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Laboratory experiment on complex investigation of wind-wave interaction at the Heidelberg Small-Scale Air-Sea Interaction Facility

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In frame of laboratory experiment several aspects of wind wave interaction were investigated: the air flow structure over steep water waves, flow structure in the water, the skin friction and vertical gradients of velocity fields at the air-water interface, flow velocity at the surface. Experiment was made at the Heidelberg Small-Scale Air-Sea Interaction Facility, the Aeolotron (annular wind-wave facility, 60 cm width, 2.4 m height, circumference of 27.3 m at the inner wall; water depth during experiments 1.0 m, water volume 18.0 m^3, air space volume 24 m^3). Wind was generated by two axial fans mounted into the ceiling, equivalent wind speeds up to 16 m/s.
Water surface position was captured by to independent methods: laser height system of a vertical airside laser sheet and a side camera that captured fluorescence emission from the near-surface water layer and imaging slope gauge [1] that was capturing slope images of the surface with high-speed camera above the surface and gradient underwater light source. Water surface velocity was estimated by tracking of heat markers made on a surface by an infrared laser.
Airside measurements were made by PIV technique: small high pH water droplets with fluorescent dye (pyranine) were generated by pneumatic nozzle, at the measuring area they were illuminated by laser sheet and captured through the side window by high-speed camera with a band-pass filter on its lens, blocking reflected laser light. Water in facility has low pH so only artificially generated water droplets emitted in fluorescence band and were visible at images. Underwater measurements were made in similar technique with underwater laser sheet and hydrogen bubbles, generated from electrolysis, or 20 μm polyamide particles as markers. Airside and underwater measurements were made separately but both were complemented by synchronized surface measurements. A phase averaging method [2] was used to obtain turbulent pulsation averaged velocity fields of the air flow over the water surface curved by a wave and average profiles of the wind velocity.
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