Watershed Modeling Tools for Stakeholders: Utilizing Fallout Radionuclides to Assess Sustainable Management, Climate Change, Disaster Recovery and Community Resilience

*Chris S Renschler[1,2], Misa Yasumiishi[1,2], Mabit Lionel[3], Moncef Benmansour[4]

1. Deptartment of Geography, University at Buffalo (UB) - The State University of New York (SUNY), Buffalo, NY, USA, 2. Landscape-based Environmental System Analysis & Modeling (LESAM) Laboratory, Buffalo, NY, USA, 3. Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Seibersdorf, Austria, 4. Centre National de l' Energie des Sciences et des Technique Nucléaires (CNESTEN), Rabat, Morocco

Existing isotope techniques based on fallout radionuclides and process-based soil redistribution modeling together are complementary techniques to provide more reliable and detailed data to a broad spectrum of stakeholders with different objectives: managers of natural resources and disaster managers of contaminated soils. On the one side, utilizing process-based model approaches and fallout radionuclides of surface atomic bomb tests more than half a century ago, enable to support more detailed soil and water conservation analysis of the past and future impact studies under changes of land use and/or climate around the world. While in the latter case the main objective is the sustainable use of natural resources, the same approach can also be used to assess a variety of land management strategies with the primary goal of minimizing erosion of radiation contaminated soils and increase the deposition of contaminated sediments before they reach a water body or stream. We present techniques to develop modeling tools for stakeholders to design, verify, validate and apply models assessing soil redistribution and the return periods of extreme events for agricultural soil conservation strategies as well as recovery of radiation contaminated soils.
The Geospatial Interface for the Water Erosion Prediction Project (GeoWEPP) is a quantitative, scenario-based watershed assessment model that is used around the world. GeoWEPP utilizes Geographic Information System (GIS) data such as digital elevation models (DEM), land use/cover and soils maps to derive and prepare valid model input parameters to start site-specific soil and water conservation planning for small watersheds. At its core is the WEPP model, a state-of-the-art, continuous simulation, process-based model for small watersheds and hillslope profiles within larger watersheds that can be of mixed land use such as agriculture, forest, rangeland, etc.
In Marchouch, Morocco, an agricultural experimental site provides five parallel transects with excellent data availability and a relatively high density of derived soil redistribution points based on ^{137}Cs and ^{210}Pb techniques. These transects are ideal to verify, validate and apply the GeoWEPP watershed simulations. Using these fall out "contaminants" as soil tracers, reinforces knowledge about the agro-environmental behavior of these anthropogenic radioisotopes (especially ^{137}Cs, but also new soil tracers such as ^{239}Pu and ^{240}Pu isotopes). The technique requires selecting stable reference sites in undisturbed areas that can be used in the future as background indicator if any other radioisotopic releases of Nuclear Power Plant accident occurs.
However, such simulation tools for sustainable development of natural resources (e.g. soil and water conservation and crop yields) and disaster risk reduction (e.g. flood risk and loss of biodiversity) are rarely performed within an integrated framework to account for the interests of a much larger, diverse group of stakeholders in a community. We therefore present a methodology to integrate quantitative models to drive the analysis of the complex, interdependent processes that interact within multi-dimensional, functional systems in landscapes. Creating potentially win-win situations based on quantitative measures among a larger group of stakeholders in a watershed is an important aspect of creating long-term

partnerships, particularly those in communities exposed to the need for natural resources development and higher risks of natural and man-made hazards (e.g. Fukushima Nuclear Power Plant Disaster). Resilience has been defined as a measure of geospatial and temporal functionality, its decay and recovery, in face of various extreme events, disasters and potential hazards. The functionality and resilience of a community are dependent on numerous components and dimensions. Seven dimensions of community resilience are represented in the holistic, interdisciplinary framework with the acronym PEOPLES: **P**opulation and Demographics, **E**nvironmental/Ecosystem, **O**rganized Governmental Services, **P**hysical Infrastructure, **L**ifestyle and Community Competence, **E**conomic Development, and **S**ocial-Cultural Capital. The 'PEOPLES Resilience Framework' provides the basis for the integration of quantitative and qualitative models that continuously measure the resilience of communities against extreme events or disasters in any or a combination of the above-mentioned dimensions.

Keywords: soil erosion, extreme events, isotopes, disaster, radioactive fallout, community resilience