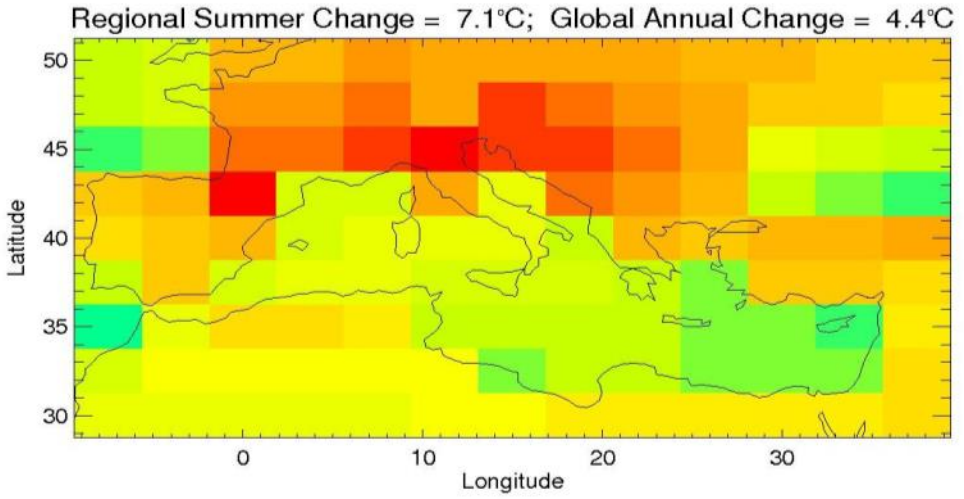
Equipping Users While Maintaining the Credibility of Science

David A Stainforth, Emma Suckling, Leonard A Smith

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

EQUIP Workshop

13th March 2013

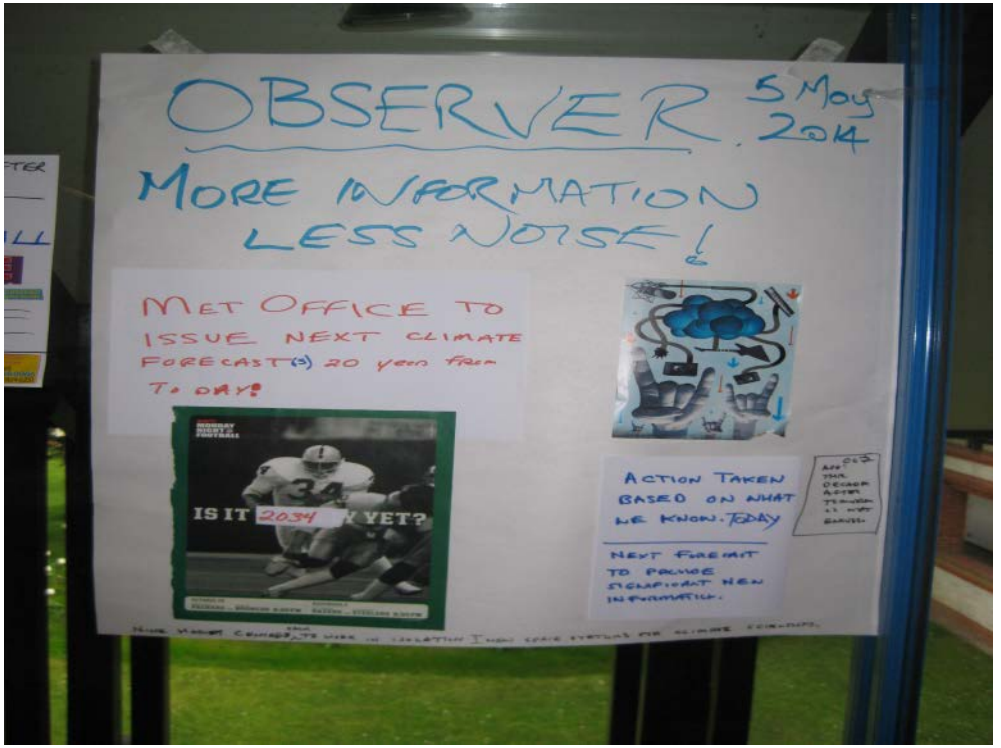


THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

EQUIP: End To End Quantification of Uncertainty for Impacts Prediction

In the beginning …

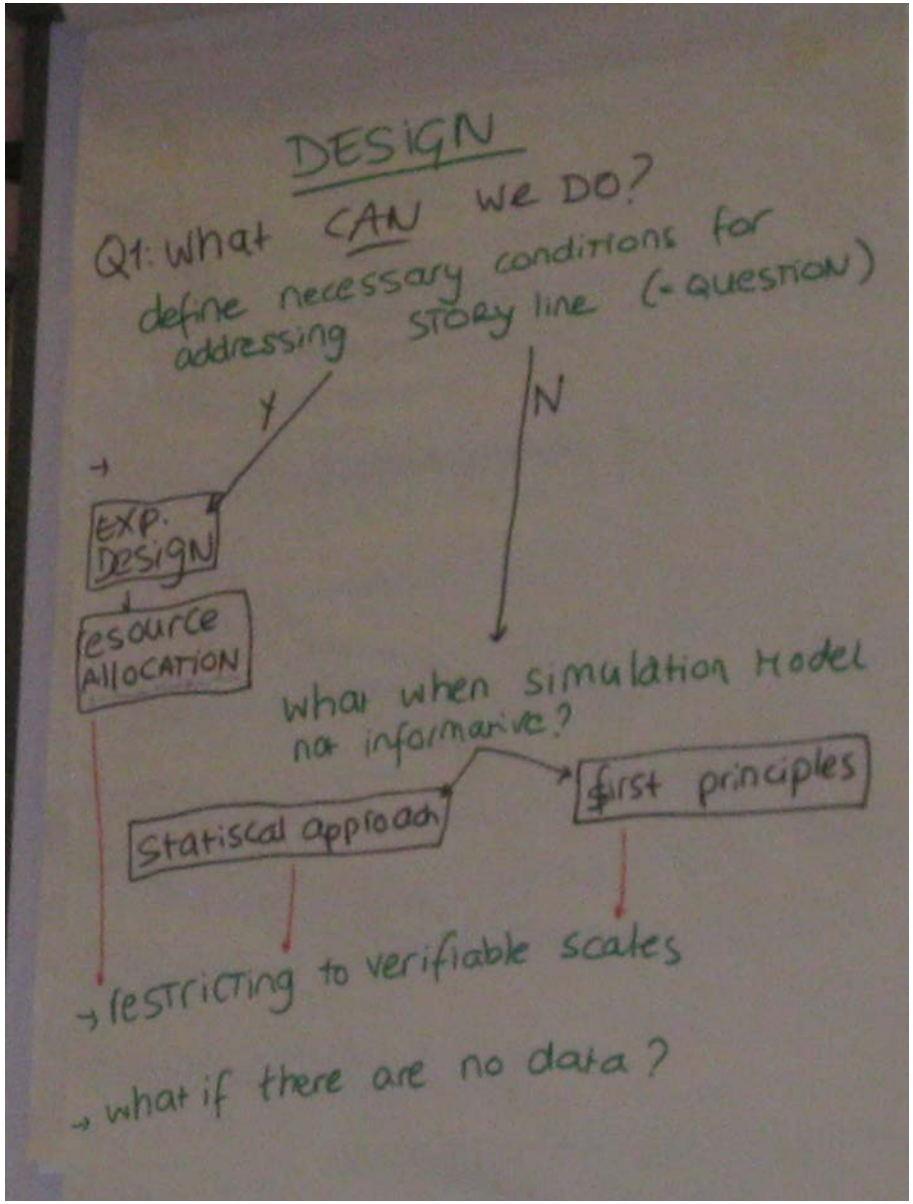

SUN!
DINOSAUR EATS PRIME MINISTER
WEATHER
Climate Forecast Latest: see p.22


OBSERVER
5 May 2014
MORE INFORMATION LESS NOISE!
MET OFFICE TO ISSUE NEXT CLIMATE FORECAST(S) 20 years from TODAY!
IS IT 2034 YET?
ACTION TAKEN BASED ON WHAT WE KNOW. TODAY
NEXT FORECAST TO PROVIDE SIGNIFICANT NEW INFORMATION.


Peter

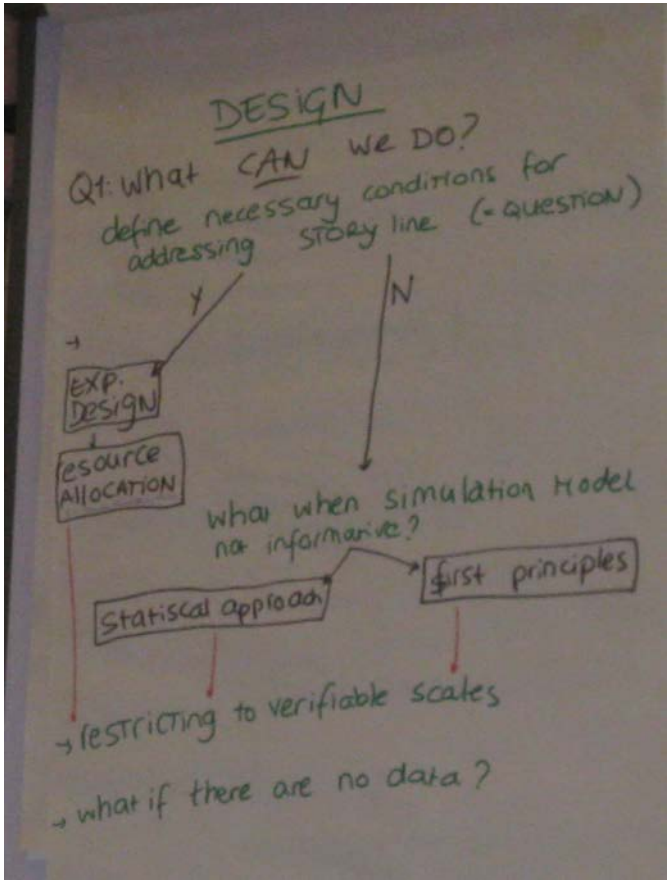
EQUIP – Question 1

EQUIP – Question 1



- What **CAN** we do?
- Define necessary conditions for addressing [the] storyline or question.

Design



Q1: What **CAN** we do?

Define necessary conditions for addressing the storyline / question.

Do today's simulation models meet those necessary conditions?

Yes

No

Experimental design

What [should we do] when simulation models [are] not informative?

Resource allocation

Statistical approaches

First principles

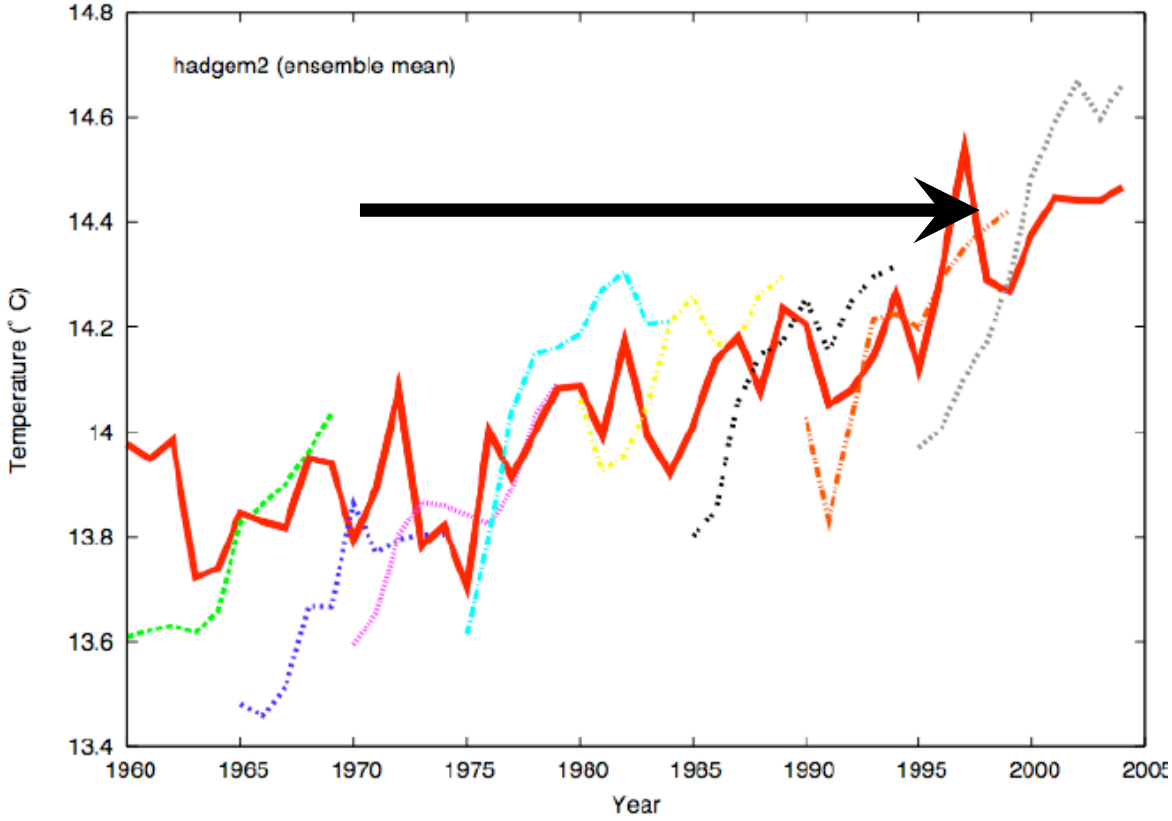
Outputs to "users?

Restricting to verifiable scales

Simulation Models .vs. Empirical Models

Empirical Models

- Model's built only on observational data.
  No inclusion of physical principles or understanding of physical processes.



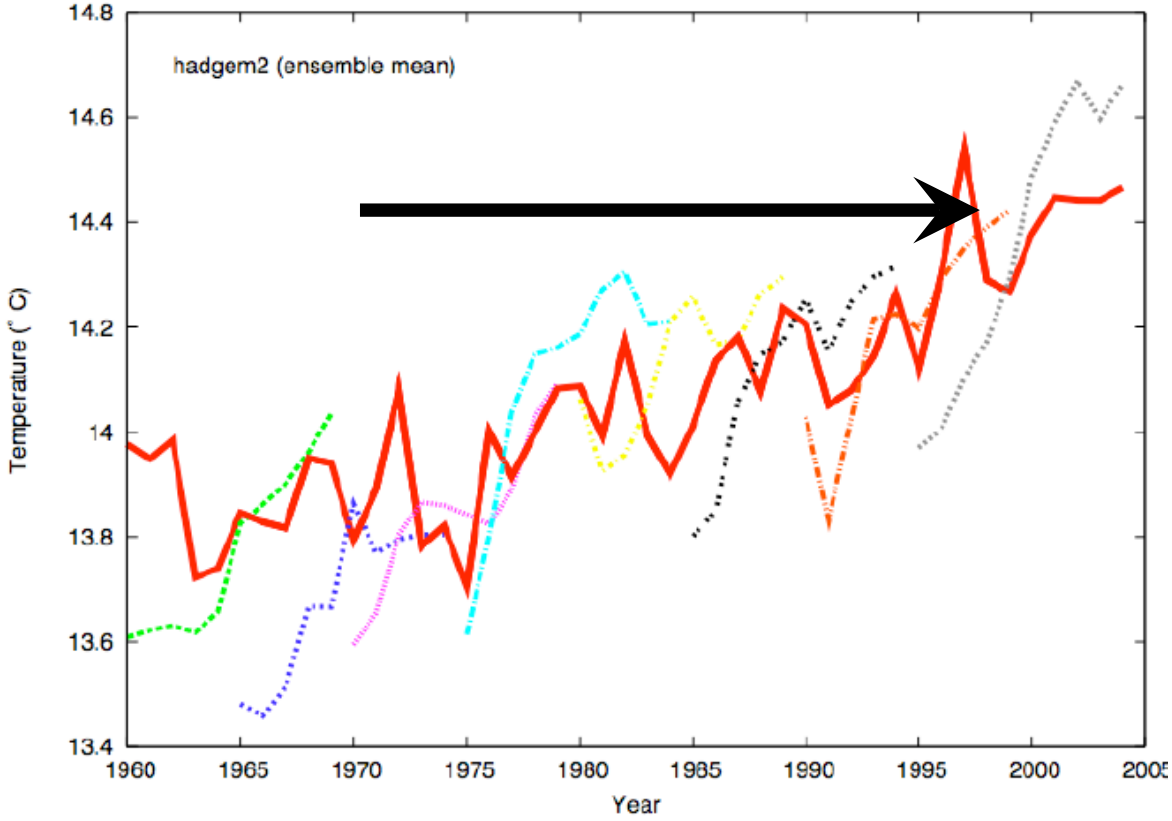
Climatology

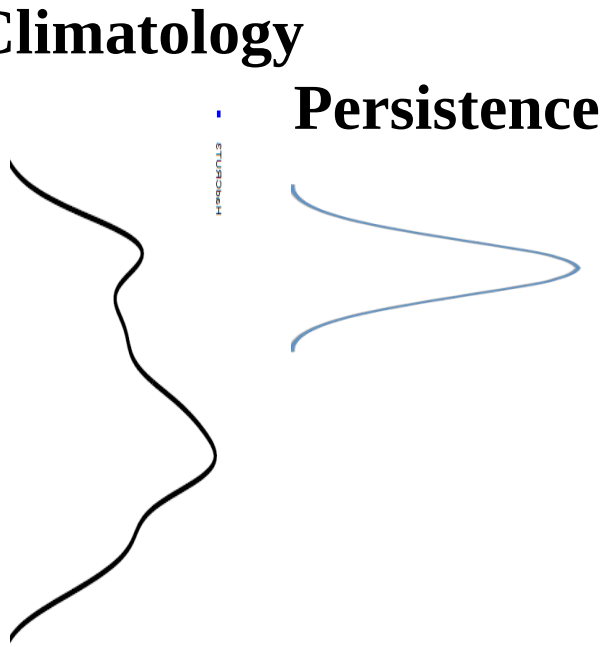
Persistence

Dynamic climatology

Empirical Models

- Model's built only on observational data.
  No (or limited) inclusion of physical principles or understanding of physical processes.

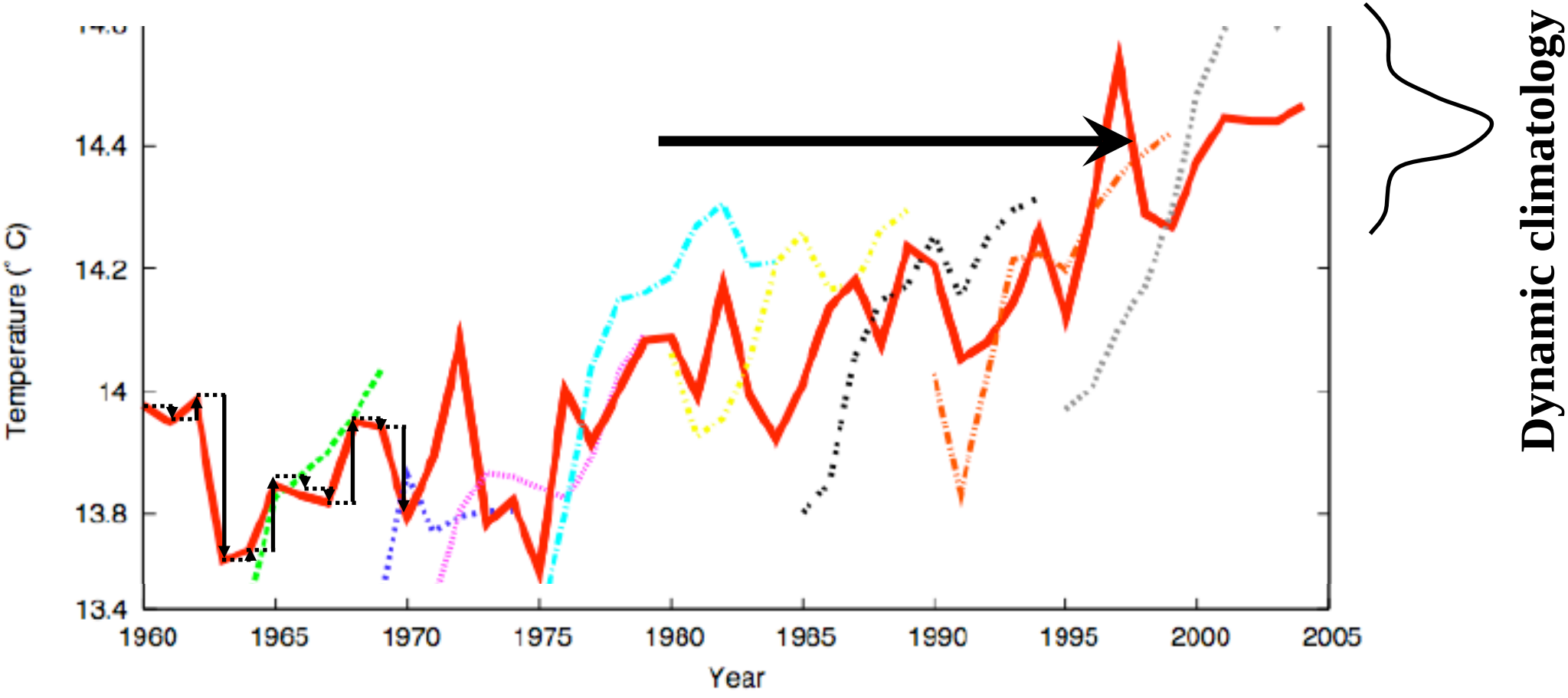




Dynamic climatology

Empirical Models

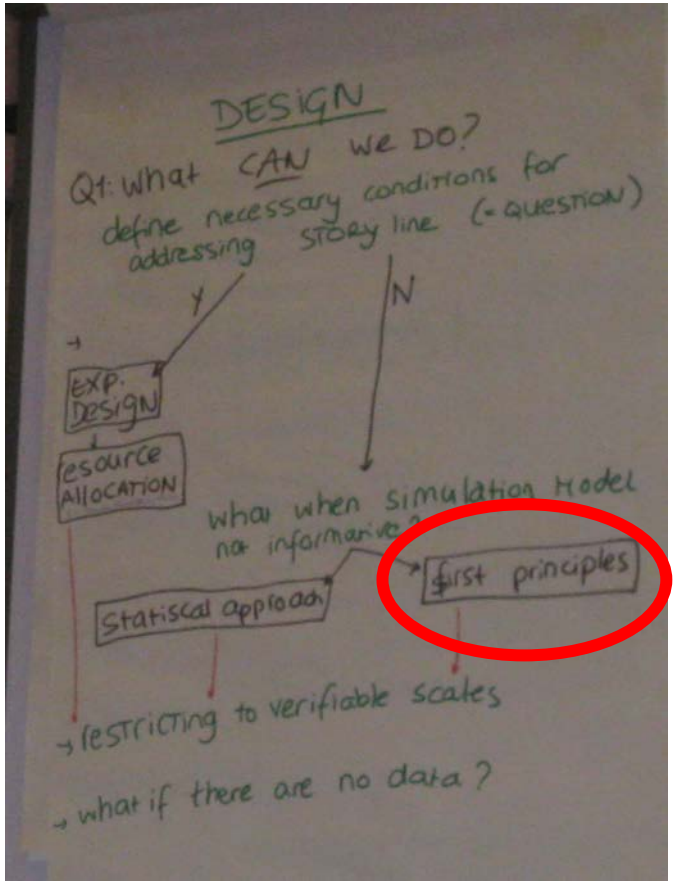
- Model's built only on data.
  No (or limited) inclusion of physical principles or understanding of physical processes.



Reliable Physics Based Models Are Particularly Desirable for Long Term (Multi-Decadal) Predictions Within a Changing Climate

- The important processes in a 2/3/4^{o}C warmer world are plausibly different to those either in a pre-industrial climate or in one which has only warmed by 0.7^{o}C.

- Hindcasts can't tell us whether those processes are reliably included in simulation models – if they are included at all.
- Thus good hindcasts should not be taken as implying reliable multi-decadal forecasts.
- But bad hindcasts are a good basis for not expecting probabilistic success in the future.



Even if they are expected to be unreliable for probability forecasts in the long term, simulation models can nevertheless help provide user-relevant scientific guidance.

What constitutes “bad”?

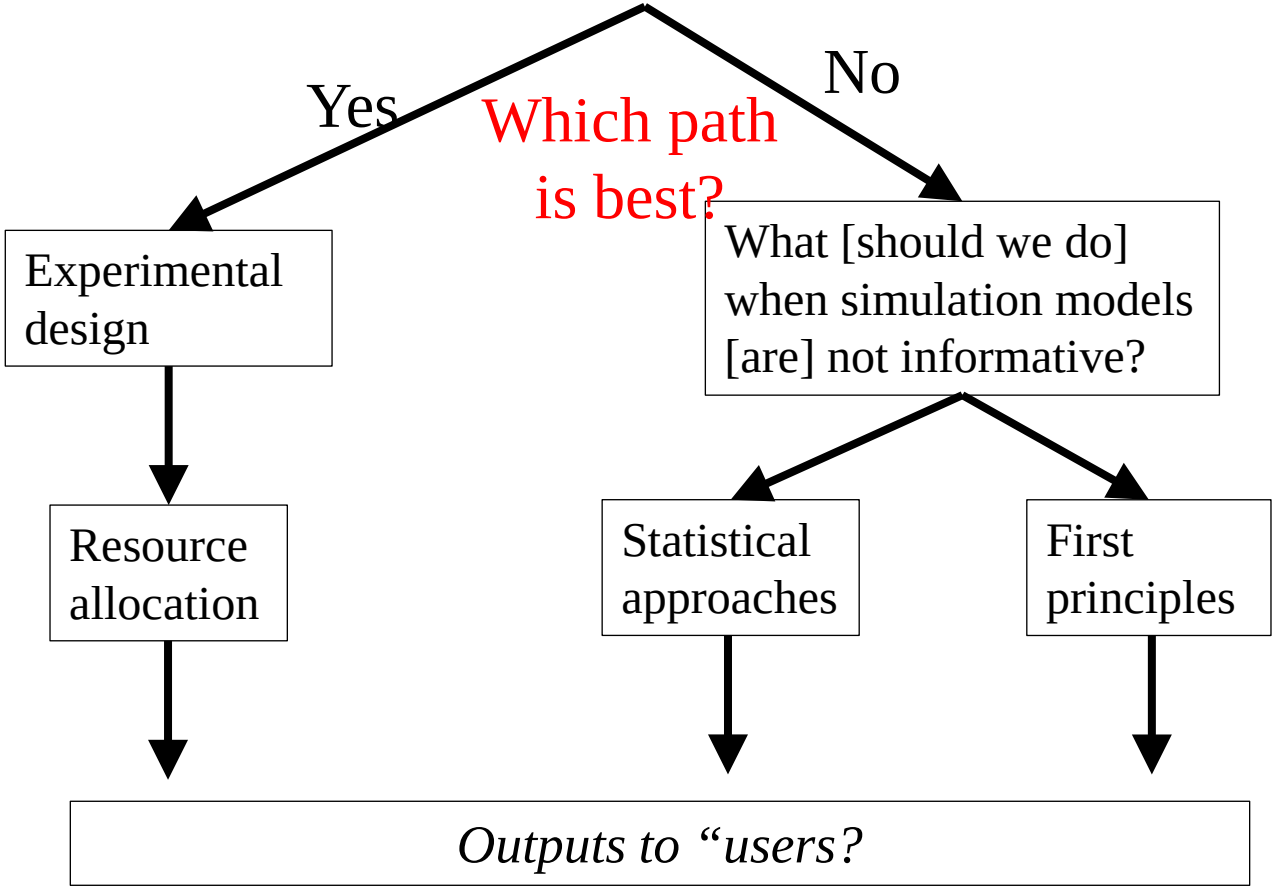
- Bad hindcasts are a good basis for not expecting probabilistic success in the future.

Design

- When empirical models provide better hindcasts, the simulation models aren't adding value *(in terms of probabilistic forecasts)*.
  - This for the timescales under which they are tested as well as longer timescales.

- This provides a tool for assessing when simulation models become the appropriate tool for providing forecasts to users.

Q1: What **CAN** we do?
Define necessary conditions for addressing the storyline / question.
Do our today's models meet those necessary conditions?

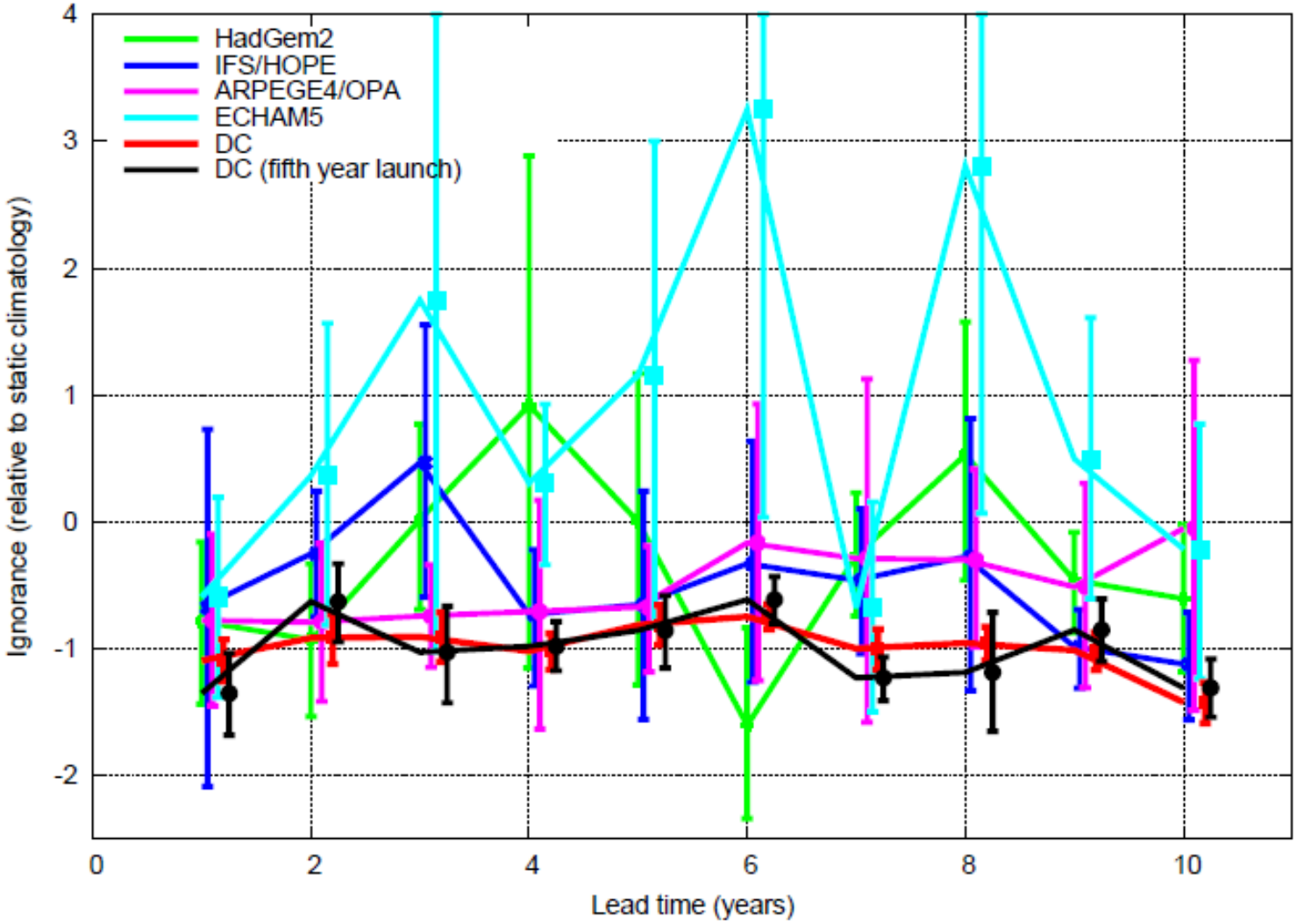


Restricting to verifiable scales

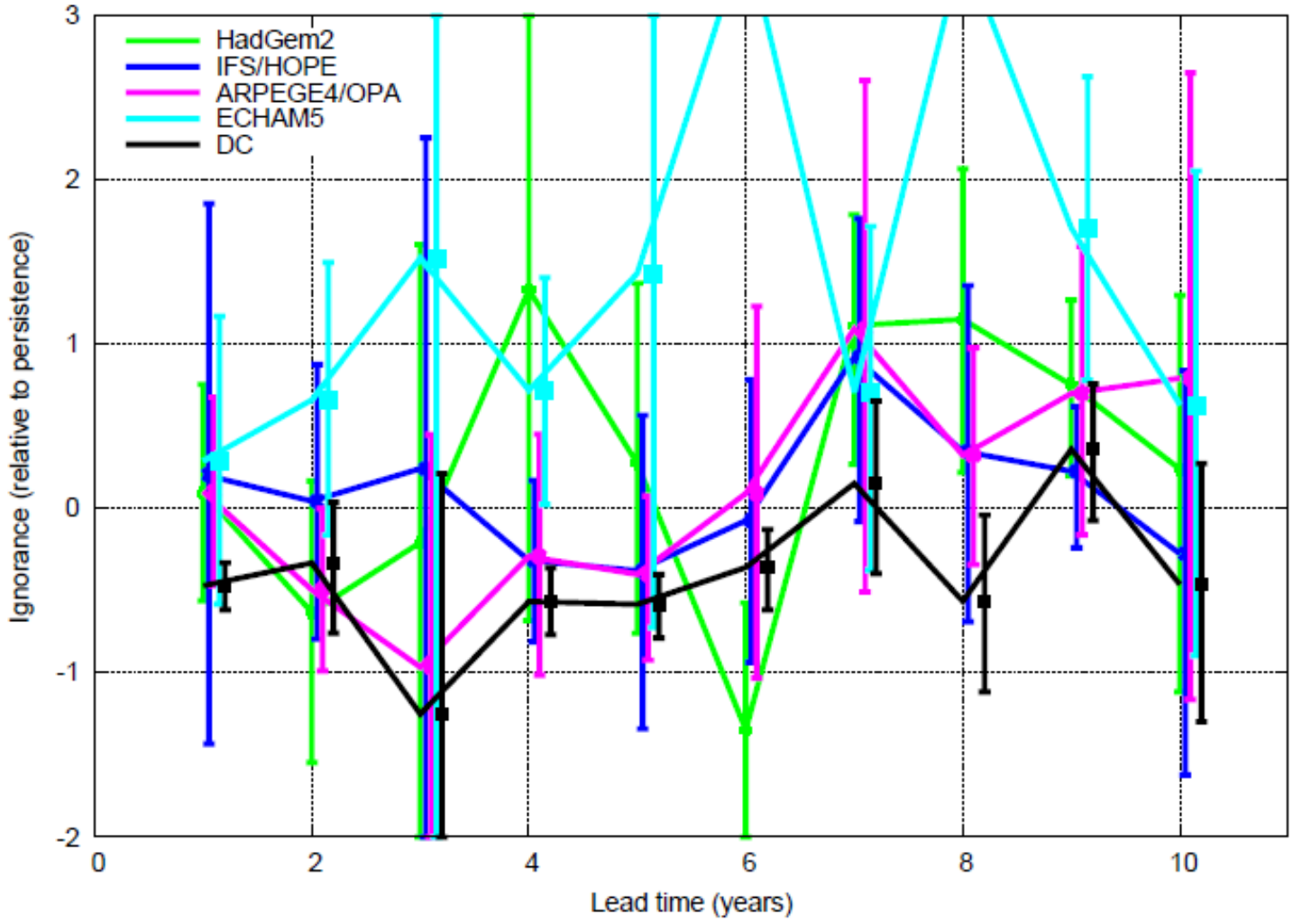
Evaluating Skill and Relevance

- Verification / confirmation / extrapolation
- In-sample v.s. out-of-sample
- Skill Scores: Ignorance, relative ignorance

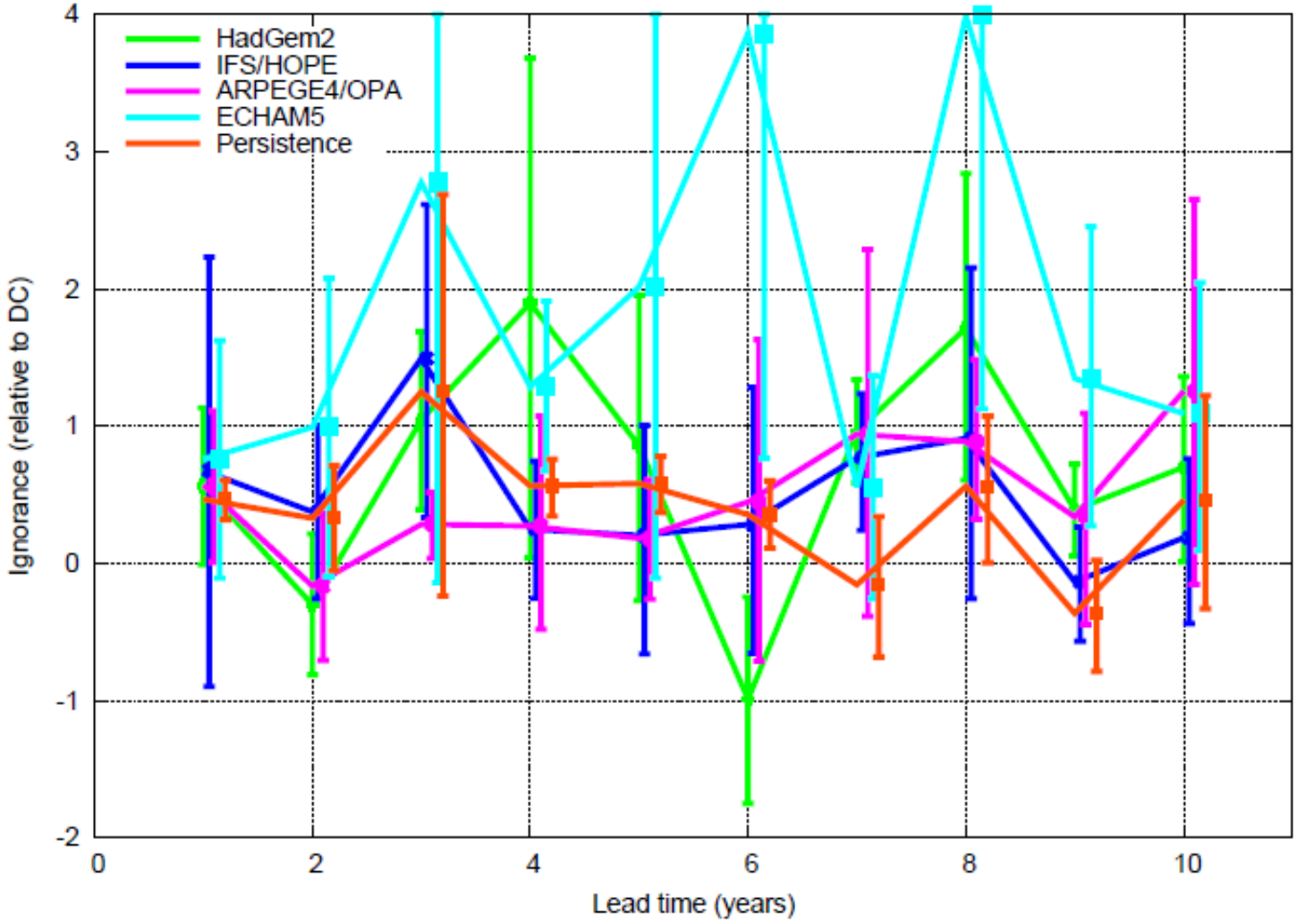
Relative to Climatology



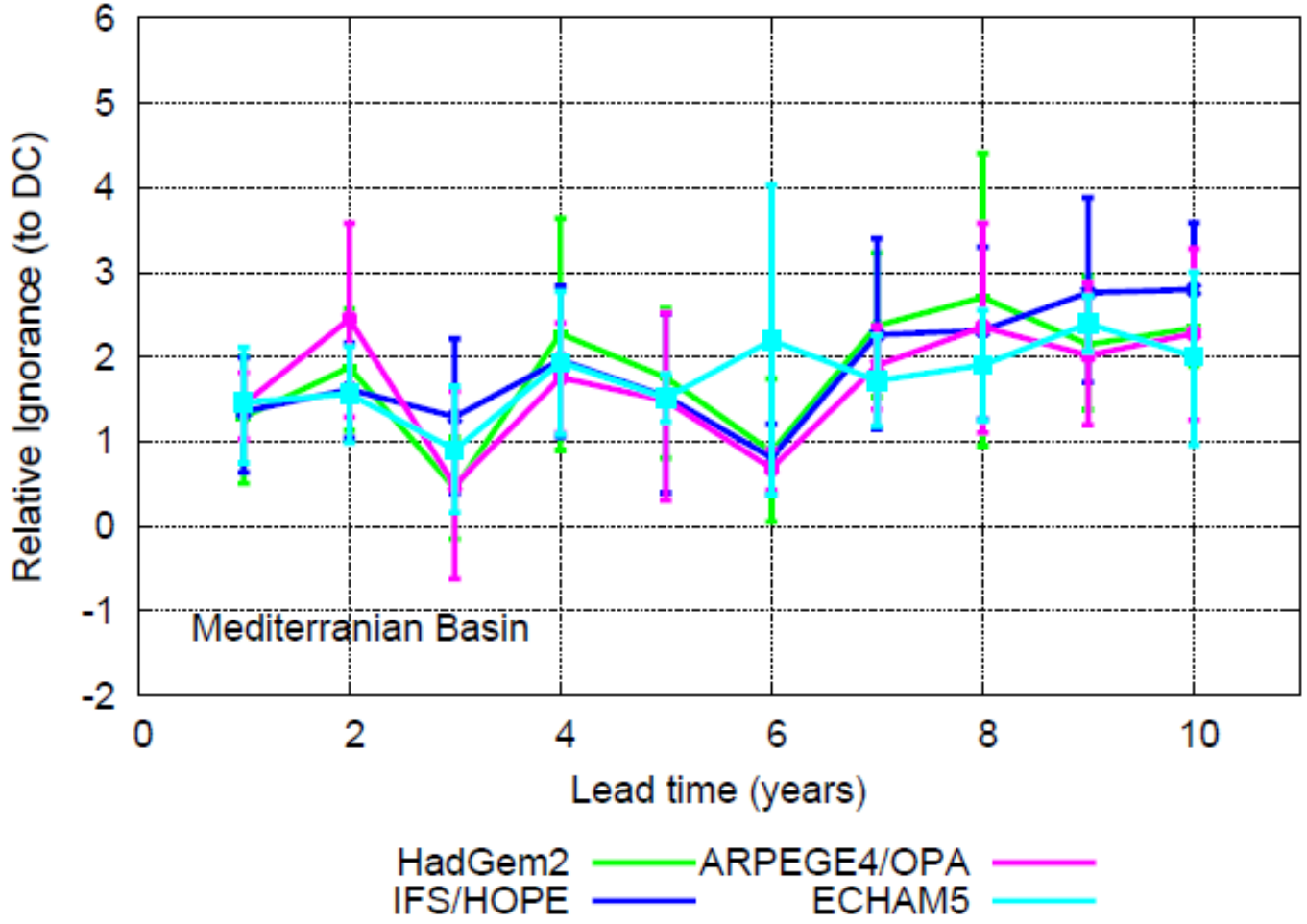
Relative to Persistence



Relative to Dynamic Climatology



It’s also the case for Regional Mean Temperatures



Empirical models versus Simulation Models

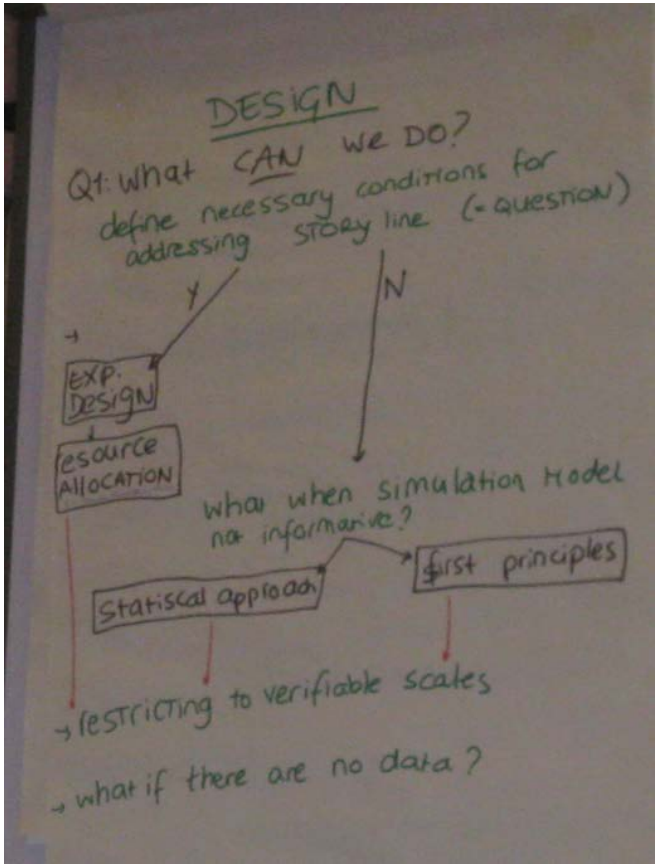
- A **good simulation model** is better than **a limited set of observations**, even under a stationary climate, because it provides extra data, improving the statistical representation in the forecast. Even more so in non-stationary climates.
- If a simple empirical model based on a **limited set** of observations, provides **as good a hindcas**t as the simulation model then the ***physics within the simulation model*** provides no added value (for that prediction problem).
- If the simulation model provides a worse forecast, then the simulation model is downgrading the information from the observations.

- On **decadal timescales** this is the case for **global mean temperature**.

Scales and Necessary Conditions
"Define necessary conditions for addressing storyline"

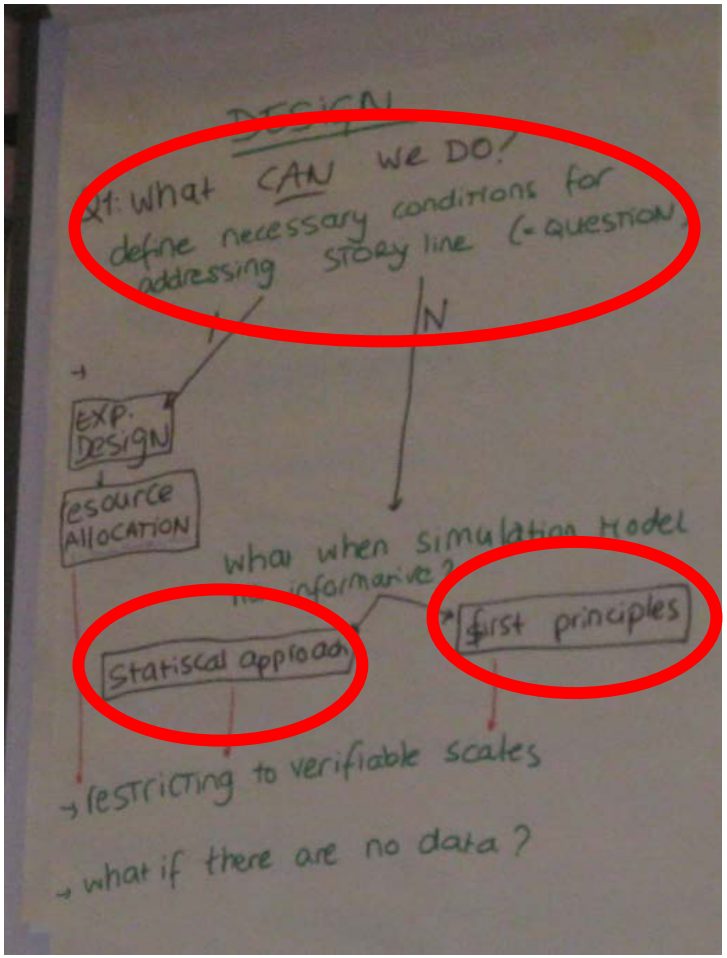
- If simulation models can't get global mean temperatures (regional mean temperatures?) better than an empirical model then is it plausible that local / regional / user-specific quantities can be reliably, probabilistically predicted?

- A: It's dependent on the timescale of the forecast.
  Weather timescales - yes.
  Seasonal timescales - yes?
  Decadal timescales - seems unlikely
  Multidecadal - surely not



Equiping Users While Maintaining the Credibility of Science

- Maintain a wide variety of approaches.
- Don’t treat GCMs as probabilistic prediction tools until they can at least show benefits against simple empirical models.
- An increased focus on scientific plausibility. Physically plausible stories / tales of the future.
- Avoid raising expectations of reliable probability forecasts.



Discussion