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Modelling the influence of irrigation on the shrinking Aral Sea

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The Aral Sea is fed by two tributaries, the Amu Darya and the Syr Darya, and often is considered as one of the most complex hydrological basins of the world. The shrinkage of the Aral Sea during the last 50 years, which has been caused by excessive irrigation projects, has led to numerous ecological, human and economical problems.

This study focuses on historic modelling (1960-2002) of the Amu Darya (535,000 km^2) and the Syr Darya (219,000 km^2) to assess the influence of land-use change, i.e. conversion of non-cultivated land to irrigated crops, on the hydrological cycle and on the shrinkage of the Aral Sea. Therefore, we have compiled crop- and irrigation-specific land use maps in five year intervals from extensive literature and data base reviews. These maps are first applied within the WaterGAP irrigation model, which has been further developed to account for the seven major crops of Central Asia, to compute crop-specific net irrigation requirements. In combination with a newly set up data base on time series of irrigation project efficiencies for Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan we have also been able to depict crop-specific gross irrigation requirements. These results have then been applied within the WaterGAP hydrology model, where they alter the water balance of each affected grid cell, and thus, runoff generation.
All irrigation and hydrology calculations have been conducted in daily time steps and five arc minutes spatial resolution ($\sim$ 8 x 10 km grid cells) for the entire Aral Sea basin. Climate forcing data for the 42 year period has been taken from the CRU TS2.1 data set.

First results of this model experiment show that not only massive water abstractions have caused the changes in the hydrological regime of both rivers, but also poor land and water management has taken its toll. Between 1960 and 1990 a state driven land use conversion from locally adapted food crops, such as cereals, to water intensive cash crops, such as cotton, has taken place. This and other factors have led to nearly doubling of water withdrawals within the basin. One further example is the on-going construction of the Karakum Canal, which diverts about 18km^3 per year from the Amu Darya to the Karakum Desert, causing immense changes in the hydrograph and inflow to the Aral Sea. Due to poor water management, i.e. transmission losses of up to $\sim$12km^3 per year and old irrigation systems, most of the diverted canal water cannot be used for irrigation purposes.
The influence of climate change in the Aral Sea basin between 1960 and 2002 is evident. However, excessive water abstractions mask climate change induced hydrological regime changes.