climate change initiative

→ CLIMATE MODELLING USER GROUP

The CMUG Earth Observation Foresight Report

Richard Jones, Met Office Hadley Centre, CMUG Science Lead,
with thanks to all CMUG partners and many CCI ECV projects for inputs

A. Benedetti, J-C Calvet, F. Cheruy, T. Crocker, F. Dobles-Reyes, R. Dragani, A. Lauer, D. Notz, D. Olonscheck, P. Ortega, U. Willen, (CMUG) and A. Bartsch, J. Boutin, M. Buchwitz, A. Ducharne, D. Ghent, T. Lavergne, C. Merchant, F. Paul, S. Sathyendranath, S. Simis (ECV projects)

cmug cci

D1.2: Earth Observation Foresight Report

Aim: To assess requirements for Earth Observation developments to provide support to the climate modelling and information community

Objective: To inform the new ESA Climate Programme proposal for 2022 via a broad community consultation

Lead author: Richard Jones, CMUG Science Leader

Contributing authors from all CMUG partners (ECMWF, IPSL, MPI-Met, Meteo France, BSC, DLR, SMHI) and Science Leads from 10 CCI ECV projects.

Review by climate modelling/information/services stakeholders

Report Structure

1. High Level Drivers of Requirements for EO data, information and services
2. Climate information and services requiring EO data and research
3. EO activities required to enable and deliver the information and services
4. Conclusions/Recommendations

High level drivers (1)

UNFCCC requirements for information on multiple aspects of climate change:

- **Monitoring**
- **Attribution**
- **Projections**
- **Implications**
- **Response options**

Science base provided by IPCC WGI, II and III assessments and Special Reports

- Requires indicators and measurements of:
  - the causal factors of climate change (e.g. GHGs, land cover change)
  - changes in the physical climate, natural and human systems
  - trends in vulnerability and exposure factors (e.g. urbanization, land-use)
- Leading to improvements in scientific understanding (e.g. WCRP Lighthouse activities)
- Supporting better predictions of future impacts/responses via assessment of:
  - needs for adaptation and building resilience
  - mitigation options

High level drivers (2)

UN 2030 Agenda for Sustainable Development

SDGs have multiple climate sensitivities,

- **agriculture**
- **water**
- **health**
- **infrastructure**
- **…**

These are at risk from climate-related hazards so building resilience in the relevant sectors and systems can contribute significantly to SDG attainment

High level drivers (3)

UN Sendai Framework for Disaster Risk Reduction (2015–2030)

Priorities:

1. Understanding (e.g. vulnerability, exposure, hazard characteristics)
2. Strengthening governance and management
3. Investing in resilience
4. Enhancing preparedness, response capacity, and recovery

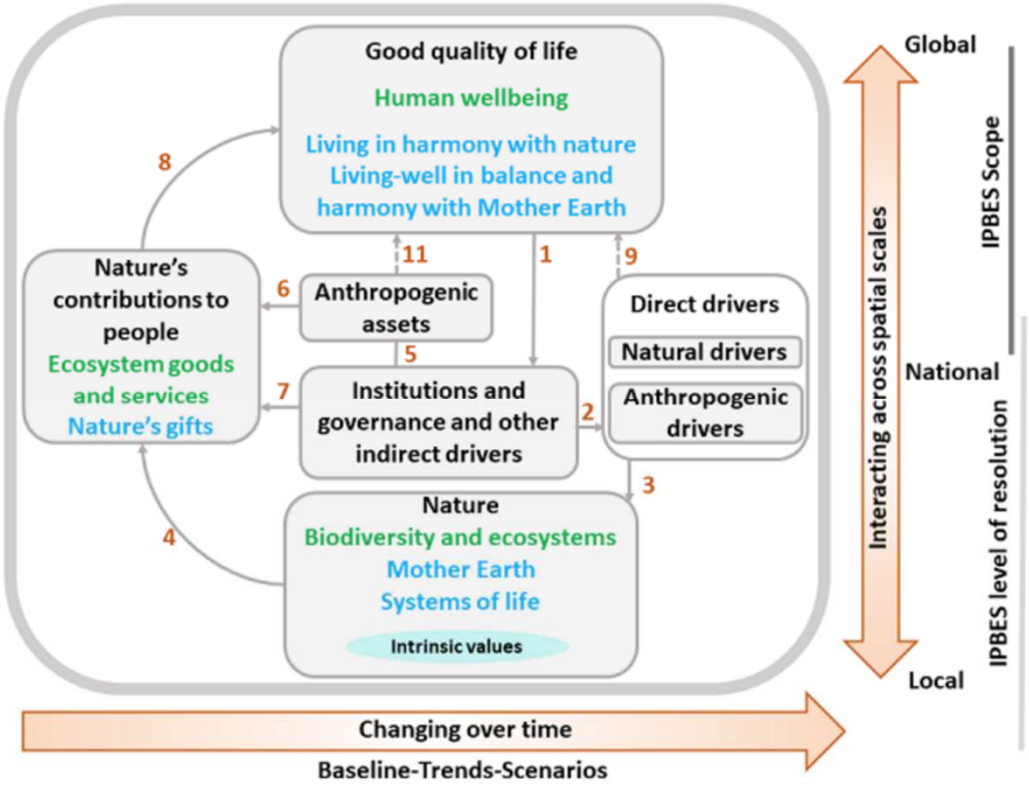
Examples related to climate:

- Improve understanding of current and projected future risks from climate hazards
- Development of risk reduction strategies: early warning systems, index insurance
- Assess potential for future intolerable risks (links back to UNFCCC/PA Article 8)

High level drivers (4)

Biodiversity and Ecosystem Services

UN Convention on Biological Diversity (UNCBD) and the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES)



Díaz et al., 2015

Essential Biodiversity Variables (Biodiversity Observation Networks: GEO-BON) - *e.g.* phenology, NPP, ecosystem extent and fragmentation.

High level drivers (5)

Economy (with links to SDGs, UNFCCC mitigation etc.)

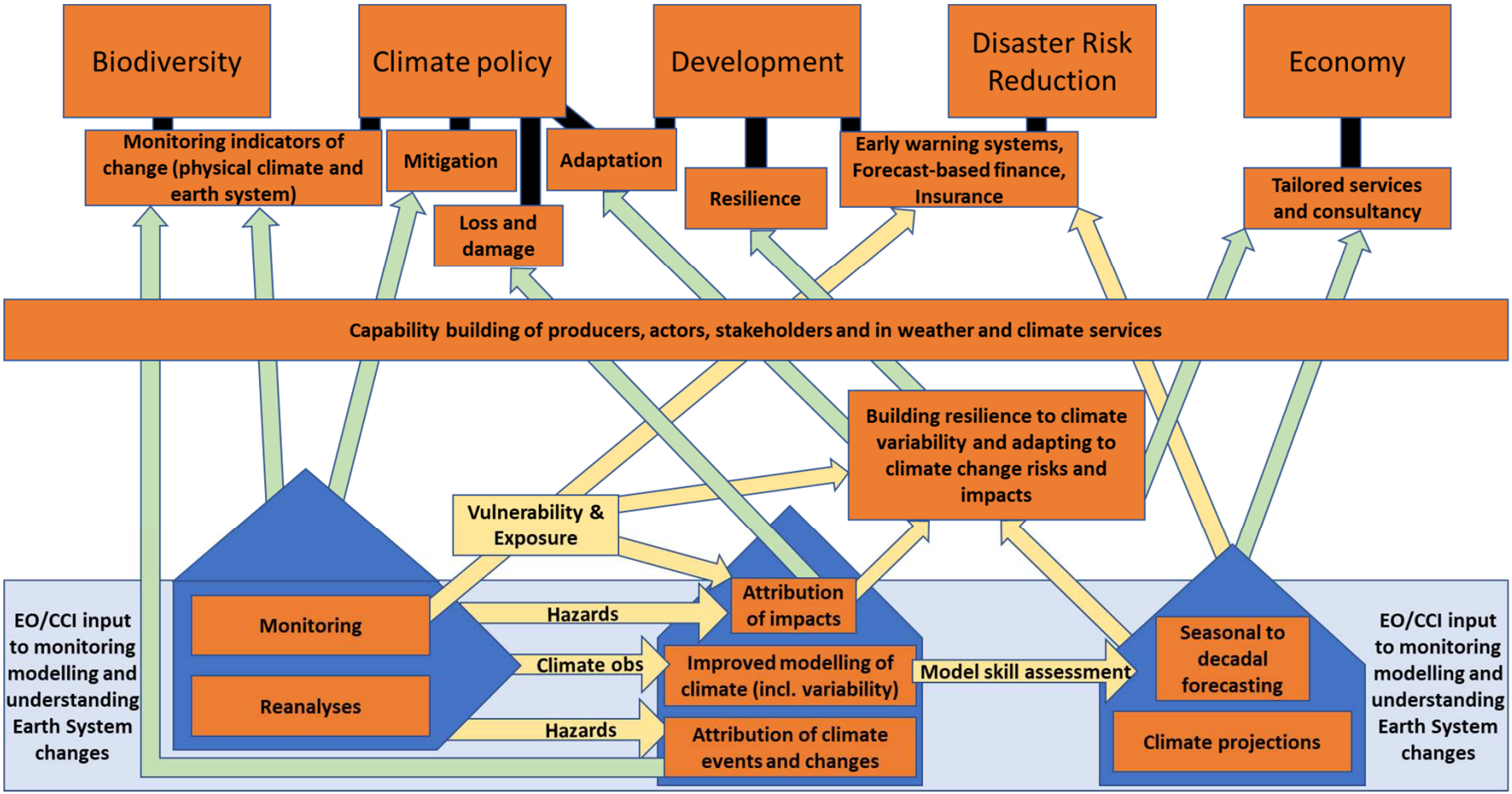
Many climate-sensitive sectors of the economy would benefit from improved climate information and prediction, e.g.

- agriculture
- offshore engineering and maritime operations
- renewable energy (solar, wind, hydro, biofuels)
- workforce productivity (impact of heatwaves, vector borne diseases such as malaria, buruli worm, dengue, etc.)

Sustainable Economic Development

Economic development in some countries could become unsustainable as a result of future climate change, reversing recent progress in poverty reduction. Accurate predictions of future limitations and adaptation strategies are needed.

High-level drivers of Earth Observation (EO) data for climate and their connections to EO data products and research.



Climate Information Services Requiring EO (1)

Monitoring and Reanalysis

- Detection and scientific understanding of long term changes in climate and the functioning of the Earth System (e.g. water, carbon, energy cycles)
- Anthropogenic drivers of change (e.g. GHG sources and sinks, land cover)
- Monitoring of natural resources (e.g. water resources and quality, land cover)

Modelling and Attribution of Climate Variability, Change and Impacts/Risks

- Accurate climate and impact attribution and prediction relies on accurate models, and therefore on model verification and process evaluation against observations.
- Attribution of impacts/risks to changes in hazards needs observations of changes in possible confounding factors of vulnerability and exposure
- High resolution fields for model downscaling

Climate Information Services Requiring EO (2)

Seasonal to Decadal Forecasting

To inform society and decision makers in climate-sensitive sectors (agriculture, energy, tourism, health)

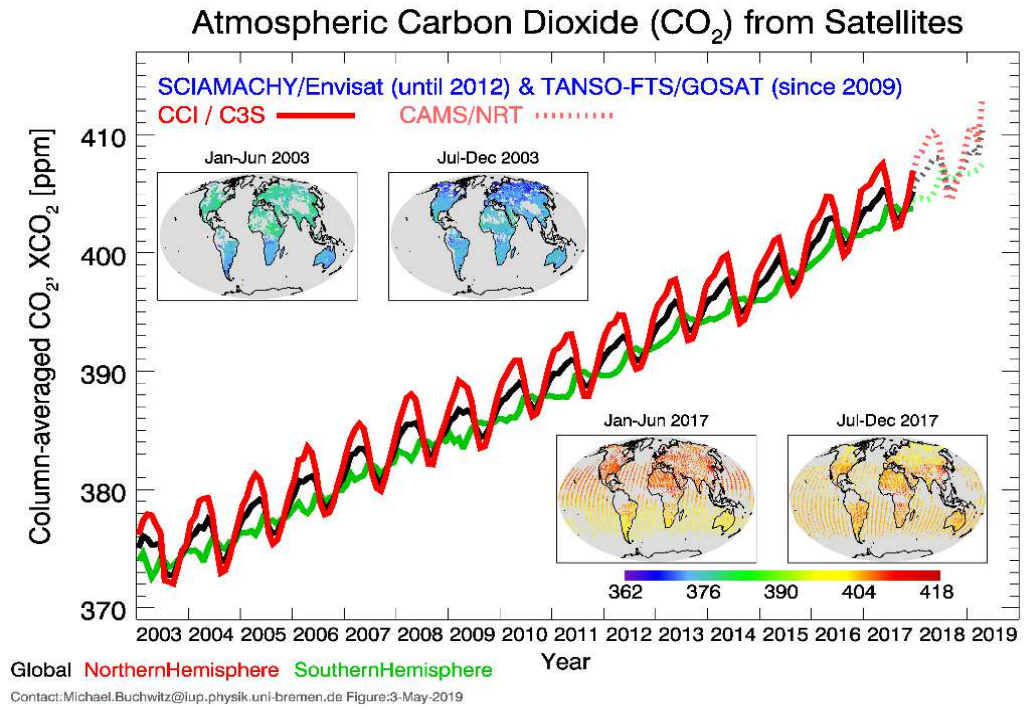
- Long term ECVs are essential for model initialisation and validation

Building Climate Resilience and Adaptation

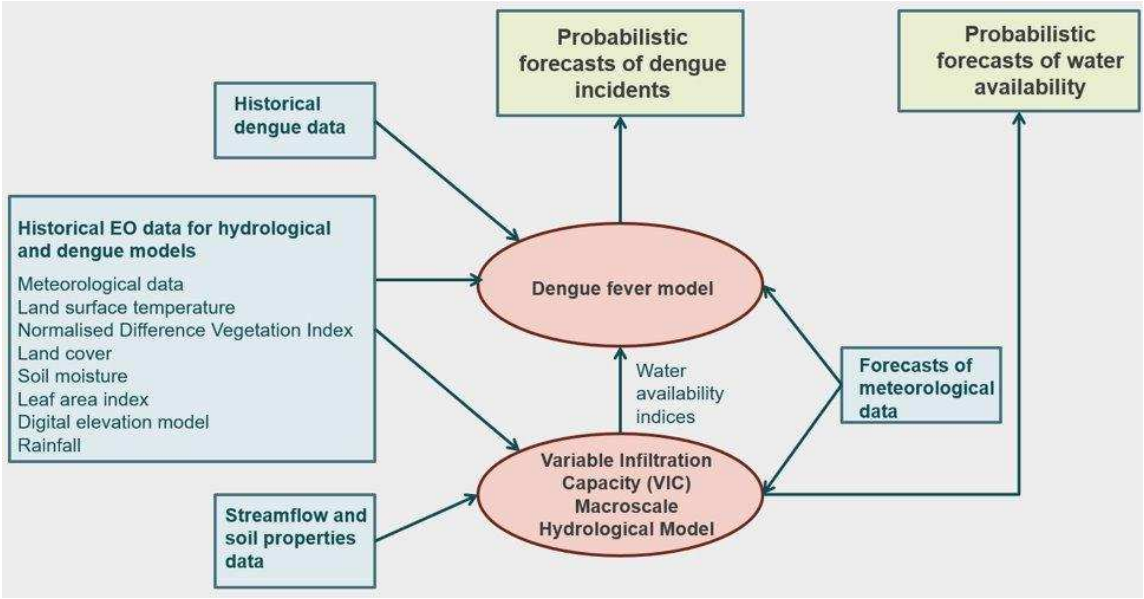
- Downscaling climate predictions to understand local impacts
- Provision of detailed local information required to design interventions to build resilience to future climate change (e.g. mapping of mangroves, forests, wetlands, lake water quality, glacier water resources, soil degradation, urban expansion and heat islands, air quality, etc)

Examples of application to monitoring and disease forecasting

Global average and regional patterns of CO_2



Building and verifying models of predicting seasonal dengue fever outbreaks



EO activities required to enable and deliver (1)

Improving Assimilations and Reanalysis

- e.g., Develop assimilation of land observations to improve reanalysis (ERA5-Land is a land model driven by the atmos reanalysis, not a model analysis of land observations)
- Give high priority to data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.

Attribution and Modelling of Climate Variability and Change

- Cross-ECV budget/cycle analysis: provide observational constraints to improve model capabilities to predict future changes. Would also highlight key gaps in the observation network.
- New short-term ECVs for model process evaluation (e.g. EarthCARE)

EO activities required to enable and deliver (2)

New and Improved Climate Data Records

- R&D to integrate data from new/future instruments: *e.g.* Sentinels, S-HPCMs, S-NGs, Earth Explorers, Altius, TRUTHS, MTG/Metop-SG, ...
- New GCOS requirements: *e.g.* GHG fluxes; better cross-ECV consistency to address climate cycles and budgets
- R&D to integrate valuable data from early instruments (~1960-1990), including data rescue activities (e.g. to collect regional direct broadcast archives)
- New ECV products: *e.g.* Vegetation Optical Depth, sea-ice snow depth, snow albedo, melt pond coverage, ...
- High resolution data sets for local adaptation activities (*e.g.* support to international development projects, civil protection agencies, NGOs)
- Respond to specific requirements from climate services

Conclusions and recommendations (1)

New observations (selected suggestions):

- More on hydrological cycle (water levels, river flow, wetlands)
- More on vegetations/ecosystems – e.g. vegetation optical depth, sea-grass, corals
- Carbon aerosols from biomass burning and fires

Continuity in and improvement of existing observations

- Including data rescue, reprocessing, uncertainty estimation, inter-ECV consistency

Integrating ECVs, modelling and in-situ observations for applications

- Including for budgets, important cycles and key quantities such as permafrost

Modelling and climate science

- Understanding processes, improved reanalyses, model evaluation and constraints

Building capability – in both users/stakeholders and producers/researchers

Conclusions and recommendations (2)

In addition to the general themes from the previous slide of:

- underpinning work of developing new observations and maintaining/enhancing current observations;
- integrated multi-ECV and modelling work focused on important processes/system component and earth system cycles;

other important cross-cutting activities should include:

- technical work on collating, documenting and disseminating data products including assessments of their uncertainties;
- work defining project/programme outcomes involving interactions between and building capability of stakeholders involved in using, communicating and producing the information or services.