Movement patterns of southern elephant seals from individual to collective scales

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The growing number of large databases of animal tracking provides an opportunity for analyses of movement patterns at the scales of populations and even species, requiring for powerful analysis methods [1, 2]. Classical studies of human mobility developed some techniques that can be implemented for the analysis of animal movement, leading to new insights in this field.

We analyze a pooled dataset of $>$500,000 locations of 272 southern elephant seals individual trajectories using novel techniques (for wildlife studies), considering movements on an individual or species level without a priori assumptions about the behaviors associated with certain movements

The aggregated distribution of displacements displays power-law distribution across several temporal and spatial scales with an exponent 0.60. However, the displacements are splitted in two different groups: those originated at low occupancy locations, characterized by a higher velocity with a more directed movement, and those originated at high occupancy locations.

This pattern arises at an aggregated level despite the individual trajectories analysis shows a wide idiosicracy, with individuals that are very predictable, with their movement restricted in a small area, and others displaying broad and complex visitation patterns. In fact, the gyration radius, an indicator of the spatial spread of trajectories, varies considerably along trajectories (Fig. 1B).

Finally, we obtain marine provinces defined by the collective movement patterns of elephant seals, applying community detection methods to the transition probability matrix between two areas (Fig. 1C).

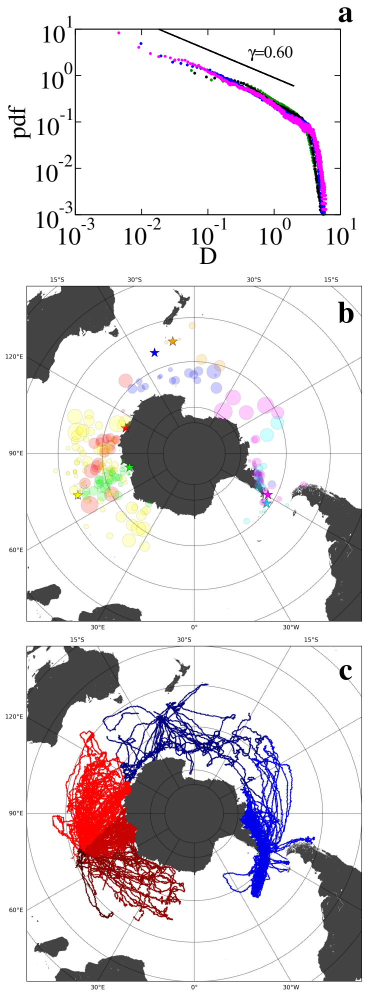

Figure 1: **a**, Probability density function (pdf) of normalized displacements D for 0.5 day (green), 1 day (black), 4 days (blue), and 10 days (magenta). The pdfs collapse into a universal function: for displacements below the average ($D < 1$), the probability decays as a power-law, while for larger displacements, the pdf decays abruptly; **b**, Map of the position of the centre of mass of each trajectory. Circle size is proportional to the gyration radius r_G; colours indicate different deployment locations, which are represented with star symbols; **c**, Map of the marine provinces. Red and blue colours indicate the communities at level 0, while the darkness of the colours separates communities at level 1.

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[1] G.C. Hays, et al. Key questions in marine megafauna movement ecology. Trends in ecology & evolution **31**, 463-475 (2016).

[2] N.E. Hussey, et al. Aquatic animal telemetry: a panoramic window into the underwater world. Science **348**, 1255642 (2015).