The role of forcings in 20th century North Atlantic-Mediterranean decadal variability

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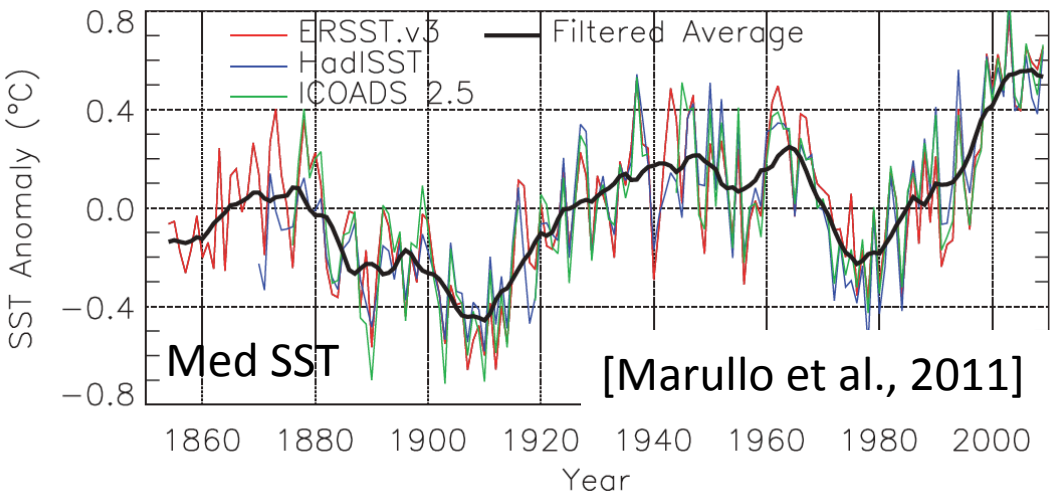
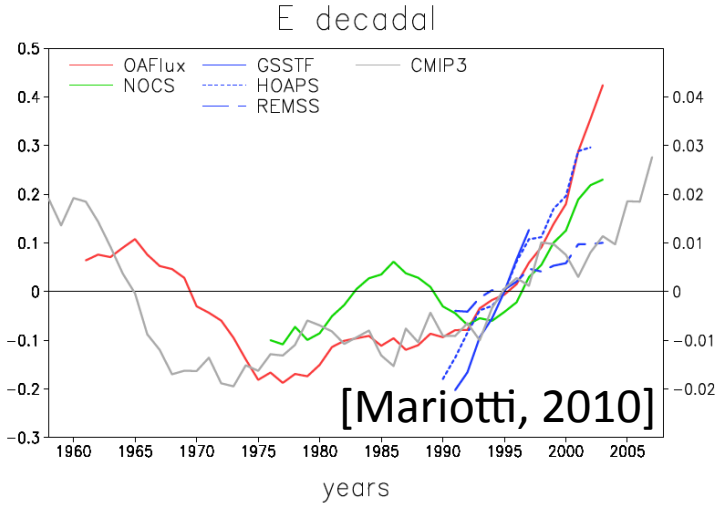
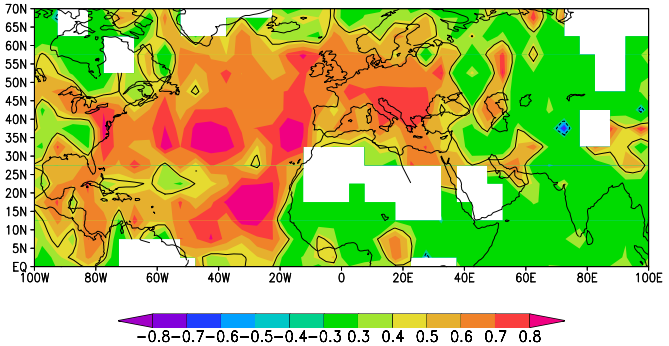
Mediterranean multi-decadal variability





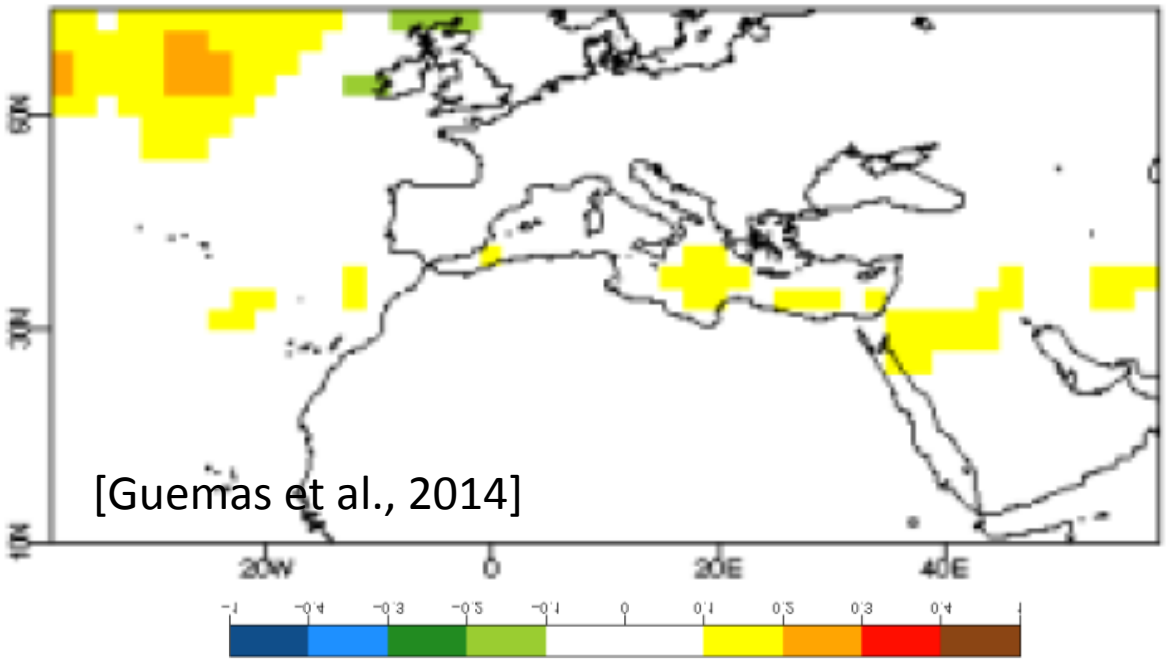


JJA Ta corr. with AMO
[Mariotti & dell'Aquila, 2011]

Multi-decadal variability is found in the Mediterranean region affecting (e.g.) SSTs [Marullo et al., 2011],surface air temperature [Mariotti & dell'Aquila, 2011], evaporation [Mariotti, 2011], coherent with the Atlantic Multidecadal Oscillation

Mediterranean multi-decadal variability

T2M: ACC Initialized-Uninitialized 2-5 lead-year



[Guemas et al., 2014]

However, initialized hindcasts show relatively little skill improvement, compared to non-initialized externally-forced integrations.
[Guemas et al., 2014]

Mediterranean multi-decadal variability

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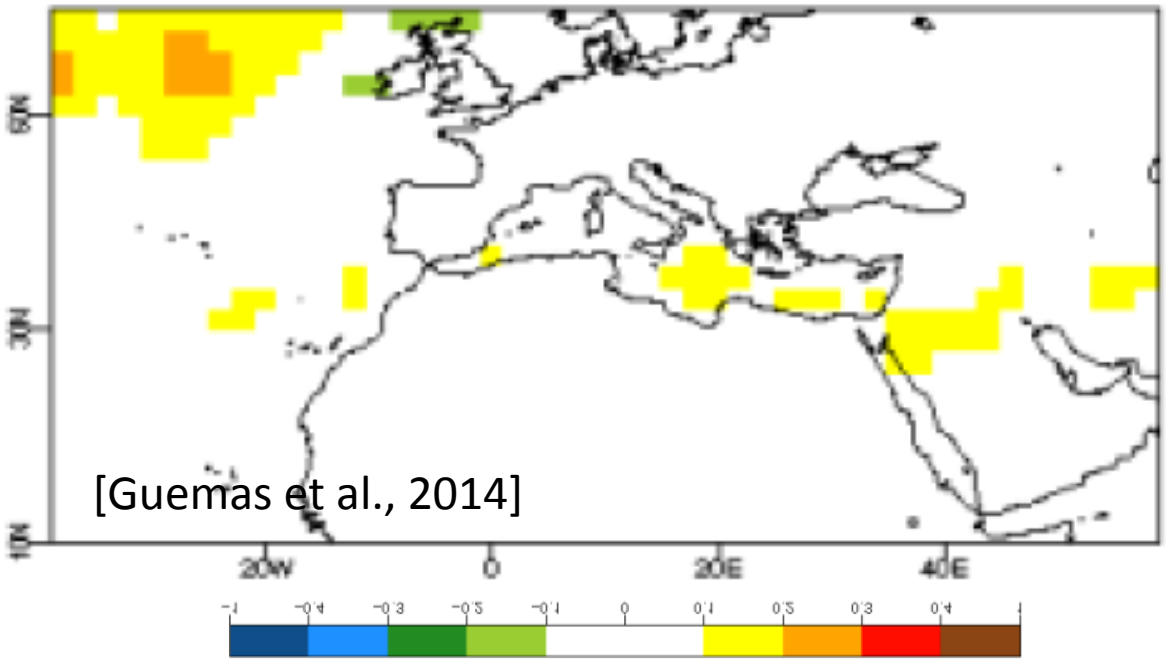


[Guemas et al., 2014]

Role of forcings on the 20th C multi-decadal variability?

A hierarchy of CMIP5 historical integrations under different forcing conditions.

HISTORICAL	HISTMISC Anthropogenic	HISTMISC NoAA
NATURAL ANTHROPOGENIC	ANTHROPOGENIC only	NATURAL ANTHROPOGENIC NO Ant. Aerosols

FORCINGS:

Natural: Volcanoes, Solar

Anthropogenic: GHG, Anthrop. Aerosols, Land Use Changes, Ozone

A hierarchy of CMIP5 historical integrations under different forcing conditions.

ENS. SIZE

HISTORICAL	HISTMISC-ANTH.	HISTMISC-NoAA
GISS-E2-H (6)	GISS-E2-Hp109 (5)	GISS-E2-H (5)
IPSL-CM5A-LR (6)	GISS-E2-Hp309 (5)	IPSL-CM5A-LR (4)
CSIRO-Mk3-6-0 (10)	IPSL-CM5A-LR (3)	CSIRO-Mk3-6-0 (5)
CCSM4 (6)	CSIRO-Mk3-6-0 (10)	
CNRM-CM5 (10)	CCSM4 (4)	
GISS-E2-R (5)	CNRM-CM5 (10)	
BCC-CSM1-1 (3)	GISS-E2-Rp109 (5)	
CanESM2 (5)	GISS-E2-Rp309 (5)	
HadGEM2-ES (4)	GFDL-CM3 (3)	
MIROC5 (5)	CESM1-CAM5 (3)	
MPI-ESM-LR (3)		
MRI-CGCM (3)		
Nor-ESM1-M (3)		

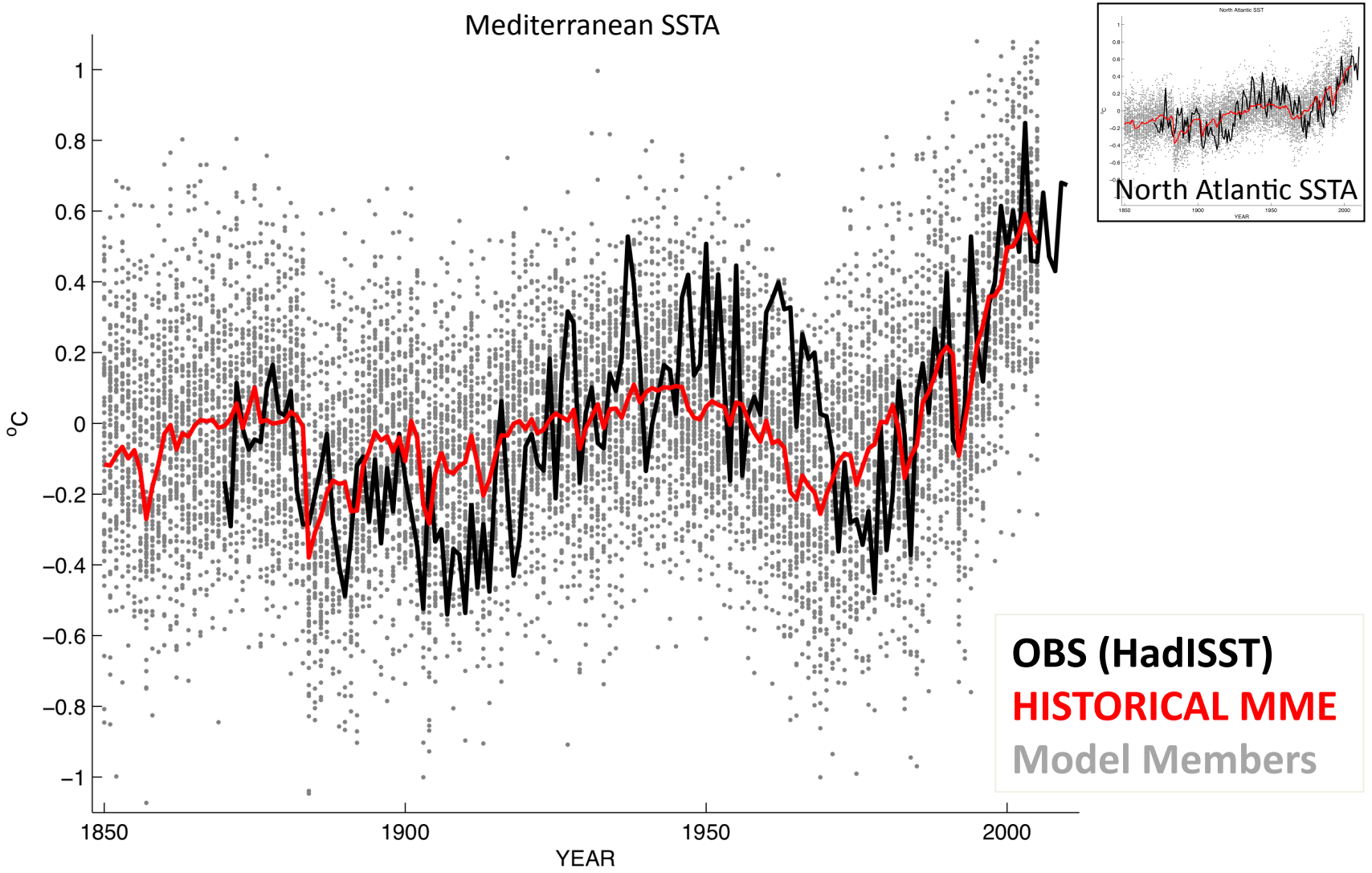
69

53

14

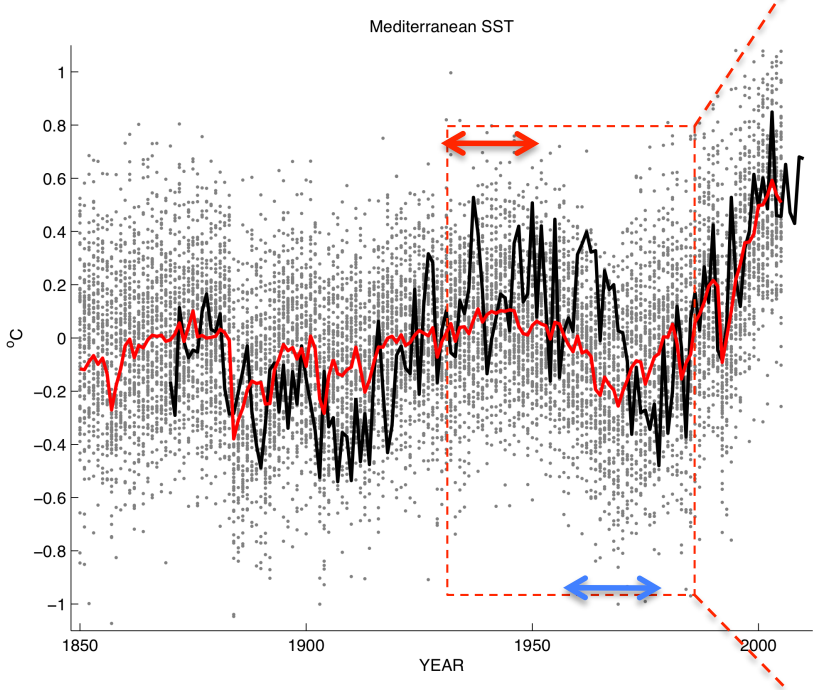
ONLY MODELS PROVIDING A MINIMUM 3-MEMBER ENSEMBLE WERE RETAINED FOR THE ANALYSIS SO AS TO FILTER-OUT THE INTERNAL, UNFORCED VARIABILITY SIGNAL.

Mediterranean-Atlantic multi-decadal SST variability in HIST CMIP5 simulations

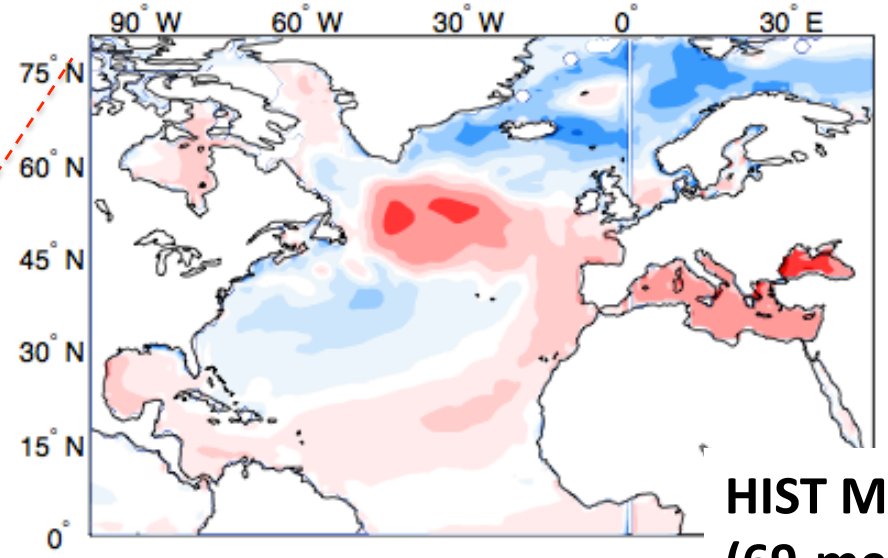


HIST MME MEAN PERFORMED OVER 13 MODELS (69 MEMBERS) SHOWS RESIDUAL MULTI-DECADAL VARIABILITY, HIGHLY COHERENT WITH THE OBSERVED RECORD.

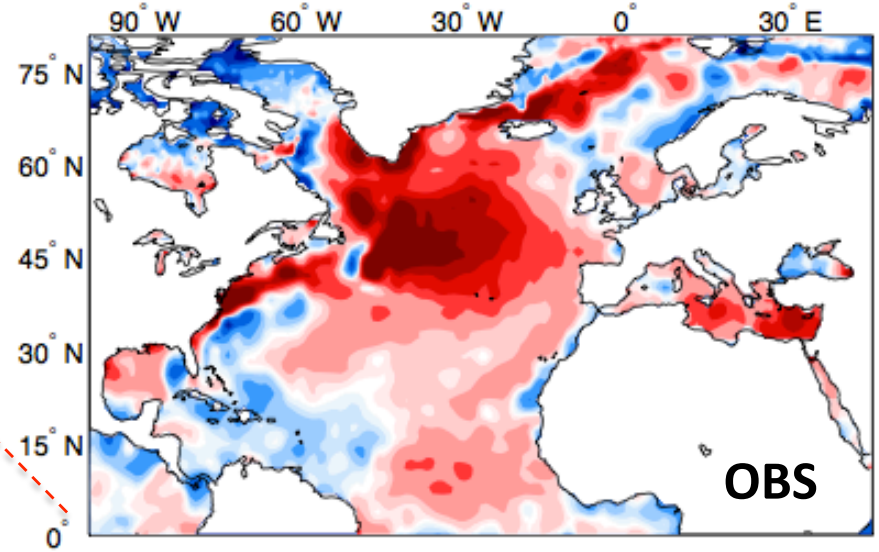
Mid-20thC cooling pattern reveals a "comma shaped" AMV-like structure with an amplified subpolar response consistent across HIST and OBS.



(1930-1950) – (1960-1980) composite



HIST MME (69-mem.)



OBS

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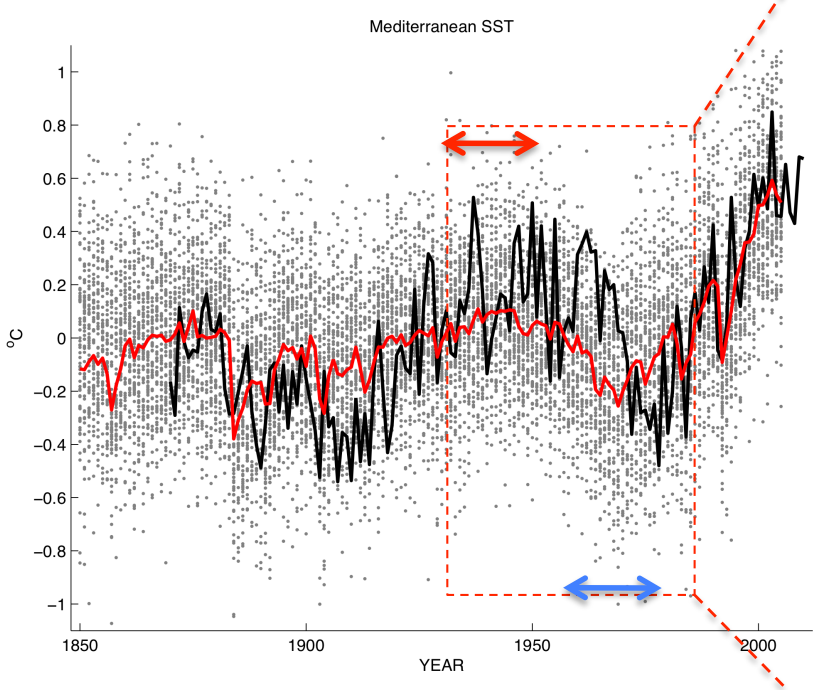

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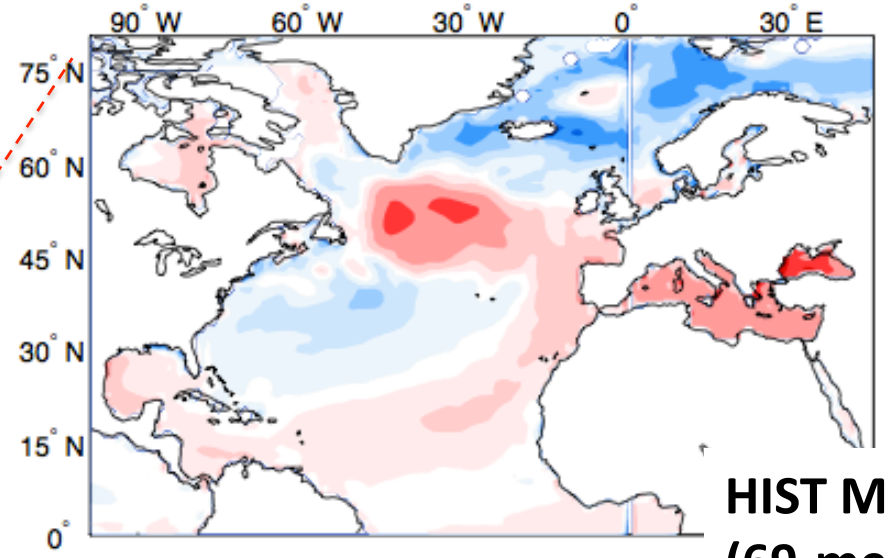

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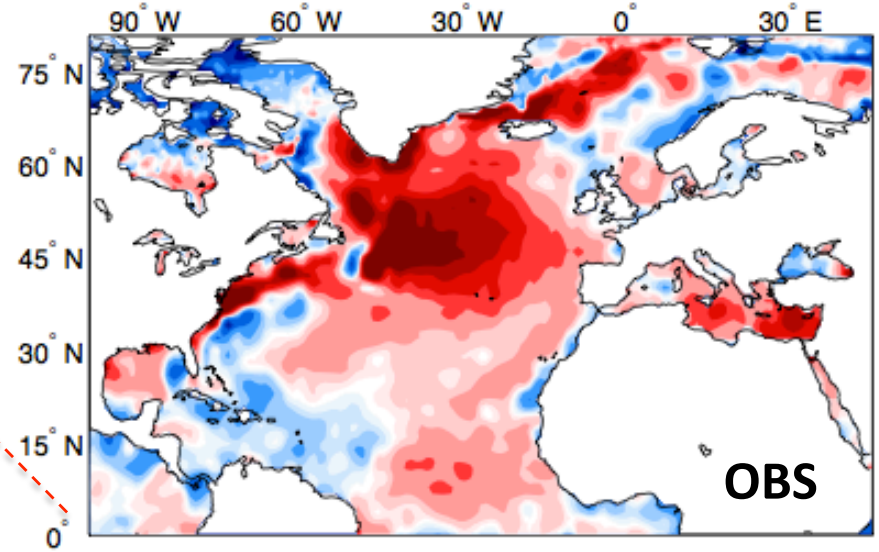


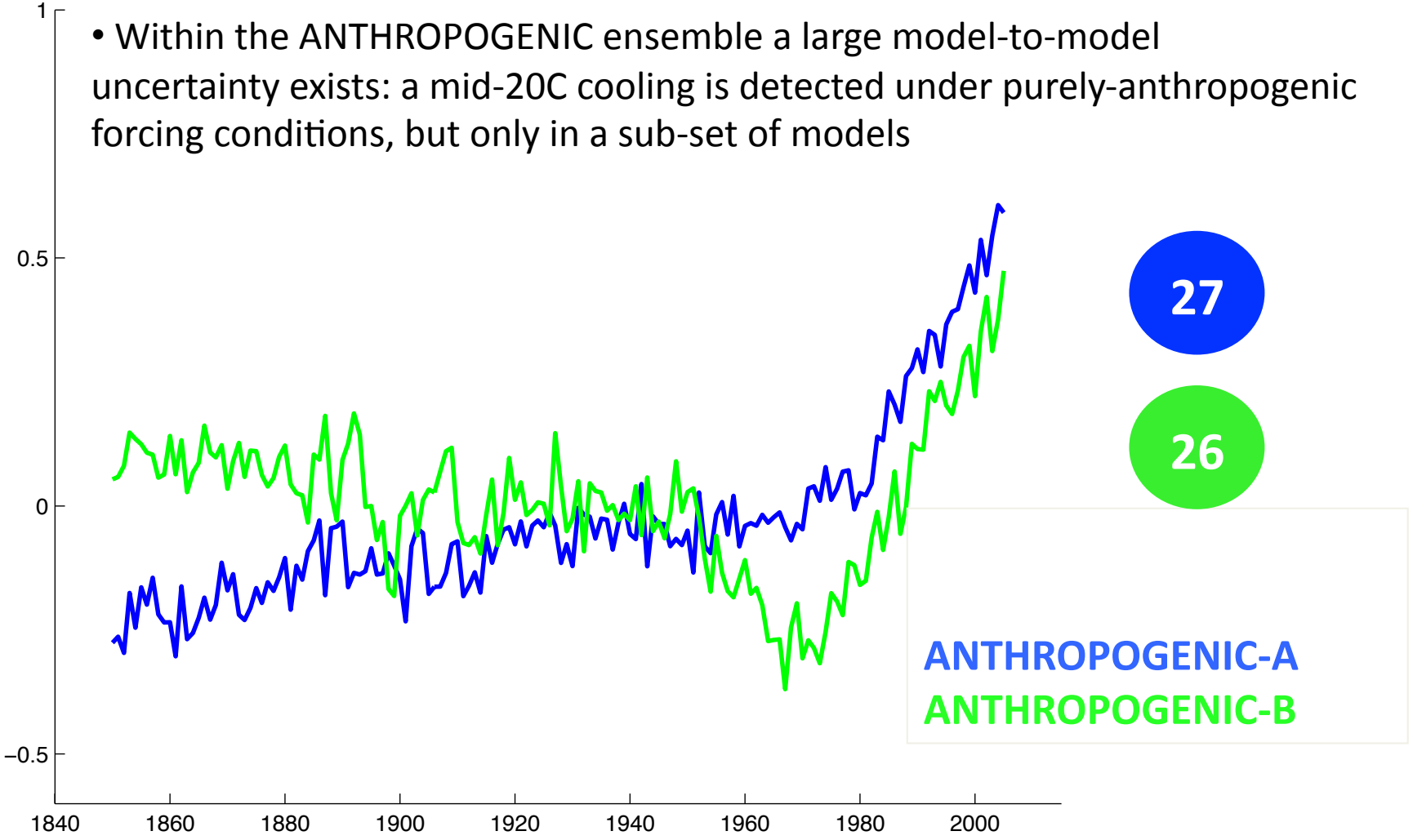
OBS

The purely-forced response (MME) accounts for the observed mid-20C cooling: but what kind of forcing is that? natural vs anthropogenic?

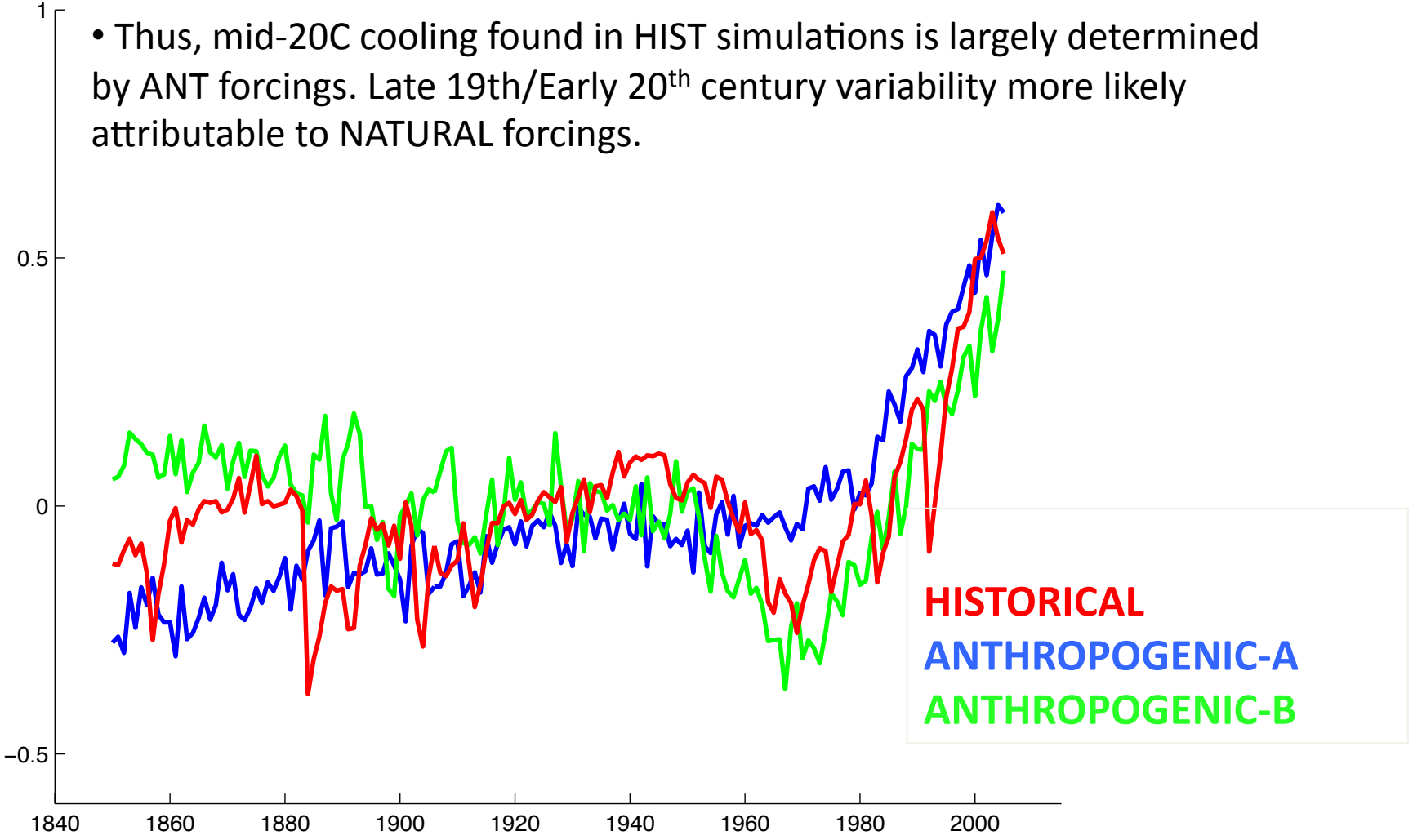

“Natural or anthropogenic
forcing ?”

Histmisc “Anthropogenic” Ensemble: two behavioral clusters

• Within the ANTHROPOGENIC ensemble a large model-to-model uncertainty exists: a mid-20C cooling is detected under purely-anthropogenic forcing conditions, but only in a sub-set of models



Histmisc “Anthropogenic” Ensemble: two behavioral clusters



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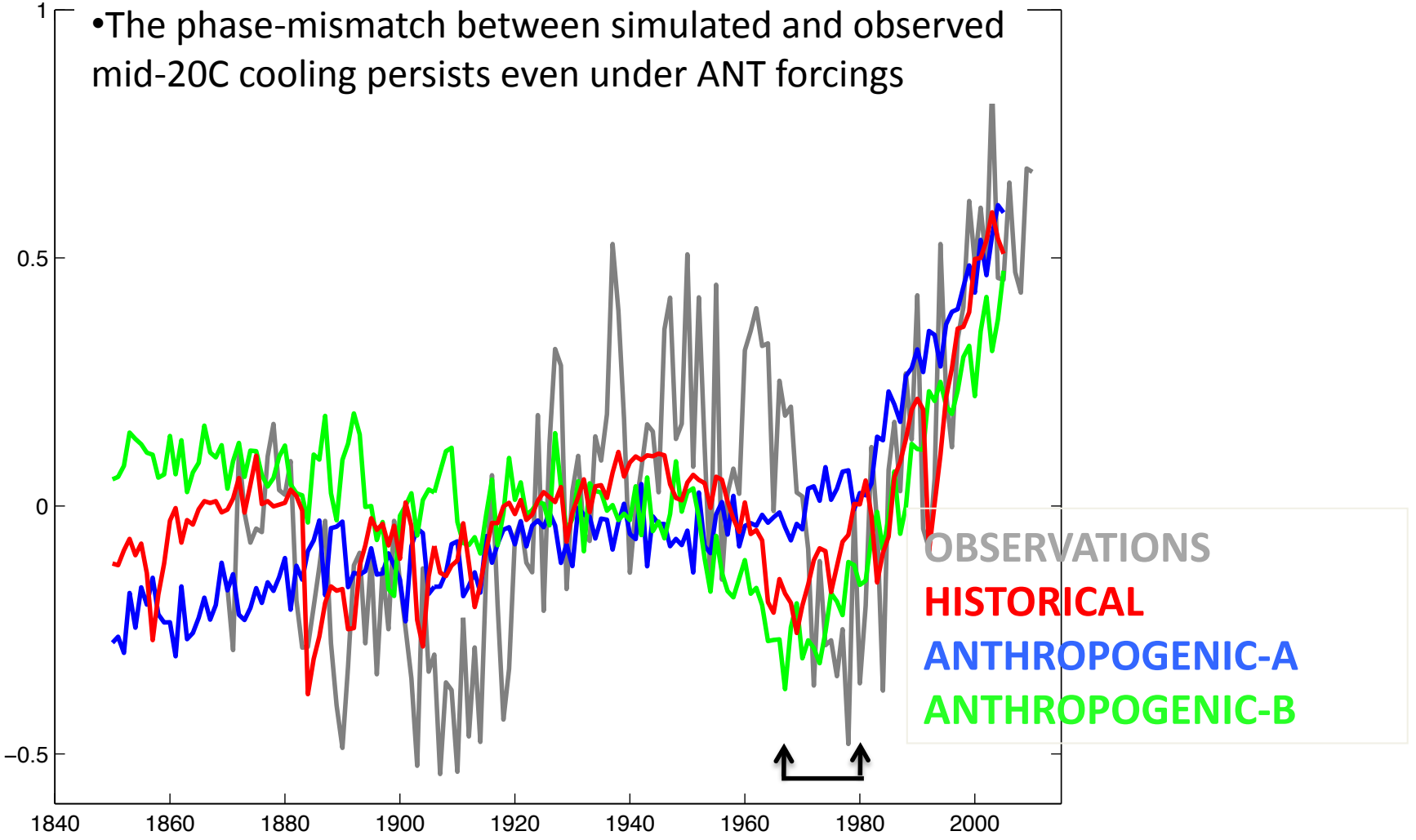
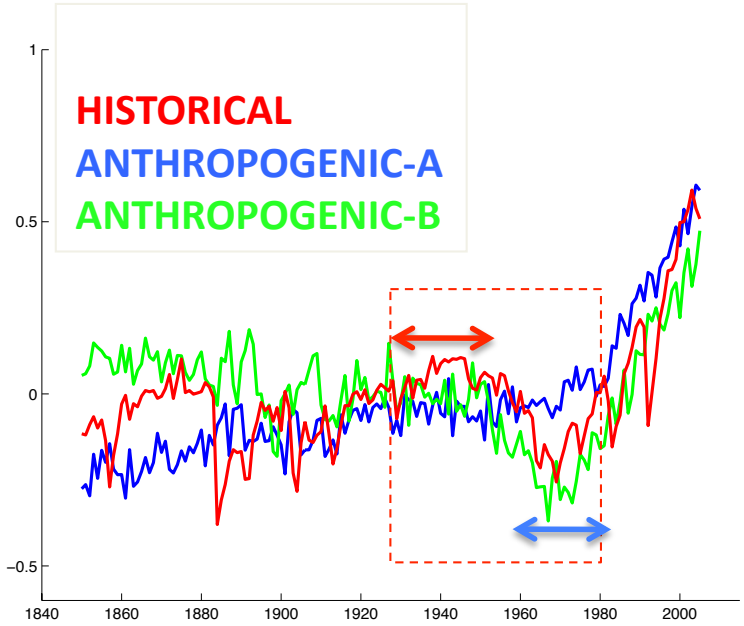
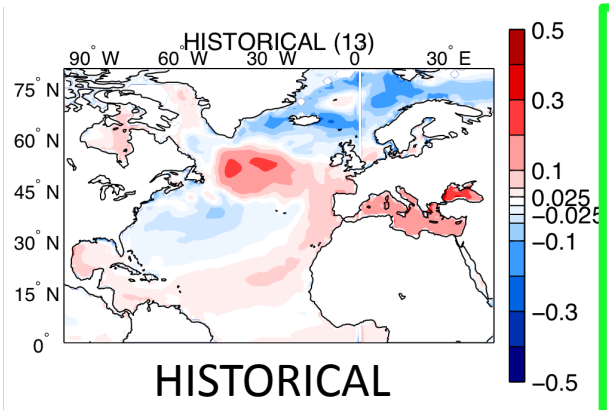
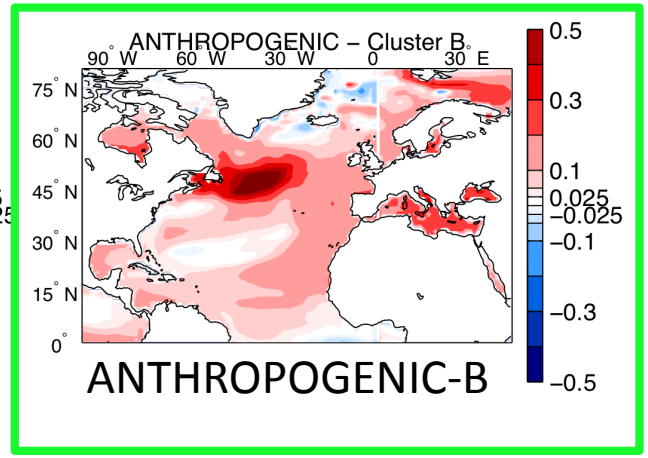
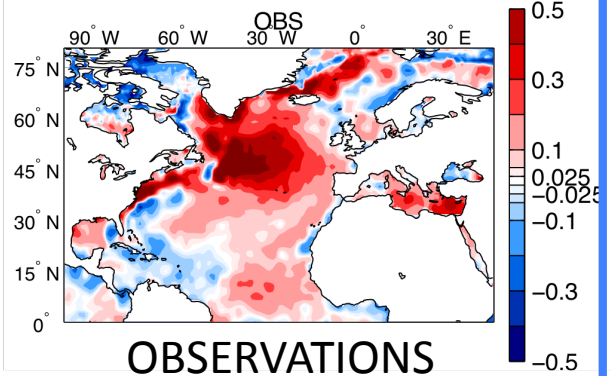


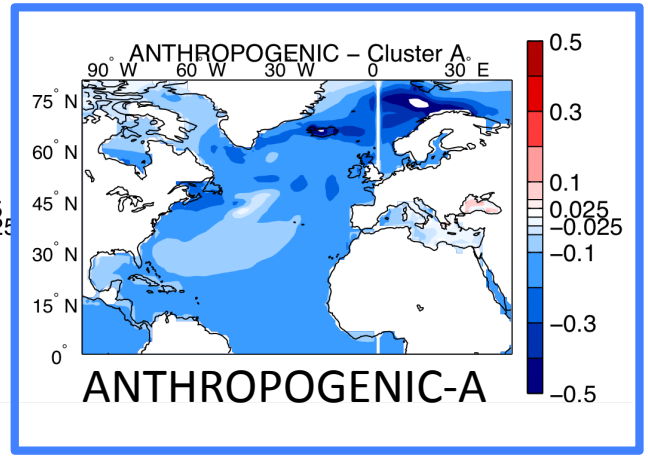
WARM [1930-1950] – COLD [1960-1980] composite patterns







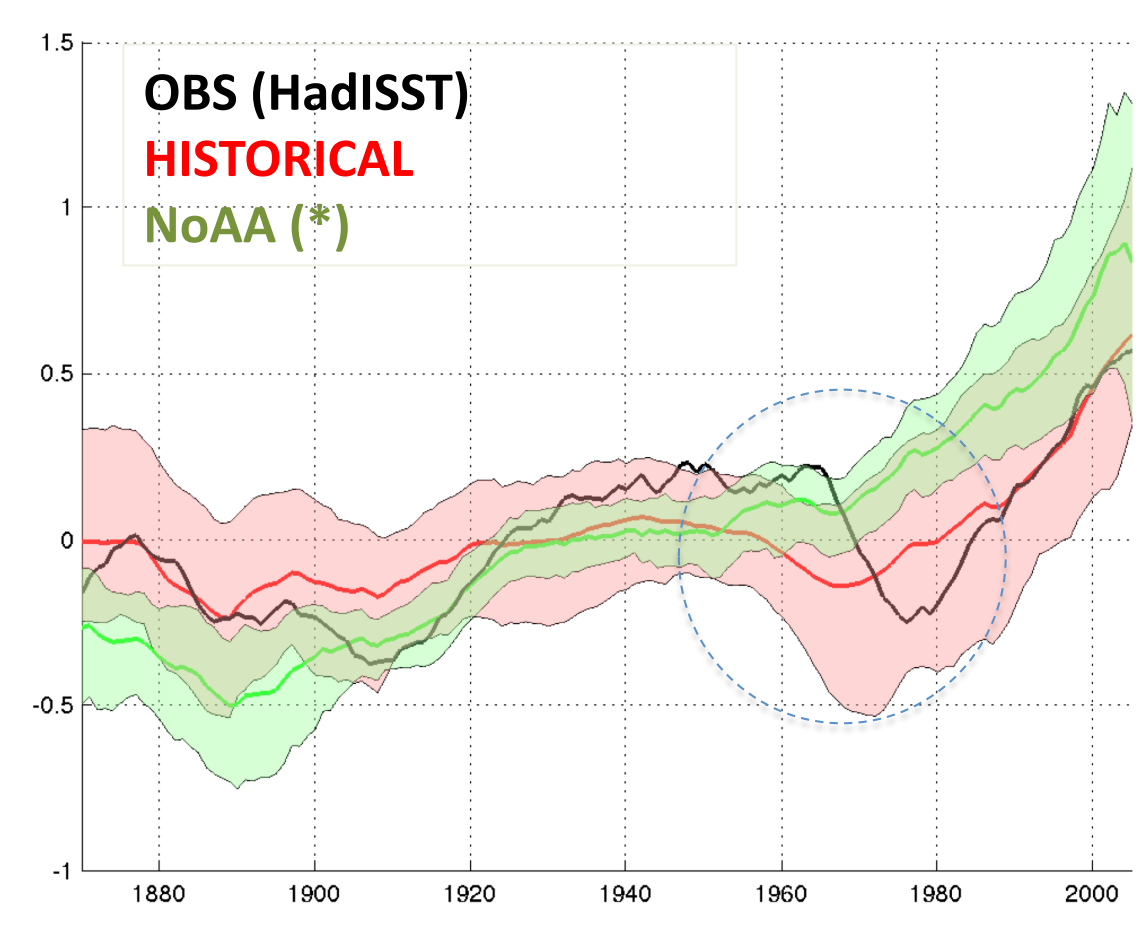




Models belonging to "Cluster-B" ANTHROPOGENIC simulations (green curve) show a pattern bearing strong similarities with HISTORICAL and OBS (comma-shaped structure & subpolar basin amplified response)

“If it *were* anthropogenic….what *kind* of anthropogenic would that be?”

Did the anthropogenic aerosols determine the mid-20th century cooling?



Same models used in HIST and NoAA to allow a fair comparison

(*) NoAA: Same forcings as HISTORICAL but **without Anthropogenic Aerosols**

After removing the Anthropogenic Aerosols forcings, the simulated SSTs do not show the mid20-Century cooling anymore, but only a monotonic increase with time.

CONCLUSIONS

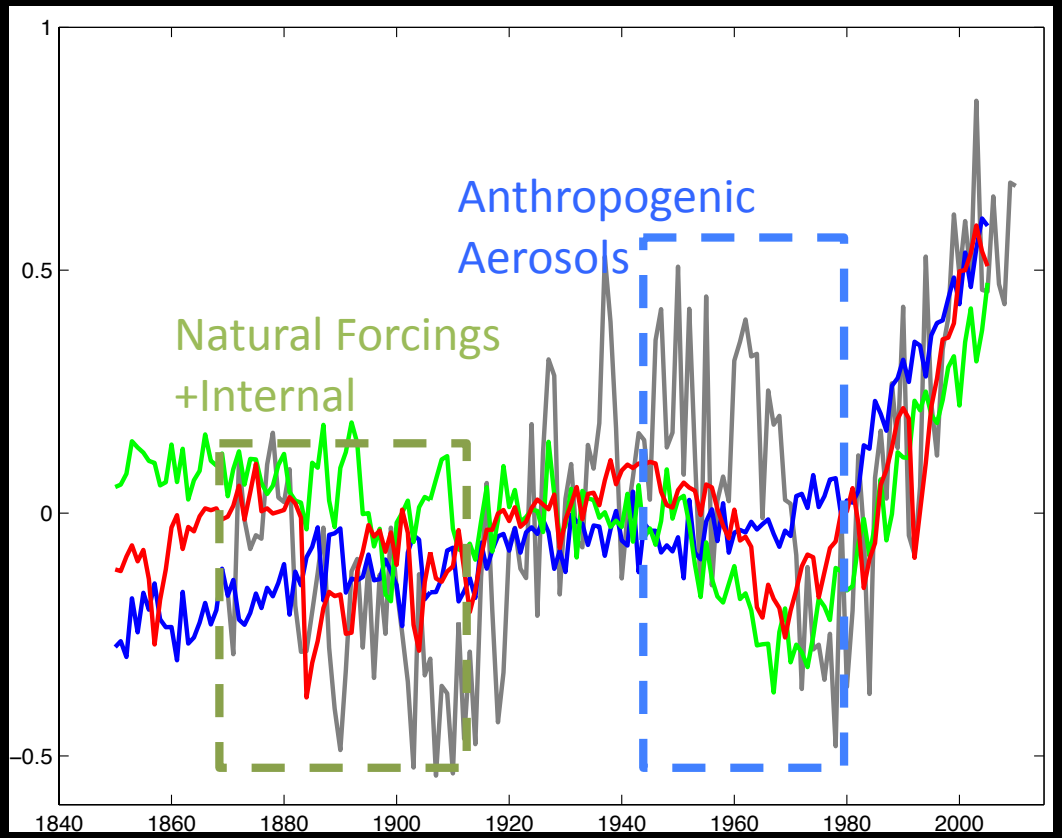
- The MME mean of 69 HISTORICAL simulations display multi-decadal SST variability over the N.Atlantic-Mediterranean area, coherent with the OBS 20th century record, indicating the influence of non-stationary forcings.

- The MME anomaly map associated with the mid-20th century SST "dip" features a comma-shaped structure over the N. Atlantic domain, encompassing the Mediterranean, and a subpolar enhanced response, consistent with OBS.

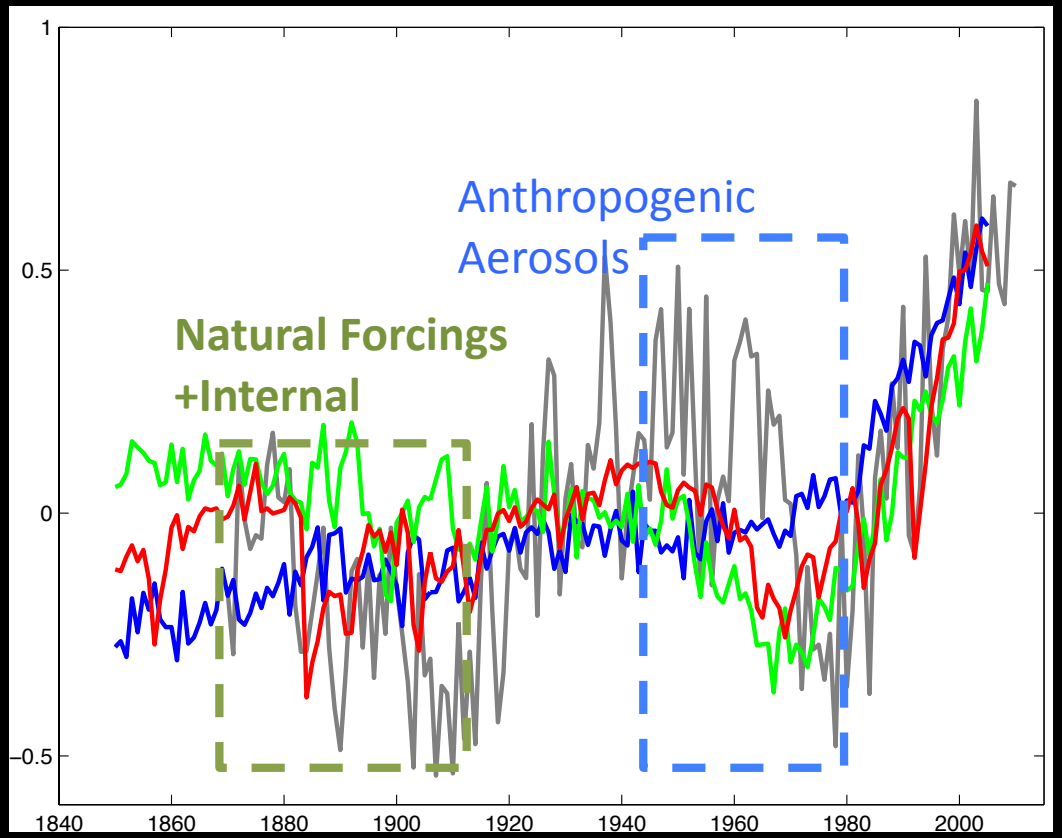
- A subset of the HISTMISC simulations performed with ANTHROPOGENIC-only forcings reproduce a forced response bearing strong resemblance with the HISTORICAL pattern.

- An analysis of the NoAA integrations suggests that the observed mid-20C multi-decadal SST fluctuations over the N Atl-Med region may be forced by anthropogenic aerosols.

20C AMV resulting from a combination of different drivers



“A Frankenstein-AMV?”




The End

ENS1: 13 mod. 69 mem.