The cycle of science

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The lowest naturally occurring temperature on our planet, −150 °C, is not found in the depths of winter on Antarctica but high in Earth's atmosphere at an altitude of 80–85 km. There, as the mesosphere gives way to the thermosphere above it, the ambient temperature stops falling, reaches its global minimum, and begins climbing again.

I first learned about mesospheric science at a session during the 2000 spring meeting of the American Geophysical Union in Washington, DC. What struck me then was how difficult the mesosphere's composition is to study. The layer's low density enfeebles spectral lines and makes them hard to detect. Solar illumination, which depends on latitude, longitude, and time of day, plays a bigger photochemical role there than it does at lower altitudes. And because the mesosphere's temperature and density both fall with altitude, the layer, like Earth's troposphere, is thermodynamically unstable; the transport of long-lived chemical species is therefore complicated.

The session led to my writing a news story about one particular scientific problem, the so-called HO_x dilemma (see PHYSICS TODAY, November 2000, page 17). The odd hydrogen species, HO_x, where $x = 0$, 1, or 2, participate in purging the atmosphere of pollutants and in the destruction of ozone. Over their typical lifetimes, single molecules of OH and HO_2 can destroy up to a million ozone molecules. Although models could reproduce the HO_x density profiles in the stratosphere, they failed puzzlingly in the less chemically active mesosphere.

My story reported on results from an innovative spaceborne instrument called the Middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI). Designed and built at the Naval Research Laboratory (NRL), MAHRSI looked horizontally through the limb of the atmosphere. Frustratingly, although one of MAHRSI's goals was to resolve the HO_x dilemma, the observations deepened it.

On page 30 of this issue you'll find a feature article by Bodil Karlsson and Theodore Shepherd about cloud formation in the middle atmosphere. Its imminent publication prompted me last month to check on the status of the HO_x dilemma. The news is good! The dilemma has been resolved, thanks to observations made by three satellite-borne successors of MAHRSI: the Microwave Limb Sounder on NASA's *Aura*,[1] the Optical Spectrograph and Infrared Imager System on Sweden's *Odin*,[2] and the Spatial Heterodyne Imager for Mesospheric Radicals on the US Defense Department's *STPSat-1*.[3] All three instruments yielded OH profiles that matched the models. It turned out that MAHRSI had a previously unnoticed calibration offset of roughly 25%.

When I reread my interview notes, I was impressed by how open-minded the HO_x researchers were at the time. None of them singled out failings in either gathering and interpreting data or constructing models as the dilemma's cause. All of the researchers looked forward to getting the answer.

What I didn't encounter—for good or bad—was the kind of brash self-confidence that some physicists have in their ideas, even when observational support is lacking or is contradictory. Does it matter whether physicists are confident or diffident? No, if it's just a matter of personality and if people agree to disagree with respect and civility. And sometimes belief in one's ideas in the face of discrepant observations can seem heroic, especially when the ideas are ultimately vindicated.

One of the MAHRSI researchers I contacted last month, Dave Siskind of NRL, told me he sees the story of the HO_x dilemma as validation of the scientific method—"the continuous cycle of hypothesis, experiment, and analysis," as he put it. He also pointed out that the dilemma's resolution has boosted confidence that another discrepancy, one to do with mesospheric ozone, arises from incomplete understanding of the photochemistry involved. "Solving one problem might have uncovered another," he says. The cycle of science continues.

In PHYSICS TODAY'S October 1968 issue, FREEMAN DYSON outlined two designs for nuclear-powered SPACESHIPS.

READ THE ARTICLE AT http://physicstoday.org/interstellar

References

1. H. M. Pickett et al., *J. Geophys. Res.* **113**, D16S30 (2008).
2. R. L. Gattinger, D. A. Degenstein, E. J. Llewellyn, *J. Geophys. Res.* **111**, D13303 (2006).
3. C. R. Englert et al., *J. Geophys. Res.* **115**, D20306 (2010).

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