FS Meteor
Expedition **M206**

01.12.2024 (Fortaleza) –
30.12.2024 (Belém)

M206, 5. Weekly Report 23.12.-28.12.2024

Last week began with the completion of our work in the French Guiana EEZ. After a final near-shore water sample in an area where the influence of the numerous estuaries was recognisable by slightly reduced salinity at the station, we returned to the route we had already taken in the EEZ of Brazil on the way there, as we did not receive permission to take a parallel route somewhat closer to the coast. We reached the mouth of the Amazon on the afternoon of 24 December and waited for the next high tide to cross the large sandbank in front of the estuary. Overall, the entire estuary area is very dynamic and very shallow in many places, with water depths of less than 10 metres in some places, meaning that not all of the stations we had originally planned were accessible for FS Meteor. As we were only allowed to make minor adjustments to the station coordinates due to the regulations of the Brazilian Navy, in the end there were only two stations left in the estuary area where we were allowed to work and use the multicorer at one station in addition to the water sampling.

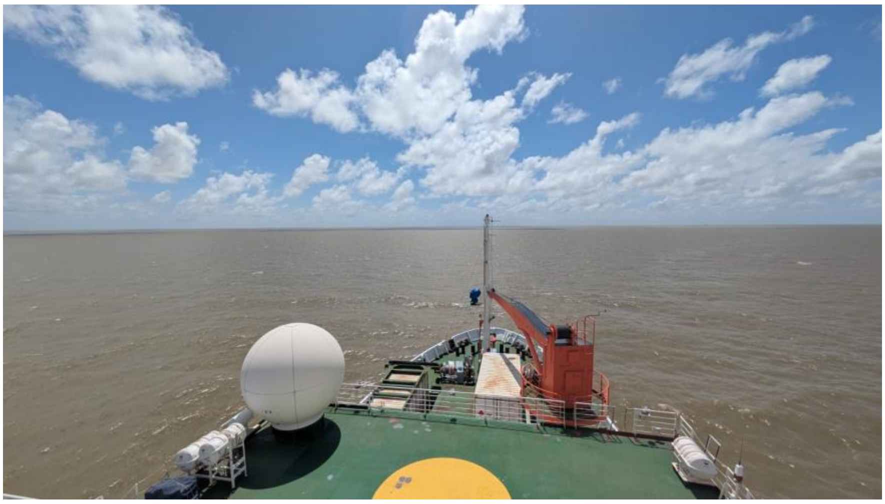


Fig. 1: At its mouth, the Amazon River appears like a vast brown sea of fresh water.

Unexpectedly, we received a scientific Christmas present when we reached the stations, which was already visually announced by the enormous brown-coloured water masses in the entire estuary area (Fig. 1); although we had not received permission to survey a little further upstream, intensive rainfall in the catchment area in recent weeks had ensured that the river water front had penetrated far into the estuary and we were able to carry out a good sampling of the river water end member at the first station at a water depth of 23 m. We deployed a standard CTD rosette and a trace metal-clean rosette three times at intervals of 4 hours; there was no stratification of the water column, but the water column is well mixed due to the constant movement over the shallow substrate. There was also hardly any change in salinity over the entire sampling period; the values always remained below or at most at 1 PSU and hardly showed any change with the tides. The sampled sediment was surprisingly sandy, but good cores and pore water were recovered.

The second station was only 27 miles downstream from the first station. We approached it on the evening of 25 December and observed the temporal changes in salinity overnight in preparation for sampling a tidal cycle. However, the salinity here also remained surprisingly low with only slight changes between 1-2 PSU, so we only carried out two water column samples at intervals of 6 hours.

On the evening of 26 December we made our way out of the estuary and after another 35 miles at low salinity of 3 PSU maximum we were then surprised by an abrupt increase in salinity to about 20 PSU over a distance of only 4 miles (Fig. 2); apparently the freshwater outflow forms a veritable front flowing towards the ocean and there is no rather gradual mixing gradient as we had observed on the M147 in this region in the wet season.

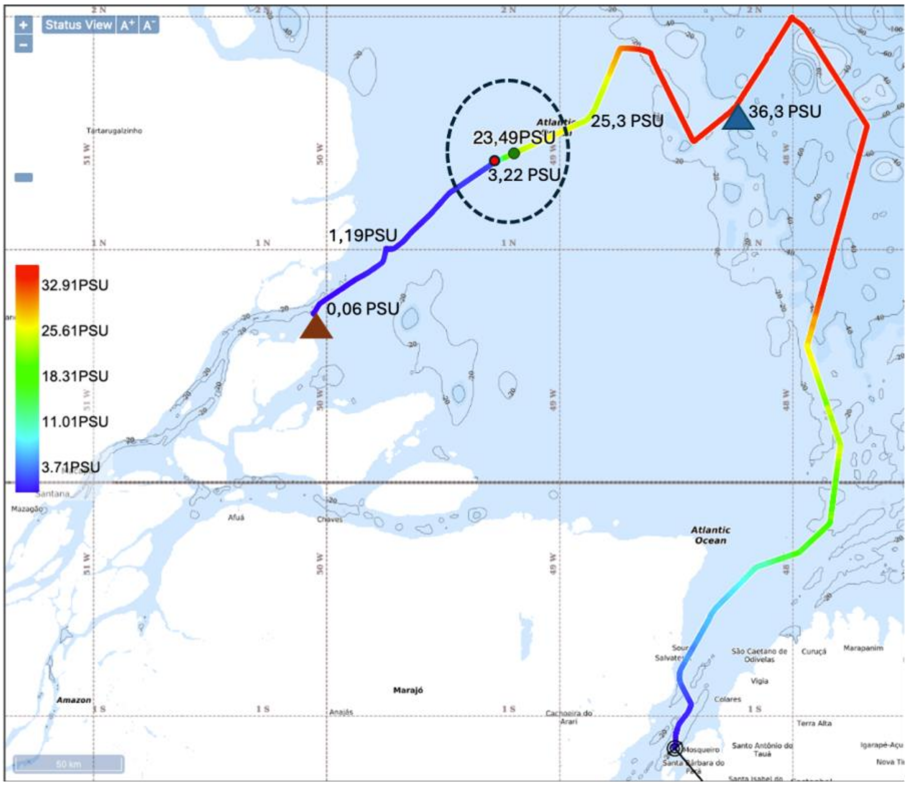
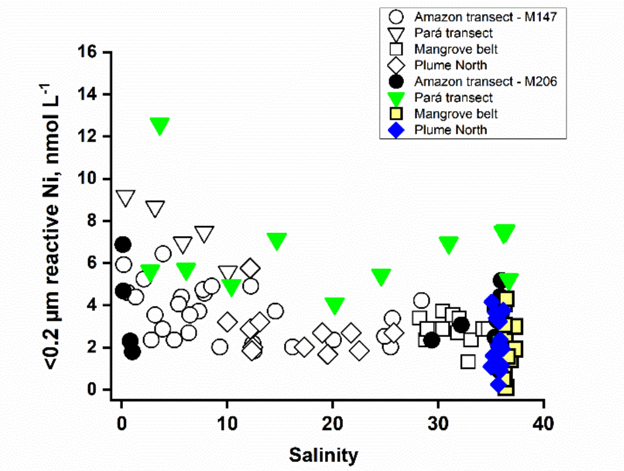


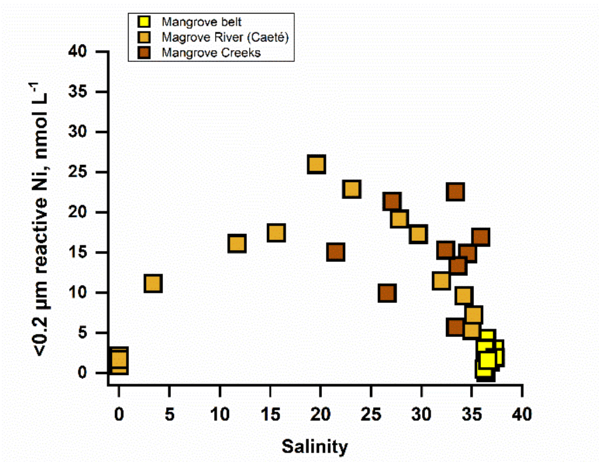
Fig 2: Map of the Amazon outflow region with salinity data along the route. The circled area marks the sharp transition between the river plume and seawater. The two triangles mark the positions where the river water and seawater end members were taken for the mixing experiments.

(TSG data FS Meteor, visualisation DSHIP Mapviewer with GEBCO contour lines)

As we unfortunately did not get permission to take surface water samples on this stretch with the tow-fish and the nearest station we had previously sampled already had a salinity of 28 PSU, this left us with a large sample and data gap for the 2-28 PSU salinity range. This covers almost the entire range in which the most important (bio)geochemical processes of the various substances take place, including colloidal flocculation, sorption of trace metals and DOM, uptake of nutrients including essential trace metals by plankton, and desorption from particle surfaces at higher salinities. We decided to replace the missing field data with a mixing experiment in the laboratory. To do this, we returned to one of the approved stations where the salinity is 36 PSU and which we can define as a seawater endmember, and mixed defined volumes of seawater with different volumes of the already collected Amazon River water endmember (locations of endmembers in Fig. 2). After a 24-hour waiting phase to adjust the chemical equilibrium, the mixtures are now filtered in the laboratory and further prepared for subsequent analyses. In this way, we were able to cover the entire range of different salinities along the mixing gradient in a river estuary and hope that we can link these laboratory data with the field data in the lower and upper salinity range. However, the limitation remains that although the laboratory experiment often provides results that are easier to interpret due to the fixed framework conditions of the experiment, it is unable to depict the complexity of the natural system, including the biological interactions with the chemical components.

Fig. 3: Voltammetry laboratory of the Brazilian colleagues Leandro de Carvalho, Alexandre Schneider and Christian Krause (from left). Here, extensive trace metal data was already compiled during the cruise in the water samples from the M206 as well as the water and pore water samples from the previous mangrove campaign of the PROBRAL project.





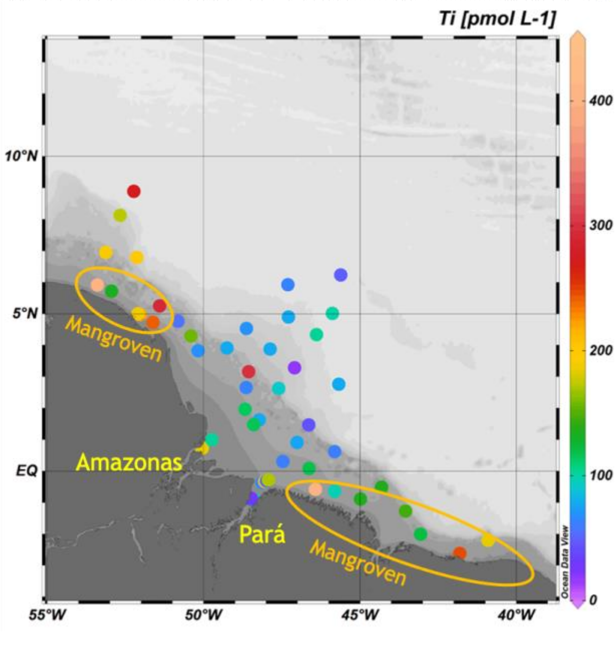


Fig. 4: The first voltammetric M206 data (coloured symbols) for dissolved nickel (Ni, top left) plotted against salinity generally show a similar trend to the data from the M147 cruise (2018, rainy season, colourless symbols), but slightly higher values for the Pará. The very high Ni contents in the samples from the mangrove area (top right) from the PROBRAL campaign prove that the mangroves provide a large contribution of the essential trace metal Ni.

In contrast to Ni, the trace metal titanium (Ti, bottom left) is a very particle-reactive element and is very quickly bound to particles in the estuary. The data from the Pará estuary are significantly lower for Ti during M206 than during M147, in contrast to Ni. Again, the mangroves with very high Ti contents indicate a strong source of this trace element.

(Data and graphs: L. de Carvalho, C. Krause, A. Schneider)

While the majority of the analyses can only be carried out in the home laboratories due to the complex infrastructure required, some groups can already present initial results from on-board analyses, which they present at the daily meetings of the science team. This also includes the trace metal analyses that some Brazilian colleagues are carrying out in their voltammetry laboratory on samples prepared by other teams (Fig. 3). The electrochemical method of voltammetry is compact in terms of equipment and easy to use on a ship and shows very high sensitivity and low detection limits in saltwater matrix. Some of the results are presented in Fig. 4.

Fig. 5: DOM laboratory of Michael Seidel (left) and Sebastian Haude. Here, dissolved organic material (DOM) is extracted and initial analyses of certain forms of DOM are carried out.

Further analyses are also carried out in the organic geochemistry laboratory (Fig. 5). This is where dissolved organic matter (DOM) is analysed. River systems such as the Amazon and water discharges from mangrove areas carry large quantities of DOM from land into the coastal ocean and thus influence the global carbon balance. In some of the samples, the DOM is concentrated by means of solid phase extraction for later detailed analyses. The on-board analyses already indicate a clear difference in the carbon cycle between the wet season (data M147) and the current cruise in the dry season (M206) and the prominent role of mangroves in the material flows.

After yesterday's belated Christmas and final celebration on the working deck, the last sample processing and analyses are still underway in some laboratories, while others have already started clearing and cleaning the laboratories, packing them into boxes and loading the containers.

Best regards from Andrea Koschinsky and Martin Frank and the entire M206 team