Antarctic Sea Ice and Global Climate

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With thanks to Ryan Bowman for his input
Do one Brave thing a Day
Todays Presentation

• What does sea ice look like?
• Sea Ice Extent trends, predictions
• Ocean/Atmosphere heat flux
• Small Scale – Physics of sea ice formation
• Ocean Circulation/Ice Shelves

**Not** Going to talk about
• Surface properties of sea ice – melt ponds, snow cover
• Polynyas
• Ecosystems and Biology in sea ice regions
• Shipping, Logistical issues
• Icebergs
• Indigenous/local populations and sea ice
• ..........
Flat, relatively smooth
Aerial photograph (from approx. 200 m height)

- Camera
- Thermistors
- Radiation station
- Snow stakes
- Major pressure ridge

Thicker
Rescue operation before ice deformation crushes instrument
Grease Ice/ Frazil
Calm Conditions

Nilas

Frost Flowers

Finger Rafting
Thick Snow Covered Ice
Arctic Sea Ice Gone in Summer Within Five Years?

Arctic ice shrinks to record low, melting faster than computers predicted

'Arctic is screaming,' say scientists seeing new data; worry over 'tipping point'

Arctic Sea Route Opens as Ice Melts - Space Agency

UK: September 17, 2007

LONDON - The Arctic's Northwest Passage has opened
Record Low Arctic Sea Ice Extent in September 2007
But this is only 30 years....
Red Line is the estimated Minimum Arctic extent
Sea Ice Extent at Last Glacial Maximum
Armand (2002)

- **MODELLED** Ganopolski et al. (1998)
- **OBSERVATIONS** Crosta et al. (1998)
- **MODELLED** Weaver et al. (1998)

- Modern winter maximum
- Modern summer minimum

We THINK there was more sea ice in the past
Sea Ice Models – Too Conservative?

Arctic September Sea Ice Extent: Observations and Model Runs

- **Observations**
- **Mean of Models**
- **Standard Deviation of Models** (IPCC)

Sea Ice Extent (million square kilometers)

Year

NSIDC data/UCAR image
- Grey bars represent an abrupt transition.

Holland et al., 2006
Air-Sea Interactions

Sea ice
• acts as a physical barrier to ocean-atmosphere heat and gas exchanges.

• increases surface albedo and reduces radiation absorption.

Summer –
More open water, more melt ponds absorb more solar radiation
Ice-Albedo Feedback

- Less ice and/or thinner ice
- More open water
- Lower albedo
- Increased absorption of short wave radiation
- More ice melts
Predictions of future Arctic Sea Ice?

• We are likely to see an ice free arctic during the summer in our lifetime.

• But not in the winter – it’s just too cold and dark.
What about the Ocean?
What happens when we freeze a bucket of sea water?

SEA WATER
Salinity ~ 35 psu
Temperature ~ -1.8 C

As sea ice freezes it rejects salt
Sea Ice Structure

- Liquid brine remains inside the sea ice isolated pockets and/or connected channels
- Sea Ice is a two(three) phase material – ice and brine (air)
- Brine will continue to drain out of the sea ice
Freezing point of brine as a function of the ratio of dissolved salts to pure water.

Changes in slope are caused by crystallisation of different salts.
Ocean Circulation

This is WRONG – far too simple, ignores the southern ocean bottom water formation.
Antarctic Bottom Water is produced around the Antarctic Continent where sea ice formation rates are high.
There may be both freezing and melting under ice shelves.
Ocean modification

Sea ice:

• Adds salt (fresh water) to the ocean during growth (melt).

• Transports net freshwater and negative heat equatorward.

• Without this heat transport, the poles would be much much much colder, and the topics would be much much warmer
Figure 4.1

Time Scale of Cryosphere components
Sea Ice – Frozen Sea Water

- Average thickness is typically less than 1 metre (in Antarctica), less than 10 m (Arctic)
- Usually covered with snow
- Reflects much of the incoming solar radiation
- Maximum extent ~21 million km$^2$ in Antarctic, ~15 million km$^2$ in Arctic. (10 % of the ocean surface)
- Insulates the relatively warm (-1.8C) ocean from the cold atmosphere
- Rejects salt into the ocean – causing vertical circulation and modification of water masses