Long-term El Niño forecasting

Josef Ludescher

Potsdam Institute for Climate Impact Research
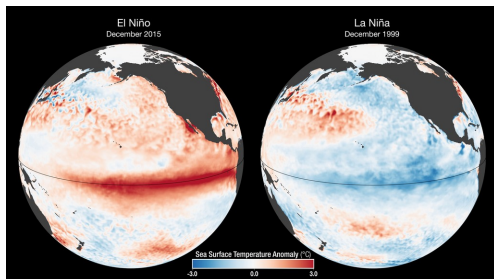
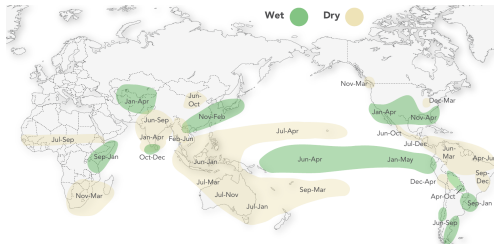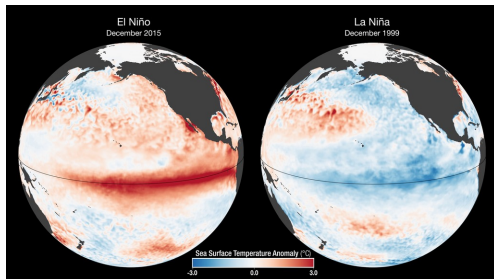Member of Leibniz Association

B-EPiCC
BRAZIL EAST AFRICA PERU INDIA
CLIMATE CAPACITIES

Supported by:
Federal Foreign Office

on the basis of a decision
by the German Bundestag

IKI INTERNATIONAL CLIMATE INITIATIVE

El Niño Southern Oscillation

El Niño Southern Oscillation

Floodings   Agriculture   Fresh Water & Power   Fisheries

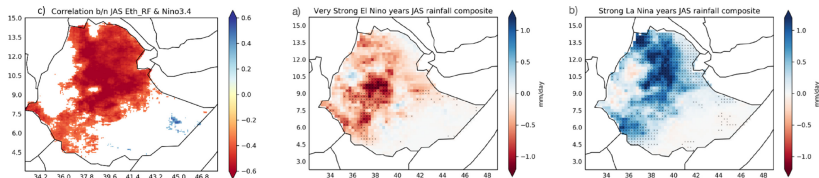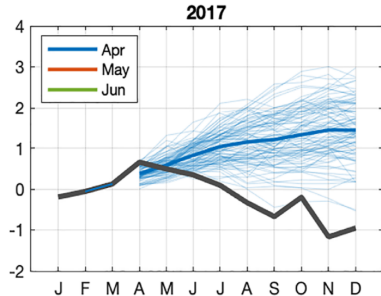Infrastructure   Wildfires   Public health   Biodiversity

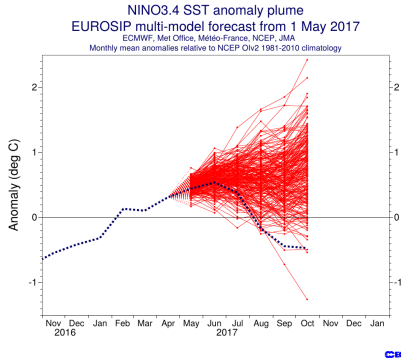# Impact of El Niño on Kiremt

- Single main rain season (June-September) for central and northwestern Ethiopia

- Accounts for 65% to 95% of all Ethiopian annual rainfall

- Up to 50% of variability due to ENSO [Gleixner et al. (2017)]

Spring predictability barrier
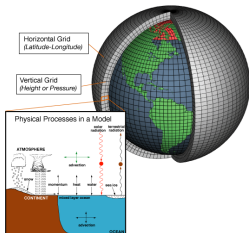

El Niño predictions before or during the boreal spring are particularly challenging

Figs: ECMWF, Tippett et al., GRL 2020

Dynamical models

- are initialized by observations

- simulate directly the development of physical quantities
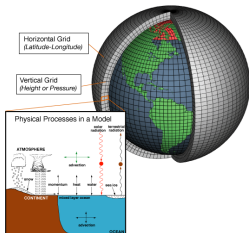
Two kinds of El Niño prediction models

Dynamical models

- are initialized by observations

- simulate directly the development of physical quantities

Statistical models
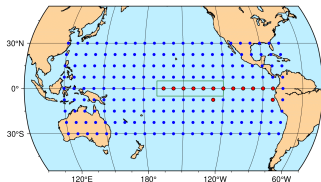
- use statistical relationships within the observational data
- In our case: regard data as a network

Climate network forecasting performance
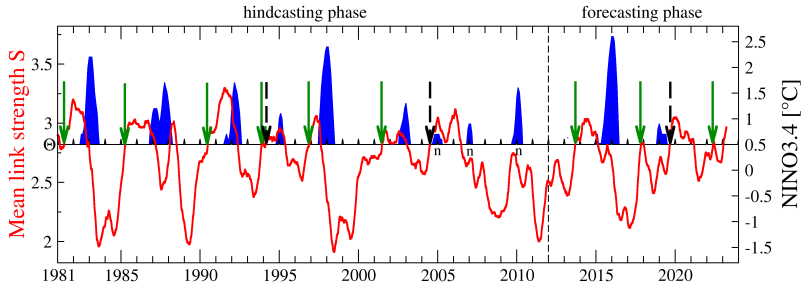
Climate network forecasting performance
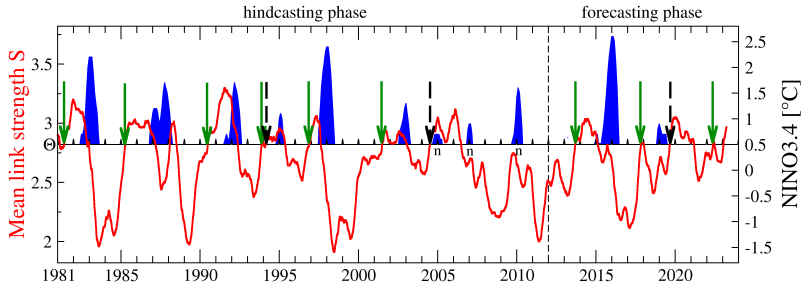
In total, 10 out of our 11 forecasts were correct ($p = 0.017$)

p-value (hindcast + forecast) = $3.5 \cdot 10^{-5}$

Climate network forecasting performance
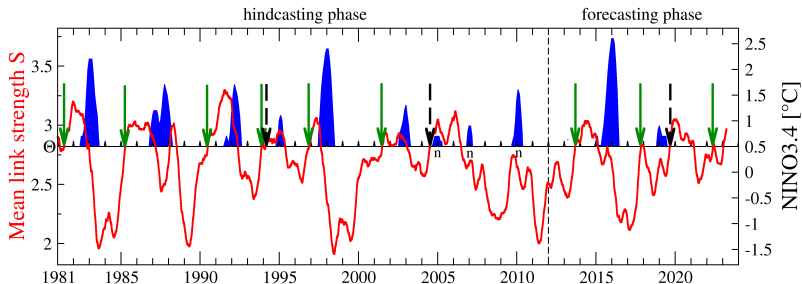
In total, 10 out of our 11 forecasts were correct ($p = 0.017$)

p-value (hindcast + forecast) = $3.5 \cdot 10^{-5}$

In June 2022, the method forecasted the onset of an El Niño in 2023

Climate network forecasting performance

In total, 10 out of our 11 forecasts were correct ($p = 0.017$)

p-value (hindcast + forecast) = $3.5 \cdot 10^{-5}$

In June 2022, the method forecasted the onset of an El Niño in 2023

- El Niño **magnitude**

- El Niño **type**

Very early warning of a moderate-to-strong El Niño in 2023
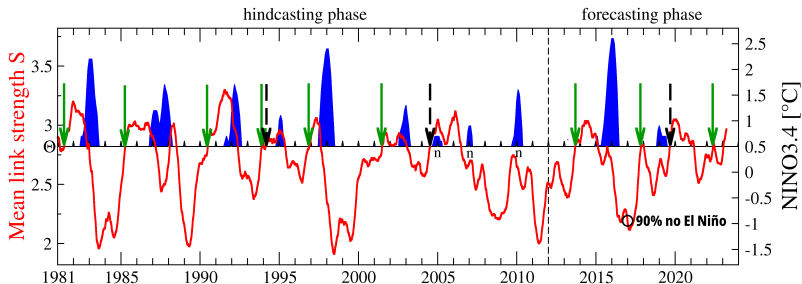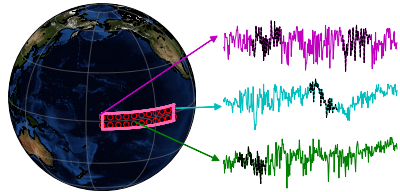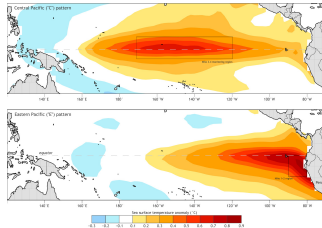
Josef Ludescher[1], Jun Meng[2], Jingfang Fan[3], Armin Bunde[4], and Hans Joachim Schellnhuber[1]

[1] Potsdam Institute for Climate Impact Research, 14412 Potsdam, Germany
[2] School of Science, Beijing University of Posts and Telecommunications, Beijing 100876, China
[3] School of Systems Science, Beijing Normal University, 1000875 Beijing, China
[4] Institute for Theoretical Physics, Justus Liebig Universität Gießen, 35392 Gießen, Germany

Abstract

The El Niño Southern Oscillation (ENSO) is the strongest driver of year-to-year variations of the global climate and can lead to extreme weather conditions and disasters in various regions around the world. Here, we review two different approaches for the early forecast of El Niño that we have developed recently: the climate network-based approach [1] allows forecasting the onset of an El Niño event about 1 year ahead, while the complexity-based approach [2] allows additionally to estimate the magnitude of an upcoming El Niño event in the calendar year before. For 2023, both approaches predict the onset of an El Niño event, with a combined onset probability of about 89%. The complexity-based approach predicts a moderate-to-strong El Niño with a magnitude of $1.49 \pm 0.37°C$. Since El Niño events temporarily increase the global temperature, we expect that the coming El Niño will increase the global temperature by about $+0.2°C$, likely making 2024 the hottest year since the beginning of instrumental observations. It is possible that as a consequence of this El Niño, the $+1.5°C$ target (compared to pre-industrial levels) will be temporarily breached already in 2024.

Our forecast, data until Nov 2022:

- El Niño onset with 89% probability

- Moderate-to-strong ($1.49 \pm 0.37°C$)

- Eastern Pacific type 86% prob.

Very early warning of a moderate-to-strong El Niño in 2023

Josef Ludescher[1], Jun Meng[2], Jingfang Fan[3], Armin Bunde[4], and Hans Joachim Schellnhuber[1]

[1] Potsdam Institute for Climate Impact Research, 14412 Potsdam, Germany
[2] School of Science, Beijing University of Posts and Telecommunications, Beijing 100876, China
[3] School of Systems Science, Beijing Normal University, 1000875 Beijing, China
[4] Institute for Theoretical Physics, Justus Liebig Universität Gießen, 35392 Gießen, Germany

Abstract

The El Niño Southern Oscillation (ENSO) is the strongest driver of year-to-year variations of the global climate and can lead to extreme weather conditions and disasters in various regions around the world. Here, we review two different approaches for the early forecast of El Niño that we have developed recently: the climate network-based approach [1] allows forecasting the onset of an El Niño event about 1 year ahead, while the complexity-based approach [2] allows additionally to estimate the magnitude of an upcoming El Niño event in the calendar year before. For 2023, both approaches predict the onset of an El Niño event, with a combined onset probability of about 89%. The complexity-based approach predicts a moderate-to-strong El Niño with a magnitude of 1.49 ± 0.37°C. Since El Niño events temporarily increase the global temperature, we expect that the coming El Niño will increase the global temperature by about +0.2°C, likely making 2024 the hottest year since the beginning of instrumental observations. It is possible that as a consequence of this El Niño, the +1.5°C target (compared to pre-industrial levels) will be temporarily breached already in 2024.

NOAA Coral Reef Watch Daily 5km SST Anomalies (v3.1) 1 May 2023

Our forecast, data until Nov 2022:

- El Niño onset with 89% probability

- Moderate-to-strong (1.49±0.37°C)

- Eastern Pacific type 86% prob.

Figs: JL et al., arXiv:2301.10763; NOAA

Forecast for 2023:

Very early warning of a moderate-to-strong El Niño in 2023

Josef Ludescher[1], Jun Meng[2], Jingfang Fan[3], Armin Bunde[4], and Hans Joachim Schellnhuber[1]

[1]Potsdam Institute for Climate Impact Research, 14412 Potsdam, Germany
[2]School of Science, Beijing University of Posts and Telecommunications, Beijing 100876, China
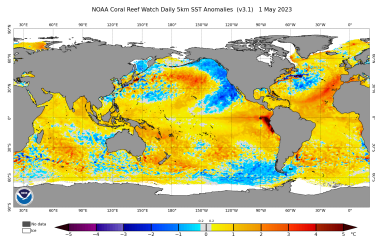[3]School of Systems Science, Beijing Normal University, 1000875 Beijing, China
[4]Institute for Theoretical Physics, Justus Liebig Universität Gießen, 35392 Gießen, Germany

Abstract

The El Niño Southern Oscillation (ENSO) is the strongest driver of year-to-year variations of the global climate and can lead to extreme weather conditions and disasters in various regions around the world. Here, we review two different approaches for the early forecast of El Niño that we have developed recently: the climate network-based approach [1] allows forecasting the onset of an El Niño event about 1 year ahead, while the complexity-based approach [2] allows additionally to estimate the magnitude of an upcoming El Niño event in the calendar year before. For 2023, both approaches predict the onset of an El Niño event, with a combined onset probability of about 89%. The complexity-based approach predicts a moderate-to-strong El Niño with a magnitude of $1.49 \pm 0.37°C$. Since El Niño events temporarily increase the global temperature, we expect that the coming El Niño will increase the global temperature by about $+0.2°C$, likely making 2024 the hottest year since the beginning of instrumental observations. It is possible that as a consequence of this El Niño, the $+1.5°C$ target (compared to pre-industrial levels) will be temporarily breached already in 2024.

NOAA Coral Reef Watch Daily 5km SST Anomalies (v3.1) 1 May 2023

Our forecast, data until Nov 2022:

- El Niño onset with 89% probability

- Moderate-to-strong ($1.49 \pm 0.37°C$)

- Eastern Pacific type 86% prob.

WMO, "Prepare for El Niño", May 2023:

- "80% between July and September"

- "At this stage there is no indication of the strength"

Figs: JL et al., arXiv:2301.10763; NOAA

Summary
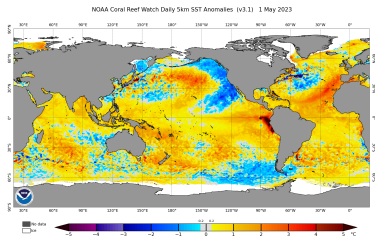
Skillful probabilistic El Niño forecasts across the spring barrier are possible:

- The climate network approach can forecast the **onset** of an El Niño event or its absence about 1 year in advance

- Forecasting the **magnitude** and **type** are also possible in the calendar year before onset