duces not only time-variable gravity, but also gravitational core-mantle coupling and thus the Earth's rotation variation. They are expected to further facilitate multidisciplinary studies of core dynamics and interactions of the core with other components of the Earth.

U33A-05 1430h INVITED

Geodetic Implications of Mass Transfer in the Deep Earth

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We review a variety of possible mass motions within the Earth that might have observable geodetic consequences. Of the wide range of possible motions, there are some with well-modeled and observed effects, e.g. the rotational wobble of the fluid core (the Free Core Nutation). Many others, e.g. the translational triplet of the inner core, rotational wobbles of the inner core (the Free Inner Core Nutation and Inner Core Wobble), and effects due to wave motions within the fluid core, have uncertain periods and marginal possibilities of being observed. This paper will present the current situation with respect to all mass changes that have been proposed, and provide estimates of the surface effects that appear either as changes in gravity or in rotational angular velocity of the Earth. Of particular interest are the inner core motions, high frequency internal gravity waves, and exchanges of angular momentum between the mantle and the inner core (due to its triaxiality). All these have periods in the range of days to a few years, and thus observable in principle both through gravity and rotation. At longer periods, gravity loses its observational power in favor of measurements of Earth rotation. The challenge is not only observational but also theoretical, because of uncertainty in properties such as the radial density profile and lateral density changes below the core mantle boundary.

U33A-06 1445h INVITED

Hydromagnetic Oscillations of the Earth's Core on Decadal and Interannual Timescales

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All observations of the properties and dynamics of the Earth's core are, by necessity, indirect. Useful sources of data include geomagnetic variations arising from flow within the fluid core, variations in the length of day, and changes in the gravity field. Interpreting this information relies on models to relate the observations to physical processes in the core. We address the need for better models by developing a new theoretical framework to describe hydromagnetic waves in the core (torsional oscillations) and the accompanying motion of the mantle and inner core. The coupled motion of the core and mantle can be decomposed into an infinite set of normal modes. The frequency and spatial form of the normal modes depend on the physical properties of the core (including the internal structure of the magnetic field), whereas the modal amplitudes are related to the excitation source (which depends on the dynamics of the convective geodynamo). The model can thus be used to constrain both physical properties and dynamics of the core-mantle system. For example, the gravitational coupling that arises from the aspherical core-mantle and inner-core boundaries is found to be capable of explaining core-mantle angular momentum transfer observed as decadal and interannual length-of-day variations.

U41A CC: 517 A Thursday 0830h

Union Frontier Lectures II

Presiding: **S King,** Purdue University; **W R Peltier,** University of Toronto

U41A-01 0830h

Advances and Challenges in Hydrogeophysics

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It is widely recognized that natural heterogeneity of hydrogeological parameters control the infiltration and spread of water and contaminants in the subsurface, and that the range of spatial scales associated with heterogeneity is typically great. Conventional wellbore sampling methods, which are used to characterize heterogeneity, are invasive and often reflect only very localized conditions, which may not capture key information about field-scale heterogeneity. Similar to how medical imaging procedures have reduced the need for invasive surgery, geophysical methods hold promise for improved and minimally invasive characterization of the subsurface. The field of hydrogeophysics has developed in recent years to investigate the potential that geophysical methods hold for providing quantitative information about subsurface parameters or processes. Geophysical methods entail the measurement of subsurface properties or contrasts of properties; from these measurements, the nature and distribution of subsurface materials can often be deduced. Many advances in the last decade have illustrated the promise that geophysical methods have for providing subsurface stratigraphic information, for estimating hydrogeological properties, and for monitoring hydrological processes. Such advances include: an improved understanding geophysical responses in the 'softer' sediments characteristic of many near subsurface environments, improved digital technology for acquisition, improvements of many geophysical methods for near-surface data acquisition and processing, and improved computational speed and capabilities associated with processing, inversion, modeling and visualization of geophysical data. However, there are many obstacles that still hinder the routine use of geophysics for hydrogeological characterization. Some of the key hydrogeophysical challenges include the integration of geophysical and hydrological measurements, development of relationships to link the geophysical and hydrogeological parameters, and associated scale and uncertainty issues. This talk, presented on behalf of the AGU Hydrogeophysics Technical Committee and collaborators, will focus on illustrating the benefit of including geophysical data into the subsurface characterization and monitoring process, and on discussing current limitations and future trends in the emerging discipline of hydrogeophysics.

U41A-02 0915h INVITED

Recent Changes in Canada's Arctic Glaciers

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Canada's Arctic islands contain over 110,000 km2 of ice caps and glaciers, the largest area of land ice in the world outside Antarctica and Greenland. This region is projected to experience summer warming of 1-4°C over the next century due to the build-up of greenhouse gases in the atmosphere. The small ice masses in this region are likely to respond more rapidly to this warming than the larger Greenland ice sheet, and they may contribute appreciably to sea level changes over the next century. Glacier mass balance in the region has been persistently negative over the past 40 years. On Devon ice cap, the mass balance of the accumulation zone has become progressively more positive over that period, while that of the ablation zone has become progressively more negative. This suggests that the hydrological cycle in this part of the Arctic has become more vigorous over time. Balance fluxes computed for Devon ice cap were compared with observed fluxes (determined from ice thickness and surface velocity measurements derived from airborne radio echo sounding and SAR interferometry respectively). This comparison suggests that, over most of the ice cap, accumulation areas are thickening at rates of up to 0.15 m a-1, while ablation areas are thinning at rates of up to 0.8 m a-1. The exception is the southeast sector of the ice cap where accumulation areas appear to be thinning at up to 0.3 m a-1. Since 1960, the extent of land ice cover in the Arctic islands has decreased by around 1.8%. Rates of change are largest along the northern and southern coastal fringes of the Arctic Archipelago and lowest in interior regions. The margins of larger ice caps and glaciers terminating on land show little change. Small ice caps and tidewater-terminating outlet glaciers are most strongly affected. This suggests that iceberg calving may have contributed significantly to mass loss in some regions. For Devon ice cap, the calving contribution may be as large as 35%. Volume-area scaling techniques have been used to make a preliminary estimate of the ice volume loss associated with the reduction in ice-covered area. The potential contribution to global sea level is on the order of 1.5mm for the period 1960-2000. A significant number of glaciers show evidence of changes in flow regime, and such changes have resulted in both advances and retreats of glacier margins. Whether these flow regime changes represent normal surge-type behaviour or a response to climate forcing is not yet clear.

U42A CC: 517 A Thursday 1030h

Union Frontier Lectures III

Presiding: **S King,** Purdue University; **W R Peltier,** University of Toronto

U42A-01 1030h

Cycles, Cycles Everywhere - Corals, Coccoliths, and Climate

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Critical to our understanding of both past and future climate change is the biogeochemcial cycle of carbon on Earth. This is popularly recognized in the context of the creation and destruction of solid organic matter such as vegetation and fossil fuels, which has a clear and intuitive relationship to the amount of carbon dioxide in the atmosphere. Less widely recognized is the cycling which involves solid inorganic carbon as carbonate minerals - the most abundant form of carbon present at or near the surface of the Earth, and one with a distinctly counter-intuitive relationship with atmospheric CO2. For instance, changes in the rate of production of coral skeletons may have played a role in Holocene climate change, but with increased carbonate carbon removal driving atmospheric CO2 higher and not lower. The carbonate skeletons produced by some species of plankton in the open ocean are also critical to the climate system. The sinking of these skeletal parts is currently suspected to be important in helping to transport organic matter to depth and thus temporarily isolating this carbon from the atmosphere. The deposition of plankton-derived carbonate to the sediments of the deep-sea also helps regulate atmospheric CO2 but on thousand year time-scales, and will play a key role in the eventual removal of fossil fuel carbon from the atmosphere. However, there is a growing awareness that carbonate production by plankton may be severely diminished in the future. Maybe the cycle of carbonate on Earth could be re-set to how it operated over two hundred million years ago. Here I review some of the current areas of interest in global carbonate cycling, particularly its relationship to climate change and to fundamental moments in the evolution of life.

U42A-02 1115h

From Core to Solar Wind: Studying the Space Environment of Planets

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Space physics permeates studies of the planets - from the magnetic field generated in a planetary core, through the charged particle bombardment of surfaces, the heating, excitation and ionization of an atmosphere or corona, to the acceleration of ions and electrons trapped in a planet's magnetosphere. This presentation provides an introductory overview of the space environment of planetary objects - from giant planets to tiny comets. The talk highlights three cases that illustrate the range of issues and applications of planetary space physics. (1) How has the solar wind interaction with Mars' strong, patchy remnant magnetization affected the loss of water? (2) How does the activity of volcanoes on Io trigger dynamics of the vast magnetosphere of Jupiter? (3) How could measurements of particles and fields by the Galileo spacecraft as it flew past Ganymede and Europa tell us that former has a liquid iron core and the latter a layer of liquid water?