RAL employs around 1200 scientists and engineers who are involved in a wide variety of research projects in partnership with the UK's universities and polytechnics.

The Laboratory provides facilities which are beyond the reach of individual institutions.

Examining Earth covers RAL's research into the life of Planet Earth – land, oceans, atmosphere and climate.

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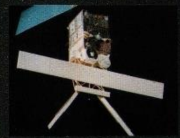
SPACE

RAL
a mission to explore

GLOBAL CLIMATE
ATSR

RAL played a leading role in the design and construction of ATSR. From its position on board ERS-1, ESA's first remote sensing satellite, ATSR is currently measuring the temperature of the surface of the sea to within half a degree. This information is important, for example, in monitoring climatic changes on Earth due to the greenhouse effect



– the sea is the major source of heat into the atmosphere. The key to ATSR's accuracy is a new technique in which a mirror spinning six times a second is used to take measurements from two different angles of the infrared radiation coming from the sea's surface. By comparing the two measurements, variations in the readings due to atmospheric effects can be eliminated. RAL is also involved with a new instrument to continue ATSR's monitoring role, ATSR-2, which will be flown on Europe's second remote sensing satellite, ERS-2. It will continue the work of ATSR and, with additional optical detectors, it will take measurements to characterise Earth's land areas. This will provide information on the state of the vegetation–its health and growth rate, as well as overall quantity and leaf moisture.

EARTH'S ATMOSPHERE
ISAMS

ISAMS is an instrument built by Oxford University, UK, industry and RAL which was launched on board NASA's Upper Atmosphere Research Satellite, UARS, in 1991. It is taking readings of the chemical composition of the atmosphere and the

chemical reactions taking place in the region of the ozone layer. The project aims to find out what causes variations in ozone and how the various chemical reactions affect each other. UARS will help us understand and predict how the everyday cycles of chemical reactions involving nitrogen and chlorine compounds relate to the balance of ozone in the upper atmosphere. The amounts of some short-lived chemicals present in the stratosphere, that are involved in the destruction of ozone, vary throughout the day. UARS is particularly well suited to study this phenomenon.

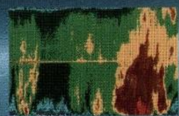
WIND VELOCITY
MST RADAR

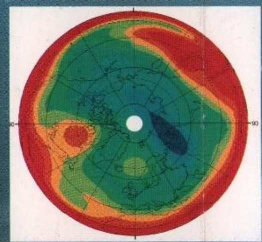
Together with University College of Wales, RAL has developed the MST radar facility near Aberystwyth which is used to measure wind speed and direction throughout the atmosphere at heights from ground level to around 80km. A square arrangement of 400 radio wave antennae transmit and receive radar signals from different heights of the atmosphere above the site. The readings give us information on weather fronts, gravitational waves, and mechanisms for the transport of atmospheric gases such as ozone. The radar is computer controlled, and produces high quality measurements

of both horizontal and vertical wind speeds and directions. It also gives us information on the structure of the troposphere and stratosphere. These data are useful in projects which study rainfall, the characteristics of meteors, and the transfer of ozone between the different layers of Earth's atmosphere.

THE COMPLETE PICTURE
GDF

The SERC Geophysical Data Facility, GDF, based at RAL is the centre of an extensive network dedicated to the storage and dissemination of information about Earth. The bulk of the data currently held is aimed at understanding processes in the atmosphere, including those involved in the destruction of ozone, and in global climatic change. The data have been collected from various sources such as satellites, aircraft, balloons, ground-based telescopes and computer model simulations. The information includes sea-surface





temperature measurements from the satellite instrument ATSR and data on the chemical composition of the stratosphere from ISAMS. Scientists at universities can gain access over the computer network and can easily sample this wide variety of data. They then plot the data or transport the information to their laboratory over the network to analyse it further on their own computers.

Examining EARTH

BNSC

SERC

LOOKING TO EARTH'S FUTURE

The future of our world in view of the greenhouse effect and the apparent depletion of the ozone layer is an issue of increasing concern. As part of its space research programme, RAL is involved in projects studying factors which affect the Earth's environment and climate.

By sending instruments into space we can take global measurements of quantities such as the temperature of the surface of the sea, and examine the composition of the atmosphere at varying heights.

SERC
Science and Engineering Research Council

BNSC
British National Space Centre

MODELS OF THE ATMOSPHERE

The movement of gases such as CFCs from the surface of populated areas of the world to the upper atmosphere results in the destruction of ozone and subsequent appearance of ozone holes. To study this and other aspects of global atmospheric behaviour, RAL is collaborating with five universities on a project to model the atmosphere using computers. The Universities Global Atmospheric Modelling Project, UGAMP, is devising a complex computer model which can predict how a gas introduced into the atmosphere at one point can end up distributed in varying amounts around the globe, as it is transported through the various layers of the Earth's atmosphere.

SATELLITES AND ORBITS

Satellites have been used since the 1960s to provide meteorologists with a global picture of Earth for weather forecasting. Satellite pictures of clouds are now frequently used to illustrate TV weather reports. But nowadays a great deal more information than just visible pictures is collected by these remote sensing satellites.

The depth of surrounding atmosphere relative to Earth's diameter is comparable to the thickness of the skin on an apple. Satellites are generally placed in orbit well outside the atmosphere, to avoid the frictional drag it would cause. The lowest possible orbit for a satellite is about 150km, where it would orbit the Earth once every 90 minutes. Any lower than this and the atmospheric drag would slow the satellite down and gravity would quickly pull it to Earth.

GEOSTATIONARY ORBIT

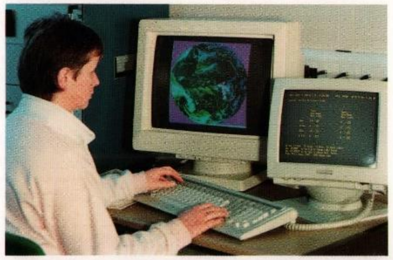
The higher a satellite is above the Earth, the longer it takes to travel round. Placed about 36,000 km above the equator, a satellite takes 24 hours to complete its orbit, and therefore can appear to remain stationary, as the Earth is rotating at the same speed. This is the geostationary orbit. It is a useful position for communications satellites which need to be in constant touch with signals from Earth, or for weather satellites that require an unchanging view of Earth.

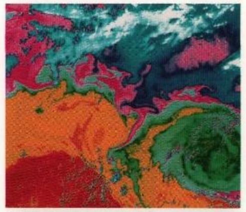
METEOSAT

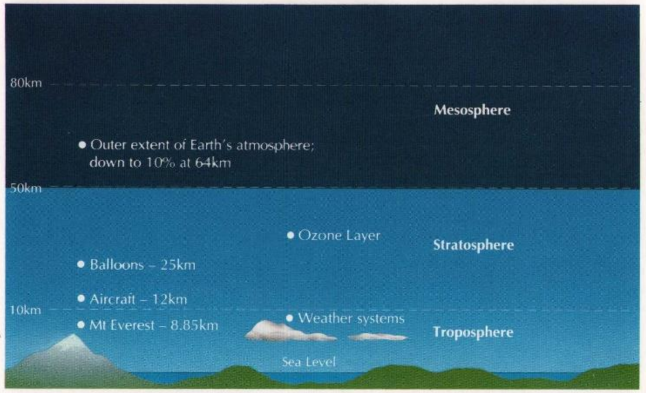
RAL receives pictures from Meteosat, a European satellite in geostationary orbit, positioned over the Equator where it crosses with the Greenwich Meridian. Great Britain and Europe are clearly visible on the resulting picture of the globe. Detectors on the satellite take readings of two ranges of infrared (IR) radiation coming from Earth as well as visible pictures. One of the IR ranges gives us thermal pictures of the Earth's surface, showing warm areas covered by low cloud and cooler areas where there is high cloud. The other is tuned to IR radiation given out by water vapour, present higher up in the atmosphere, which reveals areas of high and low humidity.

POLAR ORBITS

Satellites carrying instruments to study the Earth are called earth observation or remote sensing satellites. They travel in near-polar orbits that go approximately over the North and South Poles. In this way, as they travel around the globe, and the Earth rotates beneath them, they cover the whole surface of the globe. By circling the Earth every 100 minutes or so, 14 times a day, a satellite can view the whole of the globe systematically and repeatedly, in some cases as frequently as twice a day.







THE GREENHOUSE EFFECT

Carbon dioxide is released into the atmosphere by burning fossil fuel, having been 'fixed' in the ground through the decomposition of plants over many thousands of years.

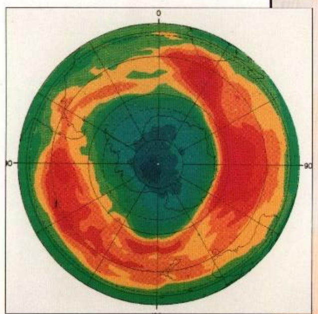
As the world's population rises and the level of industrial work increases, so does the amount of energy consumed and the amount of fuel burnt.

Carbon dioxide therefore makes up an increasing fraction of the Earth's atmosphere. It is one of the main greenhouse gases, so named because they act like glass in a greenhouse–transparent to sunshine but not to longer-wave radiation like heat.

Heat (infrared radiation) that would have escaped from Earth's surface is trapped due to the increased levels of carbon dioxide and other greenhouse gases. Shorter wavelength visible light from the Sun can still penetrate and continues to heat Earth.

Changes in the climate, and effects such as the melting of the polar icecaps and rise in sea level become, inevitable if the Earth's surface temperature increases.

The question remains as to when this increase will occur and how dramatic it will be. As part of its involvement with ATSR, RAL has developed data processing systems that enable the large volume of data being produced to be made available quickly to scientists studying the results.



THE HOLE IN THE OZONE

Ozone at ground level is poisonous to man, but a protective layer of ozone exists high in Earth's atmosphere, absorbing harmful ultraviolet light. It needs to be preserved in order that Earth remains habitable for mankind. In the early 1970s it was realised that the release into the atmosphere of man-made chlorofluorocarbons (CFCs) was causing the growing hole in the ozone layer above the South Pole. It is now known that ozone depletion is caused by complex, coupled chemical reactions. A new European satellite, UARS, is studying these phenomena, and RAL is involved with two instruments on board, including ISAMS.