Meteorology

Watery model for microbursts

from Alan Thorpe

An ingenious laboratoy simulation of the microburst — a severe hazard to aircraft on landing and taking off, and the probable cause of the fatal accident at Dallas, Fort Worth Airport in August — is reported by P.F. Linden and J.E. Simpson on page 601 of this issue. In the simulation, a dense fluid (saline water), which represents the cold air flowing out along the ground from a thunderstorm downdraught, flows into a less dense medium, producing a horizontal vortex at the leading edge of the outflow. What is observed is an increase in circulation of the vortex as it decreases in area, when the denser fluid spreads out in three dimensions away from the source. This strong circulation in the vertical plane is likely to be one of the main hazards of microbursts for aviation.

After preliminary studies some 10 years ago by T. T. Fujita of the University of Chicago into extremely localized downdraughts in thunderstorms, several campaigns were set up to observe their properties. These phenomena are now known as downbursts or microbursts if they have a horizontal scale smaller than about four kilometres. Impetus for this research was, and continues to be, given by the well-documented hazards to aviation of downbursts and related phenomena (see Kessler, E. *Nature News and Views* **315**, 179; 1985). Projects, with picturesque acronyms like NIMROD, JAWS and CLAWS, have shown, amongst other features, the existence of the horizontal vortex structure now simulated by Linden and Simpson. In common with most meteorological phenomena, complex flow patterns accompany the real event.

The meteorologist is, however, rarely in the position of the physicist who constructs a controlled laboratory experiment to test theoretical ideas. In a very real sense he is a spectator of the weather, attempting to develop theories about a system whose initial conditions are imperfectly known and certainly uncontrollable. Flows relevant to meteorology that can be simulated in the laboratory with any degree of realism are therefore of considerable scientific interest. In that respect the work of John Simpson and his collaborators over the past 15 years, using laboratory gravity currents to provide simplified models of thunderstorm outflows and sea-breeze fronts, is notable. Another valuable type of laboratory experiment is the rotating annulus, used to understand the sensitivity of global-scale circulations to basic parameters such as rotation rate, temperature differences between the pole and equator, and variations in surface elevation. In contrast, it is extremely difficult to simulate, for example, a convective cloud in the laboratory as the critical release of latent heat when water vapour condenses to liquid is difficult to reproduce with workable laboratory fluids.

It is important to consider the relationship of these laboratory results to the atmosphere. A thunderstorm is indeed a complex phenomenon from a fluid dynamical viewpoint, involving cooperation between an updraught of buoyant, moist air and a cold downdraught. Microbursts are but one aspect of some downdraught outflows; Fujita enumerates many other structures which can be hazardous, including straight-line winds, suction vortices, burst swaths and tornadoes (*J. atmos. Sci.* **38**, 1511; 1981). Meteorologists are used to describing an entity like a thunderstorm as a whole system, realizing that details of the flow may be dependent on many other related features of the storm. For example, the evaporation and drag that is produced by falling rain is necessary to maintain the storm downdraught, and this air, which feeds the downburst outflow, has both rotation and considerable downward momentum, so may be far from being in hydrostatic balance. The laboratory simulation cannot represent all these properties but can graphically illustrate those aspects of the dynamics of microbursts that are shared with gravity-current flows. A more complete description will come from a combination of observations, laboratory experiments and numerical modelling. □

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Wreckage of the Boring 747 that crashed in a thunderstorm at Dallas, Fort Worth airport in August 1985 (photograph: Popperfoto).

Developmental neurobiology

Trophic control of channel gating?

from Hans R. Brenner

Synapses are the communication points between nerve cells but do they communicate more than just electrical signals? From work on the development of synapses, the answer is clearly yes. On page 621 of this issue, Marshall[1], now demonstrates that, at neuronal synapses in frog sympathetic ganglia, the dynamic characteristics of postsynaptic ion channels are influenced by the nature of the presynaptic input.

Chemical transmission at synapses requires a high density of receptor proteins in the postsynaptic cell membrane. Binding of neurotransmitters to the receptors ultimately results in an electrical response in the postsynaptic cell. Accumulation of receptors in the postsynaptic membrane seems to be induced by the presynaptic neurone when a synapse is formed. At one specialized synapse, the neuromuscular junction, it is known that accumulation of the receptors is followed by a change in the gating and conduction properties of their ion channels. Therefore, both the number of receptors and their functional properties at this synapse may be influenced by the presence of the presynaptic neurone. Marshall[1] has now shown that the behaviour of postsynaptic channels on certain ganglionic neurones can be altered when the neurones are innervated by foreign axons.

Sympathetic ganglion cells innervate smooth muscle and glands. In frog, two types of principal cells, B and C cells, can be readily distinguished by their size and the velocity with which they conduct electrical impulses. Stimulation of the nerves entering the ganglion, which contains afferent axons innervating the B and C cells (see figure), produces a fast excitatory response followed by slower potential changes in both cell types. The fast excitatory postsynaptic potential is mediated by nicotinic acetylcholine receptors and is analogous to the endplate potential in skeletal muscle. Marshall finds that the channels activated by acetylcholine in the two ganglion cell types differ in the times for which they remain open: the apparent mean open time of B-cell channels is considerably shorter than that of C-cell channels. Furthermore, when B cells are chronically denervated, the gating behaviour of their channels is unchanged but if these cells are reinnervated by the axons that normally go to C cells the open times of the B cell channels are prolonged, becoming similar to those in C cells. This is a strong indication that the expression of specific characteristics of channels in the postsynaptic membrane may depend on the type of presynaptic neurone that innervates them.

The plasticity of the ganglion cells in