Impact Forecasting Florida Flood Model (FCHLPM) Version 3.0

FCHLPM 2021 Meeting to Determine Acceptability

8th November 2024

Agenda

1. Impact Forecast Forecasting Model Overview
2. Standards Review Presentation
   a) Corrections to Submission Document
   b) General Flood Standards
   c) Meteorological Flood Standards
   d) Hydrological and Hydraulic Flood Standards
   e) Statistical Flood Standards
   f) Vulnerability Flood Standards
   g) Actuarial Flood Standards
   h) Computer/Information Flood Standards

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ELEMENTS Version 18.0

Response to Deficiencies

Response to Deficiencies

1. Figure 16 (page 94), Figure 97 (page 293), Figure 98 (page 294), Figure 106 (page 302), Figure 124 (page 314), Figure 125 (page 315), and Figure 127 (page 317): Incomplete. The maximum is omitted from the figures.

The maximum depth value was added to all relevant figures.

2. GF-1.2, page 19: Incomplete. The use of the Tropical Cyclone Rainfall (TCR) model is not mentioned until MF-1.7 (page 60) and not described until MF-2.6 (page 72). The TCR model should be included in the summary of the model.

The Tropical Cyclone Rainfall component was added to the summary of the mode, in Disclosure GF-1.2

3. GF-1.6, pages 26-42: Incomplete. Compo et al. 2009 (page 61), Leopold 1994 (page 69), Schureman 1958 (page 74), and England 2019 (page 107) references not included in list of references.

The list of references was updated to address all missing references.

Response to Deficiencies

4. GF-2.B, page 43: Non-responsive. Response does not address the standard and is the same response as given for GF-1.B.

Our response was updated to better answer the question, detailing the review of the model and the qualifications of the reviewers.

5. MF-2.C, page 63: Incomplete. Justification is not given for the inland model resolution.

Justification for Inland flood model resolution was added.

6. MF-5.2, page 106: Incomplete. Rationales for Translational/Forward Speed and Heading Angle/Direction are not provided. GDP tails and Laplace margins are not defined.

Our response was revised, with meteorological references, to address GDP tails and Laplace margins.

7. HHF-1.2, pages 112-116: Unclear. Figure numbering on pages 115-116 needs to be resolved, including the corresponding discussion.

The editorial error leading to misnumbered figures was resolved.

Response to Deficiencies

8. HHF-1.4, page 117: Incomplete. Provide documentation on the sensitivity of the flood model results based on assumptions relevant to flooding conditions in Florida, including lake level and tide height, rather than assessments of the model sensitivity in semi-arid and snow-dominated areas.

Our response was revised to defend the suitability of hydrological conditions from non-Florida geographies.

9. HHF-1.14, pages 123-124: Incomplete. Indicate the units of the variables in Equations 10 and 11.

Units were added to the Equations 10 and 11..

10. HHF-2.A, page 128: Non-responsive. Response does not specifically address flood extent.

Our response was revised to specifically address flood extents.

11. HHF-2.1, page 128: Non-responsive. There is no discussion regarding removing Unnamed Storm in East Florida (May 2009) and adding Hurricane Hermine (2016). Moreover, the discussion that was provided contradicts the discussion in HHF-2.2, page 129.

Our response was revised to more accurately discuss the replaced storms we have used, and to resolve any contradiction in our text.

Response to Deficiencies

12. HHF-2.2, page 129: Non-responsive. Tropical Storm Fay (2008) cannot be replaced due to a lack of data by Hurricane Ian (2022) which does not provide data for validation.
Our response was revised to defend the usage of Hurricane Ian, specifically the water surface elevation and extent validation.

13. HHF-2.3, page 138: Incomplete. Figure 36 incorrectly repeats information for Hurricane Irma (2017) rather than Hurricane Hermine (2016) as stated in the figure caption.
We corrected the erroneous Irma figure and replaced it with the correct figure for Hermine.

14. Form HHF-1, page 301, Figure 105: Incomplete. The inland flooding map for Hurricane Eta (2020) is omitted.
The omitted inland flooding map for Hurricane Eta was added.

15. AF-6.A, page 253: Non-responsive. Response does not mention flood loss costs.
Response was revised to specifically discuss flood loss costs.

16. Form SF-1, page 330: Incomplete. Identify the specific Pearson Type distribution being used.
Response was revised to specify Log-Pearson distribution Type III.

17. Form AF-1.B, page 346: Incomplete. No response is provided.
A response was added to this item, detailing that no additional assumptions were made.

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General Flood Standards

GF-1 Scope of the Flood Model and its Implementation

- **Model version number**
  - Impact Forecasting Florida Flood Model (FCHLPM) Version 3.0
- **Platform**
  - ELEMENTS Version 18.0
- The model estimates loss costs and probable maximum losses to insured residential property caused by damage from flood events.
- Impact Forecasting (IF) employs standard methods and procedures to ensure agreement and correct correspondence of databases, data files, and computer source code. Source control software and error tracking systems are used to maintain accuracy.
- All software, data, and flowcharts used to develop and validate the model, project loss outputs, and to create forms comply with the Computer/Information Standards and are kept in centralized, model-level file areas.
- Impact Forecasting uses automated procedures to generate submission forms when it is indicated to do so in the form instructions.
- Impact Forecasting rigorously evaluates data, code, and scientific and technical literature on a continuous basis. When new data, code, and literature are made available, Impact Forecasting incorporates the most recent vintage of data or information when it is a sufficiently defensible improvement on older sources, and when it is demonstrably fit for use within the model's framework and development cycle.
- **Standard Verified by the Professional Team**

GF-2 Qualifications of Modeling Organization Personnel and Consultants Engaged in Development of the Flood Model

- Impact Forecasting staff and consultants involved in the development of the flood model possess a wide range of multi-disciplinary skills in meteorology, hydrology, hydraulics, structural engineering, actuarial science, statistics, computer science, and risk analysis.

- Model developers have advanced degrees and the majority hold PhDs in their fields of expertise.

- The model and submission documentation have been thoroughly reviewed by individuals holding suitable qualifications within the professional disciplines listed above.

- The resumes of the personnel engaged in the development of the flood model and responsible for the current flood model and the submission are reviewed by the Professional Team.

- Independent Peer Review of the model was performed by Holly Widen, Ph.D., at Aon Reinsurance Solutions, and by Evaluación de Riesgos Naturales.

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GF-3 Insured Exposure Location

- The model uses United States Postal Service ZIP Code data that is post processed by the third-party vendor Zip-Codes.com. The issue date of the current iteration is November 2023.

- Impact Forecasting's Industry Exposure Database (IED) uses lat/long locational data. The IED relies on exposure from Athenium, vintage of 2022.

- Three polygon layers are used in the model serving as a basis for risk aggregation. These are heald ina hierarchical structure assigning Zip Codes to Counties, and Counties to the state.
  - Zip-code polygon shape files.
  - Florida County shape files
  - Florida State shape file

- Impact Forecasting uses industry-proven geocoding API (Precisely) to convert street addresses to location coordinates that are routinely quality-checked to ensure accuracy.

GF-3 Insured Exposure Location

- The modeled storm surge elevation is based on the vertical datum of NAVD88 and the horizontal datum of NAD83. After the validation, the final surge elevation of the surge footprint is converted to EGM08 vertical datum and WGS84 horizontal datum using NOAA’s VDATUM too.

- The inland flood model consistently uses the Earth Gravitational Model (EGM) 2008 (EGM 08) vertical datum and the World Geodetic System (WGS) 1984 (WGS 84) horizontal datum

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GF-4 Independence of Flood Model Components

- The meteorological, hydrology and hydraulics, vulnerability, and actuarial components of the Impact Forecasting Florida Flood Model (FCHLPM) are theoretically sound and developed independently. Each component is validated individually without consideration of possible biases in other components.

- **Standard Verified by the Professional Team**

GF-5 Editorial Compliance

- The Impact Forecasting submission has been compiled, edited, and reviewed by persons with experience in authoring and reviewing technical documents for consistency, grammar, and editorial accuracy.
- The web-based collaboration platform, Microsoft SharePoint, is used to manage document control of the submission.
- Each signatory on Expert Certification Forms GF-1 through GF-7 was responsible for the final review of their section, in addition to preliminary reviews throughout the submission production process.

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Meteorological Flood Standards

MF-1 Flood Event Data Sources

- The Impact Forecasting Florida Flood Model uses current scientific and technical literature involving meteorological, hydrological, hydraulic, and other relevant data sources required to model coastal and inland flooding.

- Both the tropical cyclone and non tropical system stochastic catalogs used the most current and up to date hydrological observations obtained by monitoring stations operated by USGS, NOAA and the State of Florida

MF-1 Flood Event Data Sources

- The stochastic tropical cyclone catalog uses the official HURDAT2 database and the Hadley Centre Sea Ice and Sea Surface Temperature Dataset (HadISST) (Rayner, et al., 2003) as of August 2, 2021 as a basis for stochastic tropical cyclone events.

- The stochastic non tropical system catalog uses the following data sources as the basis for its creation
  - —MSWEP Reanalysis (2021)
  - —IBTrACS version v04r00 (2019)
  - —USGS watershed units (2020)
  - —Multi-Source Weather Reanalysis (2020)
  - —Multi-Error-Removed Improved-Terrain Hydrography (2019)
  - —Multi-Error-Removed Improved-Terrain Digital Elevation Model (2018):

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MF-2 Flood Parameters (Inputs)

- The Impact Forecasting Florida Flood Model parameters are based on scientifically appropriate technical literatures and data sources.
- The resolution of the storm surge model is an appropriate balance between computational expense and accurate representation of the storm surge water surface elevation when modelling storm surge at a continental scale.
- The resolution of the inland flood model is an appropriate balance between computational expense and accurate representation of water depths arising from fluvial and pluvial flooding when modelling fluvial and pluvial hazard at a continental scale.

MF-2 Flood Parameters (Inputs)

- The input parameters for storm surge modelling are appropriately comprehensive and well resolved for continental scale modelling
  - Central Pressure
  - Radius Of Maximum Winds
  - Storm Track

- The input parameters for inland flood modelling are appropriately comprehensive and well resolved for continental scale modelling
  - Mannings Roughness Coefficient
  - Channel Bathymetry
  - Hydrologic Soil Properties

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MF-3 Wind and Pressure Fields for Storm Surge

- The SLOSH parametric wind and pressure field model based on the balance of forces are used to drive storm surge due to tropical cyclones.
- The SLOSH wind model computes surface wind and pressure fields for a stationary, circularly-symmetric storm, and is based on scientifically defensible methods described in many literatures.
- The physically-based simulation of atmosphere-ocean interactions resulting in storm surge is conducted over a sufficiently large domain. The SLOSH modeling domain covers the entire U.S. Atlantic and Gulf of Mexico coastlines to ensure storm surge height convergence. SLOSH basins are being updated at an average rate of 3-6 basins per year.
- The modeled wind and pressure fields are consistent with those of historical storms affecting Florida.

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MF-4 Flood Characteristics (Outputs)

- The flood extent, elevation, and depth generated by the flood model are validated with observed historical flood events affecting Florida.
  - Validation data consists of observed gauge water level, observed high water marks and observed flood footprints provided by USGS, FEMA, NOAA and State Of Florida agencies and private vendors that Aon Impact Forecasting contracts with for flood observations.

- The flood extent and elevation or depth are modeled using methods proposed in scientific and technical literature.
  - These flood extent and depths are modeled using the well accepted and peer reviewed inland modeling framework developed by Fathom and the LISFLOOD-FP hydraulic model, peer reviewed Sea Lake and Overland Surges from Hurricanes model for storm surge modeling.

MF-4 Flood Characteristics (Outputs)

- Wave in the storm surge portion of the Impact Forecasting Florida Flood Model is addressed in vulnerability functions and is assumed to be a function of the inundation depth.
  - The vulnerability simulator explicitly accounts for the forces generated by waves when creating damage functions for a structure and its contents.

- Modeled flood depths are sufficient for the calculation of flood damage.
  - The model produces flood depths at a high resolution with respect to the model's spatial and hazard magnitude.

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MF-5 Flood Probability Distributions

- The flood model parameter probability distributions, geographic variation, modeled flood extent and elevation or depth are validated using observations from historical events.
- The non-tropical cyclone induced storm surge events are not considered in the storm surge portion of the Impact Forecasting Florida Flood Model due to its low frequency and low impact.
- The coastal wave conditions are implicitly modeled in vulnerability functions.
- The probability distributions of all flood parameters and characteristics are consistent with historical flood events affecting Florida.
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Hydrological and Hydraulic Flood Standards

HHF-1 Flood Parameters (Inputs)

- The input parameters for the flood model have been selected and developed based on the best scientific practices in the fields of hydrology, hydraulics, meteorology and geography.
- The spatial input datasets representing soil, terrain, land use, bathymetry, and meteorology were all selected to provide an accurate and timely representation of the model domain and to be usable for high resolution continental scale modeling.
- Input data derived from these spatial input datasets was used to produce additional input datasets for the model, including the partitioning of watersheds, riverine discharge, surge water surface elevation, hydraulic boundary conditions, surface roughness and the non-tropical system catalog. These derived inputs were produced using peer reviewed methods and scientific best practices.
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HHF-2 Flood Characteristics (Outputs)

- The characteristics of the output of the flood model have been validated against observed flood parameters using best practices and latest scientific techniques in the fields of hydrology, hydraulics, meteorology and geography.

- These characteristics were developed using the well accepted and peer reviewed inland modeling framework developed by Fathom and modeled using the LISFLOOD-FP hydraulic model.
- and the well accepted, peer reviewed Sea Lake and Overland Surges from Hurricanes model for storm surge modeling.

- The model characteristics are produced in a manner so that they produce direct intensity of flood, represented by maximum simulated depth for each model grid cell for a given event. This can be directly used by the vulnerability component of the model to produce an accurate modeled representation of damage to a building’s structure, its contents and the duration that a building is uninhabitable.

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HHF-3 Modeling of Major Flood Control Measures

- The IF Florida Flood model includes the effect of all levees within Florida that are included in the National Levee Database, as well as a bespoke dataset that includes state and localized flood defenses as part of the loss estimation process for fluvial and storm surge modeling.

- For each event in both the stochastic and historical catalogs , the hazard is conditioned on the presence of these flood defenses and if the modeled hazard does or does exceeds the design standard of the defenses. When no design standard is available for a structure from the party responsible for its construction or maintenance, engineers in IF used engineering guidelines to estimate the standard of protection provided.

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HHF-4 Logical Relationships Among Flood Parameters and Characteristics

- The logical relationships between model parameters and characteristics were shown to be valid across hydrologic, hydraulic and meteorological domains.

- The models used to produce the hazard used for loss estimation produce accurate and valid changes in relationship when a variable is perturbed.
  - When terrain roughness is increased, water surface elevation increase
  - When slope is increased, discharge increases
  - When the imperviousness of an area is increased, discharges increases
  - When discharge is increased, flood extent is increased
  - Inland flood modeling and storm surge is modeled separately and therefore do not have any impact on each other

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Statistical Flood Standards

SF-1 Modeled Results and Goodness-of-Fit

- Parameters and characteristics used are modeled using regression equations and probability distributions fitted to historical data. These equations and distributions are developed and validated based on methods documented in current scientific and technical literature.

- Modeled results and historical observations are made sure to be consistent across all aspects of the model. This is achieved by performing statistical tests in all stages of model development. Good agreement is observed between modeled and measured statistics of various parameters and characteristics of flood events.

- Impact Forecasting validated and verified the flood model using NFIP claims.
- The Aon residential industry exposure database (IED) represents all residential risks, regardless of insured status, and the losses produced using this IED are not comparable to the observed NFIP losses. To correctly validate the modeled loss projections for each storm, the team created an estimated NFIP Take Up Rate (TUR) for each county in Florida

- For the storm surge portion of the model, the parameters studied include central pressure (Cp), radius of maximum winds (Rmax), translational velocity (VT), and far field pressure (FFP). The far field pressure (FFP) is the major contributor to the uncertainty in storm surge loss costs for Category 1 storms. For Category 3 and Category 5 hurricanes, Rmax has the greatest impact.

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SF-2 Sensitivity Analysis for Flood Model Output

- Impact Forecasting has assessed the sensitivity of outputs with respect to the simultaneous variation of input variables using current scientific and statistical methods.
- The most sensitive aspects of the Storm Surge component in the Impact Forecasting Flood Model are far field pressure (FFP), radius of maximum winds (Rmax), and central pressure (Cp).
- For the inland modeling the individual inundation hazard maps are fixed, and events are compiled from cut-outs of individual areas as defined by the local return periods in the fixed event set. Impact Forecasting performed a set of exploratory analyses to illustrate the effect of changing key model parts and model parameters.

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SF-3 Uncertainty Analysis for Flood Model Output

- Impact Forecasting has assessed the uncertainty of the flood outputs with respect to the simultaneous variation of input variables using current scientific and statistical methods.
- The far field pressure (FFP) is the major contributor to the uncertainty in storm surge loss costs for Category 1 storms. For Category 3 and Category 5 hurricanes, Rmax has the greatest impact.
- The largest contributors to uncertainty in inland flood mode are expected to be the spatio-temporal parameters governing the event clustering.

- The uncertainties in the storm surge loss costs may also be related to the storm landfall location, angle of approach to the coast, the shape and characteristics of coastal features such as bays and estuaries, and the slope of the continental shelf.
- The uncertainties in the inland flood loss costs can be driven by the presence, capacity, operation and failure of flood defenses, inaccuracies in the representation of floodplain and channel morphology by the Digital Terrain Model, variations in rainfall rates that occur at a temporal scale below the modeled temporal scale for rainfall, and flood wave celerity

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SF-4 Flood Model Loss Cost Convergence by Geographic Zone

- The Impact Forecasting Florida Flood Model (FCHLPM) stochastic event set is constructed using 200,000 years of simulation.
- The standard error in flood loss cost is lower than 5% of the estimated loss cost value for every county in Florida.

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SF-5 Replication of Known Flood Losses

- The Aon US flood model team has performed extensive analysis of the input industry exposure database and the National Flood Insurance Program's (NFIP) policy and claims data sets.
- To take into account the increase in value of exposures that has occurred between the event's occurrence date and the IED's representative building stock date, a trending factor based on Collins and Low (2001) was applied to the NFIP loss data.
- . The Aon residential industry exposure database (IED) represents all residential risks, regardless of insured status, and the losses produced using this IED are not comparable to the observed NFIP losses. Therefore, to correctly validate the loss projections for each storm, the team created an estimated NFIP Take Up Rate (TUR) for each county in Florida. Utilizing the IED, the number of policies within each of the SFHAs, within a county, was compared against the number of total exposures within the same area. This factor was then multiplied against the total modeled gross losses to create a "modeled NFIP" loss value.
- The differences between the modeled losses and the observed losses can be attributed to numerous factors that lie in a model's inability to fully resolve the physical processes that underlie the meteorological, hydrological, hydraulic, and mechanical processes that occurred during the modeled events.
- Additionally, the changes in the building stock, NFIP take up rates, and the built environment were all analyzed to determine how each assumption contributes to the difference between the observed and modeled NFIP losses
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Vulnerability Flood Standards

VF-1 Derivation of Building Flood Vulnerability Functions

- The development of the building flood vulnerability functions incorporates rational structural analysis together with supporting information from scientific, post-event reconnaissance, and expert opinion.

- The building vulnerability functions are developed based on sound engineering principles and are calibrated and validated using NFIP claims data from multiple historical events, and publicly available research.
    - The engineering-based vulnerability functions are developed using a component-based vulnerability approach. The uncertainties in both loading, flood resistance capacity, and repair cost resistance for each component are accounted for using appropriate probability distributions.

- The residential building stock classifications are identified based on a review of construction inventories using information from the Aon's IED, U.S. Census, tax appraiser's data, public domain reference information such as the Florida Hurricane Catastrophe Fund (FHCF), and post-event reconnaissance surveys. In addition, the residential building stock classification was compared with NFIP claims. These resources were used to compile standard building types for personal residential buildings.

- Impact Forecasting's building flood vulnerability functions relate flood damage to the depth of inundation experienced by the building, accounting for the action of the hydrostatic and hydrodynamic loads applied to the building. In coastal areas, the damaging wave action, specifically for the breaking wave is considered as part of the acting loads on the building envelope.

VF-1 Derivation of Building Flood Vulnerability Functions

- The Impact Forecasting exposure module classifies buildings by their primary and secondary risk characteristics.
- Primary: occupancy type, construction material, year built, vulnerability tier (FEMA FIRM-based), number of stories, first-floor height and foundation type.
- Secondary: building enclosure, elevate or protect utility equipment, wet floodproofing, dry floodproofing
- Vulnerability functions for site-built residential buildings and manufactured homes are derived separately and are included in the model.
- The set of vulnerability functions for appurtenant structures shares identical functions as building coverage.
- The vulnerability functions rely on flood inundation depth above ground as the intensity measure, with the mean damage ratio (MDR) increasing as inundation depth rises.
- Direct damage to the building interior occurs only when the above-ground inundation surpasses the FFH. However, it's important to highlight that exterior components of the building can sustain damage even before flood depth reaches the FFH. This is consistent with fundamental engineering principals and has been validated using claims data from historical events.
- The model incorporates 483,384 structure vulnerability functions, which are applicable to both building coverage and appurtenant structure coverage.
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VF-2 Derivation of Contents Flood Vulnerability Functions

- The contents vulnerability functions were developed based on the Impact Forecasting damage simulator using engineering analysis and judgment, with supporting information from scientific literature.
  - Contents vulnerability functions are intricately tied to the building damage due to the dependency between the envelope breakage (i.e., windows, doors, envelope walls) or structural collapse condition; and the flood depth inside the building, which generates the loss to contents due to water contact.
  - For every building vulnerability function, there is a corresponding contents vulnerability function.

- The contents vulnerability functions were calibrated and validated using NFIP claims from multiple historical events.

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VF-3 Derivation of Time Element Flood Vulnerability Functions

- The time element vulnerability functions were developed using a component-based model combined with a restoration process modeling using the estimation of expected restoration times to determine time element losses.
  - The vulnerability model also considers the emergency response time after a flood event (e.g. the time required for evacuation or drying and cleaning after a flood event)
  - Additionally, expert opinion together with published peer-reviewed research, and post-event reconnaissance reports were utilized for the calibration / validation of the vulnerability functions.
  - The time element vulnerability functions describe loss behavior and are intricately tied to the building damage through restoration time of individual damaged components.

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VF-4 Flood Mitigation Measures

- The secondary risk characteristics (secondary modifiers) are used to account for the effects of flood mitigation measures. The impact of the flood mitigation measures on flood resistance of buildings and associated uncertainties are modeled based on sound engineering principles, using a component-based approach.
- The vulnerability simulator, utilized for calculating primary vulnerability functions, is also employed to define secondary modifiers.
- Key secondary modifiers were identified based on structural engineering expertise and post-event reconnaissance of historical flood damage.
- The secondary modifiers vary by primary vulnerability function. They are multiplied to the primary vulnerability functions and can increase, decrease, or maintain the primary building vulnerability functions.
- The effects of multiple secondary modifiers on the building damage ratio are combined with a multiplicative methodology.
- In the absence of any mitigation or secondary risk characteristics, the model uses the primary vulnerability curve without any modification.
- Flood mitigation measures cover flood-resistant design, construction, and retrofit techniques, including utility elevation, floodproofing, and building enclosure.

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Actuarial Flood Standards

AF-1 Flood Model Input Data and Output Reports

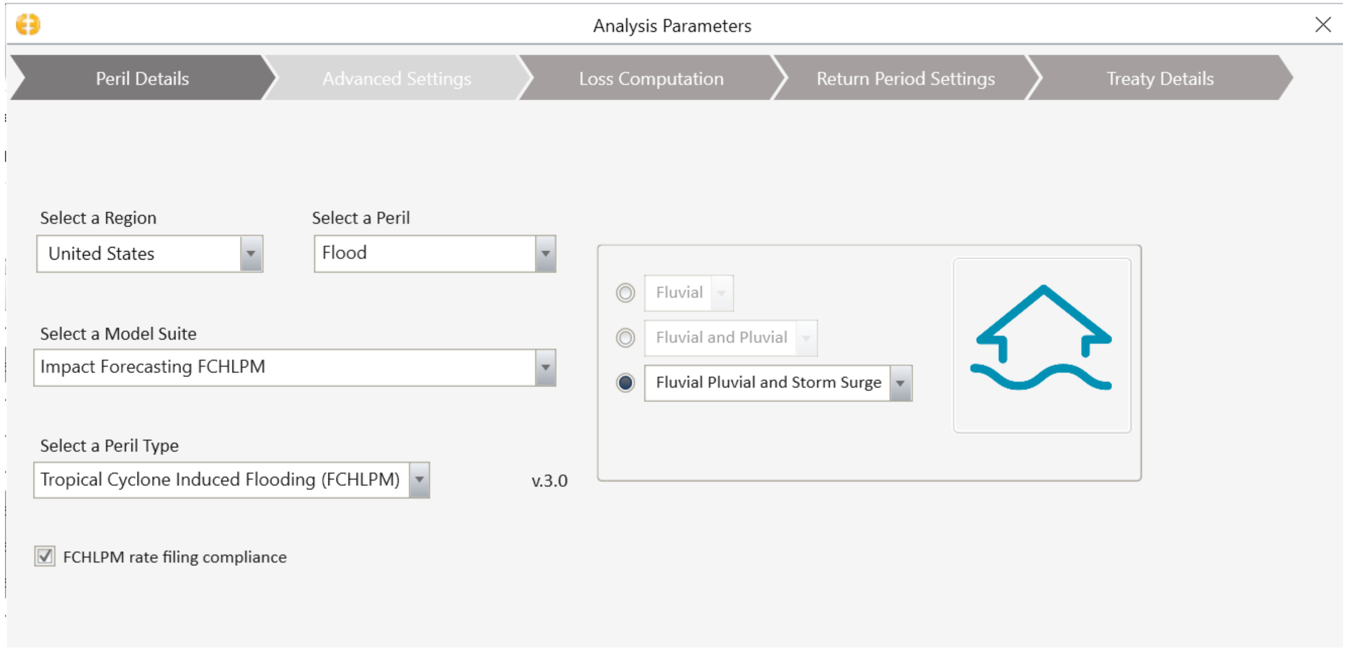
- Any adjustments, edits, inclusions, or deletions made to insurance company or other input data are based upon accepted actuarial, underwriting, and statistical procedures. Sensitivity analyses were conducted to assess how certain assumptions affect the estimated losses to ensure the reasonableness of assumptions and data mappings.
  - The insured value and insurance limits are provided as separate inputs by the user. No adjustments are made to these values within the model.
  - The IF Florida Flood model does not make assumptions of depreciation and does not reduce insured flood losses on account of depreciation. Users have the option to code the actual cash values instead of the replacement cost values into the flood model input file.
  - The IF Florida Flood model can distinguish among various personal residential policy forms based on occupancy type and construction class (for manufactured homes).

AF-1 Flood Model Input Data and Output Reports

- All modifications, adjustments, assumptions, inputs and input file identification, and defaults necessary to use the flood model are actuarially sound and are included with the flood model output report and in the Impact Forecasting documentation. Treatment of missing values required to run the flood model is actuarially sound.
  - The input forms used by the flood model are provided in Appendix E: Flood Model Input Form.
  - Analysis options for Florida rate making are in compliance with Florida Statute FS 627.0628.
  - IF model generates a suite of import, analysis and output reports for users to conduct quality control and for regulators to confirm assumptions.
  - IF maintains an Actuarial Form Exposure Generation plan that outlines the procedures and methods used to assure accuracy of insurance and other input data when creating the Actuarial Forms.

AF-1 Flood Model Input Data and Output Reports

- A check box for "FCHLPM rate filing compliance" is used in the analysis settings. Only compliant analysis options will be permitted when this check box is selected.



- A simple, documented procedure using a tool within the ELEMENTS platform allows users to combine the Non-Tropical Cyclone and Tropical Cyclone Flood results to produce combined Flood losses for rate filing. This procedure restricts users to only acceptable defaults, and is required to produce results to be used for personal residential property flood insurance rate filing in Florida

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AF-2 Flood Events Resulting in Modeled Flood Losses

- Modeled flood losses and flood probable maximum loss levels reflect all insured flood-related damages from coastal and inland flood events impacting Florida.
  - The Impact Forecasting Florida Flood Model (FCHLPM) version 3.0 simulates flood events and the losses arising from them as a direct result of tropical and non tropical precipitation
  - The calculation of flood loss costs and flood probable maximum loss levels for Florida include damage from flood events that fall within or cross the boundary of the state of Florida. This includes events that impact Florida but originate outside of Florida, such as by-passing hurricanes and riverine discharge that occurs as a result of precipitation that falls entirely outside of Florida.

AF-2 Flood Events Resulting in Modeled Flood Losses

- Impact Forecasting has a documented procedure to distinguish flood losses from other peril losses. The model only provides users the option to model flood-related losses. Flood exposures are distinguished at the exposure import step.
- The model calculates the losses from coastal and inland flooding separately. For locations where the two footprints overlap, the maximum loss for each location will be reported.
- No other types of flooding events are modeled other than coastal and inland flooding. The model does not consider non-flood water losses to be flood losses caused by water intrusion.
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AF-3 Flood Coverages

- Building: The vulnerability functions are developed based on well-established structural and flood engineering science in literature and calibrated and validated by analyzing historical claims data.

- Appurtenant structure: The Impact Forecasting Florida Flood Model calculates appurtenant structure flood loss costs separately from building, contents, and time element flood loss costs.

  - The Impact Forecasting Florida Flood Model estimates flood losses for appurtenant structure coverage associated with personal residential properties using the same method as for building coverage but using the input appurtenant structure coverage values.

AF-3 Flood Coverages

- Contents: The Impact Florida Flood Model estimates flood losses for contents coverage associated with personal residential properties using the same method as for building coverage but using the input contents coverage values. The contents damage functions are based on building damage ratio.

- Time Element: The Impact Forecasting Florida Flood Model estimates flood losses for time element coverage associated with personal residential properties based on the emergency response time and the required restoration time, using the input time element coverage values.

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AF-4 Modeled Flood Loss Cost and Flood Probable Maximum Loss Level Considerations

- Flood losses and probable maximum loss levels generated by the IF Florida Flood model do not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margins.
- The Impact Forecasting Florida Flood Model does not make a prospective provision for economic inflation.
- The Impact Forecasting Florida Flood Model only provides users the option to model storm surge and inland flood losses.
- In the Impact Forecasting Florida Flood , flood loss costs and flood probable maximum loss can be produced at the location or site level. Flood loss costs and flood probable maximum loss levels can then be calculated at any geographic level, such as ZIP Code, county, state, etc.

AF-4 Modeled Flood Loss Cost and Flood Probable Maximum Loss Level Considerations

- Demand surge is included in the IF model's calculation of flood loss costs and probable maximum loss levels. The demand surge function exists individually for both TC and non-TC components of the model, capturing the difference in the type of damage and subsequent recovery caused by individual perils.
  - The TC portion of the model function is developed based on analysis of the pricing information for the construction sector from Xactimate and XactContents.
  - For the Non-TC portions of the model, demand surge is represented by a separate function developed usin g historical loss data and fluctuations in the labor and material costs specific to the construction sector following a major event.

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AF-5 Flood Policy Conditions

- Policy deductibles and policy limits are developed based on well-established insurance theory.
- The relationship among the modeled deductible flood loss costs is reasonable. When other variables are held constant, loss costs decrease as deductibles increase.

- The Impact Forecasting Florida Flood Model is capable of handling annual deductibles. It complies with s. 627.701(5)(a), F.S.

- Regarding policy exclusions, if the user removes a coverage amount from the input files, the model would not generate losses for the excluded coverage. Loss settlement and other exclusions that are not explicitly reflected in the exposure data cannot be quantified by the model. However, loss settlement and other exclusions may be implicitly included in the model results to the extent that the claims data used to calibrate the model reflected these conditions.

- The IF Florida Flood Model does not have annual deductible functionality.

- The Aon US flood model team has performed extensive analysis of the input industry exposure database and the National Flood Insurance Program's (NFIP) policy and claims data sets. The NFIP loss databases were used by the team's analysts, scientists, and engineers as the basis of validation of event level losses.
- **Standard Verified by the Professional Team**

AF-6 Flood Loss Outputs and Logical Relationships to Risk

- IF's methods, data and assumptions used to estimate losses are actuarially sound.

- Loss costs exhibit logical relationships to risk in all cases, regarding
  - Construction type
  - Policy forms
  - Presence of mitigation features (covered in Vulnerability Standards)
  - Building code
  - Deductibles
  - Coverages
  - Geographic
  - Major Flood Control Measures
  - Elevation

- Form A-6 demonstrates all of these logical relationships to risk.

- **Standard Verified by the Professional Team**

Impact Forecasting
Florida Flood Model (FCHLPM)
Version 3.0
ELEMENTS Version 18.0

Computer/Information Flood Standards

CIF-1 Flood Model Documentation

- IF maintains the following three sets of documentation related to flood model development and implementation:
  - Model development documentation created by the Research and Development (R&D) team detailing all components, formulas, and test data for the flood model;
  - Technical notes produced by the Software Team based on model methodology described in the R&D document. The technical notes describe architectural and design strategies to implement the flood model in the ELEMENTS platform;
  - High-level documentation created for end users which describes the components of the flood model and their usage in the ELEMENTS platform.

- All documents are maintained in Microsoft Team Foundation Server (TFS) and are version controlled.

- Documents describing model requirements, system architecture, design strategy, implementation details, and the user interface are produced by the Software Team. In addition, a document related to testing plans and test results is produced by the QA (Quality Assurance) Team.

CIF-1 Flood Model Documentation

- IF maintains a table of all changes to the accepted model will be tracked for affected components
- The IF Software Team produces requirements, architecture, and design documents separately from the source code. These documents are used by the QA Team to prepare test cases and perform tests.
- **Standard Verified by the Professional Team**

CIF-2 Flood Model Requirements

- IF maintains documentation for major software components along with a database schema, technical notes, a user guide, an installation guide, and a deployment guide for successful deployment and usage of the models on the ELEMENTS platform.
- IF produces various types of internal (i.e., used only by IF) and external (i.e., client-facing) documents at different phases of the model development process. Documents produced and maintained by the Software Team include:
  - Software Development Process
  - Feature Requirement Specification
  - Architecture/Design Document
  - Technical Notes
  - Test Plans and Test Cases
  - Database Schema
  - Product Release Notes
  - ELEMENTS User Guide
  - Input Data Format
  - ELEMENTS Installation and Deployment Guide
  - Additional Tools User Guide
  - Coding Standard
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CIF-3 Flood Model Organization and Component Design

- Impact Forecasting develops and maintains documents which describe the database schema and relationships between data, including flowcharts to show the flow of information and links between data from various components of the software system. This includes schema of the Exposure/Results database and Model database.
- Interaction between software components and sub-components is captured in architecture and design documentation, including the interactions between hazard and vulnerability modules.
- A separate document describing interactions between multiple IF groups and team members is maintained using a diagram.
- All flowcharts developed and maintained by Impact Forecasting follow industry standards based on ISO 5807, and Business Process Model and Notation (BPMN).
- **Standard Verified by the Professional Team**

CIF-4 Flood Model Implementation and Component Design

- IF maintains the following:
  - Coding guidelines and a handbook of coding best practices
  - A network organization diagram involving all the servers and hardware components involved in running the flood model on the ELEMENTS platform
  - A list of all components affecting flood loss cost and probable maximum loss calculations along with implementation details, such as number of lines of code and number of lines of comments for each component and sub-component

- All model files and databases provided by the R&D group are stored and backed up regularly. The Software Team compares production-ready files and databases with original copies using MD5 Hash comparison.

- Descriptions of all static components and interactions between components are documented at various levels of detail using flowcharts and other depictions. This documentation can be used to track implementation details in actual code.

- flood model code has been stored and maintained in a TFS source control system. Changes to the flood model methodology has been documented as a part of new requirements

CIF-4 Flood Model Implementation and Component Design

- All components including Classes and Methods are sufficiently commented in the code as per industry guidelines. All Classes are commented with each class's purpose and linkage to other Classes. All methods are commented with Input and Output parameters along with inner workings of the method, exceptions, and logic. An important line of code is commented in detail with linkage to work items in the source control system (TFS) when applicable.

- A list of all components referred to in Standard GF-1 and used in software implementation is maintained and tracked. A cross-referenced list of equations and variables used in implementation is documented and maintained.

- **Standard Verified by the Professional Team**

CIF-5 Flood Model Verification

- For any change in a model component, the following steps are taken
  - Primary developers from the R&D team perform and document the changes.
  - Non-primary developers from the R&D team peer review and approve the changes.
  - Results and documentation of changes are shared with the software team.
  - The software team independently implements these changes in the production-ready software following industry standard processes.
  - The QA team performs various tests in which results (hazard and losses) are compared with original runs performed by model developers.
  - Upon successful comparison, changes are approved and released in the final product.

CIF-5 Flood Model Verification

- The model testing and verification methods include:
  - Component testing
    - The software team uses the Team Foundation Server (TFS) Unit testing framework to perform unit tests on all components when applicable. All unit test cases are documented and stored in the TFS repository.
    - Unit tests for all components are performed where applicable. For all eligible components and sub-components, an input, along with the expected output, is defined and tests are run to match expected results. Only upon passing the unit tests is the code allowed to be checked in as a part of the final build.
    - In addition to the unit tests, automated tests, which go through sets of sub-components and check the correctness of the results, are also performed.
    - Sets of regression tests are documented and performed with each iteration of internal and production releases. New regression tests are added with newly added features to complete the coverage of all cases.
    - End-to-end tests involving all flood model components are performed regularly by the QA team with each internal and production release. Multiple test cases are created to make sure all possible interactions among sub-components and components are covered.

CIF-5 Flood Model Verification

- The model testing and verification methods include:
  - Data testing
    - Specific test cases are developed for components which access model data from a database or files and are compared against expected results.
    - These tests are run periodically with every internal and production release cycle.
    - The Unified Function Test (UFT) suite by MicroFocus is used to automate test cases in addition to manual testing to verify communications between various components.
    - The combination of log files, intermediate files, and SQL databases are also used to verify data flow and inter-component communication.
    - Microsoft Excel and Word are used to document the testing process and its outcome.
    - A data hash mechanism is used when copying data from one server to another to ensure that no data are corrupted which can corrupt results. All data used by the flood model is regularly backed up.

- **Standard Verified by the Professional Team**

CIF-6 Human-Computer Interaction

- Interface was implemented using accepted principles and best practice of HCI, Interaction Design and UX engineering.
- The option to run a FCHLPM approved model is uniquely emphasized on user interface by having "FCHLPM" as a part of the model's name along with model version.
- An option to run the FCHLPM approved model rate filing is available in the interface. When this option is selected, all other options are set to approved default values, limiting users only to options found acceptable by the Commission.

- **Standard Verified by the Professional Team**

CIF-7 Flood Model Maintenance and Revision

- Impact Forecasting created policies and processes to be followed when changing model components in any form. This includes the production of a business case which includes the driving factor(s) that necessitate the change and the objective and impact of the change.

- The IF Florida Flood periodically updates to reflect new learning and advancement in understanding of the model components, a new version identifier will be assigned when the updates result in changes to the FL residential flood loss costs or PMLs.

- IF uses Team Foundation Server (TFS) as the code, documentation (including feature and change requests and requirements), and requirements repository.
  - Any changes to the model components are tracked using TFS source control system which records the change, author, and date/time of the change.

- Impact Forecasting will maintain a list of flood model changes after the initial submission. A unique version identifier will be assigned according to the versioning scheme established by IF.

- **Standard Verified by the Professional Team**

CIF-8 Flood Model Security

- Impact Forecasting documents and follows security processes to secure access to the code, data, and documentation as prescribed by company's policy and industry standard. The security processes include:
  - Secured Computer Access
    - Office Security
    - Data Center Access
  - Secured flood Model
    - Firewall and Network Security
    - User Account Access
    - Anti-virus
  - Secured Documentation, Software, and Data
    - Code
    - Model and Application Data
    - Documentation

  Impact Forecasting follows security standards provided by Aon. Aon maintains a comprehensive security and privacy program, which consists of policies and standards developed upon the ISO 27002, NIST and Department of Defense framework.

- **Standard Verified by the Professional Team**

Thank you

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