caspase-11 promotes non-canonical secretion is obscured by the cell death it causes — because cell death itself releases proteins non-specifically. Notably, activation of caspase-1 or caspase-11 led to cellular release of another inflammatory mediator, HMGB1, and neutralization of HMGB1 has protective effects against lipopolysaccharides *in vivo*[9]. In addition, another caspase, caspase-7, has a role in lipopolysaccharide-induced toxicity[8]. How caspase-11, but not caspase-1, fits into this scheme is not clear.

Finally, it seems remarkable that, despite having had access to the full genomic sequence of the 129 mouse strain for several years, researchers are only now realizing that the gene encoding caspase-11 is dysfunctional in this strain. Even a recent analysis[10] of the 129 strain — and of the C57BL/6 strain, which is also commonly used in laboratories — did not detect the caspase-11 mutation Kayagaki *et al.* describe (a five-nucleotide deletion), despite finding 24 deletions in genes that are expressed in the 129 strain, including several with immune functions. A general analysis that captures this particular mutation[2] may well reveal others. What else have we been missing? ■

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CLIMATE CHANGE

Man-made cyclones

A recent surge in the intensity of tropical cyclones in the Arabian Sea has brought unprecedented damage and loss of life. Anthropogenic air pollution might be increasing the destructiveness of these storms. SEE LETTER P.94

RYAN L. SRIVER

A tropical cyclone is a rare occurrence. It requires a delicate combination of environmental conditions, including a particular amount of heat in the upper ocean, a certain distribution of moisture in the atmosphere, and a distinct structure of horizontal atmospheric winds. Although ocean temperatures in the Arabian Sea are warm enough for tropical cyclone development during much of the year, the region is relatively inactive, with only two or three events occurring annually. However, the occasional strong cyclone can wreak havoc in the region. In 1998, a major cyclone resulted in more than 1,100 deaths in western India, and Cyclone Gonu in 2007 caused more than US$4 billion in collective damage to Oman, the United Arab Emirates and Iran[1] (Fig. 1). The frequency of intense cyclones such as these has risen in recent years, and there is evidence that the observed increase is the result of a general shift towards conditions more favourable for intense tropical cyclones[2]. On page 94 of this issue, Evan and colleagues[3] offer insight into this situation by examining the role of regional air pollution in creating these cyclone-friendly conditions.

It has long been known that the presence of strong vertical wind shear is a major factor in limiting tropical cyclone activity over the Arabian Sea[4]. Vertical wind shear is a measure of the difference in speed between the horizontal winds measured near the sea surface and those high up in the atmosphere, in the outflow regions of a developing storm. Environments with strong shear will stretch a tropical cyclone by pushing the top of the storm away from the bottom. This shearing effect can tear a developing system apart or prevent an already-formed cyclone from intensifying.

AFP/GETTY

Figure 1 | Aftermath of Cyclone Gonu. Evan and colleagues[3] find that anthropogenic air pollution and global warming might be responsible for increasing the destructiveness of intense tropical cyclones such as Gonu, which occurred in the Arabian Sea in 2007 and devastated countries such as Iran (shown).

Typical shear conditions over the Arabian Sea are large enough that cyclones rarely develop into major events. This is especially true during boreal summer monsoon months, when warm surface waters extend into the North Indian Ocean. During these months, even with the warm surface temperatures, the monsoon's atmospheric circulation produces strong environmental shear that can suppress cyclone formation completely. However, an upswing in intense pre-monsoon tropical cyclones during the past 15 years is raising serious concerns that environmental change may be responsible for increasing cyclone activity, as opposed to these being a string of anomalous events. The observed increase may be part of a broad-scale shift in the regional climate, which could be directly attributable to anthropogenic emissions.

Over much of south Asia, anthropogenic air pollution has led to the formation of thick layers of haze known as atmospheric brown clouds[5]. The main sources of the pollution are fossil-fuel consumption and biomass burning, which deposit black carbon in the atmosphere, with serious negative consequences for human health[6]. This pollution produces brownish clouds of aerosol particles that can be several kilometres thick. The hazy conditions spread out over the Arabian Sea, blocking some of the Sun's energy and preventing it from reaching the sea surface, and thus causing cooling in the upper ocean.

Evan *et al.*[3] propose that these brown clouds have an interesting effect on tropical cyclone environments. They argue that, by inhibiting the amount of incoming solar energy at the sea surface, brown clouds can effectively reduce the warmest Arabian Sea temperatures relative to the equatorial Indian Ocean. This smaller sea surface temperature difference between north and south could, in turn, reduce vertical wind shear during tropical cyclone seasons. Under this brown-cloud scenario, tropical cyclones would intensify into much more powerful systems than would be possible in an environment without pollution (and with stronger shear).

Using observational evidence from the past 30 years, Evan and colleagues show that there is an observable increase in the average Arabian cyclone intensity between the periods 1979–96 and 1997–2010, which coincides with a reduction in vertical wind-shear conditions occurring within the storms. The authors attribute these changes to the presence of atmospheric brown clouds, supporting this hypothesis with accompanying climate-model simulations. Their findings point to a causal link between increasing air pollution over south Asia and more frequent intense tropical cyclone events, suggesting that human activity may play a direct part in modulating cyclone activity over the Arabian Sea.

The authors' results[3] shed much-needed light on the relatively unexplored topic of Arabian Sea cyclones and climate. They imply that fascinating connections exist between tropical cyclone activity, air pollution in south Asia and global warming that have strong social and economic implications. Although intriguing, interpretation of these results must be treated with caution. For instance, the authors' analysis focuses on about 20 cyclones during the past 30 years, corresponding to events occurring before the annual onset of the monsoon. Out of these 20 events, the 5 most powerful storms occurred between 1998 and 2010, and it is this small fraction that determines the positive shift in cyclone intensity during the past 15 years. This is a very small number of events to use as a basis for estimating climate trends. Given the small sample size and handful of anomalous intense storms, it is difficult to disentangle meaningful climate signals from random variability of the sample.

Evan *et al.* hypothesize that the reduced shear observed in and around recent intense cyclones is indicative of a broader-scale negative trend. This proposal generally agrees with their model simulations and observational analysis. However, it is at odds with other recent work[1], which finds no discernible trend in Arabian Sea vertical shear within cyclone-development regions during the past 60 years. Perhaps surprisingly, most of the intense recent storms occurred during years exhibiting seasonal shear conditions that were either near or above the 60-year average.

Furthermore, if environmental shear over the Arabian Sea is decreasing, then should there not also be a change in the number of storms affecting this region? The potential for storm formation is quantifiable, because it depends primarily on the large-scale environmental factors previously discussed. Trends in this 'genesis potential'[7] have been increasing in the Arabian Sea since 1980, but the average potential during the past 30 years is substantially lower than that during the previous 30-year period[1]. In other words, environmental conditions from 1950 to 1980, prior to the onset of major air pollution, were potentially more favourable for cyclone formation than the period from 1980 to 2010 (although the reliability of the early portion of the record may be limited by data quality). This suggests that changes in natural environmental factors could influence the variability of tropical cyclone activity in the Arabian Sea beyond what the authors attribute to anthropogenic brown clouds. Further work is clearly needed to understand the roles of natural climate variability and human-induced effects in the context of evolving data quality.

Limitations aside, Evan and colleagues' provocative findings[3] raise fresh concerns about the potential hazards of anthropogenic aerosol pollution. If we continue on the path of unmitigated carbon emissions and brown clouds, then time will ultimately reveal whether the authors' results are robust. Nevertheless, the fact that these findings suggest the damaging effects of brown clouds extend beyond known health impacts[6] perhaps provides more urgency for instituting a sound strategy to minimize potential negative consequences. ■

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PALAEONTOLOGY

Fresh light on southern early mammals

Little is known about mammalian evolution in South America during the age of the dinosaurs. The discovery of 100-million-year-old skulls confirms that mammalian faunas were endemic in southern continents at this time. SEE LETTER P.98

CHRISTIAN DE MUIZON

Mammalian remains from the age of the dinosaurs — the Mesozoic era, from 250 million years (Myr) to 65 Myr ago — are rare. Ten times fewer mammalian genera have been identified from the Mesozoic than from the age of mammals that followed it (the Cenozoic era, from roughly 65.5 Myr ago to the present), even though the Cenozoic has lasted less than half the time. Furthermore, Mesozoic mammals are most often known from isolated teeth or partial jaws; complete skulls and/or skeletons are exceptional. Our knowledge of the first two-thirds of mammalian evolution, which extends from the first record of a mammal about 220 Myr ago to the end of the Cretaceous period 65.5 Myr ago, is therefore terribly incomplete.

Considering the poverty of the fossil record, any discovery of a reasonably well-preserved skull of a Mesozoic mammal is a major palaeontological event. This is especially true in South America, where just one Mesozoic mammal is known from well-preserved skulls and skeletons, and the few other such taxa are represented only by isolated teeth and jaws. On page 98 of this issue, Rougier *et al.*[1] describe the second Mesozoic mammal of South America to be represented by well-preserved skulls and jaws: *Cronopio dentiacutus*, found in Argentinian sedimentary rocks dating from the early Late Cretaceous (about 100 Myr ago), an epoch for which no mammals were previously known on the subcontinent.

Cronopio belongs to the superorder Dryolestoidea, whose members are regarded as close relatives of the modern therians (mammals that include the marsupials and placentals). Dryolestoid remains have been found mainly in the northern continents, but Rougier and colleagues' discovery, taken together with findings of teeth and jaws from 70-Myr-old deposits in Patagonia[2], reveals that an important evolutionary radiation of these mammals (an increase in taxonomic diversity) also occurred in the south during the Cretaceous.

The discovery of *Cronopio* is especially notable because it provides for the first time the whole cranial morphology of a dryolestoid. It also reveals some of the steps in the evolution