ing the starting polarization. NMR resonant energies are proportional to the strength of the magnetic field. Therefore, stronger magnetic fields improve the initial polarization and lead to more signal. But generating strong, uniform magnetic fields throughout a sample is expensive and requires considerable infrastructure, posing serious practical limitations. Dynamic nuclear polarization[2,3], in which the relatively large polarization of electrons compared with nuclei is transferred to nuclei, is rapidly gaining popularity and applicability, but requires specialized equipment and substantial manipulation of the sample. Furthermore, it might not work for all samples and experiments.

The second general route to more-sensitive NMR is to design detection schemes that make better use of the polarization signal. Several research groups are developing procedures that rely on mechanical coupling of the polarization to very sensitive cantilevers[4], or optical rotation of a probe beam running through the sample[5], to improve sensitivity. But these technologies, too, have limited practical application.

Sakellariou and colleagues[1] build on what has proved to be one of the most general and cost-effective ways to improve the sensitivity of solution NMR: detecting the voltages induced in a coil that is optimized for and is closer to the sample. Such a coil is by its nature more efficient, because the signal-to-noise per unit mass of sample scales inversely with the diameter of the coil[6]. Furthermore, the 'filling factor' — the volume within the coil that is taken up by the sample — is an important variable. In solution NMR, solenoidal microcoils have been used to analyse liquid sample volumes of a few nanolitres[7] and to perform magnetic resonance microscopy of individual neurons[8]. Systems for analysing volumes of 1–10 microlitres are available commercially, and the ability to reduce the sample size has also allowed for the collection of many NMR spectra simultaneously[9]. As well as being highly sensitive, solenoidal coils are quite easy to construct on a very small scale.

Until now, however, solid-state NMR had not enjoyed as much benefit from microcoils as had solution NMR. Unlike molecules in solutions, those in solid samples do not tumble rapidly or isotropically on the NMR timescale. The resulting anisotropic interactions provide important structural information, but they also lead to broad, nondescript NMR spectra that are intractable to analysis. This problem can be countered, and solid-state spectra can achieve a resolution similar to that of their solution NMR counterparts[10] by a trick known as magic-angle spinning (MAS), in which the sample is rotated at high speed at an angle of about 54.7° relative to the magnetic field. In traditional MAS NMR, the sample is spun in a rotor within a static assembly containing a fixed coil that is some distance from the sample and therefore has a poor filling factor.

Sakellariou and colleagues' simple advance[1] is to wind a solenoid microcoil directly around the sample — greatly improving the filling factor — and to spin the sample and coil together (Fig. 1). The spinning microcoil couples inductively to a coil that, just as in the conventional approach, remains static in the surrounding assembly. This 'magic-angle coil spinning' (MACS) technique uses existing commercial MAS solid-state NMR probe technology, while providing the advantages of small coil size and excellent filling factor that have been the province of solution NMR for over a decade[7].

The authors' set-up can improve the signal-to-noise ratio by about an order of magnitude, and so allows smaller samples to be studied. The microcoil can also significantly increase the radio-frequency fields for a given current within the static coil, allowing more efficient manipulation of the spin polarization with radio-frequency pulses. The MACS technique has many conceivable applications, including structural measurements of very small protein samples, 'metabolomics' studies of the biochemistry of microscopic tissue extracts, and NMR measurements of radioactive materials that must be contained within specialized barriers[1].

As with any technology, not all samples will be ideal candidates for the approach. This is especially true of samples in which the signal of interest is present in limited concentrations, such as those for trace amounts of metabolites in tissue, or membrane proteins that aggregate at higher concentrations. At low concentrations, the amount of material will still need to be increased. But for many applications in chemistry, biology and materials science, Sakellariou and colleagues' advance opens up new opportunities simply by reducing the amount of material required for solid-state NMR studies, without needing to invest substantially in new technologies. ■

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CLIMATOLOGY

Tempests in time

James B. Elsner

The frequency of severe hurricanes in the North Atlantic has increased during the past decade. Scrutiny of the prehistoric record left by such storms helps in assessing the influences on hurricane activity.

A hurricane is a product of its environment: a warm ocean provides sustenance; calm atmospheric conditions nurture an infant storm; and a high-pressure cell in the subtropical atmosphere drives it in a given direction. Increases in oceanic heat from global warming will raise a hurricane's potential intensity, all else being equal. Yet increases in wind shear — in which winds at different altitudes blowing in different directions may tear apart the developing storm — could counter this tendency by dispersing the storm's heat.

In the long run, which effect will win out? Limited instrumental records of hurricanes and climate change make it difficult to answer this question. So researchers have turned to prehistoric 'proxy' data to uncover clues about what to expect in a warmer world. Two new papers, one published on 24 May[1] and one on page 698 of this issue[2], illustrate how the approach has been applied to hurricanes in the North Atlantic.

Palaeotempestology is the study of prehistoric storms from geological and biological evidence. Coastal wetlands and lakes are subject to 'overwash' during hurricanes, when barrier sand dunes are surmounted by storm surge. The assumption is that the waves and wind-driven storm surge reach high enough over the barrier to deposit a fan of sand in the lake[3]. A sediment core from the bottom of the lake shows that fan as a sand layer distinct from the fine organic mud that accumulates slowly under normal conditions.

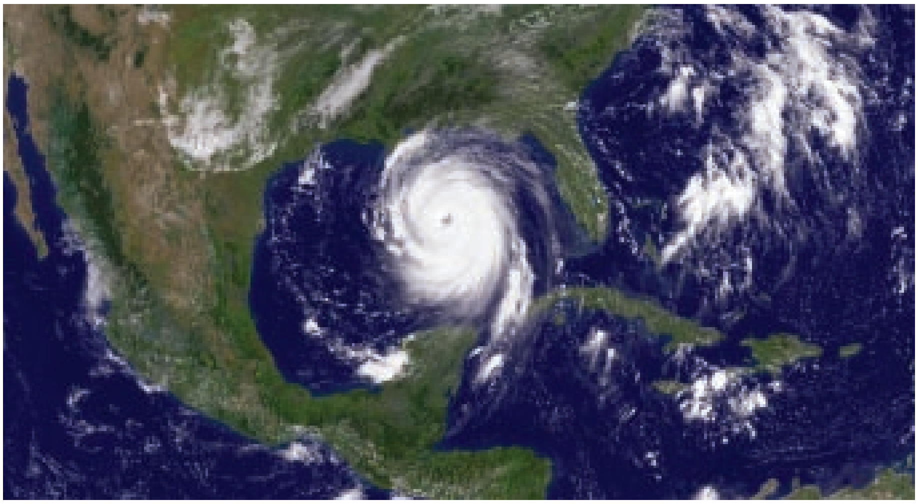
Donnelly and Woodruff[1] analysed sediment cores they extracted from a lagoon on the Puerto Rican island of Vieques. The lagoon is separated from the ocean by a stable barrier of sand. In the core, they found coarse-grained sand layers embedded in several metres of organic-rich silt. The layers are clearly the result of barrier and nearshore sediments that have been washed into the lagoon by strong hurricanes, the recent layers being correlated in time with known hurricane strikes. The authors calibrated the sensitivity of the site to storm surge by noting the intensity of known strikes that did not leave sand in the core.

Donnelly and Woodruff find more sand layers during the latter half of the Little Ice Age. This occurred between 300 and 150 years ago, and towards the end of this interval sea temperatures near Puerto Rico were 2 °C cooler than they are now. The authors say this is evidence that today's warmth is not needed for increased storminess. Not surprisingly, they find that intervals in which more hurricanes occurred correspond with periods of fewer El Niño events. El Niño events suppress hurricane activity in the North Atlantic by increasing the amount of wind shear and sinking air.

In their paper, Nyberg *et al.*[2] describe a different approach that has led them to the same conclusion — that, in the long run, shear is more important than ocean temperature in modulating hurricane activity. They use proxy records of shearing winds and ocean temperature to reconstruct a two-and-a-half century record of major hurricanes and wind shear. The proxies are based on luminescence banding in coral cores retrieved from sites in the northeastern Caribbean, and on a marine sediment core from further south.

However, studies relying on a spatially limited set of coring and proxy locations are not able to resolve changes in hurricane tracks. The northeastern Caribbean is in the direct path of hurricanes today, but has it always been? More hurricanes occurring locally could mean a shift in their direction rather than their abundance. Donnelly and Woodruff[1] find that changes in hurricane frequency over the northeastern Caribbean seem to mirror the changes in frequency inferred from cores collected in New York, but the degree of correlation is not quantified. Proxy data from the Gulf coast show a pattern of frequent hurricanes between 3,800 and 1,000 years ago, followed by relatively few hurricanes during the most recent millennium, which has been explained in terms of the shifting position of the subtropical high-pressure zone[4]. Unravelling the causes of changes in local hurricane activity requires an understanding of the factors that influence what track they will take[5]. So further work is needed.

In addition, the assumption that hurricanes are simply passive responders to climate change should be challenged. Hurricane activity influences the observations and proxies used to compute mean quantities such as wind-shear and precipitation conditions, so the arguments can easily become circular. Reduced rainfall and greater mean shear are possible consequences of fewer hurricanes, not necessarily the causes. More importantly, a hurricane removes heat and water from the ocean and transports them upward and poleward, thereby modifying the environment that supports it. A strong hurricane cools the ocean surface beneath it as a result of evaporation and mixing of water layers. This makes the area less favourable for the next storm, but at depth adds heat to the ocean that can, in the long run, influence the climate system[6].



GOES 12 SATELLITE/NASA/NOAA

Figure 1 | One for the modern record. Hurricane Katrina made its infamous assaults on the Bahamas, Cuba, south Florida and the Gulf coast in late August 2005.

Palaeotempestology is a valuable tool for answering questions on hurricane climatology. But more records are needed before localized prehistoric activity can be used to make sense of large-scale patterns of storminess. As Liu[3] has pointed out, each record serves as a 'palaeoweather station', sensitive only to nearby hurricanes. At present, fewer than a dozen sequences that have been dated and validated are available in hurricane-prone regions of the United States and Caribbean. However, the new analyses[1] and those of others[4,7] are a start.

When more palaeoweather stations have been established, a network can be constructed with links connecting sites that share similar periods of storminess. That network can then be compared to a network of storminess from modern records (Fig. 1) to better understand the evolving mechanisms responsible for changing hurricane risk. ■

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STEM CELLS

Recycling the abnormal

Alan Colman and Justine Burley

Using human eggs in the quest to make donor-specific embryonic stem cells is controversial. A method developed in mice, if applicable to humans, could eliminate the need to obtain eggs for this purpose.

On page 679 of this issue, Egli *et al.*[1] describe a promising method for generating embryonic stem cell (ESC) lineages using the technique of somatic-cell nuclear transfer (SCNT). Conventional SCNT involves replacement of the nuclear genetic material of an unfertilized egg (oocyte), with that of a somatic (non-germ) cell. After 'fertilization', which is induced by chemical or electrical triggers, the embryo undergoes several rounds of cell division and, after implantation into a foster mother, may develop to term. So far, this technique has been used successfully to clone 12 species. It also has been used in mice to generate ESCs from a 3.5-day old mouse embryo — a blastocyst[2].

Since Dolly the Sheep was cloned by SCNT more than ten years ago[3] it has been hoped that this technique would serve to create patient-matched ESCs for therapy, and human-disease-specific ESC lines for use in basic research and drug development. However, in contrast to SCNT in mice, the use of this technique in humans has been thwarted by technical difficulties, as well as logistical and ethical concerns about obtaining oocytes. Now, Egli and colleagues[1] describe a different approach to produce donor/disease-specific ESC lines, which may well revolutionize the field of human stem-cell research, and removes one of the main ethical objections to it. The crux of