Identifying the Causal Network of Sea Level Variability Domains in the Southeast Pacific:

An application of satellite altimetry

End of internship presentation by Eike Schütt

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STRUCTURE

Introduction

Datasets

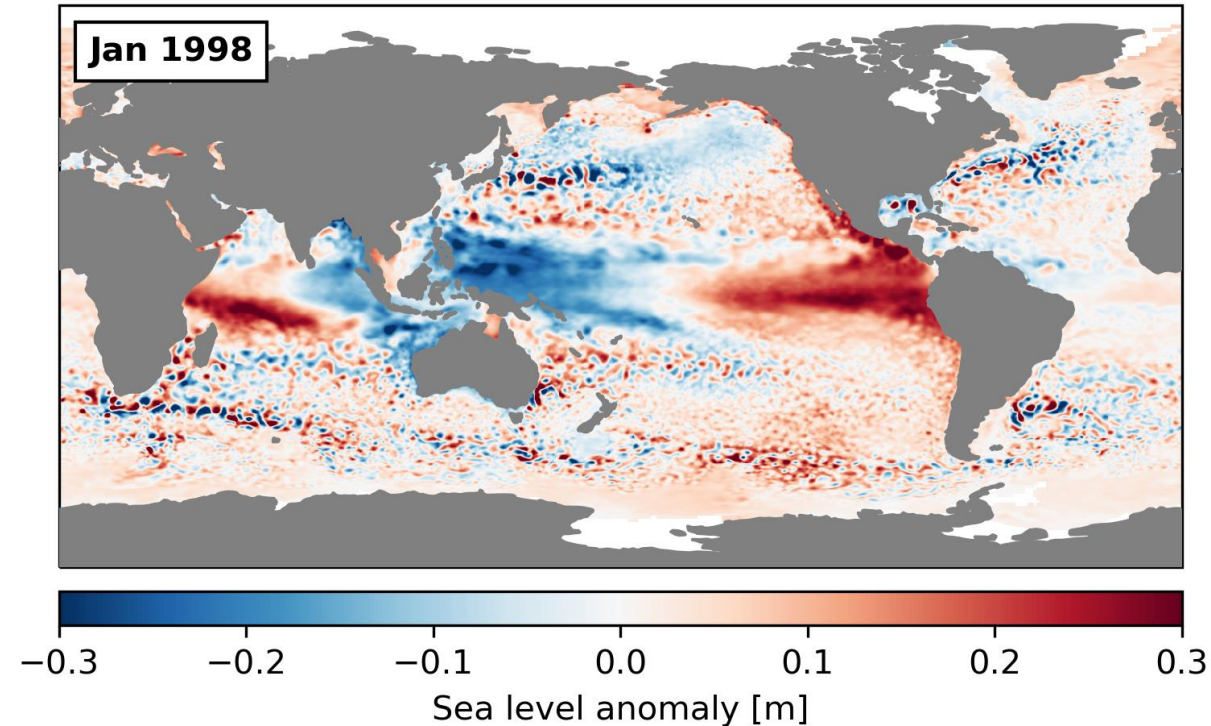deltaMaps – method and results

PCMCI – method and results

Causal SLV network in the SE Pacific

Conclusion

Introduction

- To improve SLR projections, sea level variability (SLV) must be better understood
- Many processes contribute to SLV
- Goals:
  - Identify SLV Domains
  - Infer the network between the Domains
 - Interpret SLV network in the Southeast Pacific (SEP)

Datasets

- Monthly SLA satellite altimetry data from AVISO (Jan 1993-Feb 2020)
  - Resampled to 2° and smoothed
  - Removed seasonality and linear trend
  - Removed regions higher than 66°S/N

- Current velocities from GLORYS12V1 reanalysis

- Wind and sea level pressure from ERA5 reanalysis

- Niño3.4 SST index from NOAA

deltaMaps - Method

- Novel clustering algorithm by Fountalis et al. (2018) and Falasca et al. (2019)
- Python version on GitHub

- Identifies regions in which the measured signal is relatively similar over time
- Many advantages over similar methods

# deltaMaps – Results: Domains
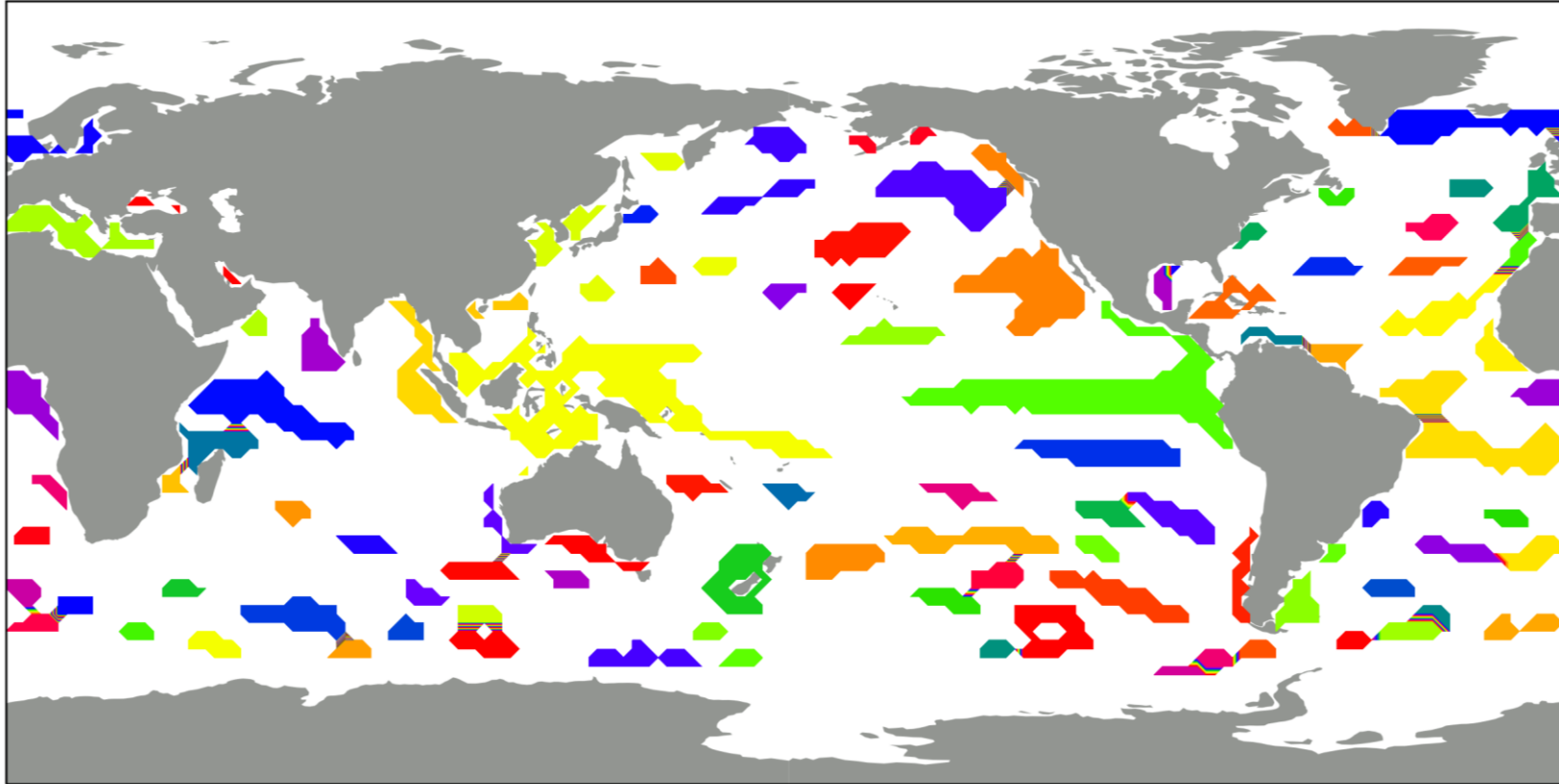
PCMCI - Method

- Method to reconstruct causal graphs from high-dimensional time series data
- Developed by Runge et al. (2019); included in the tigramite-package (Python)

- based on the graphical causal model framework
- Consists of two main steps:
  - PC_1 algorithm
  - MCI-test
- High detection power even in large datasets
- Assumes causal sufficiency

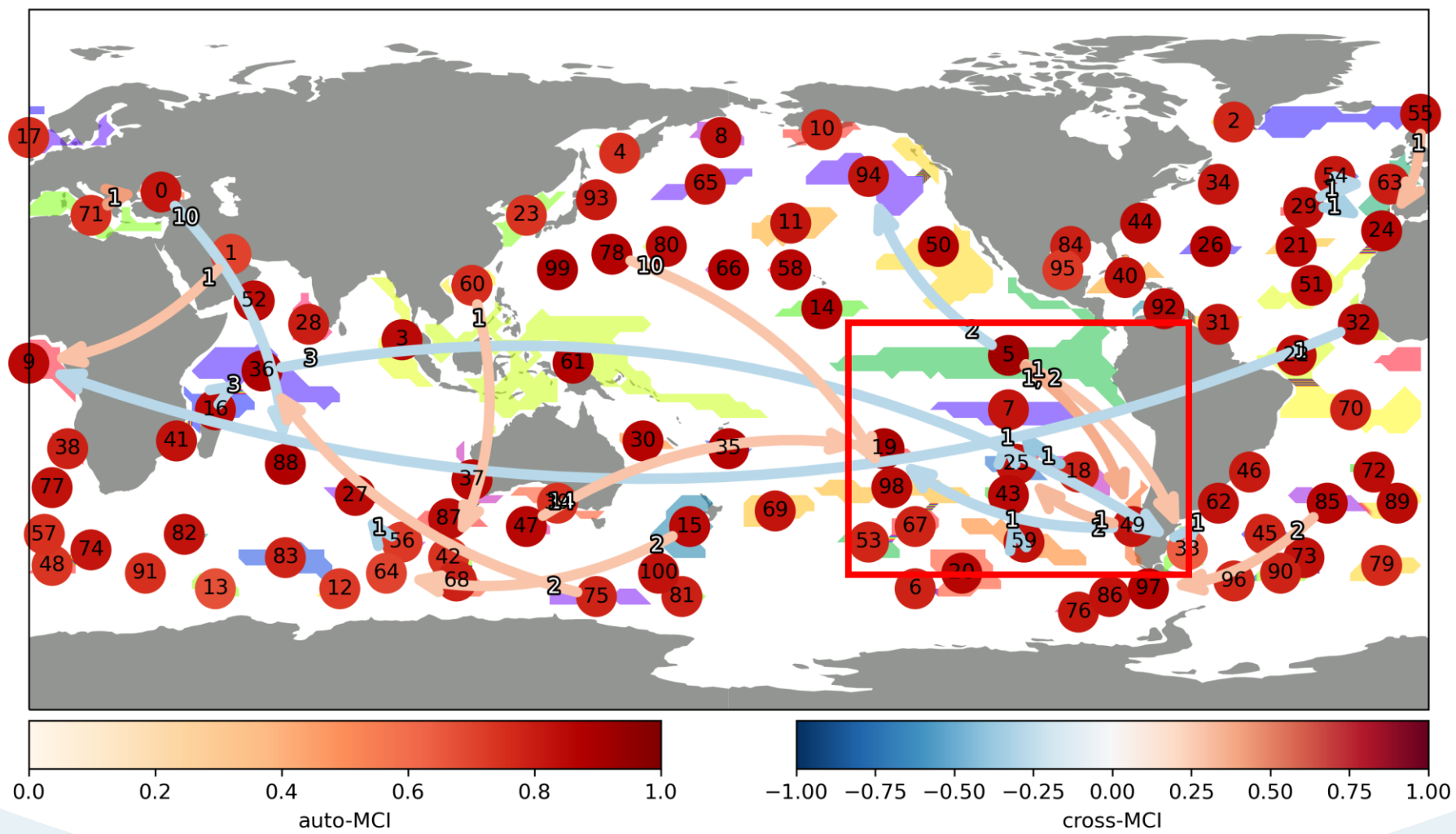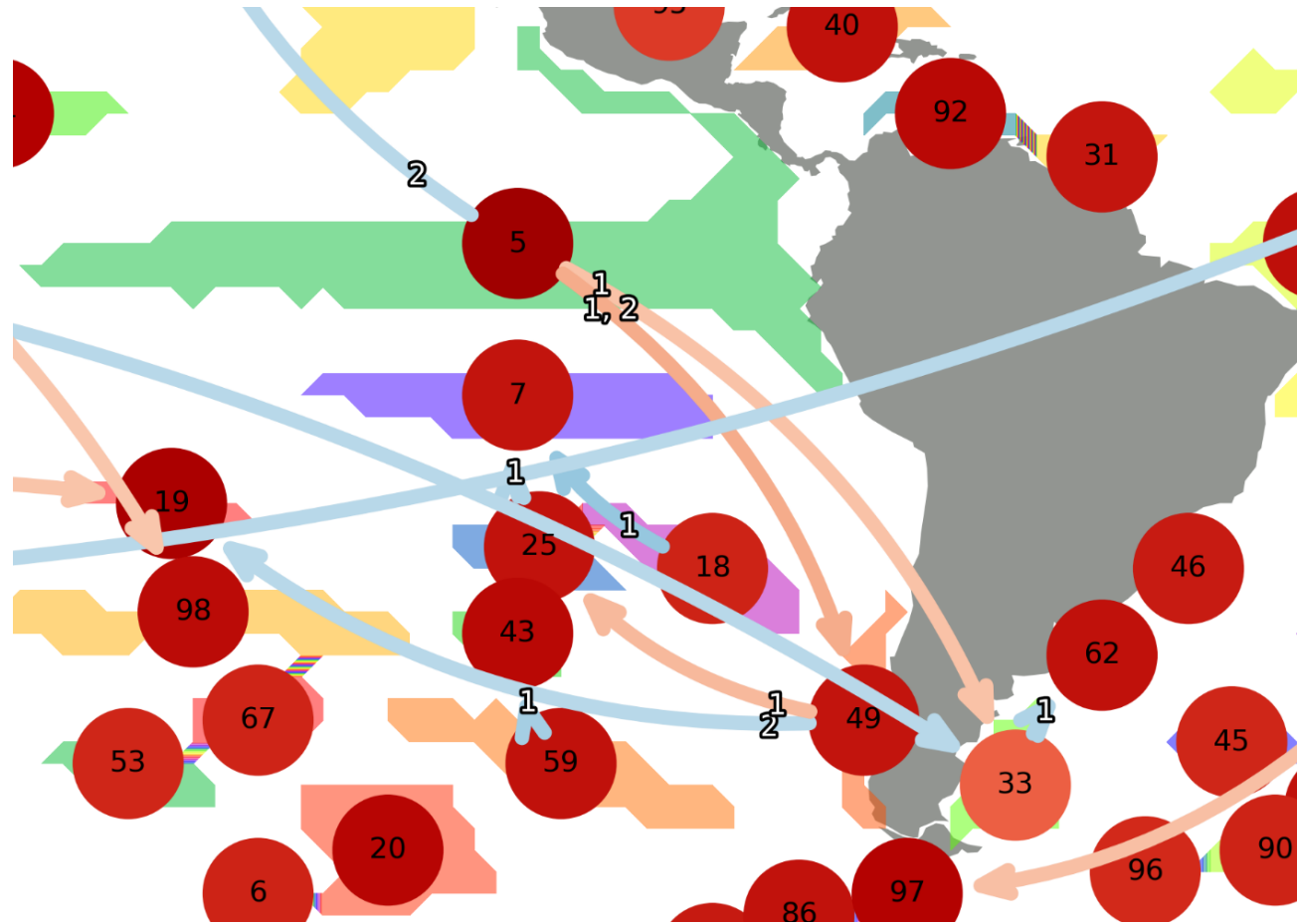- Applied PCMCI to the domain signals
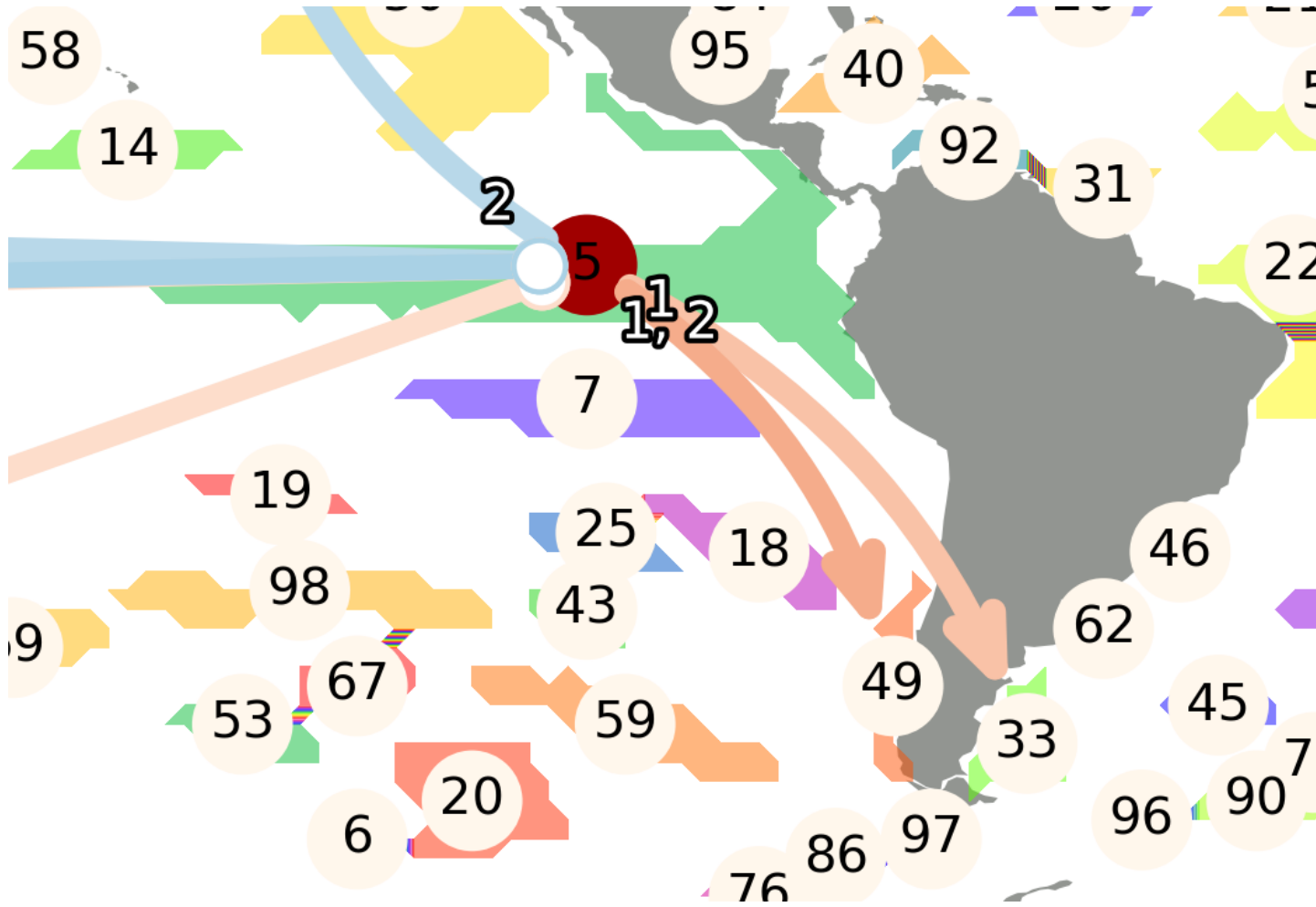
PCMCI - Results
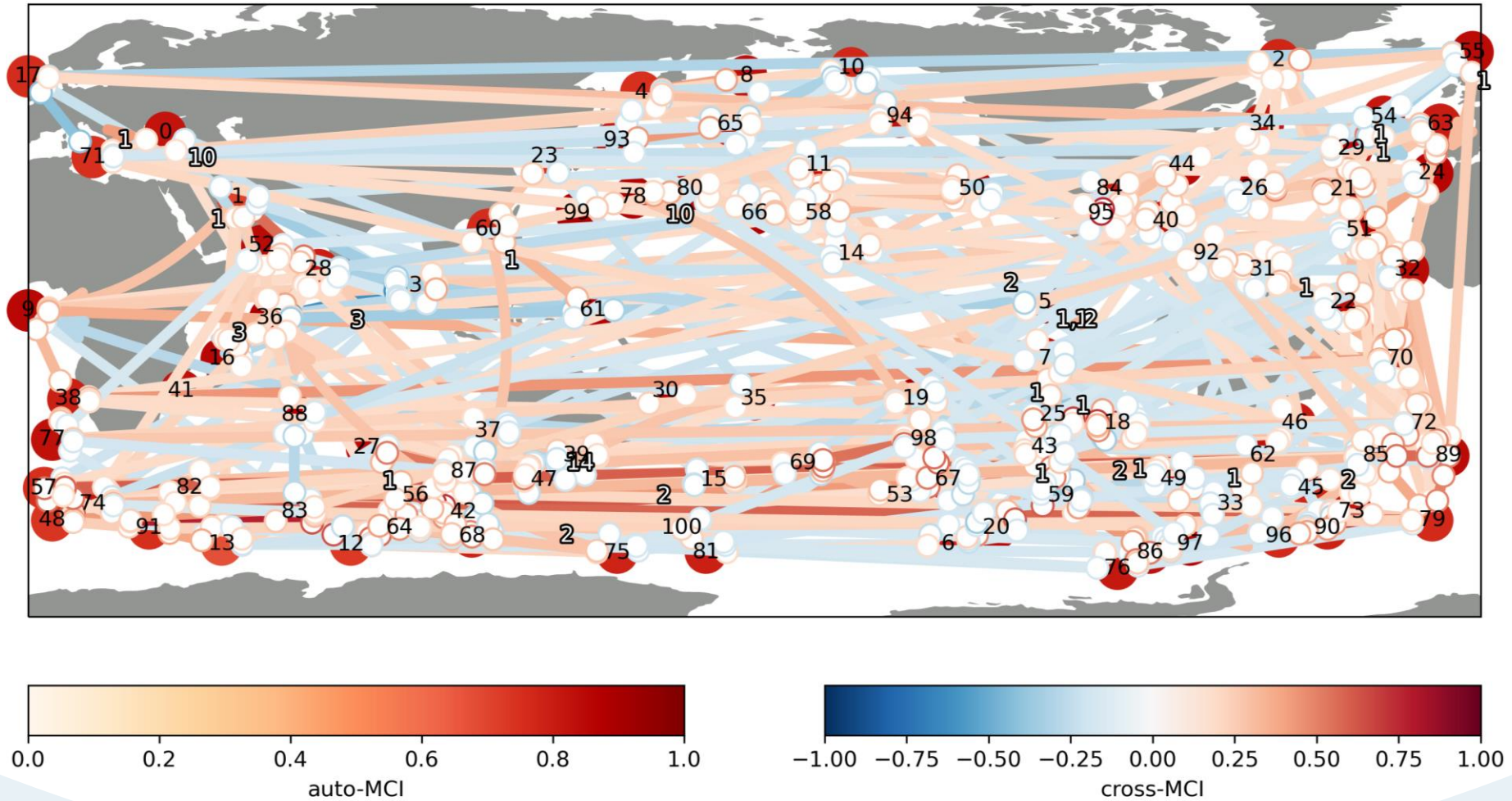
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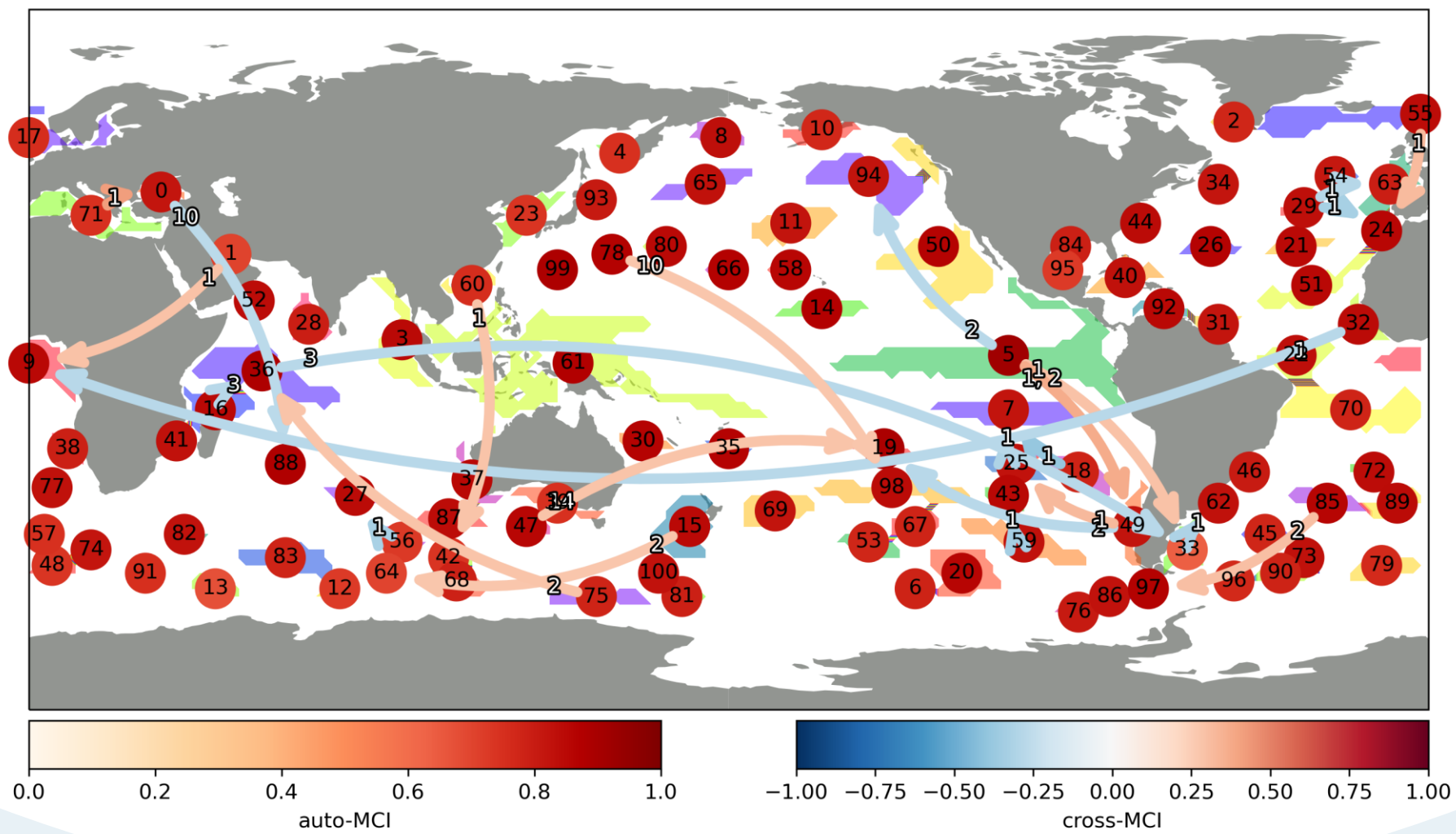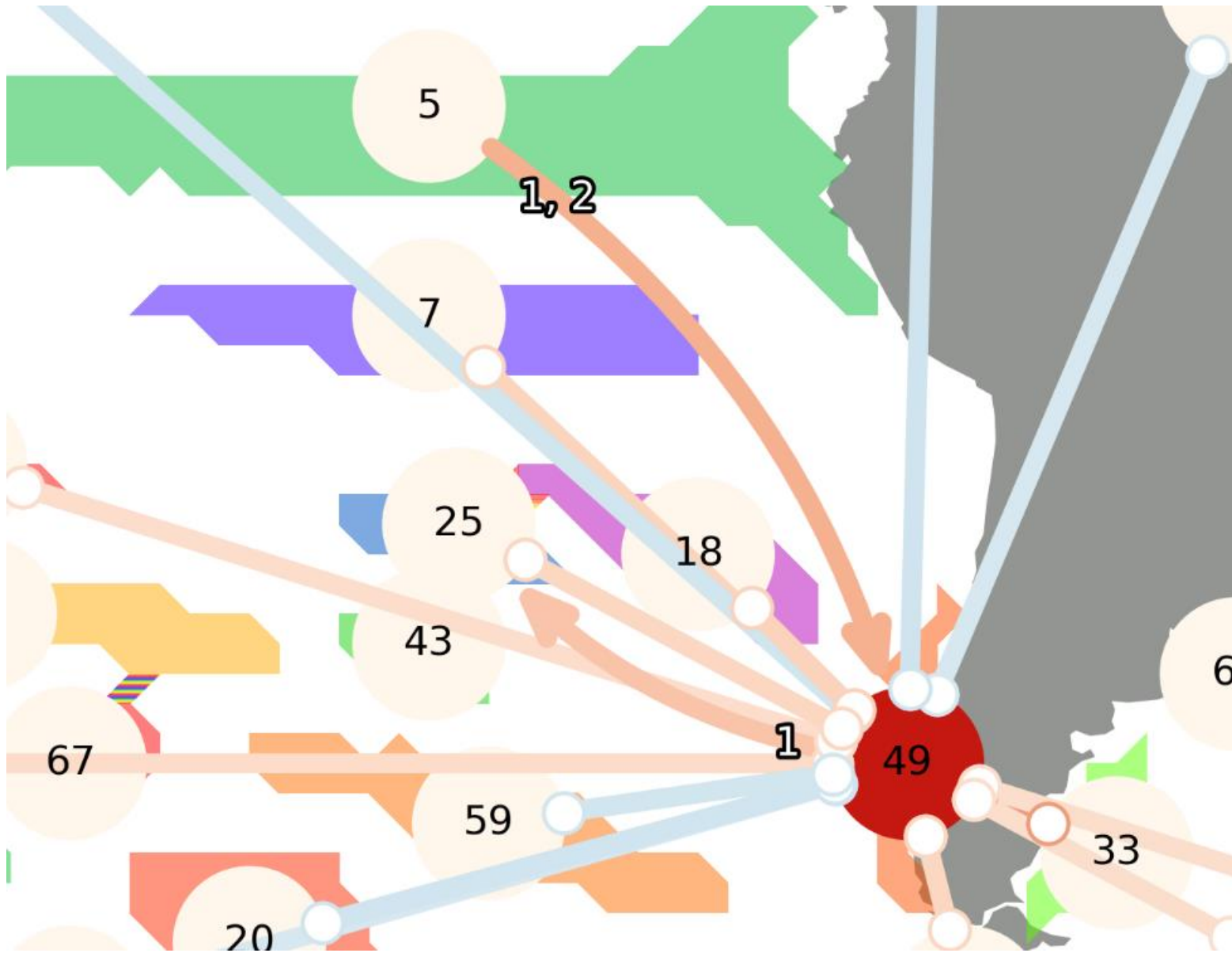
PCMCI - Results

Causal SLV network in the SE Pacific

SLV in Domain 5

- Domain 5 SLA is significantly correlated to ENSO strength (R>0.9) at small lags

- SLA leads SST anomalies by a few weeks

- Main source of SLV in this domain is ENSO

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Edge 5-49

- Significant positive cross-MCI at 1- and 2-months lag

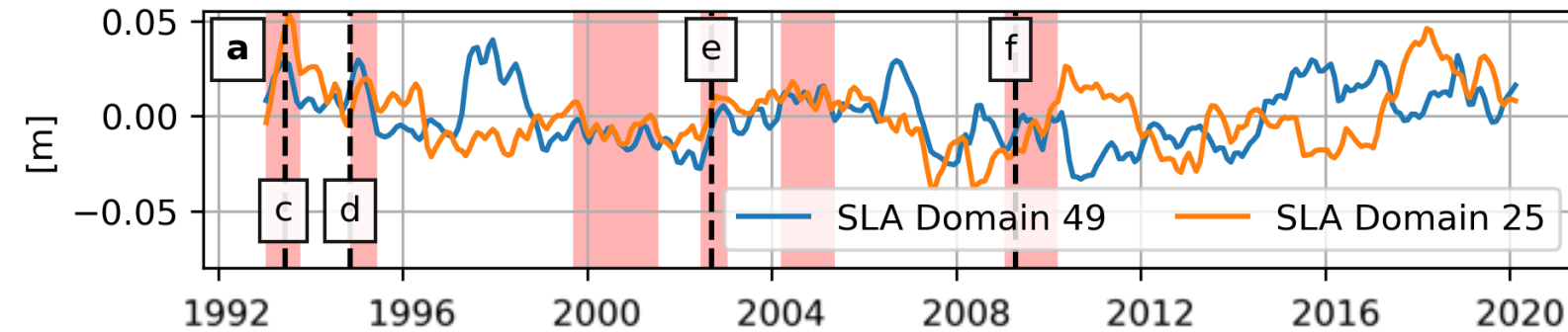- Kelvin & coastal trapped waves
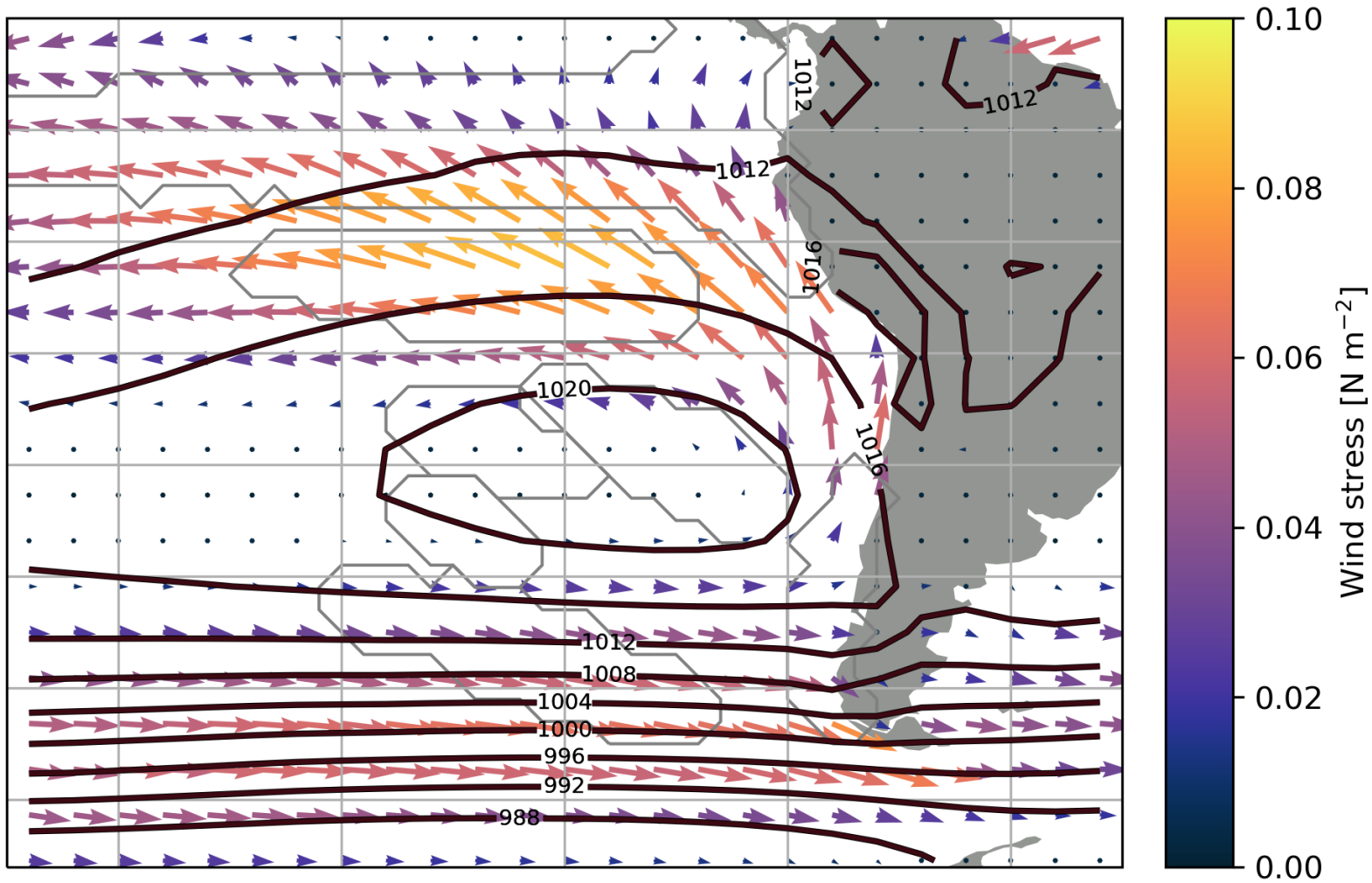
- Local atmospheric forcing

Edge 49-25

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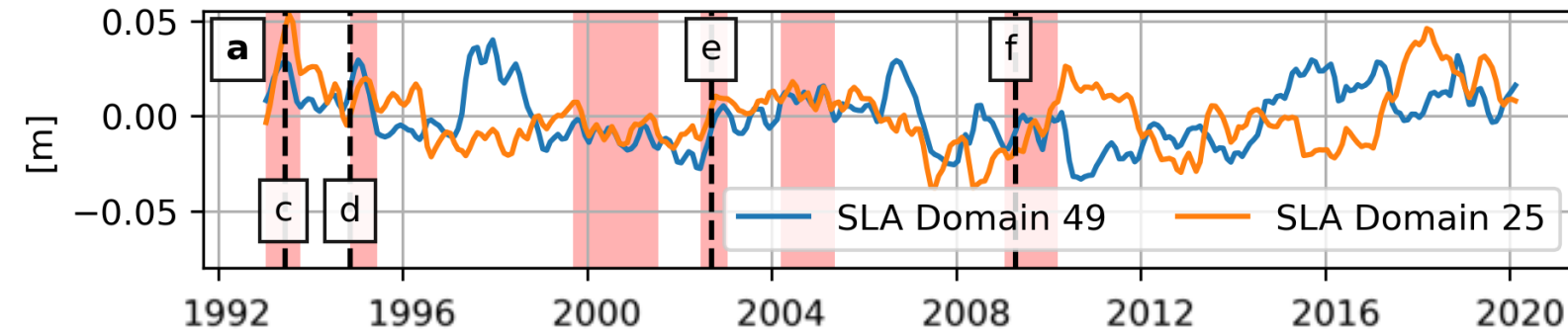
Mean SLP (hPa) and wind stress (ERA5, 1993–2018)

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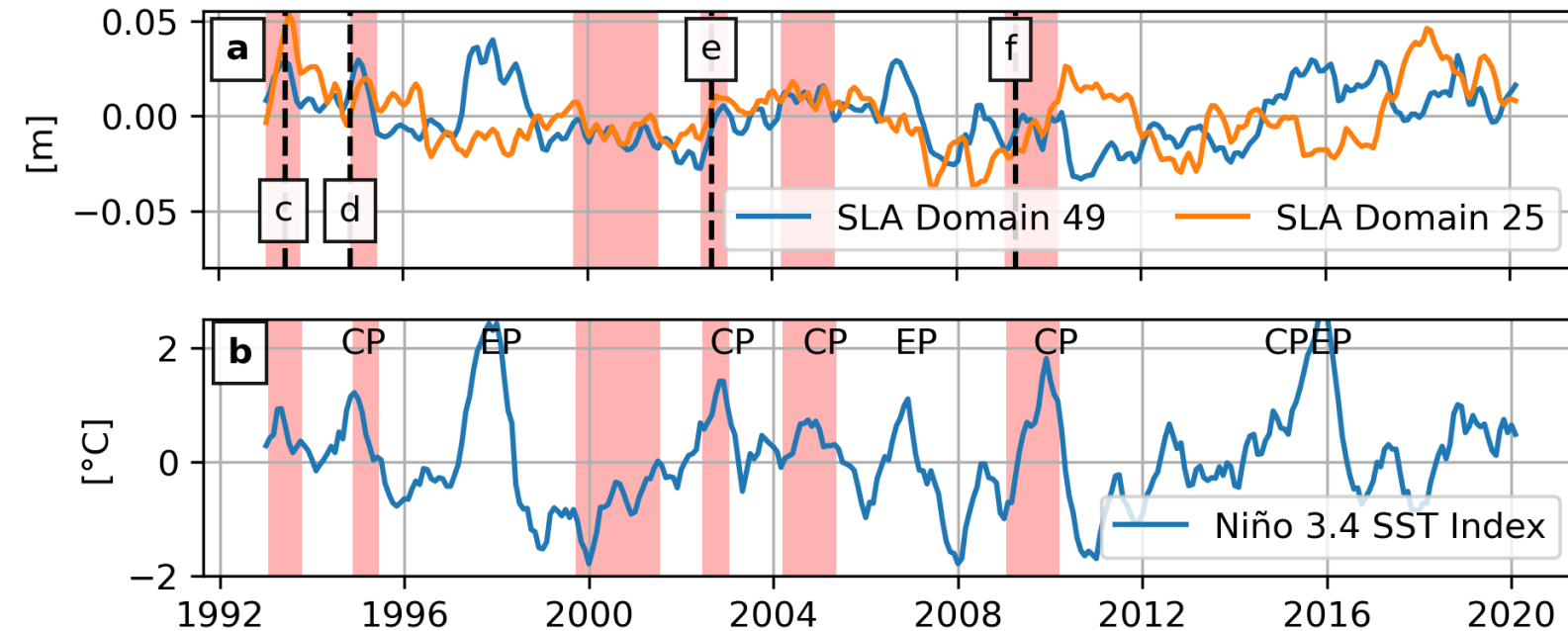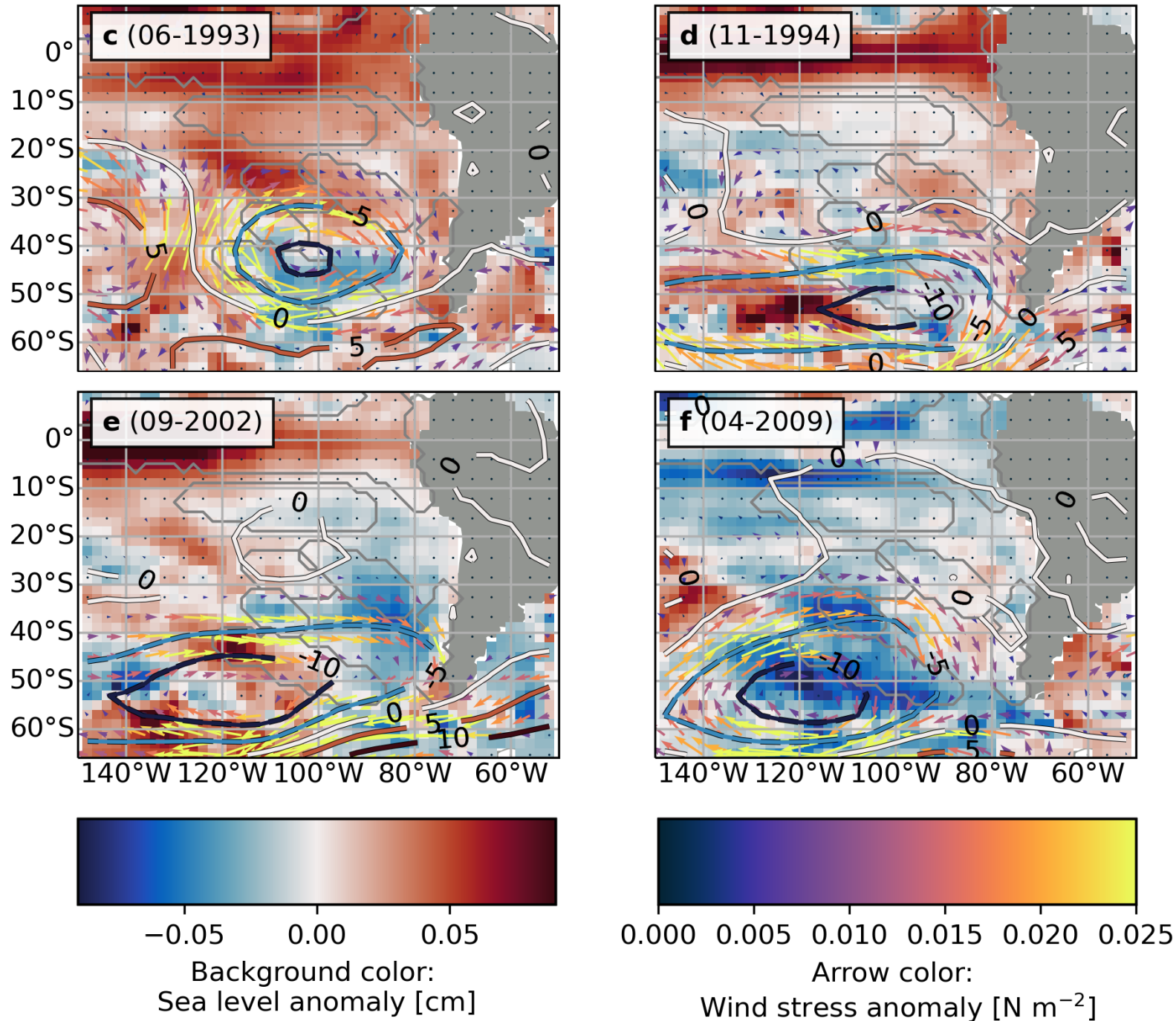
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Background color:
Sea level anomaly [cm]

Arrow color:
Wind stress anomaly [N m^{-2}]

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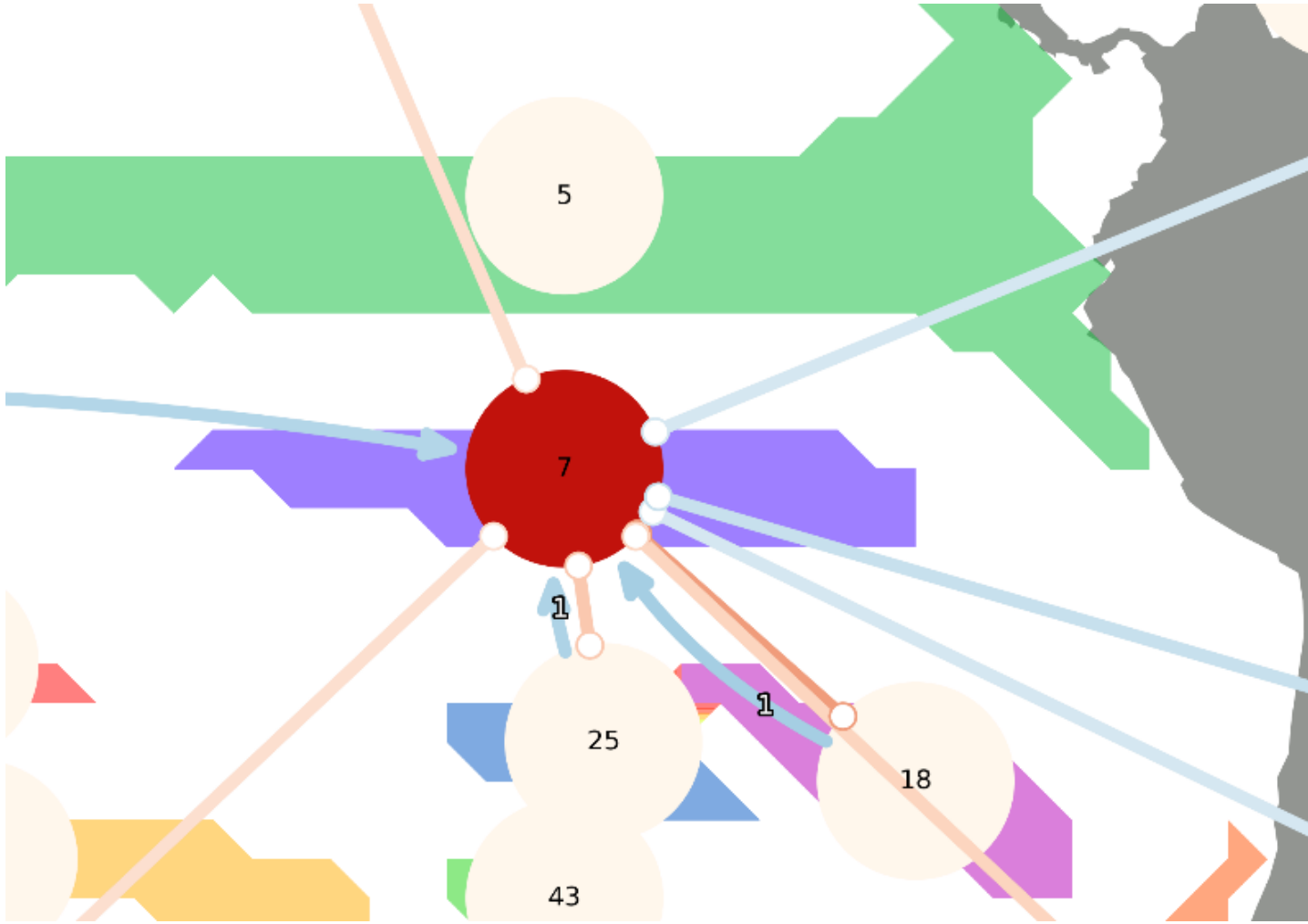- SPSA is the dominating weather system
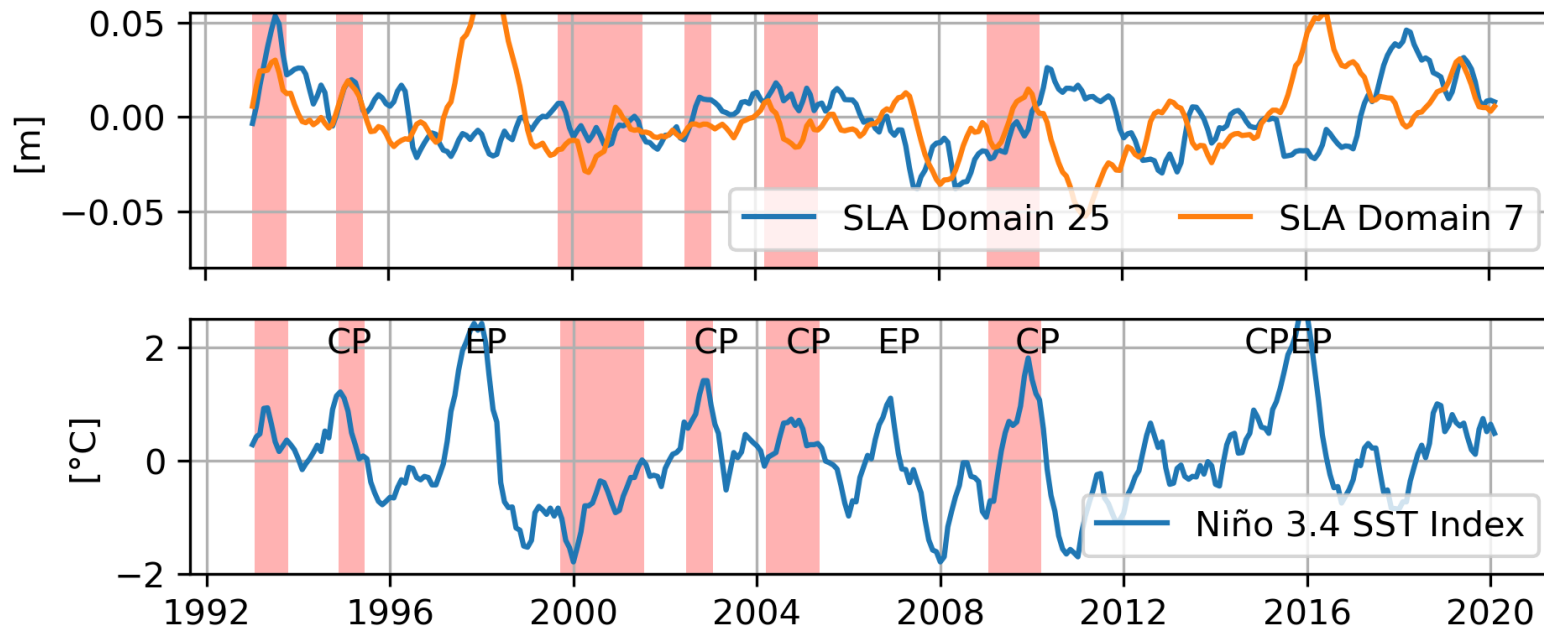- Wilson et al. (2014) suggested that CP "flavor" triggers negative SLPa in southern SEP

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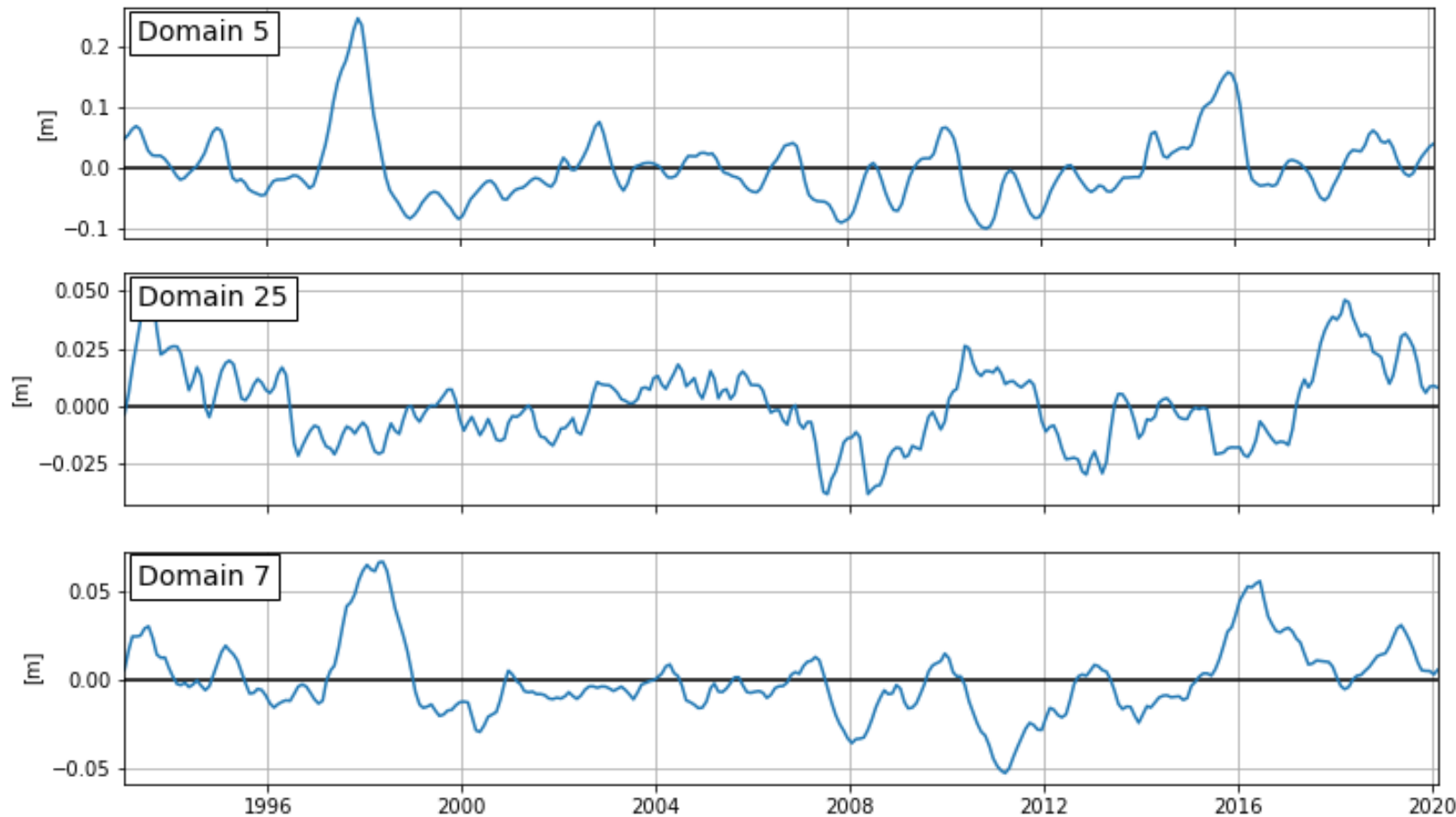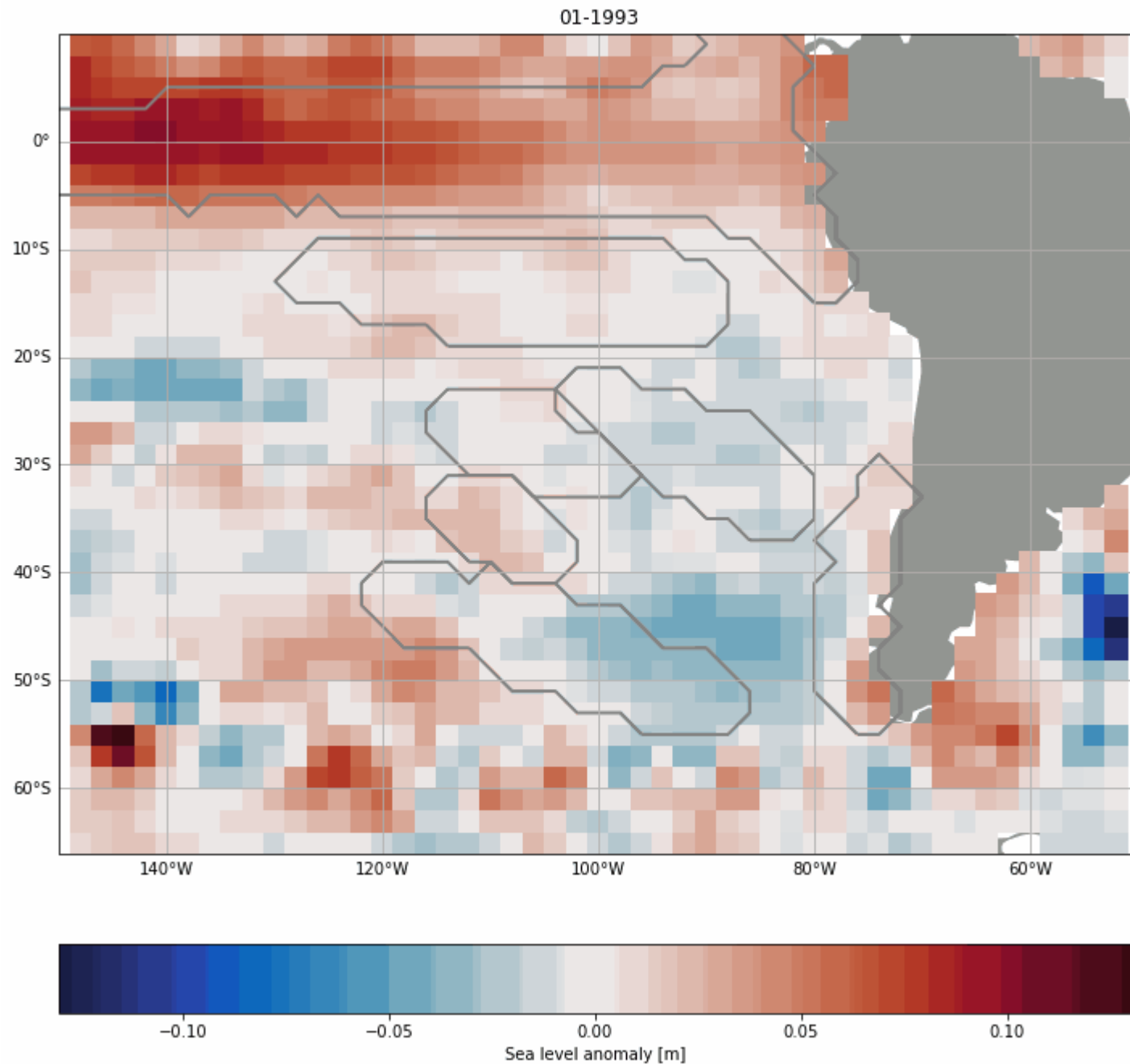
Timeseries of SLA signals

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01-1993

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Sea level anomaly [m]

Conclusion

- ENSO strongly influences SLV in the Southeast Pacific
- SLA signals are transported through oceanic and atmospheric teleconnections (e.g. Kelvin & Rossby waves, SLPa and Ekman transport)

- Monthly timesteps too large to resolve atmospheric processes
- Network not static? Flavour of ENSO appears to trigger shift in SLA patterns
- Violation against causal sufficiency assumption
- Modelling needed to reveal the underlying processes

- Report, figures and code available on GitHub!
  github.com/eikeschuett/dMaps_SLV/

THANK YOU