Probability Assessments of an Ice-Free Arctic: Comparing Statistical and Climate Model Projections

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EGU2020: Sharing Geoscience Online

Session CL4.14, Monday, 04 May 2020, 16:15-18:00

Research paper available at https://arxiv.org/abs/1912.10774

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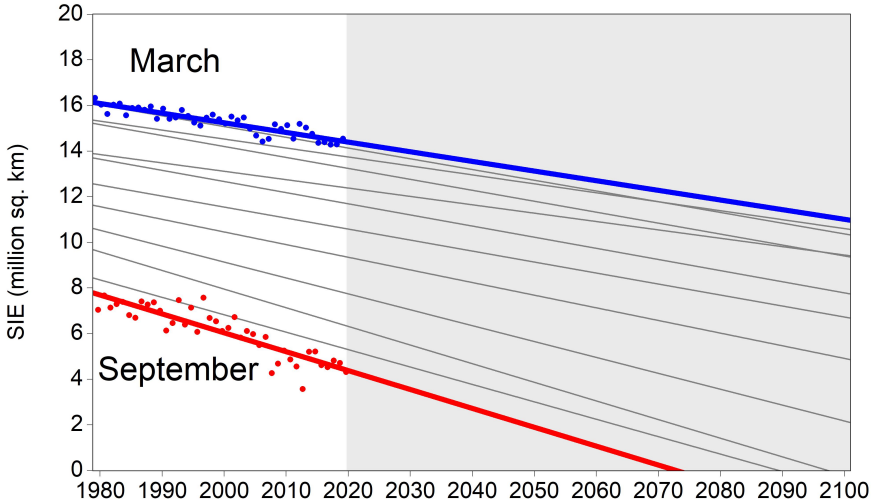
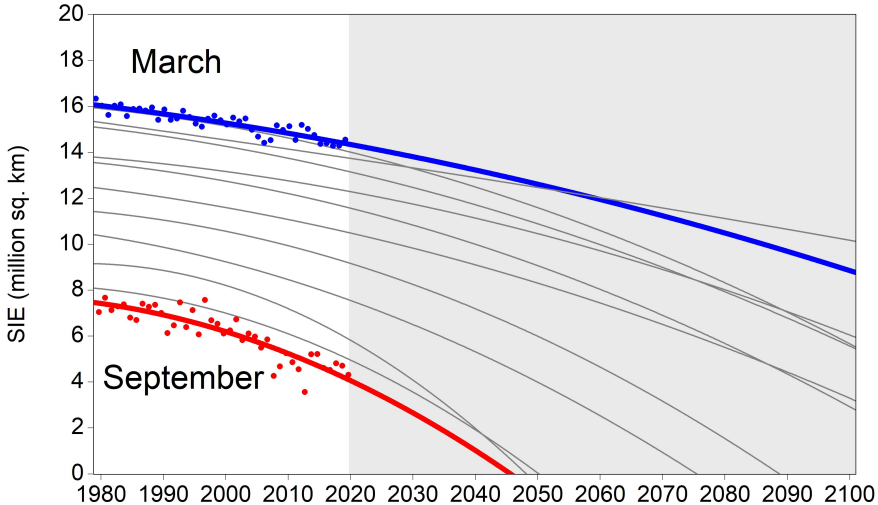
Arctic sea ice extent: data, statistical models, climate models

- **Data**
  - Arctic sea ice extent, *SIE*, monthly average from Nov. 1978 to Oct. 2019
  - Source: Satellite measurement, National Snow and Ice Data Center (NSIDC)
- **Statistical model projections of *SIE***
  - Model: SIE_t = trend for each month + inertial dynamics + random shock
- **Climate model projections of *SIE***
  - Simulations for Coupled Model Intercomparison Project (CMIP5) starting in 2006
  - 3 emissions scenarios: RCP8.5 (high), RCP6.0 (medium high), RCP4.5 (medium)
  - Multi-model means: Mean projections from set of climate models

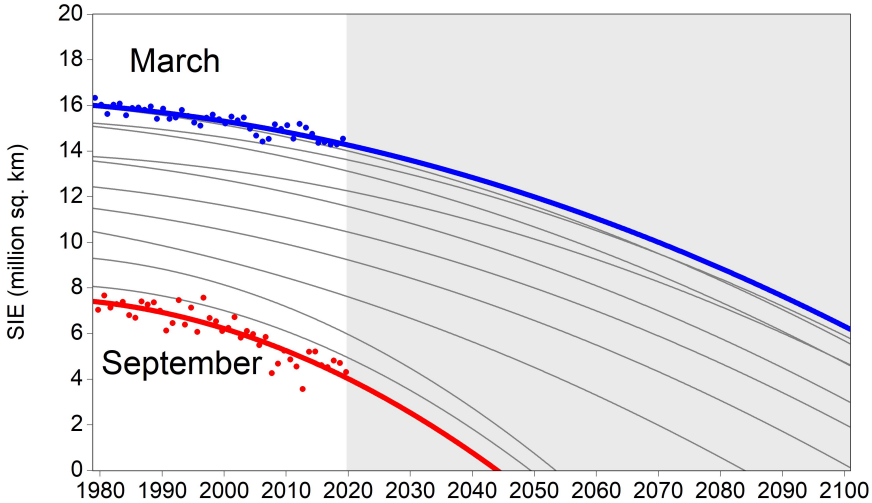
Unrestricted linear trend model: Different trend for each month



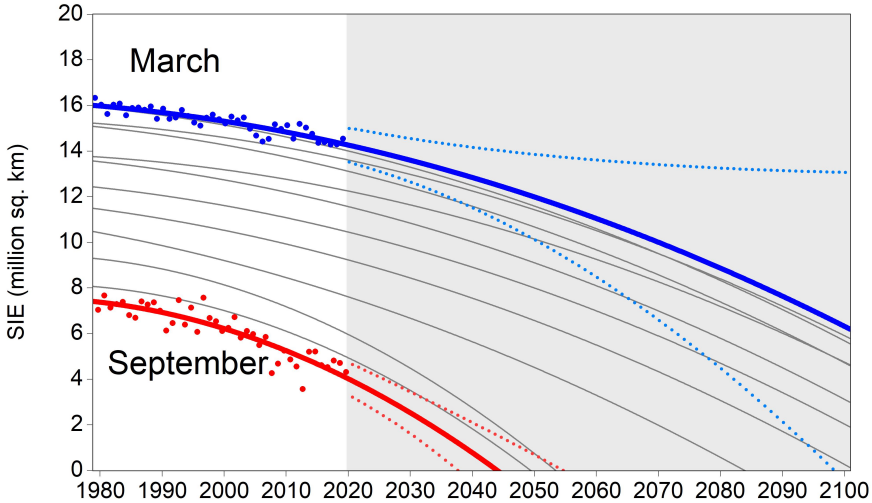
Unrestricted quadratic trend model: All trends are convex



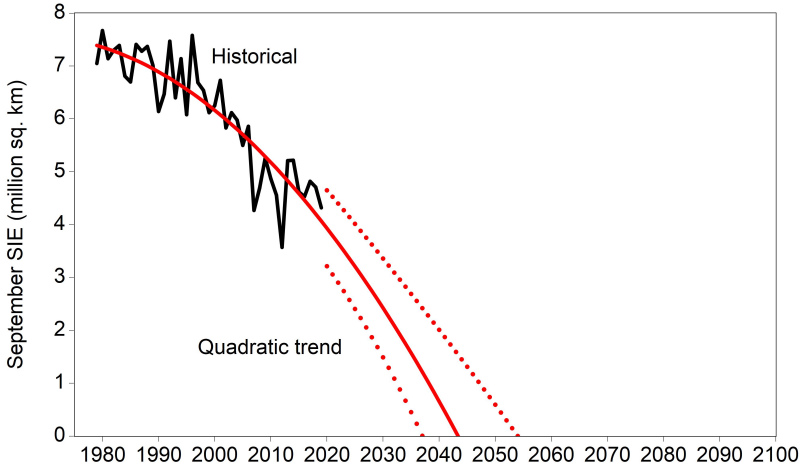
Simplified quadratic trend model: Linear model plus 2 parameters



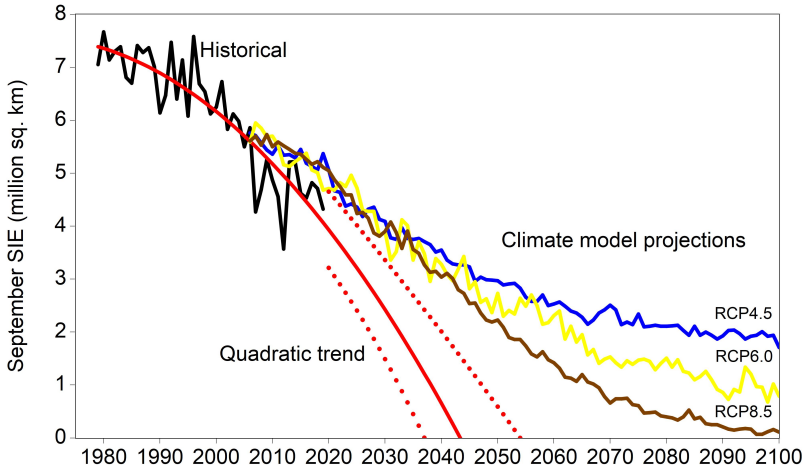
Statistical model density forecasts: 95% confidence intervals



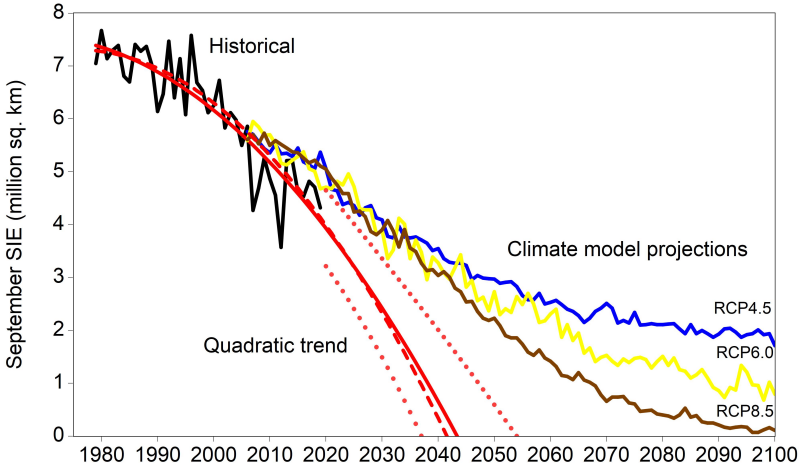
Statistical projection for Sept. *SIE* with 95% confidence intervals



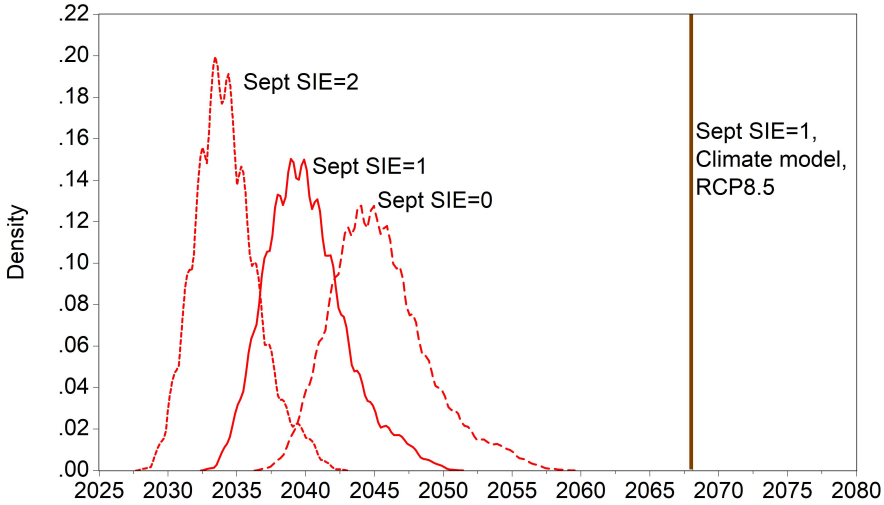
Climate model means are well outside 95% confidence interval



Pre-2006 estimation sample yields same statistical point forecast



Statistical model probability distributions for first ice-free Sept.



Discussion: What role for statistical models of Arctic sea ice?

- **Our statistical model predicts an increasingly rapid decline in Arctic sea ice.**
- **Implies 60% probability of ice-free September in 2030s** ($SIE < 1$ mil. km^2).
- **Projected ice-free Arctic is much earlier than climate model simulations.**
- In other contexts, researchers have found that parsimonious statistical models often forecast as well as complex, theory-based, structural models.
- However, not just a forecast competition. Statistical models can potentially be a useful complement to structural analysis:
  - A buttress for theoretical weak-points
  - A benchmark for overall model calibration
  - A filter for climate model selection