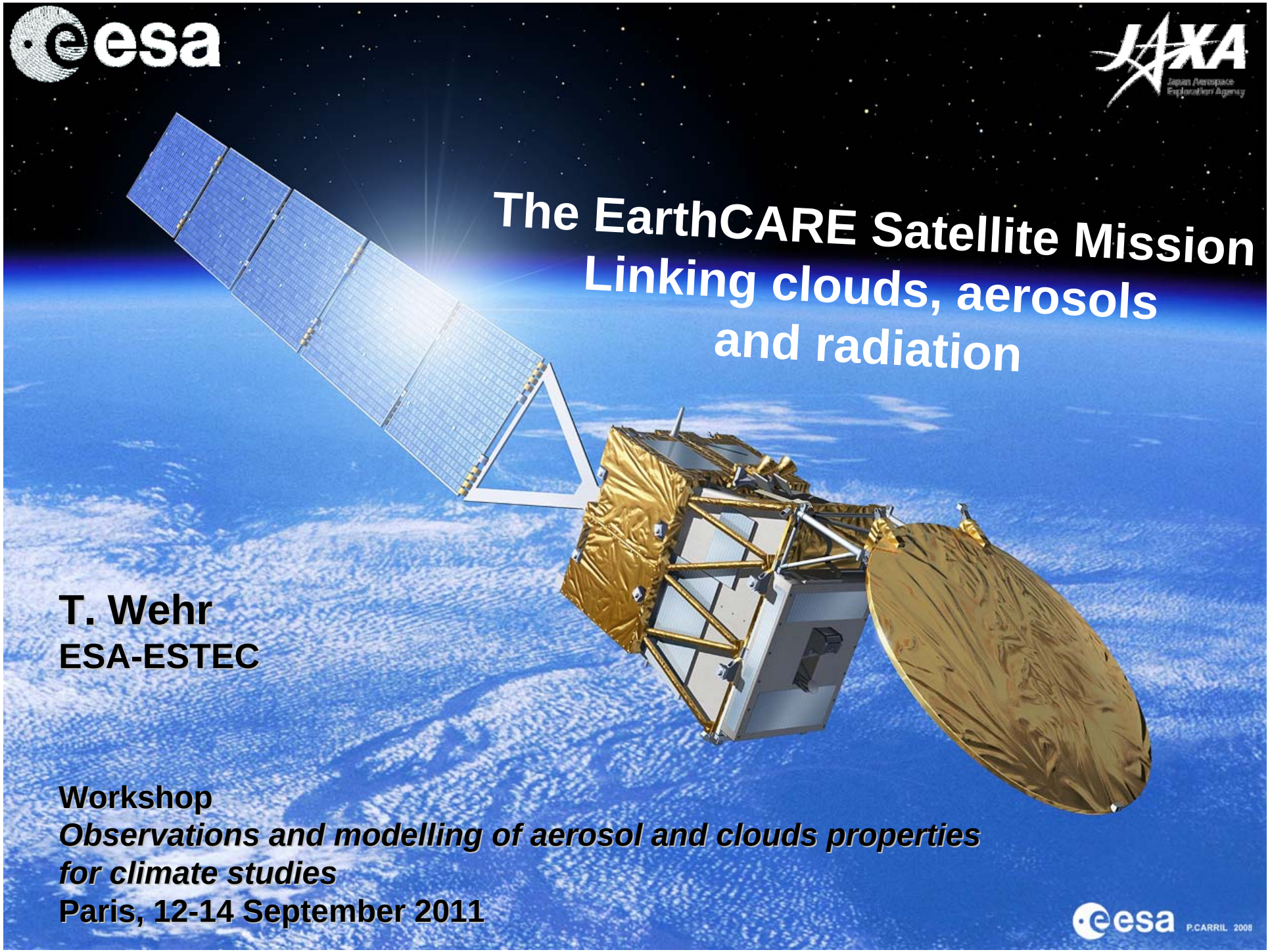

esa
JAXA
Japan Aerospace Exploration Agency
The EarthCARE Satellite Mission
Linking clouds, aerosols and radiation
T. Wehr
ESA-ESTEC
Workshop
Observations and modelling of aerosol and clouds properties for climate studies
Paris, 12-14 September 2011
esa
P.CARRIL 2008

Mission Summary

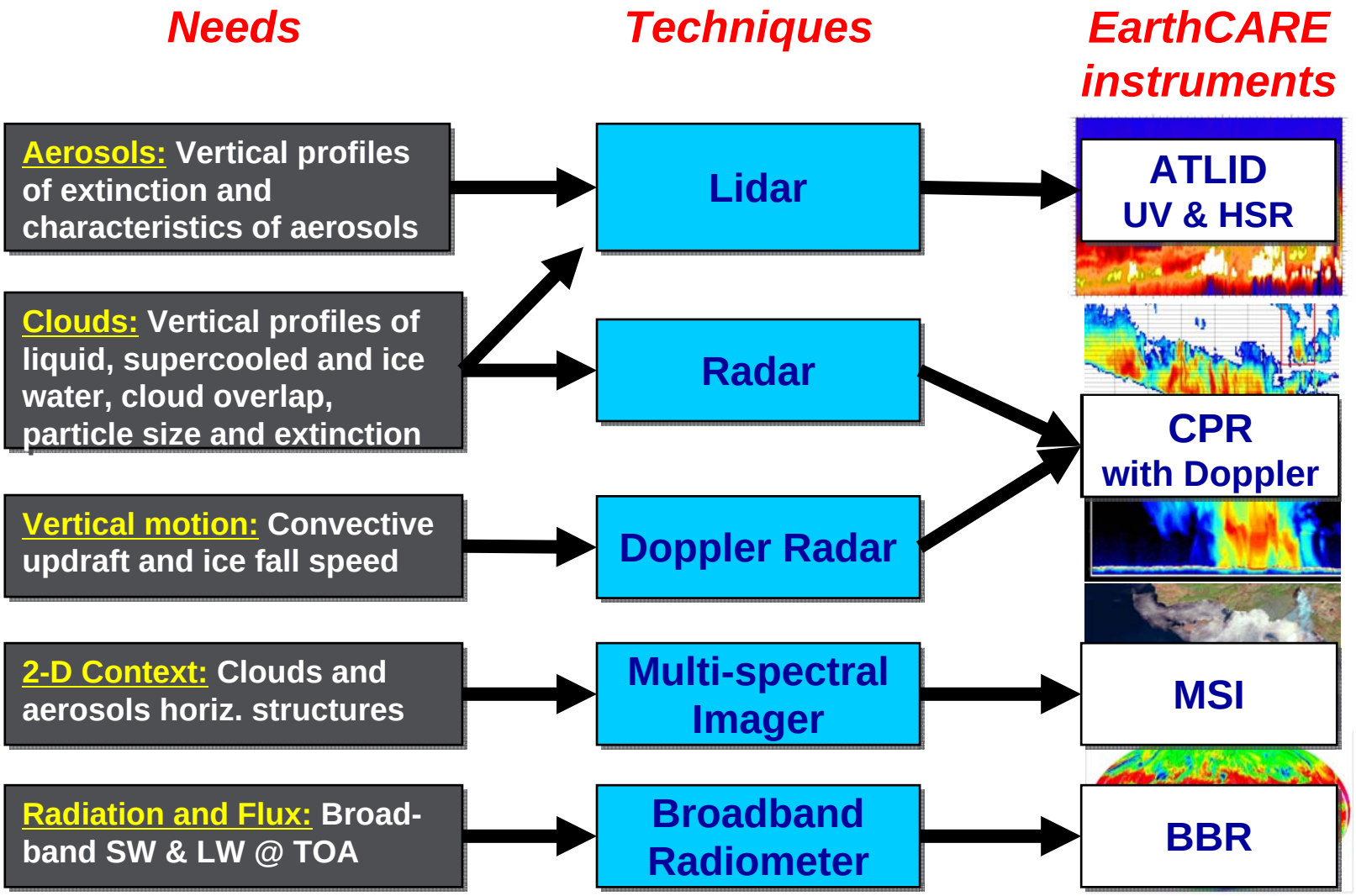
Mission Objective:

Understanding of cloud-aerosol-radiation interactions so as to include them correctly and reliably in climate and NWP models

Required Global Observations:

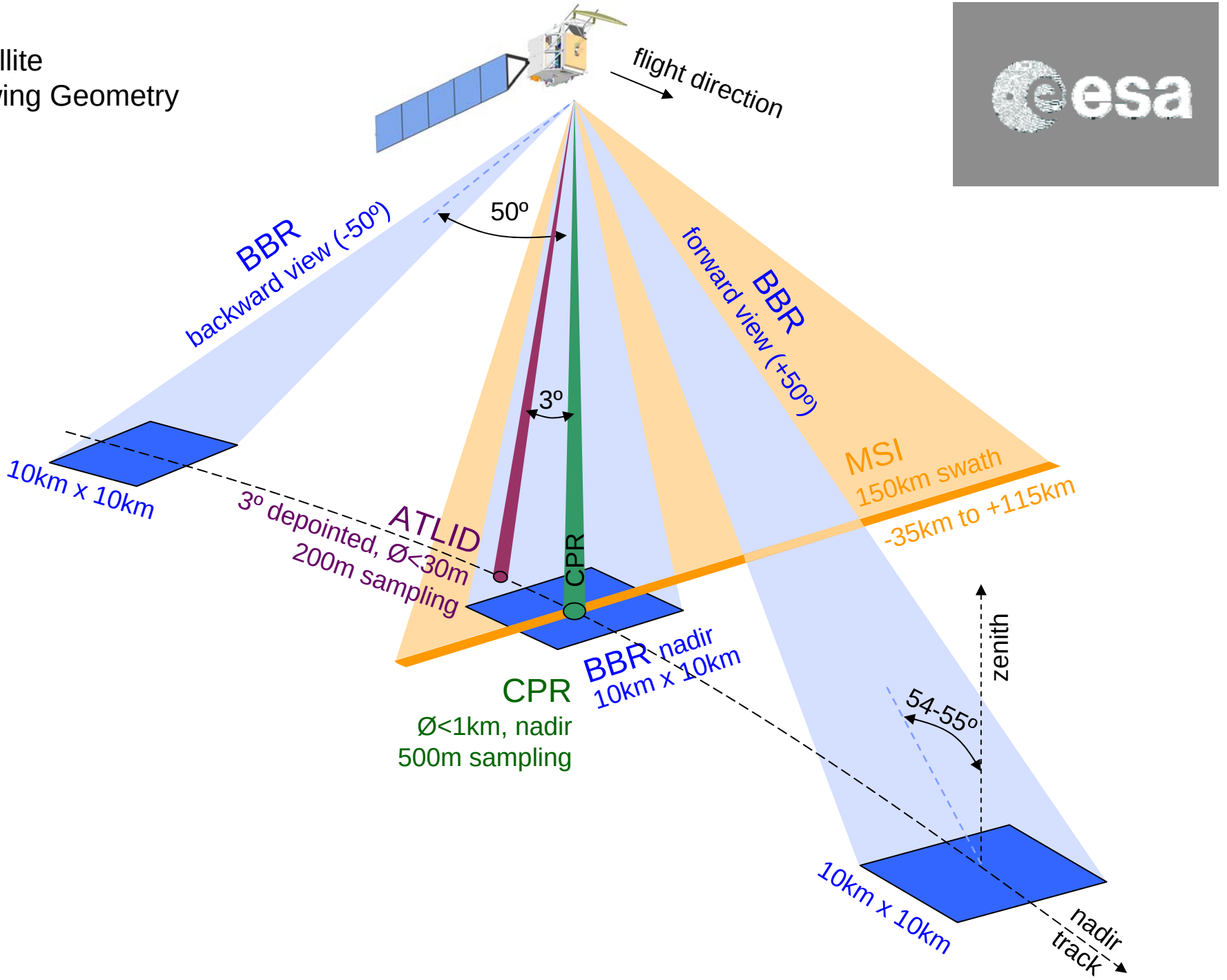
- Vertical profiles of natural and anthropogenic aerosols, their radiative properties and interaction with clouds.
- Vertical distributions of atmospheric liquid water and ice, their transport by clouds and their radiative impact.
- Cloud distribution (‘cloud overlap’), cloud-precipitation interactions and characteristics of vertical motions within clouds.
- Retrieval of profiles of atmospheric radiative heating and cooling through the combination of the retrieved aerosol and cloud properties.

Mission Summary



Temperature and humidity from operational analysis

Satellite
Viewing Geometry



Mission Summary

Primary Mission Objective

Impact of clouds and aerosols on radiation

Payload & Level 1 Products:

HSR Lidar: λ=355nm with depol. channel:

– L1: attenuated backscatter profiles

95GHz Radar with Doppler (JAXA/NICT):

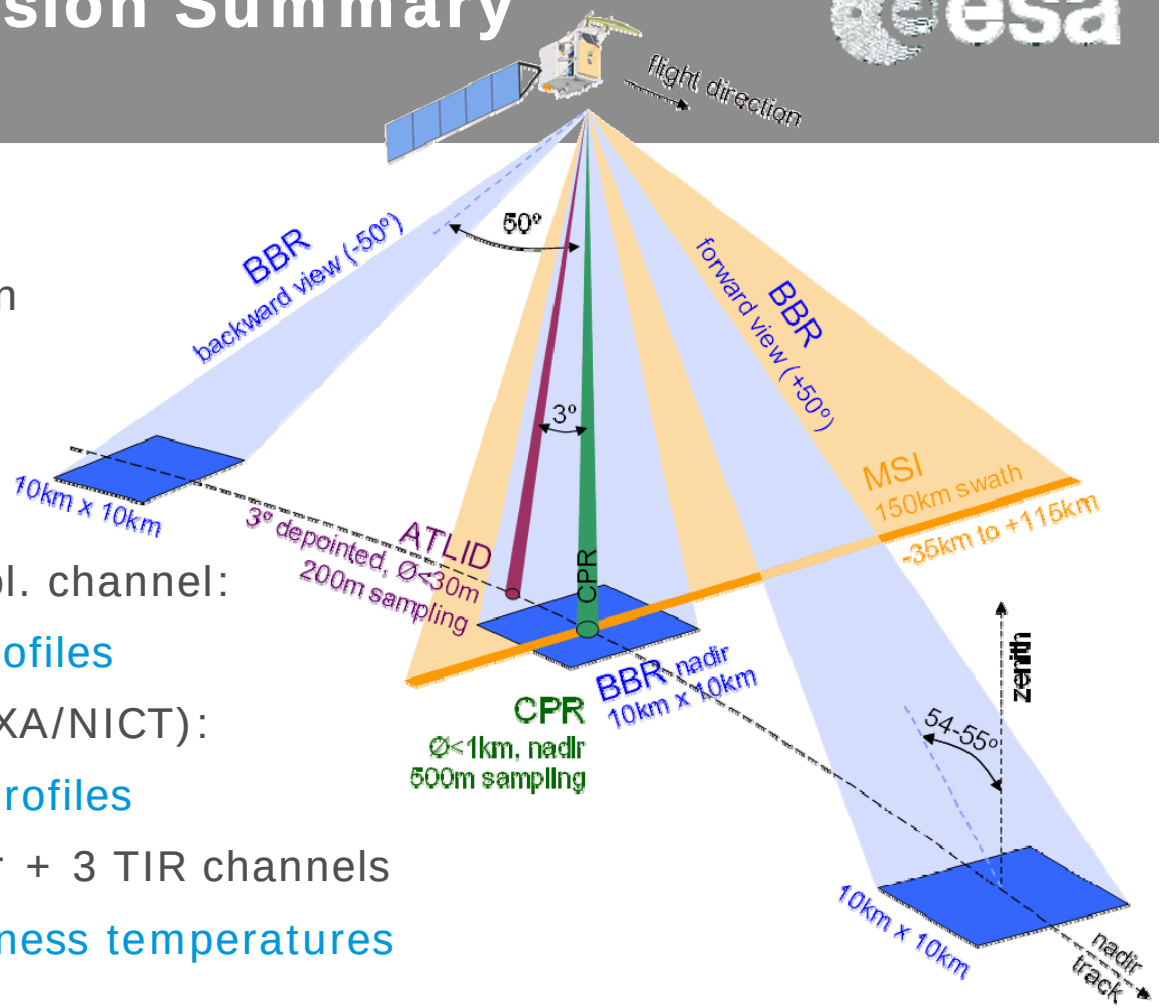
– L1: Reflectivity and Doppler profiles

Multi-spectral Imager, 4 solar + 3 TIR channels

– L1: TOA radiances and brightness temperatures in 7 spectral bands

Broad-band Radiometer, 3 fixed FoV

– L1: Filtered top-of-atmosphere radiances short- and long-wave



Mission Summary

PAYLOAD: two active and two passive instruments

ATmospheric LIDar (ATLID)

- Backscatter UV (355nm, linear pol.) with high spectral resolution receiver (HSRL)
- 3 channels receiver: Rayleigh scatter, co-polar Mie, cross-polar Mie
- 3 deg 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

ORBIT

Orbit parameter		Nominal Orbit	CAL/VAL Orbit
Repeat Cycle		25 days	9 days
Orbit period (nodal)	[s]	5552.7	5554.3
Semi major axis	[km]	6771.28	6772.57
Eccentricity		0.001283	0.001283
Inclination	[°]	97.050	97.055
MLST Descending Node	[hr]	13:45-14:00	13:45-14:00
Argument of perigee	[°]	90.0	90.0
Means Semi-major axis Altitude	[km]	393.14	394.43
Minimum Geodetic Altitude	[km]	398.4	399.6
Maximum Geodetic Altitude	[km]	426.0	427.3
Means Geodetic Altitude	[km]	408.3	409.7

Status

Industry Consortium:

- **Spacecraft Prime: Astrium GmbH** (contract signed May 2008)
- Base-Platform: Astrium-Ltd
- ATLID: Astrium-SAS with G.A as sub-contractor
- [CPR: Japanese contribution]
- BBR: SEA with RAL as sub-contractor
- MSI: SSTL with TNO as sub-contractor

Phase B completed with satisfactory outcome for System aspects but

- Effect of Laser Induced Contamination for UV optics more severe than originally foreseen. Studies of back-up during Phase B and reconfiguration from monostatic to bistatic configuration with mass/envelope impacts
- Delay in the Programme due to this reconfiguration
- Confirmation of large Launch Vehicle: Soyuz class

Phase C/D in preparation

Schedule leading to launch date in 2015

ATLID Update

Bi-static configuration in order to mitigate risk of laser-induced contamination:

- emission path fully pressurised
- exit window protected with long baffle
- bi-static design
- UV wavelength maintained

Joint Mission Advisory Group for Phase B:
Providing advice on all science related aspects of the mission

Europe/Canada*
Anthony J. Illingworth
Howard Barker
Anton Beljaars
Franz Berger
Jean-Pierre Blanchet
David Donovan
Martial Haeffelin
Gelsomina Pappalardo
Jaques Pelon
Ulla Wandinger
**membership to be revised Nov 2011*

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

US Observers
John Bates
Graham Feingold
Graeme Stephens
Deborah Vane
David Winker

Agencies
Tobias Wehr (mission scientist ESA)
Riko Oki (mission scientist JAXA)
Alain Lefebvre (project manager ESA)
Toshiyoshi Kimura (CPR project manager JAXA)

Utilisation of radar and lidar for NWP and air quality

ECMWF study “QuARL”: *(M. Janiskova, P. Bauer, and many more)*

- forward operator development radar (CloudSat CPR), lidar (CALIOP)
- validation model parameterisation of cloud and aerosol
- radar and lidar assimilation strategies
- experimental assimilation and demonstration quality monitoring

Activity completed, follow-up activity “STSE Assimilation” has started 1 September 2011:

- focus on clouds
- lidar forward operator (clouds)
- radar and lidar observation erros, quality control, bias correction
- data monitoring
- 1D-VAR analysis and 1D+4D-VAR analysis

NRT presently not project baseline, but some NRT concepts under investigation to address user data needs for L1b products and (TBC) some L2 products

Support to Science Element (STSE) Studies

DAME
P. Kollias, A. Battaglia et al., coop. S. Tanelli

Development Doppler modelling (forward, instrument, retrieval) for generic space-borne radar with generic geometry → enhancement ECSIM capabilities

Activity nearing completion, application potential EarthCARE

ICAROHS
A. Petzold et al.

Development retrieval algorithms for generic space-borne multi-λ HSRL; utilisation of DLR aircraft HSRL observations (LACE, EUCAARI, SAMUM-1/-2, Iceland volcano)

Completed. Valuable lessons learned for EarthCARE L2 developments

ESA L2 Development

Definition:

Level 2a products:

- Retrieved from individual instruments

Level 2b products:

- Synergistically retrieved products

Development stages philosophy:

1. Stage 1: research & general outline algorithm, no s/w delivered to ESA
   In the subsequent stages, continuation of research, ATBDs always updated:
2. Stage 2: first delivery ‘stand-alone’ s/w
3. Stage 3: s/w integrated into EarthCARE Simulator (ECSIM)
4. Stage 4/5: s/w integration into ESA Ground Segment

End-to-end simulator ECSIM:

- Performance assessment tool
- Interfaces, coding requirements, compatibility to feature easy science algorithm integration into ground segment, community tool

Recommended L2a (ESA)

CPR

- feature mask
- target classification
- ice water content & effective radius
- liquid water content & effective radius
- vertical motion
- precipitation / snow
- melting layer

ATLID

- feature mask
- target classification
- extinction, back-scatter, depolarisation
- aerosol extinction, backscatter, type
- ice water content, eff. rad.
- cloud top height
- aeros. layer descriptor

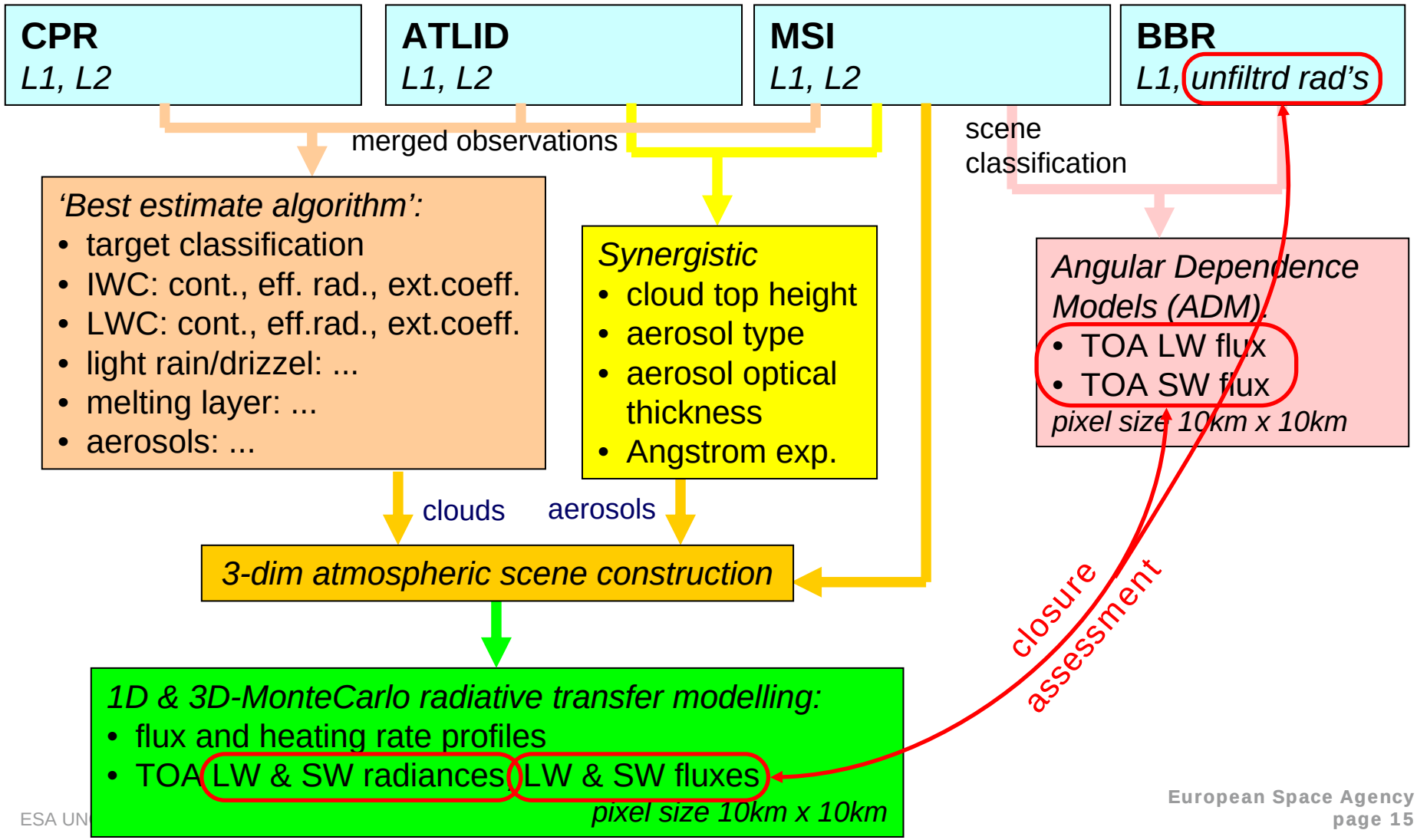
MSI

- cloud mask: flag & type & phase
- cloud µphys: OT, eff. droplet/ crystal diam., liq./ice water path
- cloud top height, T, p
- Aerosol OT & Angström exp.

BBR

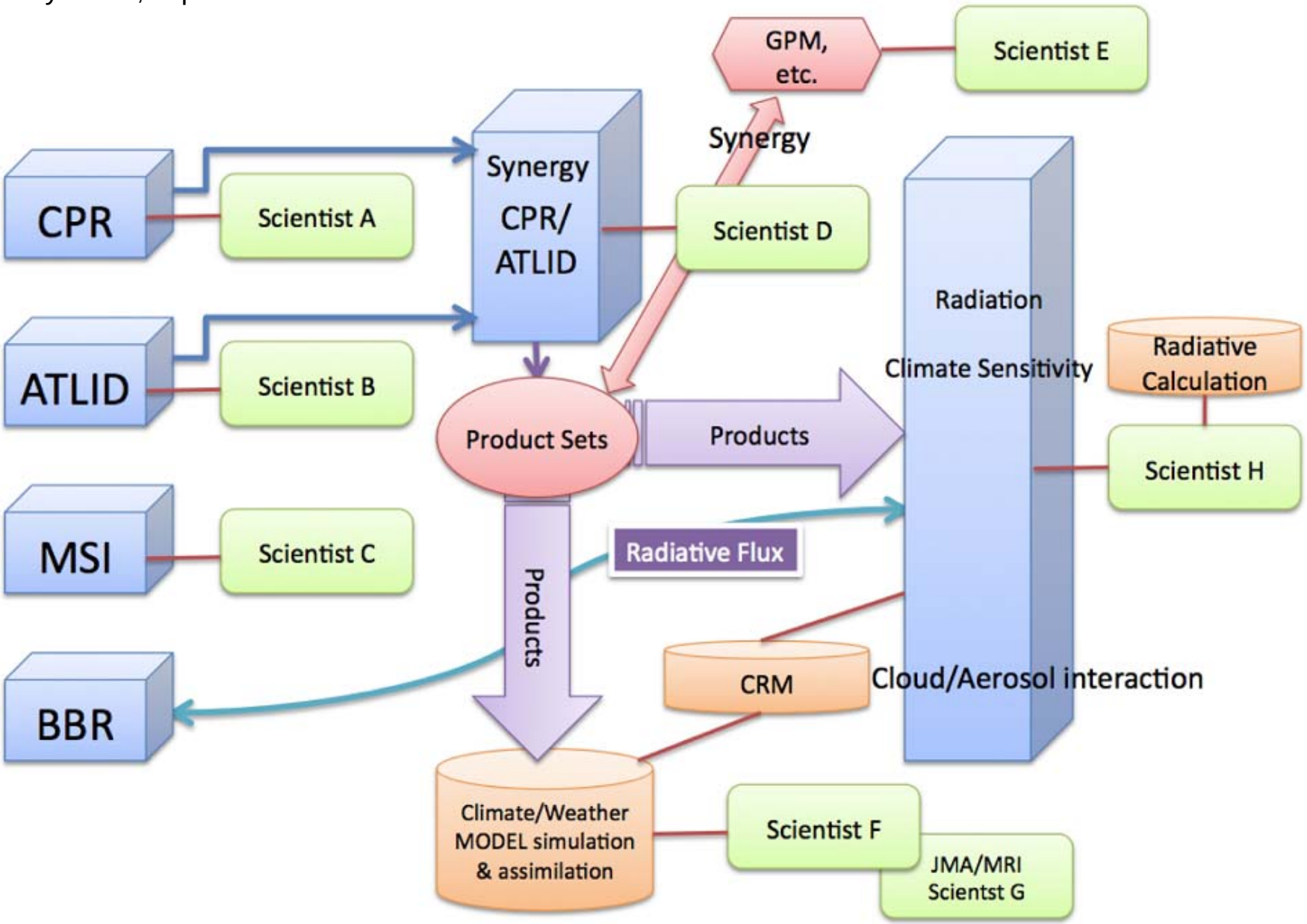
- unfiltered solar radiance
- unfiltered thermal radiance

Recommended L2b (ESA)



Japanese concept

courtesy JAXA, Japanese science team



Japanese concept

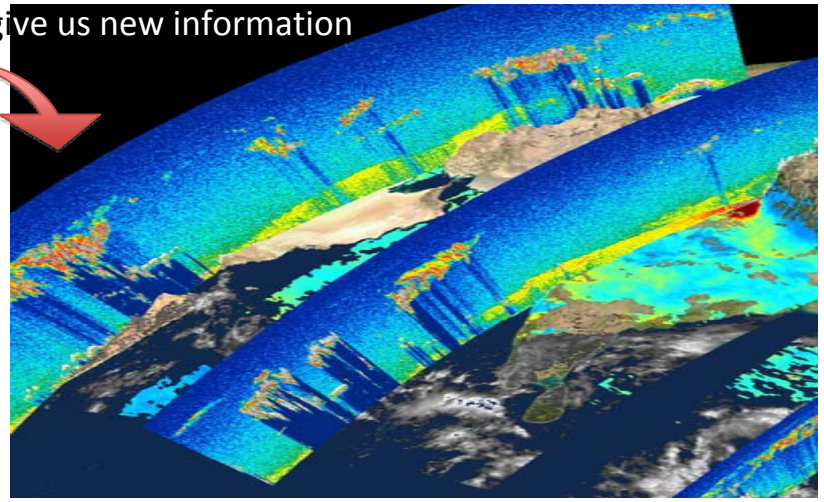
courtesy JAXA, Japanese science team

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



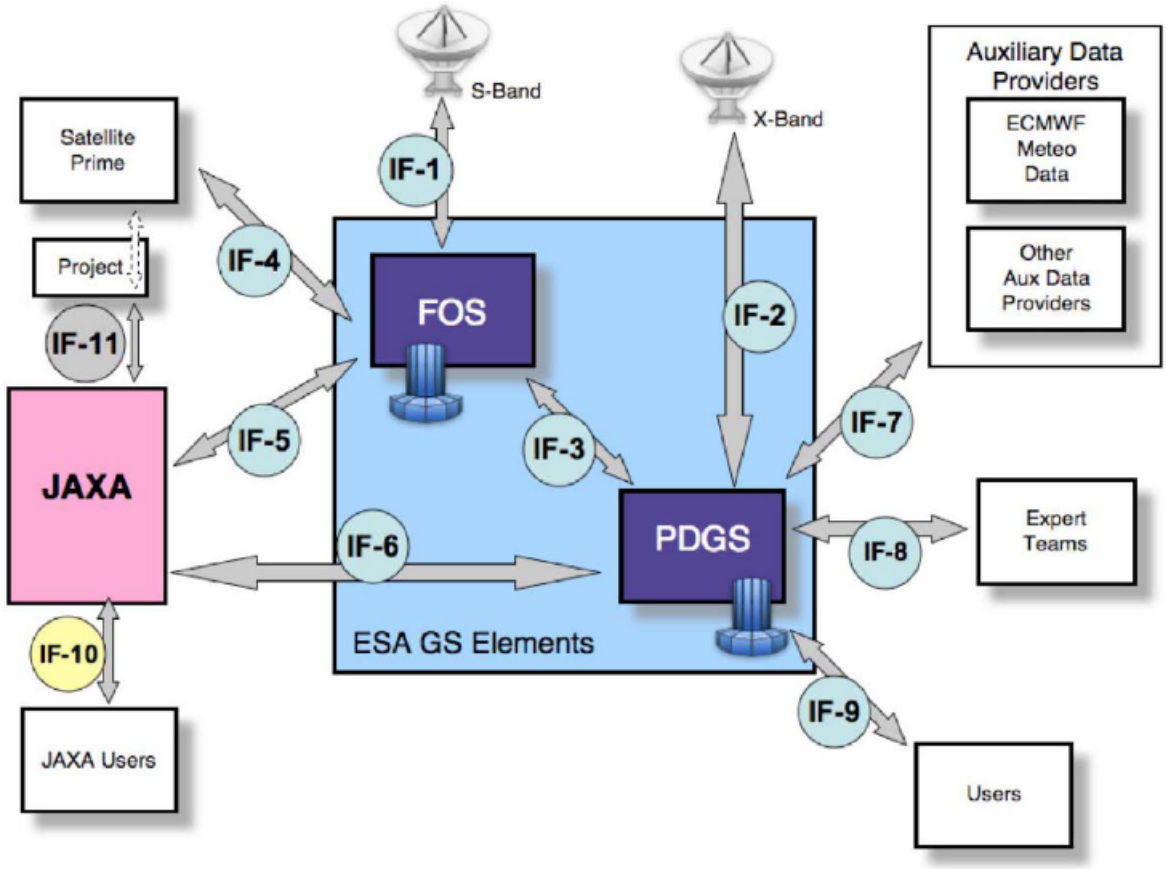
EARTHCARE IS A JOINT MISSION:

→ ESA and JAXA will coordinate L2 development activities in order to optimise use of resources

→ JADE (Joint Algorithm Development Endeavour) includes all ESA and JAXA algorithm scientists in order to implement this cooperation

→ Operational ESA and JAXA L2 products will be distributed by both agencies to the users

Ground Segment Overview



FOS : Flight Operation Segment
- platform and payload commanding
- platform and payload health monitoring
- orbit control
- on-board software and config maintenance

PDGS: Payload Data Ground Segment
- payload and acquisition planning
- real time acquisition of science data
- acquisition of stored HKTM & routing to FOS
- processing of science data to L1b and L2
- data products archiving and distribution to users
- payload performance monitoring and calibration
- data products quality monitoring

JAXA
- CPR instrument planning support
- CPR instrument health monitoring
- CPR instrument OBSW maintenance
- CPR instrument data processing
- data products distribution to JAXA users

Satellite Prime
- OBSW maintenance
- support to health monitoring

Ground segment PDR coming up

Next

Cal/Val Preparation

- AO call about 1-2 years before launch (so, not imminent)
- However, planning starting now – past experiences very important

Get involved!

With the start of Phase C/D now imminent, it is timely for the science community to start setting up and coordinate (multi-)nationally funded EarthCARE preparatory science activities. National EarthCARE Science Offices could help to coordinate & intensify collaborations, attract funding and secure team integrity and development.

Next EarthCARE Science Workshop

- Envisaged for spring/summer 2012, date and place tbd
- Intensify collaboration with CloudSat and CALIPSO communities
- Intensify contact with cloud, aerosol, modelling, ERB, ... communities

Thank you!