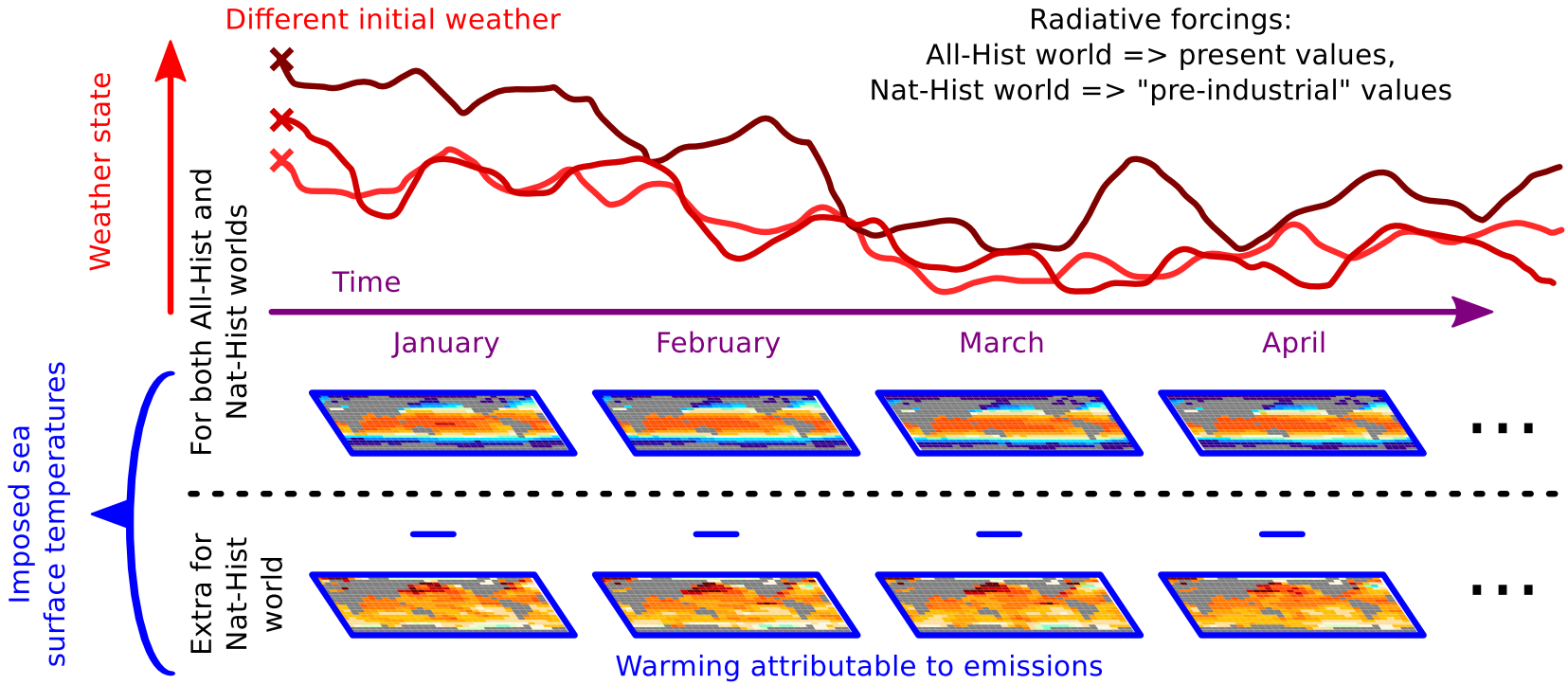
“The Climate That Might Have Been” Approach

Background

- Goal in event attribution:
  - Determining possible contributing factors on an extreme weather or climate related event e.g.,
    - Anthropogenic forcing (ghgs, ozone, aerosols)
    - Natural external forcings (solar, volcanic)
    - Internal atmospheric noise
    - Internal ocean variability
- **It is important to properly determining the anthropogenic climate change contribution**

Experiment set up



Two parallel set of experiments:

1. **Climate that has been experienced**: AMIP-style experiment with observed lower boundary conditions and radiative forcings
2. **Climate that might have been:** AMIP-style experiments with forcings that resemble the climate that might have been without impact of human influence (pre-industrial radiative forcings, modified lower boundary conditions that remove contribution attributable to anthropogenic emissions)

Different approaches to determine SSTs attributable to anthropogenic climate change

- Utilize CMIP3/5 experiments (e.g., Pall et al. 2011, Perlwitz et al 2009, C20 C&A project)
  - Utilize multimodel ensemble (e.g. Perlwitz et al. and single model estimates (Pall et al.2011) together with applying scaling factors
  - Determine combined natural and anthropogenic forcing (Perlwitz et al. 2009) versus warming attributable to ghg emissions (Pall et al. 2011)

- Estimate long-term climate change contribution based on observations (Hoerling et al. 2011, Perlwitz et al. 2014)
  - Approach cannot separate between naturally and anthropogenically induced SST change

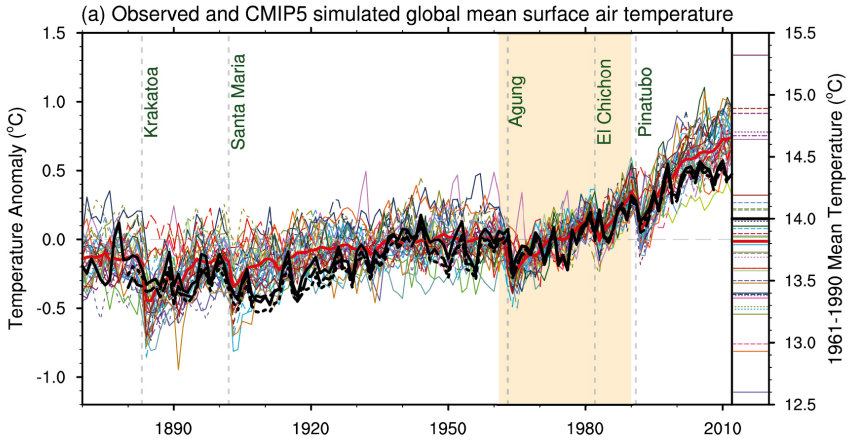
The Climate of the 20th Century Plus' Detection and Attribution Project

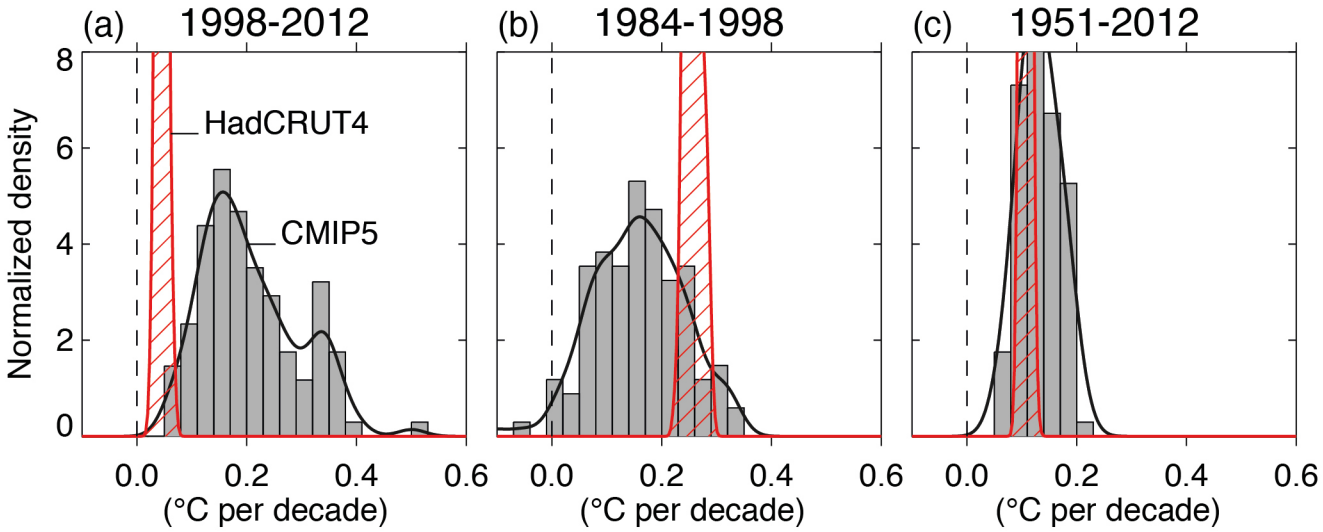
- An international collaboration to produce a multi-model product to support investigation of extremes under a changing climate
- Generating large ensembles of simulations under historical climate conditions
- Generating large ensembles of simulations under what historical climate conditions might have been without anthropogenic emissions
- Currently 12TB of output on ESGF from two atmospheric models (CAM5.1-1degree, MIROC5). Two more AGCMs expected in 2014 (HadAM3P-N96, HadGEM-3A), at least doubling that in 2015, plus regional downscaling and hydrological models.

C20 D&A Project

- Utilizes skin temperature of CMIP5 Historical +RCP4.5 and HistoricalNat simulations (19 models)
- Determine time varying difference between historical+RCP4.5 and CMIP5 historicalNat simulations=attributable warming signal
- This attributable warming signal will then be subtracted from observed SST values
- Sea ice forcing and related SST in polar regions is also modified (Pall et al. approach)

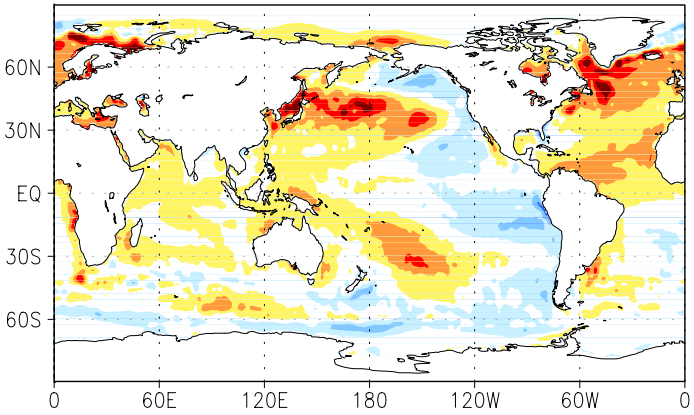
Issue: Recent Global Warming Hiatus



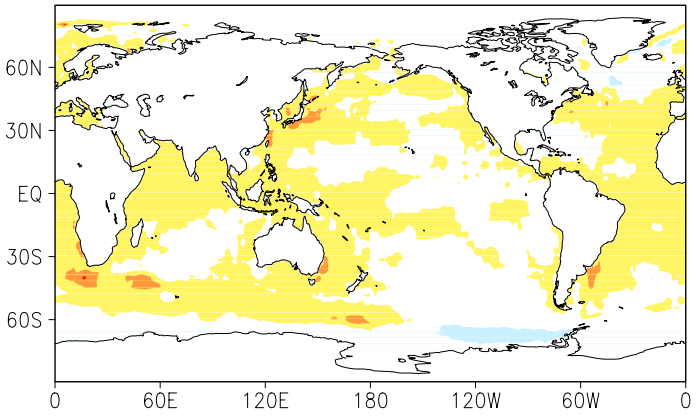


IPCC WGI AR5: Chapter 9

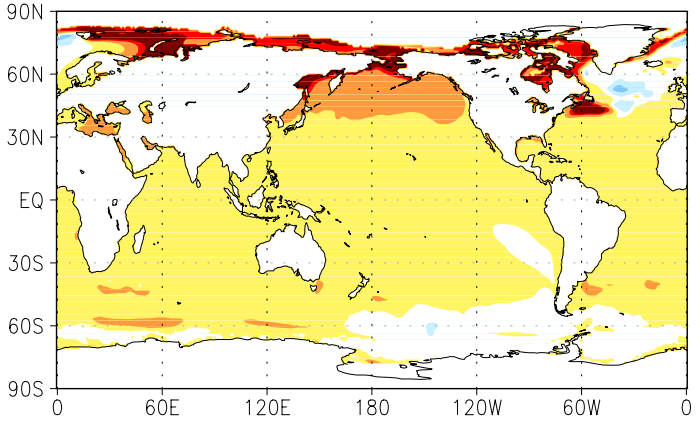
Decadal SST Difference

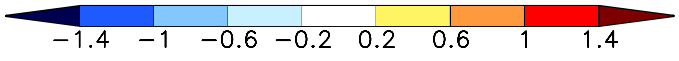


Long−term Trend Contribution to
Decadal SST Difference



CCSM4 Estimate of Decadal Climate Change Contribution





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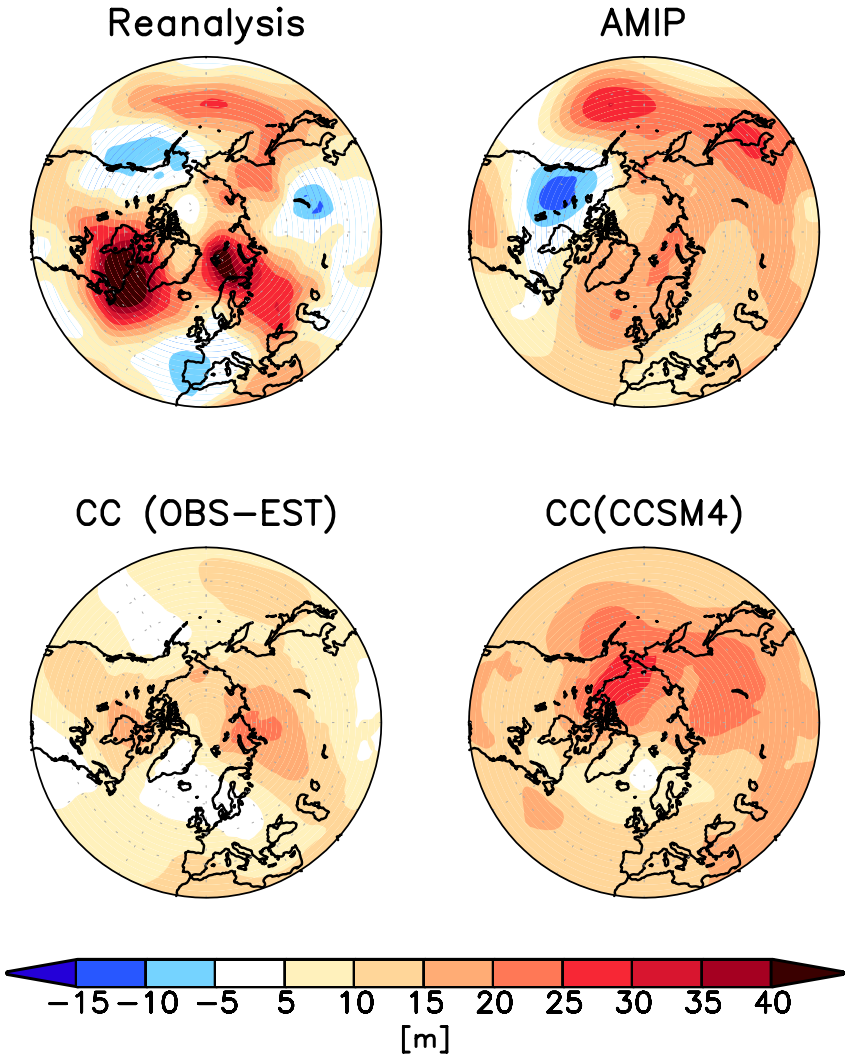
Contributions to Observed Arctic Tropospheric Warming strongly affected by method

	OBS Estimate 1	OBS Estimate 2	CCSM4-Estimate
SIC	~20%	~20%	~20%
SST-CC	~25%	~34%	~75%
Decadal Ocean Variability	~50%	~25%	-20% to +5%

Approach does not affect implications



- Arctic tropospheric warming is mainly caused by processes outside the Arctic
- Observed decrease in westerlies in North Atlantic can be mainly attributed to atmospheric noise and decadal oceanic variability.