as warm to rise and form rain, and we would expect the SST threshold to stay constant or rise more slowly. The authors also show that their results are quantitatively as well as qualitatively consistent with present climate models that predict amplified warming at upper levels. In this way they indirectly constrain the upper-air temperature trend without using the problematic upper-air temperature observations. They provide new and independent confirmation of the models and of our expectations, based on simple theory, for the vertical structure of global warming.

Johnson and Xie also show that the statistical distribution of tropical SST values has not changed shape with warming, but has simply shifted uniformly to higher values. This, as well as the correspondence between mean SST and SST threshold for convection, implies that the fractional area of the tropics in which deep convection occurs does not change much in response to greenhouse gas warming. Interestingly, the SST distribution does not change shape dramatically during El Niño events either[5,9], even though the geographic structure of the SST and precipitation fields do change significantly in such events. Invariance in the total area that supports convection can thus accompany both climate warming and geographical rearrangements of the SST patterns.

From the findings reported by Johnson and Xie[5] we should therefore not conclude that some rainy regions cannot become drier in a future, warmer climate (or vice versa), or that the tropical-cyclone-prone zones cannot shift. But the results suggest that, for climate change that might plausibly occur in the near future, there may be a conservation of total rainy area, such that losses in rain somewhere are compensated by gains elsewhere. If so, the reasons for this are unclear. There could be a fundamental principle of climate dynamics waiting to be uncovered. Alternatively it could just be that neither an El Niño event nor modest global warming is a sufficiently large change to make a dent in the shape of the statistical distribution of SSTs or the fractional area of deep convection. If the latter is the case, a larger rearrangement of tropical climate (such as we are likely to experience, eventually) might lead to more dramatic changes in SSTs and rainfall patterns. ❐

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VOLCANOLOGY

Off-rift complexity

Not many had heard of the Icelandic volcano Eyjafjallajökull before its violent eruption in April 2010. But as European air traffic came to a halt for several days, the volcano's name — unfriendly though it is to non-Icelandic tongues — quickly achieved notoriety.

As with most volcanic eruptions, the explosion in April did not come without warning. Signs of volcanic unrest had accumulated over 18 years, following at least two decades of quiescence. And starting in late March, magma had been flowing from the volcano's flanks. In a grand finale, the summit exploded on 14 April and sent fine-grained tephra to altitudes of up to nine kilometres.

However, Freysteinn Sigmundsson and colleagues report that the summit eruption that caused trouble for so many European travellers was not fed by the same magma source as the earlier effusive flank eruption (*Nature* **468,** 426–430; 2010). Nor did the surface of the volcano, as observed by satellites in the run-up to the explosion, follow the usual pattern of gradual inflation before the eruption, and rapid deflation once the lava started to emerge.


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Instead, the first, effusive eruption in late March was accompanied by very little change in the shape of the surface, suggesting that most of the magma flowed from large depths. There, it had accumulated over the preceding few months as magma filled the base of the volcano in a complicated geometry. The flank eruption ceased on 12 April. But pressure continued to build up at depth and, within two days, seems to have triggered the explosive summit eruption. How exactly the triggering worked is uncertain: geochemical analyses of the lava as well as the patterns of surface deformation point to different sources for the flank and summit eruptions.

Eyjafjallajökull is a moderately active volcano, offset from the rift between the Eurasian and North American plates. As a result, its subsurface structure is relatively cold and storage of magma at shallow depths is limited. This could be the cause of the unusual deformation patterns observed that made it difficult to foresee the explosive eruption.

If so, short-term precursors of eruptions in less-active, off-ridge volcanoes may be hard to pick up more generally, because in those locations the signs of an imminent explosive eruption can be complex and subtle.

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