Towards an automatic phase distinction algorithm of optical disdrometer data over the ocean

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**Satellite precipitation retrievals require surface reference data for validation. Surface precipitation data is particularly rare over the global oceans. The Ocean Rain And Ice-phase precipitation measurement Network (OceanRAIN; Klepp 2014) aims at providing long-term in-situ oceanic precipitation data from optical disdrometers deployed on research vessels (RVs). OceanRAIN samples particle size distributions at high resolution, whereby the precipitation phase (PP) has to be known to calculate the precipitation rate. The PP is not only essential for OceanRAIN but it is valuable information for recent and future satellite missions. We develop an algorithm to automatically retrieve the PP over the ocean.**

**Methods and Data**

- Since 2010, 9 RVs have been equipped with optical disdrometer ODM470, 5 are currently in use.
- Particle mass and terminal fall speed strongly depend on precipitation phase.
  \[ P = \sum_{bin=1}^{\text{128}} M(\text{bin}) \cdot n(\text{bin}) \cdot v_{\text{wp}}(\text{bin}) \] (Eq.1)
- Ship measurements provide meteorological data.

**Optical disdrometer ODM470 (manufacturer Eigenbrodt, Germany)**
- light extinction by precipitation particles measured as voltage and translated into particle size and transit time.
- ODM470 was developed to measure under high wind speed / sea state
- low-maintenance instrument.

**Results:** The algorithm structure

1. Temperature-humidity relationship (T-H)
   - relation of Koistinen and Saltikoff (1998) \([K&S98]\)
   - T-H is more accurate than temperature alone (Froidurot et al., 2014)
   - first-time usage over ocean that features flatter slope (dashed) than literature values over land (solid; K&S98)

2. The particle size distribution:
   - 99th percentile \((D_{99})\) used to exclude anomalously large particles
   - helps to assign solid phase to large particles at distinctly positive \(T\)

3. Overall PP probability
   - combine information and assign overall probability

**Calculation of rain probability \(p(rain)\)**

\[ p(rain) = \frac{1}{1 + e^{a + b T + c rH + d T rH}} \]

- **Accuracy (excl. mixed-phase): 94.1% (-2<T<5°C: 88.5%)**
- **Accuracy (incl. mixed-phase): 95.0% (-2<T<5°C: 90.2%)**

**Comparison with manual method (reference data set):**

- 4 years RV Polarstern ship-board synoptic observations exist by human observer (3-hourly, daylight only)
- plausibility check of precipitation rate after Eq.1 with empirical values for rain/snow

<table>
<thead>
<tr>
<th>Rain Type</th>
<th>Manual: rain</th>
<th>Manual: snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic:</td>
<td>41</td>
<td>5</td>
</tr>
<tr>
<td>Automatic:</td>
<td>1</td>
<td>53</td>
</tr>
</tbody>
</table>

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**Mixed-Phase as snow:**
- Mixed-phase carries most uncertainty (also in obs!)
- **Accuracy (incl. mixed-phase): 92.6% (-2<T<5°C: 86.9%)**

**Particle fall velocities for PP distinction not successful:**
- usually strong wind influence and turbulence effects
- ODM470 does not measure fall speed but transit time; however transit path per particle unknown (cylinder)
- **Particle fall speed not implemented in algorithm**

** References:**

