MSM 79-2

FS MARIA S. MERIAN, MSM 79/2

2. Weekly Report

Mindelo (Kap Verde) – Bahia De Las Minas (Panamá), 06.12. – 18.12.2018

The research vessel MARIA S. MERIAN will soon reach – after a successful repair to the propulsion system and with continued push by ocean currents and easterly winds – its destination in Bahia de las Minas (Panama) well in time. The scientific work is already finished, since we did not have permits for scientific work within the EEZ regions of Venezuela and Columbia. Thus, there has been some time to summarize all scientific measurements sampled between Capo Verde and Barbados Island and focus on Atlantic cross-sections near 15N degree latitude during December. The track of the vessel from Dec 6 to Dec 15 is summarized in Figure 1.

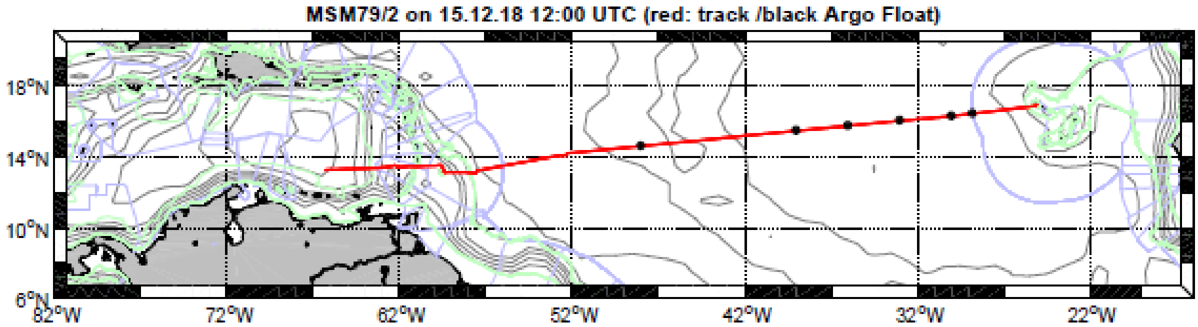

Figure 1 *The MSM 79-2 route until December15 (red line) on the research cruise from Mindelo (Capo Verde) to Panama). Also indicated are the deployment locations of the six ARGO floats (black dots). image by D.Hainbucher*

Atlantic cross-sections for December near 15N

Underway surface temperature and salinity surface measurements were continuously acquired through two SeaBird thermosalinographs. Unfortunately, comparisons and calibrations to CTD profiles were scratched, due to lack of time (with the propulsion problem still not fixed at the beginning of the cruise). Still, the salinity data in Figure 2 display reasonable values with lower values near at the north of the Amazonas mouth.

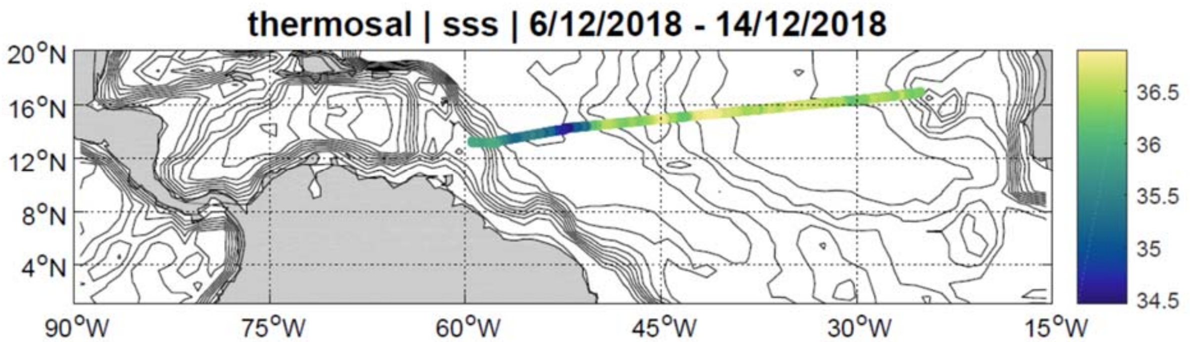

Figure 2*: Sea surface salinity gained by the thermosalinograph on cruise MSM79. image by D.Hainbucher*

Selected atmospheric data were pulled from the DSHIP data server and are presented for temperatures, relative humidity, wind and broadband radiations in Figure 3.

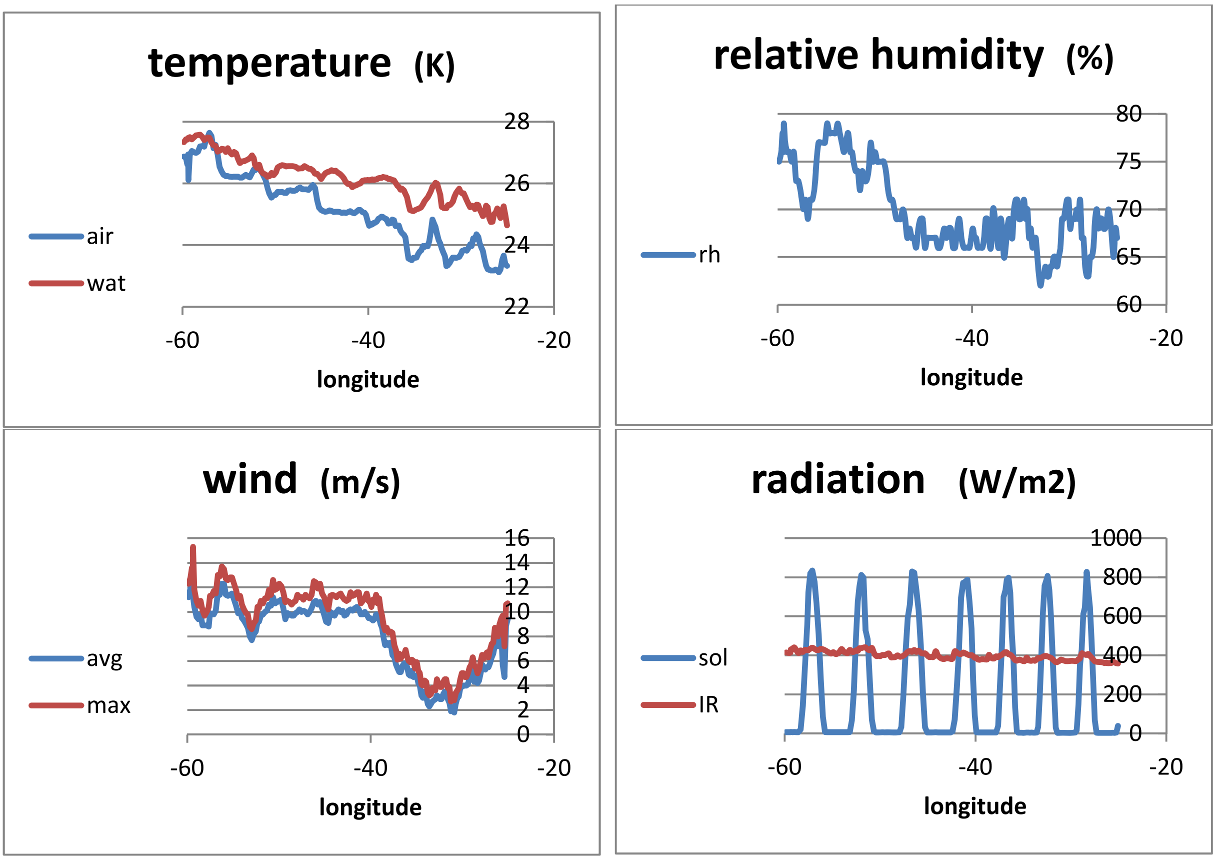

Figure 3 *Atlantic cross-sections for December at 15N between -60W and -25 W for temperature, relative humidity and wind-speed at the surface and for broadband solar and infrared radiation.*

From east to west the temperatures of oceans and air slowly increased (from ca 24 to ca 27deg C), with the water temperature always warmer by 1 to 2 deg than the air temperature. The relative humidity at the western side of the leg was higher (ca 75%) than at the center and eastern side of the leg (ca 68%). The surface wind was variable and at times very low in the eastern leg, while always strong (at more than 10m/s) over the western leg. The wind was out of the ENE to E direction (not shown) as expected for the trades. The east to west surface temperature (and atmospheric water) increase is also mirrored by a steady increase in incoming infrared radiation also as cloud fractions were relatively low. This is also illustrated by the incoming solar radiation, whose hourly averages exceeded 800W/m2 at noon each day. Since most of the time no clouds contaminated the direct sunlight, many solar direct attenuation data were sampled (with a sun-photometer). These samples provide (at sunshine during the day) data on atmospheric aerosol amount, aerosol size and atmospheric water vapor content. Cross-sections of these properties are presented in Figure 4.

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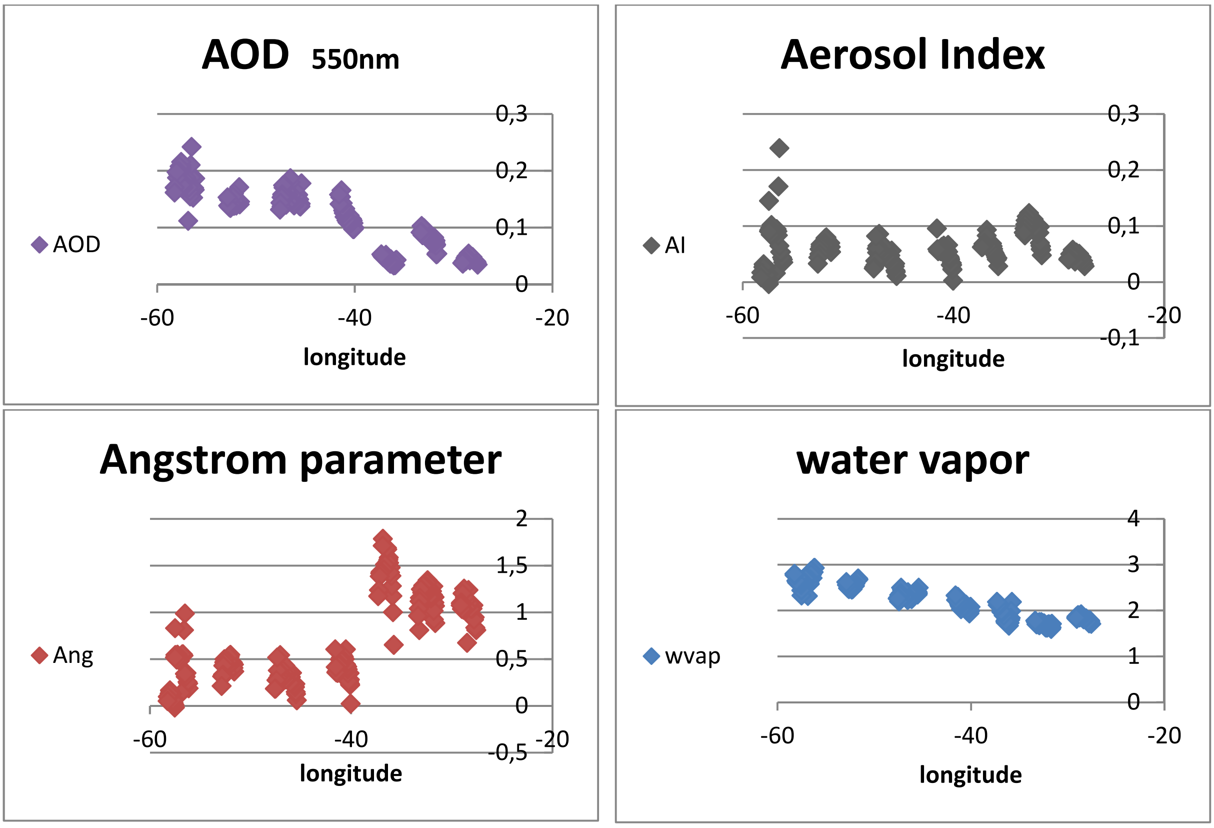

Figure 4 *Atlantic cross-sections for December at 15N between -60W and -25 W for sun-photometer derived data for AOD at 550nm, Angstrom parameter, aerosol index and water vapor.*

A sun-photometer samples the direct solar radiation at selected solar wavelengths. The sampled energy is less than the corresponding (through latitude and time defined) energy value at the top of the atmosphere. From solar energy losses these four atmospheric properties are defined:

- the total atmospheric aerosol load - via the aerosol optical depth (AOD) at solar wavelength of 550nm - a wavelength commonly used in modeling and satellite remote sensing
- the average aerosol particles size – via the Angstrom parameter, which is derived from the AOD spectral dependence with larger values (>0.8) indicating smaller aerosol sizes and vice versa.
- the aerosol potential of aerosol cloud interactions – via the Aerosol Index, which as the product of AOD and Angstrom is a good proxy for (optically active) aerosol number concentrations
- the total atmospheric water vapor content – by comparing solar energy losses in spectral regions without trace-gas absorption to a spectral region with known water vapor absorption.

The atmospheric water vapor content steadily increased from the east to the west consistent with surface temperature and relative humidity increases. Aerosol loads were variable and at times (at 0.04) very low on the eastern leg with dominant contributions by smaller (sub-micrometer) aerosol sizes. In contrast, aerosol loads where larger on the western legs, now with dominant contributions by larger

(super-micrometer) aerosol sizes. This is expected as the larger wind-speeds on the western leg contributed with increased (larger size) sea-salt concentration sizes from sea-spray. Scatter plots, which associate hourly wind-speed averages to aerosol amount (AOD) and inverse aerosol size (Angstrom), are presented in Figure 5.

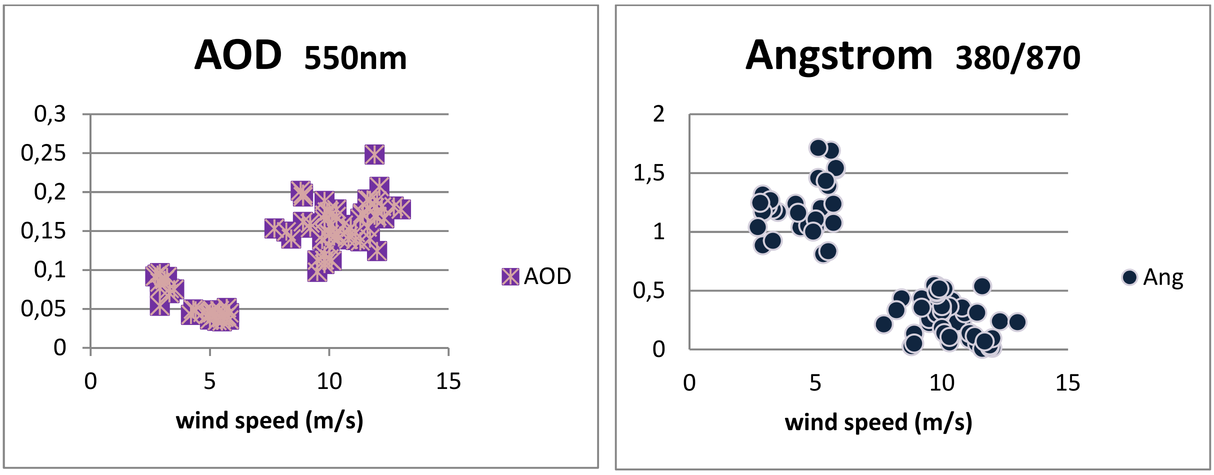

Figure 5 *associations between hourly wind-speed averages to AOD (left) and Angstrom (right)*

The scatter plots illustrate that both aerosol amount (AOD) and aerosol size (~1/Angstrom) are both positive correlated with the (average) wind-speed.

Another instrument specially deployed for atmospheric trace gas reference data is the MAX-DOAS (Multiple AXis Differential Optical Absorption Spectrometer). Two of those instruments operated during the cruise, one from KNMI and one from MPI-C. These instruments directly retrieve (by comparing solar scattering data in absorbing and non-absorbing spectral regions) trace-gas concentration along the light path (slant column densities). Retrieved trace-gases include NO_2, formaldehyde, SO_2 and glyoxal. Hereby is NO_2 is a tracer for anthropogenic pollution which is a precursor for the formation of tropospheric ozone. With samples at several elevation angles between the horizon and the zenith, even trace gas vertical profiles can be retrieved. In Figure 6 first results for NO_2 column data along the Atlantic cross section with the MPI-C MAX-DOS are presented. The data show relatively low values as expected for background conditions. However, occasionally larger values are indicated as then the ship's exhaust was sampled. Unfortunately, most of time during the research cruise we had strong winds from the back, usually stronger than our forward speed. This situation spread significant exhaust air to the front of the ship, where the MAX-DOAS instruments were located. Thus, on two days (Dec 11 and Dec12) we changed the course for ca 20 minutes in a southern directions to get at 1:30 local time a few good reference samples for comparisons to retrieved satellite (e.g. TROPOMI) satellite retrievals.

Another highlight was the approach in wind-directions towards the east coast of Barbados to compare with samples at the BCO site of the MPI-M. It is hoped with the complementary data sampled on the ship to address structure and lifetime of trade wind cumulus clouds as a function of time.

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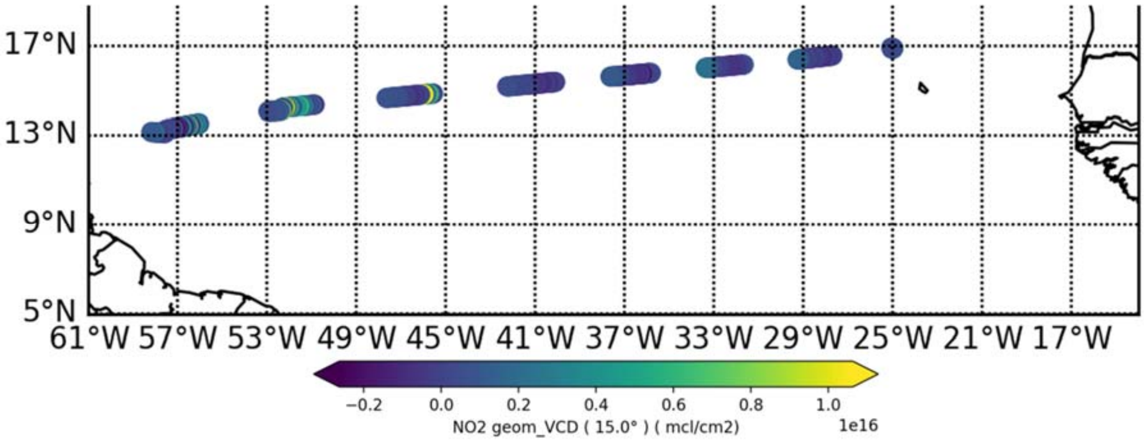

Figure 6 *NO2 column data sampled along the Atlantic cross section. The occasional higher values on the western side are caused by sampling ship exhaust (due to unfavorable winds).*

Finally, also bathymetrical (ocean depth and ocean floor) sampled data were prepared for the database of the SEABED2030 initiative. In that context, also a summarizing movie was produced. Samples of the analyzed detail are presented in Figure 7 for two selected regions along the route.

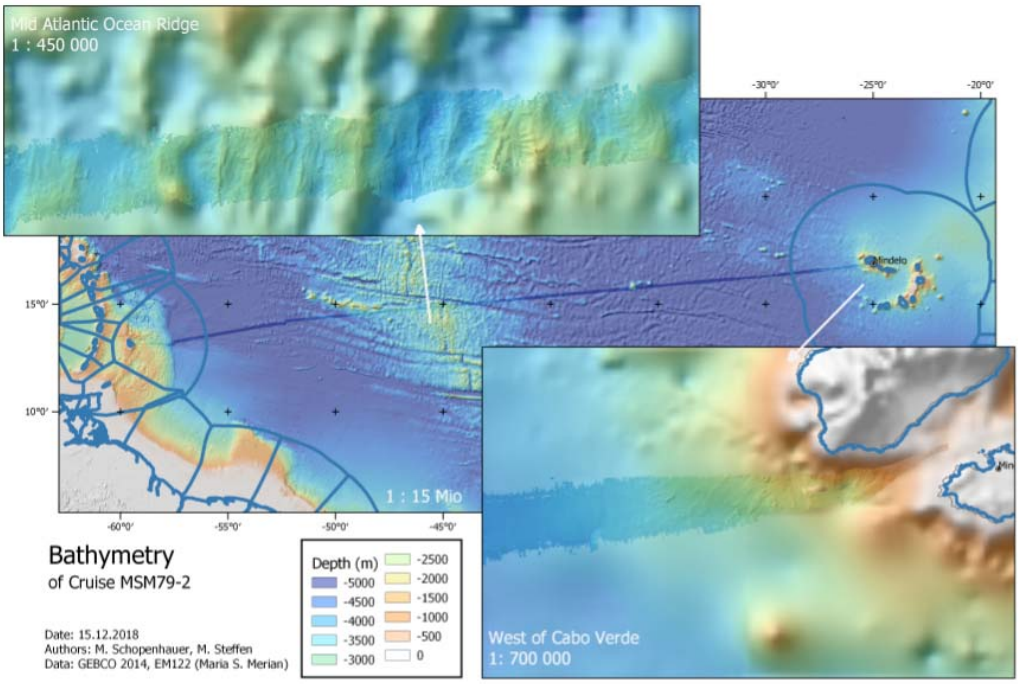

Figure 7 *ocean floor detail for the Atlantic ridge and near Capo Verde.*

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