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The Sailor-diagram. An extension of the Taylor diagram to two-dimensional variables for verification of model data.

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A new diagram is proposed for the verification of vector quantities generated by individual or multiple models against a set of observations. It has been designed with the idea of extending the Taylor diagram to two-dimensional vector such as currents, wind velocity, or horizontal fluxes of water vapour, salinity, energy and other geophysical variables. The diagram is based on a principal component analysis of the two-dimensional structure of the mean squared error matrix between model and observations. This matrix is separated in two parts corresponding to the bias and the relative rotation of the empirical orthogonal functions of the data. We test the performance of this new diagram identifying the differences amongst a reference dataset and different model outputs using examples wind velocities, current, vertically integrated moisture transport and wave energy flux time series. An alternative setup is also proposed with an application to the time-averaged spatial field of surface wind velocity in the Northern and Southern Hemispheres according to different reanalyses and realizations of an ensemble of CMIP5 models. The examples of the use of the Sailor diagram show that it is a tool which helps identifying errors due to the bias or the orientation of the simulated vector time series or fields. An implementation of the algorithm in form of an R package (sailoR) is already publicly available from the CRAN repository, and besides the ability to plot the individual components of the error matrix, functions in the package also allow to easily retrieve the individual components of the mean squared error.