Atmospheric physics

Predicting the ionosphere

from D.G. Cole

THE status of the ionosphere — modelling, measurement techniques, applications and forecasting of the ionized upper atmosphere — was discussed recently at a conference held under the auspices of the Australian Ionospheric Prediction Service in Sydney*. Regarded by some as an anachronism, ionospheric research has enjoyed a resurgence of interest to cope with a demand for high-speed digital data traffic on ionospherically propagated paths, increased high frequency (3-30 MHz) radio communications in developing countries and transionospheric propagation problems.

The fundamental tool of the ionospheric forecaster is an ionospheric model. The present status of such modelling was reviewed by J. R. Dudeney (British Antarctic Survey). At present the most widely accepted model is the International Reference Ionosphere (IRI) (eds Lincoln, J.V. and Conkright, R.O. NOAA Report, Boulder, 1981) which is distributed on magnetic tape. IRI gives profiles of electron and ion density, temperature and relative ion composition; a user supplies location, time of day, season and solar activity. The model is used widely, even though it is inapplicable to auroral zone regions and times of very high solar activity, and does not consider irregularity structures.

The two regions that still provide the greatest problems in any modelling or prediction schemata are the equatorial and polar/auroral zones. Of these, the equatorial region is the easier to model. Indian researchers have gathered much decisive data by widespread low-cost satellite-beacon scintillation and electron-content studies. The IRI model has been shown to underestimate considerably the low-latitude F-region — the ionospheric layer of maximum electron density at about 300 km above ground level — daytime plasma density scale-height and total electron content. Disagreement with the topside ionosphere is bad, which is relevant to transionospheric systems and, through vertical plasma transport, to HF ionospheric systems.

Total electron-content predictions can be improved by using theoretically calculated profiles, but this is prohibitively time-consuming and expensive even with present-day large computers. D.N. Anderson (US Air Force Geophysics Laboratory) and coworkers have recently made considerable progress with a semi-empirical low-latitude ionospheric model that uses only coefficients from such theoretical profiles to form the basis of a fast portable computer code to produce realistic low-latitude F-region electron-density profiles.

*The conference on the ionosphere and radio wave propagation was held at the University of Sydney, 11-15 February 1985, sponsored by the International Union for Radio Science.

The polar region and the behaviour of irregularities still remain a world-wide problem, requiring concerted intensive global data collection and analysis. An exercise which can be regarded as a forerunner of such a study, project SUNDIAL, was conducted late in 1984. The project arose because there was no prediction capability for day-to-day variations in ionospheric structure and it highlights the fact that the various ionospheric domains are not isolated subsystems, but are indeed interactive elements in the entire solar-terrestrial network. The project looks to progressive development of a genuinely predictive ionospheric specification capability under both quiet and disturbed conditions. Such a capability would add direct solar and magnetosphere inputs as well as latitudinal and longitudinal coupling to the fundamental ionospheric model, and requires near real-time updates from a responsive network of ionospheric monitoring stations.

The experimental period of project SUNDIAL was based on an eight-day flight of the space shuttle carrying a 1.28-GHz ground imaging radar in October 1984. This aperture-synthesis radar requires phase-path constancy through the ionosphere to obtain maximum resolution. During this period the international ground-based ionospheric programme (coordinated by E.P. Szuszczewicz, Science Applications International, Virginia) collected ionogram, electron content and scintillation data from equatorial, mid-latitude and both polar domains, later supplemented with data on solar, magnetospheric, geomagnetic and interplanetary activity. Two workshops are planned in 1985 to analyse these data and to issue guidelines, recommendations and suggest follow-on programmes. Future studies will emphasize new programmes and also the appropriate coordination to ensure that diverse existing ionosphere measurement facilities are fully used. Interestingly, the USSR Solar Terrestrial Physics group was the first to propose an intense global ionospheric study.

A final note of interest is the detection of meteor echoes by the Australian Project Jindalee, an Over-the-Horizon Backscatter Radar near Alice Springs. Conventional radar meteor studies, starting with the early work at Jodrell Bank in 1945, have always used only the direct line-of-sight return signal. It seems now that, for the first time, significant rates of meteor echoes have been detected by various ionosphere (and ionosphere-ground) reflection modes. R.M. Thomas (Project Jindalee team) also suggests that the steerable, narrow beam-width antenna pattern, coupled with the frequency, agility and sophisticated processing available to the system, can be used to optimize the radar for a particular meteor radiant by changing the appropriate parameters. Such a facility could significantly revitalize interest in delineating the faint-field meteor influx and improve the management of polar high-speed meteor forward-scatter links of interest to military and other circles. □

D.G. Cole is in the Ionospheric Prediction Service, 162-166 Goulburn Street, PO Box 702, Darlinghurst, New South Wales 2010, Australia.

Evolution

The point of a toucan's bill

from J.S. Jones

MODERN evolutionists are beguiled by random change. Recent theories about DNA sequence divergence suggest that natural selection does not determine the fate of most genes and that genetic drift is the main agent of evolution, with selection acting only to remove harmful mutations. It is therefore important to remember that not all evolution happens by accident; that natural selection is a potent force for adaptive change, and that its products can be seen all around us. Some of the most spectacular examples of the intensity of natural selection and its ability to produce rapid adaptation have emerged from recent studies of birds ranging from the mundane sparrow to the outrageous toucan.

House sparrows were introduced into the United States in 1852, and are now widespread. Since their introduction, American sparrow populations have undergone considerable morphological evolution, and northern birds are larger and have relatively shorter extremities than do those in the south[1]. These differences are maintained in the face of dispersal sufficient to produce relative uniformity in the frequencies of genes coding for soluble enzymes[2]. They probably represent an adaptive response to climatic selection: birds with short limbs survive in cold weather considerably better than do those with long. In one particularly harsh Kansas winter a 25 per cent difference in mean fitness was associated with humerus length[3]; a difference related to the extent of heat loss through the extremities. Larger males, but small females, are better at surviving the winter — an effect which might result from an advantage of more dominant males and more submissive females in conditions where fighting is metabolically costly. Differences in food items selected by birds of different body size may also help to ex-