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Simulating Airflow over Small Water Surfaces with WRF-OpenFOAM Coupled Model in the Upper East Region of Ghana

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A coupled approach used in this research involves the use of a Numerical Weather Prediction (NWP) model and Computational Fluid Dynamics (CFD) to study the airflow over small inland lakes to investigate the spatial distribution of surface fluxes over heterogeneous surfaces in (semi-)arid regions. In most current mesoscale and global atmospheric models, the influence of small inland water bodies in the surface parametrization is neglected because the dimensions of these water surfaces mostly is smaller than the grid sizes used in these atmospheric models. In addition, due to the logistical difficulties and economic issues in operating measurements over water surfaces especially for small lakes in developing countries, water-atmosphere interaction commonly has been studied less than both land- and large water-atmosphere interactions. Changes in the momentum roughness and thermal or moisture roughness lengths from land to small water surface can affect the turbulent flow in the Atmospheric Boundary Layer (ABL). To quantifying these effects on the airflow and fluxes in the ABL (especially for sensible and latent heat fluxes), the coupling of a Computational Fluid Dynamics (CFD) model (Open Source Field Operation and Manipulation (OpenFOAM) software package) with a mesoscale weather (Weather Research and Forecasting (WRF)) model is used. As the meteorological measurements around the small lakes are rarely available in the region of study (Upper East region of Ghana, Africa), the WRF simulated results (where the horizontal dimension is several kilometres) are utilized to provide the initial and boundary structures, which can affected the heat fluxes over the (small) water surfaces significantly, for the CFD model. Using OpenFOAM (with modified turbulence model) for a smaller domain includes the small water surface allows for the use of smaller grid sizes for investigating the effects of stability conditions, limited fetch of the water surface, sharp changes in roughness, temperature and wetness on the heat fluxes from (small) water surfaces. The results of the coupled model (WRF-OpenFOAM) are used to investigate the flow parameters and (heat) flux variations over small water surfaces considering the effects of the surrounding conditions as well as the atmospheric stability conditions.