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Short-Term Evaporation Estimating From Complex Small Lakes In Arid And Semi-Arid Regions

Ali Abbasi

Nick van de Giesen

SHORT-TERM EVAPORATION ESTIMATING FROM COMPLEX SMALL LAKES IN ARID AND SEMI-ARID REGIONS

ALI ABBASI (1), NICK VAN DE GIESEN (2)
(1,2): WATER RESOURCES DEPARTMENT, DELFT UNIVERSITY OF TECHNOLOGY, STEVINWEG 1, 2628 CN, DELFT, THE NETHERLANDS

In many parts of the world, the available water resources are now being used close to their limits. Global climate change, the increasing population of the earth and ever-increasing standards of living and consequent growing demand of water are bringing water sustainability into sharp focus. Evaporation as a major component of the hydrologic cycle, is the largest one of water loss from lakes especially in arid and semi-arid regions. Because of lacking of understanding of the thermodynamics of atmospheric boundary layer(ABL) and heat exchange between the water surface and atmosphere, an accurate estimation of evaporation from water surfaces is almost unknown. It is thus of major importance to have precise estimation of the amount of this undesirable, unrecoverable and unproductive water loss from water body for a good management of available water resources. However, most of the models so far described in the literature are one-dimensional with areal homogeneity assumption and can be used for long-term estimations. These models do not account for advection, the sideways movement of energy which results from differing energy and aerodynamic performance of differing land/water surfaces[4]. In arid and semi-arid regions such as Ghana, it is clear that the evaporation of a small shallow lake will be heavily influenced by hot dry air blowing from land upwind of the dam and therefore the large proportion of advected energy may be expected. Many parameters affect the evaporation from a body of water such as a lake to the surrounding air; these are the temperature of the water, size of the water body, the terrain surrounding the water body that affects the air flow over the lake surface, surface roughness of the water body, the air temperature, velocity and humidity. To account for all these parameters, the process of estimating the evaporation becomes very involved[3]. In the framework of this study, a numerical approach was developed to predict evaporation from shallow and small lakes in (semi-) arid regions considering the heat and water vapor exchanges process between the air-water surface. The model takes into account advection, oasis effect and stability conditions of ABL in the heat exchange process. To have a precise estimation of evaporation the effects of the terrain surrounding the water body, the water body size and the effects of the available fetch of water body were implemented in the model. The governing equations of the model have been solved by OpenFOAM; an open source, freely available CFD toolbox and easily extended to run in parallel. The flow field in a complex domain is solved with the incompressible RANS(Reynolds Averaged Navier-Stokes) equations complemented by transport equation for tempearture and vapor density as well. The water can be assumed to be incompressible and the constant-density(except in the gravity term) momentum equations using Boussinesq approach

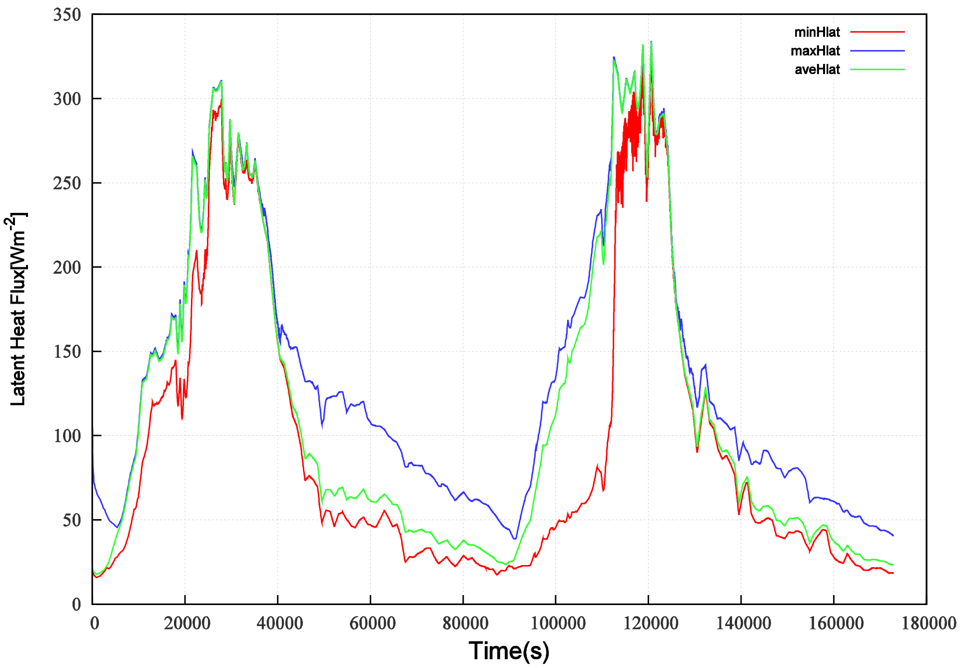

Figure 1: Calculated latent heat flux(evaporation) over the water surface

are used. The Boussinesq approximation is valid under the assumption that density differences are sufficiently small to be neglected, except where they appear in term multiplied by “g” [1]. Due to the transient conditions of flow in ABL, an adaptive time-stepping technique based on Courant numbers was used. In this study, the maximum value of *Cr* was adopted to *0.5*. As the Cournat number increase the model will be more unstable[2].The estimated evaporation values were compared against the field measurements and they showed reasonable agreement.

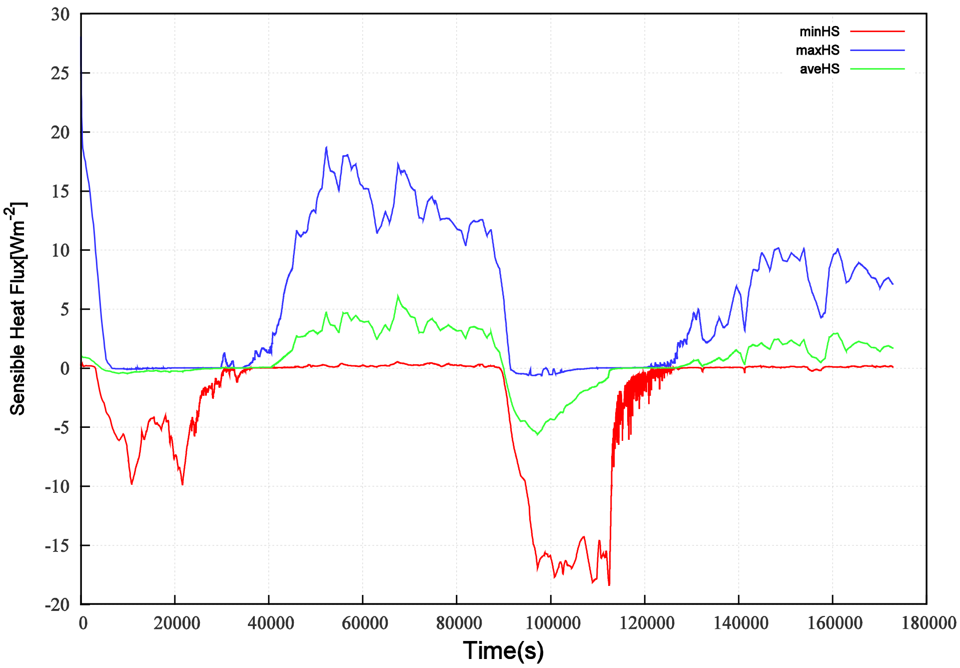

Figure 2: Calculated sensible heat flux over the water surface

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