

# New histories of Antarctic sea ice from ice cores

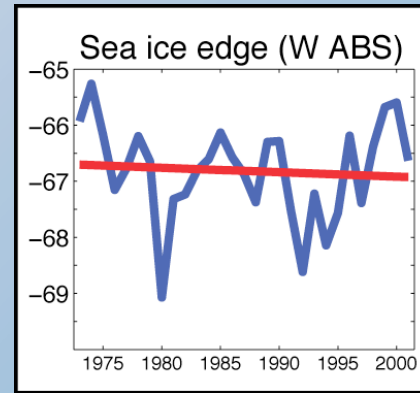
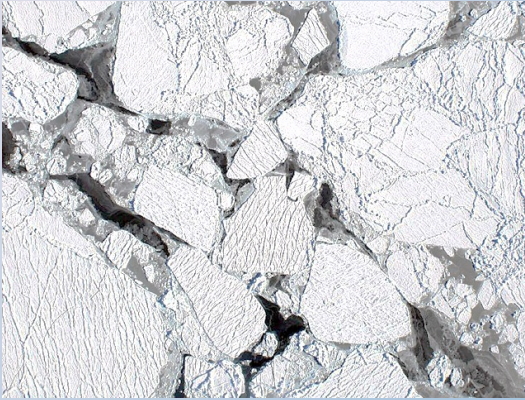
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*6th AMOMFW, June 2011, Hobart*

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Background credit: NASA

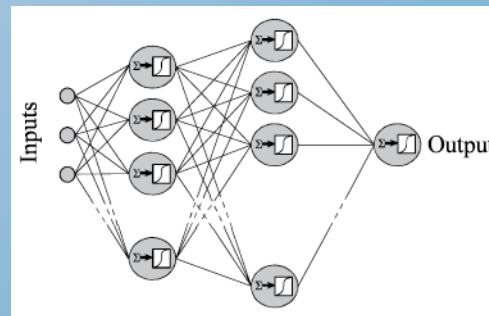
# Paleoclimate: Reconstructing X from Y



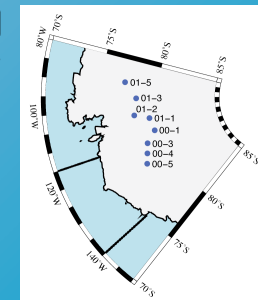
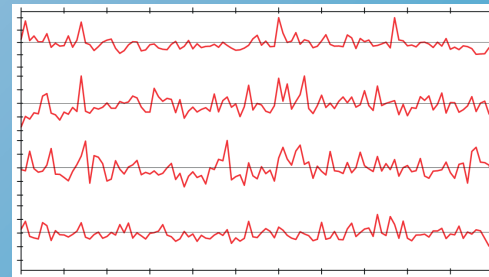
Predicted

Observed

Prediction

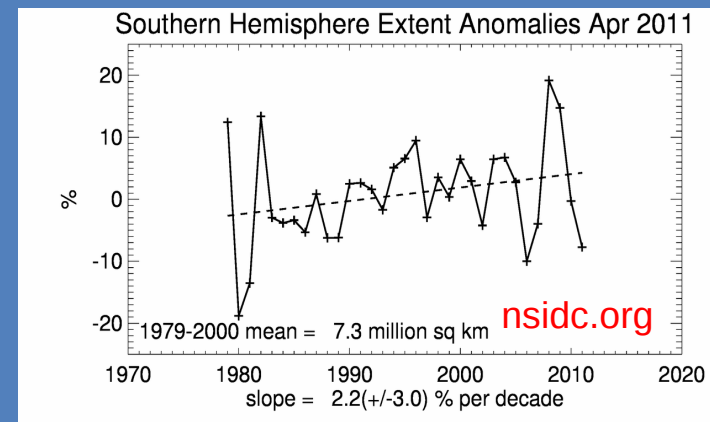


Calibration



# Motivation

Antarctic sea ice matters  
Direct records are (very) short  
Science benefits from new methods



# Long-term Sea-ice Records

Surface observations are limited/difficult

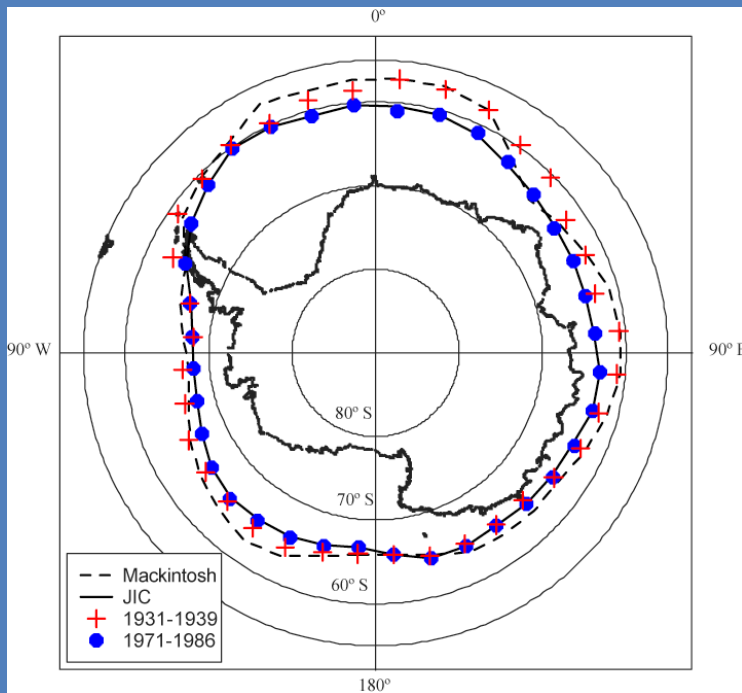
Remote sensing is essential for complete, comprehensive observations

Satellite-based data start in 1973

We really need longer records *and* we need to understand their uncertainty

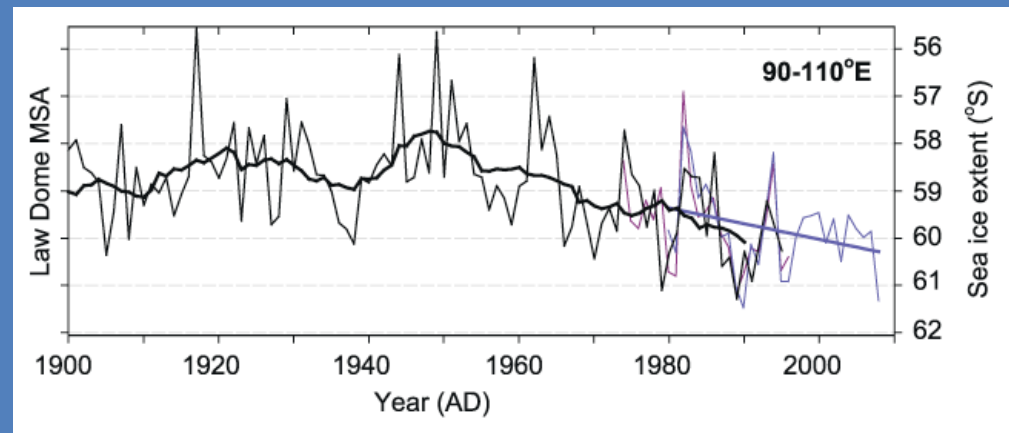
# Two examples

## Whaling Records December



Modified from de la  
Mare, 2009

## Law Dome MSA Maximum extent



Abram et al 2010; Curran et al 2003

# Ice Cores and Climate

Aerosol chemistry (most useful)

Seasalt

Sulfur species: MSA, nssSO<sub>4</sub>

Less useful for sea ice

Trapped air bubbles (CO<sub>2</sub>, CH<sub>4</sub>)

Isotopes: Oxygen, hydrogen, N, Ar, etc.

Melt layers

# Climate from Ice Cores

Linear correlation with process knowledge

But there are caveats:

What are controls on proxies?

Where are proxies valid?

When are they valid?

What about nonlinearities?

Can we let the computer do more work?

# Artificial Neural Networks (ANNs)

A tool modeled on biology for finding nonlinear relationships  
Trade process knowledge for flexibility  
Focus on the results not the physics

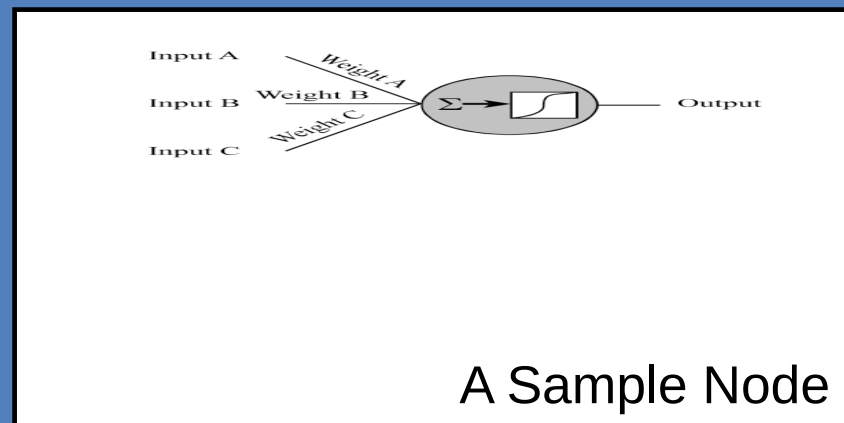


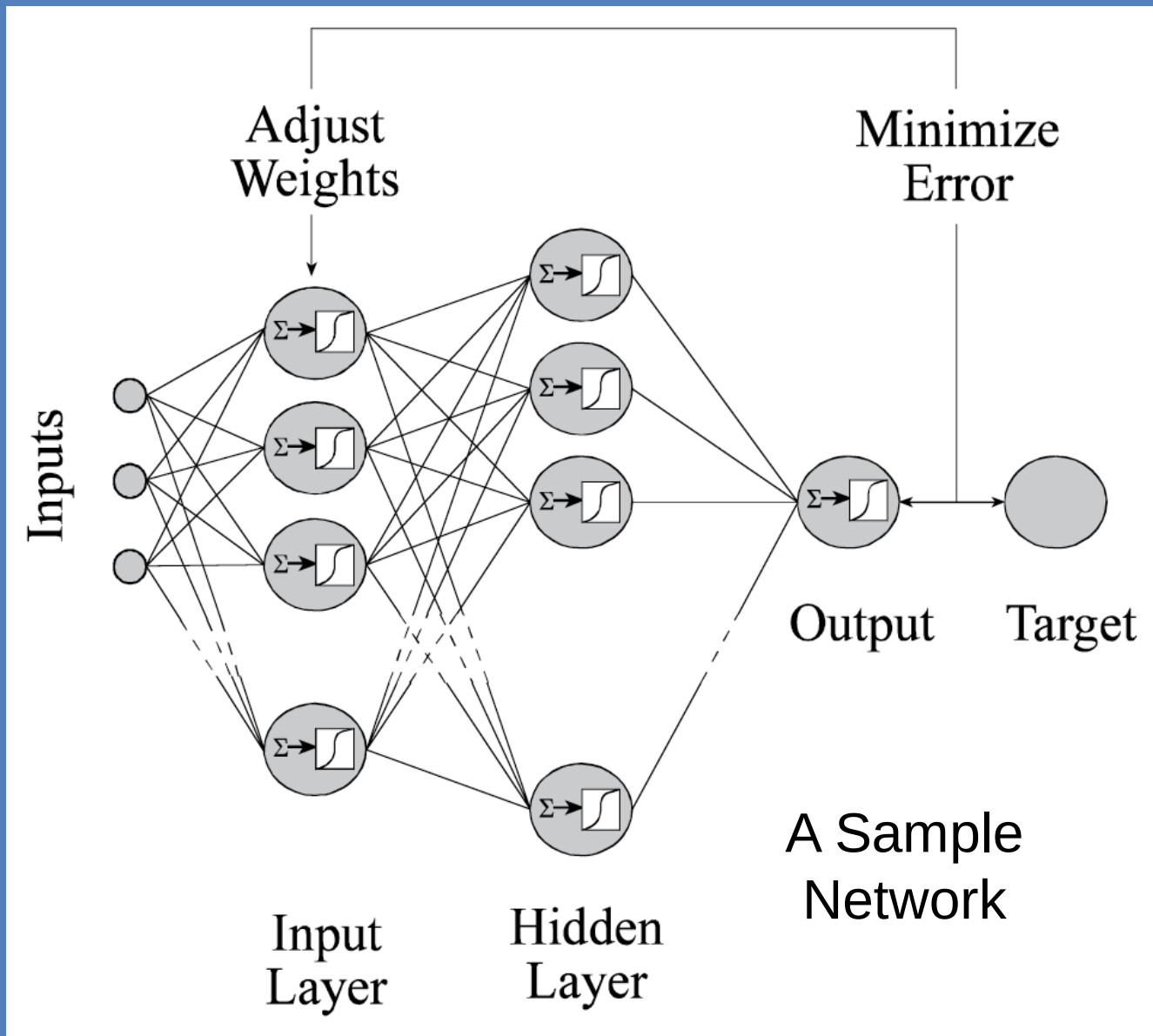
# Artificial Neurons

ANNs start with simple “neurons”

Inputs individually weighted by node

Activation function uses sum of inputs to produce node output





# Applying ANNs

Bad results easy, good results less so  
Lots of knobs (parameters)

Sensitive to initial conditions

Try different predictors, parameters, data

Need to try **many** versions (ensembles)  
Adds confidence in the results

# Experiments

(1) Specific sea ice variable (from HadISST)

What? Sea ice edge

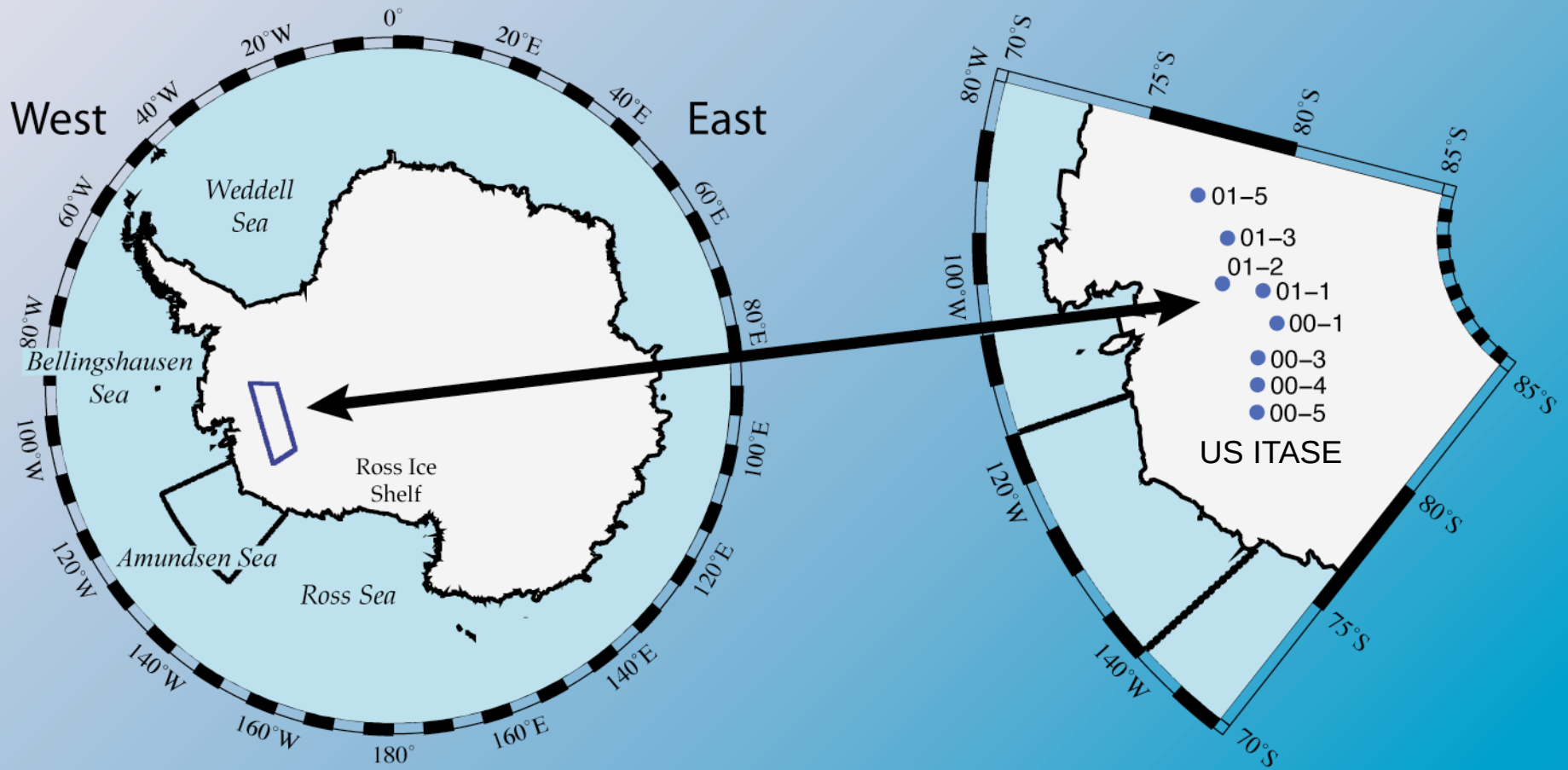
Where? Western Amundsen Sea

When? Annual average

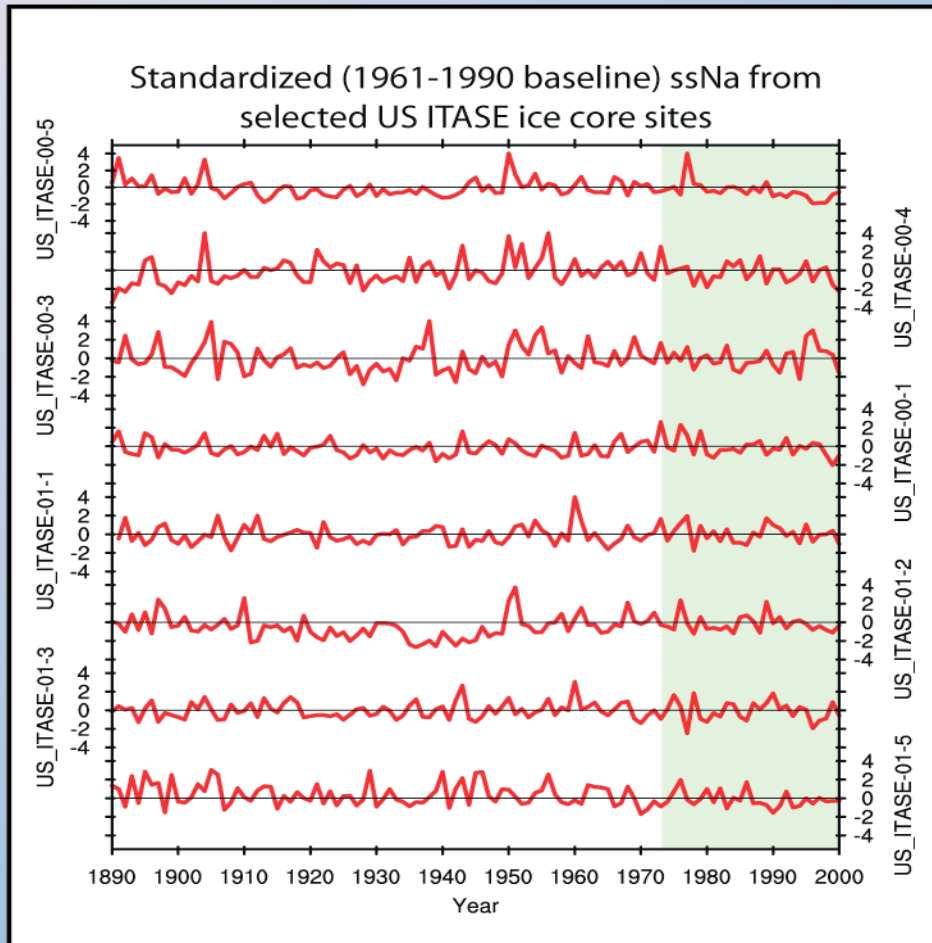
(2) Specific ice core sites and variable(s)

(3) Particular time period (e.g., 1890-2000)

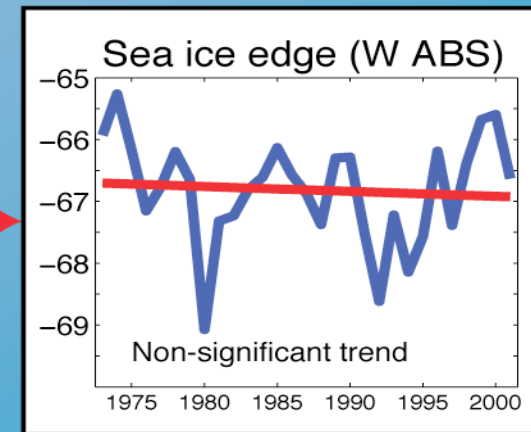
# Ice Core Locations and Sea Ice Region



# Ice Cores to Sea Ice Edge



Neural Network



HadISST  
Rayner et al 2003

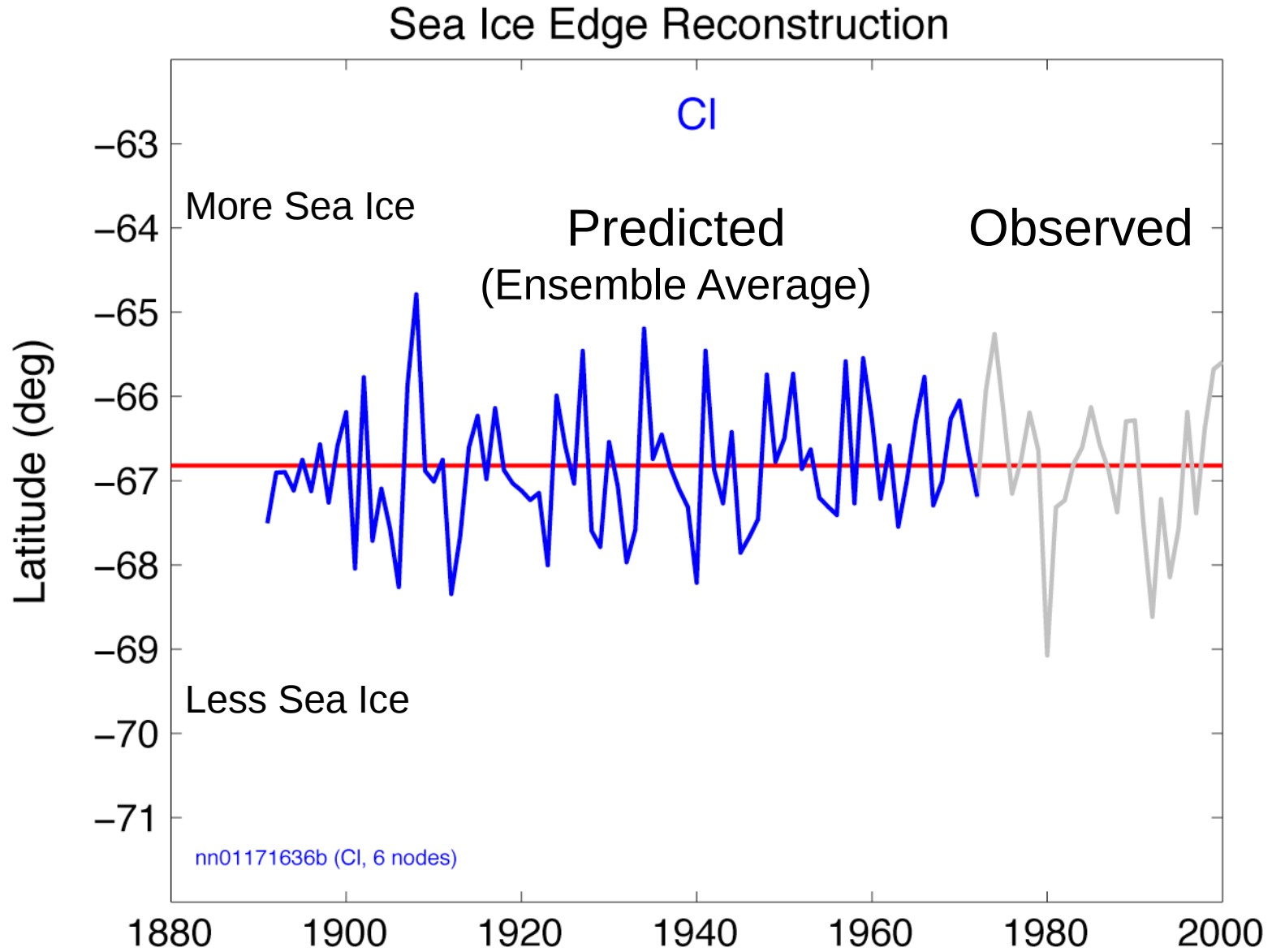
# Sea ice reconstruction

Train neural network ensemble(s)

Apply older ice-core data to trained ANNs

Create an ensemble average and develop confidence metrics using ensemble results

# Preliminary Results!





# Assessing confidence

Other datasets

- Very limited observations

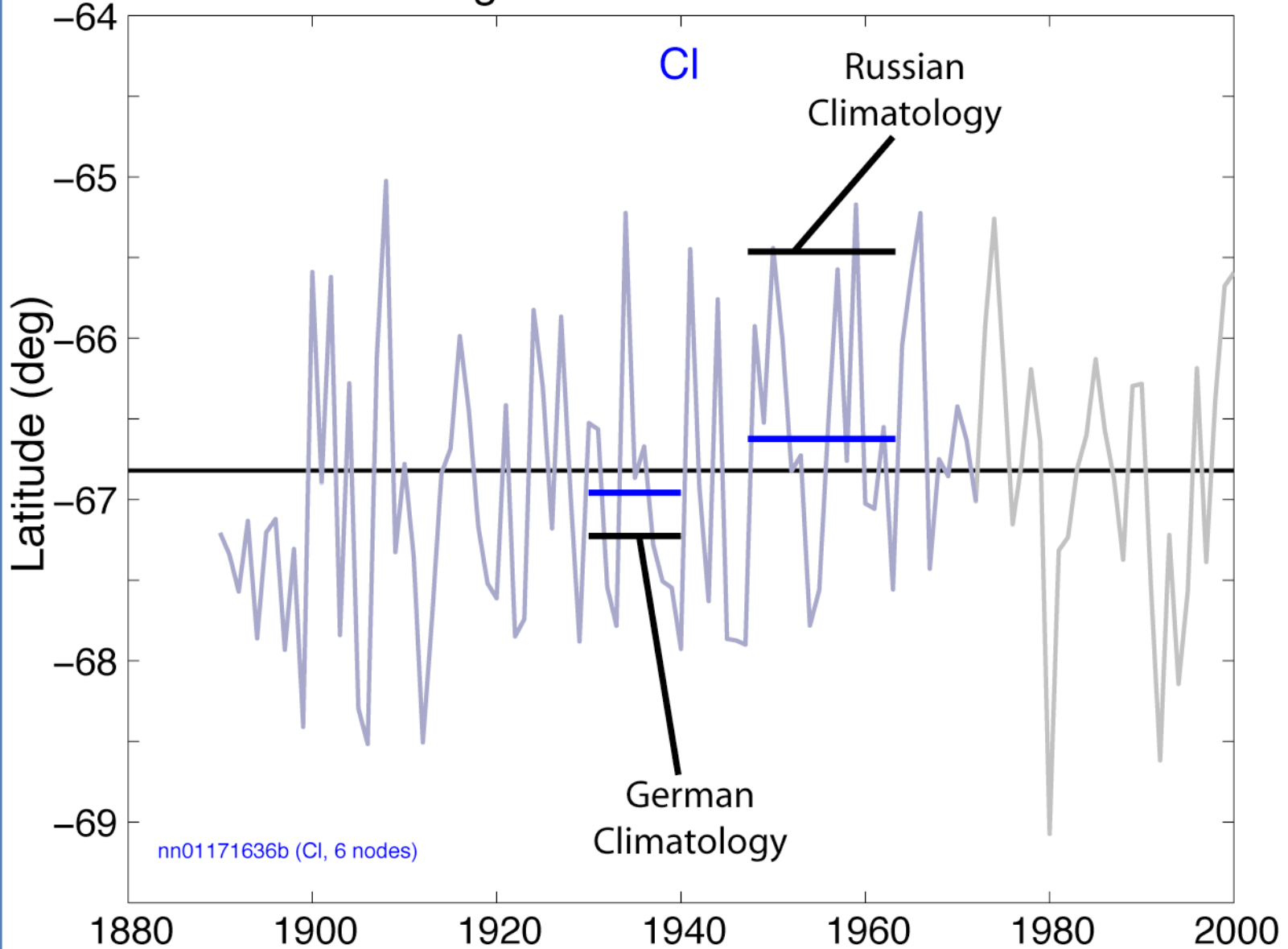
- Other reconstructions

- Challenging to match in time/space

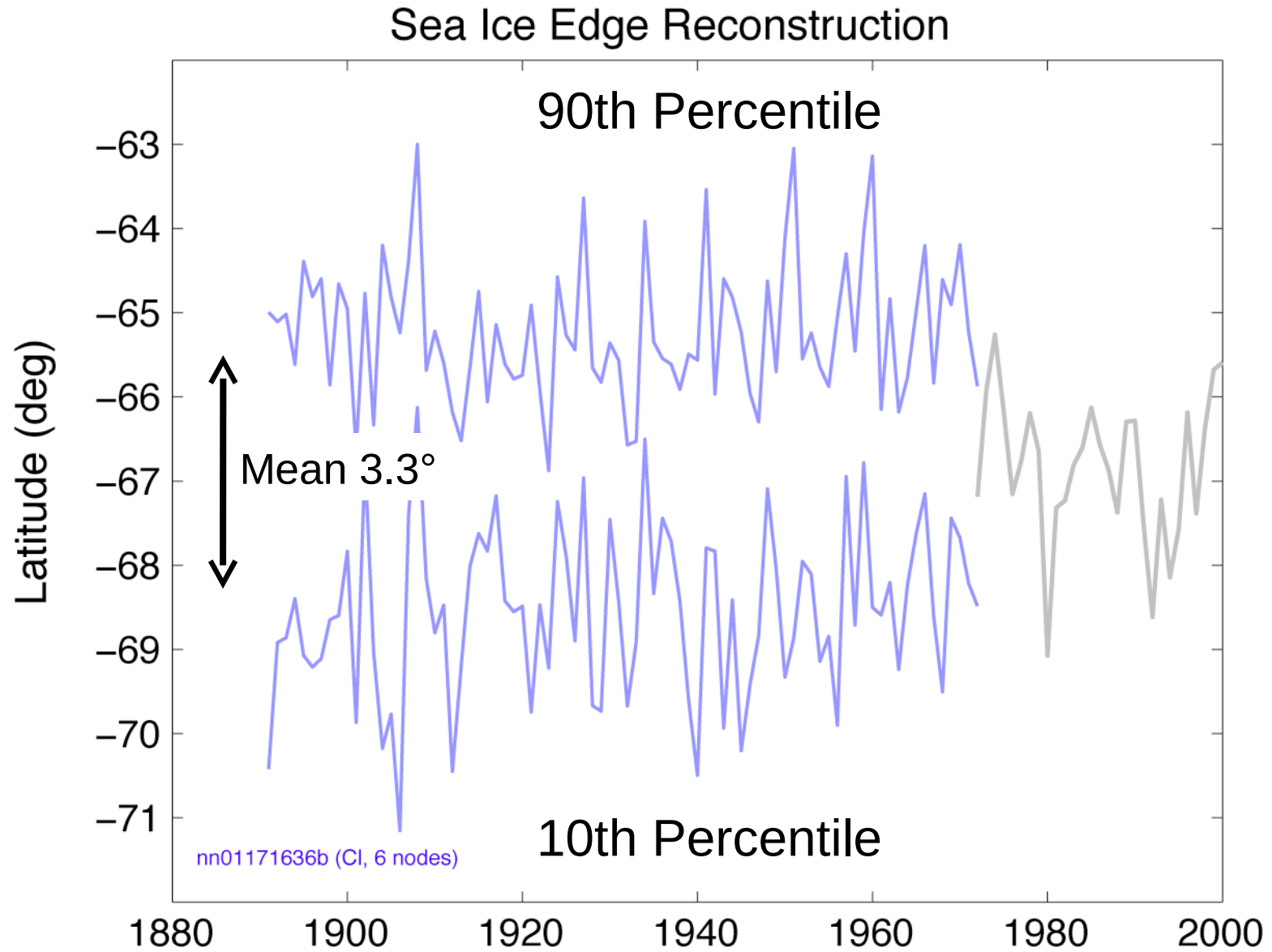
Statistical skill metrics

# Preliminary Results!

## Sea Ice Edge Reconstructions vs HadISST

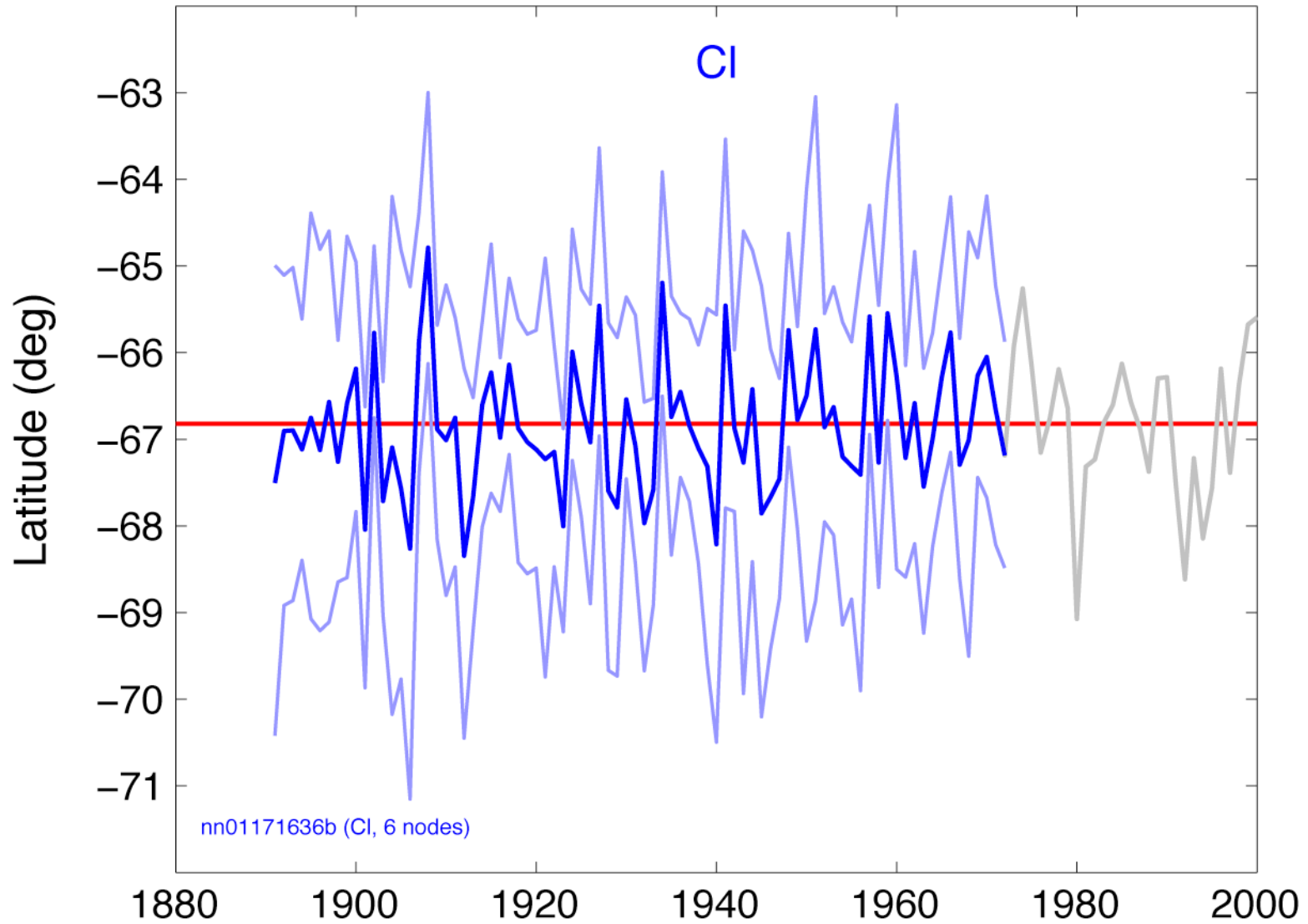


# Preliminary Results!



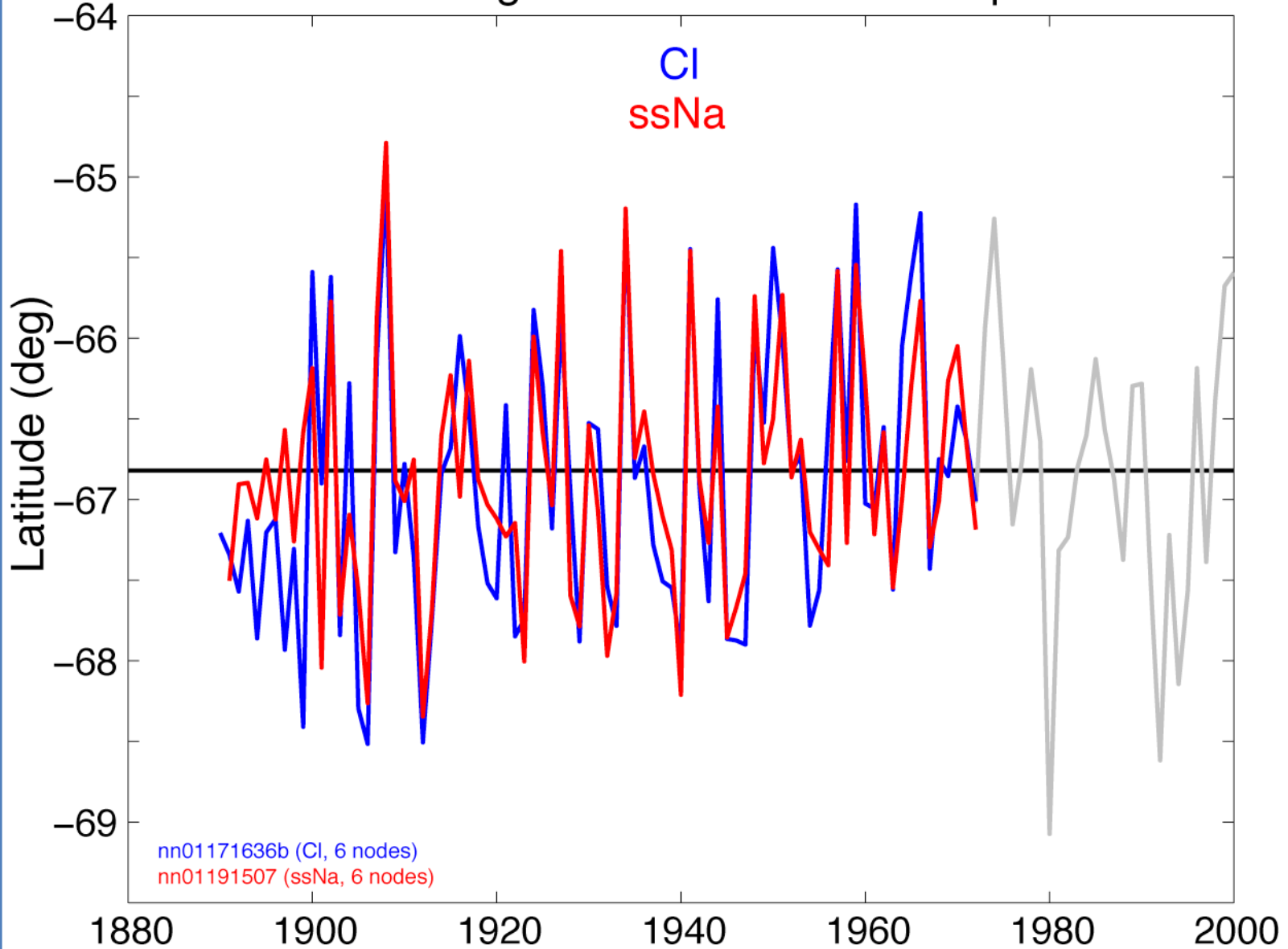
# Preliminary Results!

## Sea Ice Edge Reconstruction



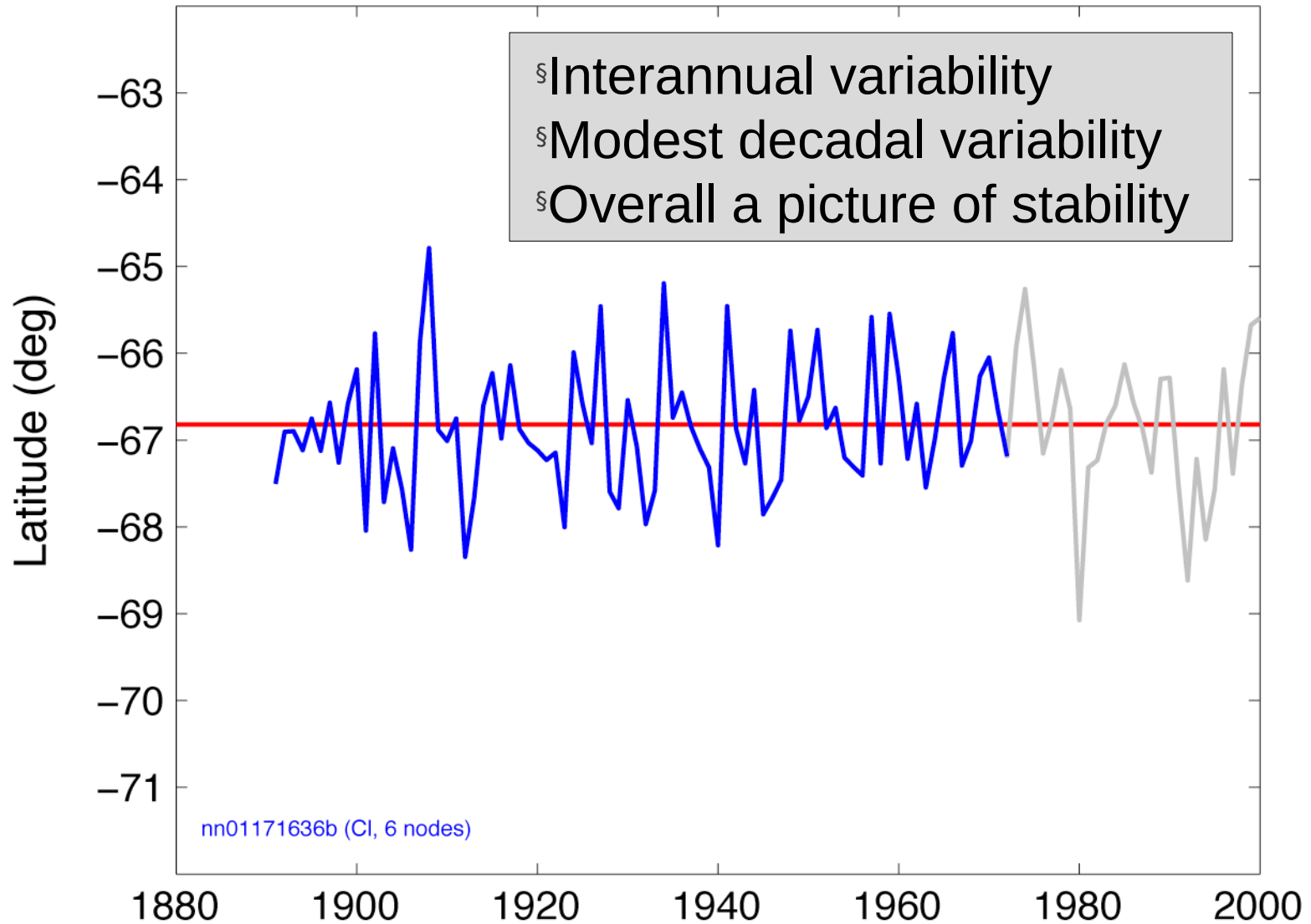
# Preliminary Results!

## Sea Ice Edge Reconstructions Compared



# Preliminary Results!

## Sea Ice Edge Reconstruction



# Conclusions

- n Neural networks can create new histories of Antarctic sea ice from ice cores
- n Different predictors produce similar histories
- n Developing trust in these histories is an ongoing process
- n Many more topics left to explore in this area



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