

4.3 Key Science Questions

Compiled from CLIVAR Panel/Working Group Reports to SSG-19 (plus additional suggestions)

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Asian-Australian Monsoon Panel (AAMP)

1. An improved understanding of the role of the Indian Ocean in modulating and limiting predictability of the Asian-Australian monsoon on subseasonal to interdecadal time scales
2. An improved understanding of the role of land surface processes in modulating and providing predictability of the Asian-Australian monsoon on subseasonal to interannual time scales (see item 6c, below)
3. A comprehensive understanding, model treatment and evaluation of the role of aerosols for monsoon variability and change.
4. Understanding the role of the oceans for driving monsoon decadal variability especially related to ENSO and its teleconnection to the monsoon

Atlantic Implementation Panel (AIP)

1. What are the causes of observed North Atlantic climate variability at interannual to interdecadal time scales and reasons for Atlantic biases (e.g., SST) in coupled-model simulations?
2. What is the impact of small-scale processes on the mean climate state and on seasonal to interannual climate variability?
3. What are the causes of African Climate Variability and Benguela Ninos? What are their impacts on regional scales? What is their role in the variability of equatorial and coastal upwelling productivity?
4. What are the causes in ocean deoxygenation? How respond ocean ventilation to climate variability and change?

CLIVAR/PAGES Working Group

1. Forward modeling of proxy data
Reducing uncertainties in proxy reconstructions (and data synthesis in general) are important for improving climate modeling targets and for understanding the intrinsic variability and forced response of the climate system.
2. Calibration of proxies against variability seen in the instrumental period
Is a pre-requisite for improved synthesis of proxy- and observation-based approaches and requires interaction between paleoclimatologists and climatologists.
3. Climate variability over the last few millennia
Well-dated, high-resolution proxy reconstructions and model simulations incorporating estimates of natural and anthropogenic forcings for the last 2 ka offer opportunities to assess the natural decadal- to centennial-variability and forced responses in conditions similar to present.
4. North Atlantic circulation changes
Interactions among the ocean, atmosphere, and sea ice are the likely cause of decadal-multi- decadal and centennial variability in the Atlantic meridional

overturning circulation (MOC), with attendant impacts on spatial patterns of temperature and precipitation. Thus improved understanding of MOC variability may serve to improve the climate projections in these regions.

Expert Team on Climate Change Detection and Indices (ETCCDI)

1. Detection and attribution of anthropogenic influence on weather and climate extremes at regional scale
2. Contribution to event attribution
3. Influence of large-scale circulation on weather and climate extremes

Global Synthesis and Observations Panel (GSOP)

1. Can coupled assimilation approaches lead to more consistent ocean and atmospheric reanalysis products with improved use of near surface data, and better initial conditions for seasonal to decadal climate forecasting?
2. Can reanalysis or synthesis methodologies be used to quantify, reduce or bias correct for model errors?

Indian Ocean Panel (IOP)

1. Prediction of Indian Ocean Dipole from coupled climate model
2. Ocean-atmospheric dynamics of monsoon system with application in improving the seasonal and intra-seasonal forecast (*the chances of predictability is high on ISO than seasonal*)
3. Indian Ocean decadal variability
4. The influence of air-sea interactions and climate variability on tropical cyclones
5. Inter-basin exchanges (ITF, Agulhas system, ACC)

Pacific Panel

1. SPCZ and model biases
How can we improve simulation in global coupled models?
2. ENSO: past, present, future
How may ENSO change in a warmer world?
3. Regional sea level and extremes
How has regional sea level changed (including relative importance of anthropogenic contribution)?

Southern Ocean Panel (SOP)

1. What is the future of Antarctic ice? Including sea ice, ice shelves, and land ice.

2. What is the impact of acidification? And how will the Southern Ocean store of CO₂ change in the future?
3. How will the ongoing projected trend in the SAM impact on air-sea heat, moisture, and carbon fluxes, and what will be the impact on Southern Hemisphere regional climate?
4. What is the future of the Antarctic continental margin?

Variability of the African Climate System (VACS)

Ocean atmosphere interaction and its relation to weather and climate is a key component underlying each of the prioritized themes outlined in Section 2 (report to SSG-19). For instance it is the impact of ENSO that gives predictability in Southern Africa. Likewise variability in the Indian Ocean and in the Tropical Atlantic also has a profound impact on regional weather and climate. The future behavior of those modes of variability will be as important as the effect of global warming for Africa. The occurrence of extreme weather such as floods or dry spells is also impacted by those modes of variability. Closer to home, the Benguela Ninos, Atlantic Ninos, IOD and the Agulhas Current have also an impact on weather and climate.

Working Group on Ocean Model Development (WGOMD)

1. Continue to look at model biases and improve model physics including biogeochemistry and ecosystems
2. High resolution modeling and regional/coastal modeling
3. Sea level and interactions with ice sheets
4. Role of ocean in decadal variability
5. Operational oceanography and data assimilation

Working Group on Seasonal and Interannual Prediction (WGSIP)

1. Can ocean-atmosphere or sea ice-atmosphere coupling drive predictable year to year changes in extratropical atmospheric circulation and hence extreme events?
2. Given that we nominally remove the model bias in both seasonal and decadal predictions, how do current ocean model errors affect the skill of predictions months to years ahead?
3. What are the key climate model changes needed to best represent the processes in Q1 and to minimize the errors in Q2 in our seasonal to decadal forecast systems?

Variability of the American Monsoon System (VAMOS)

1. Ocean-atmosphere interaction in the region of the SACZ and its impact on the continental monsoon.

2. Role of the tropical oceans in past climate over South America. How did they modulate the orbital forcing and translated the signal into the continent?

Other Suggestions

1. Marine water cycle