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Determination of Runoff from Large Scale Basins using Satellite-Gravimetry and Remote Sensing

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GRACE observations of the time dependent gravity field provide a direct measurement of the monthly state of mass and thus the total monthly water storage for large scale catchments.

Investigations of Runoff - Storage relationship for unmanaged catchments reveal a distinct individual, yet seasonally characteristic hysteresis for different climatic (fully or seasonal humid, boreal) conditions. For the Amazon basin the hysteresis is caused by a time invariant phase shift, i.e. a constant time lag between runoff and storage, which can be assigned to the finite transition time between input and hydraulic coupling. Thus the Amazon can be characterized as a linear time invariant system. Adapting the time lag by a continuous, constant temporal shift leads to a linear relationship of runoff and storage with a very high correlation coefficient of 0.98. This allows for a determination of runoff from GRACE mass with an RMSE of 5.5mm/mo or an Nash Sutcliffe Coefficient of 0.97 for the Amazon just by a fit of the unknown mass offset, the hydraulic time constants and the time lags of the hydraulic coupling processes.

For other, not fully humid tropic basins or for boreal catchments the runoff-storage relationship is much more complex. Based on the linear system behaviour of the Amazon it is assumed, that deviations from the linear R-S relationship are caused by storage components which are not hydraulically coupled to the drainage system over a certain period of time like snow/ice or which are emptied by other means like evapotranspiration as for soil or surface water storage, inundations etc. Thus for a determination of runoff from storage a quantification of the coupled/ uncoupled storage components is inevitable.

As boreal catchments are seasonally dominated by snow, the decoupled snow storage can be quantified by GRACE mass and remotely sensed snow coverage. MODIS snow coverage allows for a separation of total storage from GRACE into coupled liquid and uncoupled solid components either directly by assigning frozen solid storage to the snow covered areas or indirectly by a model based aggregation of snow and liquid according to snow covered areas. For this purpose homogenous, large scale conceptual models based on GRACE and MODIS snow coverage are developed. The investigations show, that with an adequate description of the liquid mass and a consideration of the time lag, the R-S relationship for boreal catchments is close to linear for the liquid storage. This allows for a direct determination of runoff from liquid storage.

River runoff time series determined from GRACE mass and MODIS snow coverage are presented here for the Amazon and for the boreal catchments of Sibiria and North America and are compared to the results of global hydrological models.