SPECS

Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

Volcanoes and decadal forecasts with EC-Earth

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EC-Earth Meeting, Reading, May 2015

SEVENTH FRAMEWORK PROGRAMME

Introduction

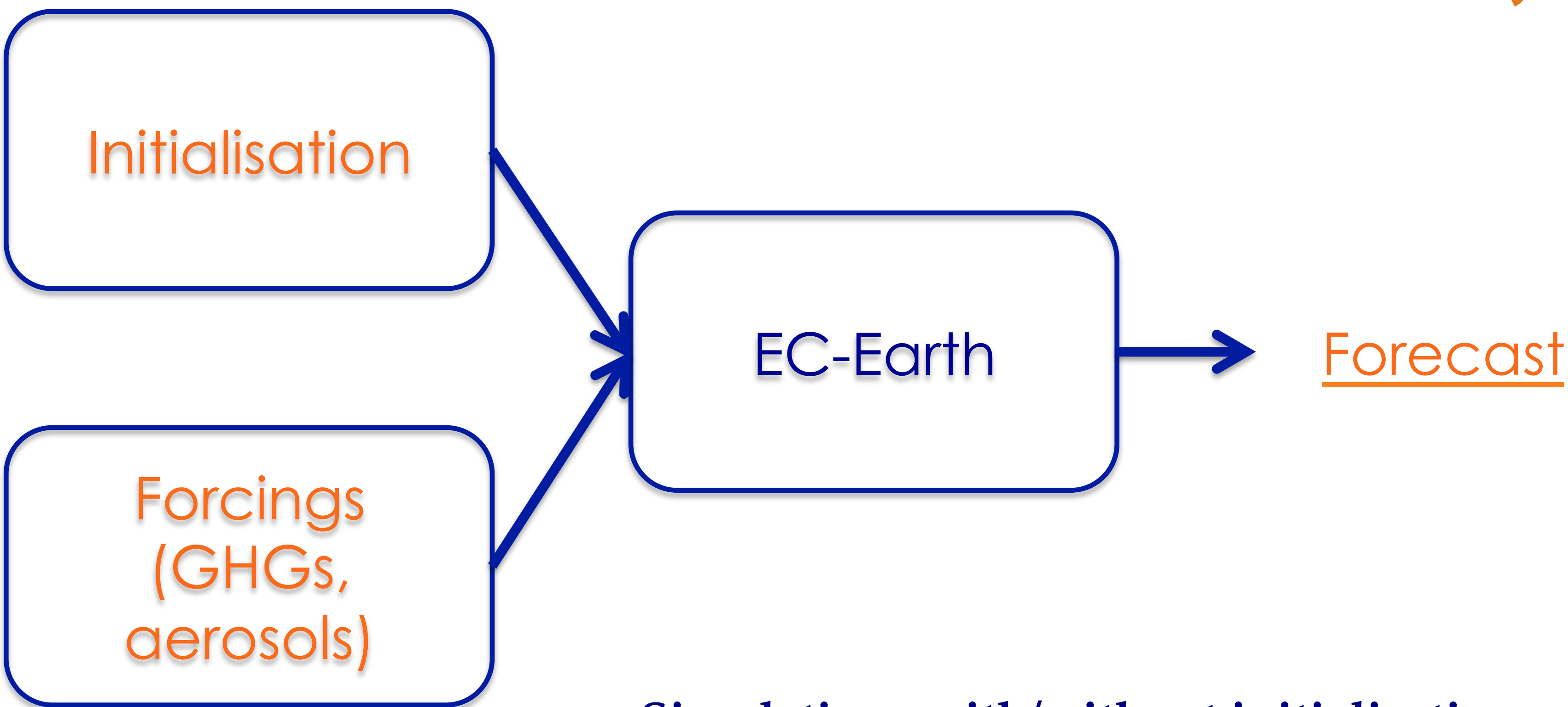
→ **Major eruptions bring large amounts (Tg) of particles in the stratosphere.**

→ **Recent eruptions: Agung (1963), El Chichon (1982) and Pinatubo (1991).**

→ **Global temperature decrease by 0.1-0.3°C, atmospheric impacts noticeable during 5 years, and potential effects on ocean circulation during 10-20 years.**

Sarychev volcano, 2009, NASA

Introduction



→ **Simulations with/without initialisation**

→ **Simulations with/without volcanic forcing**

→ **Simulations with idealized volcanic forcing**

→ Climate response to volcanoes

→ Initialisation and volcanic forcing in forecasts

→ Correlations and RMSE

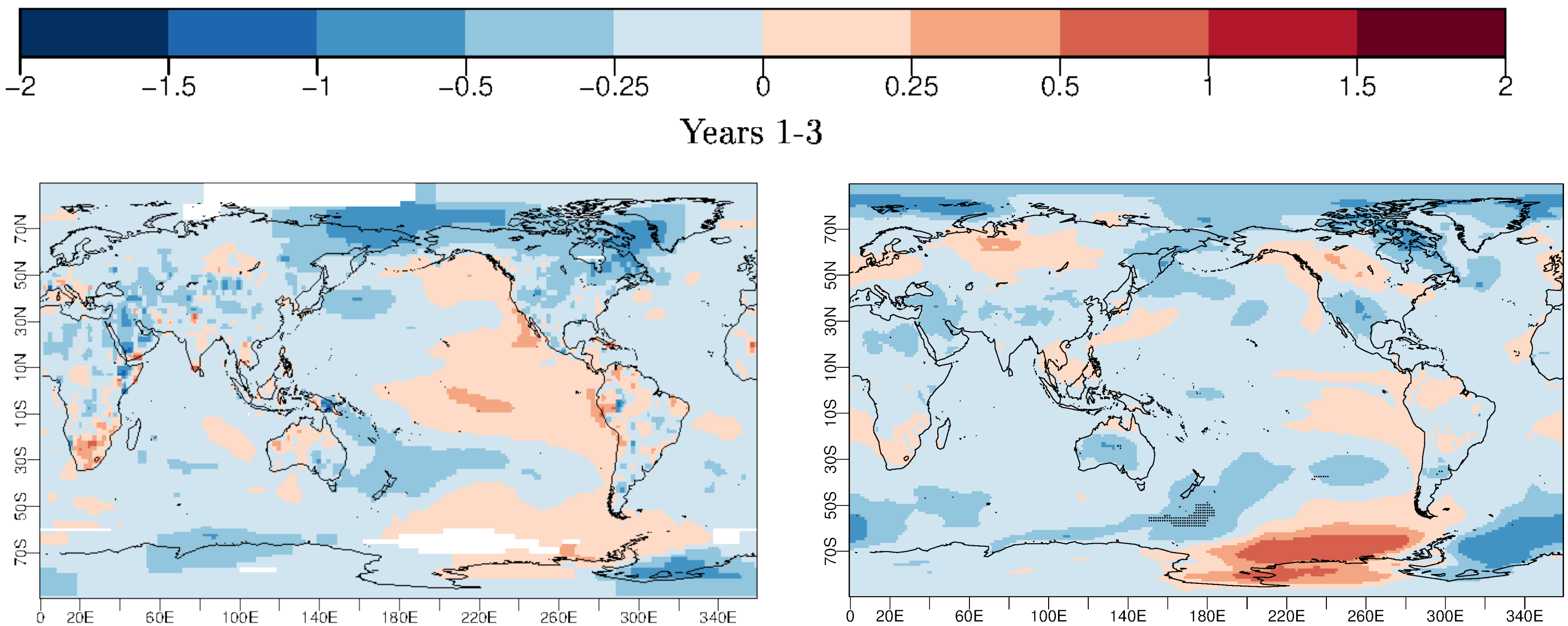
→ **Climate response to volcanoes**

→ Initialisation and volcanic forcing in forecasts

→ Correlations and RMSE

SPECS Climate response to volcanoes

→ Large inter-annual variability partly overwhelms the volcanic signal

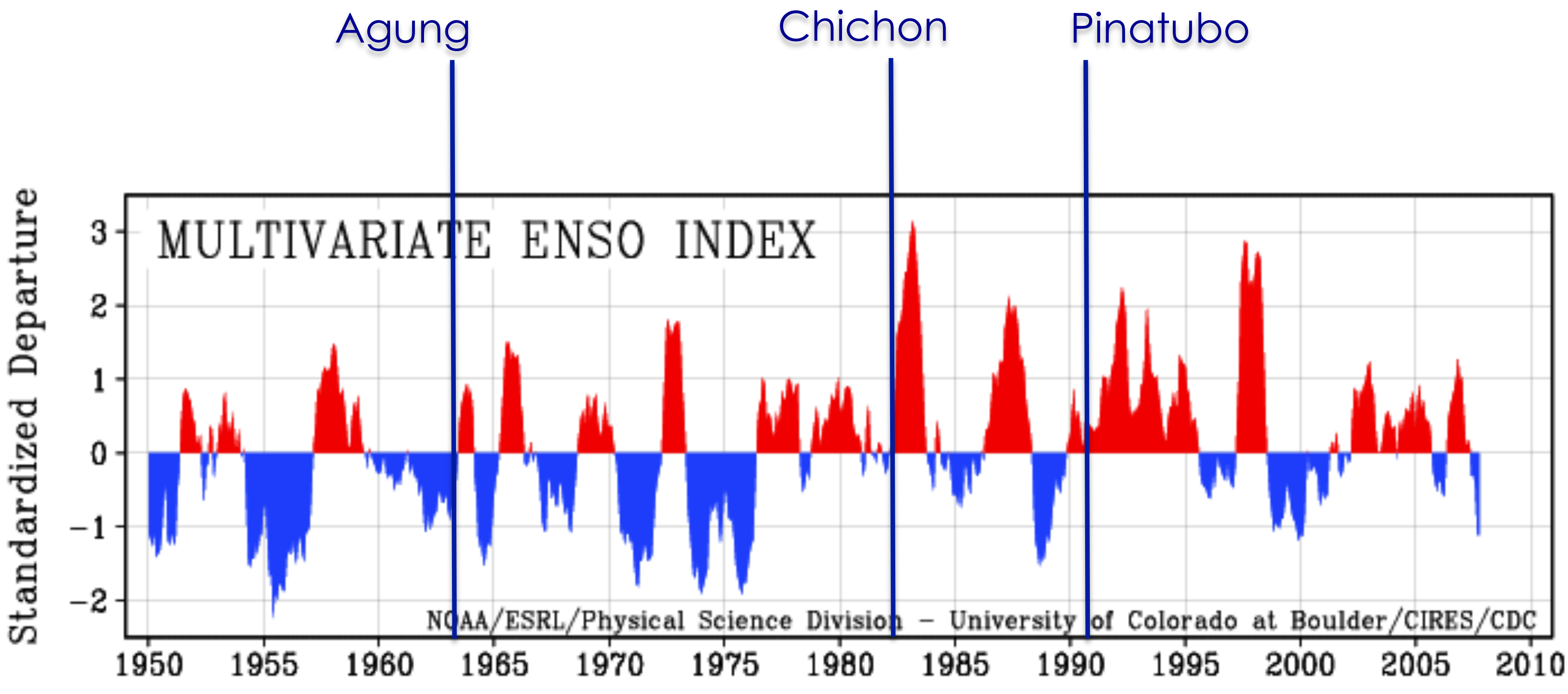


(a) Observation *(b) Model*

Surface temperature anomalies over forecast years 1-3 after the last 3 major eruptions: (a) Observation; (b) EC-Earth hindcasts. Anomalies are averaged over 3 start dates (and 5 members for the simulations). Shaded areas show regions with significant differences with a 5% level, areas without observations appear in white.

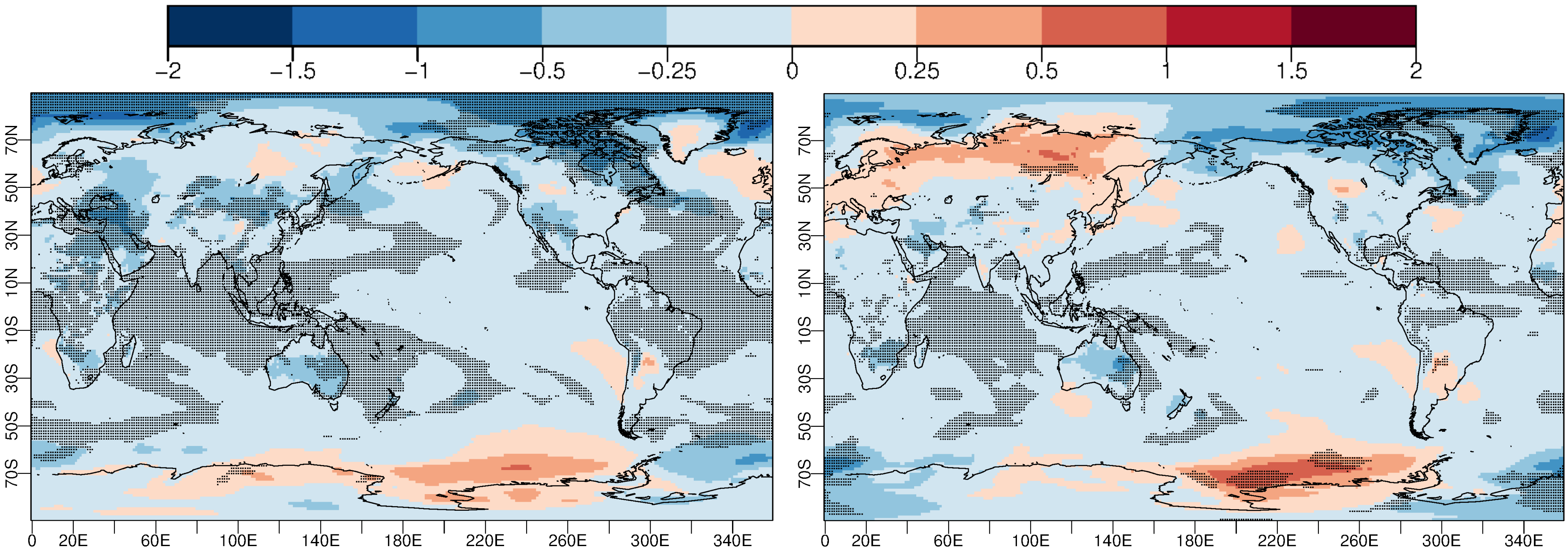
Climate response to volcanoes

→ **Mixing between ENSO and volcanoes !**



SPECS Climate response to volcanoes

Sensitivity experiment with - without volcanoes



Years 1-3 **Years 3-5**

Surface temperature difference (°C). 3-year average after the 3 last major eruptions (Agung, 1963, Chichon, 1982 and Pinatubo, 1991). Difference has been computed between two 5-members hindcasts, one including and another excluding volcanic forcing of large eruptions, and appear shaded when significant with a 5% level.

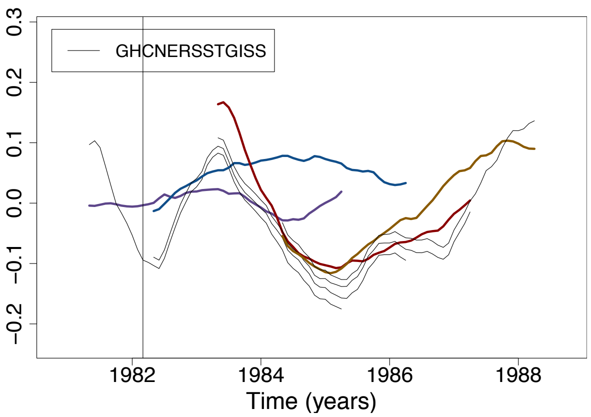
→ Climate response to volcanoes

→ **Initialisation and volcanic forcing in forecasts**

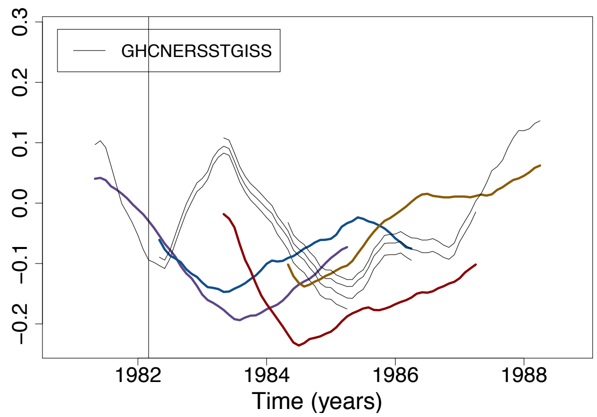
→ Correlations and RMSE

Initialisation and volcanoes

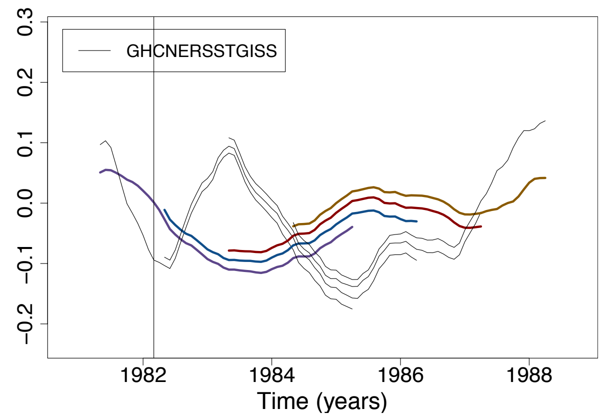
El Chichón



Initialisation without volcanoes



Initialisation with volcanoes

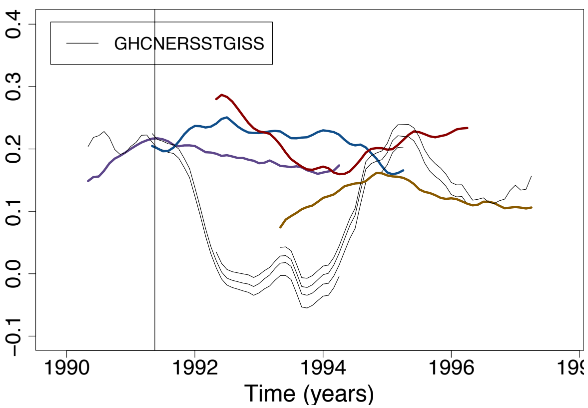


Volcanoes without initialisation

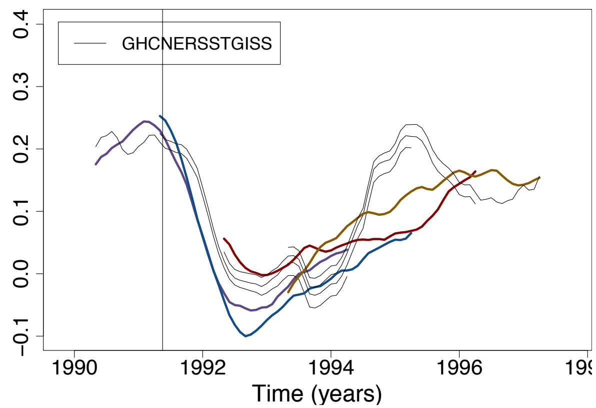
Surface temperature anomalies forecast for 4 different startdates around the El Chichón eruption (blue and purple start before the eruption; red and yellow start after the eruption). Hindcasts start in November. Observations anomalies (black) are computed with climatologies varying along the forecast time, data from ERSST and GHCN (GISS). Anomalies are smoothed with a 12-month running mean.

Initialisation and volcanoes

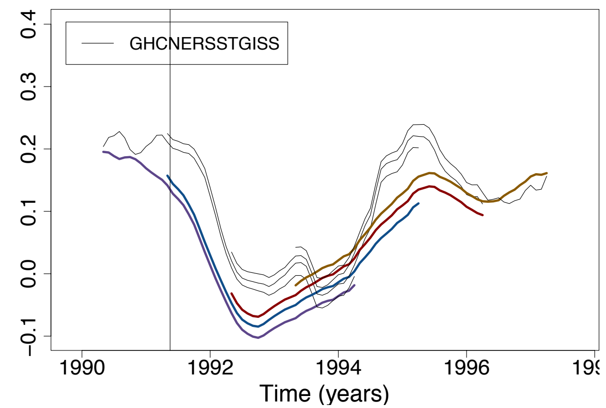
Pinatubo



Initialisation without volcanoes



Initialisation with volcanoes

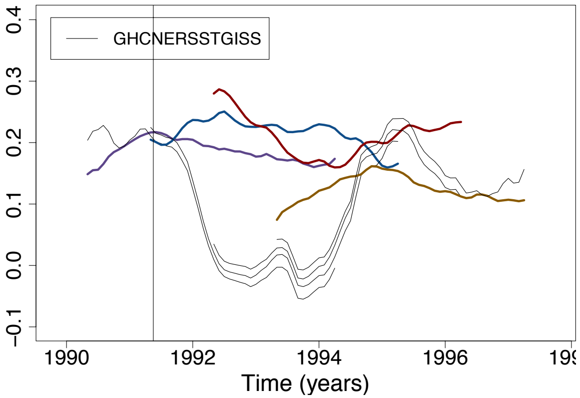


Volcanoes without initialisation

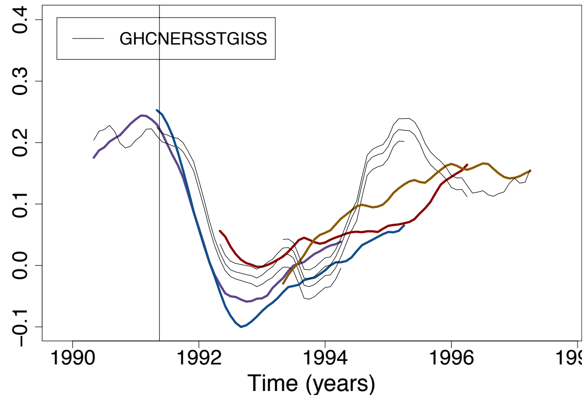
Surface temperature anomalies forecast for 4 different startdates around the Pinatubo eruption (blue and purple start before the eruption; red and yellow start after the eruption). Hindcasts start in November. Anomalies observations (black) are computed with climatologies varying along the forecast time, data from ERSST and GHCN (GISS). Anomalies are smoothed with a 12-month running mean.

Initialisation and volcanoes

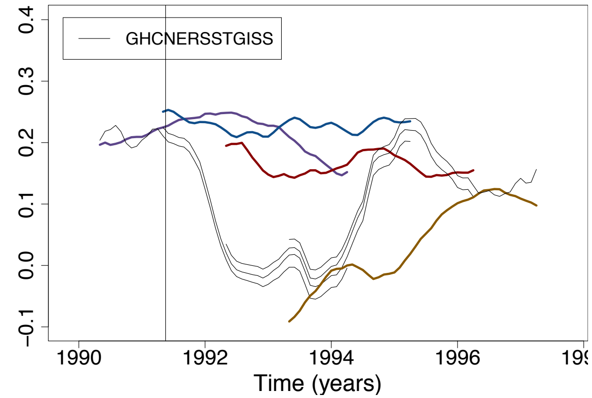
Pinatubo



Initialisation without volcanoes



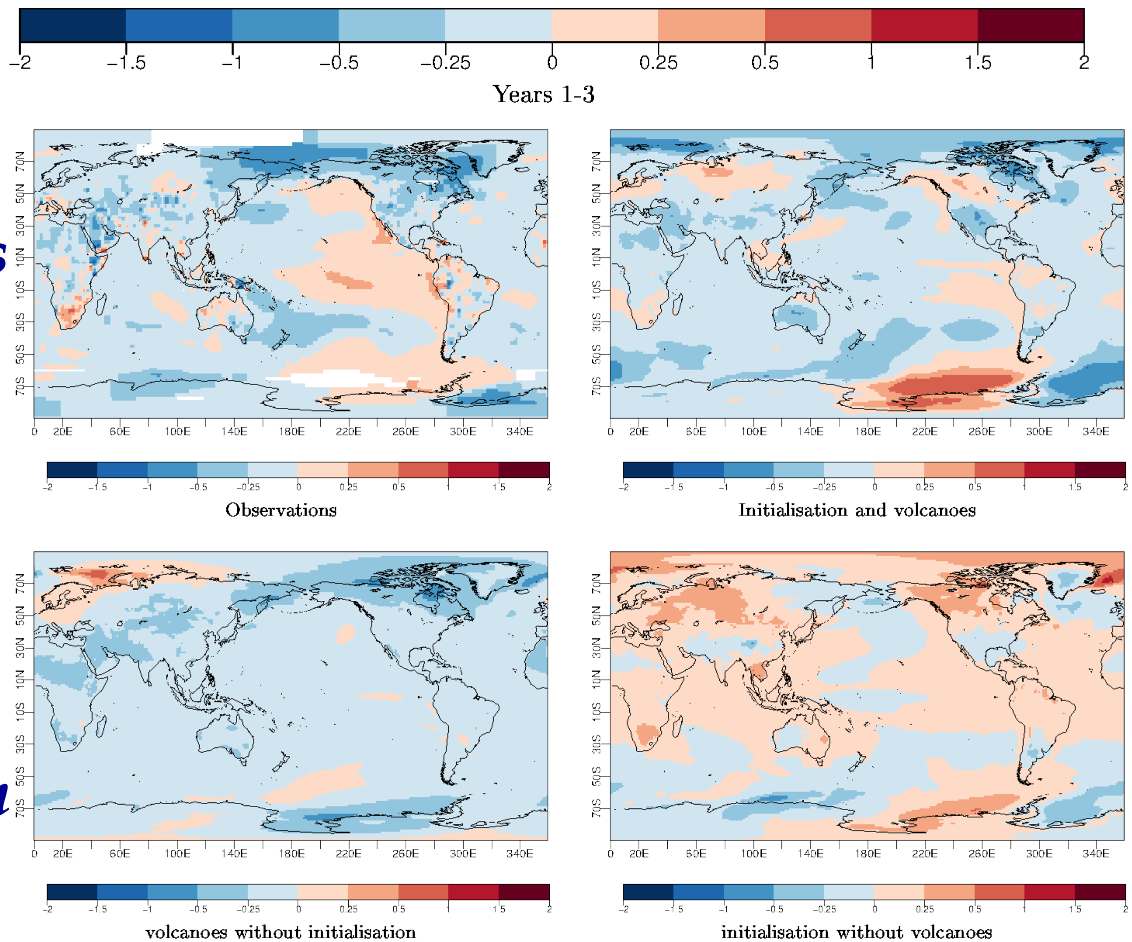
Initialisation with volcanoes



Initialisation with idealized volcanoes

Surface temperature anomalies forecast for 4 different startdates around the Pinatubo eruption (blue and purple start before the eruption; red and yellow start after the eruption). Hindcasts start in November. Anomalies observations (black) are computed with climatologies varying along the forecast time, data from ERSST and GHCN (GISS). Anomalies are smoothed with a 12-month running mean. Idealized forcing is computed as the current stratospheric aerosol load at the startdate decreasing toward "background level" after a one year exponential decay.

Initialisation and volcanoes



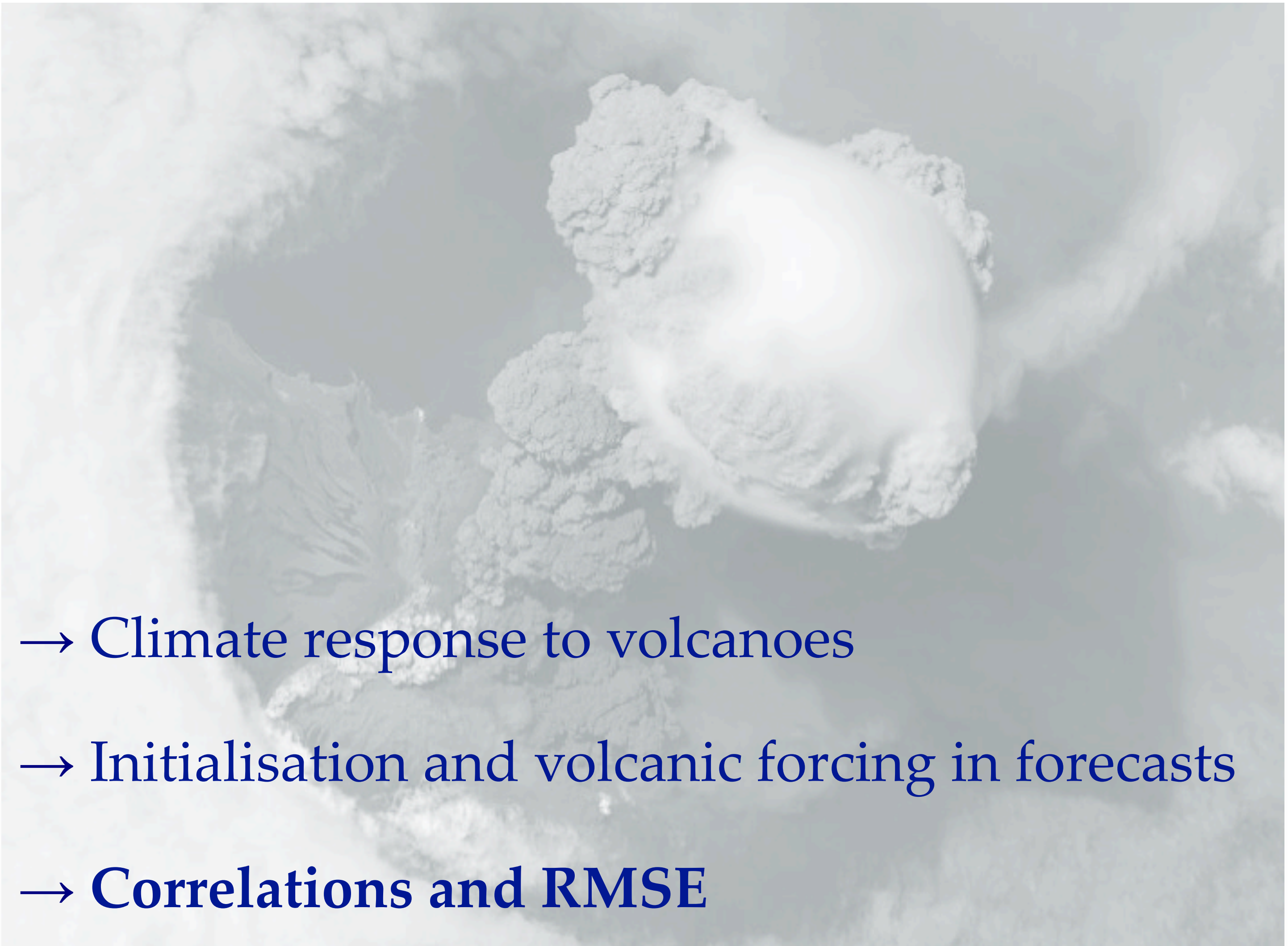
Observations

Initialisation with volcanoes

Volcanoes without initialisation

Initialisation without volcanoes

Surface temperature anomalies over forecast years 1-3 after the last 3 major eruptions. Anomalies are averaged over 3 start dates (and 5 members for the simulations).

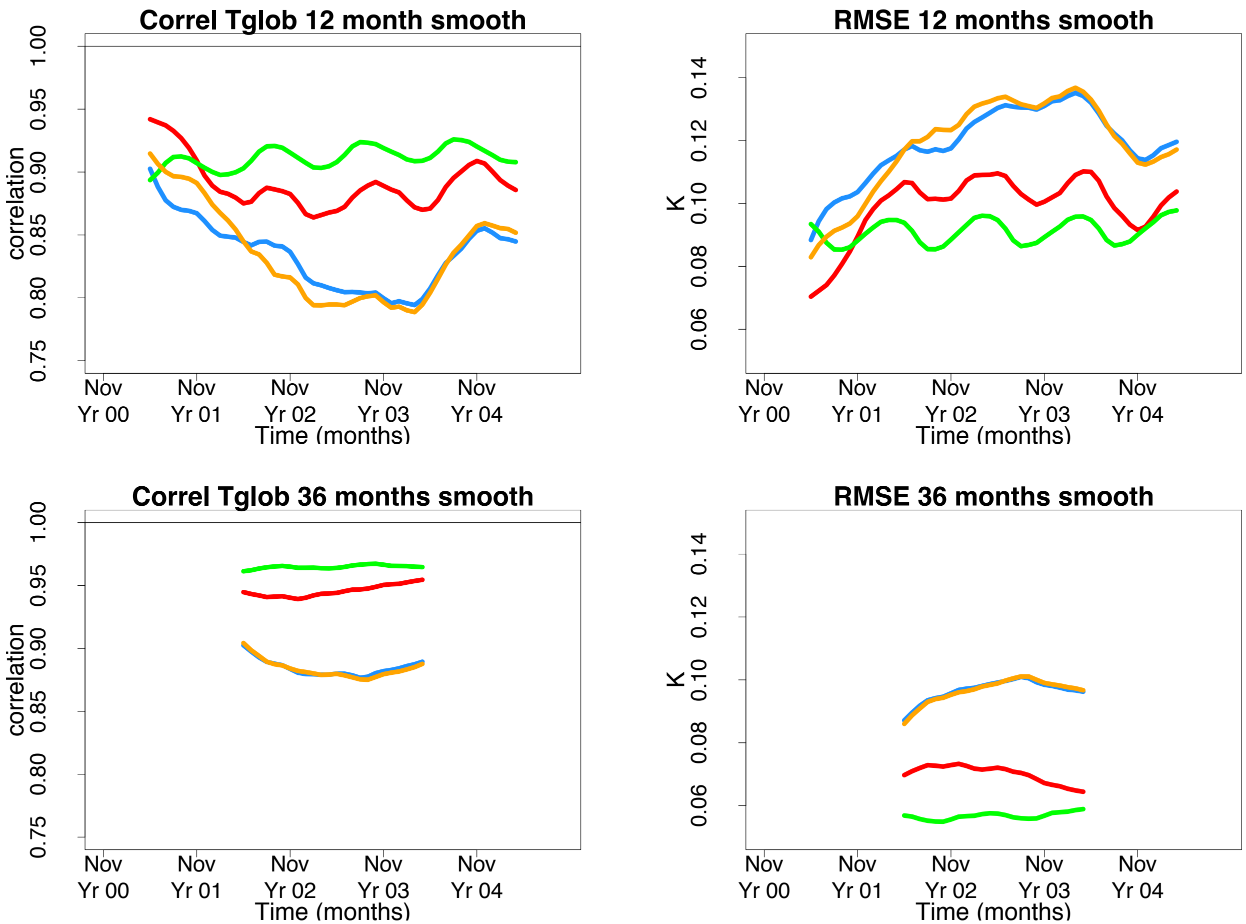


→ Climate response to volcanoes

→ Initialisation and volcanic forcing in forecasts

→ **Correlations and RMSE**

Correlation and RMSE



Volcanoes without initialisation

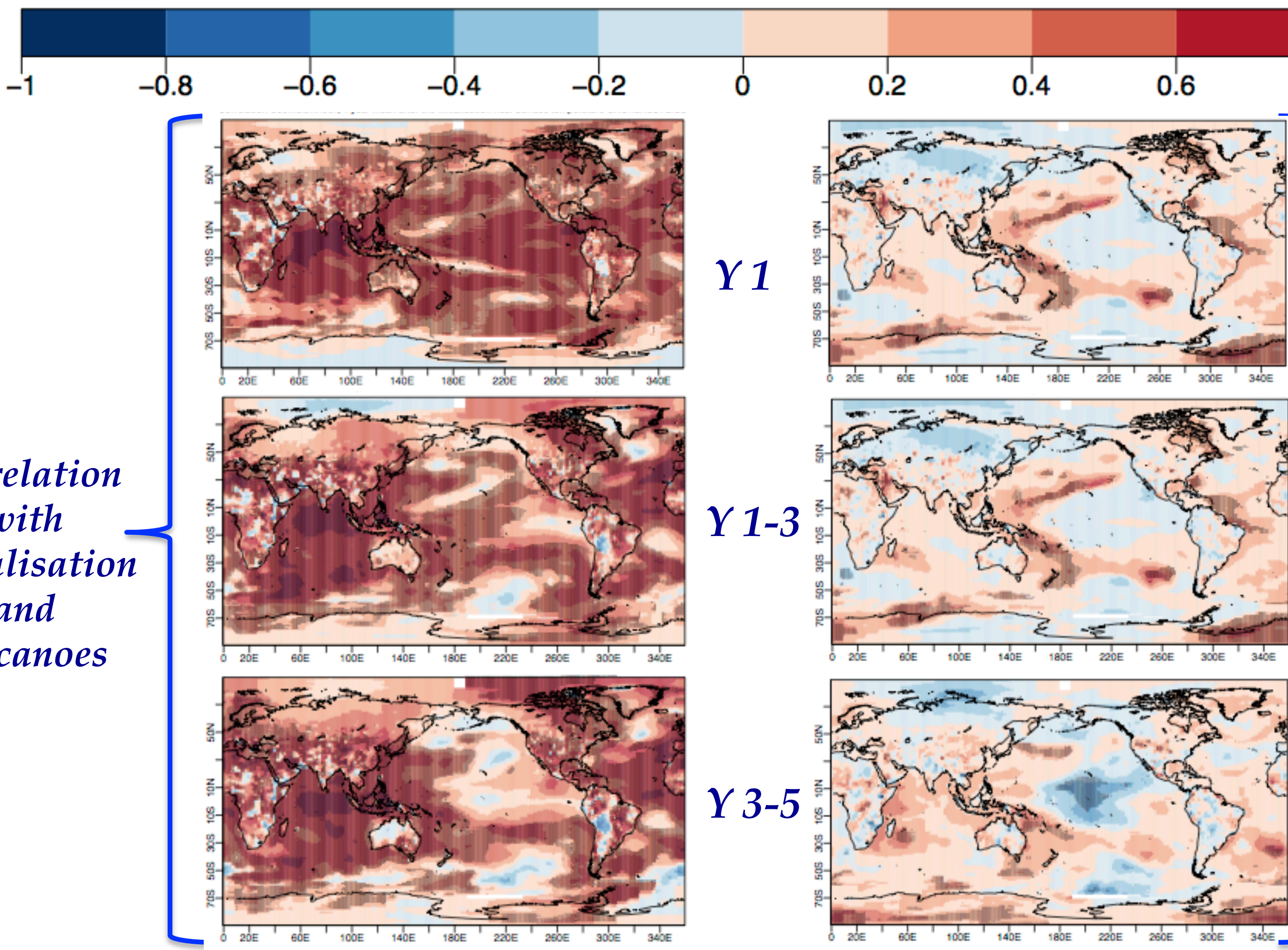
Volcanoes with initialisation

Initialisation without volcanoes

Initialisation with idealized volcanic forcing

Correlation and RMSE for 12 and 36 month smoothed running mean anomalies. Differences between hindcasts are not statistically significant.

Correlation and RMSE



Correlation with initialisation and volcanoes

Correlation increase with observed volcanic forcing

Conclusion

→ Temperature anomalies after large eruptions are a mix between internal variability and volcanic signal.

→ Evaluating the performances of climate forecast systems cannot be done without considering large eruptions that occurred during the last decades.

→ EC-Earth historical simulation has higher skill than hindcasts.

→ Including volcanic forcing in forecast systems allows an increase of the skill for surface temperature mainly in Western Pacific, tropical Atlantic and Indian Ocean.

→ It is challenging to design idealized volcanic forcing that could be used in operational forecasts.

Thank you

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Appendix

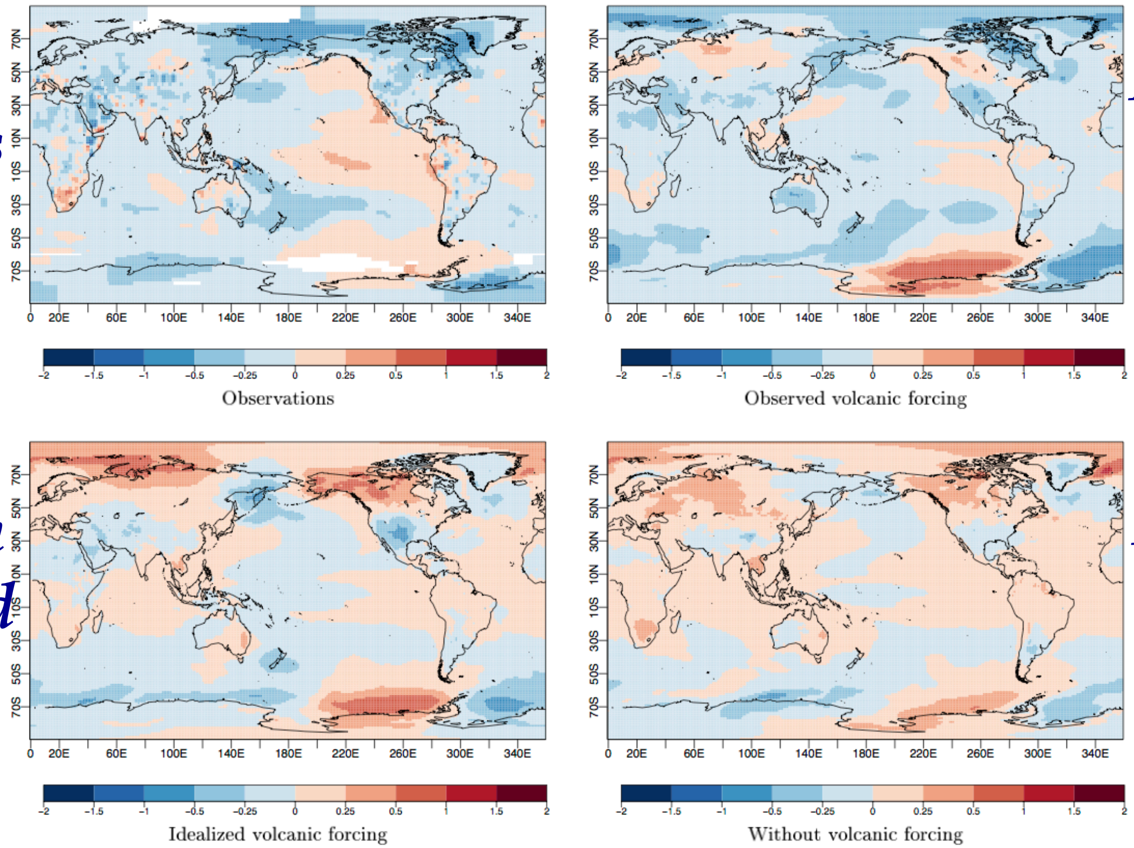
→ **Skill diagnosed with idealized forcing**

Idealized forcing

→ **Idealized forcing challenging to implement:**

Observations

Initialisation with volcanoes

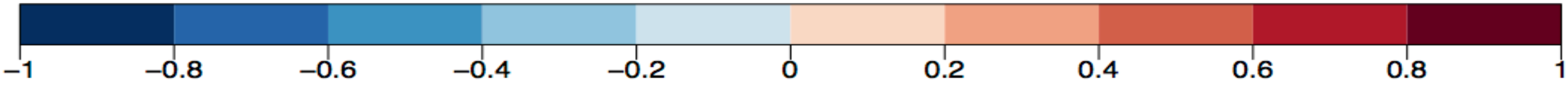


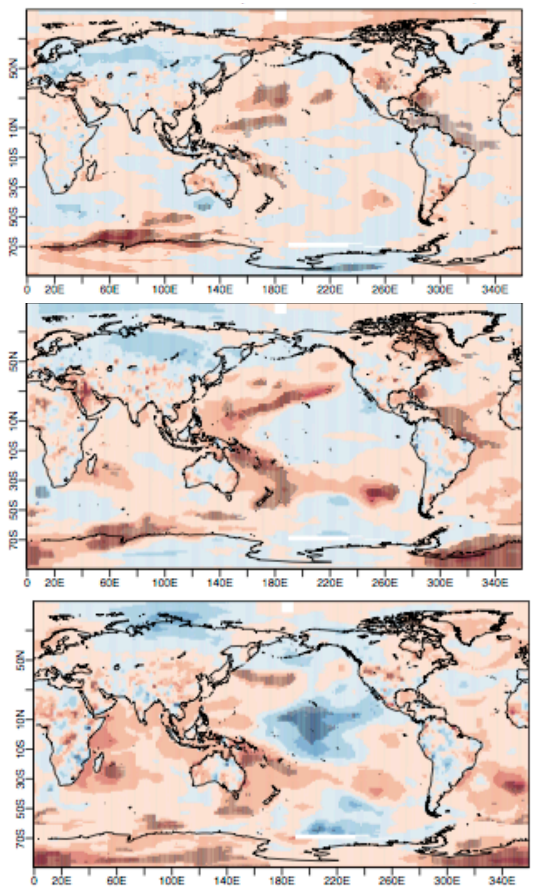
Initialisation with idealised volcanoes

Initialisation without volcanoes

Surface temperature anomalies over forecast years 1-3 after the last 3 major eruptions. Anomalies are averaged over 3 dates (and 5 members for the simulations).

Idealized forcing

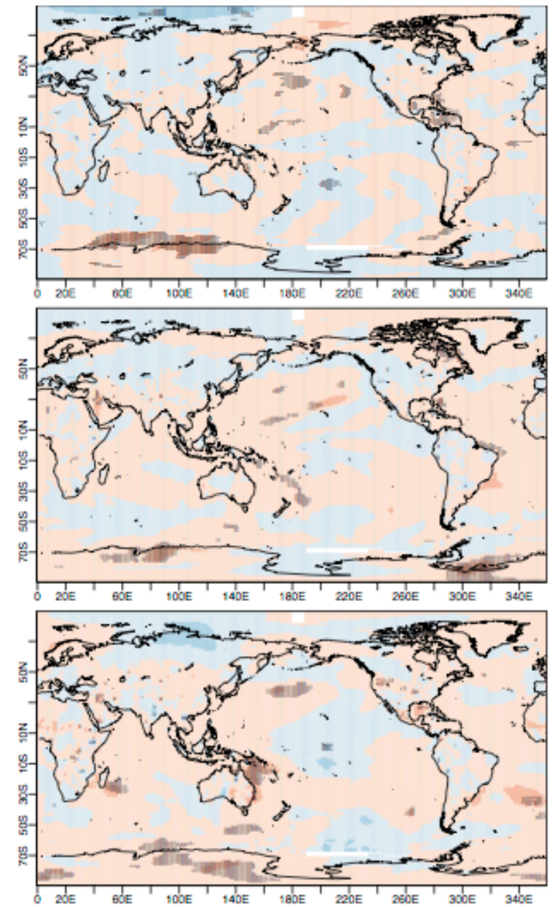




Year 1

Years 1-3

Years 3-5



Correlation difference with/without observed volcanic forcing

Correlation gain using observed versus idealized volcanic forcing

Initialisation