Geophysical Research Abstracts, Vol. 9, 10629, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10629

Reconstruction of historic changes of the Aral Sea water budget and sea-groundwater interactions by a coupled 3D sea-ice-groundwater model

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A 3D coupled sea-ice-groundwater model has been developed and applied for an estimation of the water balance and groundwater-seawater interactions in the shrinking Aral Sea. The model developed combines the complete 3D sea-ice hydrodynamics model ECOSMO, including a mass and energy conserving wetting and drying scheme, and a simple groundwater model based on changes in hydraulic gradient in response to the sea surface variability. During the simulation period 1979-1993, the model successfully reproduced the rapid Aral Sea level drop, surface area decrease, coastline position changes and salinization. Model predictions of evaporation and groundwater inflow were also consistent with independent estimations. Model results indicated that within the 15 years period of simulations the net groundwater inflow to the Aral Sea might have increased by 10% or more as a direct effect of the sea level lowering.

Furthermore, model scenario tests were carried out to examine effects of salinity on sea hydrodynamics and to estimate non-linear feedbacks of the sea thermo- and hydrodynamics, air-sea turbulent fluxes and the sea water balance. It was shown that a neglect of salinity in the sea hydro- and thermo dynamics resulted in considerable differences in the Aral Sea winter thermal conditions, which in turn influenced the air-sea exchange in the following spring and summer. As a result, the zero salinity scenario predicted higher evaporation rates and an considerably accelerated sea level lowering by up to 2 cm/yr, in comparison with the basic model run. An indirect influence of the fresh groundwater inflow in terms of water balance has been identified as less significant, however it was shown that the fresh groundwater input could influence the Aral

Sea salinity distribution considerably since 1990’s.