Ocean Rain And Ice-phase precipitation measurement Network

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Outline

• Why OceanRAIN
• Optical disdrometer system
• Calibration and Accuracy
• Data Ingest
• Data Set Construction
• Measurement Examples
• Summary
• Precipitation flux is ECV
• Energy and water cycle & freshwater flux
• Different phases (types)
• Intermittent parameter
• Measurement notoriously difficult
  • Oceans void of in-situ data, lack of suitable in-situ instrumentation for shipboard usage
  • VOS, ship gauge undercatch & snow issues
• Large uncertainties of in-situ, satellite, reanalysis and model data

Light rain and snow, no phase information.

→ High quality in-situ oceanic precipitation reference data is required and crucial for
  validation and calibration of GPM era satellites, algorithms and error characterization
  and to improve our knowledge about oceanic precipitation

Taylor (2000): “…no more than a few thousand [gauge] samples worldwide…”
Klepp (2014): “…more than 5 million samples of rain, snow and mixed-phase worldwide, steadily growing…”
Automatic Measurement System: Optical Disdrometer ODM470

- sensitive volume volume 120 mm x 22 mm
- photoelectric barrier IR-LED
- reference voltage attenuates with occurrence of hydrometeors
- a size dependent light extinction measures cross-sectional area
- 128 size bins
- measurement interval 1 minute
- allocated bins
- number of particles per bin
- residence time of particles
- relative wind speed
Logarithmic size binning

\[ D_p (\text{bin}) = \frac{e^{\left(\frac{\text{bin}}{94} \cdot \ln 10\right)} - 1 + e^{\left(\frac{\text{bin}+1}{94} \cdot \ln 10\right)} - 1}{2} \]

Particle size distributions

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

by particle counting \( N(\text{bin}) \)

after Großklaus (1996)

Rain and snowfall algorithm

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

Parameterizations for rain and snow

Rain: \[ M_{\text{particle}}(\text{bin}) = \frac{4}{3} \cdot \pi \cdot 1000 \cdot \left(\frac{D_p (\text{bin})}{200}\right)^3 \]

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

Atlas and Ulbrich, 1974

Snow (LWE):

\[ M_{\text{particle}}(\text{bin}) = 0.0000107 \cdot (D_p (\text{bin}))^{3.1} \]

\[ V_{\text{fall}}(\text{bin}) = 7.33 \cdot (D_p (\text{bin}))^{0.78} \]

Hogan, 1994 and Lempio, 2007
Automatic Measurement System: Optical Disdrometer ODM470

Advantages over existing optical disdrometers

- developed for shipboard usage
- all-weather capability
- fully automatic system
- low maintenance requirements
- cylindrical volume
- pivoting
- high dynamic range
- rain and snowfall algorithm, PSD
- high accuracy

Developed by Univ. Kiel

Meet us at the mini tradeshow and our poster on Wednesday
Calibration

Optical axis adjustments
Spherical particles from 0.5 to 22 mm
Disdrometer-constant for precip volume scaling

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

Cyclone Rainfall, 31 May 2012, Hamburg
Calibration test, hourly precipitation sums and accumulated rainfall rates

+1.3%
+0.26 mm
at 20 mm
Accuracy: SPICE extreme event, Front Range flood
9-16 Sep 2013

Total 352 mm
123.5% of reference
+23.5% to reference

Total 279 mm
97.9% of reference
-2.1% to reference

Total ~285 mm
REFERENCE
OceanRAIN

- founded 2009 at the Univ. Hamburg and MPI-M, Hamburg, Germany
- close cooperation with Eigenbrodt

- aims at a comprehensive statistical basis of long-term high-quality global oceanic precipitation data using ODM470 optical disdrometers

- provides occurrence, intensity, accumulation
- rain, snow, mixed-phase
- with minute resolution through particle size distributions
- for validation of satellite, re-analysis and model data
- statistical and process study analysis
- point to area analysis

- currently > 5 million minutes of measurements
- in all climatic regions and all seasons


Long-term data ingest

Since 2010: Installations onboard 9 ships

- R/V Celtic Explorer
- K/V Senja
- R/V Aranda
- R/V Polarstern
- R/V Akademik Ioffe
- R/V Maria S. Merian
- R/V Sonne
- R/V Meteor
- R/V S.A. Alguhas II
- R/V Investigator
- R/V Sonne II
Long-term data ingest
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R/V Meteor  R/V S.A. Alguhas II  R/V Investigator  R/V Sonne II
### Data set construction

#### Ancillary data
- NAV
- MET
- SYN

**Quality control**
- automatic screening
- manual screening

**Internal data format**

**Precipitation time series**

#### Disdrometer data
- ODM

**Quality control**
- automatic screening
- manual screening

**Internal data format**

**Precipitation particle size distributions**

### Parameters and Units

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<th>Parameter</th>
<th>Unit or Value Range</th>
<th>Source</th>
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<td>reference voltage</td>
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<td>precipitation flag</td>
<td>0=rain, 1=snow, 2=mixed, 3=true zero, 4=inoperative, 5 = harbor times</td>
<td>calculated</td>
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</table>
Measurement examples: Precipitation track occurrence

For the first time cold season Southern Ocean data with > 40,000 minutes of snow
78023 minutes of rainfall (black)
83839 minutes of snowfall (blue)
23858 minutes of mix-phase (green)

185720 minutes of precipitation equiv. 14.4% of the time

By Nov 2014:
> 5 Million minutes avail
> 500,000 non-zero values from 9 ships worldwide
Measurement examples: Precipitation particle size distributions

27 months ODM470 precipitation R/V “Polarstern” from 10 June 2010 to 07 October 2012
Summary

• OceanRAIN is to date the only systematic long-term global ocean precipitation measurement effort for surface validation.
• High precision all-weather disdrometer systems.
• Low maintenance requirements.
• Automatic optical disdrometer system installed onboard 9 research vessels since 2010.
• Rain, snow and mixed-phase occurrence, intensity and accumulation through particle size distributions
• Rain and snowfall algorithms, automatic phase detection
• About 5 million minutes of data, steadily growing

www.oceanrain.org

Meet us at the mini tradeshow and our poster on Wednesday 2:30-5:30 LeSells Stewart Center
Thank You!

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