Do models underestimate the atmospheric response to Arctic sea-ice loss?

James Screen, Russell Blackport, Erik Kolstad

Models experiments are important for determining causality but….

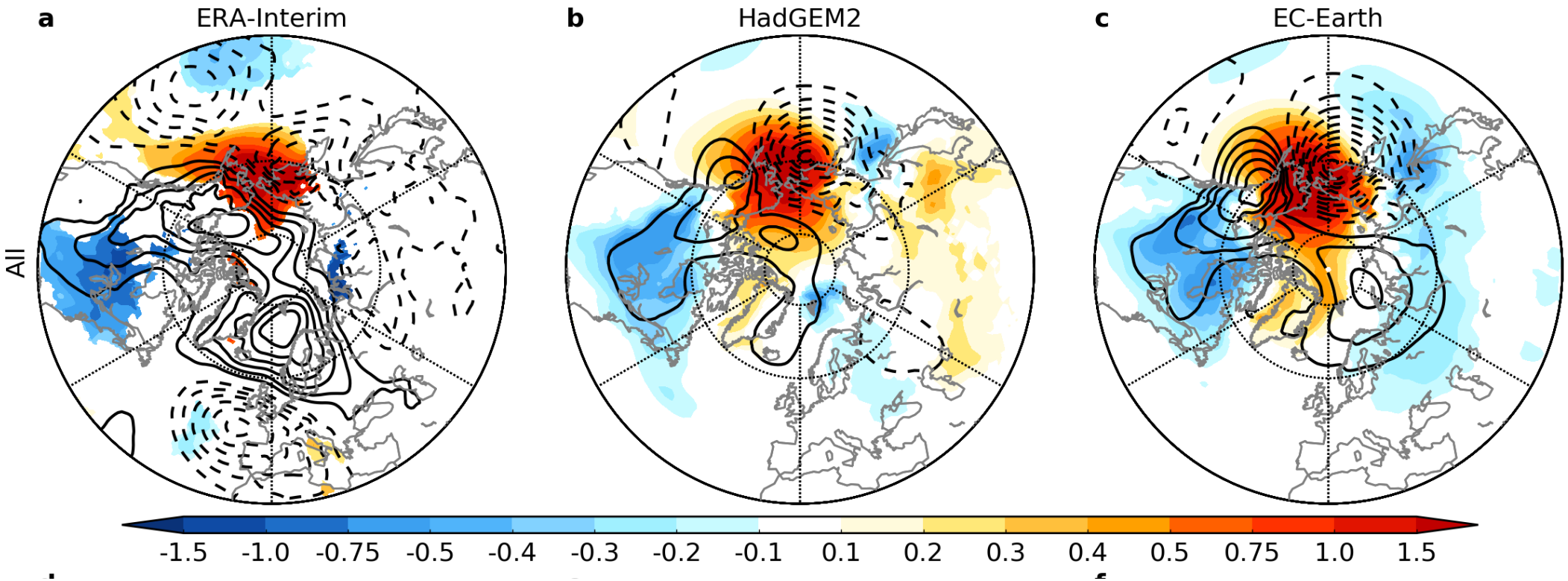
Should we trust in models to give us the right answer?

Do models capture the observed link between….

Winter Beaufort-Chukchi sea ice and North American cooling?

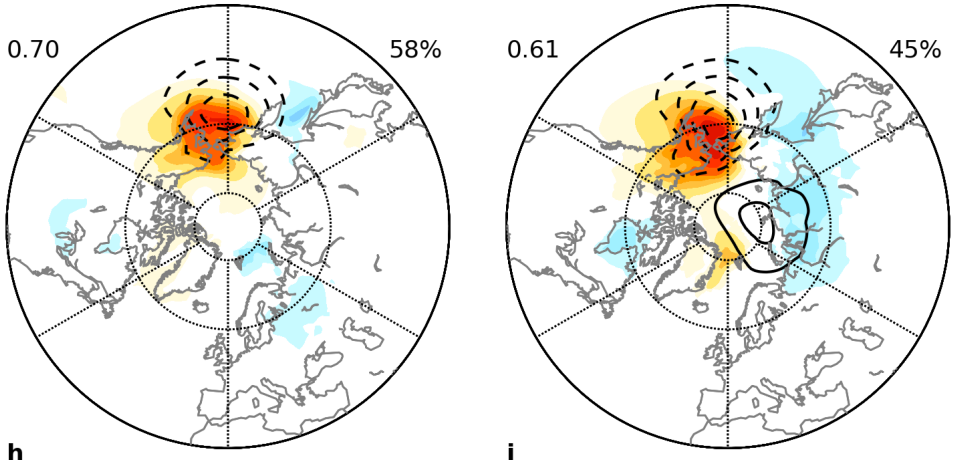
Observations and **models** depict the **same co-variability** between **Beaufort-Chukchi sea ice** and **North American winter temperature**

Regression between **Beaufort-Chukchi sea ice** and **temperature** (shading) and **sea level pressure** (contours)

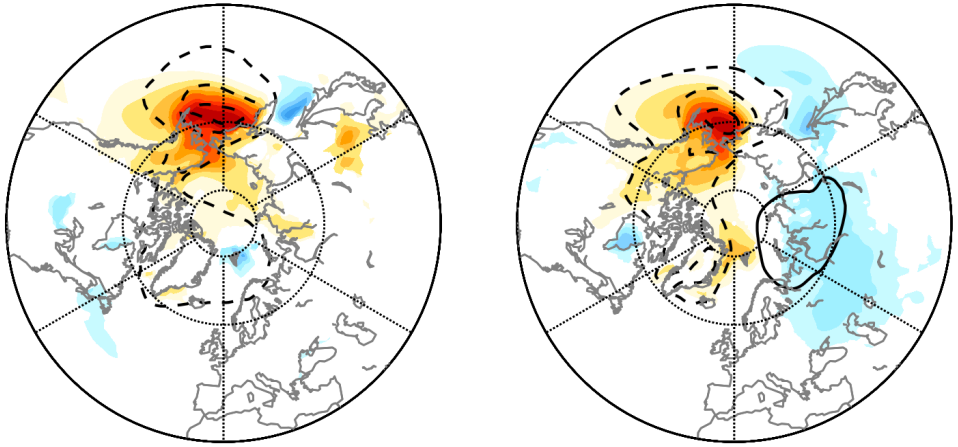


Minimal influence of **reduced sea ice** on **cold winters**

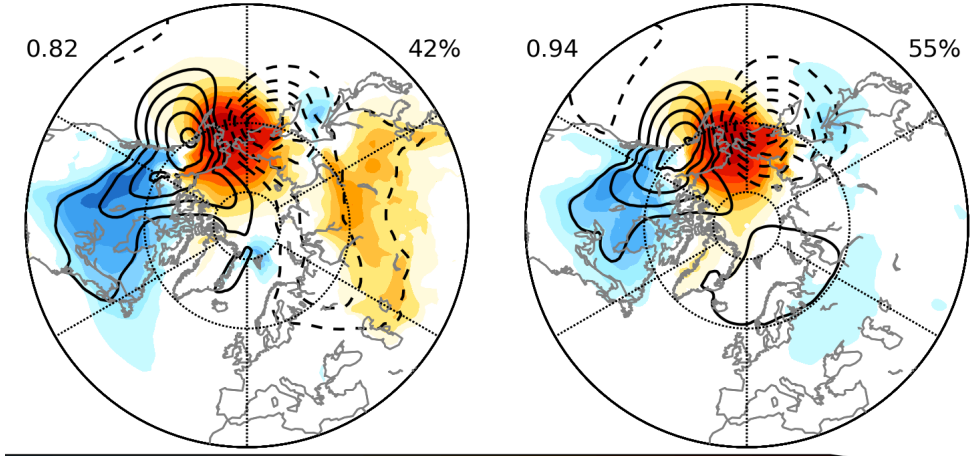
Flux-based estimate of **ice driving atmosphere**



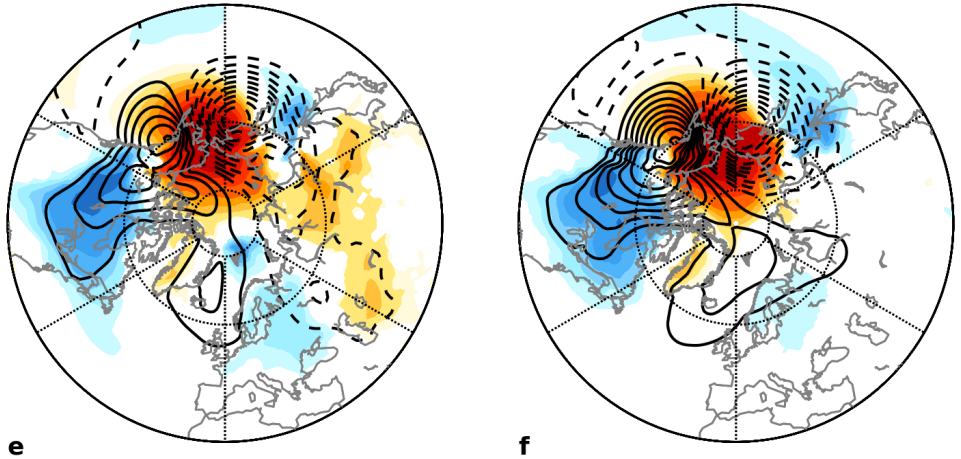
Lead-lag-based estimate of **ice driving atmosphere**



Flux-based estimate of **atmosphere driving ice**



Lead-lag-based estimate of **atmosphere driving ice**

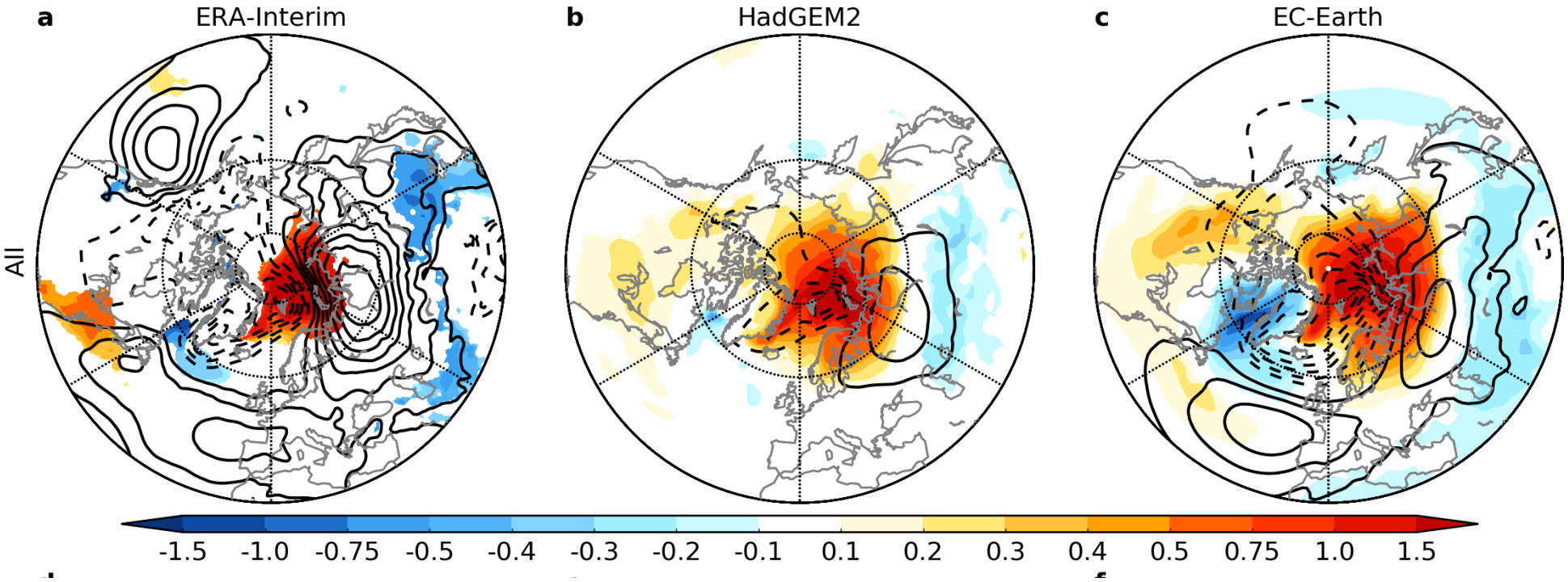


Do models capture the observed link between….

Winter Barents-Kara sea ice and Eurasian cooling?

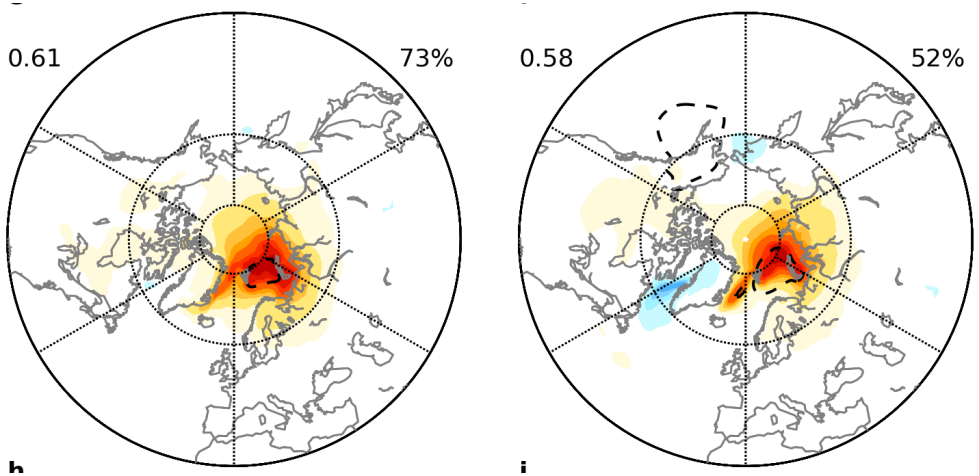
Observations and **models** depict **similar co-variability** between **Barents-Kara sea ice** and **Eurasian winter temperature**…..but **weaker in the models**

Regression between **Barents-Kara sea ice** and **temperature** (shading) and **sea level pressure** (contours)

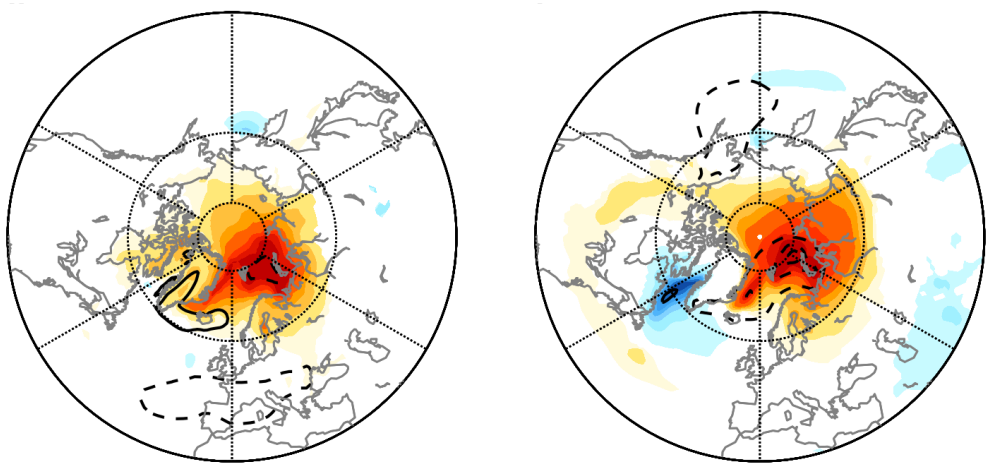


Minimal influence of **reduced sea ice** on **cold winters**

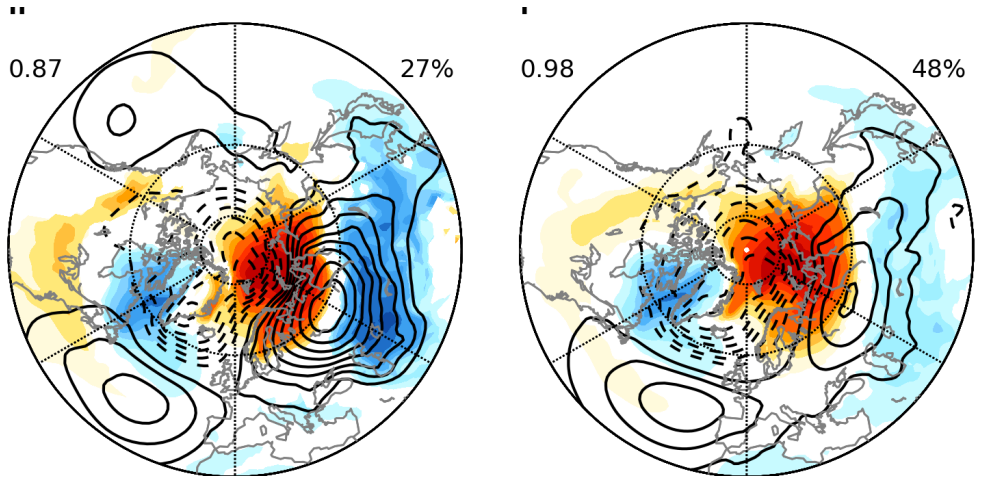
Flux-based estimate of **ice driving atmosphere**



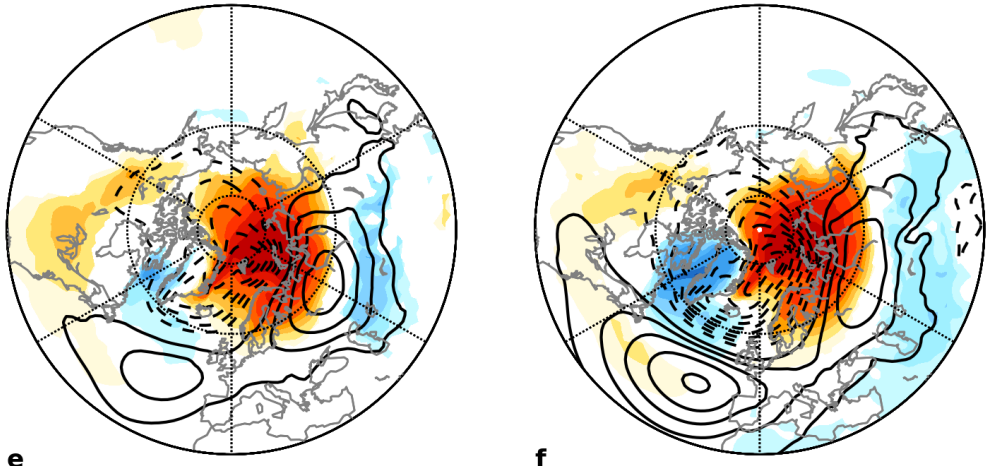
Lead-lag-based estimate of **ice driving atmosphere**



Flux-based estimate of **atmosphere driving ice**

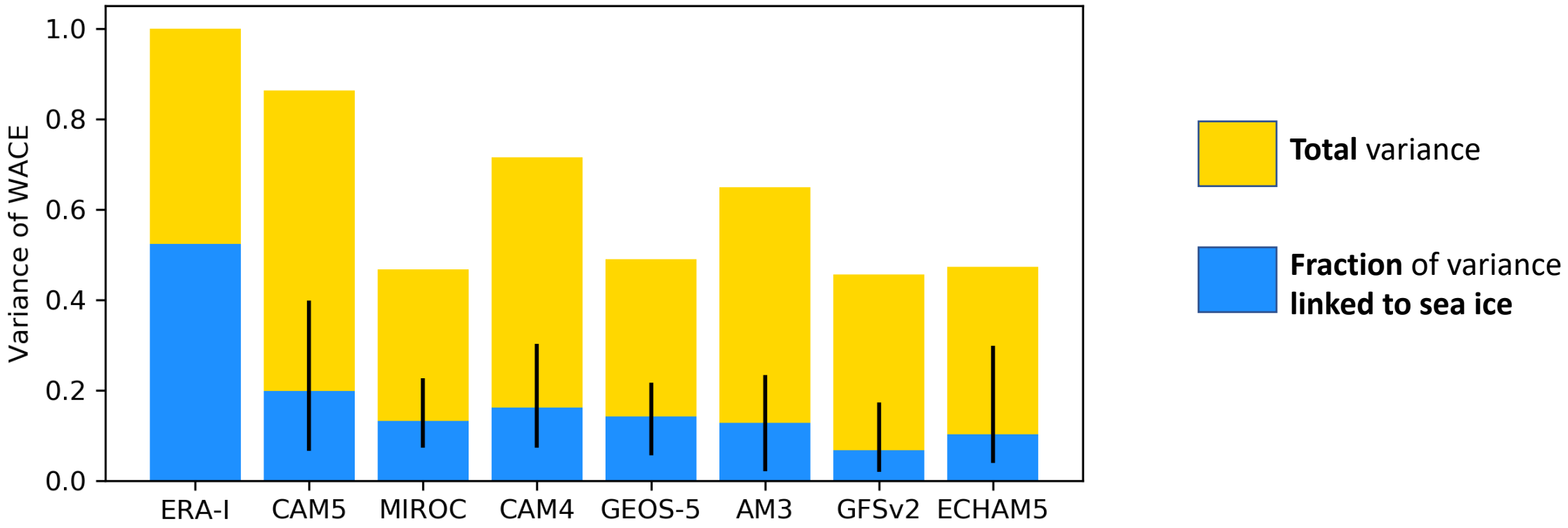


Lead-lag-based estimate of **atmosphere driving ice**



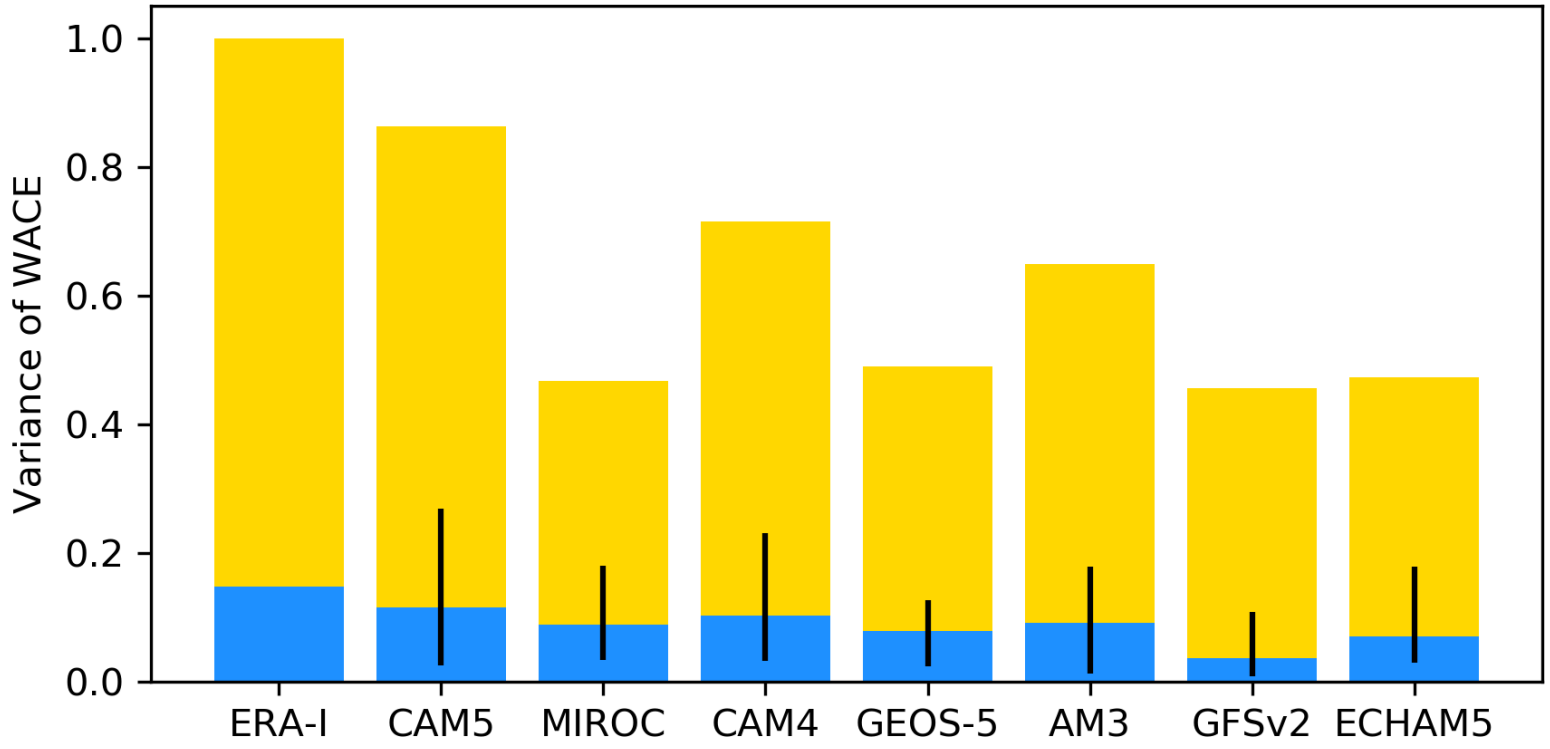
Smaller fraction of **WACE** variance is **linked** to **sea ice** than in **models than in observations**

Variance of the **warm Arctic and cold Eurasia** (WACE) pattern in **observations** and **models**



Fraction of **WACE** variance **driven** by **sea ice** is comparable in **models** and **observations**

Variance of the **warm Arctic and cold Eurasia** (WACE) pattern in **observations** and **models**



Total variance

Fraction of variance **linked to sea ice**

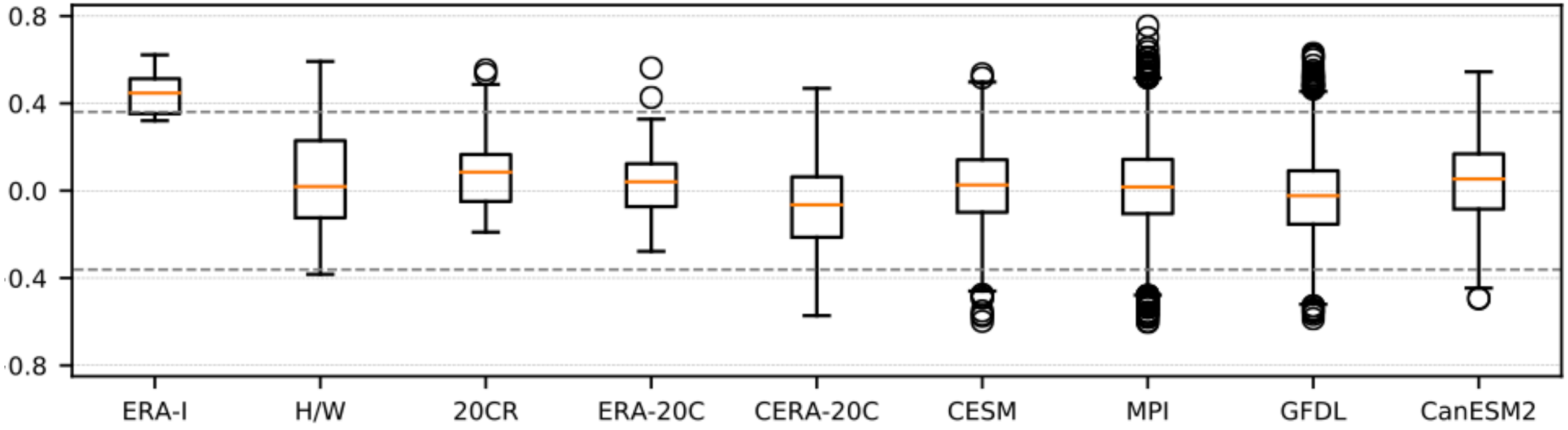
Lead-lag-based estimate of **ice driving atmosphere**

Do models capture the observed link between….

Autumn Barents-Kara sea ice and the winter North Atlantic Oscillation?

Connection between sea ice and the NAO is **unusually strong in recent years**, but **within the range** simulated by **models**, owing to internal variability

30-year correlation between **autumn Barents-Kara sea ice** and the **winter North Atlantic Oscillation**

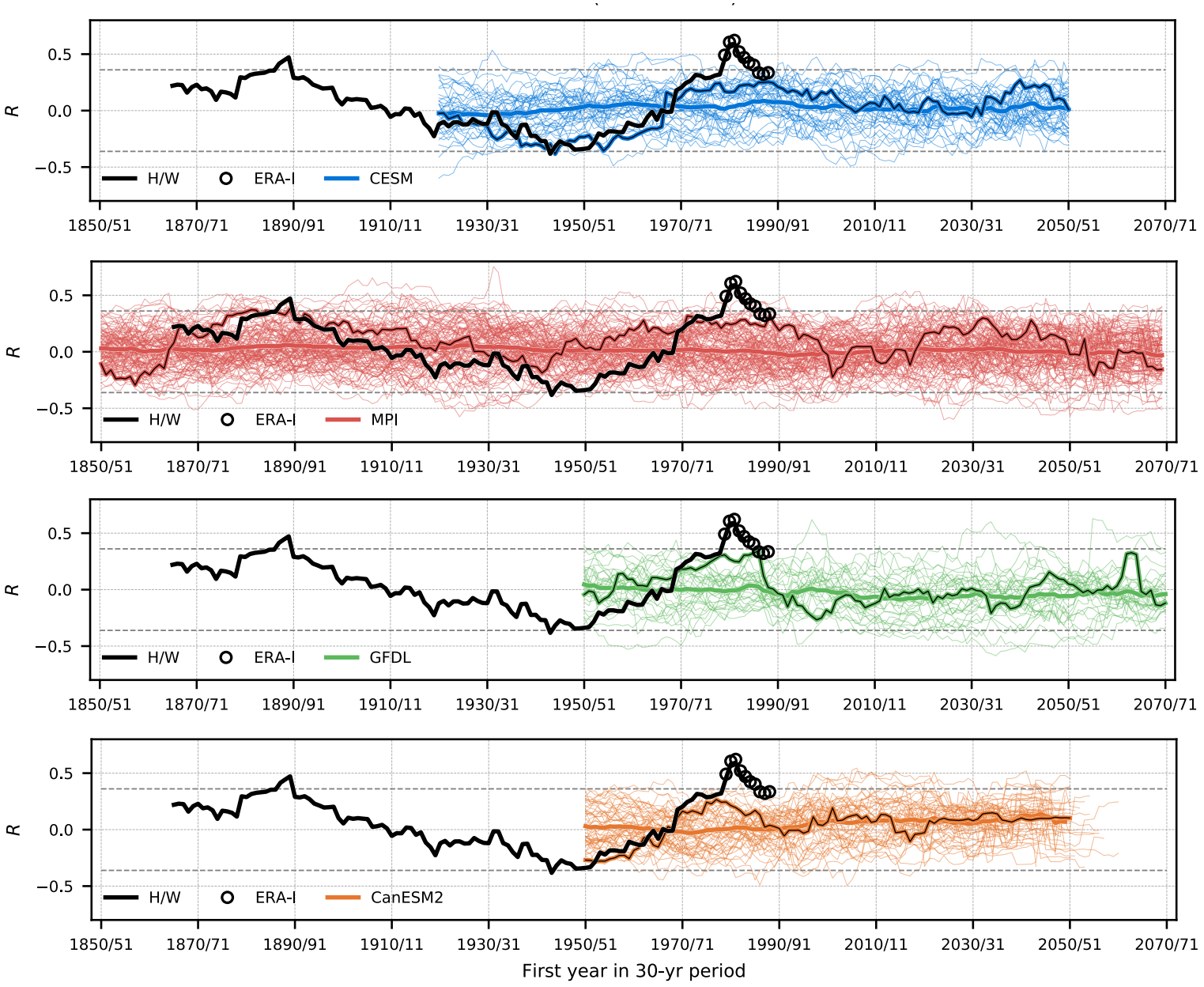


Mean correlation is close to **zero in all models** and in observations/reanalyses over the full

Magnitude and **sign** of the observed ice-NAO correlation has **fluctuated** on **decadal** timescales

Individual **model** realizations capture **similar variability** as **observed**

Running **30-year correlation** between **autumn Barents-Kara sea ice** and the **winter NAO**, in **observations** and **models**



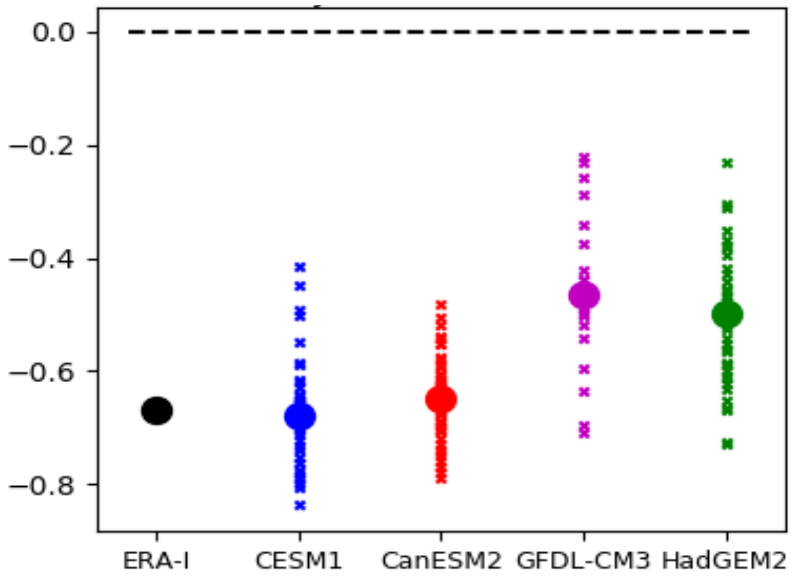
Do models capture the observed link between….

Arctic amplification and increased midlatitude planetary wave amplitude?

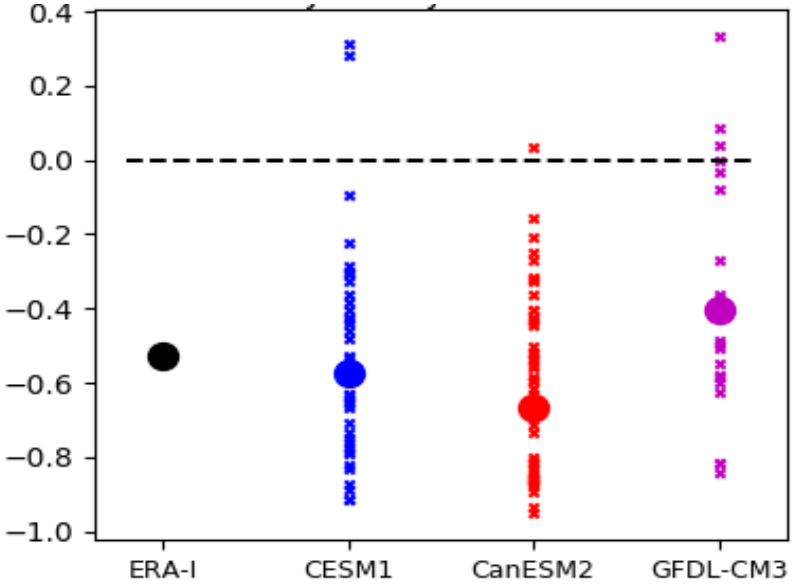
Models all show **increased waviness** when the equator-to-pole **temperature gradient is weakened**

Correlation between winter midlatitude wave **amplitude** and meridional **temperature gradient**, in **observations** and **models**

On **interannual** timescales



On **decadal** timescales

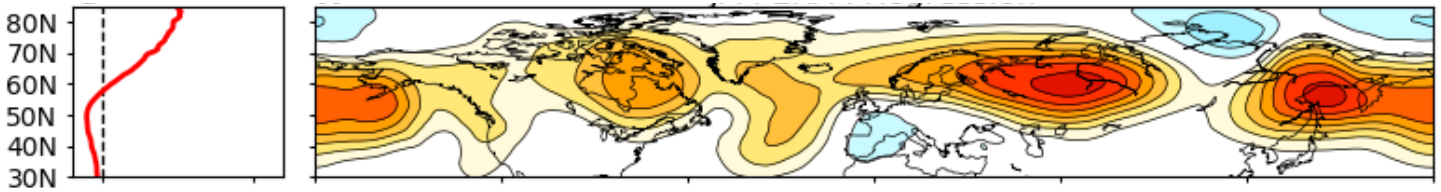


Model and observations show **same interannual variability**

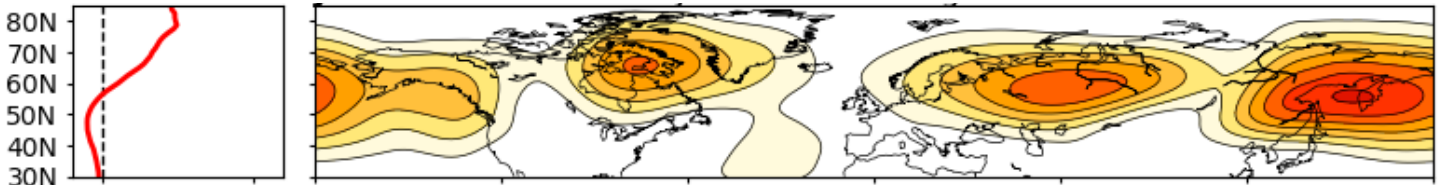
But, reduced temperature gradient is **not a cause** of changes in waviness

Regression between winter local wave **amplitude** and meridional **temperature gradient**

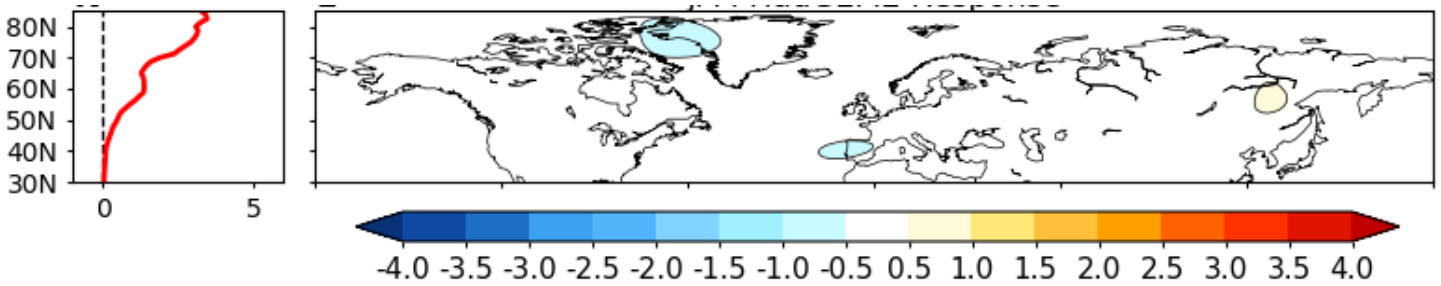
In **observed interannual variability**



In a **model's interannual variability**



Modelled response of winter local wave **amplitude** to an imposed reduced in the meridional **temperature gradient**



Do models underestimate the atmospheric response to Arctic sea-ice loss?

No

Or at least, we cannot rule out the differences between observational and model estimates are due to internal climate variability.

Blackport, R., J.A. Screen, K. van der Wiel & R. Bintanja, 2019: **Minimal influence of reduced Arctic sea ice on coincident cold winters in mid-latitudes**. Nature Clim. Change, accepted.

Screen, J.A. & R. Blackport, 2019: **Do models underestimate Eurasian cooling in response to Arctic sea-ice loss?** Nature Clim. Change, submitted.

Kolstad, E.W. & J.A. Screen, 2019: **Non-stationary relationship between autumn Arctic sea ice and the winter North Atlantic Oscillation**. Geophys. Res. Lett., accepted.

Blackport, R. & J.A. Screen, 2019: **Insignificant effect of Arctic amplification on the amplitude of mid-latitude atmospheric waves**. Sci. Adv., submitted.