Large-scale Impacts of Frozen Soil on Soil Erosion: Coupling the WEPP Model to a Macro-scale Hydrologic Model

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I. INTRODUCTION
Assessing environmental impacts of soil loss at large scales is necessary for regional management of natural resources and policy making. The process-based Water Erosion Prediction Project (WEPP) model [6] has the ability to predict the spatial and temporal distribution of soil loss at a field scale. A stand-alone version of the WEPP hillslope erosion code (WEPP-HE) provides the basis for coupling with the Variable Infiltration Capacity (VIC) hydrology model [2,3,5] to predict long-term hillslope erosion potentials for large regions. This study describes the coupling scheme and preliminary predictions of soil erosion in a selected watershed in the Great Lakes region.

II. COUPLED MODEL PATHWAYS

III. EVALUATION SIMULATIONS
A single VIC cell at a spatial resolution of 1/8' was selected from a watershed in Minnesota for preliminary evaluation. Slope profiles are derived from a 30 arc-second DEM, then rescaled to a resolution of 30 m using a simple (monofractal) scaling method [1], where fractal dimension is calculated by a variogram technique. The rescaled 30 m slope profiles are approximated by the Laplace (double exponential) probability distribution.

IV. A. ANNUAL AVERAGES
• Using precipitation data from 1981-1990, the coupled VIC-WEPP model was able to simulate water balance and cold season processes.
• Distributed precipitation application in the VIC model generated comparable snow depth when compared to the full WEPP model.
• The coupled model under-predicted annual soil erosion as compared to the full WEPP model.
• Possible reasons for differences in soil erosion estimation:
  • Different techniques used to disaggregate daily precipitation to sub-daily data in the VIC and WEPP models.
  • Differences in timing and duration of effective rainfall intensity and peak runoff generation.

IV. B. EROSION EVENTS

V. CONCLUSIONS
• Coupling of the two different scale models to estimate soil loss at large scale is possible.
• On an average annual basis, the coupled model soil loss is under-predicting erosion as compared to the full WEPP model due to different precipitation disaggregation schemes.
• Analysis of erosion events showed the coupled model captured more small event signals.
• Further modifications of the WEPP code and automation to generate adjustment parameters will simplify the process by skipping the WEPP model in the coupling pathways.
• Development of probability distribution for erosion results is needed for large-scale soil erosion prediction at a multitude of hillslopes.

VI. REFERENCES

Table: WEPP model Coupled VIC-WEPP model
<table>
<thead>
<tr>
<th>Soil loss (kg/m²)</th>
<th>Sediment yield (t/ha)</th>
<th>Soil loss (kg/m²)</th>
<th>Sediment yield (t/ha)</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.14</td>
<td>1.461</td>
<td>0.054</td>
</tr>
<tr>
<td>Standard deviation*</td>
<td>0.0044</td>
<td>0.329</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

* Standard deviation of average annual results at sampled hillslopes.