Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Institute for Meteorology and Climate Research (IMK-IFU)
Garmisch-Partenkirchen, Germany

Karlsruhe Institute of Technology

Towards integrated regional earth system modeling: A coupled biosphere-hydrosphere-atmosphere model with dynamic vegetation and chemistry

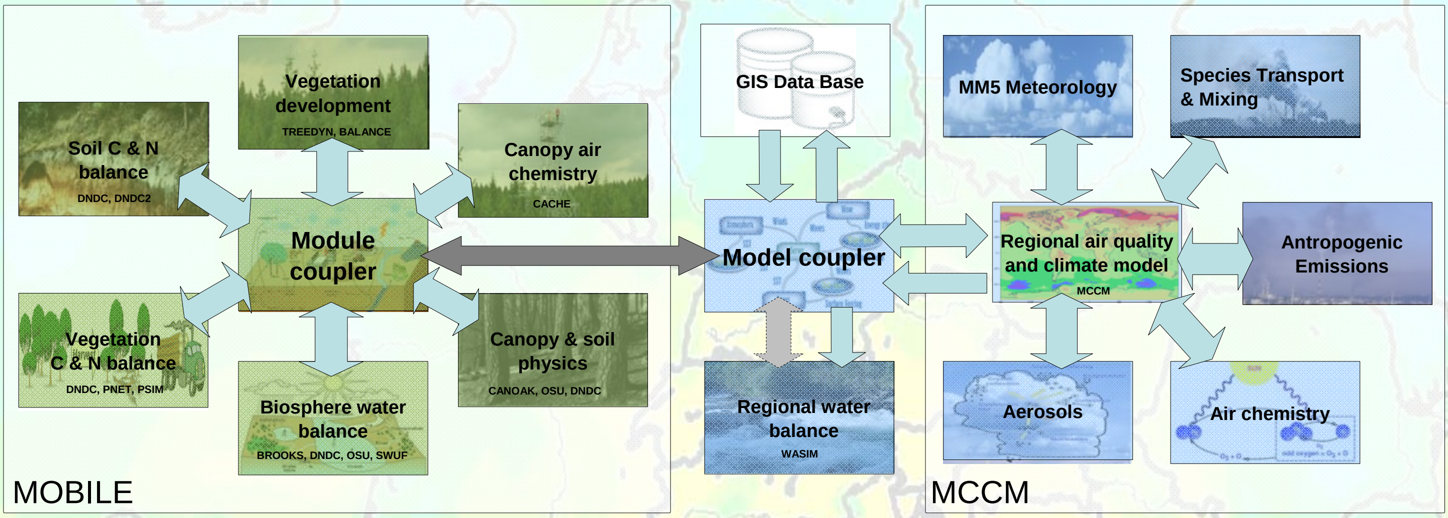
Edwin Haas, Rüdiger Grote, Renate Forkel, Richard Knoche, Harald Kunstmann
Klaus Butterbach-Bahl, Ralf Kiese, Christian Werner, Arjan de Bruijn, Daniela Kracher

Motivation Climate change influences the entire coupled Biosphere-Hydrosphere-Atmosphere (BHA) system. Quantification of the feedbacks between the BHA-System and regional climate therefore requires the consideration of physical, chemical, and biological processes. Unfortunately, climate change impact analysis still lacks a BHA-modeling system adequate for the purpose.

Solution In order to investigate these complex feedback mechanisms between climate and regional ecosystems, a new BHA-modeling system is developed that consists of 1) a biosphere-hydrosphere model-framework (MOdular BIosphere simuLation Environment, MoBiLE) coupled 2) to the regional meteorology-chemistry-climate-model MCCM. MCCM is based on a climate version of MM5, which is extended by a chemistry transport model, including gas phase air chemistry mechanisms and primary/secondary aerosols processes. MOBILE replaces the original land-surface scheme in MCCM. It consists of modules accounting for dynamic vegetation development, soil water and energy balance, biogenic VOC emissions, bio-geochemical C/N cycles in vegetation and soil. The bidirectional data exchange between MCCM and MOBILE accounts for the different time scales of the underlying processes resulting in information update frequencies between seconds and 24 hours.

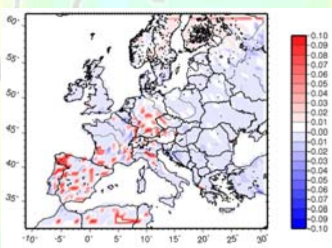
First Application The presented preliminary results are applications using empirical as well as process-based modules for seasonal vegetation development and emission (PSIM, Guenther, OSU). Monoterpene and isoprene emission is produced in response to climate and directly fed back into the atmospheric chemistry model.

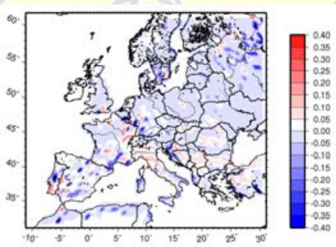
Coupled BHA-Model MCCM-MOBILE

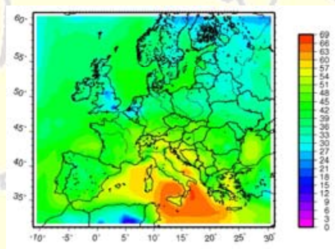


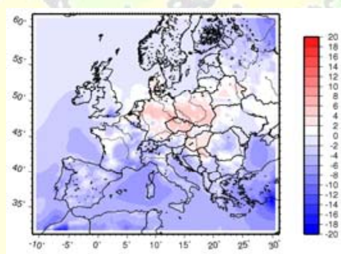
Modules available within the MOBILE-Framework:
CANOAK : micro meteorology model, Baldochi et al., 1995
DNDC (DeNitrification-DeComposition), Li 2001
DNDC2, DNDC with modified soil chemistry
OSU, Oregon State Univ. land surface model, Chen 2001
BROOK, soil water and streamflow, Federer et al. 2003
SWUF, soil water under forests, Paul et al. 2004
PNET, carbon, water and nitrogen, Federer, 1992
PSIM, vegetation physiology, Grote 2007

Preliminary results
The first model studies were performed with up to five fractional vegetation types per grid cell in the biosphere based on a high resolution vegetation inventory (replacing the MM5/USGS based single dominant vegetation type regime).
The biogenic VOC emissions were calculated with the SIMBIM VOC emission module integrated in PSIM (Grote et al. 2006, Grote 2007) based on the new vegetation initialisation and compared with the emissions derived from Guenther's algorithm.


Differences in monoterpen emissions (MCCM - MCCM-Mobile) [nmol/m²/min]


Differences in isoprene emissions (MCCM - MCCM-Mobile) [nmol/m²/min]


7-day ozone mean predicted by MCCM-Mobile [ppb]


Differences in the ozone mean (MCCM - MCCM-Mobile) [ppb]

R. Grote, S. Mayrhofer, R.J. Fischbacha, R. Steinbrecher, M. Staudt, J.-P. Schnitzler (2006); *Process-based modelling of isoprenoid emissions from evergreen leaves of Quercus ilex (L.)*, Atmospheric Environment 40
R. Grote (2007); *Sensitivity of volatile monoterpene emission to changes in canopy structure: a model-based exercise with a process-based emission model*, New Phytologist 173

Marie Curie Actions
Human resources and mobility

VOCBAS

Acknowledgements
Attendance at this conference was supported by **EC FP6 Marie-Curie iLEAPS** and by **ESF-VOCBAS**