

# Polar Climate and Ecosystems Panel

Don Perovich, Dartmouth **SEA ICE**

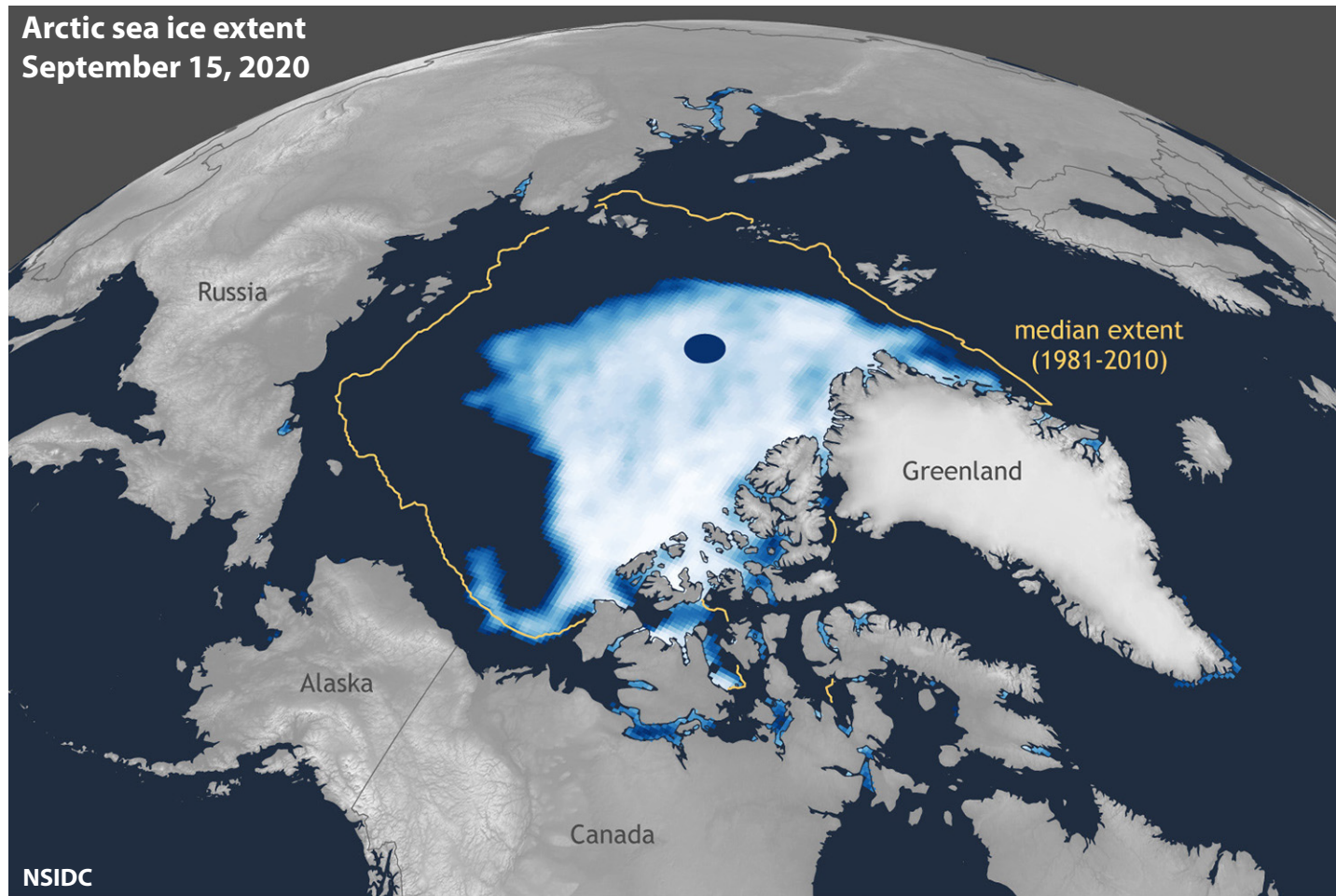
Cecilia Bitz, U. Wash. **ICE & CLIMATE**

David Holland, NYU **ICE & SEA LEVEL RISE**

Jody Deming, U. Wash. **SEA ICE MICROBES**

Byron Adams, BYU **SOIL MICROBES**

Ken Golden, U. Utah **MODERATOR**



**The Arctic is GROUND ZERO for climate change.**



*recent losses  
in comparison to  
the United States*

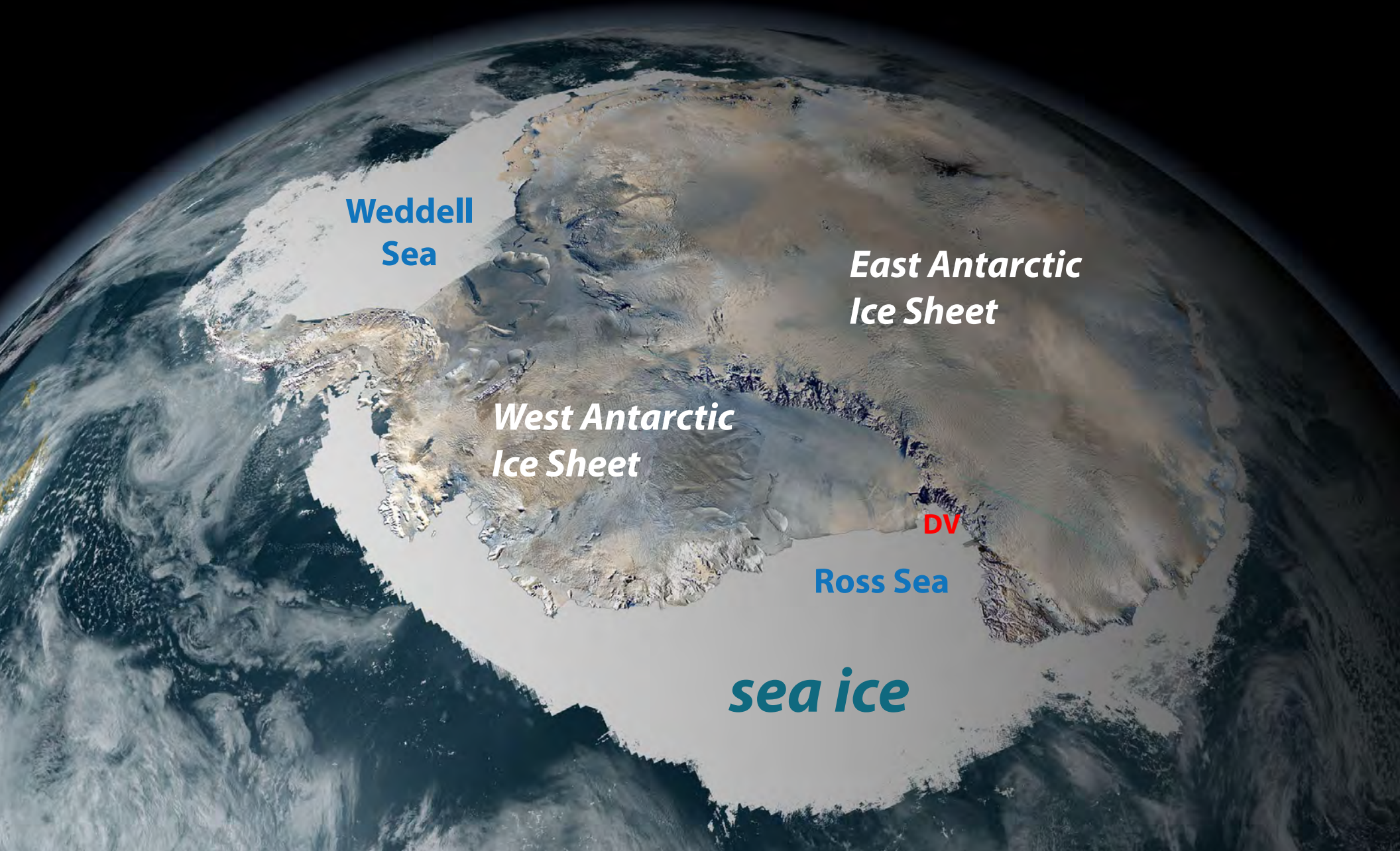
2012



*Perovich*

# ***ANTARCTICA***

southern cryosphere



**Weddell  
Sea**

***East Antarctic  
Ice Sheet***

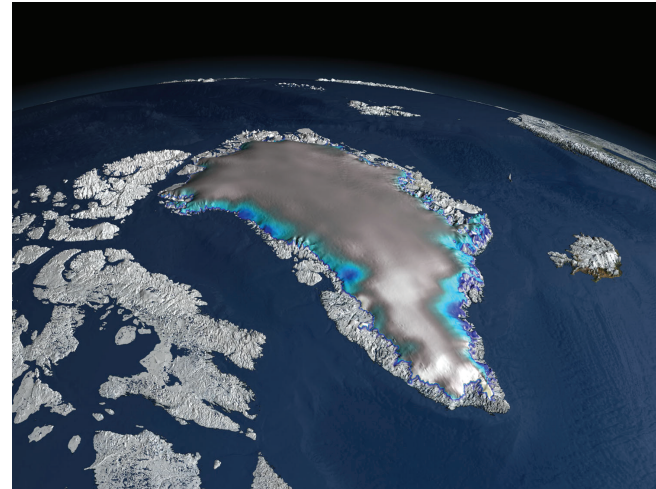
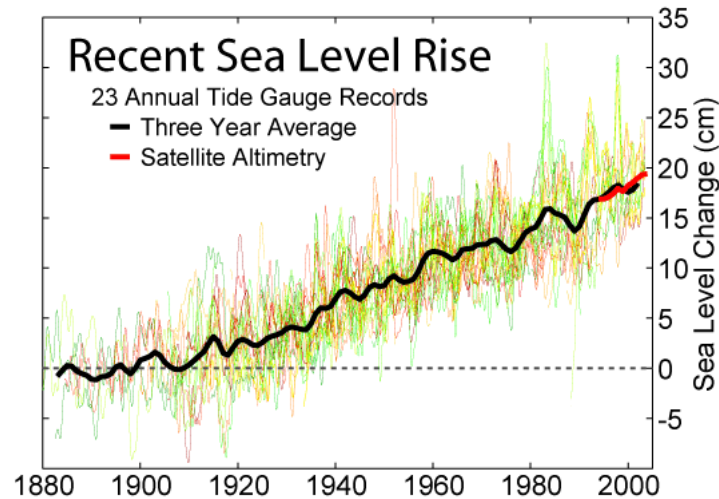
***West Antarctic  
Ice Sheet***

**DV**

**Ross Sea**

***sea ice***

# ***sea level rise in a warming climate***



- ***melting land ice: Antarctica, Greenland, mountain glaciers***
- ***thermal expansion of warming ocean***

- ***continental rebound***

*rise of land masses that were depressed by the huge weight of ice sheets*

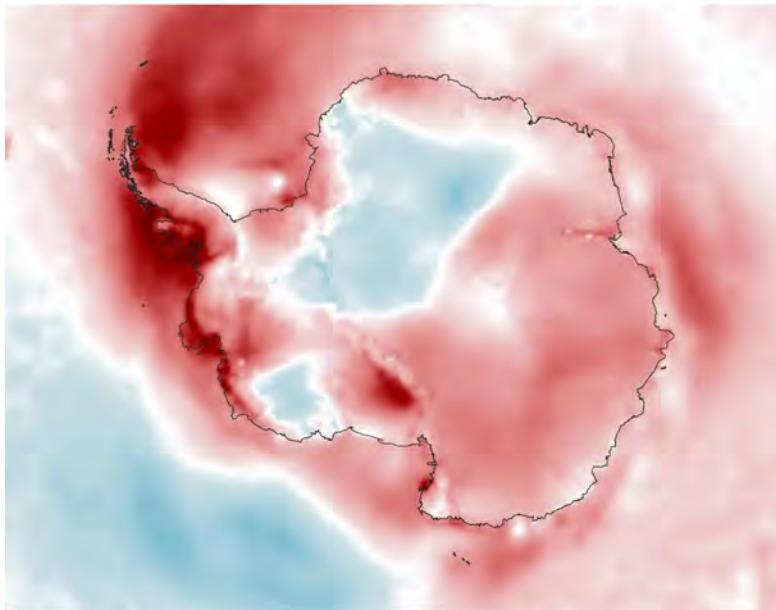
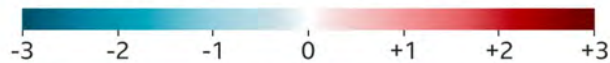


# New Record Low for Antarctic Sea Ice

February 13, 2023

**Much of Antarctica  
warmer than average**

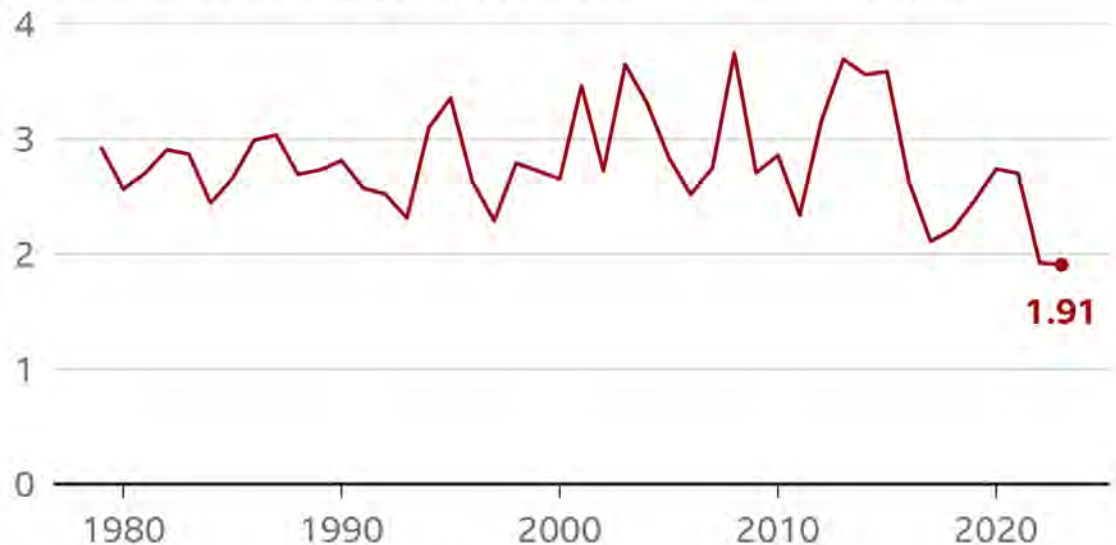
Mean 2022 surface air temp  
compared with 1991-2022 ( $^{\circ}\text{C}$ )



Source: ECMWF ERA5

BBC

**Minimum extent 1979-2023  
(million sq km)**



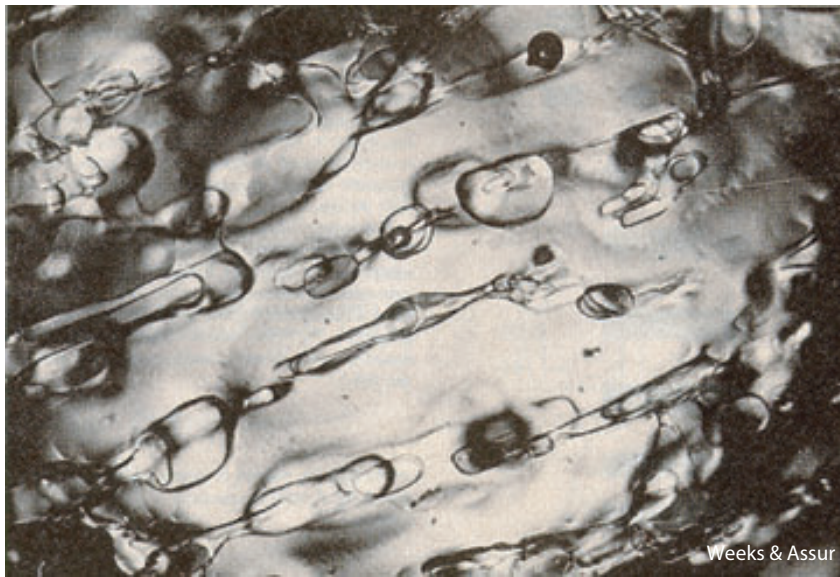
Five-day rolling average of sea-ice extent

Source: National Snow and Ice Data Center (NSIDC)

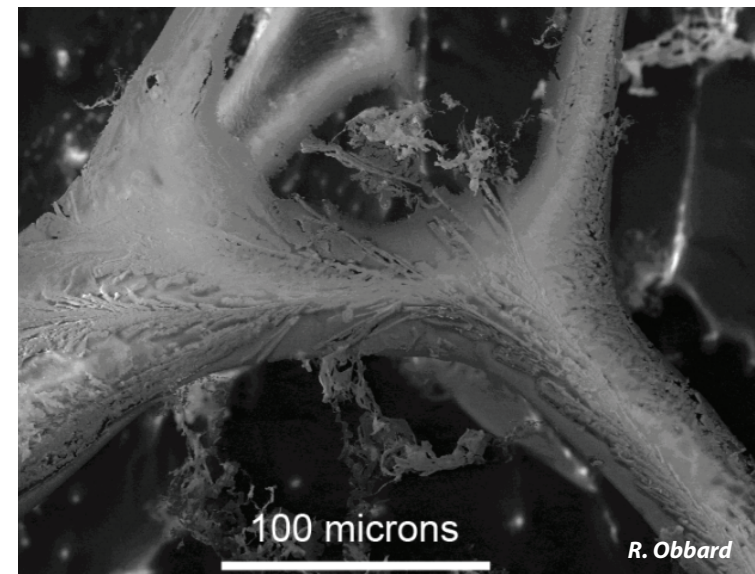
BBC



*sea ice may appear to be a  
barren, impermeable cap ...*



**brine inclusions in sea ice (mm)**



**micro - brine channel (SEM)**

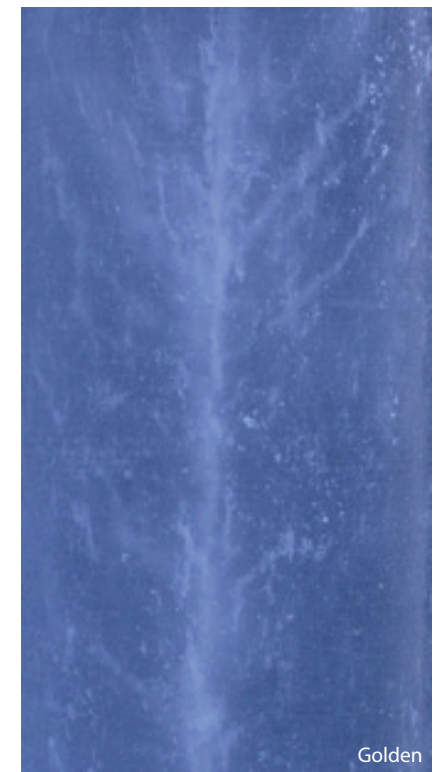
***sea ice is a  
porous composite***

pure ice with brine, air, and salt inclusions

**brine channels (cm)**



horizontal section



vertical section

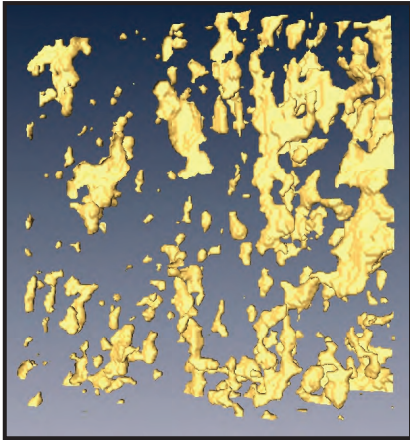
# Sea Ice is a Multiscale Composite Material

## *microscale*

brine inclusions

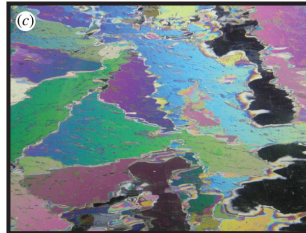
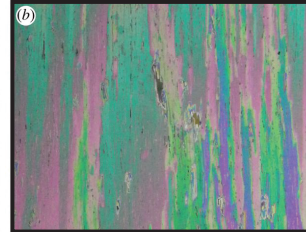


Weeks & Assur 1969



H. Eicken  
Golden et al. GRL 2007

polycrystals

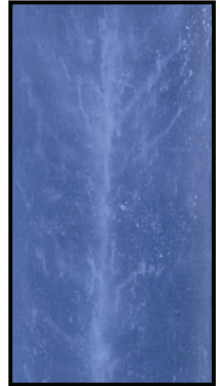


Gully et al. Proc. Roy. Soc. A 2015

brine channels



D. Cole



K. Golden

**millimeters**

**centimeters**

## *mesoscale*

Arctic melt ponds



K. Frey

Antarctic pressure ridges



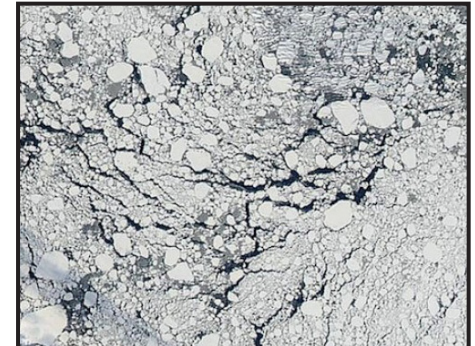
K. Golden

sea ice floes



J. Weller

sea ice pack



NASA

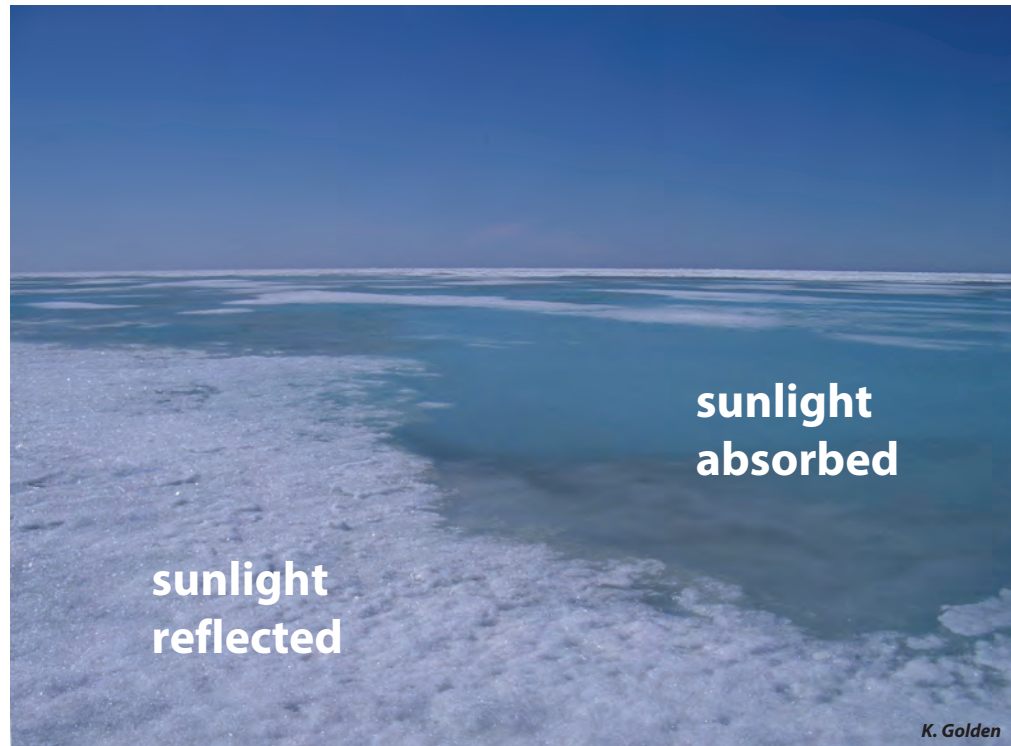
**meters**

**kilometers**

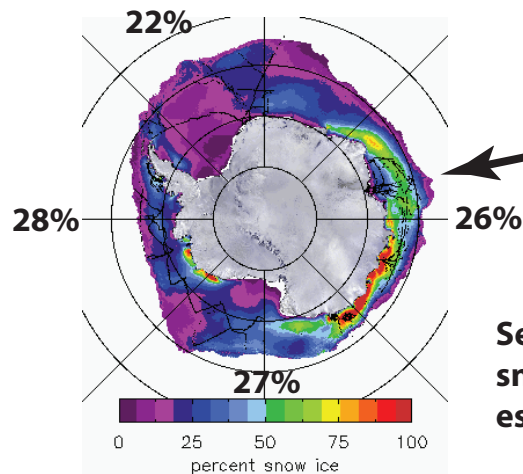
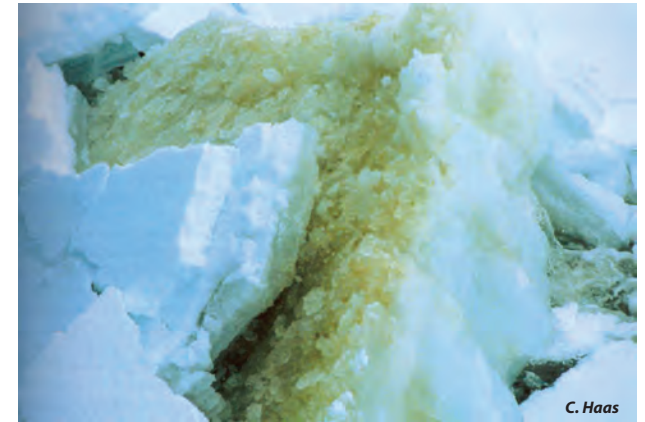
## *macroscale*

# fluid flow through the porous microstructure of sea ice governs key processes in polar climate and ecosystems

*evolution of Arctic melt ponds and sea ice **albedo***



***nutrient flux for algal communities***

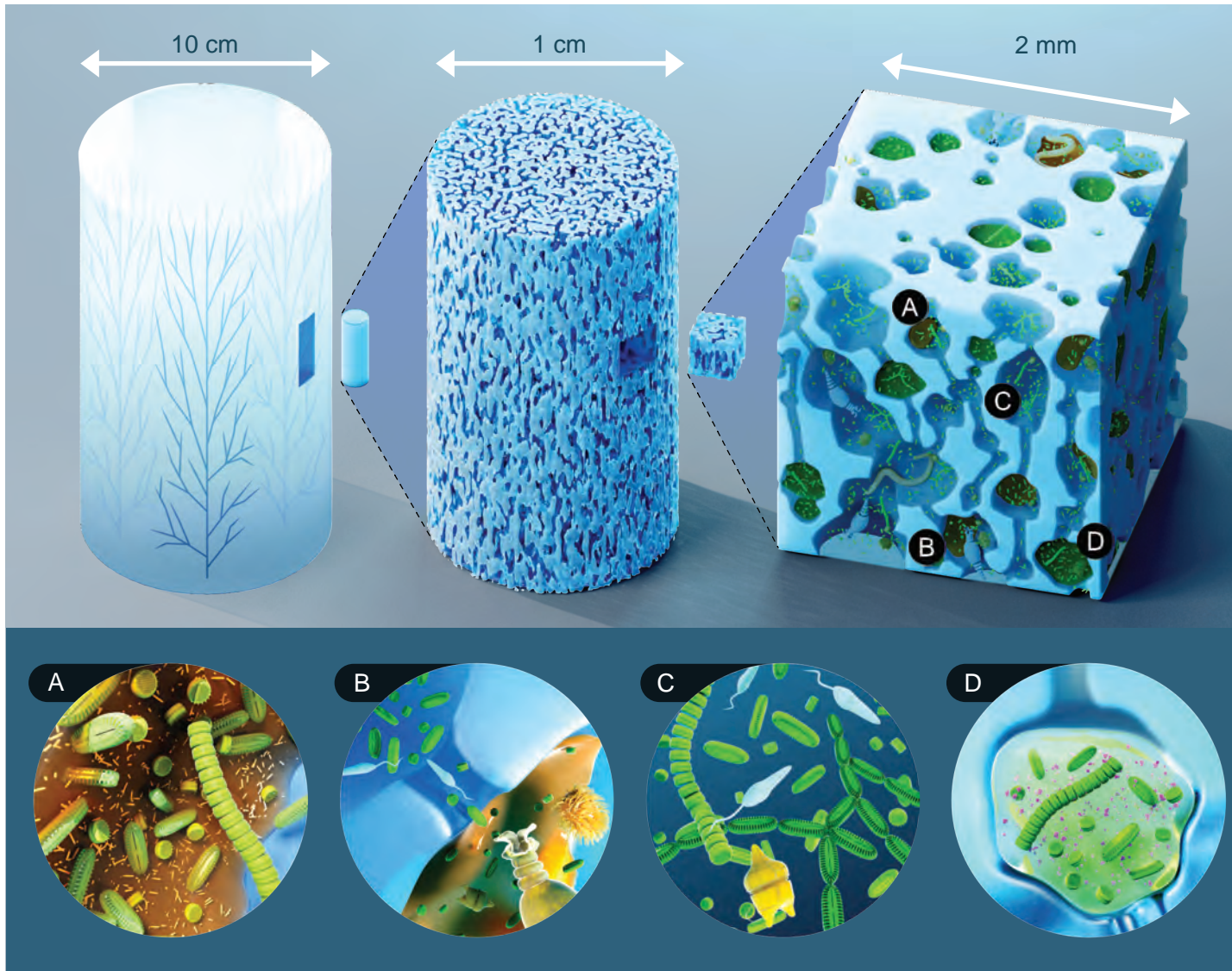


***Antarctic surface flooding  
and snow-ice formation***

September  
snow-ice  
estimates

- *evolution of salinity profiles*
- *ocean-ice-air exchanges of heat, CO<sub>2</sub>*

# Microbial Communities in the Fractal Brine Microstructure



Brine inclusions are home to ice endemic organisms, e.g., bacteria, diatoms, flagellates, rotifers, nematodes.

**The habitability of sea ice for these organisms is inextricably linked to its complex brine geometry.**

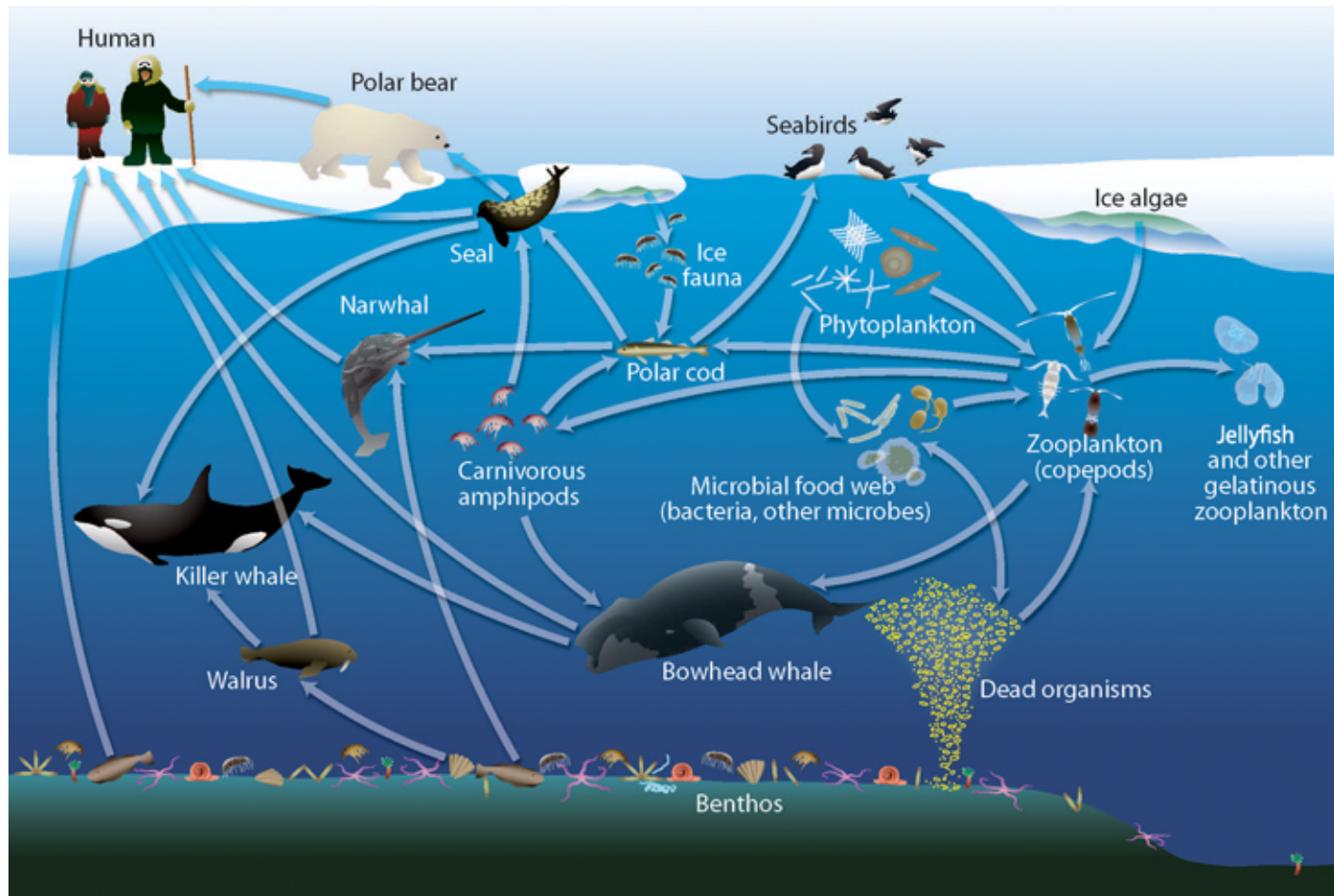
N. Ward, D. Hallman, N. B. Murphy, J. R. Reimer, Marc Oggier, Megan O'Sadnick, E. Cherkaev, and K. M. Golden, 2023

# sea ice ecosystem



sea ice algae  
support life in the polar oceans

# Arctic marine ecosystem



Darnis et al.