NPTEL ONLINE CERTIFICATION COURSES

Machine Learning for Soil and Crop Management

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Week 10: DIGITAL SOIL MAPPING – GENERAL OVERVIEW

LECTURE 46

CONCEPTS COVERED

- DSM-MOTIVATION
- DSM FOR DECISION MAKING AND POLICY MANAGEMENT
- JENNY'S MODEL OF SOIL FORMATION
- SCORPAN + e MODEL
- DSM DATA FLOW

KEYWORDS

- DSM
- Jenny's model of soil formation
- SCORPAN + e
- DEM
- Spatial interpolation

DSM: MOTIVATION

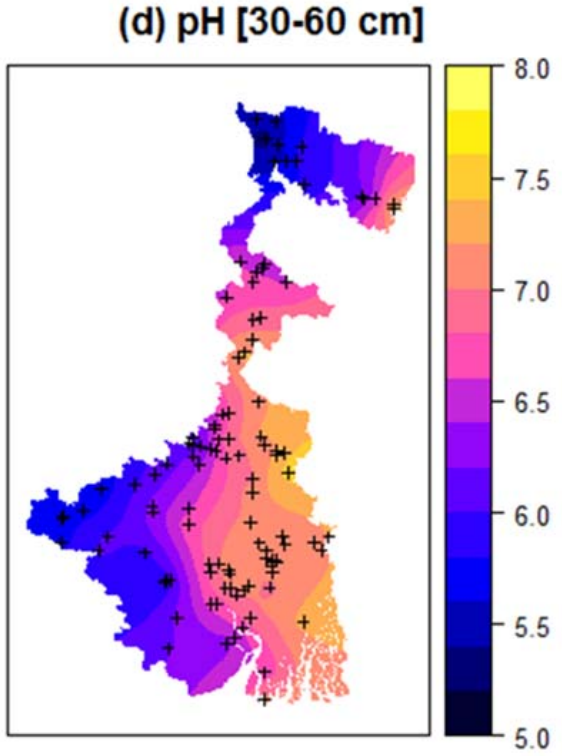
- Many crop, environmental and socio-economic models (crop growth simulation, risk assessment, scenario testing, etc.): require soil parameters as inputs to estimate and forecast changes in our future life conditions
- Available Soil info: ISSUES
  - Missing at the appropriate scale
  - Not digitized
  - Not well explained for reliable interpretation

DATA REQUIREMENT

- Easy-to-interpret-and-use database is needed for the future to support decision making and modelling
- Both national and global scale
- Pressing need for advanced data collection and SPATIAL INTERPOLATION methods: to create a digital soil database

DIGITAL SOIL MAPPING

- Predictive soil mapping
- Computer assisted production of soil maps
- Extensive use:
  - Technological advances like GPS recievers, field scanners, and RS
  - Computation advances, high-end processor
  - GIS, Geostatistics
  - ML and DL algorithms
  - DEM and available digital data



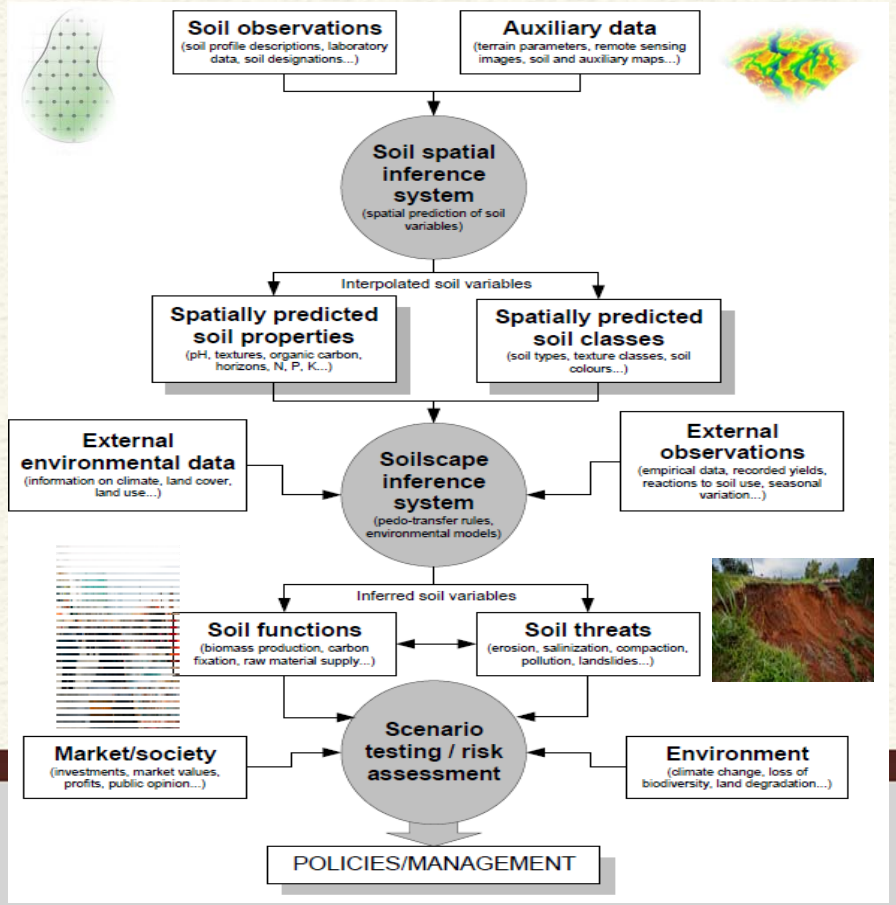
SOME IMPORTANT TERMS

- **DSM:** *computer-assisted production of digital interpolated maps of soil type and soil properties. It typically indicates use of mathematical and statistical models that pool information from soil observations with information contained in correlated environmental variables and remote sensing images.*
- **DIGITAL SOIL MAP:** *visualization of a georeferenced soil database, which exhibits spatial distribution of soil types and/or soil parameters; digital soil map can also be a digitized existing soil maps.*

USES OF DSM

- To provide quantitative soil data, producible at low cost and easy-to-interpret and use
- Better mapping of soil properties at different depths
- Helps in policy decisions
- Environmental management by interpolated maps and pollution hotspots
- Digital soil maps illustrate the spatial distribution of soil classes or properties and can document the uncertainty of the soil prediction
- Digital soil mapping can be used to create initial soil survey maps, refine or update existing soil surveys, generate specific soil interpretations, and assess risk (Carré et al., 2007).
- It can facilitate the rapid inventory, re-inventory, and project-based management of lands in a changing environment

DSM FOR DECISION MAKING AND POLICY MANAGEMENT



Adapted from Dobos (2006)

SOIL FORMATION MODELS/ FACTORS OF SOIL FORMATION

- Jenny (1941)
- *S = f (cl, o, r, p, t)*
  - *cl: climate*
  - *o: organism*
  - *r: relief*
  - *p: parent material*
  - *t: time*

MAJOR FEATURES OF JENNY'S MODEL

a) *Based on empirical studies*

b) *Uses qualitatively defined correlation that formulates a mental model in the soil surveyor's mind to understand and characterize the soil resources*

c) *Demands intensive field work*

d) *Decisions are made mainly on the field, where all environmental covariates can be directly observed and info on the soil can be inferred*

SCORPAN + e MODEL

- McBratney et al. (2003)
- *S = f (S, C, O, R, P, A, N) + e*
  - *S: soil properties at same location*
  - *C: climate*
  - *O: organism*
  - *R: relief*
  - *P: parent material*
  - *A: age, time*
  - *N: location*
  - *f= spatial inference models*

SCORPAN + e MODEL

- McBratney et al. (2003)
- *S = f (S, C, O, R, P, A, N) + e*
  - *S: soil properties at same location (legacy soil data, soil profile, soil maps, soil sensor data)*
  - *C: climate (climate model outputs)*
  - *O: organism (remote sensing of vegetation and land use)*
  - *R: relief (digital elevation models)*
  - *P: parent material (digitized geological maps)*
  - *A: age, time*
  - *N: location (maps of distance from landscape features)*
  - *f= spatial inference models*

HOW SCORPAN +e MODEL DIFFERS FROM JENNY'S MODEL?

a) *Both approaches require input data on soil and covariates*

b) *DSM: hard soil data is also needed like profile soil information*

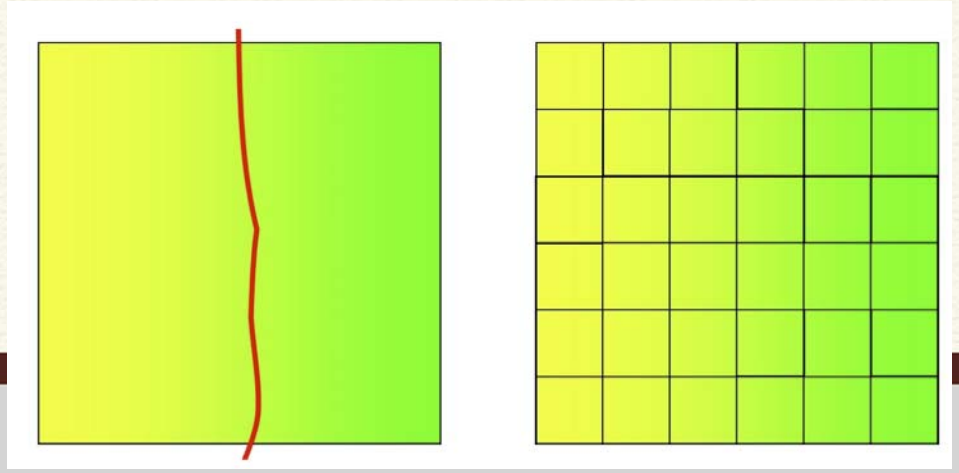
c) *DSM: needs digital data sources as inputs in ML and DL based inference models*

d) *Digital soil mapping is the prediction of soil classes or properties from point data using a statistical algorithm.*

e) *The digital soil map is a raster composed of 2-dimensional cells (pixels) organized into a grid in which each pixel has a specific geographic location and contains soil data.*

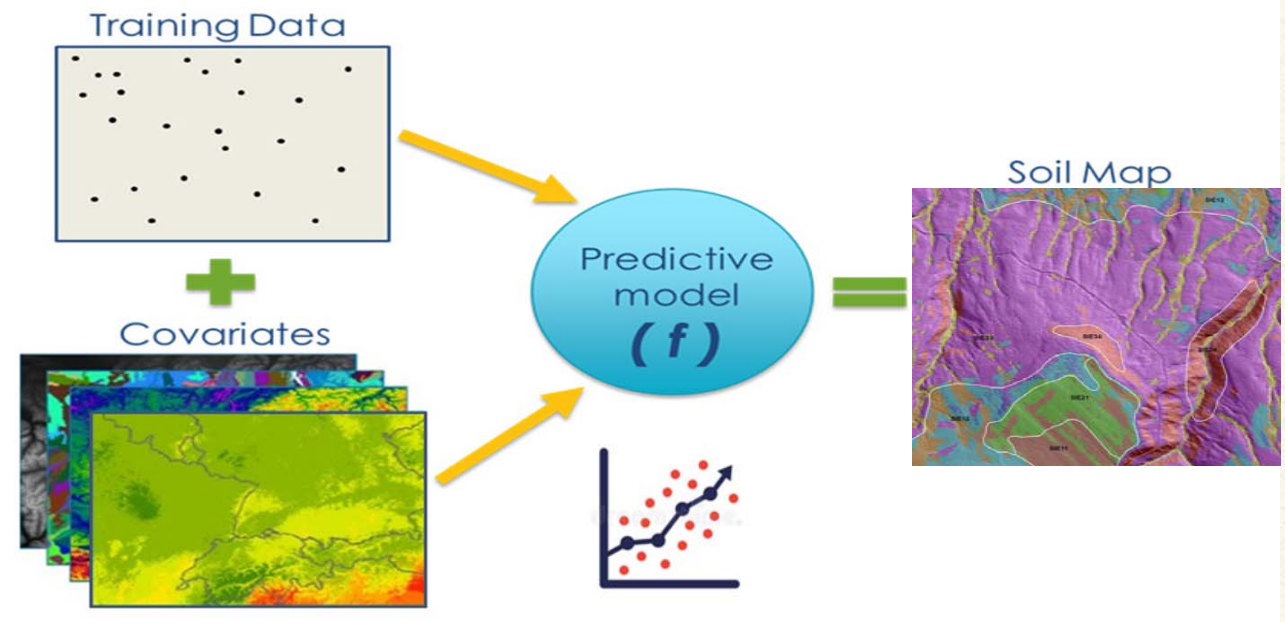
CONVENTIONAL SOIL MAP Vs. DIGITAL SOIL MAP

- *In conventional mapping, the primary question is "Where is the boundary between two soils?" and the focus is on those marginal areas*
- *In digital soil mapping, the central concept is well defined with variation expressed across the landscape*

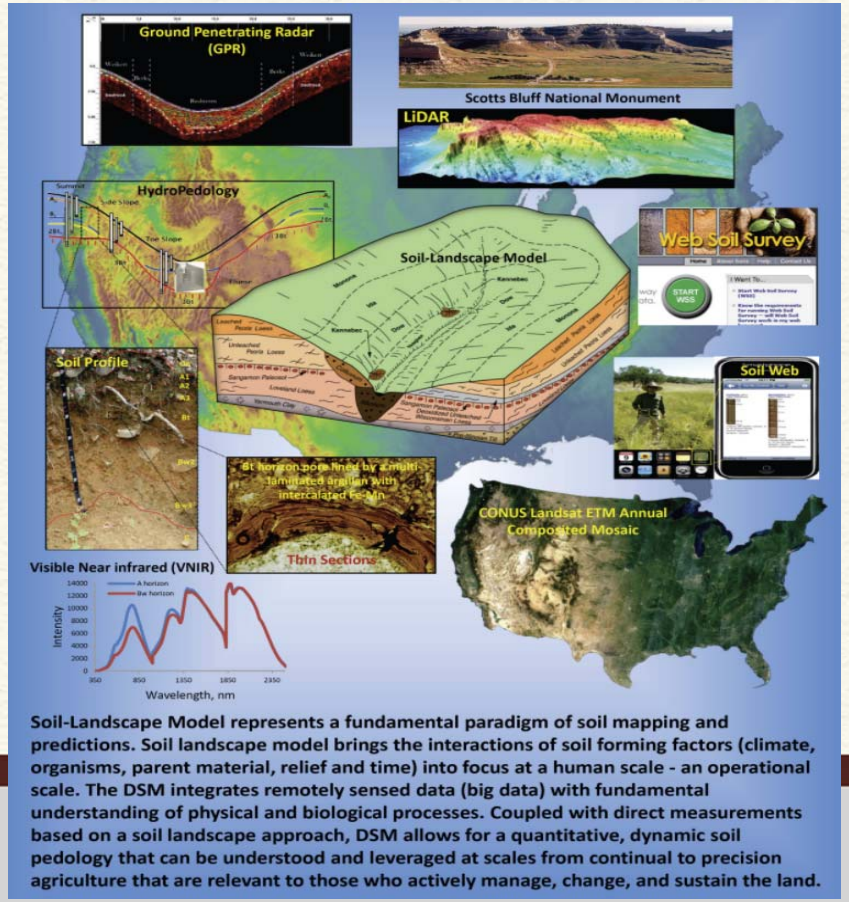


https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=stelprdb1254424

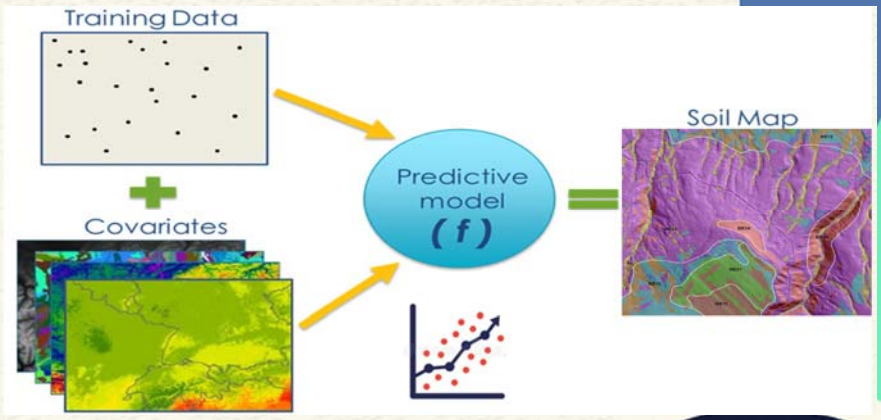
OVERVIEW OF DSM



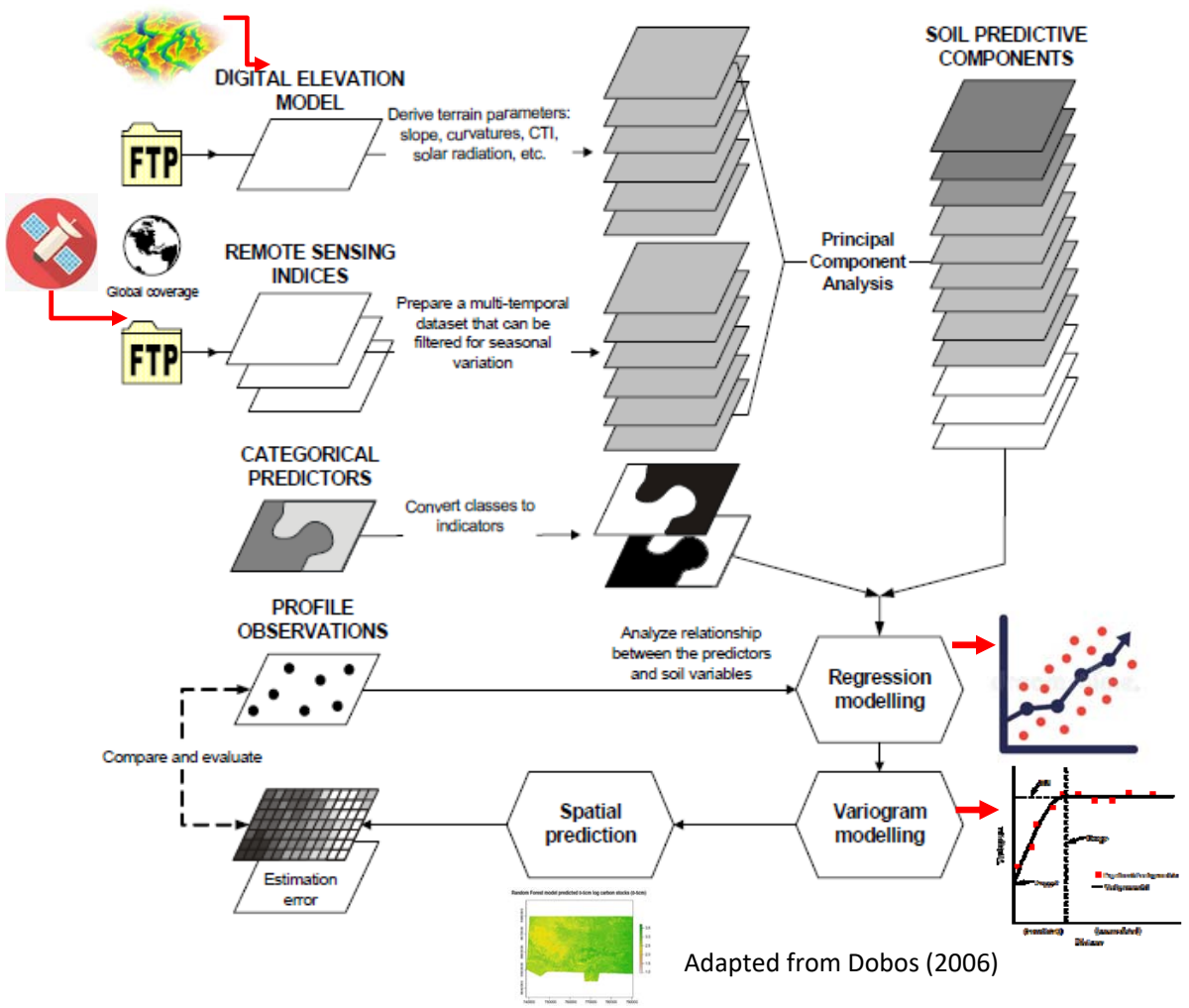
OVERVIEW OF DSM



Soil-Landscape Model represents a fundamental paradigm of soil mapping and predictions. Soil landscape model brings the interactions of soil forming factors (climate, organisms, parent material, relief and time) into focus at a human scale - an operational scale. The DSM integrates remotely sensed data (big data) with fundamental understanding of physical and biological processes. Coupled with direct measurements based on a soil landscape approach, DSM allows for a quantitative, dynamic soil pedology that can be understood and leveraged at scales from continual to precision agriculture that are relevant to those who actively manage, change, and sustain the land.



DSM : DATA FLOW



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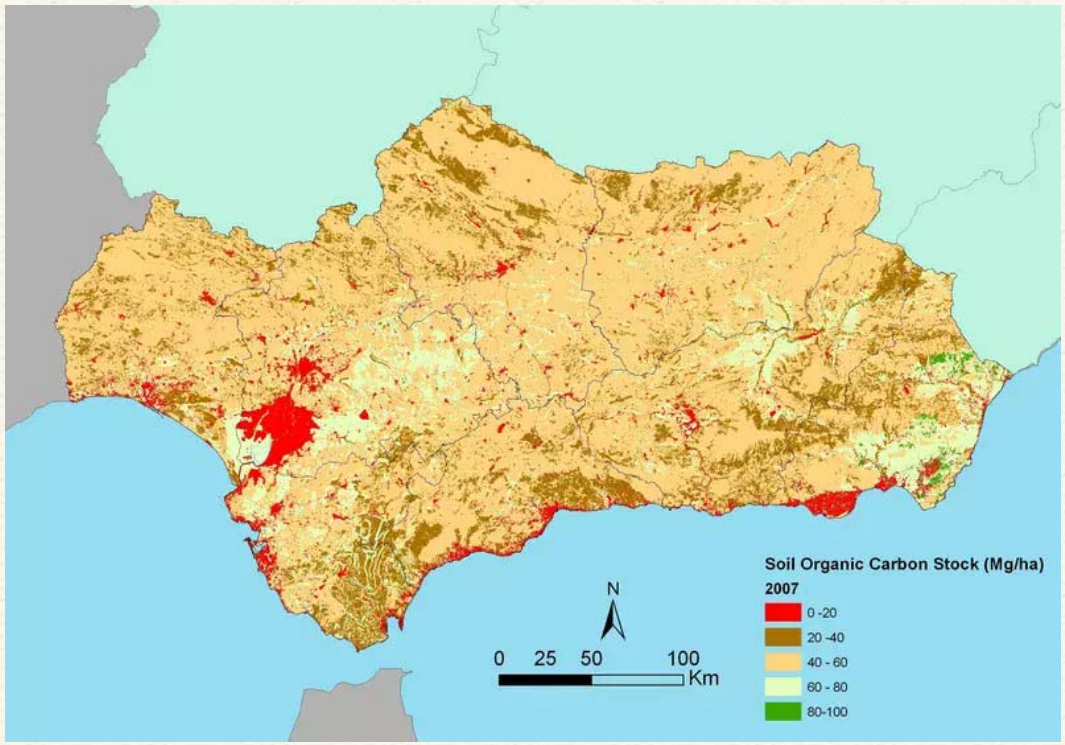
EXAMPLE OF DSM



Map of soil organic carbon content (0–75 cm) in Andalusia (southern Spain) Credit: Antonio Jordán (distributed via imaggeo.egu.eu)

REFERENCES

Dobos, E. (2006). *Digital soil mapping: as a support to production of functional maps*. Office for Official Publication of the European Communities.

Thank you