# Report on the Feasibility of Developing A South Carolina Hurricane Model

Prepared for the South Carolina
Department of Insurance

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# I. INTRODUCTION

This report has been produced to comply with 2014 S.C. Act No. 191 (S. 569), which requires the South Carolina Department of Insurance to:

> "conduct a study to assess the feasibility of the creation of a hurricane model by the State, with particular emphasis on the associated costs and physical/logistical requirements. The study also must assess the benefits to consumers of a South Carolina-produced model, including an evaluation of whether it would yield more accurate assessments of risk and better rates."

Certain terms used in the report need to be defined in order for all parties to understand the context of their usage in the report.

## A. South Carolina Produced Model

In South Carolina rate filings, property insurance companies use one or more of three proprietary models produced and owned by private corporations. These companies are Risk Management Solutions (RMS), AIR Worldwide (AIR) and CoreLogic/EQECAT (EQE). There are other models available both from private corporations or public sources, but these are not utilized at this time in company rate filings in South Carolina. In this report we define a South Carolina Produced Model as a hurricane computer simulation model that produces output similar to that from the proprietary models, but that is:

(1) Owned, licensed, or commissioned by the state of South Carolina; and
(2) Developed, maintained, and operated by public institutions and private entities within the state of South Carolina or operated by public institutions and private entities under contract with the state of South Carolina.

The South Carolina Produced Model would be utilized by the South Carolina Department of Insurance ( also referred to as "SC DOI"or "Department") within the context of regulatory activities involving property insurance ratemaking in South Carolina

## B. Better Rates

The current statutes regarding ratemaking in South Carolina for all property and casualty lines of business require that rates not be inadequate, excessive, or unfairly discriminatory. The model will produce "better rates" to the extent that it improves the ability of the state of South Carolina to approve rates that meet these statutory requirements. This will give additional confidence to the people of the state that rates reflect the best information available to the Department in determining actuarially sound property insurance rates.

This report, with attachments, addresses the definition of a hurricane model, the history of their usage in property insurance ratemaking in general and in South Carolina specifically, how the models are constructed and by whom, and finally how South Carolina could develop a hurricane

model. The report also includes the cost/benefit analysis of various options the state could pursue, as well as recommendations for future action.

## II. HISTORY AND BACKGROUND OF HURRICANE MODELS

### A. General Model Discussion

Estimated expected insured losses are the primary component of residential property insurance rates. In property insurance ratemaking, historical claims experience is used to develop these expected future losses for insured perils such as fire, liability, theft, water damage, and non-catastrophe wind/hail, among others. The nature of these types of claims is such that the historical claims are considered a credible basis for projecting future losses. Namely, these types of losses, for a large number of policyholders, will produce a considerable number of claims (frequency) that result in average claim amounts within an expected range. South Carolina is no different than the rest of the United States in regards to non-catastrophe ratemaking methodology and assumptions.

The nature of earthquake and catastrophic wind/hail losses, including hurricanes, tropical storms and other convective storms, is different. These losses occur less frequently, and result in significant damage to insured property that is affected. Using historical loss experience is not reliable due to the lack of insured events, and the comparability of losses that occurred up to 30, 50 or 100 years ago to what losses would result from these events today is severely limited. In fact, methods used prior to Hurricanes Hugo in 1989 and Andrew in 1992, as well as the Loma Prieta earthquake in 1989 and Northridge in 2004, produced estimated loss cost loads in property insurance rates that were shown to be grossly inadequate. About the same time as these events occurred, insurance companies began to use catastrophe computer simulation models that were developed to produce expected insured losses from catastrophic events that are statistically credible and reliable for ratemaking. Use of computer simulation models for ratemaking is now widely considered the current state of the science by insurance and regulatory actuaries and management. These models have been used by insurance companies and regulators to review property insurance rates for over 15 years.

### B. How Hurricane Models Work

"State of the art" hurricane models consist of a complex set of computer programs. Their development required experts in meteorology, wind and structural engineering, statistics, actuarial sciences, finance, GIS, and computer science. The programs simulate and predict:

(1) how, where and when hurricanes form,
(2) their wind speed and intensity and size etc.,
(3) their track,
(4) how they are affected by the terrain along the track after landfall,
(5) how the winds interact with different types of structures,
(6) how much they can damage house roofs, windows, doors, interior, contents etc., and
(7) how much it will cost to rebuild the damaged parts, and how much of the loss will be paid by insurers.

A hurricane model simulates hurricane losses for thousands of different scenarios that could possibly occur over a given time period to produce a probability distribution for hurricane losses during that time period. The probability distribution describes the possible hurricane losses that could possibly occur and the likelihood of these losses occurring. The model is based on current scientific research in meteorology and engineering, and is developed by experts in those fields. These are not the same as the models that develop forecasts of seasonal hurricane activity, such as Dr. William Gray's model at Colorado State University or the National Weather Service.

In general, the input to the model is a portfolio of properties with details regarding all aspects of building location and characteristics. The output of the models is the average hurricane losses for these properties over the thousands of scenarios that are simulated. From this output, actuaries can develop projected hurricane loss costs for rate filings. Also, the output produces probable maximum loss estimates (e.g., the 99$^{th}$ percentile value from the estimated probability distribution for hurricane losses) that is used in designing and pricing reinsurance arrangements. In addition, the models can be used to perform scenario analysis for storms with specified characteristics that match historical storms. For example, the models can estimate the insured losses for a portfolio should a storm similar to Hurricane Hugo make landfall today.

## C. Hurricane Models Currently Available

There are many different types of hurricane models available today, as well as new models under development or recently introduced to the market. The following section describes these models and their relevance to the development of a South Carolina produced model.

### *1. Proprietary Models Used by Insurance Industry*

Currently, there are three primary models widely used by insurance companies in their rate filings to support their projected hurricane loss costs:

(1) AIR Atlantic Tropical Cyclone Model
(2) RMS RiskLink
(3) CoreLogic EQECAT WORLDCATenterprise

A fourth model, produced by Applied Research Associates (ARA) is available, but is sparingly used in rate filings to support hurricane loss cost filings, if at all. These models are considered proprietary, in that they do not disclose algorithms or other coding information and enforce strict confidentiality agreements with anyone that is permitted to examine the inner workings of the model. The companies usually license the use of the models by their clients, who consist mainly of insurers and reinsurers. There are multiple versions of these models that vary based on the assumptions regarding the historical catalog of hurricane events used to develop the hypothetical hurricane events (stochastic storm sets) in the model. In general terms, a "Long Term" model utilizes the full database of storms cataloged by the National Oceanographic and Atmospheric Association (NOAA). "Short Term" or "Medium Term" models exclude some time periods to isolate only those storms that developed and made landfall in the United States in years that have similar atmospheric and oceanographic activity similar to the current period (El Nino, Warm

Atlantic Ocean temperatures, Sub-Saharan wave activity, etc.). Typically, only Long Term models are used in rate filings submitted to insurance departments, while the others are used by insurers and reinsurers in catastrophe risk management and reinsurance structure development and pricing.

Versions of these four models were submitted to the Florida Commission on Hurricane Loss Projection Methodology in 2013 and were found to meet all of their standards, making them acceptable for use in rate filings in Florida by insurance companies. (Hurricane model use in Florida is discussed further below).

Versions of these four models were also submitted to a panel of experts (the Catastrophe Model Panel, or the Panel) assembled by the Department for such reviews in 2012-2013 and were found to be acceptable for use in rate filings in South Carolina by insurance companies (see SC DOI Bulletin 2014-03 for the existing and new specific requirements for filing insurers).

*2.* *Florida Public Hurricane Model*

This model is utilized by the Florida Office of Insurance Regulation to review rate filings and perform scenario testing on insurers' financials. Insurance companies can use it directly as well. The computer code is still protected and confidential, but is more open than the private models described above. The model was approved by the Florida Legislature in 2001, and several universities and other institutions were responsible for contributions to the development of the model over the following five years. Florida International University in Miami, Florida houses and maintains the model under the direction of Dr. Shahid Hamid, Ph.D. The model approaches hurricane loss simulation in a way similar to the other models described above, except that only a "long term" version is available.

The Florida Public Hurricane Model was also submitted to the Florida Commission on Hurricane Loss Projection Methodology in 2012-2013 and found to meet all of their standards, making it acceptable for use in rate filings in Florida by insurance companies.

*3.* *Watson-Johnson Model*

Charles (Chuck) Watson and Mark Johnson have written several papers together that outline a different approach to modeling hurricane losses. There is no formal name for their approach, so we refer to it as Watson/Johnson in this report. The model approaches hurricane/storm simulation from a statistical basis, using actual historical events which are archived in the North Atlantic hurricane database, or HURDAT, the database for all tropical cyclones in the Atlantic Ocean, Gulf of Mexico and Caribbean Sea, since 1851.

For the other four models, several criteria are independently fitted to statistical distributions (including number of storms, storm track, maximum wind, radius of maximum wind, and forward speed). The modelers then create their hypothetical storm sets using these formulas, which are in turn then run using a portfolio of properties to produce the expected hurricane losses. For Watson/Johnson, by using the actual HURDAT data for all Atlantic Basin events on record, they only have to statistically determine the maximum wind speed at each property location. After wind speeds are estimated, damage functions calculate the value of the loss.

The Watson/Johnson model combines multiple public source meteorological and engineering components to produce multiple combinations of complete models. Results are then produced for each model combination, and the results are displayed as a range/distribution of loss estimates. The authors' papers demonstrate how this model can be used to evaluate the reasonability of the proprietary model hurricane loss estimates by evaluating where the loss cost estimate falls within the range of estimates produced by the Watson/Johnson model. We are not aware of any company utilizing this model in any submitted rate filing to determine hurricane loss costs. This model has not been submitted for review by the Florida Commission on Hurricane Loss Projection Methodology to our knowledge. This model should be considered as "open source" in that there is transparency to the user of the details of the model components.

*4. RiskInsight Model*

Karen Clark, founder of Applied Insurance Research, published a paper entitled "A Formal Approach to Catastrophe Risk Assessment and Management" in the Proceedings of the Casualty Actuarial Society in 1986. The paper laid out the stochastic approach to simulation of hurricane events to calculate expected losses that eventually manifested itself in the development of the AIR model in the 1990's. Ms. Clark is now CEO of Karen Clark, & Company (KCC), which provides software products and consulting services to help insurance companies manage risk. KCC recently introduced RiskInsight, an open platform model that allows customization of components by the user. According to the company's website, the model produces the same output that the other "vendor" models do. We are not aware of any company utilizing this model in any submitted rate filing to determine hurricane loss costs. This model has not been submitted for review by the Florida Commission on Hurricane Loss Projection Methodology to our knowledge. The Company considers the model to be "open platform" in that it can run multiple models (either open source or proprietary) from a single input source and producing output through one program. It is unclear if the RiskInsight model is "open source," meaning all the computer code underlying the model is not freely available to all users.

*5. OASIS Project*

The OASIS project is a global open platform. The model only provides the simulation kernel and the financial model component - free within the framework. The user will select the other components regarding event generation and damageability provided by third parties. It is expected that users will use the OASIS code and build new models with it.

## III. CURRENT USE OF HURRICANE MODELS

### A. Insurance Company Use

Insurance companies utilize hurricane models in ratemaking, reinsurance analysis, and strategic planning on a regular basis. Most companies use the AIR or RMS model, with a few that use the CoreLogic EQE model.

Hurricane model output is used to determine the total hurricane expected losses, as well as the hurricane losses recoverable under the insurer's reinsurance program. Information from the model is used to allocate these costs to each policy type, policy form, and territory.

## B. Florida

### *1. Florida Commission and Professional Team.*

Florida was the first state to set up a formal review process to evaluate hurricane models and their use in rate filings. The Florida Commission on Hurricane Loss Projection Methodology is an independent body of experts created by the Florida Legislature in 1995 for the purpose of developing standards and reviewing hurricane loss models used in the development of residential property insurance rates and the calculation of probable maximum loss levels. According to the Commission's published Report of Activities:

> *The Legislature specifically determined that "reliable projections of hurricane losses are necessary to assure that rates for residential insurance are neither excessive nor inadequate," and that in recent years, computer modeling has made it possible to improve on the accuracy of hurricane loss projections. The Legislature found that "it is the public policy of this state to encourage the use of the most sophisticated actuarial methods to ensure that consumers are charged lawful rates for residential property insurance coverage." The Legislature clearly supports and encourages the use of computer modeling as part of the ratemaking process.*

Several members of the Commission are specified in the statute by current position in various Florida organizations, and five are appointed by the Florida Chief Financial Officer (CFO). The Commission establishes standards for the models in several sections (General, Meteorological, Statistical, Vulnerability, Actuarial and Computer). Modeling companies submit their models to the Commission for review and acceptance every two years.

The Professional Team is employed by the Commission to perform the detail model reviews onsite and report back within the confines of the trade secret and confidentiality requirements. The members of this team are for each section of the standards (Meteorological, Statistical, Engineering, Actuarial and Computer Science). The Commission uses the report and other input from the Professional Team to make their determination on the models' compliance with the published standards. Only model versions that are accepted by the Commission can be used in rate filings in Florida.

### *2. Office of Insurance Regulation Rate Filing Review*

The Florida Office of Insurance Regulation requires that property insurance rate filings use output from only the versions of the models that were submitted to and accepted by the Commission. Further, the Florida Office of Insurance Regulation only allows the use of a single model in a rate filing, disallowing the practice of using combinations of accepted models.

A part of the required documentation in a residential property rate filing that includes the output from a hurricane model is a 60 item Questionnaire that requires detailed information from the insurer as well as the modeling company. The OIR requires this information to enable them to make a determination as to whether the model and its output meet the statutory requirements regarding the actuarial reasonability of the filed rates. Certain information is required by the OIR that the proprietary models (AIR, RMS, CoreLogic EQE, ARA) do not provide in order to preserve the confidentiality of trade secret information. The Florida Public Model, given its public nature, provides access to all of the required information. This has apparently led to the practice of the OIR actuaries in their analysis of rate filings to replace the hurricane model output from any one of the four private models with the output from the Florida Public Hurricane Model. Each company that makes a filing has to provide their input file to the OIR to produce the Public Model loss costs. So, in actuality, the Florida Public Model is the model that influences the OIR's determination as to whether the filed rates are actuarially sound.

### C. Use of Catastrophe Models in South Carolina and Their Regulation

There are over 120 licensed insurance companies that are currently writing homeowners multiple peril insurance in South Carolina. It is estimated that over 90 percent of these property insurers currently use a model produced by one of three modeling firms. Most use either AIR or RMS and an estimated 10 percent use EQE. Insurers use the models to estimate the expected claim costs on the policies that they market in South Carolina. Some insurers use more than one model, in which case the SC DOI requires that the results of the models be equally weighted.

In 2012, the SC DOI contracted with a team of experts, the SC Hurricane Model Review Panel, to evaluate the major catastrophe models approved by the FL Commission for their accuracy and reliability in estimating expected catastrophe losses in South Carolina. In essence, the experts investigated whether the models incorporated appropriate assumptions and data for forecasting expected losses in South Carolina. The report containing non-proprietary information is available on the SC DOI website. The report led to a set of general and model specific recommendations (see Davis, 2013). The overall assessment, however, was that the models used in South Carolina properly take into account the specific characteristics of South Carolina. The actuary from the Panel, Mr. Martin Simons, summarized their findings this way: "Basically, our report determined that the models do a very good job, with [several] exceptions. And when these exceptions are taken care of, we can have great confidence in the models. But, basically, the models do a very good job of determining the expected annual loss from hurricanes."

A summary of the analysis and findings is contained in Order Number 2013-05 and Bulletin 2014-03, including a listing of the models that the SC DOI found to be appropriate for use in South Carolina. In addition, the Order required that the SC DOI would (among other actions) "develop

a procedure for periodic public examination and evaluation of hurricane catastrophe models used in property insurance rate filings."

# IV. POTENTIAL BENEFITS ASSOCIATED WITH HAVING A SOUTH CAROLINA PUBLIC MODEL

To assess the potential benefits of a SC public model, we describe the various ways that a public model could contribute to the mission of the SC DOI and other public entities.

## A. DOI's Mission

As stated on its website, the mission of the SC DOI "is to protect the insurance consumers, the public interest, and the insurance marketplace by ensuring the solvency of insurers; by enforcing and implementing the insurance laws of this State; and by regulating the insurance industry in an efficient, courteous, responsive, fair, and equitable manner."

Hurricane models are primarily used for pricing property insurance policies.[1] More specifically, insurers use hurricane models to determine the expected claims costs and probable maximum loss on policies that they could potentially sell.[2] To the expected claim costs, insurers then add other costs associated with selling insurance policies (e.g., underwriting and loss adjustment costs), as well as a profit loading to cover capital costs. The sum of these components leads to the premium that will be charged. In South Carolina, the rates that insurers charge must be filed with the DOI.

Consistent with its mission, the DOI evaluates filed rates based on whether they are not inadequate, not excessive, and not unfairly discriminatory. The requirement that rates not be "inadequate" implies that rates must be sufficient to cover the insurer's costs so that (1) the solvency of the insurer is not jeopardized by consistently selling policies at prices that do not cover costs, and (2) that the state is able to attract and retain insurers to provide insurance to its citizens. "Excessive" means that the insurer is charging rates well above its costs, including its capital costs, and therefore earning unreasonable profits. "Unfairly discriminatory" means that the insurer is charging higher premiums to one group of policyholders relative to another group that is not justified by differences in costs between the two groups of policyholders or that is distinguishing the two groups of policyholders based on characteristics that the state views as inherently discriminatory and therefore does not allow.[3]

## B. Overview of How a Public Hurricane Model Could Contribute to the DOI's Mission

One way that a public hurricane model could contribute to the DOI's mission is through the DOI's evaluation of whether filed rates are not inadequate, not excessive, and not unfairly discriminatory.

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[1] Catastrophe models can also be used by insurers for internal managerial purposes, such as determining how many policies to write in particular geographical areas, determining how much capital is needed to support the insurance policies, and determining how much reinsurance should be purchased.

[2] Expected claim costs are sometimes called pure premiums.

3 For example, some states have determined that it is discriminatory to charge different premiums to males versus females, holding all other factors constant.

Since this is likely to be the primary use of a public model, we elaborate below on how a public model could be used by the DOI in evaluating insurance rates for property insurance. The remainder of this subsection discusses other potential uses of a public model.

Another part of the DOI's mission is to ensure the solvency of insurers licensed in the state. A public catastrophe model could contribute to this mission by allowing the DOI to evaluate the likelihood and severity of insurer insolvencies given the insurer's exposure to hurricanes. If an insurer is found not to have sufficient resources to cover claim costs from potential catastrophes, the DOI could encourage the insurer to obtain additional capital, utilize more reinsurance, raise rates, or decrease exposure to hurricanes.

A public model could be made available to insurers for their use in developing rates for property insurance. Doing so would allow insurers to utilize an alternative catastrophe model in South Carolina without engaging one of the modeling firms. If this service were low cost, then some insurers might take advantage of this opportunity.

A public model could be useful to the SC Wind & Hail Underwriting Association (SCWHUA) in creating an alternative baseline for assessing its risk and its need for reinsurance. Currently, the SCWHUA uses the results of multiple catastrophe models to aid in the acquisition of sufficient and properly priced reinsurance (*see* Status Report for 2013).

A public hurricane model also could potentially contribute to more efficient public policies related to mitigation of hurricane losses by identifying geographical areas with high expected losses. Understanding which areas have higher expected losses could help direct public expenditures to where they would have the largest impact on expected hurricane losses. For example, zoning and development restrictions could be targeted at areas with high expected losses. A public hurricane model could also estimate the reduction in expected losses from various mitigation policies, such as installing roof clips or straps.

### C. Using a Public Model for Assessing Filed Rates

As described above, the SC DOI is required to evaluate filed rates to make sure that they are not inadequate, not excessive and not unfairly discriminatory. The question addressed in this section is whether a SC public hurricane model would substantially add to the DOI's ability to assess filed rates.

It is useful to first discuss the use of models for pricing insurance in general, the inherent difficulties associated with forecasting hurricane losses, and the market for hurricane models. We then return to the question of whether a public hurricane model would likely give the DOI a better tool for assessing rates.

#### *1. Insurance Pricing Models in General.*

Models are used by insurers to determine premiums for all types of insurance. For example, to set life insurance premiums, insurers need to forecast mortality rates that will prevail in the future. These forecasts are largely based on statistical models that utilize historical data. However,

insurers could also utilize assumptions/models about the impact of future medical breakthroughs on future mortality rates. The point is that models are widely used by insurance companies to forecast expected losses in the future.

If different insurers use different models, then insurance premiums charged by different insurers could vary from one another.[4] On the other hand, to the extent that there is wide agreement as to the appropriate model, then insurers would be expected to price policies similarly, assuming other costs are similar across insurers. Thus, price variation across insurers is more likely when there is not a consensus on how to model uncertain future events.

Competition among insurers provides insurers with incentives to develop models that better predict expected claim costs. If an insurer consistently underestimates expected claim costs, then the insurer will attract customers, but not collect sufficient premiums to pay the claims that occur. Instead, claims will need to be covered by dipping into the insurer's capital and surplus. Eventually, the insurer will either adjust its models or go out of business. If an insurer consistently overestimates expected claim costs, then the insurer will have a difficult time attracting customers because the premium it charges will likely exceed the premiums of other insurers in the same market. Thus, there are incentives for insurers to innovate and develop better models to predict expected claim costs. This incentive is evident by the variety of classification systems used by insurers and by new methods of gathering and analyzing data that insurers and consulting firms are developing to better predict expected claim costs.[5]

*2. Difficulty of Hurricane Loss Predictions.*

The underlying problem with hurricane loss predictions is that hurricane losses for a specific location are relatively rare events. Consequently, there is limited historical data from which to make reliable predictions about the expected losses that will be suffered in a particular region. Hurricane models have been developed to overcome this problem. Moreover, the principles discussed above for pricing models in general apply to hurricane models, i.e., (1) variation in predictions of expected claim costs and therefore rates will more likely arise when there is variation in the hurricane models that are used, and (2) incentives exist to improve hurricane loss models to make predictions of expected claims costs more accurate.

How does one assess the accuracy of a hurricane model? Given the scarcity of events, one cannot assess accuracy by comparing predicted expected losses to the average loss that actually occurs over some time period. Instead, accuracy must be assessed in other ways. First, experts in various fields (e.g., meteorology, engineering, actuarial) can evaluate models based on whether they include the latest scientific advances in the field. The Florida Commission and the South Carolina Panel utilize this approach when they assess hurricane models. Second, accuracy can be gauged based on conceptual and logical grounds. For example, most people would agree that including information about the type of construction in a region would improve accuracy relative to a model

[4] Even when insurers use different models, it is possible that competition will lead them to adjust prices toward their competitors.

[5] As an example of innovative information gathering, In-Drive is used by State Farm to gather information about driving habits. As an example of innovative data analysis, Eagle-Eye Analytics uses machine learning tools to predict expected losses.

that did not take this information into account. Third, accuracy can be gauged on whether the simulated storms follow a track that resembles the tracks of actual storms. Fourth, the accuracy of the exposure components of hurricane models can be gauged by comparing the realized claim costs from an actual storm to the predicted claim costs from the model for a simulated storm that comes ashore with the same characteristics as the actual storm.

One feature of hurricane loss models that distinguishes it from models used to predict expected losses for other types of exposures (e.g., automobile accidents) is that the fixed costs of developing a model are relatively high (see the next section). As a consequence, modeling firms specialize in developing these models and provide their modeling services to insurers, reinsurers, brokers, and rating agencies using various licensing and fee arrangements, as opposed to insurers developing these models "in house."

*3. The Market for Hurricane Loss Prediction Models.*

There are currently four main suppliers of hurricane models (AIR, ARA, EQECAT, and RMS). In addition, there are some potential new entrants into the marketplace. These firms actively compete based on the sophistication and accuracy of their models. Thus, the incentive of insurers to have more accurate models of expected claims costs (discussed above) is translated into incentives for hurricane loss modeling firms to develop more accurate models. The demand for catastrophe modeling services is growing worldwide, which suggests that the return from developing a reputation for accurate models is high.

*4. Would a SC Public Model Improve Assessment of Rate Filings?*

There are at least two (non-mutually exclusive) ways that SC could use a public model to assess rate filings. First, South Carolina could follow the approach of Florida and run the public model using the policy classification data of each insurer that submits rate filings and then compare the public model's results to those submitted by the insurer. We refer to this as the Florida approach. Second, South Carolina could require each catastrophe modeling firm to submit rates for standardized classifications, and then compare the results of all of the different models, including the public model. We refer to this as the standardized approach. We now discuss each approach in more detail.

a. The Florida Approach

The Florida Office of Insurance Regulation (OIR) is the primary user of the Florida Public Hurricane Loss Model (FPHLP).[6] To use the public model to evaluate an insurer's rate submission, the OIR sends the policy data of a submitting insurer to Florida International University (FIU), which examines the data for reasonableness. FIU then inputs the insurer specific data in the public model and runs the model. The result is an estimate of the expected hurricane loss costs on a state-wide basis, as well as loss costs for the various rate classes used by the

[6] Insurers can and do contract to use the public model.

submitting insurer. The OIR can use this information to negotiate with the submitting insurer if the OIR believes that the submitted rates are too high or too low.[7]

b. Standardized Approach

An alternative approach would be to use the public model to estimate expected claim costs for standardized classifications of exposures in South Carolina and require catastrophe modelers to use their proprietary models to estimate expected claim costs for the same classifications. For example, the SC DOI could provide building characteristics by zip code to each of the modeling firms as well as the public model, and then require each model to provide an estimate of expected hurricane losses by zip code. Then, the DOI could compare all of the estimates. This would give the DOI three or four proprietary estimates and one estimate from the public model for a standardized classification of exposures.

With the standardized approach, the DOI would have four to five estimates of the expected hurricane loss costs for a given standard classification scheme, as opposed to the Florida approach in which one public model forecast is compared to the forecast of the submitting insurer. Thus, an advantage of the standardized approach is there would be four to five estimates of expected hurricane losses for standard classifications, which would be more informative about whether one of the models is out of line with the others. With the Florida approach, there are just two estimates – the submitting insurer's estimate and the public model's estimate. If these estimates are significantly different, one does not know whether it is because the public model is out of line or the submitting insurer's model is out of line (or both).

The Florida approach has the advantage of providing estimates of the hurricane loss costs for each submitting insurer using the submitting insurer's policy classification scheme, as opposed to a standardized classification scheme. Which approach is better depends on the extent to which insurer specific policy classification data are needed to evaluate the proprietary catastrophe models.

Regardless of the approach that is taken, one must decide how much weight to put on the public model versus the other models.[8] Given the expertise and experience that the private modeling firms have developed and their incentives to innovate and to develop more accurate models, it

[7] It appears that the OIR primarily uses the statewide results to negotiate with submitting insurer and not the results for specific classifications. This inference is based on a review of completed rate filing on the Florida online filing website. In these disclosures, the OIR typically replaces the insurer's modeled hurricane losses with the output from the Florida Public Model in the statewide rate level indicated change calculations, but the OIR typically does not substitute the submitting insurers' hurricane losses by territory or other rating classifications, nor in the calculation of the net cost of reinsurance expense load.

[8] Just as there is variation in the results of the existing proprietary models because of different assumptions and methods, there will be variation in the results of a public model from the proprietary models. At one extreme, one could have absolute confidence in the public model, and require all insurers to use the loss costs that it produces.

seems highly unlikely that a new public model would deserve more weight than the proprietary models. At most, the public model could be given equal weight.

It is important to note, however, that the standardized approach could be adopted at a substantially lower cost without having a public model. Instead, the DOI could require each of the proprietary models to submit expected hurricane loss costs for standardized classifications, compare the results of the proprietary models, and investigate reasons for major differences. This is similar to the approach adopted by the Panel of experts that the DOI hired in 2012-2013 to evaluate whether the proprietary models appropriately took into account South Carolina specific information.

Continuing with this line of reasoning, the issue is whether the estimates from one additional model – a public model -- provide much additional information relative to just have a comparison among the proprietary models? Currently, there are three models used in South Carolina; so a public model would add a fourth estimate. Also, if a fourth estimate was desired, then the SC DOI could contract with either (1) the one modeling firm that is currently not used by insurers in South Carolina, ARA, (2) Florida International University to develop a South Carolina model component, (3) Watson and Johnson, (4) RiskInsight, or (5) OASIS to provide a fourth estimate.

*5. Greater Transparency.*

It could be argued that a benefit of having a public model is that transparency of how insurance rates are set and regulated would be enhanced, which would provide the citizens of South Carolina and their government representatives more confidence that rates are not inadequate, not excessive, not unfairly discriminatory. Unfortunately, a public, state-of-the-art hurricane loss model is unlikely to be transparent to any single individual because these models involve components that require expertise in a variety of fields, including meteorology, engineering, actuarial science, and computer science.[9]

Instead of seeking public transparency (which is unattainable), a better approach would be to require transparency to a panel of experts and rely on their oversight, similar to the analysis done by the Panel in 2012-2013.

## D. Possible Unintended Consequences.

Depending upon its use or purpose, a SC Public Hurricane Model could introduce some unintended consequences in the personal property insurance market. Development of a Public Model could create some market uncertainty, which may impact insurers' willingness to write in the state. For example, potential new market entrants may decide not to enter the market if they conclude that the presence of such a model creates additional risk or uncertainty regarding the regulatory environment. Additionally, if the results of such a model are given greater weight than the commercial models currently in use or are otherwise not used appropriately, the result could be a disruption in the existing market. For risks where the hypothetical model provides a substantially lower hurricane loss cost than the model(s) being used by a particular insurer and its reinsurer, it is not difficult to imagine a scenario in which insurance company management determines that

[9] Even though the Florida Public Model is considered a "public" model, it should be noted that not all portions of the model are open to public inspection (e.g., the code or algorithms).

risks meeting certain criteria are not to be written. Depending upon the extent of the differences, the availability of personal property insurance for hurricane-exposed properties could deteriorate. If the Public Model is used inappropriately or its purpose is unclear, a SC Public Model could result in market disruption and the negative effects of such disruption could have a significant impact on South Carolina property owners.

Finally, there is no reason to believe that a SC Public Model will produce lower loss estimates for every risk. That is to say, it is foreseeable that such a model would produce loss costs for some hurricane-exposed risks that exceed those produced by the commercial models being used in the direct and reinsurance market today.

# V. COSTS ASSOCIATED WITH THE CREATION OF A SC PUBLIC HURRICANE MODEL

## A. Overview

Data and analysis for the cost estimates come primarily from interviews conducted with team members at the Florida Public Model (FPM) Project. As the only state to develop a public model to date, Florida provides a logical starting point to estimate costs associated with the development of a hurricane model by the state of South Carolina. Additional data and estimates come from publicly available sources. It is important to note that the cost estimates produced here are conservative and should be considered the minimum cost of developing a public model in South Carolina. It is likely that actual costs could exceed these estimates.

### *1. Development Costs*

The Florida OIR sponsored the development of the Florida Public Model, but the model was developed and is housed by academic experts at the International Hurricane Center at Florida International University. Catastrophe models are complex computer models that require expertise across a variety of disciplines. The development team included meteorologists, wind and structural engineers, statisticians, computer scientists, actuaries, and financial experts. The Florida Public Model cost approximately $4.5 million to develop from 2001-2006. In addition, any catastrophe model designed today would likely include a storm surge component. The Florida Public Model Project team is currently developing a storm surge component for the FPM at an estimated cost of $4.5 million over 3 years.

The total estimated cost of developing and maintaining a hurricane model for the state of South Carolina is a *minimum* of $7,316,500 over the first 5 years.

**Table 1**

| ***DEVELOPMENT STAGE, YEARS 1-5*** | | | | | |
|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 |
| Personnel | 1,262,500 | 1,262,500 | 1,262,500 | 1,262,500 | 1,262,500 |
| Technology | 351,200 | 100,200 | 100,200 | 100,200 | 100,200 |
| Facilities | 88,800 | 40,800 | 40,800 | 40,800 | 40,800 |
| Total | 1,702,500 | 1,403,500 | 1,403,500 | 1,403,500 | 1,403,500 |

| | |
|---|---|
| **ESTIMATED MINIMUM DEVELOPMENT EXPENSE (YEARS 1-5)** | **$7,316,500** |

| ***STEADY STATE, YEARS 5+*** | |
|---|---|
| Personnel | 775,000 |
| Technology | 100,200 |
| Facilities | 40,800 |
| Total | 916,000 |

| | |
|---|---|
| **ESTIMINATED MINIMUM ANNUAL STEADY STATE EXPENSE (YEARS 5+)** | **$916,000** |

*2. Maintenance Costs*

Members at the Florida Public Model Project receive $600,000 per year to maintain and operate the Florida Public Model. However, these cost estimates are likely biased downward from true expenses, as the FPM relies heavily on student labor which is significantly less costly than true market wages. Team members at the FPM Project suggest that even with student labor this funding is inadequate. The primary expense is personnel, but additional maintenance expenses include, but are not limited to, maintenance and updating of the computer framework and the input database.

The estimated total ongoing expenses for operating and maintaining a public hurricane model is a *minimum* of $916,000 per year.

The remainder of this section provides additional information on the assumptions underlying these estimates.

## B. Personnel Costs

A complex catastrophe model requires expertise across a variety of disciplines. Critical areas of expertise are meteorology, engineering, actuarial science, and computer science. Team members at the FPM Project estimate that they use approximately 15 professors and 20-30 students to manage and maintain the model and various enhancements that are being developed.

Meteorologists are required for the wind model and hurricane wind field modeling associated with simulating stochastic hurricanes. Engineers are needed to estimate exposure through the analysis of building stock, building codes, and enforcement of building codes. Actuaries develop the insured loss model. Computer scientists work with collecting, cleaning, and maintaining the data required by the catastrophe model. Data is a large component and requires constant updating and monitoring.

Tables 2 provides estimates of market-based personnel expenses for developing, operating and maintaining a public hurricane model at $1,262,500 per year during the development years. This amount would cover the base salary and benefits for four engineers, four computer scientists, four meteorologists, three actuaries, and one administrative person.

**Table 2: Market-Based Annual Personnel Expense Estimates (Development Stage)[10]**
**Benefits Multiplier = 1.25**

| **DEVELOPMENT STAGE ANNUAL PERSONNEL EXPENSES** | | |
|---|---|---|
| **ENGINEERS** | | |
| *Number Required* | 4 | |
| *Annual Base Salary* | $70,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $87,500 | |
| Engineering Total Cost | | $350,000 |
| **COMPUTER SCIENTISTS** | | |
| *Number Required* | 4 | |
| *Annual Base Salary* | $60,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $75,000 | |
| Computer Scientists Total Cost | | $300,000 |
| **METEOROLOGISTS** | | |
| *Number Required* | 4 | |
| *Annual Base Salary* | $60,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $75,000 | |
| Meteorologists Total Cost | | $300,000 |
| **ACTUARIES** | | |
| *Number Required* | 3 | |
| *Annual Base Salary* | $70,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $87,500 | |
| Actuaries Total Cost | | $262,500 |
| **ADMINISTRATIVE** | | |
| *Number Required* | 1 | |
| *Annual Base Salary* | $40,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $50,000 | |
| Administrative Total Cost | | $50,000 |
| **ESTIMATED MINIMUM ANNUAL PERSONNEL EXPENSE** | | **$1,262,500** |

[10] http://www.bls.gov/oes/current/oessrcst.htm;
http://www.payscale.com/research/US/Country=United_States/Salary

Table 3 provides estimates of market-based personnel expenses incurred annually once the model has been developed. The total annual personnel expenses is estimated at $775,000. This amount would cover the base salary and benefits for two engineers, three computer scientists, two meteorologists, two actuaries, and one administrative person.

**Table 3: Market-Based Annual Personnel Expense Estimates (Steady State)[11]**

**RECURRING PERSONNEL COSTS (STEADY STATE)**

| | | |
|---|---|---|
| **ENGINEERS** | | |
| *Number Required* | 2 | |
| *Annual Base Salary* | $70,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $87,500 | |
| Engineering Total Cost | | $175,000 |
| **COMPUTER SCIENTISTS** | | |
| *Number Required* | 3 | |
| *Annual Base Salary* | $60,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $75,000 | |
| Computer Scientists Total Cost | | $225,000 |
| **METEOROLOGISTS** | | |
| *Number Required* | 2 | |
| *Annual Base Salary* | $60,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $75,000 | |
| Meteorologists Total Cost | | $150,000 |
| **ACTUARIES** | | |
| *Number Required* | 2 | |
| *Annual Base Salary* | $70,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $87,500 | |
| Actuaries Total Cost | | $175,000 |
| **ADMINISTRATIVE** | | |
| *Number Required* | 1 | |
| *Annual Base Salary* | $40,000 | |
| *Benefits Multiplier* | 1.25 | |
| *Total cost per employee* | $50,000 | |
| Administrative Total Cost | | $50,000 |
| **MINIMUM ESTIMATED ANNUAL PERSONNEL EXPENSE** | | **$775,000** |

[11] http://www.bls.gov/oes/current/oessrcst.htm;
http://www.payscale.com/research/US/Country=United_States/Salary

## C. Technology Costs

Team members at the FPM Project suggest that technology expenses run in the "several hundred thousand dollar" range. Operation and maintenance of a public hurricane model requires 8-10 servers with necessary parallel processing, workstations, power supply, back-up servers, laptops, databases, Oracle and other software subscriptions, data on zip codes, population and building stock, and security systems for the protection of sensitive information.

Table 4 provides estimates of market-based technology expenses for developing and then operating and maintaining a public hurricane model. The initial capital outlay for computer equipment and power is estimated to cost $251,000, and the annual technology costs for software, data, and computer maintenance is estimated to cost $100,200 per year.

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**Table 4: Market-Based Technology Expense Estimates**

| | | |
|---|---|---|
| **CAPITAL EXPENDITURE ON TECHNOLOGY** | | |
| **Servers** | | |
| *Servers Required* | 10 | |
| *Cost per Server* | $17,500 | |
| Total Initial Server Cost | | $175,000 |
| **Computers for Workstations** | | |
| *Computer Workstations Required* | 16 | |
| *Cost per Workstation* | $2,500 | |
| Total Shared Workspace Cost | | $40,000 |
| **Laptop Computers** | | |
| *Laptops Required* | | |
| *Cost per Laptop* | $2,000 | |
| Total Additional Cost | | $16,000 |
| **Additional Technology Requirements** | | |
| *Power Supply, Security, Etc.* | $20,000 | |
| Total Additional Cost | | $20,000 |
| **MINIMUM ESTIMATED CAPITAL EXPENDITURE ON TECHNOLOGY** | | **$251,000** |
| **RECURRING TECHNOLOGY EXPENSES** | | |
| **Oracle and Other Software Subscriptions** | | |
| *Oracle Commercial Subscriptions Required* | $30,000 | |
| *Other Assorted Software Requirements* | $5,000 | |
| Total Oracle Cost per Year | | $35,000 |
| **Model Data Requirements** | | |
| *Zip Codes, Population, and Building Stock Data* | 1 | |
| *Annual Expense* | $15,000 | |
| Total Data Cost per Year | | $15,000 |
| **Technology Maintenance and Upkeep** | | |
| *Replacement Rate* | 20% | |
| *Base Capital Expenditure* | $251,000 | |
| *Total Annual Cost for Workstation Maintenance* | $50,200 | |
| Total Shared Workspace Cost | | $50,200 |
| **MINIMUM ESTIMATED ANNUAL TECHNOLOGY EXPENSE** | | **$100,200** |

## D. Facilities Costs

The Florida Public Model Project is primarily housed at the International Hurricane Center at Florida International University, but utilizes facilities and personnel across several universities in Florida. In total, the FPM Project uses nine offices across multiple universities and large computer labs in sizeable shared workspaces.

Facility expenses for the FPM Project are difficult to isolate and quantify as the FPM Project leverages university resources to assist in providing facilities and certain technologies in the maintenance and operation of the public hurricane model. The FPM Project relies heavily on resources at Florida International University, among others. It is not clear that the State of South Carolina has the academic expertise or resources in place to replicate a similar setup. It is also not clear that, even if South Carolina had the capability, the current FPM Project design would be a sustainable endeavor as it stands.

Table 5 reports that the estimated up-front market-based expenses to outfit 16 offices equals $48,000. The on-going costs associated with renting office space and computer labs, and for maintenance and upkeep of computer workstations is $40,800 annually.

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## Table 5: Market-Based Facility Expense Estimates

| | | |
|---|---|---|
| **CAPITAL EXPENDITURE ON FACILITY RELATED ASSETS** | | |
| **Workstation Furniture** | | |
| *Workstation Furniture Setups* | 16 | |
| *Price per Setup* | $3,000 | |
| Total Workstation Furniture Cost | | $48,000 |
| **MINIMUM ESTIMATED FACILITY CAPITAL EXPENDITURE** | | **$48,000** |
| **RECURRING FACILITY EXPENSES** | | |
| **Office Space** | | |
| *Offices Required* | 8 | |
| *Sq Footage per Office* | 100 | |
| *Loaded $ per Sq Foot per year* | $15 | |
| *Total Annual Cost per Office* | $1,500 | |
| Total Annual Office Space Cost | | $12,000 |
| **Shared Workspace** | | |
| *Sq Footage per Workspace* | 1,000 | |
| *Loaded $ per Sq Foot per year* | $12 | |
| *Total Annual Cost per Workspace* | $12,000 | |
| Total Shared Workspace Cost | | $12,000 |
| **Computer Lab Space** | | |
| *Sq Footage per Computer Lab* | 1,000 | |
| *Loaded $ per Sq Foot per year* | $12 | |
| *Total Annual Cost per Computer Lab* | $12,000 | |
| Total Shared Workspace Cost | | $12,000 |
| **Workstation Maintenance and Upkeep** | | |
| *Replacement Rate* | 10% | |
| *Base Capital Expenditure* | $48,000 | |
| *Total Annual Cost for Workstation Maintenance* | $4,800 | |
| Total Shared Workspace Cost | | $4,800 |
| **MINIMUM ESTIMATED ANNUAL FACILITY EXPENSE** | | **$40,800** |

## E. Other Expected (But Not Estimated) Costs

A hurricane model requires a significant amount of data on population, building stock, construction, and zoning codes from municipalities and other local governments. Without reliable data, any model is incapable of producing valid results. If easily available and accessible, the data would present a negligible cost to incorporate into the model. However, it is not clear that this data is easily available. Collecting the data will require the cooperation and resources of local authorities.

In the regulatory context, the SC DOI would likely need additional resources in order to maximize the Public Model's benefits toward its stated mission. These costs could vary depending upon the stated purpose and intended use of the public model.

Additionally, there may be unknown legal costs. Hurricane models are often the subject of litigation, and there is no reason to believe at this time that a public model would be immune from litigation or potential legal liability. Such costs cannot be quantified.

Other expenditures are likely to emerge, particularly relating to the need to contract with subject matter experts during the development of the public model. Finally, the costs that the insurance industry will incur to comply with any new mandates or changes to the regulation of property insurance rate filings should be taken into consideration as these are ultimately passed on to consumers.

Estimating the above costs is difficult, but the result could be significant.

### F. Summary

Combining the various cost components above, the estimated costs of developing and maintaining a South Carolina Produced Model for the state of South Carolina is a *minimum* of $7,316,500 over the first 5 years, and a *minimum* of $916,000 per year in operating and maintenance costs thereafter. While we have not modeled all likely expenditures (including those highlighted in the previous subsection), it should not be overlooked that there would be additional costs associated with the development, maintenance, and use of a public model. Thought should be given to the monetary and non-monetary costs associated with such an endeavor.

## VI. RECOMMENDATIONS

The SC DOI has indicated that it is open to any tool that would further enhance its rate review processes. However, the costs of such the development of a SC public hurricane model appear to outweigh the potential benefits. The benefits of a South Carolina specific public model appear marginal and, at best, are unclear, while the costs associated with developing and maintaining a public model are significant. Such a model is unlikely to be fully transparent and there is no guarantee that it will produce lower rates for property owners.

The costs of developing a public model are estimated at a minimum of $7,316,500 over the first 5 years, and $916,000 per year in operating and maintenance expenses thereafter. These costs are based upon information from public sources. Personnel costs are often dictated by the market. Consequently, the personnel costs needed to develop and maintain a public model will likely be more than projected in this report.

As such, the recommendation of this report is that South Carolina not pursue the development of a state specific public hurricane model at this time. There are several alternatives that would provide similar oversight and validation of the private models used in rate setting at significantly lower cost than the development of a public model.

Currently, there are three models used in South Carolina that compete in an innovative and competitive market. If a fourth estimate is desired for comparison, then the SC DOI could contract with either (1) the one modeling firm that is currently not used by insurers in South Carolina, ARA, (2) Florida International University to build a South Carolina model component, (3) Watson and Johnson, (4) RiskInsight, or (5) OASIS to provide a fourth estimate. Instead of seeking an open source model, which is unattainable due to the complexity of the models, a better approach would be to require transparency through a panel of experts and rely on their oversight, similar to the analysis done by the SC Panel in 2012-2013.

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