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Explaining and Predicting Earth System Change Lighthouse Activity

Explaining and Predicting Earth System Change

Scott Osprey,
on behalf of the EPESC SSG

WGSIP/WGNE Meeting - Joint Plenary Session
4 November 2024

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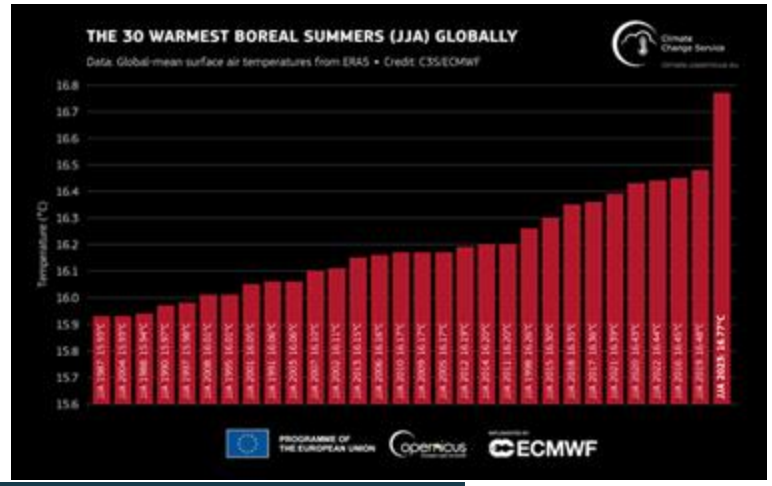
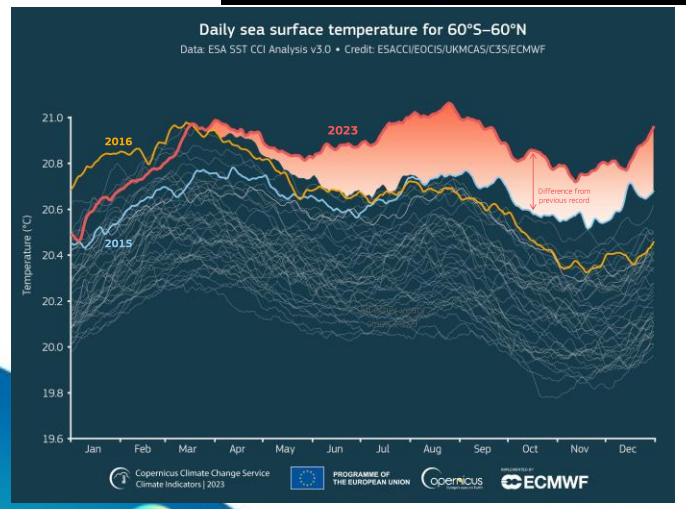
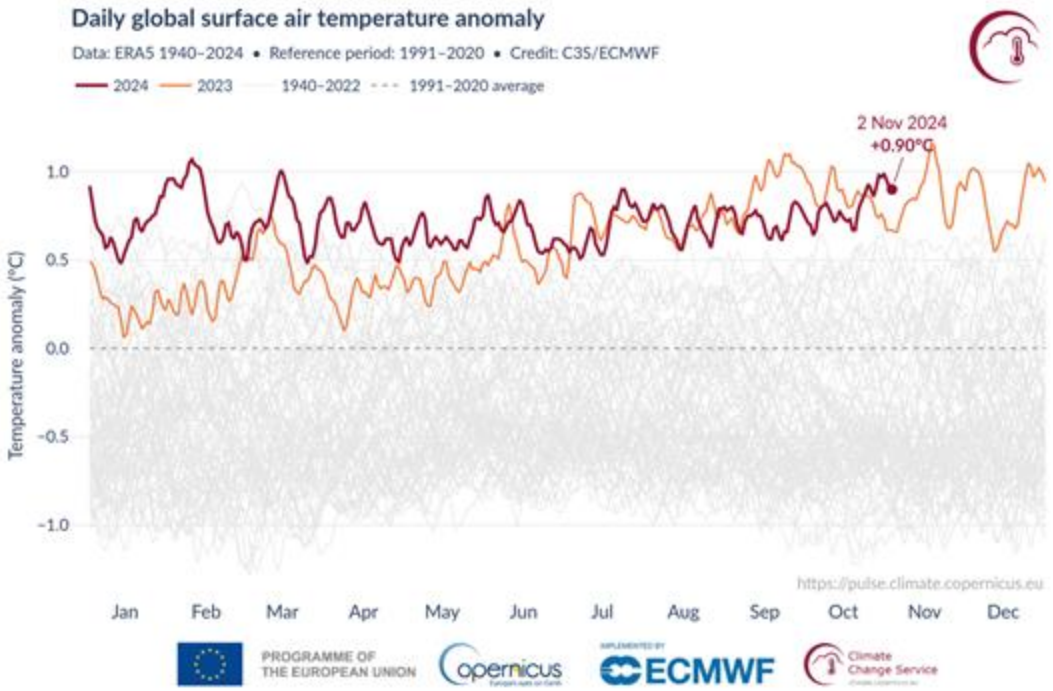
Why EPESC? – A timely reminder of our ignorance







- What were the short and long-term causes?
- Is this a one-two year anomaly or a lasting regime change?
- What are the immediate and longer-term impacts & implications?
- Why did we fail to predict it?

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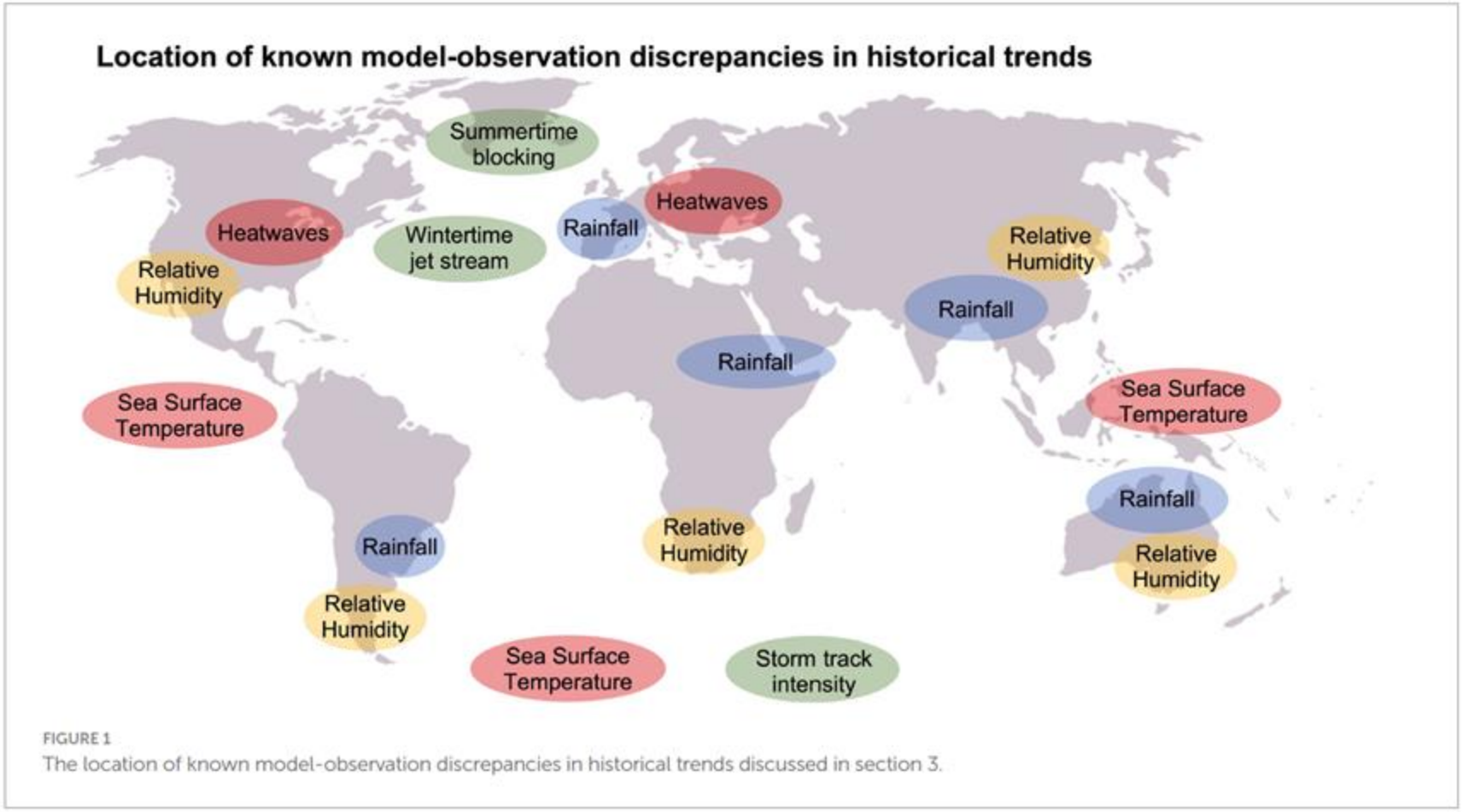

FIGURE 1
The location of known model-observation discrepancies in historical trends discussed in section 3.

Shaw et al., *Frontiers in Climate*, 2024

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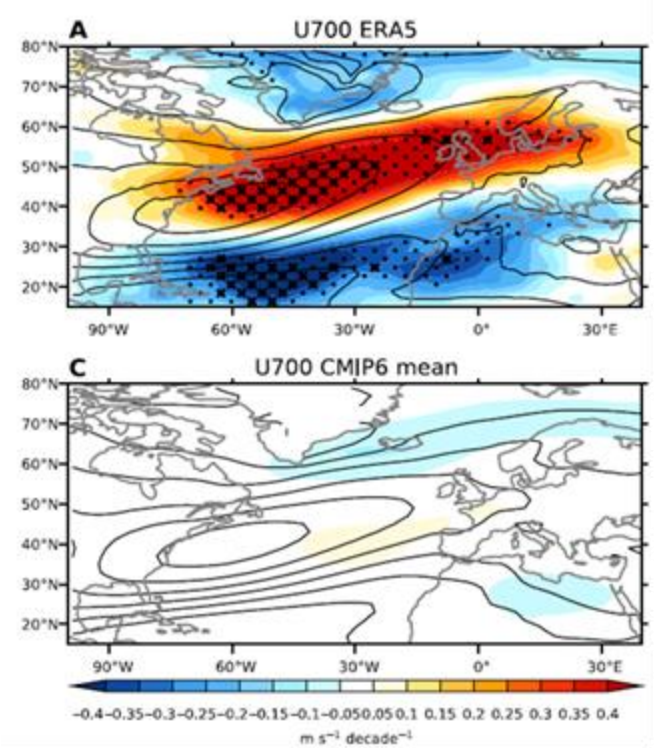
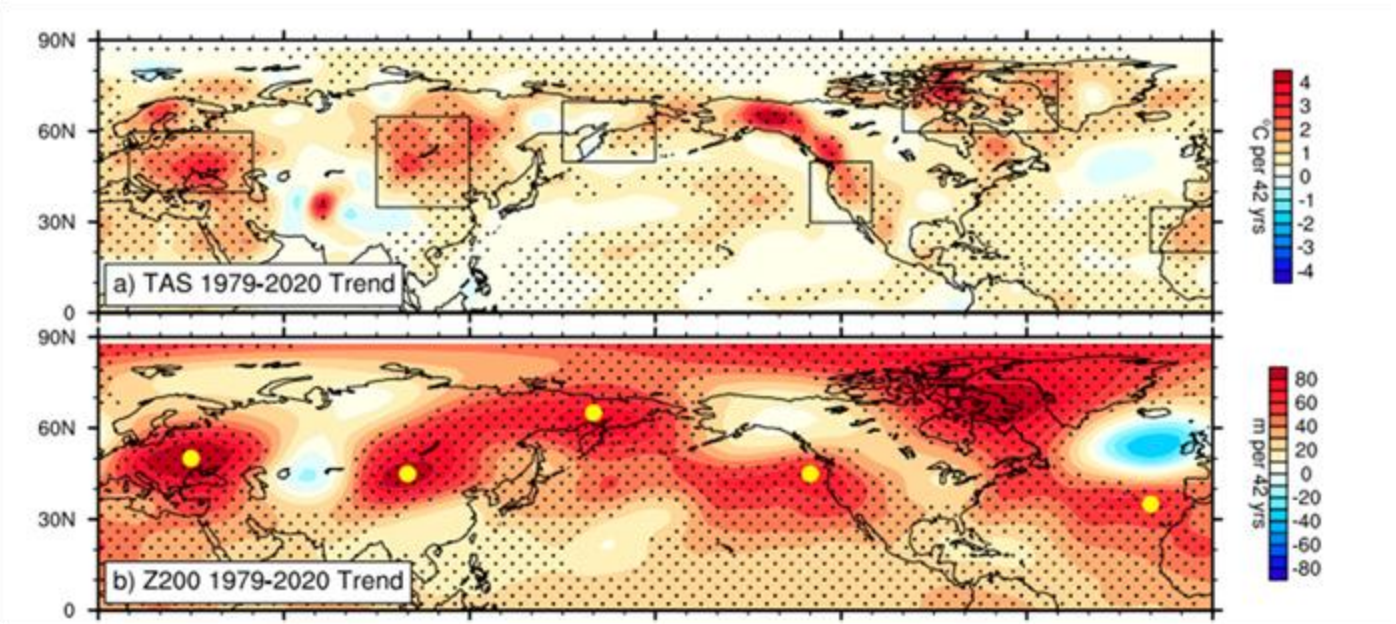
Challenges in understanding circulation change



1951-2020 winter trends

Blackport & Fyfe 2022



Summer Northern Hemisphere trends 1979-2020

Teng et al, 2022

Modelled circulation is equally uncertain - Challenging!

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Explaining and Predicting Earth System Change

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 annual to decadal (A2D) timescales

A specific priority is to understand ***A2D variability and change in atmosphere and ocean circulation and their influence on hazards***

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

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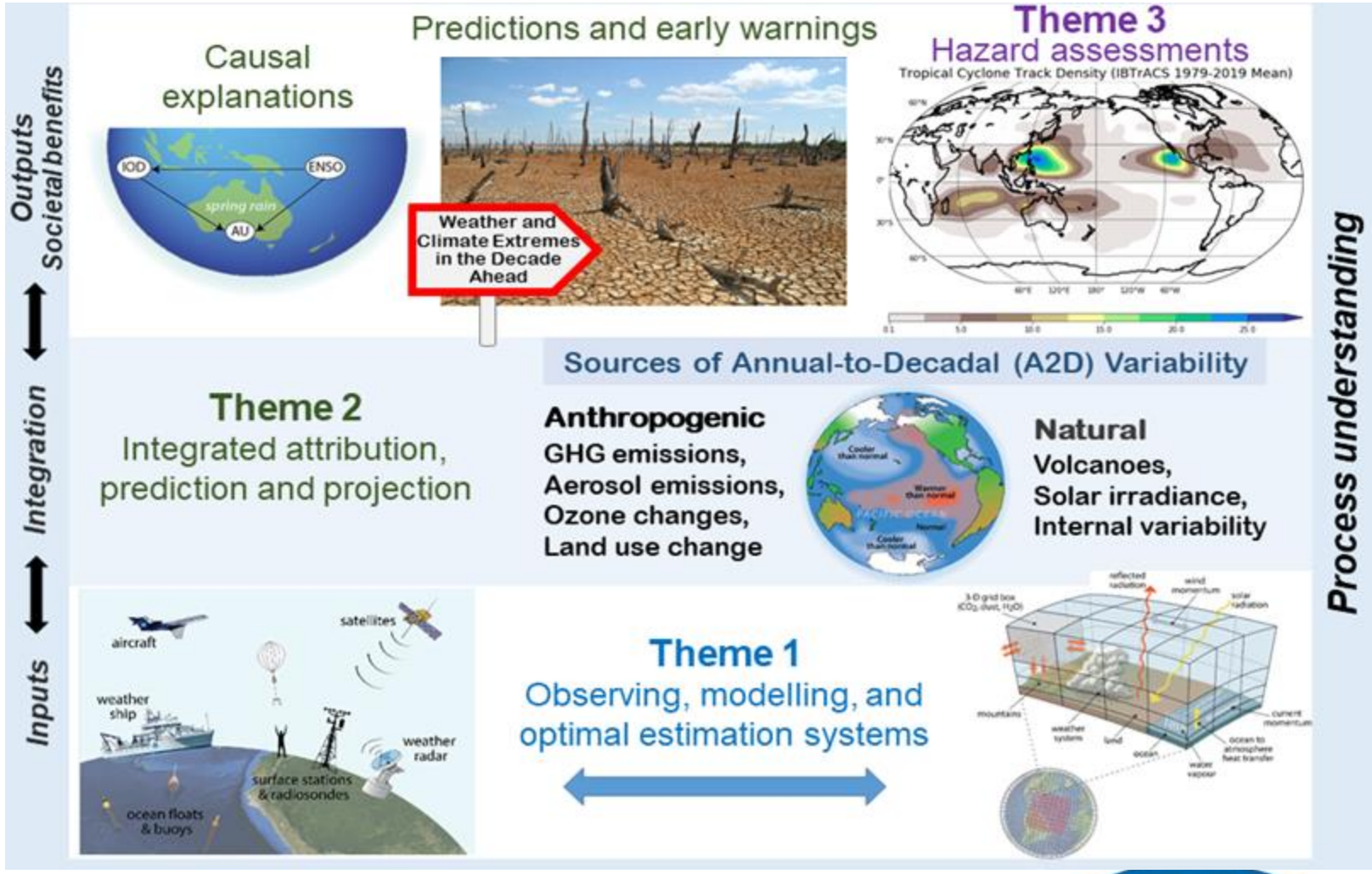
EPESC Structure

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
Co-chairs	Co-chairs	Co-chairs
Anca Brookshaw Paul Kushner	Doug Smith Scott Osprey	Zhuo Wang James Risbey
Erik Behrens	Andrea Steiner	Patrick Heimbach



Findell et al. *BAMS*, 2023

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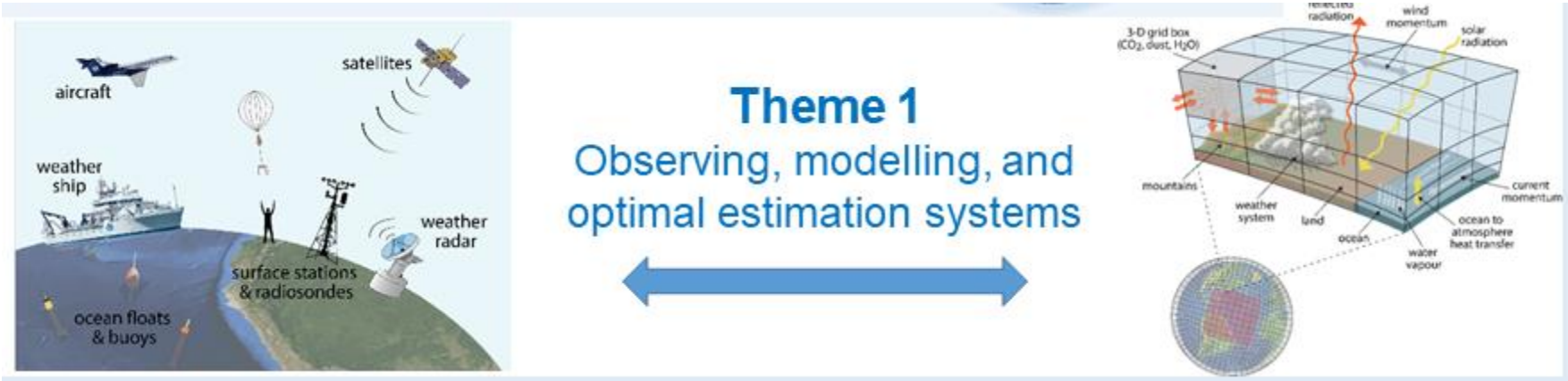
Theme 1:
Monitoring and Modeling Earth System Change

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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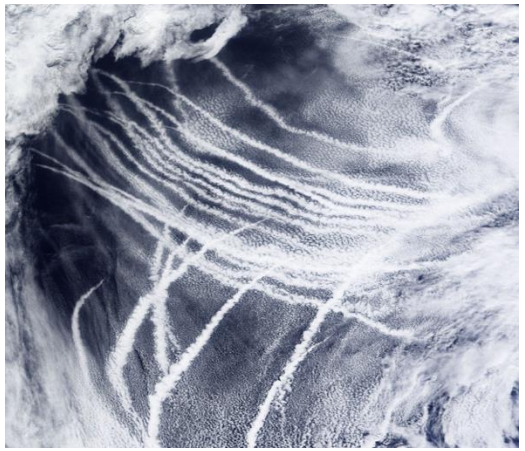
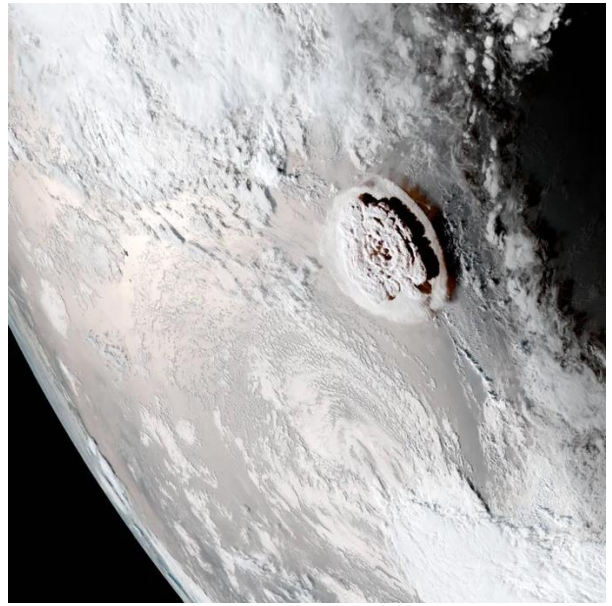
Upcoming Observations Gaps

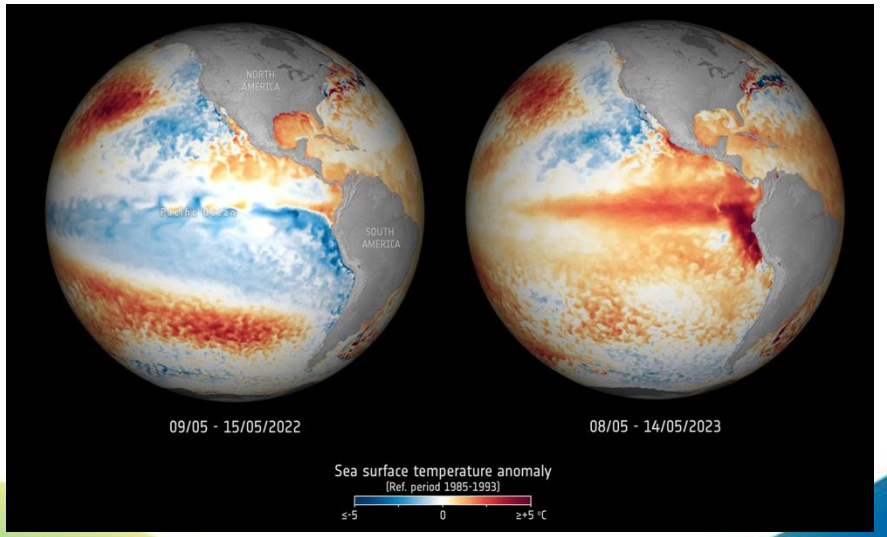
- Recent global surface temperature extremes have confounded attribution studies:
- Reduced marine stratocumulus from cleaner ship emissions
- Large El Nino event
- HT-HH eruption 2022
- General trend of GHG emissions
- Observations gaps will hinder extremes attribution and climate A2D forecasts (stratospheric water vapour, SLCF)
- Sustained observations required but not assured (e.g. ESA EE11 CAIRT)



Ship Emissions Regulations



Hunga Tonga – Hunga Ha'apai



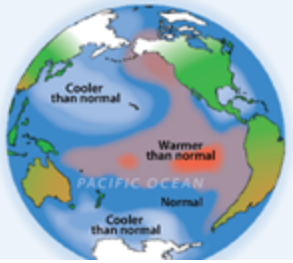
El Nino

Theme 2: Integrated Attribution, Prediction and Projection

Theme 2
Integrated attribution, prediction and projection

Sources of Annual-to-Decadal (A2D) Variability

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



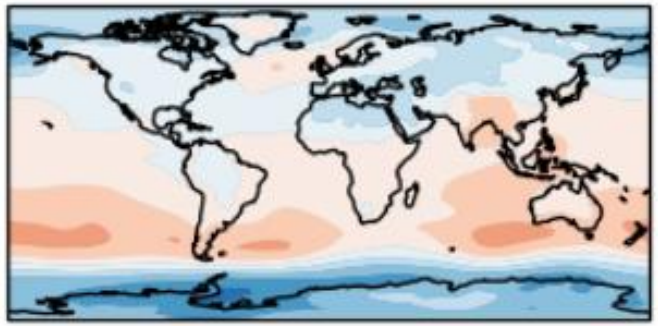
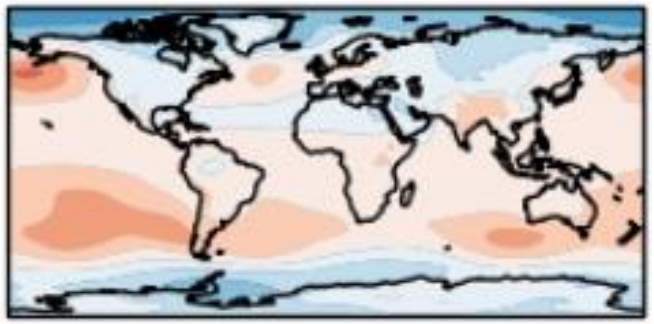
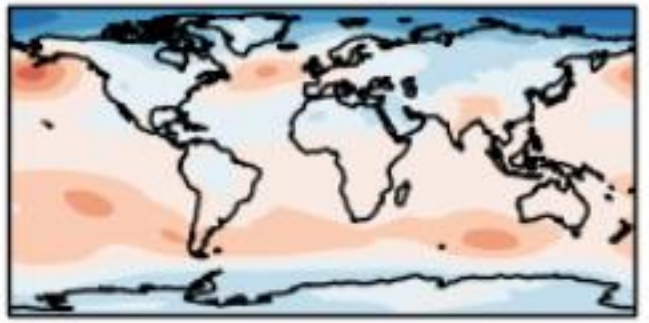
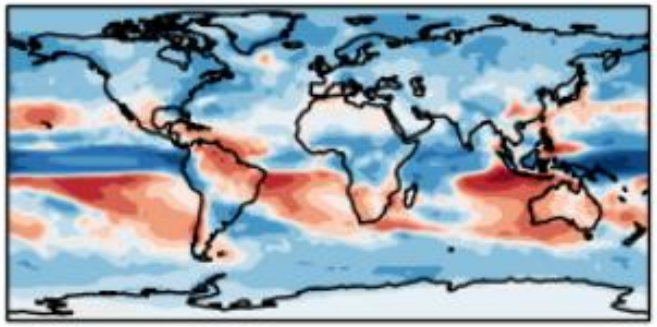
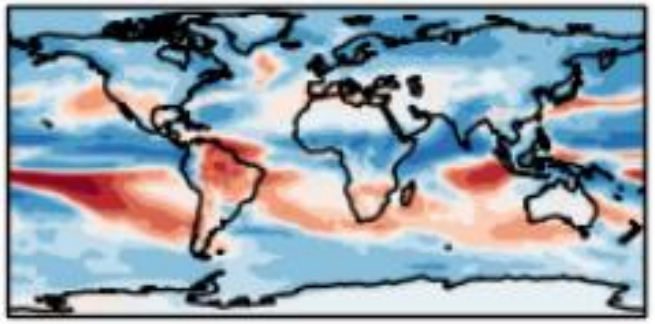
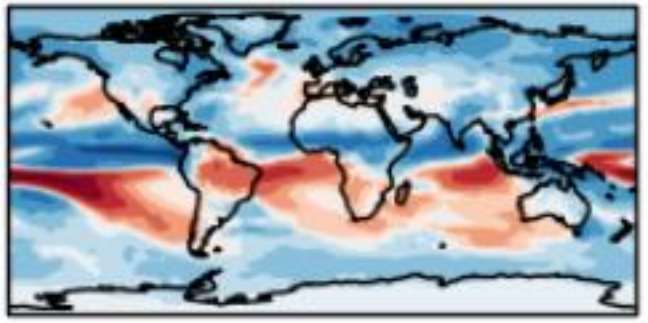
Natural
Volcanoes,
Solar irradiance,
Internal variability

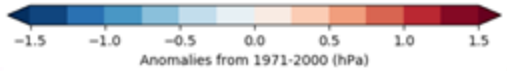
Overall WG2 objectives:

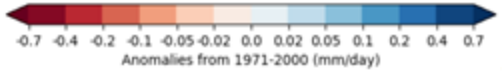
- To provide a **process-based** understanding of recent multi-annual to decadal climate changes and quantify the roles of **internal variability** and **external drivers** including **greenhouse gases, aerosols, solar, volcanoes, ozone, land-use**...
- Assess predictability, sources of skill, drivers and mechanisms – hence gain **confidence in predictions and projections**
- Make regular inputs to **WMO Global Annual to Decadal Climate Update** and **WMO State of Climate** reports

Multi-annual forecasts

WMO Lead Centre for
Annual-to-Decadal Climate Prediction

	2019-2023	2020-2024	2021-2025
Pressure			
Precipitation			





Consistent forecasts for the coming 5 years

What drives the signals?

How much confidence do we have?

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WG 2: Integrated Attribution, Prediction and Projection

The over-arching priority is to understand trends and A2D variability in atmosphere or atmosphere-ocean circulation

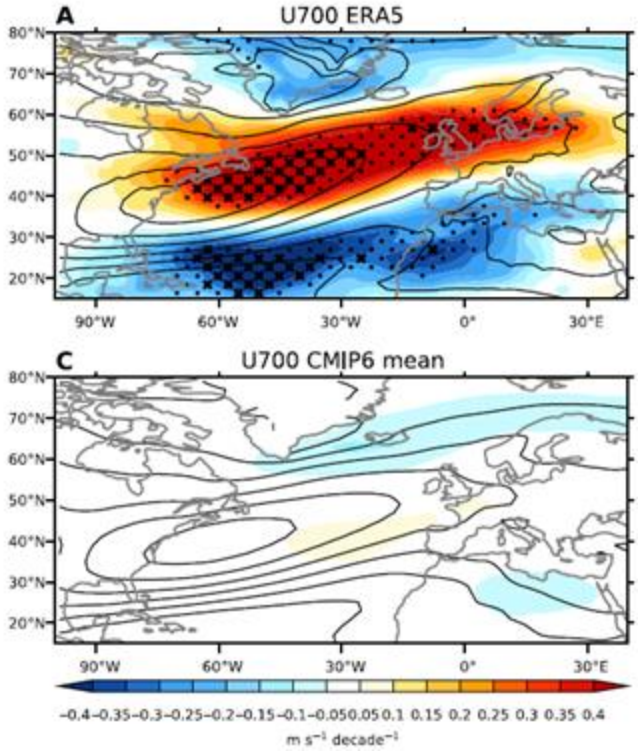
Priority science themes:

1. North Atlantic atmosphere and ocean circulation
2. Southern Hemisphere circulation trends and extremes
3. Summer northern hemisphere atmospheric circulation
4. Tropical circulation variability and trends

Key implementation steps:

- Complete **LESFMIP** (Large Ensemble Single Forcing MIP) simulations:
  - We don't currently have the tools to attribute A2D changes in climate
  - Need large ensembles because of signal to noise error
  - Need to assess multiple drivers

Experiment name	Description
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-totalO3	Ozone-only historical simulations (stratospheric and tropospheric ozone)
hist-lu	Historical simulations with only land use changes



1951-2020 winter trends
Blackport & Fyfe 2022

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Links to WCRP Core Activities - LEADER

a) Role of **annual to decadal variability** of the **polar vortex** for surface climate

b) Identifying the forced response of the **Southern Hemispheric atmospheric circulation** to greenhouse gases, aerosols, and ozone, and associated surface impacts on extremes

c) Identifying the forced response of the **Northern Hemispheric atmospheric circulation** to greenhouse gases, aerosols, and ozone, and associated surface impacts on extremes

d) Surface response to **solar** variability

e) Surface response to **Pinatubo** and other large **eruptions**

f) **QBO** influences on surface climate

g) Identifying the forced response of the **Asian monsoon** to greenhouse gases, aerosols, and ozone, and associated surface impacts on extremes

h) Role of external forcings and internal variability for **atmospheric temperature trends**

Theme 3: Assessment of Current and Future Hazards

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
- 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**

Priority Hazards

1. Tropical Cyclones
2. Extreme precipitation & droughts
3. Heatwaves
4. Compound extremes

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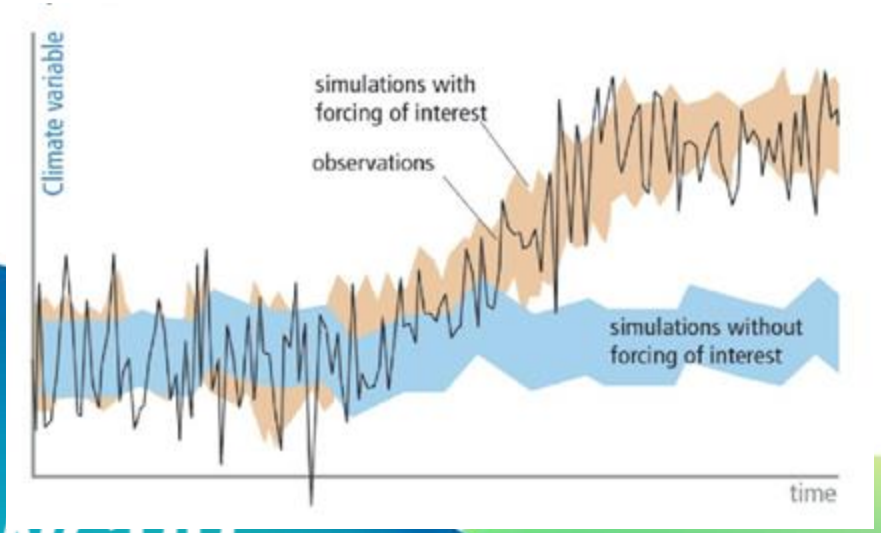
WG3: Assessment of Current and Future Hazards



- **Objectives**:
  1. Quantifying the current likelihood of specific weather and climate hazards
  2. Quantifying changes in weather and climate hazards on multi-annual to decadal timescales
  3. Understanding the processes connecting changes in hazards to natural and anthropogenic drivers of climate variability and change
  4. Advancing capabilities to predict and project changes in hazards

➢ *Extreme event & hazard attribution on A2D scale*

➢ *Links between hazards & large-scale circulation*

Upcoming EPESC Activity & Opportunities

- Strong participation of *LEADER* group aligned with EPESC themes and assessment of A2D variability and its attribution
- Joint EPESC-LEADER Meeting in Busan-Korea, July 2025
- Opportunity to showcase A2D relevant science and inform EPESC planning of LESFMIP phase 2 (A2D predictions)
- Challenge of obtaining annual updates of climate forcers for annual cadence of A2D climate forecasts

Thank You

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