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Finding Order in the Apparent Chaos of Currents

The patterns of the flow in oceans and rivers have really captured the minds of thinkers for centuries. The brilliant artist Leonardo de Vinci would sketch the swirls of water in rivers and the vortexes of blood he imagined to flow in the human arteries. Recently, scientists have studied the water currents of the Monterey Bay in California. Due to new technology there has been great findings and research in the way things "flow" specifically within the Monterey Bay. The teams of scientists have been studying the Monterey Bay since 2000. The scientists used high-frequency radars that track the speed and direction of the flowing waters in Monterey Bay as well as computers that rapidly perform millions of calculations to help find structure in the flow of the bay. The scientists have concluded that the bay has a specific flow and that while it may appear to have many jumbled currents, it really has structure.

In order to look at the different elements of flow, different techniques much be used. In laboratories, the researchers shine lasers on small particles that are caught in the flow, and then captured their trajectory, or path, with really fast high-resolution digital cameras. In the earth's atmosphere or oceans, scientists rely on high-frequency radar, satellites, and laser detection systems. While in the human body, researchers map the complex patterns in blood flow using very small detail and phase-contrast magnetic resonance is utilized. But overall, computers take in the data from all the sources and apply algorithms to their apparent flow path that then uncover the flow structures and the flow patterns. The concept of the structures grew out of dynamical systems theory, a branch of mathematics used to understand complicated phenomena that change over time. The discovery of the structures in a wide range of real-world cases has shown that they play a key role in complex and chaotic fluid flows in the atmosphere and ocean.

The eighteenth century savant named Joseph-Louis Lagrange was a pioneer in the study of moving fluids, but his ideas outran the computational tools of today. Now only with the technology we currently have and the supercomputers available to help with calculations, it is possible to explore these ideas completely. What is emerging is a picture of fluid dynamics with more subtle and more complex than anything thought of ten years ago. The atmosphere and the ocean are, it seems dominated by invisible barriers that have come to be known as “Lagrangian Coherent Structures.” The structures are invisible because the often exist only dividing lines between parts of a flow that are moving at different speeds and in different directions. In the ocean, the path of a drop of water on one side of such a structure might diverge from the path of a drop of water on the other side; they will drift farther apart as time passes. These structures govern the movement of everything from trajectories, or path’s, of aircraft to distribution of pollution, the migration of jellyfish and the tracks taken by hurricanes. Overall, Lagrangian Coherent Structures can be seen as skeletons of the air and sea.

What the scientists see in the Bay predicts an ever-shifting Lagrangian pattern, which predicts at any given moment that regions of the bay will wash pollutants out to sea and will confine them to the coast. This information will ultimately help authorities work out when it is safe to permit operations that risk causing leakage, such as repairs to shore-based oil tanks.

What this research reveals is that there is a hidden structure within liquids and gases that guides the movement of everything from pollution to airplanes and blood to ocean flow. Although flow appears to have a jumbled chaotic pattern, it instead holds an underlying complex structure that actually guides dispersal patterns. When scientists look at the data sets, these structures can be found. Ultimately flow seems to be a random or a chaotic act while it actually takes on structure. If you are able to observe enough datasets, one can start to view these structures and enables researchers to explain these patterns.

This article shows how one topic about flow can encompass and be very important to many different sciences such as pollution control, biomedicine, architecture, and oceanography. Even though these fields of science are all different they all include the key element, which is the understanding of the structures and patterns of flow. The Lagrangian coherent structure approach may help predict the passage of hurricanes that are too constrained by the invisible barriers that Lagrange's theory describes. This technique might also even improve understanding of how water from melting caps will affect ocean currents, including the Gulf Streams as well as aerodynamic drag on cars and lift under aircraft wings.