4. weekly report SO 259-3

We passed the equator on Dec 29 and deployed the other two ARGO floats. The three instruments as they were floating immediately after their release in the water are captured in Figure 1.

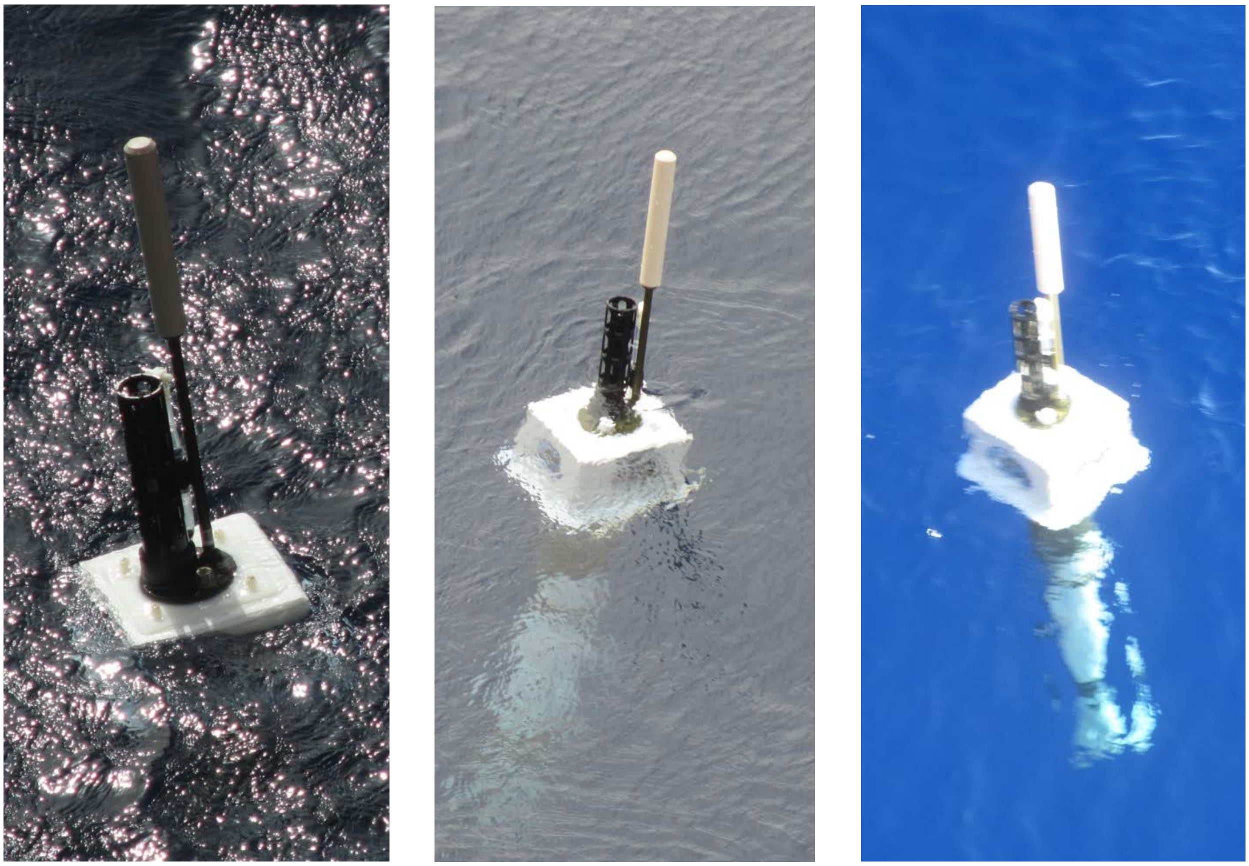

Figure 1 *ARGO floats swimming at the surface immediately after their deployment. The first float was deployed near 20W/25N on Dec 25, 2017 (left), the second float was deployed near 22W/2S on Dec 30, 2017 (center) and the third float was deployed near 28W/14S on Jan 1, 2018 (right).*

The cruise continued southward into now extended days, and as aerosol loads and pollution levels dropped to background conditions (AOD ca 0.05) any outside work over the Southern Atlantic outside work in the sun (e.g. sun-photometer sampling) meant being exposed to intense sunlight.

From KNMI's MAXDOAS samples now first results on NO2 concentrations are available. The instrument measured continuously from sunrise to sunset every day with a sample every couple of second. Data are analyzed using the 'mmd software' from Ankie Piters (KNMI) and the QDOAS software. Figure 2 shows NO_2 slant column data for December 20, 2017 and for January 1, 2018.

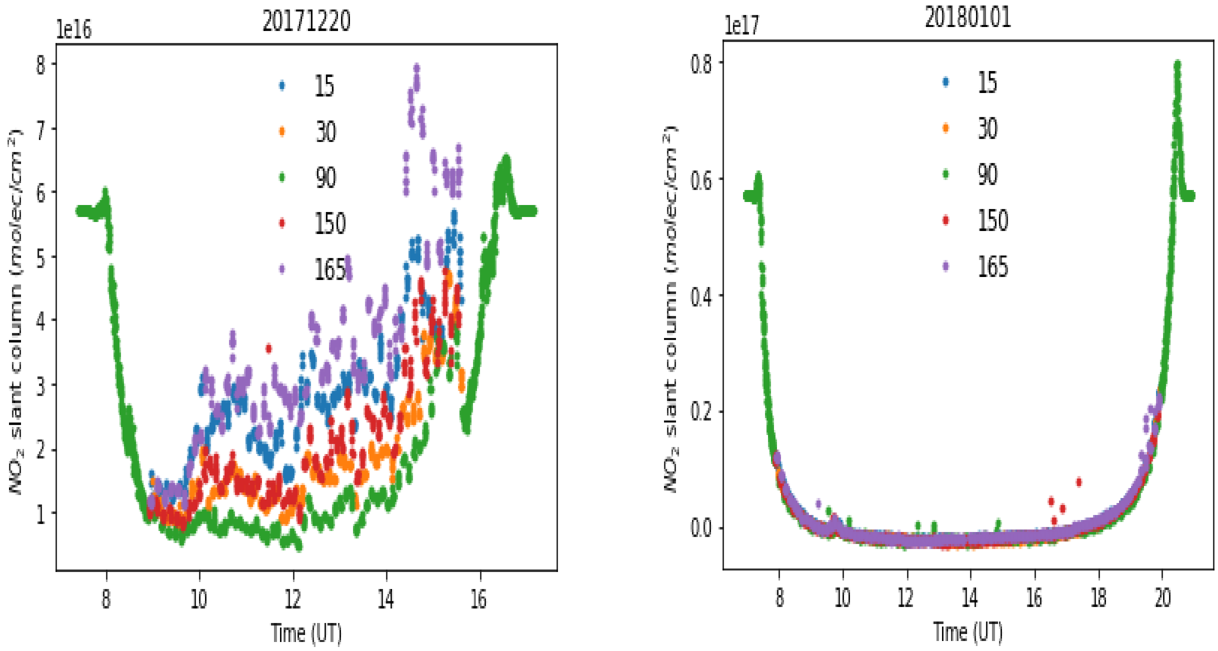

Figure 2 *NO_2 slant columns derived using QDOAS for (a) polluted troposphere case on December 20, 2017 when at Brest France, (b) a clean troposphere case on January 1, 2018, when in the southern tropical Atlantic (25W/10S). The KNMI MAXDOAS scans at 15 (or 165), 30 (or 150) and 90 degree elevation angles, thus in two directions.*

On December 20, 2017 (at Brest), the NO_2 slant columns displayed large variations at different elevation angles. This indicated that there were both tropospheric NO_2 and some clouds. In contrast, on January 1, 2018 (in the southern Atlantic near 25W/10S) the NO_2 slant columns were very smooth. They showed almost no differences for samples at different elevation angles. This is because in this southern Atlantic region far away from pollution sources the tropospheric NO_2 amount is very low, so mainly stratospheric NO_2 is detected. Hereby, the increase of NO_2 columns in the morning and evening is due to the extended path of the sun through the stratosphere (as scattered radiation is sampled). Summarizing the all MAX-DOAS samples with the KNMI instruments, there were mainly two distinct domains. From December 17 to 20, 2017 (on the way from Emden to Brest) enhanced tropospheric NO_2 columns were detected. And from December 21 on (on the way from the Bay of Biscay to the southern Atlantic) mainly stratospheric NO_2 columns were sampled. A more detailed analysis will be provided after the campaign.

In terms of precipitation (other than dust) the entire cruise had been rather disappointing. Even when crossing the convection path of the ITCZ near the equator at most a few raindrops reached the ship. This however changed when the RV Sonne hit a squall line perpendicular to its path off Rio de Janeiro during the afternoon of January 4. An illustration of the cloud and the rain radar-image just before entering the squall line is presented and a picture of a rain-soaked deck are shown in Figure 3.

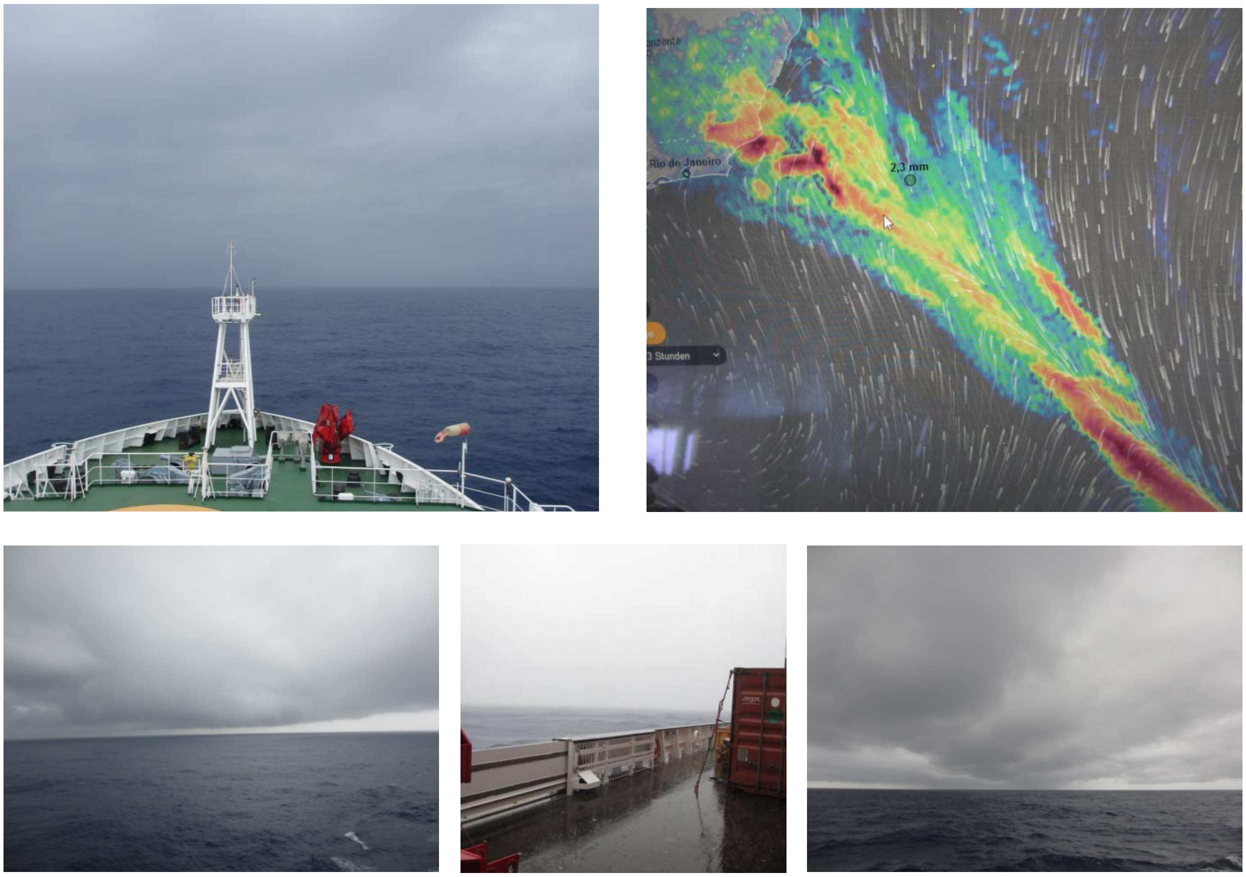

Figure 3 *Images while approaching a squall line, which brought significant precipitation - off Rio de Janeiro, Brazil. The upper left panel provides a view from the ship and the right upper panel shows (1) the rain radar image, (2) wind vectors (southward from the NE and northward from the SW) and (3) the location of the ship. Pictures of the clouds in the lower panel corners were taken shortly before the rain started to fall on the ship, as documented in the center of the lower panel.*

The SO 259-3 will come to an end in the next couple of days. Thus it seem fitting, to summarize data aerosol and water vapor data (from sun-photometer samples) and cloud properties (by the thermal camera), there were collected so far, because a major scientific goal of this cruise was to establish latitudinal cross-sections for these atmospheric properties. Sun-photometer based latitudinal cross-sections for aerosol and clouds properties are presented in Figure 4 and those for cloud properties, as derived from thermal camera images, are summarized Figure 5.

In Figure 4 latitudinal cross-sections for four properties are shown: The AOD, 550nm presents the total aerosol in the atmosphere and represents the Aerosol Optical Depth at a wavelength of 550nm, as it is commonly diagnosed in (global) modeling. The Angstrom parameter provides general information on aerosol size: Smaller values (<0.4) indicate the dominant influence by relatively large aerosol particles (as to expect from sea-salt and mineral dust). Larger values (larger than 1.0) indicate strong contributions from relatively small aerosol particles (as to expect from pollution and wildfires).

The other two plotted properties are the Aerosol Index (AI =AOD*Angstrom) as a general indicator for aerosol impact potential on clouds and the retrieved atmospheric water vapor content.

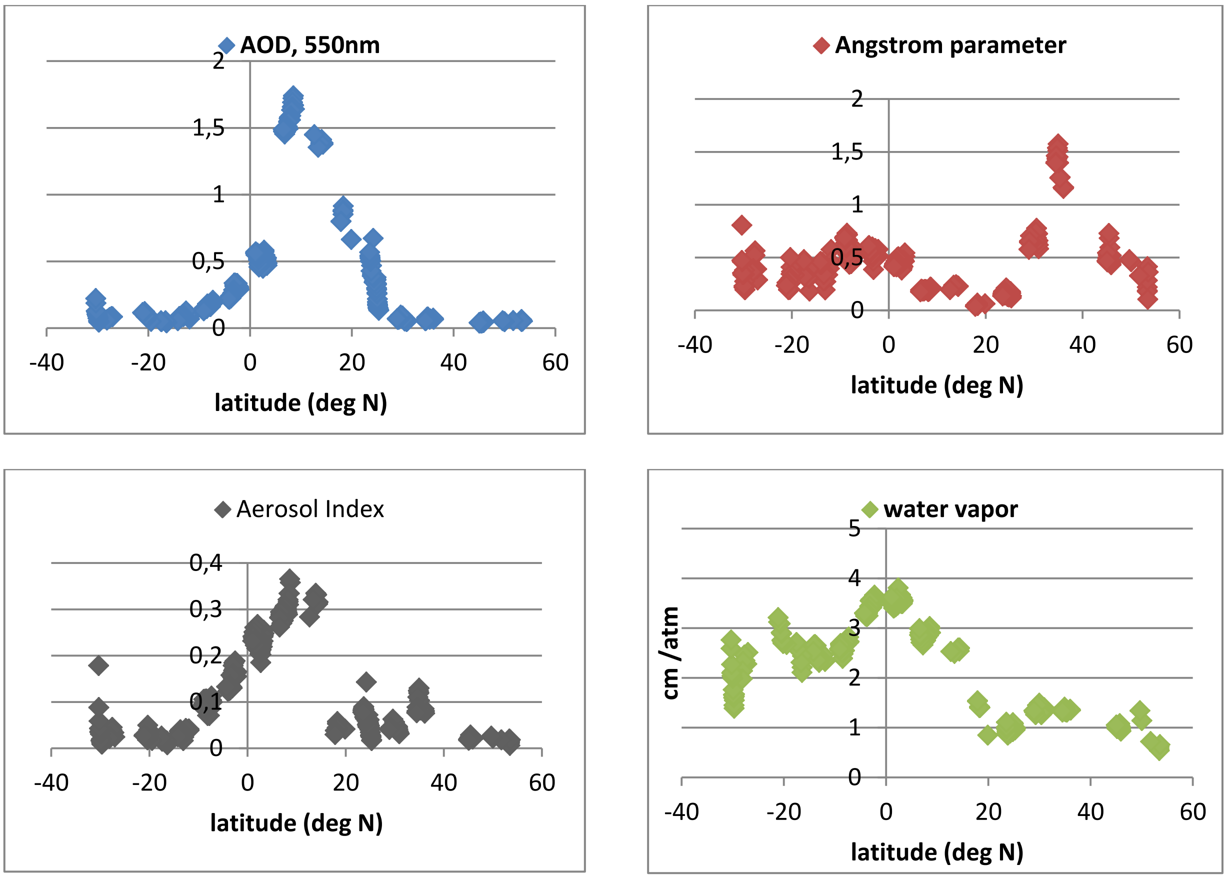

Figure 4 *Properties of atmospheric aerosol und water vapor as detected by sun-photometer samples for the entire SO 259-3 voyage. Presented are latitudinal dependencies for (1) aerosol amount (AOD at 550nm, upper left), (2) relative aerosol size (lower Angstrom values indicate large aerosol sizes, upper right), (3) aerosol potential to influence water clouds (Aerosol Index [=AOD*Angstrom], lower left) and (4) water in the atmospheric column (water vapor, lower right).*

The aerosol time-series is dominated by the strong dust event just north of the equator and by the relative clean aerosol conditions in the southern Atlantic. The water vapor amount reached its maximum near the equator yet the increase from lower water vapor at lower latitude was often non-monotonic and controlled by air-mass transport into the sub-tropics.

Cloud cover fraction of the entire transect (as function of latitude) based on hourly averages are presented in Figure 5. Hereby, cloud-fractions, as seen by a ground-observer, are attributed according the cloud-base height. This was done by applying different threshold temperatures to represent cloud cover below approximate 0.5, 1, 1.5, 2, 3, 6 and 10km according to the sensed IR window temperature. The total cloud-fraction is estimated by applying the coldest threshold temperature (for 10km).

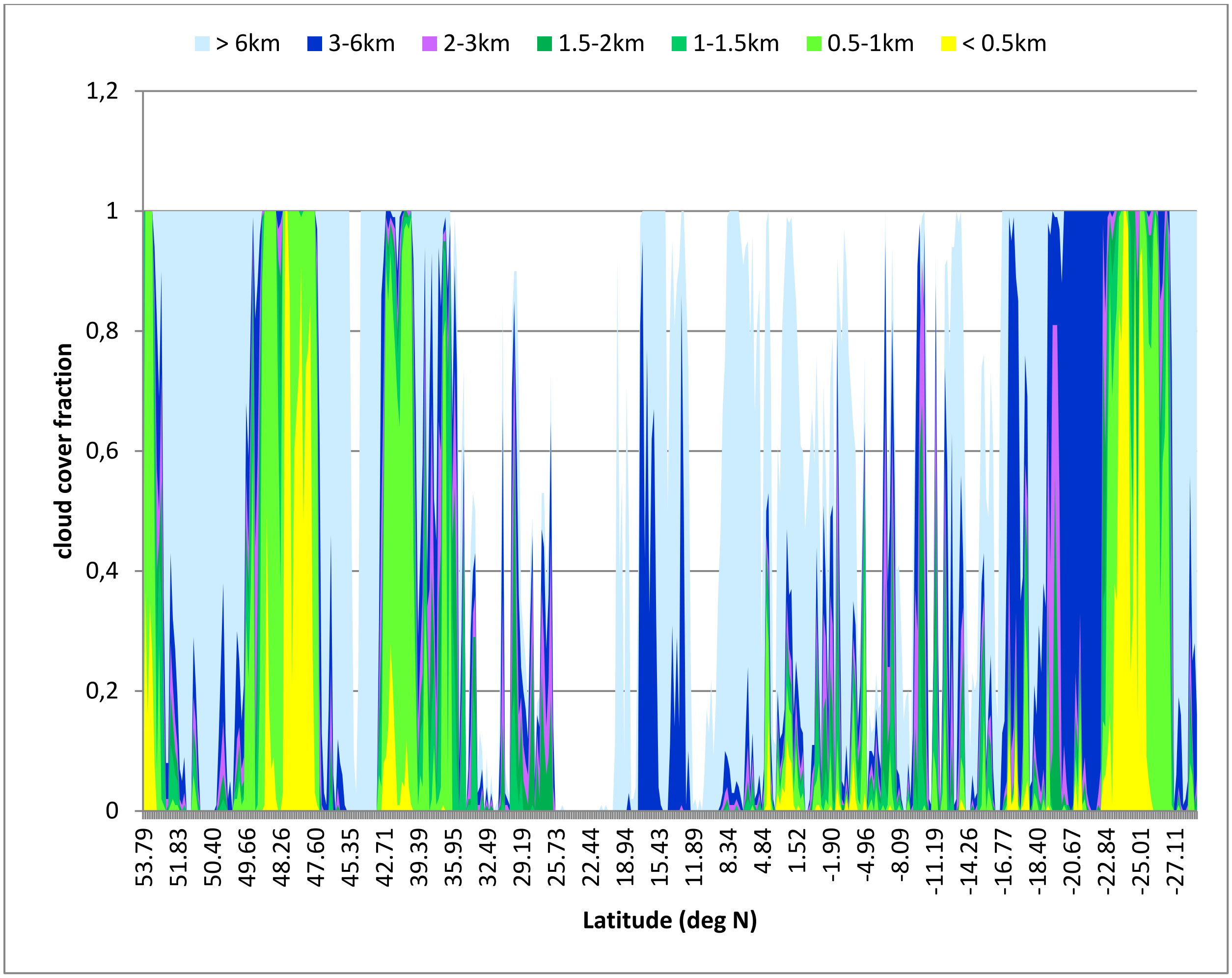

Figure 5 *cloud cover data from thermal camera averages based on hourly averages during SO 259-3. Low altitude clouds as observed by a ground observer are in green (and if very low in yellow), mid-level clouds are in blue and high altitude clouds are in light blue. A white color indicates cloud-free conditions.*

The cloud cover data confirm the high altitude clouds (and contrails) over the Channel. For the heavy dust case initially (near 19N) high altitude clouds and later on (between 17 to 12N) mid-level clouds interfered, as observed. The crossing of the squall line (near 24S) is associated with a low altitude cloud-base also due to the precipitation.

As this is the last weekly report of the cruise it seems fitting to add selected figures of clouds. Figure 6 gives a glimpse into the complexities and facets of clouds, which even more are changing by the minute. Remember, that clouds are the main modulators for weather and climate. Their proper representation in modeling is far from perfect and will remain a future challenge. Progress can most likely be expected if processes that lead to the development of the dissipation of clouds are better understood. And toward that goal samples of this cruise will certainly contribute.

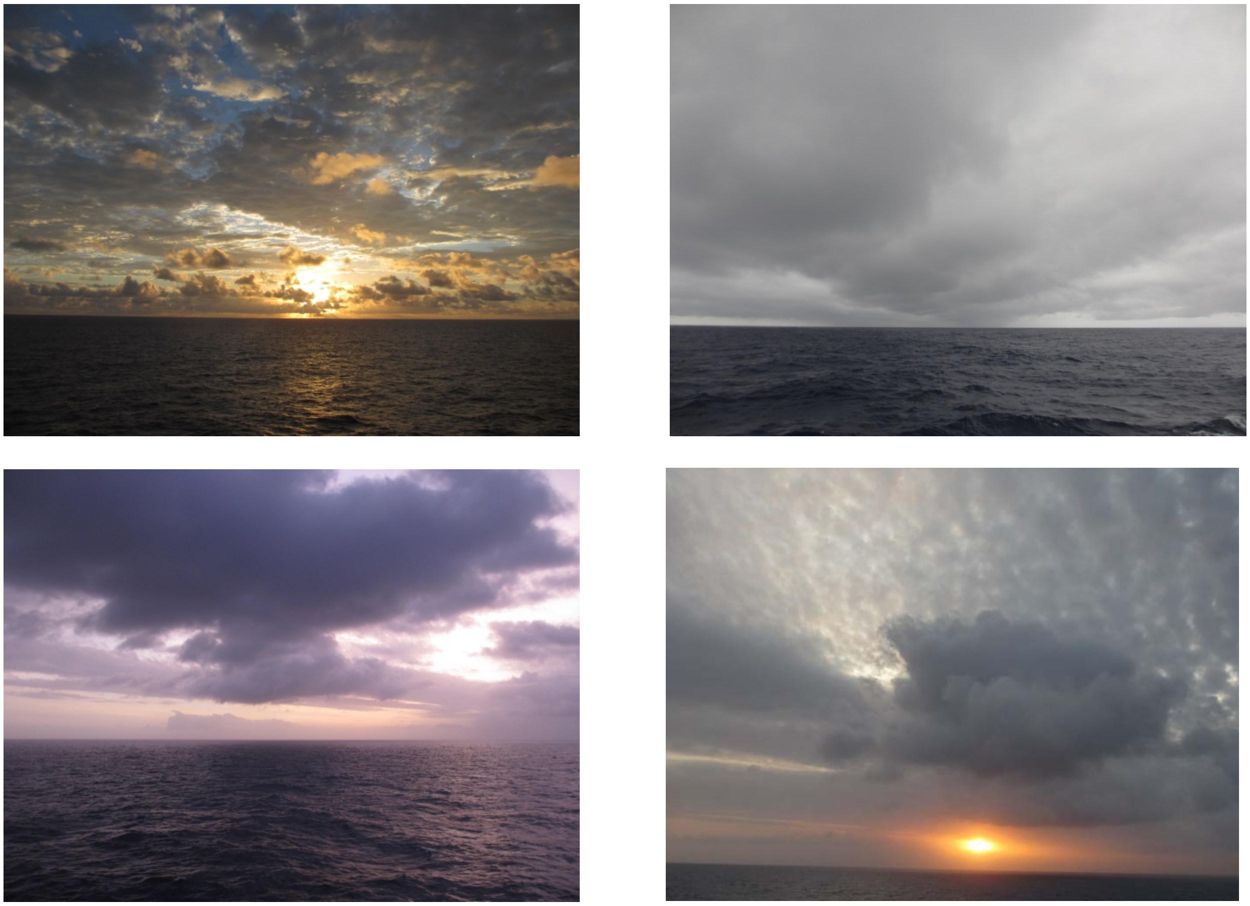

Figure 6 *Images of clouds in the Southern Atlantic just to provide a glimpse at the complexity, to illustrate the simplified nature of the detected summaries for cloud-cover, cloud base altitude and cloud structure of our analysis*

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Appendix

cloud properties corresponding to Figure 5 from the SO 259-2 cruise (Capetown to Emden in Oct 2017)

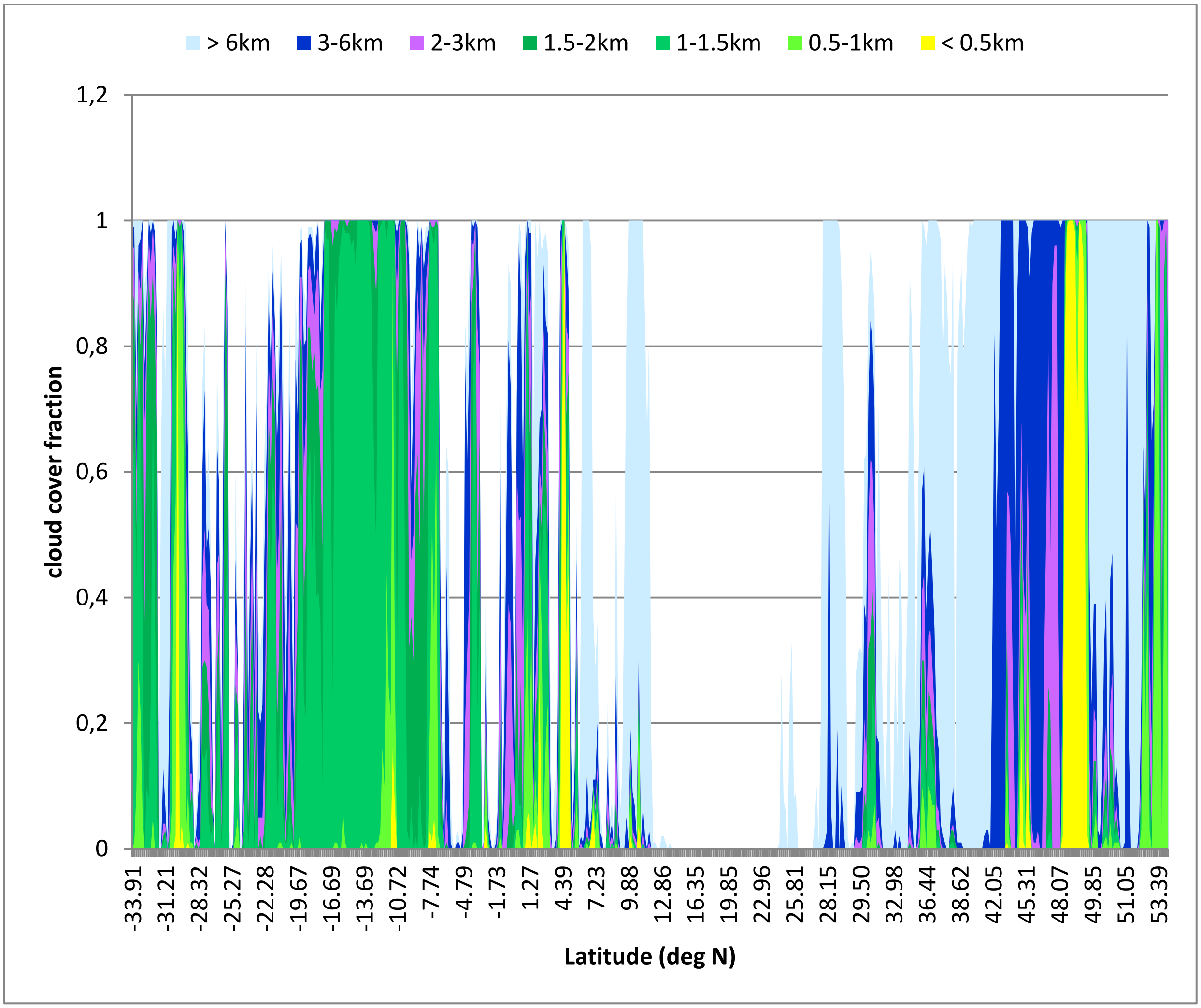

Figure A1 *cloud cover data from thermal camera averages based on hourly averages during SO 259-2. Low altitude clouds as observed by a ground observer are in green (and if very low in yellow), mid-level clouds are in blue and high altitude clouds are in light blue. A white color indicates cloud-free conditions.*