



ESA Climate Change Initiative

**Making Transition from Research exercises
to operational life cycles for ECV product
generation**

**Pascal Lecomte
Head of the ESA Climate Office
ECSAT – Harwell - UK**

Realise the full potential of the long-term global EO archives that ESA, together with its Member states, has established over the last thirty years ...

... as a significant and timely contribution to the ECV databases required by the United Nations Framework Convention on Climate Change



WMO



of UNESCO



UNEP



ICSU



UNESCO



UNEP



ICSU

WORLD METEOROLOGICAL
ORGANIZATION

INTERGOVERNMENTAL
OCEANOGRAPHIC COMMISSION

INTERGOVERNMENTAL
OCEANOGRAPHIC COMMISSION

THE SECOND REPORT ON THE ADEQUACY OF THE GLOBAL OBSERVING SYSTEMS FOR CLIMATE IN SUPPORT OF THE UNFCCC

FOR THE FOR CLIMATE UNFCCC

EXECUTIVE SUMMARY

April 2003

GCOS – 82 (ES)

(WMO/TD No. 1143)

UNITED NATIONS
ENVIRONMENT PROGRAMME

INTERNATIONAL COUNCIL FOR
SCIENCE

INTERNATIONAL COUNCIL FOR
SCIENCE

Satellite-based ECVs

Domain	Essential Climate Variables
Atmospheric (over land sea and ice)	Surface: Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.
	Upper-air: Earth radiation budget (including solar irradiances), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties.
	Composition: Carbon dioxide, Methane, Ozone, Other Long-Lived greenhouse gases, Aerosol properties.
Oceanic	Surface: Sea-surface temperature, Sea-surface salinity, Sea-level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.
	Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land Cover (including vegetation type), Fraction of absorbed photosynthetically active Radiation (fAPAR), Leaf area index (LAI), Biomass, Fire disturbance. Soil moisture.

Climate Architecture

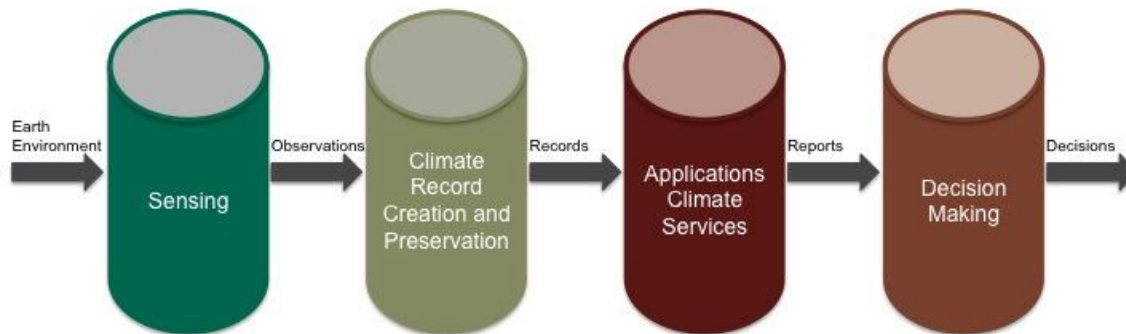
- The document outlines a strategy for an international architecture that ensures delivery of satellite observations for climate monitoring from space over the time frames required for analysis of the Earth's climate system.
- Produced by CEOS-CGMS-WMO, it has been finalised and is being printed.
- The implementation starts with an ECV Inventory, including balance of past/current and future datasets.
- An approach for analysis of the data is being prepared (Gap Analysis).
- Other activities include Case Studies and Macroscale space system requirements.

Strategy Towards an Architecture for Climate Monitoring from Space



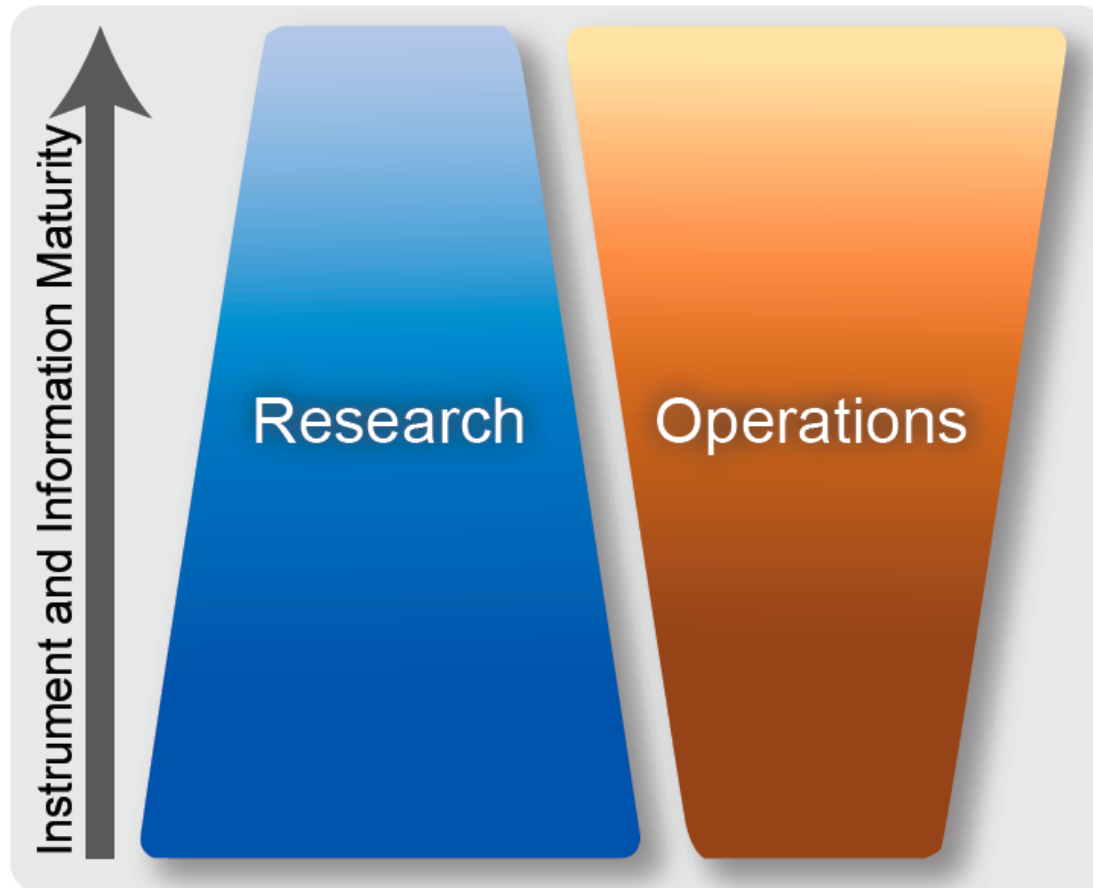
Why an Architecture for Climate Monitoring from Space ?

- **Two main needs/usage scenarios for an architecture have emerged.**
 - To promote a common understanding, amongst the various stakeholders, of the implementation implications of meeting the various climate monitoring requirements.
 - To support an assessment of the degree to which the current and planned systems meet the requirements, and the generation of an action plan to address any identified shortfalls/gaps. It is anticipated that such an action plan would help promote the fulfilment of user needs through the coordinated implementation of activities across agencies.



coordinated implementation of activities across agencies.

From Research to Operations

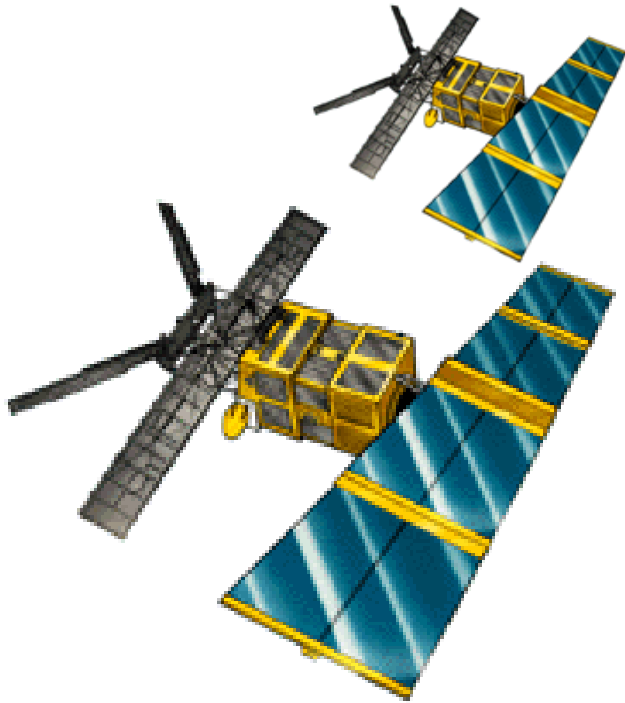


Notional evolution of the level of effort in a research to operations transition for a satellite mission.

From ERS to Metop

ERS-1 17/07/1991 – 10/03/2000

ERS-2 21/04/1995 – 05/07/2011

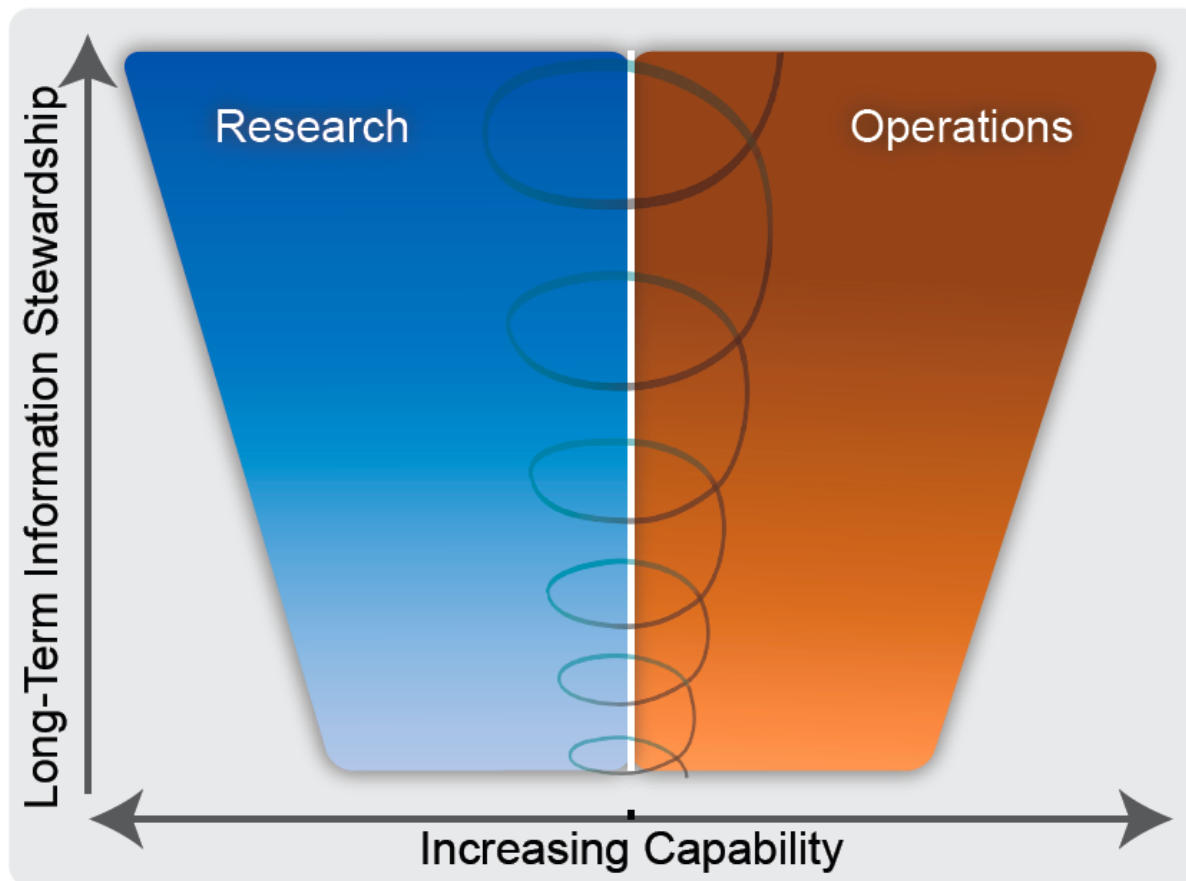


METOP-A 19/10/2006 – on going

METOP-B 17/09/2012 – on going

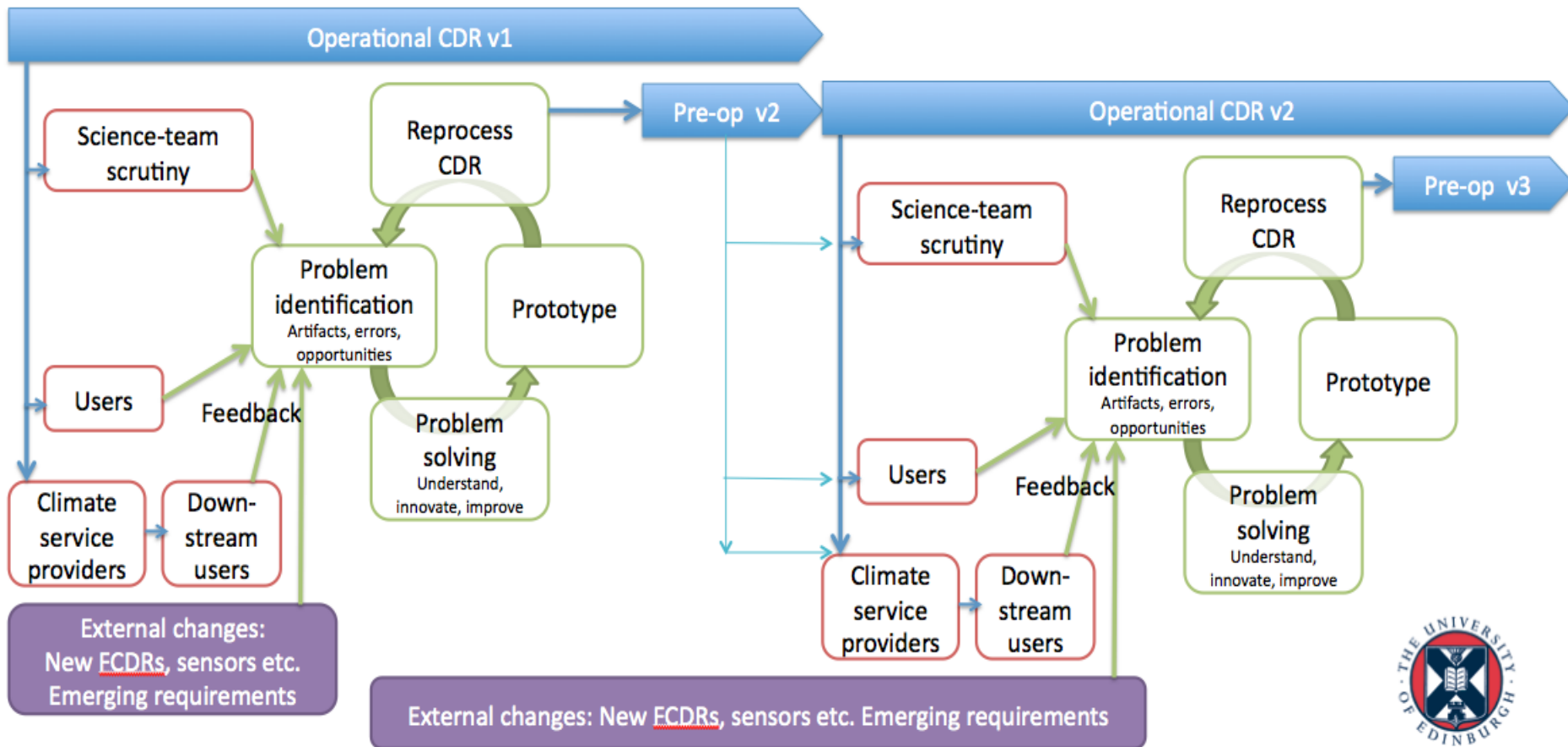
METOP-C launch planned in 2018

Research and Operations



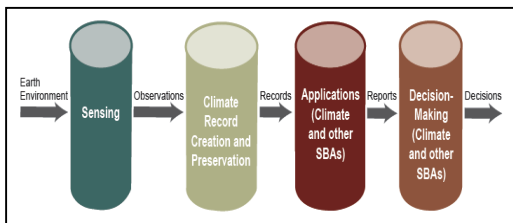
A holistic view of the interdependency of research and operations needed for sustained and routine climate monitoring.

Climate Operations Model



Flow of Requirements to Products

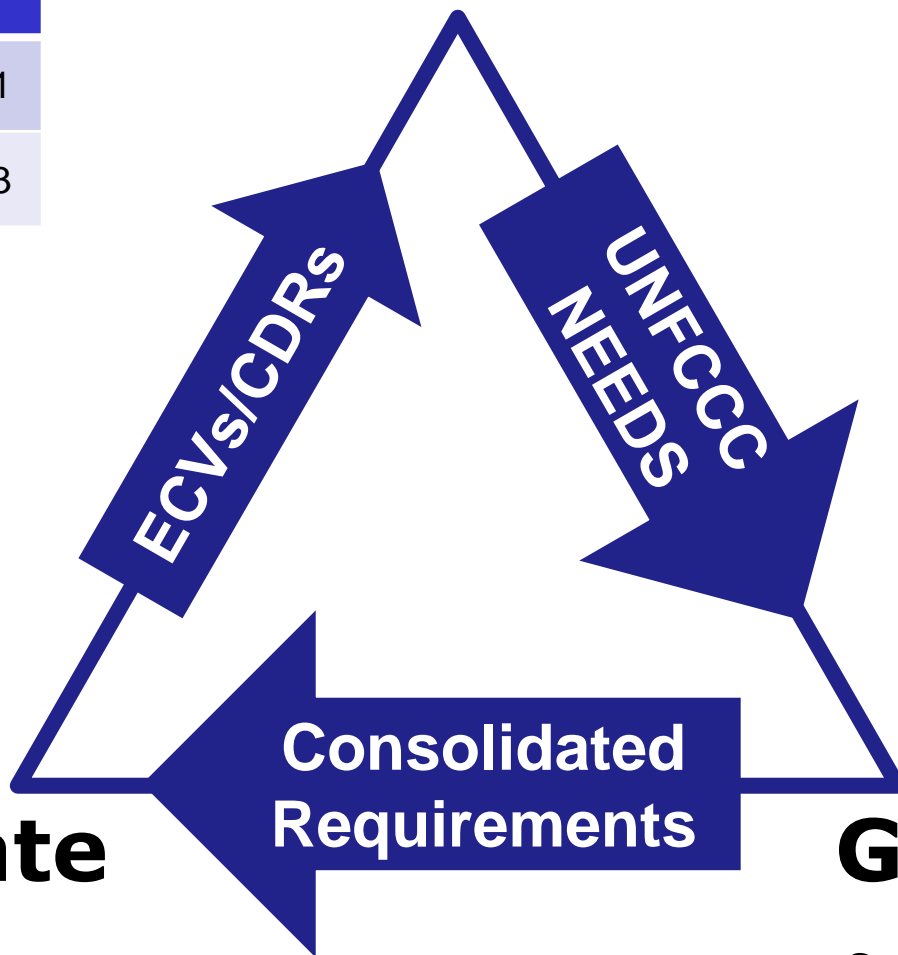
ECV	Carbon Cycle	Water Cycle
Precipitation	Priority 2	Priority 1
CO2	Priority 1	Priority 3



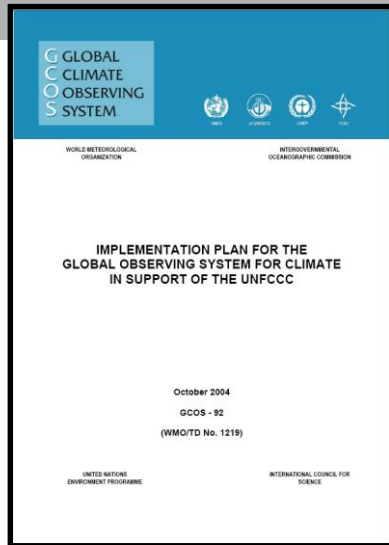
WGClimate

USERS

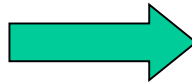
GCOS



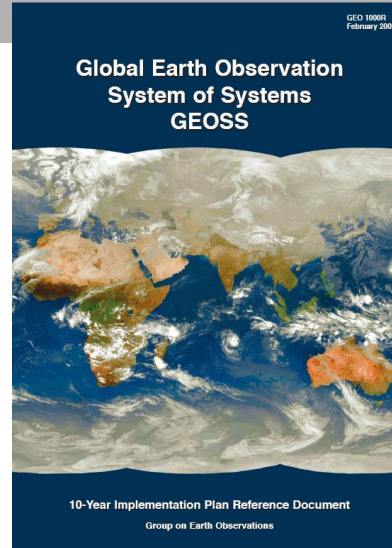
GCOS IP 2004



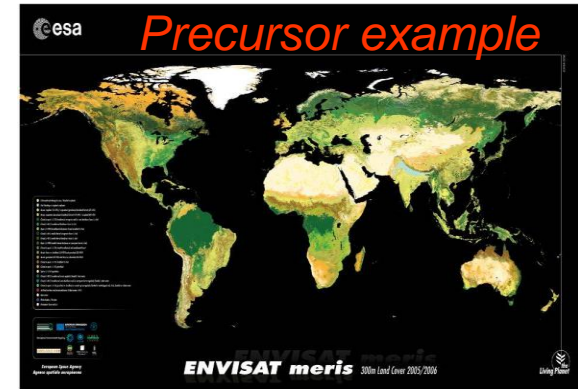
Part of
GEO
task
CL-06-01



GEOSS IP 2005



ESA CCI: Production of Essential Climate Variables (ECV) according to GCOS requirements



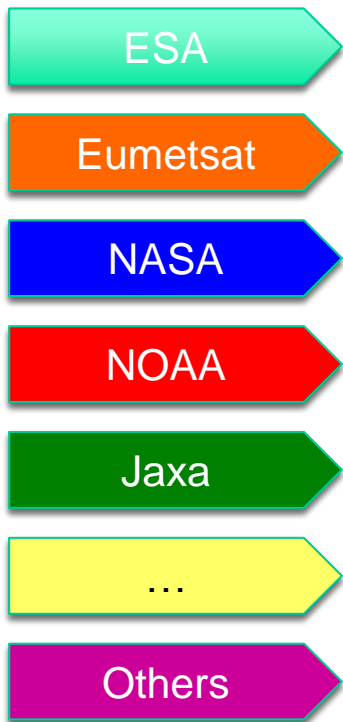
ESA Ministerial Council, Nov 2008:

Approval of 75.5 M€ for a six year programme that will contribute to about twenty satellite-based ECVs. A strong interaction with the scientific community is an essential part of the programme. (Funding since increased to 95 MEuro)

The CCI initiative will ensure that ESA can play a full role in deriving relevant ECVs specified by GCOS, based on ESA current and archived EO data. ESA will work with CEOS agencies to ensure as complete a coverage of the entire suite of ECVs as possible.

System Context

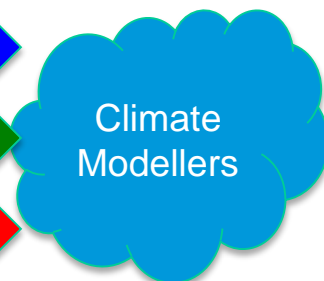
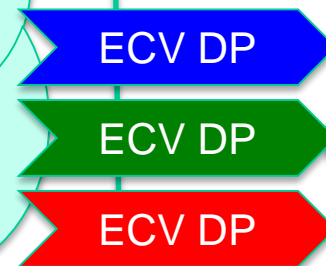
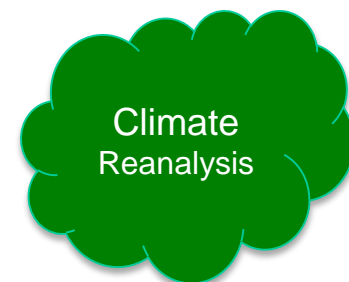
Satellites Ground Segments



CCI



Climate Data Users



Within the scope of the CCI as presented in 2009

Atmosphere	Ocean	Terrestrial
Composition	Surface	
Aerosols Properties	Sea Surface Temperature	Land Cover
Carbon Dioxide & Methane	Sea Level	Fire Disturbance
Ozone	Sea Ice	Soil Moisture
Long-Lived GHGs	Ocean Color	Glacier and Ice Caps
Precursors (for Aerosols and O3)	Sea State	Ice Sheets
Upper Air	Current	Snow Cover
Cloud Properties	Sea Surface Salinity	Albedo
Temperature	Carbon Dioxide Partial Pressure	Leaf Area Index (LAI)
Water Vapor	Phytoplankton	(FAPAR)
Wind Speed and Direction	Ocean Acidity	Lakes
Earth Radiation Budget	Sub Surface	Above Ground Biomass
Surface	Carbon	Permafrost
Surface Air Pressure	Current	Ground Water
Surface Air Temperature	Nutrients	River Discharge
Surface Precipitation	Ocean Acidity	Soil Carbon
Surface Radiation Budget	Oxygen	
Water Vapour (Surface humidity)	Salinity	
Near-Surface Wind Speed, Dir	Temperature	
	Tracers	
	Global Ocean Heat Content	

CCI Scope	
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Implemented by the CCI

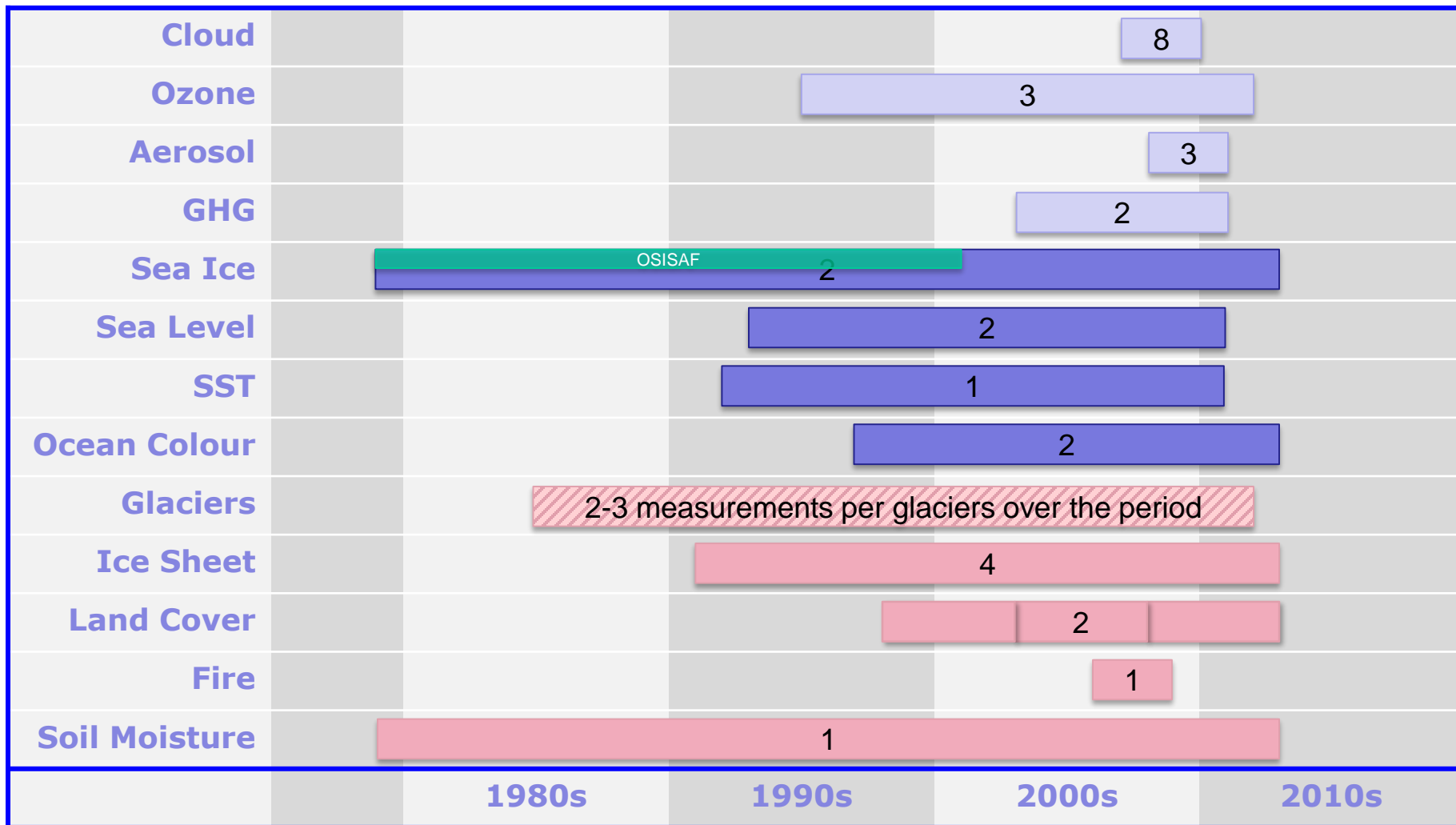
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	Tracers	
	Global Ocean Heat Content	
CCI Scope	Started in CCI	

- **10 CCI projects have been completed end 2013**
 - Data are available via the CCI Web site (www.esa-cci.org)
 - Climate Assessment Reports have been produced
 - The Fire project delayed mostly because of system engineering aspects finished its Phase 1 in September 2014.

- **CMUG has terminated its phase 1 activities on 30 June 2014**

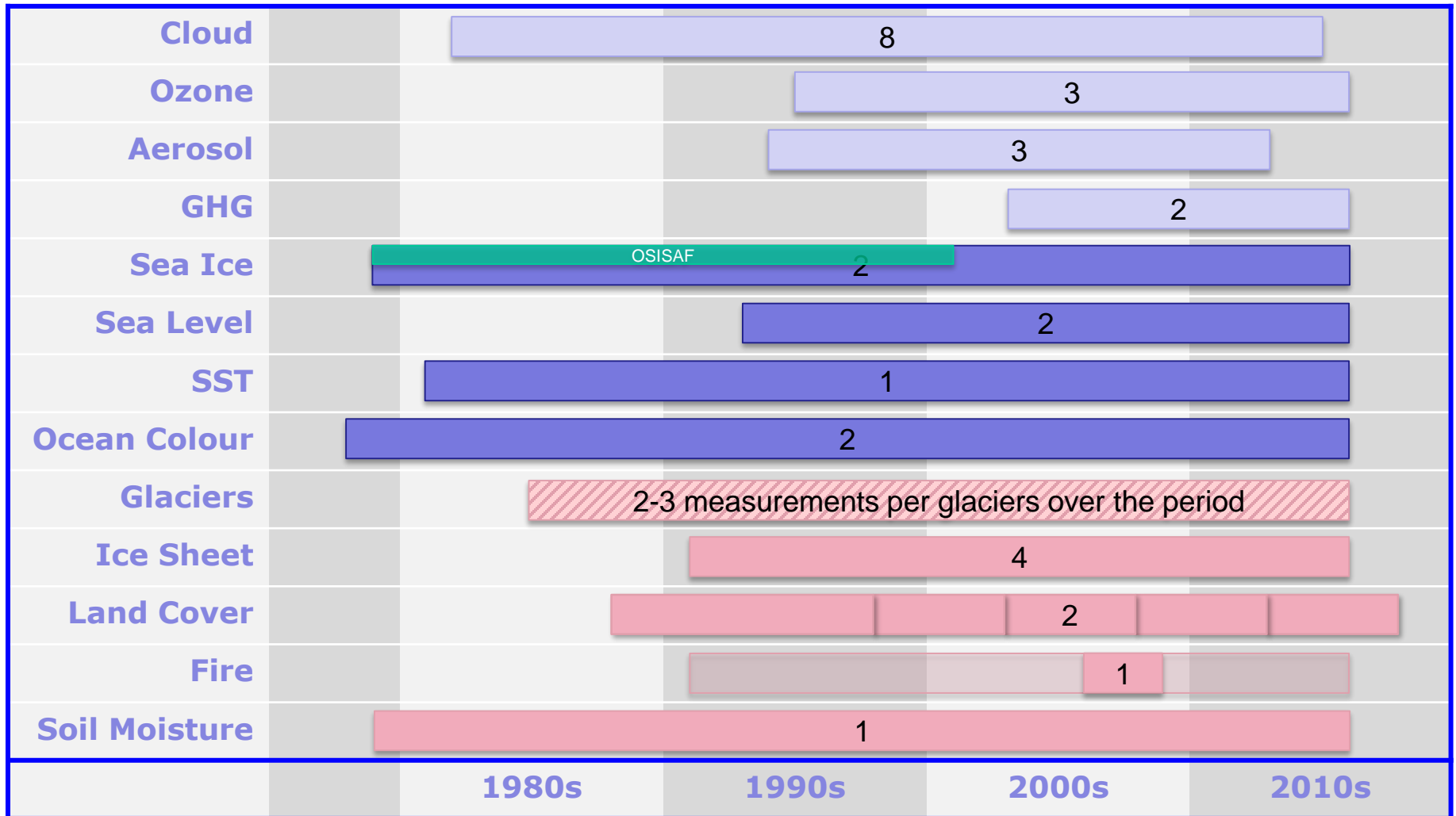
- **3 CCI projects (which started in January 2012) terminated end 2014**
 - Ice sheet
 - *will be split into two projects, Greenland and Antarctica, for phase 2.*
 - Sea-Ice
 - Soil Moisture

CCI Products Time Coverage Phase 1



- **9 CCI projects have been started beginning 2014**
- **CMUG has started its phase 2 activities on July 1st, 2014**
- **The Four later projects (Ice Sheet being divided in Greenland and Antarctica) have been kicked off early 2015.**
 - Soil-Moisture
 - Sea-Ice
 - Ice-Sheet Greenland
 - Ice-Sheet Antarctica
- **The Fire project Phase 2 should be kicked off during summer 2015.**

CCI Products Time Coverage Phase 2



Where ESA data is cited in IPCC WGI AR5: highlights



Chapter 2: Observations: Atmosphere and Surface

- The (A)ATSR series of **sea surface temperature** measurements (the ARC data set) has improved understanding of uncertainties and biases in SST records.

Chapter 4: Observations: Cryosphere

- The cryosphere provides some of the most visible signatures of climate change. 20 years of *ESA altimetry* measurements have helped record the decline in Arctic **sea ice thickness and volume**.
- *Cryosat-2* is beginning to have an impact, providing more accurate measurements of Arctic **sea ice at higher latitudes**.
- *Altimetry and SAR data from ERS-1, ERS-2 and Envisat* have been vital in measuring changes in **ice sheets**.
- The ESA/NASA Ice sheet Mass Balance Intercomparison Exercise (IMBIE) provided a reconciled estimate of **ice sheet mass balance changes** from the satellite community.

Chapter 13: Sea Level Change

- *Altimeters on ERS-1, ERS-2 and Envisat* not only provide a key role in measuring changes sea level but also the contributions to **sea level change** from **ice sheets** and **glaciers**.

The Climate Change Initiative in IPCC's WGI AR5

Results from the CCI are cited in AR5, notably:

- **CCI Glaciers** played a leading role in creating the first globally-complete glacier inventory, the Randolph Glacier Inventory.
- **CCI Sea Level** produced improved Global Mean Sea Level estimates using Envisat data.
- The **Ice sheets Mass Balance Intercomparison Exercise**, involving **CCI Ice Sheets**, has led to improved confidence in the measurement of ice sheet mass balance and the associated global sea level contribution.

Further CCI projects are also cited in the report:



Glaciers_cci

- Observations: Cryosphere
- Sea Level Change



Greenhouse_Gases_cci

- Carbon and Other Biogeochemical Cycles



Ice_Sheets_cci

- Observations: Cryosphere
- Sea Level Change



Ozone_cci

- Evaluation of Climate Models



Sea_Level_cci

- Observations: Cryosphere
- Sea Level Change



Sea_Surface_Temperature_cci

- Observations: Atmosphere and Surface



Soil_Moisture_cci

- Observations: Atmosphere and Surface

CCI ECVs



**CLIMATE
CHANGE
INITIATIVE**

- **The CCI portal has been kicked off,**
 - To be an uncomplicated web-based interface acting as the single dedicated point-of-access for all CCI data products and for all ESA Climate Change enquiries
 - To incorporate search and data discovery tools for CCI data products and to facilitate efficient and expedient data access, including multiple ECV download
 - To perform a central coordinating role by providing a comprehensive depository for information on the CCI and also housing a user forum for queries / discussion / feedback
 - To interoperate with the Earth System Grid Federation (ESGF) as a services layer and to be based on Open Source to allow adaption and evolution (Obs4MIPS)
 - To act as the physical host for a CCI toolbox dedicated to the discovery, interrogation and analysis of CCI data products

- **Proposals for the CCI Tool Box have been received**
 - To incorporate generic functions applicable to all ECV data products in order to simplify handling, inspection and analysis
 - To provide functionality to analytically discover and interrogate CCI data products
 - To incorporate specialist functions for use with CCI data products, e.g.:
 - *for detailed expert analysis,*
 - *for exploitation & propagation of uncertainty estimates,*
 - *to support combination & interrogation across ECVs, etc.*
 - *to facilitate data conversion (format & transform),*
 - *to check conformity of CCI data products in terms of format*
 - To follow an Open Source software approach so that users can potentially add in their own functions

CCI Postdoctoral Scheme Living Planet Fellowship

Support for 9 2-year postdoctoral positions to undertake research activities relevant to the Climate Change Initiative (esa.cci.int).

Focus on projects dedicated to:

- Exploiting Essential Climate Variable (ECV) products from CCI for improved understanding of the Earth System;
- Examining Cross-ECV consistency and multiple ECV use (those under the CCI Programme in particular).
- Enhancing interactions between CCI members and other Earth science laboratories, research centres and universities.

Funding available: 40kEuro/year for two years

In view of the success a new call has been made for another 5 positions

<http://livingplanetfellowship.esa.int>

Implemented by the CCI

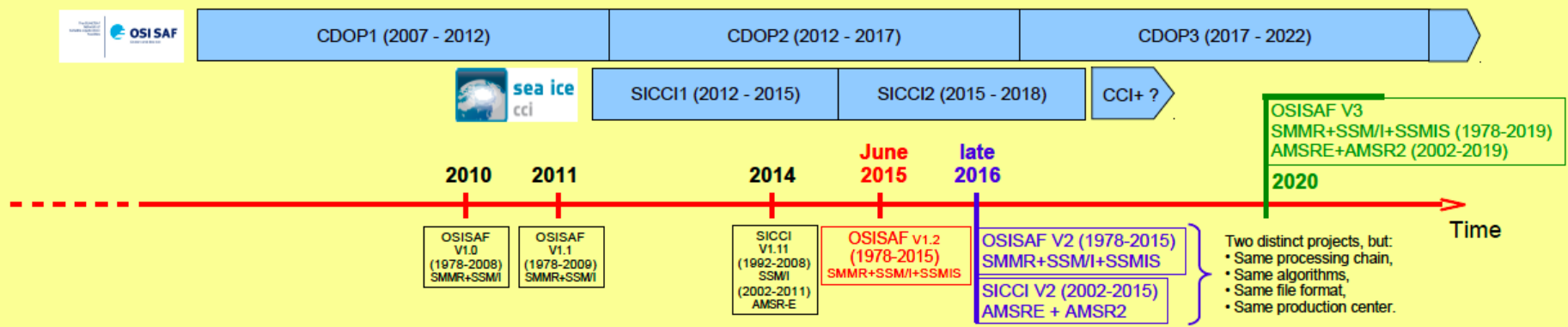
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Surface Air Temperature	Nutrients	River Discharge
Surface Precipitation	Ocean Acidity	Soil Carbon
Surface Radiation Budget	Oxygen	
Water Vapour (Surface humidity)	Salinity	
Near-Surface Wind Speed, Dir	Temperature	
	Tracers	
	Global Ocean Heat Content	
CCI Scope	Started in CCI	

Developing and Operating the Sea Ice Concentration ECV: the ESA CCI and EUMETSAT OSISAF join forces.

Thomas Lavergne^(*) and colleagues from the CCI Sea Ice and OSISAF projects
 (*) Norwegian Meteorological Institute
 thomas.lavergne@met.no



Past releases, and future scenarios for SIC ECV dataset extension



- **In the current context (role of ESA, of EUMETSAT and of Services developed by EC)**
 - The role of ESA is to focus on Research and Development

- **The main strategic line consist in:**
 - Propose new ECV.
 - Propose projects using many ECVs.

- **Take into account CSAB recommendations**

- **Take into account requests from delegations**

Implemented by the CCI

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Surface Radiation Budget	Oxygen	
Water Vapour (Surface humidity)	Salinity	
Near-Surface Wind Speed, Dir	Temperature	
	Tracers	
	Global Ocean Heat Content	
CCI Scope	Started in CCI	

Proposed within CCI Extension

Atmosphere	Ocean	Terrestrial
Composition	Surface	
Aerosols Properties	Sea Surface Temperature	Land Cover - High Resolution
Carbon Dioxide & Methane	Sea Level	Fire Disturbance
Ozone	Sea Ice	Soil Moisture
Long-Lived GHGs	Ocean Color	Glacier and Ice Caps
Precursors (for Aerosols and O3)	Sea State	Ice Sheets
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CCI Scope	Implemented in CCI	Proposed in CCI Extension
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- **Extra products from existing CCI ECVs, e.g.:**
 - Sea ice drift
 - Cloud heights from O2A and O2-O2 band
 - Aerosol absorption properties
 - Ocean colour in highly-productive coastal Case-2
 - Improved accuracies and improved error estimation

- **Adaptation of CCI processing chains to new Sentinel data**
 - New instrument capabilities
e.g. new spectral bands, higher resolution, different observing geometry
 - Time series consistency between different instruments
e.g. ATSR-1, ATSR-2, AATSR, SLSTR

- **Cross-ECV Exploitation, e.g.:**
 - Ice-sheet mass balance, Global Water Cycle, ...
 - Fluxes (air/sea, land/sea, energy, water, gases, aerosols)
 - Permafrost
 - International LAI/FAPAR reconciliation
 - Hiatus, El Nino, ...

- **The CCI has allowed progress on 14 ECV (35 variables).**
- **During Phase 2, even better results are being achieved.**
- **ESA doesn't have the mandate to "Operate" ECV production systems and the current funding will be consumed by 2018.**
- **Operational "homes" (funding) should be found for all of the 14 ECVs.**
- **A potential extension of the CCI is in preliminary discussion for new ECVs and/or new variables (CCI+).**

PRAGUE 09-13 MAY 2016



living planet | PRAGUE
symposium | 09-13 May
2016



<http://lps16.esa.int>