

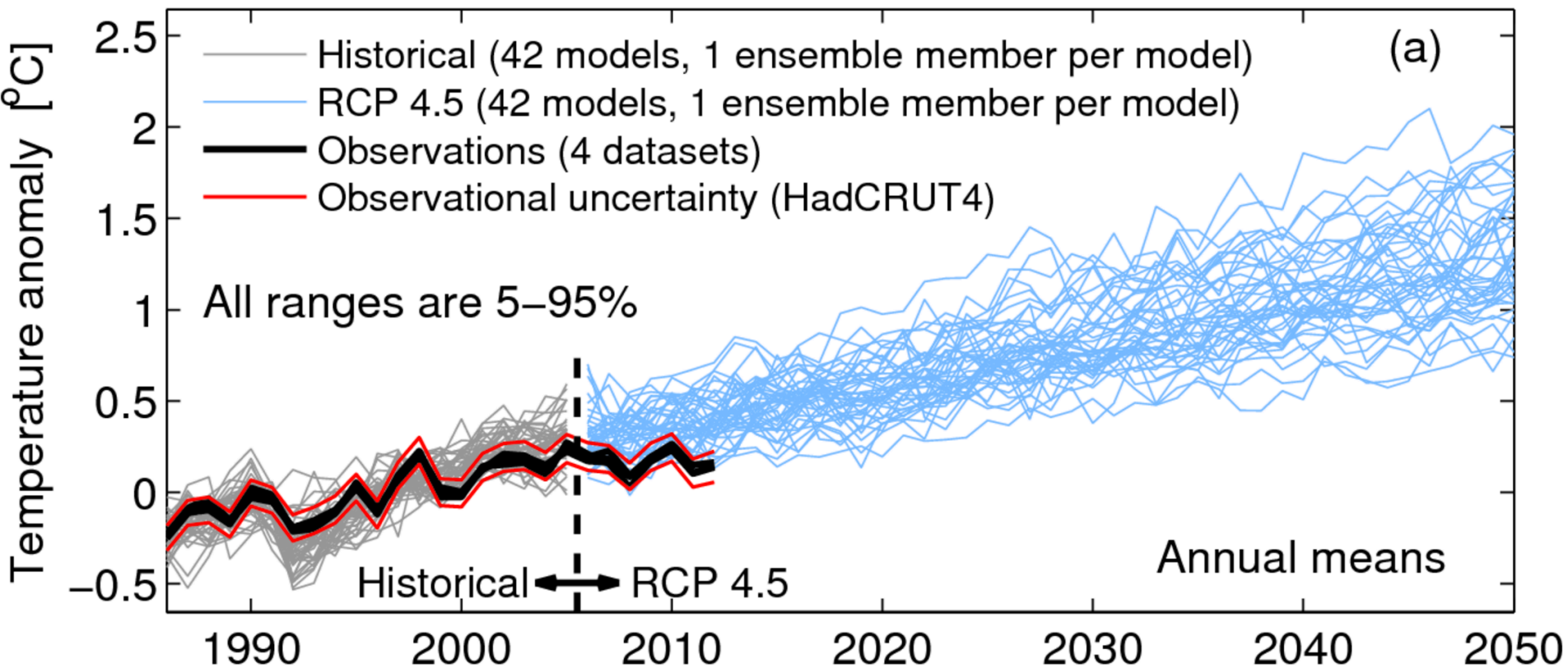
# Robust comparison of climate models with observations using blended land air and ocean sea surface temperatures

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# Climate Models are Often Compared with Observations

Global mean temperature projections (RCP 4.5), relative to 1986–2005

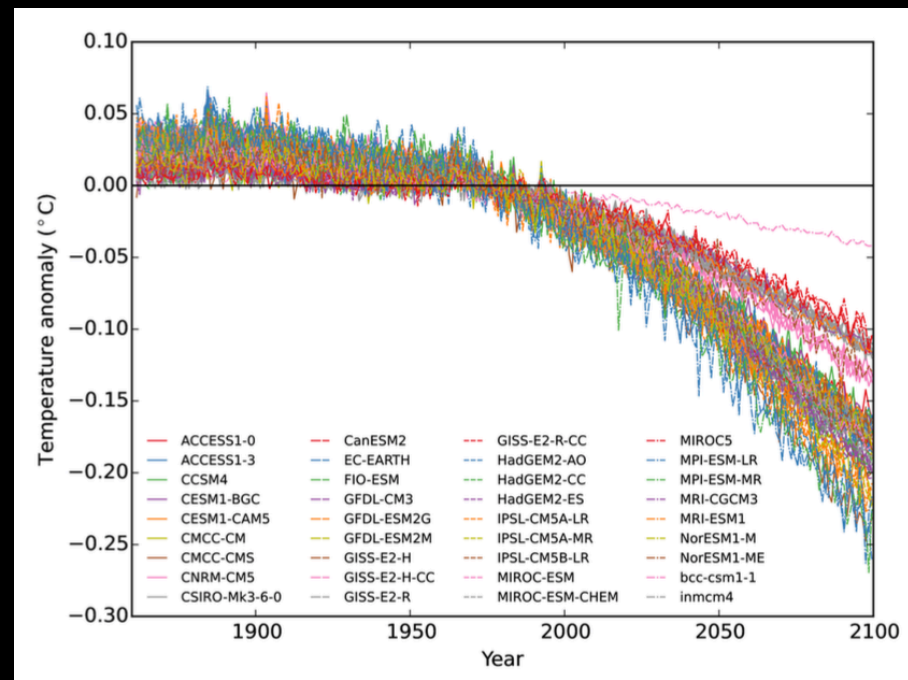


# An Apples to Apples Model/ Observation Comparison

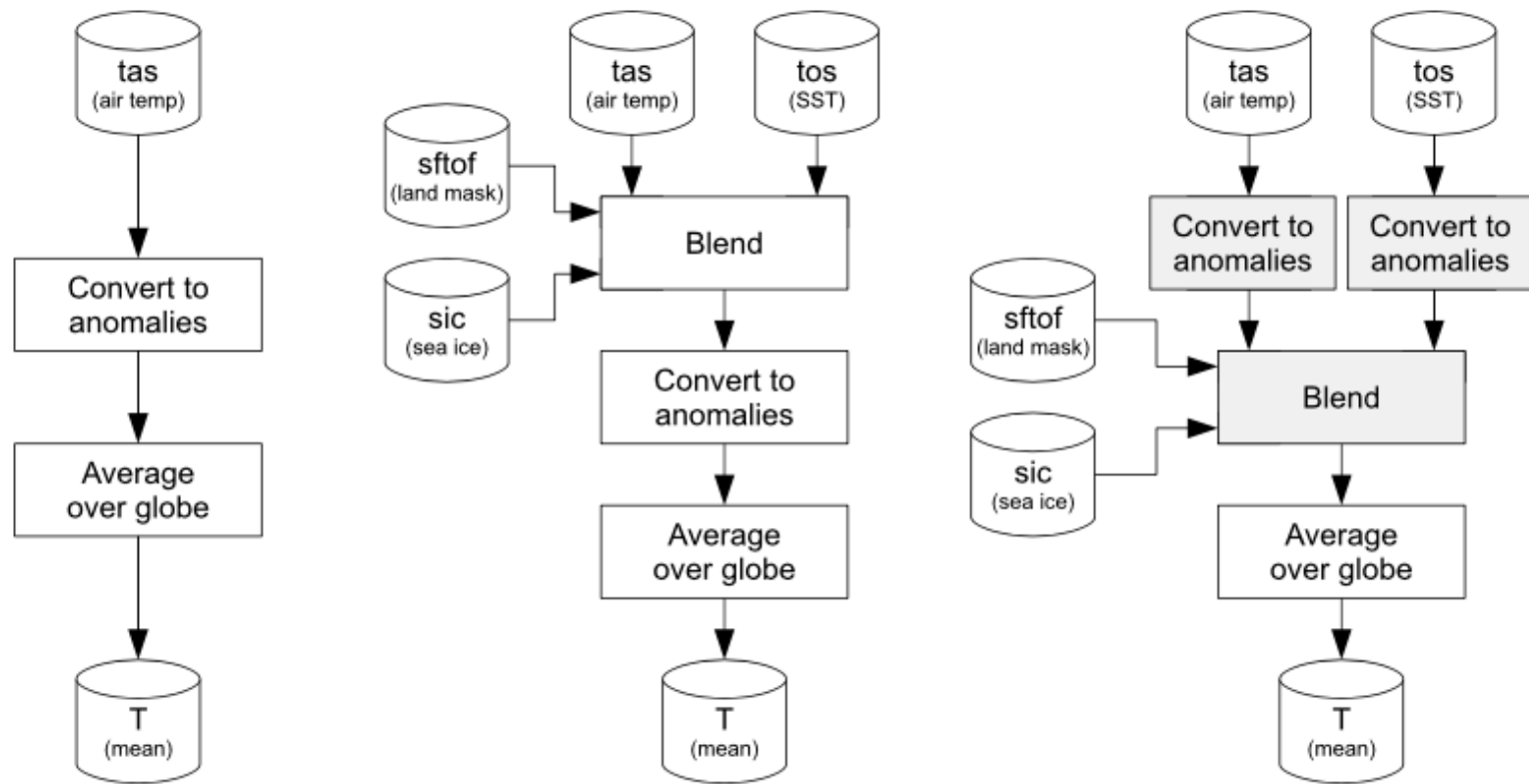
Surface temperature record combines land-based surface air temperature (SAT) with sea surface temperature (SST) measurements.

Most comparisons of models and observations (including those in the IPCC AR5) compare global model SAT to observations.

CMIP5 RCP8.5: SST minus SAT



# Blended SAT/SST Model Fields



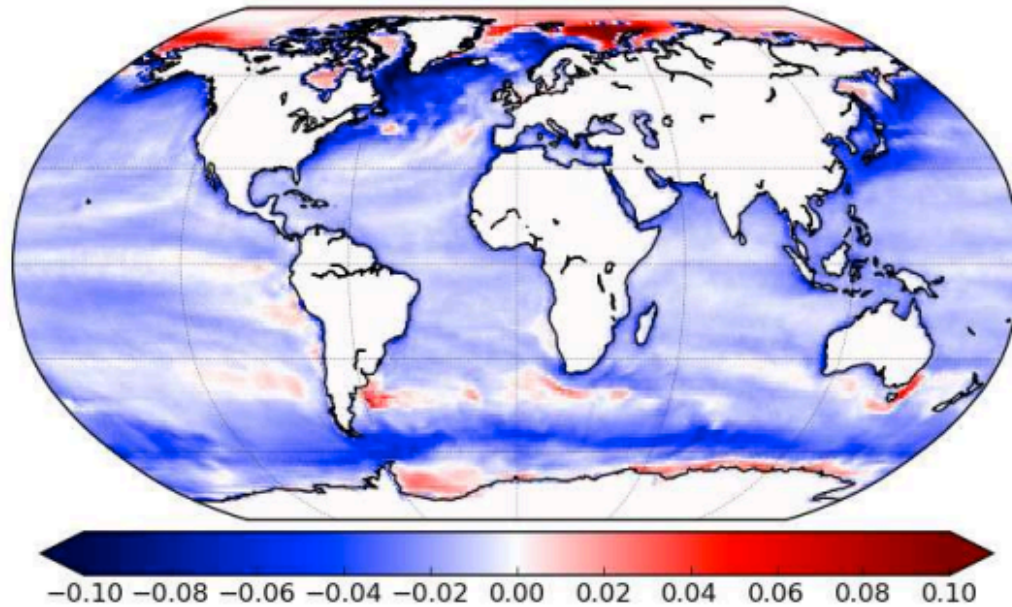
(a) Air temperatures only

(b) Blended absolute temperatures

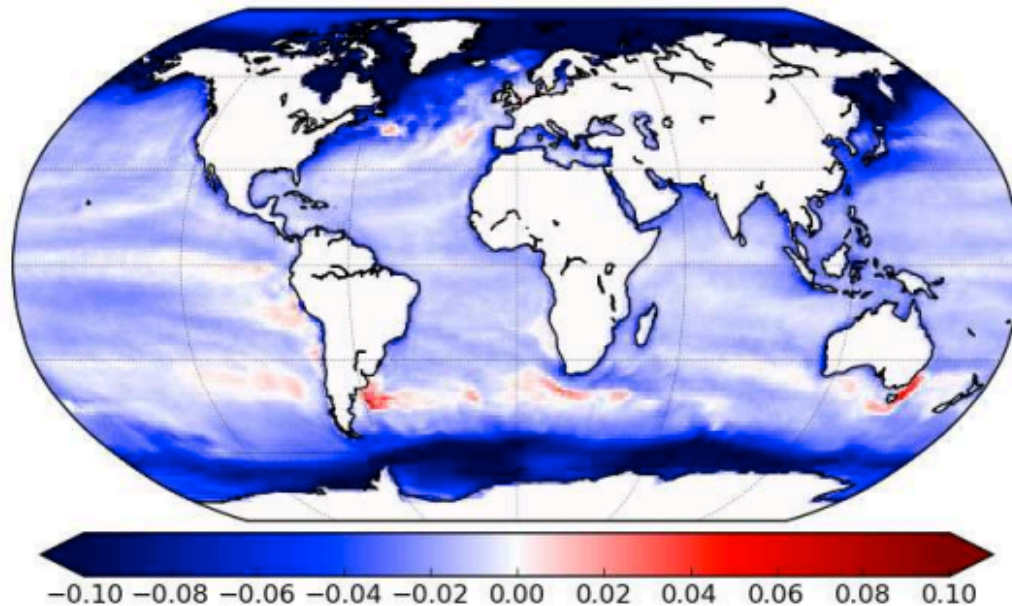
(c) Blended anomalies

**Figure 1.** Flowcharts describing the calculation of global mean temperature ( $T$ ) from the original CMIP5 fields. Three different methods are illustrated: (a) air temperatures only (i.e., unblended), (b) blended absolute temperatures (no mask, variable ice), and (c) blended temperature anomalies (no mask, variable ice). The use of anomalies in Figure 1c involves reversal of the shaded steps; it will be shown that this significantly affects the results.

(a) Trend difference, blended absolute temperatures



(b) Trend difference, blended temperature anomalies

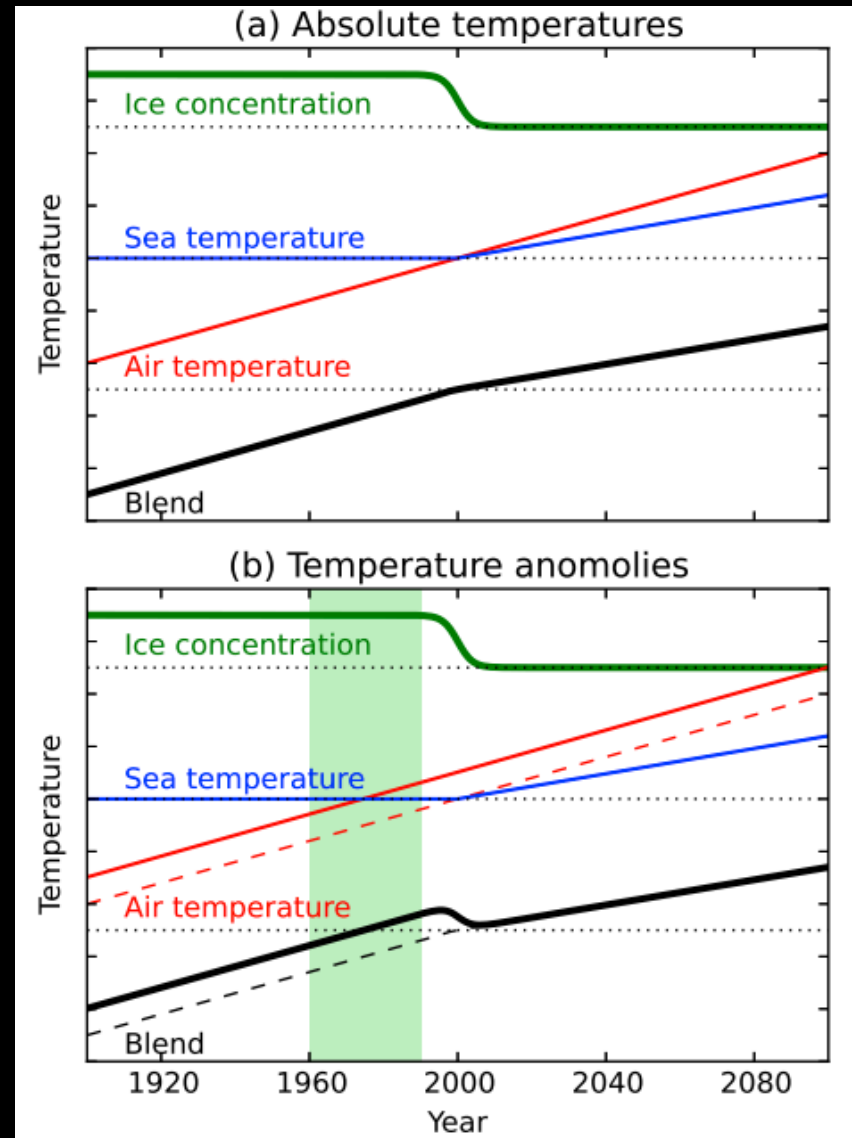


Trends over  
1985-2014

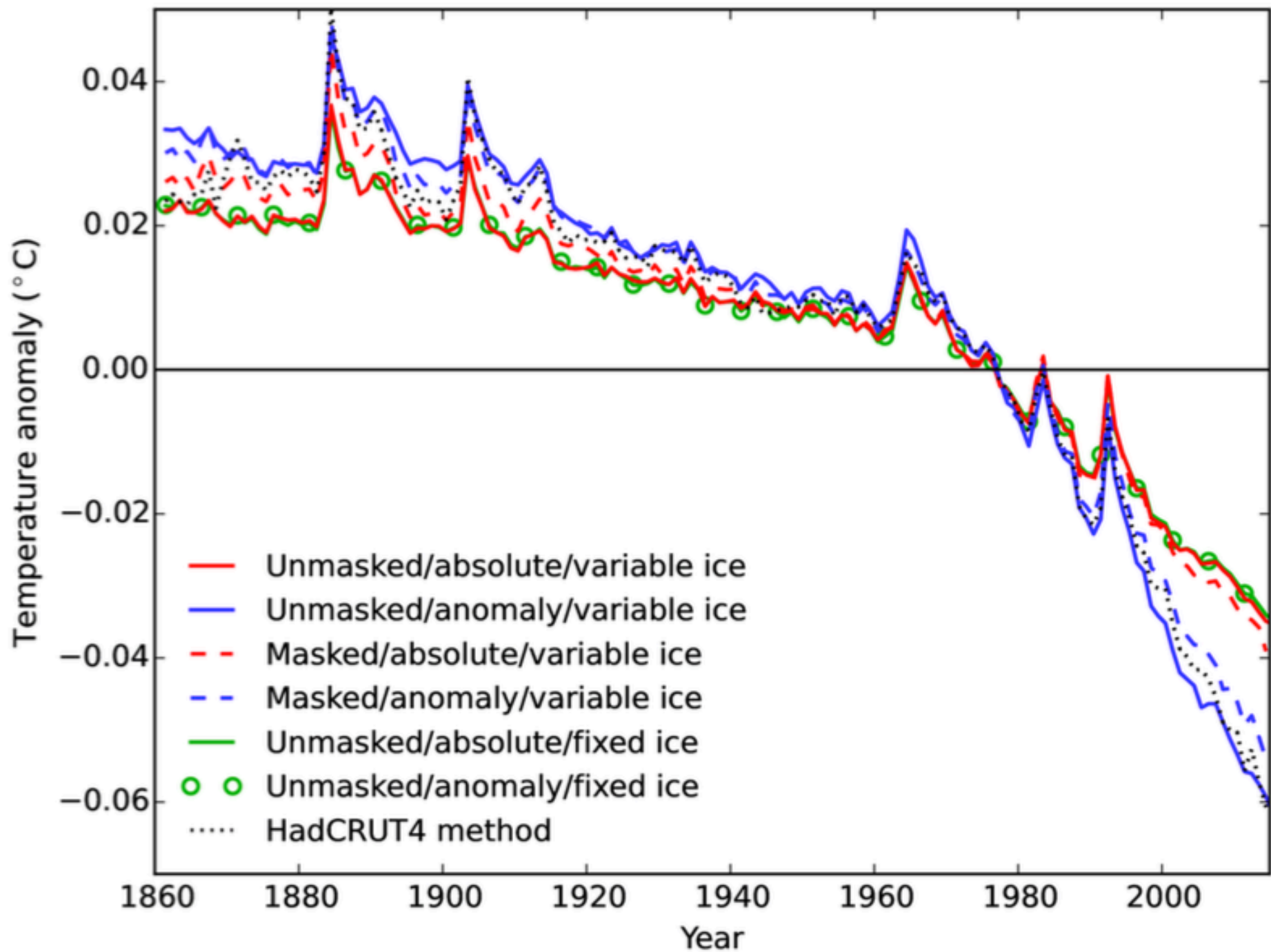
# Dealing with Ice Edge Bias Effects

Instrumental record combines SAT and SST anomalies. This introduces some bias in areas with changing sea ice coverage as SSTs are constrained by freezing point.

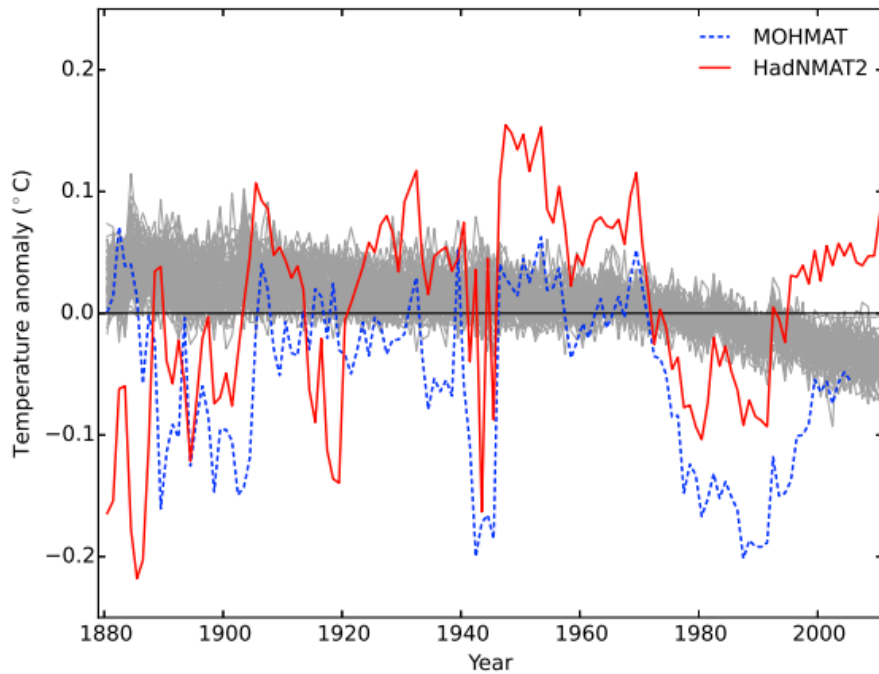
To properly compare models and observations we need to use a similar anomaly approach.



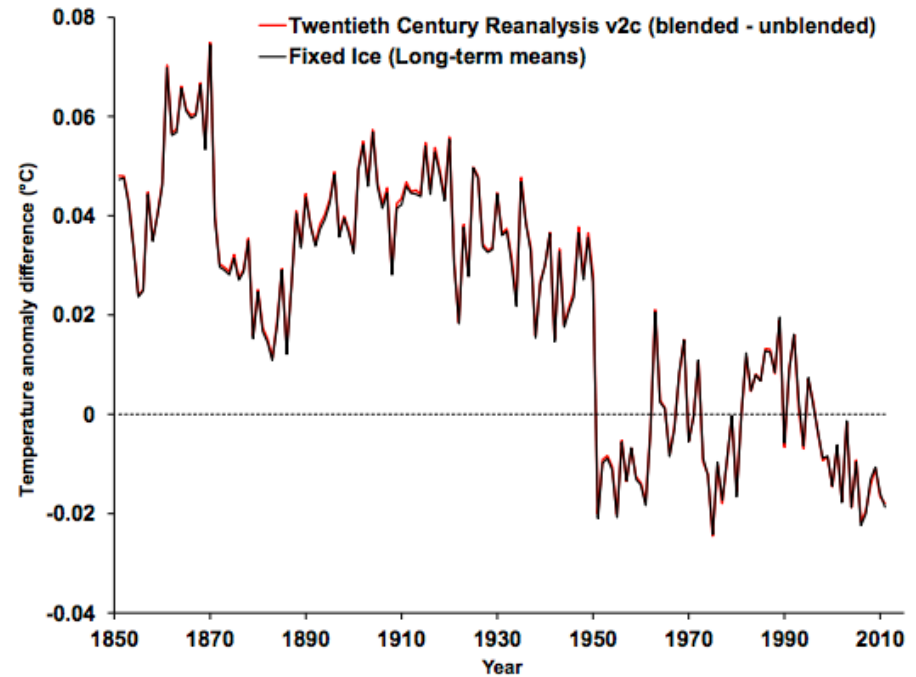




# SAT/SST Differences in the Observational Record



Instrumental Data



Reanalysis Data

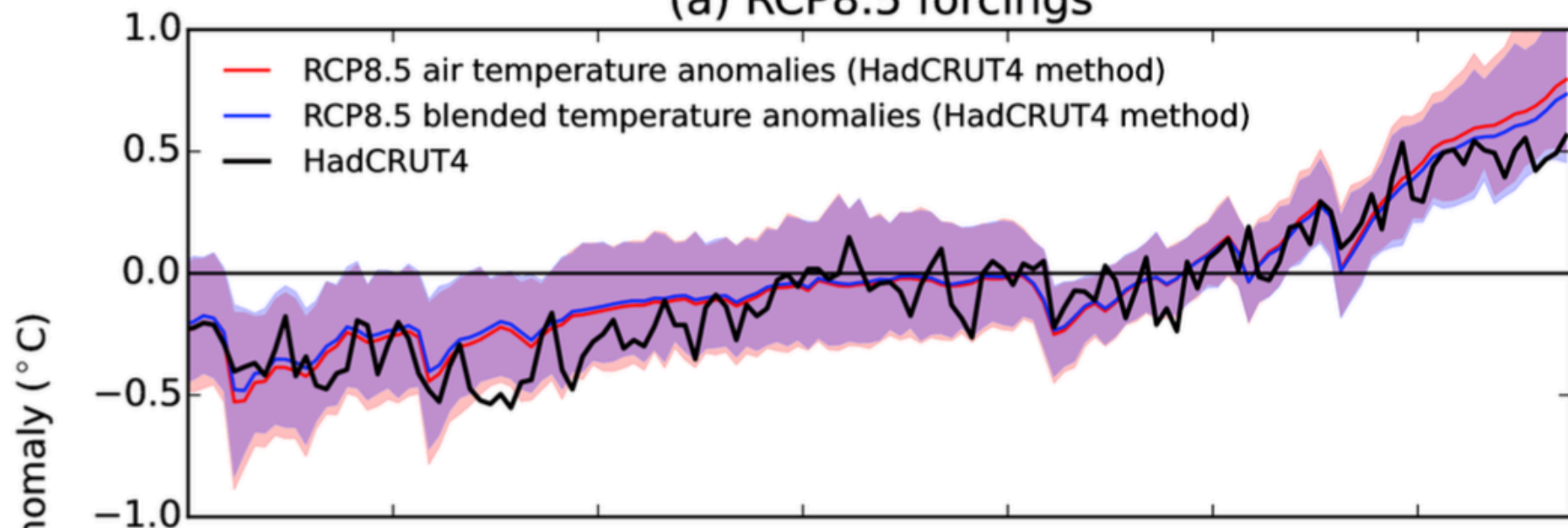


# Correctly Comparing Models and Observations Matters

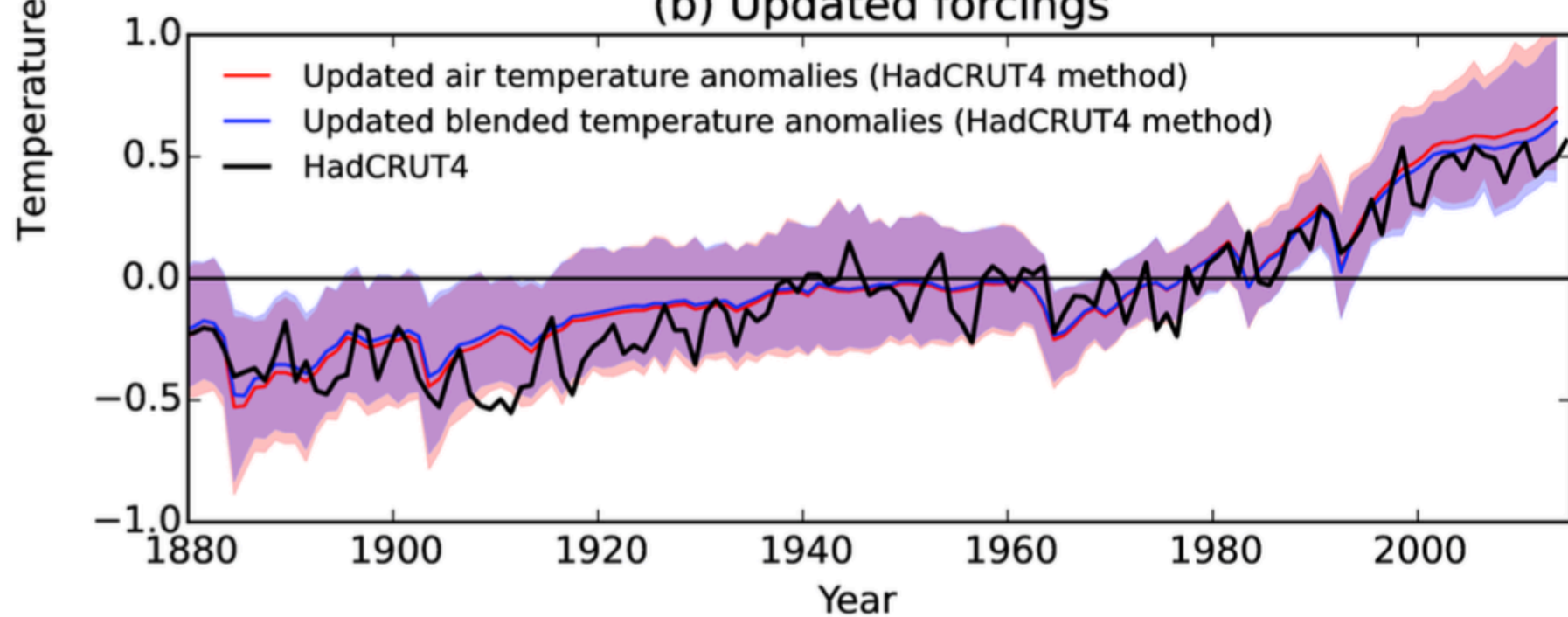
Noticeably improves performance of models vis-à-vis observations in recent years.

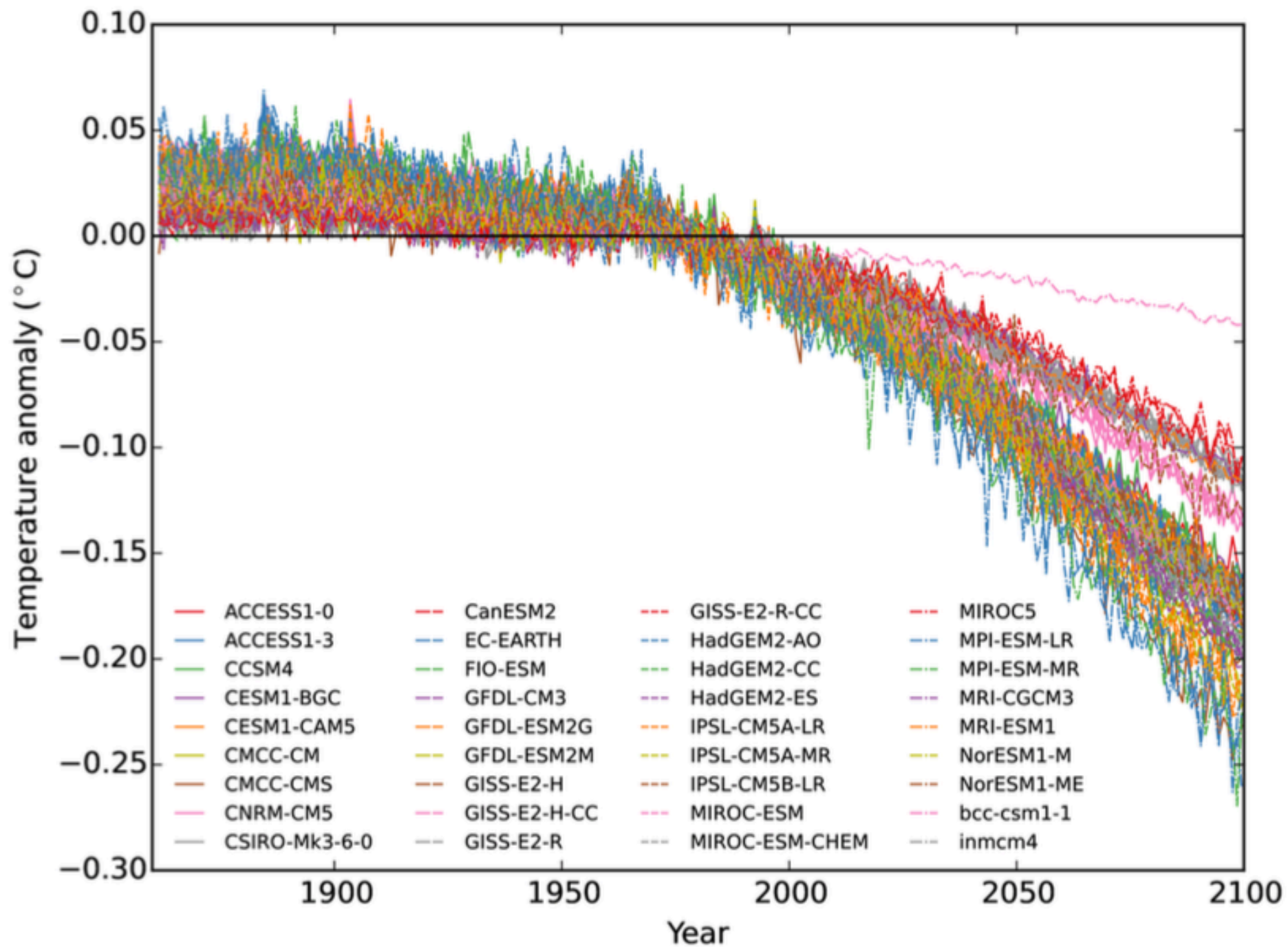
Eliminates approximately 38% of the discrepancy in trend between models and HadCRUT4 over the period 1975–2014.

(a) RCP8.5 forcings

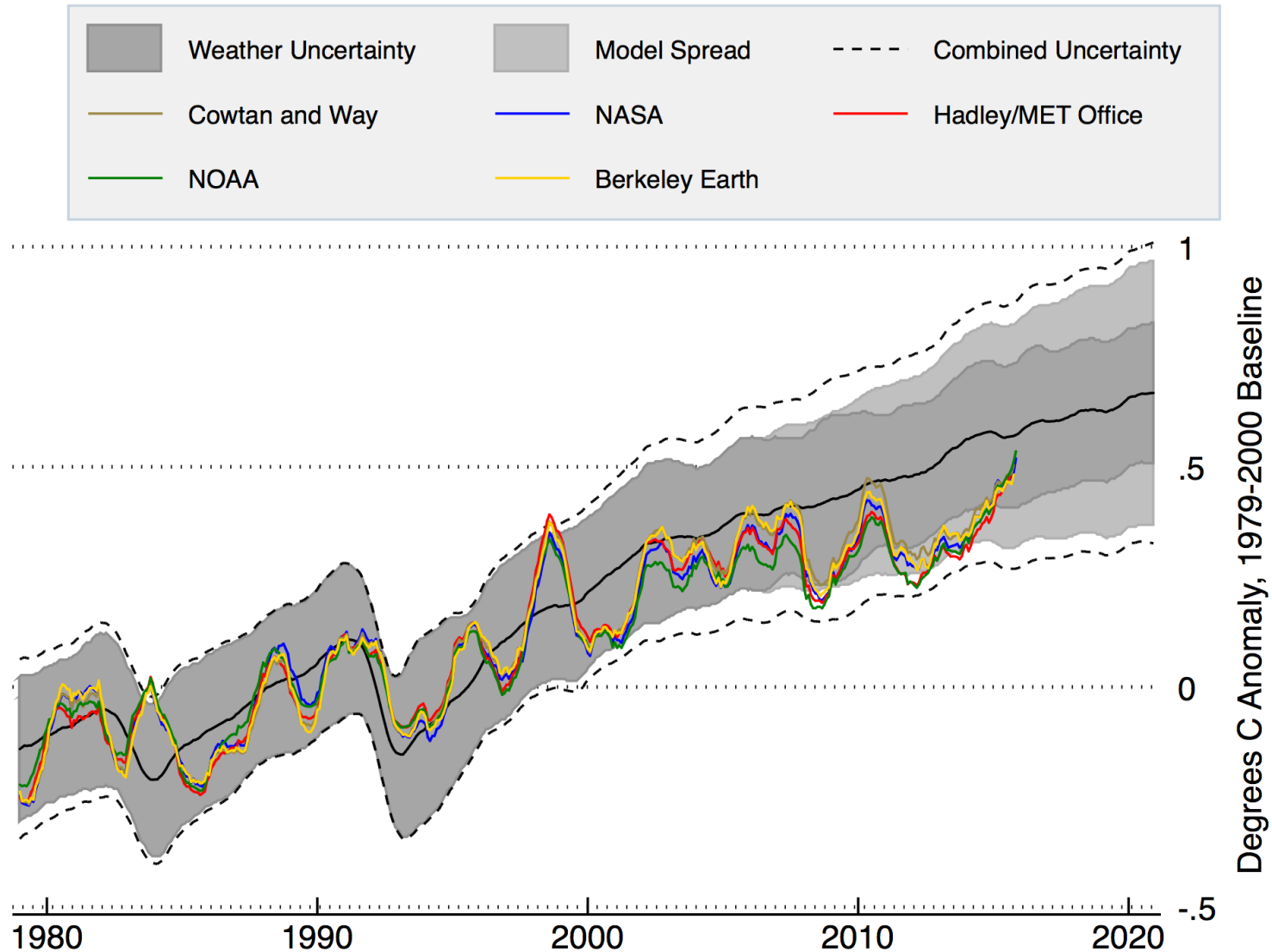


(b) Updated forcings





# Blended Model-Observation Comparisons, 1979-2020



12-month lagging average. Black line shows multi-model mean. Includes 109 runs from 38 RCP45 models.

# Takeaways

- Proper comparison of models and surface temperature records requires blended land/ocean fields
- Models have SAT warming significantly faster than SST.
- Blended fields eliminate about a third of model/observation trend differences over the past 40 years.