IOGP/JCOMM/WCRP WORKSHOP

Our Future Climate – **Executive Summary**

Understanding the spread of physical risk for the oil and gas industry

25-27 September 2018 – BP Upstream Learning Centre in Sunbury, UK

Changes in climate have the potential to create significant disruption and uncertainty in the oil and gas sector.

These include:

- **cost impacts** such as reduced plant efficiency from temperature rise and environmental impacts from the overflow of drainage systems from increased precipitation.
- **social impacts** related to increased water stress and physical risks from, for example, increased flood levels, sea level rise, and changing storm patterns. Climate change can impact the communities and environments in which the industry operates. Stakeholder expectations around climate change (including shareholders and governments) are also changing and are likely to continue to change.

Understanding both the physical risks and vulnerabilities of the oil and gas sector will help IOGP Members develop and implement adaptation strategies to manage the physical impacts of climate change.

Workshop objectives

1. Raise awareness and disseminate knowledge related to risks, methodologies, and approaches that help organisations adapt to climate change
2. Improve confidence in the use of climate data by identifying its limitations and develop improved methodologies that reduce and quantify uncertainty
3. Understand the potential risk picture that climate change poses for all aspects of the industry

Executive Summary

A second IOGP-JCOMM-WCRP sponsored workshop on the physical risks of climate change for the oil and gas industry was held at BP's Upstream Learning Centre in Sunbury on Thames on 25-27th September 2018, the first workshop having been held in 2008 at the World Meteorological Organisation in Geneva. The aim of the workshop was to gather together climate science experts and IOGP members to understand what has changed since the first workshop, how climate change may impact the oil and gas industry and what steps IOGP members can take to better understand these risks to assist with planning for adaptation to potential changes.

Climate science has moved on significantly in the last decade, with higher resolution and more detailed global climate models (GCMs) now available to conduct long simulations. There is also clear evidence of anthropogenic climate change in air and sea temperatures and in sea level rise. However, the implications for other elements of the climate system are not so evident or readily attributable. Detection and attribution remain active areas of research for all parameters.

The global scientific community has high confidence that global mean air temperature has risen 1ºC above pre-industrial levels and that it continues to increase, but there are significant regional differences and projections of future temperatures are dependent on the emissions scenario considered. Representative Concentration Pathways (RCPs) tell different stories and hence can be used to assess different future risk scenarios. Per RCP2.6 (emissions compatible with the Paris Agreement), global warming is unlikely to exceed 2°C above pre-industrial levels (source IPCC AR5) and can be taken as one bound. It was recommended that IOGP members consider RCP4.5 and 6.0 respectively as a best estimate and a less optimistic case for estimating the range in potential outcomes, that could impact adaptation planning. The speakers felt that RCP8.5 (the "business as usual" case) now appears too extreme and is highly unlikely to be realized. In addition to greenhouse gases emissions scenarios, it was emphasised that a number of aerosol forcing scenarios, with their associated additional cooling effect, should also be considered.

Ocean heat content has increased and will continue to absorb much of the heat gain of the atmosphere. This is likely to result in changes in ocean circulation, particularly intensification of stratification and increased near-surface currents speeds, but the evidence of this is mixed. There is a clear signal in the Northwest Pacific Gyre, but not in the Atlantic. Atlantic overturning may slow by 30-40% by 2100 due to warming in the Arctic.

The largest uncertainties in regional sea level projections are associated with contributions from ice sheets in Antarctica and Greenland, ocean dynamics and vertical land movement. While the increasing loss of sea ice (smaller/thinner/faster) has been demonstrated, the trends with numbers, size distributions and other characteristics of icebergs remain unclear.

Global mean sea level is rising faster than expected, but there are significant regional variations and uncertainties. A departure from the global equilibrium is observed in the record since the mid-19th century, rising at 1.7 mmpa (millimetres per annum) until 1993, when the rate of sea level rise accelerated to 3.2 mmpa. Regional trends may outpace global by up to factor 5, however, regional decadal signals are still dominated by natural climate variability. Regional modelling and probabilistic (e.g. Monte Carlo) simulations to define a range of sea level rise in the current and future climate are recommended to assess the risk of inundation for coastal infrastructure.

Tropical cyclones are projected to become slightly less frequent, but there is a lack of consensus and of physical understanding why this signal should be expected. On the other hand, climate models suggest there will be more storms that reach Category 4 and 5 and there is already a robust trend in observational data which corroborates this projection. However, the true trends could be masked by limited data, together with significant decadal and multidecadal variability, particularly in the North Atlantic Basin. There is evidence of tropical cyclone peak intensity migrating poleward, bringing increased or additional risk to some areas. There is some limited evidence that the translation speeds of landfalling tropical cyclones is reducing, which could result in heavier rainfall events.

Extra-tropical transition is expected to migrate polewards as the tropics expand under a warmer climate. This may result in more frequent storms with higher moisture content reaching mid-latitudes in the later part of the season. Multi-model ensembles, perturbed ensembles, and long climate simulations in the current and future climate provide a useful means of assessing the probability distribution of extremes and the likely tracks of extra-tropical storms.

Studies of wave climate suggest a reduction in mean significant wave height in the North Atlantic, but an increased variance that might lead to higher extremes. However, wave studies under future climate to date have been undertaken in an uncoordinated manner, which introduces questions over the consistency and comparability of the results. Empirical techniques used to fit extreme wave heights in models to observations result in significant uncertainties and, in some instances, physically unjustified behaviour. This is caused by the fact that the highest wave heights are rarely observed in nature, and wave models are often validated and tuned using poor observational data. The COWCLIP-2 project aims to address this. Last, waves in the Arctic Seas are likely to increase with increased fetch due to melting of the Arctic Polar Ice Sheet.

Scientists have less confidence in future projections of rainfall and flooding than they have in air temperature and sea level rise, but the observational record suggests increases in precipitation rates in the mid-latitudes and a poleward expansion of drier regions associated with tropical expansion under a warmer climate. Additionally, there is a physical law that relates the amount of water air can hold with the temperature of air called the Clausius-Clapeyron equation. This equation predicts air should increase its capacity to hold water at a rate of approximately 7%/°C. This relationship suggests there is a physical foundation for expecting higher rainfall rates with a warming climate. Regional differences are large and the impact at a given location is best considered using a regional model.

Flooding, drought and water availability are highly uncertain as these are dependent on so many other factors than just the climate system. Factors such as land use, groundwater abstraction rates and water policy far outweigh any signature in climate variables. However, coastal flooding is expected to increase from a combination of sea level rise, storm surge events and increased precipitation. Drought risk is also expected to increase due to the poleward expansion of drier areas and to longer periods between rainfall events. Even with more extreme rain, average rain decreases in locations and warming temperatures exacerbate wildfires. Last, water demand is expected to double by 2050, which will result in water scarcity in many areas.

In conclusion, there are potential physical risks of climate change that the oil and gas industry needs to focus on, associated with projections for:

- Increases in air and sea temperatures which may impact production rates (due to reduced cooling) and expose of personnel to an increased risk of heat stress
- Increases in the risk of inundation for coastal facilities due to sea level rise, storm surge events and precipitation
- Localised increases in extreme waves in some regions, from changes to storm tracks, frequency and intensity
- Increases in extreme precipitation in some areas which may impacts on industrysupply chains and operations
- Localised increases in the risk of drought in some areas due to poleward migration of drier areas, increased duration between rainfall events and changes to water policy.

The IOGP Metocean Committee will assess the outcomes of the workshop and propose working groups or Joint Industry Projects to address uncertainties in projections, in order to develop more robust estimates of future risks that can be used in adaptation planning.

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