EGU2019-4907-1: Measuring fog precipitation and fog deposition in the Namib Desert

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Photography encouraged

Introduction and research area

Non-rainfall atmospheric water input (NRWI) consisting of fog, dew and soil water adsorption is an important water source for fauna and flora in (semi-)arid environments. Its measurement is extremely challenging as it requires instruments that are accurate enough to detect even smallest amounts of water input of less than 0.1 mm. **Microlysimeters**, if regularly serviced, have been proven to provide robust and high precision data of NRWI. In the frame of the **Namib Fog Life Cycle Analysis (NaFoLiCA) project**, aiming to improve the knowledge of the temporal and spatial patterns of fog in the Namib region, three of nine stations of the **FogNet measurement network** have been equipped with pairs of microlysimeters (inhouse construction after Heusinkveld et al., 2006). Data from 9 SEP 2017 until 13 OCT are analyzed, covering the period of the NaFoLiCA IOP (Spirig et al., 2019, submitted to BAMS)

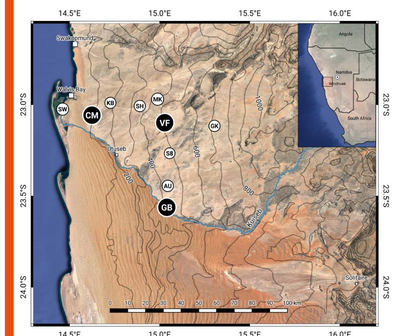

Figure 1: *Research area and FogNet stations. Black sites are equipped with microlysimeters.*

Microlysimeter specifications, functionality and evaluation

Calibration
- calibration weights of 2, 5 and 10 g placed in the center of dishes
- calibration steps/sequence: 0, 2, 7, 17, 15, 10, 0 g
- stabilization time between each step: 60 s
- raw data scaled to mm (liter per m-2) assuming a water density of 1

Evaluation
- **diameter of soil-dish has no impact on performance**
- **well suited for the purpose of NRWI deposition in arid regions**
- **no temperature dependence of electronics and load cell (tested by covering one device and comparison to 3 uncovered devices)**
- **able to record even smallest NRWI inputs accurately**

<u>drawbacks</u>
- **sensitive to external distortions (aeolian deposition, insects)**
- **needs frequent calibration and visual survey**
- **needs complete reset after heavy rainfall**

(Heusinkveld et al., 2006)

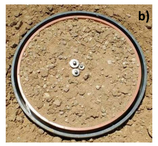

Figure 2: *a) Microlysimeter functionality and b) with calibration weights.*

Figure 3: *Juvik-type fog sampler*

Microlysimeter technical specifications

standard soil dishes (GB, VF, CM)	∅250 mm , depth 65 mm
special soil dishes (GB only)	∅140 mm , depth 35 mm
material	PVC, box with aluminum bottom
Load cell	Tedea Huntleigh 1042-7kg-C3-M6, total error 0.02% of rated output
Load cell amplifier(ADC)	Sparkfun HX711 24-bit
Controller	Arduino Pro Mini 5V/16MHz
Temperature/RH	DHT 22, accuracy ± 0.5°, ± 2% RH
Resolution	~ 1.7 mg/0.03 mm precipitation
measurement frequency	1 Hz, averaged to 1 min.
data transmission	RS232
data aquisition	data logger Campbell CR6

Performance of microlysimeters

Mean diurnal NRWI course during no-fog days

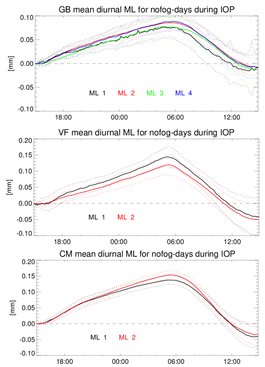

Figure 4: *Mean diurnal course of microlysimeter readings during no-fog nigths at FogNet stations GB, VF and CM (from top to bottom). Dashed lines denote standard deviation. Time refers to UTC.*

- Microlysimeters show a regular diurnal course with amplitudes between 0.1 - 0.2 mm
- minimum in the afternoon
- maximum just before sunrise
- actual water deposition through adsorption/dew and loss through daytime evaporation

Duration of fog deposition

- start: fog deposition rate rises above a certain threshold (0.01 mm/10 min.)
- end: the time of the maximum deposition

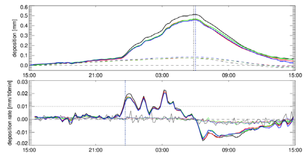

Figure 5: *top: end of fog deposition at max. value bottom: start of fog deposition when deposition rate threshold is reached the first time (example for 10 SEP 2017). Time refers to UTC.*

Performance of microlysimeters and fog samplers during selected fog events

- fog events in the investigation area are generally characterized by **stratus/low clouds advected from the coast and eventually touching the ground at elevated inland stations**
- fog samplers (Juvik-Type) measure fog precipitation while microlysimeters measure fog deposition
- fog precipitation signals coincide with the time of stratus/low cloud "touch-down"
- fog deposition also occurs during drizzle events (no "touch-down")
- other variables such as humidity, radiation, visibility, leaf wetness support the understanding of fog events

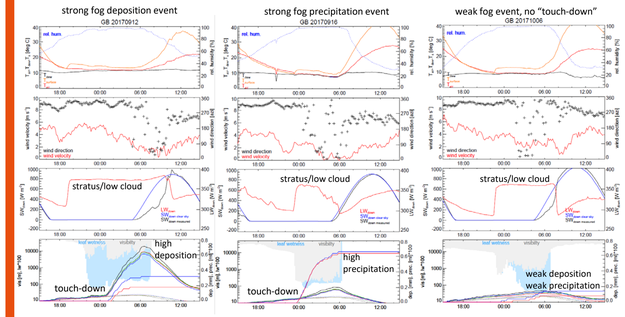

Figure 6: *Selected fog events during IOP 1 with different event characteristics. Left: stratus arrives early, touch-down occurs 6 hrs later. Center: arrival of stratus/low cloud and precipitation/deposition occur simultaneously. Right: no touch-down of stratus/low cloud.*

Duration of stratus and fog events

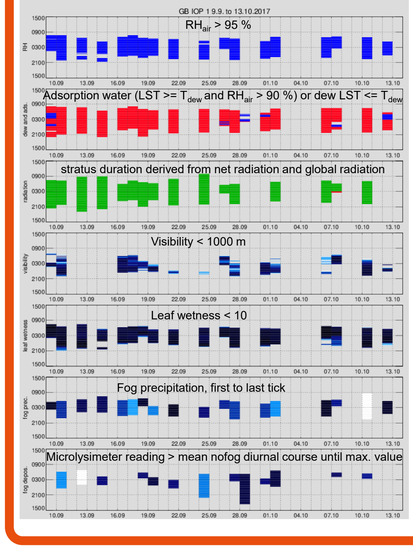

Figure 7 shows the duration of stratus/low cloud and fog events derived from various parameters.
The beginning and end of stratus/low cloud duration can be accurately detected by the analysis of the nightly net radiation (and short wave downward radiation, if the end is later than sunrise).
Fog events (i.e. stratus "touch-down") occur either when fog precipitation is measured by the Juvik-type fog samplers and/or fog deposition is measured by the micro-lysimeters. Humidity, adsorption water and dew fall, visibility and leaf wetness provide additional information to interprete durations of fog events.

Figure 7: *Duration of stratus/low cloud and fog events. Dark blue and white colors refer to low/high values, respectively. Time refers to UTC.*

Correlation between fog deposition and fog precipitation

No correlation could be found between the amounts of fog precipitation (from Juvik-type fog samplers) and fog deposition from microlysimeters. However, a clear relation between fog deposition rate and total droplet counts measured by a **Thies disdrometer** was observed (Fig. 8). Fog precipitation was only measured, when the maximum of droplet size distribution was in the smallest class (droplet diameter less than 0.25 mm) and visibility was low (< 1000 m), suggesting a stratus "touch-down".

Figure 8:
Relation between total disdrometer counts and fog deposition rate from microlysimeters.

Figure 9: *Droplet size distribution during 5 events with (blue) and without (grey) fog precipitation but fog deposition.*

Conclusions

Main findings:
- Microlysimeters are able to detect even smallest amounts of NRWI (non-rainfall water input), i.e. adsorption water, dew fall and fog deposition. The diurnal course during no-fog days/nights is very consistent (Fig. 4). This allows to determine the duration of fog deposition during fog events.
- Fog deposition starts when the deposition rate exceeds a threshold of 0.01 mm/10 min and ends with the maximum of microlysimeter reading (Fig. 5).
- Stratus/low cloud occurrence is always required for a fog event and can be easily detected in the radiation signal. However, stratus/low clouds do not always reach the ground ("touch-down"). Fog event duration is determined by the ongoing occurrence of fog precipitation and/or fog deposition together with low visibility, low cloud base and high leaf wetness (Figs. 6 and 7).
- No correlation was found between fog precipitation (measured by Juvik-type fog samplers) and fog deposition. Nights with fog precipitation but without fog deposition were observed and vice versa.
- Measurements of total droplet counts by disdrometer correlate well with fog drizzle deposition rate (Fig. 8) suggesting that disdrometer data can be used to define fog deposition when total disdrometer counts are high enough (e.g. > 1000 counts).

Future research:
- The analysis of droplet size distribution and fog precipitation needs further analysis and a more robust data base (Fig. 9).

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Related contributions at the EGU

EGU2019-13918:
The vertical and spatial structure of fog events in the Namib Desert
Hall X5, Board X5.297, AS1.41
Thursday, 11 Apr 2019, 10:45-12:30

EGU2019-17459:
Modeling the life cycle of fog in the Namib desert with COSMO-PAFOG
Hall X5, Board X5.299, AS1.41
Thursday, 11 Apr 2019, 10:45-12:30

EGU2019-18036:
An animated combination of satellite and ground measurement to visualize fog as a water source
PICO4.14, HS7.6/AS4.23/NP3.4
Monday, 08 Apr 2019, 09:00-10:15

EGU2019-5237:
Fog and low clouds in the Namib: Patterns and processes
Room 0.49, AS3.8
Thursday, 11 April 2019, 08:45-09:00

download the poster as pdf

Find out more about the NaFoLiCA project

Follow the projects process on ResearchGate