is often useful for subtle tasks that people take for granted but conventional computers find hard to perform: understanding language, reading handwritten notes or identifying a category of objects in a messy data set, such as spotting cats in YouTube videos.

Weather, another complex topic, is well suited to analysis by deep-learning approaches. In 2016, researchers reported the first use of a deep-learning system to identify tropical cyclones, atmospheric rivers and weather fronts: loosely defined features whose identification depends on expert judgement[1]. That feat showed that the algorithm could replicate human expertise. Now the team, which is based at Lawrence Berkeley National Laboratory (LBNL) in California, hopes to use similar techniques to study all kinds of extreme events — including ones not yet identified. The researchers' ultimate goal is to better assess and predict how these events are shifting in the face of climate change. "It's not simple," says Prabhat, lead author of the 2016 paper, who directs big-data efforts for the National Energy Research Scientific Computing Center at the LBNL. "But it's not as hard as the commercial applications for deep learning", such as language translation and image identification.

Vipin Kumar, a computer scientist at the University of Minnesota in Minneapolis, has used machine learning to create algorithms for monitoring forest fires and assessing deforestation. When his team tasked a computer with learning to identify air-pressure patterns called teleconnections, such as the El Niño weather pattern, the algorithm found a previously unrecognized example over the Tasman Sea[2].

And Monteleoni has developed machine-learning algorithms to create weighted averages of the roughly 30 climate models used by the Intergovernmental Panel on Climate Change. By learning the models' strengths and weaknesses, such algorithms generate better results than conventional approaches that treat all models equally, Monteleoni says. The climate community is starting to adopt AI algorithms that weight climate models as a way to help improve forecasts.

"Climate is now a data problem."

MACHINE MYSTERIES

Because deep-learning systems develop their own rules, researchers often can't say how or why these algorithms arrive at a given result. That makes some people uneasy about relying on these 'black boxes' to forecast imminent weather emergencies such as floods. "I'm reluctant to use [AI] as an answer machine," says William Drew Collins, a climate modeller at the LBNL. "If I can't explain what the machine is doing, then there's a problem."

Instead, Collins says that AI algorithms are best suited to help test the next generation of climate models. These models aim to incorporate complex climate phenomena such as the fine structures of clouds, atmospheric rivers and ocean eddies. "We need a benchmark of the level of detail that these models should be aiming for," Collins says. "We need a guide star. Machine learning is well suited for that."

Nevertheless, some AI algorithms are proving useful for weather forecasting. In a 2016 test, nine meteorologists from the US National Weather Service chose to use an AI algorithm in about 75% of their forecasts of storm duration when given a choice between AI and conventional methods[3]. The study's lead author, computer scientist Amy McGovern of the University of Oklahoma in Norman, now plans to incorporate an AI algorithm into the weather service's hail forecasts.

Most climatologists are still using conventional methods to analyse their data — but that is changing. "If you go to the major modelling centres and ask them how they work, the answer won't be machine learning," says Collins. "But it will get there." ■

1. Liu, Y. *et al.* Preprint at http://arxiv.org/abs/1605.01156 (2016).
2. Liess, S. *et al. J. Clim.* **27,** 8466–8486 (2014).
3. McGovern, A. *et al. Bull. Am. Meteorol. Soc.* http://dx.doi.org/10.1175/BAMS-D-16-0123.1 (2017).

ASTROPHYSICS

Supernova origins probed

Observations of exploding star cast doubt on astronomy's 'standard candle'.

BY SHANNON HALL

The exploding stars known as type Ia supernovae are so consistently bright that astronomers refer to them as standard candles — trusty beacons that are used to measure vast cosmological distances. But these cosmic mileposts may not be so uniform. A study now finds evidence that the supernovae can arise by two different processes, adding to lingering suspicions that standard candles aren't so standard after all.

The findings, which have been posted on the arXiv preprint server and accepted for publication in *The Astrophysical Journal*, could help astronomers to calibrate measurements of the Universe's expansion (G. Hosseinzadeh *et al.* Preprint at http://arxiv.org/abs/1706.08990; 2017). Tracking type Ia supernovae showed that the Universe is expanding at an ever-increasing rate, and helped to prove the existence of dark energy — advances that secured the 2011 Nobel Prize in Physics.

The fact that scientists don't fully understand these cosmological tools is embarrassing, says the latest study's lead author, Griffin Hosseinzadeh, an astronomer at the University of California, Santa Barbara. "One of the greatest discoveries of the century is based on these things and we don't even know what they are, really."

It's not for lack of trying: astronomers have put forth a range of hypotheses to explain how these stellar explosions arise. Scientists once thought that the supernovae were built uniformly, like fireworks in a cosmic assembly line. That changed in the 1990s, when astronomers noticed that some of the supernovae were dimmer than the others.

Astronomers try to correct for the difference, but the fact that each 'standard candle' looks slightly different from the next has got them concerned. "When you're trying to measure the expansion rate of the Universe to 1%, these subtle differences make you worry that maybe type Ia supernovae are throwing you off," says Peter Garnavich, an astronomer at the University of Notre Dame in Indiana.

BURNING BRIGHT

At least one thing seems clear, astronomers say. They remain convinced that a white dwarf, an Earth-sized remnant of a Sun-like star, plays a central part in the formation of each type Ia supernova. But they're not sure what pushes white dwarves over the edge, because these stars are too stable to explode on their own. That suggests that a companion star — another white dwarf, a star like the Sun or even a giant star — helps to set each supernova in motion.

If this companion star is large, the idea goes, then the white dwarf would siphon material from it. Eventually, the white dwarf would accumulate so much extra mass that the pressure would ignite a runaway thermonuclear explosion. But if the companion star is small — perhaps a second white dwarf — the two celestial bodies would spiral towards each other and merge together before exploding.

Researchers have been searching for evidence of these processes by hunting for newly formed supernovae. That's because a supernova created in the first scenario would leave evidence behind: material travelling out from the stellar explosion would light up as it hit the still-intact companion star. But a supernova formed by the merger of a white dwarf and a small companion would obliterate all traces of the stars involved in its birth.

Astronomers had seen evidence for only the second scenario — until now. Griffin and his team's paper is the first to report a supernova formed by a white dwarf leaching material from a massive companion star. The results add weight to the idea that type Ia supernovae can form through two different stellar assembly lines.

ON THE HUNT

The first hint of the discovery came on 10 March, when a supernova appeared on the outskirts of the spiral galaxy NGC 5643, 16.9 million parsecs (55 million light years) from Earth. David Sand, an astronomer at the University of Arizona in Tucson and a co-author of the study, found it as he pored over data from the DLT40 supernova search, which scans roughly 500 galaxies every night.

Sand quickly took another image to verify that what he had seen was a stellar explosion, not an unknown asteroid. Within a few minutes, he knew it was time to alert the Las Cumbres Observatory — a network of 18 telescopes around the world that allows astronomers to monitor objects continuously as they move across the sky.

Hosseinzadeh, Sand and their colleagues observed the supernova every 5 hours for roughly 6 days and then once a night for another 40 days — allowing them to map its changing luminosity. During this period, they saw a temporary jump in brightness caused by material ejected from the supernova striking the companion star.

"This is the best evidence yet for a shock due to a companion star in a normal type Ia supernova," Garnavich says.

But the discovery is just the start of the process to unravel the mystery behind these not-so-standard candles. To better pin down their measurements of the cosmos, astronomers will keep searching for more of these dim young supernovae.

"It's like having a tool that you know how to use, but you don't know how it works," Hosseinzadeh says. "Understanding the physics of the tool that you're using seems better than just using it blindly." ■

THEO ALLOFS/GETTY

Field sites in the Simpson Desert are part of Australia's Long Term Ecological Research Network.

ECOLOGY

Research cuts rile Australian ecologists

Move could hamper efforts to predict ecosystem changes.

BY NICKY PHILLIPS

Every year since 1990, ecologist Glenda Wardle of the University of Sydney has ventured to the same expanse of desert in central Australia to take stock of its flora and fauna. But this year could be the last time she collects data there. The consortium that operates her research area and 11 other long-term sites will stop funding this network by the end of the year because of budget cuts and shifting priorities, say its leaders.

Without the support, which totalled nearly Aus\$1 million (US\$800,000) for 2016–17 and covers a large portion of the sites' operating costs, half will probably close, says network science director David Lindenmayer, an ecologist at the Australian National University in Canberra. This would break data sets that scientists have collected over decades, he says.

"It's a foolish decision given the environmental effects that are occurring throughout the world, and especially in Australia," says Gene Likens, an ecologist at the Cary Institute of Ecosystem Studies in Millbrook, New York.

As Australia plans to cut its ecosystem-surveillance network, other countries are expanding theirs. The US National Science Foundation announced in March that it would add 3 new sites to the 25 in its own long-term ecological research (LTER) network. "Terminating Australia's LTER network is totally out of step with international trends and national imperatives," wrote Lindenmayer and 68 co-authors in a letter in *Science* on 11 August (D. Lindenmayer *et al. Science* **357,** 557; 2017).

The cuts in Australia follow years of piecemeal support for ecological research infrastructure. Five years ago, the government tasked a consortium known as the Terrestrial Ecosystem Research Network (TERN) with bringing together the country's existing LTER sites. The dozen locations in the resulting Long Term Ecological Research Network (LTERN) cover a variety of landscapes from deserts to rainforests (see 'Endangered network').

In June, TERN director Beryl Morris and chair of the advisory board Lyn Beazley sent a letter to LTERN's executive director, Emma Burns, stating that the network would not be funded beyond 2017. "I was completely blindsided," says Burns, an ecologist at the Australian National University.

Morris, who is based at the University of Queensland in Brisbane, says that TERN is funded as research infrastructure and so it must now develop an environmental prediction system open to all researchers. To do that, she says, it must collect data on a "continental scale that is generalized, not bespoke, so ▶