Exhibition of the (AC)³ drawings by Kerstin Heymach during "Lange Nach der Wissenschaften" in Leipzig.

Transregional Collaborative Research Center on Arctic Amplification

(AC)³ Newsletter

EDITORIAL

Dear Reader,

another half of a year has passed and our project (AC)³ is in what might be called the "hot production phase". Several major observational and modelling activities have been completed and the whole (AC)³ community, in particular our PhD students, are working hard to obtain concrete results that can be published. We have been granted a Special Issue in *Atmos. Chem. Phys./Atmos. Meas. Tech.* to start a collection of papers mainly dealing with the results from the ACLOUD/PASCAL observations. Furthermore, an overview paper introducing the ACLOUD/PASCAL campaigns has been submitted to Bull. Am. Meteorol. Soc. We would like to thank all the numerous co-authors of this paper; your contributions were overwhelming.

This fifth (AC)³ Newsletter includes several interesting topics. We report on the PAMARCMiP aircraft campaign, which adds to the series of (AC)³ measurement campaigns. This time the effects of black carbon (BC) was in the focus of our observations. If deposited in snow or ice surfaces, BC warms the respective layer and may lead to enhanced melting due to absorption of solar radiation. BC may also decrease the reflectivity/albedo of the snow/ice surface. However, the question is how strong this warming actually is, taking into account the relatively small BC mass concentrations observed. When suspended in the atmosphere, the BC also warms the layer in which it is embedded; however, it cools the atmosphere/surface system below the BC layer. It is speculated that the BC is more important as absorbing/scattering agent in the atmosphere, and that it is of less significance as a component of surface snow/ice. We are curious to hear the results from PAMARCMiP to answer the question of the importance of BC absorption/scattering effects in both the snow/ice surface and the atmosphere.

Also, some very recent and exciting results from the (AC)³ modelling groups are reported in this Newsletter. The Cologne group made some major progress, please have a look at their contribution in this Newsletter. Furthermore, we have hosted some guests (see the report by Annette Rinke), the PhD students performed a Machine Learning Workshop, and the (AC)³ crowd actively participated in several conferences. You will additionally find three introductions of (AC)³ fellows (Markus Hartmann, Christine Pohl, Leif-Leonard Kliesch) in this issue, a summary of a significant publication submitted and led by Erlend Knudsen, and a report of an outreach activity (Lange Nacht der Wissenschaften in Leipzig).

Please enjoy this concise compilation of the (AC)³ activities within the past half year, it is worth reading!

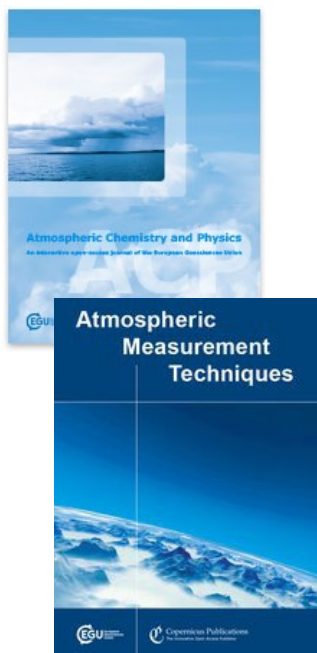Manfred Wendisch, Speaker of (AC)³, Christa Engler, Scientific Coordinator.

August 2018
5th Issue

TOPICS IN THIS ISSUE

Atmospheric Chemistry and Physics
An interactive open access journal of the European Geosciences Union

Atmospheric Measurement Techniques

Copernicus Publications

- Announcement: 2nd Science Conference on Arctic Amplification in Bremerhaven, Germany, 12 to 14 November 2018. Further details at http://www.ac3-tr.de/news/2nd-ac3-science-conference-on-arctic-amplification/

- Stay informed: if you want to receive this newsletter regularly, please subscribe online at http://ac3-tr.de

News from the Field Observations - Aircraft

SUCCESSFUL ATMOSPHERIC AND SEA ICE MEASUREMENTS IN NORTHERN GREENLAND

by André Ehrlich (University of Leipzig) and Andreas Herber (AWI-Bremerhaven)

The second large field campaign of (AC)³, PAMARCMiP (Pan-Arctic Measurements and Arctic Climate Model Intercomparison Project) ended successfully mid of April after 4 weeks of intense measurements in one of the most remote and coldest environments of the world. About 30 (AC)³ students and scientists and colleagues from Denmark, Netherlands, and Japan visited the Greenlandic Villum Research Station at Station Nord (81° 36′ N, 16° 40′ W). Starting from 10 March ground-based, balloon-borne, and airborne measurements were set up to sample the aerosol and trace gas composition in the atmosphere and to characterize the snow and sea ice surface.

In the first week of the campaign, the ground-based measurements were installed in the excellent facilities of the Villum research station providing two measurement huts outside the main camp. In the air lab, continuous observations analyzing the chemical and physical properties of trace gases and aerosol particles including black carbon were integrated and complement the basic monitoring program by Aarhus University. Close by, in the so called flyers hut, the balloon measurements were based. The balloon was equipped with different payloads for turbulent and radiative quantities. It reached about 1500 m altitude. Almost every day one or two profiles were obtained, in total 36, revealing the typical strong stratification of the lowest boundary layer with strong inversion layers. For one day, when a synoptic front passed the station, a 24h-measurement program of continuous profiling was realized.

The snow surface was characterized at different places with a 50 m sampling line, a sledge equipped with different radiation sensors and by snow mobile collecting samples at different locations in the vicinity of the station. Twice the daily procedure was extended into small expeditions to reach and characterize the snow on sea ice.

After a delay of the ferry flight, due to bad weather, the airborne activities started in the second week of PARMARCMiP. In total the AWI aircraft Polar 5

Polar 5 aircraft - Preparation for airborne miossion (courtesy Esther Horvath, AWI).

spend 55 hours in the air during 13 research flights, which covered different areas of sea ice north and east of Greenland. The measurements showed, that the sea ice was highly variable in terms of roughness, thickness and surface albedo, even if almost 100% of the sea was covered by ice. The atmospheric measure-

Group picture at Station Nord before Saturday evening dinner (courtesy Esther Horvath, AWI).

ments on board of Polar 5 spotted several layers of pollution in higher altitudes, which were identified by a higher concentration of black carbon particles and trace gases such as carbon monoxide.

All activities were accompanied by a media team of AWI, that took lots of pictures and videos of the science operation but also of the daily life at the station. Life during the campaign was organized quite strictly with respect to the regular meal times; miss one meal and you have to bake a cake. This routine helped a lot to keep a good pace during polar day. For basic life at the station, but also our science activities, we were supported by the team of soldiers who run the station throughout the year. They always kept roads and runway free of snow and helped with such ordinary issues like getting new washing water.

And finally here is the answer to the question most reader will promptly have raised when starting to read: The coldest temperature we experienced were below

-35°C. No big issue with the good polar clothes provided by AWI, but still it made all activities more difficult and time consuming than at home. Fortunately, we were supported by Bente, our cook from Denmark, who always prepared amazing food to recharge our batteries for the next day.

Now that all of us are back home, the science part of PAMARCMiP will start. We hope to find some answers on questions related to the transport path of aerosol into the Arctic, understand the variability of sea ice properties, and evaluation of models forecasting these processes. After experiencing the real Arctic, we eagerly look forward to analyze the very promising data set in the coming months and years.

In-situ sampling of snow on the sea ice (courtesy Esther Horvath, AWI).

DR. LINETTE BOISVERT-MCPARTLAND (NASA) AT AWI-POTSDAM

by Annette Rinke (AWI-Potsdam, Cluster Speaker D & PI)

NASA scientist Linette Boisvert-McPartland from Goddard Space Flight Center visited the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research in Potsdam (AWI-P) May 28 - 31, 2018. Her research interests, which cover Arctic sea ice, moisture flux and Arctic precipitation establish a strong link to our (AC)³ project-related work, particularly in the projects E04 and D03. She introduced her submitted paper on Arctic Ocean precipitation in reanalyses. We discussed this in context of Benjamin Seggers complementary work on characteristics and variability of Arctic precipitation and snowfall from a reanalysis ensemble. We exchange our findings of the widely different results in the magnitude and phase of precipitation across the reanalyses, which highlights in particular the differences in model's cloud microphysical parameterization. Although there are discrepancies between the different reanalyses, they agree that the amount of snowfall is decreasing over recent decade. We discussed potential feedbacks on sea ice, which is a joint interest in our future research.

(AC)³ @ EGU IN VIENNA

by Elena Ruiz-Donoso and Daniel Mewes (University of Leipzig)

Vienna Panorama (photo by Daniel Mewes).

The European Geosciences Union General Assembly (EGU) took place in Vienna (Austria) from 8th to 13th of April 2018.With about 15000 participants from 106 different countries, this is the biggest geosciences conference in Europe.

It consisted of about 4800 oral presentations, 11100 posters and 1419 PICO presentations (Presenting Interactive COntent). Although at first this number of possibilities was overwhelming, we managed to find our way as the week progressed. Especially interesting for our point of view were the sessions "Arctic climate change: governing mechanism and global implications", where Sandro Dahlke and Daniel Mewes contributed a talk and a poster, and "Clouds and precipitation in the Polar Regions", where many (AC)³ colleagues participated (Elena Ruiz Donoso, Vera Schemann, Robert Rauterkus, Tatiana Nomokonova, Soheila Jafariserajehlou, and Narges Khosravi).

Additionally to the traditional sessions, the EGU is offering multiple other formats like workshops, short courses and Grand Debates. Some of them are especially relevant for early career scientist, e.g. the workshop "How do peer-review?", which Daniel Mewes attended. It provided useful information on how to properly and

Empty poster hall (photo by Daniel Mewes).

time effectively review a paper.

After each day of the EGU there were a lot of possibilities to establish new connections by visiting one of the nice locations in Vienna.

EGU gave us the chance to present and share our work with members of the community. The opportunity to discuss our results resulted in a lot of new ideas. All in all this helped to put our work in context, while we built up connections that hopefully might turn into future collaborations.

LES IN THE FREEZER: SIMULATING ARCTIC AIR MASSES OBSERVED DURING ACLOUD AND PASCAL

by Vera Schemann and Roel Neggers (University of Cologne)

Airmass exchanges play an important role in the Arctic climate system and its response to a warming planet. Northward intrusions supply warm and moist air to the high latitudes, while southward outbreaks of cold air are associated with intense convection featuring distinct opaque cloud patterns. Processes at very small scales such as vertical mixing and cloud formation and evolution play an important role in setting the surface energy budget and radiative fluxes. The complexity of this system is considerable, and our understanding has been limited by the absence of dense observational networks in the area.

The recent $(AC)^3$ field campaigns ACLOUD and PASCAL were aimed to fill this data gap. Large-Eddy Simulation (LES) is an integral part of these efforts, providing a virtual four-dimensional context for interpreting measurements, fine-tuning deployment strategies, and for testing scientific hypotheses. Despite good skill in resolving turbulent dynamics, known shortcomings include a reduced performance near strong inversions and the necessity to parameterize all cloud microphysics. Furthermore, the lack of measurements made building Arctic cases for LES difficult.
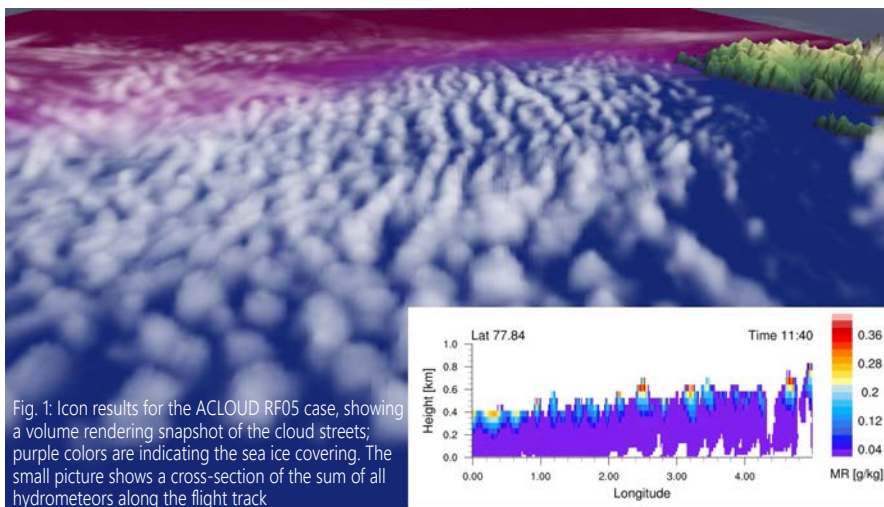

Fig. 1: Icon results for the ACLOUD RF05 case, showing a volume rendering snapshot of the cloud streets; purple colors are indicating the sea ice covering. The small picture shows a cross-section of the sum of all hydrometeors along the flight track

MEET THE $(AC)^3$ FELLOWS

Hi, my name is Christine Pohl. I studied meteorology in Hanover with a research focus on solar radiation and remote sensing. In my master thesis, I derived sky spectral radiances at high spatial and temporal resolution.

Since September 2016, I have been working in sub-project C01 at the University of Bremen. In my PhD, I am quantifying the uncertainties when deriving the Arctic sea ice albedo from field, airborne and satellite measurements under different field and observation conditions. During the campaign PAMARCMiP 2018, I had the opportunity to obtain experiences in airborne and field albedo measurements. As next step, I will develop empirical correction factors to reduce the uncertainties in the albedo retrievals and measurements. With the corrected data, I am going to validate existing albedo retrieval algorithms.

In $(AC)^3$ projects A01, E01, and E03 we try to gain insight and overcome these problems by means of targeted LES experiments based on ACLOUD and PASCAL observational datasets. Novel ways are explored to use sparse observational data to constrain LES experiments. The simulations are confronted with independent cloud observations, and give insight into i) the physics and dynamics behind flow features like cloud streets and ii) the formation and evolution of capping humidity layers.

Of crucial importance is to let the air mass evolve freely for a significant period of time, to capture the typically slow evolution of Arctic clouds. Two approaches are explored, each with a separate code, both driven by large-scale data from the Integrated Forecasting System (IFS) of the ECMWF. Existing biases in the IFS fields over the sea ice are adjusted under certain constraints, such that a good match is obtained with available sounding data from PASCAL (radiosondes) and ACLOUD (dropsondes). Novel ways are explored to blend these high-resolution in-situ soundings into the IFS data, using an iterative procedure featuring swarms of LES simulations on microgrids.

LES IN THE FREEZER: SIMULATING ARCTIC AIR MASSES... (continued)

Case 1: Convective clouds in a weak cold air outbreak

Nested regional simulations of the ACLOUD RF05 (Research Flight #5) case were performed with the ICON model, forced at the boundaries with IFS data and inclduing realistic topography. The domain reaches from 5ºW to 15ºE and 77.5ºN to 81.5ºN, resolved at a resolution of 600 m. The goal with this setup is to approach realism as closely as possible, to allow comparisons with the P5 aircraft observations. Results are shown in Fig. 1, illustrating the simulated cloud streets which form when the air mass moves off the sea ice. In the top-right corner the west coast of Svalbard can be seen. The inset figure shows a cross-section perpendicular to the cloud streets, giving a more detailed impression of their height and width, and allowing a better comparison to the remote sensing data gathered by the P5 aircraft.

Case 2: Shallow mixed layers under strong inversions

Idealized air-mass following Lagrangian simulations were performed of Arctic mixed layers as observed during the PASCAL campaign in the period 5-7 June 2017, when the PolarStern (PS) was situated in the sea ice (see Fig. 2a). The Dutch Atmospheric LES model (DALES) was run on a 12.8 × 12.8 km domain at a horizontal resolution of 50 m, using pe-
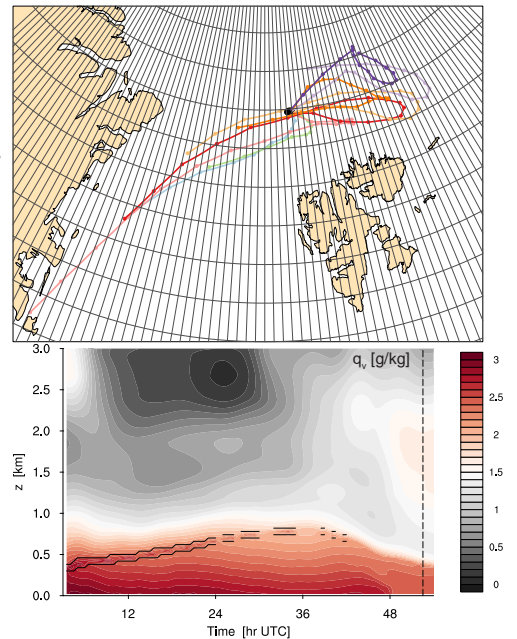

Fig. 2: Lagrangian DALES results for PASCAL cases between 5-7 June 2017, with a) the 8 simulated trajectories and b) water vapor specific humidity in the lowest 3 km for a single trajectory. The capping humidity layer is indicated by the solid black lines. The dashed vertical line indicates the intersection time with the PolarStern.

riodic boundary conditions and fully double moment microphysics including 5 hydrometeor species. 8 trajectories are simulated that intersect with the PS location at the time of radiosonde releases. The result for one simulation is shown in Fig. 2, featuring a strongly evolving Arctic mixed layer under a capping humidity layer. Such layers are argued to play an important role in the evolution of the mixed layer, by affecting the properties of the entrained air and thus influencing cloud existence. The simulations, constrained by $(AC)^3$ data, are currently being analyzed in more detail, and are already yielding new insights into these phenomena.

Although the simulation work is still in progress, the results already provide insight into the coupling of large-scale forcing and small-scale turbulence and offer a playground for hypothesis testing. The next step is to confront these simulations with additional independent measurements made during the $(AC)^3$ field campaigns, which is currently in full progress.

MEET THE $(AC)^3$ FELLOWS

My name is Leif. I'm fascinated about any natural sciences. Because I was really fascinated about thunderstorms and snow, I decided to study meteorology when I was a child. Then, due to the additional focus on other geophysical topics I decided to study meteorology at the Institute for Geophysics and Meteorology at the University of Cologne. In March (2018) I graduated with my Master Thesis with the topic "Cloud Liquid Water Path Observations within the Trade Wind Environment on Barbados". The observations of the cloud liquid water path on Barbados were made by the remote sensing instrument "Humidity and Temperature Profiler (HATPRO) - SUNHAT". Even if the topic of my Master Thesis belongs to tropical meteorology, I decided to begin the PhD in $(AC)^3$ B03: Characterization of Arctic Mixed-Phase Clouds (MPC) by Airborne In-situ Measurements and Remote Sensing. In this project I will characterize MPC's by airborne remote sensing using the novel Microwave Radar/Radiometer for Arctic Clouds (MiRAC). Hence, I will generally work with observations of cloud liquid water path and radar reflectivity to improve the knowledge of MPC's and their impact on the Arctic Amplification. To free my mind and to be motivated all the time in everything I do I enjoy sports if I'm not at the University. I really like swimming and lifting weights in the gym.

Outreach activities
"LANGE NACHT DER WISSENSCHAFTEN IN POTSDAM AND LEIPZIG

by Anja Sommerfeld (AWI-Potsdam) and Christa Engler (University of Leipzig)

The "Lange Nacht der Wissenschaften" in Potsdam and Leipzig attracted more than 1900 and 6000 people, respectively. There were several highlights from AWI, University of Leipzig and TROPOS including oral presentations and exhibitions. In both cities, the drawings by Kerstin Heymach were shown, who joined the ACLOUD/PASCAL campaign in 2017 and created a series of paintings that show the life and scientific work in Ny-Ålesund, the aircraft POLAR 5 and POLAR 6, and the RV POLARSTERN. Furthermore, the MOSAiC project was introduced to the public by a model of RV POLARSTERN, a topographic model of the Arctic region and three posters. The 3D photographes by Stephan Schön from "Sächsische Zeitung" were shown as well. With this material, the visitors could get an insight into the campaign as well as the planned expedition, the potential drift trajectory and the life onboard of RV POLARSTERN.

PhD students workshop in Leipzig
MACHINE LEARNING

by Ilias Bougoudis (University of Bremen)

The workshop was held on the 9th of March, in Leipzig Institute for Meteorology and was focusing on the main aspects of machine learning and how they can be implemented in an efficient and effortless way. For this purpose, the workshop was split in both lectures and exercises sessions. All the exercise sessions were held in Python, so that every student could practice and access them freely.

The first lecture session was an introduction to machine learning; a little theoretical background was provided, next to the main categories of machine learning algorithms. Subsequently, the first exercise session was an introduction on these categories, together with the dataset that would be used afterwards. Every next session was focused on one of the previously addressed categories. As a result, the second lecture and exercise sessions were about supervised learning, where the algorithm can predict a specific value, based on the inputs that are provided. It can be used for regression and classification as well, and both of them were addressed in the exercise session. The next session was about unsupervised learning, were no desired outputs are required by the algorithm. Finally, the last session was a short introduction in deep learning, a more advanced category of machine learning, together with a summary of the whole workshop.

During the workshop, the students were intrigued by the introduced concepts; many questions arose, focusing on both the theoretical side and the practical sessions. In conclusion, the workshop was considered successful by the students, who stated that it is possible to use machine learning techniques in their research projects.

MEET THE $(AC)^3$ FELLOWS

Hello, my name is Markus Hartmann and I studied Applied Geosciences at the TU Darmstadt. In my Master Thesis I looked into the composition and hygroscopic properties of aerosol particles on Barbados via Environmental Scanning Electron Microscopy. My first experience beyond the Arctic circle was with the BEXUS programme (Balloon Experiments for University Students) at the Esrange Space Center near Kiruna. Since my feel-good temperature ends a few degrees above room temperature it was obvious to seek a PhD position related to the poles ;-) That is how I found 2016 my way into the $(AC)^3$ project B04.

In B04 we investigate the physical and chemical characteristics and sources of Arctic ice nucleating particles (INP) and cloud condensation nuclei (CCN) during the RV Polarstern cruise PS106, which took place about a year ago. CCN and INP are the base for cloud formation and ice formation in clouds respectively, and therefore may significantly influence precipitation, life time and radiative effects of clouds. During the cruise we measured online, but also took offline samples (air, sea surface micro layer, bulk sea water, fog and snow), which need to be measured in the laboratory at TROPOS. While I am still busy analyzing them, I expect to finish all 400+ samples within the next months.

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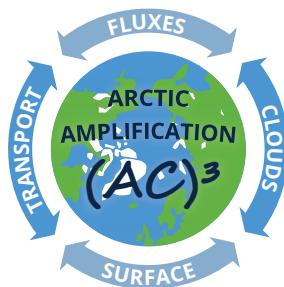Christa Engler (LIM)
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(AC)³ Publications

SYNOPTIC DEVELOPMENT DURING THE ACLOUD/PASCAL FIELD CAMPAIGN NEAR SVALBARD IN SPRING 2017

Abstract

The two concerted field campaigns Arctic CLoud Observations Using airborne measurements during polar Day (ACLOUD) and the Physical feedbacks of Arctic planetary boundary level Sea ice, Cloud and AerosoL (PASCAL) took place near Svalbard from 23 May to 26 June 2017. They were focused on studying Arctic mixed-phase clouds and involved observations from two airplanes (ACLOUD), an icebreaker (PASCAL), as well as surface-based stations, a tethered balloon, and satellites. Here, we present the synoptic development during the 35 day period of the campaigns, using classical near-surface and upper-air meteorological observations, as well as operational satellite and model data. Over the campaign period, short-term synoptic variability was substantial, dominating over the long-term background effect of Arctic amplification. During the first campaign week, cold and dry Arctic air from the north persisted, with a distinct but seasonally unusual cold air outbreak. Cloudy conditions with mostly low-level clouds prevailed. The subsequent two weeks were characterized by warm and moist maritime air from the south and east, which included two warm air advections. These synoptical disturbances caused lower cloud cover fractions and higher-reaching cloud systems. In the final two weeks, adiabatically warmed westerly air dominated, with a strongly varying cloud distribution in between the two other periods. Results presented here provide synoptic information needed to analyze and interpret data of upcoming studies from ACLOUD/PASCAL, while also offering unprecedented measurements in a sparsely observed region.

E.M. Knudsen, **B. Heinold**, **S. Dahlke**, **H. Bozem**, **S. Crewell**, **G. Heygster**, D. Kunkel, **M. Maturilli**, **M. Mech**, **A. Rinke**, H. Schmithüsen, **A. Ehrlich**, **A. Macke**, **C. Lüpkes**, **M. Wendisch**, 2018, Atmos. Chem. Phys. Diss., doi:10.5194/acp-2018-494, https://www.atmos-chem-phys-discuss.net/acp-2018-494/

(AC)³ PROJECT PARTNERS