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ABSTRACT

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10 *Significance statement.* This is significant because I wrote it.

11 **1. Introduction**

12 yada yada SAM yada yada circulation.. yada yada so important. yada yada many impacts.

13 **2. Methods**

14 1) DATA

15 We used monthly geopotential height at 2.5 longitude by 2.5 latitude resolution from ERA5
16 (Hersbach et al.) for the period 1979 to 2018 (inclusive).

17 Monthly temperature NOAA Global Surface Temperature (NOAAGlobalTemp) 5.0 degree lati-
18 tude x 5.0 degree longitude global grid (Vose et al. 2012; Smith et al. 2008). The same analysis
19 was carried out using CRUTEM4 (Osborn and Jones 2014) (not shown).

20 We used monthly precipitation data from CPC Merged Analysis of Precipitation (Xie and Arkin
21 1997) 2.5 degree latitude x 2.5 degree longitude.

22 2) DEFINITION OF INDEXES

23 We defined the Southern Annular Mode (SAM) as the leading EOF of the monthly anomalies of
24 geopotential field at 700 hPa south of 20°S (citation?). The EOF was performed by computing the
25 Singular Value Decomposition of the data matrix consisting in 481 rows and 4176 columns (144
26 points of longitude and 29 points of latitude). The values were weighted by the square root of the
27 cosine of latitude to account for the non-equal area of each gridpoint (Chung and Nigam 1999).
28 This same method was used at the rest of the levels considered in this paper.

29 To separate between the zonally symmetric and asymmetric components of the SAM, we com-
30 puted the zonal mean and anomalies of the full SAM spatial pattern. The results are shown in

31 Figure 5 for 700hPa. The full spatial signal ($\text{EOF}_1(\lambda, \phi)$) is the sum of the zonally asymmetric
32 ($\text{EOF}_1^*(\lambda, \phi)$) and symmetric ($[\text{EOF}_1](\lambda, \phi)$) components. We then compute the “Full”, “Asymmet-
33 ric” and “Symmetric” indexes, by regressing each geopotential field on these patterns (weighting
34 by the cosine of latitude).

35 The three indexes are normalised by dividing them by the standard deviation of the “Full” index
36 at each level. This means that comparing the magnitude between indexes is meaningful, but it also
37 means that not every index will have unit standard deviation.

38 3) SIGNIFICANCE

39 We adjusted p-values for False Detection Rate following Wilks (2016).

40 3. Results

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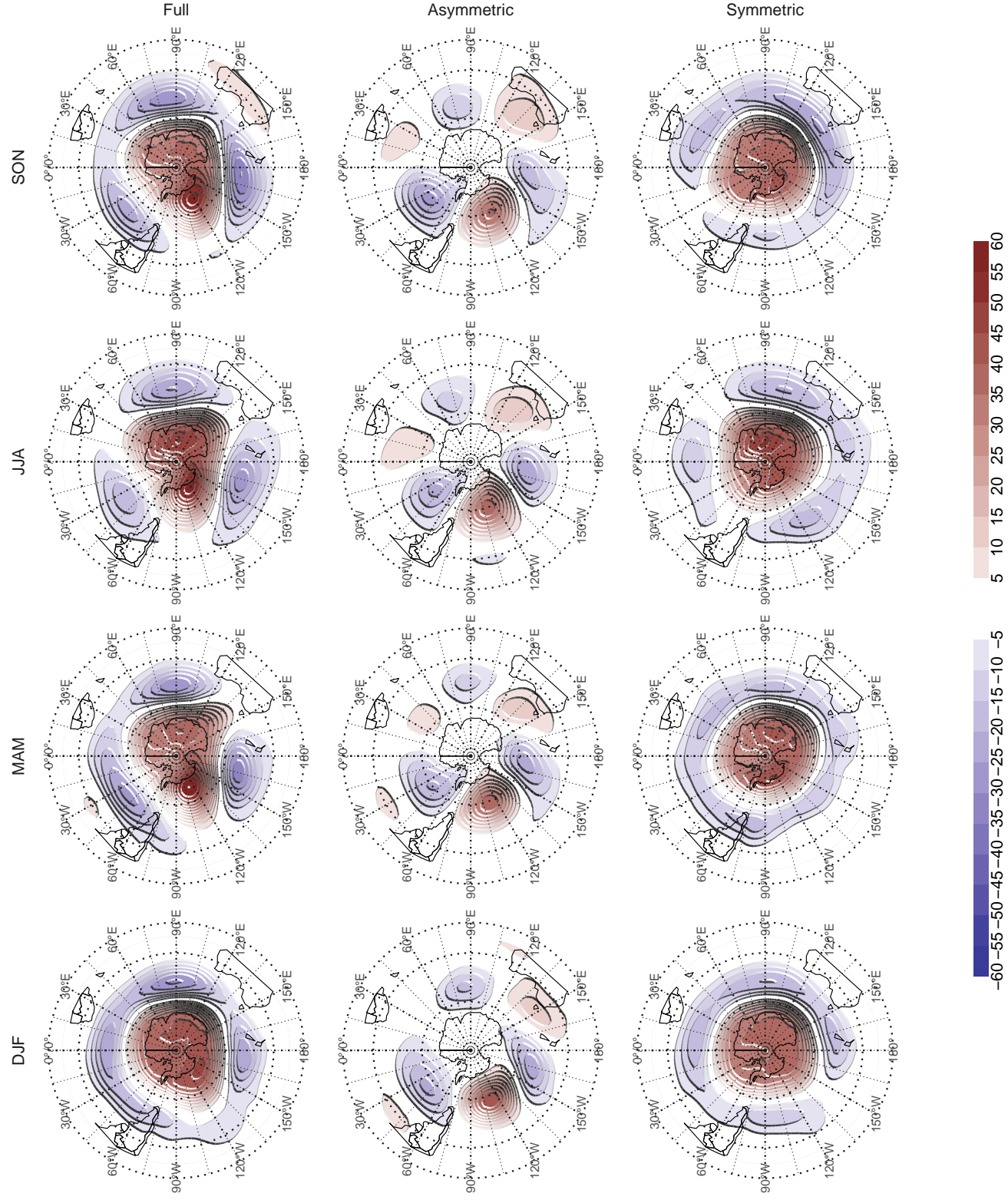


Fig. 1. Seasonal regression patterns of geopotential height at 700 hPa with the Full, Asymmetric and Symmetric SAM. The regression patterns for Asymmetric and Symmetric SAM are the result of one multiple regression using both indices, not of two simple regressions involving each index by

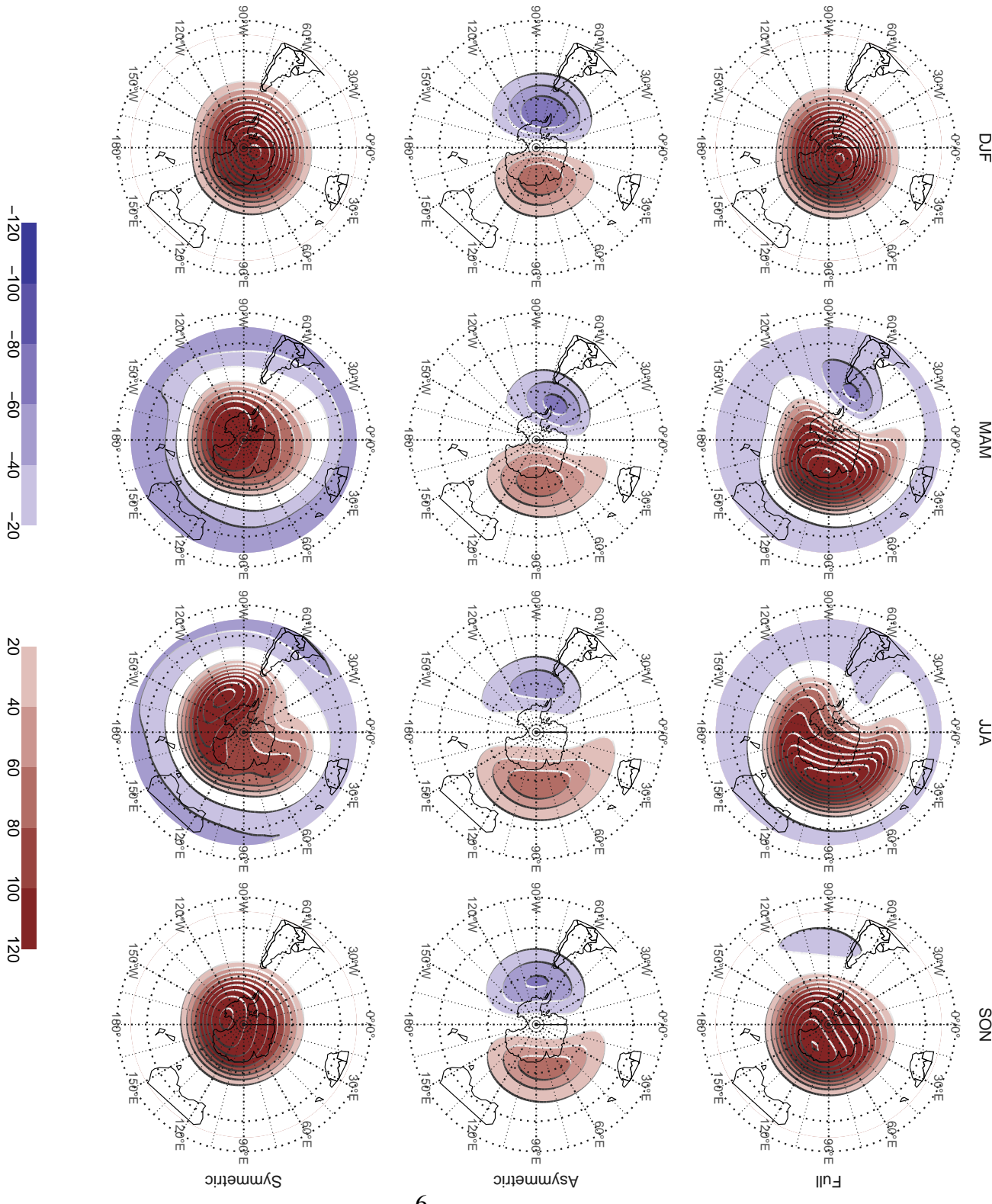


Fig. 2. Seasonal regression patterns of geopotential height at 30 hPa with the Full, Asymmetric and Symmetric SAM. The regression patterns for Asymmetric and Symmetric SAM are the result of one multiple regression using both indices, not of two simple regressions involving each index by itself.

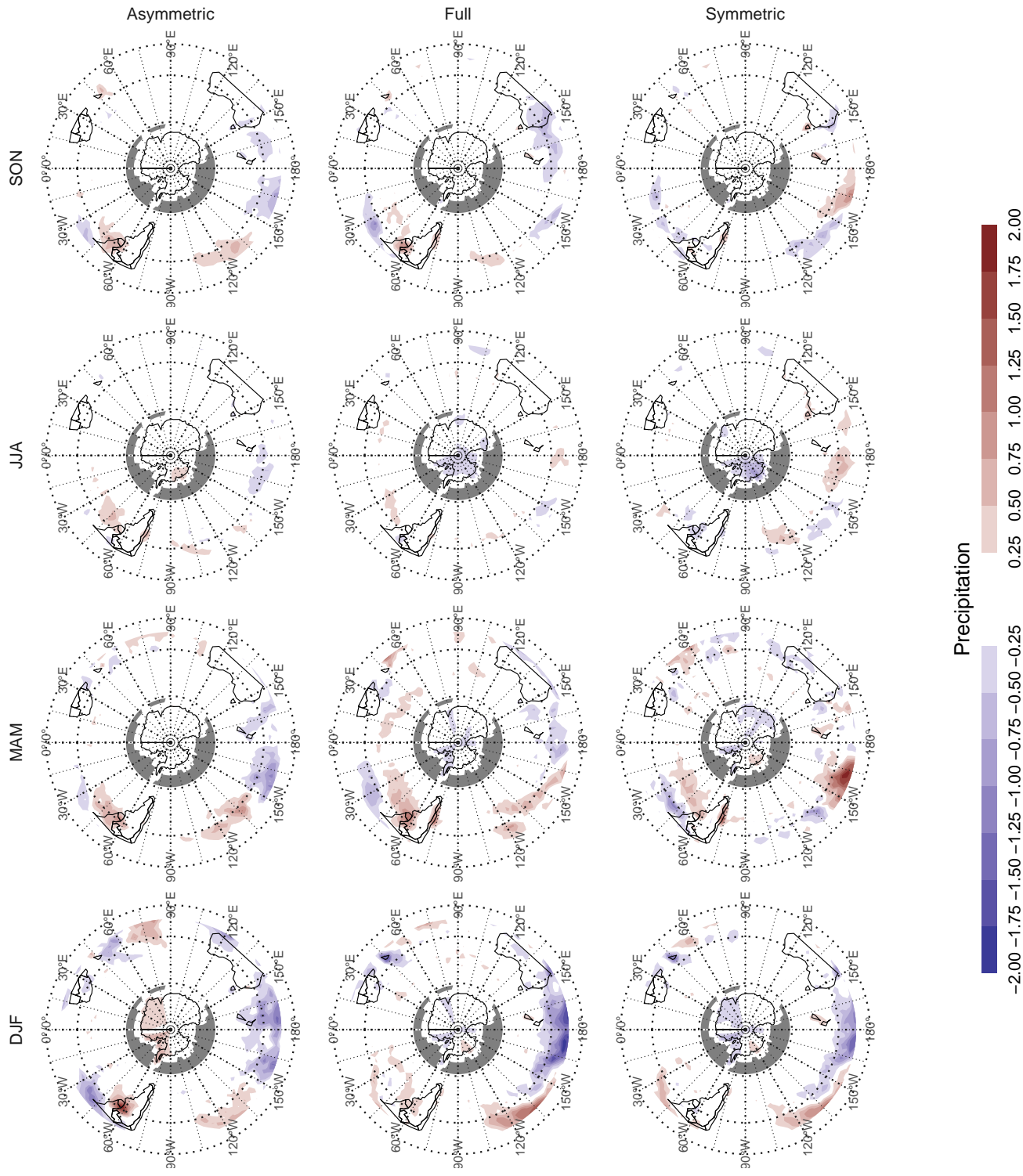


Fig. 3. Regression pattern of precipitation with Asymmetric and Symmetric SAM. P-values smaller than 0.05 (controlling for False Detection Rate) as hatched areas.

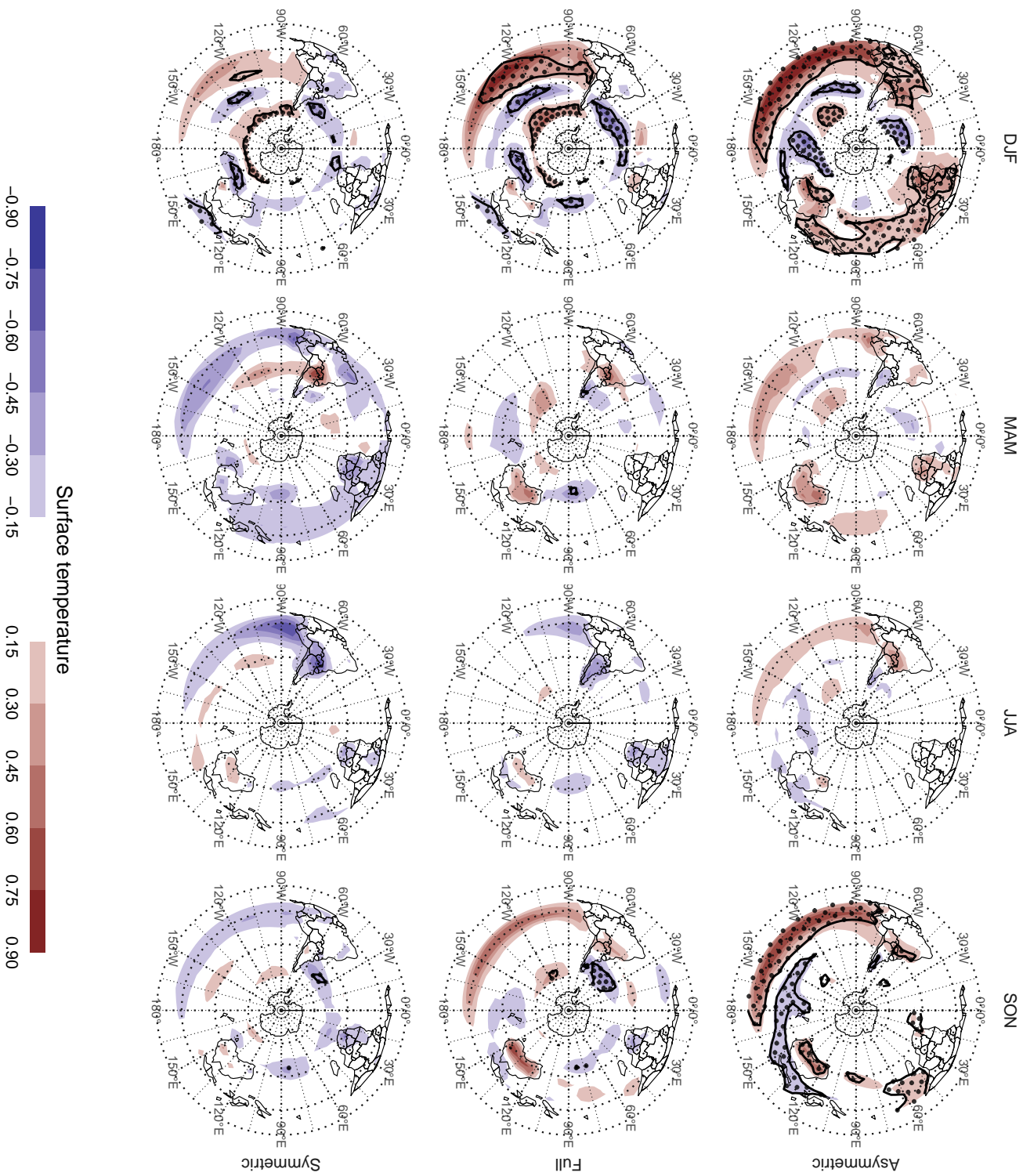


Fig. 4. Regression pattern of surface temperature with Asymmetric and Symmetric SAM. P-values smaller than 0.05 (controlling for False Detection

63 *Acknowledgments.* CMAP Precipitation data provided by the NOAA/OAR/ESRL PSL, Boulder,
64 Colorado, USA, from their Web site at <https://psl.noaa.gov/>

65 NOAA Global Surface Temperature (NOAAGlobalTemp) data provided by the
66 NOAA/OAR/ESRL PSL, Boulder, Colorado, USA, from their Web site at <https://psl.noaa.gov/>

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87 APPENDIX

88 **Extra figures**

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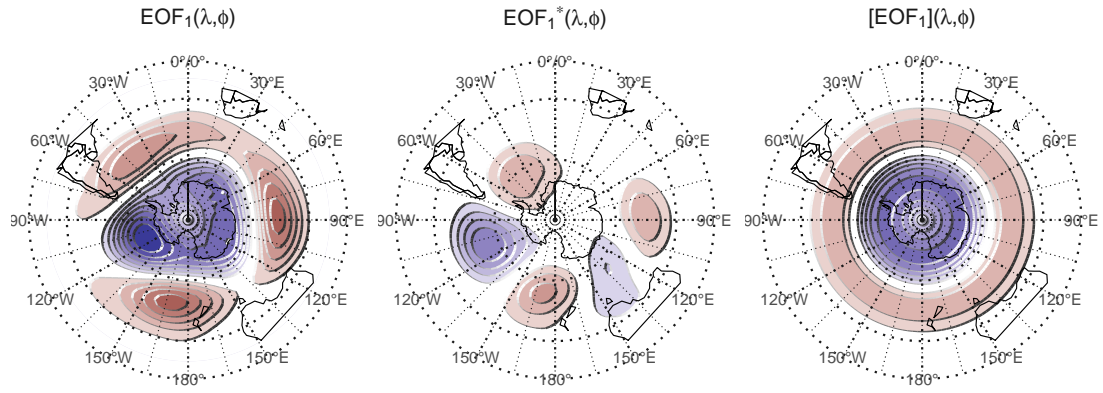


FIG. 5. Spatial patterns of the first EOF of 700 hPa geopotential height. Full field (left), zonally asymmetric component (middle) and zonally symmetric component (right). Arbitrary units.

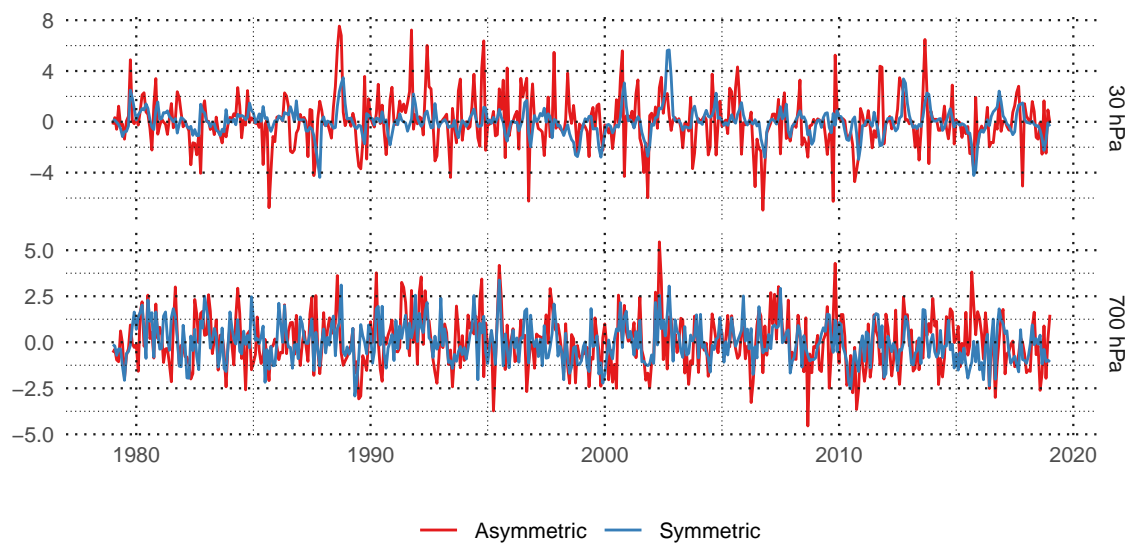


FIG. 6. Time series for the asymmetric SAM and symmetric SAM.

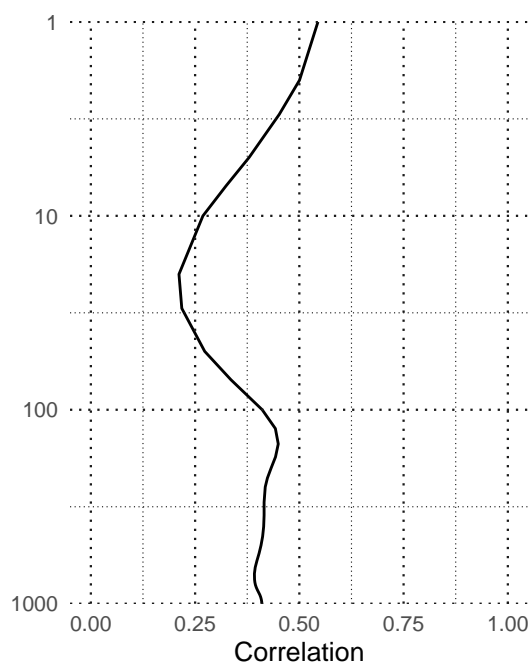


FIG. 7. Correlation between the Symmetric and Asymmetric SAM at each level.

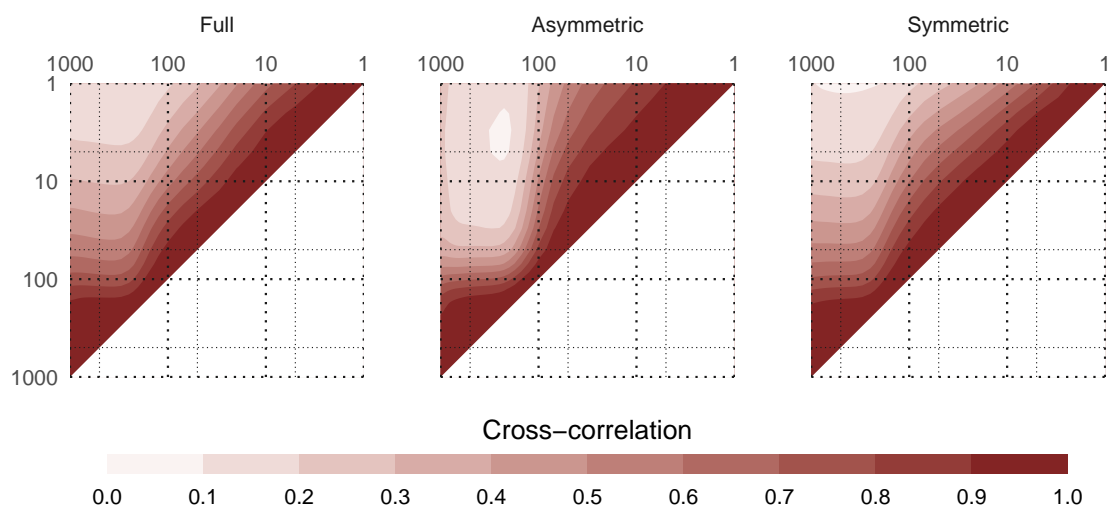


FIG. 8. Cross correlation between levels of the Full, Asymmetric and Symmetric SAM.

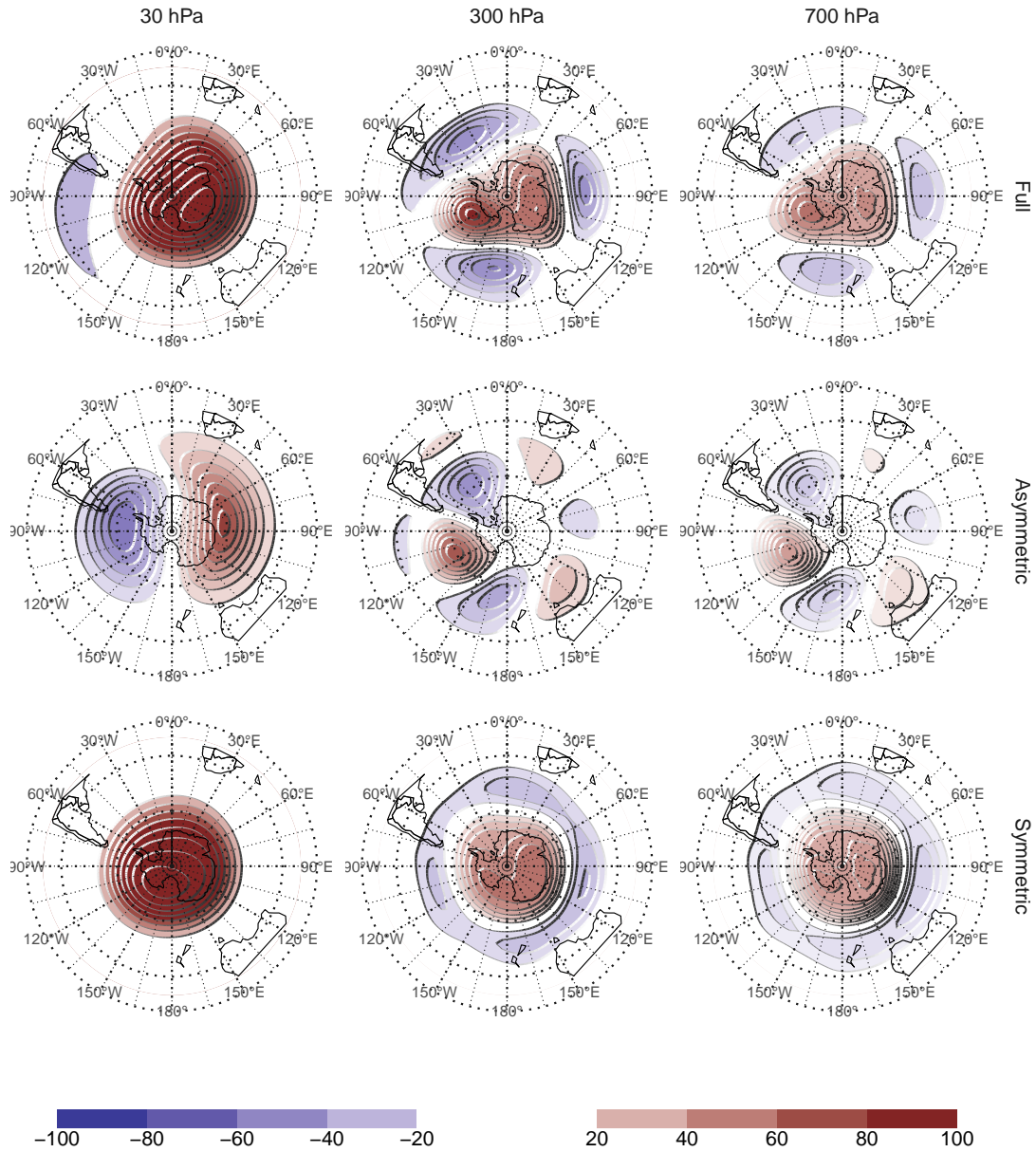


FIG. 9. Regression patterns of geopotential height at 30, 300 and 700 hPa with the Full, Asymmetric and Symmetric SAM. The regression patterns for Asymmetric and Symmetric SAM are the result of one multiple regression using both indices, not of two simple regressions involving each index by itself.

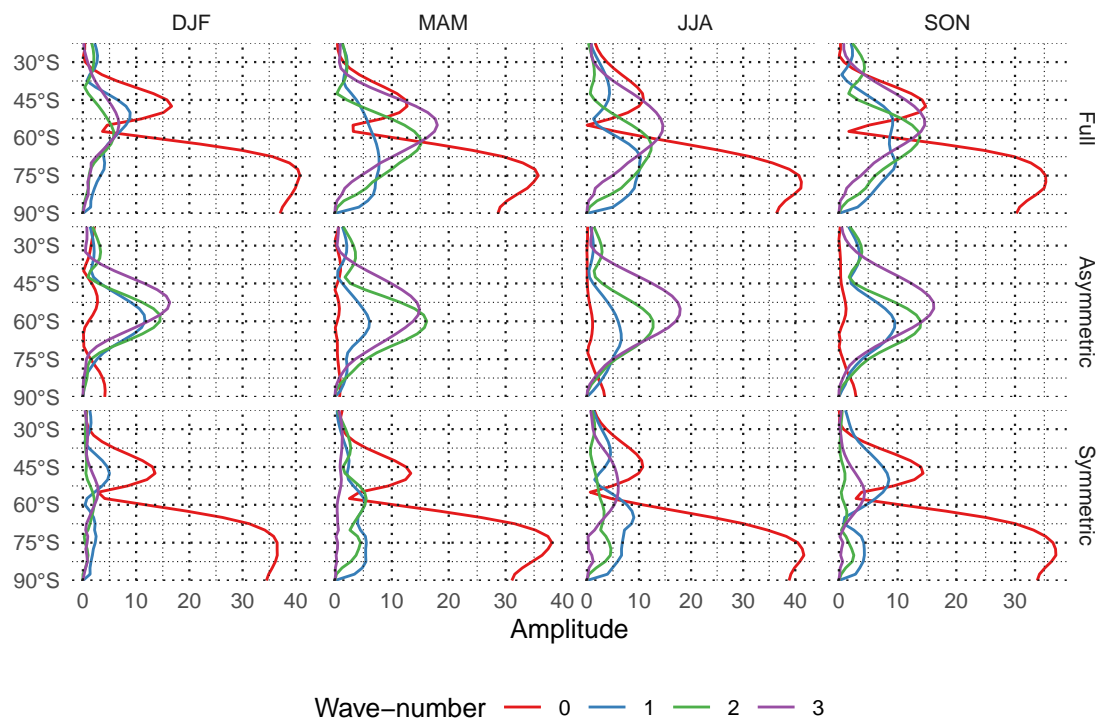


FIG. 10. Planteray wave amplitude for the regression patterns at 700 hPa.

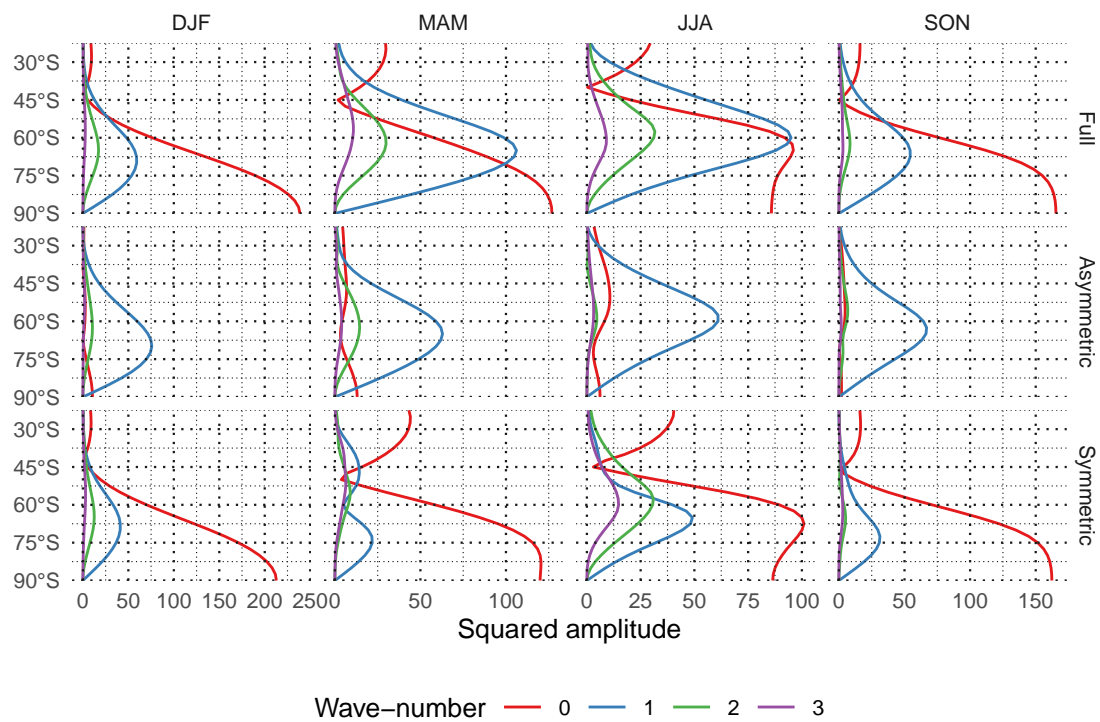


FIG. 11. Planetary wave amplitude for the regression patterns at 30 hPa.

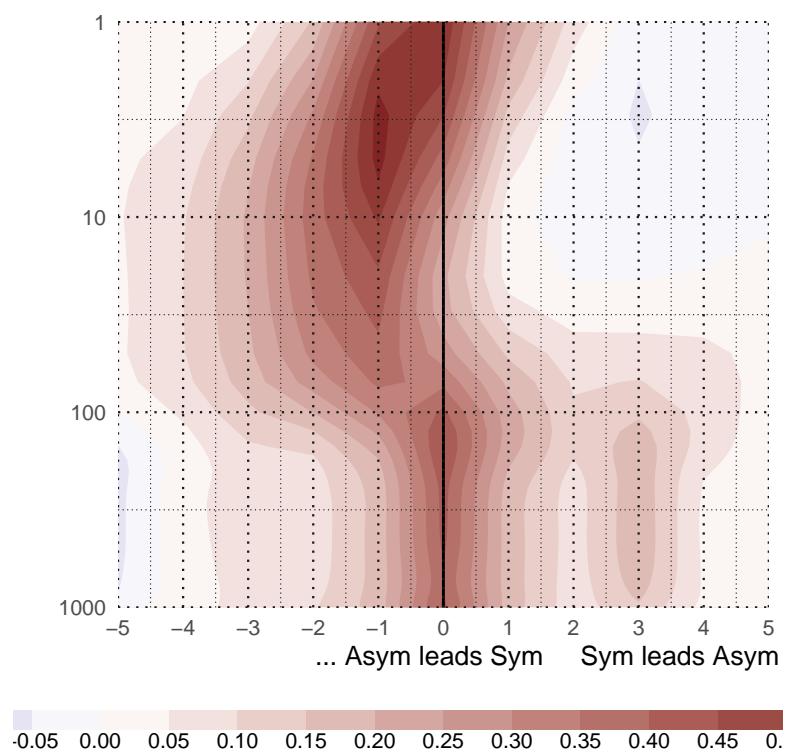


Fig. A1. Lag-correlation between Symmetric and Asymmetric SAM at each level.

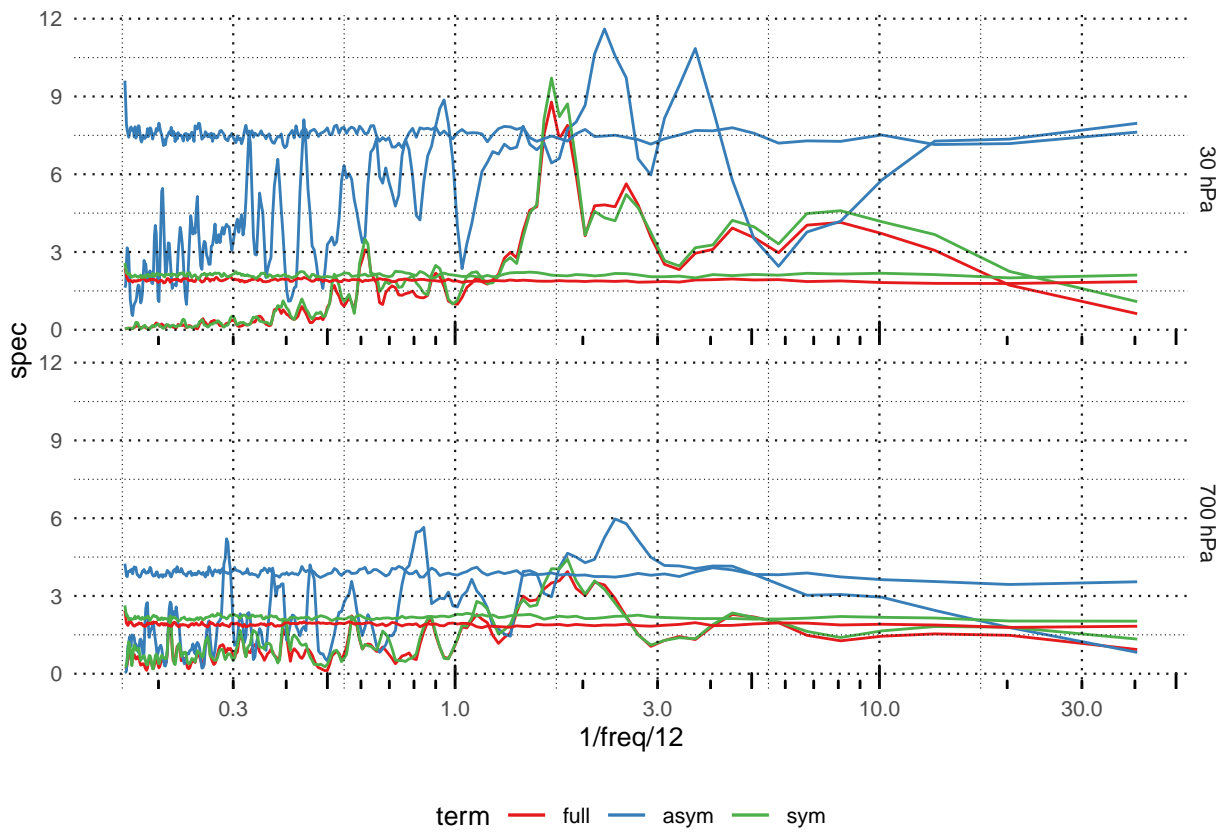


Fig. A2. Foutier spectrum

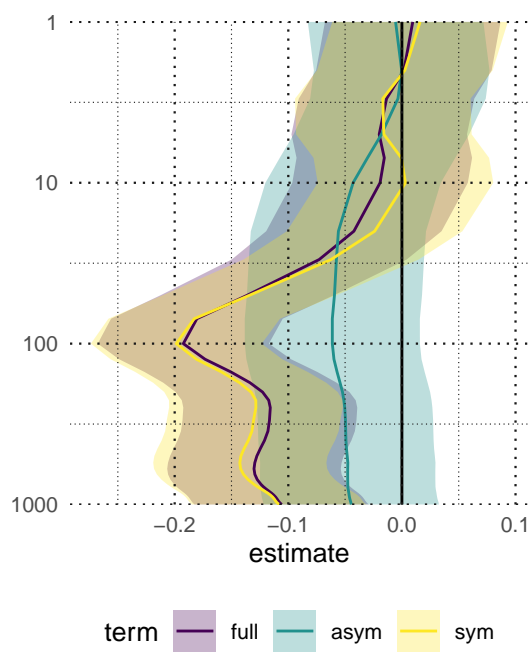


Fig. A3. Trends for each index at each level. Shading indicates the 95% confidence interval.