PAGES
PAST GLOBAL CHANGES

cirques & lakes
PN-II-RU-TE-2012-3-0386

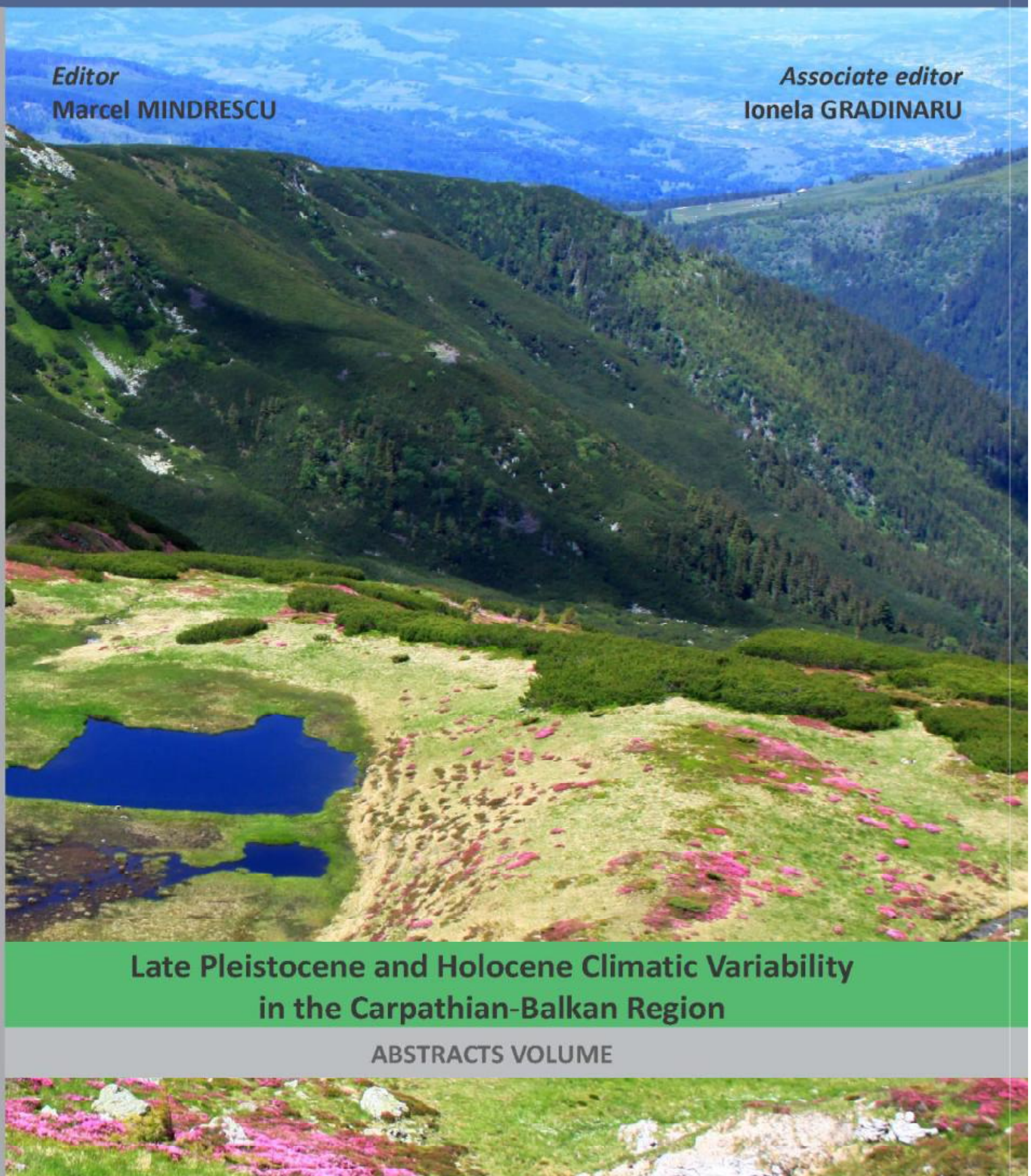
Nov. 2014

Late Pleistocene and Holocene climatic variability in the Carpathian-Balkan region. Abstracts volume

Ştefan cel Mare University Press

Editor
Marcel MINDRESCU

Associate editor
Ionela GRADINARU



Late Pleistocene and Holocene Climatic Variability in the Carpathian-Balkan Region

ABSTRACTS VOLUME

Ştefan cel Mare University Press

Towards modelling of loess-paleosol sequence formation

Christian Zeeden[1], Ulrich Hambach[2], Slobodan Markovic[3], Igor Obreht[1] and Frank Lehmkuhl[1]

[1] RWTH Aachen University, Department of Geography, Germany, christian.zeeden@geo.rwth-aachen.de

[2] Chair of Geomorphology, University of Bayreuth, Universitätsstr. 30, D-95440 Bayreuth, Germany

[3] University of Novi Sad, Department of Geography, Tourism and Hotel Management

A simple modelling approach of loess-paleosol sequences combining both local insolation (as represented by a combination of precession and obliquity; p-0.5t) and a global climate signal (represented by the LR04 benthic oxygen isotope stack) is presented. Aim is the combination of these signals and the setting of threshold values to mimic loess-paleosol formation in the Pannonian Basin. As a good fit does not necessarily imply a causal link, results require critical discussion.

Rationale

Proxy records for paleoenvironmental conditions of loess-paleosol sequences in the Pannonian Basin, especially of the magnetic susceptibility (MS), show a pattern comparable to the global oxygen isotope record (e.g. Huybers and Wunsch, 2004; Lisiecki and Raymo, 2005), which is generally assumed to represent a global composite signal of deep sea temperatures and ice volumes. As a result, time scales for loess-paleosol sequences were constructed by correlation of MS records to the oxygen isotope record of benthic foraminifera (e.g. Buggle et al., 2009). Further, some authors discuss to directly relate European loess-paleosol sequences to astronomical parameters (precession, obliquity and eccentricity; Basarin et al., 2014; Marković et al., 2012; Necula and Panaiotu, 2008). Though similarities of these records are obvious, also differences between the marine and European loess deposits are apparent. These discrepancies may lie in diverse formation mechanisms, (local or regional) soil formations or other (more complex?) influences.

Observations

Comparing loess (here from Batajnica, Vojvodina, Serbia) to the LR04 stack (Lisiecki and Raymo, 2005), the Imbrie & Imbrie 1980 ice model (parameterized as by Lisiecki and Raymo, 2005 and based on the June insolation by Laskar et al. 2004; Imbrie and Imbrie, 1980) and an ET-P curve (mix from eccentricity, obliquity and precession) shows that the ~100 kyr component (of eccentricity) is strongly developed in loess, while the higher frequency signals (corresponding to precession and obliquity) are not clearly recognizable in the loess. However, some peaks in the MS which are not as present in the oxygen isotope record seem to relate to high obliquity, specifically at ca. 160, 290 and 370 ka. Further, the MS signal shows a clear baseline during cold conditions, whereas the LR04 stack and also summer insolation curves show both peaks and troughs. Comparing MS data and the summer insolation at 65° north, the 405 kyr component of eccentricity does not seem to play a role in loess (as for the marine oxygen isotope records).

Pronounced differences between the LR04 stack and the MS at Batajnica are: 1) a weak MS peak at the end of MIS7, which is present in the Imbrie & Imbrie 1980 ice model (when parameterized as by Lisiecki and Raymo, 2005), 2) the non-division of MIS 7 and MIS 9 in loess 3) general low intensity variations of the paleosols, relative to the ice model and benthic oxygen isotope composite records.

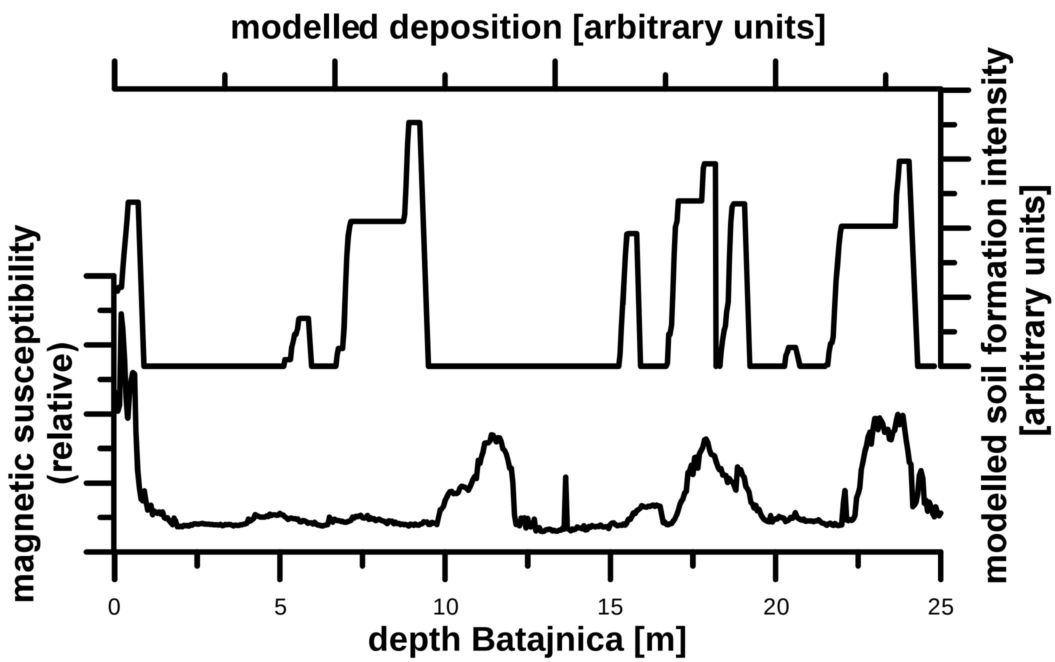


Fig. 1 Results from modelling soil formation and loess deposition (top) and data of the magnetic susceptibility from Batajnica (Serbia, Marković et al., 2009, bottom).

Towards modelling

Here the attempt is made to model loess-paleosol sequence formation and magnetic enhancement of soils by forcing a simple model. A combination of global climate as represented by the marine oxygen isotope record (Lisiecki and Raymo, 2005) and a direct orbital signal (derived from data by Laskar et al., 2004). Based on these observations, a modelling attempt is made combining the (standardized) LR04 stack and the (standardized) p-0.5t (standardized precession minus 0.5*standardized tilt) curve representative for northern hemisphere summer insolation (see Lourens et al., 1996 for discussion). A threshold value of this combined curve is set to simulate soil formation under 'locally favourable' conditions (high summer insolation), and no-soil-formation during 'locally unfavourable' conditions (low summer insolation). Soils are simulated to overprint material accumulated during 'favourable conditions', but not material accumulated during 'unfavourable conditions'. Further, an accumulation model is developed that deposits 'pure' loess during periods of no soil formation, and accumulates little material during soil formation.

Results

Comparing results of a simple model to data from Batajnica (Marković et al., 2009, see Fig. 1), similar patterns are apparent. This is not surprising, as thresholds have been set to give a decent fit between the simple model and geological data. However, experimenting with thresholds and data of either the LR04 stack (thought to represent global climate) or an insulation curve could not result in a fit as good as the here presented one. Though the pattern of soil formation results in a reasonable fit, modelled sedimentation deviates from observations. As the (last glacial) sedimentation rates differ throughout the Pannonian Basin (see e.g. the compilation of Buggle et al., 2009) we do not regard this an issue here.

Perspectives

The presented approach has much space for improvement. The next steps will be to incorporate an automatic matching procedure to use Monte Carlo type simulations to optimize thresholds and transfer functions (for soil formation and sedimentation) to adjust the fit between model and data. Once achieved, a model can be fitted to numerous datasets, and the variability of thresholds and transfer functions can be investigated, hopefully leading to a better understanding of the forcing mechanisms of loess-paleosol sequences in the Pannonian Basin.

Acknowledgements

The authors would like to thank the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) for funding of the project in the context of the CRC 806 "Our way to Europe", subproject B1 "The „Eastern Trajectory“: Last Glacial Palaeogeography and Archaeology of the Eastern Mediterranean and of the Balkan Peninsula". We would like to thank several colleagues for inspiring discussions.

References

Basarin, B., Buggle, B., Hambach, U., Marković, S.B., Dhand, K.O., Kovačević, A., Stevens, T., Guo, Z., Lukić, T., n.d. Time-scale and astronomical forcing of serbian loess-palaeosol sequences. Global and Planetary Change. doi:10.1016/j.gloplacha.2014.08.007

Buggle, B., Hambach, U., Glaser, B., Gerasimenko, N., Marković, S., Glaser, I., Zöller, L., 2009. Stratigraphy, and spatial and temporal paleoclimatic trends in Southeastern/Eastern European loess–paleosol sequences. Quaternary International, Lower Latitudes Loess-Dust Transport Past and Present 196, 86–106. doi:10.1016/j.quaint.2008.07.013

Huybers, P., Wunsch, C., 2004. A depth-derived Pleistocene age model: Uncertainty estimates, sedimentation variability, and nonlinear climate change. Paleoceanography 19, PA1028. doi:10.1029/2002PA000857

Imbrie, J., Imbrie, J.Z., 1980. Modeling the Climatic Response to Orbital Variations. Science 207, 943–953. doi:10.1126/science.207.4434.943

Laskar, J., Robutel, P., Joutel, F., Gastineau, M., Correia, A.C.M., Levrard, B., 2004. A long-term numerical solution for the insolation quantities of the Earth. Astronomy and astrophysics 428, 261–285.

Lisiecki, L.E., Raymo, M.E., 2005. A Pliocene-Pleistocene stack of 57 globally distributed benthic δ18O records. Paleoceanography 20, PA1003. doi:10.1029/2004PA001071

Lourens, L.J., Antonarakou, A., Hilgen, F.J., Van Hoof, A. a. M., Vergnaud-Grazzini, C., Zachariasse, W.J., 1996. Evaluation of the Plio-Pleistocene astronomical timescale. Paleoceanography 11, 391–413. doi:10.1029/96PA01125

Marković, S.B., Hambach, U., Catto, N., Jovanović, M., Buggle, B., Machalett, B., Zöller, L., Glaser, B., Frechen, M., 2009. Middle and Late Pleistocene loess sequences at Batajnica, Vojvodina, Serbia. Quaternary International, Loess in the Danube Region and Surrounding Loess Provinces: The Marsigli Memorial Volume 198, 255–266. doi:10.1016/j.quaint.2008.12.004

Marković, S.B., Hambach, U., Stevens, T., Basarin, B., O’Hara-Dhand, K., Gavrilov, M.M., Gavrilov, M.B., Smalley, I., Teofanov, N., 2012. Relating the Astronomical Timescale to the Loess–Paleosol Sequences in Vojvodina, Northern Serbia, in: Berger, A., Mesinger, F., Sijacki, D. (Eds.), Climate Change. Springer Vienna, pp. 65–78.

Necula, C., Panaiotu, C., 2008. Application of dynamic programming to the dating of a loess-paleosol sequence. Romanian Reports in Physics 60, 157–171.