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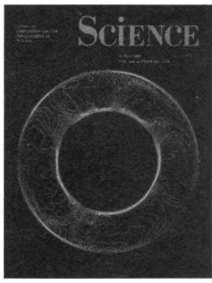

COVER Contours of constant entropy in a cross section of a spherical shell in which thermal convection in the mantle is numerically simulated. The shell is uniformly heated along its inner boundary. Red and yellow contours show hot upwelling currents; light and dark blue contours show regions of relatively cold downwelling currents. Upwelling occurs in columnar plumes and downwelling occurs primarily in planar sheets, similar to upwelling and downwelling in the earth's mantle. See page 950. [Image was made on a DICOMED D48CR film recorder from numerical data generated on a CRAY XMP-48 at the San Diego Supercomputer Center by D. Bercovici, G. Schubert, and G. A. Glatzmaier]

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Earth Observations from Space

For most of its existence the National Aeronautics and Space Administration (NASA) has emphasized projects other than detailed exploration of Planet Earth. But public concerns about the consequences of human activities on our habitat are forcing consideration of a shift in relative priorities. The discovery and confirmation of chlorofluorocarbon effects on polar ozone have lent added emphasis to the need for profound understanding of factors affecting global change.

In testimony before a Senate committee, Lennard A. Fisk, Associate Administrator of NASA for Space Science and Applications, has outlined some of NASA's present rationale and plans. He reminded the committee that human activities were altering the composition of the atmosphere and destroying tropical forests. Consequences from these trends are expectable. But what is not known is how much and when. Modelers have attempted to find the answers, but they have been dealing with incomplete data. As a result, they cannot predict the magnitude and timing of any global warming accurately. Various global circulation models differ by 50% in the predicted temperature rise for a doubling of atmospheric CO_2 and by a factor of 2 for changes in precipitation. The models differ even more in their predictions of regional and seasonal climate changes.

Fisk stated that the models fail because our knowledge of earth processes is insufficient. The modelers are not yet able to include major feedback phenomena. One of these is the effects of clouds, which can either warm or cool the global climate. Global warming is projected to lead to more clouds. Recent analysis of data collected in April 1983 has shown that cloud cover at that time resulted in a cooling of the earth by 15°C, or about three times the amount of warming predicted to accompany a doubling of CO_2. A better understanding of natural variations in climate and of mechanisms of global response to greenhouse gases is needed.

NASA has under construction three satellite projects that will provide some data on global change. One, to be launched in 1991, will measure chemistry and dynamics of the upper atmosphere, including a complete global set on the ozone layer. Another satellite (1992), a joint project with France, will measure with great accuracy the height of the world's oceans from which global ocean circulation can be deduced. A third project (1994) involves equipment to be flown on a Japanese satellite to measure wind stress on ocean surfaces.

NASA is engaged in planning for an extensive, integrated set of measurements to be obtained by an Earth Observing System. Major components of the system would be polar-orbiting satellites equipped with instrument packages capable of monitoring in detail terrestrial, oceanic, and atmospheric phenomena. The first satellite of a series would be launched in 1996. About 5 years of preliminary studies for the system have already been conducted. Most of the sensors are under development. The large number of instrument packages have impressive capabilities. As one example, the High-Resolution Imaging Spectrometer is designed to acquire simultaneous images in 192 spectral bands in wave lengths between 0.4 and 2.5 micrometers. Observing reflected solar illumination with this kind of resolution will make possible detailed identification of minerals and soils, examination of suspended sediments and phytoplankton in coastal and inland waters, estimation of grain size of snow and its impurities, and study of biochemical processes in vegetation canopies.

Another package uses lasers to measure atmospheric water vapor, surface topography, atmospheric scattering properties, and tropospheric winds. Synthetic aperture radar will create images of land, ocean, and ice surfaces during cloudy weather or at night.

The Earth Observing System will involve substantial international collaboration both in the design of instruments and the manufacture of their satellites. The cooperation of many countries in collecting ground truth will be essential. Personnel of other government agencies as well as thousands of academic scientists will participate in using information from the satellites. Enormous data streams and their storage and analysis will challenge human capabilities. But from this complex activity will come a vastly enhanced capability to understand and predict earth processes.—PHILIP H. ABELSON