# Topic 2: Research needs for operational services

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with inputs from ET-OCPS, WGSIP colleagues

# Objectives and backgrounds

**Background:**

- Currently, no formal mechanism exists to convey the research needs of operational centers to the broader research community.
- High level strategic plans of the WWRP and WCRP are aligned with the WMO strategic plan. Additionally, informal and internal discussions take place within individual organizations to address their own needs.

**Objectives:**

- To foster communication and collaboration between the WCRP and operational centers to advance climate prediction.
- To ensure coordination of WMO research bodies to support research efforts to address unresolved and urgent issues in operational climate prediction.

# Advantages and Impediments (personal view)

## Advantages

Regular communications on research requirements may promote addressing “research in need”.

Identifying and sharing research needs and unresolved scientific questions can serve as a guiding "lighthouse" for peers.

## Impediments

Research activities are primarily supported by national funding agencies, and individual institutions and universities, WCRP contributions are mostly on a voluntary basis. Their objectives may be different.

Some operational requirements (wish lists) may be ill-posed or simply unattainable.

It can sometimes be challenging to attract interest for studying technical aspects.
(the gap between science and engineering)

# So, what we could do?

- **Identifying research requirements and promoting “research in need”**
  Recently, research requirements have been identified and prioritized
  by conducting a questionnaire within ET-OCPS.
- **Aligning ESMO/WGSIP activities to address the identified requirements**
  Matching scientific interest and operational needs is not always easy.
  But, some topics could be incorporated in the next/future WGSIP activities.
  **It would be great if we could try this time.**

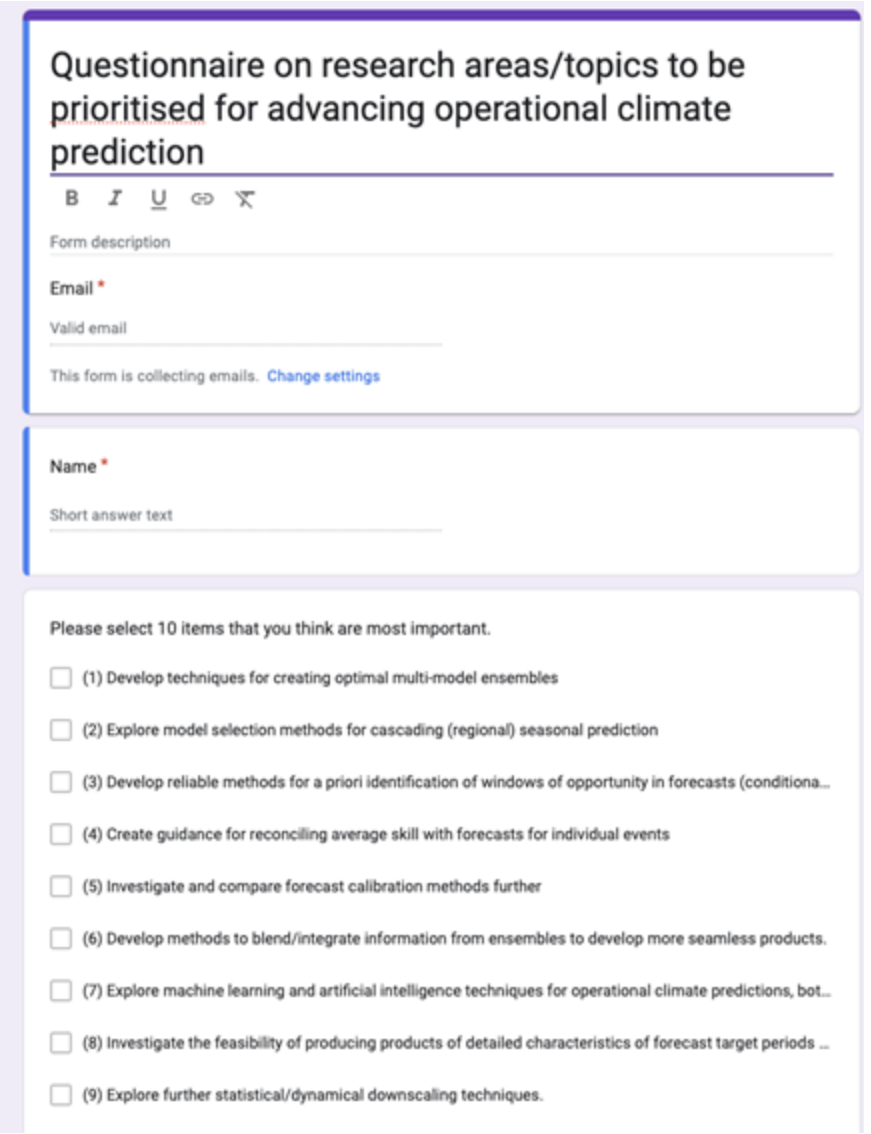
*“You can't always get what you want, but if you try sometimes, you might find, you get what you need.”*

You Can't Always Get What You Want / The Rolling Stones (1969)

# Developing a list of research requirements of operational climate predictions

A tentative list of research requirements was prepared based on previous discussions among experts from WGSIP and ET-OCPS, outcome from the Third WMO Workshop on Operational Climate Prediction (OCP-3, Lisbon, 2022; Kumar et al. 2024 BAMS) as well as a document on potential needs for operational subseasonal-to-decadal (S2S) prediction prepared by the chair and co-chair of ET-OPSLS in 2017.

A questionnaire has been done to prioritize the research items. (**14 responses**)



# Results of the questionnaire

(select 10 items from 20 items in total, 14 responses in total)

(1) Explore machine learning and artificial intelligence techniques for operational climate predictions, both in modeling and post-processing (14/14, 100%) **AL/ML**

(1) Understand of predictability sources across scales (14/14, 100%)

(2) Develop reliable methods for a priori identification of windows of opportunity in forecasts (conditional prediction skill) (11/14, 79%)

(3) Advance methods for constructing ensembles, including ensemble generation, multi-system approaches, and sub-setting models/members (10/14, 71%) Ensemble

(3) Assess the AI-based climate prediction models (10/14, 71%) **AL/ML**

(4) Develop techniques for creating optimal multi-model ensembles (9/14, 64%) Ensemble

(5) Explore model selection methods for cascading (regional) seasonal prediction (8/14, 57.1%) Ensemble

(5) Explore the more complete Earth System components (atmospheric chemistry, aerosols, vegetation, ocean biogeochemistry, etc.) (8/14, 57.1%) Earth system

(5) Verification methods of newly emerging products (extremes, seasonal TC prediction etc.) (8/14, 57.1%) Verification

(5) Identify optimal verification datasets (or combinations thereof) for Earth system variables for which observations are sparse and/or uncertain. (8/14, 57.1%) Verification

* Some items were overlapped…

# Results of the questionnaire
(select 10 items from 20 items in total, 14 responses in total)

(6) Create guidance for reconciling average skill with forecasts for individual events (7/14, 50%)

(6) Explore further statistical/dynamical downscaling techniques (7/14, 50%)

(7) Investigate the feasibility of producing products of detailed characteristics of forecast target periods rather than average statistics (e.g. probabilistic forecasts of rainy season onset, wet/dry spells, extremes such as heat/cold waves) together with the corresponding forecast verification products. (6/14, 42.9%)

(7) Integrate attribution and prediction for extremes (6/14, 42.9%)

(7) Assess the potentials of high-resolution modeling in the context of operational forecasting (6/14, 42.9%)

(7) Knowledge on the level of consistency required for the specification of initial condition between hindcasts and real-time forecasts, and for Earth System components (land, sea-ice etc.) (6/14, 42.9%)

(8) Develop methods to blend/integrate information from ensembles to develop more seamless products (5/14, 35.7%)

(9) Develop advanced verification techniques for probabilistic forecasts (4/14, 28.6%)

# Additional requirements/comments

- Assessing representation of climate modes and their teleconnections (ENSO and monsoons etc.)
- What factors (Earth system components), models, and data are important for S2S forecasting (which may not be currently part of medium-range prediction) and how to prioritize them based on current knowledge about their contribution to predictability.
- Generalise attribution to support an understanding of forecast success and failures, and the drivers behind significant climate events.
- Predictions are limited by lack of skill, not by our ability to use them. We must focus on improving the understanding of climate dynamics, though progress is slow. Exploring diverse aspects may help, but could distract from the core goal of developing models to enhance skill.

# Summary (Top 6 keywords)

- AI/ML methods
- Sources of the predictability and mechanisms
- a-priori identification of the windows of forecast opportunity
- Ensemble (techniques, MME, model selection)
- Earth System
- Verification

*Merci*

# Supplementary slide

**OCP-3 recommendations (of research only) Kumar et al. (2024) *BAMS***

- Focus on advancing understanding of mechanisms and drivers of climate predictability.
- Identify reliable methods of a-priori identification of windows of forecast opportunity.
- Address the need for **forecast calibration** considering the existence of conditional skill (specific to certain conditions) and unconditional skill (overall forecast system performance estimated using all available hindcasts)

  My question: Currently available calibration methods are able to reflect the conditional skill?