World Meteorological Organization

Weather • Climate • Water

Satellites for Climate Services:
Case Studies for Establishing an Architecture for Climate Monitoring from Space

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CEOS-CGMS Working Group Climate

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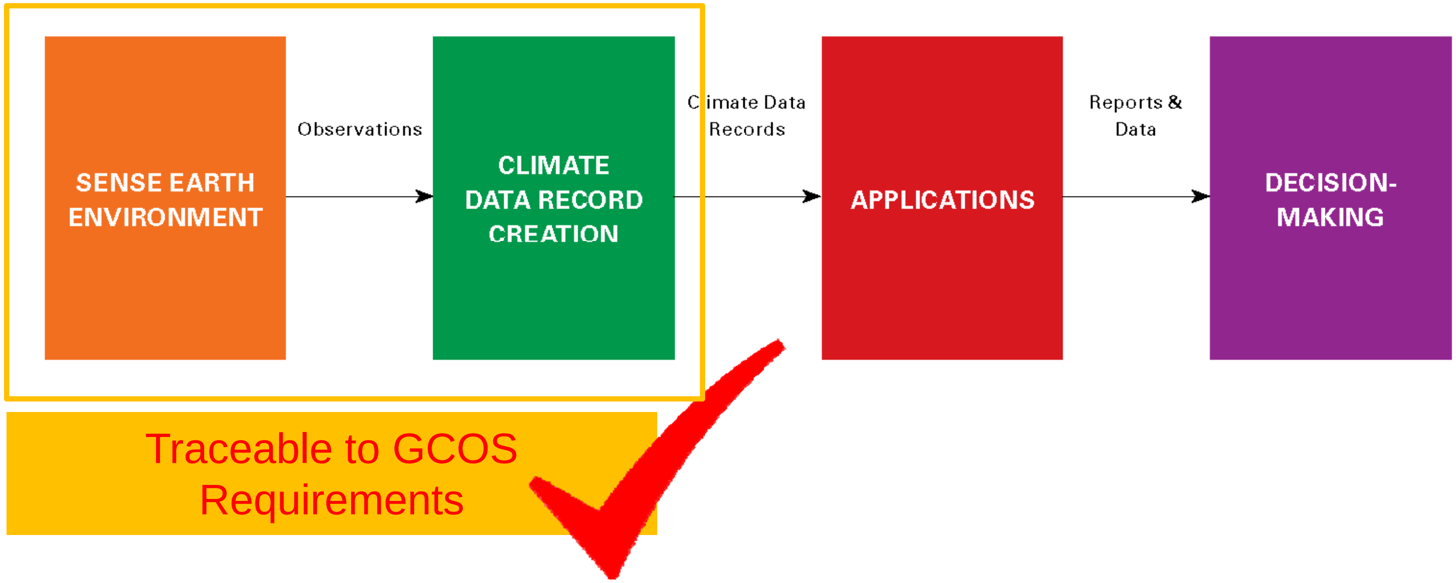
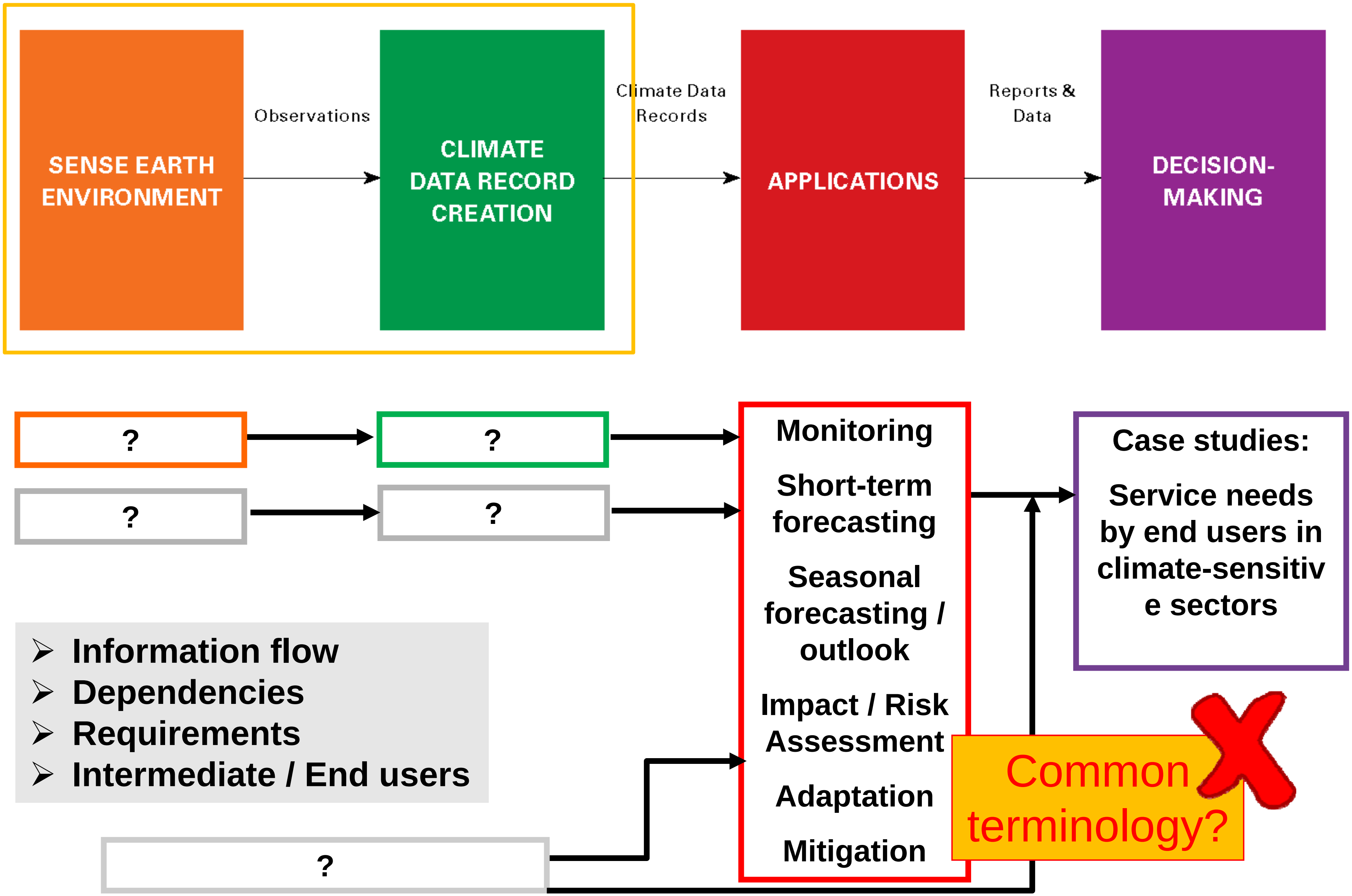
Architecture for Climate Monitoring from Space



- “Strategy Towards an Architecture for Climate Monitoring from Space” (2013) articulated an end-to-end flow of information
- Common terminology, generic functions, dependencies, information flows
- Some major ECV CDR programmes launched around 2010, such as ESA CCI
- “No systematic int’l approach to ensure transparency, traceability and scientific judgment in generation of CDRs” (GCOS-WCRP Letter 2010)
- Implementation for satellites, by ECV – CEOS-CGMS WG Climate
- Contribution to GFCS Observation and Monitoring pillar
- Applicable to non-satellite datasets

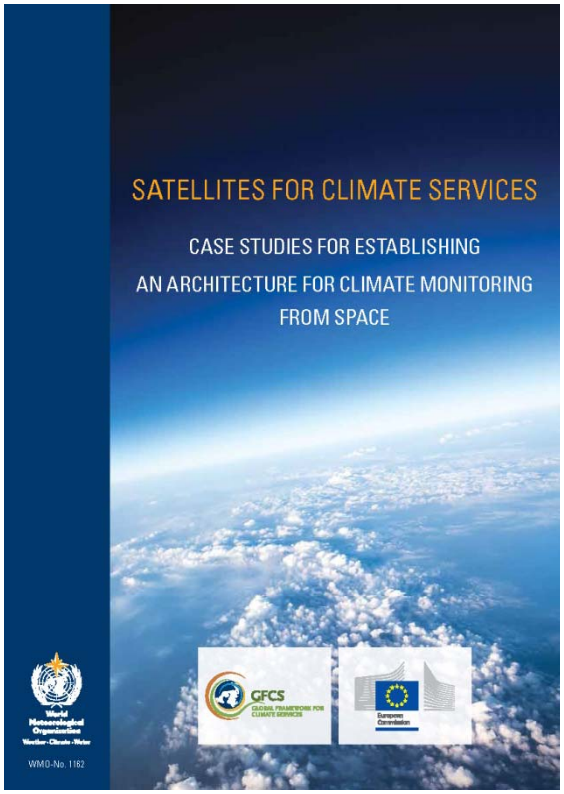
Starting from climate service end users:



- Information flow
- Dependencies
- Requirements
- Intermediate / End users

Case Studies Report (1)

- Objectives:
  - Validate the Architecture logic starting from the end user, and demonstrate its benefits
  - Investigate how satellite data are used in climate services
  - Better understand information flows, dependencies, requirements
  - Formulate recommendations



http://library.wmo.int/pmb_ged/wmo_1162_en.pdf

- 13 case studies in areas of

Agriculture and food security	Disaster risk assessment (floods)
Health	Energy
Transport	Ecosystems
Mitigation	Protocol monitoring
Adaptation	

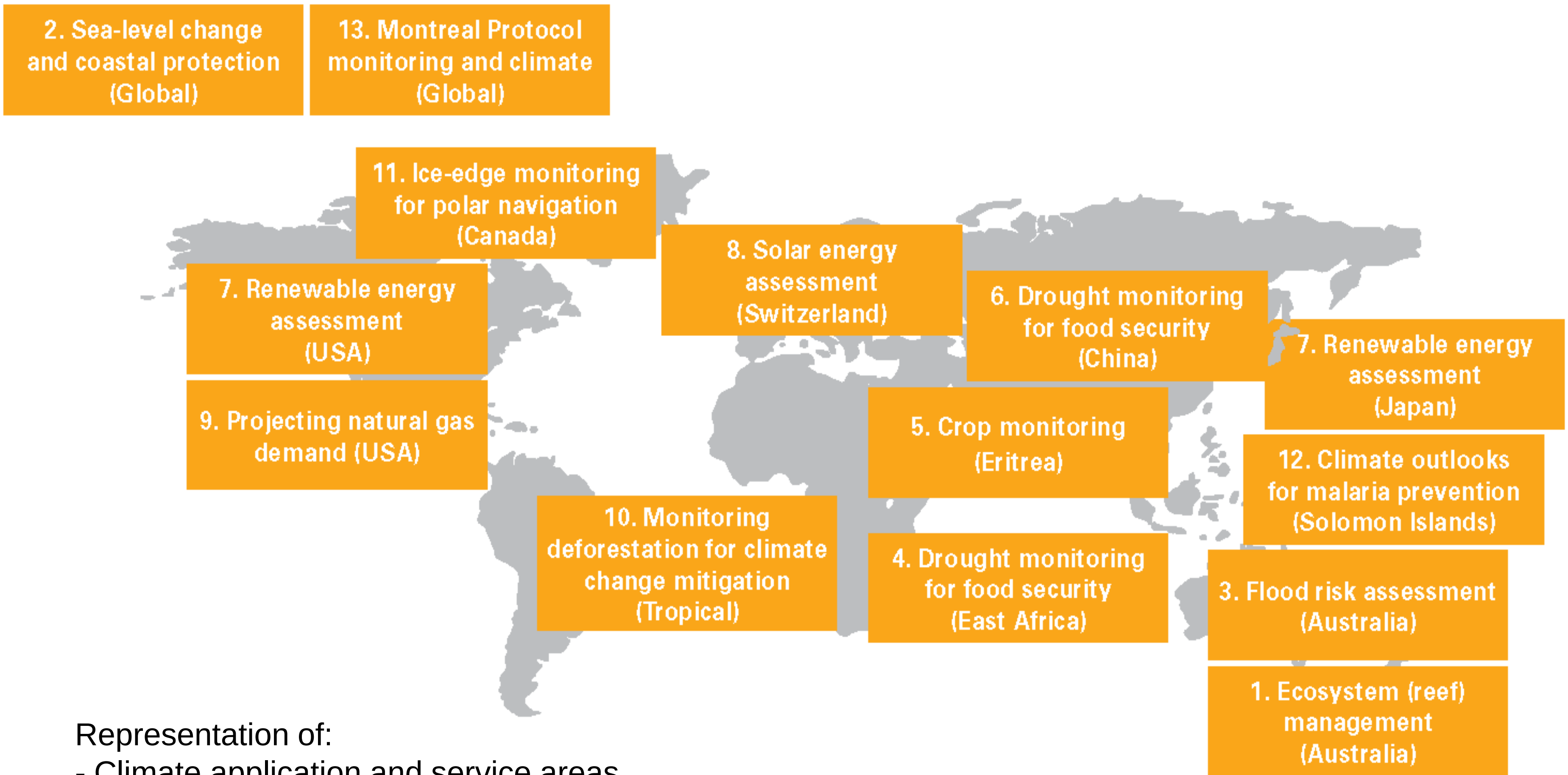
GFCS Priority Areas

Case Studies Report (2)

- Sources:
  - GFCS priority areas
  - European Union key policy areas
  - WMO publication *Climate ExChange*
  - Environmental protocols
  - Existing climate services
  - National and regional climate adaptation policies
  - Communities (e.g, SIDS)
  - Writing team members (see Abstract)

- Defined common template for consistent presentation
- Finalized in Sep 2015
- Presented as draft to WMO 17th Congress, and to UNFCCC COP 21 as part of the CEOS report to SBSTA

Case Studies Overview



Representation of:
- Climate application and service areas
- Geographical contexts
- Developing and developed countries, and economies in transition
- Global, regional, and local scales

Case Study: Drought monitoring for food security (China)

sense

NOAA AVHRR

In situ temperature, precipitation and soil moisture observations

→

create climate data

Land surface temperature record (2002–present)

NDVI record (2002–present)

Temperature and precipitation records (in situ)

→

apply

Analysis of vegetation and soil state

Drought indices (PDI, MPDI)

Nationwide drought monitoring image

→

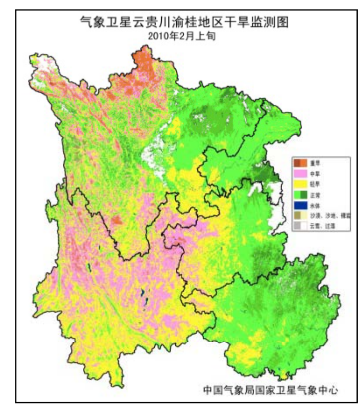
decide

Drought mitigation measures in agriculture and water management

Precipitation estimates (FY-2E)
Soil moisture (FY-3/MWRI)
Soil thermal inertia model

use additional data

- **Service**: Monitoring of drought indicators (basic mode), generation of additional information in case of drought (special mode)
- **End users:** Decision-making service of CMA; provincial governments and agriculture services
- **Intermediate users:** National Climate Centre; provincial meteo



- Combination of satellite CDR and near real-time data needed for this service
- Non-ECV records are relevant

Case Study: Sea-ice edge monitoring for polar navigation (Canada)

sense

Synthetic aperture radar imagery (CSA RADARSAT–1/-2, Envisat ASAR, EC/ESA Sentinel-1)

Optical imagers (AVHRR)

create climate data

30-year historical record of sea-ice edge (floe) locations

apply

Open water, land-fast, and moving ice location

Floe edge position

Maps of variability in sea-ice extent

decide

Marine transport and navigation

Arctic travel routes

Agriculture, fisheries and hunting

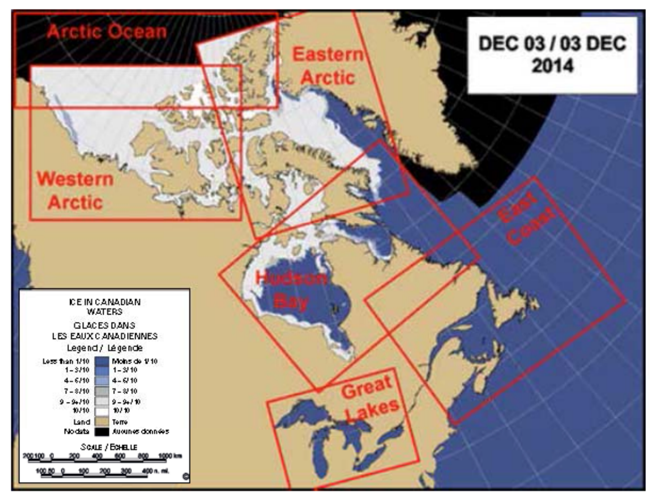
Climate modelling

Climate change adaptation

Near-real time satellite-based sea-ice products

use additional data

- **<u>Service</u>**: Assessment of sea ice conditions in support of Inuit communities' access to safe travel routes and hunting areas
- **<u>End users:</u>** Inuit communities, local government
- **<u>Intermediate users:</u>** Noetix Research Inc., Environment Canada



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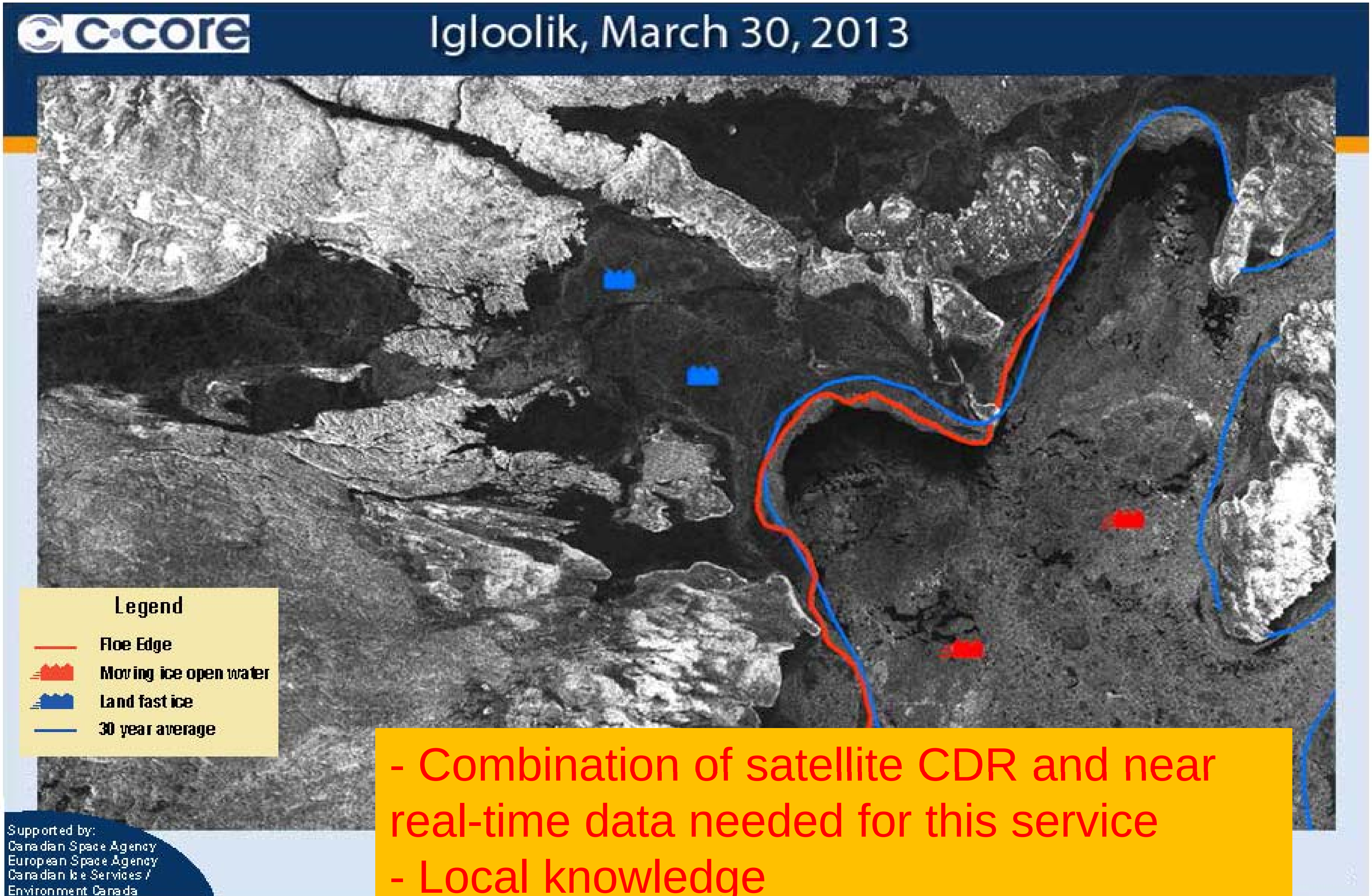


- Combination of satellite CDR and near real-time data needed for this service
- Local knowledge

Case Study: Crop monitoring (Eritrea)

sense

Satellite data used in ECMWF reanalysis

Metop, SPOT-VGT, AVHRR

create climate data

Precipitation reanalysis

NDVI

apply

Bulletins of crop-yield forecast for Eritrea

decide

Development policy and implementation

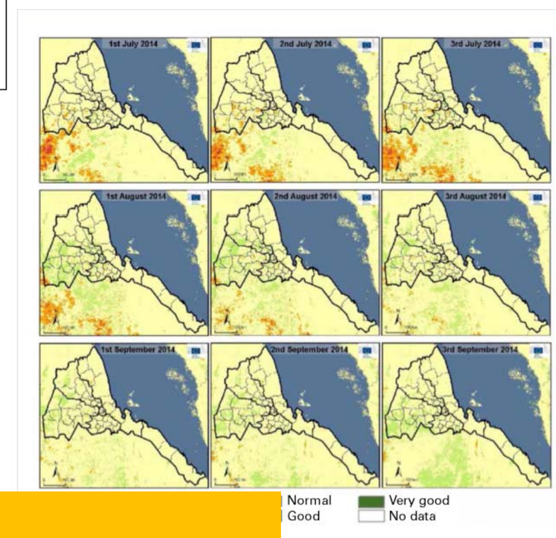
CAP (Europe)

Agriculture and food security (Eritrea)

Commodity markets

Ancillary data layers in JRC crop mask uses global land-cover analyses

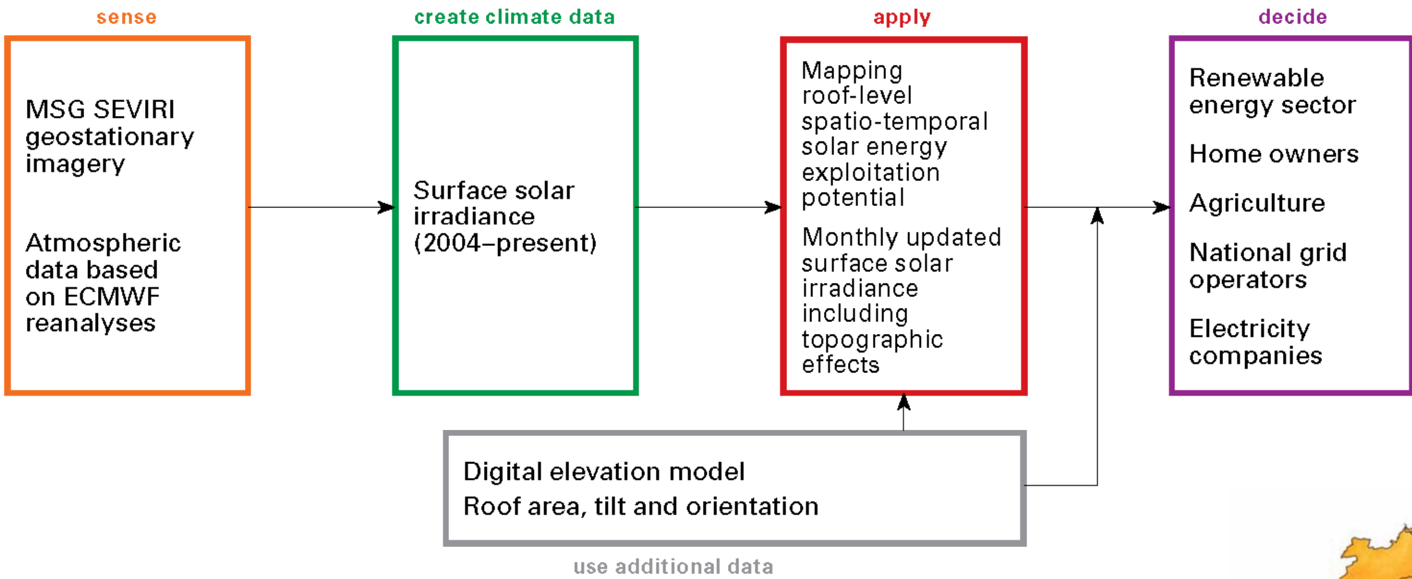
use additional data



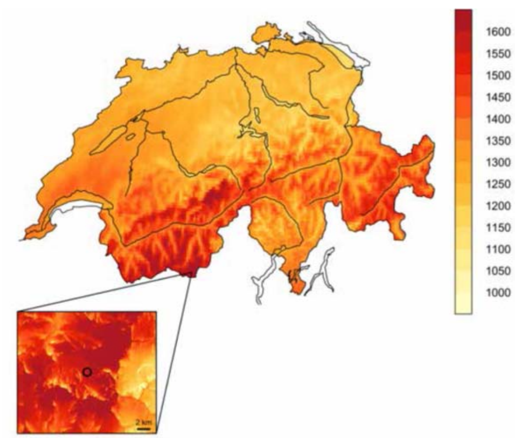
- **<u>Service</u>**: Bulletins of crop yield forecasts
- **<u>End users:</u>** Eritrean institutions; European policy institutions and development aid agencies
- **<u>Intermediate user:</u>** European Commission JRC

- Reanalysis, as user of satellite and other observations, provides basis for service
- Jointly with other sources of information (NDVI, geospatial, situational awareness)

Case Study: Solar energy potential in complex terrain (Switzerland)



- **<u>Service</u>**: Solar energy mapping including effects of topography and bright surface targets
- **<u>End users:</u>** Renewable energy companies, land use and infrastructure planners, architects, farmers
- **<u>Intermediate user:</u>** Electricity grid operators; government agencies; solar energy businesses



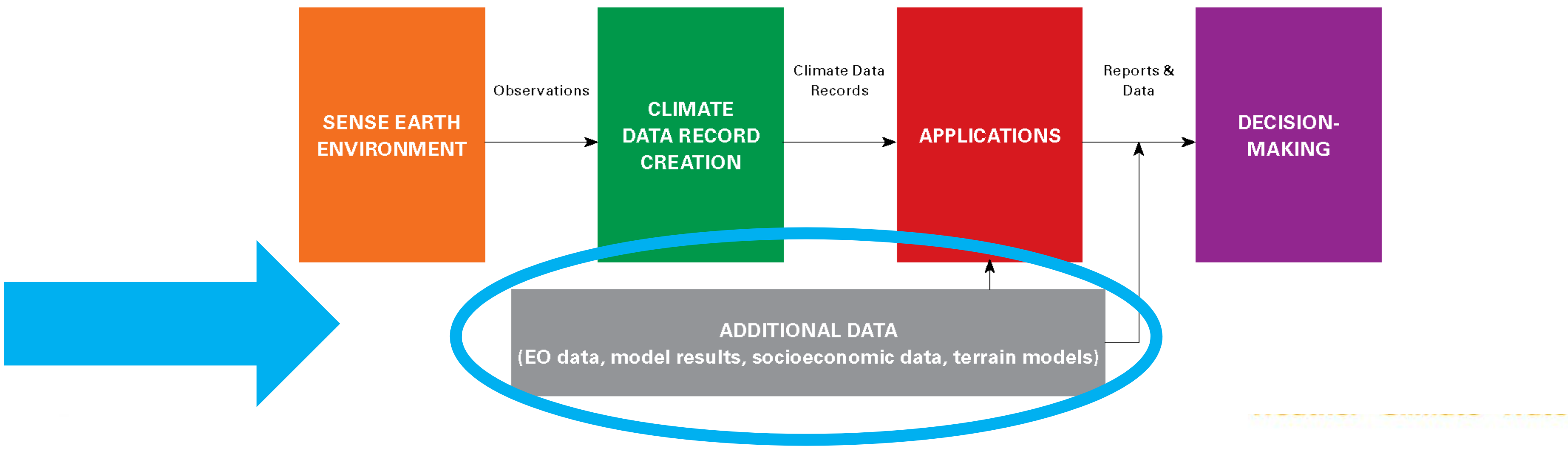
- Operational service based on surface solar irradiance CDR
- Demonstration use of NRT direct and diffuse irradiance

Concluding Remarks

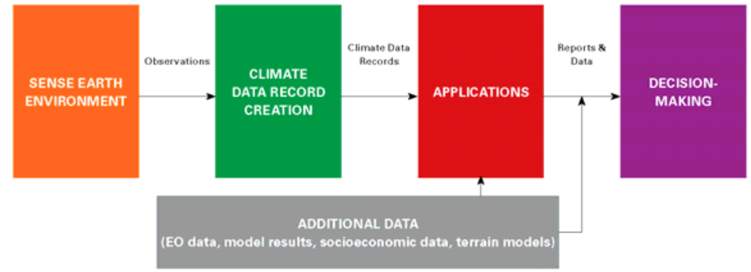
- Case studies show variety and complexity of contexts in which satellite data support climate services

- <u>Satellite-based - and in-situ - CDRs are observation baseline for climate services</u>:
  - Directly (anomalies, …)
  - Indirectly (e.g. through reanalyses which underpin a range of services)

- <u>Other datasets and information sources are critical or very important</u>:
  - Near real-time data, “interim CDRs”, model output, socio-economic data, contextual data, terrain models
  - Not necessarily meeting, or have to meet, “climate” standards



Concluding Remarks



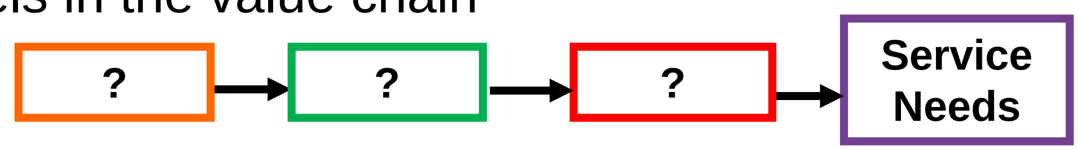
- Architecture overall valid

- To guide coordinated and sustainable generation of CDRs, in:
  - Defining a common approach
  - Positioning activities in a wider context
  - Identifying gaps, and addressing them
  - Communicating with decision-makers

- To trigger research and capacity building in areas of need

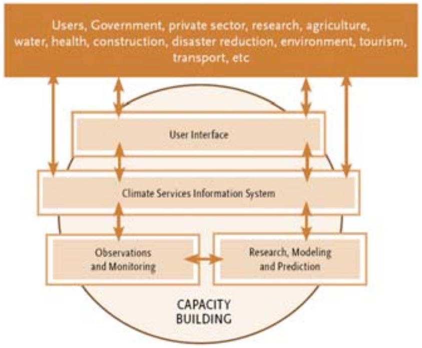
BUT:
- Beneficiaries of climate services require a resilient value chain

- Therefore, identification of user requirements for climate services :
  - Needs to occur at all levels in the value chain



  - Across all ECVs and applications
  - Global – national – local

Concluding Remarks

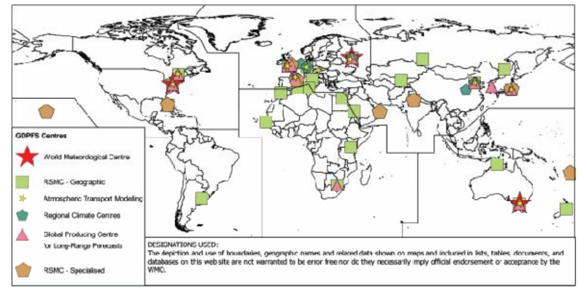


- No mechanism exists globally, and in many countries, to:
  - Systematically identify climate service requirements
  - Translate these into technical deliverables
  - Maintain a user feedback cycle
- Need to build on existing efforts:
  GFCS User Interface Platform, C3S User Forum, GCOS, WCRP, WMO, CEOS-CGMS WG Climate, …
- Satellite agencies should catalyze and foster such mechanisms

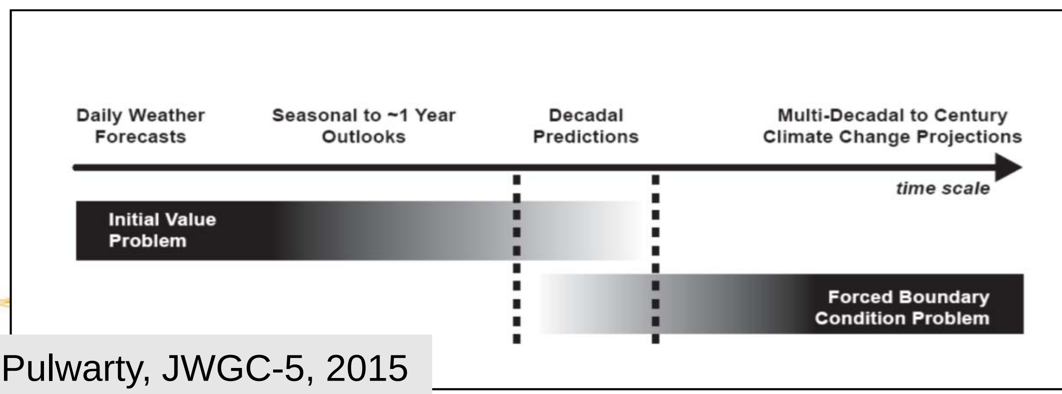
Concluding Remarks

- There is no organized information flow from global to national to local scales for climate services, as for weather services

WMO Global Data Processing and Forecasting System



- Research needs should be identified in the dialogue with users
(e.g., on seamless prediction; decadal prediction; using new data streams in services)



Pulwarty, JWGC-5, 2015

Shaping the next GCOS IP

- GCOS mechanism has proved highly valuable to set requirements for ECV CDRs and for the needed observing systems (pillars 1 and 2 of the Architecture); this should continue

- Questions related to the Architecture:

1. To what extent does the new GCOS IP define climate applications and needs by other Conventions, and distinguishes observation requirements for these?

2. How does the new GCOS IP put requirements for ECV CDRs in context with other data required in climate applications? (non-geophysical, etc)

3. Which requirements will be owned by GCOS, which will not?

4. Does the requirements baseline for the Architecture need changing with the new GCOS IP?

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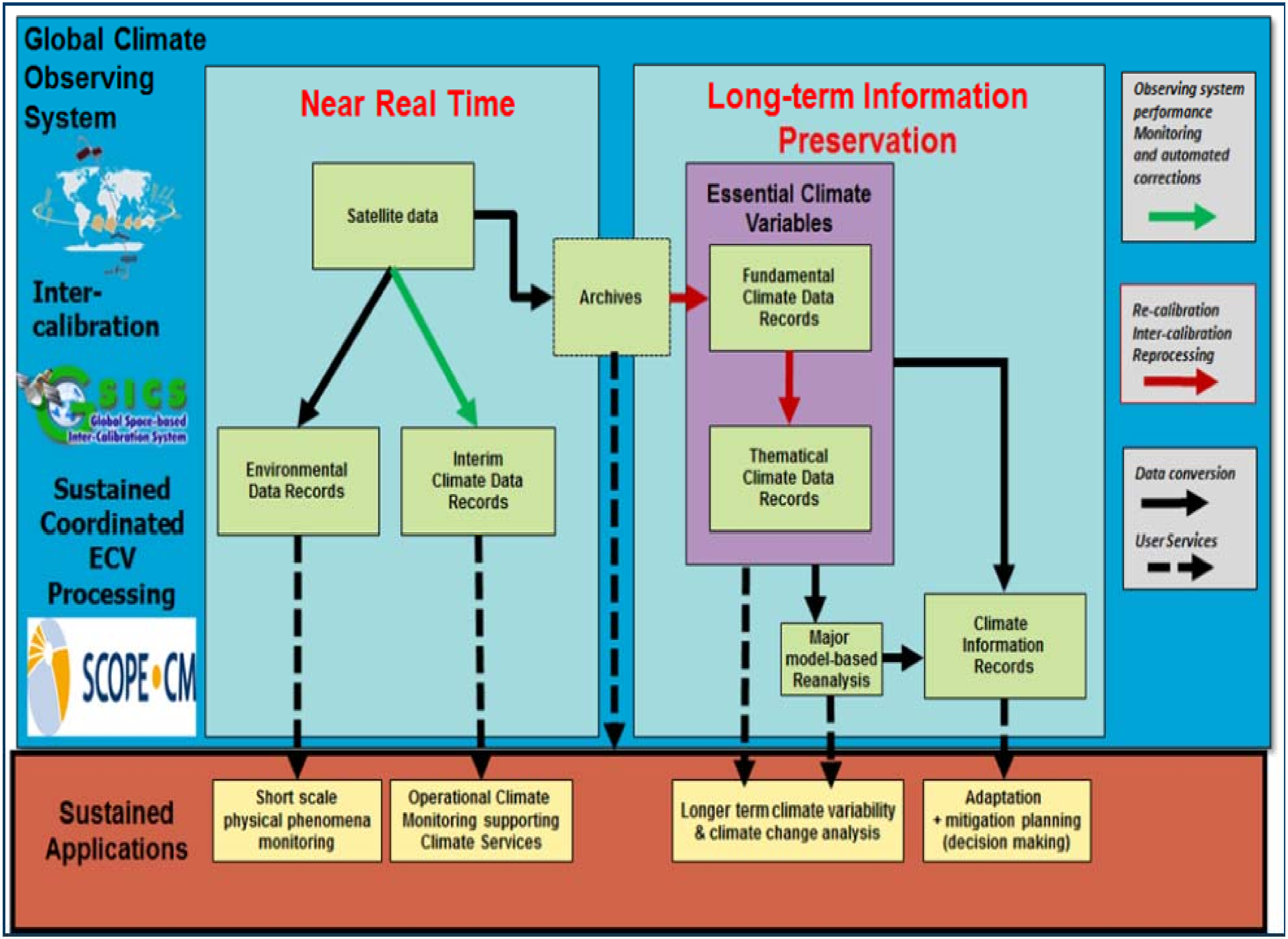
Definition of "climate service"

- "Climate information prepared and delivered to meet a user's needs" (GFCS HLT)



Global Climate Observing System
Inter-calibration
GSICS
Global Space-based Inter-Calibration System
Sustained Coordinated ECV Processing
SCOPE•CM
Near Real Time
Satellite data
Archives
Environmental Data Records
Interim Climate Data Records
Long-term Information Preservation
Essential Climate Variables
Fundamental Climate Data Records
Thematical Climate Data Records
Major model-based Reanalysis
Climate Information Records
Observing system performance Monitoring and automated corrections
Re-calibration Inter-calibration Reprocessing
Data conversion
User Services
Sustained Applications
Short scale physical phenomena monitoring
Operational Climate Monitoring supporting Climate Services
Longer term climate variability & climate change analysis
Adaptation + mitigation planning (decision making)

Climate information needs of users and related knowledge gaps

Decision-making process and user information gaps

1 Strategic ahead-of-season planning (1- 12 month lead time)

2 Risk monitoring and management: intra-season operations

(1wk to 40 days range)

- timing/duration/intensity of dry/ wet spells

3 Longer-term strategic planning/policy development (next 1-10 years)

- Trends/frequencies of rainfall/temperature over next 5-10 years

4 Climate change adaptation policy development/planning (next 50 years)

- Robust climate change projections
- Information on the role of climate change in observed events

Climate Research Frontier

1 Improving Seasonal prediction

- Remote drivers of variability (SSTs, teleconnections, MJO, etc)
- Local drivers of variability(land-atmosphere coupling)

2 Sub-seasonal prediction

Improved understanding of sources of sub-seasonal predictability

3 Decadal prediction

Drivers of decadal and multi-decadal variability (AMO, PDO)

Role of aerosols

4 Climate change scenarios

Earth System Modelling

Attribution methodology

Understanding Uncertainty

Climate information needs for end users and related knowledge gaps

Decision-making process and end-user information gaps

5 **Assessing current vulnerability due to recent climate events**

Lack of 'impacts' datasets (e.g. crop yields, river flows, health/hospital admission statistics) to aid development and targeting of applications models

6 **Decision making at local scales**

Detailed climate services (geographically)

7 **Estimation of the impacts of climate variability and change**

8 **Mainstreaming climate services for all timescales**

Climate Research Frontier

5 **Observation / database development**

-Enhancing the observations network for both biophysical and socio-economic climate variables;

6 **Downscaling**

- understanding and improvement of the downscaling process
- quantification of benefits and uncertainties to users

7 **Applications modelling**

Improved understanding/ modeling of climate impacts on hydrology, food security and crop yields, health

8 **Communication and climate service provider/user interactions**

- Improving availability/usability of services
- strategies for bridging the gap between service providers and end users