Transient relationships between chemical and physical erosion rates in regolith-mantled landscapes

KEN L. FERRIER[1]

[1]Georgia Institute of Technology, ferrier@gatech.edu

Chemical erosion of regolith is of wide interest due to its role in landscape evolution, nutrient supply, and the carbon cycle. Theory suggests that chemical erosion rates (*W*) should be strongly controlled by physical erosion rates (*E*), which affect *W* by removing weathered regolith and regulating mineral supply rates to the regolith from its underlying parent material. A global compilation of field measurements reveals a wide range of relationships between *W* and *E*, with some sites exhibiting positive relationships between *W* and *E*, some exhibiting negative relationships, and others exhibiting a flat relationship within uncertainty. Here we apply a numerical model to explore the variety of *W*-*E* relationships that can be generated by transient perturbations in *E* in well-mixed regolith.

Our model results show that transient relationships between *W* and *E* can strongly deviate from steady-state relationships. These deviations result from the lag in *W* following changes in *E*, which produces a hysteresis in plots of *W* versus *E*, with positive relationships between *W* and *E* at some times, and flat or negative relationships at other times. The shape and duration of these hystereses are modulated by climate and lithology through their effects on the lag time, which increases with a characteristic regolith production time and decreases with a characteristic mineral dissolution time. Even in the absence of variations in climate and lithology, a range of *W*-*E* relationships can be generated by a single perturbation in *E*. To the extent that these model results capture the behavior of chemical and physical erosion in natural landscapes, these results may aid interpretation of field measurements of *W* and *E*.