# Numerical tactics to disentangle Lower-Middle Jurassic nannoplankton biogeographic relationships

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Raw counts of calcareous nannofossils were used to test for spatial and temporal differences during the ~8 my across the middle Toarcian to lower Aalenian (Lower-Middle Jurassic). Four complementary numerical approaches were used in order to investigate and graphically represent multivariate data in a two-dimensional coordinate system from six western Tethys sites. Three of the locations displayed Mediterranean affinity (Portugal, Italy, and Algeria), whereas the other three yielded typical NW Tethyan margin assemblages (Germany, northwestern France, and southern France). The first set reflects a semi-arid climate and the second a humid climatic belt. Based on a distance matrix and built upon the concept of similarity within and among groups, the different datasets, each one representing a whole assemblage in a given site, were first grouped through clustering and ordination methods. Then, the main species responsible for any differences and groupings were identified through a similarity/dissimilarity breakdown. Finally, significant differences among the six assemblages were assessed through statistical tests and linked to western Tethyan water mass displacements.

Our results show a clear split between southern and northern biogeographic structures, which supports numerous earlier publications. The primary species that showed these differences were the pairs *Schizosphaerella* and *Lotharingius velatus* (bearing a southern Tethys margin affinity) and *Lotharingius sigillatus* and *Crepidolithus crassus* (bearing a northern Tethys margin affinity). Consideration of the global time interval, ranking and ordination techniques, as well statistic tests, showed a tight taxonomic nesting among northern assemblages, whereas southern assemblages displayed a looser and more taxonomically divergent similarity. Our results strongly support an important southward incursion of NW Tethyan water masses during the middle Toarcian. Coeval with the global sea-level drop, both northern and southern water masses mixed before splitting into two distinct biogeographic structures during the lower Aalenian.