NASA Developing Initial Plans for New Mission to Jupiter System

PAGE 26

NASA is proceeding with initial efforts toward developing a new mission to explore the icy moons of Jupiter, members of a NASA-chartered science definition team said at an 8 December briefing at the AGU Fall Meeting in San Francisco. The Jupiter Icy Moons Orbiter Mission (JIMO) would include some key science and engineering goals, and could be launched at some point after 2011, if technical and funding issues are resolved, they said.

The spacecraft, to be powered by a nuclear fission reactor, would orbit three of Jupiter’s planet-sized moons: Callisto, Ganymede, and Europa. Among the mission’s goals would be to determine, finally, whether these moons have subsurface oceans; to measure surface ice thickness; and to conduct in-depth studies of these oceans. The mission also would search for possible signs of life by mapping organic compounds and other chemicals on the surface that may be of biological interest, study interior structures and radiation environments around the moons, and investigate the interactions of the Jovian system as a whole.

The mission would also conduct further investigations of Io, though not enter into its orbit.

Ronald Greeley, co-chair of the JIMO science definition team, who is with Arizona State University in Tempe, said that Europa, Ganymede, and Callisto “are worlds in their own right,” and that the mission would be an opportunity to learn the characteristics of the largest planetary system in our solar system.

Christopher McKay, co-leader for the science definition team’s astrobiology group, said that his group’s focus is for the search for life on Europa, which scientists believe contains an ocean. McKay, with NASA’s Ames Research Center in Moffett Field, California, said that a search of Europa’s surface, which has a thick ice cover, could reveal what lies beneath.

However, he said this would depend on finding subsurface material from the ocean that may have made its way to the surface through cracks in the lithosphere recently enough that radiation effects would not have erased any evidence of organic material of biological origin.

He said, “The question is, does [an ocean on Europa] have life? If it does, maybe surface features we see, which possibly represent the ocean coming to the surface, could bring evidence of that life to the surface.”

Louise Prockter, co-leader of the science definition team’s geology and geochemistry group, and who is with the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, indicated that her group had established two overarching goals: determining the origin of surface features of various moons, and what that may indicate about geological history and evolution; and identifying potential landing sites for future missions. Specific goals, she said, include investigating ridge formation on Europa through topographic mapping, high-resolution spectral imaging to examine the effect of impact cratering processes on Callisto and other moons, and thermal imaging of volcanoes on Io.

According to science definition team members, while a JIMO launch could be years into the future, one possible design would position the fusion reactor at one end of the spacecraft, with instruments at the opposite end, protected by a large radiation shield. Likely onboard equipment would include a radar instrument to map surface ice thickness, and a laser to map surface elevations. Others likely would include a camera, infrared imager, magnetometer, and instruments to study charged particles, atoms, and near distant moons.

JIMO has grown out of NASA’s Project Prometheus—formerly known as the nuclear technology initiative—which the Bush administration proposed, and for which the U.S. Congress provided initial funding of about $20 million in fiscal year 2003. A key goal of Project Prometheus is to establish and develop technology for a radioisotope power system for spacecraft to explore the solar system.

JIMO was identified as the first mission to use this technology.

The amount of power that could be available from nuclear power is estimated to be potentially hundreds of times more than what is available on current interplanetary spacecraft, such as Cassini. The extra power would allow for more and more powerful instrumentation, and for faster transmission of data.

JIMO would be a follow-on to the NASA Galileo mission through the Jovian system, and would also incorporate aspects of the cancelled Europa mission.

—RANDY SHOWSTACK, Staff Writer

MEETINGS

Exploring Drought and Its Implications for the Future

PAGE 27

Worsening drought, water restrictions, and wildfires have been widely featured in news reports across North America during recent years. Area burned by wildfire was at unprecedented levels in the United States in the summer of 2002, and devastating wildfires in California were in the news just a few months ago.

Drought is not only gripping parts of North America, but also parts of Northern Africa and other regions worldwide, serving as a reminder of society’s vulnerability to drought and its enormous economic impact.

But what is the full range of past drought variability, as revealed by paleoclimate data? What role might droughts associated with abrupt climate change play? Are droughts likely to become more frequent, longer, or more extensive as we move into the future with global warming?

All of these considerations were motivation for organizing a meeting, “A Multi-millennia Perspective on Drought and Implications for the Future.” It was arranged by the international CLIVAR-PAGES joint working group, which brings together the climate dynamics and paleo-communities, and fosters interactions that have been exceedingly fruitful. (CLIVAR is the World Climate Research Program’s project on Climate Variability and Predictability, and PAGES is the International Geosphere Biosphere’s project on Past Global Changes.)

Drought is among the topics of the Intergovernmental Panel on Climate Change (IPCC) for the forthcoming 2007 fourth assessment report (AR4), and co-sponsorship of the meeting by the IPCC enabled attendance by scientists from developing countries in Africa and elsewhere.

The purpose of the meeting, which was attended by about 70 people, was to bring a focus on new ideas, observations, analyses, and theories about drought to improve understanding, analysis approaches, and predictive capabilities. The main focus regionally was on North America and Northern Africa, the two regions with the largest amount of available, drought-related paleo-data and research, as well as serious ongoing droughts.

Meteorological drought is defined in terms of a deficit of precipitation. Agricultural drought relates mostly to deficiency of soil moisture, while hydrological drought relates to deficiencies in lake levels and streamflow. The characteristics of precipitation of frequency of occurrence, sequence, intensity, and phase (snow versus rain), in addition to amount, are important. Regular light or moderate rains soak into soils and benefit agriculture, but may not run off to produce streamflow; while occasional, intense rains may cause local flooding and runoff into streams, but may not replenish soil moisture enough to last until the next event.

Drought and flood are extremes of the frequency, intensity, and amounts of precipitation characteristics [Trenberth et al., 2003].

Observational Studies of Drought

The greatest severity and extent of drought in the United States occurred during the Dust Bowl years of the 1930s, particularly during...
incidence of drought. Furthermore, paleo-model results for Africa 8500 B.P. in the National Center for Atmospheric Research Community Climate System Model reveal that the large changes in the orbit of the Earth around the Sun increase insolation in the boreal summer, enhance land-sea contrast, and drive a stronger and 7° latitude farther northward ITCZ (Inter-Tropical Convergence Zone) over Africa, making for a much wetter Sahel and a smaller Sahara desert.

A longstanding concern has been the possibility of increased drought in the future, as the climate changes with increased greenhouse gases in the atmosphere. Increased heating (“global warming”) produces increased drying and hence evaporation if moisture is available [Trenberth et al., 2003]. Because evaporation generally exceeds precipitation across the United States in the deep summer months of July and August, a primary risk is of increased summer continental drought. Drier soils and less recycled moisture in the atmosphere is a recipe for increased intensity, frequency and duration of drought. These general mechanisms were found to occur in the new version of the Geophysical Fluid Dynamics Laboratory model.

But are there other physical processes that could operate in specific regions? Observed major droughts wax and wane in extent and duration, often in an apparently random manner. The meeting highlighted some underlying patterns and their causes. Generally, changes in global sea surface temperatures (SSTs) that are most pronounced during El Niño result in weather patterns that selectively favor drier regions in some locations, and wetter regions elsewhere, as storm tracks and anticyclones shift. Changes in the land surface—whether caused by humans or by the changing climate—can produce amplifying effects, especially in summer. In models, soil moisture is an important feedback, but most models do not allow vegetation and ecosystems to evolve other than as specified by season. As a result, the full response to climate variations and change is not apt to be simulated, although work is progressing on developing dynamic vegetation models.

Meeting presentations illustrated how several improved climate models now suggest that major droughts, such as those during the Dust Bowl and in the Sahel, can be simulated in atmospheric models by specifying the SSTs, suggesting that they may have some predictability [e.g., Giannini et al., 2003]. These studies also indicate that changes in vegetation and land use are much less likely to be a fundamental cause of droughts in these two cases, but rather, represent strong feedbacks that may extend the duration of drought.

Key areas of SST change include the warming of the tropical Indian Ocean, the cold phase of the Pacific Decadal Oscillation (PDO), inter-hemispheric SST differences, and Atlantic SSTs. As some changes in SSTs in recent decades are linked to global warming and human influences, are particular regions already at an increased risk of drought due to human activities?

Wide-ranging discussions at the meeting also focused on definitions of drought, how good the observational record is and how to improve it, the role of external forcings (such as the Sun and volcanoes), internal forcings (such as SSTs and land surface properties) and human influences, and linearity of records. The paleo-record discussion centered on replication of records, the spatial distribution of sites, improving chronologies and temporal resolution, data limitations, uncertainty and errors affecting the validity of paleoclimate data, implicit time-averaging of coarse-resolution paleo-records, calibration and verification issues, difficulties with interpretation of isotopic indicators, and whether it is possible to get at intensity, frequency, amount of precipitation, as well as phase.

It was noted that the direct relevance of the glacial-era record to abrupt climate change is hard to defend, as conditions today and in the future are or will be very different. Examples of recent, relevant, abrupt change in the instrumental record include the 1960s Sahel drying and the 1976 climate shift in the Pacific and ENSO. More significant abrupt shifts in North American and North African hydrologic regimes occurred in the past as well. The feedback from vegetation changes, which was highlighted in the meeting, may be among the non-linear factors involved in abrupt change [see also Alley et al., 2003]. It is expected that unanticipated drought will be a feature of climate in the near future, particularly given continued global warming.

Acknowledgments

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References

Awaiting Halley’s Return

PAGE 26

When Comet Halley perihelioned in early 1986, there were people still around who had witnessed its previous 1910 apparition. (Then there is Mark Twain, who was born under the comet in 1835, wished for his demise upon its return, and died one day after it perihelioned in 1910! I so enjoyed my 1986 view of Halley, and I decided I would like to be among those who see it again when it perihelions in 2061. The big problem with this ambition is that I would need to live to a Guinness Book of World Records age of 131 years. Now, thanks to Randy Showstack’s In Brief news note, “Farthest, faintest detection of a comet” (Eos, 16 September 2003), I have been handed a fallback position which, literally, I may be able to live with: a telescopic photo of Halley at aphelion.

Showstack reported that, using the three 8.2-m telescopes of the European Southern Observatory (ESO) in Paranal, Chile, scientists will be able to observe Halley all the way through its 76-year orbit, including when it aphelions in December 2023. Since I was born mid-December 1930, it will not then be impossible to attain 92 or 93 years, depending on the comet’s exact moment of aphelion. If I’m too blind to see ESO’s photo of Halley heading back, I at least hope to be able to throw an aphelion party and alert my grandchildren to begin preparing for Halley’s 2061 return.

—HERMAN M. HEYN, Baltimore, Md.

BOOK REVIEW

The Sun’s Surface and Subsurface. Investigating Shape and Irradiance

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JEAN PIERRE ROZELOT (EDITOR)


PAGE 32

Since the Sun’s radiative output establishes the Earth’s thermal environment, knowing the source and nature of its variability is essential for understanding and predicting the interactions in the Earth-Sun system, among which are climate changes and the energy balance, photochemistry, and dynamics of the middle and upper atmosphere. The Sun’s Surface and Subsurface brilliantly demonstrates how precise measurements of the Sun’s properties, such as the solar diameter, oblateness, irradiance, and oscillation frequencies of normal modes provide insight into the structure and dynamics of the deep interior and the physical mechanisms of solar variability.

This relatively compact book provides a comprehensive review of the basic principles, methodology, and tools for studying the solar variability. The main focus is on measurements and interpretation of the solar properties rather than on theory. It provides both an excellent introduction to the field and an exciting review of the recent advances in solar observations from the ground and space.