The Earth Radiation Mission

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1. Introduction

For the post-2000 time-frame two general classes of Earth Observation missions have been identified to address user requirements (see ESA, 1995), namely:

- **Earth Watch Missions** - these are pre-operational missions.
- **Earth Explorer Missions** - these are research/demonstration missions.

Nine Earth Explorer missions had been identified as potential candidates for Phase A study. After a selection process four mission were recommended for further study including among others the Earth Radiation Mission (ERM) (ESA, 1996).

2. The Objectives and Products of the Earth Radiation Mission

The scientific objective of the Earth Radiation Mission (ERM) is, for the first time, to provide a multi-year set of cloud profiling and aerosol observations essential to progress in understanding the transport of energy and water between the Earth's surface and the top of the atmosphere.

The ERM components will *measure*:-

- the vertical structure of cloud and aerosol fields and their horizontal distribution, over all climate zones;
- the radiation budget components at the top of the atmosphere.

From these observations the vertical structure and horizontal distribution of radiation budget components, cloud water and cloud ice content, cloud/aerosol optical thickness, and other geophysical parameters will be derived, using the ERM measurements in synergy with other simultaneous data. This is shown schematically in Figure 1. Such observations will provide constraints not achievable by other means helping in the improvement of atmospheric models, e.g. for climate research and numerical weather prediction (NWP).

The products can be classified into three categories, namely those at the top-of-the-atmosphere (TOA), within the atmosphere (e.g. clouds, aerosols), and at the Earth's surface as depicted in Figure 2. Shaded products would require ancillary data from other sensors assumed to be in space at the time of the ERM. The accuracies required for the net radiative fluxes have been based on the requirements of the World Climate Research Programme (WCRP) (e.g. WMO, 1984). They are summarised in Table 1.

The objectives of the mission support the goals of the World Climate Research Programme (WCRP) and, in particular, of its subprogramme Global Energy and Water Experiment (GEWEX) which are aiming at an improved understanding of energy and water fluxes within the climate system to secure reliable forecasts at various scales of weather and climate through measurements that are critical for the Earth radiation balance.

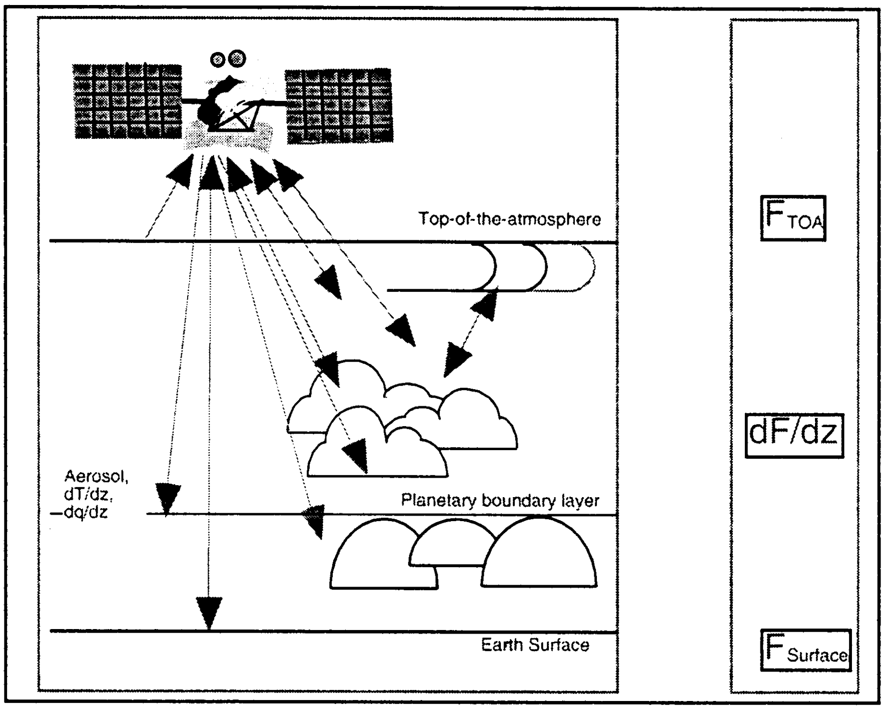

Figure 1: The mission objectives of the Earth Radiation Mission (F = radiative flux, dF/dz = vertical radiative flux gradient). The objective is to determine the radiative flux gradients within the atmosphere as well as the radiative fluxes at the Earth's surface, at the same time as the measurements of radiative fluxes at the top of the atmosphere. The left-hand part of the figure schematically shows the atmospheric elements to be observed.

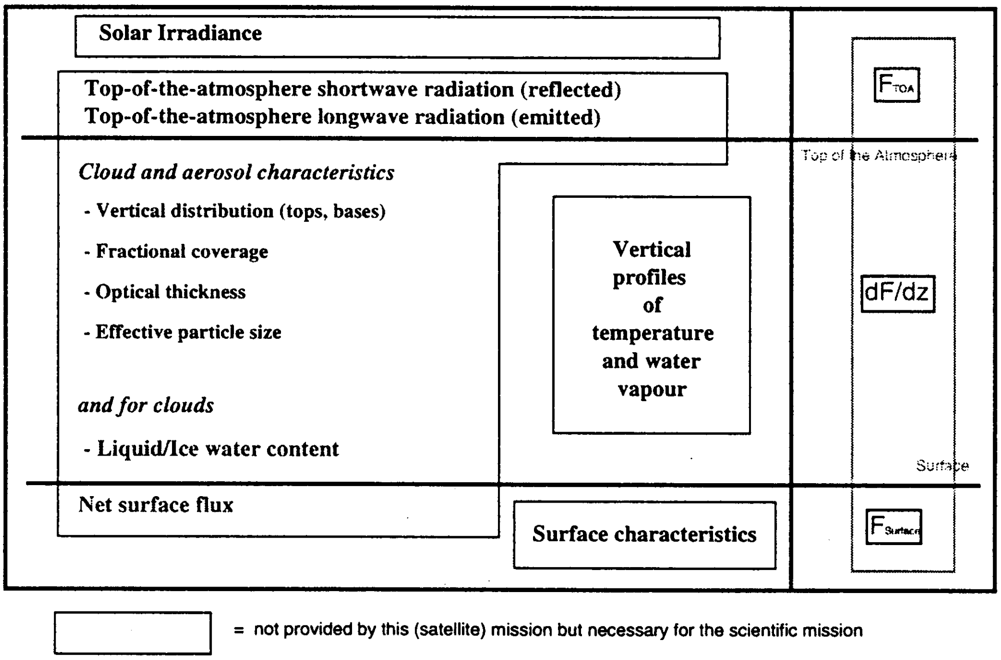

Figure 2: Products required from the Earth Radiation Mission (shaded products require ancillary data).

Measurement objective	Spatial coverage	Time domain	Desired Accuracy
Top of the atmosphere net radiative fluxes	50 x 50 km^2	instantaneous	< 10 Wm^{-2} (TBC)
Net radiative flux gradients, divergences within the atmosphere	50 x 50 km^2	instantaneous	< 10 $Wm^{-2}km^{-1}$ (TBC)
Net Earth surface fluxes	50 x 50 km^2	instantaneous	< 25 Wm^{-2} (TBC)

Table 1: Required accuracies for net radiative fluxes.

There are two general classes of products from the ERM, namely "snapshot" data for e.g. direct use by models through data assimilation and climatological data forming the basis for cloud or aerosol climatologies.

3. Elements of the ESA Earth Radiation Mission

Reflecting the above requirements on Earth Radiation Mission Products the following elements are required for the Earth Radiation Mission in order to fulfil the mission objectives as stated in Section 2:-

- A broadband radiometer - this would provide measurements of the reflected SW and emitted LW radiation at the TOA;
- An active sounder package consisting of a cloud profiling radar and a backscatter lidar - this would allow the detection or retrieval of cloud tops, cloud bases and vertical distribution of thick clouds (cloud radar) and will detect aerosol layers and thin clouds (i.e. clouds containing very small particles) (backscatter lidar);
- A passive visible (VIS)/infrared (IR) high resolution imager (resolution compatible with the active instruments) - this would be required to validate the representativity of measured cloud fields by the active instruments (backscatter lidar and cloud radar) and provide complementary measurements of cloud optical properties, horizontal structure and cloud top.

4. Status of Technical Implementation

Based on preliminary instrument studies for the two active instruments, namely the backscatter lidar and the cloud radar, a preliminary design at satellite level has been elaborated. The estimated weight of the satellite would be about 1400 kg (wet mass) with a power requirement of about 1100 W. An outline design is shown in Figure 3. The ERM satellite is planned to be launched into a 400 to 500 km sun-synchronous orbit with an equator crossing time of 14.00 hrs (descending node).

A refined concept is expected from the system level Phase A study which is planned to start in early summer 1998.

5. Conclusions

The Earth Radiation Earth Explorer Mission is one of the four missions recommended for further study which are considered in the context of future Earth Observation missions. The synergy between active and passive instruments on board ERM is unique and essential to test to

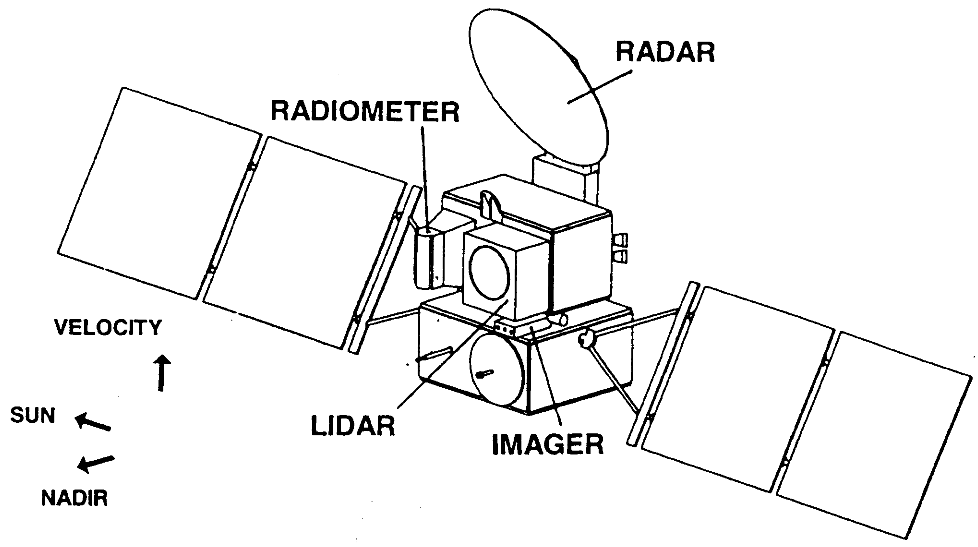

Figure 3: Potential design for the Earth Radiation Mission satellite with the four core instruments, namely (cloud profiling) radar, (broadband) radiometer, (high resolution) imager and (backscatter) lidar.

what extent and under what conditions the incomplete information derived from passive instruments can match the information on the full vertical profiles in both clear and cloudy areas derived at some times in some places from the active-passive combination. Simultaneous collocated active and passive observations are essential to this synergy.

For the first time, the ERM will provide the quasi 3-dimensional spatial and temporal structure of clouds, aerosols, and radiative transfer at the TOA and within the atmosphere at the time of overflight.

This will allow:

- The quantification of key radiative processes, controlling the Earth's climate;
- The improvement of Atmospheric Numerical Models used to predict future climate response to perturbations by adding model constraints and by providing observations for model validation;
- A major step forward in climate research and, most probably, also in operational meteorology compared with the current status.

References

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