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.

OS42K-05 1430h

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.

OS42K-06 1445h

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.

OS42K-07 1530h

Radiometric measurements of air-sea temperature difference

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The temperature difference between the ocean and the overlying atmospheric boundary layer is an important controlling parameter in the fluxes of heat momentum and gases between the ocean and atmosphere - important factors in understanding the climate, the biogeochemical cycles, the hydrological cycle, marine cloud formation?.., and their responses to changes in climate forcing.

The M-AERI (Marine Atmosphere Emitted Radiance Interferometer) has been mounted on several research ships on cruises in the world?s oceans. Accurate measurements of the skin sea-surface temperature and near-surface air temperatures are derived from the infrared spectral measurements, which, unlike conventional measurements of air-sea temperature difference, have a common calibration. This removes the largest source of uncertainty in the measurement of air-sea temperature differences, and thereby a major uncertainty in estimates of turbulent air-sea exchanges which couple the atmosphere and ocean. Examples from the M-AERI, radiometric measurements of air-sea temperature difference will be compared with those made by conventional means on the same ships, and on a nearby buoy. The causes and consequences of the discrepancies will be discussed.

OS42K-08 1545h

Simultaneous Measurements of Spatial and Temporal Variability in the Oceanic Upper Mixed Layer

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During July 2001 several different moored and drifting platforms were deployed south of Martha's Vineyard as part of the ongoing ONR funded CBLAST-Low (Coupled Boundary Layer Air Sea Transfer - Low Wind Conditions) project. The purpose of the experiment was to investigate air-sea interaction and the upper oceans response under low winds with particular focus on kilometer to meter scale spatial variability. Meteorological packages mounted on small surface buoys were used to measure local meteorological forcing. These moorings also carried vertical sub-surface instrument arrays to study oceanic variability. In addition, a new mooring concept designed to simultaneously record the temporal variability of temperature, salinity and velocity of the upper ocean in 3 dimensions (x, y, z) was deployed for 5 days during the intensive operating period. The mooring was constructed as a 183 m by 183 m floating buoyant grid or net with a 9 m mesh spacing between nodes. Once deployed the net covered an area of approximately 33500 m^2. The grid effectively acted as a coherent framework that supported a single ADCP and numerous vertical arrays of self-logging temperature and temperature/conductivity recorders to a depth of 18 m. To further explore larger scale horizontal variability, trials of a long line fishing array with vertical arrays of self-logging temperature recorders at various spatial lags was conducted. Preliminary data analysis suggests local air-sea interaction, tidal advection and wind related processes drove temporal and spatial evolution. The aim of this paper is to discuss these observations and demonstrate some new perspectives on smaller scale variability in the upper ocean.

OS42K-09 1600h

Horizontal Variability of Ocean Skin Temperature From Airborne Infrared Imagery During the CBLAST-LOW Pilot Experiment

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Recent results from TOGA-COARE have demonstrated the importance of ocean surface skin temperature in air-sea interaction. Accurate knowledge of the skin temperature has been shown to be critical to estimating surface fluxes and as a result its spatial variability influences the small-scale distribution of those fluxes. There is also evidence that the horizontal variability of surface temperature may be related to subsurface circulation. Here, we present measurements of ocean skin temperature made during the ONR CBLAST-LOW (Coupled Boundary Layer Air-Sea Transfer for Low to Moderate Winds) Pilot Experiment in August 2001 off the south coast of Marthas Vineyard from the NOAA LongEZ aircraft. We used an infrared (IR) imager with a spatial resolution of 1 m and temperature resolution of less than 0.1°C. The results elucidate a variety of mechanisms related to atmospheric and sub-surface phenomena that produce horizontal variability in ocean skin temperature over a wide range of scales under low to moderate wind conditions. Low-noise, high-resolution time series of skin temperature show variability of O(1°C) and a range of spatial scales from O(10 km) down to O(100 m). Fine-scale maps of ocean surface temperature with a spatial coverage of roughly 245 m x 245 m show a myriad of processes including breaking waves, sharp temperature fronts, and distinctive streaks of various scales that are aligned with the wind. These streaky features are likely the surface manifestation of Langmuir circulation cells and exhibit a temporally-evolving spatial scale from roughly 10 m up to 50 m. To the best of our knowledge, these are the first such digital airborne IR images accompanied by high-quality wind data to confirm the features are aligned with the wind.

OS42K-10 1615h

Air–Sea Interfacial $p\mathrm{CO}_2$ from High–Resolution Temperature Profiles and Skin Temperature Measurements

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Underway $p\mathrm{CO}_2$ measurement systems determine the partial pressure of atmospheric and oceanic CO_2 with the aim to building a comprehensive global database of air–sea CO_2 fluxes. Implied in these measurements is that the $p\mathrm{CO}_2$ measured at the depth of the ship's water intake is the same as the $p\mathrm{CO}_2$ at the surface. However, aqueous $p\mathrm{CO}_2$ is temperature dependent and temperature gradients result in $p\mathrm{CO}_2$ gradients. Also, the solubility of atmospheric $p\mathrm{CO}_2$ requires a correction for the oceanic skin temperature. The GasEx2001 experiment was conducted in the Equatorial Pacific, an oceanic source of CO_2 where low wind speeds were predominant. Near–surface temperature profiles were determined with SkinDeEP, an autonomous upwardly–rising instrument equipped with high resolution temperature and conductivity sensors. The oceanic skin temperature was determined with the CIRIMS radiometer. By applying a correction to the oceanic and atmospheric $p\mathrm{CO}_2$ from the SkinDeEP and CIRIMS data, respectively, an air–sea CO_2 flux error of up to 10% is present under low wind speeds during the daytime.

OS42K-11 1630h

Measurements of Air-Sea Heat Flux using Neutrally Buoyant Floats

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Direct measurements of air-sea fluxes have been made almost exclusively from the atmospheric side of the interface. Neutrally buoyant floats deployed in the ocean mixed layer can accurately measure both a vertical velocity which is nearly free of surface wave contamination and temperature. This, plus their water-following ability, allows such floats to measure all terms in the horizontally-averaged heat equation: the rate of heating is measured from the average temperature change, the product of velocity and temperature yields the usual covariance heat flux and the Lagrangian rate of heating yields the diffusive (or small scale) heat flux. The resulting flux measurements are generally self-consistent and agree well with bulk estimates, when available. However, systematic errors can occur when floats are buoyant, the boundary layer is thin, nonstationary or insufficiently turbulent. Furthermore, statistical errors cause the flux estimates to converge quite slowly. Examples from both wind-forced and convectively-forced mixed layers will be shown, including measurements in deep convection and under a hurricane.

OS42K-12 1645h

Diurnal Warming from Satellite and In Situ Observations

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Extending localized results to a global parameterization is vital to achieving accurate multi-sensor SST products. NASAs TRMM satellite offers an exceptional opportunity to investigate the SSTskin-SSTbulk diurnal cycle. The skin-bulk temperature difference, which has a pronounced diurnal variation, impacts the formulation of retrieval algorithms as well as SST validation activities performed by comparison with in situ measurements. In this presentation, measurements of skin-bulk differences and diurnal warming from several cruises are compared to global results obtained via TRMM satellite SSTs.

URL: http://www.remss.com

OS42L HC: 314 Thursday 1330h

Marine Ecosystem Responses to Climate: The Responses of Large Marine Ecosystems to Interdecadal-Scale Climate Variability I

Presiding: **C Greene,** Cornell University**; N Mantua,** University of Washington

OS42L-01 1330h

Top-down and Bottom-up Forcing of Marine Ecosystems

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Possible impacts of climatic change and overfishing within marine ecosystems are considered using simple network analysis. The processes are illustrated by calculations for the North Sea. The results suggest that (a) an increase or decrease in basic productivity from physical changes in nutrient input could be amplified through the microbial loop by as much as an order of magnitude at the level of fish yields; whereas (b) changes in fish production could require redistribution at adjacent higher trophic levels rather than draw on the microbial and detrital components of the food web.

OS42L-02 1345h

Modeling regional responses by marine pelagic ecosystems to global climate change

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Marine biota play an important role in the Earth's climate by regulating atmospheric CO2 levels on decadal to millennial time-scales. Current coupled ocean-atmosphere model (COAM) projections of future oceanic anthropogenic carbon uptake suggest reduced rates due to surface warming, enhanced stratification, and slowed thermohaline overturning. Such