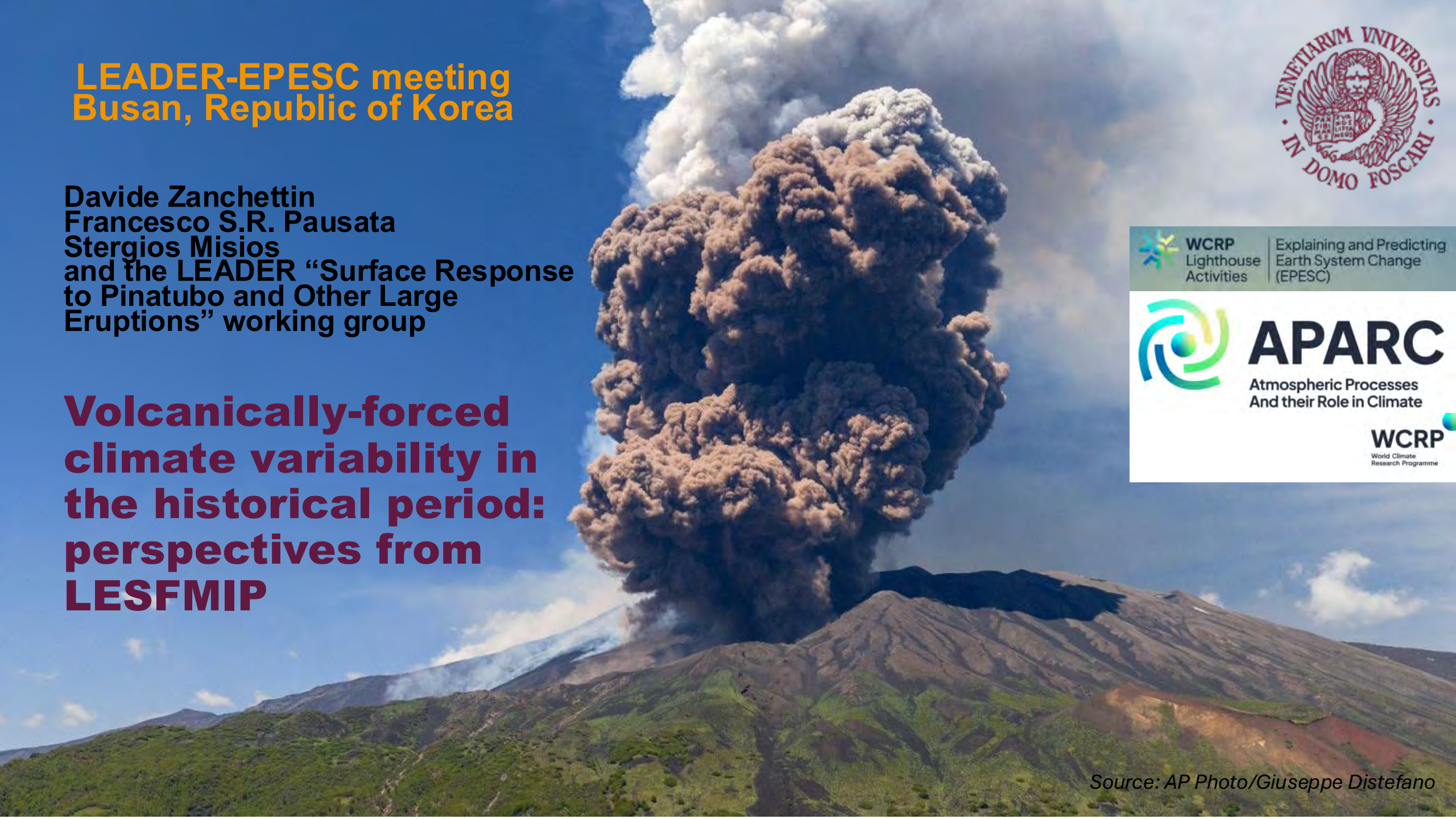


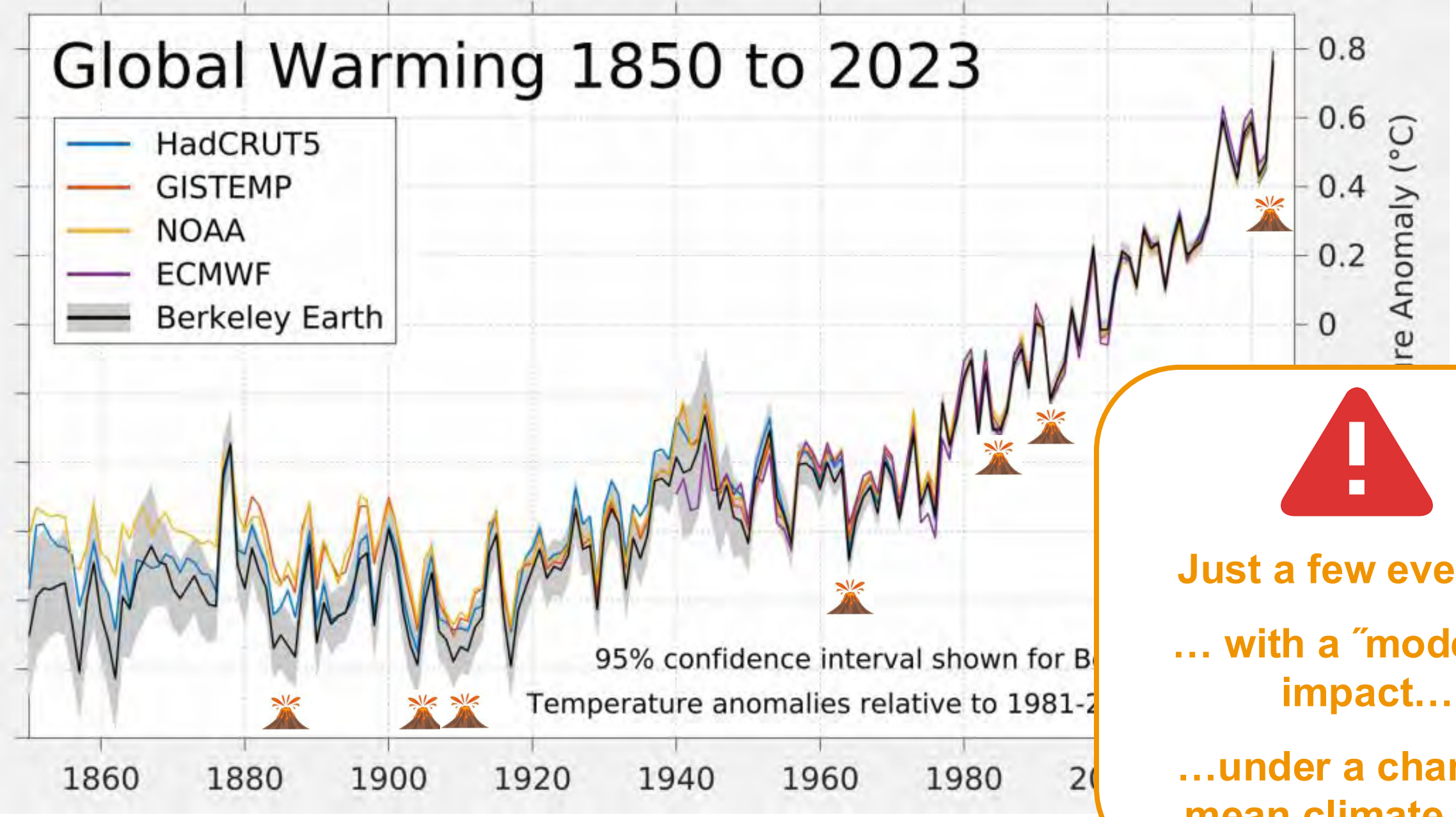
LEADER-EPESC meeting
Busan, Republic of Korea

Davide Zanchettin
Francesco S.R. Pausata
Stergios Misios
and the LEADER "Surface Response to Pinatubo and Other Large Eruptions" working group

Volcanically-forced climate variability in the historical period: perspectives from LESFMIP

Source: AP Photo/Giuseppe Distefano

The main direct radiative effect of large explosive volcanic eruptions is to temporarily enhance the planetary albedo, resulting in a net surface cooling



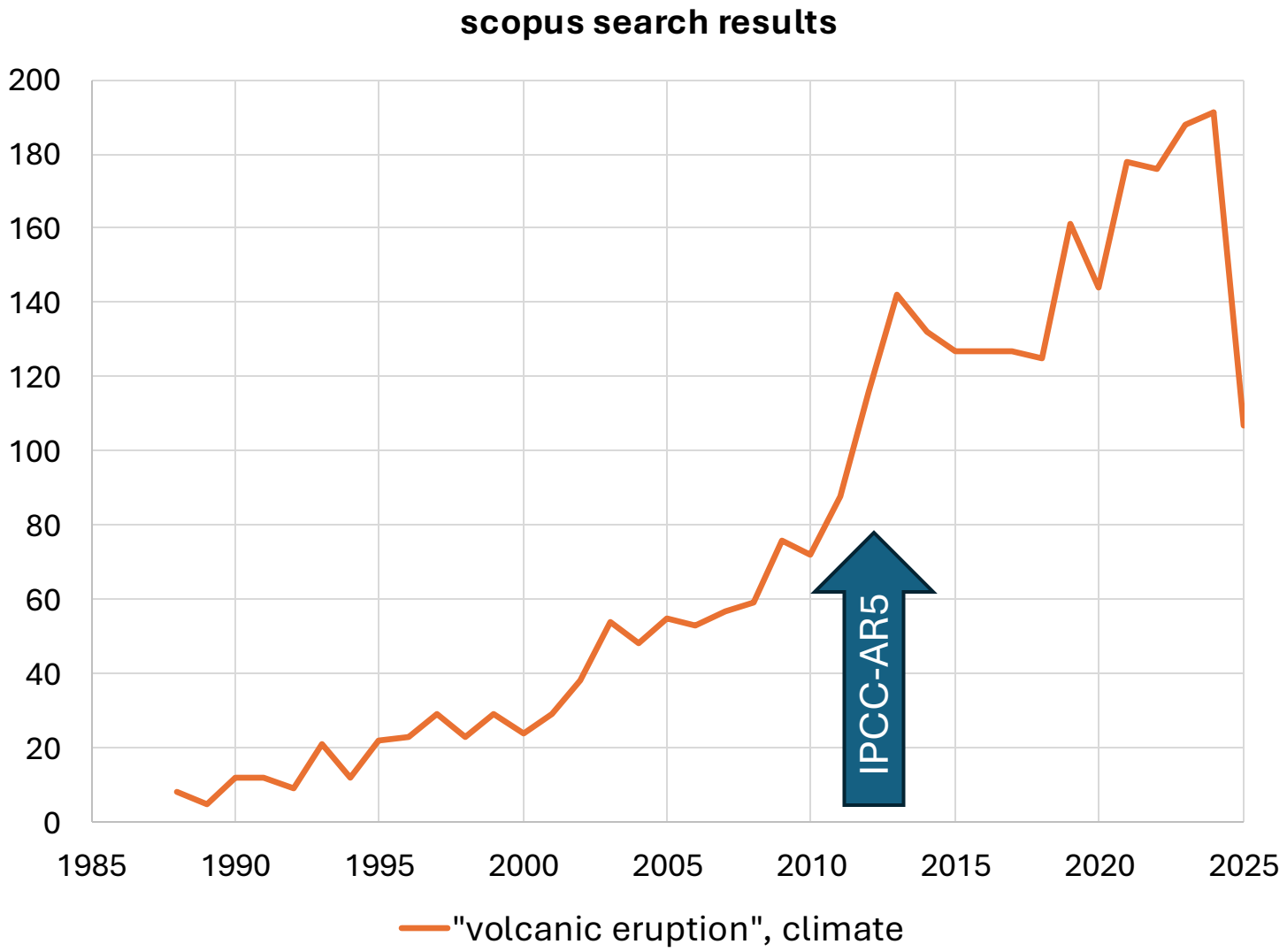
Just a few events…

… with a ″moderate″ impact…

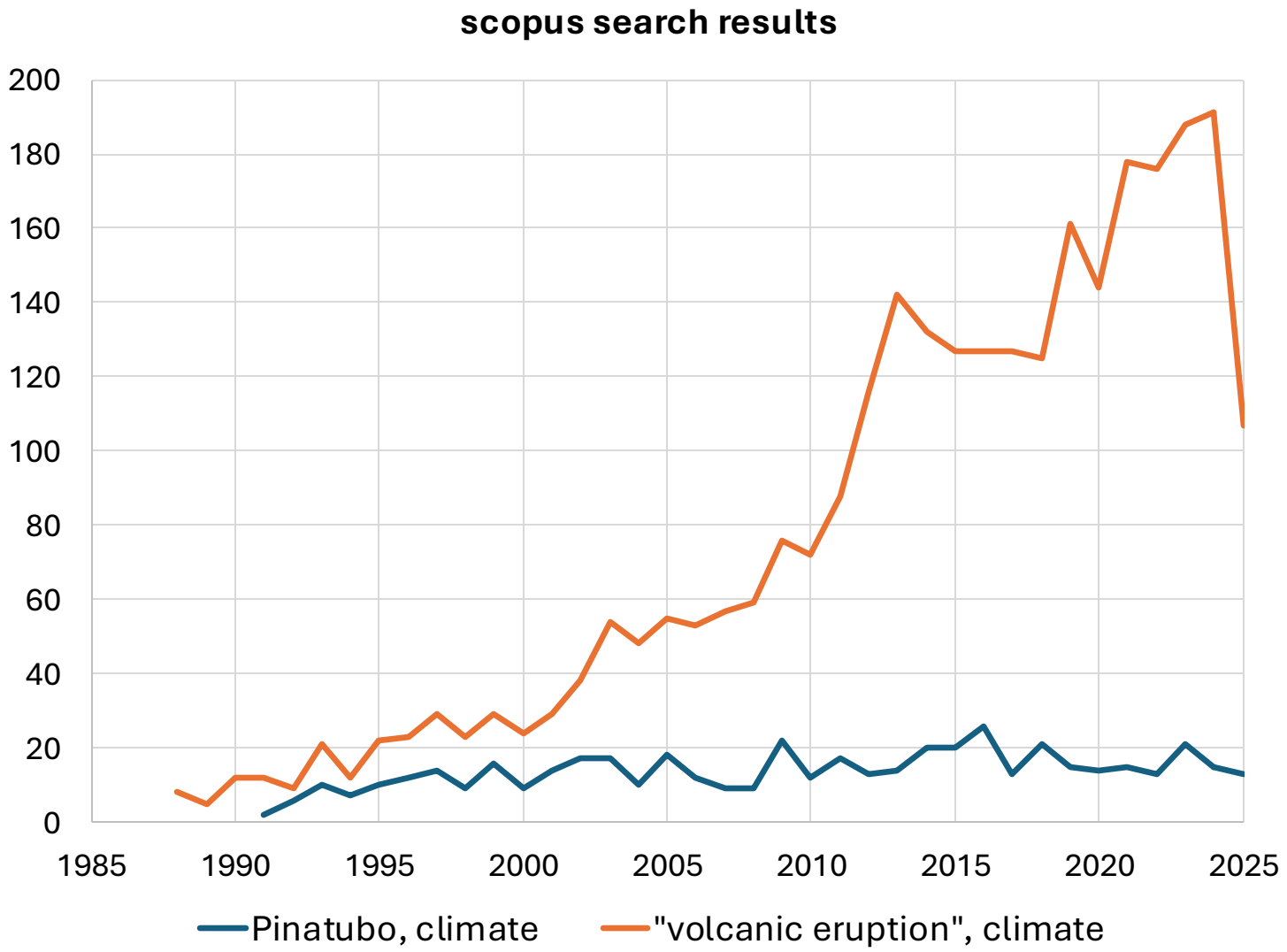
…under a changing mean climate state

Framing the problem /1

Source: Berkley Earth

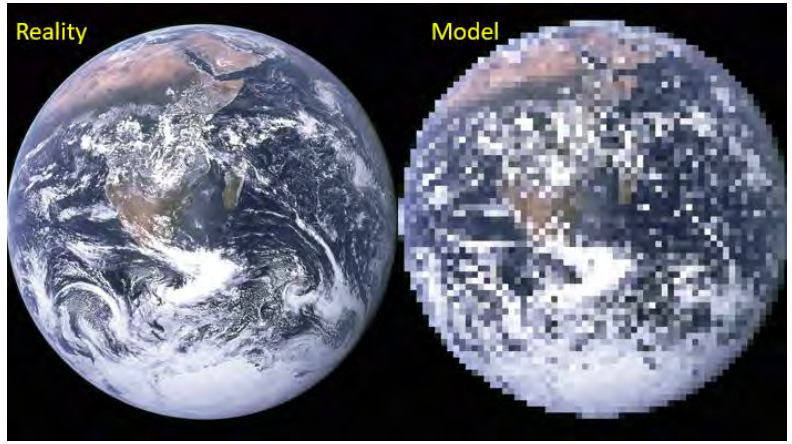


Framing the problem /2



What can we still learn from Pinatubo and other eruptions during the *historical* period?

How can we exploit LES/SMILEs approaches?



Framing the problem /2

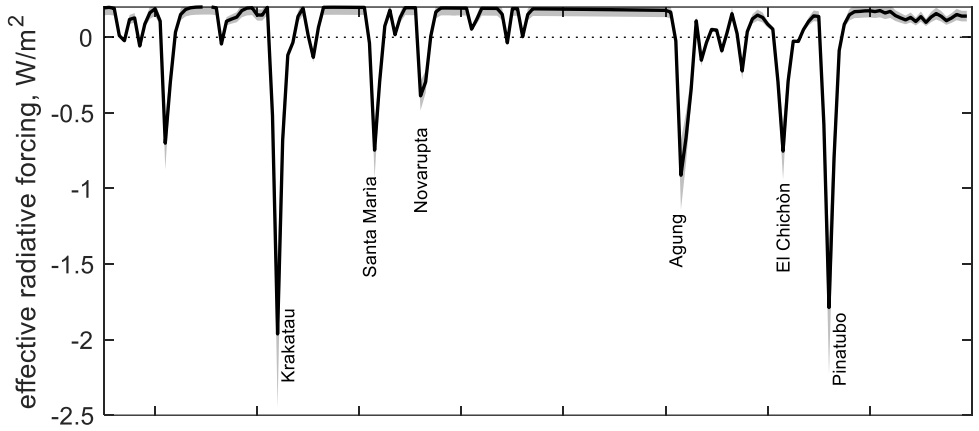
The data: the volc-hist ensemble

Volcanic-forcing only simulations of the historical period (1850-XXXX)

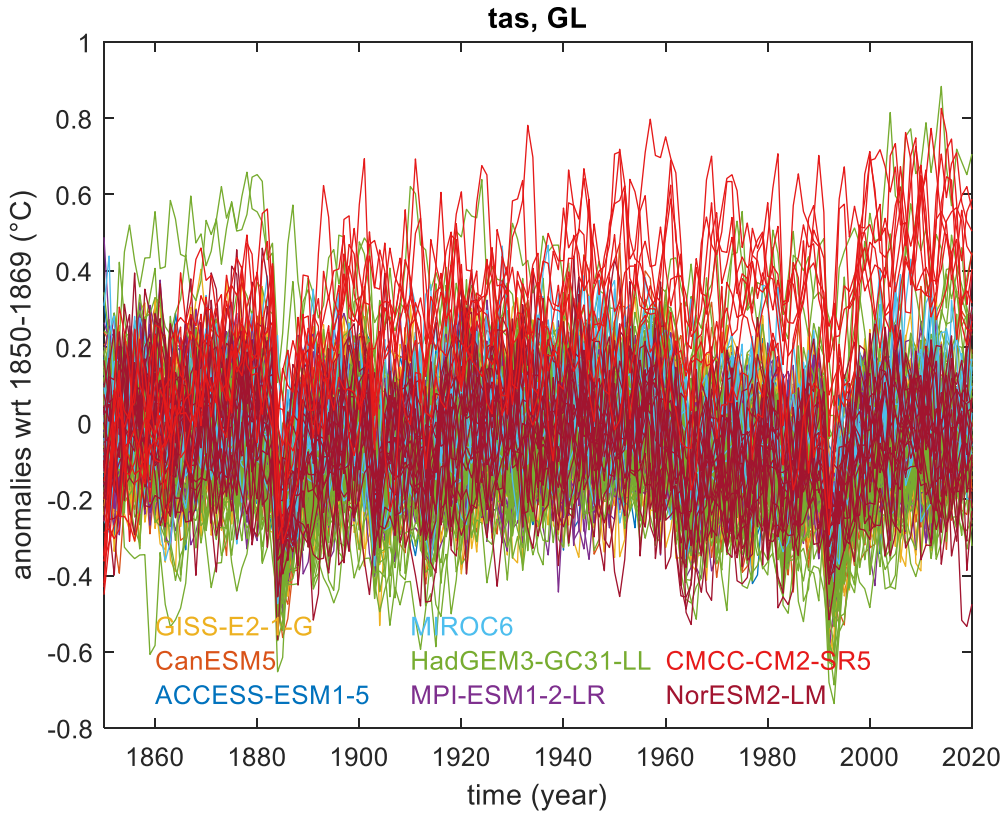
Model	Ensemble size	ipf	End year
ACCESS-ESM1-5	10	i1p1f1	2014
CanESM5	25	i1p2f1	*2020*
CMCC-CM2-SR5	10	i1p1f1	2020
GISS-E2-1-G	20	i1p3f1	2014
HadGEM3-GC31-LL	50	i1p1f3	2020
MIROC6	10	i1p1f1	2020
MPI-ESM1-2-LR	30	i1p1f1	2014
NorESM2-LM	20	i1p1f1	2020

Are these *good* **S**ingle-**M**odel **I**nitial-condition ***L****arge* **E**nsembles?

First look



Global mean near-surface air temperature (tas, GL)



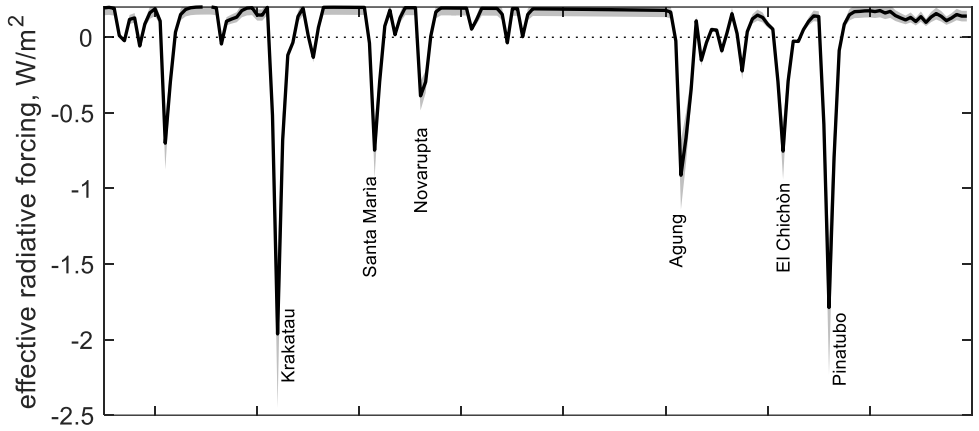
→ Masks different climatologies!

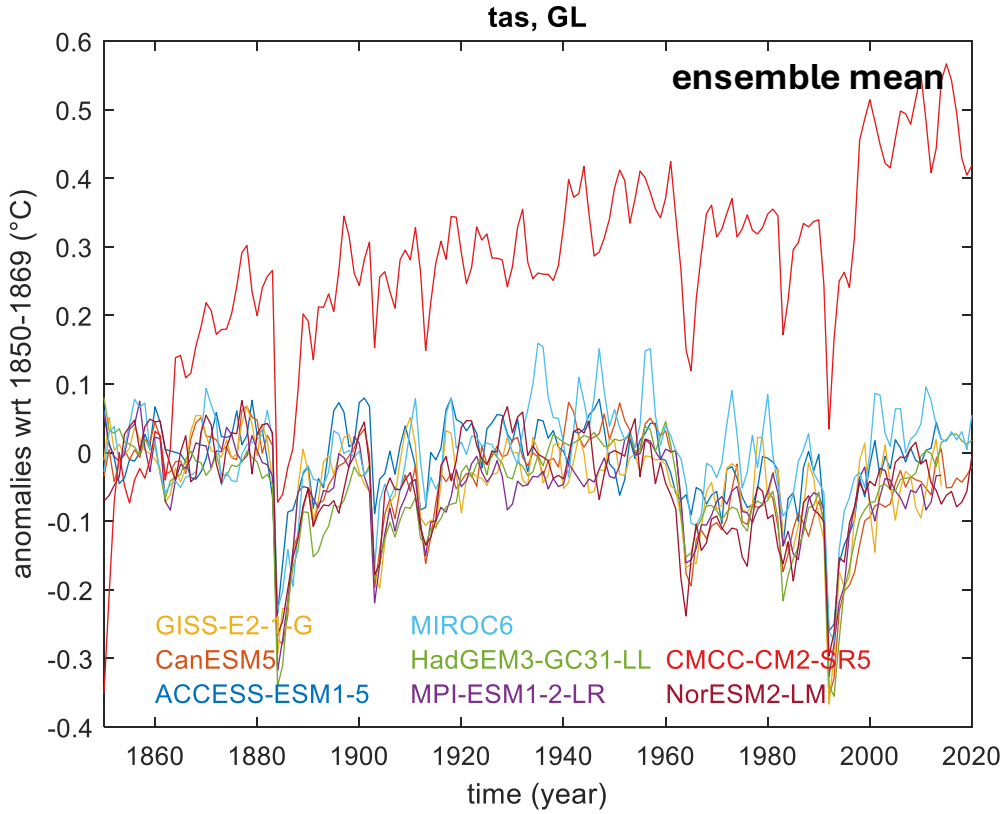
Annual means!

Author: Davide Zanchettin

First look

Global mean near-surface air temperature (tas, GL)





→ Masks different climatologies!

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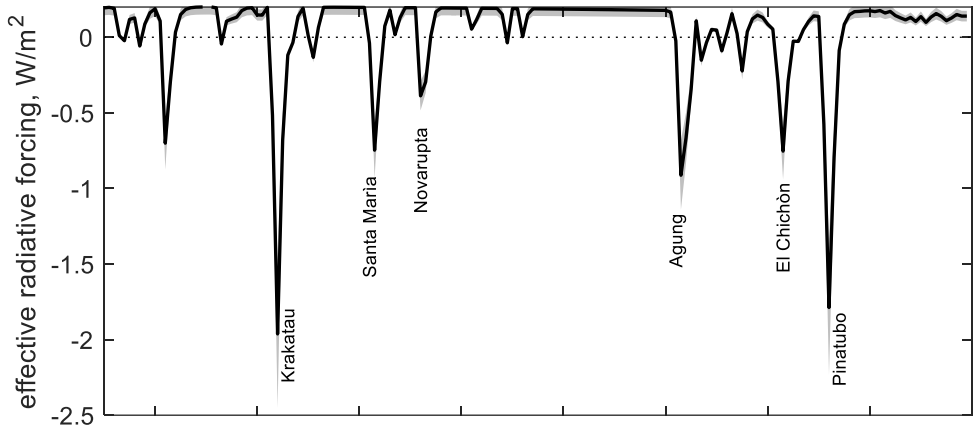
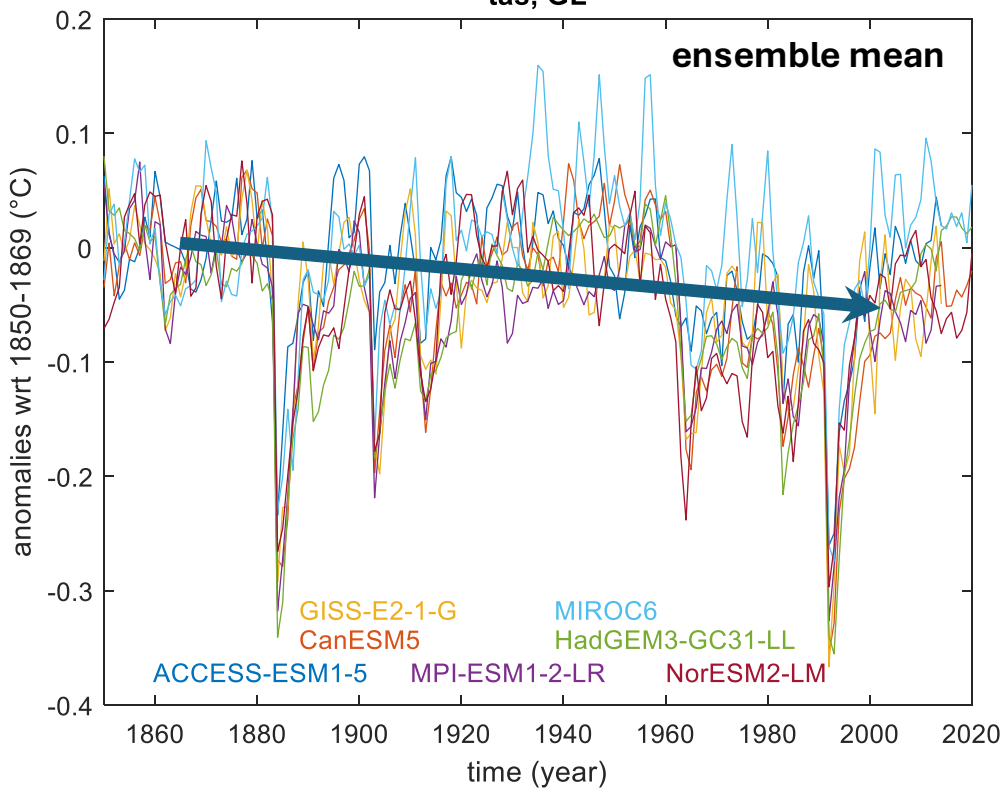
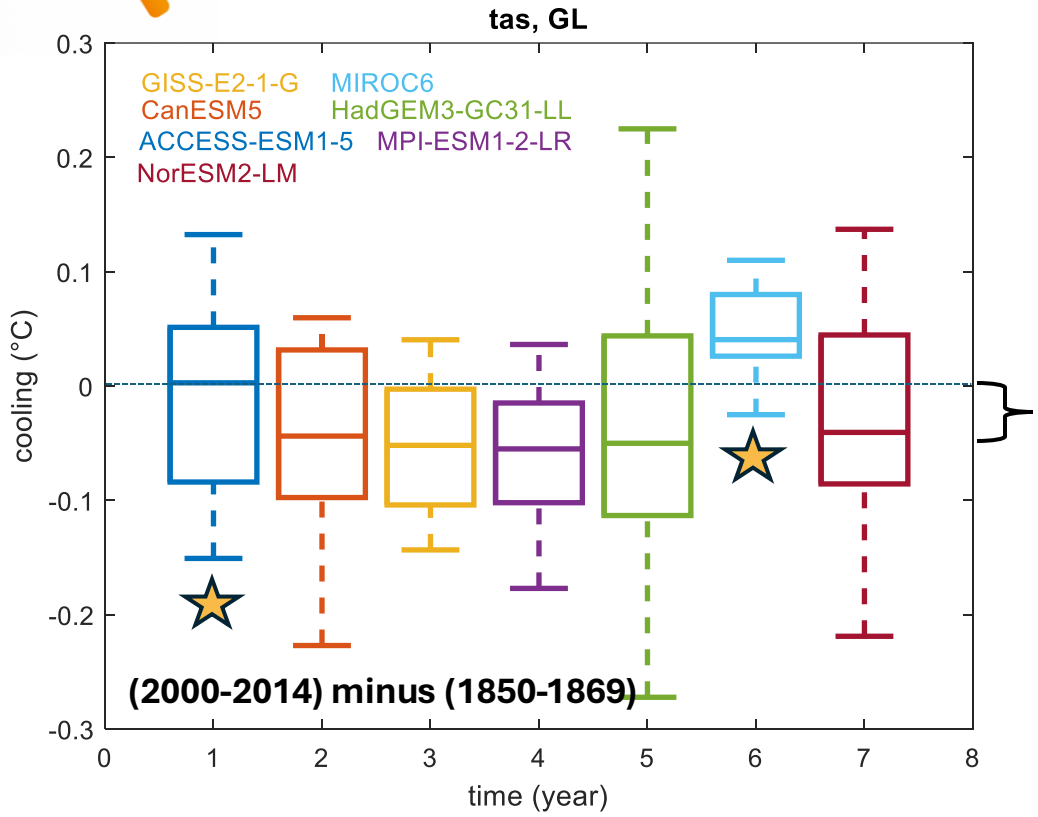
Author: Davide Zanchettin

First look





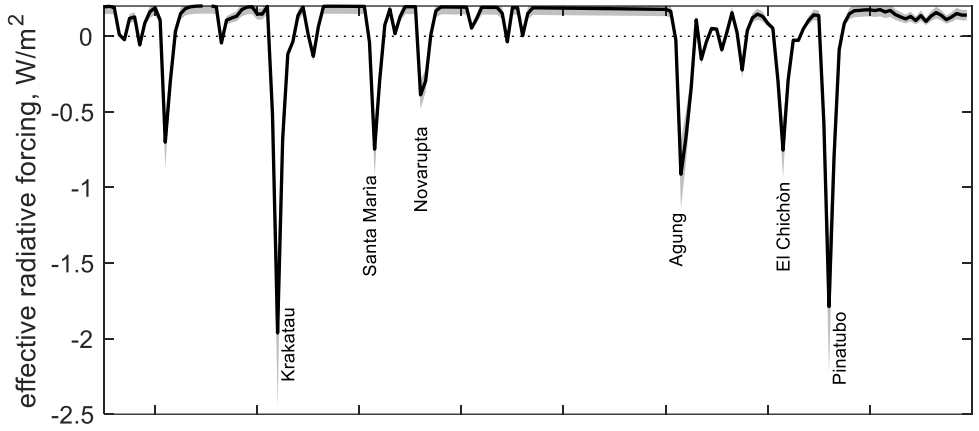
Global mean near-surface air temperature (tas, GL)

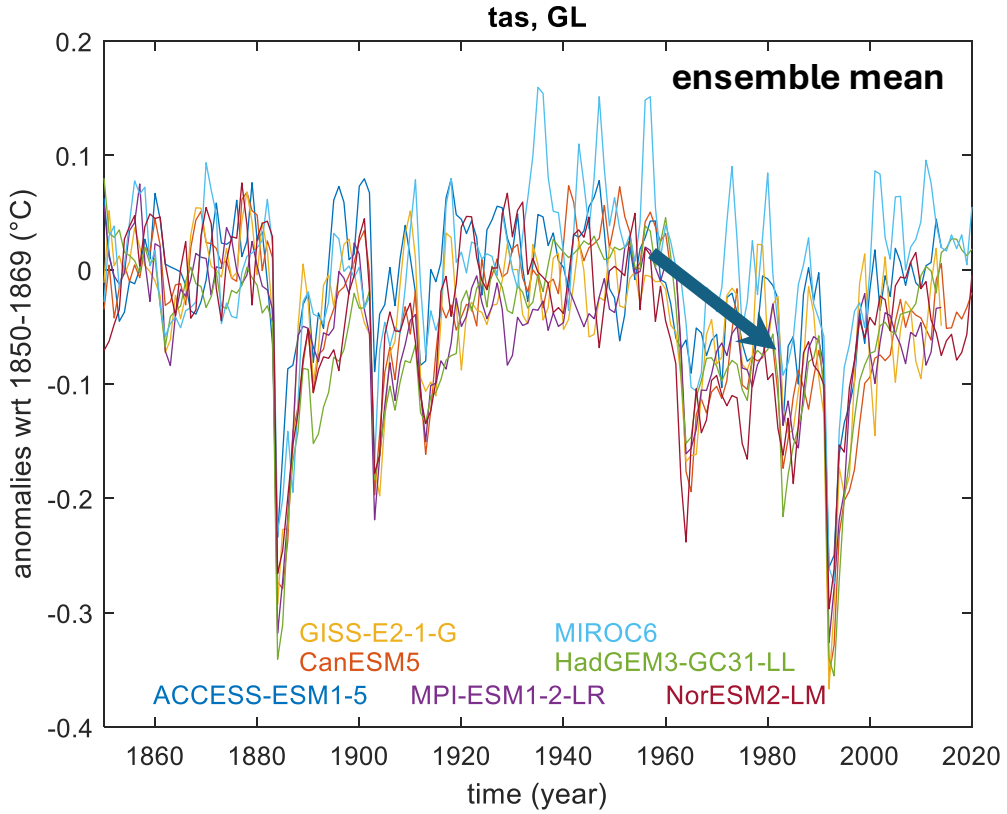


Consistent cumulative effect?
Ocean heat content changes?
Why ACCESS and MIROC?

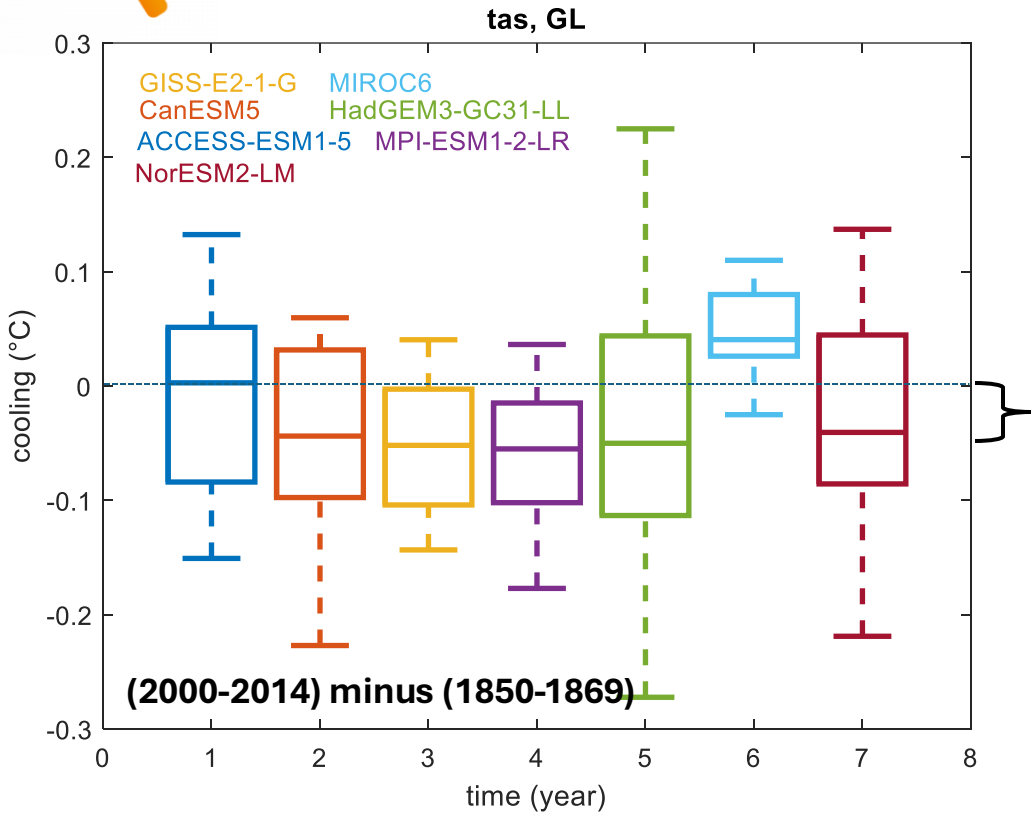
Author: Davide Zanchettin

First look





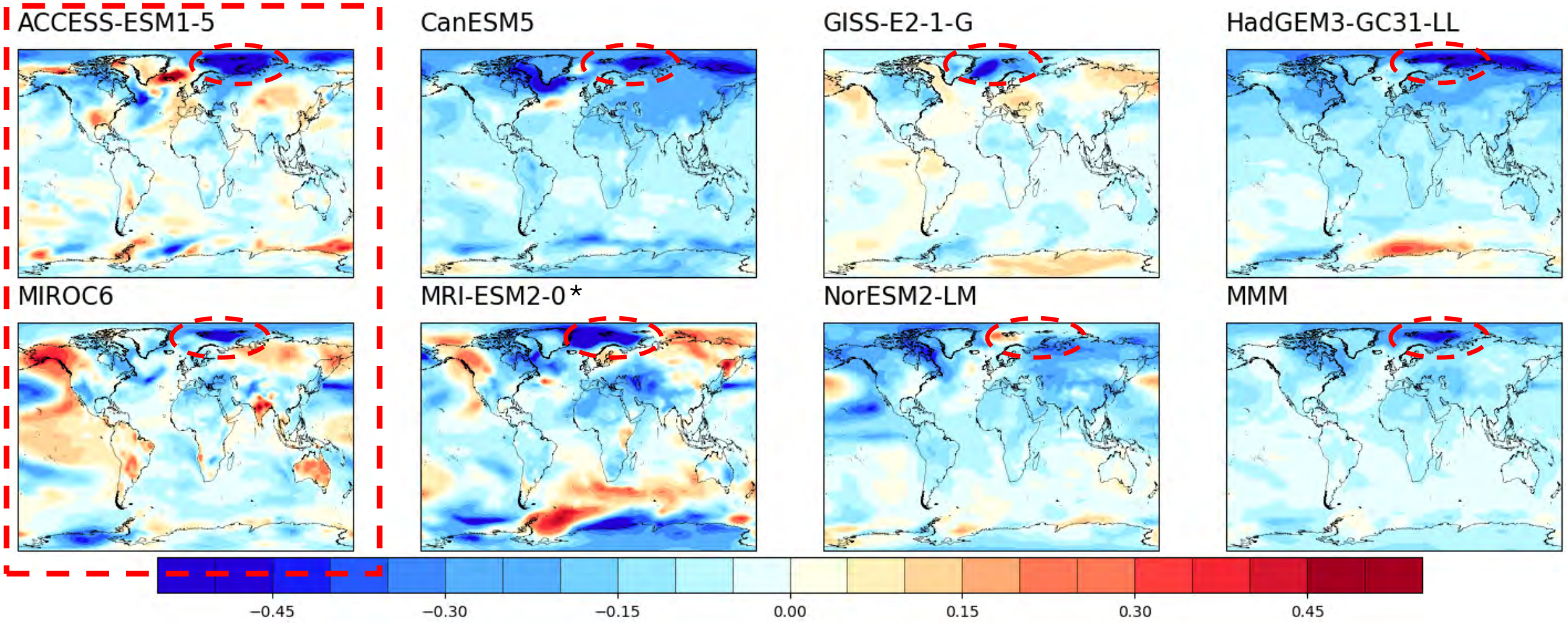
Global mean near-surface air temperature (tas, GL)



Consistent cumulative effect?
Ocean heat content changes?
Why ACCESS and MIROC?

Author: Davide Zanchettin

Persistent cooling post-Agung



tas, (1972-1981) minus (1953-1962)

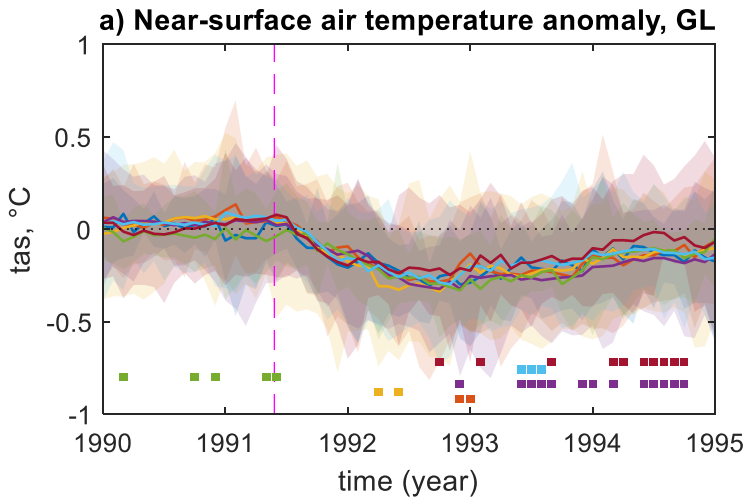
Arctic sea-ice feedbacks?

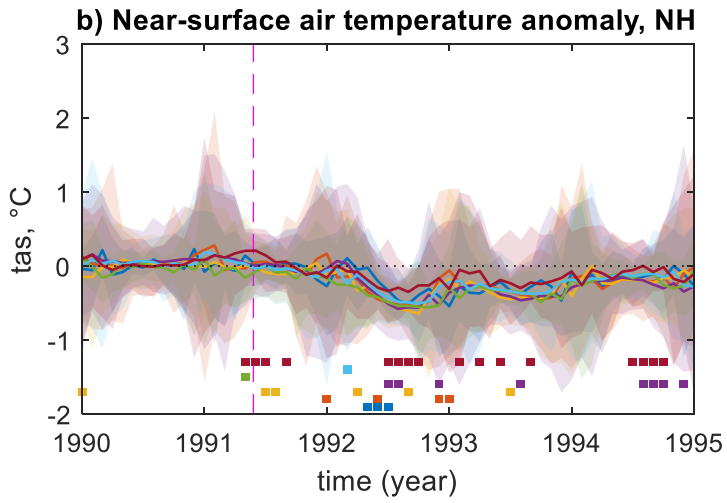
Mt Fuego (1974)?

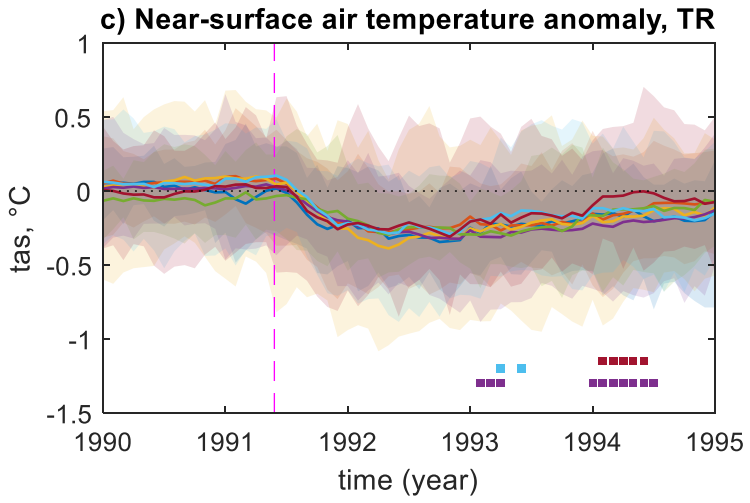
* need to double check

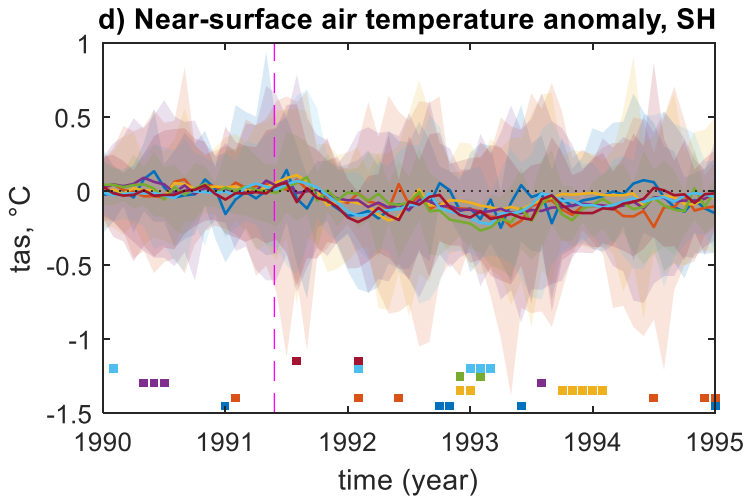
Author: Stergios Misios

Response to Pinatubo









ACCESS-ESM1-5 hist-volc
CanESM5 hist-volc
NorESM2-LM hist-volc
GISS-E2-1-G hist-volc
HadGEM3-GC31-LL hist-volc
MIROC6 hist-volc
MPI-ESM1-2-LR hist-volc

GL: global; **TR**: tropics (30S-30N); **NH**: northern extratropics (30-90N); **SH**: southern extratropics (30-90S)
Squares at bottom: model significantly different from rest of ensemble (ranksum)

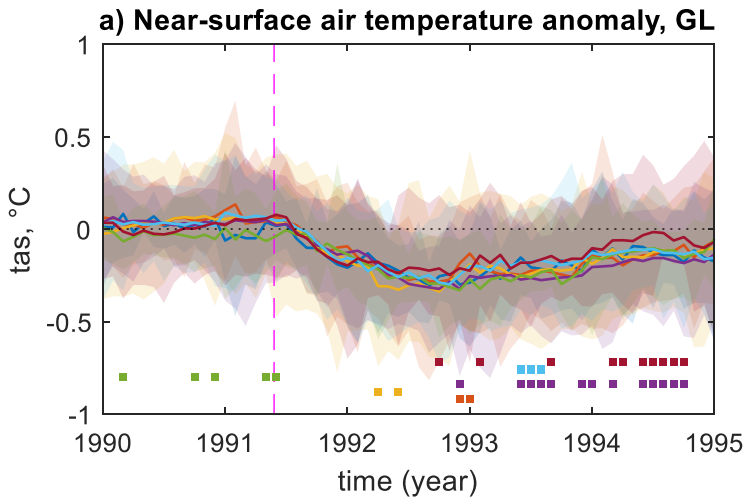
Author: Davide Zanchettin

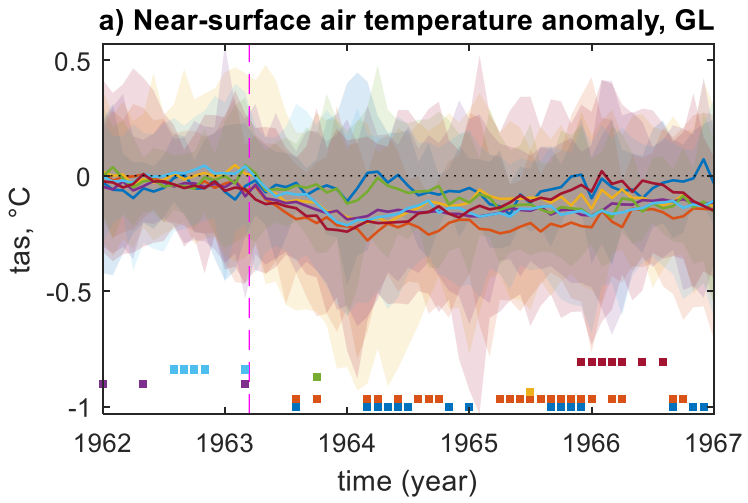
Response to Pinatubo vs response to Agung

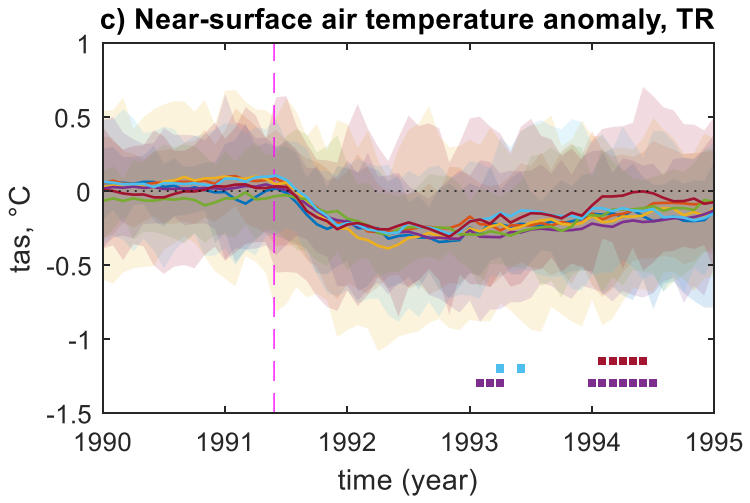
IC/Mean state

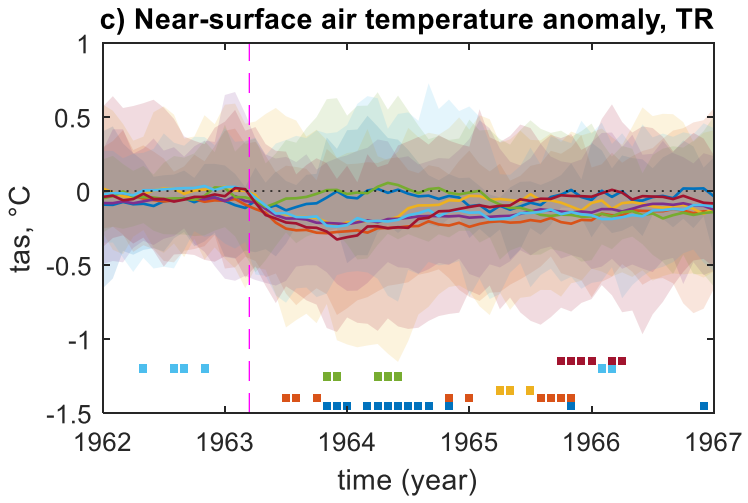
Volcanic forcing structure

ENSO (not really seen in TR)









ACCESS-ESM1-5 hist-volc
CanESM5 hist-volc
NorESM2-LM hist-volc
GISS-E2-1-G hist-volc
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MIROC6 hist-volc
MPI-ESM1-2-LR hist-volc

GL: global; **TR**: tropics (30S-30N)
Squares at bottom: model significantly different from rest of ensemble

Author: Davide Zanchettin

CMIP6 experiments with Pinatubo

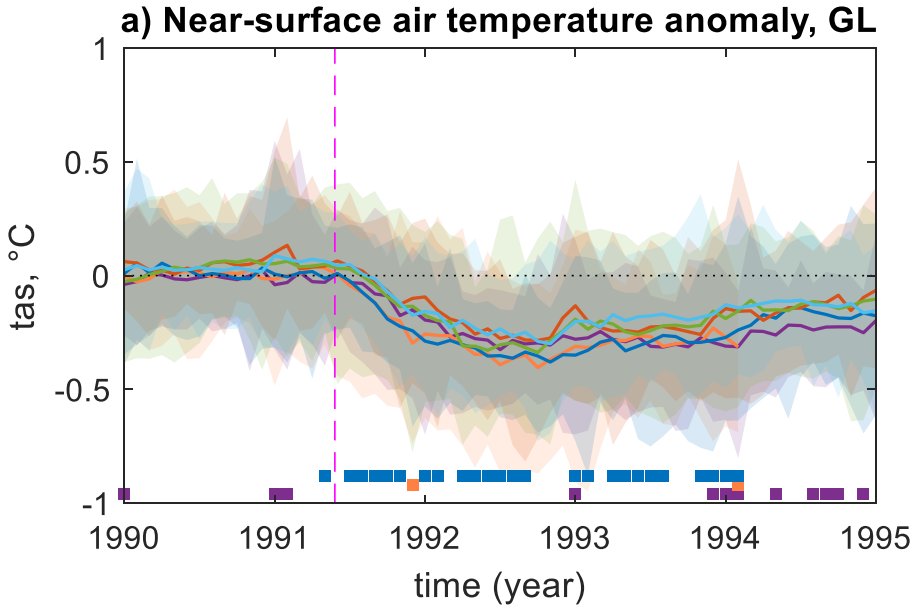
	DAMIP hist-volc	VolMIP volc-pinatubo-full
forcing	GloSSAC version 1.0 or 1.1 (?)	GloSSAC version 1.0
Initial conditions (climate background)	*historical* volcanic forcing only	*piControl*
Initial conditions (sampling)	**Unsupervised** (transient)	**Supervised** (ENSO, NAO)
Ensemble size	Variable (from 20 to 30)	27

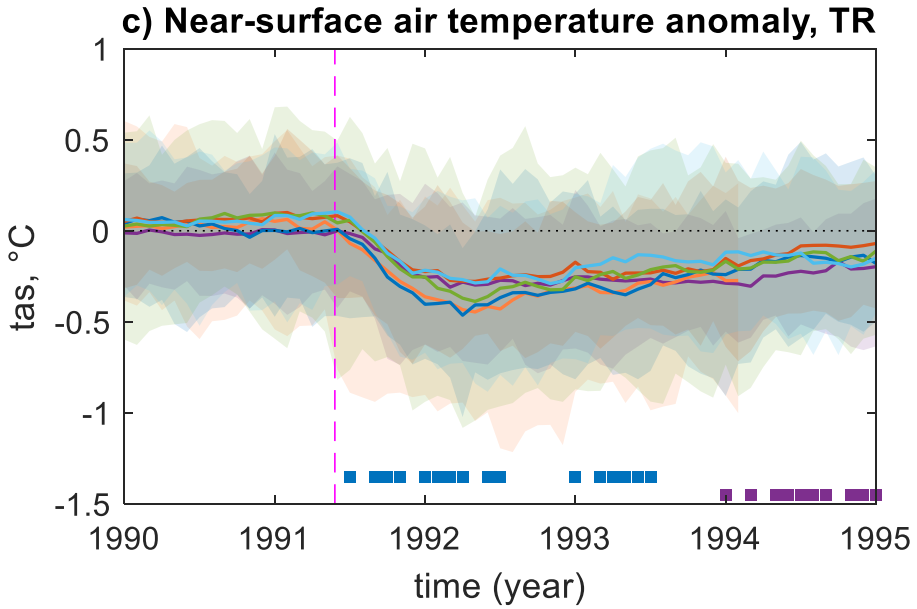
CanESM5 MPI-ESM-1-2LR GISS-E2-1-G

VolMIP vs hist-volc

MPI-ESM1-2-LR
IC or ozone in hist-volc

But, …





CanESM5 volmip
CanESM5 hist-volc

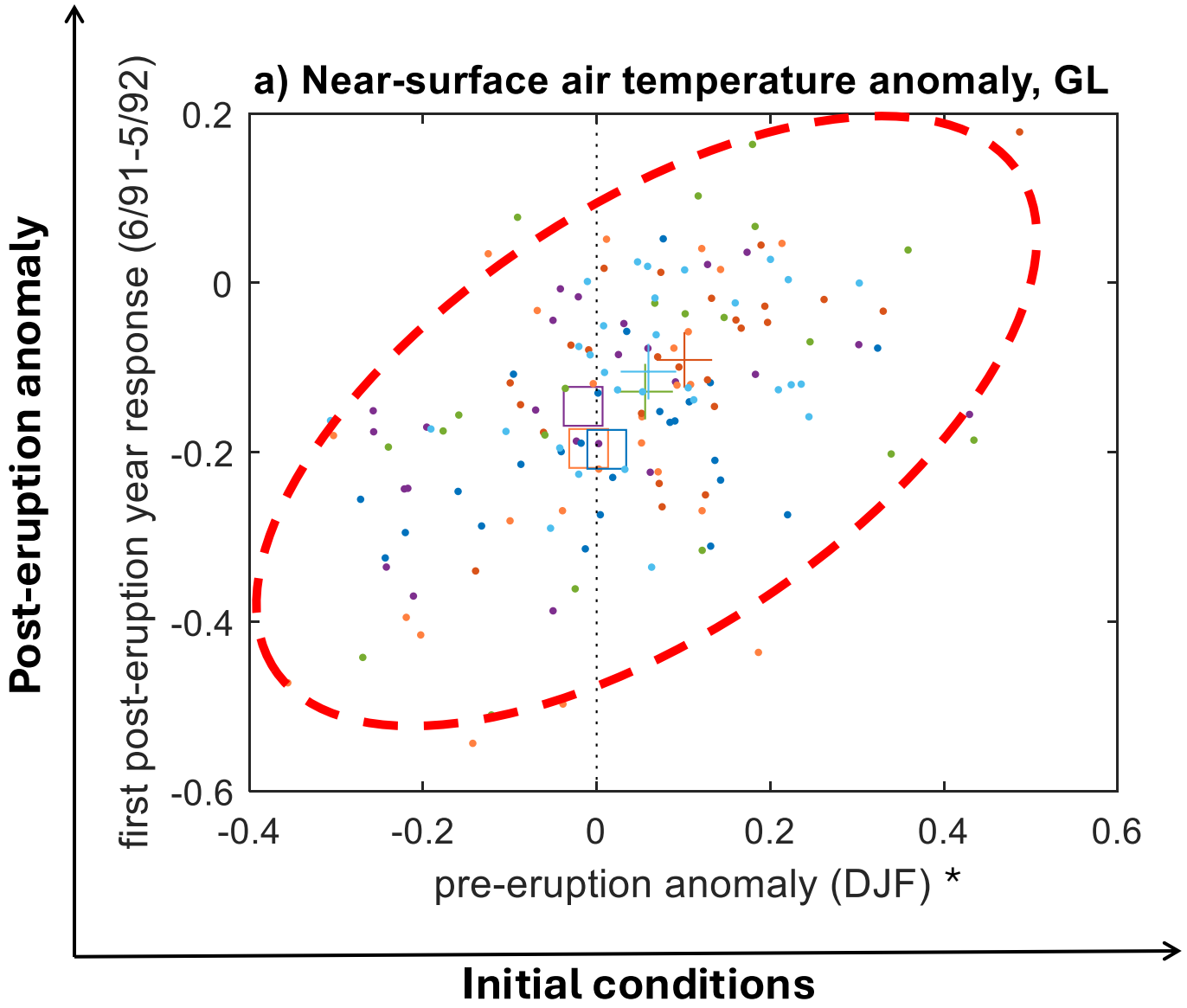
MPI-ESM-LR volmip
MPI-ESM1-2-LR hist-volc

GISS-E2.1-G volmip
GISS-E2-1-G hist-volc

GL: global; **TR**: tropics (30S-30N)
Squares at bottom: volmip significantly different from hist-volc

Author: Davide Zanchettin

VolMIP vs hist-volc



Ensemble means:

□ volc-pinatubo

\+ hist-volc

dots: individual realizations

CanESM5 volmip
CanESM5 hist-volc

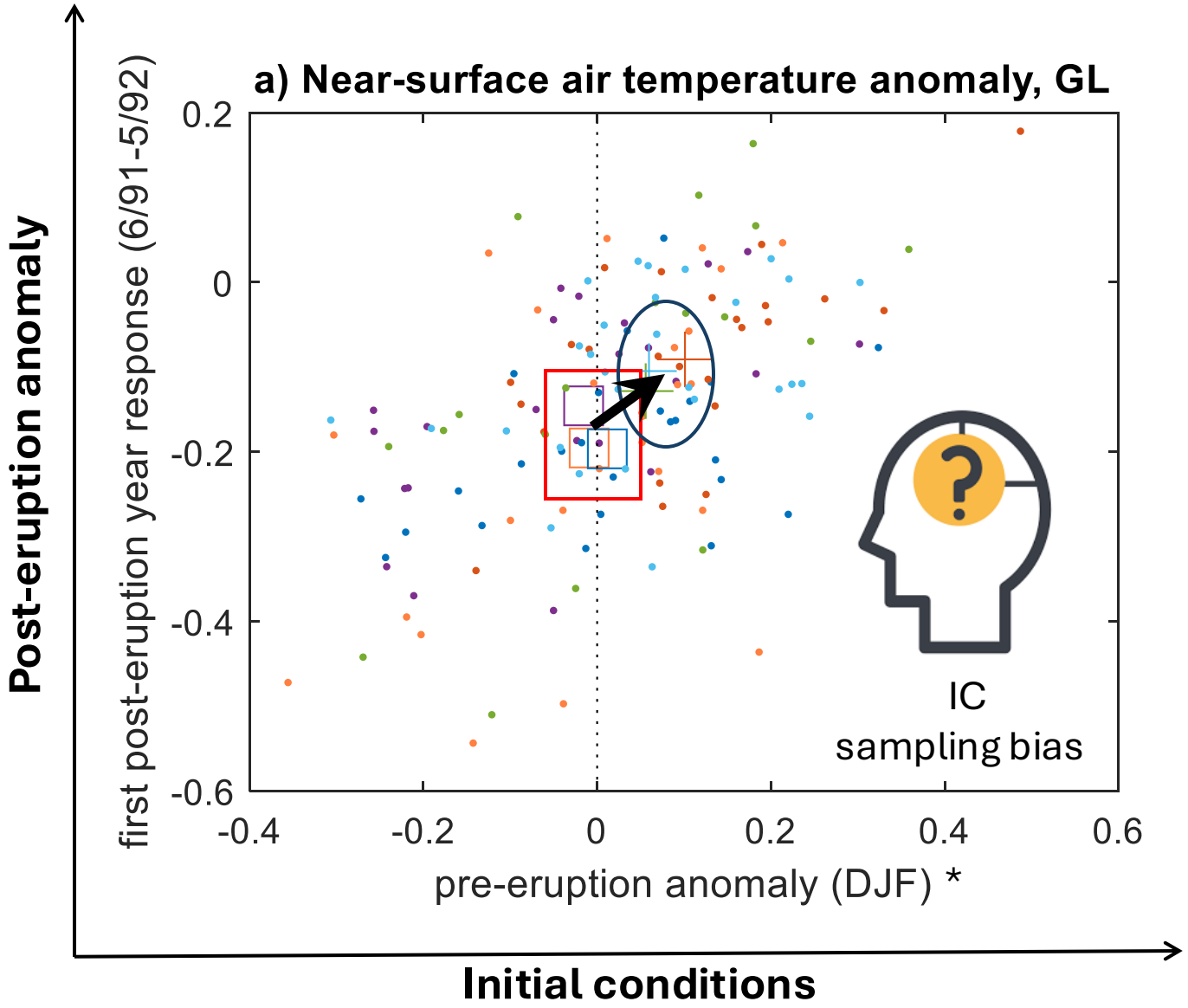
MPI-ESM-LR volmip
MPI-ESM1-2-LR hist-volc

GISS-E2.1-G volmip
GISS-E2-1-G hist-volc

*wrt 1986-1990 mean

Author: Davide Zanchettin

VolMIP vs hist-volc



Ensemble means:

volc-pinatubo

hist-volc

dots: individual realizations

CanESM5 volmip
CanESM5 hist-volc

MPI-ESM-LR volmip
MPI-ESM1-2-LR hist-volc

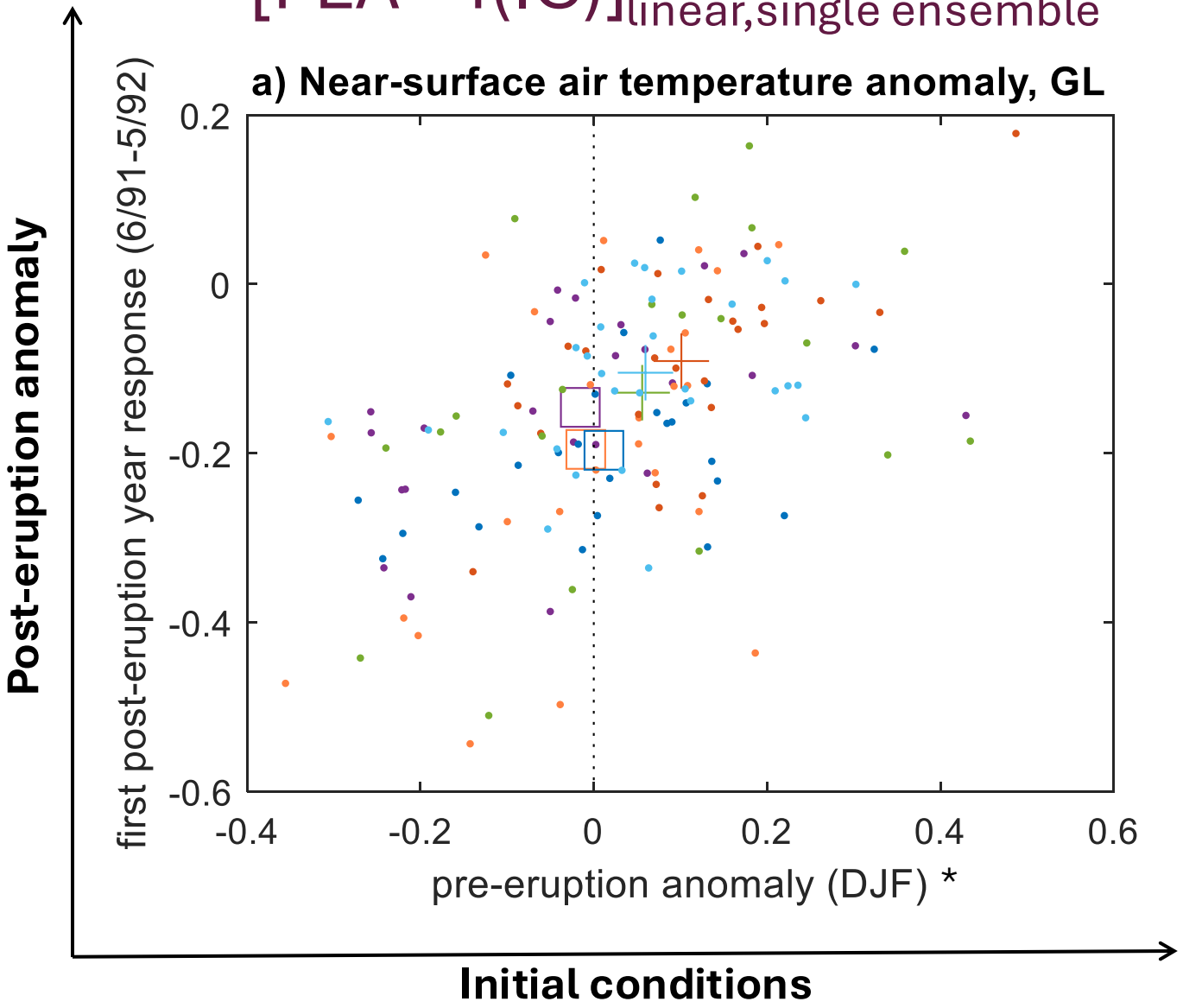
GISS-E2.1-G volmip
GISS-E2-1-G hist-volc

*wrt 1986-1990 mean

Author: Davide Zanchettin

VolMIP vs hist-volc

$[PEA = f(IC)]_{linear,single\ ensemble}$



Ensemble means:

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GISS-E2.1-G volmip
GISS-E2-1-G hist-volc

*wrt 1986-1990 mean

Author: Davide Zanchettin

VolMIP vs hist-volc

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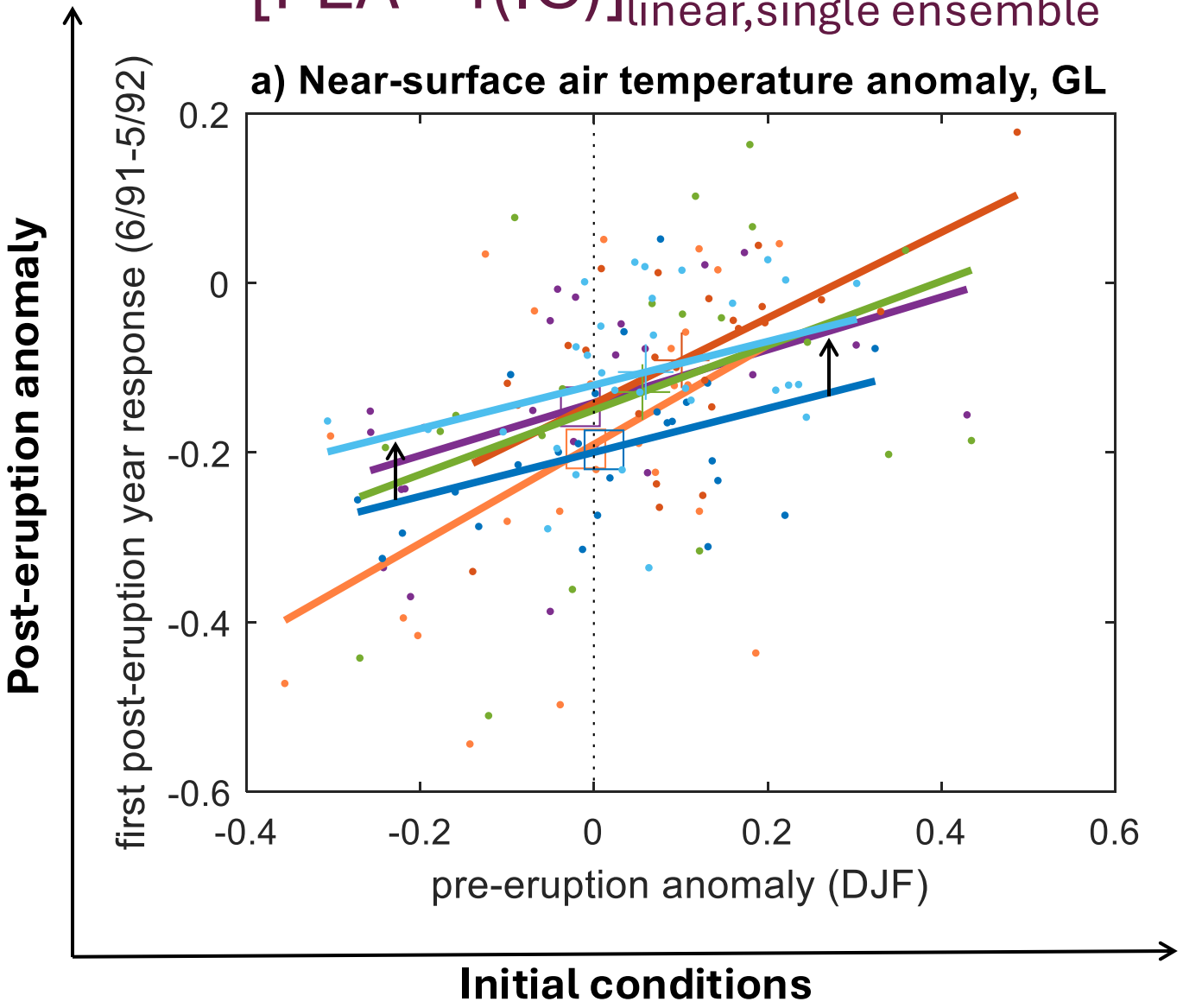

Ensemble means:

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CanESM5 volmip
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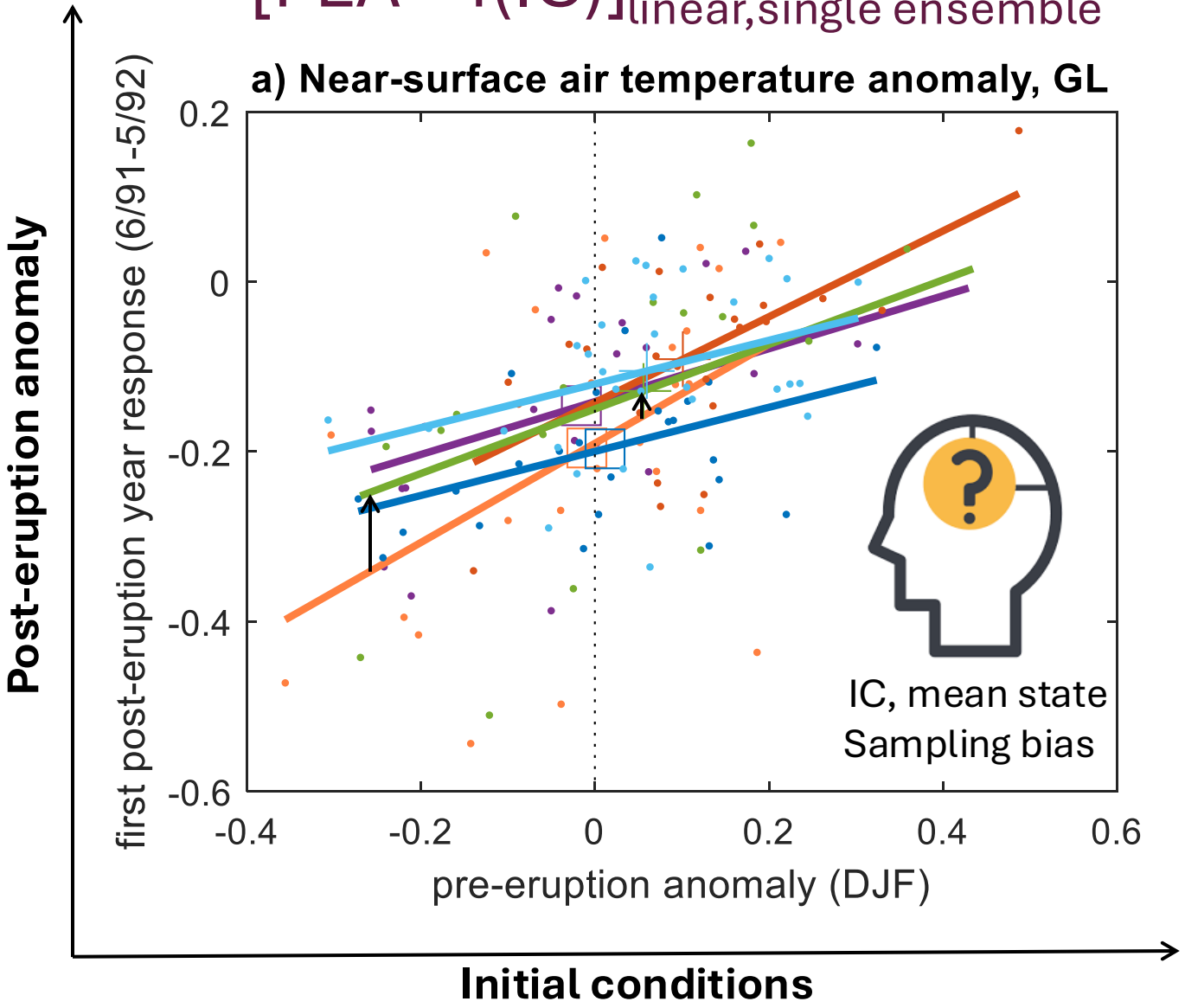
GISS-E2.1-G volmip
GISS-E2-1-G hist-volc

Author: Davide Zanchettin

VolMIP vs hist-volc

$[PEA = f(IC)]_{linear,single\ ensemble}$



Ensemble means:

□ volc-pinatubo

\+ hist-volc

dots: individual realizations

CanESM5 volmip
CanESM5 hist-volc

MPI-ESM-LR volmip
MPI-ESM1-2-LR hist-volc

GISS-E2.1-G volmip
GISS-E2-1-G hist-volc

Author: Davide Zanchettin


AT THIS POINT, I
WOULD SAY AT
BEST IT'S
INCONCLUSIVE.

Community paper (lead: Davide, Stergios)

Focus on:
- Agung/Agung vs Pinatubo response
- volc-hist vs VolMIP

Proposed work (EPESC/LEADER output) (*in progress?*)

- Response to high-latitude eruptions (lead: Hera Guðlaugsdóttir)
- Forcing uncertainty vs internal variability (lead: Ewa Bednarz)
- Solar + volcanic forcing (lead: Stergios)
- Indian summer monsoon (lead: Stergios)
- Energy balance, 2-layer model (lead: Matt Toohey)
- AMOC response/phasing (lead: Davide)

Proposed work (possible EPESC/LEADER extension)

CMIP7-VolMIP "volc-Duo-Forcer" (*volc-DuoForc*) climate-response experiment (lead: Graham Mann)

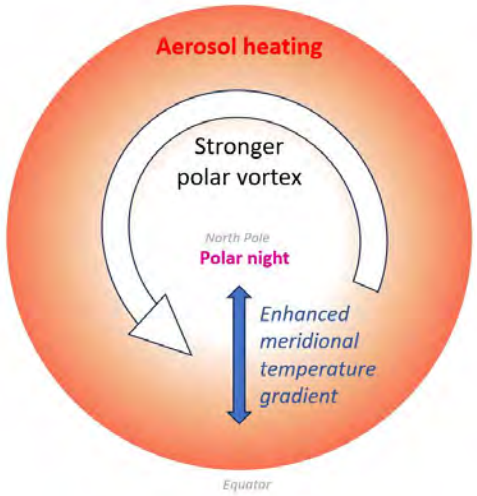
→ scaled-up Hunga-Tonga sWV & aerosol (5x)→ test how strong long-wave and short-wave volcanic forcings combine and compensate)

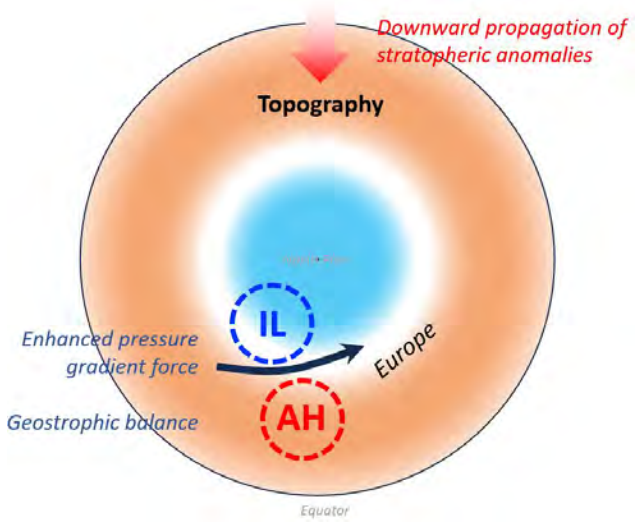
→ volc-pinatubo-full (VolMIP) design: Can we extend this under LESFMIP approach?

Thank you for your attention!

Dynamical responses (post-eruption winter warming)

Top-down mechanism(s)

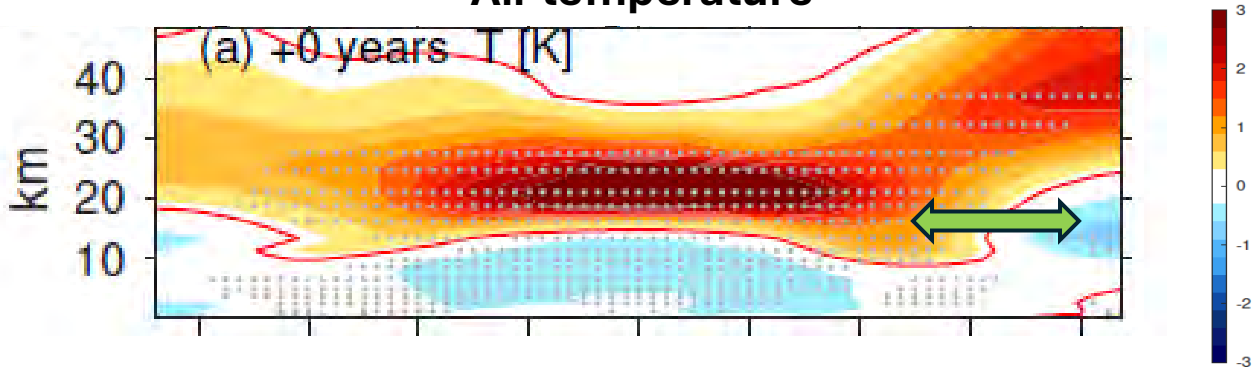




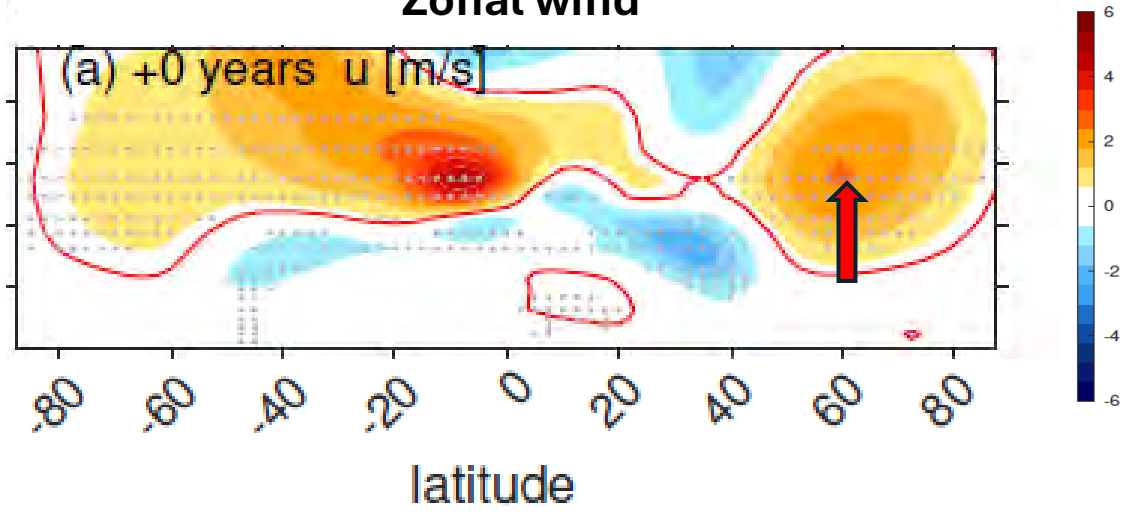
Pinatubo

1992 minus (1986-1990), DJF, ensemble mean

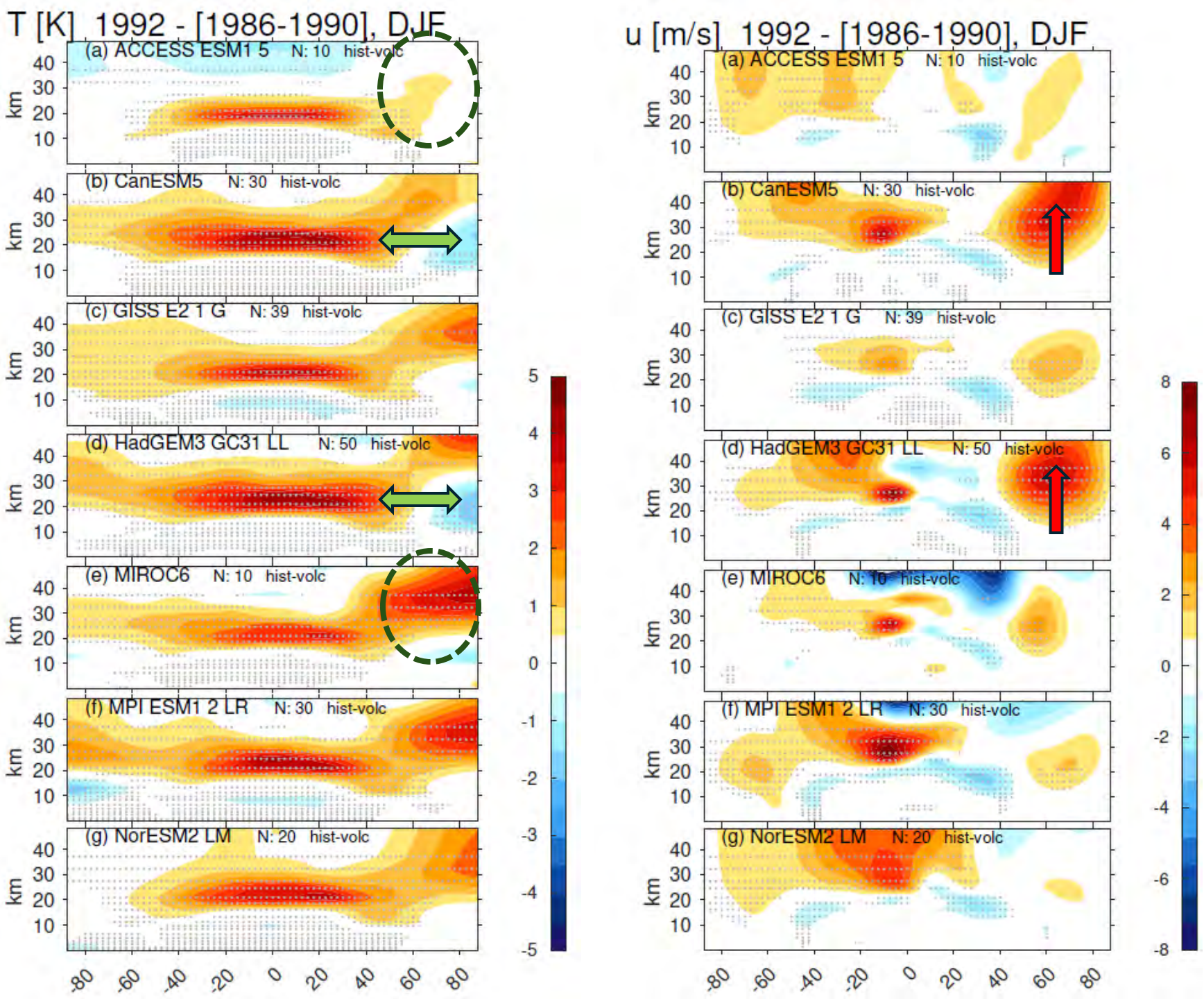
Air temperature



Zonal wind



Authors: Chaim Garfinkel, David Avisar

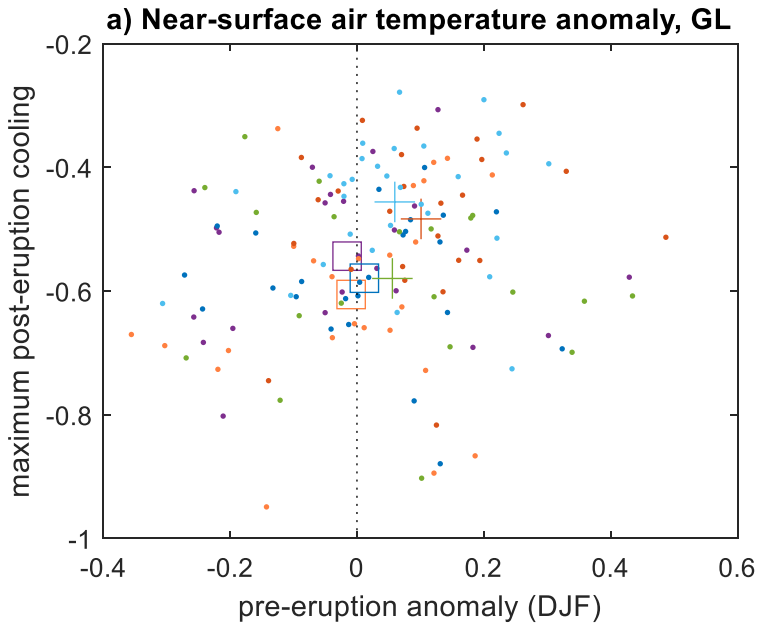


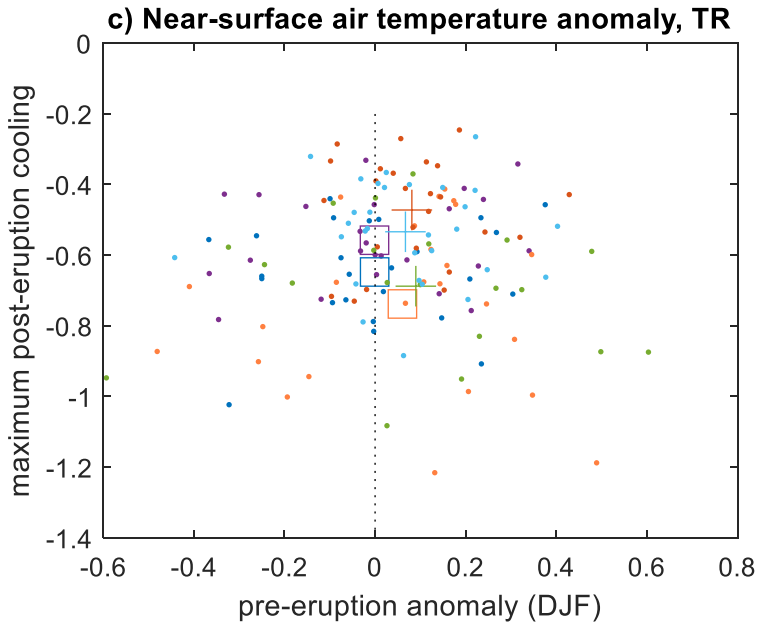
Large differences in high-latitude stratospheric warming

Authors: Chaim Garfinkel, David Avisar

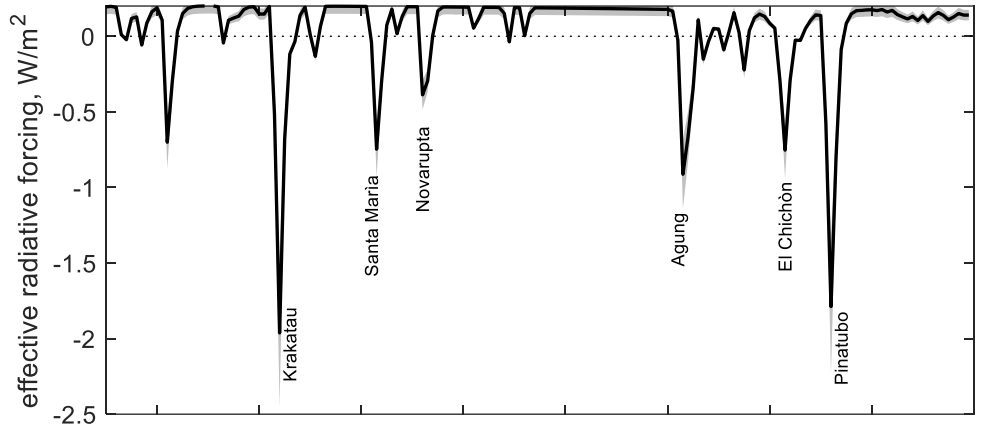
volc-pinatubo

hist-volc



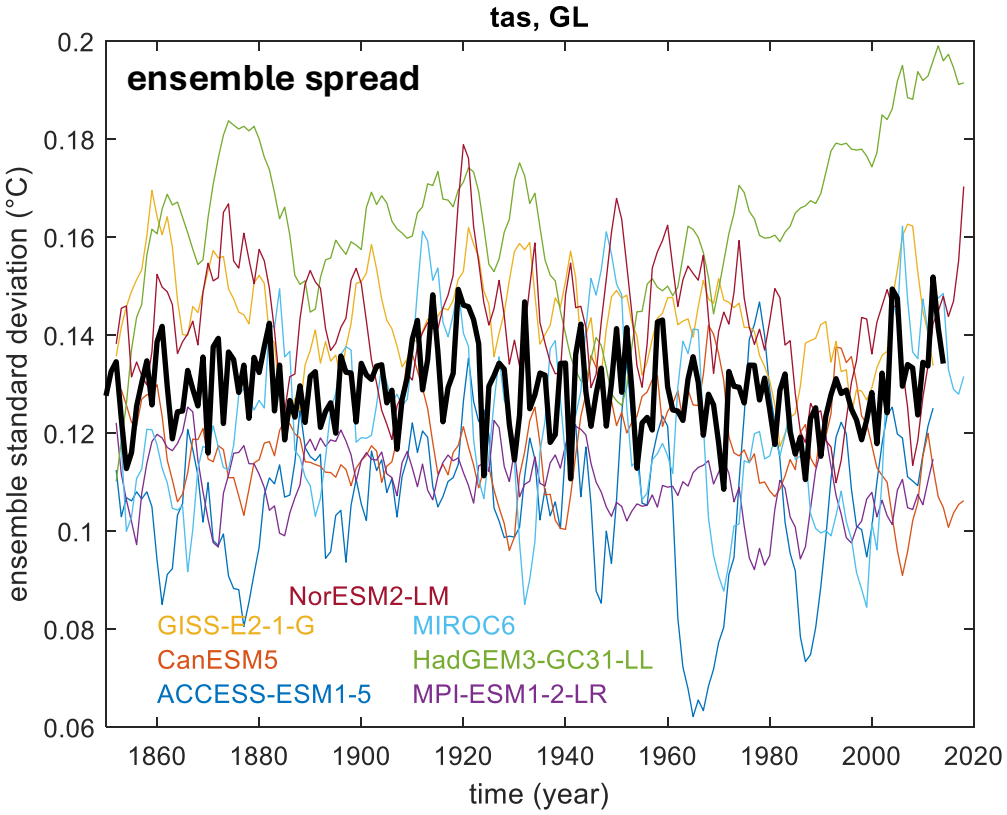


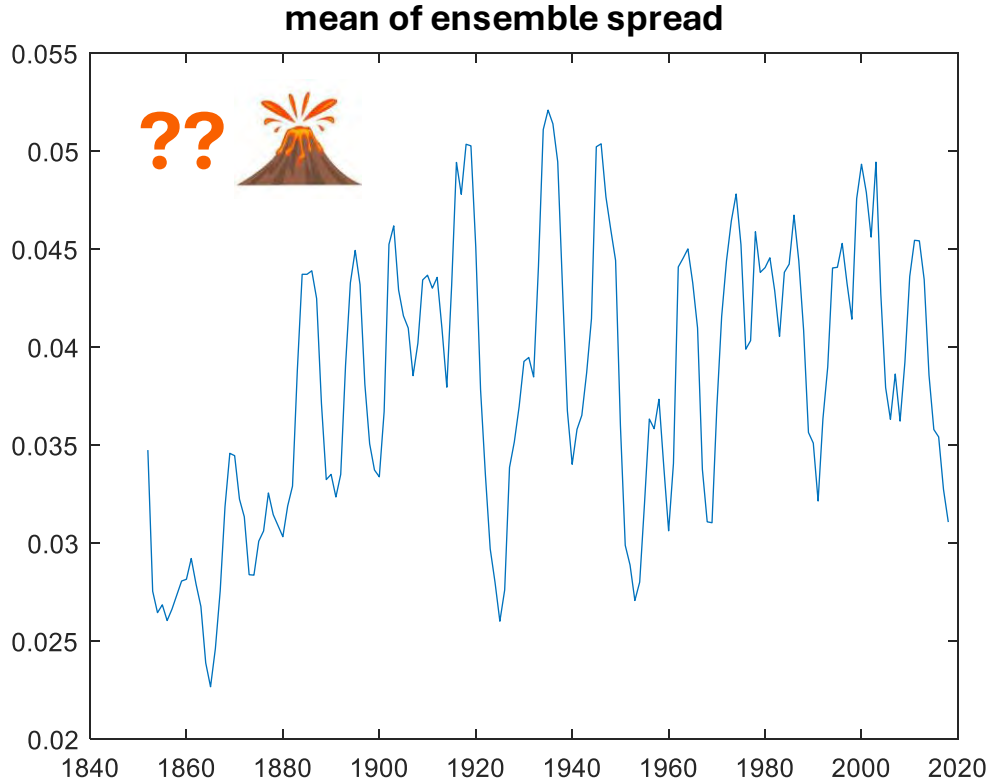
Author: Davide Zanchettin



Global mean near-surface air temperature (tas, GL)

Inconsistent volcanic effect on phasing of climatic modes (?)





Author: Davide Zanchettin