Five years of ship-based remote sensing observations of clouds, water vapor and radiation over the Atlantic Ocean

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Introduction

Within the framework of the OCEANET project, ship-based observations have been performed since 2007 on board of the German research vessel Polarstern on the Atlantic Ocean at ten cruises between Bremerhaven (Germany) and Cape Town (South Africa) or Punta Arenas (Chile), respectively. These observations were designated to measure the full energy budget and exchange processes at the sea surface as well as the state of the upper ocean and the troposphere in different climate zones.

Measurements

Fig. 1: Research vessel Polarstern

The primary research areas of Polarstern are the polar oceanic regions. However, most polar research campaigns are performed in the respective summer seasons. Therefore, north-south transects over the Atlantic Ocean are performed twice a year. In the year 2007, these Atlantic cruises were used for the first time as a platform to perform ship-based remote sensing observations over the ocean. Since then, the instrumentation increased constantly in order to get a complete characterization of the atmospheric state on a north-south transect. Currently, the 10th OCEANET cruise is on its way from Punta Arenas and is scheduled to arrive in Bremerhaven on May 16, 2012.

ANT-XXIII/10	Apr/May 2007	Cape Town-Bremerhaven
ANT-XXIV/1	Oct/Nov 2007	Bremerhaven-Cape Town
ANT-XXIV/4	Apr/May 2008	Punta Arenas-Bremerhaven
ANT-XXV/5	Apr/May 2009	Punta Arenas-Bremerhaven
ANT-XXVI/1	Oct/Nov 2009	Bremerhaven-Punta Arenas
ANT-XXVI/4	Apr/May 2010	Punta Arenas-Bremerhaven
ANT-XXVII/1	Oct/Nov 2010	Bremerhaven-Cape Town
ANT-XXVII/4	Apr/May 2011	Cape Town-Bremerhaven
ANT-XXVIII/1	Oct/Nov 2011	Bremerhaven-Cape Town
ANT-XXVIII/5	Apr/May 2012	Punta Arenas-Bremerhaven

Tab. 1: List of OCEANET cruises (name, period, route)

The main instrumentation on all cruises to infer the atmospheric composition consisted of a passive microwave radiometer, a full sky imager, sun photometer and additional lidar ceilometer and broadband solar and infrared radiation measurements. On four cruises, a portable Raman lidar (POLLY) was on board of Polarstern as well.

With five years of measurements - always at the same time of the year - it is possible now to assess the variability of the atmosphere with respect to the radiation budget, especially in the subtropical and tropical regions where the intra-seasonal variations are rather small.

Acknowledgements: The authors are grateful to the Alfred-Wegener-Institute for the opportunity to perform measurements during the Atlantic transfer cruises and to all people who contributed to the successful operation of these instruments during the cruises.

Water vapor / Clouds / Temperature

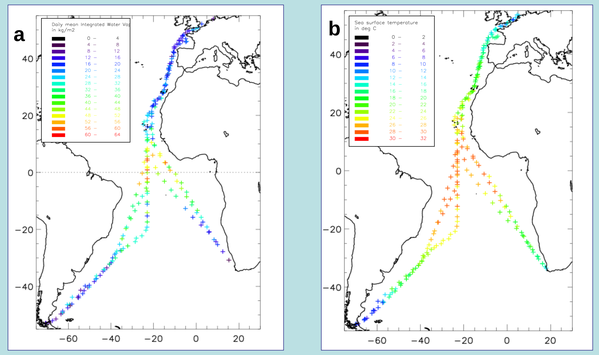

Fig. 2: a) Daily mean integrated water vapor and b) sea surface temperature for 7 cruises

An overview over the routes covered in this work is given in Fig. 2. Integrated water vapor and sea surface temperature show a very typical distribution with their maximum within the tropics. However, the water vapor maximum is much more pronounced than the temperature pattern. It has to be noted that sea surface temperature and air temperature are very close together and do usually not differ by more than 1 K in the daily mean. Fig. 3 presents the increase on temporal information as well as a quality assessment for IWV by microwave radiometer with respect to radiosonde ascents. In addition, the temperature and humidity profiles for one cruise are presented in Fig. 4. Typical patterns appear in these graphs, like the strong temperature inversion in the northern trade wind region as well as the deep convection (high humidity up to 10 km altitude) around the equator.

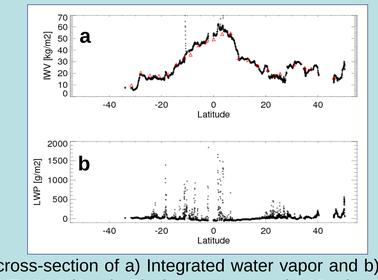

Fig. 3: Latitudinal cross-section of a) Integrated water vapor and b) cloud liquid water path of cruise ANT-XXVII/4. a) Black crosses mark 10-minute mean HATPRO observations, red triangles show radiosonde ascents. b) Black crosses for LWP mark 10-minute maximum LWP.

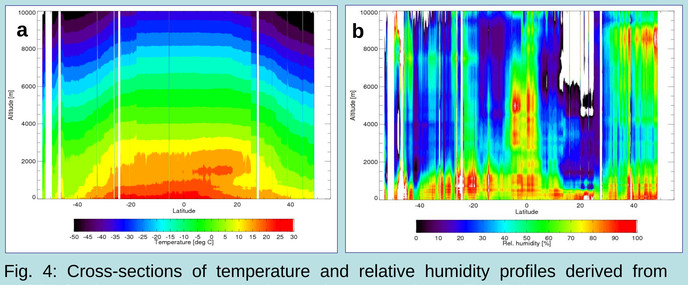

Fig. 4: Cross-sections of temperature and relative humidity profiles derived from HATPRO microwave radiometer observations on cruise ANT-XXIV/4.

Radiation / Interannual variation

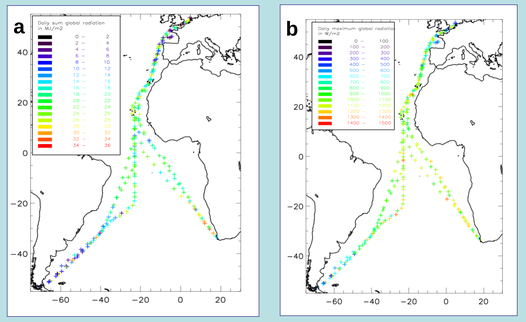

Fig. 5: a) Geographical distribution of daily sum of global radiation (in MJ/m²) for seven Polarstern cruises. b) Same for daily maximum global radiation (in W/m²).

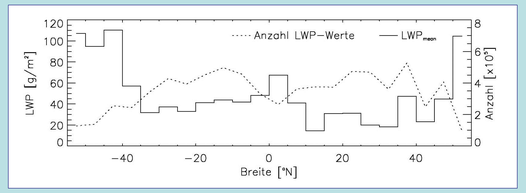

Fig. 6: Latitudinal cross-section of cloud liquid water path (mean over all cruises), together with number of observations (dotted line).

Maps of observed global radiation (Fig. 5) present less latitudinal variation within the tropical region than the water vapor. The highest radiation values occurred in the trade wind areas (sun zenith position of the sun was around 15°N/S during the cruises). In the equatorial region some days with low global radiation indicate deep cloudiness. However, the general shadowing of these clouds is relatively weak.

The latitudinal distribution of cloud liquid water path (LWP, Fig.6) confirms this finding with a distinct maximum LWP between 0° and 5°N and very low values in the northern trade wind region.

The interannual variation is presented in Fig. 7 (IWV cross-sections) with relatively strong differences in the position of the transition between the inter-tropical convergence zone (ITCZ) and northern trade wind region.

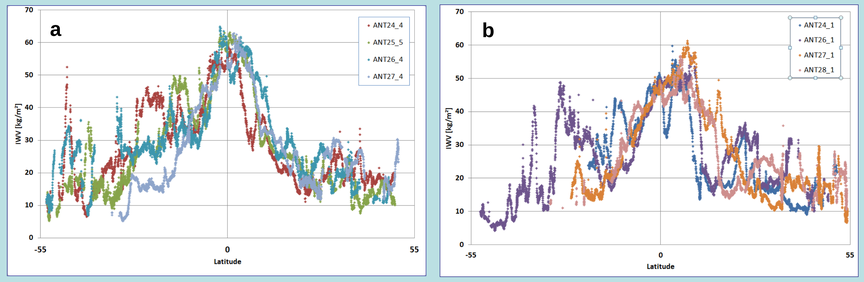

Fig. 7: IWV latitudinal cross-sections for eight Polarstern cruises, separated into April/May season (left) and October/November (right). No difference was made in terms of the route on the southern hemisphere.

Discussion and Outlook

- The measurements on Polarstern are a unique dataset of ship-based atmospheric remote sensing observations over the ocean over different climate zones. Five years of observations allow a first glimpse on the climatic distribution of atmospheric conditions and give a first glimpse on the inter-annual variability of relatively robust variables like the integrated water vapor. As a first finding, the position of the transition from the very moist tropical regions connected to the ITCZ to the dry trade wind areas is relatively variable
- Furthermore, this dataset is very valuable for determining the radiation and energy budgets over the ocean which are also further evaluated.
- The analysis of the ongoing cruise (ANT-XXVIII/5) and the cruise in late 2012 (ANT-XXIX/1) will bring additional valuable information to this dataset.

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