Model (S2S to climate) representation of subtropical processes
Atmospheric temperature and moisture characteristics based on scaling relationships

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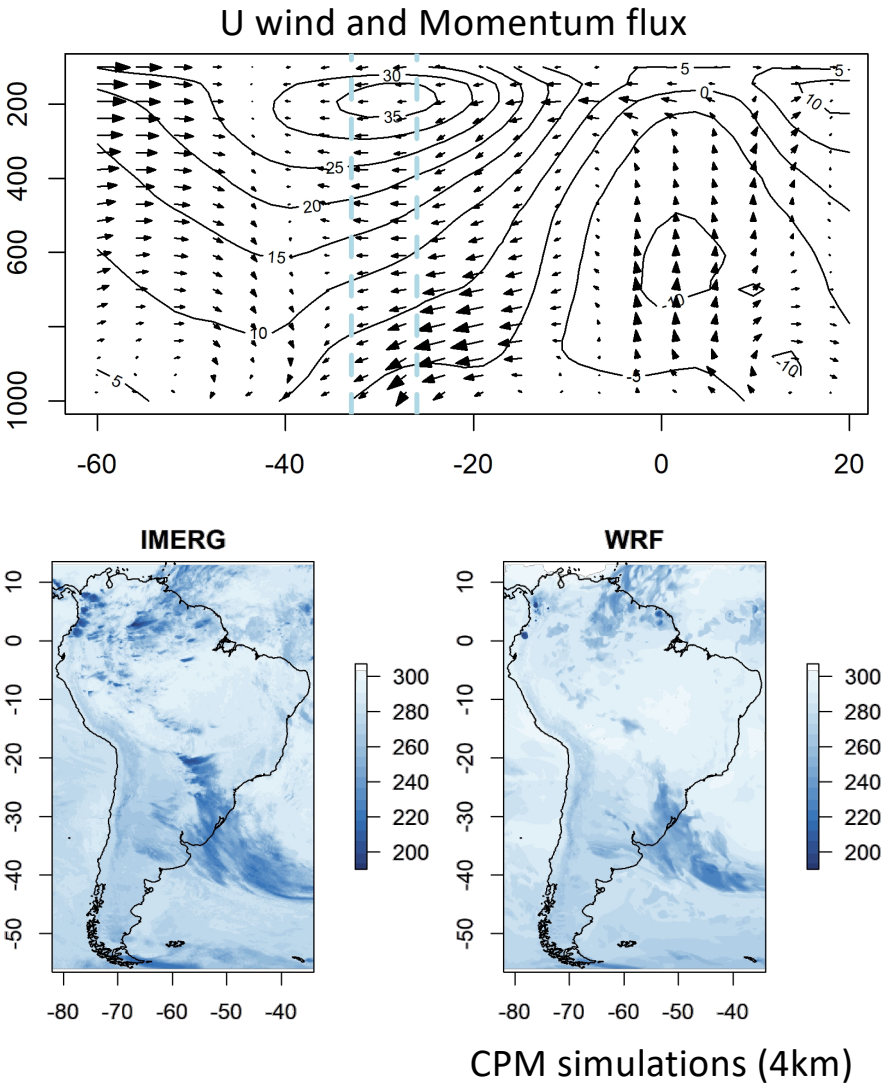
Our plan

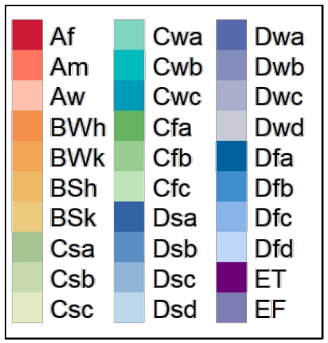
- Basic oscillating mechanisms for S2S to climate
- Some ideas of modelling techniques
- Emerging topics of subtropical regions for discussion
  - Luminita will provide new ideas for looking at scaling relationships

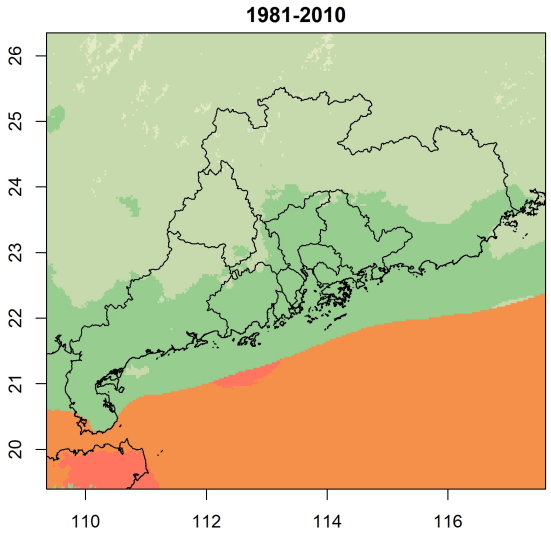


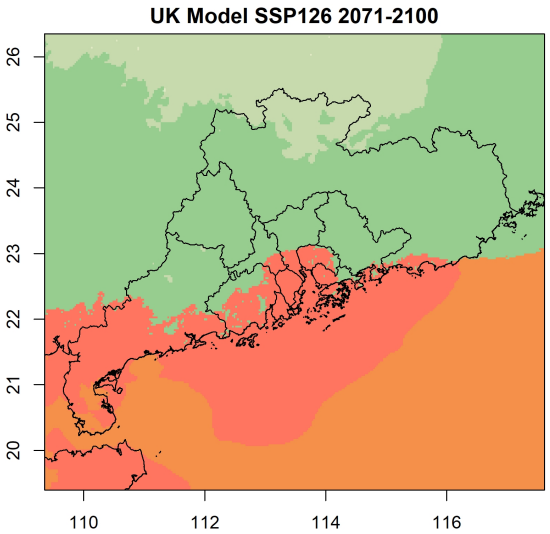
CPM simulations (4km)

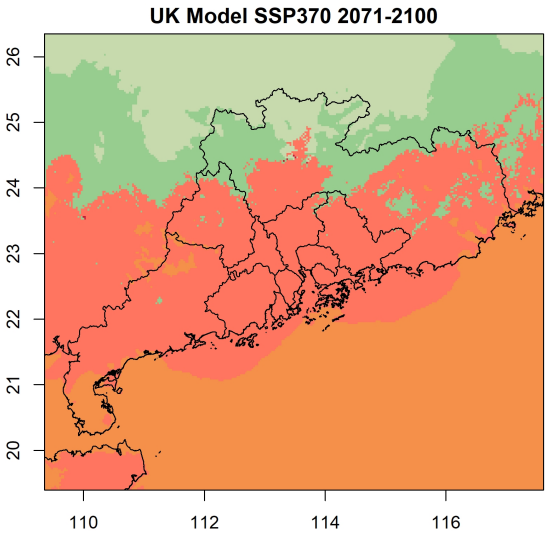
Climate change projections (CMIP6 downscaled to 1km)

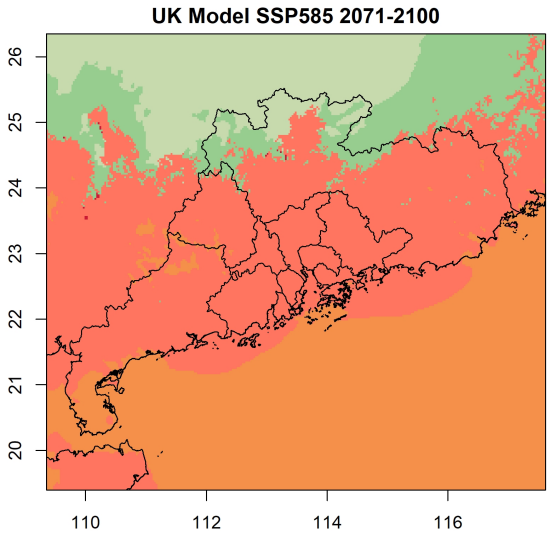
- Shifting Koeppen regions
- Subtropical climate (Green)
- Tropical climate (Orange)











Köppen Geiger after Peel, M. C., Finlayson, B. L., McMahon, T. A. (2007): Updated world map of the Koeppen-Geiger climate classification. Hydrology and earth system sciences discussions, 4(2), 439-473.

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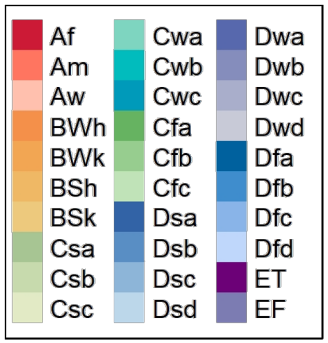

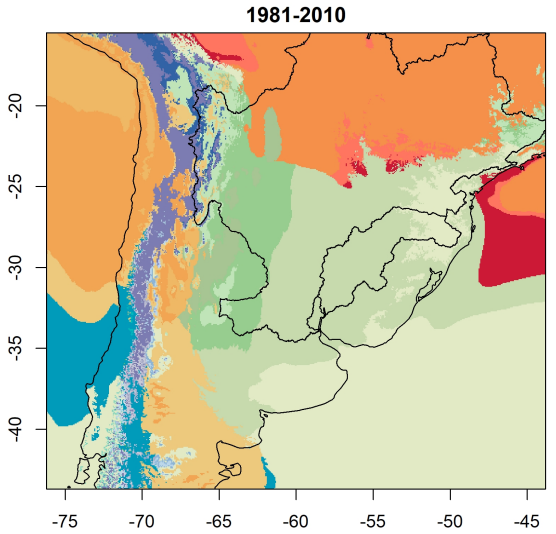

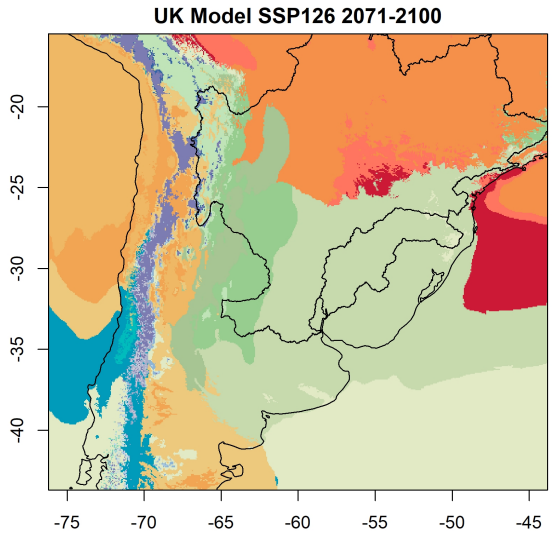

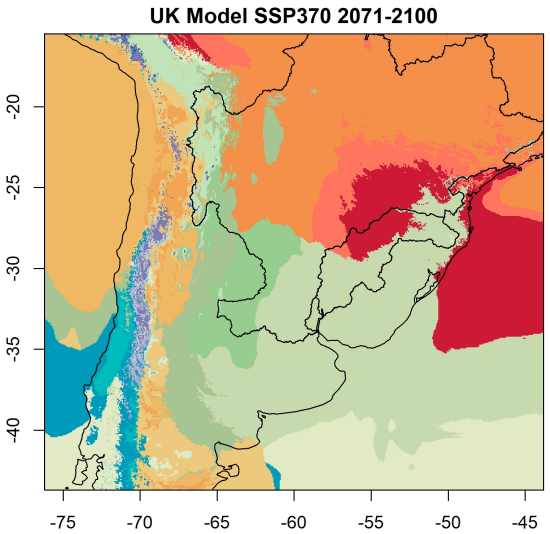

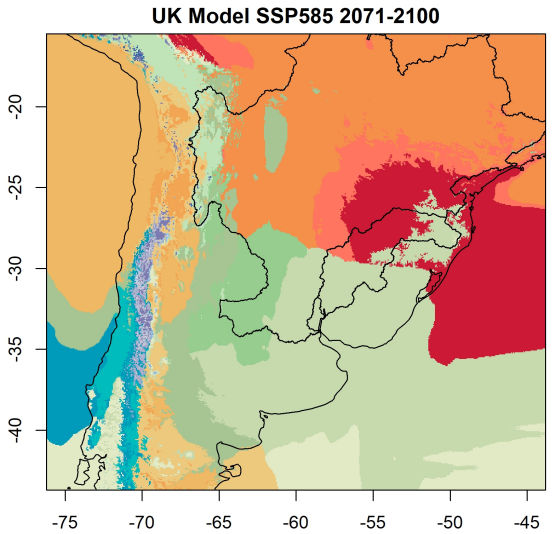

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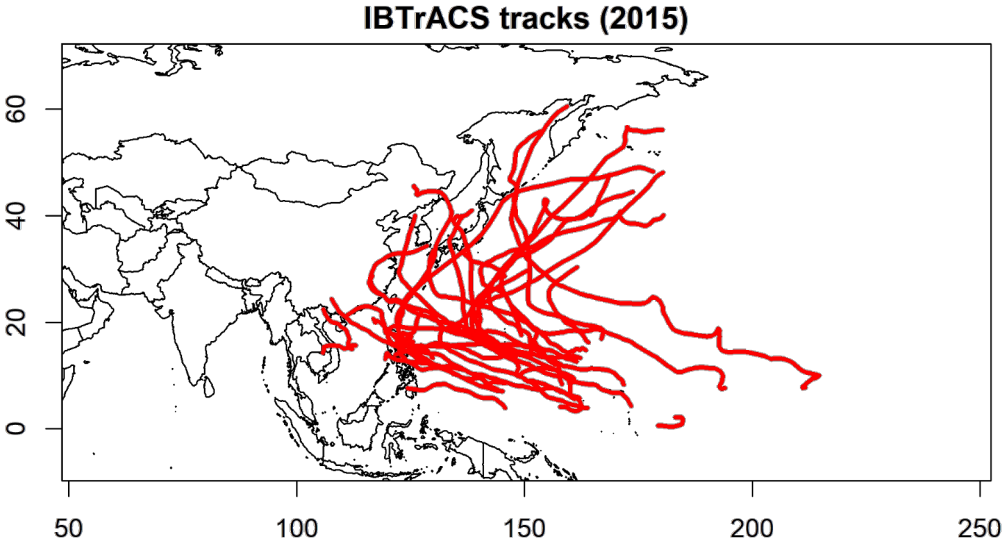
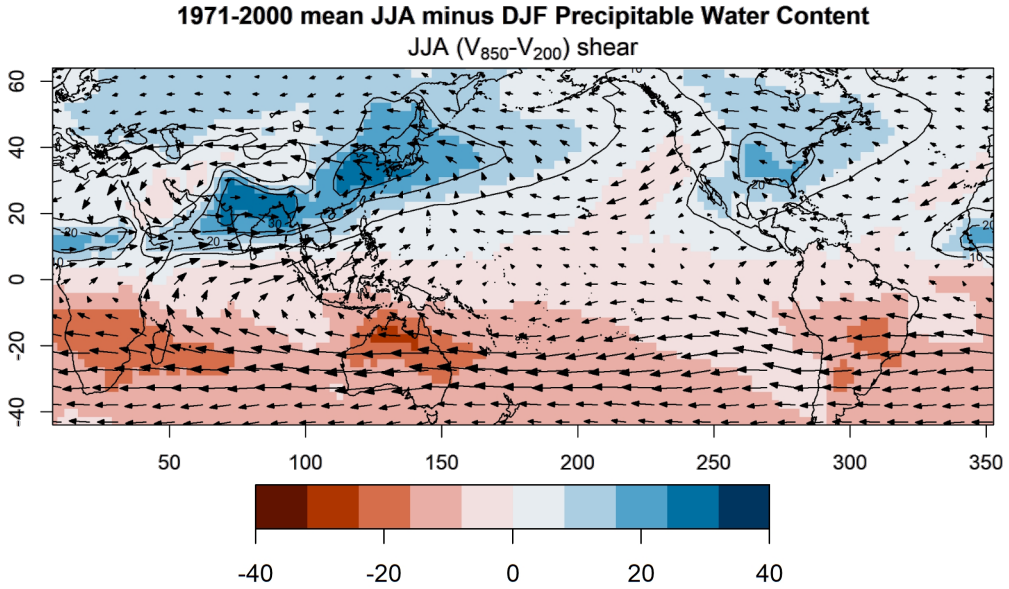
Mechanisms

- Tropical
  - Trade wind
  - Typhoons
- Midlatitude
  - Westerlies
  - Extratropical cyclones (frontal systems)
  - Polar jet stream (Rossby waves)
- Subtropical
  - Monsoon interacting with interannual variability (ENSO)
  - Subtropical jet
  - Squalls
    - Unsteadiness; propagating convective disturbance; Mesoscale Convective System (MCS)





Subtropical stories

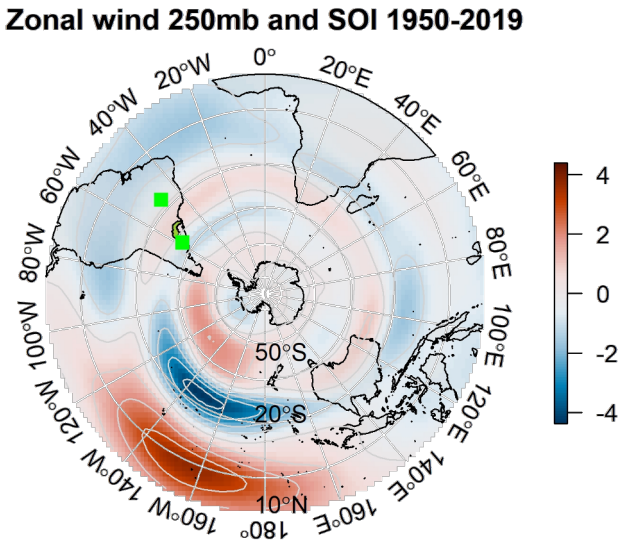
- Diagonal wind (Transition between Easterlies to Westerlies)
- Extratropical-tropical interactions
  - Interannual scales and Planetary oscillations
    - Air-sea interactions
    - Tropospheric and stratospheric teleconnections

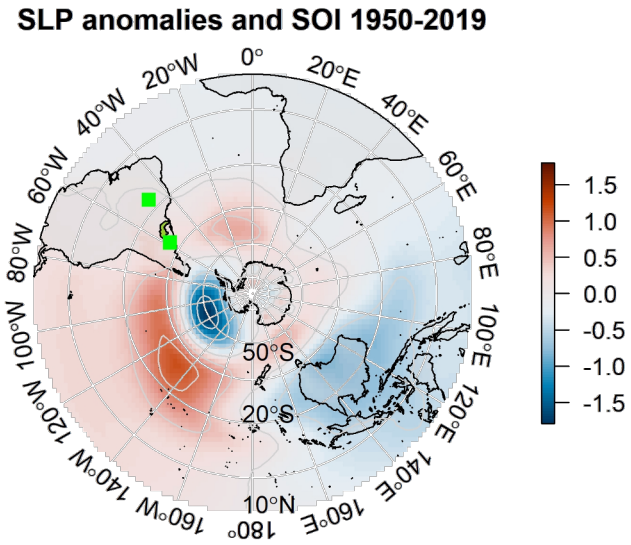
- Emerging hypotheses for changing climate
  - Intensify circulation features
    - Intensifying convection: the Hadley Cell Overturning and the Walker Circulation
    - Thermodynamic change affecting the transfer rate of surface energy and moisture fluxes
  - Hot spot location changes
    - Convergence location changes (e.g. Expansion of the Hadley Cell)
    - Ocean-land interaction affect local circulation (e.g. Shifting monsoon system)
      - Pressure gradient changes
      - Thermodynamic change affecting convection locations
    - Affecting the impacts of interannual variability (e.g. ENSO)

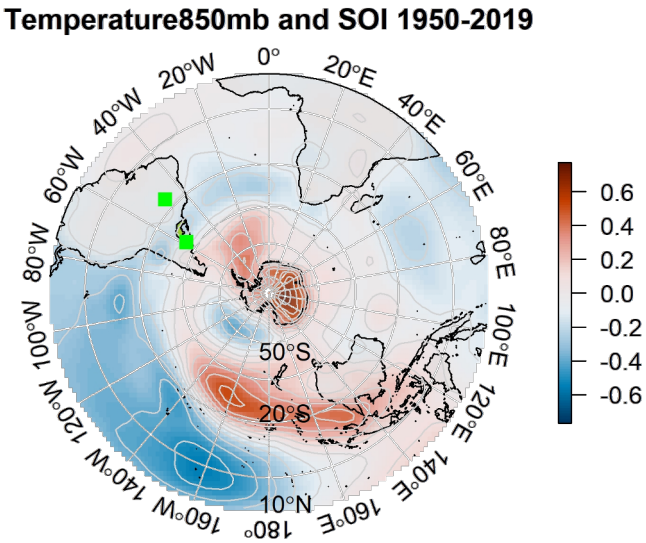
ENSO

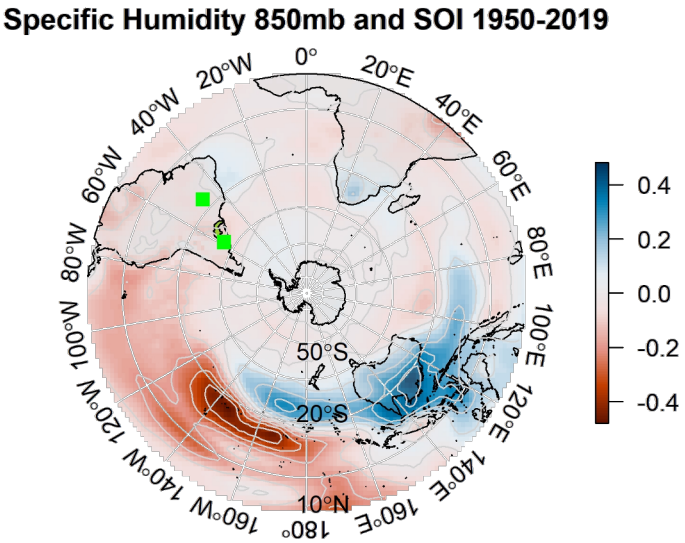
- 3-5 years
- Tropical air-sea interactions
- SOI

- Subtropical effects
  - Jet and SLP
  - Temperature and Specific Humidity







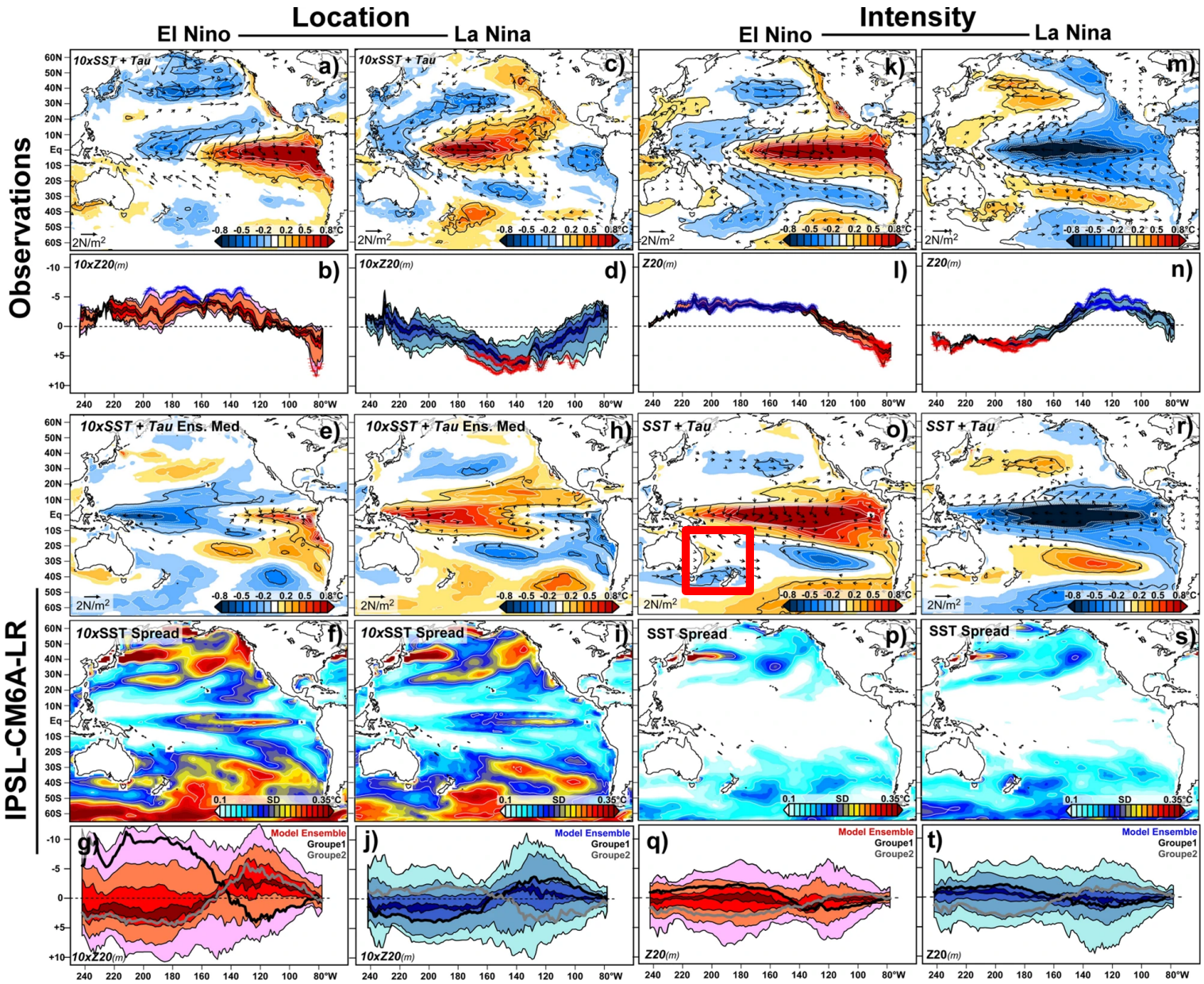


ENSO

- Locations
- Intensity

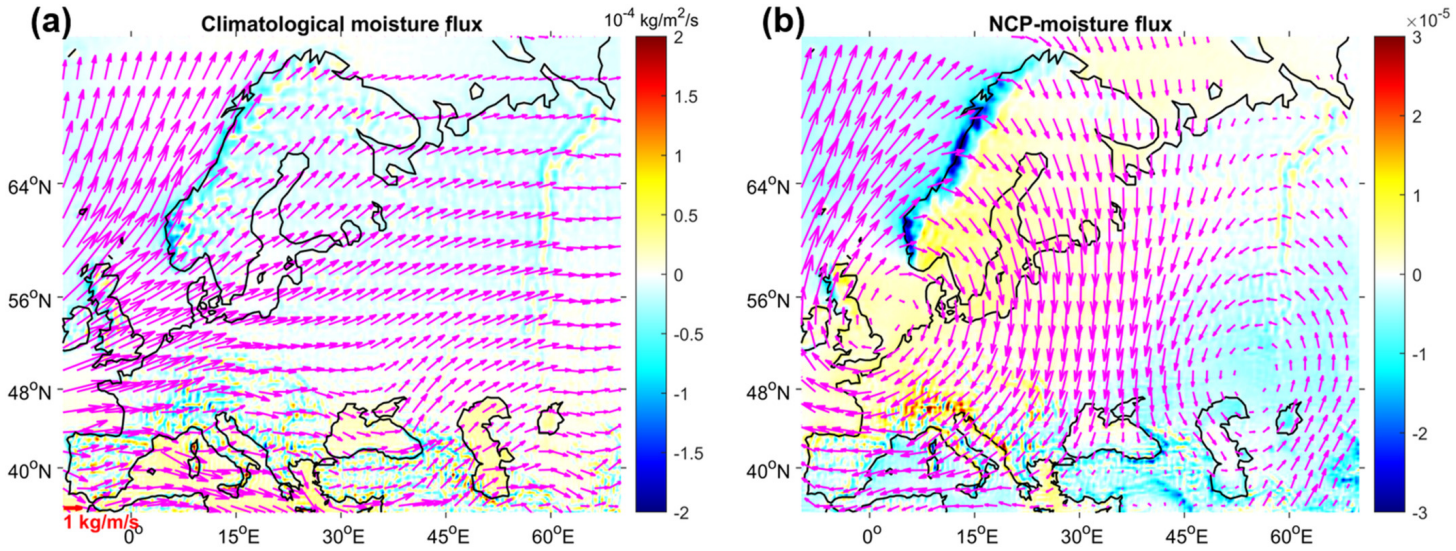
- Air-Ocean
- Thermocline

Dieppois, B., Capotondi, A., Pohl, B., Chun, K.P., Monerie, P.A. and Eden, J., 2021. ENSO diversity shows robust decadal variations that must be captured for accurate future projections. *Communications Earth & Environment*, *2*(1), pp.1-13.



Northern Annular Mode (NAM)? North-Sea Caspian pattern (NCP)

- Defined based on Pressure
- Northern Annular Mode (NAM)
  - AO, NAO, etc.
- Locations of dipole centres
- Intensity
- Moisture transport
- Vegetation



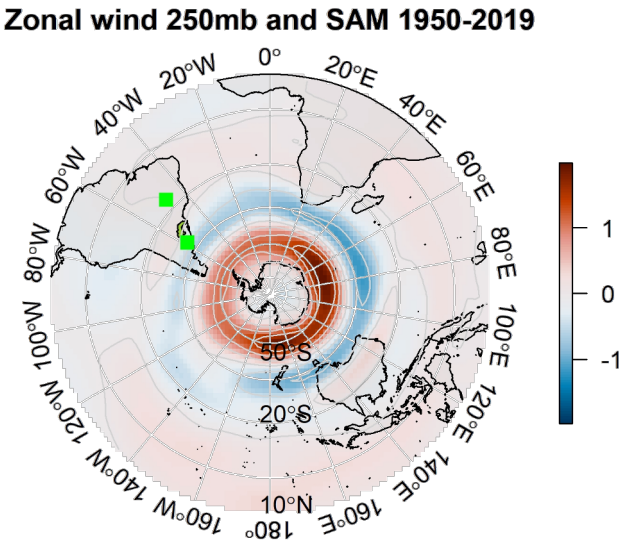
He, Q., Xu, B., Dieppois, B., Yetemen, Ö., Sen, O.L., Klaus, J., Schoppach, R., Çağlar, F., Fan, P.Y., Chen, L. and Danaila, L., 2022. Impact of the North-Sea Caspian pattern on Meteorological drought and Vegetation Response over diverging environmental systems in western Eurasia. *Ecohydrology*, p.e2446.

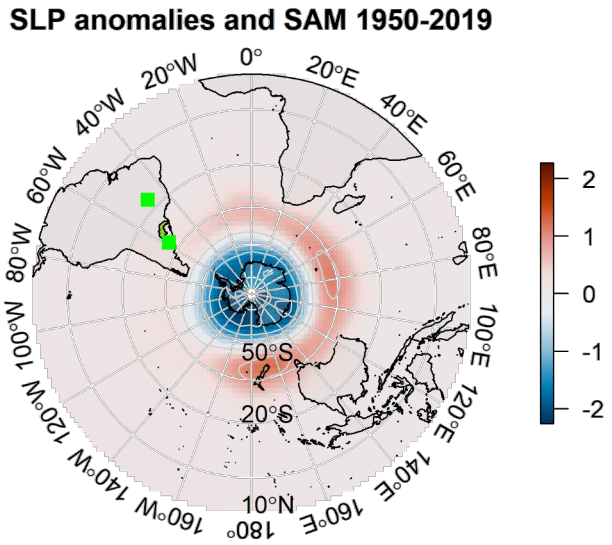
SAM

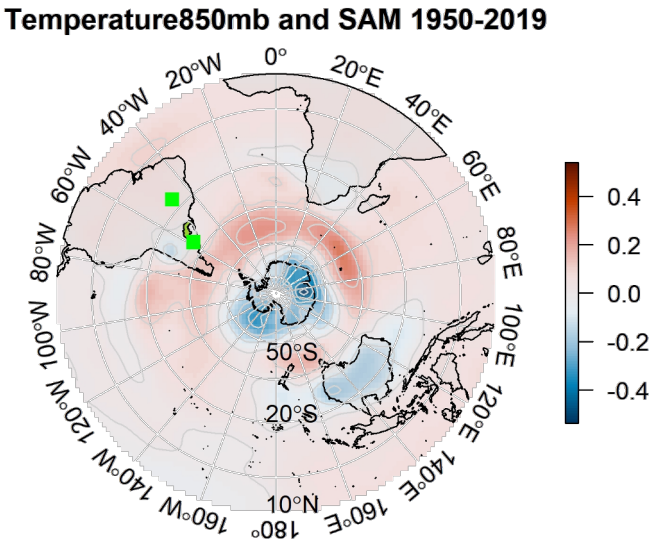
- Southern Annular Mode (SAM)
- Antarctic oscillation (AAO)

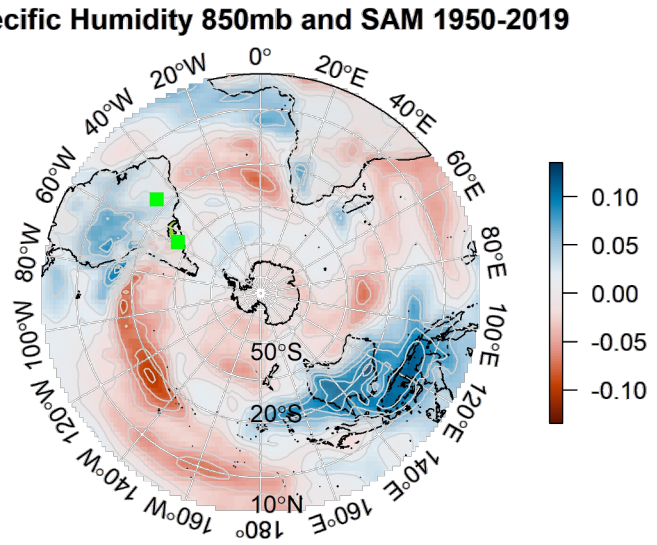
- Midlatitude
- Pressure driven

- Subtropical effects
  - Jet and SLP
  - Temperature and Specific Humidity



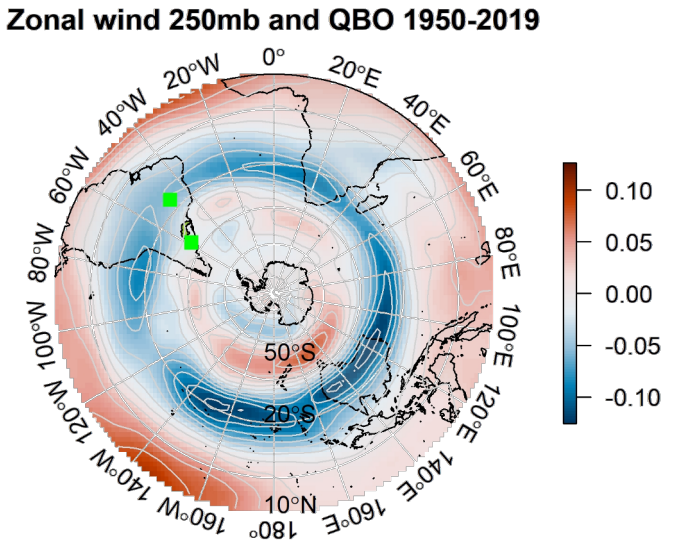


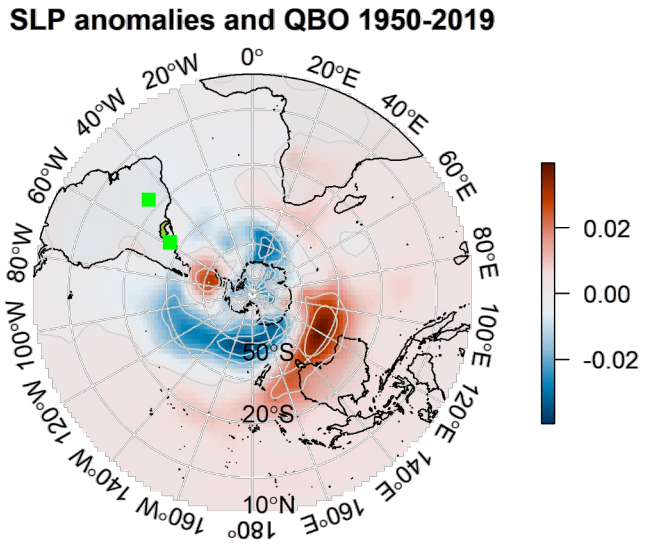


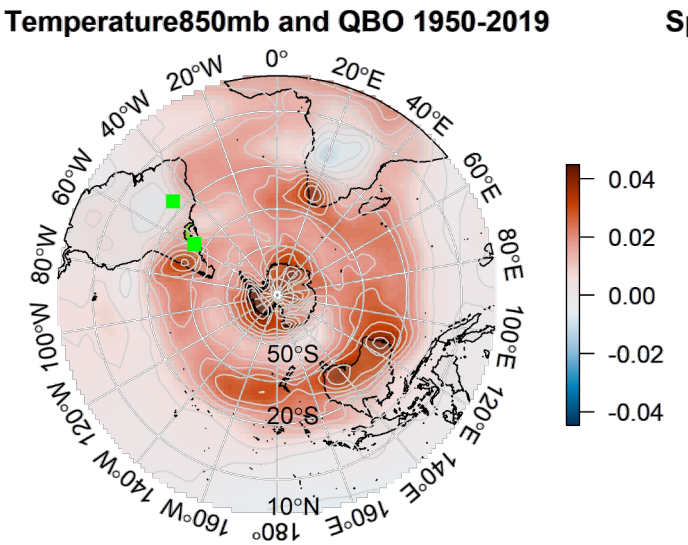


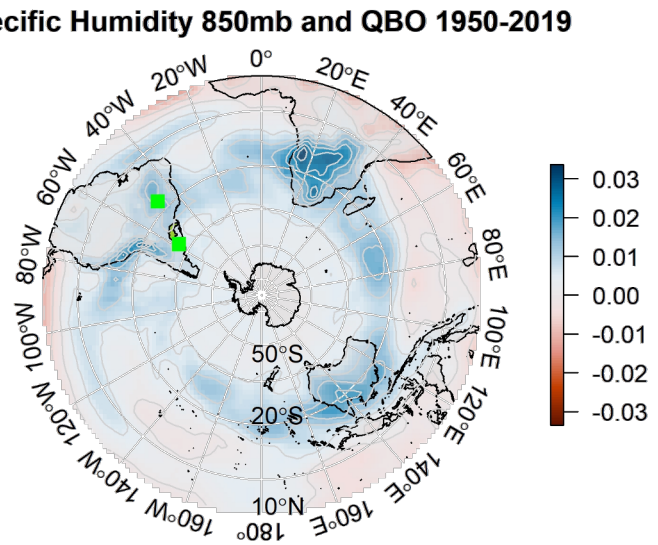
QBO

- Quasi-Biennial Oscillation (QBO)
- 2-3 years
- Extratropical-tropical interactions
  - Tropospheric and stratospheric teleconnections
- Subtropical effects
  - Jet and SLP
  - Temperature and Specific Humidity





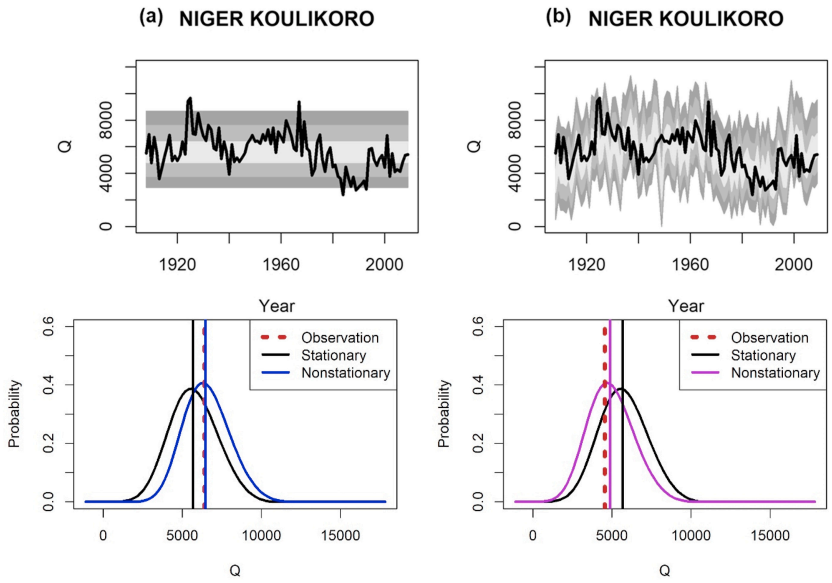


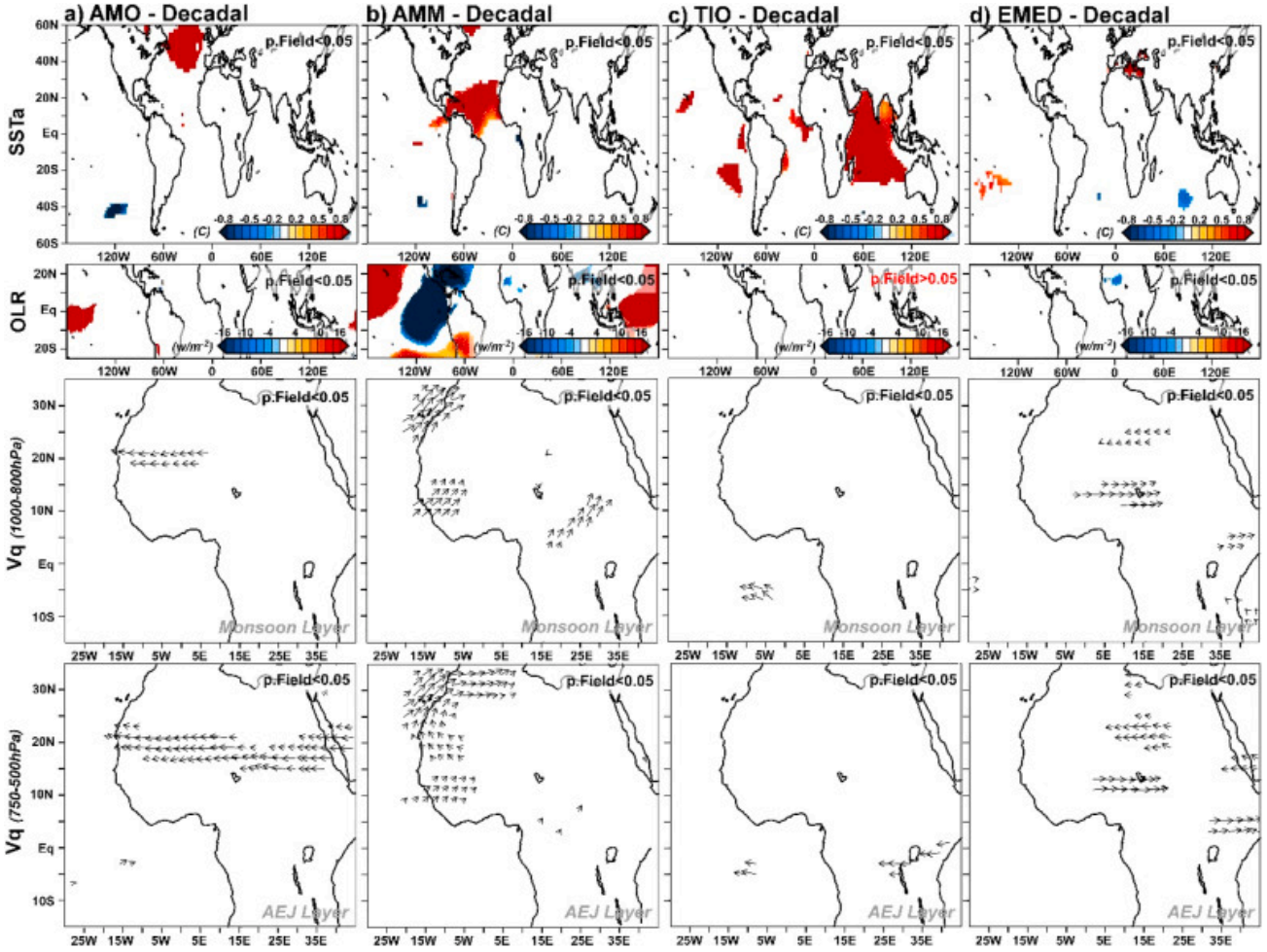


Extremes

Chun, K.P., Dieppois, B., He, Q., Sidibe, M., Eden, J., Paturel, J.E., Mahé, G., Rouché, N., Klaus, J. and Conway, D., 2021. Identifying drivers of streamflow extremes in West Africa to inform a nonstationary prediction model. *Weather and Climate Extremes*, *33*, p.100346.

- Variance decomposition of long records to separate drivers' contributions
- Nonstationary statistical models to reveal driving modes
- Dry and Wet Regimes: Droughts and Flooding

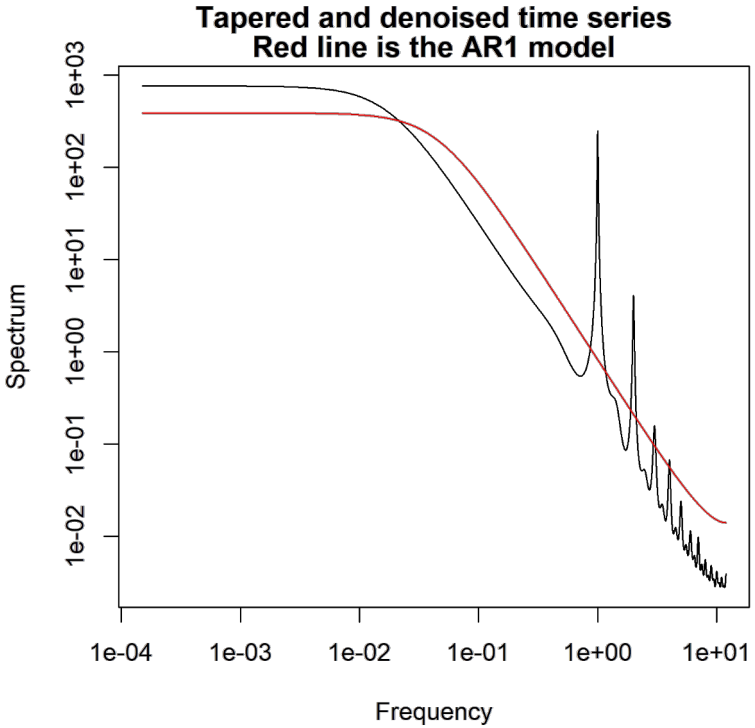




Some ideas of modelling techniques
Emerging Topics

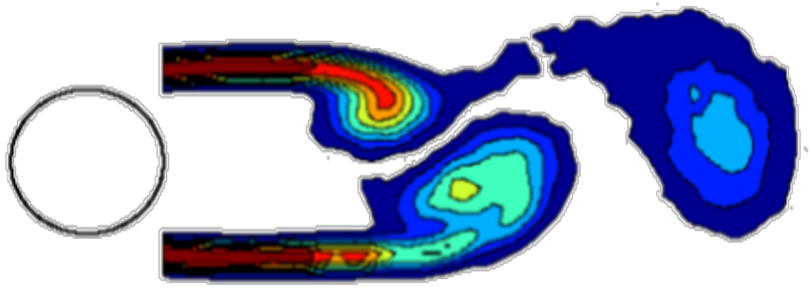
- Convection-permitting models (CPMs) to provide simulations
  - Persistent patterns (stability)
  - Lagging dynamics (heat storage and capacity)
  - Mode decomposition for feature detections
    - Variance decomposition (e.g. PCA)
    - Big data methods for identifying patterns (e.g. Clustering)

- Scaling relationships based on observations and CPM outputs
  - Oscillation over interannual and decadal scales for extremes including flooding and droughts



Some ideas of modelling techniques
Emerging Topics (Take home message)

- Internal feedback which is balancing the uneven moisture and energy distribution in subtropical regions



- Scaling chain
- Turbulence Theory (Luminita)
  - Scale-by-Scale-budget of turbulent fluctuations

Decadal AMO	Interannual ENSO QBO	Sub-seasonal and Seasonal NAO, NCP, SAM	Extremes Storms; Typhoon; Droughts