OS42J HC: 318 B Thursday 1330h

Physics and Biology of Antarctic Continental Shelf Waters II

Presiding: **J Torres,** University of South Florida**; P Wiebe,** Woods Hole Oceanographic Institution Woods Hole

OS42J-01 1330h

Decadal Variability of Antarctic Sea ice and Surface Temperature

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The seasonal variability of the Antarctic sea ice cover is among the largest of any parameter on the surface of the earth. Large interannual variability is also expected, especially in light of the occurrences of anomalous ENSO events in recent years and an apparent global warming that is expected to be amplified in the polar regions. The results of trend analysis using two decades of passive microwave satellite data, however, show a remarkably stable sea ice cover with the ice extent and ice area changing only by 0.4 +/- 0.3 %/decade and 1.7 +/- 0.3 %/decade, respectively, over the entire hemisphere. Regionally, however, although the ice cover appears stable in other regions, it has been decreasing at a rate of -8.1 +/- 1.4 %/decade in the Bellingshausen/Amundsen Seas while it is increasing at an almost equal but opposite rate of 7.0 +/- 1.0 %/decade in the Ross Sea. The impact of sea ice on the ocean and the atmosphere is well known and such trends would imply changing climates in the two regions. Surface temperatures derived from satellite infrared data during approximately the same period have also been examined and are shown to have good but negative correlation with ice extent and ice concentrations. Where there are large positive surface temperature anomalies, large negative anomalies in the sea ice cover are also observed. More positive temperature anomalies in the Bellingshausen/ Amundsen Seas region are also observed in the last few years than in the previous years causing constant retreat in the ice cover and the disappearance of much of the multiyear ice cover in the region. The slight (but insignificant) positive trend in the ice extent for the entire hemisphere is consistent with a slight (but insignificant) negative trend in surface temperature in the Antarctic continent over the same period. A high coherence of the Antarctic Circumpolar Wave pattern and ENSO indices with the variability of the sea ice cover and surface temperature is also observed and the implications using longer records of station temperature data will be discussed. The summer conditions are also examined in detail since the trend in the yearly minimum extents is about -3.6 %/decade.

OS42J-02 1345h

Hydrographic Distributions in Marguerite Bay: Seasonal and Oceanic Effects

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Hydrographic measurements from two cruises that took place on the western Antarctic Peninsula continental shelf from April to June and July to September of 2001, provide a description of changes in water mass distributions and circulation patterns that occurred in the Marguerite Bay region as a result of seasonal variability and offshore forcing by the southern boundary of the Antarctic Circumpolar Current (ACC). The primary seasonal changes in water mass properties is the reduction in Antarctic Surface Water and replacement by a thick Winter Water layer. The primary effect of the ACC is to pump Circumpolar Deep Water (CDW) onto the continental shelf below 200 m at specific sites that correspond to bathymetric features, such as the Marguerite Trough. The pulse of CDW that was observed in austral fall had entered Marguerite Bay by the austral winter and a second CDW intrusion was beginning at the shelf edge. These observations suggest that onshelf intrusions of CDW may be a frequent occurrence in this region, which has implications for heat and salt budgets. The hydrographic distributions also show a narrow southwestern flowing coastal current that enters Marguerite Bay around Adelaide Island and exits around Alexander Island. This current was well developed in austral fall but appeared to be absent in the austral winter. This current may be the result of seasonal buoyancy forcing .

URL: http://www.ccpo.odu.edu:80/Research/globec_menu.html

OS42J-03 1400h

Mesoscale Circulation in George VI Sound, Antarctica

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A process study of physical and biological fields in George VI Sound was conducted between May 14 and 16, 2001 as part of the US GLOBEC Southern Ocean Project. High abundances of krill and macrofauna were found during our survey. Understanding physical processes and their effects on biological processes in George VI Sound is of importance to understand the winter ecosystem in the Southern Ocean. Temperature, salinity and currents were observed using a CTD and a 153 kHz Narrow Band Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP).

The deep water below 400 m in George VI Sound shows a T-S signature similar to the deep water below 400 m on the shelf. The shelf water follows a deep channel into George VI Sound. At the center of the sound, the water is relatively saltier and denser than surrounding water. Associated with this feature, a clockwise circulation is measured by the ADCP. Conversely, a low-salinity low-density center present at the mouth of the sound produces an anticlockwise gyre. These two eddies, with a horizontal scale of approximately 15 km, dominate the circulation pattern in George VI Sound. The divergence and convergence associated with these eddies are further investigated from CTD and ADCP data, and the vorticity equation.

OS42J-04 1415h

A Model Study of Circulation and Biogeochemical Processes on the West Antarctic Peninsula

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Circumpolar Deep Water (CDW) is a relatively warm, salty and nutrient rich water mass which flows across the shelf break of the west Antarctic Peninsula. This water mass moderates the ice cover through heat flux, provides a relatively warm subsurface environment for some animals and provides nutrients to stimulate primary production. CDW exchange is known to be episodic, but persistent, and is thought to occur at specific locations due to bottom topography. A circulation study using an eddy permitting 3D numerical circulation model analyzes the exchange of CDW. Macronutrients and estimated biological uptake processes are included to analyze nutrient pathways and selection processes that result in diatoms or algae blooms.

We use the Rutgers/UCLA Regional Ocean Model System (ROMS) with a grid resolution of 5 km horizontally and 24 levels vertically. A gridded bathymetry is derived from the Smith and Sandwell bathymetry with modifications around Marguerite Bay from digitized nautical charts (Beardsley). Initial temperature, salinity, nitrate and silicate are derived from the World Ocean Atlas (WOA98). Monthly climatological ECMWF reanalysis wind stress is applied to the top three layers of the model. Ice concentrations are specified using the SSM/I climatology. The COARE bulk flux algorithms are used to compute the model surface heat and salt fluxes, as modified by the sea ice. Vertical mixing in the interior and surface boundary layer uses the K profile parameter (KPP) scheme (modified for the presence of ice). An annual climatology of depth averaged volume transport was estimated from the Orsi et al. (1995) frontal locations. A radiation boundary condition with adaptive nudging (Marchesiello 2000) to monthly climatologies of the tracers and the estimated volume transport is used on open boundaries.

The model circulation compares favorably to general schematics of the flow. The Antarctic Circumpolar Current (ACC) flows along the shelf break, although the model has stronger and less variable circulation than is shown by recent ADCP measurements. A weak, southward coastal flow, which turns into Marguerite Bay and flows cyclonically around the bay, matches the general pattern of recent ADCP measurements (Muench and Padman). Subpycnocline temperature shows evidence of intrusion of warm water from the ACC onto the shelf.

OS42J-05 1430h

Modelling the Mertz Glacier Polynya With the C-HOPE Global Ocean/Sea Ice Model

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The new Arakawa C-Grid version of the Hamburg Ocean Primitive Equation model (C-HOPE) is used to study processes of water mass transformation associated with sea ice formation in the Mertz Glacier polynya system, East Antarctica. The C-HOPE model employs a generalised curvilinear coordinate system that allows for arbitrary placement of the model's poles. Placing a small radius 'south' pole inland of the Mertz Glacier polynya, and a large radius 'north pole' over Eurasia, results in a high horizontal resolution (10-15 km) model of the polynya system. The global set-up has the advantage that open or closed boundaries are avoided.

An initial 20 year simulation with climatological forcing derived from the ECMWF re-analysis demonstrates that the model is capable of reproducing the polynya with sea ice concentrations, thicknesses and growth rates comparable to observations. Brine rejection associated with high sea ice growth rates in the polynya (5-10 m/yr) result in the production of High Salinity Shelf Water (HSSW) in the Adelie depression. The HSSW exits the depression through an outlet at approximately 143 East and mixes with the ambient waters, that include westward flowing Ross Sea Bottom Water, to form Adelie Land Bottom Water (ALBW). It has been suggested that ALBW accounts for roughly 20% of Antarctic Bottom Water production, and it is believed the Mertz Glacier polynya may be a significant contributing source. A second simulation uses NCEP-NCAR daily reanalysis fields for the 1990s as surface forcing. Results from the model are compared with ship based observations made by the Australian ice breaker *Aurora Australis* during austral winter 1998.

OS42J-06 1445h

The annual cycle of surface CO_2 and O_2 in the Ross Sea: A model for gas exchange on the continental shelves of Antarctica

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From the surface data and sea ice concentrations annual sea-air fluxes of CO_2 (-1.5 ± 1.5 mol C m^{-2}) and O_2 (-3.7 ± 3.0 mol C m^{-2}) are calculated and confirmed by a mass balance approach which accounts for the total flux of CO_2 (0.16 ± 0.13 mol m^{-2}) and O_2 (-5.2 ± 0.2 mol m^{-2}) entering the Ross Sea from off the shelf. The mass balance approach assumes that a negligible amount of carbon and oxygen accumulates in the sediments and that all of the gas that ventilates to the atmosphere must be supplied from lower salinity waters entering the Ross Sea from off the continental shelf. Based on this study, a combination of winter sea ice cover and summer primary productivity prevent any significant change in the CO_2 inventory due to gas exchange despite the high partial pressure of CO_2 surface waters (425 uatm) during the winter. Oxygen inventories in the Ross Sea, on the other hand, are significantly increased as a result of gas exchange with the atmosphere due to low O_2 concentrations in the Ross Sea which are 90 umol kg^{-1} below saturation at sea surface temperatures of -1.89 C. The high flux associated with the large sea surface gradient in O_2 is the source of high PO_4* found in deep waters formed along the Antarctic continental shelf.

Based on stability of wintertime CO_2 concentrations and the "ice rectification" hypothesis introduced by Yager et al. (1995), it is projected that with increases in atmospheric pCO_2 and greater seasonal ice

cover, the Ross Sea will become a greater CO_2 sink with time. This analysis also supports the hypothesis that winter ice cover and summer primary productivity at the polar front may have been an important factor contributing to the decrease in CO_2 during the last glacial maximum.

OS42J-07 1500h

CFC Distributions Along the Ross Ice Shelf: Water Mass Structure and Circulation

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Oceanographic stations with CTD and CFC measurements were occupied along the front of the Ross Ice Shelf in the austral winters of 1984, 1994, and 2000. Vertical sections of potential temperature, salinity, and CFCs along the front of the Ross Ice Shelf clearly reveal 4 subsurface water masses: Low Salinity Shelf Water (LSSW), High Salinity Shelf Water (HSSW), Modified Circumpolar Deep Water (MCDW), and Ice Shelf Water (ISW). HSSW is most clearly seen in the salinity distribution as the highest salinity water along the section intensified at the deep western end of the section. LSSW is observed along the bottom in the eastern half of the section. HSSW generally has the highest CFC concentrations of the four subsurface water masses. ISW is clearly delineated as a lobe of very cold water in the center of the section. MCDW is observed as lobes of warmer water to the east and west of the ISW and somewhat shallower than ISW, with the eastern lobe being the most intense. CFC concentrations are lowest in the ISW reflecting isolation of this water from exchange with the atmosphere while residing beneath the Ross Ice Shelf. CFC concentrations are also low in MCDW as the result of mixing between high CFC near surface water and very low CFC Circumpolar Deep Water. The basic structure of the sections was the same for each year, but salinity decreases with time and CFC concentrations increase with time on a section wide basis. The increase in CFC concentration is caused by the increase in the atmosphere and hence in the water. ISW is thought to form mainly from HSSW flowing beneath the Ross Ice Shelf, melting the base of the ice shelf, and then exiting as colder, fresher ISW. The CFC concentrations in HSSW as a function of time were estimated from a box model calculation that included gas exchange as a function of wind speed, ice cover, and exchange of water between Circumpolar Deep Water and the continental shelf and tuned to the measured CFC concentrations in HSSW. The residence time of water beneath the Ross Ice Shelf was calculated using a simple time dependent budget with the HSSW CFC concentration as a boundary condition. A value of about 5 years gives the best overall fit to all of the CFC data. A better fit can be obtained with residence times of 2.5 years prior to 1984, 6.0 years from 1984 to 1994, and 4.0 years from 1994 to 2000. The basal melt rate of the Ross Ice Shelf was estimated from the residence time and the difference in salinity between HSSW and ISW to be 71 km3/yr.

OS42J-08 1535h

Physical-Biological Interactions Influencing the Distribution and Dynamics of Winter Sea Ice Microbial Communities of the Western Antarctic Peninsula

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The distributions and activities of sea ice microbial communities were assessed in the sea ice and water column environments of the Western Antarctic Peninsula centering around Marguerite Bay during the austral fall and winter (April 17-June 3, and July 17-September 1) of 2001. These interdisciplinary studies were conducted to determine how the stocks and dynamics of materials associated with sea ice are linked to oceanographic and atmospheric forcing. Such information is necessary for an interdisciplinary evaluation of the potential for over-wintering krill populations to utilize this over-wintering resource (see http://www.ccpo.odu.edu:80/Research/globec_menu.html for more information regarding the Southern Ocean GLOBEC Program).

The dynamics of the late forming ice cover (formed in Marguerite Bay during late June to early July) were dominated by the dynamic pancake ice cycle that then became strongly influenced by flooding, freezing and snow ice formation (up to 17 cm) associated with high snow deposition (> 20 cm of snow on 35 cm of flat ice). Chlorophyll a was 4 to 50-fold more concentrated (average, 1.04 ug per liter) in the late forming pack ice compared to the water column concentrations that decreased from an average of 0.25 to 0.02 ug per liter from May to July. Although chlorophyll a biomass was low in sea ice compared to other seasons (e.g. chla concentrations > 100 to 1000 ug per liter in spring and summer in the Ross Sea) the relative distribution of biomass reaffirms the seemingly ubiquitous characteristic of ice-covered oceans- that microbes and algae are much more concentrated in ice environments, regardless of season. The dynamics of flood freeze cycles are not likely to have stimulated primary production in the near-surface sea ice habitats (as evidenced by conservative behavior of macronutrients) although the general habitat warming in association with flooding processes likely stimulated heterotrophic production and release of particulate organic matter from ablating ice surfaces. Such sea ice dynamics and links to microbial ecology will continue to be evaluated in context of krill ecology and physiology throughout the upcoming SO GLOBEC studies.

URL: http://www.ccpo.odu.edu:80/Research/globec_menu.html

OS42J-09 1550h

The Role of Antarctic Coastal Polynyas in Southern Ocean Primary Production

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Primary production in Antarctic polynyas (in this context defined as an open water area surrounded by ice) can be very high due to the stability of the water column and high abundance of macronutrients. One of the best understood examples is the Ross Sea Polynya, where annual productivity can be greater than 200 g C/m^2 as compared to typical values of 40-100 g C/m^2 in the open waters of the Southern Ocean. Many other coastal polynyas form in the Antarctic and have the potential for high accumulation of phytoplankton biomass, however, no estimates exist of the contribution by these polynyas to total primary production on the Antarctic continental shelf.

In this study, daily maps of brightness temperature around the Antarctic continent were constructed from Special Sensor Microwave/Imager (SSM/I) microwave data and were further processed using the PSSM algorithm of Markus and Burns (JGR, 1995) to obtain sea ice extent at the needed higher spatial resolution (6.25 km). Phytoplankton chlorophyll *a* was obtained from weekly SeaWiFS ocean color composites and used as input to the primary production algorithm of Arrigo *et al.* (JGR, 1998).

Satellite imagery show that numerous coastal polynyas exist in association with the Antarctic continental shelf. Within each polynya, we will characterize the dynamics of both polynya formation and phytoplankton biomass during the spring and summer for the years 1997-2001. This will allow us to identify those polynyas which exhibit consistently high levels of production and to quantify the degree of interannual variability within each polynya. Finally, the cumulative annual primary production for these polynyas will be compared to estimates of primary production for the entire continental shelf and for all waters south of $50^{\circ}S$ to assess the relative importance of coastal polynyas to Southern Ocean productivity.

OS42J-10 1605h

Winter Foraging Ecology of Crabeater Seals in the Western Antarctic Peninsula

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The Antarctic marine environment undergoes considerable inter- and intra- annual variability, resulting in marked variation in the spatial and temporal availability of prey for vertebrate predators. Crabeater seals offer a unique opportunity to better understand the foraging strategies utilized by marine predators in the face of meso- and fine-scale ecological variability. As part of the US Southern Ocean GLOBEC program we deployed a total of 16 (8 tags during Fall 2001, April-May and 8 during Winter July-August 2001) satellite linked time depth recorders on crabeater seals to monitor their foraging patterns (locations and dive patterns). The seals spent considerable effort foraging, spending more than half their time at depths >6m, and the majority of dives were deeper than 100m. The deepest dive was to 605 m a new record for this species. During the fall seals tagged in Marguerite Bay did not move with the sea ice, but remained near the tagging site, or exhibited directed movements to other regions (e.g. 220km in 8 days). Foraging was concentrated in ice-free waters of the coastal fjords or continental shelf. During the winter when sea-ice formation was greatest the seals exhibited a distinct northerly migration, such that by September only one of the 16 tagged animals remained in the area they were tagged within Marguerite Bay. Most of these animals moved to the North East along the Antarctic Peninsula. One animal moved to Anvers Island some 560 miles away.

OS42J-11 1620h

A Preliminary Analysis of Baleen Whale Distribution Around the Western Antarctic Peninsula in the Austral Fall and Winter

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The International Whaling Commission (IWC) and Southern Ocean Global Ocean Ecosystem Dynamics (SO GLOBEC) program are collaborating on an ecosystem approach to understand baleen whale distributions in Antarctica. A primary research goal is to determine the winter distribution and foraging ecology of baleen whales relative to environmental characteristics and the distribution of primary prey, Antarctic krill, Euphausia superba. Observations from the first year of U.S. SO GLOBEC survey cruises, along the western Antarctic Peninsula near Marguerite Bay (68S, 69W) during April-May and July-August 2001, provide a comprehensive data set that can be used to address physical and biological relationships contributing to baleen whale distribution patterns. Visual cetacean sighting observations were made using standard line transect survey protocols, and data were recorded using the Wincruz Antarctic computer-based tracking program. Sightings data show humpback (Megaptera novaeangliae) and minke (balaenoptera acutorostrata) whales present in the study region in the austral fall and winter. Sighting numbers for both species were nearly equal around Marguerite Bay in late Austral fall. A GIS, using cetacean sightings data and concurrent hydrographic measurements, show whale distributions associated with: 1) the southern boundary of the Antarctic Circumpolar Current, 2) the frontal boundary between intrusions of warm Upper Circumpolar Deep Water and continental shelf water, and 3) the frontal boundary between inner shelf coastal current and continental shelf waters. Cetacean sightings were particularly numerous along the frontal boundary formed as the coastal current exits the southern end of Marguerite Bay. Humpback whales were associated with all three frontal boundaries while minke whales were found only along the continental shelf and coastal frontal boundaries. The correspondence between the cetacean sightings and hydrographic features suggests that the austral winter distribution of cetaceans along the west Antarctic Peninsula is not random, but rather is determined in part by the structure of the physical environment, which in turn determines prey distribution. Continued analyses and collection of cetacean sightings data in conjunction with concurrent prey and hydrographic distributions will allow determination of the causal relationships underlying austral winter cetacean distributions in the Antarctic Peninsula region.

THU

OS42K HC: 318 A Thursday 1330h

Air-Sea Exchange III

Presiding: **R Najjar,** Pennsylvania State University Department of Meteorololgy**; A T Jessup,** Applied Physics Laboratory, University of Washington

OS42K-01 1330h

Control of Inert Gas Saturations in the Deep Ocean by Surface Gas Exchange Processes

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The saturation levels of inert gases in the deep ocean yield important information about processes that were occurring when a water mass was last in contact with the surface. We present recent nitrogen, argon and neon data from Hawaii Ocean Time-series, Bermuda Atlantic Time-series, Kyodo North pacific Ocean Time-series, and the Drake Passage. In the mixed layers of the subtropics, all three gases were supersaturated. However in the colder surface waters and in all the deep water, N_2 and Ar were undersaturated, while Ne remained supersaturated. This suite of gases can provide information about the dominant processes at work during deep-water formation because the different physical properties of N_2, Ar and Ne cause them to react differently to processes of interest. First, the saturations of the low solubility gases (N_2 and Ne) are more affected by bubble-mediated gas exchange. Bubbles may be forced into seawater at the surface by breaking waves or at greater depths by the melting of ice shelves derived from glaciers, which contain air pockets. Second, the solubilities of N_2 and Ar are three times more dependent on temperature, so a warming or cooling changes the saturation of these gases more. Third, the formation and melting of sea ice affects Ne differently because Ne is soluble in ice, while N_2 and Ar are excluded from the ice matrix. Finally, Ne has a larger diffusion coefficient and therefore responds faster to diffusive gas exchange. Using a quasi-steady state model, which incorporates only temperature change and gas exchange by diffusive and bubble-mediated mechanisms, we are able to explain our observations from all locations. This result seems to indicate that temperature change, bubbles, and diffusive gas exchange are the main controls on gas saturations. However, the effects of bubble injection on dissolved gases by breaking waves and by the melting of glaciers are indistinguishable from each other. Likewise, melting of sea ice and rapid cooling of the mixed layer are indistinguishable in the way they affect the saturations of these gases. A mass balance approach constraining the amount of ice melt present in deep waters will be necessary to evaluate whether ice processes are an important control on gas saturations in the deep ocean.

OS42K-02 1345h

The Seasonal Oxygen Budget of a Three-dimensional Marine Biogeochemical Model

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Seasonal oxygen variations have frequently been used to estimate export production and shallow remineralization. It is often difficult, however, to account for the purely physical causes of such variations, including the roles of advection, diffusion and air-sea exchange. Here we use a seven-compartment nitrogen-based ecosystem model embedded in an ocean general circulation model to quantify the relationship between the seasonal net outgassing of oxygen and export production and the relationship between the seasonal drawdown of oxygen in the thermocline and the rate of remineralization. To separate biological and physical influences on the oxygen cycle, two oxygen tracers are used, one linked to nitrogen through fixed Redfield ratios and one driven solely by air-sea gas exchange. Preliminary results suggest that most of the seasonal variability in the air-sea oxygen flux and thermocline oxygen concentration is driven by biological processes.

OS42K-03 1400h

Relationship Between DMS Ventilation and Ocean DMS Pool Viewed in a Coupled Biogeochemical-Ocean Model

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Dimethylsulfide (DMS) is a climatically-active gas produced by oceanic plankton. Its ventilation to the atmosphere constitutes the major natural source of reduced sulfur in marine environment. Sea-to-air flux of DMS depend on wind strength, sea surface temperature, and on the availability of DMS in the ocean surface layer. Current coupled ocean-atmosphere models use constant DMS concentrations, which does not take into account rapid changes in the DMS pool. To investigate the relationship between wind, DMS ventilation rate and the ocean mixed layer DMS reservoir, we performed short sensitivity experiments with a 1-D coupled biogeochemical-ocean model. The model includes a DMS production module with 6 biological compartments (NODEM; Northern Ocean DMS Emission Model) and a state-of-the-art ocean turbulent model (GOTM; General Ocean Turbulent Model). Simulations with theoretical wind scenarios allow us to evaluate the temporal evolution of ocean surface DMS levels and sea-to-air fluxes in the North West Atlantic. The role of wind-induced turbulence on the deepening of the mixed layer and on the replenishment of the subsurface water in DMS is investigated. The impact of the currently used gas transfer models is also tested. The ability of biological processes to replenish the DMS pool after wind events will be discussed.

OS42K-04 1415h

Estimation of Air-Sea Gas Transfer Velocity Using Radar Backscatter From Dual Frequency Altimeters and Conically Scanning Scatterometers for 1993–2000

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An algorithm has been derived to calculate air-sea gas transfer velocity (k) from nadir-looking, dual frequency altimeter radar backscatter. Results from applying this algorithm will be presented as a global, eight year time series (1993–2000). The instruments have been TOPEX and will be Jason-1 altimeters and the initial comparison between the two will provide calibration and validation of this algorithm between different platforms. The time series has a temporal resolution of one month and variability of k on seasonal and interannual time scales will be discussed in light of such physical phenomena as ENSO. Patterns revealed in the spatial resolution of 2.5° permits global to basin scale variations to be observed. We compare the results of this time series to globally distributed, marine in situ time series stations by applying the more traditional wind speed-gas transfer velocity parameterizations to the wind speed estimates made by the National Center for Environmental Prediction reanalysis project for the same period and locations. The theory for calculating gas transfer velocity from radar backscatter will be discussed. The improvement of the space and time scales resolved, through extension of the altimeter algorithm to a conically scanning scatterometer (QuikSCAT), will be explored.

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Latent and Sensible Heat Fluxes Over Tropical Oceans Observed by TRMM Satellite

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The latent and sensible heat fluxes between air-sea interface are important parameters in understanding the atmospheric/ocean heat and fresh water transports. This study estimates these fluxes over tropical oceans (30N to 30S) using Tropical Rainfall Measuring Mission (TRMM) Microwave Image (TMI) data. TMI has dual polarized 10, 19, 37 and 85 GHz and vertically polarized 21 GHz channels. The brightness temperature (Tb) measurements at these frequencies are used to retrieve surface air specific humidity (Qa) based on Tb simulations of a microwave radiative transfer model (Lin et al. 1998). The sea surface skin temperature (SST) and near sea surface wind speed (WS) are estimated empirically from the TMI Tb values. Air temperature is obtained by adding the simulated gradients between the skin and air temperatures of European Centre for Medium-Range Weather Forecasts (ECMWF) to TMI estimated SST. With these meteorological parameters, the bulk algorithm based on stability-dependent aerodynamic model for TOGA COARE (Fairall et al. 1997) is used to calculate sea surface latent and sensible heat fluxes.

The results are compared to the GSFC version 2 products of surface turbulent flux data derived from all available SSM/I observations (F-8, -10, -11, -13, -14). Both data sets are averaged into 1X1 degree gird boxes. The zonal means of latent heat fluxes of the two data correlatted very well. The values from TMI are lower than those from SSM/I between 20N and 20S degrees. For higher latitudes, current estimates are higher than those from SSM/I due to higher wind speed estimations of TMI. The monthly averaged difference for entire tropical oceans (30S to 30N) are -6.6, -3.2, -2.9, -2.0, -7.2, 1.1, 2.9, and -2.4 w/m**2 for the first 8 months of 1998. The sensible heat from TMI are lower than those from SSM/I across all compared latitudes by 6-7 w/m**2. The advantage of using TRMM data is that the TMI estimates show clear diurnal cycle, while SSM/I data are daily averaged values. The diurnal variations of the latent heat fluxes lead the tropical convection in phase indicating the importance of the moisture convergence in triggering and maintaining tropical deep convection.

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Global Sea Surface Fluxes Estimates Obtained Through Ocean Data Assimilation

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The ECCO ocean state estimation procedure, combining ocean data and an ocean model, leads to improved estimates of sea surface fluxes of heat, freshwater and momentum on basin scales. Adjustments made to the net surface heat and freshwater fields from NCEP reanalysis are, overall, consistent with independent estimates of the biases, primarily from bulk formulas, and within assumed prior uncertainties. Wind stress adjustments are also within prescribed error bars, but show substantially enhanced small scale structures, that likely arise to correct inadequate ocean model dynamics. But on large spatial scales, the changes are overall consistent with known deviations of NCEP reanalysis stress fields from independent NSCAT and ERS measurements. Because our ocean estimates are preliminary, the fluxes presented here are tentative and will improve as more ocean data are included and as the model physics improve. The potential for this form of analysis is discussed.