Land surface process and climate responses to anthropogenic groundwater exploitation

With the support by the National Natural Science Foundation of China, and the National Basic Research Program of China, Prof. Xie Zhenghui's laboratory at the Institute of Atmospheric Physics, Chinese Academy of Sciences, reported the land surface process and climate responses to anthropogenic groundwater exploitation for the Haihe River Basin, Northern China, which were published in *Climate Dynamics* (2014, 42: 2125—2145) and *Journal of Hydrology* (2015, 524: 625—641).

Owing to population growth and economic development, groundwater exploitation is becoming severer to meet the rapidly increasing water demands. The sustainability of groundwater resources and the effects of groundwater exploitation on land surface processes and climate are urgently needed to be evaluated. In this work, a groundwater exploitation scheme is incorporated into the land surface model CLM3.5 and the regional climate model RegCM4, and the land surface process and climate responses to anthropogenic alteration of groundwater are then investigated over the Haihe River Basin in Northern China, where groundwater resources are over-exploited. Three 30-year exploitation simulations-Test1, Test2 and Test3, which respectively use the fixed total human water demand D_t (kg m^{-2} s^{-1}) estimated in 2000, the half of D_t and the variable water demand D (kg m^{-2} s^{-1}) from 1971 to 2000 as input data-and a CTL run that simulates the natural state are conducted by the developed model. The results reveal that the groundwater exploitation and water consumption cause increasing wetting and cooling effects on the local land surface and in the lower troposphere, along with a rapidly declining groundwater table in the basin. The cooling and wetting effects also extend outside the basin, especially in the regions downwind of the prevailing westerly wind, where increased precipitation occurs. The loss of terrestrial water storage indicates that water resource is unsustainable with the current high groundwater pumping rate. Therefore, a balance between slow groundwater restoration and rapid human development of land must be achieved to maintain available water resource in future.

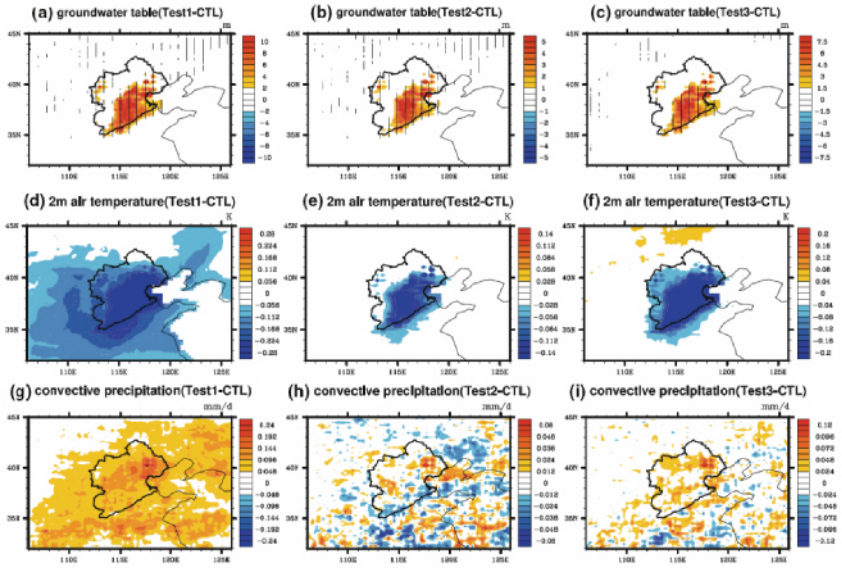

Figure Spatial distribution of climatology. (a) groundwater table (Test1-CTL); (b) groundwater table (Test2-CTL); (c) groundwater table (Test3-CTL); (d) 2 m air temperature (Test1-CTL); (e) 2 m air temperature (Test2-CTL); (f) 2 m air temperature (Test3-CTL); (g) convective precipitation (Test1-CTL); (h) convective precipitation (Test2-CTL); (i) convective precipitation (Test3-CTL).