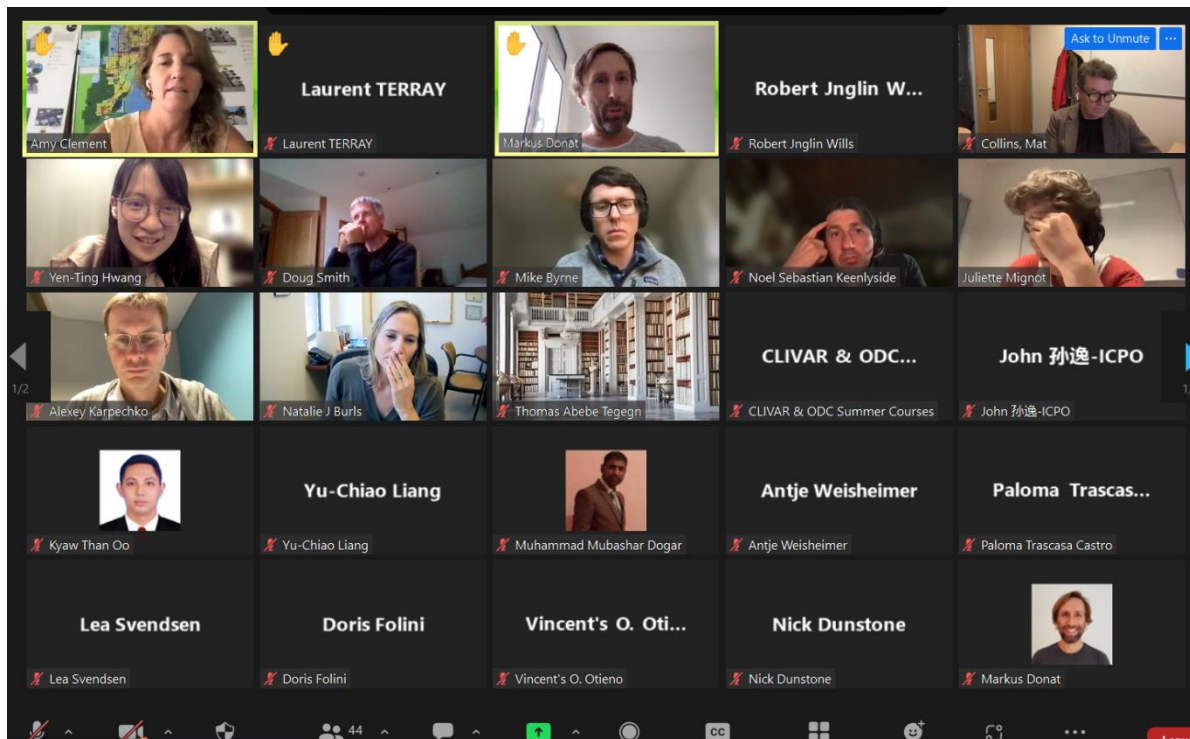# CLIVAR REPORT

Climate and Ocean: Variability, Predictability, and Change

Workshop Report

CLIVAR CDP 2022 annual workshop

December 2022
CLIVAR Report No. 02/2022

WCRP
World Climate Research Programme

Table of Content

1. Meeting introduction

The first CLIVAR Climate Dynamics Panel (CDP) annual workshop took place from the 14th of September to the 19th of October 2022. The theme of this workshop was external versus internal variability on decadal and longer time scales. It used a webinar-series format, lasting 6 weeks with a 2-hour session per week.

The workshop attracted about 270 registrants presenting on topics that spanned research topics on model comparison (including SMILEs), theory, historical and proxy observations, novel methods (e.g. ensemble paleoclimate reanalysis). Due to the time zone issues, the actual number of participants of each session was between 50 and 120. The first four sessions consisted of 3 to 4 invited presentations targeting the current research on the corresponding session theme. These were then followed by an online poster session during the 5th week. It was divided into two parts in order to accommodate different time zones, and provided a broader view across all the research topics. During the sixth week, a summary from the first five sessions was reported by the scientific committee, and followed by a heated debate around the four issues which involved all the participants. The detailed information is available on this page.

The workshop targeted our understanding of internal and externally forced variability in the climate system, their interaction on decadal timescales and longer, and the effects of variability on extreme events, aiming to seek solutions of the following four issues:
- How to isolate the relative contributions of external and internal variability to observed decadal and longer variability?
- How do the various external forcings modulate internal variability?
- Progress in narrowing observational and modeling uncertainties in external and internal variability
- Effects of external and internal variability on extreme events

Capacity building

Capacity building was highlighted during the organising phase. The scientific committee encouraged the Early Career Scientists (ECS) to showcase their studies during the workshop. A lightning talk session and Early Career Scientist Best Poster Award was set for the ECS during the poster session to highlight the work of ECSs.

The winners were selected from many outstanding posters at the online poster gallery. During the selection procedure, each poster was evaluated by three judges who are senior experts in relevant fields. The factors of scientific merit and presenting skills were both considered. Specific metrics included the description of the objective and background, conclusions supported by data and analysis, the originality and creativity of the approach, organisation and visual clarity, as well as oral presentation skills. Based on these scores, four posters were tied top.

- Benjamin H. Tiger, "Volcanic eruptions and multi-decadal Indo-Pacific variability amplify extreme Indian Ocean Dipole events in Last Millennium Ensemble simulations"
- Chengfei He, "Recent Atlantic Multidecadal Variability and its tropical impacts are driven by external forcings"
- Stephen Po-Chedley, "Internal variability influences model-satellite differences in the rate of tropical tropospheric warming"
- Zachary M. Labe, "Temporary slowdowns in decadal warming predictions by a neural network"

Logistics

CLIVAR and WCRP sponsored this workshop, and played an important role in the advertising. The University of Bergen kindly provided the the ZOOM webinar account, which was crucial for the first four sessions. The members of the scientific members included Sarah Kang, Noel Keenlyside

(University of Bergen), Juliette Mignot, Natalie Burls, Alexey Karpechko, and Michael Byrne, all of whom are CDP members.

The ZOOM webinar was used for the first four sessions in order to prevent unexpected intruders. Thanks to the CLIVAR funding, we were able to buy a "virtual poster session" account which was excellent for the participants to showcase their works on a webpage. At the same time, we used the ZOOM meeting breakout rooms for participants to move freely from one poster booth to another. The ZOOM meeting was used for the panel discussion so that all the participants can join in the discussion.

All the recordings of the talks can be downloaded from the <u>meeting webpage</u>. After each session, a survey related with the topic of the session was sent out to the participants, soliciting their perspectives on the topics. In addition, the main content was tweeted from CLIVAR account after each session.

2. Scientific Outcome

Session 1: How to isolate the relative contributions of external and internal variability to observed decadal and longer variability?

Talks and posters highlighted the need to account for internal climate variability when interpreting observed climate and climate change simulations.

The talks of this session were:
- Spurious Pacific Connections to Internal Atlantic Multidecadal Variability Introduced by the Global Residual Method from Clara Deser.
- A stronger Walker circulation and colder eastern equatorial Pacific in the early 21st century: a transient forced response to global warming versus natural variability given by Alexey Fedorov.
- Human Emissions Drive the Pacific Decadal Oscillation given by Jeremy Klavans.
- "Anomalous SST trends 1979-present: Internal variability or systematic climate model forced response bias? " which are presented by Robert Jnglin Wills.

The following approaches were presented:
- Large ensemble models simulations. There are currently at least 16 available.
- Statistical approaches including machine learning, signal to noise maximising, multiple linear regression, and Kriging for Climate Change (KCC), State space models and Kalman Filter techniques
- Bayesian approach (equivalent to data assimilation) used to fit models to observations accounting for uncertainties in both model and observations
- Sensitivity experiments (pacemakers, single forcing)
- Decadal prediction experiments. They have been shown to help to isolate contributions of volcanoes and initial conditions for example
- Climate dynamics approaches to identify different feedbacks (e.g., equatorial upwelling thermostat)

The questionnaire highlighted the following points:

Largest obstacles preventing scientific progress
- Model errors, model biases, signal-to-noise issue, missing processes in models/poor parameterisations
- Lack of long observation records and paleo-climate reconstructions
- Need to reconsider some basic assumptions, like the definition of external forced component based on the mean of large-ensemble model simulations that does not account for interactions between internal and external variability

What is needed to overcome these obstacles
- Better constraints on aerosol forcing
- Better models, increased resolution, large ensembles, single forcing experiments
- Collaboration with paleo-climate researchers to extract long observation records and generate paleo-climate reanalysis
- New statistical approaches, for example based on deep learning
- Build-up standard pre-processed multi-model large ensemble dataset interpolated to common grids et

Future initiative to compare statistical approaches to separate forced and internal variability will be starting up – ForcedSMIP (Robert Wills)

Key question
- Do current climate models overestimate the forced component, on decadal and long-time scales?
- How to reduce uncertainties on the aerosol forcing?

Session 2: How do the various external forcings modulate internal variability?

The talks of this session were:
- Relative roles of ozone-depleting substances, greenhouse gases and internal variability on recent Southern Hemisphere stratosphere-troposphere coupled circulation trends given by Antara Banerjee.
- The Sun's role in decadal climate predictability in the North Atlantic given by Annika Drews.
- Weakening of the Silk Road teleconnection pattern under global warming in CMIP6 projections given by Yu Kosaka.

The talks and posters highlighted various emerging topics:

- The importance of improving the way some processes associated with the external forcing are implemented in models. The need for sophisticated ozone chemistry for capturing forced SH circulation trends was in particular suggested. The link between SAM response to ozone depletion and observed Southern Ocean cooling is still an open question. The influence of GHG and ozone-depleting substances was furthermore also suggested for northern hemisphere polar trends? More generally, several studies have highlighted the current difficulties to distinguish the processes driving strengthening of observed zonal winds in SH. Which are the precise mechanism(s) by which the Silk Road teleconnection weakens with warming?
- On another topic, the imprint of solar cycle in modes other than NAO, like the PDO or AMV, still requires investigation.

Session 3: How to narrow observational and modeling uncertainties in external and internal variability?

The talks of this session were:
- Implications of historical radiative forcing and its uncertainties for understanding observed climate variability and change given by Amanda Maycock.
- Reconstructing internal and forced centennial variability in the Southern Ocean using data assimilation given by Hugues Gooses.
- The Big Breakup: A mid-20th Century Transition in the Behavior of Modes of Climate Variability given by Amy Clement.

Presented approaches to reduce uncertainties are very wide:
- New perturbed parameter, emulator simulations, and statistical techniques through application of emergent constraint approaches
- longer-term paleo reanalysis of climate variability

- Scale/process selective ensemble bias correction approaches
- Removal of biases in simulated long-term climate change to identify forced response on decadal to multi-decadal timescales. Percentile remapping techniques can better preserve internal variability.
- Use of model hierarchies to separate internal/forced variability
- Climate dynamics approaches, theoretical (diagnostic) and experimental (wind nudging experiments) to isolate dynamical responses
- Observational constraints using a Bayesian statistical method and Kriging for Climate Change to reduce uncertainties in future changes in the hydrological cycle
- Large-Ensemble single forcing simulations to detect and attribute changes in extremes; (MIROC6 simulations data freely available, or will be).

In terms of representing and communicating the uncertainties, the storyline approach to present uncertainties in terms of possible future dynamical scenarios was shown to be very promising

Challenges:
- Uncertainties in forcing and response of models to them is large and can not be isolated based on past experiment protocols.
- Development of emergent constraints are for regional scales is difficult, because climate dynamics is often not well understood
- Model errors and shortness of observations are major challenges to constraining uncertainties.

Some input from the questionnaires: Largest obstacles preventing scientific progress
- Lack of single forcing large ensemble simulations
- Largest obstacles is the fact that climate is a non equilibrium nonlinear system
- Insufficient observational data
- We have the techniques, but need time to do the analysis

Session 4: How to isolate the effects of external and internal variability on extreme events?

Several talks and posters were presented on the stationarity of internal processes of variability, and examples of analysis of various extreme events, based on various tools or approaches, like single forcing simulations, last millennium simulations and storylines.

The titles of the oral talks were:
- The Decadal Variability of Extreme European Heat and Drought Stress given by Laura Suarez-Gutierrez.
- Relative Contributions of Internal and External Drivers for Decadal Rainfall Extremes in Mainland Southeast Asia Over the Last Millennium given by Shawn Wang.
- Assessing the influence of low-frequency internal variability on extreme events presented by Laurent Terray.

The main outcome from these presentations are:
- The compound characteristics of extreme events, with potentially cascading effects (vegetation, carbon cycle, etc) has been highlighted
- Signal-to-noise (S/N) issues in models vs observations, the relatively weak ensemble members and lack of data were identified as the largest obstacles preventing isolating the effects of external and internal variability on extreme events
- Several studies demonstrated the added-value of using several types of model experiments (single forcing, last millennium, …).

- Paleoclimatic proxies can probably help with some of the identified issues (possibly not ensemble members)
- The likelihood vs storyline approach helps to understand and attribute observed and future climate events.

3. Experience learned from the workshop

As far as we know, this is the first CLIVAR workshop that uses the series webinar format. The whole event lasted for 6 weeks, including topic presentation, poster, and panel discussion. This webinar format proved to be successful based on the experience of this event. Several participants testified that this format was very beneficial for allowing the participants to remain focus during the relatively limited duration of the webinars and digest the presentations over the week that followed.

The scientific organising committee organised about 10 preparation telecon for this workshop. During these meetings, the workshop format, the topics of each session, the presentations, online platforms, how to promote the capacity building from the workshop, etc. were thoroughly discussed.

Some good experiences were :
- Capacity building: 1-min lightning talk gave the opportunity for the ECS to showcase their work. The ECS best poster award stimulated the enthusiasm to attend the workshop, and will provide a line in the CV.
- 6-week webinar enabled the participants to think of the about 4 issues proposed by the scientific committee.
- A survey after each session was helpful to collect ideas/opinions from all the participants.
- The advertising of WCRP helped us to get a broad audience.
- The ZOOM webinar is a good balance between the interaction of the participants and internet safety.
- The panel discussion is important to summarize the first five sessions.

We also made a questionnaire immediately after the workshop, and finally received 17 responses. Generally, this workshop is approved to be successful from the topic, content, organising format, logistics perspectives. Among those who filled in the survey, most of them attended the majority of the sessions, which are 6 in total. The number of people who want to attend online meeting and those who want to attend in -person in the future is in equal, maybe because the online meeting is more flexible which allows them to access part of the sessions in between the work commitments, according to the survey.
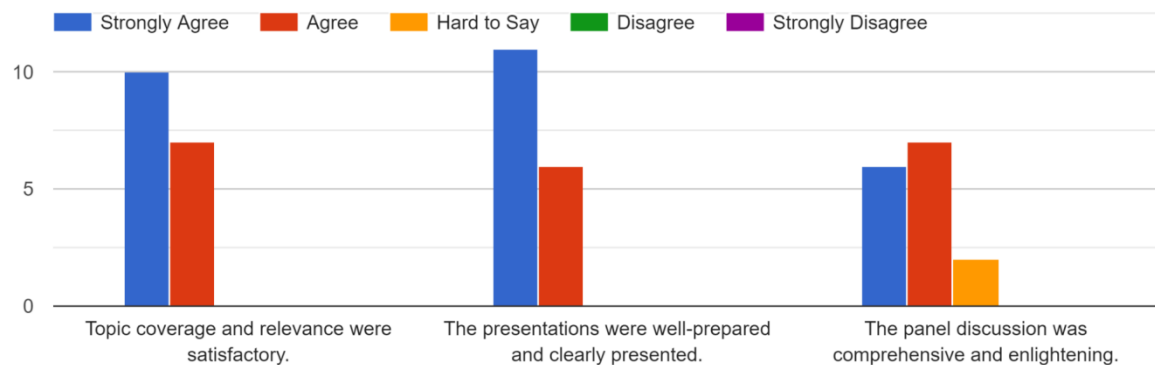
Annex 1 Results of the questionnaire

1. Whether the workshop help to address the four issues that the scientist committee proposed?

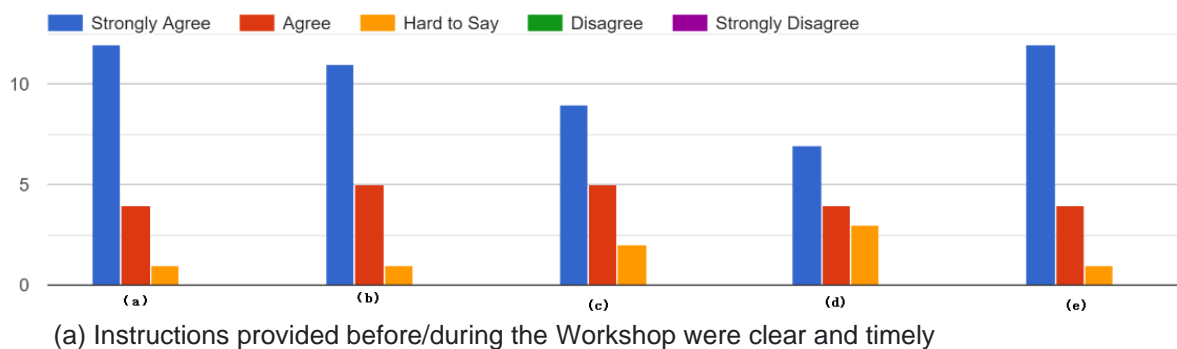Did the workshop help to address the following four issues?
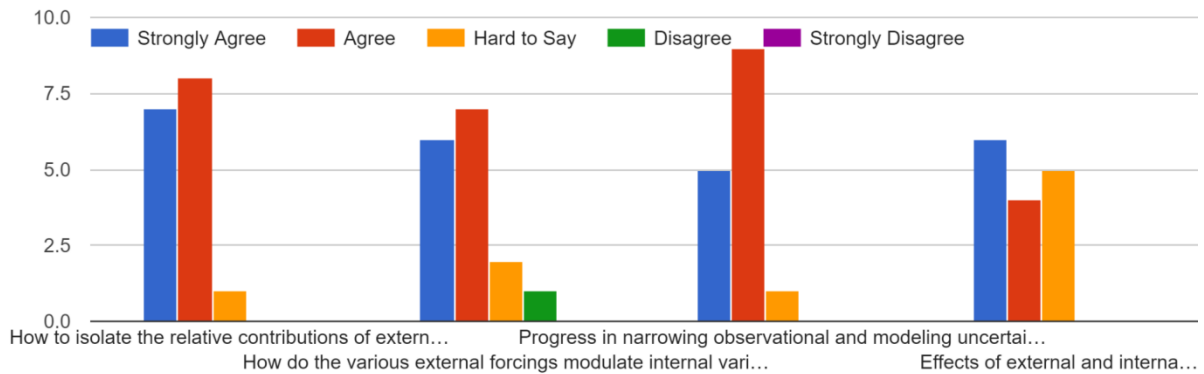
2. Please rate the content of the workshop

Please rate the content of the workshop

3. Please rate the online logistics of the Workshop

(a) Instructions provided before/during the Workshop were clear and timely

(b) The zoom webinar platform was satisfactory for smooth interaction with presenters, panelists, and participants
(c)The poster webpage was efficient for the agenda of the workshop]
(d) The lightning talk by Early Career Scientist (ECS) was helpful
(e)The frequency of occurrence of the events per week was reasonable]

1. What percentage of the workshop did you attend?

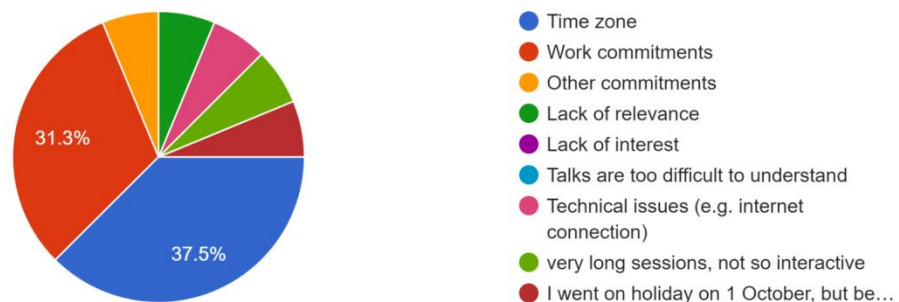What percentage of the workshop did you attend?
17 responses

- >90%
- 75-90%
- 50-75%
- 25-50%
- < 25%
- None
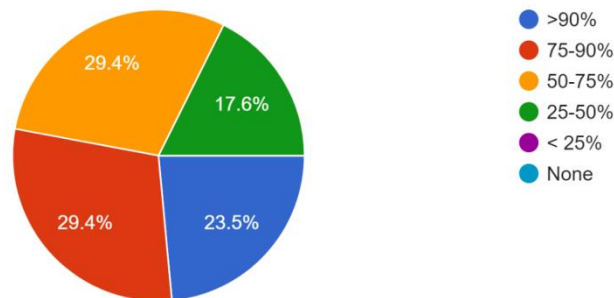
2. What factors prevented you from attending the whole workshop?

What factors prevented you from attending the whole workshop?
16 responses

- Time zone
- Work commitments
- Other commitments
- Lack of relevance
- Lack of interest
- Talks are too difficult to understand
- Technical issues (e.g. internet connection)
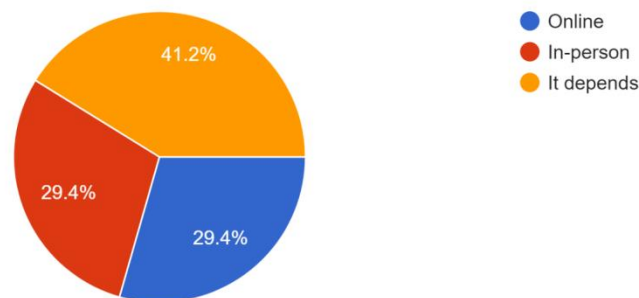- very long sessions, not so interactive
- I went on holiday on 1 October, but be…

3. What kind of format do you want to attend?

I would prefer to participate in the future workshops
17 responses

● Online
● In-person
● It depends

41.2%
29.4%
29.4%

4.   What is the most interesting/useful thing you've learned during the Workshop?

(a) Internal and External Drivers for Decadal Rainfall Extremes over Southeast Asia.

(b) I think the proposed testing of ways to disentangle internal and external variability with large ensemble simulation might be very insightful.

(c) More research is needed to really understand what is behind the signal-to-noise paradox and whether we should really worry about it.

(d) For me it was just general interest in progress in the field.

(e) Role of simple models, need of performing ensemble simulations, local vs global signal to noise ratio.

8. Do you have any suggestions about how to improve the workshop, especially in terms of the online format

(a) I would like to have more interactive sessions, discussing on common research ideas

(b) I found a very small number of participants during the online poster presentation. I would recommend that the poster presentation should be organized in the same day after the oral presentation to get more audience.

(c) Nothing Special.

(d) During the presenting session the interaction with the speakers was not that good, being able to only submit questions via the chat.

(e) I think the format was really great, the frequency and duration of each session were fine.

(f) The discussions didn't keep my interest. Would prefer to hear people asking their own questions than have them filtered through the organisers.

(g) Less talks per day, more review talks, one session on technical aspects and statistical methods

8. Any other comments on the Workshop that you would like to share?

(a) I was more than disappointed that the 4 poster awards went to 4 men. I would very much appreciate more diversity.

(b) I think it went very well for an online meeting. Many thanks for organising it!

(c) I really enjoyed it !

(d) I enjoyed participating in the workshop and I know that I would not be able to participate in person, both due to work commitments and due to budget. If the workshop goes back to in-person, it would be lovely if it kept an online component.

(e) Thanks a lot!

Annex 2 Programme

Session 1: 14th September, 2022 (Wednesday)
Isolate the relative contributions of external and internal variability to observed decadal and longer variability

Time (UTC)	Chairs: Natalie Burls, Noel Keenlyside	
12:55-15:00	Topic	Presenter
12:55-13:00	Opening remark	Noel Keenlyside
13:00-13:20	Talk 1: Spurious Pacific Connections to Internal Atlantic Multidecadal Variability Introduced by the Global Residual Method	Clara Deser (NCAR, USA)
13:20-13:40	Talk 2: A stronger Walker circulation and colder eastern equatorial Pacific in the early 21st century: a transient forced response to global warming versus natural variability	Alexey Fedorov (Yale University and LOCEAN/Sorbonne University, USA)
13:40-14:00	Talk 3: Human Emissions Drive the Pacific Decadal Oscillation	Jeremy Klavans (University of Colorado, USA)
14:00-14:20	Talk 4: Anomalous SST trends 1979-present: Internal variability or systematic climate model forced response bias?	Robert Jnglin Wills (University of Washington, USA)
14:20-15:00	Q&A	

Session 2: 21st September 2022 (Wednesday)
Modulation of internal variability by external forcings

Time (UTC)	Chairs: Michael Byrne, Juliette Mignot, Sarah Kang	
5:00-6:30	Topic	Presenter
5:00-5:20	Talk 5: Relative roles of ozone-depleting substances, greenhouse gases and internal variability on recent Southern Hemisphere stratosphere-troposphere coupled circulation trends	Antara Banerjee (CIRES/NOAA, USA)
5:20-5:40	Talk 6: The Sun's role in decadal climate predictability in the North Atlantic	Annika Drews (Danish Meteorological Institute, Denmark)
5:40-6:00	Talk 7: Weakening of the Silk Road teleconnection pattern under global warming in CMIP6 projections	Yu Kosaka, University of Tokyo, Japan
6:00-6:30	Q&A	

Session 3: 28th September 2022 (Wednesday)
Progress in narrowing observational and modeling uncertainties in external and internal variability

Time (UTC)	Chairs: Noel Keenlyside, Alexey Karpechko

15:00-16:30	Topic	Presenter
15:00-15:20	Talk 8: Implications of historical radiative forcing and its uncertainties for understanding observed climate variability and change	Amanda Maycock (University of Leeds, UK)
15:20-15:40	Talk 9: Reconstructing internal and forced centennial variability in the Southern Ocean using data assimilation	Hugues Gooses (Universite catholique de Louvain, Belgium)
15:40-16:10	Q&A	

Session 4: 5th October 2022 (Wednesday)
Effects of external and internal variability on extreme events

Time (UTC)	Chairs: Natalie Burls, Juliette Mignot	
15:00-17:00	Topic	Presenter
15:00-15:20	Talk 10: The Big Breakup: A mid-20th Century Transition in the Behavior of Modes of Climate Variability	Amy Clement (University of Miami, USA)
15:20-15:40	Talk 11: The Decadal Variability of Extreme European Heat and Drought Stress	Laura Suarez-Gutierrez (Max Planck Institute for Meteorology, Germany)
15:40-16:00	Talk 12: Relative Contributions of Internal and External Drivers for Decadal Rainfall Extremes in Mainland Southeast Asia Over the Last Millennium	Shawn Wang (Woods Hole Oceanographic Institution, USA)
16:00-16:20	Talk 13: Assessing the influence of low-frequency internal variability on extreme events	Laurent Terray (CECI, CNRS/Cerfacs, France)
16:20-17:00	Q&A	

Session 5: 12th October 2022 (Wednesday)
Poster

Time (UTC)	Chairs
5:30-7:30	Alexey Karpechko, Sarah Kang
14:30-16:30	Noel Keenlyside, Juliette Mignot: Natalie Burls, Michael Byrne

Session 6: 19th October, 2022 (Wednesday)
Plenary discussion

Time (UTC)	Chairs
14:30-16:00-16:00	Theme 1: Doug Smith Theme 2: Yen-Ting Hwang Theme 3: Amy Clement Theme 4: Laura Suarez-Gutierrez

Annex 3 Titles of the poster presentations

All the posters have been uploaded to the webpage which is open to public. The audience can review them anytime they want. In this report we just post the titles which are classified by sessions. Please note that the order is random and means nothing.

Session 1

1. The Nonlinear Northern Hemisphere Stratospheric Temperature Response to External Radiative Forcing in Decadal Climate Simulations
2. Separating internal and external global temperature variability using a Bayesian stochastic energy balance framework
3. Internally Generated and Externally Forced Multidecadal Oceanic Modes and Their Influence on the Summer Rainfall over East Asia
4. Unforced Trends and Variability of Surface Solar Radiation
5. The Mount Pinatubo "Gulp" Long-lasting impacts on ocean oxygen and carbon
6. Investigating the forced and free global-mean surface temperature variations in CMIP6 historical simulations
7. Two Distinct Modes of Climate Responses to the Anthropogenic Aerosol Forcing Changes
8. The role of external forcing for centennial climate variability
9. Pacific contributions to decadal surface temperature trends in the Arctic during the 20th century
10. Revisiting the existence of the global warming slowdown during the early 21st century
11. Sensitivity of the Middle East and North Africa (MENA) to External and Internal Variability
12. Coupled stratosphere-troposphere-Atlantic multidecadal oscillation and its importance for near-future climate projection
13. Impact of volcanic eruptions in CMIP6 decadal prediction systems: a multi-model analysis.
14. Decrease of the dynamical and spatial variability of the Euro-Atlantic eddy-driven jet stream under global warming
15. Understanding surface warming trend in East Asia and a role of internal variability
16. Internal variability influences model-satellite differences in the rate of tropical tropospheric warming
17. The relative roles of external forcing and internal variability on multi-decadal rainfall variability and change over south-west of Australia
18. Evaluation of external forcing and initial conditions contributions to decadal predictions of the INMCM5 climate model
19. Antarctic Sea Ice Multidecadal Variability and Predictability in GFDL SPEAR_LO Model
20. Temporary slowdowns in decadal warming predictions by a neural network

Session 2

1. Volcanic eruptions and multi-decadal Indo-Pacific variability amplify extreme Indian Ocean Dipole
2. Interannual variability in the tropical Indian Ocean simulated by the Palaeoclimate Model
3. Large-scale emergence of regional changes in year-to-year temperature variability by the end of the 21st century
4. Widespread changes in surface temperature persistence under climate change
5. Understanding the role of internal climate variability and anthropogenic forcing on the Paris Agreement target of 2C in climate models
6. Does the Indian summer monsoon modulate the Arctic sea ice?
7. Are multidecadal climate modes in the Northern Hemisphere connected?
8. Fast and Slow Responses of the Tropical Pacific to Radiative Forcing in Northern High Latitudes
9. Understanding the role of greenhouse gas forcing leading to a long-term positive trend of Arctic Oscillation

Session 3
1. Assessing the role of internal variability in projections of northern Europe wintertime climate change at near-term (2020-2040) using a storyline approach
2. Recent Atlantic Multidecadal Variability and its tropical impacts are driven by external forcings
3. How discrepancies between observations and climate models of large-scale wind-driven Greenland melt influence sea-level rise projections
4. Observational constraints on the externally-forced water cycle response to past and future human activities
5. Large ensemble of MIROC6 for understanding internal and externally forced variability in the climate system
6. Warm phase of AMV damps ENSO through weakened thermocline feedback
7. Ensemble bias correction of climate simulations: preserving internal variability

Session 4
1. Influence of the Atlantic Multidecadal Variability and of Soil Moisture on Extreme Heatwaves in Europe
2. Ocean-atmosphere processes in response to Climate Change in the tropical South Atlantic
3. Emergence of climate change in the tropical Pacific
4. Understanding Modes of Climate Variability during Extreme Dry Climatic Seasons in the Greater Horn of Africa (GHA) region