Inference Spiral of System Science

System Model
- Verification (better theory, more computation)

Real World
- Validation (better data, more computation)

Data Assimilation
- model formulation
- model simulation
- prediction

Reductionistic analysis
- constructionistic synthesis
Verification

• Model “does what’s it’s supposed to do” at a specified level of precision
  – Mathematics is correct
  – Physics is properly implemented

• Techniques
  – Comparisons with known (e.g., analytic) solutions
  – Cross-comparisons between different models
  – Consistency with observations (validation)

• Procedures need to be available on-demand throughout the modeling process
  – Difficult from a practical perspective
  – Facilitated by vertical integration of cyberinfrastructure
Validation

• Criteria for asserting model is credible representation of the real system, usable for forecasting behaviors (not that “model is true”)
  – Consistent with knowledge of the system (includes verification)
  – Not too sensitive to initial conditions or unknown forcings
  – Aleatory and epistemic uncertainties are properly characterized
  – Consistent with relevant observations

• Substantiation that a model is sufficiently accurate in predicting system behaviors
  – within its domain of applicability
  – consistent with its intended purposes

• Techniques
  – Testing against observations (surviving invalidation)
  – Competition among models
  – Validation of model components
  – Improvement by data assimilation (inversion)