Proposal from

The Cooperative Institute for the Marine Ecosystem and Climate at the Scripps Institution of Oceanography

To

The Data Buoy Cooperation Panel

For a Pilot Project on the

"Evaluation of the Impact of Sea Level Atmospheric Pressure Data Over the Ocean from Drifting Buoys on Numerical Weather Prediction Models"

By

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1. Background

The "Global Drifter Program" (GDP) [*Niiler, 2001*] is the principal international component of the Joint WMO-IOC Technical Commission for Oceanography and Marine Measurements Meteorology (JCOMM) "Global Surface Drifting Buoy Array". It is a "Scientific Project" of the

Data Buoy Cooperation Panel (DBCP) of World Meteorological Organization (WMO) and the /International Intergovernmental Oceanographic Commission of UNESCO (IOC) contributing data in real-time and delayed-mode on a free and unrestricted basis to the programs of both Organizations, including the WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS), the WMO-IOC-UNEP-ICSU Global Ocean Observing System (GOOS), the WMO World Weather Watch (WWW), and the developing Global Framework for Climate Services (GFCS). In addition to serving the needs of scientific users in physical oceanography and beyond, GDP data thereby contribute to Numerical Weather Prediction (NWP), Ocean Mesoscale Forecasting, climate monitoring, marine services, marine climatology, and emerging climate services.

The GDP is a near-operational ocean-observing network that, through the ARGOS and Iridium satellite systems and the Global Telecommunication System (GTS) of the WWW, returns real time data primarily on ocean near-surface currents, Sea Surface Temperature (SST) and Sea-Level Atmospheric Pressure (SLP). The GDP provides a data processing system for the scientific utilization of these data. In addition to GDP-funded cruises (via NOAA), drifters are deployed by operational oceanographic and meteorological agencies and individual scientific research projects. These data are utilized by the GDP and in turn, GDP data are made available to operational users and to scientists at large [see *Lumpkin and Garzoli, 2005; Maximenko et al. 2009* for examples of scientific use of drifter data]. Wind-sensors, salinity sensors [*Reverdin et al, 2007*] and thermistor chains [*Black et al., 2007; Centurioni, 2010*] are also added to drifters, presently for specific operational and research requirements. The international protocols for these data exchanges and sensor additions are worked out each year by the DBCP.

SLP measurements are made from SVPB drifters (B stands for barometer) with an accuracy of +/- 1hPa [*Sybrandy et al. 2009*]. Deployments of SVPB drifters began in 1979. Surface pressure sensors, supported primarily by the Cooperative Institute for the Marine Ecosystem and Climate (CIMEC) with NOAA funds and to a lesser extent by NMHSs based on regional needs, now amount to about half of the GDP array nodes. Much of the barometer upgrades are therefore supported by climate research money while they have direct use for NWP assimilation. This proposed pilot project will help demonstrate the value of atmospheric pressure data in improving the weather forecast.

Since September 2005, the GDP array is made of 1250 drifters (nominal) with a 5°X5° global coverage. The array is composed of the NOAA/GDP supported drifters(~85%), purchased directly by CIMEC and by the Atlantic Oceanographic and Meteorological Laboratory (AOML) with NOAA funds, and of drifters fully or partially funded by international oceanographic and meteorological agencies (about 120 per year) and other principal investigators who are contributing to the GDP by making their data publicly available. In turn, their data is included in the GDP real-time data that is placed onto the GTS.

SVPB drifters-borne SLP measurements are widely recognized by meteorological agencies as a very important source of data for assimilation in Numerical Weather Prediction (NWP) models. The requirements for the SVPB array are described in the DBCP implementation strategy documents, which are revised every year. Emphasis in such documents is given to deployments in the tropical regions and in maintaining an array of 300 SVPB drifters in the southern ocean south of 40°S. Even sparse SLP data from SVPB drifters are regarded as a valuable validation tool for NWP pressure fields. While the DBCP has plans to retrofit the whole GDP array with barometers by 2012, the current funding level suggests that this target will be delayed.

It is proposed here to engage several DBCP members in a pilot project which has the overall goal to carefully quantify the role of SLP from drifters in improving the skills of NWP models.

2. Objectives

Given the increasing cost of maintaining the GDP array, mainly influenced by inflation and rising energy costs, all of which is offsetting the purchasing power of the steady GDP US budget at CIMEC and AOML, there is urgency to optimize the SVPB drifter array implementation strategy. The objective of the proposed pilot project is two-fold:

1) Quantify the impact of SLP data from the existing SVPB network on improving the quality of NWP;

2) Provide a scientific/operational rationale for designing the temporal and spatial resolution, as well as the optimal geographical distribution of the SVPB array taking into account all sources of data (e.g. moorings, ships).

It is anticipated that addressing these two objectives will assist the GDP in planning the implementation, possible expansion and/or re-distribution of the SVPB array and will provide

CIMEC, AOML and its international partners with guidelines for the technical developments of future SVPB platforms. The results of this project will also provide national policy makers and funding agencies with a solid background and a scientifically sound foundation to promote, support and eventually enhance the global SVPB array.

3. Work Plan

The proposed work requires the active collaboration of NMHSs (specifically weather prediction centers) with their oceanographic counterparts. To address objective 1 we propose to run a set of "data denial/Observing System Experiments (OSE)" in the regions which are presently well populated with SVPB drifters and in few selected ocean areas not presently covered by SLP observations. The pilot project members will then address the issue of finding the resources to deploy SVPBs in such sparsely populated areas, such as the Arctic regions in boreal summer and the equatorial and tropical regions of the Pacific Ocean where tropical cyclones form. We anticipate that boreal summer deployment opportunities for SVPB drifters in the Arctic Ocean will arise in concert with several, already planned, US field programs (for example by ONR and NOAA, via the International Arctic Buoy Program).It is worth noting that the WMO Commission for Basic Systems (CBS) has proposed addressing "What density of surface pressure observations over ocean is needed to complement high-density surface wind observations from satellites? Suggestions: (a) network density reduction OSE in N.Atlantic, (b) southern oceans OSSE" as part of the forthcoming fifth International Workshop on the Impact of Observations on NWP (Sedona, Arizona, USA, 22-25 May 2012).

To address objective 2, OSEs will be run in regions populated with SVPB Iridium buoys to investigate the effect of downgrading the temporal resolution of SLP data. A global Observing System Simulation Experiment (OSSE) is also proposed to evaluate the optimal geographical distribution of SVPB resources and to evaluate the need for hourly, low latency, SLP data.

Preliminary OSEs run by ECMWF to evaluate the impact of marine buoys and ship-borne SLP data [*Andersson, 2009*] have shown a large impact of such data on forecast accuracy, especially in the short term forecasts (48 to 72 hours) and that there is little need to enhance the North Atlantic array, which presently serves the forecast needs of Europe and North America. The ECMWF report also highlights the significance of SLP data over the ocean in improving the

forecast of large storms and the need to run longer OSE to evaluate the impact of such data in rain forecast. This pilot project will also look at these issues.

4. Timeline and Budgetary Considerations

This pilot project will last two years. In year 1 a kick-off meeting will be organized by Dr. Luca Centurioni at the Scripps Institution of Oceanography in San Diego, California. The purpose of the meeting will be to identify the required numerical tools, define the metrics for the evaluation and to design the OSEs and OSSEs outlined above. During year 1, the GDP in partnership with Météo-France will provide the pilot project members with a comprehensive quality controlled SVPB-SLP dataset. OSEs/OSSEs will be run. A mix of Argos and Iridium SVPB drifters will be deployed in poorly sampled areas which are deemed important by the pilot project members. The pilot project members will reach out to ECMWF for coordinating the OSE/OSSE efforts and for collaboration. The results of the first year of activities will be reported at the annual DBCP meeting.

In year 2 a workshop will be organized (location TBD), in which the results of year 1 experiments will be reviewed, a refined experimental strategy will be discussed and more experiments will be run. SVPB deployments in sparsely populated areas will continue. A final report will be produced at the end of year two. A preliminary budget of $75K/year is anticipated to cover the cost of the analysis and meeting organizations.

5. Proposed list of participants: steering committee

Dr. Luca Centurioni (SIO) chair

Dr. Rick Lumpkin (AOML) co-chair

Graeme Ball (BMM)

Jean Rolland (E-SURFMAR)

Johan Stander (SAWS)

Jon Turton (UKMO)

Julie Fletcher (MSNZ)

Pierre Blouch (MF)

Val Swail (EC)

Etienne Charpentier (WMO)

Erik Andersson (ECMWF)

6. Terms of Reference

The objectives outlined in the proposal fulfill the overall goal of this pilot project, which is to quantify the impact of SLP data over the ocean in improving the quality NWP outputs. It is anticipated that proposed approach will be discussed, revised and adopted in year 1. The deliverable of this project will be a written report containing a set of recommendations, for the benefit of both scientists and policy-makers, on the requirements and best practices for managing the SVPB drifter array.

Dr. Centurioni and Dr. Lumpkin, who will be chairing this effort, represent the oceanographic component of the team. They will have an active role in planning the experiments, facilitating the drifter deployments and in the interpretation of the results. The other members of the steering team will be responsible to initiate and maintain a dialog with their offices to identify the required numerical tools and human resources needed to run the proposed OSEs, OSSEs and to perform the data analysis, and will .also contribute to the interpretation of the results.

Financial support will be sought from DBCP, and is required to accomplish the tasks described in the work plan.

7. References

Andersson, E. (2011), Observing System Studies, CBS/OPAG-IOS/ET-EGOS-6/Doc. 9 (13.05.2011), available online at: http://www.wmo.int/pages/prog/www/OSY/Meetings/ET-EGOS_Geneva2011/documents/ET-EGOS-6-Doc-8.3.2_9-SIAF.doc

Black, P. G., E. A. Asaro, W. M. Drennan, J. R. French, P. P. Niiler, T. B. Sanford, E. J. Terrill, E. J. Walsh, and J. A. Zhang (2007), Air-Sea Exchange in Hurricanes: Synthesis of Observations from the Coupled Boundary Layer Air-Sea Transfer Experiment, Bulletin of the American Meteorological Society, 88(3), 357-374.

Centurioni, L. R. (2010), Observations of Large-Amplitude Nonlinear Internal Waves from a Drifting Array: Instruments and Methods, J Atmos Ocean Tech, 27(10), 1711-1731.

Lumpkin, R., and S. L. Garzoli (2005), Near-surface circulation in the tropical Atlantic Ocean, Deep-Sea Research Part I-Oceanographic Research Papers, 52(3), 495-518.

Maximenko, N., P. Niiler, L. Centurioni, M.-H. Rio, O. Melnichenko, D. Chambers, V. Zlotnicki, and B. Galperin (2009), Mean Dynamic Topography of the Ocean Derived from Satellite and Drifting Buoy Data Using Three Different Techniques*, J Atmos Ocean Tech, 26(9), 1910-1919.

Niiler, P. P. (2001), The world ocean surface circulation, in Ocean Circulation and Climate, edited by G. Siedler, J. Church and J. Gould, pp. 193-204, Academic Press.

Reverdin, G., J. Boutin, A. Lourenco, P. Blouch, J. Rolland, P. P. Niiler, W. Scuba, and A. F. Rios (2007), Surface Salinity Measurements—COSMOS 2005 Experiment in the Bay of Biscay, J Atmos Ocean Tech, 24(9), 1643-1654.

Sybrandy, A. L., P.P. Niiler, W. Scuba, E. Charpentier, and D. T. Meldrum (2009), Global Drifter Programme – Barometer Drifter Design Reference, 2009: DBCP report No. 4, Rev. 2.2. Available online at http://www.jcommops.org/doc/DBCP/svpb_design_manual.pdf