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PROJECT SUMMARY (example)

Developments in computer resources and laboratory methods over the past 20 years are expanding our understanding of turbulence and revolutionizing the field of environmental fluid mechanics. Through these advances, environmental fluid mechanics is increasingly in a position to evaluate the instantaneous, turbulent velocity and concentration fields and no longer must rely on mere average quantities. This Career proposal addresses intermittency, turbulent fluctuations, and coherent structures for multiphase plumes in environmental applications and advances the curriculum available for teaching and communicating a modern view of environmental fluid mechanics.

Multiphase plumes in stratified and flowing ambient environments occur in a wide range of industrial and environmental applications. This Career proposal seeks to understand the instantaneous characteristics of field-scale plumes to predict biologic impacts and to interpret real-time field measurements of purposeful, natural, and accidental injections. Laboratory experiments will measure full-fields of instantaneous velocity and concentration for multiphase plumes in stratification, crossflow, and combinations of both. A primary orthogonal decomposition (POD) of the dispersed phase and entrained fluid motions will elucidate mechanisms for separation between phases and correlations between coherent structures in the dispersed-phase and entrained ambient fluid. The laboratory data will be used to develop dynamic sub-grid scale models for turbulence simulations. To test the analysis methods developed in this proposal, field data for carbon dioxide sequestration plumes in the oceans will be made available.

Environmental fluid mechanics is a rapidly advancing field of engineering, and new materials are needed to bring these advances into the classroom. The objective of this Career proposal is to develop curriculum and resources for teaching environmental fluid mechanics to a wide range of audiences. A textbook for senior-level undergraduates and first-year graduate students will be developed and complimented by a comprehensive, interactive website and online assessment tools. The visualization and animation capabilities of the web will also be exploited to introduce K-12 students to common problems in environmental fluid mechanics and to the results of the proposed research on multiphase plumes. International forums and partnerships, in the form of an international exchange with Germany and participation in the International Association of Hydraulic Engineering and Research (IAHR) European Engineering Graduate School Environment Water (EGW) are also proposed to give the broadest possible impact to the proposed activities.

Intellectual Merit
The intellectual merits of the proposed activity: This Career proposal responds to current needs in design, analysis, and prediction of multiphase plumes in environmental applications with advanced investigative methods. The laboratory measurements will provide fundamental insight into the turbulent properties of multiphase plumes. The POD analysis will be used to evaluate the role of coherent structures in controlling pollutant transport in multiphase plumes and to develop appropriate turbulence models. Through the curriculum development, the utility of visualization and animation to communicate complex topics will be investigated.

Broader Impacts
The broader impacts resulting from the proposed activity: The activities identified in this Career proposal provide important resources for learning, understanding, and advancing environmental fluid mechanics. A research website will be developed that gives access to the laboratory data, developed numerical models, and animations illustrating important multiphase plume physics. A course textbook and educational website will also be developed that emphasizes outreach to a broad audience through use of visualization, animation, and interactive components. A research and educational exchange program with Germany will also be developed to promote cross-cultural communication and understanding.