A Climate Monitoring architecture for space-based observations

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World Climate Conference-3: A historic event to define Global Framework for Climate Services-GFCS (31 Aug–4 Sept, 2009, Geneva)

Users, Government, private sector, research, agriculture, water, health, construction, disaster reduction, environment, tourism, transport, etc

Climate Services Information System

- Observations and Monitoring
- Research, Modeling and Prediction

User Interface
Sixteenth WMO Congress Resolution 19 (Cg-XVI, 2011)
DEVELOPMENT OF AN ARCHITECTURE FOR CLIMATE MONITORING FROM SPACE

• Considering:
  – The underpinning role that observations will play in the Global Framework for Climate Services (GFCS),

• Decides that an architecture should be developed, as an important component of WMO Integrated Global Observing System (WIGOS), to provide a framework for the sustained and coordinated monitoring of the Earth’s climate from space;

• Invites CEOS, CGMS, GCOS, GEO & WCRP to collaborate with the WMO Space Programme on the development of an architecture for climate monitoring from space.
"Coordinate and encourage collaborative activities between the world’s major space agencies in the area of climate monitoring."

The Copernicus Climate Change Service will provide the EU contribution to this global framework for climate services.
A report: Strategy Towards an Architecture for Climate Monitoring from Space

• CEOS-CGMS-WMO ad hoc group on Architecture for Climate Monitoring from Space, Chair: Mark Dowell

• The strategy presents a proposed logical architecture that represents a first step in the development of a physical architecture.

• Outline of the report
  – Executive Summary and recommendations
  – Introduction, Objectives & Targets
  – Climate Monitoring Principles, Requirements & Guidelines
  – State of the Art
  – Beyond research to operations
  – Climate Architecture definition
  – Mechanisms for Interaction
  – Roadmap for way forward
  – Recommendations
World Climate Conferences

1990 – WCRP – World Climate Research Programme. **SCIENCE**

2000 – GCOS – Global Climate Observing System. **OBSERVATIONS**

2010 – GFCS- Global Framework for Climate Services. **SERVICES**


21 June 2014
Why do we need a Climate Monitoring Architecture?

• To provide a structured and comprehensive view as to what Climate Data Records are available from Earth Observation satellites

• To create the conditions for delivering further Climate Data Records through best use of existing data holdings

• To optimise the planning of future satellite missions and constellations in order to expand existing and planned Climate Data Records, in terms of both coverage and record length, and address possible gaps
Document broader climate requirements - What

- **Services Requirements:**
  - The Global Framework for Climate Services (GFCS) Implementation Plan (WMO extraordinary Session, October 2012) adds another dimension to the requirements directly link to the user’s application areas: agriculture and food security, water resources, health and disaster risk reduction.

- **Assessment Requirements:**
  - The IPCC’s 4th Assessment Report (2007) underscores the urgent need for critical climate data, and an international architecture supporting them, to observe and monitor the global water cycle and the global carbon cycle.

- **Climate Modelling Requirements:**
  - Model initialisation and definition of boundary conditions
  - Model development and validation

- **Observing and Data Requirements**
  - Climate Observations: Essential Climate Variables (GCOS ECV Inventory) defined by Global Climate Observing System (GCOS-82, 2003), Fundamental Climate Data Record (FCDR)...

- It is clear that the requirements extending beyond the capabilities of one-time research missions and operational satellite systems in existence today.
Pillars of the Architecture - What

- Earth Environment → Sensing
- Observations → Climate Record Creation and Preservation
- Records → Applications (Climate and other SBAs)
- Reports → Decision-Making (Climate and other SBAs)
- Decisions
An end-to-end Architecture Design for monitoring climate for both long-term trend & extreme events in real time
An end-to-end Architecture Design for monitoring climate for both long-term trend & extreme events in real time
Inventory Questionnaire

- Joint activity CEOS, CGMS and WMO – call issued in May 2012
- Questionnaire form – through a web interface
- 45 total questions based on 5 topics (General, Usage, Stewardship, Properties, Access)
- Responses requested at the dataset level
- Addresses both existing/past missions and future/planned mission in two separate questionnaires
- Each single entry takes on average 25 minutes to complete
- ~220 dataset entries as of March 2013 with good representation across domains
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Road Map – How & Who

Define, Validate and Obtain Consensus on Overall Approach (including logical representation)

Describe Current and Planned Implementation Arrangements (ECV-by-ECV) within an Inventory

Use the Inventory & GFCS to Develop a Coordinated Action Plan to Address Identified Gaps/Shortfalls

Short-term (within 2 years)

Medium-term (2-4 years)

Current status
Technical challenges: from user requirements into missions/instruments/observations/products/info

Service requirements:
- Content, Presentation,
- Delivery media,
- Timeliness,
- Continuity,
- User support, Training, ...

Product requirements:
- Type (numerical, graphical, binary, alert),
- Algorithm,
- Spatial/temporal resolution,
- Quality control

Observational requirements:
- Geophysical variable,
- Unit, Domain,
- Spatial resolution,
- Temporal resolution,
- Uncertainty ...

Specifications:
- Instrument type,
- Orbit, Scanning mode,
- Spectral bands,
- Channel width, SNR, ...

ECV Products and climate extremes

Observation & Monitoring

Datasets

Source, Format, Projection, Segmentation, Quality flag, Compression, Metadata...

Users’ needs

Users’ satisfaction

Services info needs
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Technical Challenge: Long-term quality climate records through QA & Integration of Space & Surface observations

Local equatorial crossing time for NOAA satellites show the long-term drift (from Wentz, 2002).

Longest surface T instruments measurements (>140 years) Against 30 years average (1961-1990)

Global air temperature
2012 anomaly +0.43°C (equal 10th warmest on record)
Technical Challenge: Turning Observations into Knowledge Climate Products & Information
The Architecture with enhanced observations will motivate advances in understanding, prediction, and application.
Success of World Weather Watch 50+ years development (1963--)

- Political challenge: to convince politicians and budget authorities for greater investment on enhanced space architecture & application

• Excerpt from President J.F. Kennedy’s address to the UN General Assembly, 25 September 1961..., he said:

  Here, new scientific tools have become available. With modern computers and satellites, the time is ripe to harness a variety of disciplines for a concerted attack ... the atmospheric sciences require worldwide observations and, hence, international cooperation ... lead to World Weather Watch Program

• Space Architecture for Climate needs greater governmental & Intl Org support
Key Role of Governments/Space Agencies and International Organizations

- **Governments**: To strengthen National Space Programme to meet National Climate Service Needs – Opportunities for more new National Space Programme developments

- **International Organizations**
  - To enhance international collaboration to the development of an Space Architecture for supporting global climate services and facilitating the global climate data & products exchange
  - To promote collaborations of space agencies with user communities for realizing economic and societal benefits through climate services

- **Governments and Space Agencies**: Support free and open exchange of climate-relevant space observational data and Products – Contribute to WMO Open Data Policy
Number of satellite-borne instruments data were assimilated routinely by ECMWF. Expect enhanced satellite data utilization for improved climate prediction performance for Climate Services.
WMO Space Programme contribution at both ends of the chain

Space Segment analysis building on OSCAR/Space

- Identify CGMS missions with potential to deliver FCDRs (with ET/SAT)
- Encourage CGMS commitment to deliver and sustain such FCDRs
- Highlight gaps & prompt actions

Usage scenarios in GFCS priority areas

- Identify end user requirements for climate services in key areas
- Infer the product requirements and specifications (with ET-SUP)
- Highlight gaps and prompt actions
Conclusions

• The initiative to develop a climate monitoring architecture has attracted widespread support from EO space agencies, with consensus achieved on the overall approach – now in the implementation phase

• 2014 is an important year:
  - introduction of a new joint CEOS/CGMS Climate Working Group be charged with the further development of the architecture
  - completion of the first version of a comprehensive inventory that systematically exposes the climate data records held by space agencies (first major deliverable)
Conclusions

• Benefits for users and space agencies of the approach numerous:
  • systematic exposure of records held by space agencies
  • built-in compliance assessment to requirements, traceability, flexibility, consistency
  • future planning, integrated view from sensing => CDR record creation => applications => decision-making…….

• The architecture also provides the foundation for implementing the Observations and Monitoring pillar of GFCS, thus sustaining the provision of observations for climate services at the global, regional and national scales.

• See http://www.ceos.org/wgclimate (for strategy report)
Thank You
Backup slides
WMO Standard Practice: Rolling Review of Requirements - to identify new observing requirements & gaps to meet new initiatives (GFCS, Architecture.)

- Requirements
- Gap Analysis on observations
- Derived variables Performances
- "Statement of Guidance" and Implementation Plan for observing capabilities (Actions, Recommendations)
- Members’ organizations and programmes

Space and ground-based capabilities
Adequate investment in R&D on utilisation of data will increase the return on investment & REAP BENEFITS

Utilisation of data (or return on Investment)

Depend upon Investment:
- Space & ground segment
- Satellites vs R&D on utilization—often insufficient

Readiness for full utilization at launch

Ideal learning curve

Actual learning curve

End of Satellite Life

100%
Inventory Statistics

• Number of records per ECV, continued
Inventory Statistics

• Number of records per responsible organization
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Need more investment in Application/ utilization of data will increase the return on investment & REAP BENEFITS

Do we have the overall right balance: space vs applications?

Utilisation of data
(or return on investment)

End of Satellite Life

100%

Ideal learning curve

Actual learning curve

Readiness for full utilization at launch

Depend upon Investment Balance between:

- Space & ground segment
- Satellites vs R&D on utilization—often insufficient

Thank you for your attention!!