Ocean Rainfall And Ice-phase precipitation measurement Network

OceanRAIN is an international research project based in Hamburg, Germany, that aims at measuring high-quality rain and snowfall data onboard research vessels (RV) on the global oceans. The long-term project was initiated in 2009 by Dr. Christian Klepp at the University of Hamburg (CliSAP/CEN) and the Max Planck Institute for Meteorology in close cooperation with Mabanaft—Initiative Pro Klima.

The value of OceanRAIN for the science community

Precipitation, falling over the global oceans as rain, snow and mixed-phase, is among the most important climate variables and a key player in the global water cycle. However, precipitation is notoriously difficult to measure. To obtain precipitation maps with global coverage several times a day, only satellites can be used. However, satellites do not measure precipitation but a radiation field that has to be converted into precipitation using physical or statistical algorithms. Thus, the results depend on the algorithm applied. The differing precipitation estimates produced by several international research centers call for independent surface data for validation. This is where OceanRAIN comes into play being to date the only systematic long-term shipboard precipitation data collection effort. OceanRAIN utilizes a unique measurement system: an optical disdrometer that is specifically designed to measure onboard of ships under all weather conditions. Supplying the research community with this instrumentation and data set, OceanRAIN contributes to:

- improve the understanding of microphysical properties of precipitation,
- increase the knowledge of precipitation statistics,
- validate satellite and model precipitation products,
- analyze the errors in the satellite algorithms,
- calibrate shipborne and spaceborne precipitation radars.

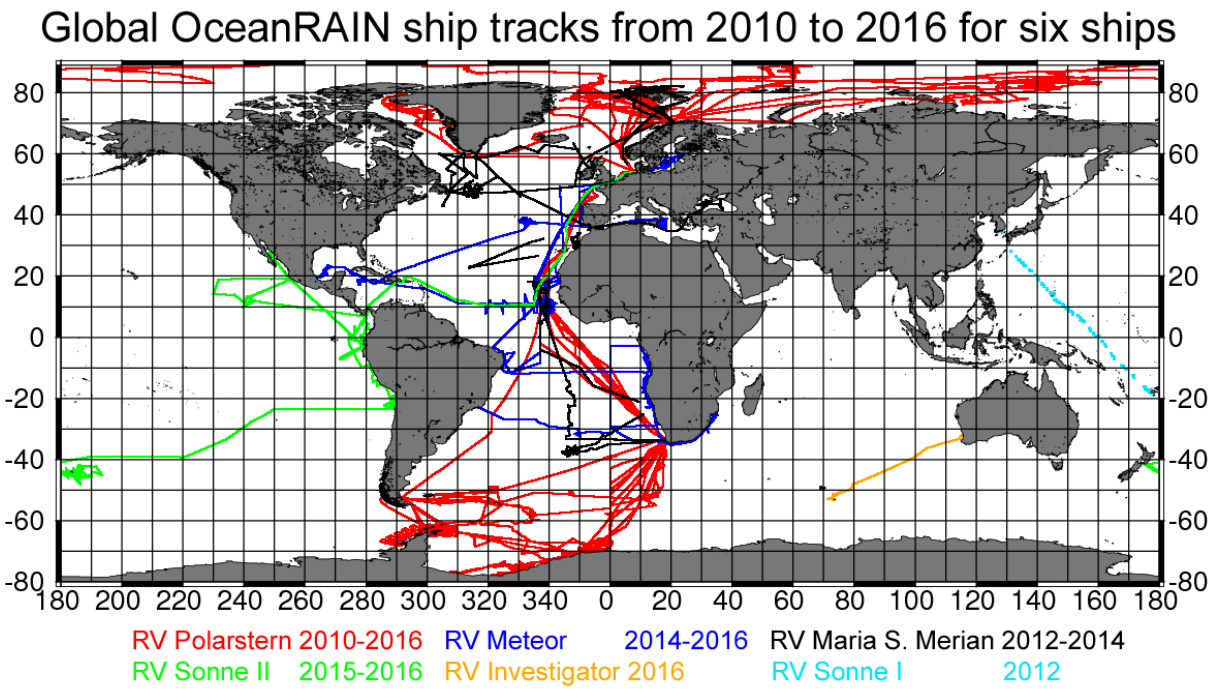
OceanRAIN started over the Norwegian Sea

The idea for OceanRAIN was born in 2005. A cold-season shipboard research campaign was planned at the University of Hamburg to take place onboard the Irish research vessel “Celtic Explorer” over the Norwegian Sea. At that time, Klepp was working in the Hamburg based HOAPS satellite group (www.hoaps.org) deriving a global satellite-based water cycle climatology that contained the critical precipitation parameter. In trying to obtain shipboard precipitation data to compare against the HOAPS satellite climatology, Klepp established contact to the Geomar Institute in Kiel, Germany, where the prototype of the later OceanRAIN disdrometer was developed. To cut a long story short, the operation of this prototype instrument onboard “Celtic Explorer” delivered data that revealed its great potential to validate satellite data and to fill a longstanding gap in science—the accurate measurement of precipitation onboard ships. A second successful measurement campaign was carried out in 2008 onboard the Norwegian Kystvakten ship K/V Senja. In late 2008, Klepp successfully applied for the OceanRAIN project within the Excellence Cluster of the University of Hamburg. Since then two major instrument upgrades followed in close cooperation with today’s instrument developer Eigenbrodt (http://www.eigenbrodt.de/en/projects/ocean-rain.html) that has solved all problems encountered during the harsh environments of the shipboard operation. After six years of experience, we are working in a group of 4 people with robust and reliable instrumentation and an automated data processing. We link OceanRAIN with the international science teams to increase our knowledge about oceanic precipitation.

The OceanRAIN ship fleet

By June 2016, OceanRAIN has ingested more than 6 million minutes of precipitation data from 12 research ships that operate worldwide in all climate regions. Four of these ships are long-term equipped: For already six years the German icebreaker RV Polarstern is operating in the summer hemispheric Arctic and Antarctic Oceans and remained in Antarctica during the austral winter of 2013. For three and two years, the German RV Meteor and RV Sonne are sailing the subtropical and tropical Atlantic and Pacific Ocean, and since January 2016 the Australian RV Investigator is exploring the Southern Oceans encircling the Antarctic.

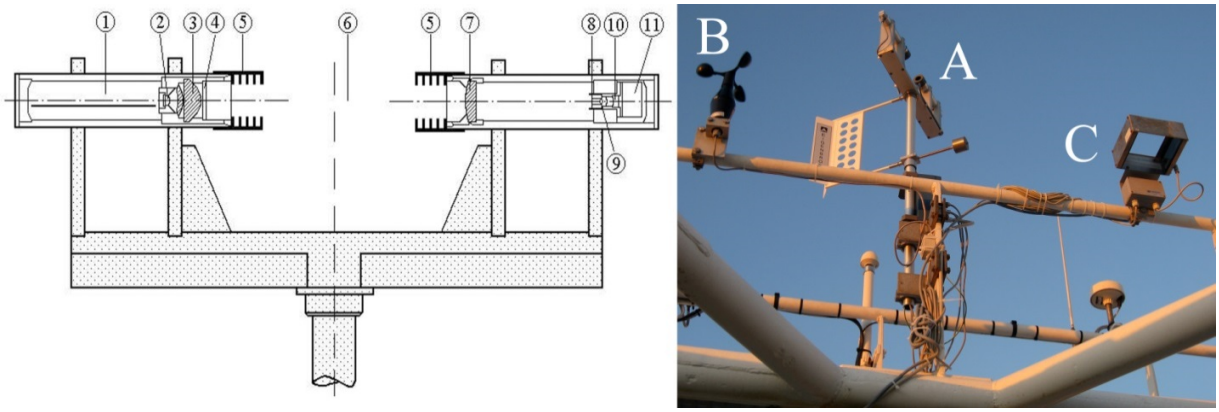
The four OceanRAIN flagships: The German icebreaker RV Polarstern (upper left) in the inner Arctic, the German RV Meteor (upper right) and RV Sonne (lower left) operating in the tropical and subtropical Atlantic and Pacific Oceans, and the Australian RV Investigator that operates in Antarctic waters of the Southern Oceans (lower right) with Dr. Christian Klepp (right person) during the installation in Perth.



Global ocean ship tracks for six OceanRAIN ships from 2010 to 2016. The data coverage on the Southern Oceans is increasing fast from 2016 onward onboard the RV Investigator (orange). The data set also grows on the Pacific Ocean onboard the Sonne II (green) and the American RV Roger Revelle that will sail the tropical Pacific Ocean in August 2016.

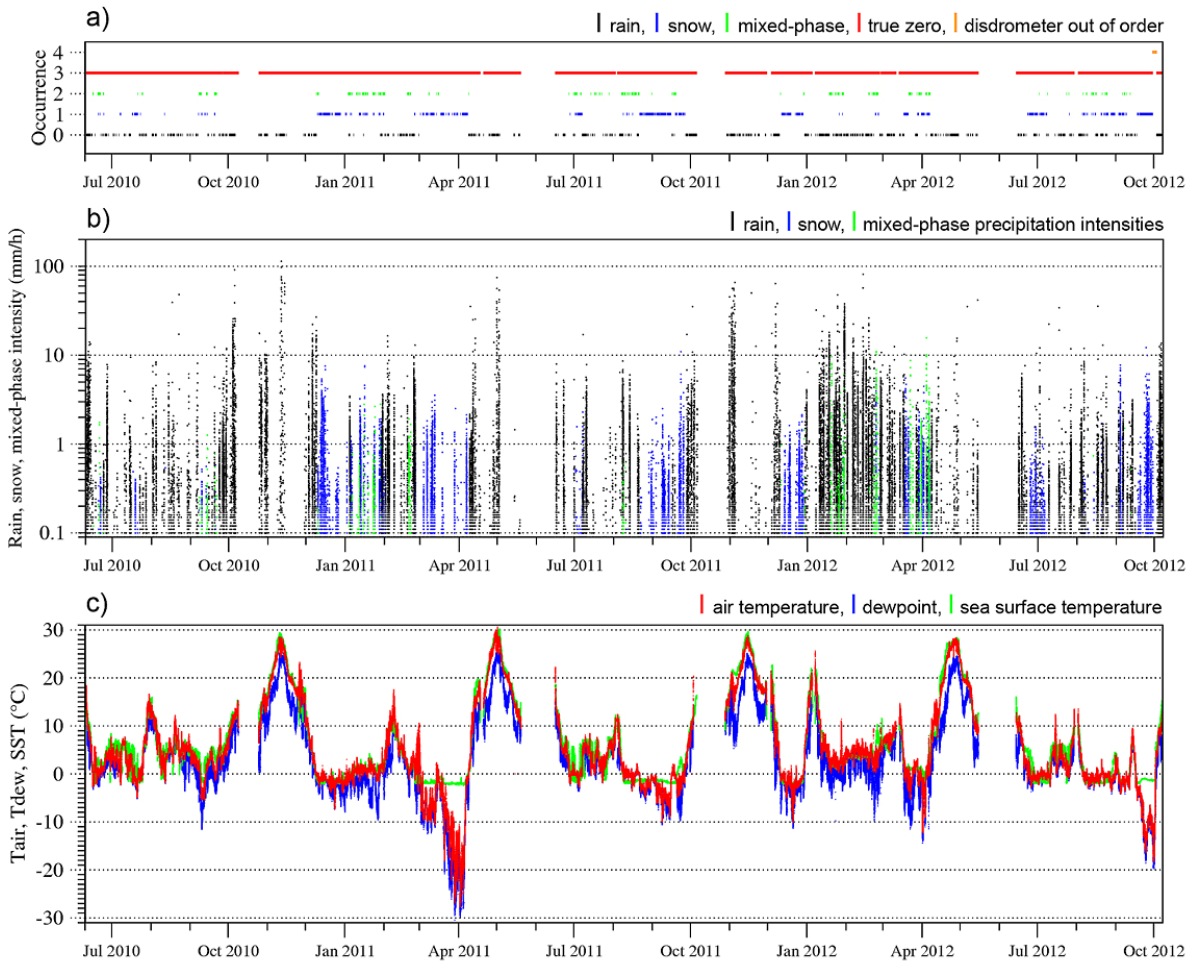
The OceanRAIN instrumentation and data

The equipment to accurately measure occurrence, intensity and accumulation of precipitation onboard ships is called optical disdrometer, which is the abbreviation for distribution droplet meter. Unlike rain gauges that collect the falling amount of rain in a bucket, an optical disdrometer remotely senses each droplet or snowflake falling through its photoelectric barrier. The particles are then sorted and counted by size. This data is stored every minute into a so called particle size distribution. From this, an algorithm calculates the mass of each particle and its fall speed. This information is sufficient to derive the rainfall or snowfall rate.



The cross-section of the optical disdrometer (left) with a light emitting diode (2) and a receiver photo diode (10) is showing the optical volume (6) through which the precipitation particles fall. The picture to the right shows the OceanRAIN setup on the icebreaker "Polarstern" in the mast top at 43 m height with the optical disdrometer (A), the wind sensor (B) and a precipitation detector (C).

The OceanRAIN disdrometer is unique among the different existing disdrometer types. It is able to automatically operate under all weather conditions that may include temperatures as low as -40°C, rough sea states, strong and varying wind speeds and local turbulences induced by the ships superstructure. Along with the precipitation data, all important meteorological and navigational data, e.g. air and water temperature, wind, humidity, pressure and GPS data, is stored and available to the international science community. From very light rain and snow to extremes with torrential rainfall up to 160 mm/h in the tropics the data set covers the whole spectrum of precipitation events from all climatic regions of the planet including snow storms.



The time series shows the precipitation occurrence (a) for no precipitation in red, rain in black, snow in blue and mixed-phase in green as well as the intensities (b) in the same color coding. Note, that the y-axis in (b) is logarithmic. Maximum rainfall rates exceed 100 mm/h. The corresponding air temperature (red) and water temperatures (green) are illustrated in (c) showing a range from -30°C in Antarctica to +30°C in the inner tropics. The time series exemplarily shows a "Polarstern cruise track" from July 2010 to October 2012.

Further reading

More information on the OceanRAIN project can be found at

www.oceanrain.org

http://www.initiative-pro-klima.de/forschungsprojekte/forschungsprojekt-niederschlaege/oceanrain/

http://www.eigenbrodt.de/en/projects/ocean-rain.html

or in the scientific publications:

Klepp, C., 2015: The Oceanic Shipboard Precipitation Measurement Network for Surface Validation – OceanRAIN. Atmos. Res., Special issue of the International Precipitation Working Group (IPWG), 163, 74-90, doi: 10.1016/j.atmosres.2014.12.014.

Burdanowitz, J., Klepp, C., and Bakan, S., 2016: An automatic precipitation-phase distinction algorithm for optical disdrometer data over the global ocean, Atmos. Meas. Tech., 9, 1637-1652, doi:10.5194/amt-9-1637-2016.

Andersson, A., C. Klepp, K. Fennig, S. Bakan, H. Graßl, and J. Schulz, 2011: Evaluation of HOAPS-3 ocean surface freshwater flux components. J. Atm. Meteor. Climatol., 50, 379-398,doi: 0.1175/2010JAMC2341.1

C. Klepp, K. Bumke, S. Bakan, and P. Bauer, 2010: Ground validation of oceanic snowfall detection in satellite climatologies during LOFZY, Tellus A, 62(4), 469-480, doi:10.1111/j.1600-0870.2010.00459.x.

All images, text and figures by Dr. Christian Klepp

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