INFRARED REMOTE SENSING OF COHERENT STRUCTURES IN AN ESTUARINE RIVER

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Coherent structures in rivers are generated by the interaction of the flow with bathymetric and shoreline features. These coherent structures produce surface signatures that can be detected and quantified using remote sensing instruments such as infrared (IR) cameras and microwave radars. Furthermore, the existing evidence suggests a number of relationships between coherent structures and flow characteristics that have the potential to allow flow parameters to be inferred from remote measurements. The Coherent Structures in Rivers and Estuaries Experiment, or COHSTREX is a five-year, multi-institutional collaboration to determine the extent to which the remotely-sensed signatures of coherent structures can be used to initialize and constrain predictive models for river and estuarine flows. Following a brief overview of COHSTREX, we report on the use of IR imagery to characterize and quantify the flow in the Snohomish River, in Everett, WA. Applications of IR techniques include using Digital Particle Imaging Velocimetry techniques to derive surface velocity and detecting coherent structures such as vortices and boils.

During the 2006 COHSTREX measurement campaign, we found that the thermal signature of boils generated by the flow over a submerged sill can be used to detect the presence of stratification due to an estuarine salt wedge. The boils were observed to have both warm and cold surface signatures depending on the phase of the tide. In the absence of stratification, the boil signature was warm relative to the surrounding undisturbed surface. A warm signature is consistent with disruption of the cool thermal boundary layer that is typically present at the surface of natural water bodies. When the stratification was present, the boil signature was cool relative to its surroundings. Comparisons with in situ temperature and salinity measurements show that a cold signature is due to deep, colder water from the salt wedge being brought to the surface. We also found that near-surface diurnal heating due to solar radiation can significantly affect the thermal signatures of boils and other surface disruptions such as surface wakes. Our findings indicate that the thermal signature of coherent structures generated by flow over topography can provide information on the presence and degree of stratification.

More recently in the fall of 2008, we moved upriver where the tide still influences the river flow but away from the influence of the salt wedge. The goal of this preliminary study was to to determine if quantifiable signatures of coherent structures in unstratified flows were possible using infrared techniques. We used a recently developed remote sensing system which combines a stabilized gimbaled turret containing EO and IR cameras with a helikite (helium-filled kite). This system provides long dwell time and large area coverage. We found that the disruption of the surface thermal boundary alone provided detectable infrared signatures of boils. These preliminary measurements suggest that boils are generated by distributed roughness in addition to individual bathymetric features, such as bumps and holes. We highlight these recent findings and outline our plans for a major field experiment in the fall of 2009 to determine if the infrared signature of boils can be used to characterize bottom roughness.