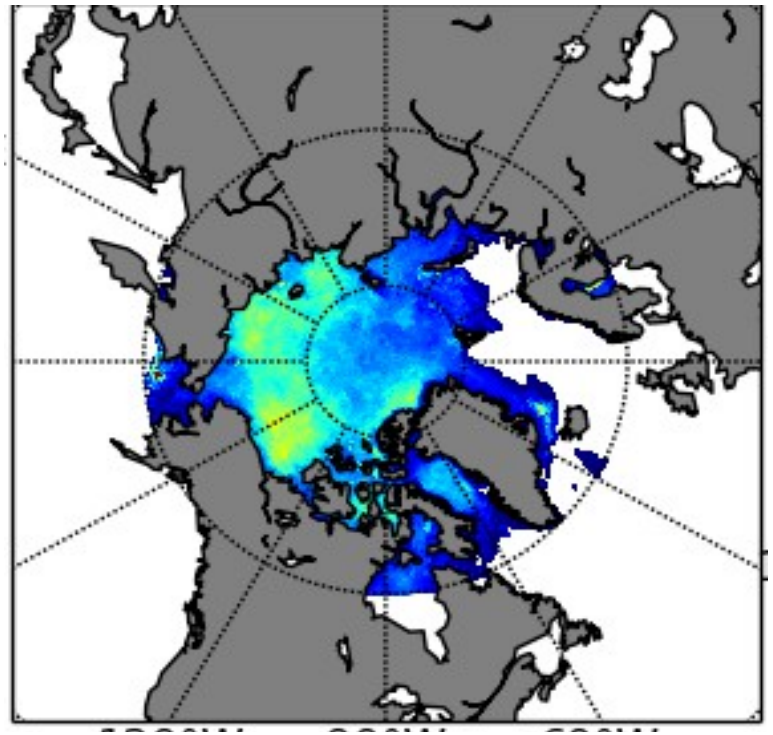
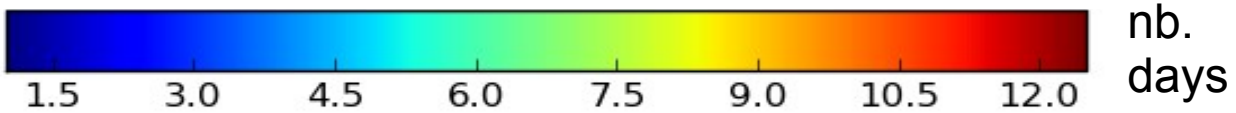
Mean timescale
dt>10C

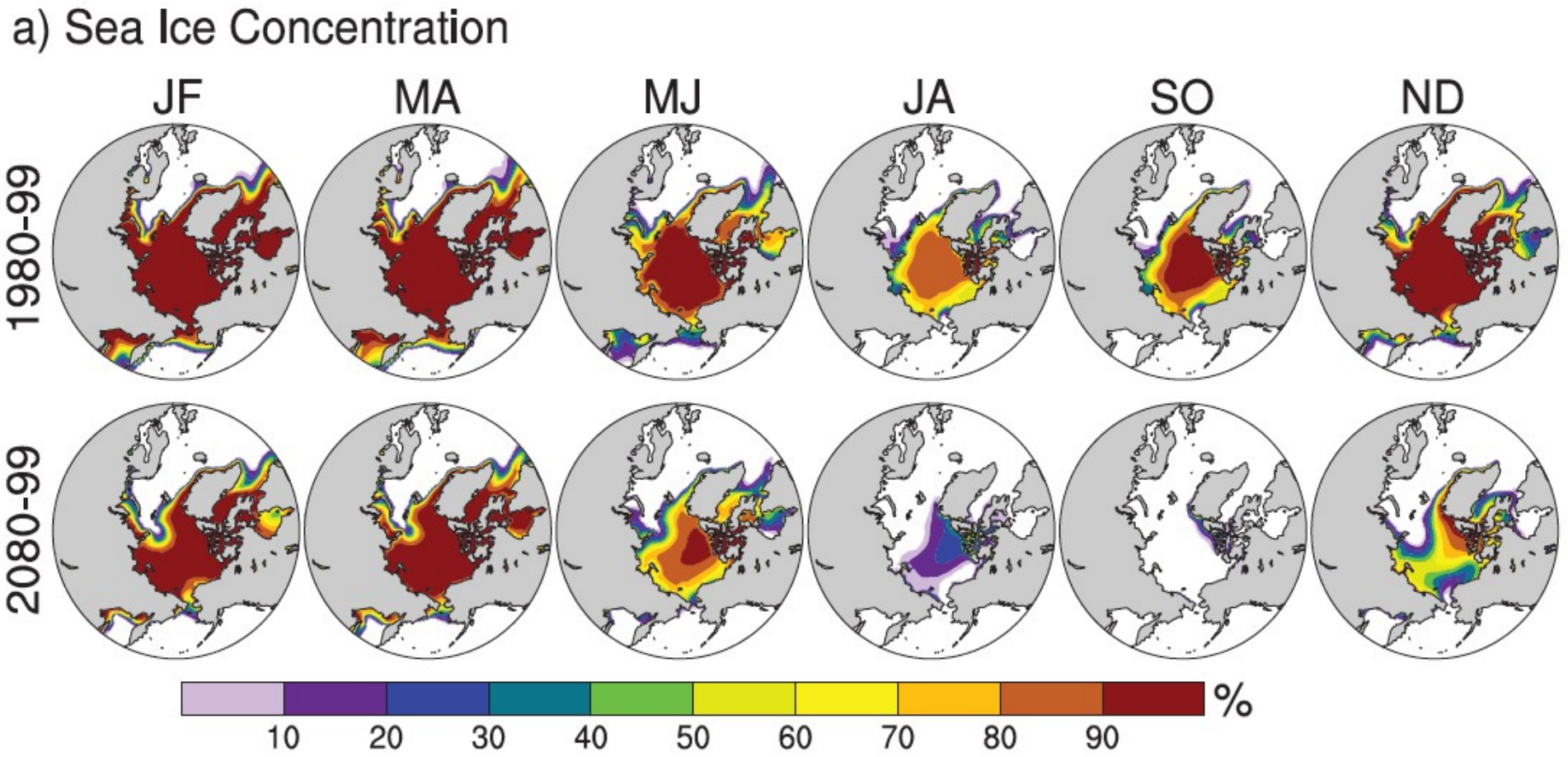




Thank You!

Questions/comments?

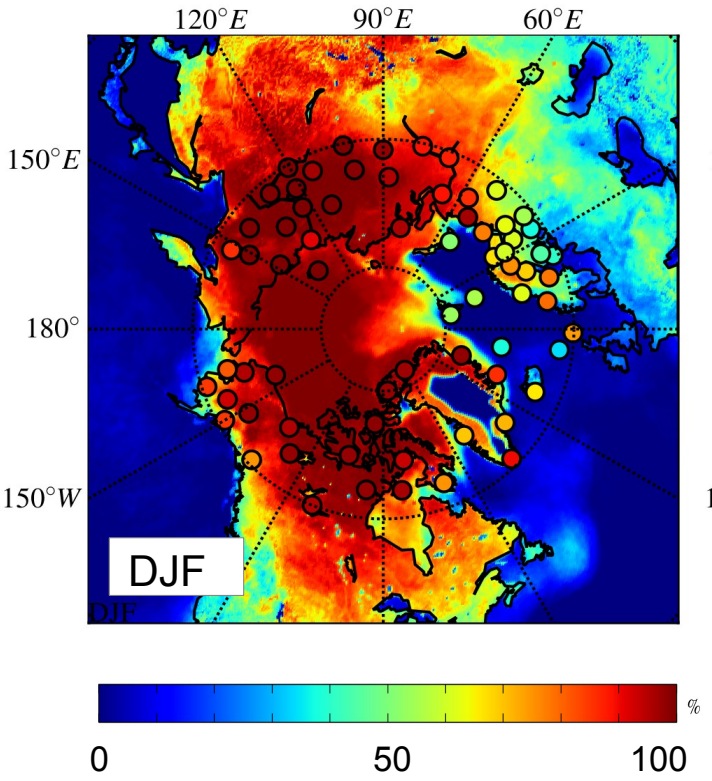
Preliminary Results



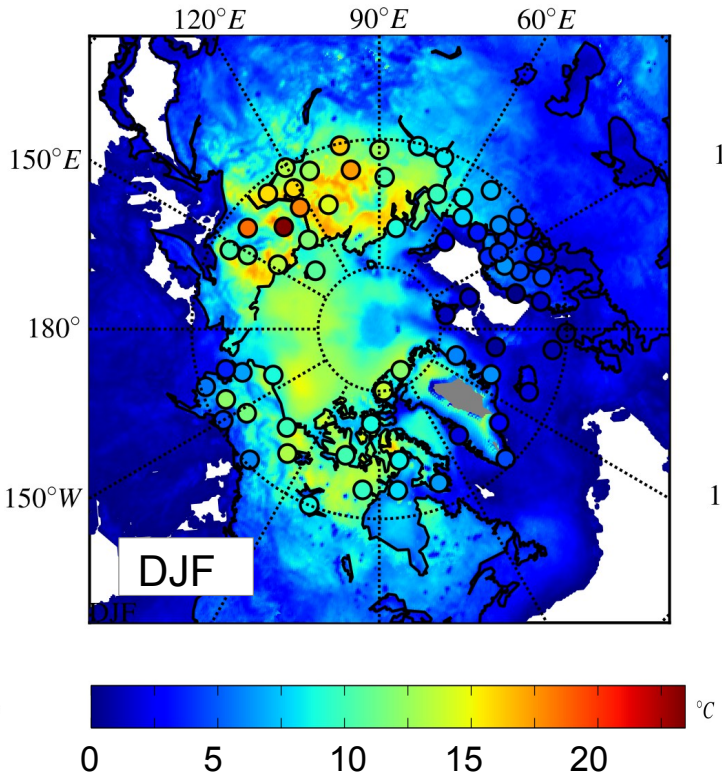
Deser et al. 2010.

Tool

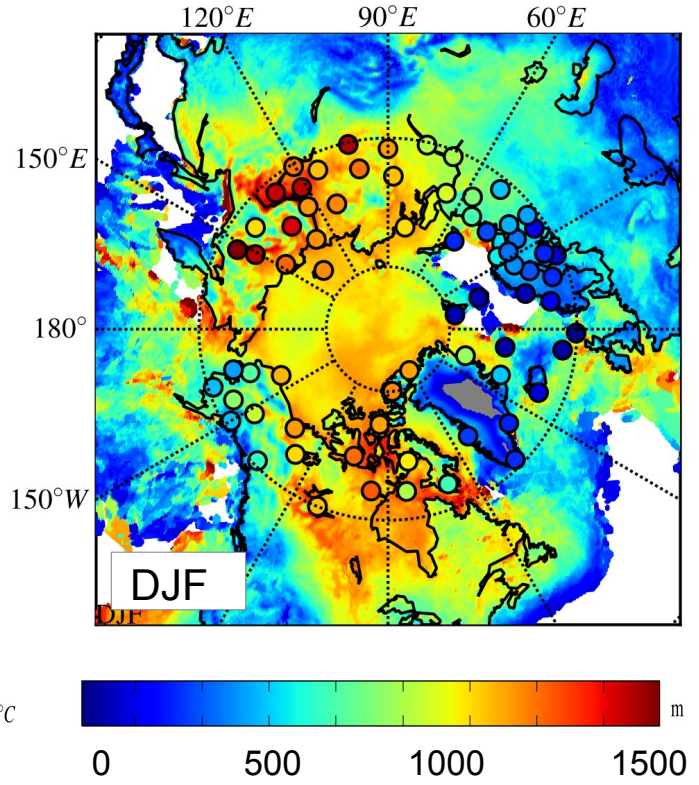
Fréquence inversion (%)



Δ T inversion (C)



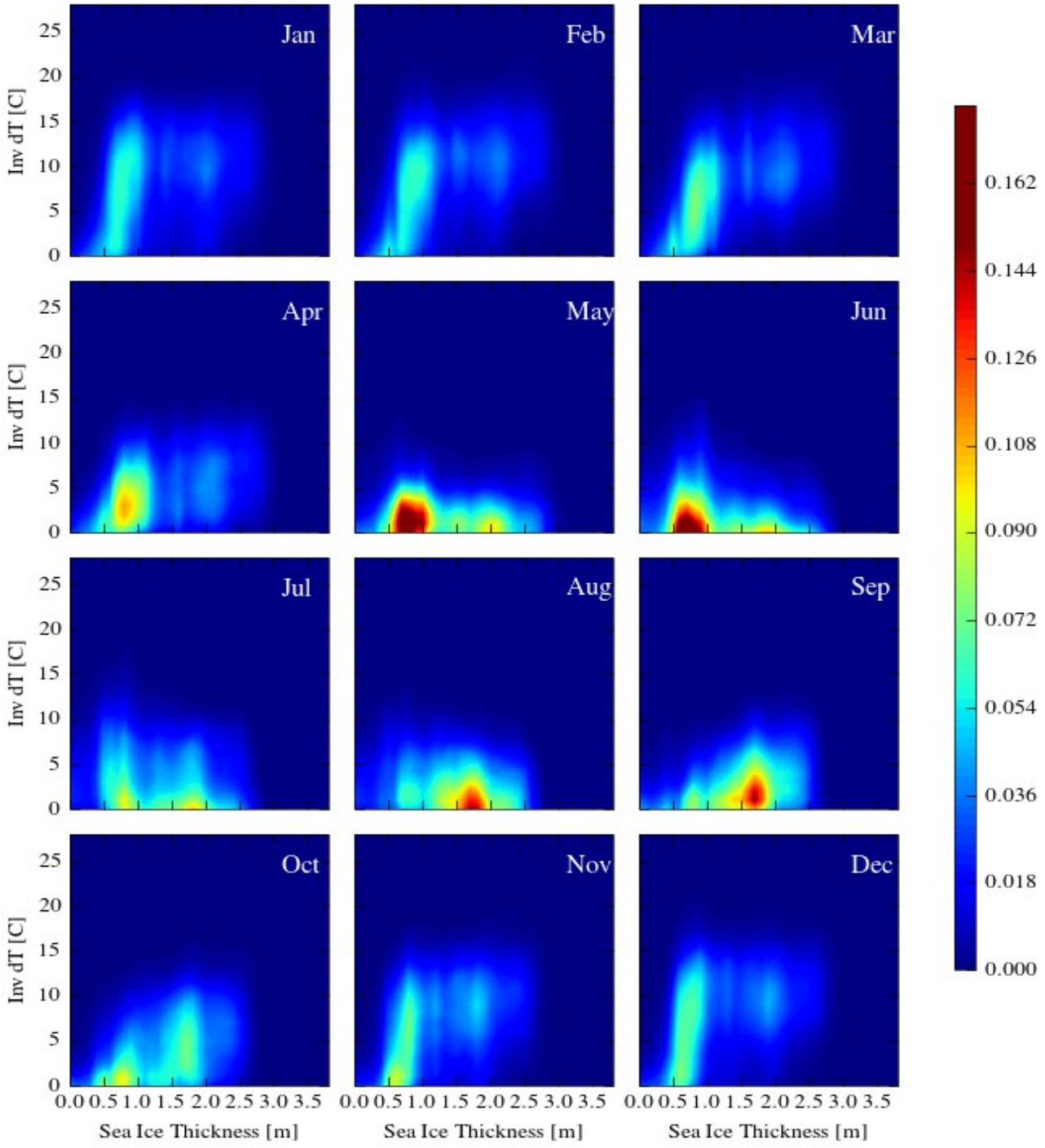
Hauteur inversion (m)



Comparison with Integrated Global Radiosonde Archive (IGRA ; Durre et al. 2008)

Data source: IGRA and ASR, 2000

Preliminary Results



Data source: ASR, 2000-2007

Preliminary Results

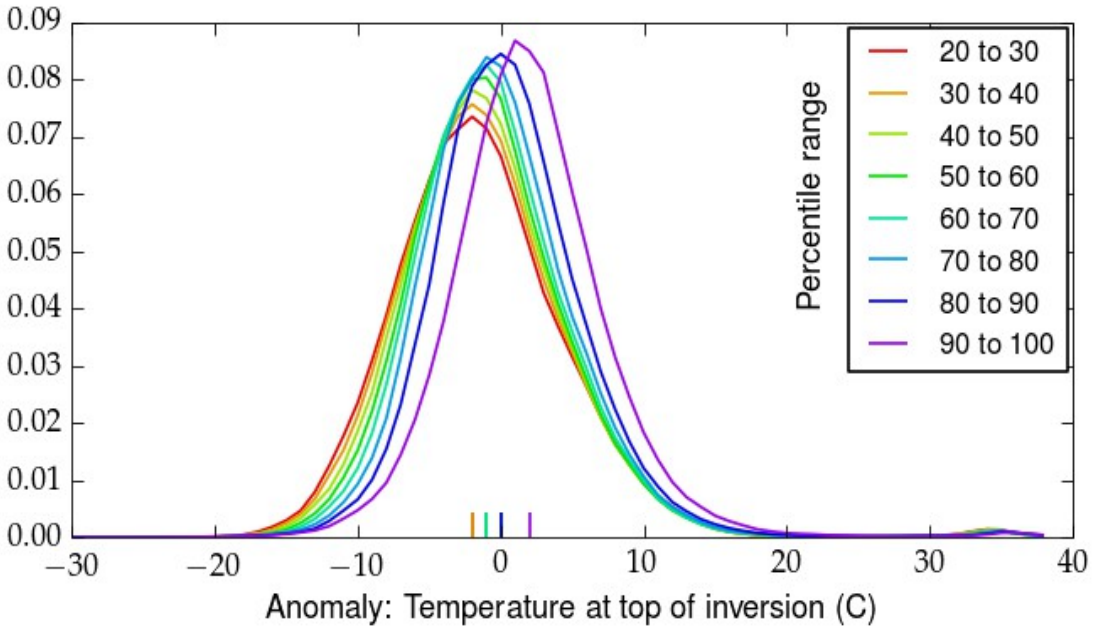
Local anomalies to separate contribution of each factor

1) Calculate local anomalies in ΔT

2) Separate in percentile range (e.g. 10% strongest inversions)

3) Pool all grid points

4) Calculate anomalies
- **Top and surface T**
- **pressure**
- **moisture**
- **etc...**



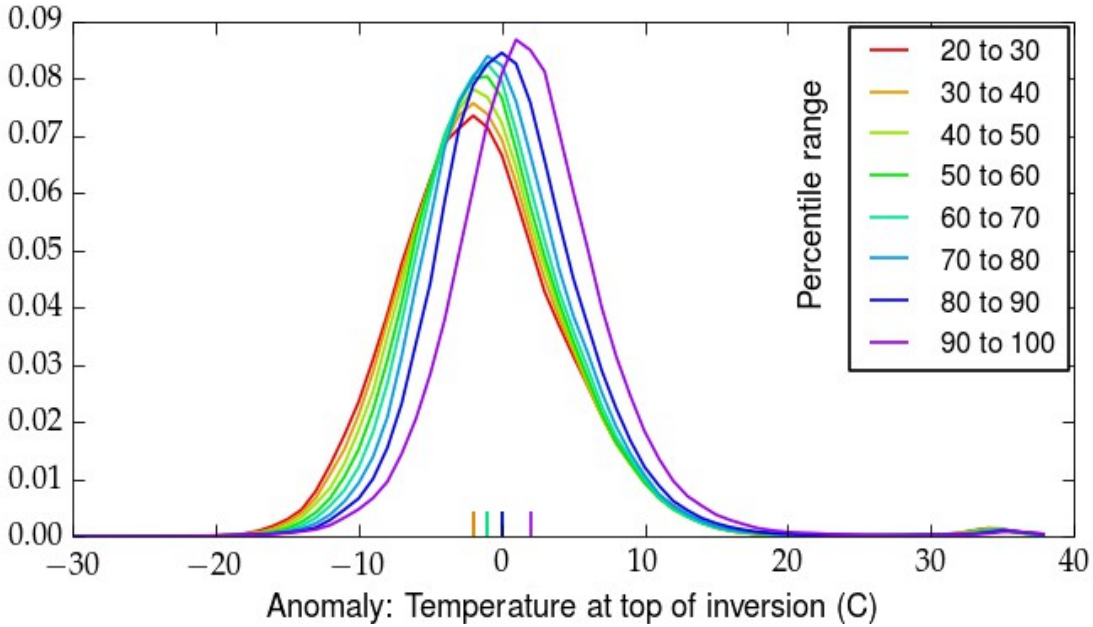
Data source: ASR, 2000-2007

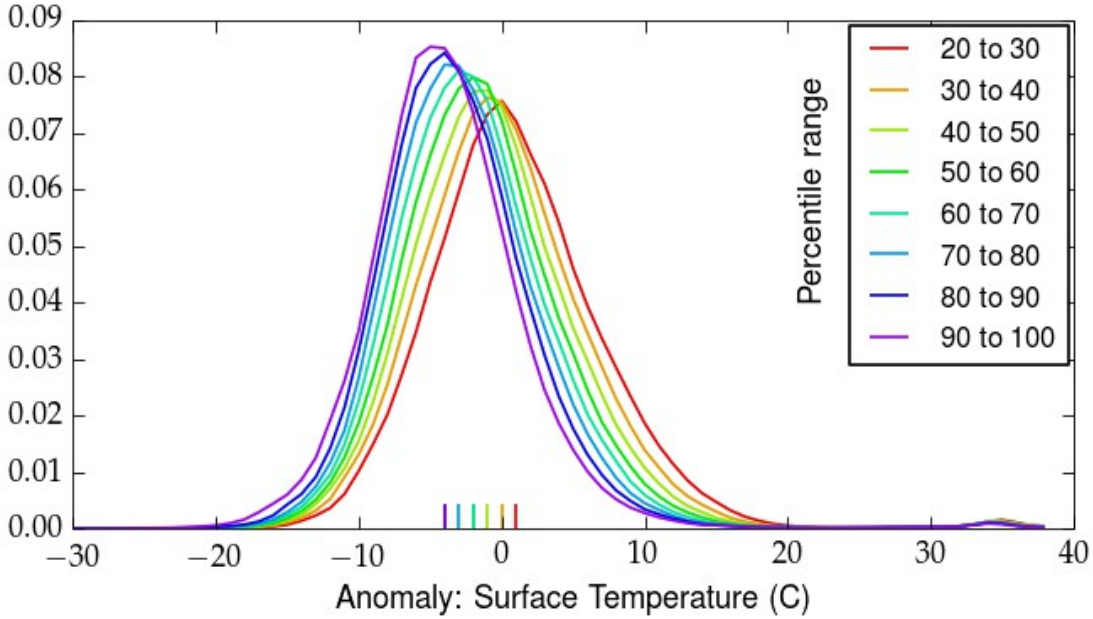
Preliminary Results

Preliminary results:

Strong Inversions have:

- Warmer Top temperature
- Colder Surface temperature





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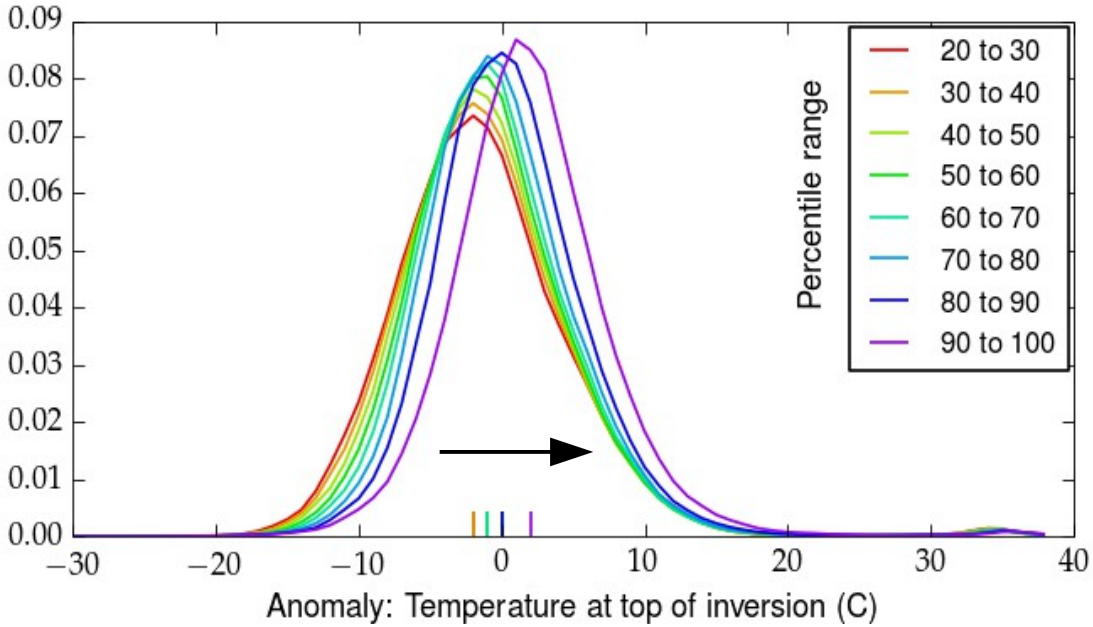
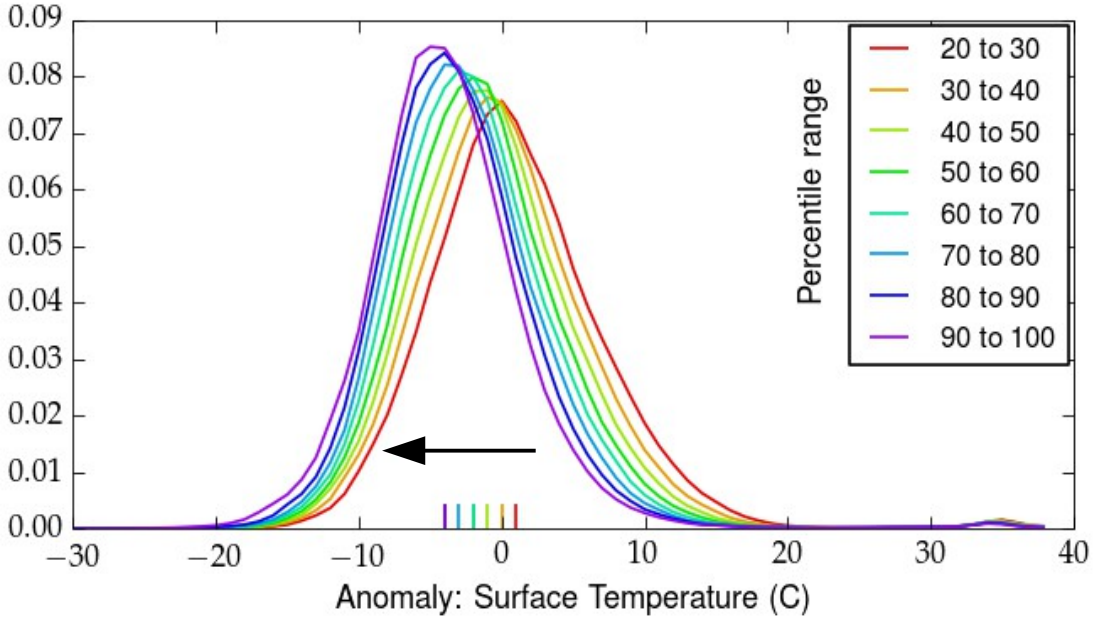




Data source: ASR, 2000-2007

Preliminary Results

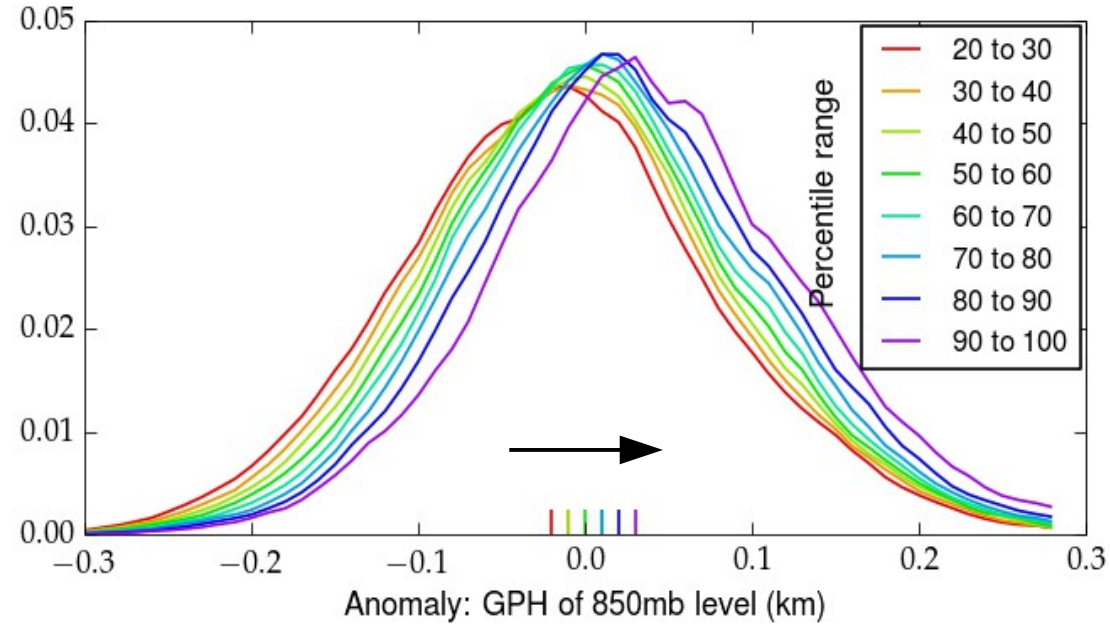
Preliminary results:

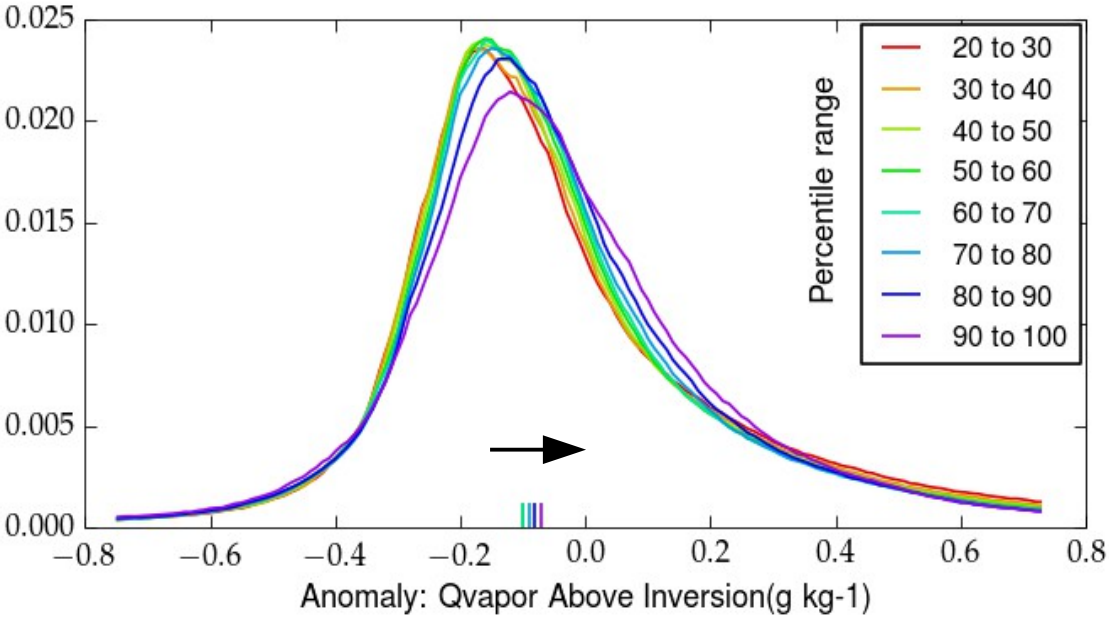
Strong Inversions have:

- Warmer Top temperature
- Colder Surface temperature

- Higher Pressure
- Increased moisture above inversion

Counter intuitive
Can these inversions last?





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