Focus on

Fluid physics, turbulence and vegetation modeling: Martin Claussen and his research interests

After 16 years as Professor of General Meteorology at Universität Hamburg and as Director at the Max Planck Institute for Meteorology (MPI-M), Prof. Dr. Martin Claussen will officially retire at the end of September 2021. However, he will remain with the MPI-M as emeritus professor for the next two years and will continue to devote himself to his research interests. Read about his scientific career, and what motivated Martin Claussen during his years as a researcher.

School, studies and dissertation — fluid physics and turbulence

Martin Claussen is a true northern German. He was born in Fockbek near Rendsburg in Schleswig-Holstein and grew up in Flensburg, where he also graduated from high school. Even in his school days, he knew that he wanted to do “something with physics” later on. Initially, however, he was interested in pursuing a career as a shipbuilding engineer, obvious when one grows up near the sea. An uncle advised him against it because of the lack of career prospects, but this later proved to be a misjudgement. A new passion was quickly discovered: meteorology, because his interest was and still is fluid physics. Studying meteorology suggested itself. He completed his studies at Universität Hamburg, where he wrote his diploma thesis on the radiative transfer in three-dimensional cloud fields under the supervision of Prof. Hans Hinzpeter in 1981. Lectures on climate history and thermodynamics by Prof. Hartmut Graßl, who was a post-doctoral fellow at Universität Hamburg at the time, awakened his interest in the topic of climate.

In addition to fluid physics, he was also very interested in turbulence research. He was able to look deeper into this topic in his doctorate after receiving his diploma — with a doctoral scholarship
from the Max Planck Society. His work, again under supervision of Hans Hinzpeter, was on turbulence spectra in the near-surface atmosphere. At that time, before the era of supercomputers, he performed his calculations with paper and pencil and used a pocket calculator programmed with BASIC. While being a doctoral student, Martin Claussen received a grant by the German Academic Exchange Service (DAAD) to spend a full year as a visiting scientist at the Massachusetts Institute of Technology (MIT) in Cambridge, USA. There he worked with Willem Malkus, who held the professorship of Applied Mathematics, and worked on problems of thermal convection, magnetohydrodynamics, and geophysical fluid dynamics. During this time, Martin Claussen gained valuable insights into fluid dynamics and addressed rotating flows, which also led to his first publications on turbulence. Along the way, he continued to work on his doctoral thesis at MIT. After returning from the USA, another year of doctoral studies followed in Hamburg, which he completed in 1984. He received the junior award of the German Meteorological Society (DMG) for his thesis.

**GKSS — flow modeling**

His doctorate was followed by a period as a postdoctoral researcher at the GKSS Research Center in Geesthacht (GKSS — Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt, now Helmholtz-Zentrum Hereon). Here Martin Claussen began his work with atmospheric models, in particular with the GESIMA model (Geesthacht Simulation Model of the Atmosphere), for which he programmed the lower boundary condition of the atmosphere (boundary layer). During his first six months in Geesthacht, Prof. Klaus Hasselmann, founding director of the MPI-M, offered him a postdoctoral position at the MPI-M, which he initially accepted because working with Klaus Hasselmann appealed to him. After six months, however, Martin Claussen was able to obtain a permanent position at the Institute of Physics at the GKSS that by then was headed by Hartmut Graßl, which was very attractive to him as a young postdoc. So he moved back to GKSS and worked in Dieter Eppel’s group for six years.

Having previously worked more analytically, he began to develop and program his own numerical flow model over complex terrain, taking into account abrupt changes in roughness, moisture, and temperature in the internal boundary layer. With this topic Martin Claussen habilitated on surface-near air flows over inhomogeneous surfaces at Universität Hamburg in 1991.

**MPI-M — vegetation modeling**

In the meantime, the new department “Climate Modeling” had been founded at MPI-M with Prof. Lennart Bengtsson as director. After meeting Lennart Bengtsson, Martin Claussen’s interest in climate modeling was piqued. He applied to MPI-M as a boundary layer meteorologist and after lunch with Lennart Bengtsson got a position. After about a year at MPI-M, his scientific interest got a decisive impulse from a lecture by Colin Prentice, who was a scientist in Uppsala, Sweden, then. He inspired Martin Claussen with his biome model, i.e., the ability to calculate and model biomes (macroecosystems) or global vegetation patterns. Martin Claussen stripped Prentice’s biome model down to the FORTRAN code, which can be used to calculate climate conditions for biomes. He coupled this model with the atmospheric model at MPI-M at the time, ECHAM3, with support from Monika Esch and Uwe Schulzweida. This was the initial spark for Martin Claussen to focus on vegetation in the climate. He was thus one of the first to link models of atmospheric dynamics and global vegetation patterns. He posed the question: what happens to the climate when biomes
are calculated with the biome model and then the climate model is fed back the change, namely the calculated new roughness, leaf area and albedo (“asynchronous coupling”)? The results of ECHAM3 were robust and proved the quality of the model. However, it became interesting when “playing” with the initial conditions, for example, deforestation or reforestation in certain regions of the world. Martin Claussen experimented with desert reforestation and was thus also the first to explicitly simulate desert/vegetation albedo feedback in an interactively coupled atmosphere-biome model. He demonstrated that the interaction between atmosphere and vegetation is one of the most important processes to explain paleoclimatic changes in North Africa, especially the expansion and retreat of the Sahara during glacial cycles.

Martin Claussen was also the first to successfully simulate a “green Sahara” in the early Holocene. Together with his co-workers, he analyzed the internal feedback and synergy factors that contribute to this greening. This work has inspired many paleoclimate modelers and paleoclimatologists not only with regard to African climate dynamics, but also to search for “hot spots” of atmosphere-biosphere interaction in other parts of the world. In particular, Martin Claussen found that the atmosphere-vegetation system can have multiple equilibria. This discovery is of high importance and has advanced our understanding of the living Earth system as a nonlinear dynamical system.

**Potsdam and Berlin — EMICs**

The Potsdam Institute for Climate Impact Research (PIK) showed interest in Martin Claussen’s work on the interaction between the climate and the global ecosystem and asked him in 1993 if he would like to become head of the “Climate System” department. Martin Claussen gladly accepted this challenge, especially since the position in Potsdam was linked to a professorship he was seeking. He was appointed Professor of Theoretical Climatology at Freie Universität Berlin in 1996, where he taught climate physics and climate history.

Martin Claussen established an internationally highly regarded climate system modeling group at PIK, where he actively promoted Earth system modeling using Earth system models of intermediate complexity (EMICs — an acronym proposed by Martin Claussen). His department included several Russian-born scientists such as Victor Brovkin, Andrey Ganopolski, and Vladimir Petoukhov, who had previously worked at IIASA (International Institute for Applied Systems Analysis) in Laxenburg, Austria. Brovkin and his colleagues had begun to develop the CLIMBER model (CLIMate and BiosphERe Model), just the right model with vegetation dynamics for Martin Claussen’s project: a model of medium complexity for coupling atmosphere, ocean and vegetation development, in order to simulate the changing climate over thousand years, which was not possible with the Hamburg model ECHAM3.

With few exceptions, most paleoclimate models were simplified models designed to demonstrate the plausibility of processes or extremely complex models that required large computational resources. Martin Claussen recognized that progress in the physical understanding of the dynamics of the paleoclimate can only be achieved by explicitly simulating the interaction between all relevant components of the natural Earth system and describing the relevant dynamics of these components in a geographically explicit manner. Prof. André Berger and his ideas on paleomodeling, especially on the Milanković theory and modeling with EMICs, have always inspired Martin
Claussen. André Berger was one of the first to work with an EMIC, and the two complemented and supported each other well.

During his time at PIK in Potsdam, Martin Claussen was offered a full professorship in climate physics at the University of Potsdam in 2002. In Potsdam, he was able to combine teaching with his research interests at PIK. In the same year, he became Deputy Director at PIK after Director Prof. Hans-Joachim Schellnhuber moved to the Tyndall Centre for Climate Change Research in England for three years.

Back to the MPI-M in Hamburg — Earth system modeling with JSBACH

PIK was a partner in the ‘Earth System Research Partnership’ (ESRP) of the Max Planck Society (MPG), which at the time included the Max Planck Institutes of Chemistry in Mainz and of Biogeochemistry in Jena, in addition to MPI-M. Martin Claussen participated in the annual ESRP meetings, where the succession of MPI-M Director Prof. Hartmut Graßl was discussed, who had moved to Universität Hamburg and MPI-M in 1988 after his time at GKSS. At a meeting of the International Geosphere-Biosphere Program (IGBP), in which Martin Claussen was an active member of several scientific committees, and which was chaired by Prof. Guy Brasseur, then Director at MPI-M, Guy Brasseur asked Martin Claussen if he would like to establish a “Land in the Earth System” department to complement the two departments Atmosphere and Ocean in the Earth System. Guy Brasseur had established the idea of Earth system research at the MPI-M and had promoted the extension of climate models to Earth system models. In 2005, Martin Claussen accepted the appointment as Professor of Physical Meteorology at Universität Hamburg and MPI-M Director, succeeding Hartmut Graßl in these positions.

The move from Potsdam to Hamburg was easy for Martin Claussen, as the combination of positions and the possibilities at MPI-M to establish a new department was very attractive.
Scientifically, developing complex land and vegetation models to couple with MPI-M’s atmosphere and ocean models to create a comprehensive Earth system model was very appealing to him. Victor Brovkin, his coworker and companion at PIK, also moved to Hamburg to his new department to continue working with Martin Claussen.

Milestones in Hamburg

As a leader in both positions at the university and at the MPI-M, Martin Claussen succeeded in 2007 in bringing to Hamburg, together with his professor colleagues Hans von Storch, Klaus Frädrich, Detlef Stammer and Jochem Marotzke, the then first and only Cluster of Excellence in the newly proclaimed Excellence Initiative of the Federal Government with a successful application: CliSAP (Integrated Climate System Analysis and Prediction). He led CliSAP for seven years. The subsequent application for a second phase from 2012 to 2018 was also successfully pushed through by Martin Claussen in collaboration with the university and partners.

From a scientific point of view, Martin Claussen and his employees, first Christian Reick, Karl-Georg ’Kalle’ Schnitzler and Thomas Raddatz — who were still employed at the MPI in Jena at that time — and later Victor Brovkin, Veronika Gayler and Reiner Schnur and many others developed the land model JSBACH (Jena Scheme for Biosphere-Atmosphere Coupling in Hamburg). With this model, the department “Land in the Earth System” led by Martin Claussen became a world leader in coupling biogeochemistry and biogeophysics. Most existing models had a carbon cycle, but not a carbon cycle coupled with vegetation dynamics. The modeling of the last thousand years (“millennium run”) was only possible with the Earth system model of MPI-M with the land component JSBACH. MPI-M was thus one of the first to build an Earth system model driven only by external forcings such as volcanoes and the insolation parameters of the sun (according to Milanković), and that was fully coupled with land, vegetation dynamics, and land use to calculate the carbon cycle. The breakthrough was the fully coupled Earth system model with a terrestrial carbon cycle.

Prof. Julia Pongratz, now Professor at LMU Munich, was one of his first doctoral students to use the new model to investigate how land use acted physically, i.e. via energy fluxes, and how this affected the carbon cycle or the greenhouse effect. Later, Sabine Egerer was the first to prove in her PhD thesis that dust input found in sediment cores of the North Atlantic was directly related to land use changes in the Sahara during the last millennia, and Anne Dallmeyer provided a meteorological explanation of the spatially heterogeneous, rapid termination of the last African Humid Period some 5000 years ago — to name just a few important contributions.

Martin Claussen himself continued to work on the Sahara, exploring questions such as: Why was the Sahara much greener and the Saharan climate much more humid during warmer periods of the last millennia than it is today? Why did the Sahara expand very rapidly — in geological terms, quasi-abruptly — in some regions a few thousand years ago and more gradually in others? Could the Sahara become greener again due to current global climate change?
Retrospect and outlook

In retrospect, a number of scientists in Martin Claussen’s scientific career have set an important course through their work and ideas: Hartmut Graßl got him excited about climate in his lectures, and Colin Prentice gave him the idea of modeling global vegetation patterns. André Berger and his ideas on paleoclimate theory and modeling have always inspired Martin Claussen. Guy Brasseur’s Earth system initiative has brought complex coupled Earth system modeling with JSBACH to the forefront of the world. Martin Claussen thus recognizes his scientific path as coherent; with the fundamentals as a fluid physicist, he could, for example, also have made shipbuilding and propeller theory his area of expertise. However, the knowledge he acquired was a good foundation for his research in meteorology, climate and Earth system modeling.

In his coming years as Professor Emeritus at the MPI-M, Martin Claussen will continue to supervise a couple of PhD candidates and will continue to work on the “green Sahara”, its structures, and investigate it in models. His advice for young scientists: “Think about the direction you want to go, set guard rails, make late decisions, and seize opportunities along the way.”

Selected publications


More information:

MPI-M:
https://mpimet.mpg.de/mitarbeiter/martin-claussen

Leopoldina:
https://www.leopoldina.org/fileadmin/redaktion/Mitglieder/CV_Claussen_Martin_D.pdf

EGU, Laudatio Milutin Milanković Medal:

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