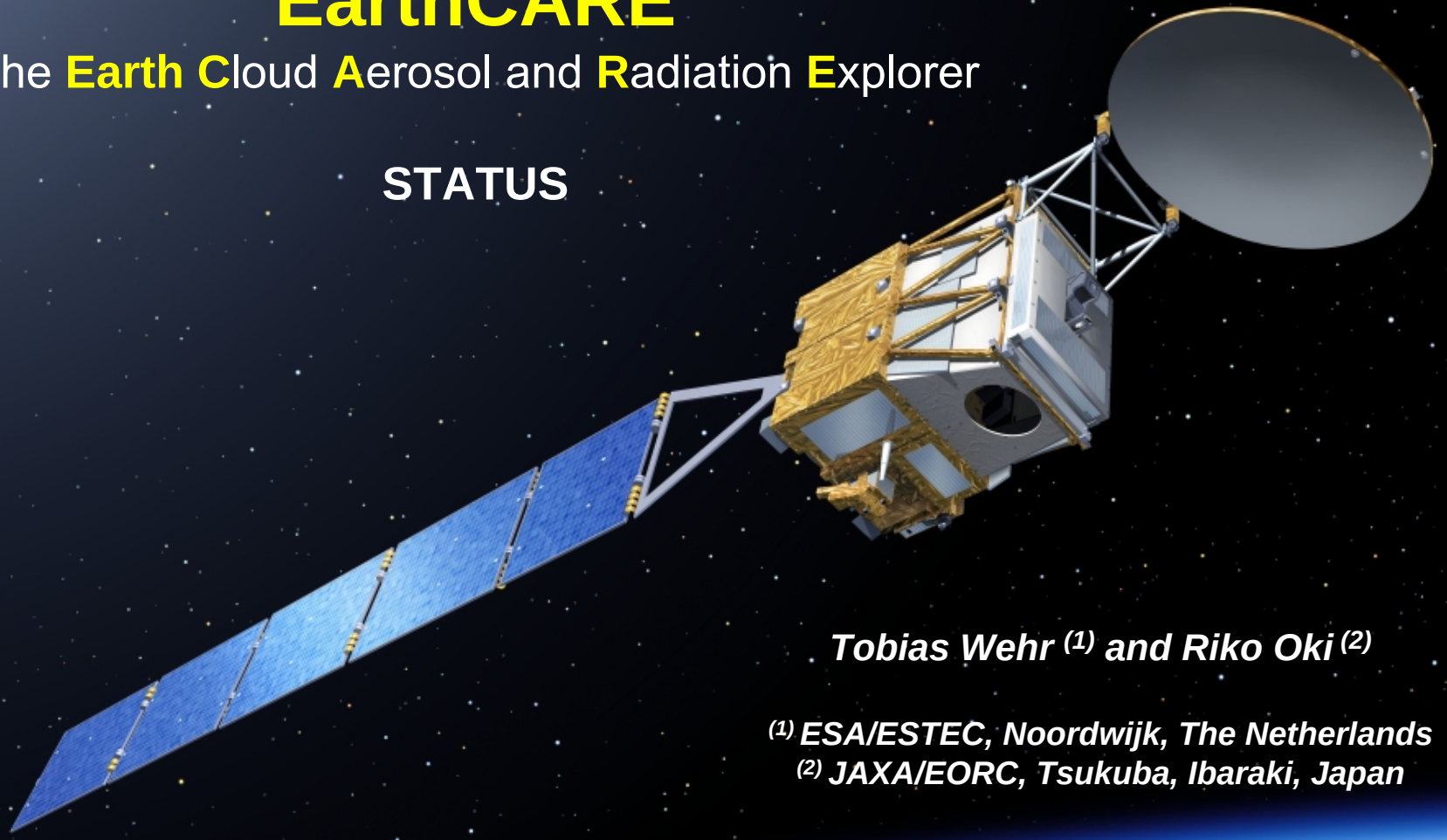
# EarthCARE

The **E**arth **C**loud **A**erosol and **R**adiation **E**xplorer

## STATUS

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# Mission Summary

# Overview

**Scope:**

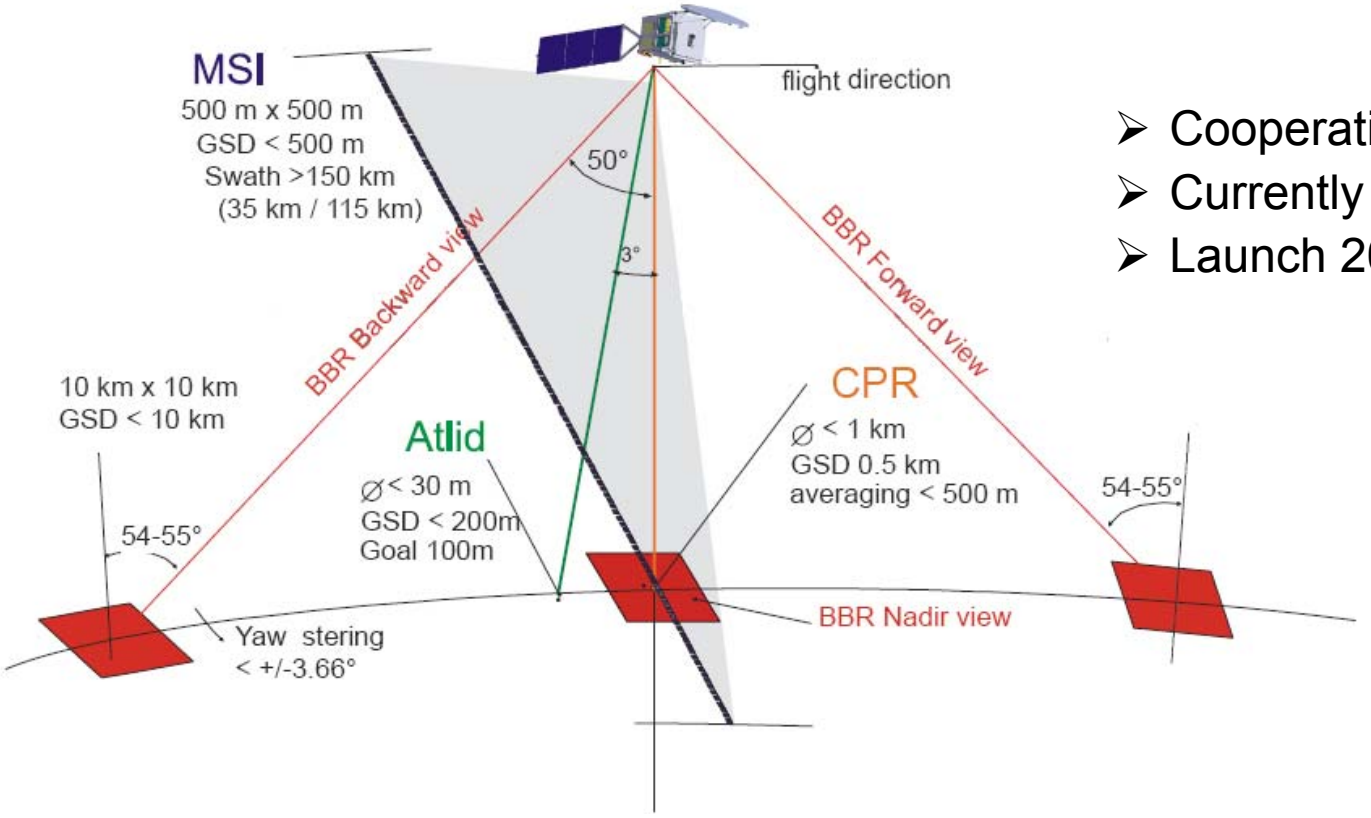
Global simultaneous observations of

- Cloud & aerosol profiles, 3D structures
- Cloud-precipitation-convection
- Radiation and flux

**Mission Concept:**

- Cloud-aerosol HSR-lidar, ATLID
- Cloud radar with Doppler, CPR (JAXA/NICT)
- Cloud-(aerosol?) imager, MSI
- Broad-band radiometer, BBR

- Cooperation ESA - JAXA/NICT
- Currently in Phase B
- Launch 2013



# INSTRUMENTS

## ATmospheric LIDar (ATLID)

- Backscatter UV (355nm, circular pol.) with high spectral resolution receiver (HSRL)
- 3 channels receiver: Rayleigh scatter, co-polar Mie, cross-polar Mie
- Sampling: horizontal: 200m (=2x100m integrated), vertical: 100m
- 2 to 3 deg (tbd) off-nadir (backwards) pointing to reduce specular reflection on ice clouds
- Products: extinction, backscatter, aerosol, ice clouds, ...

## Cloud Profiling Radar (CPR), contribution of JAXA, built by NICT

- 94GHz with Doppler capability
- Sensitivity at least -35dBZ@20km height, Doppler accuracy: 1 m/s
- Sampling: horizontal: 500m, vertical 100m (vertical resolution 500m)
- Products: Z, vertical velocity, ice clouds, water clouds, (light) precip., ...

## Multi-Spectral Imager (MSI)

- 4 solar channels: Vis (670nm), NIR (865nm), SWIR1&2 (1.65µm & 2.21µm)
  3 TIR channels: 8.80µm, 10.80µm, 12.00µm
- Nadir viewing push-broom, swath: -35km to +115km (to minimize sunglint), $(500m)^2$ res.
- Products: scene identification, 'imager cloud products' (ice clouds, water clouds), aerosols (limited over land), ...

## Broad-Band Radiometer (BBR)

- Short-wave (0.25µm-4µm) and total wave channel (0.25µm-50µm)
- 3 views: nadir, foreward (55deg), backwards (-55deg), 10km x 10km pixels
- Products: TOA radiance and flux

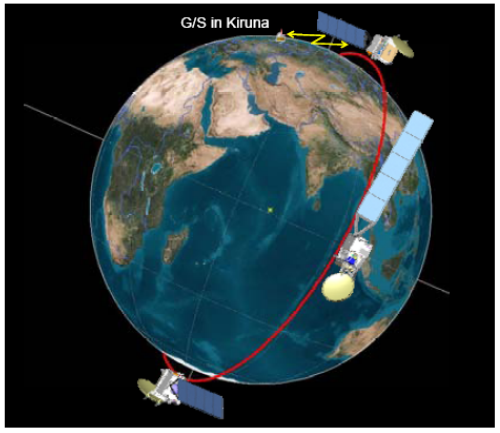
# Technical Status

# Programmatic Status (ESA)

- **Industry Consortium:**
  - **Spacecraft Prime: Astrium GmbH** (contract signed May 2008)
  - Base-Platform: Astrium-Ltd
  - ATLID: Astrium-SAS with G.A as sub-contractor
  - BBR: SEA with RAL as sub-contractor
  - MSI: SSTL with TNO as sub-contractor
  - Industry team to be completed during Phase B2
- **System Requirements Review (SRR)**
  - Space System: started in Dec 08, action items and recommendations being implemented
  - Ground Segment SRR: started May 09, nearing completion
- **Preliminary Design Review (PDR)**
  - Started summer 2009 with instrument PDR's
  - System PDR to start Sept/Oct 2009
  - Completion will mark end of Phase B
- **After successful completion of Phase B, Phase C/D will commence**
- **Leading to launch in 2013**

# Technical Status – Mission Key-data

- **Reference Orbits & Design Cases:**
  - Local Time: **13:45 - 14:00** (LTDN)
    - solar array sizing is more sensitive to local time (10% for 13:30->14:00) than orbit altitude variation
  - **Cal/Val orbit @ 394.4 km** / 9 days repeat cycle
  - **Ops orbit @ 393.1 km** / 25 days

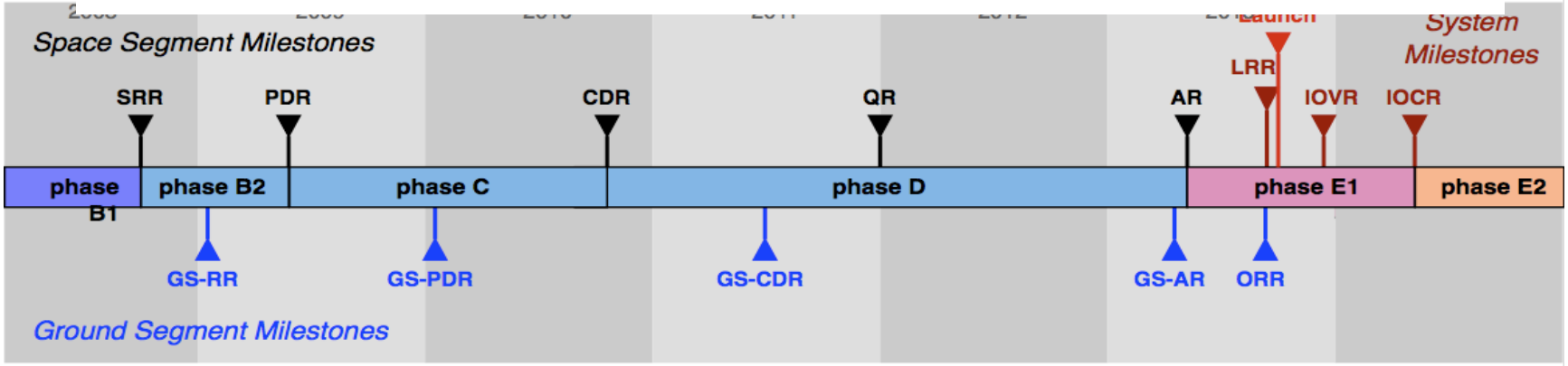



| Parameter | Mean Kepler |
|---|---|
| Semi-major axis | $a$ = 6772.57 km |
| Eccentricity | $e$ = 0.001283 |
| Inclination (sun-synchronous) | $i$ = 97.055° |
| Argument of perigee | $\omega$ = 90° |
| Mean Local Solar Time, Descending Node | MLST = 13:45-14:00 |
| Repeat cycle / cycle length | 9 days, 140 orbits |
| Orbital duration | 5554.3 s |
| Mean Spherical Altitude | 394.43 km |
| Minimum Geodetic Altitude | 399.6 km |
| Maximum Geodetic Altitude | 427.3 km |
| Average Geodetic Altitude | 409.7 km |

| Parameter | Mean Kepler |
|---|---|
| Semi-major axis | $a$ = 6771.28 km |
| Eccentricity | $e$ = 0.001283 |
| Inclination (sun-synchronous) | $i$ = 97.050° |
| Argument of perigee | $\omega$ = 90° |
| Mean Local Solar Time, Descending Node | MLST = 13:45-14:00 |
| Repeat cycle / cycle length | 25 days, 389 orbits |
| Orbital duration | 5552.7 s |
| Mean Spherical Altitude | 393.14 km |
| Minimum Geodetic Altitude | 398.4 km |
| Maximum Geodetic Altitude | 426.0 km |
| Average Geodetic Altitude | 408.3 km |

# Programmatic Status In Europe – Schedule Timeline

- Overall Satellite & Ground Segment Development Timeline:




***Space Segment Milestones:***

- **SRR** = System Requirements Review
- **PDR** = Preliminary Design Review
- **CDR** = Critical Design Review
- **QR** = Qualification Review
- **AR** = Acceptance Review
- **FRR** = Flight Readiness Review

***Ground Segment Milestones:***

- **GS-RR** = GS Requirements Review
- **GS-PDR** = GS Preliminary Design Review
- **GS-CDR** = GS Critical Design Review
- **GS-AR** = GS Acceptance Review
- **ORR** = Operations Readiness Review

***System Milestones:***

- **LRR** = Launch Readiness Review
- **IOVR** = In-Orbit Verification Review
- **IOCR** = In-Orbit Commissioning Review

# Science Activities

## JMAG (Joint Mission Advisory Group):

Howard Barker
Anton Beljaars
Franz Berger
Jean-Pierre Blanchet
David Donovan
Martial Haeffelin
Anthony J. Illingworth*
Gelsomina Pappalardo
Jaques Pelon
Ulla Wandinger

Hiroshi Kumagai
Takashi Nakajima
Terry Nakajima*
Hajime Okamoto
Nobue Sugimoto
Yukari Takayabu

*Observers:*
John Bates
Graham Feingold
Graeme Stephens
Deborah Vane
David Winker

**Co-chairs and overall science leaders*

Mission Scientists: Riko Oki (JAXA), Tobias Wehr (ESA)

ESA EarthCARE Project Manager: Alain Lefebvre
JAXA CPR Project Manager: Toshiyoshi Kimura

## QuARL Study

**Quantitative Assessment of the Operational Value of Space-borne Radar and Lidar Measurements of Cloud and Aerosol Profiles**

Objectives:

- Quantitative assessment of value of satellite lidar & radar data for NWP
- Assessment of operational potential of CloudSat, Calipso, EarthCARE – EarthCARE suitable for assimilation into NWP?
- Assess how CloudSAT, CALIPSO and EarthCARE data can improve cloud & aerosol parameterisation in ECMWF's model
- NRT question

# Gaining experiences with CloudSat & Calipso: QuARL

QuARL Status:

- Started: September 2008, progressing on schedule
- Radar forward operator adapted to 94GHz
- Various activities performed on verification of model assumptions
- Validation of aerosol & cloud parameterisation in progress
- Strategy for radar & lidar data assimilation under development
- Overall work plan progressing as planned

Team:

- ECMWF in-house collaboration across various disciplines (assimilation, cloud physics, satellite data, GEMS, ...)
- Direct collaboration with CloudSat PI
- Collaboration with U. Reading for validation cloud parameterisation

Funding: ESA & ECMWF

# Level 2 Development Activities

**Level 2 defintion: L2a = product retrieved from one instrument**
**L2b = synergistic product from 2 or more instruments**

## JADE

## Joint Algorithm Development Endeavour

Multi-continental working group for L2 developments:

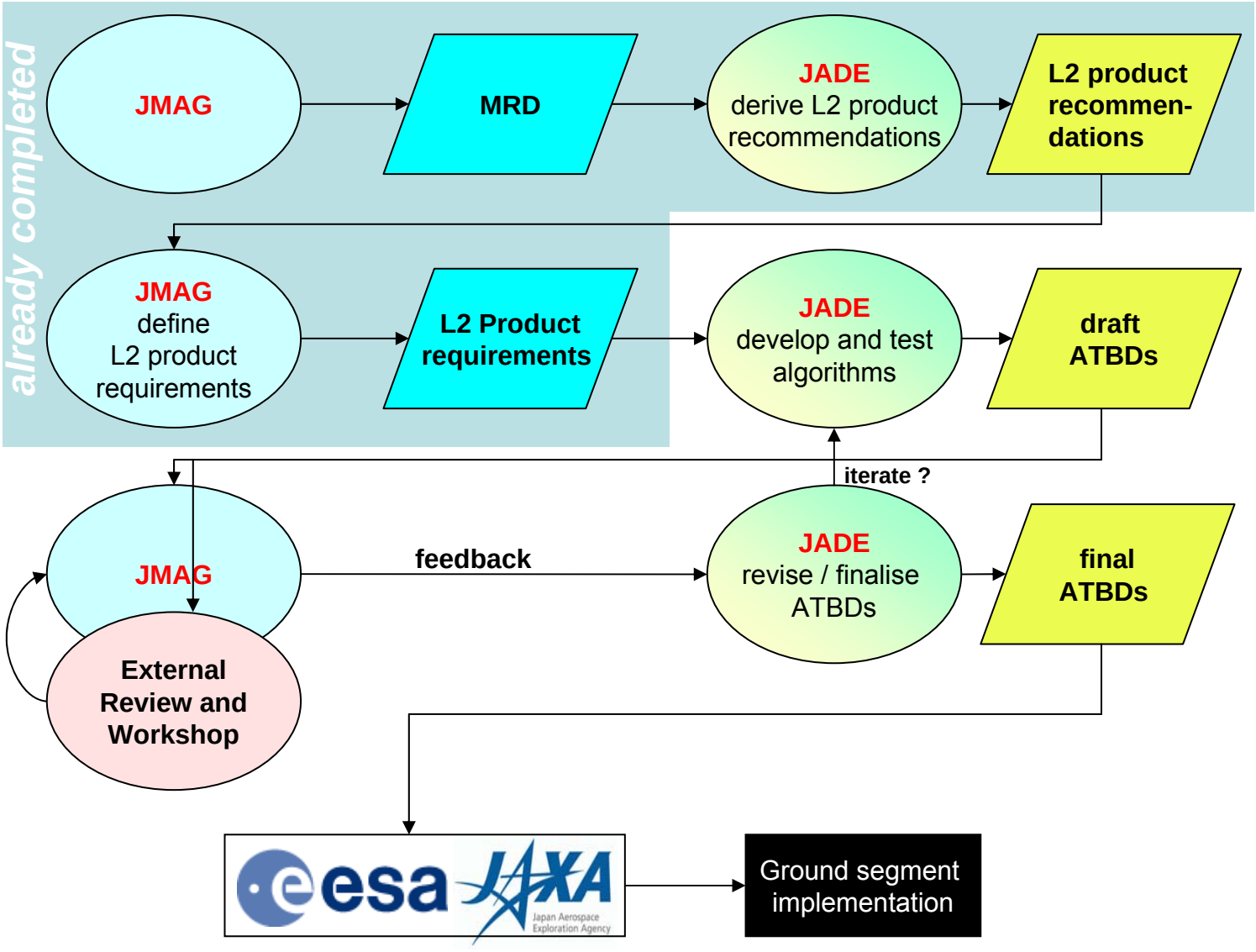
- Retrieval algorithm PI's / CO-I's and user representatives
  Subgroups:
  - ATLID stand-alone algorithms: ATLID L2a
  - CPR stand-alone algorithms: CPR L2a
  - MSI stand-alone algorithms: MSI L2a
  - Radiation algorithms: BBR L2a, Radiation L2b
  - Synergistic products: Cloud & aerosol L2b
  - Modellers (data user subgroup)

- Formal meetings twice per year (so far back-to-back with JMAG)

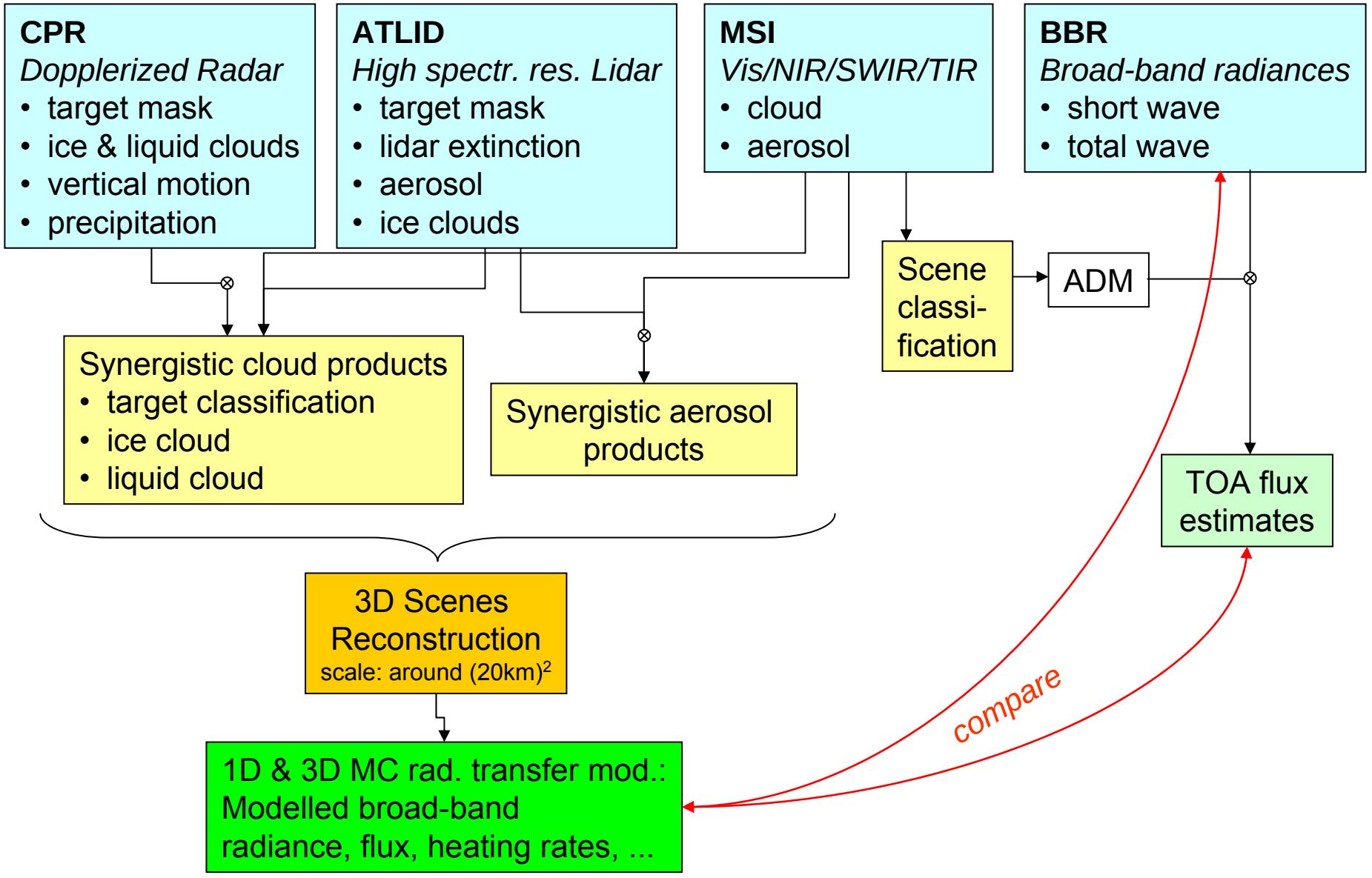
- Overall authority for recommendations remains with the **JMAG** (Joint Mission Advisory Group)

# Level 2 Development Process

## Development Steps



# Level 2 Products Philosophy



# ESA's Level 2 Development Activities

**Level 2 defintion: L2a = product retrieved from one instrument**
**L2b = synergistic product from 2 or more instruments**

**ATLID L2a:**
- feature mask
- HSRL extinct., backscatter, depol.
- target classification
- aerosol extinct., backscatter, type
- ice cloud properties

**CPR L2a:**
- feature mask
- IWC, eff. rad. ice clouds
- additional work - TBD

**Exploitation HSRL**
- learning from lidar campaigns
- multi-λ HSRL modelling

→ fut. miss. & EC

**ATLID-MSI L2b (synergy)**
- synergistic aerosol retrievals

**ATLID-CPR-MSI L2b (synergy):**
- synergistic target classification (incl. Doppler)

*Best estimates variational scheme:*
- ice & water cloud profiles
- precipitation properties
- aerosol property profiles

**Doppler Modelling Development**
- forward modelling (incl. multiple scattering)
- instrument modelling
- retrieval modelling

→ fut. miss. & EC

**Radiation products (L2b):**
- TOA unfiltered SW, LW, TW radiances
- TOA SW, LW flux (ADM method)

***Rad. transfer-modelling derived (1D, 3D-MC RTM) using retrieved EarthCARE cloud & aerosol profiles and 3D scenes:***
- SW, LW flux and heating rate profiles
- TOA radiances vs. BBR observations

**MSI L2a:**
- Cloud opt. thickness, droplet eff. rad., cryst. eff. diamtr., cloud top temp.
- Cloud scene classification
- Aerosol opt. thickness, Angstrom spectr. slope, aerosol size distribution

# ESA's Level 2 Development Activities

**Level 2 defintion: L2a = product retrieved from one instrument**
**L2b = synergistic product from several instruments**

**ATLID L2a:**
- feature mask
- HSRL extinct., backscatter, depol.
- target classification
- aeros
- ice cl

**CPR L2a:**
- feature mask
- IWC, eff. rad. ice clouds
- ... (tbd)

## Schedule (ESA):

- Theoretical developments until end of 2010
  → delivery of ATBDs version 1
- 2011: prototyping for ECSIM (EarthCARE Simulator)
- 2012 → until launch: coding, refining, finishing up of GS

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**MSI L2a:**
- Cloud opt. thickness, droplet eff. rad., cryst. eff. diamtr., cloud top temp.
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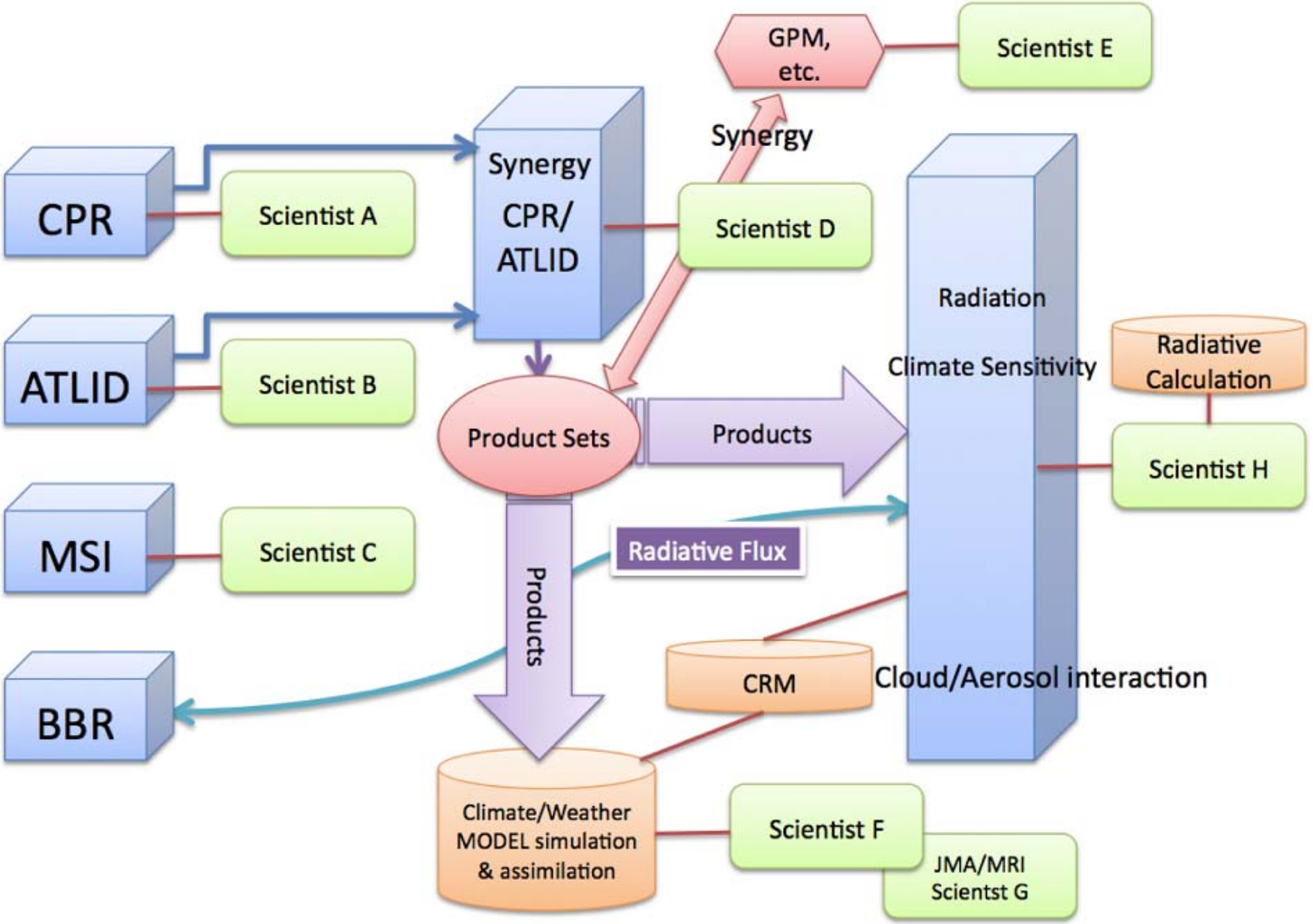
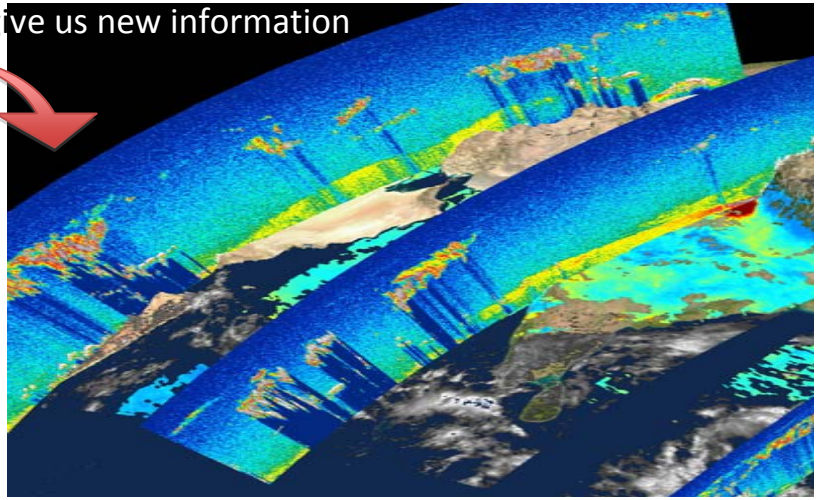
# Japanese concept



# Science derived from EarthCARE mission

## The four instruments on board EarthCARE together.

(CPR: Cloud Profiling Doppler Radar ATLID: Lidar MSI: Imager BBR: Broad-band Radiometer)
Algorithms for these active sensors yield vertical profiles of microphysical parameters of cloud with its phase and aerosol with its species, and can detect drizzle and light rain.
Especially doppler velocities of particles can be retrieve to give us new information



EarthCARE

Parameters: vertical cloud, aerosol, drizzle, *vertical motion* from active sensors

+

Parameters: horizontal cloud, aerosol from MSI

collaboration with Model

Parameters: 3D cloud, aerosol

Radiative Transfer Calculation vs. BBR data (True)

Radiative Flux: BBR Data

Model Use: assimilation validation

Model Improvement: ***Cloud-Aerosol interaction***

Algorithm development

Cloud Scheme Improvement

Climate Sensitivity

IPCC

Scene Generator & Signal Simulator

Radiatve Transfer & 3D Montecarlo

# EarthCARE Data Formats and Policy

## Data Formats:

Under discussion: JAXA will use HDF-5, ESA tbd (NetCDF or HDF-5)

## Data Distribution:

- Aiming at minimising redundant data products through algorithm development co-operations between European/Canadian and Japanese PIs
- ESA and JAXA will exchange all Level 1b and Level 2a & 2b data produced by either agency and distribute to their users

**Thank you**