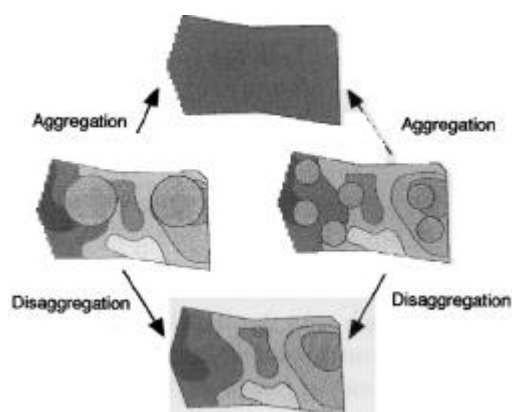


Upscaling and downscaling in soil science: theory and practice



Mini Symposium
Thursday 11th January 2001



ISRIC
35 years
(1966-2001)

Programme

Chair: **Alfred Hartemink**

13.30 – 13.40 **Roel Oldeman** (ISRIC)

Welcome

13.40 – 14.10 **Marc Bierkens** (Alterra)

Upscaling and downscaling methods for environmental research:
an overview

14.10 – 14.40 **Gerard Heuvelink** (University of Amsterdam)

Change of support issues with soil acidification modelling
at the European scale

14.40 – 15.10 **Marc Hoffmann** (WU section Water Resources)

Upscaling in soil science: The use of real space renormalization

15.10 – 15.30 Tea break

15.30 – 16.00 **Hugo Denier van der Gon** (WU Lab Soil Science & Geology)

Upscaling of methane emission from rice fields, a soil-borne
greenhouse gas

16.00 – 16.30 **Vincent van Engelen** (ISRIC)

Regionalization of soil data: from point to (sub)continental level

16.30 – 17.00 General Discussion

> 17.00 Drinks

Upscaling and downscaling methods for environmental research: an overview

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Environmental studies typically involve the combination of dynamic models with data sources at various spatial and temporal scales. Also, the scale of the model output is rarely in tune with the scale at which decision-makers require answers or implement environmental measures. Consequently, the question has been raised how to obtain results at the appropriate scale. Models, usually developed at the scale of a research project, have to be applied to larger areas (extrapolation), with incomplete data coverage (interpolation) and to different supports (upscaling and downscaling) to facilitate studies for decision-makers. This presentation gives an overview of the various ways in which problems of scale transfer occur, and of the upscaling and downscaling methods used to solve these problems. Several examples are given.

Change of support issues with soil acidification modelling at the European scale

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Mechanistic soil process models, such as those that are used to describe the transport of water and solutes in the unsaturated zone of the soil, are usually defined at the point support (a ‘point’ in this case being a volume in the order of a dm^3). This is because these models are implementations of physical laws that are established and proven ‘valid’ at the point support and because these models have often been calibrated at the point support. Due to their non-linear behaviour, these point support models are generally not valid at the larger ‘block’ support. However, the scale at which the output of these models becomes interesting for farmers, planners and groundwater managers is the size of hectares or larger. So an important problem is how to obtain valid output at ‘block’ support, given that the model is only valid at point support. In this presentation we propose to solve this problem simply by running the model at many points within the block and by aggregating the point support model outputs to the desired block support. We discuss the procedure in detail, also paying attention to how uncertainties in model inputs (such as interpolation errors) propagate to the aggregated model output. We demonstrate that the degree of spatial (auto)correlation in input uncertainties is of critical importance to the outcome of the uncertainty analysis. The proposed procedure is computationally demanding, but it has several important advantages. One is that it avoids the fundamental problems associated with current upscaling procedures, another that it yields unbiased predictions of model outputs and their uncertainties. An interesting property of the procedure is also that it nicely separates spatial variability from uncertainty. The theory is illustrated with a case study on modelling soil acidification at the European scale. We address how the uncertainty in categorical maps of soil type and vegetation type and in derived continuous parameters propagate to the output of SMART2. SMART2 is a fairly simple, strictly vertical, one layer dynamic model that predicts for natural and semi-natural areas the long-term response of aluminium (and nitrate) concentration below the root zone to changes in atmospheric deposition.

Upscaling in soil science:

The use of Real Space Renormalization

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Real Space Renormalization (RSR) is an upscaling technique which is used routinely in oil reservoir engineering. It has many potential applications in the upscaling of transport processes in soils. The scope of this technique is the upscaling from the process scale to the required grid scale for a numerical model. Schematically the upscaling process using RSR is explained and a practical example for the upscaling of hydraulic conductivity is presented. Upscaled hydraulic conductivities are needed for climate models and large scale groundwater models. Further ideas are introduced on how to apply RSR to different upscaling processes, e.g. backscatter in remote sensing and infiltration.

Upscaling of methane emission from rice fields, a soil-borne greenhouse gas

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Rice paddies are one of the most important anthropogenic sources of atmospheric methane, a potent greenhouse gas. The uncertainty of about 65% in the global source strength of rice paddies is among the highest of all sources in the global CH₄ budget. Methods to estimate the source strength of rice paddies can be divided into two categories; bottom-up scaling methodologies (upscaling) and top-down scaling methodologies (downscaling). In the case of rice paddy emissions, upscaling is from the soil-plant perspective whereas downscaling is from an atmospheric perspective. At present there is no closure between both approaches which can be (partly) attributed to the lack of CH₄ measurements and accurate CH₄ budgets at the so-called intermediate scale, e.g., landscape-, regional- or national scale, especially for the tropics. Our research project “*Upscaling and Downscaling of Regional Methane Sources – Rice agriculture as a case study*” (1995-2000) proposed a combination of upscaling and downscaling methodologies as a potential method to reduce the uncertainty in the CH₄ source strength of rice paddies at the intermediate scale. I will present some of our findings with respect to upscaling from the soil-plant perspective and its limitations as quantified in case studies on Java, Philippines and China. Due to the lack of regional measurements, upscaling is generally done from the local scale directly to the global scale and large scaling errors may be expected. Although process-based emission models are now becoming available, coupling of models and spatially explicit data sets does not yet allow reductions in the uncertainty of the rice paddy source strength. This is caused by our inability to deal with the uncertainties at each of the steps in an upscaling procedure, as will be discussed. (Soil) Data accuracy introduced the highest uncertainties in emission estimates, but is rarely accounted for in the estimation of global emissions. While acknowledging and quantifying the problems with scaling from local scales to the global scale is important, there is still a need for new emission maps as input for atmospheric models. How can we presently make such maps? An emission factor and a proxy method will be briefly discussed - both approaches "by-pass" the unreliable, unrealistic or non-existent soil data. Now, how reliable is that?

Regionalization of soil data: from point to (sub)continental level

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Interpretation of soil data often takes place by using models developed for small areas. Extrapolation of results faces is hampered by lack of appropriate data at the required spatial scale. This presentation gives an overview of the approaches to solve this problem. Several examples of soil data sets at low resolutions are given together with some interpretations.