Tropical Atlantic Meeting Report

(Toulouse, February 3-6, 2009)

Report on the Ocean Processes and Model Validation session

The following items were discussed as priorities for new research and collaborative study:

1. EUC Structure and Termination in the Gulf of Guinea

The German/US/PIRATA mooring program in the eastern equatorial Atlantic along with the French EGEE/PIRATA cruises in the Gulf of Guinea should provide an opportunity to study the EUC termination in a more comprehensive way than previously possible. Results presented at the meeting showed evidence for high-salinity tongues embedded in westward flows north (and sometimes south) off the equator during summer/fall, that indicate zonal recirculation of EUC core waters. Some of the cruises also permit investigation of poleward transport along the eastern boundary. The fate of the EUC waters, including the fraction upwelled at the equator, the part feeding into eastern coastal currents and coastal upwelling regimes, and remnants recirculating within the equatorial region, is a key question posed in TACE. Further, its seasonal dependence and interannual variation (e.g. during Atlantic Nino's) need to be determined to the extent possible. It was recommended and agreed by the meeting participants that cooperation to achieve these objectives, including comparisons with available models, would be undertaken by the scientists involved in these projects.

2. Formation and Fate of the Equatorial Thermostad

Vertical mixing at the base of the mixed layer as well as in the thermocline at the equator has been identified as one of the key processes that has to be improved in high-resolution ocean models. These models have to produce a correct thermostad including circulation at and below the depth level of the EUC. Failure to do so means that important currents like the SEUC will not be properly represented, since this current occurs at the southern boundary of the thermostad and appears to be intimately related to its formation. In particular, low vertical mixing at depth seems to be important to obtained realistic transports of the different current branches, but might affect also SST. Also, assimilation models (e.g. the Mercator model) shows particularly large temperature trends between 200 and 500m after initialization and the comparison between model and observations reveals substantial differences in velocity and hydrographic fields. Model validation with regard to the thermostad can be done using data from previous cruises. However there are relatively sparse measurements available in the far eastern equatorial Atlantic. This could also be a problem for studying the seasonal termination of the EUC, as there are almost no measurements during the boreal winter season.

3. Define model output that can be compared with observational data

For the validation of assimilation models we have to define sections and time series that are able to allow an evaluation of the realism of ocean dynamics in the different models.
For MERCATOR:
The Tropical Atlantic Region is defined between 20°N and 20°S; transport sections must be implemented online. We suggest to calculate the EUC transport at 23°W between 2.5°N and 2.5°S in the density ranges sigma_theta = 24.5- 26.8 kg/m³ as well as above sigma_theta

=24.5 kg/m³. Other important meridional sections, for which transport data should be separately saved are 35°W, 23°W, 10°W, 0°W, 6°E.
To test the correct working of the dynamic Bjerkness feedback, we suggest to store besides the transport time series of the EUC at the equator time series of the warm water volume in the whole tropical Atlantic (3°S-3°N above the 20°C isotherm), wind in the western tropical Atlantic (WAtl; 3°S–3°N, 40°–20°W) and SST in the eastern tropical Atlantic (Atl3; 3°S–3°N, 20°W–0°).

Identified problems with the MERCATOR assimilation are the lack of a diurnal cycle (only operational fluxes with daily averages are used) and the amplitude of TIWs and wind-generated Yanai waves. Probably due to phase differences between simulated and observed TIWs, the negative feedback between wind anomalies produced by SST anomalies of TIWs on the amplitude of TIWs can not be simulated correctly and leads to overestimated TIW amplitudes, including their effect on the upper ocean heat budget. First theoretical studies were aimed to identify the amount of data that are needed to improve the phase information of tropical waves in assimilation models.

4. Vertical Velocity

Vertical motion produced by the model seems to be dependent on model resolution. A better understanding of the sources of vertical motion is required. Vertical motions should be analyzed in the different models, mainly on seasonal time scales. Observations of different tracers like e.g. Helium and Beryllium, might help to clarify possible model errors with respect to vertical motions. It was also suggested to include additional moorings at 10°W to observe zonal divergences of the flow. It must be shown that the accuracy of these measurements are helpful to validate numerical models with respect to their differences in the vertical velocities, as the accuracy of the measurements might not be great enough. Study of previous such attempts in the Pacific was recommended to determine the available accuracy from this technique.

5. Impacts of Intraseasonal Waves

The role of intraseasonal waves, particulary TIWs, in the heat budget, remains an unresolved question and a source of significant disagreement among modeling studies. It is thought that TIWs warm and wind-generated Yanai waves in the Gulf of Guinea cool the SST. However, a dedicated observational study testing these hypotheses is lacking. A dedicated TIW process study is recommended for 2011 possibly including upwelling moorings as suggest above to determine vertical motions. Meridional and zonal divergences are also needed for the evaluation of mixed layer heat budget. Changes in the heat budget will be observed with ship and glider sections (already planned by IFM-GEOMAR) during onset and height of equatorial upwelling. Drifting thermistor chains would also be a valuable tool for this study. It is recommended to also include longwave radiation sensors at the PIRATA buoys at least at 10°W, 0°N.

6. Salinity measurements and the Barrier Layer problem

Conductivity measurements with higher vertical resolution (same as temperature measurements) at the PIRATA buoys are important to address the Barrier layer problem. In general, the surface freshening seems to be a problem in (assimilation) models. It is believed that precipitation/evaporation from NCEP or ECMWF must be corrected to obtain a realistic hydrological cycle. Other possible measurements that would be helpful in addressing the hydrological cycle are surface salinity measurements with drifting buoys. However, due to biofouling these measurements are only valid for a few month of operation. With the SMOS satellite there is a chance of improving surface salinity information in the tropical Atlantic. However, up to now there are no dedicate SMOS validation campaigns in the tropical Atlantic planned. Further, there are not enough data to address the river discharges in the tropical Atlantic region in particular with regard to the interannual variability.

Report by P.Brandt, B.Johns & coll.

Report on the model biases session

The Tropical Atlantic community (PIRATA/TACE/AMMA researchers and engineers) met at Météo-France in Toulouse after the PIRATA SSG. A specific session was dedicated to model biases. The workshop showed that some advances have recently been made in documenting the biases in the current generation of coupled models. Recent studies on the CMIP3, DEMETER and ENSEMBLES (stream 1 and 2) datasets have suggested that the majority of current coupled models are still unable to simulate correctly the summer equatorial SST gradient in the tropical Atlantic. The SST gradient has the wrong sign in comparison with observation, with the western Atlantic being in general colder than the eastern Atlantic. Westerly wind biases in the western equatorial Atlantic during springtime seem to be responsible for a deepening of the thermocline in the eastern Atlantic. Although the wind biases decrease in summer and the total winds are favourable for upwelling, the too deep thermocline is preventing the development of the eastern cold tongue in the coupled models. A similar wind bias is also presented in AMIP-type experiments, suggesting that the origin of the bias may be from the atmosphere.

The biases also affect the hydrological cycle. In spring, the simulated ITCZ is too diffuse and displaced south of the equator with warm SST biases mainly located in the southeast tropical Atlantic. The spring SST bias pattern is different from the summer one: it shows larger biases along the African coast compared to those of the equatorial waveguide. In general, it seems coherently associated with weaker southern trades. Occurrence of the drift is extremely rapid as was shown by recent results from the ENSEMBLES stream2 dataset. Seasonal hindcasts (performed in ENSEMBLES with 5 coupled models over the 1960-2005 period) initialized from ocean and atmosphere reanalysis data already exhibit the spring temperature bias spatial pattern after just one month (month of may with the models initialized May first) with a weak amplitude. At 3-month lead time (March-April-May period with initialization in February), the SST bias is already well established in terms of both pattern and amplitude and is almost similar to the one at 5-month lead time (same period but with initialization in November). There are SST biases in the other seasons as well (in spite of smaller amplitude usually). There is a need to better understand the seasonal evolution of the biases and the associated mechanisms. The workshop also showed that current models exhibits biases in other regions such as the Atlantic Warm Pool. As this region has strong teleconnections to the tropical Pacific and to the North Atlantic and European region, it is also important to better document and understand the biases there and the relevant mechanisms. The participants also felt that the existing ocean reanalysis datasets are not sufficiently used. Synthesis products that optimally combine data and model information should become easily available to users now. There is a strong need to better organize the dissemination of these products (common format, a unique database, etc …).

Recommended ACTION ITEMS

The first three items are of the highest priority and some progress can be achieved on these issues within one year. The other items are as important but the expected time frame is longer.

1) To focus on the big problems first; when they are solved then worry for the minor ones. It was felt by most of the participants that making progress on the SST gradient bias is of the foremost importance and that this problem should be on the top of the list for the interested modelling groups.

2) To exhaustively document the various model biases in the tropical Atlantic by analyzing a large set of models (CMIP3, AMIP, ENSEMBLES, WGSIP simulations, OMIP, ocean synthesis products). This could take the form of a white paper which will summarize the findings and results from the various multimodel analysis recently performed.

3) To clearly separate the coupled feedbacks which amplify the original bias from the underlying initial causes. It appears that the Bjerknes feedback (which is also operating in the tropical Atlantic interannual variability) is playing a dominant role in amplifying the equatorial spring biases in models. What is less clear (and seems to vary among models) is the original cause of the westerly wind spring bias. Various atmospheric causes have been suggested from analyses of AMIP type simulations: displacement of the subtropical High's, bias in continental precipitation over the Amazon and West Africa, atmospheric convection over the ocean, stratus cloud representation. There are also suggestions for an oceanic role on the wind bias origin off-equator. There is a need to better document the different causes which can lead to the equatorial westerly wind bias in the western Atlantic (using both forced and coupled models).

4) To better understand the phase relationship between the SST biases in the Benguela Niño region (where are located the largest biases during the spring season) and at the equator (largest biases during summer). Are the Benguela SST anomalies propagating to the equator? Are they amplified or damped during the propagation? Are they linked in any way to the westerly wind bias? How are the biases related to the main tropical modes of interannual variability?

5) To assess the biases influence on predictability at seasonal to decadal time scale. Recent studies suggest the role of weather noise as a potentially disrupting factor for the predictive skill in the tropical Atlantic. Other studies have pointed out the overestimation of the simulated SST-heat flux feedback (more negative in the models than in the observations) as a potential damping source of seasonal to interannual variability. These diagnostics should be applied to the most recent datasets. A large amount of work is still needed to fully exploit the seasonal predictability of climate in the tropical Atlantic region.

6) To better document and understand the remote influence on the model biases in tropical Atlantic. For example, ENSO's bias may influence on the tropical Atlantic modes as well as on its time evolution (the variation of the influence).

7) To identify and understand processes and/or parameterizations in coupled models that are responsible for generating model biases in the Atlantic Warm Pool (AWP). Many state-of-the-art climate models exhibit cold SST bias in the AWP. In boreal summer, the cold bias can reach up to -3°C and lead to precipitation bias of up to -5 mm/day (dry bias). As this region is important for hurricane genesis and intensification, there is a need to better document potential causes that lead to the cold bias using AGCMs, OGCMs and coupled GCMs. In addition, we need to investigate the possible relationships between model biases in the AWP and the equatorial Atlantic. The analysis and study of model biases in the AWP region is one of top priorities for the Phase I of the CLIVAR/VAMOS IASCLIP Program (2009-2014).

8) To use clever modelling strategies in order to make progress on the above issues.
First of all, as the climate drift is extremely fast (few months), the seasonal hindcast framework is well adapted to test various working hypotheses. We would like to recommend the following case studies: one could pick up two contrasting years in terms of cold tongue anomaly (for instance 2005 and 2006 for which we have quite a lot of observed data). We could then replay ensemble seasonal hindcasts with different model setups. Strategies such as spectral nudging in atmospheric models, partial coupling, and forced AGCM and OGCM sensitivity experiments could be used separately or together in order to test various hypotheses as to the origin of the wind westerly biases in spring and to identify problems linked to the representation of processes and/or feedbacks associated to the development of the Atlantic cold tongue.

Report by L.Terray, A.Lazar, P.Chang, C.Wang, and coll.