Non-linear World – switching from linear to non-linear modelling
Alpine snow cover – “Water Tower” for Humanity

The main aim of the presented research is two-folded:
I. to provide a new and much needed methodology to improve spatial and temporal snow cover estimations in the complex alpine-forested regions,
II. to provide a comprehensive comparison between linear and non-linear models set in the Artificial Neural Networks (ANNs) framework to estimate Landsat Fractional Snow Cover (Landsat-FSC) in complex alpine-forested environments.

The research area

ANN Landsat-FSC training is based on combined image datasets from Creede, CO, Telluride, CO, and Black Hills, SD, 36,000 points (pixels) were used in the training process.

Results: ANN Landsat Fractional Snow Cover

The ANN Landsat-FSC model represents the first attempt to develop an estimator of fractional snow values from actual ground equivalent reference data and non-linear modeling.

It is the first endeavor to estimate FSC values by combining terrain and reflectance data:
ANN Landsat-FSC exhibits:
- very low error values: mean error ~ 0.1%
- high correlation with the ground equivalent reference: R² = 0.9

The research was funded by NASA Earth Science Graduate Fellowship, Graduate Fellowship from the Mountain Studies Institute, Salt River Project (SRP), Graduate Interdisciplinary Program in Arid Lands Resource Sciences, and the Institute of the Environment at the University of Arizona.

The presented here data and results are part of my PhD research conducted under supervision of Prof. Katherine Hinrichs-Koller, Prof. Charles Hutchinson, Prof. Stuart Marsh, Dr. William van Lieshout, and Dr. Dave Meko, and many hours of discussions regarding ANNs training, and philosophy with Dr. WR Wisniewski.

Contact information: elzbieta.wisniewski@gmail.com

ANN non-linear and linear models for snow cover

Error evaluation

Both ANN Landsat-FSC models, ANN Landsat-FSC \text{linear} and ANN Landsat-FSC \text{non-linear} used the same ANN architecture and the same input data (15 data inputs) to simulate Landsat FSC. The only difference between both models are activation functions.

In ANN LandsatFSC \text{linear} model -- a linear activation function was used during the training process.

ANN LandsatFSC \text{non-linear} model indicates significantly lower performance when compared to ANN LandsatFSC \text{linear} model.

The non-linear model indicates high plasticity and a high ability to adopt to complex data information found in alpine-forested environments.

The results of the research have moved us towards the conclusion that the nature of the relationships between vegetation, snow, and terrain heterogeneity in alpine-forested environments, indicate a non-linear complex behavior. Natural environments indicate strong non-linear relations among its endmembers.

Mountains are environmental sky-islands, and research investigating their distinct compound complexity needs sky-island specific input data and methodologies.

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