Hunting for Precipitation

Ocean Rain And Ice-phase precipitation measurement Network

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OceanRAIN aims at establishing a comprehensive statistical basis of high-quality in-situ global oceanic precipitation and evaporation for water cycle analysis and validation of satellite data and evaluation re-analysis and model data.

The backbone of OceanRAIN: The **ODM470 optical disdrometer**
- developed for shipboard operation
- high wind, all-weather, fully automatic
- cylindrical volume, pivoting into wind
- accuracy 2% for rainfall; snow: WMO SPICE results expected
- rain and snowfall algorithm thru PSDs
- **NEW**: automated precip-phase distinction algorithm
- **NEW**: automated post processing chain including QC

A small selection of **new** OceanRAIN water cycle parameters

<table>
<thead>
<tr>
<th>Ancillary Shipboard Data</th>
<th>Disdrometer Shipboard Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tair, Twater, SST</td>
<td>probability for rain, snow, mixed phase</td>
</tr>
<tr>
<td>RH, qa,qs</td>
<td>precipitation phase flag and QC flags</td>
</tr>
<tr>
<td>wind speed and direction</td>
<td>particle size distributions</td>
</tr>
<tr>
<td>salinity</td>
<td>reflectivity</td>
</tr>
<tr>
<td>latent and sensible heat flux</td>
<td>liquid water content</td>
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</tbody>
</table>

**evaporation E** → **precipitation P**

along-track **freshwater flux E-P** in minute-resolution for 5.5 million samples worldwide


OceanRAIN Ship Fleet

RV Celtic Explorer  KV Senja  RV Aranda  RV Roger Revelle

RV Polarstern  RV Akademik Ioffe  RV Maria S. Merian  RV Sonne

RV Meteor  RV S.A. Agulhas II  RV Investigator  RV Sonne II
> 5.5 million data samples worldwide in the OceanRAIN data base; rapidly growing
special recent cruises to be included these days:
RV Sonne, Pacific cruise from New Zealand to Alaska
RV Roger Revelle, tropical Pacific rain chasing cruise (coorp. Kyla Drushka, Univ. Wash.)
RV Polarstern sampled the Antarctic winter Southern Oceans in JJA 2013 with more than 130,000 minutes of snowfall.

RV Meteor sampled the ITCZ with record rainfall rates ranging from 100 to 360 mm/h.
• drizzle < 0.5 mm/h, stratiform < 5 mm/h, convective > 5 mm/h after Houze (1993); currently to be replaced by PSD separation using mean volume diameter
• drizzle occurs most frequently
• needs to be analyzed as a function of rate > 0.00, 0.01, 0.1 mm/h
• in the tropics 11% convective rainfall account for 81% of the accumulation
• OceanRAIN statistics are currently analyzed using the entire data base
Adding heat fluxes, evaporation and freshwater flux into OceanRAIN
input: shipboard air temperature, bulk water temperature, relative humidity and wind speed
applied to:
• Tennekes, 1972: → wind speed in 10 m height
• Murphy and Koop, 2005: → specific humidity
• Donlon et al., 2000 → SST
• COARE 3.0 bulk flux algorithm, Fairall et al., 2003 → transfer coefficients, sensible and latent heat fluxes, evaporation E
OceanRAIN: precipitation P
freshwater flux: E-P (as in HOAPS satellite climatology)
• Along-track precip is a true-zero in about 90% of the time

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
HOAPS precipitation uncertainty estimation using point to area corrected collocations

24,990 collocations of along-track averaged OceanRAIN disdrometer data and scan-based oceanic HOAPS satellite data (2010-2015):

- Quality check
- Line-area correction
- Sensitivity adaption

Precipitation detection

HOAPS "false detections" merely caused by track-to-area discrepancy; misses by lower sensitivity.

HOAPS underestimates precipitation by 13% but more high uncertainty; more OceanRAIN data needed.

from Burdanowitz (2016), PhD thesis
RV Investigator 2016 scientific (V) and transfer (T) cruises starting in Perth (Jan 2016)

- 43512 minutes of precip: 81% rainfall, 14% snowfall, 5% mixed-phase

**CAPRICORN:** Clouds, Aerosols, Precipitation, Radiation, and Atmospheric Composition Over the Southern Ocean

- in cooperation with Alain Protat, BoM, Melbourne
- and Walt Petersen, NASA

→ data is collected, processed and analysis started

CloudSat/OceanRAIN climatological statistics planned in cooperation with Tristan L’Ecuyer

A-Train and GPM direct collocation of RV Investigator during CAPRICORN (V02)

- RV Investigator 2016 scientific (V) and transfer (T) cruises starting in Perth (Jan 2016)
- 43512 minutes of precip: 81% rainfall, 14% snowfall, 5% mixed-phase
Testing a PSD-based Convective – Stratiform Separation

according to Testud et al. (2000) the “mean volume diameter” \( D_m \) (dividing moments \( M_4/M_3 \)) plotted over \( \log_{10}(R) \) yields a perfect separator function defined by \( R = 1.64 \ D_m^{4.25} \) when using TOGA-COARE aircraft probe PSD rainfall data at 3 km height. \( D_m \) is shown more useful than \( D_0 \).

\[ \text{Figure 2a in Testud et al. (2000)} \]

\[ \text{Method repeated for tropical OceanRAIN data} \]

\[ > 5000 \text{ tropical ship cases} \]

red: convective after Testud
blue: stratiform after Testud

\[ \text{convective regime: OceanRAIN PSDs contain high rainfall rates at higher } D_m \text{ values that do not occur in Testud data and therefore end up classified stratiform according to Testud while they are obviously convective as suggested by the rain rate, LWC and reflectivity values (see figures below)} \]

\[ > 10 \text{ mm/h, convective:} \]

Testud: \( D_m \) max = 1.8 mm
OceanRAIN: \( D_m \) max = 4.7 mm

\textbf{Question:} Is an aircraft measurement at 3 km height representative for surface rainfall? Evaporation of falling small drops may increase \( D_m \).
OceanRAIN – IMERG Comparison Background

- OceanRAIN was used to evaluate IMERG V3 Final Run 0.1° x 0.1° half-hourly product (precipitationCal data field), grids were shifted north by one grid (input from Walt and George)
- Comparison period: 20/03/2014 – 31/01/2016
- OceanRAIN and IMERG were matched for the criteria:
  - OceanRAIN observed >= 10 min continuous precip (1-min resolution)
  - OceanRAIN precip rate >= 1 mm/h
  - Focused on “Wet Pixels” for initial evaluation
  - Comparison ± 60° Latitude (many additional samples available at high latitudes)
- Matched Pairs:
  - 1101 rain cases
  - 46 snow cases (IMERG detected snow in only 3 cases)

Location of matched OceanRAIN-IMERG pairs
- Red – R/V Investigator
- Magenta – R/V Merian
- Blue – R/V Meteor
- Cyan – R/V Polarstern
- Yellow – R/V Sonne
Results show large scatter in the OceanRAIN-IMERG grid comparison. IMERG misses the small, intense tropical rain systems (bottom circle). IMERG grid miss-match for some of the larger systems (top circle). Errors have minimal dependency on sample size and track location (below, left). Boxplot (above) shows largest errors in the tropical region with the large sub-grid variability (below). Currently stratifying by size of events (averaging continuous matched grids) and spatial correlation analysis. Future, high resolution orbit evaluation.
Summary

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

- utilizes all-weather optical disdrometer systems
- a broad variety of meteorological parameters
- operated onboard 12 research vessels
- covers all climatic regions and seasons of the world oceans
- rain, snow and mixed-phase occurrence, rates and accumulation through PSD
- automated precipitation phase detection algorithm
- automated post processing chain including QC
- more than 5 million minutes of data, steadily growing

OceanRAIN aims at

- improving knowledge on oceanic precipitation, evaporation and freshwater flux and microphysical precipitation properties
- validation of satellite; evaluation of re-analysis and model data
- point to area based error characterization for satellite retrievals in conjunction with shipboard radars

www.oceanrain.org