Simulated temperature response to external forcing in the last millennium

Raible, C.	U. Bern	Phipps, S. J.	U. N. South Wales
Amman, C.	NCAR	Servonat, J.	LSCE
Barriopedro, D.	UCMadrid	Swingedouw, D.	LSCE
García-Bustamante, E.	U. Giessen	Tett, S.F.B	U. Edinburg
Jungclaus, J.	MPI , Hamburg	Wagner, S.	HZGeesthacht
Lorentz, S. J.	MPI, Hamburg	Yiou, P.	LSCE
Luterbacher, J.	U. Giessen	Zorita, E.	HZGeesthacht

FUPSOL-PAGES Workshop Davos 5-7.09.2012

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Outline

1.- Last millennium AOGCM simulations & solar forcing

2.- Model & data comparison: NH temperatures

3.- MCA-LIA transition

4.- Climate sensitivity: PTCR

4.- Conclusions

AOGCM last millennium simulations & solar forcing

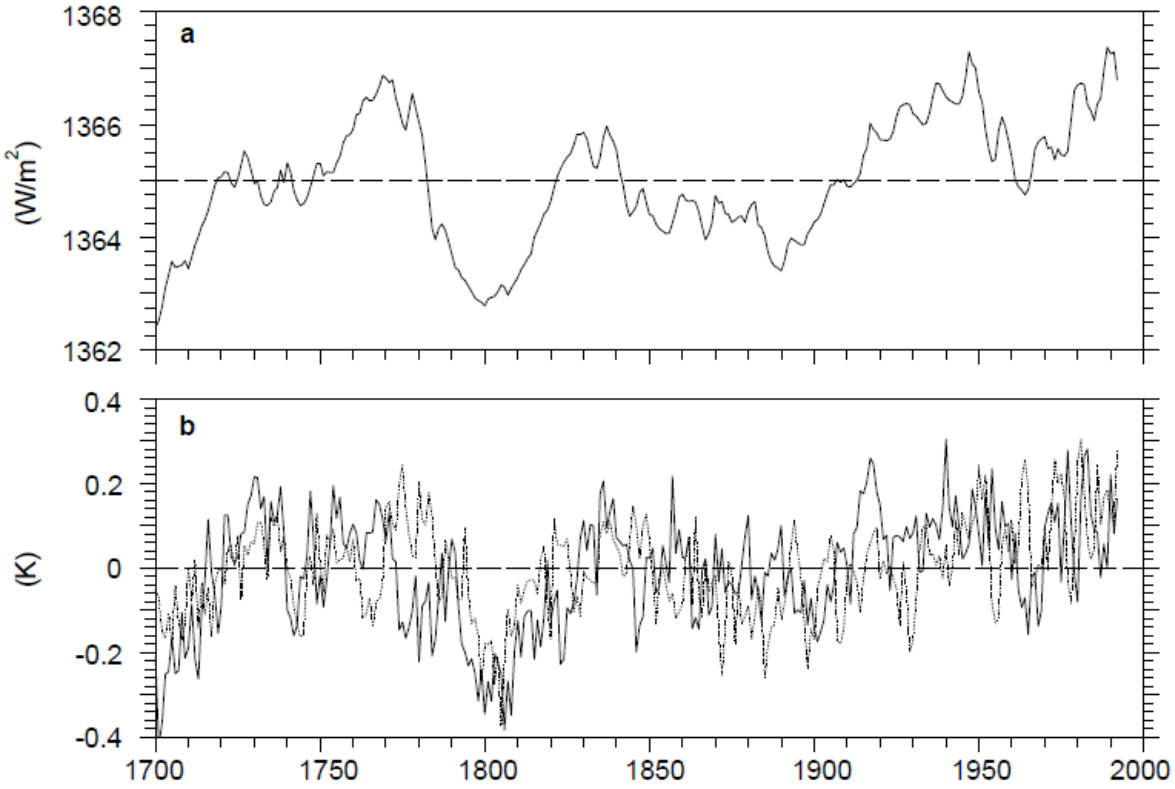


Fig. 1. **a** The solar radiance after Hoyt and Schatten (1993), normalized so that its average value is 1365 W/m^2, **b** the global mean near-surface temperature response to the solar variability for both experiments

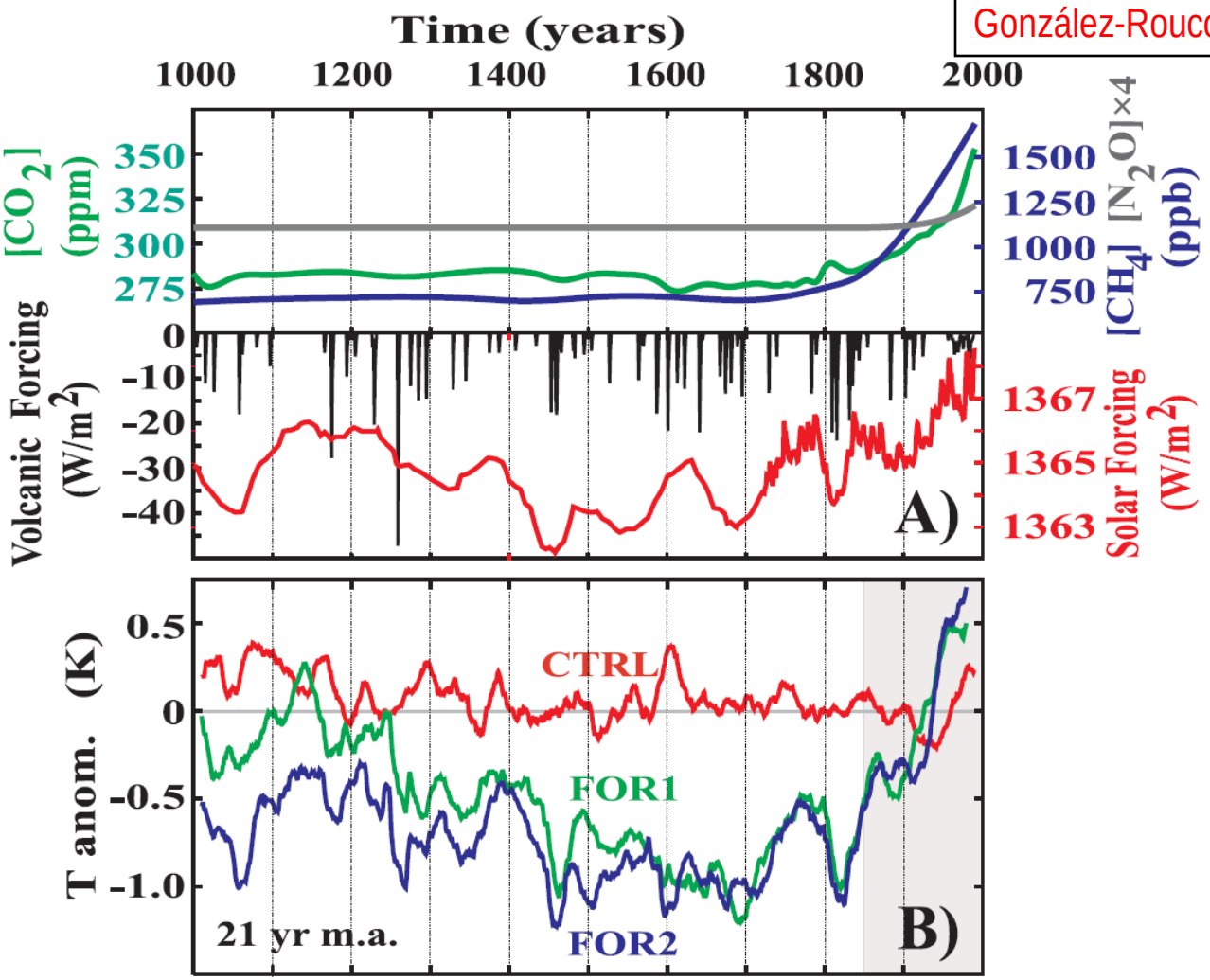
Cubasch et al (1997)

ECHAM3-LSG

AOGCM last millennium simulations & solar forcing

González-Rouco et al (2003,2006)

ECHO-G

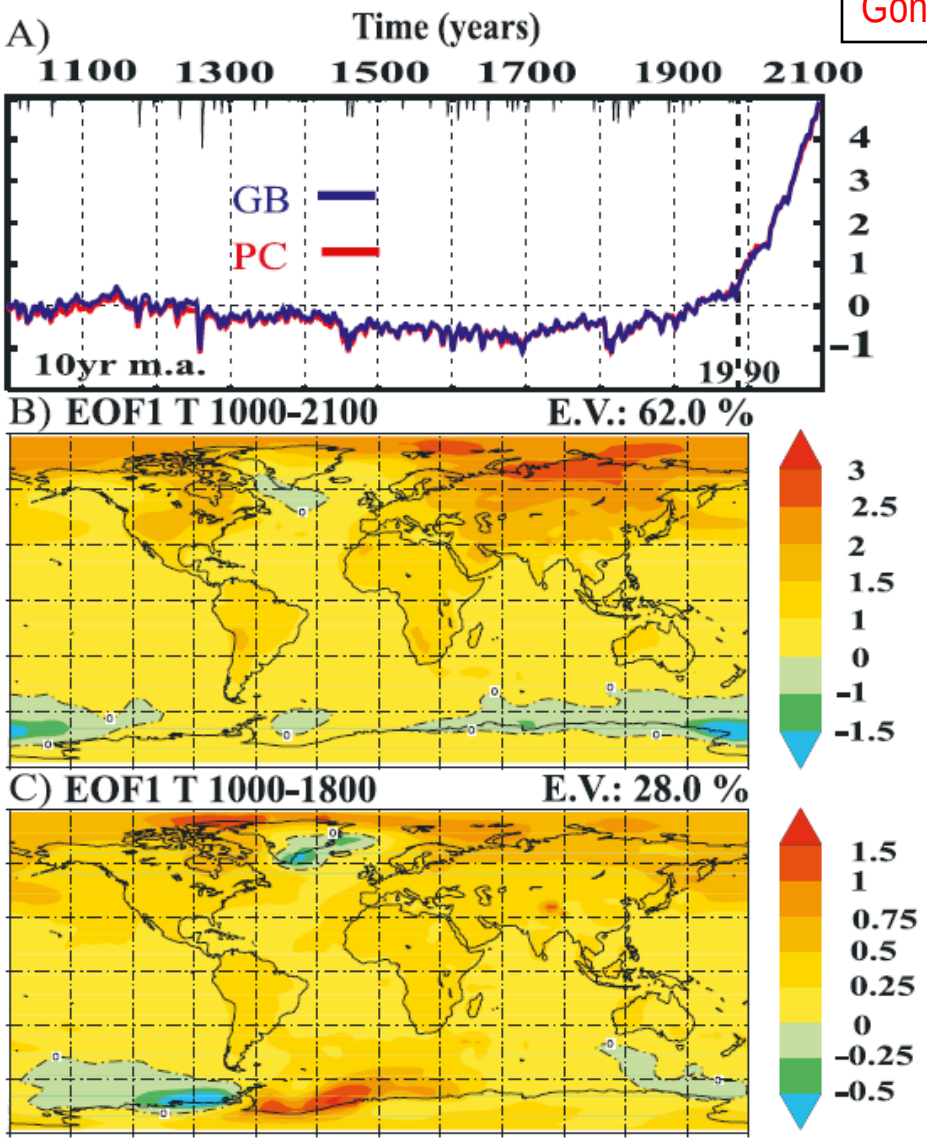


Solar forcing: Bard et al (2000) spliced to Lean et al (1995)

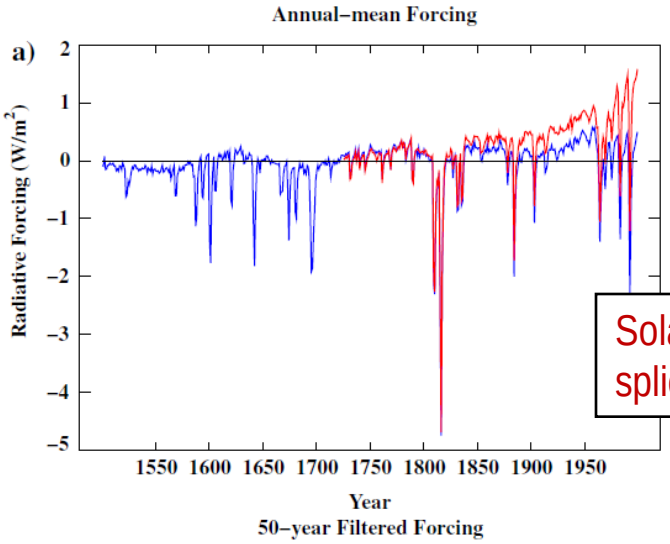
AOGCM last millennium simulations & solar forcing

González-Rouco et al (2003,2006)

ECHO-G



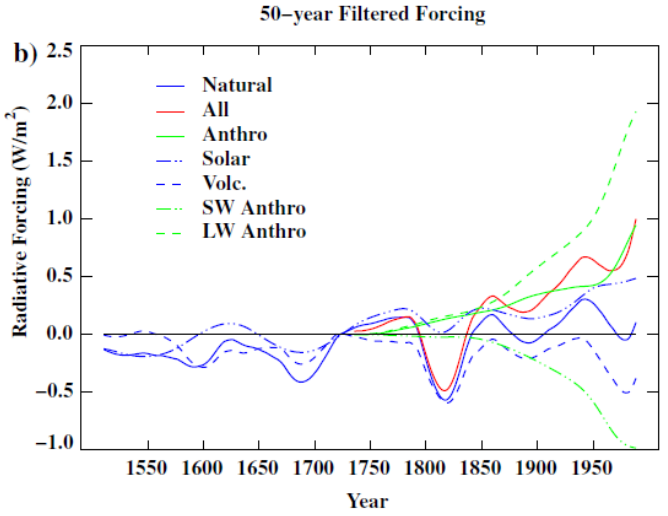
AOGCM last millennium simulations & solar forcing

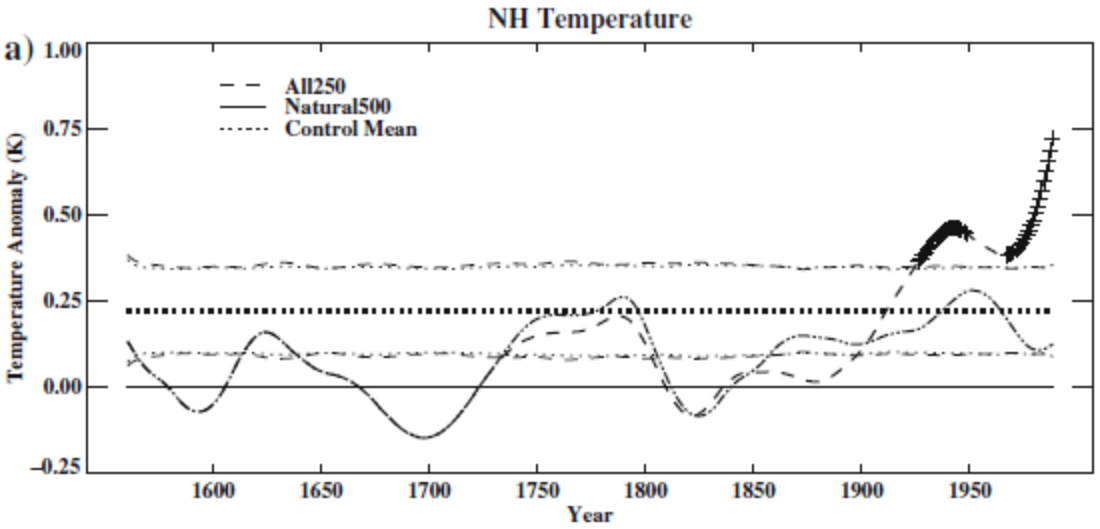


Tett et al (2007)

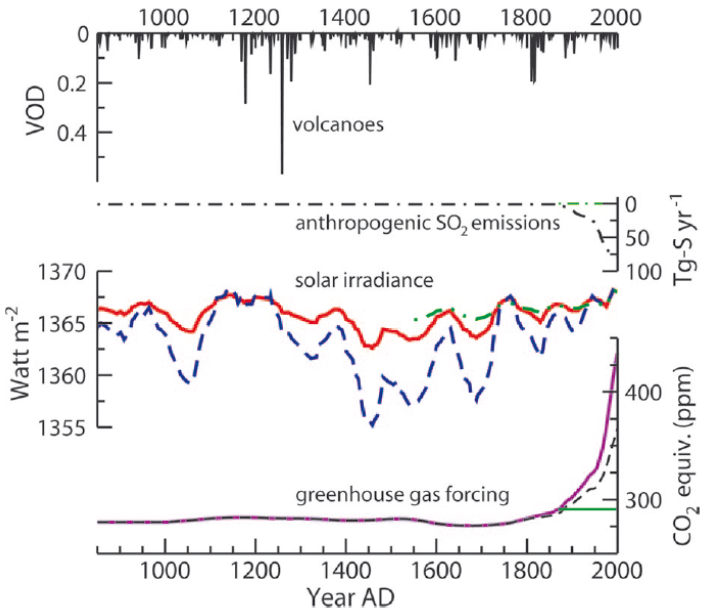
HadCM3

Solar forcing: Bard et al (2000) spliced to Lean et al (1995)





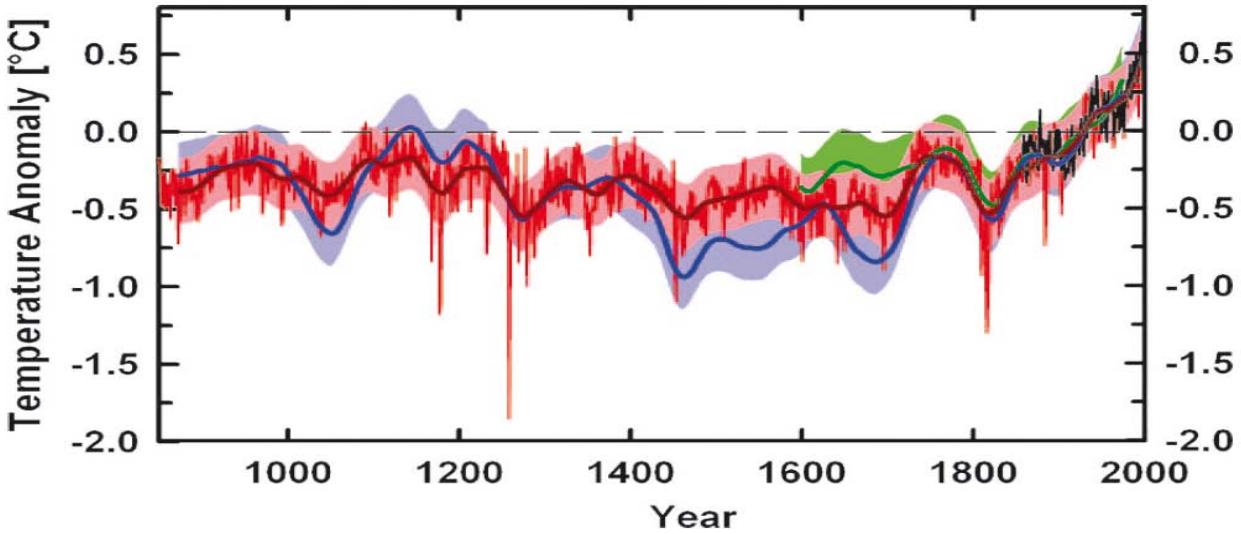
AOGCM last millennium simulations & solar forcing



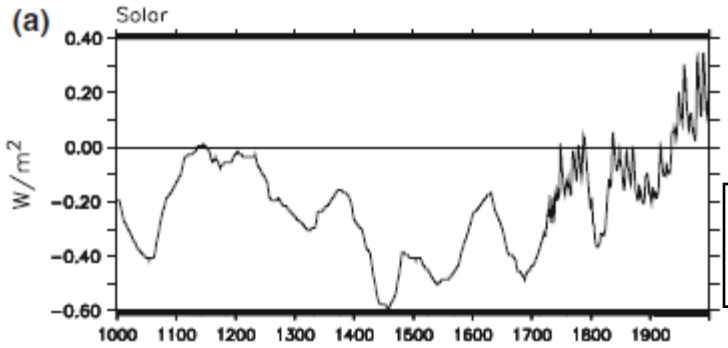
Ammann et al (2007)

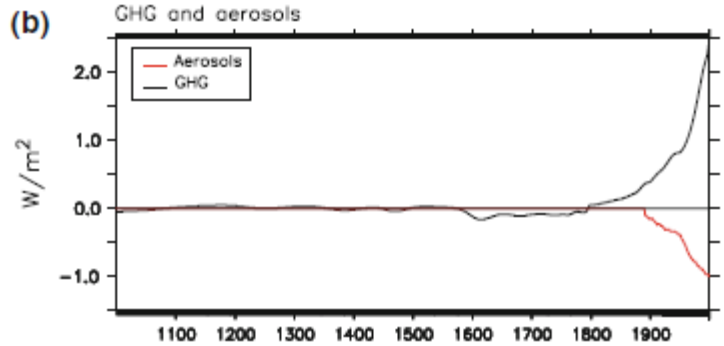
CSM1.4

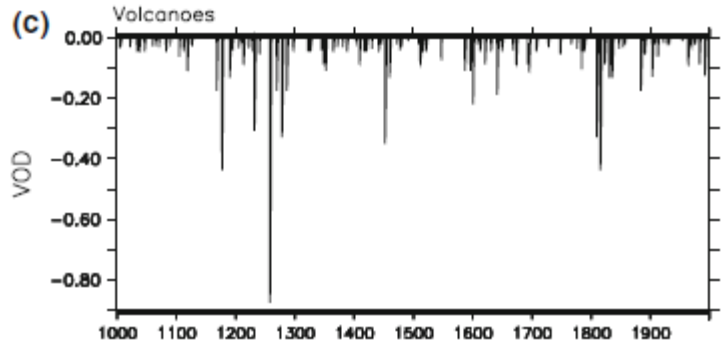
Solar forcing: Bard et al (2000)



AOGCM last millennium simulations & solar forcing



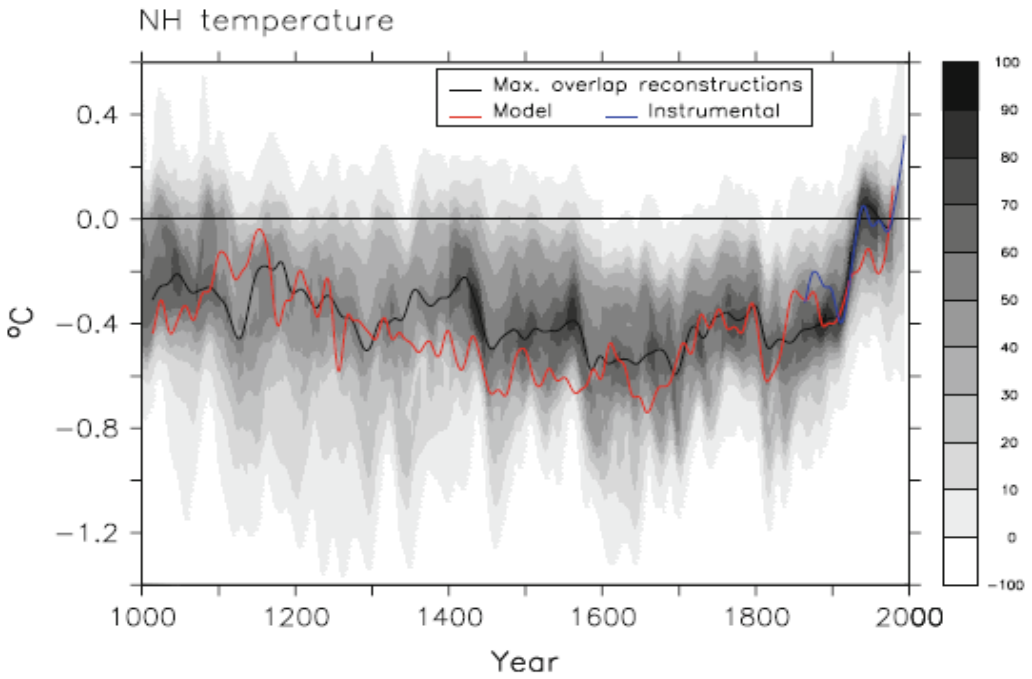




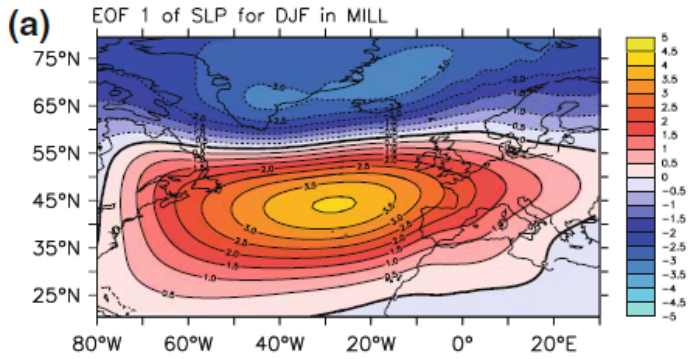
Swingedouw et al (2007)

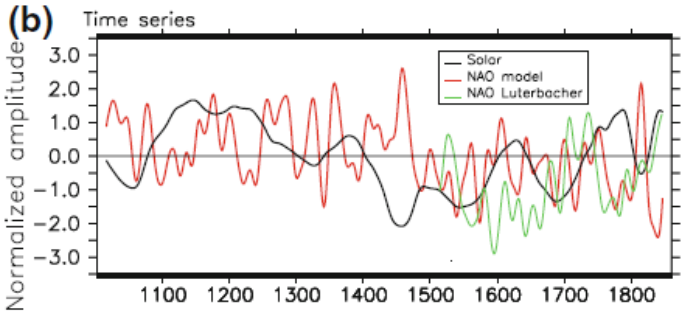
CNRM

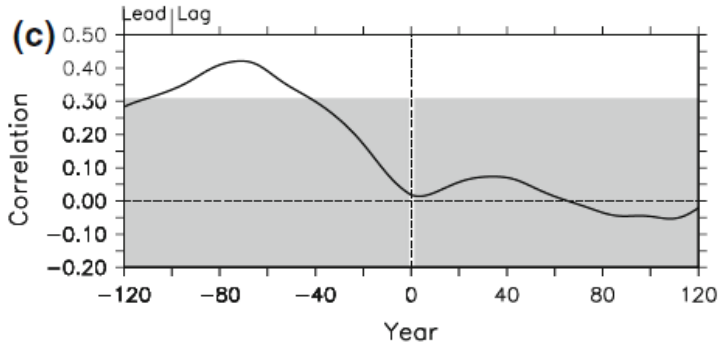
Solar forcing: Bard et al (2000)
spliced to Lean et al (1995)



AOGCM last millennium simulations & solar forcing







Swingedouw et al (2007)

CNRM

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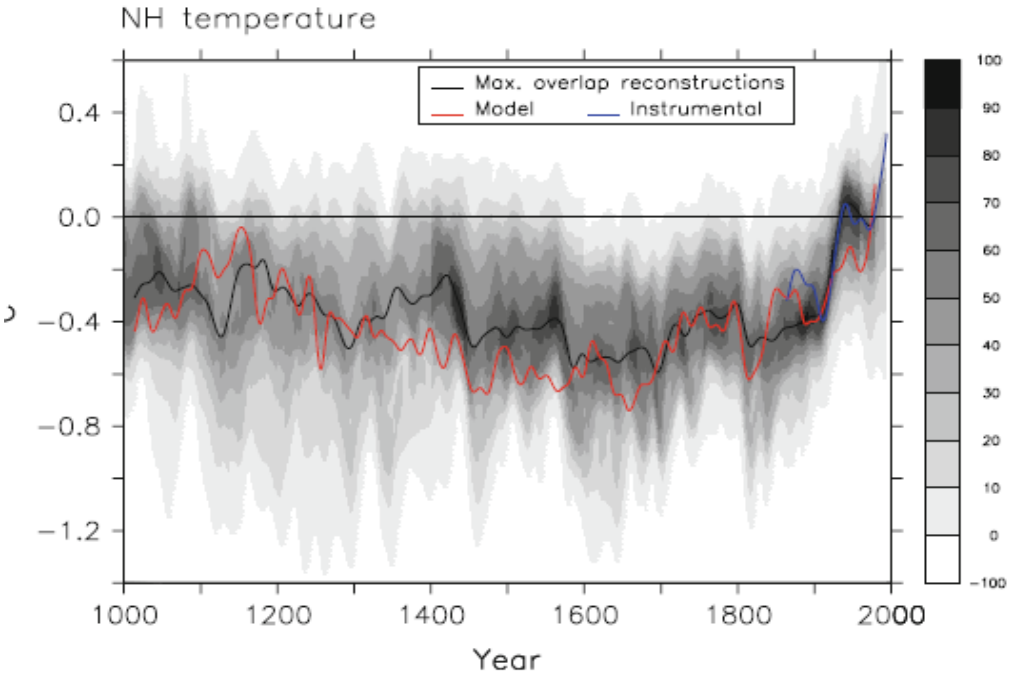
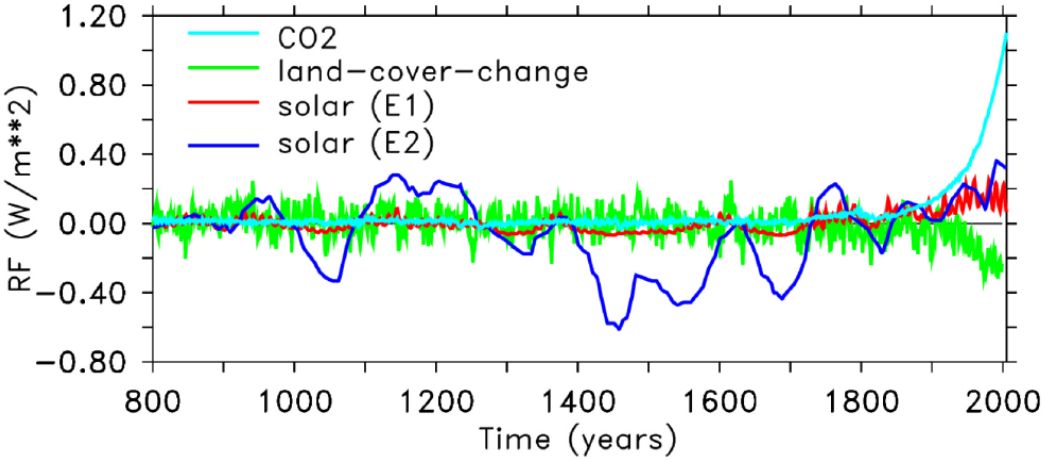


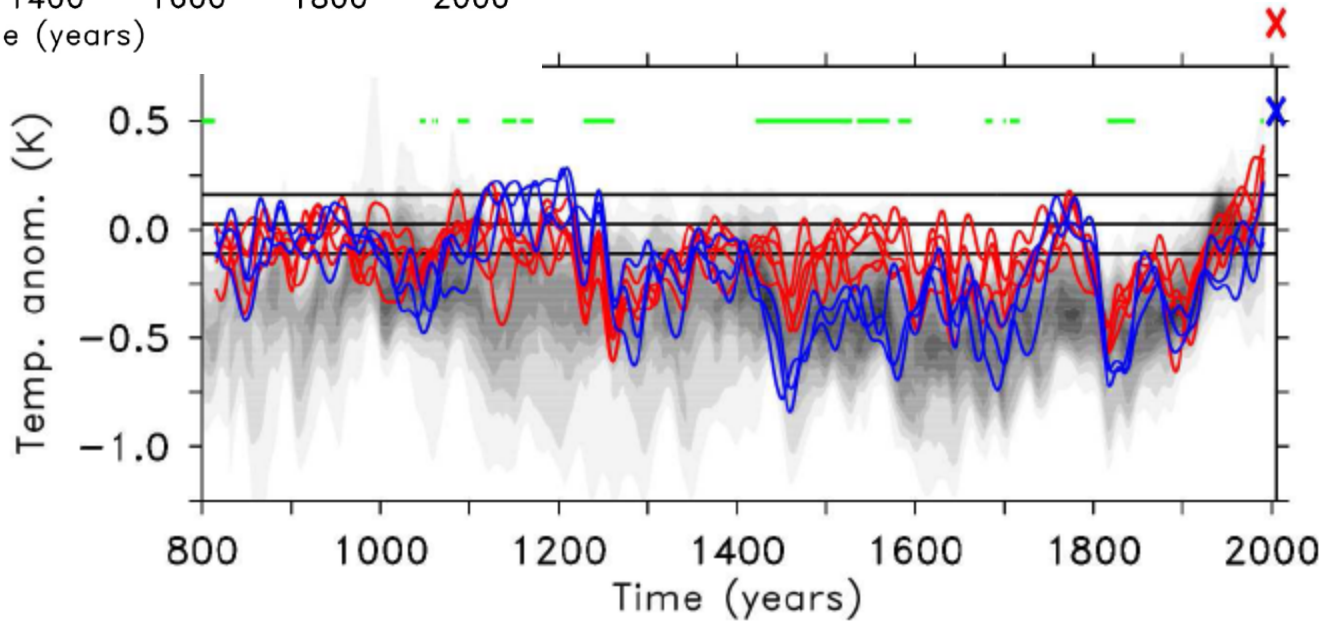
AOGCM last millennium simulations & solar forcing

Jungclaus et al (2007)

ECHAM5-MPIOM



Solar forcing: Krivova et al (2007)



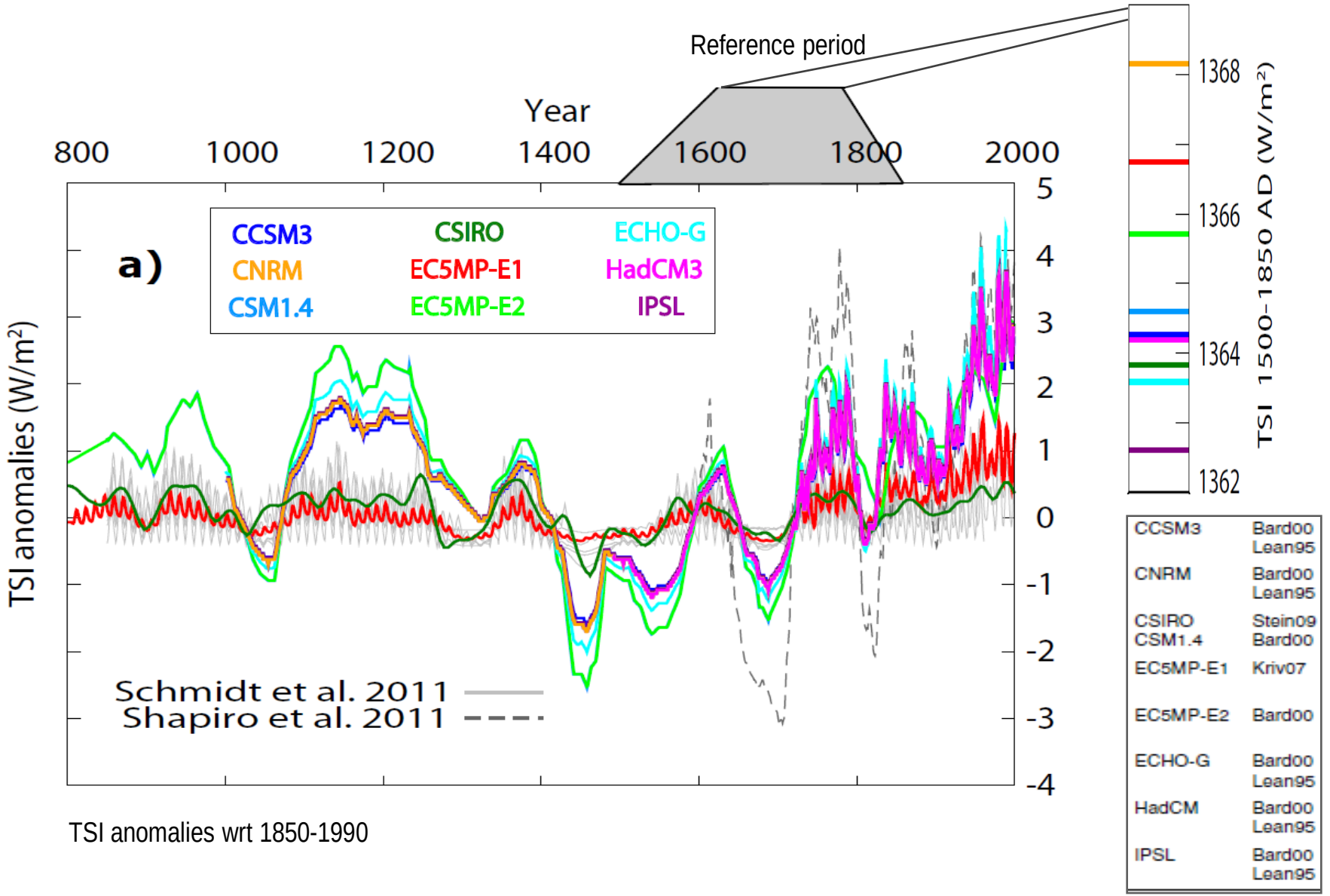
AOGCMs & forcing

Fernández-Donado et al, CPD, 8, 4003-4073, 2012

Model	Atmosphere [Resolution/vertical levels]	Ocean	Forcings	Simulations [(No. runs) length]	Reference
CCSM3	T31/18	3.6 x 2.8/25	SVG	(1) 1000–2100 AD (4) 1500–2100	Hofer et al. (2010)
CNRM	T42/31	2 x 2/31	SVGAL	(1) 1001–1999 AD	Swingedouw et al. (2010)
CSIRO	R21/18	2.8 x 1.6/21	ssGO	(3)1–2000 AD	Phipps et al. (2012)
			ssVGO	(3) 501–2000 AD	
CSM1.4	T31/18	3.6 x 1.8/25	SVGA	(1) 850–1999 AD	Ammann et al. (2007)
EC5MP	T31/19	3 x 3/40	ssVGALO	E1 (5) 800–2000 AD	Jungclaus et al. (2010)
			SVGALO	E2 (3) 800–2000 AD	
ECHO-G	T30/19	2.8 x 2.8/20	SVG	(2)1000–1990 AD	González-Rouco et al. (2006)
			SGO	(1) 8000–0 BP	Wagner et al. (2007)
HadCM	3.75 x 2.5/19	1.25 x 1.25/20	SVGALO	(1) 1492–1999 AD	Tett et al. (2007)
IPSL	3.75 x 2.5/19	2 x 2/31	SGAO	(1) 1001–2000 AD	Servonnat et al. (2010)

8 AOGCMs, 26 forced simulations

FORCING: SOLAR

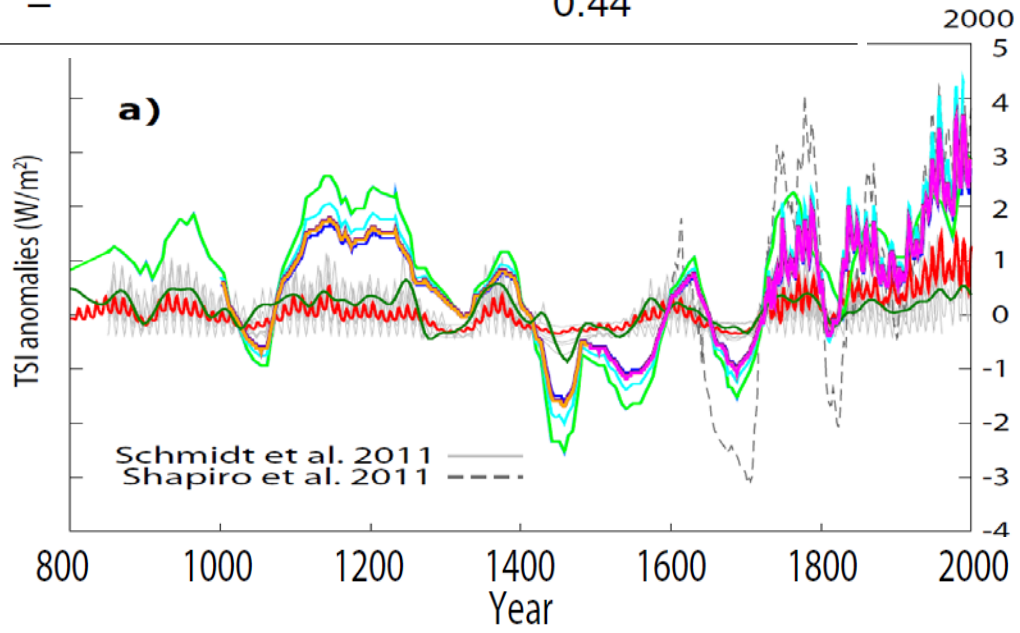


TSI anomalies wrt 1850-1990

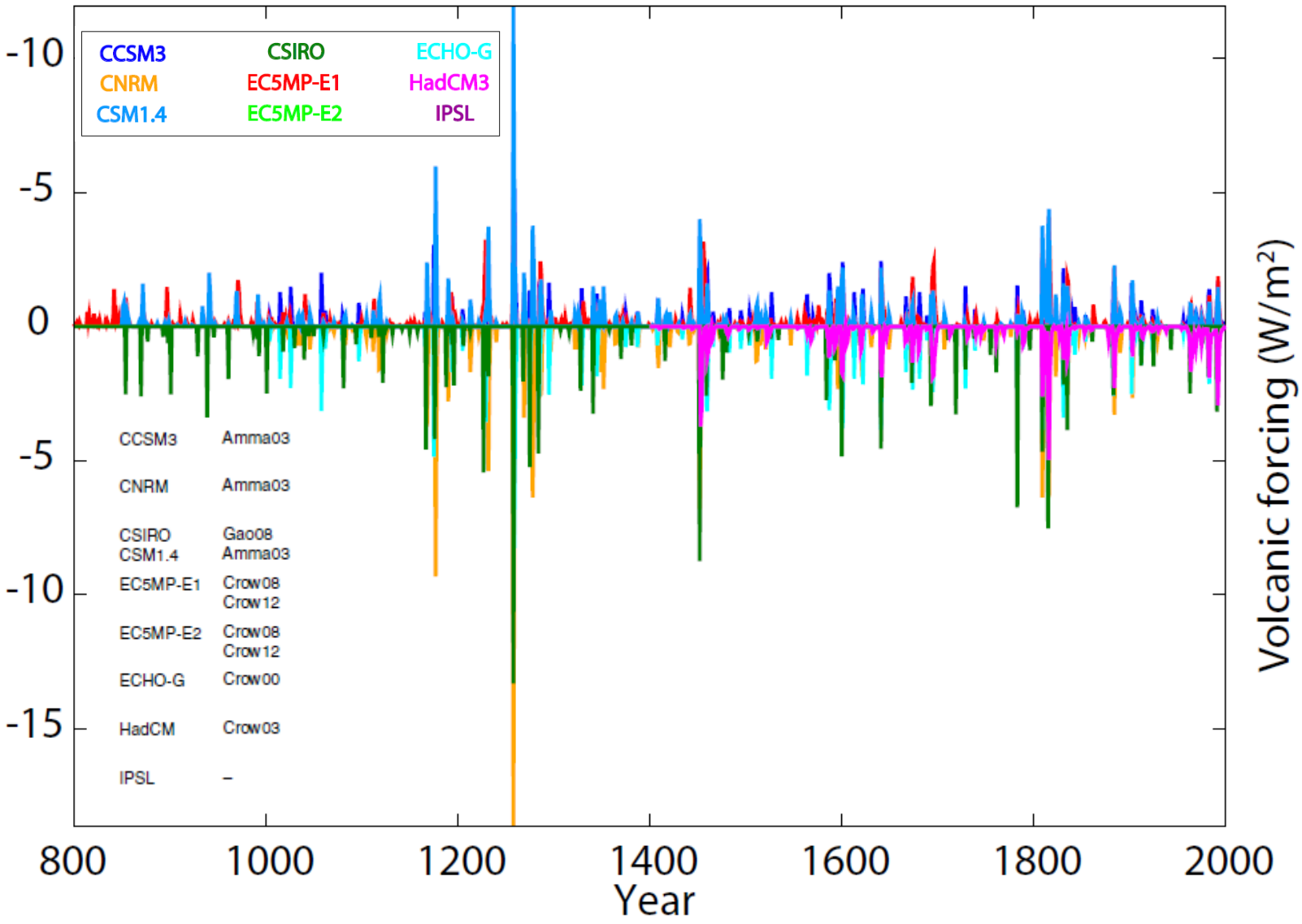
FORCING: SOLAR, TSI changes

Model	Medieval Maximum-LMM (%)		LMM-late 20th century (%)
	1130-1160 AD	1680-1710 AD	1960-1990 AD
CCSM3	−0.27		0.23
CNRM	−0.18		0.25
CSIRO	−0.04		0.05
CSM1.4	−0.17		0.24
EC5MP-E1	−0.04		0.09
EC5MP-E2	−0.27		0.24
ECHO-G	−0.22		0.29
HadCM	–		0.25
IPSL	−0.18		0.25
Shapiro et al.	–		0.44

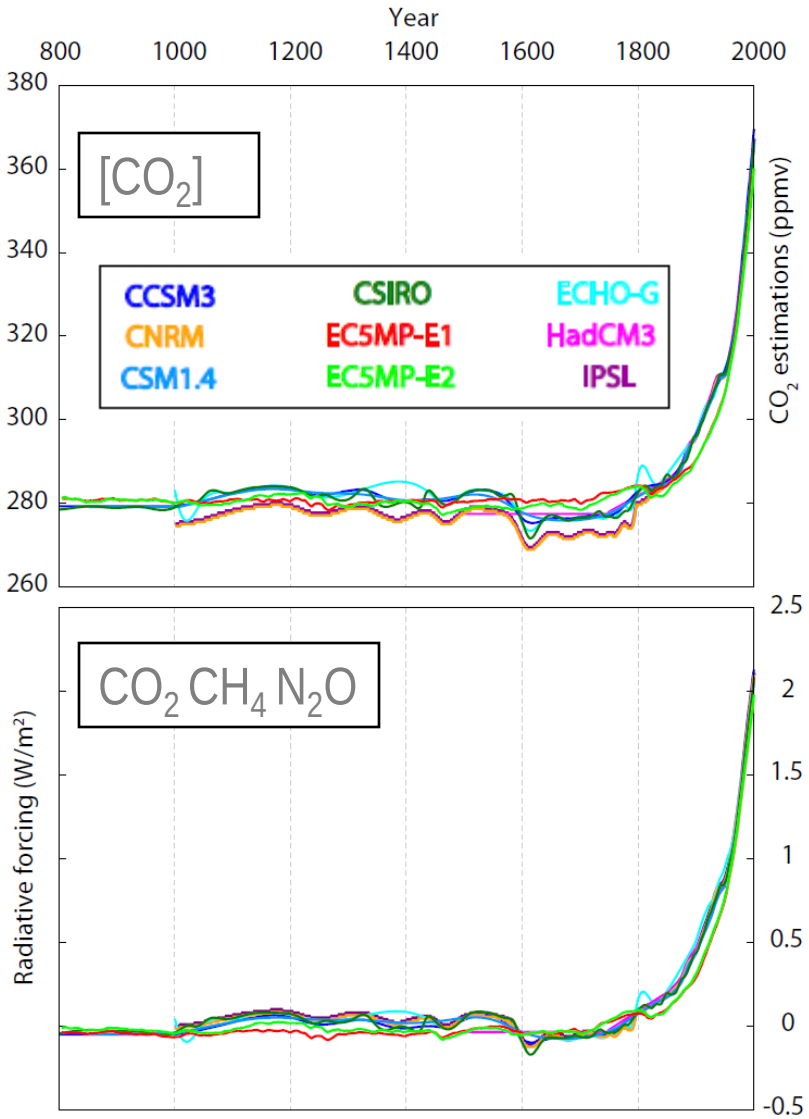
Note: a 0.25 % change between the LMM and late 20th century is equivalent to a ΔTSI~ 3.4 Wm^{-2}

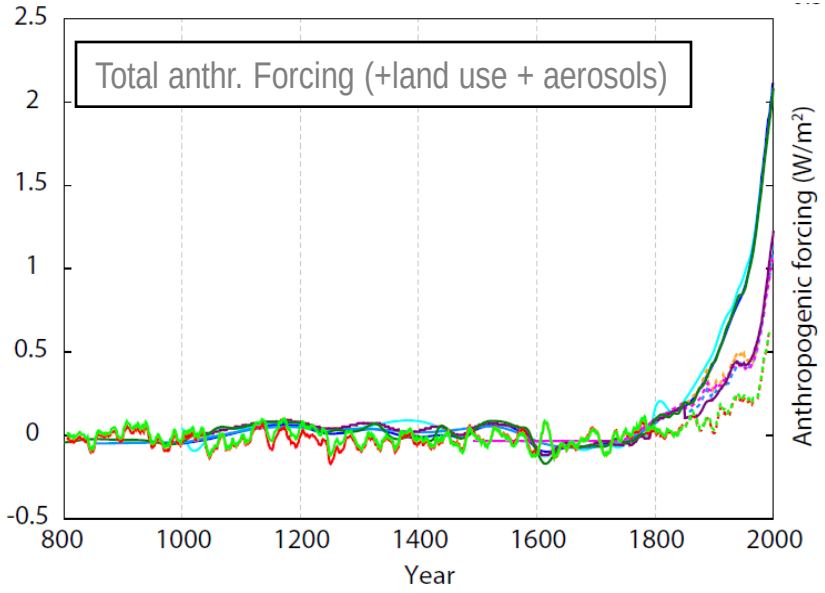


FORCING: volcanic



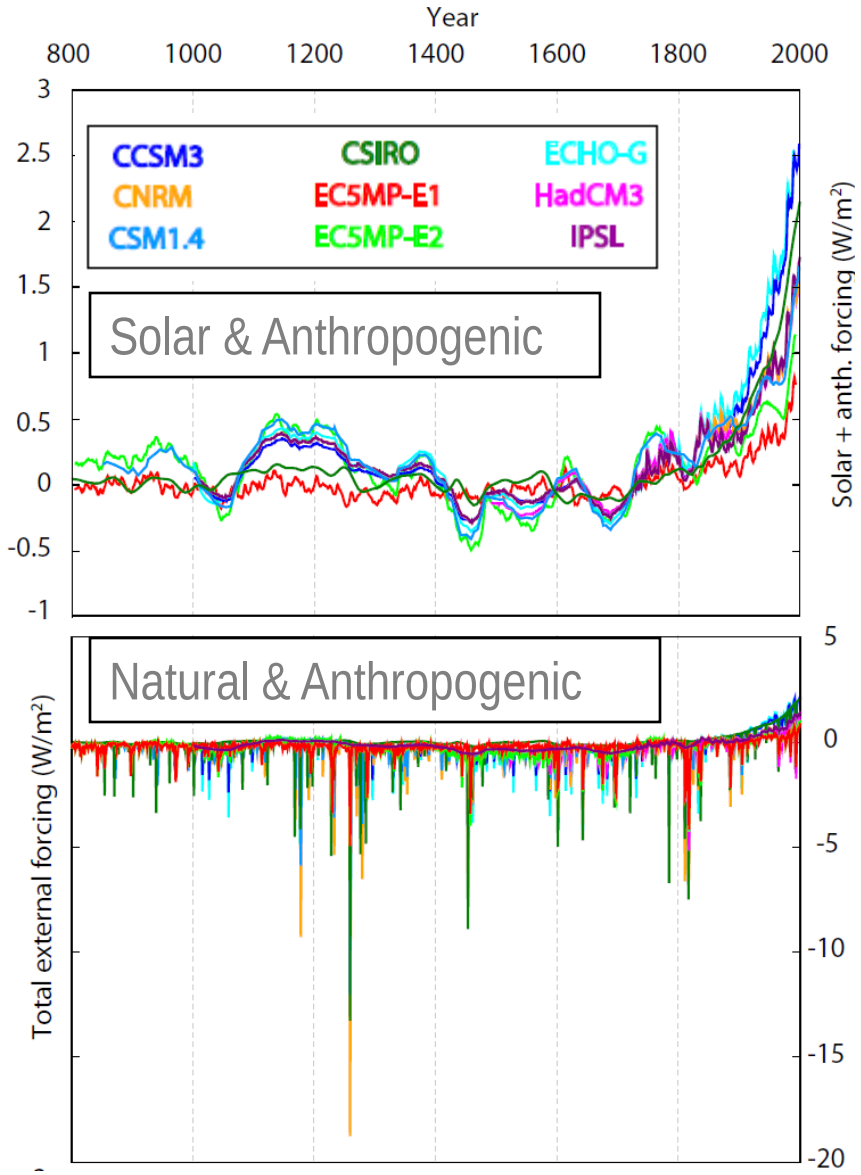
FORCING: anthropogenic forcing

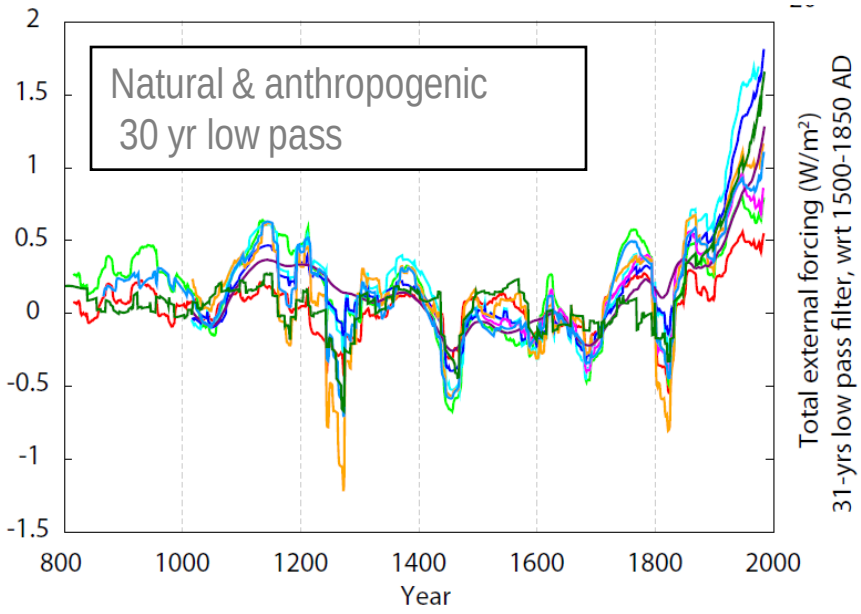




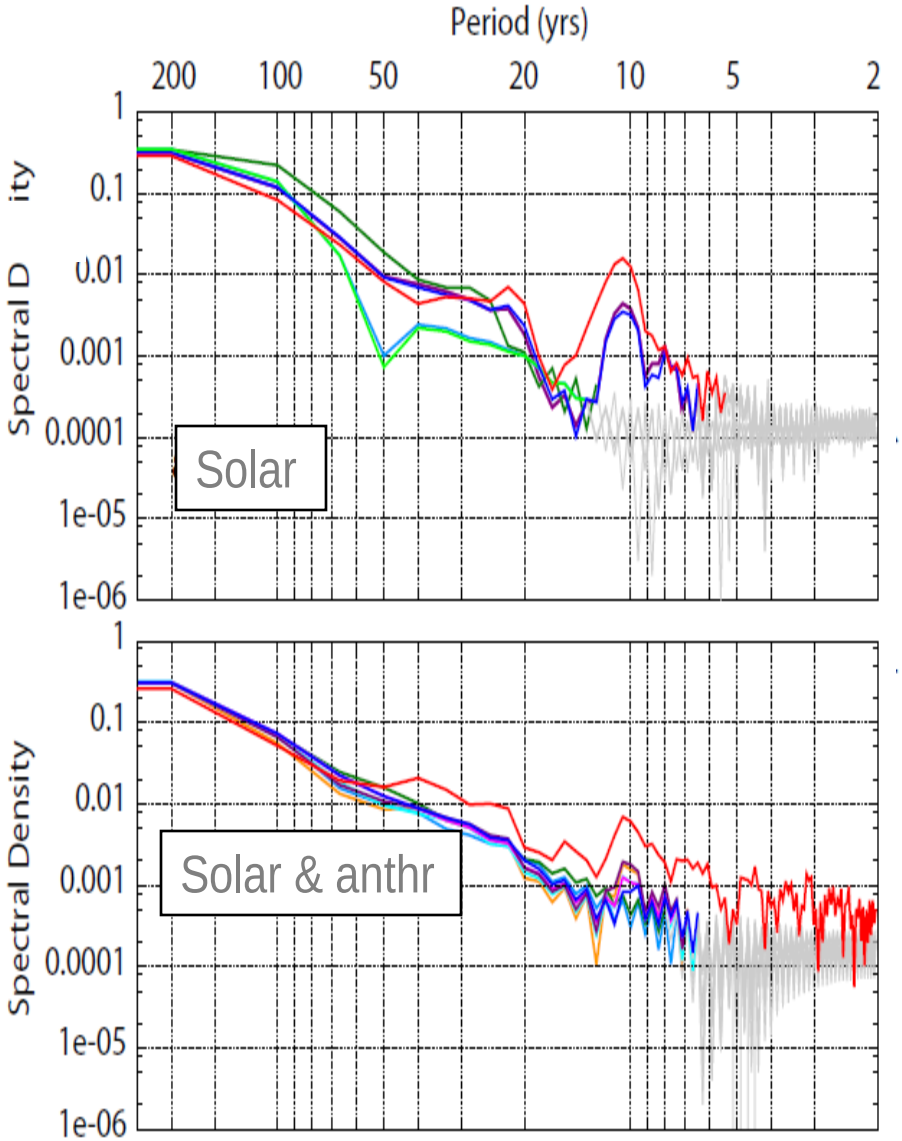
Model	CO_2	CH_4	N_2O
CCSM3	Ether96	Blun95	Fluck02
CNRM	McFM06	Blun95	Fluck02
CSIRO	McFM06	McFM06	McFM06
CSM1.4	Ether96	Blun95	Fluck02
EC5MP-E1	Diagnosed Marl03	McFM06	McFM06
EC5MP-E2	Diagnosed Marl03	McFM06	McFM06
ECHO-G	Ether96	Ether98	Batt96
HadCM	Johns03	Johns03	Johns03
IPSL	McFM06	Blun95	Fluck02

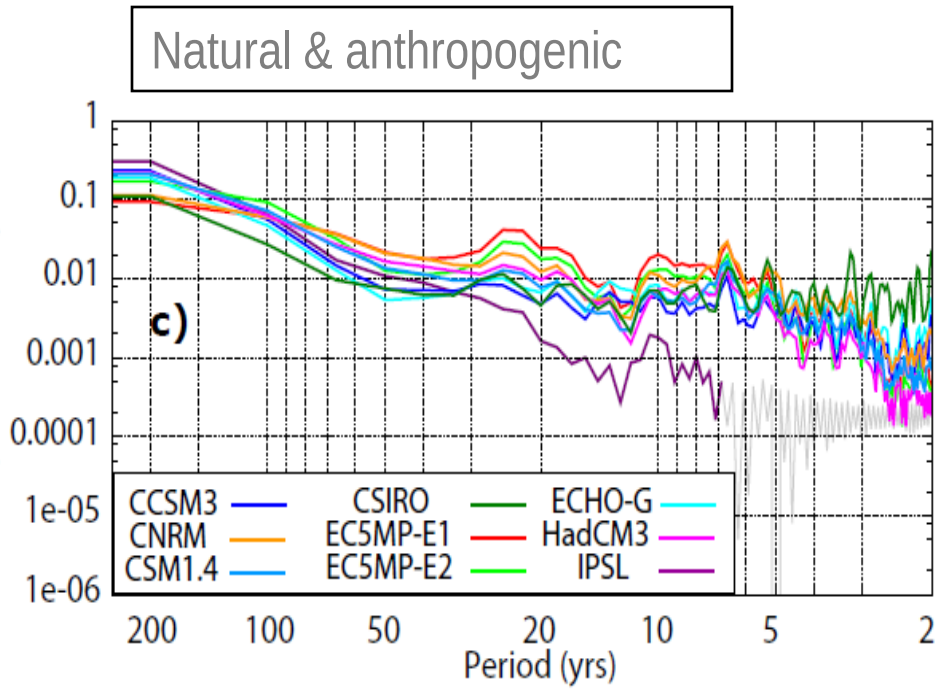
FORCING: TEF (Total External Forcing)



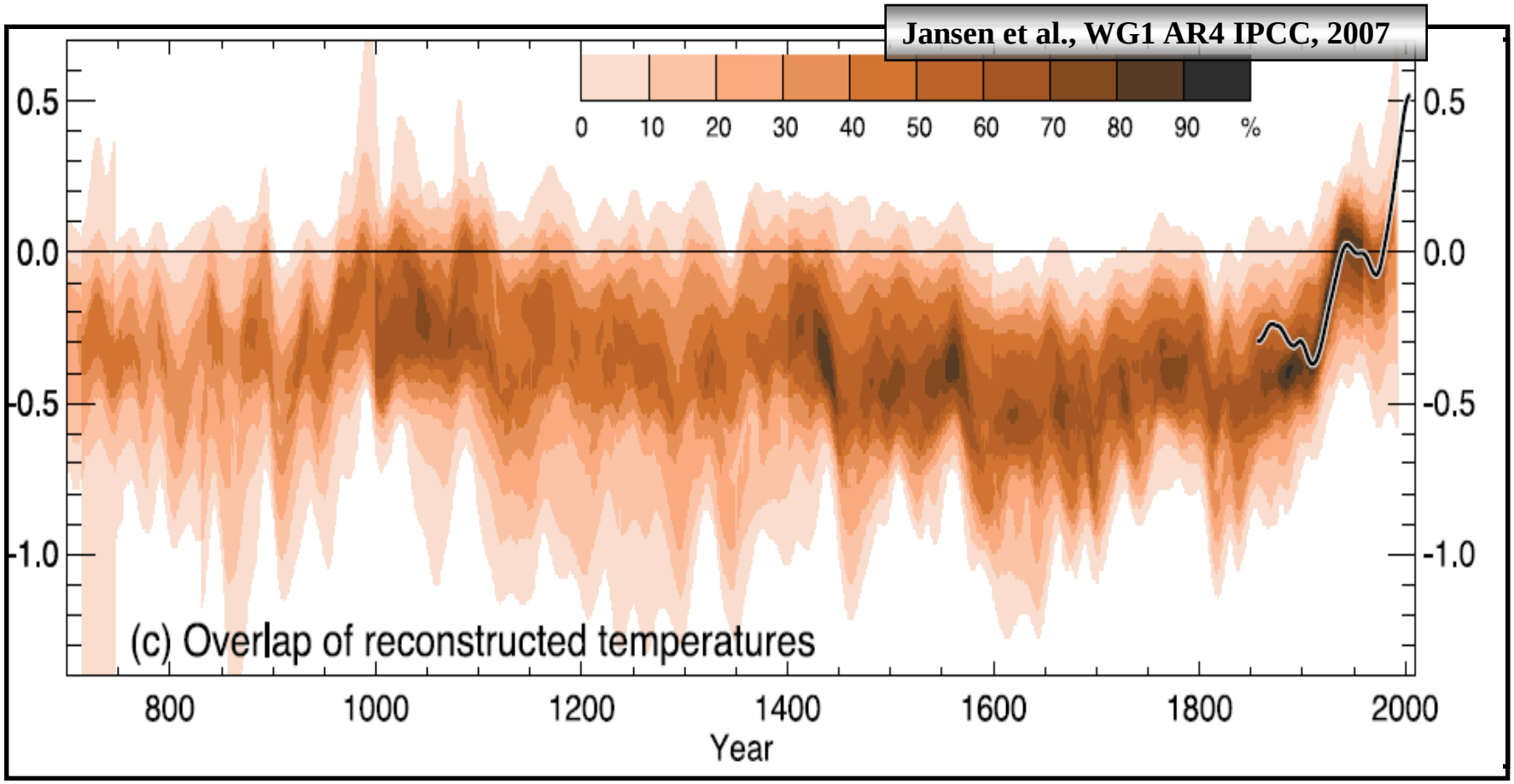


FORCING: TEF normalized spectra



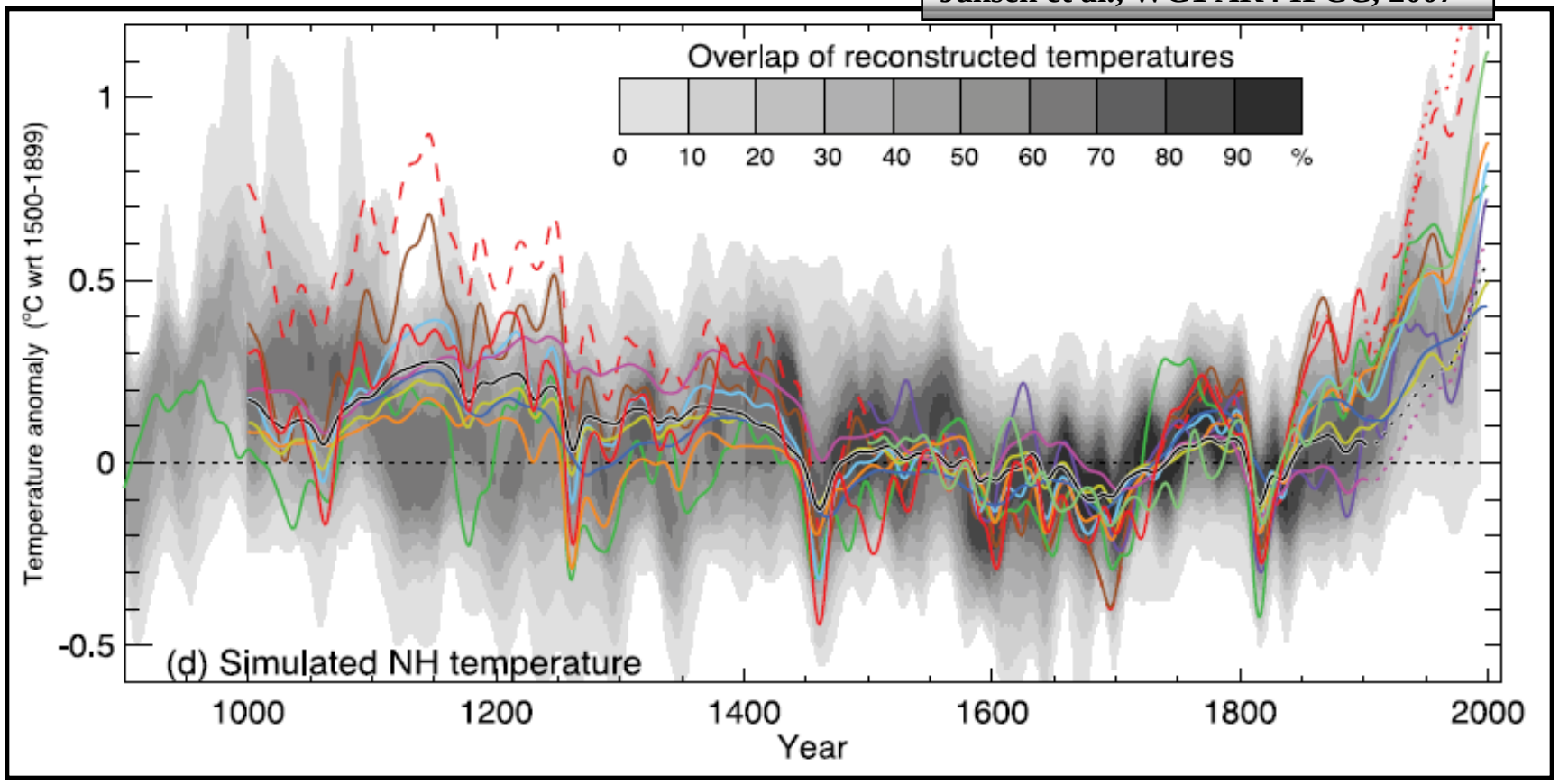


Model & reconstruction comparison

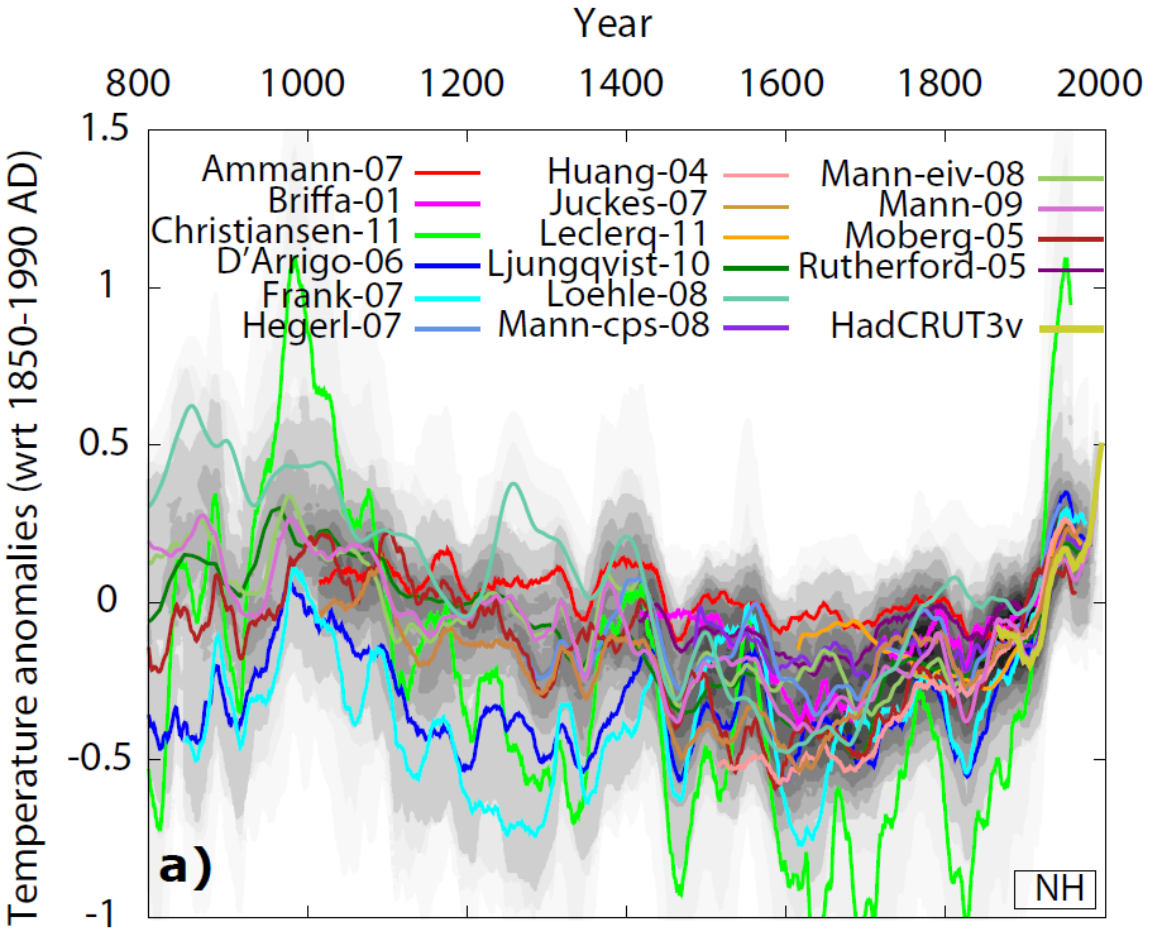


Model & reconstruction comparison

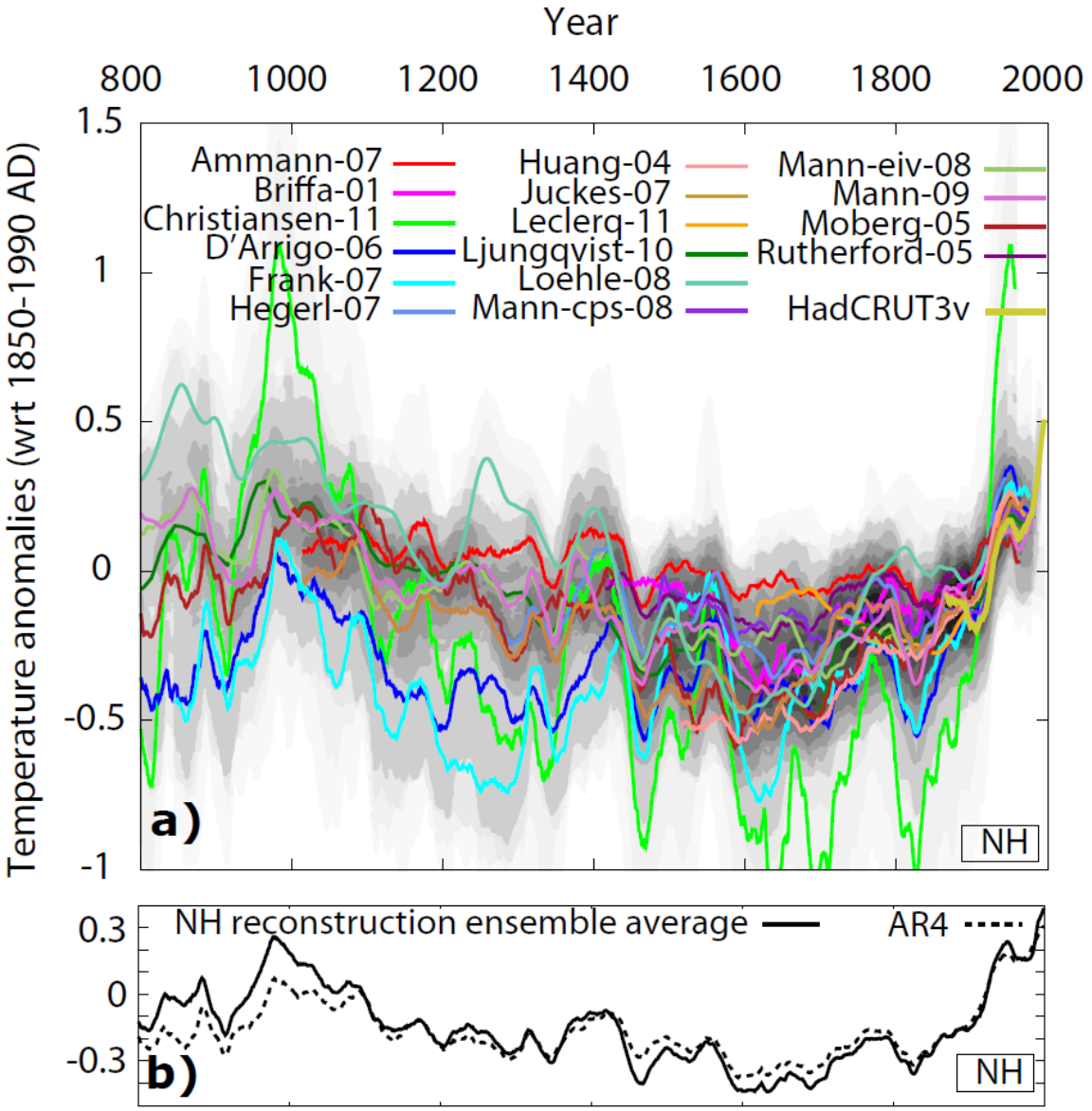
Jansen et al., WG1 AR4 IPCC, 2007



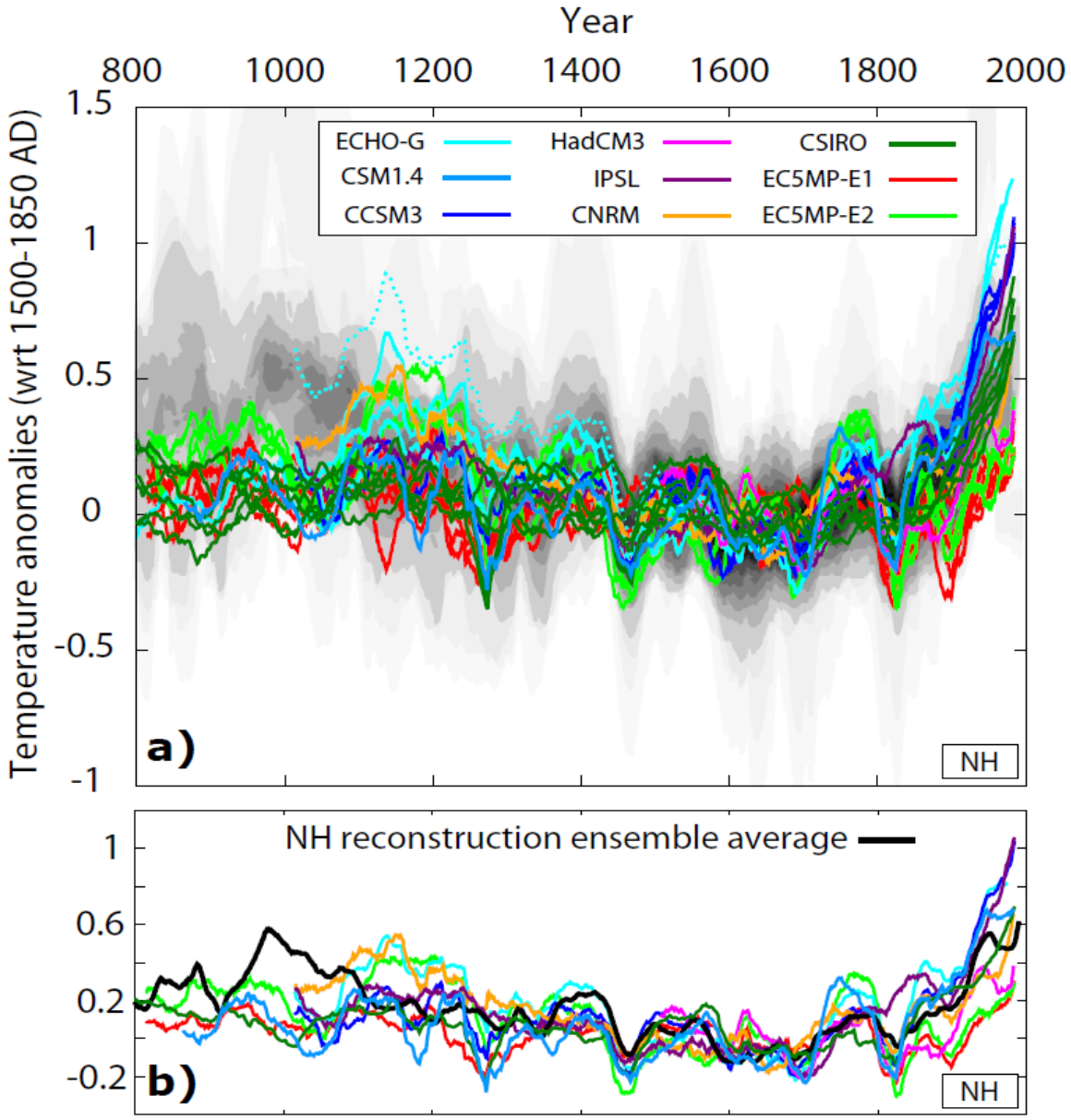
TEMPERATURE response NH/ reconstructions wrt 1500-1850



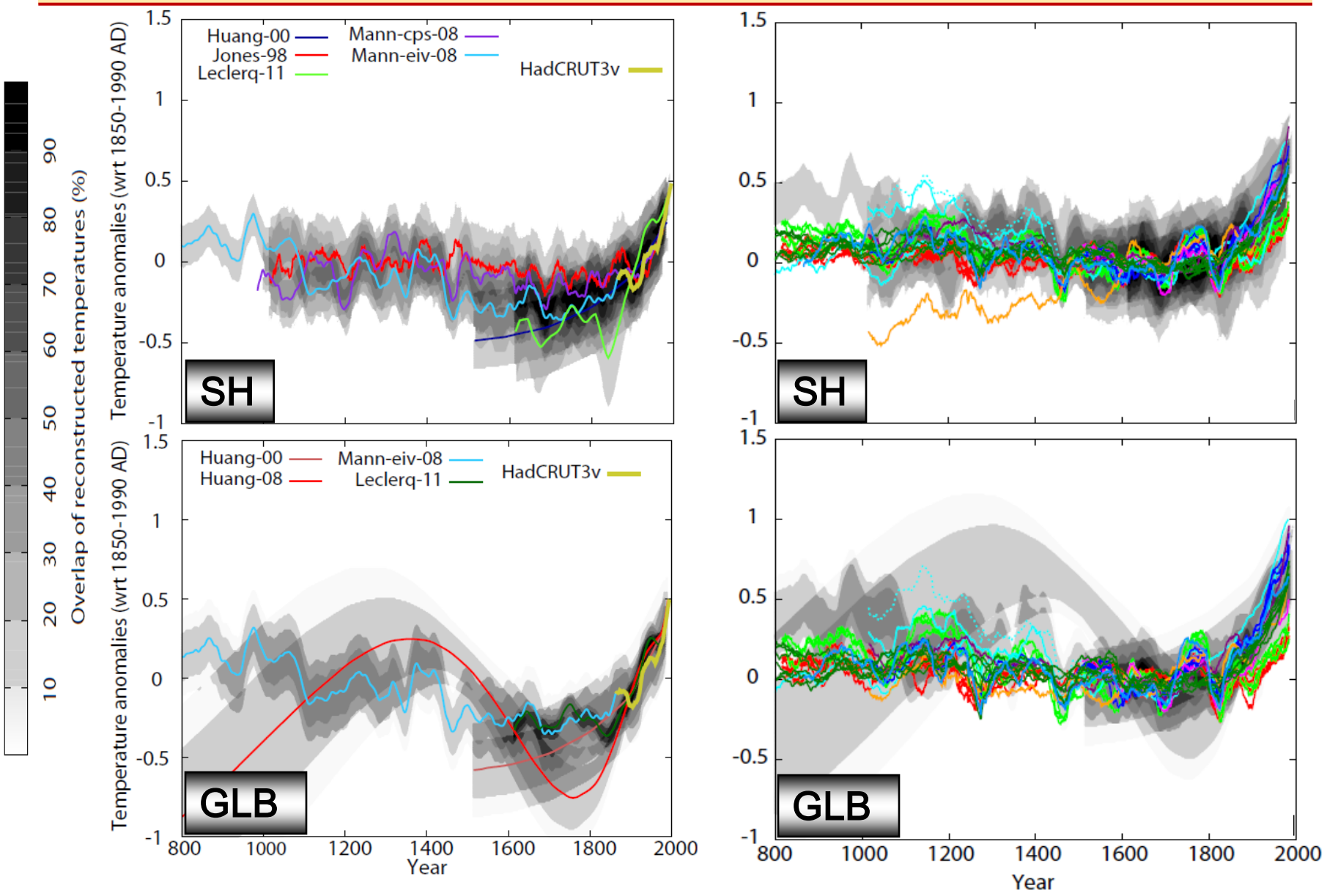
TEMPERATURE response NH/ reconstructions wrt 1500-1850



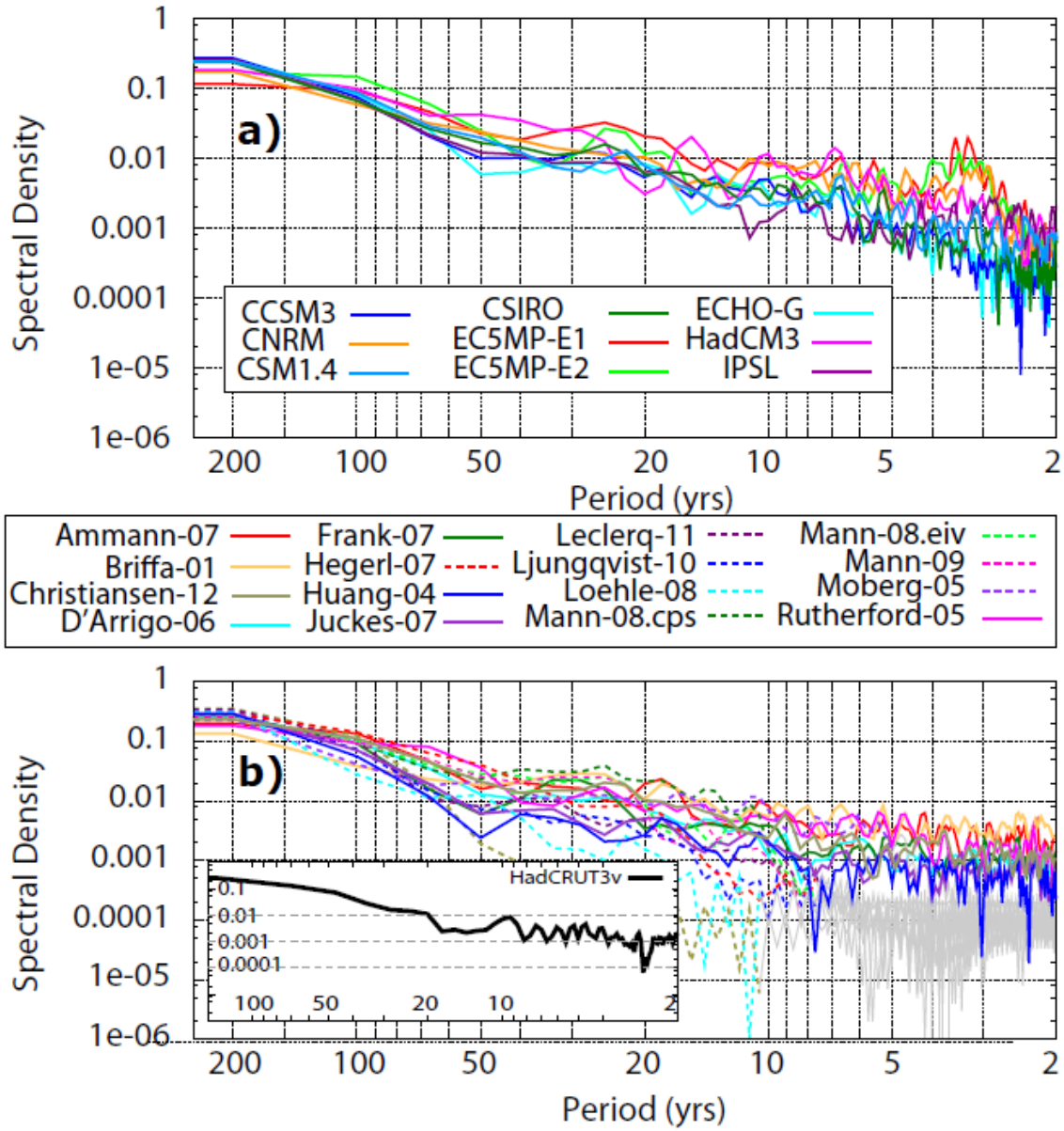
TEMPERATURE NH/ reconstructions & simulations wrt 1500-1850



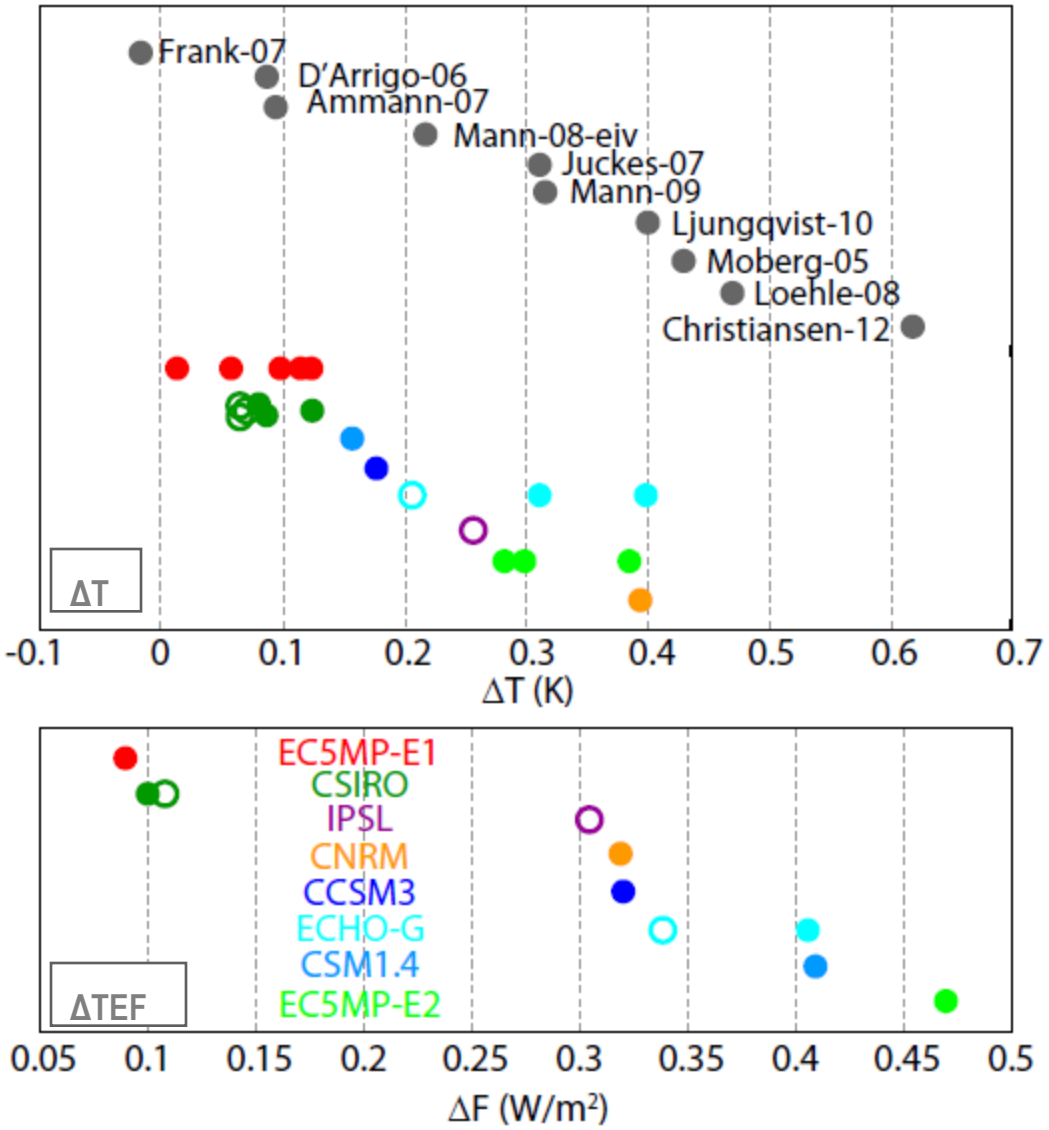
TEMPERATURE response SH GLB/ model & data wrt 1500-1850



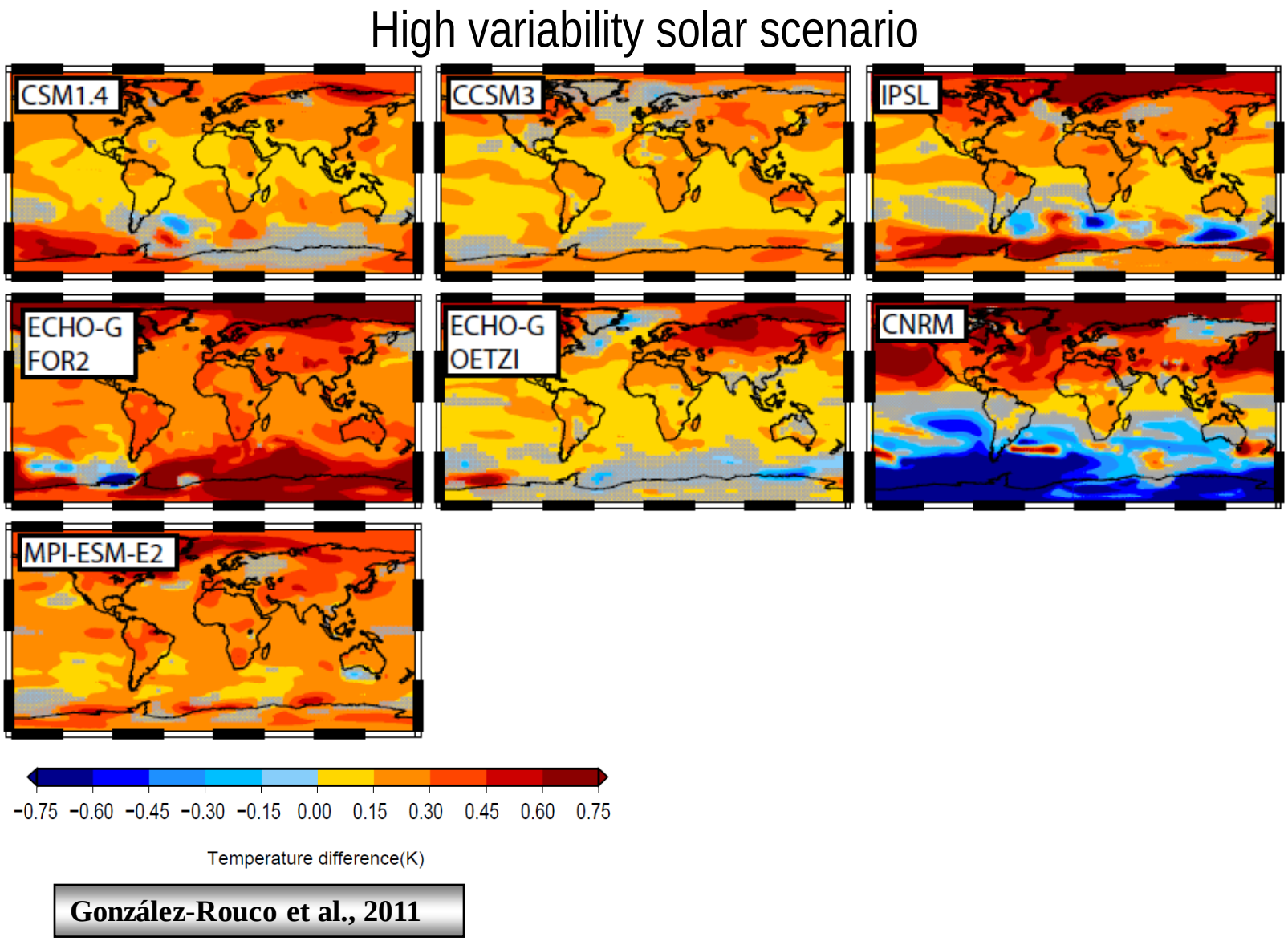
TEMPERATURE response: NH model-data norm. spectra



MCA-LIA transition 900-1250 / 1400-1700



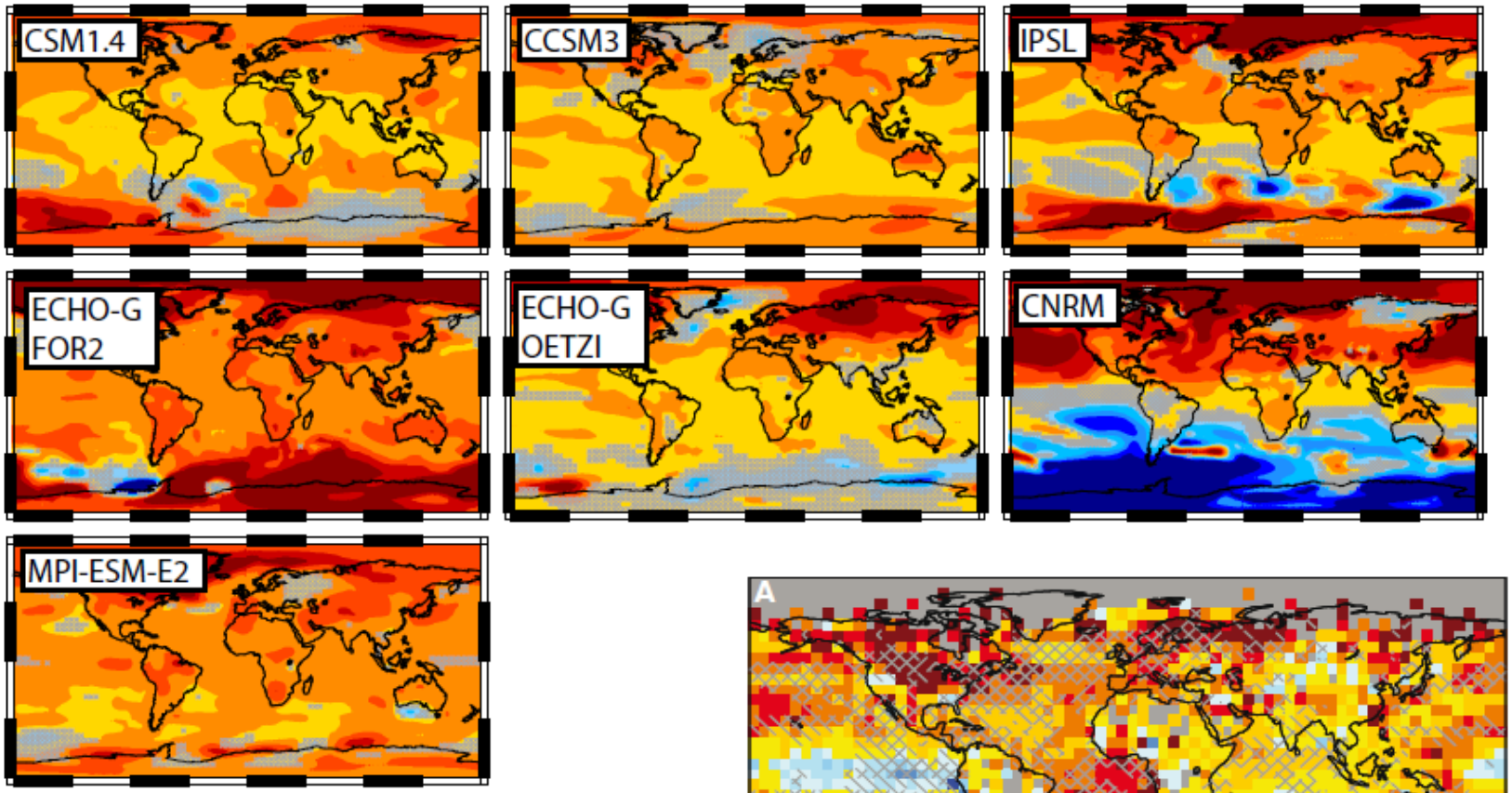
MCA-LIA transition: spatial changes



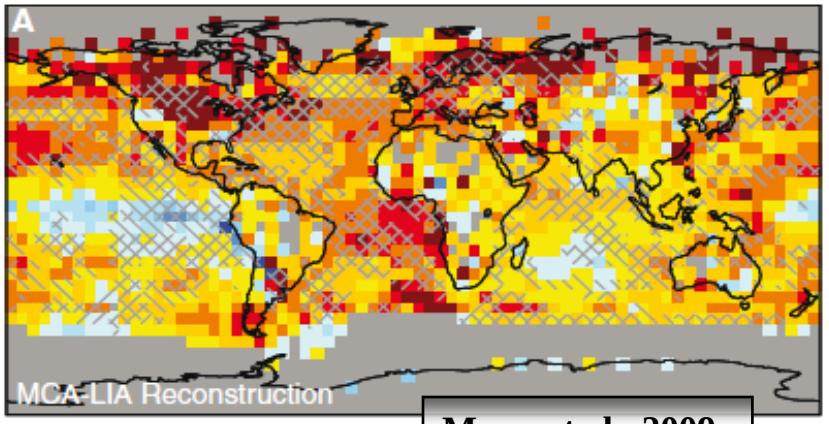
González-Rouco et al., 2011

MCA-LIA transition: spatial changes

High variability solar scenario



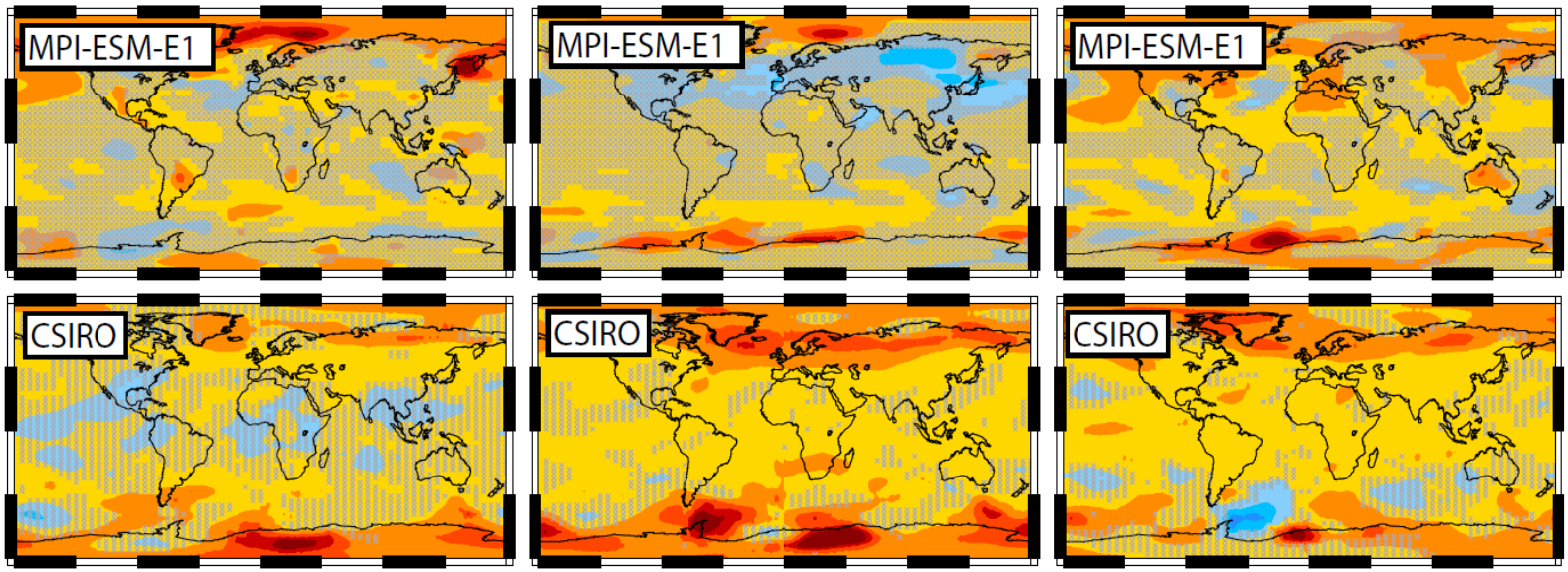
González-Rouco et al., 2011

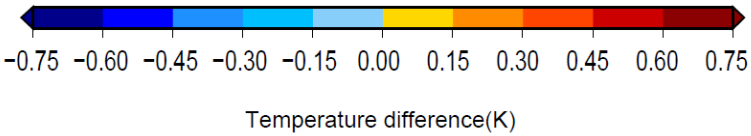


Mann et al., 2009

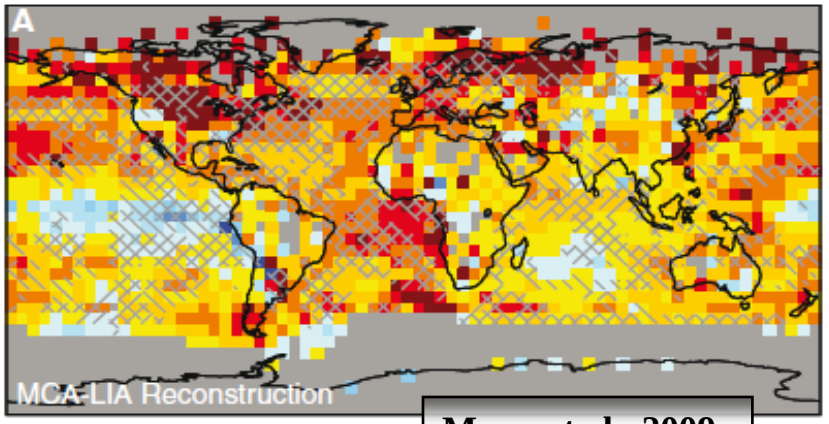
MCA-LIA transition: spatial changes

Low variability solar scenario



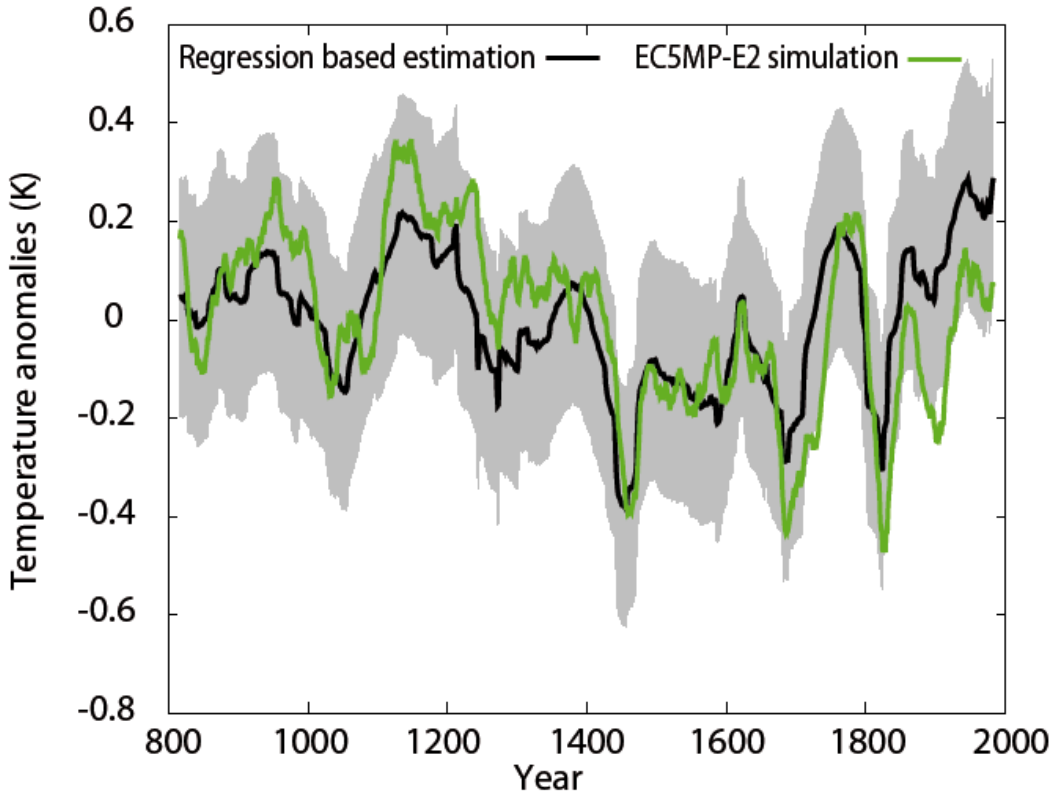


González-Rouco et al., 2011



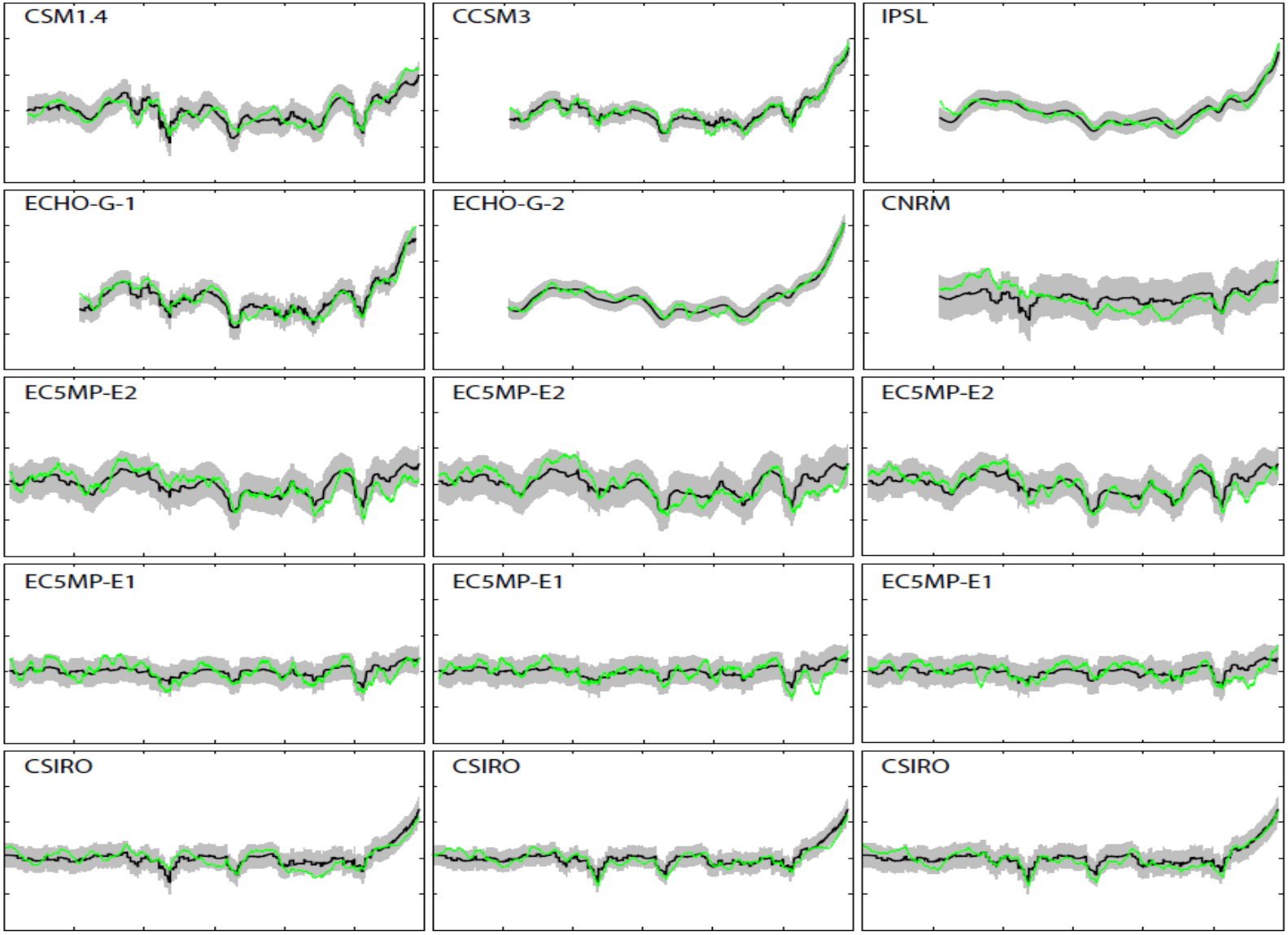
Mann et al., 2009

T response & external forcing: corr. 30 yr low pass filtered

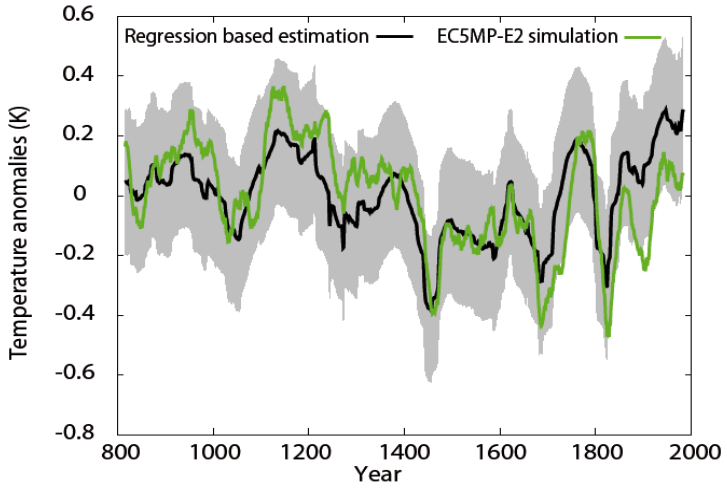


Simulated ~ linear response to total equivalent external forcing at low frequencies (30-yrs low pass)

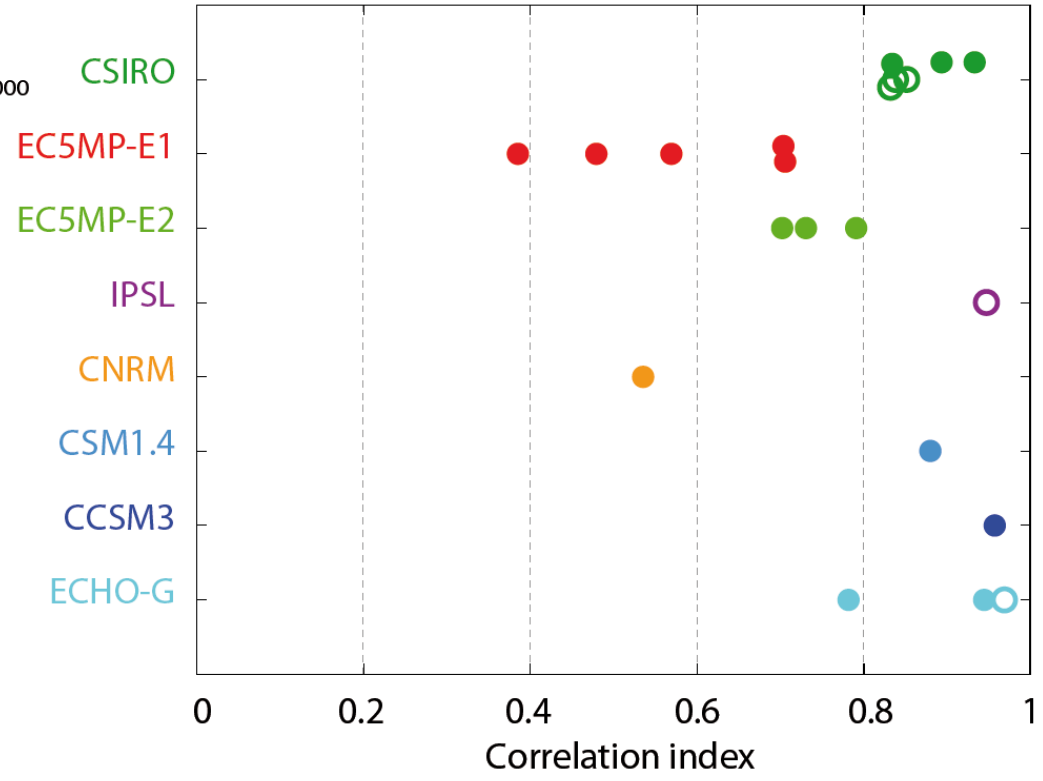
T response & external forcing: 30 yr low pass filtered



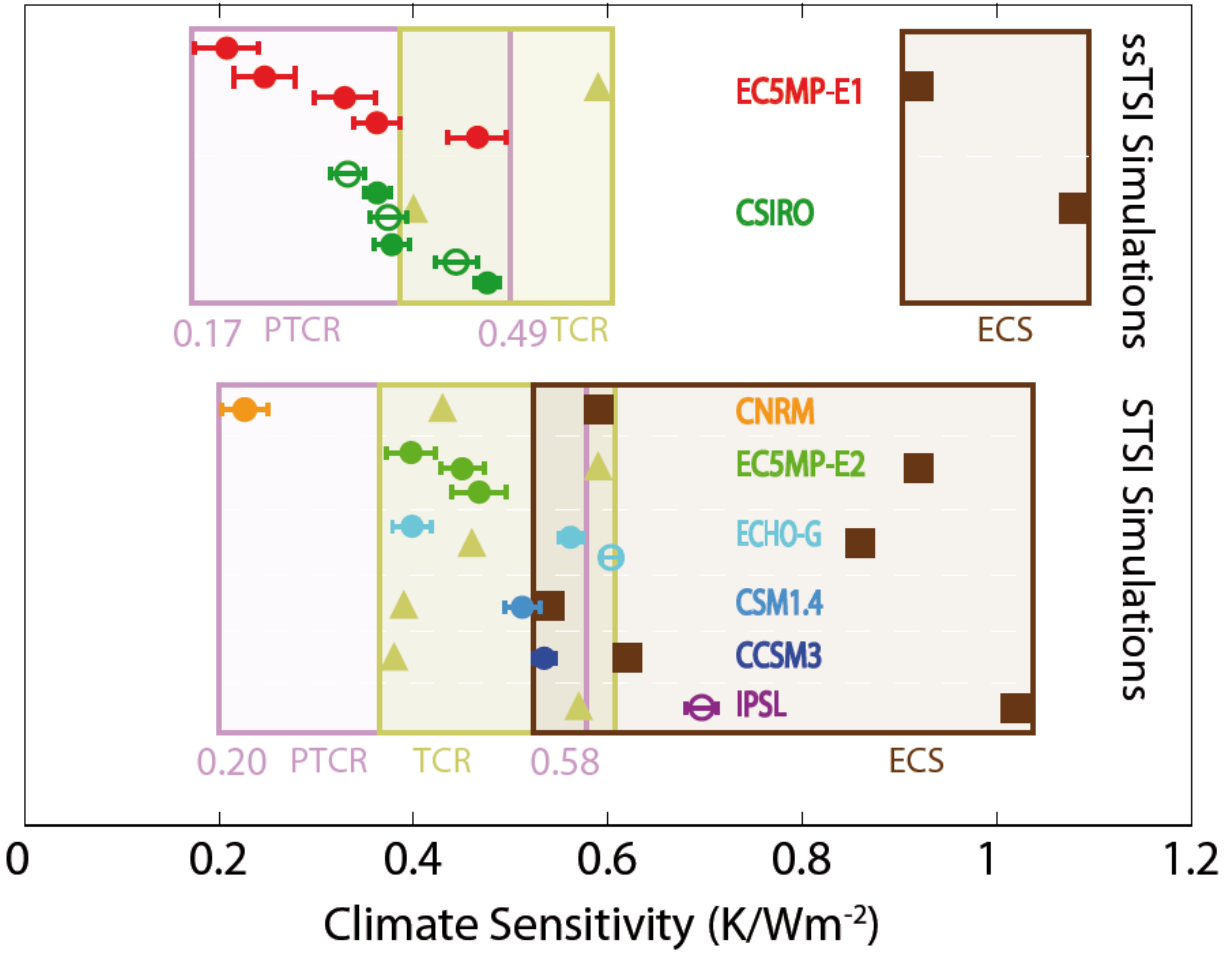
T response & external forcing: 30 yr low pass filtered



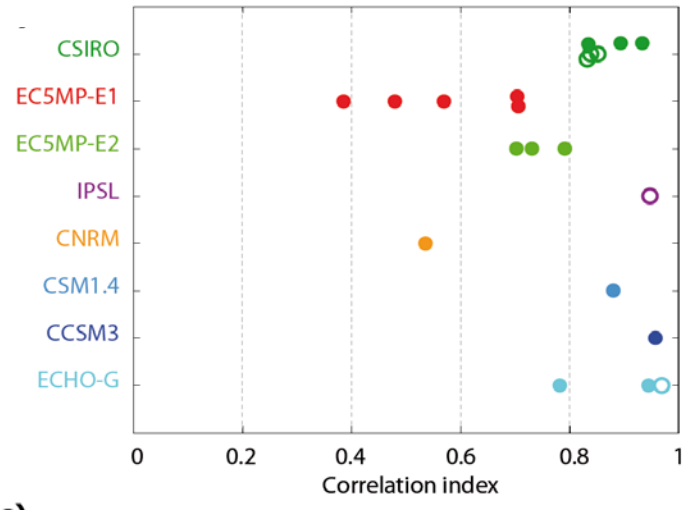
Simulated ~ linear response to total equivalent external forcing at low frequencies (30-yrs low pass)

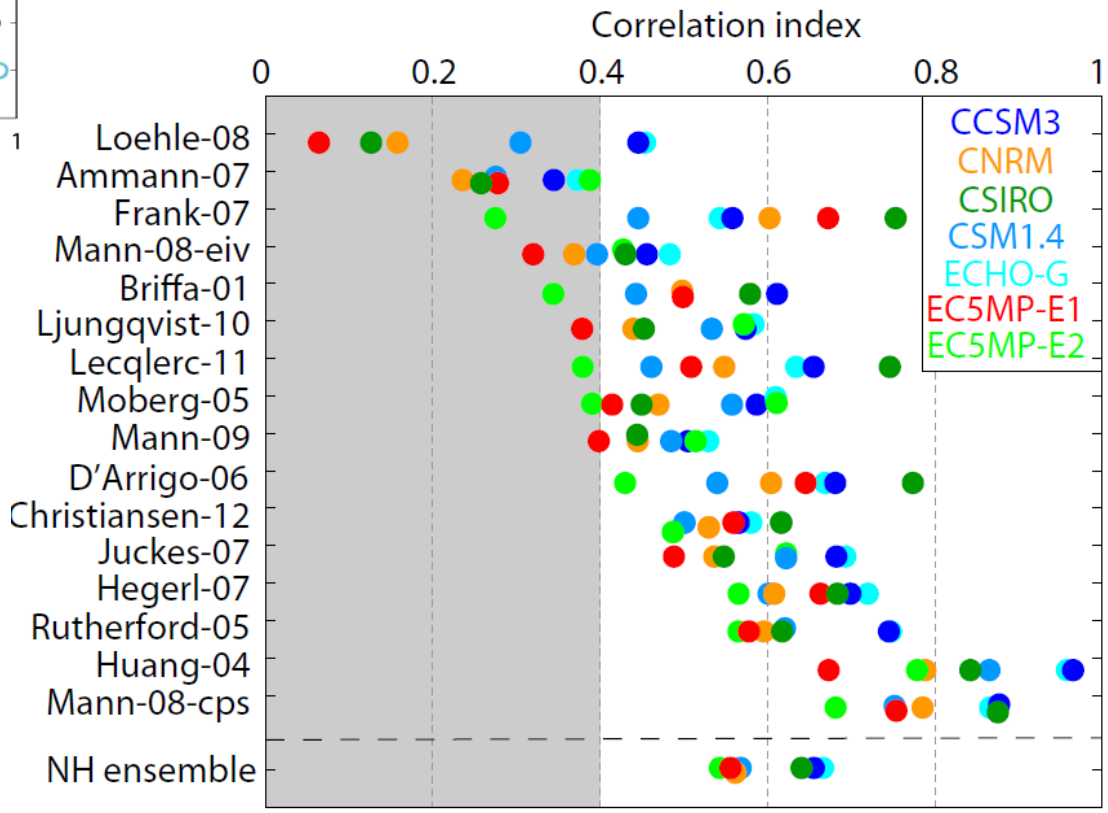


Climate Sensitivity: Paleo TCR, TCR & ECS (GCMs)

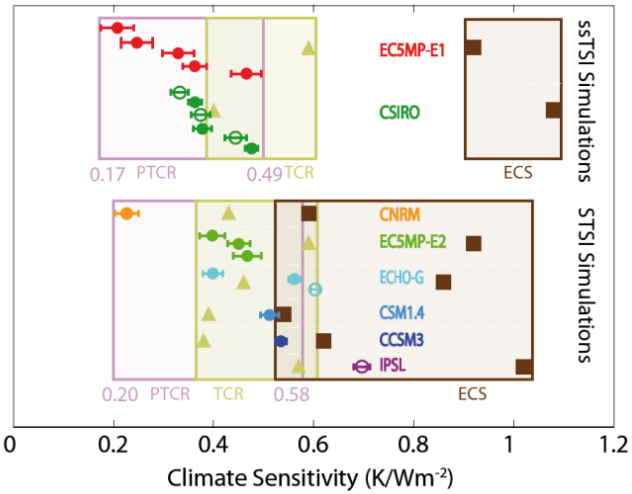


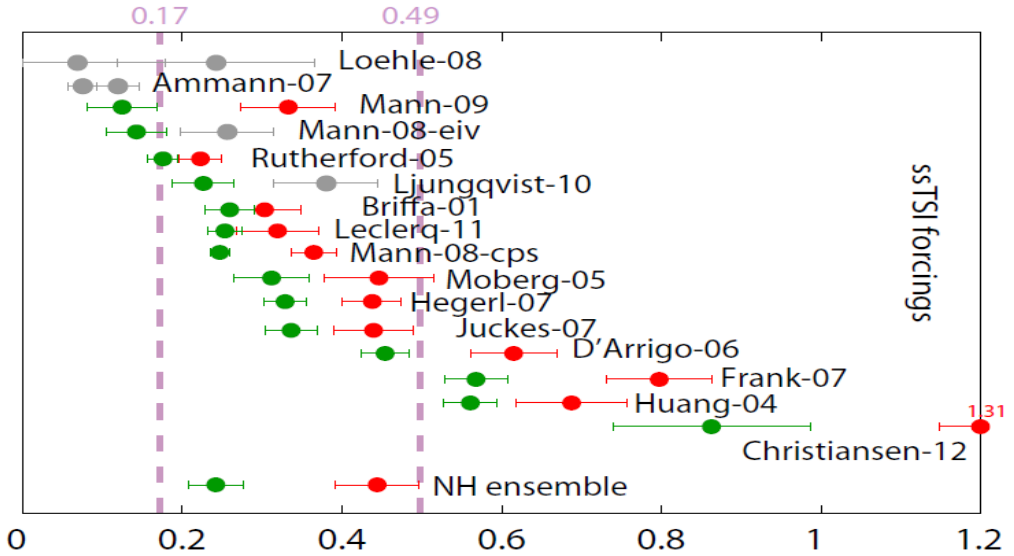
T response & external forcing: **reconstructions**

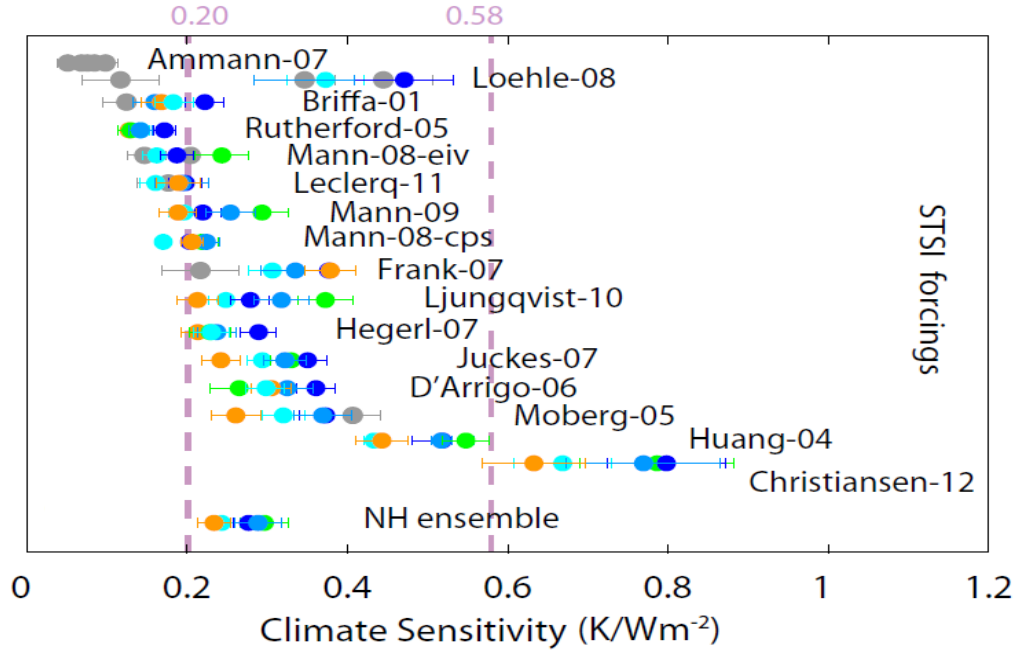




Climate Sensitivity: reconstructions PTCR







CONCLUSIONS

Gracias *Thank you*

•**Forcing: PMIP3-CMIP5 good and useful agreement on forcing scenarios (Schmidt et al 2011). Higher solar forcing variability scenarios downgraded. Worth revisiting?**

• Temperature response= ~linear_f (forcing, clim. Sensitivity,). Broad agreement with reconstructions but…

• MCA-LIA: Forcing on hemispherical and Global plausible. Regional: contribution of internal variability?

• PTCR: reasonable values wr. TCR & ECS. It allows more quantitative consistency assessment between simulated and reconstructed climate.

•Could not discriminate high/low solar variability In model-data comparison