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Editorial: Applications of Infrared Methods in Fluid Mechanics

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Editorial on the Research Topic

Applications of Infrared Methods in Fluid Mechanics

Visible electro-optic systems have a long history as tools for sensing and documenting physical phenomena in fields such as oceanography and astronomy. However, thermal infrared (IR) radiation bands are increasingly included in sensing systems, as they have matured from single pixel detectors, to line scan systems, and to the modern staring focal plane array cameras of today. These systems have benefited greatly from numerous technological advances in electronics, integrated circuit design, closed-cycle cooling systems, and materials engineering. Now commercially available high definition high dynamic range fast frame rate cameras with pixel pitch on the order of 15 microns are available. Engineering applications include the detection of energy losses in buildings, detection of atmospheric and waterborne pollutants, medical imaging, and many others too numerous to mention.

In spite of the wide applicability of these advanced systems in geophysics and astronomy, their use in exploring smaller scale fluid dynamical processes has only recently begun. Unlike visible or near-infrared (non-thermal) electro-optic sensor systems that primarily rely on the reflective and scattering properties of an object, thermal infrared cameras sense emitted radiation. In many applications, sensors are designed to detect IR radiation in the 3–5 micron (Mid-Wave-IR or MWIR) and 8–14 micron (Long-Wave-IR or LWIR) wavelength bands. With a typical camera thermal resolution of 25 mK or better, many subtle temperature changes unable to be detected easily by other means, are now accessible.

It is our intent to provide the reader of these contributions a glimpse into a field which can be referred to as *infrared hydrodynamics*. Here, researchers use these highly sensitive modern infrared methods to reveal complex hydro-thermal processes such as free-surface turbulence interactions, surfactant effects on surface fluid motions, and air-sea transport of heat and gas at air-liquid interfaces. Articles in this Research Topic cover passive and active experimental techniques, theoretical approaches, and numerical modeling.

Two papers (Kunz and Jähne; Savelyev and Fuchs) in this collection examine laboratory scale experimental methods for extracting information related to small-scale exchange processes and motion of air-water interfaces. As a consequence of the thermal resolution of modern IR sensor systems, passive imaging of a scene exploiting naturally occurring processes that form thermal gradients is frequently sufficient to produce meaningful image data. However, often it is more instructive to actively stimulate a surface with a known amount of energy in order to quantify, in a meaningful way, a particular process or too use as a surrogate, the transfer of energy (heat), to shed light on gas transfer mechanisms and fluxes. Succinctly, it is the accurate prediction of the transport of mass, momentum, and energy across the air-sea interface that is of importance for determining the long term global climate.

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At the heart of many remote thermal IR detection techniques is the assumption that sufficient signal exists, at least under some quasi-ideal conditions. This is especially valid when remotely examining oceanic heat flux from airborne or satellite platforms. Significant non-ideality comes in the form of non-flat water surfaces (i.e., surface-waves), scattering of radiation in the water column and atmosphere, and a variable emissivity. Two theoretical works (Handler and Judd; Judd and Handler) in this collection approach this problem by using a form of the radiation transport equation and simplified models for subsurface thermal stratification to generate a non-dimensional expression for estimating the signal strength as a function of the parameters and length scales of the problem.

The final contribution (Marmorino et al.) to this collection is a more traditional application of IR imaging to oceanic features at the submesoscale. It combines IR imaging from an airborne platform with simultaneous *in-situ* water surface and column measurements from waterborne assets to quantify eddies on this scale and to provide ground truth.

This collection of papers should appeal to experimentalists and theoreticians alike in the fields of oceanography, mechanical engineering, environmental engineering, and physics as well as those interested in applying various infrared imaging techniques to quantify the spatiotemporal characteristics of micro- and macro- fluid flows.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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