Remote sensing data assimilation in modeling of urban dynamics

Objectives and methodology

Johannes van der Kwast[a*], Frank Canters[b], Derek Karssenberg[c], Guy Engelen[a], Tim Van de Voorde[b], Inge Uljee[a] and Kor de Jong[c]

[a]*Flemish Institute for Technological Research (VITO), Boeretang 200, 2400 Mol, Belgium*

[b]*Vrije Universiteit Brussel, Department of Geography, Brussels, Belgium*

[c]*Utrecht University, Department of Physical Geography, Utrecht, the Netherlands*

**Corresponding author. Tel.: +32 14 33 67 36; Fax: +32 14 33 67 99; E-mail: hans.vanderkwast@vito.be*

The problem analysis, planning and monitoring phases of sustainable urban management policies require reliable information on the urban environment and its dynamics. Geospatial and socio-economic data supplemented with knowledge on dynamic urban processes are incorporated in the land-use change models currently available to planners and policy makers. They enable them to assess the impacts of decisions on the spatial systems that they are to manage.

To be usefully applicable the models need extensive calibration. Current calibration methods, however, do not take into account uncertainties in reference land-use data and uncertainties in the parameterization of land-use change models. As a result, uncertainty in land-use change predictions are mostly unknown.

PROBABILISTIC FRAMEWORK

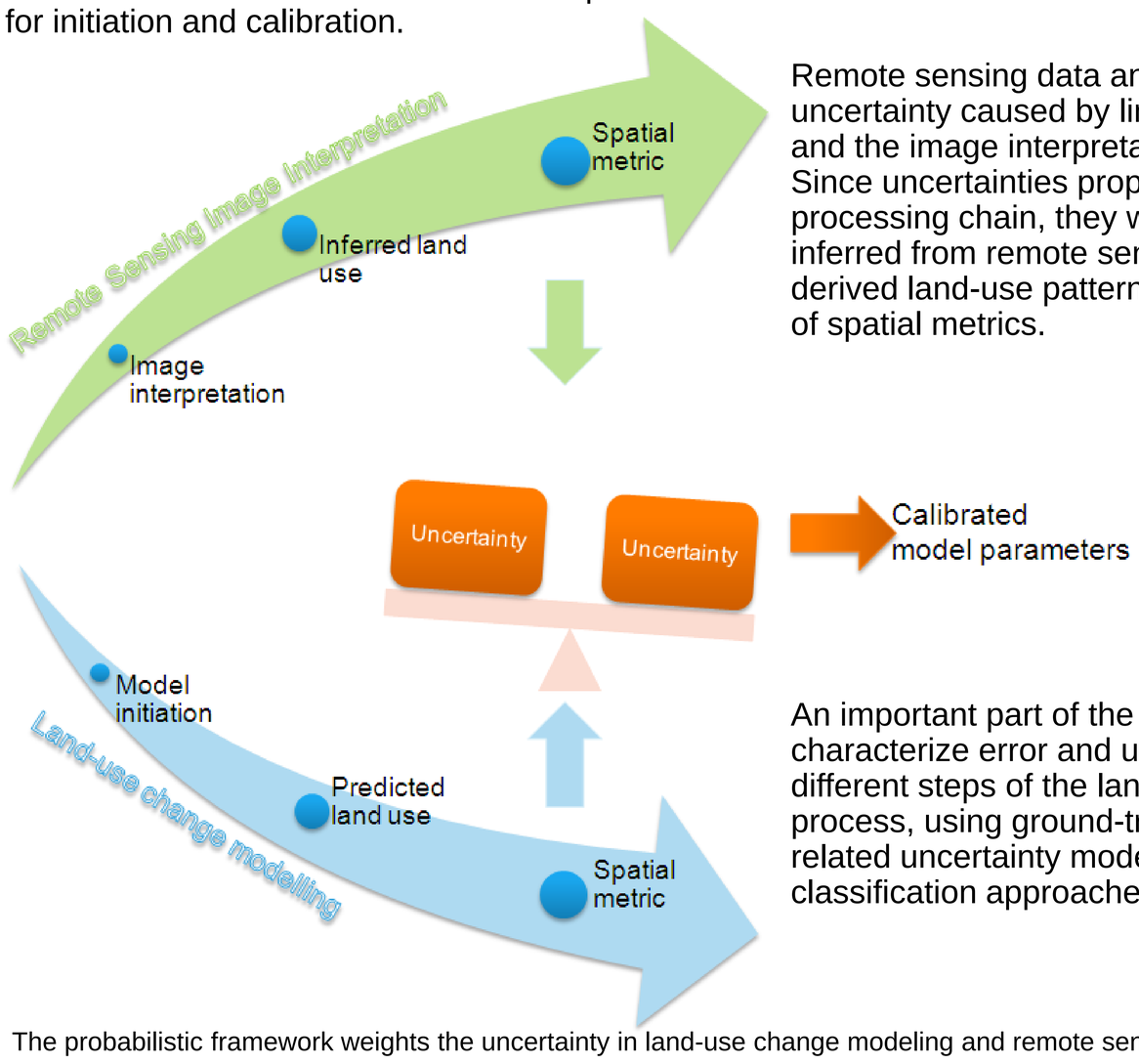
In the ASIMUD project a particle filter data-assimilation algorithm will be used in a probabilistic framework in order to quantify and reduce uncertainties in land-use simulations. Its advantage is that no assumptions are made on the probability distribution of the model states. The particle filter calculates state predictions and their confidence intervals. This requires that the uncertainties of the model input variables and parameters are known. To our knowledge, the particle filter has not been used in land-use change modeling before.

CALIBRATION FRAMEWORK USING REMOTE SENSING

The probabilistic framework will be applied to a calibration procedure developed in the Belspo STEREO II MAMUD project. This procedure uses remote sensing data in the historic calibration process instead of land-use map time series, which are often lacking or show poor consistency. Spatial metrics derived from the land-use simulation and remote sensing observations are compared and used to tune model parameters.

UNCERTAINTY IN LAND-USE CHANGE MODELING

Spatially-dynamic modeling of land-use change involves uncertainty caused by attribute errors, positional errors, logical inconsistencies, incompleteness and temporal errors in the model and in the reference land-use maps used for initiation and calibration.



The probabilistic framework weights the uncertainty in land-use change modeling and remote sensing image interpretation

Uncertainties in the reference land-use maps can be important, but are difficult to quantify objectively. Therefore, the only uncertainties that will be considered here are uncertainties in input parameters.

UNCERTAINTY IN REMOTE SENSING DATA ANALYSIS

Remote sensing data analysis involves uncertainty caused by limitations of the data and the image interpretation methods used. Since uncertainties propagate through the processing chain, they will affect land-use maps inferred from remote sensing images and the derived land-use patterns, quantified by means of spatial metrics.

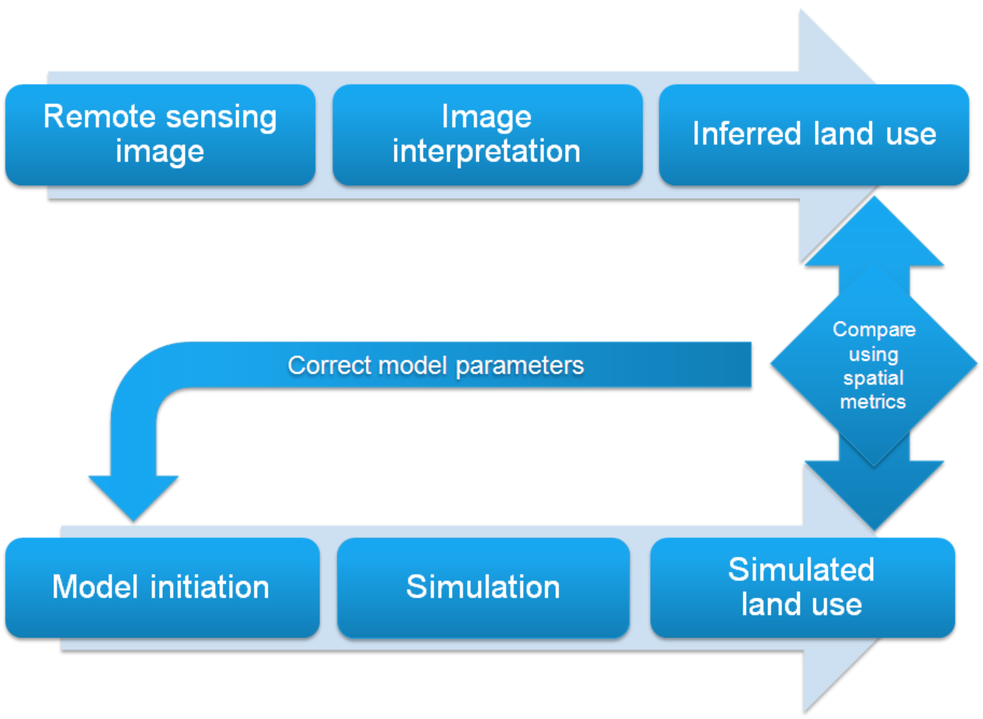
An important part of the project is to characterize error and uncertainty in the different steps of the land-use interpretation process, using ground-truth data and process-related uncertainty models based on classification approaches.

CONCLUSION

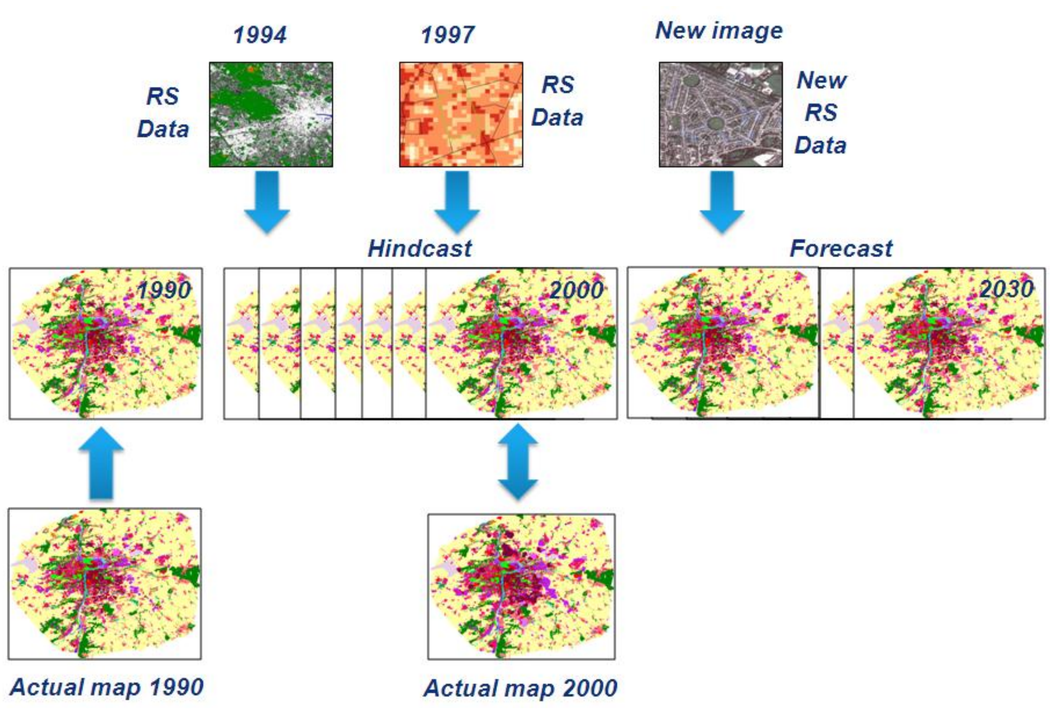
Current calibration methods of land-use change models do not take into account uncertainties in the parameterization of these models and in the land-use data used as a reference. This leads to uncertainties in the prediction of future land use, which need to be quantified and reduced.

The ASIMUD project aims to provide a solution to this issue by applying a data-assimilation framework to the calibration of land-use change models. The particle filter algorithm optimizes parameters of the land-use change model by taking into account the uncertainties in input parameters that propagate through the model and uncertainties in reference data derived from remote sensing images, which are expressed by the probability density function of spatial metrics derived from both sources.

It is expected that the approach will result in a quantification and reduction of the uncertainty in simulations of future land use. The framework will be tested for land-use change models of the city of Dublin (Ireland) and the region of Flanders (Belgium).



Concept of using spatial metrics for calibrating land-use change models



Concept of the historic calibration of a land-use change model using remote sensing data