Exam 4: The Catastrophe Modeling Process
Learning Objectives

Assignment 1. General Data Concepts

Overall goal:

Module Title	Learning Objectives
1. SQL as a data description language	(LO1) Identify the utility and challenges when using SQL as a query language in catastrophe modelling (LO2) Recognize the use of other analytical tools in catastrophe modeling (R, Python) (LO3) Recognize the differences, advantages and disadvantages of relational database (star, snowflake etc.) (LO4) Understand the concept of permissions and how DBAs would control permissions on critical databases. (LO5) Describe how relational databases are used in the catastrophe modeling process • Exposure database: location, account, portfolio, reinsurance, conditions tables • Result database • Reference database (LO6) Understand the concept of data lake vs data warehouse, structured vs unstructured data. Pros and cons of both.
READINGS	
• Relational databases: https://searchdatamanagement.techtarget.com/definition/relational-database • Databases design: https://www.guru99.com/star-snowflake-data-warehousing.html • Background reading on permissions: https://www.red-gate.com/simple-talk/sql/database-administration/sql-server-security-cribsheet/ • AIR CEDE open source data scheme: https://docs.air-worldwide.com/Database/CEDE/10.0/webframe.html#topic1.html (Exposure data & reference data) • Data lake explained simply: https://www.forbes.com/sites/bernardmarr/2018/08/27/what-is-a-data-lake-a-super-simple-explanation-for-anyone/#5e5391ba76e0 • Data lake explained simply: https://aws.amazon.com/big-data/datalakes-and-analytics/what-is-a-data-lake/	

Module Title	Learning Objectives
2. Data, queries and stored procedure	(LO7) Describe the use of the following data types: Int, bigint, smallint Float Varchar(n), Nvarchar(n), char(n) Datetime Bit (LO8) Explain the role of following concepts in query and stored procedures: Null / not null Primary key Variable Stored procedures
READINGS	
• Data types: https//www.journaldev.com/16774/sql-data-types • NULL: https://www.w3schools.com/sql/sql_null_values.asp • Primary key: https://www.essentialsql.com/what-is-the-difference-between-a-primary-key-and-a-foreign-key/ • Variables: https://www.techonthenet.com/sql_server/declare_vars.php • Stored procedures: https://www.w3schools.com/sql/sql_stored_procedures.asp	

Module Title	Learning Objectives
3. Special considerations for geocoding	(LO9) Understand the definition of geocoding (LO10) Describe the key concepts of geocoding ● Process and major steps ● Hierarchy ● Geodetic Datum (LO11) Explain the various resolutions of geocoding (LO12) Understand the important attributes of geocoding (LO13) Explain the concept of centroid and average property
READINGS	
• Geocoding definition; https://www.techopedia.com/definition/12809/geocoding • Geocoding process (ArcGIS); http://desktop.arcgis.com/en/arcmap/10.3/guide-books/geocoding/the-geocoding-process.htm • Geodetic Datum: https://gisgeography.com/geodetic-datums-nad27-nad83-wgs84/ • Geocoding: https://www.rms.com/blog/2018/05/03/geocoding-the-underappreciated-science-of-	

catastrophe-modeling/; https://www.air-worldwide.com/siteassets/Client-Support/documents/Best-Practices-for-Using-Catastrophe-Models • ABI Industry Good Practice for Catastrophe Modelling – Chapter 4.4.3: https://catriskconsultants.com/wp-content/uploads/2011/12/Industry-Good-Practice-for-CAT-modelling-under-SII1.pdf • Natural Catastrophe Risk Management and Modelling: A Practitioner's Guide 1st Edition (Chapter 4.6): https://www.amazon.com/Natural-Catastrophe-Risk-Management-Modelling/dp/1118906047 • Study Note

Module Title	**Learning Objectives**
4. Basics of SQL queries	(LO14) Describe the basic structure of a \ SELECT query including ● SELECT... ● FROM... ● WHERE... ● LIKE… (LO15) Describe the difference between ● INNER JOIN ● OUTER JOIN ● LEFT/RIGHT JOIN (LO16) Describe the basic structure of an UPDATE query (LO17) Understand the CAST command and how it is used
READINGS	
• Select / from: https://www.w3schools.com/sql/sql_select.asp • Where: https://www.w3schools.com/sql/sql_where.asp • Like: https://www.w3schools.com/sql/sql_ref_like.asp • Joins: https://www.w3schools.com/sql/sql_join.asp • Update: https://www.w3schools.com/sql/sql_update.asp • Cast: https://www.w3schools.com/sql/func_sqlserver_cast.asp	

Module Title	**Learning Objectives**
5. Aggregating	(LO18) Describe basic aggregating statements ● COUNT ● SUM ● MIN/MAX ● AVG (LO19) Explain how GROUP BY and HAVING are used with aggregating statements
READINGS	

- Aggregations: https://www.w3schools.com/sql/sql_count_avg_sum.asp; https://www.w3schools.com/sql/sql_min_max.asp
- Group by: https://www.w3schools.com/sql/sql_groupby.asp
- Having: https://www.w3schools.com/sql/sql_having.asp

Module Title	Learning Objectives
6. Indexes and table creation	(LO20) Describe the difference between CREATE TABLE and INTO (LO21) Explain the concepts of ALTER TABLE and APPEND (LO22) Describe the difference between DROP TABLE, DELETE and TRUNCATE (LO23) Identify a SQL temporary table and the rationale for using them (LO24) Explain the rationale behind having an index, and the commands used to create an index (LO25) Understand the use of permissions in SQL databases; including why, in catastrophe modelling, some tables or databases may be read only.
READINGS	
• CREATE vs INTO: https://dba.stackexchange.com/questions/156105/create-table-as-vs-select-into • Temporary tables: http://www.sqlservertutorial.net/sql-server-basics/sql-server-temporary-tables/ • Indexes: https://dev.mysql.com/doc/refman/8.0/en/mysql-indexes.html	

Assignment 2: Managing the Process and Workflow

Module Title	Learning Objectives
1. Major steps in a catastrophe modelling exercise	(LO26) Understand the major steps in the cat modelling process and the important considerations at each step. *Please note that the process will look different at every company. Not all steps may be completed, additional steps may be added, or the steps may happen in a different order.* ● Identification of policies ● Data cleansing ● Data quality

	• Import / attach • Application of financial terms • Running models
READINGS	
• Study Note • Natural Catastrophe Risk Management and Modelling: A Practitioner's Guide: 1 Fundamentals; 2 Applications of Catastrophe Modeling; 4.2 Introduction to Building Catastrophe Models; 5.2 Introduction to Developing a View of Risk	

Module Title	**Learning Objectives**
2. Determining and testing data quality	(LO27) Describe the most important exposure data fields and their purpose. Explain what COPE data, primary modifiers and secondary modifiers are. (LO28) Describe what aggregate data is, the potential pitfalls of using this type of data & possible methods of disaggregation. (LO29) Determine and explain the impact of address accuracy and geocoding on modeled loss, including an understanding of the material differences by peril and region. (LO30) Describe instances where mailing address may have been provided in place of risk address. (LO31) Explain the difficulty of obtaining accurate address information for certain classes of business (such as builders' risk, offshore energy, workers compensation). (LO32) Define bulk coding along with its potential uses and pitfalls in modeling. (LO33) Identify validation checks which would indicate potential erroneous data or poor data quality. (e.g. 100 story wood frame building). (LO34) Define data quality and explain the rationale behind assessing it.
READINGS	

- Study Note
- 1.9.1.3 Primary and secondary modifiers: Natural Catastrophe Risk Management and Modelling: A Practitioner's Guide
- Unicede: https://unicede.air-worldwide.com/
- COPE: https://www.investopedia.com/terms/c/cope-insurance.asp
- Bulk coding (Uncertainty in exposure data section): http://www.lmalloyds.com/AsiCommon/Controls/BSA/Downloader.aspx?iDocumentStorageKey=cc44f6be-b83f-4cf9-903c-e802c1f312a8&iFileTypeCode=PDF&iFileName=Understanding%20uncertainty%20in%20cat%20modelling%20for%20non-cat%20modellers
- 7 Step Quality Process: https://www.moodysanalytics.com/risk-perspectives-magazine/managing-insurance-risk/insurance-regulatory-spotlight/data-quality-is-the-biggest-challenge
- Geocoding Resolution: https://www.willistowerswatson.com/en-US/Insights/2018/05/geocoding-the-underappreciated-science-of-catastrophe-modeling
- ABI Industry Good Practice for Catastrophe Modelling – Chapter 4: https://catriskconsultants.com/wp-content/uploads/2011/12/Industry-Good-Practice-for-CAT-modelling-under-SII1.pdf
- Catastrophe Modeling: A New Approach to Managing Risk (Huebner International Series on Risk, Insurance and Economic Security) 2005th Edition (Chapters 2.5.4.1 and 4.3): https://www.amazon.com/Catastrophe-Modeling-Approach-International-Insurance/dp/0387241051

Module Title	Learning Objectives
3. Auditing consistency with prior year data	(LO35) Describe the reasons that modelled results may change over time in relation to exposure data consistency. (LO36) List the main steps to perform a data audit.
READINGS	
• Study Note • Data audit process reference https://www.data-audit.eu/DAF_Methodology.pdf	

Module Title	Learning Objectives
4. Relevant queries and reports	(LO37) Describe the potential outputs that may be required from the following analyses and compare the differences by potential users. ● Data quality matrix ● Geocoding resolution ● Modeling assumptions and configuration ● Stochastic loss analysis ● Driving perils, accounts and locations ● Deterministic loss analysis (RDS, bomb blast, Historical event as-if) ● Hazard analysis ● GeoSpatial analysis ● Zonal aggregates and accumulations ● Marginal impact

	• Portfolio optimization • Capital allocation • Company own view of risk and adjustments made by Company • Trend analysis • Model completeness and validation • Modeling process and controls

READINGS

- Natural Catastrophe Risk Management and Modelling: A Practitioner's Guide 1st Edition (Chapter 2 Applications of Catastrophe modeling): https://www.amazon.com/Natural-Catastrophe-Risk-Management-Modelling/dp/1118906047
- Catastrophe Modeling: A New Approach to Managing Risk (Huebner International Series on Risk, Insurance and Economic Security) 2005th Edition (Chapter 1 Introduction): https://www.amazon.com/Catastrophe-Modeling-Approach-International-Insurance/dp/0387241051; https://www.casact.org/education/rpm/2010/handouts/CMWA-Hess.pdf
- Section 9 IBC Handbook for Economic Capital Modelling (attached in references)
- Section 4 (4.4.4 for accuracy and completeness): https://catriskconsultants.com/wp-content/uploads/2011/12/Industry-Good-Practice-for-CAT-modelling-under-SII1.pdf
- Chapter 7: Model validation: https://catriskconsultants.com/wp-content/uploads/2011/12/Industry-Good-Practice-for-CAT-modelling-under-SII1.pdf
- Chapter 6: View of Risk: https://catriskconsultants.com/wp-content/uploads/2011/12/Industry-Good-Practice-for-CAT-modelling-under-SII1.pdf
- Section 1.5 Processes and Controls, Chapter 3 documentation/ own view of risk: https://catriskconsultants.com/wp-content/uploads/2011/12/Industry-Good-Practice-for-CAT-modelling-under-SII1.pdf
- Section 5: Rating Agency data requirements
- Cat modeling best practices 2011 (attached in references)
- Section 6: Special data considerations for Reinsurers (and regulators)
- Cat modeling best practices 2011 (attached in references)
- Users of catastrophe models diagram, page 42
- Cat modeling best practices 2011 (attached in references)
- Section 9: how are the results of the models used
- Cat modeling best practices 2011 (attached in references)
- Catastrophe models and the rating process, AM BEST: http://www.ambest.com/press/031002catmodels.pdf
- Catastrophe Analysis for Rating: http://www3.ambest.com/ambv/ratingmethodology/OpenPDF.aspx?rc=190784
- AM Best Rating for US Insurers: http://www3.ambest.com/ambv/ratingmethodology/OpenPDF.aspx?rc=197686
- AM Best Rating for Canadian Insurers: http://www3.ambest.com/ambv/ratingmethodology/OpenPDF.aspx?rc=197675
- DFA: https://www.worldfinance.com/home/risk-encyclopaedia/dynamic-financial-analysis

Module Title	Learning Objectives

5. Annual renewal cycles, resources and technology	(LO38) Describe the market renewal cycles and what the cat modeling focus is of each renewal period. (LO39) Describe different staffing models. (LO40) Deployment methods for cat modelling applications.
READINGS	
• Study Note	

Assignment 3: Understanding Cat Model Output

Module Title	**Learning Objectives**
6. Uncertainty in Modeling Results	(LO41) Identify, define, and explain the differences in types of uncertainty as they pertain to catastrophe modeling. (LO42) Identify key sources of primary and secondary uncertainty within models. (LO43) Describe and be able to identify the impact uncertainty has on an exceedance probability curve and modelled results as well as the different approaches of incorporating and reporting uncertainty. (LO44) Identify and describe examples of uncertainty around Hazard, Exposure, Vulnerability (LO45) Understand the different approaches of incorporating and reporting uncertainty in modeled output.
READINGS	
• Modeling Fundamentals – Understanding Uncertainty • Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (2.16)	

Module Title	**Learning Objectives**

7. Model Output: Basic Metrics and Concepts	(LO46) Understand the various components of an Event Loss Table and Year Loss Table. Including how these are used to develop exceedance probability curve. (LO47) Identify, define, and understand relationships between common model output metrics such as AAL, PML, VaR and TVaR. Be able to compare and contrast these relationships for different portfolios. (LO48) Understand the differences between Occurrence EP and Aggregate EP curves and be able to apply this information in the underwriting and/or pricing process.
READINGS	
• Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (1.10, 1.11.1.1, 2.5.2, and 2.6.1-2.6.4.2.3)	

Module Title	**Learning Objectives**
8. Model Output: Advanced Metrics and Concepts	(LO49) Be able to distinguish and explain the differences between XSAAL and TVAR (LO50) Define the concepts of convergence and the importance of the number of simulations. (LO51) Understand and be able to explain different statistical approaches of models to address frequency and severity (Poisson, neg binomial, beta, pareto) and the importance of each in developing loss estimates.
READINGS	
• Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (1.10, 1.11.1-1.11.2, and 4.3.6.1) • Quantifying the source of simulation uncertainty in natural catastrophe models (Pgs. 591-605): https://link.springer.com/article/10.1007/s00477-017-1393-0; https://www.casact.org/pubs/forum/17spforumv2/02_Notes%20on%20Using%20Property%20Catastrophe%20Model%20Results.pdf	

Module Title	**Learning Objectives**
9. Financial Structure and Loss Perspectives	(LO52) Be able to identify, define, and explain the differences between the financial loss perspectives of cat model output (Ground Up, Gross, Pre-Cat, Net)

	(LO53) Be able to identify, define, and explain how location, policy, and reinsurance financial terms impact the financial loss perspectives of both a primary and reinsurance company.
READINGS	
• Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (1.8.4) • Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (1.9.2 • Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (2.4.2)	

Assignment 4: Working with and Communicating Cat Model Output

Module Title	Learning Objectives
1. Impact of Loss Curves of on Business Decision Making	(LO54) Be able to describe the impacts of data quality and approaches to improve gaps in exposure data. (LO55) Explain how modeled output may be used in the underwriting process to accept/decline a piece of business. (LO56) Explain actions that can be taken to turn an unacceptable piece of business into an acceptable piece of business. (LO57) Explain how modeled output is used to develop the technical pricing for a reinsurance program (e.g., facultative, cat XOL treaty, etc.).
READINGS	
• Swiss Re Cat Modeling & Pricing Seminar on Reinsurance – Philadelphia June 6, 2011: https://www.casact.org/education/reinsure/2011/handouts/INTMD4-CatModel.pdf • Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (2.6.1, 2.6.2) • Uses of Catastrophe Model Output, American Academy of Actuaries • Extreme Events and Property Lines Committee, July 2018: https://www.actuary.org/sites/default/files/files/publications/Catastrophe_Modeling_Monograph_07.25.2018.pdf • International Actuarial Association Risk Book – Chapter 5 Catastrophe Risk, Section I. Underwriting and Pricing: https://thecasinstitute.org/wp-content/uploads/2023/09/Ch5_CatRisk_2015-08-12.pdf • Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (2.4.2)	

Module Title	Learning Objectives
2. Actual vs Modeled Losses	(LO58) Explain the importance of comparing a company's own loss experience for actual events to a model's reconstruction of these events.
READINGS	
• Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (5.4.3)	

Module Title	Learning Objectives

3. Event Repsonse	(LO59) Explain why an event response process is necessary for a company. (LO60) Describe how an event response process may vary between events. (LO61) Describe how modeled footprints can be leveraged in an event response process, and identify characteristics of actual events that could lead to model underperformance in the loss estimation process. (LO62) Identify the various business areas/departments within a (re)insurance company which may be included in any real time event response communication. (LO63) Identify the types of information that may be included in any real time event response communication. (LO64) Describe caveats/disclaimers that should be noted in any real time event response communication.
READINGS	
• Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (2.9) • Insurance Journal: Insurance Industry is Rethinking Cat Modeling After Last Year's Disasters • https://www.insurancejournal.com/news/national/2018/07/16/495213.htm	

Module Title	**Learning Objectives**
4. Rating Agencies and Regulators	(LO65) Describe the role of rating agencies in assessing a (re) insurer's ability to meet its financial obligations and be able to identify what is considered in the Standard & Poor's catastrophe charge and the AM Best rating questionnaire. (LO66) Explain why regulators are interested in understanding a (re)insurance company's exposure to catastrophe risk and describe the link between regulation and catastrophe modeling.
READINGS	
• Natural Catastrophe Risk Management and Modeling: A Practitioner's Guide (2.11.2 – 2.11.3.1) • Catastrophe Modeling: A New Approach to Managing Risks (1.2.5) • Catastrophe Analysis in A.M. Best Ratings	