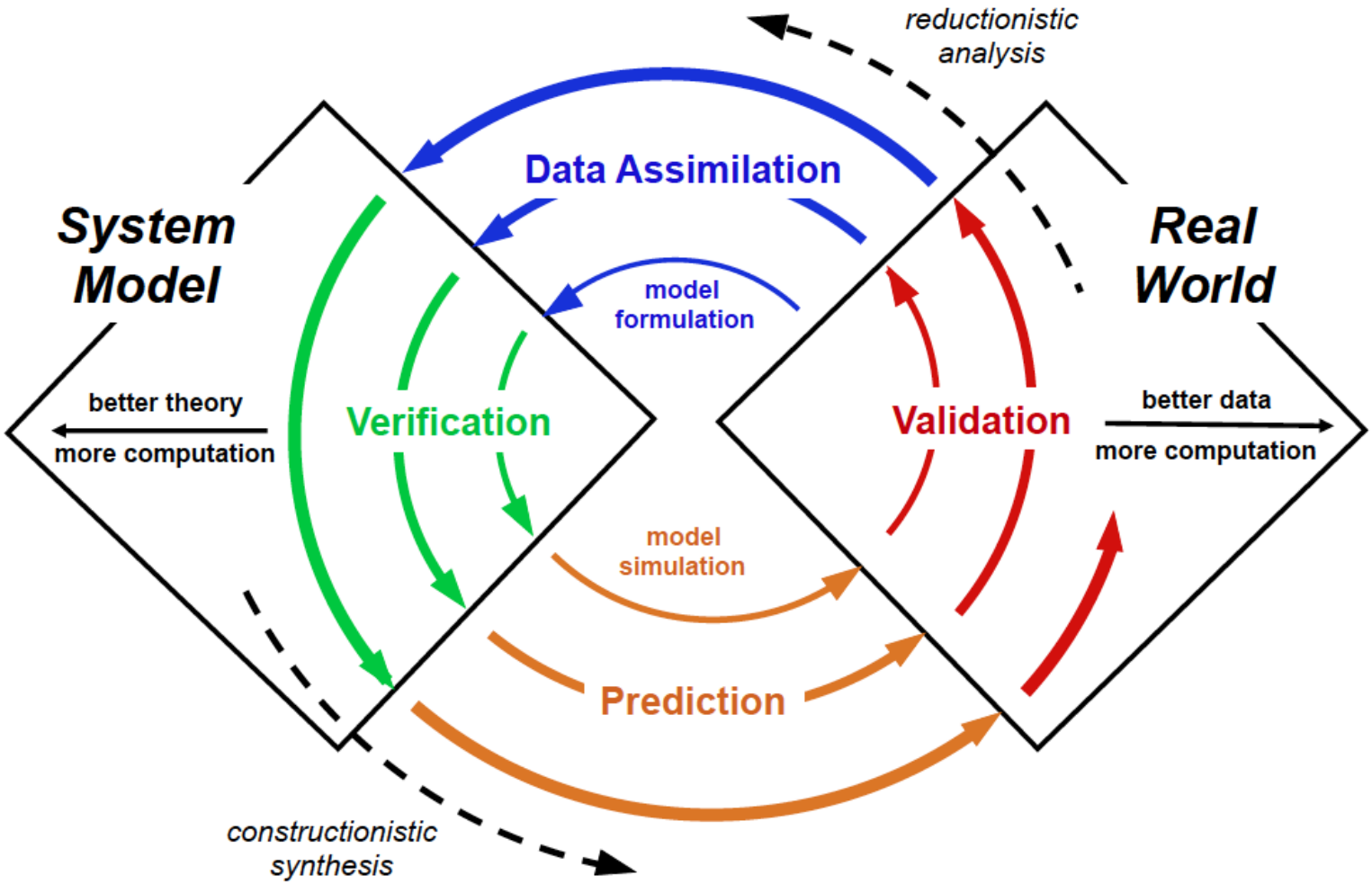
Inference Spiral of System Science



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)**