

EFFECTS OF NEARBY SUPERNOVAE IN THE EARLY PLEISTOCENE. B. C. Thomas¹, A. L. Melott², A. C. Overholt³, M. Kachelrieß⁴, D.V. Semikoz⁵, and E. E. Engler¹. ¹Washburn University, Topeka KS (br-an.thomas@washburn.edu), ²University of Kansas, ³MidAmerica Nazarene University, ⁴Instituut for fysikk, NTNU, Norway, ⁵APC, Universite Paris Diderot.

Introduction: Recent measurements [1] of ⁶⁰Fe in ocean sediment, FeMn crust, and FeMn nodules have strongly confirmed that multiple supernovae happened at distances of about 150-300 light years [2,3], consisting of two main events: one at 1.7 to 3.2 million years ago, and the other at 6.5 to 8.7 million years ago. We ask whether such supernovae are expected to have had substantial effects on the terrestrial atmosphere and biota.

I will review work recently published by our group [4] and new work in progress, in which we model the effects of supernovae at 300 and 150 light years, including effects from both electromagnetic and charged particle (cosmic ray) radiation.

We find a small effect on terrestrial organisms from visible light, and that high energy (x-ray) photons do not deliver enough energy to cause significant changes. Cosmic rays, however, are greatly enhanced and have significant impacts. In particular, atmospheric ionization is increased by an order of magnitude or more, especially in the lower atmosphere, lasting thousands of years.

Increased ionization in the upper atmosphere has implications for chemistry changes such as depletion of stratospheric ozone. Lower atmosphere ionization is likely connected to lightning rates and may have a connection to changes in climate and biome types, as well as a minor mass extinction, around the Pliocene-Pleistocene boundary.

References: [1] Wallner A., Feige J., Kinoshita N., et al. (2016) *Nature*, 532, 69. [2] Breitschwerdt D., Feige J., Schulreich M.M., et al. (2016) *Nature*, 532, 73. [3] Fry B.J., Fields B.D., and Ellis J.R. (2016) *Astrophys. J.*, 827, 48. [4] Thomas B.C., Engler E.E., Kachelrieß M., Melott A.L., Overholt A.C., and Semikoz D.V. (2016) *Astrophys. J. Lett.*, 826, L3.

Acknowledgments: This work has been supported by NASA Exobiology grant NNX14AK22G.