Climate impact of a hypothetical large tropical eruption

Claudia Timmreck [1], Matthias Bittner[1], Sebastian Illing[2], Christopher Kadow[2], Kirstin Krüger[3], Wolfgang Müller[1], Ulrike Niemeier[1], Holger Pohlmann[1], Hauke Schmidt[1] and Matthew Toohey[4]

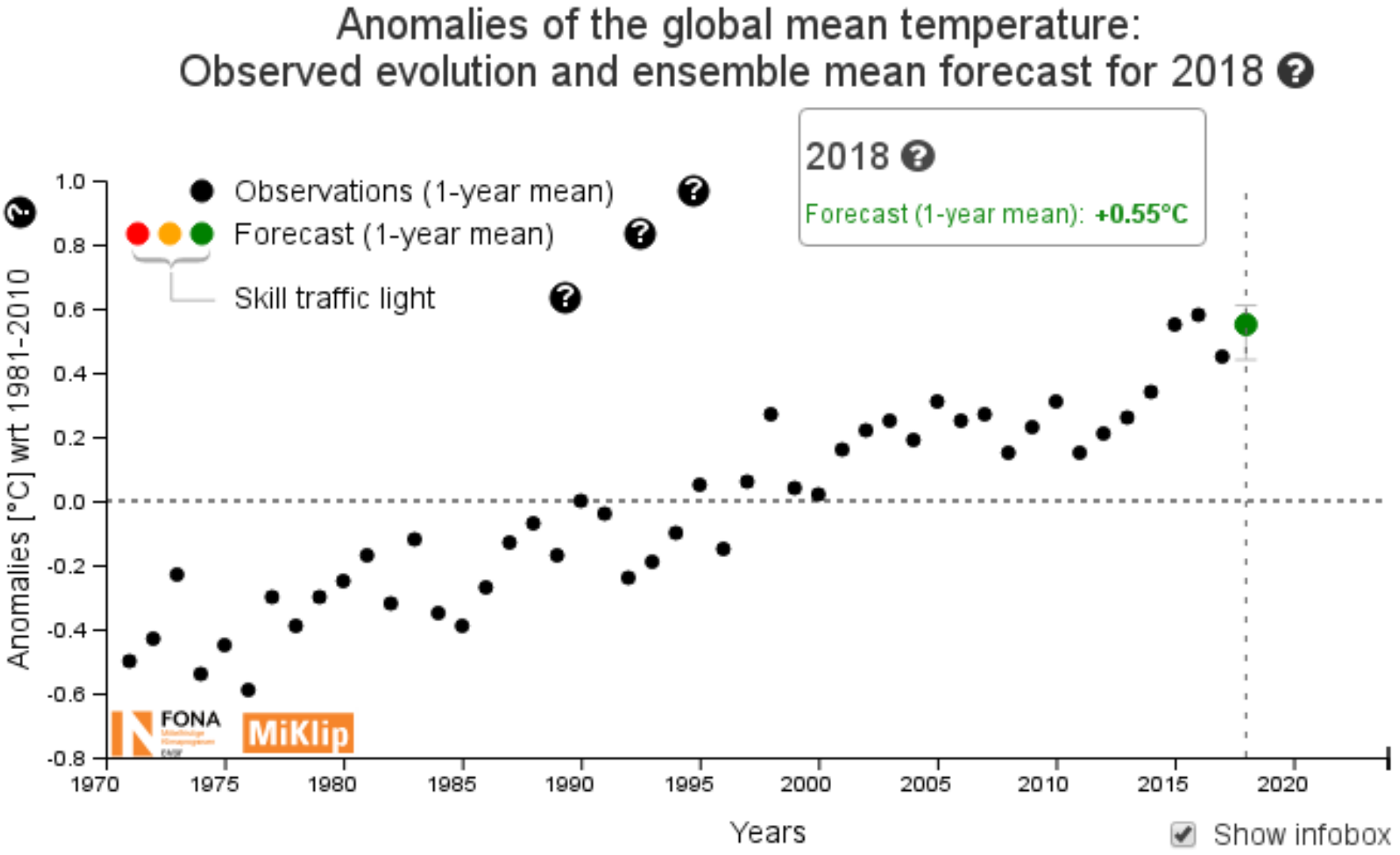
[1]MPI for Meteorology, Hamburg, [2] FUB Berlin, [3]Univ. of Oslo, [4]GEOMAR, Kiel,

Chapman Conference

Max-Planck-Institut für Meteorologie

FONA Mittelfristige Klimaprognosen BMBF

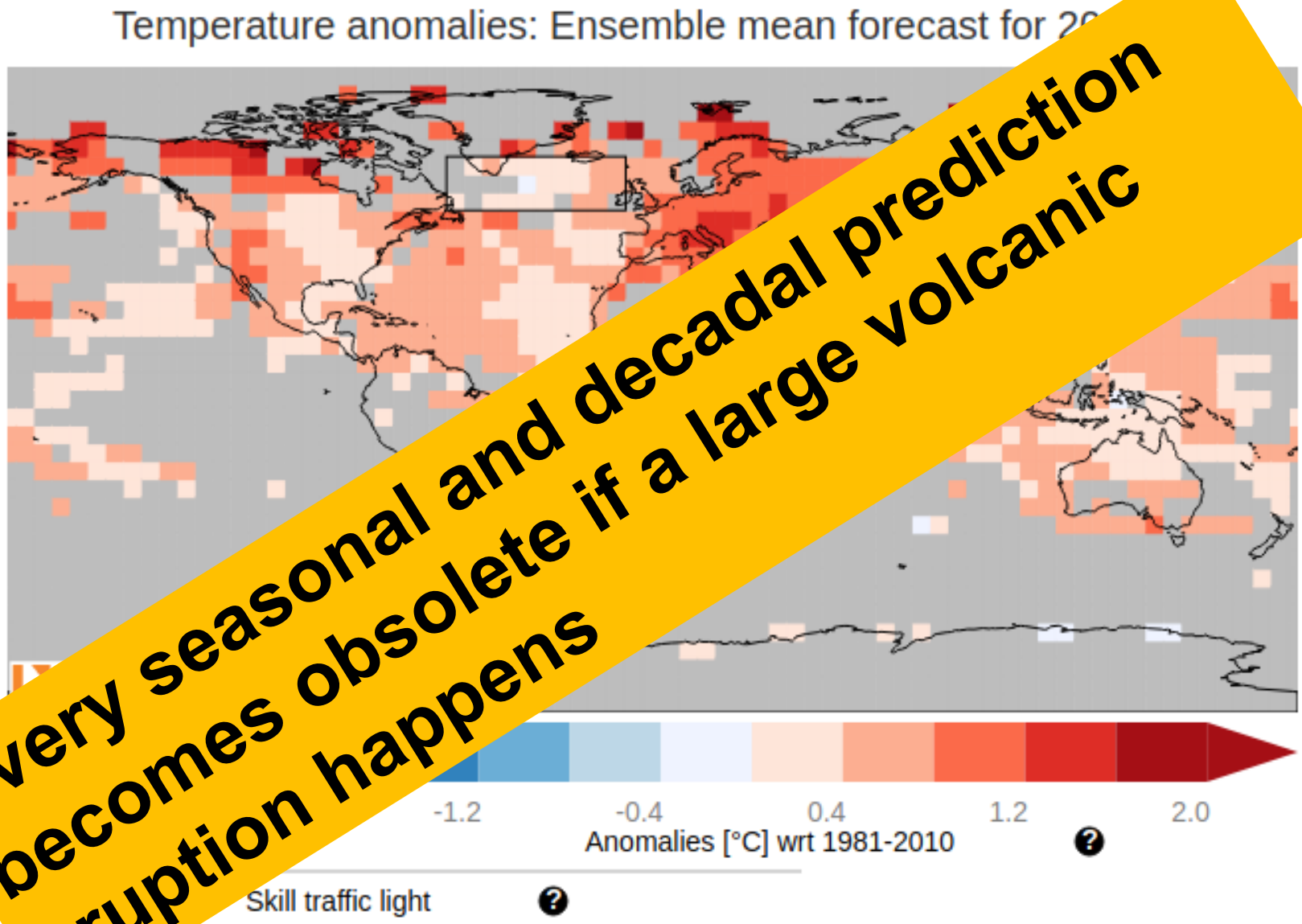
MiKlip



Max-Planck-Institut
für Meteorologie

FONA
Mittelfristige
Klimaprognosen
BMBF

MiKlip



Every seasonal and decadal prediction becomes obsolete if a large volcanic eruption happens

anck-Institut
für Meteorologie

FONA
Mittelfristige Klimaprognosen
BMBF

MiKlip

Important Questions

Source:USGS

How predictable is the response of the earth system to future eruptions?

How strong will the volcanic perturbation effect seasonal and decadal climate predictions?

How dependent is the signal to initialization values?

Two Case Studies

Source:USGS

A hypothetical large Mt. Agung eruption in autumn 2017

A hypothetical Mt. Pinatubo like eruption in July 2013 and 2015

Climate Impact of a Hypothetical Large Mt. Agung Eruption in Boreal Autumn 2017

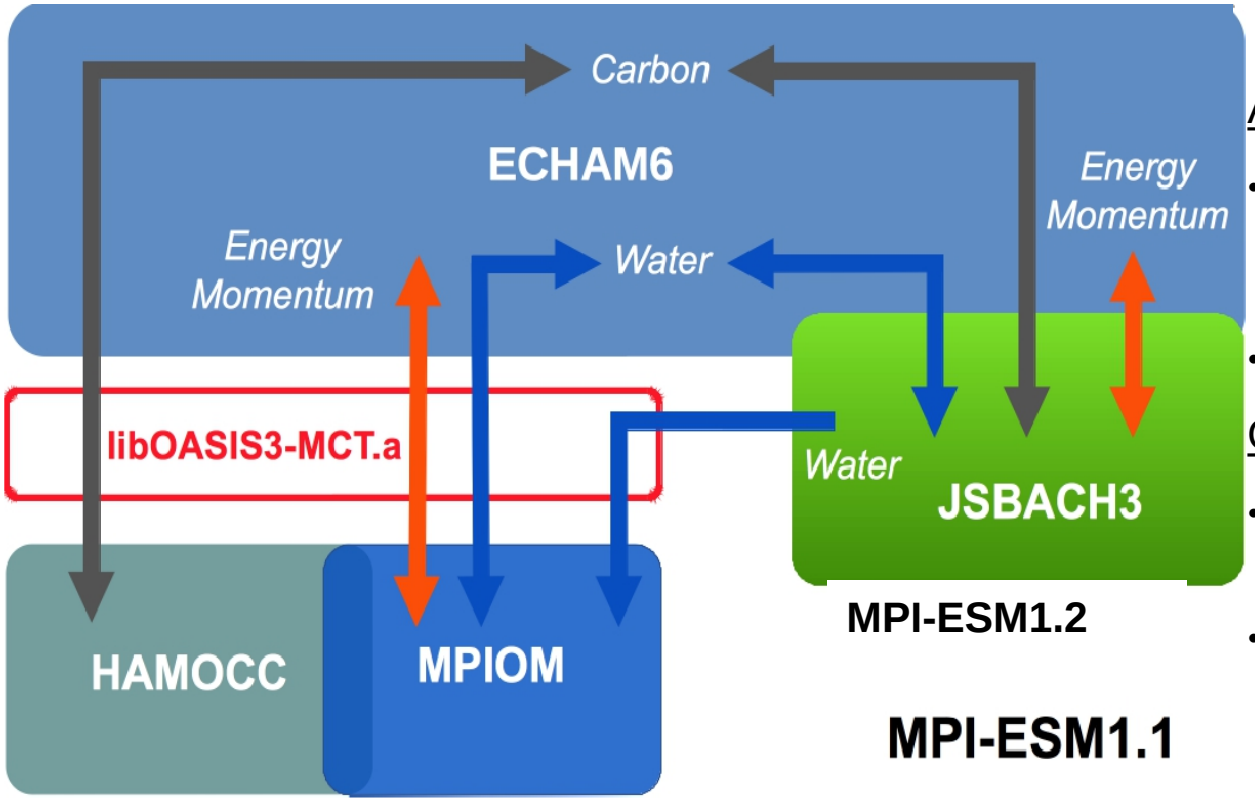
Mt. Agung began displaying heightened seismic activity on the August 10, 2017.

- On September 23, 2017 the Alert Level was raised to its maximum value.
- During boreal autumn 2017 the activity was quite high and a very large eruption seems to be very likely

Preparation of the MIKLIP decadal forecast system

Source:www.myreefsdiary.com

The Mittelfristige Klimaprognose (MiKlip: midterm climate forecast) Prediction System



Atmosphere:

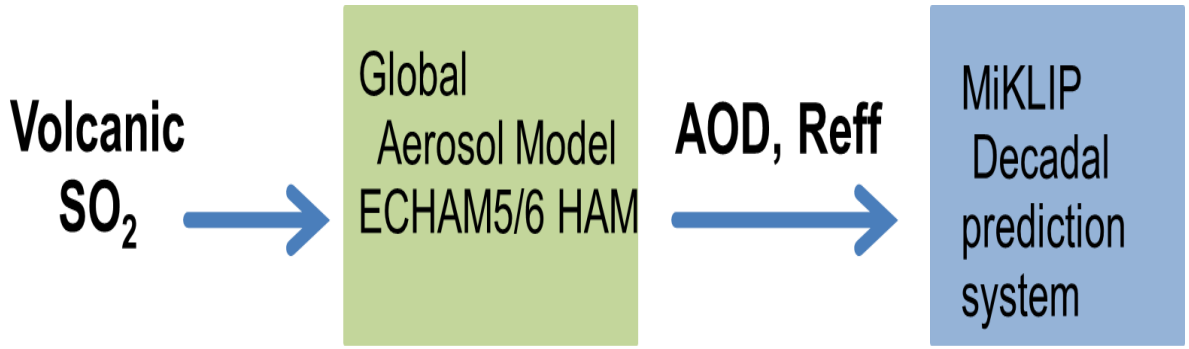
- ECHAM6.3, T63 (96x192 Gaussian grid, ~200km,)
- 47 levels

Ocean:

- GR15 (256x220 bipolar grid, 12 to 180km),
- 64 levels

Oceanic initialization: T, sea –ice & salinity anomalies from ORAS4
Atmospheric initialization: P, T, vorticity & divergence from ERA-40 & ERA-I

Alert for Mt. Agung: MiKlip Preparations



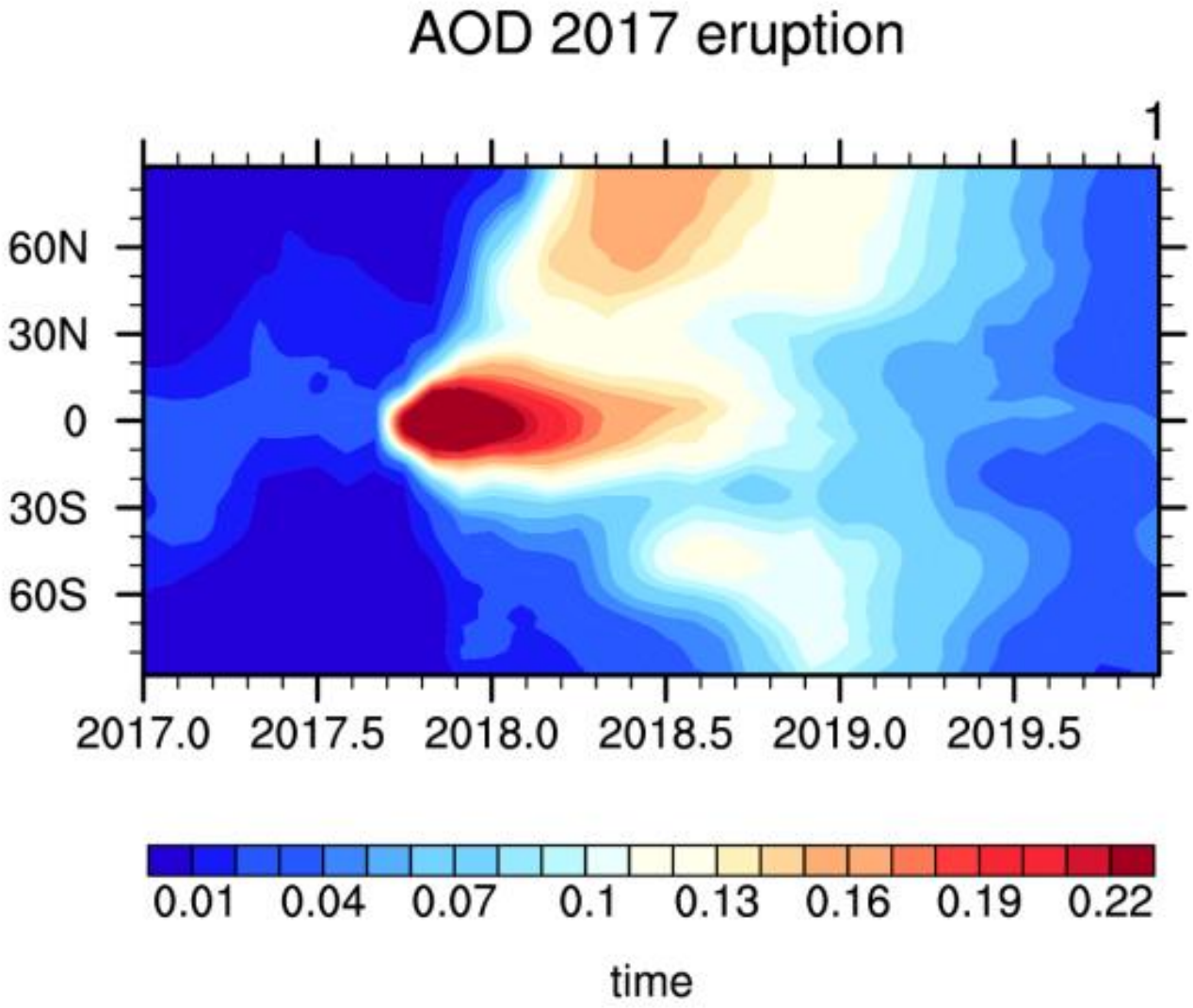
Preparation of forcing files

- Simulation with MAECHAM5/HAM in L90
- QBO above 30 hPa easterly phase below westerly phase
- Nudged QBO until eruption
- Test run for historic Agung eruption (1963) assuming 6.5 Tg SO_2

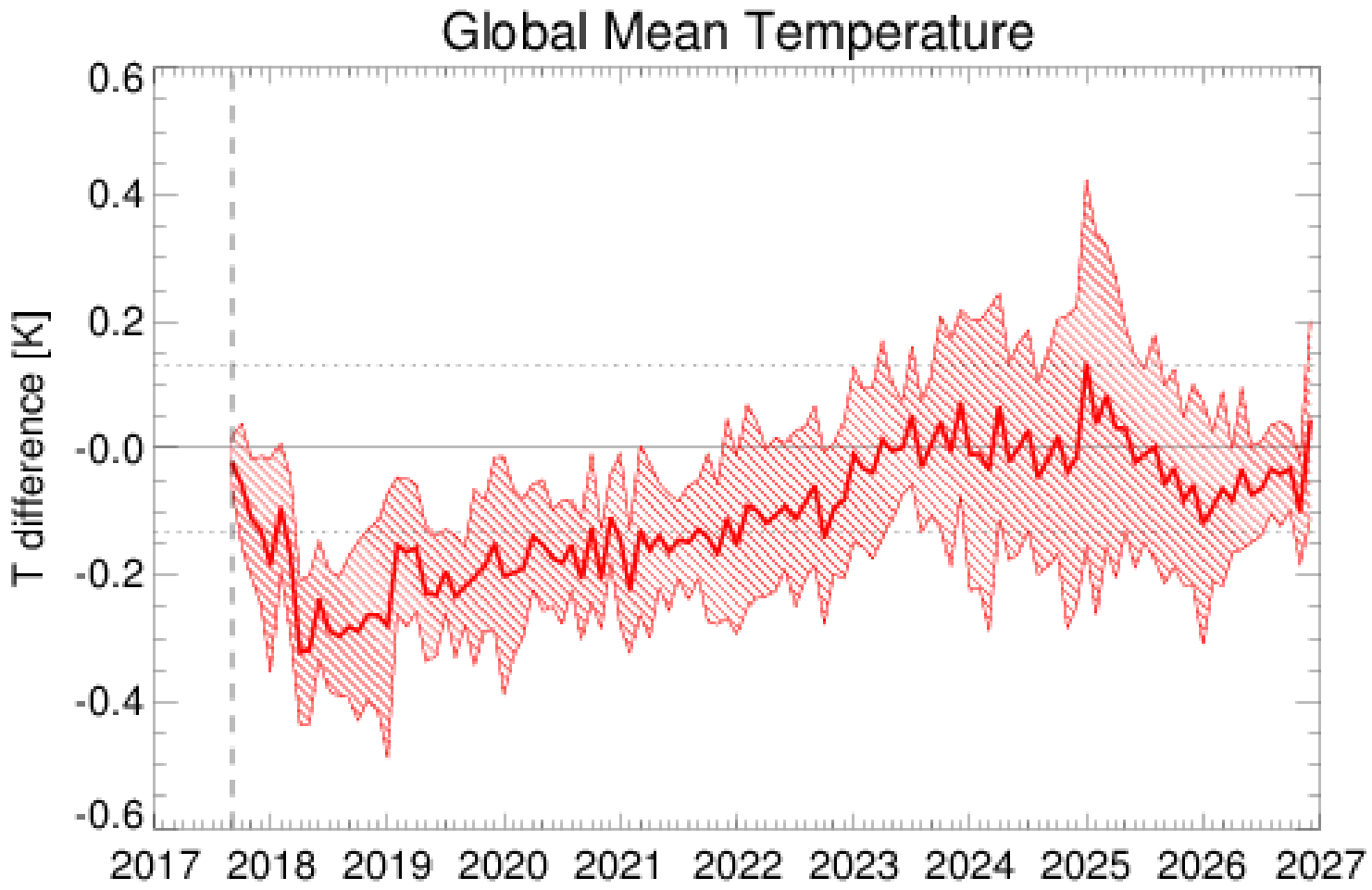
Preparation for Forecast system

- Compilation of new initial files for September
- Start new decadal prediction runs in October 2017
- 10 realizations with and without volcanic eruption (lagged initializations)

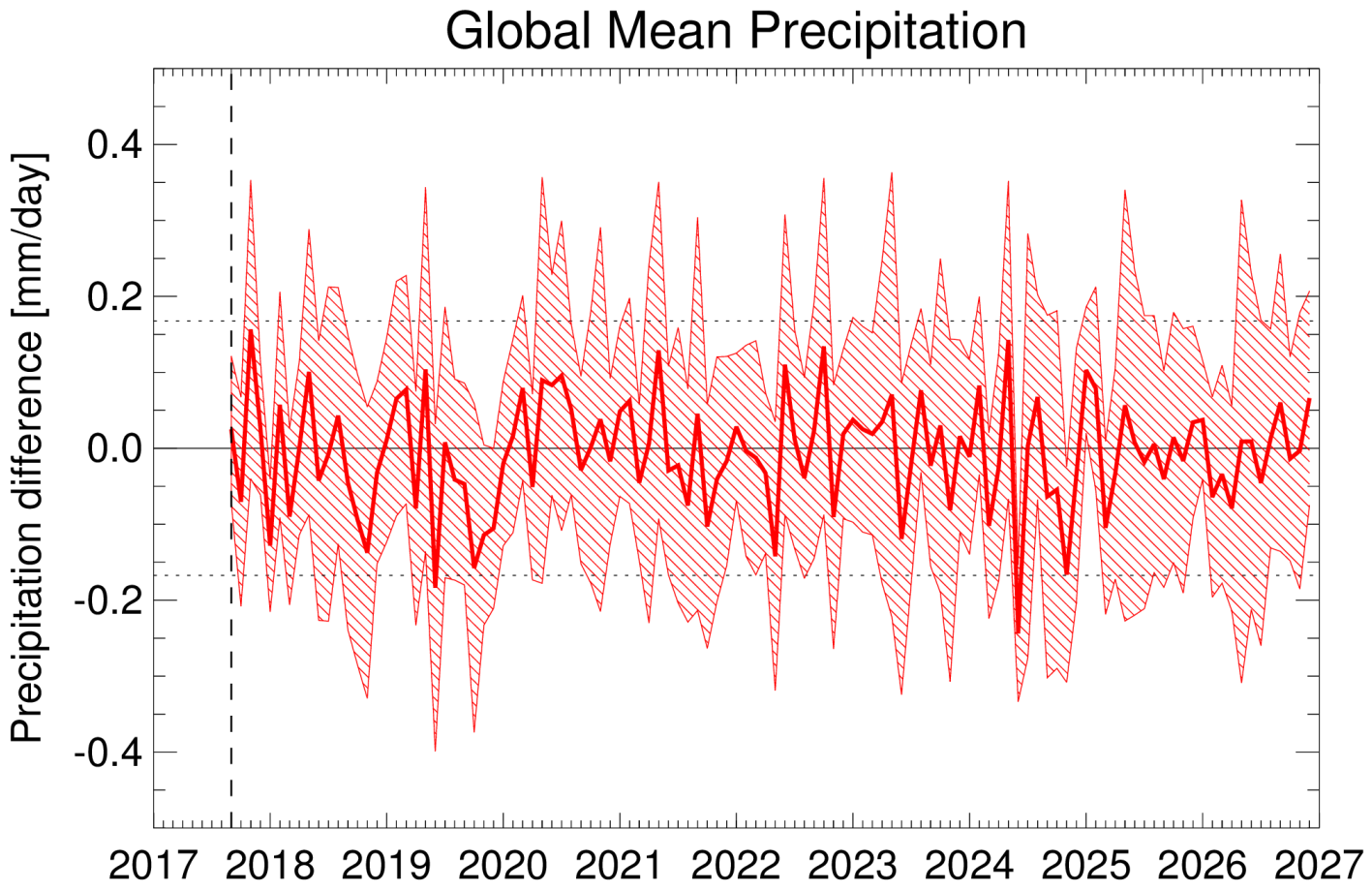
Volcanic Radiative Forcing



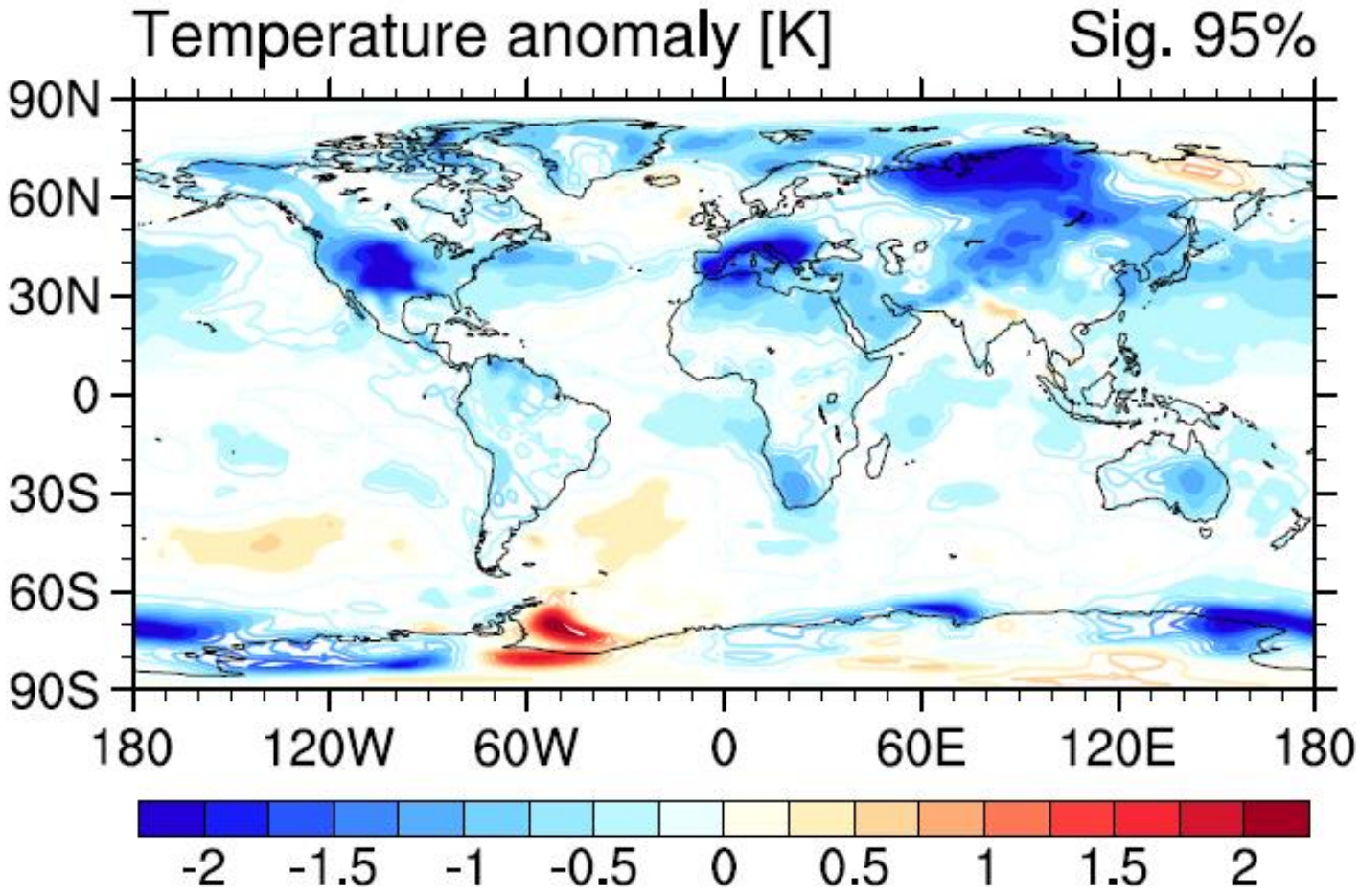
Global Temperature Anomaly



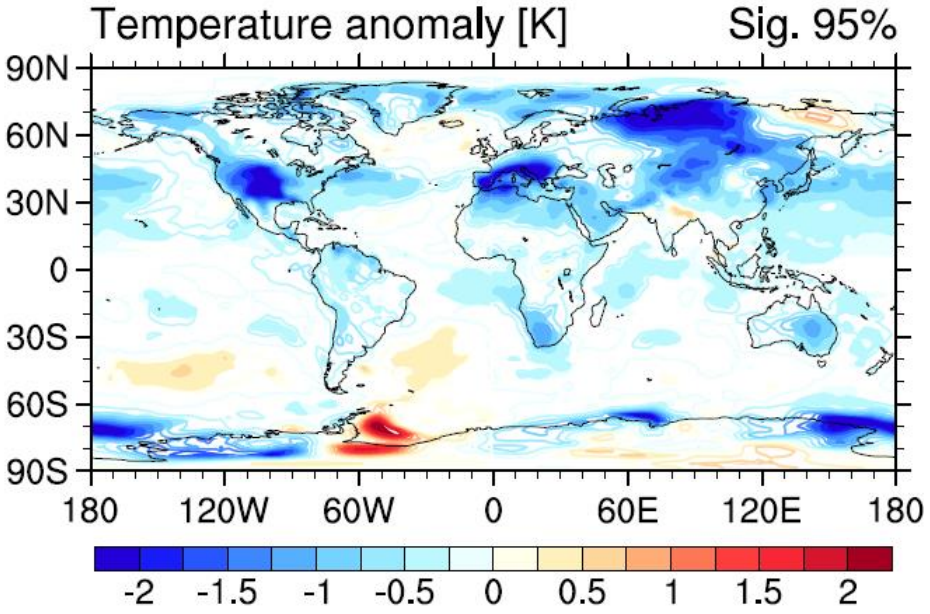
Global Precipitation Anomaly

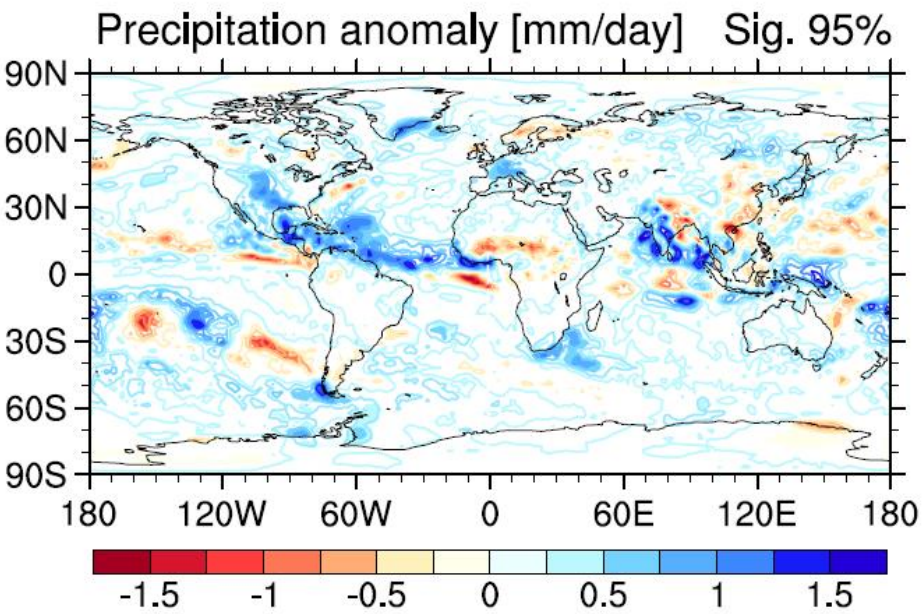


Temperature Anomalies JJA 2018



Temperature and Precipitation Anomalies JJA 2018





Strong regional differences which might be vary from year to year
Question of initial conditions

Importance of Initial Conditions

Source:USGS

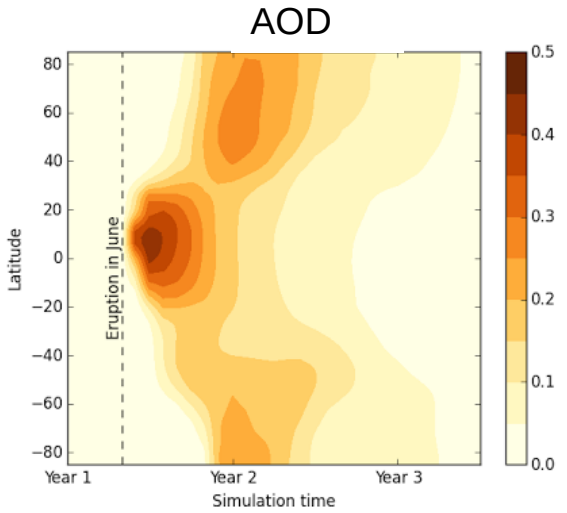
- Two decadal forecasts initialized in December 2012 and 2015
- Pinatubo-like eruption in June of the first prediction year
- Experiments have similar greenhouse gas forcing, but differ in important climate variables.
- MiKlip Baseline1 experiments as reference

Illing, S., Kadow, C., Pohlmann, H., and Timmreck, C.: Assessing the Impact of a Future Volcanic Eruption on Decadal Predictions, Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2018-5, in review, 2018.

Experimental set up

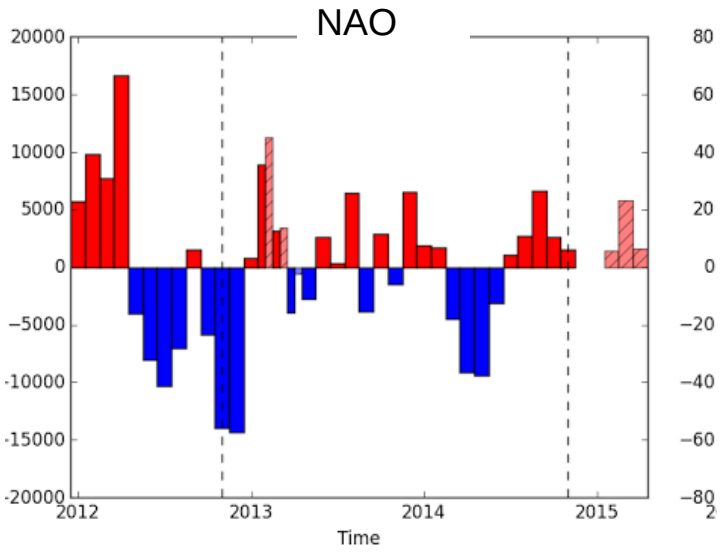
Global aerosol model

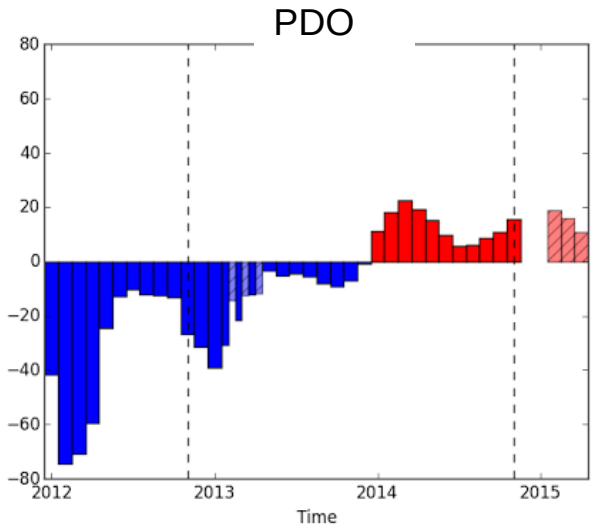
- ECHAM5-HAM adapted for volcanic studies
- Simulation includes only sulfate aerosol



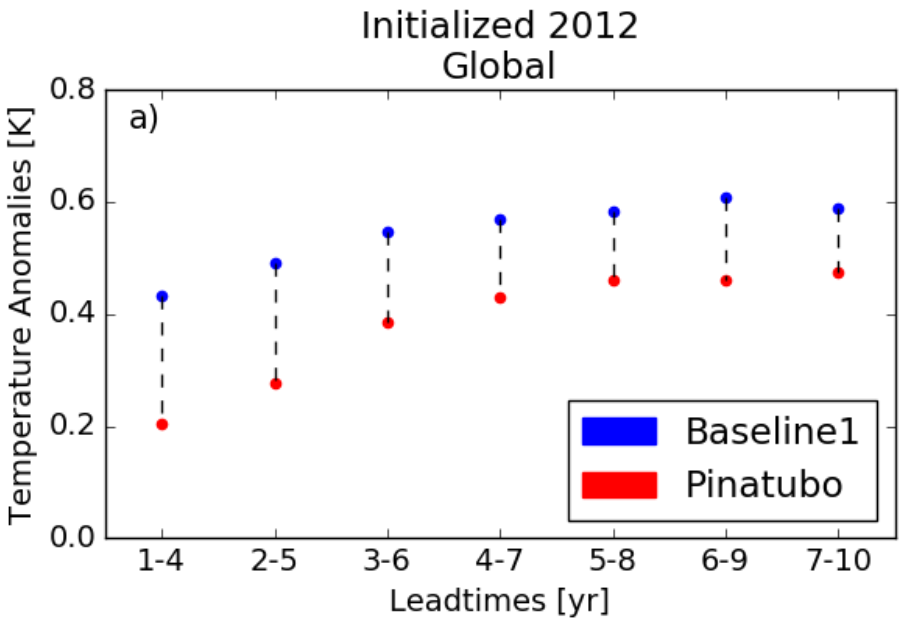
MiKlip decadal prediction system 2:

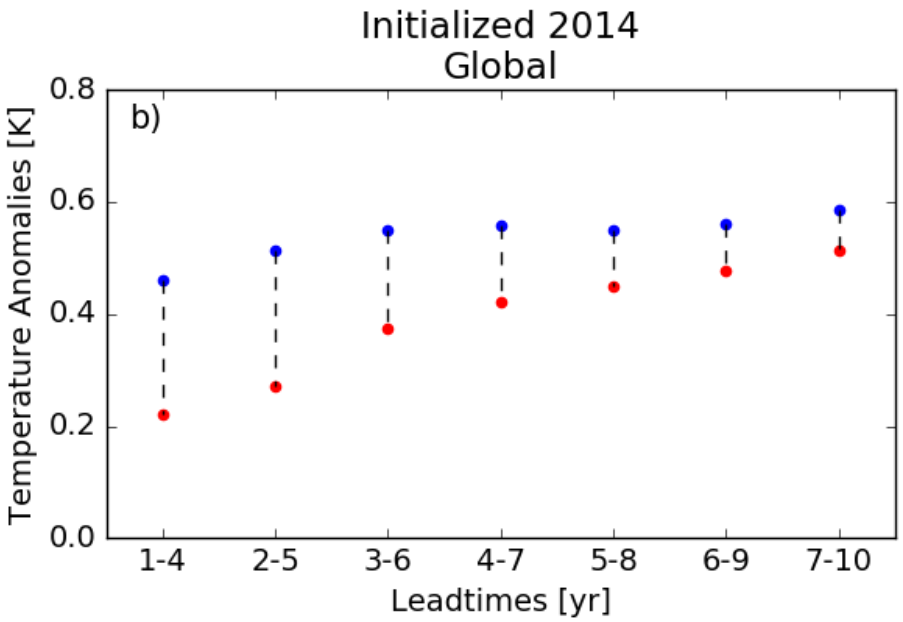
- 10 ensemble member
- lagged day initialization end of 2012 and end of 2014
- NAO and PDO negative (positive) phase in 2013 (2015)





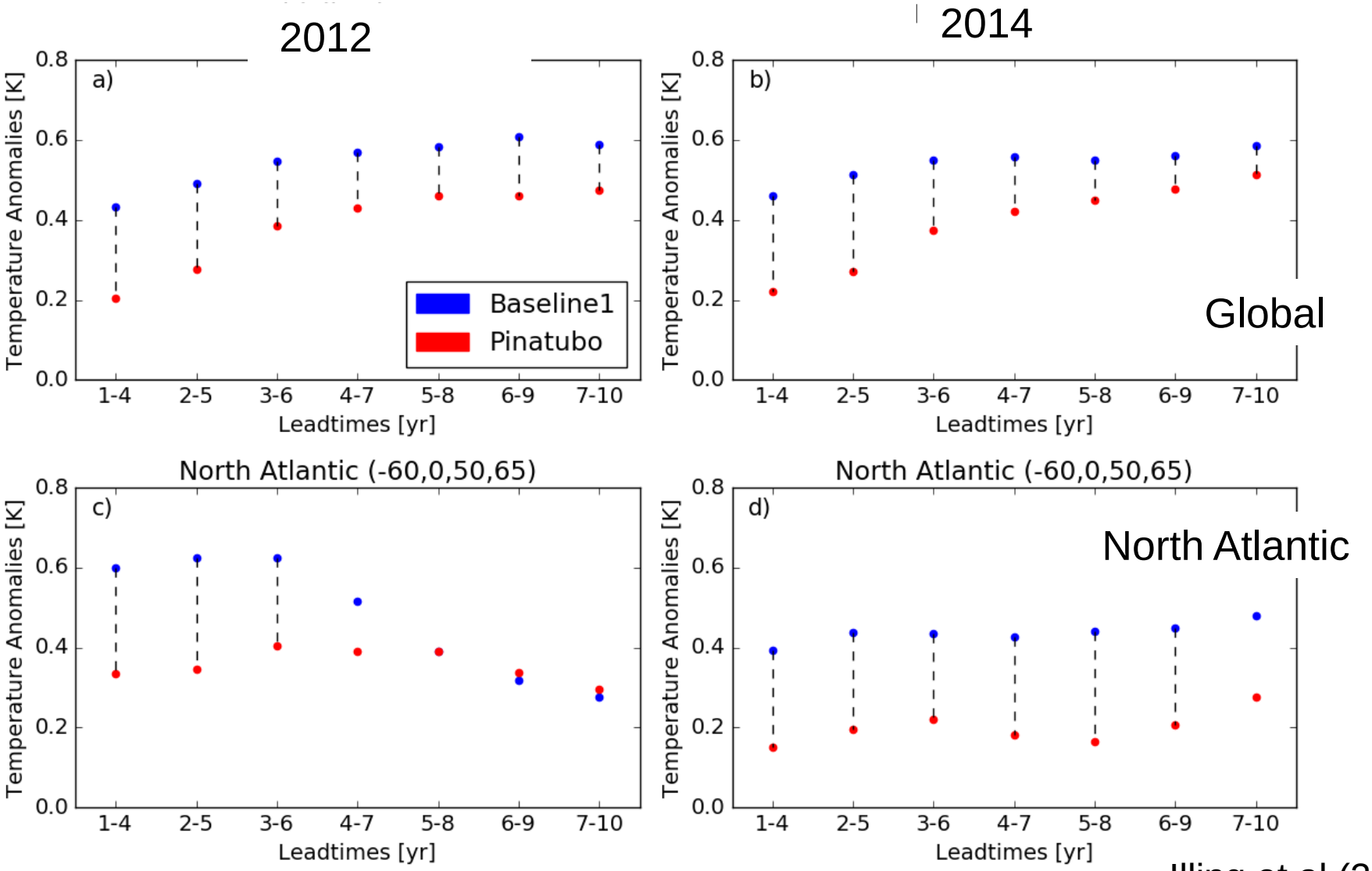
Global Time Series of Near-surface Air Temperature





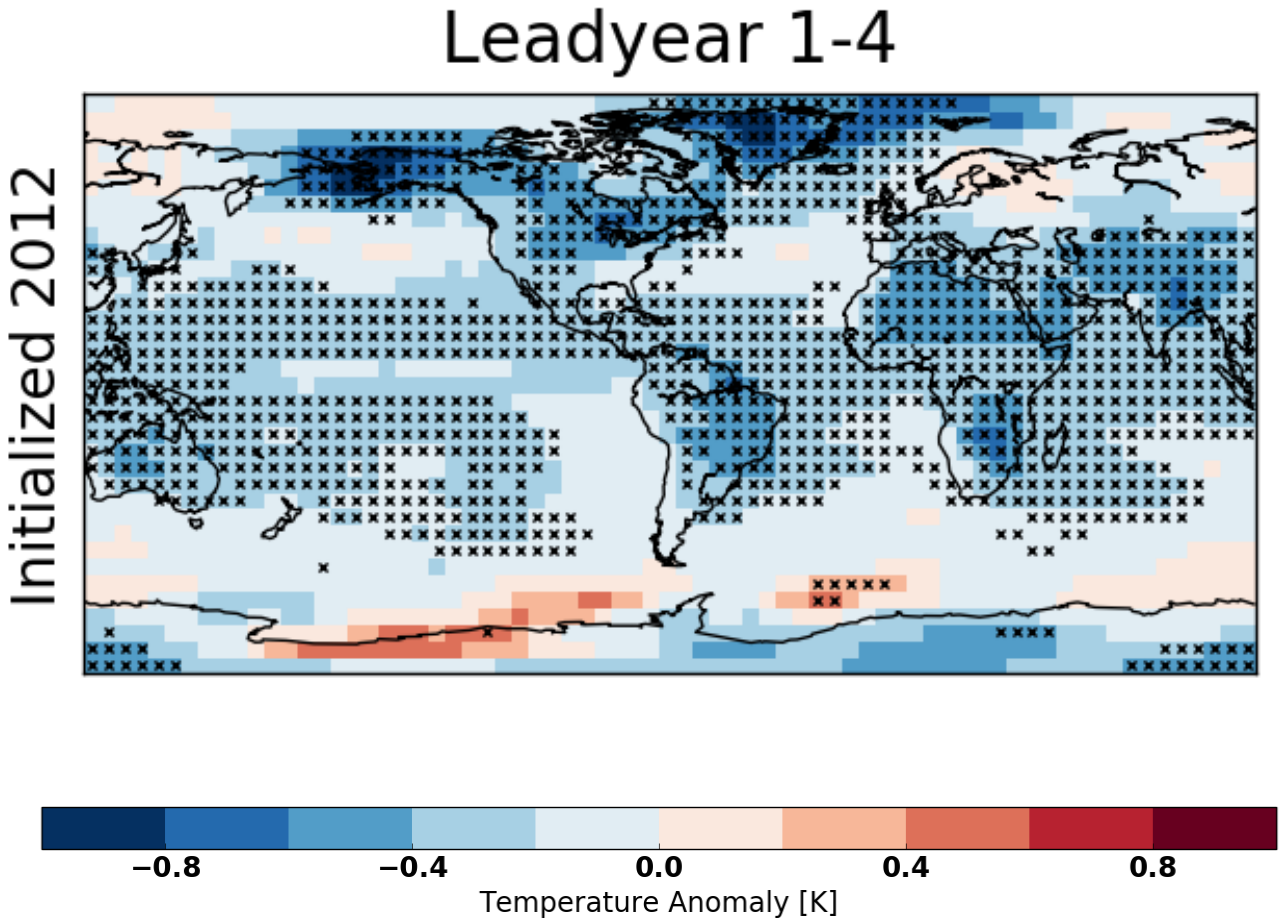
Illing et al (2018)

Timeseries of Near-Surface Air temperature (TAS)



Illing et al (2018)

Near-Surface Air temperature (TAS) anomalies

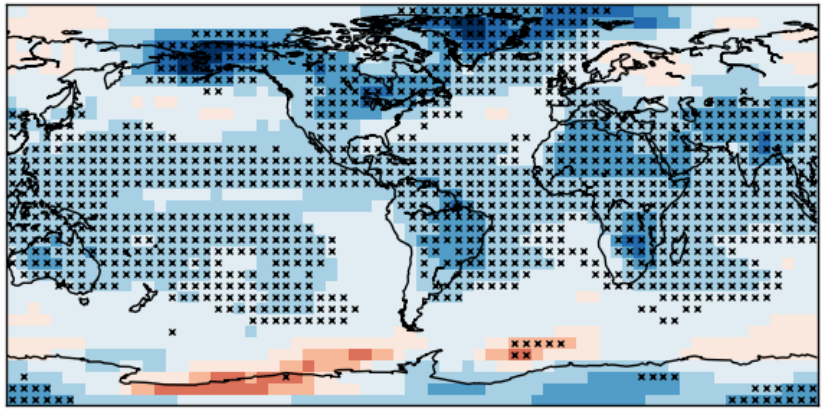


Illing et al (2018)

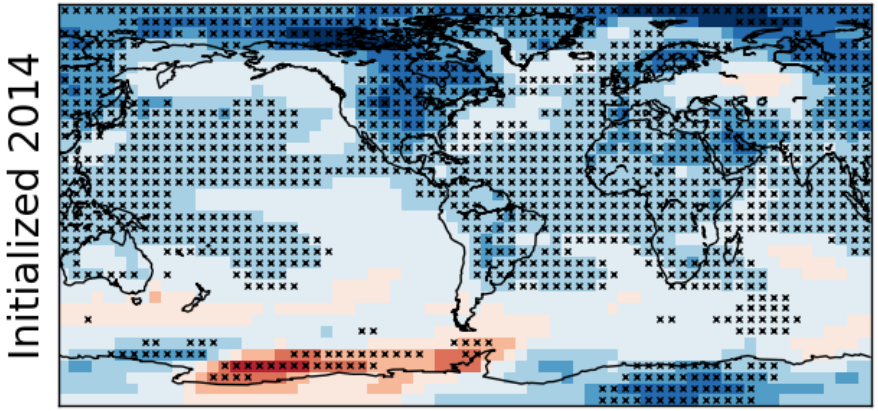
Near-Surface Air temperature Anomalies

Leadyear1-4

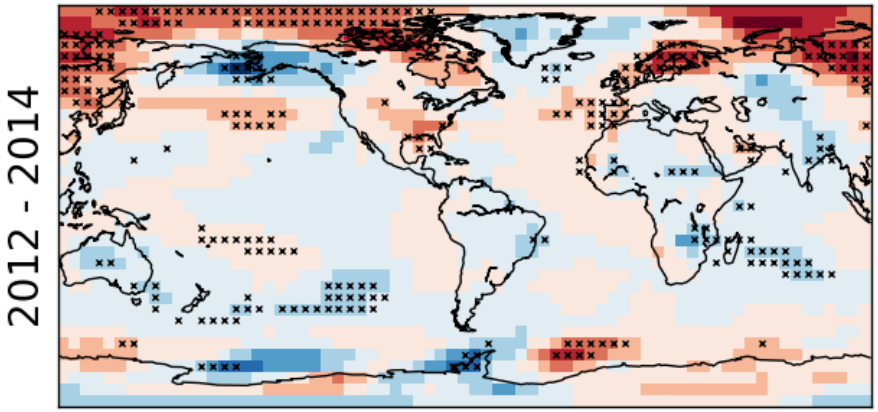
2012

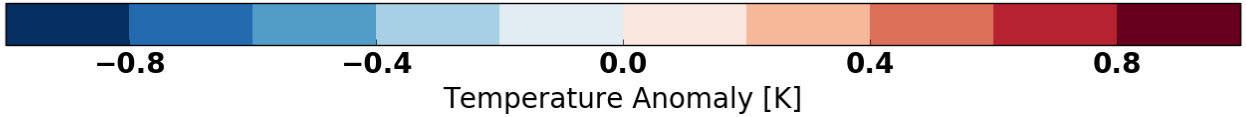


2014



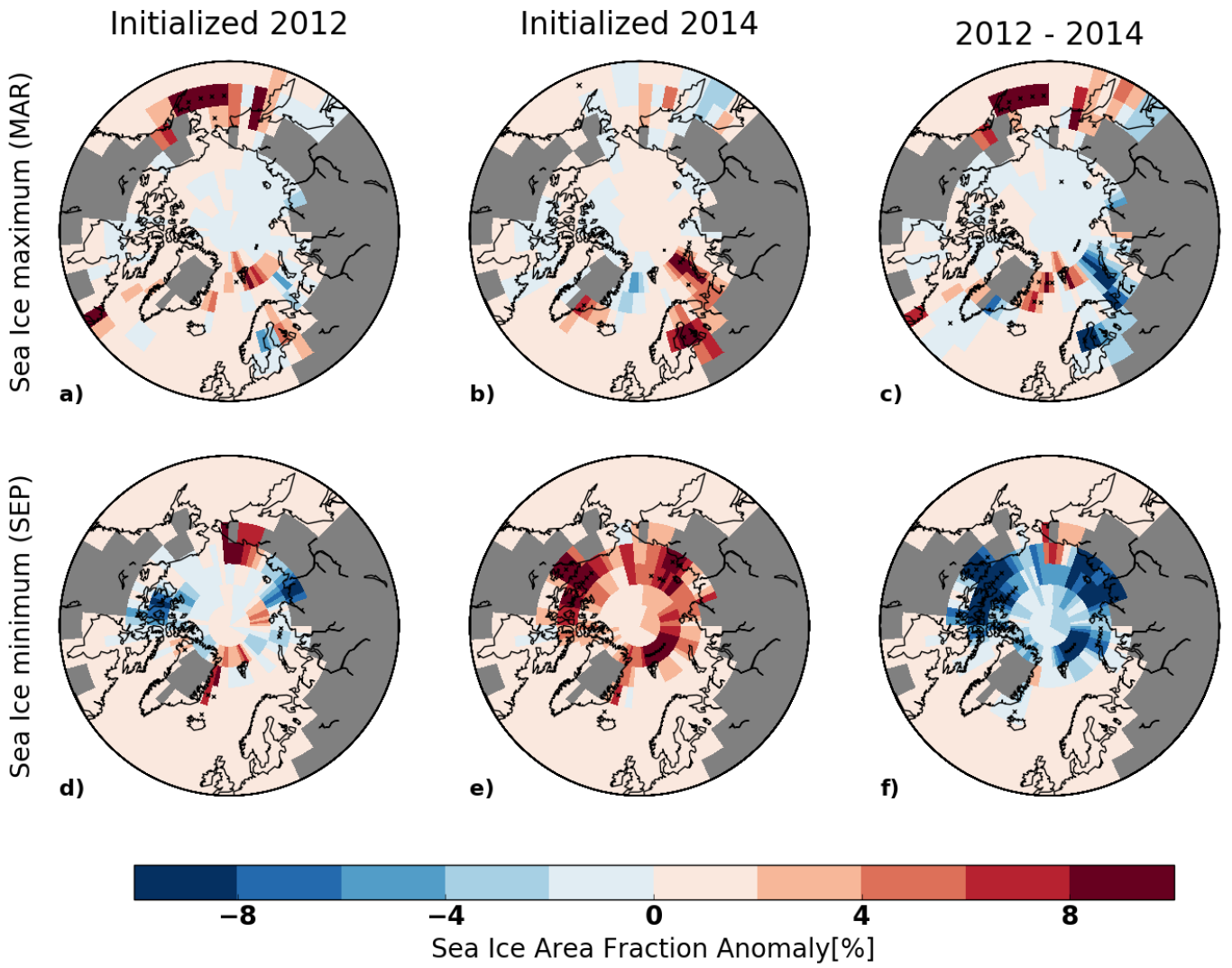
2012-2014





Illing et al (2018)

Sea Ice Area Fraction Anomaly (%)



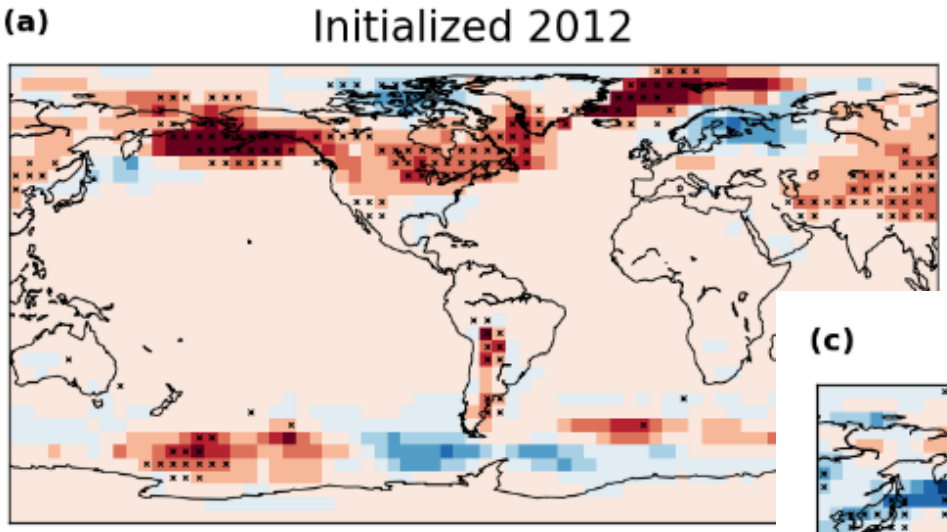
Max-Planck-Institut für Meteorologie

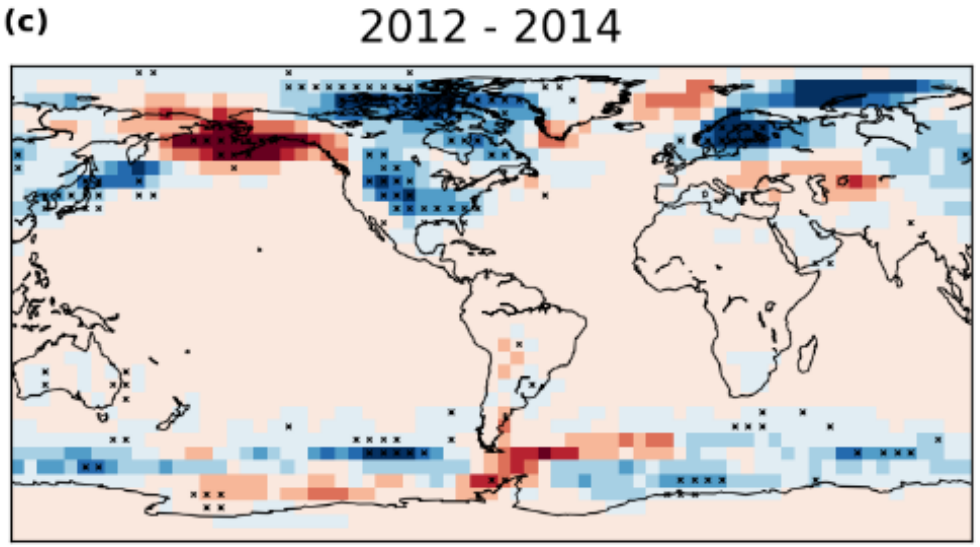
Illing et al (2018)

FONA Mittelfristige Klimaprognosen BMBF

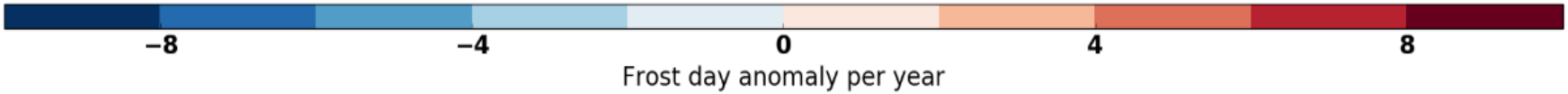
MiKlip

Number of Frost days





.....



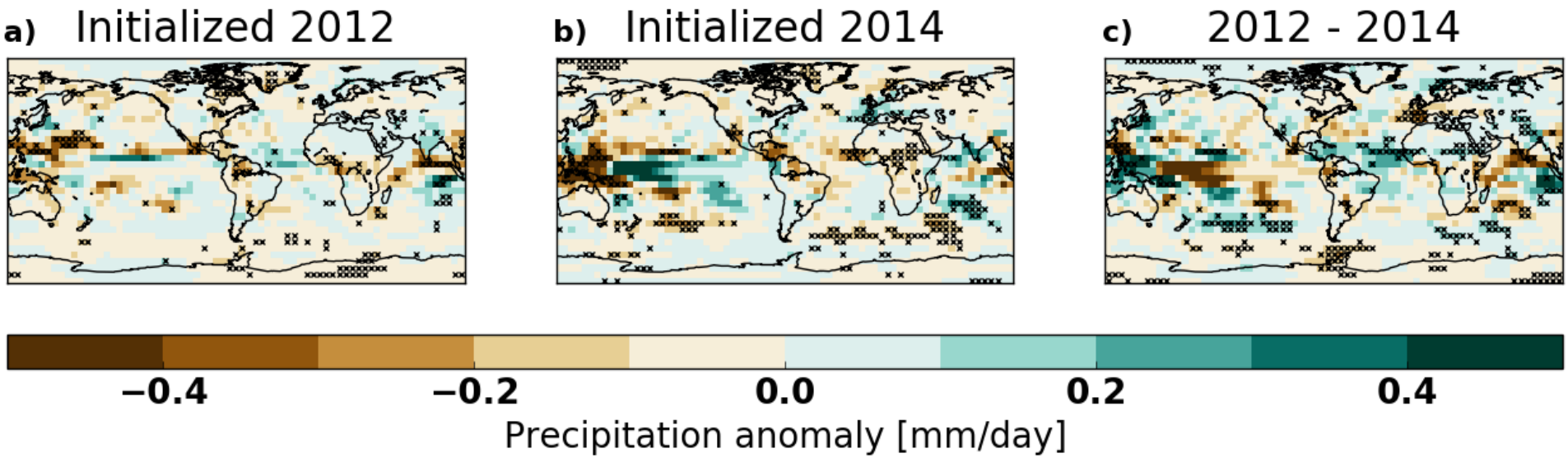
Max-Planck-Institut für Meteorologie

Illing et al (2018)

FONA Mittelfristige Klimaprognosen BMBF

MiKlip

Precipitation Anomaly (mm/day)



- Strongest drying over the tropics (more pronounced in 2014)
- Wetting over Western Europe in 2014 initialization

Max-Planck-Institut für Meteorologie

Illing et al (2018)

FONA Mittelfristige Klimaprognosen BMBF

MiKlip

Summary Future Eruption Experiments

Volcanic eruptions have an impact on decadal predictions.

Pre-eruption climate conditions play an important role for regional decadal predictions of surface temperature, sea ice content, frost days, and precipitation for the whole forecast period.

One of the most substantial differences is found in the predictions of minimum sea ice area fraction. A negative PDO - as in the 2012 initialized experiments - brings colder temperatures to Alaska and strengthens the Arctic wintertime warming.

No clear link between the different initial states of the NAO and one of these changes.

Dependency of other factors ENSO, QBO are neglected