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 the confluence of meteorological and hydrological events and circumstances occurring either inside or outside of Florida that result in flooding in Florida.

C. Annual frequencies used in both flood model calibration and flood model validation shall be consistent with peer reviewed data sources, publically developed data sources, or both types representing an unadjusted long-term record. [cite data sources and dates including the most current hydrological 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 flooding associated with storm surge, fluvial flooding, and pluvial 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, modeling organizations shall model coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding and data sources associated with each type of flooding will be utilized. However, if the modeling organization models other types of flooding and adequate data is available to project loss costs and probable maximum loss levels, relevant data sources shall be incorporated based on their latest publication dates.

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
AF-2, Flood Event Data Sources Statewide Losses
SF-1, Probability and Frequency of Florida Flood Events per Year
SF-5, Average Annual Zero Deductible Statewide Flood Loss Costs – Historical versus Modeled

Disclosures

1. Identify relevant data sources, the release dates, and the time periods used to develop and implement flood frequencies for coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding into the flood model.

2. If the modeling organization has made any modifications to original data sources related to flood frequencies and characteristics for any aspect of coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding, provide justification for each such modification.

3. State whether the modeling organization models other types of flooding (which can be characterized as other than coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding) and whether adequate data sources are available in order to project flood loss costs and flood probable maximum loss levels in a scientifically feasible manner. Identify all other types of flooding modeled and the data sources utilized for each. Provide justification for any modifications to such data sources.

4. Where the flood model incorporates short-term or long-term modification of the historical data leading to differences between modeled climatology and that in the original data, describe how this is incorporated.

5. Provide a completed Form MHF-1, Annual Flood Occurrence Rates for storm surge, fluvial flooding, and pluvial flooding by region or for specified locations, which includes data for various probabilities of exceedances (corresponding to 5, 25, 50, and 100 year return periods). Provide a link to the location of the form [insert hyperlink here].

Audit

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

2. Reasoning and justification underlying any short-term and long-term variations in coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding frequencies incorporated in the flood model will be reviewed.

3. Modeled probabilities 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 flooding associated with storm surge, fluvial flooding, and pluvial flooding flood frequencies as provided in Form MHF-1 (Annual Flood Occurrence Rates by County) will be reviewed.

4. Form MHF-1 (Annual Flood Occurrence Rates) will be reviewed for consistency with Form SF-1 (Probability and Frequency of Florida Flood Events per Year).

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

6. If the historical flood data are partitioned or modified, describe how the various flood parameters and characteristics are affected.

MHF-2 Flood Parameters and Characteristics

A. The flood model shall be developed with consideration given to flood parameters and characteristics that are scientifically appropriate for various types of flooding being modeled (i.e., coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding). The modeling organization shall justify the use of all flood parameters and characteristics based on information currently available in scientific literature.

B. Parameters used to model flooding associated with storm surge, fluvial flooding, and pluvial flooding shall be scientifically defensible.

C. Flood characteristics produced by the model will be scientifically defensible.

Purpose: This standard requires that the modeling organization use only scientifically sound information for determining coastal flooding associated with storm surge, fluvial flooding and pluvial flooding parameters and characteristics. The stochastic flood event data sources shall be scientifically defensible. Any differences in the treatment of flood parameters between historical and stochastic floods shall be justified.

A flood parameter is an input to the flood model. Flood parameters are needed by the model to define or determine the windfield and rain associated with a flood event as well as to define the nature of the fluvial and pluvial areas (e.g., catchments, topography, urban development, soil type and saturation, etc.).

Flood characteristics are outputs of the flood model. An example of a flood characteristic is a modeled flood footprint of coastal flooding associated with storm surge.

Characteristics associated with flood parameters shall be scientifically determined and recognized in the flood model.

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, Fluvial, Pluvial)

Disclosures

1. Identify and justify the various flood parameters and characteristics which are used in each of the flood model components: coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding.

2. Describe the dependencies among variables and specify any assumed mathematical dependencies among these variables for each of the following components of the flood model:
    a. Coastal flooding associated with storm surge,
    b. fluvial flooding, and
    c. pluvial flooding.

3. Describe the dependencies which exist among the following components of the flood model:
    a. Coastal flooding associated with storm surge,
    b. fluvial flooding, and
    c. pluvial flooding.

4. Identify whether flood parameters are modeled as random variables, as functions, or as 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., a fixed value in one event set and not the other).

6. For coastal flooding associated with storm surge, state whether the flood model simulates surface winds directly. If the storm surge component relies on conversion of winds between some other reference level or layer and the surface, describe the process used including the treatment of the inherent uncertainties in the conversion factor.

7. For coastal flooding associated with storm surge, describe how the coastline is segmented (or partitioned) in determining the parameters for coastal flood frequency used in the flood model.

8. For fluvial flooding, describe how the fluvial area is segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.

9. For pluvial flooding, describe how the pluvial area is segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.

10. Describe any evolution of the functional representation of flood parameters during an individual flood life cycle.

11. Describe any assumptions or calculations used in the model relating to antecedent conditions in the flood footprint area.

12. Provide the source and resolution of the bathymetry and coastal topography used in the storm surge calculation at the risk location level.

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

14. As applicable, describe the method or methods used to account for soil saturation in the flood model. Provide citations to published papers, if any, used to develop and support the soil saturation methodology.

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,
    b. The modeled dependencies among correlated parameters in the flood model and how they are represented,
    c. The fitting methods used and any smoothing techniques employed.

3. For coastal flooding associated with storm surge, 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.

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

5. All external data sources that affect the model generated windfields associated with coastal flooding due to storm surge will be identified, and their appropriateness will be reviewed.

6. For coastal flooding associated with storm surge, describe how the relevant intensity parameters are calculated in the flood model.

7. For fluvial flooding, describe how the relevant intensity parameters are calculated in the flood model.

8. For pluvial flooding, describe how the relevant intensity parameters are calculated in the flood model.

9. For coastal flooding associated with storm surge, provide the frequency distribution of the flood footprint associated with each coastal segment.

10. For fluvial flooding, provide the frequency distribution of the flood footprint associated with each fluvial area segment.

11. For pluvial flooding, provide the frequency distribution of the flood footprint associated with each pluvial area segment.

12. Describe how the flood event is initialized in an individual event calculation.

13. Provide a comparison of the flood footprint calculated in the model with historical flood events for five locations, each location from a different county.

14. Provide a comparison of the water depth calculated in the model worst case for the same five locations and compare with the NOAA *Maximum of MEOW* for each location. The modeling organization should use the most reasonable vintage of the *MEOW* data for this exercise.

15. 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.

16. 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 Flood Probabilities

A. Modeled probability distributions of flood parameters and characteristics shall be consistent with historical floods for Florida resulting from coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding.

B. Modeled flood frequency distributions 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.

C. Flood models shall use pertinent characteristics of standing water prior to receding to assess severity of damage for coastal flooding associated with wind related flood events.

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 flooding associated with storm surge, fluvial flooding, and pluvial 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 massive rains in North Georgia).

This standard also notes the necessity to recognize the impacts from flooding driven by wind related events.

The probability of occurrence of floods and flood footprints 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, Annual Flood Occurrence Rates
AF-2, Flood Event Data Sources Statewide Losses
SF-1, Probability and Frequency of Florida Flood Events per Year
SF-3, Distributions of Stochastic Flood Parameters (Coastal, Fluvial, Pluvial)

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 flooding associated with storm surge, fluvial, and pluvial flood events.

3. Describe and support the method of determining flood footprints for coastal flooding associated with storm surge, fluvial flooding, and pluvial 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, Fluvial, Pluvial) will be reviewed for the probability distributions and data sources.

6. Comparisons of modeled flood probabilities and characteristics for coastal flooding associated with storm surge, fluvial flooding, and pluvial 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.

7. Comparisons of coastal flood extremes will be reviewed and compared with the historically-determined Maximum Envelope of Water (*MEOW*) database at a county level or finer.

MHF-4 Flood Footprint Structure

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

B. Consideration of topography, land use and land cover, soil type, and other hydrological characteristics associated with the flood footprint area shall be consistent with the current state-of-the-science.

C. The land use and land cover database shall be consistent with National Land Cover Database (NLCD) 2006 or later. Use of alternate data sets shall be justified.

D. The flood model shall account for relevant forces that interact with structures.

E. Methods for depicting all modeled flood parameters and characteristics shall be based on information documented in currently accepted scientific literature.

Purpose: This standard requires that the flood model be implemented consistently with a contemporary land use and land cover distribution (including soil type). The resulting surface flood footprint shall be representative of historical floods in Florida.

Note: The NLCD products are created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey (USGS) and are updated every five years.

Comparison of the flood footprints produced by the stochastic flood events and historical flood footprints 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 Footprints 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 footprint for coastal and inland flooding.

2. For coastal flooding associated with storm surge, describe how the model accounts for relevant forces that interact with structures.

3. Identify all hydrological variables that affect the flood footprint.

4. Provide the collection and publication dates of the land use and land cover data and soil type data used in the flood model and justify their timeliness for Florida.

5. Describe the methodology used to convert land use and land cover information into a spatial distribution of roughness coefficients in Florida as related to the flood footprint.

6. Demonstrate the consistency of the spatial distribution of model-generated flood footprints with observed flood footprints for floods affecting Florida. Describe and justify the appropriateness of the databases used in the flood footprint validations.

7. Describe how the model's flood footprint is consistent with the inherent differences in flood footprints for such diverse floods as Hurricane Dennis (2005) for coastal, South Florida flooding (2000), and Tropical Storm Debby (2012) for North Florida.

8. Describe any variations in the treatment of the flood model flood footprint for stochastic versus historical floods and justify this variation.

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

10. Provide a completed Form MHF-2, Maps of Flood Footprints by Return Period. Explain any differences between modeled flood footprints and historical flood footprints. 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 footprint functions used in the flood model. Identify the databases used.

2. Provide any modeling organization-specific research performed to derive the topography, land use and land cover and soil type distributions, including any associated hydrological characteristics for the flood footprint area.

3. Provide the current flood parameters used in calculating the flood loss costs for three historical flood events which include coastal flooding associated with storm surge, fluvial flooding, and pluvial flooding, and justify the choices used. Provide the resulting spatial distribution of the surface hydrology. These will be reviewed with Form AF-2 (Flood Event Data Sources Statewide Losses). [consider for deletion if this form 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 footprint 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 Footprints by Return Period) will be reviewed.

MHF-5 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 reflect 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. 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 to off) in the flood model.

2. List the flood mitigation and prevention measures used in the flood model and the sources of all data employed.

3. If applicable, illustrate the flood footprint distributions showing the impact of flood mitigation and prevention measures versus no flood mitigation and prevention measures.

4. 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.

5. 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.

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

7. State whether the flood model incorporates nature discharge of flood waters 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.

8. 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.

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.

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-6 Logical Relationships of Flood Characteristics

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

B. The interaction of coastal flooding associated with storm surge and inland flooding shall increase the flood footprint area, 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 area of the over water windfield, the greater the coastal flood footprint area, all other factors held constant.

E. The coastal flooding associated with storm surge shall increase with a shallow and gently sloping shoreline, all other factors held constant.

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

G. The fluvial footprint 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 hydrograph (rate of flow versus time) associated with flooding for an area in each region of the Florida Panhandle, Gulf Coast, North Florida, Central Florida, and South Florida. Discuss how the flood characteristics result in logical relationships.

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

A. Provide annual flood occurrence rates for storm surge, fluvial, and pluvial flooding by region or for specified locations, which includes data for various probabilities of exceedance (corresponding to 5, 25, 50, and 100 year return periods). Annual flood occurrence rates shall be rounded to four decimal places.

B. Describe variations in the flood model frequencies from the historical frequencies.

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

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

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 (Annual Flood Occurrence Rates).

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 (Annual Flood Occurrence Rates) shall also be included in a submission appendix.

Form MHF-2: Maps of Flood Footprints by Return Period

Historical Florida Floods

A. Identify six recent historical Florida floods that illustrate coastal flooding associated with storm surge, fluvial flooding, and pluvial 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 storm surge, fluvial areas, or pluvial 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 footprints with observed flood footprints for storm surge, fluvial, and pluvial 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 footprints 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 footprint area.