Estimating uncertainty of HOAPS precipitation rates from satellite data over the Atlantic Ocean

Jörg Burdanowitz[1,2], Stephan Bakan[1], Christian Klepp[3]

(1) Max Planck Institute for Meteorology, Hamburg, Germany (2) International Max Planck Research School on Earth System Modeling (IMPRS-ESM), Hamburg, Germany (3) KlimaCampus, Hamburg, Germany

Introduction

The global hydrological cycle as an essential part of the Earth's climate system is closely linked to the global energy cycle. In order to understand the climate system and thus predict its changes, Earth system models are applied. Aiming at a realistic representation of the relevant climate-related processes, accurate and continuous global observations are required to validate climate models.

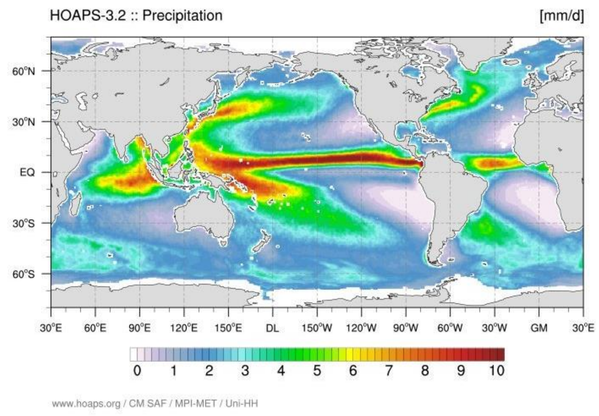
Quantifying the freshwater fluxes over the global oceans such as the Atlantic Ocean still remains a challenge. In particular, precipitation is highly variable in space and time and therefore hard to measure. Therefore, satellites are inevitable to monitor precipitation with high spatial coverage over the oceans and sparsely populated areas. But still, the coarse spatial resolution and a rather low sampling rate by polar-orbiting satellites as well as uncertainties in the retrieval procedures limit these space-borne measurements. For these reasons an uncertainty estimate is required to quantify the reliability of the satellite data.

Data

Hamburg Ocean Atmosphere Parameters and fluxes from Satellite data (v3.2)

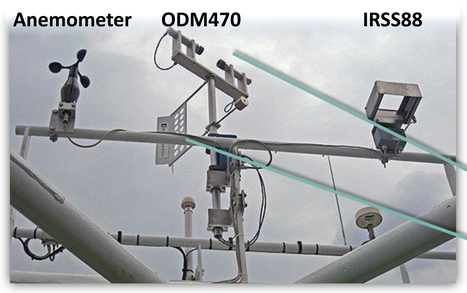
Global satellite climatology of 15 water-cycle related parameters:

- Only ice-free ocean
- Passive microwave sensors onboard polar-orbiting DMSP satellites
- Period: 1987-2008
- 3 products (un/gridded, 6-hourly/monthly)
- 0.5° spatial resolution



Oceanic Precipitation Measurement - Surface Validation data set from optical disdrometer (ODM470):

- Disdrometer currently deployed on 5 different research vessels
- ODM can measure under varying and high wind speeds and sea state
- light extinction from light emitting diode by particles measured as voltage



Cylindrical measuring volume assures independency of wind-driven precipitation incidence angle.
Wind vane keeps ODM constantly in wind direction.

Methods

ODM is capable in providing particle size distributions (PSD) for distinct phases:

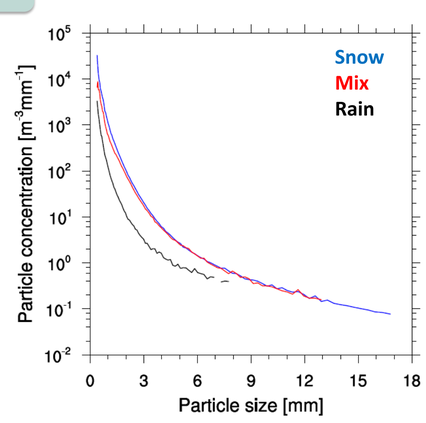
→ Auxiliary data required to distinguish:

Temperature as first guess (**< -1°C snow, > 2°C rain**)

→ Inaccurate but shows different precipitation regimes

Snow reaches bigger particle sizes, more tiny particles

→ For improvement further auxiliary data for phase distinction is needed



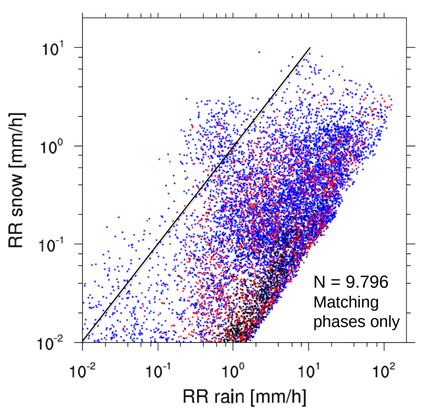
From PSD towards precipitation rates:

Precipitation rate R is correlated with number n of precipitation particles and its terminal fall velocity v_∞:

$$R = 6\pi \cdot 10^{-4} \int_0^\infty D^3 \cdot n(D) \cdot v_\infty(D) dD$$

→ As density largely differs for snow and rain, v_∞ and thus R are calculated with different formulas

The snowfall calculation is rather uncertain than for rain.



Uncertainty

Precipitation as a meteorological quantity is hard to measure because of its high spatiotemporal variability and varying phases.

Satellite observation: + **continuous** observation of **large areas** (quasi-global)

- **coarse** in space (passive microwave) and time (polar orbiting)
- **no distinction** of precipitation **phases**

In-situ disdrometer: + provides particle size distributions in **high temporal** resolution

+ able to **discriminate precipitation phases** using auxiliary data

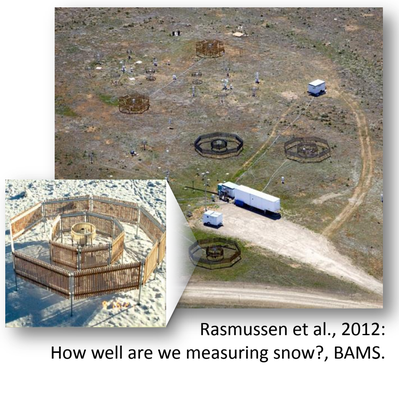
- **point** measurement, precipitation rate **not directly** measured

First results

Solid Precipitation InterComparison Experiment at Marshall Field site (Boulder, CO) for gathering training data:

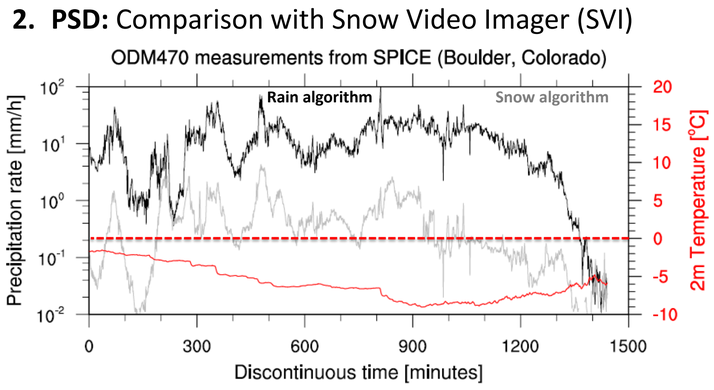
1. **Snow amount:** Comparison with DFIR Geonor
   - double fence decreases wind-driven undercatch of snow
   - Includes ordinary weighing gauge

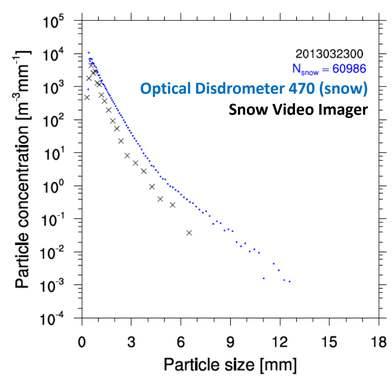
   → **Check how accurate ODM measures snow**



Rasmussen et al., 2012: How well are we measuring snow?, BAMS.

2. **PSD:** Comparison with Snow Video Imager (SVI)





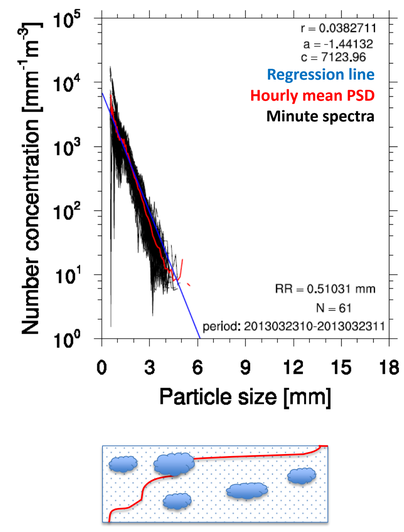
→ **Check accuracy of PSD from ODM**

3. **Phase distinction algorithm: Auxiliary data** *(planned)*
   - using auxiliary data to discriminate phases, e.g.: Precipitation rate, 2m-Temperature, PSD spectra
   - use weather sensor as reference for precipitation phases

   → **Goal: Automatic phase distinction algorithm**

4. **Point-to-area statistics: Sensitivity study** *(planned)*
   - How representative is a line (ship track) in an area (satellite pixel) concerning precipitation?

   → **Ensure OPM-SV data is suitable to compare with HOAPS satellite data**



Conclusions

- Optical disdrometers measure precipitation rates on moving ships around the world to gather reference data for the HOAPS satellite climatology
- Automatic phase distinction and evaluated data in combination with point-to-area statistics should enable to **calculate uncertainty estimates for HOAPS** (planned)
- **In terms of uncertainty:** Precipitation measurements from satellites have a relatively high uncertainty → is tried to reduce with the help of **OPM-SV** being to date **the only systematic oceanic precipitation measurement surface validation effort!**

Max-Planck-Institut für Meteorologie

Contact:
joerg.burdanowitz@mpimet.mpg.de

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