SOLAS OPEN SCIENCE CONFERENCE

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Protocol Session # 3:

Priorities and integrated programs for the study of Eastern Boundary Upwelling Systems (EBUS)

Convenors: Francisco Chavez, Veronique Garçon

Rapporteur: Damian L. Arévalo-Martínez

Date and time: 9th September 2015, 14:30 h

Introductory talk EBUS by F. Chavez (F.C.)

The main biogeochemical features which are common to all EBUS result from the occurrence of coastal upwelling. In these systems cold, nutrient and CO_2-rich waters transported to the surface not only result in enhanced gas exchange with the atmosphere, but also in fertilization of the upper layers of the ocean which in turn stimulates biological production at all trophic levels. In addition, the creation of low oxygen (O_2) environments is a typical characteristic of EBUS, due to the enhanced rain of organic material from the surface.

Understanding long-term physical and biogeochemical variability in EBUS is important considering their potential socio-economic impact for activities such as fisheries. EBUS are susceptible to climatic variability due to their close association with atmospheric circulation. Hence, large-scale climatic changes (e.g. ongoing global warming) might have significant effects, although the individual responses of different EBUS can be markedly different. Nevertheless, EBUS are poorly represented in global models and more work is needed to elucidate their potential responses to future climate change.

Given the fact that EBUS are sites of intense ocean-atmosphere coupling, and because their study requires a multidisciplinary approach with cooperative efforts from different areas of expertise, EBUS are suggested to be one of the focal points of SOLAS.

Introduction to cross-topics: Veronique Garcon (V.G.)

Due to the upcoming transition from IGBP to Future Earth, a call for more integrated efforts from the various scientific, socio-economic and political sectors is in order, with the main purpose being the improvement of the current regional coupled models considering ocean-atmosphere interactions. In

order to achieve this goal it is suggested to coordinate international multi-model experiments with enhanced observations both in atmosphere and ocean, and which also include socio-economic impacts. The development of a monitoring system for near-coastal areas is particularly relevant considering the current observational limitations as well as the bias between in situ and modeled data. Recent studies showed that, for example, there is a clear trend towards higher biases between in situ and global climate models-derived SST in EBUS. Some possible reasons for this are: underestimation of stratocumulus clouds, errors in surface wind stress, as well as unresolved offshore transport by ocean eddies.

Start of discussion

The discussion was centered on the identification of key questions which could lead to set priorities for the study of EBUS. As a start, the following points were presented:

- Changing climate
- Declining/varying oxygen, fisheries
- Changing fluxes of critical elements
- Integration with other scientific and social programs
- Define observational and experimental programs
- Define how to improve model forecasts
- Define technology development efforts

Comments from the audience:

J. Lavrik (MPI-Jena, Germany), F.C. V.G.: Joint efforts from atmospheric and oceanographic communities need to be improved. The atmospheric community has not so far being well represented in studies of EBUS and such cooperation could be beneficial for all. MPI Jena has, for example, a permanent station in a close-coastal location in Namibia, which is ideal for detecting atmospheric variability in different time scales and with better resolution that what can be achieved with satellite data. Moreover, more cooperation is needed in order to check atmospheric models.

L. Bopp (IPSL), V.G., F.C.: Paleoceanographic information proposed to help as a tool for understanding future changes in EBUS (see e.g. Gutierrez et al. 2009 BGS).

F.C.: One of the open questions that need to be targeted is the relevance of the different scales of variability of e.g. SST (i.e. ENSO, AMO, PDO and NPGO-like time scales vs. centennial time scales).

A.Oschlies (GEOMAR), K. Krueger (UIO): definition of concepts/metrics in order to quantitatively assess the role of upwelling in coupled models is needed. Current models do not sufficiently account for transport, in particular close to the coast. Furthermore, atmospheric models of upwelling off Peru are limited due to poor resolution close to the coast.

V.G.: Further constrain in coupled models is the lack of representation both physical and biogeochemical processes in the equatorial region in those models (see Cabre et al., BGD, 2015; spatial overlap observed vs. modeled OMZs tropical Pacific).

T. Ilyina (MPI-Met): The equatorial upwelling regions are poorly represented in global models, which results from difficulties in representing the circulation and the lack of “communication” between the atmospheric and oceanic component of the models. Some of the most important gaps that need to be filled in the context of the current modeling efforts are: improved representation of winds and improved representation of biogeochemical processes (e.g. N-cycling). Furthermore, comprehensive observations of rates and reactions of relevant biogeochemical cycles (such as N) could also help to improve the models.

K. Six (MPI-Met): A definition of boundary conditions for OMZs is important in the effort to improve the representation of biogeochemical processes in the coupled models, since at the moment is not even clear at which oxygen thresholds the different processes are active.

F.C., V.C.: Defining and targeting key processes in EBUS that might change over time is important for developing an observational/modelling program to study them. Long-term observations (e.g. time series and moorings) as part of an observational network can help to fill in the gaps of knowledge regarding relevant parameters in EBUS.

So, how a measurement network for EBUS would/should look like?

Remote sensing tools have a potential to enhance an observational network. However, technical constraints to define the near-coastal area hamper their suitability to track e.g. mesoscale features. Furthermore, most models do not integrate the effects of the benthic layer in the water column properties on the shelf. Thus, sustained observations in moorings and atmospheric observatories (like the one run by MPI-Jena) are a good way to follow. However, other technological developments such as those brought with the ARGO program could also provide an alternative.

R. Sabia (ESA), V.G.: There has been considerable advances in the development of sensors capable of obtain better measurements in the close-coastal area. Thus integration of the remote sensing approaches and modeling efforts could represent a crucial tool for understanding relevant oceanographic processes such as eddies.

Michelle Graco (IMARPE): Besides additional data collection, it is very important to direct efforts to process studies which actually elucidate the dynamics of coastal upwelling. Benthic-Pelagic coupling processes for example, could help to improve the representation of EBUS in global models, since typically coastal upwelling occurs in spatial scales much smaller than those targeted by global models.

V.G.: Definition of a common data set of relevant parameters such as oxygen should be taken care of, in order to provide a common network for the scientific community, enabling also model comparisons.

T. Tanhua (GEOMAR): Definition of central variables within the framework of GOOS is as an example of combined effort for global observational network. Such network should be used as a base of study processes which brings together modeling and observational expertise.

K. Krueger (NIO), H. Bange (GEOMAR): Develop a common data base for EBUS? How much data is actually available? A portal (information network) where all the data banks which archive data relevant

for EBUS as opposed to create a new data base for EBUS only is a recommended procedure. This could moreover, serve as an outreach component for SOLAS.

A. Salinas (IMTA): High frequency (daily) climate variability should be included in studies from EBUS. Short experiments (1-2 months) for example could be used to describe the local variability and see how it compares to climatological values. This variability is relevant due to the persistency of the processes. Thus, the accumulative effect of the forcing on climate should be taken into consideration. Nevertheless, the suitability of such resolution is constrained by technical capabilities in observational programs.

A.Oschlies (GEOMAR), F.C.: One way of achieving close cooperation between disciplines is by defining general questions that are of interest for all such as:

What is the strength of upwelling (volume transport), which is the depth of upwelling, the spatial scale of the wind, what are differences between curl and Ekman driven upwelling; is that relevant?, how to quantify N-loss?

U. Riebesell (GEOMAR), F.C.: Efforts to include a socio-economic component within SOLAS should be encouraged since so far only the natural sciences questions have been targeted. One idea is to try to use the EBUS-topic as a platform to “attract” stakeholders from the bordering countries since the EBUS directly impact their economies. This could be done via IMBER since it already has a strong social component. Thus instead of creating a new social component, SOLAS could “use” or cooperate with existing programs.

V.G., F.C.: Study of extreme events in EBUS is a good opportunity to get the interest of local stakeholders and to motivate cooperation of non-scientific actors since such events directly impact the financial situation of their countries. Finding mechanisms for this to happen should be one of the tasks of SOLAS.

F.C.: Why to concentrate on EBUS instead of other regions with strong upwelling, like for example the equatorial region? The focus is set in EBUS due to the social component and due to their large contribution to the global biogeochemical cycles, in spite of their relatively small area. However a common working framework for EBUS could be extended to other areas.

H. Bange (GEOMAR): Other tropical coastal upwelling areas such as the Arabian Sea could be included due to the similarity with EBUS in terms of biogeochemical, physical and social implications.

M. Graco (IMARPE), V.G., U. Riebesell (GEOMAR), L. Bopp (IPSL): Changes in phytoplankton groups (and also changes in stoichiometry) are not considered in all models. Model representation of biogeochemical processes such as remineralization is not fully constrained not only because of their complexity but also because observations and difficulties in representing the physical process appropriately. Hence, observational constraints hamper the capabilities of some models in reproducing both physical and biogeochemical properties.

T. Tanhua (GEOMAR), F.C.: Developing a common framework to put together different approaches for measuring processes in the ocean and the atmosphere should be the target for funding observations. For this, the first step it is to establish which kind of technologies are needed and for which time scales, as well as key parameters towards which efforts should be directed to.

D. Capelle (UVIC): Moored observatory off Victoria (Canada) is an example of the kind of initiatives which could be interest for the community.

V.G., J. Lavric (MPI-Jena): How to target the social dimension? No success with previous attempts within SOLAS. The key point is to work on how to present the scientific work as an attractive offer to the governments of the bordering countries. This communication needs to be improved.

U. Riebesell (GEOMAR), F.C., V.G.: Are there initiatives to consolidate a group dedicated to the study of EBUS? SCORE working group was proposed as an attempt to keep the interested community together. Further meetings could be scheduled within the framework of CLIVAR, and possibly also during the upcoming IMBER and AGU meetings.

As a result of the discussion, a list of general questions/needs based upon which it would be easy to achieve a synergy between scientists of different expertise was produced:

- Quantification of upwelling (e.g. volume transport, depth of upwelling)
- Are the respiration rates in OMZ's oxygen-dependent? (direct measurements of rates are needed)
- What is the extent of vertical transport and decay of organic matter? (in situ export profiles are needed)
- More information about remineralization rates is required.
- Higher resolution view of oxygen vertical distribution in OMZ's.
- What is the role of sedimentary rates of N-cycling?
- What is the role of iron in sediments underlying EBUS?
- How to include upper trophic levels?
- How primary productivity will change with global change and what is the impact for the local economies of the bordering countries?
- Detect trends and variability? Develop and implement an observational system: where to observe, how to observe, what to observe and how often?

End of the meeting: 16:09 h

List of participants

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