12th International Workshop on Modeling of Mantle Convection and Lithospheric Dynamics

August 20th to 25th 2011, Döllnsee Germany

A new 3D surface processes model for coupling with thermomechanical models and its application to the Pamir-Tien Shan orogen

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Main goals of the **Ti**en Shan-**Pa**mir **Ge**odynamic Program (TIPAGE) founded by the German Science Foundation is to exploit the Pamir, the western part of the Pamir-Tibet-Himalaya orogenic system, to address key questions in the geodynamics of continental collision and orocline formation. Numerical modeling, being the key part of the Project, integrates heterogeneous geological and geophysical observations to identify and quantify the major controls of the Pamir-Tien Shan evolution. In TIPAGE, traditional lithospheric-scale 3D numerical thermomechanical modeling is being coupled to the high-resolution modeling of the surface processes. The fact that erosion is very important to understand orogen evolution is known since eighties. Due to the input of many researches, especially, modellers, it became clear that erosion is not only a passive player shaping an orogen in response to tectonic evolution, but in contrast may also provide a strong feedback to the deep processes. Thus, Beaumont et al. (2001) examined the effect of enhanced erosion along the Himalayan flank of the Tibet plateau in the development of lower crustal channel flow under Tibet, e.g. a feature that may also occur in the Pamir region. Recently, Pysklywec (2006) analyzed possible erosional control on the evolution of the mantle lithosphere in zones of continental collision. His results demonstrate that the influence of climate-controlled surface processes may reach much deeper into the lithosphere than the crust. Another important aspect of coupling tectonics and erosion—mechanical weakening of a compressed orogen due to enhanced denudation at the plateau margin—was recently studied by Babeyko et al. (2006).
That is why models which realistically describe orogen evolution should include climate-controlled surface processes. Erosion processes in the Pamir-Tien Shan region are not so exemplified as in the Himalaya region. Nevertheless, there are some geomorphological features which should be replicated by any successful regional thermomechanical model. They include the prominent east-west erosional asymetry of the Pamir as well as abrupt change of the flow direction of the main river Pjandj from sub-longitudal to sub-latitudal.

Here we present our new 3D numerical model of surface processes in the Pamir-Tien Shan region. First of all an analytical digital elevation model is implemented as a structured grid. On this grid are performed several time steps. Each step includes analytical uplift and a modern filling algorithm (Planchon, 2001), that furthermore adds little offsets to guarantee a flow direction in all pixels. The flow direction is calculated by searching in every pixel the steepest slope to its eight neighbours. By counting the number of inflowing streams the springs are identified. Starting at one by one spring it's relatively fast to evaluate the amount of cumulated water in each pixel that is needed for the incision algorithm. Up to now the model incorporates long-range processes in the form of bed-rock incision as well as short-range processes in the form of (hillslope) diffusion. The incision is a 3D form of the 2D-model of Willet(2009). The diffusive model rests upon Beaumonts (1992) suggestion of a 3D short range transport model.

In present version, tectonic drive is simulated by kinematically imposed boundary conditions at the bottom of the model. The next step would be coupling our model with the full 3D thermomechanical code SLIM3D (Popov and Sobolev 2008) to start joint modeling of the Pamir-Tien Shan evolution.

References

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