CE 360
Fluid Dynamics
Extra Credit Essay

Computational Fluid Dynamics – Environmental Flows

Fluid dynamics is the science of explaining liquids and gases in motion and how they interact with solid bodies. This science has been studied for centuries and with each progressing century this field continues to become more exciting and challenging due to the complexity and the broad spectrum of applications this subject applies too in our everyday lives. Fluid dynamics is by far one of the most intricate fields of science and is at the core to much of engineering and science. The real world applications in which fluid dynamics applies range from the environment and energy, medicine, homeland security, defense, transportation, biology, and manufacturing. Whether they understood the subject, the Wright brothers utilized fluid dynamics by successfully creating an aerodynamic plane that flew. This same concept is still one of the most important factors in creating cars and ships of today. Scientists and medical experts are able to predict how blood flows throughout the human body and the behavior of fluidic devices on the micro and nano scale. Engineers are determining the most effective and efficient methods of cooling electronics devices and weather experts are able to analyze and predict the impact of weather and climate. All of these abilities would not have been possible without a strong knowledge of fluid dynamics.

Striving for deeper understanding of the subject has led to advances in several fields of science. These include applied mathematics, physics and computational physics, and experimental techniques. One of the more complex branches of fluid dynamics is computational fluid dynamics. Using algorithms and numerical methods supercomputers execute millions of calculations attempting to simulate as accurately as possible the interactions of liquids and gases with solid bodies. Ongoing research is continually carried out to obtain the most accurate simulations possible, however even the supercomputers of today using simplified equations have difficulty with this. One of the main problems affecting this accurateness is the Navier-Stokes equations which have no general analytical solutions. Challenges in this science only probe scientists and engineers to devote more time largely in part because of the new advancements in technology that use analytical methods for simulation using parallel computers. These advancements allow fluid dynamics to be seen like never before in its full complexity and unbelievable detail. One of more astonishing applications of this technology made available in thanks to fluid dynamics are computational fluid dynamics showing environmental flows.

The enormous impact of studying environmental flows may be taken for granted by the majority of people, however, the investment of time and money into this research will inevitably help to allow man to understand the world and all the natural phenomenon that come with it. Whether people realize it or not fluid dynamics is the core behind predicting occurrences such as hurricanes, tsunamis, El Niño, the ozone hole, and pollution transport. This science may not be given its full appreciation now, however, in the future this branch of computational fluid dynamics will help the U.S. and the world to live safer lives and prolong the existence of an inhabitable earth. The better understanding of environmental flows will lead to critical decisions for engineering, planning, and policy making. These flows can range in magnitude from analyzing space to the modeling of enormous weather systems that encompass the globe. Smaller focuses include atmospheric waves caused by mountains, vortices in the atmosphere, hurricanes, thunderstorms, ocean gyres, and even contaminant dispersal throughout cities. Understanding environmental flows once again will help to prevent destruction and death.

Studying environmental flows is an ongoing research project that will continually become more accurate and precise. By constantly collecting data, scientists and engineers are able to update environmental flow modeling applications. These mathematical models allow those involved to understand what governs the formation and growth of global weather patterns. This knowledge will be a key tool in predicting weather and allow for better comprehension of the processes that power near-term weather along with predicting climate change in the future. Climate modeling is especially valuable in aiding to national and international climate assessments along with understanding climate change, whether it is human or naturally induced. Forecasting El-Nino events which are known to cause instability in weather patterns is another skill of climate modeling. As mentioned before, studying flows is not only beneficial on the large scale, but is just as important on a smaller scale as well.

Understanding smaller scale flows are something people might be able better visualize or grasp. For example imagine a nuclear power plant were to begin emitting radioactive material into the atmosphere. These particles would be at the mercy of the wind streams and potentially led towards an urban area or city. Computer modeling techniques would allow for the almost exact prediction of the path of these contaminant particles. Scientists would have the ability to visualize the dispersion of air through city streets and even if the air began to seep into the buildings themselves. With the recent rise in terrorism there has been a vast worry of bio-chemical terrorism. Fluid dynamics allow computer modeling simulations to determine the best emergency evacuation plans that will deter human loss. Safe transportation by sea or air is also improved due to fluid dynamics. Whether it is predicting liquid flows of ocean waves and currents or determining the most efficient flight route to bypass turbulent wing gusts. On an even smaller scale simulations can be run to show the airflow into human lungs. Computer modeling can detect millimeter-sized flows that give off energy and these energies help to suspend particles that affect human health on even the micro or nano scale such as biota, aerosols, or pollutants. Distributions of nutrients are controlled by natural flows and allow biodiversity to be maintained. The combinations of large and small scale flows are what sustain life on earth. Fluid dynamics makes it possible to understand these flows and helps scientists and engineers to maintain the earth’s life.

Fluid dynamics has also helped to solve and combat the problems of hydraulics in the environment. Hydraulics is another branch of fluid dynamics that look into the mechanical properties of water. As for the environment this can include river channel behavior and erosion. Many of these problems deal with the sustainability of resources and the ecosystem. A huge concern is sustainable water supply and the drainage of rivers that control the flow of sedimentation which is crucial to plant and animal life. These flows maintain vegetation, stability of river banks to prevent erosion, wetlands, fish populations and habitats, and interactions between rivers and floodplains. Another concern is pollution and subsurface seepage, where the seepage is stored and recharged. All of these factors have the potential to cause economic repercussions if not maintained.

At the forefront of environmental flow forecasting are the sub-grid scale parameterizations. These parameters are mathematical representations of processes occurring within the computational grid boxes of predictive models. These processes (turbulence, mixing, eddies, waves, convection, and diffusion are understood qualitatively, but not quantitatively, due to the nonlinearity of natural phenomena (4). This is the environmental flow research of the future. This research is cutting-edge and will allow the study of real life applications of flow configurations.

Environmental fluid dynamics is a branch of fluid dynamics that will have huge impacts on the future sustainability of life and the well being of the habitants on earth. Fluid dynamics allow for the prediction of huge weather storms to the preventing of human loss in case of bio-terrorism attack. This science will continue to be researched and explored and the benefits seem endless. The majority of people don’t realize it but this field is having a huge effect on their lives.

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