Geophysical Research Abstracts, Vol. 8, 02660, 2006
SRef-ID: 1607-7962/gra/EGU06-A-02660

Distributed hydrological modelling as a planning tool for sustainable water resources management: experiences in the Arno River Basin, Italy

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Many application concerning water resources management, such as the development of policies for the sustainable allocation of resources, require the estimation of the water balance also on minor branches of the hydrographic network and the assessment of the interactions between groundwater, surface water and ecosystems. Despite of this evidence, conventional approaches to water balance computation are usually supply-oriented and focused on major rivers, and lack in flexibility in accounting for spatially variable issues concerning environmental flow, simulation of withdrawals and reservoirs operations. A distributed approach, where the basin is represented as discrete cells with assigned geomorphologic and hydraulic properties and the river network can be modeled in separate elementary branches at a very fine level of detail, appears as a much more suitable tool for the water resources management at watershed scale. The Basin Authority of the Arno River, one of the major watersheds in Central Italy, has set up a modeling framework for the estimation of water balance using the distributed model MOBIDIC (MOdello di Bilancio Idrologico DIstribuito e Continuo). MOBIDIC is a physically-based model that allows the estimation of the components of the hydrologic balance in the subsurface layer, the soil-vegetation system and surface water bodies. Main innovations with respect to existing models concern: a) the coupling of the water balance in soil and vegetation with surface energy balance, to the benefit of evapotranspiration computation and use of Remotely sensed maps of Land Surface Temperature for calibration and validation; b) the detailed interaction between ground water and surface water bodies. Given the characteristics of the model, MOBIDIC can be used as an effective tool for the evaluation of watershed scenarios (e.g

effects of changes in land cover/deforestation and irrigation strategies on surface water and energy balance/evapotranspiration regimes, exploitation policies for groundwater). It then provides a reliable hydrologic base for the assessment of crisis indicators such as vegetation stress and lack of environmental flow. Parameter calibration benefits from the energy-surface-groundwater coupling as many different data can be used, from satellite maps of land surface temperature to river discharge and water table level at many gauge points. In the application on the Arno basin, the water balance has been computed on a daily time scale for a 10 years period (1992-2002). The geomorphology of the basin and related hillslope processes have been modeled starting from a Digital Elevation Model with 10 m square cells. Information on land cover, geology and soil hydraulic properties have been retrieved from existing maps and remote sensing data. Both natural (where no withdrawals have been considered) and 'anthropogenic' scenarios have been simulated. The results include modeled discharge time series on nearly 20,000 river branches and more than 2,000 withdrawal sites, flow duration curves, and maps of hydrological components over the basin area (soil moisture, evapotranspiration, infiltration). For each river branch, the average monthly and annual water balance corresponding to different scenarios in terms of withdrawal and environmental flow requirements has been computed. Parameter estimation and hydrologic simulations are performed at spatial scales ranging from 100 to 2000 m, so that the model sensitivity to the scale aggregation can be analyzed.