NEWSLETTER OF THE
AIR-SEA FLUX COMMUNITY

WCRP World Climate Research Programme CLIVAR

FLUX NEWS

Issue 6 November 2013

WELCOME TO THE RESTART OF THE FLUX NEWSLETTER!

Dear colleagues and friends,

This is the new issue of Flux News – the bulletin for covering the most important areas of air-sea flux research, coordinated experiments, and relevant datasets and publications. CLIVAR has now become a home for air-sea interaction studies – the role previously played by the World Climate Research Programme (WCRP). Five issues of Flux News were published in 2006-2008, which received a good response from the flux community. It was then the press organ of the WCRP WG on Surface Fluxes with the circulation of 1000. We are re-launching this publication upon the recommendation of the CLIVAR-GSOP Workshop on air-sea fluxes and ocean synthesis held at WHOI in November 2012. Since the accurate assessment and validation of surface fluxes remain critically important in many science areas (e.g., surface flux products based on observations, atmospheric reanalyses, and ocean synthesis), there is clearly a continued need for a periodical for reviewing and coordinating air-sea flux activities. As before, this reinstated bulletin will cover the wide spectrum of air-sea flux studies – from observations and data processing to evaluation of global products and forcing ocean models. There will also be reports from major conferences and workshops, announcements of upcoming meetings related to surface fluxes, and highlights of recent publications on surface fluxes.

As the editor I shall work closely with the informal 'editorial board' currently consisting of M. Balmaseda, B. Barnier, M. Bourassa, N. Caltabiano, M. Cronin, K. Haines, S. Josey, T. Lee, L. Yu. N. Kovaleva will continue working as the executive editor undertaking responsibilities for the collection of papers and design. We welcome your ideas, suggestions, and contribution to the bulletin.

S. Gulev

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Greetings to the readership of FLUXNEWS. As the Chairman of the Joint Scientific Committee (JSC) of the WCRP, and on behalf of the JSC I offer our thanks and gratitude to Sergey Gulev for all his years of service on the JSC, the Working Group on Surface Fluxes, the SOLAS SSC, the CLIVAR SSG, and, of course, his support of this publication.

It should go without saying, but nonetheless I will use this opportunity to do so, that radiative and turbulent fluxes are what really ties the WCRP core projects together, i.e., CLIVAR, GEWEX, CliC, and SPARC as well as the modeling components of the program, WGSIP, WGNE and WGCM. Similarly, SOLAS serves as an initiative that brings together WCRP and IGBP with emphasis on fluxes across the air-sea interface.

The extent to which the hydrological cycle is accelerating, our ability to improve seasonal to interannual climate predictions, or our understanding of year to year changes in sea ice are just a few among many examples of the importance of improved monitoring and prediction of surface fluxes of heat and momentum.

Another example where the importance of surface fluxes will be at the forefront of the WCRP are across the Grand Challenges the JSC has developed for the decade ahead, i.e., provisions of regional climate information, regional sea level rise, cryosphere in a changing climate, climate sensitivity and its role in atmospheric circulation and clouds, changes in the global water cycle, and the prediction and attribution of extreme events.

Needless to say, surface fluxes are an important component of each and every one of these Grand Challenges, and hence the whole of the WCRP moving forward.

WE INVITE CONTRIBUTIONS FOR THE UPCOMING ISSUES OF FLUX NEWS

Please share your ideas on processing global, regional or local air-sea flux data from in-situ/satellite measurements or NWP. We also invite opinions on how to better facilitate surface flux related activities and to provide better synergy across the groups and agencies. Any important novel scientific results in the area of air-sea interaction are also welcome. Please send your short contribution (preferably under 1000 words, with figures) to Nadia Kovaleva (nadia@sail.msk.ru).

CLIVAR–GSOP MEETING ON AIR-SEA FLUXES AND OCEAN SYNTHESIS

WHOI, 27-30 November 2012


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Air-sea fluxes are recognised to be an important cross-cutting area within WCRP that link the interests of different programs including CLIVAR and GEWEX. The twin challenges of closing global ocean heat and freshwater budgets using models and observations, along with the importance of improving surface forcing functions for ocean and coupled climate modelling purposes, highlight the need for close collaboration between observation, modelling and synthesis communities. The Global Synthesis and Observational Panel of CLIVAR brought more than 60 international scientists from the air-sea flux and ocean synthesis communities together for a WHOI workshop to address these challenges.

This workshop aimed to:
(1) review the current state of surface fluxes of heat, freshwater and momentum obtained from ocean syntheses, atmospheric reanalyses, other observation based products, and coupled models,
(2) discuss the gaps and current limitations in these products with particular reference to balancing ocean heat and freshwater budgets, and
(3) develop recommendations and requirements for future global/regional synthesis activities. These areas of activity are relevant to the interests of the WOAP, WGSF and WCRP Data Council, specifically addressing recommendations in the Action Plan for WCRP Research Activities on Surface Fluxes (http://www.wcrp-climate.org/documents/woap_fluxes_report_01_2012.pdf).

Given the gaps in present-day knowledge and understanding, a consensus was reached during the workshop that achieving globally balanced energy and freshwater budgets is a long- term challenge, and should be broken down into incremental steps with achievable targets at each stage. Guided by the NASA and NOAA perspectives and objectives, the workshop discussions were directed toward seeking areas of collaborative research by:

- maximizing the use of existing observations made at the ocean surface and subsurface, and
- integrating regional budget analysis with direct pointwise comparison with in situ buoy/ship measurements.

The full workshop report can be found at (http://www.clivar.org/sites/default/files/ICPO189_WHOI_fluxes_workshop.pdf).

Two key collaborative activities were recommended.

1. A working group should be set up to develop strategy for regional heat/salt budget analysis and regional flux assessment using moored buoys and upper ocean observations from Argo.

Rationale: Argo upper ocean heat/salt content observations can be regarded as a means of providing direct estimates of the total integrated air–sea fluxes of heat and freshwater averaged on some spatial and temporal scale. Argo observations, if estimates of uncertainty are included, should be capable of providing regional references for calibration of temporally integrated air–sea flux estimates in the same way that flux buoy and ship measurements have previously provided pointwise calibration information. These ocean data would greatly help to resolve the issues of regional biases and global imbalance that currently affect almost all flux products constructed from satellites, ships, and atmospheric reanalyses.

Caveats: Regional ocean heat budgets can provide information on the integrated heat flux but not the components. Advective convergence and divergence of heat may be important in the regional heat budgets, and

KEY CLIMATE LOCATIONS FOR OCEANSITES (FULL-FLUX) BUOYS

The Tropical Oceans (20°S-20°N, 9 buoys):

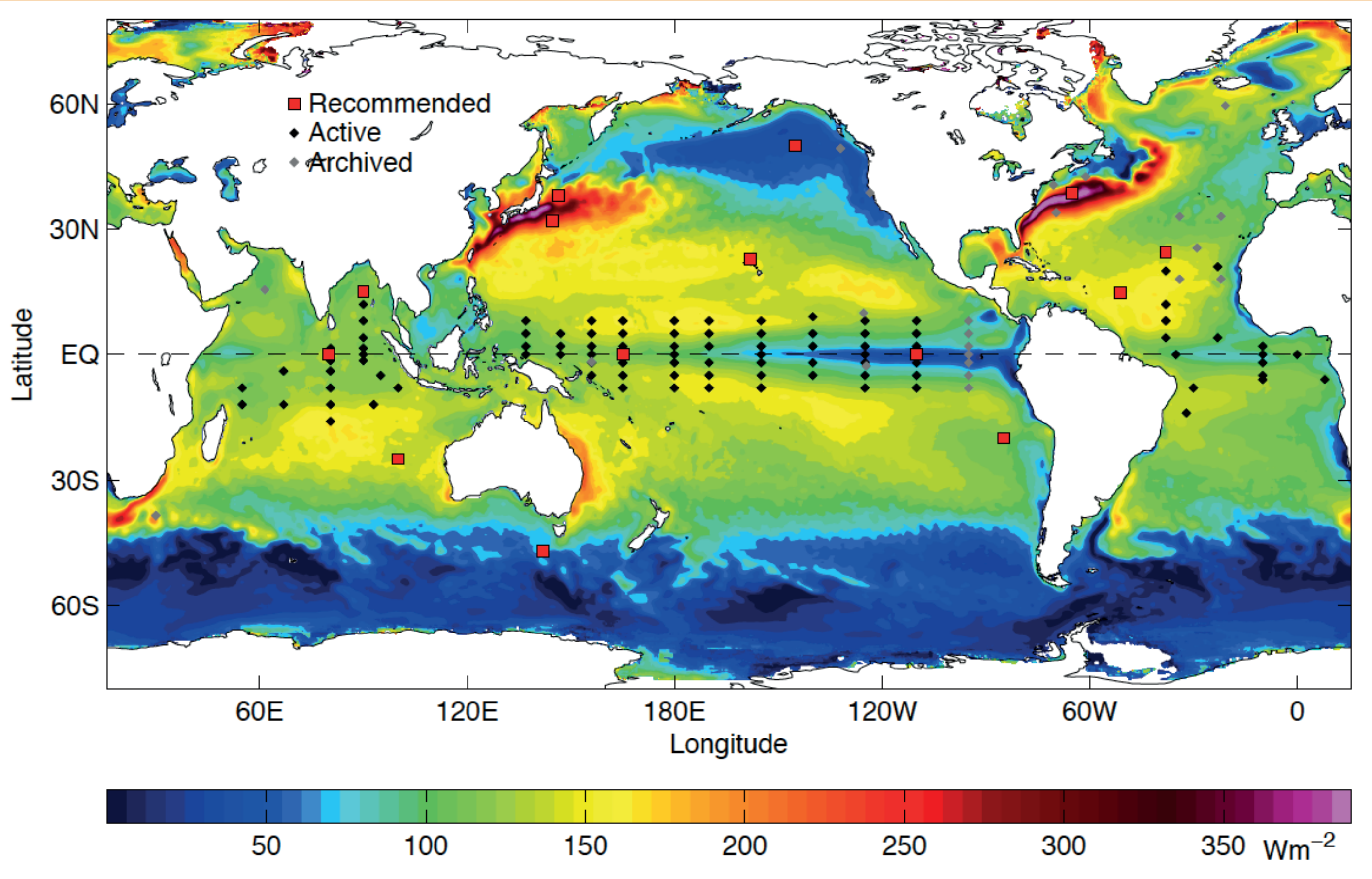
- 2 TAO buoys: (EQ, 110°W), (EQ, 165°E)
- 2 RAMA buoys: (EQ, 80°E), (15°N, 90°E)
- 3 PIRATA buoys:(EQ, 23°W), (10°S, 10°W), (15°N, 38°W)
- STRATUS (20°S, 85°W)
- Northwest Tropical Atlantic Station (NTAS) (15°N, 51°W)

The subtropical region (20–40° north and south, 6 buoys):

- RAMA in the Indian Ocean southeast trade wind regime: (20°S, 100°E)
- WHOI Hawaii Ocean Time-series Station (WHOTS) in the north Pacific: (22.5°N, 158°W)
- Salinity Processes in the Upper Ocean Regional Study (SPURS) buoy: (24.5°N, 38°W)
- Kuroshio Extension Observatory (KEO) buoy: (32.4°N, 144.6°E)
- JAMSTEC Kuroshio Extension Observatory (JKEO): (38°N, 146.5°E)
- CLIVAR Mode Water Dynamic Experiment (CLIMODE) buoy: 38.5ºN, 65ºW

Higher latitudes (poleward of 40° north and south, 2 buoys):

- Ocean Station PAPA: (50°N, 145°W)
- Southern Ocean Flux Station (SOFS): (47°S, 140°E)



Buoy locations superimposed onto WHOI OAFlux 0.25° Analysis.

if they cannot be sufficiently constrained these transport terms may dominate the error estimate on the regional air–sea flux budgets.

Selection of ocean regions for flux budget studies:

- seek areas away from boundary currents where advective convergence is minimal, (e.g., enclosed and semi-enclosed basins such as the Mediterranean and the Red and Black seas);
- seek areas that include within them one or more flux buoys, (e.g., the OceanSITES flux buoys or an ongoing field program such as SPURS, particularly buoys associated with process study data (e.g., STRATUS and PAPA).

It was also recommended that satellite data and other in situ data (ships and drifters) be used to observe and/or assess the regional variability around the buoys. Analyze areas of particular interest for ocean processes (e.g., areas of water mass formation). Choose areas with the best Argo sampling over the longest period.

2. Comprehensive direct pointwise comparison of flux products and syntheses should be made with selected OceanSITES.

Rationale: In situ air–sea measurements set the accuracy standard for gridded flux products.

Recommendations: It is recommended that these comparisons should be carried out for all global flux products, including atmospheric reanalyses, ocean syntheses, and parameterized flux products based on satellite data. The analysis of the heat and freshwater budgets from the different products around the calibration sites should yield insight into synthesis product consistency, distributions and scaling effects, and areas of common biases, as well as enable flux component comparisons.

The above mentioned and a further six recommendations from the Workshop are listed below.

CLIVAR–GSOP WORKSHOP RECOMMENDATIONS:

1. **A working group should be set up to develop strategy for regional heat/salt budget analysis and regional flux assessment using moored buoys and upper ocean observations from Argo.**

2. **Comprehensive direct pointwise comparison of flux products and syntheses should be made with selected OceanSITES.**

3. **Ocean synthesis and reanalyses should separately archive components of the air-sea heat flux, i.e. Short and Longwave radiation, and sensible and latent heat fluxes, to facilitate comparisons with OceanSITES measurements.**

4. **Simple Web-based table with ftp links should be created to facilitate access to daily averaged and higher resolution net heat flux, the flux components, and meteorological state variables from moored buoys.**

5. **Reference station data (WMO type "84") should be withheld from reanalyses to allow independent assessment. WMO numbers of all data that are assimilated into NWP should be listed and made available.**

6. **The SeaFlux website should be updated with recent data and metadata.**

7. **The Flux News Letter should be revived, to provide review of surface flux research, coordinated experiments, and relevant dataset publication.**

8. **The surface fluxes and synthesis communities should continue to enhance the interaction with relevant programs funded by different agencies, e.g., NASA and ESA Science Teams, NOAA program activities.**

JOINT CLIVAR–ESA SCIENTIFIC CONSULTATION WORKSHOP

Reading, 3-4 June 2013

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The Climate Variability and Change in the Atmosphere-Ocean System Programme (CLIVAR) has recently established a new research opportunity on Consistency between Planetary Heat Balance and Ocean Heat Storage (http://www.clivar.org/science/clivar-research-opportunities#six).The main objective of this cross-cutting activity (relevant for CLIVAR's Global Synthesis and Observations Panel (GSOP), as well as to other international programs such as GEWEX, GOOS and Seaflux (http://seaflux.org) is to analyse consistency of heat budget components as seen by independent global observing systems, including
(i) Earth Observation (EO) from space,
(ii) in-situ measurements of ocean heat content changes, and
(iii) Ocean reanalysis for heat exchange and storage.

In this context, the European Space Agency (ESA) and the CLIVAR Project Office held a workshop on 3-4th July 2013 at the University of Reading (UK) aimed at exploring and consolidating the scientific basis for a potential joint activity Ocean Heat Flux addressing the EO component of the new CLIVAR research focus. This workshop gave an opportunity to the scientific community to help shape the ESA activity by gathering the scientific requirements for EO data and products to support the CLIVAR objectives. The aim was also to build upon the recommendations from the CLIVAR GSOP-WHOI Workshop on Ocean Syntheses and Surface Flux Evaluation (http://www.clivar.org/sites/default/files/ICPO189_WHOI_fluxes_workshop.pdf) reported elsewhere in this Newsletter, and to complement existing activities such as SEAFLUX.

The meeting, supported by ESA, WMO and the National Centre for Earth Observation (NCEO), attracted 27 participants from Europe and the US, with additional presentations delivered from the US by Videoconference. The presentations are available from http://www.clivar.org/organization/gsop/activities/clivar-esa-scientific-consultation-workshop-earth-observation-measurement.

The meeting discussions were focussed on four areas:

- Assessing current air-sea heat flux products from satellites and other sources, including their uncertainties and methods of calibration;
- Planetary energy balance measurements from Top of Atmosphere fluxes and from Argo;
- The availability of satellite products relevant to constraining surface fluxes;
- Ocean synthesis and ocean products as constraints on air-sea fluxes.

Conclusions and recommendations from this meeting (still in development) will be used to define the scope and develop guidelines of a potential open competitive tender funded by ESA under the Support To Science Element (STSE) (http://due.esrin.esa.int/stse). This activity will be expected to use global EO data and products, in particular from ESA missions (e.g. Envisat, ERS, Cryosat) and programmes (e.g. Climate Change Initiative (CCI), Glob product Data User Element (DUE), STSE) in combination with other data sets to
(i) produce ensemble-based estimate of ocean surface fluxes using the latest EO measurements, and
(ii) develop a methodology and reference data sets to benchmark different flux data sets, and assess their quality and uncertainty across suitable oceanic regions of interest by exploiting ocean heat budget constraints as recommended by GSOP (Yu *et al*., 2012).

This activity could also be seen as a European contribution to the Seaflux efforts, by complementing their data sets (mainly currently focusing on non-European missions, such as AVHRR, and SSM/I) with ESA and third party data and products.

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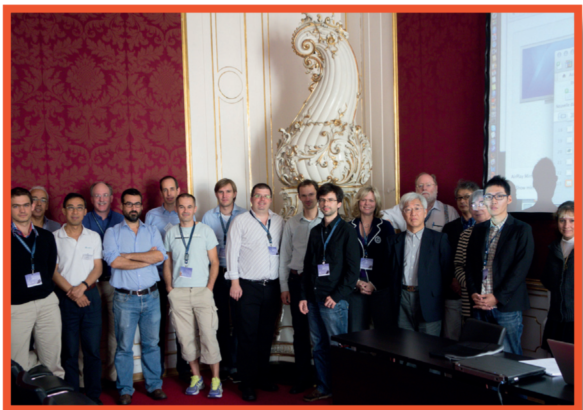
One component of the mission of the GEWEX Data and Assessments Panel (GDAP) is to guide GEWEX projects towards providing an integrated product of the global water and energy fluxes in the atmosphere and at the surface. Two projects under GDAP are SeaFlux and LandFlux, which are focused on providing high-resolution ocean-atmosphere and land-atmosphere turbulent flux datasets, respectively. These two projects met as a group together for the first time in a combined SeaFlux/LandFlux workshop, held in conjunction with the EUMETSAT/AMS Satellite Conference in Vienna, Austria on September 19-20, 2013. This combined workshop brought together experts in satellite remote sensing from both the land surface and ocean surface communities to discuss issues associated with understanding the global water energy and water cycles.

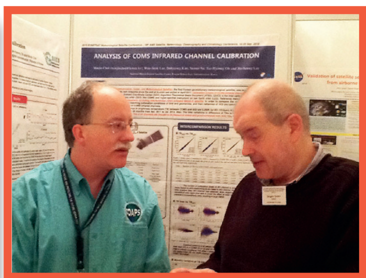
The workshop served both as a forum for exchange about the leading-order difficulties and new advances in surface flux products and as an opportunity to strategize about potential improvements to the GEWEX products. The role of the SeaFlux and LandFlux products within the larger GEWEX GDAP suite of products and the goal of producing a truly integrated global and energy water cycle dataset was outlined by Chris Kummerow, GDAP chair. Presentations by both the SeaFlux and LandFlux effort leaders on current products and planned improvements were then followed by presentations on other current land and ocean flux datasets, including the HOAPS, IFREMER, and J-OFURO projects.

Further discussions followed surrounding the various methods used to produce the flux datasets and possible in situ datasets that can be used for characterization of the data sets. Issues associated with short time or space scale variability in sea surface or land temperature and effect on the surface fluxes were explored, as were possible methodologies appropriate for intercomparison of the satellite flux data sets with each other and in situ datasets. Several presentations focused on the scientific analyses of components of the water and energy budgets using SeaFlux and other satellite products.

Issues associated with further product development include calibration of the SSM/I brightness temperatures, the need for improved ice masks, understanding the effects of current sea surface temperature datasets and their temporal/spatial resolution on the surface fluxes, and trends in surface fluxes particularly due to trends in current wind speed products were discussed. Several community-wide follow-on activities were identified: the first is an analysis of existing SSM/I brightness temperature calibrated datasets and effects of the use of differing techniques on the resulting retrievals of the surface fluxes, and secondly an intercomparison of the differing surface flux datasets including comparison with in situ datasets.

For those researchers who were unable to attend the workshop but would like to participate on the efforts towards understanding the effect of the varying calibrated SSM/I brightness temperature data on the flux products, or the intercomparison effort, should contact the SeaFlux project director, Carol Anne Clayson. The SeaFlux data and further information about the SeaFlux project can be found at http://www.seaflux.org, along with a full listing of conference participants and continuing efforts related to the 6th workshop.





SUMMARY OF FINDINGS OF THE US CLIVAR WORKING GROUP ON HIGH-LATITUDE SURFACE FLUXES

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The US CLIVAR Working Group on High-Latitude Surface Fluxes published its final report (Bourassa *et al*. 2013) this year. The report focuses on ocean-surface flux requirements. The Snow, Water, Ice, Permafrost of the Arctic (SWIPA) assessment (Arctic Monitoring and Assessment Programme 2011, http://www.amap.no/swipa/) address fluxes over ice and tundra. Numerous problems with high-latitude observations, reanalyses, and other such data products are described in the Working Group's report (and in issue 5 of **Flux News**), and are summarized below. Recommendations for moving forward are also summarized.

There are many substantial problems to overcome.

1) Flux products disagree enormously, and as a result we have little confidence in any existing products. These products are improving, but they are still challenged in the Arctic.

2) The small Rossby radius means that the length scales that should be resolved are tiny compared with traditional NWP reanalyses.

3) Rough conditions mean that there have been essentially no in situ observations in open-ocean or pack-ice conditions.

4) Fluxes over permanent sea ice are fairly well understood from SHEBA, but that is the condition that is disappearing most rapidly.

5) Climate change scenarios suggest standards for fluxes on the order of 1 W/m^2 bias that are unachievable with current and projected technology, but that should not be a distraction. Observing fluxes accurate to 10 W/m^2 would represent a significant improvement, and we believe this is achievable through a concerted observing effort coupled with a satellite analysis effort. Such observations would greatly enable process studies.

The recommendations toward improvements in Arctic data are multifaceted. The rough and remote conditions necessitate improvements in satellite observations and reanalyses that make use of these observations, e.g., the Arctic System Reanalysis (ASR, Bromwich *et al*. 2010). More in situ observations are required to test parameterizations and numerical models, to examine variability in the marginal ice zones, and to aid in satellite calibration. Surface fluxes must be measured by satellite: they vary too much in space and time for a purely in situ observing system. The in situ and satellite data must be made easily available, and they should be used in flux intercomparisons.

Determining accurate surface turbulent fluxes from space has been considered difficult. Recent improvements in retrievals (Jackson *et al*. 2009; Roberts *et al*. 2010; Bourassa *et al*. 2010) of the bulk variables used to calculate fluxes, demonstrates sufficiently small biases over a very wide range of conditions, indicating that bulk fluxes can likely be retrieved with sufficient accuracy for many applications. Recent preliminary efforts in formulating a new satellite mission found that satellite observations needed for determining fluxes and high-resolution surface winds are very well suited for a wide range of other observations. Although obtaining fluxes is likely to be a secondary benefit of such a satellite mission, it is very encouraging to see a path toward making such observations possible.

Acknowledgements

All participants in the Working Group on High-Latitude Fluxes are thanked for their contributions to that activity, and some of their ongoing work which is mentioned herein.

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NEW RELEASE OF DAILY SATELLITE TURBULENT FLUXES

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The surface turbulent fluxes estimated from satellite observations are reprocessed for QuikSCAT period October 1999 – November 2009 (Bentamy *et al*, 2013). They are calculated as daily turbulent air-sea fluxes over global oceans with a spatial resolution of 0.25° in longitude and latitude.

The main improvements with respect to V2 version flux products (Bentamy *et al*, 2008) are related to the improvements of the specific air humidity estimation from radiometer measurements, to the assessment of the surface winds retrieved from QuikSCAT scatterometers, and to the use of the new objective method allowing the calculation of flux analyses over the global oceans.

The new turbulent fluxes are estimated using Fairall *et al* (2003) bulk algorithm. The required bulk variables such as surface wind speed (W_{10}) and specific air humidity (Qa_{10}) at 10m height are both estimated from remotely sensed measurements. W_{10} is obtained from SeaWind scatterometer on board QuikSCAT satellite.

A new empirical model relating brightness temperatures (Tb) from special sensor microwave imager (SSM/I) and Qa_{10} is developed. It is an extension of the previous model (Bentamy *et al*, 2003). In addition to Tb variables, it includes sea surface temperature (SST) and air – sea temperature difference variables.

The new satellite Qa_{10} are used in combination with the newly reprocessed QuikSCAT *V3*, the latest version of sea surface temperature (SST) analyses provided by the National Climatic Data Center (NCDC), and with 10m air temperature estimated from the European Centre for Medium Weather Forecasts (ECMWF) re-analyses (ERA Interim). The resulting gridded fields of W_{10}, Qa_{10}, wind stress (τ), latent heat flux (LHF), and sensible heat (SHF) flux fields are first validated against daily-averaged in-situ data.

For the accuracy determination purpose, in-situ data derived from buoys are used. They are provided by Météo-France and U.K. MetOffice (MFUK), the National Data Buoy Center (NDBC), the Tropical Atmosphere Ocean Project (TAO), the Pilot Research Moored Array in the Atlantic project (PIRATA), and by the Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction project (RAMA). They consist of buoys moored off US coasts (NDBC), off European seas (MFUK), and along the Atlantic (PIRATA), Indian (RAMA), and Pacific (TAO) tropical oceans. To further investigate the quality of satellite daily fluxes, comparisons are performed with in-situ from scientific experiments such as GASEX, EGEE, SHOWEX, and ETL. At global scale, the spatial and temporal satellite flux patterns are compared to those from ICOADS, ERA Interim, and CSFR.

Data and documentation are available at ftp://ftp.ifremer.fr/ifremer/cersat/products/gridded/flux-merged/v3/.

THE OCEANIC SHIPBOARD PRECIPITATION MEASUREMENT NETWORK FOR SURFACE VALIDATION – OceanRAIN

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Introduction

The precipitation flux is a fundamental component of the Earth's hydrological and energy cycle and thus a crucial parameter for understanding and modelling of the climate system. Moreover, precipitation is among the most intermittent and inhomogeneous parameters with high spatio-temporal variability and occurs in liquid, solid or mixed-phase. Consequently, measuring precipitation is notoriously difficult resulting in large uncertainties. The balance between precipitation and evaporation results in the freshwater flux. Besides evaporation, more realistic precipitation observations also improve the freshwater flux estimates.

Measurements of precipitation over ocean with adequate sampling largely improved with the advent of active and passive microwave remote sensing from space. Nonetheless, satellite based climatologies of precipitation (e.g. GPCP, TMPA, HOAPS) do not discriminate between liquid and solid precipitation. Detection of snowfall and mixed-phase precipitation from space remains a challenging task. Furthermore, evaluation studies of satellite, re-analysis and model climatologies exhibit large differences among each other, especially for light rainfall and high-latitude cold season precipitation (e.g. Andersson et al., 2011).

These deficits call for high quality in-situ validation data. Over land this is carried out by GPCC using rain gauges. In contrast, the global ocean, covering about 71% of Earth's surface, is almost void of quantitative precipitation surface reference data. Shipboard requirements to measure under high wind speeds, frequently varying relative wind directions, flow distortion around the ships superstructure, ship movement in high sea states and frozen precipitation disclose the lack of available disdrometer-type instrumentation. Gauges are in principle inapplicable for this task.

Recommendations of the International Precipitation Working Group (IPWG), the Global Precipitation Measurement – Ground Validation (GPM-GV) group and the SeaFlux and OceanObs communities are summarizing this surface measurement deficiency in expressing the urgent need for improved and robust automatic sensors being capable of measuring all precipitation types with high quality under all weather conditions with appropriate statistical sampling.

This motivated initiating OceanRAIN (Ocean Rainfall And Ice-phase precipitation measurement Network) for oceanic shipboard precipitation measurement for surface validation at the KlimaCampus, University of Hamburg and the Max Planck Institute for Meteorology in Hamburg, Germany in 2009. The network aims at a systematic shipboard data collection effort to establish a comprehensive statistical basis of phase-distinctive precipitation for surface validation of satellite, re-analysis and model data. The optical disdrometer ODM470 is the mainstay of the in-situ precipitation measurement and was especially designed to perform under rough sea states and high wind speed conditions onboard moving

Fig. 1: The automatic measurement system ODM470-400 consisting of the ODM470 (middle), the cup anemometer (left) and the precipitation detector IRSS88 (right) in the highest parts of the ships mast onboard R/V "Polarstern". The ODM470 rotates 360° into the local wind direction by aid of a wind vane.

ships. The selected ships operate in climate-relevant remote ocean areas (e.g. Arctic/Antarctic, Southern Oceans, subtropics, ITCZ, mid-latitude stormtracks) and do not circumvent high-impact weather.

The optical disdrometer ODM470

Originally developed by Großklaus et al. (1996) at IFM-GEOMAR in Kiel, Germany, the ODM470 performed reliably in a snowfall campaign (Lempio et al., 2007). Furthermore, it was successfully used to validate HOAPS satellite data over the cold-season Norwegian Sea (Klepp et al., 2010; Brümmer et al., 2010). This disdrometer was further developed into its currently fourth version, the automated data logging system (called ODM470-400), in close cooperation between the OceanRAIN project and manufacturer Eigenbrodt, located near Hamburg, Germany. It consists of the ODM470 along with the precipitation detector IRSS88 and a cup anemometer for relative wind speed measurements (Fig. 1).

The main advantage of the ODM470 over other instrumentation is threefold: First, the cylindrical optical volume, homogeneously illuminated by an IR-LED, is independent of the incident angle of the incoming hydrometeors. Second, the optical volume is always kept perpendicular to the local wind direction by aid of a wind vane. Third, the wide dynamic range allows resolving 129 size bins with logarithmic increase in size to detect hydrometeors from 0.43 to 22 mm in diameter (Klepp et al., 2010). The number of particles per size bin during the integration time of one minute is logged along with the residence time of the particles in the volume. From this, particle size distribution (PSD) densities are calculated using the number of particles per bin, local wind speed and terminal fall velocity (Lempio et al., 2007). Additionally, the mass of the hydrometeor is calculated using different parameterizations for rain and snow (including mixed-phase) after Atlas and Ulbrich (1974) and Hogan (1994). The precipitation rate for rain or snow (including mixed-phase) is calculated after Pruppacher and Klett (1978).

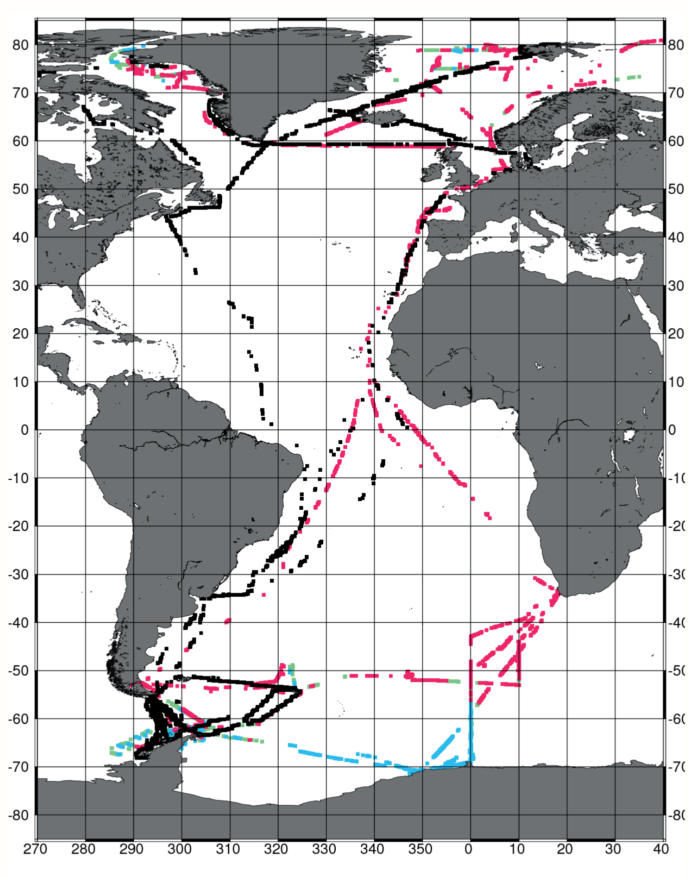

Fig. 2: Two years each (2010 to 2012) of discontinuous precipitation tracks (precipitation occurrence only) from R/V "Akademic Ioffe" in black and R/V "Polarstern" in color-coding, indicating rainfall in red, snowfall in blue and mixed-pase precipitation in green.

Data Collection

All instruments undergo rigorous calibration procedures before shipboard installation. First, the ODM470 is hardware calibrated using potentiometers and metal spheres dropped through the volume. The second step comprises outdoor calibration using rainfall and comparisons against a reference measurement. Between 2009 and 2013 seven ODM470 systems were installed on research and military ships. Three of them are long-term mounted onboard German R/V *Polarstern* since 6/2010, Russian R/V *Akademik Ioffe* (since 10/2010 in cooperation with the P.P. Shirshov Institute in Moscow), and German R/V *Maria S. Merian* (since 12/2011). The remaining four disdrometers are used for shorter-term cruises and experiments. The instruments are frequently maintained, exchanged and re-calibrated during harbour times during which also the data is collected. The ODM470 data files are discontinuous in time as data is logged during precipitation events only (Fig. 2). Additionally, continuous ancillary shipboard standard meteorological, navigation and observation data is utilized.

Data Products

All offline arriving data streams are automatically and manually quality controlled, suspicious data is flagged and visually inspected. Using a cascading process, PSDs, rain- and snowfall rates, air temperature, humidity and weather observations determine the ODM470 data flagging into the precipitation types rain, snow and mixed-phase. The precipitation flagged ODM470 minute interval measurements are finally calculated into PSD, precipitation occurrence, intensity, accumulation and are collocated and merged with the

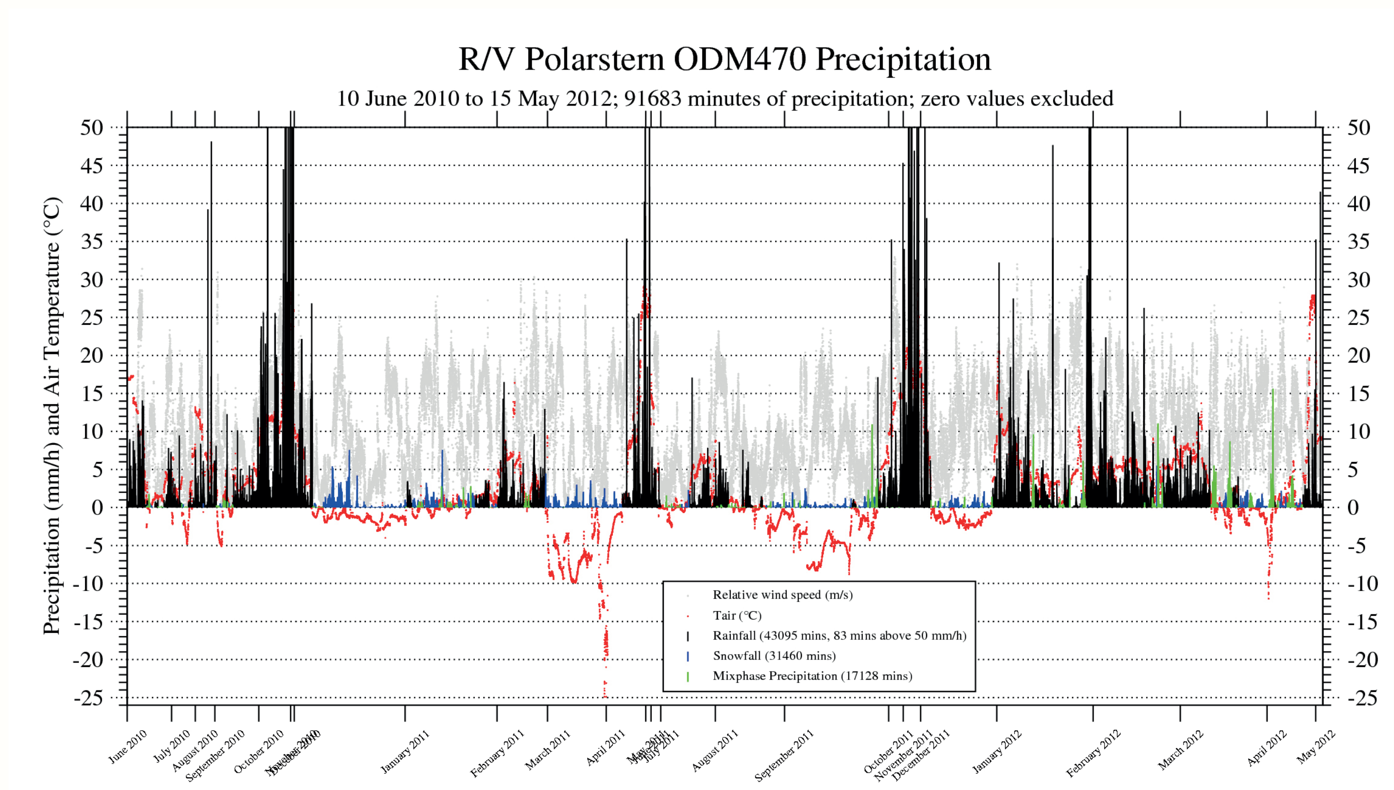

Fig. 3: Two years of R/V "Polarstern" discontinuous precipitation time-series in mm/h from June 2010 to May 2012 containing 91683 minutes of precipitation with 43095 minutes of rainfall (black), 31460 minutes of snowfall (blue), and 17128 minutes of mix-phase (green). The air temperature (°C) is shown in red and the relative wind speed (m/s) in grey.

shipboard standard meteorological and navigation data. The resulting precipitation time series (Fig. 3) and PSD products (Fig. 4) are discontinuous in time (precipitation events only), and contain up to 22 parameters (Klepp, 2013).

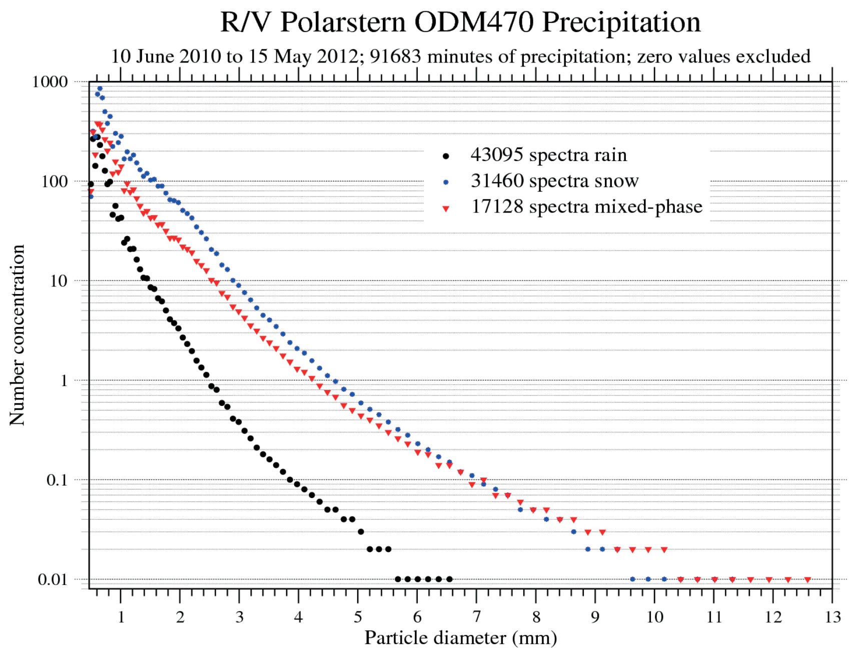

Fig. 4: Particle size distributions for 91683 minutes of precipitation using the same time period as in Fig. 3 with rainfall in black, snowfall in blue and mixed-phase precipitation in red.

Conclusion

OceanRAIN is to date the only disdrometer-based long-term systematic oceanic shipboard precipitation data collection effort for surface validation of satellite, re-analysis and model data. Especially the new satellite generations of GPM, SSMIS and MeghaTropiques may benefit from this surface reference data that also allows investigating the point-to-area problem which arises from the surface point measurements and satellite aerial footprints. Through the provision of minute-resolution precipitation time series and PSDs for the precipitation types rain, snow and mixed-phase the data base is suitable to constrain satellite retrievals and to investigate precipitation statistics, both globally and for specific regions or seasons. Furthermore, case study analysis of precipitation events reveal detailed insight into the microphysical processes of precipitation formation (e.g. cyclones or tropical convective showers) and documents the occurrence of extreme events.

By 2013 the steadily growing data base contains more than 300000 minutes of precipitation from seven instruments on seven ships covering all climatic regions. Overall, precipitation occurs in 9.6% of the time with 4.5% rain, 3.3% snow, and 1.8% mixed-phase. Convective rainfall occurs in 0.1% but accounts for 52% of the rain volume. A large fraction of the precipitation measured is very light precipitation that is especially difficult to be measured by passive microwave satellites. In contrast, a large fraction of the Cloudsat CPR precipitation is very light precipitation. Consequently, validation between OceanRAIN and Cloudsat data may reveal insight determining the fraction of virga-precipitation.

The OceanRAIN data is freely available in ASCII or NetCDF upon request and the project is constantly seeking for opportunities to increase the number of research and merchant ships involved.

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RECENT PUBLICATIONS

Xiangzhou S., L. Yu. How much net surface heat flux should go into the Western Pacific Warm Pool. *Journal of Geophysical Research: Oceans,* Volume 118, Issue 7, pp. 3569–3585, July 2013.

The western tropical Pacific warm pool, with the surface area bounded by the 28°C isotherm, receives heat from the atmosphere through the year. However, the exact amount of net surface heat flux into this area remains to be determined. A survey of nine heat flux climatologies (including three latest atmospheric reanalyses, three early reanalyses, and three analyzed products) shows that the estimates are clustered into two groups, with a mean of 18 Wm^{-2} for the five-member low net heat flux group (ERA-Interim, CORE.2, NCEP 1 and 2, and ERA-40) and of 49 Wm^{-2} for the four-member high net heat flux group (CFSR, OAFlux+ISCCP, NOCSv2.0, and MERRA). This study used a pool-area based heat budget analysis together with in situ air-sea and subsurface measurements to examine the physical consistency of the nine flux climatologies and to ascribe the statistical uncertainty of each product. The heat budget analysis indicates that the annual mean net surface heat flux should be 28 ± 10 W m^{-2}. The observed eddy coefficient along the 28°C isotherm is 1.5 $cm^2\ s^{-1}$ based on the TAO/TRION buoys and the historical records. The ocean cannot dissipate the excessive high heat fluxes, while the low fluxes cannot balance the estimated diffusive heat flux across the isotherm. Both the one-point direct comparison and pool integrated eddy diffusive heat flux analysis demonstrate that, the high net heat flux climatologies have high bias; on the other hand, the low fluxes have low bias. These biases and uncertainties are given and documented in this paper.

CALENDAR

94th AMERICAN METEOROLOGICAL SOCIETY ANNUAL MEETING

2-6 February 2014, Atlanta, Georgia, USA

18th Conference on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS)

EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY 2014

27 April – 02 May 2014, Vienna, Austria

OS1.4 Air-sea energy and mass exchanges and their impacts on the ocean and atmosphere

2014 OCEAN SCIENCES MEETING

23-28 February 2014, Honolulu, Hawaii, USA

- *Session 005 - Air-Sea Gas Exchange*
- *Session 039 - Ocean Circulation Variability and Air-Sea Interactions in the Western Pacific and Eastern Indian Ocean*

7th INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL WATER AND ENERGY CYCLE

14-17 July 2014, The Hague, Netherlands

EUMETSAT METEOROLOGICAL SATELLITE CONFERENCE 2014

22-26 September 2014, Geneva, Switzerland.

WE INVITE CONTRIBUTIONS FOR THE UPCOMING ISSUES OF FLUX NEWS.

Please share your ideas on processing global, regional or local air-sea flux data from in-situ/satellite measurements or NWP. We also invite opinions on how to better facilitate surface flux related activities and to provide better synergy across the groups and agencies. Any important novel scientific results in the area of air-sea interaction are also welcome. Please send your short contribution (preferably under 1000 words, with figures) to Nadia Kovaleva (nadia@sail.msk.ru).

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