Exchange Processes between Ocean and Atmosphere play a Key Role in the Understanding of Earth’s Climate

The world’s oceans constitute an enormous capacity to absorb heat and dissolved gases. The net uptake by the ocean is about 34% of all carbon released into the atmosphere and thus representing a major sink.

In the wind-wave facility AEOLOTRON all aspects of small scale air-sea interaction are investigated under laboratory conditions. It is the goal to understand the fundamental principles of the underlying exchange processes at the water surface.

The knowledge of the underlying transport processes is quite incomplete because the transfer across the air-sea interface is very difficult to observe. To obtain new insights, digital imaging techniques (including visualization of short wind-wave slope, concentration fields in the boundary layer, active and passive thermography) for the quantitative investigation of heat and gas exchange have been developed and are deployed in the wind-wave facility to investigate the transport processes under laboratory conditions.

The AEOLOTRON provides realistic wind conditions (unlimited fetch) while environmental parameters (e.g. wind, temperature, humidity, pH value) are controllable.

Exchange of Heat, Gas and Momentum

The exchange of inert and weakly soluble gases including carbon dioxide, methane and oxygen between atmosphere and ocean is governed by the interplay of turbulent transport and molecular diffusion in the 20–200 μm thick aqueous diffusive boundary layer, roughly one order of magnitude thinner than the thermal and viscous sublayer.

The turbulent wind field generates a shear current and turbulence by viscous friction at the water surface and thus determines the thickness of the boundary layers. Therefore, the transport of momentum, mass, and heat across the air-sea interface are closely related.

Measurement of Gas Exchange Coefficients

Tracers with different solubilities and diffusivities are used. Their concentrations, determined using UV and IR spectroscopy, are monitored over time. Gas transfer rates of tracers are calculated using mass balance methods.

Visualization of Short Wind-Wave Slope

The blue planet: two-thirds of the earth’s surface is covered by water.

Active and Passive Thermography

The analysis of infrared image sequences enables the investigation of heat flux, surface flow field, and heat exchange directly at the water surface.

Visualization of Concentration Fields in Boundary Layers

The complexity of the transport processes is caused by the wind blowing over the surface which not only causes a turbulent shear layer but also generates wind waves that interact with the turbulent shear layer and in turn influence the air flow. Moreover, short wind waves and near-surface turbulence are strongly influenced by traces of surface active material.

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