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Planar time-resolved PIV for velocity and pressure retrieval in atmospheric boundary layer over surface waves.

Yuliya Troitskaya (1,2), Alexander Kandaurov (1,2), Daniil Sergeev (1,2), Maximilian Bopp (3), and Guillemette Caulliez (4)

(1) Institute of Applied Physics, Nonlinear Oscillations and waves, Nizhny Novgorod, Russian Federation (yuliya@hydro.appl.sci-nnov.ru), (2) University of Nizhni Novgorod, Russian Federation, (3) Heidelberg Collaboratory for Image Processing, Heidelberg, Germany, (4) Mediterranean Institute of Oceanography, Marseille, France

Air-sea coupling in general is important for weather, climate, fluxes. Wind wave source is crucially important for surface waves' modeling. But the wind-wave growth rate is strongly uncertain. Using direct measurements of pressure by wave-following Elliott probe [1] showed, weak and indefinite dependence of wind-wave growth rate on the wave steepness, while Grare et.al. [2] discuss the limitations of direct measurements of pressure associated with the inability to measure the pressure close to the surface by contact methods. Recently non-invasive methods for determining the pressure on the basis of technology of time-resolved PIV are actively developed [3]. Retrieving air flow velocities by 2D PIV techniques was started from Reul et al [4]. The first attempt for retrieving wind pressure field of waves in the laboratory tank from the time-resolved PIV measurements was done in [5].
The experiments were performed at the Large Air-Sea Interaction Facility (LASIF) - MIO/Luminy (length 40 m, cross section of air channel 3.2 x 1.6 m). For 18 regimes with wind speed up to 14 m/s including presence of puddle waves, a combination of time resolved PIV technique and optical measurements of water surface form was applied to detailed investigation of the characteristics of the wind flow over the water surface. Ammonium chloride smoke was used for flow visualization illuminated by two 6 Wt blue diode lasers combined into a vertical laser plane. Particle movement was captured with high-speed camera using Scheimpflug technique (up to 20 kHz frame rate with 4-frame bursts, spatial resolution about 190 μm, field of view 314x12 mm). Velocity air flow field was retrieved by PIV images processing with adaptive cross-correlation method on the curvilinear grid following surface wave form. The resulting time resolved instantaneous velocity fields on regular grid allowed us to obtain momentum fluxes directly from measured air velocity fluctuations. The average wind velocity patterns were retrieved using conditional averaging with phase like in [5]. Basing on these data we then retrieve the pressure field and find the air-sea interaction parameters. Peculiarity of these experiments was the presence of noticeable modulation of the waves, so we describe peculiarities of the pressure distribution over a wave-train.

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