EarthCARE: The Earth Cloud, Aerosol and Radiation Explorer Mission

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1. Introduction

Clouds, aerosols and convection are factors that determine the radiation balance and the Earth temperature, directly influencing on the precipitation and controlling the hydrological cycle.

The difficulties in representing these factors in numerical models limit the ability to obtain accurate weather forecasts and reliable predictions of future climate.

The Earth Cloud, Aerosol and Radiation Explorer (EarthCARE) is a research mission within ESA's Living Planet Program. This mission will help in understanding the interactions between clouds, aerosols and radiation and improving their parameterization in climate and Numerical Weather Prediction models by providing detailed global observations of vertical cloud and aerosol profiles.

2. Science Objectives

Quantify **cloud-aerosol-radiation interactions** so they may be included correctly in climate and numerical weather prediction models to provide:

- Vertical distribution of atmospheric **liquid water and ice** on a global scale, their transport by clouds and radiative impact.
- **Cloud overlap** in the vertical, **cloud-precipitation** interactions and the characteristics of **vertical motion** within clouds.
- Vertical profiles of natural and anthropogenic **aerosols** on a global scale, their radiative properties and interaction with clouds.
- The profiles of atmospheric **radiative heating and cooling** through a combination of retrieved aerosol and cloud properties.

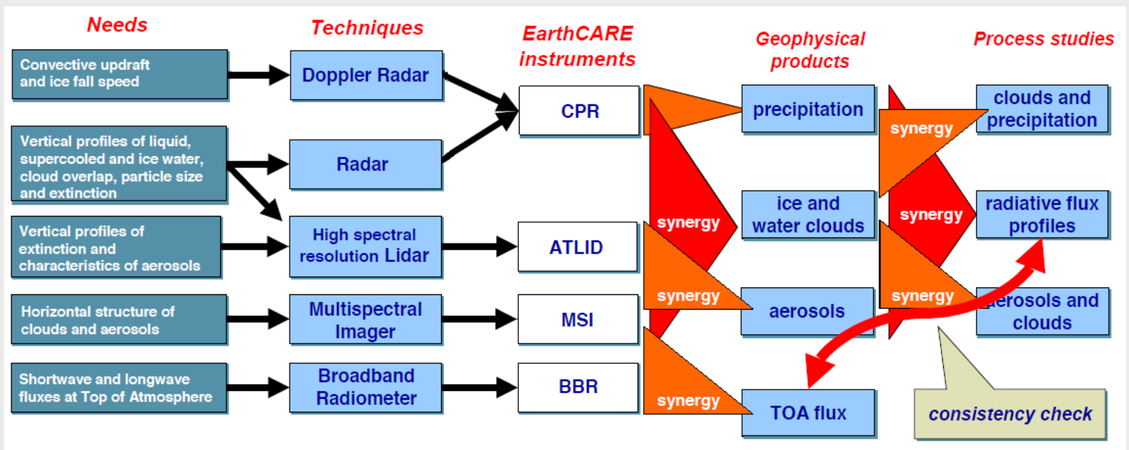

Fig. 1 - Mission concept of the techniques used to meet the science objectives and the synergies to process the data

3. Mission

- EarhCARE is one of the ESA Earth Explorer Core Mission (Science mission) developed in cooperation with JAXA/NICT
- Currently at the end of phase B (preliminary design phase)
- Orbit: polar sun-synchronous, mean altitude of 410 km, and repeat cycle of 389 orbits in 25 days
- Mean local solar time between 13:45h-14:00h at descending node
- Estimated launch date: end of 2013 (subject to delays due to the payload design)

The EartCARE mission is a single satellite with 4 instruments employed in synergy:

- 2 active:
  - ATLID lidar
  - CPR radar
- 2 passive:
  - MSI imager
  - BBR radiometer

4. EarthCARE instruments

ATmospheric LIDar (ATLID)

- Backscatter UV (355nm) High spectral resolution 3 channels receiver: Rayleigh, co-polar Mie and cross-polar Mie
- Pulse repetition rate 74 Hz
- Sampling: horizontal: 200m, vertical: 100m
- Receiver footprint on ground < 30 m
- 3 deg. off-nadir (backwards) pointing to reduce specular reflection on ice clouds
- **Level 1 product**: Attenuated backscatter profile

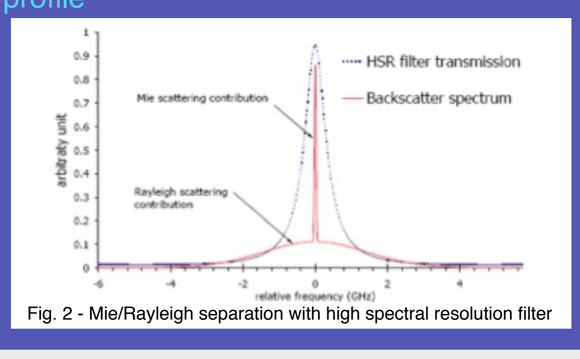

Fig. 2 - Mie/Rayleigh separation with high spectral resolution filter

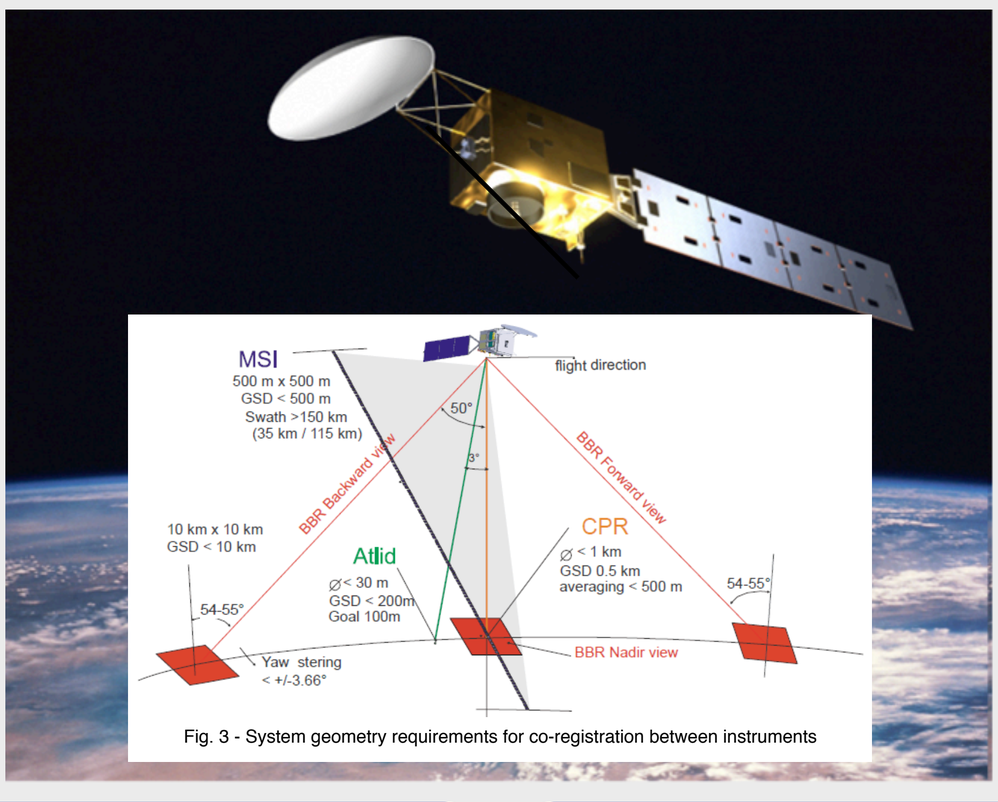

Fig. 3 - System geometry requirements for co-registration between instruments

Broad Band Radiometer (BBR)

- Short-wave (0.2μm-4μm) and total wave channel (0.2μm-50μm)
- 3 views:
  - nadir (0°)
  - forward (+50°)
  - backward (-50°)
- Linear microbolometer array detectors, ground pixels < 1km x 1km
- Rotating chopper wheel (261 rpm)
- 10km x 10km pixels spatially integrated in ground processing
- Radiometric accuracy: 2.5 W/m2.sr (SW), 1.5 W/m2.sr (LW)
- Calibration views: sun, internal cold and warm blackbodies
- **Level 1 product**: Filtered Top-Of-Atmosphere (TOA) radiances short- and long-wave

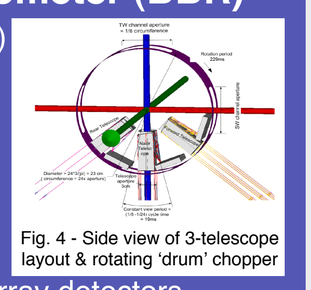

Fig. 4 - Side view of 3-telescope layout & rotating 'drum' chopper

Cloud Profiling Radar (CPR)

- High power W band (94GHz) nadir-pointing radar with Doppler capability
- Antenna subtended aperture 2.5 m
- Variable Pulse Repetition Frequency (PRF) 6100-7500 Hz
- Sensitivity at least -35dBZ @ 20km height
- Sampling: horizontal: 500m, vertical 100m (vertical resolution 500m)
- Beam footprint on ground < 800 m
- Doppler accuracy 1 m/s (for 10 km along-track integration and -19dBZ)
- **Level 1 product**: Reflectivity and Doppler profiles

Multi Spectral Imager (MSI)

- Nadir viewing push-broom imager
- 4 solar channels: Vis (670nm), NIR (865nm), SWIR1&2 (1.65μm & 2.21μm) 3 TIR channels: 8.80μm, 10.80μm, 12.00μm
- Swath: -35km to +115km (tilted away from sun to minimize sunglint)
- Sampling (eff.): horizontal 500m x 500m
- Calibration views: Sun, on-board warm blackbody, cold space
- **Level 1 product**: Top-Of-Atmosphere (TOA) radiances and brightness temperatures in 7 spectral bands

5. EarthCARE Simulator (ECSIM)

- ECSIM is the End-to-End simulator framework developed by KNMI (NL) and Deimos (E) for EarthCARE, with an efficient easy-to-use flexible graphical user interface.
- ECSIM works with a collection of models well-suited for instrument trade-off studies and retrieval algorithm development.

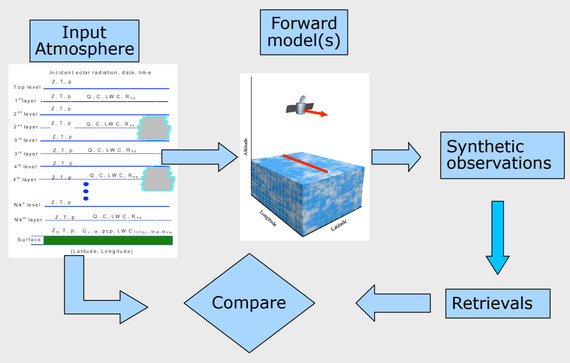

Fig. 5 - ECSIM End-to-End concept

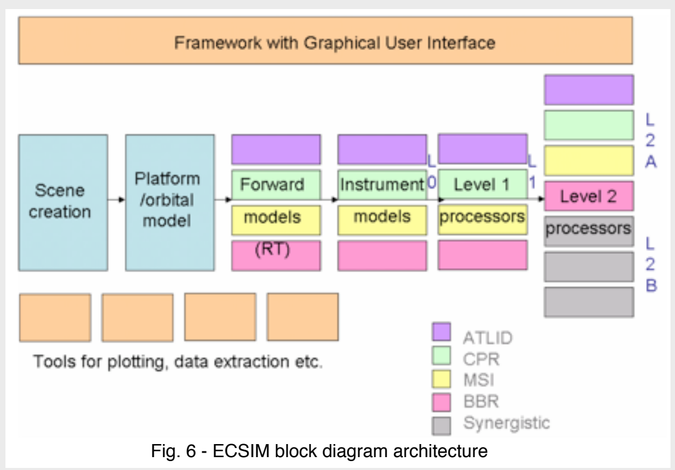

Fig. 6 - ECSIM block diagram architecture

- ECSIM will allow to develop models and algorithms to obtain the Level 1 and Level 2 single instrument and synergistic products, as well as the EarthCARE ground processor, anticipating the EarthCARE observation data.

6. Conclusions

A major innovation of the EarthCARE mission is the inclusion of 2 active and 2 passive instruments together on a single platform. Their co-related measurements will have a unique ability to provide global information on the profiles of clouds and aerosols in a radiatively consistent manner.
The active sensors will give vertical profiles of microphysical parameters of clouds with their phase and aerosols with their species, and will detect drizzle and light rain. Especially, retrievals of doppler velocities of particles will give new information on vertical motion.
ESA is coordinating several science activities to advance in science and to early assess the performance of the mission.

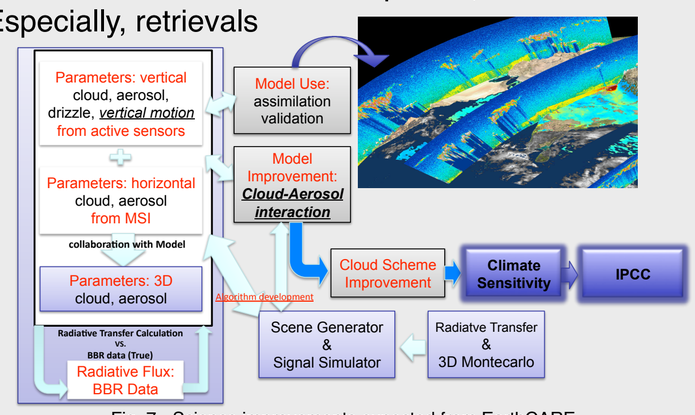

Fig. 7 - Science improvements expected from EarthCARE

5th ESA Earth Observation Summer School on Earth System Monitoring & Modelling
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