WORLD CLIMATE RESEARCH PROGRAMME

Lighthouse Activity on Explaining and Predicting Earth System Change (EPESC)

Co-chairs:
Rowan Sutton, NCAS & U. Reading, U.K.
Kirsten Findell, NOAA/GFDL, U.S.A.

WMO UNESCO INTERNATIONAL COUNCIL FOR SCIENCE WCRP World Climate Research Programme

WCRP Lighthouse Activity on Explaining and Predicting Earth System Change

Motivation

- Capabilities for quantitative explanation and prediction of changes on multi-annual to decadal timescales are primitive (e.g., “hiatus”; heat waves, regional detail; …)
- The formulation of robust policies for mitigation of, and adaptation to, climate change *requires quantitative understanding of how and why specific changes are unfolding* in the Earth system.
- Quantitative, process-based explanation (attribution) of observed changes is essential for quantifying current risks and fundamental to confidence in climate predictions and projections.

WMO UNESCO INTERNATIONAL COUNCIL FOR SCIENCE WCRP World Climate Research Programme

WCRP Lighthouse Activity on Explaining and Predicting Earth System Change

Overarching objective of EPESC

- ***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 <u>global and regional space</u> and <u>multi-annual to decadal time scales.</u>***

- *Examples: "hiatus", changes in IPO phase, changes in AMOC, rapid regional ocean warming, marine heatwaves, persistent drought.*

- *Changes in ocean and atmosphere circulation and their influence on hazards is a specific focus – key issue for adaptation.*

Science Plan Structure

Theme 1: Monitoring and modelling Earth System Change

- Observational and modelling requirements to monitor, explain and predict earth system change
- Convergence between climate modelling and Earth system data assimilation & reanalysis

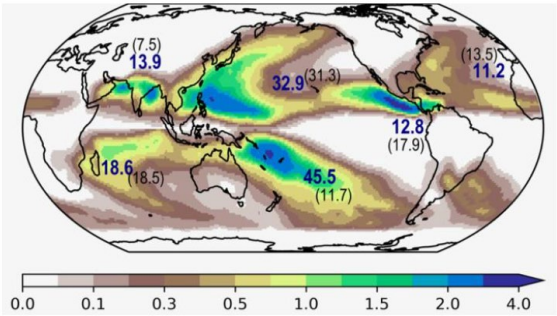
Theme 2: Integrated attribution, prediction, projection and early warning

- Quantitative process-based attribution of Earth System Change
- Integrated attribution, prediction and projection (building on GC in NTCP) including signal-to-noise "paradox"
- Contribute to WMO State of Global Climate & Annual to Decadal Climate Update reports
- Early warning of major changes – collaboration with SLC

Theme 3: Assessment of Current and Future hazards

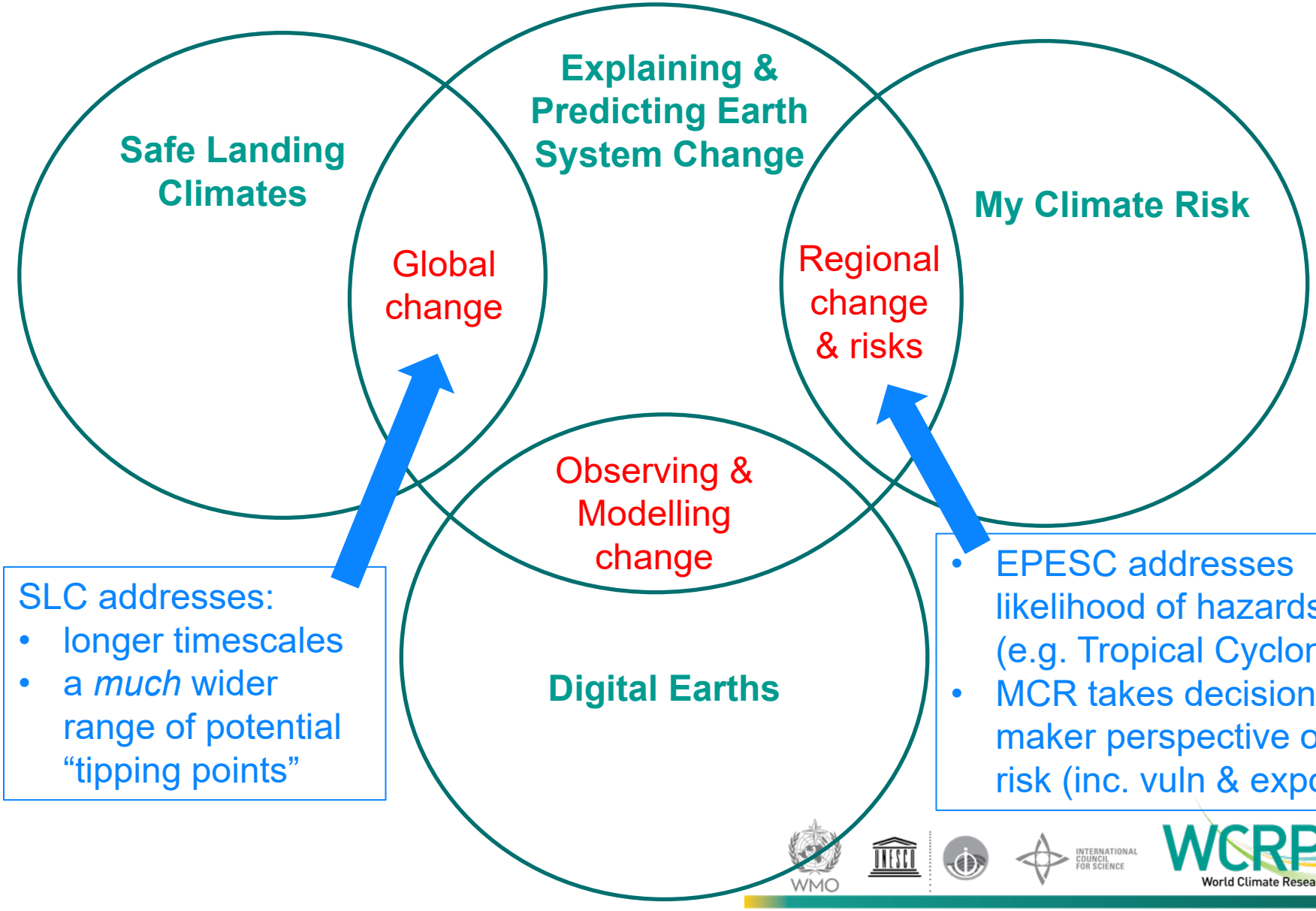
- Focus on classes of events rather than individual events
- Understanding the natural and anthropogenic drivers of changing hazards in different regions; extending "event attribution" methodologies
- Collaboration with My Climate Risk & RifS

Simulated Tropical Cyclone Track density



WMO UNESCO INTERNATIONAL COUNCIL FOR SCIENCE WCRP World Climate Research Programme

Collaboration with other LHAs



SLC addresses:
- longer timescales
- a *much* wider range of potential "tipping points"

- EPESC addresses likelihood of hazards (e.g. Tropical Cyclones)
- MCR takes decision-maker perspective on risk (inc. vuln & expo)

WMO UNESCO INTERNATIONAL COUNCIL FOR SCIENCE WCRP World Climate Research Programme

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

A: Monitoring and observing Earth System change

B: Modelling Earth System change

We propose that these should be considered jointly!

Possible partners:

1. WCRP Models & Data
2. WCRP LHA Digital Twins Earth
3. WDAC, WMAC
4. GCOS, GOOS

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

Working Group members:

Johanna Baehr	University of Hamburg, Germany
Anca Brookshaw (Co-Lead)	ECMWF, UK
Lijing Cheng	IAP, China
Maria Paz Chidichimo	CONICET, Argentina
Patrick Heimbach (Co-Lead)	University of Texas at Austin, USA
Hans-Werner Jacobi	Université Grenoble Alpes / CNRS, France
Paul Kushner	University of Toronto, Canada
Feiyu Lu	NOAA/GFDL, USA
Benoit Meyssignac	LEGOS, Toulouse, France
Andrea Storto	CNR ISMAR, Italy
Isabel Trigo	Instituto Português do Mar e da Atmosfera, Portugal

WMO UNESCO INTERNATIONAL COUNCIL FOR SCIENCE WCRP World Climate Research Programme

Identified Gaps:

1. Persistent biases in model simulations, model error accumulation over time unclear;
2. Under-utilization of diverse observational data from GCOS and GOOS *to inform* (rather than "*assess*") climate models & calibration, which may alleviate climate model biases;
3. A disconnect between Earth system reanalysis and climate modelling, and/or data assimilation efforts/approaches that are not necessarily targeting major needs (e.g., initial condition estimation versus model parameter calibration);

Identified Gaps (continued):

4. Sparse observational sampling of parts of the Earth system, in particular the ocean, which warrants extra care in using the observations that do exist in the context of modelling; quantitative observing system design for climate;
5. At the present time, only simple, ad-hoc approaches at dealing with the combined stream of diverse sources of uncertainties from observations and models.

Proposed Activities:

Select (small) number of examples of climate anomalies that have occurred over the past 1 – 2 decades, develop (process) studies to understand, among others,

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; …);

Proposed Activities (continued…):

4. Do observations enable mechanistic understanding of anomaly propagation/evolution, in particular, observational coverage of "upstream"/back-in-time processes that led to the "events" of interest?
5. What methods could inform quantitative observing system design?
6. Performance of "models" & DA in representing these events, in particular
   - Earth system/climate models
   - Earth system "reanalyses"

Final thoughts:

- Observing networks under GCOS & GOOS play major role
- Need for developing /maturing coupled *Earth system DA for climate*
- incorporate ideas/approaches from coupled Earth System DA into comprehensive Earth system/climate model calibration and initialization
- Quantifying uncertainties in relevant climate metrics, based on observations, models, and synthesis / DA products, remains a grand challenge