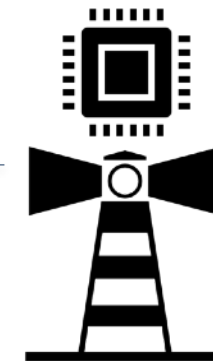# Digital Earths Lighthouse Activity

Digital Earths = horizontal, cutting across other LHA!

Christian Jakob & Peter Bauer (co-chairs)
Andreas Prein
Andrew Gettelman
Aneesh Subramanian
Bryan Lawrence
Camille Lique
Chihiro Kodama
Claas Teichmann
Dai Yamazaki
Daniel Klocke
Helene Seroussi
Mark Govett
Martin Visbeck
Michael Morgan
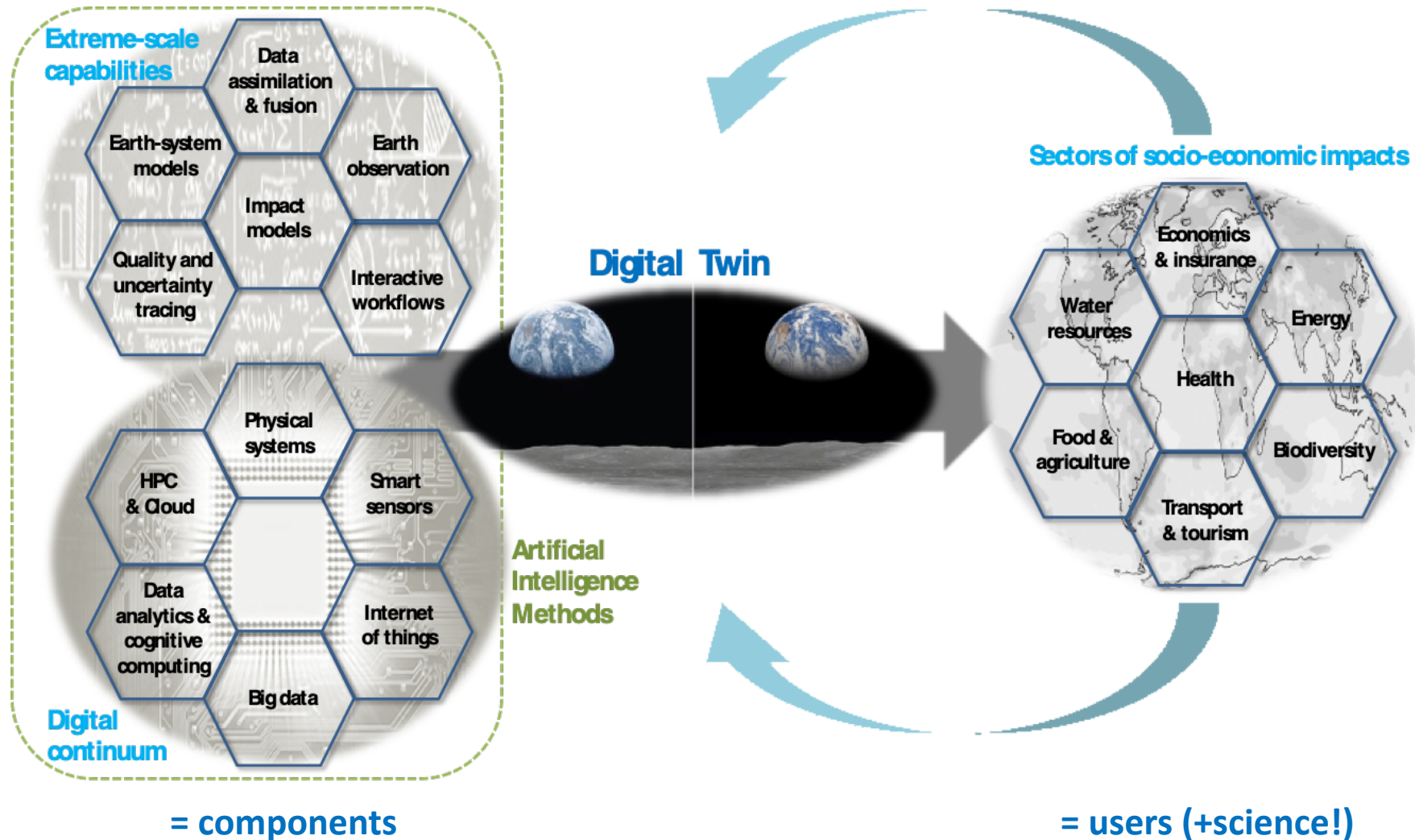Pascale Braconnot
Peter Dueben
Pier Luigi Vidale
Svetlana Jebvrejeva
& Narelle van der Wel & Wenchao Cao
(soon Nico Caltabiano)

What is Digital Earths?

An interactive information system describing past, present and future states of Earth

= components

= users (+science!)

# A framework rather than an implementation

Terms:

- Digital Earths in WCRP should be a <u>framework</u> to develop <u>new capabilities</u> across the globe

- This requires to create <u>software infrastructures</u> that are <u>open and freely available</u>, <u>modular and interoperable</u>

- Use cases are <u>Global and regional Digital Twins</u> that demonstrate benefit across WMO

- Relies on rather <u>wide range of expertise</u> within the WCRP family and beyond

Approach:

- Assembled team with expertise in most of the above areas, incl. representation from main projects; great support from Narelle & Wenchao, and recently, Nico! - THANK YOU

- Formed sub-groups on key topics

- Drafted 1st version of science plan
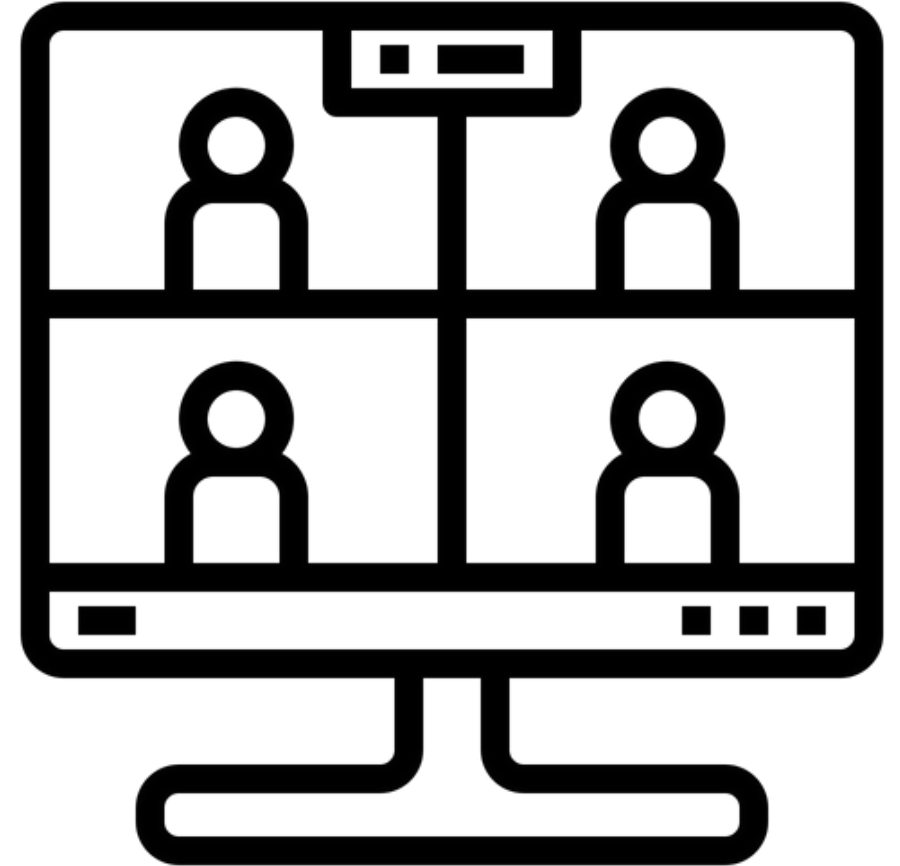
# We propose 4 main areas of objectives for Digital Earths:

1. Establish a global research network with expertise in ultra-high-resolution (kilometer-scale or finer) of the global Earth system and its individual components

2. Establish an active research community in data assimilation for climate that builds on the existing numerical weather prediction and re-analysis efforts and significantly expands them to fulfil the needs of Digital Earths applications

3. Support the establishment of both global and regional Digital Earths demonstration projects across the globe and provide a collaborative network for their development

4. Enable the above by optimally exploiting extreme-scale computing and data handling resources through inter-operable software infrastructures

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Digital Earths will contribute to all WCRP objectives:

- *Objective 1*: Availability of a comprehensive, high-resolution description of the Earth system is an opportunity for a leap in our understanding of its workings.

- *Objectives 2 and 3*: Much advanced prediction/projection capabilities forms basis of high-resolution ensembles, integration of climate and Earth-system components in a single modeling (not a single model) framework, a common experimental design, and enhanced synergy between observations and models.

- *Objective 4*: Provision and co-production with all relevant sectors of industry and society enables step-change in climate-related decision making
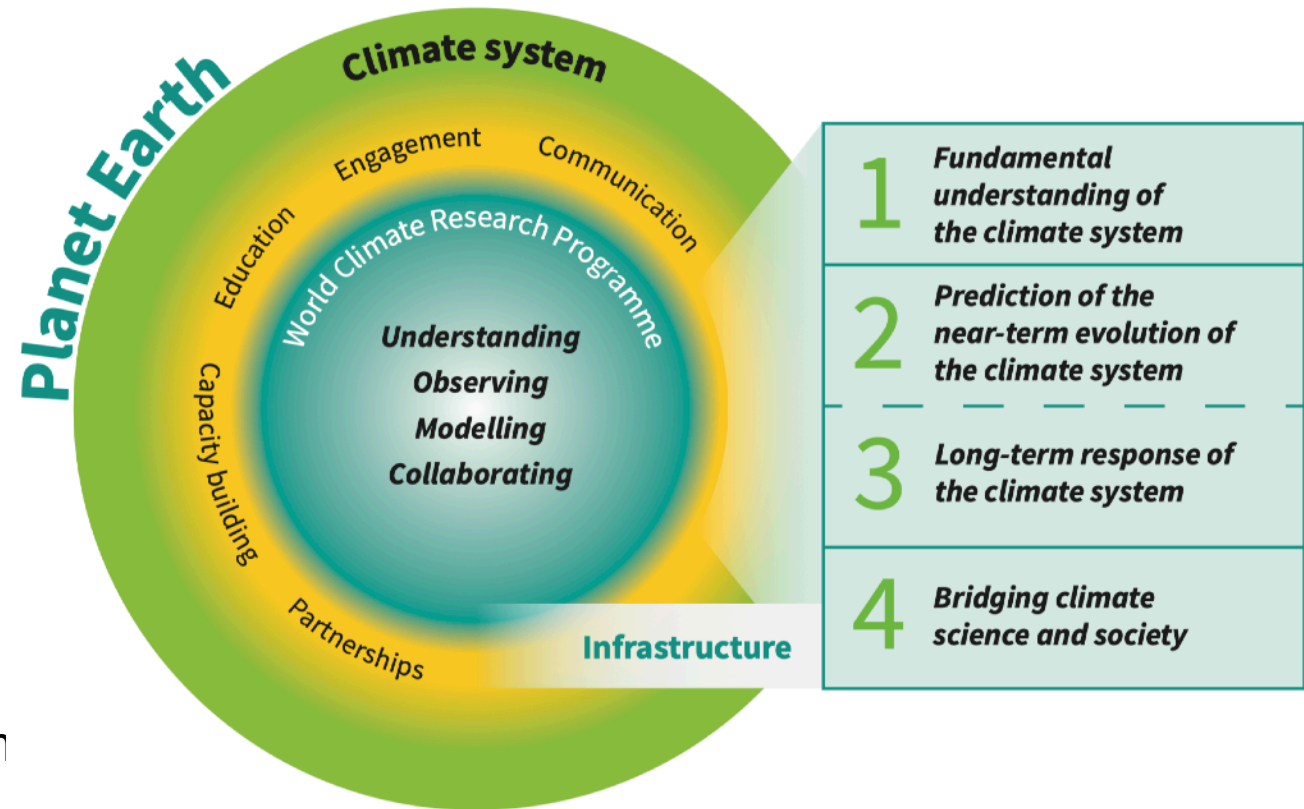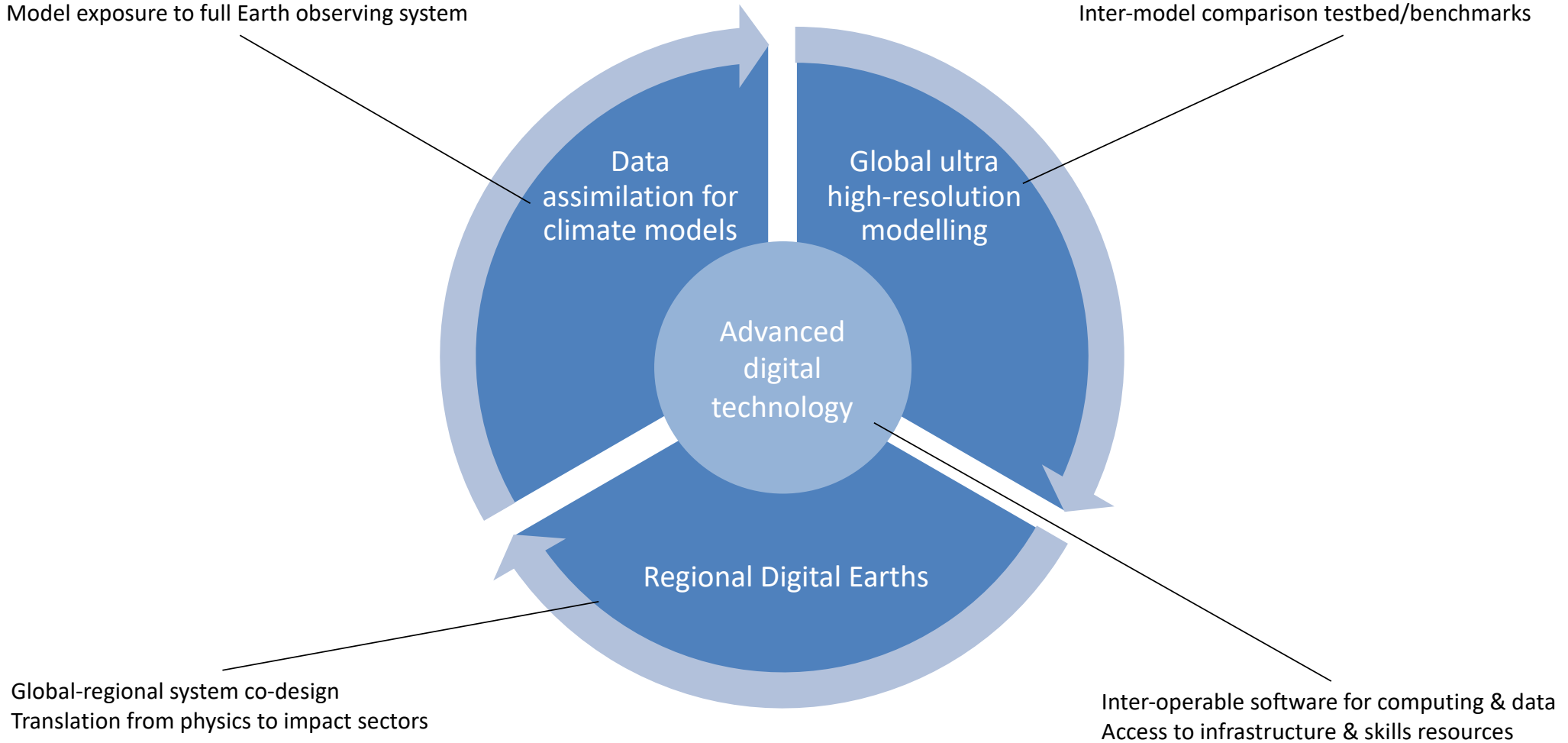

WCRP Strategic Plan

Digital Earths at a glance

Operational model diagnostics framework
Model exposure to full Earth observing system

Substrate for high-resolution, coupled developments
Inter-model comparison testbed/benchmarks

Data assimilation for climate models

Global ultra high-resolution modelling

Advanced digital technology

Regional Digital Earths

Global-regional system co-design
Translation from physics to impact sectors

Inter-operable software for computing & data
Access to infrastructure & skills resources

https:// draft science plan

# Activity area 1: Global, ultra high-resolution modelling

Goals:

- Advance global modeling of the Earth system towards Digital Earths trelevant for human communities.

- Make Digital Earths the substrate for scientific innovation, within the WCRP and beyond

First steps:

- A global model ultra-high-resolution coupled modelling workshop involving existing efforts (e.g., DYAMOND) with a focus on extending the concept to all spheres and the coupled systems led by relevant WCRP groups.

- Development of a white paper supported by the workshop.

- Establishment of the km-scale modelling coordination group within the WCRP structure.

Beyond:

- A CMIP-scale enterprise in ultra-high-resolution climate modelling supported by a range of activities in the WCRP Core Projects.

Palmer and Stevens, PNAS, 2019
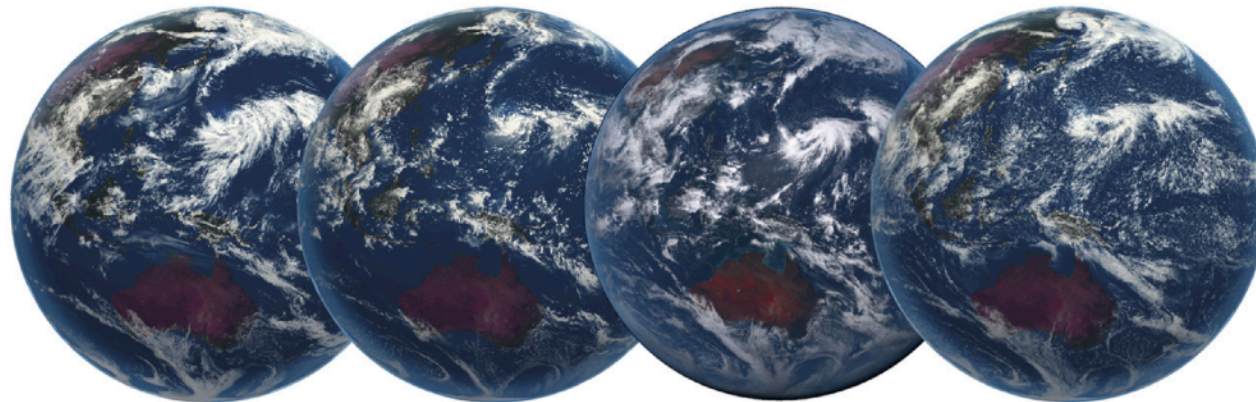
# Activity area 2: Data assimilation for climate

Goals:

- Extend data assimilation capabilities to climate prediction/ projection in an operational framework.

- Provide consistent and accurate descriptions of the past and present states of the Earth System.

- Perform model testing and optimization within a unified framework.

First steps:

- Organise foundational workshop on Data Assimilation for Climate involving the above communities with the aim to review suitable scientific methodologies and provide a strategy for establishing, growing and institutionalizing this area of research in WCRP.

Beyond:

- Create highly visible data-assimilation-for-climate effort, supported by its own structure and led by WCRP, which integrates across WMO weather and climate activities as well as with the impacts modelling community.
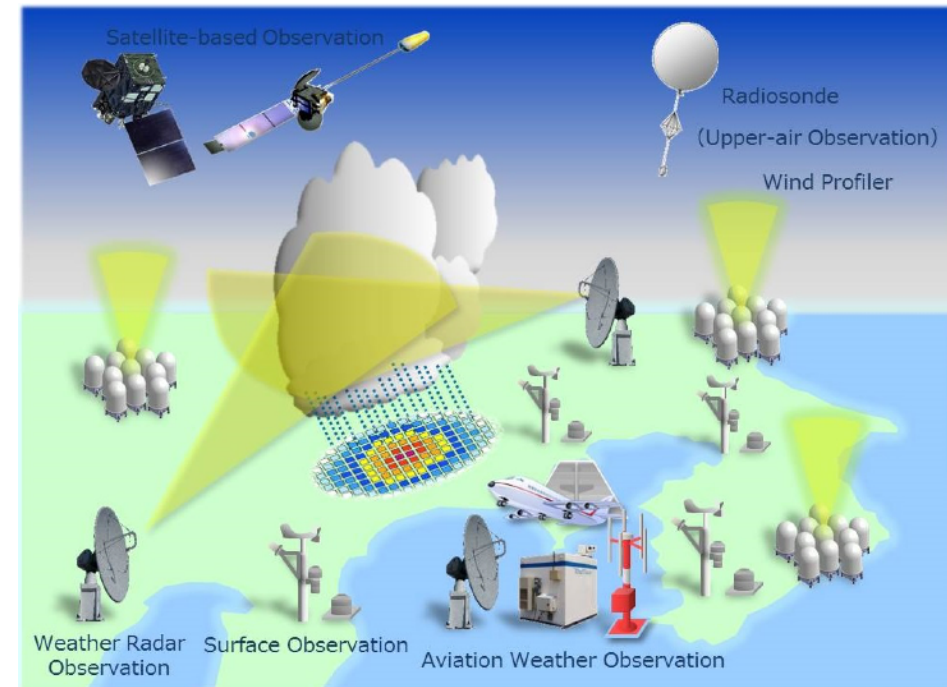
JMA website

Activity area 3: Regional Digital Earths

Goals:

- Establish a global-regional modeling alliance that includes the all regions in the design and application of global and regional Digital Earths Systems

- Define several demonstration projects covering diversity of regional foci, and regional-global dependencies.

First steps:

- Launch demonstration project (with GEWEX) on integration of hydrological reservoirs and fluxes (e.g., ground water, streamflow) in a data assimilation and prediction system at regional scale.

- Organize a workshop dedicated to the development of regional Digital Earths systems.

- Create WCRP-wide Task Force that identifies opportunities for the application of Digital Earths outputs and propose demonstration projects for their potential utility.
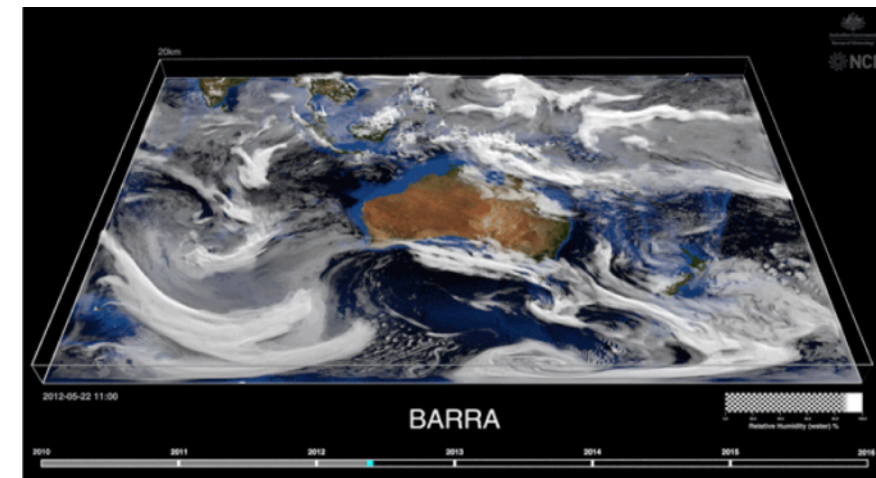
Beyond:

- Create global-regional modeling alliance as a core activity of the Earth System Modelling and Observations (ESMO) Core Project.

WRF Hydro - NOAA National Water Model
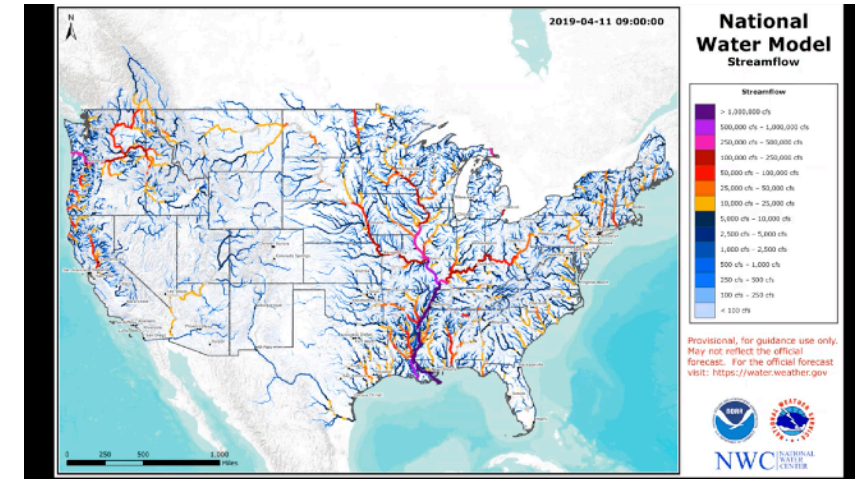
NCAR website

Australian re-analysis

Su et al., GMD 2019

Activity area 4: Digital technology

Goals:

- Host WCRP relevant coordination activities proposed by the Research Board scoping papers on extreme-scale computing, data handling and machine learning.

-

First steps:

- Organise workshop engaging both public and private sectors to (i) identify solutions for generic software development, (ii) provide a roadmap for complementary, internationally coordinated delivery, (iii) enable HPC access and software and data governance mechanisms fulfilling the needs for climate prediction/projection in the future, (iv) take along impact and policy sectors.

- Establish WMO policy action for how to institutionalize this topic through WMO members and the private sector.

Beyond:

- Create WMO-wide digital technology effort in which the WCRP is a key player

Partnerships

- WWRP, GAW, national hydro-meteorological services, national climate centres and services

- Main national funding agencies supporting digital infrastructure development (e.g. European Commission's EuroHPC, US Department of Energy, Japan's MEXT and RIKEN etc.); philanthropic support

- Copernicus in Europe, Earth Cube in the US, International Society on Digital Earth

- HPC and software industry

- Existing weather/climate-computational science efforts (e.g. US Energy Exascale Earth System Model (E3SM), European Centre for Medium-Range Weather Forecasts (ECMWF) Scalability Programme, Centre of Excellence in Simulation of Weather and Climate in Europe (ESiWACE), e-infrastructure of the European Network for Earth System Modeling (IS-ENES))

- Academia

- Applications communities - Future Earth

What do we want from the JSC?

- Feedback on our proposed areas of activity

- Feedback on our proposed first steps

- Feedback on our longer-term suggestions

- Support in our initial engagement with the Core Projects and other LHAs

- Communication of the importance of this activity for our long-term success as a community

Digital Earths will have succeeded when it is fully integrated in the WCRP core activities and has become invisible as an activity in itself!