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Ocean Asteroid Impact Could Deplete Ozone Layer

by Alan Fischer

New research by PSI Senior Scientist Elisabetta Pierazzo has found that an asteroid crashing into the deep ocean could have dramatic worldwide environmental effects, including depleting the Earth's protective ozone layer for several years. This could result in a huge spike in ultraviolet radiation levels and hamper efforts to grow crops, as well as affect other life forms on Earth.

Artist's rendering of an asteroid impacting the ocean. Credit: NASA

In the past, interest in oceanic impacts of medium-sized asteroids focused on the danger of regional tsunami, but Pierazzo's new approach, published recently in *Earth and Planetary Science Letters*, has used computer modeling scenarios to look at the effects such a strike would have on the atmospheric ozone.

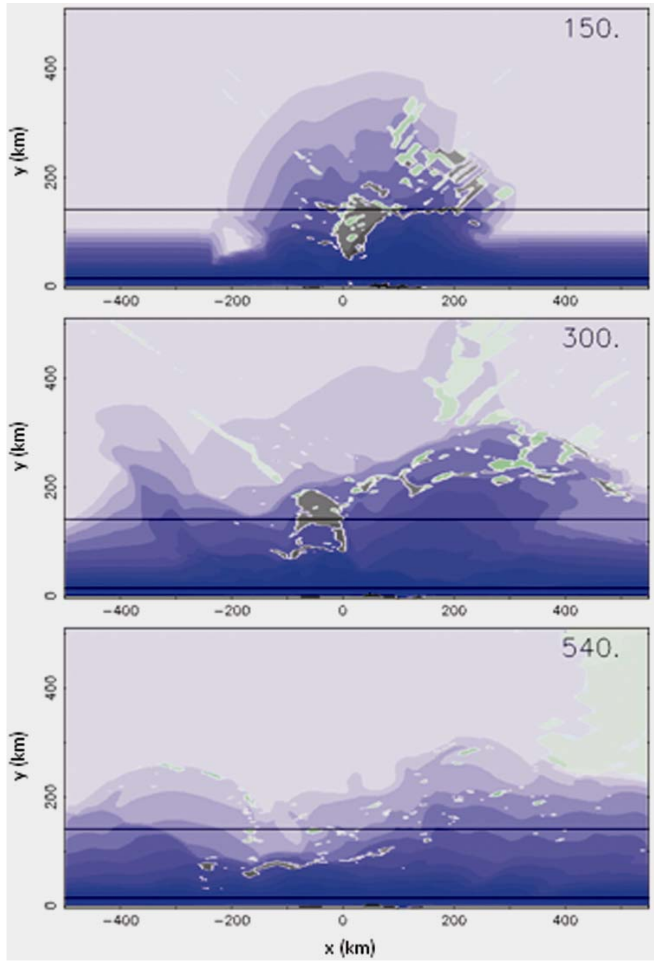
Working with a team of atmospheric scientists, she looked at two asteroid impact scenarios: a 500-meter-diameter asteroid and a one-kilometer-diameter asteroid, each impacting an ocean four kilometers deep. An impact by either size asteroid would send vast amounts of seawater into the air.

"This work represents the first attempt at combining 3D impact simulations with 3D atmospheric simulations and interactive chemistry," she said. "The results suggest that mid-latitude oceanic impacts of one-km asteroids can produce significant global change in the upper atmospheric chemistry, including ozone depletion lasting several years, comparable to record ozone holes recorded in the mid 1990s."

The simulations depicted rapidly-ejected seawater adding lots of water vapor — and with it chloride and bromide — into the upper atmosphere, thereby hastening the destruction of the ozone, said Pierazzo, the paper's lead author and project Principal Investigator.

"The removal of a significant amount of ozone in the upper atmosphere for an extended period of time can have important biological

(Continued next page)



This model shows an expanding impact plume resulting from a 500-meter-sized asteroid impacting the ocean. The 3 graphs show the plume — a mix of air (blue), water (gray), and asteroid material (light green) — at 2.5 minutes (top), 5 minutes (middle), and 9 minutes after impact (bottom). This interesting sequence shows the far reach of the plume, over 500 kilometers above the surface and well over 1,000 kilometers horizontally, all within10 minutes!

Inside this issue:

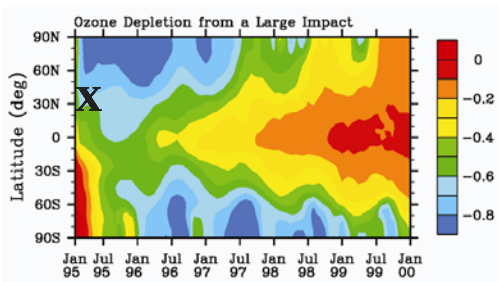
Ocean Asteroid Could Deplete Ozone *(continued)*

Elisabetta Pierazzo on the local NBC television news broadcast in November.

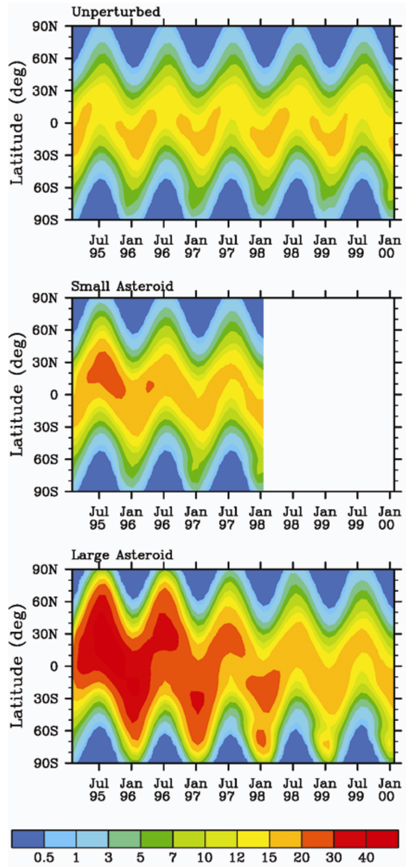
repercussions at the Earth's surface as a consequence of increase in surface UV-B irradiance," she said. "These include increased incidence of erythema (skin reddening), cataracts, changes in plant growth, and changes in molecular DNA."

While the technology does not currently exist for diverting or destroying an asteroid headed for Earth, with enough lead time and preparation the long-term consequences of such an impact could be diminished. Farmers could plant crops with higher tolerance to UV radiation, and food could be stored to prepare for a few years of reduced productivity.

The ultraviolet index, or UVI, is a scale used to indicate the intensity of UV radiation at the Earth's surface, and the higher the number the greater chance of damage to the skin and eyes. A UVI of 10 or greater tends to be dangerous, resulting in burns to people with fair skin in just a few minutes exposure. The highest UVI recorded on Earth has been 20.



This graph tracks the ozone depletion and its recovery over time after a one-kilometer-sized asteroid impacted the Central Pacific at latitude 30N (X above), in 1995. Red signifies normal ozone levels and, at the other extreme, deep blue represents 80% depletion of ozone.



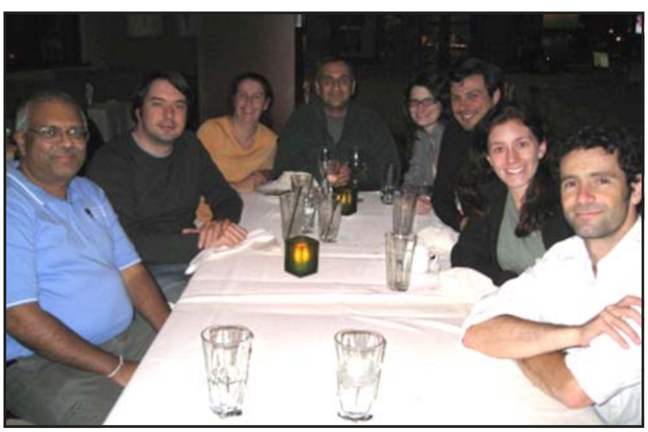
An impact by a 500-meter asteroid could see the UVI jump to values above 20 for several months in the northern subtropics, and an impact by a one-km asteroid would see the UVI rise to 56, with levels exceeding 20 for about two years in the region between 50 degrees North and South in latitude, she said.

"A level of 56 has never been recorded before, and we are not sure what it will do," she said. "We do know that if you went outside during daylight hours you would burn; you would have to go out at night, after sunset, to avoid major damage."

The research was funded by a NASA Exobiology grant. ▫

The three graphs above represent the ultraviolet radiation index (UVI) over several years, in three different scenarios:
Top graph: normal conditions
Middle graph: after a 500-meter asteroid impact
Bottom graph: after a one-kilometer asteroid impact
Blue indicates lowest level of UV radiation and red the highest

PSI Postcards



PSI scientists attended the Division of Planetary Sciences' annual October meeting, which was held this year in Pasadena, CA. The scientists, from PSI off-site and on, gathered for dinner at Roy's Restaurant. Attendees, from left to right: Nalin Samarasinha, Pasquale Tricarico, Beatrice Mueller, Nader Haghighipour (PSI-HI), Karly Pitman (PSI-CA), Damian Crevello (Karly's husband), Teresa Gonczy (guest) and Eldar Noe Dobrea (PSI-CA).

PSI Scientist Mary Bourke takes a break from the Second International Planetary Dunes Workshop to look at the tallest dunes in north America at the Great Sand Dunes National Park, Colorado. These dunes are of interest to planetary geologists because of the seasonal snowfall they receive; Martian dunes are also covered by a seasonal snowfall. However, on Mars the snow cover is made up of both water and carbon dioxide snowflakes. Enjoying the view with her are Romy and Asti Bishop, Caoimhe Bourke (napping) and Rachael Humeniuk (behind the lens).

A Participating Planetary Scientist: Candice Hansen *(in her own words)*

As a preteen, I loved science fiction. Robert Heinlein's books were my favorites — women could be found in command of spaceships in his stories. I never imagined that I would someday have a front seat in the exploration of our solar system. When I started college at California State University, Fullerton (CSUF), my declared major was accounting. A general science course was required, and I took physics just because it fit neatly into my schedule. The CSUF physics department recruited me to change my major because they noticed my interest in the subject. There were 7 women out of 70 physics majors at the time, with one female professor, who turned out to be a fabulous mentor. She had worked on the Apollo missions and inspired me to consider a career in planetary science.

After getting a B.A. in Physics from CSUF, a brief stint as a research assistant for Dr. Bradford Smith (University of Arizona, Tucson) led to a summer job at the Jet Propulsion Laboratory. I was hired full-time in 1977 to be on the Voyager flight team, working for the Imaging Science Subsystem team, designing the camera observations for every satellite flyby that occurred during Voyager's encounters with Jupiter, Saturn, Uranus, and Neptune.

In 1987, I went back to graduate school at the University of California, Los Angeles (UCLA). For my Ph.D. dissertation I applied my advisor's Mars climate model to the tenuous nitrogen atmospheres of Triton and Pluto. This vapor pressure equilibrium model allows one to predict when a volatile will condense on the surface as a polar cap and when it will be in the atmosphere. Most recently we've applied this model to some of the larger Kuiper Belt objects.

It was natural to move to Cassini in 1990 when Voyager downsized for the last phase of its mission. On Cassini, I have been the Ultraviolet Imaging Spectrograph (UVIS) team Co-Investigator responsible for definition and execution of icy satellite science objectives achievable in the ultraviolet.

Studying spring sublimation (transitioning from a solid to gas) of Mars' seasonal polar cap is the bulk of my current Mars research. As the deputy PI of the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) team I am responsible for choosing targets and analyzing data for Mars' seasonal processes. On Mars the spring CO_2 sublimation process manifests as the most active erosional process in the current Mars climate. (Interestingly, the seasonal-ice-basal-sublimation process originally proposed for Triton's plumes is our baseline hypothesis for seasonal activity on Mars.)

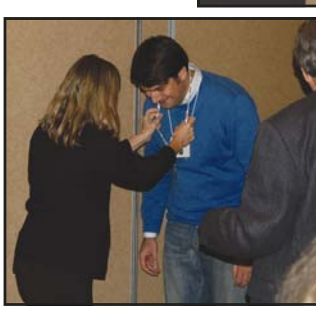
I worked at JPL for 33 years, taking early "retirement" last October to live in the beautiful desert of southern Utah. I was not ready however to retire from planetary science — my lifelong love! Thus my career continues at Planetary Science Institute as a Co-Investigator on Cassini, Mars Reconnaissance Orbiter (MRO), and Juno. The connecting thread through these seemingly disparate missions is the study of ices and seasonal processes. My overarching personal objective, which has not changed in the course of my career, is to make meaningful contributions to the exploration of our solar system.

My husband and I enjoy going for long walks in the desert with our two German shepherds, motorcycling, and boating. Our daughter just graduated from college and is helping us to care for my husband's father while she considers what to do in the next phase of her life. I hope that she will find a career that gives her as much pleasure as mine has!

Note: Candice joined PSI in August 2010 and we are proud to welcome her to the Institute.

Albuquerque Dawn Science Team Meeting *by Tom Prettyman*

In November, recently selected Participating Scientists for the NASA Dawn Discovery Mission's encounter with Vesta attended their first Science Team meeting in Albuquerque. Dawn is the ninth of NASA's Discovery Program missions, and it will investigate the two largest asteroids in the main asteroid belt, Vesta and Ceres.



The Participating Scientists were inducted into the Dawn team on the first day of the meeting. The photos show PSI Participating Scientists (clockwise from left) Aileen Yingst, Bob Reedy, David O'Brien, Brent Garry, and Pasquale Tricarico receiving their certificates and mission pins from Carol Raymond (Dawn Deputy Principal Investigator), Chris Russell (Dawn Principal Investigator, with his back to the camera), and Michael Kelley (NASA PGG Division Scientist, upper right, in blue).

They join team members from PSI, Bill Feldman, Tom Prettyman, and Mark Sykes, and the rest of the Dawn team as Dawn approaches Vesta. PSI now has more members on the Dawn Science Team than any other organization.

The Dawn spacecraft will enter into orbit around Vesta in the summer of 2011. Stay tuned!

Catherine Johnson's Path to PSI

Catherine Johnson recently joined PSI as a Senior Scientist, based in Vancouver, B.C. Her research focuses on geophysical studies of the interior structure and evolution of the rocky planets. Most recently, with former Ph.D. student Kristin Lawrence, she has been working with old and new lunar data sets to understand why some regions of the Moon have magnetized rocks, as seen in satellite data sets and samples from the Apollo missions that were brought back to Earth and measured in a lab.

She has also led several new investigations of seismograms recorded as part of the Apollo Passive Seismic Experiment. These studies (with former Ph.D. student Renee Weber) have resulted in the discovery of previously unidentified moonquakes. The lunar seismograms are very different from their terrestrial counterparts. In particular, seismic energy is recorded for a long time after an event due to scattering in the highly-fractured, outer few kilometers of the ancient lunar crust. With colleague Jesse Lawrence at Stanford, Catherine is using the characteristics of these long duration seismograms to investigate the depth, extent, and magnitude of scattering in the lunar crust. These kinds of studies will also be important for the design of future lunar seismic experiments.

Catherine is also currently a Participating Scientist on the MESSENGER mission to Mercury. Her major interest here is in understanding Mercury's magnetic field environment, specifically the structure, origin, and temporal variability of the internal field. (PSI currently has five Participating Scientists on MESSENGER.)

Although she was born and raised in England, residing most of the time in Lancashire, Catherine now identifies herself as "American by choice." She received her Bachelor's degree (Honours Geophysics) from the University of Edinburgh, Scotland, in 1989. Her third year was spent at the University of Pennsylvania, the catalyst for a subsequently permanent move to North America.

She received her Ph.D. from Scripps Institution of Oceanography in 1994, having had a somewhat schizophrenic research existence combining paleomagnetic studies of Earth and studies of Venus's gravity and topography into a single thesis. (She still works on problems in geomagnetism.) She spent her first postdoctoral year at Scripps, followed by a two-year fellowship at the Dept. of Terrestrial Magnetism at the Carnegie Institution of Washington.

She then took a break from the research world (in theory) to start and run an Education and Outreach Program for the Incorporated Research Institutions for Seismology (IRIS), located in Washington D.C. During this time she was involved in designing and placing seismology-related exhibits in major science museums and science centers across the U.S.; working with television (PBS, Discovery Channel) in designing and running professional development programs for teachers and Teach For America; and starting an undergraduate internship program. However, after 3 years of realizing that she was unable to break the weekend and evening research habit, she became a full time researcher again, first as a faculty member at Scripps Institution of Oceanography, and then moving to the University of British Columbia in 2006.

When not working on her research, Catherine can usually be found at the beach or in the mountains, with her husband, Mark, and their (large) dog, Summer.

We are very pleased that Catherine has found her way to PSI.

Director's Note: *A Day in Court*

In October, I attended oral arguments for *NASA et al. v. Nelson et al.* at the United States Supreme Court, sitting among some of the plaintiffs and their friends and family. This is a privacy case in which a group of Jet Propulsion Laboratory (JPL) employees (including Robert M. Nelson) challenged, and succeeded in getting an injunction against, a NASA decision to conduct what they considered intrusive background investigations. This scrutiny, to which the employees have not previously been subjected, would include details regarding medical and drug treatment, and any "adverse" information, including private sexual matters. The plaintiffs are not government employees, nor are they engaged in classified work. Are there limits to what the government can do?

I arrived in front of the Supreme Court about 5:00 a.m. and joined Nelson's sister in line. Soon other JPL plaintiffs and families began arriving. We waited in the chill until 9:00 a.m., when we were allowed to go inside for some breakfast at the cafeteria, then resumed our positions in line outside. Finally we were led into the court chamber, which was remarkably small, but nonetheless impressive. Court began at 10:00 a.m. sharp. The justices walked in, looking just as they do on television, minus Justice Kagan who had recused herself. Each side had 30 minutes for opening remarks, beginning with the government attorney; however, neither side made it through their statements before the justices jumped in and started asking questions such as:

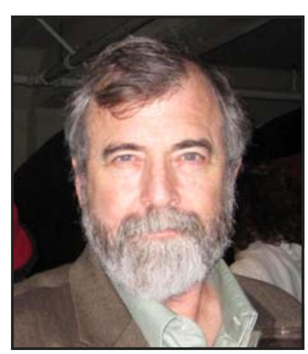
Is there any limit to the information the government can gather about someone? Do citizens have any right to informational privacy? Can the government make any demand that a private employer might make?

Both sides were grilled thoroughly by the justices. Clearly, you needed to bring your 'A' game to argue in this venue! The attorneys on both sides struggled to maintain their focused messages.

After the arguments, I joined the plaintiffs and their attorneys for a debrief on what had just occurred. There had been no slam dunks. Unless a tie was announced a few days later (which would be a win for the plaintiffs), the decision would not likely be handed down until after March.

There was no tie.

In addition to being scientists, so many of our colleagues at PSI and elsewhere are athletes, artists, musicians, writers and also engaged in the political process. Add fighting for individual liberties. Taking a case to court, especially this far, is a drain on personal resources, time and energy, and is not without personal risk. Regardless of how this case is decided, I honor Nelson and our JPL colleagues for their courage and commitment.



Mark V. Sykes
December 2010

Comets Capture Interest at Science Event

by Alan Fischer

Students are eager to see how a comet they made at the Math, Science and Technology FunFest turned out as Alan Fischer, right, PSI's Public Information Officer, prepares to show them their icy creation.

At the Math, Science, and Technology Fun-Fest, Nov. 5, 2010, students and teachers from Southern Arizona learned about — and *made* — comets.

Thousands of students and hundreds of teachers attended the event held at the Tucson Convention Center, where exhibitors, including PSI, offered hands-on science-related activities. The PSI booth was popular, with a steady stream of children and teachers eagerly awaiting the next opportunity to participate.

The PSI exhibit offered attendees a slide show on comets followed by teams of young participants actually making a model of a comet's nucleus. Over 20 comets were constructed during the five-hour event.

Thea Cañizo, right, PSI's Education Support Specialist, offers information about comets to school children at the Math, Science and Technology FunFest, prior to a comet making exercise.

"It was a great event. The students were very interested in the topic and excited about making their comet model. There were many 'oohs' and 'aahs'," said Thea Cañizo, Education Support Specialist at PSI. "The teachers and parent chaperones also enjoyed the activity and were grateful to PSI for giving the children the chance to learn and also have fun."

Recipe for a comet!

Ingredients needed to make your own comet nucleus model:

Crushed dry ice, about one pound per comet
Crushed charcoal, one teaspoon per comet
Water
A dash of ammonia
A dash of organic material like Karo syrup
Large plastic mixing bowl
Two plastic shopping bags
One food storage bag, one-gallon size
Large scooping spoon
Tablespoon
Mixing spoon
Heavy insulated gloves
Five-ounce paper cups

Warning: always wear protective gloves when handling dry ice!

Start by lining the plastic bowl with two plastic shopping bags.
Place an opened one-gallon freezer storage bag in the bowl.
Pour two five-ounce cups of water into the bag.
Add one tablespoon of charcoal. Mix well.
Add dash of ammonia. Mix well.
Add dash of organic material. Mix well.
Wearing insulated gloves, add two five-ounce cups of crushed dry ice into the mixture.
Mix the ingredients thoroughly, until the liquid becomes nearly frozen.
Carefully pull the plastic bags from the bowl, removing air around the material.
Begin molding the material as if you were making a snowball.
Continue forming it like a snowball, being careful to keep it compacted into one piece and not break any parts off.
When the snowball is solid and compact, open the interior bag and remove the comet nucleus.
The comet may sizzle and emit small jets of gas. This is where the carbon dioxide gas is escaping through small holes in the model comet's nucleus, just like in real comets.

David Levy Explores "Poetry of the Night"

At PSI's main office in early December, our Board member, David Levy, Ph.D., gave a presentation at our weekly science seminar entitled "*Poetry of the Night: Exploring the relationship between the night sky and English literature.*" His talk, accompanied by slides and music, described how he developed a new career relating the night sky to different periods of English literature. Great writers of plays, poetry, and novels — such as Shakespeare in *King Lear* and Jonathan Swift in *Gulliver's Travels* — used their knowledge of the sky to enrich their work, he explained.

David Levy is renowned for his enthusiasm for the cosmos and his many scientific achievements including discovering 22 comets — among them the Shoemaker-Levy 9 that famously collided with Jupiter in 1994 — his many books and periodical contributions, his award-winning Discovery Channel documentary, and many other endeavors.

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