Flood Standards Development

Input to Draft Meteorology Flood Standards Dated 2-20-15

March 19, 2015

AIR WORLDWIDE

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1 Introduction

AIR Worldwide (AIR) appreciates the opportunity to provide input into the development of the Florida Commission on Hurricane Loss Projection Methodology (FCHLPM or Commission). This document contains AIR's input into the draft Meteorological/Hydrological Flood Standards published on February 20, 2015.

The remainder of this document presents AIR's suggestions for edits to the draft Met/Hydro Standards using the required format.

2 Standard MHF-1 Flood Event Data Sources

The Commission requested input from the modelers about Form MHF-1; AIR's suggested edits in MHF-1 respond to this request. The Problem Statement and Explanation sections below discuss suggested edits to the various sections (Standards, Purpose, Disclosures, Audit).

2.1 MHF-1 Disclosures

AIR's suggested edits to the MHF-1 Disclosures are described, explained and justified below.

2.1.1 MHF-1 Disclosure 4

- Problem Statement: We have provided suggested edits to Form MHF-1. The wording in Disclosure 4 is edited to be consistent.
- Explanation: This is technical edit to bring the language in the disclosure in line with Form MHF-1.
- Amendatory Language:

~~4. Provide a completed Form MHF-1 (Annual Flood Occurrence Rates) for coastal and inland flooding, which includes data for various flood extent and depth corresponding to 5, 25, 50, 100, 200, 500, and 1,000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen. Provide a link to the location of the form [insert hyperlink here]. Modelers to submit additional language for consideration at March meeting.~~

~~5.~~4 Provide a completed Form (MHF-1) (Flood Severity Quantile Estimates) for coastal and inland flooding, which includes data for flood extents and depths corresponding to 5, 20, 50, 100, 200, 500, and 1000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen. Provide a link to the location of the form [insert hyperlink here].

2.2 MHF-1 Audit Items

AIR's suggested edits to the MHF-1 Audit Items are described, explained and justified below.

2.2.1 MHF-1 Audit Items 3 and 4

- Problem Statement: We have suggested a change in the name of Form MHF-1; this name needs to be updated throughout the document. We also suggest the name of Form SF-1 be changed to be consistent with the name Form MHF-1 name change.
- Explanation: This is an technical edit.

- Amendatory Language:

3. Modeled frequencies will be compared with the observed spatial distribution of flood frequencies across Florida using methods documented in currently accepted scientific literature. The goodness-of-fit of modeled to historical statewide and regional coastal and inland flooding flood frequencies as provided in Form MHF-1 (Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~) will be reviewed.

4. Form MHF-1 (Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~) will be reviewed for consistency with Form SF-1 (Severity of Florida Flood Events for specified probabilities and frequencies~~Probability and Frequency of Florida Flood Events per Year~~).

3 Standard MHF- 3 Wind and Pressure Field Structures for Storm Surge

The Problem Statement and Explanation sections below discuss suggested edits to the various sections (Standards, Purpose, Disclosures, Audit).

3.1 MHF-3 Standards

AIR's suggested edit to the MHF-3 Standards is described, explained and justified below.

3.1.1 Standard MHF-3.D

- Problem Statement: New Standard MHF-3.D. requires that wind and pressure fields that drive coastal flood models shall be modeled for an appropriate length of time. Since this standard is specific to storm surge, we think an additional clarifying word should be added in the second to last line of this standard. Adding the word "coastal" will clarify that the standard is not also talking about an inland flood event.
- Explanation: This is a general edit to clarify the intent of the standard
- Amendatory Language:

> ***D. Wind and pressure fields that drive coastal flood models shall be modeled for a time period that extends from at least before the storm's passage over the continental shelf waters of Florida and neighboring states to at least the time the storm no longer affects coastal flooding in Florida.***

4 Form MHF-1 Flood Severity Quantile Estimates

4.1 Items in Form MHF-1

AIR's suggested edits to Form MHF-1 are described, explained and justified below.

4.1.1 Form MHF-1 Item A

- Problem Statement: On the wind hazard side, the concept of an occurrence rate is directly tied to the five Saffir-Simpson categories. In other words, if you talk about the hurricane occurrence rate, it is the rate *with respect to a particular SS-category*. The issue we have been struggling with on the flood side is defining what the occurrence rates are *with respect to* because floods do not have a handy "category" like winds do. AIR suggests that the concept of flood severity quantiles corresponding to specific return periods is an appropriate "*with respect to*" for the flood peril. The word "Quantile" typically is used for referring to the magnitude of any variable that

corresponds to certain probability of exceedance (or return period). In this case, it is basically to say Flood (magnitude) Quantile estimate corresponding to 2, 5 , 10, … return periods.

- Explanation: This is an edit to the nature of the data requested in the form in order and to make things clearer.
- Amendatory Language:

> ~~A. Provide annual flood occurrence rates for coastal and inland flooding which includes data for various flood extent and depth corresponding to 5, 25, 50, 100, 200, 500, and 1,000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen. Annual flood occurrence rates shall be rounded to four decimal places.~~
>
> ~~B.~~A. Provide flood severity quantile estimates for coastal and inland flooding, which includes data for flood extents and depths corresponding to 5, 20, 50, 100, 200, 500, and 1000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen.

5 Attachment with Track Changes

The attached document called AIR_Meteorological Hydrological Flood Standards 2-20-15-TrackChgs.docx contains all of AIR's suggested edits in track-changes format. If there is any disagreement between the appendix and the content in the report, the report edits take precedence.

METEOROLOGICAL/HYDROLOGICAL FLOOD STANDARDS

MHF-1 Flood Event Data Sources

A. The modeling of floods in Florida shall involve meteorological, hydrological, and other relevant data sources.

B. The model shall incorporate relevant data sources in order to account for meteorological and hydrological events and circumstances occurring either inside or outside of Florida that result in or contribute to flooding in Florida.

C. Flood model calibration and validation shall be scientifically justified based upon historical data consistent with peer reviewed or publically developed data sources.

D. Calibration and validation shall encompass relevant flood event data sources required to model flood, which shall include, but not be limited to, coastal and inland flooding, as well as any partitions or subsets.

E. Any trends, weighting, or partitioning shall be justified and consistent with currently accepted scientific literature and statistical techniques.

Purpose: As a minimum, the flood model shall include coastal and inland flooding. Coastal flooding includes storm surge, and inland flooding includes riverine, lacustrine, and surface water flooding.

Utilized data sources associated with each type of flooding shall be documented, and the stochastic flood event data sources shall be scientifically defensible. If other flood sub-perils are included, they shall be identified.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification
MHF-1, ~~Annual Flood Occurrence Rates~~ Flood Severity Quantile Estimates
AF-2, Flood Event Data Sources Statewide Losses
SF-1, ~~Probability and Frequency of~~ Severity of Florida Flood Events for specified probabilities and frequencies~~per Year~~
SF-5, Average Annual Zero Deductible Statewide Flood Loss Costs – Historical versus Modeled

Disclosures

1. Identify relevant data sources, their release dates, and the time periods used to develop and incorporate flood frequencies for coastal and inland flooding into the flood model.

2. Where the flood model incorporates modification, partitioning, or adjustment of the historical data leading to differences between modeled climatology and historical data, justify each modification and describe how it is incorporated.

3. State whether the model includes flooding other than coastal and inland flooding. State whether the other flooding types are independent of the minimum required sub-perils of coastal and inland flooding.

~~4. Provide a completed Form MHF-1 (Annual Flood Occurrence Rates) for coastal and inland flooding, which includes data for various flood extent and depth corresponding to 5, 25, 50, 100, 200, 500, and 1,000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen. Provide a link to the location of the form [insert hyperlink here]. **Modelers to submit additional language for consideration at March meeting.**~~

~~5.~~4. Provide a completed Form (MHF-1) (Flood Severity Quantile Estimates) for coastal and inland flooding, which includes data for flood extents and depths corresponding to 5, 20, 50, 100, 200, 500, and 1000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen. Provide a link to the location of the form [insert hyperlink here].

Audit

1. The modeling organization's data sources will be reviewed.

2. Justification for any modification, partitioning, or adjustment to historical data and the impact on flood model parameters and characteristics will be reviewed.

3. Modeled frequencies will be compared with the observed spatial distribution of flood frequencies across Florida using methods documented in currently accepted scientific literature. The goodness-of-fit of modeled to historical statewide and regional coastal and inland flooding flood frequencies as provided in Form MHF-1 (Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~) will be reviewed.

4. Form MHF-1 (Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~) will be reviewed for consistency with Form SF-1 (Severity of Florida Flood Events for specified probabilities and frequencies~~Probability and Frequency of Florida Flood Events per Year~~).

5. Describe the historical data used as the basis for the model's flood extent and depth. Discuss the appropriateness of the model's stochastic flood extent and depth with reference to the historical flood databases.

MHF-2 Flood Parameters (Inputs)

A. The flood model shall be developed with consideration given to flood parameters that are scientifically appropriate for modeling coastal and inland flooding. The modeling organization shall justify the use of all flood parameters based on information currently available in scientific literature.

B. Any differences in the treatment of flood parameters between historical and stochastic events shall be justified.

C. The land use and land cover (LULC) database shall be consistent with the National Land Cover Database (NLCD) 2011 or later. Use of alternate datasets shall be allowable if justified.

Purpose: This standard requires that the modeling organization use only scientifically sound information for determining coastal and inland flooding parameters. Flood parameters are inputs to the flood model and are needed by the model to define or determine the nature, severity, and physical characteristics associated with coastal and inland flooding.

This standard requires that the flood model be implemented consistently with contemporary soil categories and LULC distributions.

This standard requires that any differences in the treatment of flood parameters between historical and stochastic floods be justified.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification
SF-3, Distributions of Stochastic Flood Parameters (Coastal and Inland)

Disclosures

1. For coastal and inland flood model components, identify and justify the various flood parameters used in model.

2. For coastal and inland flood model components, describe the dependencies among model parameters and specify any assumed mathematical dependencies among these parameters.

3. For coastal and inland flood model components, describe the dependencies which exist among and between each of the model components.

4. Identify whether flood parameters are modeled as random variables, functions, or fixed values for the stochastic flood event generation. Provide rationale for the choice of parameter representations.

5. Describe how any flood parameters are treated differently in the historical and stochastic flood event sets (e.g., varying versus fixed).

6. For coastal flood analyses, describe how the coastline is segmented (or partitioned) in determining the parameters for coastal flood frequency used in the flood model.

7. For inland flood analyses associated with riverine and lacustrine flooding, describe how the rivers, lakes, and associated floodplains are segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.

8. For inland flood analyses associated with surface water flooding, describe how the affected area is segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.

9. Describe how any flood parameters change or evolve during an individual flood life cycle (e.g., the functional representation of Manning's roughness of trees varying with flood depth).

10. Describe any assumptions or calculations used in the model relating to antecedent conditions (e.g., groundwater levels, lake levels, river discharges, tides, waves, etc.).

11. For coastal modeling, describe any assumptions or calculations for wave radiation stresses and their impact on storm surge stillwater elevations.

12. Describe any assumptions or calculations used in the model relating to future conditions (e.g., sea level rise, changes in precipitation patterns, changes in storm frequency or severity).

13. Provide the source, resolution, and accuracy of the topography and bathymetry throughout the flood model domain.

14. Describe any assumptions or calculations used in the model relating to flood-induced erosion or topographic changes.

15. As applicable, describe the methods used to account for soil infiltration rates and saturation in the flood model. Provide citations to published papers, if any, used to develop and support the soil infiltration rate methodology.

16. Describe the methods used to account for land-use conditions and future changes in land-use, if any, in the flood model. Provide citations to published papers, if any, used to develop and support the land-use evaluation methodology.

17. Provide the collection and publication dates of the soil and LULC data used in the flood model, and justify their applicability and timeliness for Florida.

18. Describe the methodology used to convert LULC information into a spatial distribution of hydrological parameters, including roughness coefficients, throughout the model domain.

19. For each parameter used in the model, provide the horizontal and vertical projection and datum references, if applicable. If any horizontal or vertical datum conversions are required, provide conversion factors and describe the conversion methodology utilized.

Audit

1. All flood parameters used in the flood model will be reviewed.

2. Prepare graphical depictions of flood parameters as used in the flood model. Describe and justify:
    a. The data set basis for any fitted distributions, the methods used, and any smoothing techniques employed,
    b. The modeled dependencies among correlated parameters in the flood model and how they are represented,
    c. The dependencies between the coastal and inland flooding analyses.

3. Scientific literature cited in Standard GF-1 (Scope of the Computer Flood Model and Its Implementation) may be reviewed to determine applicability.

4. The initial conditions for each flood event and how the flood event is initialized in an individual event calculation will be reviewed.

5. Provide any modeling organization specific research performed to develop the soil infiltration rates used in the flood model. Identify the databases used. This material will be reviewed in the context of the cited scientific literature.

6. Provide any modeling organization specific research performed to develop soil saturation in the food model. Identify the databases used. This material will be reviewed in the context of the cited scientific literature.

MHF-3 Wind and Pressure Field Structures for Storm Surge

A. Representations of the spatial and temporal structures of wind and pressure fields shall be employed to drive storm surge models.

B. The wind and pressure fields shall be based on contemporary scientific literature or developed using scientifically defensible methods.

C. Wind and pressure fields for coastal flood modeling shall be employed for at least two classes of storms: tropical cyclones and extra-tropical cyclones. **Requesting input from Modelers, Professional Team and Commission members for discussion at March meeting, re: extra-tropical.**

D. Wind and pressure fields that drive coastal flood models shall be modeled for a time period that extends from at least before the storm's passage over the continental shelf waters of Florida and neighboring states to at least the time the storm no longer affects coastal flooding in Florida.

E. The features of modeled wind and pressure fields shall be consistent with those of historical storms affecting Florida.

Purpose: Storm surge is frequently the dominant component of flooding due to cyclonic storms, and wind is the dominant feature of cyclonic storms that drives surge. The representation of the windfield and related pressure field is, therefore, crucial to surge modeling. This standard ensures that the wind and pressure fields used to drive surge as part of flood models are scientifically sound and have been evaluated by comparison to historical storms affecting Florida. Modeling organizations have leeway in their methods of representing wind and pressure fields, and different storm classes may well require different approaches.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification
AF-2, Flood Event Data Sources Statewide Losses

Disclosures

1. Describe the nature of the wind and pressure field representation (e.g., parametric or resampled reanalysis of historical storms).

2. Provide the historical data used to estimate parameters and to develop stochastic storm sets from reanalysis.

3. If parametric gradient wind and pressure fields are employed, state and justify the choice of the parametric forms and the parameter values.

4. Provide a rotational (*y*-axis) versus radial (*x*-axis) plot of the average or default wind and pressure profiles for parametric, symmetric fields or a latitude-longitude map of typical reanalysis-based wind and pressure fields.

5. If parametric gradient wind and pressure fields are employed, describe how these winds are translated to surface winds (e.g., numerically via planetary boundary layer models or parametrically via empirical surface wind reduction factors and inflow angles). Discuss the associated uncertainties.

6. If parametric gradient wind and pressure fields are employed, describe how storm translation is accounted for when computing surface winds.

7. State if and describe how high-frequency windspeeds typically reported by meteorological agencies (e.g., 1-minute average peak) are converted to the longer averages more appropriate for driving storm surge models (e.g., 10- to 30-minute average peak).

8. Describe the derivation of surface water wind stress from surface windspeed. If a sea-surface drag coefficient is employed, describe how it is related to the surface windspeed. Provide a comparison of the sea-surface drag coefficient to coefficients from the scientific literature.

Audit

1. All external data sources that affect the model generated wind and pressure fields associated with storm surge will be identified and their appropriateness reviewed.

2. Calibration and evaluation of wind and pressure fields will be reviewed. Provide accepted scientific comparisons of simulated wind and pressure fields to historical storms.

3. The sensitivity of final flood results to the nature of the wind and pressure field representations will be reviewed.

4. The over-land evolution of simulated wind and pressure fields and what impact, if any, they have on flooding will be reviewed.

5. The treatment of the inherent uncertainty in the factor used to convert from a reference windfield to a geographic distribution of surface winds and the impact of the resulting winds upon the storm surge will be reviewed and compared with

currently accepted scientific literature. Treatment of conversion factor uncertainty at a fixed time and location will be reviewed.

MHF-4 Flood Characteristics (Outputs)

A. Flood extent and depth generated by the flood model shall be consistent with observed historical floods affecting Florida.

B. Methods for deriving flood extent and depth shall be scientifically defensible.

C. Inland flooding and its interaction with storm surge shall be represented.

D. The model shall yield flood characteristics relevant to the calculation of flood damage.

Purpose: This standard requires that the modeling organization use only scientifically sound information for determining inland and coastal flooding characteristics.

The resulting surface flood extent, depth, and other characteristics shall be representative of historical floods in Florida.

Comparison of the flood characteristics produced by the stochastic flood events and historical flood events shall be documented, and variations between them shall be justified.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification
MHF-2, Maps of Flood Extent and Depth by Return Period
AF-2, Flood Event Data Sources Statewide Losses

Disclosures

1. Provide visual descriptions (sufficient to illustrate various regions in Florida) illustrating the flood characteristics for coastal and inland flooding.

2. For coastal flooding, describe how the model accounts for wave generation and decay, wave breaking, wave run-up, and other wave effects.

3. For inland and coastal modeling, describe how the model accounts for flow velocity and other relevant flood characteristics in the calculation of flood damage.

4. Identify all hydrological variables that affect the flood extent, depth, and other flood characteristics.

5. Describe the effect of any assumptions or calculations relating to antecedent conditions, as referenced in MHF-2, Disclosure 10, on the flood characteristics.
6. Describe and provide visual depictions of how the characteristics of each flood model component are utilized in or interface with the other components, if applicable.

7. Demonstrate the consistency of the model-generated flood extent and depth with observed floods affecting Florida. Describe and justify the appropriateness of the databases used in the flood extent and depth validations.

8. Provide comparisons of the model calculated and historical flood extents and depths for a minimum of XX events. The minimum number will include Y number of storms as provided in Table MHF-1. The comparisons must demonstrate that the events selected are of sufficient variety, and each model component (storm surge, riverine/lacustrine flooding, and surface water flooding) is sufficiently robust, to incorporate important flood parameters, replicate historical flood characteristics, and accommodate the varied geographic, geologic, hydraulic, and LULC conditions in Florida. Provide justification for validation using any historical events not specified in Table MHF-1.

9. For each of the coastal storm events in Disclosure 8, provide a comparison of the model calculated flood extents and water surface elevations with either the NOAA Maximum Envelope of Water (MEOW) or NOAA validation case studies using Sea, Lake, and Overland Surges from Hurricanes (SLOSH) data, if applicable. The modeling organization should use the most reasonable vintage of the MEOW data for this exercise.

10. Describe any variations in the treatment of the flood model flood extent and depth for stochastic versus historical floods and justify this variation.

11. Provide the level of resolution of the grid or areas modeled for the flood extent and depth and how the hydrological characteristics associated with the grid or areas are determined.

12. Provide a completed Form MHF-2, Maps of Flood Extent and Depth by Return Period. Explain any differences between modeled flood extent and depth and historical flood extent and depth. Provide a link to the location of the form [insert hyperlink here].

Audit

1. Provide any modeling organization specific research performed to develop the flood extent and depth functions used in the flood model. Identify the databases used.

2. Provide any modeling organization specific research performed to derive the hydrological characteristics associated with the topography, soil type, and LULC distributions for the flood extent and depth.

3. Provide the current flood parameters used in calculating the flood loss costs for X historical flood events. Calculations based on flood model results for coastal and inland flooding will be reviewed. Specification of flood parameters used in the model for all storm events will be reviewed. Provide the resulting temporal and spatial distributions of any flood characteristics contributing to flood damage. These will be reviewed with Form AF-2 (Flood Event Data Sources Statewide Losses). [consider deletion of this sentence if Form AF-2 is not going to specify a list]

4. If applicable, present time-based contour animations (capable of being paused) to demonstrate scientifically reasonable temporal evolution of flood characteristics. (Trade Secret item to be provided during the closed meeting portion of the Commission meeting to review the flood model for acceptability.)

5. Form MHF-2 (Maps of Flood Extent and Depth by Return Period) will be reviewed.

6. Calculation of relevant characteristics in the flood model for coastal and inland flooding will be reviewed. The methods by which each flood model component utilizes the characteristics of or interfaces with other model components, if applicable, will be reviewed.

7. The flood elevation frequency distributions associated with each segment for coastal and inland flooding will be reviewed.

8. The comparison of the calculated characteristics with historical flood events will be reviewed. The selected locations and corresponding storm events will be reviewed to verify sufficient representation of the variety of geographic areas. If a single storm is used for both coastal and inland flooding validation, then its appropriateness will be reviewed.

9. The comparison of the flood extents and water surface elevations calculated in the model with the NOAA Maximum of MEOW or NOAA validation studies using SLOSH data for each location will be reviewed, if applicable. The reasonableness of the MEOW data vintage used will be reviewed.

MHF-5 Flood Probabilities and Severities

A. Modeled probability distributions of flood parameters and characteristics shall be consistent with historical floods for Florida resulting from coastal and inland flooding.

B. Modeled flood frequency distributions and the flood extent and depth shall be scientifically defensible and shall be consistent with flooding observed for Florida over the time frames relevant to each data source and shall be consistent with those observed for each coastal and inland segment (or partition) of Florida and in which the flood event could occur in other parts of the United States where flooding damage impacts Florida.

Purpose: This standard requires that the modeled probability distributions of flood parameters and characteristics be consistent with those documented in official meteorological and hydrological databases. Consistent means that spatial distributions of modeled flood probabilities accurately depict coastal and inland flooding in Florida. This standard addresses consideration of flooding events in neighboring states (e.g., Georgia) which could impact Florida (e.g., Chattahoochee River floods from rainfall in North Georgia).

The probability of occurrence of floods and flood extent and depth shall reasonably reflect the historical record with respect to severity and geographical locations.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification
MHF-1, Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~
AF-2, Flood Event Data Sources Statewide Losses
SF-1, Severity of Florida Flood Events for specified probabilities and frequencies~~Probability and Frequency of Florida Flood Events per Year~~
SF-3, Distributions of Stochastic Flood Parameters (Coastal and Inland)

Disclosures

1. List assumptions used in creating the database(s) containing flood parameters and characteristics.

2. Provide a brief rationale for the probability distributions used for relevant flood parameters and characteristics.

Audit

1. Demonstrate that similar model flood parameters and characteristics are accounted for in the same manner across Florida and are appropriate for adjacent segments in Alabama and Georgia.

2. Describe and support the method of generating stochastic coastal and inland flood events.

3. Describe and support the method of determining flood extent and depth for coastal and inland flooding.

4. Provide any modeling organization specific research performed to develop the functions used for simulating flood model variables or to develop flood databases.

5. Form SF-3 (Distributions of Stochastic Flood Parameters – Coastal and Inland) will be reviewed for the probability distributions and data sources.

6. Comparisons of modeled flood probabilities and characteristics for coastal and inland flooding against the available historical record will be reviewed. Modeled probabilities from any subset, trend, or fitted function will be reviewed, compared, and justified against this historical record. In the case of partitioning, modeled probabilities from the partition and its complement will be reviewed and compared with the complete historical record.

MHF-6 Modeling of Flood Mitigation and Prevention Measures and Their Failures

A. The model's treatment of flood mitigation and prevention measures shall be consistent with historical records and with current state-of-the-science.

B. The modeling organization shall have a documented procedure for reviewing available flood mitigation and prevention data sets and shall update the flood model mitigation and prevention databases as necessary.

C. Any treatment of the potential failure of flood mitigation or prevention measures shall be based upon currently accepted scientific literature, empirical studies, or engineering analyses.

Purpose: This standard ensures that flood mitigation and prevention measures are accounted for and updated on a periodic basis. It also ensures that any treatment of the potential failure of flood mitigation or prevention measures properly reflects the scientific and engineering basis.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification

Disclosures

1. List the flood mitigation and prevention measures incorporated in the flood model and the sources of all data employed.

2. If applicable, describe the methodology to account for flood mitigation and prevention measures in the flood model and indicate if these measures can be set (either to on or off) in the flood model.

3. Describe if temporary/ongoing flood mitigation and prevention measures, and measures requiring human intervention, are incorporated into the flood model. Disclose if consideration is given on how much time is required to construct, install or activate such measures, as compared with warning time that may be available before a flood event. Disclose if consideration is given for the likelihood of construction/installation/activation based on reports in the literature for past storm events.

4. If applicable, illustrate the distributions of flood extent, depth, and other characteristics showing the impact of flood mitigation and prevention measures versus no flood mitigation and prevention measures.

5. Describe how a determination is made to update any flood mitigation and prevention measure modeling databases or the time period planned for regular updating of databases.

6. If applicable, describe and justify the methodology used to account for the potential failure or alteration of flood mitigation and prevention measures in the flood model and if the level of failure can be adjusted in the flood model.

7. If applicable, provide the probability distribution for flooding scenarios incorporating the failure of flood mitigation and prevention measures.

8. State whether the flood model incorporates natural or intentional discharge of flood waters by governmental or other human actions for flood mitigation purposes. If so, describe how this is handled in the flood model.

9. If applicable, describe the flood loss distributions assuming no failure of flood mitigation and prevention measures compared to the flood loss distribution accounting for failure.

Audit

1. Treatment of flood mitigation and prevention measures incorporated in the flood model will be reviewed.

2. The documented procedure addressing the periodic updating of current flood mitigation and prevention measures will be reviewed.

3. As applicable, the methodology and justification used to account for the potential failure or alteration of flood mitigation and prevention measures in the flood model will be reviewed.

4. As applicable, the probability distribution for flooding scenarios incorporating the failure of flood mitigation and prevention measures will be reviewed.

~~6.~~5. If the flood model incorporates discharge of flood waters by governmental or other human actions, the methodology used in the model will be reviewed.

~~7.~~6. As applicable, the flood loss distributions assuming no failure of flood mitigation and prevention measures compared to the flood loss distribution accounting for failure will be reviewed.

MHF-7 Logical Relationships of Flood Characteristics

A. The water level shall increase with increasing surface roughness, all other factors held constant.

B. The coincidence of storm surge and inland flooding shall increase the flood extent and depth, all other factors held constant.

C. The rate of water flow shall increase with increase in steepness in the topography and increase in surface slope, all other factors held constant.

D. The larger the over-water storm, as measured by the area enclosed by windspeed or pressure contours, the greater the storm surge extent and depth area, all other factors held constant.

E. Storm surge shall increase with increasingly shallow bathymetry, all other factors held constant.

F. The height of storm surge shall increase with increasing windspeeds, all other factors held constant.

G. If coastal waves are represented, wave (sea as distinct from swell) heights and periods shall increase with increasing windspeed, subject to depth, fetch and duration limits, all other factors held constant.

H. The inland flood extent and depth associated with riverine and lacustrine flooding shall increase with increasing discharge in the river.

Purpose: The flood model shall produce logical consistencies associated among the flood parameters and the flood characteristics used in the flood model.

Relevant Forms: GF-2A, Meteorological/Hydrological Flood Standards Meteorologist Expert Certification
GF-2B, Meteorological/Hydrological Flood Standards Hydrologist Expert Certification

Disclosure

1. Provide a sample graph of water surface elevation and discharge versus time associated with inland flooding for each region in Florida: Panhandle, Gulf Coast, North Florida, Central Florida, and South Florida. Discuss how the flood characteristics result in logical relationships.

2. Provide sample plots and tabulations of storm surge elevations and associated wave conditions at open coast and bay/estuarine locations around the Florida coastline. The

number of examples shall be sufficient to demonstrate model applicability to a variety of geographic, oceanographic, hydraulic, and meteorological conditions.

Audit

1. The modeling organization's sensitivity analyses will provide the information used in auditing this standard.

2. Verify that the flood model produces logical relationships among flood characteristics, as listed in this standard.

Form MHF-1: Annual Flood Occurrence Rates

Modelers to submit additional language for consideration at the March meeting.

~~A. Provide annual flood occurrence rates for coastal and inland flooding which includes data for various flood extent and depth corresponding to 5, 25, 50, 100, 200, 500, and 1,000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen. Annual flood occurrence rates shall be rounded to four decimal places.~~

~~B.~~A. Provide flood severity quantile estimates for coastal and inland flooding, which includes data for flood extents and depths corresponding to 5, 20, 50, 100, 200, 500, and 1000 year return periods. Provide a separate form for coastal and inland flooding subdivided for each specific location chosen.

~~C.~~B. Compare the flood model frequencies with the historical flood frequencies to the extent of available data.

~~D.~~C. Provide vertical bar graphs depicting distributions of flood frequencies.

~~E.~~D. Provide a color coded map with a legend displaying the flood frequency ranges. Increasing flood frequency shall correspond to greater color intensity.

~~F.~~E. If the data are partitioned or modified, provide the annual flood occurrence rates for the applicable partition (and its complement) or modification in additional copies of Form MHF-1 (Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~).

~~G.~~F. Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the standards year, and the form name. Form MHF-1 (Flood Severity Quantile Estimates~~Annual Flood Occurrence Rates~~) shall also be included in a submission appendix.

Form MHF-2: Maps of Flood Extent and Depth by Return Period

Historical Florida Floods

A. Identify six recent historical Florida floods that illustrate coastal and inland flooding.

B. Provide exhibits for the selected historical flood events illustrating modeled return periods for different river or coastal segments.

   Plot the locations and numerical measures of the maximum flood level relative to the local datum for coastal and inland areas on each contour map for the six historical events.

Modeled Florida Floods

C. Demonstrate the consistency of the spatial distribution of model-generated flood extent and depth with observed flood extent and depth for coastal and inland floods affecting Florida. Contour colors will be the same as those used for the maps provided in response to B above.

D. Explain any differences between the modeled flood extent and depth and the historical floods identified in item A. above. Include an explanation if the differences are impacted by flood mitigation and prevention measures.

All maps shall be color coded or shaded at elevation contours to describe the topography associated with the flood extent and depth.