

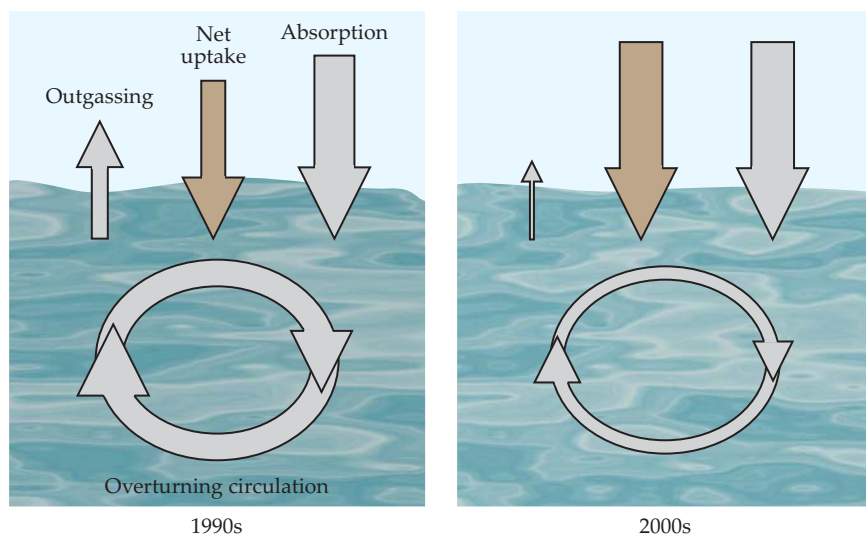


FIGURE 2. CIRCULATION'S ROLE in the ocean's carbon dioxide uptake. The overturning circulation in the upper 1000 m of the ocean transports absorbed atmospheric CO_2 downward but simultaneously brings up natural CO_2 from the deep. Combined with increased atmospheric CO_2 concentrations, weakening overturning circulation in the 2000s resulted in greater net uptake (brown) of CO_2 in that decade. (Adapted from ref. 3.)

(1 Pg = 10^{15} g). The largest reduction occurred in the subantarctic (latitudes 55° S to 35° S), where newly risen deep water in the Southern Ocean encounters the atmosphere.

When the overturning circulation weakened in the 2000s, less anthropogenic CO_2 was sent down to the depths, but even less deep-ocean carbon escaped into the air. On balance, therefore, the

ocean took up more CO_2 than before. That might sound like good news; after all, it means less CO_2 accumulated in the atmosphere. However, coral bleaching and other consequences of ocean acidification make increased CO_2 uptake by the ocean a mixed blessing at best.

Besides, says DeVries, “we think that the effect is going to gradually wear off.” The amount of deep ocean CO_2 rising to the surface will eventually plateau even as ever more fossil-fuel CO_2 makes its way into the atmosphere. The balance will tip in favor of reduced ocean CO_2 uptake. Then the slowing ocean overturning circulation will seem to be bad news all around.

Sung Chang

References

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2. P. Landschützer et al., *Science* **349**, 1221 (2015); D. Munro et al., *Geophys. Res. Lett.* **42**, 7623 (2015).
3. T. DeVries, M. Holzer, F. Primeau, *Nature* **542**, 215 (2017).
4. T. DeVries, F. Primeau, *J. Phys. Oceanogr.* **41**, 2381 (2011).

PHYSICS UPDATE

These items, with supplementary material, first appeared at www.physicstoday.org.

THE UPPER ATMOSPHERE'S NATURAL THERMOSTAT

Occasionally, our sun belches massive plumes of plasma from its corona that stream Earthward. When a fast coronal mass ejection (CME) arrives, it compresses Earth's magnetosphere and can reconfigure the planet's magnetic field lines. The reconfiguration enhances electric currents and energizes charged particles.

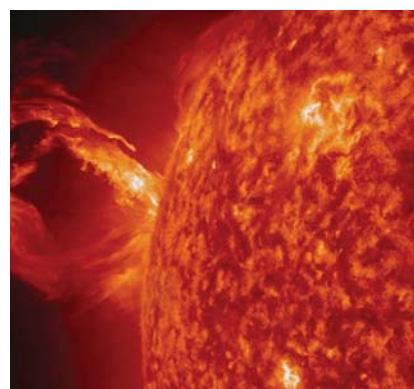
Those currents and particles heat

the tenuous atmosphere—hundreds of kilometers in altitude—which then expands outward. Low-orbiting satellites should thus experience more drag. But measurements of their orbital decay reveal that the drag from CMEs isn't always as great as expected. Researchers led by Delores Knipp (University of Colorado Boulder) now explain why. Under some circumstances, the same CME that heats the upper atmosphere also triggers chemical reactions that quickly cool it. Charged particles with energies greater than about 10 keV split molecular nitrogen, and the free N atoms react with oxygen to produce nitric oxide. The NO molecules, often created in a vibrationally excited state, spontaneously radiate in the IR. The upshot is that they remove energy from the heaving atmosphere and thereby cool and contract it.

From an archive of satellite data, the researchers analyzed the IR flux from NO as it responded to nearly 200 isolated CMEs that struck Earth between 2002 and 2014. They found that the fastest CMEs—ones whose speeds exceeded 500 km/s and produced shock waves ahead of the ejected plasma—led to early and copi-

ous NO production and emission. The shock-led CMEs transferred so much energy into the upper atmosphere that they generated more than twice the IR flux as non-shock-led storms. Knipp and her colleagues are hopeful their analysis will offer new insights for atmospheric modelers and satellite-drag forecasters trying to plan and track orbits that avoid collisions with space debris. (D. J. Knipp et al., *Space Weather*, doi:10.1002/2016SW001567.)

—RMW



NASA/GODDARD/SDO

HELIUM COMPOUND MAY FORM UNDER PRESSURE

Helium doesn't play well with others. Beyond its noble gas designation on the periodic table, it has the lowest electron affinity—zero—among the elements, and the highest ionization energy. Scientists have managed to mechanically pack He atoms with other elements, but the He has little effect on those compounds' characteristics.

Now an international team has presented evidence for a compound whose electronic structure and thus its physical properties are influenced by its He components. Researchers led by Artem Oganov ran a crystal structure prediction algorithm to play matchmaker for He and found that the compound Na_2He should form at high pressures. The researchers shared their prediction