Geophysical Research Abstracts
Vol. 15, EGU2013-9990, 2013
EGU General Assembly 2013

Numerical modelling of the effect of changing surface geometry on mountain glacier mass balance

Chris Williams, Jonathan Carrivick, Andrew Evans, and Steve Carver
School of Geography, University of Leeds, Leeds, United Kingdom (gycnw@leeds.ac.uk)

Mountain glaciers and ice caps are extremely useful indicators of environmental change. Due to their small size, they have much faster response times to climate changes than the large ice masses of Greenland and Antarctica. Mountain glaciers are important for society as sources of water for energy production and irrigation and the melt-water cycles significantly impact local ecology.

We have applied a spatially distributed surface energy balance model to a glacier record spanning 100 years. Our study encompasses (i) the creation of a GIS enabling quantitative analysis of changing glacier geometry; absolute length, area, surface lowering and volume change, over the 20th and early 21st Centuries and (ii) the development and testing of a novel user-friendly distributed-surface energy balance model that is designed specifically to consider the effect that these geometrical changes have on mountain glacier mass balance.

Our study site is Kårsaglaciären in Arctic Sweden for which there is a variety of data for the past 100 years, sourced from historical surveys, satellite imagery and recent field work. This contrasts with other Arctic mountain glaciers where long-term records are rare, making model development and evaluation very difficult.

Kårsaglaciären has been in a state of negative balance throughout the 20^{th} century. Disintegration of the glacier occurred during the 1920s, breaking the glacier into two separate bodies. Between 1926 and 2008, the glacier retreated 1.3 km and reduced in area by 3.41km^2. In 2008 the glacier had an estimated surface area of 0.89km^2 and a length of approximately 1.0km.

Firstly, we present the GIS based construction of robust three-dimensional glacier surface reconstructions for Kårsaglaciären from 1926 to 2010 using a decadal interval. We highlight the kriging interpolation methods used for surface development and the importance of inter-model sensitivity analyses as well as the use of Monte Carlo simulations used to assess the effect of the input data utilised in the kriging algorithms. Analyses integral to the modelling stage of the project, such as the geometries of the resultant surfaces as well as the interrelationships between them, will be discussed.

Secondly, we present the melt model which has been constructed in order to test the effect of changing geometry on mass balance. Our melt model can carry out systematic testing of the inclusion of different geometric parameters on glacier melt processes and has the advantage of taking into account different surface grids from the GIS, such as elevation, slope, aspect and glacier thickness. The model is run using daily and monthly time steps. As glacier mass is lost, the model recalculates surface geometries. For different model runs, specific geometrical components are fixed in time, enabling assessment of mass balance sensitivity to them. The user-friendly interface of the model makes it possible for a wide range of users to apply it to different glaciers.

We present the development and possible applications of our melt model to other glaciers as well as discussing its application to Kårsaglaciären and possible environmental impacts and controls of the detected changes in geometry and mass balance.