Uncertainty: The Good, the Bad and the Beneficial

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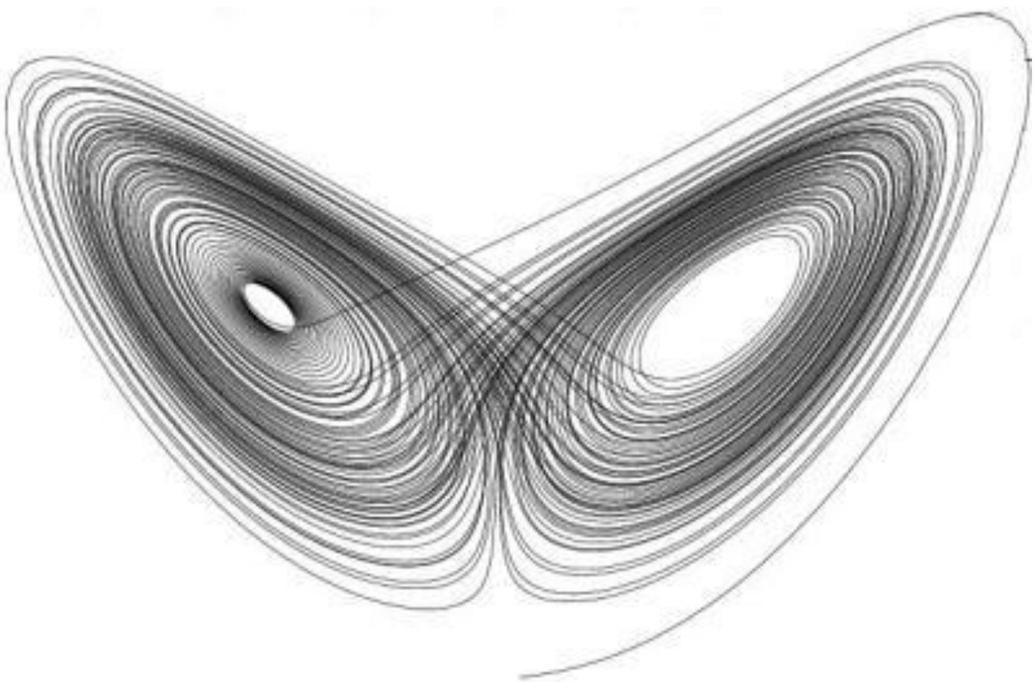
Doubt is not a pleasant condition, but certainty is absurd.

- Voltaire



Main Points

- Determining important sources of uncertainty for your project.
- Understanding uncertainty through ensemble modeling.
- Concept of relevant and useful uncertainty.

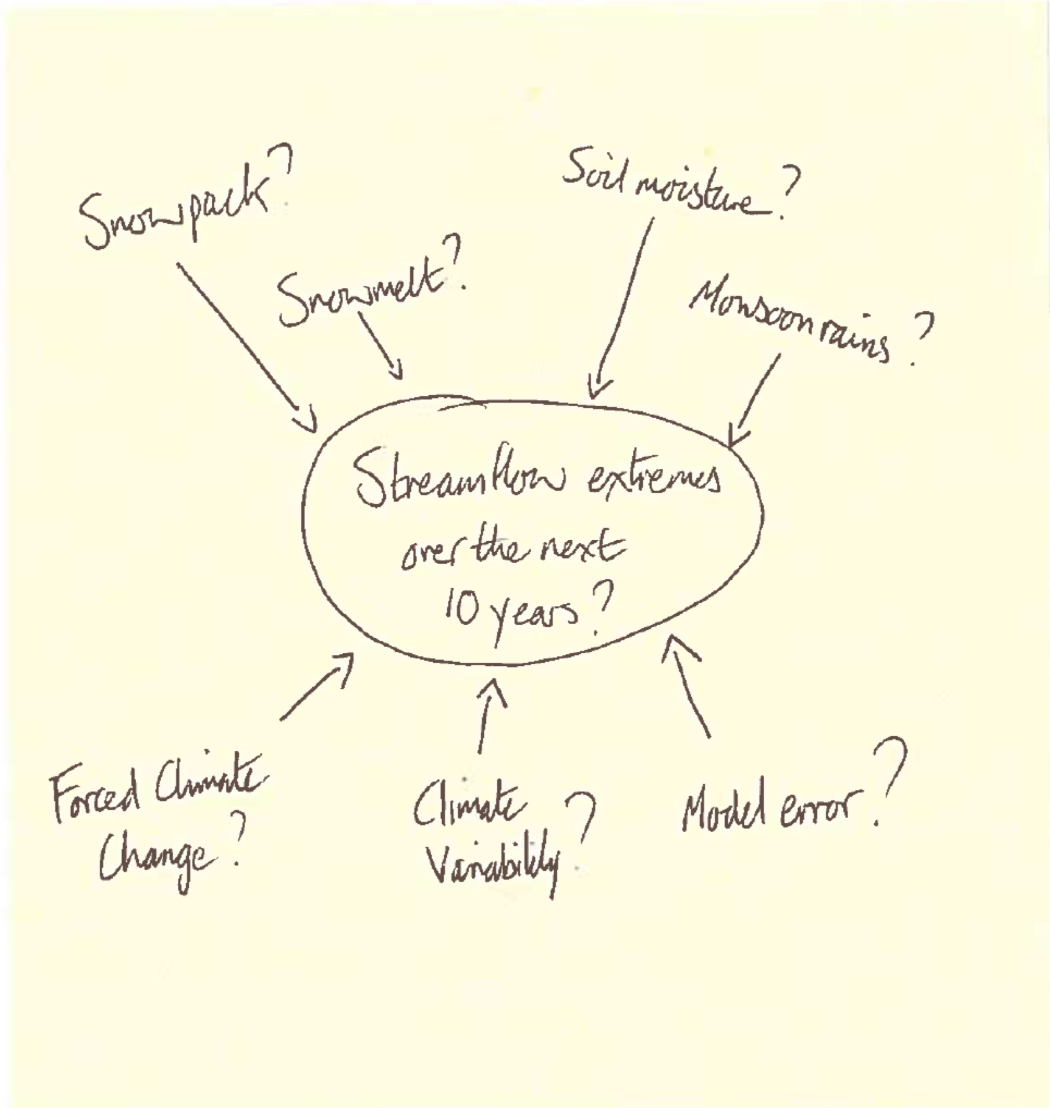
Taming the Uncertainty Monster

(Van der Sluijs, 2005; Curry and Webster, 2011)

- Monster Hiding
- Monster Exorcism
- Monster Simplification
- Monster Detection
- Monster Integration

What uncertainty monster do you deal with?

Sketch your uncertainty concept map



Future Weather Extremes are Unknown

We don’t know what the future extreme weather will be,
but we know the range of possibilities and their likelihoods.

Future Weather Extremes are Unknown and Uncertain

If future extreme weather is a roll of the die:

Then our projections of future extreme weather are rolls of what we think that die looks like:

Many Uncertainty Sources

Model Uncertainty

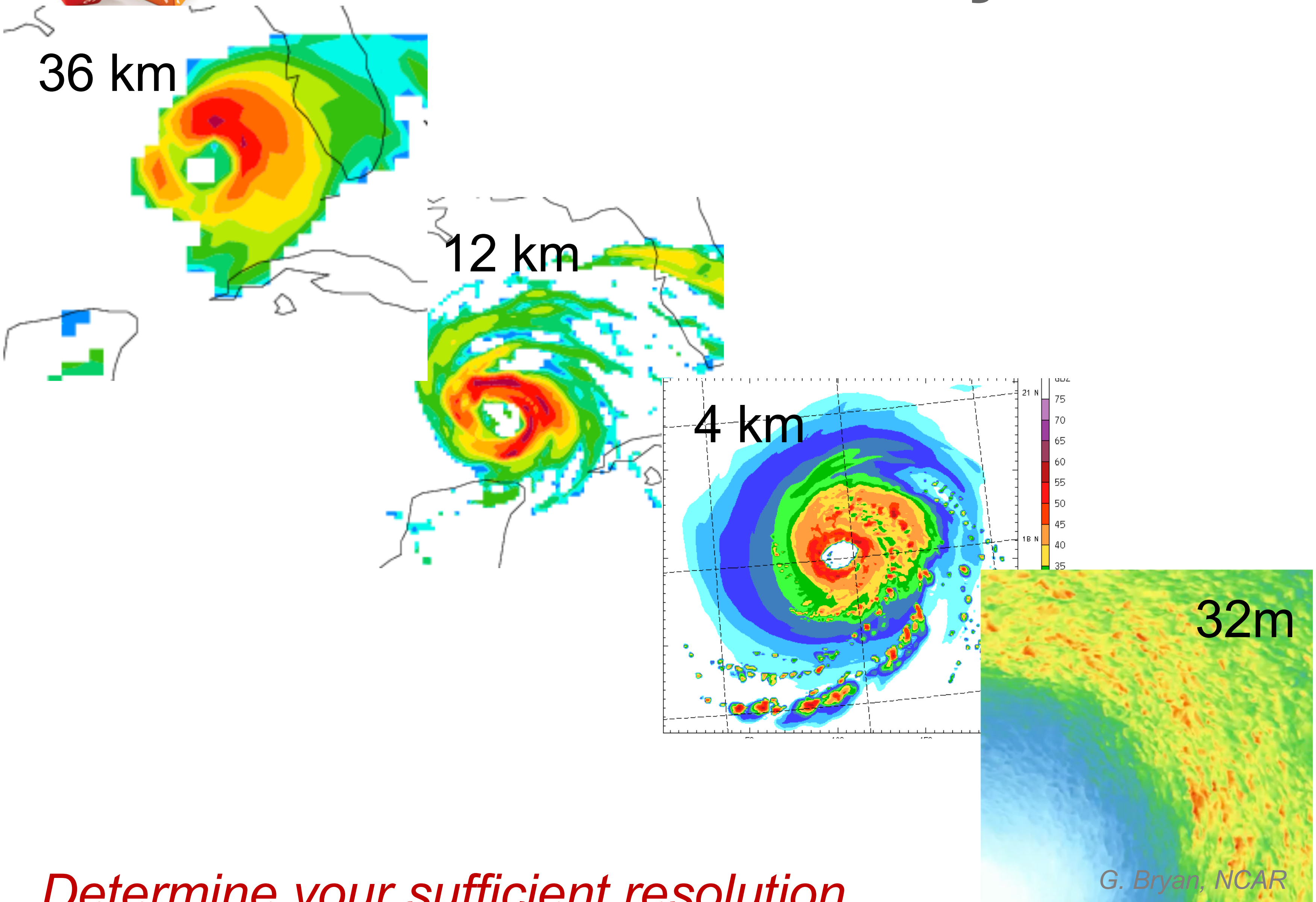
Boundary Forcing Uncertainty

Weather Extremes

Initial Condition Uncertainty

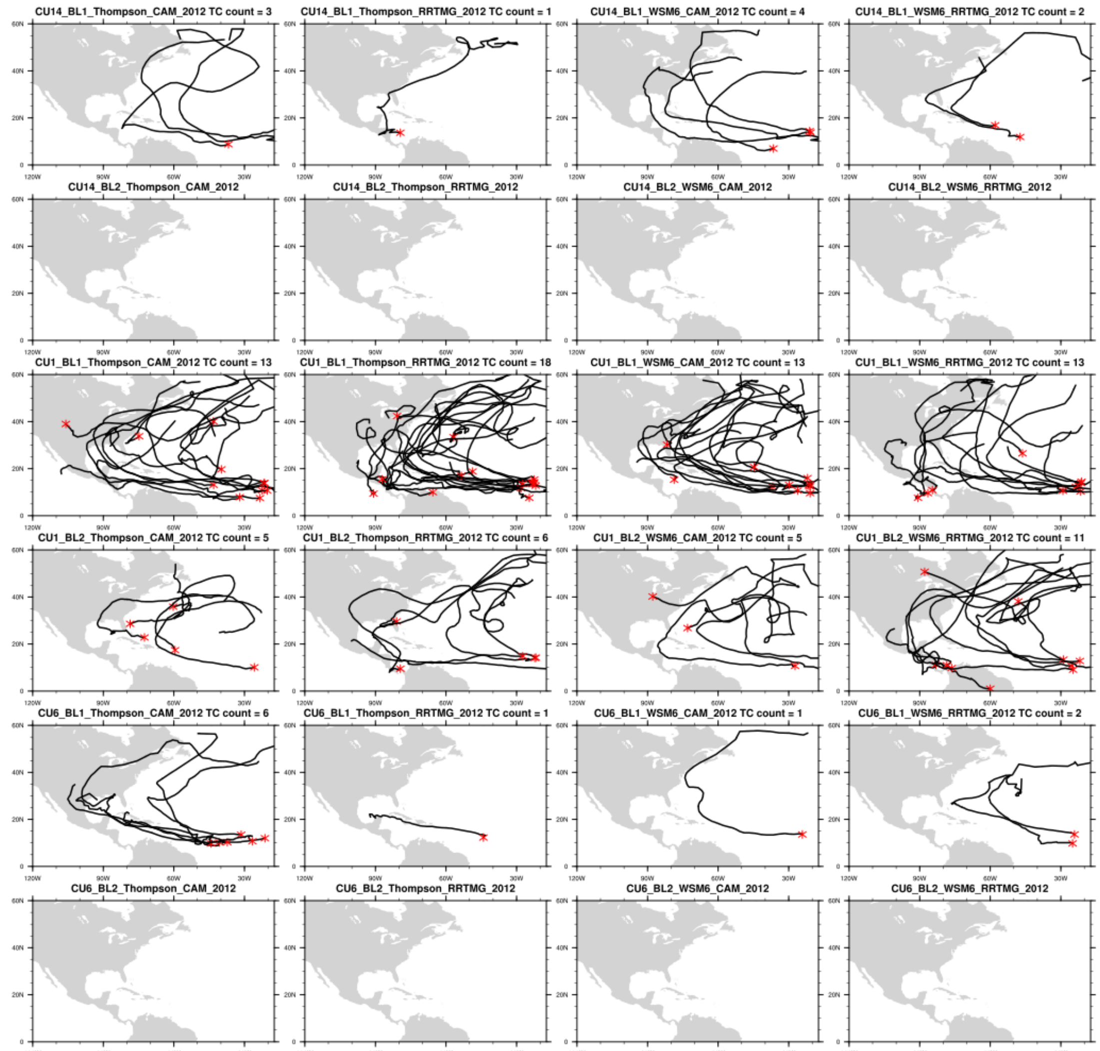
Which uncertainty source affects your project?

Model Uncertainty: Resolution



Determine your sufficient resolution

Model Uncertainty: Physics



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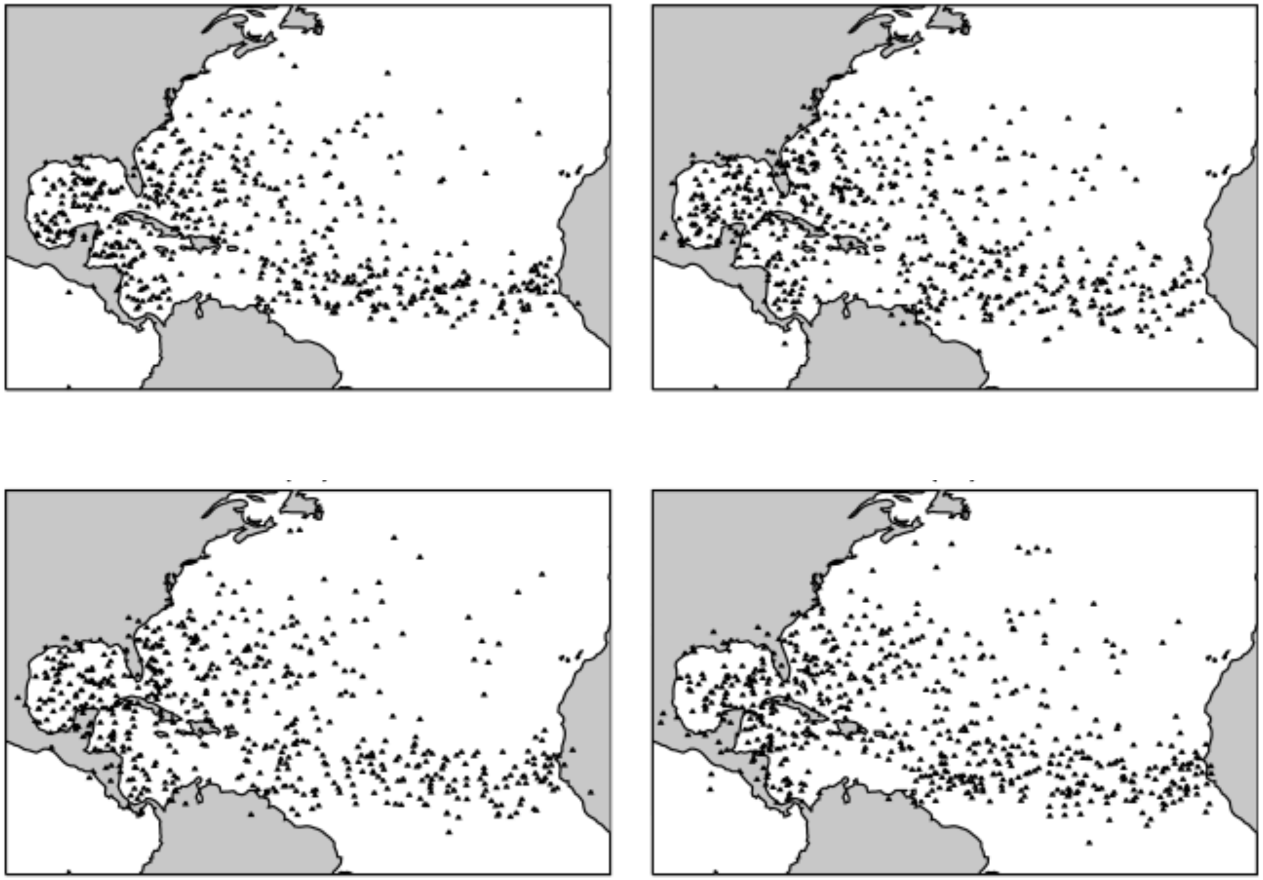
Can your model generate the extreme phenomena?

Model Uncertainty: Sample Size

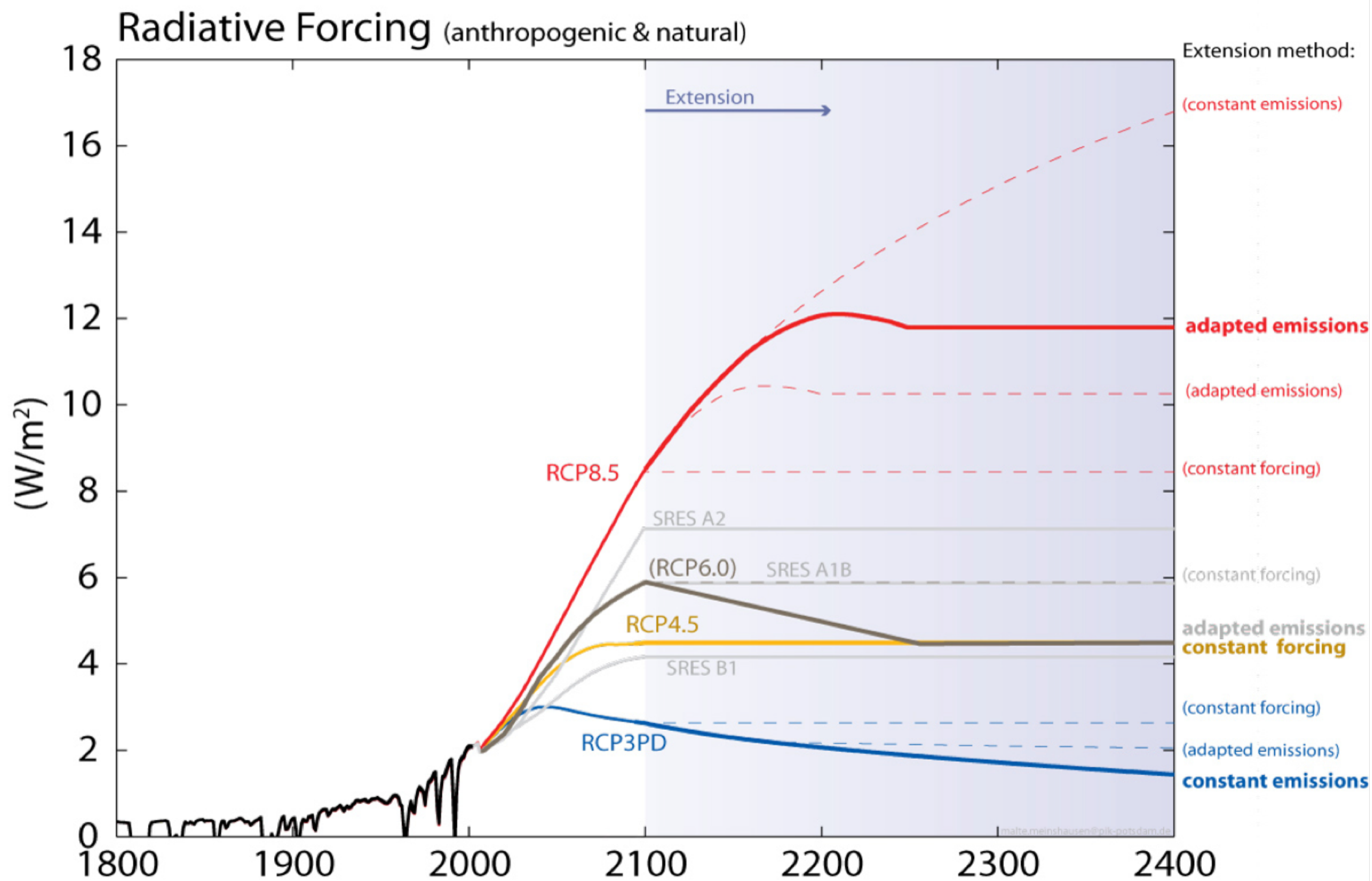
Tropical cyclogenesis locations from 1950 to 2003



Determine your sufficient sample size

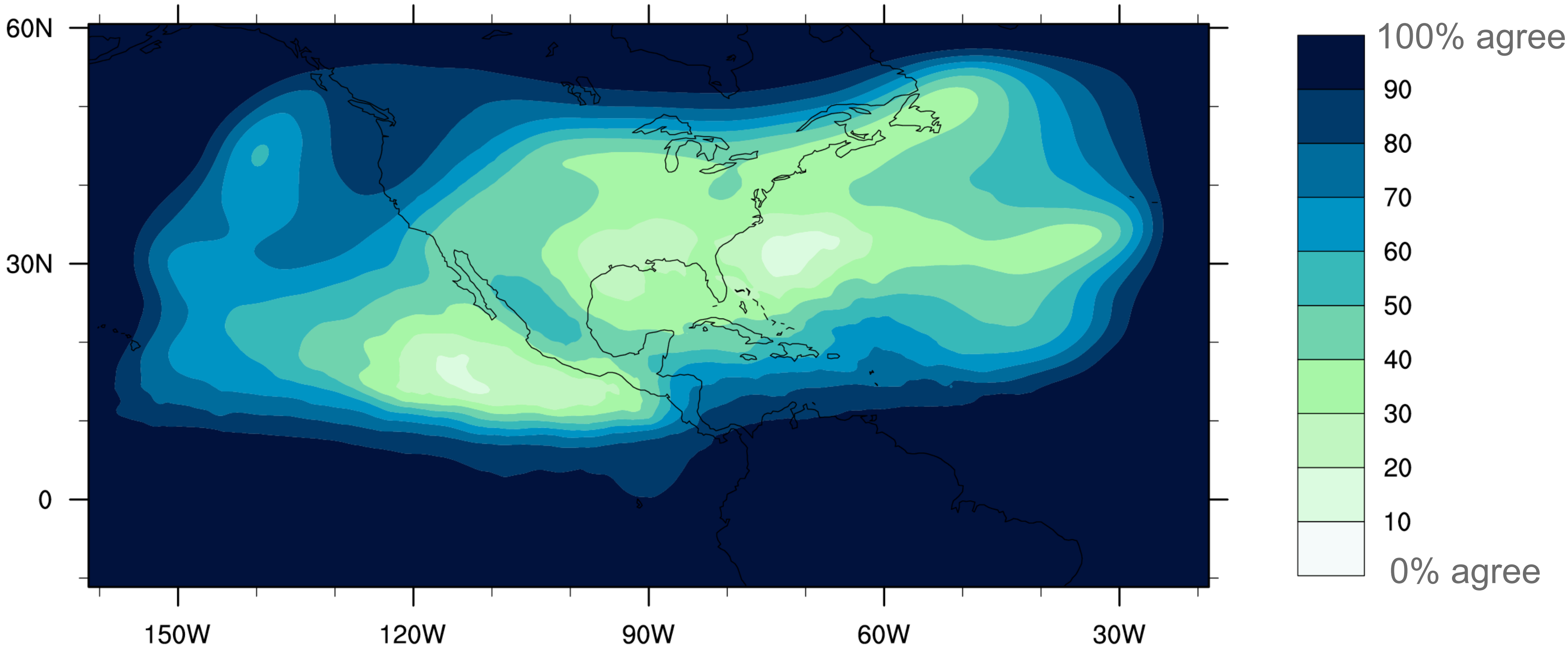
Hall and Jewson (2007)

Boundary Forcing Uncertainty



Perhaps choose the strongest forcing to get a signal

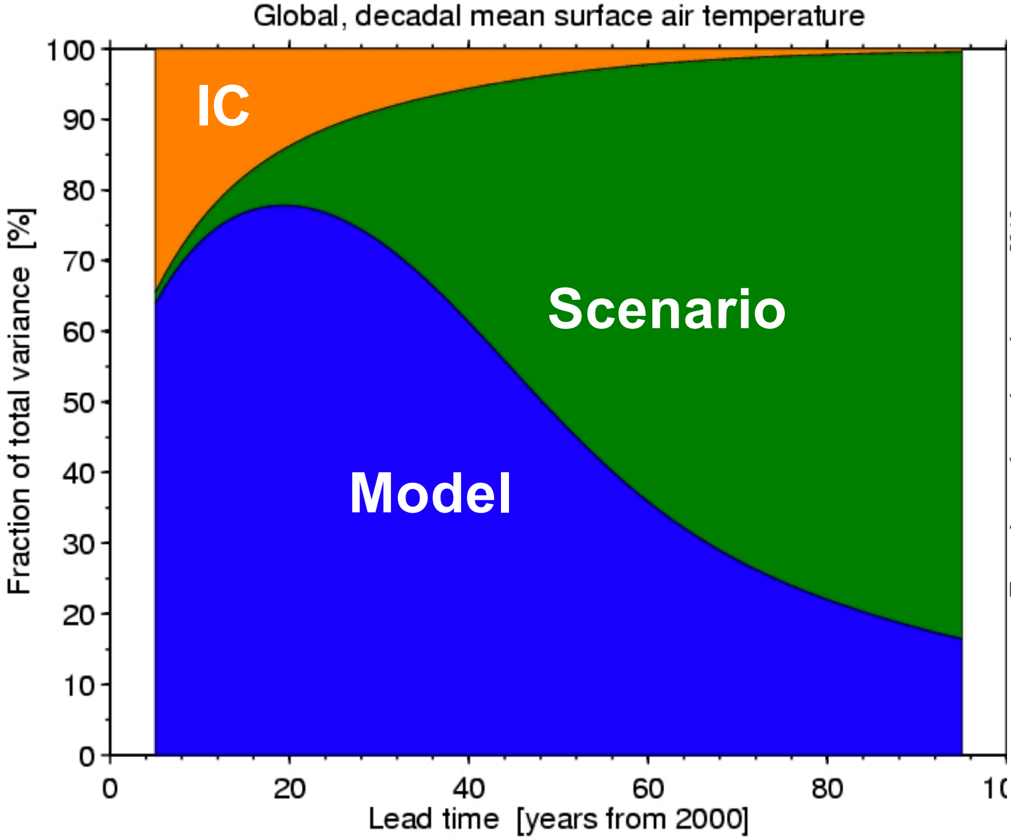
Initial Condition Uncertainty



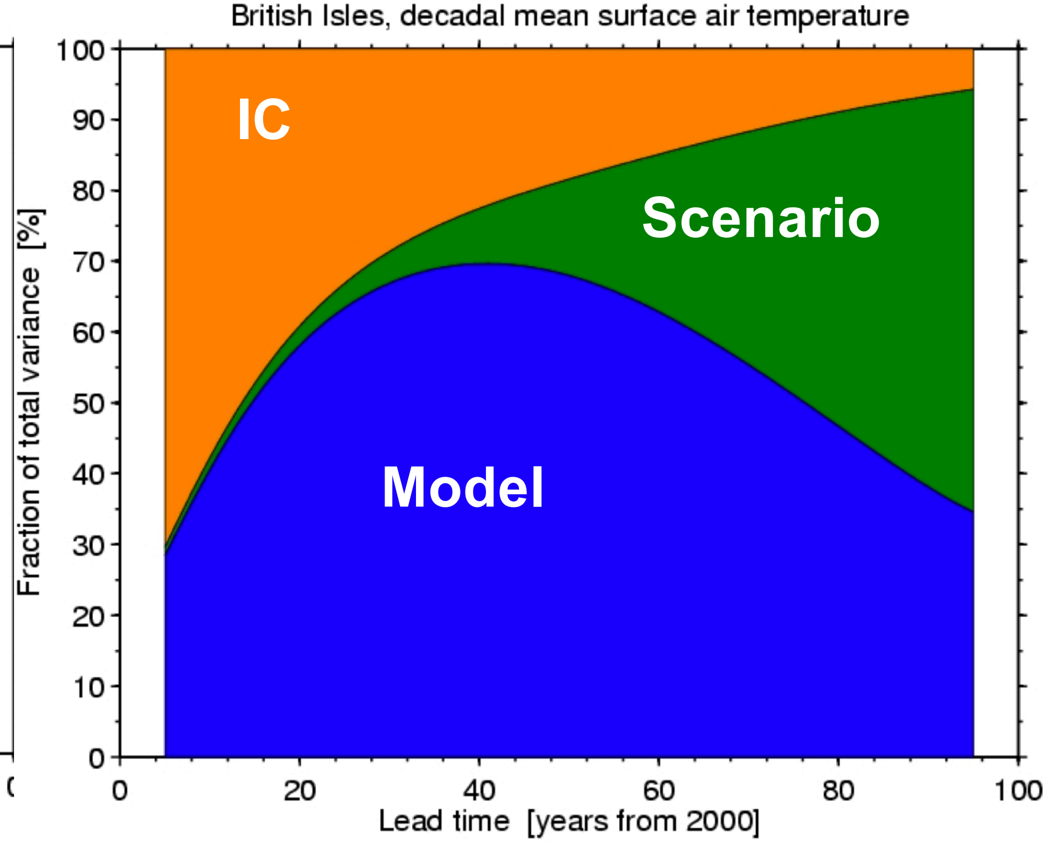
Need a large domain to sample initial condition uncertainty

The Dominant Uncertainty Varies with Scale

Global



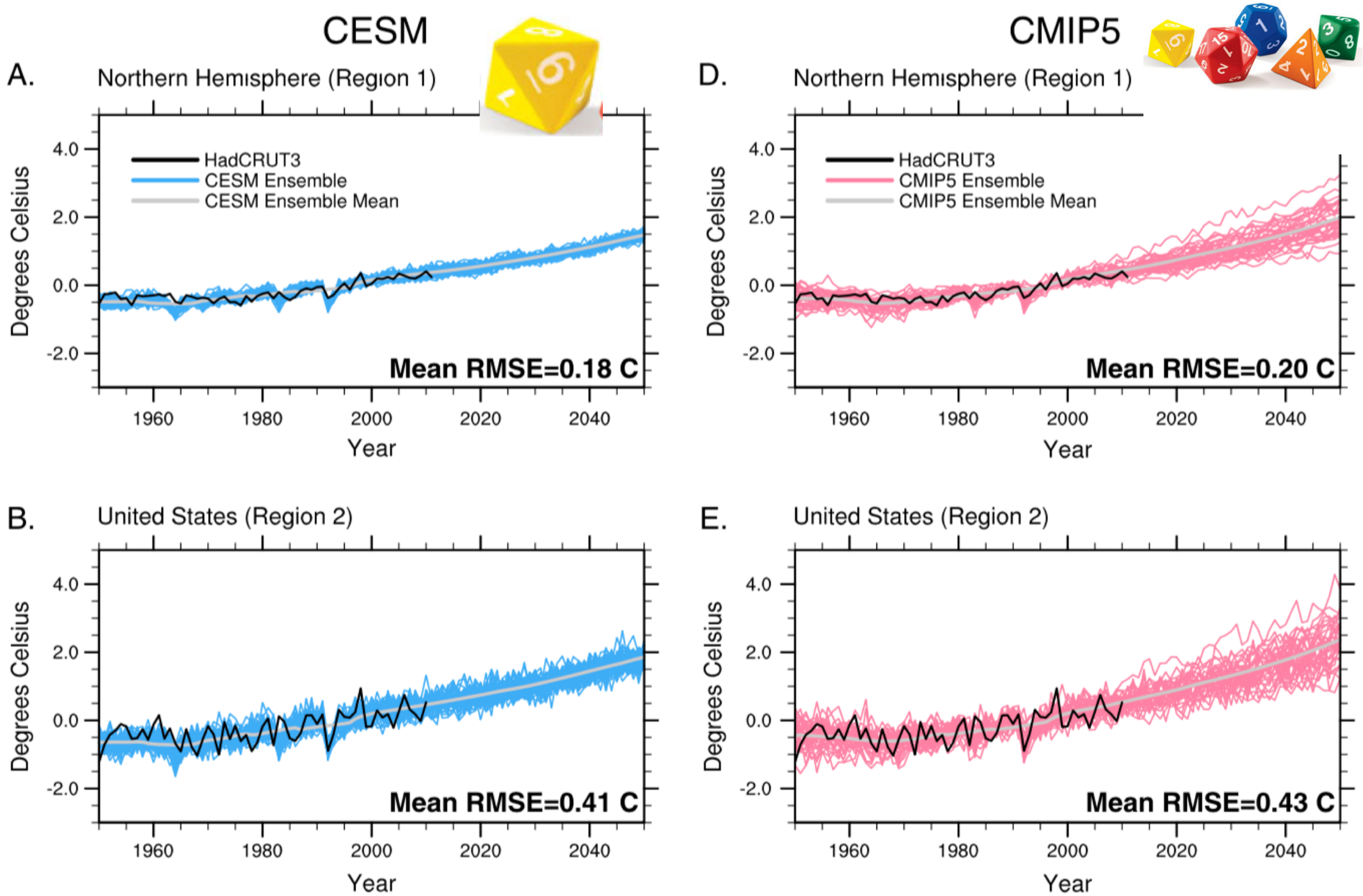
Regional



Hawkins and Sutton (2009)

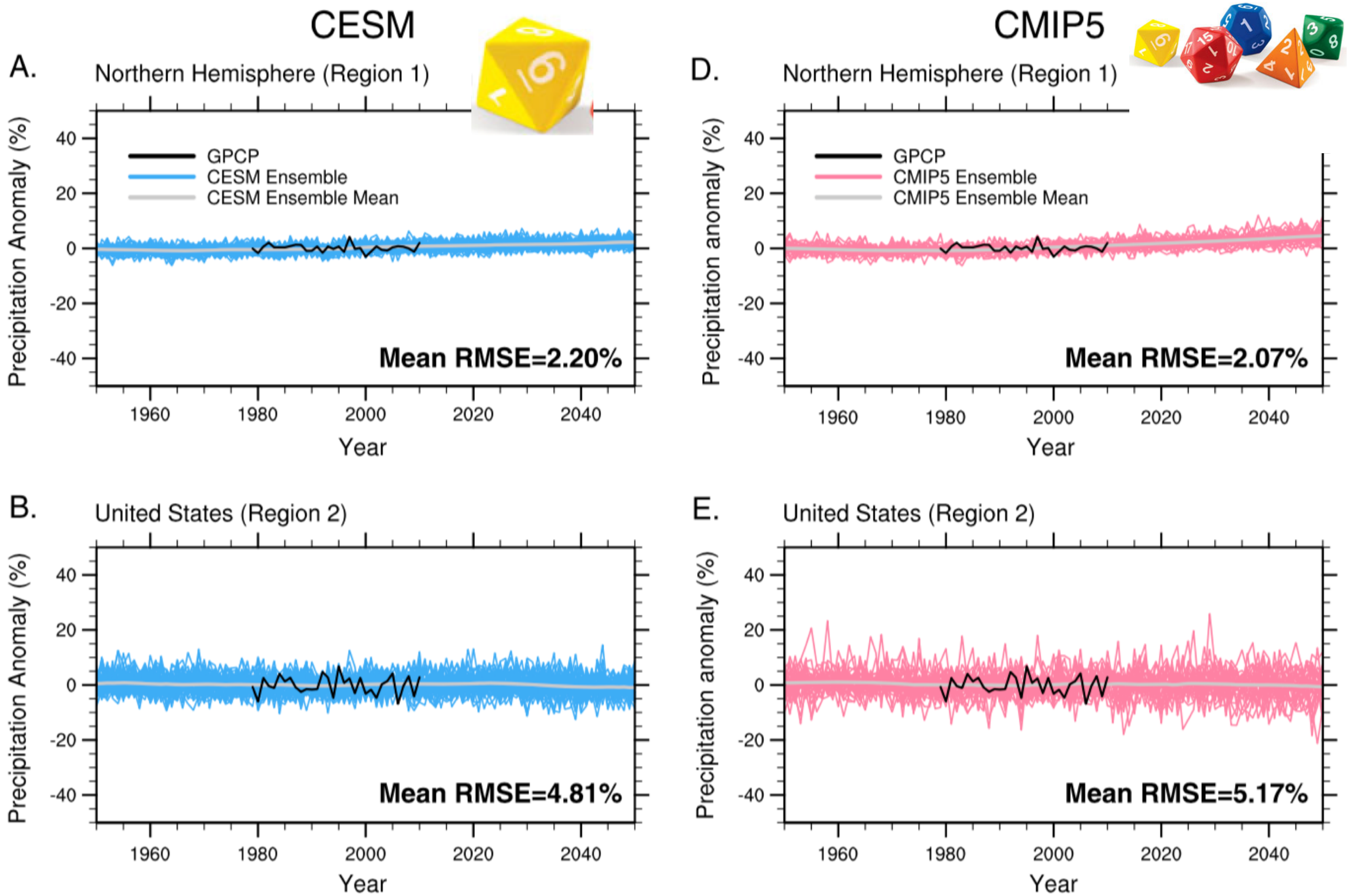
On regional scales, sample IC and model uncertainty

Initial Condition vs. Physics Uncertainty



Multi-model approach samples greater uncertainty.

Uncertainty depends on the variable



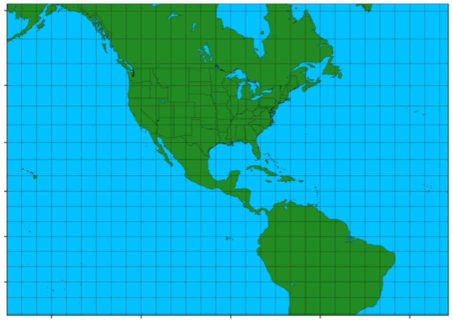
Can you use temperature instead?

Laboratory Task 1

What are the relative contributions to uncertainty in seasonal tropical cyclone (TC) numbers and intensity from internal variability and model physics?

TC track data:

- Single year (1998) 16-member initial condition ensemble.
- Single year (1998) 14-member model physics ensemble.



Done, J. M., C. L. Bruyère, M. Ge, and A. Jaye (2014), Internal variability of North Atlantic tropical cyclones, J. Geophys. Res. Atmos., 119, 6506–6519, doi:10.1002/2014JD021542.

Lab Task 1: Suggested Approach

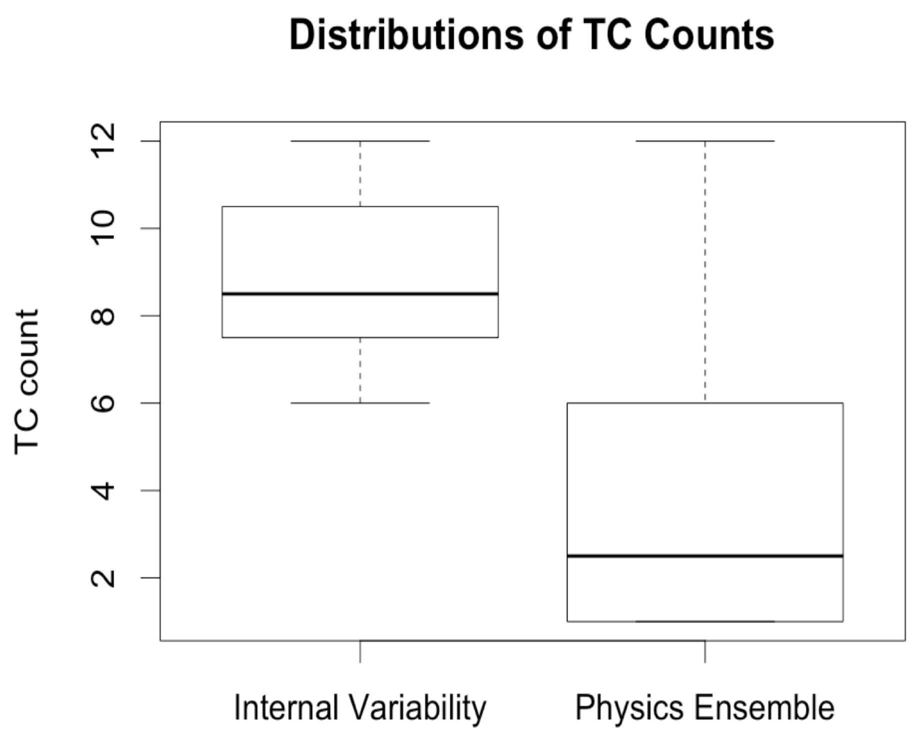
Using R, compare box plots of seasonal TC number and seasonal TC intensity to quantify and visualize the spread due to internal variability and model physics.

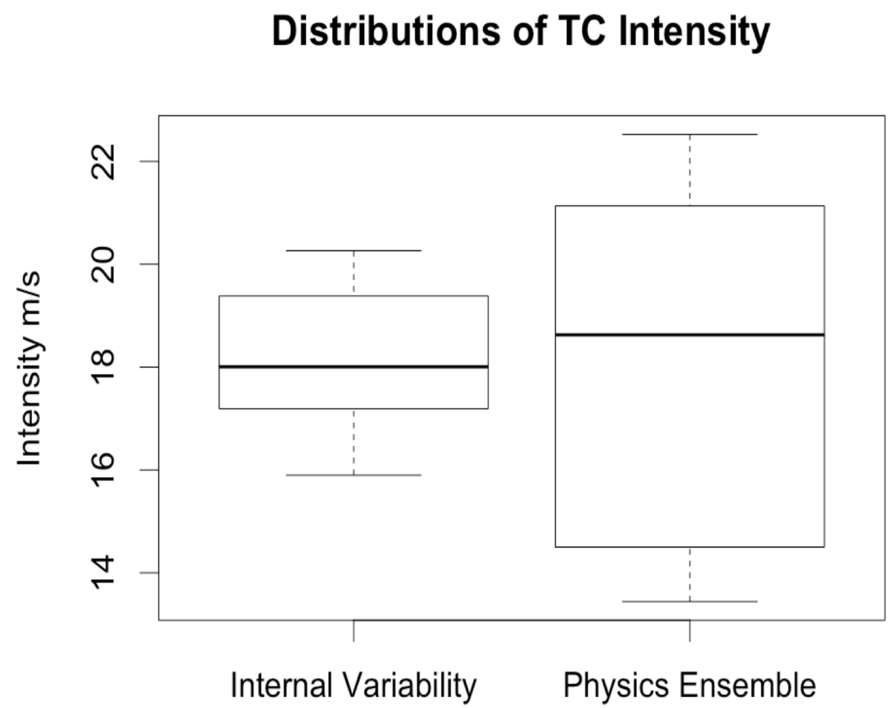
Download data and follow instructions under the ‘Uncertainty’ link under ‘Lab Projects’ tab on our website.

TC track data zip files:

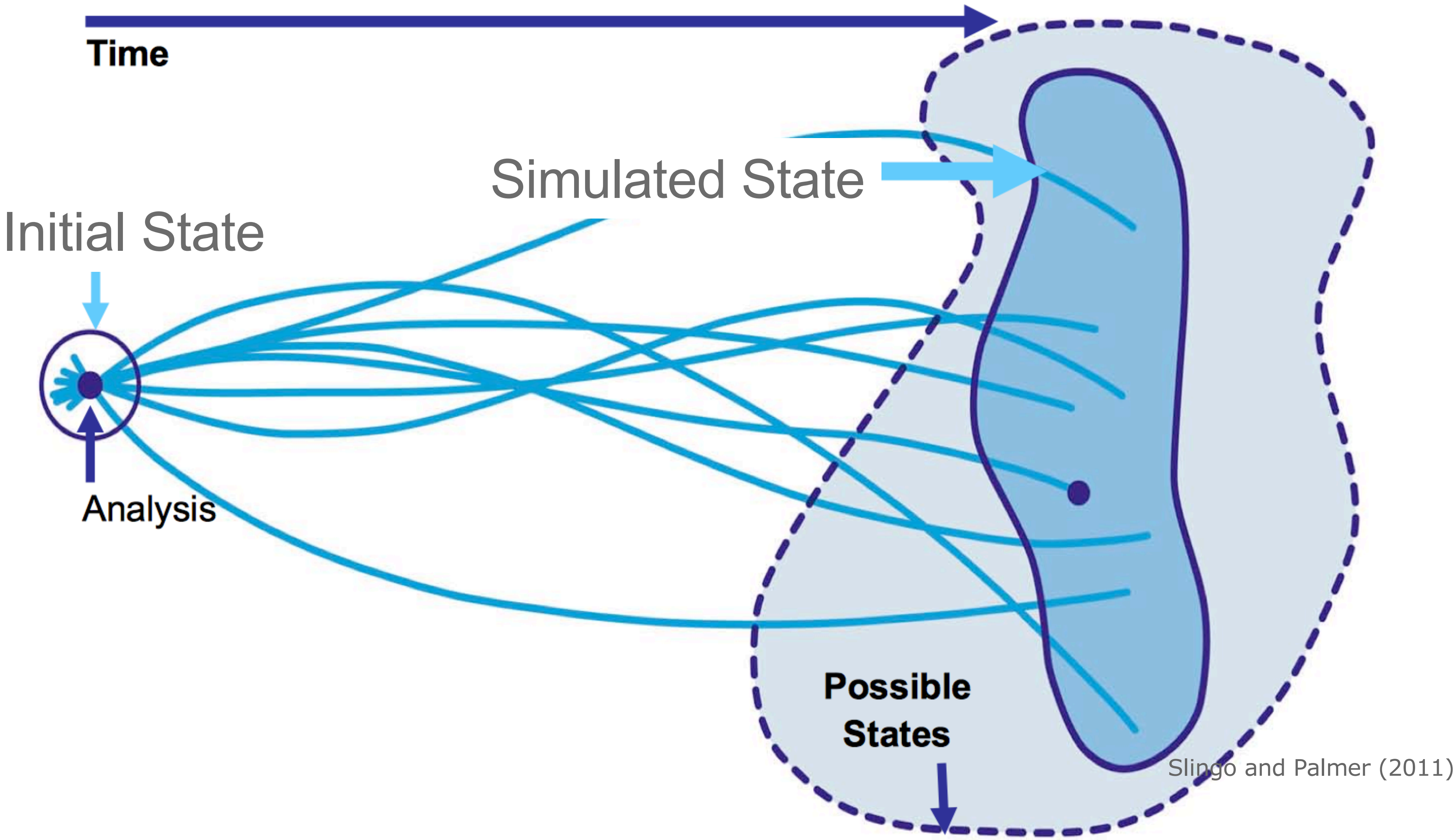
- initial_condition_ensemble.zip
- physics_ensemble.zip

Lab Task 1: Results



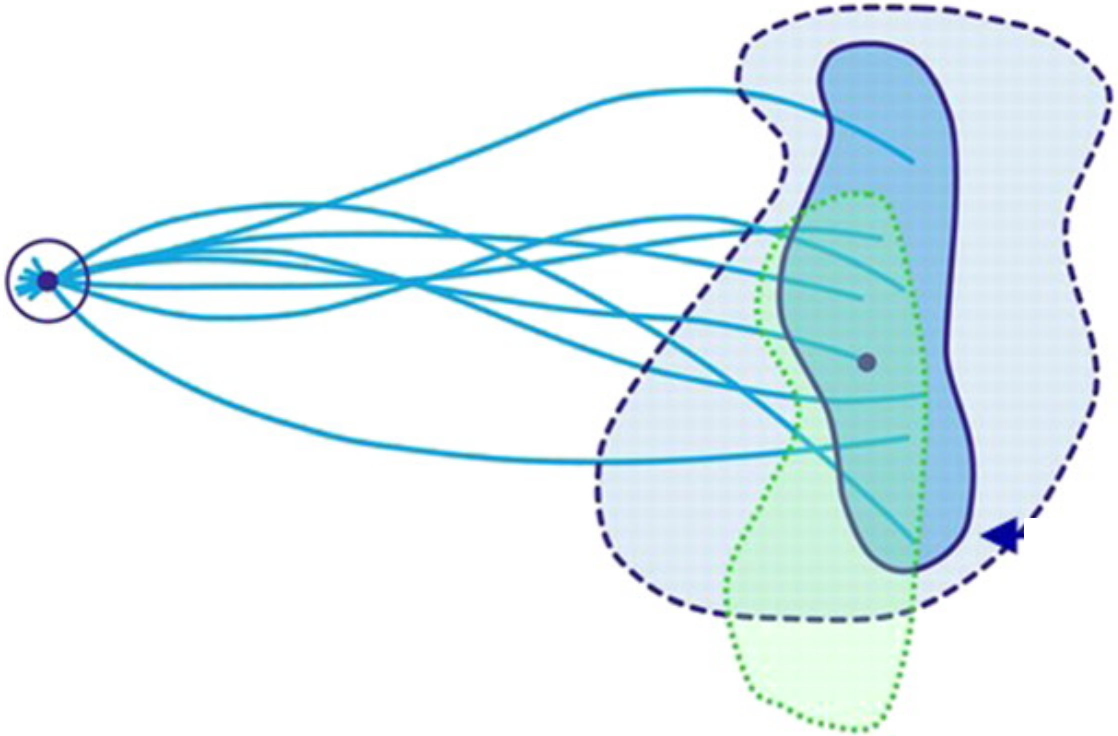


Ensemble Climate Simulation



Ensembles provide a lower uncertainty bound (Stainforth 2007)

Impact of Model Bias



Slingo and Palmer (2011)

Computational Limitations

A balance between competing multiplicative demands:

$$C \sim L^2 * N_V * T * N_e / (Dx^3)$$

Domain size

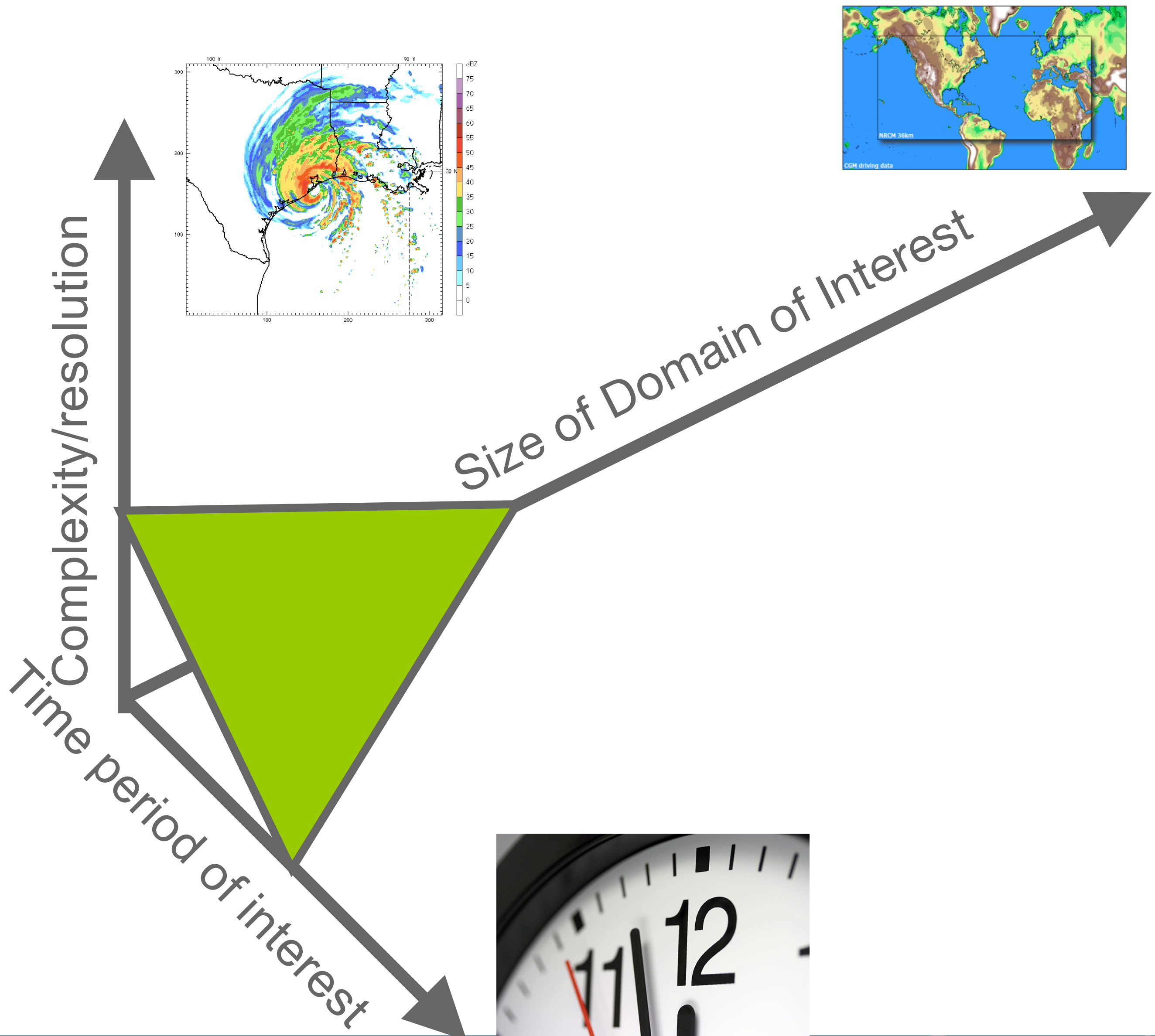
Complexity

Length of integration

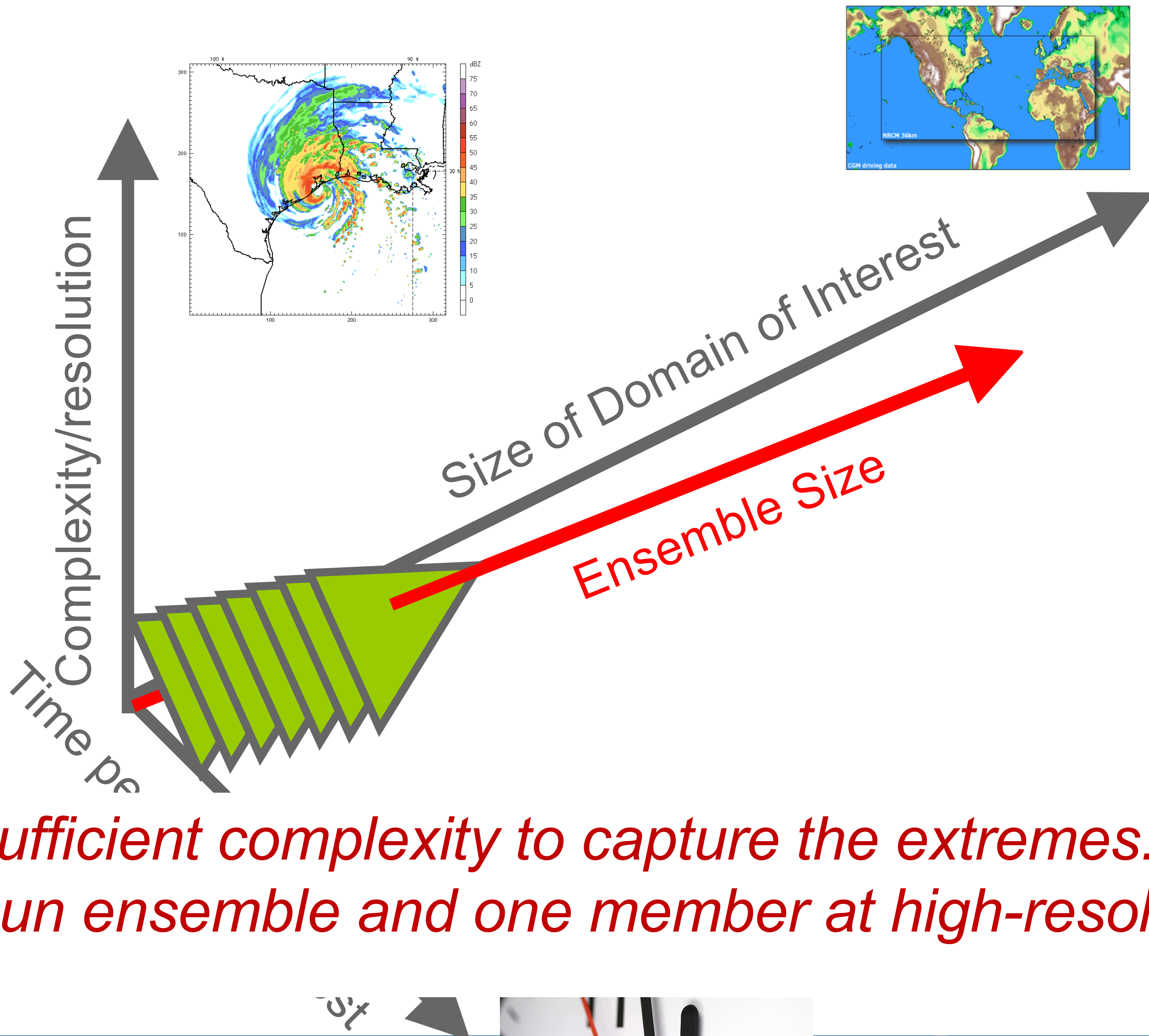
Ensemble size

Resolution

Computational Limitations



Computational Limitations



Sufficient complexity to capture the extremes.
Run ensemble and one member at high-resolution.

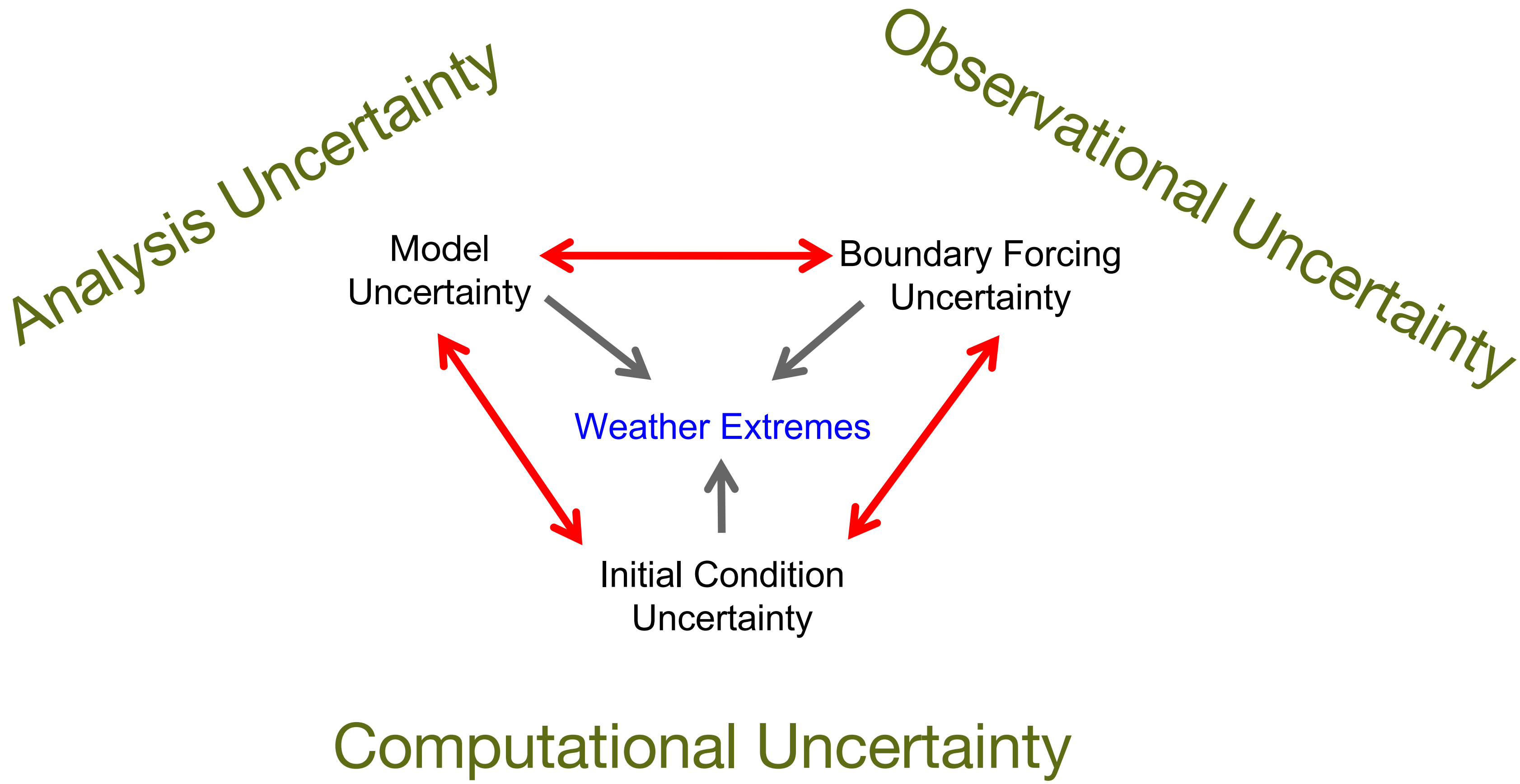
Ensemble Considerations

- Which uncertainty to sample?
- How many ensemble members . . .3? . . .30? . . .3000?
- Weight the members, even discard some?

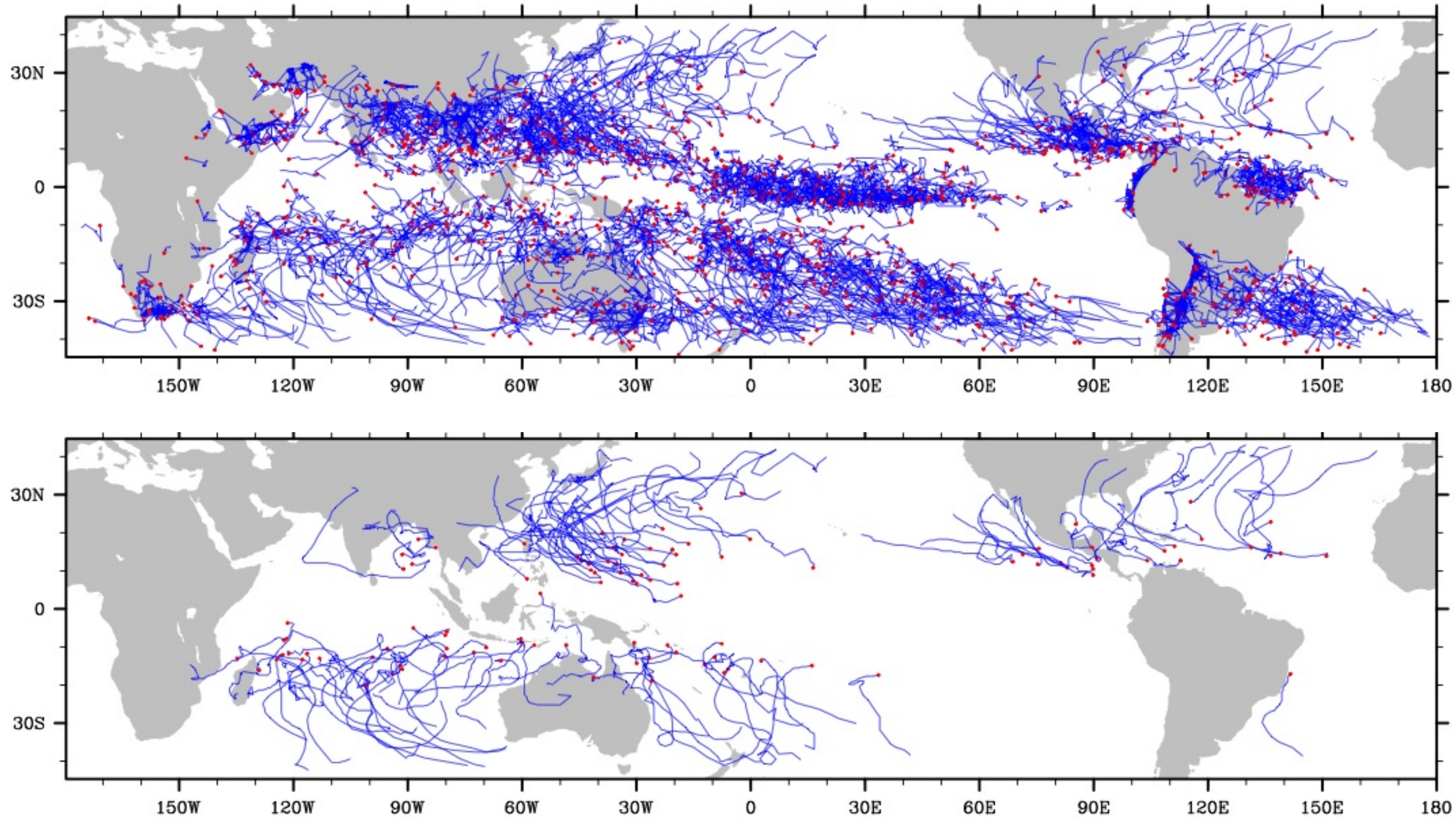
When uncertainty poorly understood, use less quantitative measures: range or sign of a change (Kandlikar et al, 2005).

All ensembles are useful, the key is the interpretation.

More Uncertainty Sources!



Analysis Uncertainty



Relaxed Tracking Criteria
1468 tracks/yr

Strict Tracking Criteria
106 tracks/yr

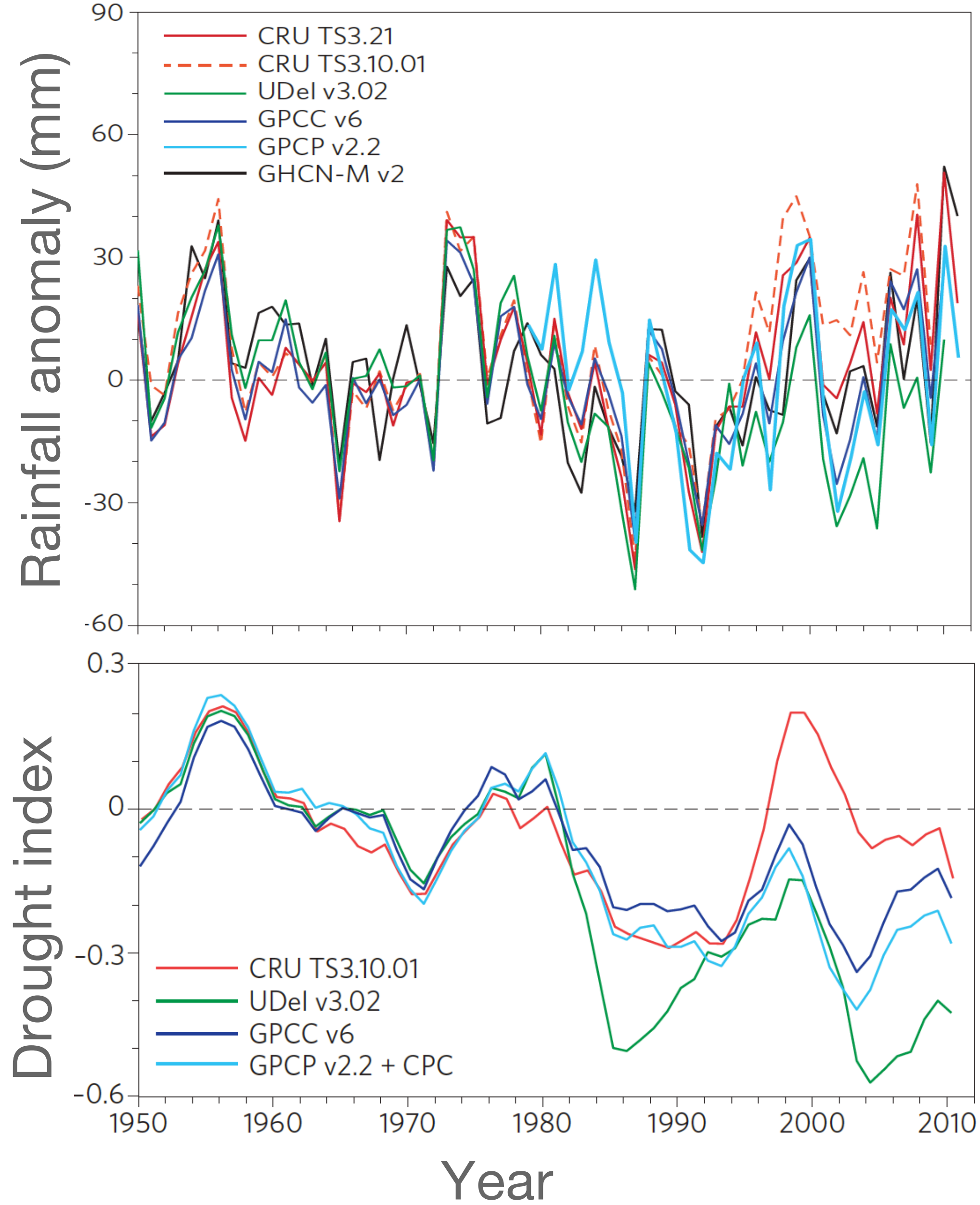
Be consistent across datasets

Asuka Suzuki-Parker

Observational Uncertainty

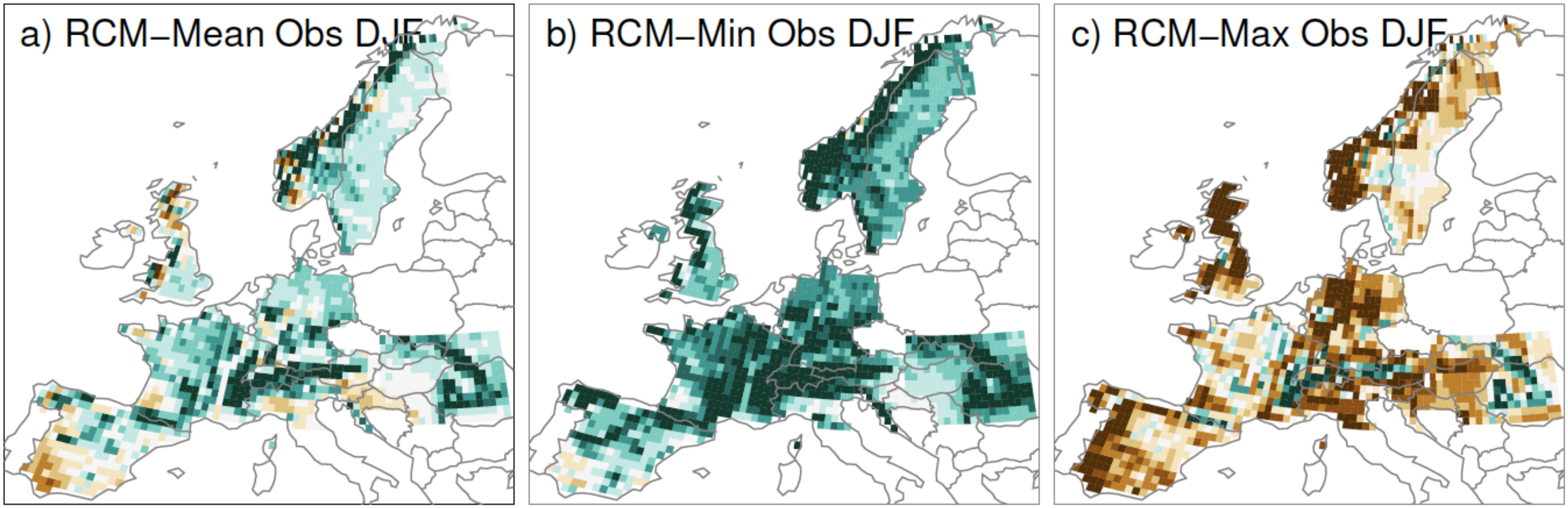
What we observe is not nature itself, but nature exposed to our method of questioning. – Heisenberg

Large impact of observed rainfall uncertainty on drought index



Trenberth et al. (2013)

Differences among observational datasets can have similar magnitude to model error

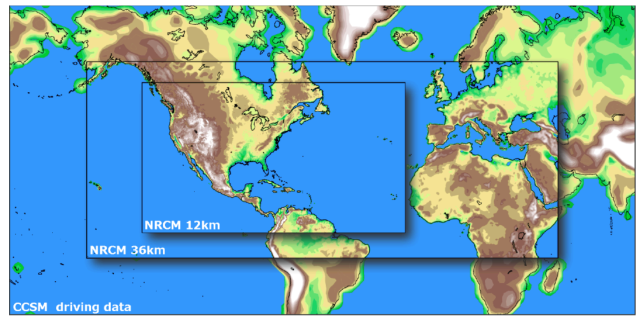


Prein and Gobiet (2016)

Use multiple observational datasets for model evaluation

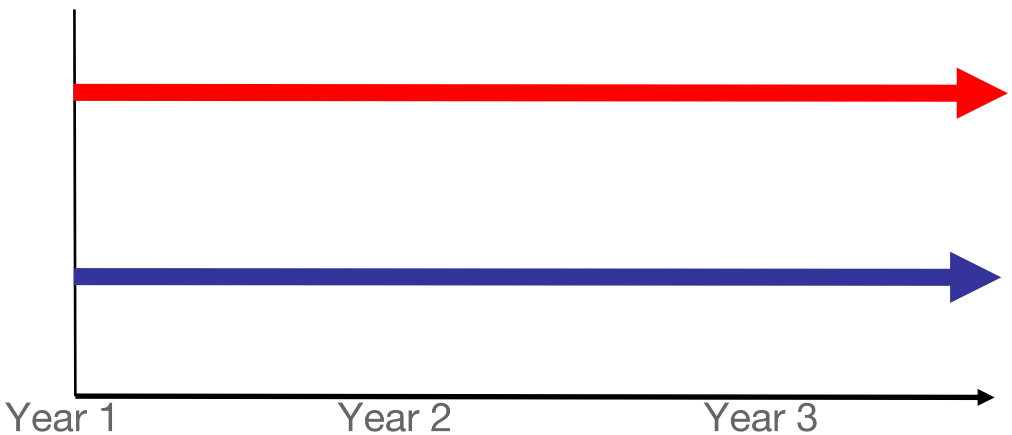
Computational Uncertainty

Experimental Design:

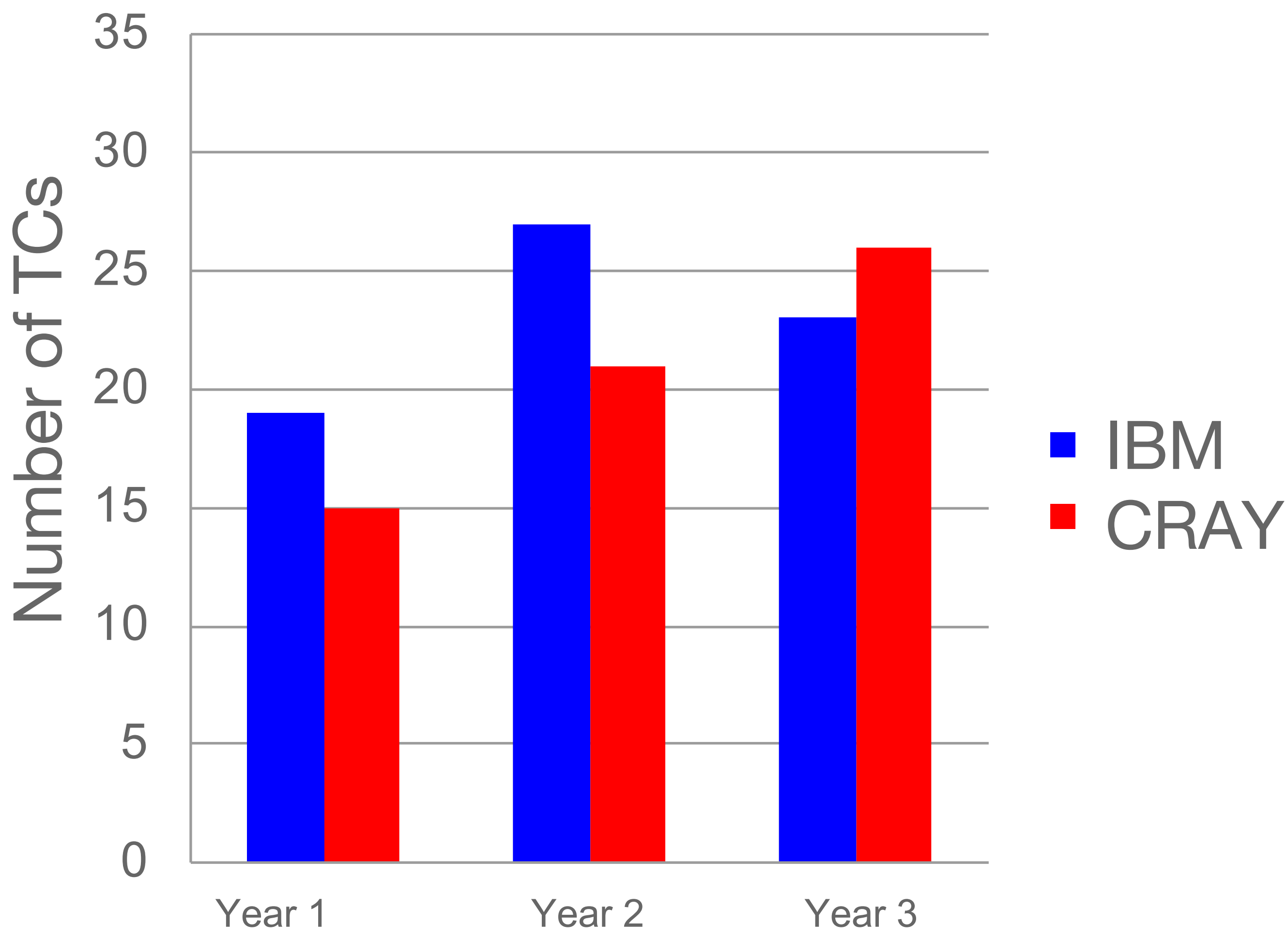


IBM
(ANL's Intrepid)

CRAY
(NCAR's Lynx)



Computational Uncertainty

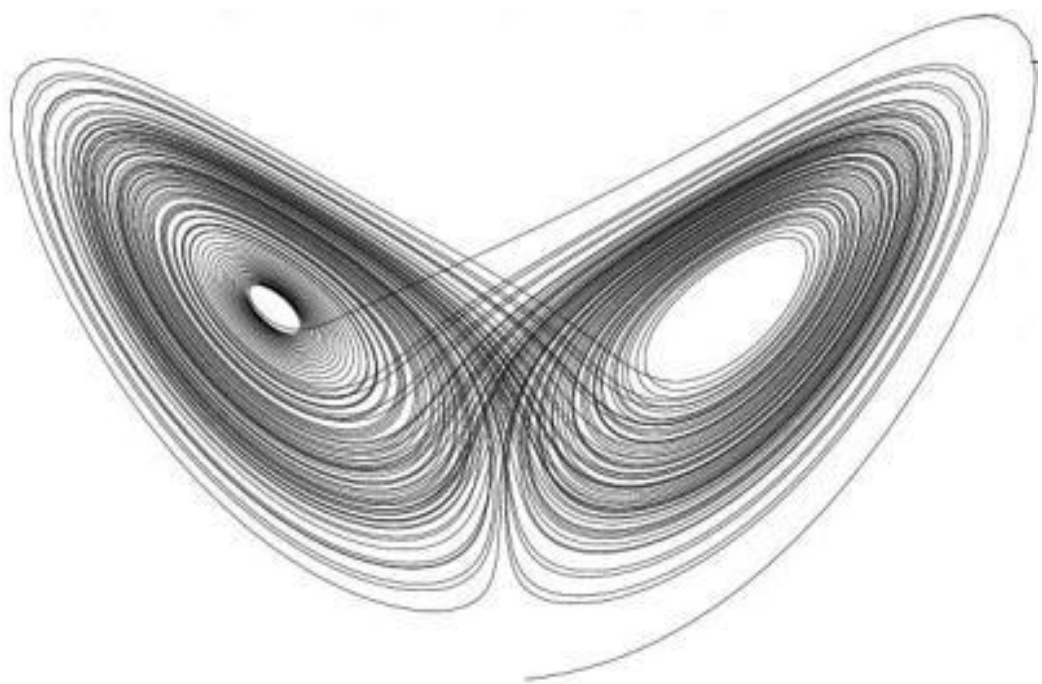


Differences in annual numbers and interannual variability

A Goal For Ensemble Simulation

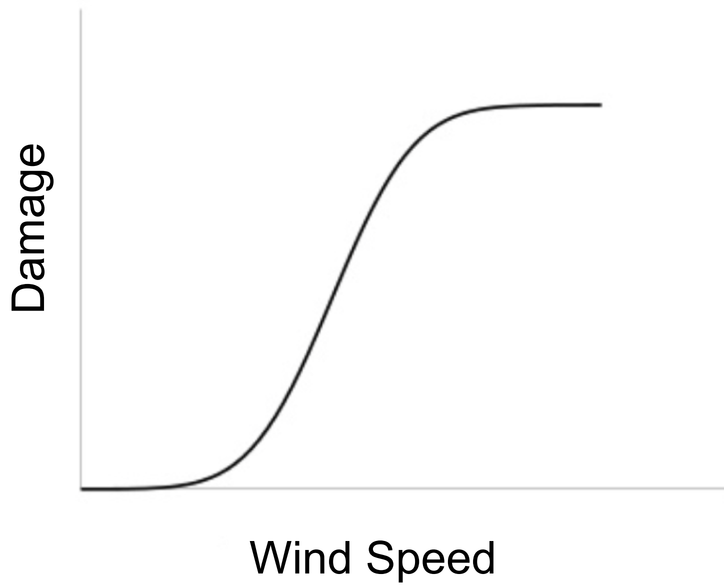
The goal is not to reproduce the observed weather extremes, but rather to produce a range of possible scenarios consistent with known large-scale conditions.

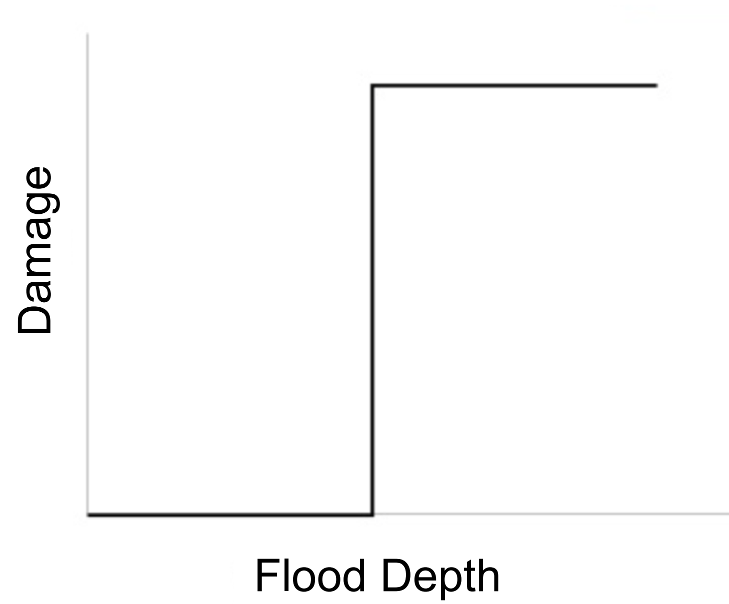
Historical weather extremes are just one of many possibilities.



Relevant Uncertainty

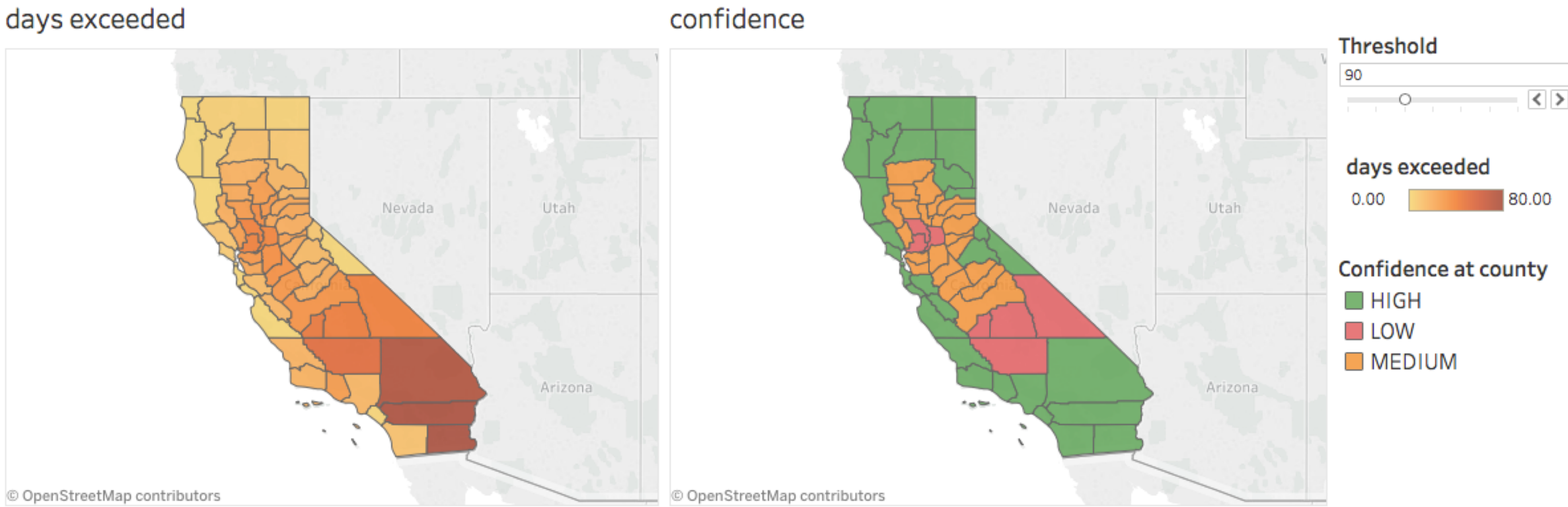
Threshold sensitive decisions:





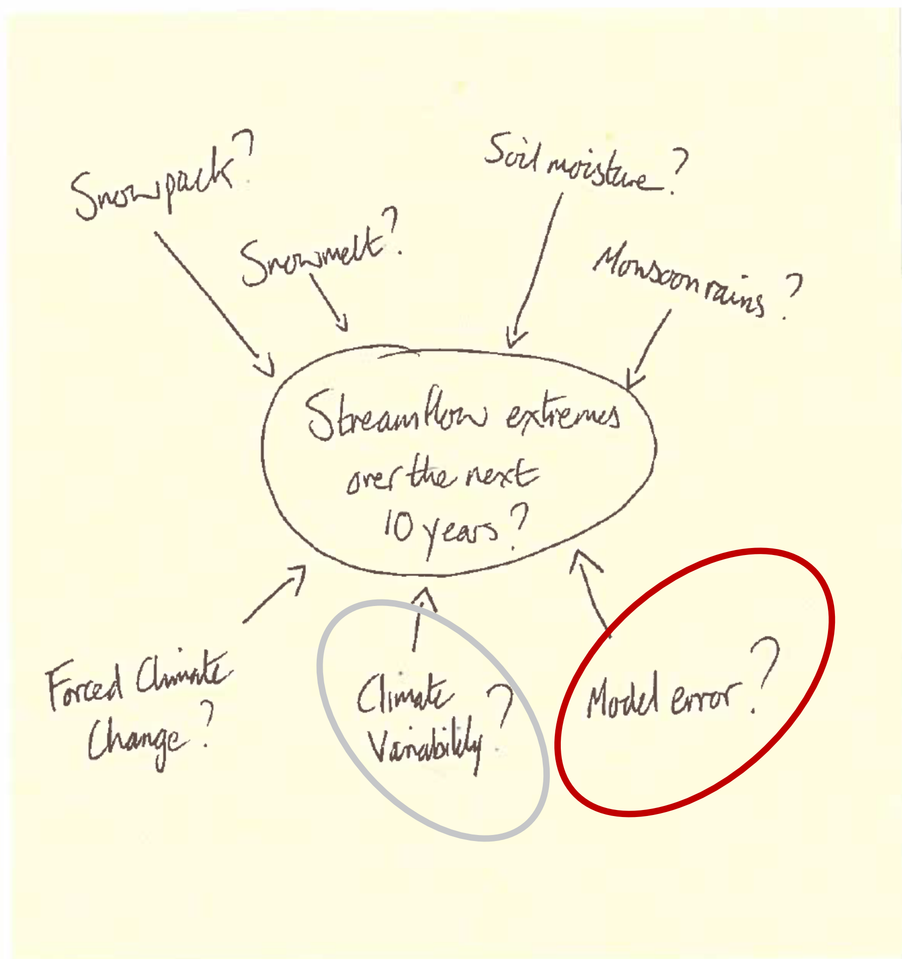
Focus uncertainty assessment
on the scales and variables of interest

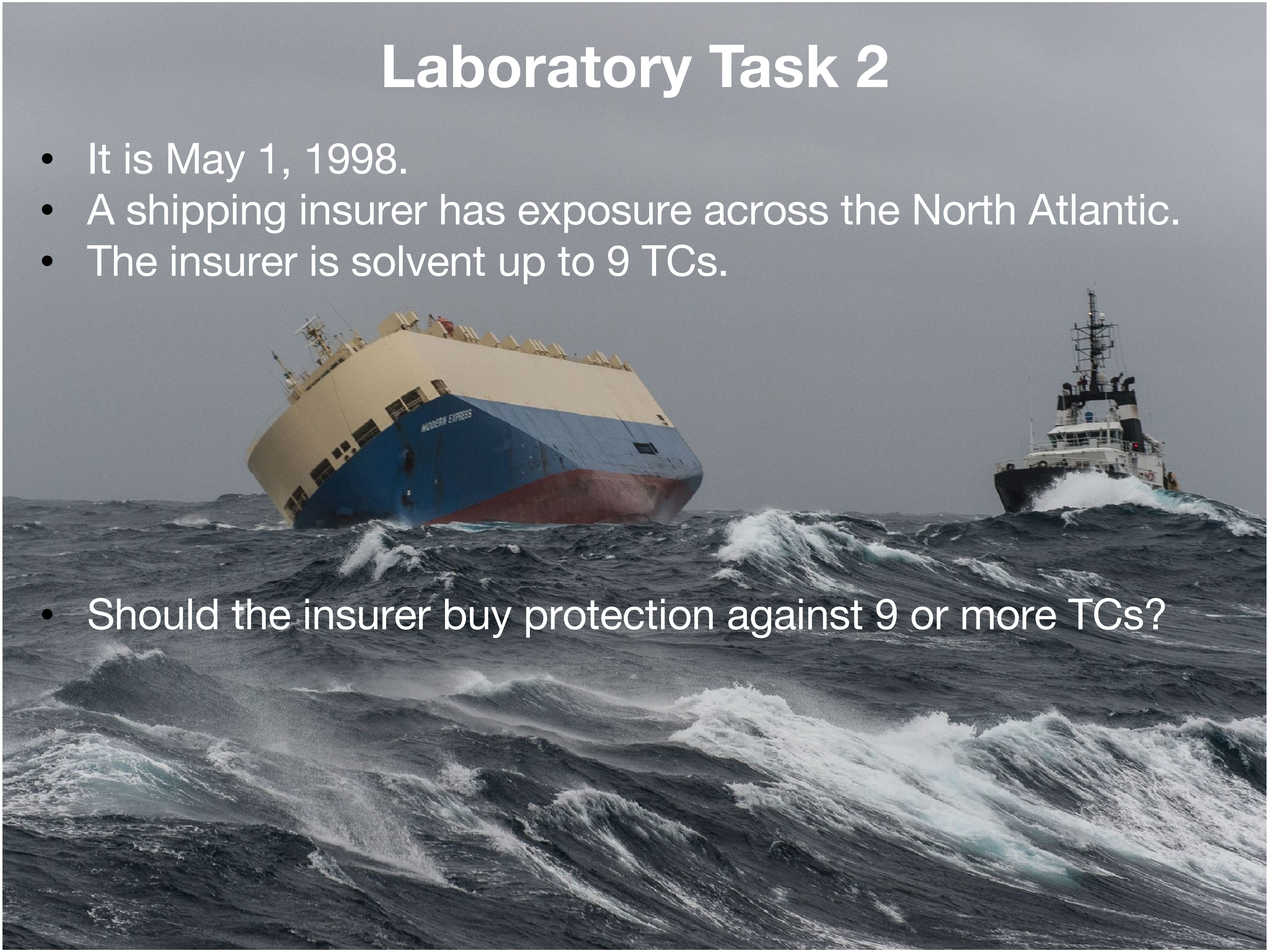
Useful Uncertainty: Example



Provide useful uncertainty

Prioritize your Uncertainty Sources





Laboratory Task 2
It is May 1, 1998.
A shipping insurer has exposure across the North Atlantic.
The insurer is solvent up to 9 TCs.
Should the insurer buy protection against 9 or more TCs?

Lab Task 2: Suggested Approach

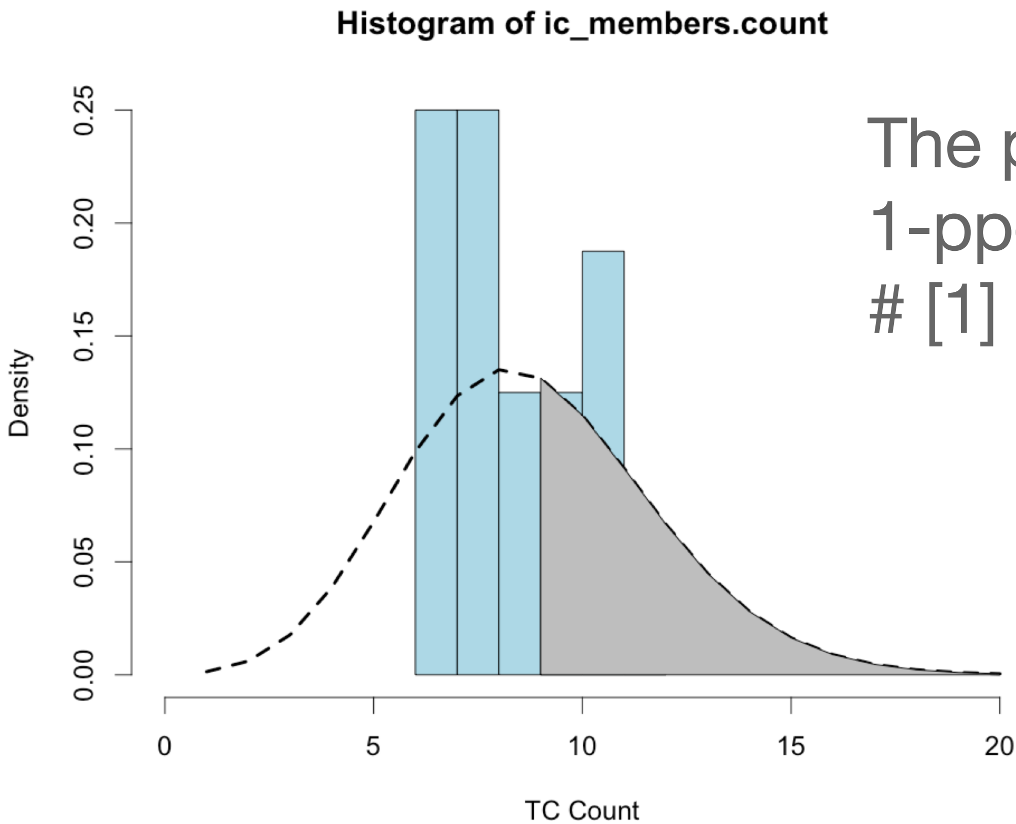
Using R, calculate and visualize the exceedance probability of 9 TCs, by fitting a distribution function to the seasonal TC numbers from the ensemble simulations.

Download data and follow instructions under the ‘Uncertainty’ link under the ‘Lab Projects’ tab on our website.

TC track data zip files

- initial_condition_ensemble.zip
- physics_ensemble.zip

Lab Task 2: Results



The probability of exceeding 9 TCs

1-ppois(9, lambda)

[1] 0.3796915

Main Points

- Determining important sources of uncertainty for your project.
- Understanding uncertainty through ensemble modeling.
- Concept of relevant and useful uncertainty.

References

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