

# Seasonal Sea Ice Forecasting:

Bertrand Denis -- Bruno Tremblay

Pan-Arctic Regional Climate Outlook Forum

Ottawa, May 15-16, 2018

# What are seasonal forecasts?

## Weather forecast

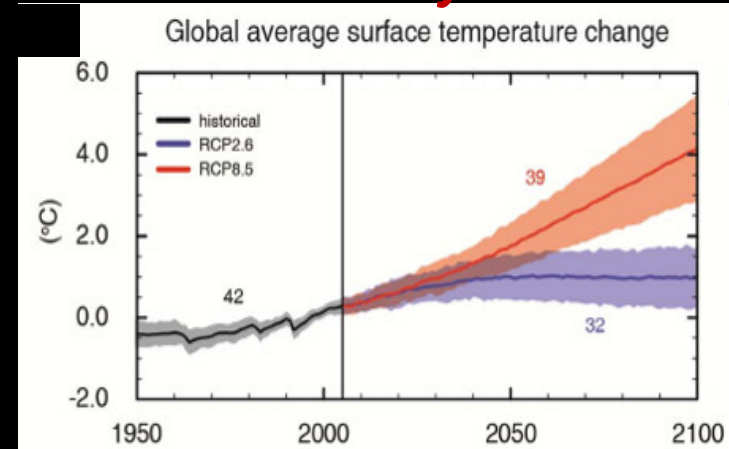
*1-10 days*



- Weather prediction model
- Current global observations used to initialize model

## Climate projection

*10-100 years*



- Climate model (atmosphere /ocean/land/sea ice)
- Initial conditions not critical

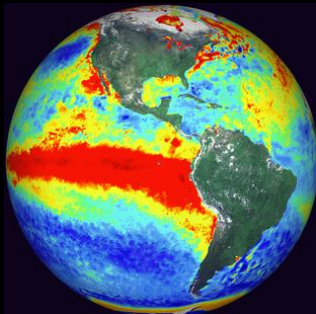
# What are seasonal forecasts?

## Weather forecast

*1-10 days*



- Weather prediction model
- Current global observations used to initialize model

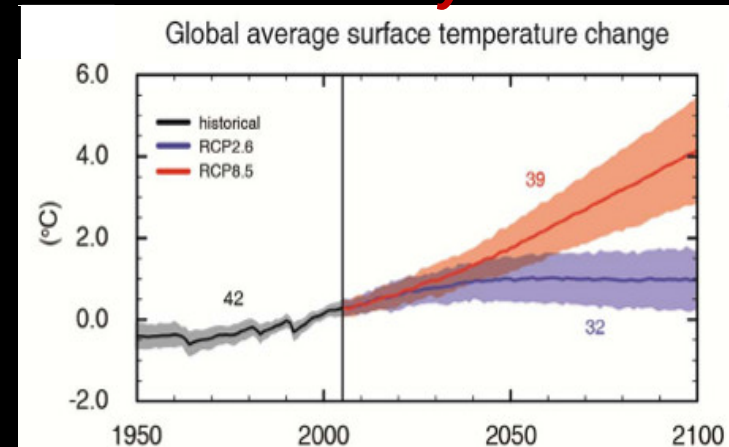


## Seasonal forecast

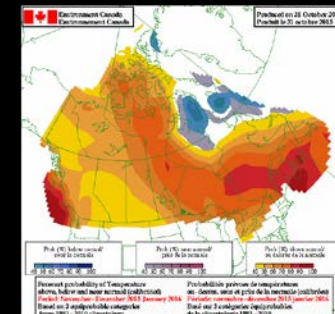
*1-12 months*

## Climate projection

*10-100 years*



- Climate model (atmosphere /ocean/land/sea ice)
- Initial conditions not critical



# Type of Forecast

- Deterministic - memory of initial conditions  
→ Single forecast.
- Probabilistic - loss of memory of initial conditions → Ensemble Forecast.

Atmosphere: ~10 days.

Ice: ~months to year

Ocean – surface: ~months to years

Ocean – deep: ~decades to centuries

# Type of Forecasting Models

- Deterministic - memory of initial conditions.
- Probabilistic - loss of memory of initial conditions. Output in terms of probability.

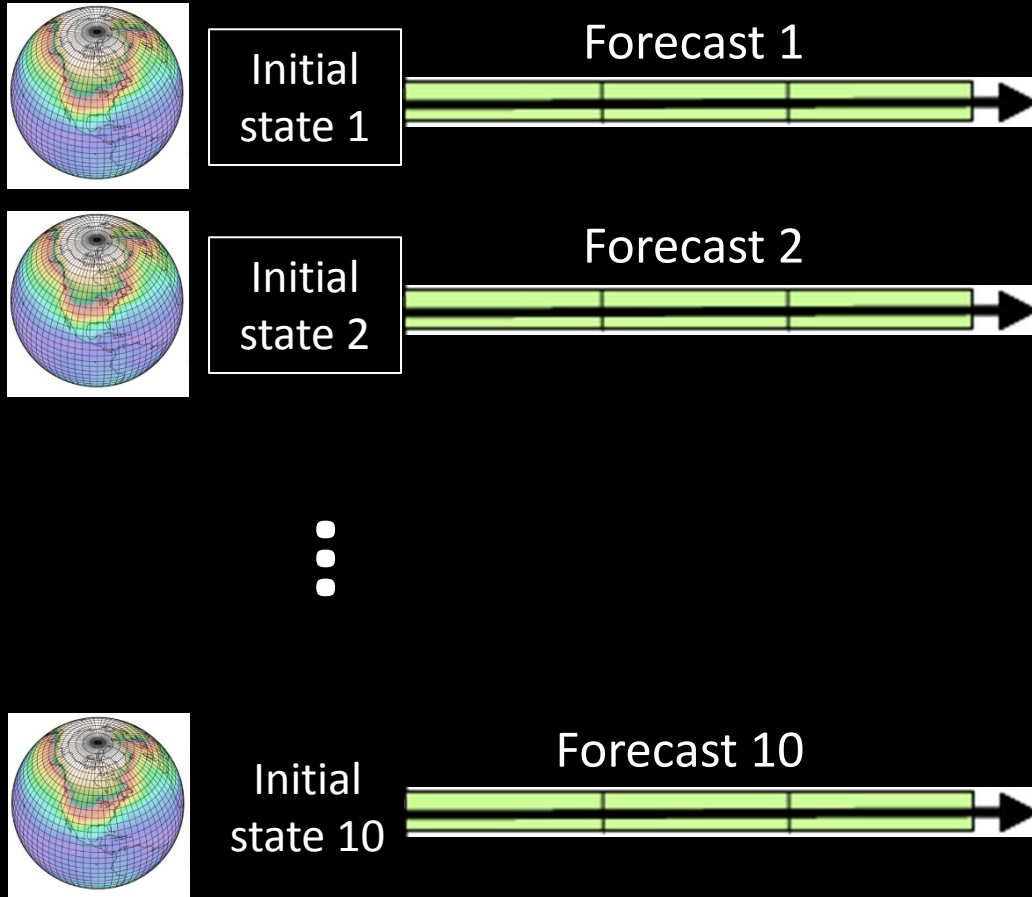
Atmosphere: ~10 days.

Ice: ~months to year

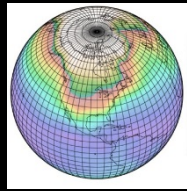
Ocean –surface: ~months to years

Ocean – deep: ~decades to centuries

# Ensemble forecast

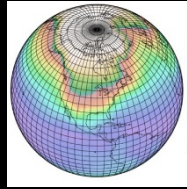


# Ensemble forecast



Initial  
state 1

Forecast 1

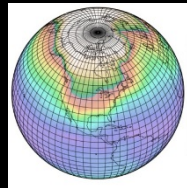


Initial  
state 2

Forecast 2

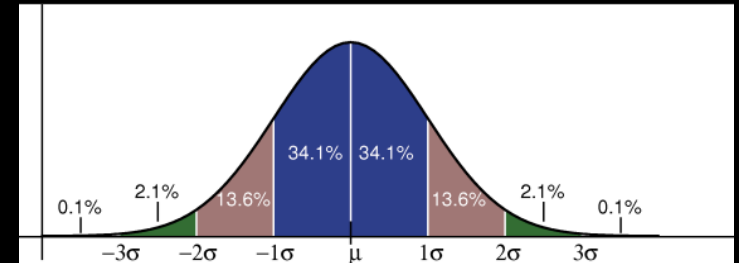


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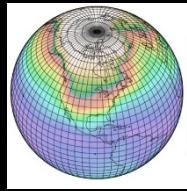
Initial  
state 10

Forecast 10



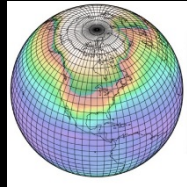
# Ensemble forecast

## Multi-Model Forecasts



Initial  
state 1

Forecast 1

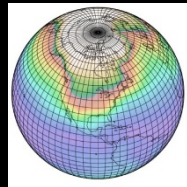


Initial  
state 2

Forecast 2



⋮



Initial  
state 10

Forecast 10

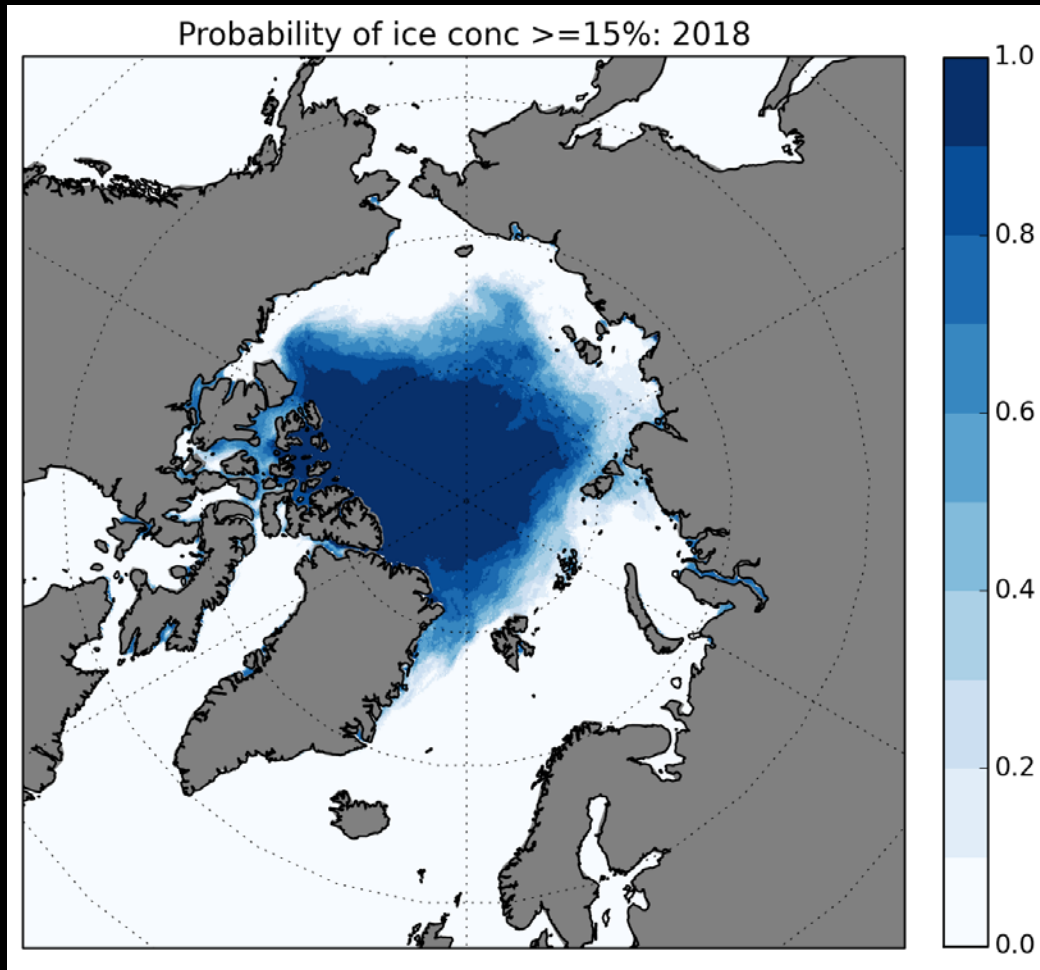




# Why Multi-Model Forecast?

- Different models have different strengths.
- Average of all models is often a better predictor than any of the model alone.
- This is the case for the climate models and also for seasonal forecasting models.

# Seasonal forecasts in terms of probabilities



May 1, 2018



September 2018

# Types of Models

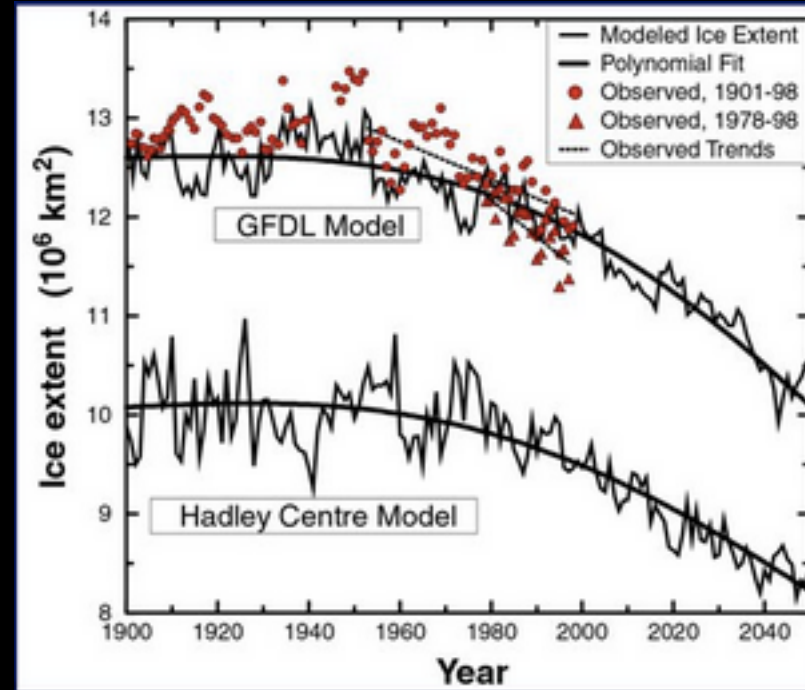
- Heuristics (e.g. persistence).
- Statistical (e.g. SIC, SIT, AO, ocean temperature)
- Dynamical forecasts
  - Forced ice-ocean model (specified atmospheric field)
  - Fully coupled models (specified boundary conditions)

# Initializations

- Model is run for several years to allow for the surface ocean and ice to adjust
- Model is run with or without assimilation
- Model is run in free mode for the forecast period
  - Forced ice-ocean models: with specified atmospheric fields
  - Fully coupled models: with specified boundary conditions

# Skill

- Bias (low or high)
- Root mean square error

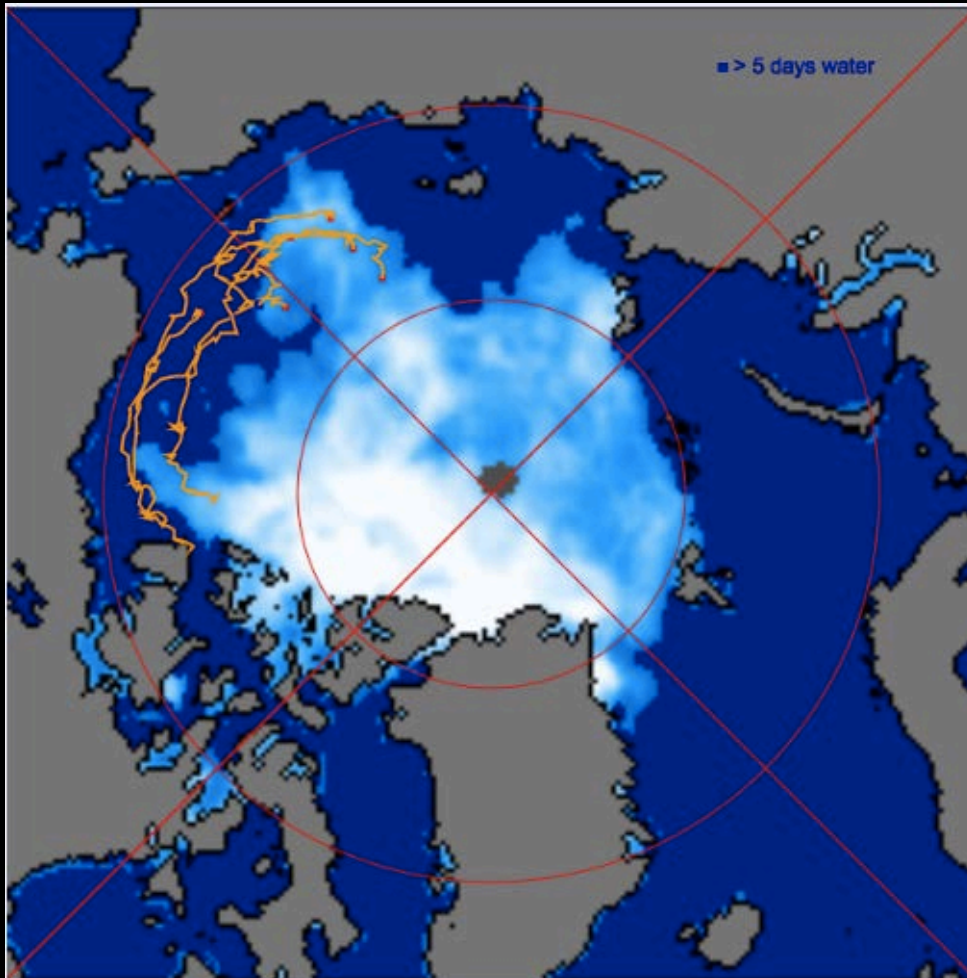


# Source of Predictability

- Persistence + advection
- Atmosphere (e.g. NAO)
- Ocean (heat transport)
- Reemergence
- Pre-conditioning.
- Radiative forcing

# Persistence + Advection

## Ice Volume back trajectories



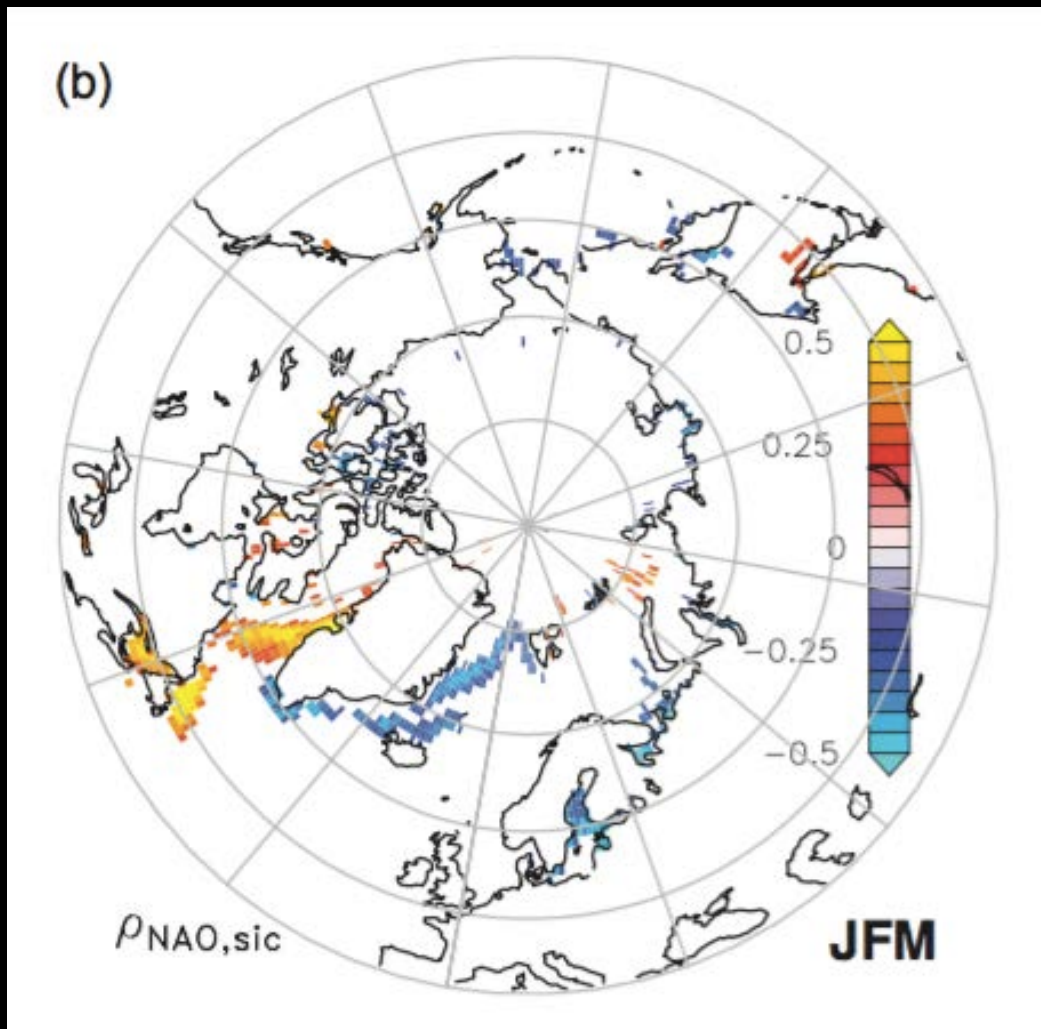
September 2009



September 2010

# Atmosphere

## North Atlantic Oscillation

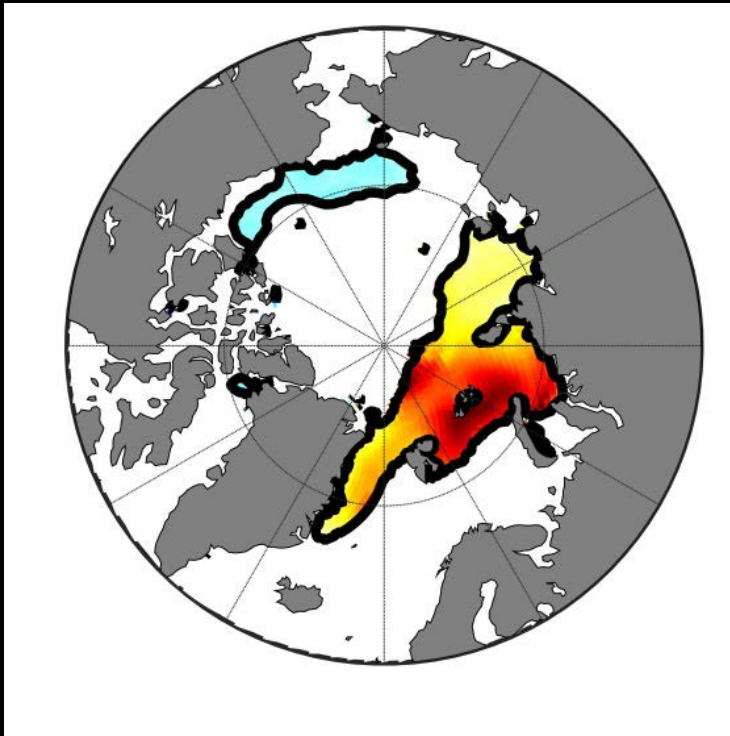


Dipole between  
Greenland/Barents seas  
and Labrador Sea

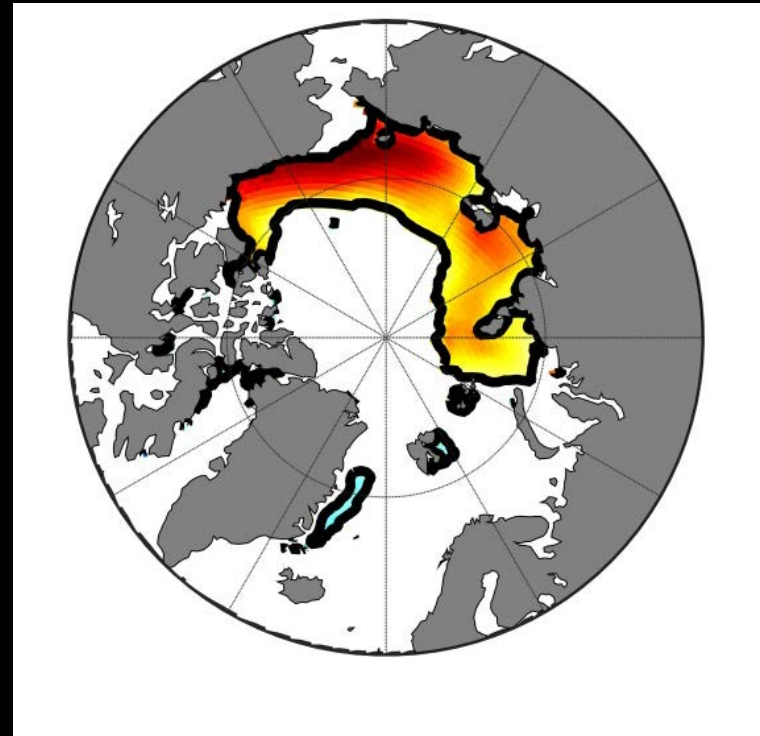


# Ocean

## Ocean Heat Transport (OHT)



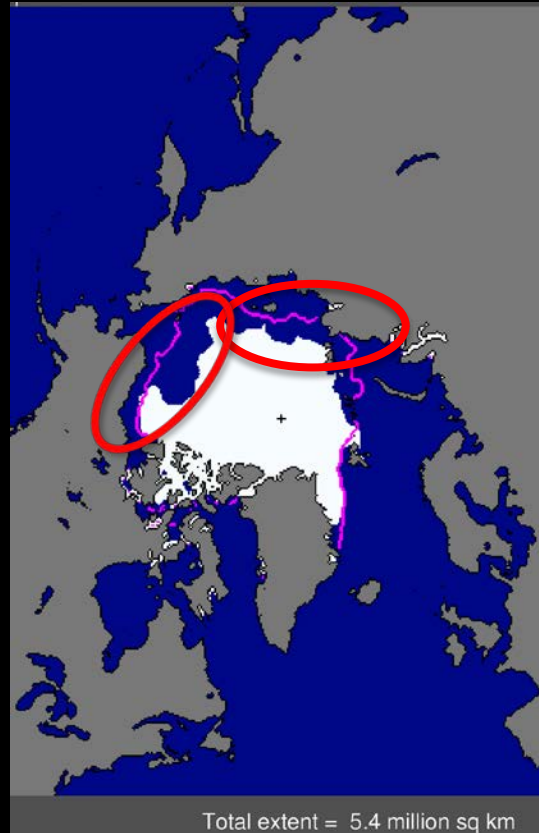
Barents Sea OHT



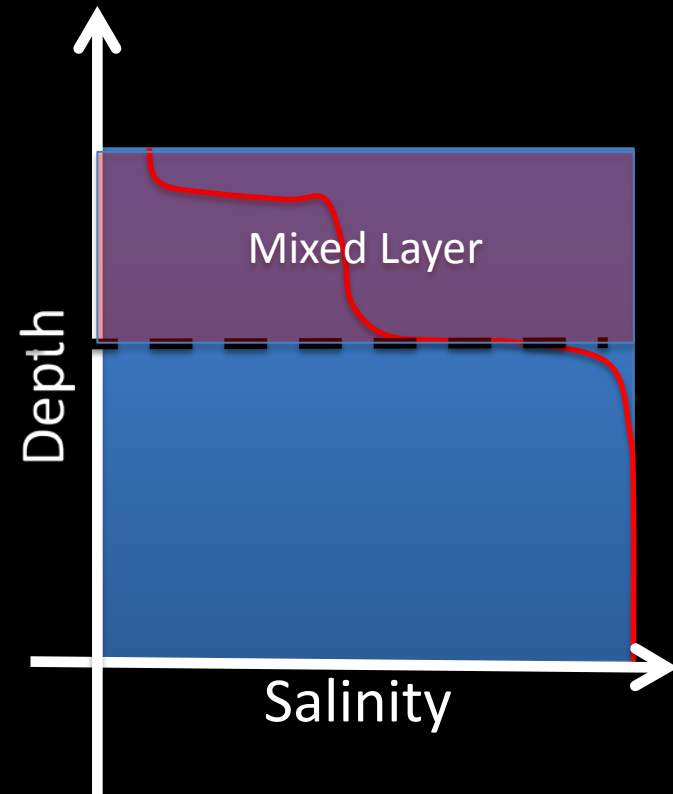
Bering Strait OHT

# Reemergence

Growth to Melt  
Ice Volume



Melt to Growth  
Ocean

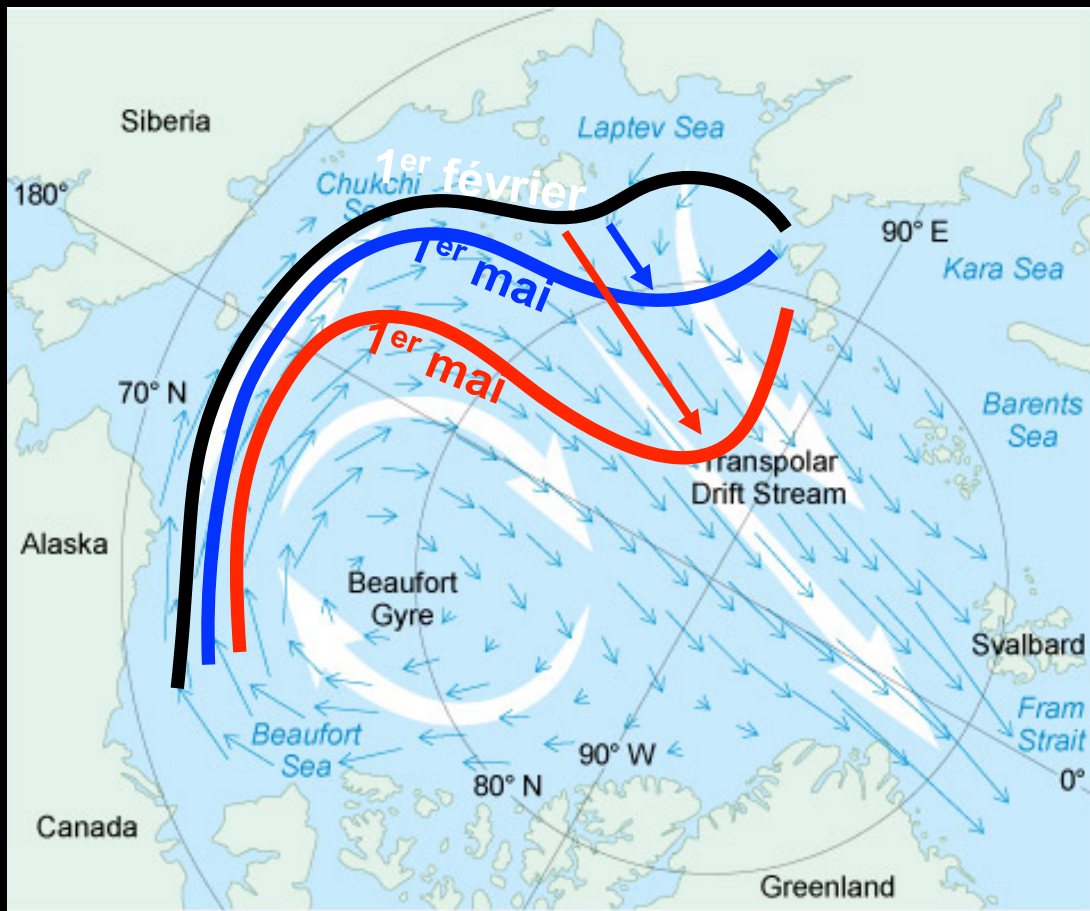


January → April  
December → June  
November → July

May → December  
June → November  
July → October

# Winter Preconditioning

# Coastal Divergence



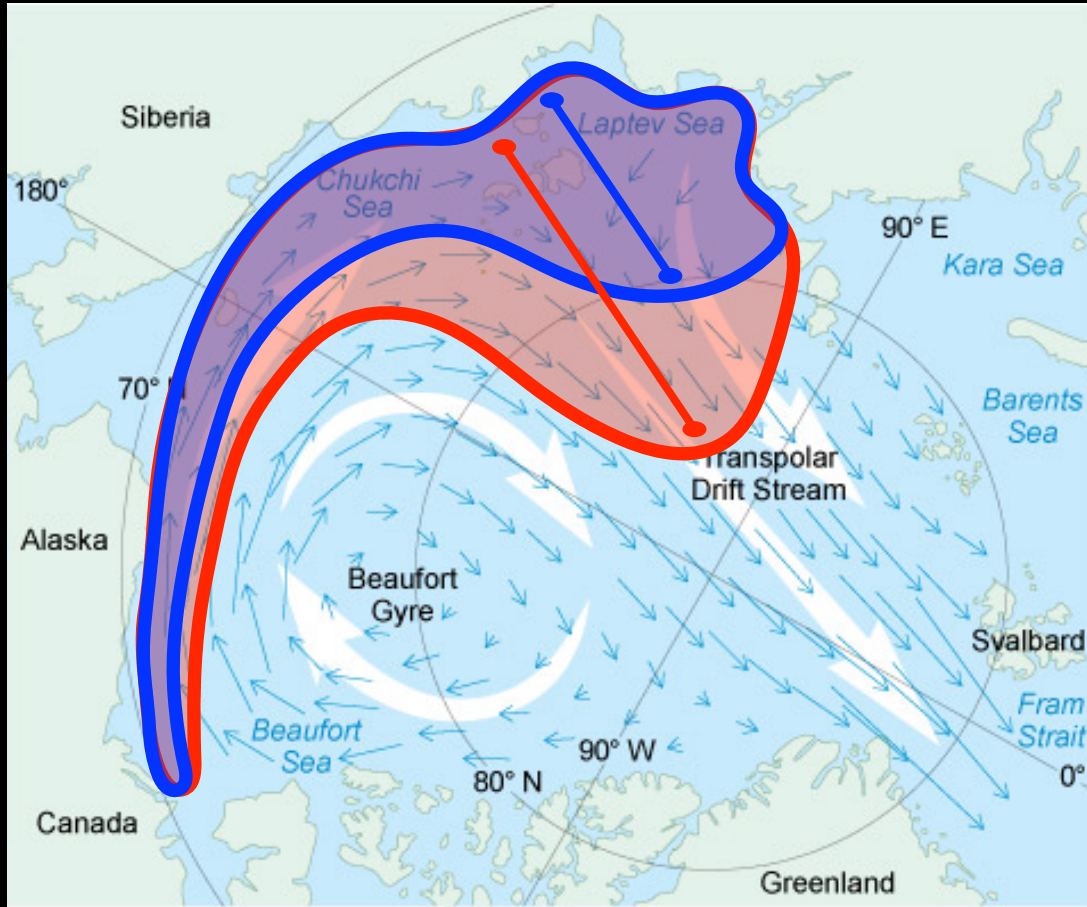
Mark Brandon, adapted from MacDonald et al



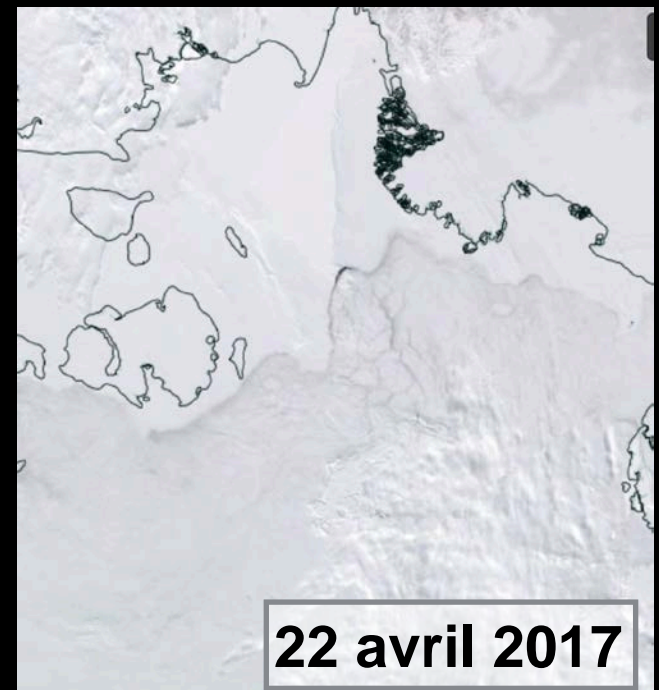
In agreement with Chevalier and Salas-Melia, 2012



# Coastal Divergence

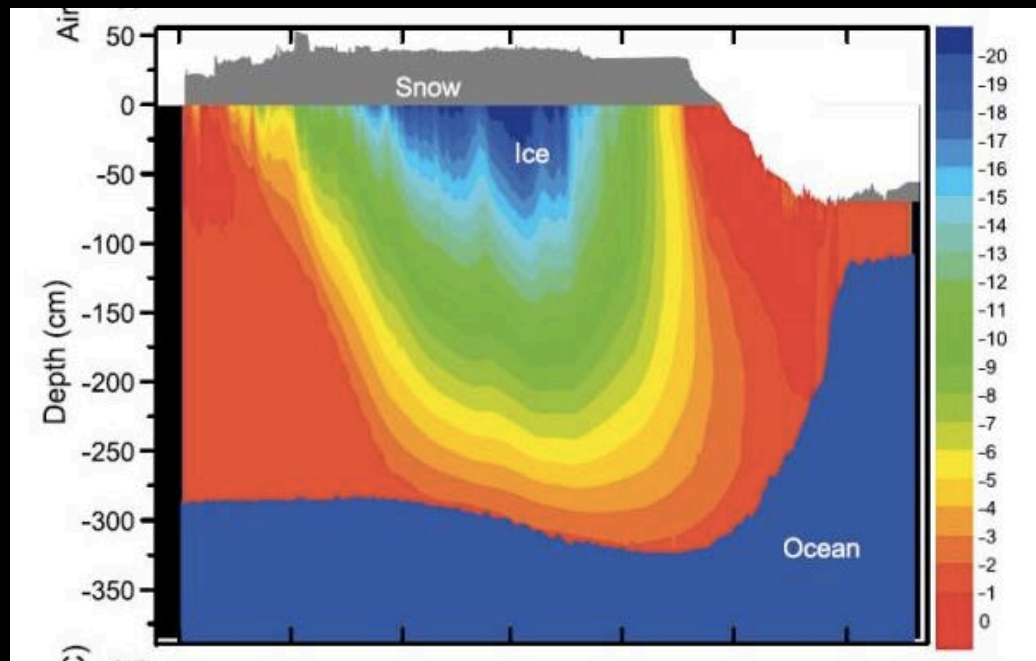


Mark Brandon, adapted from MacDonald et al



# Radiative Forcing

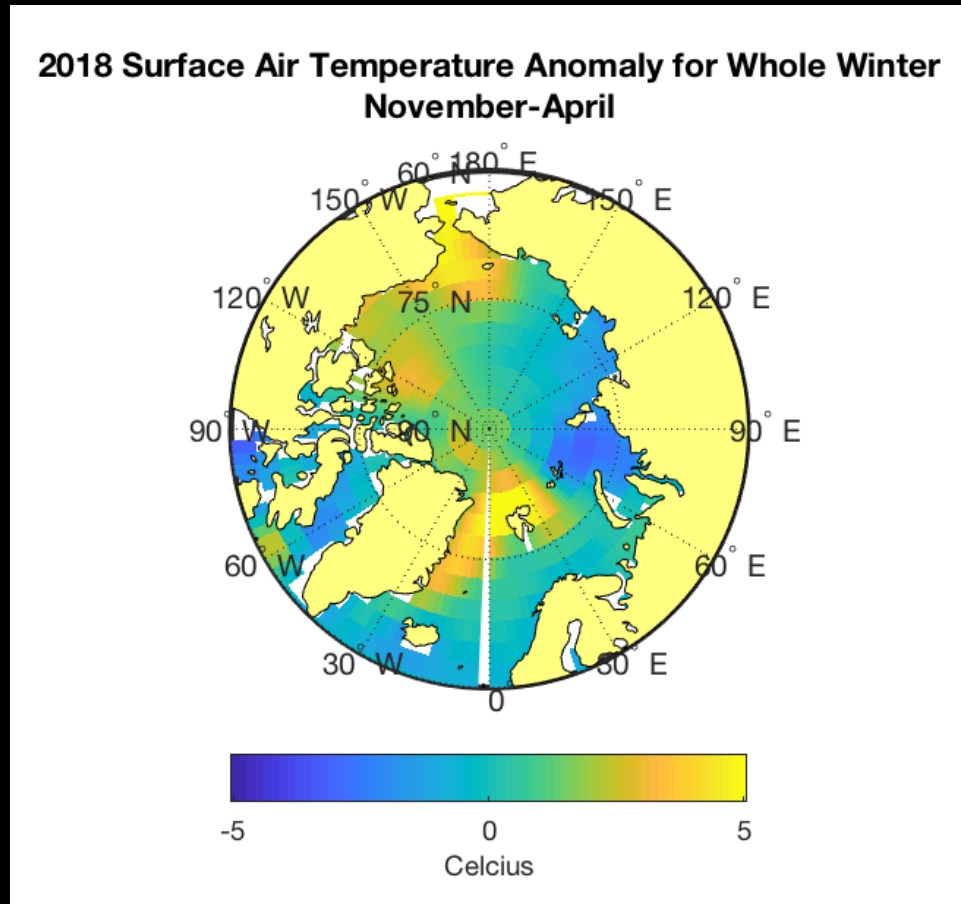
- Warm air and moisture advection → link with melt onset (amplified by ice-albedo feedback)



1 day in June == 10 days in September!

# Consensus Forecast

# Surface Air Temperature Anomaly



Nov-April 2018



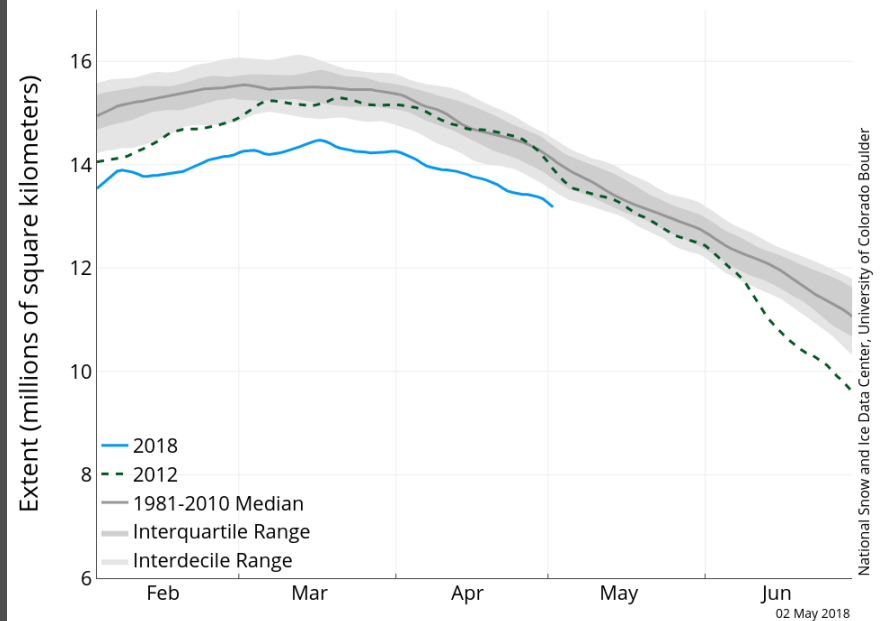
# Sea Ice Extent - May

Sea Ice Extent, 02 May 2018



National Snow and Ice Data Center, University of Colorado Boulder

Arctic Sea Ice Extent  
(Area of ocean with at least 15% sea ice)



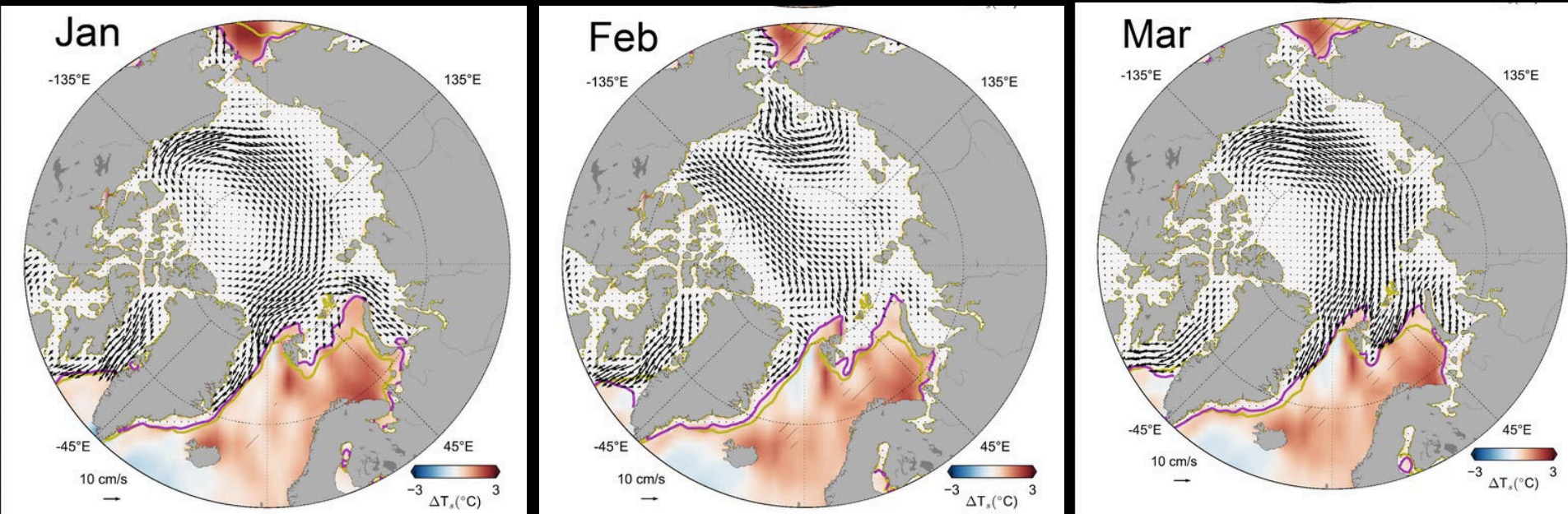
National Snow and Ice Data Center, University of Colorado Boulder

NSIDC

NSIDC

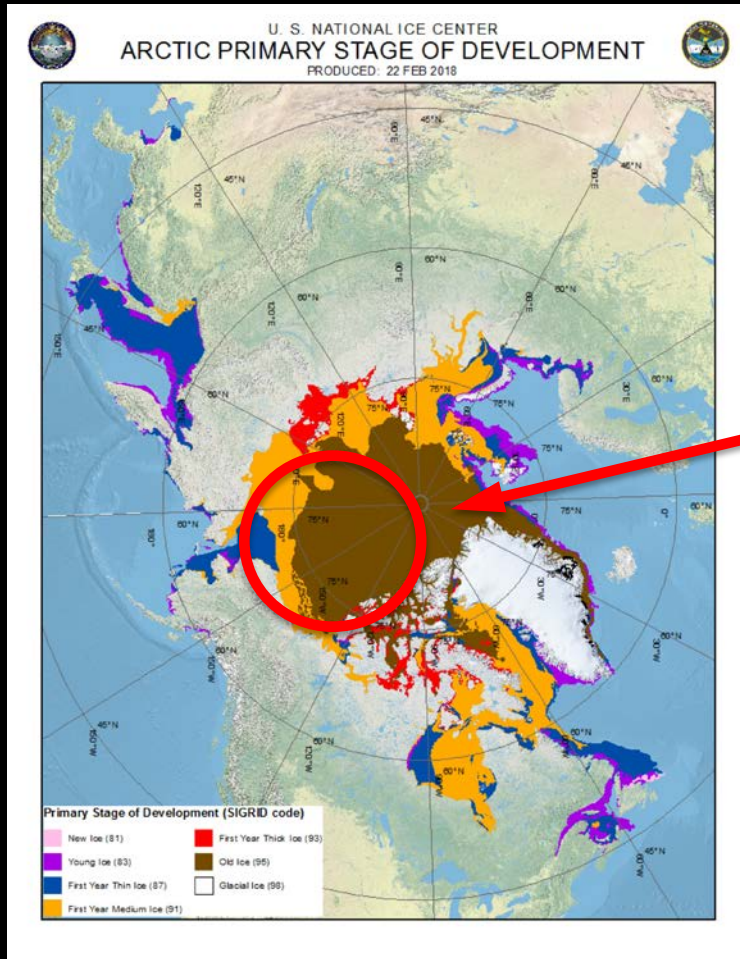
Adrienne Tivy, CIS

# Average Sea Ice Motion

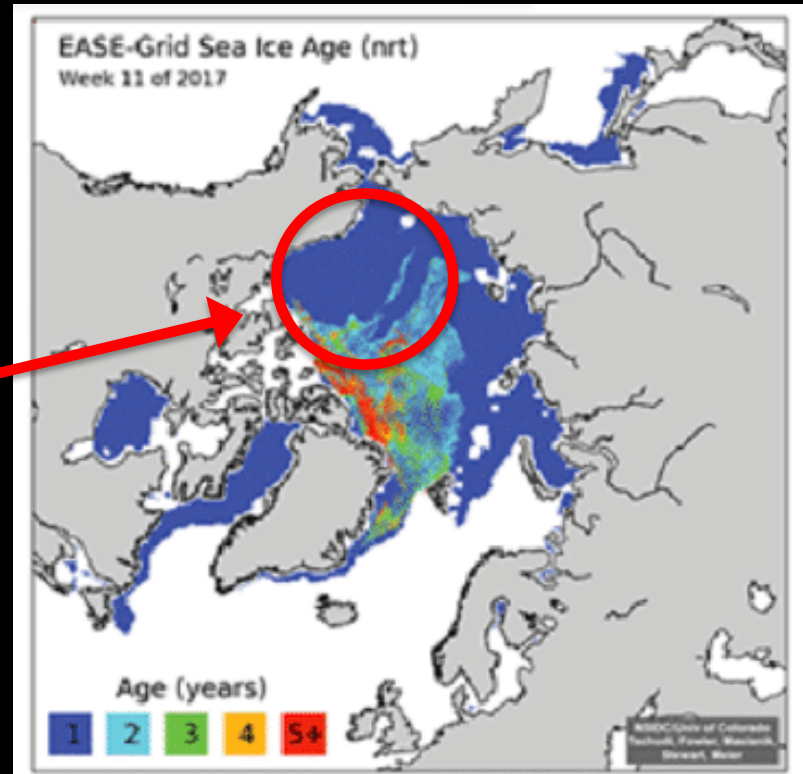


# Multi-year Ice

Mid-winter 2018 (MYI > 4/10 = brown)



Mid-winter 2017



University of Colorado – ice age product

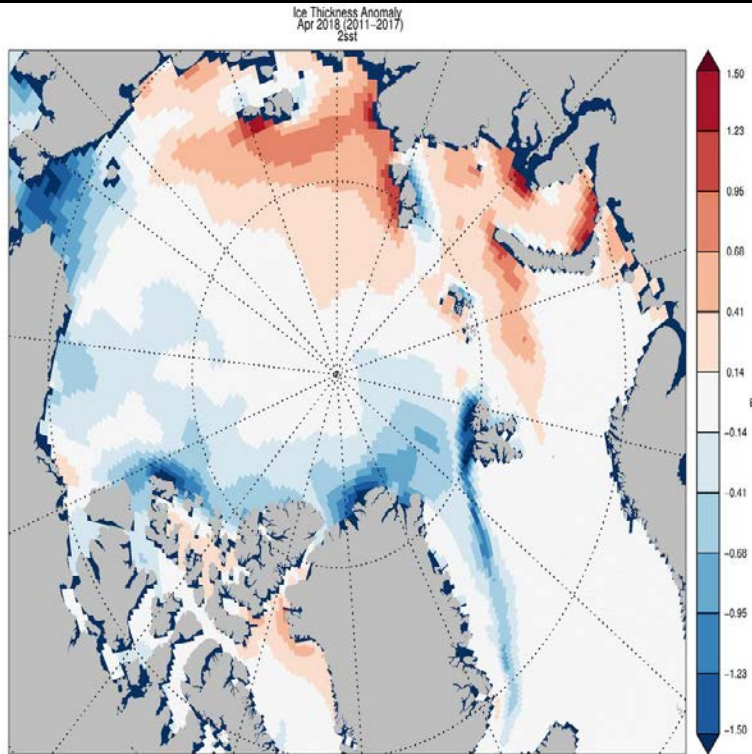
NIC – ice analysis

\* some recovery of MYI in the Beaufort Sea

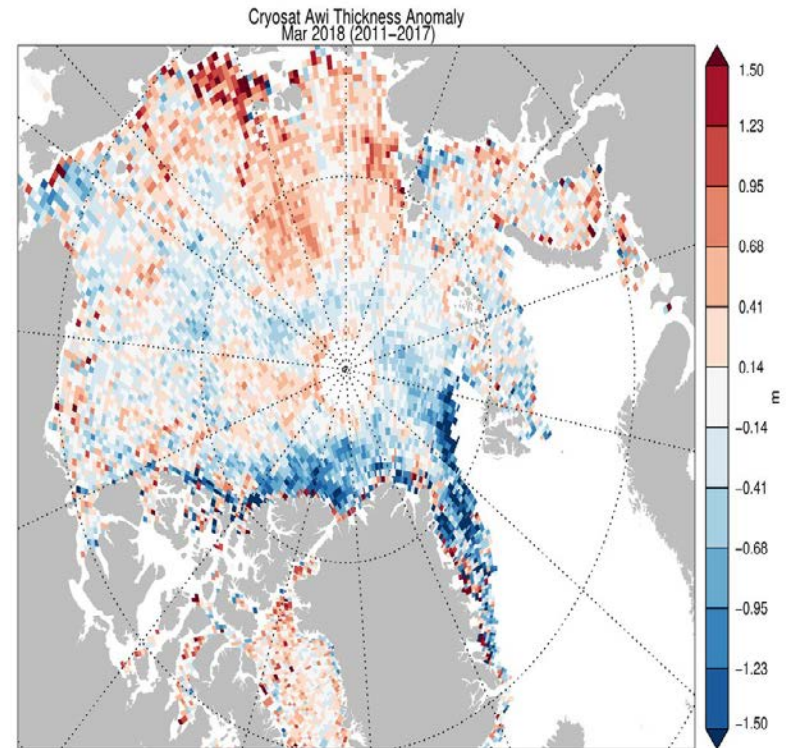
Adrienne Tivy, CIS



# Ice Thickness Anomalies April 2018 (2011-2017)



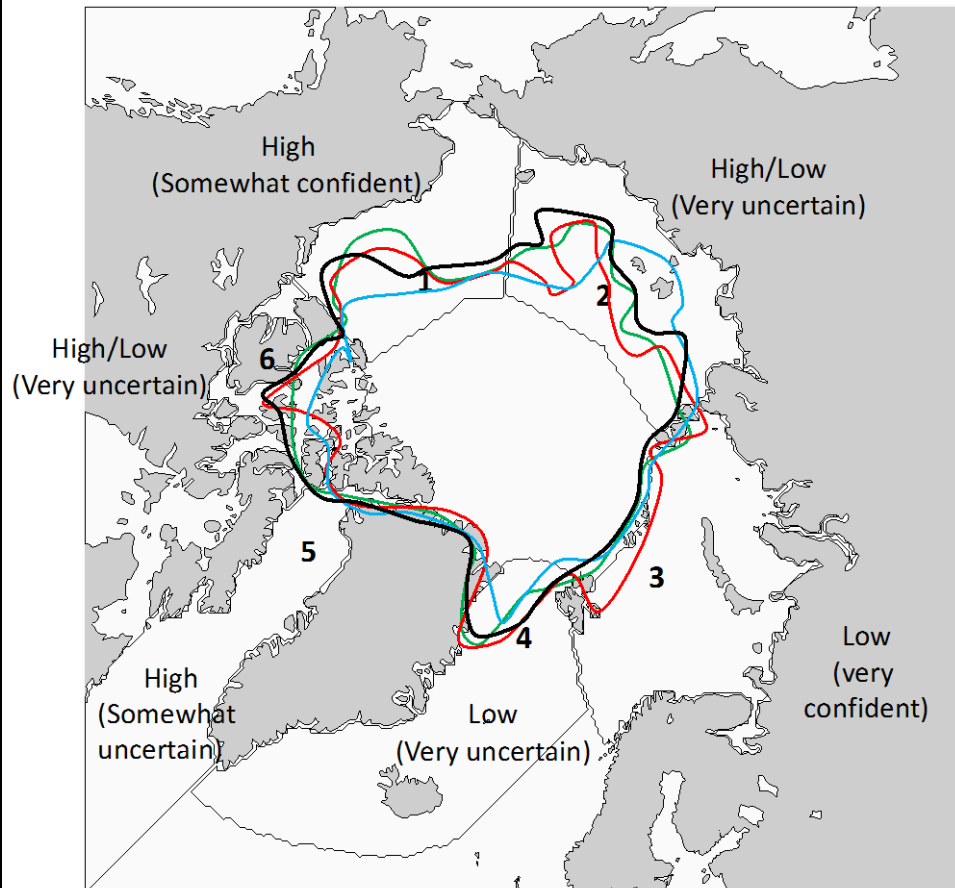
PIOMAS



CryoSat 2, AWI

# Consensus Forecast Exercise

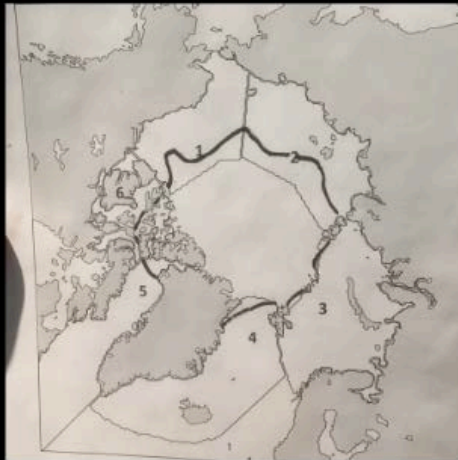
## PPW-2018



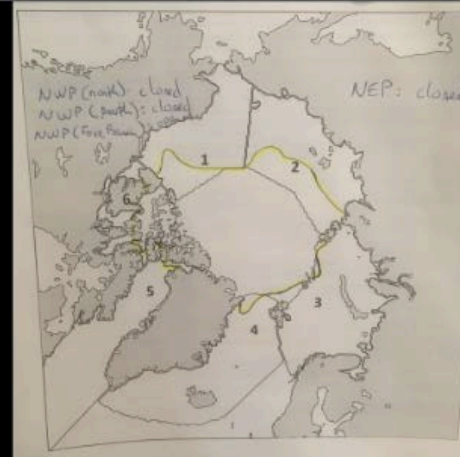
High//Low: relative to regional median over 2009-2017.

1) Beaufort/Chukchi, 2) Laptev/East Siberian, 3) Barents/Kara,  
4) Greenland Sea, 5) Baffin Bay, 6) Canadian Arctic Archipelago

# Consensus Expert Forecasts



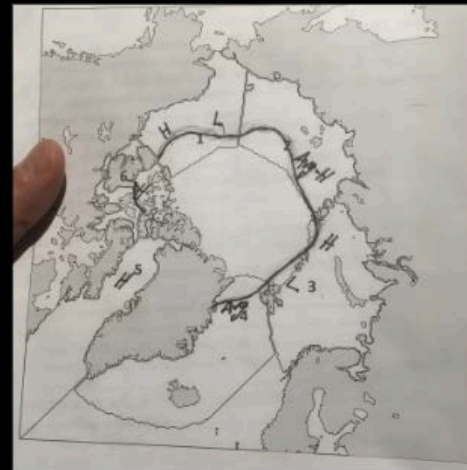
Group 1



Group 2



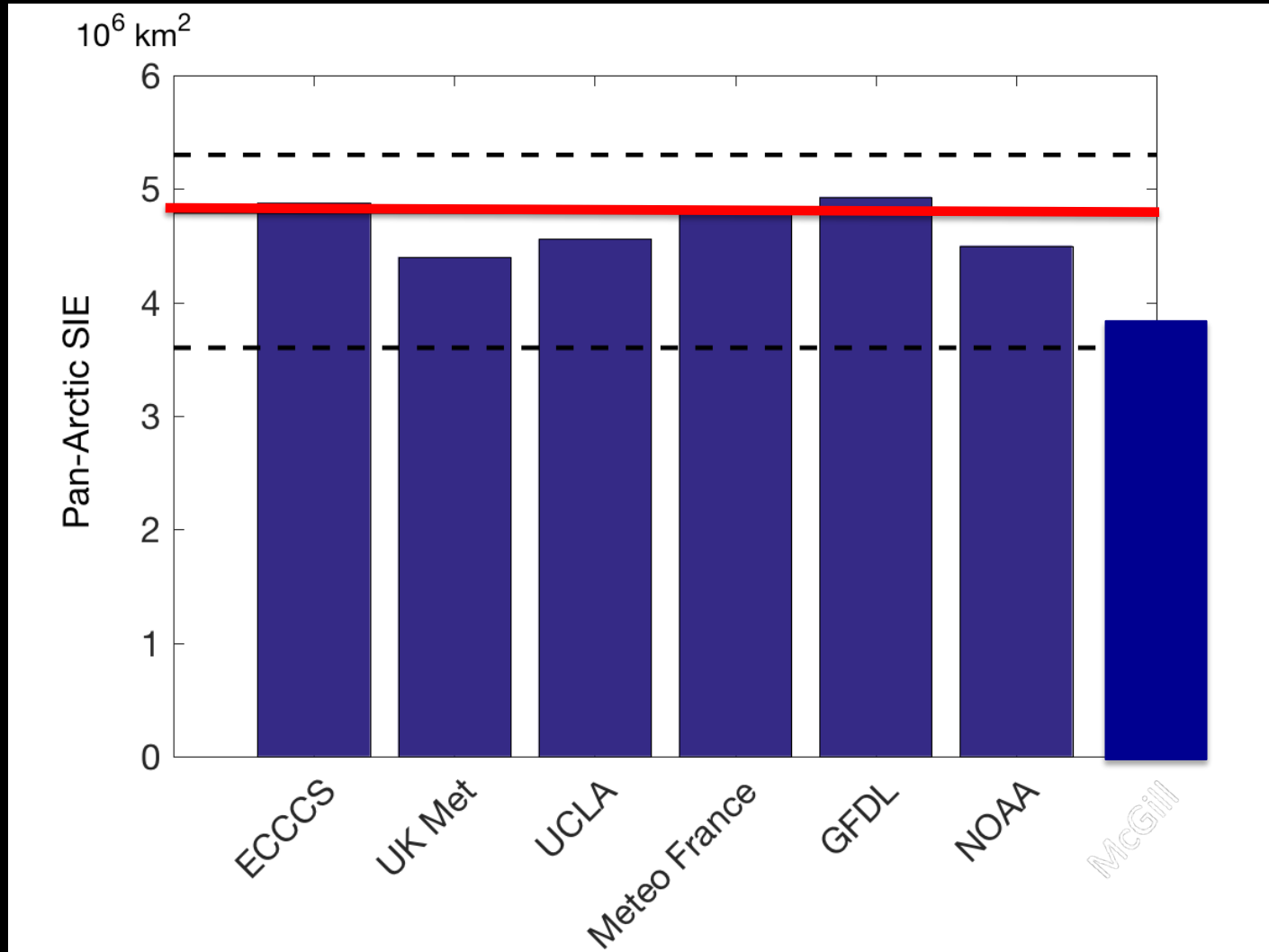
Group3



Group 4

# Pan Arctic SIE

4.4 – 4.9



END of TALK