Digital Earths Lighthouse Activity

Digital Earths = horizontal, cutting across other LHA!

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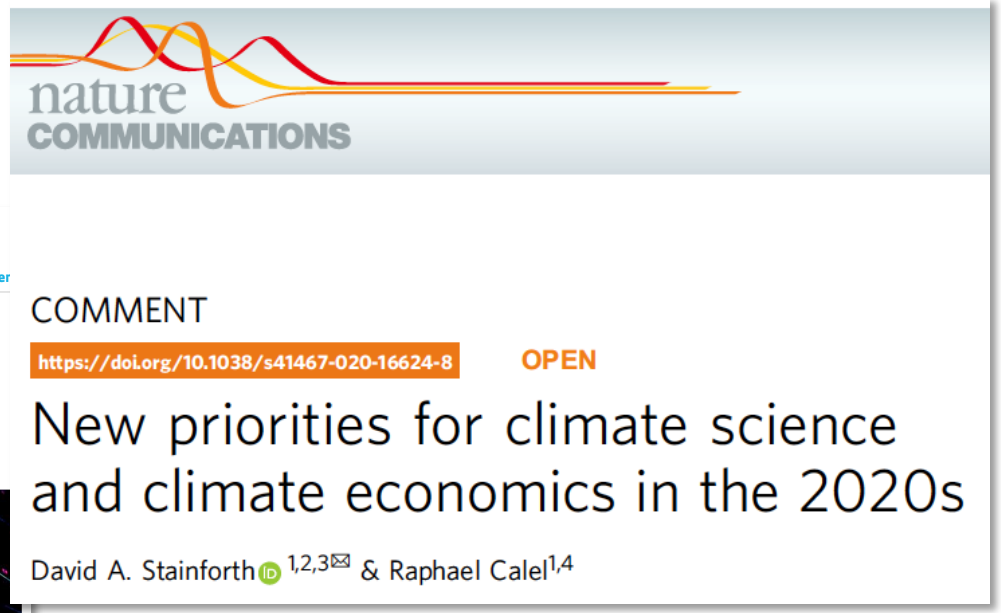
Why this one?

Break-throughs:

1. Extreme-scale computing and data handling:
   = much more realistic models + better combination of simulations + observations
2. Full integration of policy sectors in monitoring and prediction workflow
   = Earth-system + energy + food + water + finance
3. Open and interactive access to data, software and workflows for users
   = non-expert access and intervention



Digital Earth objectives & scope

Digital Earths is a:

- digital and dynamic representation of the Earth system;
- optimal blend of models and observations;
- enable exploration of past, present and possible futures of the Earth system;
- give open access to data, methodologies and software;
- create innovation in in support of the WCRP Objectives;
- push co-development of modelling with digital technologies HPC, BD & ML;
- key instrument to achieve the goals of the other Lighthouse Activities.

Digital Earths will be a:

- joint activity with existing/novel, technology driven national and international projects;
- WCRP will implement selected versions for topics where significant progress is required (e.g. other LHA)

The core of Digital Earths is to:

- develop generic software-hardware solutions that allow simulation models and data assimilation to perform several orders of magnitude more efficiently;
- facilitate the extraction of Earth-system sector specific information from vast amounts of environmental data, both simulated and observed;
- allow to invest efficiency gains in upgrading simulations, ensembles and/or running more comprehensive scenarios.

1st assessment on where to place Digital Earths LHA

We started with asking ourselves a few questions

Why would we do this?

- What is the biggest challenge (that is presently limited by digital technologies)?
- What can the Digital Earths LHA do that existing national & international programmes can't do?

→ definition of what the Digital Earths LHA will be

How would we do this?

- How should LHA interact with existing national & international programmes?
- What could be realistic milestones in 12, 24, 48 months?
- Can we assign/build up responsibilities in team?
- Can the LHA create new funding opportunities?
- How do we organize ourselves (one vs several teams)?

→ definition of implementation and success for the Digital Earths LHA within WCRP strategy timeframe

What will Digital Earths LHA be?

- both **resolution and complexity** are needed to develop more realistic Earth-system models:
  - both come with significant computing & data footprint

- the link to **impact models** is weak:
  - expert knowledge is required everywhere (monoliths)
  - information gets lost between processing steps

- keys to the **effective use of resources** are:
  - inter-operable models and data, facilitating research and R2O
  - easy-to-use tools for data analytics and data exploration (Google Earth)
  - access to extreme-scale HPC and BD resources and their cost-effective use
  - generic software infrastructures that are portable between systems (global – regional, well developed – less well developed)

- LHA should work on those parts of modeling systems that can be **standardized**, provide **inter-operability** and **efficiency/scalability**:
  - (shared) workflows
  - (shared) data structures and their use by model components
  - (shared) tools for comparison with observations (a la data assimilation) and other models
  - (shared) hardware optimized back-ends

Some of this has been tried before but without sufficient success!

Digital Earths partnerships

1st action: do housekeeping; assess what has been done, what exists and where true potential lies

2nd action: partner up with

- main national funding agencies supporting digital infrastructure development (e.g. European Commission's EuroHPC (High Performance Computing (HPC)), Department of Energy, Japan's MEXT and RIKEN etc.); philanthropic support
- WWRP and GAW, national hydro-meteorological services, national climate centres
- Copernicus in Europe, Earth Cube in 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 Modelling (IS-ENES)
- academia (model/data assimilation development, computational science)

3rd action: select a use-case, possibly tied to other LHAs

Models: today's three schools of thought

"Resolution":
Focus on spatial resolution to eliminate parametrisations
→ *Computing*?

"Traditional":
Focus on models holistically, rely on parametrisations
→ *Realism*?

"Technology":
Focus on ML/data driven modelling
→ *Training*?

› Proc Natl Acad Sci U S A. 2019 Dec 3;116(49):24390-24395. doi: 10.1073/pnas.1906691116.

The scientific challenge of understanding and estimating climate change

Tim Palmer [1], Bjorn Stevens [2]

Affiliations + expand

PMID: 31792170 PMCID: PMC6900733 DOI: 10.1073/pnas.1906691116

Free PMC article

Abstract

Given the slow unfolding of what may become catastrophic changes to Earth's climate, many are understandably distraught by failures of public policy to rise to the magnitude of the challenge. Few in the science community would think to question the scientific response to the unfolding changes. However, is the science community continuing to do its part to the best of its ability? In the domains where we can have the greatest influence, is the scientific community articulating a vision commensurate with the challenges posed by climate change? We think not.

AGU Advances

Commentary | Open Access

The Relevance of Theory for Contemporary Research in Atmospheres, Oceans, and Climate

Kerry Emanuel

First published: 25 June 2020 | https://doi.org/10.1029/2019AV000129

Peer Review The peer review history for this article is available as a PDF in the Supporting Information

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Abstract

Dealing with large data sets and complex computational codes demands increasing time and effort by researchers in atmospheres, oceans, and climate. The author argues for a more balanced approach to using models, observations, and theory to advance basic understanding.

Geophysical Research Letters

Frontier Article | Free Access

Earth System Modeling 2.0: A Blueprint for Models That Learn From Observations and Targeted High-Resolution Simulations

Tapio Schneider, Shiwei Lan, Andrew Stuart, João Teixeira

First published: 30 November 2017 | https://doi.org/10.1002/2017GL076101 | Citations: 48

Digital Earths LHA should allow to trial all options within the same framework!

A framework rather than an implementation

- Digital Earths in WCRP should be a ***FRAMEWORK*** to develop activities across the globe.
- This requires to create science activities whose software outcomes are: ***open and freely available, modular and interoperable, and built to agree upon standards***.
- We envisage both ***global and regional*** Digital Twins to be developed under this Framework

GLOBAL
e.g., Destination Earth

REGIONAL
e.g., Digital Vietnam

LOCAL
e.g., Digital Buenos Aires