ESA's Earth Explorer Missions

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Estec

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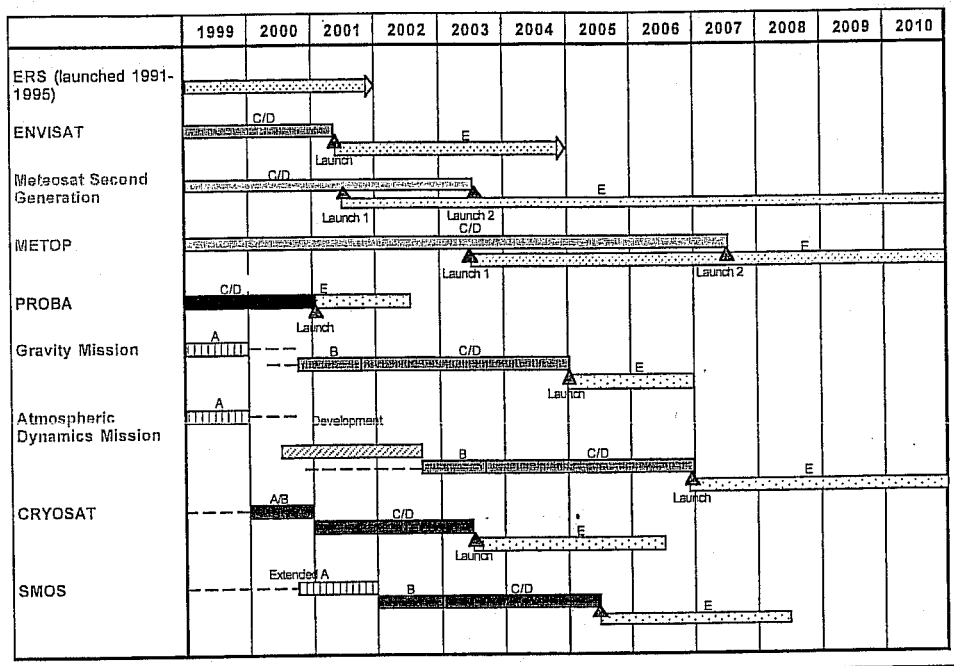
ESA's Current Programme



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The E O Envelope Programme

- Includes funding for:
  - The Earth Explorer Missions
  - Development and Exploitation
    - Instrument pre-development
    - Earth Watch Preparation
    - Market Development
    - Mission Continuity
- Apart from the implementation of Earth Watch Missions, the intent is that most of ESA's Earth Observation activities should be covered by the one optional programme (EOEP)

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General Background

- Increasing public concern over the Earth, its environment and mankind's impact on it. Both regional and global:
    - Global concerns over Climate Warming, Ozone Depletion, Tropospheric Pollution, El Niño, etc.
    - Regional concerns over Sea Level Change, Fires in South East Asia, Floods in Europe, Droughts in the USA, etc.
- Establishment of the Intergovernmental Panel on Climate Change (IPCC) to advise on state of knowledge - reports highlight general lack of knowledge in many crucial areas.
- International research initiatives include the establishment of the World Climate Research Programme (WCRP) and the International Biosphere/Geosphere Programme (IG/BP).

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The Underlying Rationale

❑ Four key points:

- The need to address public concerns about the Earth, its environment and mankind's impact on it.
- The Earth is a complex (and evolving) system which is not properly understood.
- Data required to improve knowledge of the processes involved, to develop and validate models.
- Space has a role to play in the helping to ensure the provision of the requisite data.

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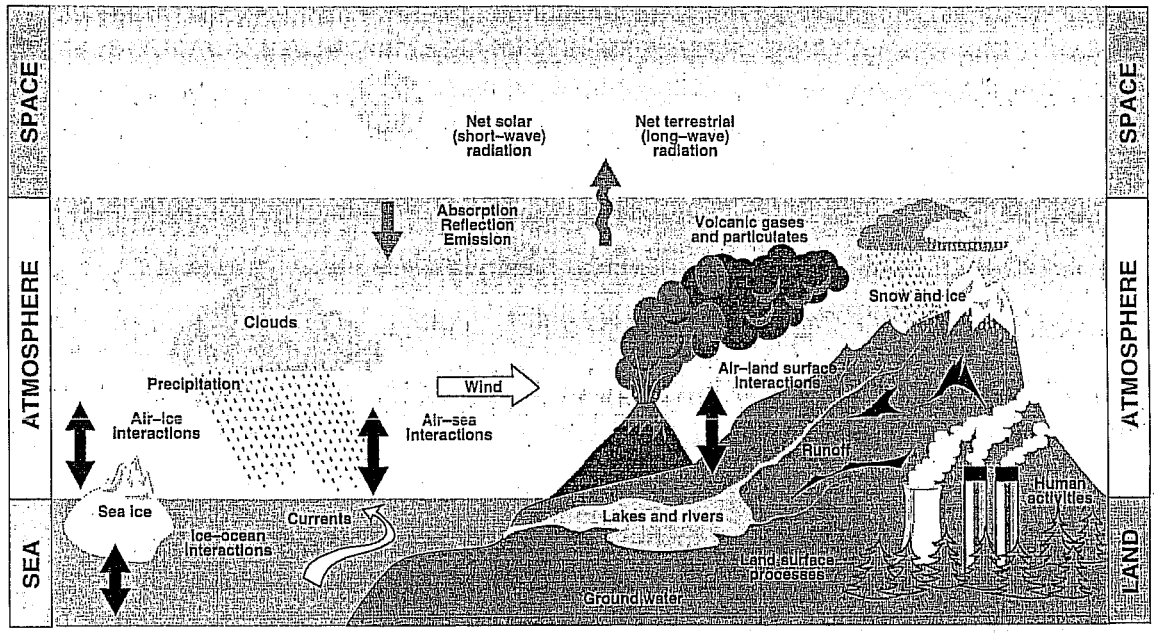
The Earth System



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Earth System Models - Scope

Understanding of the Earth will improve by the development and elaboration of global Earth System models which describe:

- the evolution of the state and composition of the atmosphere
- the physical state of the ocean and cryosphere
- the physical state of the top few metres of soil and dynamical interactions with the Earth's interior
- the physical state of terrestrial vegetation
- the key bio-geochemical cycles which in turn require the representation of terrestrial and ocean biota

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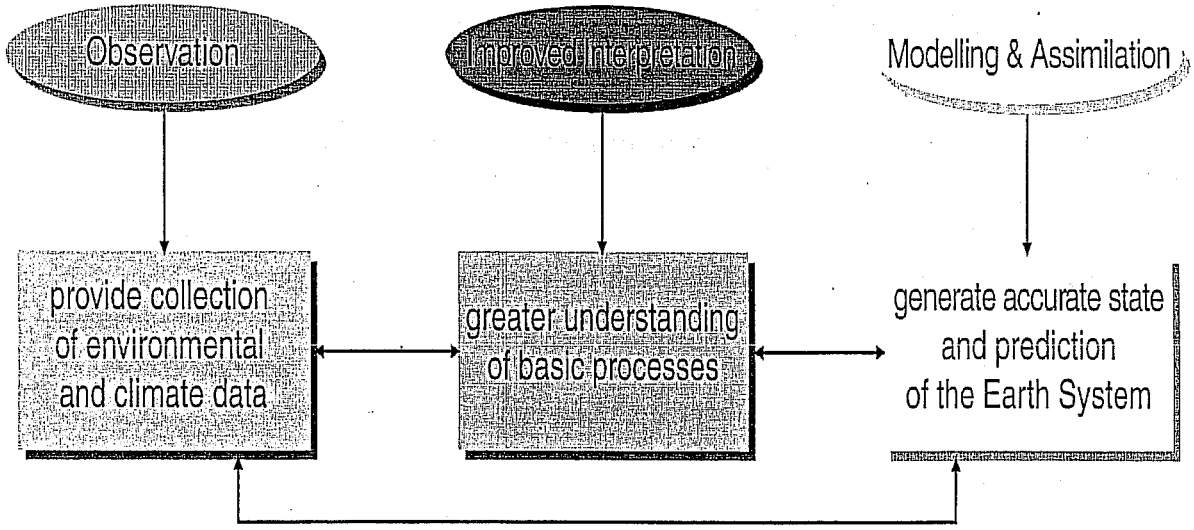
Earth System Models - Evolution



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Hierarchy of Earth System Models

ATMOSPHERE	Stratosphere	DYNAMICS - RADIATION - CHEMISTRY		
	Troposphere	DYNAMICS - RADIATION - CLOUDS - ENERGY & WATER CYCLE - CARBON CYCLE		
EARTH SURFACE		OCEAN	LAND HYDROSPHERE	LAND GEO-BIOSPHERE
		AIR-SEA INTERACTION, OCEAN CIRCULATION, OCEAN BIOLOGY, COASTAL ZONES, SEA ICE ENERGY TRANSPORT	HYDROLOGY, SOIL MOISTURE	LAND SURFACE PROCESSES, LAND BIOLOGY, ECOSYSTEMS, SNOW & LAND ICE
EARTH INTERIOR		GEOID	GEODESY	GRAVITY & MAGNETIC FIELDS

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Earth System Models - Formulation

The formulation of these models is difficult, especially as non-linear processes involved. Requires simultaneous progress in three different areas :

- Area 1 - to identify and increase understanding of the various processes involved to the point where they can be represented in models.
- Area 2 - to extend the existing hierarchy of Earth System models to include these processes.
- Area 3 - to ensure the provision of the relevant data for use in these models to help address the issues highlighted above.

The provision of observations from space is of fundamental importance.

The Four Themes

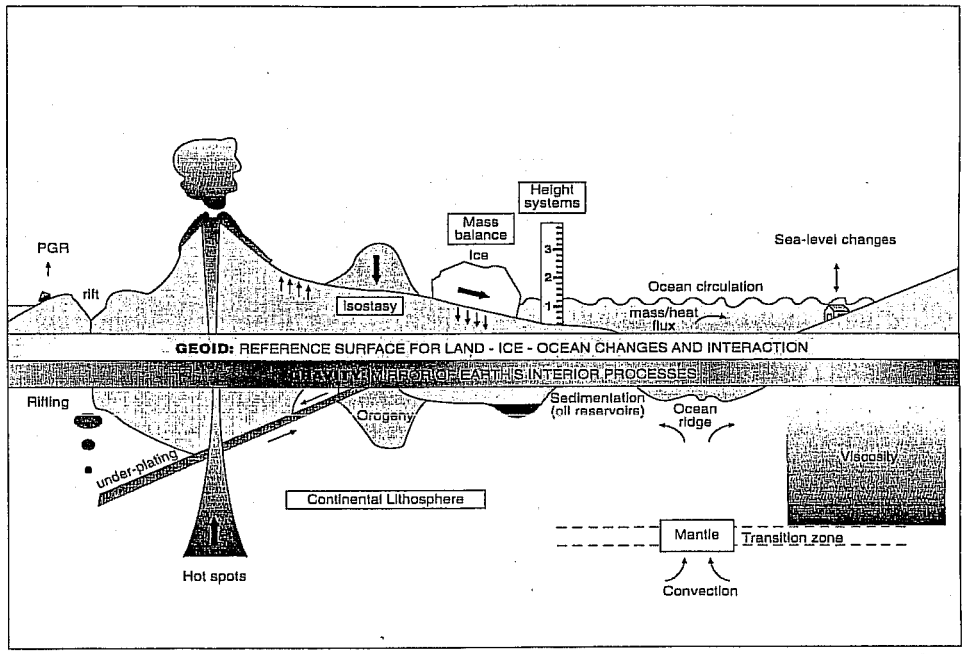
Four major interdisciplinary themes identified, each of which may encompass phenomena in several of the classical regimes:

- Theme 1 - Earth Interior
- Theme 2 - Physical Climate System
- Theme 3 - Geosphere-Biosphere
- Theme 4 - Anthropogenic Influences on the Atmospheric and Marine Environment

The four Themes span the full Earth System and recognise the need for the detailed treatment of interactions between the regimes.

Theme 1 - Earth Interior (1)

- Marine Geoid and Ocean Circulation
- Gravity Field and Earth Interior Processes
- Magnetic Field and Earth Interior Processes
- Geodesy



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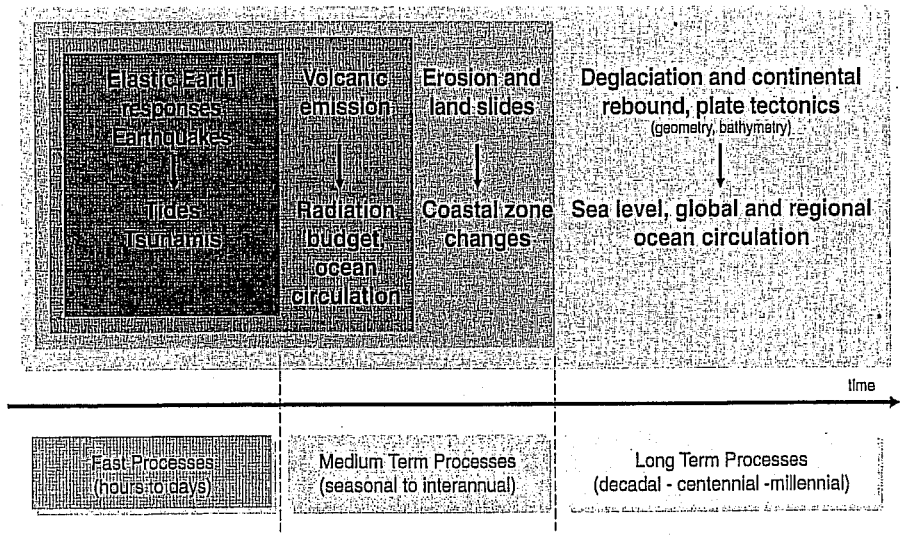
Theme 1 - Earth Interior (2)



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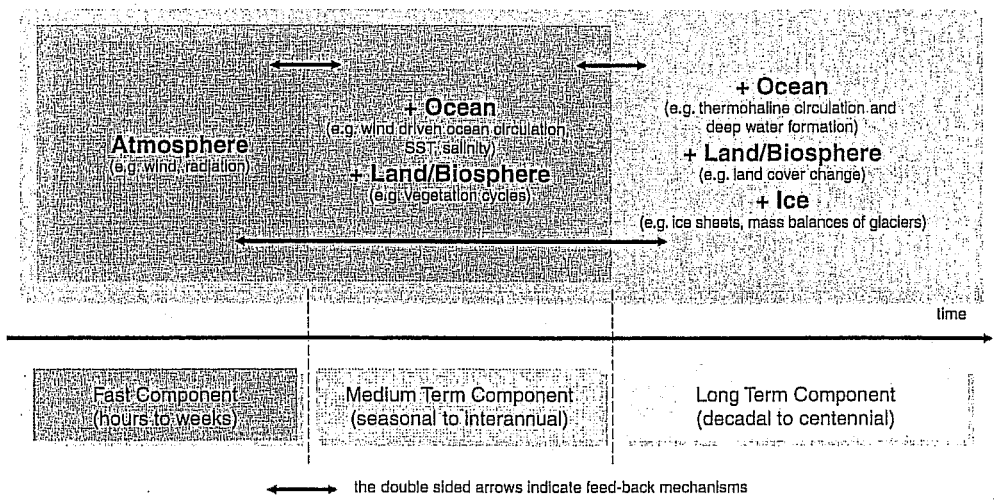
Theme 2 - Physical Climate



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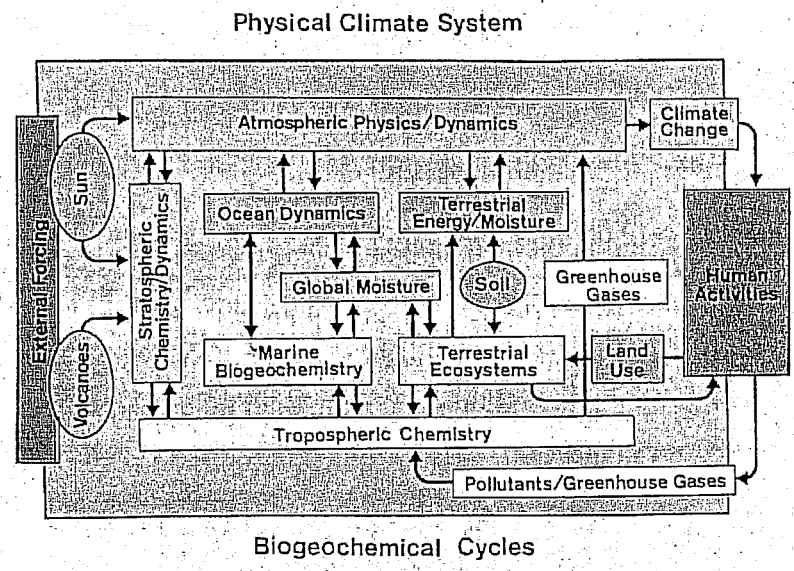
The Physical and Biophysical Systems



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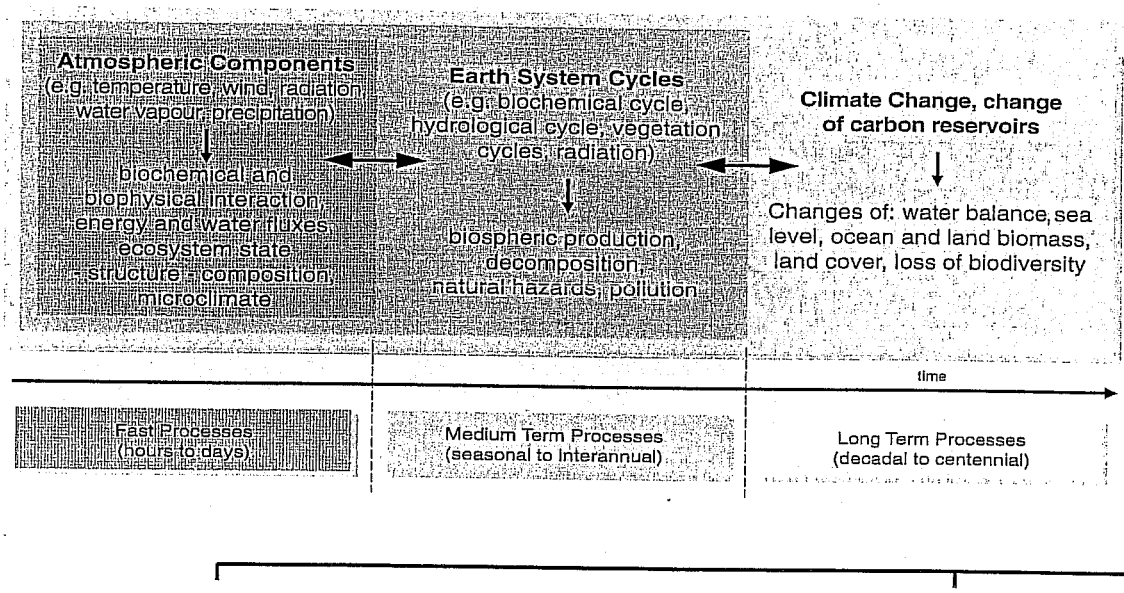
Theme 3 - Geosphere/Biosphere

Examples for geo-biospheric interaction: The links between the components



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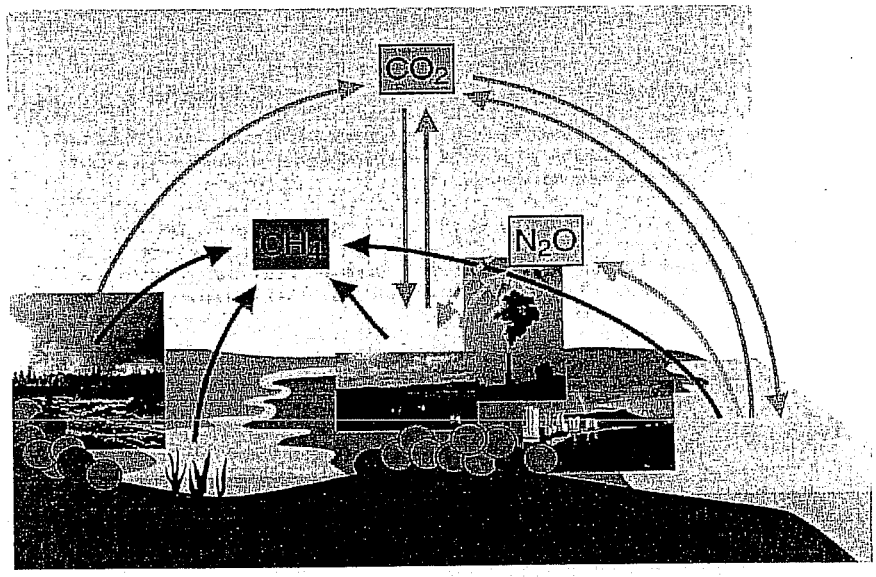
Theme 4 - Anthropogenic Impact (1)

- Changes in Atmospheric Composition Induced by Human Activity
- Chemical Processes in the Stratosphere and Upper Troposphere
- Marine Polution



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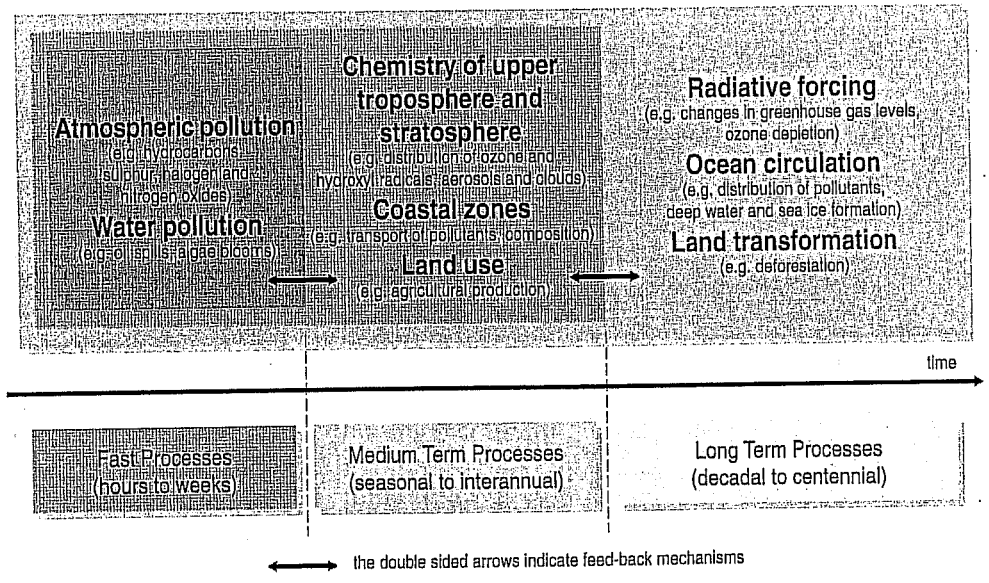
Theme 4 - Anthropogenic Impact (2)



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The Earth Explorer Missions (1)

- Means of addressing objectives (see ESA SP-1227)
- Regular flight opportunities funded under the Earth Observation Envelope Programme
- Objectives of Earth Explorer Missions - research and development focussing on specific topics/techniques
- Two complementary types of Earth Explorer missions, namely:

  Earth Explorer Core Missions - larger research/demonstration missions led by ESA.
  Earth Explorer Opportunity Missions - smaller research and demonstration missions not necessarily ESA led.

- Complemented by Earth Watch - thematic pre-operational missions focussing on specific emerging Earth Observation application areas

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The Earth Explorer Missions (2)

- Earth Explorer Core Missions:

  Granada I (May 1996) - presentation of 9 missions for Phase A Study: 4 selected for Phase A study
  Granada II (October 1999) - presentation of 4 missions for Phase B Study and implementation: 2 selected for implementation
  Call for Ideas (June 2000) - responses due September 2000; being evaluated

- Earth Explorer Opportunity Missions:

  First Call for Proposals (July 1998) - 27 proposals submitted: 5 missions recommended in order of priority by the Earth Sciences Advisory Committee for implementation (April 1999): recommendations endorsed by the Programme Board for Earth Observation

- Cyclic selection process; further calls and consultation meetings planned
- Information on *<http:/www.estec.esa.nl/explorer/>*

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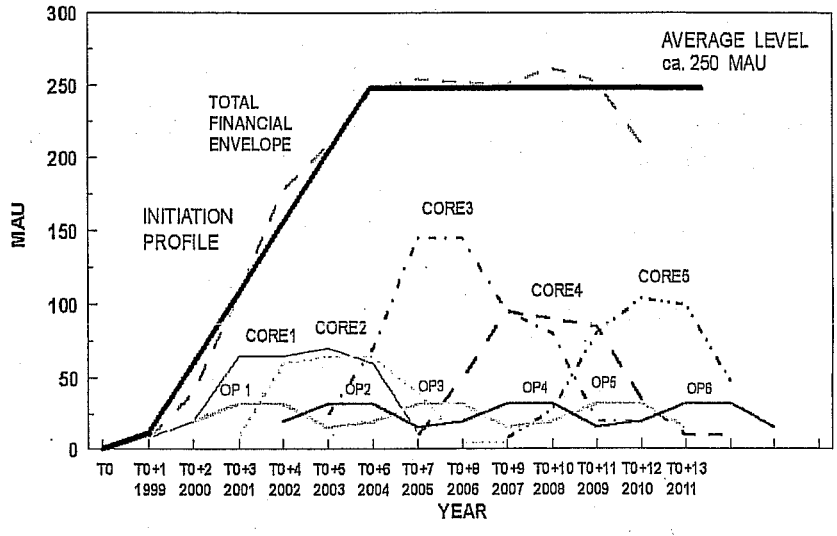
The Earth Explorer Missions (3)

Characteristics:

- Within Financial Envelope - flexibility in allocation of resources
- Cyclic Process
- Regular Flight Opportunities



The Earth Explorer Missions (4)

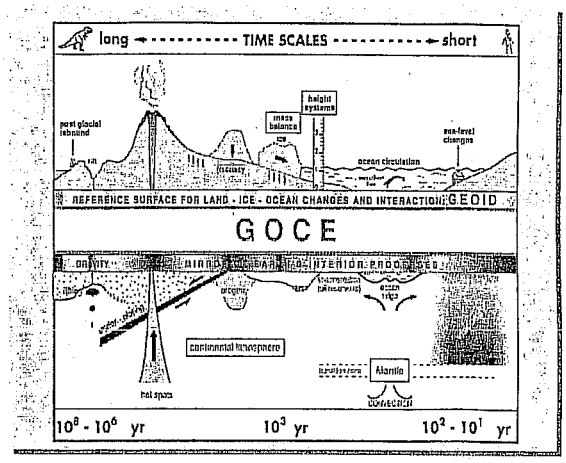
Selected missions :

- The Earth Explorer Core Missions
  - The Gravity Field and Steady State Ocean Circulation Experiment (GOCE)
  - The Atmospheric Dynamics Mission (Aeolus-ADM)
- The Earth Explorer Opportunity Missions
  - Cryosat
  - SMOS
  - Hot spare - ACE (only GRAS)
  - Other reserve missions - SWARM and SWIFT

Plus work in support of potential future missions - notably atmospheric chemistry, land surface and Earth's radiation budget

The GOCE Mission Objectives

- Determination of Earth's gravity field and its geoid (equipotential surface for a hypothetical ocean at rest):
  - high accuracy (1 mgal and 1 cm)
  - fine spatial resolution (~ 100 km)
- Improved knowledge of the gravity field important for studies in:
  - Solid Earth Physics - anomalous density structure of lithosphere and upper mantle
  - Oceanography - dynamic ocean topography and absolute ocean circulation
  - Ice Sheet Dynamics - ice sheet mass balance
  - Geodesy - unified height systems
  - Sea Level change



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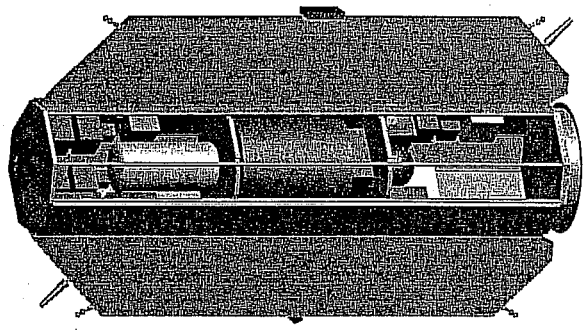
The GOCE Technical Concept

- Gradiometry and precise satellite orbit tracking (high-low satellite to satellite tracking)
- 2 key instruments:
  - Capacitive 3-axis gradiometer
  - GPS-GLONASS receiver
- Mission duration: 20 months
- Orbit: 250 km altitude, sun-sync.
- Launch in 2004/2005



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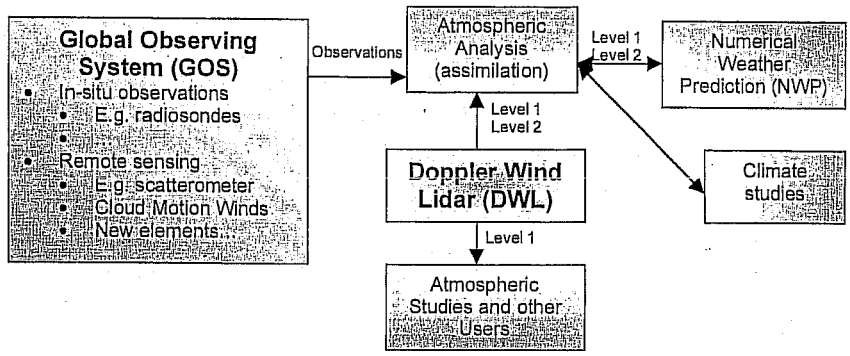
The Aeolus Mission Objectives

Mission Objectives :

- Improve parameterisations of atmospheric processes in models
- Advance climate and atmospheric flow modelling
- Provide better initial conditions for weather forecasting



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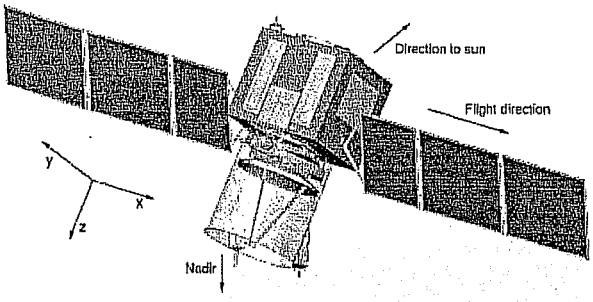
The Aeolus Technical Concept



- Main mission parameters:
  - sun-synchronous orbit
  - ~400 km altitude
  - dawn-dusk crossing time
- Main instrument characteristics
  - Doppler Wind Lidar operating in the UV (355 nm)
  - Two channel receiver to detect aerosol and molecular backscatter signal
- Main sampling characteristics
  - LOS perpendicular to orbit plane
  - Vertical resolution:

    0-2 km 500 m
    2-16 km 1 km
    16-27 km 2 km

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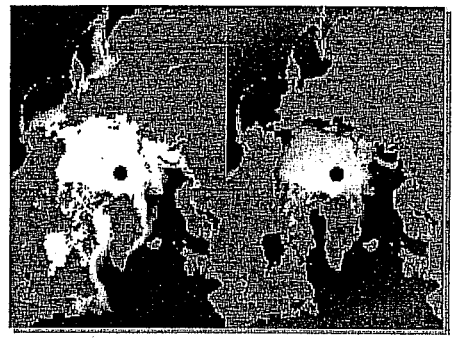
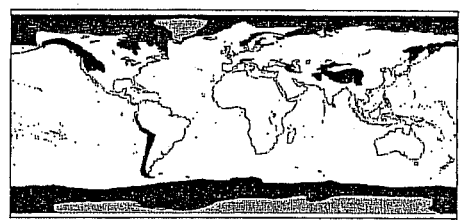
CryoSat Mission Objectives

- CryoSat will measure:
  - variations in the thickness of the polar ice sheets
  - thickness of floating sea ice
- Research goals:
  - Study of mass imbalances of Antarctic and Greenland ice sheets
  - Investigate the influence of the Cryosphere on global sea level rise
  - Use of sea ice thickness information for advances in Arctic and global climate studies



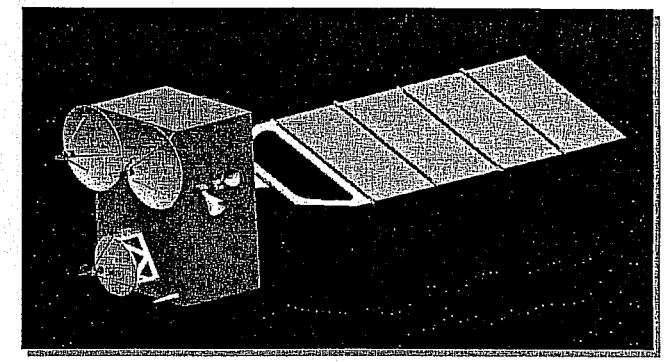
Seasonal Arctic sea ice variations



CryoSat Coverage

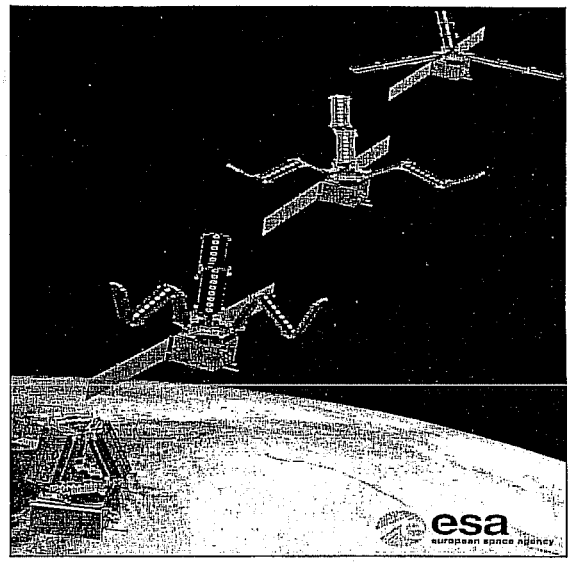
CryoSat Technical Concept

- Ku-band radar altimeter in three operation modes:
  - Conventional pulse limited mode
  - Synthetic aperture processing along track (over sea ice)
  - Interferometric processing across track (over ice sheets)
- Mission duration: 3 years
- High inclination orbit with 500-600 km altitude
- Launch in 2003



SMOS Mission Objectives

- To demonstrate the use of L-band 2-D interferometry to observe:
  - *salinity over oceans,*
  - *soil moisture over land*
  - *ice characteristics*
- To advance the development of, climatological, hydrological and meteorological models.



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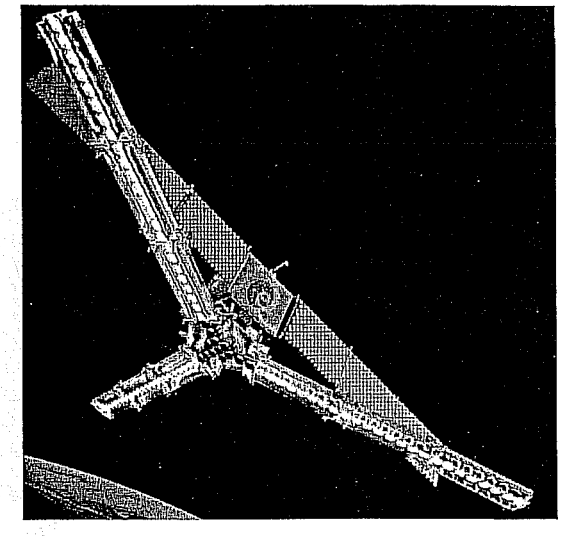
SMOS Technical Concept

- passive microwave radiometer (L-band - 1.4GHz)
- 2D interferometry
- multi-incident angles (0°-55°)
- polarimetric observations
- spatial resolution: 20-50km
- revisit time: 1-3 days
- mission duration: 3-5 years



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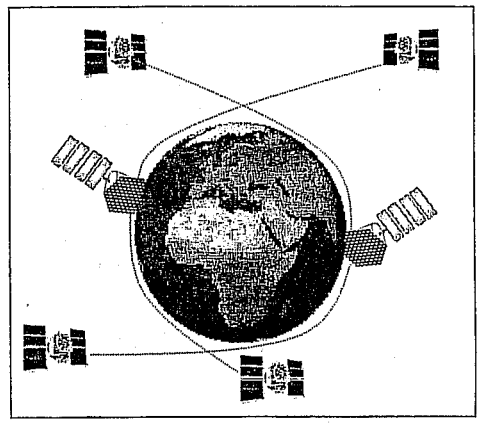
ACE Mission Objectives

- To provide data for:-
  - atmospheric analysis and modelling
  - studies of energy balance and transport
- Exploits the refraction of signals from GNSS satellites to provide:
  - temperature soundings (1 K at 1 km vertical resolution in the stratosphere);
  - humidity soundings (10 % in the troposphere);



=> Averaged values of 0.1 K in temperature and 2 % in humidity

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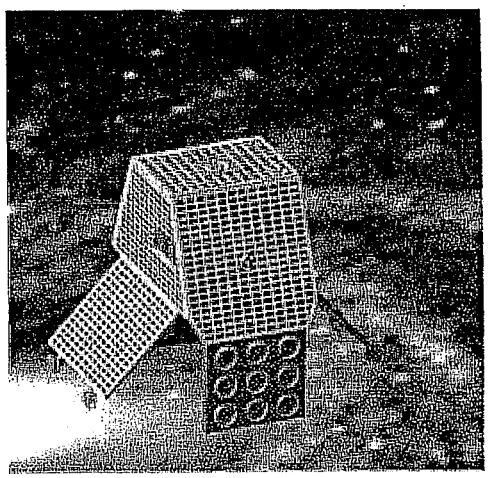
ACE Technical Concept

- 6 satellites in 2 planes separated 90^{O} in longitude.
- 800 km altitude, 75^{O} inclination.
- 80 kg, 60 W, 50 kbps satellite.
- Near-real time data assimilation



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The Earth Explorer Missions

1. In addition to ACE the reserve list of Earth Explorer Opportunity Missions:

   - SWARM - observation of the Earth's magnetic field
   - SWIFT - measurement of stratospheric winds using a Doppler interferometer

2. SWIFT and GRAS under consideration for GCOM (Japanese satellite)

3. The next call for Earth Explorer Opportunity Missions is planned for 2001

4. A call for ideas for the next Earth Explorer Core Missions was issued on 1 June 2000; deadline for receipt of proposals 1 September 2000

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