Approved
~~Possible~~ future atmospheric Earth Explorer missions

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European satellites

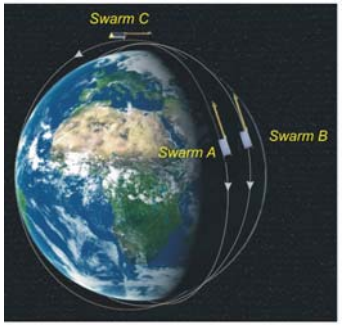
Envisat

GOCE

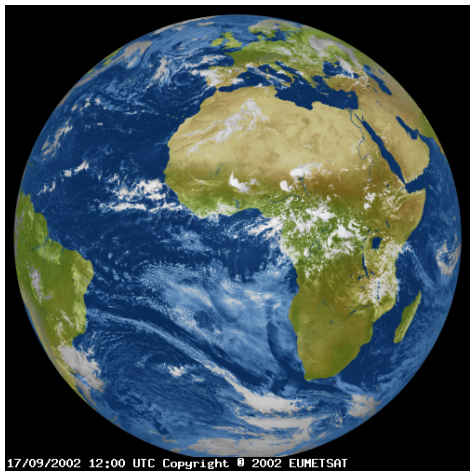
AEOLUS

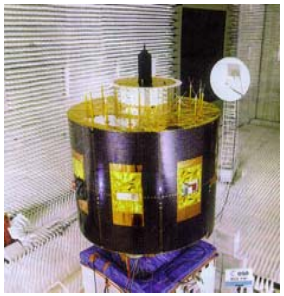
2004

Swarm



MetOp

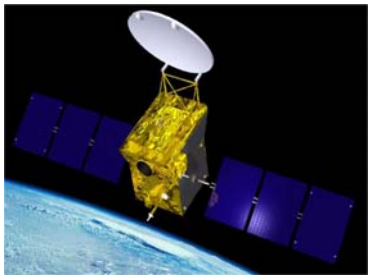




MSG

+

EarthCARE



CRYOSAT

ERS

SMOS

the Living Planet

The ESA EO missions: The Living Planet

The Living Planet programme

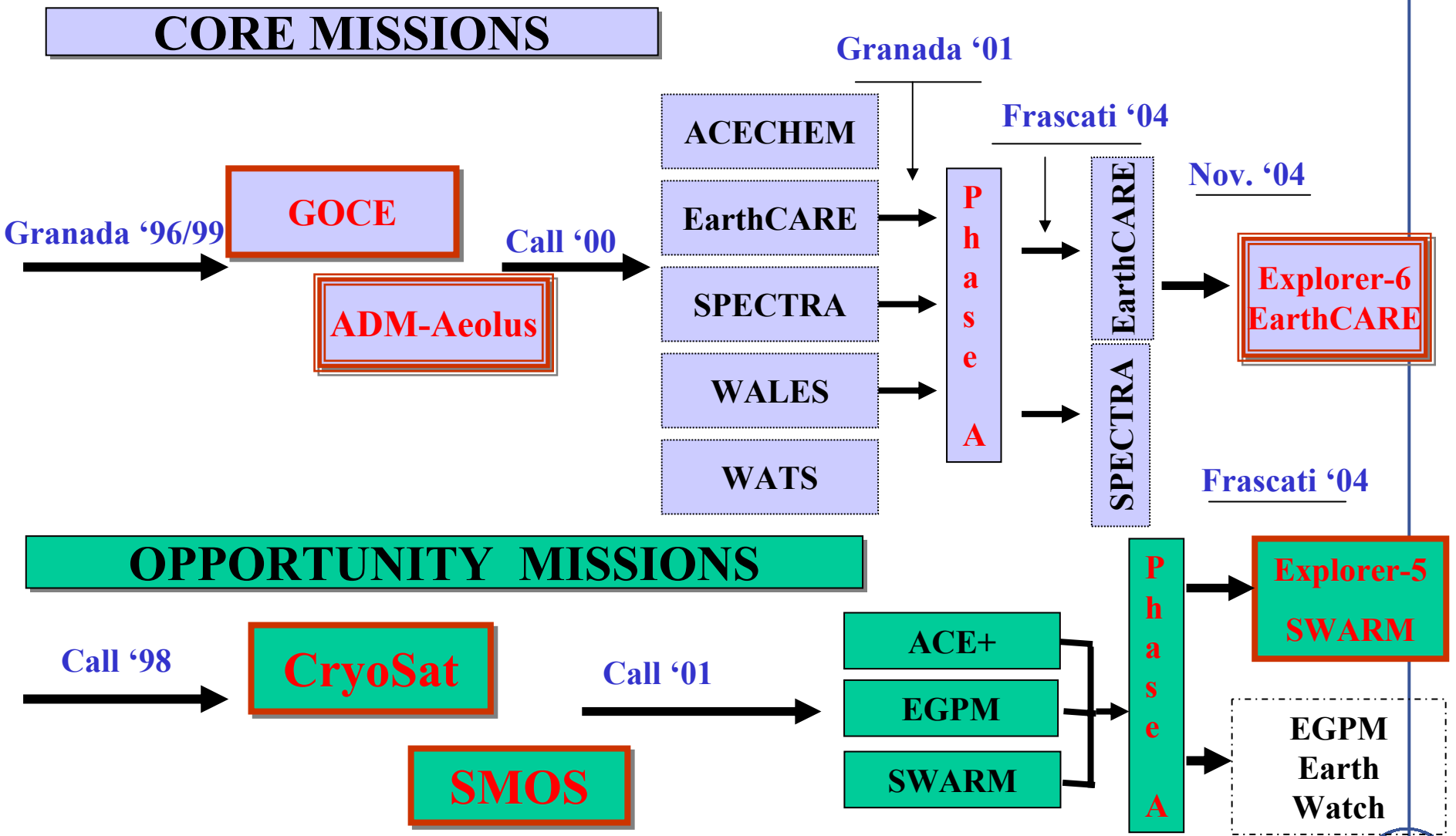
- The ESA Living Planet Programme was created in consultation with the key players: Europe's scientists, Industry, European Commission, EUMETSAT and many others.
- The programme has 3 basic elements:

Earth Explorer — To better understand the Earth

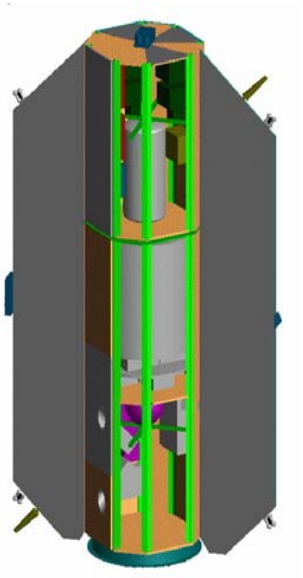
Earth Watch — To initiate long term monitoring systems and services ⇒ **GMES Sentinels**

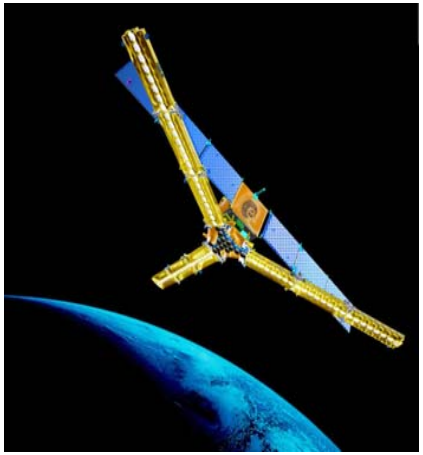
Technology / exploitation — To develop more efficient approaches

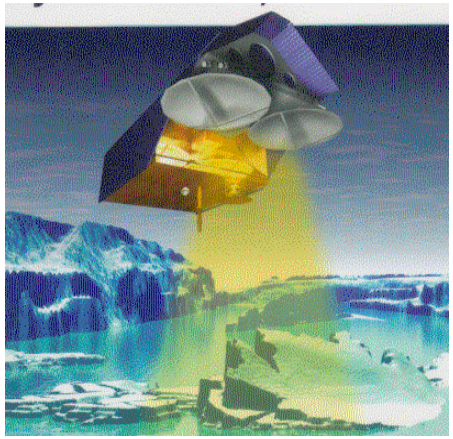
The Earth Explorers



Current Launch Schedule ’06 - ’09





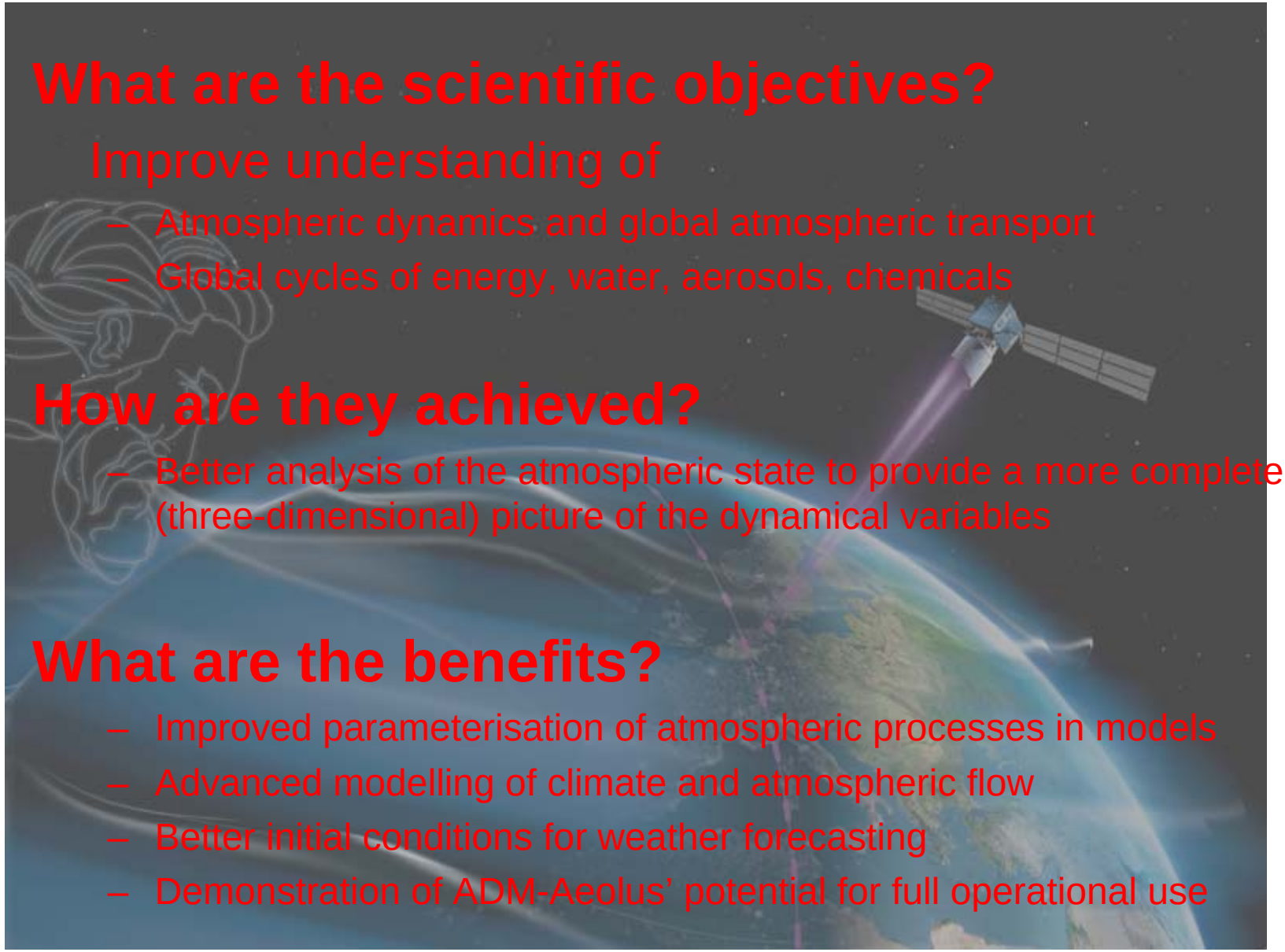


GOCE	SMOS	ADM-Aeolus	CRYOSAT-2
Launch 2007	Launch 2007	Launch 2008	Launch 2009
Core-1	**Opportunity-2**	**Core-2**	**Opportunity-1**

http://www.esa.int/livingplanet

ADM-Aeolus

ADM-Aeolus: The Mission



What are the scientific objectives?

Improve understanding of

- Atmospheric dynamics and global atmospheric transport
- Global cycles of energy, water, aerosols, chemicals

How are they achieved?

- Better analysis of the atmospheric state to provide a more complete (three-dimensional) picture of the dynamical variables

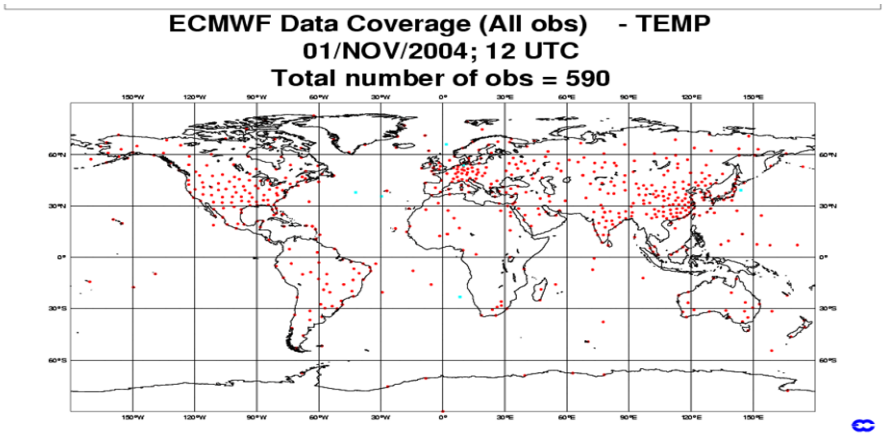
What are the benefits?

- Improved parameterisation of atmospheric processes in models
- Advanced modelling of climate and atmospheric flow
- Better initial conditions for weather forecasting
- Demonstration of ADM-Aeolus' potential for full operational use

Existing wind field information

Wind field information available to date in the Global Observation System (GOS):

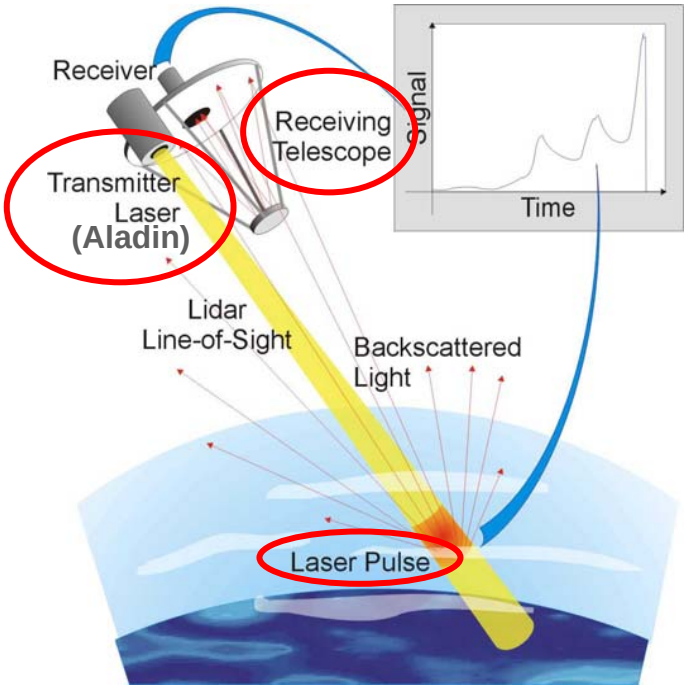
- Radiosonde and pilot soundings (NH continents dominate)

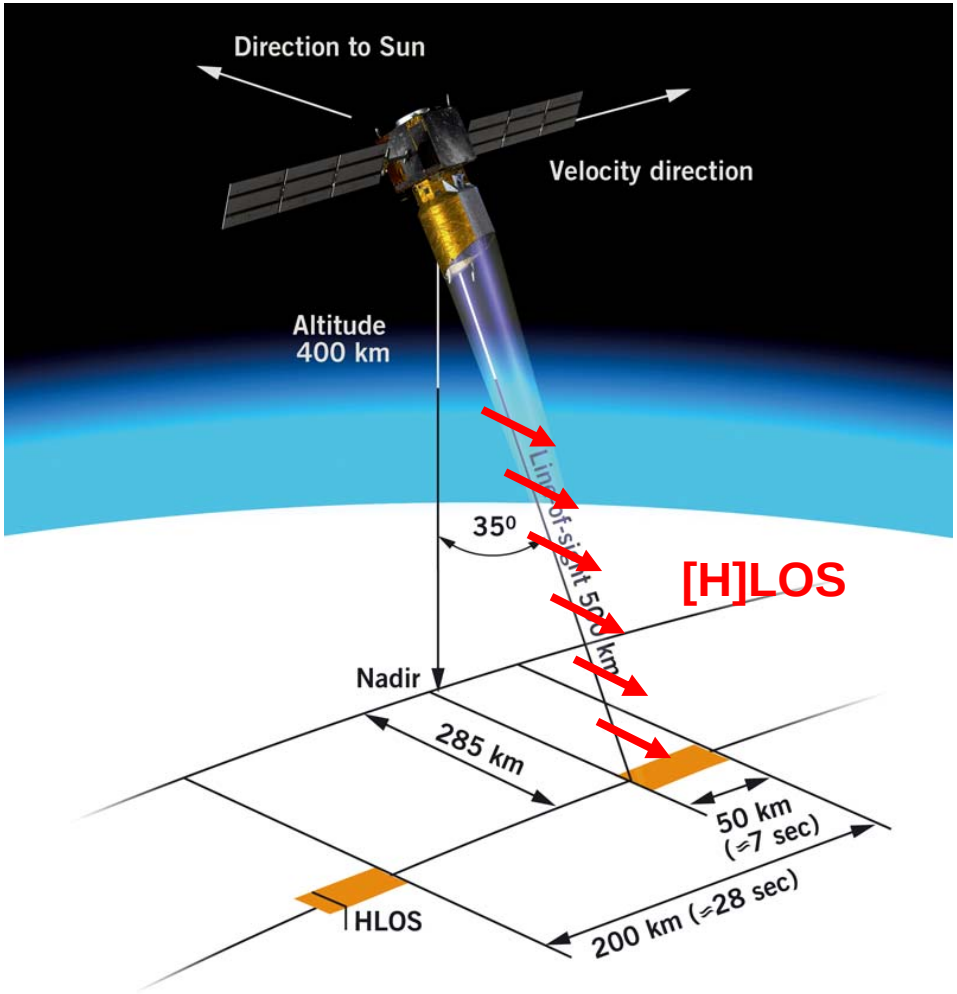


- Aircraft data (NH densely populated areas dominate)
- Atmospheric motion vectors (only in the presence of clouds and tracers)
- Satellite soundings of temperature and humidity from Polar orbiting satellites (mass information, indirect measure of large-scale phenomenon wind outside the tropics)

➔No DIRECT, GLOBAL and UNIQUE measurements of atmospheric wind fields yet

ADM-Aeolus: Measurement Concept

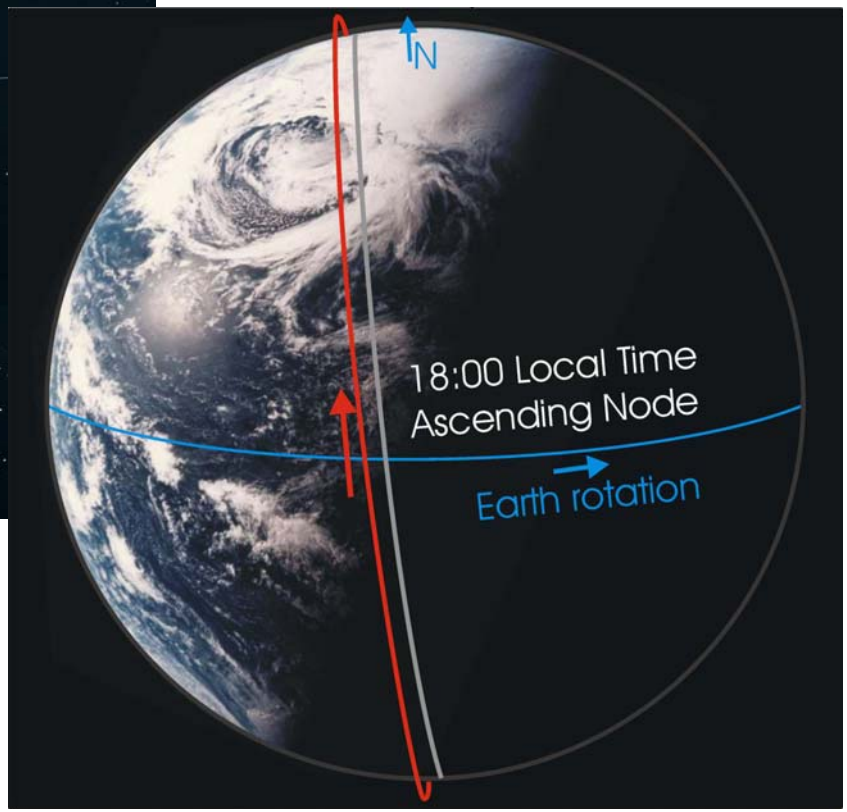




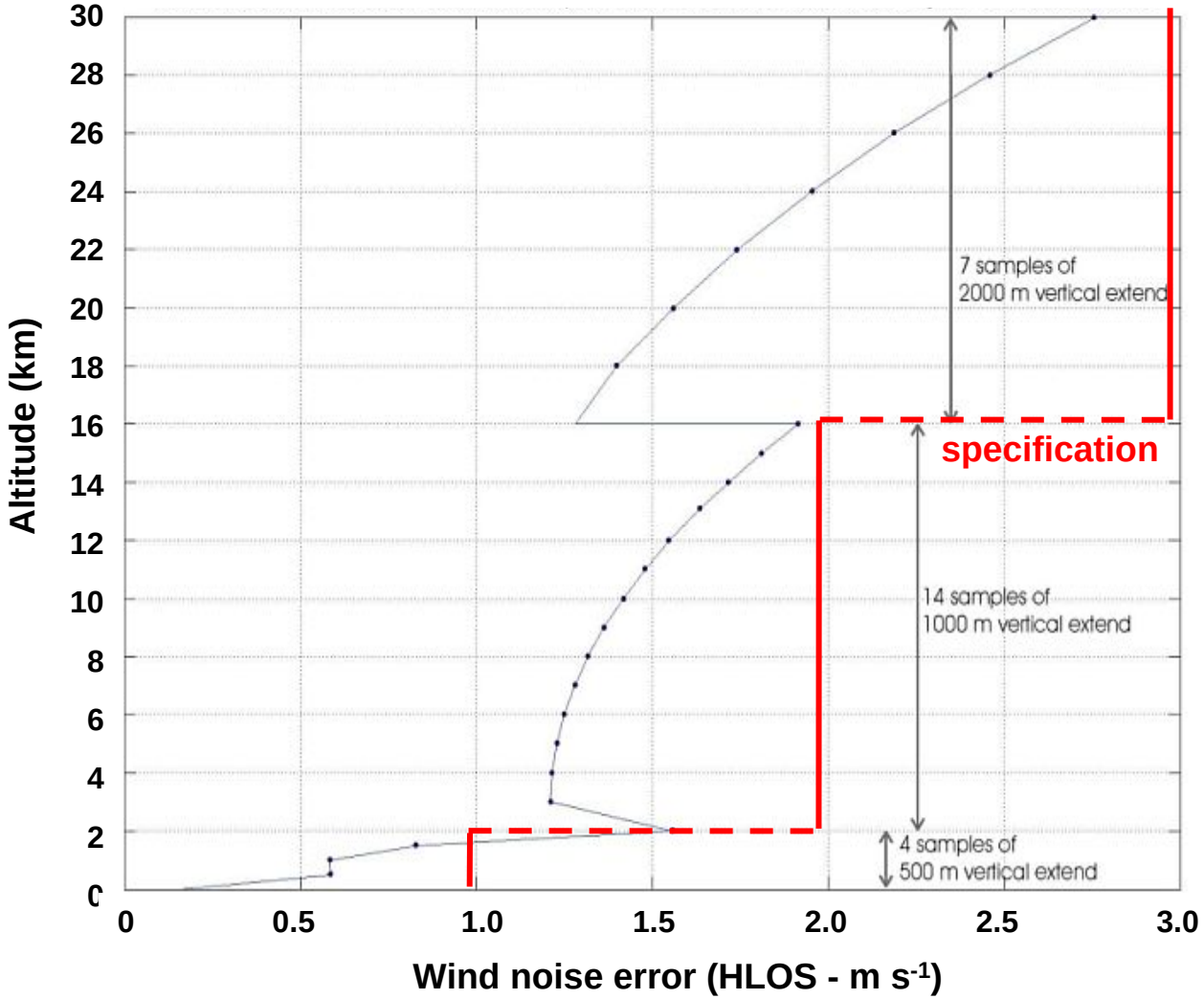
- Wind measurements are derived from the Doppler shifted signal that is back-scattered by aerosols **and** molecules along the lidar line-of-sight (LOS)

ADM-Aeolus: The Orbit

- Altitude: 400 km
- Sun-synchronous
- Dawn-dusk



ADM-Aeolus: Performance



Additional Benefits from ADM-Aeolus

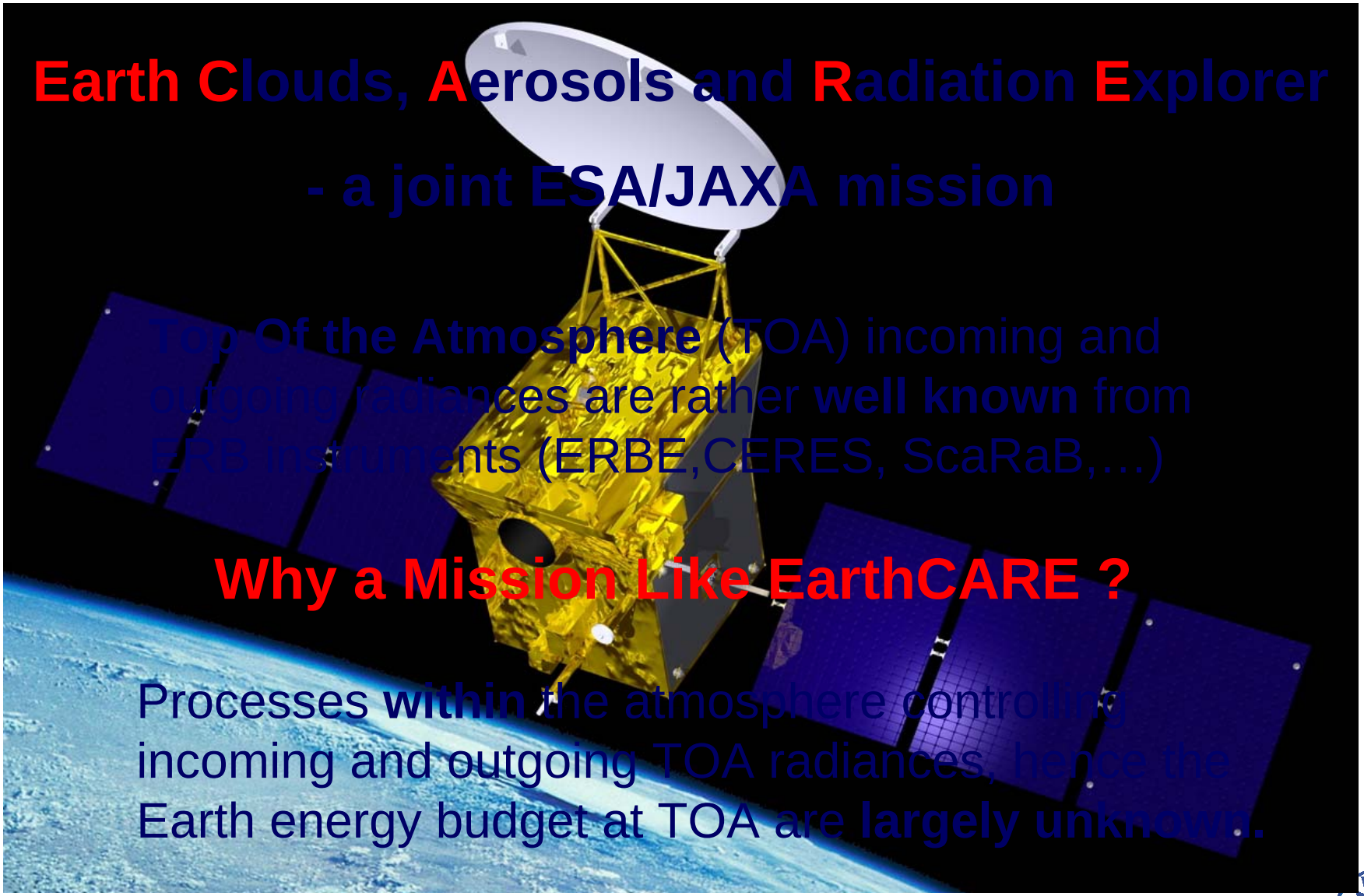
In addition to the main wind observation product, the following information can be retrieved:

- Clouds
  - Cloud heights
  - Multi-layer clouds
  - Optical thickness
  - Cloud type
- Tropospheric aerosol
  - Optical thickness
  - Aerosol type (lidar ratio - separating anthropogenic from natural)
  - Stratification
- Wind variability, clear air turbulence
- Validation of products from other satellites
- Model validation

Science Benefits from ADM-Aeolus

- More direct observations of winds in the tropics and over mid-latitude oceans
- Use of observations in model verification
- Better description of transports (ozone, humidity, aerosols,…)
- Dynamics in the lower stratosphere

EarthCARE: Rationale



Earth Clouds, Aerosols and Radiation Explorer

- a joint ESA/JAXA mission

Top Of the **Atmosphere** (TOA) incoming and outgoing radiances are rather **well known** from ERB instruments (ERBE,CERES, ScaRaB,…)

Why a Mission Like EarthCARE ?

Processes **within** the atmosphere controlling incoming and outgoing TOA radiances, hence the Earth energy budget at TOA are **largely unknown.**

EarthCARE: Mission Summary

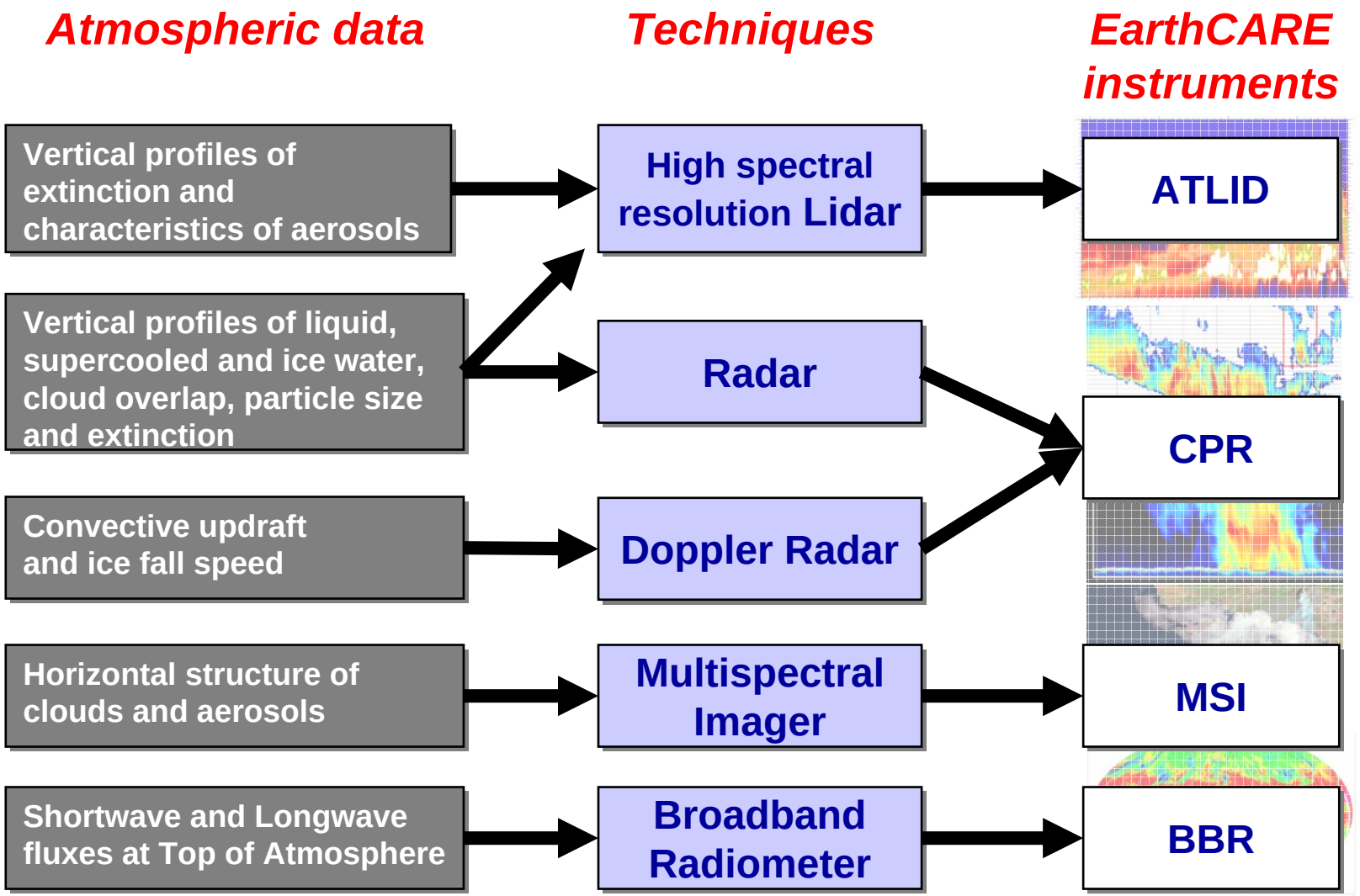
Scientific objective :

Quantification of aerosol-cloud-radiation interactions

so they may be included correctly in climate and NWP models,
by providing :

- ➔Vertical profiles of **natural and anthropogenic aerosols** on a global scale, their radiative properties and interaction with clouds.
- ➔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.
- ➔The profiles of atmospheric radiative heating and cooling through a combination of **retrieved aerosol** and **cloud properties**.

EarthCARE: Observation Techniques



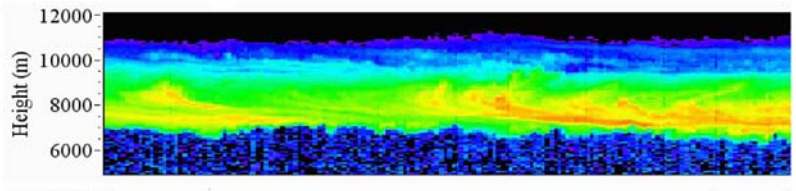
Temperature and humidity from operational analysis

EarthCARE: Synergy Example

Synergy: Lidar and Radar combination (from aircraft)

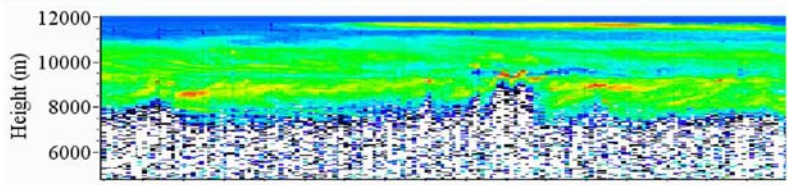
APEX/ECAV 2003, Japan

Radar reflectivity



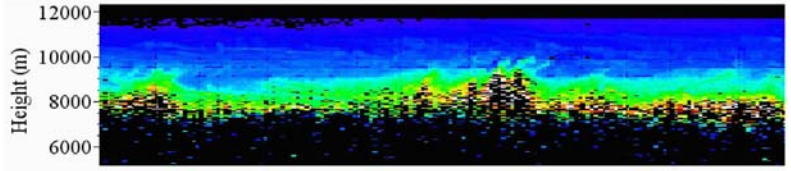
Radar: $Z \sim D^6$

Lidar backscatter



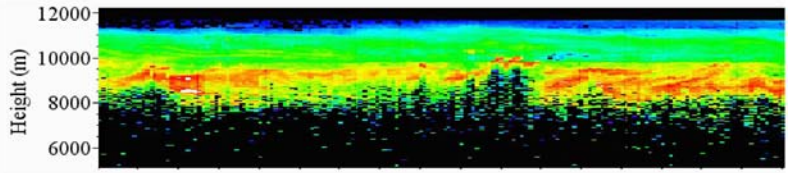
Lidar: $\beta \sim D^2$

Effective radius

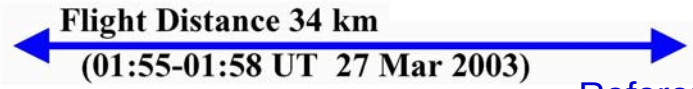


Particle size from Z/β

Ice water content

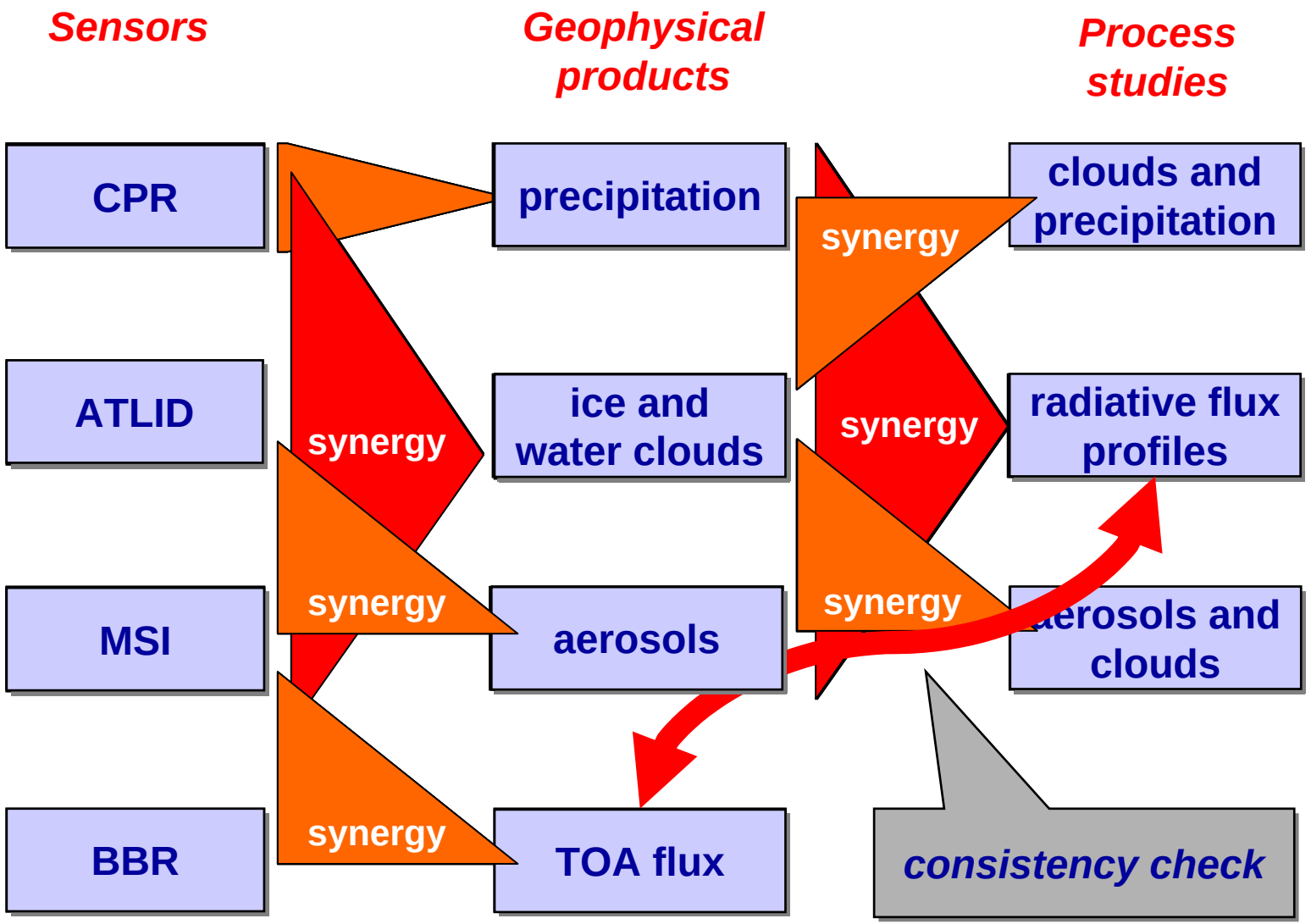


Accurate D and Z gives IWC



Reference: Kumagai et al 2004

EarthCARE: Measurement Synergy



Call for New Earth Explorer Missions

Call for Ideas for Earth Explorer 7

Focus areas of the call:

- **Global water cycle**
- **Global carbon cycle**
- **Atmospheric chemistry and its interaction with climate**
- **The human element**

- **24 proposals received by deadline mid August 2005**

  14 proposals address atmosphere, 9 of them composition

- **Evaluation in 5 scientific and 3 technical panels complete**
- **Earth Science Advisory Committee recommendations April 2006**
- **Selection of ≤ 6 proposals for pre-phase A by PB-EO:**

18/19 May 2006

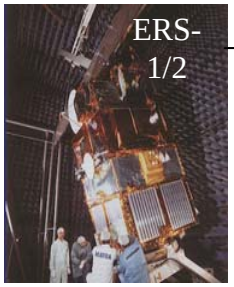
Candidate EECM - Atmosphere

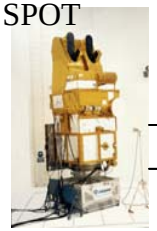
REF NO	MISSION_TITLE	TOPIC
CCM2-01	Geostationary Observatory for Microwave Atmospheric Sounding (GOMAS)	Atmos. Dynamics
CCM2-02	PRocess Exploration through Measurements of Infrared and millimetre-wave Emitted Radiation (PREMIER)	Atmos. Chemistry
CCM2-04	Cloud Ice Water Submillimeter Imaging Radiometer (CIWSIR)	Atmos. Dynamics
CCM2-05	Measuring Atmosphere Turbulence and Humidity Atmospheric Water Content (MATH-AWC)	Atmos. Dynamics
CCM2-06	Space-borne Profiling with high Accuracy in clear and Cloudy skies for the Exploration of WAter Vapour in the Earth System (SPACE WAVES)	Atmos. Dynamics
CCM2-09	Dual-Frequency Doppler Radar for Observing Precipitation Systems (Du-DROPS)	Atmos. Dynamics
CCM2-10	The Geostationary TROpospheric Pollution Explorer-Regional (GeoTROPE-R)	Atmos. Chemistry
CCM2-13	Atmospheric Climate and Chemistry in the UTLS Region And climate Trends Explorer (ACCURATE)	Atmos. Dynamics & Atmos. Chemistry
CCM2-14	Kyoto protocoL and Informed Management of the Adaptation (KLIMA)	Atmos. Chemistry
CCM2-15	Occultation and Limb Viewing of the Atmosphere (OLIVIA)	Atmos. Chemistry
CCM2-16	Impact of Lightning activity on Atmospheric Chemistry (ILAC)	Atmos. Chemistry
CCM2-18	Tropospheric Composition and Air Quality (TRAQ)	Atmos. Chemistry
CCM2-22	Measuring Atmosphere Turbulence and Humidity Atmospheric Water Content (MATH-AWC)	Atmos. Dynamics
CCM2-23	Advanced Space Carbon and Climate Observation of Planet Earth (A-SCOPE)	Atmos. Chemistry
CCM2-26	ECOsat Three Microsat Constellation for Earth Observation of the global Carbon and H_20 cycles using advanced Miniature Integrated-Optic NIR and IR Spectrometers	Atmos. Chemistry

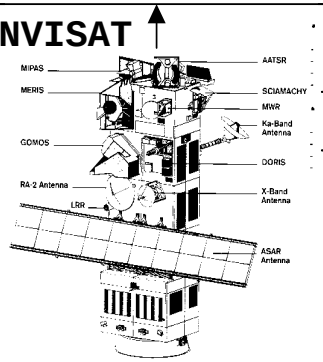
GMES: The Sentinels

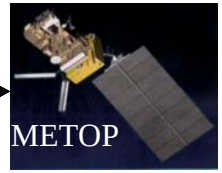
1. Continuation of C-band SAR observations
2. Land superspectral mission
3. Ocean monitoring mission
4. Atmospheric composition from geostationary orbit
5. Atmospheric composition from low earth orbit

Sentinels: Earth Observation Heritage









Poseidon-1

Jason-1

WSOA / OSTM

Jason-2

ALT

OCEAN

RA-1

RA-2

Radarsat

SAR

GMES S-1

ASAR

SAR, ATSR

GOMOS, MIPAS, SCIA

SCAT

GOME

MERIS AATSR

Vegetation

VIRI

GMES S-3

LAND SUPER

GMES S-2

LANDSAT, AIRBORNE

ATMOS-GEO

GMES S-4

ATMOS-LEO

GMES S-5

Sentinel Requirements Definition - Steps

URD

1.User Service Needs

- User Requirements Documents for GSE studies
- Must agree on the relevant needs of NWP, FP5/6, and others

2.Operational Product/Parameter Needs

- e.g. Chla to n% accuracy, SST accurate to 0.3K abs. & 0.1K/decade

MRD

3.Observational Requirements

- Measurement Requirements
  - **parameters/timeliness/frequency/etc.**
  - **bands, swath width, resolution sampling requirements/orbits etc.)**
- Basic sensor requirements
  - **e.g. Alt, MERIS follow-on, AATSR follow-on**

4.Ground Segment Requirements

- timeliness/data latency
- NRT (<3 h) data flow to the product service providers

SRD

5.System Requirements

- instrument specifications (e.g. PRF/accuracy/sensitivity)
- Mass/Power launch constraints; Downlink rates etc

Sentinel 4/5: Atmospheric Chemistry

- The mission would cover three environmental issues:
  - Stratospheric Ozone and Surface UV
  - Air Quality
  - Climate
- For each theme, three different kinds of applications / users:
  - Monitoring of international protocols, national legislation
  - Near-real-time services, such as forecast
  - Assessments supporting future policy decisions
- Individual applications are then mapped against the environmental issues
- Observational requirements defined for each application and environmental issue, both for space and non-space data
- Closely linked to Eumetsat's activities