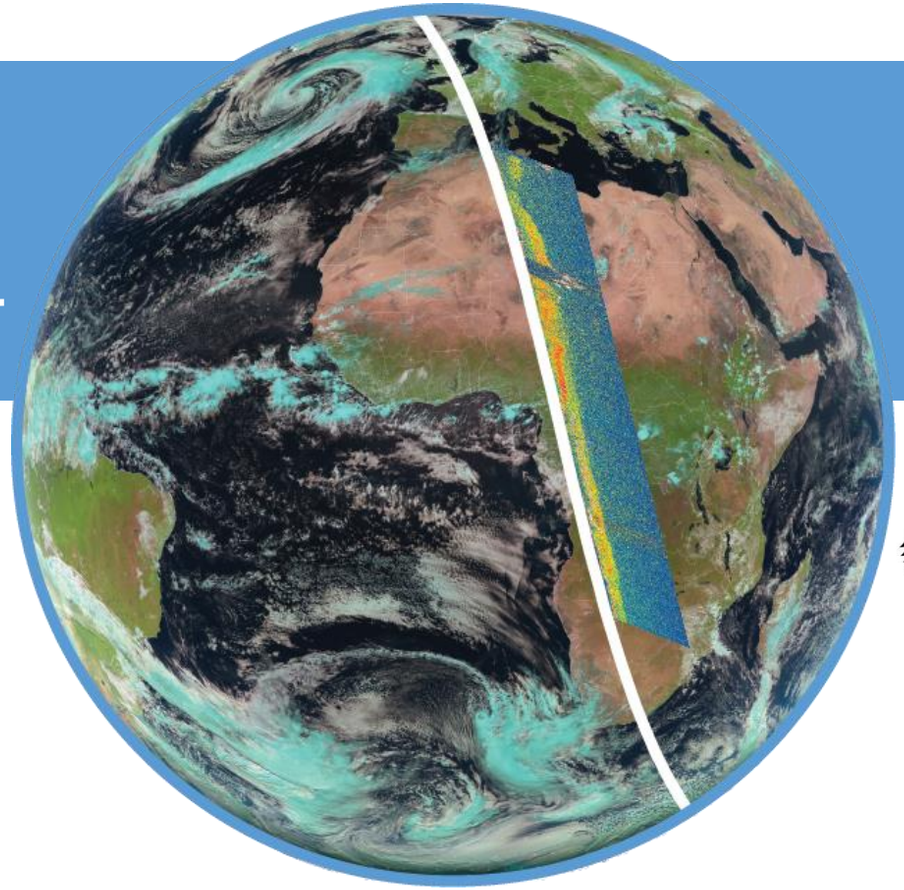
Aerosol-cloud interactions from combined observations with geostationary and polar-orbiting sensors

Matthias Tesche, Torsten Seelig, Fani Alexandri, Peter Bräuer

Goutam Choudhury, Yuanyuan Hu, and Johannes Quaas



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Bundesministerium für Bildung und Forschung

MAKE OUR PLANET GREAT AGAIN

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This presentation consist of two parts

Part one: Overview of MOPGA-GRI

Gives an overview of the German part (GRI = German Research Initiative) of the French-German Make Our Planet Great Again (MOPGA) programme

Part two: Our project PACIFIC

Gives an introduction of and first results of the MOPGA-GRI project PACIFIC (Particles in Aerosol Cloud Interactions: Stratification, CCN/INP concentrations, and Cloud Lifecycle)

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Franco-German Fellowship-Programme on Climate, Energy and Earth System Research

Make our Planet Great Again

Kick-off Conference 1 October 2019 in Paris

https://makeourplanetgreatagain-cnrs.com/

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Donald Trump, President of the United States of America: „The United States will withdraw from the Paris agreement…“ June 1, 2017

https://www.youtube.com/watch?v=jP55meWlLt4

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Emmanuel Macron, President of France: „Make our planet great again“ June 1, 2017

UNE INITIATIVE du Président de la République

https://www.youtube.com/watch?v=tc3yEJ3yBv8

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Programme goals

Objective 1: Strengthening international science in the field of climate, energy and earth system research by providing missing resources

Objective 2: Facilitating and accelerating the achievement of energy- and climate-related research results that are under great time pressure in the face of global development

Objective 3: Generating visual impulses (signalling effect) for a European assumption of responsibility and leadership in matters of global development

Objective 4: Contributing to a sustainable networking of international scientists with regard to climate, energy and earth system research

On 1 June 2017, in response to the United States' decision to leave the Paris Agreement, the President of the French Republic, Emmanuel MACRON, called on researchers and teachers, entrepreneurs, associations and NGOs, students and the civil society to mobilize and join France in the fight against global warming. In July, this call was followed by Germany, illustrating thereby France's and Germany's desire to be at the forefront of the fight against climate change.

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Joint « MAKE OUR PLANET GREAT AGAIN » statement released at the Kick-off Conference in Paris 2019

As a group of scientists from a wide field of expertise, we are here together today because we are deeply concerned about climate change and the grave risk it poses for our planet, the interplay between the ocean, the atmosphere and the climate, and ultimately the well-being of all humankind. We recognise the need to continue building upon the scientific heritage of humanity and our work is part of the ongoing effort to advance our understanding of Planet Earth and to make it a better place to live.

Climate change is already negatively affecting our society on a global scale and scientific future scenarios predict further negative impacts. We face challenges on many levels, which include the development of sustainable lifestyles that limit the effects of a globally changing climate and its impact on marine and terrestrial biodiversity.

Understanding the way our planet and society work and searching for solutions to limit and adapt to the global changes ahead are major duties and responsibilities both for us and for future generations. Global change will affect all of us and we all share responsibility to address it.

Addressing these challenges means we must adapt, which requires an enhanced understanding of the mechanisms of climate change to improve predictions and alleviate their negative impacts. We must also mitigate the effects resulting from the underlying anthropogenic activities and necessitating a transition to non-fossil-fuel-based lifestyle. Food security is also at risk due to current and future climate change and requires urgent attention using innovative approaches that guarantee sustainability. Urgent action is called for, and we are convinced that policy makers and stakeholders require sound scientific and technical evidence to guide effective decisions.

More research efforts are needed. General predictions about the extent of climate change in the next century do exist. However, neither regional climate effects, nor their precise impacts on biodiversity, nutrition or water availability are sufficiently well-known. There are large knowledge gaps concerning the magnitude of future warming, the rates of melting of glaciers and hence the rates of sea level rise, and future changes in weather extremes ranging from tropical cyclones to El Niño. This is mainly due to an imperfect understanding of the Earth's and ocean's climate systems, which requires sustained efforts to improve earth system observations and modelling. Nevertheless, using our current knowledge, it is imperative that we find new and innovative engineering and policy approaches for an efficient transition to an energy supply that no longer relies on fossil fuels.

We call for more international cooperation to engage with these global tasks. We firmly stand behind the French-German initiative "Make our Planet Great Again". Our aim is to mobilise the global scientific community, to train the next generation of researchers and decision-makers, and to raise awareness for the changes that will first impact the most vulnerable regions and populations of the world. We, MOPGA participants, junior and senior researchers, together with our host teams and home institutions, are eager to help address these global challenges. Working together, let us make our planet better!

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MOPGA-GRI

has been launched, bringing together thirteen international researchers to investigate relevant issues from the fields of climate, energy and earth systems research.

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Kick-off meeting October 2018 in Königswinter

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MOPGA-GRI

The projects are carried out between the 1st May 2018 and the 31st December 2022. In this period the research groups can dispose of a budget of up to 1 Mio. EUR (Junior Researcher) or 1.5 Mio. EUR (Senior Researcher).

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MOPGA-GRI Annual Meeting December 2019 in Cologne

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Franco - German Fellowship Programme on Climate-, Energy- and Earthsystem Research
Make Our Planet Great Again – German Research Initiative

German Research Initiative

MOPGA-GRI

Earth System Research
4 Research Groups
Budget: 5 Million Euros

Climate Research
4 Research Groups
Budget: 5 Million Euros

Energy Research
5 Research Groups
Budget: 5 Million Euros

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Earth System Research: The Projects

A key issue in the field of earth systems research is the analysis of how the systems and processes that determine life on our planet function and interact with one another. These activities thus constitute basic research on improving our understanding of the Earth as a system. (www.fona.de)

- **Dr Gayane Asatryan: Plankton and productivity in the polar region during the Paleogene (P4 Project) - Leibniz Institute for Evolution and Biodiversity Science**
- **Dr Christina Richards: Genomics and Epigenomics of Plant Invasion - University of Tübingen**
- **Dr Helmuth Thomas: The Ocean's Alkalinity: Connecting geological and metabolic processes and time-scales - Helmholtz-Zentrum Geesthacht**
- **Dr Henry Wu: Witnesses to the Climate Emergency: Ocean acidification crisis and global warming observations from tropical corals (OASIS) - Leibniz Centre for Tropical Marine Research (ZMT) Bremen**

Gayane Asatryan

Christina Richards

Helmuth Thomas

Henry Wu

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Climate Research: The Projects

Climate research plays an important role in shaping social and political awareness of the challenges posed by climate change. Climate data and models provide information about how the Earth's ecosystem is changing and form a foundation of knowledge for decision-making. The field of climate change research covers activities in the areas of monitoring, modelling and mitigation. (www.fona.de)

- **Dr Jed O. Kaplan: Feedback between land cover, people, and climate in the seasonally arid tropics. - MONSOON, University of Augsburg**
- **Dr Anna Possner: Organisation and Cloud-Radiative Properties of Low-Level Mixed-Phase Clouds. - University of Frankfurt**
- **Dr Clemens Scheer: Climate change, reactive nitrogen, denitrification and N^2O: Identifying sustainable solutions for the globe. - KIT Karlsruhe Institute of Technology**
- **Dr Matthias Tesche: Particles in Aerosol Cloud Interactions: Stratification, CCN/INP concentrations, and Cloud Lifecycle. - PACIFIC, University of Leipzig)**


Jed Kaplan


Anna Possner


Clemens Scheer


Matthias Tesche

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Energy Research: The Projects

In the field of energy research, the main focus is on finding solutions for a sustainable, secure and affordable energy supply that is based on renewable energy sources. This includes basic research on the development of new materials for the efficient generation, storage and use of renewable energy. (www.fona.de)


Heechae Choi


Andreas Goldthau

- **Dr Heechae Choi: Amorphous-crystal junction: a new class of cost-effective, high activity photochemical semiconductors - University of Cologne**
- **Professor Andreas Goldthau: Low Carbon Transition in Developing Countries: How To Ensure Energy Justice? - Institute for Advanced Sustainability Studies e.V. (IASS), Potsdam**


Eric Hill


Yutsung Tsai


Michael Zürch

- **Dr Eric Hill: Nanocomposites and Materials for Energy Solutions, Institute of Advanced Ceramics - Hamburg University of Technology**
- **Dr Yutsung Tsai: Lateral multi-junctions of 2-D transition metal dichalcogenides as optoelectronic platform for transparent photovoltaics - Helmholtz Centre Berlin for Materials and Energy**
- **Dr Michael Zürch: Quantifying Ultrafast non-Equilibrium dynamicS in semicon-ducTor quantum nanomaterials for nExt geNEration eneRGY Materials, QUESTforENERGY - University Jena**

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German Host Institutions

UNIVERSITÄT LEIPZIG

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

ZMT LEIBNIZ CENTRE for Tropical Marine Research

FRIEDRICH-SCHILLER-UNIVERSITÄT JENA

Universität zu Köln

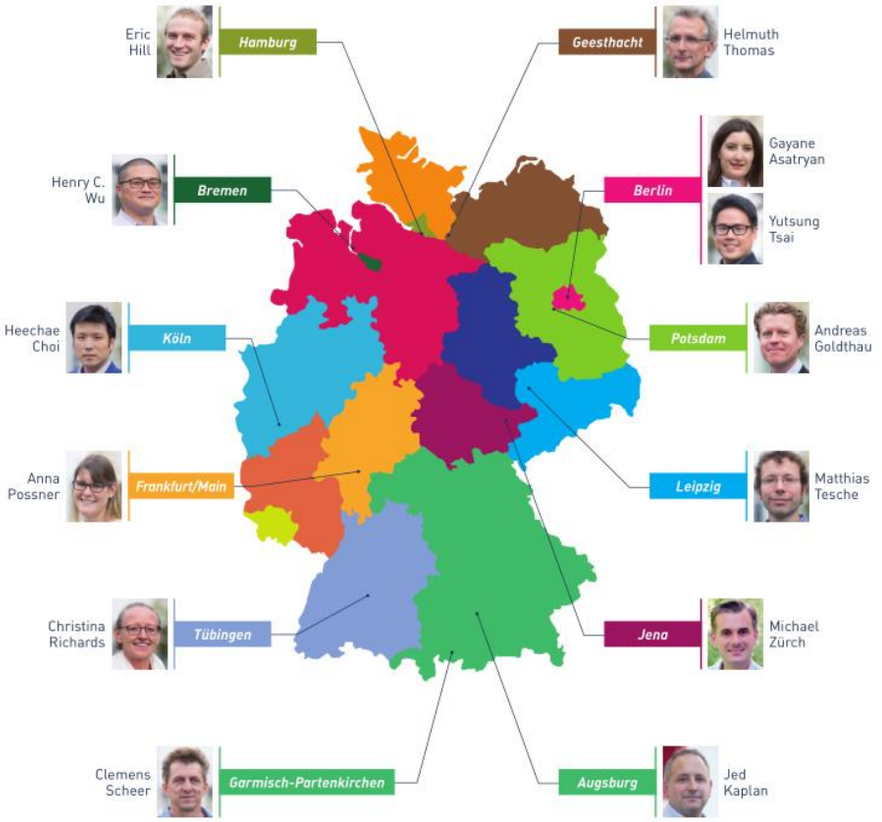
KIT Karlsruher Institut für Technologie

TUHH Technische Universität Hamburg

IASS POTSDAM

Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung

EBERHARD KARLS UNIVERSITÄT TÜBINGEN



UNIVERSITÄT AUGSBURG University

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HZB Helmholtz Zentrum Berlin

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Event Planning 2018 - 2022

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- MOPGA-GRI Kick-off Meeting **2018** Königswinter
- First French-German Conference **2019** Paris (Political)
- MOPGA-GRI Meeting **2019**
- MOPGA-GRI Meeting **2020**
- French-German Mid-Term Conference **2021** Strasbourg (Scientific)
- MOPGA-GRI Meeting **2021**
- French-German Final Conference **2022** Berlin (Political)

For further information please contact:
MOPGA-GRI@DAAD.DE

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Part two: Our project PACIFIC

Motivation:

(i) Aerosol-cloud interactions (ACI) are the largest source of uncertainty in our understanding of climate change

(ii) Observations are needed to bound model estimates of the impact of ACI and only satellites can provide a global perspective

(iii) Current spaceborne ACI estimates are based on imperfect proxies for cloud-condensation nuclei (CCN) and ice nucleating particles (INP)

Goal: Study aerosol-cloud interactions from the combination of observations with polar-orbiting and geostationary sensors

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Part two: Our project PACIFIC

The approach consists of three steps:

1. Use active remote sensing with the polar-orbiting spaceborne CALIPSO lidar to infer concentrations of cloud-condensation nuclei (CCN) and ice nucleating particles (INP)
2. Use geostationary observations to track individual clouds and obtain time series of their physical properties
3. Match detailed snap-shot observations of clouds and aerosols from polar-orbiting satellites with time-resolved information from geostationary satellites

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Use active remote sensing with the spaceborne CALIPSO lidar to infer CCN and INP concentrations

- Aerosol optical properties of dry particles can be used to estimate CCN number concentrations (e.g. *Shinozuka et al., 2015*)
- This idea has been adapted to polarization lidar measurements together with extinction-to-number-concentration conversion factors to provide vertical profiles of CCN and INP concentrations (*Mamouri and Ansmann, 2015; 2016*)
- The method has shown promising validation results for ground-based measurements (*Marinou et al., 2019*)
- Here, we want to apply the method of *Mamouri and Ansmann* to spaceborne lidar measurements

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Use active remote sensing with the spaceborne CALIPSO lidar to infer CCN and INP concentrations

Spaceborne Lidar

- Backscatter coefficient
- Depolarization ratio
- Lidar ratio

Aerosol-type separation

AERONET-based conversion factors

Aerosol concentration

$n_{d,250}$

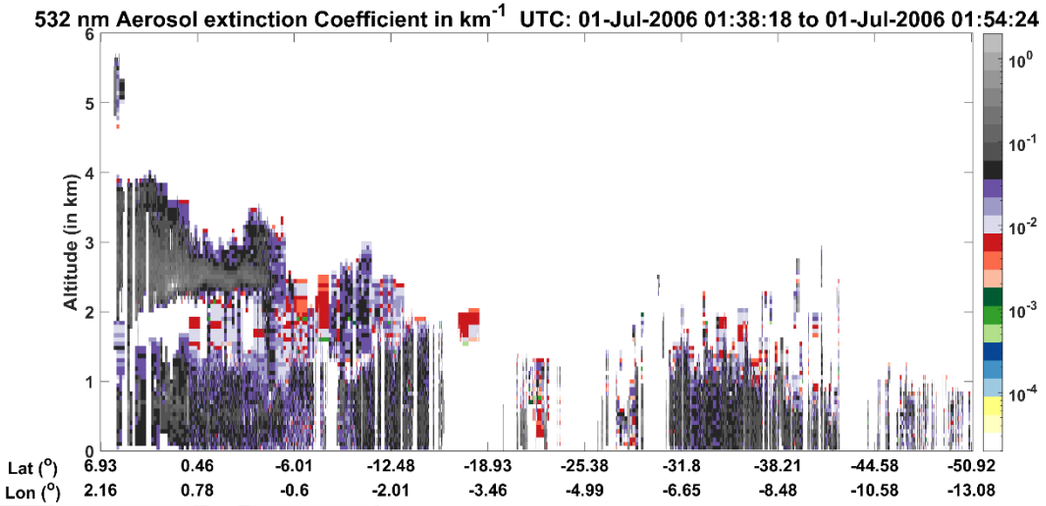
S_{dry}

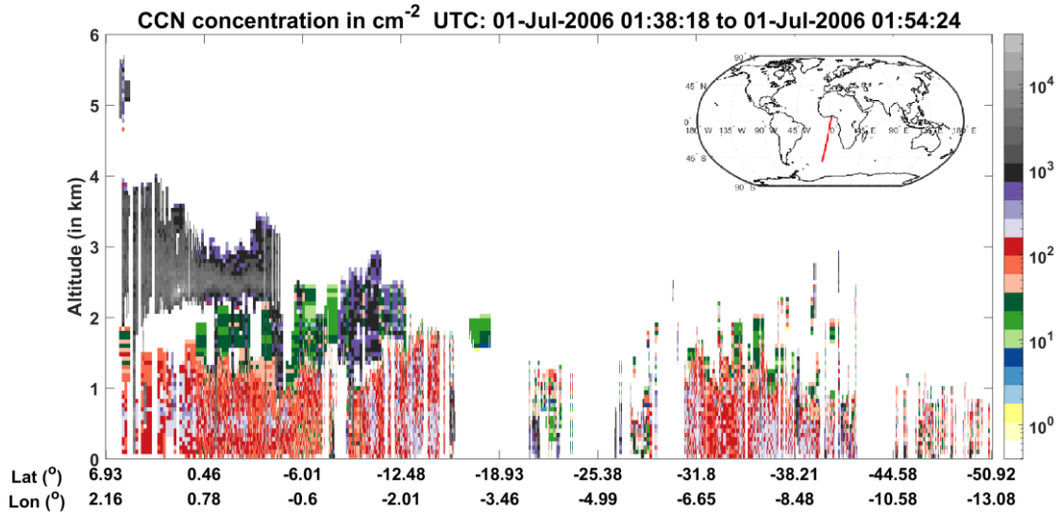
T, P, RH

CCN and INP parameterizations

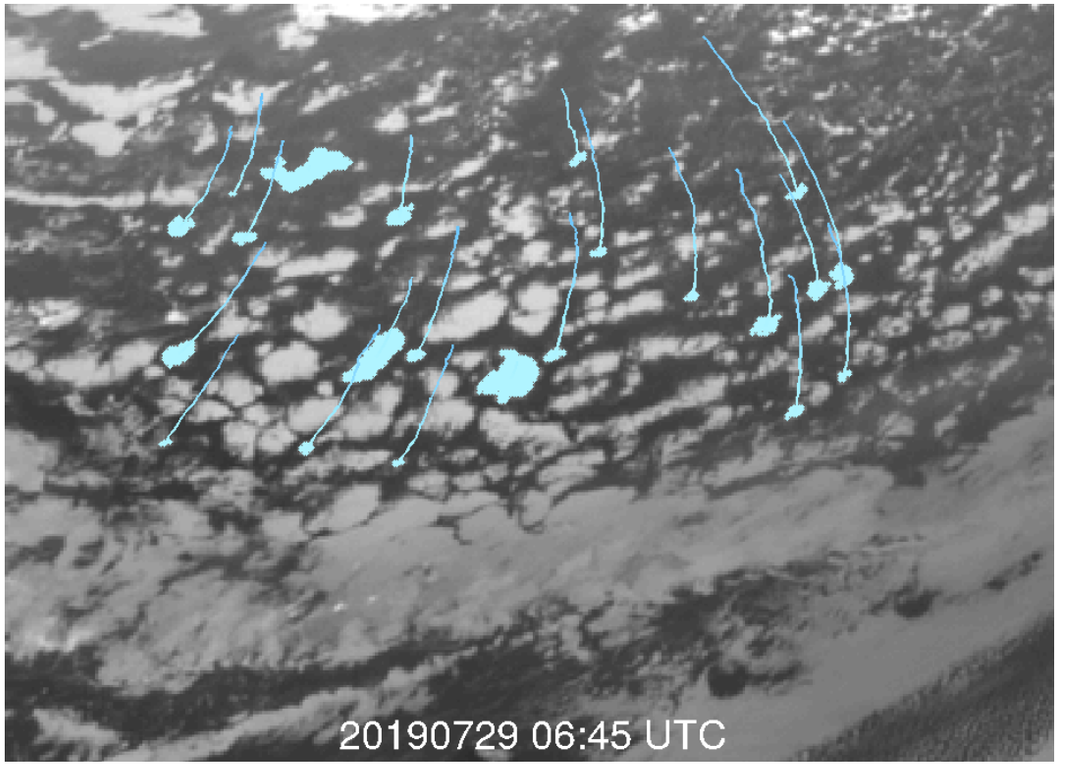
CCN and INP estimations

Vertical profiles of INP concentrations for different aerosol types



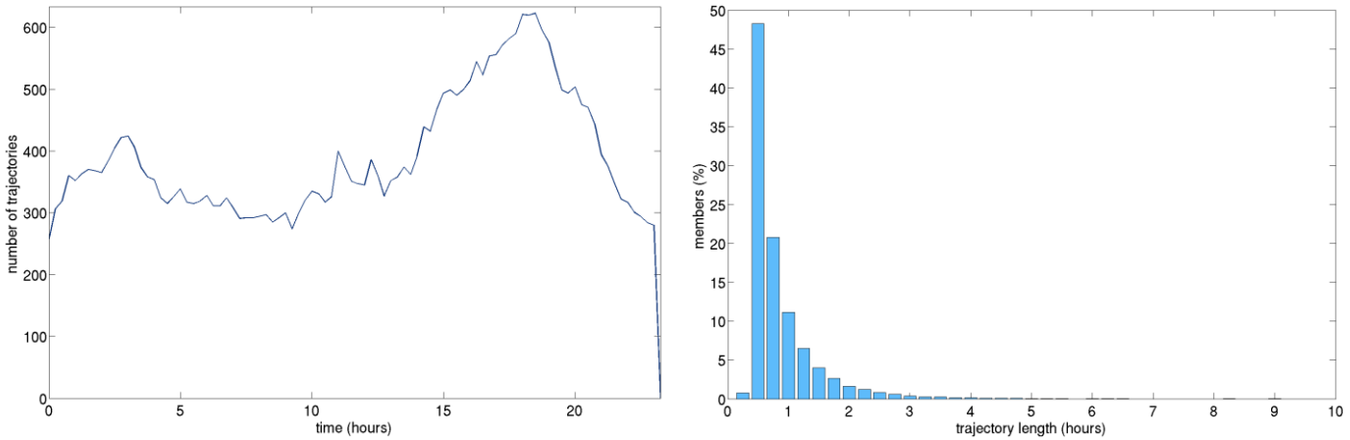


Use geostationary observations to track individual clouds and obtain time series of their physical properties



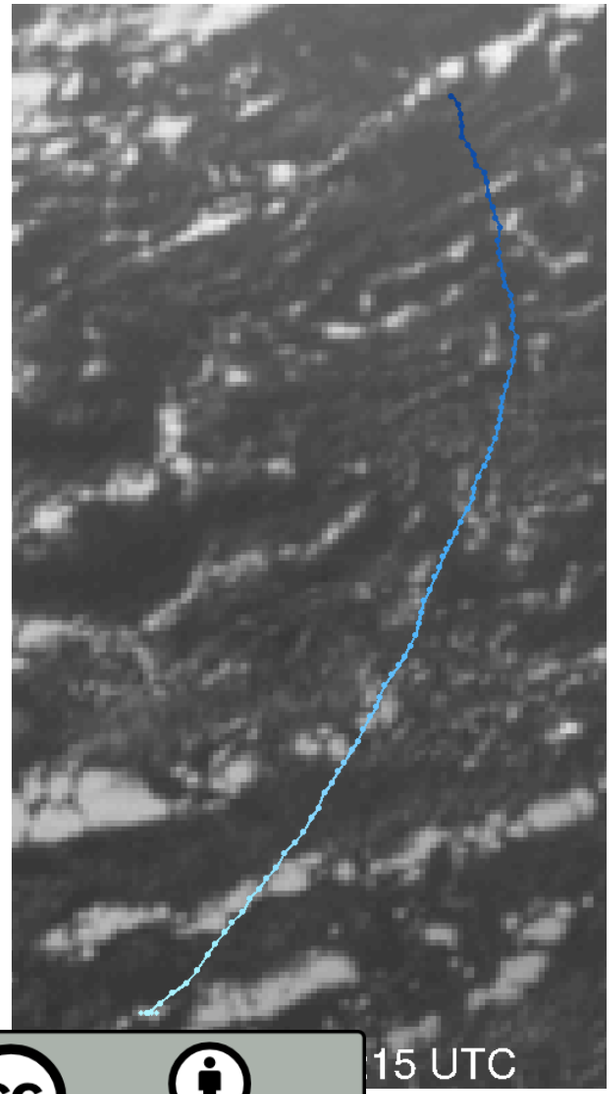
Brightness temperature measured with MSG-SEVIRI's (Level 1.5) 10.8-µm infrared channel 29 August 2015. Light colour refers to low temperature. Blue lines mark the cloud trajectory with older time steps in darker colour. Cloud area is marked in light blue.

- Detect and track clouds in time-resolved geostationary measurements with the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) aboard Meteosat Second Generation (MSG)
- Details on the methodology can be found in Seelig et al. | EGU2020-3544 | BG4.1/OS2.13

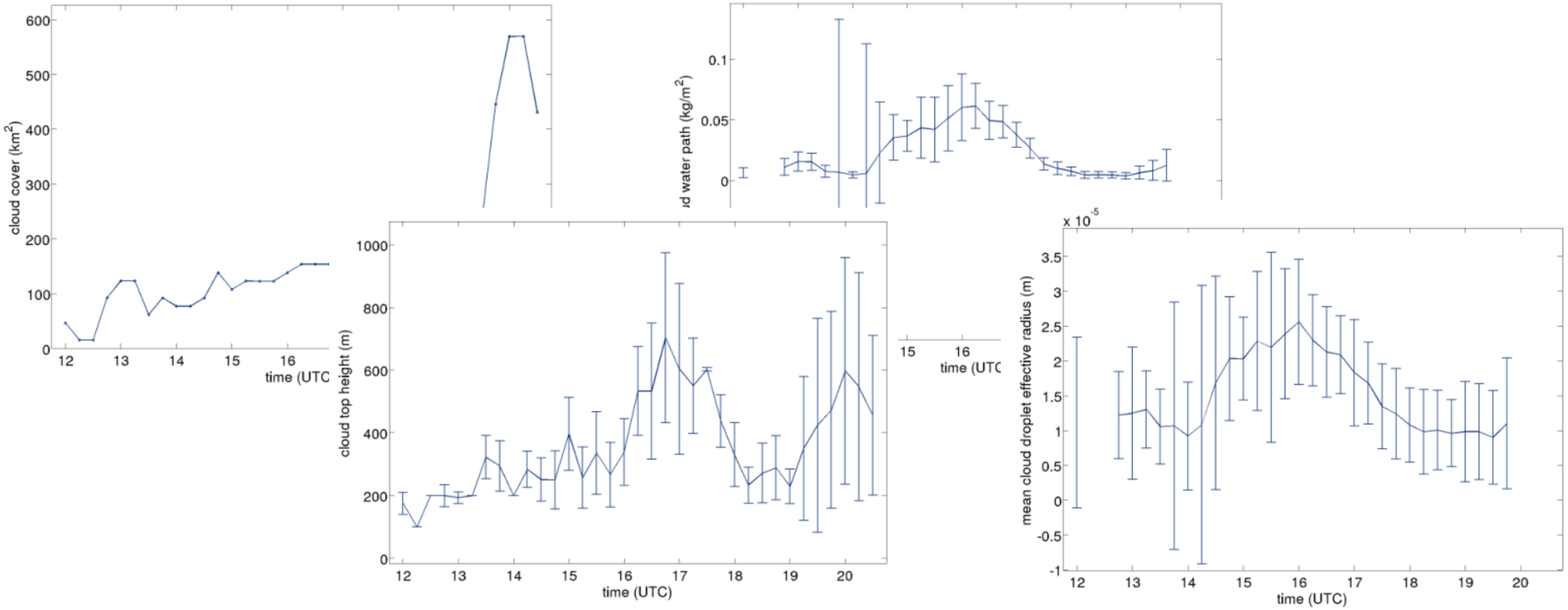


Temporal evolution of the number of detected cloud trajectories (left) and histogram of corresponding trajectory length (right). Some clouds can be tracked for more than 24 h.

Use geostationary observations to track individual clouds and obtain time series of their physical properties



- Match tracked cloudy pixels with information in CLAAS-2 (CM SAF CLoud property dAtAset using SEVIRI - Edition 2)
- The resulting data set includes time series of age, area, top height and temperature, optical thickness, droplet effective radius, liquid water path for individual clouds



Match detailed snap-shot observations of clouds and aerosols from polar-orbiting satellites with time-resolved information from geostationary satellites

- Matching of along-track height-resolved data from active remote-sensing instruments to observations at a ground site or collocation to a moving platform (research vessel or research aircraft) has proven to be for from straightforward
- We have developed an algorithm to match satellite ground tracks to trajectories that include latitude, longitude, height, and auxiliary information, e.g. tracks from clouds, ships, or aircraft
- Details are outlined in Bräuer et al. | EGU2020-2899 | AS1.37
- The method is used to match time-resolved cloud data from the geostationary observations with the detailed cloud and aerosol observations from the polar-orbiting sensors

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Summary and Outlook

- We have developed new tools to study ACI from spaceborne observations:

i) A method to infer CCN and INP concentrations from spaceborne lidar measurements

ii) A method to infer time-resolved information on clouds and their life cycle from geostationary observations

iii) A method to match the data from polar-orbiting sensors to the cloud-tracks from the geostationary sensors

- The tools are ready to use but still require validation. The next step is to combine to build up a data set for ACI studies based on individual matched cloud observations from different spaceborne sensors

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