WCRP Lighthouse Activity on Explaining and Predicting Earth System Change

June-Yi Lee

By Courtesy of Kirsten Findell and Rowan Sutton

WGSIP 24
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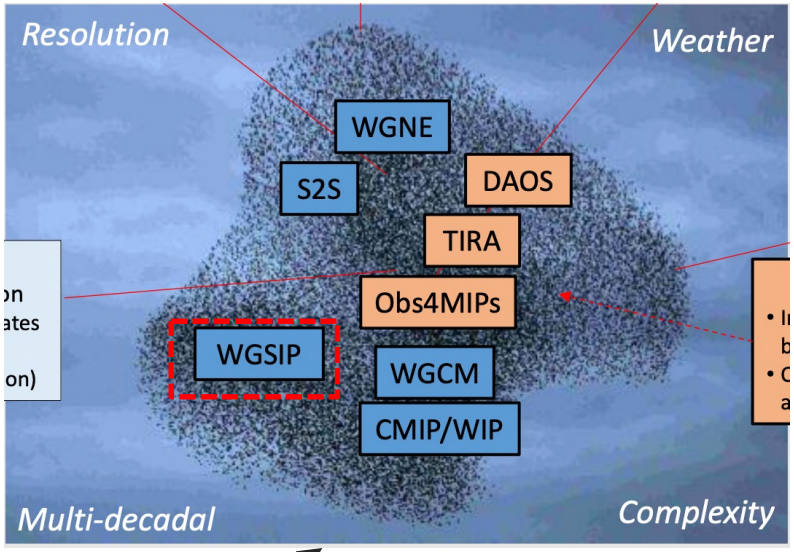
WGSIP, ESMO and EPESC



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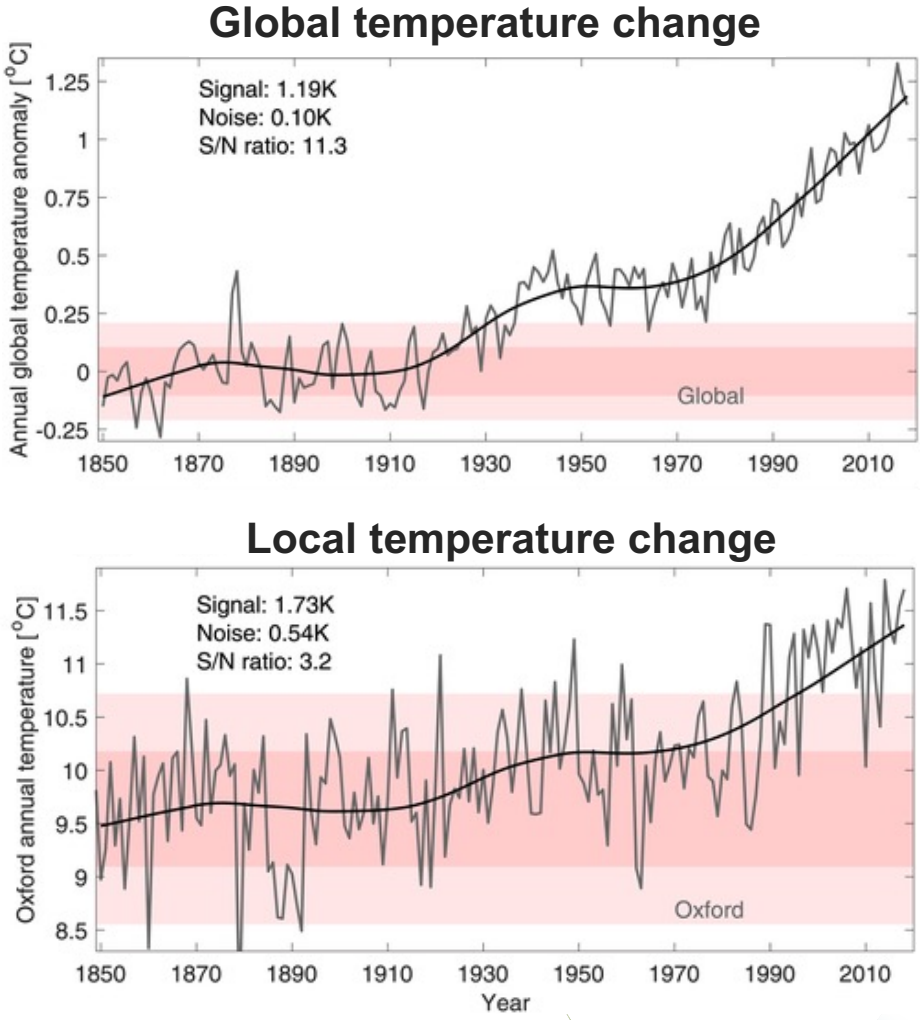
The **signal** of anthropogenic climate change is **emerging** progressively from the background of **natural variability**

- on multi-annual timescales,
- on progressively smaller spatial scales,
- in a greater range of variables.



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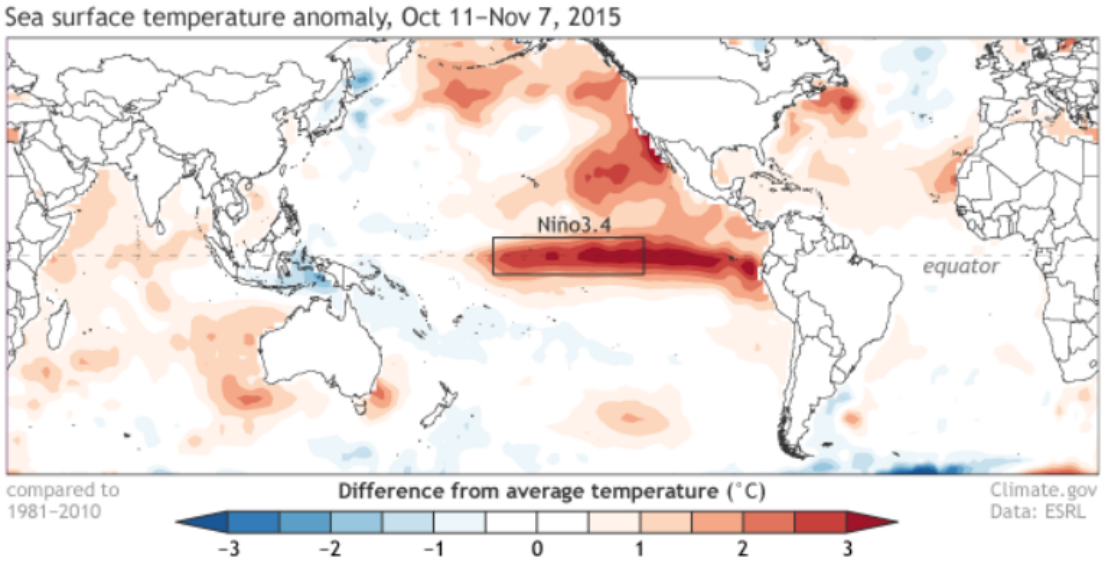
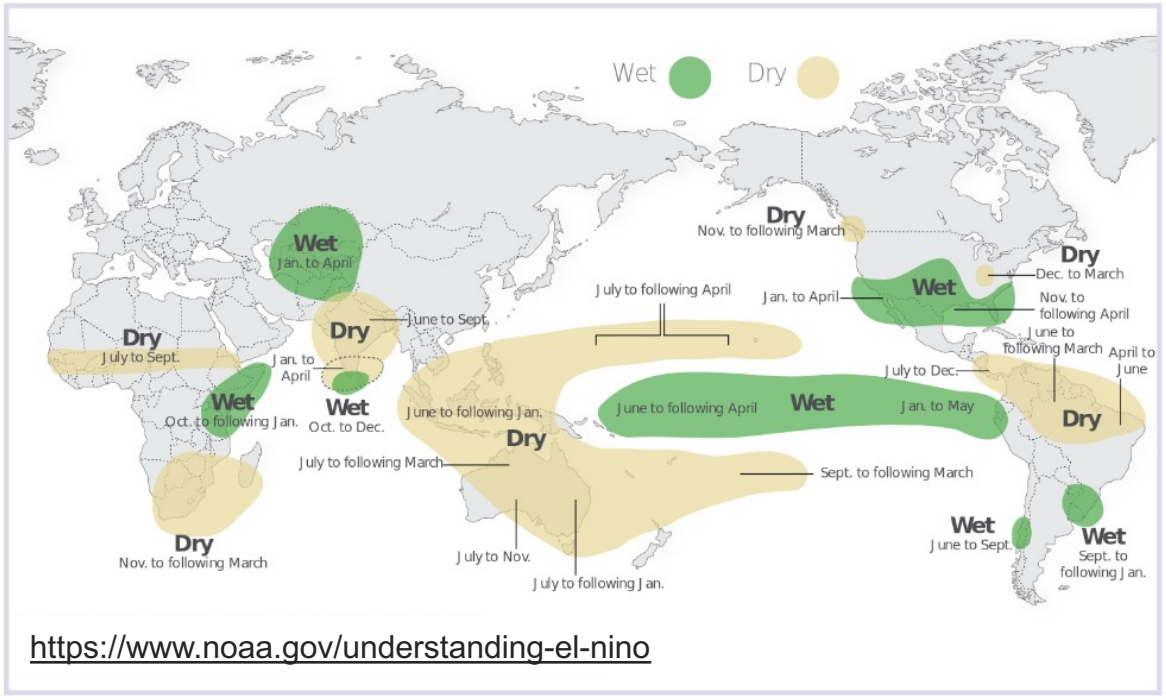


- *We know that changes in atmospheric and oceanic circulation patterns can have enormous impacts on weather and climate all over the world*

El Niño and Rainfall

El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.



https://www.noaa.gov/understanding-el-nino

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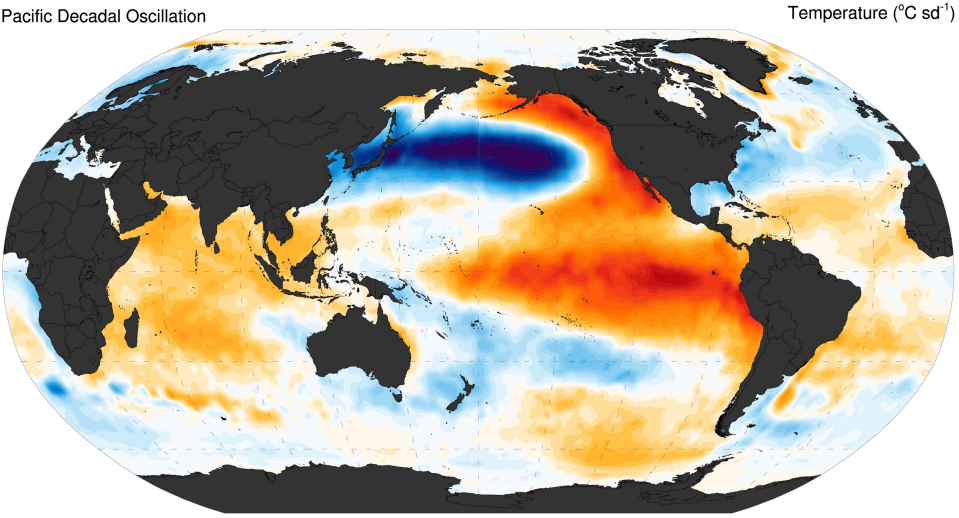
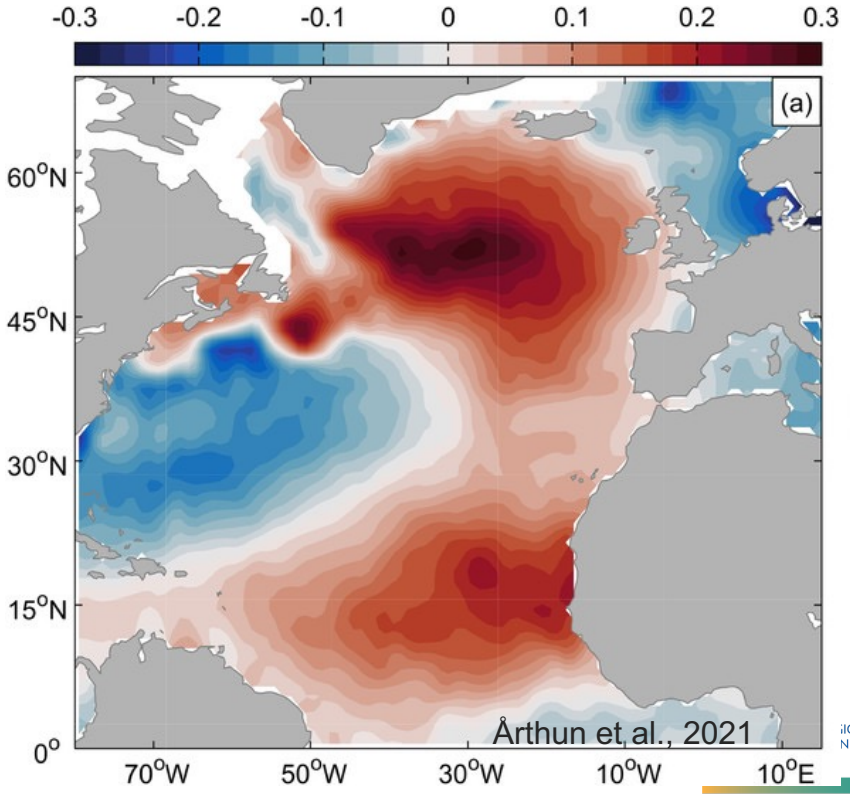
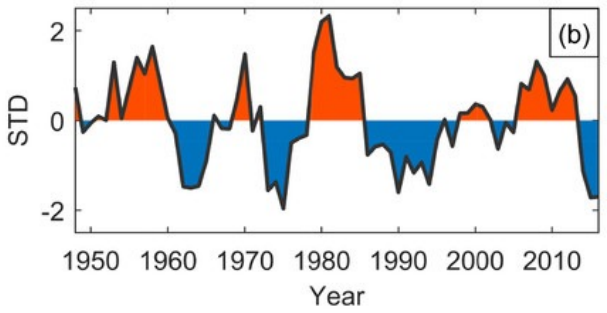


By Giorgiogp2 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=18754081

- *These play a key role in shaping extreme events and hazards*
- *Yet capabilities for quantitative explanation and prediction of changes on multi-annual timescales are limited*





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Explaining and Predicting Earth System Change

Overarching objective:

an integrated capability for quantitative observation, explanation, early warning and prediction of Earth System Change on global and regional scales and annual to decadal (A2D) timescales

We need these capabilities and knowledge *to inform adaptation and improve resilience*

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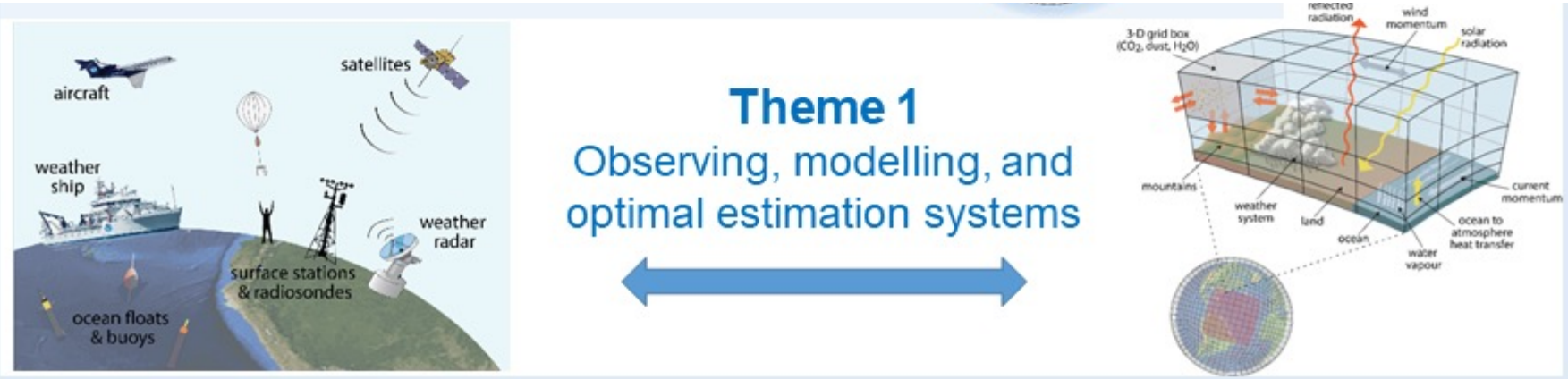
Theme 1:
Monitoring and Modeling Earth System Change

Co-leads: Anca Brookshaw (ECMWF, UK) and Patrick Heimbach (University of Texas at Austin, USA)

We seek **tighter integration of models and observations to monitor and understand Earth system change**



- How can we address persistent biases in model simulations?
- How can we address under-utilization of diverse observational data?
- Which enhanced observations will offer the greatest improvements in predictive and explanatory skill? Where should those enhancements be targeted?

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Theme 2:
Integrated Attribution, Prediction and Projection

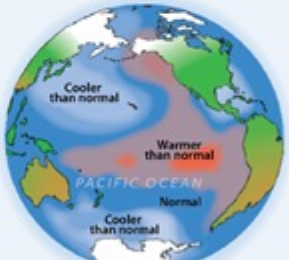
Co-leads: Doug Smith (Metoffice, UK) and Scott Osprey (University of Oxford, UK)

We seek to **identify and attribute the primary drivers of Earth system change on A2D scales** (e.g., anthropogenic vs internal sources of variability)

Theme 2
Integrated attribution, prediction and projection

Sources of Annual-to-Decadal (A2D) Variability

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



Natural
Volcanoes,
Solar irradiance,
Internal variability

- Advocate for the generation of large ensembles of single-forcing experiments
- The goal: to integrate attribution and prediction capabilities to provide seamless information for decision making

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Theme 3:
Assessment of Current and Future Hazards

Co-leads: Zhuo Wang (Illinois University, USA) and James Risbey (CSIRO, Australia)

We seek to **understand how internal variability and external forcings influence the characteristics and occurrence of meteorological hazards** on A2D scales in different regions

- Focus on a subset of hazards (e.g. tropical cyclones, heatwaves, droughts)
- Make use of large ensembles
- The goal: to use observations, models and process understanding to deliver robust assessments of current and future hazards for specific regions and hazard classes

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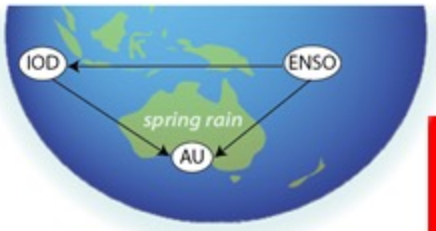
Outputs Societal benefits

Integration

Inputs

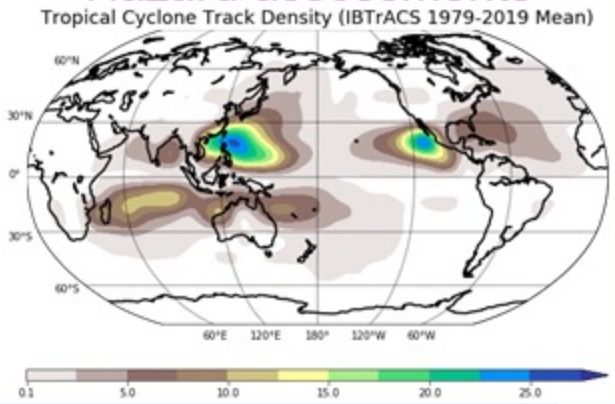
Process understanding

Causal explanations



Predictions and early warnings

Theme 3
Hazard assessments



Sources of Annual-to-Decadal (A2D) Variability

Theme 2
Integrated attribution, prediction and projection

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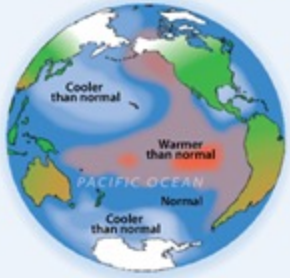

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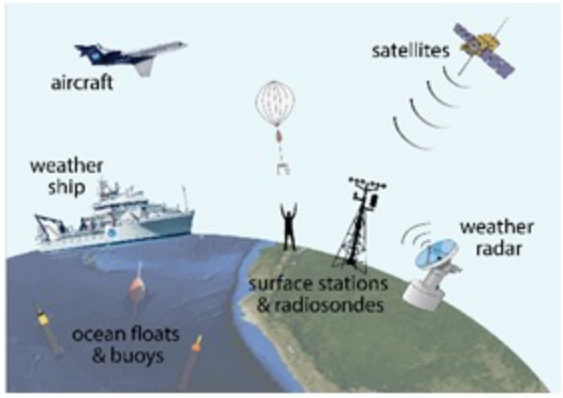
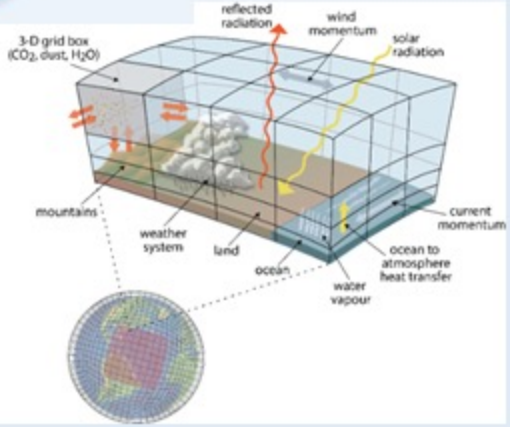


Theme 1
Observing, modelling, and optimal estimation systems



Findell et al. *BAMS*, 2022

Plans and Expected Outcomes

- 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

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Plans and Expected Outcomes

Benefits to society:

- Quantitative process-based explanation of ongoing and emerging changes in the climate system
- Understanding and quantification of changes in classes of meteorological hazards on A2D scales
- Improved predictions and early warnings

Nile Upper Egypt- Flickr/Michael Gwyther-Jones

These efforts will help us integrate attribution and prediction capabilities to provide seamless information for decision making for near-term climate needs

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