CCLM Simulations over Southern Africa - Impact of the Agulhas Leakage on precipitation and sea surface temperatures

- CLM General Assembly 2021 -

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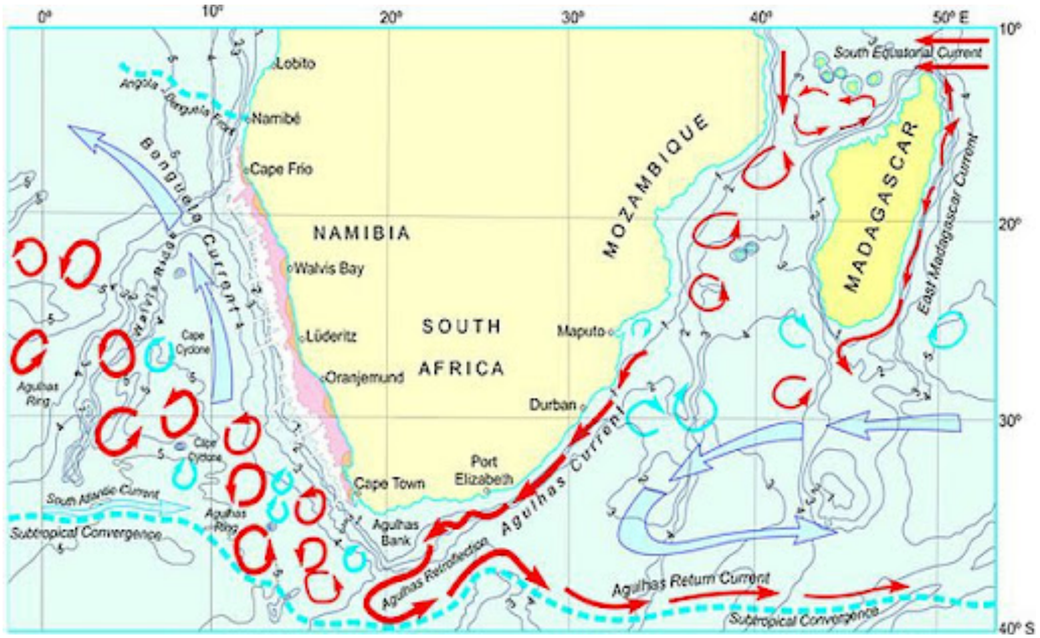
Motivation

- CASISAC Project: Changes in the Agulhas System and its Impact on Southern African Coasts
  - Subproject Hereon: Regional atmospheric modelling and precipitation changes
- Agulhas Current System: warm water current along the South African coast that connects the Indian Ocean with the Atlantic Ocean
- Precipitation: one of the most important variables for stake holders
- Extremes: droughts, heavy rainfall and tropical cyclone



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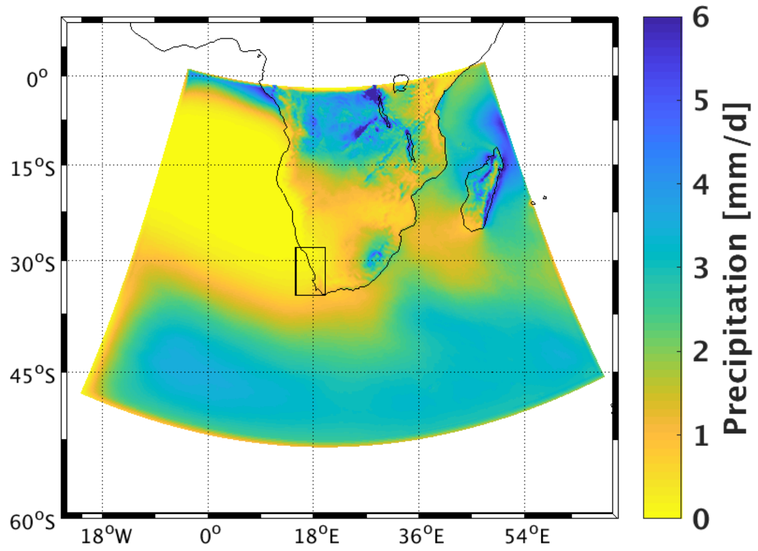
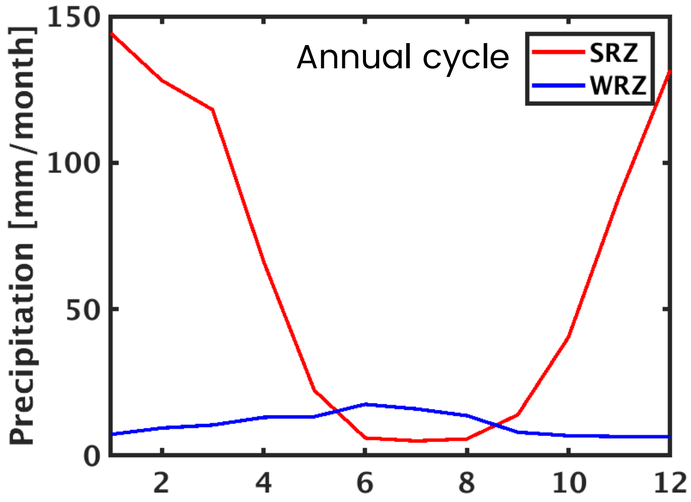
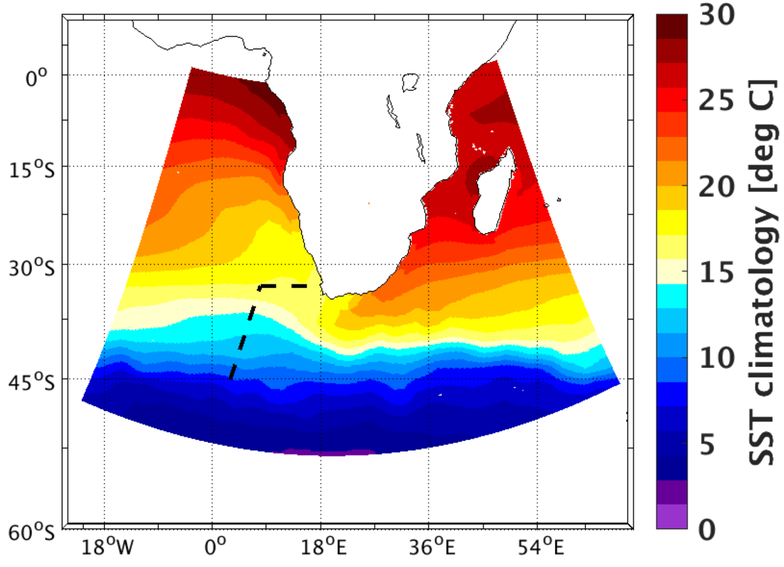
CCLM simulations

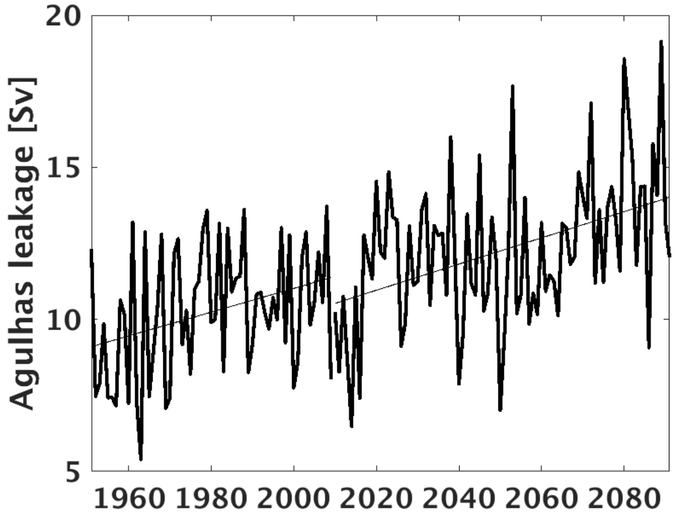
- CCLM simulations:
  - Hindcast: 1958 - 2019 (driven by JRA55 reanalysis)
  - Historical: 1951 - 2013 (driven by global coupled model FOCI)
  - Future scenario: 2014 - 2099, RCP8.5 (driven by global coupled model FOCI)
- Model version 5.0 clm10
- 10W - 55E, 0S - 55S
- 16 km horizontal resolution
- 36 vertical layers (up to 30000m)
- Hourly output
- Spectral nudging





Agulhas Leakage





Simple linear regression:

$$Prec(t) = Prec_mean + a\,AL(t) + b(t)$$

- Prec(t) is precipitation over the 5 year period
- Prec_mean is climatological mean of precipitation
- AL(t) is the Agulhas Leakage intensity over the 5 year period
- a is the regression slope
- b(t) is the part of the precipitation that is not related to the Agulhas Leakage

The portion of variability in precipitation that can then linearly attributed to the Agulhas Leakage Prec_AL is:

$$Prec_AL(t) = a\,AL(t)$$

(Same for sea surface temperatures by replacing Precip by SST)

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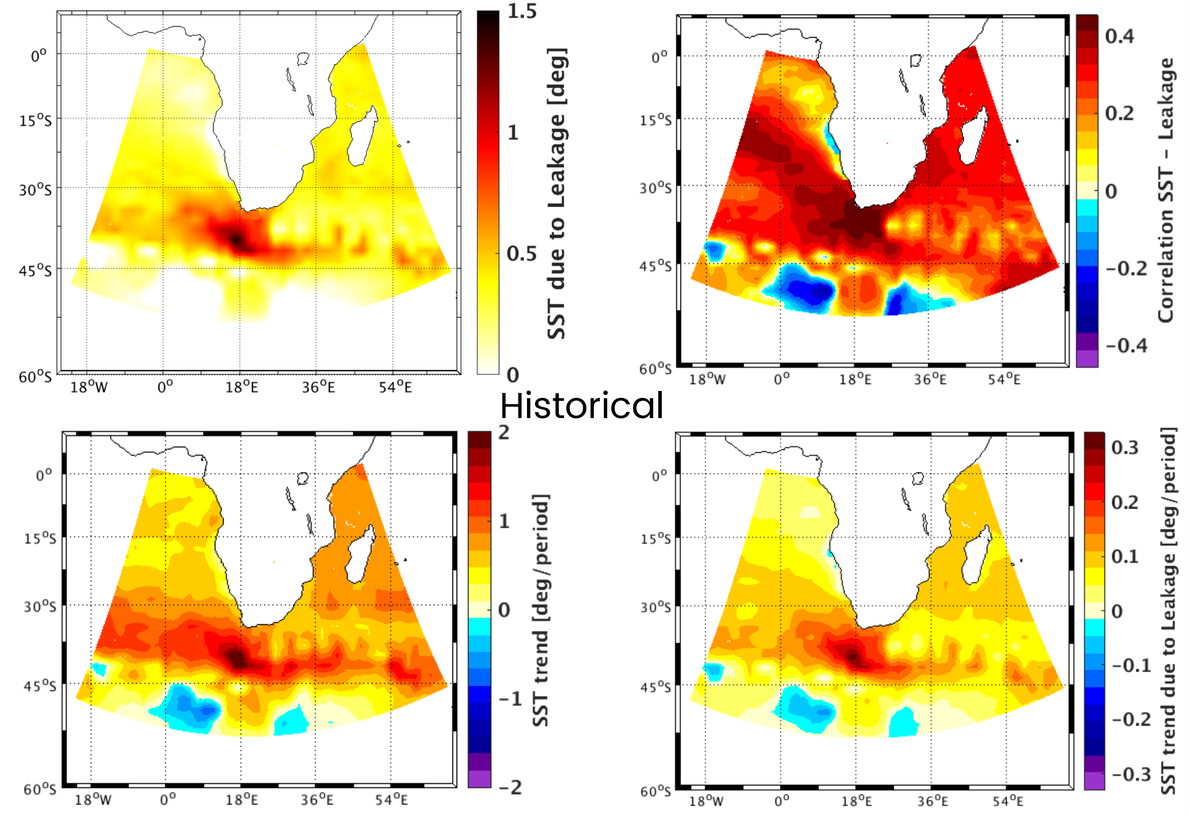
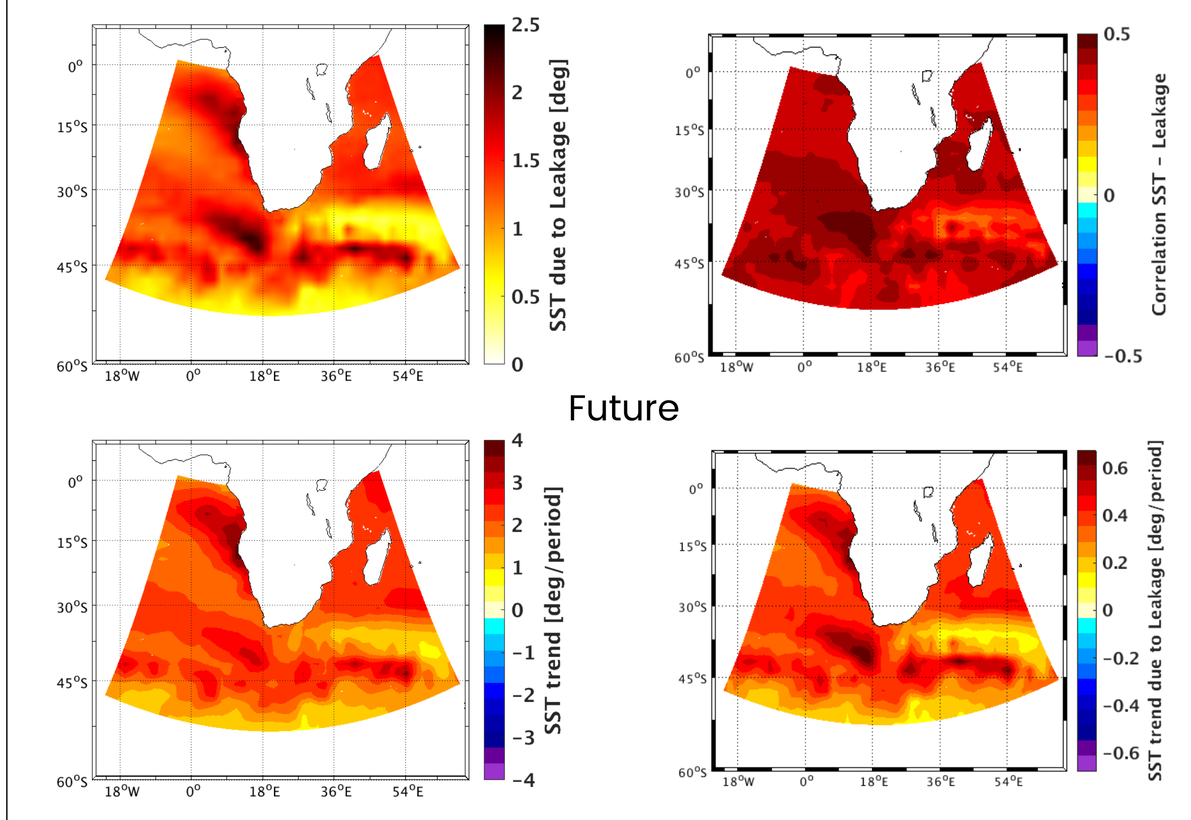
Agulhas Leakage impact on SST

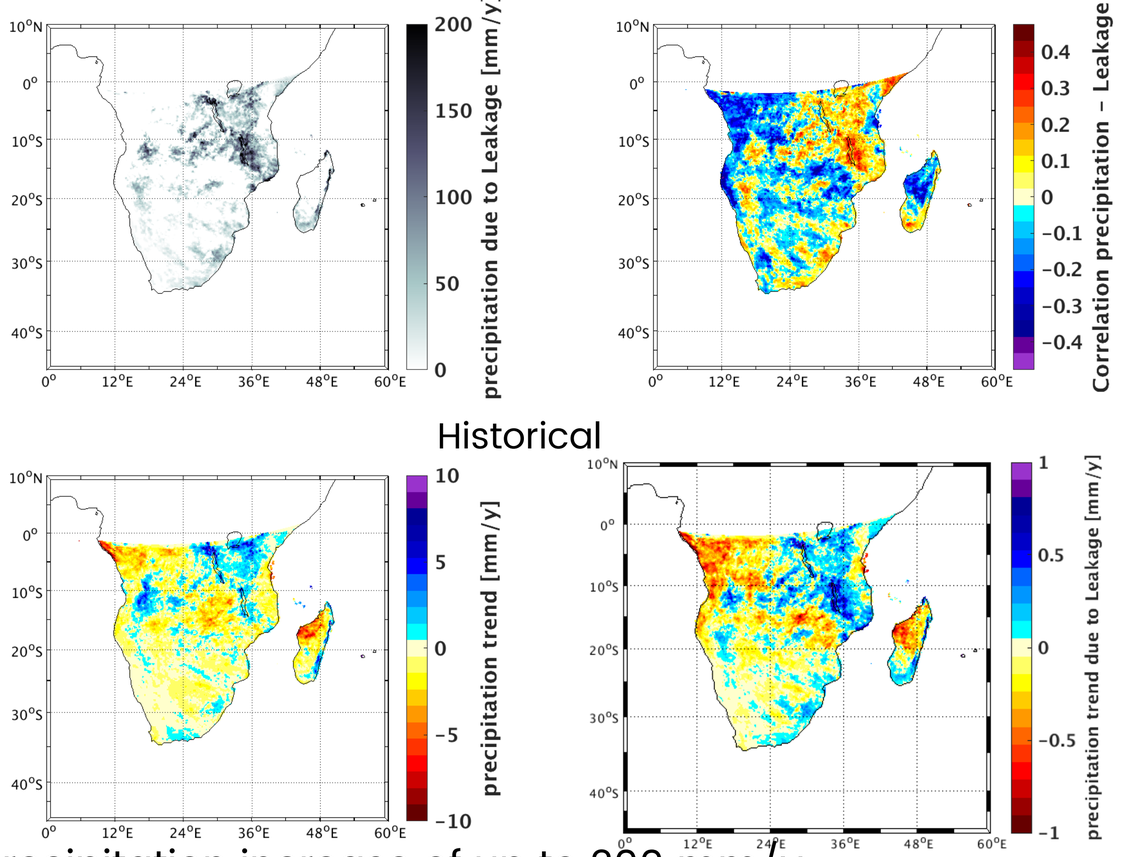


- SST increase of up to 1.5°C
- Positively correlated with 0.4
- Warming of up to 2°C
- 1/6 of the trend due to AL



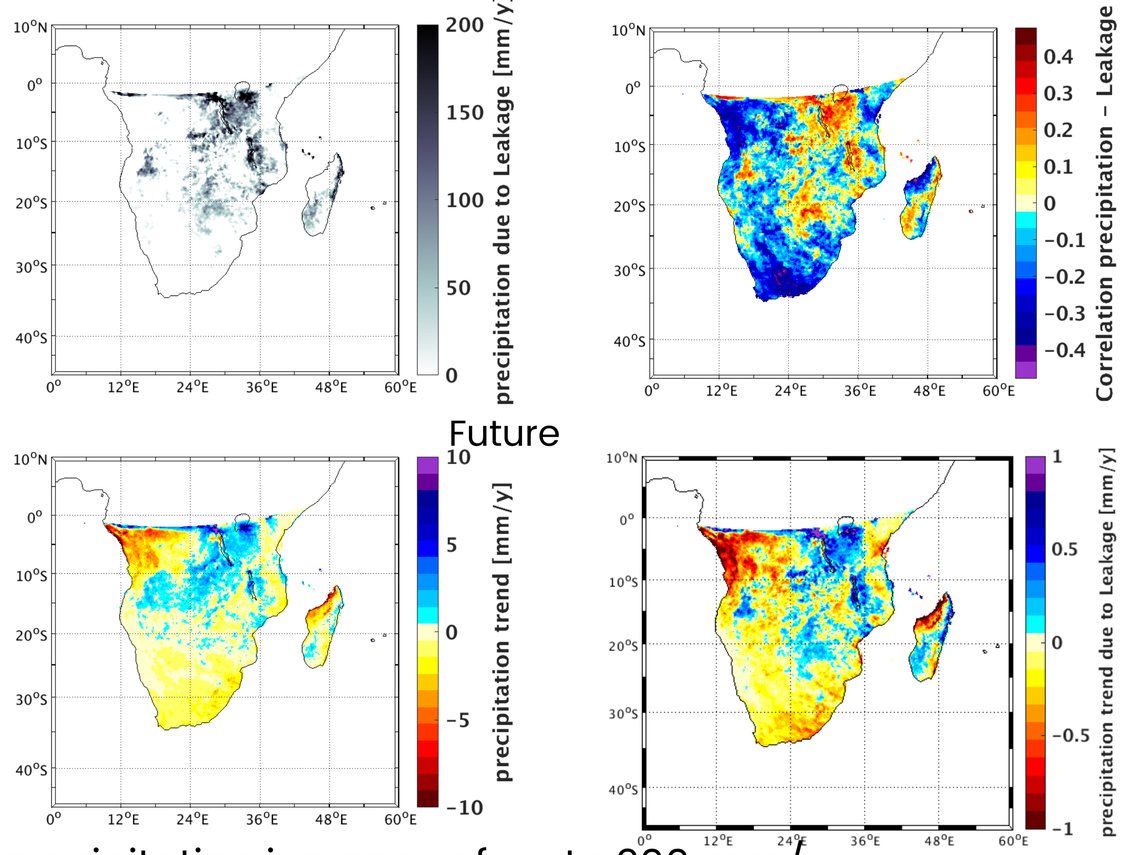
- SST increase of up to 2.5°C
- Positively correlated with 0.5
- Warming of up to 4°C
- 1/6 of the trend due to AL

Agulhas leakage impact on precipitation



Historical

- precipitation increase of up to 200 mm/y
- Positively correlated at SE coast and negatively in Cape region
- Wetting along southeast and drying in Cape region
- 1/10 of the trend due to Agulhas leakage

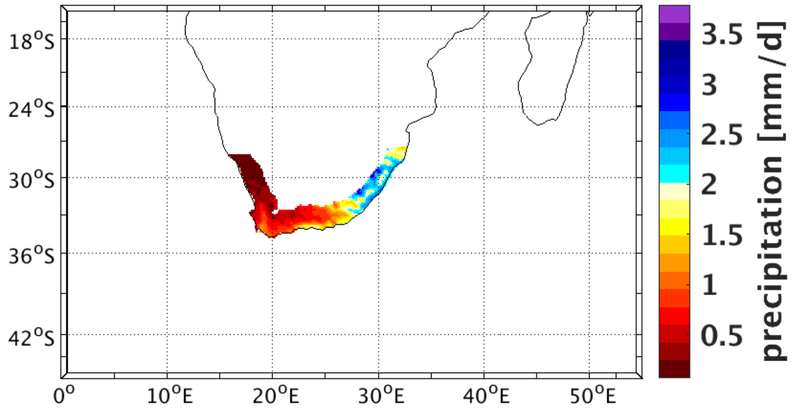


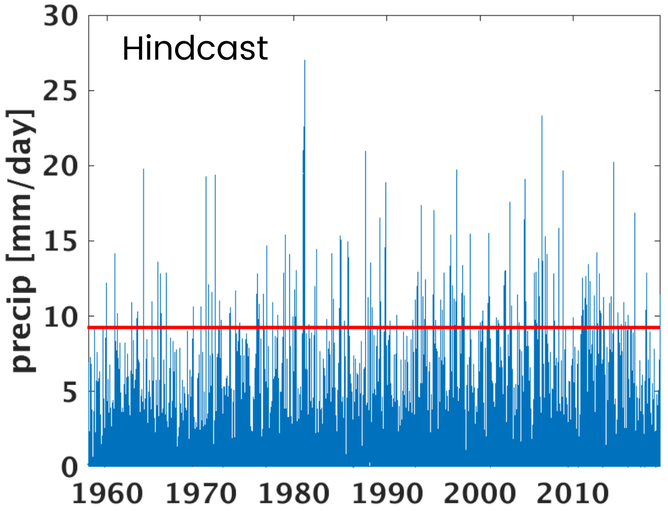
Future

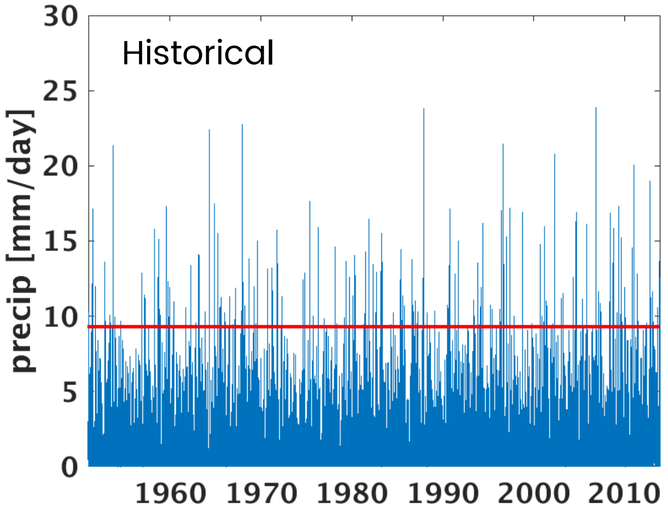
- precipitation increase of up to 200 mm/y
- Negatively correlated at coasts
- Drying in South Africa
- 1/10 of the trend due to Agulhas leakage

Precipitation extremes at the coast

- Extreme precipitation along the coast
- South of 28°S
- ~200 km wide coastal zone

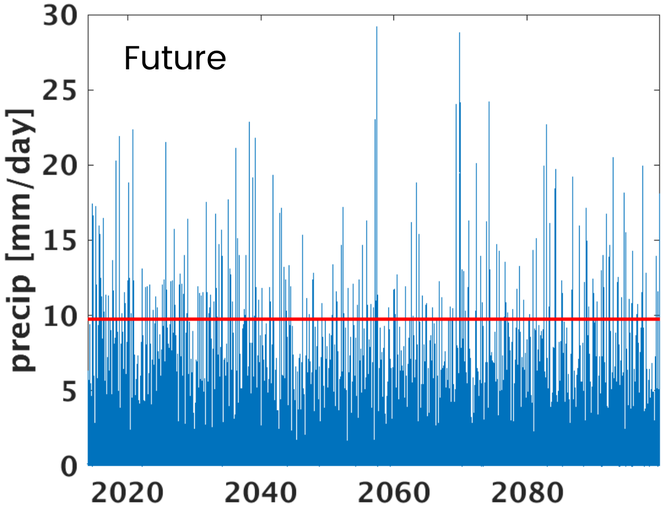




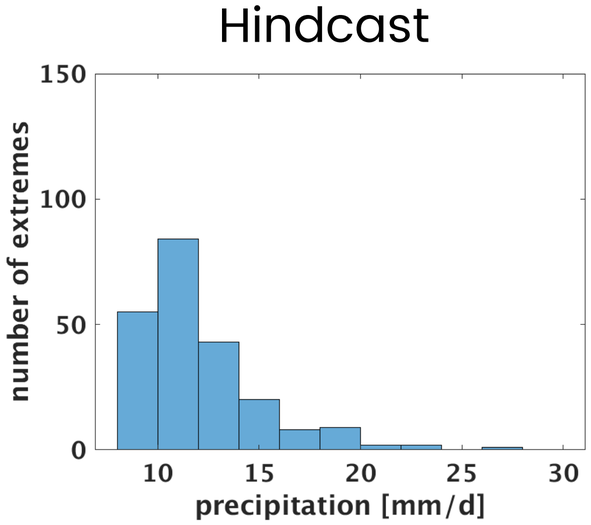


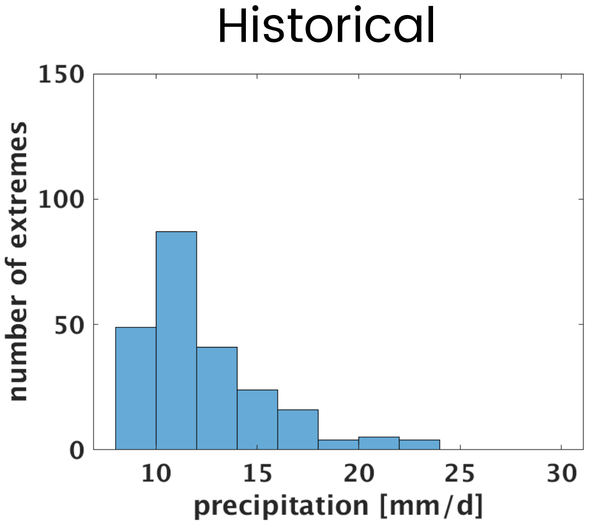
99th percentile:

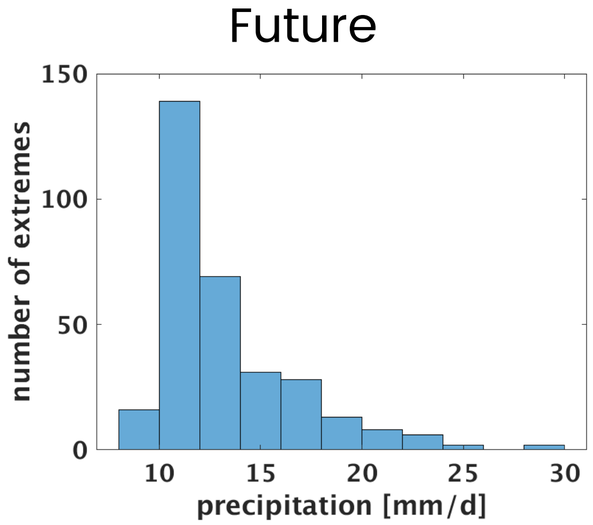
- Hindcast: 9.3 mm/d
- Historical: 9.4 mm/d
- Future: 9.8 mm/d

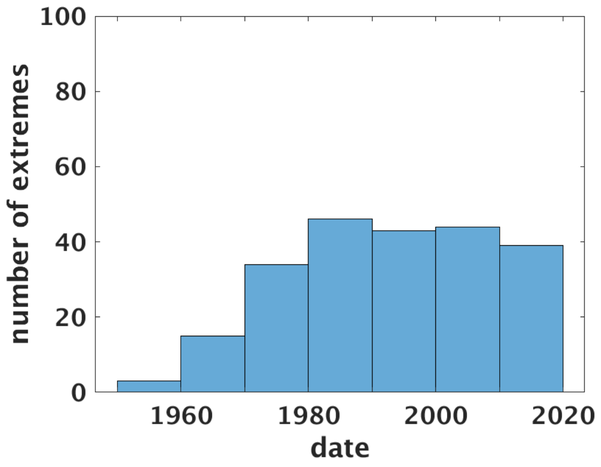


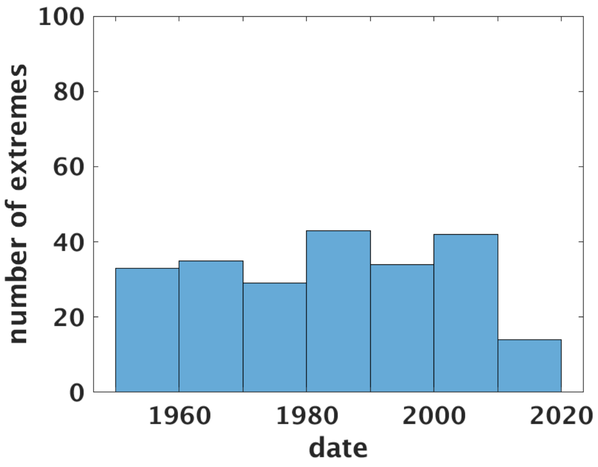
Precipitation extremes at the coast

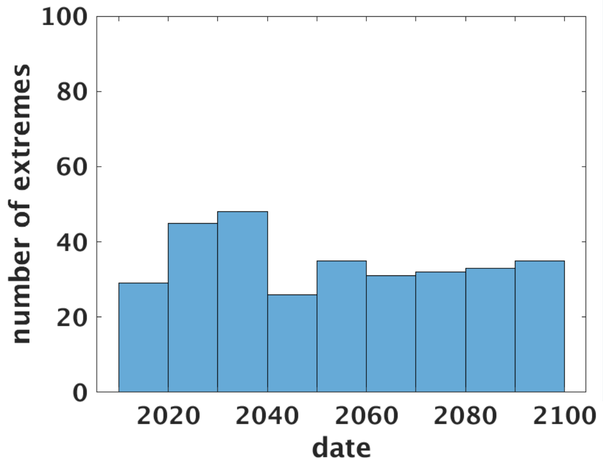












- Similar distribution in hindcast and historical
- More extremes after 1980 (hindcast)
- Equally distributed extremes in historical and future simulation

Precipitation extremes at the coast - Agulhas Leakage

Historical:

- Minimum Leakage:
  - 1963-1967: 5.5 Sv
  - 24 days of extreme precipitation
- Maximum Leakage:
  - 2008-2012: 13.7 Sv
  - 23 days of extreme precipitation

Future:

Minimum Leakage:

2018-2022: 6.6 Sv

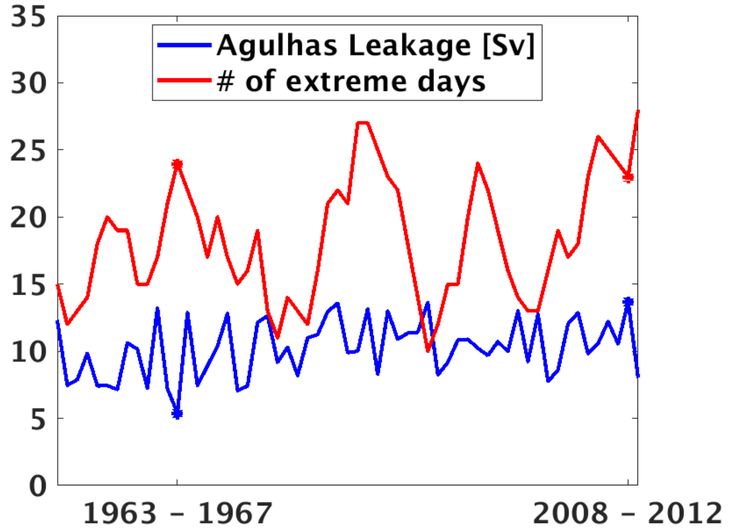
20 days of extreme precipitation

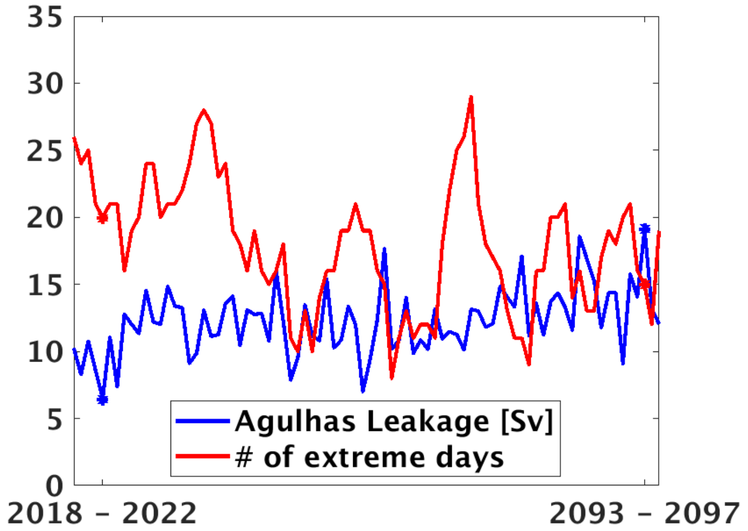
Maximum Leakage:

2093-2097: 19.0 Sv

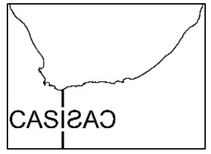
15 days of extreme precipitation

- Leakage maximum at the end of simulation periods
- Leakage stronger in future than in historical
- No correlation between precipitation extremes and Agulhas Leakage



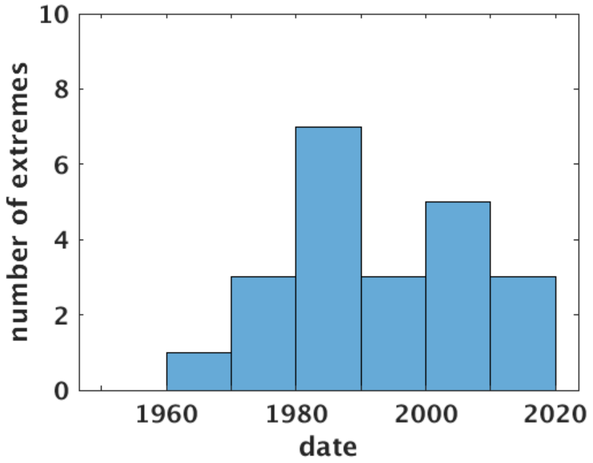


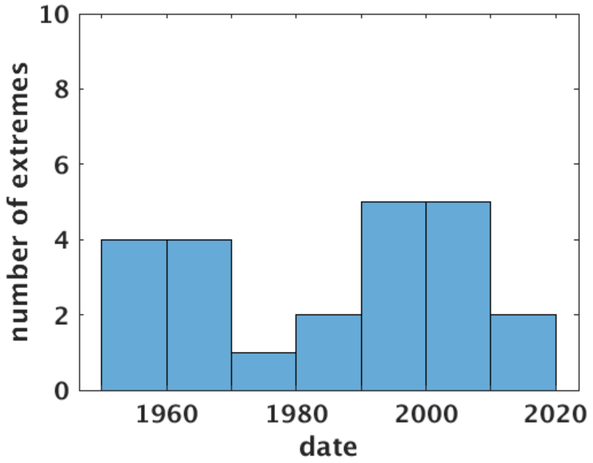
Precipitation extremes at the coast-99.9th percentile

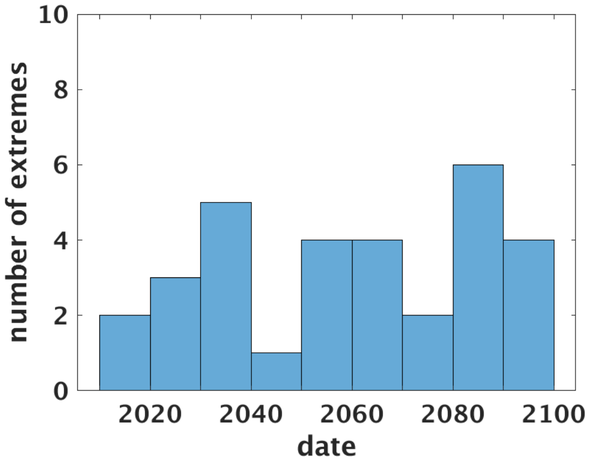


99.9th percentile:

- Hindcast: 15.9 mm/d
- Historical: 16.9 mm/d
- Future: 17.7 mm/d







- Stronger extremes in historical than hindcast
- Stronger extremes in future than historical
- Again more extremes after 1980 (hindcast)
- More extremes in 1950s/1960s the 1990s/2000s (historical)
- Slightly more extremes 2030s and 2080s (future)
- No correlation between precipitation extremes and Agulhas Leakage

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Take home message

- 3 CCLM simulations:
    - Hindcast: 1958 - 2019
    - Historical: 1951 - 2013
    - Future scenario: 2014 - 2099

- Precipitation and SST are impacted by the Agulhas Leakage
    - Correlations of up to 0.5
    - Warming of the ocean and reduction in precipitation can be with 1/6 and 1/10 explained by the Agulhas Leakage

- Extreme precipitation get slightly stronger in the future
- Extreme precipitation is not related to the Agulhas Leakage

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Outlook

- Agulhas Current and extremes
- Tropical cyclones
- Drought
- Regional differences in precipitation trends

Thank you.

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