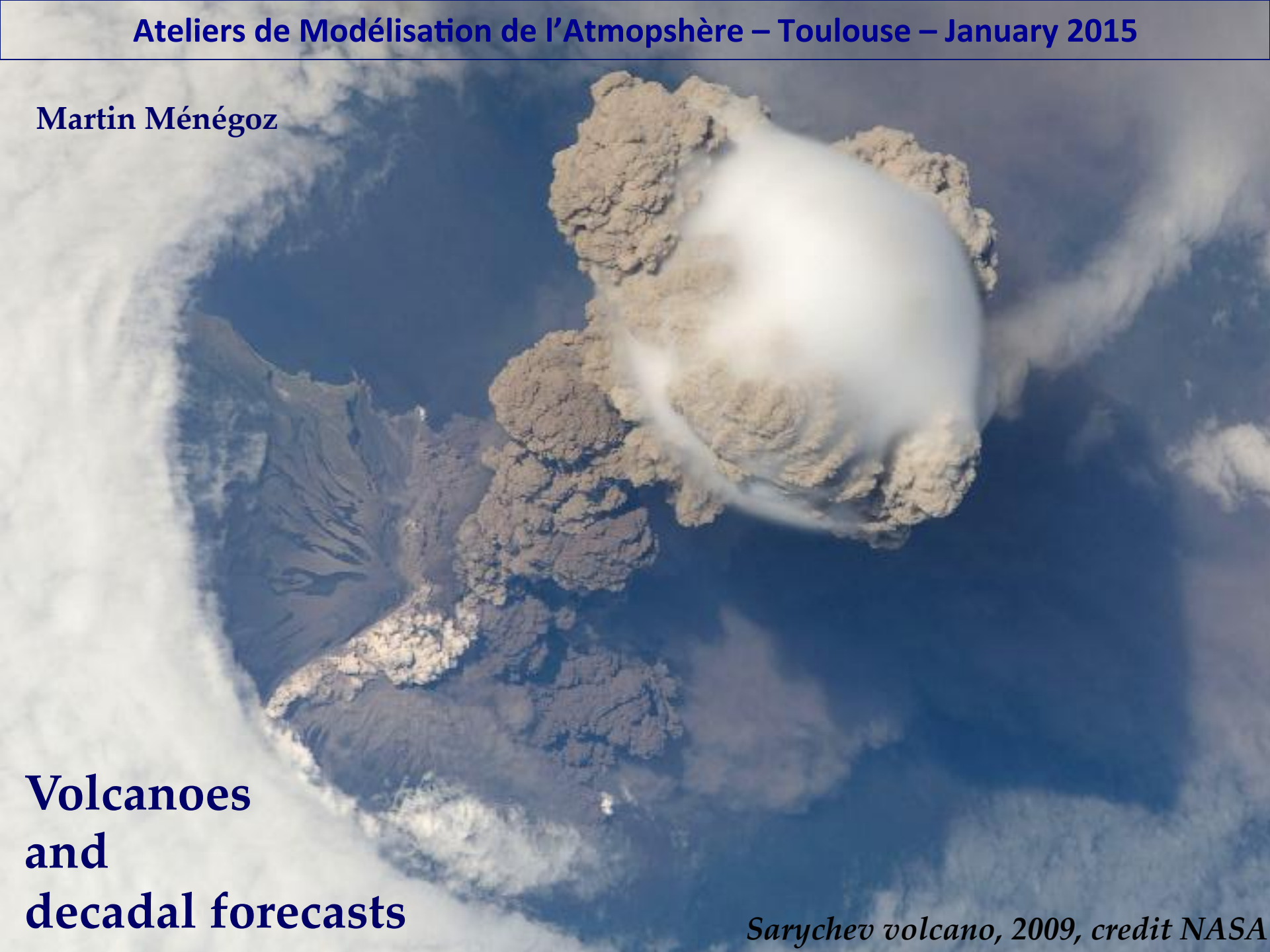


Martin Ménégoz



**Volcanoes  
and  
decadal forecasts**

*Sarychev volcano, 2009, credit NASA*



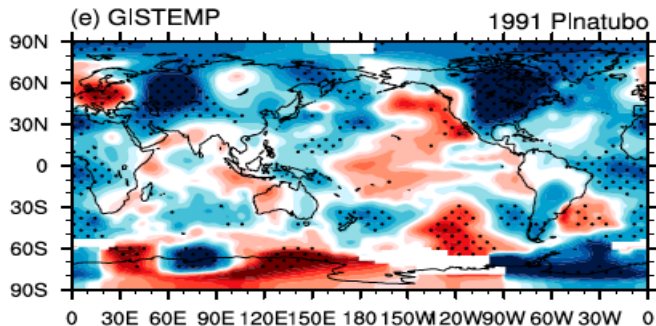
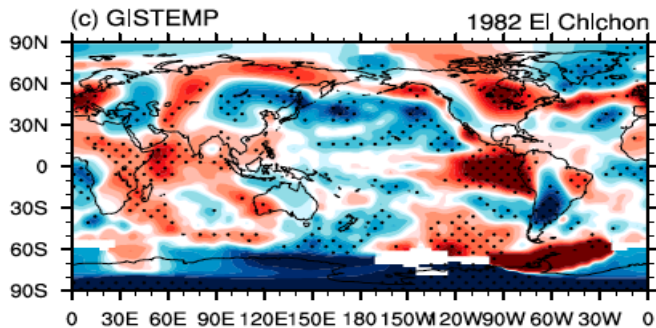
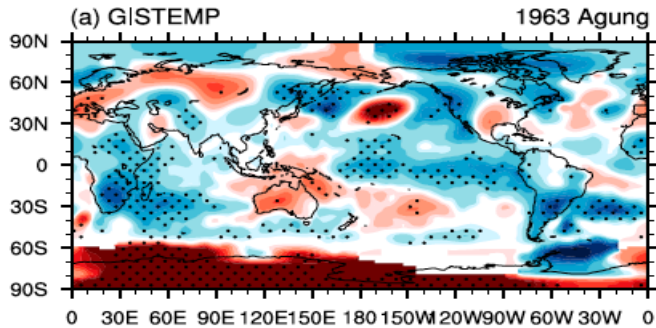
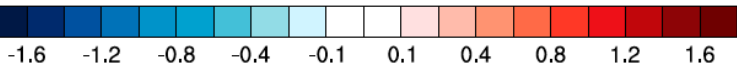
## **Climate response to volcanoes**

---

- Major eruptions bring large amounts (Tg) of particles in the stratosphere.
- Last large eruptions: Agung (1963), El Chichon (1982) and El Pinatubo (1991).
- Global temperature decrease of 0.1-0.3°C, atmospheric impacts noticeable during 5 years, and potential effects on ocean circulation during 10-20 years.
- Summer cooling, winter warming (?) in some parts of the NH.

## Climate response to volcanoes

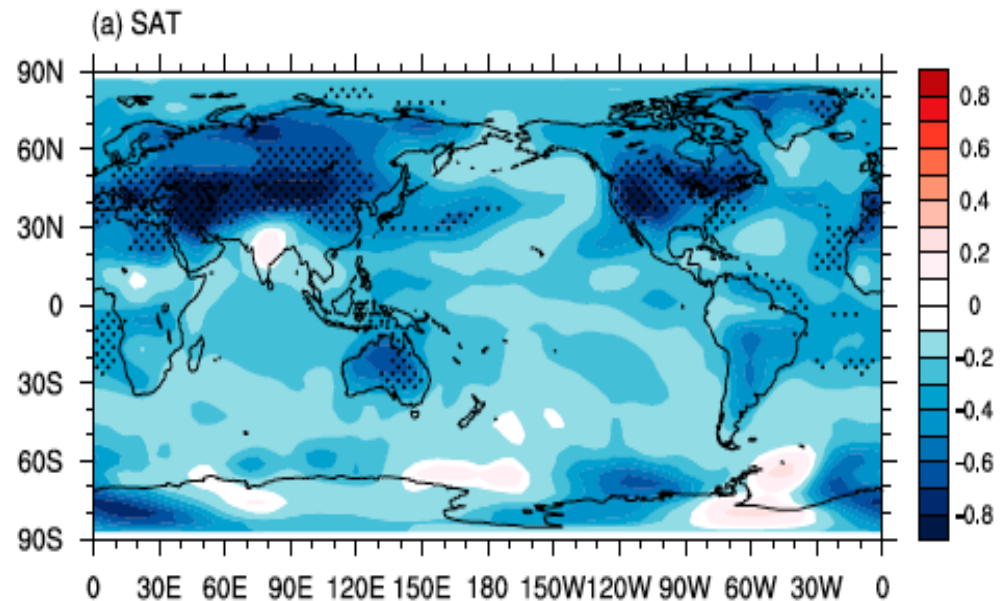
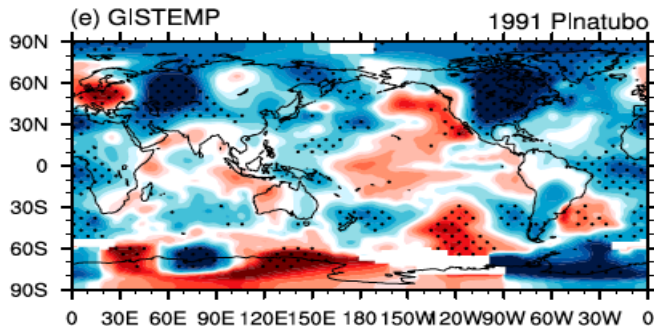
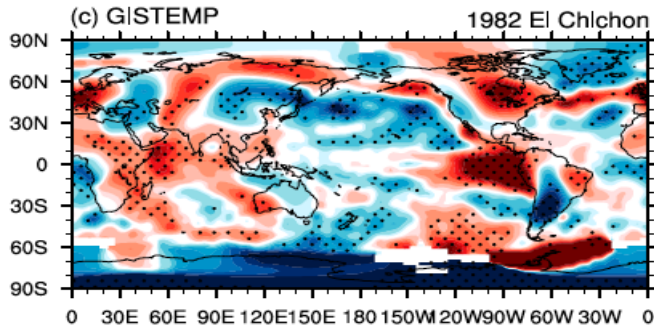
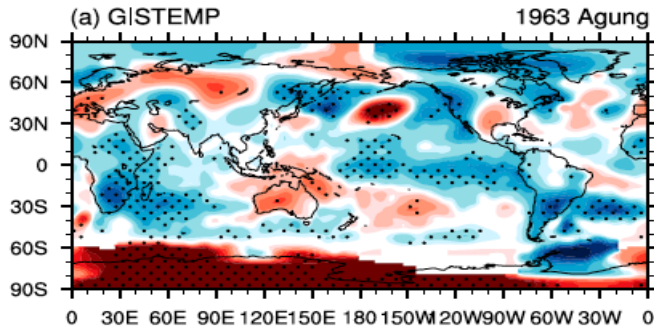
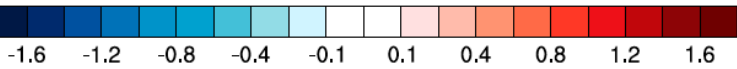
→ High climate natural variability can overwhelm the volcanic signal



*Surface temperature anomalies (°C) the first summer after eruptions (Man et al., 2014).*

## Climate response to volcanoes

→ High climate natural variability can overwhelm the volcanic signal



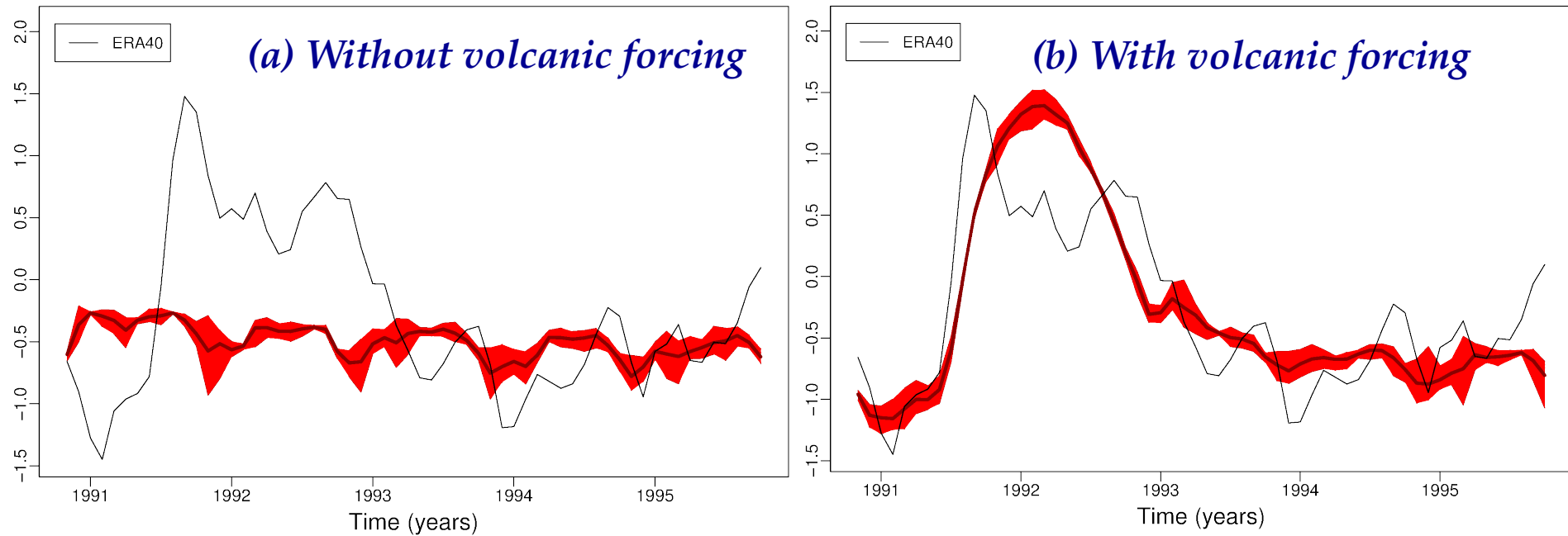
*Composite of the surface temperature the first summer after the 21 major eruptions simulated over the last 1000 years (Man et al., 2014).*

*Surface temperature anomalies ( $^{\circ}\text{C}$ ) the first summer after eruptions (Man et al., 2014).*



## EC-Earth experiments

- CMIP5 Decadal hindcasts
- Decadal hindcasts, years with eruptions without volcanic forcing



*Stratospheric temperature anomaly after Pinatubo eruption in EC-Earth simulations*

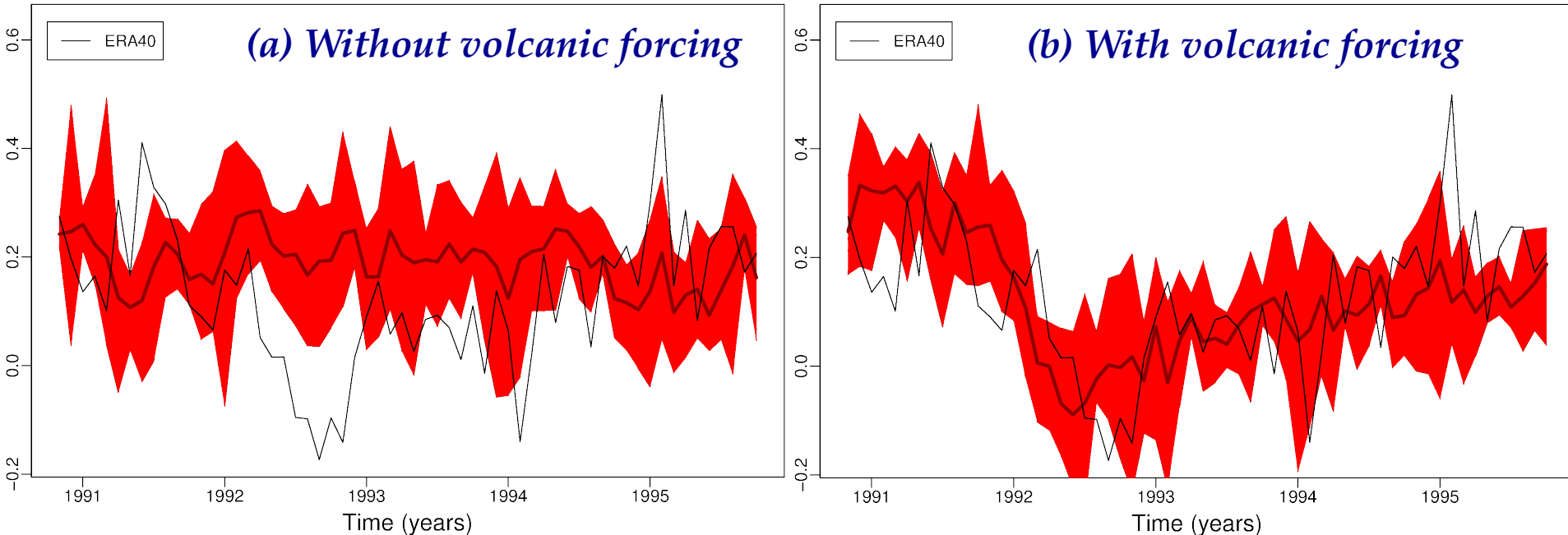


## EC-Earth experiments

---

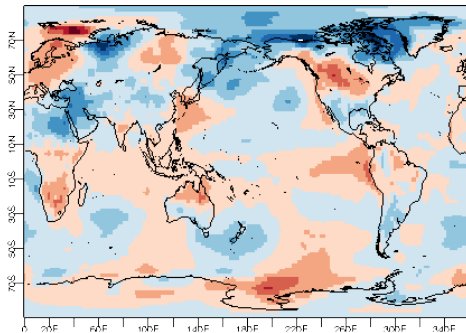
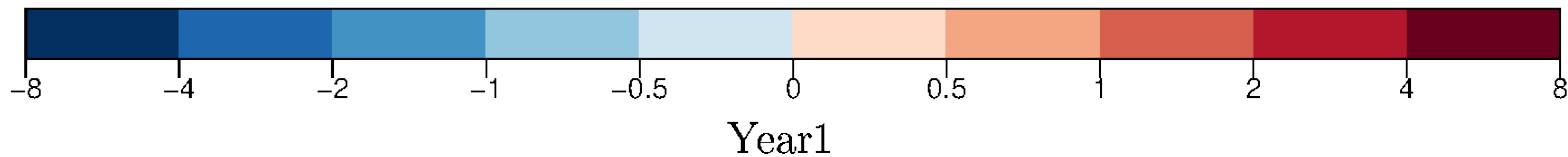
→ CMIP5 Decadal hindcasts

→ Decadal hindcasts, years with eruptions without volcanic forcing

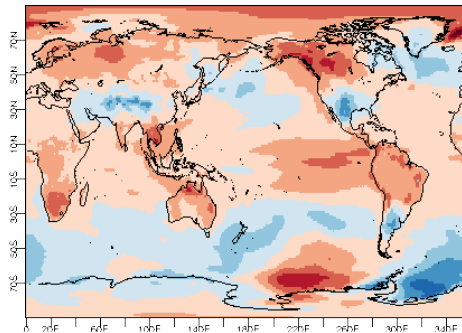


*Tropospheric temperature anomaly after Pinatubo eruption in EC-Earth simulations*

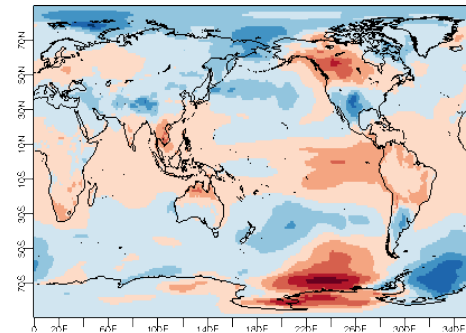
## Modelled climate response to volcanoes: temperature anomalies (°C)



obs

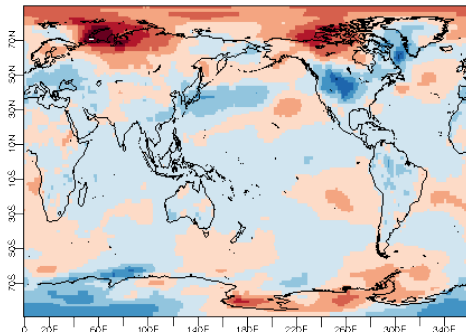


only initialization

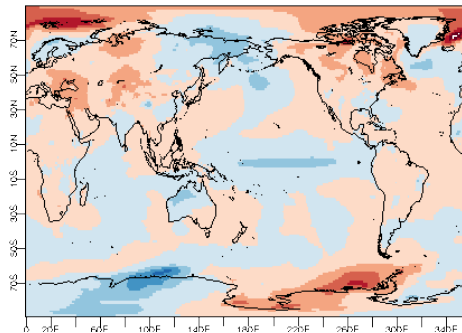


initialisation and volcanoes forcing

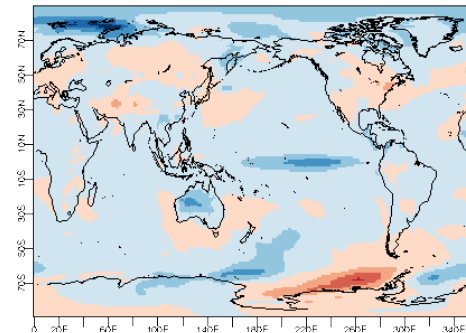
Year2



obs



only initialization

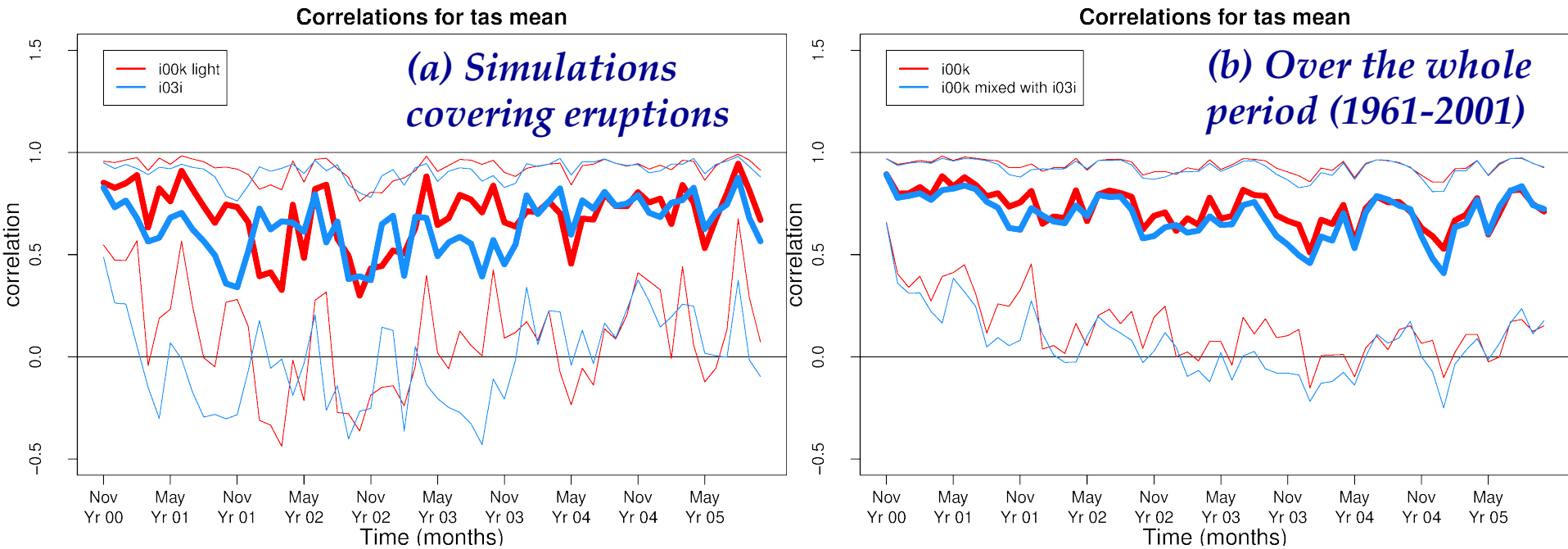


initialisation and volcanoes forcing

→ 1 observation versus (5 members x 3 startdates = 15) simulations

→ Volcanic signal => significant cooling, but partly masked by ENSO !

# Skills



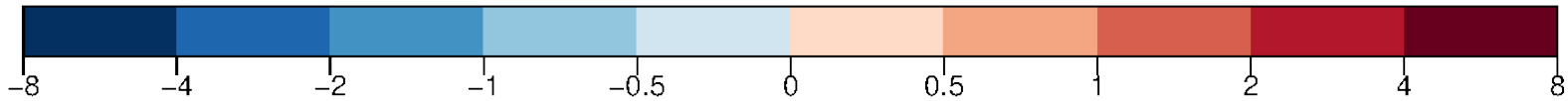
**Without volcanoes**

**With volcanoes**

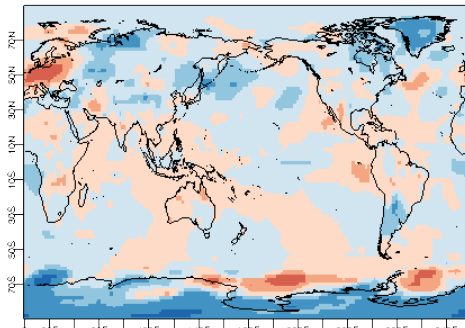
- Increase of TAS correlation when adding volcanic forcing for years 1 and 3
- Limited skill increase when computing it over all the startdates (1961-2001)



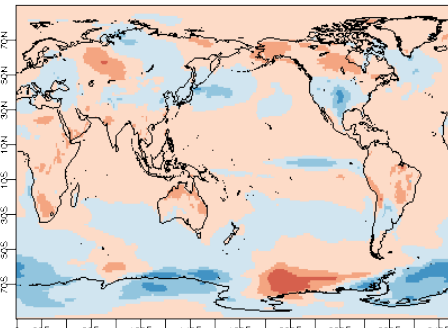
## Modelled climate response to volcanoes: surface temperature (°C)



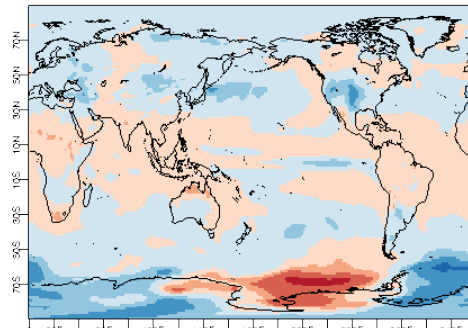
*JJA 1*



obs

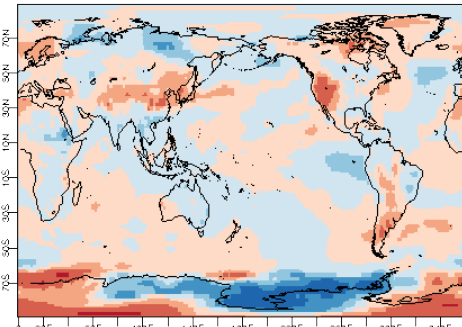


only initialization

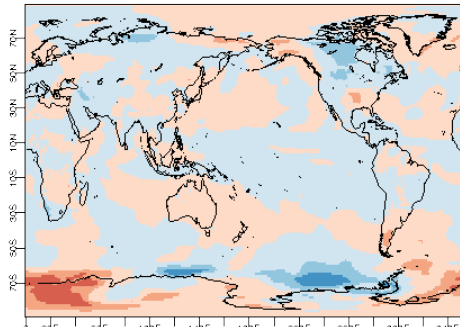


initialisation and volcanoes forcing

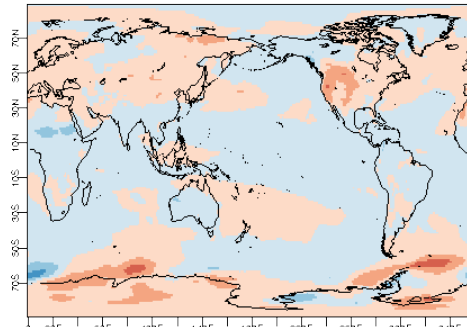
*JJA 3*



obs



only initialization



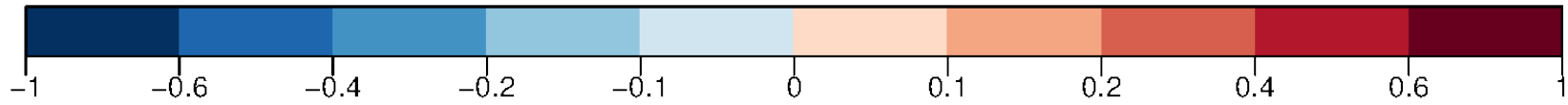
initialisation and volcanoes forcing

→ General cooling better simulated with volcanic forcing during JJA 1

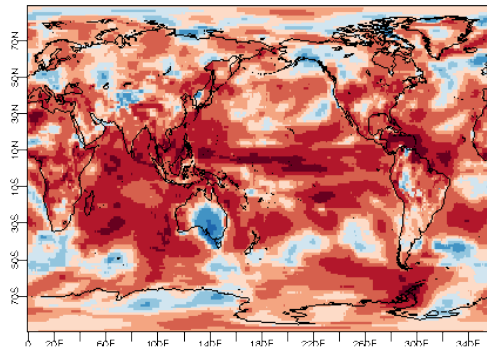
→ Warming in some NH continental areas with volcanic forcing during JJA 3



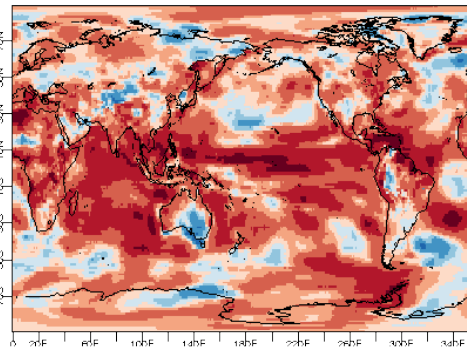
# Skills for surface temperature



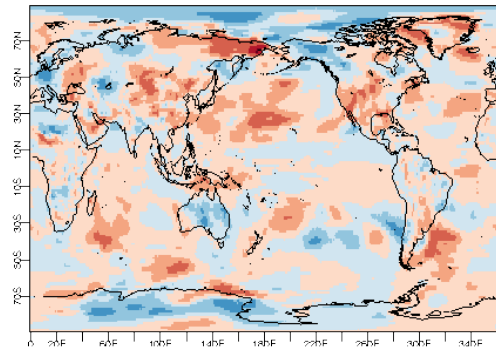
*JJA 1*



all forcings

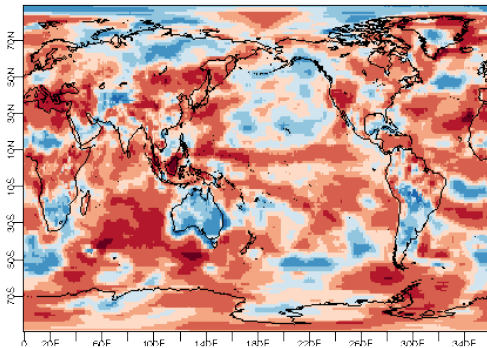


without volcanoes

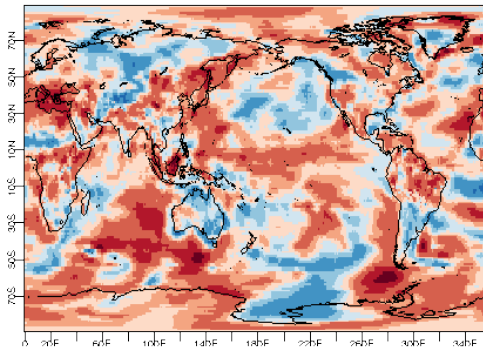


additional cor with volcanoes

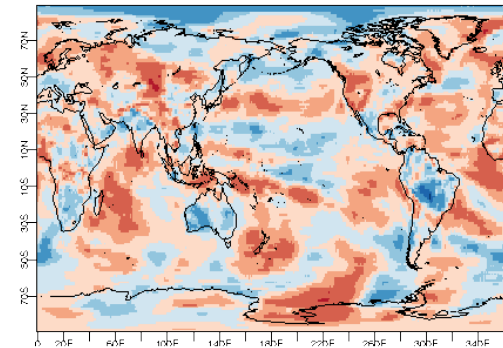
*JJA 3*



all forcings



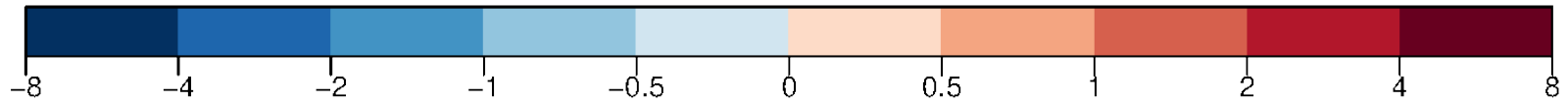
without volcanoes



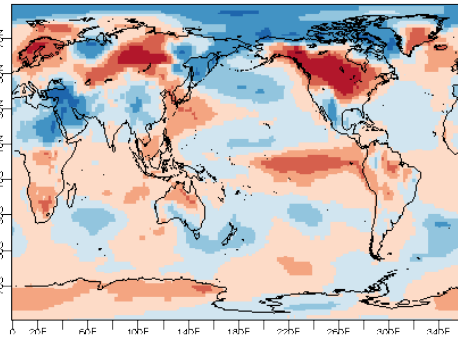
additional cor with volcanoes

→ General increase of correlation during JJA, significant but noisy

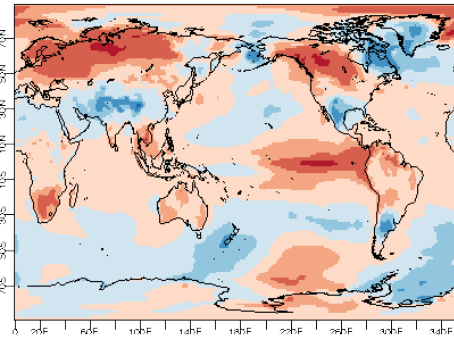
# Modelled climate response to volcanoes (surface temperature anomalies °C)



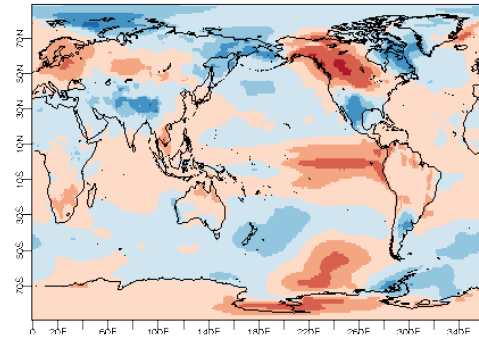
*DJF 1*



obs

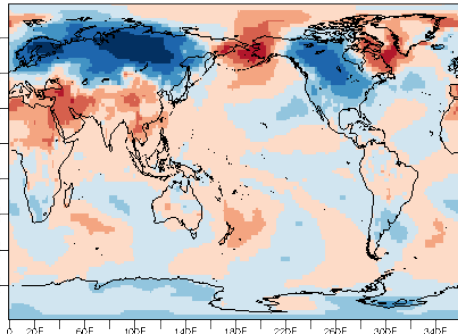


only initialization

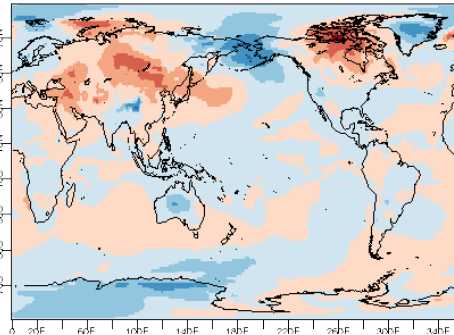


initialisation and volcanoes forcing

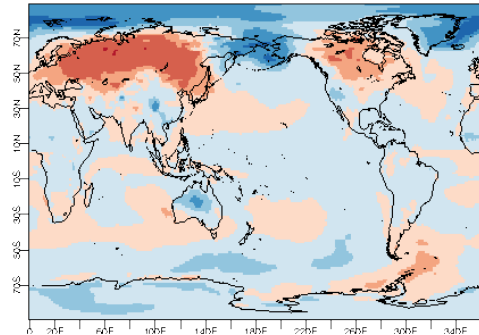
*DJF 3*



obs



only initialization



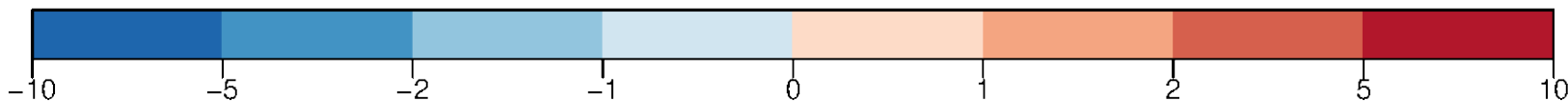
initialisation and volcanoes forcing

→ General cooling better simulated with volcanic forcing in NH winter 1

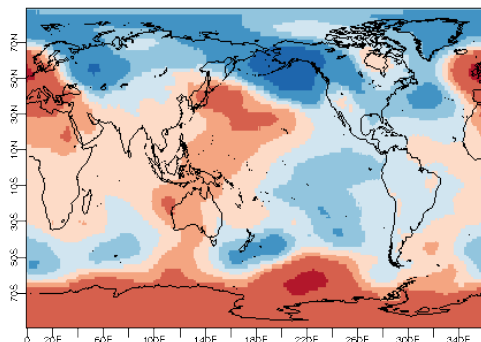
→ Potential winter dynamical response in NH?



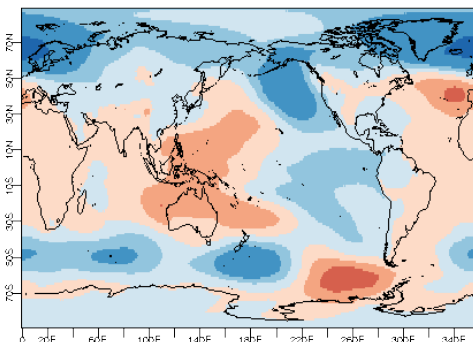
# Modelled climate response to volcanoes (Sea level pressure anomalies hPa)



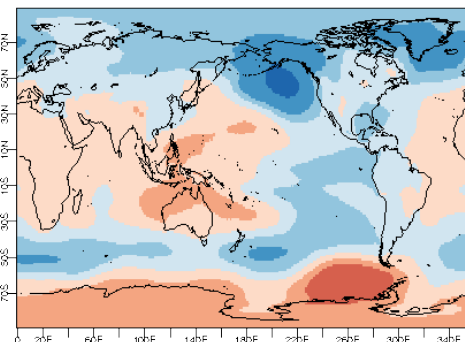
DJF 1



obs

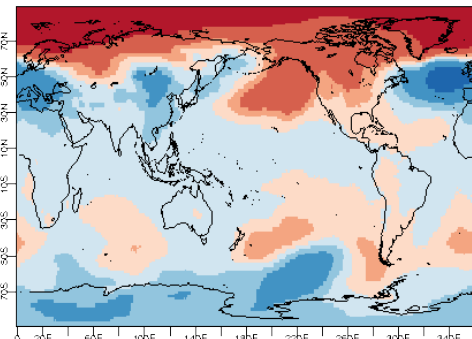


only initialization

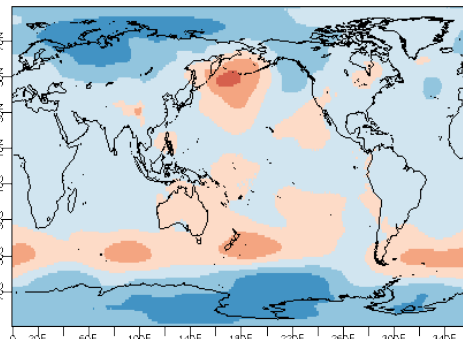


initialisation and volcanoes forcing

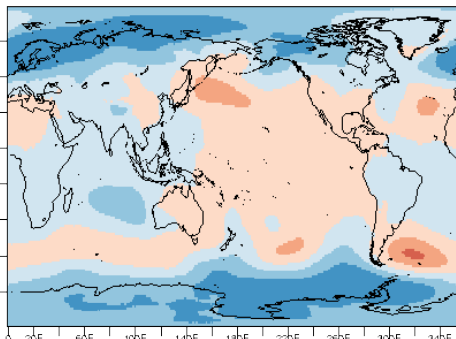
DJF 3



obs



only initialization



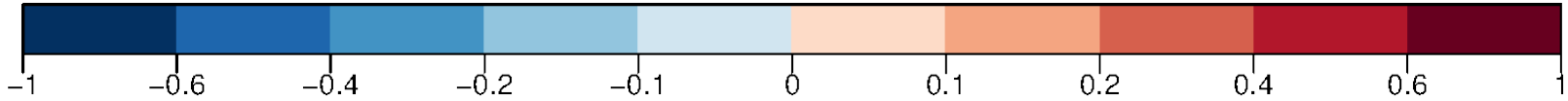
initialisation and volcanoes forcing

→ SLP increase in SH better simulated with volcanic forcing during DJF 1

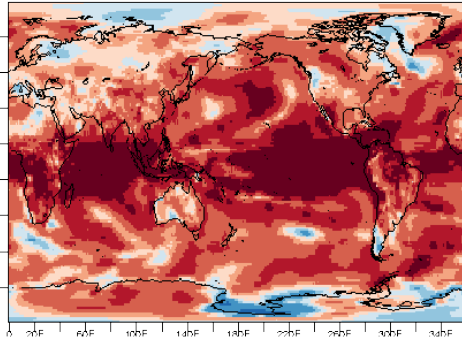
→ Potential winter dynamical response in NH difficult to catch with models



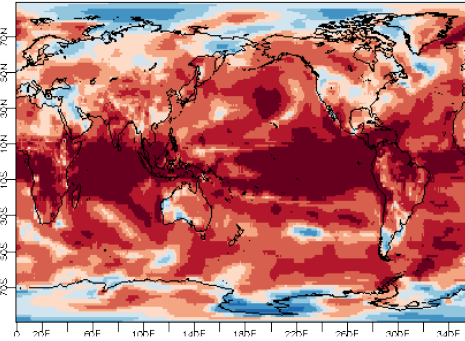
# Skills for surface temperature



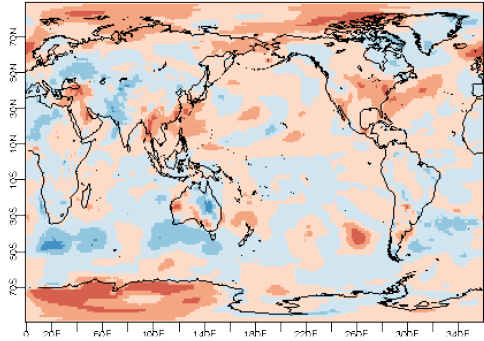
*DJF 1*



all forcings

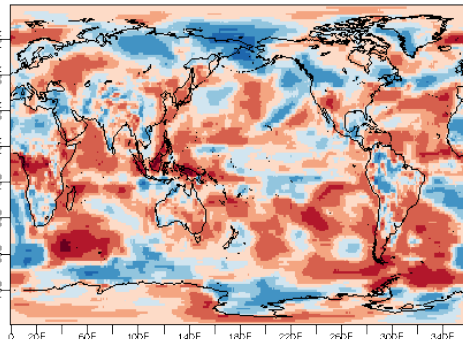


without volcanoes

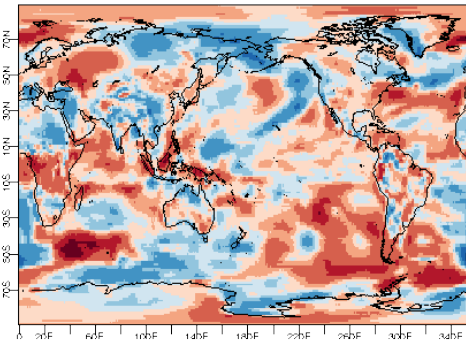


additional cor with volcanoes

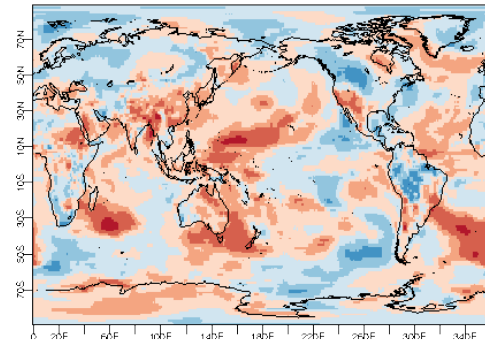
*DJF 3*



all forcings



without volcanoes



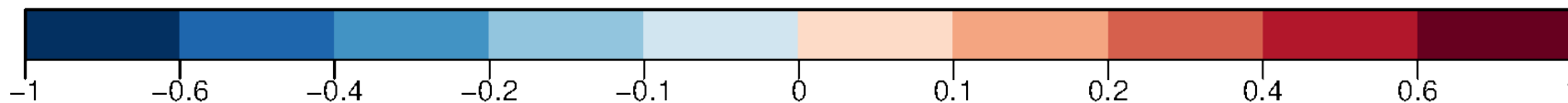
additional cor with volcanoes

→ Significant increase of correlation at high latitudes during DJF 1

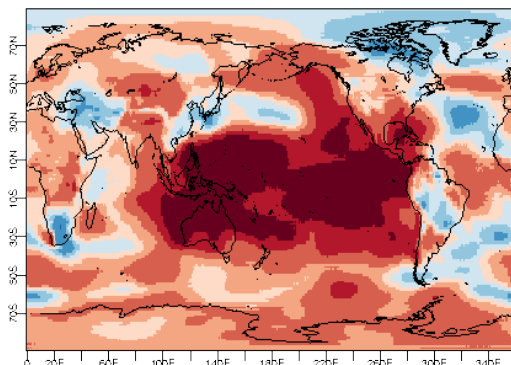
→ Skill increase in the tropics in DJF 3



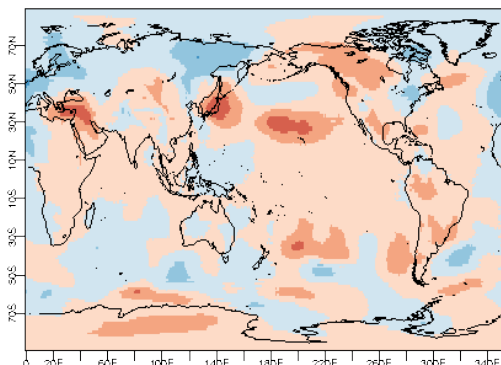
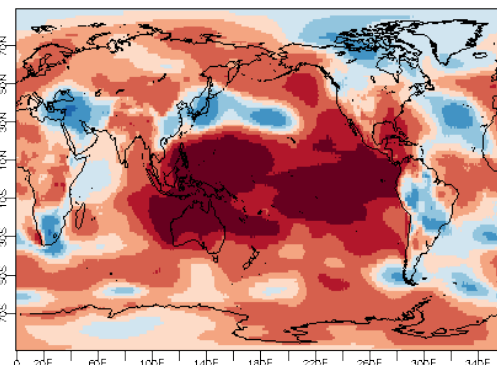
# Skills for surface pressure



*DJF 1*

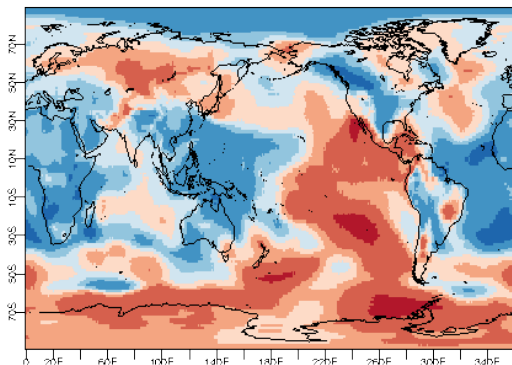


all forcings

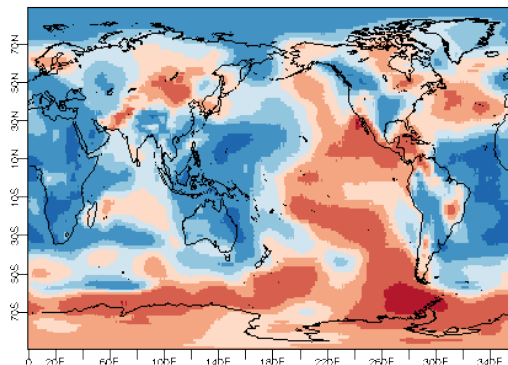


additional cor with volcanoes

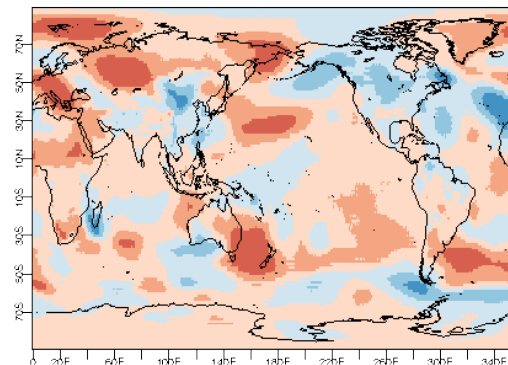
*DJF 3*



all forcings



without volcanoes



additional cor with volcanoes

→ Increase of correlation during DJF 3, more pronounced than for DJF 1, and especially marked for middle to high latitudes



## Conclusions

---

- Increase of skills related to volcanoes forcing in years 1 and 3 in EC-Earth simulations
- Increase explained by the significant general cooling of the atmosphere that follows an eruption (radiative forcing).
- It is challenging to understand the dynamical response with the limited number of observations; it is also tricky to simulate it with models.

### *Next step:*

- New experiments using idealized volcanoes forcing for real-time forecasts
- Testing stratospheric background levels changes based on recent observations

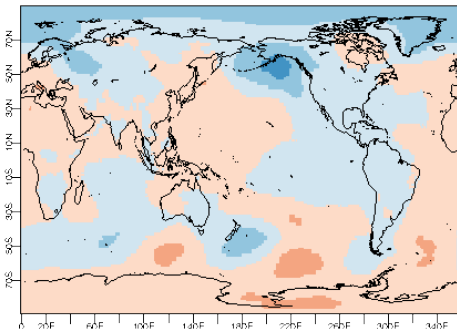
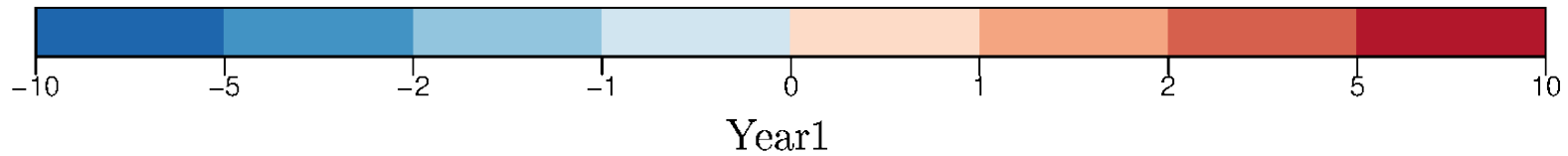
Thank you



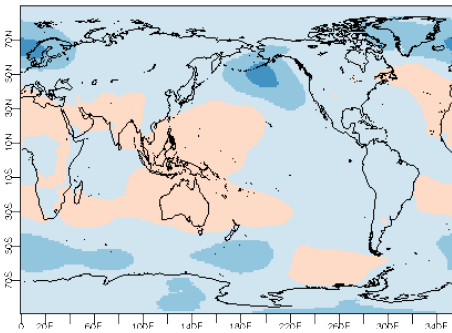




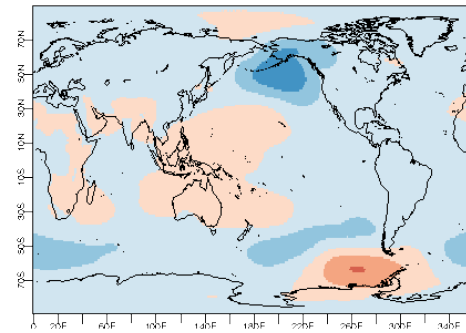
# Modelled climate response to volcanoes: pressure anomalies



obs

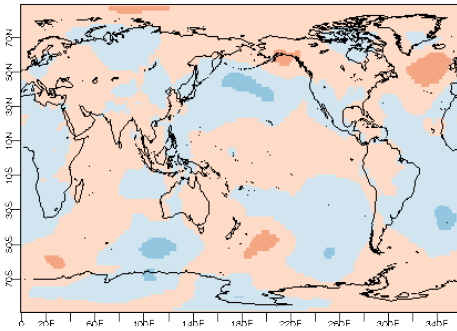


only initialization

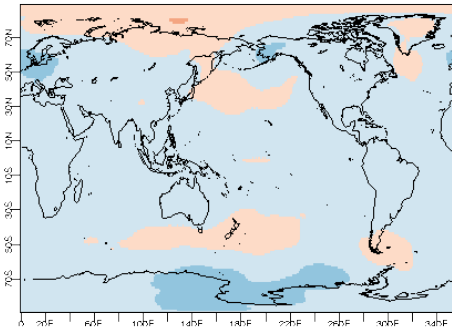


initialisation and volcanoes forcing

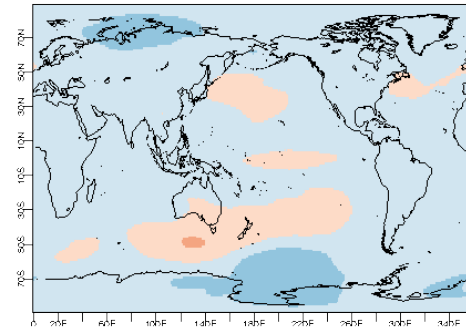
Year2



obs



only initialization

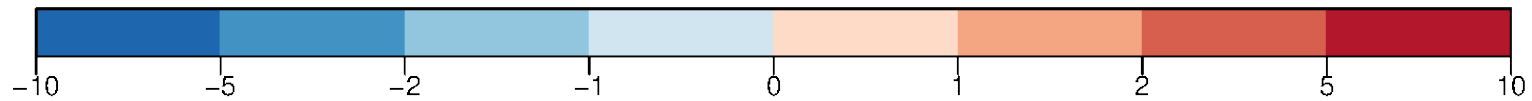


initialisation and volcanoes forcing

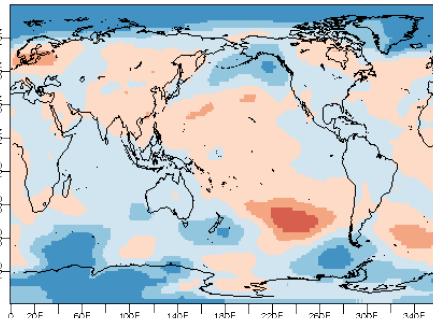
→ 1 observation versus (5 members x 3 startdates = 15) simulations

→ No significant signal of volcanoes on sea level response at yearly scale

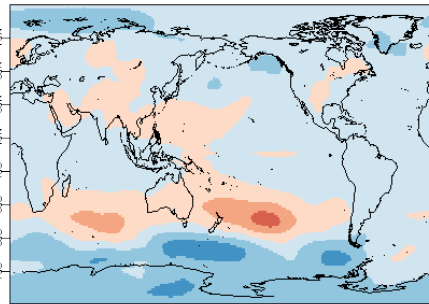
## Modelled climate response to volcanoes: sea level pressure (hPa)



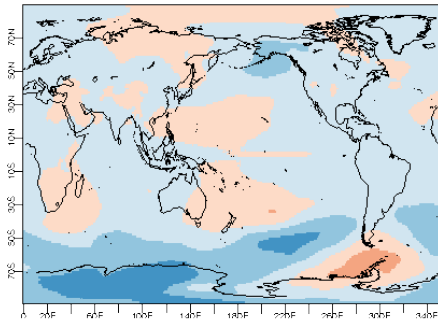
*JJA 1*



obs

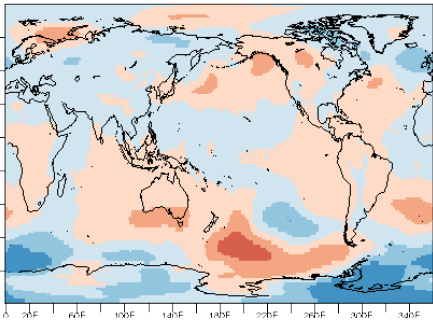


only initialization

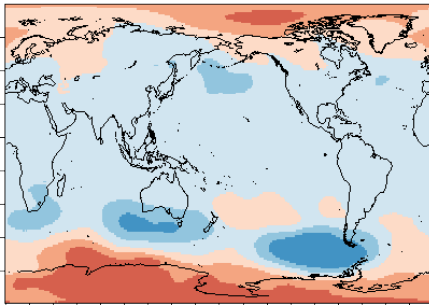


initialisation and volcanoes forcing

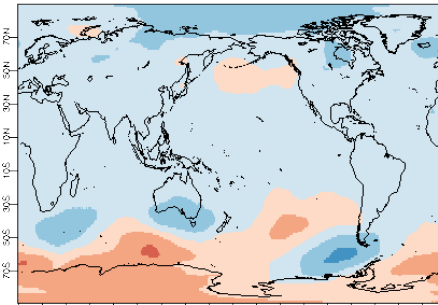
*JJA 3*



obs



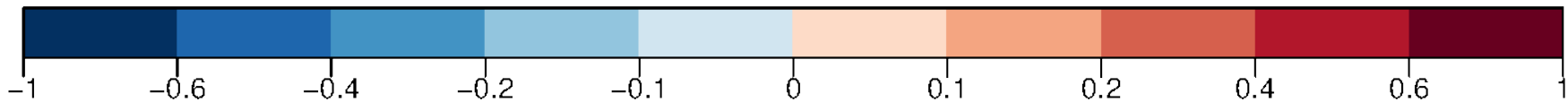
only initialization



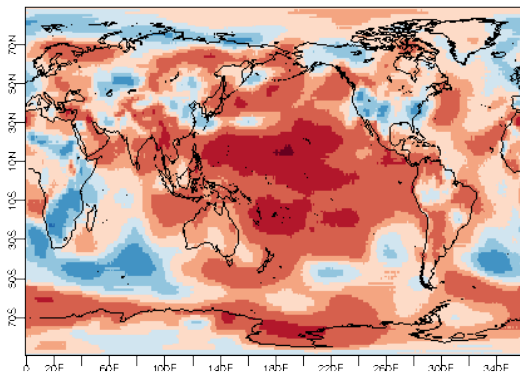
initialisation and volcanoes forcing

→ SLP response to volcanoes during austral winter ?

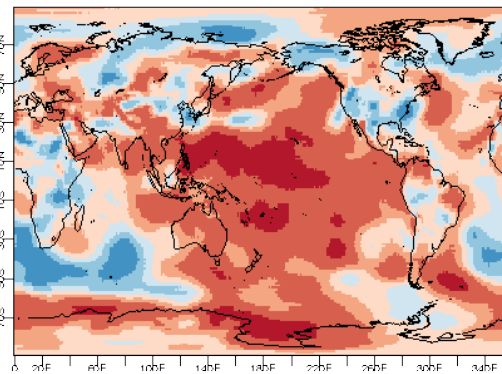
## Skills for sea level pressure



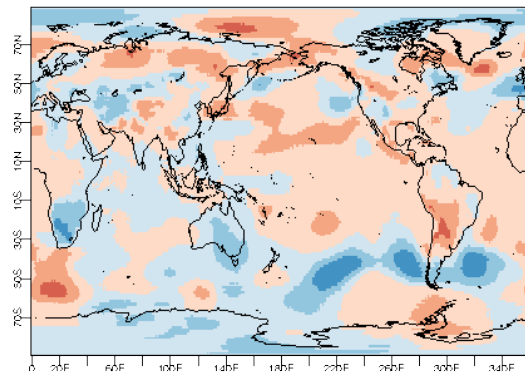
*JJA 1*



all forcings

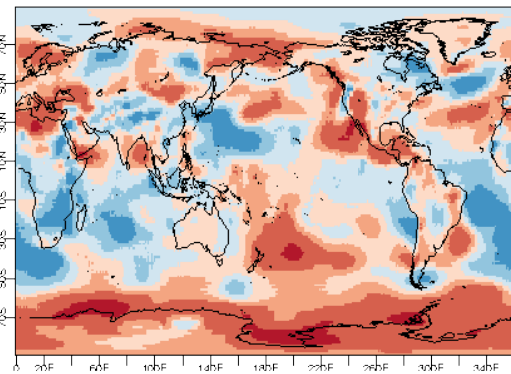


without volcanoes

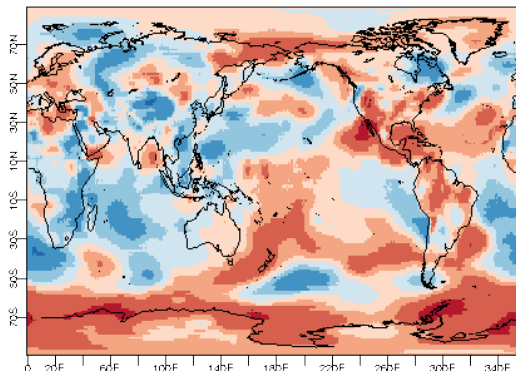


additional cor with volcanoes

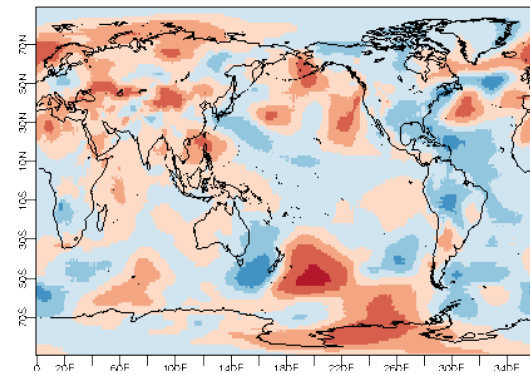
*JJA 3*



all forcings



without volcanoes



additional cor with volcanoes

→ General increase of correlation during JJA, significant but noisy



## Appendix

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→ precipitation, Z500 and SLP analysis

→ comments of Paco:

**Linear trend not excluded when computing skills**

**Cross-validation for volcanoes anomalies?**