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Fusing measurements from remote sensing and unmanned underwater vehicles

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Remote sensing and unmanned underwater vehicles (UUVs) are becoming key technologies of present ocean observation systems. Both technologies can provide sustained observations over spatially extended ocean regions at relatively low cost. The environmental information gathered by remote sensing and UUVs is not complete. The former provides data about some surface conditions and water column integrated variables while the latter samples volumetric slides with size depending on the vehicle endurance. Under this scenario, data fusion techniques to maximize the information content of the collected data are essential. A method to estimate volumetric oceanographic conditions in a given marine area merging information from remote sensing and UUVs is presented. The method relies on the application of the Gauss-Markov smoothing theorem using a degenerated three dimensional covariance model inferred from measurements. A set of infinite Fredholm integral equations of the first kind results when applying the smoothing theorem to the super-dense data gathered by the remote and in situ platforms. These integral equations are typically ill-posed in that existence, uniqueness and stability of solutions are not guaranteed in the absence of additional constraints. A centroid collocation method with piecewise constant bases and a specific class of stabilizing functional are employed to numerically solve the problem.
The proposed methodology has been validated during the oceanographic cruise TSS08 conducted by NURC during September 2008 in a region of the Black Sea, offshore the Bosporus Strait. Data sampled with a towed vehicle emulating a glider was merged with remote sensing information to estimate the 3D temperature field at unobserved locations. A set of the observations was only considered for validation. Results indicated good agreement between observations in the validation set and corresponding estimations.