REMOTE SENSING BASED WATER BALANCE ESTIMATION IN THE MAIN ETHIOPIAN RIFT VALLEY

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1. INTRODUCTION

Severe lake level changes in the Main Ethiopian Rift have been recorded since the early 1970s. Besides, simultaneous different lake level fluctuations have been observed. The opposing lake level trends both imply serious consequences such as increasing flood risks and the destruction of the rich biodiversity of the lake region. Alarmingly, the reasons for this development are still unknown. Geological activities, climatic and land cover changes are considered to be the most probable triggering factors. By assessing the water balance of three insufficiently studied lakes in the Southern Main Ethiopian Rift Valley we would like to contribute to the clarification of this phenomenon. As the recorded meteorological and hydrological data is very incomplete, we propose a new estimation approach based on Remote Sensing.

2. STUDY AREA

We focus on Lake Awassa, Lake Abaya and Lake Chamo, three Rift Valley Lakes located between 37° 27' E and 38° 29' E and 5° 42' N and 7° 7' N in the tectonically active Southern Main Ethiopian Rift. The Ethiopian Rift Valley Lakes constitute one of the country's most important water resources and are well known for their outstanding ecological function. Within the region a fast growing population increases the demand for an efficient water management. The lakes under investigation belong to two different sub-basins of the greater Rift Valley Lake Basin: the Awassa Lake Basin and the Abaya- Chamo Basin. As the two latter lakes are hydrologically interconnected they can be treated in conjunction as a single basin [1]. Because of their shallow depth they are particularly vulnerable to human activities [2]. Their lake level characteristics are very complex and disputed. Lake Awassa represents an endhoreic lake without any surface outflow. Accordingly, the watershed experienced exceptionally high lake level rising involving a high flood risk for the city of Awassa [3].

3. DATA AND METHODS

Our approach involves satellite data acquired by LANDSAT, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Moderate Resolution Imaging Spectroradiometer (MODIS), the Tropical Rainfall Measuring Mission (TRMM), the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Oceanic and Atmospheric Administration (NOAA) in order to solve the following water balance equation and to model the lake level variations of the past decades:

$$\frac{\Delta v}{\Delta t} = S(t) * [P(t) - E(t)] + R_i - R_O + Q + G_i - G_O \quad (1)$$

where $\Delta v/\Delta t$ is the lake volume variation with the time, S is the surface area of the lake, P is the precipitation, E are the evaporation and condensation fluxes, R_i is the river inflow, R_O is the river outflow, Q is the surface runoff, G_i is the groundwater inflow and G_O is the groundwater outflow. In order to calculate the surface area and the lake volume the different lake boundaries derived from historical LANDSAT MSS 1973/1976, TM /19841986, ETM+ 2000 and ASTER

2005 as well as the corresponding bathymetric maps were digitized. Furthermore, the optical satellite images are used to conduct a land cover classification and continuatively a land cover change detection. The classification has a special focus on atmospheric correction involving MODIS 4, 5 and 9 data. With the help of additional soil type and slope information derived from the FAO soil map and SRTM data the changing runoff coefficient of the watershed ise determined so that the runoff Q can be calculated. In order to determine the amount of precipitation we use ECWMF and TRMM satellite data and compare it with ground truth data provided by the National Meteorological Services Agency of Ethiopia. The evaporation and condensation fluxes are calculated with the help of a modified Penman equation proposed by Calder and Neal [4] that accounts for salinity. The equation is based upon four meteorological raw parameters that are be derived from ECWMF and NOAA. Namely, these parameters are specific humidity, wind speed, air temperature and net radiation. Aside from the net radiation, it is possible to ground truth the data with information that we received from the National Meteorological Services Agency. Concerning the river discharge, we use exclusively data provided by the Ministry of Water Resources (MoWR). Finally, by resolving equation 1 it is possible to calculate the groundwater flow.

4. CONCLUSION

It is now possible to determine the contributing force of each component to the absolute lake level changes. Furthermore, we conduct a sensitivity analysis i.e. we assume different amounts of changes for single parameters in order to assess the impact of each component on the water balance. Thereby, the changes in surface runoff are considered as a measure for human activities. Water abstraction that is not considered explicitly as varying amounts of river discharge is accounted for this parameter. The impact of geological activities on the water balance is very hard to estimate and can only be inferred due to the dependence of the groundwater flow on the tectonic structures.

4. REFERENCES

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