WP 4: Upscaling to Assess European Soil Threats

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Summary

• Regional Upscaling
• European Upscaling
• Development of Maps/Indicators of Soil Functions and Soil Threats
WP4 Objectives

- Development of a hierarchical process meta-model for upscaling soil data from plot/field scale to catchment/local scale and moreover to Regional and European Scale (RESEARCH)

- Incorporate smaller scale data into the larger European Soil Information System (DEMONSTRATION)

- Proof-of-Concept for methodology to assess soil threats and Impacts at European level and for better delineation of soil risk areas (POLICY)
Problem? The Scientific Challenge?

- Development of a model to ‘upscale’ Point Data to Geospatial information (Data & Maps)
How to solve it? Our proposal

A GIS platform implementing Digital Soil Mapping (DSM):

**Regression-kriging (RK)** is a spatial prediction technique that Combines:

- **Regression analysis**
  Regression of the dependent variable (OC, N, Soil Text., pH..) on auxiliary variables (Topography, Meteorological, Land use/cover etc.)

- **Kriging interpolation**
  with kriging of the regression residuals.
1. Regional Upscaling
Mapping and Upscaling of Soil Data
Koiliaris > Crete, Damma> Switzerland

Digital Soil Mapping techniques,

have been used to map soil properties in the Critical Zone Observatories (CZOs).

And, have been used to upscale the CZO catchments to Regional and Continental scales. Analysis of two CZOs (Koiliaris and Damma Glacier) and the upscales (Crete Island and Switzerland) were completed for soil organic carbon (SOC) during the previous reporting period.

The SOC distribution was predicted and mapped as continuous surface using the Regression-Kriging approach.
Mapping and Upscaling of Soil Data

Damma > Switzerland

Damma Glacier

Koiliaris CZO

Switzerland

Crete

28 October 2013
Mapping and Upscaling of Soil Data
Lysina > Northwest Czech Republic

INPUT:
- 76 points have been taken from the datasets (LUCAS: 43 points and SoilTrEC: 33 points)
- Due to the “homogeneous spatial distribution” concerns, only 1 single value is taken from Lysina out of 33

PREDICTORS:

SRTM Derived Predictors (100m)
- Aspect
- Slope
- Slope Length
- Elevation

CORINE Land Cover (100m) - EEA
- Agricultural Lands
- Forest and Semi-natural lands
- Wetlands

Climate Data (1000m) - WorldClim
- Mean Annual Temperature
- Annual Precipitation
Mapping and Upscaling of Soil Data
Lysina > Northwest Czech Republic

Method – Regression Kriging
RK method as one of the widely used geostatistical techniques has been used for producing and upscaling of soil property maps. The method is a spatial prediction technique that combines a regression of the dependent variable on auxiliary variables with kriging of the regression residuals.

It is mathematically equivalent to the interpolation method universal kriging and kriging with external drift, where auxiliary predictors are used directly to solve the kriging weights.

The method RK was selected as the optimum interpolation algorithm to produce continuous surfaces for soil properties.
Mapping and Upscaling of Soil Data
Lysina > Northwest Czech Republic

Layers Included in the model
Aspect, Slope, Forest and Semi-natural lands, Wetlands,
Mean Annual Temperature
Model R² = 0.36

Min: 0.09 Max: 14.33 mean: 4.48
Mapping and Upscaling of Soil Data
Plynlimon – Soil organic Carbon

**Input Data:**

85 SoilTrEC samples have been used for interpolation (40 samples from WYE catchment and 45 samples from Severn Catchment).

**Method:** Ordinary kriging method has been applied to interpolate soil organic carbon in Plynlimon. The SOC map will be enhanced by using regression kriging approach using high quality data

- Land Cover Map 2007 (LCM2007) – has been received,
- Vegetation Data – in progress
Open Questions? Future Challenges

• Scale/Resolution?

• Political or Natural Borders?

• Which of the 5 upscaling process (Koiliars, Damma, Lysina,....) works better? Comparison?
2. European Upscaling
Mapping and Upscaling of Soil Data
Digital soil mapping of SOC in Europe Scale

Version 1
In this study, assessment of SOC distribution has been predicted with Regression-Kriging method in Europe scale. In this prediction, combination of the soil samples which were collected from the LUCAS (European Land Use/Cover Area frame statistical Survey) with local soil data which were collected from six different CZOs in Europe (Koiliaris, Damma Glacier, Lysina, Fuchsenbigl, Plynlimon CZOs and Switzerland) and seven spatial predictors (DEM, CORINE land-cover classification, geological formations, parent material, texture, WRB soil classification, climatic data) were used.
Mapping and Upscaling of Soil Data
Digital soil mapping of SOC in Europe Scale

Covariates (ctn);

- **DEM** (SRTM-100m) (4 layers) (200)
- SLOPE, ASPECT, ELEVATION, CTI
- **GEOLOGICAL FORMATIONS** (10 layers)(IGME 5000; Digital Data of the 1:5Million International Geological Map of Europe and Adjacent Areas, 2010)
- **CORINE LAND COVER** (6 re-classified layers)
- **SOIL MAP** (WRB Classification-21 soil class/21 layers-ESBN Data)
- **TEXTURE** (6 layers-ESBN Data)
- **PARENT MATERIAL** (8 layers-ESBN Data)
- **CLIMATIC** (Temperature, Precipitation)
Conclusions:

**SOC** is predicted with $R^2 = 0.2762$, **RMSE** = 4.85.

- Significant correlation between the covariates (Elevation, slope, CTI, average temperature, total precipitation, minimum temperature, some texture classes, WRB classes, parent material classes, and CORINE classes) and the organic carbon dependent variable were found.

- Best model is chosen by R and the validation is made with “Leave-10%-out-cross-validation” in R and $R^2 = 0.35$, RMSE = 4.71

Average SOC prediction found as 7%?
Mapping and Upscaling of Soil Data
Mapping of SOC at European Scale

Future works;

- Version 2; BIOSOIL dataset will be added to the samples (approximately 3400 points more)
- Version 3; Different predicting models (Regression trees & Cubic models) will be tested with the same dataset
3. Data/Maps of Soil Functions & Threats

- Soil Organic Carbon
- Soil Erosion
- Nitrogen Content
- Soil Sealing
- Soil Biodiversity
Soil Threats
Crete– Soil Sealing

Input data:
Orthorectified satellite data coverage for Europe (Image2006), acquired primarily in the reference year 2006 (+/- 1 year), covering two dates, used sensors SPOT 4 and 5 (HRVIR) and IRS-P6 LISSIII.

Methodology:
Supervised classification of built-up areas with following visual improvement of classification results and derivation of degree of soil sealing based on calibrated NDVI.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sealed Lands (ha)</th>
<th>Total Land (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>9383</td>
<td>833600</td>
<td>1.126</td>
</tr>
</tbody>
</table>

Source: Summarised from the Delivery Report of Greece (EEA FTSP Sealing Country Delivery Report GR, 2008, Claudio La Mantia, Dr. Hanjo Kahabka)
Total Nitrogen content (g.kg$^{-1}$) has been mapped in the whole Crete with LUCAS Soil samples using regression kriging method.

28 points were extracted from the LUCAS database for the area. In the model total nitrogen content values (g.kg$^{-1}$) were used as dependent variable, 

land cover (agricultural, forest and seminatural lands, wetlands), meteorological data (annual mean temperature, annual rainfall), topographical parameters (elevation, aspect, slope) were used as predictors.

The figure shows the Total Soil Nitrogen prediction map of Crete.
Soil Erosion

G2 Model (RUSLE like): 

\[ E = \left( \frac{R}{V} \right) \times S \times \left( \frac{T}{I} \right) \]

R: Rainfall Erosivity

V: Vegetation Retention

S: Soil Erodibility

T: Topographic Influence

I: Slope Intercept
Prediction of Rainfall erosivity (R-factor) in Crete

Input data:
• 4 Rainfall stations (R-calculated). 10-minutes
• 24 Rainfall stations (R-estimated). Daily data

Methodology:
Brown & Foster (1987)

Model:
Regression Kriging using as covariates WorldClim Dataset

Output: 12 Maps (Jan – December) of R

\[
R^2 = 0.86
\]
Prediction of Soil Erodibility (S-factor) in Crete

Input data:
- 31 LUCAS points
- 60 Points in Koiliaris CZO

Attributes:
- Organic carbon,
- Texture (Silt, Clay, sand)
- Coarse fragments

Methodology:
Wischmeir equation (1978)

Model:
Regression Kriging with ESDB covariates, Topography
Soil Erosion (t/ha) annually

300m resolution Maps

12 datasets of soil erosion (Jan – Dec)

80% soil loss Oct – Jan
18% soil loss Feb – Apr

Average annual rate Crete: 8t/ha
Agricultural areas: 3 t/ha
Shrubland – Grassland: 14 t/ha
Delineate risk areas

Spatio-Temporal Erosion Relative Index (STERI)
87% of soil erosion in some parts of Lasithi (East) in December
Critical seasons, Hotspots and land uses susceptible to erosion
Available for policy makers

4. Integration with WP5
Soil Data: As input to the LCA
Erosion – Nitrogen – Soil Sealing - SOC

A datasheet created, containing extracted mean values from the data on soil organic carbon, erosion, soil sealing and soil nitrogen content for each CORINE land cover classes (up to 3rd level). The extracted data will be used as in a soil quality indicator set for LCA.

To extract the mean values from each of the layers, zonal statistics were calculated using CORINE land cover data (Raster, 100m) which defined the land cover zones. The tool “Zonal Statistics as Table” (ArcGIS 10.0) were used to summarise the values of a raster (SOC, Soil Sealing, Nitrogen, Erosion) within the zones (CORINE, 2000) of another dataset and reports the results to a table.
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