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Variational data analysis for generating ocean climatologies

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A tool for multidimensional variational analysis (diva-nd) is presented. It allows the interpolation of observations on curvilinear orthogonal grids in an arbitrary high dimensional space by minimizing a cost function. This cost function penalizes the deviation from the observations, the deviation from a first guess and abruptly varying fields based on a given correlation length (potentially varying in space and time). Additional constraints can be added to this cost function such as an advection constraint. The method decouples naturally disconnected areas based on topography. This is useful in oceanography where disconnected water masses often have very different properties. Individual elements of the a priori and a posteriori error covariance matrix can also be computed, in particular expected error variances of the analysis. A multidimensional approach (as opposed to stacking 2-dimensional analysis) has the benefit that the analysis is smooth in all dimensions, but it increases also the computational cost.

Primal (problem is solved in the grid space) and dual formulations (problem is solved in observation space) are implemented using either direct solvers (based on Cholesky factorization) or iterative solvers (conjugate gradient method). In most applications the primal formulation with the direct solver is the most efficient, especially if an a posteriori error estimate is needed. However, for correlated observation errors the dual formulation with an iterative solver is more efficient.

The method is tested by using pseudo observations from a global model. The distribution of the observations is based on the position of the ARGO floats. The benefit of the 3-dimensional analysis (longitude, latitude and time) compared to 2-dimensional analysis (longitude and latitude) and the role of the advection constraint are highlighted.

The tool diva-nd is developed in the frame of the SeaDataNet 2 project and distributed under the terms of the GPL license (http://modb.oce.ulg.ac.be/mediawiki/index.php/divand).