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**Conference and School on Predictability of Natural Disasters for our
Planet in Danger. A System View; Theory, Models, Data Analysis**

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**The end-to-end climate change attribution problem:
from emissions to impacts**

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Newcastle, NSW, Australia, June 2007



Courtesy Graeme Anderson

Newcastle, NSW, Australia, June 2007

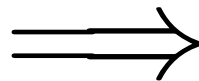


Courtesy Graeme Anderson

Was this just another flood, or can we blame greenhouse gas emissions?

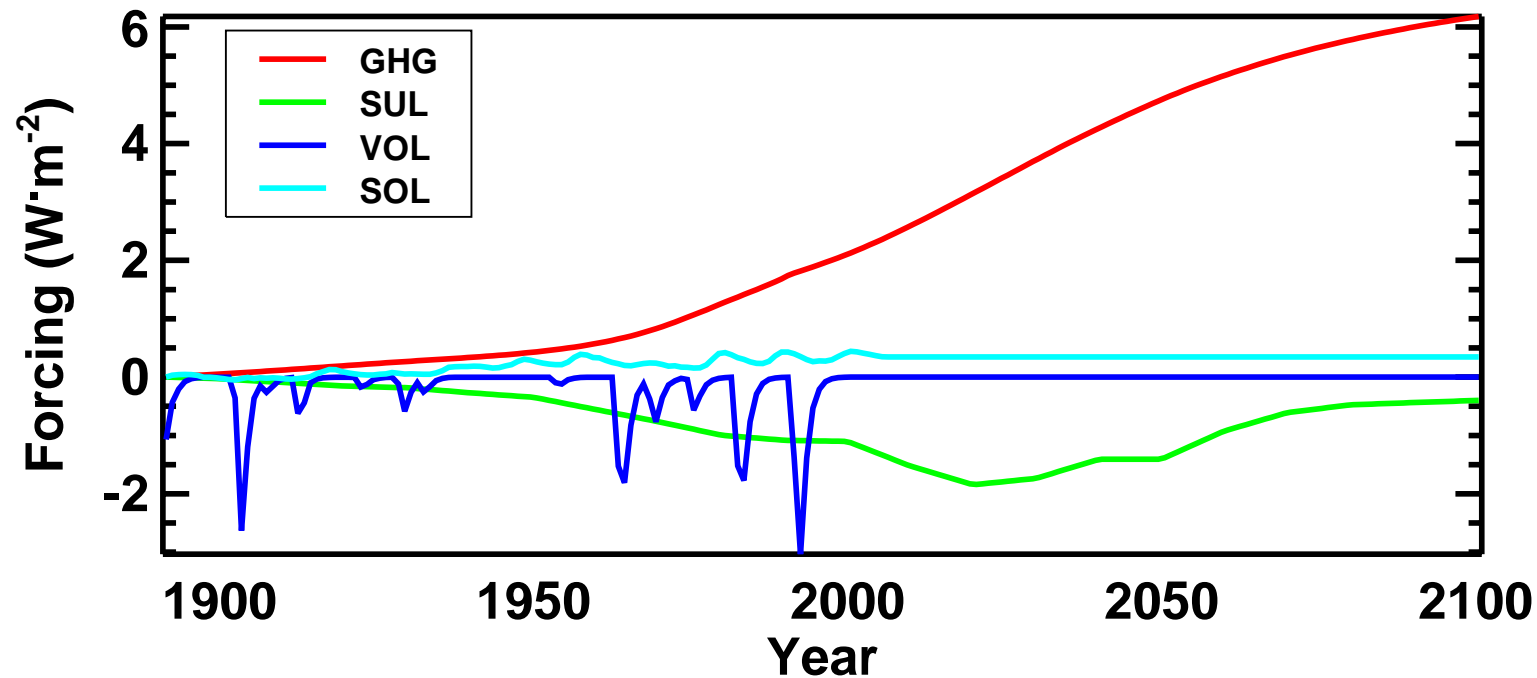


Province of Ontario



Graeme Anderson

What could affect the climate?



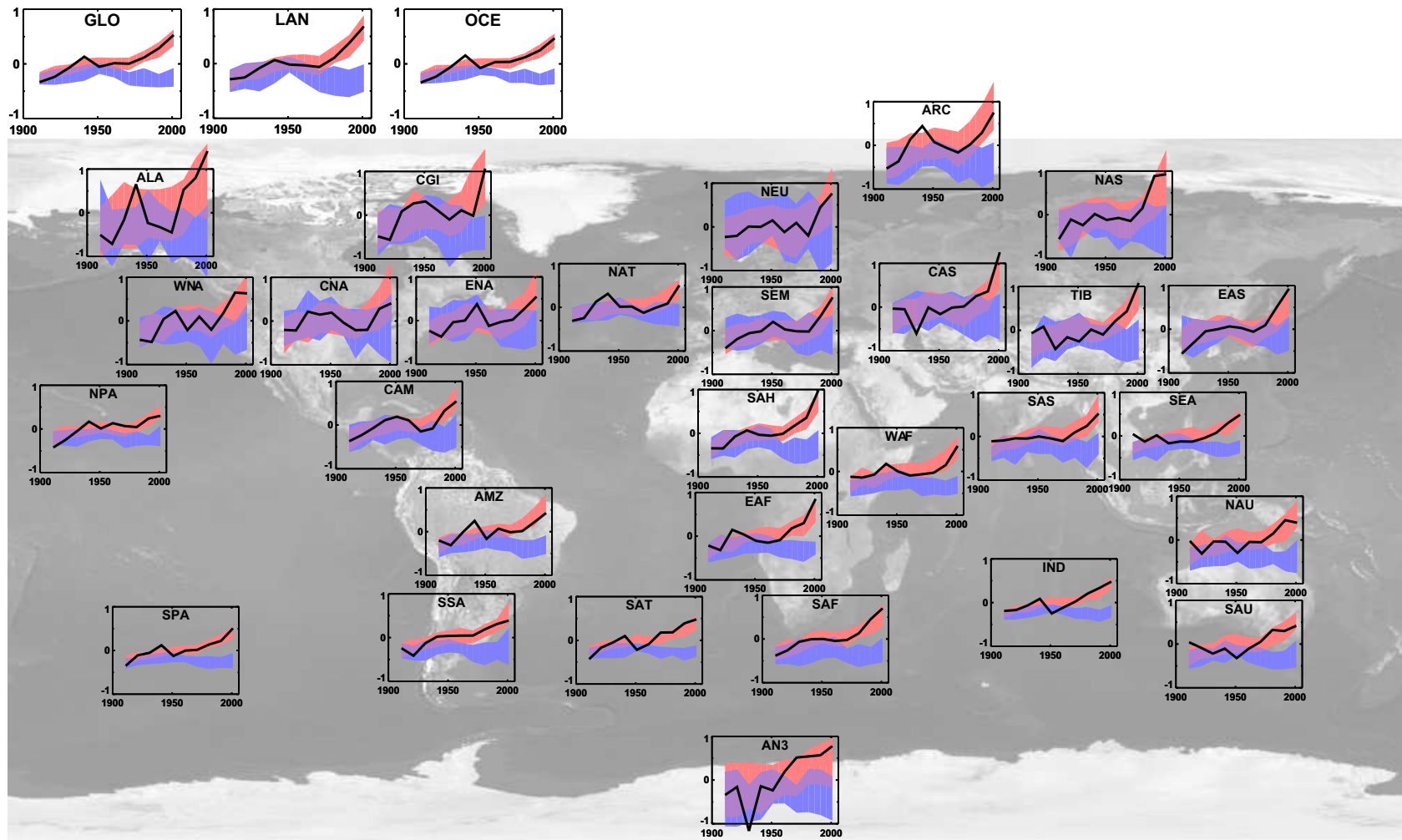
- “Natural”: large volcanic eruptions, solar luminosity changes
- “Anthropogenic”: greenhouse gas emissions, sulphur dioxide emissions, black carbon emissions, organic carbon emissions, land surface changes, CFC emissions, airplane contrails

The attribution problem

If changes in the observed weather are consistent with a certain plausible forcing scenario and inconsistent with the lack of that scenario

- We have only one sample.
 - We will never be able to get a second sample.
- ⇒ We must resort to computer models.

Attributing regional warming



But you have not answered the question!

Was this weather event caused by emissions?

While this event may be expected to be more (or less) likely under human induced climate change, we cannot attribute this single event to human activities.

What is climate?

- Often defined as the statistics of weather.
 - But this is an observable definition.
 - Implies “abrupt” climate change is impossible.

The definition given by Prof. Shukla yesterday.

- Edward Lorenz:

“Climate is what you expect, weather is what you get.”

- Weather is a sample of a statistical (or chaotic) process called climate.

- Climate can be completely *predictable* (provided you know the external forcings).

- Today Lorenz might say:

“Climate is what you affect, weather is what affects you.”

Do as the epidemiologists do

- Do not consider cases, but instead consider likelihood (risk).
 - Risk is predictable, cases are not.

So for our flood we just need to compare the risk of flooded houses on a population of Earths in 2007 with the risk on a population of Earths in which humans had never been emitting greenhouse gases.

But...

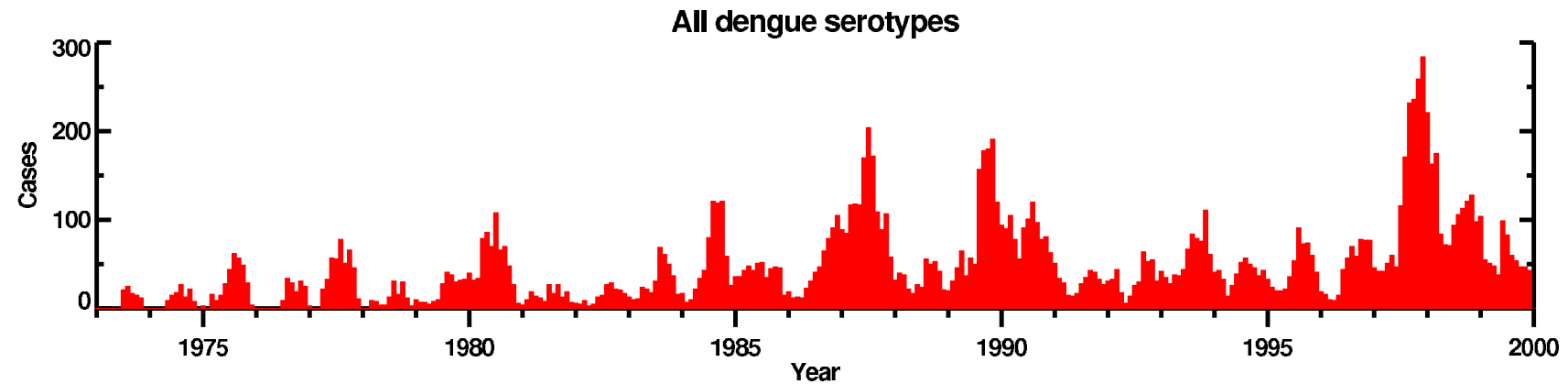
- We cannot sample from populations of Earths.
- We have to resort to numerical models.
- Both P_{2007} and $P_{2007-GHG}$ are sampled from finite populations of uncertain relevance to the real world.

But rainfall does not equal flooding!

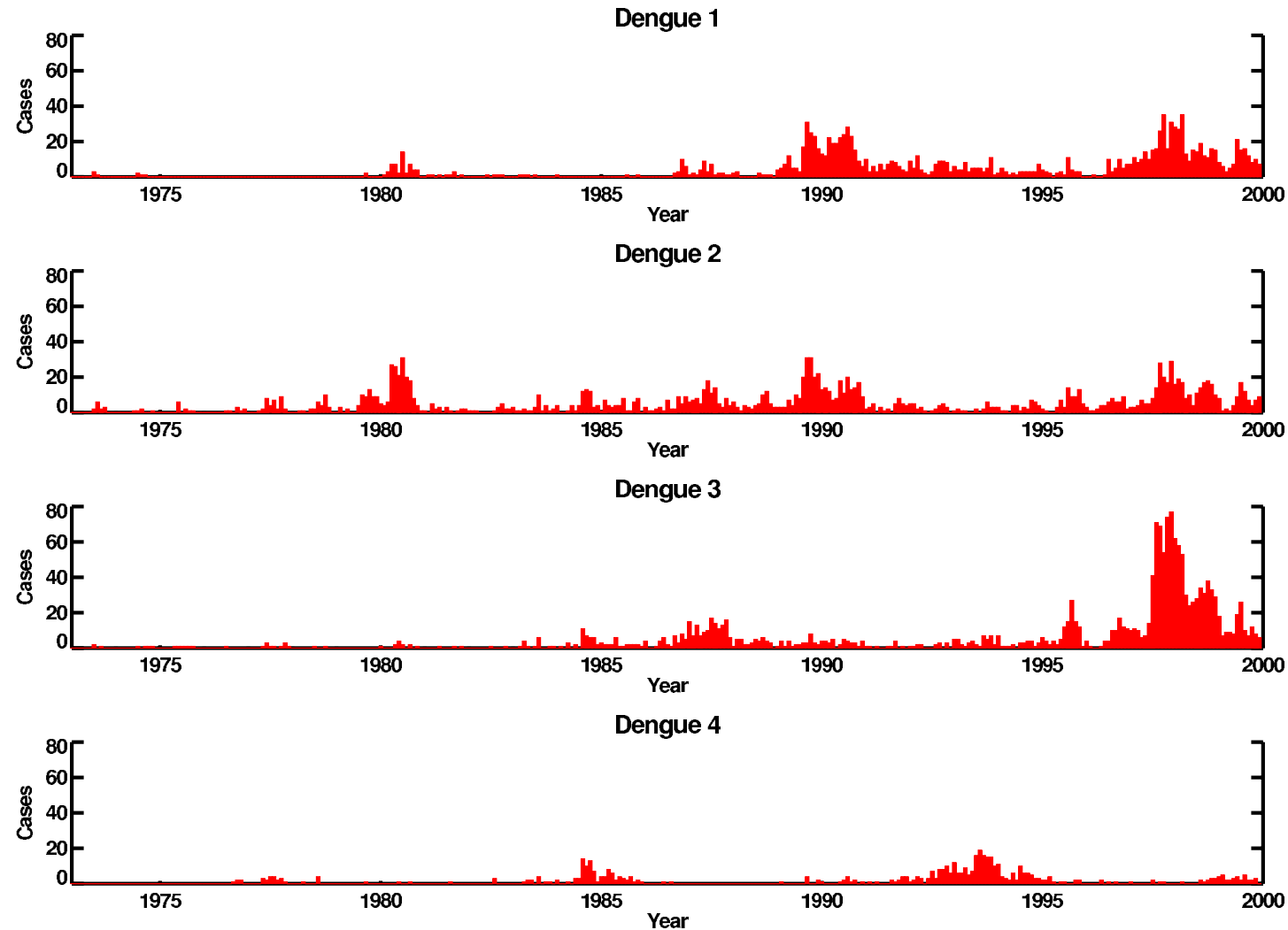
Or sea-side coffee sales!

Attributing disease incidence to weather

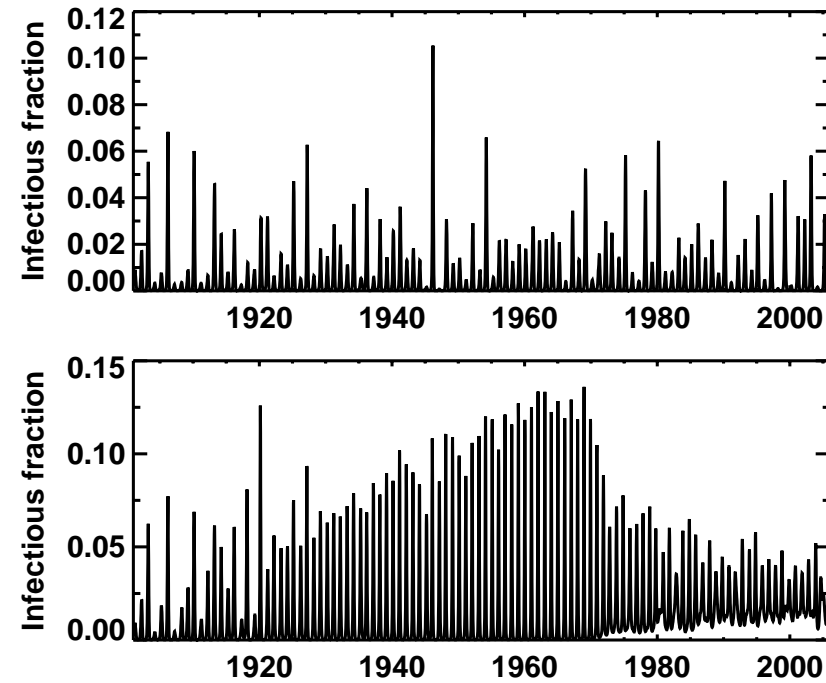
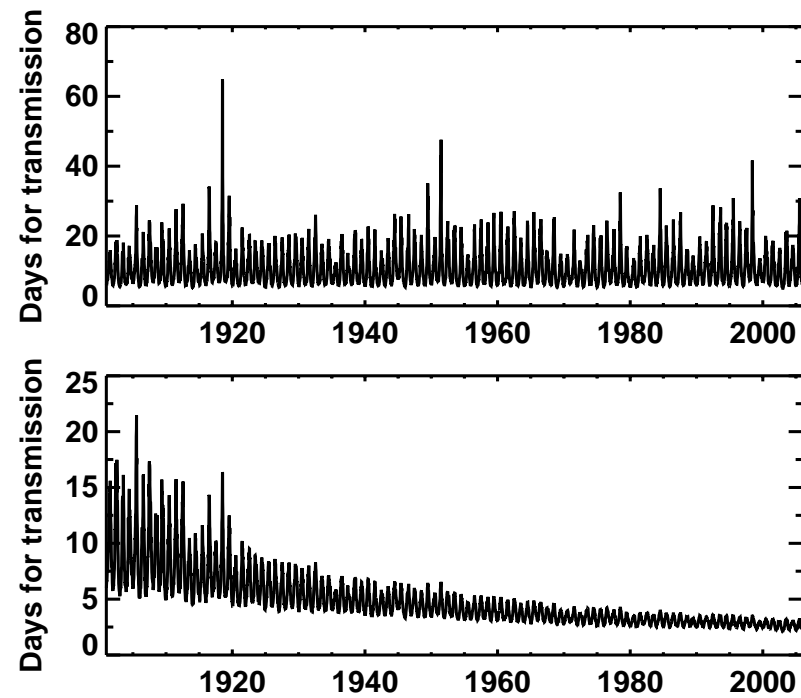
Recorded dengue incidence in Bangkok



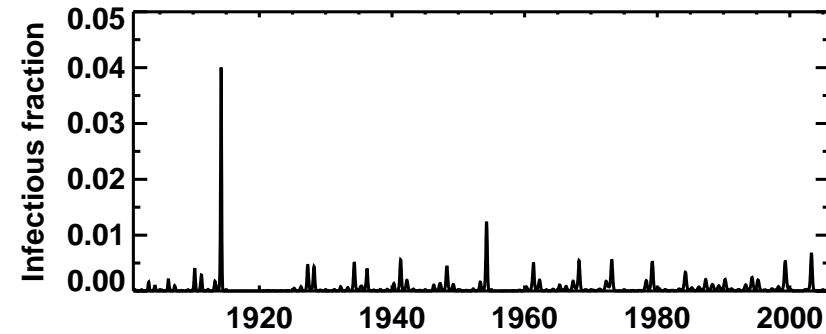
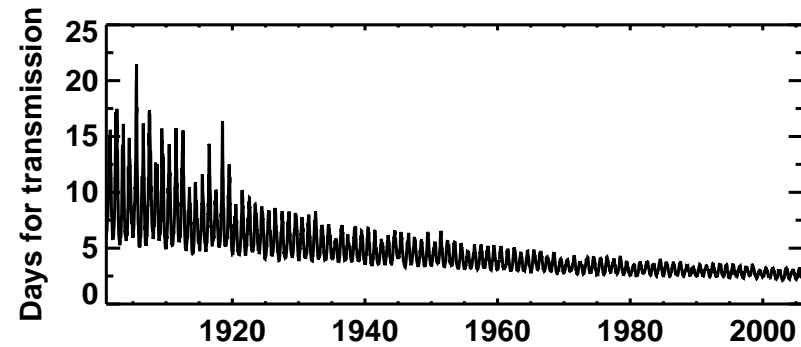
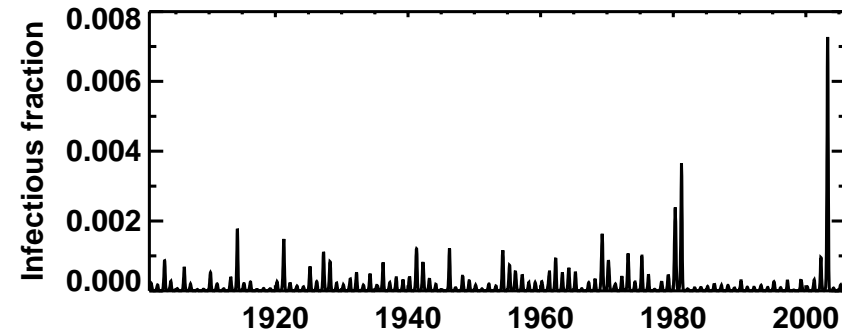
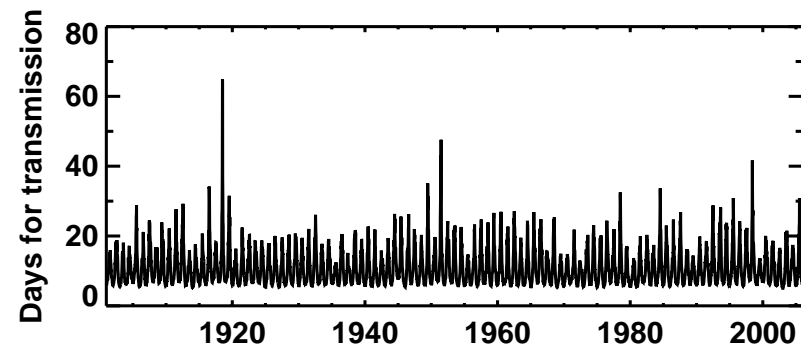
But it is more complicated than that.



If immunity lasts about 1 year



If immunity lasts about 40 years



But you still have not answered the question!

Our question:

- Can we attribute the risk of this flood/health event to greenhouse gas emissions?

What we have been addressing:

- Can we attribute changes in weather to emissions?
- Can we attribute changes in an “impact” to weather changes?

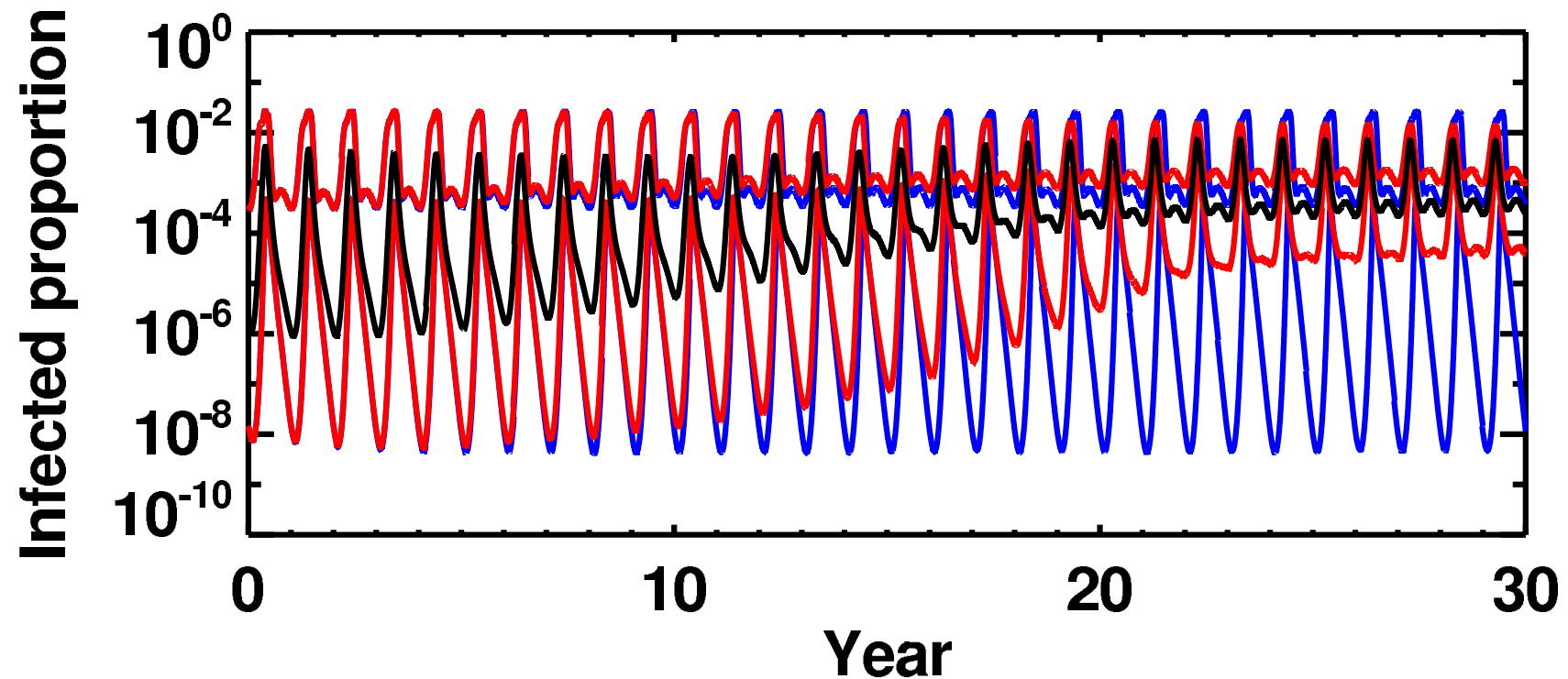
- Most impact attribution studies use this “joint” or “sequential” attribution.
- Often used in a collective (ensemble?) sense: look at lots of impacts, see if they are doing what is expected.

- But these would never satisfy a court: it depends on “expert opinion”.
 - How important is coupled, other possible causes?
 - What events are relevant for including in the collection?
 - Who is an expert?

So how should the attribution question be addressed? (the opinion of one climatologist)

- Attribute to the appropriate cause.
 - e.g. weather or emissions
- Use the appropriate reference point.
 - e.g. “non-industrial” or 20 years ago
- Include all plausible causes. - e.g. emissions, vaccination
- Model everything.
 - e.g. adaptation (the Phillip’s curve)

A very, very preliminary attempt



Measure	Ratio (5th, 95th percentiles)
$\frac{\text{GHG}_{\text{Years 21-30}}}{\text{GHG}_{\text{Years 1-10}}}$	1.18 (0.04, 1.87)
$\frac{\text{NOGHG}_{\text{Years 21-30}}}{\text{NOGHG}_{\text{Years 1-10}}}$	0.03 (-1.27, 1.39)
$\frac{\text{GHG}_{\text{Years 21-30}}}{\text{NOGHG}_{\text{Years 21-30}}}$	1.19 (0.11, 1.94)

Is this possible?

The beginning of the end of the climate change field

- Decent, useful climate modelling systems are no longer exclusive to supercomputers.
 - *climateprediction.net*, *seasonal.cpdn.net*, RegCM, PRECIS
- “Impacts” models are at or are reaching applicable levels.
 - The model does not have to be perfect, only applicable to the problem.
- Feasibility will depend on impact and location.