A persistent influence of supernovae on biodiversity

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The extraterrestrial processes responsible for influencing the diversity of life forms are usually invisible to the human eye. The Milky Way is where large stars explode, leading to supernova remnants whose shock fronts accelerate cosmic

ray particles to high energies. Cosmic rays find their way to the solar system, where some collide with the atmosphere producing cascades of secondary particles which ionize the atmosphere. Ions influence the formation of clouds which ultimately affect climate. Therefore, changes in supernova activity change climate, which is responsible for mixing and transporting life's essential nutrients to the ecosystems. Credit: Henrik: Svensmark, DTU Space

The number of exploding stars (supernovae) has significantly influenced marine life's biodiversity during the last 500 million years. This is the essence of a new study published in *Ecology and Evolution* by Henrik Svensmark, DTU space.

Extensive studies of the fossil record have shown that the diversity of life forms has varied significantly over geological time, and a fundamental question of evolutionary biology is which processes are responsible for these variations.

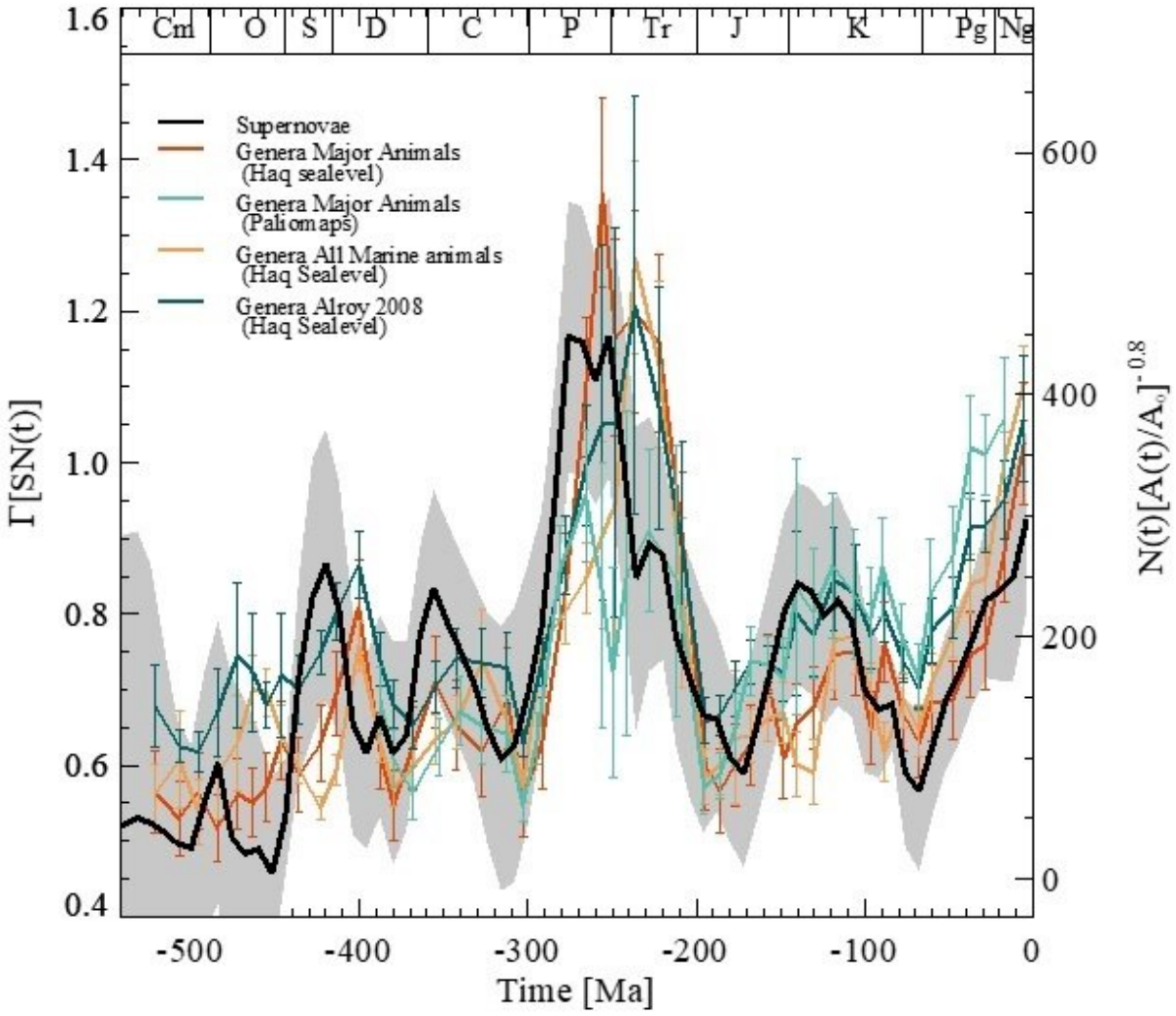
The new study reveals a major surprise: The varying number of nearby exploding stars (supernovae) closely follows changes in marine genera (the taxonomic rank above species) biodiversity during the last 500 million years. The agreement appears after normalizing the marine diversity curve by the changes in shallow marine areas along the continental coasts.

Shallow marine shelves are relevant since most marine life lives in these areas, and changes in shelf areas open new regions where species can evolve. Therefore, changes in available shallow areas influence biodiversity.

"A possible explanation for the supernova-diversity link is that supernovae influence Earth's climate," says Henrik Svensmark, author of

the paper and senior researcher at DTU Space.

"A high number of supernovae leads to a cold climate with a large temperature difference between the equator and polar regions. This results in stronger winds, ocean mixing, and transportation of life-essential nutrients to the surface waters along the continental shelves."



Variations in relative supernova history (black curve) compared with genera-level diversity curves normalized with the area of shallow marine margins

(shallow areas along the coasts). The brown and light green curves are major marine animals' genera-level diversity. The orange is marine invertebrate genera-level diversity. Finally, the dark green curve is all marine animals' genera-level diversity. Abbreviations for geological periods are Cm Cambrian, O Ordovician, S Silurian, D Devonian, C Carboniferous, P Permian, Tr Triassic, J Jurassic, K Cretaceous, Pg Palaeogene, Ng Neogene. Credit: Henrik Svensmark, DTU Space

The paper concludes that supernovae are vital for primary bioproductivity by influencing the transport of nutrients. Gross primary bioproductivity provides energy to the ecological systems, and speculations have suggested that changes in bioproductivity may influence biodiversity. The present results are in agreement with this hypothesis.

"The new evidence points to a connection between life on Earth and supernovae, mediated by the effect of cosmic rays on clouds and climate," says Henrik Svensmark.

When heavy stars explode, they produce cosmic rays, which are elementary particles with enormous energies. Cosmic rays travel to our solar system, where some end their journey by colliding with Earth's atmosphere. Previous studies by Henrik Svensmark and colleagues referenced below show that they become the primary source of ions help form and grow aerosols required in cloud formation.

Since clouds can regulate the solar energy reaching Earth's surface, the cosmic-ray-aerosol-cloud influences climate. Evidence shows substantial climate shifts when the intensity of cosmic rays changes by several hundred percent over millions of years.

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