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Lloyd's Exposure Management
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Thematic Review: Catastrophe Modelling & Climate Change

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Contents

1. Foreword

Climate change has been high on social, political, and regulatory agendas for several years with 2021 being a transformational year for Lloyd's across several climate-related areas. These include:

- Participating in the Bank of England's Climate Biennial Exploratory Scenario (CBES)
- Embedding climate risks into the Lloyd's risk framework
- Appointing a new Sustainability Director and publication of our directional guidance and best practice for establishing an ESG framework
- Leadership of the Sustainable Markets Initiative (SMI) Insurance Task Force, convened by HRH Prince of Wales
- Joining the UN-convened Net Zero Insurance Alliance (NZIA)
- Launching the Lloyd's Climate Action Campaign and
- New research from Lloyd's Futureset

Given this backdrop, and with a global spotlight on world leaders at COP 26 in Glasgow, it is appropriate for Lloyd's to take stock of progress made so far and consider what more should be done.

In 2020 Exposure Management market messaging, Lloyd's stated "We expect all Syndicates' Views of Catastrophe Risk (as represented within capital models) to be appropriate for the current climate, and to reflect changes in climate which have already occurred and may be influencing hazard now and over the timeframe covered by policies underwritten". In 2021, we elected to carry out a thematic review to learn how a sample of managing agents are approaching this requirement, with the aim of sharing good practice with the Lloyd's market.

Our conclusions have led to three requirements. Firstly, Boards must explicitly reference and discuss climate change in Board discussion of view of risk. Secondly, explicit reference to climate change must be made in validation of climate-related perils. Finally, managing agents must develop a framework to address potential current and future climate impacts on their natural catastrophe-exposed portfolio by region-peril. We believe these requirements are not only achievable, but they will also progress discussion on the challenging topic of climate change, allowing Lloyd's to lead the market and enable sustainable, profitable underwriting.

Kirsten Mitchell-Wallace
Director of Portfolio Risk Management
Lloyd's

2. Executive summary

Lloyd's managing agents must ensure that their view of risk is validated and appropriate by explicitly reviewing the representation of the current climate for each relevant peril region. Currently, the level to which this requirement is met varies across the market.

Four of the twelve participating managing agents reviewed demonstrate very robust methodologies backed by extensive research into climate change science and its impact on the perils they cover. They have clear frameworks, which guide the depth of research and resultant actions required, such as adjusting their view of risk. These frameworks incorporate the likely impact of climate change on specific perils as well as the confidence of the science for those perils, combined with the materiality of the perils. These approaches are considered examples of good practice.

In contrast, the majority of managing agents reviewed relied on model vendors' validation, without obviously judging whether vendor validation is adequate and appropriate for the current climate themselves. Justifications for this included belief that there is not yet a clear enough signal to identify a climate change trend, or a lack of guidance on how to best capture current climate in their view of risk.

A forward-looking approach is key to ensuring that current and near-term future risk is being adequately represented. Syndicates should not simply be reconsidering their view of risk appropriateness to current climate in response to historical experience.

Three key requirements have emerged from the thematic review.

i. Firstly, Boards must explicitly reference and discuss climate change in Board discussion of view of risk.

ii. Secondly, although we expect a large part of validation can be independent of the syndicate's own business profile and completed by the model vendors, both model validation policy and model validation analysis documentation must make explicit reference to, or contain a section on, current climate.

iii. Finally, Lloyd's will require all managing agents to implement their own framework for managing physical climate risk in the context of their view of catastrophe risk to ensure a forward-looking approach to addressing climate impacts on their natural catastrophe exposed portfolio by region peril.

In conducting this thematic review, Lloyd's hopes to begin to address the lack of guidance cited through sharing good practice from the participating managing agents.

3. Introduction

3.1 Background

This review continues Portfolio Risk Management's programme of thematic reviews, exploring the completeness and appropriateness of syndicates' catastrophe view of risk. Lloyd's has identified that syndicates' understanding of the extent to which current climate conditions are captured in catastrophe models varies widely; a closer review of market practice in this area is merited. By using a thematic approach, feedback can be provided at a market level, sharing best practice across managing agents.

Global temperatures have increased on average by approximately 0.1˚C per decade since 1880 and by almost 0.2˚C in the last thirty years. There has been much discussion of whether this change in climate is already having a significant impact on the frequency and severity of some natural catastrophe perils globally.

Lloyd's already requires managing agents to consider the impact of climate change in their internal model, as the Lloyd's Capital Guidance states "Lloyd's expects all syndicates' views of Catastrophe Risk (as represented within capital models) to be appropriate for the current climate, and to reflect changes in climate which have already occurred and may be influencing hazard now and over the timeframe covered by policies underwritten". The focus of this thematic review is to explore how managing agents can consider climate change in catastrophe modelling.

The stochastic models used by syndicates to quantify natural catastrophe risk rely on historic meteorological and hydrological data for parameterisation, and hence as the climate changes, it is critical to ensure that the model baselines remain appropriate given changes in the underlying climate. The historical records that form the foundation for stochastic loss modelling may not be the best indicators of current or future risk, and it is unclear whether such models are able to adequately capture evolving climate conditions.

It is widely acknowledged that some perils appear to be more impacted than others. Wildfire and flood are the perils typically at the forefront when discussing physical risks with increased uncertainty due to climate change. This is exemplified by the ongoing discussion of the California wildfire seasons of 2017 and 2019 and increased prevalence of extreme flooding events, including those attributed to Tropical Cyclone Induced Precipitation (TCIP).

For the purposes of this review, Lloyd's defines **"current climate"** as climatic conditions observed during the relevant time period for policies underwritten.

3. Introduction

3.2 Aim and objectives

The primary aim of this thematic review was for Lloyd's to understand the methodologies for ensuring any changes in climate that have already occurred, or are expected to occur over the relevant period, are accounted for in syndicates' views of risk and as part of catastrophe model validations. The goals were to determine areas of good practice and to develop new requirements to ensure alignment across the market.

In practice this entailed:

- Reviewing managing agents' overall approach to representing current climate conditions in catastrophe models
- Understanding managing agents' culture regarding climate change risks and their approach towards possible future changes to business models and/or portfolio management

Focus was on:

- How managing agents explicitly validate the adequacy of the representation of climate conditions in catastrophe models
- The most widely used sources of climate data for analysis
- Triggers that would cause a managing agent to review how climate is represented
- Whether models are conditioned for natural variability/cyclical behaviour, or adjusted for a longer-term trend
- Adjustments made for changes in climate conditions affecting a climate-related physical view of risk
- How changes in climate, relative to risks underwritten, are discussed and challenged throughout the business
- Whether considerations are being made for how portfolios and programmes of validation may need to be managed in the future to ensure the representation of current climate in catastrophe models

Twelve managing agents with a range of natural catastrophe risk materiality were selected for participation in the review.

Managing agents were invited to complete a predominantly qualitative questionnaire, and to provide any documentation pertinent to the review. Upon review of this information, Lloyd's also engaged with managing agents through follow-up conversations.

The review engaged numerous stakeholders, including heads of exposure management and research analysts. All discussions and information received were highly insightful, and Lloyd's would like to take the opportunity to thank everyone who contributed their valuable time.

4. Insights

4.1 Validation approach

Lloyd's has seen limited evidence that syndicates are meeting the requirement to validate models with respect to current climate.

Of the managing agents that do explicitly consider current climate conditions in their climate-driven peril views of risk, all consult a range of peer-reviewed scientific and academic research documents to help draw their conclusions. These materials are studied closely and continuously to ensure that any knowledge gained remains accurate and relevant. Such rigorous reviews are made possible in most cases by access to dedicated research analysts and teams within their company; Lloyd's recommends all managing agents engage as much as possible with whatever research resources are available to them.

Knowledge collaborations are becoming more available, such as market initiatives to bring the climate science and academia together to better support the insurance industry's understanding. Other options could involve drawing expertise from parent companies, or related entities, or simply ensuring that responsibility for frequent literature (or meta-analysis studies) review is clearly assigned. Lloyd's expects the resources dedicated to this to be commensurate to the materiality of the risk presented by each climate-impacted peril.

Four managing agents have developed clear climate change frameworks underpinned by knowledge and insight gained from their aforementioned literature reviews. These frameworks classify perils and observations about their frequency, severity, and deviations from a baseline into groups depending on the urgency to amend a view of risk and/or the confidence in the observations to be able to declare clear trend shifts or even a "new normal". They also can identify where a change is likely even if it cannot be attributed to climate change right now.

Perils that have been highlighted as requiring a revised view of risk are then tested, validated and adjusted in accordance with usual procedures. Further commentary on adjustments to view of risk can be found in section 4.4.

Some of the example frameworks observed by Lloyd's are described below.

One framework categorises risks based on potential impacts or evidence of climate change. It is updated continuously and for each critical peril a "change ramp" has been assigned to demonstrate how quickly climate change may affect a particular peril; this determines the frequency of review required.

A detailed approach splits each region peril into its sub perils and severities when reviewing climate change research and evidence; for example, North Atlantic Hurricane was broken down into separate observations for intensity categories 1-2, 3 and 4-5, storm surge, and tropical cyclone induced precipitation. Confidence for each sub-peril is assigned (minimal, moderate, strong) and if the confidence is strong (i.e. a clear-cut deviation from historical experience with demonstrable evidence) then an action is taken, such as applying uplifts to the view of risk.

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This framework allows more granular adjustments to be made, but also drives action even if confidence is not high when considering climate change impacts on the peril as a whole (for example, hypothetically, a managing agent could decide they are confident in adjusting for storm surge trends now, but not yet for wind frequency rates).

One managing agent discussed the importance of being proactive when it comes to capturing the impact climate change is having on perils and Lloyd's agrees with this perspective: managing agents should not simply be responding to events and reconsidering their view of risk after the fact. Staying abreast of high-quality literature/publications is key; where information provided is quantifiable, from peer-reviewed scientific work and trusted sources, and if there is a clear consensus then this makes it easier to amend a view of risk. Some useful studies and sources of climate data can be found in Appendix B.

Managing agents not following the approach described above are typically validating their models based on historical data and only re-validating their view of risk once recent years' experience has been incorporated into catastrophe models and their underlying datasets. This practice is not sufficiently forward-looking to demonstrate that current and near-term future risk is being adequately represented; further analysis is required.

4.2 Review triggers and frequency

Typically managing agents review whether their view of risk accurately reflects current climate conditions in the aftermath of a major event, with the release of an updated model version from a third party, or with the release of a new white paper from peer-reviewed sources, such as academia, journals or the Intergovernmental Panel on Climate Change (IPCC). While the above triggers may result in out of cycle reviews, best practice would be to review key driver perils annually in the run-up to the peak season for that peril e.g. renewal period for the NAHU wind season. Lloyd's found the least frequent reviews to be conducted biennially.

4.3 Long-term conditioning vs natural variability

Lloyd's was interested to learn whether managing agents condition perils towards long-term trends or for natural variability. See chart opposite.

In summary, Lloyd's does not have preference as to whether adjustments are attributed to long-term climate change or natural variability.

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Long-term conditioning vs natural variability

MA	Approach	Lloyd's View
A	Assume model vendor medium term outlook or warm sea surface temperature capture natural variability/latest climatic conditions.	Acceptable provided model validation documents make explicit reference to current climate, including attesting to whether, in the managing agent's view, the model vendor has represented current climate well enough.
B	Adjust model vendor's natural variability base view of risk. E.g. depending upon the driving force behind the Atlantic Multidecadal Oscillation (AMO).	Acceptable provided adjustments are suitably validated.
C	Base view of risk is conditioned for long-term, but if evidence suggests losses are understated (e.g. active previous wildfire season) or there is a period of enhanced sea surface temperatures or tropical cyclone activity then loadings/adjustments are applied.	Long-term conditioning baseline is acceptable, however a more proactive approach than adjusting after the event is preferred.
D	Two views of risk: One based on long-term conditioning feeding the capital model. Another based on natural variability for underwriting decisions, portfolio construction and reinsurance purchasing. Reasoning for this is to maintain stability and continuity in the capital model, which is used for risk appetite setting, whilst still accounting for seasonal outlooks and uncertainty to reflect the prospective climate conditions in an average year.	Near-term view of risk/current climate is considered at point of underwriting and for timeframe of policy underwritten. However, there is a risk that the two views of risk diverge too much and there is not a consistent view of risk used throughout business to frame risk appetite.
E	Long-term conditioning and natural variability considered simultaneously. Define the long-term view taking into account historical data to create a baseline and then alter this view considering a combination of natural variability (such as sea surface temperature (SST) patterns and anomalies), climate change, observations from recent events (e.g. California Wildfires) and other risk factors, including social inflation to create a present day view of risk.	Best practice for considering both. Considers vulnerability and exposure shifts in addition to hazard impacts thus improving the accuracy of catastrophe loss projections.

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4.4 Adjustments to view of risk

Adjustments to views of risk are expected where the model vendor baseline is judged not to reflect current climate.

Lloyd's found that managing agents' adjustments to views of risk to represent current climate range from basic to sophisticated. We recognise that it can be difficult to make detailed adjustments due to constraints imposed by the current state of science and uncertainties, and that as knowledge and expertise develop it will become much easier. However, in the meantime Lloyd's expects model validations to explicitly consider whether current climate conditions are represented in the syndicate's view of risk and as such decide if making an adjustment is appropriate to achieve this.

Some managing agents have only referred to the inclusion of Tropical Cyclone Induced Precipitation (TCIP) loadings as evidence their view of risk is validated for current climate. Lloyd's does not consider this approach to be sufficient as TCIP should already be accounted for in fundamental model completeness.

US wind frequency rates are among the most commonly adjusted parameters. The granularity of uplifts varied: entire curves, portfolio level, event level, regional level.

The most detailed approach for adjusting view of risk extrapolates a view of the year 2100 backwards across all years to the present, in order to capture incremental change from a base point to future expectations for the peril based on research from the IPCC and other credible sources.

The incremental changes are re-evaluated every few years to ensure they remain valid. Although in Lloyd's view, the assumption of linear change in hazard is weak, in the absence of other information at present this is still an acceptable approach because it is proactive and recognises potential near-term impacts. It should be noted here that Lloyd's does not expect syndicates to adjust their present-day view of risk for far-future changes in hazard.

4.5 Forward-looking approaches

Managing agents that have developed their own climate change frameworks discussed how they envisage these would influence pricing and their programme of model validation. For example, if a peril has been categorised as having high confidence in observed changes to its frequency and/or severity then this would trigger a "deep dive" model validation, and underwriting teams are likely to take this information into consideration when assessing a risk.

Lloyd's recommends re-designing model change/validation cycles and timelines to ensure that, at a minimum, the most material perils in terms of climate-related physical hazard risk are scheduled for annual review of whether the latest data, trends and climate conditions are appropriately considered in the syndicate's view of risk. For those managing agents using third party models, Lloyd's recommends regular interaction with the model vendor to ensure the model vendor is maintaining their own review programme of current climate conditions to allow the syndicate to have the information required to demonstrate effectively that the models they are relying upon are up to date for current climate.

4. Insights

4.6 Culture and implementation

4.6.1 Board discussions

Lloyd's is encouraged by managing agents' culture towards climate change and associated model validations. The topic is frequently featured on Board agendas (which is consistent with the recent focus from regulators e.g. the requirements in the PRA's SS 3/19 and the BoE's CBES exercise), and committees and working groups have been set-up to facilitate discussion and challenge. Some syndicates have their own specialist research teams which enable more comprehensive reviews of models, academic papers, and other resources. The best catastrophe risk cultures consider climate change along with all other risk factors at the point of underwriting and this attention to detail disseminates throughout the organisation with feedback loops through the lifecycle of the risk.

Lloyd's expects Boards to explicitly reference and discuss climate change in their approval of the syndicate's view of risk.

4.6.2 Model Validation Documentation

Both model validation policy and model validation analysis documentation must make explicit reference to, or contain a section on, current climate. To limit repetition in the latter, this section could reference analysis in other sections of the document, but it must make statements attesting to the representation of current climate in the view of risk, including (where relevant) whether the current climate is suitability represented by model vendors.

This requirement will be considered in future reviews of model validation and view of risk capabilities as part of natural catastrophe maturity assessments.

4.6.3 Region peril action planning

A forward-looking approach to model validation should be adopted. Lloyd's expects all managing agents to develop and monitor a plan to address climate impacts on their natural catastrophe exposed portfolio by region peril. Lloyd's will look to discuss these with syndicates as part of business as usual interactions from 2023 onwards.

As discussed in section 4.1, the best way to approach this is to develop a framework. An example framework relating action to materiality and climate science is provided below. The climate change impact on peril axis is a function of confidence/scientific consensus and expected magnitude of impact. Syndicates do not need to follow this format, but their framework/matrix must clearly articulate the triggers for action on view of risk.

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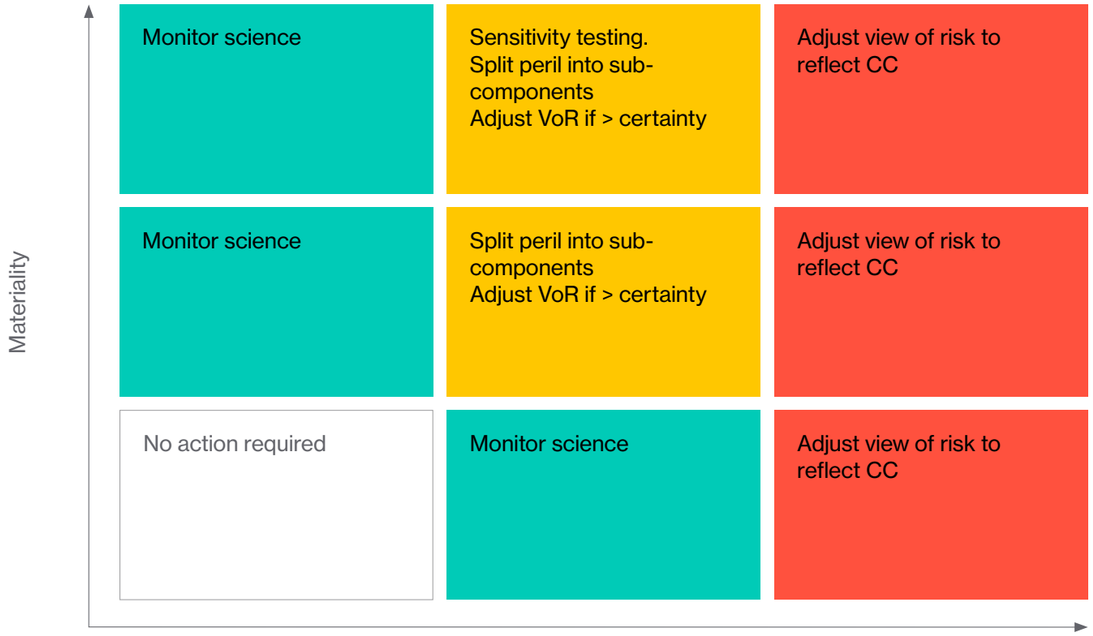
4. Insights

Climate Change Matrix



4.6.4 Science Monitoring

Lloyd's recommends syndicates consider building capability in the proactive review of independent, verified scientific literature, publications or meta-analysis studies alongside white papers and model documentation from model vendors. In line with the PRA's Supervisory Statement SS3/19 requirement to "[devote] adequate resources, sufficient skills and expertise" to climate change risk management, Lloyd's expects the resources dedicated to science monitoring to be commensurate to the materiality of the risk presented by each climate-impacted region peril.

5. Requirements

In summary, there are three new requirements relating to climate change and catastrophe modelling:

1. **Explicit reference to and discussion of climate change in Board discussion of view of risk.**

Syndicate Boards must ensure that syndicates' views of catastrophe risk are materially complete and appropriate to the current risk landscape, including in respect of climate conditions. Lloyd's expects that meeting minutes will clearly demonstrate that Boards are confident that an appropriate view of risk has been used.

2. **Explicit reference to climate change in validation of climate-related perils.**

As outlined in Lloyd's new "Principles for doing business", view of risk should be appropriate to current conditions, including climate. Lloyd's now requires a clear section in model validations (for climate related perils) which demonstrates that the syndicate's view of risk is appropriate for current climate conditions.

As this is specifically related to the hazard, it is acceptable for content to be provided by the model vendor, provided the syndicate demonstrates robust review and understanding of the vendor's approach.

3. **Development of a framework to address potential current and future climate impacts on their natural catastrophe-exposed portfolio by region-peril.**

Managing agents must consider region peril materiality, climate change observations, trends, and the rate of change. The framework should illustrate how the combination of these factors determines future approaches to addressing risk. Lloyd's will look to discuss these with syndicates as part of business as usual interactions from 2023 onwards.

6. Contacts

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Appendix

7. Appendix

7.1 Appendix A: Extract from Lloyd's Handbook for 2021 Climate CBES

Primary loss modelling approach
The following options are available for adjusting catastrophe models, presented in order of complexity/desirability:

i. Making direct event-based adjustments to the hazard component of a catastrophe model, considering:

   a. which damage drivers will not be covered by such adjustments from the pre-identified variables,
   b. further caveats/assumptions that may need to be considered given limitations in (a)

ii. Making adjustments to ELTs or YLTs / PLTs, to uplift event specific losses or to edit loss distributions.

iii. Making indirect but appropriate adjustment to EP curves for each region peril at well-considered spatial resolutions, to scale losses simply (choices between AEP or OEP should also be documented during this process).

iv. Adopting the philosophy in (ii) and (iii) to develop methods for actuarial based pricing model adjustments (i.e. for those instances where cat models are not used to quantify a peril).

It is desirable for method (i) to be the primary method, as this is the most direct way to make climate-isolated changes in the models. However, given the relatively large list of peril-regions to run through, Lloyd's acknowledges that running the catastrophe models through a re/insurance portfolio will be extremely demanding, and additionally direct hazard adjustments may be impossible given constraints of some vendor catastrophe models.

Thus, where (i) is not possible, MAs are encouraged to use method (ii), and making reasoned and documented choices about what loss data to use (e.g. ILCs vs own direct portfolio loss adjustments) if employing this method. In instances of relatively low materiality, or inability to disaggregate the science appropriately, we suggest methods (iii) and (iv) to be the final methods employed, but at this point it should be considered whether the peril is material enough that direct vendor interaction should be considered.

While selecting a method for loss model adjustment, it may become apparent that the variables selected during the literature review may not be directly applicable to a catastrophe model. Thus, Lloyd's encourages an iterative approach in which the team tasked with the loss modelling are able to feedback information/requests for variable adjustment to the team involved the scientific review, such that the most appropriate variables are used for the adjustment. MAs are also encouraged to document any caveats and assumptions they make when embarking on this iterative process.

For those new to adjusting cat models in such a way as (i), the adjustments can be made in the following ways:

In an Event Rate World:

- Direct batch editing of all event rates.
- Direct editing of key event loss-driving rates (i.e. from cross-comparing your key exposures).

In an Event ID World:

- Careful duplication/removal of events to simulate the event rate changes.

7. Appendix

Certain models (e.g. some flood models) may not have user-accessible stochastic hazard events. In this instance, MAs are unlikely to be able to directly adjust hazard layers of these catastrophe models and should therefore try to find a defensible method to employ methods (ii) or (iii). If this is not possible, MAs may want to engage a model vendor for adjusted event set output. It must be stressed, however, that these types of adjustments are not a trivial task, even for a model vendor.

v. Secondary loss modelling approach

In the previous step, the focus is on capturing the primary drivers of loss (e.g. event occurrence). However, there are a number of perils for which it is difficult to ignore secondary loss-drivers related to climate change. As an example, it is consistently projected that rain rate in Tropical Cyclones (Hurricanes, Typhoons) will increase in a warmer climate, but this effect is impossible to isolate in a vendor model in such a way as the frequency/severity adjustments suggested above. Thus, MAs are encouraged to try to make "secondary" adjustments for any missing loss drivers after the key adjustment variables have been decided. Ideally this would be done using method (iii) from the previous section, but we appreciate this may not be possible given limitations in science, or just not necessary because of limited materiality.

vi. Validation

MAs will need to consider the plausibility of the generated results and validate those against expectations including how the results back test against loss experience.

As mentioned earlier, this could be done by assessing the summary of sources available; engaging exposure management and portfolio aggregation teams to sense check the changes in loss; or by using external party to conduct the review.

Key questions that should be considered during this process might include:

– Do the results look sensible, given the magnitude of model adjustments suggested by the literature review?

– Are there any data sources one can use to check to see if the loss amounts reflect expectations/current trends? (For example, looking at historical loss studies that normalise for exposure and vulnerability trends).

7.2 Appendix B: Useful Climate Data/Sources

A table of key scientific sources is shown on the next page, which provides further information to help bridge the gap between the literature and the practical hazard adjustments that can be made in a contemporary catastrophe/loss model. The literature referenced aims to act as a current "summary-of-the-science" but managing agents are encouraged to build on this where needed and where capacity allows.

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7.2 Appendix B: Useful Climate Data/Sources

Peril-Region	BoE Data Source(s)	Further Sources
US Hurricane	**Knutson et al., 2020:** – Frequency 4-5 change – Intensity – Precipitation **UK Met Office Sea Level Rise:** – Storm Surge	**Knutson et al., 2020:** – All frequencies **Knutson et al., 2020:** – Storm surge discussion
US Wildfire	**NGFS:** – % land area exposed change	**California's 4th Climate Change Assessment + Williams et al., 2019:** – California specific regional changes in wildfire characteristics and area burned trends
Canada Wildfire	**NGFS:** – % land area exposed change	**Wotton et al., 2017:** – Canada specific changes in wildfire characteristics under different RCP scenarios
US Severe Convective Storm	*Not provided*	**Diffenbaugh et al., 2013:** – CAPE and Shear changes for SCS frequency **Gensini & Mote, 2015:** – Historical trends of SCS frequency Koch et al., 2021: – Tornado frequency (in particular individual events vs clusters of events)
Canada Inland Flood	*Not provided*	**Clausius Clapeyron relationship** **Ali et al., 2020:** –further adjustment of that relationship.
EU Windstorm	**Oasis Hub:** – % change in windspeed (annual average/daily max) **Met Office/Oasis Hub:** – Storm surge/sea level rise	**Zappa et al., 2013:** – Frequency, Intensity and Precipitation changes **Harvey et al., 2020:** – Non-linear Frequency changes **Martinez-Alvarado et al., 2018** – Changes in Intense Features in Strong/Explosive EUWS

Peril-Region	BoE Data Source(s)	Further Sources
US Winterstorm	*Not provided*	**Chang, 2013:** – Frequency/Intensity changes in winter cyclones
US Inland Flood	*Not provided*	**Clausius Clapeyron relationship** **Ali et al., 2020:** – Further adjustment of that relationship. **Swain et al., 2020:** – Regional adjustment & different intensity/RP views
UK Inland Flood	**UK Met Office**	**Clausius Clapeyron relationship** **Ali et al., 2020:** – Further adjustment of that relationship. **Swain et al., 2020:** – Regional adjustment & different intensity/RP views
Japan Typhoon	**Knutson et al., 2020:** – Freq 4-5 change – Intensity – Precipitation **UK Met Office Sea Level Rise:** – Storm Surge	**Knutson et al., 2020:** – All frequencies **Knutson et al., 2020:** – Storm surge discussion
Canada Winterstorm	*Not provided*	**Chang, 2013:** – Frequency/Intensity changes in winter cyclones
US Drought	**NGFS:** – % land area exposed change	**Leng & Hall, 2019:** – Crop specific drought impacts by country

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