Multidecadal MOC Variability

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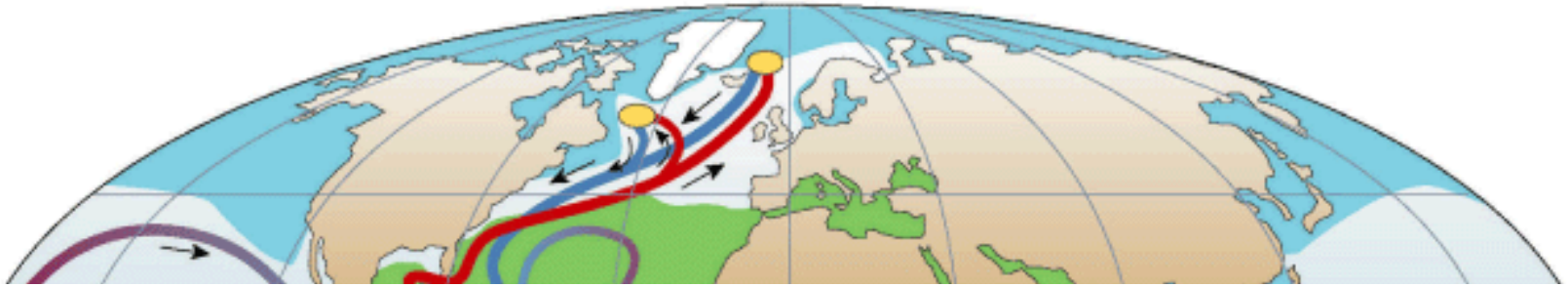
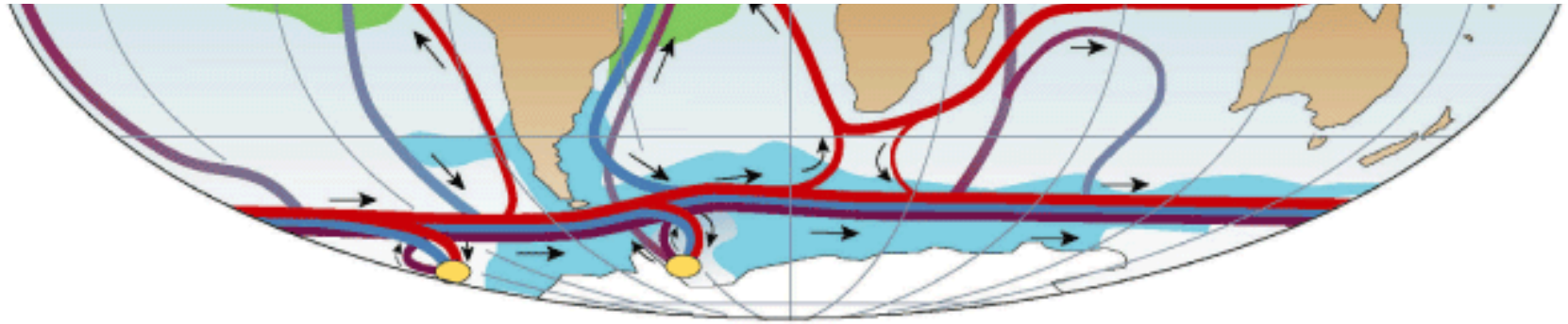


Take home message: Internal multidecadal MOC variability matters even on a global scale



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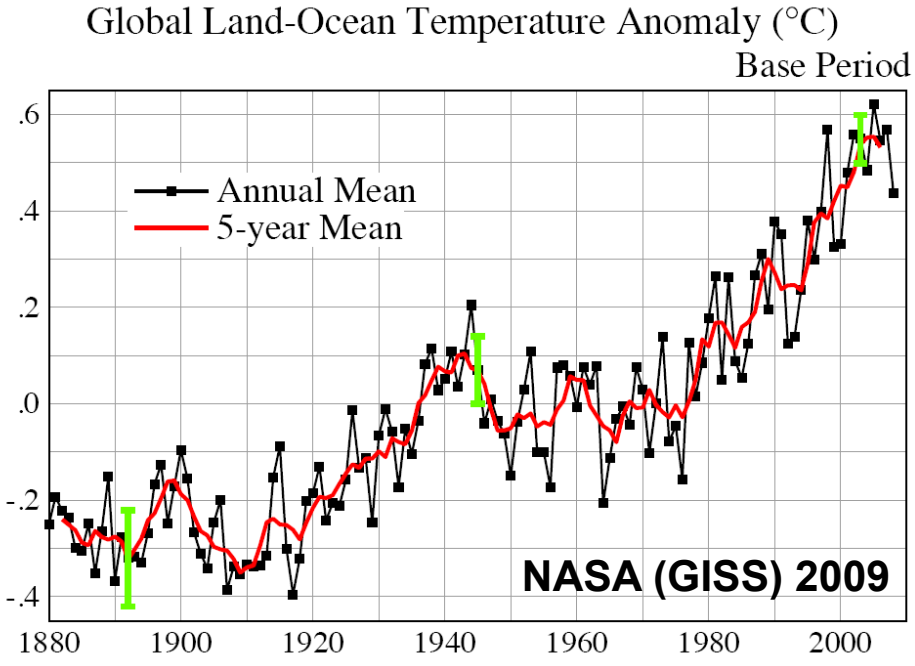
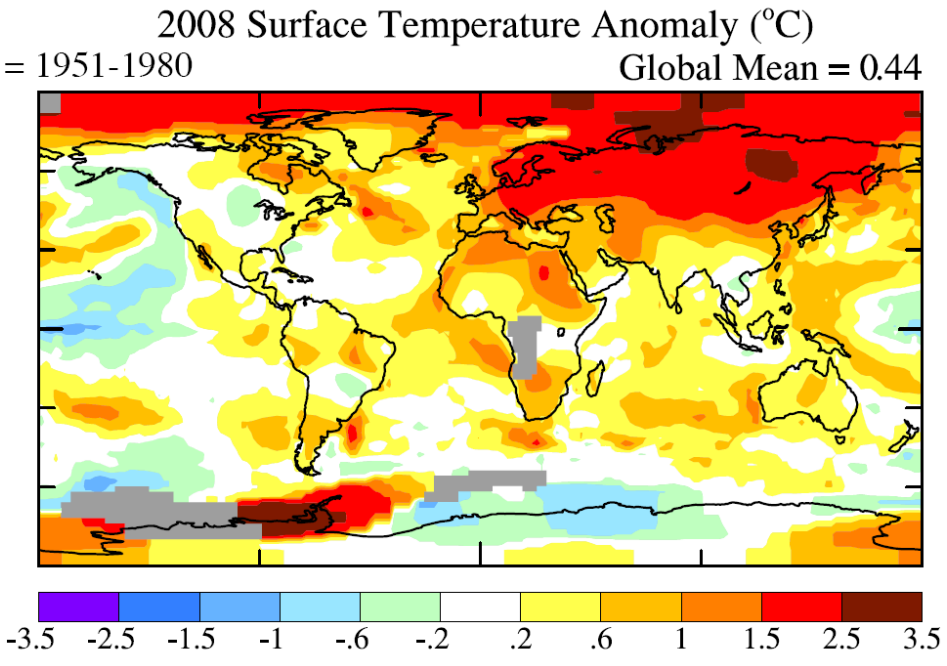
Outline

1. General remarks
2. Dynamical considerations
3. Internal vs. external variability
4. Predictability and prediction

1. General remarks





Strong multidecadal variability is observed in the global mean SAT

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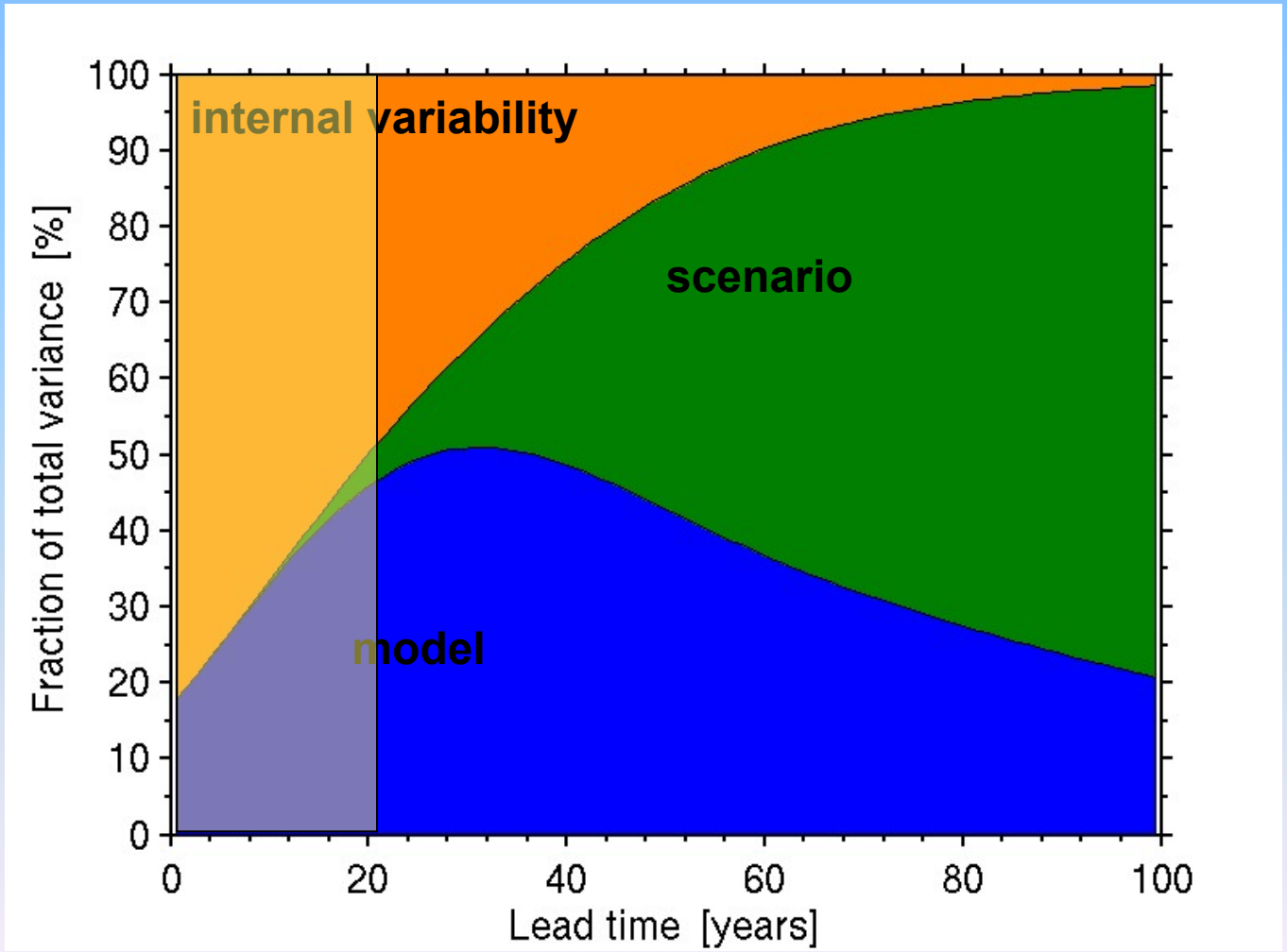
Uncertainties in global change projections



Hawkins and Sutton 2009

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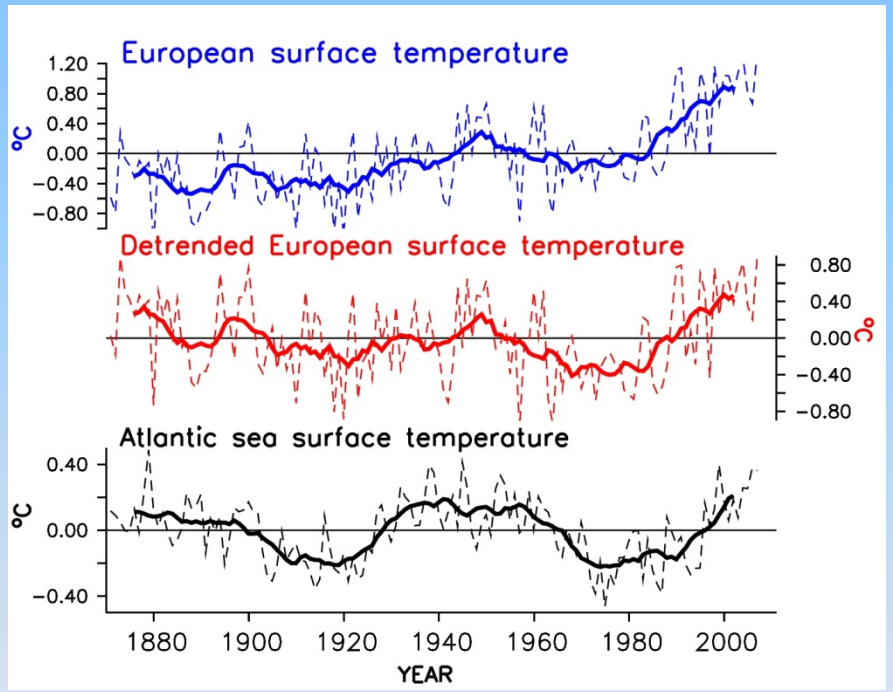
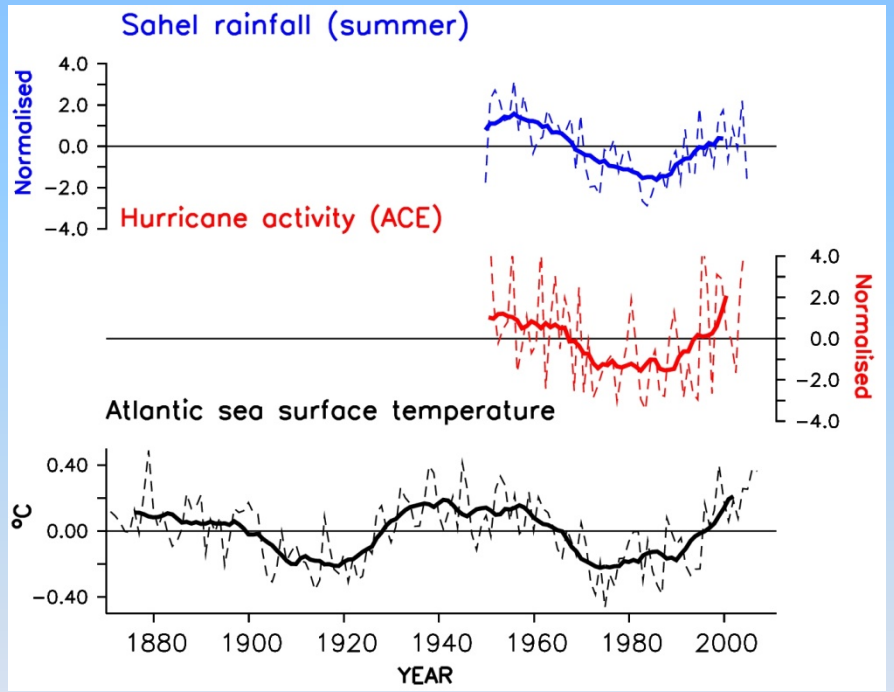
Societal relevance of multidecadal variability





Latif et al. 2009

Is the cause of the multidecadal variability external or internal?

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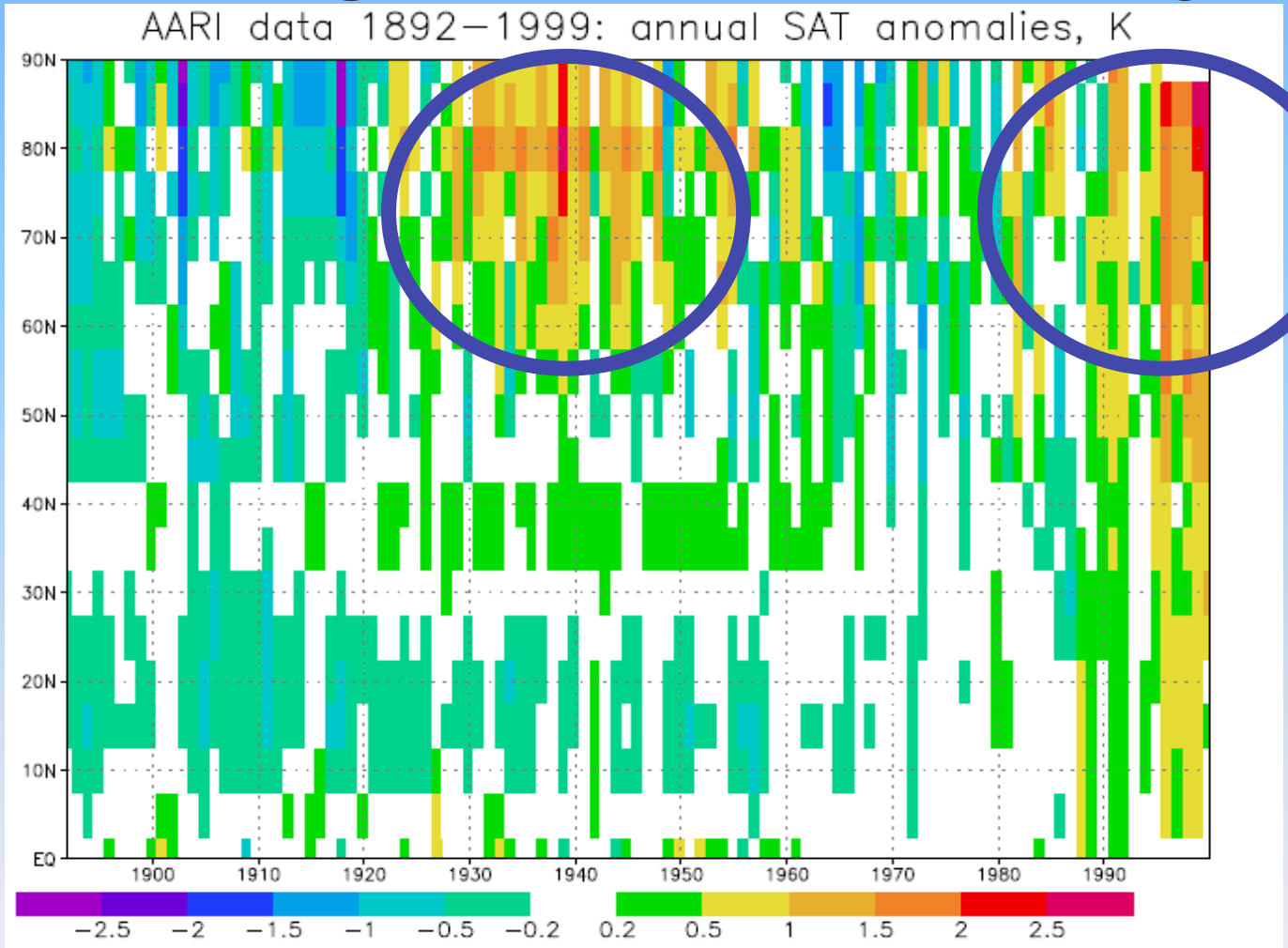
Zonal mean temperatures during the 20th century



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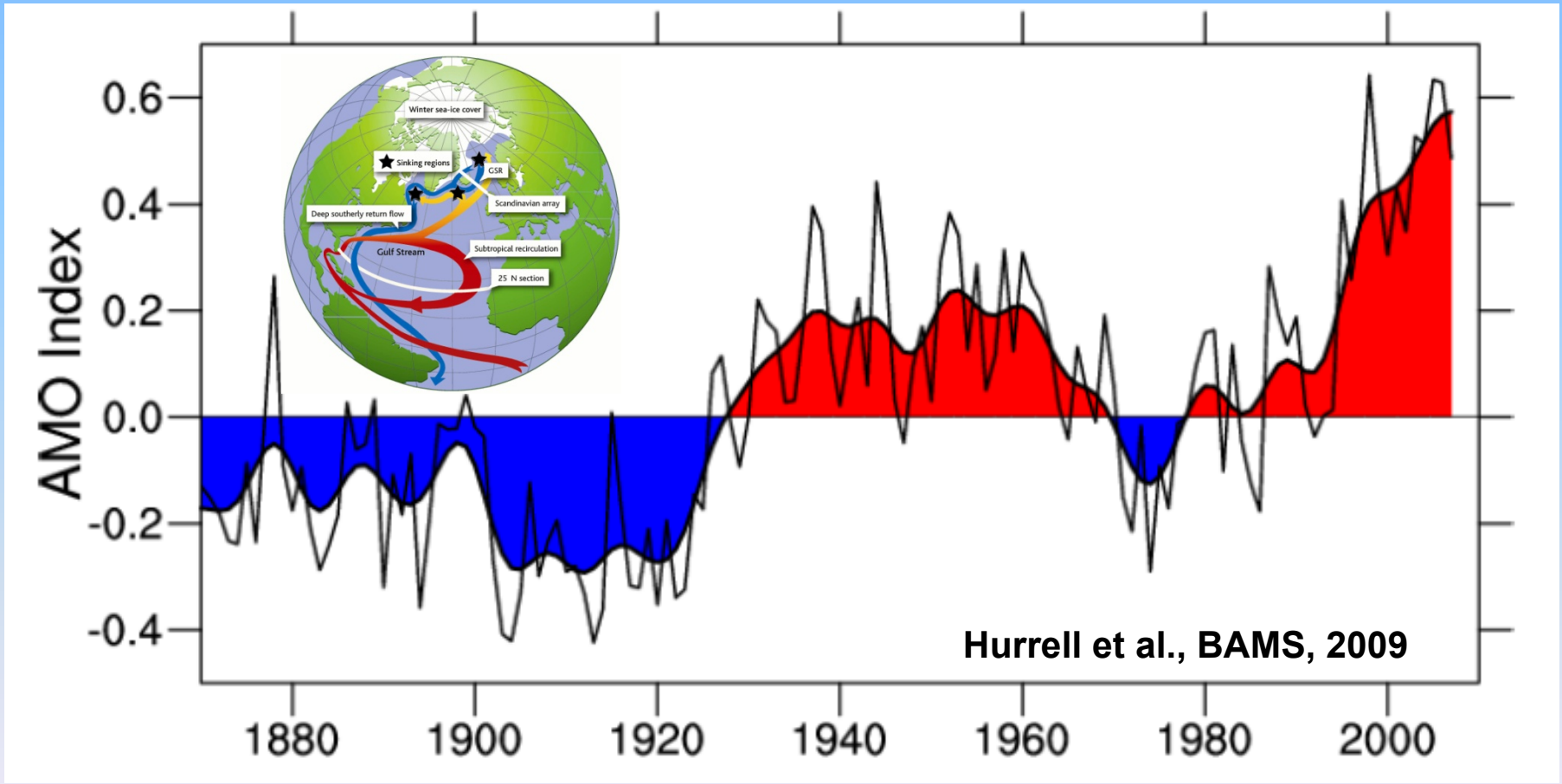
SST in the North Atlantic may record MOC changes



Does the multidecadal variability originate in the Atlantic/Arctic?

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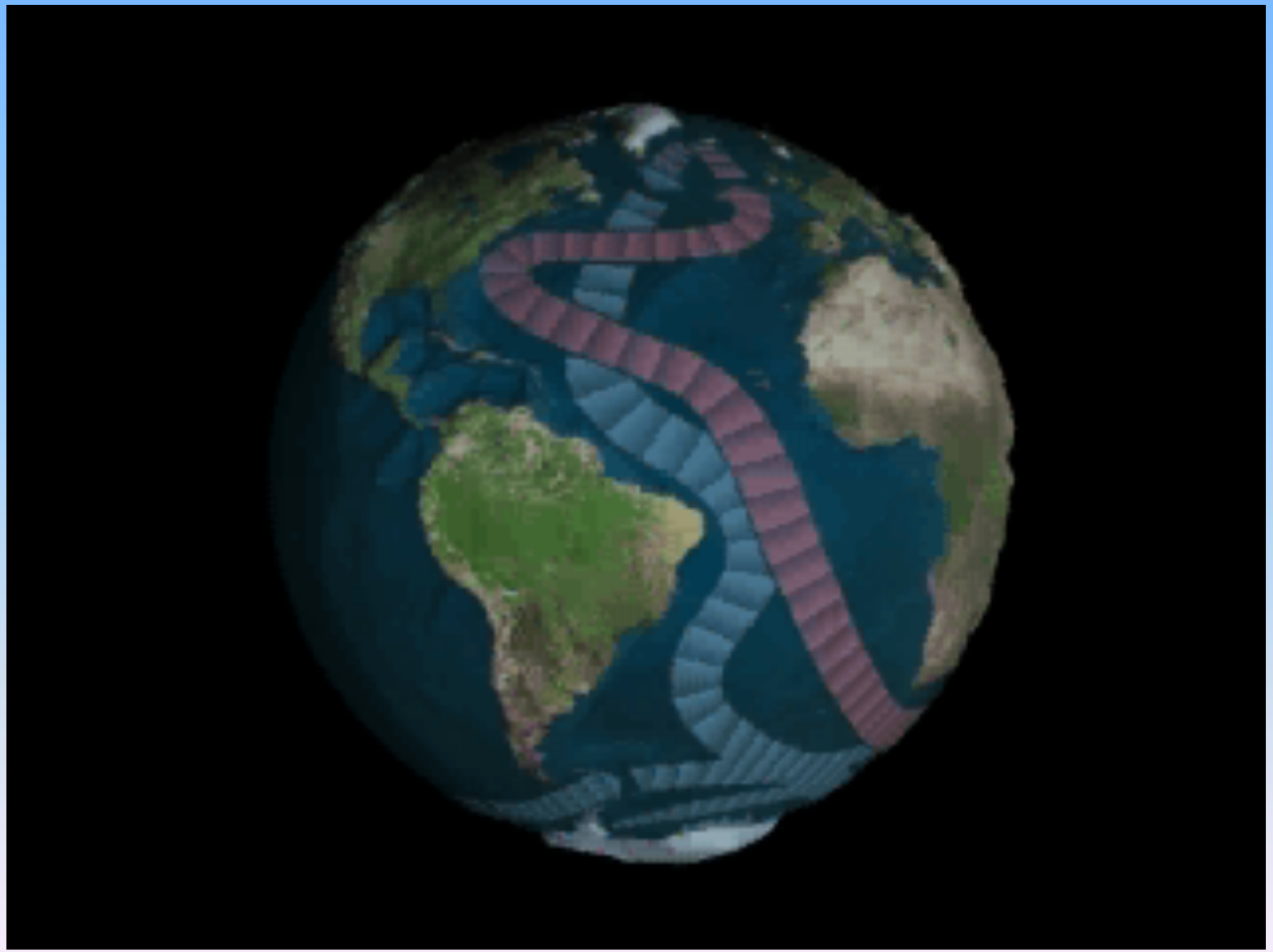
2. Dynamical considerations



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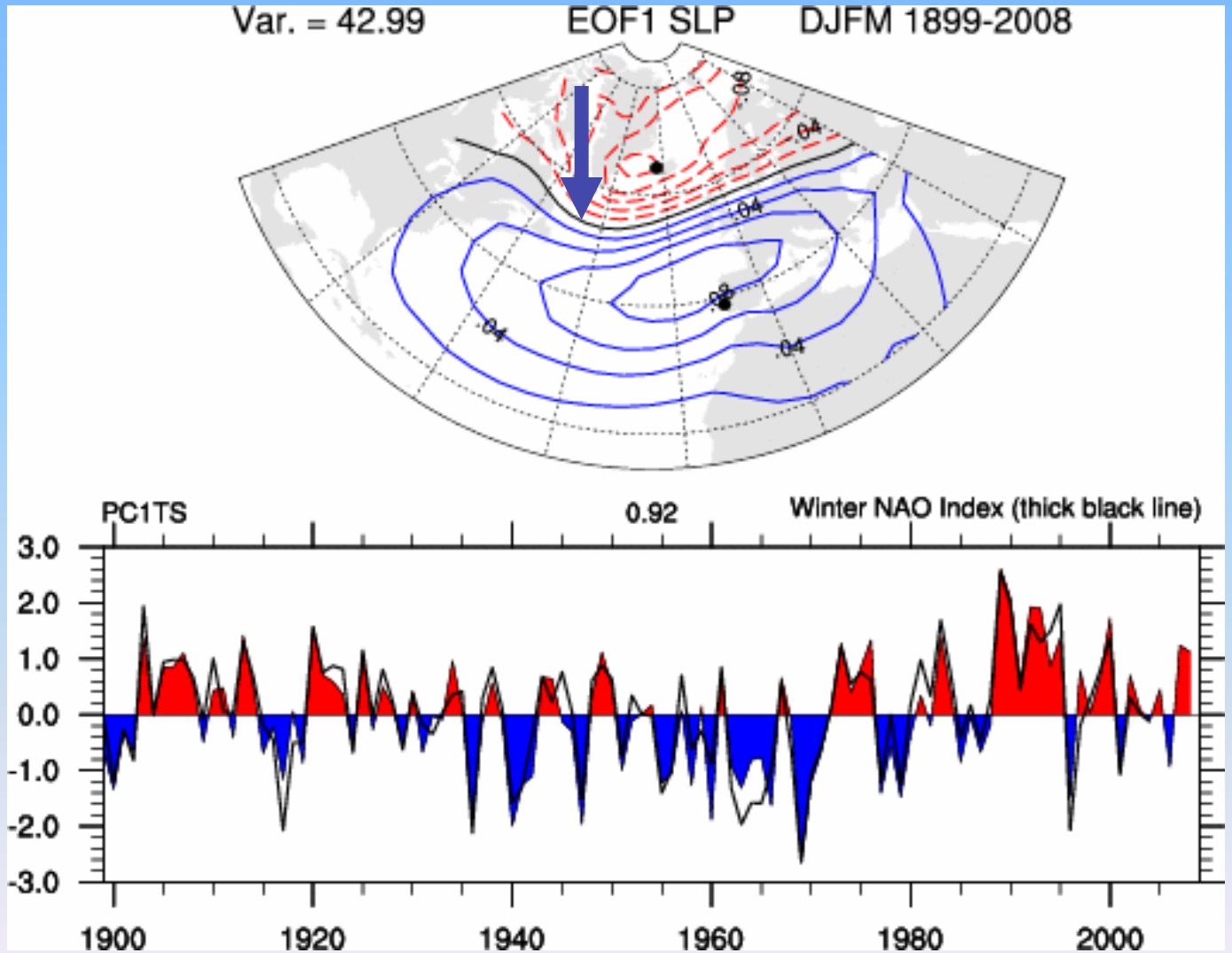
The North Atlantic Oscillation



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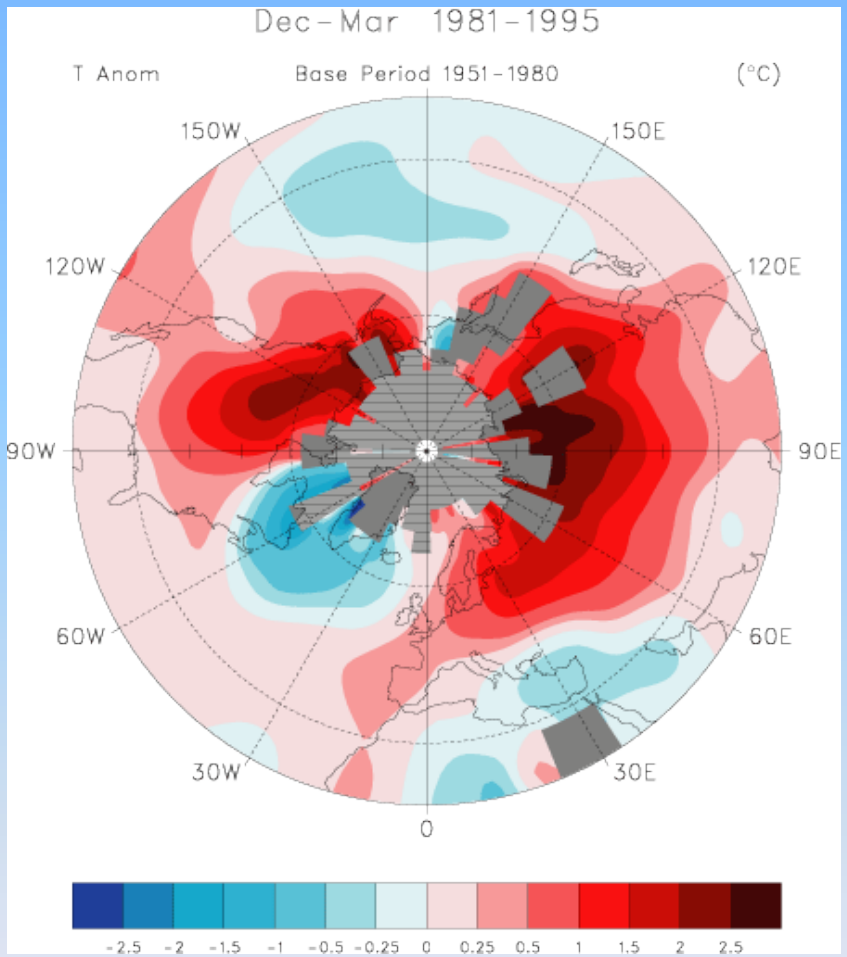
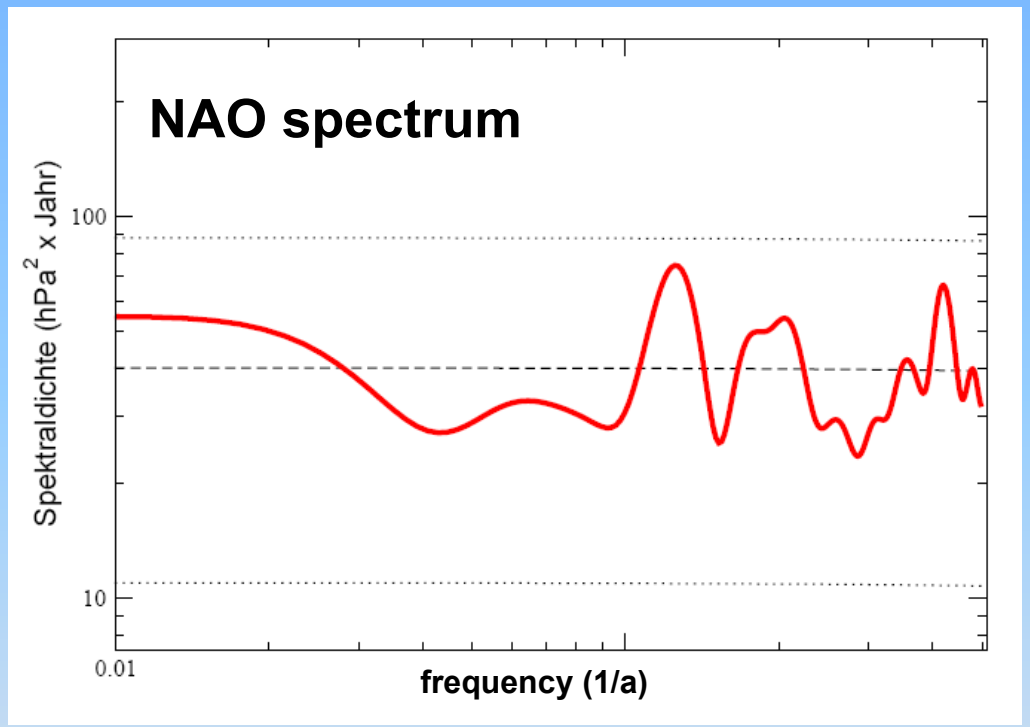
NAO spectrum



associated SAT anomalies



The NAO spectrum is almost white, so that a simple stochastic scenario may apply

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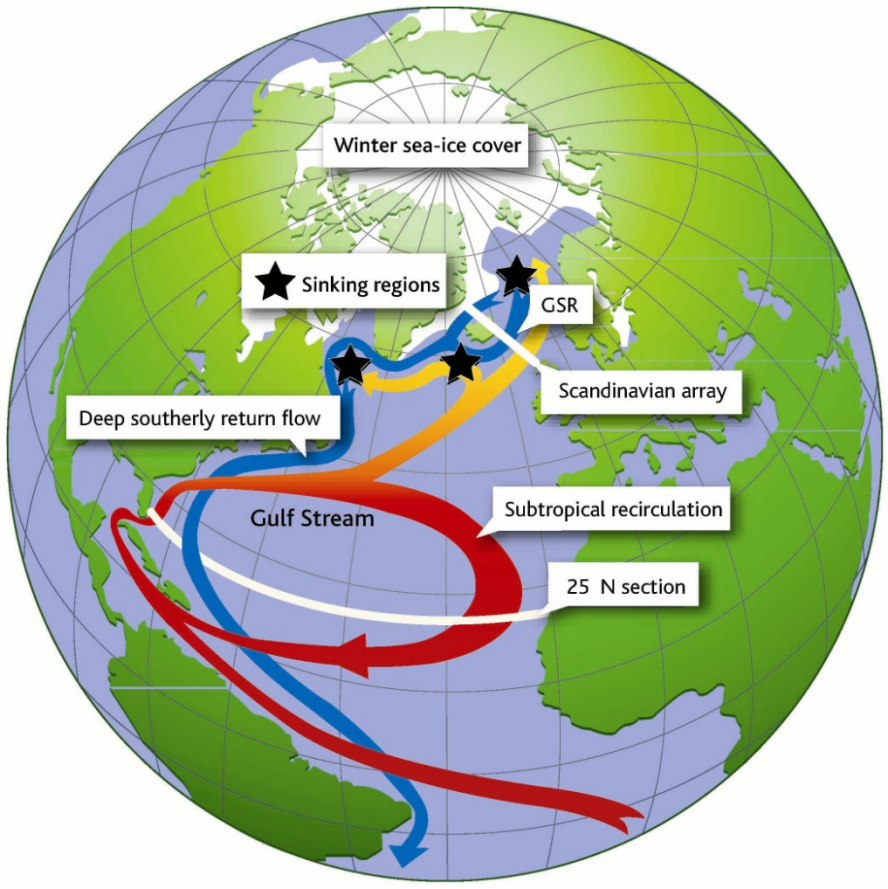
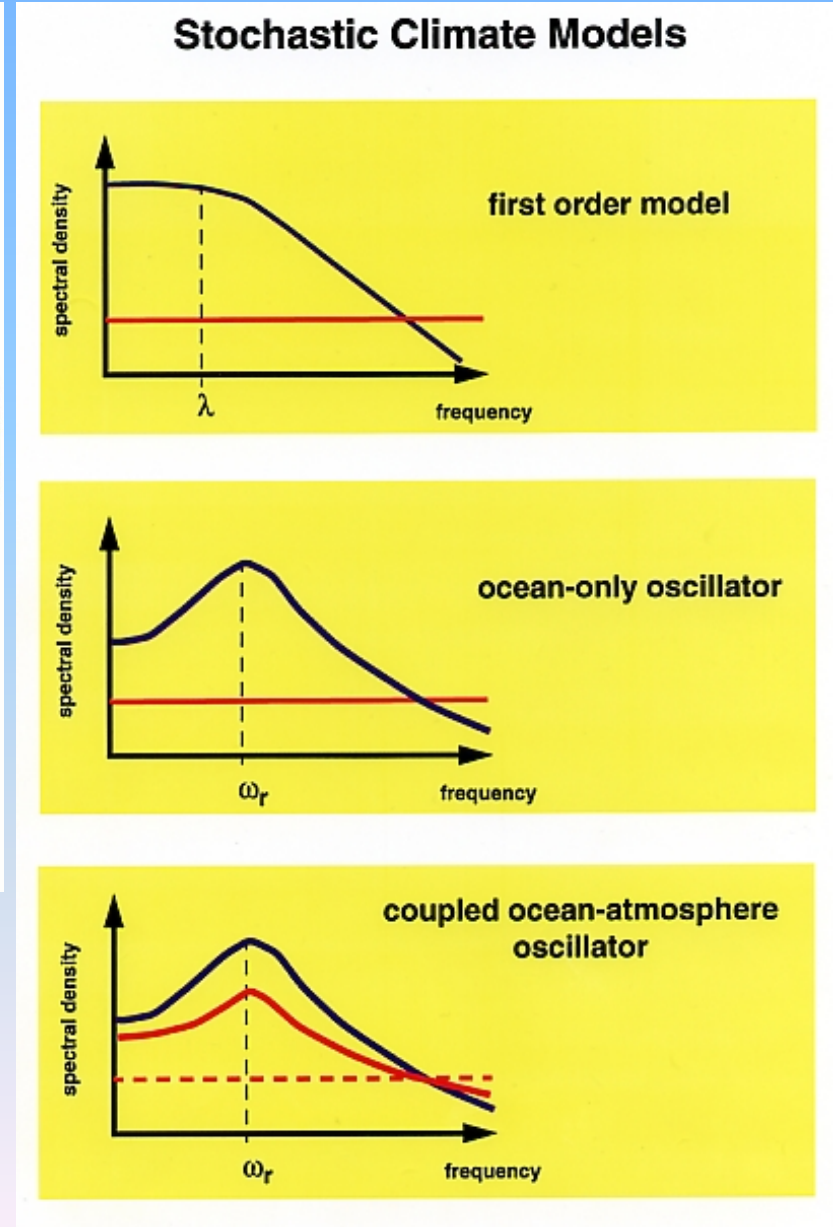
Stochastic climate model





Most evidence points towards the "ocean-only" oscillator

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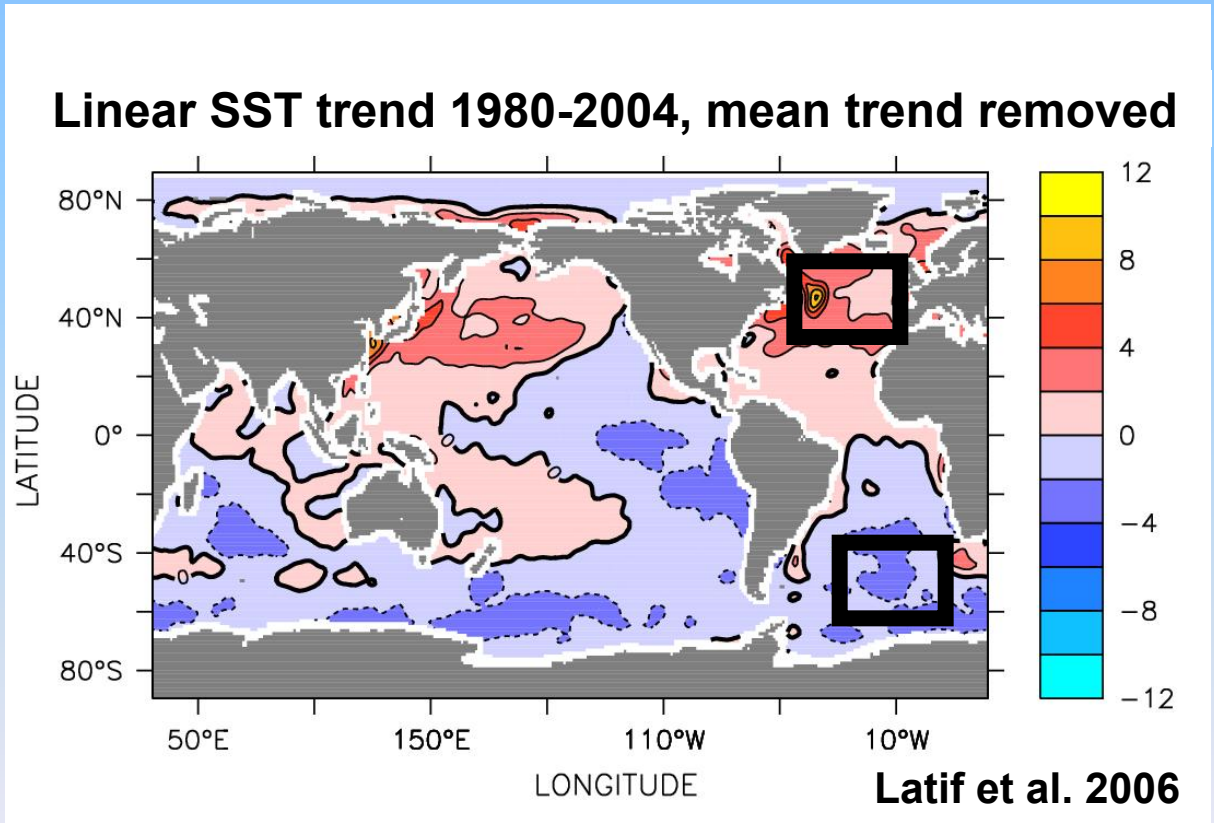
The Atlantic SST dipole, an index of relative MOC variations



The variability in the dipole index will be used in the following as surrogate of MOC variability

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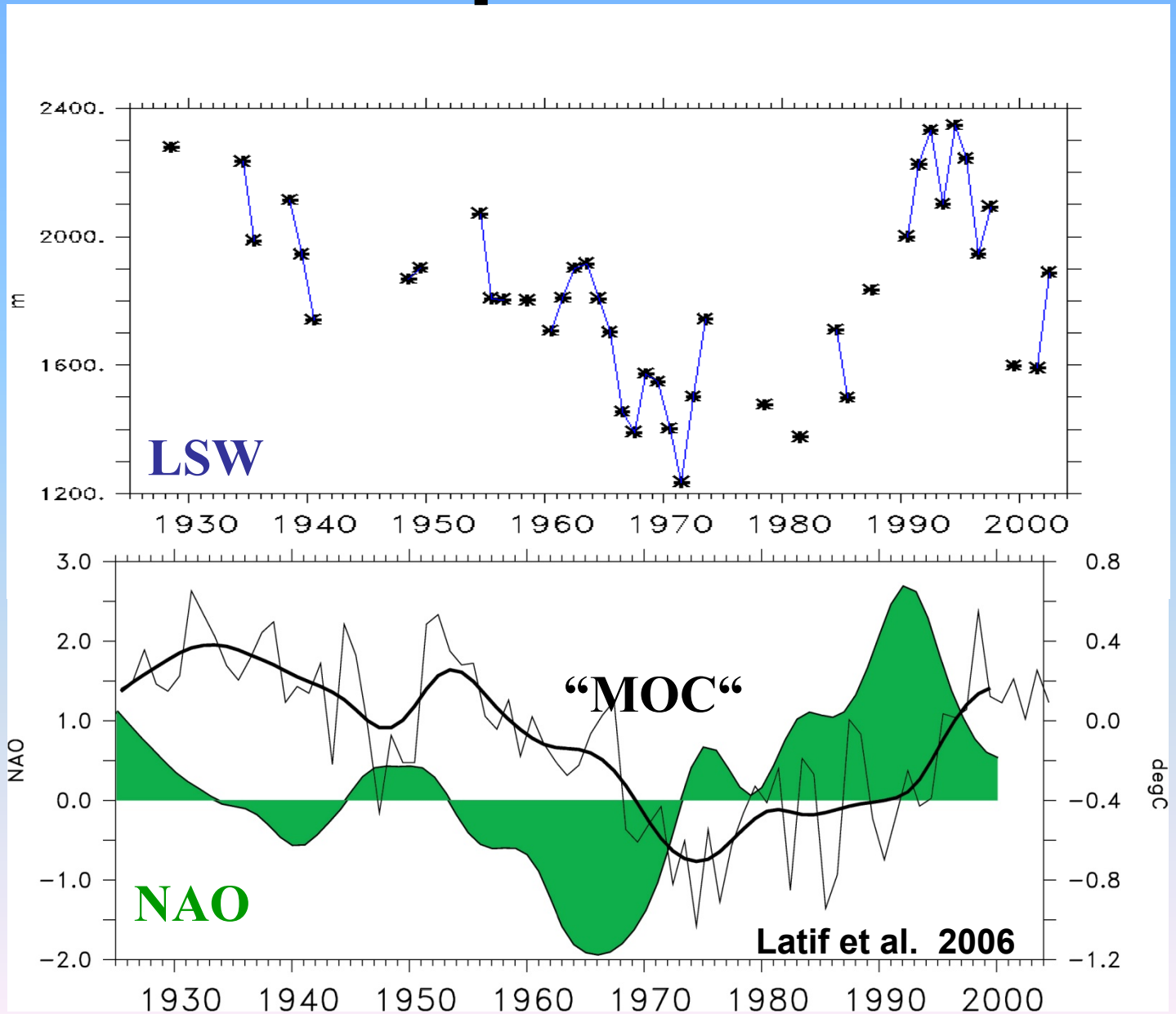
Ocean-atmosphere interactions



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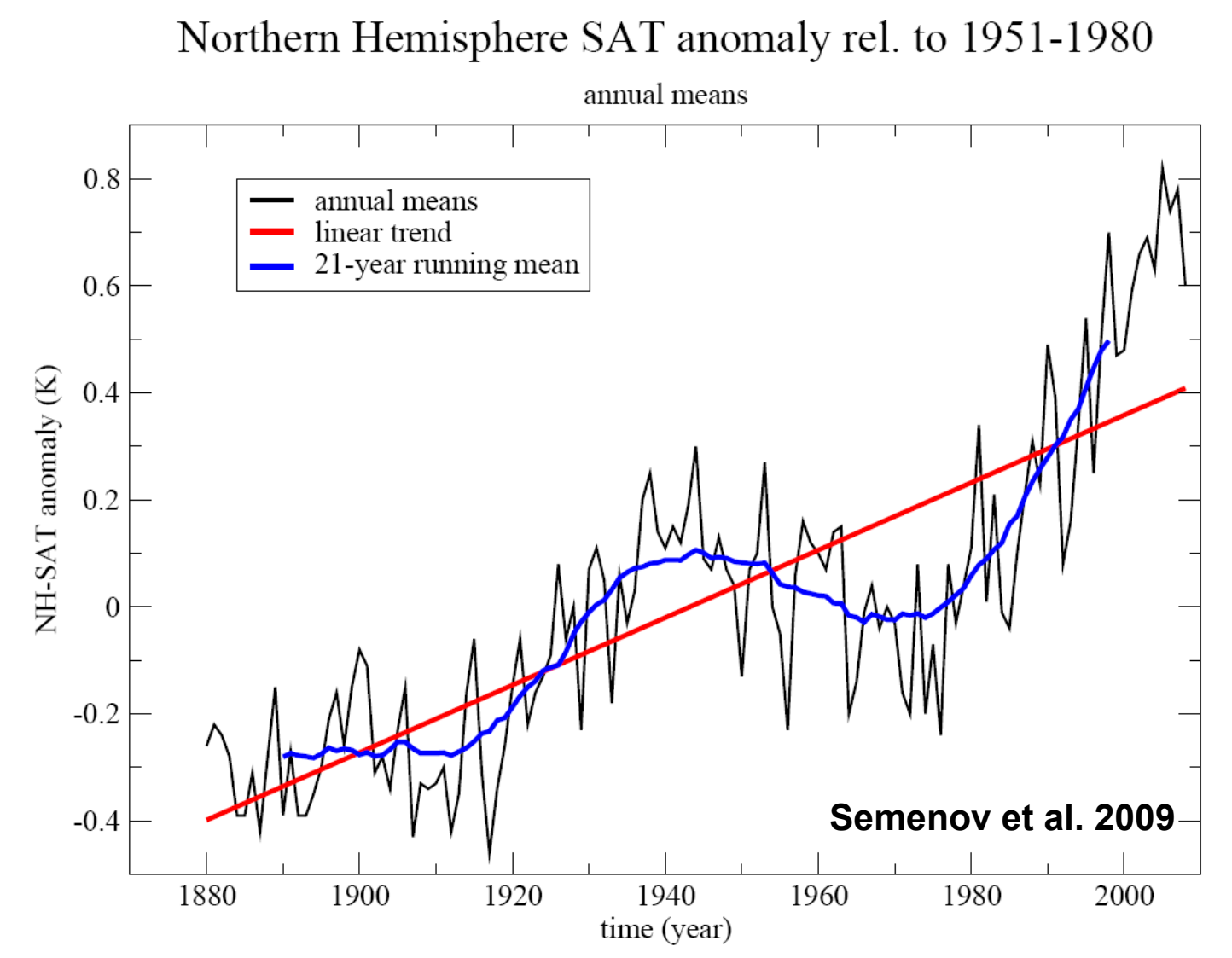
3. Internal vs. external variability



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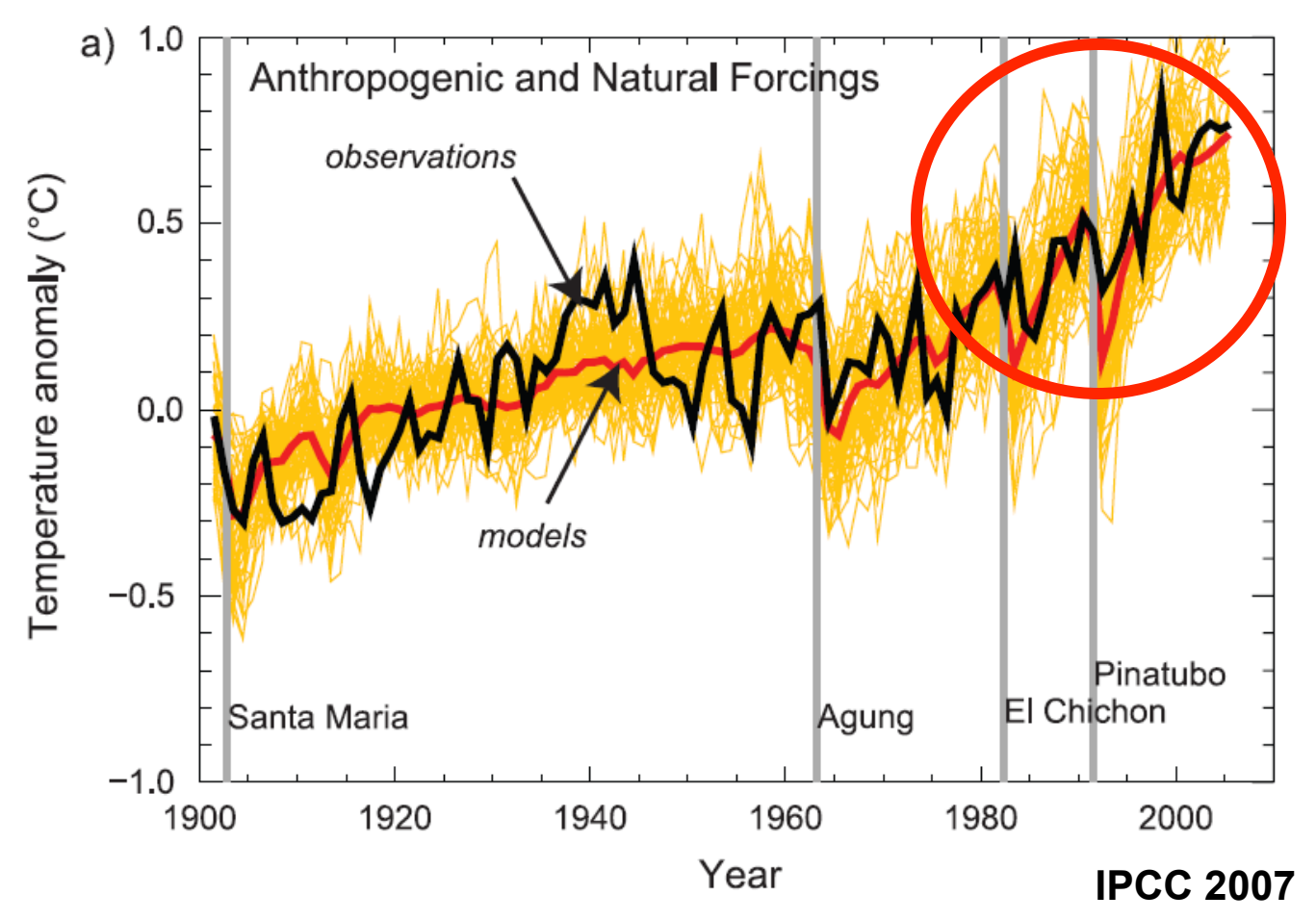
The IPCC models reproduce the warming in the global mean



This does not leave much room for internal variability

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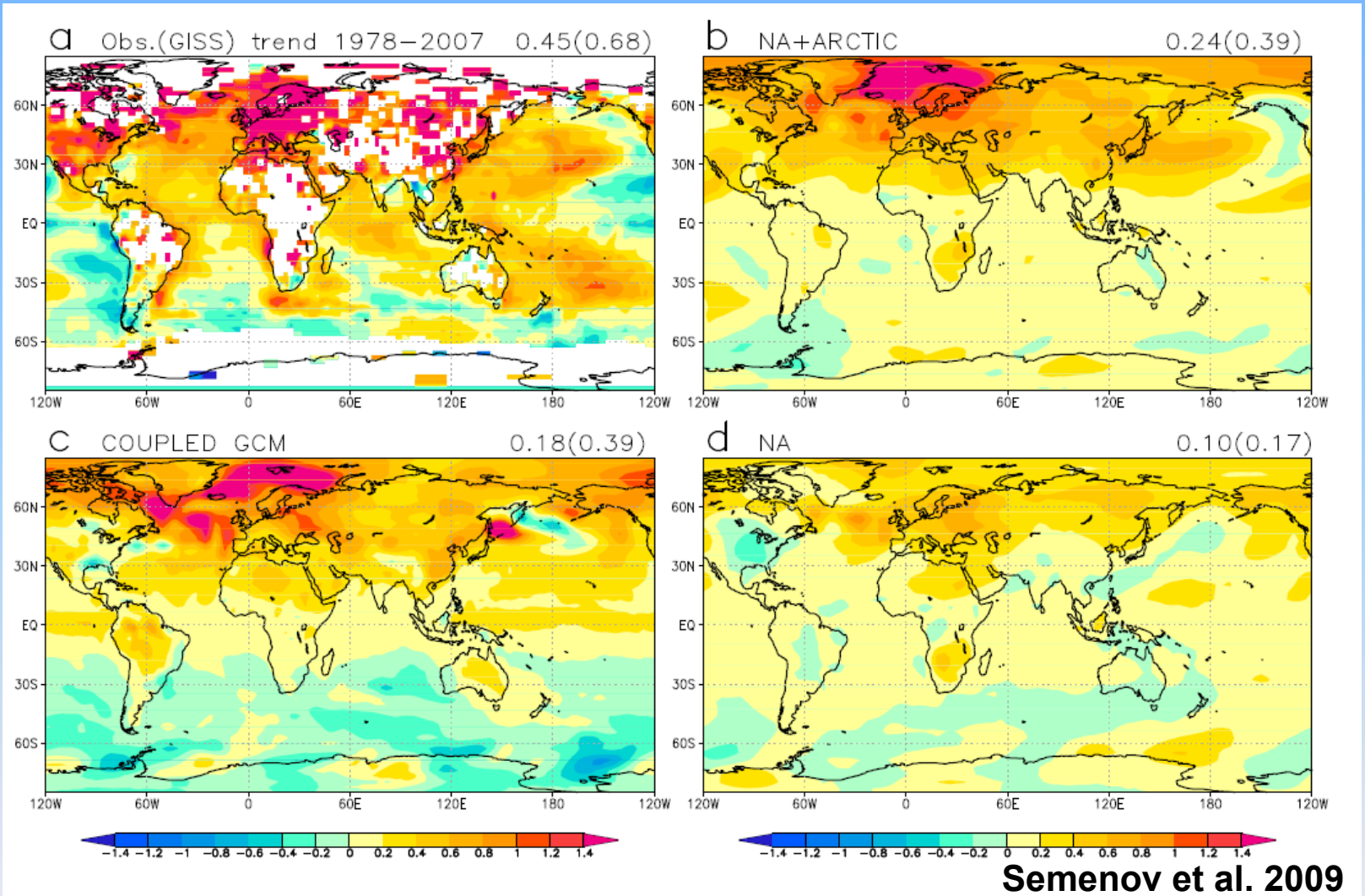
AMO impact, SAT 1978-2007?



Semenov et al. 2009

The last decades may contain a strong contribution from internal variability

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Diagnostic approach to separate external and internal climate signals during the 20th century

$$T(x,y,t)=\alpha \cdot \psi(x,y) \cdot F(t) + R(x,y,t)$$

$F(t) = \log[CO_2(t\text{-}11yr)/CO_2(0)]$

$\psi(x,y)$ = 1st EOF of multi-model ensemble mean 20thcentury SAT

R(x,y,t) = Residual internal variability

Strehz et al. 2009, in prep.

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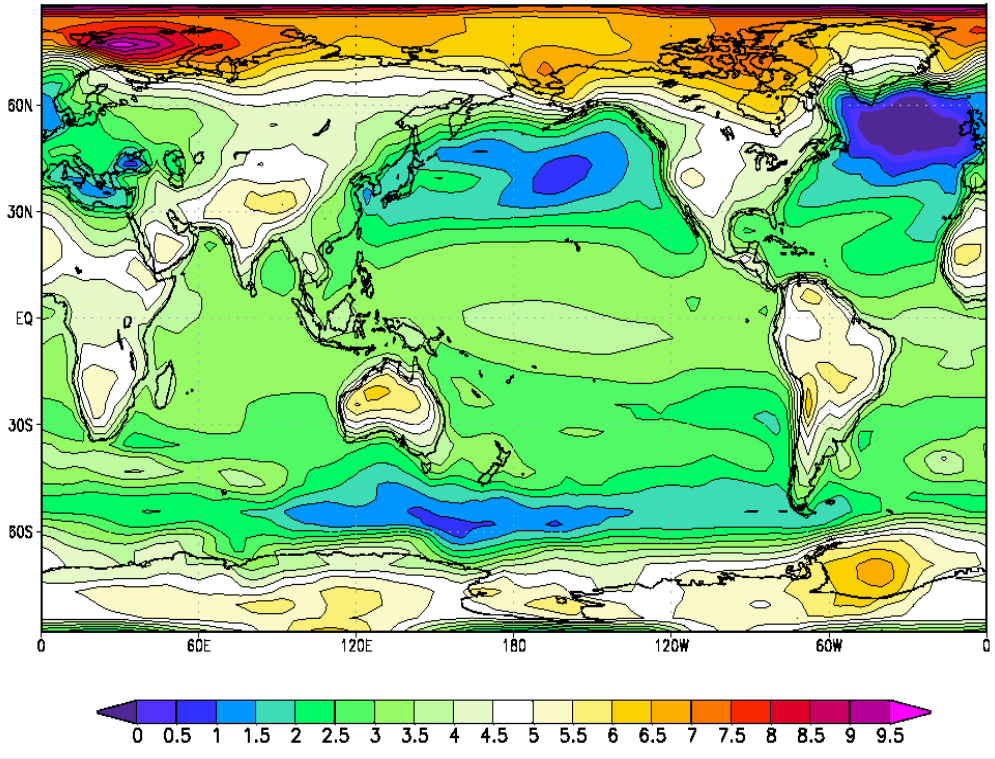
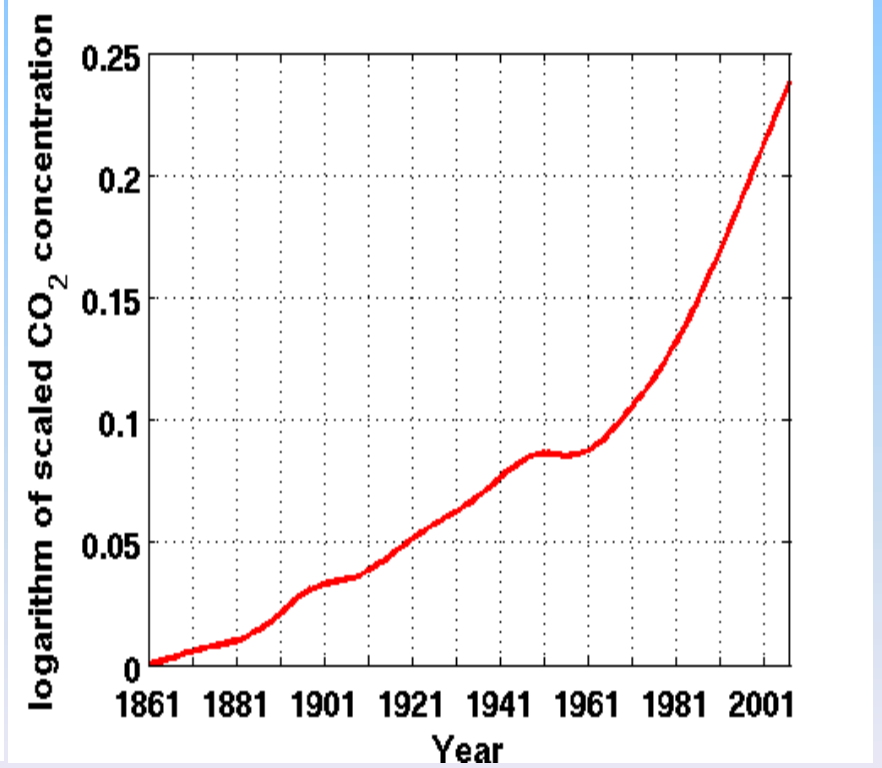
$T(x,y,t) = \alpha \cdot \psi(x,y) \cdot F(t) + R(x,y,t)$

$\psi(x,y)$ = 1st eof of multi-model mean 20thcentury temperature (87%)

$F(t) = \log[CO_2(t\text{-}11yr)/CO_2(0)]$





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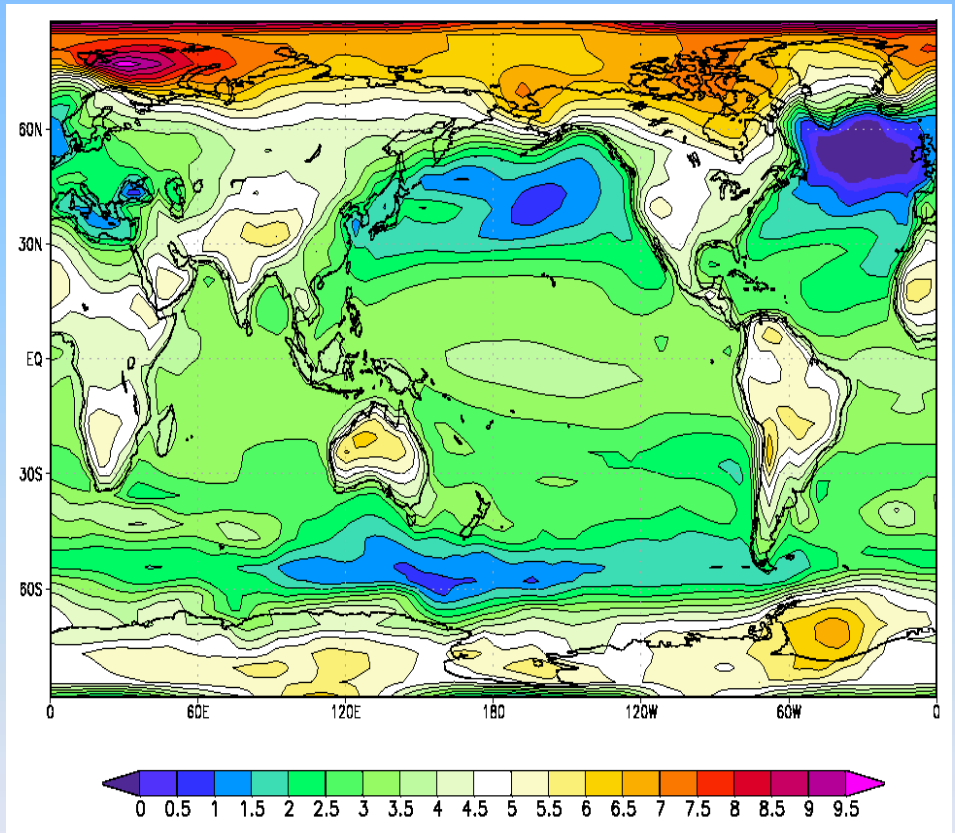
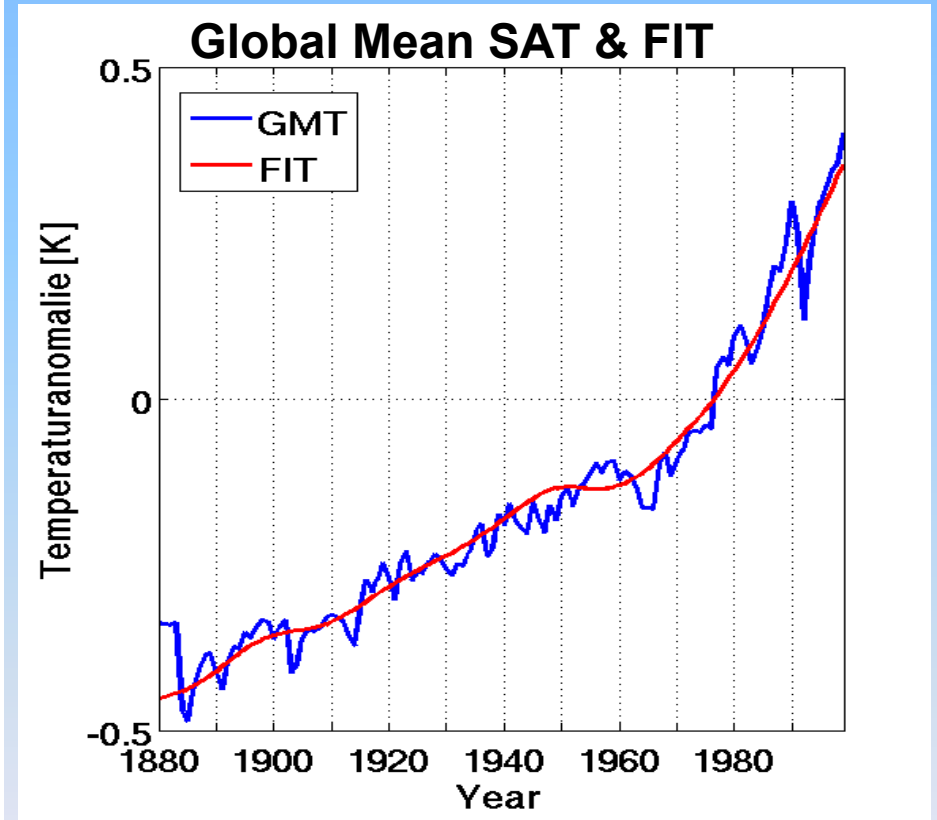
Proof of concept in the model world





Approach works fine in the model world

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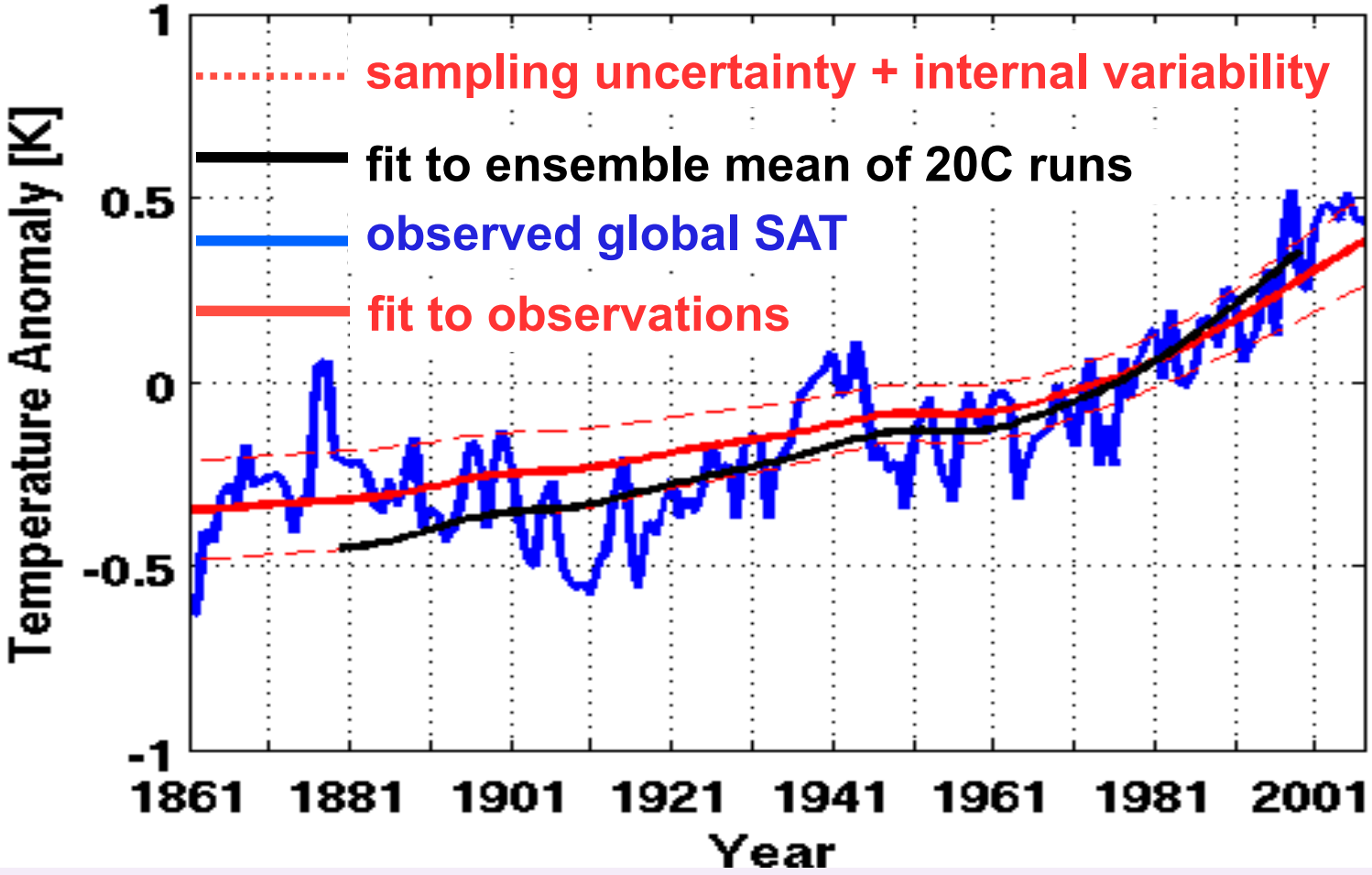
Observed global SAT and fitted external component



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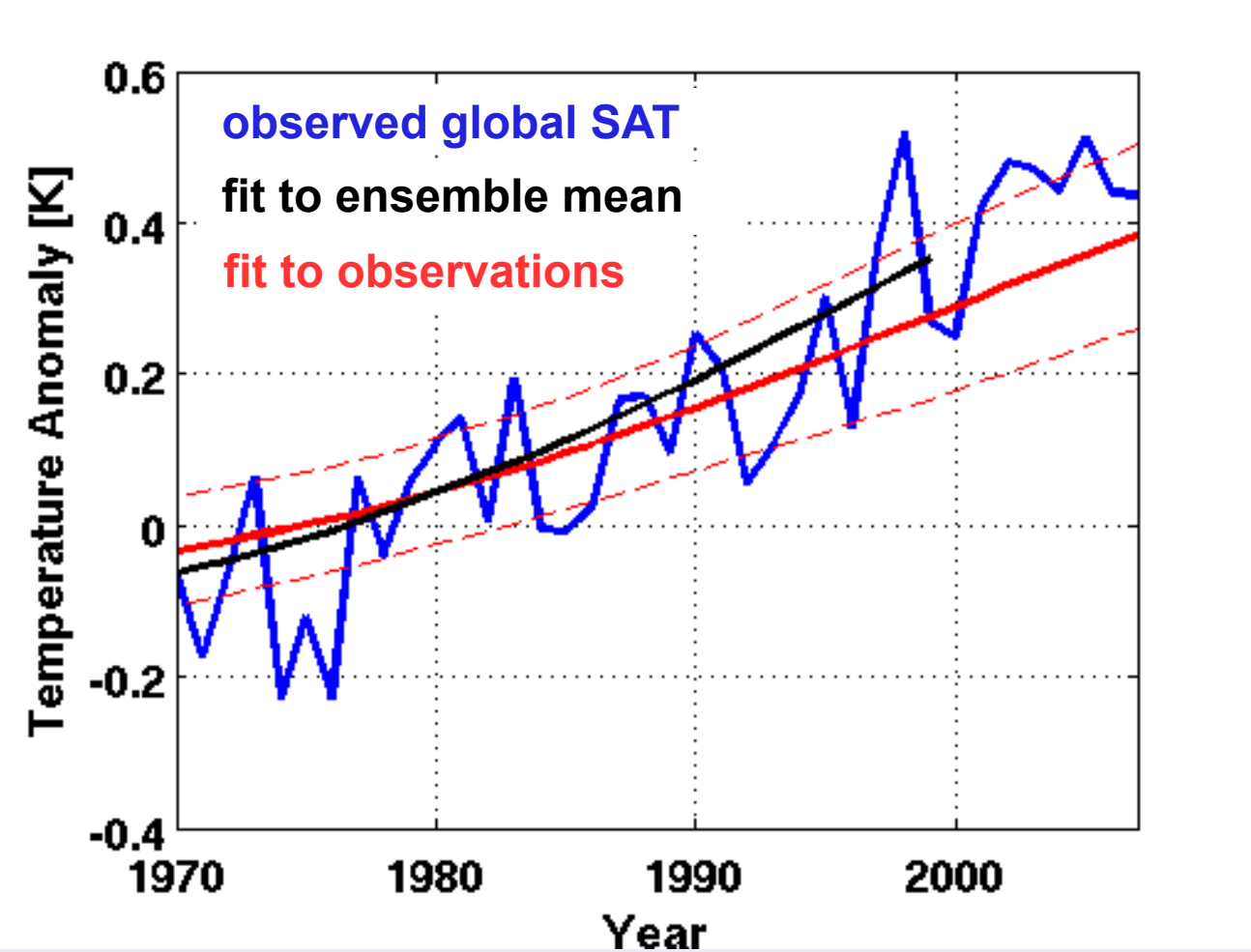
The most recent period



Implication: Climate sensitivity is too high

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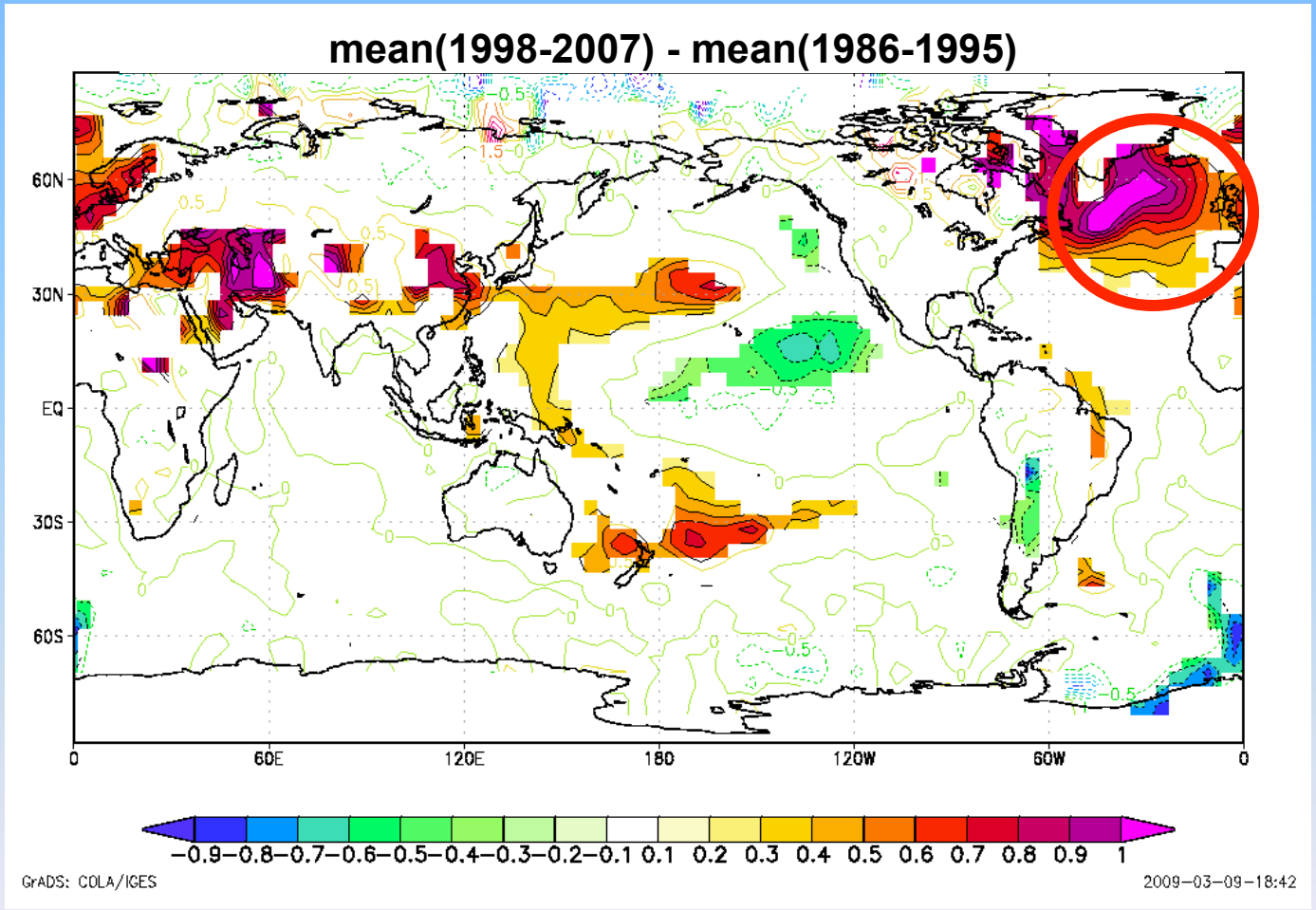
The internal variability during the most recent decades



The last decades contain indeed a strong contribution from internal (MOC) variability

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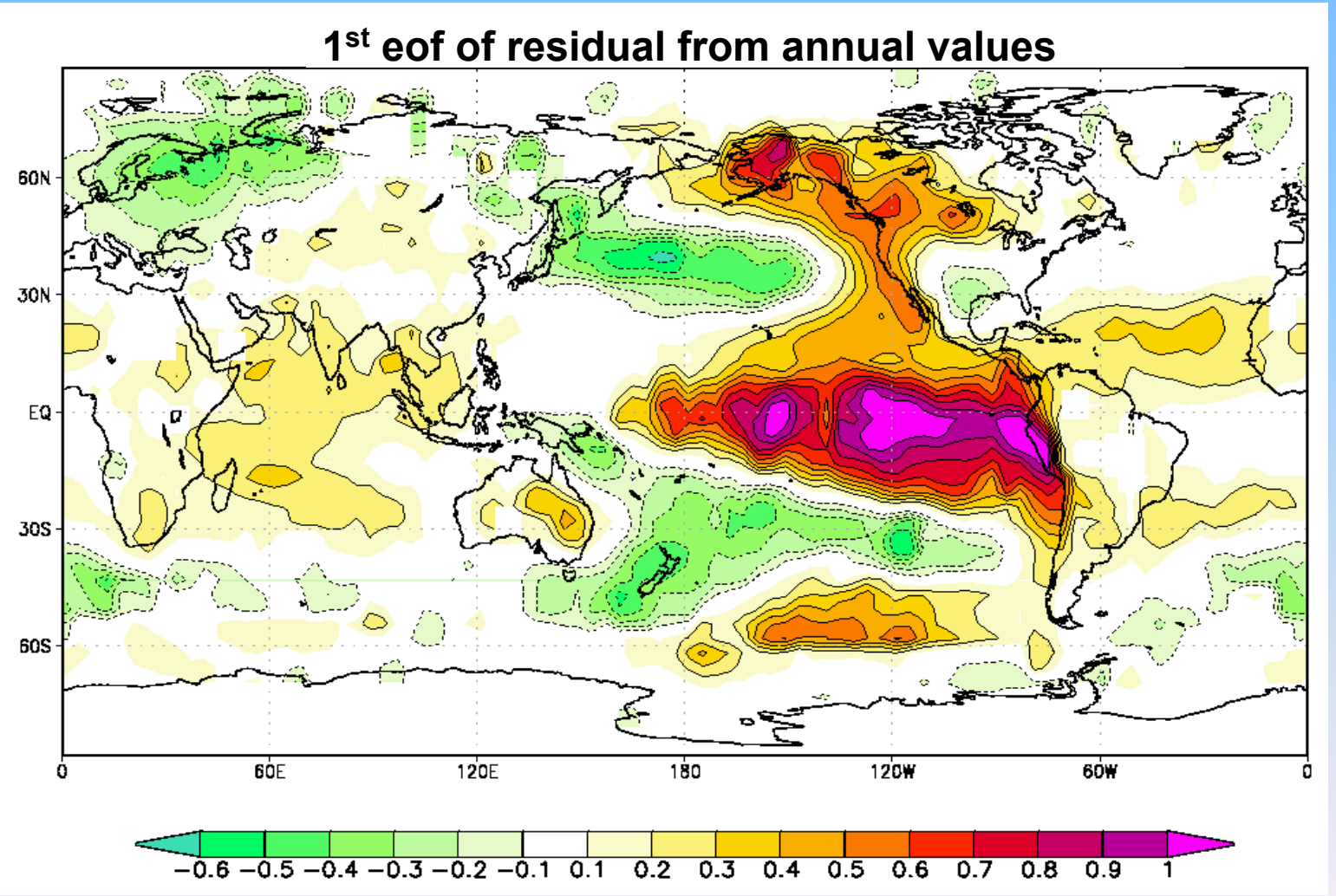
The leading mode from the annual residuals R(x,y,t) is ENSO



$$T(x,y,t) = \alpha \cdot \psi(x,y) \cdot F(t) + R(x,y,t)$$

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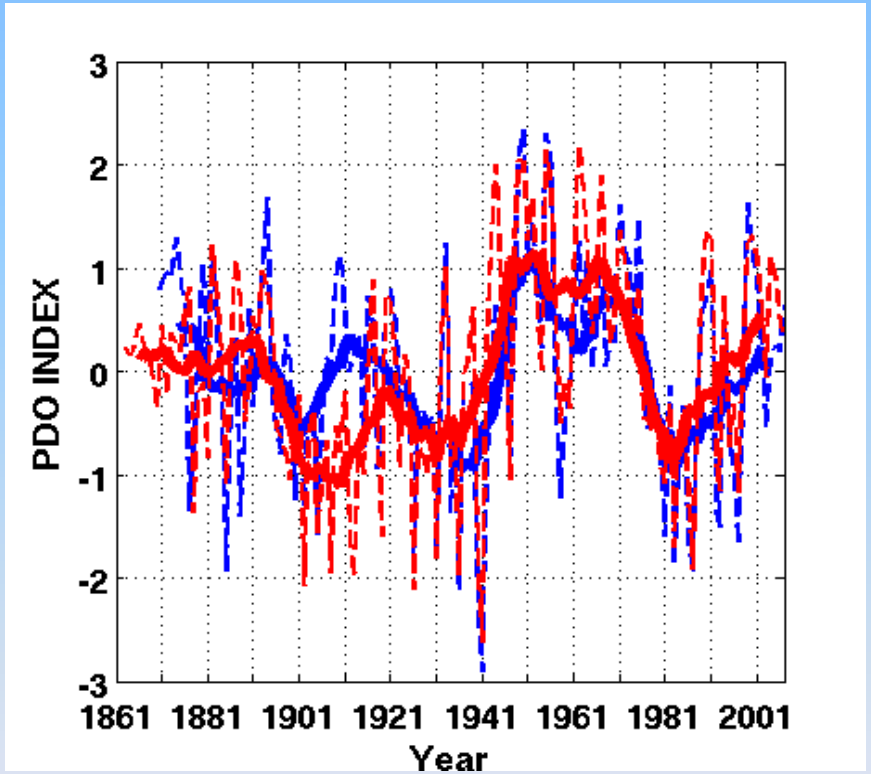
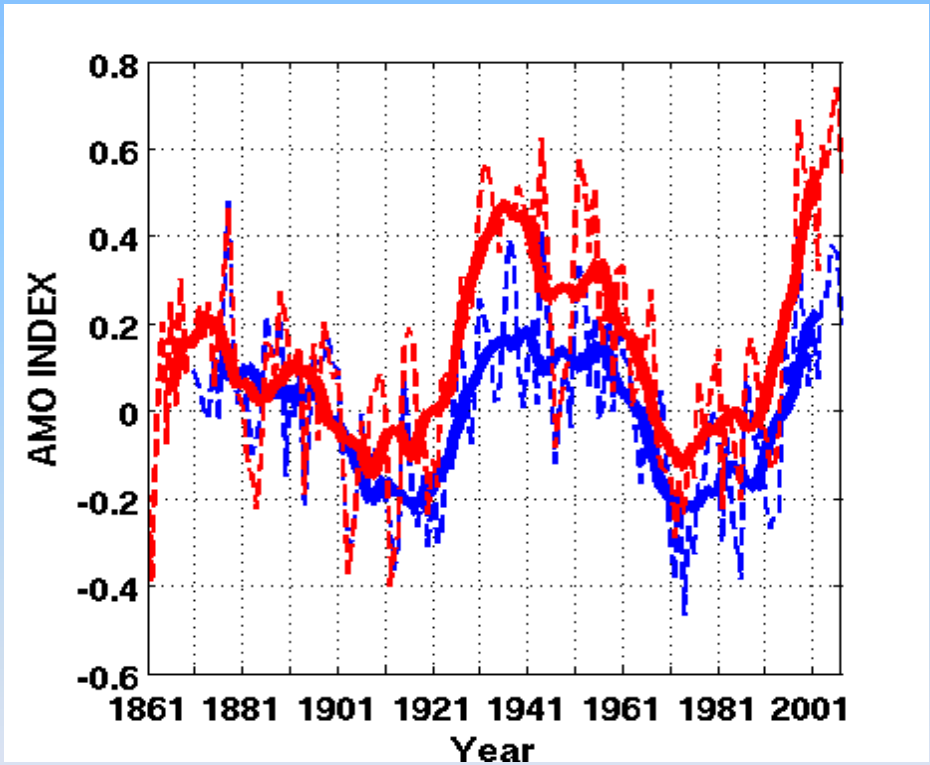
Indices of internal variability (PDO, AMO) from R(x,y,t)





The analysis recovers the decadal variations in the PDO and the AMO

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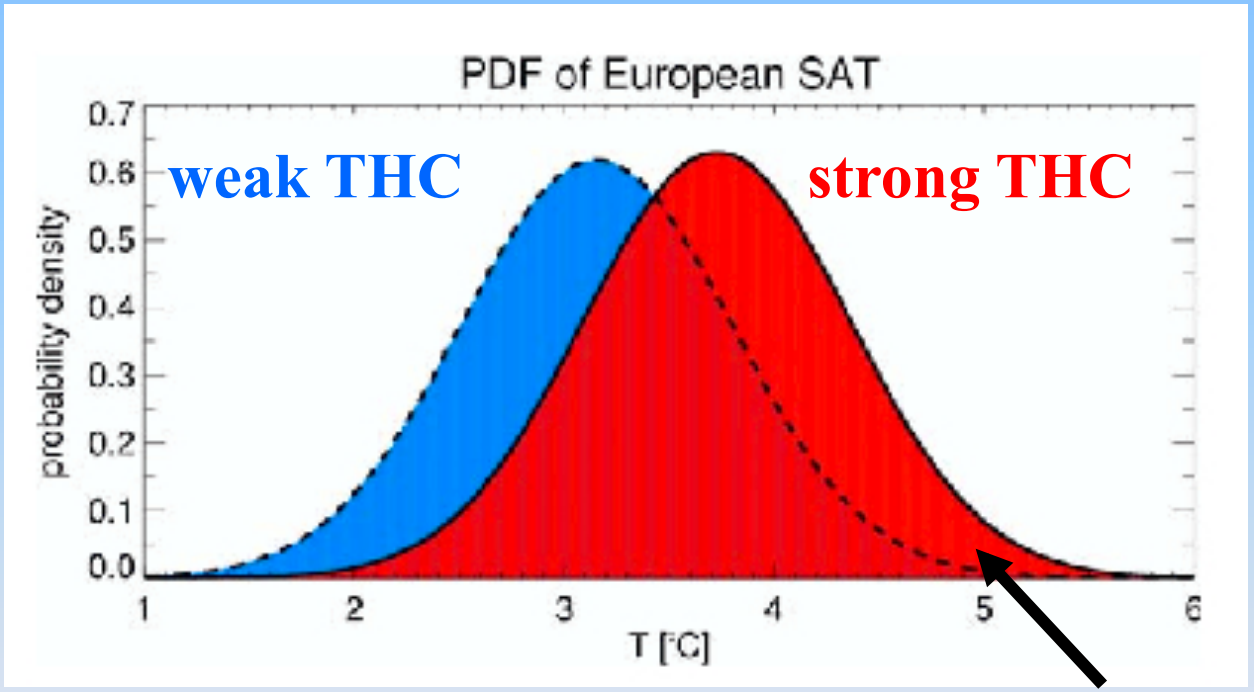
4. Predictability and prediction



Shifts in PDFs of European SAT from decade to decade in response to THC changes (Pohlmann et al. 2004)

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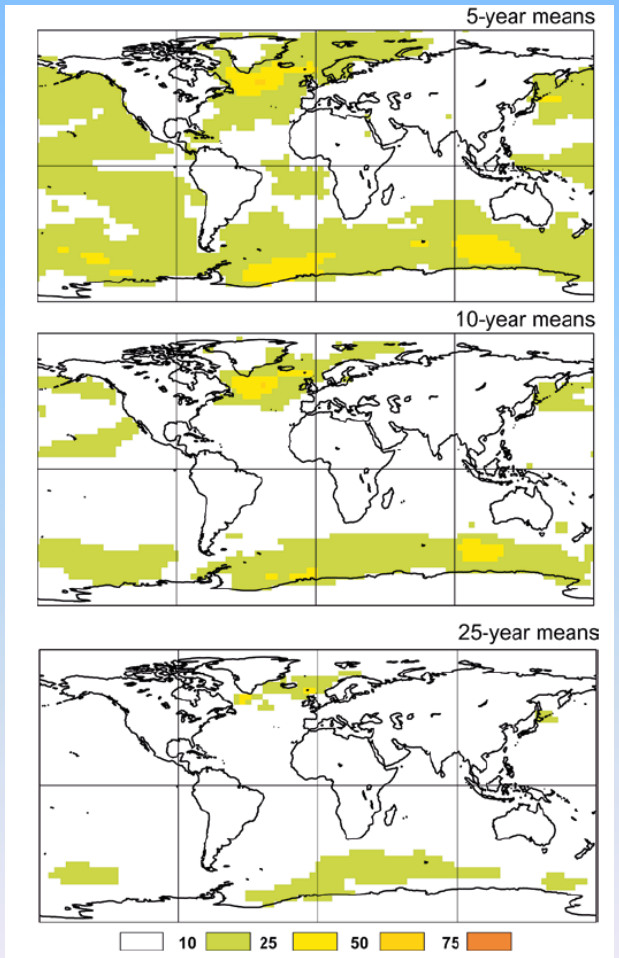
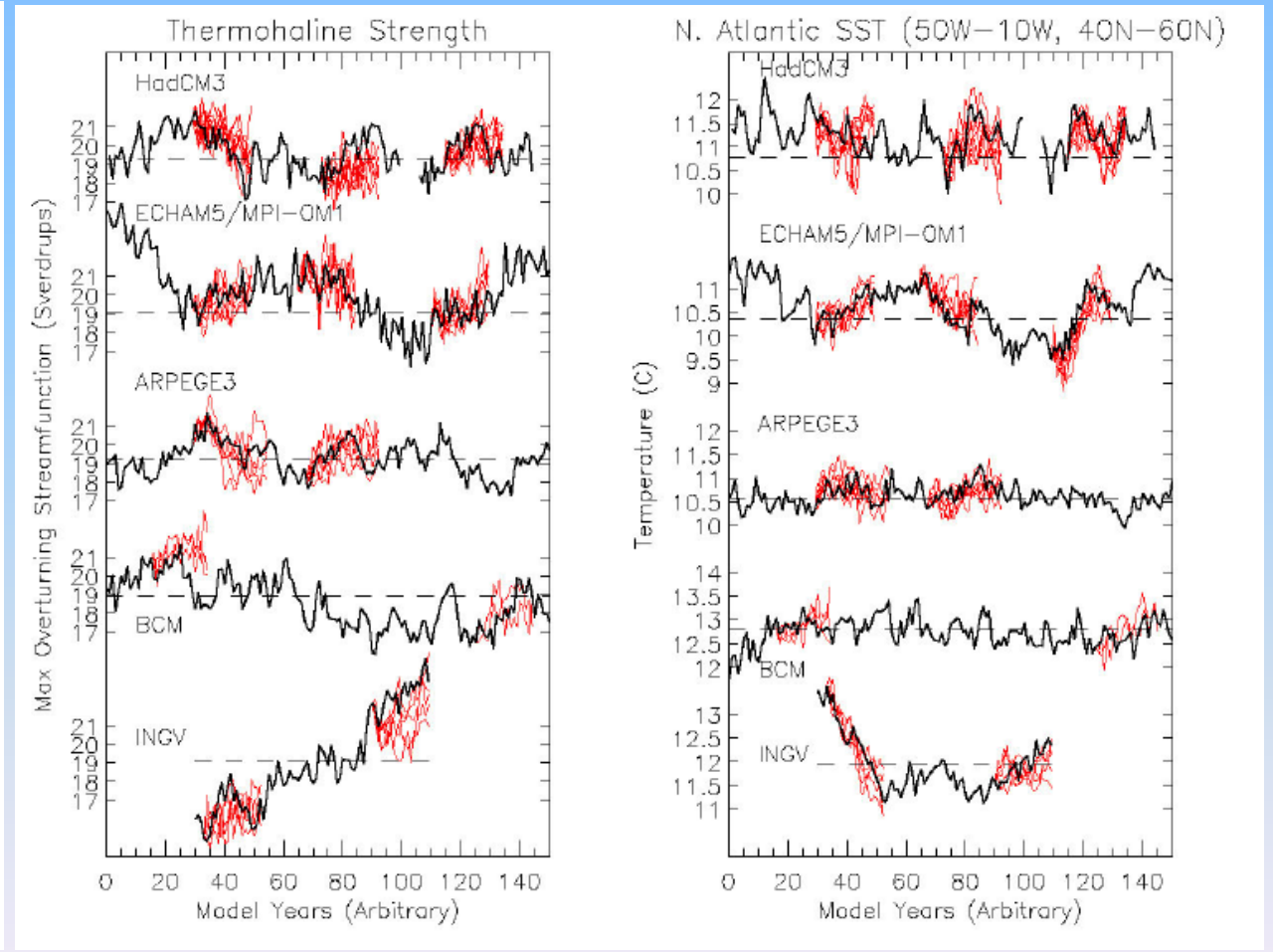
Predictability

Potential (diagnostic) predictability of SAT



Boer 2004

Classical (prognostic) predictability



Latif et al. 2006b

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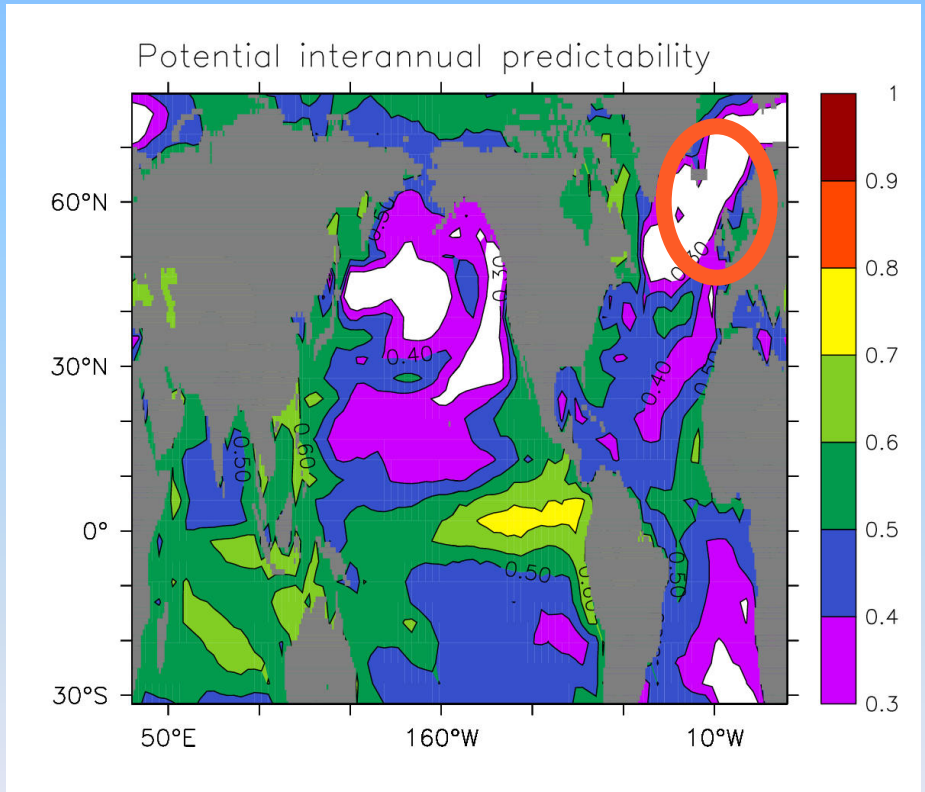
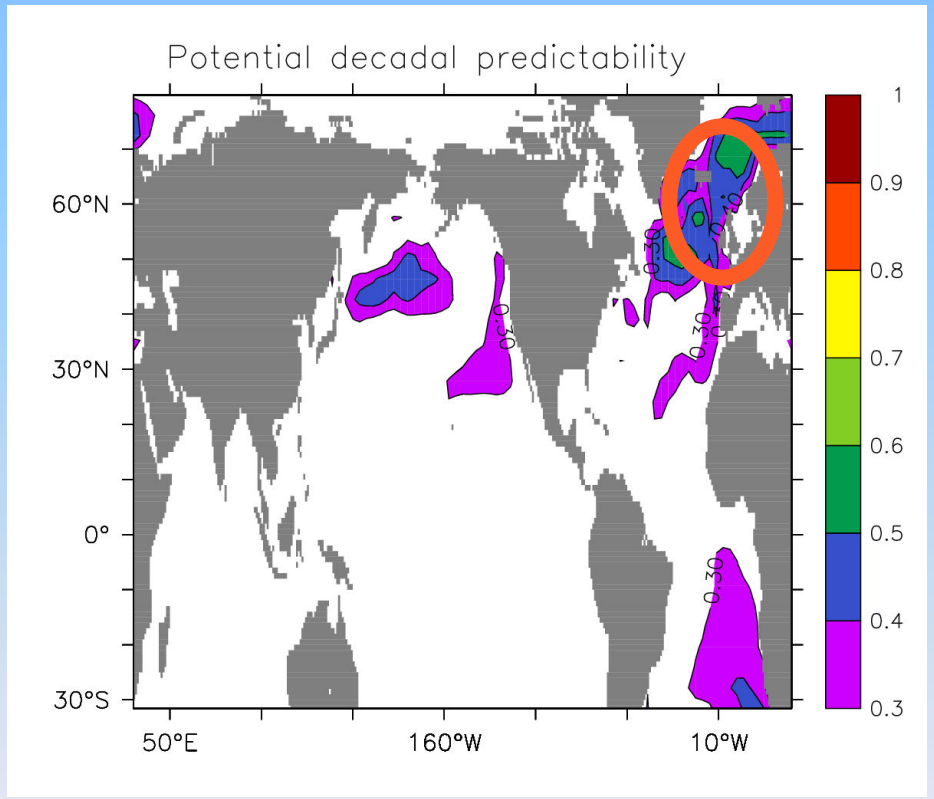
Interannual vs. decadal potential predictability

interannual (1-5 years)



decadal (10-100 years)



Latif et al. 2009

Obtained from the Kiel Climate Model (KCM)

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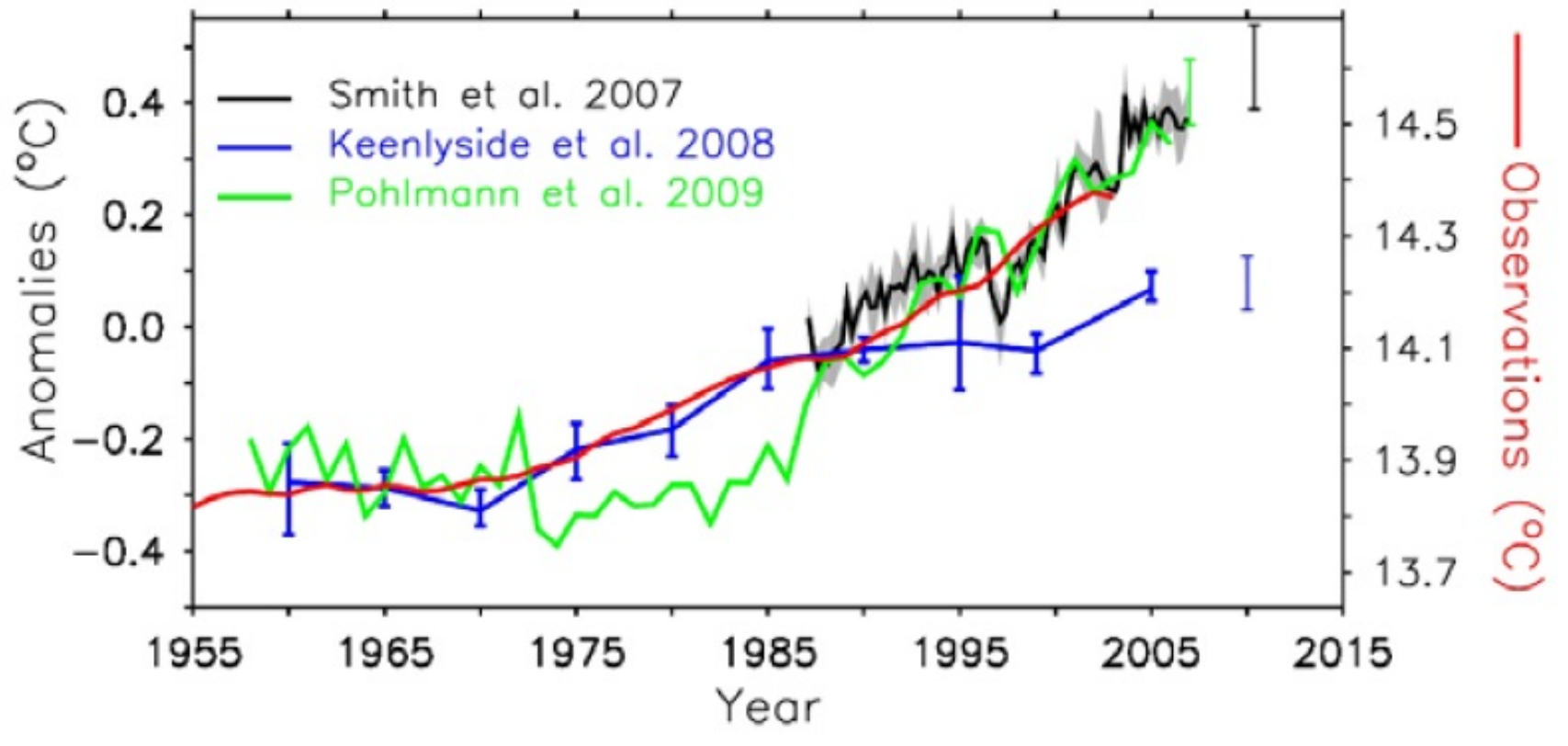
Prediction of global SAT for the next decade



Hurrell et al., BAMS, 2009

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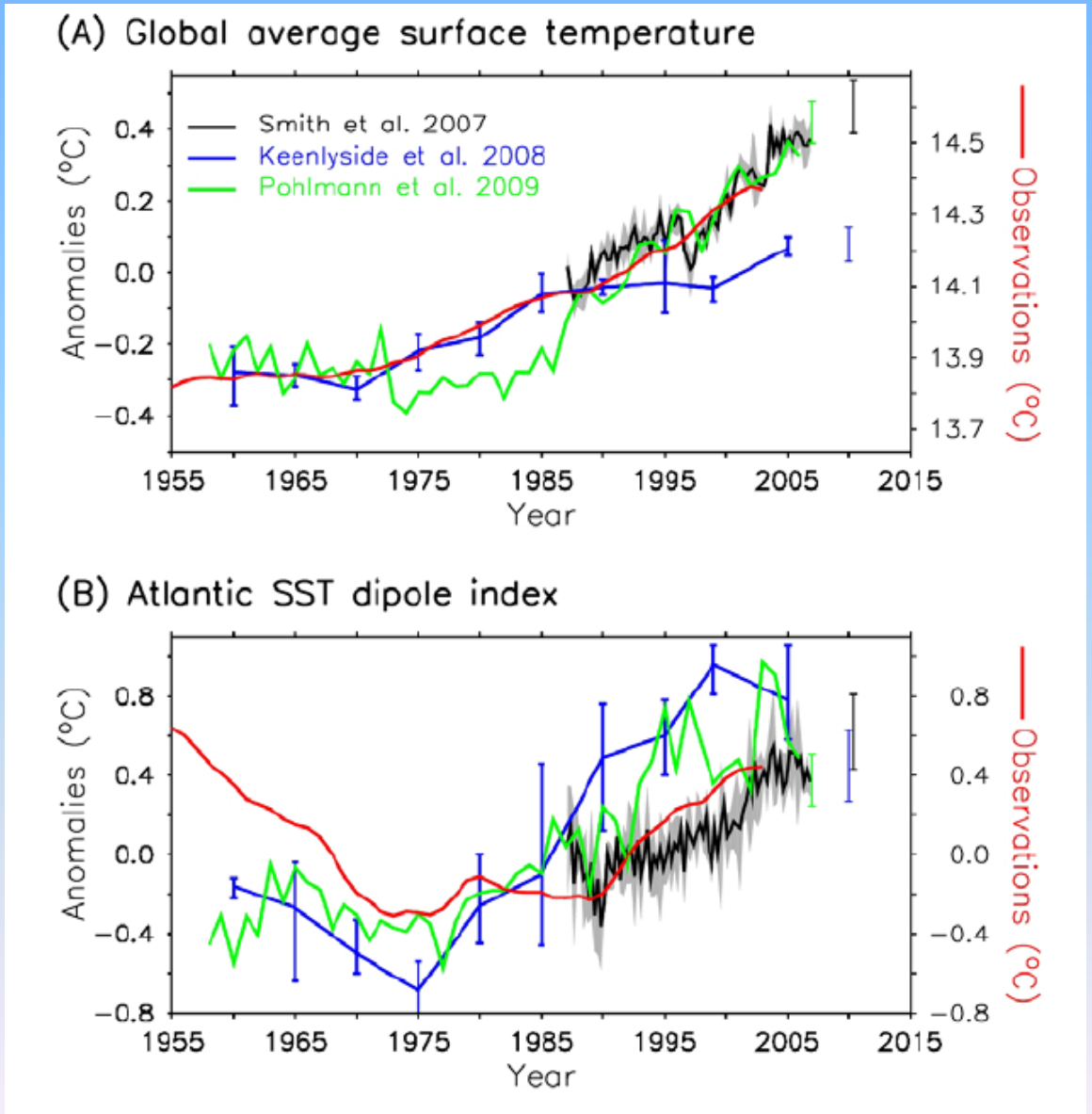
Prediction of global SAT and MOC



Hurrell et al., BAMS, 2009

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Conclusions

- There is strong evidence that the multidecadal SAT variability in the Atlantic (and globally) is driven (at least partly) by variations in the MOC
- A stochastic scenario is most plausible, in which the ocean is driven by the low-frequency portion of the atmospheric variability (NAO)
- However, the atmospheric response to SST anomalies is still not understood and the role of coupled feedbacks is unclear
- MOC variability appears to be predictable about a decade ahead
- The most recent decades contain a strong contribution from the AMO (MOC) even on a global scale. This raises questions about the average climate sensitivity of the IPCC models