Focus on <u>Question 2</u>:

- Pathways of arctic/mid-latitude teleconnections?
- Robustness of these links?

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Different proposed Pathways: Ordered from HIGH confidence to LOW confidence:

1) Arctic amplification moderating cold air outbreaks
2) Increasing geopotential thickness
3) Thermal wind affect/weakening zonal flow
4) Stratosphere-Troposphere coupling –conditional on the QBO phase
5) Transient (synoptic-scale) waves
6) Planetary waves
7) Resonance with surface forcing

These pathways/mechanisms are supported by:

- Physics
- Observational studies
- At least some modeling studies

Important to keep in mind:

- State dependence: background state matters, non-linearities, regional dependence
- (Still) a very useful concept: Forcing of complex system changes the odds, and the response maps on the natural modes of variability (Tim Palmer). Difficult to extract the forced response from natural variability

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How strong are these mechanisms as compared to tropical teleconnections affecting mid-latitude weather?

Probabilistic Attribution? How much more likely has Arctic Amplification / sea-ice melt made the observed central Asian cooling trend? (Analogous to extreme weather attribution studies)

Extreme Weather:

- (often) multiple sources interact leading to extreme weather events
- Probabilistic: Remote pathways might change the odds

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Central challenge:

How can we reconcile model and observation studies?

→ Merging of observational and modeling approaches

- (Coupled) data assimilation, relaxation experiments
- Process-based model validation using complex system tools (e.g. causal effect networks): Understand the pathways: *Why* does a model produce a certain response?

Sample Size (Question 3):

Proxies: capitalize on paleo-proxy data / use surface-temperature fingerprint methods