

Mapping the Arctic Ocean from Space: Impacts of a Declining Ice Cover on Climate and Society



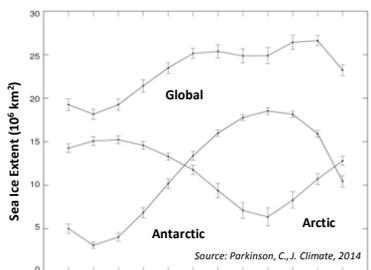
Sinéad Louise Farrell
Earth System Science Interdisciplinary Center, University of Maryland
sineadf@umd.edu

AMS Washington Forum 2018 24 April 2018

Sea Ice in the Climate System



Annual average Arctic, Antarctic and Global sea ice extent (1979-2013)



Min. extent: Feb. $18.2 \times 10^6 \text{ km}^2$ • Max. extent: Nov. $26.6 \times 10^6 \text{ km}^2$

Sinéad L. Farrell AMS Washington Forum 2018

Sea Ice Characteristics



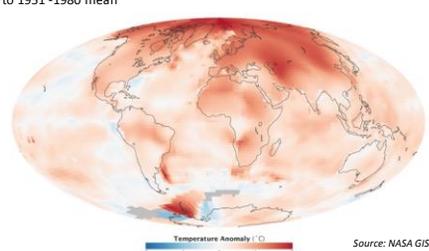

Photo Credit: Sinéad L. Farrell

- Complex system of level sea ice floes topped with snow, deformed ice, pressure ridges, interspersed with open water (leads/polynyas)
- Sea ice is a reflective barrier - insulates ocean from atmosphere

Sinéad L. Farrell AMS Washington Forum 2018

Arctic Amplification

Global temperature anomalies for 2000 – 2009, relative to 1951 - 1980 mean

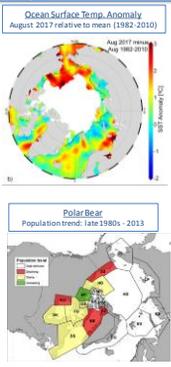


Source: NASA GISS

- Global temperatures from 2000–2009 were $\sim 0.6^\circ\text{C}$ higher than average
- However, due to Arctic amplification, **the Arctic was $\sim 2^\circ\text{C}$ warmer**

Sinéad L. Farrell AMS Washington Forum 2018

Arctic System Change



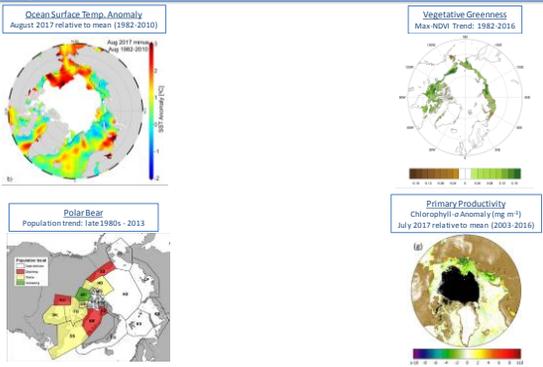
Ocean Surface Temp. Anomaly
August 2017 relative to mean (1982-2010)

Aug 2017 relative to Aug 1982-2010

Polar Bear
Population trend: late 1980s - 2013

Sinéad L. Farrell AMS Washington Forum 2018

Arctic System Change



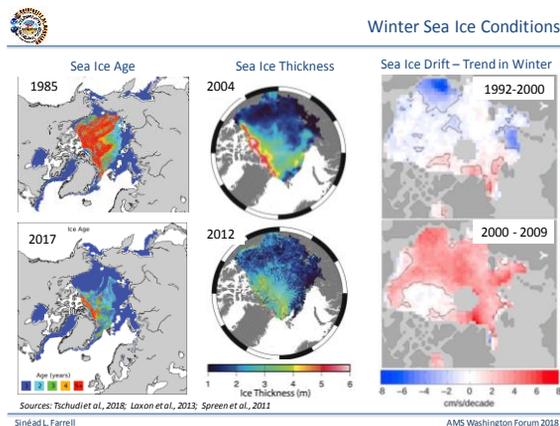
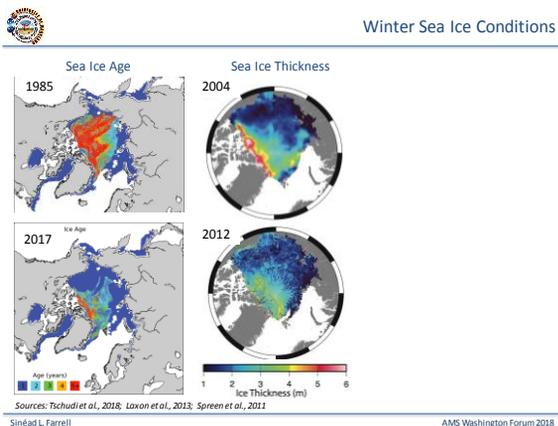
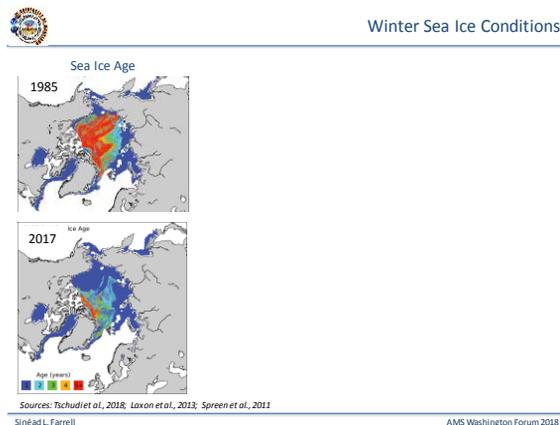
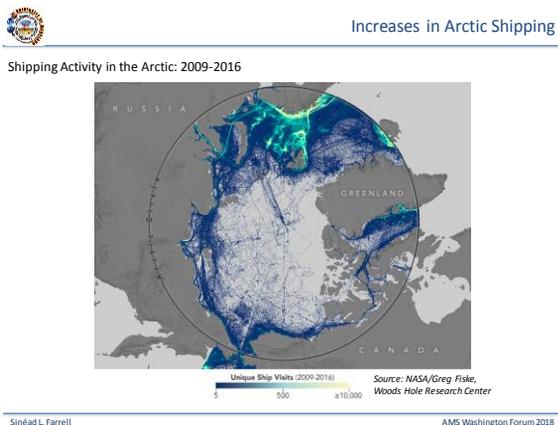
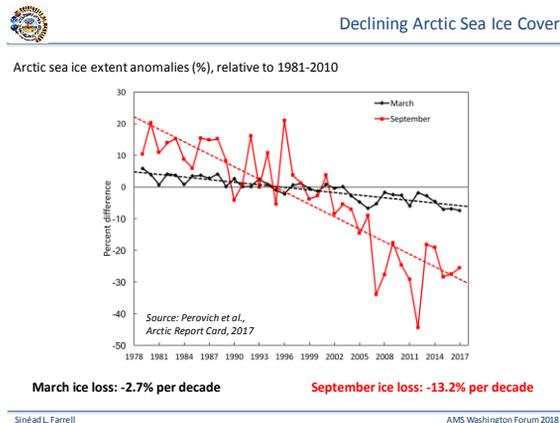
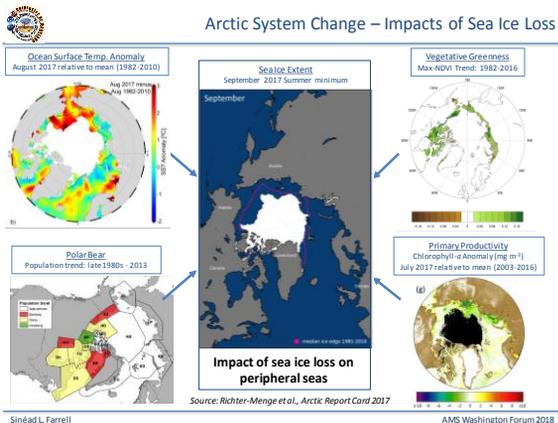
Ocean Surface Temp. Anomaly
August 2017 relative to mean (1982-2010)

Aug 2017 relative to Aug 1982-2010

Vegetative Greenness
Max-NDVI Trend: 1982-2016

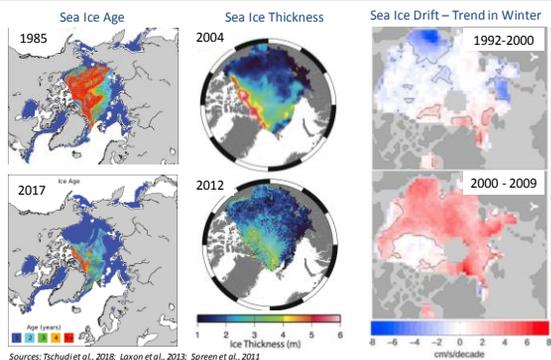
Primary Productivity
Chlorophyll-a Anomaly (mg m^{-3})
July 2017 relative to mean (2003-2016)

Sinéad L. Farrell AMS Washington Forum 2018





Younger, Thinner, Faster!



Sources: Tschudi et al., 2018; Laxon et al., 2013; Spreen et al., 2011
AMS Washington Forum 2018

Sinéad L. Farrell



Ocean-Atmosphere Heat Exchange



Photo Credit: Sinéad L. Farrell

- As the ice thins, and drift speeds increase, areas of open water, leads and polynyas increase
- Sea ice may no longer efficiently insulate ocean from atmosphere

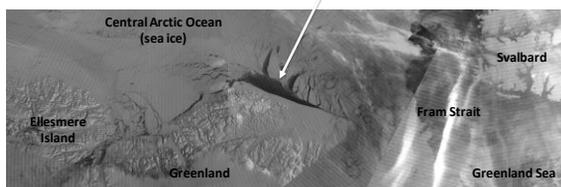
Sinéad L. Farrell

AMS Washington Forum 2018



Winter Polynya – Central Arctic Ocean

Suomi/NPP VIIRS Nighttime Imagery (enhanced day/night band)
Polynya (hole in sea ice cover) opening off northern coast of Greenland



Feb. 2018: large polynya formation in central Arctic Ocean, as a result of winter storm system

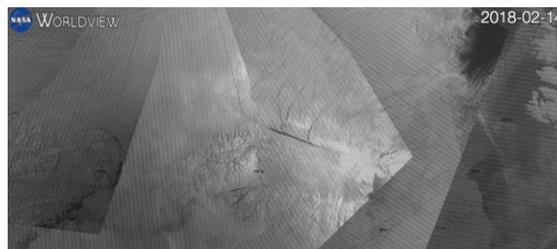
Sinéad L. Farrell

AMS Washington Forum 2018



Winter Polynya – Central Arctic Ocean

Suomi/NPP VIIRS Nighttime Imagery (enhanced day/night band)



- 14 – 28 February 2018: Polynya formation
- New ice production, break-up of shore-fast ice, temporary reversal of ice drift northwards

Sinéad L. Farrell

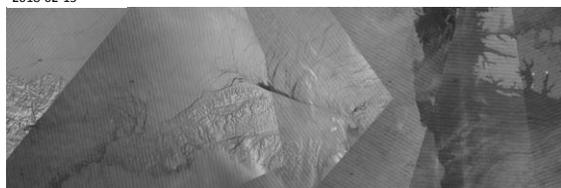
AMS Washington Forum 2018



Winter Polynya – Central Arctic Ocean

Suomi/NPP VIIRS Nighttime Imagery (enhanced day/night band)

2018-02-15



- 14 – 28 February 2018: Polynya formation
- New ice production, break-up of shore-fast ice, temporary reversal of ice drift northwards

Sinéad L. Farrell

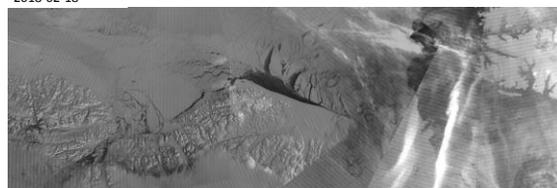
AMS Washington Forum 2018



Winter Polynya – Central Arctic Ocean

Suomi/NPP VIIRS Nighttime Imagery (enhanced day/night band)

2018-02-18



- 14 – 28 February 2018: Polynya formation
- New ice production, break-up of shore-fast ice, temporary reversal of ice drift northwards

Sinéad L. Farrell

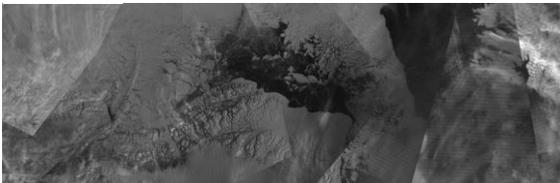
AMS Washington Forum 2018



Winter Polynya – Central Arctic Ocean

Suomi/NPP VIIRS Nighttime Imagery (enhanced day/night band)

2018-02-26



- 14 – 28 February 2018: Polynya formation
- New ice production, break-up of shore-fast ice, temporary reversal of ice drift northwards

Sinéad L. Farrell

AMS Washington Forum 2018



Winter Polynya – Central Arctic Ocean

Suomi/NPP VIIRS Nighttime Imagery (enhanced day/night band)

2018-02-28



- 14 – 28 February 2018: Polynya formation
- New ice production, break-up of shore-fast ice, temporary reversal of ice drift northwards

Sinéad L. Farrell

AMS Washington Forum 2018



- Preparing for ICESat-2
- Launch: 12th Sept. 2018
- Multi-beam Photon Counting Altimetry



Science Goals:

- Quantify polar ice-sheet contributions to current and future sea-level change
- Estimate sea-ice thickness to examine ice-ocean-atmosphere exchanges of energy, mass and moisture
- Measure vegetation canopy height as a basis for estimating biomass change
- Ocean, land and inland water (rivers/lakes/reservoir) heights
- Atmospheric column profiles and cloud heights

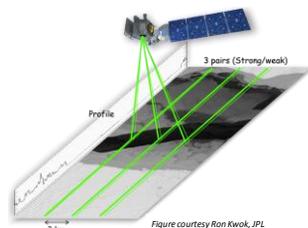


Figure courtesy Ron Kwok, JPL

Sinéad L. Farrell

AMS Washington Forum 2018

Thanks for your attention!

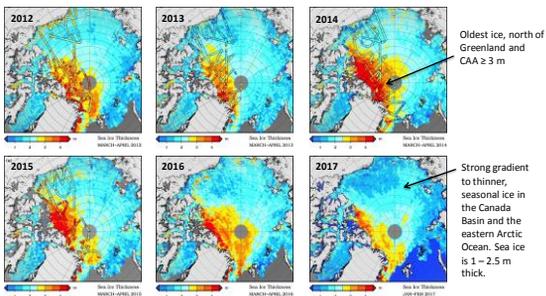


Sinéad Louise Farrell
 Earth System Science Interdisciplinary Center, University of Maryland
 Email: sineadf@umd.edu Twitter: @sineadfarrell



Interannual Variability in Winter Sea Ice Thickness

Independent estimates of sea ice thickness from IceBridge and CryoSat-2



Sinéad L. Farrell

AMS Washington Forum 2018



Sinéad L. Farrell

AMS Washington Forum 2018