Precipitation Validation over the Ocean

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Distribution Droplet Meter

Mechanical:
- Impact causes momentum of hydrometeors on membrane (Joss Waldvogel)

Acoustic:
- Underwater probe detects size dependent sound of hydrometeors
- Vaisala

Radar:
- Microwave Rain Radar @ 24 GHz, Z-R relation

Optical:
- Löffler-Mang, fixed instrument cannot adjust to local wind direction
- 2D Video uses two cameras perpendicular to each other, no wind adjustment
- Parsivel (also a Löffler-Mang)
- HVSD – Hydrometeor Velocity and Shape Detector
- Thies – all similar to Löffler-Mang
- all designed for land use under low wind speed conditions

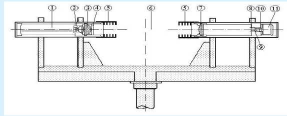
all problematic on moving ships:

→ frequently varying local wind
→ high wind speed
→ high sea state

The operation on moving ships under high sea states and wind speeds motivated the development of the ODM 470 at IFM Geomar, Kiel, Germany →

Optical Disdrometer ODM 470

- cylindrical measurement volume
- pivoting by aid of a wind vane
- adjusts perpendicular to local wind direction
- photoelectric barrier
- sensitive volume homogeneously illuminated
- 120 mm long and 22 mm diameter
- a size dependant light extinction
- cross-sectional area
- residence time

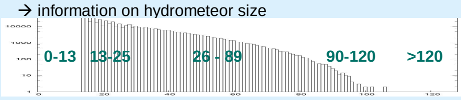


Hydrometeor Measurements

Cross-sectional area
→ Diameter of equivalent circular area [dp]
129 size bins
- with constant 0.05 mm bin size for RAIN (129)
- snowflakes may reach diameter of 22 mm (440)
- logarithmic scale (129)

$$d_P(\text{bin}) = \frac{e^{\left(\frac{\text{bin}}{94}\cdot\ln 10\right)} - 1 + e^{\left(\frac{\text{bin}-1}{94}\cdot\ln 10\right)} - 1}{2}, \qquad [\text{mm}]$$

Reference voltage 5 V attenuates with occurrence of hydrometeors
Electronic comparator measures difference voltage
→ information on hydrometeor size



Parameterizations

Measurement interval 1 minute
- date, time, reference voltage, relative windspeed)
- number of allocated size bins
- number of hydrometeors in each size bin

RAIN:
Terminal fall velocity and mass of hydrometeor (Atlas and Ulbrich, 1974)

Vfall(bin)=9.65-10.3*EXP(-1.2*(dp(bin)*12./2.)
Mtr(bin)=PI*(4./3.)*1000.*(dp(bin)/200.)3.**

SNOW: (liquid water equivalent)
Terminal fall velocity and mass of hydrometeor (Hogan, 1994)
One common parameterization for lump graupel works best (Lempio, 2007)

Vfall(bin)=7.33*(dp(bin))0.78**
Mtr(bin)=0.0000107*(dp(bin))3.1**

Rain and Snowrate in mm/h

$$R = 3600 \cdot \sum_{\text{bin}=0}^{128} n(\text{bin}) \cdot V_\infty(\text{bin}) \cdot M_{tr}(\text{bin}).$$

liquid water equivalent
bin = size bin 0 to 128, log size
v∞(bin) = terminal velocity of the hydrometeors
Mtr(bin) = mass of the hydrometeors
n(bin) = particle size distribution density (Clemens, 2002) by particle counting N(bin)

$$n(\text{bin}) = \frac{N(\text{bin})}{L \cdot D \cdot T \cdot \sqrt{ff^2 + (v_\infty(\text{bin}))^2}}$$

after Großklaus (1996)
- ff = measured local wind speed
- T = measuring time interval
- L = length
- D = diameter of sensitive volume

Collocated ship to HOAPS satellite F13, F14, F15 data for 52 precip events and 119 correct negatives in March 2005

IRS88
Hits: 50
Misses: 2
False Alarms: 0
Correct Negatives: 119

IRS88		Observation yes	Observation no	total	
	yes	50	0	50	Accuracy IRS88 0.99
	no	2	119	121	
total		52	119	171	

Disdrometer: temporal window ± 45 min around individual SSM/I overpass

Disdrometer
Hits: 52
Misses: 0
False Alarms: 0
Correct Negatives: 119

Disdrometer		Observation yes	Observation no	total	
	yes	52	0	52	Accuracy Disdrometer 1.00
	no	0	119	119	
total		52	119	171	

HOAPS: spatial window 55km radius around ship position

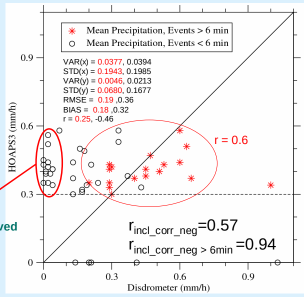
HOAPS
Hits: 45
Misses: 5
False Alarms: 2
Correct Negatives: 119

HOAPS		Disdrometer yes	Disdrometer no	total	
	yes	45	2	47	Accuracy HOAPS 0.96
	no	5	119	124	
total		50	121	171	

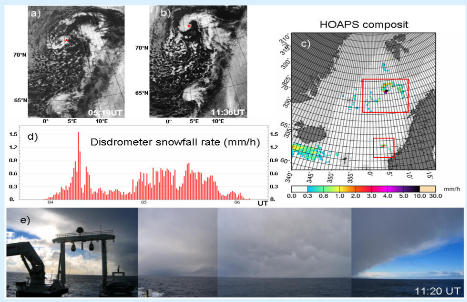
BIAS= 0.94
POD= 0.90
FAR= 0.04
POFD=0.02

GPROF2004 SSM/I: Hits 0, Misses 30
GPROF2004 AMSR-E: Hits 0, Misses 11
GPCP 1DD: Hits 2, Misses 9

Field Campaigns 2005-2008



15MAR2005: A rare polar low passage @ Celtic Explorer position



The automatic system

modified automatic measurement system (Eigenbrodt, Geomar, MPI / Clisap)

- 4 instruments available (20.000 Euro each)
- Measures RAIN and SNOW
- Automatic data back-up on memory stick
- Maintenance-free system
- Uninterruptible Power Supply (USV)
- Automatic start-up of data logging
- Software and Hardware Updates
- New device design (flow distortion)
- IRSS88 shuts-down disdrometer LED
- GPS and OBS data from ships


ODM 470


IRSS88

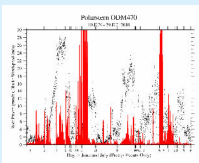

Anemometer

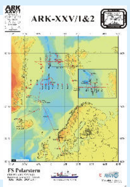

data logging PC signal box, UPS

Long-term point to area ground validation measurements started 2010

R/V Polarstern since 08 June 2010

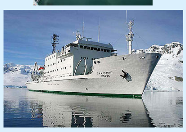
Arctic, Baffin Bay, Atlantic crossing, Antarctic and Southern Oceans





R/V Akademik Ioffe since 02 September 2010

Labradorsea, Atlantic transect, Antarctic and Southern Oceans

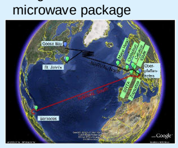


R/V Aranda since 13 September 2010

Baltic Sea LPVEX 2010

HALO Jan/Feb 2012

NAR*VAL* Next-generation Aircraft Remote-Sensing for Validation Studies using the HAMP microwave package



Project objectives

- Project within the KlimaCampus, University of Hamburg for 5+ years, sponsored by MABANAFT, Initiative-Pro-Klima
- up to 6 automatic optical disdrometers ODM470 available for continuous operation onboard ships
- Operation periods: at least 2010 to 2014
- Application of this data set for high resolution satellite and reanalysis precipitation validation within IPWG and GPM-GV
- Point-to-area validation using ship, HALO, Cloudsat, and HOAPS data
- Cooperation with institutes operating ships is highly desired

Publications

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Klepp, C., K. Bumke, S. Bakan, and P. Bauer, 2010: Ground Validation of Oceanic Snowfall Detection in Satellite Climatologies during LOFZY. Tellus 62A (2010), 4, DOI: 10.1111/j.1600-0870.2010.00459.x, 469–480.
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HOAPS
MABANAFT
Initiative Pro Klima
Universität Hamburg
Max-Planck-Institut für Meteorologie
Max Planck Institute for Meteorology
KlimaCampus