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ESA's EARTH OBSERVATION PRIORITY RESEARCH OBJECTIVES AND SATELLITE INSTRUMENT REQUIREMENTS

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1 - INTRODUCTION

Since 1996 the European Space Agency has been pursuing an Earth Observation strategy based on a resolution endorsed by European Minister at a meeting in Toulouse.

This resolution recognised a broard distinction between purely research objectives, on the one hand, and purely application objectives on the other. However, this is not to be understood as an absolute separation, but rather as an identification of the major driving emphasis for the definition of mission requirement. Indeed, application satellites can provide a wealth of data for research objectives and scientific earth observation programmes can equally provide an important source of data to develop and demonstrate new applications. It is sufficient to look at the data utilisation of Meteosat and ERS to find very many examples of this.

This paper identifies the priority research objectives defined for scientific Earth Explorer missions and the resulting instrument needs. It then outlines the requirements for optical instruments.

2 - DEFINING THE RESEARCH OBJECTIVES

Identification of the major themes of research can be traced back to 1994 (ESA SP-1186) where the concept of nine potential missions were identified. This initial identification corresponded to more or less nine classical earth science areas.

Each of these missions ideas were then subject to detailed technical and scientific assessments (ESA SP-1196(1-9)) which were presented to the wide scientific community in a dedicated workshop at Granada in 1995. Each of these studies were supported by a Mission Working Group composed of scientific experts in the appropriate field.

Following the workshop, each of the missions was subject to a detailed evaluation by scientific Peer Review groups reporting to the Earth Science Advisory Committee (ESAC), which advises the ESA Director responsible for Earth Observations. This resulted in an evaluation report and recommendations for each of the missions together with an initial scientific priority list for four of the missions. These missions were proposed to go forward to Phase A study.

In parallel, the ESAC has identified the significance of the missions in the context of overall research objectives and priorities

3 - THE RESEARCH PRIORITIES

The Research Priorities, as established by the ESAC (soon to be published) are derived directly from the major concerns of our time; namely the potential impact of the activities of mankind on the environment and Earth's climate. Allied to this is the fundamental question of mankind's survival which is closely linked to levels of exploitation, sustainability and political responsibility.

These concerns are of direct relevance to Europe; a point well illustrated by the various international commitments Europe has entered into which, in many instances, our underwritten by international treaties.

To address many of these problems improved Earth System Models are required. These must be capable of describing the evolution of the systems on time scales ranging from days to centuries. The models take the form of sets of inter-linked computer models arranged in a hierarchy of fine to coarse resolution.

Formulation of these mathematical representations represents a major scientific challenge of global proportions to which Europe can and must contribute through a systematic and coordinated research programme. The Earth Explorer programme responds to this challenge by the proposed provision and exploitation of a series of focused satellite missions.

Fig. 1 gives a schematic representation of the various elements that must be included in the hierarchy of the Earth System models.

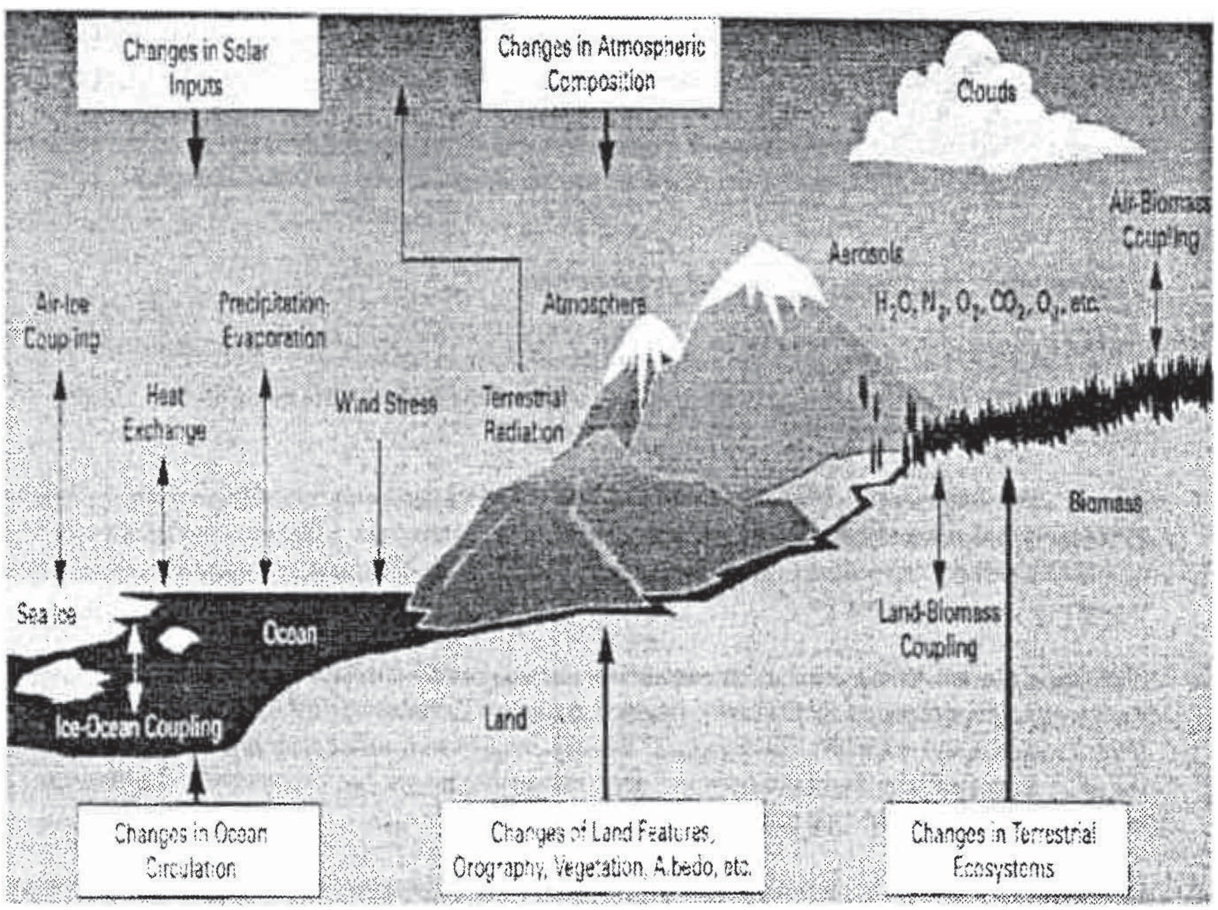

Fig. 1 Schematic of the Earth System

4 - SPACE MISSION PRIORITIES

From the above research priorities and taking into account already ongoing and planned space missions and the results of the assessment exercise mentioned above, the ESAC has derived a set of four missions as first priority for study. These are:

The Gravity Field and Steady State Ocean Circulation Explorer (GOCE)
The Atmospheric Dynamics Mission (ADM)
The Earth Radiation Mission (ERM)
The Land Surface Processes and Interaction Mission (LSPIM)

In addition, the Atmospheric Profiling Earth Explorer Mission, devoted to the sounding of the ionosphere and neutral atmospheric using the GPS and GLONASS signals, will be implemented by embarking an instrument called GRAS (GNSS Receiver for Atmospheric Sounding) on available satellites. It is already planned for METOP. The remaining four of the original nine missions (Atmospheric Chemistry, Precipitation, Topography and Magnetometry) will be retained as candidates for future (re)assessment, as will new, emerging mission concepts such as sea salinity and soil moisture.

The set of four first priority missions will be the subject of detailed Phase A studies.

5 - INSTRUMENT REQUIREMENTS

The baseline instruments requirements for each of the four missions needs are summarised in Table 1.

Mission	Instruments
GOCE	Gradiometer GNSS receiver (GRAS)
ADM	Doppler lidar
ERM	Cloud profiling radar Backscatter lidar Cloud imager Broadband radiometer
LSPIM	Imaging spectrometer Imaging infrared radiometer

Table 1

It is seen that three of the four missions call upon optical instruments in primary and secondary rolls. The four missions are currently the subject of Invitation to Tender for Phase A studies

The Atmospheric dynamics mission has the objective to demonstrate the utility of Doppler lidar towards numerical weather forecasting and to assess it use for climate modelling. Mission requirements are to determine the horizontal component of wind speed to better than 3 m/sec with 95% confidence to an altitude of 10 km

Although considerable effort has been made towards the development of a coherent, 10 μm system, alternative technologies at other wavelength and detection techniques are still to be traded-off. The demonstration mission is baselined to consider utilising the International Space Station.

The Earth Radiation mission will investigate the role of radiation and radiation/atmospheric coupling in maintaining and governing the amplitude and evolution of large-scale climate anomalies. It will provide global observations of the vertical distribution of cloud and aerosol fields, which are to be used to improve parameterisation of global circulation models.

The backscatter lidar requirements call for an instrument co-aligned with the cloud radar. Neither instruments are required to scan. It is assumed that the lidar will be based on 1.06 micron technology. Detection is "incoherent" or "direct"

The cloud imager is to provide contextual information on cloud classification, cloud cover, reflectance and top temperature. Observation are to be made at 0.67, 0.87, 1.6, 8.7 and 10.8 μm.

The broadband radiometer will provide total radiance observations in two bands, 0.2 - 4 μm and 0.2 - 50 μm. Such an instrument could be derived, for example, from a simplification of SCARAB.

The Land Surface Processes and Interaction Mission is to increase the understanding of biophysical processes and land/atmospheric interactions. The capability to make repetitive measurements in a large number of spectral bands of the angular anisotropy of the reflected and emitted radiation at selected sites is the crucial feature of the mission.

These requirements lead to a hyperspectral imager measuring reflected solar radiation in the range 450 - 2350 nm at 10 nm intervals and two thermal IR bands, 8.2 - 8.7 and 8.7 - 9.2 μm. Spatial resolution required is 50 m over a 50 km swath.

6 - CONCLUSIONS

The research objectives of the Earth Explorer programme lead to significant and challenging requirements for new optical instruments. A secondary, but important feature, is that the technology of some of these instrument promise a potentially high utility in future application systems.