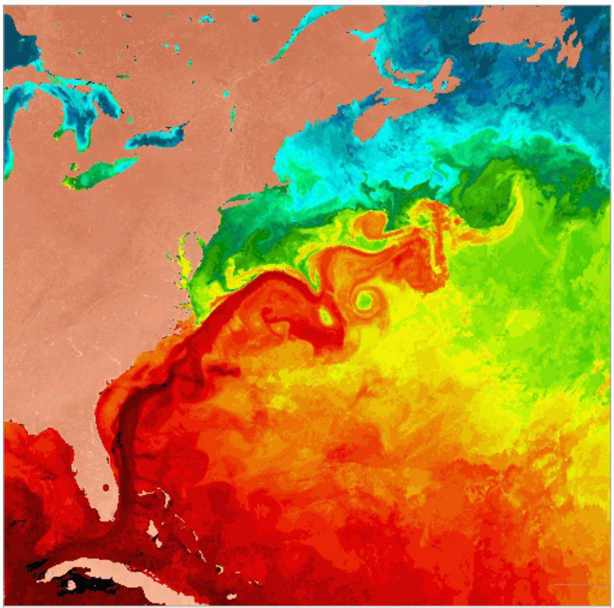


Eddies bud off large ocean currents, like the Gulf Stream, bringing packages of cold water into warmer regions and pockets of warmer water into colder regions. These 10–100 km across masses of water have a big impact on local wind and rainfall patterns. The colour is indicative of relative water temperature. (Credit: National Science Foundation/NOAA)

An eddy can be a package of warm water in an otherwise cold ocean, or a pocket of cold in the warm, and they affect the atmosphere differently, depending on their temperature.

The effect of an eddy on atmospheric circulation has, until now, been rather overlooked, as they were initially thought to be too small to have a significant impact. A group of Swiss scientists set out to solve the mystery of how eddies effect the atmosphere by looking at some 600,000 eddies in the Southern Ocean. Using satellite data, they tracked both eddies and the properties of the surrounding atmosphere, taking into account temperature, cloud cover, wind and rainfall. They found the warmer eddies in the Southern Ocean were typically 0.5°C warmer than their surroundings and the cold ones were 0.5°C colder than the water beyond. Throughout the Southern Ocean, these temperature anomalies correspond to changes in cloud cover and water content, as well as the frequency and probability of rainfall. The reason? They alter the flux of heat between the ocean and the atmosphere.

In the atmosphere, low pressure systems are the ones that generate rainfall. As these systems pass cold-core eddies, which have less heat to release, the cloud cover drops, moisture declines and rainfall reduces by 2-6%. The converse is true for warm-core eddies, which stimulate rainfall in their local vicinity.

As well as providing the fuel for rain-filled clouds, the oceans shape where rain forms and falls around the planet. The heat energy heist undertaken by the Northern Hemisphere as it harvests energy from the south drives the differences in rainfall either side of the equator. And an eddy in the ocean is all that's needed to create a small, but significant, change in the amount of rainfall close to the water mass. Combined, these studies highlight just how wonderfully connected the waters of the Earth are.

Sara Mynott
EGU Communications Officer

References

Fasullo, J.: Rainfall's oceanic underpinnings, Nature Geosci., 6, 901–902, 2013

Frenger, I. et al.: Imprint of Southern Ocean eddies on winds, clouds and rainfall, Nature Geosci., 6, 608–612, 2013

Frierson, D. M. et al.: Contribution of ocean overturning circulation to tropical rainfall peak in the Northern Hemisphere, Nature Geosci., 6, 940–944, 2013

Evolution, extinction and the fossil record

Life of the Earth

Recent research suggests that the Earth is entering a biodiversity crisis and we may be on the brink of our planet's sixth mass extinction. Under these circumstances, an understanding of macroevolutionary patterns in diversification and extinction will be vital to guide conservation strategies. In a recent analysis, Barnosky and colleagues from the University of California showed current extinction rates are highly elevated when compared to background rates in the geological past. If extinctions continue at this pace, we could be seeing an event that qualifies as the Earth's sixth mass extinction (defined by a loss of at least 75% of species) in as little as 300 years from now. Fortunately, the team also discovered that it may not be too late to slow down extinction rates and avoid a catastrophic event. So far we have only lost a few percent of species, and we may be able to reduce extinction rates by targeting conservation where it is most needed, or will be most effective.

Uncertainty remains in these estimates, though. To get a clear picture of which conservation approaches could avoid a mass extinction, it is important to address this uncertainty. A huge amount of information is available on present day extinction patterns and risk factors, but this is only a snapshot of the 3.5 billion years that life has existed on Earth. To map out and truly understand macroevolutionary processes that could help us today, we have to use data from fossils, and the researchers emphasise that integration of palaeontological and present day data will be crucial. Previously, the differences between these types of data have often made it difficult

BACK TO CONTENTS

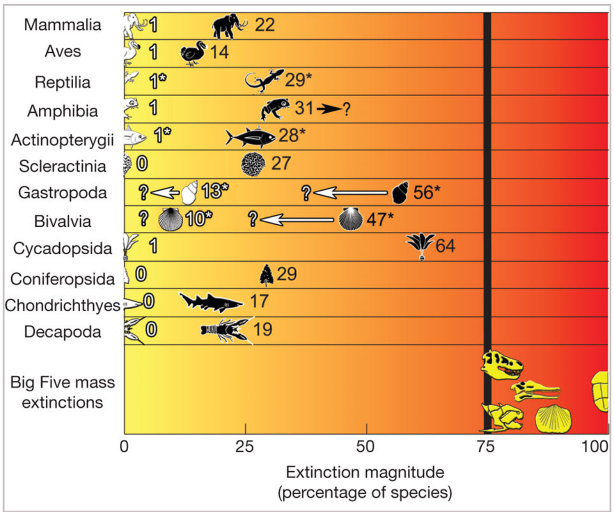
to use both of them in combination. However, advances in methods used to analyse the fossil record, and an increase in data available from ongoing collection efforts, have led to interesting insights into the interrelated factors that have shaped the diversity of life on Earth as we see it today.

In their paper, Barnosky's team outline the key complications in merging fossil and recent data, the most apparent of which is timescale. Modern data goes back a few hundred years at the most, whereas fossil data are recorded on geological timescales, and the majority of past mass extinction events are estimated to have occurred over millions of years. The apparent rate of extinction varies with the time period over which it is measured, so this is a particularly important problem to solve.

Other difficulties include the sparsity of fossil data: estimated sampling rates are around 70% for the very best preserved fossil groups, but are generally more like 10% at the most. Out of the species that we have discovered, many are in fact only known from a single specimen (and sometimes a single tooth!). Some ancient groups had high preservation potential – such as marine gastropods and bivalves – but, unfortunately, these groups have received far less research attention in the present day than larger and more easily accessible groups like birds and mammals.

Fortunately there is some hope for improving the basis for comparison, in the form of phylogenies. A phylogeny is a hypothesis of the evolutionary relationships between species, represented as an evolutionary 'tree' with branches scaled either to the time the species lived for, or the amount of evolutionary change along a branch. In a 2008 review focussing on understanding patterns in extinction, Andy Purvis summarised the progress that has been made in uncovering rates of speciation and extinction using phylogeny as a framework. He also showed how extinction patterns relate to phylogenetic relationships between species (i.e. do close relatives go extinct at the same time?), in different scenarios. Phylogeny can be used to test whether factors like the geographic range of a species or a particular physical trait correlate with extinction proneness. This is often done in present day analyses, but less so for the geological past. He finished by calling for more work in improving methods to model combined data sets in a phylogenetic framework.

In a review published last year, Graham Slater and Luke Harmon summarise innovative new methods based upon phylogeny that are being employed to help tackle some of these data comparison and modelling problems. One such method can be used to stochastically scale evolutionary trees of fossil taxa to time, and will allow palaeobiologists to more accurately estimate the timescales of evolutionary change and extinction in the fossil record. This, in turn, will enable them to make valid comparisons with the rate of events in the present day. In addition, Slater and Harmon point to several new methods that will allow researchers to develop and analyse phylogenies that include similar numbers of extinct and living species, and to more accurately model phenotypic change using fossil and living data in tandem. Further data collection by conservation biologists on the modern day groups that have the most well researched fossil records will also improve results.



Extinction magnitudes in the geological past and the present day. Numbers next to each icon indicate the percentage of species extinct. White icons indicate species 'extinct' and 'extinct in the wild' over the past 500 years. Black icons add currently 'threatened' species to those already 'extinct' or 'extinct in the wild'. Yellow icons indicate the big five mass extinctions, with a black line at the 75% benchmark for comparison. (Reprinted by permission from Macmillan Publishers Ltd: Nature, Barnosky et al., 2011)

These new methods can be used to untangle the relative importance of factors such as body size, population size and ecological specialism, so that we can begin to identify the species most at risk of extinction, and those whose survival will be most effective for maintaining biodiversity. To move forward from these advances we must incorporate them into the effort to standardise different types of data, and into developing predictive models of how different risk factors interact.

A final and particularly interesting idea to come out of Barnosky's research is that of the 'perfect storm'. Past mass extinctions often seem to have occurred during synergies of unusual events. The Earth's current changing climate dynamics, in combination with new ecological stressors like habitat fragmentation, pollution, overfishing and invasive species, may represent such a synergy. The fossil record could act as an ideal natural laboratory to formulate, model and test this hypothesis. Although the Earth has recovered from catastrophic extinction events in the past, it has never before supported 7 billion humans, and modelling macroevolutionary patterns in order to help mitigate against escalating extinction threats may be key in determining our own future as a species.

Laura Soul
Postgraduate Student at the Department of Earth Sciences, University of Oxford

References

Barnosky, A. D. et al.: Has the Earth's sixth mass extinction already arrived?, Nature, 471, 51–57, 2011

Purvis, A.: Phylogenetic approaches to the study of extinction, Annu. Rev. Ecol. Evol. Syst., 39, 301–319, 2008

Slater, G. J. and Harmon, L. J.: Unifying fossils and phylogenies for comparative analyses of diversification and trait evolution, Method. Ecol. Evol., 4, 699–702, 2013