WGSF

Newsletter
of the WCRP Working Group
on Surface Fluxes

WCRP

FLUX NEWS

Issue 3 • January 2007

www.etl.noaa.gov/et6/wgsf

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Air-sea fluxes for the forcing of OGCMs

Bernard Barnier and Sergey Gulev

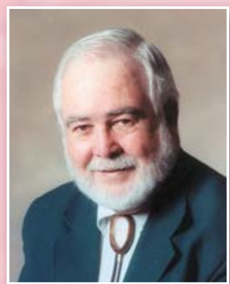
This issue of Flux News considers air-sea fluxes in relation to the forcing of ocean general circulation models (OGCMs). Air-sea fluxes drive surface transformation of water masses and momentum inputs into the ocean. Accurate formulation of surface energy fluxes is as important for the adequate simulation of ocean dynamics as the formulation of dynamic components of the models themselves, if only these can be separated.

In driving ocean models by observed fluxes with parameterisations of ocean feedbacks on forcing to account for the ocean-atmosphere coupling, ocean modellers have learned that the construction of a proper forcing function for OGCMs is somehow different from the estimation of surface fluxes for budget studies. Ocean GCMs now include on-line calculation of turbulent fluxes based on bulk formulas, thus using atmospheric surface variables as input rather than independent estimates of the turbulent fluxes. This calls for more accurate and computationally efficient turbulent bulk formulas, while the need for accurate direct estimates of downward short and long wave radiation at the ocean surface remains strong.

New challenges have emerged in air-sea flux science, stimulated by the use of eddy-resolving ocean GCMs to investigate the ocean decadal variability and by the rapid development of operational oceanography. The demand for high resolution surface variables and fluxes increases and diversifies rapidly. One needs today to resolve the diurnal cycle at global scale with a few kilometre spatial resolution. Increasing the accuracy of surface flux estimation on a global scale is a particularly hard problem, and meeting the demands of the oceanographic community will certainly require sustained observational means and efforts. Therefore, uncertainties in the forcing function of ocean models are likely to remain a concern for some time.

Ocean-atmosphere surface fluxes for ocean modelling remain one of the central subjects in WCRP science in general and among the activities of the WG on Surface Fluxes in particular. Surface fluxes represent a strong bridge linking the WGSF with CLIVAR through, e.g., the Ocean Reanalyses project. In a wider context of WCRP Framework Strategy, surface forcing of ocean GCMs has definite implications on modelling climate changes, and therefore, on practically all WCRP core-projects.

Over 40 years in air-sea interactions: Interview with Prof. James J. O'Brien



In this issue of Flux News dedicated to the atmospheric forcing of the ocean circulation, WGSF is honoured to pay tribute to Jim O'Brien, whose vision in the field has always been ahead of his time. Prof. O'Brien who is Robert O. Lawton Distinguished Professor in Meteorology & Oceanography, is also the Director Emeritus of the Center for Ocean-Atmospheric Prediction Studies at Florida State University. Having promoted excellence in interdisciplinary research in air-sea interaction, he received the Sverdrup Gold Medal in 1987 for his research on the relationship between oceanic oscillations and climate.

Prof. O'Brien has kindly agreed to answer our questions about estimating the wind stress over the ocean, from Voluntary Observing Ships to the Spaceborne Scatterometer (see the interveiw on page 8).

Core Forcing for Coupled Ocean and Sea-Ice Models

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The CLIVAR Working Group on Ocean Model Development has recently designed a series of Coordinated Ocean Research Experiments (CORE) by which to compare and contrast the solutions of diverse ocean general circulation models (OGCMs) coupled to their favorite sea-ice model (SIM). Coupled model behavior depends both on the models themselves, including the ocean-ice coupling, and the applied atmospheric forcing. In order to reduce the sources of variability among the solutions, the CORE use a common set of forcing data that is described in detail in Large and Yeager (2004). The forcing could also serve other projects such as the AOMIP (Arctic-Ocean Model Intercomparison Project).

CORE purposes set specific requirements on the forcing data sets. In rough priority order, these are: 1) global coverage over both ocean and sea-ice; 2) accuracy; to minimize drift and facilitate comparisons with observations; 3) duration; interannual variability through to the past year or two; 4) frequency; to resolve storms and the seasonal cycle, and 5) spatial resolution.

The CORE forcing is designed for OGCMs and SIMs whose surface boundary conditions are derived from the near surface atmospheric state (zonal and meridional wind components, potential temperature, specific humidity, and density), the surface radiation (solar isolation and downwelling longwave radiation), the precipitation, and the continental runoff. The OGCM is expected to provide its prognostic sea surface temperature (SST) and near surface current, as well as the ocean albedo. The SIM must provide ice surface temperature, velocity, concentration, and albedo, as well as partition precipitation into snow and rain. In general, the atmospheric fluxes will differ between coupled models, mostly because of differences in the evolving surface temperatures. There are numerous, acceptable bulk formulae to compute the turbulent fluxes, which could lead to additional variability. Therefore, the scheme detailed in Large and Yeager (2004) is provided with the data sets. Forcing differences could also be reduced with common rain/snow partition and ocean albedo, but snow/ice albedo should remain an important product of SIMs.

The CORE atmospheric state is based on the first NCEP/NCAR reanalysis (Kalnay et al., 1996), because it is long (from 1948 through 2004) and kept current (criteria 3). However, cloud observations are assimilated neither into reanalyses, nor operational forecast analyses, so related products such as radiation and precipitation are deemed too unconstrained to be useful for CORE forcing. Therefore, alternative global data are used, even though they don't start until the satellite era. The above two CORE radiation components are derived from the ISCCP-FD data set (Zhang et al., 2003) from 1983 through 2004. Satellite measurements are also the basic ingredient of two global precipitation data sets (1979 through 2004), CMAP (Xie and Arkin, 1996), and GPCP (Huffman et al., 1997). Continental runoff includes the discharge of both gauged and ungauged rivers and of groundwater. For ease of use and to simply mimic estuarine dilution, it is given as a near coast surface freshwater flux with an exponential decay from its coastal source.

It is well known that there are significant biases in these data (e.g. Smith et al., 2001). Therefore, their accuracy (criteria 2) is improved by adjusting variables to agree better with more reliable observations that are either too short or too regional to be used directly as CORE forcing. Specifically, the satellite vector winds from QSCAT (Chin et al., 1998) are used to adjust both the speed and direction of the near surface vector wind. Over the Arctic cap north of 70N, the air temperature is modified monthly to agree with the mean monthly climatology from the POLES (Polar Exchange at the sea Surface) project. The specific humidity is adjusted to agree in the mean with the Josey et al. (1998) climatological specific humidity derived from ship observations. Solar insolation is reduced in the tropics to agree with ocean surface buoys in the Atlantic and Pacific. Unfortunately, CMAP and GPCP are similar in the zonal mean only at about 35N and 35S and, although not ideal, preference is based on coupled model behavior. The choices are GPCP between these latitudes and south of 60S and CMAP elsewhere, except in the Arctic where the Serreze and Hurst (2000) climatology is used. The merged precipitation is uniformly increased to make the peak zonal mean in the ITCZ match the average from several data sets. The overall adjustment procedure makes the forcing much less dependent on specific choices of base data sets; for example NCEP versus ECMWF (Gibson et al., 1997) reanalyses. It can also incorporate additional high quality data sets as they become available.

The air-sea fluxes have been computed globally from the CORE forcing by using observed SST and sea-ice concentration, zero surface current, and a constant ice albedo of 0.7. Differences with coupled model fluxes will primarily reflect SST differences. The effects of the above adjustments on the global mean air-sea heat and freshwater fluxes are shown in Table 1. With no corrections, mean heat flux is much too high at 30 W/m^2. Individually, the increase in wind speed, the generally lower specific humidity, and reduced solar radiation, respectively decrease this imbalance by 10, 11, and 8 W/m^2. In combination, the mean over the 21 years becomes 2 W/m^2, which is not inconsistent with observed changes in ocean temperature. The uncorrected data give too much freshwater entering the ocean. After the increase in evaporation due to the wind speed and humidity changes, there is then too little freshwater flux, but with the ITCZ matching the global freshwater imbalance is near zero (-0.3 cm/year). The implied ocean heat and freshwater transports are independent of observed estimates (Bryden and Imawaki, 2001; Wijffels et al., 2001), but still in good agreement. For example, the implied northward Atlantic transport across 22N is 1.3 PW.

	ADJUSTMENTS			
	NONE	WIND	HUMIDITY	ALL
Q_{as}	30	20	19	2
F_{as}	– .4	–10.3	–13.7	–11.2
$F_{as} + R$	10.5	0.6	–2.8	–0.3

Table 1: Global mean air-sea fluxes of heat Q_{as} in *W/m*^{2} and of freshwater, F_{as}, in cm/year, over 21 years (1984—2004). A climatological estimate of total continental runoff, expressed as a flux over the global ocean area, is R = 10.9 *cm/year*. All fluxes are positive into the ocean.

At present only the first version of the CORE forcing (CF1), updated through 2004, is being distributed through the Geophysical Fluid Dynamics Laboratory (http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE.html). The main differences are that wind direction is unaltered and the humidity adjustment is made to relative humidity such that there is a drying in the equatorial Pacific instead an increase in specific humidity. CF1 includes a single annual cycle of «Normal Year Forcing» that is constructed to give the same climatological pseudo fluxes to transition smoothly when used for repeat annual forcing and to retain high frequency storm events. An alternative forcing, based on the 15 year ECMWF reanalysis, is described by Roske (2006). It places a higher premium on resolution, uses reanalysis radiation, as well as precipitation over both ocean and land, and can't be updated beyond 1993. The data set is «closed» using the inverse procedure of Isemer et al. (1989), so it is not independent of observed ocean tranport estimates.

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Design Considerations for Coordinated Ocean-Ice Reference Experiments

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1. Introduction

Simulations with coupled ocean-ice models are commonly used to assist in understanding climate dynamics, and as a step towards the development of more complete earth system models. Unfortunately, there is little consensus in the global modelling community regarding the design of ocean-ice experiments, especially those run for centennial and longer time scales. Furthermore, differences in forcing methods can lead to large deviations in circulation behaviour and sensitivities.

Members of the CLIVAR Working Group for Ocean Model Development (WGOMD) have been addressing various aspects of the issue of forcing ocean-ice models. The result of this effort is the *Coordinated Ocean-ice Reference Experiments* (COREs). COREs do not resolve problems related to forcing global ocean-ice models. Rather, COREs highlight difficulties, and provide a means to lift disparate modelling efforts onto a common plateau from which alternative experimental designs and forcing data sets can be systematically explored.

2. Boundary fluxes for ocean-ice models

A coupled ocean-ice model requires momentum, thermal, and hydrological fluxes to drive the simulated ocean and ice fields. When decoupling the ocean and sea ice models from the atmosphere, one must introduce a method to generate these fluxes. Three general approaches have been used. The first is to damp sea surface temperature (SST) and salinity (SSS) to prescribed values. This approach is reasonable since SST anomalies experience a negative feedback in the climate system (Haney, 1971), whereby they are damped by interactions with the atmosphere. Unfortunately, the thermohaline fluxes generated can be quite unrealistic (Killworth et al., 2000; Large et al., 1997). A complement is to use undamped thermohaline fluxes from a dataset. However, fluxes from observations and/or reanalysis products have huge error bars (Taylor, 2000; Large and Yeager, 2004). Running ocean-ice models for decades or longer with such large uncertainties, especially absent a restoring flux, leads to unacceptable model drift (Rosati and Miyakoda, 1988). A third approach prognostically computes turbulent fluxes for heat, moisture, and momentum from a planetary boundary layer scheme (Parkinson and Washington, 1979; Barnier et al., 1995; Barnier, 1998), in addition to applying radiative heating, precipitation and river runoff. Turbulent fluxes are computed from bulk formulae as a function of the ocean surface state (SST and surface currents) and a prescribed atmospheric state (air temperature, humidity, sea level pressure, and wind velocity or wind speed).

The third method is proposed for COREs since it is closest to what is used in earth system models. Hence, it is important to recognize its limitations. A fundamental problem relates to the use of a prescribed and nonresponsive atmosphere that effectively has an infinite heat capacity and infinite moisture capacity. This situation is the converse to what occurs in Nature, where the ocean has a far larger heat and moisture capacity than the atmosphere. We summarize two problems that arise when running ocean-ice models with a fixed atmospheric state.

2.1. Salinity fluxes and mixed boundary conditions

Relatively strong salinity restoring, analogous to the effective restoring of SSTs arising from bulk formulae, can reduce drift in the ocean-ice simulations. However, salinity restoring has no physical basis. It is thus desirable physically to use weak restoring. Weak restoring also has the benefit of allowing increased, and typically more realistic, variability in the surface salinity and deep circulation. Unfortunately, when the restoring timescale for SSS is much longer than the effective SST restoring timescale, the thermohaline fluxes move into a regime commonly known as *mixed boundary conditions* (Bryan, 1987). Stommel (1961) showed that ideal thermohaline systems forced with mixed boundary conditions admit multiple equilibria. Mixed boundary condition simulations can be susceptible to unrealistically large amplitude thermohaline oscillations, as well as a polar halocline catastrophe, in which a fresh cap develops in high latitudes of the North Atlantic and shuts down the overturning circulation (Zhang et al., 1993; Rahmstorf and Willebrand, 1995; Rahmstorf et al., 1996; Lohmann et al., 1996).

2.2. Absence of an atmospheric response as the ice edge moves

Windy, cold, and dry air is often found near the sea ice edge in Nature. Interaction of this air with the ocean leads to large fluxes of latent and sensible heat which cool the surface ocean, as well as evaporation which increases salinity. This huge buoyancy loss increases surface density, which provides a critical element in the downward branch of the thermohaline circulation (e.g., Marshall and Schott, 1999).

When the sea ice edge and/or halocline moves, the region of large air-sea fluxes also moves when the atmosphere is allowed to evolve, as in an earth system model with an interactive atmosphere. In contrast, when the atmospheric state is prescribed and the simulated sea ice edge moves, the air-sea fluxes are spuriously shut down in the ocean-ice simulation. The ocean column becomes prone to freshwater pooling at the surface, and this provides a positive feedback on the heat flux reduction. This process is similar to the polar halocline catastrophe of mixed boundary conditions mentioned above. The net effect is to weaken the simulated thermohaline circulation.

3. A proposal for COREs

Even a perfect ocean-ice model is exposed to limitations inherent in computing fluxes from a prescribed and nonresponsive atmospheric state. Nonetheless, working under the assumption that we wish to conduct productive research and developmentwith ocean-ice models, we seek a standard modelling practice to help establish benchmark simulations, thus facilitating comparisons and further refinements to the flux data sets and experimental design.

3.1. The Large and Yeager dataset

In order to be widely applicable in global ocean-ice modelling, a dataset should produce near zero global mean heat and freshwater fluxes when used in combination with observed SSTs. This criteria precludes the direct use of atmospheric reanalysis products. As discussed in Taylor (2000), a combination of reanalysis and remote sensing products provides a reasonable choice to force global ocean-ice models. That is the approach taken by Large and Yeager (2004). Furthermore, it is desirable for many research purposes to provide both a repeating «normal» year forcing (NYF) as well as an interannually varying forcing. The Large and Yeager (2004) NYF is derived from the 43 years of interannual varying forcing. Access to the dataset, Fortran code for the bulk formulae, technical report, support code, and release notes are freely available at

nomads.gfdl.noaa.gov/nomads/forms/mom4/CORE.html

3.2. Three proposed COREs

The WGOMD has proposed three COREs, whose elements are outlined here.

- CORE-I: This experiment is aimed at investigations of the climatological mean ocean and sea ice states realized using the idealized repeating NYF of Large and Yeager (2004). Models should ideally be run to quasi-equilibrium of the deep circulation (order hundreds to thousands of years). Preliminary tests (Griffies et al., 2007) indicate that 500 years is suitable for many metrics.
- CORE-II: This experiment is aimed at investigations of the forced response of the ocean and/or ocean hindcast. It therefore employs the interannual varying dataset of Large and Yeager (2004).

• CORE-III: This is a perturbation experiment involving ideas proposed by Gerdes et al. (2006). Here, enhanced fresh water enters the North Atlantic in response to increased meltwater runoff distributed around the Greenland coast. Response of the regional and global ocean and sea ice system on the decadal to centennial time scales is the focus of CORE-III.

3.3. Status of CORE simulations

Modelling groups at GFDL, Kiel, KNMI, MPI, and NCAR have explored the CORE-I suite of experiments (Griffies et al., 2007). Each group used the CCSM bulk formulae, reflecting the approach used to develop the Large and Yeager (2004) dataset. Salinity or fresh water forcing was a frequent point of debate, largely due to difficulties raised in Section 2. Each group used their favorite salinity restoring, with restoring to the same salinity dataset.

Analyses of water mass properties, sea ice distribution, tropical circulation, overturning circulation, etc., have revealed a wide spread amongst the above models for certain metrics (e.g., overturning circulation), and general agreement for other metrics (e.g., tropical circulation). As for many other model comparison projects, these early results raise more questions than they answer. Thus, fully understanding the simulation differences will require further research. We consider this outcome a successful illustration of the CORE idea in that it (A) provided a common experimental platform to compare a wide class of global ocean-ice models, (B) has provoked many new research projects in hopes of furthering our understanding of the ocean-ice climate system.

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Call for contributions:

We invite contributions to the next issue of Flux News, which will be a regular issue. We welcome articles on a wide range of topics related to air-sea fluxes.

The closing date for submissions is 15 June 2007.

Comparing sea surface atmospheric variables from ERA40 and CORE with a focus on global net heat flux




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Introduction

The solution of ocean «only» circulation models (not coupled to an AGCM) greatly depends on the pertinence of the surface boundary conditions of momentum, heat and mass. So far, bulk forcing has proven to be the best option as a degree of freedom is added to the system, and thus allows a direct feedback of the model SST on the fluxes (*Large et al. 1997*). These fluxes are partly estimated on-line using prognostic model SST and prescribed atmospheric state variables.

The objective of the present work is to compare two recent inter-annual atmospheric datasets extracted from reanalysis, CORE[(1)] and ERA40[(2)], with a focus on their ability to generate a relevant and suitable bulk heat flux forcing for a given model. Both datasets are global and cover most of the last 50 years at high temporal resolution (6-hourly). Their spatial resolution is about one degree. This study was carried out over the period 1958 to 2000.

The three surface variables under investigation are air temperature, specific humidity, and wind module. They are required (together with SST) to compute the turbulent part (i.e. latent and sensible) of the net heat flux, so downwelling radiation must be provided as a complementary product. To fulfil this need, the ISCCP[(4)] satellite-derived dataset already implemented in CORE, has been used. These satellite data are expected to be more reliable than products extracted from reanalyses such as ERA40. They are however only available from 1984, so a daily climatology derived from the 1984—2000 period is used prior to this era.

This study is done in three steps; first, input variables of each dataset are compared. Then, the net heat flux computed with bulk formulae and a given reference climatic SST[(5)], is analysed for both datasets (*Approach 1 of Fig.1*). Lastly, two coarse resolution global OGCM simulations at 2° resolution are performed with each forcing function (*Approach 2 of Figure 1*). This step extends the former results by representing the feedback of large-scale ocean dynamics on SST and air-sea interactions.

The emphasis is on the value of Q_{turb} (the turbulent component of the net heat flux) produced by these two approaches.

Input data

Since CORE temperature and humidity are provided at a height of 10m, it was necessary to adjust ERA40 values from 2m to 10m following the Monin-Obukhov similarity parameterisation given by Large & Yeager (2004).

Discrepancies between CORE and ERA40 are mainly found on surface wind and air humidity. Despite a very similar inter-annual time variability pattern, CORE winds are indeed constantly stronger than ERA40 at every latitude (*Fig. 2*). CORE shows wetter air than ERA40 except in the [0ºN 20ºN] latitude band (*Fig. 2*). High winds have a cooling effect as they enhance heat loss by evaporation whereas high humidity, by limiting evaporation, has a warming effect.

There is however a good agreement on air temperature.

Interpolation artefacts are also a substantial weakness of CORE atmospheric fields as their spatial resolution suffers from unwanted noisy structures.

Heat fluxes derived from prescribed SST

By simply applying bulk formulae with a given climatic inter-annual SST field[(5)] and the atmospheric state of each dataset it is possible to derive two climatological heat flux estimates. The iterative algorithm of Large & Yeager (2004) is used to compute air/sea exchange coefficients (C_D, C_E and C_H) required by bulk formulae.

By using the same SST field for both experiments, the influence of the radiative flux on the difference of net heat flux is neutralised. Comparing net heat flux thus becomes equivalent to comparing turbulent heat flux (latent+sensible).

In this configuration, surprisingly, CORE leads to less turbulent heat loss than ERA40 except in low latitudes where it gathers two cooling effects of stronger winds and dryer air (*Figure 3*). This proves that despite its weaker winds, and because of a globally dryer air, ERA40 leads to a stronger evaporation than CORE. *Figure 2* and *Figure 4* also show that a negative anomaly of humidity of about 0.5 g/kg is able to produce a higher heat loss than a positive anomaly of wind of 0.5 m/s.

2º-resolution model simulations

The 2° global ocean/sea-ice ocean general circulation model used in the DRAKKAR[(7)] project, based on the NEMO[(6)] code has been forced over 43 years (1958—2000) by ISCCP radiative product and surface atmospheric variables from each dataset. The bulk algorithm used is the same as in the previous section. There is no SST restoring and a gentle SSS restoring.

Simulating the oceanic feedback on heat fluxes through prognostic SST substantially modifies the expectations derived from fixed-SST investigation. Much better agreement is found on zonally-averaged flux profiles from the runs (compare *Figure 4* to *Figure 5*). This underlines the important role of the SST feedback on the regulation of the heat flux while using bulk forcing. It is however interesting to note that the ERA40

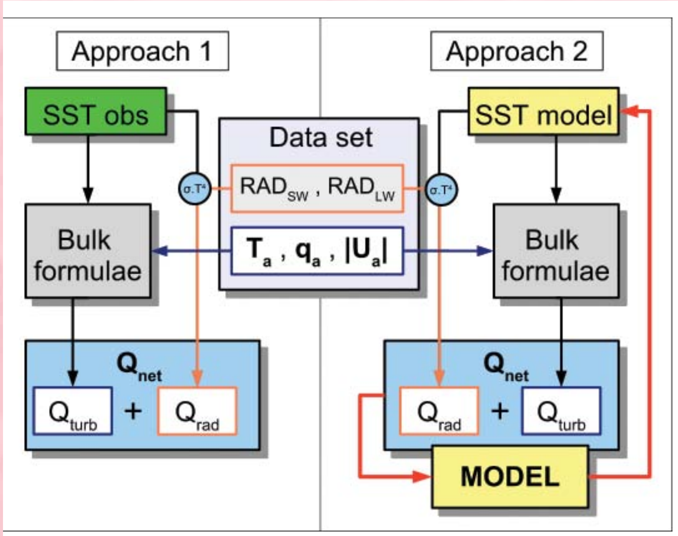

Figure 1:
Two different approaches tested for evaluating the impact of each dataset on air/sea heat flux.
Approach 1 = observed SST offline test.
Approach 2 = OGCM simulation.

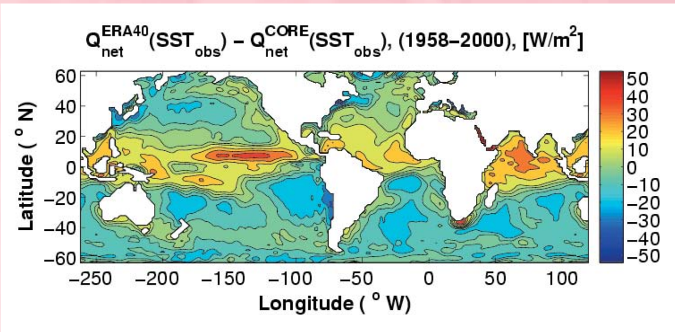

Figure 3:
Difference of mean net heat flux between ERA40 and CORE obtained with the same prescribed SST. Positive values highlight regions where the ocean loses more turbulent heat with CORE than with ERA40.

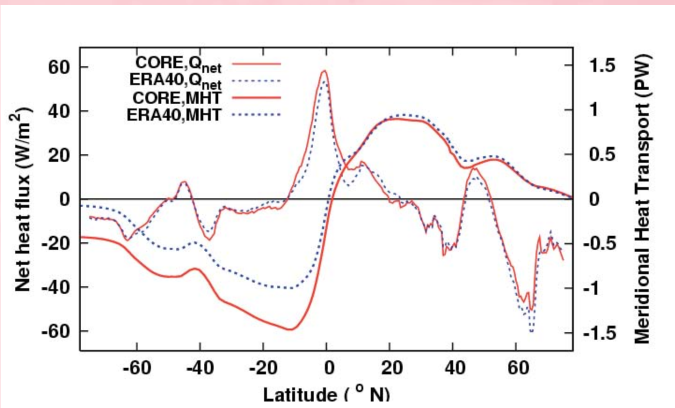

Figure 5:
Zonally averaged profiles of mean net surface heat flux from the model; resulting meridional heat transport (1958—2000).

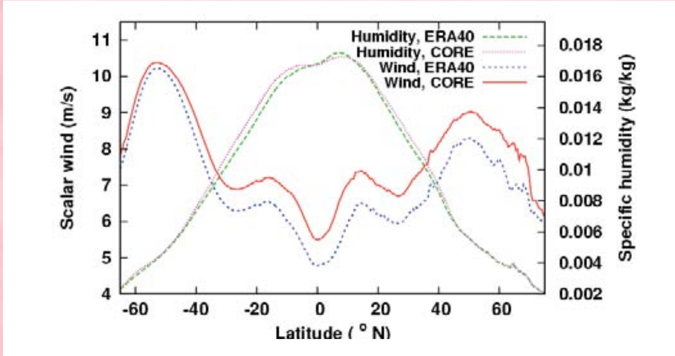

Figure 2: Zonally averaged profiles of mean scalar wind at 10m and mean specific humidity at 10m for each dataset (1958—2000).

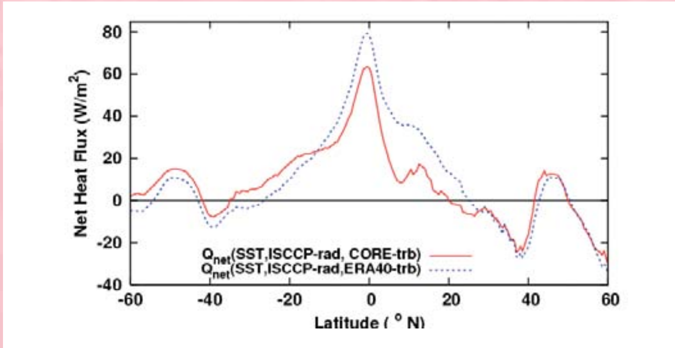

Figure 4: Zonally averaged profiles of mean net surface heat flux computed with the same fixed SST for the two tested datasets (1958—2000).

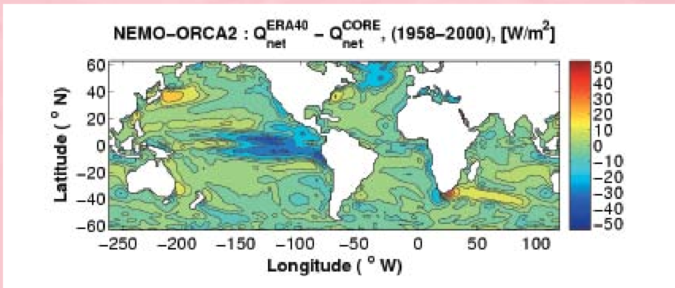

Figure 6: Difference of mean net surface heat flux between ERA40 and CORE obtained from model simulations. Positive values highlight regions where the ocean loses more heat with CORE than with ERA40.

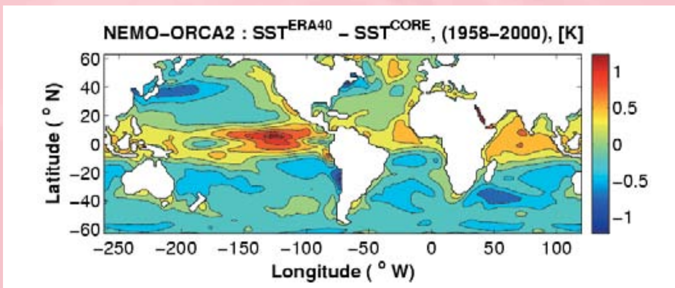

Figure 7: Difference of mean SST between ERA40 and CORE obtained from model simulations. Positive values highlight regions where the ocean surface is warmer with ERA40 than with CORE.

run is the most affected by this «retroactive SST correction». Zonal net heat flux values at the equator were indeed lowered towards 60W/m^2, which is roughly the value obtained with CORE in both approaches (*Figure 4* and *5*).

Contrary to *fixed-SST* expectations, the CORE forcing yields the strongest input of heat in the equatorial region (*Figure 5*). This is consistent with the warmer SST obtained with the ERA40 simulation (*Figure 7*) which tends to increase turbulent and infrared heat losses, especially in the eastern equatorial region (*Figure 6* and *7*). This process seems partly responsible for the greater global warming noticed in the CORE run. ERA40 forcing generates the weakest heat imbalance (*Figure 5*).

Meridional heat transport computed from net surface heat flux, shown on *Figure 5* also shows that the disagreement of net heat flux in the tropics is responsible for the greater southward heat transport in the CORE-driven run.

Conclusion

This study demonstrates that the oceanic impact of various atmospheric forcing functions cannot be estimated from SST climatologies but requires prognostic ocean simulations (at least mixed layer dynamics). Model simulations exhibit totally different thermal trends than those that could be inferred from bulk formulae with a fixed SST. A prognostic SST is an essential degree of freedom to mimic the oceanic feedback on air-sea fluxes. Humidity also plays an important role since latent heat fluxes extract a large amount of heat from the ocean.

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Over 40 years in air-sea interactions:
Interview with Prof. James J. O'Brien

In this issue of Flux News dedicated to the atmospheric forcing of the ocean circulation, WGSF is honoured to pay tribute to Jim O'Brien, whose vision in the field has always been ahead of his time. Prof. O'Brien who is Robert O. Lawton Distinguished Professor in Meteorology & Oceanography, is also the Director Emeritus of the Center for Ocean-Atmospheric Prediction Studies at Florida State University. Having promoted excellence in interdisciplinary research in air-sea interaction, he received the Sverdrup Gold Medal in 1987 for his research on the relationship between oceanic oscillations and climate. Prof. O'Brien has kindly agreed to answer our questions about estimating the wind stress over the ocean, from Voluntary Observing Ships to the Spaceborne Scatterometer.

FSU pseudo wind stress, well known as FSU winds, have been very widely used and greatly appreciated by many ocean scientists. What triggered your idea to produce it?

JJO: In the mid 1970's, EL NINO theories were simple. They explained Kelvin waves and Rossby waves to all. But they were ridiculed as simple GFD toys. In the summer of 1979 I hired 13 young undergraduates of meteorology and we hand-drew and hand-digitized monthly maps of pseudo wind stress for 20 years. K.Wrytki invented *Pseudo Stress* because there was so many arguments about drag coefficients. When TOGA started we continued to produce monthly pseudo stress what we still do today.

Would you comment on your great support of Scatterometer winds, since their early days?

JJO: In 1980 I chaired a NASA committee to get a new start called a SCATTEROMETER. NSCAT was launched in 1986 on ADEOS I. It lasted only 9 months but was so successful that NASA found $100 M to launch QUIKSCAT which is still going strong. Now everyone who needs to observe heavy winds at sea uses this data. Now we really need at least two polar orbiting scatterometers to get the needed coverage.

What is your opinion on the future of wind observation from space? Do you think that the time when wind observations are specifically designed for data assimilation in NWP models has come?

JJO: After QSCAT dies I believe the Nations will know what they have lost and will launch what is needed. I think the cry for better hurricane and typhoon intensity forecasts will drive the big NWP centers to improve the boundary layers over the oceans, and learn to use scatterometer data for improved intensity forecasts.

Innovations in Modeling Gulf of Mexico Surface Turbulent Fluxes

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Center for Ocean-Atmospheric Prediction Studies and Department of Meteorology, The Florida State University, Tallahassee, FL 32306

Fine resolution modeling of the Gulf of Mexico has shown that wind driven currents (Morey et al. 2005) and remotely forced storm surge (Morey et al. 2006) can be modeled with very good accuracy. Several of the factors that contribute to these successes are fine resolution (5 km) of the ocean model, accuracy of surface turbulent fluxes, and fine temporal evolution of these fluxes. The relatively fine spatial/temporal resolution is needed because of the key physical processes due to episodic forcing, such are cold fronts and tropical cyclones.

Ocean forcing associated with episodic events evolves rapidly, and cannot be well approximated from the surrounding environment. The winds and air/sea differences in temperature and humidity evolve rapidly in time. Linear interpolation of such events over periods of more than a few hours leads to highly unrealistic evolution of the surface forcing. To avoid this problem we apply an EOF based interpolation technique (Zavala et al. 2003) to smoothly translate features. In contrast, linear interpolation would have features slowly disappear at one location while strengthening at another location. We could interpolate the surface forcing in such a manner; however, we prefer to allow the ocean model's evolving sea surface temperatures (SSTs) to directly modify the surface forcing. This approach provides a more physically sound coupling, as well as a negative feedback for SST change.

For the studies mentioned above we have applied a variant of the Bourassa-Vincent-Wood (BVW; Bourassa et al. 1999) flux model. The original BVW model worked very well for low to moderate wind speeds (the conditions for which it had been designed), but had some deficiencies at high wind speeds ($U_{10} > 10$ ms^{-1}). These problems were greatly reduced by replacing roughness length dependency on wave age with a constant value of Charnock's constant. The original BWV code was developed for testing flux models, rather than use in ocean models: it was too computationally inefficient for use in a fine resolution ocean model. A much more computationally efficient lookup table version was developed for use in our Gulf of Mexico model.

A new development in flux modeling is a model that works well for swell-related variability as well as developing seas in high winds (Bourassa 2006). This model treats the waves as modifying the lower boundary condition of the modified log-wind profile. Traditionally the lower boundary condition on speed is assumed to be zero. The new model treats the near surface boundary wind vector as equal to the current plus 80% of the orbital wave velocity (in the propagation direction of the dominant waves). This boundary condition is equivalent to picking an appropriate Newtonian frame of reference. This approach is a tremendous improvement for high wind speeds. It also account for difference in the directions of wind and stress, as well as observed variations in stress magnitude due to differences in the directions of wind and swell propagation. For high wind speeds and high waves, it was also found that the wind profile was displaced upward by 80% of the height of the dominant waves. Note that since atmospheric weather prediction models do not consider the upward displacement of the wind profile, it is unreasonable to try to apply such an adjustment to winds from such models. The Bourassa (2006) results in an excellent fit to observations of winds up to 24 ms^{-1}; the strongest winds available for comparison. It is reasonable to assume that the model will work well up to at least 20 ms^{-1}, and possibly up to 50 ms^{-1}, where spray is likely to modify fluxes.

There are several additional advantages of the new flux model. The value of Charnock's parameter appears to be constant, thereby simplifying the calculation of roughness length for gravity waves. The wave information enters only through the modification of the vector wind shear. From the perspective of parameterization, this means that the wind, wave, and current information can be combined together, reducing the number of parameter that need to be passed into a model. A computationally efficient version of this model is therefore also easy to construct. We look forward to using this new flux model in upcoming ocean modeling studies.

Acknowledgment: Funding for this work came from NOAA, NASA, and NSF.

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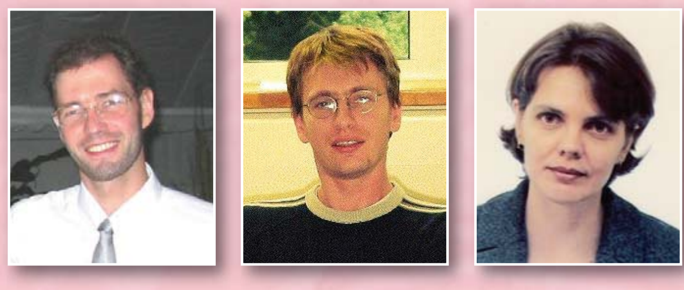
Air Sea fluxes in operational oceanography and ocean reanalyses



Nicolas Ferry,
Gilles Garric and
Silvana Buarque

MERCATOR-OCEAN,
Toulouse, France

1. Introduction

Air sea fluxes are the main driver of the ocean circulation. Since the beginning of the nineties our knowledge of fluxes of heat, water and momentum has drastically improved: atmospheric analyses and forecasts provided by Numerical Weather Prediction (NWP) Centres as well as new types of satellite measurements (e.g. scatterometer wind measurements) provided access for the first time to surface fluxes with high spatial and temporal resolution. The availability of these fluxes offered a favourable context for the emergence of operational oceanography centres such as MERCATOR-Océan (http://www.mercator.eu.org) whose activities greatly contribute to GODAE (Global Ocean Data Assimilation Experiment). The objective of MERCATOR is to perform ocean monitoring and forecasting. Namely:

1. To be able to simulate the global ocean with a primitive equation high resolution model, to assimilate satellite and in situ data, and to provide hindcasts and near-real time nowcasts and forecasts of the global ocean circulation.
2. To be in operational mode (i.e. routine and near-real-time) and to provide continuous and well-assessed global/regional ocean monitoring and forecasting information.
3. To create a new ocean service with duties towards: (1) institutional operational applications; (2) the research community; (3) private sector operational recreational and commercial applications and (4) environmental policy makers.

A large part of operational oceanography is clearly related to routine and near-real time ocean analysis / forecasts. However, tasks identified as duties for the above mentioned users make it necessary to produce ocean reanalyses. All these objectives have strong implications for flux products used by ocean analysis/forecasting systems such as data availability and continuity, data used in forecast mode, etc. This article reviews the peculiarity of air sea fluxes used in an operational oceanography context with application to the MERCATOR system (section two) as well as their use in ocean reanalyses (section three).

2. Operational oceanography

The MERCATOR system provides a full 3D depiction of the ocean dynamics and thermohaline circulation (temperature, salinity, currents, sea surface elevation), with priority given to high resolution (eddy resolving) scales. Information is available on a near-real-time and routine basis, by providing weekly near-real-time analysis (with data assimilation) and 2-week forecasts. The MERCATOR system consists of a series of ocean general circulation models (GCMs) with data assimilation, driven by air-sea surface fluxes. Most of the ocean models used in operational mode use bulk formulation for the fluxes. This means that the models use 10m wind speed, 2m air temperature and dew-point, sea level pressure and precipitation to compute at each time step the turbulent heat (latent and sensible), and momentum fluxes. Radiative air-sea surface fluxes include the net short-wave (radiation absorbed by the ocean) and the net long-wave radiations. The net air-sea heat fluxes used to force ocean models is the sum of turbulent heat and radiative fluxes. For high latitudes, the ocean model may be coupled to an ice model which takes into account the ocean-ice-atmosphere interactions and energy exchanges. Due to the near real time aspect of the ocean analyses and forecasts, the only possible choice for operational oceanography is to use boundary conditions provided by NWP Centres like the European Centre for Medium-range Forecasts (ECMWF). Only NWP Centres are able to provide atmospheric boundary conditions in a fast delivery mode both for the past and for the future, and with continuity. Thanks to this, every week the MERCATOR system performs two retrospective analyses and a two-week forecast (Figure 1).

The first analysis (from D0-14 to D0-7) is carried out in order to produce what is called the «best analysis». The system is used in «reanalysis» mode, ensuring that all atmospheric boundary conditions fields and all observation data used by the system that could have been delayed (long processing, transmission delay, etc…) have been delivered for this time period and are the best possible. By contrast, the second analysis performed over the [D-7; D0] assimilation window is not optimal in the sense that some data used for the analysis may not have been delivered. For example, the fluxes used for the day D0-1 are often forecasts performed the day before, or the latest observations of some ocean variable may not have been yet received. The last period [D0; D0+14] is the ocean forecast which is done using deterministic atmospheric forecasts.

Even if analyses provided by meteorological centres represent one of the most reliable boundary conditions for operational oceanography, ocean analyses and forecasts skill may suffer from errors inherent to surface fluxes. For example, the use of NWP analyses to constrain oceanic circulation models implies spatial interpolation from the atmospheric grid to the oceanic one. It creates inconsistencies, for example, near the coast where the two land-sea masks do not match exactly (i.e. with atmospheric land values used as oceanic values and vice-versa). These mismatches are particularly large in the presence of high continental topography near the oceanic coast where a strong localised atmospheric circulation can disturb the coastal oceanic circulation. Moreover, the spectral atmospheric model produces Gibbs fringing near the relief, a phenomenon particularly well marked close to high mountains (Dhomps et al., 2006). That is why a special effort is needed to improve the quality of surface flux calculations, (e.g. Skachko et al., 2006, Dhomps et al., 2006) both in analysis and forecast mode (see Fig. 1). It is interesting to notice that the ocean forecast skill is particularly sensitive to these surface boundary conditions. (i.e. to the atmosphere), and this is a specificity of the ocean with regard to the atmosphere.

Another shortcoming of operational oceanography is the fact that operational atmospheric GCMs are regularly upgraded (new physical parameterisations, finer resolution, more vertical levels, etc.) and these changes can introduce large discontinuities in air-sea fluxes which have a negative impact on the ocean model prediction skill. That is one of the reasons why ocean reanalyses have to be undertaken.

3. Ocean Reanalysis

Ocean reanalysis is a way to build in a hindcast mode a four dimensional (space and time) view of the world ocean by combining together information contained in oceanic observations (sea surface temperature, sea level anomalies, temperature and salinity profiles, etc…) with physical constrains imposed by an ocean GCM (surface boundary condition, thermodynamic conservation laws). The objective is to produce the most realistic (i.e. close to the observations and consistent with ocean physics) description of the ocean state over a particular time period. From a technical point of view, the reanalysis will use the most accurate observations, surface fluxes, ocean GCM and data assimilation technique to produce what is supposed to be the most realistic ocean state. We shall focus now on the specificity of ocean-atmosphere fluxes used for ocean reanalyses.

The main difference between operational oceanography and ocean reanalysis is that in the latter we try to evaluate the ocean state in hindcast mode. This means that we are not working in near real time mode and one has the possibility to perform quality control on the fluxes and to improve their accuracy. For example, MERCATOR North Atlantic Reanalysis (MERA-11) covering the 1992—2002 time period was done using the ERA-40 bulk parameters. Another improvement that can be done for reanalysis is the correction of surface fluxes which are known to have systematic deficiencies. This is the case for precipitation fields provided by NWP products which suffer from a systematic overestimation of tropical rainfall. The methodology proposed by Troccoli et al. (2004) has shown that it is possible to correct this precipitation bias and to improve the sea surface salinity representation in ocean model simulations. Table 1 shows the results obtained in two ocean GCM simulations differing in their precipitation flux (with, versus without, the tropical rain correction). The simulation with the rain correction (EXP2) has a much more realistic SSS representation (reduced misfit with respect to Levitus

TABLES AND FIGURES:

OCEAN MEAN VALUES (mm.day^{-1})						
EXPERIMENT	P mm.day^{-1}	E mm.day^{-1}	mass budget mm.day^{-1}	∂_t(SSH) mm.year^{-1}	∂_t(SSS) PSU.year^{-1}	SSS damping 10^{-3} *mm.day^{-1}
ECMWF (1993—2004)/EXP1 without precipitation correction	3.78	3.32	0.76	283	–0.07	–2.36
ECMWF (1993—2004)/EXP2 with precipitation correction	2.99	3.32	5.10^{-4}	–3.9	+0.0067	–1.55

Table 1: Mean values for precipitation (P), Evaporation (E), total mass budget (P+R-E-SSS damping), SSS trend (∂_t(SSS)), SSH trend (∂_t(SSH)) and surface mass damping towards Levitus seasonal salinity. Values issued from EXP1 in which precipitations is not corrected and EXP2 in which precipitations is corrected.

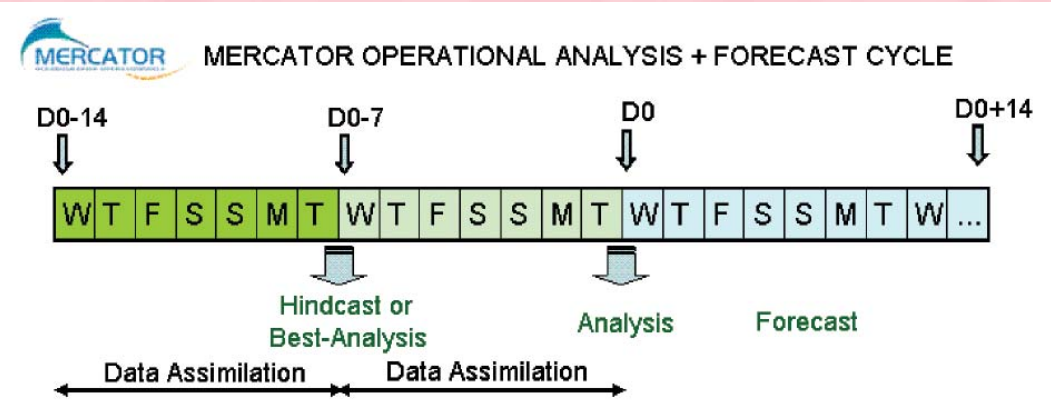


Figure 1: Scheme of MERCATOR operational analysis and forecast cycle performed every week.

climatology, weak global sea level trend) than the one without correction (EXP1) (Garric, 2006). Another example of air sea flux improvement is proposed by Bentamy et al. (2006) who shows that ECMWF wind stress products blended to remotely sensed wind retrievals (scatterometer wind) help to improve the representation of wind stress in coastal areas (Dhomps et al., 2006).

These two examples show that it is possible, in reanalysis mode, to improve air sea fluxes in a significant manner. However, these flux improvements are not straightforward and generally are the result of collaborative research work. The use of such flux correction method in operational oceanography (i.e. near real time mode) is often impossible because the correction method requires access to additional observations not available at the time of the analysis. Another crucial aspect of operational oceanography is the forecast, and it becomes clear that blended or «corrected» fluxes cannot be used for this forecast. This restricts strongly the use of this kind of air sea fluxes to ocean reanalyses. A challenge for the future is to develop methodologies to improve fluxes in operational mode (analysis and forecasts) and this will require a strong collaboration between the ocean and atmosphere research communities.

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Recent meetings

WCRP Officers, Chairs and Directors Meeting: The WGSF prospects

Beijing, 7—8 November 2006

Sergey Gulev

Officers, Chairs and Directors Meeting (OCDM) was held in Beijing at the premises of the Institute of Atmospheric Physics, the Chinese Academy of Science. The meeting was hosted by Professor Guoxiong Wu. OCDM reviewed some major WCRP cross-cutting issues, first of all Anthropogenic Climate Change and associated strategies for the development of the further IPCC scenarios. These were presented by JSC vice-chair V.Ramaswamy and WGCM Chair J. Mitchell. The follow up on SBSTA ESSP, and general prospects on a better integration of WCRP into ESSP, were presented by WCRP Director A. Henderson-Sellers and JSC Chair J. Church. Two regular reports of the WOAP and WMP were presented by K. Trenberth and J. Shukla. G. Wu presented the first pilot results of the evaluation of the WCRP GEWEX core project — the very first WCRP project volunteered for internal evaluation.

Besides the routine business, the central focus of this OCDM was on the development of WCRP Roadmap, implementation of WCRP 2005—2015 Strategic Framework and improvement and development of WCRP networking. During the second day of the meeting Officers, Chairs and Directors held a Workshop chaired by A. Henderson-Sellers to identify the problems in WCRP internal and external cooperation and to outline the strategies for overcoming any problems. The workshop was focused on the needs of the stakeholders, identification of the major challenges, enhancement of cooperation and communication between WCRP and stakeholders and improvement of the recognition of WCRP's role in climate science. The further discussions will continue during the WCRP XXVIII Annual Session in Zanzibar in March 2007.

With regard to the prospects of the Working Group on Surface Fluxes and its role in WCRP activities, it is of great importance to develop WGSF strategy as a part of WCRP Strategic Framework for 2005-2015 within the nearest couple of months. Currently the WCRP Strategic Framework 2005-2015 identifies the priorities in surface fluxes forming the present WGSF mandate.

It is now vital that WGSF implements this outline in order:

- To contribute to better climate predictability and increased understanding of human impact on climate.
- To provide effective contributions to the WCRP cross-cutting topics, primarily to ACC, AC&C, Sea Level Rise, Extreme events, Monsoons.
- To further enhance the understanding of the synergy between physical air-sea fluxes and air-sea biogeochemical exchanges and continue to uphold WCRP-IGBP.
- To develop WGSF in the direction of covering surface fluxes over both sea and land.

These issues are to be further considered and discussed by the surface flux community as part of the continuing process towards the implementation of the WCRP Strategic Framework. Finally, it is important to continue to develop the surface flux network as a valuable component of the WCRP network.

WGSF of WCRP and IMP2 of SOLAS: Joint Meeting in Heidelberg

4—5 September 2006,
Heidelberg University, Germany
Nadia Kovaleva

On 4—5 September 2006 representatives of the WCRP Working Group on Surface Fluxes and the SOLAS Focus-2 Working Group met in Heidelberg to discuss urgent international research activities and collaborations. It was a meeting of opportunity prior to the International Workshop on Transport at the Air Sea Interface held on 6—8 September in Heidelberg, Germany. The meeting was hosted by Christoph Garbe of IWR, University of Heidelberg, who is a member of WGSF.

SOLAS/Focus-2 and WCRP/WGSF work together to establish the dependence of interfacial transfer processes on physical, biological, and chemical factors at the ocean-atmosphere interface, throughout the atmospheric and oceanic boundary layers, and to account for the contribution of horizontal and vertical transport and transformation of CWRCs. Focus-2 and WGSF activities also include the development of review manuscripts on both air-sea gas and aerosol fluxes, the production of a handbook for ship-based flux observations (authored by Frank Bradley and Chris Fairall).

SOLAS Focus-2 and the WCRP WGSF first met jointly in Montreal in May 2004. Subsequent meetings have occurred in Halifax (October 2004), Montreal (March 2005), and in Tokyo (May 2005). A joint Working Group meeting was held in Honolulu (February 2006) during the 2006 AGU/ASLO/TOS Ocean Sciences Meeting.

At the Heidelberg meeting Chris Fairall (WGSF Chair) presented WGSF activities and Wade McGillis (Internatrional SOLAS Focus-2 Chair) and Daniela Turk (EPO, International SOLAS Focus-2) reviewed Focus-2 activities. Vladimir Ryabinin (JPS for WCRP) and Jeffrey Hare (SOLAS IPO) discussed the interests and enthusiasm of the joint SOLAS Focus-2 and WCRP/WGSF collaborations. From the WCRP perspective V. Ryabinin suggested the emphasis on models and operational products and, also, suggested thinking about setting up linkages with GEWEX. Both Drs. Ryabinin and Hare continue to be supportive of joint Working Group activities. Sergey Gulev and Nadia Kovaleva presented a special issue of WGSF FLUX Newsletter that highlights the Focus-2 WGSF collaboration.

The presentations on urgent international research activities and collaborations included:

- David Ho: *Southern Ocean air-sea gas exchange experiment*;
- Phil Nightingale: *DOGEE (pronounced DOG-E) and everything you wanted to know about a gas transfer field experiment*;
- Christoph Garbe: *Novel techniques and highly resolved measurements of small-scale air-sea interactions and usability in laboratory facilities and in the field*;
- Jacqueline Boutin: *Remote sensing: the only way to get global gas-transfer on short time scales*.

The next joint WGSF and SOLAS IMP2 meeting is scheduled to take place in Xiamen, China (March 2007). Future official and ad hoc meetings include New York City (2008), Europe (2009), and at the Air-Water Gas Transfer Conference in Kyoto, Japan (2010).

Surface wind waves: air-sea fluxes and related issues
9TH International Workshop On Wave Hindcasting And Forecasting

24—29 September 2006,
Victoria, B.C., Canada
Sergey Gulev and Val Swail

The 9th International Workshop on Wave Hindcasting and Forecasting was held in Victoria (B.C. Canada) between 24—29 September 2006. The Workshop was sponsored by Environment Canada, the U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory, and the WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM). It was chaired by Val Swail of Environment Canada and Don Resio of U.S. Army Engineer Research and Development Center. This is the 9th Workshop in a series lasting 20 years from 1986. The meeting addressed all aspects of studies of ocean waves, including ocean wind wave climate, extreme wind seas, wind wave physics, and wave modeling on global and regional scales. The Workshop program, abstracts and papers can be accessed at www.waveworkshop.org.

The following papers were of particular note in the context of wave climate, its variability change and impact:

- The WMO/IOC JCOMM Wave Programme and The JCOMM Extremes Wave Database; Alice Soares and Val Swail — described JCOMM wave activities and introduced the new extremes data base of wave measurements exceeding 14 metres significant wave height for use in model validation, forecast verification and satellite wave calibration/validation.
- The MSC50 Wind and Wave Reanalysis; V.R. Swail, et al. — described the new high resolution, high quality wave hindcast of the North Atlantic ocean 1954—2006 and accompanying wave climate atlas.
- Performance of Third Generation Wave Models In Extreme Hurricanes; R.E. Jensen et al. — suggested that the adoption of a simple cap on drag coefficient appears to greatly improve model performance in situations of extreme wind forcing.
- Detection of Human Influence on Trends of North Atlantic Ocean Wave Heights and Atmospheric Storminess; Xiaolan Wang et al. — detected human influence on the storm and ocean wave climate, on the basis of multiple climate model simulations of human-induced climate change and statistical simulations of the corresponding changes in ocean wave heights.
- Changes in the North Sea Extreme Waves; Sofia Caires et al. — described how the North Sea extreme wave climate changed in the last decades, and how is it expected to change in the future.
- Applications of the Dynamical and Statistical Downscaling Techniques to the Local Multi-Decade Wave Simulations; Lidia Gaslikova — described the development of a downscaling method appropriate for the localization of the existing regional wave data for several decades in the surroundings of the Helgoland Island.
- Extreme Wind Waves Worldwide from the VOS Data and Their Changes over the Last 50 Years; Vika Grigorieva and Sergey Gulev — described the use of the collection of visual wave observations over the Northern Hemisphere for the last 5 decades for statistical estimation of extreme wave parameters and analysis of their decadal variability.
- Climatic Variations in Hurricane Characteristics And their Potential Effects on Waves and Surges in the Gulf of Mexico; Donald Resio and Liz Orelup examined climatic variations in large-scale atmospheric and oceanic conditions and related these variations to potential changes in waves and coastal surges within the Gulf of Mexico.
- Reasons for Focussing More on Prediction of the Very Extreme Sea States; Sverre Haver — discussed the use of the accidental limit state (ALS) to capture very rare metocean loads.

While not directly related to either surface fluxes or wave climate, waves are a very important factor in maritime safety. The sea state is now again a mandatory parameter in weather forecasts, and dangerous sea / rogue waves are listed as potential parameters for warnings. Important research is being carried out on the issue of climate variability and change and its potential impacts on future design criteria for offshore platforms and coastal infrastructure.

Considering the WCRP-relevant air-sea flux issues in particular and WCRP Strategic Framework in general, waves may stay as a very effective test bed for numerous WCRP tasks. Since they are generated by wind, surface waves play a crucial role in modification of surface fluxes of momentum and, thus, are critical for accurate estimation of the wind energy input to the ocean. Furthermore, waves play a critical role in ocean-atmosphere gas exchanges, being responsible for the small-scale mechanisms regulating surface gas fluxes and associated with bubbles, foam and surface mixing.

Surface wind waves can be considered in a wider context of WCRP strategy. Given the importance of Extreme Events (one of WCRP cross-cutting topics), studies of ocean wind wave climate provide valuable input to WCRP science. Currently, extreme wind waves represent one of the most accurately quantified climate extremes. Of special importance is the contribution of extreme waves to the extreme sea levels, previously considered as a special topic at Sea Level Rise Workshop in Paris (6—9 June 2006). In a more general context, ocean wind waves may be considered as an important indicator of climate variability in low atmosphere dynamics, cyclone activity and large-scale atmospheric general circulation.

The above points demonstrate the importance of emphasizing ocean wind waves for WCRP science and call for efforts to integrate the whole spectrum of the wind wave studies into WCRP science.

The 10th International Workshop on Wave Hindcasting and Forecasting which will be held November 11—16, 2007, in Oahu, Hawaii , and to reference the Workshop web site www.waveworkshop.org. The CLIMAR-III conference also has some relevance to flux and WCRP; it is planned for May 2008 in Poland (probably Gdynia).

Report on the joint WGSF – WGNE meeting on SURFA

26 October 2006,
Boulder, Colorado, USA

C.W. Fairall and M. Miller

In October 2006 representatives of the WGSF gave a series of talks at the WGNE meeting in Boulder on the topic of the SURFA project. The purpose was to present to WGNE a new proposal to begin the SURFA project with an archive at NOAA National Climate Data Center (NCDC).

SURFA was originally conceived in 2000 as a project to improve NWP and GCM representations of surface fluxes by archiving operational NWP flux products and high-quality *in situ* observations for subsequent intercomparison and analysis. After the WGSF was formed in 2004, the group was charged with re-invigorated SURFA. Bob Weller and Peter Gleckler led the initial discussions held at the first WG meeting in Halifax. Progress continued in late 2005 and early 2006 with a dialogue between Chris Fairall (WGSF chair) and Martin Miller (WGNE chair). It was agreed that the WGSF would attend the WGNE meeting in Boulder and present a plan for SURFA. SURFA was the main topic of discussions at the second WGSF meeting (held in Heidelberg, Germany, in September 2006). Following Heidelberg, the WG approached NOAA NCDC about serving as the SURFA archive and they agreed.

At the WGNE meeting in Boulder WGSF members made three presentations (Fairall — background; E. Kent — in situ comparisons with NWP; Bentamy — satellite fluxes and NWP). Huai-Min Zhang of NCDC made a presentation on NWP and climate archiving activities at NCDC (including the new NOMAD system). The remainder of the afternoon was devoted to discussions of NWP variables to archive, grids, time resolution, and other related details, possibilities of sources of *in situ* data, and software within the NOMAD system for easy access to the data archives (in the interest of promoting research on SURFA issues).

Presentations by WGSF members are available in PowerPoint at

ftp://ftp.etl.noaa.gov/user/cfairall/wcrp_wgsf/surfa/WGNE_06_Boulder.

The results of the meeting are as follows:

- A proposed list of NWP variables is available for comment.
- A strategy was developed to initially begin archiving NWP flux products from NCEP and ECMWF as a pilot study of about one year duration to evaluate and streamline the process. After the initial problems are worked out, NCDC will begin accepting data from other NWP centers.
- Detlev Majeweski was appointed WGNE point of contact to arrange for archiving with the NWP centers. The WGSF will coordinate archiving the *in situ* data.
- Huai-Min Zhang returned to NCDC and began to investigate arrangements to set up the archive.

While there are still many steps remaining before SURFA becomes a useful reality, it appears that the crucial first step has been taken.

New development

Marineclimatology.net

D.Berry and E.Kent

October saw the launch of a new web site intended to help researchers working in marine climate share information and expertise. The web site uses wiki software which allows anyone to make changes and additions to the web site, once they have signed in. The initial aim of marineclimatology.net is to track progress towards meeting the recommendations of the Second International Workshop on Advances in the Use of Historical Marine Climate Data (MARCDAT-II) held a year ago at the Met Office in Exeter (see the first edition of Flux News for meeting report). It is hoped that the web site will quickly develop to meet the needs of the marine climatology community in order to share the latest information on datasets, publications and meetings. It can also be used as a forum for discussions on current research and for highlighting and solving problems.

So please visit **http://www.marineclimatology.net/,** tell your colleagues about it and contribute to making marineclimatology.net a success.

CALENDAR

6—9 March 2007, SOLAS Science 2007: A SOLAS Open Science Conference, Xiamen, China, http://www.solas2007.confmanager.com

19—21 March 2007, North Atlantic Subpolar Gyre Workshop, Kiel Germany, http://www.ifm-geomar.de/index.php?id=subpolar-gyre

3—4 May 2007, NEESPI Summit, Helsinki, Finland, http://neespi.org/

2—13 July 2007 University Centre in Svalbard, International Sea-Ice Summer School, http://www.seaice.info/

2—13 July 2007, IUGG XXIV General Assembly, Perugia, Italy, http://www.iugg2007 perugia.it/

20—24 August 2007, 15th AMS Conference on Air-Sea Interaction, Portland, OR, USA, http://www.ametsoc.org/meet/meetinfo.html

Get the latest news about WCRP science, personalities and upcoming events from the WCRP Newsletter «EZINE» published by JPS for WCRP in Geneva.

WCRP NEWS
World Climate Research Programme

Download the December 2006 (No. 4) and March 2007 (No. 5) EZINE issue from http://wcrp.wmo.int/pdf/WCRPezine_Dec06.pdf

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Call for contributions:

We invite contributions to the next issue of Flux News, which will be a regular issue. We welcome articles on a wide range of topics related to air-sea fluxes.

The closing date for submissions is 15 June 2007.

FLUX News is published by the WCRP Working Group on Surface Fluxes

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FLUX News is published biannually.
If you are interested in contributing an article or receiving further copies, please contact fluxnews@sail.msk.ru.

This and the previous issues can be downloaded from www.sail.msk.ru

Printed by Max Press, Moscow, Russia
Circulation 1000

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