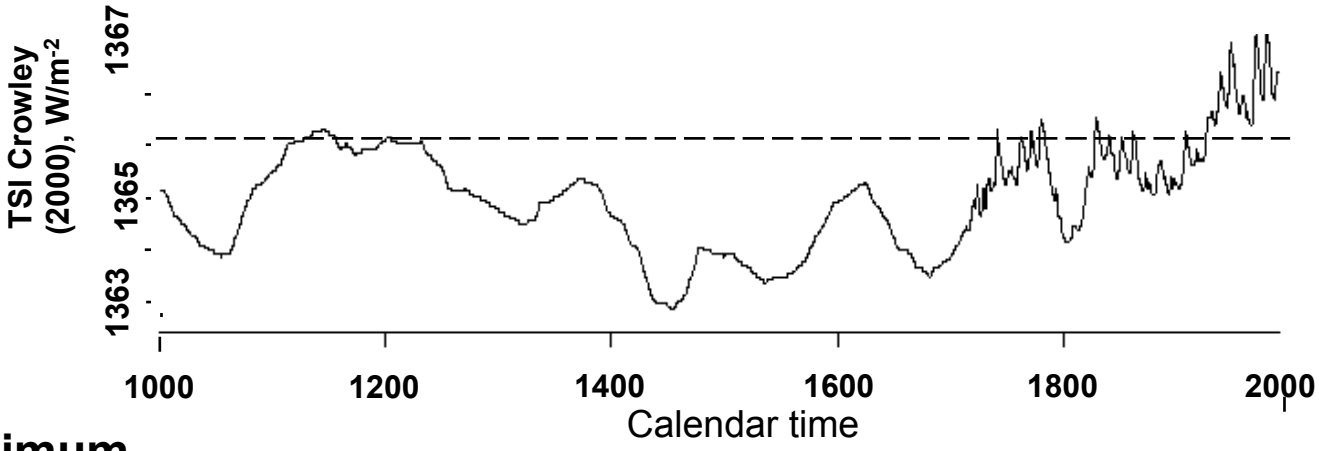
Climate variability over the last millennium and link to volcanic forcing: First results with IPSL-CM4v2

M Khodri, J Servonnat, F Fluteau, J Mignot, P Yiou, MA Sicre

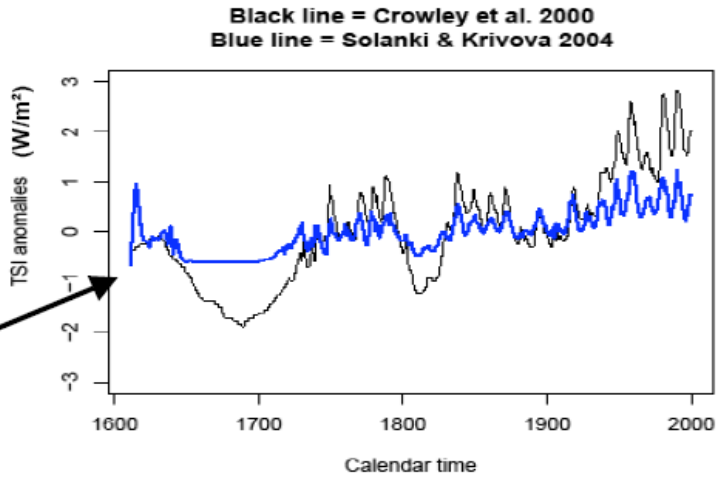
Les Forçages et les Simulations

IPSL-CM4v2

SOLAIRE + CO2

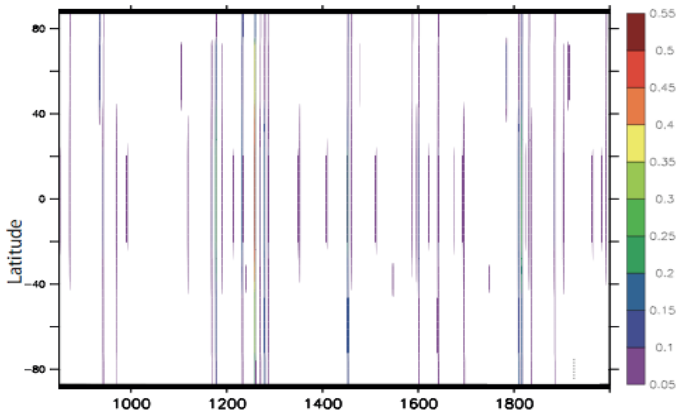


-0.25% TSI at the Maunder minimum



Krivova , pers. com. 2009

Aerosol Optical Thickness



SOLAIRE + CO2+ VOLCANISME

More recent estimates: -0.1 % TSI at the Maunder minimum

Ammann et al , pers. com. 2008

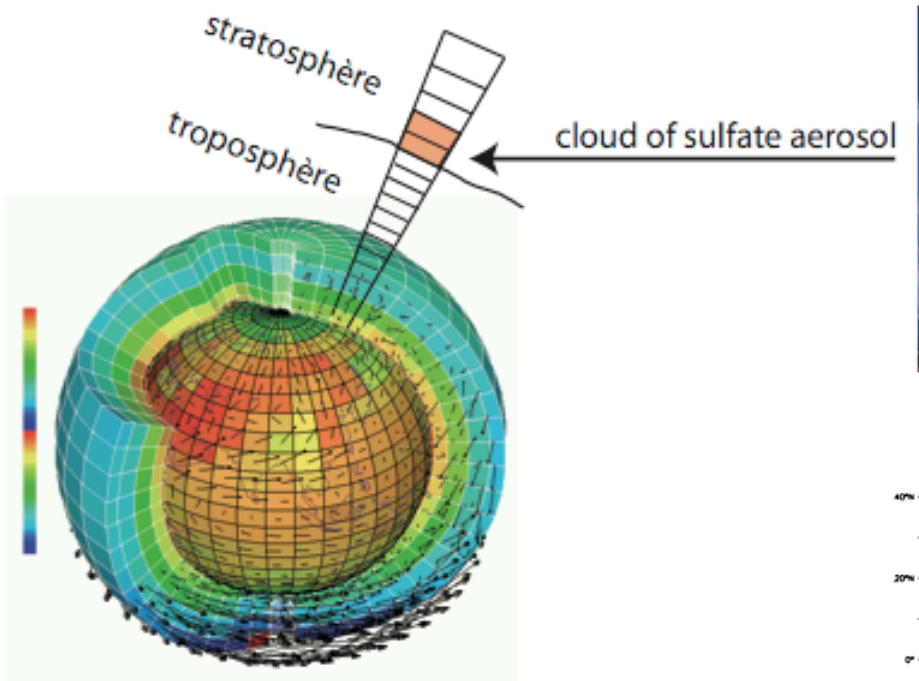
Projets Millénaire

- Projet ANR-ESCARSEL (2008-2010, PI J. Guiot, CEREGE): Evolution Séculaire du Climat dans les régions circum-Atlantiques et Réponse de Systèmes Eco-Lacustres (M Khodri, J Servonnat, P Yiou)

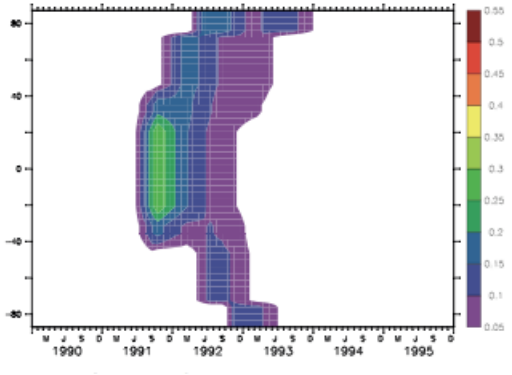
- Projet FP7-THOR (2008-2012, PI D. Quadfasel): Circulation Thermohaline, Atlantique Nord, échange air-mer (J Mignot, C Frankignoul, G Gastineau, C Marini)

- Projet ANR-ANVOL (à soumettre, PI M. Khodri) : Comparaison modèle-données, modulation basse fréquence des modes de variabilité et des téléconnexions, lien solaire-ozone stratosphérique (M Khodri, J Mignot, D Swingedouw, M Marchand)

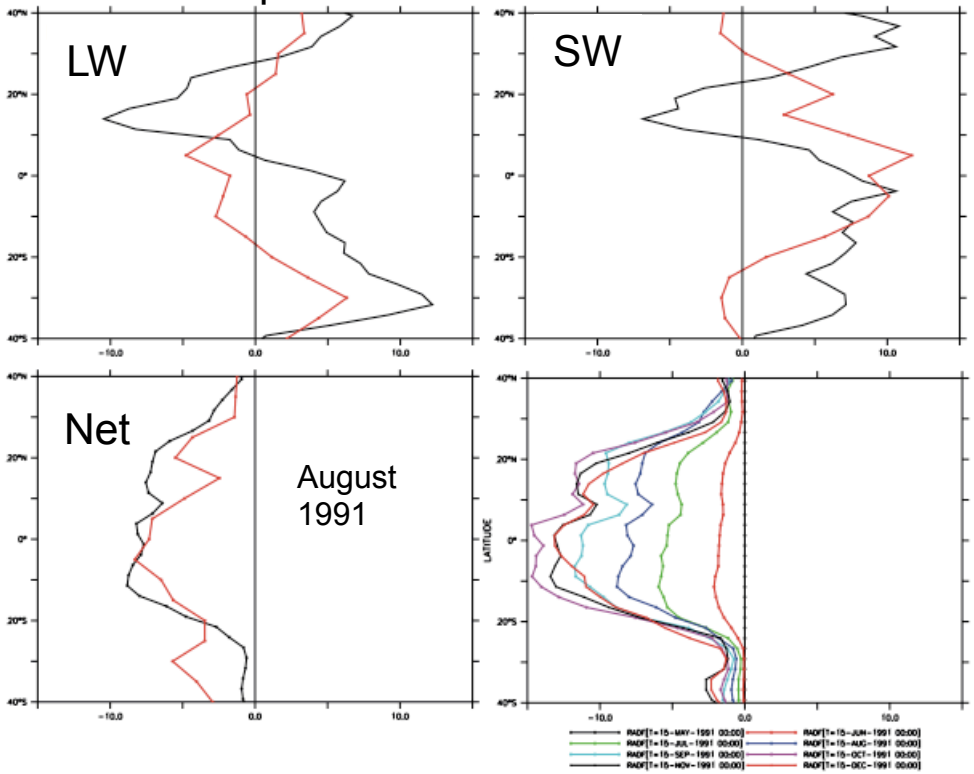
Forçage Volcanique: Le Mont Pinatubo




(picture from Wikipedia)



Comparaison ERBE-IPSL-CM4v2



➢Implémentation de l'impact radiatif des aérosols volcanique dans LMDZ

➢ Code de Mie: Calcul de l'albédo de simple diffusion (cg) et le facteur d'asymétrie (piz) pour les aérosols aérosols stratosphériques sulfatés en phase aqueuse.

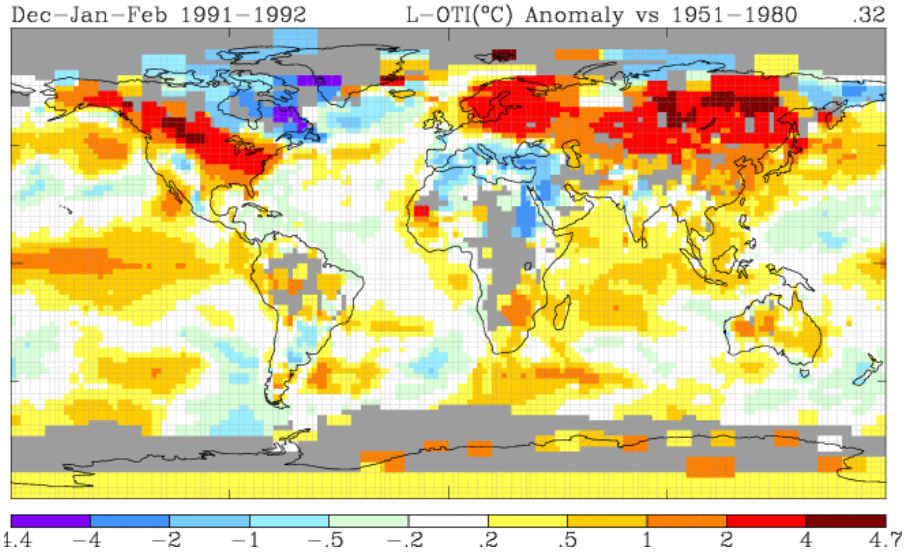
Forme binaire H2SOA/H2O: 75%/25%)
El Chichon + Pinatubo (SO4 droplet, Reff=0.55)

Yves Balkanski

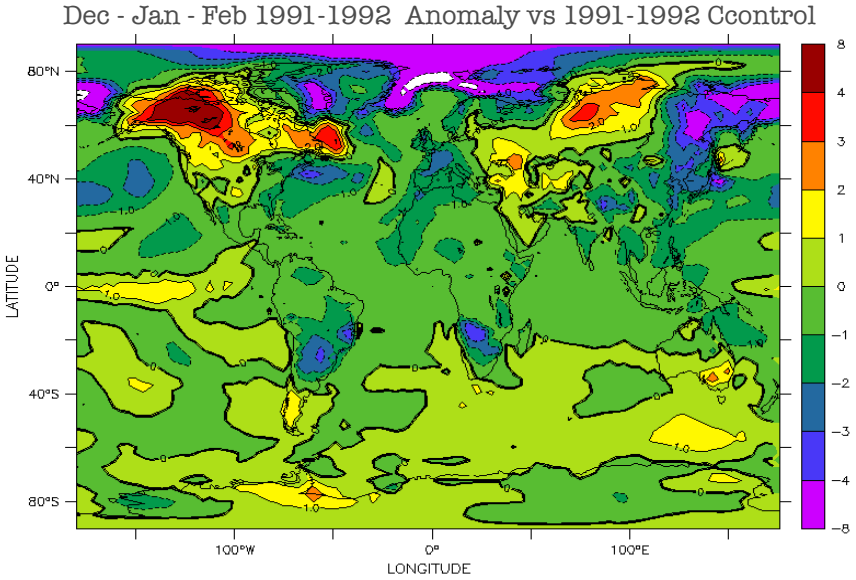
Le Mont Pinatubo

Premier hiver post éruption

GISS Analysis/Hadley HadISST1

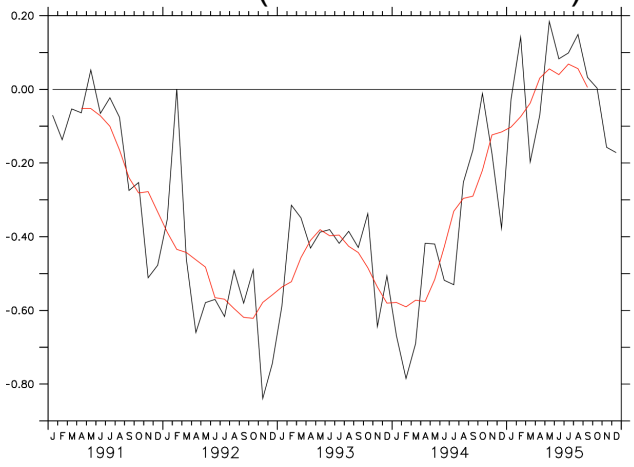


IPSL-CM4 (4 members mean)

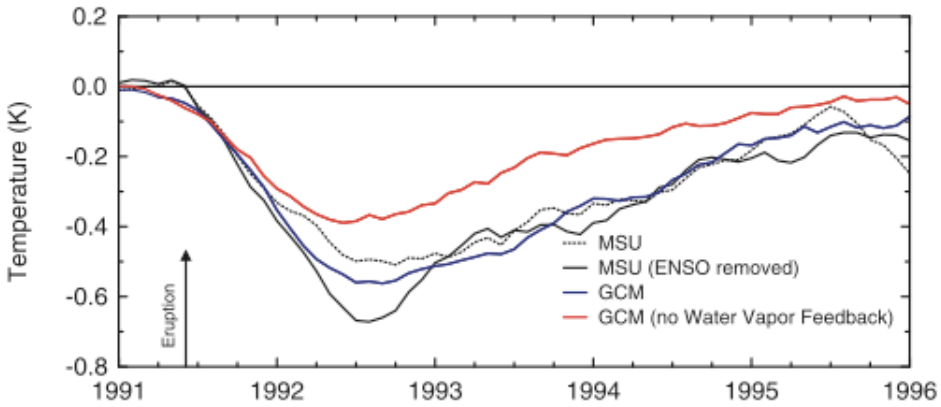


Evolution des températures globales

IPSL-CM4 (4 members mean)



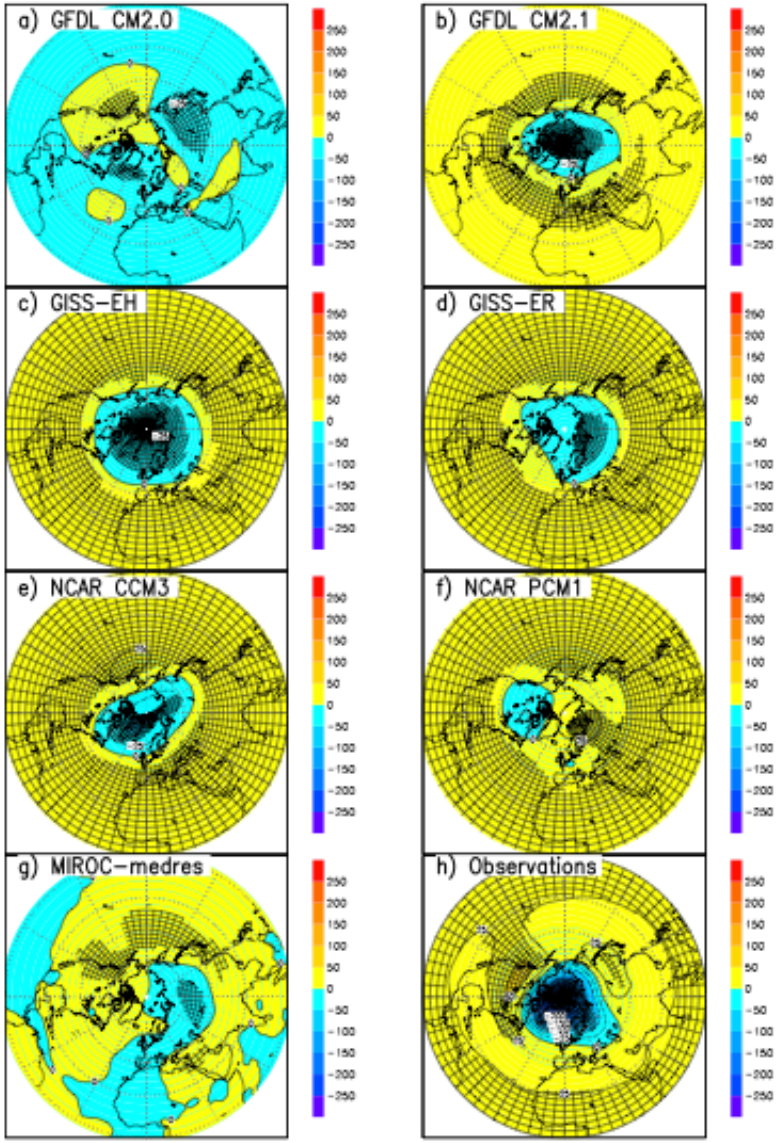
Soden et al 2002



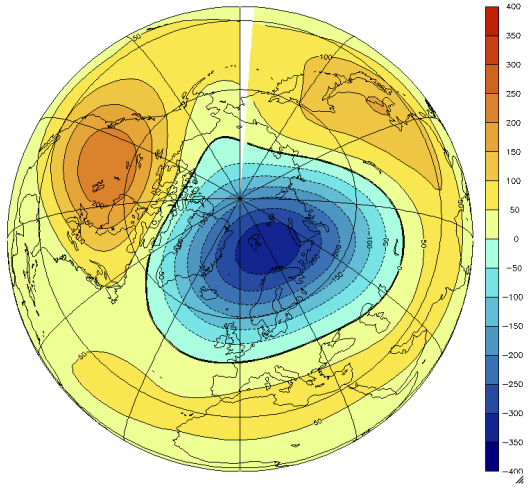
Le Mont Pinatubo

Impact sur la dynamique

IPCC-AR4 Models
(Stenchikov et al, 2006)



IPSL-CM4v2
Geopotential Height 50mb



Réchauffement strato/ refroidissement tropo

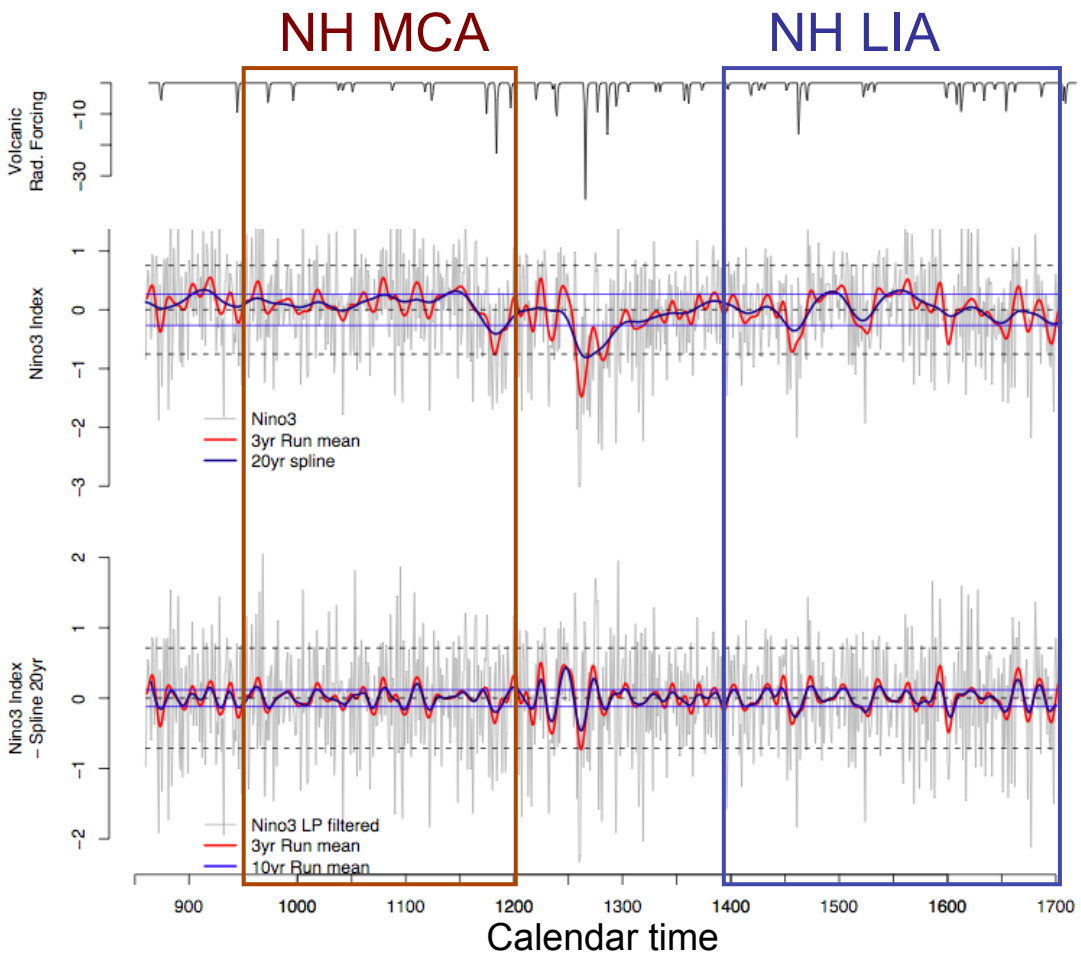
- augmentation du géopotentiel dans la strato/ diminution dans la tropo
- augmentation du gradient température et géopotentiel Equateur-Pôle
- renforcement du jet aux moyennes latitudes
- assèchement de la troposphère (tropiques)

Khodri et al, in prep

What is the influence of volcanic forcing over the climate inter annual to low frequency variability?

Cumulative effect of tropical eruptions on Tropical Pacific response:

IPSL-CM3v2 Niño3 SSTs



PROXY DATA:

Transition from

Medieval Climate Anomaly (MCA, 950-1200AD)

Little Ice Age (LIA, 1400-1700)

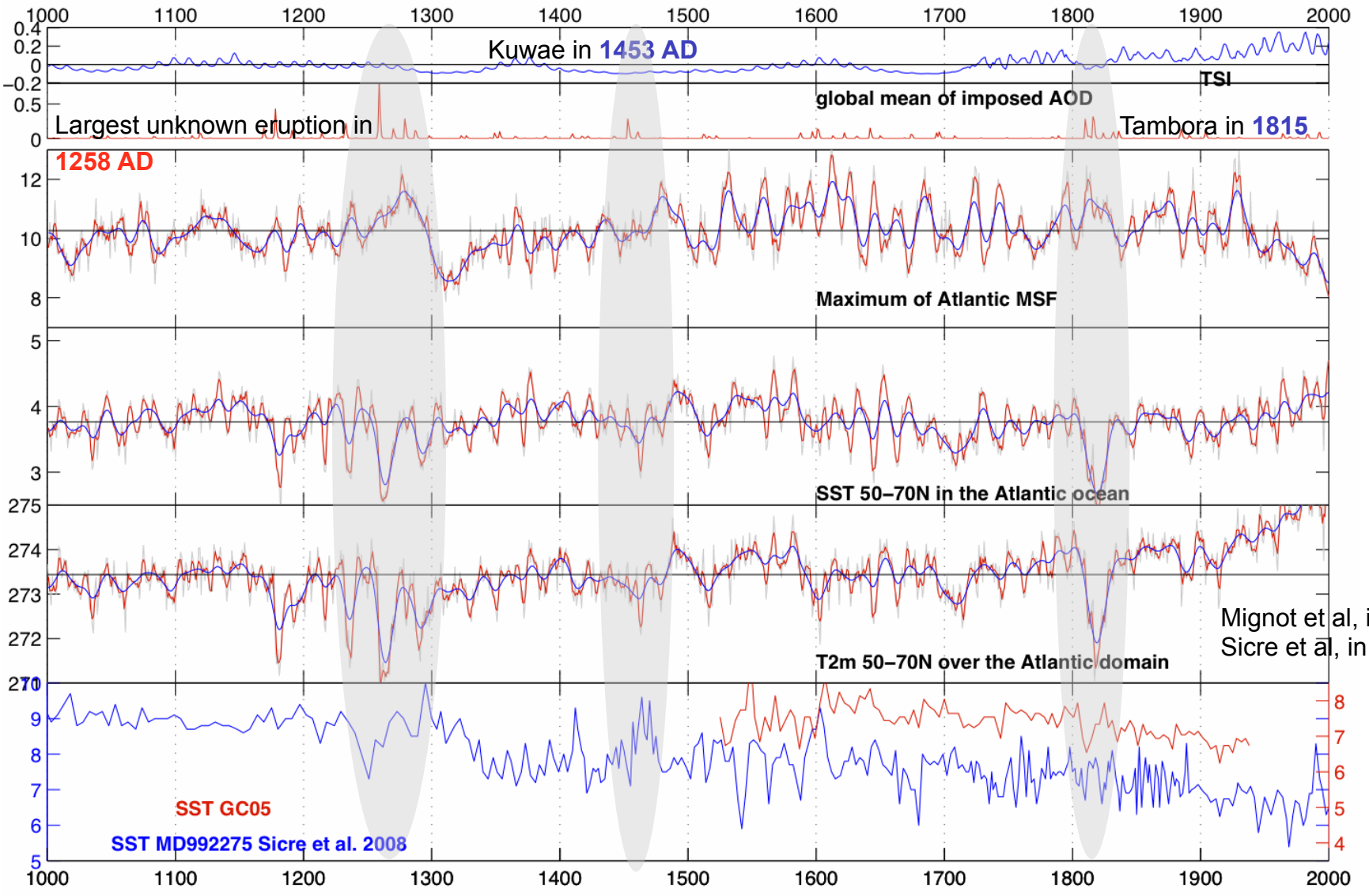
Persistent cooling in the Tropical Pacific

Higher Low Frequency (decadal) Variability

Khodri et al, in prep

What is the influence of volcanic forcing over the climate inter annual to low frequency variability?

Cumulative effect of tropical eruptions on North Atlantic :



Mignot et al, in prep
Sicre et al, in prep

Simulation pour l'IPCC AR5

- Vers une stratosphère mieux représentée (à l'IPSL 39 niveaux)
- Vers une paramétrisation des méga-éruptions améliorée
- Millénaire peut servir de base pour le 20eme siècle !!

- Recommandations PMIP3 pour le dernier millénaire:

(1) TSI: Plusieurs choix possible avec et sans background (0.25 et 0.1%): à l'IPSL 0.1% (Krivova et al)

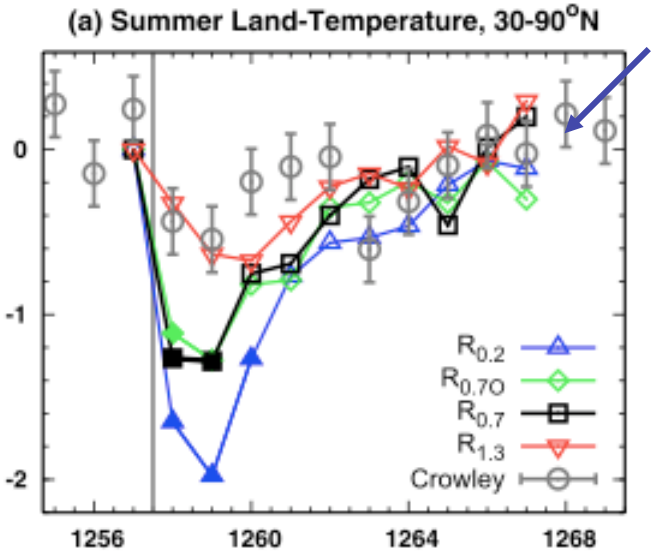
(2) Test sur les incertitudes liées au forçage solaire TSI/SSI, plusieurs choix possibles dont SSI et Ozone d'après Shindell et al. (2006)

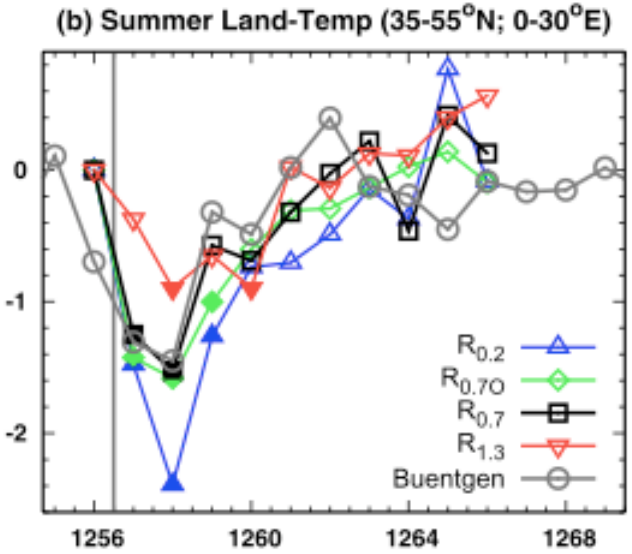
À l'IPSL/LATMOS: TSI/SSI, Ozone-LMDZ-Reprobus (Thuillier et al, Marchand et al)

Large volcanic eruptions

Eruption of A.D.1258

Timmreck et al, 2009



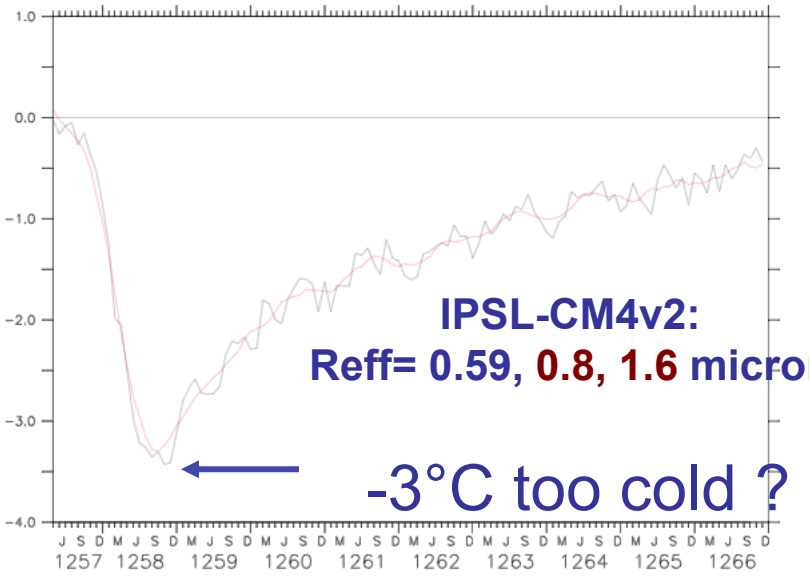


Model-Data comparison gives best match for **Reff= 0.7-1.3 micron**

Current Tests:
Reff= 0.1 - 0.4 micron
+
tau_i = tau_550 * w_i

weighting introduced using background aerosols (Morcrette, pers com)

Northern Hemisphere Temperature

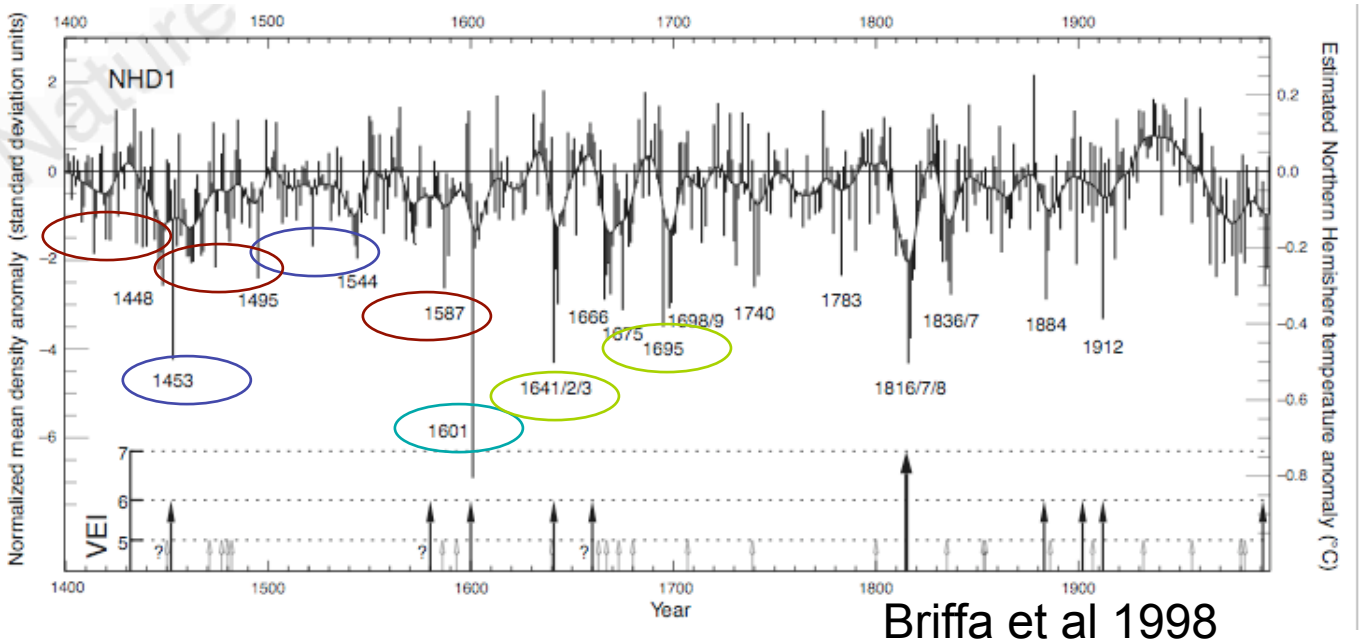


IPSL-CM4v2:
Reff= 0.59, 0.8, 1.6 micron

-3°C too cold ?

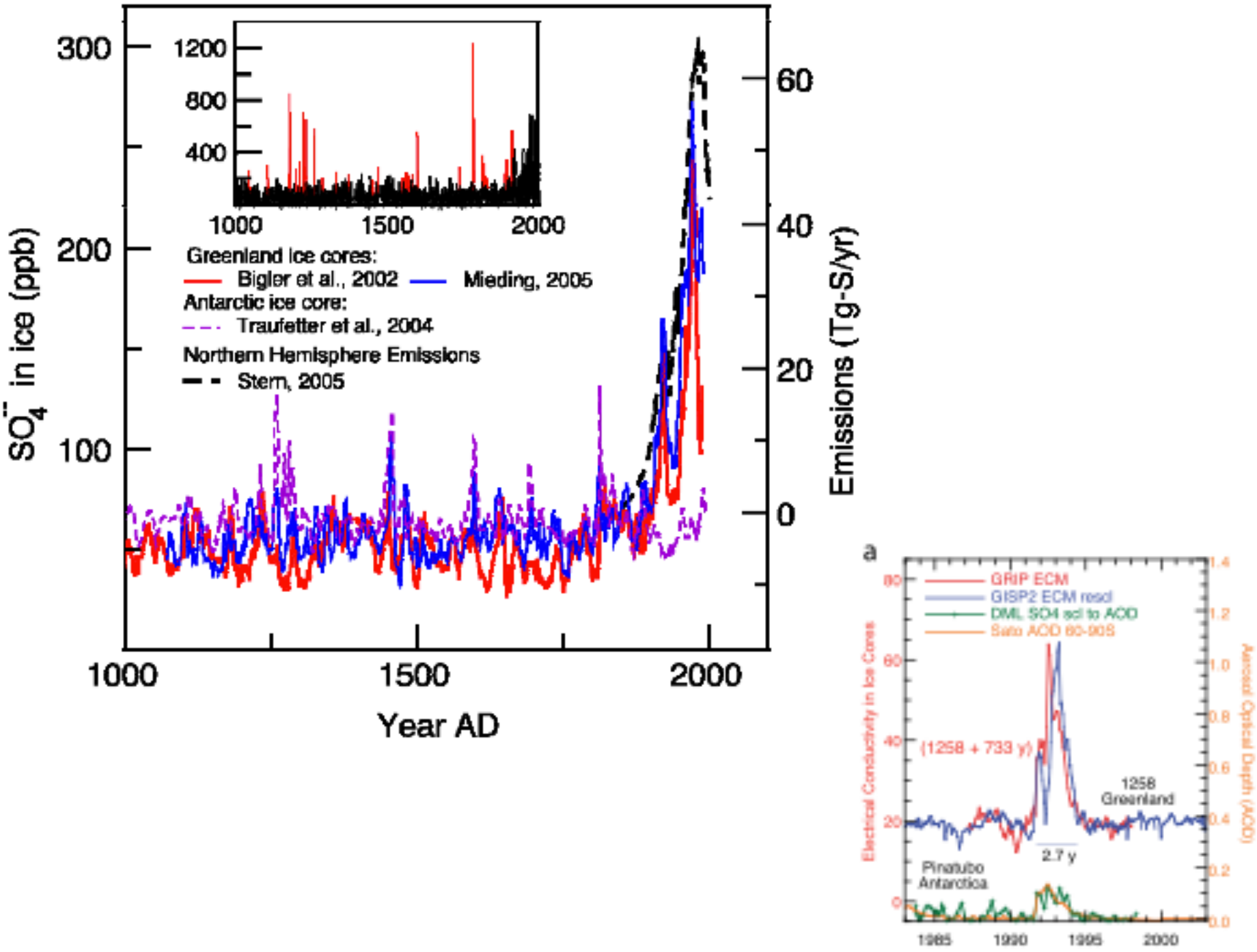
What is the influence of volcanic forcing over the tropical inter annual to low frequency variability?

Northern Hemisphere Temperatures



Briffa et al 1998

Date	Briffa et al	SOLVOL
1453 (January)	-0.5°C	-1.2°C
1641 & 1695 (January)	-0.4 / -0.6°C	-0.62°C
1511 & 1673 (April)	-0.2 / -0.4°C	-0,4°C
1601 (April)	-0.8°C	-0.8°C
1408&1459&1587 (July)	-0.15°C to -0.4°C	-0.3°C

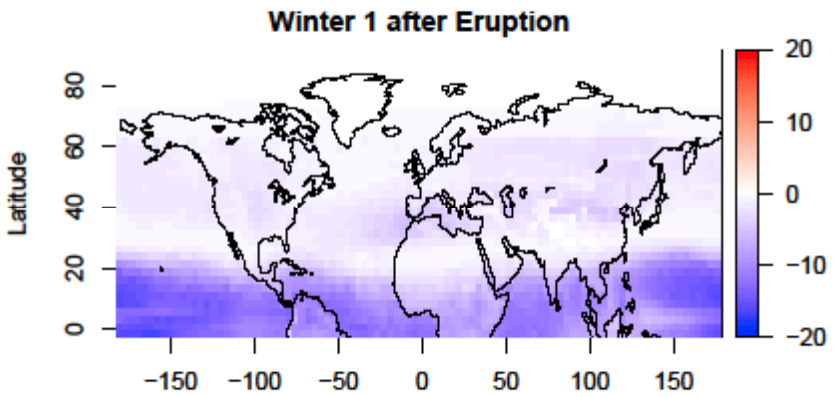

300
200
100
1200
800
400
1000
1500
2000
60
40
20
0
SO_4^{--} in ice (ppb)
Emissions (Tg-S/yr)
Greenland Ice cores:
Bigler et al., 2002
Mieding, 2005
Antarctic ice core:
Traufetter et al., 2004
Northern Hemisphere Emissions
Stern, 2005
1000
1500
2000
Year AD
a
GRIP ECM
GISP2 ECM resol
DML SO4 scl to ACD
Sato ACD 60-90S
(1258 + 733 y)
1258
Greenland
2.7 y
Pinatubo
Antarctica
Electrical Conductivity in Ice Cores
Aerosol Optical Depth (AOD)
1985
1990
1995
2000

Hiver 1 post-éruption

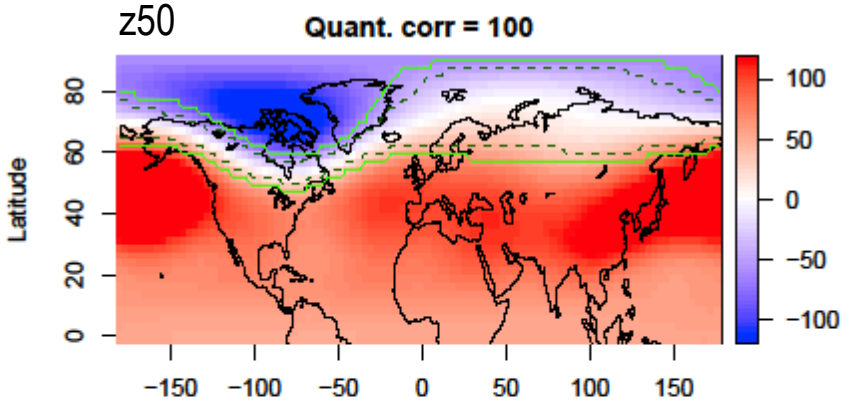
- Température = winter warming
- Z50 = augmentation gradient Equateur-Pôle
- Z500 = pattern d'onde, diminution du géopotentiel
- SLP = pattern d'onde, amplification vortex polaire

Significativité : Bootstrap sur CTRLA + corrélation entre les cartes

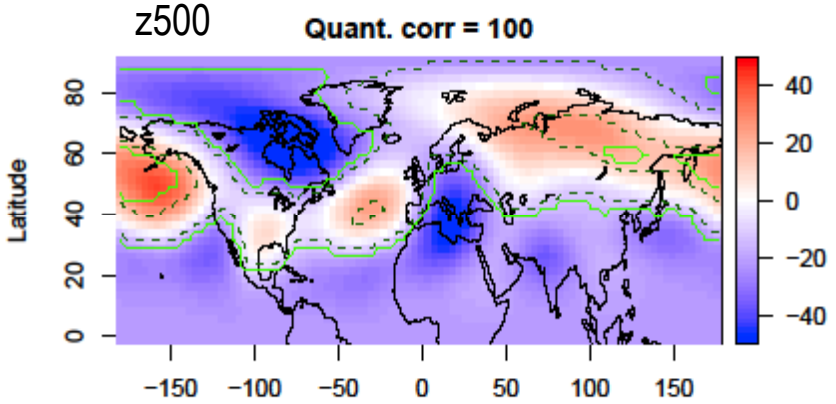
Tirets : 90% ; Lignes pleines : 99%



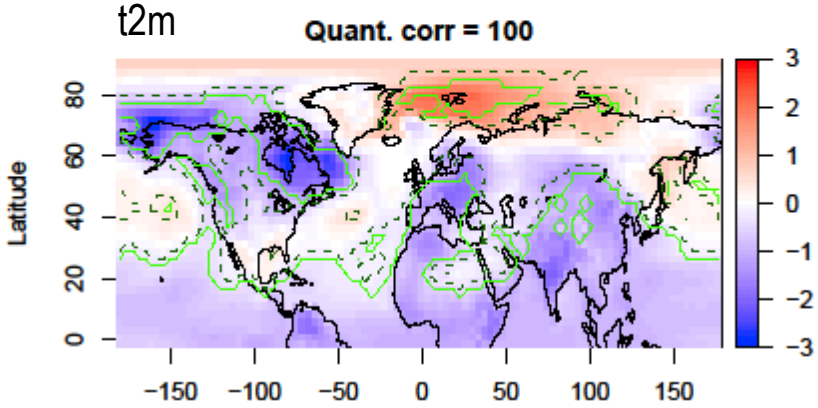
z50



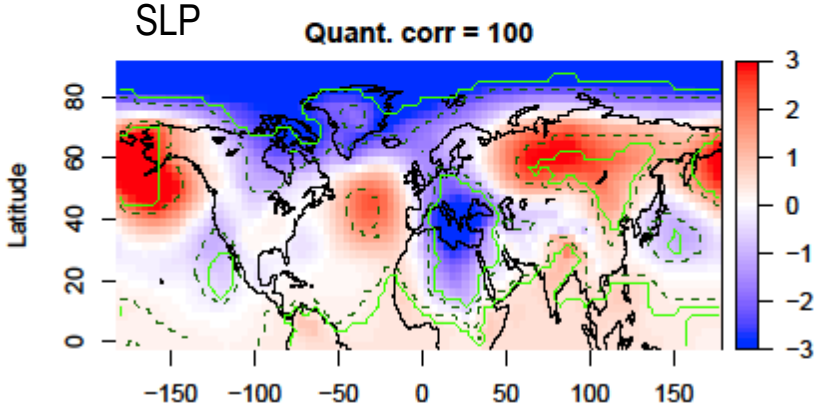
z500



t2m



SLP



Impact des éruptions sur l'atmosphère

IPSL-CM4v2

Année 1 post-éruption

- Réchauffement strato/ refroidissement tropo
- augmentation du géopotentiel dans la strato/ diminution dans la tropo
- augmentation du gradient température et géopotentiel Equateur-Pôle
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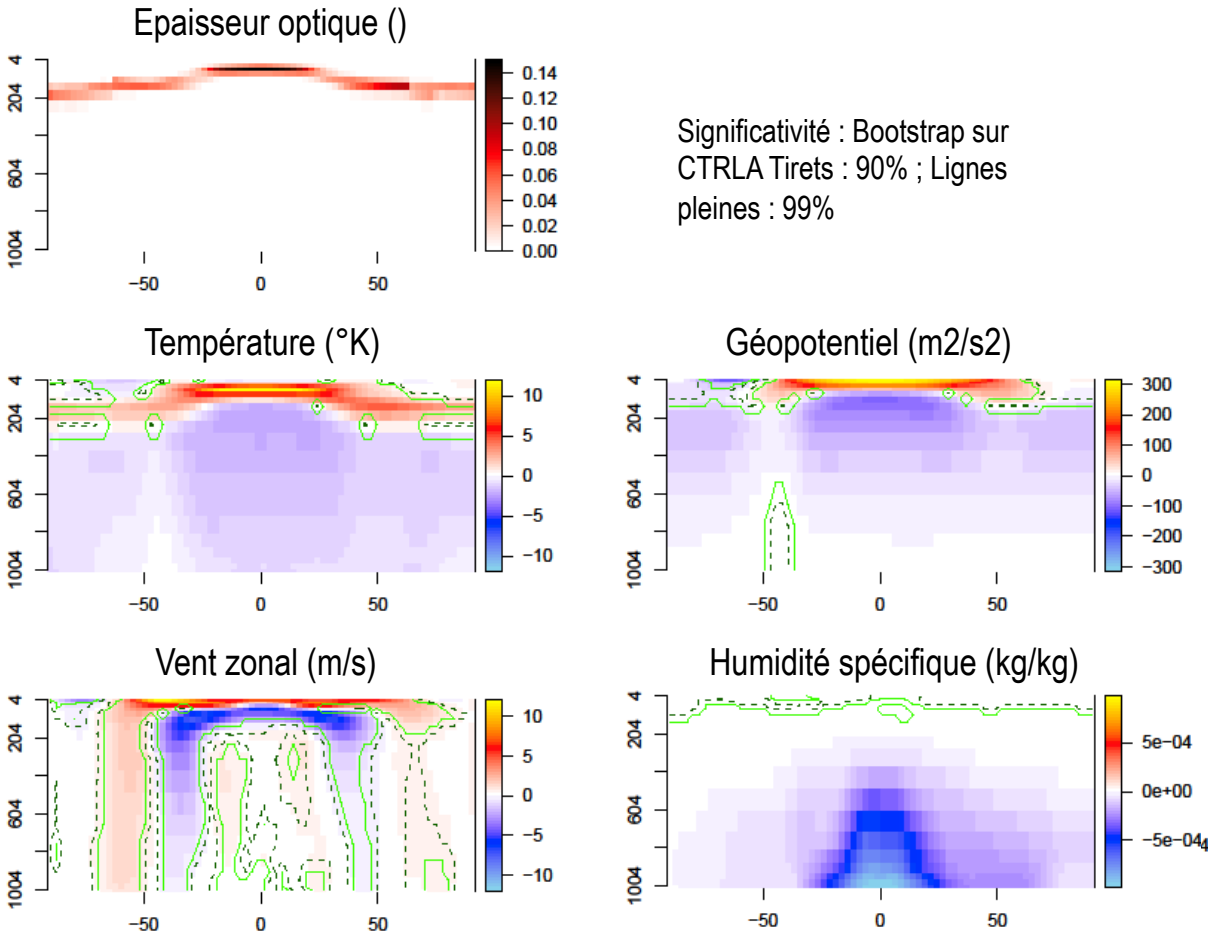
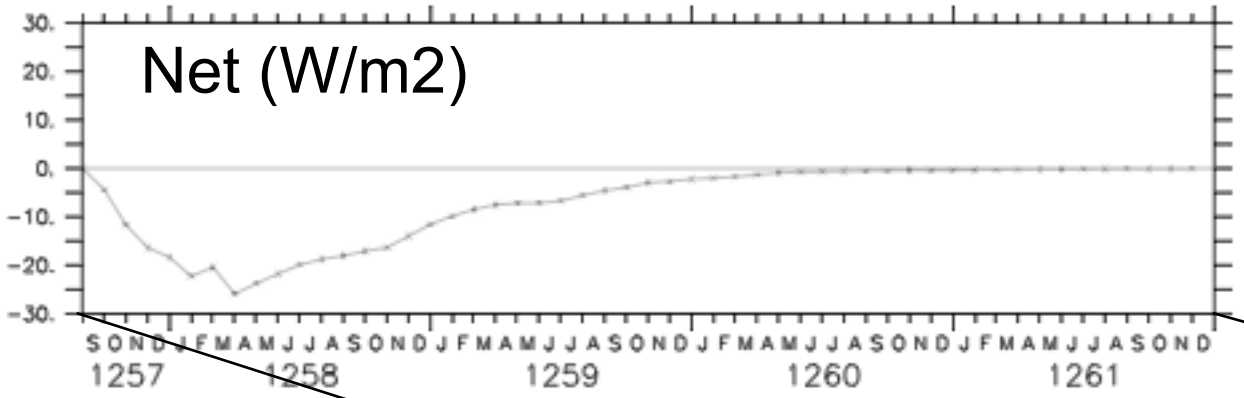
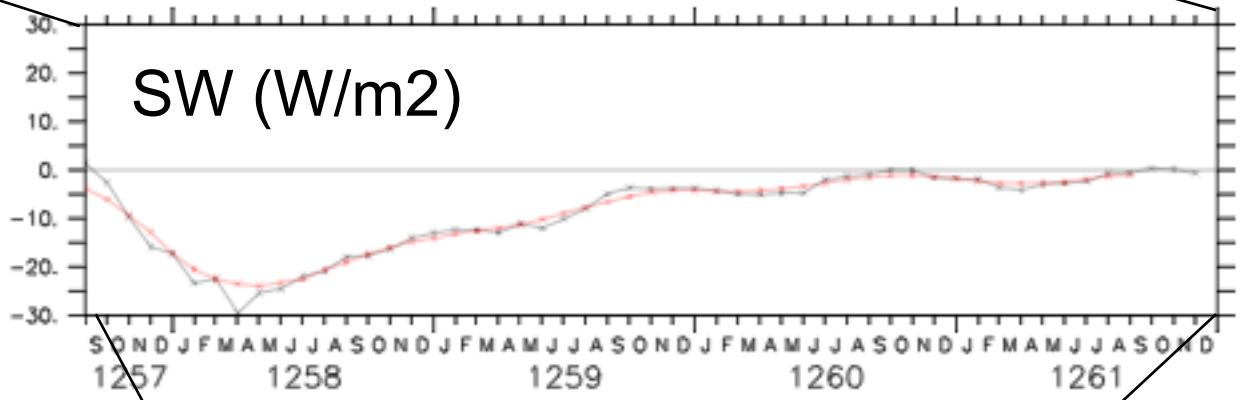


Khodri et al, in prep

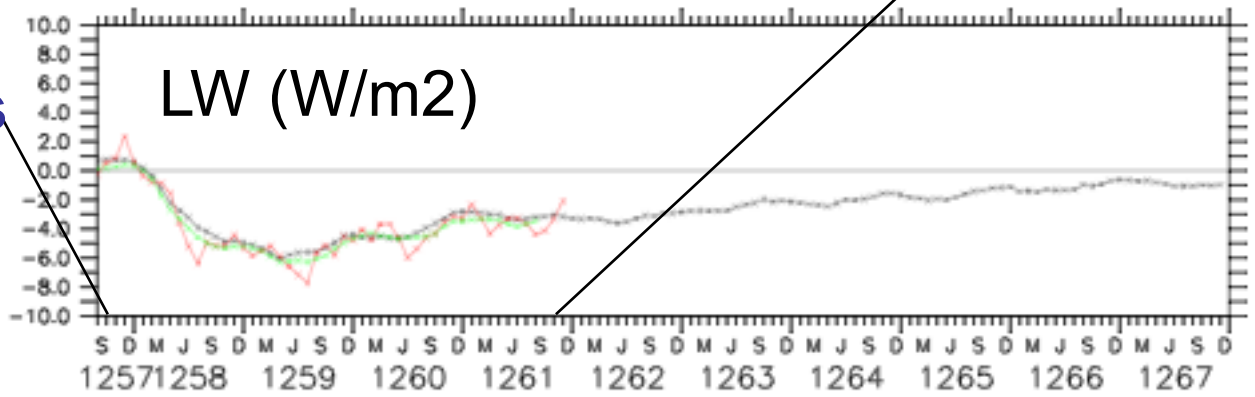
What is the influence of volcanic forcing over the climate inter annual to low frequency variability?



Radiative heat Budget for the A.D. 1258 eruption

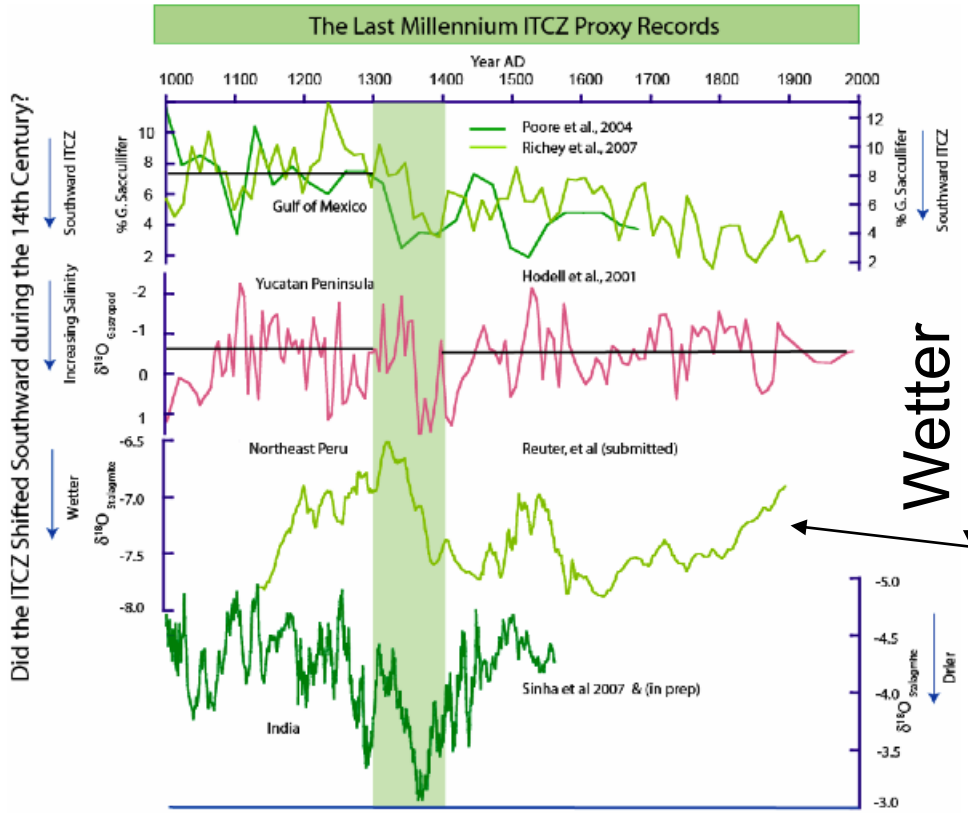


Water vapour Feedback transmits the individual volcanic forcing to longer timescale



What is the influence of volcanic forcing over the climate inter annual to low frequency variability?

"Sneak Peak" into the tropical hydrological cycle



Courtesy of A. Sinha