The UARS Cornucopia: A Legacy of Research

Goddard Space Flight Center DAAC

by Matt Nelson

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Nine years after its initial deployment, the Upper Atmosphere Research Satellite (UARS) is more than just an antiquated piece of metal floating around in space. Actually, it has already surpassed its original mission lifetime of 18 months and is still providing scientists like Andrew Dessler, an associate research scientist in the Earth Science System Interdisciplinary Center, a cooperative institute between the University of Maryland and the Laboratory for Atmospheres at NASA's Goddard Space Flight Center, with valuable atmospheric data.

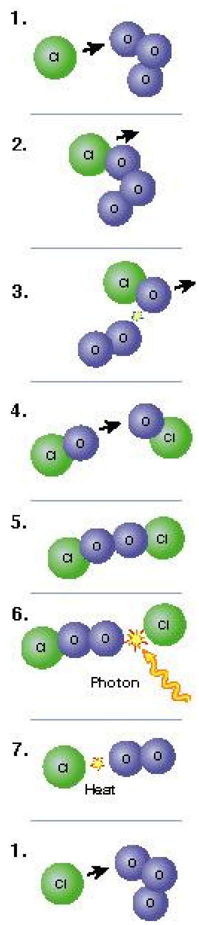
Considered the first major element of NASA's Earth Science Enterprise, UARS was deployed from the Shuttle Discovery on September 15, 1991. Forty guest investigators were selected to use the UARS measurements with the goal of improving our knowledge of the atmosphere above the troposphere and our understanding of solar variability.

Focusing primarily between 15 km and 100 km above the Earth's surface, the 10 instruments aboard the satellite quickly proved their abilities. By mid-1996, almost 400 peer-reviewed articles had been written with the help of UARS data, according to a research paper written by Dessler.

What makes the UARS data different from previous data collected in the upper atmosphere is the fact that the 10 unique instruments are able to record data simultaneously. Before UARS, scientists had no tools for so comprehensively monitoring the stratosphere on a continuing basis.

As the Cryogenic Limb Array Etalon Spectrometer (CLAES), the Improved Stratospheric and Mesospheric Sounder (ISAMS), the Microwave Limb Sounder (MLS), and the Halogen Occultation Experiment (HALOE) sent back data on the concentrations and distributions of gases important to ozone depletion, climate change and other atmospheric phenomena, the High Resolution Doppler Imager (HRDI) and the Wind Imaging Interferometer (WINDII) collected the first directly-measured global pictures of horizontal winds that disperse chemicals and aerosols through the upper atmosphere.

At the same time, the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM), the Solar Stellar Irradiance Comparison Experiment (SOLSTICE), and the Particle Environment Monitor (PEM) returned measurements of the solar energy reaching Earth, providing insights into the effect of solar energy on the atmosphere. The Active Cavity Radiometer Irradiance Monitor (ACRIM II) is the 10th instrument aboard UARS; it provides precise measurements of the total amount of the sun's energy that reaches our planet.



Chlorine reacts with ozone, forming chlorine monoxide (1-3), starting the catalytic ozone-destruction cycle. Chlorine monoxide can react with itself to form Cl_2O_2 (4-5), which is broken apart by sunlight (6), producing chlorine atoms and an oxygen molecule (6-7). The cycle begins again as a chlorine atom reacts with more ozone (1). (Image courtesy of Upper Atmosphere Research Satellite (UARS).)

The goal of the Upper Atmosphere Research Satellite (UARS) is to understand the chemistry, dynamics, and energy balance above the troposphere, as well as the coupling between these processes and between regions of the atmosphere.

According to Dessler, the instruments on UARS have been vital for studies of stratospheric chlorine chemistry, stratospheric tracer-tracer correlation, tropospheric water vapor, the chemistry of the wintertime Arctic lower stratosphere, and tropospheric aircraft exhaust studies.

"Until UARS, we did not have enough measurements to really know whether or not we understood atmospheric chlorine," said Dessler. "You never know if a prediction is right. But, you can gain some idea that it's right by seeing how well it predicts the current atmosphere. We have seen that our model does a reasonably good job of simulating the chlorine that UARS has measured in the atmosphere.

"Chlorine partitioning theories agree reasonably well with the measurements," said Dessler. "By comparing UARS data with the models, we see good agreement and that lends a lot of credibility to what we project will happen in the future. This correlation suggests that our understanding of chlorine is reasonably good. In the lower stratosphere, it is clear that chlorine is likely responsible for the decline in ozone that we have been seeing both in the ozone hole (over Antarctica) and at mid-latitudes."

The measurements of the MLS, CLAES, and HALOE instruments aboard UARS allowed Dessler to closely examine the partitioning of chlorine atoms in the upper atmosphere, a dynamic that contributes to the stratospheric ozone depletion process.

"UARS provided simultaneous measurements of chlorine oxide and chlorine nitrate and near simultaneous measurements of hydrogen chloride," Dessler said "These are basically the three big players in stratospheric chlorine. So the measurements of the various chlorine species are made at the same time which helps you to understand what is really going on up there."

Because approximately 20 percent of the chlorine in the atmosphere comes from a natural source of methyl chloride, the other 80 percent is thought to come from man-made sources — primarily chlorofluorocarbons, or CFCs.

When CFCs rise to the stratosphere they are destroyed by high-energy ultraviolet sunlight. This destruction process works to pop chlorine atoms off the CFCs to form new constituents in the stratosphere. The now unstable chlorine atoms react with oxygen species to form one of three molecules — hydrogen chloride, chlorine monoxide, or chlorine nitrate. Of these three, chlorine monoxide is the most important to ozone destruction.

Using UARS measurements of chlorine monoxide, hydrogen chloride and chlorine nitrate from the MLS, CLAES, and HALOE instruments, Dessler concluded that "the combination of the [chlorine nitrate-chlorine monoxide] and [hydrogen chloride-chlorine nitrate] analyses have provided the first complete view of chlorine partitioning in the stratosphere between 20 and 30 km."

With the help of two-dimensional models and UARS measurements, Dessler concluded his research on upper atmospheric chlorine and began pursuing other research interests. The agreement between UARS measurements and scientific models has satisfied Dessler with his findings.

The UARS platform provides near global (-80 degrees to +80 degrees), simultaneous, coordinated measurements of atmospheric internal structure (trace constituents, physical dynamics, radiative emission, thermal structure, density) and measurements of the external influences acting upon the upper atmosphere (solar radiation, tropospheric conditions, electric fields). Coverage ranges from September 18, 1991 through August 31, 1999. UARS data are available from the Goddard Space Flight Center DAAC. For more information, visit the Goddard Space Flight Center DAAC (now named the GSFC Earth Sciences DAAC) and the Upper Atmosphere Research Satellite (UARS) home page.