

# Polar Amplification MIP (PAMIP)

**Objective:** to investigate the causes and consequences of polar amplification

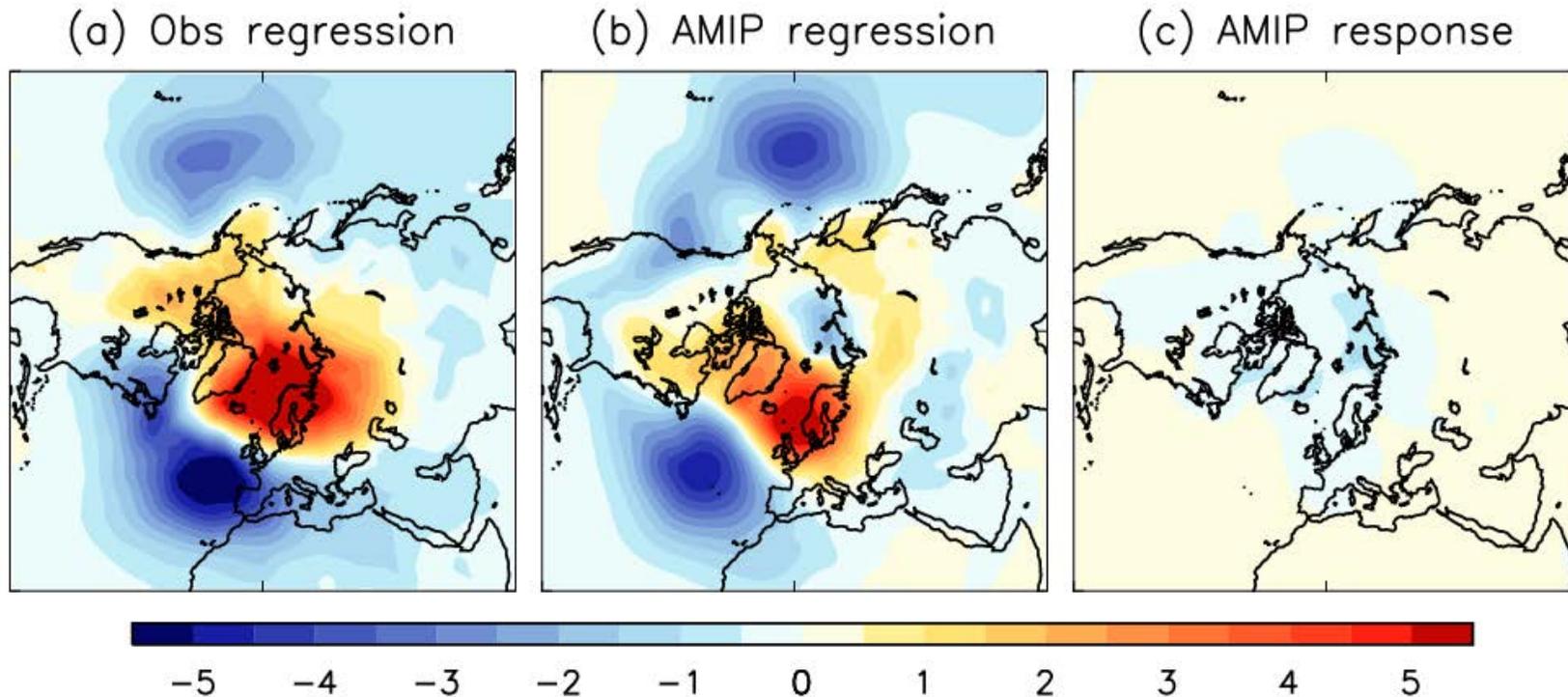
**Co-chairs:**

Doug Smith (Met Office), James Screen (University of Exeter),  
Clara Deser (NCAR)

**Team:**

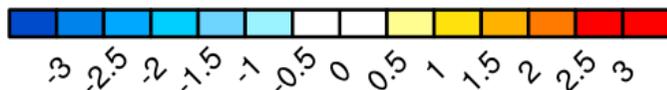
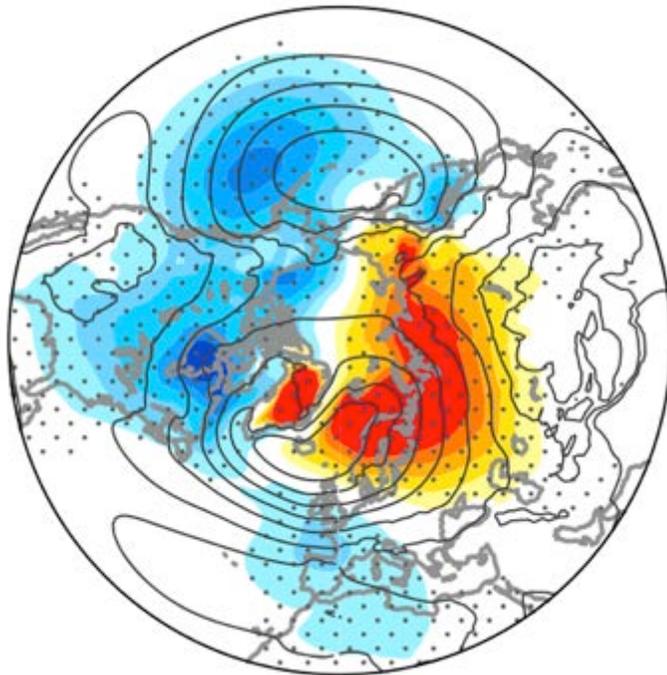
Judah Cohen (AER), John Fyfe (CCCma),  
Javier García-Serrano (BSC), Thomas Jung (AWI),  
Daniela Matei (MPI), Rym Msadek (CERFACS),  
Yannick Peings (University of California), Jinro Ukita (Niigata University),  
Jin-Ho Yoon (GIST), Xiangdong Zhang (University of Alaska)

# Real world response? *Cannot be diagnosed from regression*



- Regression between autumn (SON) sea ice extent and winter (DJF) sea level pressure (sign reversed)
- Obs and AMIP agree
- BUT AMIP response forced by reduced ice in model experiments sea ice is completely different
- The pattern is forced by SSTs rather than sea ice

# Non-robust response: full range of NAO responses have been reported

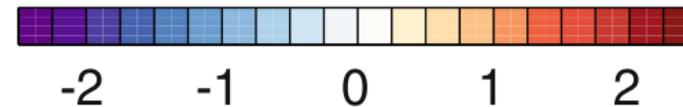
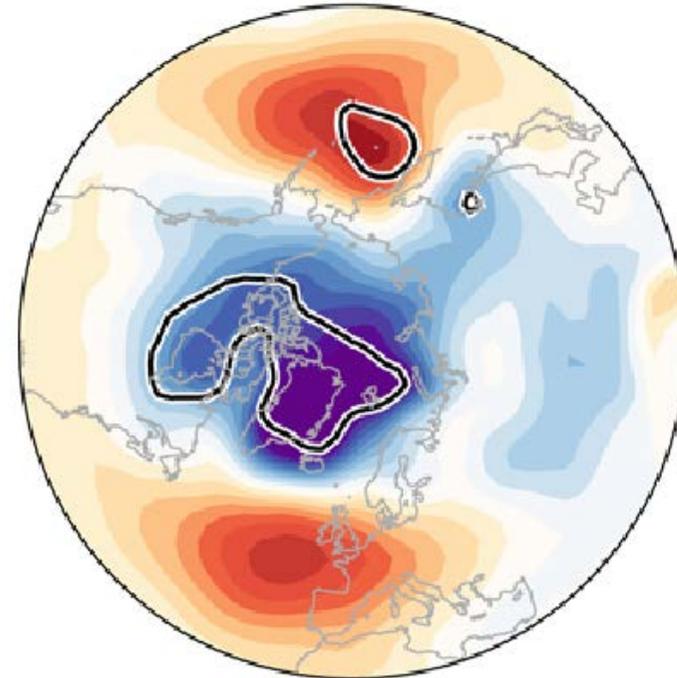


- **Negative NAO** (DJF, mslp, hPa)

- Deser et al 2016; Honda et al 2009; Seierstad and Bader 2009; Mori et al 2014; Kim et al 2014; Nakamura et al 2015 ...

- **Little NAO response**

- Screen et al. 2013; Petrie et al 2015; Blackport and Kushner 2016 ...



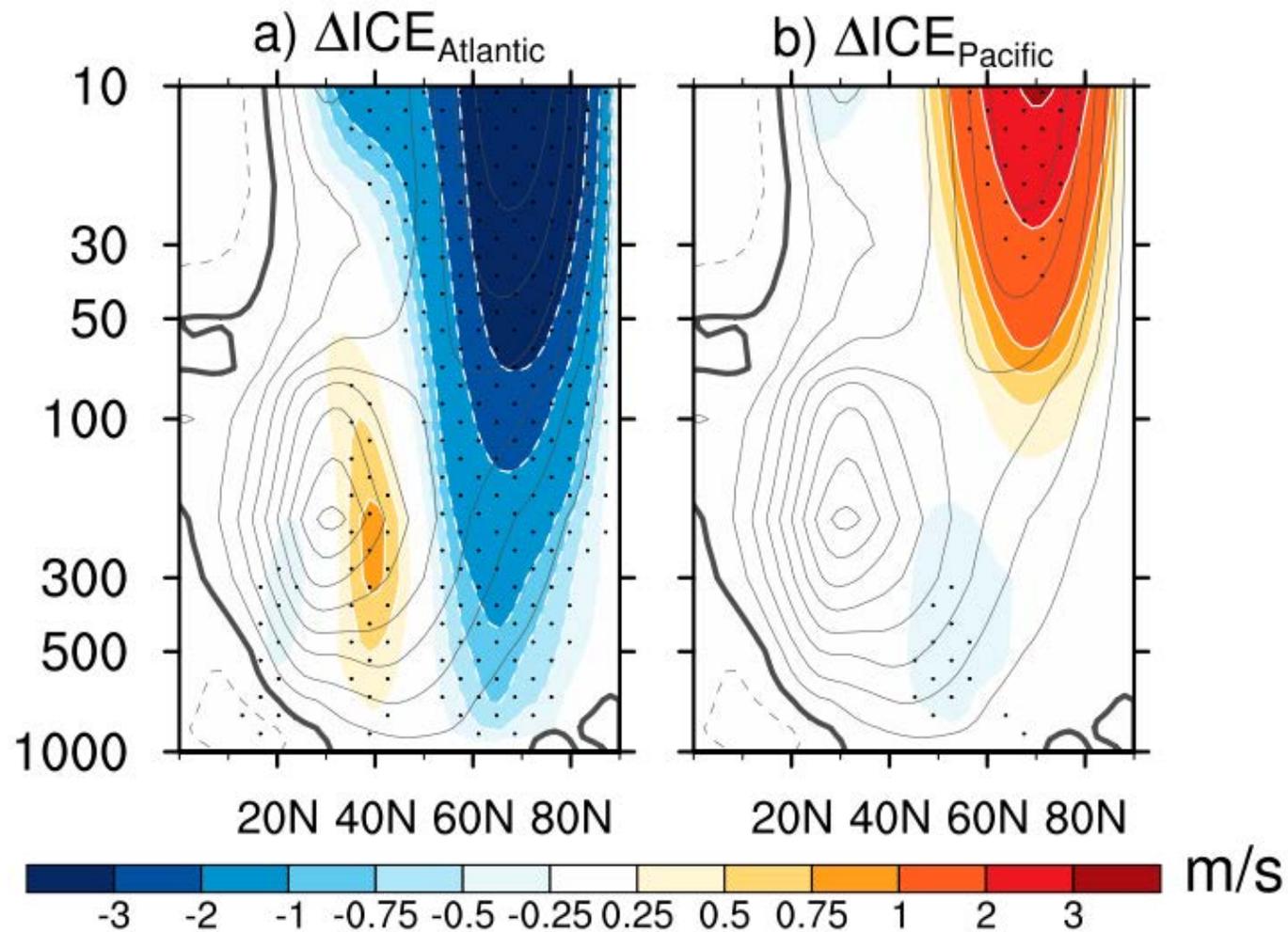
- **Positive NAO**

- Screen et al 2014; Singarayer et al 2006; Strey et al 2010; Orsolini et al 2012; Rinke et al 2013; Cassano et al 2014 ...

- **NAO response that depends on the forcing**

- Alexander et al 2004; Petoukhov and Semenov 2010; Peings and Magnusdottir 2014; Sun et al. 2015; Pedersen et al 2016; Chen et al 2016 ...

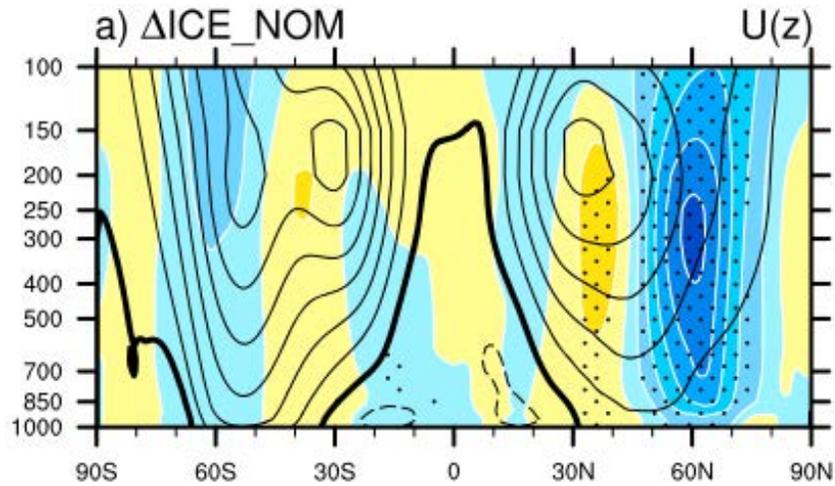
# Pattern of forcing



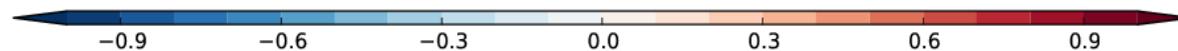
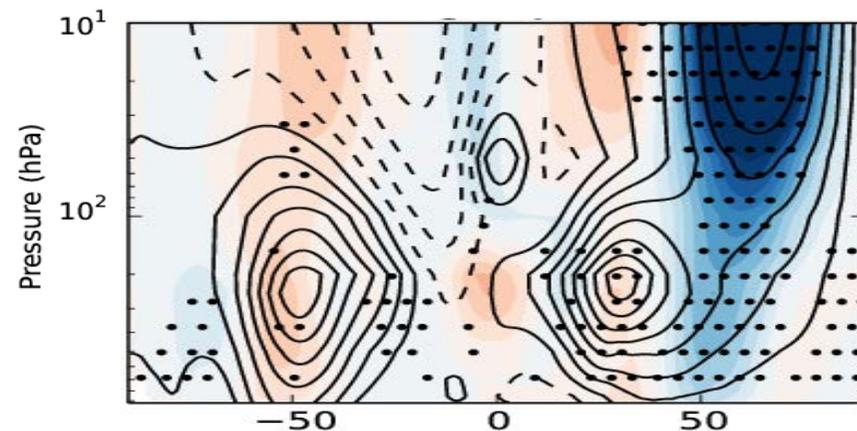
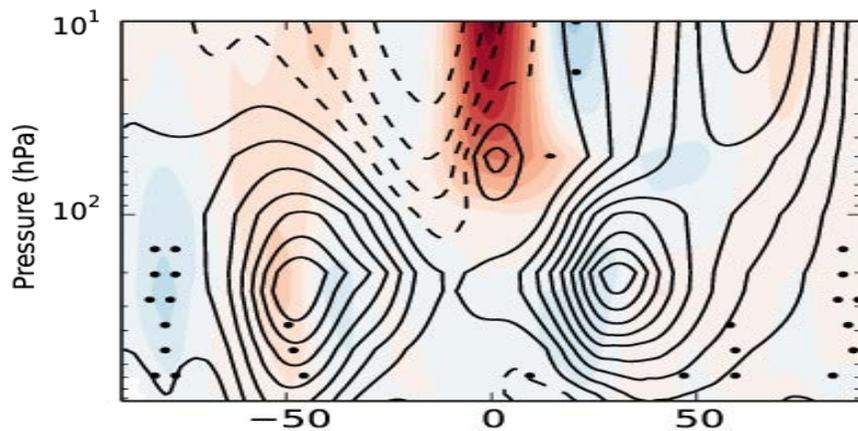
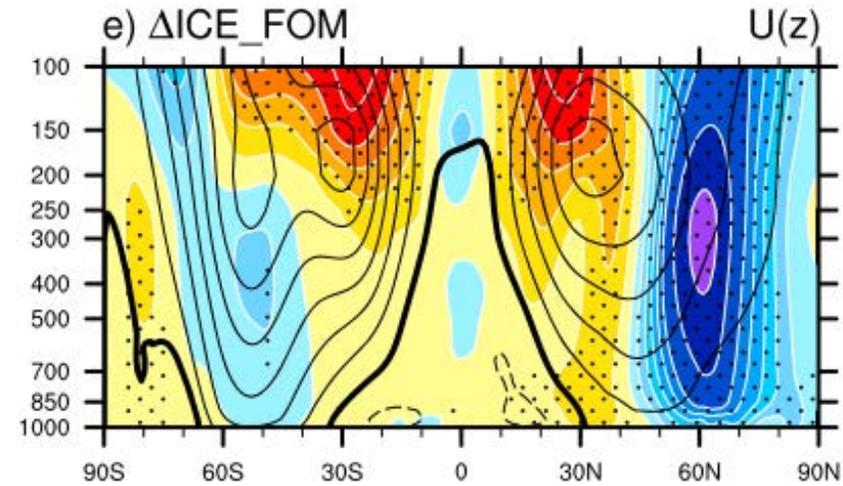
- Opposite response if forcing is applied in Atlantic and Pacific sectors separately
- Sun et al 2015; Alexander et al 2004; Peings and Magnusdottir 2014; Screen 2017

# Atmosphere vs coupled models

Atmosphere only model

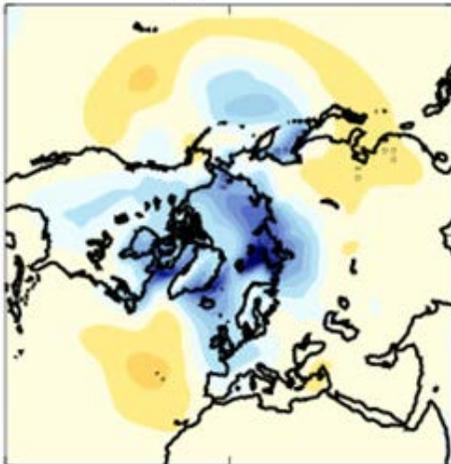


Fully coupled model

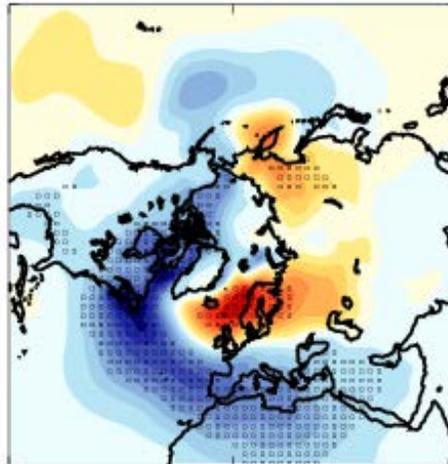


# Dependence on background state

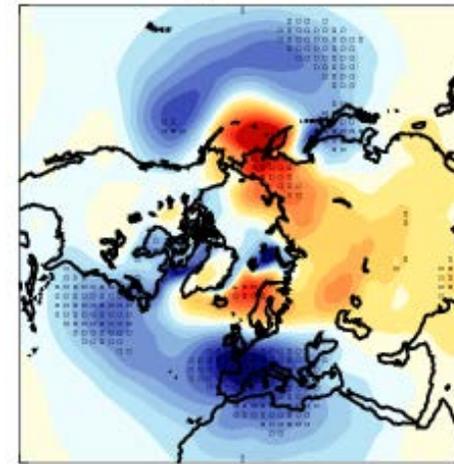
Atmosphere model



Coupled model



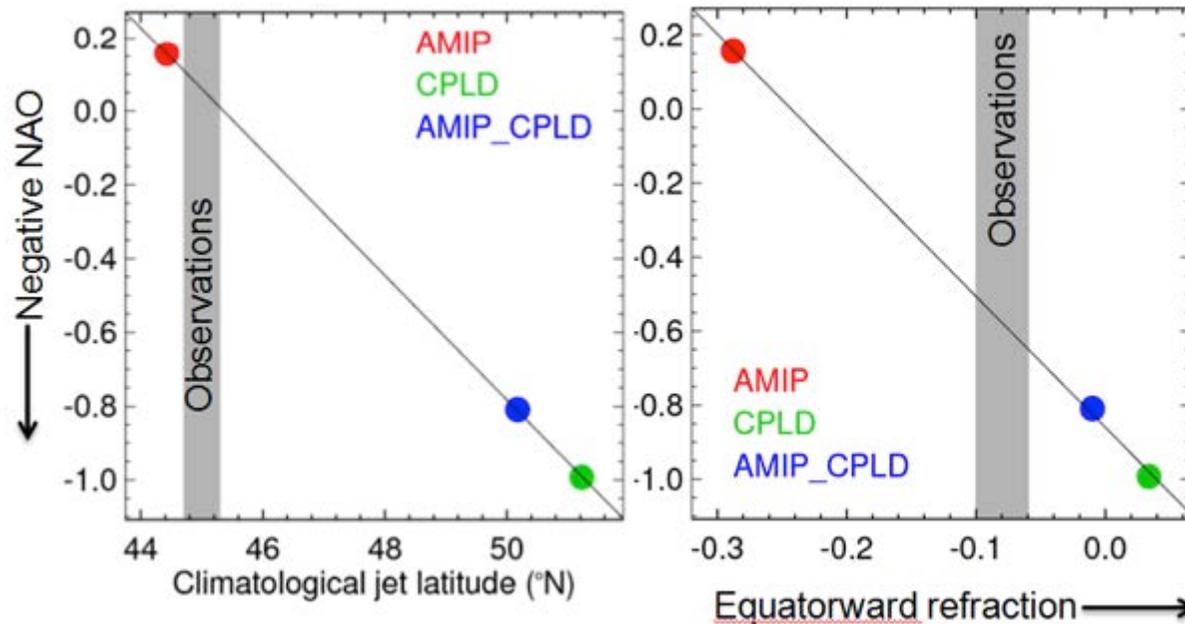
AMIP\_CPLD



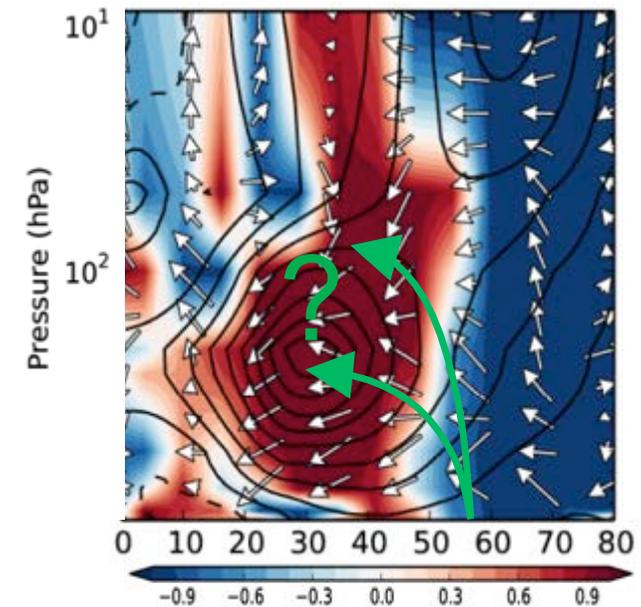
- Different response could be caused by coupling or background state (model bias)
- Test by repeating atmosphere model but imposing COUPLED SST bias → AMIP\_CPLD
- Reproduces COUPLED response → **background state is key**

# Emergent constraint?

## Response in Atlantic jet



Correlation of jet response with EP flux response and background refractive index (NB for *increased* sea ice)



- Response is correlated with jet latitude
- Possibility of “emergent constraint”?
- But response depends on wave propagation, and hence background refractive index
- Need constraint to be based on underlying physics
- **Need more models → coordinated multi-model experiments**

# Experiments (1)

No.	Experiment name	Description	Notes	Tier	Number of years	Minimum ensemble size
<b>1. Atmosphere-only time slice experiments</b>						
1.1	amip-control	AMIP simulations forced by climatological monthly mean sea surface temperature (SST) and sea ice concentration (SIC) for the present day <sup>1,2</sup>		1	1	100
1.2	amip-piSST	Repeat 1.1 but with pre-industrial SST	Investigate the role of SSTs in polar amplification	1	1	100
1.3	amip-2degSST	Repeat 1.1 but with future SST representing 2 degree global warming		2	1	100
1.4	amip-piSIC-Arctic	Repeat 1.1 but with pre-industrial Arctic SIC <sup>3</sup>	Investigate the impacts of present day and future Arctic sea ice, and the role of Arctic SIC in polar amplification	1	1	100
1.5	amip-2degSIC-Arctic	Repeat 1.1 but with future Arctic SIC <sup>3</sup>		1	1	100
1.6	amip-piSIC-Antarctic	Repeat 1.1 but with pre-industrial Antarctic SIC <sup>3</sup>	Investigate the impacts of present day and future Antarctic sea ice, and the role of Antarctic SIC in polar amplification	2	1	100
1.7	amip-2degSIC-Antarctic	Repeat 1.1 but with future Antarctic SIC <sup>3</sup>		2	1	100
<b>2. Coupled time slice experiments</b>						
2.1	cpId-control	Coupled model simulation constrained by climatological monthly mean sea ice concentration for the present day <sup>2,4</sup>		2	1	100
2.2	cpId-piSIC-Arctic	Repeat 2.1 but with pre-industrial Arctic SIC <sup>3</sup>	As 1.4 and 1.5 but with coupled model	2	1	100
2.3	cpId-2degSIC-Arctic	Repeat 2.1 but with future Arctic SIC <sup>3</sup>		2	1	100
2.4	cpId-piSIC-Antarctic	Repeat 2.1 but with pre-industrial Antarctic SIC <sup>3</sup>	As 1.6 and 1.7 but with coupled model	3	1	100
2.5	cpId-2degSIC-Antarctic	Repeat 2.1 but with future Antarctic SIC <sup>3</sup>		3	1	100

## Notes:

<sup>1</sup>All necessary SST and sea ice fields will be provided to participants.

<sup>2</sup>Time slice simulations to begin on 1<sup>st</sup> April (?) and run for one year (or do we need an extra month or 2?)

<sup>3</sup>Past and future sea ice will be computed from the ensemble of CMIP5 projections as described below. SST where sea ice has reduced will be provided.

<sup>4</sup>Sea ice concentration to be nudged into coupled model with a relaxation time-scale of 6 hours (?)

# Experiments (2)

	Antarctic					
<b>3. Atmosphere-only time slice experiments to investigate regional forcing</b>						
3.1	amip-2degSIC-Arctic-Pacific	Repeat 1.5 but with future Arctic SIC only in the Pacific sector (or just Sea of Okhotsk?)	Investigate how the response depends on the pattern of Arctic sea ice forcing	3	1	100
3.2	amip-2degSIC-Arctic-Atlantic	Repeat 1.5 but with future Arctic SIC only in the Atlantic sector (or just Barents/Kara Seas?)		3	1	100
<b>4. Atmosphere-only time slice experiments to investigate the role of the background state</b>						
4.1	amip-control-cpldSST	Repeat 1.1 but with climatological SST from 2.1 rather than observations	Isolate the effects of the background state from the effects of coupling	3	1	100
4.2	amip-2degSIC - Arctic-cpldSST	Repeat 4.1 but with future Arctic SIC <sup>3</sup>		3	1	100
<b>5. Atmosphere-only transient experiments</b>						
5.1	amip-climSST-transientSIC	Repeat CMIP6 AMIP (1979-2014) but with climatological monthly mean SST	Use CMIP6 AMIP as the control. Investigate transient response and individual years	3	36	3
5.2	amip-transientSST-climSIC	Repeat CMIP6 AMIP (1979-2014) but with climatological monthly mean SIC		3	36	3
<b>6. Coupled transient experiments</b>						
6.1	cpld-control-transient	Coupled model control simulation of present day sea ice	Experiments to investigate the decadal and longer impacts of Arctic sea ice on the ocean. <b>Not sure how to do this!</b>	3	100	1
6.2	cpld-2degSIC-Arctic-transient	Coupled model simulation but with reduced Arctic sea ice		3	100	1

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