Explaining and Predicting Earth System Change

43rd Session of the
WCRP Joint Scientific Committee

Kirsten Findell, Rowan Sutton & Nico Caltabiano

July 2022

Online

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Progress and achievements

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")*

- Update on our membership
- Our Working Groups, their objectives, interactions, and first tasks
- Near-term plans

Structure and Membership Update

SSG Co-chairs:
Kirsten Findell & Rowan Sutton

Explaining and Predicting Earth System Change Lighthouse Activity

Scientific Steering Group

Working Group I
Observing and Modelling Earth System Change

Working Group II
Integrated Attribution, Prediction and Projection

Working Group III
Assessment of current and future Hazards

WGI Co-chairs:
Patrick Heimbach
Anca Brookshaw

Plus
1 Member staying on
8 New members joining

WGII Co-chairs:
Doug Smith
Scott Osprey

Plus
6 Members staying on
11 New members

WGIII Co-chairs:
Zhuo Wang
James Risbey

Plus
2 Members staying on
6 New members joining

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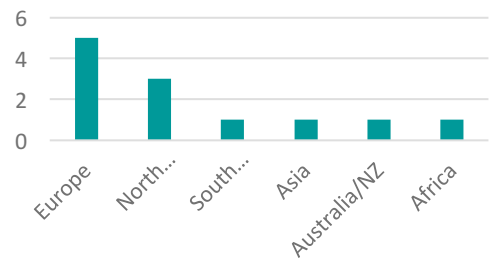
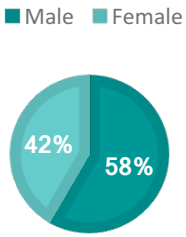
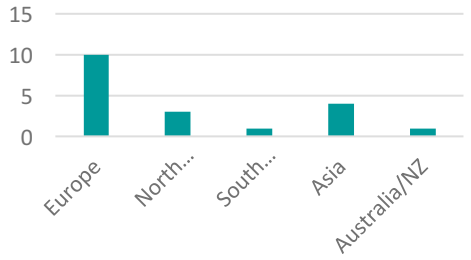
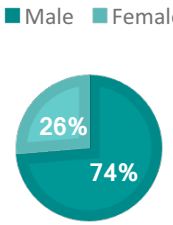
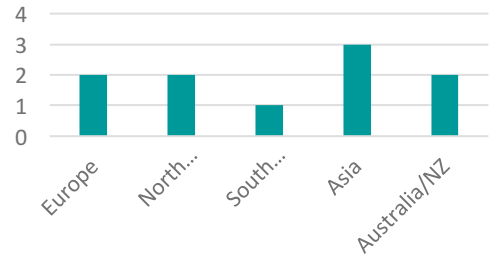
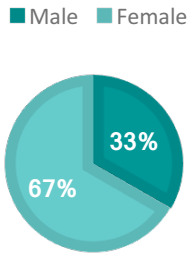
WGs Membership diversity

WORKING GROUP 1		
WORKING GROUP 2		
WORKING GROUP 3		

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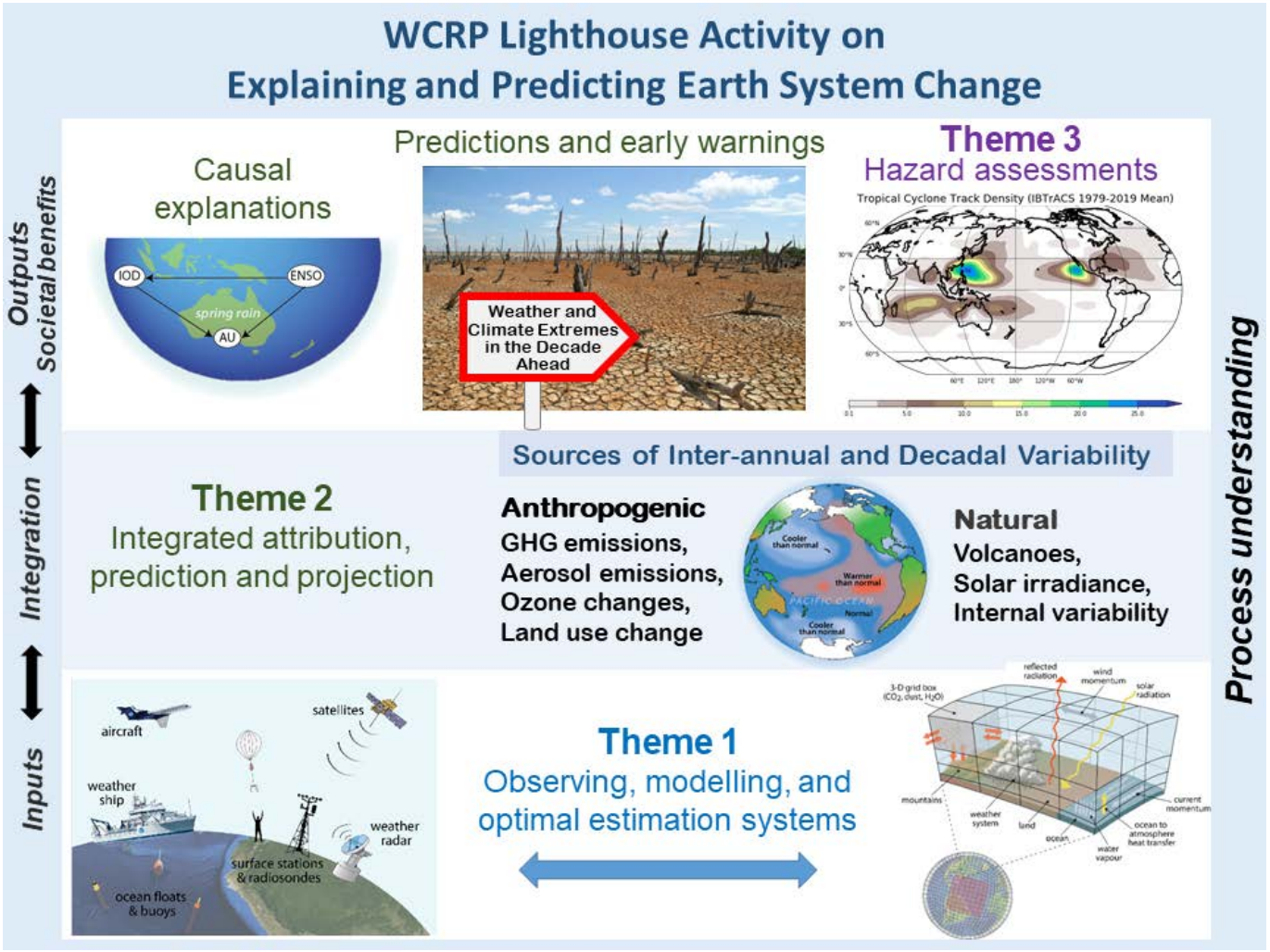
Explaining and Predicting Earth System Change: A World Climate Research Programme Call to Action



From Findell et al. 2022: an expansion of our LHA science plan submitted to *BAMS*

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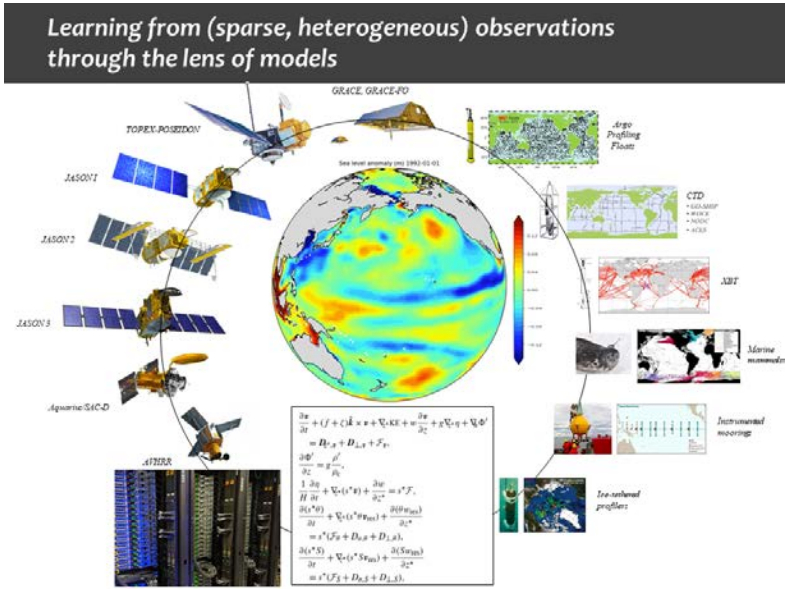
WCRP LHA EPESC – Theme 1
Monitoring and modelling Earth system change

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

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?

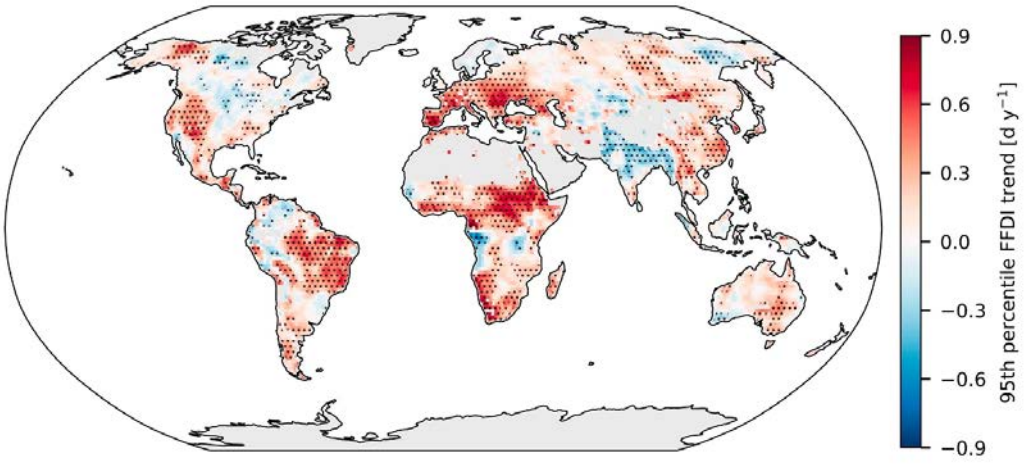
Activities:

- **WCRP Workshop on attribution of multi-annual to decadal changes in the climate system September 2021** - Report on LHA website
- **Large Ensemble Single Forcing Model Intercomparison Project (LESFMIP)** extension of DAMIP. Protocol paper by in review (Smith et al, 2022). 9 modelling groups already signed up.
  - Initial analysis to focus on explaining changes in SST with goal to provide attribution statements to WMO State of Climate and GADCU in April 2024.
  - Subsequent steps to address forcing & SST impacts on hazards, with WG3.
- **Exploring a Joint meeting with DCPP in Feb/Mar 2023**

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?

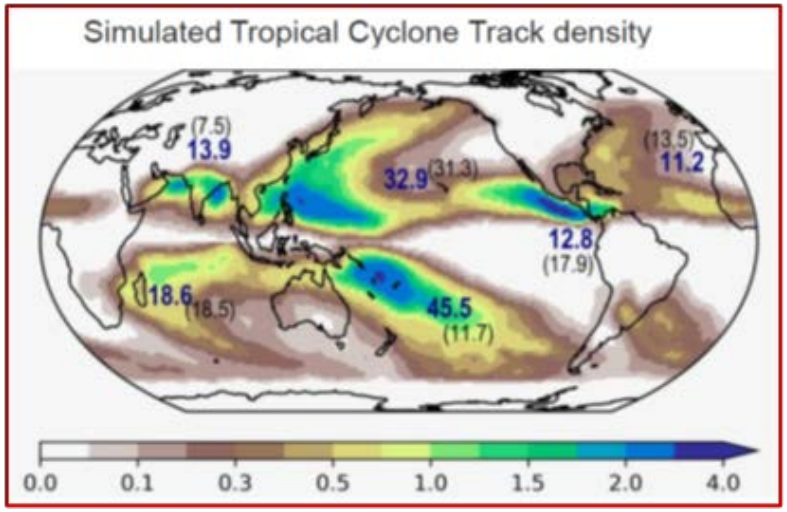


Trend in the number of days per year between 1970 and 2020 for which the Forest Fire Danger Index (FFDI) exceeds the climatological 95th percentile. Adapted from Richardson et al. (2022).

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

Approach:

- Exploit large ensembles (SMILES & LESFMIP) in collaboration with WG2
- Focus on a subset of hazards (e.g. TCs, heatwaves, droughts)



- Evaluation of hazard simulation (process & statistical, including biases)
- Assess hazard distributions and likelihoods
- Assess non-stationarity and changes in hazards; identify drivers
- Provide narrative understanding of hazard changes – storylines – ***opportunities for collaboration with My Climate Risk***
- Repeat for other hazards and draw lessons

Take home messages

- 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

Future plans

- **Lighthouse Activities:** (a) Summary of proposed key outcomes and impacts, including approximate timeline (b) How will your Lighthouse Activity work with the Core Projects and other Lighthouse Activities?
- Near-term outputs (2024 onwards):
  - contributions to WMO State of the Climate and Global Annual-to-decadal climate update reports
  - Advice to GCOS on observational requirements for explaining and predicting earth system change
  - Improved climate reanalyses
- Outcomes for society:
  - Quantitative processed based explanation of ongoing and emerging changes in the climate system
  - Understanding and quantification of changes in meteorological hazards on EPESC scales
  - Improved predictions and early warnings

Emerging issues

- Please let the JSC know of any emerging issues or problems that require action or the JSC to be aware of

- **Global Cycles**: Which group in WCRP should "own" explaining and predicting changes in the global carbon cycle (including initialized predictions) and how can this topic connect with other work on cycles?

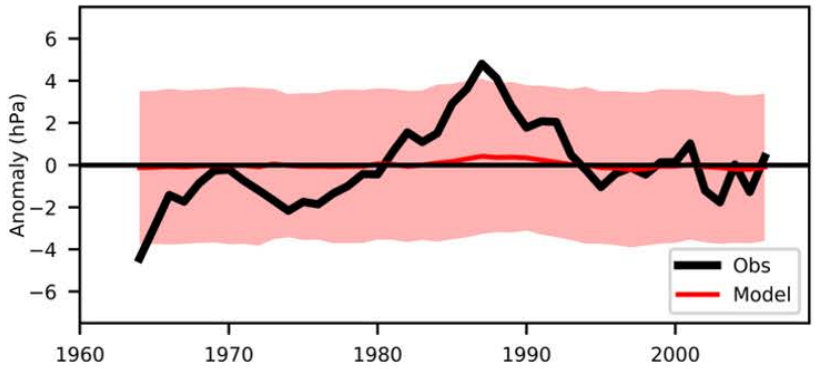
Additional Slides

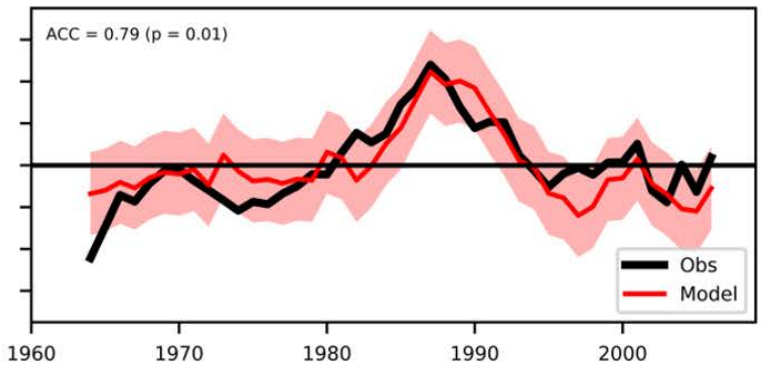
WCRP LHA EPESC – Theme 2
Integrated Attribution, Prediction and Projection

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)

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