OceanRAIN Release 2.0
User Manual

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Abstract

OceanRAIN—the Ocean Rainfall And Ice-phase precipitation measurement Network—provides in-situ along-track shipboard data of precipitation, evaporation and the resulting freshwater flux at 1-min resolution over the global oceans from June 2010 to December 2018. More than 11.6 million minutes with 82 parameters from 8 ships cover all routinely measured atmospheric and oceanographic state variables along with those required to derive the turbulent heat fluxes. The precipitation parameter is based on measurements of the optical disdrometer ODM470 specifically designed for all-weather shipboard operations. The rain, snow and mixed-phase precipitation occurrence, intensity and accumulation are derived from particle size distributions. Additionally, microphysical parameters and radar-related parameters are provided. Addressing the need for high-quality in-situ precipitation data over the global oceans, OceanRAIN-2.0 is the first comprehensive along-track in-situ water cycle surface reference dataset for satellite product validation and retrieval calibration of the GPM (Global Precipitation Measurement) era, to improve the representation of precipitation and air-sea interactions in re-analyses and models, and to improve understanding of water cycle processes over the global oceans. This manual provides an overview on the dataset, gives guidelines on how to read and use the different datasets and file formats.

OceanRAIN release 2.0

OceanRAIN release 2.0 (OR2) covers the time period from 10 JUN 2010 to 31 DEC 2018 for eight ships, among them seven research vessels and one luxury cruise liner. The OceanRAIN release 1.0 (OR1) data volume of 6.830.365 minutes increased to 11.629.390 minutes in OR2 that corresponds to a factor of 1.7 data increase. The precipitation minutes therein increased from 696.740 to 1.102.777, corresponding to a factor of 1.6 data increase. The OR2 dataset comprises 8.047.595 true-zero minutes that are minutes with measured precipitation absence. The 1.102.777 minutes with precipitation split into 698.362 with rain, 339.031 with snow and 65.384 with mixed-phase precipitation. A total of

871.947 minutes could not be measured due to a malfunction of the ODM470 optical disdrometer and during 1.607.071 minutes the ships were in harbor with no GPS and MET data recording.

Seven new radar-related parameters are added to the OR2 database including a complete reprocessing of the OR1 data. This additional work exceeds the scope of the contract, however, it was decided to be an important step, as the S-Band radar data and the inclusion of the one-way attenuation for all four radar bands was highly demanded by the international science community working with the OceanRAIN data.

The OR2 data set authors are Christian Klepp, Alain Protat, Jörg Burdanowitz, Simon Michel, Nicole Albern, Valentin Louf, Andrea Dahl, Tanja Thiele and Marc Schroeder.

Table 1 provides a detailed overview on the data contribution and time period covered for the individual ships to the entire database including the data increase factor compared to OceanRAIN release 1.0.

***Table 1**: Temporal and percentage data contribution of the OceanRAIN 2.0 ships. The total number of processed records in the data set comprises 11.629.390 minutes.*

Ship name	Date Start OR1	Date Stop OR1	Date Start OR2	Date Stop OR2	Minutes OR1	Minutes OR2	Adds to OR1
Polarstern	10.06.2010	02.11.2016	03.11.2016	31.12.2018	3.264.480	4.400.527	x 1.4
Sonne 2	28.11.2014	10.04.2017	11.04.2017	31.12.2018	1.245.592	2.152.797	x 1.7
Sonne 1	11.09.2012	05.10.2012	no add data	no add data	36.0000	36.0000	x 1.0
Maria Merian	24.10.2012	10.06.2014	01.05.2017	31.12.2018	856.229	1.734.628	x 2.0
Meteor	17.03.2014	20.03.2016	21.03.2016	26.03.2017	1.058.400	1.591.614	x 1.5
Investigator	08.01.2016	04.03.2017	16.03.2017	20.05.2018	303.144	624.430	x 2.1
The World	16.01.2017	05.02.2017	05.02.2017	31.12.2018	29.081	1.013.082	x 34.8
Roger Revelle	22.08.2016	16.09.2016	19.10.2017	14.11.2017	37.439	76.312	x 2.0
All ships	**JUN 2017**	**APR2017**	**MAR 2016**	**DEC 2018**	**6.830.365**	**11.629.390**	**x 1.7**

The extended shipyard repair period of Maria S. Merian caused a long data gap between OR1 and OR2. All other ships have continuous data transitions between OR1 and OR2. The large amount of Meteor data reduced to an end data of 26 MAR 2017 because the optical system of the ODM470 gradually failed and stopped recording meaningful data by March 2017. The luxury cruise liner The World added a significant amount of new data to OR2. However, this ship is not equipped with professional scientific instrumentation and only delivers the air temperature, relative humidity, air pressure and GPS data. However, the ODM470 data from this ship is adding new ship tracks in regions previously uncovered. Table 2 gives an overview on the individual ship contribution of total minutes recorded to number of minutes with no precipitation (true-zero data), rain, snowfall, mixed-phase precipitation as well as minutes with no ODM data recorded and minutes where the ships were in harbor and did not collect GPS and MET data.

***Table 2**: Total data contribution and precipitation data contribution of the OceanRAIN 2.0 ships.*

Ship name	Minutes total	Minutes true-zero	Minutes precip	Minutes rain	Minutes snow	Minutes mixed	Minutes no ODM	Minutes harbor
Polarstern	4.400.527	2.732.514	626.486	255.259	317.481	53.746	316.233	725.294
Sonne 2	2.152.797	1.647.653	122.548	121.813	719	16	84.960	297.636
Sonne 1	36.0000	31.418	4.582	4.582	0	0	0	0
Maria Merian	1.734.628	1.020.179	130.550	121.062	4.587	4.901	301.574	282.325
Meteor	1.591.614	1.251.708	39.272	38.033	150	1.089	0	300.634
Investigator	624.430	510.619	84.569	65.158	15.004	4.407	28.060	1.182
The World	1.013.082	811.287	60.675	58.360	1.090	1.225	141.120	0
Roger Revelle	76.312	42.232	34.080	34.080	0	0	0	0
All ships	**11.629.390**	**8.047.595**	**1.102.777**	**698.362**	**339.031**	**65.384**	**871.947**	**1.607.071**

Table 3 provides an overview on the precipitation occurrence for each individual ship. It is easily seen which ships predominantly sail the seas in precipitation-dominant and precipitation-sparse regions. The highest precipitation percentage of 44.7% comes from Roger Revelle. This few campaign data was collected in the inner tropics of the Pacific Ocean with the aim of chasing tropical rain cells. Polarstern cruises the mid and high latitudes most of the time and thus shows a high precipitation occurrence of 22.9%. In contrast, Meteor shows a precipitation occurrence of only 3.1% due to its tracks predominantly sailed in the precipitation-sparse subtropical oceans. Averaged over all ships the precipitation occurrence yields 13.7%.

***Table 3**: Precipitation occurrence in OceanRAIN 2.0.*

Ship name	Precipitation occurrence
Polarstern	22.9%
Sonne 2	7.4%
Sonne 1	14.6%
Maria Merian	12.8%
Meteor	3.1%
Investigator	16.6%
The World	7.5%
Thompson	no data
Roger Revelle	44.7%
All ships	**13.7%**

Figure 1 displays the timeline from June 2010 to December 2018 for all eight OR2 ships in the fleet. Green data lines comprise successfully checked underway data, blue data indicate times when the ODM 470 data could not be recorded while red data denotes harbor times when no GPS signal and MET data was recorded because the recording devices were under maintenance.

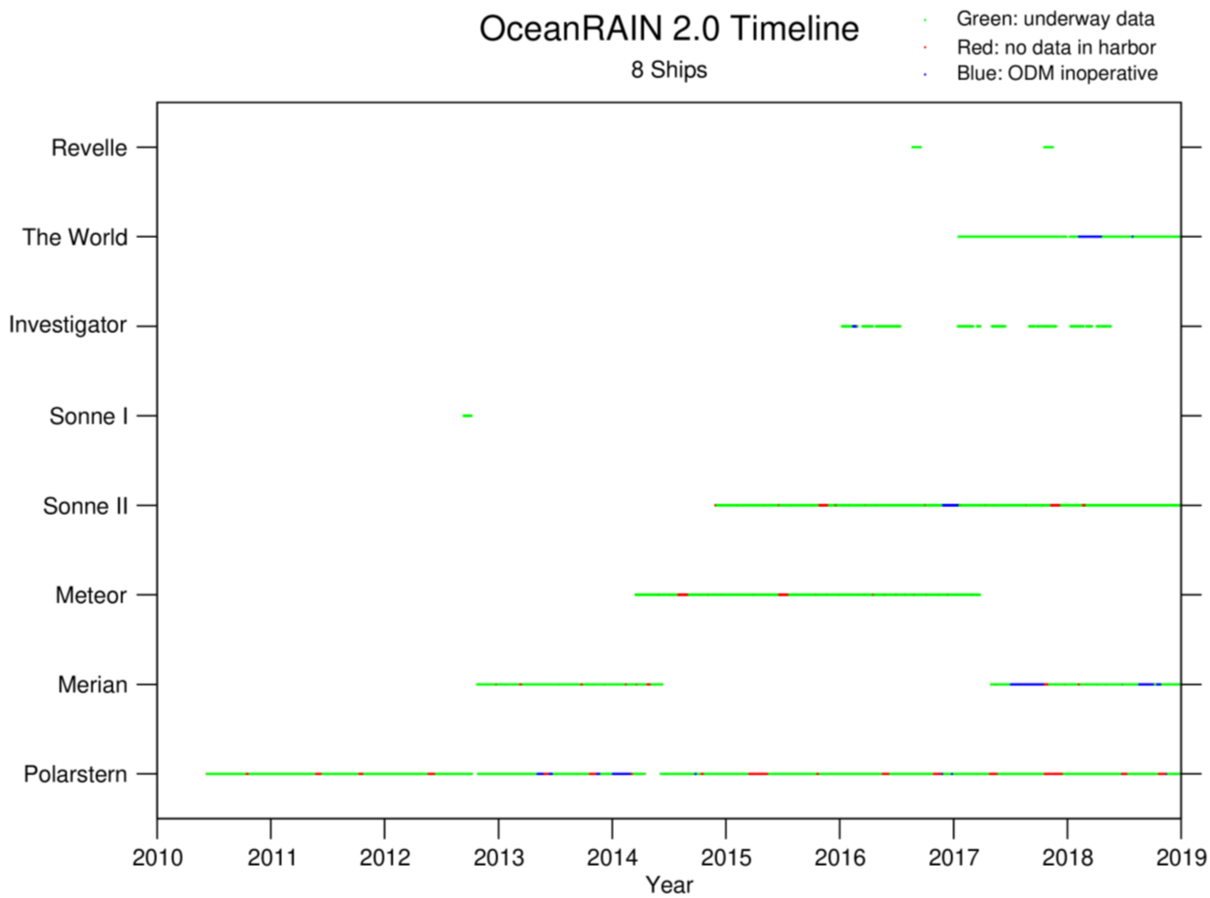

***Fig 1**: Timeline of OceanRAIN 2.0 for all 8 ships in the fleet. Green data points comprise successfully checked underway data, blue data points indicate ODM 470 data outages (no precipitation data) while red data points denote harbor times when no GPS signal was recorded and the recording devices were under maintenance.*

Figure 2 shows the OR2 ships tracks for all eight ships separated for data contributions from OR1 (blue) and the new tracks added in OR2. Polarstern cruises on pre-defined supply tracks that leave few freedom for new legs. However, Polarstern went to the Antarctic Pacific Ocean for the first time. Sonne II is adding a significant amount of new data in the tropical and subtropical Pacific Ocean and also adds new tracks in the Atlantic Ocean. Moreover, the Indian Ocean is covered for the first time. Maria S. Merian remained in the Atlantic Ocean for most of the time and adds significant new data in the northern high latitudes. Meteor sailed the Atlantic and Eastern Pacific including hitherto unsailed tracks. Investigator encircled Australia and went to the Antarctic. Roger Revelle added new data from the tropical SPURS cruise chasing tropical rain cells. Sonne I was discarded and replaced by Sonne II, so no new data contributes to OR2. However, the OR1 data was recalculated to include the seven new radar parameters. The Word adds a significant amount of new data cruising the Atlantic and Pacific Oceans. The Word also traversed the subtropical Pacific.

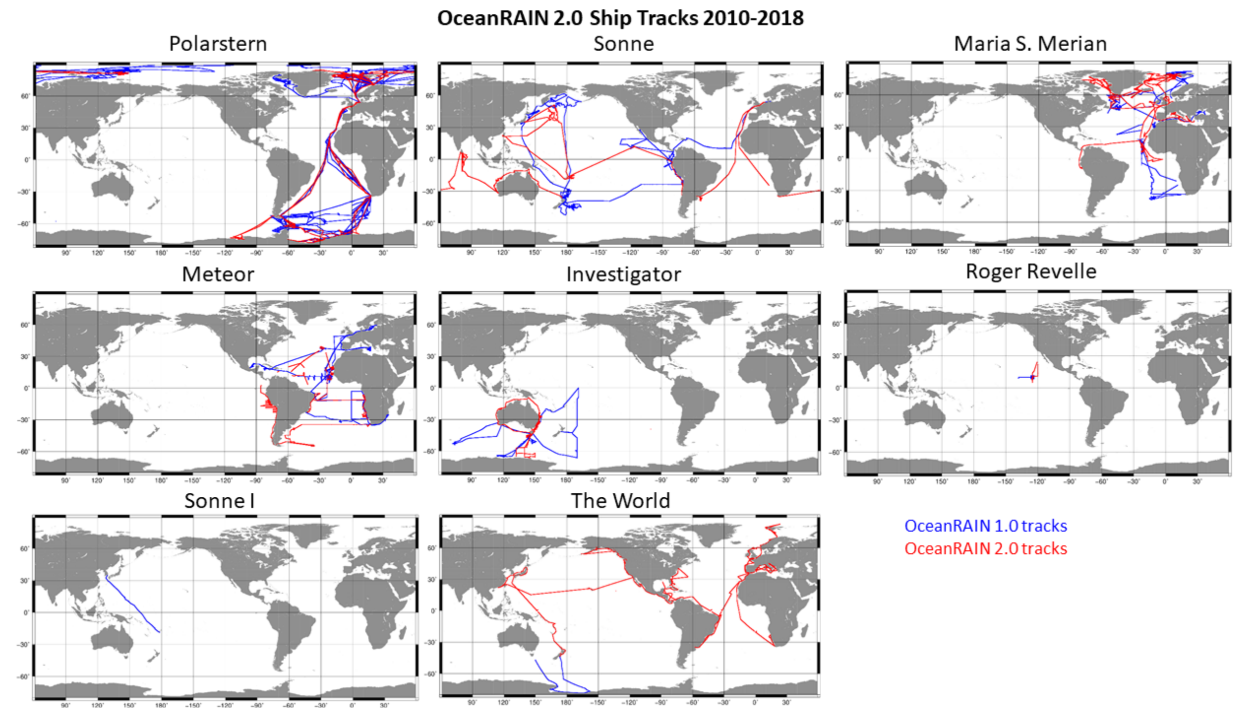

***Fig. 2**: OR2 shiptracks for all 8 ships in the fleet separated for tracks recorded during OR1 (blue) and OR2 (red). The data new to release 2.0 is denoted in red.*

The ship tracks of Figure 2 are summarized for all ships in Figure 3 to Figure 6. Figure 3 shows the ship tracks of OR2 color-coded for the individual ships. The oceanic coverage increased significantly over OR1 (not shown here). Figure 4 separates the data into seasons in which the data was sampled. Figure 5 separates for the years in which the data was sampled while Figure 6 shows the precipitation phase with true-zero data in grey, rain in red, snowfall in blue and mixed-phase precipitation in green. Additionally, ODM data outage periods are visualized in yellow. Note, that most Southern Ocean data is sampled during the austral summer with the exception of the Polarstern cruise in 2013 when the ship remained in Antarctic waters throughout the year.

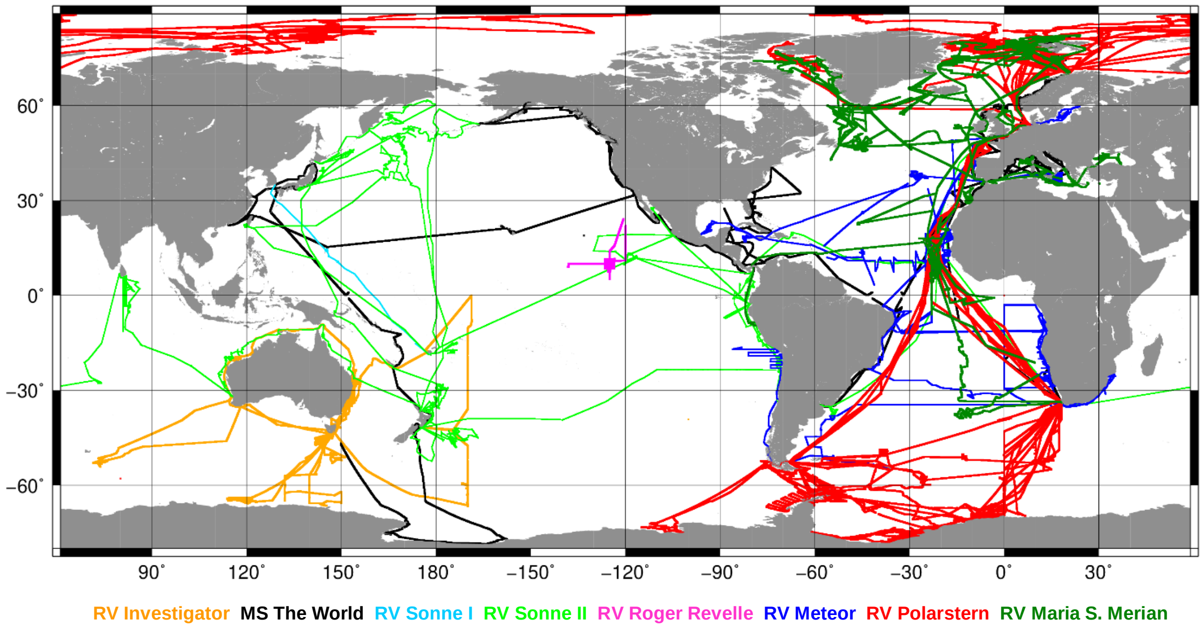

Fig 3: *Ship Tracks of OR2 color-coded for the individual ships. The oceanic coverage increased significantly over OR1 (not shown here).*

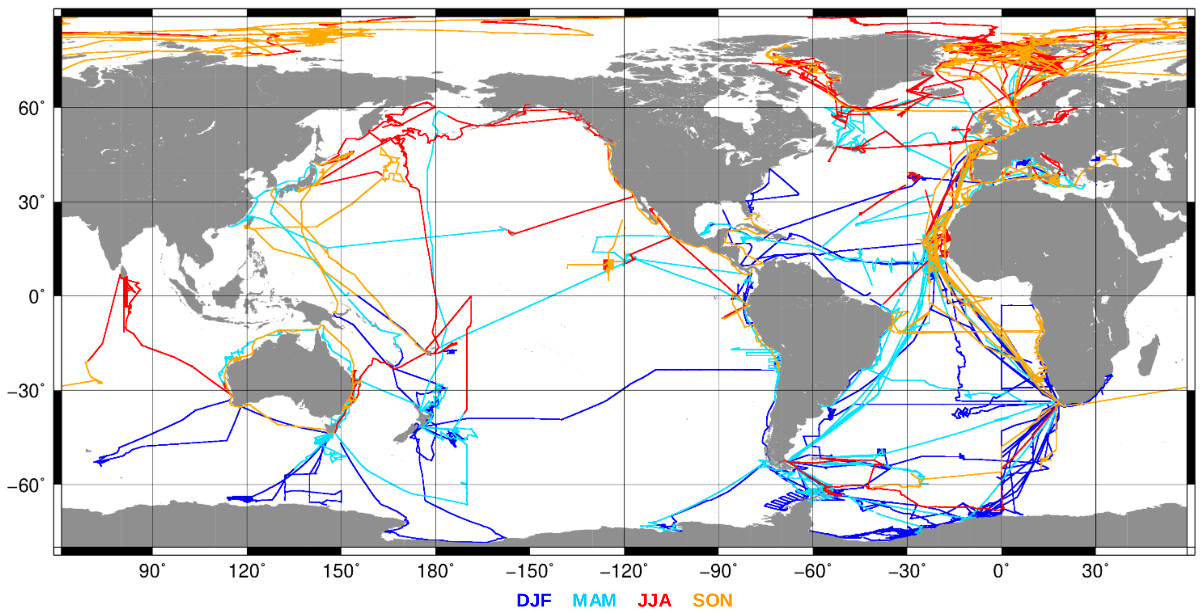

Fig 4: *Ship Tracks of OR2 as in Fig. 3 but separated for season in which the data was sampled.*

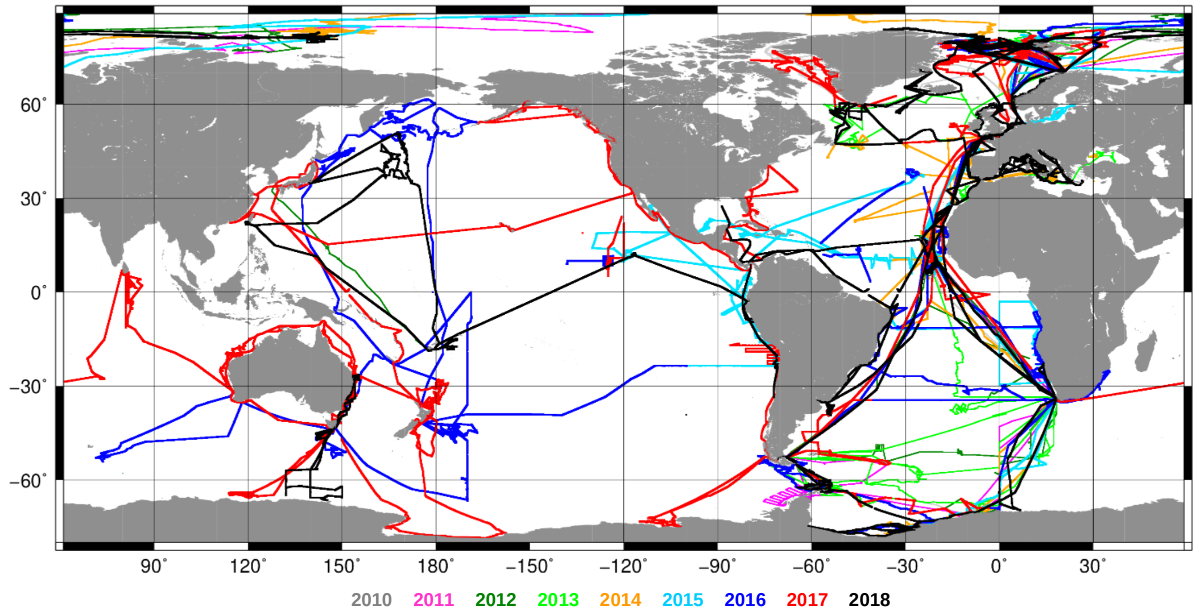

***Fig 5**: Ship Track for OR2 separated for the years in which the data was sampled.*

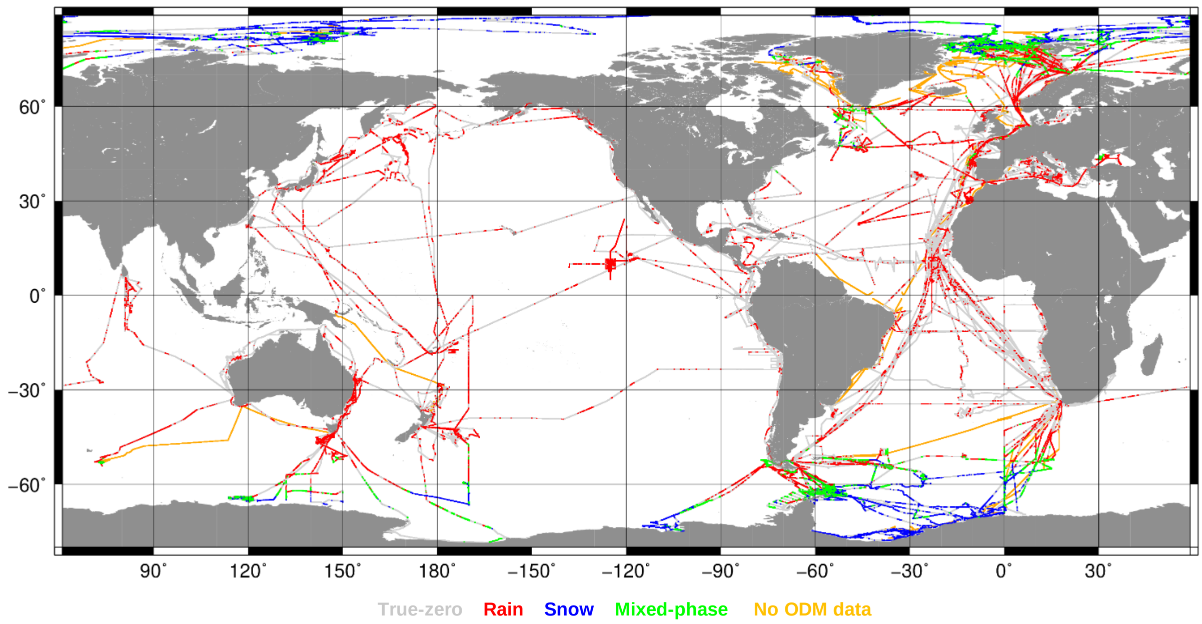

Fig 6: Ship Track for OR2 separated for the precipitation phase. Additionally, ODM data outage periods are visualized in yellow.

New Parameters in OceanRAIN 2.0

The demand of the international science community for additional radar-related parameters let to the decision to include the S-Band frequency at 2-4 GHz as well as the one-way attenuation for the hitherto included radar bands (Table 4). This is adding seven parameters to OceanRAIN 2.0 and is increasing the total number of parameters to 82. Thereof 80 are contained in OceanRAIN-W files while the other two are contained in the OceanRAIN-M and OceanRAIN-R files and comprise the 128 bins of the 1-min particle size distributions for the number concentration and the raw drop count of the ODM470 disdrometer.

To guarantee consistency with respect to the number of parameters, the entire OceanRAIN 1.0 database was reprocessed to now also include the seven new parameters within release OceanRAIN 2.0.
The atmospheric one-way attenuation (ATT) is primarily due to water vapor absorption lines and is very significant in many spectral regions in the millimeter wavelengths and is impacted differently by weather conditions such as fog, rain, snow and humidity. Table 4 lists the parameters that are now provided using the pyTmatrix tool developed by Leinonen.

***Table 4**: Radar parameter list in OceanRAIN 2.0 data. New parameters are highlighted bold.*

Parameters	Radar Band	Radar Frequency	Radar Wavelength
T-matrix simulation of reflectivity from DSD	**S-Band**	**2-4 GHz**	**15-7.5 cm**
T-matrix simulation of differential reflectivity from DSD	C-band	5.6 GHz	7.5-3.75 cm
T-matrix simulation of specific differential phase from DSD	Ku-band	13.6 GHz	2.5-1.76 cm
T-matrix simulation of specific one-way attenuation from DSD	Ka-Band	35 GHz	1.11 cm – 7.5 mm

Data Records

OceanRAIN provides users with three dataset versions (OceanRAIN-W, OceanRAIN-M, OceanRAIN-R) for each of the eight ships in the OceanRAIN fleet. The aim is that users can choose the dataset version that best meets their research needs. The along-track point data covers the global oceans from -90° to 90°N latitude and -180° to 180°E longitude from 10 June 2010 to 31 December 2018.

The file name convention for the OR2 netCDF data is as follows: Data subset –W, -M or –R followed by the ship name, ship code, data period covered and the publisher institutions with the appendix version 2.0.
OceanRAIN-M_MS-The-World_C6RW4_JAN2017-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-Investigator_VLMJ_JAN2016-MAY2018_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-Maria-S-Merian_DBBT_OCT2012-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-Meteor_DBBH_MAR2014-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-Polarstern_DBLK_JUN2010-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-Roger-Revelle_KAOU_AUG2016-DEC2017_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-SonneI_DFCG_SEP2012-OCT2012_DWD-MPIM_V2_0.nc
OceanRAIN-M_RV-SonneII_DBBE_NOV2014-DEC2018_DWD-MPIM_V2_0.nc

OceanRAIN-R_MS-The-World_C6RW4_JAN2017-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-Investigator_VLMJ_JAN2016-MAY2018_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-Maria-S-Merian_DBBT_OCT2012-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-Meteor_DBBH_MAR2014-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-Polarstern_DBLK_JUN2010-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-Roger-Revelle_KAOU_AUG2016-DEC2017_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-SonneI_DFCG_SEP2012-OCT2012_DWD-MPIM_V2_0.nc
OceanRAIN-R_RV-SonneII_DBBE_NOV2014-DEC2018_DWD-MPIM_V2_0.nc

OceanRAIN-W_MS-The-World_C6RW4_JAN2017-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-W_RV-Investigator_VLMJ_JAN2016-MAY2018_DWD-MPIM_V2_0.nc
OceanRAIN-W_RV-Maria-S-Merian_DBBT_OCT2012-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-W_RV-Meteor_DBBH_MAR2014-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-W_RV-Polarstern_DBLK_JUN2010-DEC2018_DWD-MPIM_V2_0.nc
OceanRAIN-W_RV-Roger-Revelle_KAOU_AUG2016-DEC2017_DWD-MPIM_V2_0.nc

OceanRAIN-W_RV-SonneI_DFCG_SEP2012-OCT2012_DWD-MPIM_V2_0.nc
OceanRAIN-W_RV-SonneII_DBBE_NOV2014-DEC2018_DWD-MPIM_V2_0.nc

The ascii files follow the same name convention logic with the suffix .ascii:

OceanRAIN-M_MS-The-World_C6RW4_JAN2017-DEC2018.ascii
OceanRAIN-M_RV-Investigator_VLMJ_JAN2016-MAY2018.ascii
OceanRAIN-M_RV-Maria-S-Merian_DBBT_OCT2012-DEC2018.ascii
OceanRAIN-M_RV-Meteor_DBBH_MAR2014-DEC2018.ascii
OceanRAIN-M_RV-Polarstern_DBLK_JUN2010-DEC2018.ascii
OceanRAIN-M_RV-Roger-Revelle_KAOU_AUG2016-DEC2017.ascii
OceanRAIN-M_RV-SonneI_DFCG_SEP2012-OCT2012.ascii
OceanRAIN-M_RV-SonneII_DBBE_NOV2014-DEC2018.ascii

OceanRAIN-R_MS-The-World_C6RW4_JAN2017-DEC2018.ascii
OceanRAIN-R_RV-Investigator_VLMJ_JAN2016-MAY2018.ascii
OceanRAIN-R_RV-Maria-S-Merian_DBBT_OCT2012-DEC2018.ascii
OceanRAIN-R_RV-Meteor_DBBH_MAR2014-DEC2018.ascii
OceanRAIN-R_RV-Polarstern_DBLK_JUN2010-DEC2018.ascii
OceanRAIN-R_RV-Roger-Revelle_KAOU_AUG2016-DEC2017.ascii
OceanRAIN-R_RV-SonneI_DFCG_SEP2012-OCT2012.ascii
OceanRAIN-R_RV-SonneII_DBBE_NOV2014-DEC2018.ascii

OceanRAIN-W_MS-The-World_C6RW4_JAN2017-DEC2018.ascii
OceanRAIN-W_RV-Investigator_VLMJ_JAN2016-MAY2018.ascii
OceanRAIN-W_RV-Maria-S-Merian_DBBT_OCT2012-DEC2018.ascii
OceanRAIN-W_RV-Meteor_DBBH_MAR2014-DEC2018.ascii
OceanRAIN-W_RV-Polarstern_DBLK_JUN2010-DEC2018.ascii
OceanRAIN-W_RV-Roger-Revelle_KAOU_AUG2016-DEC2017.ascii
OceanRAIN-W_RV-SonneI_DFCG_SEP2012-OCT2012.ascii
OceanRAIN-W_RV-SonneII_DBBE_NOV2014-DEC2018.ascii

The files were produced at the Max Planck Institute for Meteorology, Hamburg, Germany and are hosted at the German Meteorological Service in Offenbach, Germany.

The OceanRAIN-W contains the 1-minute resolution water cycle components of evaporation, precipitation and the freshwater flux along with all meteorological and oceanographic state variables required to derive these fluxes. The dataset is continuous in time and contains 82 parameters and more than 11.6 million minutes of data (Table 5). Typical applications for OceanRAIN-W comprise process studies and statistical analysis as well as satellite validation and re-analysis or model evaluation. OceanRAIN point data can serve as the surface reference and can be collocated with satellite or model data to analyse and improve their error characteristics. Therefore, it is important to highlight that the RVs sampled on the global oceans during all seasons including the cold-season Southern Oceans.

OceanRAIN-M and OceanRAIN-R focus on minutes containing precipitation and are therefore discontinuous in time. Both datasets comprise 44 precipitation-relevant parameters plus the 128 size bin number concentration PSDs (OceanRAIN-M) and raw number count PSDs (OceanRAIN-R) for 1.102.777 minutes in total with rain, snow or mixed-phase precipitation (Table 6). The precipitation-related parameters are identical in the three versions of the dataset. Applications for these datasets especially comprise satellite retrieval performance evaluation for liquid and solid precipitation. For this purpose, OceanRAIN-M and OceanRAIN-R supply the user with a convective versus stratiform precipitation classification and contain the main PSD characteristics and the radar reflectivities at important frequencies for radar rainfall studies. This is of special importance for users aiming at TRMM, CloudSat and GPM product and retrieval validation because these satellite missions carry spaceborne radars.

***Table 5**: Parameter list of OceanRAIN-W data.*

# Parameter description OceanRAIN-W	NAME	Error value	Units	Data source	Format, Algorithm, Metadata, Citation
01 counter	COUNT	----------	[ ]	calculated	
02 date UTC	DATE	----------	UTC	NAV	DDMOYYYY
03 time UTC	TIME	----------	UTC	NAV	HHMM
04 date local	LDATE	----------	LT	calculated	DDMOYYYY
05 time local	LTIME	----------	LT	calculated	HHMM
06 minute of day UTC	MDAY	----------	[ ]	calculated	value range 1 to 1440
07 Julian date	JLD	----------	days	calculated	since 01JAN1994, 00 UTC
08 Unix epoch timestamp	USEC	----------	s	calculated	seconds since 01JAN1970, 00 UTC
09 latitude	LAT	-99,9999	deg	NAV	degree north from -90 to 90°
10 longitude	LON	-999,9999	deg	NAV	degree east from -180° to 180°
11 heading	HEAD	-99,9	deg	NAV	0° to 360°
12 air temperature	TAIR	-99,9	°C	MET	
13 dewpoint temperature	TDEW	-99,9	°C	calculated	
14 bulk water temperature	WATER	-99,9	°C	MET	
15 sea surface temperature	SST	-99,9	°C	calculated	Donlon et al.[91]
16 relative humidity	RH	-99	%	MET	
17 specific humidity at sea surface	QS	-9,9	g kg^{-1}	calculated	Murphy and Coop[90]
18 specific air humidity	QA	-9,9	g kg^{-1}	calculated	Murphy and Coop[90]
19 air pressure	MSLP	-999,9	hPa	MET	at instrument height
20 relative wind speed	UREL	-9,9	m s^{-1}	MET	
21 relative wind direction	RELDIR	-99	deg	MET	
22 true wind speed	UTRUE	-9,9	m s^{-1}	MET	
23 true wind direction	TRUEDIR	-99	deg	MET	
24 wind speed in 10 m height	U10	-9,9	m s^{-1}	calculated	Tennekes[89]
25 global radiation	GLORAD	-999,9	W m^{-2}	MET	
26 visibility	VIS	-9999	m	MET	
27 ceiling	CEIL	-99999	m	MET	
28 max gusts	UMAX	-99,9	m s^{-1}	MET	
29 salinity	SAL	-99,99	PSU	MET	
30 drag transfer coefficient	CD	-99,9	[ ]	calculated	Fairall et al.[88]
31 latent heat transfer coefficient	CE	-99,9	[ ]	calculated	Fairall et al.[88]
32 sensible heat transfer coefficient	CH	-99,9	[ ]	calculated	Fairall et al.[88]
33 warm layer flag	WLF	3	[ ]	calculated	Fairall et al.[88]
34 sensible heat flux	SHF	-9999	W m^{-2}	calculated	Fairall et al.[88]
35 latent heat flux	LHF	-9999	W m^{-2}	calculated	Fairall et al.[88]

36 evaporation E	EVAP	-999	mm h^{-1}	calculated	Fairall et al.[88]
37 freshwater budget E-P	BUDG	-999	mm h^{-1}	calculated	difference of E and P
38 rain gauge precipitation rate	GAUGE	-99,99	mm h^{-1}	MET	
39 ww present weather code	WW	-99	[ ]	SYN	human weather type observation
40 W1 past weather code	W1	-99	[ ]	SYN	human weather type observation
41 W2 past weather code	W2	-99	[ ]	SYN	human weather type observation
42 99th percentile particle diameter	PERC	-999,99	mm	calculated	
43 theoretical rain rate disdrometer	TRAIN	-99,99	mm h^{-1}	calculated	#43 or #44 is identical to #52
44 theoretical snow rate disdrometer	TSNOW	-99,99	mm h^{-1}	calculated	#43 or #44 is identical to #52
45 probability for rain	PRAIN	-999,99	[ ]	calculated	value range 0.00 to 1.00
46 probability for snow	PSNOW	-999,99	[ ]	calculated	value range 0.00 to 1.00
47 probability for mixed-phase	PMIX	-999,99	[ ]	calculated	value range 0.00 to 1.00
48 precipitation flag1	FLAG1	9	[ ]	calculated	precipitation type and status
49 precipitation flag2	FLAG2	99	[ ]	calculated	precipitation classification
50 number of bins	BINS	-99	[ ]	ODM	number of bins
51 number of particles	NUMS	-9999	[ ]	ODM	number of particles
52 ODM precipitation rate R	PRECIP	-99,99	mm h^{-1}	calculated	according to #42-48
53 Rayleigh reflectivity Z	REFL	-99,99	mm^6 m^{-3}	calculated	
54 10 log R	DBR	-99,99	dBR	calculated	
55 10 log Z	DBZ	-99,99	dBZ	calculated	
56 relative wind speed	ODMREL	-88,88	m s^{-1}	ODM	flag1= 4 or 5; missval= -99.99
57 reference voltage	UREF	-88,88	V	ODM	flag1= 4 or 5; missval= -99.99
58 convective=1 /stratiform=0 index	CONV	-9	[ ]	calculated	Thurai et al.[82], No* < -1.65 * Dm + 6.35
59 Intercept of normalized gamma DSD	No*	-999	mm^{-1} m^{-3}	calculated	Testud et al.[82]
60 mass-weighted mean diameter of normalized gamma DSD	Dm	-999	mm	calculated	Testud et al.[82]
61 shape parameter of normalized gamma DSD	mu	-999	[ ]	calculated	Testud et al.[82]
62 median volume diameter of normalized gamma DSD	D0	-999	mm	calculated	Testud et al.[82]
63 DSD mass spectrum standard deviation	sigmam	-999	mm	calculated	Williams et al.[84]
64 Intercept parameter of a standard gamma DSD	N0	-999	mm^{-1} m^{-3}	calculated	Tokay and Short[83]
65 T-matrix simulation of S-band reflectivity from DSD	DBZ_S	-999	dBZ	calculated	pyTmatrix
66 T-matrix simulation of S-band differential reflectivity from DSD	ZDR_S	-999	dB	calculated	pyTmatrix
67 T-matrix simulation of S-band specific differential phase from DSD	KDP_S	-999	deg km^{-1}	calculated	pyTmatrix
68 T-matrix simulation of S-band specific one-way attenuation from DSD	ATT_S	-999	dB km^{-1}	calculated	pyTmatrix
69 T-matrix simulation of C-band reflectivity from DSD	DBZ_C	-999	dBZ	calculated	pyTmatrix
70 T-matrix simulation of C-band differential reflectivity from DSD	ZDR_C	-999	dB	calculated	pyTmatrix
71 T-matrix simulation of C-band specific differential phase from DSD	KDP_C	-999	deg km^{-1}	calculated	pyTmatrix
72 T-matrix simulation of C-band specific one-way attenuation from DSD	ATT_C	-999	dB km^{-1}	calculated	pyTmatrix
73 T-matrix simulation of Ku-band reflectivity from DSD	DBZ_Ku	-999	dBZ	calculated	pyTmatrix
74 T-matrix simulation of Ku-band differential reflectivity from DSD	ZDR_Ku	-999	dB	calculated	pyTmatrix

75 T-matrix simulation of Ku-band specific differential phase from DSD	KDP_Ku	-999	deg km^{-1}	calculated	pyTmatrix
76 T-matrix simulation of Ku-band specific one-way attenuation from DSD	ATT_Ku	-999	dB km^{-1}	calculated	pyTmatrix
77 T-matrix simulation of Ka-band reflectivity from DSD	DBZ_Ka	-999	dBZ	calculated	pyTmatrix
78 T-matrix simulation of Ka-band differential reflectivity from DSD	ZDR_Ka	-999	dB	calculated	pyTmatrix
79 T-matrix simulation of Ka-band specific differential phase from DSD	KDP_Ka	-999	deg km^{-1}	calculated	pyTmatrix
80 T-matrix simulation of Ka-band specific one-way attenuation from DSD	ATT_Ka	-999	dB km^{-1}	calculated	pyTmatrix

Table 6 lists all 172 parameters in the OR2 OceanRAIN-M (microphysical properties) and OceanRAIN-R (raw drop count data) files that comprise of the 1-min resolution temporally discontinuous particle size distributions.

# Parameter description **OceanRAIN-M and OceanRAIN-R**	**NAME**	**Error value**	**Units**	**Data source**	**Format, Algorithm, Metadata, Citation**
01 counter	COUNT	----------	[ ]	calculated	
02 date UTC	DATE	----------	UTC	NAV	DDMOYYYY
03 time UTC	TIME	----------	UTC	NAV	HHMM
04 minute of day UTC	MDAY	----------	[ ]	calculated	value range 1 to 1440
05 Julian date	JLD	----------	days	calculated	since 01JAN1994, 00 UTC
06 Unix epoch timestamp	USEC	----------	s	calculated	seconds since 01JAN1970, 00 UTC
07 latitude	LAT	-99,9999	deg	NAV	degree north from -90 to 90°
08 longitude	LON	-999,9999	deg	NAV	degree east from -180° to 180°
09 probability for rain	PRAIN	-999,99	[ ]	calculated	value range 0.00 to 1.00
10 probability for snow	PSNOW	-999,99	[ ]	calculated	value range 0.00 to 1.00
11 probability for mixed-phase	PMIX	-999,99	[ ]	calculated	value range 0.00 to 1.00
12 precipitation flag1	FLAG1	9	[ ]	calculated	precipitation type and status
13 precipitation flag2	FLAG2	99	[ ]	calculated	precipitation classification
14 number of bins	BINS	-99	[ ]	ODM	number of bins
15 number of particles	NUMS	-9999	[ ]	ODM	number of particles
16 ODM precipitation rate R	PRECIP	-99,99	mm h^{-1}	calculated	according to #42-48
17 Rayleigh reflectivity Z	REFL	-99,99	mm^6 m^{-3}	calculated	
18 10 log R	DBR	-99,99	dBR	calculated	
19 10 log Z	DBZ	-99,99	dBZ	calculated	
20 relative wind speed	ODMREL	-88,88	m s^{-1}	ODM	flag1= 4 or 5; missval= -99.99
21 reference voltage	UREF	-88,88	V	ODM	flag1= 4 or 5; missval= -99.99
22 convective=1 /stratiform=0 index	CONV	-9	[ ]	calculated	Thurai et al.[82], No* < -1.65 * Dm + 6.35
23 Intercept of normalized gamma DSD	No*	-999	mm^{-1} m^{-3}	calculated	Testud et al.[82]
24 mass-weighted mean diameter of normalized gamma DSD	Dm	-999	mm	calculated	Testud et al.[82]
25 shape parameter of normalized gamma DSD	mu	-999	[ ]	calculated	Testud et al.[82]
26 median volume diameter of normalized gamma DSD	D0	-999	mm	calculated	Testud et al.[82]

27 DSD mass spectrum standard deviation	sigmam	-999	mm	calculated	Williams et al.[84]
28 Intercept parameter of a standard gamma DSD	N0	-999	$mm^{-1}\,m^{-3}$	calculated	Tokay and Short[83]
29 T-matrix simulation of S-band reflectivity from DSD	DBZ_S	-999	dBZ	calculated	pyTmatrix
30 T-matrix simulation of S-band differential reflectivity from DSD	ZDR_S	-999	dB	calculated	pyTmatrix
31 T-matrix simulation of S-band specific differential phase from DSD	KDP_S	-999	deg km^{-1}	calculated	pyTmatrix
32 T-matrix simulation of S-band specific one-way attenuation from DSD	ATT_S	-999	dB km^{-1}	calculated	pyTmatrix
33 T-matrix simulation of C-band reflectivity from DSD	DBZ_C	-999	dBZ	calculated	pyTmatrix
34 T-matrix simulation of C-band differential reflectivity from DSD	ZDR_C	-999	dB	calculated	pyTmatrix
35 T-matrix simulation of C-band specific differential phase from DSD	KDP_C	-999	deg km^{-1}	calculated	pyTmatrix
36 T-matrix simulation of C-band specific one-way attenuation from DSD	ATT_C	-999	dB km^{-1}	calculated	pyTmatrix
37 T-matrix simulation of Ku-band reflectivity from DSD	DBZ_Ku	-999	dBZ	calculated	pyTmatrix
38 T-matrix simulation of Ku-band differential reflectivity from DSD	ZDR_Ku	-999	dB	calculated	pyTmatrix
39 T-matrix simulation of Ku-band specific differential phase from DSD	KDP_Ku	-999	deg km^{-1}	calculated	pyTmatrix
40 T-matrix simulation of Ku-band specific one-way attenuation from DSD	ATT_Ku	-999	dB km^{-1}	calculated	pyTmatrix
41 T-matrix simulation of Ka-band reflectivity from DSD	DBZ_Ka	-999	dBZ	calculated	pyTmatrix
42 T-matrix simulation of Ka-band differential reflectivity from DSD	ZDR_Ka	-999	dB	calculated	pyTmatrix
43 T-matrix simulation of Ka-band specific differential phase from DSD	KDP_Ka	-999	deg km^{-1}	calculated	pyTmatrix
44 T-matrix simulation of Ka-band specific one-way attenuation from DSD	ATT_Ka	-999	dB km^{-1}	calculated	pyTmatrix
45-172: 128-times number concentration PSD	PSD	----------	$m^{-3}\,mm^{-1}$	calculated	**OceanRAIN-M files**
45-172: 128-times raw particle count PSD	RAW	----------	n	ODM	**OceanRAIN-R files**

***Table 6**: Parameter list of OceanRAIN-M and OceanRAIN-R data. The –M denotes the microphysical parameters including the 128 bins of the number concentration particle size distributions per minute. The –R denotes the raw ODMdata parameters including the 128 bins of the raw particle count particle size distributions per minute.*

Usage Notes

Users requiring surface reference data of precipitation including PSDs should use the OceanRAIN-M (number concentration PSD) or OceanRAIN-R (particle count PSD) files both of which are discontinuous in time. The continuous in time OceanRAIN-W data should be used if the true-zero precipitation information is needed or if additional meteorological and oceanographic parameters are required such as the along-track turbulent heat fluxes, the evaporation or the freshwater flux.

Usage of precipitation flags

Two precipitation flags are consistently used in all three versions of the dataset in order to discriminate the precipitation phase and intensity. Flag1 (Table 7) assigns a value for rainfall (0), snowfall (1), mixed-phase precipitation (2) or no precipitation (true zero) (3) to each minute. Note that the data records in the OceanRAIN-M and OceanRAIN-R files are discontinuous in time and thus contain precipitation minutes only. However, it is important to note, that very light precipitation may result in a precipitation rate of 0.00 mm h-1 (flag1=0, 1, 2) due to an insignificant number of particles measured. In contrast to these events, during true-zero precipitation occurrences in the OceanRAIN-W files (flag1=3), the

ODM470 relative wind speed and reference voltage is set to -888.88 in order to distinguish these minutes from the missing value (-999.99). Flag1 also indicates instrument outages with a value of 4 and harbour times with a value of 5.

Precipitation flag2 allows to further classify precipitation intensities (Table 8). True-zero minutes (flag1=3) correspond to flag2=10. Value 11 assigns spurious precipitation with less than 20 particles with less than 5 bins occupied. The associated insignificant precipitation rates may result from very light precipitation or strong vibration of the instrument resulting in artificial signals. The decision is left to the user whether to consider or discard these values. Value 12 contains all precipitation minutes with a rate of 0.00 mm h-1. Values of 13 to 17 indicate increasing precipitation rates according to Table 3.

Additionally, a physically-derived convective-stratiform precipitation index for rainfall is provided. Rayleigh reflectivities are provided for snow and mixed phase but should be treated with care. Due to the unknown liquid-to-solid ratio, mixed-phase precipitation carries the largest uncertainty and should therefore be treated with care, as well. Precipitation minutes that fail the quality check are either set to true-zero precipitation or instrument malfunction. Rejection reasons include interference by wave water, riming, icing, birds and maintenance. However, the original values can be tracked in the OceanRAIN-W dataset using the number of particles, number of bins and the theoretical rain and snowfall values.

Table 7: Precipitation flag1 classification for precipitation types

Flag1	precipitation phase and ODM instrument condition
0	rainfall occurrence
1	snowfall occurrence
2	mixed-phase precipitation occurrence
3	true-zero value, no precipitation occurrence
4	inoperative instrument, no ODM data recorded
5	harbor time, no data recorded
9	missing value

Table 8: Precipitation flag2 classification for precipitation intensities.

Flag2	classification	information
10	true-zero value, no precipitation	No precipitation occurrence. Note, if allocated bins and numbers are not equal zero this minute was identified as an electronic artefact and the precipitation rate is set to zero.
11	spurious signals or extremely light precipitation	Precipitation occurrences with number of bins smaller to 5 and number of particles smaller to 20. The rates are insignificant or zero. Reasons for such signals be include real precipitation, vibration of the instrument or any kind of artifacts. It is left to the user to consider these minutes as being precipitation or not.
12	insignificant precipitation occurrence	Precipitation rates lower than 0.01 mm h^{-1} are set to 0.00 mm h^{-1}. These are minutes with insignificant precipitation rates.
13	very light precipitation occurrence	Precipitation rates from 0.01 to 0.09 mm h^{-1}. The values are below the threshold of what typical gauges are able to measure.

14	light precipitation occurrence	Precipitation rates from 0.1 to 0.99 mm h^{-1}. The values are above the threshold of what typical gauges are able to measure.
15	moderate precipitation occurrence	Precipitation rates from 1.00 to 9.99 mm h^{-1} containing light to moderate precipitation events. The stratiform-convective flag can be additionally used to separate these minutes.
16	intense precipitation occurrence	Precipitation rates from 10.00 to 49.99 mm h^{-1} containing intense, convective precipitation.
17	extreme precipitation occurrence	Precipitation rates above 50 mm h^{-1} contain extreme convective precipitation events.
99	missing value	missing data.

Software to read the OceanRAIN 2.0 Data

The software to read the ascii and netCDF data for the OceanRAIN-W, OceanRAIN-M and OceanRAIN-R files for each of the eight ships is supplied below in Fortran 95 code for the asci files and Python code for the netCDF data files.

```
*************************
   program oceanrain-w_read
   IMPLICIT NONE

! author: Christian Klepp, www.christianklepp.com

   integer :: ii,jj        !do loops

! parameter declaration for OceanRAIN-W ascii file parameters
   integer :: day,month,year,time
   integer :: mmday                        ! minutes of day
   real(kind=8) :: kc                      ! julian date
   integer(kind=8) :: UTC                  ! epoch time
   integer :: rh, relDD, trueDD
   real :: lat, head, temp, dewt, wtemp, pres, relFF, trueFF
   real(kind=8) :: lon
   real :: rad1, maxFF, sal, gauge
   integer :: vis, ceil, ww, w1, w2
   integer :: flag, flag2, c
   real :: perc99, train,tsnow,rpar,spar,mpar,precip,wind,uref
   integer :: bins, nums
   real :: refl,dbr,dbz

   integer :: datelocal,timelocal
   integer :: dateUT,timeUT

   real :: sst,qs,qa,wind10
   real :: CD,CE,CH
   integer :: warmlayer
   real :: shf,lhf,evap,freshwater
   integer :: conv
   real :: n0star,dm,mu,d0,sigma,N0

   real :: dbzs,zdrs,kdps,atts
```

```
    real :: dbzc,zdrc,kdpc,attc
    real :: dbzku,zdrku,kdpku,attku
    real :: dbzka,zdrka,kdpka,attka


!C####################################################################
!C###### Input and Output-files        ##############################
!C####################################################################


1000  format(i8.8,1x,i8.8,1x,i4.4,1x,i8.8,1x,i4.4,1x,i4.4,1x,f11.6,1x,i12,1x,f8.4,1x,&
      & f9.4,1x,5(f5.1,1x),i4,1x,2(f5.1,1x),f6.1,1x,f5.1,1x,i4,1x,f5.1,1x,i4,1x,f5.1,1x,f6.1, &
      & 1x,i6,1x,i6,1x,f5.1,1x,f6.2,1x, &
      & 3(f10.6,1x),i2,1x,f9.3,1x,f10.3,1x,f10.4,1x,f9.4,1x, &
      & f6.2,1x,3(i3.2,1x),     &
      & 6(f7.2,1x),i5,1x,i5,1x,i3,1x,i5,1x,f7.2,1x,f18.2,   &
      & 2(1x,f8.2),2(1x,f7.2), &
          & 1x,i2,1x,f12.2,1x,f8.3,1x,f8.3,1x,f8.3,1x,f8.3,  &
          & 1x,f13.0,1x,15(f7.2,1x),f7.2)

    open(10,file="OceanRAIN-W_RV-SonneI_DFCG_SEP2012-OCT2012.ascii") ! input file
    open(11,file="OceanRAIN-W_RV-SonneI-your-needs.ascii") ! output file



!C####################################################################
!C###### Read in and write out data #################



    do jj = 1,include-number-of-lines


     read(10,1000)c,dateUT,timeUT,datelocal,timelocal,mmday,kc,UTC,lat,lon,head,temp,dewt, &
           & wtemp,sst,rh,qs,qa,pres,relFF,relDD,trueFF,trueDD,wind10,rad1,vis,&
           & ceil,maxFF,sal,CD,CE,CH,warmlayer,shf,lhf,evap,freshwater,&
           & gauge,ww,w1,w2,perc99,train,tsnow,&
           & rpar,spar,mpar,flag,flag2,bins,nums,precip,refl, &
           & dbr,dbz,wind,uref, &
           & conv,n0star,dm,mu,d0,sigma,N0, &
                   & dbzs,zdrs,kdps,atts, &
           & dbzc,zdrc,kdpc,attc, &
                   & dbzku,zdrku,kdpku,attku, &
                   & dbzka,zdrka,kdpka,attka

! do whatever you require to do here

     write(11,1000)c,dateUT,timeUT,datelocal,timelocal,mmday,kc,UTC,lat,lon,head,temp,dewt, &
                  & wtemp,sst,rh,qs,qa,pres,relFF,relDD,trueFF,trueDD,wind10,rad1,vis,&
                  & ceil,maxFF,sal,CD,CE,CH,warmlayer,shf,lhf,evap,freshwater,&
                  & gauge,ww,w1,w2,perc99,train,tsnow,&
                  & rpar,spar,mpar,flag,flag2,bins,nums,precip,refl, &
```

```
                  & dbr,dbz,wind,uref, &
                  & conv,n0star,dm,mu,d0,sigma,N0, &
              & dbzs,zdrs,kdps,atts, &
              & dbzc,zdrc,kdpc,attc, &
              & dbzku,zdrku,kdpku,attku, &
              & dbzka,zdrka,kdpka,attka

      enddo


      end

********************

      program oceanrain-m_read
      IMPLICIT NONE

! author: Christian Klepp, www.christianklepp.com

      integer :: ii,jj        !do loops

! parameter declaration for OceanRAIN-M ascii file parameters

      integer :: c,date,time,mmday
            real(kind=8) :: kc
            integer(kind=8) :: UTC
            real :: lat
            real(kind=8) :: lon
            real :: rpar,spar,mpar
            integer :: flag,flag2,bins,nums
            real :: precip,refl,dbr,dbz,wind,uref
      real, dimension(128) :: precip_psd
!     integer, dimension(128) :: precip_psd

      integer :: conv
      real :: n0star,dm,mu,d0,sigma,N0

      real :: dbzs,zdrs,kdps,atts
      real :: dbzc,zdrc,kdpc,attc
      real :: dbzku,zdrku,kdpku,attku
      real :: dbzka,zdrka,kdpka,attka

!C####################################################################
!C###### Input and Output-files        ##############################
!C####################################################################

      open(11,file='OceanRAIN-M_RV-SonneI_DFCG_SEP2012-OCT2012.ascii')
      open(12,file='OceanRAIN-M_RV-SonneI-your-needs.ascii')
```

```
!C#########################################################################
!C###### Read in and write out data #################


    read(11,*)   ! if header line present overread it

    do ii = 1,include-number-of-lines-1 ! n-1 substract header


     read(11,*)c,date,time,mmday,kc,UTC,lat,lon,    &
                 & rpar,spar,mpar,flag,flag2,bins,nums,     &
                 & precip,refl,dbr,dbz,wind,uref,  &
                          & conv,n0star,dm,mu,d0,sigma,N0, &
                       & dbzs,zdrs,kdps,atts, &
                 & dbzc,zdrc,kdpc,attc, &
                       & dbzku,zdrku,kdpku,attku, &
                       & dbzka,zdrka,kdpka,attka,  &
                          & precip_psd

! do whatever you require to do here


     read(12,*)c,date,time,mmday,kc,UTC,lat,lon,    &
                 & rpar,spar,mpar,flag,flag2,bins,nums,     &
                 & precip,refl,dbr,dbz,wind,uref,  &
                          & conv,n0star,dm,mu,d0,sigma,N0, &
                       & dbzs,zdrs,kdps,atts, &
                 & dbzc,zdrc,kdpc,attc, &
                       & dbzku,zdrku,kdpku,attku, &
                       & dbzka,zdrka,kdpka,attka,  &
                          & precip_psd

     enddo

     end

******************************

    program oceanrain-r_read
    IMPLICIT NONE

! author: Christian Klepp, www.christianklepp.com

    integer :: ii,jj         !do loops

! parameter declaration for OceanRAIN-R ascii file parameters

    integer :: c,date,time,mmday
         real(kind=8) :: kc
         integer(kind=8) :: UTC
         real :: lat
         real(kind=8) :: lon
```

```
          real :: rpar,spar,mpar
          integer :: flag,flag2,bins,nums
          real :: precip,refl,dbr,dbz,wind,uref
!    real, dimension(128) :: precip_psd
     integer, dimension(128) :: precip_psd

     integer :: conv
     real :: n0star,dm,mu,d0,sigma,N0

     real :: dbzs,zdrs,kdps,atts
     real :: dbzc,zdrc,kdpc,attc
     real :: dbzku,zdrku,kdpku,attku
     real :: dbzka,zdrka,kdpka,attka

!C#######################################################################
!C###### Input and Output-files        ###############################
!C#######################################################################

     open(11,file='OceanRAIN-R_RV-SonneI_DFCG_SEP2012-OCT2012.ascii')
     open(12,file='OceanRAIN-R_RV-SonneI-your-needs.ascii')




!C#######################################################################
!C###### Read in and write out data #################


     read(11,*)   ! if header line present overread it

     do ii = 1,include-number-of-lines-1 ! n-1 substract header


      read(11,*)c,date,time,mmday,kc,UTC,lat,lon,    &
                 & rpar,spar,mpar,flag,flag2,bins,nums,     &
                 & precip,refl,dbr,dbz,wind,uref,  &
                          & conv,n0star,dm,mu,d0,sigma,N0, &
                       & dbzs,zdrs,kdps,atts, &
                 & dbzc,zdrc,kdpc,attc, &
                       & dbzku,zdrku,kdpku,attku, &
                       & dbzka,zdrka,kdpka,attka,  &
                          & precip_psd

! do whatever you require to do here


      read(12,*)c,date,time,mmday,kc,UTC,lat,lon,    &
                 & rpar,spar,mpar,flag,flag2,bins,nums,     &
                 & precip,refl,dbr,dbz,wind,uref,  &
                          & conv,n0star,dm,mu,d0,sigma,N0, &
                       & dbzs,zdrs,kdps,atts, &
                 & dbzc,zdrc,kdpc,attc, &
```

```
                        & dbzku,zdrku,kdpku,attku, &
                        & dbzka,zdrka,kdpka,attka,  &
                            & precip_psd

     enddo

     end
```

****

```
# -*- coding: utf-8 -*-

"""
Created on Wed Jun 24 11:11 2020

DESCRIPTION:
  - List and load OceanRAIN files from FTP server
  - Load and Explore data using puthon library xarray
  - plot original time-series

"""
# Load functions:
import functions as fc
# Load python modules:
import os
import xarray as xr

# =================================
# STEP 1: Download data from FTP:
# =================================

# Initialize INPUT:
# ----------------
url        = 'ftp.zmaw.de'
url_path    = 'outgoing/klepp/netcdf/'

# List data files:
# ----------------
data,ftp = fc.list_data(url, url_path)
print(data)

# Load the data from FTP:
# -----------------------
#    i:: num of single file in the data list to download

fc.download_data(ftp, data, i=5, download_all=False)

# Move loaded files to data folder:
os.system('mv *.nc ../data')

# ========================
# STEP 2: Load the data:
```

```
# ==========================

data_path = '../data/'
file = 'OceanRAIN-R_RV-Investigator_VLMJ_JAN2016-MAY2018_DWD-MPIM_V2_0.nc'
data = xr.open_dataset(data_path + file)

# Print data base:
print(data)

# Print time dimension:
print(data.time)

# Get variable names:
var_names = list(data.var())

# Get data for one variable:
var1 = data[var_names[10]]

# Plot time-series for one variable:
var1.plot(color='gray',marker='o',markerfacecolor='r')
```

****

netCDF Variables list:

OceanRAIN-W

```
namesList =
['count','date_UT','time_UT','local_date','local_time','minute_of_day','julian_date','time',
 'latitude', 'longitude', 'heading', 'air_temperature',
'dew_point_temperature', 'bulkwater_temperature', 'sea_surface_temperature',
 'relative_humidity', 'specific_humidity_at_sea_surface',
'specific_air_humidity', 'air_pressure', 'relative_wind_speed',
 'relative_wind_direction', 'true_wind_speed', 'true_wind_direction',
'wind_speed_in_10m_height', 'global_radiation', 'visibility',
 'ceiling', 'max_gusts', 'salinity', 'drag_transfer_coeff', 'lhf_transfer_coeff',
'shf_transfer_coeff', 'warm_layer_flag',
 'sensible_heat_flux_shf', 'latent_heat_flux_lhf', 'evaporation',
'freshwater_budget', 'rain_gauge_precipitation_rate', 'ww_present_weather_code',
 'W1_past_weather_code', 'W2_past_weather_code',
'particle_diameter_99th_percentile', 'theoretical_rain_rate_disdrometer',
 'theoretical_snow_rate_disdrometer', 'probability_for_rain',
'probability_for_snow', 'probability_for_mixed_phase', 'precip_flag',
 'precip_flag2', 'number_of_bins', 'number_of_particles',
'ODM470_precipitation_rate_R', 'rayleigh_reflectivity_Z', 'dBR', 'dBZ',
'relative_wind_speed_ODM470', 'reference_voltage',
 'convective_stratiform_index', 'intercept_of_normalized_gamma',
'mass_weighted_mean_diameter_of_normalized_gamma',
 'shape_parameter_of_normalized_gamma',
'median_volume_diameter_of_normalized_gamma', 'mass_spectrum_standard_deviation',
 'intercept_parameter_of_a_standard_gamma',
```

'S_band_reflectivity', 'S_band_differential_reflectivity', 'S_band_specific_differential_phase', 'S-band_specific_oneway_attenuation',
'C_band_reflectivity', 'C_band_differential_reflectivity', 'C_band_specific_differential_phase', 'C-band_specific_oneway_attenuation',
'Ku_band_reflectivity', 'Ku_band_differential_reflectivity', 'Ku_band_specific_differential_phase', 'Ku-band_specific_oneway_attenuation',
'Ka_band_reflectivity', 'Ka_band_differential_reflectivity', 'Ka_band_specific_differential_phase', 'Ka-band_specific_oneway_attenuation']

OceanRAIN-R and OceanRAIN-M

```
namesList = ['count','date_UT','time_UT', 'minute_of_day', 'julian_date', 'time', 'latitude', 'longitude',
        'probability_for_rain', 'probability_for_snow', 'probability_for_mixed_phase', 'precip_flag', 'precip_flag2', 'number_of_bins', 'number_of_particles',
        'ODM470_precipitation_rate_R', 'rayleigh_reflectivity_Z', 'dBR', 'dBZ', 'relative_wind_speed_ODM470', 'reference_voltage',
        'convective_stratiform_index', 'intercept_of_normalized_gamma', 'mass_weighted_mean_diameter_of_normalized_gamma',
        'shape_parameter_of_normalized_gamma', 'median_volume_diameter_of_normalized_gamma', 'mass_spectrum_standard_deviation',
        'intercept_parameter_of_a_standard_gamma',
        'S_band_reflectivity', 'S_band_differential_reflectivity', 'S_band_specific_differential_phase', 'S-band_specific_oneway_attenuation',
        'C_band_reflectivity', 'C_band_differential_reflectivity', 'C_band_specific_differential_phase', 'C-band_specific_oneway_attenuation',
        'Ku_band_reflectivity', 'Ku_band_differential_reflectivity', 'Ku_band_specific_differential_phase', 'Ku-band_specific_oneway_attenuation',
        'Ka_band_reflectivity', 'Ka_band_differential_reflectivity', 'Ka_band_specific_differential_phase', 'Ka-band_specific_oneway_attenuation']
for i in range(1,129):
    namesList.append("bin"+str(i))
```

References

A comprehensive documentation of the data set, the parameters, the processing chain, the optical disdrometer ODM470 and OceanRAIN overall can be obtained from published literature:

Klepp, C., Michel S., Protat, A., Burdanowitz J., Albern N., Dahl A., Kähnert M., Louf V., Bakan S. & Buehler, S.A. (2018). OceanRAIN, a new in-situ shipboard global ocean surface-reference dataset of all water cycle components. **Nature Scientific Data**, 5:180122|DOI:10.1038/sdata.2018.122.

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