USE OF UK CLIMATE PROJECTIONS 2018 (UKCP18)

POSITION STATEMENT – NOVEMBER 2020

REVISION 1

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The 'Use of UK Climate Projections 2018 (UKCP18) Position Statement' has been updated to provide further clarity on the regulators' expectations for the use of UKCP18 and to incorporate UKCP18 developments since March 2019, including the release of the 2.2 km local projections. Revision 1 also includes the expectations of the Scottish Environment Protection Agency.

INTRODUCTION AND SCOPE

This position statement sets out the expectations of the Office for Nuclear Regulation (ONR), the Environment Agency (EA), Natural Resources Wales (NRW) and the Scottish Environment Protection Agency (SEPA) [referred to hereafter as the regulators] regarding the UK Climate Projections 2018 (UKCP18) and their application. The statement provides guidance to duty holders in the nuclear industry and operators of sites for radioactive waste disposal when undertaking climate change assessments in support of, for example, planning permission/development consent, environmental permit applications or safety cases[1].

The UK Climate Projections 2018 (released in November 2018) is a set of climate model projections for the UK produced by the UK Meteorological Office (Met Office) and partners. A second set of outputs, the 2.2 km local projections, were released in September 2019. UKCP18 builds on the UK Climate Projections 2009 (UKCP09) based on evolutions in science and computing capabilities. The impacts of climate change on hazard magnitude and frequency for some natural hazards could be significant over the lifetime of nuclear licensed sites and disposal sites for radioactive waste. The use of UKCP18 is considered to be relevant good practice in determining climate change allowances for relevant natural hazards at existing or proposed sites.

This position statement also provides duty holders in the nuclear industry with some background on UKCP18 and information on some of the most significant areas of change from UKCP09, namely:

- the use of Representative Concentration Pathways (RCPs) instead of the Special Report on Emission Scenarios (SRES) used in UKCP09; and
- provision of projections at a higher spatial and temporal resolution in UKCP18 than has been previously available, for example daily and sub-daily.

[1] In this UKCP18 Position Statement the term 'duty holder' refers to nuclear site licensees, potential licensees, current and potential environmental permit holders for radioactive waste disposal, applicants for planning consents and Requesting Parties undergoing the Generic Design Assessment process.

WHAT IS UKCP18?

The UK Climate Projections 2018 have been produced by the Met Office with expert input from the Environment Agency and funded by the Department for Environment, Food and Rural Affairs (Defra) and the Department for Business, Energy and Industrial Strategy (BEIS). UKCP18 projections have been developed from recent advances in modelling the climate system, and the use of the new Met Office supercomputing facilities has enabled higher resolution climate projections to be produced compared with UKCP09. UKCP18 updates the UKCP09 projections over UK land areas and updates UKCP09 projections of sea level rise, giving greater regional detail and providing more information on potential extremes of climate change.

UKCP18 provides information on temperature, precipitation, wind, sea level rise and storm surge, snow and weather types (Ref. 1).

Although UKCP18 provides the latest information on our future climate, it does not provide information on impacts. This information will need to be derived, taking into account the UKCP18 projections.

THE REGULATORS' EXPECTATIONS ON THE USE OF UKCP18

TRANSITIONING TO UKCP18

The regulators expect that duty holders in the nuclear industry and operators of sites for radioactive waste disposal[2] will take account of UKCP18 when assessing the impacts of climate change. This includes taking UKCP18 into account at all stages of the facility lifecycle, from design, planning, construction, operation, and through to decommissioning and eventual release from regulation[3]. For existing sites, the implications of UKCP18 for climate change considerations should be taken into account when any new analysis of climate change is undertaken and, during Periodic Safety Reviews (PSRs). For new build sites, the regulators expect duty holders to update their safety cases to take UKCP18 into account within a reasonable timeframe and provide the regulators with a programme of work setting out when and how they will do this. The regulators will evaluate this on a case-by-case basis.

The service providing UKCP09 data closed in December 2018. The UKCP09 website remains available in an archived format and the underlying UKCP09 data is available from the Centre for Environmental Data Analysis (CEDA) catalogue but there will be no further updates to material on the UKCP09 website (Ref. 5). There is no longer access to the UKCP09 helpdesk or User Interface and the associated weather generator that was part of UKCP09 has been shut down.

The Environment Agency's advice for planners and developers preparing strategic and site specific flood risk assessments is provided in "Flood Risk Assessments:

[2] Facilities on land for the disposal of solid radioactive wastes permitted or to be permitted under the Environmental Permitting (England and Wales) Regulations 2016 or the Environmental Authorisations (Scotland) Regulations 2018.

[3] Environmental permit holders should ensure that the various forms of environmental safety cases take into account the potential consequences of climate change (see Refs. 2, 3 and 4).

Climate Change Allowances" (Ref. 6). This was updated in December 2019 to reflect the UKCP18 sea level rise data, and again in July 2020 to incorporate H++ allowances which were previously set out in separate guidance. In Wales, climate change allowances in relation to flood risk are set out in Welsh Government guidance produced by NRW (Refs. 7 and 8). In Scotland, advice for planners and developers on preparing flood risk assessments is set out in guidance produced by SEPA (Ref. 9). These allowances remain the best national representation of how climate change is likely to affect flood risk for peak river flow and peak rainfall intensity, however ongoing research and analysis on peak rainfall intensity and peak river flow may result in some subsequent changes to these allowances. Allowances for sea level rise for major infrastructure projects such as nuclear installations are covered below and in Table 3.

REPRESENTATIVE CONCENTRATION PATHWAYS

UKCP18 uses Representative Concentration Pathways (RCPs), which were used in the most recent Intergovernmental Panel on Climate Change (IPCC) report to develop projections. These replace the emissions scenarios used in UKCP09 (Special Report on Emissions Scenarios (SRES)).

RCPs specify the concentrations of greenhouse gases that will result in the total radiative forcing[4] increasing by a specified amount by 2100, relative to pre-industrial levels (Ref. 10). Radiative forcing scenarios for 2100 have been set at 2.6, 4.5, 6.0 and 8.5 W/m^2 and these are reflected in the four RCPs; RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 (Ref. 10). Each RCP results in a different range of global mean temperature increases until 2100 (Table 1). Each RCP can be met by a combination of different socioeconomic assumptions (Ref. 10).

In UKCP18, probabilistic projections at 25 km spatial resolution over land are available for RCP 2.6, 4.5, 6.0 and 8.5 as well as for SRES A1B. SRES A1B has been included in the probabilistic projections to allow direct comparison between UKCP09 and UKCP18. Marine and coastal projections are available for RCP 2.6, 4.5 and 8.5 in UKCP18. RCP 6.0 has not been included in marine and coastal projections for UKCP18.

Table 1: The increase in global mean surface temperature averaged over 2081-2100 compared to the pre-industrial period (averaged between 1850 and 1900) for the RCPs (best estimate, 5-95% range). From IPCC AR5 WG1 Table 12.3 (Ref. 11).

RCP	Change in temperature (°C) by 2081-2100
2.6	1.6 (0.9-2.3)
4.5	2.4 (1.7-3.2)
6.0	2.8 (2.0-3.7)
8.5	4.3 (3.2-5.4)

[4] Total radiative forcing is the difference between the incoming and outgoing radiation at the top of the atmosphere (Ref. 10).

As SRES scenarios and RCPs were derived using different methods, it is not possible to directly compare the two. There are some similarities between SRES scenarios and RCPs in terms of median global temperature increase by 2100 (Table 2).

Table 2: SRES scenarios that are most similar to RCPs, in terms of median global temperature increase by 2100 (Ref. 10).

RCP	Most similar SRES scenario (in terms of temperature)
2.6	None
4.5	SRES B1 (low emissions scenario in UKCP09)
6.0	SRES B2 (between the low and medium emissions scenarios in UKCP09)
8.5	SRES A1F1 (high emissions scenario in UKCP09)

Advice from ONR, EA, NRW and SEPA on the use of RCPs, return periods, and sensitivity studies is provided in the table below (Table 3). The subsequent text after Table 3 outlines how duty holders could meet the expectations of all regulators.

Table 3: The use of RCPs, return periods, and sensitivity studies in climate change assessments – ONR, EA, NRW and SEPA expectations.

Expectation	ONR	EA	NRW	SEPA
RCP to select	ONR does not prescribe the use of a particular RCP to define a design basis event[5]. The duty holder will need to provide evidence that the RCP that they have selected is adequately conservative in line with ONR's Safety Assessment Principles (SAPs) (Ref. 14). ONR expects that there would not be a reduction in conservatism from the approaches that have been used in UKCP09 (ONR has generally accepted the UKCP09 medium emissions scenario at the 84th percentile as	The Environment Agency "Flood Risk Assessments: Climate Change Allowances" guidance (Ref. 6), states that a range of likely climate change scenarios should be assessed, covering peak rainfall intensity, peak river flow, sea level rise, offshore wind speed and extreme wave height. For sea level rise, these should be based on the 70th and 95th percentiles of the RCP 8.5 scenario for the specific cell(s) applicable to the site in question. For peak river flow and rainfall intensity, these are currently based on the	The Welsh Government guidance "Flood Consequence Assessments: Climate Change Allowances" (Ref. 8) sets out the current recommended climate change allowances for peak river flow and sea level rise. It also recommends consideration of extreme wave action is undertaken at coastal locations. For peak river flow, an assessment of risk should be undertaken for both the central estimate and the upper end estimate to inform mitigation measures and ensure long term resilience	SEPA guidance (Ref. 9) for sea level rise is based on the 95th percentile for RCP 8.5 from UKCP18. This guidance is due to be updated in 2020 for peak river flows and peak rainfall intensity to reflect UKCP18 projections.

[5] In addition, duty holders are expected to ensure that there is no disproportionate increase in risk for events more severe than the design basis. They are also required to provide enhanced protection against even more severe events and provisions for recovery in the unlikely event that the protection capability is exceeded. Further information can be found in ONR's External Hazards TAG (Refs. 12 and 13) and ONR's External Hazards SAPs (Ref. 14).

	adequately conservative for defining a design basis (more information on this is available in Ref. 12)).	UKCP09 medium and high emissions scenarios while further research and analysis is undertaken of UKCP18 local data.	of the development. The allowances are based on the UKCP09 medium and high emissions scenarios. Projections for mean sea level rise are provided as an annual allowance, increasing with each epoch. The allowances were consistent with the global predictions for sea level rise at the time of publication. Welsh Government is currently reviewing its climate change guidance to align with revised UKCP18 data.	
Annual exceedance probability	Design basis analysis – 0.01% annual probability flood event (SAP EHA.4, para. 239) Beyond design basis analysis - assess cliff-edge effects etc. (SAPs EHA.7 & EHA.18, paras. 246- 248) Probabilistic safety analysis	Tidal flooding - 0.5% annual probability event Fluvial flooding- 1% annual probability event Fluvial and Tidal flooding – 0.1% annual probability event	Tidal flooding - 0.5% annual probability event Fluvial flooding- 1% annual probability event Fluvial and Tidal flooding – 0.1% annual probability event	0.5% annual probability event for all flood sources.

	(SAP EHA.18, para. 246(c)) Severe accident analysis (SAP EHA.18, para. 246(e))			
Sensitivity Studies	Regardless of the RCP selected, sensitivity studies are also needed against more onerous scenarios including the H++ scenario, which is outside or on the margins of the 10th-90th percentile of UKCP09 (see the section on H++ below for more detail). Further information can be found in ONR's External Hazards Technical Assessment Guide (TAG 13) (Refs. 12 and 13).	H++ is an example of a 'credible maximum' climate change scenario (see below). H++ should be assessed for developments that could be particularly vulnerable to the impacts of climate change, such as major infrastructure projects. H++ allowances are available in Environment Agency guidance "Flood risk assessments: climate change allowances" (Ref. 6). Duty holders will need to devise an adaptive approach which would manage the impacts of a credible maximum climate change scenario.	Consideration of the H++ 'credible maximum' climate change scenario is helpful for contingency planning and should be assessed for those developments that are very sensitive to flood risk and have lifetimes beyond the end of the century, for example major infrastructure projects. Guidance on H++ allowances can be found in the Welsh Government document "Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales" (Ref. 7).	SEPA guidance specifies a range of sensitivity testing for developments that are particularly likely to be vulnerable to climate change; this includes nuclear sites (Refs. 9 and 15).

Duty holders will need to satisfy the requirements of the regulators and, where relevant, the planning authorities, with respect to their consideration of climate change. The submissions will respond to different regulatory requirements and expectations as set out in the table above, but where they overlap they should be consistent; differences in data, methods used and judgments should be reconcilable and justified. This is set out in ONR and EA's "Principles for Flood and Coastal Erosion Risk Management" (Ref. 16).

Duty holders could satisfy the regulators and planning authorities while maintaining this consistency by, for example, performing an analysis of climate change using a range of climate scenarios, return periods, and sensitivity studies. This should include consideration of RCP 4.5, RCP 8.5 and H++ scenarios. This analysis would then feed into individual submissions to each regulator in accordance with their expectations.

H++ SCENARIOS

More extreme climate change scenarios outside or on the margins of the 10th-90th percentile range of UKCP09 were developed and are known as the H++ scenarios. These can be used to assess the impacts of low probability, high impact climate events including heatwaves, drought, extreme winds, sea level rise and storm surge. H++ scenarios can also be used for sensitivity testing different adaptation options over time periods appropriate for the nuclear industry. ONR and EA's "Principles for Flood and Coastal Erosion Risk Management" (Ref. 16) state that the current H++ scenarios based on UKCP09 for sea level rise and storm surge are an example of the credible maximum scenario.

The regulators expect duty holders to use the most up to date H++ scenarios in any new analysis of climate change.

EXPLORATORY POST-2100 SEA LEVEL RISE SCENARIOS

Some nuclear licensed sites and sites for storing or disposing of radioactive waste will have lifetimes that will extend well beyond 2100. Assessments will therefore need to cover the full lifetime of the development proposed. There is now a large body of literature that suggests that increasing sea level is likely to continue beyond 2100 for a considerable period of time, even if global greenhouse gas emissions are restricted. Therefore, UKCP18 has produced some extended projections for sea level rise beyond 2100 for RCP 2.6, RCP 4.5 and RCP 8.5 – these are referred to as 'exploratory post-2100 sea level rise scenarios' (Ref. 17). These scenarios are based on idealised assumptions about emissions (rather than being linked to specific technologies and societal actions) and extend to 2300. These extended projections show uncertainty increasing with time and have much wider confidence intervals than projections up to 2100 (Ref. 17). For projections beyond 2100, duty holders are encouraged to use the exploratory post-2100 sea level rise dataset (also called the UKCP18 Exploratory Extended Time-mean Sea Level Projections) provided by the UKCP18 project, rather than extrapolating the UKCP18 sea level rise dataset. Regardless of the methodology selected beyond 2100, duty holders should be aware that a high degree of uncertainty is present and should also take into account the managed adaptive approach (see below).

EXTREME VALUE ANALYSIS

Extreme value analysis (EVA) is a branch of statistics that seeks to assess the probability of events that are more extreme than any previously observed. The regulators expect duty holders to make use of EVA techniques when analysing the impacts of climate change.

In UKCP09, many duty holders used the weather generator facility to generate data that could be used to undertake EVA. The weather generator is not included in UKCP18 and is no longer being updated. Duty holders may still wish to undertake EVA and one way of doing this in UKCP18 could be to use the 2.2 km sub-daily data for RCP 8.5. Whilst the regulators do not prescribe a methodology for EVA, duty holders should discuss and agree their approach to EVA early in the process.

2.2 KM LOCAL PROJECTIONS

In September 2019, the 2.2 km local projections were released as part of the UKCP18 suite of projections. The UKCP local (2.2 km) projections is a new set of 12 climate projections using a model as detailed as those typically used for weather forecasts. The 2.2 km local projections represent an ensemble of climate projections at convection-permitting scale and are sometimes referred to as a ‘Convection Permitting Model’ (CPM) (Ref. 18). The 2.2 km local projections provide data on hourly timescales and on local kilometre scales. The 2.2 km local projections are considered to better represent small scale behaviour in the atmosphere, such as convection, than the 12 km regional projections. The high resolution also better captures the local variability in climate that is particularly significant in mountainous, coastal and urban areas.

With the release of the 2.2 km local projections, the UKCP18 project is now complete and all outputs are available on the UKCP18 website (Ref. 19). ONR expects duty holders to take account of the 2.2 km local projections in any new analysis of climate change. Additional analysis of the 2.2 km local projections is currently being undertaken as part of the Future Drainage Project being led by Newcastle University (Ref. 20). The EA, NRW and SEPA’s interim position is that until this work is completed, duty holders should continue to use its existing guidance for peak river flow and peak rainfall intensity (Refs. 6, 7, 8 and 9). Upon completion, the EA, NRW and SEPA will consider whether their guidance (Refs. 6, 7, 8 and 9) should be updated further.

MANAGED ADAPTIVE APPROACH

The regulators encourage a ‘managed adaptive approach’ to flood and coastal erosion risk management when planning for climate change (Ref. 16). The managed adaptive approach sets out a way for dealing with the significant uncertainty surrounding climate change in the future. The aim of the managed adaptive approach is to build flexibility into options and decisions today so that they can be adjusted depending on what happens in future.

There are two key elements of the managed adaptive approach. One approach is to build in the ability to adjust an option should it be required. A complementary approach

for duty holders to adopt is to develop flexible plans to build flexibility into the decision process itself through waiting and learning as scientific understanding of climate-related risks increases.

Not all of the options to manage future climate change will be suitable for a managed adaptive approach of waiting and learning, so a combination of a design containing precautionary elements and the managed adaptive approach is likely to be the most suitable approach for nuclear sites.

There are a number of elements of a managed adaptive approach (Ref. 16):

- Understanding the full range of risks that might need to be managed. This comes from understanding the full range of climate change as described by the credible maximum scenario. A current example of the credible maximum scenario for peak river flow or sea level rise for the period to 2100 is the H++ scenario provided by UKCP09.
- Understanding how much flexibility and what options might be needed – and when – depending on the different climate change projections.
- Iterative decision-making (evaluating results and adjusting actions on the basis of what has been learned).
- Feedback between monitoring and decisions (learning) knowing when a decision will be needed given the changing risks and the lead time to make an adjustment, or implement a new option.

More information on the managed adaptive approach can be found in ONR and EA's "Principles for Flood Risk and Coastal Erosion Risk Management" (Ref. 16).

STATUS OF REGULATORS' POSITION ON UKCP18

The regulators will continue to keep the position on UKCP18 under review, and if appropriate, reconsider this statement in light of any such developments.

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