Modelling of heat exchange in system of atmosphere-water-sediments

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In almost all 3D circulation models the heat exchange with the bottom is neglected. The rationale for this is given by fact that in deep water basins the bottom heat flux is negligible in comparison with the surface flux and with the advection of heat by currents. However, for shallow areas of water bodies the heat flux through bottom can contribute significantly to the heat balance of flows in diurnal and seasonal scale. In this work a new parameterization of atmosphere-water-bottom heat exchange was considered in 3D hydrostatic free-surface circulation model THREETOX (Maderich et al., 2008). In this model the Reynolds averaged equations of continuity and horizontal momentum and hydrostatic relation are completed by equations for heat and salt transport, the state equation and by the $k-\varepsilon$ turbulence model. The horizontal turbulent viscosity and diffusivity are parameterized by the Smagorinsky (1963) formula. Special attention is paid to the parameterization of heat fluxes between water and atmosphere and water and bottom. In the model a short wave radiation is absorbed by water column and bottom surface. In contrast to most hydrological models that use thermal slab approximation for the sediment layer, the new model describes profile of temperature in the sediments. This profile is calculated from numerical solution of heat conduction equation. The bottom heat flux parameterization includes both forced and free convection mechanisms of turbulent exchange between water and bottom.

The comparison of numerical and analytical solutions for the heat conduction equation with periodical boundary conditions shows that the numerical solution accurately describes profile of temperature at growth of computational time about 5%. A number of numerical experiments were carried out to analyze influence of bottom heat fluxes on diurnal regime of small lake. It was shown that in shallow lagoon (depth less than 1m) water-bottom heat interaction changes temperature profile in the water and reduces amplitude of temperature variations due to day-night exchange sediment layer with the water column. Besides the developed approach leads even to some increase of day-averaged temperature that is explained by redistribution of heating by penetrating solar radiation that in turn relatively decrease backward heat flux into the atmosphere.