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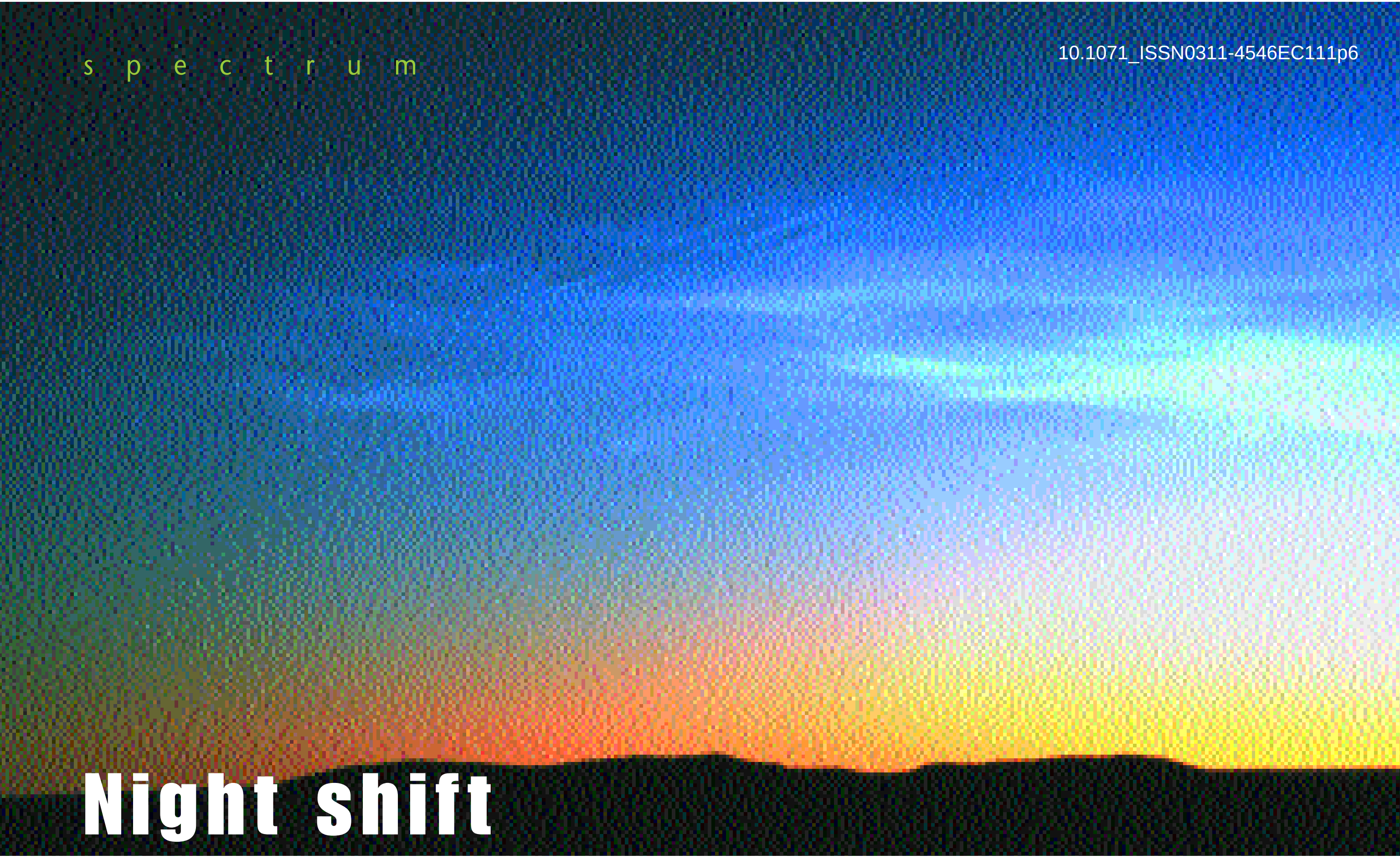

Night shift

Eighty-three kilometres up, a thin cloud has formed in the bitterly cold 'mesopause' region of the Earth's atmosphere. It's the end of a summer's day in Antarctica, and as the sun sinks low, the cloud, which streaks and ripples its way across the darkening sky, takes on a pearly-blue sheen.

Such 'noctilucent' or night-shining clouds regularly delight star-gazers in the northern hemisphere, and to a lesser extent in the south. Since the late 1960s, the appearance of noctilucent clouds has increased, providing inspiration for those inclined towards photography, romance and prose. But for some, noctilucent clouds are harbingers of climate change.

Dr Gary Burns from the Australian Antarctic Division in Hobart, and colleagues, John French, Karen French and Pene Greet, are investigating a possible link between noctilucent clouds and climate change.

They are measuring temperatures near the mesopause, 87 km above Davis station in Antarctica. During summer, the mesopause region is the coldest part of the Earth's atmosphere, reaching a frosty minus 130°C. Unlike the lower atmosphere, which warms in response to increasing concentrations of greenhouse gasses, theoretical models predict that the mesopause will cool by about 0.5°C per decade.

'Theoretical predictions of cooling in the mesopause indicate that it should be dramatically faster than the warming at ground level,' Burns says. 'So it may be easier to monitor global climate change in this region of the atmosphere.'

The cooling effect in the upper atmosphere seems to go against the general understanding that hot air rises. But physicists such as Burns can reveal that the temperature in a particular region is controlled by how that region gains of loses kinetic energy.

For example, greenhouse gasses (about 0.04% of gas molecules in the lower atmosphere) can absorb electromagnetic energy radiated by the Earth. When this happens, they begin to rotate and vibrate. If this jiggling gas molecule (such as CO_2) doesn't encounter any other gas molecules, it will eventually 'regurgitate' this electromagnetic energy and there has been no energy gain for the region. But if it collides with another gas molecule, it may convert its rotating and vibrating energy to kinetic energy, which is shared with the second molecule.

'As the average kinetic energy of the molecules has increased, the temperature of the region has increased,' Burns says.

In the lower atmosphere where the density of air molecules is high, there are lots of collisions and an overall warming of the atmosphere. At higher altitudes, air density decreases and there are fewer collisions. And more greenhouse gas means more kinetic energy is converted to electromagnetic energy, which is lost to space.

Increased sightings of noctilucent clouds are thought to be due to cooling temperatures in the upper 'mesopause' region of the atmosphere, and increasing amounts of water vapour. Could they be harbingers of climate change?

'The change-over altitude from enhanced greenhouse warming to enhanced greenhouse cooling is approximately 10 km,' Burns says. 'Above this height more CO_2 will cool the atmosphere and below this height more CO_2 will warm it.'

How are CO_2 and falling temperatures related to the formation of noctilucent clouds?

A second greenhouse gas, methane, now takes centre stage. The increasing release of methane into the atmosphere from sources such as rice paddies, land-fills and cattle, increases the amount of water in the dry mesopause region. As the gas rises through the lower atmosphere, sunlight strips the hydrogen from the methane molecule, leaving it free to react with oxygen and form water vapour. The commonly held view is that when this vapour reaches the freezing mesopause region, ice crystals form and turn into noctilucent clouds.

'So the combination of decreasing temperatures and increasing water vapour in