Smithsonian

Spotlight on Science at the Smithsonian

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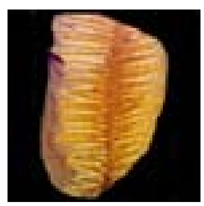

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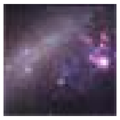

Introduction from the Under Secretary for Science

In this installment of Spotlight on Science we learn how Smithsonian astronomers have measured the speed of dwarf galaxies orbiting the Milky Way, and what this tells us about the mysterious "dark matter" that pervades the galaxy. Closer to home, we learn the connections between jellyfish and oysters in the Chesapeake Bay. Swimmers may hate stinging sea nettles, but they play an important role in the Bay's food web. Finally, we take a look at carbon dioxide, melting glaciers, and ecological upheaval – 300 million years ago. What can the deep past tell us about our own future?

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The large Magellanic cloud, visible in the southern hemisphere, is a dwarf galaxy orbiting our own galaxy, the Milky Way.

Orbiting Galaxies Provide Clues to the Milky Way's Dark Halo

Smithsonian Researchers

Nitya Kallivayalil and Charles Alcock (Harvard-Smithsonian Center for Astrophysics)

Reference

Nitya Kallivayalil, Roeland P. van der Marel, and Charles Alcock. Is the SMC bound to the LMC? The Hubble Space Telescope proper motion of the SMC. *The Astrophysical Journal*, 652:1213-1229. December 1, 2006.

Findings

New measurements indicate that the Large Magellanic Cloud and the Small Magellanic Cloud, two dwarf galaxies orbiting our own galaxy, are hurtling through space at speeds nearly twice as high as previously thought.

Why It Matters

As two of the Milky Way Galaxy's nearest neighbors, the Large and Small Magellanic Clouds are intimately linked to our galaxy's evolution. One of the most momentous astronomical discoveries of recent decades is that of a halo of so-called dark matter surrounding our galaxy. As befits its name, dark matter cannot be seen by astronomers, but its presence can be inferred from its gravitational effects on normal visible matter. Because they orbit beyond the outer reaches of the visible galaxy, the Magellanic Clouds are in the right place to give key information on the shape and extent of the dark halo. The high speed of the clouds can mean one of two things: either they are not gravitationally bound to our galaxy (or each other, for that matter) and will eventually break free from their orbits, or that mass of the dark halo is significantly greater than previously assumed, because it would require a stronger pull of gravity to permanently hold the Clouds in such fast-moving orbits. Either way, this finding significantly changes our picture of how our galaxy and its neighbors are evolving.

Methods

To calculate the orbits of the Magellanic Clouds, the researchers needed to know the three-dimensional trajectory of their motion through space. The rate at which they are traveling away from Earth, known as their radial velocity, was already well-established by previous studies. What remained to be determined was the rate at which they move across the sky, known as their proper motion. This measurement is difficult because it requires extremely precise measurements of the positions of the clouds against some fixed background over several years. Previous attempts had used measurements spaced more than a decade apart, but lacked the precision necessary for accurate results. Instruments aboard the Hubble Space Telescope are precise enough, however, that the researchers were able to use measurements separated only by two years and get results that are the most accurate thus far.

What's Next

The success of this study implies that the Hubble Space Telescope can be used to accurately measure proper motions of other objects besides the Magellanic Clouds over shorter time periods than were previously needed. The researchers can also make further measurements to improve the estimates of the Clouds' motions, which will make it possible to more precisely determine their orbits. That way, we can learn if the Magellanic Clouds are held in their orbits by a Milky Way far more massive than previously thought, or if they are just passing through.

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Declining numbers of sea nettle jellyfish in the Chesapeake Bay are linked to the decline of oysters over the past several decades.

Oysters, Jellyfish, and the Chesapeake Food Web

Findings

Declining oyster abundances in Chesapeake Bay have led to declining abundances of stinging jellyfish known as sea nettles over the past several decades. Because sea nettles are major predators of other gelatinous animals known as ctenophores, the decline in sea nettles has led to a population boom of ctenophores. Because ctenophores are voracious predators of zooplankton—including oyster and fish larvae—the chain of effects from the decline of oysters in the Bay may have dramatic effects on the structure of the food web and hamper efforts to restore oyster populations.

Why It Matters

Overfishing is a major problem in many aquatic ecosystems and it is becoming increasingly clear to scientists that its effects can be complex. Oysters are not only key members of the food web in many estuaries, but by building reefs they provide habitat for many other species. Sea nettles spend their adult lives swimming through the water in search of ctenophores and other prey, but they spend an earlier stage of their life cycle on the bottom attached to hard surfaces such as oyster shells. With fewer available oyster reefs in recent years, fewer sea nettles survive to adulthood and the population has declined. Because the sea nettles help control predators of oyster larvae such as ctenophores, the loss of sea nettles may lead to a further decline in oysters, or at the least make it difficult for oyster populations to rebound. This in itself has important implications for the ecology and economics of the Chesapeake, but there are also implications for the Bay's fish populations. Not only do the fast-reproducing ctenophores prey on fish larvae, but they also compete for food with many adult fish such as the Bay Anchovy. Despite the decline of sea nettles, the overall effect of the loss of oyster reefs might be to tip the ecological balance in the Chesapeake food web away from fish and toward gelatinous predators.

Methods

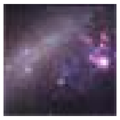
The study's conclusions are based on trawls and visual counts of sea nettles and ctenophores in the Chesapeake Bay and its tributaries over several decades, beginning in the 1960s. By comparing the results to stream discharge and climatic data over the same time period, the researchers ruled out salinity and climatic changes as causes of the decline in sea nettles and the rise in ctenophores, which previous work had suggested.

Smithsonian Researchers

Denise L. Breitburg and Richard S. Fulford (Smithsonian Environmental Research Center)

Reference

Denise L. Breitburg and Richard S. Fulford. Oyster-sea nettle interdependence and altered control within the Chesapeake Bay ecosystem. *Estuaries and Coasts*, 29:776-784. October, 2006.



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What's Next

The SERC Marine Ecology Lab has received an additional two years of funding from Maryland Sea Grant to continue research on the changing abundances and importance of gelatinous zooplankton in Chesapeake Bay. The Smithsonian scientists will work with researchers involved in studies during the 1960s and 1970s to convert qualitative observations into quantitative estimates of abundance, and will continue collaborations with former SERC postdoctoral fellow, Richard Fulford (now an Assistant Professor at University of Southern Mississippi) on food web models to understand how changing abundances of gelatinous zooplankton may affect fish and fisheries in Chesapeake Bay.

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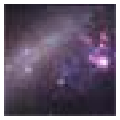

Branches of a fossil conifer from Lower Permian strata in north central Texas. Rise in atmospheric carbon dioxide led to drastic environmental changes during this time interval.

Ancient Global Warming Led to Ecologic Instability

Smithsonian Researcher

William A. DiMichele (National Museum of Natural History)

Findings

Melting of polar ice at the end of a global ice age 300 million years ago was driven by a rise in atmospheric carbon dioxide similar to that occurring today. The changes resulted in severe climatic fluctuations and triggered marked changes in tropical plant communities.

Why It Matters

Carbon dioxide levels in the atmosphere are today higher than at any time in the past 650,000 years and will continue to rise this century. To understand the climatic and ecological consequences of this we must look to the geologic past. The Late Paleozoic Ice Age was the longest period of glaciation in the last half billion years of earth history. It waned over a time span of 40 million years between 305 to 265 million years ago, during the late Carboniferous and Permian periods of geologic time. Estimated carbon dioxide in the atmosphere went from levels approximately the same as today (280 parts per million) to as high as 3,500 parts per million. The increase was not a smooth rise, but a series of peaks and valleys, which matched fluctuations in inferred temperatures. With each fluctuation the fossil plant communities also changed: ferns and other plants adapted to the ever-moist conditions typical of coal swamps were abruptly replaced by conifers and other plants typical of seasonal and semi-arid climates. What is especially significant is that, unlike the earlier rhythmic climatic fluctuations seen during the ice age itself, the fluctuations during deglaciation appear to have produced highly variable conditions and vegetation types. The implied climatic and ecologic instability suggests that the consequences of rising carbon dioxide may not only be severe, but also extremely difficult to predict.

Methods

The research team, led by Isabel Montañez of the University of California, Davis, used a procedure called stable isotope analysis to estimate atmospheric carbon dioxide and surface temperatures during the Carboniferous and Permian time periods. Earlier work has shown that the ratio of carbon isotopes in soil minerals and buried organic matter is linked to the concentration of carbon dioxide in the atmosphere. The researchers collected closely-spaced samples of mineral nodules and plant fossils from Carboniferous and Permian strata in the southwest United States where these layers are exposed. To estimate global temperatures, they analyzed the oxygen isotopes in fossil calcite shells in nearby shallow marine

Reference

Isabel P. Montañez, Neil J. Tabor, Deb Niemeier, William A. DiMichele, Tracy D. Frank, Christopher R Fielding, John L. Isbell, Lauren P. Birgenheier, and Michael C. Rygel. CO2-Forced Climate and Vegetation Instability During Late Paleozoic Deglaciation. *Science* 314: 87-91. January 5, 2007

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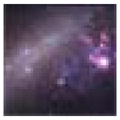

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sedimentary deposits. The ratio of oxygen isotopes in marine shells is a well-established method of estimating paleotemperatures. The biological process of shell secretion is sensitive to temperature and shells formed under different climates have different isotopic ratios.

What's Next

The study's "deep time" perspective gives a broad view of the large scale changes at the end of the Late Paleozoic Ice Age. In further work the team will attempt to refine the details of environmental change on scales closer to a human time frame and collaborate with scientists developing climate change models for this time period.

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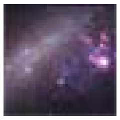

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