Modelling the Relationship between Climate Modes and Eastern Australia Atmospheric Carbon Monoxide

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Introduction

- The 2019/2020 Australian wildfire season was notably severe, with impacts on local ecosystems, lives, and property.
- Climate modes, especially El Niño Southern Oscillation (ENSO), have an effect on global and local climate conditions.
  - Specifically, the effect of southern hemisphere climate modes on eastern Australian wildfires.
- NSF NCAR project: Atmospheric impacts of the extreme Australian 2019/2020 wildfire season.
- Goal is to create a statistical model for the relationships between climate modes and atmospheric compositions during the fire season.

Background

- Using anomaly carbon monoxide (CO) as proxy for wildfire intensity Buchholz et al., 2018.
  - MOPITT total column CO.
  - Excluding 2019/2020 data.
- Exploring CO anomalies in north east Australia (NE Aus) and south east Australia (SE Aus).
- Using climate mode indices in table 14.
  - Sea-surface tempareatue (SST) anomalies.

Climate Mode	Index	Source
El Niño-Southern Oscillation (ENSO)	Niño 3.4	NOAA, 2021b
Indian Ocean Dipole (IOD)	DMI	NOAA, 2021b
Tropical South Atlantic (TSA)	TS)	NOAA, 2021b
Antarctic Oscillation (AAO)	SAM	NOAA, 2021a

Table: Climate modes considered as predictors with index and source.

Motivation

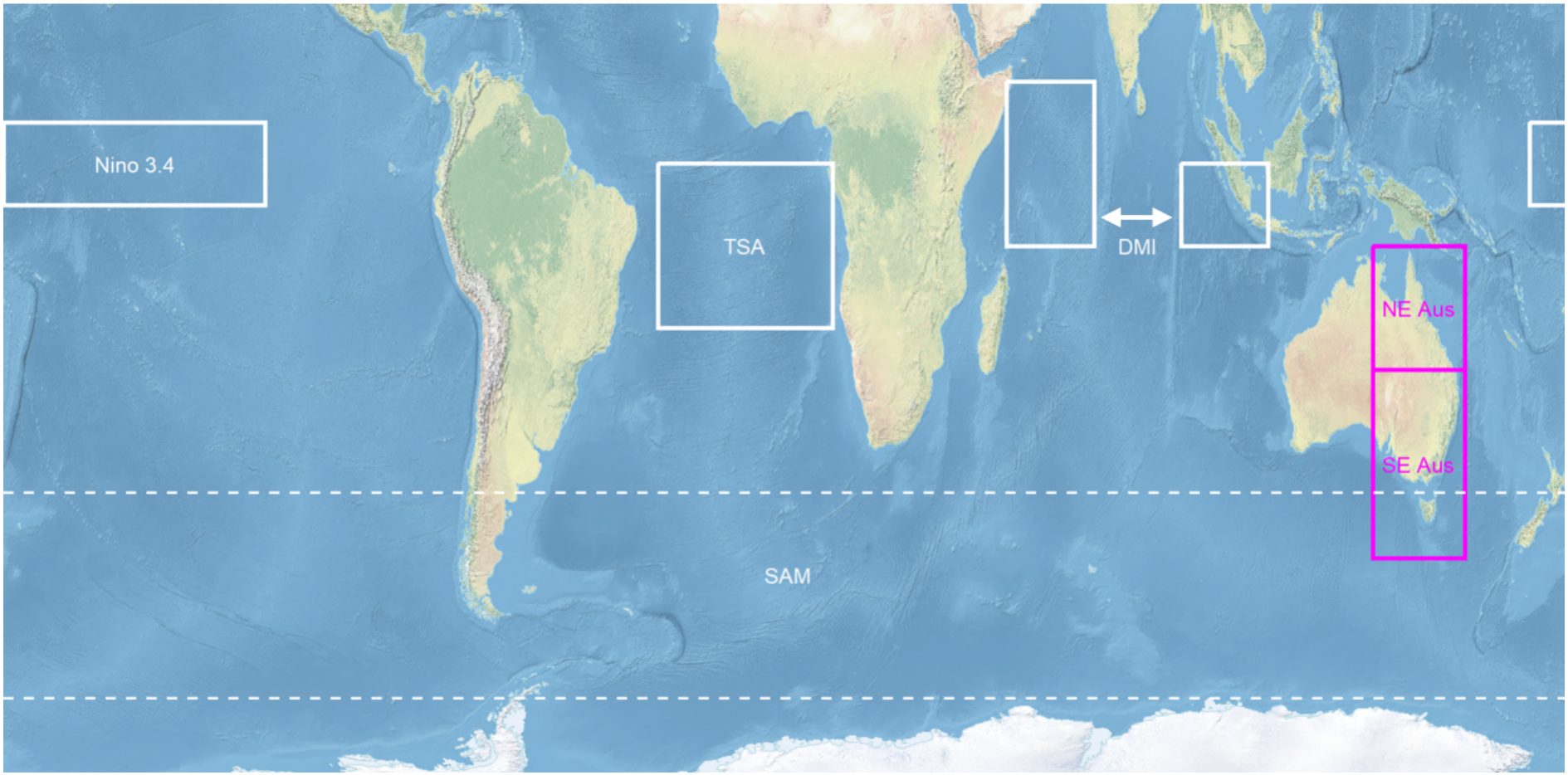


Figure: Climate Mode indices and response regions.

Response Time Series

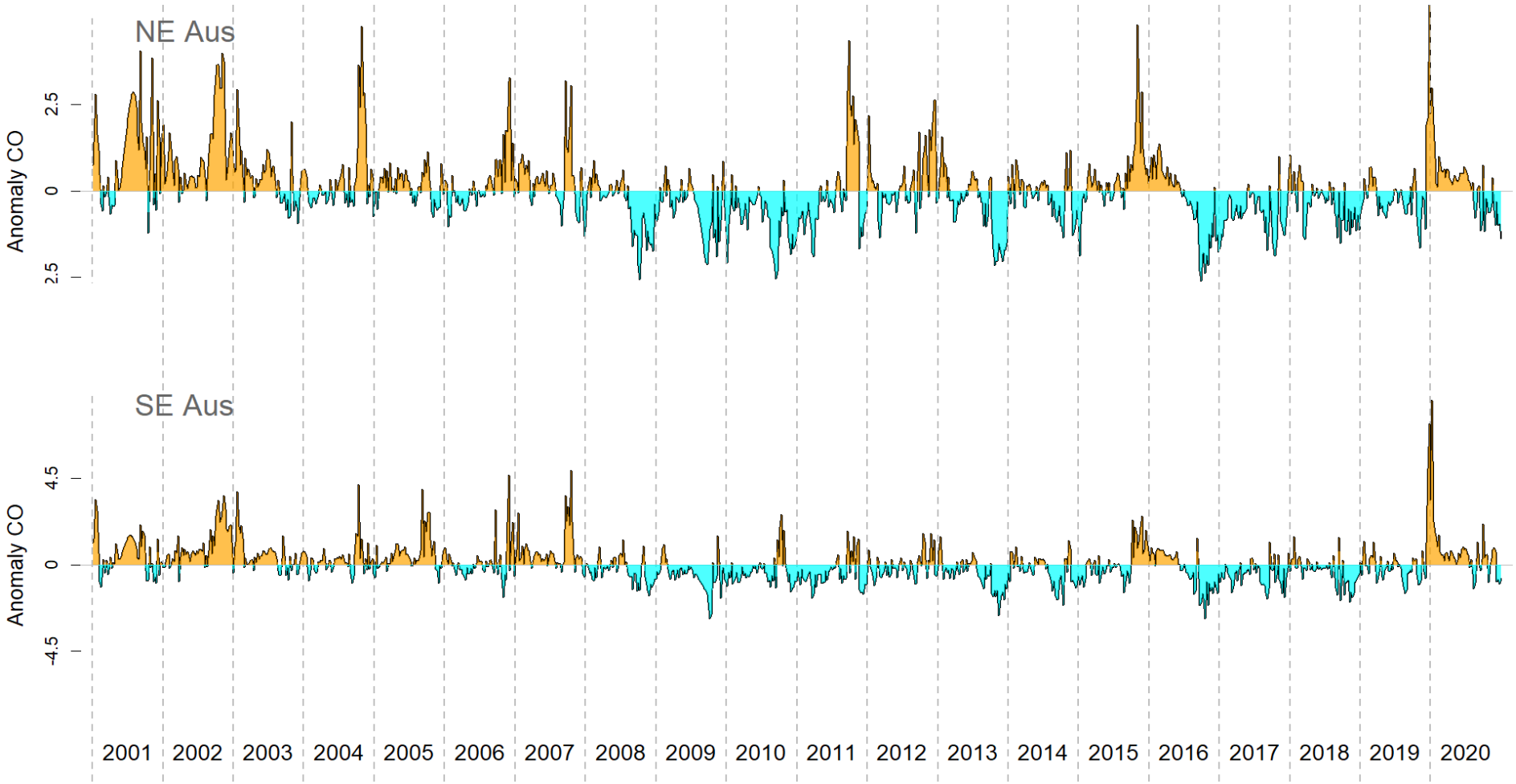


Figure: Response time series for response regions.

Predictor Time Series

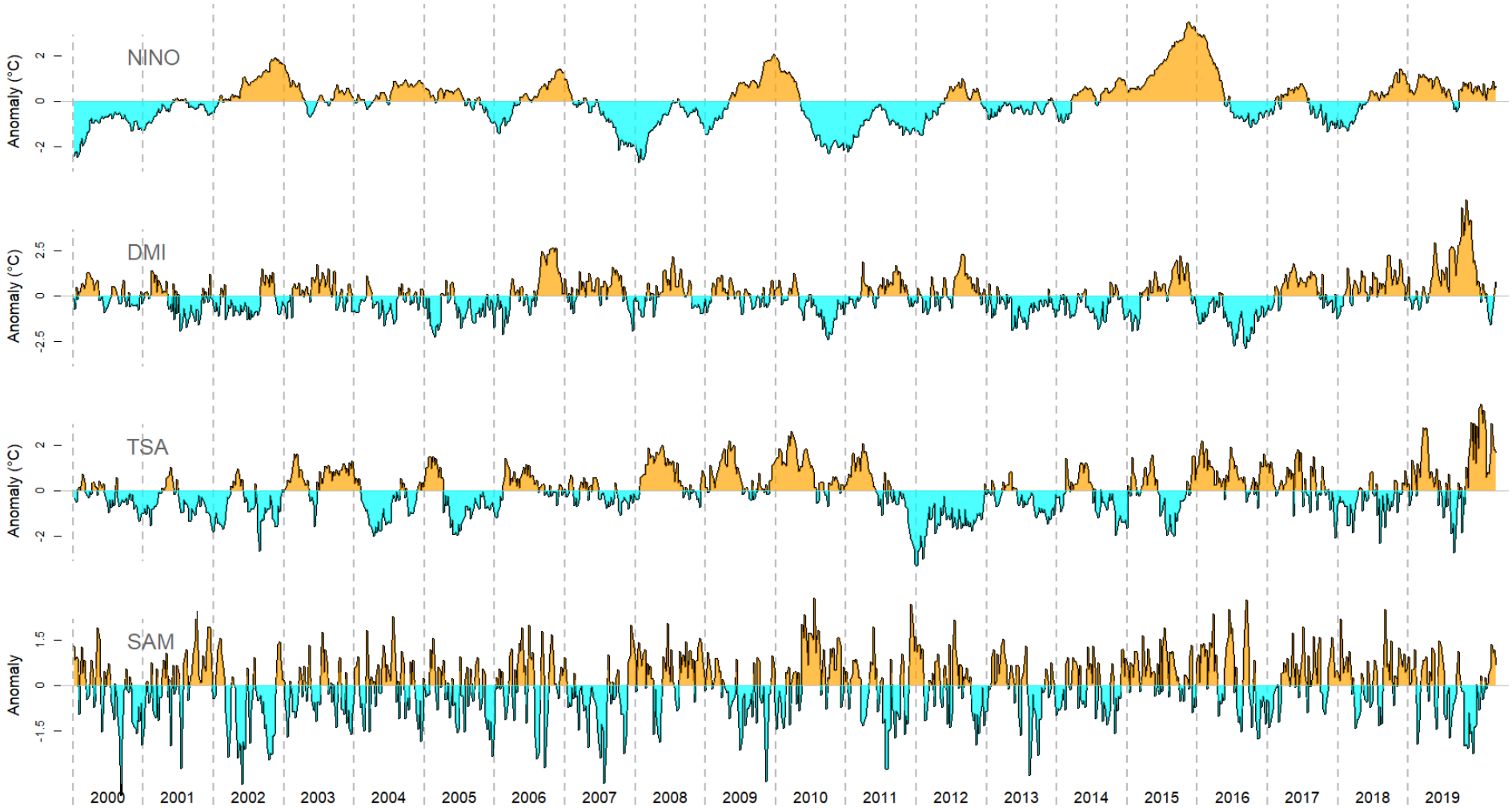


Figure: Predictors time series for climate mode indices.

Vector Autoregression

- Consider the following time series for NE Aus $Y_{t,1}$ and SE Aus $Y_{t,2}$.
- And for climate mode indices; Niño 3.4 $X_{t,1}$, DMI $X_{t,2}$, TSA $X_{t,3}$, and SAM (AAO) $X_{t,4}$.
- Then a VAR(p) model for a given time series $Y_{t,j}$ for $j = 1, 2$, can be written as

$$Y_{t,j} = \alpha + \sum_{i=1}^{p} \Phi_i^T \boldsymbol{X}_{t-i} + w_t,$$

where $\Phi_i = [\phi_{i,j}, \phi_{i,1}, \phi_{i,2}, \phi_{i,3}, \phi_{i,4}]^T$ and $\boldsymbol{X}_{t-i} = [Y_{t-i,j}, X_{t-i,1}, X_{t-i,2}, X_{t-i,3}, X_{t-i,4}]^T$, with α as an intercept and $w_t \sim iid(0, \sigma_w^2)$.

Model Selection

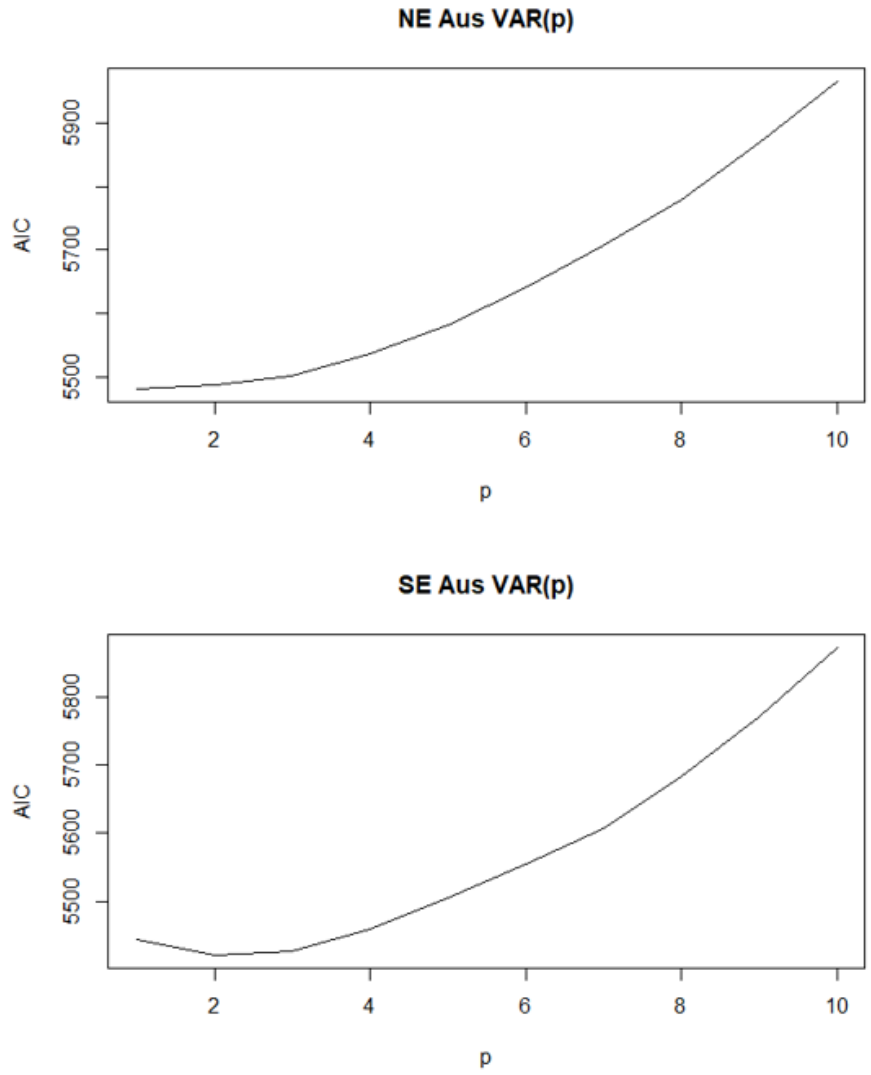
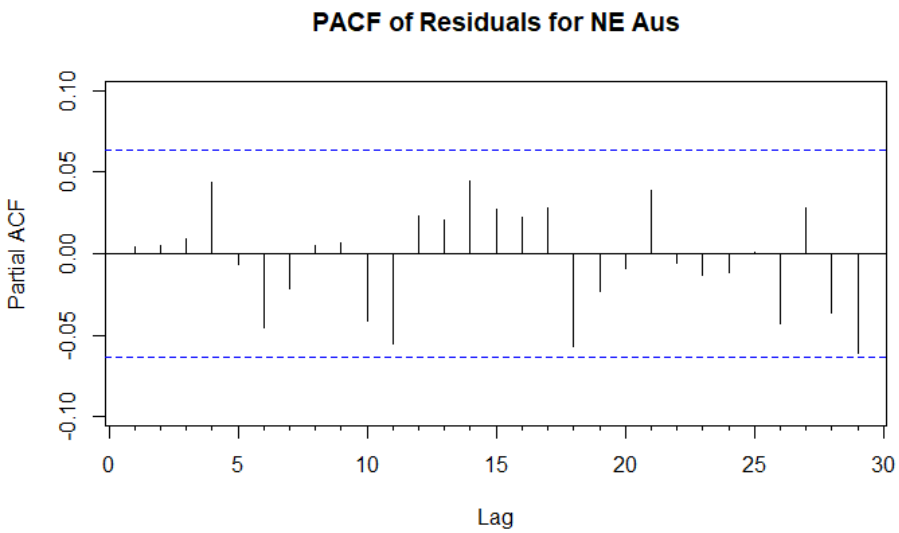
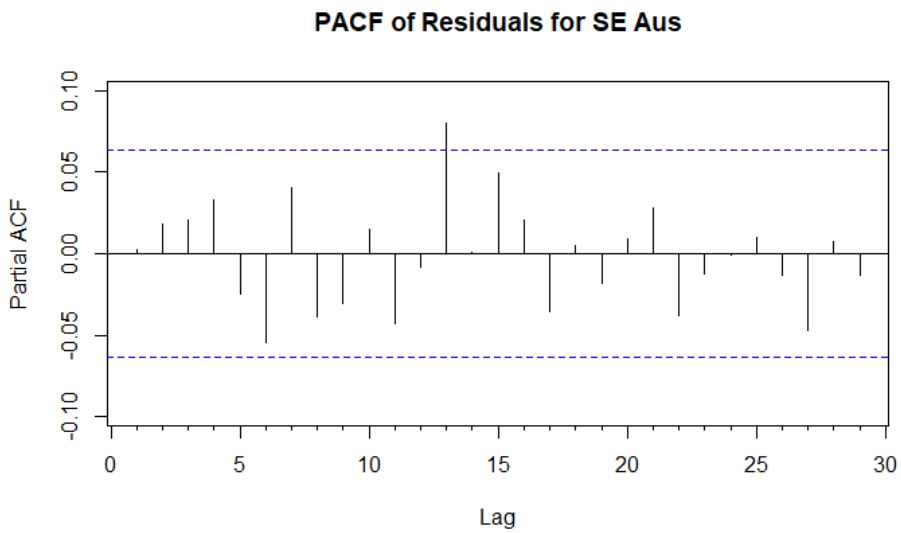


Figure: Used AIC to inform choice of p.

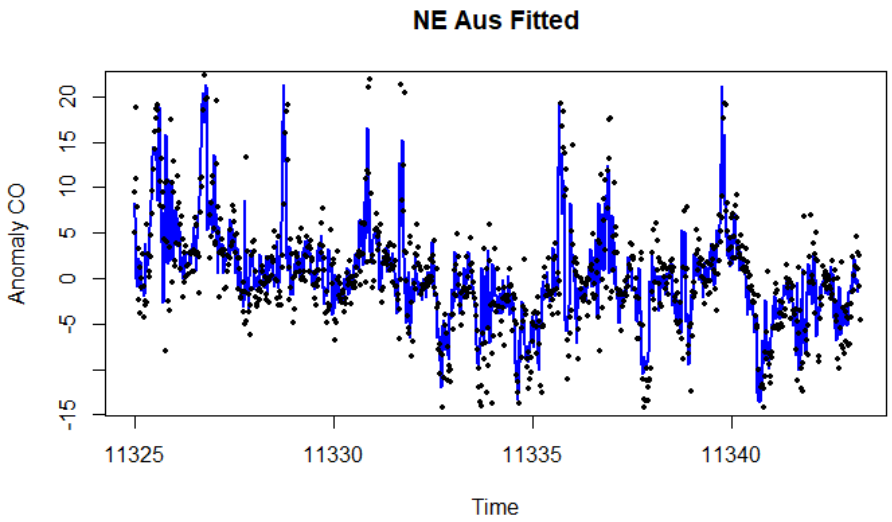
VAR Models

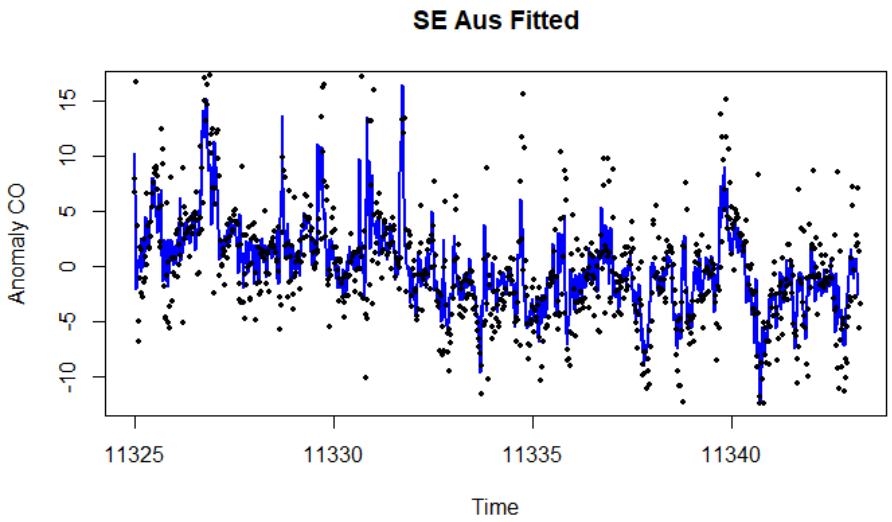
- We choose a VAR(4) for both NE Aus and SE Aus.
- Using the ‘vars‘ package to fit the model.



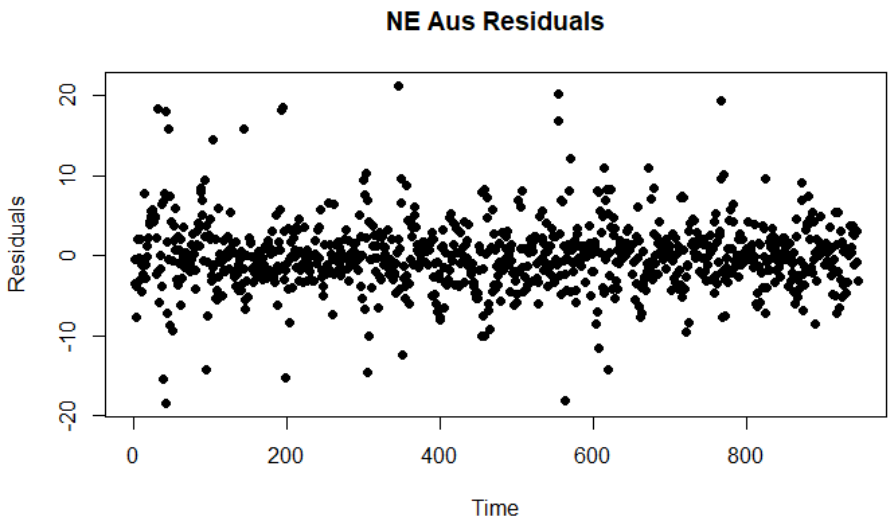


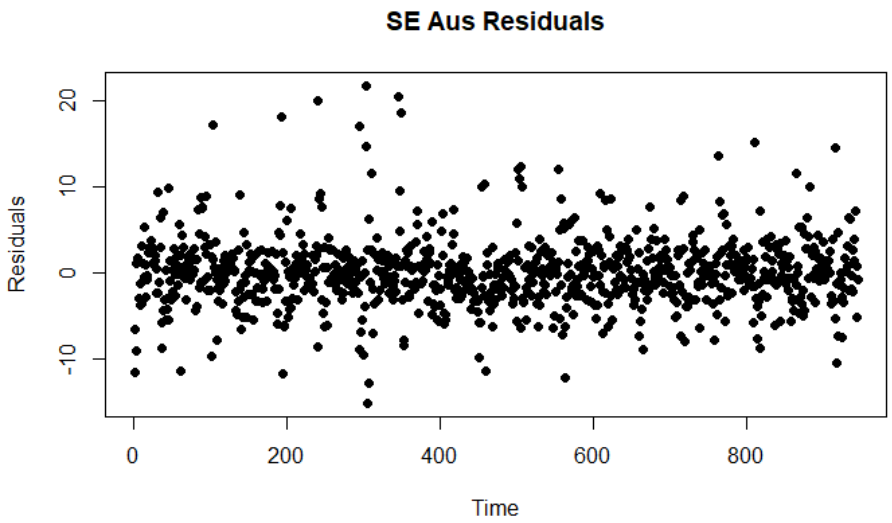
Fitted Model





Residuals


NE Aus Residuals
Residuals
20
10
0
-10
-20
0
200
400
600
800
Time


SE Aus Residuals
Residuals
20
10
0
-10
0
200
400
600
800
Time

Summary

- Using climate mode indices we are able create a time series model for CO anomalies in eastern Australia.
- Surprisingly, we did not need to distinguish wildfire season data.
- We also checked a VARMA(p,q) model but results were effectively the same.

Future Work

- Further refinement of these models specifically using:
  - Regression with ARMA errors.
  - Regularization methods.
  - Dynamic regression models.
- Add in Outgoing Longwave Radiation (OLR) as a predictor time series over the response regions.
  - This is effectively a measurement of rainfall.

Acknowledgments

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References

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Thank you! Questions?

Frame Title