GULTEM - The Model to Predict Gully Thermoerosion and Erosion.

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The three-dimensional hydraulic model GULTEM to predict rapid changes of gully morphology at the first period of gully development is presented. It is based on solution of the equations of mass conservation and gully bed deformation for different types of soil (including frozen soil).

At the first, quick stage of gully development the following main processes occur:

a) During the snowmelt or rainstorm event the flowing water erodes a rectangular channel in the topsoil or at the gully bottom. Change of the gully bottom elevations is controlled mainly by upward detachment of the particles from the bed and by sedimentation on the gully bottom. This process is described by transport equation.
b) The vertical walls of this trench can be unstable. Shallow landslides transform a rectangular gully cross - section into trapezoidal along the period between adjacent water flow events if the depth of incision became more than critical value. In this case a model of straight slope stability can be used for prediction of gully sides inclination.

The GULTEM was realised on the net of flowlines, evaluated from topographical DEM. The multy-layered soil texture (including top layer with the vegetation cover) was derived from DEMs of the top surfaces of each layer with similar lithology. The runoff due to snowmelt and rainfall was calculated from meteorological information with physical-based hydrological models.

The model was verified on the data of gully's morphology and dynamics at Yamal peninsula (north of the Western Siberia, Russia). In this region the human developmental activities accompanied by deterioration of the vegetation and an increase of runoff causes intensive thermoerosion and erosion. To minimise it several methods can be tried: mechanical removal of the snow from gully catchments; vertical drainage of industrial and rainfall waters; covering of disturbed slopes with a peat layer; filling of the gullies with heavy loam and a peat cover; recultivation of vegetation cover. All these measures led to water discharge decrease and critical shear stress of erosion initiation increase. As GULTEM include these parameters, the effectiveness of land conservation measures can be checked by the numerical experiments. The numerical experiments provided with the model can be used to choose the system of land conservation measures and to stabilise buildings and constructions on the catchments with high gully erosion potential.

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