Translation of data for climate change assessments

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LUC4C

Key findings from *Protocols and guidelines for transparent, flexible and realistic options of translating land-use and cover change data for climate change assessments*:

- Today's global satellite based land-cover change information does not allow a proper change detection from natural vegetation to agricultural land. Global model output and regional satellite products indicate, that a single set of rules for climate and vegetation models may not account for the complexity of such transitions. A more flexible implementation in the form of change matrices provided by land change models is therefore highly recommended.
- A review and comparison of historical reconstructions of land use changes shows a wide range in the quantity of human-influenced areas, and when and where agricultural lands were created. These uncertainties arise from different assumptions that have been made in the reconstruction method and different data used for reconstructions.
- The currently available harmonization strategies for historical reconstructions and future projections of land-use change were collected and reviewed.
- A review of current "gross" change representations inLUC4C land-use and land-cover change models revealed conceptual discrepancies in terms of the understanding of gross changes across the different modelling communities. Gross land change representation has therefore been identified as one of the key issues of land-climate interaction assessments.

Land-use change: assessing the net climate forcing, and options for climate change mitigation and adaptation

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What are the challenges?

No reliable global-scale observations exist of the spatial patterns of historical land-use and land-cover changes (LUC). For the future, the magnitude and location of LUC, naturally, is unknown. Therefore reconstructions and projections of LUC typically have to rely on a variety of LUC models. When assessing LUC effects on climate change, the past and future estimates of land-use and land-cover change have to be translated to serve as input for global ecosystem and climate models. Due to differences between all these different type of models but also due to incomplete or missing information on land-use change dynamics a common guidance how to achieve this is challenging. In particular, four questions are still open:

1) Is it possible to provide observation-based evidence for whether, when croplands (or pastures) are newly created, this is preferentially done by deforestation or by transforming natural grasslands? And if so, are there differences between regions?
2) How do historical reconstructions of land-use and land-cover change differ (e.g., total area, regional variation)?
3) How can time series of the separate historical reconstructions and future projections of LUC be smoothly combined?
4) How important is the representation of sub-grid processes in LUC hindcasts and projections, and what is the effect when assessing LUC-related climate impacts?

How were these addressed

A number of satellite remote sensing products were analysed to identify changes from natural vegetation to agricultural land that took place over recent years. The satellite-derived information was corroborated with LUC model analysis, and both used to draw conclusions.

Summary of important findings

1) Which type of natural vegetation in a location is reduced (or expanded) as a consequence of land-use change may influence the kind and rate of simulated exchange processes between the biosphere and the atmosphere. By tracking changes from natural vegetation to agricultural land in several satellite land-use products and the output of two LUC models, we attempted to find evidences for the most probable transitions and hence identifying rules for the implementation in climate and vegetation models. We found that today's global satellite based land-cover change information does not allow a proper change detection, since the accuracy of classification is too low to track changes in vegetation cover from one year to the next reliably. In high-resolution high-quality satellite data

for Europe and North America and the two global-scale model applications we found large variability regarding the referred conversions from particular natural vegetation types to agricultural land. A single set of rules for climate and vegetation models may not account for the complexity of such transitions. A more flexible implementation in the form of change matrices provided by land change models is therefore highly recommended.

2) Historical reconstructions of land use changes are a basic requirement to understand and quantify the impacts of land use on the climate in previous times (e.g. the portion of greenhouse gas emissions attributed to conversion of natural vegetation to agricultural area). A review and comparison of four different reconstructions shows a wide range in the quantity of human-influenced areas, and when and where agricultural lands were created. These uncertainties arise from different assumptions that have been made in the reconstruction method and different data used for reconstructions.
3) Historical reconstructions and future projections of land-use change originate from different modelling strategies leading to different quantities and patterns of land under usage at the transition zone, which is typically around the year 2000. For assessments of the impacts of LUC on climate change they need to be connected harmonically without sudden changes to avoid artificial disturbances. We collected and reviewed currently available harmonization strategies in the LUC4C models. In addition to the strategy that had been applied for the latest report of the Intergovernmental Panel on Climate change, three LUC products from models within the LUC4C project were prepared.
4) Current land-use and land-cover change data sets mostly represent net changes between two time steps, while neglecting bidirectional changes that might happen in a region during the same time step (e.g. deforestation to create cropland and cropland abandonment and forest regrowth). This can lead to severe underestimation of the total actual land-use and land-cover changes over an area and subsequently to the underestimation of land-use effects on climate. We collected and reviewed current "gross" change representations of the LUC4C land change models. We found that there are still conceptual discrepancies in terms of the understanding of gross changes across the different modelling communities.

What are the next steps

Flexibility is needed how time series of land-cover and land-use change are to be implemented into climate and vegetation models. At present, the best way foreseen is in the form of change matrices, which explicitly determine the source (e.g., type of natural vegetation) and target (e.g., type of managed land) of transitions. Vegetation models participating in LUC4C now working on a common methodology to implement these kind of matrices. Further research within the project will test the impacts of different land-use histories on climate and vegetation processes. In this context, efforts for testing the sensitivity of climate relevant variables to different land-use and land-cover change histories should be strengthened in order to define a minimum accuracy at which errors in the land use history does not affect climate relevant variables significantly.

From a more model-structural perspective, the different methods of providing consistent land-use change, land-cover change time series can now be further investigated regarding their effects on climate relevant variables. Such efforts should give us a much better understanding of uncertainties in LUC modelling, as well as related impacts on ecosystems and climate change that are due to how data along two different time series is treated. Moreover, sub-grid scale processes ("gross transitions") have been identified as a large factor that can alter total area of land-use change, as well as the related impacts, and will be subject of further research across LUC4C work packages.