GLOBAL CLIMATE OBSERVING SYSTEM

**GCOS STEERING COMMITTEE
THIRTY FIRST SESSION**

GCOS SC-31, 2–5 July 2024
WMO, Geneva, Switzerland

GCOS co-authoring article

GCOS co-authoring paper

Over the last several months, GCOS Secretariat has been approached by Dr. Jean-Philippe Montillet (Physikalisch-Meteorologische Observatorium Davos, Switzerland) with the request to co-author a paper on promoting novel techniques (e.g., machine/deep learning) to process big datasets for the purpose of monitoring essential climate variables. The Steering Committee is asked to provide advice to the GCOS Secretariat on how to answer this request.

DRAFT DECISION (x)

The Steering Committee decides that the GCOS Secretariat **will/will NOT** collaborate with Dr. Jean-Philippe Montillet on an article with the outline as proposed below.

Summary:

Dr. J.-P. Montillet, alongside a group of esteemed scientists (including Prof. C.K. Shum, Dr. W. Finsterle, Dr. M. Haberreiter, Prof. E. Forootan, Prof. R. Fernandes, Prof. Em. H. Schuh), envisions collaboration in writing an (high-level scientific) article with the GCOS scientific officers and expert panel members promoting novel techniques (e.g., machine/deep learning) to process big datasets for the purpose of monitoring essential climate variables. Additionally, they welcome the participation of other experts affiliated with the United Nations who are involved in advancing climate science and resilience strategies via holistic exploitation of climate observations and proposed generations of essential climate variables.

Background: this article focuses on the interconnectedness of monitoring ECVs, GCOS database, and big data analysis in accelerating the advances in climate science, and the creation of new resilience strategies at local and global scales. Many programs have been launched recently by various states (e.g., CASEarth (China), AI4EO (CNES), ACCESS (NASA)) which contributes towards Earth 2.0 to simulate and understand in near real time, short and long term trends generated by climate change. The GCOS as part of the UN has a unique opportunity to play a central role to catalyze all those initiatives which could contribute to facilitate the making of global policies, thus accelerating the global endeavor towards a more sustainable future.

Tentative Title (TBD):

Global Climate Observing System (GCOS): Enhancing Global Climate Understanding and Informed Climate Actions

Or

GCOS: Bridging Climate Science and Policy Towards Climate Resilience

Or

Timely and adequate spatiotemporal monitoring of climate-induced hazards using satellite observations with plausible novel processing

Abstract :

Enhancing our understanding of the adverse effects of climate change hinges on the comprehensive generation of Essential Climate Variables (ECVs) at adequate spatiotemporal scales and identify their interconnectedness. These variables serve as vital indicators, shedding light on the complex interplay of climate system dynamics. The Global Climate Observing System (GCOS) stands as a cornerstone in this effort, orchestrating global collaboration to furnish innovative, interdisciplinary and fully validated ECVs essential for enhancing our understanding of climate change towards informed climate actions.

Moreover, physics-informed Machine Learning (ML) and Deep Learning (DL) analytics emerge as potential tools, promising to amplify the robustness of analyses of big datasets. By harnessing these analytics, we can unravel complex climate patterns, forecast trends with greater precision, and refine climate models, thus improving ECV monitoring and potentially fast-tracking climate research and policy formulation.

Consider, for instance, the integration of geodetic measurements into climate monitoring and disaster management frameworks, aided by ML/DL analytics. These measurements encompass a spectrum of critical domains such as oceanic dynamics, terrestrial landscapes, glaciated regions, permafrost zones, ice sheets, mountain/peripheral glaciers, sea level, ocean circulation, solid Earth/ice reservoir/hydrologic/seafloor deformations, space weather, gravitational and geomagnetic fields. Leveraging interdisciplinary Earth observations and model outputs, this approach furnishes a holistic comprehension of climate dynamics, imperative for tackling not only climate change but also associated challenges like disaster mitigation and ground water depletation. Such endeavors underscore the pressing need for adaptive policies, grounded in robust scientific understanding and empowered by technological innovation, to navigate the complexities of our changing climate.

Potential frame of the article

1. **Introduction**
   - Brief overview of climate change and its impacts (short paragraph).
   - Introduction to essential climate variables (ECVs) and their importance in understanding climate change.

- Overview of the Global Climate Observing System (GCOS) and the role of ECVs as a tool with adequately fine spatiotemporal scales for the monitoring of climate-induced hazards, water resource scarcity, etc …

2. **Essential Climate Variables (ECVs)**

- Explanation of various ECVs including, but not limited to, air/sea surface/land/atmospheric temperature, precipitation, pressure, greenhouse gases, water vapor, sea ice, water level, soil moisture, discharge, storage change, sea level, ice thickness.
- Importance of monitoring and understanding each ECV in the context of climate change.
- Discussion on how ECV data is collected, innovatively processed, spatiotemporally downscaled, robustly validated, uncertainty assessed, and disseminated globally plausibly in near-real time, through networks like GCOS, accessible in the form of observation portals or APIs (Application Programming Interface).

3. **GCOS: Data Infrastructure (*)**

- Detailed explanation of the Global Climate Observing System (GCOS) and its objectives.
- Discussion on how the GCOS contributes to climate research, climate actions, and informed policy decision-makings.

4. **Big Data in Climate Science** (Note: We can write this section based on the review paper in EarthArXiv)

- Big Data anlysis in Earth and Space Sciences
- The role of machine learning techniques and their applications in climate science
- Modeling the Earth complex dynamical systems based on the physics-informed ML-/DL-aided analysis of these big datasets and the interconectivness of the ECVs towards the global initiative Earth 2.0. At notional level, several programs are already complemented such as CASEarth (China), AI4EO (CNES), ACCESS (NASA), …[Nivida's Earth Climate Digital Twin, mostly a weather forecasting of typhoons at 2 km scale, https://nvidianews.nvidia.com/news/nvidia-announces-earth-climate-digital-twin]

5. **Integration of the GCOS database in fostering new resilience strategies and accelerating the development of new ones**
6.
    - Integrating GCOS: data-driven solutions to foster new resilience strategies: Adapting and accelerating the development of policies at regional and global scale (Note: this is an interesting point where experts in policy making at the GCOS and other departments of the UN could contribute).
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7. **Conclusions**
    - Summary of key insights from the paper.
    - Recommendations for future research and policy initiatives in the field of climate science, data infrastructure, physics-informed machine-/deep-learning.

In summary, this article highlights the use of ECV-driven (data-driven) prediction method incorporating ML/DL algorithms to potentially build hazards early-warning systems, (prediction, projection – prediction for data-driven methods; projection perhaps involves physical modeling).

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