

An aerial photograph of a vast, dark sea covered with numerous small, white ice floes. In the lower right quadrant, a single polar bear is standing on one of the larger ice floes. The sky is overcast with grey clouds, and the horizon is visible in the distance. The overall scene conveys a sense of isolation and the impact of climate change on the Arctic environment.

Impact of Melting Arctic Sea Ice

Who here has ever been north of
the Arctic Circle?

Agenda

- The Past

- Arctic sea ice history
- Paleoclimate data

- The Present

- Observations
- Physical Bases
- Gaps in understanding
- What can we say for sure in terms of other climate impacts?

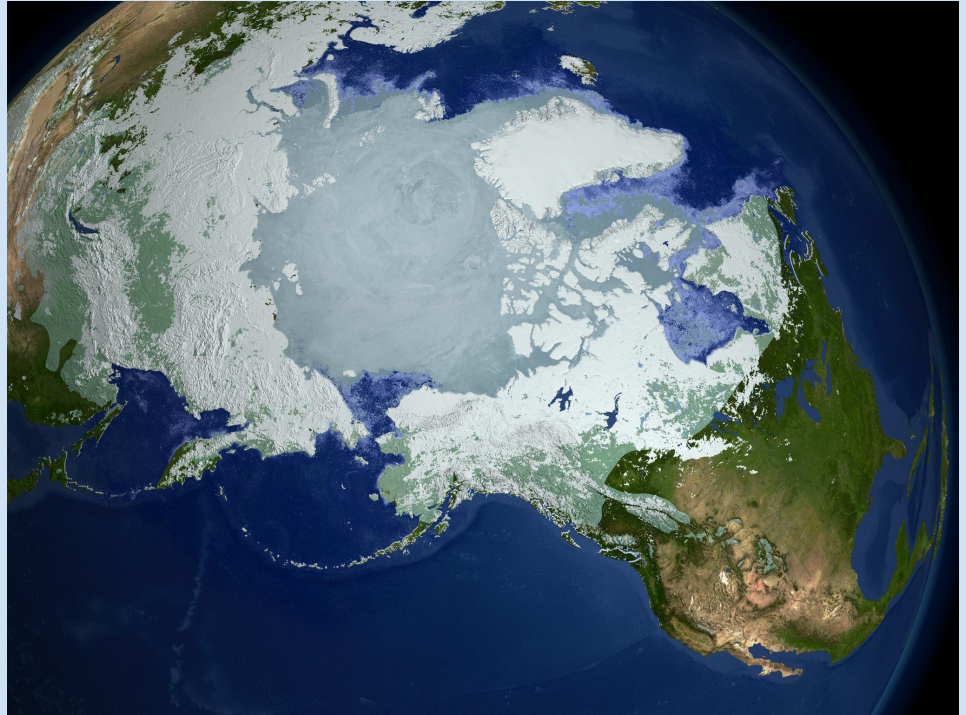
- The Future

- Models
- Implications
- Why should you care?



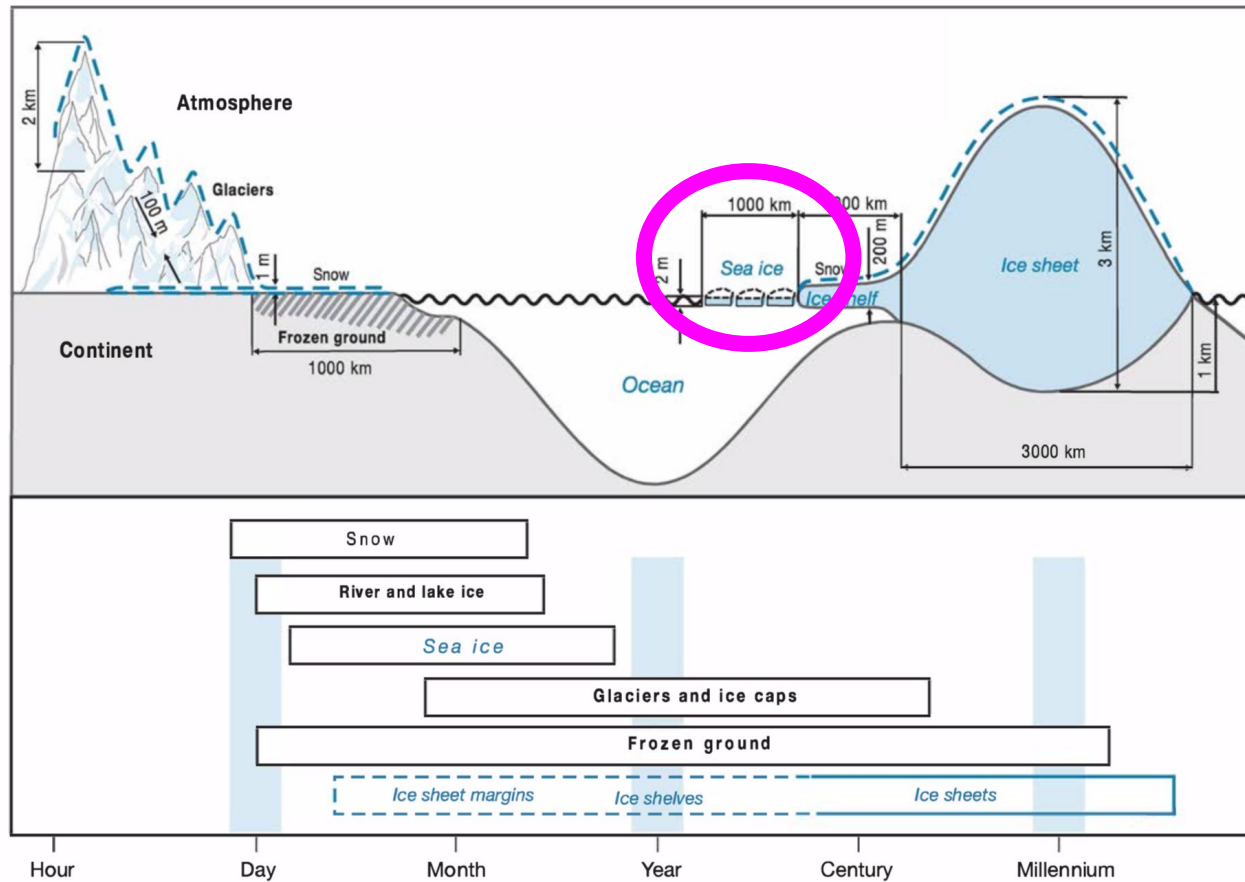
A Brief History of Arctic Ice (Polyak et al., 2010)

- 47 mya - First time Arctic sea ice formed
- ~3 mya - Modern ice sheets formed
- 11 kya - Ice free summers
 - 4 C warmer than mid-20th century temperatures
- General seasonal retreat since 1900
- Accelerated retreated since 1960



Source: NASA, 2010.

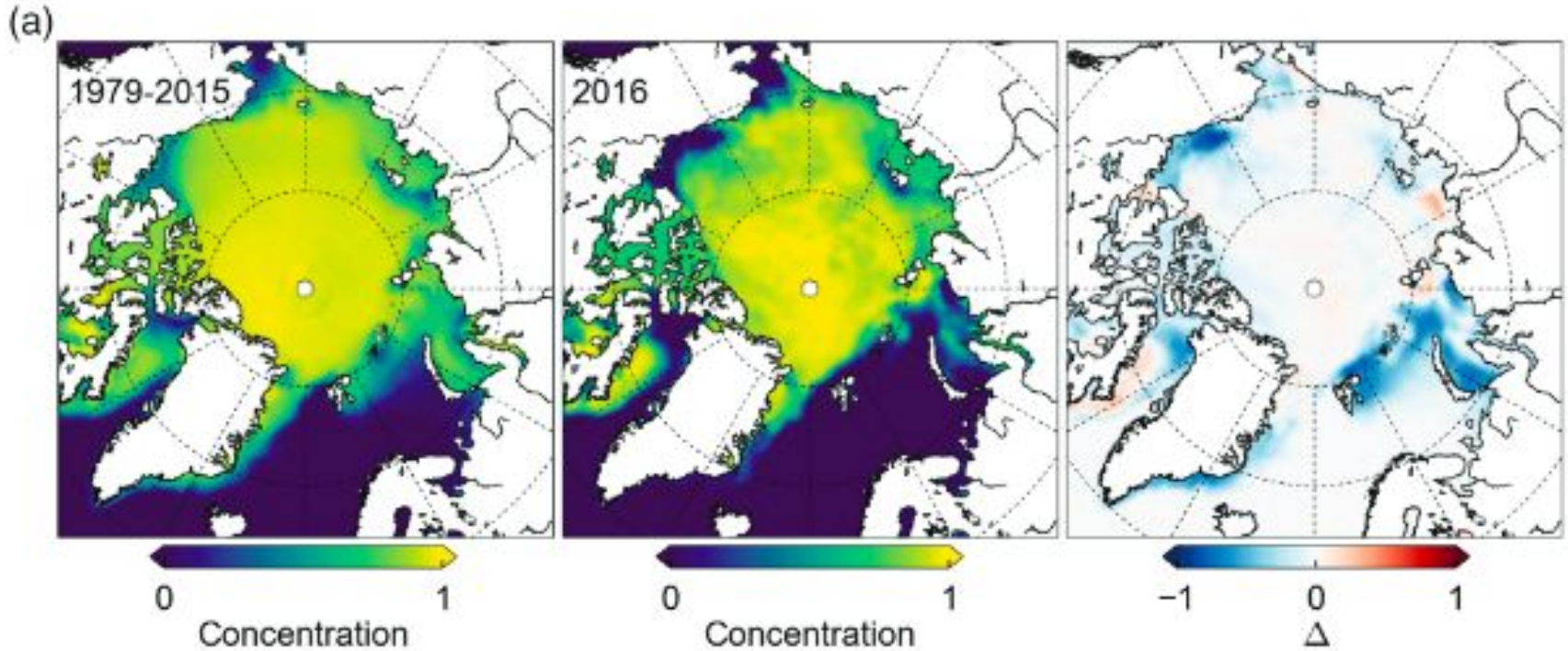
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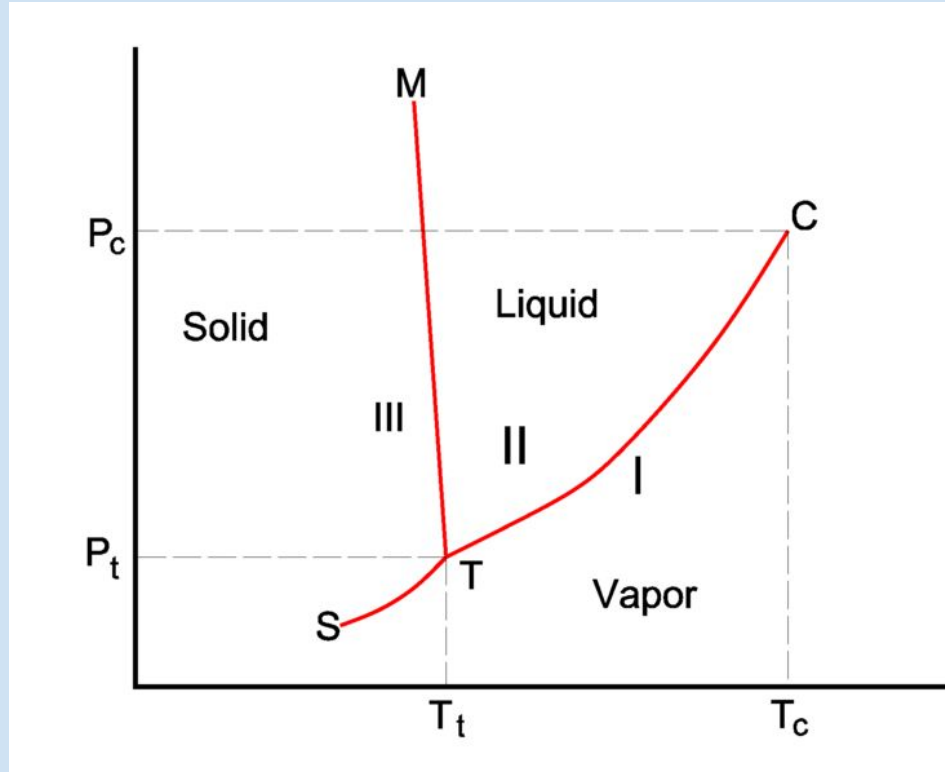
FIGURE 6-1 Components of the cryosphere and their time scales. (Source: Lemke, P., J. Ren, R. B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R. H. Thomas, and T. Zhang, 2007: “Observations: Changes in Snow, Ice and Frozen Ground.” In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA.)

Observations

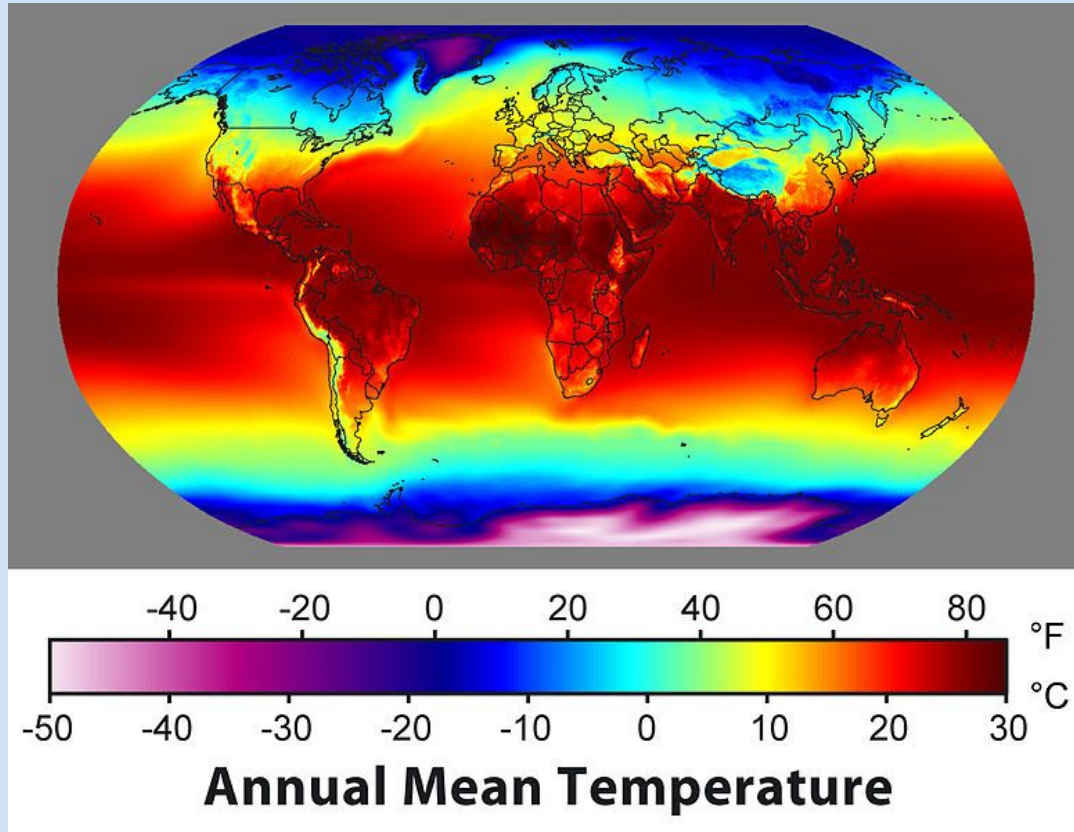


Physical Bases

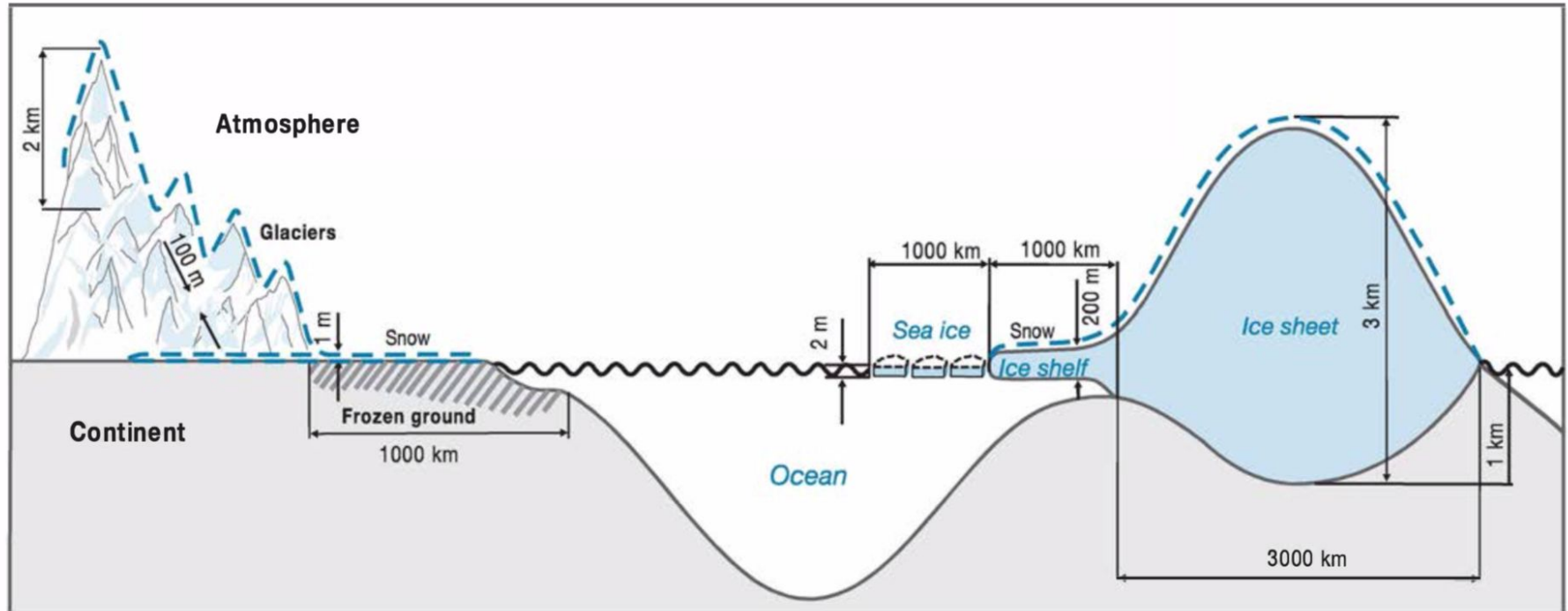
Physical Basis - Latent Heat



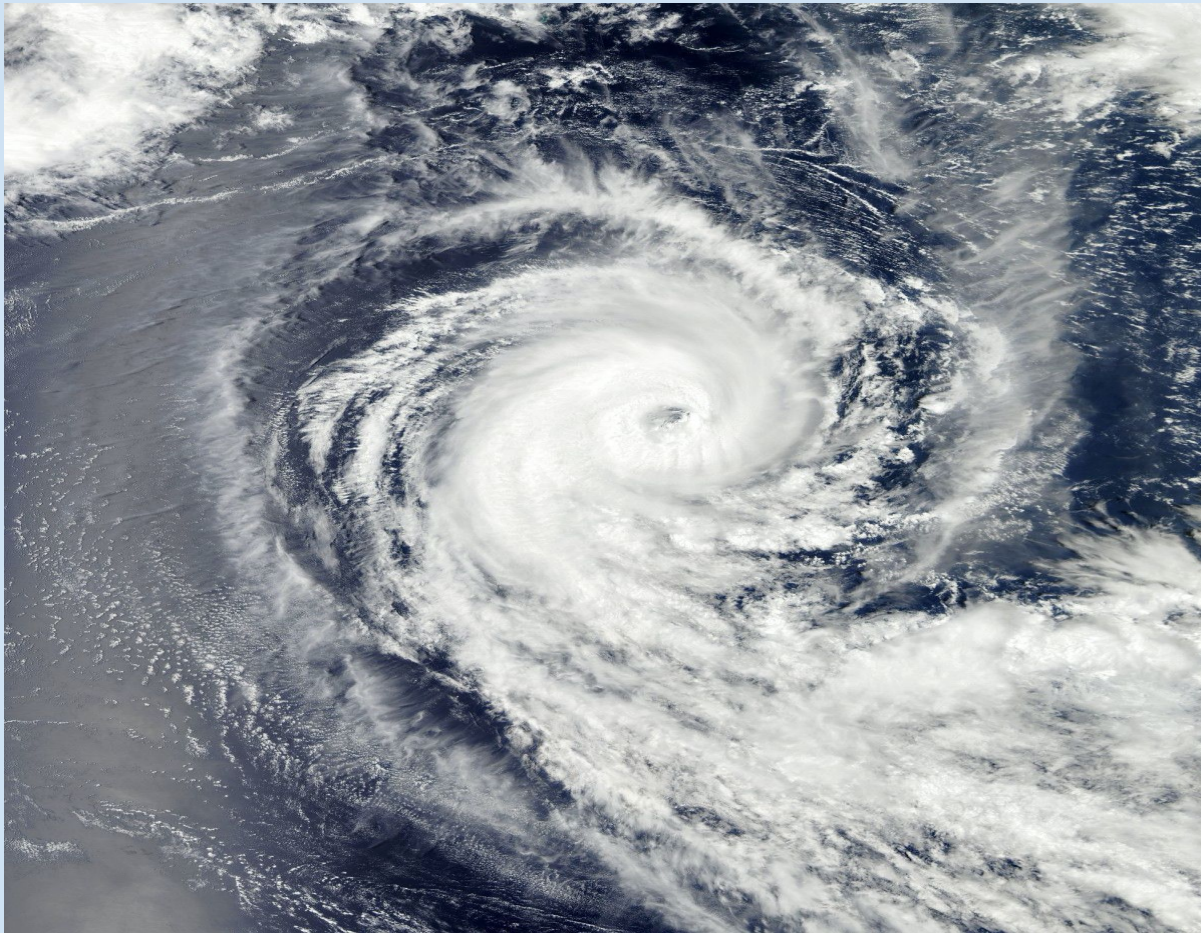
Physical Basis - Thin Atmosphere



Physical Basis - Sea Ice Mediation



Physical Basis - Circulation Changes



Modeling

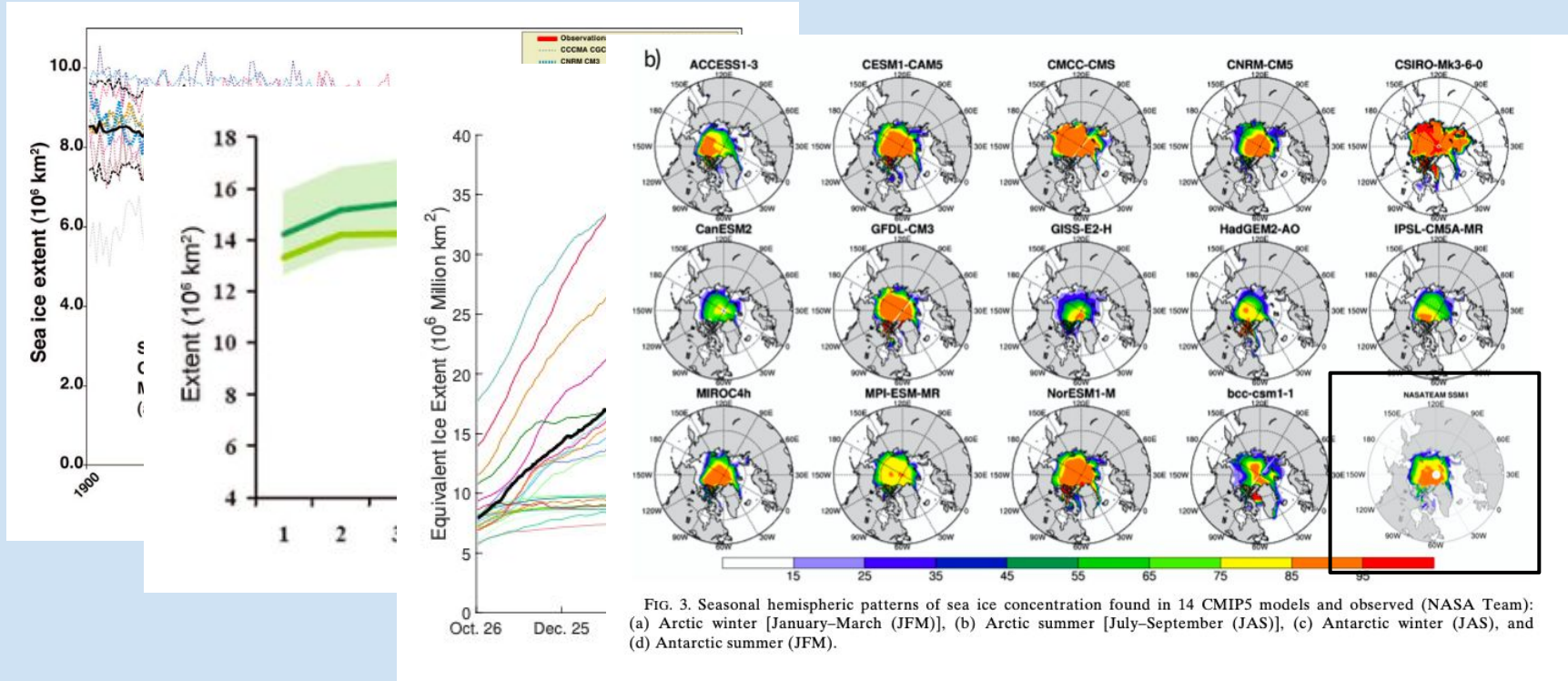


FIG. 3. Seasonal hemispheric patterns of sea ice concentration found in 14 CMIP5 models and observed (NASA Team): (a) Arctic winter [January–March (JFM)], (b) Arctic summer [July–September (JAS)], (c) Antarctic winter (JAS), and (d) Antarctic summer (JFM).

Kattsov et al, 2010; Agarwal et al, 2018;
Ivanova et al, 2016

Modeling

Sea Ice Extent

Ice Motion and Shear

Sea Ice Thickness

Total Sea Ice

Sea Ice Age

Precipitation

Snow

Open Water Exposure

Winds and Drift

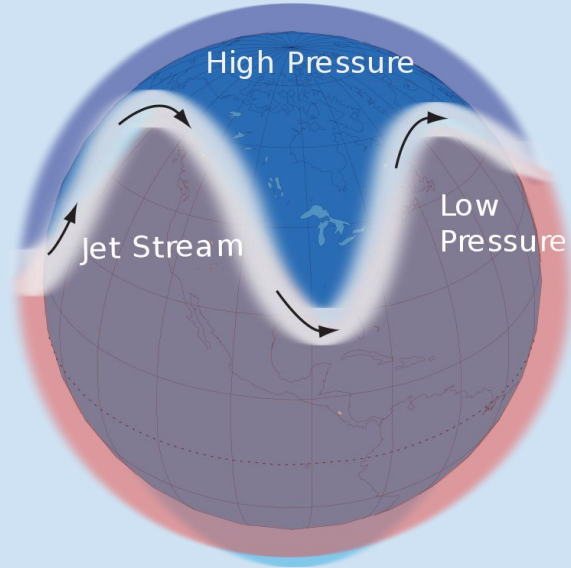
Rheology

Which Looks Like...

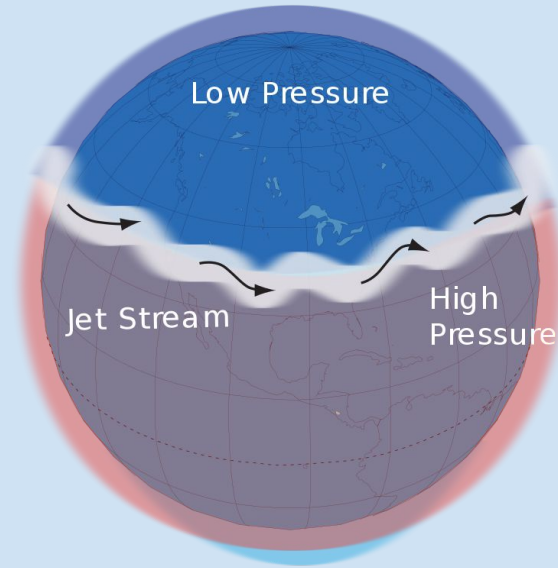


Arctic Oscillation

Arctic Oscillation
Negative Phase

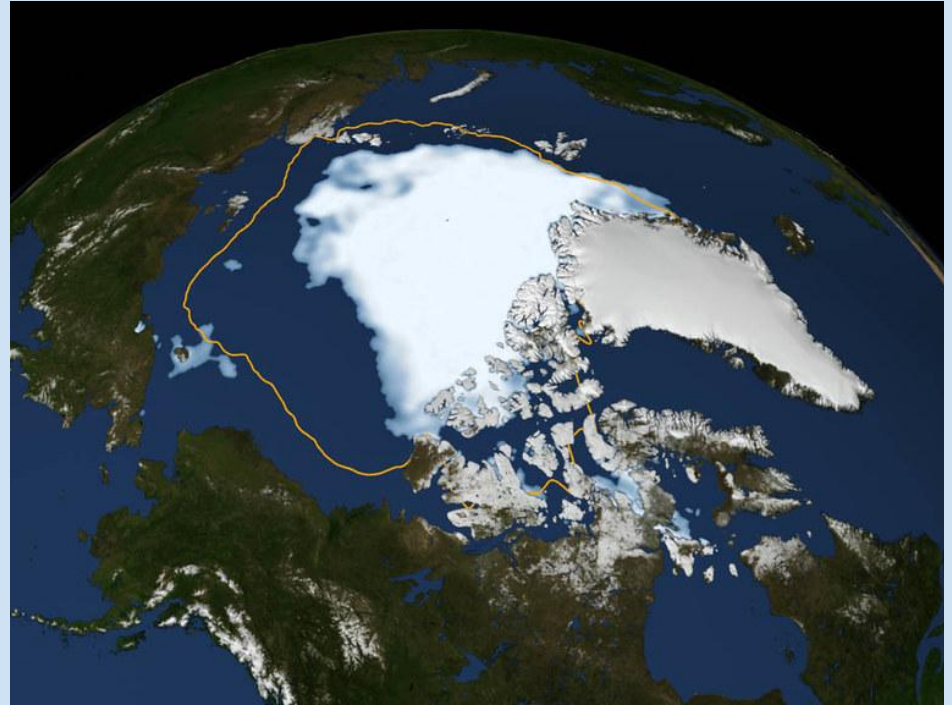


Positive Phase



Nevertheless

“CMIP5 arrives at a seasonally ice-free Arctic sooner than CMIP3, leading to the conclusion that a seasonally ice-free Arctic Ocean within the next few decades is a distinct possibility.”
(Stroeve, 2012)



A Sea Ice-Free Arctic

Albedo

(Polyak et al., 2010)

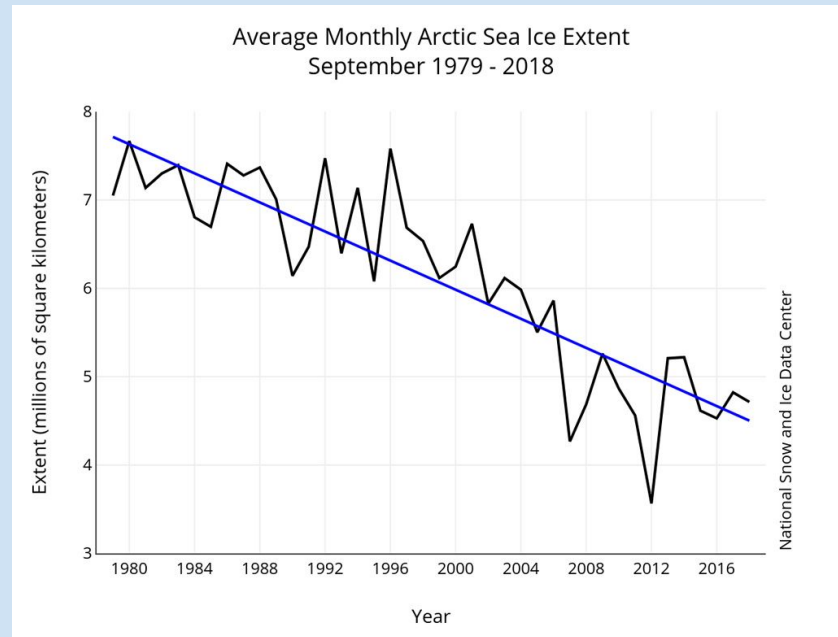
Decrease
in sea ice



Albedo
decreases

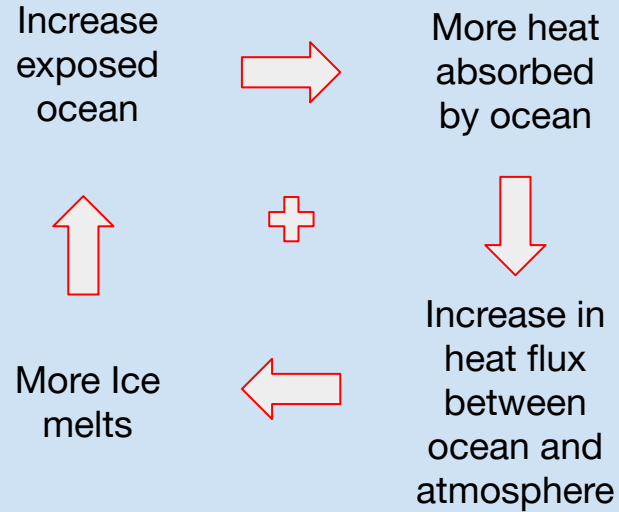


Global
temperature
increases



Ocean-Atmosphere Coupling

(Kump et al., 2010)



“The **polar vortex** is a deep low-pressure center in the upper atmosphere (between ~10 and 50 km) that sits near the North Pole during winter and is encircled by a fast river of westerly wind known as a jet.”

(Francis et al., 2017)

Polar Vortex

(Cohen et al., 2018)

Loss of sea ice



Increase of atmospheric temperature



“Dilated geopotential height”



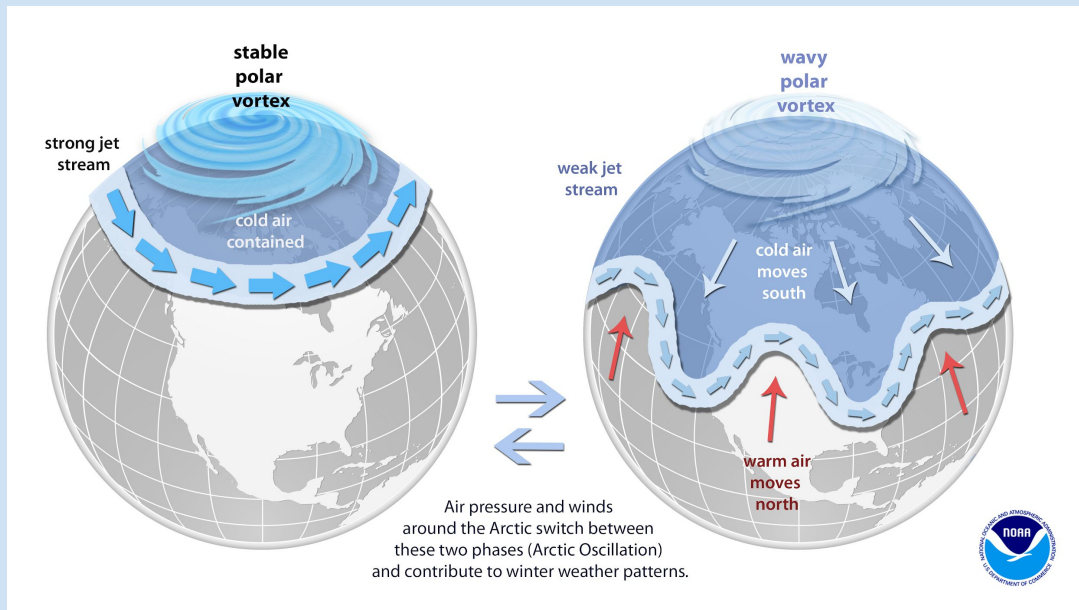
Weaker jet stream

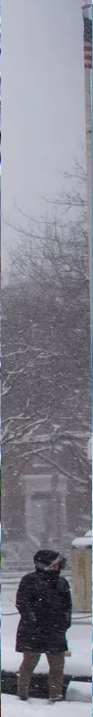


Wavy polar vortex



Colder mid-latitude temperatures and warmer Arctic temperatures





WCRP

GRAND CHALLENGES



MELTING ICE
AND GLOBAL
CONSEQUENCES



CLOUDS,
CIRCULATION AND
CLIMATE SENSITIVITY



REGIONAL
SEA LEVEL
CHANGE AND
COASTAL IMPACTS



WATER FOR
THE FOOD BASKETS
OF THE WORLD



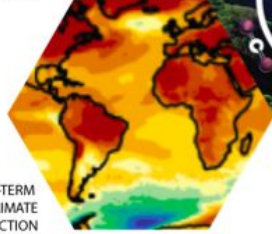
WEATHER AND
CLIMATE EXTREMES



CARBON
FEEDBACKS
IN THE
CLIMATE SYSTEM



NEAR-TERM
CLIMATE
PREDICTION



A polar bear is standing on a large, flat ice floe in the middle of a sea of smaller, jagged ice floes. The bear is facing left. The background is a vast expanse of ice floes under a pale, overcast sky. A speech bubble is positioned above the bear, containing the text "Thank you!".

Thank you!

Sources

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