oceanRAIN

The automatic shipboard
Ocean Rain And Ice-phase precipitation measurement Network

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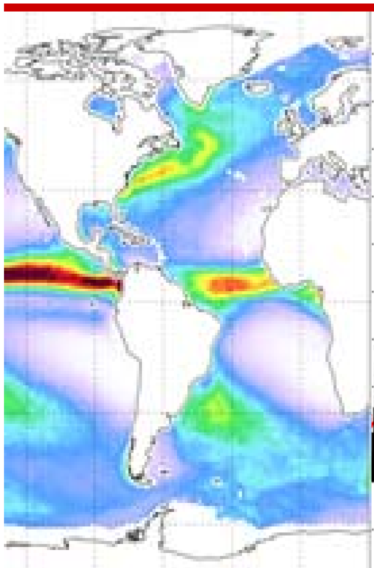
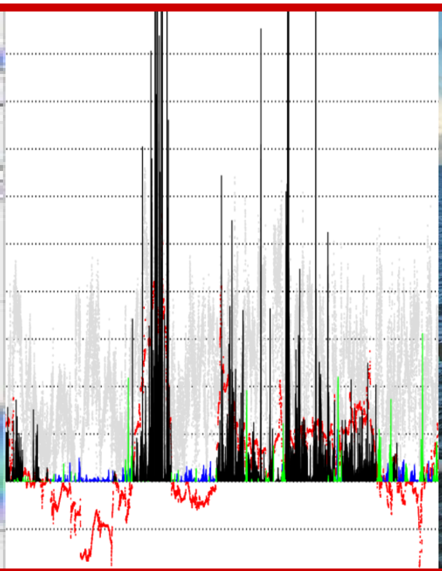
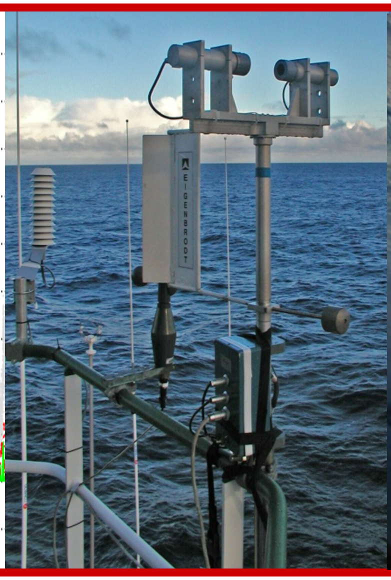





Outline

- Why oceanRAIN
- Automatic optical disdrometer system
- Advantages, Calibration and Accuracy
- Ship Fleet, Data Ingest and Data Set Construction
- Measurement Examples and Applications
- Summary

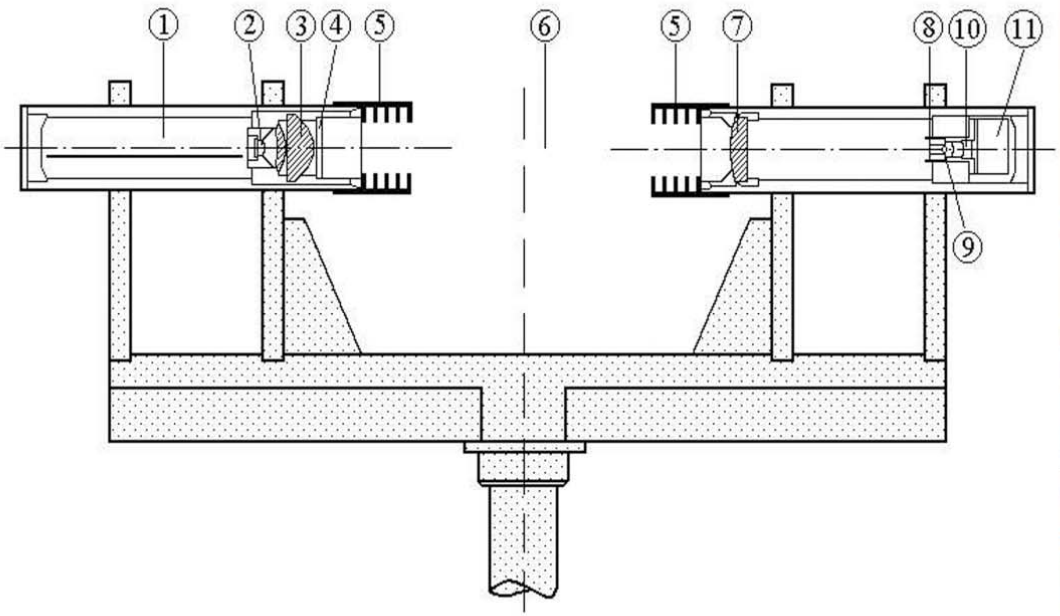
Why oceanRAIN ?

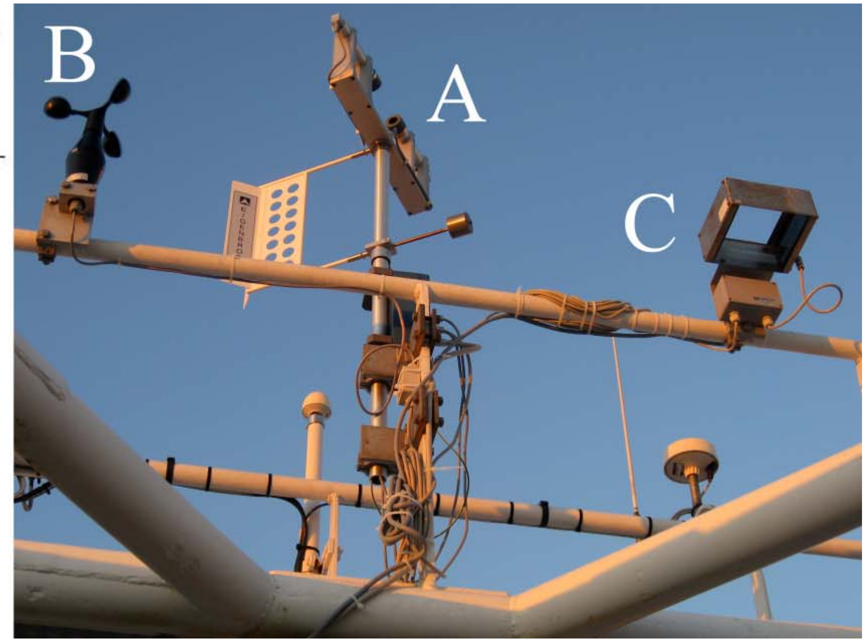
- Precipitation is … notoriously difficult to measure: spatio-temporal variability, intermittent, phase dependent, part of the energy and water cycle, freshwater flux and thus an ECV
- Oceans void of in-situ precipitation data due to lack of suitable instrumentation, VOS, ship and buoy gauge undercatch and snow issues
- Large uncertainties and variability of GPM era satellite data (and re-analysis / model) requires in-situ surface validation and calibration reference data for rain and snow
- Development of ODM470 into an automatic measurement device

In-situ Shipboard Global Ocean Water Cycle Components Dataset

aims at providing a comprehensive statistical basis of high-quality in-situ
global oceanic phase-dependent precipitation through PSDs
evaporation and freshwater flux data
for water cycle analysis and satellite validation
and to improve our knowledge about oceanic precipitation

Automatic optical disdrometer system ODM470





- sensitive volume 120 mm x 22 mm
- photoelectric barrier IR-LED
- reference voltage attenuation
- size dependent light extinction measures cross-sectional area
- 128 size bin allocation with particle counting during 1 min integration
- relative wind speed
- IRSS88 precipitation detector

Advantages over existing optical disdrometers

- developed for shipboard usage
- all-weather capability
- fully automatic
- low maintenance requirements
- cylindrical volume
- pivoting
- high dynamic range
- rain and snowfall algorithm (PSD)
- sensitivity 0.01 mm/h
- high accuracy

Output

rain/snow/mixed occurrence incl. true-zeros, intensity, accumulation and raw/NC PSD

Automatic operation improvements

- network data logger (IP time server synchronization) / data feed into ship system
- log files to check instrument state
- automatic rebooting if power is lost
- instruments feed into the computer box at the ODM, onle cable for data and power
- IRSS coupling to the ODM
- delay-mode to near real-time possible

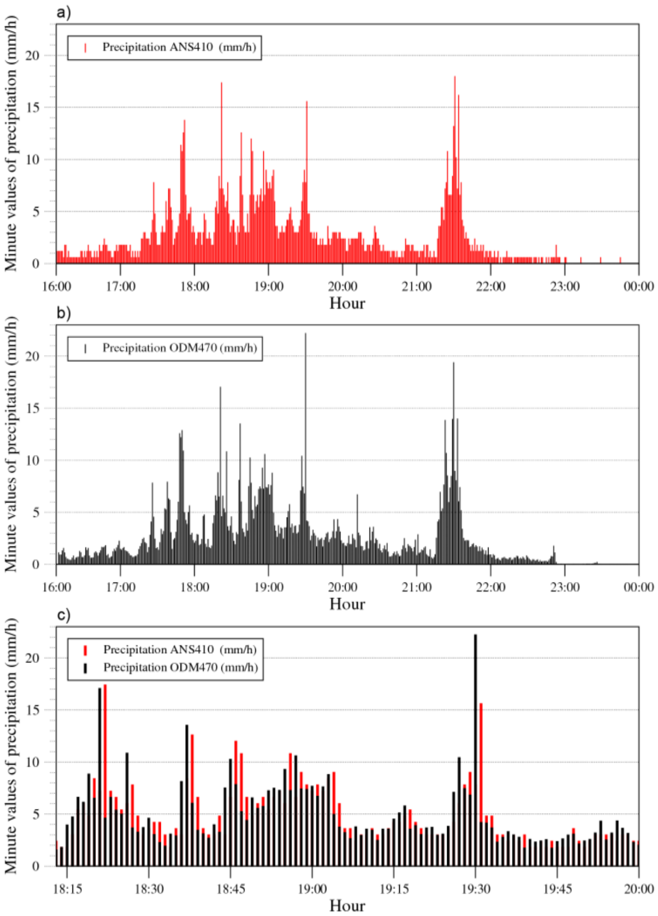
Klepp, C., 2015: The Oceanic Shipboard Precipitation Measurement Network for Surface Validation – OceanRAIN. Atmos. Res., Special issue of the International Precipitation Working Group (IPWG), 163, 74-90, doi: 10.1016/j.atmosres.2014.12.014.

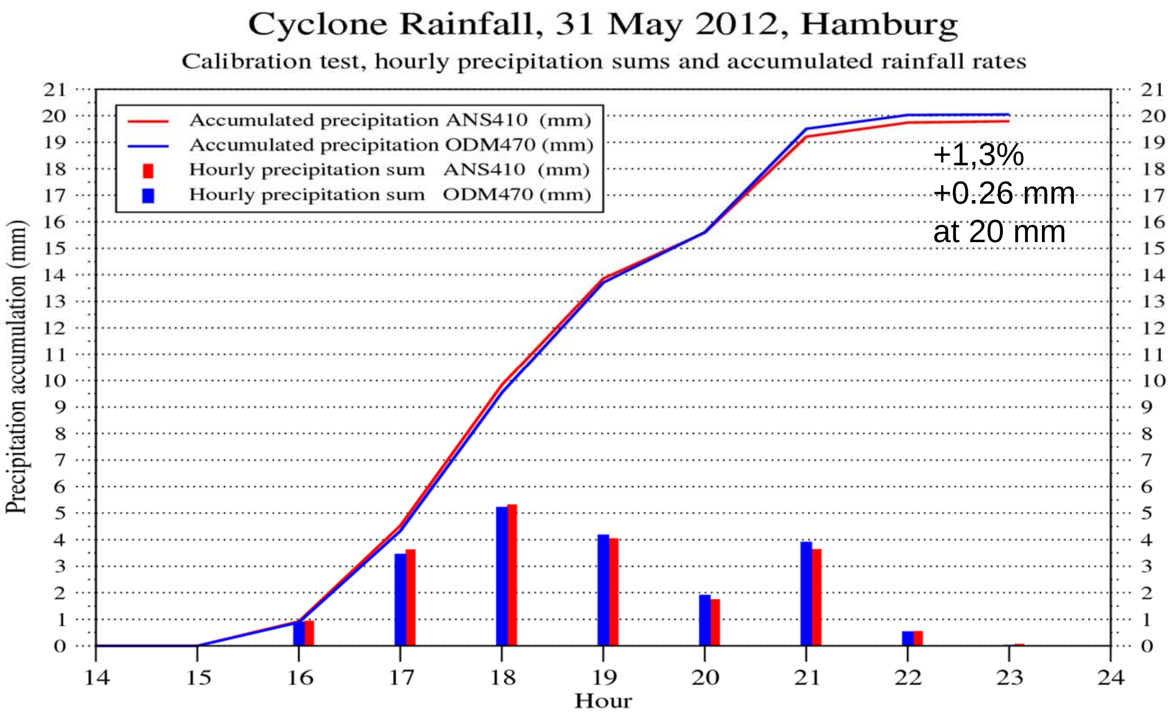
Burdanowitz, J., Klepp, C., and Bakan, S.: An automatic precipitation-phase distinction algorithm for optical disdrometer data over the global ocean, Atmos. Meas. Tech., 9, 1637-1652, doi:10.5194/amt-9-1637-2016, 2016.

ODM470 Calibration and Accuracy

Optical axis adjustments
Steel ball bearing calibration
Disdrometer-constant for precip volume scaling

ANS410 gauge vs ODM470 disdrometer
Windspeed < 1 m/s to avoid gauge undercatch





oceanRAIN Ship Fleet

bold = permanent installation
black = campaign data

RV Polarstern

RV Meteor

RV Maria S. Merian

RV Sonne II

RV Sonne

RV Investigator

RV Roger Revelle

MS The World

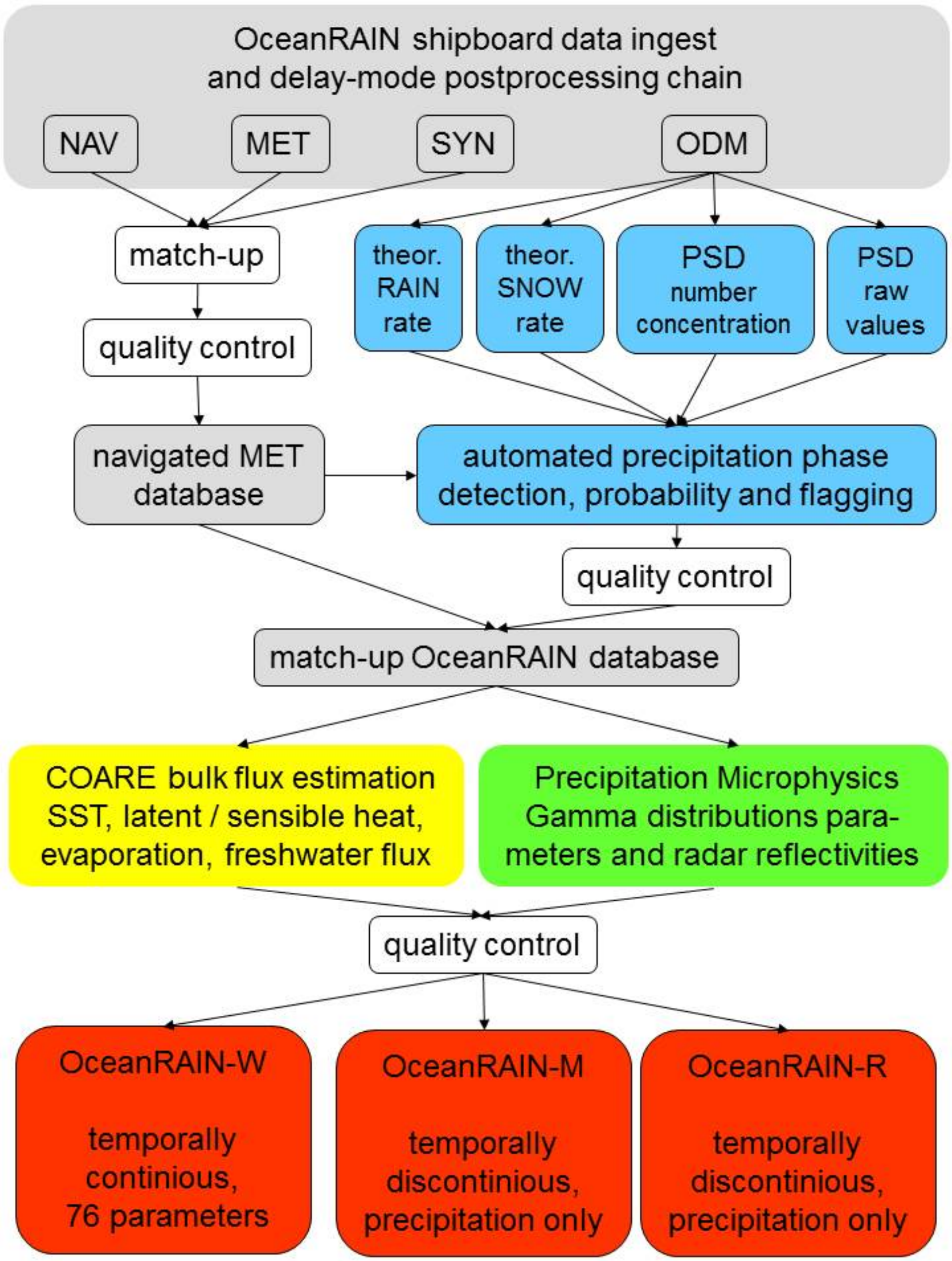
RV Thompson

RV Aurora Australis

plus experimental campaign data from

RV Celtic Explorer
KV Senja
RV Aranda
RV Akademik Ioffe
RV Agulhas II

oceanRAIN Data Ingest and Dataset Construction



Input
4 shipboard data streams
+ meta data

Postprocessing
Precipitation module
Precipitation microphysics module
Evaporation module

Output
minute-resolution

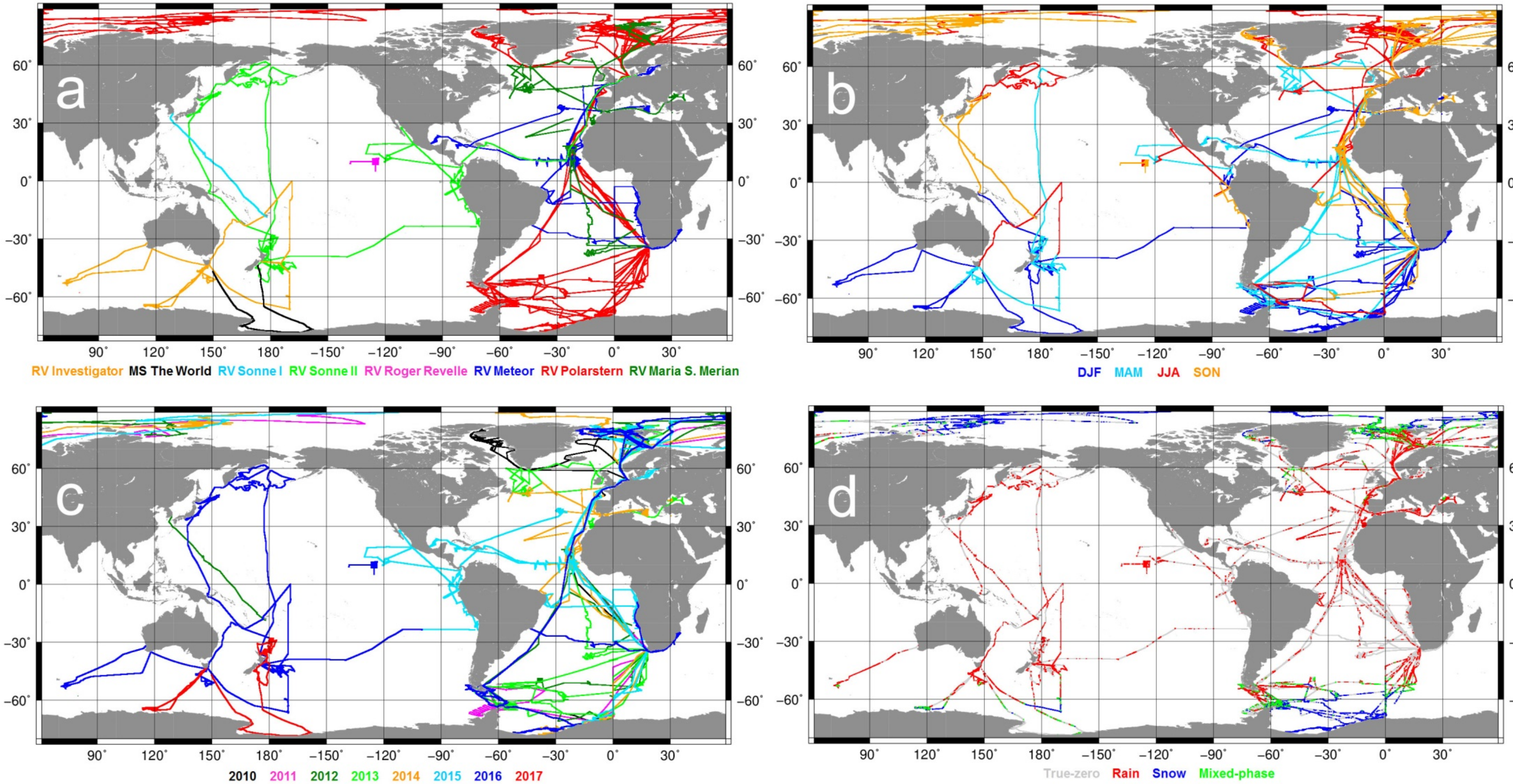
OceanRAIN-W:
76 parameters, temporally continuous

OceanRAIN-M:
NC PSD and microphysics

OceanRAIN-R
Raw PSD and microphysics

oceanRAIN Data Distribution

Ships | Seasons



Year | Precipitation phase

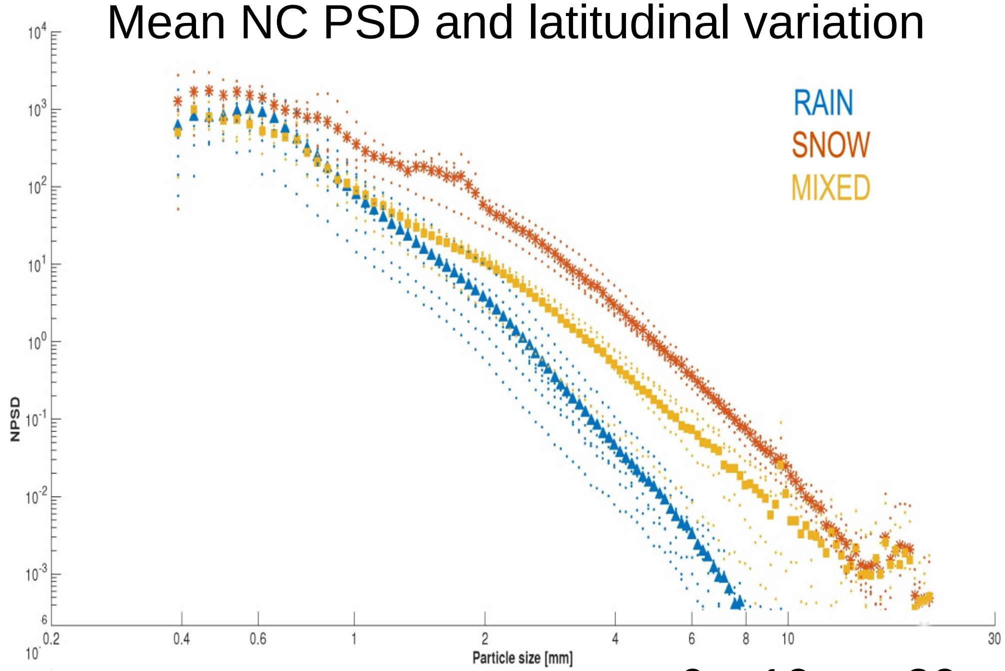
> 6.83 million minutes

> 0.69 million minutes with precipitation

OceanRAIN-M applications

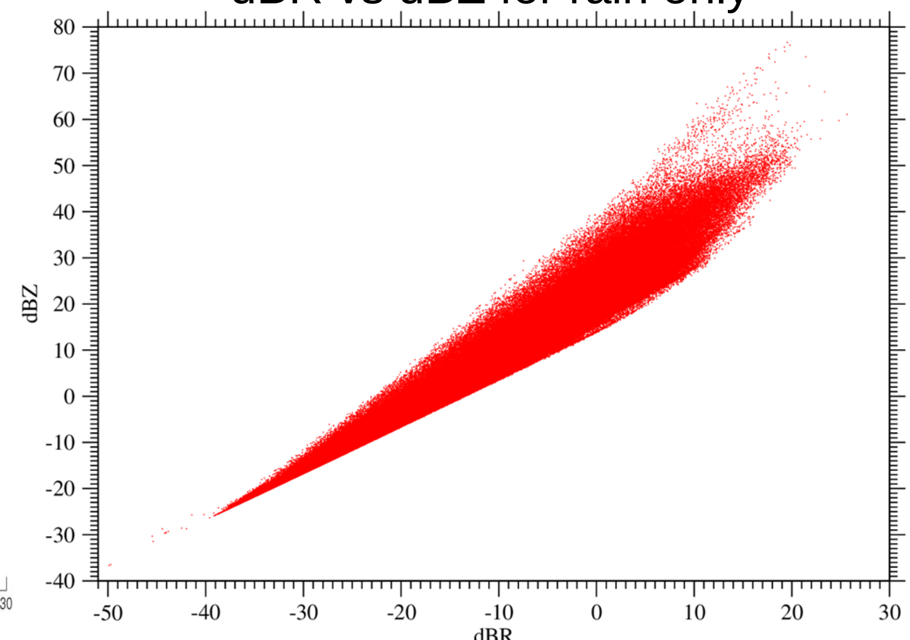
input: Raw and NC PSD
output:
→ normalized gamma distribition parameters (Testud et al. 2001)
→ microphysical parameters
→ conv / strat (Thurai et al. 2010)
→ Reflectivity, differential reflectivity and specific differential phase for different radar frequencies
→ derivation of Z-R relationships
→ currently in analysis for GPM IMERG, CloudSat, HOAPS, CAPRICORN shipboard radar data

Mean NC PSD and latitudinal variation



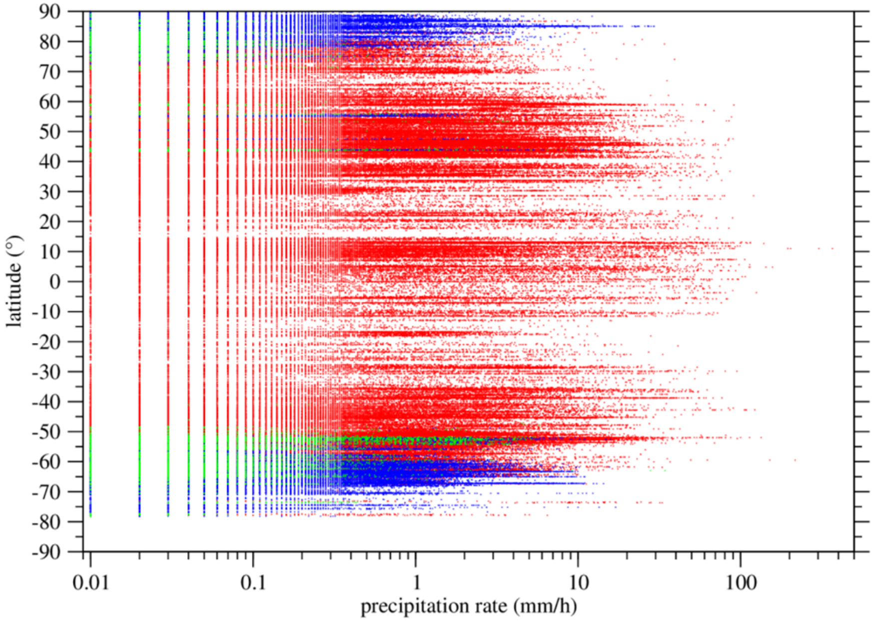
6 10 20 mm

dBR vs dBZ for rain only

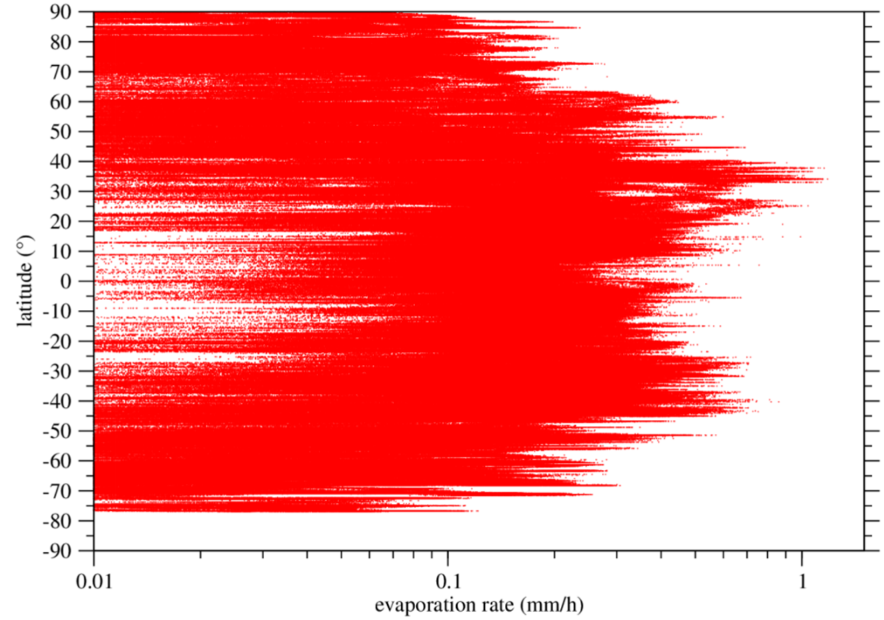


OceanRAIN-W applications

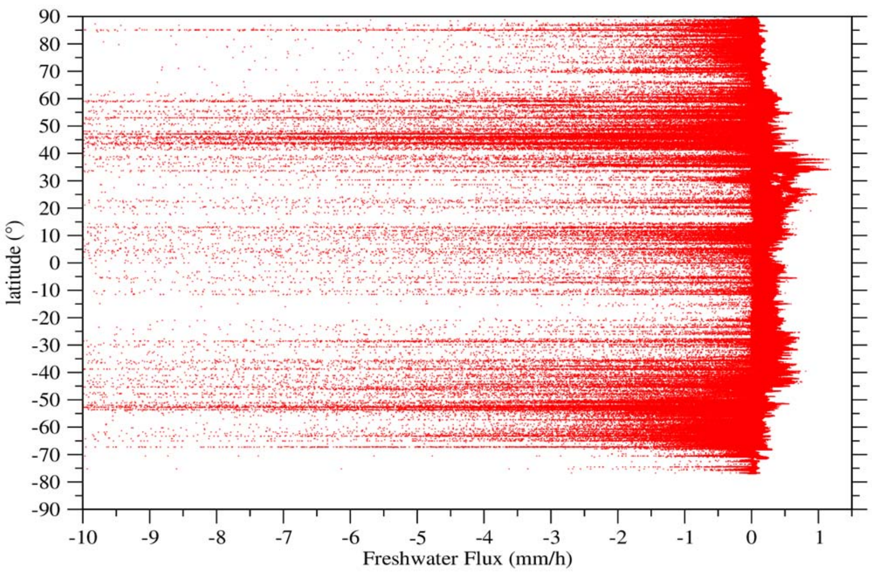
P (690.000)



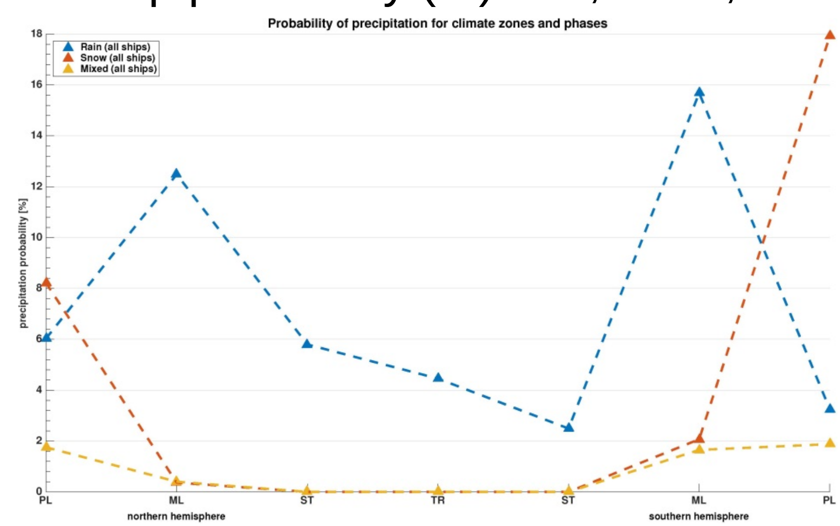
E (6.83 million)



E-P



Precip probability (%) rain, snow, mixed



Summary

OceanRAIN is to date the only systematic long-term global ocean measurement effort to combine in-situ precipitation, evaporation and freshwater flux products

- automatic all-weather optical disdrometers
- 76 meteorological and oceanic parameters plus 128 class PSDs
- 15 research vessels
- all climatic regions and seasons
- precipitation phase, occurrence, rates and accumulation through PSD
- more than 6.8 million minutes of data, steadily growing

OceanRAIN aims at

- improving knowledge on oceanic water cycle components and precip microphysics
- validation of satellite (re-analysis and model) data
- error characterization for satellite retrievals

- 3 dataset DOIs
- data descriptor paper

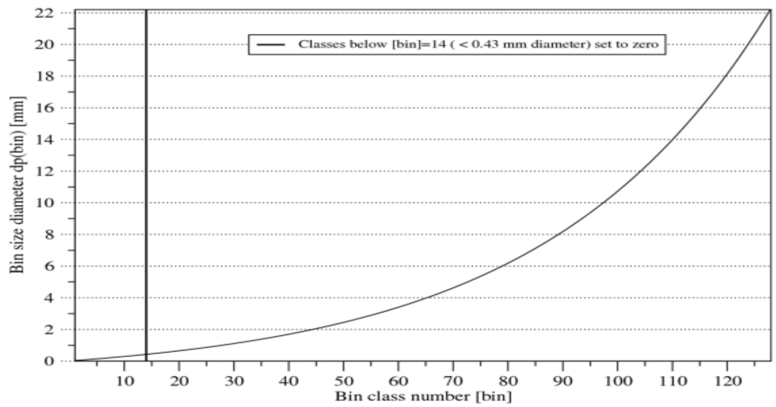
www.oceanrain.org


Thank You!
R/V Polarstern mast in 45 m height on 2 October 2012 in the Arctic

ODM470 precipitation algorithm

Logarithmic size binning

$$D_p(bin) = \frac{e^{(\frac{bin}{94}\cdot \ln 10)} - 1 + e^{(\frac{bin+1}{94}\cdot \ln 10)} - 1}{2}$$



Particle size distributions

n(bin) = particle size distribution density (Clemens, 2002)
by particle counting N(bin)

$$n(bin) = \frac{N(bin)}{l \cdot d \cdot t \cdot \sqrt{U_{rel}^{\,2} + (V_{fall}(bin))^2}}$$

after Großklaus (1996)

Rain and snowfall algorithm

$$P = 3600 \cdot \sum_{bin=0}^{128} n(bin) \cdot V_{fall}(bin) \cdot M_{particle}(bin)$$

Parameterizations for rain and snow

Rain:

$$M_{particle}(bin) = \frac{4}{3} \cdot \pi \cdot 1000 \cdot \left(\frac{D_p(bin)}{200}\right)^3$$

$$V_{fall}(bin) = 9.65 - 10.3 \cdot e^{(-1.2 \cdot \frac{D_p(bin) \cdot 10}{2})}$$

Atlas and Ulbrich, 1974

Snow (LWE):

$$M_{particle}(bin) = 0.0000107 \cdot \left(D_p(bin)\right)^{3.1}$$

$$V_{fall}(bin) = 7.33 \cdot \left(D_p(bin)\right)^{0.78}$$

Hogan, 1994 and Lempio, 2007

Adding turbulent heat fluxes, evaporation and freshwater flux

input: Tair, Twater, RH and abs. wind speed

output: COARE 3.0 bulk flux algorithm, Fairall et al.,2003:

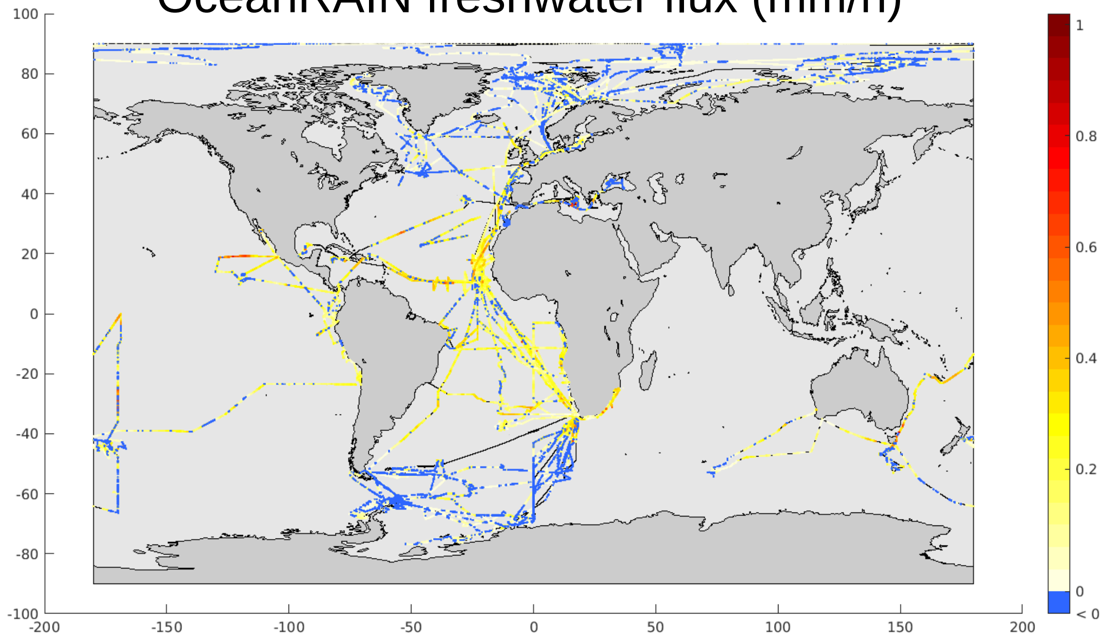
- Tennekes, 1972: → wind speed in 10 m height
- Murphy and Koop, 2005: → specific humidity
- Donlon et al., 2000 → SST

→ transfer coefficients, sensible and latent heat fluxes, E and E-P

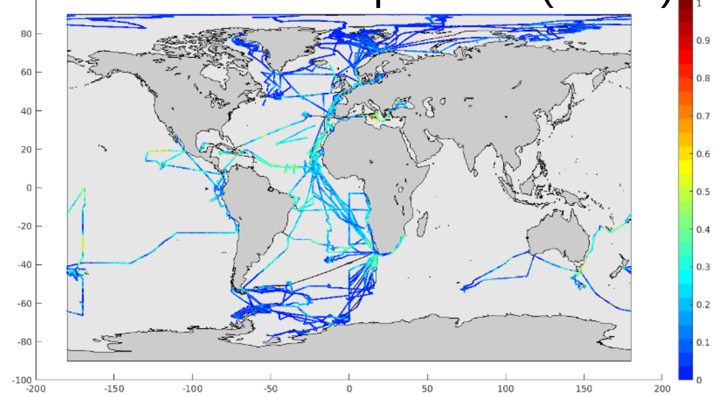
→ ocean salinity

- Along-track precip is a true-zero in about 90% of the time
- Relevance for the SEAFLUX and SPURS working groups

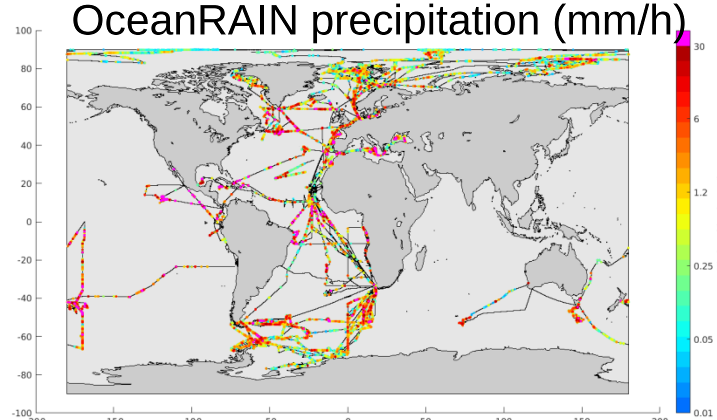
OceanRAIN freshwater flux (mm/h)



OceanRAIN evaporation (mm/h)



OceanRAIN precipitation (mm/h)



OceanRAIN E-P (mm/d): tropics 1.9, subtropics 2.1, mid-lats -2.1, high lats 0