Catalyzing Innovation in Weather Science: the World Weather Research Programme

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WWRP Structure

WWRP Working Groups
- Tropical Meteorology
- Predictability, Dynamics and Ensemble Forecasting
- Data Assimilation and Observing Systems
- WWRP-JSC / CAS Working Group on Numerical Experimentation
- Nowcasting and Mesoscale

WWRP Core Projects
- Weather Modification
- Socio-Economic Research Applications
- Polar Prediction
- WCRP World Climate Research Programme
- Subseasonal-to-Seasonal Prediction Project

WWRP Regional Portfolio
Research Development & Forecast Demonstration Projects
- Convective Systems, Tropical Cyclones, Aviation, Olympic Games, Nowcasting Systems, Sand & Dust Prediction etc
- China, Argentina, US, Lake Victoria, Mediterranean, Hong Kong, South Africa, Canada, Australia, South Korea ....
WWRP Action Areas

Societal Challenges

Action Areas

- **Address Limitations**
  - Uncertainty
  - Fully Coupled
  - Applications
  - Verification
  - Attribution

- **Integrated**
  - Water Cycle
  - New Observations
  - Precipitation Processes
  - Hydrological Uncertainty

- **Understand Needs**
  - Observations & Processes
  - Urban Prediction

- **Advanced Methods**
  - Support Facilities
  - Tools
  - New Observations
  - Future GOS

Objectives and Concrete Activities

Each Action Area comes along with a set of objectives. Concrete Activities have been defined that will ensure to achieve the objectives and make progress in the action areas.
High-impact Weather:
Toward impact-based forecasts in a variable and changing climate
Action Areas 2: Uncertainty

Identify, characterize and quantify analysis and forecast uncertainty using advanced probabilistic methods, and develop corresponding data channels and communication mechanisms which support decision-making under uncertainty.

- Quantitative descriptions of the uncertainty of the initial state, its evolution forward in time.
- Improve the resolution and reliability of ensemble-based meteorological predictions.
- Co-design communication mechanisms of uncertainty with users.
- Improved diagnostics and verification tools from high-resolution ensembles that assist operational forecasters.
**Action Areas 2: Uncertainty**

**Example:** *Upscale error growth in high-resolution experiment*

Perturbation error growth: Shown as difference between control and perturbed experiment

Perturbations spread out from the convective regions at a speed consistent with that of a deep (troposphere filling) gravity wave to synoptic scale disturbances.

- **500 hPa geopotential line spacing 250 m²/s²**
- **500 hPa geopotential difference on large scales (>1000 km). Red positive, blue negative, line spacing 5 m²/s²**

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Water: Modelling and predicting the water cycle for improved disaster risk reduction and resource management
Action Areas 9: Precipitation Processes

Improve understanding, observation and modelling of aerosol, cloud and water vapour aspects of precipitation processes, with a view to improved estimation and predictions of precipitation

- Develop new/better convective parameterizations for non-convection-permitting models (which remain relevant).
- In collaboration with GAW improve the understanding of aerosol activation in the atmosphere and how this affects radiative forcing of weather and climate & cloud processes
- Make improvements to model physics and related data assimilation for improving rainfall processes
Example: Statistical characteristics of raindrop size distributions observed in Asian summer monsoon

Convective spectrum has the highest concentrations at all size ranges, resulting in a higher number concentration, a higher rain rate, and more rain water content. The stratiform spectrum is narrower, and that of shallow rain is the narrowest and has much higher concentrations below 1.1 mm, resulting in higher rain water contents.

Composite raindrop spectrum curves (fitted to the observations) for the convective, the stratiform, and the shallow rain types, as well as for the total categorized data set.
Evolving Technologies: Their impact on science and their use
Action Areas 15: Support Facilities

Enhance access to services (observations, model output, data collection and pre-processing and global models) that require exceptional HPC and data handling.

- Continue to support TIGGE, S2S, and similar data collection efforts, to enable and accelerate research worldwide.
- In light of increasing data volumes, develop policies and methods for distributed data archival/retrieval.
- Develop and share (open source) tools and lessons-learned for handling and pre-processing such datasets and developing applications.
- Make available to the international community model datasets in formats suitable for post-processing and verification.
Action Areas 15: Big-Data

100 Mb observational data per day

2 million grid-column calculations per time step

25x more forecast product data per day in critical path

30x more data sent to customers per day in critical path

70 Tb data archived per day

By courtesy of P Bauer ECMWF. See also P Bauer et al, Nature 2015
WWRP IP & WCRP Strategy
WWRP IP & WCRP Strategy

01 - Understanding the climate system

- WWRP Polar Prediction and High-Impact Weather projects and their field-modeling experiments, S2S and its coordinated modelling experiments
- Coordinated International Experiments
- Define sustained observations required for future science needs
- Sources, reservoirs and fluxes of a particular constituent
- Methodologies of tipping point detection and/or projection
- Development of model parametrizations and numerical formulation of newly resolved processes
- Climate system model component development
- Extended climate datasets

- WWRP, Evolving Technologies: AA 17 (New Observations) AA 18 (Future GOS)
- WWRP, Water: AA 8 (New Observations)
- WWRP, Water: AA 7 (Integrated Water Cycle)
- WWRP, High Impact Weather: AA 1 (Address Limitations)
- WWRP, High Impact Weather: AA 6 (Attribution)
- WWRP, High Impact Weather: AA 2 (Uncertainty)
- WWRP, Water: AA 9 (Precipitation Processes), AA 10 (Hydrological Uncertainty)
- WWRP, High Impact Weather: AA 3 (Fully Coupled)
WWRP IP & WCRP Strategy

O2 - Advance predictive skill on sub-decadal timescales

- WWRP, High Impact Weather: AA 6 (Attribution)
- Methodologies for climate extremes, detection and attribution
- Understand the impact of resolution on sub-seasonal to decadal prediction
- Scientific understanding of sources of shorter time scale predictability
- WWRP, High Impact Weather: AA 2 (Uncertainty)
- Determine the level of complexity needed for seamless prediction from short range to decadal time scales
- WWRP, High Impact Weather: AA 3 (Fully Coupled)
- Improve our ability to simulate and predict modes of variability, such as ENSO
- WWRP, Evolving Technologies: AA 14 (Advanced Methods), AA 17 (New Observations)
- Regional and global climate model development
- Advance science for coupled data assimilation and initialisation systems
- WWRP, High Impact Weather: AA 5 (Verification)
- Model Intercomparison projects and skill assessment
Topics for further interaction

• Advancing modeling and observations
  – Research to define future observing systems must consider needs for weather, climate, and the environment
  – Process oriented activities - How to translate process understanding into predictive skill?
• Supporting development of joint research infrastructure and networks
  – Enhance access to observations and model output
  – Share data exploration tools
  – Ensure engagement of Early Career Scientists
• Strengthening regional activities
  – Sustained development requires working in partnership to enhance regional capacity
  – Societal impacts depend crucially on regional characteristics
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There is a need for co-design of science activities to make needed advances in our science and its service for society, and a need to coordinate WCRP and WWRP activities to make the most efficient use of available resources. Such coordination and co-design avoids unnecessary duplication of effort and brings to bear the diverse talents of our respective communities to tackle some of humanity’s most vexing environmental challenges.
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Thank you

Merci