CLIMATE MODELS

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Questions in climate modeling

- Deterministic vs. Stochastic climate modeling
- Choosing a climate model
- Fusing data and climate models
- Stochastic parameterization of climate models
- Characterization of uncertainty in climate models
- Computational considerations (run in real time)

Deterministic versus Stochastic?

- Most climate models are large dynamical deterministic systems involving a million variables on big computers
- Climate models could be stochastic:
  - Using physical knowledge
  - Making sure results make physical sense (conservation of mass, momentum…)
  - Need to be computational feasible

What climate model to use?

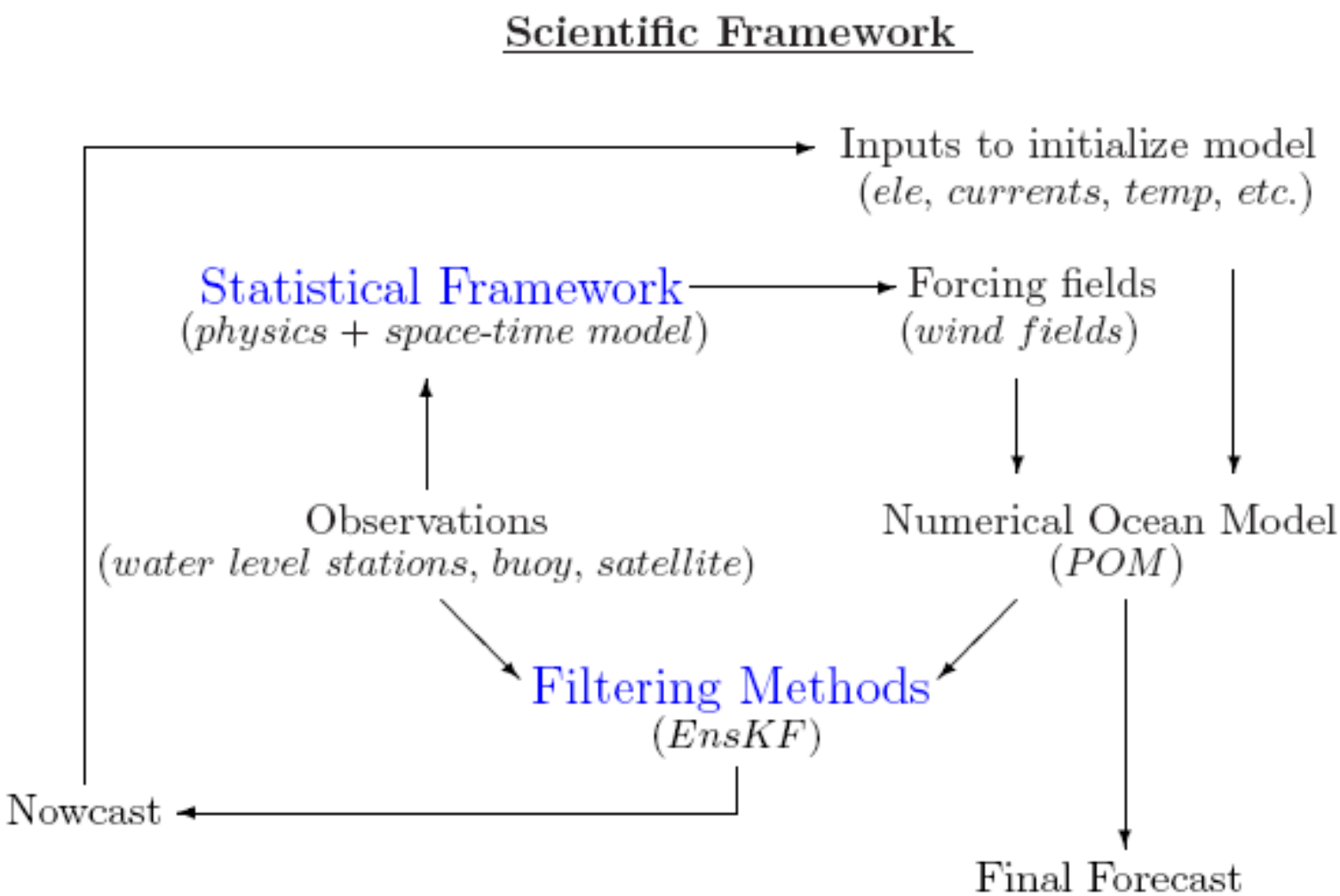
- There are different climate models. How to decide which one to use?
- Bayesian modeling averaging. Does the results make physical sense?
- Ensemble modeling.
- Need for more model evaluation (taking into account uncertainty in data).

Fusing Data and Models

- Data can help to correct some of the model errors.
- Data assimilation (fusing data and models) approaches for climate models.

Fusing data and models

Foley, Fuentes et al. (2005, 2006)

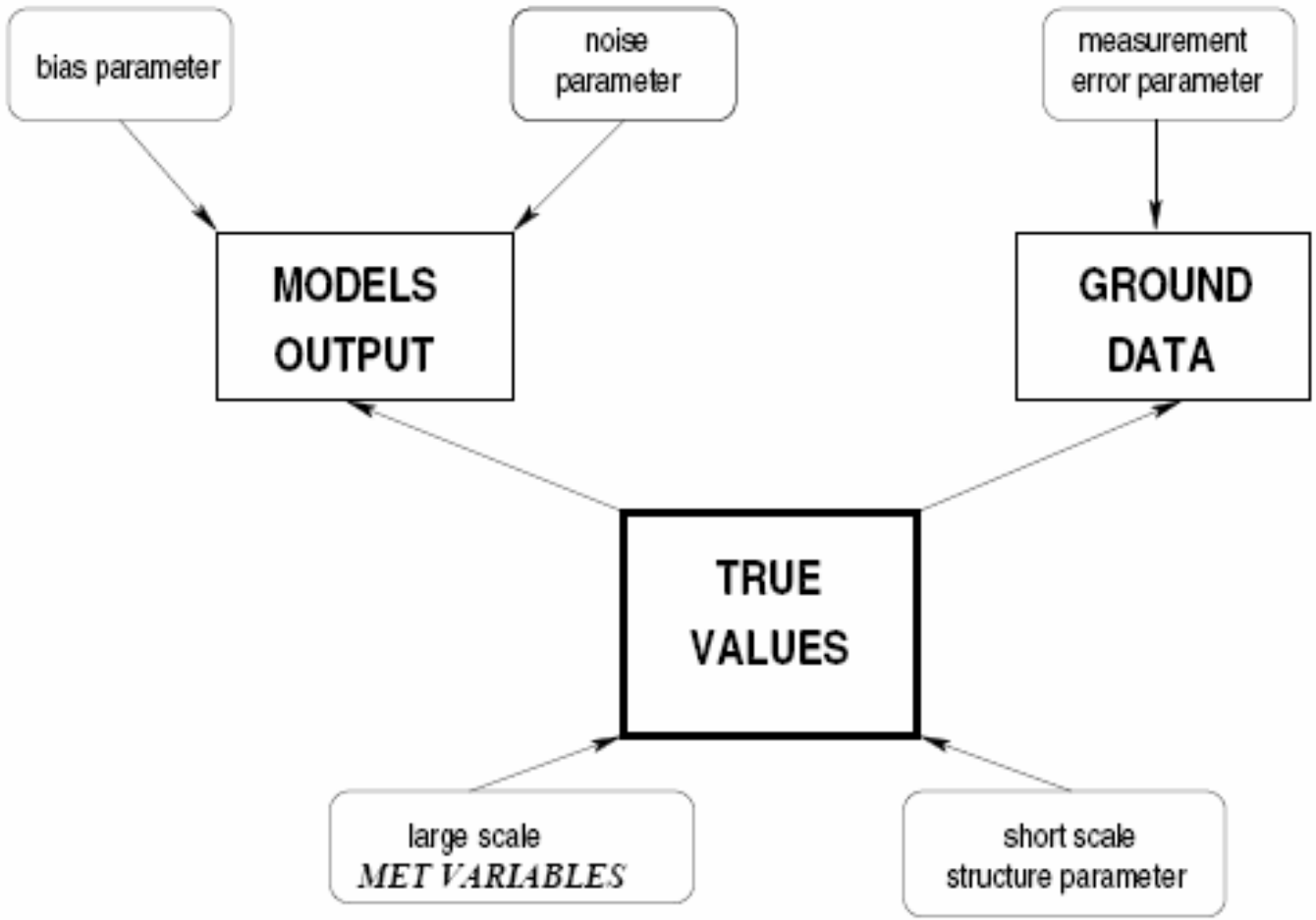


Fusing Data and Models (cont.)

- Model output could be treated as another source of data.

Fusing Data and Models (cont.)

Statistical framework (Fuentes and Raftery, 2005)



Fusing Data and Models (cont.)

- Hierarchical (Bayesian) frameworks ideal to combine disparate data and models
  - Bayesian methods can be computational intensive (infeasible??)

Uncertainty in Climate Models

- Sources of uncertainty in climate models:
  - Boundary and Initial conditions
  - Model parameterization
  - Mathematical approximations
  - Simplified or neglected physical processes
- Statistical tools can help to characterize the different sources of uncertainty

Stochastic parameterization

- A Bayesian framework is a natural choice.
- Having a (prior) distribution for some of the parameters, using physical and expert knowledge.

Computational Considerations

- Statistical approaches are available to handle the issues previously discussed.
- The feasibility of the implementation of these statistical approaches is the main challenge
- Bayesian techniques can be expensive, but they can be run in parallel.

Interdisciplinary research

- For Climate Modeling we need:
  - To use physical knowledge
  - To characterize uncertainty
  - To provide efficient computational tools
- This can only be done with interdisciplinary teams (atmospheric scientists, mathematicians, statisticians, computer scientists)

Recommendations

- Climate deterministic models need characterization of uncertainty
- Data can help to correct model errors
- Computational feasibility can be a barrier for the use of sophisticated statistical frameworks
- Interdisciplinary effort. SAMSI provides a perfect umbrella for this research.