Evaluating the Predictive Capability of Fire and Egress Models

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Different Needs and Responsibilities

- Model users
  - Applicability of model and its validation to problem
- Model developers
  - Mathematical verification, range of experimental validation
- AHJs
- Others ….

- Broader overview than yesterday's talks from the model developer's perspective

Consensus Standards

- NFPA 805, “Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants” requires validated predictive models
- ASTM standards provide methodology for fire model evaluation
  - ASTM E 1355 defines methodology for model evaluation
  - ASTM E 1472 defines documentation requirements
  - ASTM E 1895 assists model user in identifying model limitations
- ISO 16730:2008 provides a framework for assessment, verification and validation of all types of calculation methods used as tools for fire safety engineering.
- IMO MSC/Circ. 1238 includes guidelines for evacuation analysis for passenger ships

Data, Data, Data (and Documentation)

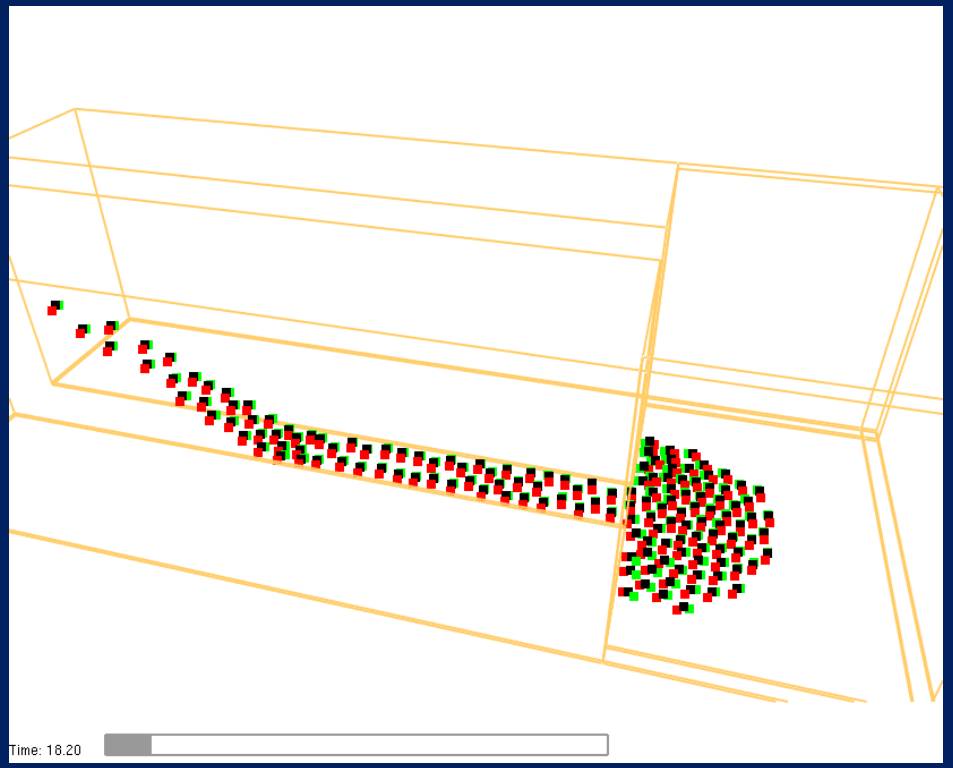
- Model documentation forms the core of needed information about a model
  - Technical documentation provides in-depth explanation of scientific basis of models
  - User's manual provide reference to inputs and output
  - V&V guides detail available code verification and comparisons with **experimental and other data**
- Bulk of validation efforts are comparison with experimental data
  - NRC NUREG 1824
  - FDS and CFAST Validation Guides built on 1824

Qualitative (and Quantitative)

- Typical comparisons between models and experimental data quoted from actual papers
  - “good to excellent”
  - “favorable”
  - “quite satisfactorily”
  - “reasonably accurate” “none of the models did well”
  - “achieved in a qualitative sense”
  - “well predicted”
  - “good, fair, or excellent”
  - green, yellow, or red
- **While qualitative comparisons serve a purpose, engineering applications require quantitative comparisons**

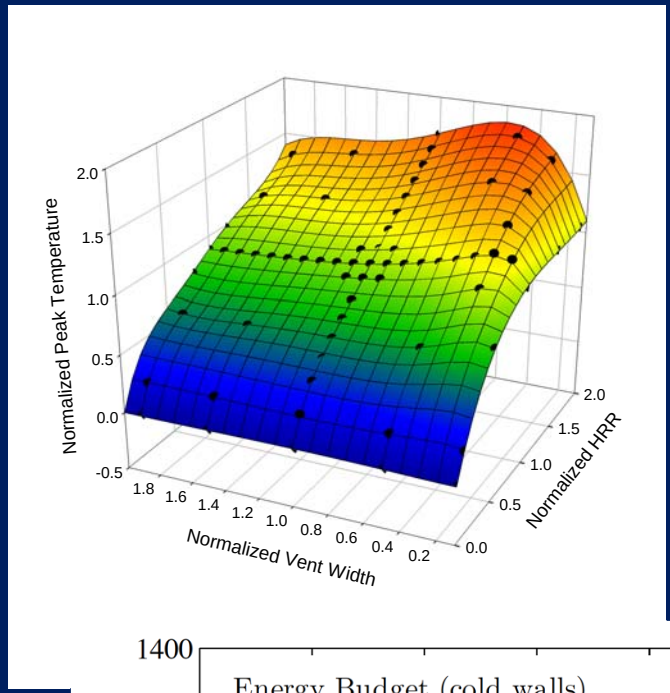
Qualitative (and Quantitative)

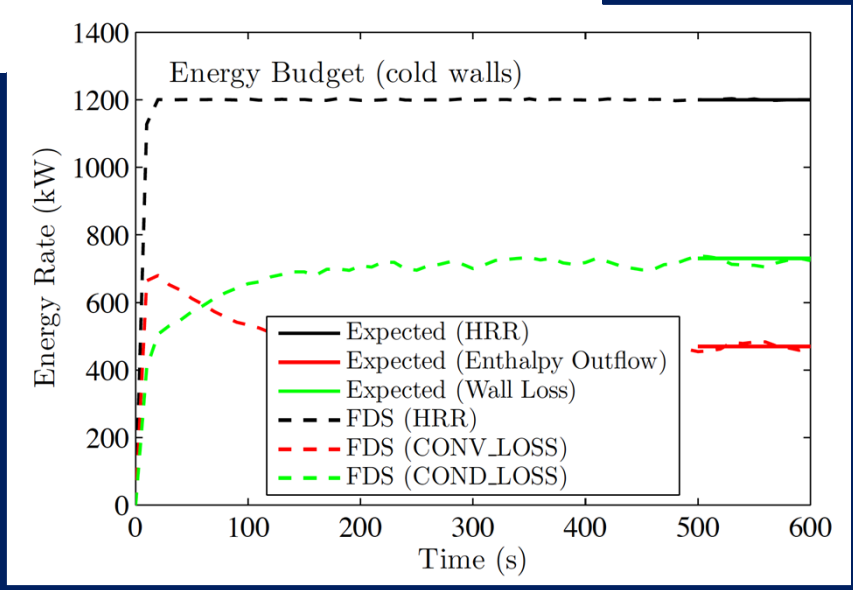
- For egress/movement models, IMO specifies a series of component and qualitative tests.
  - Walking speed in corridors and stairs
  - Exit flow rate
  - Exit route allocation
- Common sense tests to provide a level of confidence that model is operating as expected.



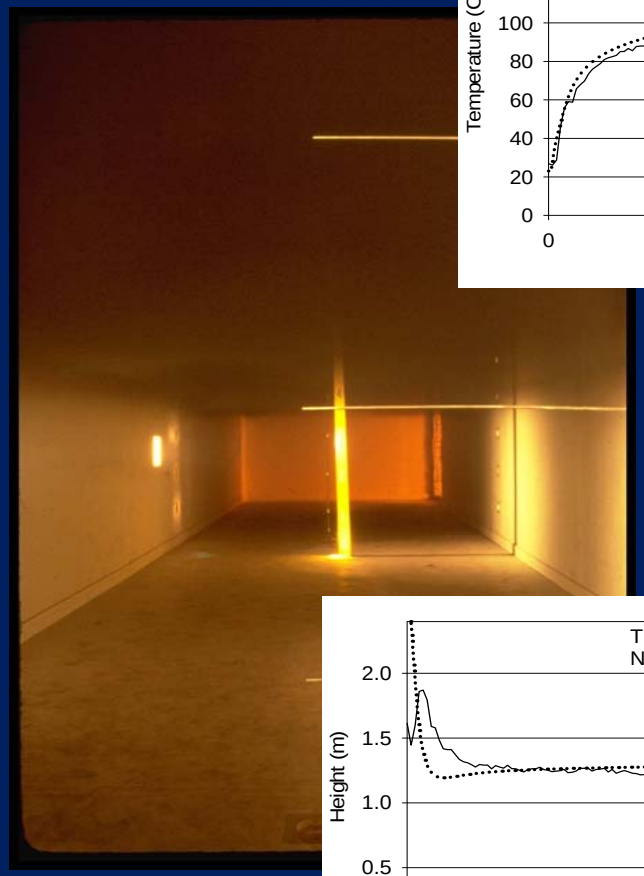
Qualitative (and Quantitative)

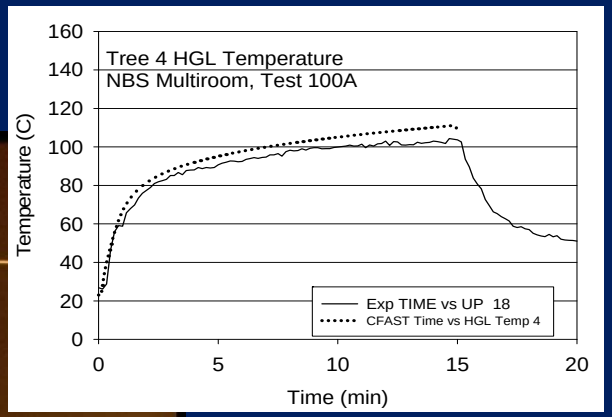
- ASTM E 1355 for fire models only provides general guidance on verification and sensitivity analysis.
- Model documentation includes a wide range of detail and topics.
  - CFAST includes chapters on model structure and sensitivity analysis
  - FDS has entire volume on verification that includes numerous analytical tests
- **Fire modeling guides are ripe for further guidance on verification**

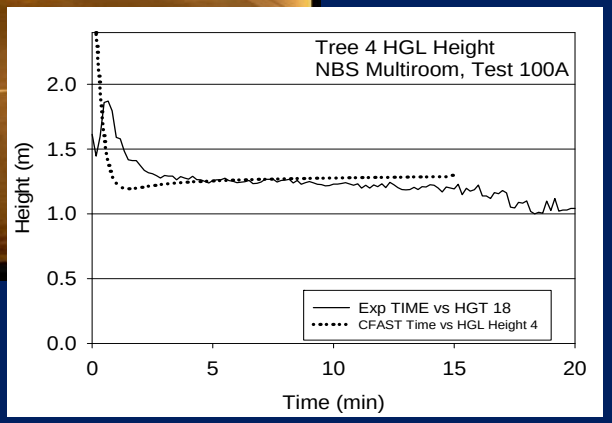


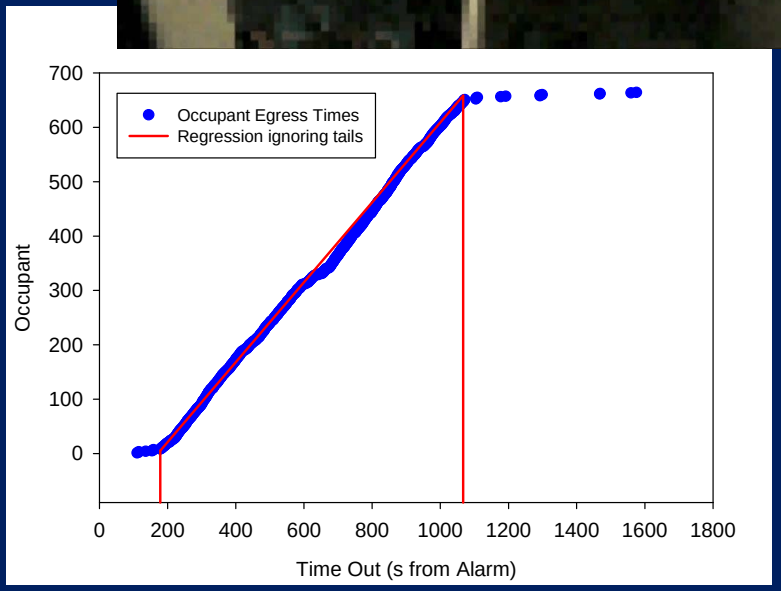


(Qualitative and) Quantitative









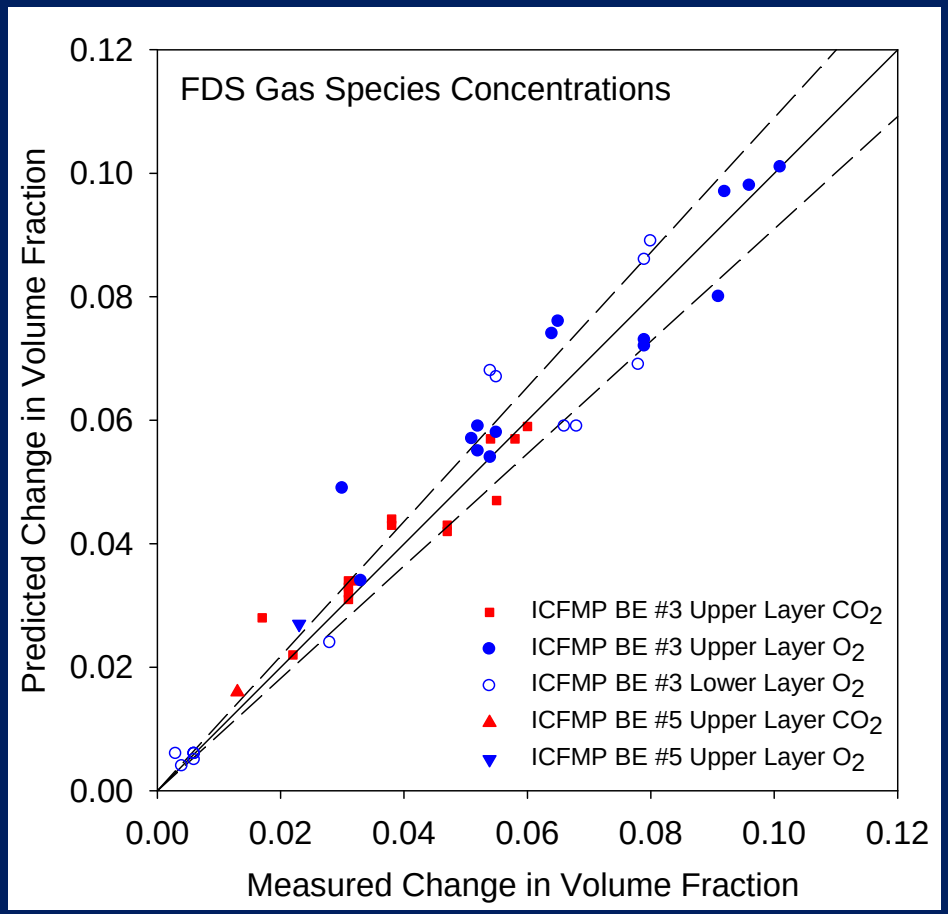
(Qualitative and) Quantitative

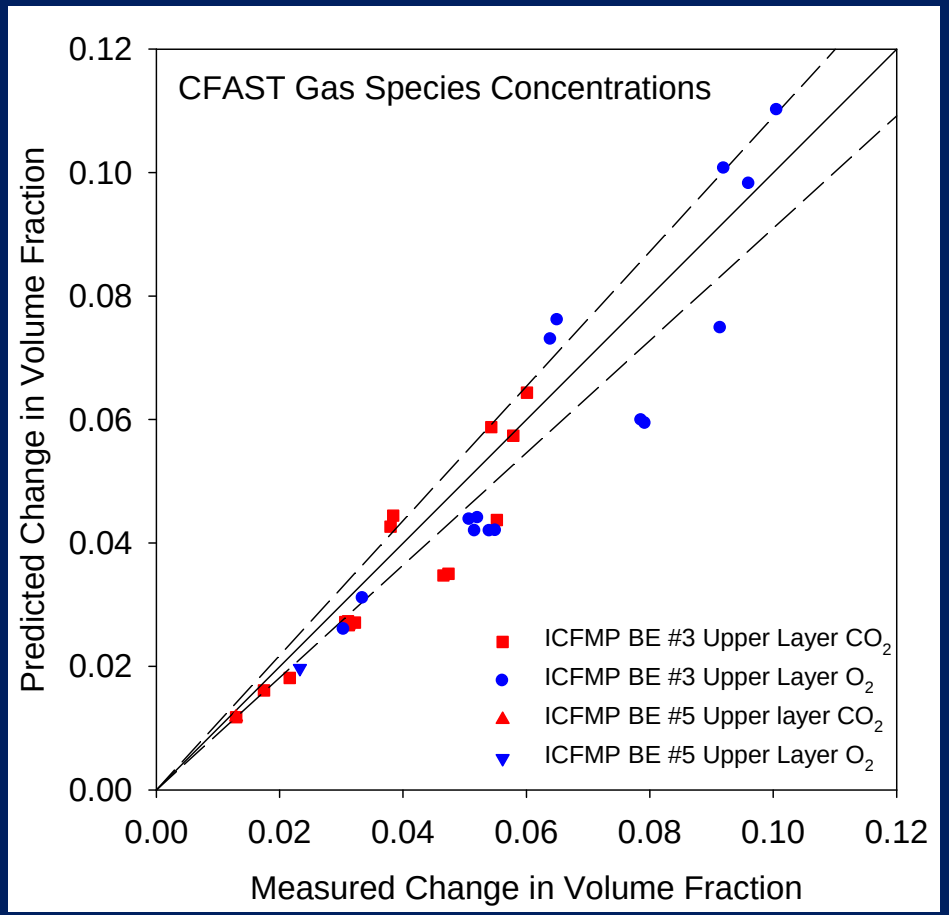
- Bulk of validation efforts are comparisons to experimental data
  - Nearly 1600 comparisons of FDS with 42 different test series and growing
  - About 800 comparisons of CFAST with 12 different test series and growing
  - FDS_Evac compared to a number of different evacuation geometries and scenarios
- **Significant efforts required to obtain high quality data compared correctly to high quality simulations**

Data, Data, Data, and more data

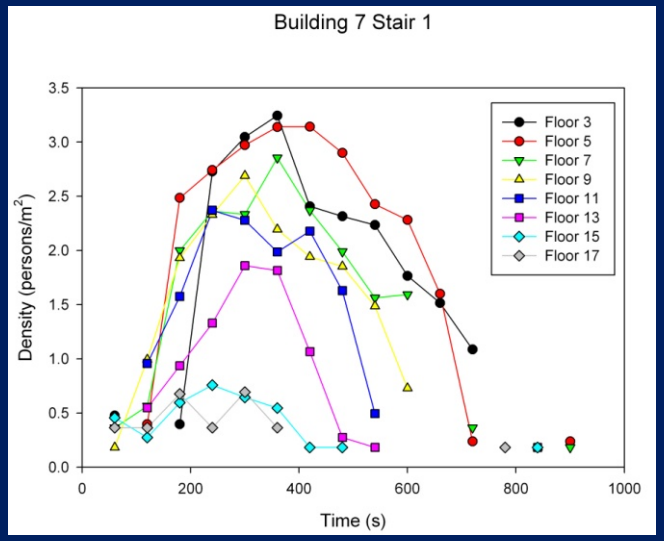
- Data for comparison exists; **high quality data is more scarce**
  - http://fire.nist.gov/fds
  - http://cfast.nist.gov
  - http://www.nist.gov/el/fire_research/egress.cfm
- **Range of data is limited** for many fundamental submodels
  - Heat transfer to objects and surfaces during a fire
  - Vent flows, particularly mechanical ventilaiton
  - Stairwell data for tall buildings; elevator data
  - Human behavior

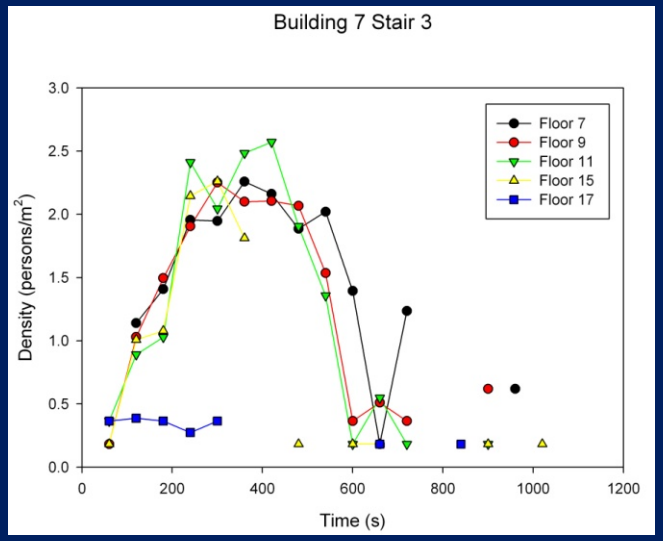
Fire Modeling Data

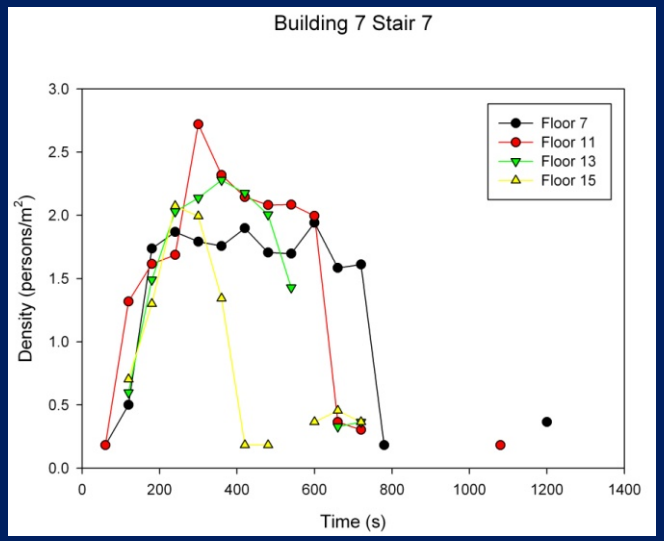


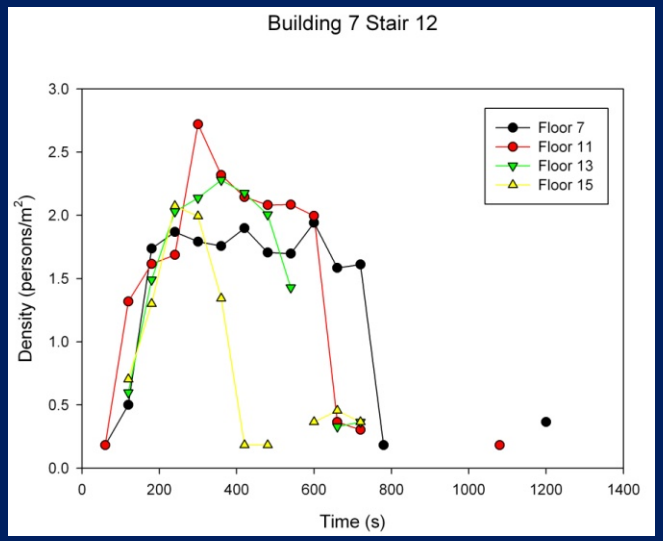


Building Evacuation Data



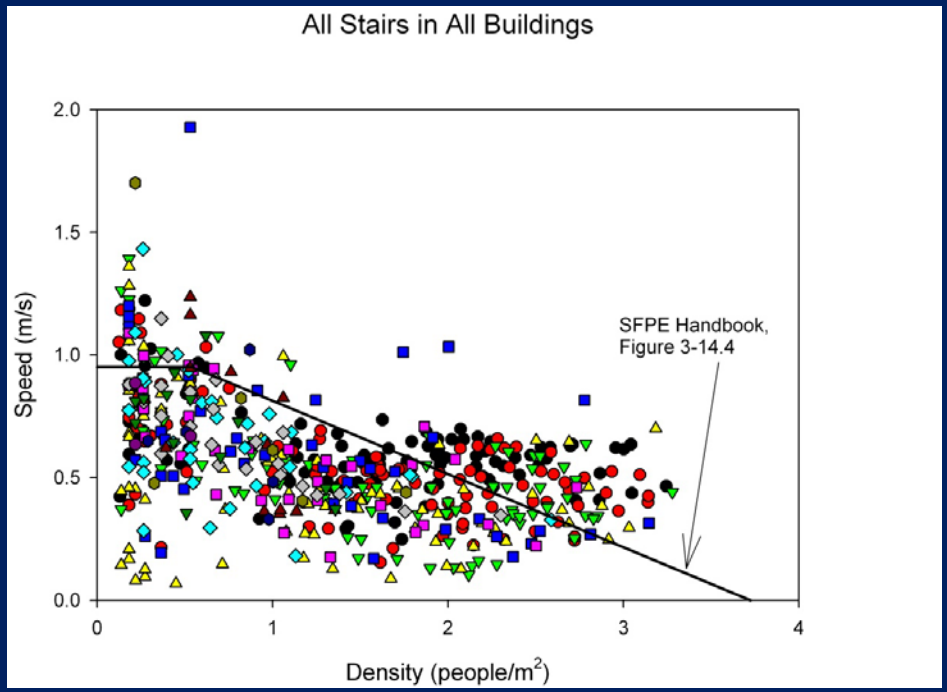






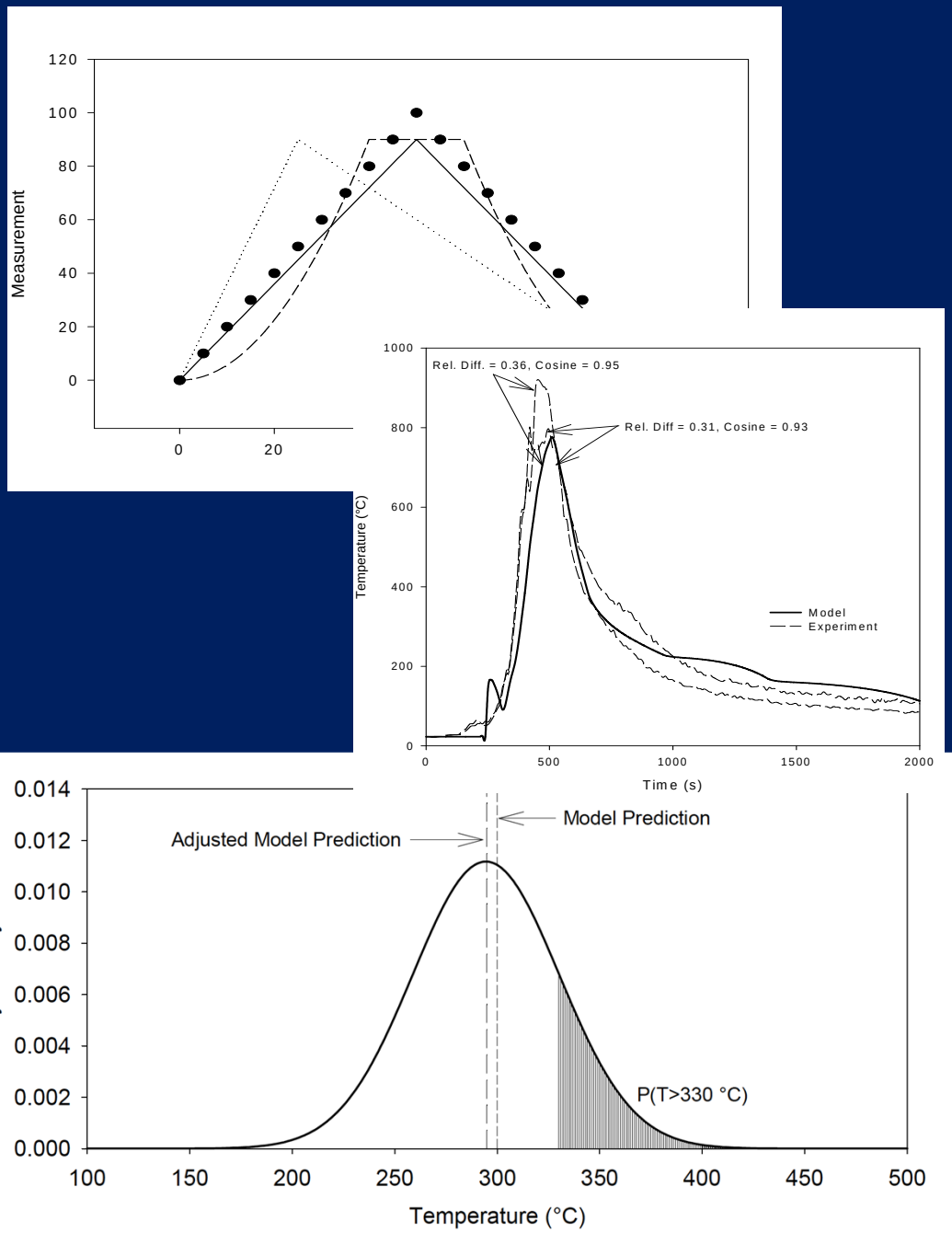
Data, Data, Data, and more data

- Quality of comparisons depends on quality of underlying data and model simulations
- Blind experiments useful exactly once; better to have numerous well-documented data sets



What you do with the Data, and more data

- How do you compare model and experiment?
  - Peak values
  - Average values
  - Range of relative differences
  - Time-integrated values
  - Norms for magnitude and functional form
- Guidance on which is appropriate for a given application is limited and may depend on application
- **Research on expressing agreement including uncertainty is ongoing**



Standards, Documentation, and Data

- Consensus standards exist and continue to evolve; need more effort for movement models
- Documentation by model developers is key to V&V efforts
- Both qualitative and quantitative assessments contribute to V&V
- Data exists, but significant data needs still exist