Minjerribah and K'gari rainfall

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Kgari ENSO work

"Is there a different spatial origin of precipitation to K'gari and/or Minjerribah during ENSO phases?"

A contiguous suite of HYSPLIT atmospheric trajectory model runs were used to trace the atmospheric pathways of precipitation to K'gari and Minjerribah. Trajectories from each location were run backwards, daily, for 1950 - 2022. Release height of 2000 m, duration 72 hr, using NCEP/NCAR 2.5-degree reanalysis data.

Rainall records from Sandy Cape and Point Lookout were used to filter the trajectories to those arriving at the sites on days where >100 mm of rainfall was recorded. Remaining trajectories were grouped into 5 clusters using an angle-based distance matrix based upon Sirois and Bottenheim (1995) through the openair package for R. Within-cluster frequencies were extracted and compared against the Nino3.4 index to determine possible spatial modulation by ENSO. A single outlier was removed from the Point Lookout trajectory dataset, with the trajectory associated with the rainfall event on 26/04/1956 consistently biasing the clustering calculations.

A note on NCEP/NCAR reanalysis data The NCEP/NCAR reanalysis data is reasonably coarse but as the focus is on large (>100mm) events driven by (presumably) synoptic-scale dynamics, this product should be appropriate. There is some fairly severe uncertainty in the NCEP/NCAR reanalysis prior to the late 1970s (erroneous inverted integration of SH pressure buoy data).

Nino 3.4 SST anomaly data at monthly resolution was obtained from NOAA. Phase events (i.e. La Nina, El Nino, or neutral) were defined based on the definition utilised by NOAA. That is, an El Nino event is a time period where the three-month-averaged-smoothed Nino3.4 anomaly timeseries exceeds a value of 0.5 for 5 months or more. La Nina, where the value falls below -0.5 for >5 months. A neutral period is used here to denote any time period where there is no El Nino or La Nina event occuring, as per the definition.
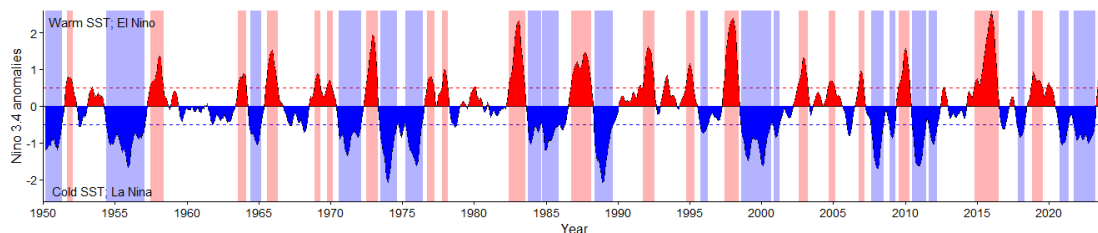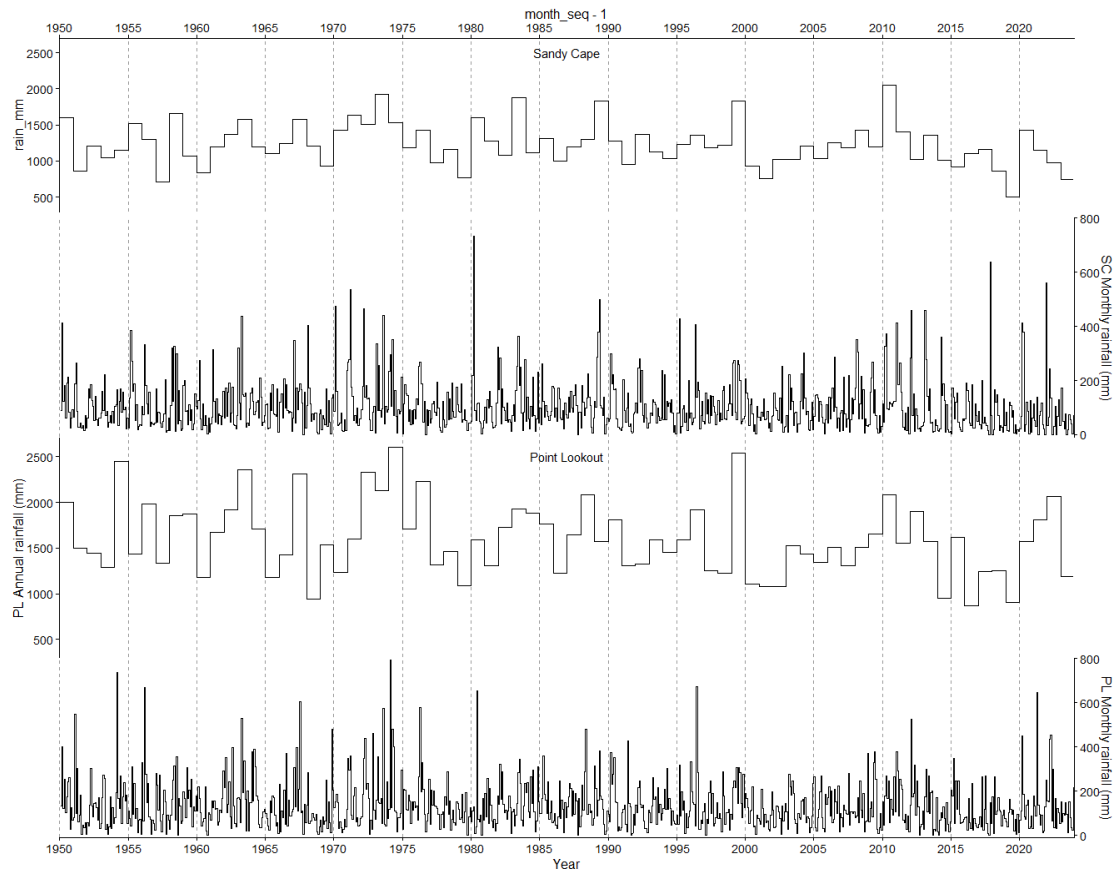
NINO3.4 time series

Fig. ENSO time series used for phase event definition.

Rainfall time series

Monthly and annual total rainfall for Sandy Cape and Point Lookout between 1950 and 2022.

To determine potential differences in the spatial dynamics of large event precipitation, trajectories from days where >100 mm of rain was recorded were grouped using cluster analysis. To prioritise the importance of backwards travel direction, and angle-based distance matrix calculation was used, based upon Sirois and Bottenheim (1995). Clustering was performed using the openair package in R. Four clusters were chosen in order to provide a balance between separation of disparate trajectories whilst not exacerbating the potential bias introduced by individual outlier trajectories as a result of the relatively small trajectory sample sizes (104 event trajectories for PL, 68 for SC).
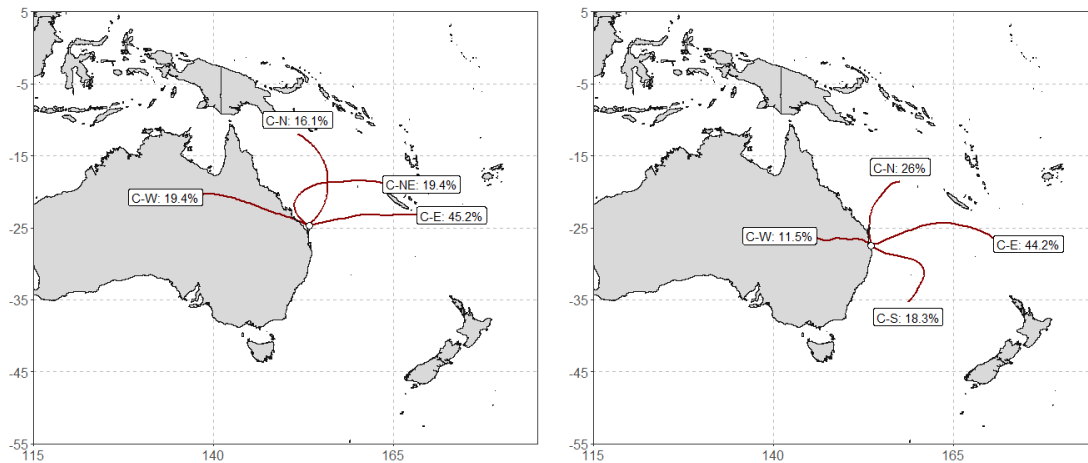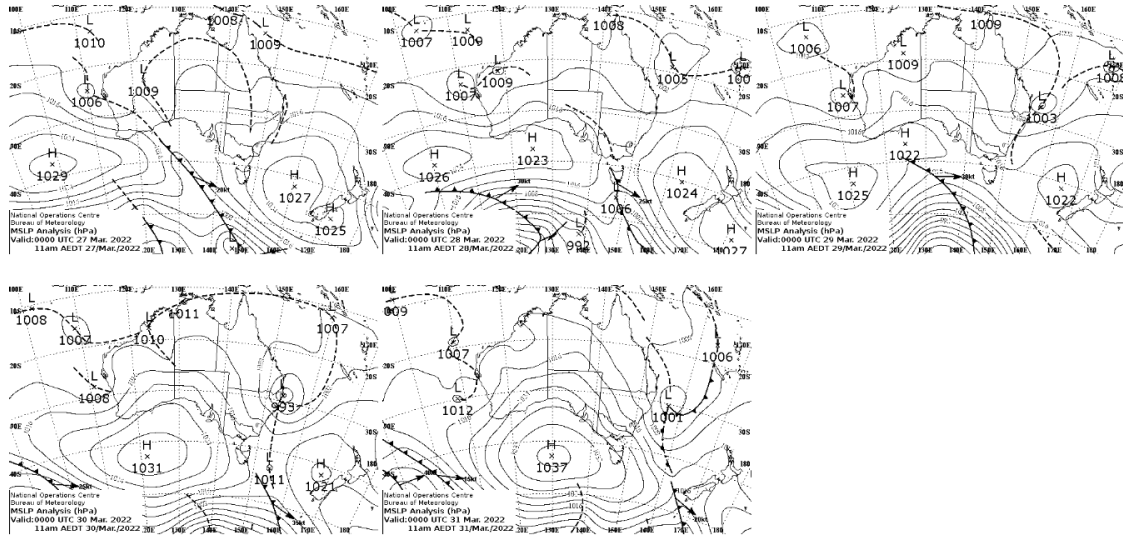
Fig. Trajectory clusters (n = 4) to Sandy Cape (left) and Point Lookout (right). Frequencies display the >100 mm within each cluster as a proportion of the total number at each site. Cluster names have no statistical significance and were designated to draw parity between each site where possible. Clusters are named based upon their approximate direction of travel. Note that this naming scheme (and any cluster designation method) is inherently and unavoidably reductive, and each cluster will be comprised of trajectories that, whilst similar spatially, will travel in different ways and from different directions. The clustering simply serves to reduce the dimensionality of the data in a meaningful way.

For the period of 2002 to present, daily BOM MSLP charts can be used to perform a very limited and selective interrogation of the behaviour of the model (i.e., are the pathways consistent with how we might expect airmasses to move along isobars).

On 29/03/22, ~240 mm of rain was recorded at Point Lookout. Inspecting the BOM MSLP charts for this period shows a front associated with a fast-moving low-pressure cell moving down to PL from the tropics.

Fig. Five days of MSLP charts from BOM, 27/03/22 - 31/03/22.

The trajectories from this period all behave as we might expect, moving anti-clockwise around the high-pressure cell over the Tasman sea, before being perturbed by the low-pressure cell when it arrives at point lookout. The event trajectory for 29/03/22 was classified into the 'C-E' cluster.
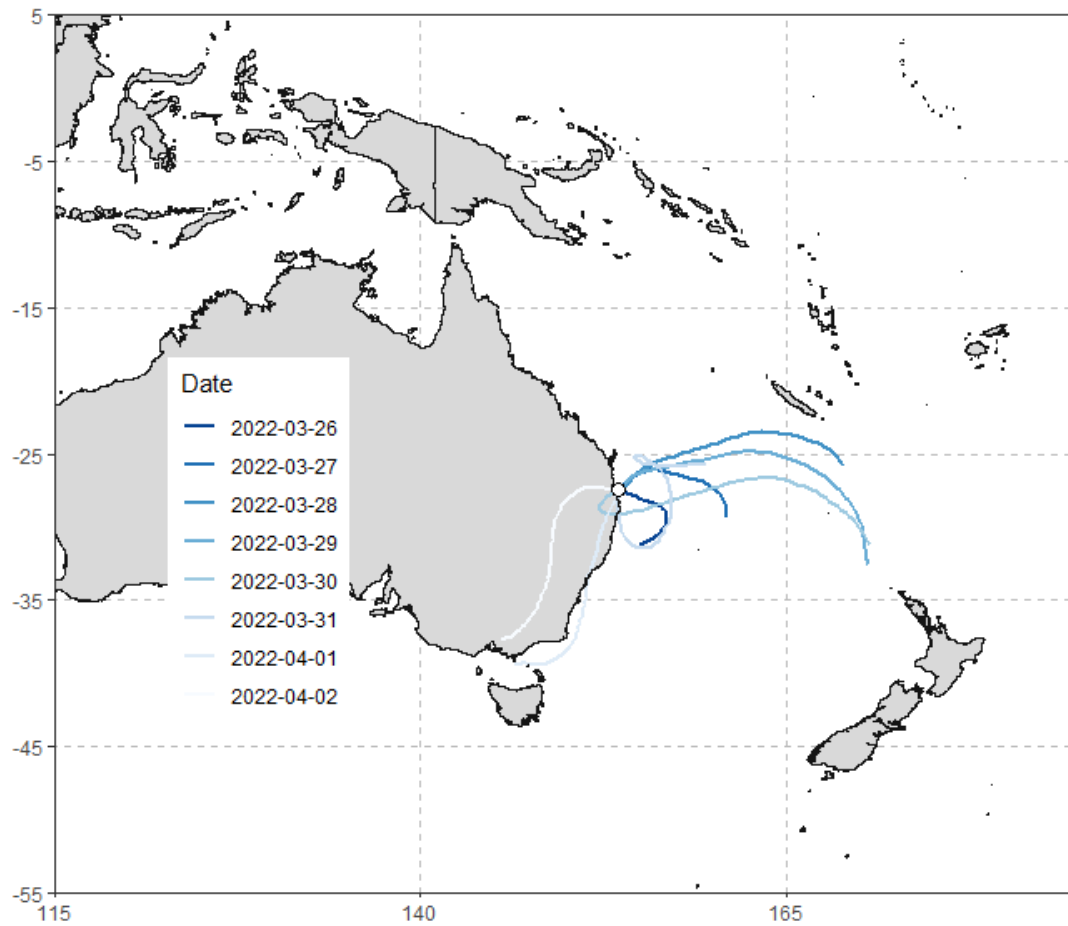
Fig. Daily trajectory paths between 26/03/22 and 02/04/22. Lighter colours = later days.

Hidden code block here for cluster time series WIP code. Insufficient sample size to do anything interesting at this stage.

Broad patterns in rainfall

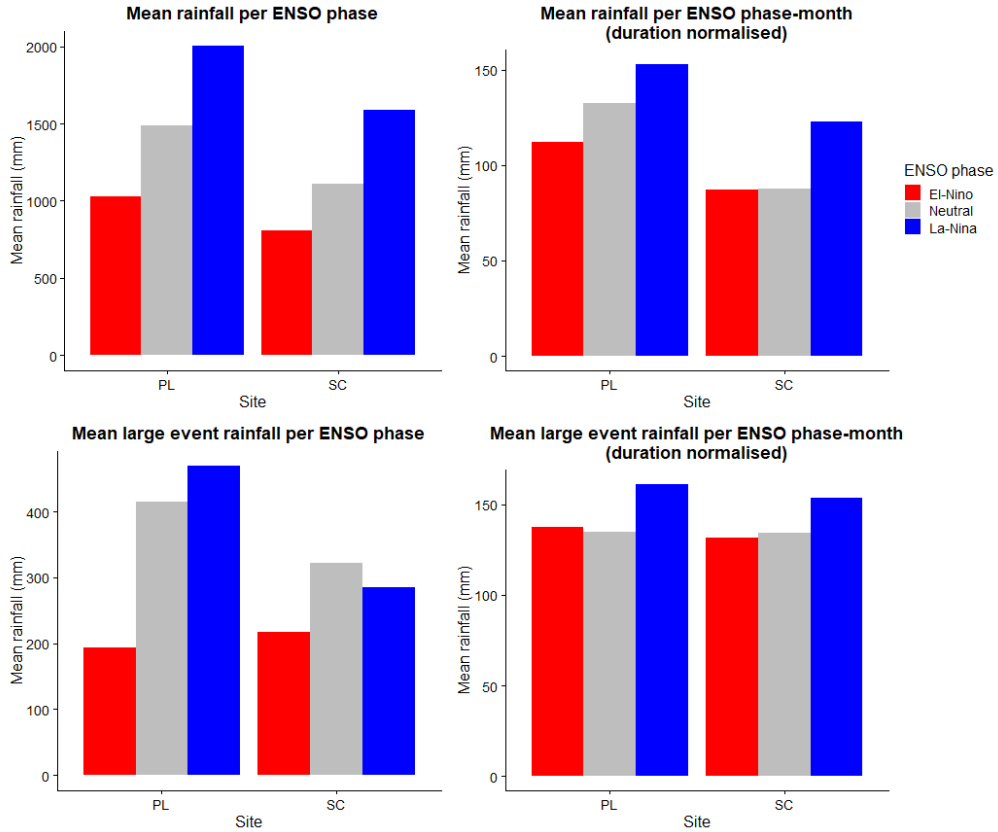Rainfall proportions during different ENSO phases

Fig. Mean rainfall at each site during ENSO phases. Top row is using the mean of all rainfall that falls during a given ENSO phase, and the lower row is restricted to the rainfall contributed to by large events. The right column plots are normalised by event duration (i.e. the results are not biased by longer phases, which will often inevitably exhibit greater rainfall totals).

Broad patterns in large event trajectory travel

Bulk groupings of cluster proportions for each site are displayed below, both in total (i.e. number of events) and as frequencies (i.e. percentages).
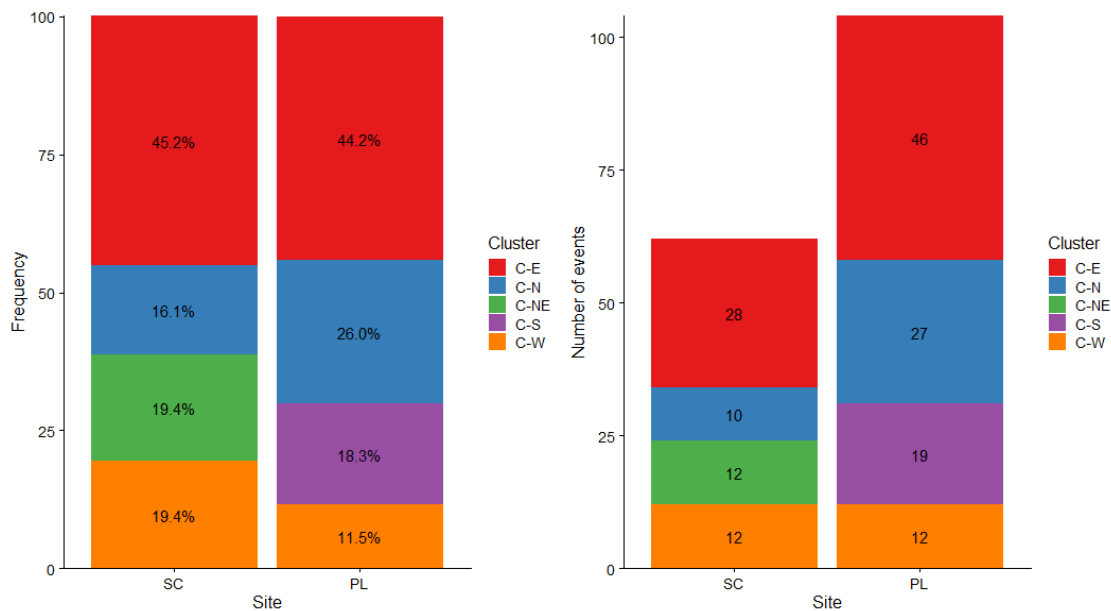
Fig. Proportions (frequencies) and quantities of large (>100 mm) rainfall events associated with trajectory clusters to Sandy Cape and Point Lookout, 1950-2022. Some similarities are immediately apparent - for instance, whilst Point Lookout received more large events during this period, both sites received an identical number of C-W events. Interestingly, none of these are on the same day! So, this

ENSO phase effect on trajectory travel

Trajectory clusters were grouped by month (i.e., the same resolution as the Nino3.4 series and parsed into their respective ENSO phases.
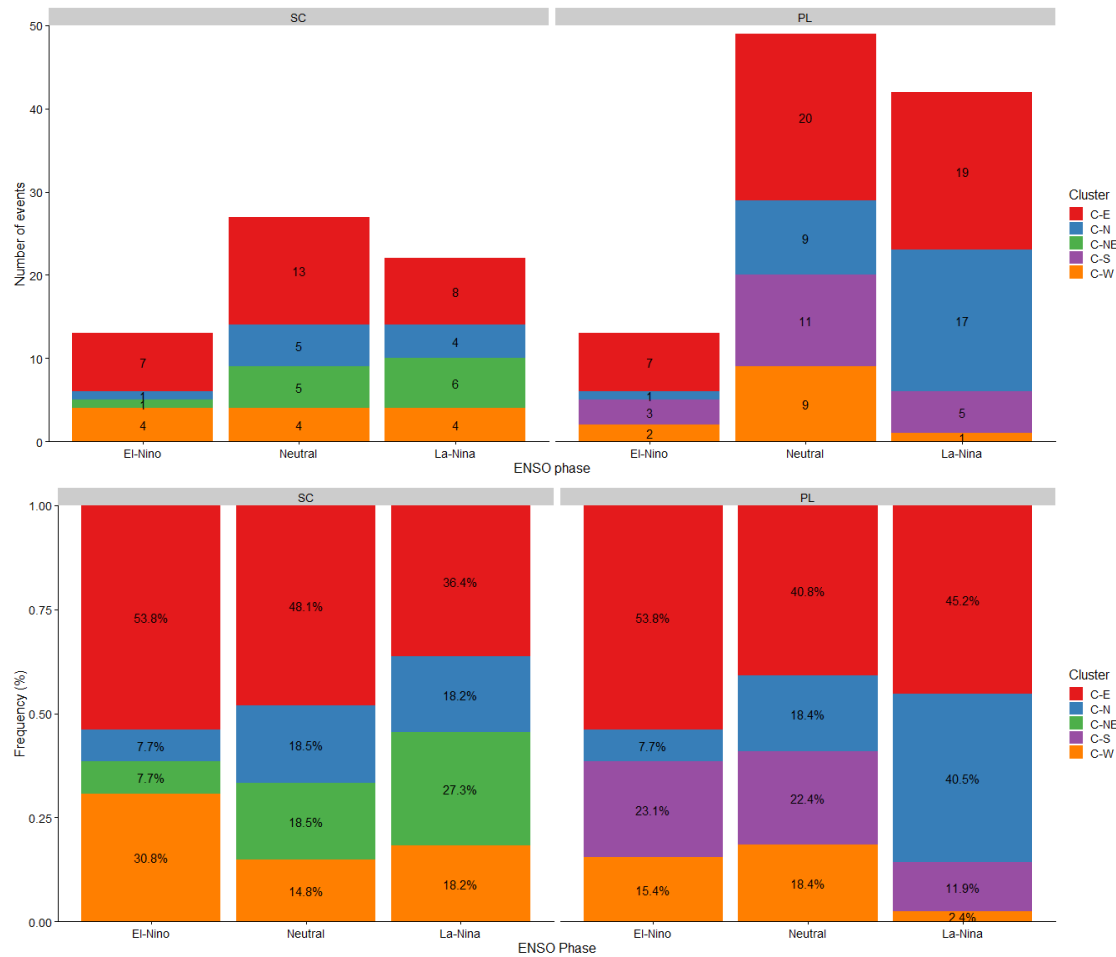
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