



Temporal and Regional Variability of Arctic Sea Ice Extent from Satellite Data

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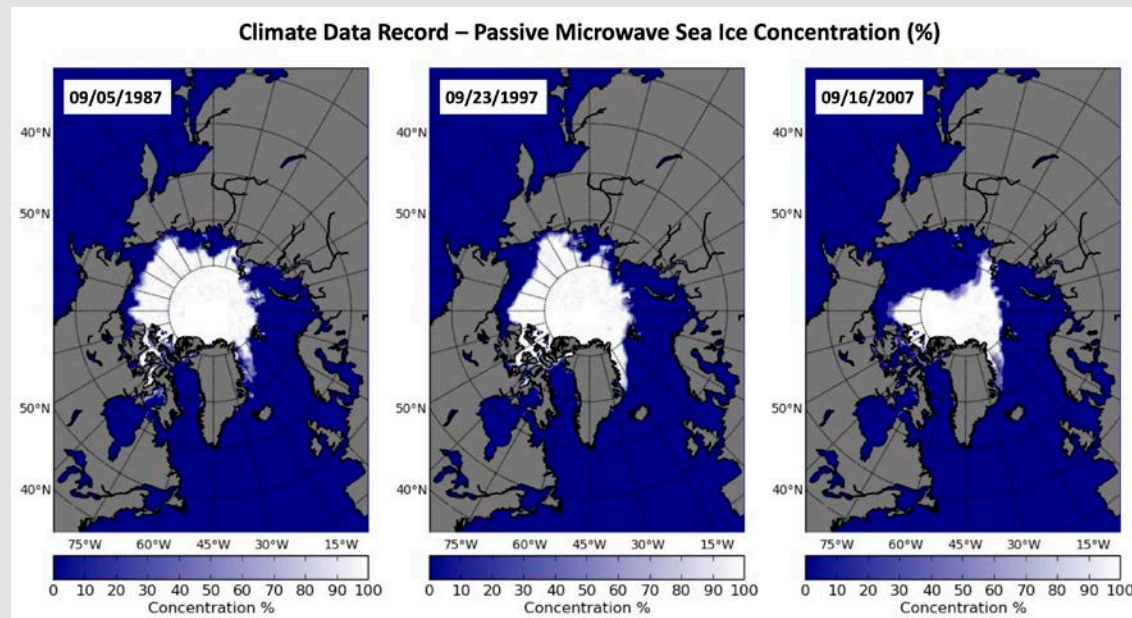
*North Carolina State University, Cooperative Institute for Climate and Satellites - North Carolina (CICS-NC)
at NOAA's National Centers for Environmental Information (NCEI)*

7 Nov 2017, CICS Science Conference, College Park, MD

NOAA Satellite and Information Service | National Centers for Environmental Information



Sea Ice Data for Climate Study and Monitoring



NOAA/NSIDC Passive Microwave Sea Ice Concentration (SIC) Climate Data Record (CDR)

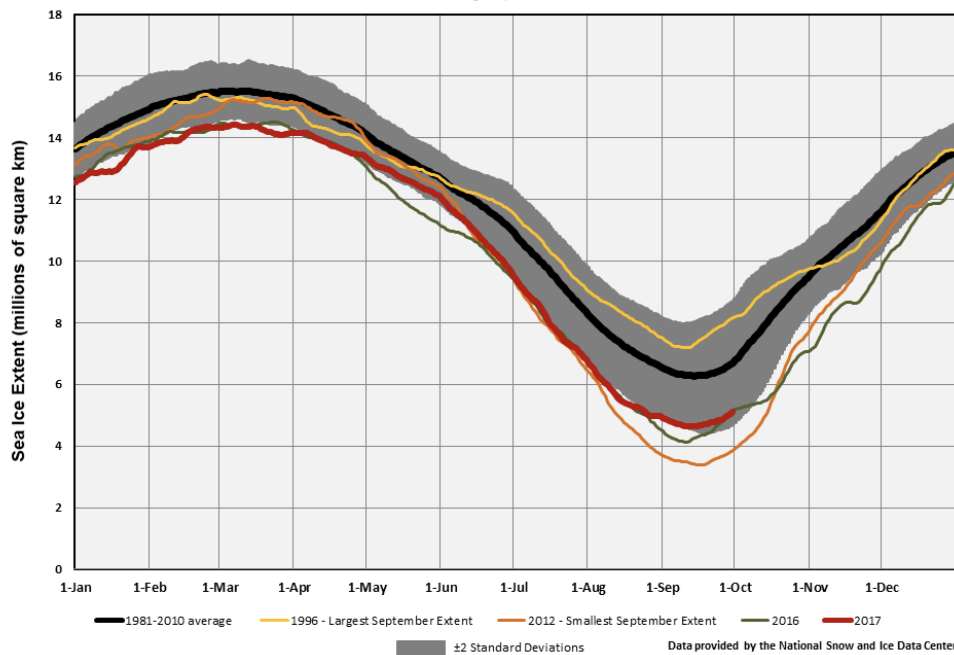
- Two mature algorithms: NASA Team (NT) and Bootstrap (BT) Algorithms
- 25 km x 25 km over both Arctic and Antarctic regions; NetCDF-4; CF-compliant
- v1 IOC (Initial Operation Capability) – Oct 2011 annual update; now v3 daily and annual updates
- ~1000 unique data users per year
- Additional information: <https://www.ncdc.noaa.gov/cdr/oceanic/sea-ice-concentration>

Consistency; Documentation; Transparency; Preservation; Sustainability

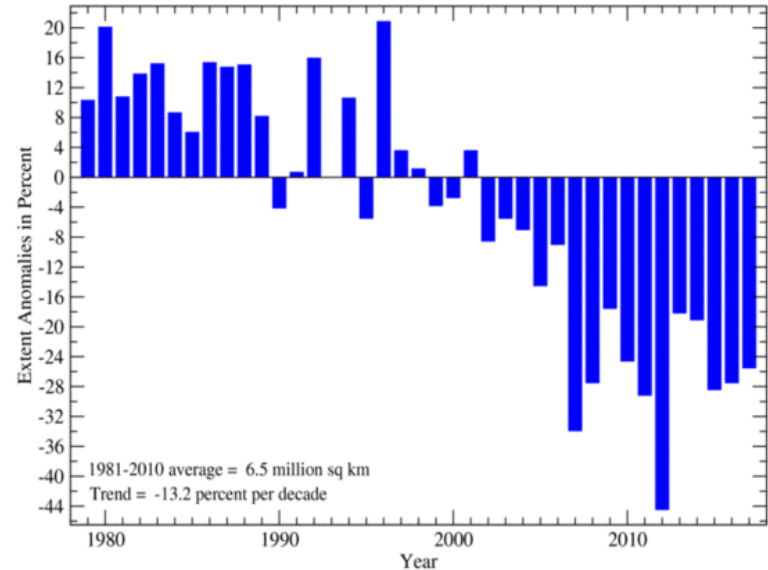
NCEI Sea Ice Climate Monitoring Products

Arctic Sea Ice Extent - Daily

Data through September 30, 2017



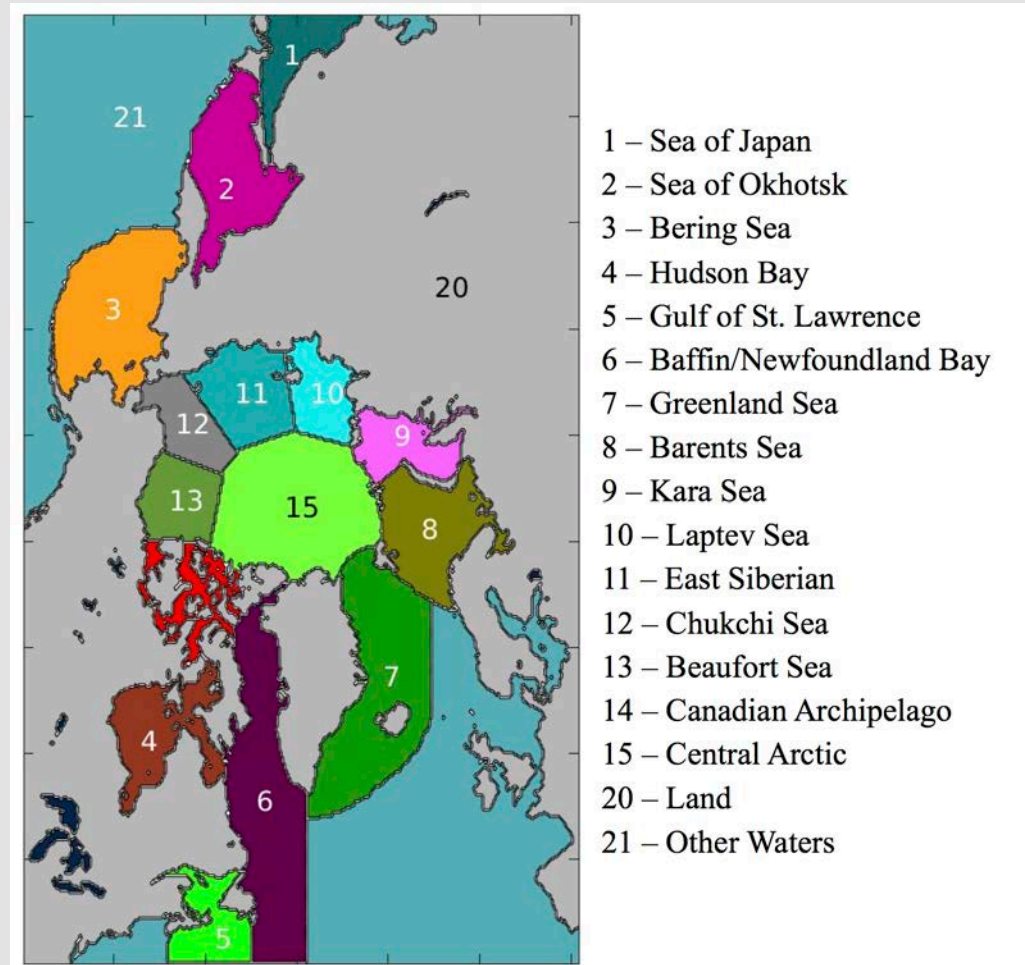
Northern Hemisphere Sea Ice Extent September Anomalies, 1979-2017



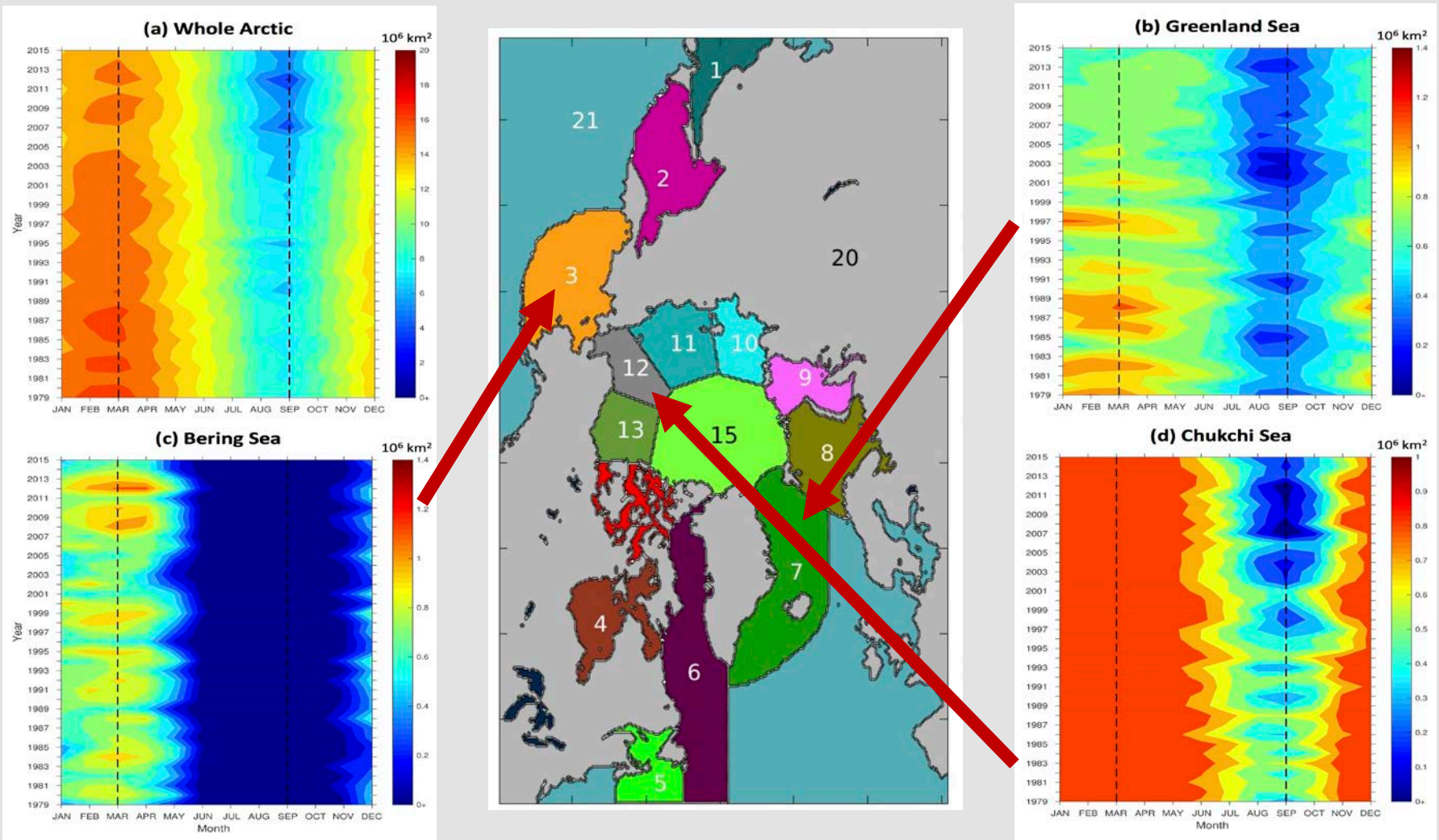
Data provided by the National Snow and Ice Data Center (NSIDC)

(Image Source: <https://www.ncdc.noaa.gov/sotc/global-snow/201709>)

Temporal and Regional Variability of Sea Ice Extent



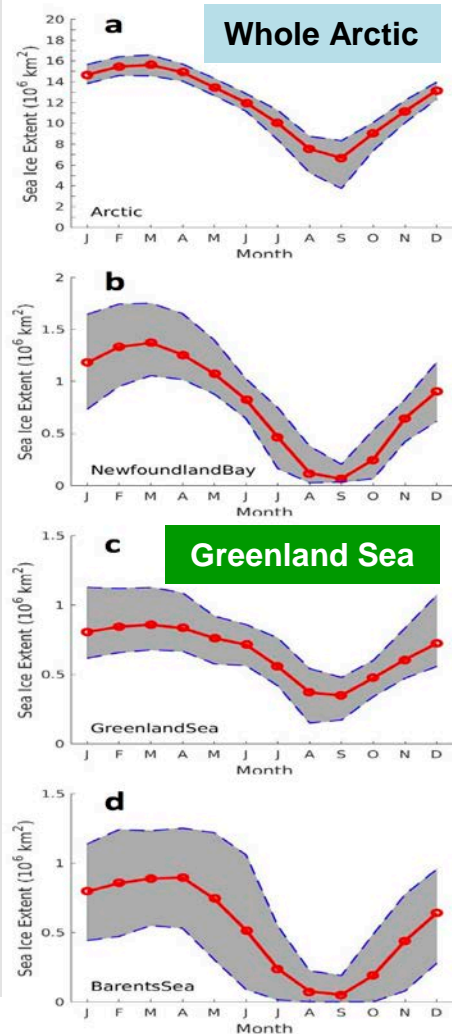
Temporal and Regional Variability of Sea Ice Extent



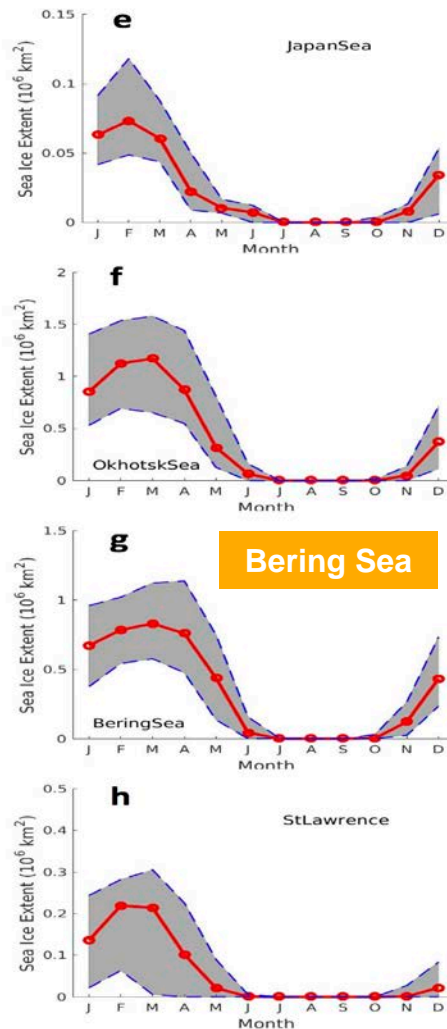
(Peng and Meier 2017, Annals of Glaciology, in press)

Three Types of Regional Sea Ice Extent Evolution

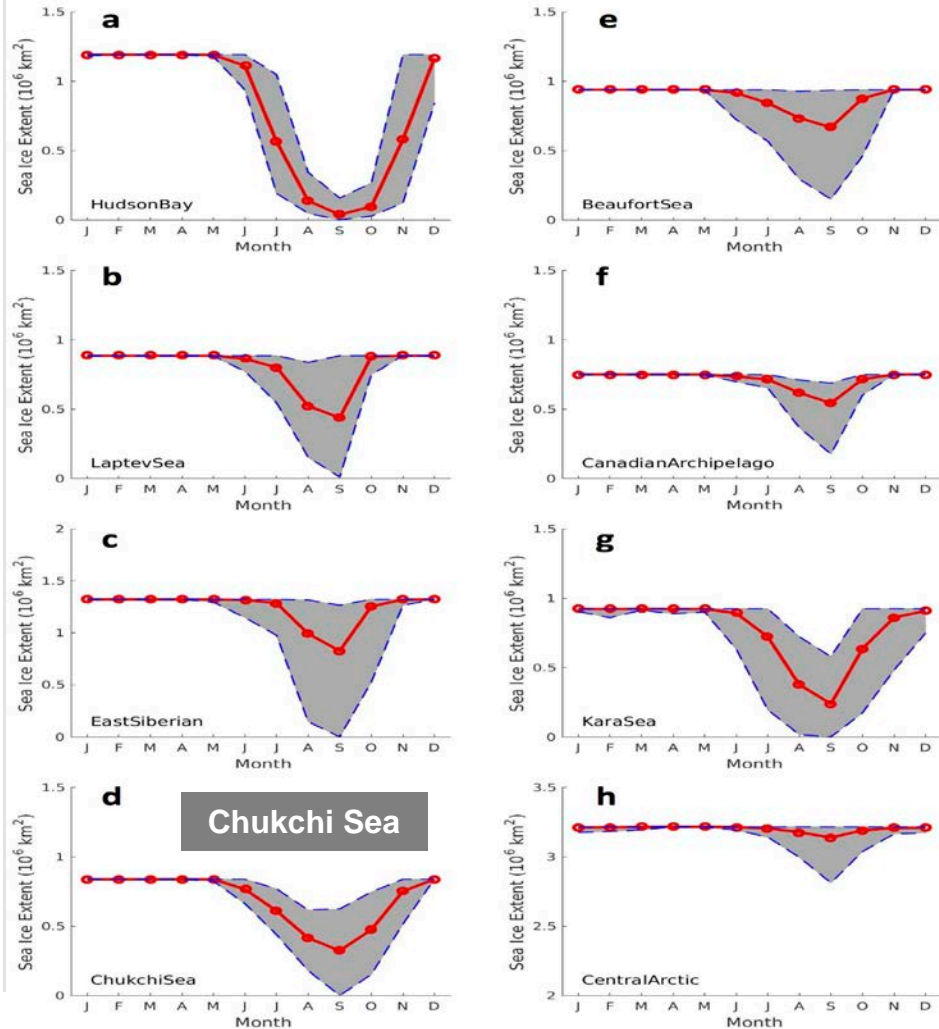
Type I



Type II



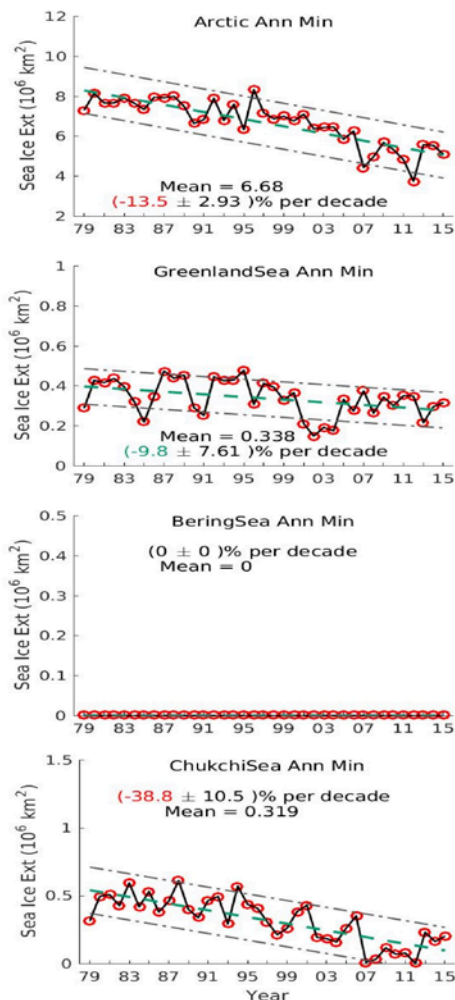
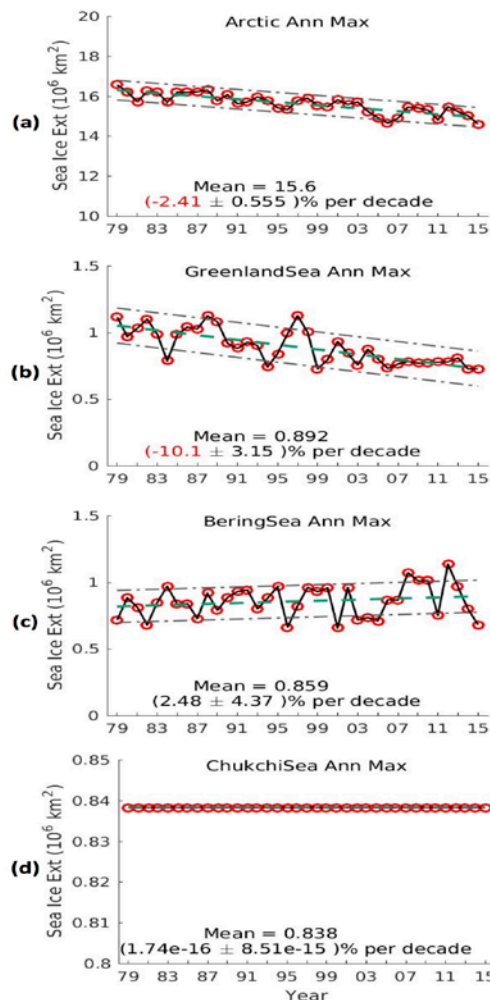
Type III



Decadal Trends of Sea Ice Extent

Annual Max

Annual Min

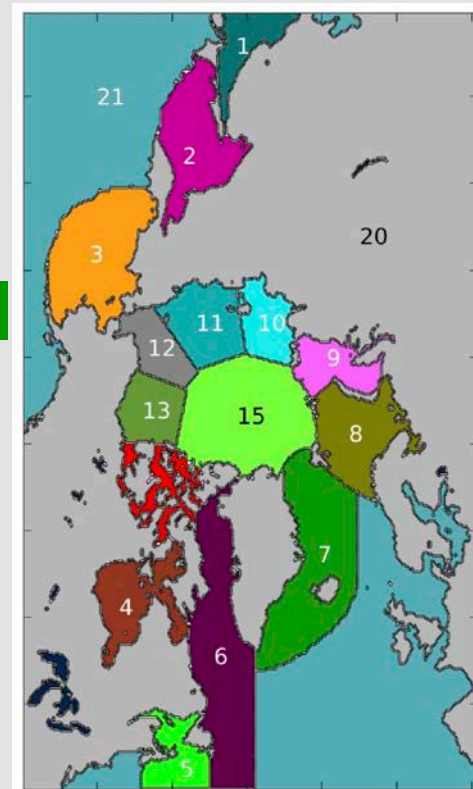


Whole Arctic

Greenland Sea

Bering Sea

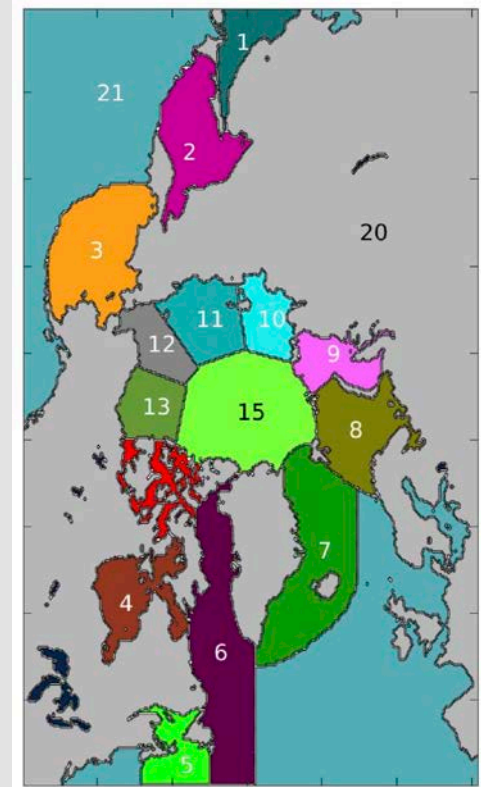
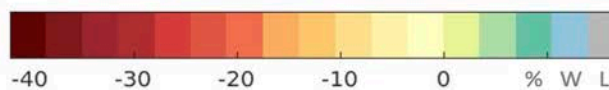
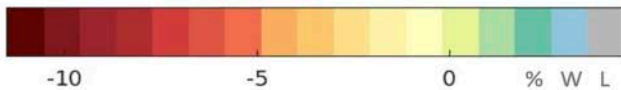
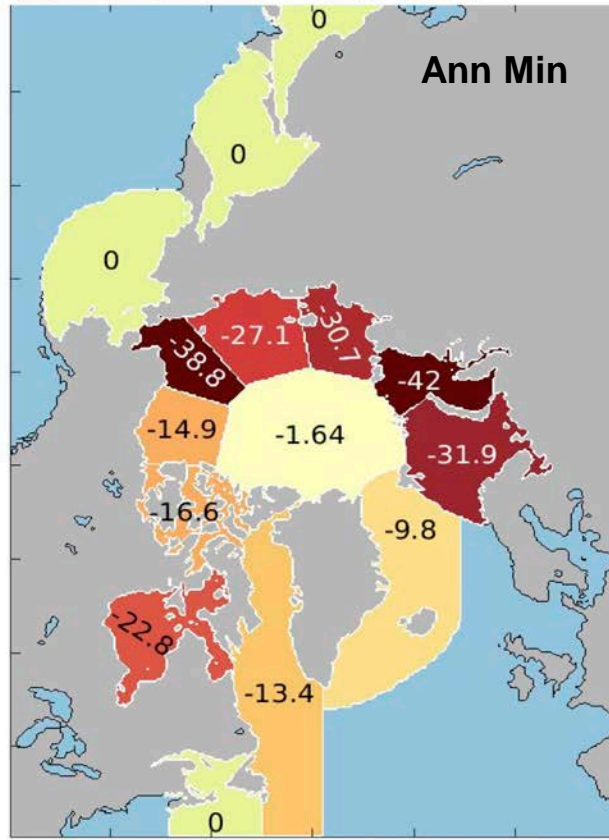
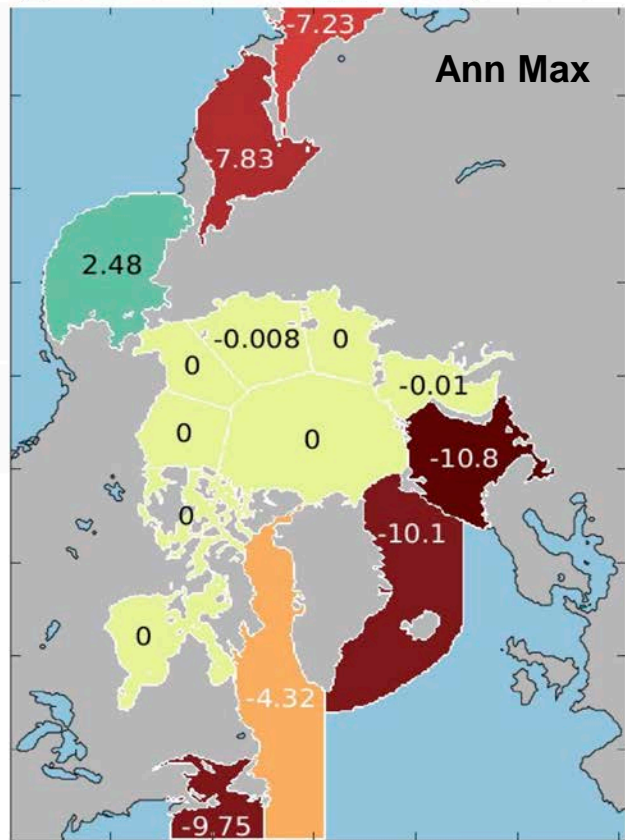
Chukchi Sea



(Peng and Meier 2017, Annals of Glaciology, in press)

Regional Distribution: Decadal Trends of Sea Ice Extent

1979-2015 SIE Trend (%/Decade)



(Peng and Meier 2017, Annals of Glaciology, in press)



Ice-Free Summer Arctic Predictions In the News

1960, Mr. Murphy: *If the Arctic warming continues, the Arctic Ocean will be open around the **turn of the century**.*

1972, Arctic specialist Bernt Balchen: *a general warming trend over the North Pole is melting the polar ice cap and may produce an ice-free Arctic Ocean **by the year 2000**.*

2007, NASA climate scientist Jay Zwally: *At this rate, the Arctic Ocean could be nearly ice-free at the end of summer **by 2012**, much faster than previous predictions. **Professor Wieslaw Maslowski:** Arctic summers ice-free **by 2013**. **Louis Fortier, scientific director of ArcticNet:** ice-free Arctic in the summer **as soon as 2010 or 2015**.*

Dr. Walter Meier: *"I'd be very surprised if it's 2013 - I wouldn't be totally surprised if it's 2019. ... **lean towards 2040/50**."*

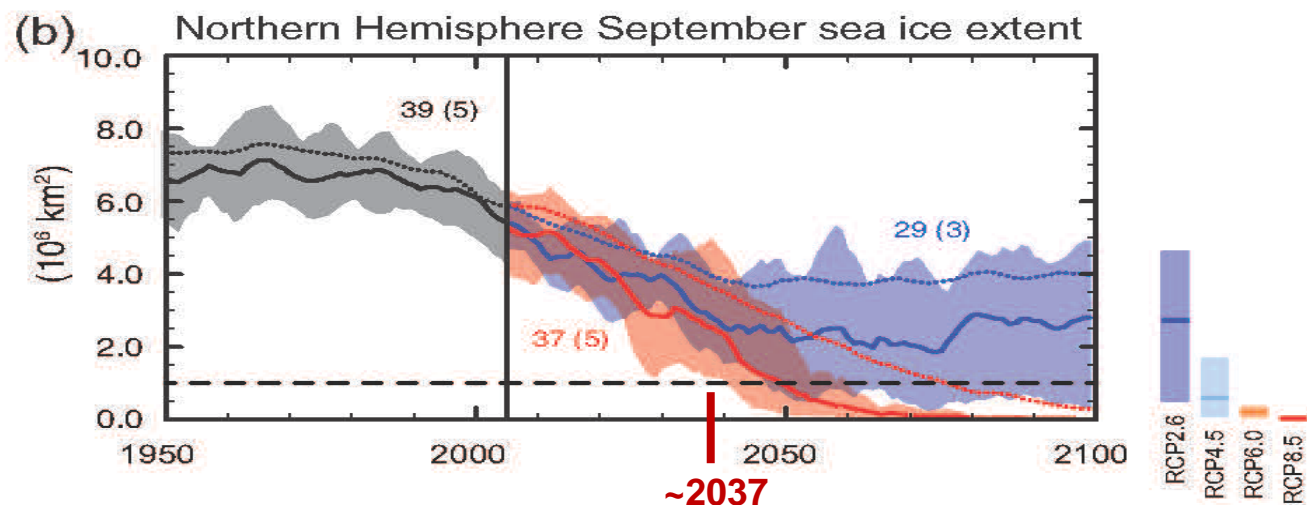
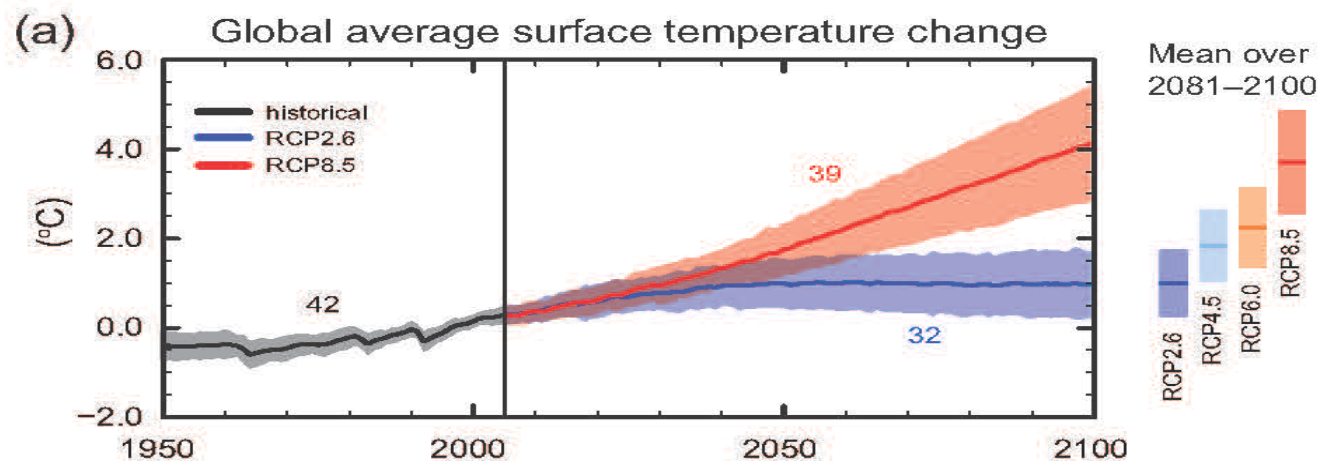
2011, Professor Wieslaw Maslowski: *Arctic summers ice-free **by 2016**.*

NSIDC Director Serreze says *"we are on track to see an ice-free summer **by 2030**."*

2016, Cambridge Univ. Professor Peter Wadhams: *Arctic summers ice-free **this year or next**.*

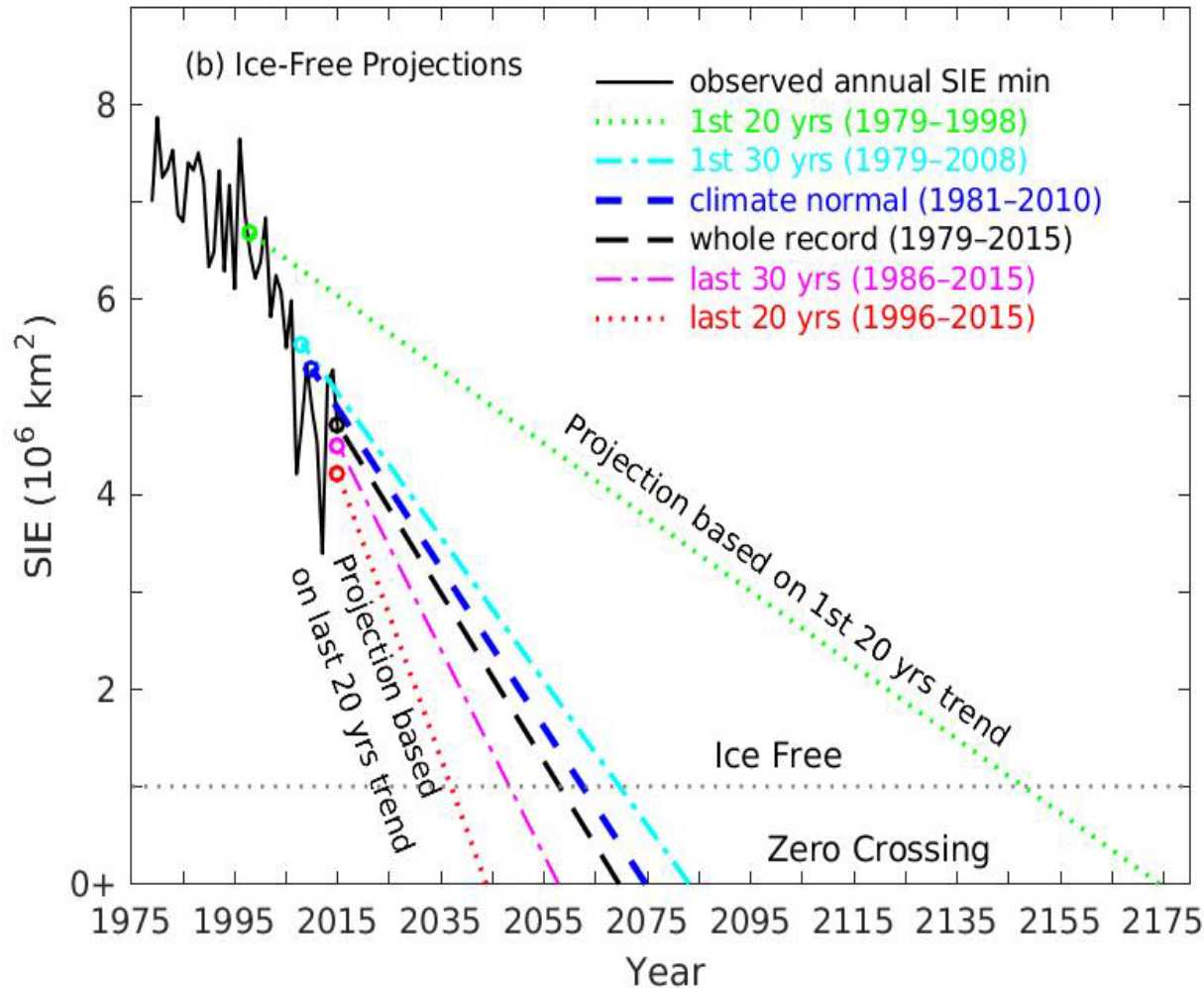
Professor Jennifer Francis: *That is highly unlikely, **2030–2050 as a likely timeframe**.*

Ice-Free Arctic Summer Prediction by Climate Models



IPCC AR5, 2013
≥ 2040
Lurking around 2030.

Ice-Free Arctic Summer: Linear Projection



Case ID	Data Period	Ice-Free Summer Year
1 st 20 yrs	1979–1998	2147
1 st 30 yrs	1979–2008	2069
Climate Normal	1981–2010	2062
All years	1979–2015	2057
Last 30 yrs	1986–2015	2048
Last 20 yrs	1996–2015	2036

(Peng et al. 2017, in prep)

Ice-Free Arctic Summer Projection: Statistical Models

Exponential: $y(t) = \alpha_1 + e^{\alpha_2 t}$

Gompertz: $y(t) = \alpha_1 e^{-e^{\frac{t-\alpha_2}{\alpha_3}}}$

Log: $y(t) = \alpha_1 e^{-e^{\frac{t-\alpha_2}{\alpha_3}}}$

Quadratic: $y(t) = \alpha_1 + \alpha_2 t + \alpha_3 t^2$

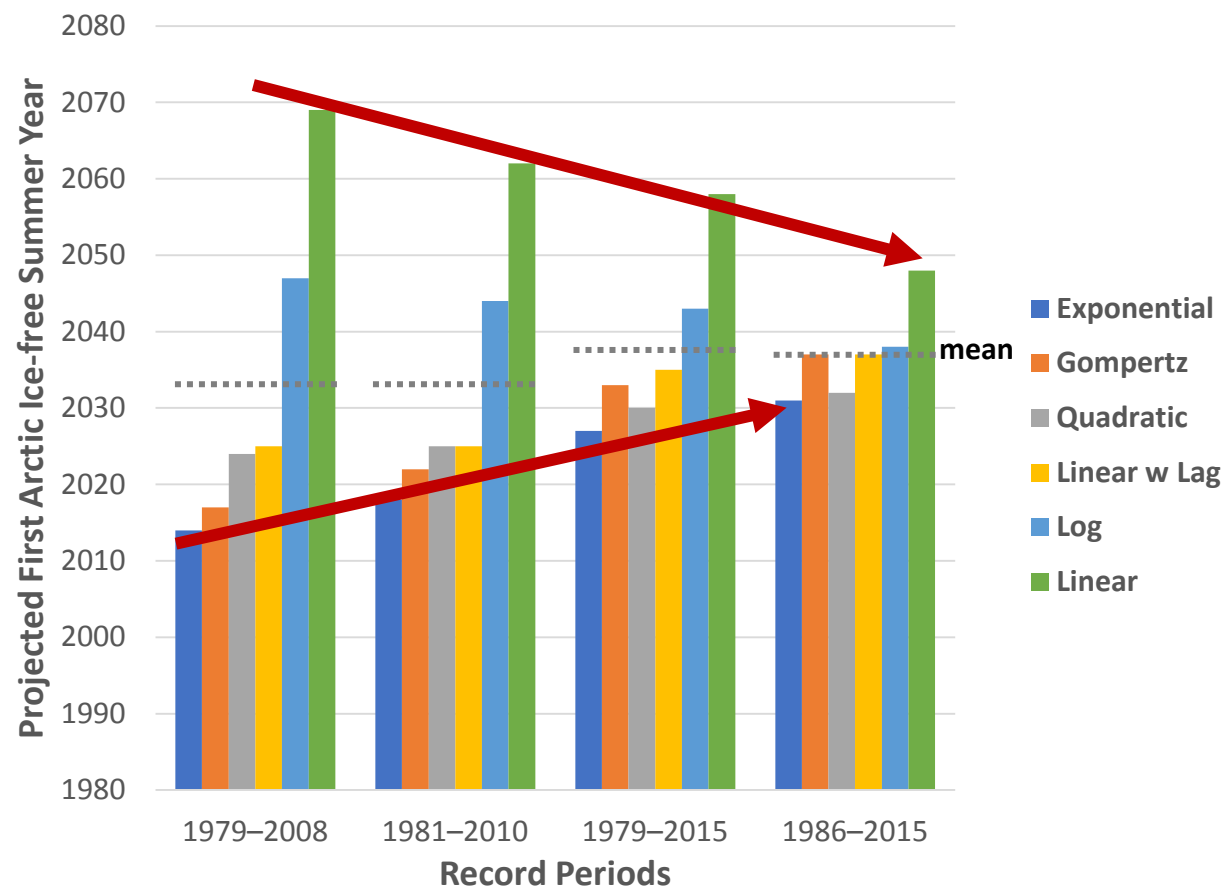
Linear: $y(t) = \alpha_1 + \alpha_2 t$

Linear with lag: $y(t) = \alpha_1 + \alpha_2 t + \alpha_3 e^{-\left(\frac{t-\alpha_4}{\alpha_5}\right)}$

Case ID	Best First Ice-Free Summer Year Projection	Best Fit Model
1 st 20 yrs	>2100	Linear
1 st 30 yrs	2014	Exponential
Climate Normal	2022	Gompertz
All years	2030	Quadratic
Last 30 yrs	2048	Linear
Last 20 yrs	2036	Exponential, Log, Linear, Linear w Lag

(Peng et al. 2017, in prep)

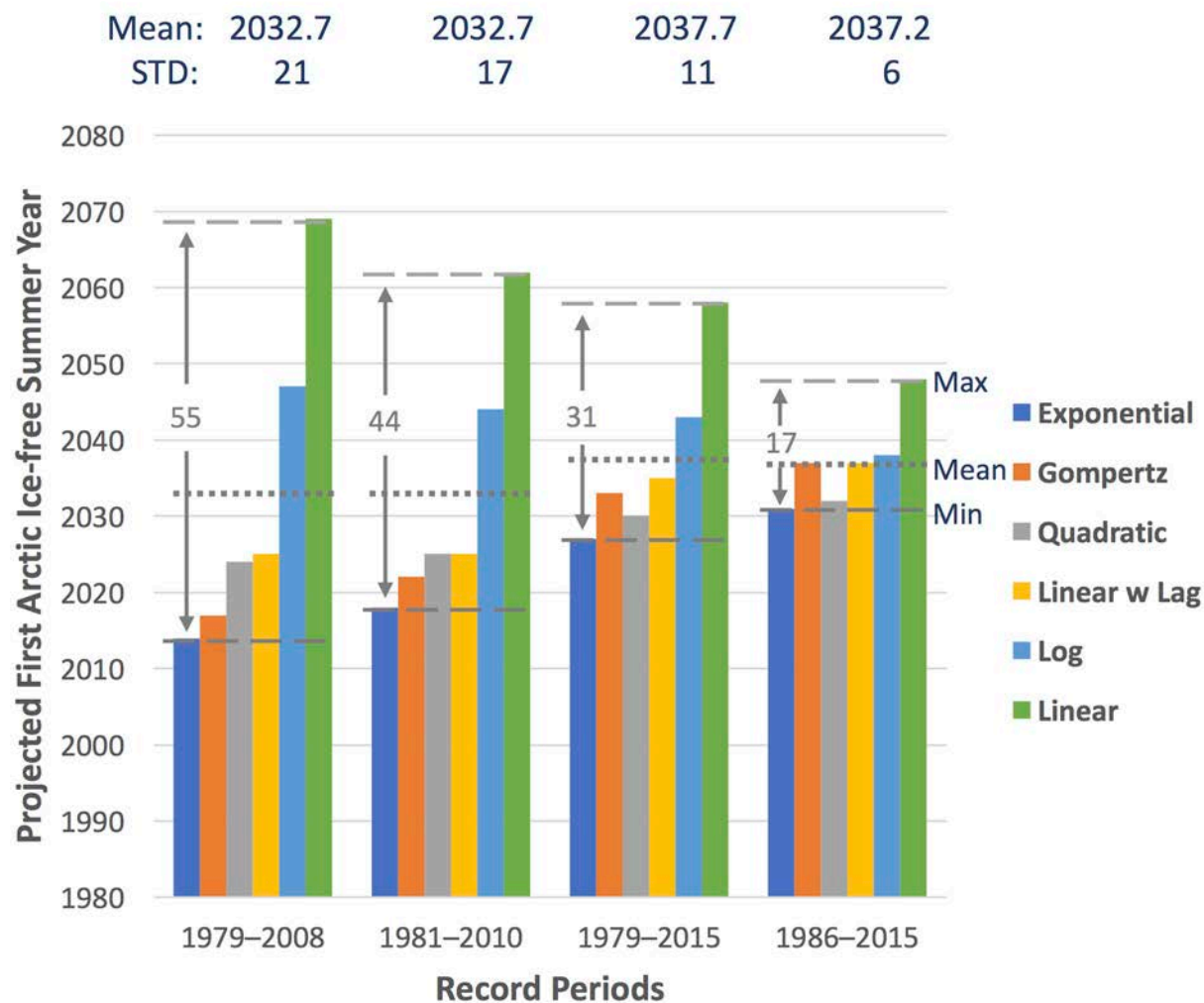
Ice Free Arctic Projection: Statistical Models



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(Peng et al. 2017, in prep)

Ice-Free Arctic Summer Projection: Statistical Models



Converging to: **2037 +/- 6**
(2031-2043)

Case ID	Best Ice-Free Year Projection	Best Fit Model
1 st 20 yrs	>2100	Linear
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Climate Normal	2022	Gompertz
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(Peng et al. 2017, in prep)



Future Work

- **Regional Sea Ice Climate Normal Products**
 - Evaluation
- **Temporal and Regional Variability of Other Sea Ice Climate Indicators**
 - Melt onset and freeze-up dates
 - Sea ice retreat/advance dates
(collaborating with W. Meier and M. Steele)
- **Enterprise Scientific Data Stewardship Framework**

Question or Suggestion?

Thank You!

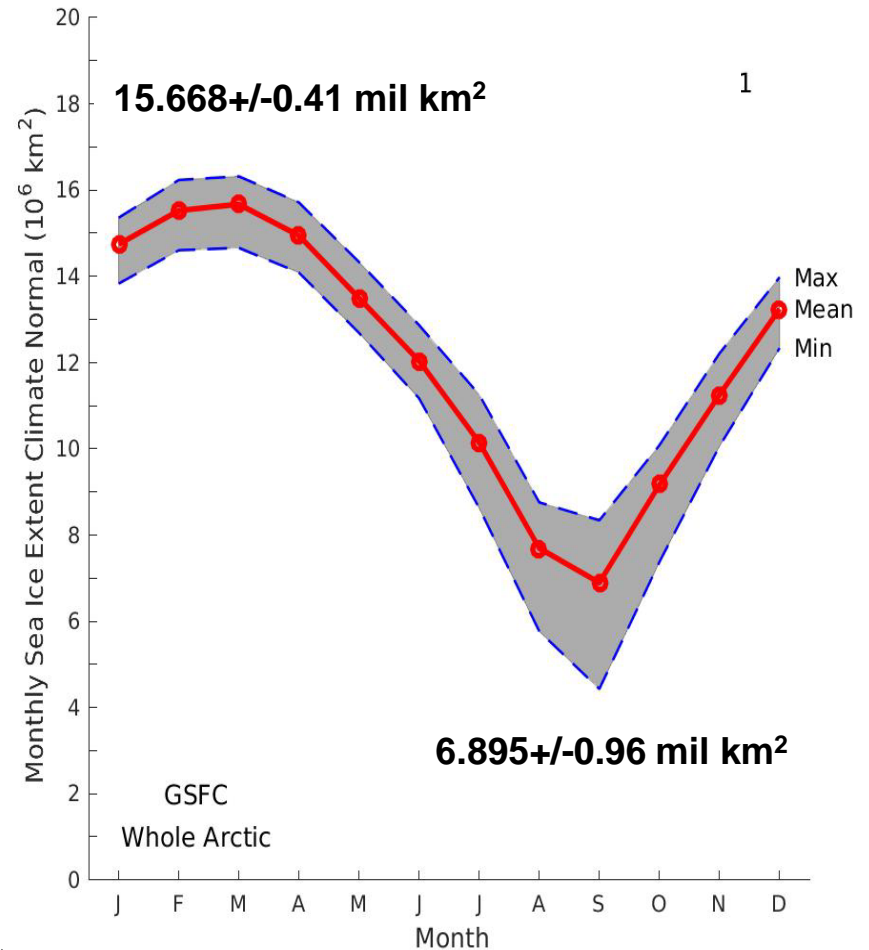
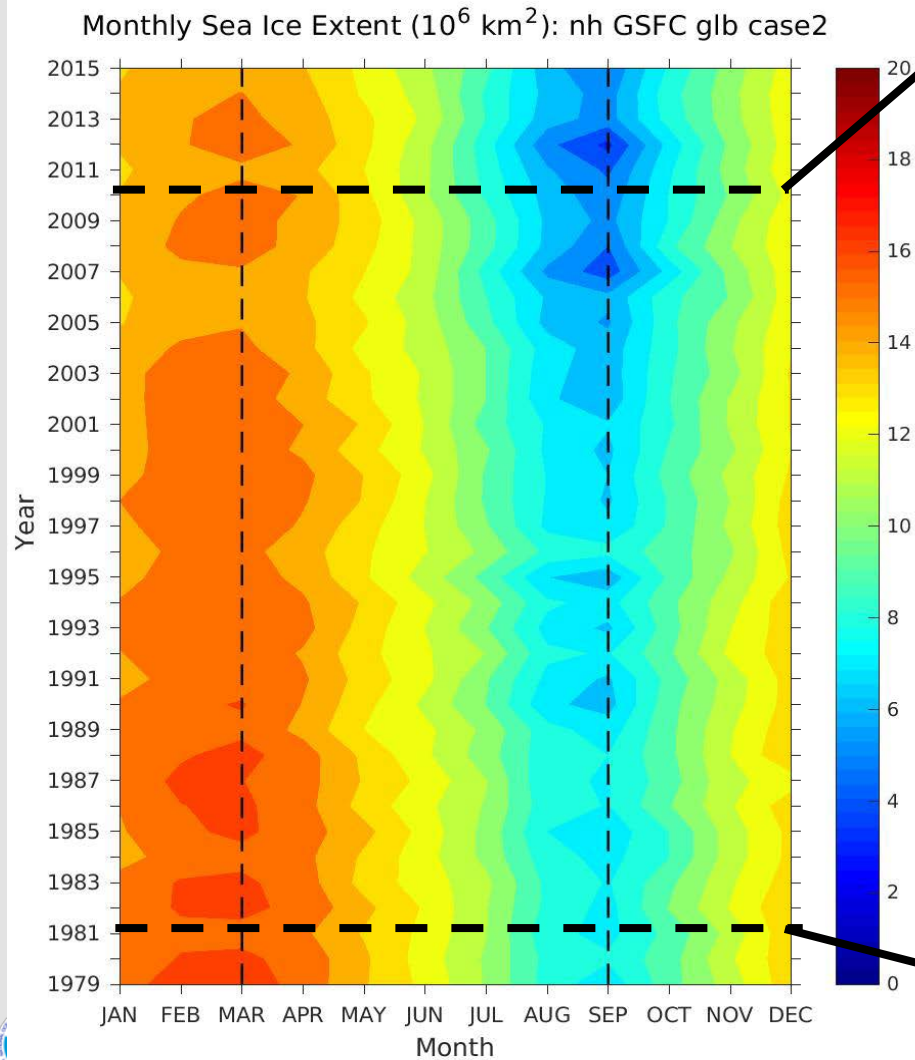


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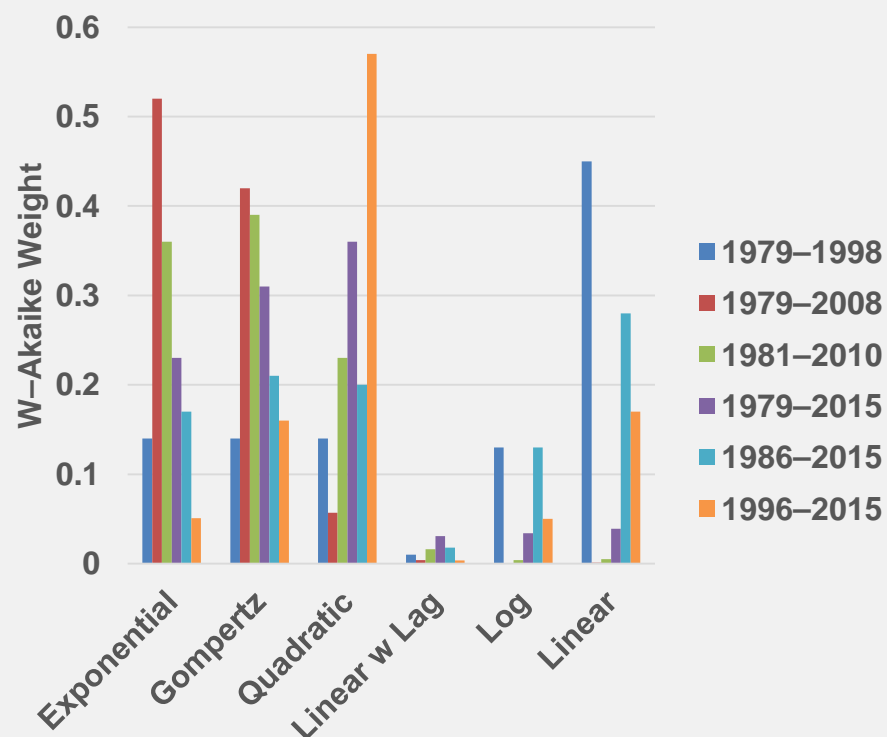
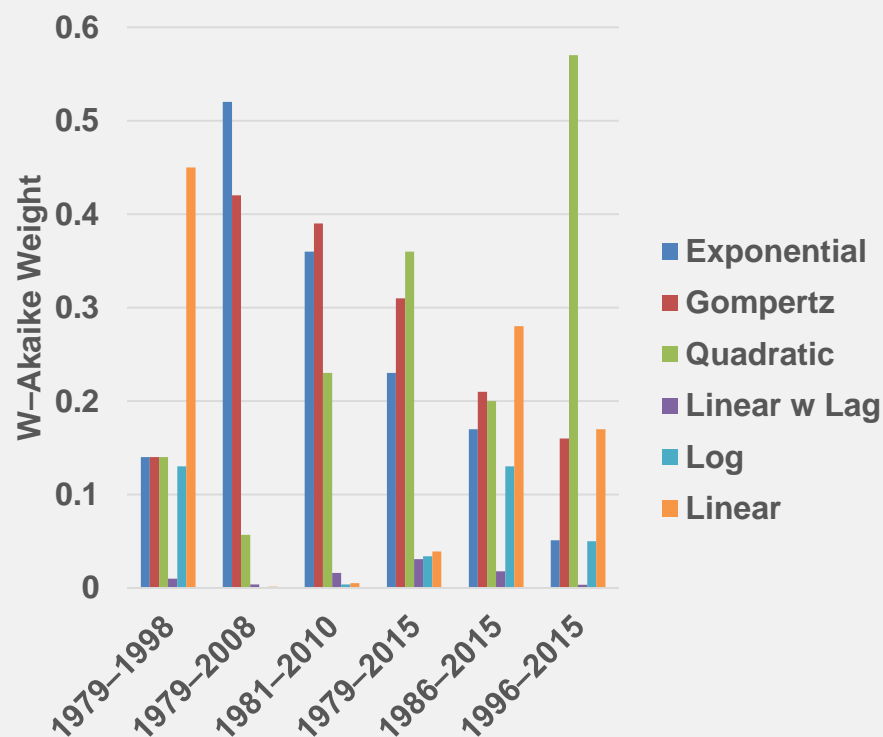
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Sea Ice Extent Climate Normal



Model Optimization



W-Akaike weight can be interpreted as the probability that this model is the best of the sample/