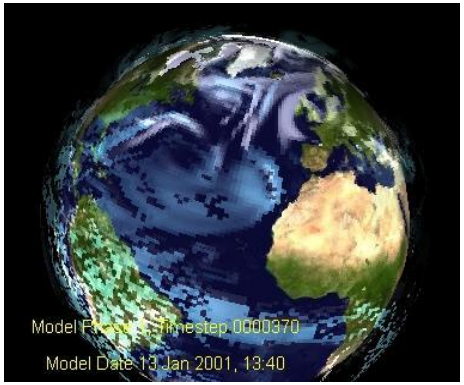
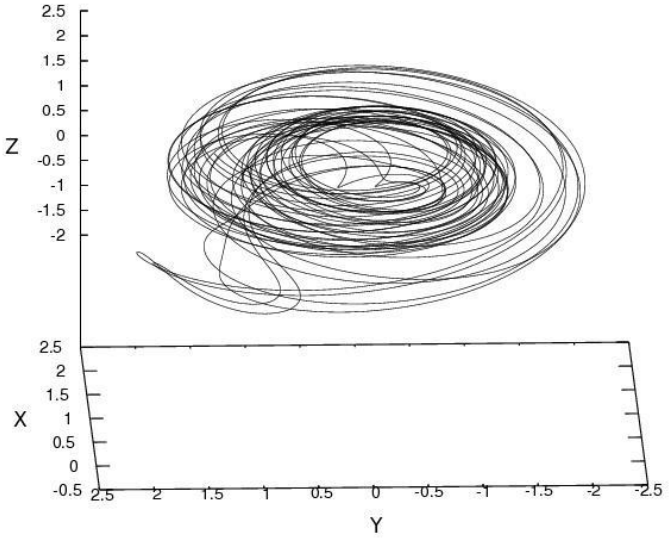
Ensembles and Uncertainty III



Dave Stainforth

Acknowledgements to: Lenny Smith, Roman Frigg, Seamus Bradley and Hailiang Du

Centre for the Analysis of Timeseries and Grantham Research Institute on Climate Change and the Environment, **London School of Economics**.



DCMIP Summer School

Boulder

1st August 2012

"I am the muskrat, [...] A philosopher you know."
"It's all a matter of thinking. I sit and think about how unnecessary everything is."
The Muskrat,
Comet in Moominland,
Tove Jansson

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Lecture 3

- When does weighting a model make sense?
- Does an increasingly realistic model provide increasingly reliable probabilities of future behaviour?
- Excluding model-versions in climateprediction.net
- Non-Floridian statisticians.

Weighting Considerations

Black: Observations

Orange: 14 models; 58 simulations

Red: Multi-model mean

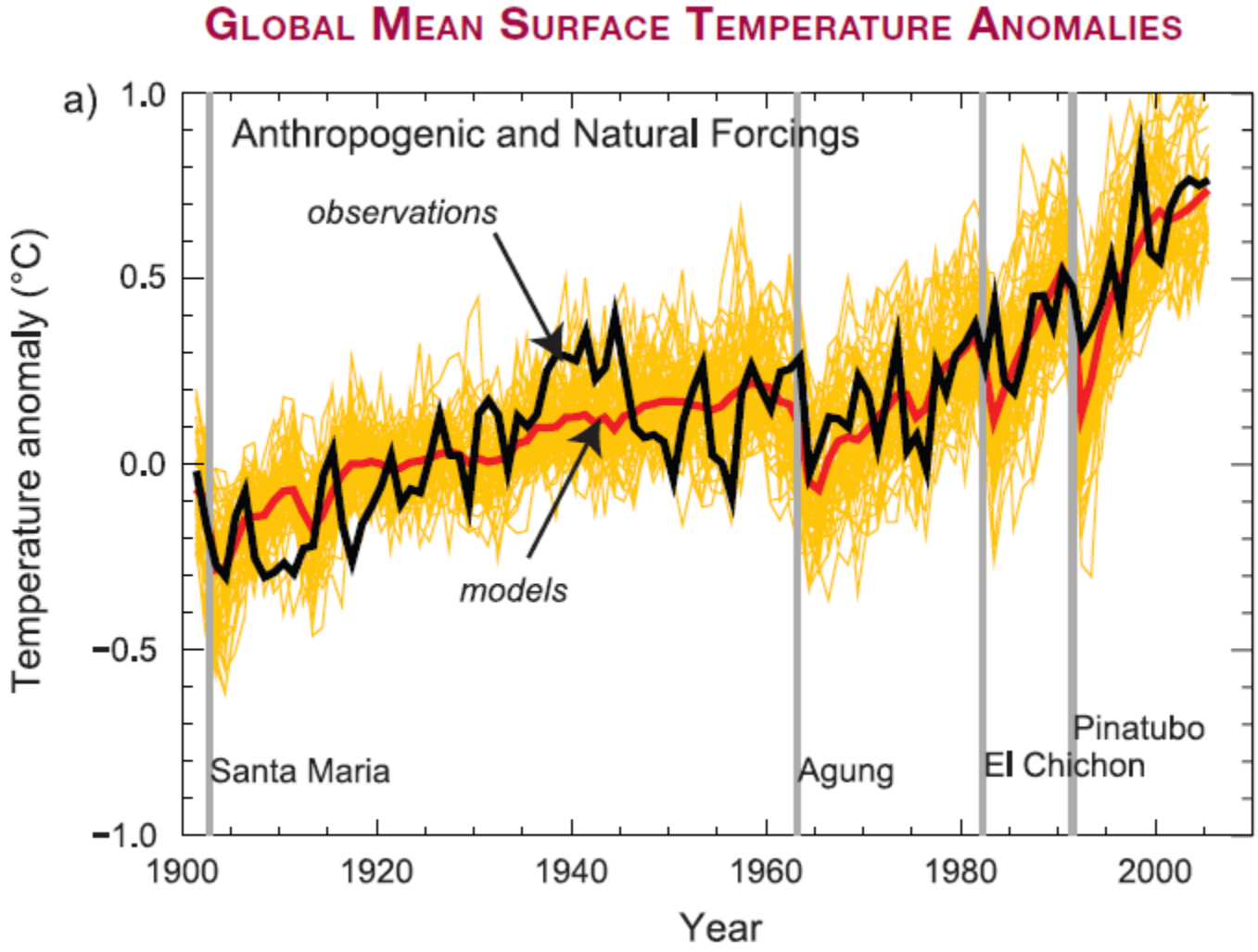
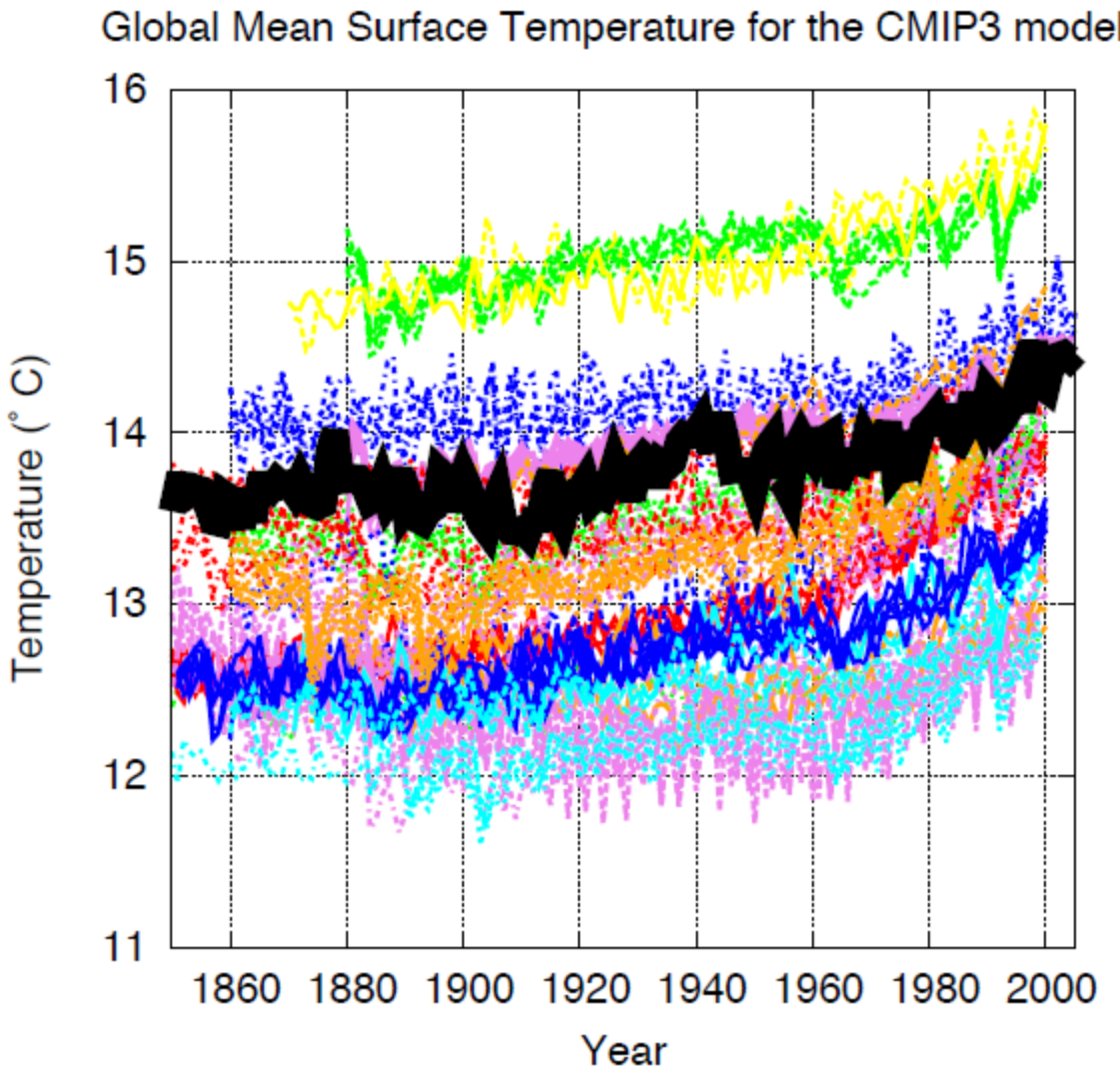


Fig 9.5 and Fig TS.23 from IPCC WG1 AR4

CMIP3 Global Mean Temperature Timeseries: 1850-2000



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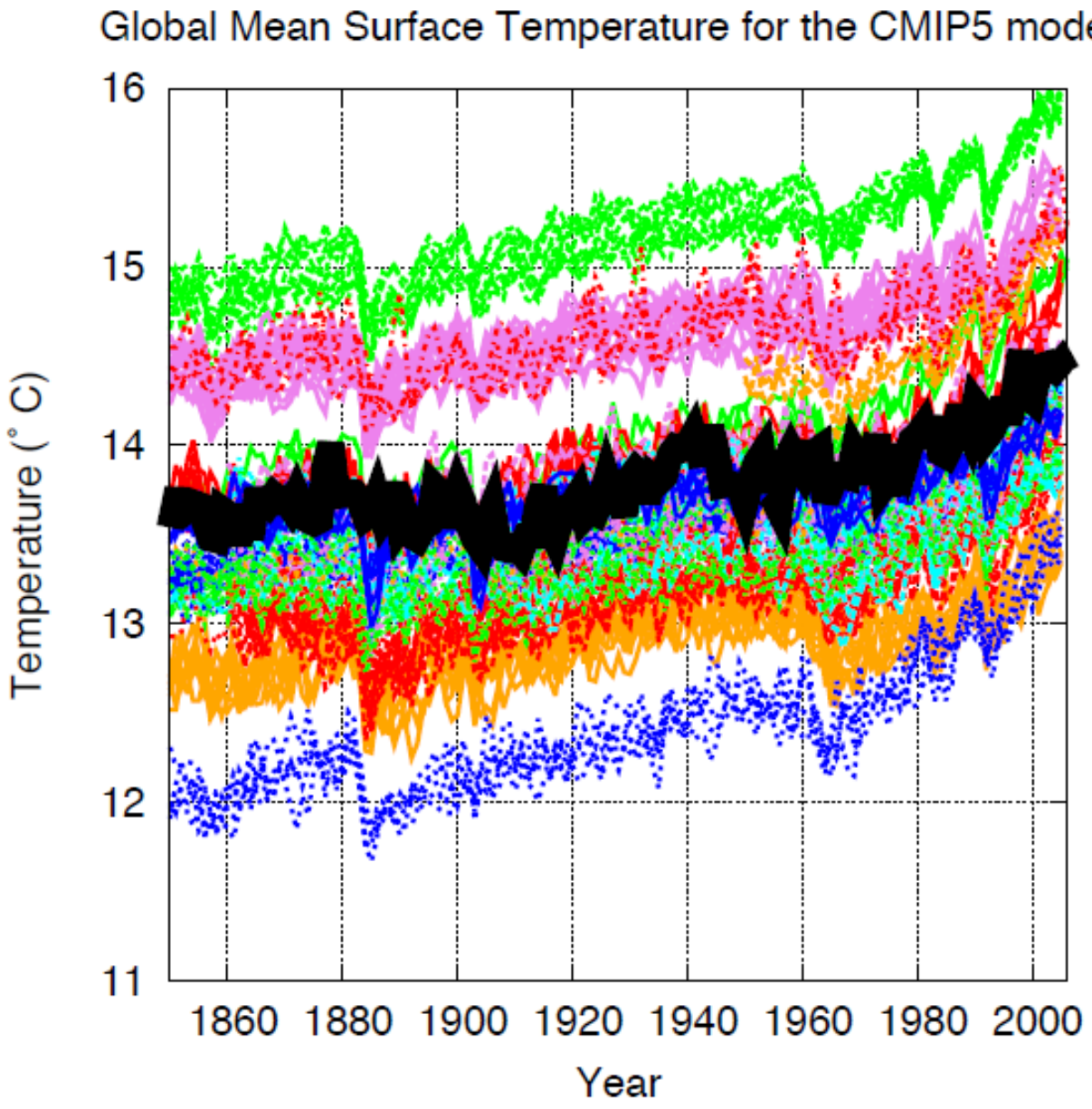


What's the aim of model improvement?

- Getting closer to our observations of interest?
- Getting closer to all observations?
- Getting closer to representing the entirety of our physical understanding.
  Regardless of whether that takes us further away from the observations.

As our models get closer to representing reality do our predictions of future climatic distributions necessarily approach probabilities of future real world behaviour?

- If a model is remarkably good at weather prediction, or of 20th century hindcasts, does that it a good model for climate prediction?

- **Time for another nonlinear systems analogy.**

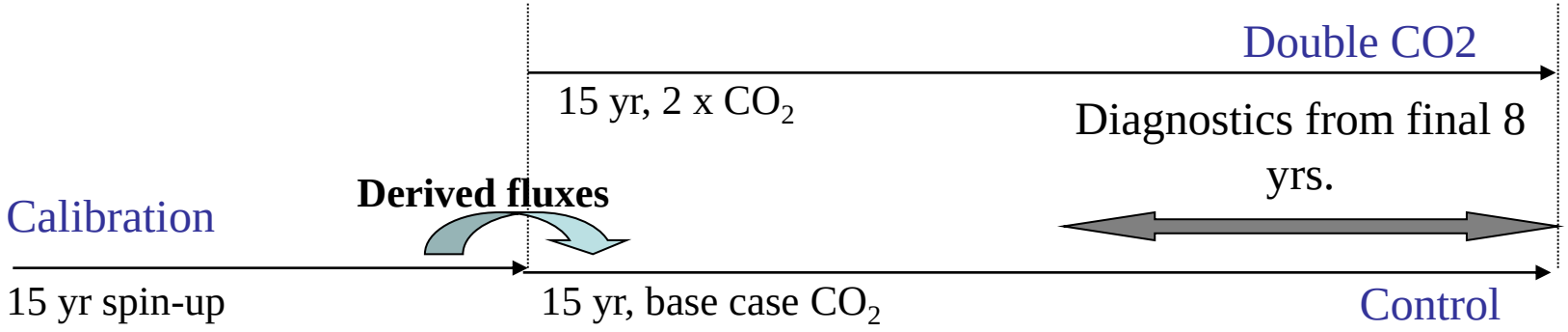
With the prospect of an almost perfect model unable to give probabilities (climatic distributions) what is the role of weighting different models by consistency with past observations?

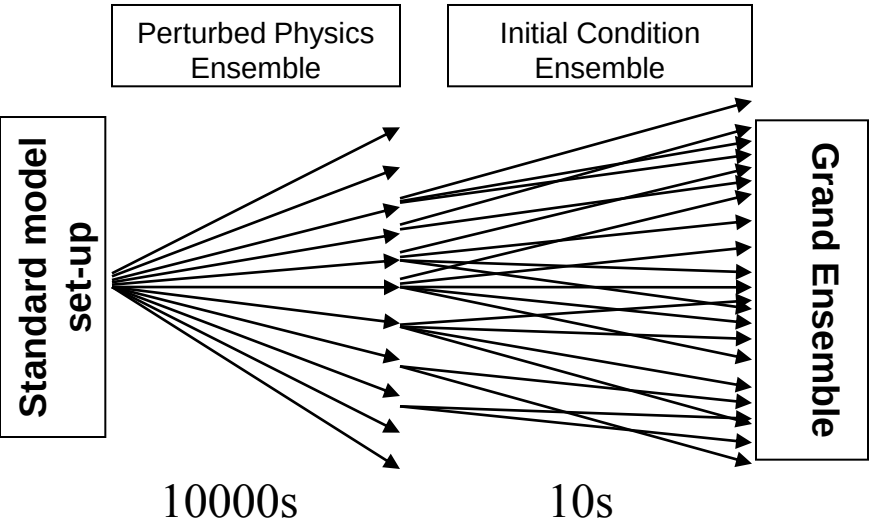
Yet there is a need to identify whether our model is suitable for a given purpose.

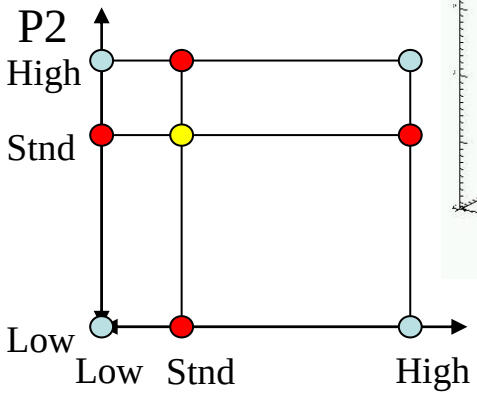
- Not weighting but exclusion.

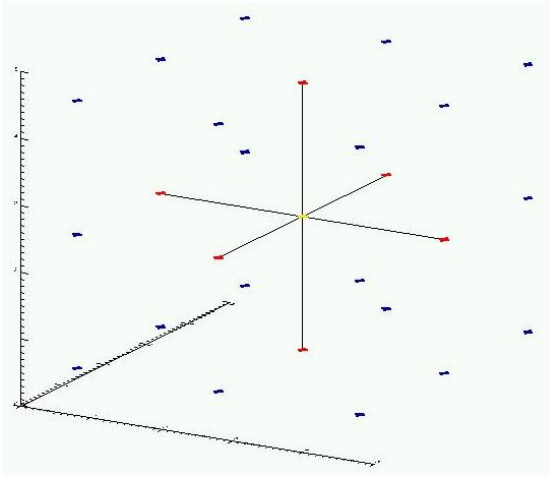
Climate*prediction*.net: The Slab Model Experiment

- Unified Model with thermodynamic ocean. (HadSM3)

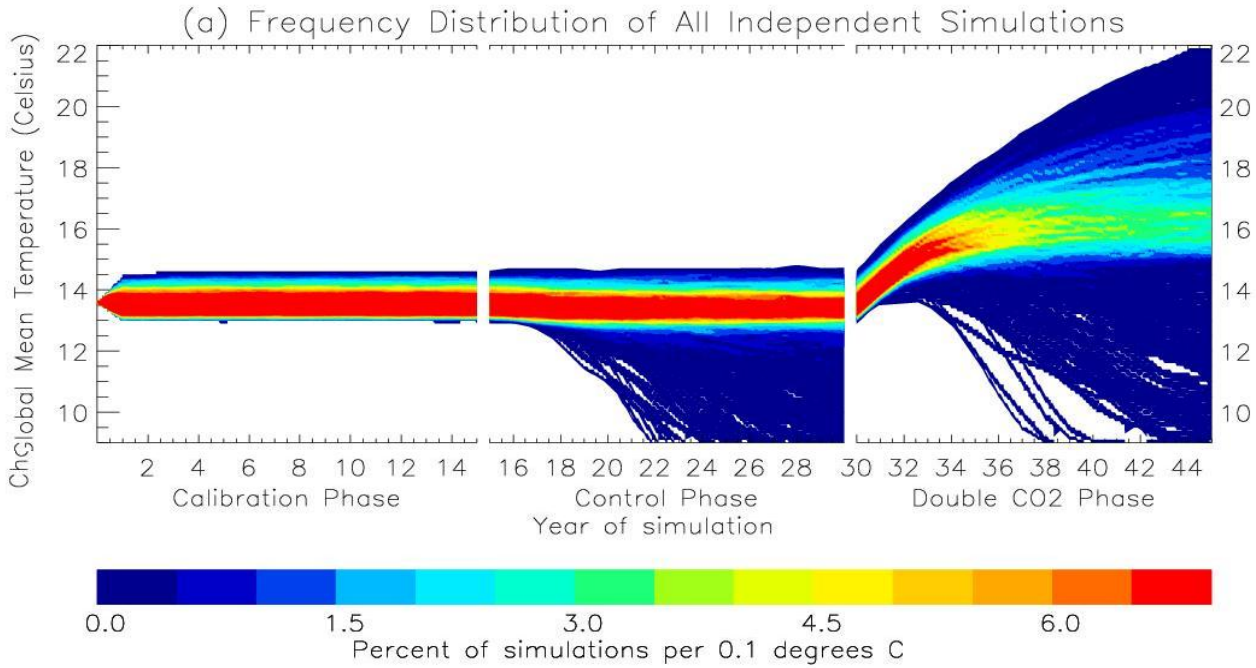






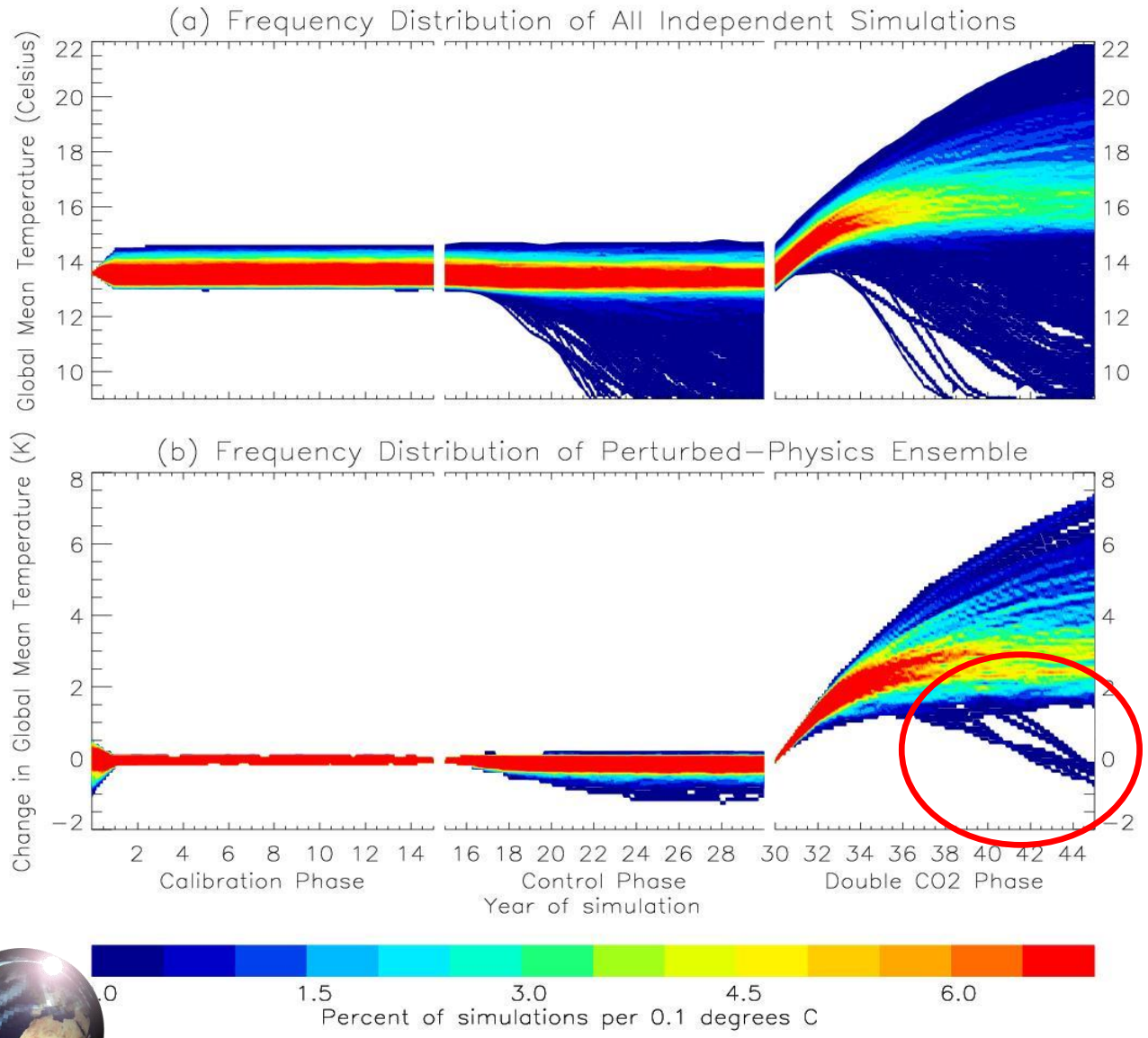


Frequency Distribution of Simulations



climate*prediction*.net

Frequency Distribution of Simulations and Model Versions

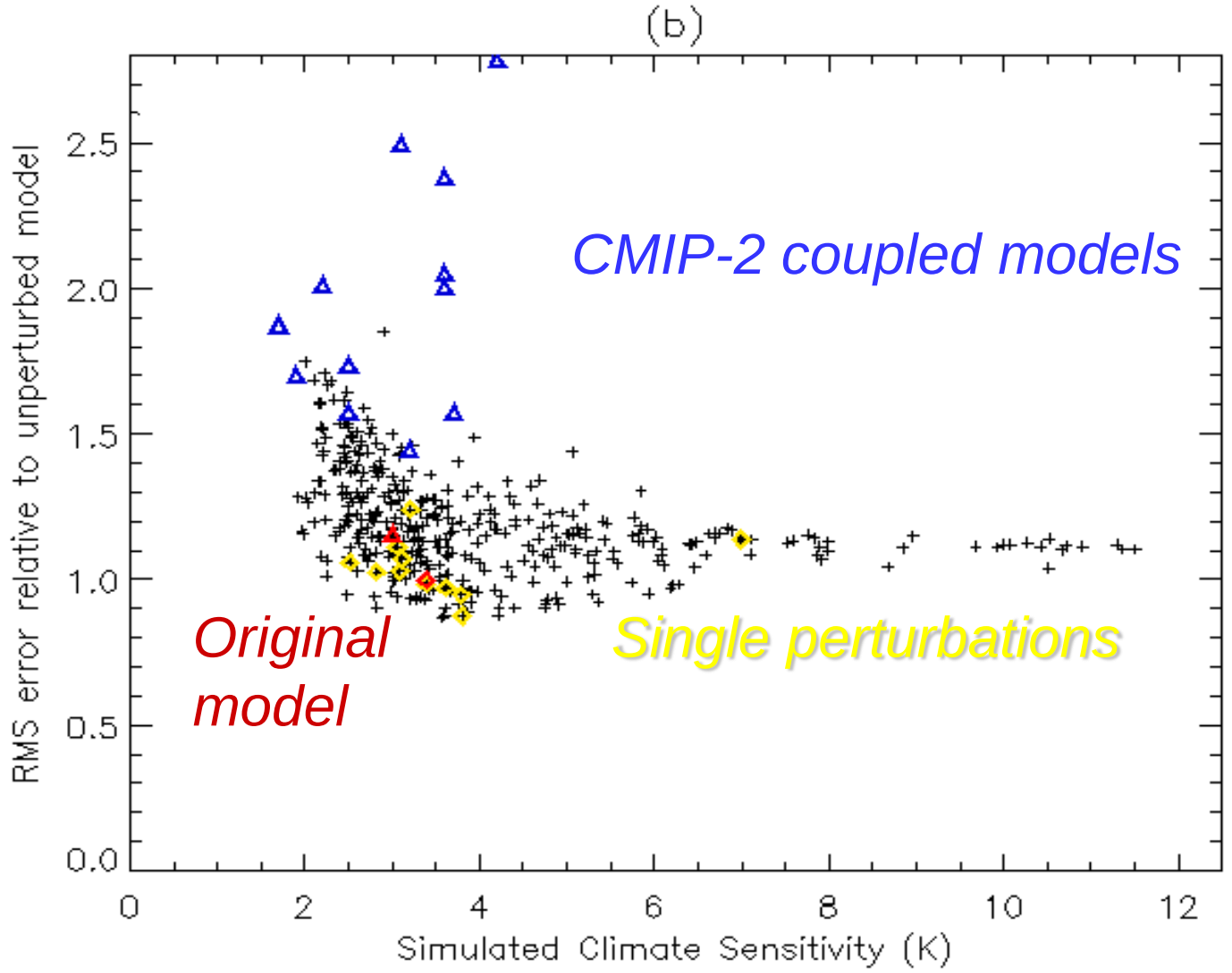


To find potentially realistic model versions we remove those which are unstable in the control.

The remaining negatively drifting $2xCO_2$ model versions are an unrealistic consequence of using a slab ocean.

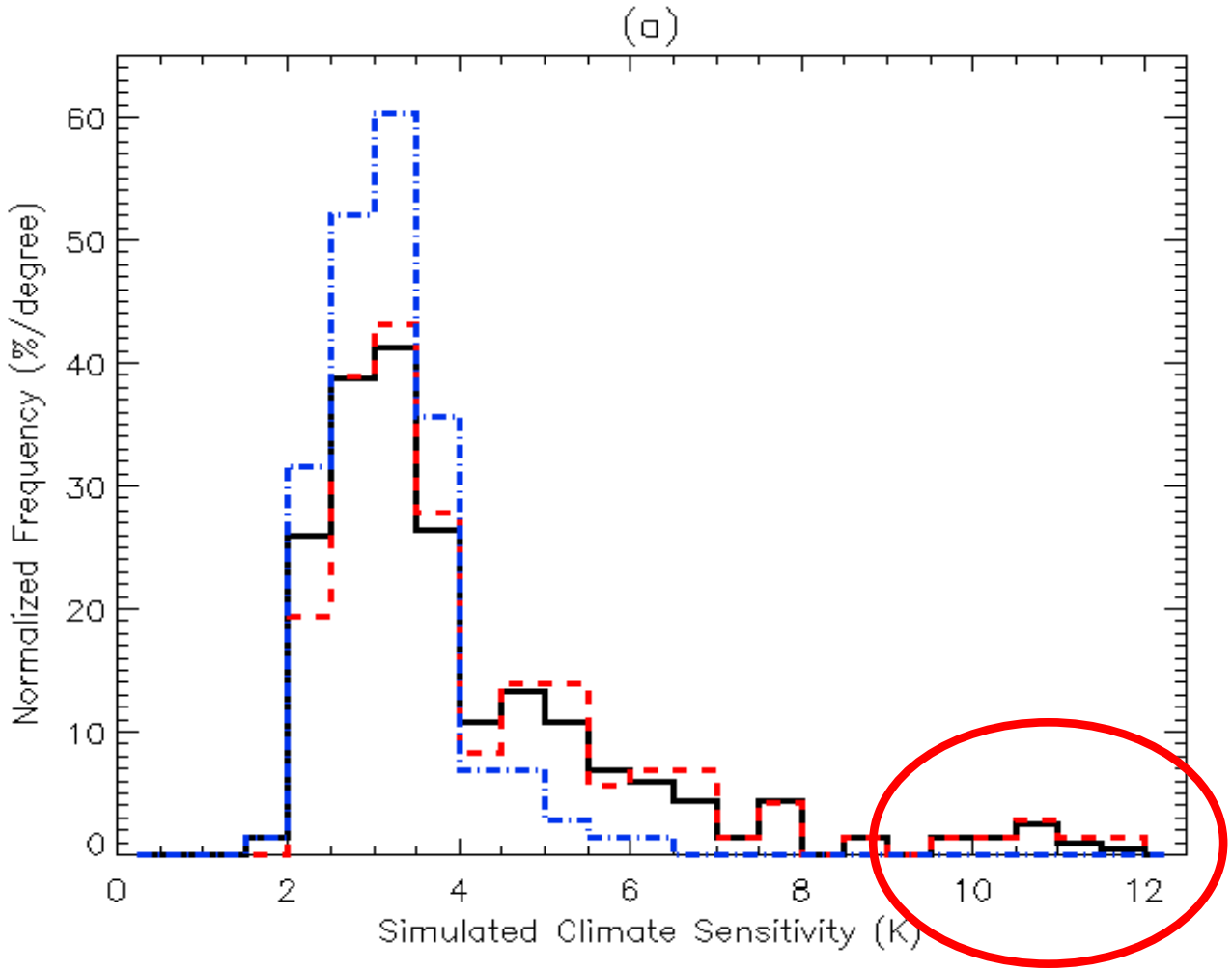
climateprediction.net

Can observations constrain the distribution?



From Stainforth et al. 2005

Weighting and Exclusion



Climate sensitivity is defined as the equilibrium global mean surface temperature change for a doubling of CO_2 levels.

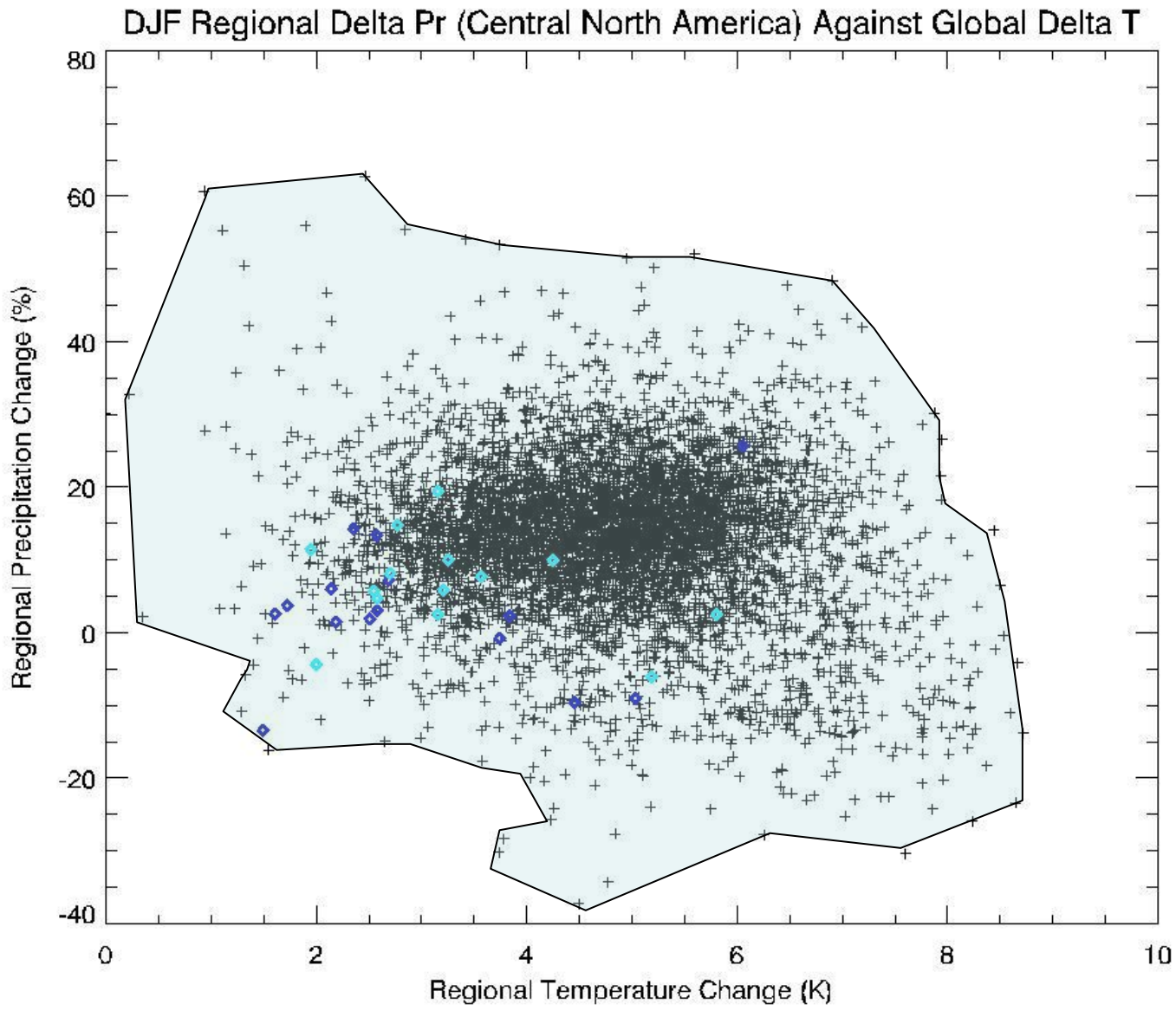
Blue: No perturbations to entrainment coefficient

Red: No perturbations to cloud to rain conversion threshold

climateprediction.net

From Stainforth et al. 2005

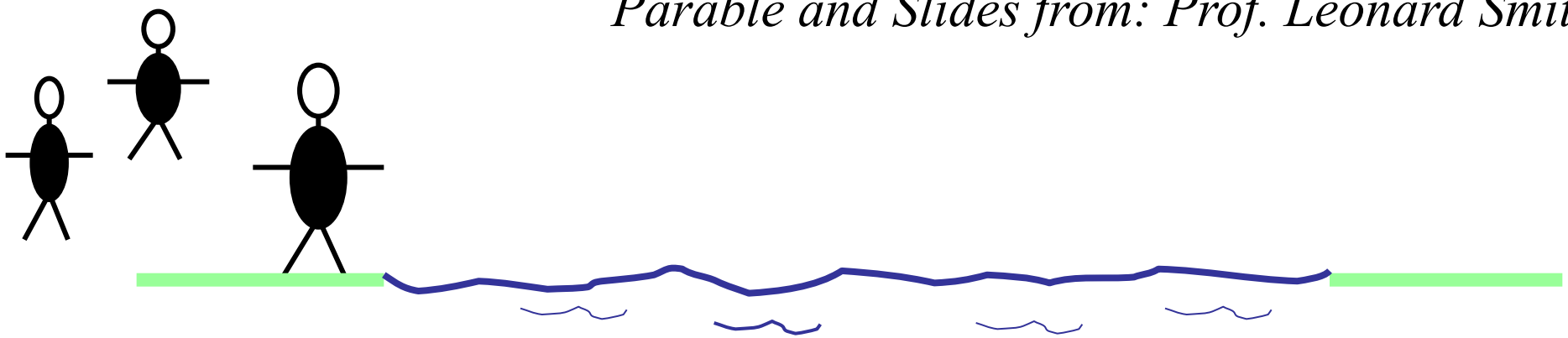
Non-discountable Envelopes: In-sample issues



So How Should We Interpret Ensembles?

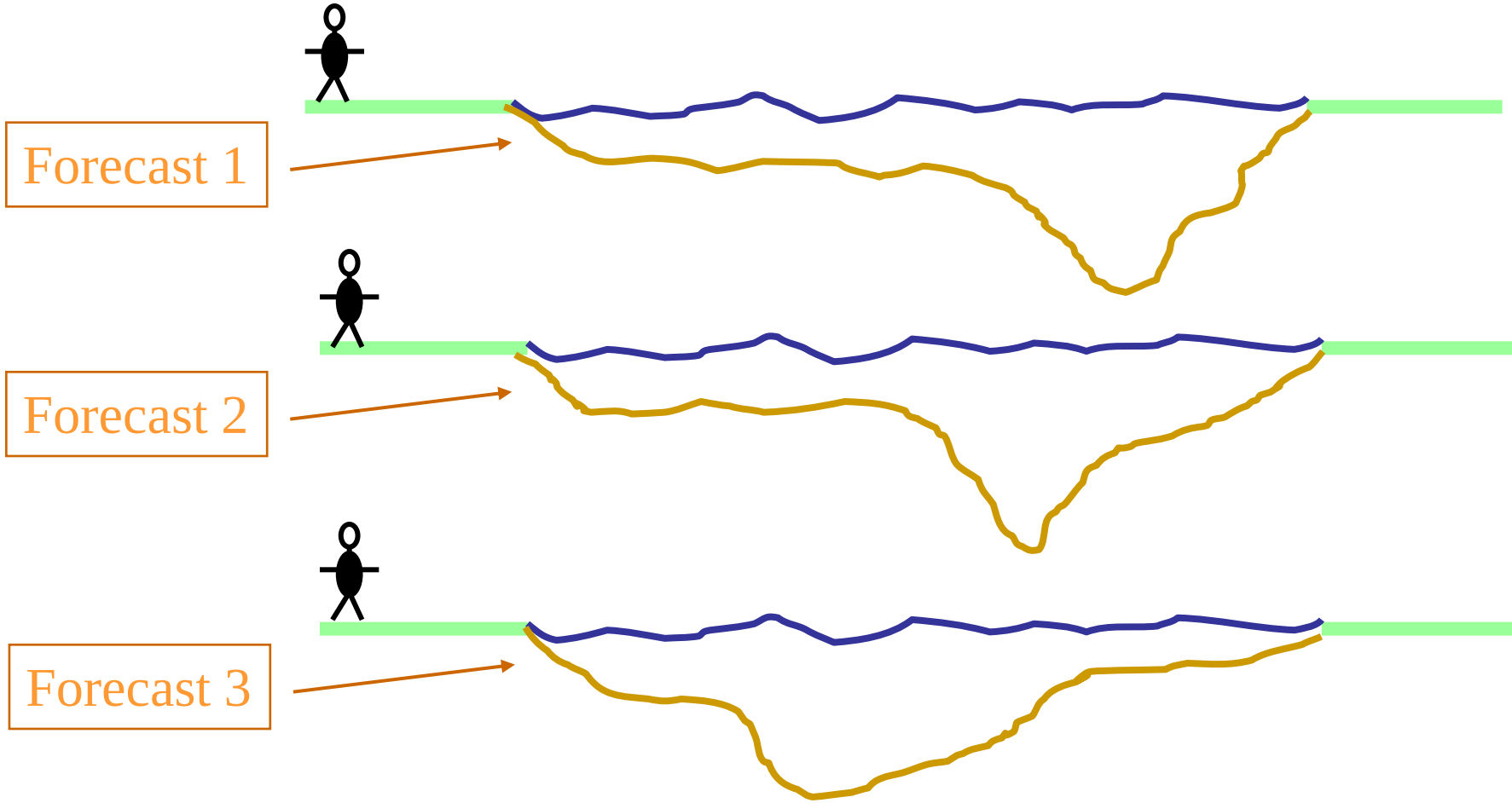
The parable of the three statisticians.

Parable and Slides from: Prof. Leonard Smith



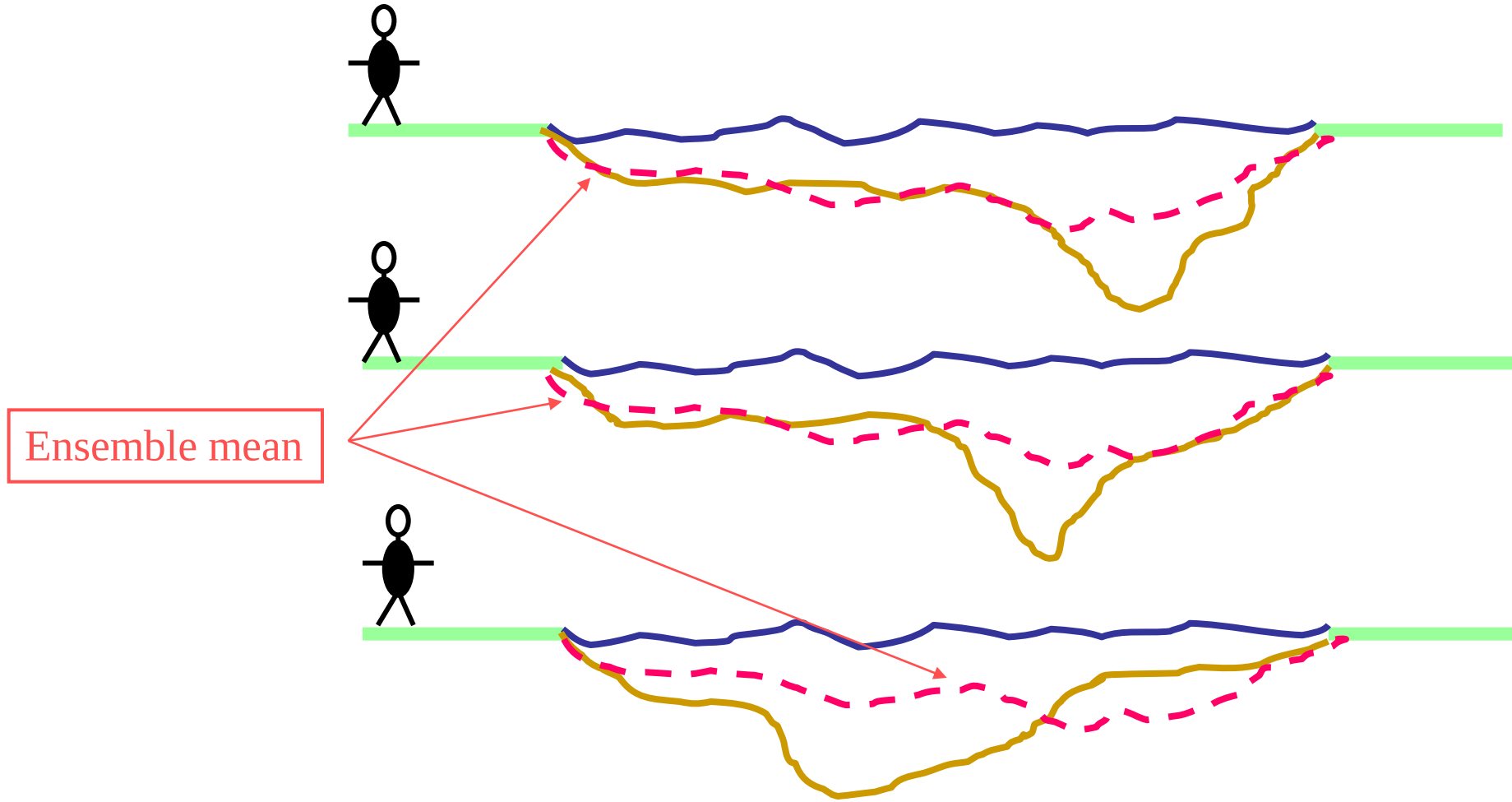
Three non-Floridian statisticians come to a river, they want to know if they can cross safely. (They cannot swim.)

Three non-Floridian statisticians wish to cross a river.
Each has a forecast of depth which indicates they will drown.



So they have an ensemble forecast,with three members

Three non-Floridian statisticians wish to cross a river.
Each has a forecast of depth which indicates they will drown.
So they average their forecasts and decide based on the ensemble mean…



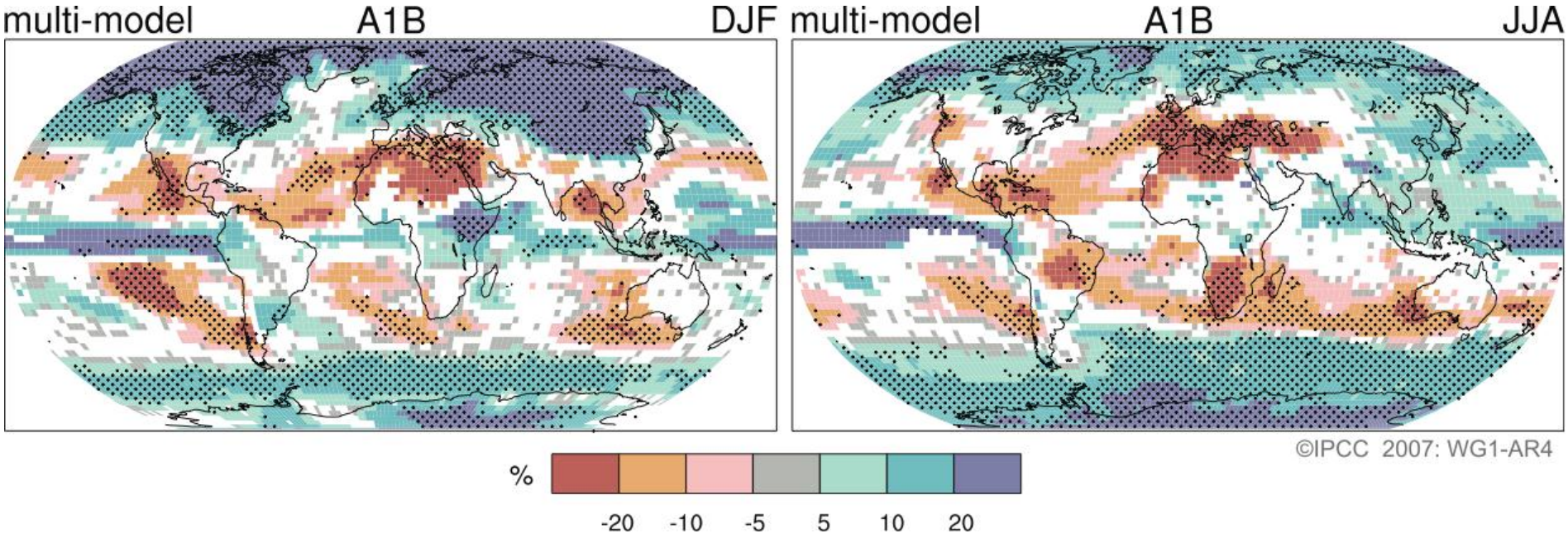
Is this a good idea?

No!

Ensembles may have lots of information, we must be careful not to destroy or discard it!

But how can we distinguish better ways of combining information-rich simulations?

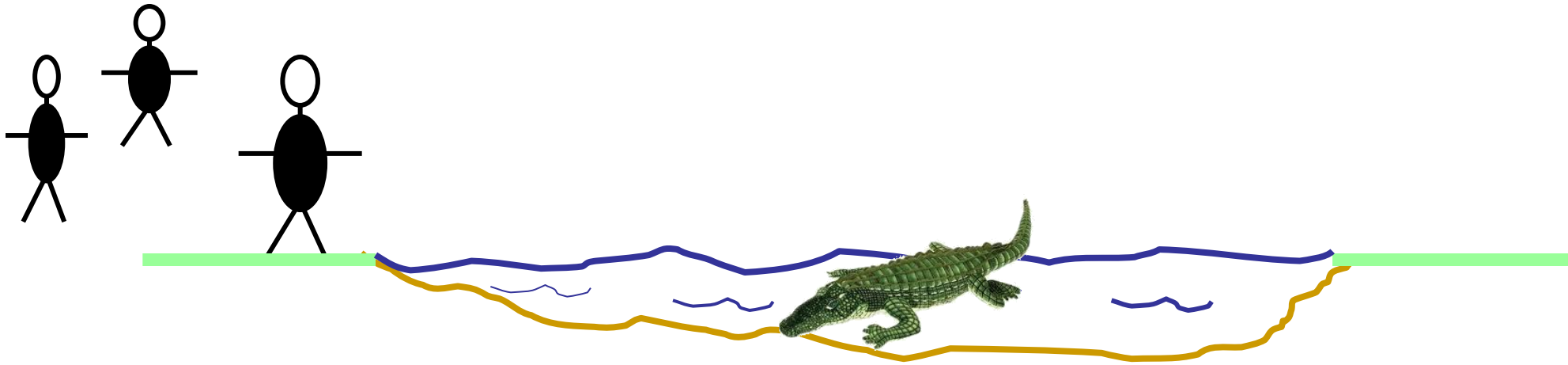
Multi-model Means



Source: IPCC AR4 WG1 Summary for Policy Makers

Figure SPM.7. *Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. **Values are multi-model averages based** on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}*

Model Inadequacy and our three non-Floridian statisticians.



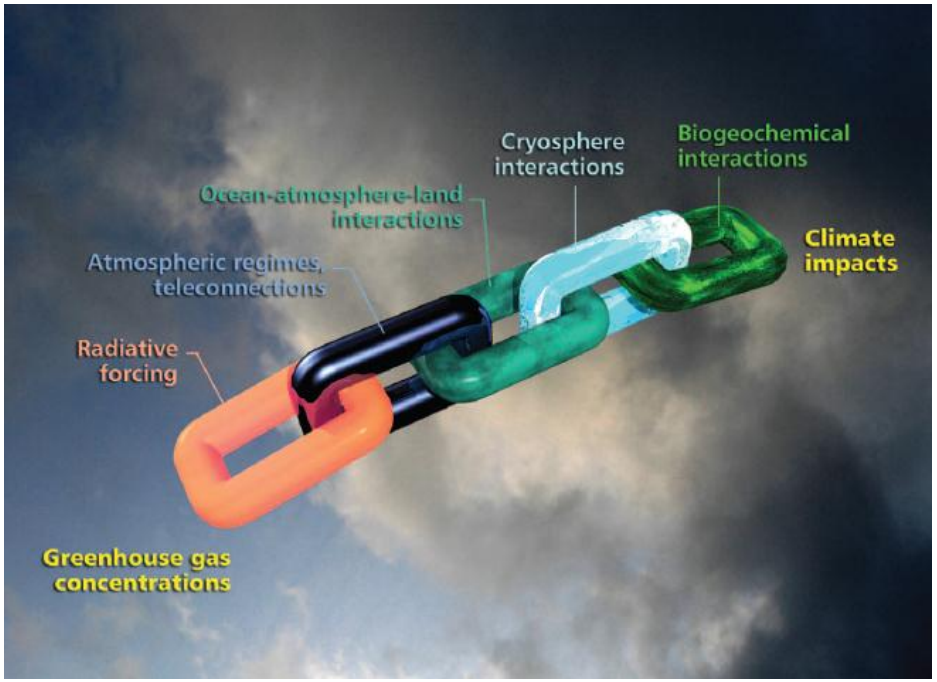
As it turns out, the river is rather shallow.

Model inadequacy covers things in the system that are not in the model. The real question was could they make it across, the depth of the river was only one component…

A Word on Seamless Forecasting

- Two interpretations of seamless forecasting:

1. The users are presented with seamless information according to their timeframe of interest. Though the source of that information may be very different on different timescales.
2. The same model should be used for climate forecasting as weather forecasting.



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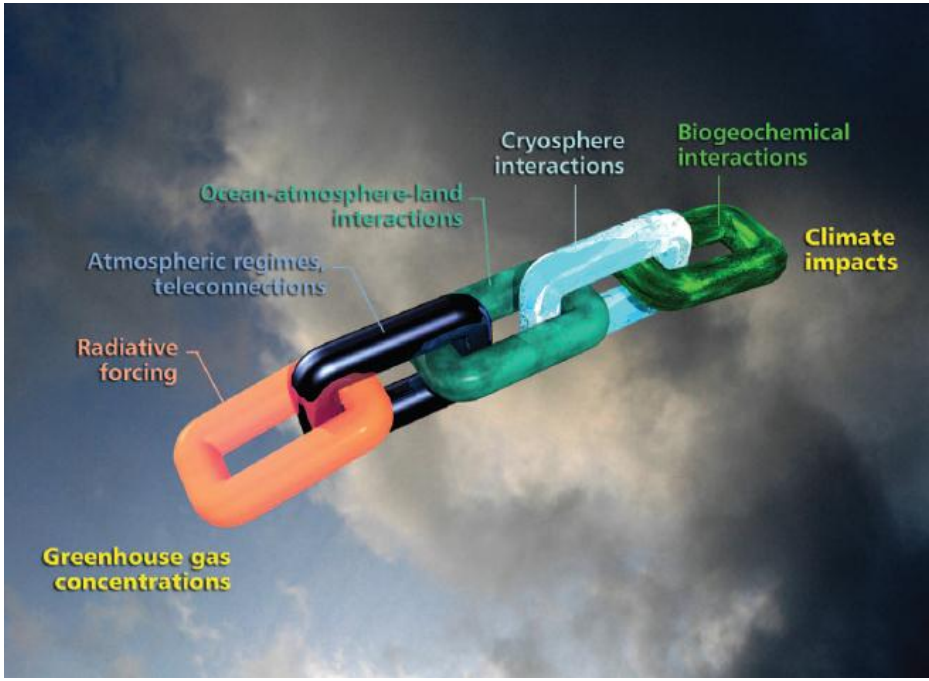
"The use of a seamless prediction system allows probabilistic projections of climate change to be constrained by validations on weather or seasonal forecast time scales."
Palmer, Doblas-Reyes, Weisheimer, Rodewell, BAMS, 2008



Climate Prediction – An Exceptionally Difficult Problem

- A problem of extrapolation:
  - Verification / confirmation is not possible.
- Model deficiencies:
  - Model inadequacy: they don't contain some processes which could have global impact. (methane clathrates, ice sheet dynamics, a stratosphere, etc.)
  - Model uncertainty: Some processes which are included are poorly represented – e.g. ENSO, diurnal cycle of tropical precipitation.
- Model interpretation:
  - Lack of model independence.
- Metrics of model quality
  - Observations are in-sample.
  - Ensembles are analysed in-sample.
  - Models which are bad in some respects may contain critical feedbacks in others.
  - Non-linear interactions: selecting on a subset of variables denies the highly non-linear nature of climatic interactions.

Remember communication can be difficult

darkest secret PAGE 27

y Telegraph

PAPER OF THE YEAR Irish Republic €1.20 No 48,173 £1.00

Met Office got it wrong over ban on flights

By Caroline Gammell
David Millward
and Bruno Waterfield

THE Met Office was blamed last night for triggering the "unnecessary" six-day closure of British airspace which has cost airlines, passengers and the economy more than £1.5billion.

The government agency was accused of using a scientific model based on "probability" rather than fact to forecast the spread of the volcanic ash cloud that made Europe a no-fly zone and ruined the plans of more than 2.5 million travellers in and out of Britain.

A senior European official said there was no clear scientific evidence behind the model, which air traffic control services used to justify the unprecedented shutdown.

Eleven major British airlines joined forces last night to publicly criticise Nats, the air traffic control centre, over the way it interpreted the Met Office's "very limited empirical data".

Legal experts suggested passengers and airlines may be able to sue the Government for more than £1billion in compensation. Flights in and out of Britain are scheduled to resume today for the first time

£1m flotilla Warships used as ferries

Britain is to spend up to £1 million using three Royal Navy ships to rescue British travellers stranded by the ash cloud, despite thousands of spaces available on cross-Channel ferries and the Eurostar.

Two carriers, HMS Ark Royal and HMS Ocean, and the landing ship HMS Albion are being sent to rescue passengers at a cost of £100,000 per ship per day.

Gordon Brown announced the mission yesterday, six days after the chaos began and despite there being nearly 60,000 spaces on ferries and trains over the next three days.

HMS Ark Royal will be on ferry duties

The Navy ships can carry only 4,000 passengers between them and run only two or three return trips to Ireland a day.

The MoD also said Ocean was awaiting a destination, Ark Royal was on exercises off Scotland and Albion was heading to Spain to pick up troops returning from Afghanistan.

Adml Lord Boyce, the former chief of the defence staff, spoke recently of the appropriate to use warships to evacuate non-military personnel. "I hope it's not the case that these ships are being used for political gain," he said.

traffic authorities should not have relied on a single source of scientific evidence before imposing the widespread ban. He suggested the no-fly zone should have been restricted to a '20 to 30-mile limit around

behind the model we are running at the moment is based on certain assumptions where we do not have clear scientific evidence," he said.

"We don't even know what density the cloud should be in

have a model that runs on mathematical projections. It is probability rather than actual things happening."

Mr Ruete said the commission had to intervene to allow airlines to make test flights in order to check the VAAC data "to help us move on from the mathematical model".

Of the 40 test flights across Europe, including a British Airways flight on Sunday, none found any evidence of ash in jet engines, windows or lubrication systems.

In a joint letter to Lord Adonis, the 11 British airlines said the official response to the volcanic eruption presented "a clear case for government compensation".

Jeff Zindani, of Forum Law solicitors, said: "Legal analysis suggests that there may be a raft of class actions brought by airlines and companies that are dependent on air travel to move their goods.

"This may well open the way for wider litigation against the Met Office and other government agencies who are found to have failed in their duty of care. The damages and legal costs could break the £1billion mark."

Andy Harrison, the chief executive of easyJet, said the

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£1m flotilla W

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