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A new high spatial resolution low stratus/fog retrieval for the Atacama Desert

Lukas Lehnert, Boris Thies, and Joerg Bendix

The Atacama Desert is considered one of the driest places in the world. Along the coastline, however, small-scale fog oases are home to a special vegetation and fauna that is supplied with water by fog. The fog water is also used by humans for industrial projects. So far, knowledge about fog and low stratus (FLS) clouds and their physical properties is limited because only local observations or spatial products from satellite data with coarse resolution are available. The existing satellite products usually do not capture the local patterns resulting from the complex topography. Consequently, we developed the first fog and low stratus climatology with 30 m spatial resolution based on over 400 Landsat scenes recorded since 1986. The new product provides valuable estimates of the optical and microphysical properties of FLS. Fog and low stratus over the Pacific Ocean showed optical thicknesses around 13.5, which decreased to 4.2 over land. The effective radii were 5.3 μm. The liquid water path ranged from 71.0 g m^{-2} over the ocean to 14.9 g m^{-2} on land. The climatologies of the new Landsat product were successfully validated against those of the MODIS Cloud property product over homogeneous surfaces. In areas with heterogeneous topographies, the new product outperforms existing products with coarse spatial resolutions if compared to in situ measurements. This shows the general need for cloud products with high spatial resolution in areas where the development of small-scale clouds is favoured e.g., by a complex topography.

Related References:

Lehnert, L., Jung, P., Obermeier, W., Büdel, B. & Bendix, J. (2018): Estimating Net Photosynthesis of Biological Soil Crusts in the Atacama Using Hyperspectral Remote Sensing. Remote Sensing 10, 891. DOI10.3390/rs10060891

Lehnert, L., Thies, B., Trachte, K., Achilles, S., Osses, P., Baumann, K., Schmidt, J., Samolov, E., Jung, P., Leinweber, P., Büdel, B. & Bendix, J. (2018a): A Case Study on Fog/Low Stratus Occurrence at Las Lomitas, Atacama Desert (Chile) as a Water Source for Biological Soil Crusts. Aerosol and Air Quality Research 18, 254-269.

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Microlysimeter and fog collector measurements in the Namib desert

Christian Feigenwinter, Roland Vogt, Jarl Are Larsen, Robert Spirig, and Joel Franceschi
(christian.feigenwinter@unibas.ch)

The measurement of non-rainfall atmospheric water input (NRWI) consisting of fog, dew and soil water adsorption 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 have been proven to provide robust and high precision data of NRWI, even in arid environments. We present results from two intensive observation periods (IOPs) from SEP/OCT 2017 and FEB/MAR 2018 conducted in the frame of the Namib Fog Life Cycle Analysis (NaFoLiCA) project. Three out of nine stations of the FogNet measurement network have been equipped with pairs of microlysimeters (adapted self-construction after Heusinkveld, 2006). Together with Juvik-type passive fog collectors (metal mesh wrapped in a cylinder) and standard meteorology measurements (temperature, humidity, wind and radiation), the amount of NRWI for days with/without fog is analyzed. It is shown that days/nights without fog show a constant and persistent diurnal course of NRWI with deposition starting around sunset and evaporation starting shortly after sunrise. Deviations from this curve in microlysimeter data are used, together with measurements of fog precipitation, to analyze more than 20 fog events with respect to duration, intensity and amount of fog precipitation and fog deposition, including additional information from leaf wetness sensors, visibility sensors and a disdrometer at the station of the Gobabeb Research and Training Center. No clear relation between fog precipitation and fog deposition could be observed. However, the relation between microlysimeter data and the smallest disdrometer dropsize distribution class (< 0.125 mm) followed a clear exponential function.

8th International Conference on Fog, Fog Collection and Dew
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Quantification of Dew and Fog Water Inputs for Swiss Grasslands

Andreas Riedl, Yafei Li, and Werner Eugster
ETH Zürich, Institute of Agrictultural Sciences, Departement of Environmental Systems Science, Zürich, Switzerland (andreas.riedl@usys.ethz.ch)

Dew and fog occur rather frequently in temperate ecosystems. Yet, little is known about the quantity of water input of dew and fog events to grassland ecosystems and its influence on plant water relations. The goal of this project is to quantify dew and fog water yields for Swiss grasslands over a representative spatial and elevational scale and to assess its effect on plant water relations now and in the future.

Dew and radiation fog form under similar conditions, when thermal energy is lost from the soil surface to the atmosphere. As a consequence, gaseous water vapour from the air condenses on the leaves, or fog droplets form on condensation nuclei in the atmospheric air and are then deposited to plants.
These two phenomena both provide water to ecosystems. We thus hypothesize that during summer fair weather and drought periods, nocturnal dew and fog formation have a measurable and non-negligible quantitative effect on the water status of plants in Swiss grasslands.
This is due to the fact that plants cannot only take up water via their roots, but also directly via the leaves, referred to as foliar water uptake (FWU). We will investigate the role of this effect during intensive field campaigns. Furthermore, there may be other physiological effects of dew and fog, such as enhanced cooling through leaf-wetting during the early morning hours of hot summer days.

To quantify the amount of dew and fog water that is provided to grassland leaves under today's climate conditions in Switzerland, existing long-term meteorological field sites will be supplemented with lysimeters, visibility and leaf moisture sensors at ten locations with different climatic conditions and elevations throughout Switzerland.
Self-made high-precision lysimeters are developed and constructed to measure even small weight gains on plant leaves that are caused by dew and fog water inputs. At each field site, three lysimeters will be installed as replications. Visibility sensors (MiniOFS, Sweden) allow to determine if water inputs stem from solely dew or from dew and fog in combination (fog: visibility < 1000 m). The leaf moisture sensors (LWS, Decagon, USA) give a redundant measurement whether leaves really are wet.
The observed data will be set into relation with meteorological measurements to establish a functional relationship that allows for explicit spatial estimations of dew formation and fog deposition. In a further step, this functional relationship will be used in combination with the most recent climate scenarios for Switzerland (CH2018) in pursuit of estimating the effect in the future, where prolonged drought periods during summer fair weather conditions tend to increase.
Overall, the outcome of the project is expected to be useful for grassland management decisions, with impacts on grassland productivity and resilience today and in the future.

8th International Conference on Fog, Fog Collection and Dew
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Natural dew conditions in the laboratory

Daniel Beysens (1), Joachim Trosseille (2), Anne Mongruel (2), and Laurent Royon (3)

(1) Physique et Mecanique des Milieux Heterogenes, CNRS, ESPCI Paris Tech, PSL Research University, Sorbonne Universite, Univ. Paris Diderot, Paris, France; OPUR, Paris, France (daniel.beysens@espci.fr), (2) Physique et Mecanique des Milieux Heterogenes, CNRS, ESPCI Paris Tech, PSL Research University, Sorbonne Universite, Univ. Paris Diderot, Paris, France, (3) Univ. Paris Diderot, CNRS, Sorbonne Paris Cite, Laboratoire Interdisciplinaire des Energies de Demain, Paris, France

Natural dew condensation on a substrate is the result of outdoor radiative cooling below the dew point temperature of the ambient atmosphere. Studies of this phenomenon in the laboratory have been carried out so far by contact cooling. Such procedure is different from radiative cooling and can lead to differences in the condensation process, especially for thin and light structures where contact cooling becomes inefficient in contrast to radiative cooling.
This study describes a device making it possible to perform dew condensation in the laboratory by radiative cooling. It is based on a radiative deficit between a substrate in a humid environment and a cold source. The studied substrate is positioned on a support connected to a precision balance to record the evolution of the condensed mass. The substrate is set in the center of a condensing chamber of approximatively 1 L and supplied in humid air at room temperature. A cold source is positioned under the condensing chamber such as a radiative heat flux is established between source and substrate through a window and a conical mirror surrounding the substrate. The window is made of a polypropylene film, transparent to the infra-red (transmittancy >0.9) and the mirror is an aluminum foil, with reflectivity larger than 0.8. Three thermocouples record the temperature of the coming air, the mirror and the radiative window. Two cameras visualize, through windows, the evolution of condensation on the substrate.
The different heat fluxes exchanged with the substrate are of different nature: (i) radiative (ii) latent heat due to condensation (iii) convective with ambient air (iv) conductive through the support. The incident radiative flow on the studied substrate over the entire wavelengths is measured thanks to a sensor of radiative flow. For materials of great emissivity the value of the incidental heat flux is about 350 W/m2, leading to a radiation deficit of about 55 W/m2 for water (emissivity 0.95), a value currently encountered with natural dew. With incident humid air flow 0.8 L/min., temperature 20.3 °C and relative humidity 85 %, the condensation rate is found around 0.6 L for 10h., corresponding to usual time duration for natural dew. This value corresponds to a latent flux of 40 W/m2. The energy balance gives convective and conductive losses of about 15 W/m2, which compares well with current estimations of the support heat conductivity and convective heat transfer coefficient.
Examples of condensation on different substrates that cannot be efficiently cooled by contact will be presented. Light materials structures (spring, bulb), plants (cactus, flower) and insects (spider, stag beetle) can indeed exhibit interesting condensation features. It is anticipated that small living animals and insects can be studied by this technique.

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Rough surfaces increase dew drop collection

Daniel Beysens (1), Joachim Trosseille (2), Anne Mongruel (2), Laurent Royon (3), and Marie Gabrielle Medici (4)

(1) Physique et Mecanique des Milieux Heterogenes, CNRS, ESPCI Paris Tech, PSL Research University, Sorbonne Universite, Univ. Paris Diderot, Paris, France; OPUR, Paris, France (daniel.beysens@espci.fr), (2) Physique et Mecanique des Milieux Heterogenes, CNRS, ESPCI Paris Tech, PSL Research University, Sorbonne Universite, Univ. Paris Diderot, Paris, France, (3) Univ. Paris Diderot, CNRS, Sorbonne Paris Cite, Laboratoire Interdisciplinaire des Energies de Demain, Paris, France, (4) Universite de Nice, LPMC-CNRS-UMR 7336, Nice, France

Gravity collection of droplets is the main phenomenon limiting dew water collection for its use as an alternative source of water. The amount of collected water remains often limited by the drops runoff, the latter remaining attached on the substrate by pinning forces and evaporating in the morning. To reduce this limitation one can act on the condensation surface texture in order to enhance drops mobility under gravity, the latter being passively collected. Micropatterning such as micro grooving can improve collection efficiency. However, micropatterning is in general difficult to implement on large surfaces. A simple and inexpensive technique, sand blasting, is studied to obtain microstructured surfaces in order to promote efficient drop collection. The advantages of this technique are (i) the possibility of creating a random roughness and (ii) the simplicity of the method to treat large surfaces.
Experimental investigation.of water vapor condensation on substrates developed with sand blasting is thus presented. The study was performed in a temperature and humidity-controlled environmental chamber at ambient pressure. Duralumin plates, 173 mm x 173 mm x 2 mm dimensions, were sand blasted with 25 μm silica beads projected with a pressure of 2 bars pressure. It results a mean roughness Ra = 2 μm, to be compared with the natural roughness of plates Ra = 0.46 μm. Plates are set vertical; they are cooled below the dew point thanks to a Peltier element. Condensation is continuously measured (i) visually by an image treatment of the drops and (ii) by weighing a tissue set within 0.1 mm from the bottom of the plate. Condensation is simultaneously performed for sake of comparison with the same, smooth, plate placed aside the rough plate.
Results show that sand blasting, by increasing the number of nucleation sites, leads to a better collection rate than the same, smooth substrate, provided that sandblasting does not increase too much the surface roughness. Edges of the substrate, where drops grow faster, also improve water collection, early shedding of edge drops making such drops acting as natural wipers. Sand blasting and edge effects thus increase significantly the rate of collection of dropwise condensation; gains with respect to the same smooth surface of about 30% can be commonly obtained. This study shows in addition that coalescence events during condensation lower the drop pinning forces and have an important positive impact on drop sliding.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
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CFD study of a corrugated hollow cone for enhanced dew yield

Daniel Beysens (1), Robert Cook (2), Enrico Crobu (2), and Laurent Royon (3)

(1) OPUR, Paris, France (daniel.beysens@espci.fr), (2) BuroHappold Engineering, Bath, United Kingdom, (3) Univ. Paris Diderot, CNRS, Sorbonne Paris Cite, Laboratoire Interdisciplinaire des Energies de Demain, Paris, France

Dew condensation is the result of cooling by radiative deficit between a substrate and the atmosphere. The yield is limited by the latent heat of condensation and the heat flux between the substrate and the atmosphere, which increases with wind speed. Then dew yield can be enhanced in hollow structures like hollow cones where the influence of wind is lowered. Passive dew collection involves in addition the shedding of small droplets by gravity, which increases with the angle of the structure with horizontal. However, radiative cooling diminishes with this angle. A good compromise is a tilt angle of 30° with horizontal. Hollow cones with 60° half-angle give thus good results for dew condensation and dew collection.

Another process improves the dew drop collection efficiency: On edges or other singularities, dew drop grow faster thanks to a solid angle of vapor collection larger than in the middle of the substrate (Phys. Rev. E 90, 062403 (2014).). Then edge drops detach sooner and act as natural wipers. In addition, corrugation increases the local tilt angle with horizontal, thus increasing locally the gravity forces acting on the drops.

In order to combine all positive effects (hollow structures, edge effects), a corrugated, w-shaped hollow cone is compared to the same, smooth structure by Computational Fluid Dynamics. Two softwares were used: ANSYS CFX for detailed aerodynamics where the computational domain is modelled to obtain a fully developed wind profile assuming an unobstructed inlet and COMSOL Multiphysics for heat flux, including radiative exchange surface-to-sky and surface-to-surface. Local temperatures are obtained, which can be related to the dew yield within some assumptions that will be discussed.

The cone dimensions are 4.635 m upper radius, 0.2115m lower radius, 2.554 m height with upper part at 8 m above the ground. The cone external sides and the lower hole are thermally insulated. Air temperature is set at 15°C and wind speed is varied from zero to 5m/s (CFX) or at two typical values, 0.0001 and 2 m/s (COMSOL).

Turbulence is seen at all speeds but stagnation of the flow is also observed, which limits the convective heat exchanges and facilitates dew formation. For 0.0001 m/s windspeed, mean cone cooling is found to be 5.8 K (smooth) and 6.5 K (corrugated), and for 2 m/s windspeed, 5.5 K (smooth) and 5.2 K (corrugated). Corrugation increases radiative and convective heat exchange. At low speed, convective heat exchange is however similar for both smooth and corrugated surfaces, and corrugation increases cooling. At higher air flow velocities, convective heat exchange is larger for the w-cone and cooling is smaller than found on the smooth cone. However, the difference (0.3 K) remains small, which makes the w-cone in general a better dew condenser.

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Dew condensation on polyacrylamide gels

Daniel Beysens (1), Ruddy Urbina (2), Sylvain Lefavrais (1), Laurent Royon (3), Anne Mongruel (4), and Wenceslao Gonzalez Vinas (2)

(1) Physique et Mecanique des Milieux Heterogenes, CNRS, ESPCI Paris Tech, PSL Research University, Sorbonne Universite, Univ. Paris Diderot, Paris, France; OPUR, Paris, France (daniel.beysens@espci.fr), (2) Dept. Physics and Appl. Math., University of Navarra, Pamplona, Spain, (3) Univ. Paris Diderot, CNRS, Sorbonne Paris Cite, Laboratoire Interdisciplinaire des Energies de Demain, Paris, France, (4) Physique et Mecanique des Milieux Heterogenes, CNRS, ESPCI Paris Tech, PSL Research University, Sorbonne Universite, Univ. Paris Diderot, Paris, France; OPUR, Paris, France (daniel.beysens@espci.fr)

Polyacrilamide gels are known to absorb liquid water by a very large amount. Static or osmotic pressure can then be used to recover water. Once mixed with soil in arid regions such swollen gels can give water to the young plants to help the roots to reach the deep, humid soil layers. There is an obvious interest to swell the gels with water obtained at the place where they have to be used. In this aspect, collecting water from air by dew condensation is very appealing. This study thus addresses the conditions where the gels can collect dew water.
For this purpose a setup was designed consisting of a 10 cm diameter silicon plate, either bare or filled of a gel layer, and cooled by a Peltier element. The Peltier element is hold by a motorized support which moves it from an upper position, where contact with the plate is ensured, to a lower position, where the plate, suspended by holders attached to a balance, can be weighted. Experiments were performed with Aquabsorb 3005, medium-size (0.3 - 1 mm), a granular polyacrylamide manufactured by SNF Floeger, a cross-linked copolymer of acrylamide and potassium. A layer of grains with thickness about 1.5 mm is deposited on the plate. The device is placed in a climatic chamber with controlled air temperature (20°C) and relative humidity (50%), yielding a dew point temperature Td=9.3 °C.
Three kinds of experiments were performed. With Tp the plate temperature, case (i) is concerned with the reference case where the bare Si substrate is at Tp=Td-4°C. It corresponds to a condensation rate of 0.09 mm/h. Case (ii) corresponds to condensation with gel below the dew point at also Tp=Td-4°C. It sees a constant increases of mass, with slope 1.5 kg/kg water mass per gel mass per h. or 0.14 mm/h., with some weak deviations from linearity at late times corresponding to the fact that gel swelling has to diminish until it reaches its maximum. Case (iii) is concerned with water adsorption above the dew point (Tp=Td+4°C). Saturation occurs with a typical time of 250 min., giving saturation at 0.2 mm (0.2 kg/kg) after about 24h.
Such preliminary experiments thus show that gels, when cooled below the dew point temperature, can condense water at a larger rate than a bare substrate. In addition, when gel temperature is above the dew point temperature, water adsorption still occurs. Further studies will proceed by using different gels placed in different humid air conditions and plate temperature to determine the best gel candidates to harvest atmospheric moisture.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-39

C-FOG Project for Marine Fog

Ismail Gultepe (1), Harindra J.S. Fernando (2), Eric Pardyjak (3), Qing Wang (4), Chris Hocut (5), Edward Creegan (5), Sebastian W. Hoch (6), David D. Flagg (7), Norman Scantland (8), Serge Desjardins (9), Mark Pilon (9), Michael Pavolonis (10), Andrew J. Heymsfield (11), Sasa Gabersek (7), Sandeep Wagh (2), and Denny P. Alappattu (12)

(1) Environment and Climate Change Canada, MRD, Toronto, ON, Canada, and UOIT, Engineering and Applied Science Department, Oshawa, ON, Canada, (2) Department of Civil and Environmental Engineering and Earth Sciences, and Department of Aerospace and Mechanical Engineering, University of Notre Dame, Notre Dame, IN, USA, (3) Department of Mechanical Engineering, University of Utah, Salt Lake City, UT, USA, (4) Department of Meteorology, Naval Postgraduate School, Monterey, CA, USA., (5) US Army Research Laboratory, White Sands Missile Range, NM USA, (6) Atmospheric Sciences Department, University of Utah, Salt Lake City, UT, USA, (7) U.S. Naval Research Laboratory, Marine Meteorology Division, Monterey, CA, USA, (8) Meteorology and Oceanography Centre, Canadian Forces Base, Halifax, NS, Canada, (9) Environment and Climate Change Canada, MSC, Predictions Services, Halifax, NS, Canada, (10) NOAA CIMSS/NESDIS, University of Wisconsin – Madison 1225 W. Dayton St., Madison, WI, USA, (11) NCAR/MMM, 3450 Mitchell Lane, Boulder, CO, USA, (12) Moss Landing Marine Laboratory, Moss Landing, CA, USA, and Department of Meteorology, Naval Postgraduate School, Monterey, CA, USA

Abstract
The objective of the C-FOG (Toward Improving Coastal Fog Prediction) project is, using in-situ observations and numerical weather prediction models, to improve fog predictability over coastal environments. This project took place over Eastern Canada (Nova Scotia, NS and the Island of Newfoundland, NL) coastlines and open water environments during August-October of 2018 where environmental conditions play an important role for late-season fog formation. The C-FOG field campaign was designed optimally measure fog variability in time and space, with tools including ground, airborne, and shipborne in-situ instruments, remote sensing platforms, as well as numerical models. Visibility and winds are the most critical weather-related phenomena affecting marine and aviation transportation; they contribute is to more than 70% of weather-related delays.

In-situ and remote sensing instruments were located at a supersite (Ferryland, NL) and four satellite sites, as well as on a research sea vessel. These instruments measure high-frequency wind, gust, and turbulence, droplet and aerosol microphysics, radiation, and thermodynamic properties of the environment. Special platforms were developed for fog microphysics investigation, including a gondola carrying sensors such as CDP (cloud droplet probe) and BCP (backscatter cloud probe) for droplets ranging in size from 1-75 μm. A LPM (laser precipitation monitor) measured hydrometeors from 100 μm to mm in diameter and an OPC (optical particle counter) covered particles larger than 0.3 micron in 20 spectral channels, providing information for fog and drizzle discrimination. Remote sensing platforms (e.g. MWR (microwave radiometer), Ceilometer, Lidar), meteorological towers, tethered balloons, UAV platforms, and GOES-R products (e.g., fog coverage and droplet size) provided fog information over short time and space scales. These data are used for fog parameterization development, with a focus on moisture advection and turbulent mixing. The outcome of this project is to validate and improve numerical model predictions of fog and to develop fog monitoring systems. Investigators will use observations to evaluate the role of dynamical conditions on fog life cycles, and to develop integrated observing systems utilizing model predictions. Overall, C-FOG measurements will be used to evaluate prediction challenges and emphasize the importance of current work.

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Non-rainfall water inputs in Hulu catchment of Qilian Mountains, northwest China

Chuntan Han, Rensheng Chen, and Zhangwen Liu
The Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou, Gansu, China

Purpose: Non-rainfall water inputs (NRWIs) mainly includes dew/frost, fog water and water vapor adsorption (Agama et al., 2006; Ucles et al., 2013). NRWIs has important ecological significance for the survival and growth of animals, plants and microorganisms in a dry environment (Beysens et al., 2016). NRWIs is frequently abundant in high mountain areas. What is the effect of NRWIs on the hydrological cycle and response to climate change in the high mountain region?
Methods: Lysimeter is a container used to measure gains and losses of water including NRWIs. To measure the amount of dew water by two lysimeters from 2013 and to harvest fog water use three identical standard fog collectors in different elevation from July 2014.
Results: From 2013 to 2016, dew water quantity observed in alpine grassland area of Hulu catchment was 32.5mm, 31.7mm, 29.4mm and 30.0mm, respectively. One year fog collecting observational data shows: fog water with elevation gradient is obvious. NRWIs amount can reach 5.1-6.2% of the precipitation in the same period, which is an important part of the hydrological process in this area. Frequency of NRWIs continue to occur is considerably higher than the precipitation; NRWIs can be seen as the adjustment amount water resource of alpine mountain hydrological cycle process.
Interpretation: As the temperature increases, the atmospheric water holding capacity increases and the water cycle accelerates. The change relationship between saturated water vapor pressure and temperature represents an increase of one degree Celsius in temperature will increase the atmospheric water content by 6.1-7.0%. With the increase of atmospheric moisture content, the occurrence frequency of NRWIs events and amount also increases.
Conclusion: NRWIs is an important part of the hydrological process in the high mountain area. NRWIs is of great significance for maintaining fragile ecosystems in high mountain areas and is a sustained-release agent for ecological and hydrological processes in high mountain areas. The condensation and evaporation process of shallow soil may be one reason why the surface energy is not balanced. Seasonal NRWIs frequent enrichment is a potential exploration point for hidden water sources in high mountains.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-49

Composites of hydrophilic and hydrophobic fibers with controlled mechanical and wetting properties for water harvesting

Joanna Knapczyk-Korczak (1), Daniel P. Ura (1), John P. Chiverton (2), and Urszula Stachewicz (1)

(1) International Centre of Electron Microscopy for Materials Science, Faculty of Metals Engineering and Industrial Computer Science, University of Science and Technology AGH , Kraków, Poland (jknapczyk@agh.edu.pl), (2) School of Engineering, University of Portsmouth, Portsmouth, UK

In our studies we investigated surface and mechanical properties of composites made of hydrophilic and hydrophobic electrospun fibers to water harvesting applications. As a hydrophilic polymer we used polyamide 6 (PA6) and hydrophobic polystyrene (PS).
Prior electrospinning PS was dissolved in dimethylformamide (DMF), at 25%wt. and PA6 in formic and acetic acids with ratio 1:1, 12%wt. The hydrophobic, PS and hydrophilic, PA6 composites were produced using two nozzles electrospinning setup (Apparatus EC-DIG with Climate-control, IME Technologies, the Netherlands). Fibers were electrospun layer by layer and hydrophilic and hydrophobic parts were controlled with the deposition time. Fibers morphology and sizes were analyzed by scanning electron microscope (SEM, Merlin Gemini II, ZEISS, Germany). Water contact angle was measured in horizontally and vertically on produced fibers and composites. The mechanical properties were verified using tensile module with 1 N Load Cell (Kammrath Weiss GmbH, Germany). Prior the mechanical testing the thickness of the sample was measure with versatile digital microscope DinoCapture 2.0 (Dino-Lite Europe/IDCP B.V., The Netherlands)
The water contact angle measured horizontally for PS fibers was 142 $\pm$ 2o, whereas for PA6 was 45 $\pm$ 2o. For the composites, the water contact angle was decreased up to 123 $\pm$ 2o with the increase of PA6 fraction. Simultaneously, this composite had the best mechanical properties. Additionally, the wetting experiment in vertical settings showed possibility to collect water in very effective way. Composites combine hydrophobic and hydrophilic fibers show great possibility to be applied in fog collectors to increase the potential of catching larger fraction of rain and fog droplets.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-53

Detection of Fog Involving Heavy Pollutants by Using the New Geostationary satellite Himawari-8

Hongbin Wang (1,2) and Zhiwei Zhang (3)

(1) Key Laboratory of Transportation Meteorology of China Meteorological Administration, (2) Jiangsu Institute of Meteorological Sciences, Nanjing 210009, China (kaihren@163.com), (3) Jiangsu Meteorological Service Center, Nanjing 210008, China

Himawari-8 is the new geostationary satellite of the Japan Meteorological Agency (JMA) and carries the Advanced Himawari Imager (AHI), which is greatly improved over past imagers in terms of its number of bands and its temporal/spatial resolution. In this work, two different methods for the detection of the different levels of fog involving heavy pollutants by using the Himawari-8 were developed in China. The two different methods are the method of the difference between the 11.2 um and 3.9 um brightness temperatures (BTD3.9-11.2) and the method of 3.9 um Pseudo-Emissivity (ems3.9). The 3.9 um Pseudo-Emissivity is the ratio of the observed 3.9 um radiance and the 3.9 um blackbody radiance calculated using the 11.2 um brightness temperature. We identified the parameters optimal threshold at the 2400 stations and the grid points using the BTD3.9-11.2 and ems3.9 for different levels of fog involving heavy pollutants. Results on land and sea from the two methods were compared with surface observations from 2400 weather stations in China and CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) VFM (Vertical Feature Mask) products. The results show that both the method of BTD3.9-11.2 and the method of ems3.9 can accurately identify the different levels of fog involving heavy pollutants and the accuracy of ems3.9 method is slightly better than the BTD3.9-11.2. The accuracy of two methods has increased significantly and the false alarm rate has significantly decreased with the decrease of the visibility. When the visibility is less than 50 m, the HR, FAR and KSS of the BTD3.9-11.2 method (the ems3.9 method) were 0.89 (0.90), 0.15 (0.15) and 0.74 (0.75), respectively. When mid- or high-level clouds were removed using surface temperature of the ground observations, the HR and KSS of two methods for the different levels of fog has increased significantly, and the FAR has significantly decreased. When the visibility is less than 1000 m, the HR of the BTD3.9-11.2 method (the ems3.9 method) is increased to 0.81(0.85) from 0.71 (0.74), the FAR is decreased to 0.12 (0.13) from 0.27 (0.28), and the KSS is increased to 0.69 (0.72) from 0.44 (0.46). The KSS of two method increase by 0.23 and 0.26, respectively. Three cases analysis show that the fog area can be clearly identified by using the BTD3.9-11.2, ems3.9 and RGB composite image. The results of the detection of sea fog by using Himawari-8 data and using CALIPSO VFM products have consistency.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-56

Daytime Sea Fog retrieval over the Yellow Sea based on FY-4A data Using Convolutional Neural Networks

Shuxiao Liu and Li Yi

College of Ocean and Atmospheric Sciences, Ocean University of China, Department of Marine Meteorology, Qingdao, China (liushuxiao@stu.ouc.edu.cn)

Sea fog is a dangerous weather phenomenon over Yellow Sea. It hazards maritime activities such as fishery operations and traffic by low visibility. It is necessary to monitor sea fog to reduce the influence on navigation and transportation. Due to rare meteorological stations over ocean, using satellite data to detect sea fog becomes the best choice. Geostationary-orbit satellites (GEOs) are able to acquire the continuous satellite cloud imagery, which provides the sea fog distribution as well as the potential possibility of sea fog short time forecasting. In particular, FY-4A satellite launched in 2016 with 14 channels (3 visible channels and 11 infrared channels) could scan the Yellow Sea as short time as every 15 minutes in the first half hour and every 5 minutes in the second half hour. Since Convolutional Neural Network (CNN) architecture can classify the content of input data by automatically learning hierarchies of features and save lots of time compared with increasingly sophisticated sea fog detection methods, CNN would be highly suitable for image segmentation and then used for monitoring sea fog. Based on FY-4A AGRI multispectral data images and sea fog mask retrieved by threshold algorithm method at daytime over the Yellow Sea in 2018, we use CNN method to train the data and then try to detect sea fog. After the training, the CNN method could fast get the sea fog distribution based on FY-4 data alone. In case validation, sea fog retrieval of CNN method is similar with sea fog mask of previous threshold algorithm method. It indicates that the CNN method would reliably detect daytime sea fog distribution.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-66

Methodology and synergetic approach to better understand and forecast the fog life cycle based on ground-based remote sensing instruments and in-situ sensors.

Jean-Charles Dupont (1), Martial Haeffelin (2), Felipe Toledo (3), Julien Delanoe (4), and Marc-Antoine Drouin (5)

(1) UVSQ, IPSL/LMD, Palaiseau, France (jean-charles.dupont@ipsl.polytechnique.fr), (2) CNRS, IPSL, Palaiseau, France (martial.haeffelin@ipsl.fr), (3) MODEM, Ury, France (felipe.toledo@lmd.polytechnique.fr), (4) UVSQ, LATMOS, Guyancourt (julien.delanoe@latmos.ipsl.fr), (5) CNRS, LMD, Palaiseau (marc-antoine.drouin@lmd.polytechnique.fr)

Low visibility during fog events is a result of complex radiative, turbulent and microphysical processes as well as interactions between the atmospheric boundary layer (ABL) and the underlying surface. The mechanisms of fog formation, development and dissipation are very complex and have been extensively studied with a series of numerical simulations and comprehensive observational programs including in-situ measurements and remote sensing instruments.
Our study is based on multiple observation sources. Firstly, backscatter profiles of ceilometer (and automatic lidars) to trace aerosol hydration in clear atmosphere, a precursor to fog formation, and the transition from fog to low stratus. In Europe, these ceilometers are found every 100km, and in some areas every 10km. Secondly, Doppler lidar and sodar to trace the vertical structure of dynamics (wind speed, TKE, CT2) and identify thresholds leading to clear-sky stratification or fog dissipation. Thirdly, cloud radar and microwave radiometer measurements can accurately characterize processes within the fog layers. The radar retrieves high-resolution profiles of reflectivity and Doppler velocity, while scanning cloud radars can perform 3D observations of these quantities. Radars and radiometers are deployed on about fifteen super-sites in Europe as part of the ACTRIS research infrastructure that strives to improve instrument calibration and data quality. These devices will likely become more numerous in the future.
We present three major results, (1) the Parafog algorithm that uses the temporal evolution of attenuated backscatter measurements to derive pre-fog formation alerts, (2) a tool to estimate vertical profiles of fog properties combining one calibrated cloud radar and in-situ granulometer to better document and understand the physical processes, and (3) some preliminary results concerning the turbulence parameters that can have a significant impact on the fog life cycle, based on more than 100 fog events observed at the SIRTA observatory (Palaiseau, France).
This instrumental synergy provides us the opportunity to better document the spatiotemporal heterogeneities of fog at several scales, thus enabling us to progress in the development of a decision support tool for nowcasting of formation and dissipation of radiative fog and stratus lowering fog. Such a tool would be complementary to prediction tools based on NWP models.

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A new method to retrieve cloud-edge top heights over Arctic Sea using cloud-shadow based on MODIS

Xueying Cheng and Li Yi

College of Ocean and Atmospheric Sciences, Ocean University of China, Department of Marine Meteorology, Qingdao, China (Sherry9701@126.com)

Cloud top height plays an important role in the earth's radiation budget and climate change. However, the accurate cloud top height retrieval based on satellite data over the Arctic Ocean remains a challenge. Especially, it is more difficult to retrieve cloud-edge top heights (CETH) based on Moderate Resolution Imaging Spectroradiometer (MODIS) in spite of its high spatial resolution. Clouds cast shadows over sea ice surface, there is geometric correlations between clouds and cloud shadows, higher cloud top height faces with larger cloud shadows; thus, this method can determine CETH. Based on this concept, geometric relationships were established between clouds and their shadows using satellite data and satellite-solar geometries. In this paper, we use Geometry-based cloud-shadow detection method to retrieve the CETH according to MODIS data over Arctic oceanic region. In details, we first calculate the distances of cloud shadows according to the reflectance data from MODIS and then determine the CETH by using cloud-shadow detection methods, and finally examine the precision of CETH estimation by compared to Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data. In this study, 16 cases in August 2016 and 2018 over Arctic oceanic region are analyzed, the mean difference and standard deviation of the differences between CETH obtained using cloud-shadow detection methods and CALIPSO are -101.068m and 1.363km respectively, while the bias and STDE of MODIS CETH – CALIPSO CETH are -1376.41m and 1.799km respectively. Therefore, it indicates that cloud-shadow detection methods can be used to improve the accuracy of CETH of MODIS over Arctic oceanic region.

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Taipei, Taiwan, 14–19 July 2019
IFDA2019-74

Fog-observed performance of low-cost atmospheric particulate matter sensors

Yen-Jen Lai (1) and Po-Hsiung Lin (2)

(1) Experimental Forest, National Taiwan University, JuShan, Taiwan (alanlai@ntu.edu.tw), (2) Department of Atmospheric Sciences, National Taiwan University , Taipei, Taiwan

The visibility sensor is one of the most commonly used instruments to detect fog evolution. However, the expensive costs of visibility sensors limit the number of deployment for monitoring the spatial and temporal distributive characteristics of fog evolution. In recent years, accomplishment with the technology of Internet of Things (IoT), 3D printer and low-cost sensors, development of the cost-reasonable instruments for specific approaches by individual researchers has become easier.
Air pollution is a big issue in Taiwan and many researchers make their own instruments for monitoring the air quality using the low-cost atmospheric particulate matter. This kind of sensor can detect any matter of 2.5 and 10 micrometers or less in size and outputs the values of PM2.5 and PM10 concentration respectively. The fog droplet size is usually distributed from 1 to 35 um. It is worthy to understand the ability of these low-cost sensors for detecting fog droplets.
This study cooperated with “Maker” to develop an atmospheric particulate matter observation system suitable for Taiwan’s high-humidity forest environment. This study set up two models (PMS3003 and PMS5005, Plantower) of low-cost atmospheric particulate matter sensors beside the EPA observed station to compare the performance of detecting PM2.5. The results showed R2 can reach 0.70 or more. The linear regression showed the PM2.5 values were overestimated by about 2% since these sensors detect both air pollution matter and atmospheric water vapor. Another comparison of the PMS5005 with visibility sensor (MIRA visibility sensor 3544, AANDERAA INSTRUMENTS) at the Xitou Flow Tower inside the cloud forest of central Taiwan showed the observed PM2.5 values would rise dramatically with fog formatting. The preliminary results indicated the low-cost sensor is sensitive to the fog droplet. How to further quantify the volume of fog/cloud water and covert the PM2.5 values to the visibility are on-going topics.

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Taipei, Taiwan, 14–19 July 2019
IFDA2019-75

Measuring microphysical inhomogeneities in boundary layer clouds using a holographic imager on a tethered kytoon system

Fabiola Ramelli, Alexander Beck, Jan Henneberger, and Ulrike Lohmann
ETH Zürich, Institute for Atmospheric and Climate Science, Zürich, Switzerland (jan.henneberger@env.ethz.ch)

There is a gap in observations within the planetary boundary layer (PBL) between ground-based tower measurements, which are limited in height, and manned airplanes, which have minimum altitude constrains, in particular in hilly, densely-populated regions. Yet, information about the vertical structure of microphysical cloud properties in the PBL is crucial to improve the forecast of fog.

We developed a measurement platform with a holographic imager on a tethered kytoon system called HoloBalloon. A kytoon, which is a combination of a kite with a helium-filled balloon, has enough payload to lift a single-particle cloud-imager up to 1 km above ground. The one order lower aspiration speed, in comparison to aircrafts, allows probing the fog properties with higher spatial resolution, but have the drawback that the direction and the speed of the air flow towards the instrument is fluctuating. Commonly used cloud imager (e.g. OAPs, CPI), have a sample volume that depends on the aspiration velocity, which necessitates an inlet design to balance the fluctuating aspiration speeds. Holographic cloud imager have sample volume that is completely independent of the aspiration speed, which makes them the most suited measurement technique for tethered kytoon systems.

Observations of a supercooled low stratus event (high fog event) over the Swiss Plateau in February 2018 showed inhomogeneities on different scales. The cloud droplet number concentrations varied between multiple profiles by a factor of two within an hour. On a 10-meter scale, pockets without large droplets where found in single profiles. Boundary layer clouds or turbulences due to cloud-top cooling could have caused these inhomogeneities. These measurements demonstrate the capability of the HoloBalloon platform to measure the microphysical properties of boundary layer clouds on multiple scales.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
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Fog gauge measurements of cloud liquid water content: proposing a new standard

Han Tseng (1), Thomas Giambelluca (1), Jennifer Griswold (2), Steffen Freitag (3), Steven Howell (3), Alison Nugent (2), David Beilman (1), Cody Winchester (3), John DeLay (4), and Michael Nullet (1)

(1) University of Hawai‘i at Mānoa, Department of Geography and Environment, Honolulu, United States, (2) University of Hawai‘i at Mānoa, Department of Atmospheric Sciences, Honolulu, United States, (3) University of Hawai‘i at Mānoa, Department of Oceanography, Honolulu, United States, (4) University of Hawai‘i, Honolulu Community College, Honolulu, United States

Quantifying fog is a major challenge in tropical montane cloud forest (TMCF) research. Fog gauges are popular for their low maintenance and operational simplicity, qualities particularly valuable at remote TMCF sites. The use of fog gauges raises questions when making comparisons between studies and between gauge catch and cloud water interception by vegetation (CWI). Comparing results of different fog gauge studies is hindered by the uncertainty in gauge-specific collection efficiency. In addition, CWI in continuous, complex natural vegetation canopies is clearly not represented by the water catch of an isolated, artificial fog gauge. To facilitate inter-study comparisons and to estimate CWI based on fog gauge measurements, the raw fog gauge catch should be calibrated to an independent measure of fog water such as cloud liquid water content (LWC). While the effects of varying wind direction and wind-driven rain can be corrected, few have examined the performance of different gauge types and information on their efficiency is sparse. One reason for this knowledge gap is that most LWC sensors are designed for in-flight cloud physics observations. These instruments are expensive and often include bulky, power-consuming and non-waterproof electronics, making them difficult to use at TMCF sites.

In this study, we propose the use of LWC as the standard variable to report when using fog gauges and present a method to calibrate fog gauge observations using cloud droplet measurements. We obtained assistance to make cloud droplet measurements through collaboration with two research groups across the university campus. To enable in situ observations, we designed a mobile station that can be easily transported and assembled on a pickup truck, provides an elevated sensor-mounting platform, and protects the weather-sensitive instruments. We tested the mobile station at the summit of Mt. Ka‘ala (1,200 m) on O‘ahu Island within a TMCF equipped with a long-term climate station. We deployed 10 instruments including two types of cloud droplet sensors, a Juvik-type fog gauge, wind monitor, rain gauge, visibility sensor, digital camera, water isotope sampler, UAV atmospheric sensor, and aerosol spectrometer. Almost 18 hours of observations were recorded on three days from April to July 2018. We analyzed the cloud droplet measurements for LWC and compared it with the fog gauge observations to calculate the fog gauge collection efficiency. The results showed that the Juvik gauge efficiency was 13%, much lower than previously thought. However, the fog gauge-derived estimates were well correlated with the droplet-based LWC and this relationship seems to be consistent under the range of wind speed and LWC conditions tested. Although these results are preliminary due to the small sample size at the time of writing, it is promising that after calibration, fog gauges are capable of estimating fog LWC with reasonable accuracy.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-85

Deposition characteristics of fog in mountainous region

Yize Wang, Taise Kinoshita, and Manabu Igawa
Kanagawa University, Faculty of Engineering, Yokohama, Japan (igawam01@kanagawa-u.ac.jp)

Context/Purpose: Fog is formed frequently and deposited as throughfall on mountainous regions, but the deposition properties have not been fully clarified because of the observation difficulties in the regions. In this paper, we discuss the deposition properties of fog with the results of some observation instruments and the collection characteristics of passive fog sampler.
Methods: We have collected fog, rain, and throughfall samples in Mt. Oyama (1252m) situated at the southwest of Tokyo. Fog is also observed by cameras at the base and the summit of the mountain and a visibility meter at the summit. Passive fog samplers were placed not only in the mountain but also on the roof of our university and the components of the collected samples was analyzed. Weather phenomena were also observed in the mountain and the university.
Results/Interpretation: In our sampling site, fog is formed about 30% of a year at the summit, while fog is rarely formed at the hillside of 680 m altitude. The precipitation of throughfall at the summit and that on 680 m altitude under cedar trees have been observed and their difference has a good correlation between the fog sample amount collected by the fog sampler at the summit. We have collected water samples by the passive collector in our university, although fog events have not been observed there. The sample composition resembles to that of drizzle in the same sampling site, and then, passive fog sampler collects not only fog but also drizzle. We have observed fog events by three instruments, but the data were different to each other. The camera at the base overestimates the fog event frequency because of 8 km distance from the summit. The fog frequency data obtained by visibility meter sometimes different to that obtained by the observation of the camera at the summit because fog is sometimes covered at the limited site of the summit and the thickness of the fog layer is thinner than the definition of fog, 1 km, or fog covered upper side of the mountain but the summit is locally clear as a hollow.
Conclusion: Passive fog collectors collect not only fog water but also drizzle. Fog is formed frequently at mountainside and sometimes limited partially in a mountain.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-97

The relation between potential fog water collection and meteorological variables

Carlos M. Regalado (1) and Axel Ritter (2)

(1) Instituto Canario de Investigaciones Agrarias (ICIA), Dep. Soils and Irrigation, Tenerife, Spain (cregalad@icia.es), (2) Universidad de La Laguna, Área de Ingeniería Agroforestal, Ctra. Geneto, 2, La Laguna, 38200 Tenerife

Among the many techniques available for characterizing the dynamics of wind-driven fogs and their associated water contribution, fog gauges remain as one of the simplest instruments extensively used. However, one of their limitations is the dependence of fog water yields on the specific design of the artificial collector (geometry, textile characteristics, topology of the fabric), which are not standardized, and thus comparisons between different studies are problematic. One way to circumvent the above discussed shortcomings may be to relate the gauge's water yields with some of the atmospheric variables they presumably depend on, and thus make estimates of fog water collection independent of the particularities of the type of artificial device used. We provide here a method for estimating potential fog water collection (FWCp) from concomitant continuous records of visibility (v) and wind speed (u), at two fog-affected sites in Tenerife (Canary Islands, Spain). One is located within the Anaga Massif forest Park, UNESCO Biosphere Reserve, and vegetation is typical of windy crests hyperhumic laurisilva ecosystems. A second site, located at 1093 m a.s.l., is surrounded by wax myrtle-tree heath autochthonous vegetation. Various passive artificial fog catcher assemblies, wire-harps and screens with cylindrical geometry and uni- or omni-directional square flat gauges, were used for calibrating an empirical model of FWCp vs. u-v with good fitting performance ($0.762 \leq$ NSE ≤ 0.921; 0.063 l m-2 $\leq$ RMSE $\leq$ 0.247 l m-2). The method may be useful for characterization of locations for fog water exploitation, forest fog interception or potential cloud forest distribution. The proposed technique may be promising at predicting potential fog water yields both locally, from records provided by ground meteorological stations, but also at larger scales, using data retrieved from satellites, displayed networks of microwave wireless communication systems.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-129

Near-surface dynamics during Fog Events: An approach to connect fog precipitation with fog deposition at the Gobabeb Namib Research Institute

Joel Franceschi, Christian Feigenwinter, Robert Spirig, and Roland Vogt
Basel, Atmospheric Sciences, Environmental Sciences, Switzerland (joel.franceschi@unibas.ch)

In hyper-arid coastal regions of the Namib Desert the regular occurrence of fog provides essential water supply for flora and fauna. Previous studies provide a basic understanding of the fog climatology. The occurrence of fog has often been detected with passive fog collectors and their yield, called fog precipitation (FP), has been interpreted quantitatively as hydrological input of fog water to the ecosystem. Comparisons between FP measurements and estimates of fog water deposition (FD) using microlysimeters at the Gobabeb Namib Research Institute showed that there is not a simple correlation between FP and FD. This was the motivation to look in more detail at the processes during fog events. There, apart from standard meteorology, a multitude of fog-related measurements in 1-min resolution are available. Including: Fog precipitation using four different types of passive fog collectors ("Juvik"-type, "Grunow"-type, harp, SFC; since 2014), visibility and precipitation type using a present weather sensor (Campbell CS125; since 2017) and a laser disdrometer (Thies; since 2018), wetting using a leaf wetness sensor combined with a thermocouple close to the ground (Campbell 237; since 2017) and fog water deposition using four microlysimeters (self-construction; SEP/OCT 2017 and FEB/MAR 2018). Catch characteristics of the different fog collectors are inter-compared with focus on total yields and sampling efficiency for 100 fog events. The typical response time between fog occurrence to first FP signals is around 30 min. As expected FP amount and sample rates depend on the geometry and structural properties of the collectors. A distinct correlation between impact area and total FP amount exists. The inclusion of visibility, precipitation type and dew measurements do not yield an easy explanation for the relation between FP and FD, but it looks like drizzle plays a key role in FD processes.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-131

Fog water collection in the hyper arid coastal Atacama desert (20°S). Differences, contrast and coincidence between different geographical locations

Pablo Osses (1), Camilo Del Rio (1), Constanza Vargas (1), Francisca Riveros (1), Victoria Marzol (2), Juan Garcia (1), Alexander Siegmund (3,4)

(1) Pontificia Universidad Catolica de Chile, Geography, Physical geography, Chile (posses@uc.cl), (2) Departamento de Geografía e Historia, Universidad de La Laguna, Islas Canarias, España, (3) Heidelberg Center for the Environment & Institute for Geography, Heidelberg University, (4) Research Group for Earth Observation (rgeo), Department of Geography, Heidelberg University of Education

Purpose: Fog water collection has been studied in the coastal Atacama, but mainly in separated or unique location, thus the main purpose of this research is to characterize and describe the fog water yields, from a seasonal to daily variability, comparing different geographical locations, which cover different distances to the coast and altitudes. The value of this research lies in the integration and synchronization in time of the different locations, allowing a better understanding of fog water as an alternative water resource.

Method: Five Standard Fog Collector (SFCs) conected to meteorlogical stations (2 Campbell and 3 Thies) and measuring records every 10 minutes were locatedin a transect from 750 m asl and 2.3 km from the coastline to 1.220 m asl and 10.75 km from the coast. Monthly fog water amount averages were contrasted and double checked with a reservoir backup. Statistical process were carry out, in order to characterize and compare the fog water yields and atmospheric variables. Comparison with remote sensing information and optical devices installed in the area (GOFOS) were also used to improve the trustability of the data.

Results: There is a clear seasonality in the area, with higher differences and oscillation from coast to inland. The fog water yields, as expected, decrease from west to east (5 l/m2/day coast to 1 l/m2/day inland). Daily cycle is also defined, being slightly different among he coastal and inland sectors (morning evening peak and evening only respectively). There is a relation in time between the events in the area, mainly below the inversion layer, over this, behavior look like is under other drivers.

Interpretation: Results show a defined spatial variation strongly related with distance to coast and elevation. Inversion layer seasonal variation also define different behavior and water availability. Daily cycle is also related with seasonality in terms of one or two water collection peaks in a 24 hours frame

Conclusion: The consideration and feasibility of the use of the fog water as an alternative resource implies an accurate quantification of its potential. The characterization and better understanding of how local geographic factors influence its potential is of great importance for a territory of hyper aridity. Especially if the water need are increasing and the production should be considerable.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-141

The SOuth west FOGs 3D experiment for processes study (SOFOG3D) project

Frédéric Burnet (1), Christine Lac (1), Pauline Martinet (1), Nadia Fourrié (1), Martial Haeffelin (2), Julien Delanoë (3), Jeremy Price (4), Sebastien Barrau (1), Thierry Bergot (1), Guylaine Canut (1), Alain Dabas (1), Cyrielle Denjean (1), Jean-Charles Dupont (2), Rachel Honnert (1), Jean-François Mahfouf (1), Thibault Montmerle (1), Alexandre Paci (1), Greg Roberts (1), Yann Seity (1), and Benoit Vié (1)

(1) CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France, (2) IPSL/LMD - Ecole Polytechnique - Palaiseau, France, (3) LATMOS/IPSL/UVSQ, Guyancourt, France, (4) Met Office, Exeter, United Kingdom

Fog strongly perturbs the aviation, marine and land transportation, leading to human losses and high financial costs. The primary objective of SOFOG3D is to advance our understanding of fog processes at the smallest scale to improve forecasts of fog events by numerical weather prediction (NWP) models. Specifically, SOFOG3D conducts process studies on very well documented situations, using synergy between 3D high-resolution Large Eddy Simulation (LES) and unprecedented 3D detailed observations.

A 6 months field experiment will take place during wintertime 2019/2020 in the South-West of France to provide 3D mapping of the boundary layer during fog events. The observation strategy is to combine vertical profiles derived from new remote sensing instruments (microwave radiometer (MWR), Doppler cloud radar and Doppler lidars) and balloon-borne in-situ measurements, with local observations provided by a network of surface stations, and a fleet of Unmanned Aerial Vehicles (UAV) to explore fog spatial heterogeneities.
Three nested domains will be instrumented with increasing density to provide observations from regional scale (300x200 km) down to local scale on the super-site (10x10 km), thanks to Meteo France and U.K. Meteorological Office sensors. On the super site, meteorological conditions, visibility, aerosol optical, microphysical and hygroscopic properties, fog microphysics and liquid water content, water deposition, radiation budget, heat and momentum fluxes on flux-masts will be performed on four areas to investigate the impacts of surface heterogeneities on fog processes, as well as turbulence anisotropy. Combination of cloud radar and MWR measurements will allow optimal retrieval of temperature, humidity and liquid water content profiles. They will be validated with in situ measurements from tethered-balloon, radiosoundings and UAV.

LES of the most documented fog cases of the campaign will be run at metric resolutions to provide spatio-temporal turbulence and microphysical characteristics of the fog layer and the atmosphere above, supplementary from measurements. They will assess recent advances in parametrizations (two-moment microphysical schemes, turbulence and radiation). Their combination with 3D experimental data will deliver a comprehensive description of the impact of surface heterogeneities (types of vegetation, rivers, orography) on the fog life cycle.
SOFOG3D will particularly focus on the impact of entrainment at fog top, the surface energy budget, the impact of aerosols on radiative cooling and heating, and the dissipation period, through radiation, droplet sedimentation and deposition processes.
SOFOG3D will also investigate how improving the initial conditions of NWP models can improve fog forecasts. To that end, data from a ground-based MWR network will be assimilated using an innovative ensemble-based variational data assimilation scheme.

We will present the instrumental set-up that will be deployed during this campaign and discuss the main objectives of the project.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-147

Small-scale collection variability associated with high-density deployments of standard fog collectors

Daniel Fernandez, Jordan McCabe, Blanche Duann, and Evalina Hansen
CSUMB, College of Science, School of Natural Sciences, United States (dfernandez@csumb.edu)

In Monterey, CA (USA) in Spring 2018 and Spring 2019 two different high-density deployments of 8-10 fog standard and standard '+' (area 2.4 m2) fog collectors were deployed within relatively small areas of approximately 1 and 4 hectares. Both sets of fog collectors were constructed using double-layered 35% shade coefficient raschel coresa mesh manufactured by Marienberg. The purposes of these deployments were multi-fold. One of them, consisting of ten standard '+' fog collectors, deployed near the library of California State University, Monterey Bay, were set up to assist in providing moisture to sapling oak trees that were planted on site. In addition to being deployed with tipping bucket rain gauges to measure the water collected, the water obtained from these passive devices was routed through a series of tubes to the roots of the newly-planted sapling oak trees. They also highlight to the campus community the unique opportunities that living in a foggy zone may provide for novel means of water collection.

The eight standard fog collectors deployed at the other site, several kilometers away, at a natural reserve, were set up specifically to determine the optimal placement of a large fog collector that is intended for this location as a beta test. This other site is also intended to examine the small-scale gradients in fog water collection over a chaparral area.

Initial results from the ten collectors near the Library site indicate significant collection variability between sites that contradicted our expectations. The four larger fog collectors that were deployed closer to the library, at a location that we would have suspected would result in greater sheltering from the Library and other buildings, seemed to show in many cases over double the volume of water collected per event compared to the more-exposed fog collectors. This may be evidence of small-scale building-induced circulations of fog-laden winds that accompanied the larger-scale northwesterly winds that are typically generated during fog events.

Results are forthcoming from the chaparral site, but summaries of the data from both sites will yield interesting suggestions on the small-scale spatial variability of potential fog-water deposition.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-158

Analysis of the Water Moisture Influence for Plume Opacity after a Wet Flue Gas Desulfurization (FGD) Scrubber

Wen-Fu Tu

National Kaohsiung University of Science and Technology, College of Maritime, Marine Engineering, Taiwan, Province Of China (twf@nkust.edu.tw)

Generally, Opacity is only consider the mass concentration of particulate matters emission at a coal-fired power plant, but after installed a wet flue gas desulfurization (FGD) scrubber to remove the SOx, additional spray water of the nozzles with exhaust gas scavenging so that the exhaust gas would be saturated with water moisture (under water dew point temperature) at 49-52 Celsius degree. When the exhaust gas of coal-fired power plant from Electrostatic Precipitator (ESP) into FGD unit, the water vapor of exhaust gas saturated became the water moisture and would affect the in-stack plume opacity measurement. From the literature review, two very important factors affect in-stack plume opacity are conducted—light extinction of particle emission and water moisture content after a flue gas desulfurization (FGD) unit. The mass light extinction coefficient for water moisture is conducted for experimental method by using Beer's law with minimum least square method. In this study, In order to give various data for mass concentration of water moisture with plume opacity, we adjust a wet FGD pre-cooling and circulating water flow rate to give data and all data with 95% confidence interval boundaries, In addition, exhaust gas temperature and water relative humidity coefficients are also conducted for water moisture extinction factors.
The experimental results show that the water moisture affect the plume opacity near from 7.1% to 8.8% when the mass concentration of water moisture from 72.6 to 97.8 g/Nm3 and water relative humidity from 66.5% to 96%. In addition, decreased the exhaust gas temperature or increased the flue gas humidity condition will increase plume opacity measurement.

8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-168

Characterization of particle-droplet interactions in wintertime fog in Hungary: results of an intensive monitoring campaign

Kornélia Imre (1,2), Agnes Molnar (1,2), Andras Peterka (2), Zita Ferenczi (3), Akos Horvath (4), Tamas Weidinger (5), Andras Gelencser (1,2)

(1) MTA-PE Air Chemistry Group, Veszprém, Hungary, (2) University of Pannonia, Veszprém, Hungary, (3) Hungarian Meteorological Service, Budapest, Hungary, (4) Hungarian Meteorological Service, Siófok, Hungary, (5) Eötvös Loránd University, Budapest, Hungary

Intense air pollution episodes regularly occur during the winter months as a result of the complex interplay between the emission of air pollutants and adverse meteorological conditions. Under strong stable air, horizontal and vertical mixing are limited due to the development of a thermal inversion layer; consequently, fog formation is a frequent accompaniment of severe smog episodes. In Hungary the formation of these strong stable atmospheric conditions is further aggravated by the unfavorable topography of the Carpathian basin leading to particularly lengthy and severe episodes.

In this work we summarize our results on the characterization of fog events during a wintertime intensive monitoring campaign. This campaign was carried out on a rural site near Lake Balaton (Hungary) between October 15 and December 13, 2018. The sampling site was characterized by features conducive to local fog formation and was also impacted by local pollution from home heating in the region. The monitoring program was carried out using various instruments including optical particle counter (OPC), Single-Column Cloud Condensation Nuclei Counter (CCNC), fog water collector, meteorological instrumentations.

We present detailed analysis of the period of November 3–12, 2018 during which 6 fog formation events were observed. We interpret the dynamical processes of fog formation from the aspect of atmospheric aerosol and water vapor interaction. The evolution of fog together with the variation of aerosol characteristics is studied with high time resolution. During these events the variations of aerosol number concentrations and size distribution are studied as a function of relative humidity and available water vapor concentration and other meteorological parameters. The rate of water uptake by the particles and the hygroscopic mass growth of PM10 and PM2.5 are also estimated and the temporal variation of activated CCN concentration as a function supersaturation is discussed. The work contributes to better understanding of the complex interactions between aerosol particles and atmospheric water in dynamic microphysical processes of fog formation and dissipation.

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Detection of cloud droplets or fog by a polarization optical counting sensor: Circumstantial evidence for cloudwater deposition of radionuclides in mountainous areas of Japan during the Fukushima nuclear accident

Naoki Kaneyasu
National Institute of Advanced Industrial Science and Technology, Atmospheric Environment Study Group, Japan (kane.n@aist.go.jp)

Introduction

Radionuclides emitted from the accident of Fukushima Dai-ichi Nuclear Power Plant contaminated extensive region in eastern Japan, including mountainous areas. Hososhima and Kaneyasu (2015) observed that the Nikko mountain area, located north of the Kanto Plain, was characteristically contaminated across an altitude range of 700–1400 m above sea level and they suggested that the altitude-dependent contamination was the result of cloudwater deposition (fog deposition, or occult deposition) of radionuclides included in the cloud droplets.

Methods

To establish the validity of this mechanism of contamination the author utilized data derived from pollen sensors, deployed on radio towers by a mobile phone company (NTT Docomo Ltd). The principle of operation of the pollen sensor is that it distinguishes particle shape using a depolarization of scattered light by the article. Therefore, if the sensor can distinguish spherical water droplets with a geometric diameter greater than several micrometers from Cedar pollen and local soil dust particles, then the deployed sensors can detect the presence of cloud droplets.

The pollen sensor PS2 (Shinei Technology, Japan) was first tested on the balcony of the National Institute of Advanced Industrial Science and Technology building in Tsukuba, Japan, during early spring, when Cedar pollen and local soil dust particles were present in the atmosphere. The sensor was also tested in a water spraying chamber in the Meteorological Research Institute, Japan.

Results

A depolarization ratio was calculated from the output of the sensor, as defined by:

$$D = S/P$$

where S denotes photodiode voltage (V) generated as a result of light being scattered by a particle, with a polarization filter *in situ*, and P denotes the voltage generated by scattered light without using a polarization filter. The depolarization ratio$D$ was less than 0.25 when the sensor was placed in the water spraying chamber, and was generally greater than 0.17 during periods when there was extensive Cedar pollen in the atmosphere or local dust storm events. From these measurements, we concluded that a particle detected by the sensor was a water droplet when D was less than 0.17.

Sensor data deployed in Fukushima, Tochigi, Gunma, and Ibaraki prefectures were analyzed for the period of 1200–2400 JST, March 15, 2011, when the radioactive plume arrived at the mountainous area of northern Kanto and southern Tohoku areas, Japan. The analysis showed that 24 out of 73 sites exceeded the tentative criterion (100 counts) for D $<$0.17, which we regarded as reflecting the presence of cloud droplets or fog at that time. The location of these sites generally coincided with that of the radio-contaminated area, although some differences were apparent, which should be attributed to other surface contamination mechanisms.

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The missing tie of climate research in South Tyrol: the presence of fog?

Glenda Garcia-Santos (1), Thomas Velina (2), Gert Wolf (3), Peter Mandl (4), Nikolaus Obojes (5), and Leonardo Montagnani (6)

(1) Alpen-Adria-University Klagenfurt, Klagenfurt, Austria (glenda.garciasantos@aau.at), (2) Alpen-Adria-University Klagenfurt, Klagenfurt, Austria (thomas.velina@aau.at), (3) Alpen-Adria-University Klagenfurt, Klagenfurt, Austria (gert.wolf@aau.at), (4) Alpen-Adria-University Klagenfurt, Klagenfurt, Austria (peter.mandl@aau.at), (5) EURAC Research, Via Druso, Bozen, Italy (nikolaus.obojes@eurac.edu), (6) Free University of Bolzano, Faculty of Science and Technology, Italy (leonardo.montagnani@unibz.it)

Rainfall inputs to Alpine forests has been extensively studied. A good example is the case of South Tyrol, which is within the CarboEurope-IP network located in Renon. Although the presence of fog has been observed, this water component has been neglected in all past energy balance studies. Since fog patterns change with climate change conditions, it is therefore important to understand fog presence and how it might influence the forest physiology through changes in local carbon and transpiration fluxes. Functional delays might be of special interest. The aim of this study is to prove the validity of the proposed methodology used to characterize fog distribution without direct fog measurements. The Renon/Ritten site (RE) is operated by the Forest Service and the Agency of the Environment of the Autonomous Province of Bolzano (APB) and is situated at 1735 m a.s.l. in the Italian Alps 12 km NNE of Bolzano (Alto Adige, Italy). Renon/Ritten is in[U+FB02]uenced by an alpine, windy and humid climate. Its topography is characterized by an alpine slope with a mean slope of about 11 grades N–S direction. Fog monitoring was achieved through the interpretation of an in-situ phenocam sensor and comparison with traditional meteorological equipment like raingauges, temperature, relative humidity and wind sensors. Ground-based information and field campaigns were used to validate satellite remote sensing information. This proxy methodology will be tested in the future with fog measurement (active and passive fog collectors) and the results will be used to better understand how fog and rainfall influence forest physiology through changes in local carbon and transpiration fluxes.