Arctic temperature inversions in the CESM- Large Ensemble

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Background

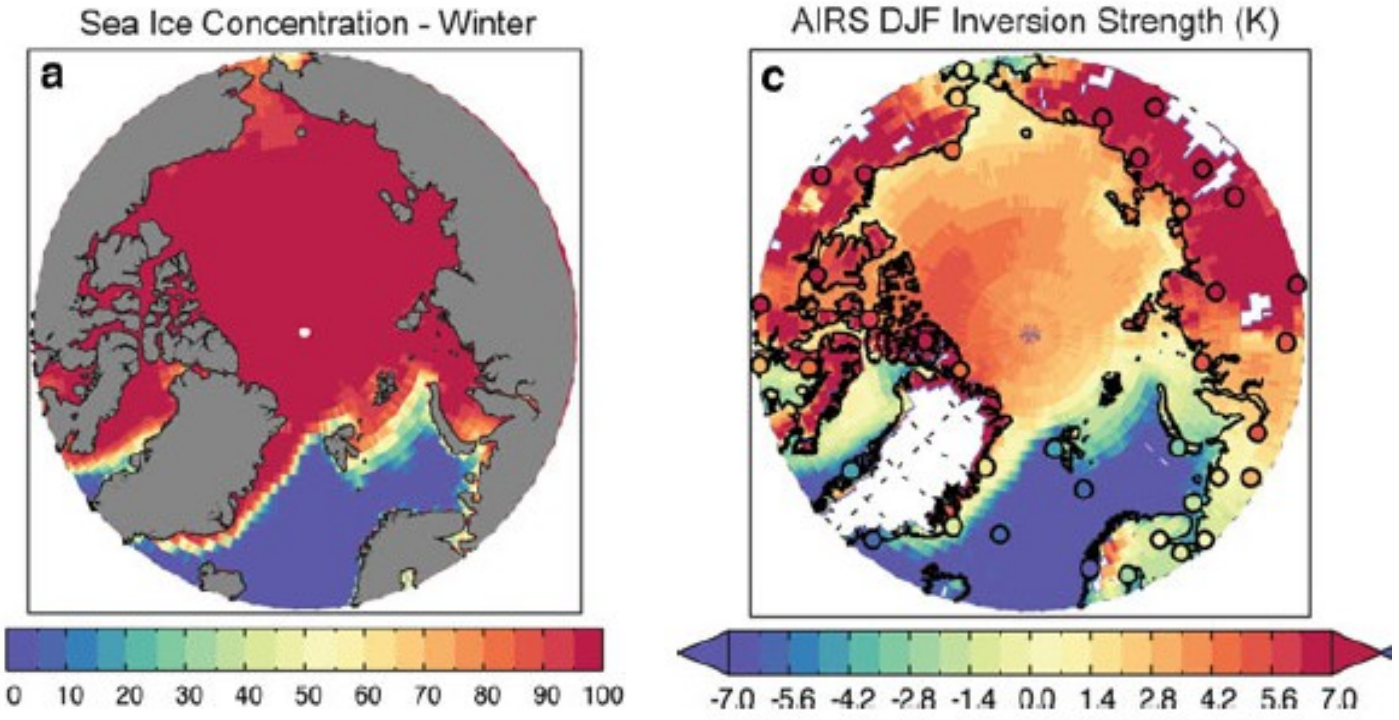
Wintertime inversion

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

Recent studies:

- Regulated by sea ice [Pavelsky et al (2011)]

SSM/I
2002-2008



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

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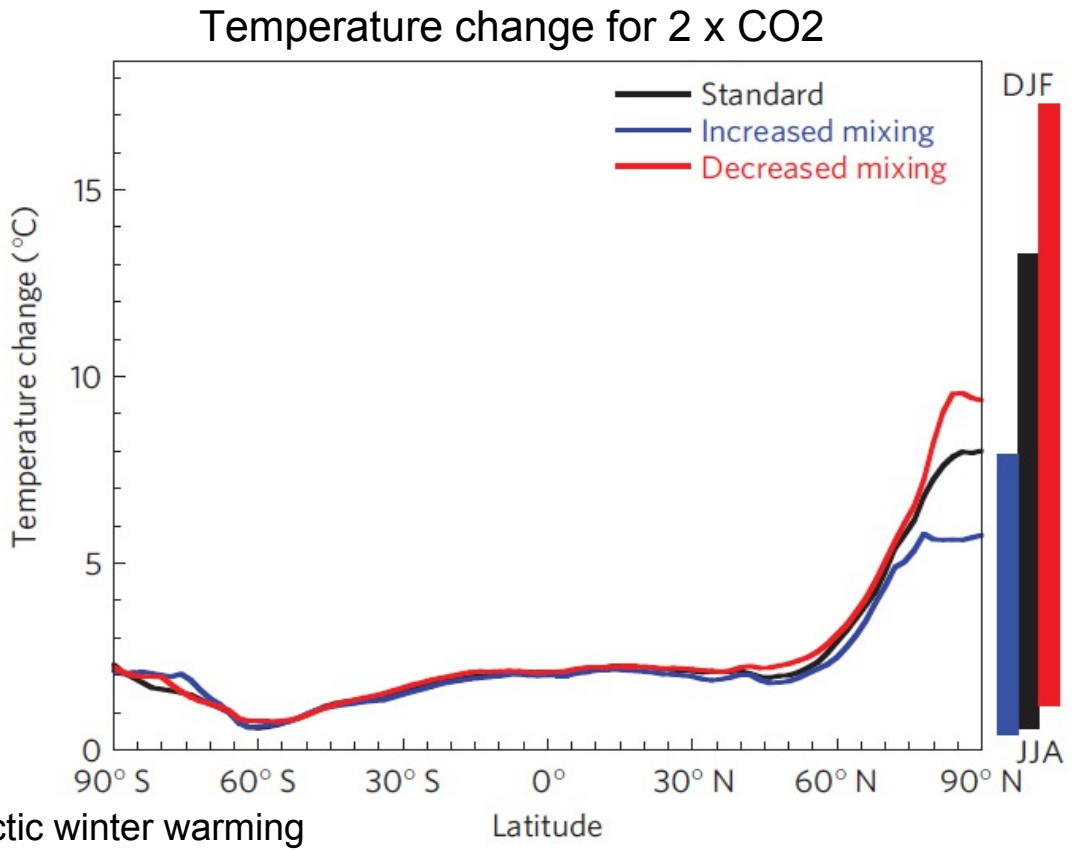
- Linked to Arctic Amplification [e.g Bintanja et al. (2011)]



Using EC-Earth Global coupled model

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

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Recent studies:

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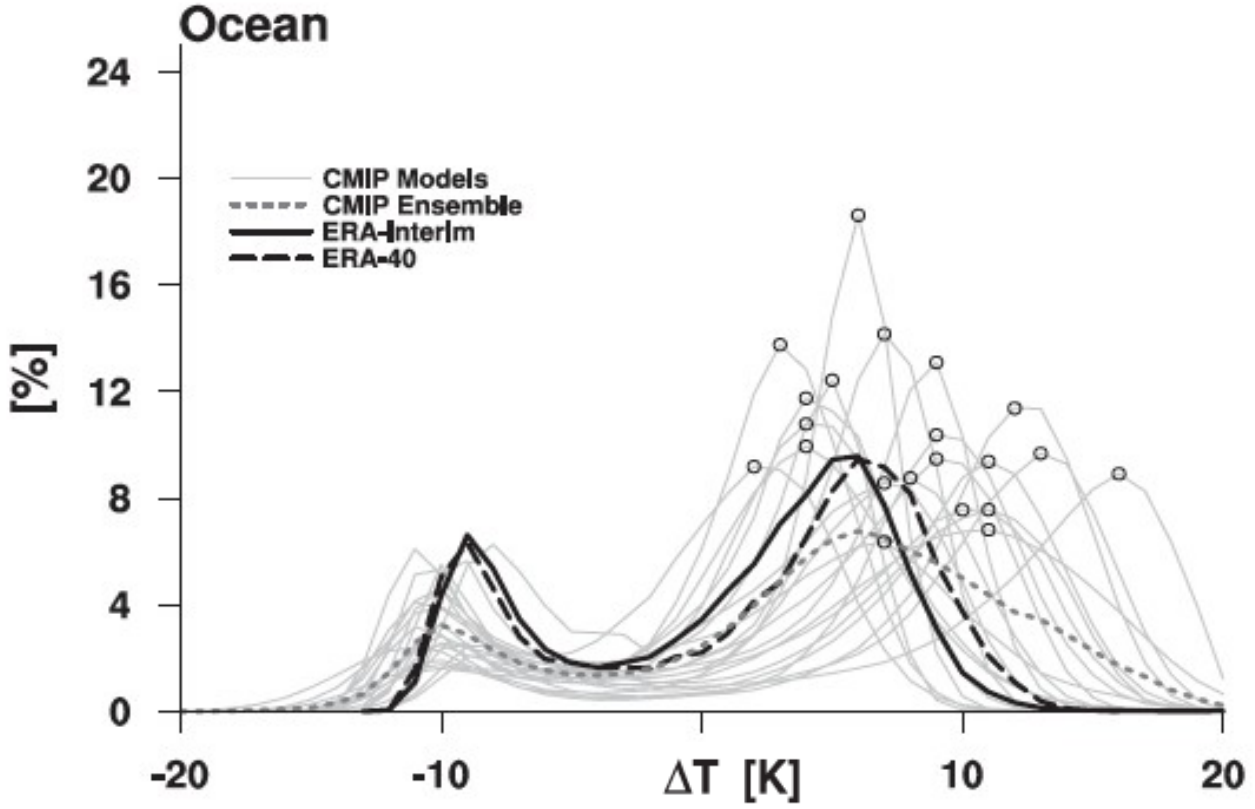
- Linked to Arctic Amplification [e.g Bintanja et al. (2011)]
- Large variability in GCM representation of inversions [Medeiros et al. (2011)]



Source:
Medeiros et al. 2011

Datasets

CESM-LE (Kay et al. 2014)
used to characterize natural variability of climate
Approx. 1 deg horizontal resolution

30 ensemble members
1920 – 2005 : historical forcing
2006 – 2100 : Representative Concentration Pathway (RCP) 8.5

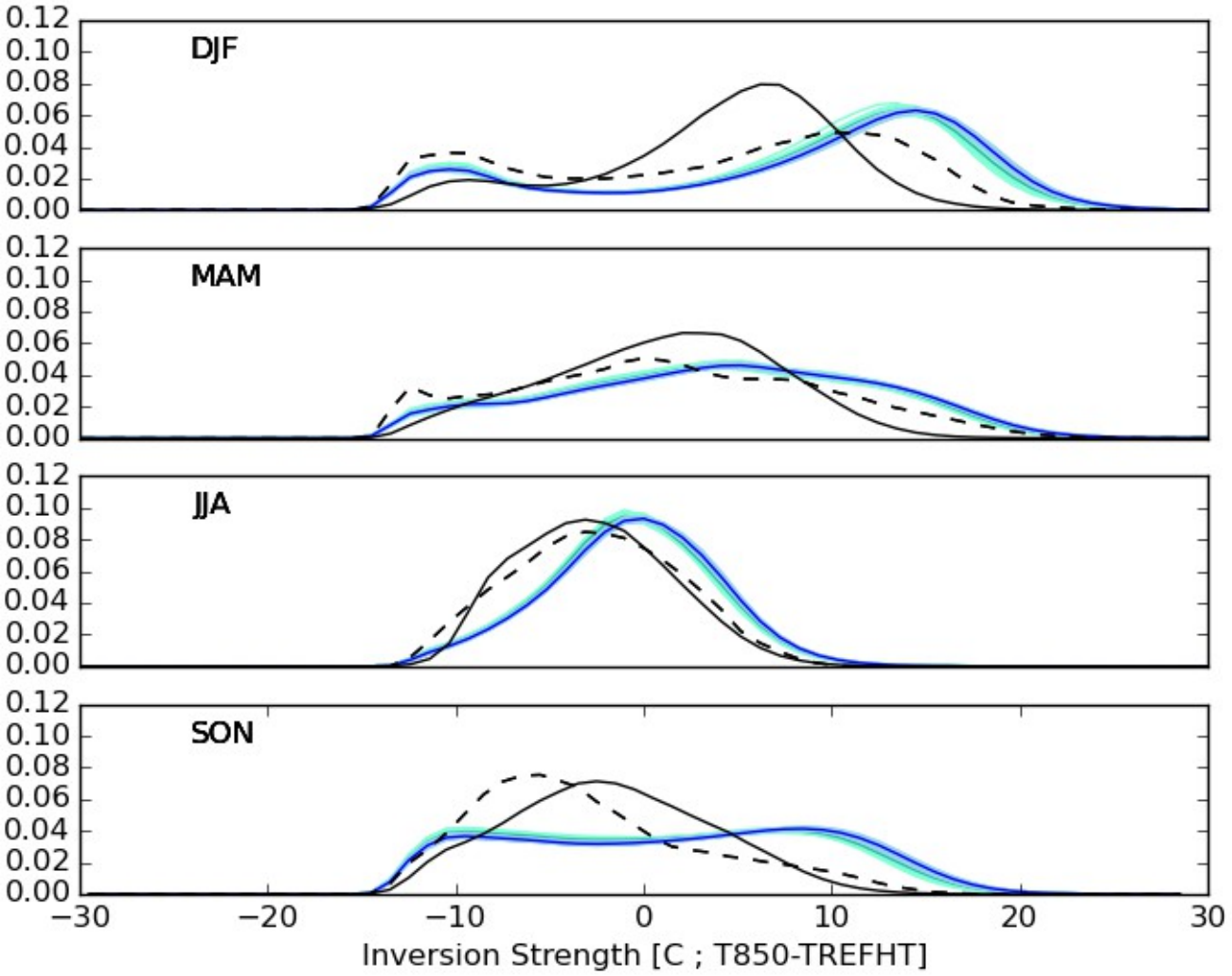
ERA-Interim (Dee et al. 2011)
Global reanalysis
Approx 80km resolution
1979 – 2014

Arctic System Reanalysis (Bromwich et al. 2012)
Regional reanalysis with improved Arctic climate features and mesoscale circulation
30km resolution
2000-2010

Preliminary Results

Inversions in CESM-LE

Ocean (ice + open water)



ERA-Interim
ASR (- - -)
REF Recent 1980-2005
REF 1920-2005

Arctic: Latitude > 64N

Inversion definition:
T (850mb) – T (surface)

Preliminary Results

Inversions in CESM-LE

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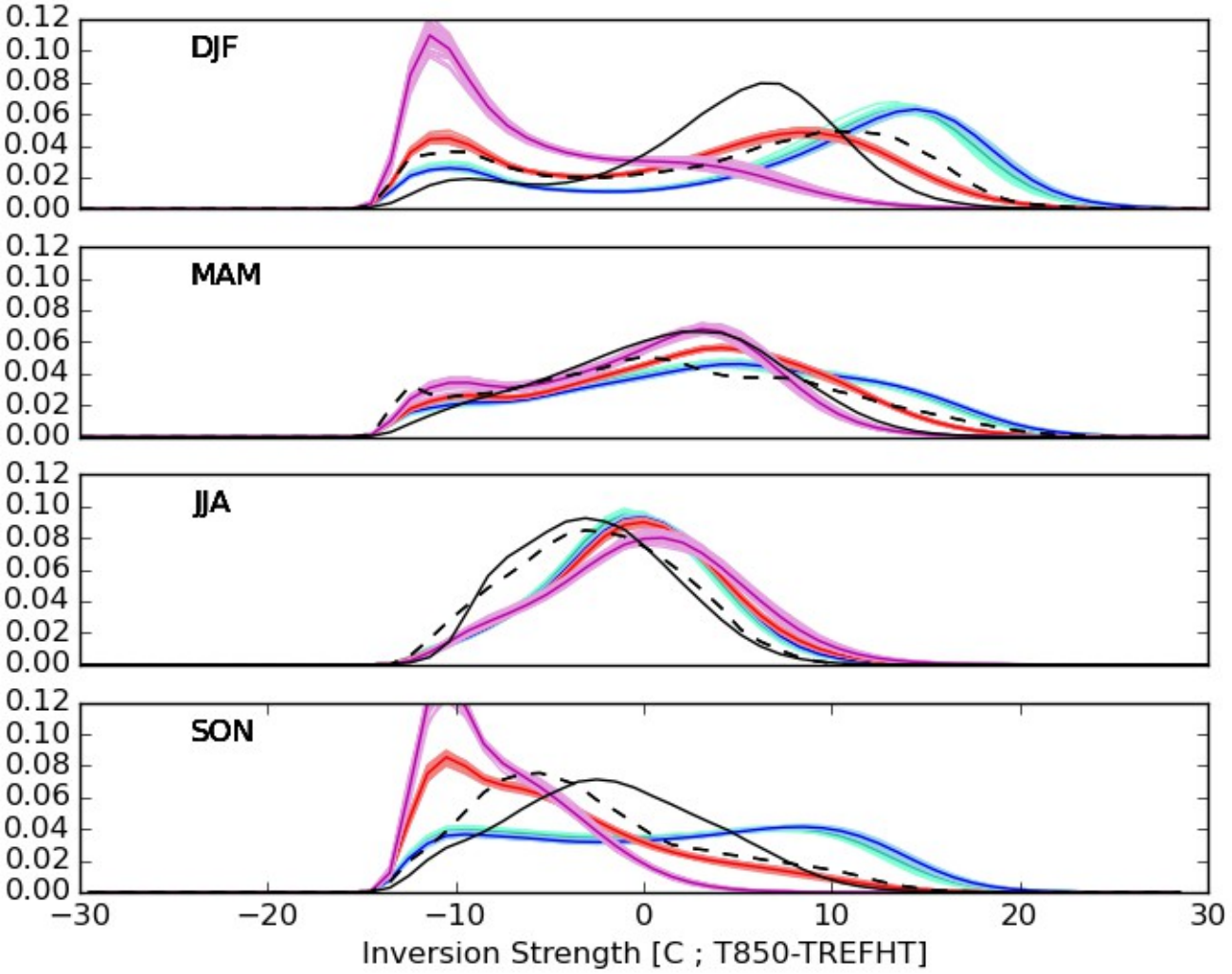

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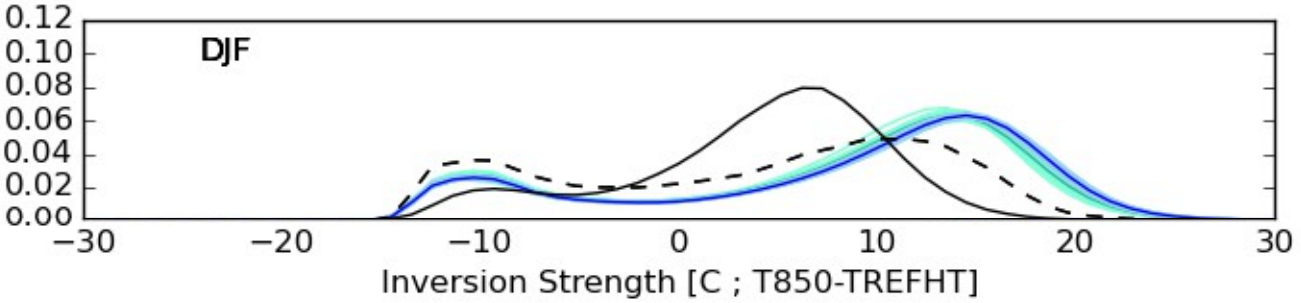

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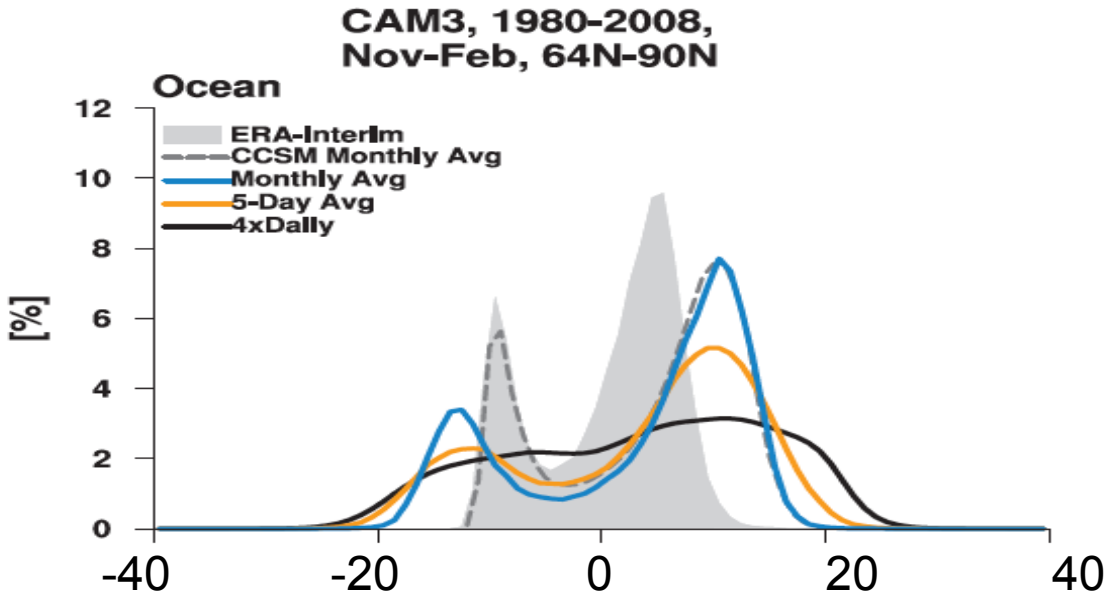


Inv Delta T ; Medeiros et al. 2011

Similar results to CAM3

ERA-Interim has biases and doesn't accurately represent low level inversions

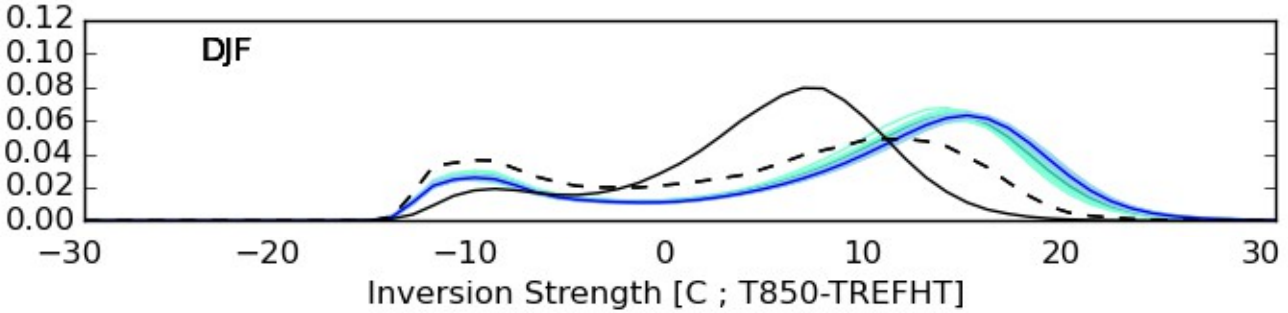
Does ASR?

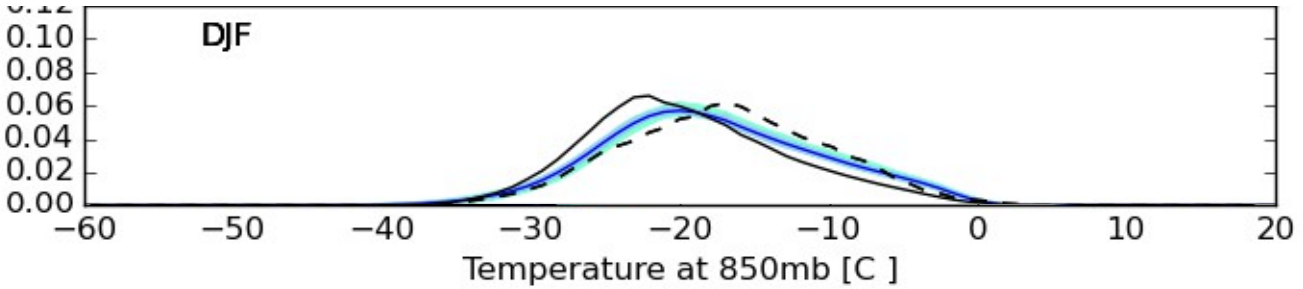
Pithan et al. 2014: model biases more important than reanalysis bias.

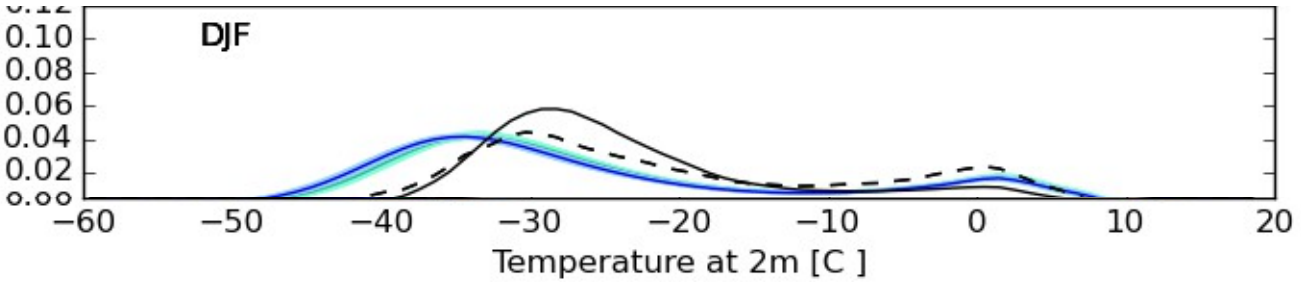
Preliminary Results

Inversions in CESM-LE

Ocean (ice + open water)







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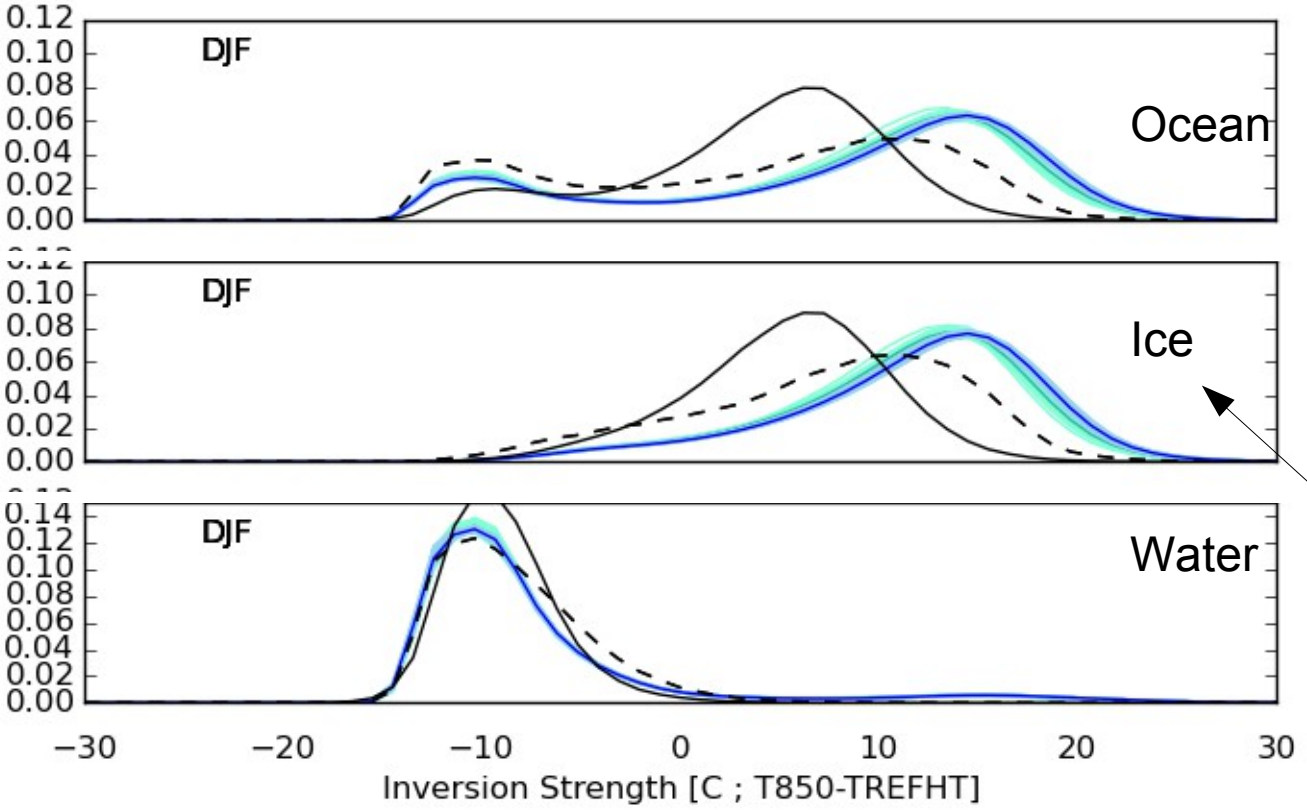
Preliminary Results

Inversions in CESM-LE



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Main differences above the ice, near the surface

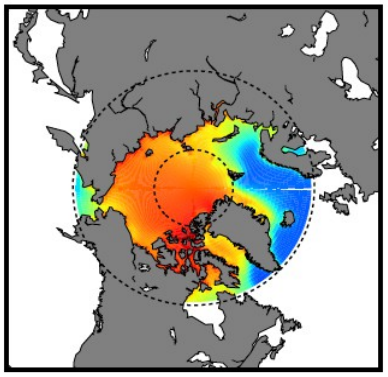
Preliminary Results

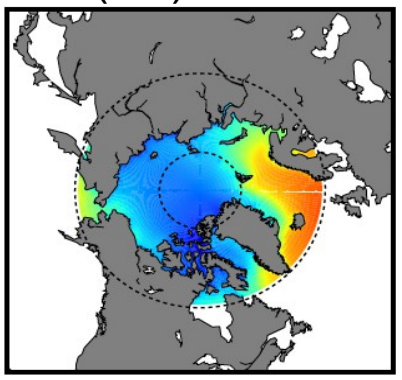
CESM-LE vs Reanalysis

T(850mb) – T(sfc)

T(sfc)

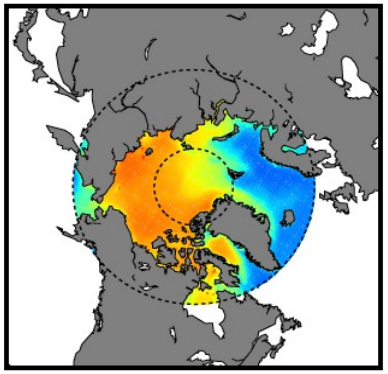
CESM-LE mean

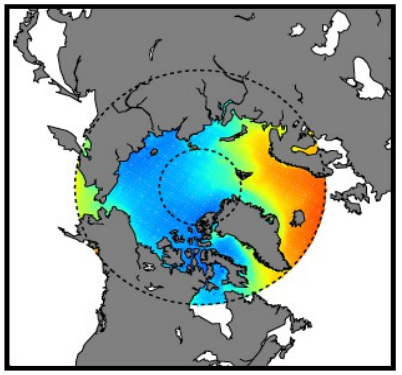




2000 – 2010
DJF means

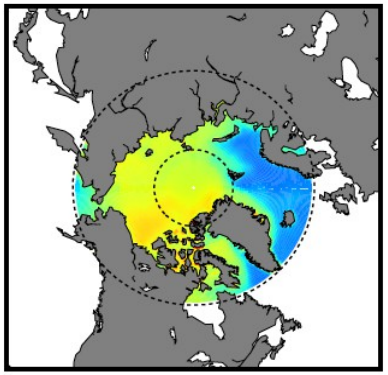
ASR

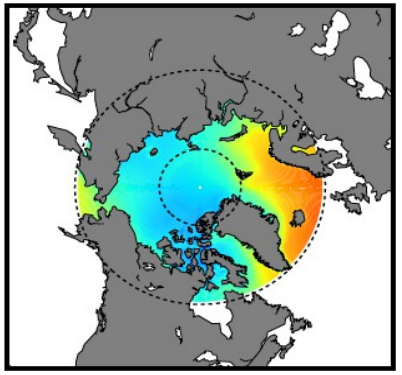




ASR has reduced T (sfc)
- near the sea ice edge (storms?)
- near Canadian Archipelago (sea ice thickness bias?)

ERA-I



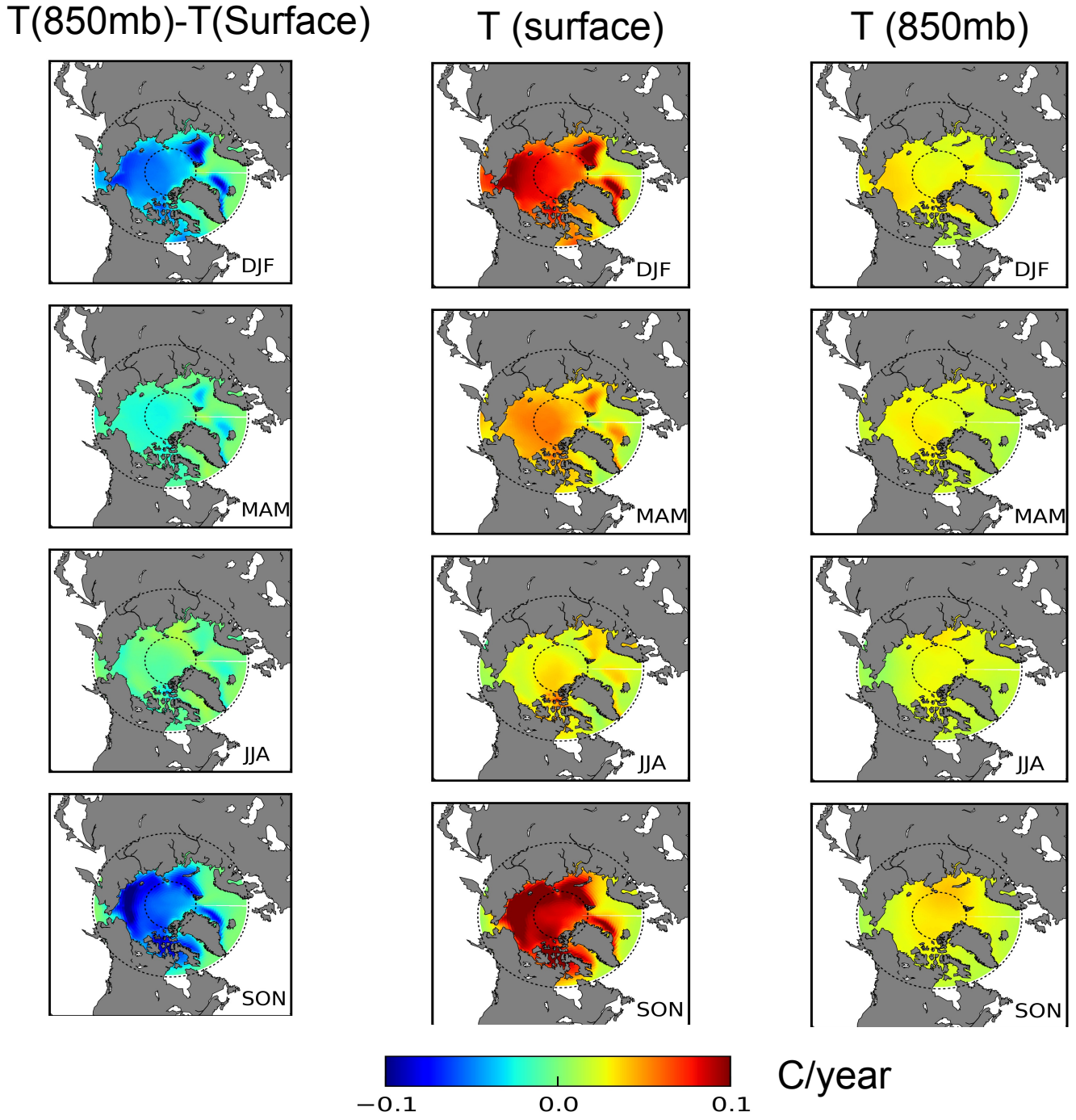


ERA-I has reduced T (sfc)
- Over sea ice

All plots in Celcius

Preliminary Results

Recent past trends



1970 - 2005

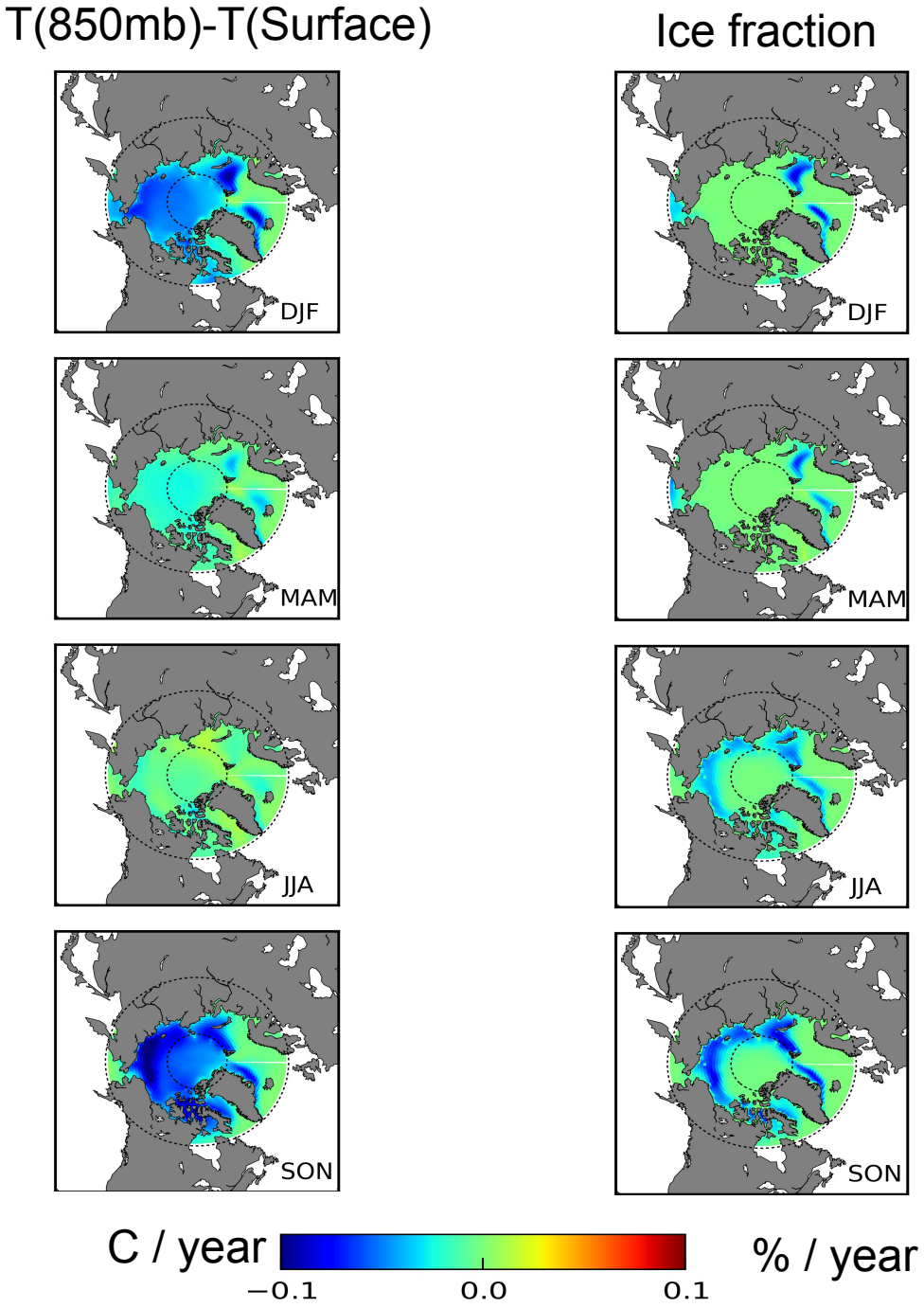
T850 increase can reduce trend in inversion strength

Strongest increase at surface co-located w/ sea ice loss pattern

Significant increase over sea ice

Preliminary Results

Recent past trends



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T850 increase can reduce trend in inversion strength

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Summary / Future Work

Arctic temperature inversion strength is overestimated in CESM-LE

Bias is mostly near surface, but need to verify against observations instead of reanalysis

Bias linked to sea ice, possibly to mixing near sea ice edge

Inversion strength is projected to decrease, particularly over ice.

What are implications of inversion bias for projections of Arctic change?
Will lapse rate feedback become a negative feedback? When?
What is the importance of different processes (mixing, transport, conduction) ?

Thank You!

Questions/comments?

Background

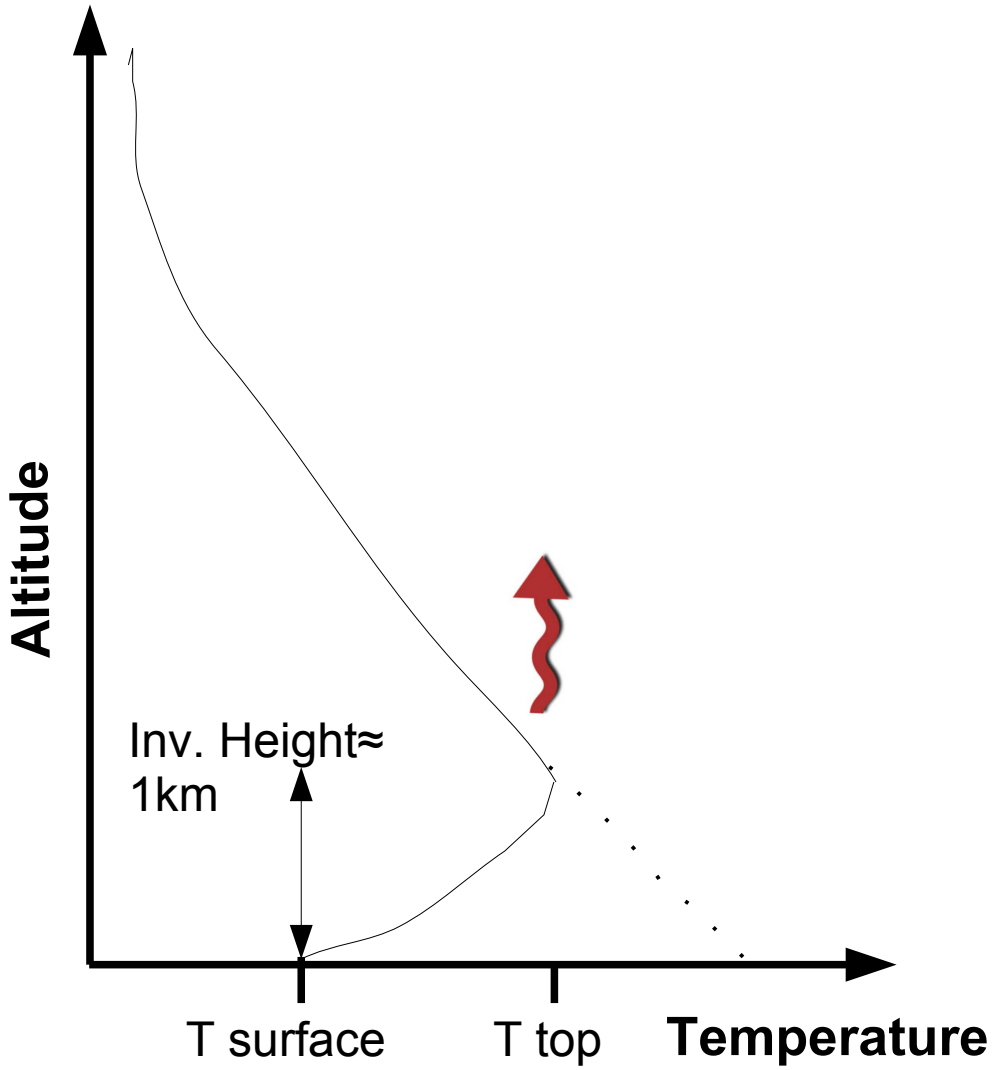
Wintertime inversion

Surface

- **LW deficit: equilibrium at low temperature**
- **Reduced mixing**
- **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)



Research Objectives

Main Goal:

Characterize representation of inversion in CMIP5 models and understand impact of inversion on feedbacks related to the Arctic amplification phenomenon.

1) Inversion : processes and biases

- Quantify main inversion formation and strengthening processes
- Quantify differences between GCMs and reanalyses (and reanalyses vs obs)

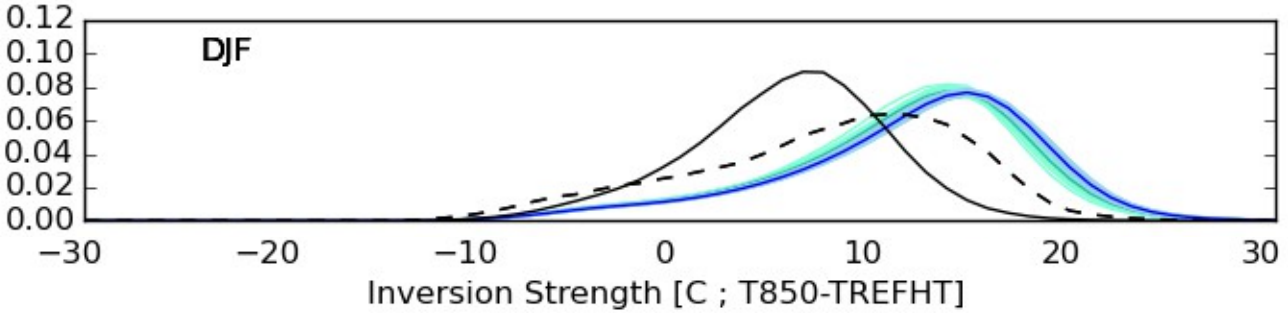
2) Projected climate changes

- Develop climate scenarios of inversion change
- Which processes have the largest projected change?
- Implications of inversion biases for arctic amplification

Preliminary Results

Inversions in CESM-LE

Sea ice



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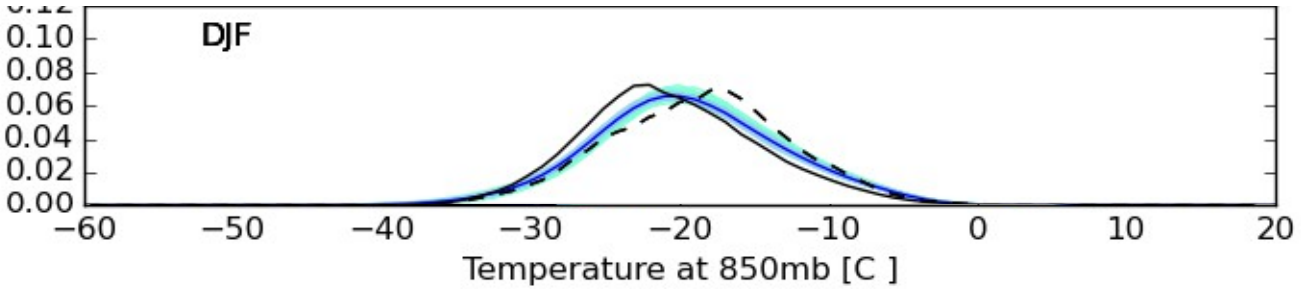
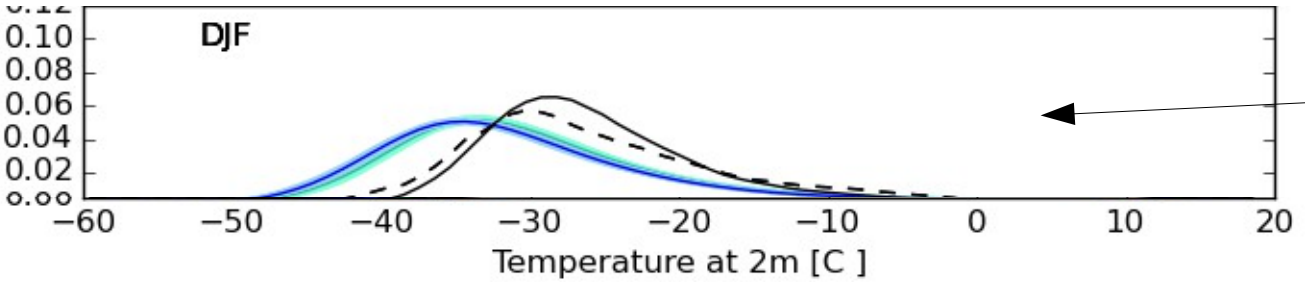




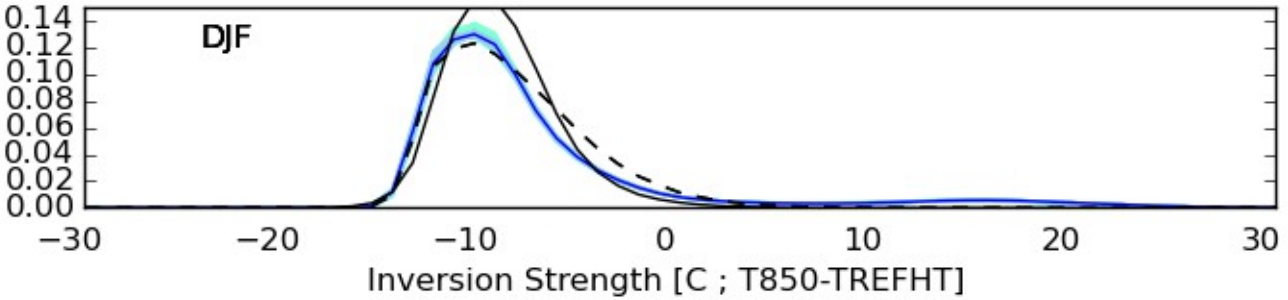
Main differences above the ice, near the surface

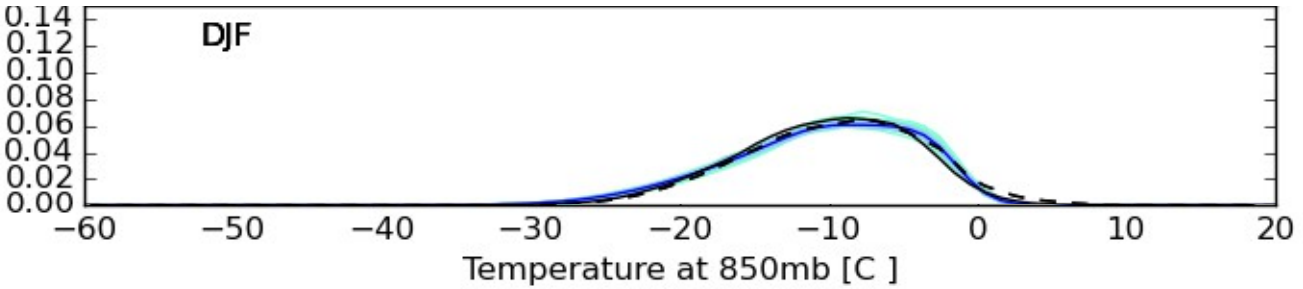
Source:
Bourdages and Kay (2015). In prep.

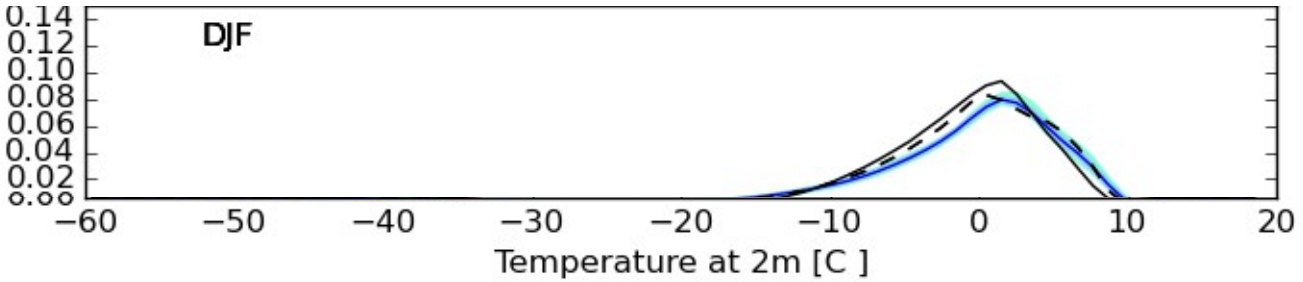
Preliminary Results

Inversions in CESM-LE

Open water







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Source:
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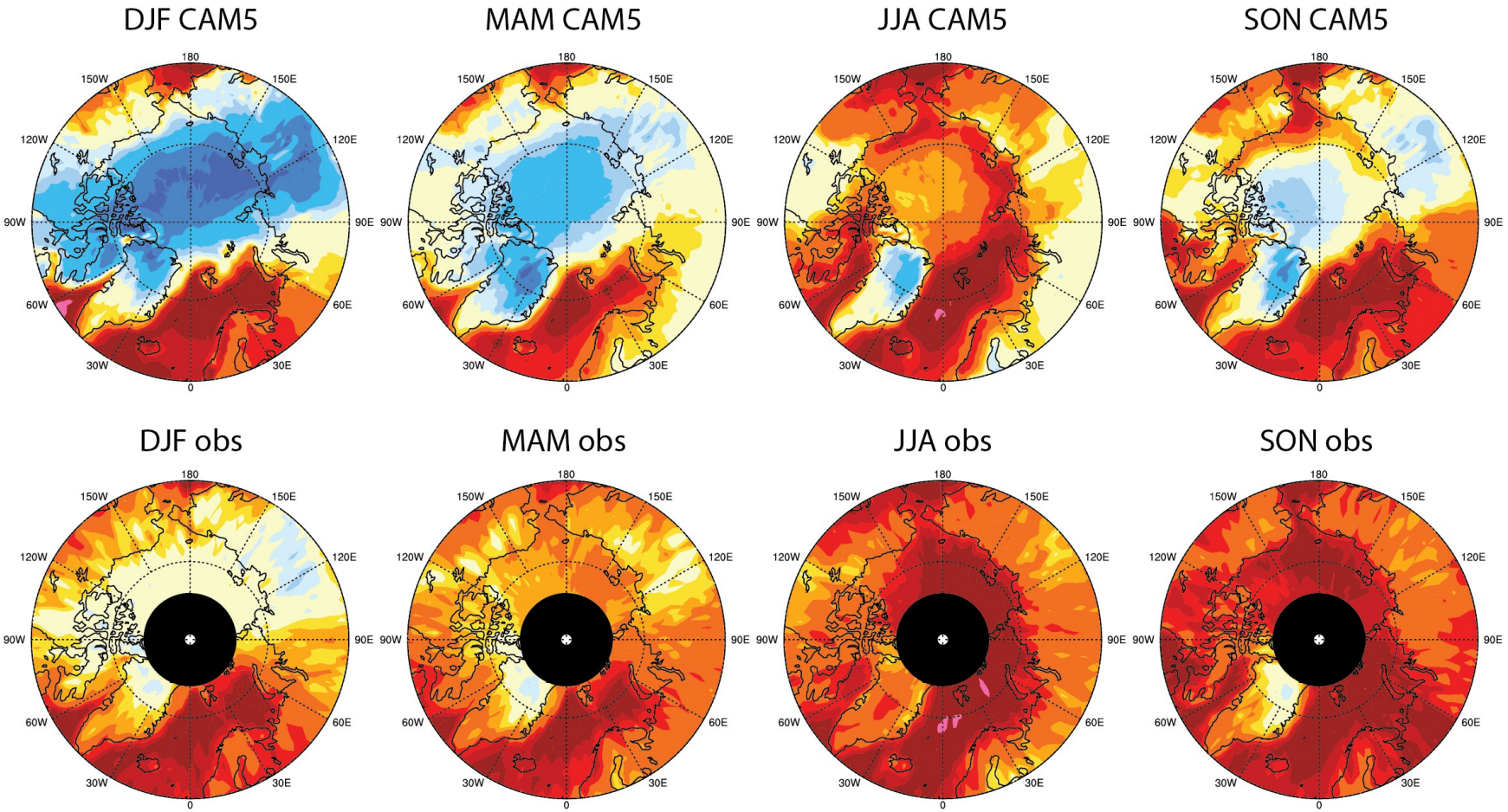
Preliminary Results

Surface Radiation

1) Bias in cloud fraction in CAM5

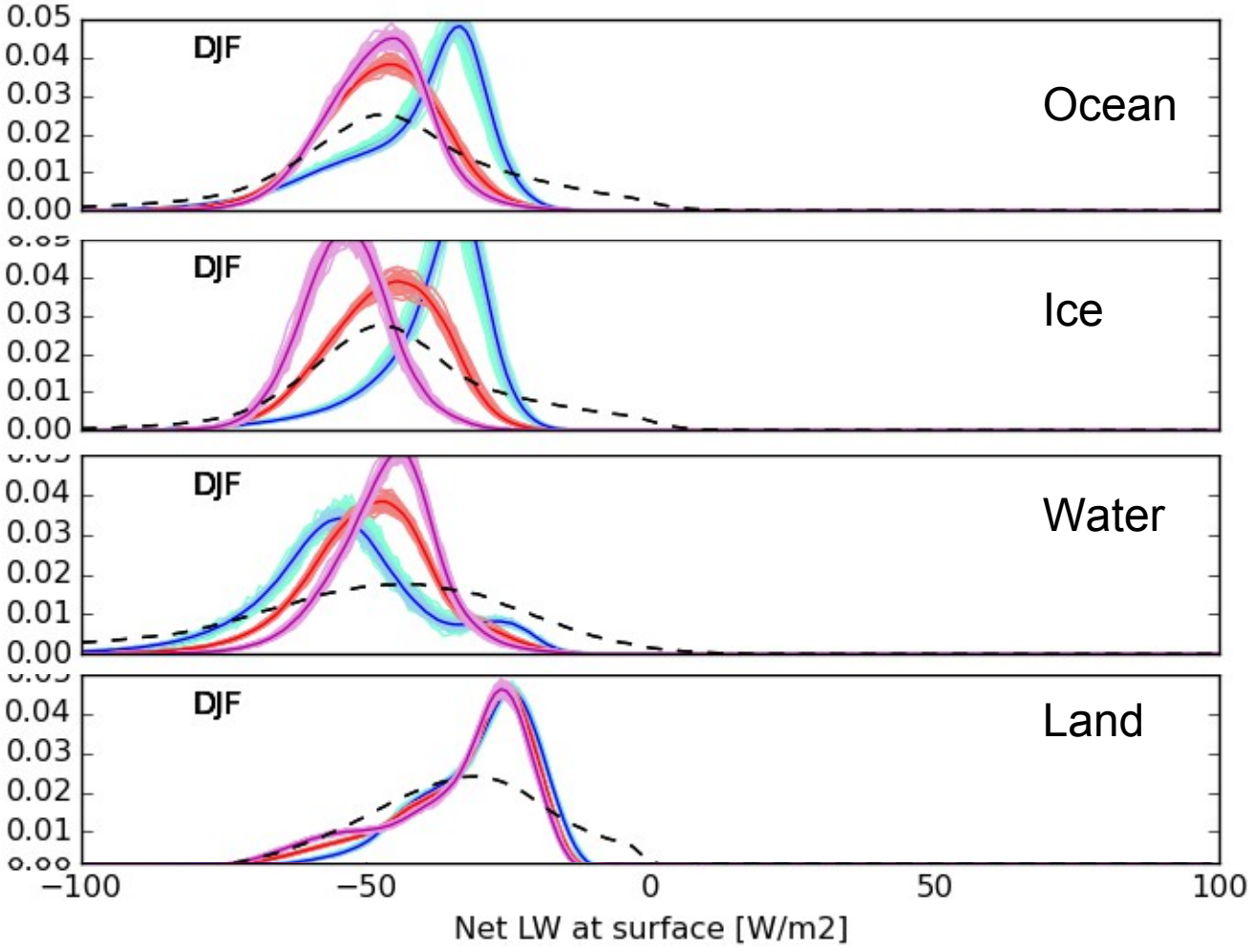


Source:
Kay et al. (2015). In prep.
See poster by Jen Kay

Preliminary Results

Surface Radiation

1) Bias in cloud fraction in CAM5
2) Bias in Downwelling LW radiation at surface



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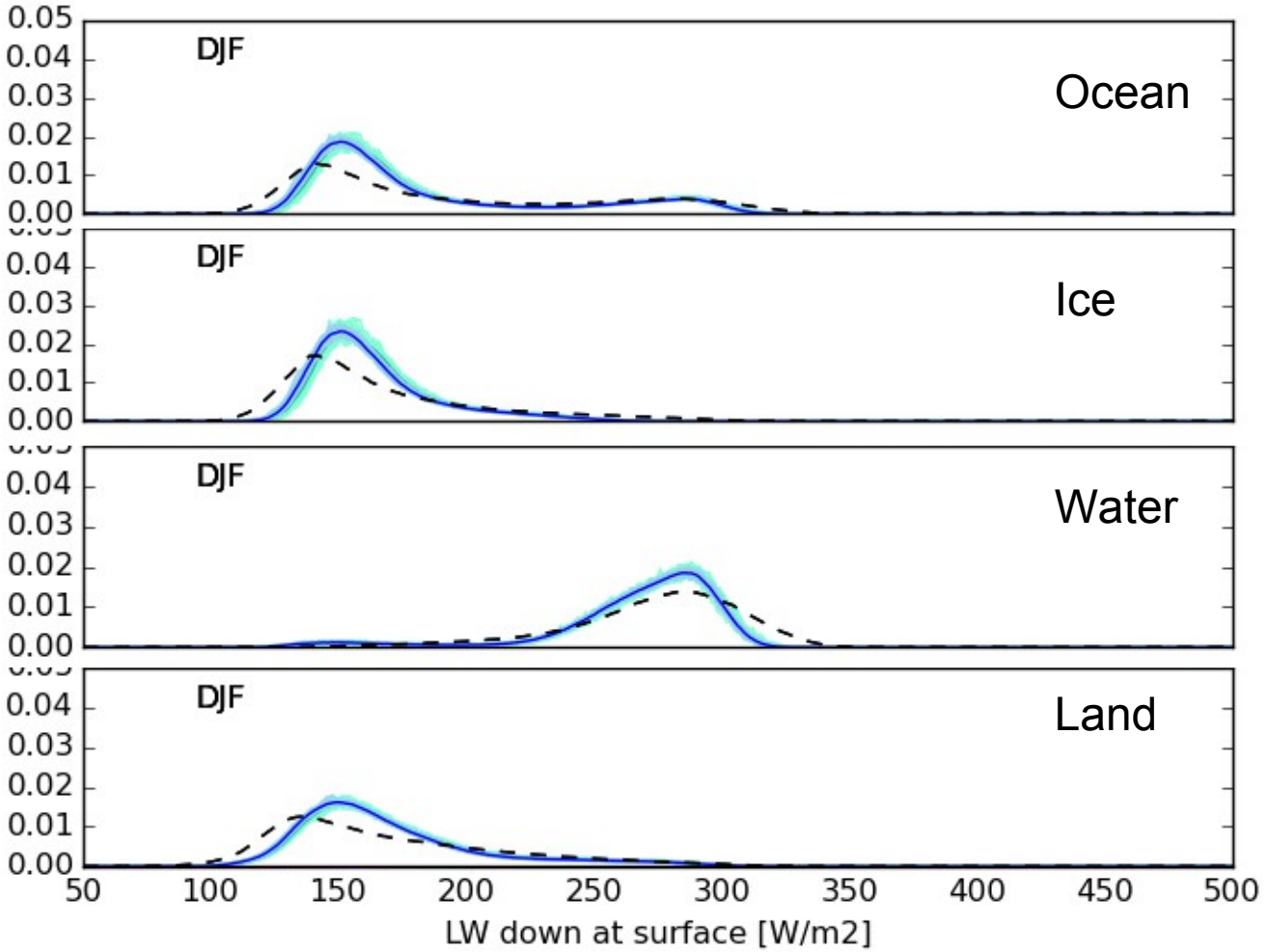

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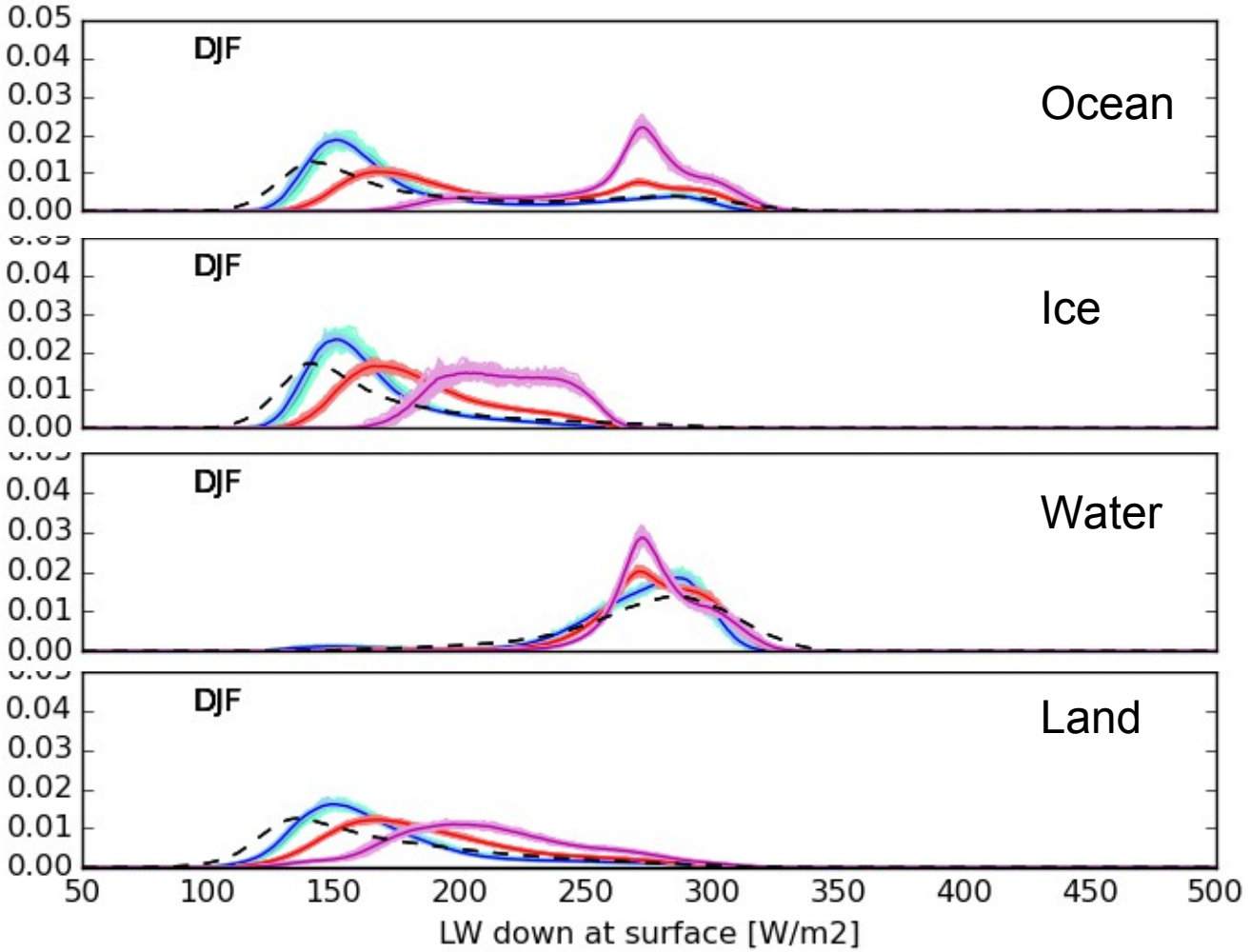
Since T850 is well represented, Errors in cloud amounts, phase and/or height



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Are my labels wrong in the script plot_dist? Lwup loks like Lwd