WORLD CLIMATE RESEARCH PROGRAMME

Lighthouse Activity on Explaining and Predicting Earth System Change

Rowan Sutton, Kirsten Findell, Nico Caltabiano

With thanks to all members of EPESC SSG

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WCRP Structure

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International Science Council

Joint Scientific Committee (JSC)

WCRP Secretariat

Lighthouse Activities

International Offices

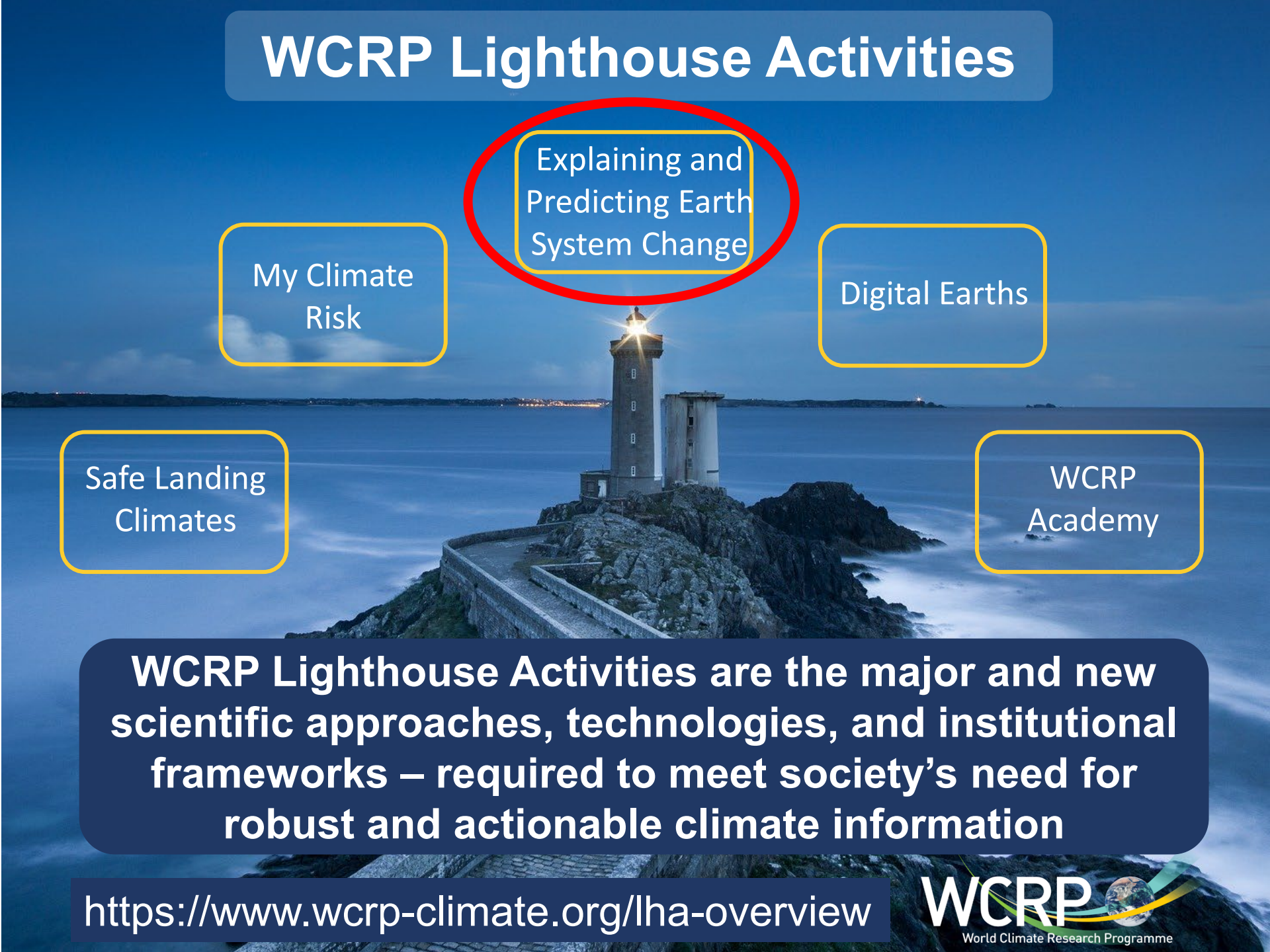
Core Projects and Research Communities

- Climate and Cryosphere (CliC)
- Global Energy and Water Exchanges (GEWEX)
- Climate and Ocean Variability, Predictability and Change (CLIVAR)
- Stratosphere-troposphere Processes And their Role in Climate (SPARC)
- *Earth System Modelling and Observations (ESMO)*
- *Regional Information for Society (RIfS)*

Ongoing Activities and Fora

- Fixed-term projects
- Conferences and workshops
- Reference datasets, evaluations and benchmarking
- Diversity and capacity building: ECRs, regions
- Rapid updates, syntheses, assessments, gap analysis
- Communications and outreach

WCRP Lighthouse Activities



WCRP Lighthouse Activities are the major and new scientific approaches, technologies, and institutional frameworks – required to meet society's need for robust and actionable climate information

https://www.wcrp-climate.org/lha-overview

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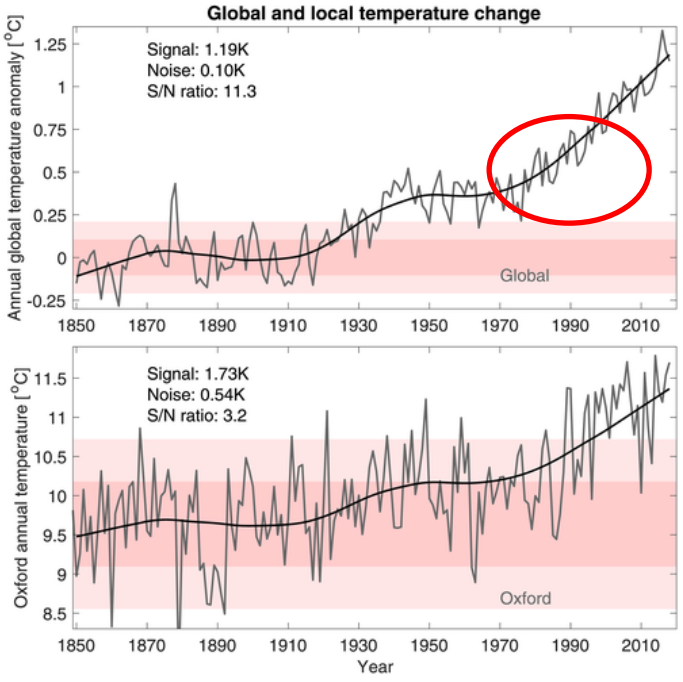
WCRP Lighthouse Activity on Explaining and Predicting Earth System Change

The signal of anthropogenic climate change is emerging progressively from the background of natural variability. ***Yet capabilities for quantitative explanation and prediction of changes on these timescales are exceedingly primitive*** (e.g. “hiatus”)

We are particularly poor at explaining changes in dynamical variables, e.g. atmosphere and ocean circulation
- These play a key role in shaping hazards



Hawkins et al, GRL (2020)

Overarching objective

To design, and take major steps toward delivery of, an integrated capability for quantitative observation, explanation, early warning and prediction of Earth System Change on global and regional scales and multi-annual to decadal timescales *(“EPESC scales”)*

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LHA Structure

SSG Co-chairs:
Kirsten Findell & Rowan Sutton

Explaining and Predicting Earth System Change
Lighthouse Activity

Scientific Steering Group

Working Group I	**Working Group II**	**Working Group III**
Observing and Modelling Earth System Change	Integrated Attribution, Prediction and Projection	Assessment of current and future Hazards
WGI Co-chairs: Patrick Heimbach, Anca Brookshaw	WGII Co-chairs: Doug Smith, Scott Osprey	WGIII Co-chairs: Zhuo Wang, James Risbey

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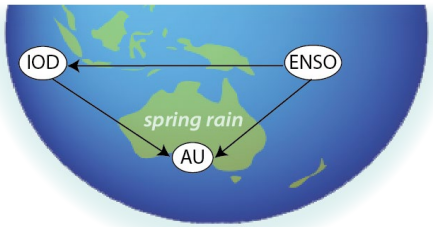
Outputs
Societal benefits

Integration

Inputs

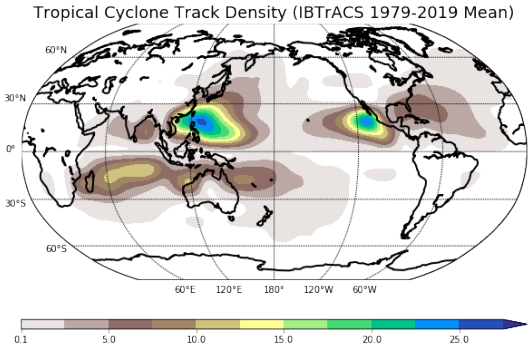
Process understanding

Causal explanations



Predictions and early warnings

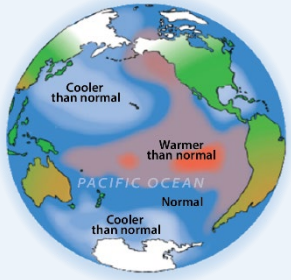
Theme 3
Hazard assessments



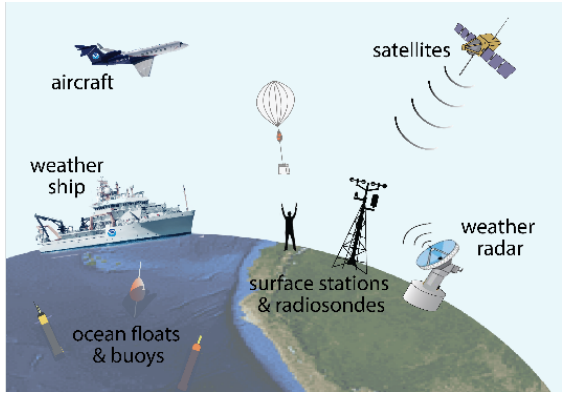
Sources of Decadal Variability

Theme 2
Integrated attribution, prediction and projection

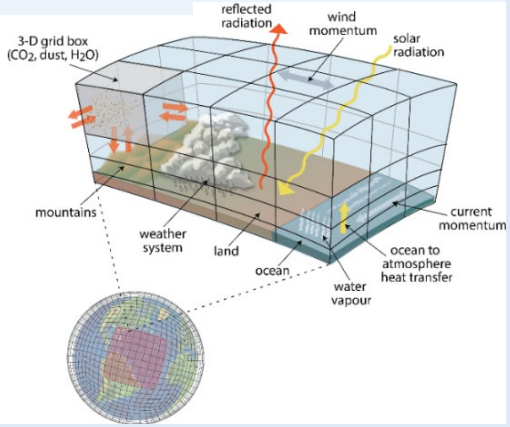
Anthropogenic
GHG emissions,
Aerosol emissions,
Ozone changes,
Land use change



Natural
Volcanoes,
Solar irradiance,
Internal variability

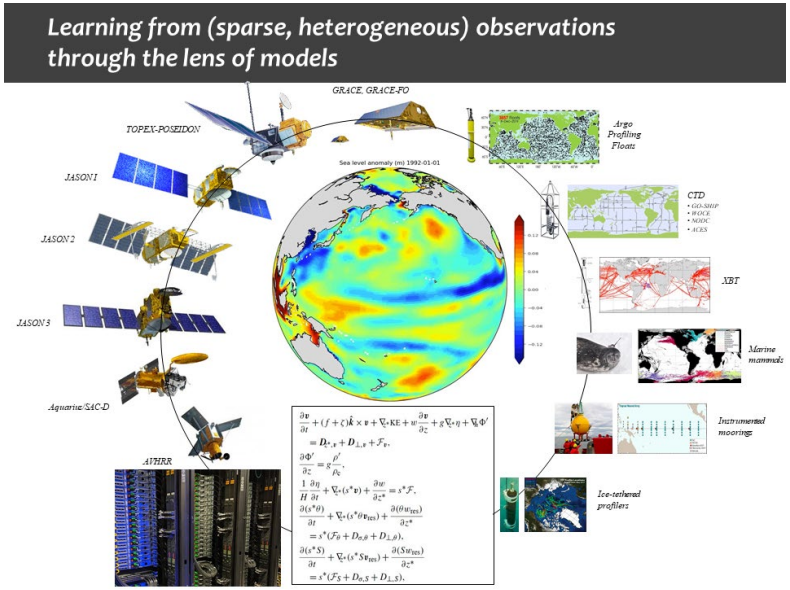


Theme 1
Observing, modelling, and optimal estimation systems



WCRP LHA EPESC – Theme 1
Monitoring and modelling Earth system changes

How can we most effectively combine observations and models to quantify, explain and predict changes in the Earth system on EPESC scales?



Some identified Gaps:

1. Persistent biases in model simulations
2. Under-utilization of diverse observational data
3. A disconnect between Earth system reanalysis and climate modelling

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Proposed Activities:

Select (small) number of cases, develop process study to understand

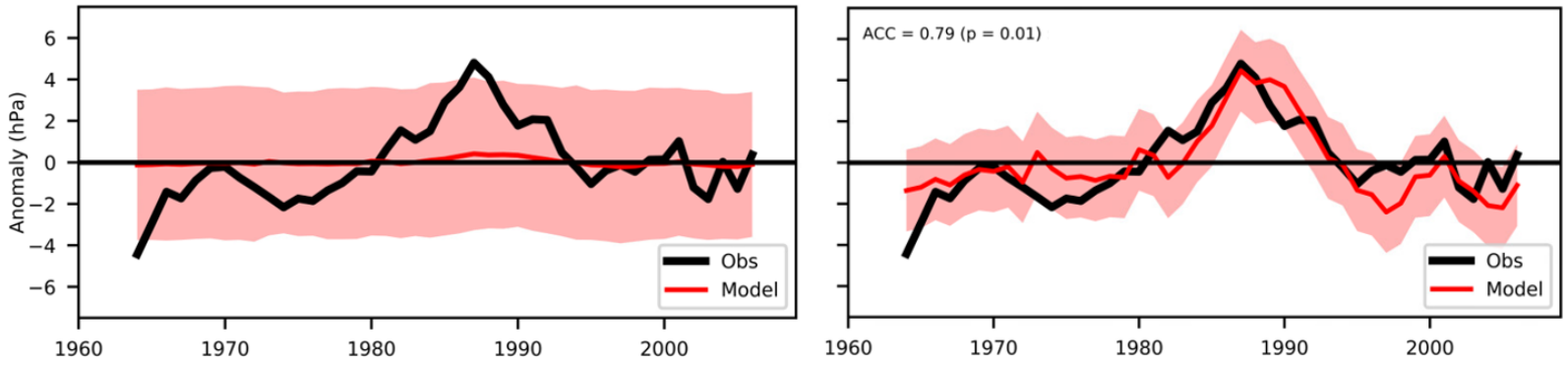
1. How early were these "events" recognized as such;
2. How well monitored by different elements of GCOS and GOOS (highlighting the ocean, where sparse sampling remains a major issue);
3. How well were underlying metrics constrained (e.g., regional vs. global heat content anomalies; global mean values as small residuals of large regional variations; …);
4. Performance of "models" & DA in representing these events, in particular
   - Earth system/climate models
   - Earth system reanalyses

Integrated Attribution, Prediction and Projection

Climate models underestimate atmospheric circulation signals from sub-seasonal to decadal predictions, and historical projections.

E.g., NAO ensemble mean has little signal and high uncertainty but high correlation skill (0.79) between the forecast ensemble mean and the observations

Ensemble mean forecasts scaled to match the observed variance clearly capture the observed changes.



Adapted from Smith et al. (2020)

WCRP LHA EPESC – Theme 2
Integrated Attribution, Prediction and Projection

- How can we best identify and attribute the drivers of changes in the Earth system on EPESC scales?
- How can we integrate attribution and prediction capabilities to provide seamless information to inform decision making?

Proposed Activity

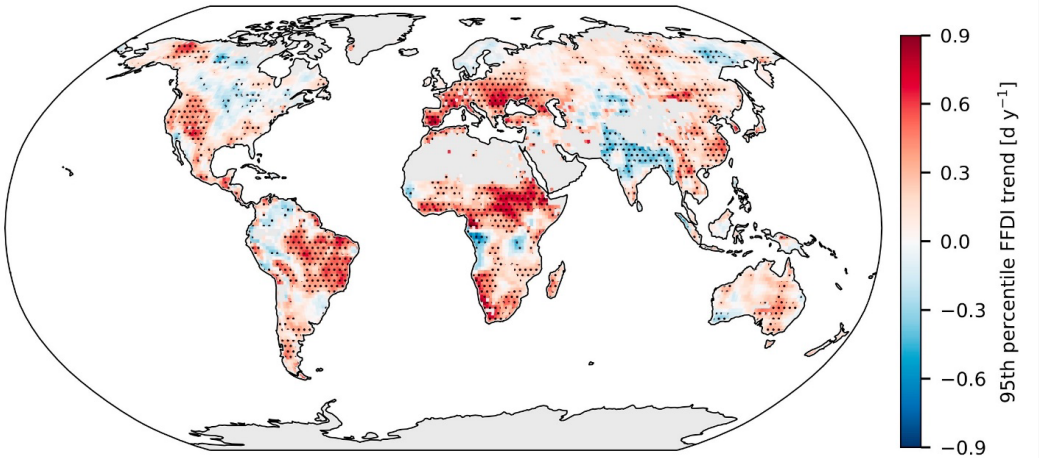
***Large ensemble single forcing experiments**. All experiments to cover the time period 1850 to 2020, and then to be extended with real time estimates of radiative forcings. All experiments are part of DAMIP (Gillett et al., 2016) except for hist-LU. Target ensemble size is 50 members for all simulations, with a minimum of 10 members.*

Experiment name	Description (*period 1850 to 2020*)
hist-GHG	Well-mixed greenhouse-gas-only historical simulations (WMGHGs)
hist-aer	Anthropogenic-aerosol-only historical simulations (BC, OC, SO2, SO4, NOx, NH3, CO, NMVOC)
hist-sol	Solar-only historical simulations (solar irradiance)
hist-volc	Volcanic-only historical simulations (stratospheric aerosol)
hist-stratO3	Stratospheric-ozone-only historical simulations (stratospheric ozone)
hist-LU	Historical simulations with only land use changes

WCRP LHA EPESC – Theme 3
Assessment of Current and Future Hazards

- How do internal variability and external forcings influence the characteristics and occurrence of meteorological hazards on EPESC scales in different regions?

- How can we use observations, models and process understanding to deliver robust assessments of current and future hazards for specific regions and classes of hazard?



Trend in the number of days per year between 1970 and 2020 for which the Forest Fire Danger Index (FFDI) exceeds the climatological 95th percentile. Adapted from Richardson et al. (2022).

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Take home messages

- The **WCRP Lighthouse Activities** are new frameworks for exciting science required to meet society's need for robust and actionable climate information
- The **Explaining and Predicting Earth System Change LHA** will work on an integrated capability for quantitative observation, explanation, early warning and prediction of Earth System Change
- **Integration** of observations and modelling, including DA
- **Focus** on classes of events rather than individual events
- **Contribute** to WMO State of Global Climate & Annual to Decadal Climate Update reports

Announcement

WCRP CORDEX

25-29 SEPTEMBER 2023 TRIESTE, ITALY

ICRC-CORDEX 2023

International Conference On Regional Climate

Themes of the conference

- **Coordination of strategies and methods**
- **Modelling across scales**
- **The relevance of CORDEX to society - connecting climate science with solutions**

In-person and online attendance, **25-29 September 2023.**

Main venue

The Abdus Salam International Centre for Theoretical Physics

ICTP in Trieste, Italy. Call for regional hubs.

The way forward, CORDEX contributions to the WCRP Open Science Conference in October, specific regional challenges and so-lutions, needs for National Adaptation Plans and climate financing.

Knowledge needs to be shared > bridge to action!

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Announcement

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