U24A-04 1615h

A Proposed Arctic Ocean Field Program During the International Polar Year 2007-2008

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The Arctic Ocean represents a glaring void of measurements appropriate for monitoring and understanding the climate changes currently occurring in the Arctic region. We propose a field program in the central Arctic Ocean to develop and improve methods for the long-term monitoring of the Arctic atmosphere, ice, and ocean and the interactions among them, and to study physical processes crucial to the regional climate change. The approach will include developing and evaluating methods by which long-term satellite-, surface-, and ocean-based measurements of the thermodynamic and kinematic properties of the atmosphere, ice, and ocean can be integrated to measure key parameters with accuracies necessary to detect climatic change, to attribute responsibility to the processes causing this change, and to evaluate the role of anthropogenic sources in this change. Key measurements include the atmospheric circulation above and within the atmospheric boundary layer, cloud macro and microphysical properties, atmospheric aerosols and chemical constituents, all components of the energy budget of the pack ice including the oceanic heat flux, and the pack ice mass balance. Many of the techniques to be developed will likely use in-situ surface and ocean-based measurements to evaluate and improve the accuracy of the satellite-based measurements. These measurements will generally integrate existing technology, though some will require technological development as well. Many physical processes over the pack ice are different than those over the circumpolar land areas where SEARCH (Study of Environmental Arctic Change) intensive observing sites are being established. Observations at the land sites are largely influenced by processes forced by coastal gradients or by orography, and are much less influenced by the oceanic heat source omnipresent over the Arctic Ocean. The proposed pack ice field program will make measurements specific to processes important for climate models and that are unique to the pack ice environment. The long-term utility of such process studies comes from improving numerical models through improved parameterizations, using the detailed process observations for validating numerical models, and enhancing the conceptual understanding of the pack-ice environment. We propose that this ocean deployment be undertaken with support of at least one icebreaker and that the deployment ideally last a year. The successes of recent field programs demonstrate the logistical viability of such a project. This proposed field program is an appropriate contribution to IPY2007 because it will provide 1) short-term, detailed measurements at a point in a crucial but data-sparse region of the Arctic during the IPY, 2) a long-term legacy by developing long-term measurement methodologies and model improvements, and 3) a direct and substantial benefit to the ongoing SEARCH and CliC (Climate and Cryosphere) programs.

U24A-05 1630h

Capturing Large-Scale Change in the Arctic Ocean and Cryosphere

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Dramatic changes in the Arctic have been documented over the past few decades in the ocean and ice cover that are attributable to atmospheric forcing and longer-term climate change. The polar regions are the most sensitive to changes in global climate and the oceanographic, cryospheric, and atmospheric changes noted there could be harbingers of dramatic global change. The obstacle to completely understanding the nature and genesis of the change is the difficulty of adequate sampling as a result of logistical problems associated with the year-round ice cover. Advances in satellite measurement have greatly expanded our monitoring capability; however, to be fully utilized, these measurements must be calibrated and validated with surface measurements. The Naval Research Laboratory has developed a suite of tools to provide a "snapshot" of the state of the ocean and cryosphere over large regions. We propose to use these tools to help better understand Arctic changes for the International Polar Year effort. Using long-range aircraft, we are able to measure ice freeboard with radar and laser altimeters, sample temperature and salinity (T&S) of the water column using expendable bathythermographs (XBT) and CTD profilers, and calculate dynamic sea-surface height (SSH) by steric leveling determined from XBT and XCTD data and by comparison with our gravimetric geoid. Synoptic measurements of ice freeboard, water column T&S, and dynamic SSH can be made over large grids to provide baselines of these quantities which can be re-measured to provide time series of change. This information could be assimilated into models of ocean circulation and climate change and used to calibrate and validate ice-freeboard measurements of concurrent ice-observing satellites.

U24A-06 1645h

An Uninhabited Aerial Vehicle (UAV) Concept for Low-Altitude Geophysical Exploration in Antarctica

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A concept for a small, agile UAV platform for conducting geophysical mapping in the IPY and beyond has been explored. We have developed a framework concept for community input and feedback based on a low-cost, autonomous vehicle with onboard high-precision inertial navigation that performs vertical take-off and landing (VTOL). The vehicle we have focused on is the GoldenEye-100, developed by Aurora Flight Sciences Corp. (www.aurora.aero), which can carry a lightweight payload and achieve a range of 300-500 km (roundtrip). The VTOL capability would potentially allow flights to be launched from the helicopter deck of an icebreaker, and would remove the logistical burden of ensuring a hazard-free runway on the ice. Vehicle operations are controlled using a portable ground station. A payload concept has also been developed, indicating that the vehicle could easily carry a lightweight, compact magnetometer, camera and laser altimeter. Instruments developed for space missions exist that would enable a high performance system to be carried within the 10 kg payload envelope. A gravity measurement system and radar sounder are also considered. A capable UAV platform for geophysical mapping would complement the existing aerial research platforms in Antarctica and has the potential to accelerate the exploration and monitoring of critical but remote areas in a cost-effective manner.

U31A CC: 517 A Wednesday 0830h

Time-Variable Gravity: Observation, Modeling, and Interpretation I

Presiding: **J Hinderer,** Ecole et Observatoire des Sciences de la Terre

U31A-01 0830h

Status and Early Results from the GRACE Mission

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The objective of Gravity Recovery and Climate Experiment (GRACE) is to map the global gravity field with unprecedented accuracy over a spectral range from 500 km to 40,000 km. The measurement precision supports gravity field solutions in this frequency range whose accuracy is between 10 and 1000 times better than our current knowledge. The mission profile calls for a gravity field solution with this accuracy every thirty days. Accurate measurements, with this spatial and temporal resolution, will allow studies of the gravitational signals associated with the seasonal mass exchange between the Earths solid, ocean and atmospheric system components. The two Grace satellites, which were launched on March 17, 2002, are completing their second year of operation. The initial data has provided a significant improvement in the mean field and, for the first eighteen months of the mission, the results have demonstrated the ability to discriminate the time varying gravity signal associated with the seasonal redistribution of the mass in the earth's dynamic system. This presentation will describe the Status of the Project, including the plans for calibration and validation, the characteristics of the solutions and the methods used to account for high frequency mass variability associated with the atmosphere and oceans,

URL: http://www.csr.utexas.edu/grace/

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U31A-02 0845h

GRACE: From Measurement to Gravity

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The twin satellites of the US/German GRACE mission are now beginning their third year in orbit and produce nearly continuous measurements, which allows the estimation of monthly and mean global gravity field solutions with unprecedented accuracy. In this talk the focus will be on the GRACE science measurements used for the gravity field determination process. A review will be given of each measurement and its contribution to the overall process of determining the gravity field. Furthermore, the unique aspects associated with the GRACE science measurements will be highlighted and how these impact the gravity result. Also, other non-gravity science possibilities from the GRACE science measurements will be discussed, for example aeronomy and ionospheric studies. Finally a status will be given of the Level-1 processing, which processes raw GRACE science measurements into the input data for the gravity field determination process called Level-2.

URL: http://www.csr.utexas.edu/grace

U31A-03 0900h

Geodetic characterization of the monthly GRACE gravity field estimates

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The joint NASA/DLR Gravity Recovery And Climate Experiment (GRACE) was launched in March 2002, with the goal of mapping mean & time-variable components of the Earth's gravity field. The mass balance and variability within the Earth system can be traced by a sequence of monthly gravity field estimates. For this purpose, sequences of monthly gravity field spherical harmonic coefficients, spanning between launch and end of 2003 were derived from GRACE science data, and were made available to the GRACE Science Team. The presentation starts with an overview of the relationship of the GRACE gravity estimates to the omissions and errors in background models used in GRACE data processing at UTCSR. We then present the current assessment of the errors in these models. The patterns of errors are discussed both spectrally (by spherical harmonic degrees) and by their geographic distribution. For various levels of spatial smoothings,

the geographic patterns and sizes of the geoid height errors are contrasted with the variability evident in the sequence of monthly gravity estimates. For the low degree spherical harmonics, the relative significance of errors in background gravitational force models used in GRACE data processing is discussed in relation to the size of the signal from monthly fields. These results should aid in geophysical interpretation of the GRACE data products, and in its comparison to results from other geodetic techniques.

U31A-04 0915h INVITED

Hydrological Information Inferred From GRACE Estimates OF Time-Variable Gravity

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Data from the GRACE satellite mission are now being used to generate regular, monthly solutions for the Earth's gravity field. The time-variable gravity fields derived from these solutions can be used to study such things as changes in the large-scale distribution of water stored on land and in the ocean, mass variations of the polar ice sheets, and post-glacial-rebound in the solid Earth. In this talk we discuss the quality of these initial GRACE fields, and we use the time-variable results inferred from these fields to estimate hydrological signals over large regions. We compare these estimates with the output of independent hydrological models, to help assess both the GRACE data and the models.

U31A-05 0930h

Water Storage Variations and Associated Errors Estimates from GRACE

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Four different basin functions are designed to estimate water storage variations from GRACE, and associated errors (measurement, leakage and atmospheric pressure errors) are evaluated: one of the basin functions is changed monthly using knowledge of true load variation. To test basin functions performance, Stokes coefficient variation from land and oceans models are synthesized, and error levels 50 and 100 times greater than the nominal GRACE error estimate are used to corrupt the Stokes coefficients. Five different basins (Amazon, Mississippi, Lena, Huang He and Oranje) are selected in this experiment representing a variety of basin sizes, locations and signal variance. In the large basins (Amazon, Mississippi and Lena), water storage variations are recovered successfully with the two error levels. As error level changes from 50 to 100 times, the shapes of basin functions are changed, yielding less atmospheric pressure error and more leakage error. Amplitude spectra of measurement and atmospheric pressure errors have different shapes but the best results are obtained when both are used.

U31A-06 0945h

Annual Gravity Field Variation from GRACE - Initial Analysis.

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GRACE is currently mapping the Earth's gravity field in space and time with un-precedented resolution and accuracy. The first 11 monthly global gravity fields solutions, recently being released to the GRACE science working team, have been used to study the long wavelength component of the annual gravity variation (Spherical harmonic deg. 10). The GRACE data shows an annual component in the gravity field peaking at 7.1 microGal over the Amazon Basin. Over the central southern Africa amplitudes peaks at 4.2 microGal and over Bangladesh at 3.4 microGal. The peaks follow the solar Equinoxes being in opposite phase on the two hemispheres. The annual component in the gravity field is compared with gravity changes due to a simple water storage model based on simultaneous hydrological NCEP reanalysis data. This model peaks at 6.6 microGal over the Amazon Basin. Comparisons with other models and in-situ data have also been performed to validate the findings. The spatial correlation between the amplitude of the annual gravity signal in GRACE and hydrology computed over 10 degree zonal latitude bands is higher than 80 percent everywhere.

U32A CC: 517 A Wednesday 1030h

Time-Variable Gravity: Observation, Modeling, and Interpretation II

Presiding: **B F Chao,** NASA Goddard Space Flight Center**; J Hinderer,** Ecole et Observatoire des Sciences de la Terre

U32A-01 1030h

First Results From GRACE Time Variable Gravity Field in Europe: a Comparison With Surface Gravity Changes Observed by Superconducting Gravimeters and With Hydrology Model Predictions

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We investigate the time-variable gravity changes in Europe retrieved from 11 initial GRACE monthly solutions provided by UT-CSR, ranging from April 2002 to October 2003. We first infer from each of the satellite solutions (expressed in spherical harmonics to degree 120) gravity anomaly maps according to various truncation levels. An empirical orthogonal function (EOF) decomposition of the time-variable gravity field is done to exhibit the main spatial and temporal characteristics. We show that the dominant signal is found to be annual with an amplitude and a phase both in agreement with predictions in Europe using snow and soil-moisture variations from recent hydrology models. We compare these GRACE gravity field changes to surface gravity observations from superconducting gravimeters of the GGP (Global Geodynamics Project) European sub-network, with a special attention to loading corrections. Initial results suggest that all 3 data sets (GRACE, hydrology and GGP) are responding to annual changes in near-surface water of a few microGal (at length scales of 1000 km) that show a high value in winter and a summer minimum. To this level of accuracy, and noting we have as yet insufficient data to support a strong conclusion, the calibration and validation aspects of the GRACE data processing would appear to be tentatively confirmed.

U32A-02 1045h

Variation of Ocean Bottom Pressure in Global Ocean Models, and Compared with Satellite Measurements of Dynamic Oblateness J_2

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The time series of J_2 produced from Lageos measurements by Cox and Chao is a measure of fluctuations in the mass distribution of the earth-ocean-atmosphere-hydrosphere-cryosphere system. At periods shorter than annual, after subtraction of the atmospheric contribution, the ocean is expected to be a significant contributor to this signal. We show here, using a global barotropic ocean model, that a significant part of the observed J_2 signal is due to the ocean, and is related to coherent circumpolar modes in both the Arctic and Antarctic. At periods shorter than about 7 days we also show that ocean loading and self-attraction effects have a significant impact on predictions of non-tidal ocean pressure fluctuations, although the absolute value of these fluctuations is generally small (less than 1 cm of water). At longer timescales, we use diagnostics from the HADCM3 climate simulation to identify the major global ocean modes of pressure fluctuation, identifying in particular a long period mode in which water moves between the Atlantic and Pacific oceans, which shows correlations with both model J_2 and El Niño time series.

U32A-03 1100h

Global Ocean Mass Variations from GRACE Gravity Fields

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A time-series of mean water mass variations over the ocean is computed from the initial release of monthly GRACE gravity field models, using an optimal averaging kernel. The time-series is used to study non-steric global mean sea level variations and is compared to a time-series constructed from altimetry corrected with a climatological steric signal. Seasonal signals are clearly apparent in both time-series, with similar amplitudes and phases. Although the time-span of the GRACE measurements is only slightly longer than one yearly cycle, we will also examine residuals in order to quantify a bound on the non-seasonal ocean mass signals during the time period.

U32A-04 1115h

Decadal Ocean Bottom Pressure Variability and its Associated Gravitational Effects in a Coupled Ocean-Atmosphere Model

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The launch of the GRACE satellite mission in March 2002 has made timely the study of geophysical processes that redistribute the Earth's mass. This study uses the Hadley Centre coupled ocean-atmosphere model HadCM3 to examine the ocean's role in mass redistribution. This state-of-the-art model simulates a realistic present day climate, and both the thermohaline circulation and El Nino are well represented. From the model output we derive a one-hundred year time-series of global ocean bottom pressure. The length of this time-series makes it well suited to the study of low-frequency bottom pressure variability. After removal of the mean seasonal cycle, the leading empirical orthogonal function of bottom pressure is a striking, basin-wide, oscillation between the Atlantic and Pacific Oceans. Statistical analysis of the forcing fields suggest that this mode is primarily a wind driven phenomenon. This was confirmed by performing experiments in which an ocean-only model was forced by anomalous winds from HadCM3. Next, the gravitational effects of this mode are considered. A surprising result is that oceanic mass redistribution can lead to decadal linear trends in the zonal harmonic J_2, with a slope of approximately one-third that observed in geodetic measurements of J_2, and which is thought to be due, primarily, to post glacial rebound. Although there is tantalising evidence that such a low-frequency mode of variability may actually occur in the physical ocean, the indirect nature of the evidence means no certain conclusions can yet be drawn. Thus, we consider the potential of GRACE to detect this low-frequency oceanic mass redistribution amongst the many other factors affecting the Earth's gravitational field.