

Climate Physics: Meteorology and Physical Oceanography (Master of Science)

The study of climate physics (meteorology and physical oceanography) will provide students with advanced knowledge and skills using the terms and laws of physics in atmosphere, ocean and the climate system. Students will become familiar with experimental and theoretical methods, and will be guided toward current research. The courses will provide instruction on how to present physical context, how to critically assess scientific problems, and how to apply modern methodology in experimental and theoretical climate physics. Mathematical methods are an indispensable tool for processing physical relations, and they are essential for the comprehension of physical context.

Meteorology (physics of the atmosphere) and oceanography (physics of the ocean) are part of geophysical sciences with primary relevance for the climate system of our planet.

The subject of meteorology is the atmosphere, i.e. the atmospheric envelope covering our planet Earth. As an open-boundary physical system, the atmosphere has varied interactions with the other physical systems (space, sun, ocean, land) as well as living systems of this planet. Meteorology can be defined as the science investigating the atmosphere and its interaction with other systems through exact scientific methods.

Physical oceanography is primarily concerned with physics of the ocean and its interaction with the atmosphere. Its central goal is the comprehension and description of complex motions in the ocean, on various scales of time and space. These motions include strong and persistent currents, such as the Gulf Stream, but also time-varying eddy fields which dominate vast areas of the world's ocean.

An active research field is the interaction between ocean and atmosphere. Both systems force each other in ways that are only partly understood but are of major importance for understanding climate variability. This is the topic of climate physics. One of the striking examples is the El Niño phenomenon, evidenced through a warming of surface waters in the Pacific off the coast of Peru but with equally major and far-reaching consequences in various regions of the world, such as changes in local rainfall and the subsequent occurrence of flooding or droughts. Other related coupled phenomena exist in the other two tropical oceans. An additional example are global interactions mediated by the large-scale ocean currents, for example the thermohaline circulations in the Atlantic and Southern oceans. Changes in atmospheric forcing alter ocean circulation, and therefore the ocean's uptake of gases, such as CO₂ and oxygen. An altered carbon cycle has direct feedback on atmospheric radiation, and oxygen is one of the key elements of marine biogeochemical cycles.

The goal of the master's program is to allow students to achieve a better understanding of the role that ocean and atmosphere play in such coupled climate scenarios on time scales from years to decades and to improve prediction feasibility for the Earth's physical climate. By now it has become an accepted fact that the ocean takes on a key role in anthropogenic climate changes. Important aspects are here the uptake of greenhouse gases from the atmosphere, and the related feedback on global warming, circulation changes and their impact on the marine ecosystem as well as sea level rise. The multitude of factors influencing the climate of ocean and atmosphere requires a multi-disciplinary collaboration between various sciences. Therefore, the investigation of ocean climate and related phenomena is specifically based on a combination of oceanographic, meteorological and to some extent bio-geochemical observational programs. These are closely related to various computer models which permit not only a more and more realistic simulation of structure and variability of climate phenomena, ocean currents and their interaction with the marine ecosystem but also the identification of possible scenarios with anthropogenic contributions to climate change.