Pipeline feeds cloudburst

HEAVY RAINFALL IS SOMETIMES THE DISCHARGE OF A MASSIVE RIVER OF WATER VAPOUR THAT FLOWS THROUGH THE SKY, WRITES **S ANANTHANARAYAN**

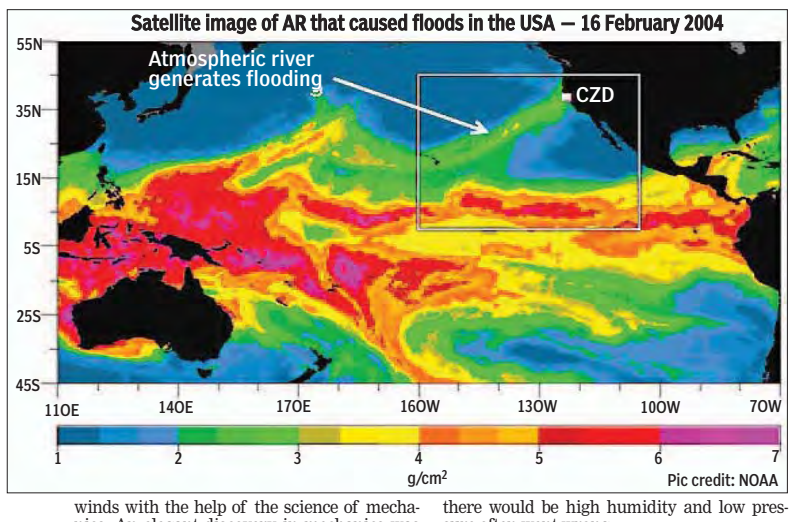
The nature of rainfall has been generally understood as winds picking up water vapour, which they release when they rise and cool, in the face of landmass. This simple picture has been enriched since the use of radar detection of motion and moisture content of air, with the help of the Doppler effect, and also satellite imaging, and these have revealed the structure and unsuspected streams of movement of moisture in the atmosphere.

David A Lavers, Florian Pappenberger and Ervin Zsoter, of the European Centre for Weather Forecasts at Reading, and the School of Geographical Sciences, Bristol, in the UK, report in the journal *Nature Communications* that the new understanding of the character of rainfall could enable early forecast of heavy downpour events.

The early weather studies concentrated on winds with the help of the science of mechanics. An elegant discovery in mechanics was the *Coriolis effect*, which is a force that seems to act on anything that moves within a context that is itself rotating. A simple and classic instance is of the movement of air, or the wind, across the surface of the rotating earth. Air moving towards the equator comes from the direction of the poles. As the movement of the earth, due to rotation, is faster at the equator than when nearer the poles, air approaching the equator finds the ground below rushing away to the east and seems to feel a westward force. And when the air crosses the equator, it moves to places that are moving slower than the equator and the air seems to feel an eastward force.

This understanding helped explain the movement of the monsoons and other wind currents and rainfall was effectively explained and then studied, with the help of data winds or movements of the air.

Arrangements were made to measure wind speeds at a large number of places and at different altitudes, to generate a three-dimensional map of winds. Sharing of data over large areas was used to see where the low and high pressures zones moved and, hence, to predict where there was likely to be rain or fair weather. But the data was invariably sketchy or not exact and, hence, the predictions of where there would be high humidity and low pressure often went wrong.



Atmospheric rivers

Better techniques and modern technology enabled a more detailed study of the atmosphere and it was found that filaments of cool or warm air, with high moisture content, sometimes got generated in the interaction of tropical cyclones and these streams could push aside and penetrate bodies of air and transport moisture over long distances.

Reginald Newell and Jong Zhu of the Massachusetts Institute of Technology, in the later 1990s, proposed the name *atmospheric rivers* for these filaments, as they were narrow, could be massive and often moved hundreds of kilometres. These plumes of moisture, in fact, can be thousands of kilometres long and as narrow as just a few hundreds of kilometres wide. This is a huge cross section, in any case, and transports a great deal of moisture, and the water content in many of them can be larger than the water that flows through the world's largest rivers.


David A Lavers


Florian Pappenberger

These channels of water vapour, or atmospheric rivers, which are now known to criss-cross the skies at all times, have now been seen as an important part of the *global water cycle*. Although they are narrow and extend to cover less than 10 per cent of the earth's circumference, they are responsible for 90 per cent of the movement of water vapour from one hemisphere to another. And as they are at best unstable carriers of such a great mass of water, they are the reason for most of the instances of concentrated and very heavy rainfall and devastating floods at places where they discharge their load. On the other hand, a large number of smaller instances of such channels are also the means for useful rainfall and the source for many of the earth's surface rivers.

Predicting weather

While this phenomenon of vapour transport is expected to become more acute with climate change, the UK team examined how reliable the study of the water transport, over long distances, rather than the local wind data, could be to predict rain and particularly major rainfall events. One hypothesis is that as the water vapour streams arise from much wider spread atmospheric processes, their progress would be less affected by local factors and, hence, more easily estimated. This principle was tested by the UK team by making weather estimates for the British Isles in the winter of 2013-14, when widespread flooding had occurred, and also across Europe, using both the Integrated Water Transport data as well as the conventional methods of drawing conclusions from local rainfall growth data.

The results reported are that using IWT, or atmospheric river concepts, gave rise to an increase of the forecast horizon by a whole three days. A mechanism for the higher predictability of IWT that is suggested is that conventional prediction depends on evidence of the convergence of a vapour-rich mass of air.

This could happen where there is upward movement of a current of air, like on an encounter with a mountain. But in the case of heavy rainfall events, there is often no local wind movement data to help foresee the event. It is the study of the trajectory of atmosheric vapour streams, as indicated by IWT data, that provides more reliable pointers, which are less subject to break-down because of the uncertainty of parameters.

This proposed mechanism is supported by the study of the clear warning that was available, using IWT, as compared to what was used during the flooding events of 2012-14 in Europe. While how and where rainfall will occur is generally a complicated process, prediction from local data is unreliable because local data is highly variable. But IWT data is dependent on factors over a larger scale and shows resilience to local data variation. Data of movement of a vapour stream that could cause heavy rainfall at a place with the necessary topography could hence enable more reliable prediction of drastic rainfall events.

The UK team has demonstrated that this greater reliability of vapour streams as a means to foresee heavy rainfall events permits making weather forecasts much earlier than with forecasts based on local build-up of rainfall conditions. This is an important advantage that is now available with satellite-based data, and all the more because modelling shows that heavy rainfall events would become more severe and frequent with global warming.

While the UK team mentions the benefits to the flood-prone regions in Europe and western North America, atmospheric river study would also help early action in instances like the downpour over Mumbai in 2005 and the flooding at Uttakashi in 2013.

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PRECISION IS THE KEY

TAPAN KUMAR MAITRA EXPLAINS HOW SPLICEOSOMES REMOVE INTRONS FROM PRE-mRNA

To produce a functional molecule of mRNA from a pre-mRNA that contains introns, eukaryotes must somehow remove the introns and splice together the remaining RNA segments (exons). The entire process of removing introns and rejoining the exons is termed *RNA splicing*.

RNA splicing must be very precise because a single nucleotide error would alter the mRNA reading frame and render it useless. Proper splicing can, in fact, be disrupted by simply altering the base sequence of short nucleotide stretches located at either end of an intron, indicating that these sequences determine the exact location of the *5' and 3' splice sites* — that is, the points where the two ends of an intron are cleaved during its removal.

Analysis of the base sequences of hundreds of different introns has revealed that the 5' end of an intron typically starts with the sequence GU and the 3' end terminates with the sequence AG. In addition, a short stretch of bases adjacent to these GU and AG sequences tends to be similar among different introns. The base sequence of the remainder of the intron appears to be largely irrelevant to the splicing process.

Though introns vary from a few dozen to thousands of nucleotides in length, most of the intron can be artificially removed without altering the splicing process. One exception is a special sequence located several dozen nucleotides upstream from the 3' end of the intron and referred to as the *branch-point*. The branch-point plays an important role in the mechanism by which introns are removed.

The process of intron removal is catalySed by an RNA-protein complex called a *spliceosome*, which is assembled from a group of smaller RNA-protein complexes known as *snRNPs* (small nuclear ribonucleoproteins) and additional proteins. Each snRNP (pronounced "snurp") contains one or two small molecules of a special type of RNA called *snRNA* (small nuclear RNA). During RNA splicing, a group of several snRNPs bind sequentially to an intron to form the spliceosome.

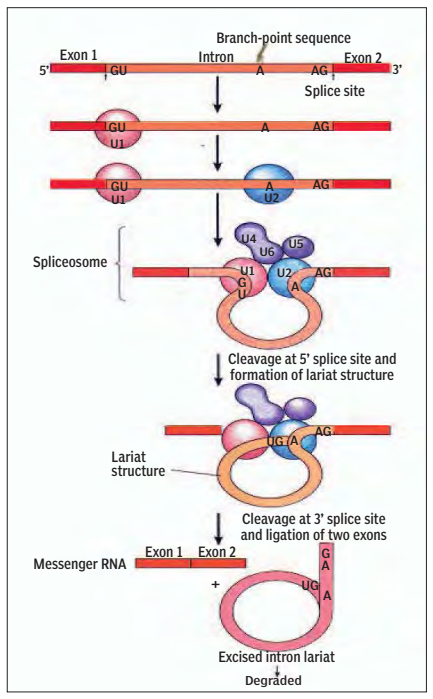
The first step in this process is the binding of a snRNP called *U1*, whose RNA contains a nucleotide sequence that allows it to base-pair with the 5' splice site. A second snRNP, called *U2*, then binds to the branch-point sequence. Finally, another group of snRNPs (*U4/U6* and *U5*) brings the two ends of the intron together to form a mature spliceosome. The completed spliceosome, containing five RNAs and more than 50 proteins, is a massive complex almost as big as a ribosome.

At this stage, the pre-mRNA is cleaved at the 5' splice site and the newly released 5' end of the intron reveals the presence of snRNPs and mature spliceosomes bound to RNA molecules that are still in the process of being synthesised, indicating that intron removal begins before transcription of the pre-mRNA molecule is completed.

Both the primary transcript and the mature mRNA are associated along their lengths with non-snRNP proteins, forming *RNP particles* that look something like DNA nucleosomes. The mRNA remains associated with these proteins until it enters the cytoplasm, where it joins with other proteins and the ribosomal sub-units.

In addition to the main class of introns characterised by GU and AG sequences located at their 5' and 3' boundaries, respectively, a second class of introns containing AU and AC at these two sites has been discovered.

These "AU-AC" introns are often excised by a second type of spliceosome that differs in snRNP composition from the spliceosome illustrated. But in spite of the complexities provided by the existence of multiple types of introns and spliceosomes, a unifying principle has emerged: the snRNA molecules found in spliceosomes appear to be involved in the catalytic mechanism of splicing, as well as in spliceosome assembly and splice-site recognition. The idea of a catalytic role for snRNAs arose from the discovery of self-splicing RNA introns.



Intron removal by spliceosomes. The spliceosome is an RNA-protein complex that splices intron-containing pre-mRNA in the eukaryotic nucleus. The substrate here is a molecule of pre-mRNA with two exons and one intron. In a stepwise fashion, the pre-mRNA assembles with the UI snRNP, U2 snRNP, and U4/U6 and U5 snRNPs (along with some non-snRNP splicing factors), forming a mature spliceosome. The pre-mRNA is then cleaved at the 5' splice site and the newly released 5' end is linked to an adenine (A) nucleotide located at the branch-point sequence, creating a looped lariat structure. Next, the 3' splice site is cleaved and the two ends of the exon are joined together, releasing the intron for subsequent degradation.

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First homes on the moon

THE EUROPEAN SPACE AGENCY MAY HAVE SOLVED THE ISSUE OF GETTING BUILDING MATERIALS TO THE DISTANT ROCK ~ USING WHAT IS ALREADY THERE, SAYS **ADAM WITHNALL**

Humankind has taken one small step closer to colonising the moon after the European Space Agency revealed its latest plans to provide affordable housing — something we can't even manage in most citiea around the world. It's been 45 years since humans first stepped on to the rocky satellite, yet we're still to solve the problem of how to cost-effectively get enough building materials up there to put together permanent — and safe — structures.

Now, thanks to the magic of 3D printing, experts say the first people could be living on the moon in as little as 40 years. The ESA's latest video briefing shows more fleshed-out plans for how robotic 3D printers on wheels would, with a single unit, collect material from the surface of the moon and convert it into a radiation- and meteor-resistant coating for human accommodation.

It has been a while since the ESA set out its idea for transporting self-contained pod-like homes to the distant rock using individual rockets. Multiple pods would eventually link together to form larger "terraces" of structures, each with its own airlock and technical support module.

But the new release shows how "regolith", the dusty material that coats the surface of the moon, could be harnessed to coat the inflatable domes that would otherwise be vulnerable to the harsh off-earth elements.

The research has been carried out by the ESA with the help of architects Foster + Partners, who said that as with all moon colonisation plans, the 3D printing scheme was still on the drawing board.

But Scott Hovland, from the ESA's human spaceflight team, said, "3D printing offers a potential means of facilitating lunar settlement with reduced logistics from earth."

Xavier De Kestelier, from the specialist modelling team at Foster + Partners, said, "As a practice, we are used to designing for extreme climates on earth and exploiting the environmental benefits of using local, sustainable materials. Our lunar habitation follows a similar logic."

THE INDEPENDENT

PLUS POINTS

Ghostly experiment

The hallucination of a ghostly presence is common among people with psychiatric disorders such as schizophrenia and sometimes occurs in healthy people under extreme conditions. To investigate the cause of this "Feeling of Presence", researchers at the École Polytechnique Fédérale de Lausanne in Switzerland and their colleagues observed study participants' reactions to a specially designed robot that mimicked their movements. The findings, reported in *Current Biology* suggest that FoP results from a mismatch between perceptions of the self and of external signals.

As part of the study, the team scanned the brains of 12 patients who had reported FoP and discovered lesions in the frontoparietal cortex, which integrates sensory and motor signals and is involved in self-

awareness. This led to the idea that FoP was prompted by conflict between external and internal inputs. To test this hypothesis, the researchers created a "master-slave" robot to recreate the phenomenon in healthy people.

Blindfolded participants used their index fingers to move a robotic arm in front of them, while a robot behind them made the same movements on their backs. When the movements were simultaneous, people felt as if they were touching their own backs, but delaying the robot's motions by a half-second produced the illusion of another person behind them.

"Our brain possesses several representations of our body in space," study co-author Giulio Rognini said. "Under normal conditions, it is able to assemble a unified self-perception of the self from these representations. But when the system malfunctions because of disease — or, in this case, a robot — this can create a second representation of one's own body, which is no longer perceived as 'me' but as someone else, a 'presence'."

Rognini and his team hope to create a robot that can help schizophrenic patients to differentiate their own actions from those of others.

MOLLY SHARLACH/SCIDEV.NET

'Sad music is good'

It turns out there's a reason why sad people listen to sad music: it makes them feel better. According to a new study, sad songs evoke complex emotional reactions that lead to feelings of relief and fulfillment.

Researchers from the Free University of Berlin surveyed 722 people around the world and found that sad music, more than happy music, "can actually lead to beneficial emotional effects". It

achieves this by providing the listener with four different rewards: imagination, emotion regulation, empathy and "no real-life" implications.

Nostalgia rather than misery is most often triggered by sad music, with the study finding that "memory-related processes are central in music-evoked sadness". In the USA and Europe, listeners reported feelings of nostalgia when listening to sad music whereas in Asia they said they felt at "peace".

The study explained, "The average number of emotions that participants reported to have experienced in response to sad music was above three. This suggests that a multifaceted emotional experience elicited by sad music enhances its aesthetic appeal."

In their conclusion, published in the journal *Plos One,* Stefan Koelsch and Liila Taruffi said, "The fact that people seek and appreciate sadness in music may appear paradoxical, given the strong popular and scientific emphasis on happiness as a source of personal well-being." They also reported that "appreciation of sad music is enhanced when listeners are experiencing emotional distress, as well as among individuals with high empathy and low emotional stability."

ZACHARY DAVIES BOREN/THE INDEPENDENT