will be cheap enough to run that it could ultimately see several events.

The shape of the neutrino pulse would tell astrophysicists whether they really understand how such stars explode and would clear up such mysteries as whether a black hole, from whose gravity nothing can escape, sometimes forms when the star's core collapses. "A sudden cutoff of neutrinos would be strong evidence for black-hole formation," says Super-K's Vagins. The dual detectors would help pinpoint a supernova's location and ensure that at least one detector is constantly working, says Richard Boyd, a collaborator at Ohio State University in Columbus.

Meanwhile, OMNIS's ability to pick out tau and muon neutrinos could help show whether neutrinos have mass. For a fixed energy, a particle with even a minute mass will move more slowly and hence take longer to traverse thousands of light-years than a massless particle will. The relative timing and pulse shapes of a supernova's electron-neutrino signal—seen primarily at Super-K and other detectors—and the muon and tau signals at OMNIS should reveal even slight mass differences. The Sudbury Neutrino Observatory in Ontario, Canada, which should begin taking data on solar neutrinos next year, could beat out OMNIS, because it could see as many as a quarter of OMNIS's expected haul of muon and tau neutrinos. But it relies on a tank of heavy water, provided through a lease from the Canadian government that is due to expire in 2001.

OMNIS collaborators are now putting together funding proposals for submission to the U.S. Department of Energy and the National Science Foundation. Estimates of construction costs range between $20 million and $40 million. One thing the project won't have to pay for is space underground. Wendell Weart of Sandia National Laboratory in Albuquerque, New Mexico, until recently technical project manager of the Carlsbad waste dump, says site managers would be happy to have the physicists as their guests. "It would be nice to think we're using it for some truly beneficial, scientific purpose in addition to disposing of this waste."

–James Glanz

ATMOSPHERIC CHEMISTRY

Rising Damp From Small Comets?

First, there were the strange, dark spots in the upper atmosphere, seen this spring in ultraviolet images from a satellite. Now comes evidence that the atmosphere has a relatively wet layer 70 to 80 kilometers (km) up.

In the standard picture of the atmosphere, water vapor is trapped below 12 km or so by a moisture barrier at the bottom of the stratosphere, keeping the mesosphere—the region between 50 and 90 km—almost bone dry. But last week, a satellite instrument detected signs of as much as 50% more water vapor at those altitudes than is called for by any conventional theory.

To space physicist Louis Frank of the University of Iowa in Iowa City, the explanation is clear: Fluffy, house-size comets are pummeling the outer reaches of the atmosphere 20 times a minute, releasing water that ultimately ends up in the mesosphere. Other researchers are far more cautious. "You have to give the man credit for predicting something we're now seeing," says Robert Conway of the Naval Research Laboratory (NRL) in Washington, D.C., principal investigator of the latest orbiting instrument to see signs of abundant mesospheric water. But Robert Meier of NRL, who endorsed Frank's detection of dark spots last spring (*Science*, 30 May, p. 1333), stresses that "this doesn't confirm snowballs in space. You have to look at alternative explanations" for a moist mesosphere.

The first hints of excess water in the mesosphere actually came late last year, when James Russell of Hampton University in Virginia and his colleagues reported a reanalysis of data gathered by the Halogen Occultation Experiment (HALOE) on the Upper Atmosphere Research Satellite. The satellite has been flying since 1991, and earlier analyses of data from HALOE, which measures solar absorption by the upper atmosphere, didn't show any unusual concentrations of water. But the latest look at the data revealed a peak in water vapor at an altitude of about 70 km.

"We were very skeptical at first" of the HALOE reanalysis, says Conway. But now his own instrument, NRL's Middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI), has found abundant hydroxyl radicals, a breakdown product of water, in the mesosphere above high northern latitudes. Flown on a satellite deployed by the Space Shuttle, MAHRSI is the first instrument that is able to pick out the sunlight-induced glow of hydroxyl from the glare of scattered sunlight in the mesosphere. Its observations reveal high concentrations of hydroxyl at an altitude of about 70 km, right where HALOE saw the peak in water. Both instruments also show that the mesosphere is dampest in summer at high latitudes, where the added water could help explain noctilucent clouds—the wispy clouds of ice particles seen at 85 km during high-latitude summers. "There's a startling amount of water above altitudes of 65 km," says Conway—8 to 10 parts per million versus the 6 to 7 parts per million predicted by what is considered quite reliable theory.


P. PARVIAINEN

Wet layer. Unexpected water in the high atmosphere could help form icy noctilucent clouds.

"There's definitely something very unusual going on in the mesosphere that we don't understand at all," says theoretician Michael Summers of NRL, "but I'm not even close to saying this supports the small-comet hypothesis." For one thing, he and others are skeptical of Frank's scenario for funneling water from an altitude of 800 km, where Frank says the comets would break up, down to the mesosphere, where increasing atmospheric density would stop the water. The clouds of vapor would have to slam through 700 km of thin atmosphere, leaving hardly a trace of water on the way.

Summers and others add that even if the mesosphere is damp, it's not nearly as damp as Frank's theory would have it. David Siskind of NRL, Summers, and others have calculated how big an influx of water from above would be needed to explain the 70-km peak seen by HALOE. Frank's small comets exceed it "by at least a factor of three," says Summers. "My preferred view is that it's off by a factor of 30." Summers and his colleagues are therefore pursuing other explanations for the water: Perhaps it is deposited by meteorites or created by unexpected chemical reactions.

The loose ends don't worry Frank. "The most important thing is the finding of excess water up there," he says. "It's a big step." Sorting out water fluxes and why the water abundance varies with latitude and season will require close monitoring of the variations he has already detected in the small-comet bombardment, he says. Meteorologist John Olivero of Embry-Riddle Aeronautical University in Daytona Beach, Florida, agrees that it's time to start taking small comets seriously. "It's when we get challenging observations like this that we start to rethink all of our assumptions," he says. "That's what science is supposed to be all about."

–Richard A. Kerr