# Informing Arctic/agriculture linkages using climate model ensembles

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**Food Security Implications of a Changing Arctic**

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# Roadmap

① **Climate model ensembles are valuable but require careful use and interpretation**

- Sources of uncertainty in sea level projections

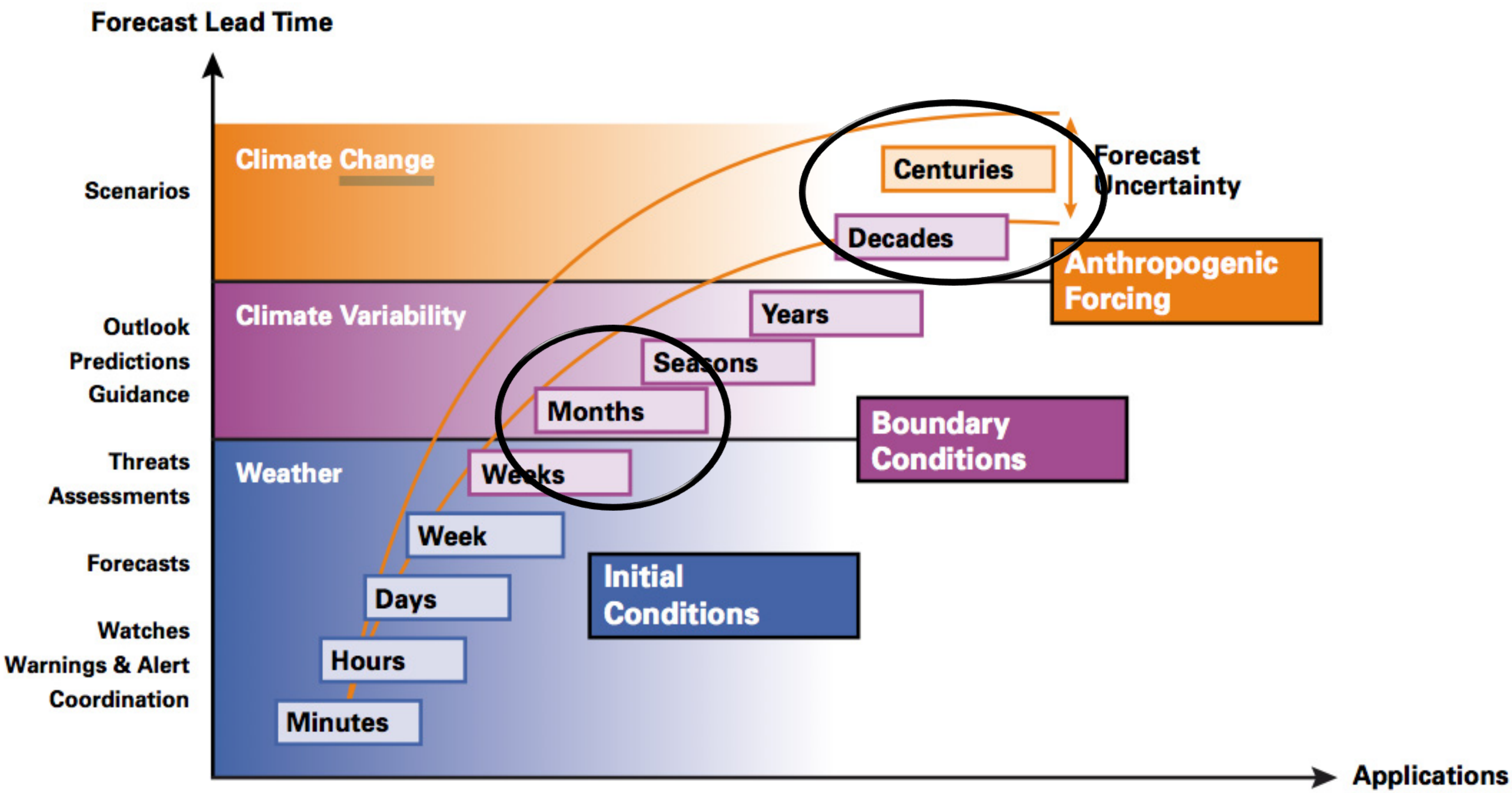
② **Across-ensemble linkages may be more robust (and more informative) than magnitude of impact**

- Spatial correlations in regional warming near Antarctica
- Joint impacts of sea level/storm surge

③ **Application to Arctic/Agriculture**

- Timescales of predictability
- Opportunities for climate ensemble insights

# Timescales of prediction



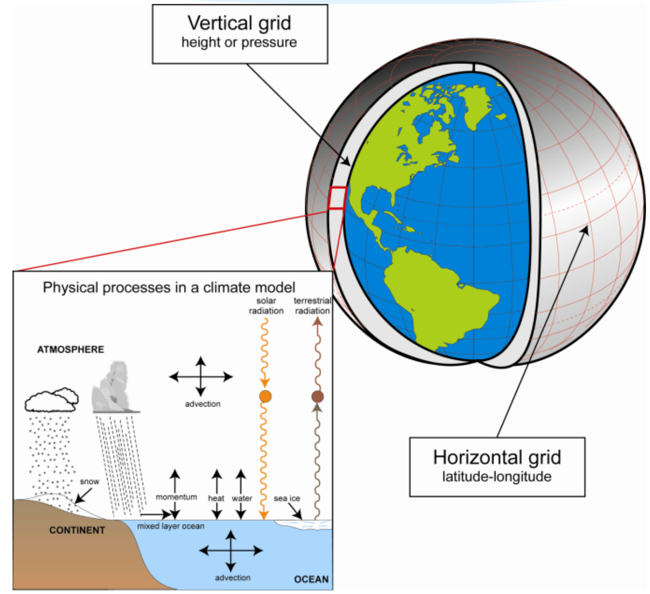
# Climate models 101

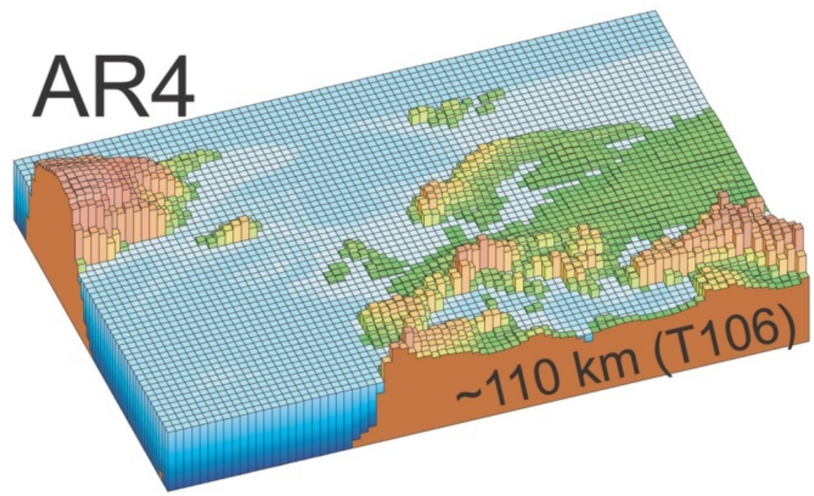
* Are physics-based, and solve conservation equations for mass, momentum, and energy within ‘gridboxes’

* Include parameterizations of hydrology, clouds, vegetation, and ocean

* Couple fluxes between the atmosphere, ocean, land, and cryosphere

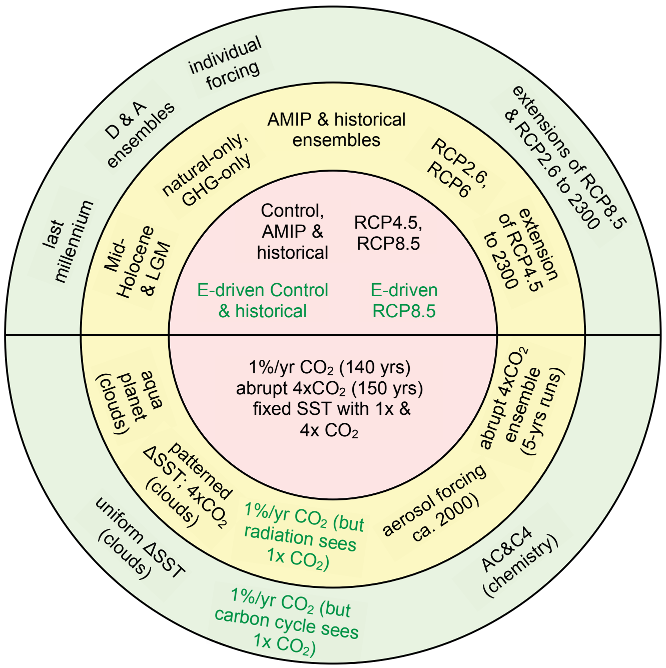
* Sensitive to initial conditions
  * El Nino/AO/PDO
  * “Phase” difference

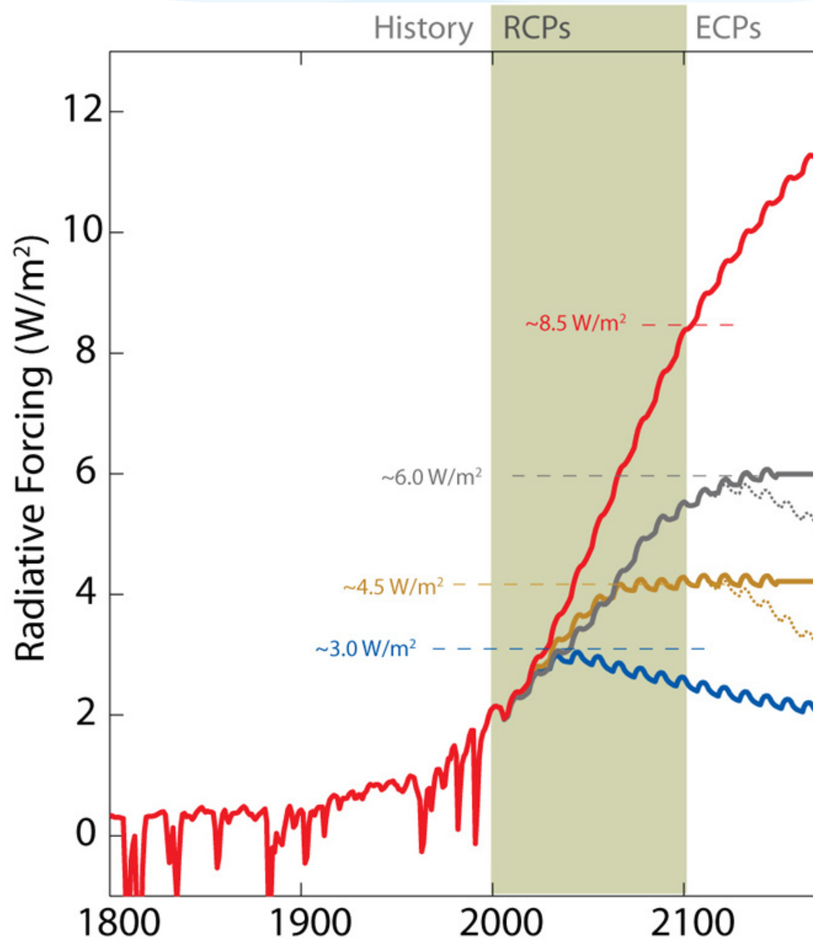



*IPCC AR5 2013*

# Climate model ensembles

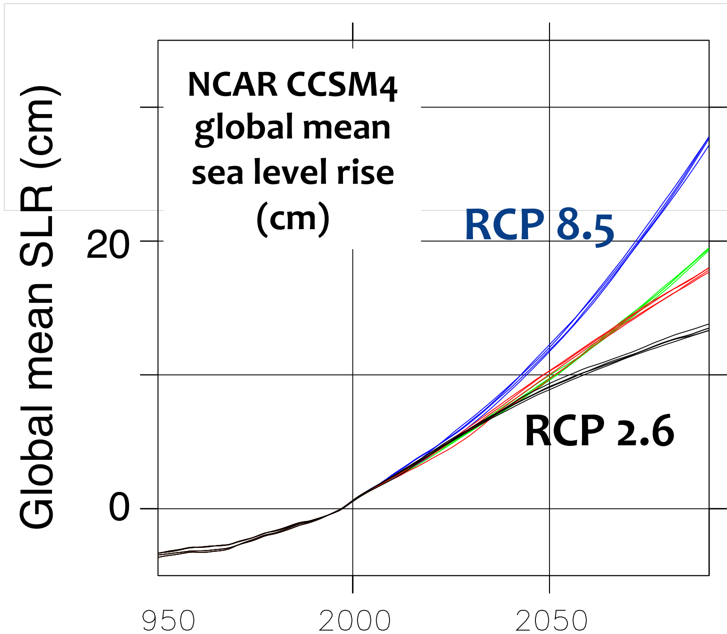


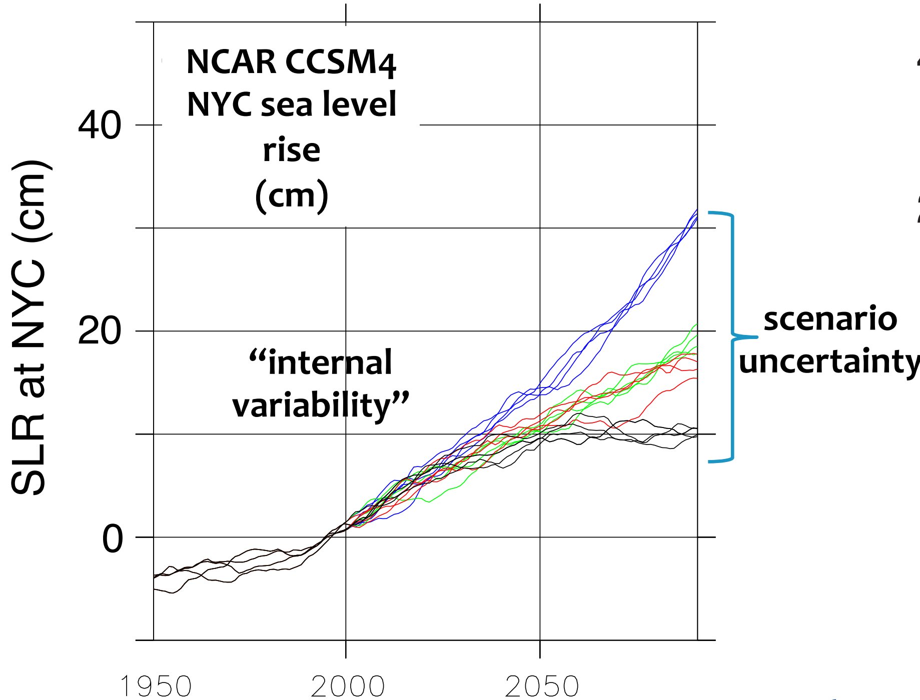



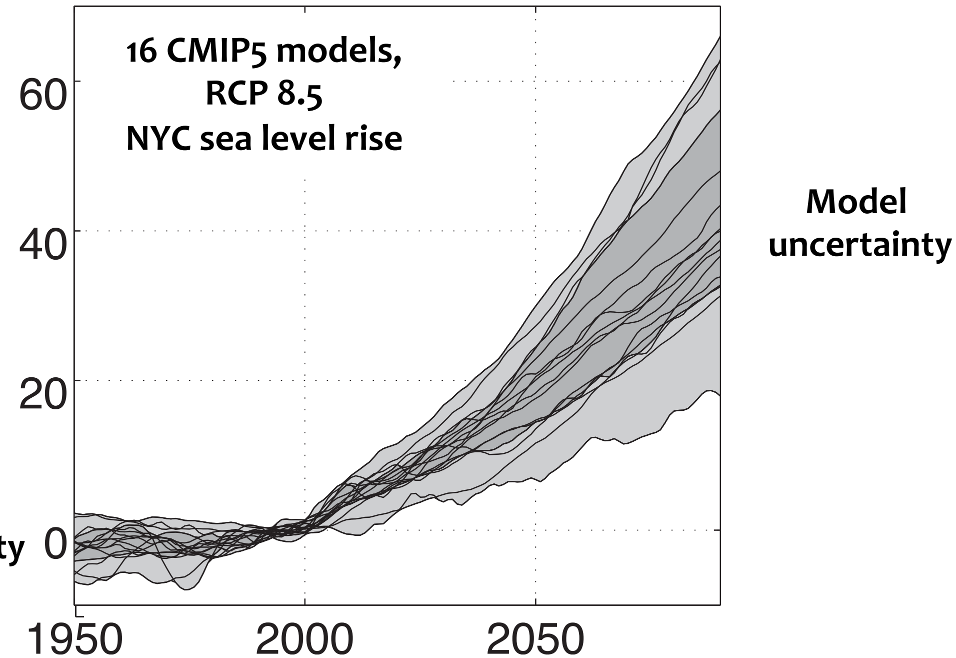

- Many (30-40) models, differ in resolution/structure/parameterizations
- Evolving; forcing and baseline are evolving too
  - Last round 2010-2013 (CMIP5)
  - New CMIP6 results end 2016

*Taylor et al. 2011, Meinshausen et al. 2011*

# Sources of uncertainty

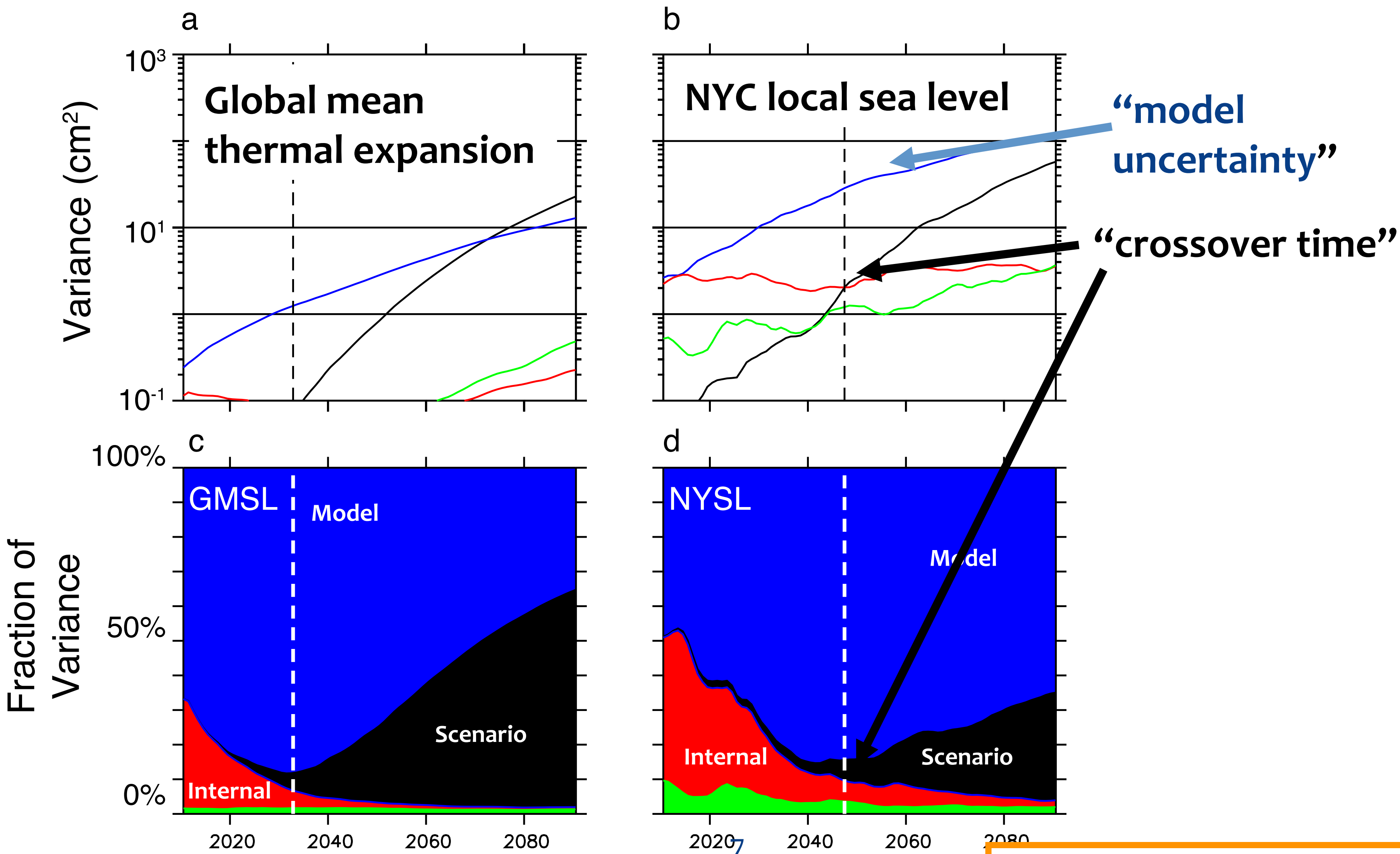



*C. M. Little, R. M. Horton, R. E. Kopp, M. Oppenheimer, and S. Yip (2015).* ***Uncertainty in 21st century CMIP5 sea-level projections.*** *Journal of Climate 28, 838–852.*

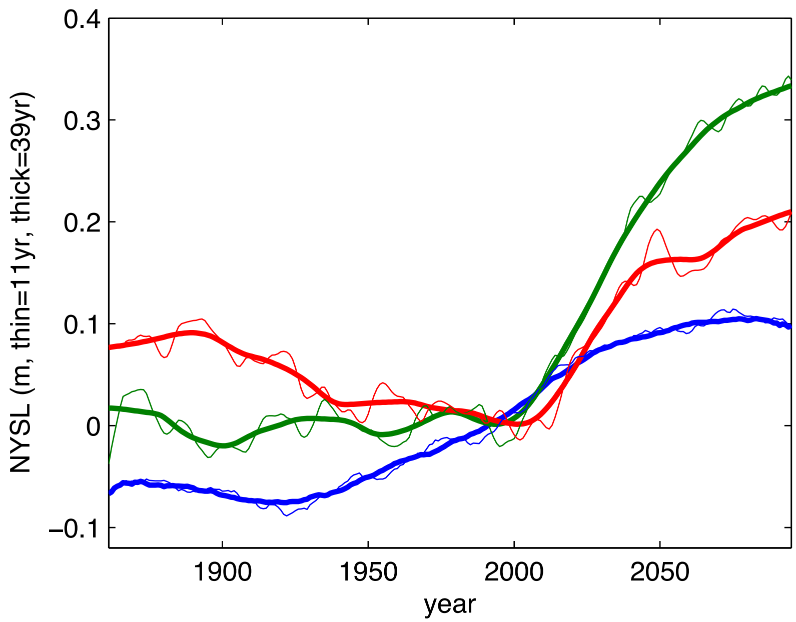
# Uncertainty partitioning and emergence




*After Hawkins and Sutton 2009*

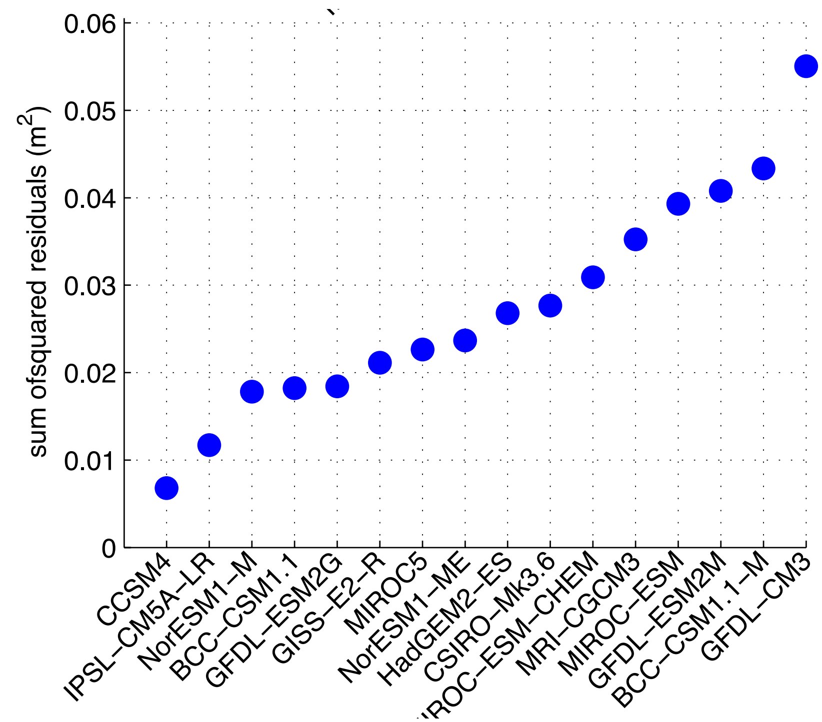
# Model spread in internal variability

**New York sea level in three different models**



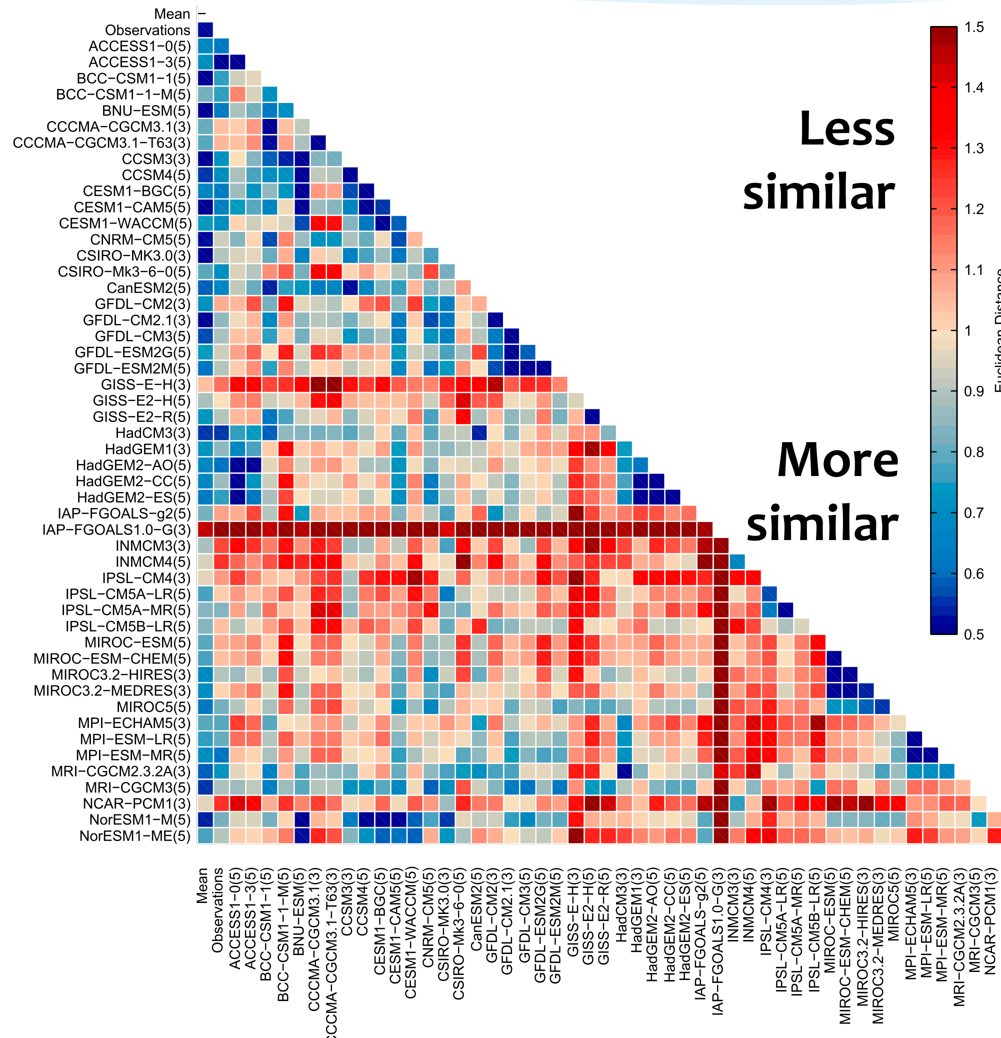

**Thin lines = 11-year smoothing**

**Thick lines = 39-year smoothing**



# Difficult to distinguish “good” models

- Outliers are (usually) not common across different variables of interest
- Observational metrics do not meaningfully constrain projections
- Models are not independent




*Sanderson et al. 2015*

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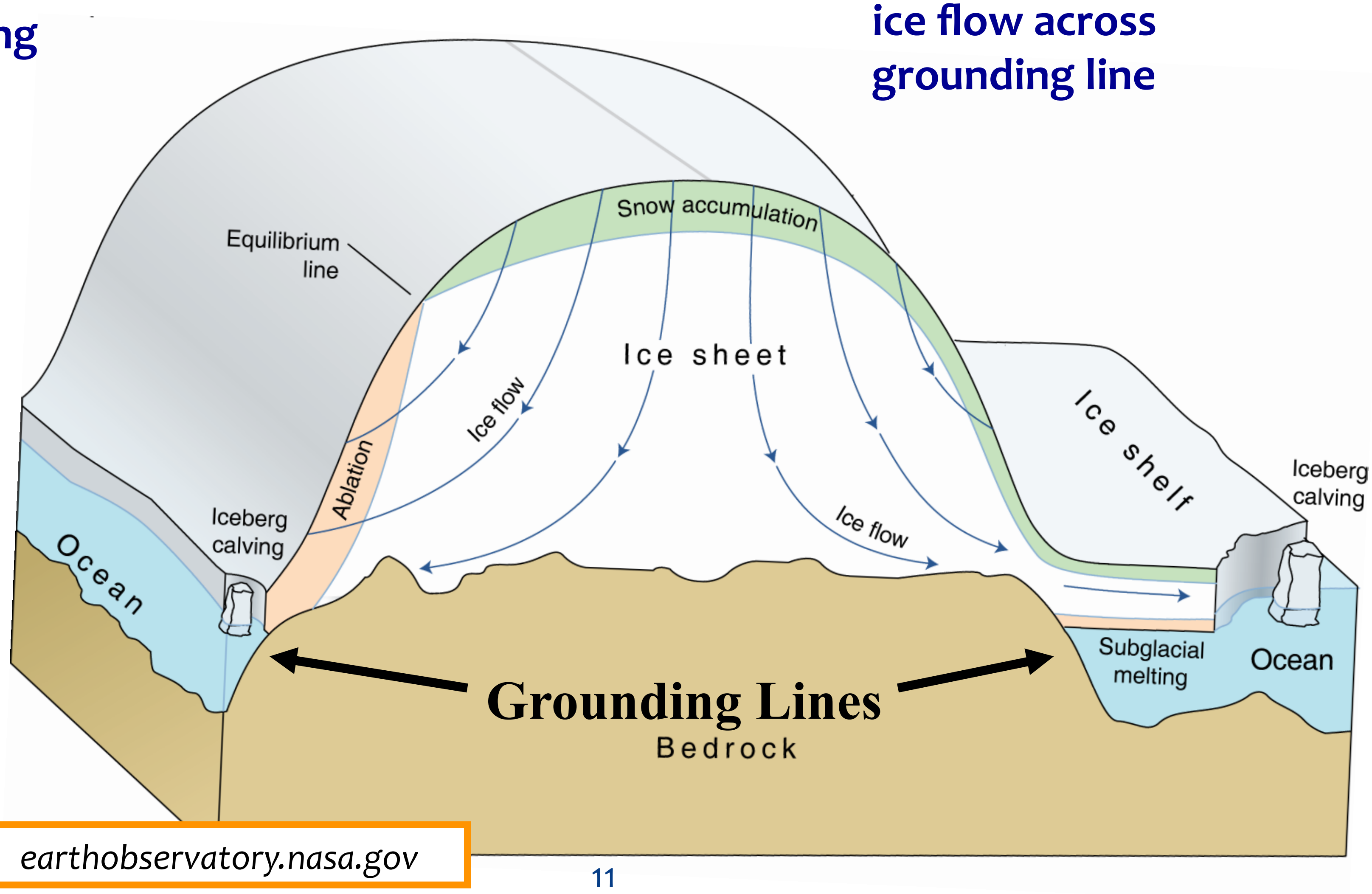
# The ice sheet contribution to sea level

**"Surface mass balance" = snowfall and surface melting**

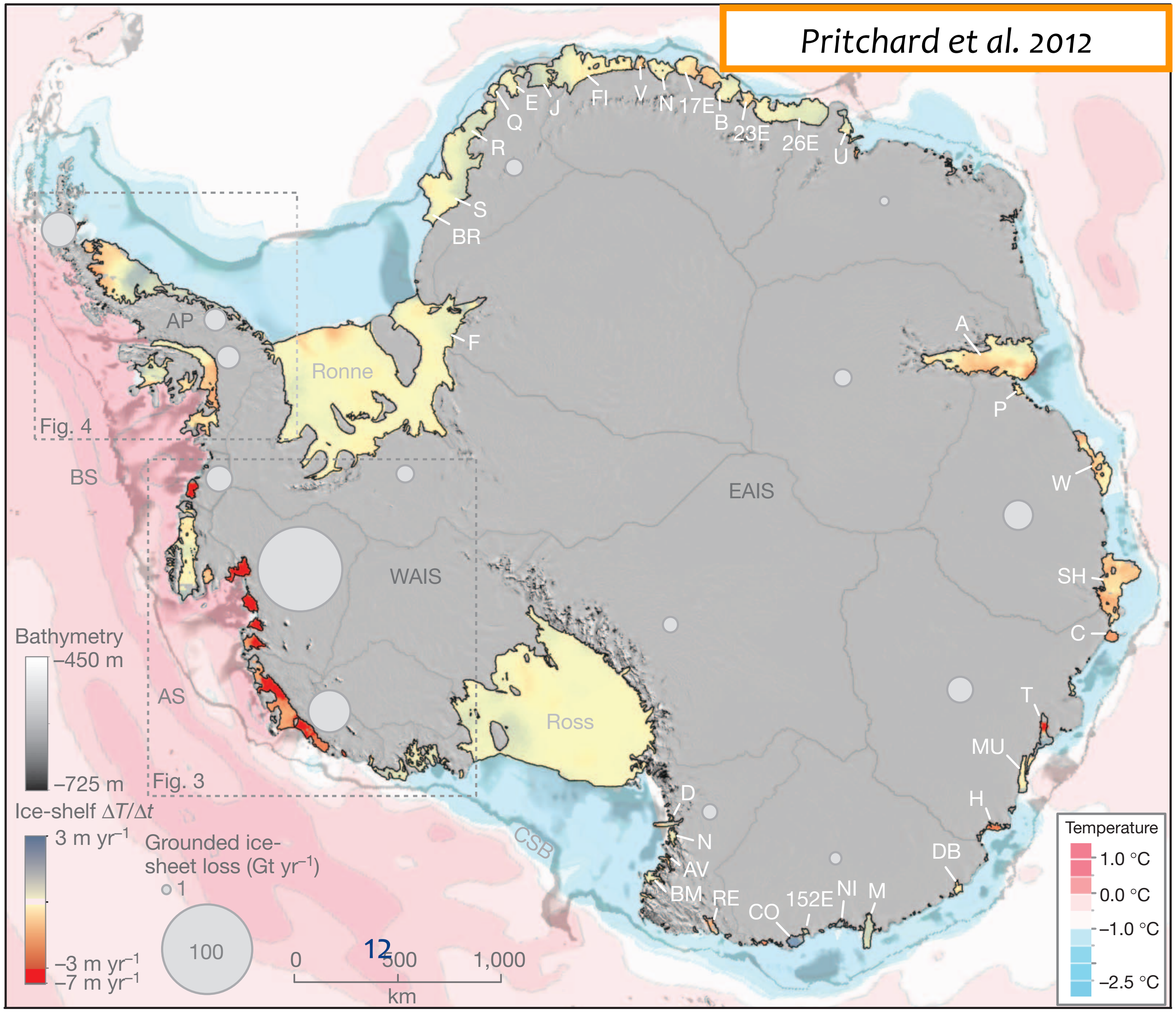
**"Dynamic" = change in ice flow across grounding line**



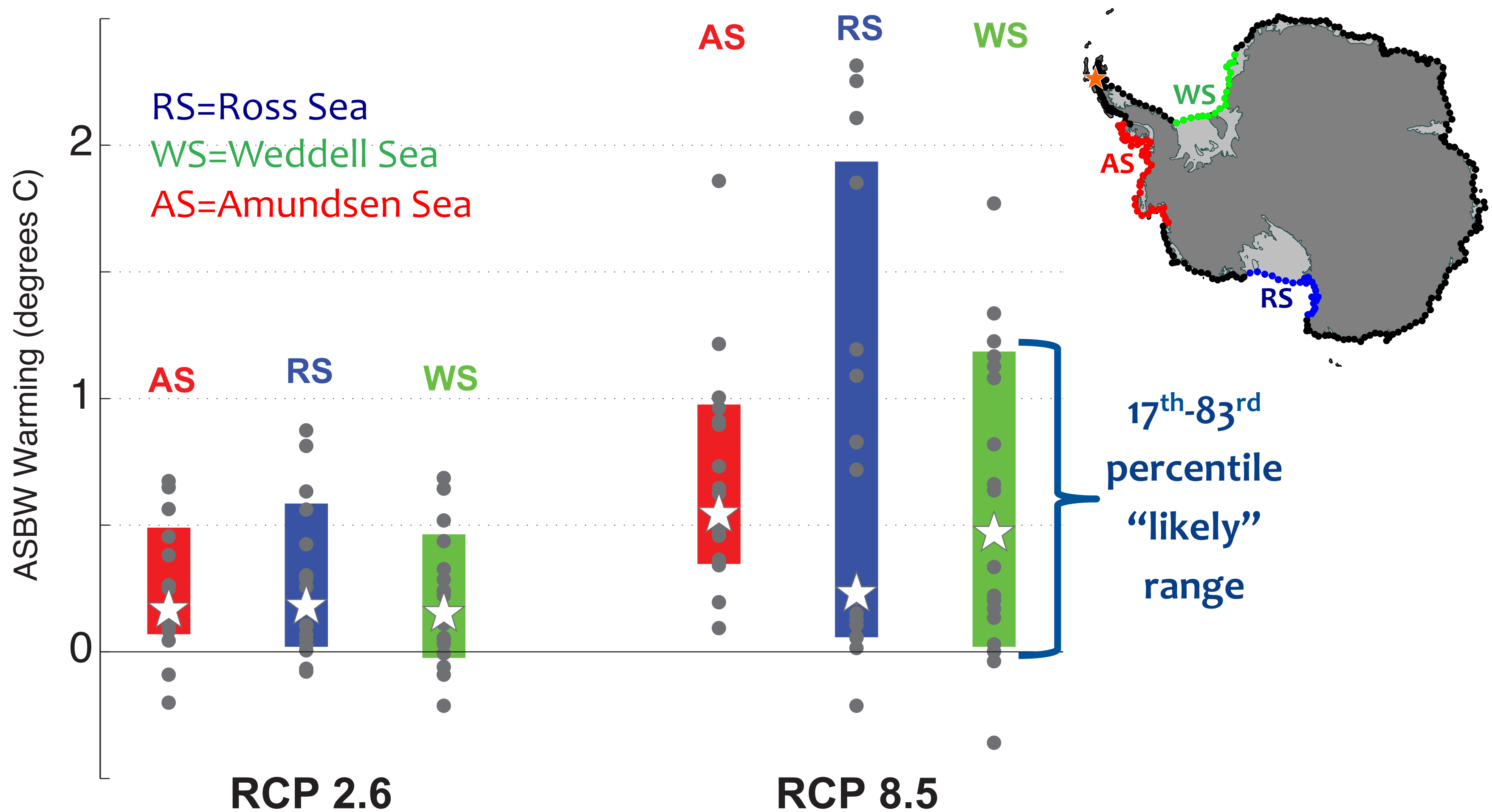

earthobservatory.nasa.gov

# Regional “regimes” around Antarctica

**Shading = sea floor ocean temperature**

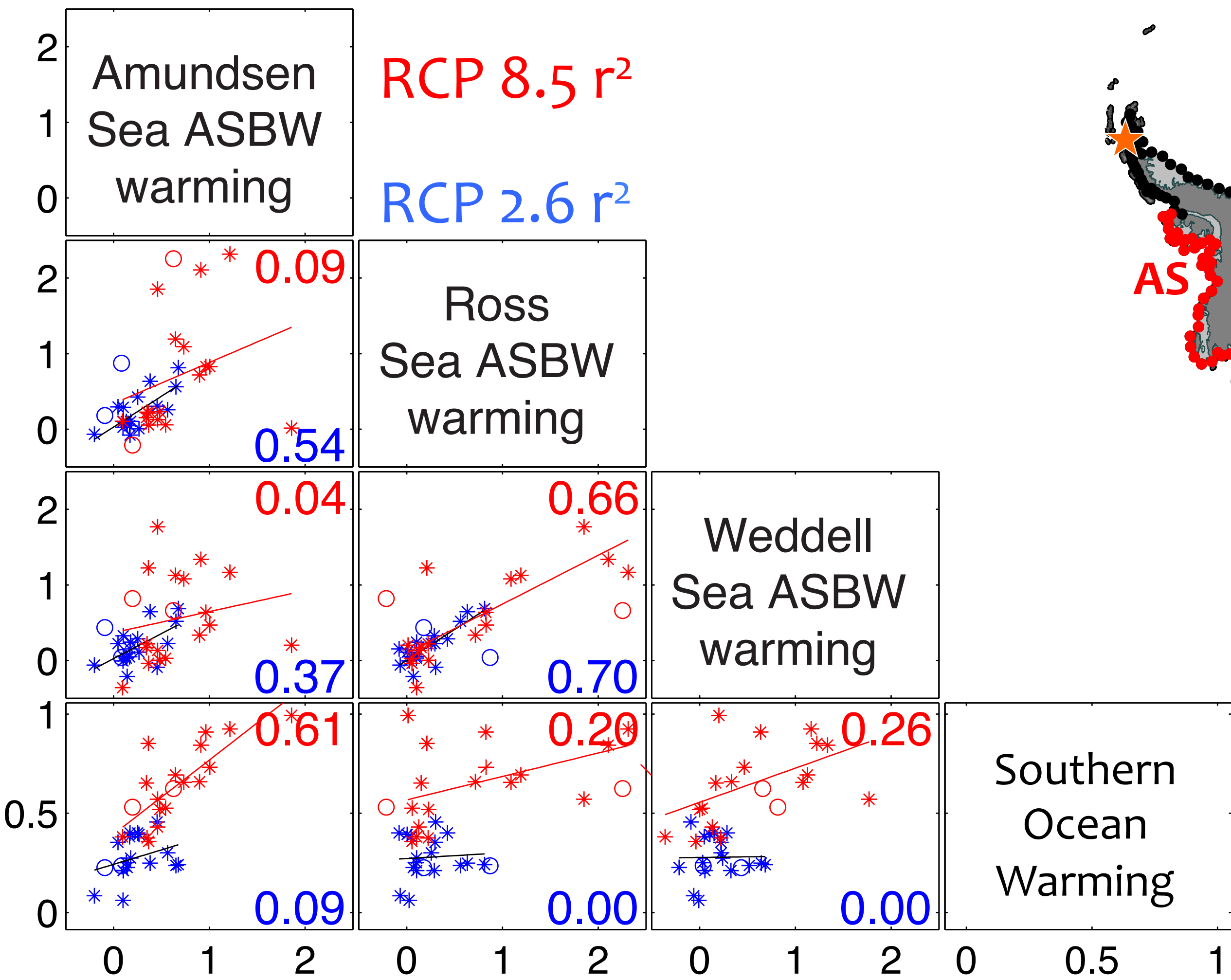


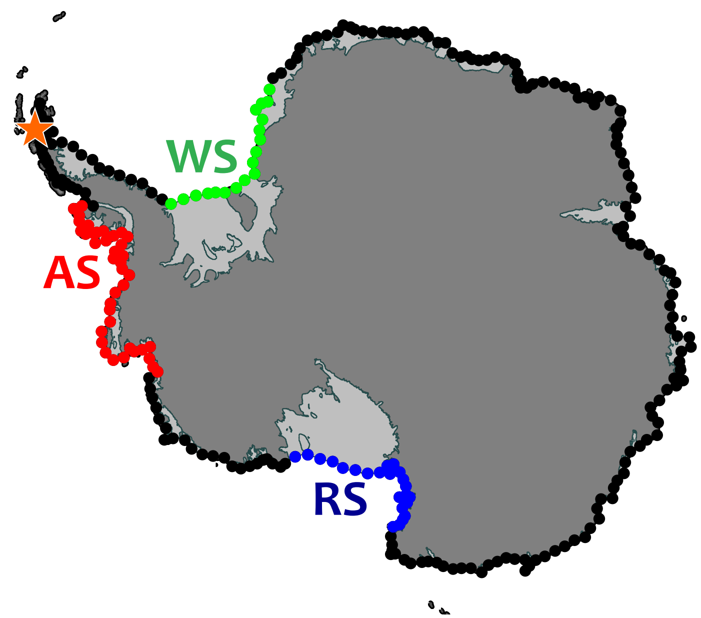
# Sectoral warming (2080-2100 - 1986-2005 )




*C. M. Little and N.M. Urban. CMIP5 temperature biases and 21st century warming around the Antarctic coast. Submitted to Annals of Glaciology.*

# Inter-region warming correlations
# (2080-2100 - 1986-2005 )



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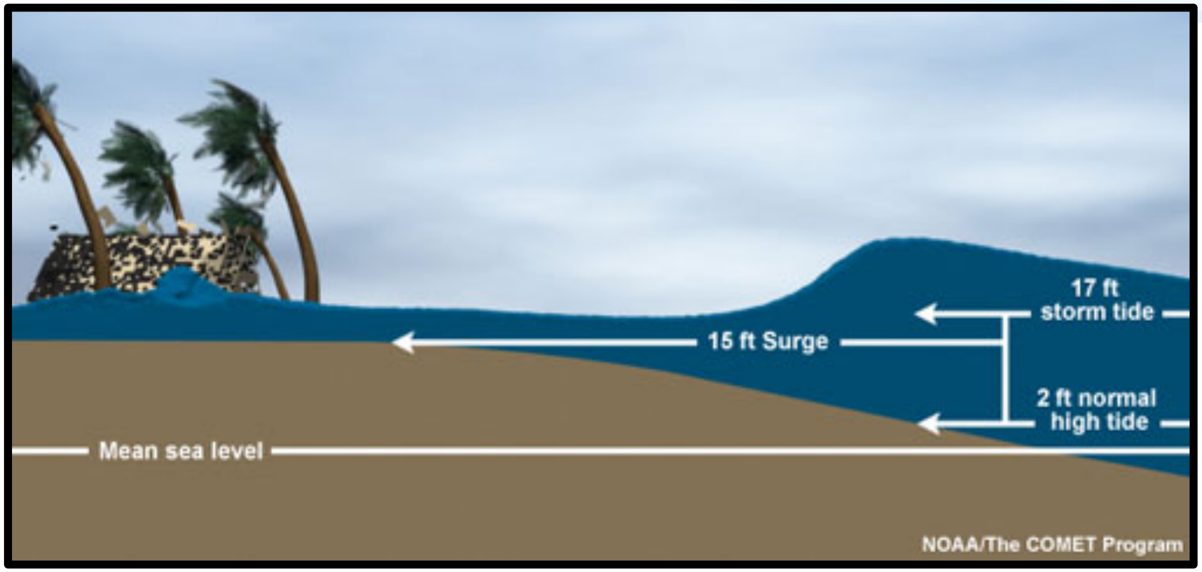
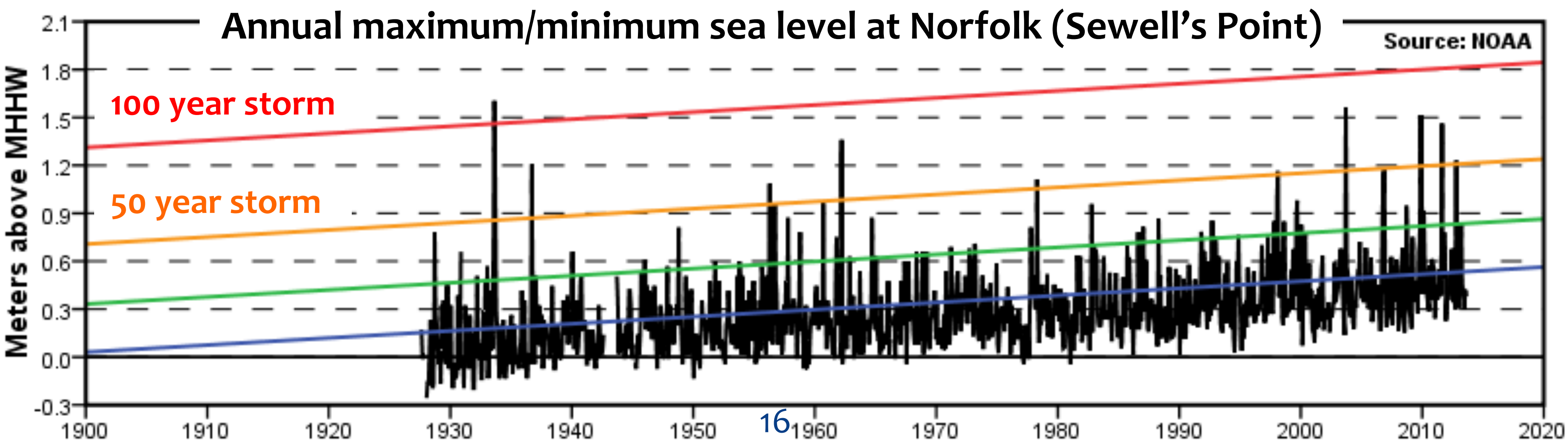
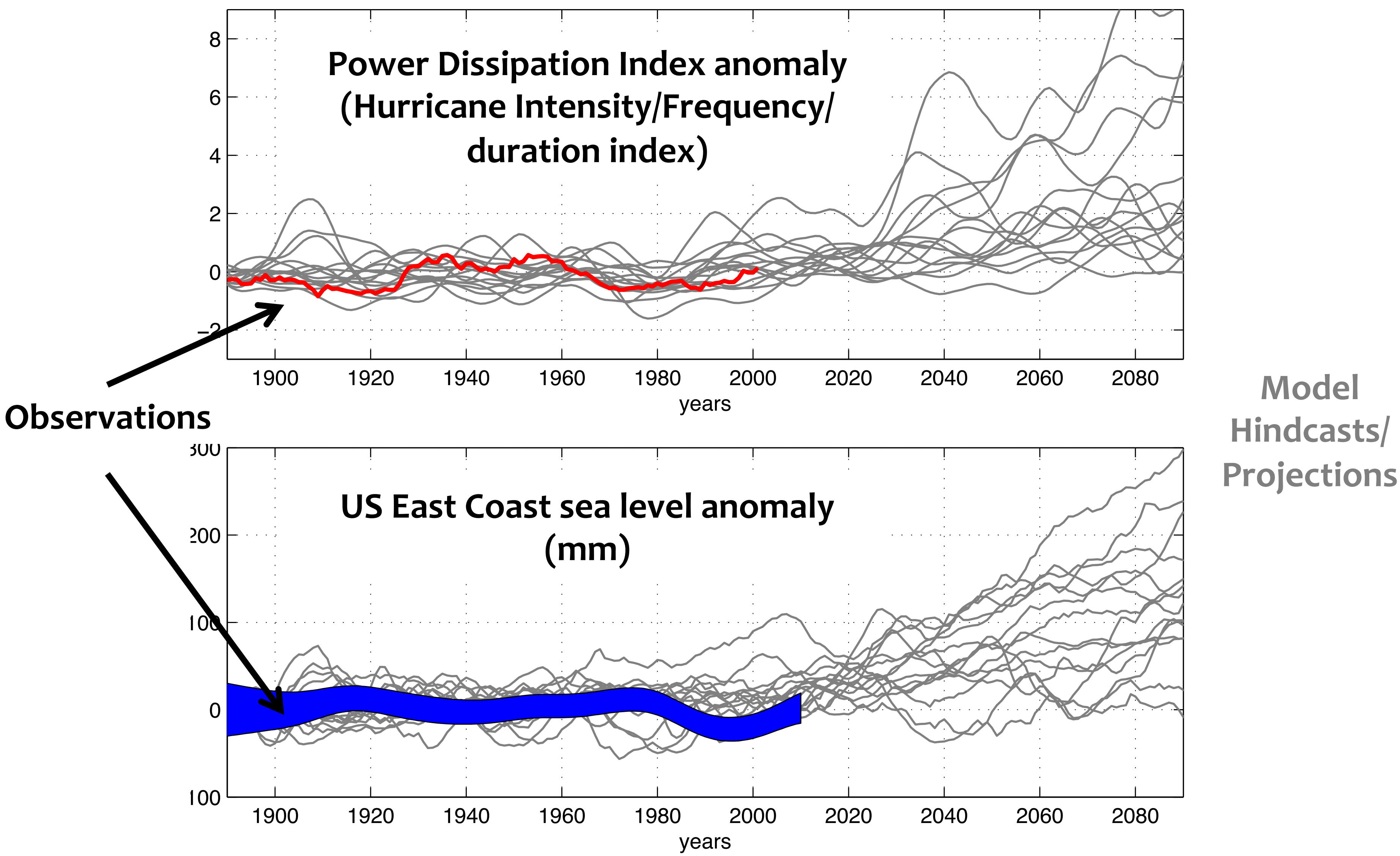
# Coastal sea level variability 101



# Joint Projections of PDI/SLR



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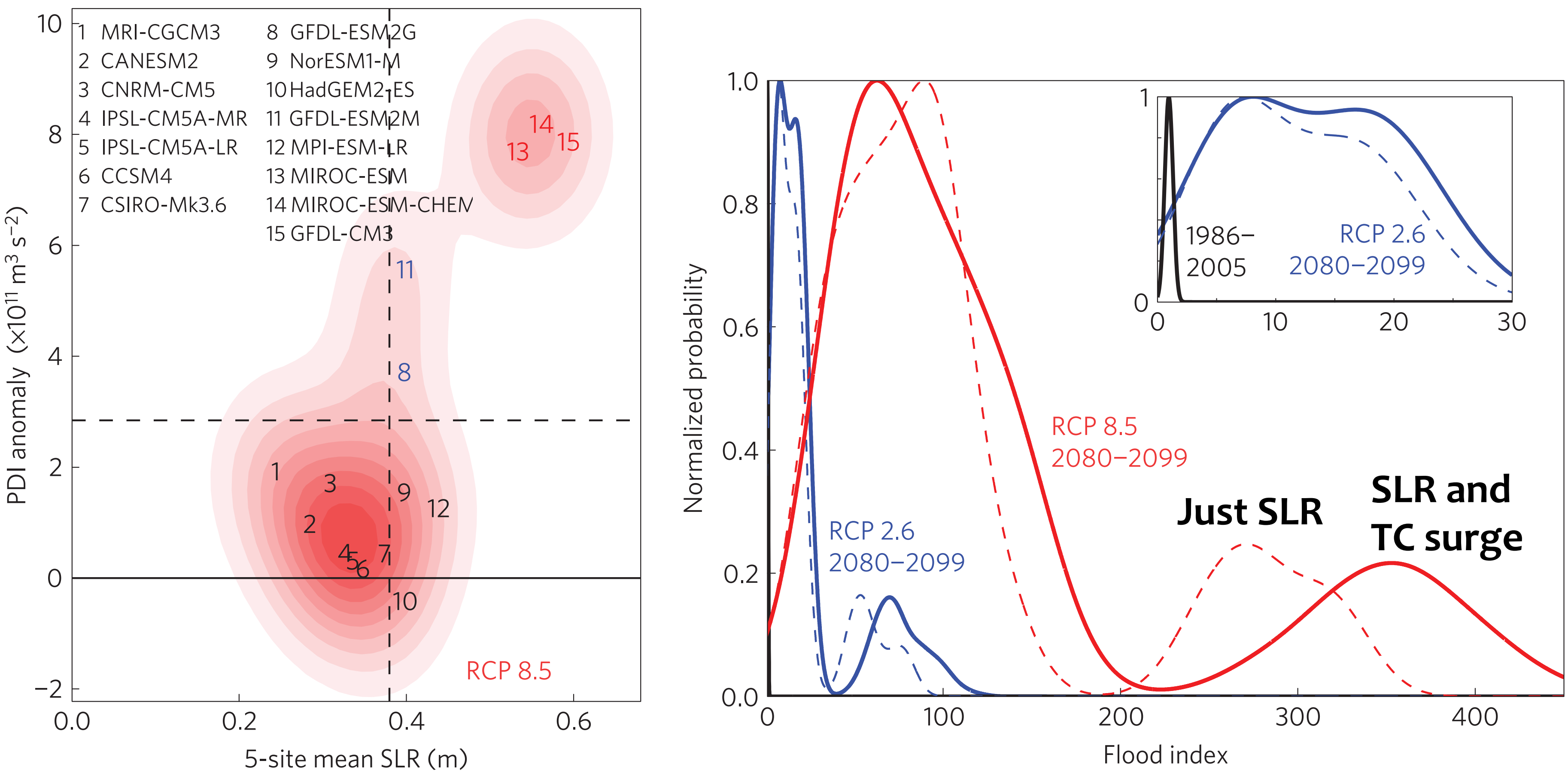


*C. M. Little, R. M. Horton, R. E. Kopp, M. Oppenheimer, G.A. Vecchi and G. Villarini, (in press). Joint projections of US East Coast sea level and storm surge. Nature Climate Change.*

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# Back to the topic at hand…

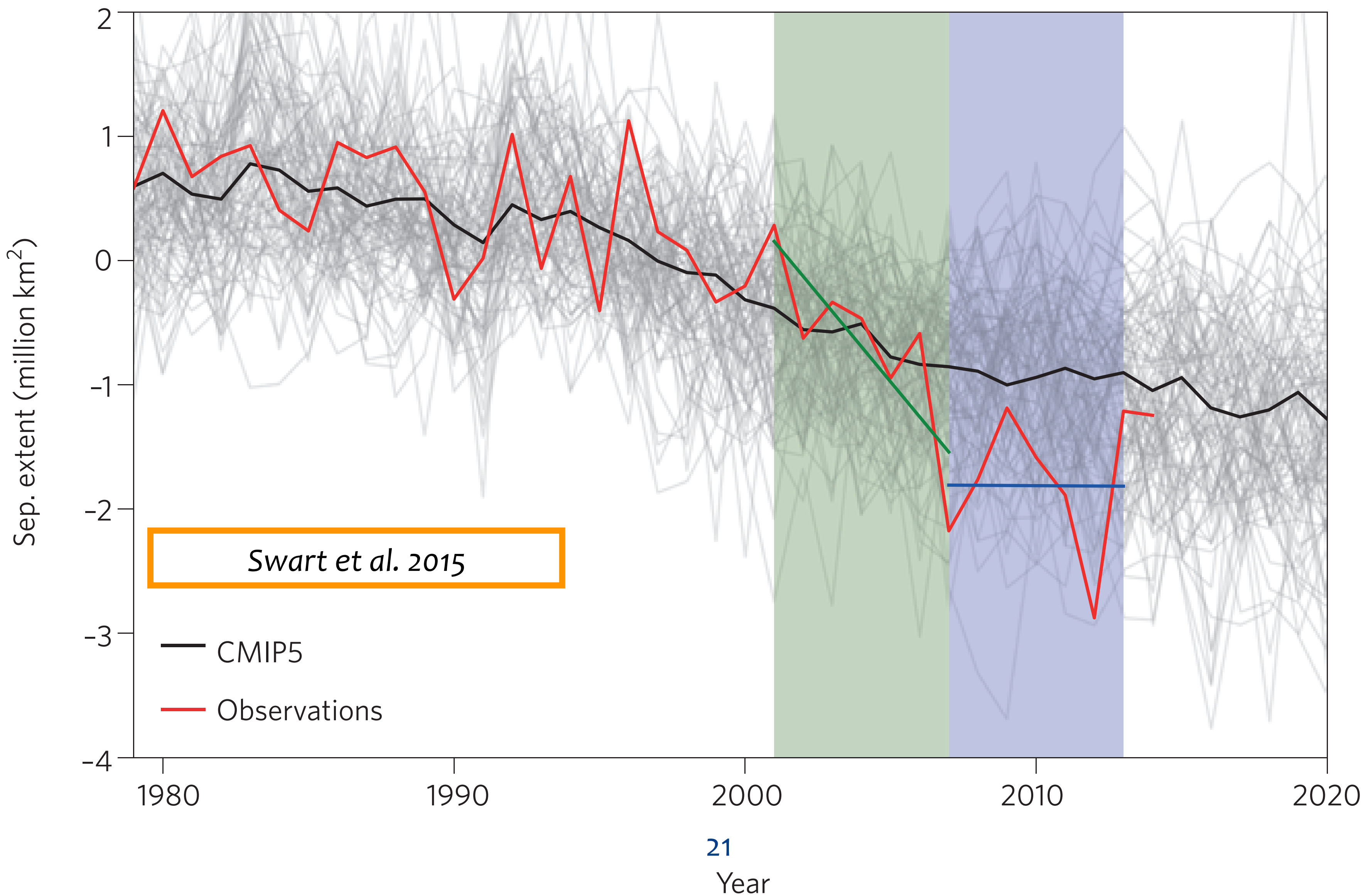
* Sea ice/arctic system is subject to high internal variability

* Intra-model correlations (either in internal variability or longer term forced response) may cast insight into linkages
  * Between Arctic phenomena

  * Between Arctic and midlatitudes

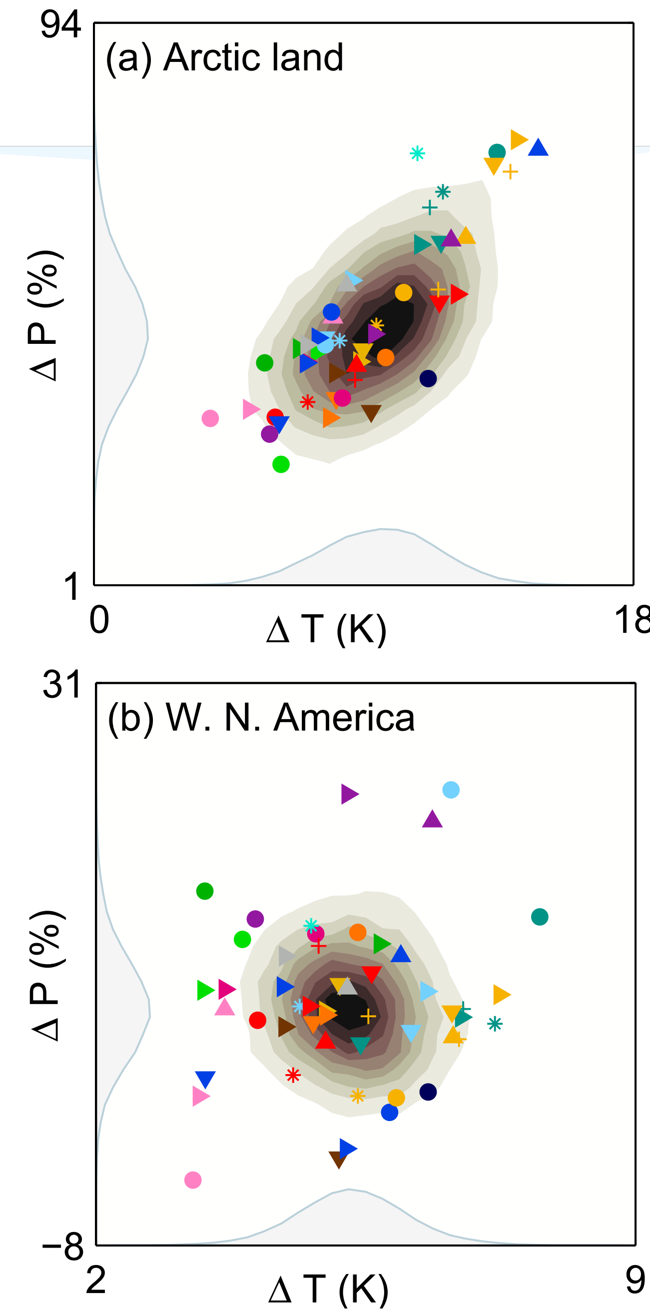
* Joint impacts are omnipresent, and are important to agriculture/national security

# NH sea ice extent: model-data comparison



# Joint impacts

* Long-timescale correlations are evident in some regions
  * Across regions -- Arctic to Midlatitudes?
  * What are the timescales/physics over which T and P might be correlated
  * What are those that have impacts (short or long-duration drought)




*Sanderson et al. 2015*

# Summary

* The representation of forced climate change and natural variability are model-specific
  * Do not rely on a single model and/or realization for projections
* The magnitude and source of uncertainty depend upon the timescale
  * Unforced variability dominates at less than 2 decades; longer at smaller spatial scales
  * Forced response starts to emerge at longer timescales
* The appropriate models, and the measurements that are most important for validating and improving models of the Arctic (and midlatitudes), are a function of the timescales over which impacts are assessed
  * At some point, global influences are important → the most valuable observations may be global quantities (ocean heat uptake/expansion)
* Correlations between impacts may be more robust than magnitude
  * Think about possible joint impacts; rarely is there a single risk driver