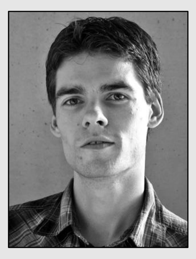


The validation of oceanic precipitation using the ship-based oceanRAIN dataset

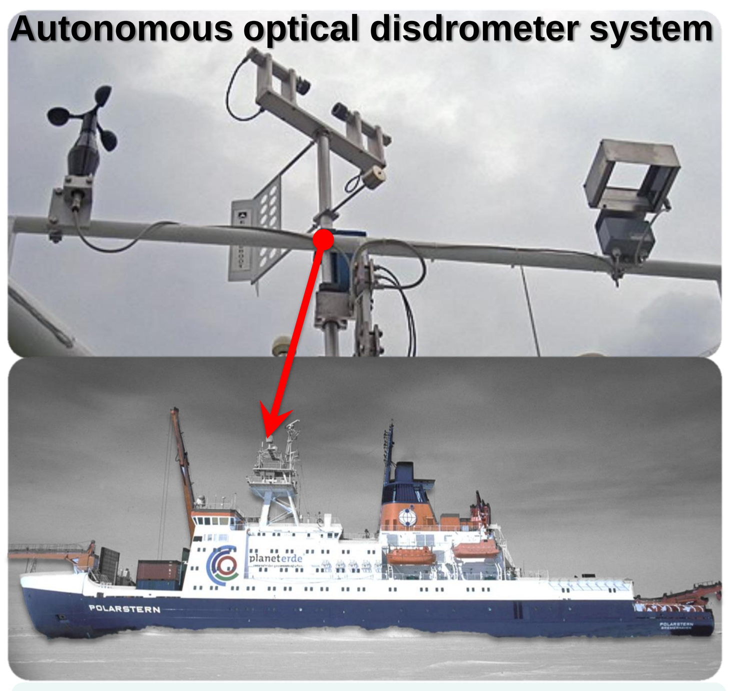
Jörg Burdanowitz[1,2], Christian Klepp[3], Stephan Bakan[2] and Stefan A. Buehler[1]

[1] Universität Hamburg, Meteorological Institute, Hamburg, Germany [2] Max Planck Institute for Meteorology, Hamburg, Germany
[3] University of Hamburg, CliSAP/CEN, Hamburg, Germany

Motivation

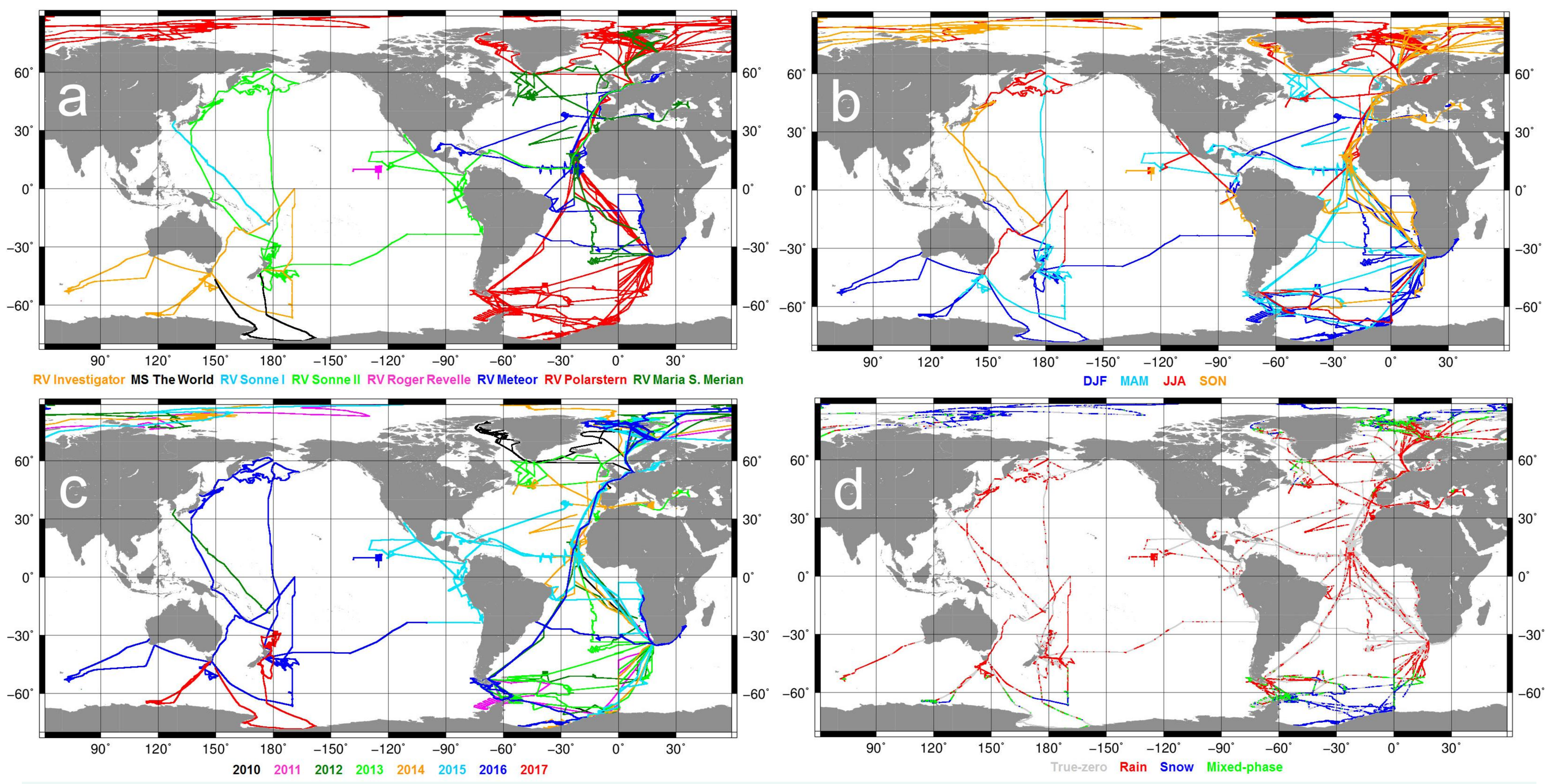
- The highly variable precipitation parameter challenges both, models and satellite observations; thus, its validation is extremely important.
- The validation of satellite climatologies, used for climate model validation, requires high-quality surface reference data.
- The Ocean Rainfall And Ice-phase precipitation measurement Network (OceanRAIN; Klepp 2015) provides the first systematic long-term database for oceanic surface precipitation, particle microphysics and water cycle parameters data from optical disdrometers deployed on research vessels over the global ocean.

oceanRAIN



F1: Example of a long-term disdrometer installation onboard the RV Polarstern (1 out of currently 8 RVs equipped).

- Optical disdrometer measures light extinction by precipitation particles as voltage drop, translated into **particle size spectra** and **precipitation rate**.
- RV measurements and derived parameters such as **SST**, **evaporation**, **salinity**, **radiation**, **pressure**, **wind speed** and GPS data.
- For more info please visit **www.oceanrain.org**



F2: Maps of different RVs (**a**), seasons (**b**), years (**c**) and precipitation phases (**d**) sampled in OceanRAIN.

Challenges using oceanRAIN for validation

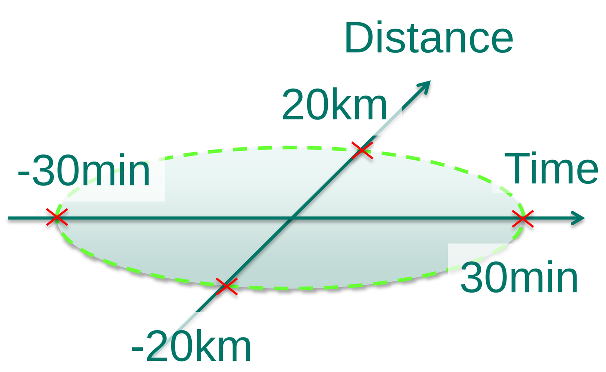
1. The precipitation phase needs to be known:

$$p_{rain} = \frac{1}{1 + e^{\alpha + \beta \cdot T + \gamma \cdot rH + \delta \cdot D}}$$

Calculation of rain probability
(after Koistinen and Saltikoff, 1998)

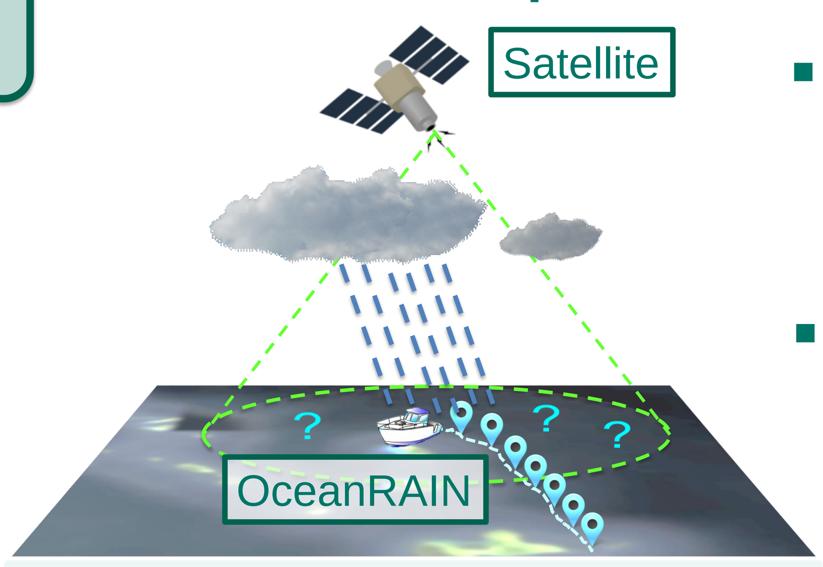
- Air temperature T, relative humidity rH and max. particle diameter D serve best to determine the **precipitation phase** (Burdanowitz et al., 2016, AMT)
- First-time usage for oceanic precipitation

2. The collocation needs to fit the parameter:



- Spatial ($\pm$20 km) and temporal ($\pm$30 min) boundaries serve as a compromise between resulting data density and decorrelation lengths of precipitation.

3. Point-to-area problem needs to be addressed:

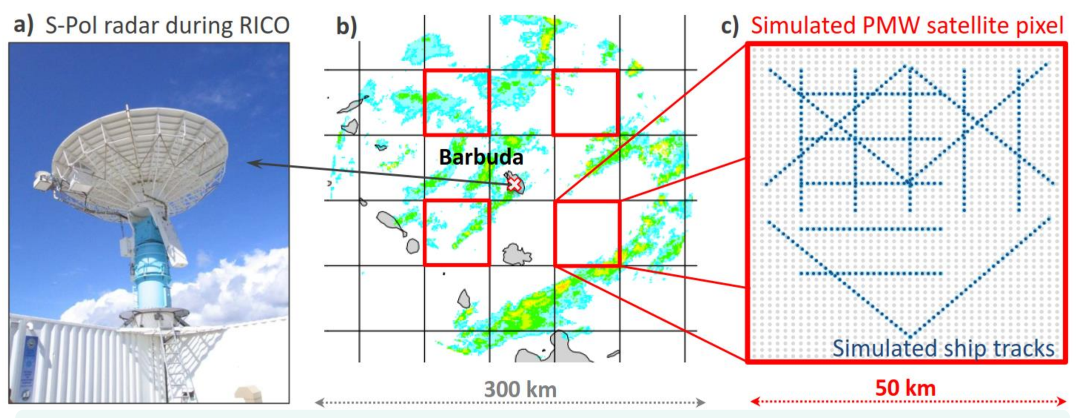


F3: Sketch of collocated ship track and satellite pixel.

- Along-track averaging of collocated OceanRAIN data to one satellite pixel
- **But:** Off-track areas are not represented by OceanRAIN data!

The track-to-area adjustment for oceanRAIN

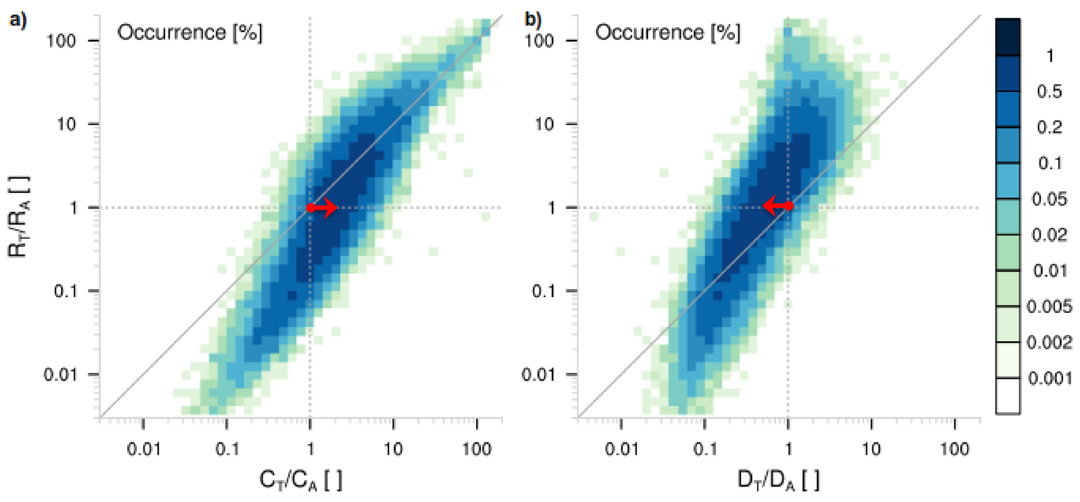
- Along-track and satellite-pixel retrieved precipitation-rate differences (see F3) can be simulated using weather **radar data**. (Burdanowitz et al., 2017)



F4: (**a**) S-Pol radar from RICO to simulate track-to-area difference. (**b**) Red box shows satellite pixel, (**c**) 16 lines: arbitrary ship tracks.

- Despite along-track averaging, systematic differences occur (F5):

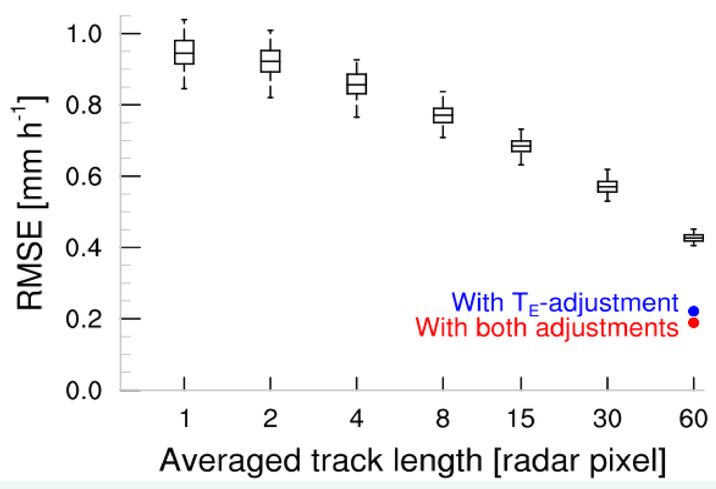
"Rain showers along the track seem to be **larger** and **weaker** compared to the satellite pixel."



F5: 2D histogram with relative occurrence in % of hit cases of average rain-rate ratio R_T/R_A as a function of (**a**) the **rain coverage** ratio C_T/C_A ; and (**b**) the **conditional rain-rate** ratio D_T/D_A.

- A statistical adjustment makes OceanRAIN **more representative** of satellite pixels using the rain event duration and the mean rain rate along the track, R_T.
- Both adjustments **reduce RMSE** (F6) by >50% (0.2 mm/h).

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(R_{T,i} - R_{A,i})^2}$$



F6: Root mean squared error as function of averaged track length with additional statistical adjustments (blue/red dots).

Take-home message

- OceanRAIN provides **oceanic precipitation and water cycle** parameters to **validate** satellite climatologies and climate models.
- A precipitation phase distinction algorithm determines the **phase** of the **falling precipitation particles** – an essential information.
- Statistical adjustments serve to make the OceanRAIN along-track data **better representative** of an **area** (e.g., a satellite pixel).
- Despite all efforts, the **point-to-area problem cannot be solved** completely; uncertainties remain for all validation applications!

Contact: joerg.burdanowitz@uni-hamburg.de

Ref

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Koistinen, J., and E. Saltikoff, 1998: Experience of customer products of accumulated snow, sleet and rain, *Adv. weather radar systems,* 397.

Max-Planck-Institut für Meteorologie
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International Max Planck Research School on Earth System Modelling