PRIMER-e
Empowering Research

PRIMER/PERMANOVA Essentials

Outline of Topics

1. Properties of multivariate data
    a. Pre-treatment options, including transformation, standardization, normalization & dispersion weighting
    b. Distance/dissimilarity/similarity measures for a variety of data types
2. Cluster analysis (**CLUSTER**), including tests for significant structure within clusters (**SIMPROF**) to permit non-arbitrary classifications of samples or variables (species)
3. Ordination *via* projection:
    a. Principal component analysis (**PCA**); and
    b. Principal coordinate analysis (**PCO**)
4. Ordination to preserve inter-sample relationships *via* non-metric, metric or threshold metric multi-dimensional scaling (**nMDS**, **mMDS**, **tmMDS**)
5. Relating biotic to abiotic data, including tests of association between resemblance matrices (**RELATE**); tests of seriation and cyclicity.
6. Finding optimal subsets of environmental (or other) variables that generate a 'best' match to patterns among samples based on species variables (**BEST – BIOENV**)
7. Non-parametric permutation tests for differences among *a priori* groups of samples:
    a. Analysis of Similarities (**ANOSIM**);
    b. Ordination of **Bootstrap averages**; and
    c. Finding important variables (**SIMPER** and **BEST – BVSTEP**)
8. Diversity measures; Taxonomic distinctness; Taxonomic resemblance
9. Partitioning variation for high-dimensional data on the basis of a resemblance measure of choice and tests for differences in centroids (location) for *a priori groups* (**PERMANOVA**), including:
    a. One-way and two-way cases & constructing *a priori* contrasts;
    b. Tests for interactions and pairwise tests
10. Tests for homogeneity of multivariate dispersions and comparisons of beta diversity (**PERMDISP**); **PERMANOVA** tests for centroid differences in the presence of heterogeneity.
11. Complex multi-factor experimental designs (**PERMANOVA**), including:
    a. Fixed/random factors; Crossed/nested relationships; Expectations of mean squares; Components of variation; Types of SS; Covariates; Pooling; Unbalanced designs
    b. **Centroid plots** for Main Effects and Interactions; Residual plots.
12. Finite factors and asymmetrical designs (**PERMANOVA**)
13. Fitting multivariate response data (e.g., species) to continuous predictor variables (e.g., environmental), including:
    a. model selection (**DISTLM**); and
    b. dissimilarity-based redundancy analysis (**dbRDA**) to visualise fitted variation
14. Identifying when an observation is 'unusual', given previous observations (e.g., in a time-series / monitoring program) using multivariate dissimilarity-based **Control Charts**.
15. Wrap-up and Overview of the week / Open Q&A Session / Own-data Session.

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Provisional Time-Table

The time-table below should be taken as a rough guide. Breaks will be taken at the specified times each day, but individual topics may flow over or under allotted time-slots, depending on the depth of coverage, questions asked and ensuing discussions. Participants will be given real data sets to analyse during practical sessions. Participants are encouraged to ask questions throughout the week.

	Monday	Tuesday	Wednesday	Thursday	Friday
Session 1 **8:30 – 10:30**	1. Pre-treatment options; resemblance measures	4. Ordination with nMDS, mMDS, tmMDS (cont'd)	7. SIMPER; BVSTEP (continued)	10. Test centroids when dispersions differ (PERMANOVA)	13. DISTLM / dbRDA
Coffee Break **10:30 – 11:00**					
Session 2 **11:00 – 12:30**	2. CLUSTER; SIMPROF	5. RELATE; seriation or cyclical models	8. Diversity	11. Complex designs (PERMANOVA)	14. Multivariate Control Charts
Lunch **12:30 – 13:30**					
Session 3 **13:30 – 15:30**	3. Ordination with PCA/PCO	6. BEST; BIOENV; global test	9. PERMANOVA: (one-way; two-way; interactions; contrasts)	11. Centroid plots (PERMANOVA, cont'd)	15. Wrap up / Overview / Q&A
Coffee Break **15:30 – 16:00**					
Session 4 **16:00 – 17:30**	4. Ordination with nMDS	7. ANOSIM & Bootstrap averages	10. PERMDISP; beta diversity	12. Finite factors; asymm. designs (PERMANOVA, cont'd)	15. Q&A / 'Own-data' Session