Probability and uncertainty: two concepts to be expanded in meteorology

by Anders Persson

I.1: -Why probabilities??

-Why all this talk about uncertainty and probabilities?

– The computer forecasts have never been so accurate!

Why is forecast uncertainty an issue today?

- The **increasing forecast quality** has made people more motivated to use weather forecasts
- An increasing emphasis and interest in **extreme weather**, and less predictable high impact events
- The emergence of **over-detailed deterministic forecasts** which misleads the decision makers
- **A world-wide *change in attitude* among economists, politicians and scientists**

Using probabilities*) will turn a disadvantage into an advantage

for the public (better decisions)

and

for meteorologists (our expertise)

***) or uncertainty information in any way**

I.1.1 Why isn’t the traditional deterministic NWP enough?

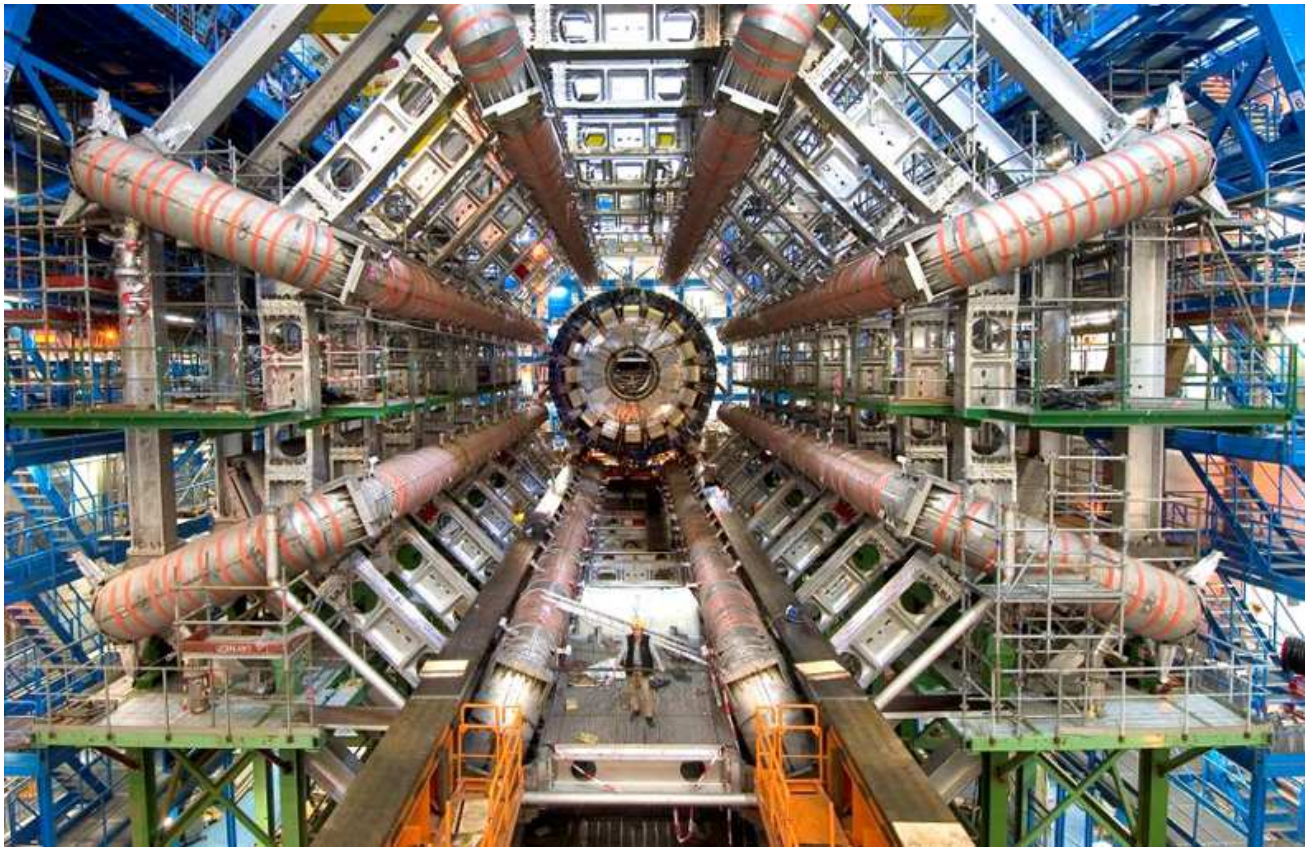
What the science of NWP is *really* about:

We humans are engaged in three project related to fundamental problems about our existence

(Warning: this might be ironic;-)

Cosmology: What is our position and role in the Universe? How was it created? Is there life in other solar systems?

Quantum mechanics: What are the basic building blocks of matter? What is life? Are there parallel universes?



The 3rd project is to prove or disprove Laplace's conjecture from 1812 ("Laplace's Demon")

"We may regard the present state of the universe as the effect of its past and the cause of its future.

An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom.

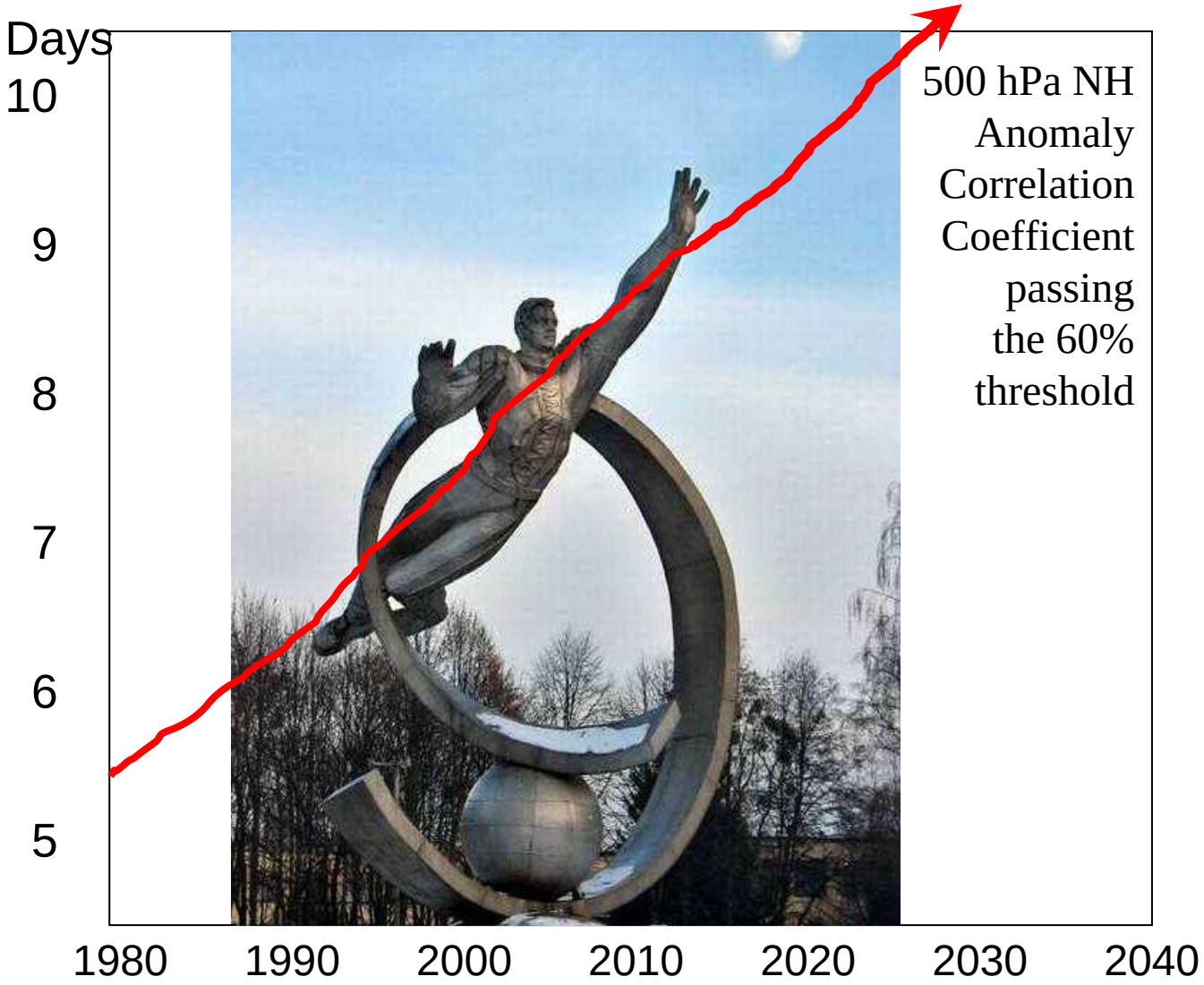
For such an intellect nothing would be uncertain and the future just like the past would be present before its eyes."

Futurology: Do we live in a deterministic world? Is there a free will? Does God play dice?

For this 3rd purpose several scientific super-computer centres compete

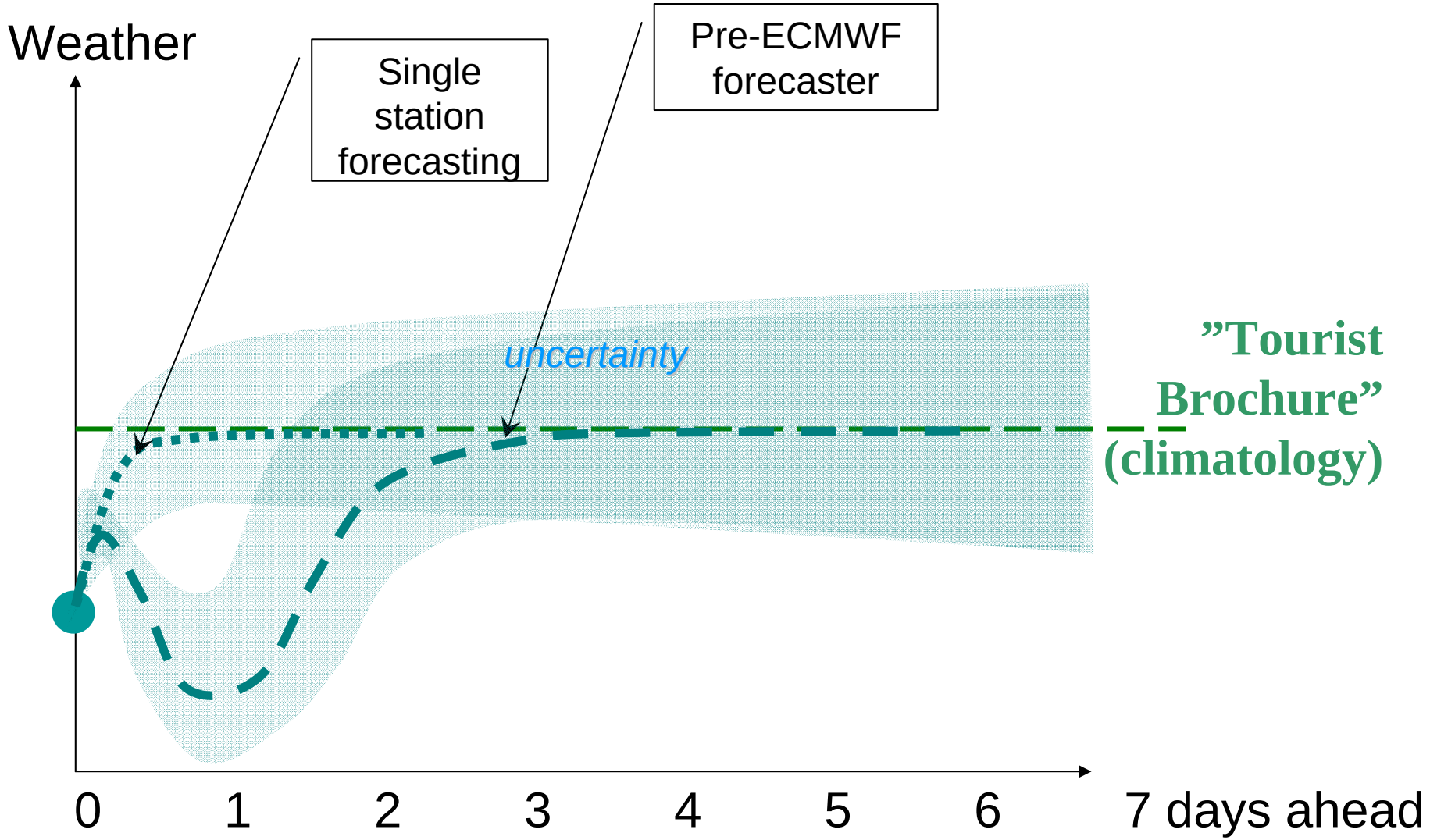
..with the atmosphere as a test ground to explore the limits of deterministic predictability – can we create Laplace's Demon?

…very much like the “Space Race” between the Super Powers

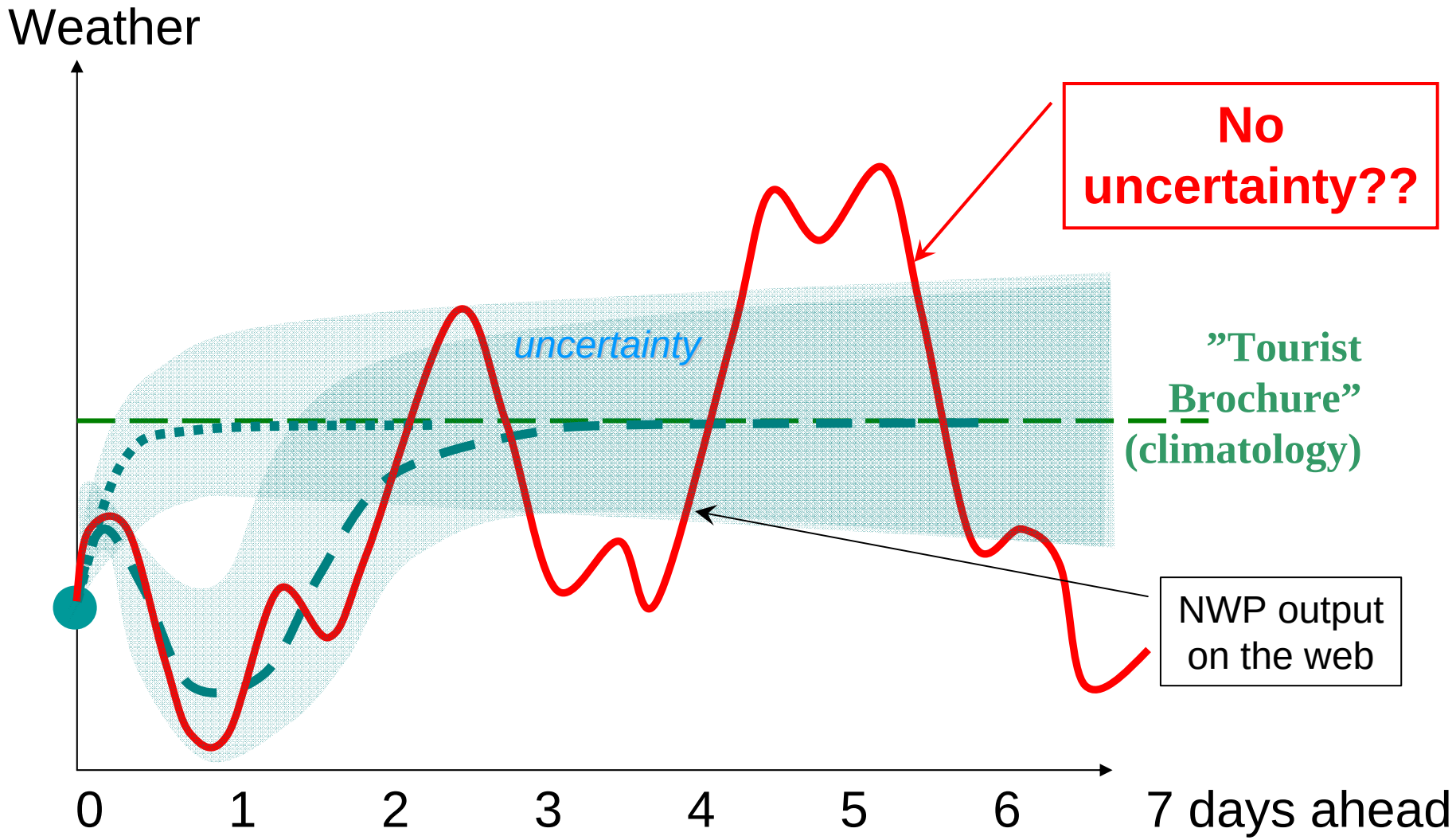


I.1.2 The three negative sides of the current deterministic NWP when used in weather forecasting

a1) A realistic impression of accuracy (before 1980)



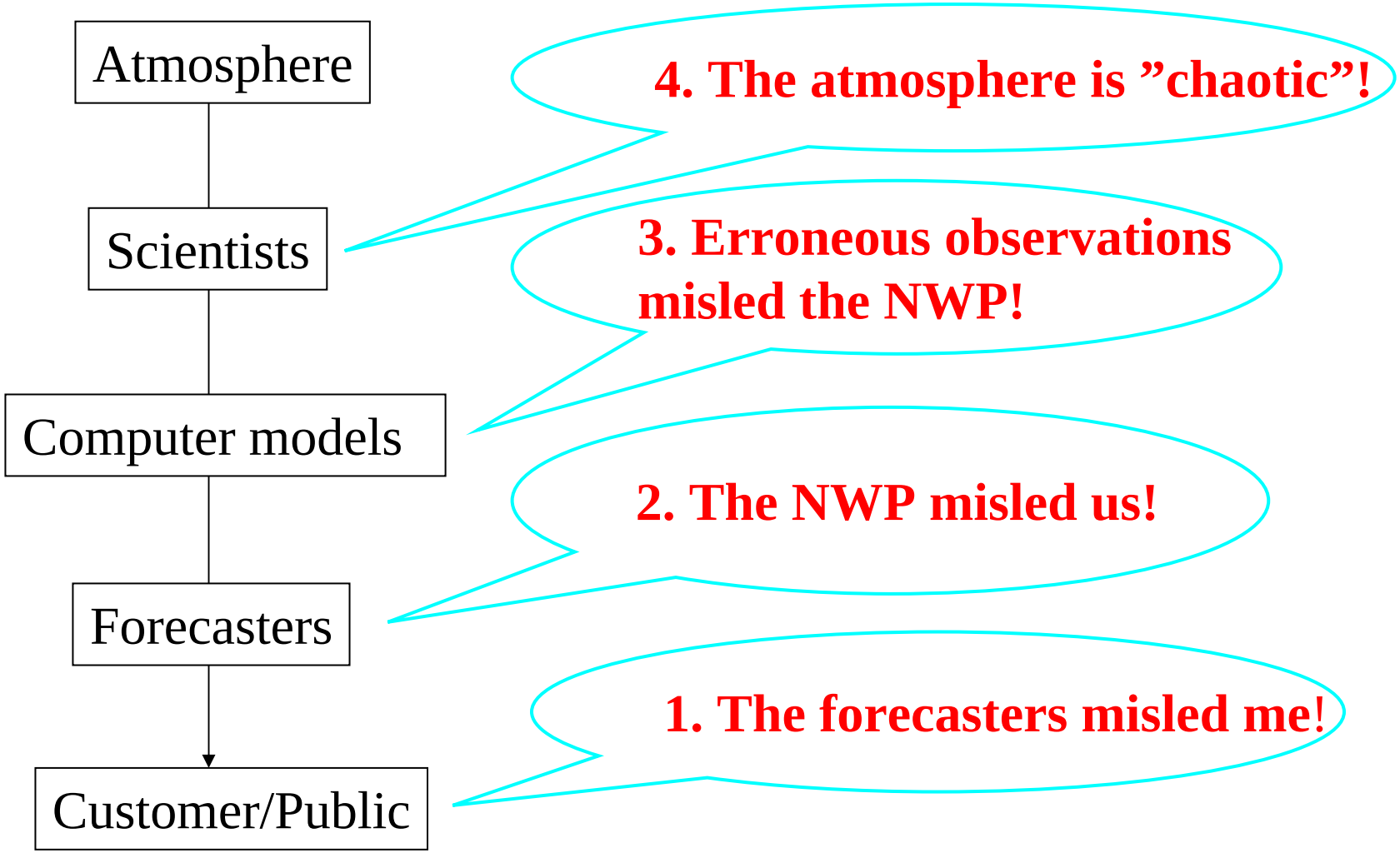
a2) A false impression of accuracy (after 1980)



b) Difficult to make decisions from deterministic NWP

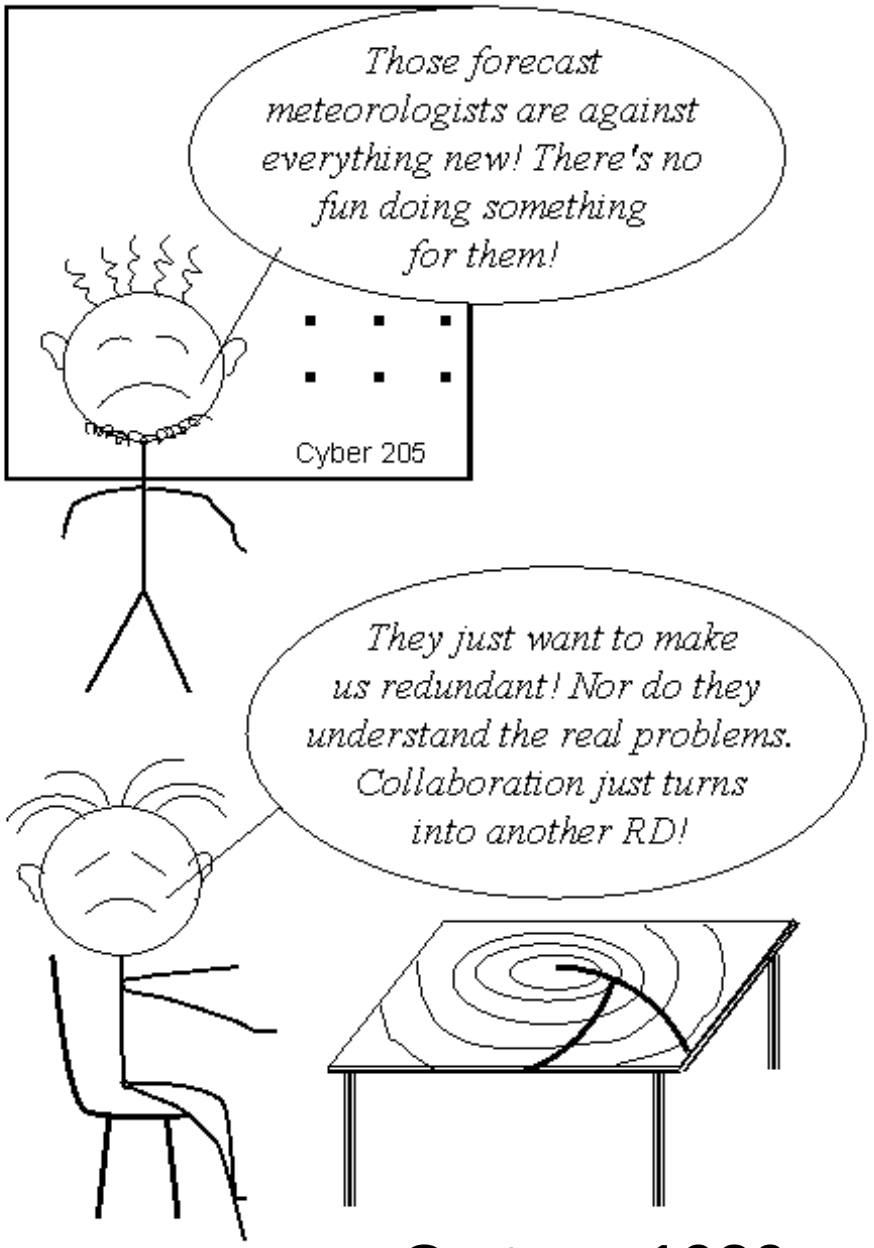
In 1986 at ECMWF a group of Dutch scientists, pointed out that **“medium-range forecasts suffer significant changes from one day to the next…Can we provide the public with useful and objective information on the reliability?”**

c) The culture of meteorological “Blame Game” where nobody is really responsible



I.1.3 Unnecessary conflict with weather forecasters

Unsubstantiated promises were made that “in 5-10 years” there will be no need of weather forecasters.



Cartoon 1980

The weather forecasters are still with us, even in – or rather ***particular in*** - the commercial sector

Because there are. . .

Different NWP models
Later observations
Different statistical interpretations
Different ensemble systems

They might not point in the same direction

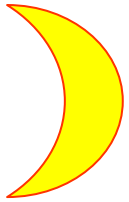
A typical weather forecast problem:

Clouds are forecast to disperse and the temperature to drop

+2º

A classical, physical-meteorological, deterministic problem. .

Clouds are forecast to disperse and the temperature to drop



→ **-4º**

The weather forecasters are invited to "prove their value" compared to the NWP by modifying the forecast

However, their "added value" might be of some other kind. . .

-Will the clouds clear???

Assume there is 40% probability for a clearing and the drop to around **-4°** (and a 60% for no change)

Then 3 different forecasts might be provided

Three possible forecasts

I. A “tactical” weighted average or “consensus” forecast **0º**

←Minimizing errors

Suitable to put into the verification form

Three possible forecasts

I. A “tactical” weighted average or “consensus” forecast **0º**

II. A missed event is worse than a false alarm so **-1º** or **-2º** is forecast ←**Non-symmetric cost functions**

Suitable to present through the media (TV, web, press etc)

Three possible forecasts

I. A “tactical” weighted average or “consensus” forecast **0º**

II. A missed event is worse than a false alarm so **-1º** or **-2º** is forecast

III. The forecasts conveys a message about a slightly lower probability (40%) for the clouds to disperse with **-4º,** rather than to remain (60%) with **+2º**

←**Probability theory**

Suitable to present to specialized customers

Three possible forecasts

Minimizing errors

Non-symmetric cost functions

Probability theory

All of these involve clever use of intuitive statistics

The forecasters have ***always*** applied statistical thinking, in particular probabilities, and will continue to do so

Although the ***absolute forecast uncertainty*** has decreased, thanks to the NWP, the ***relative forecast uncertainty*** has remained at the same level.

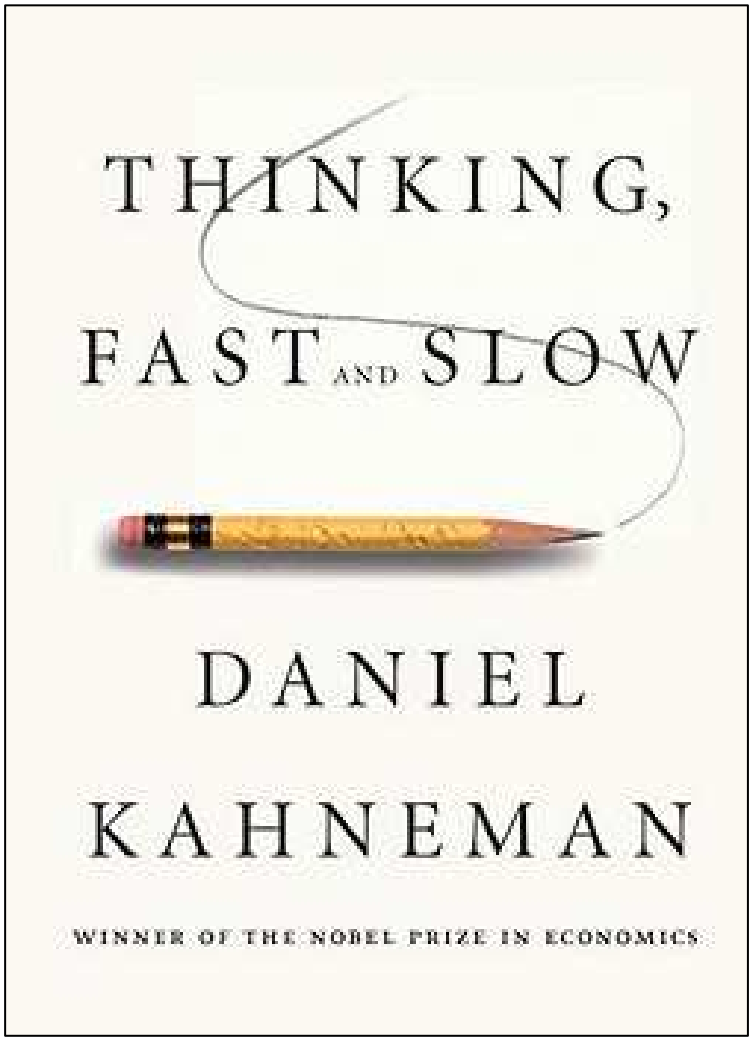
I.1.5 The weather forecasters as “intuitive statisticians”

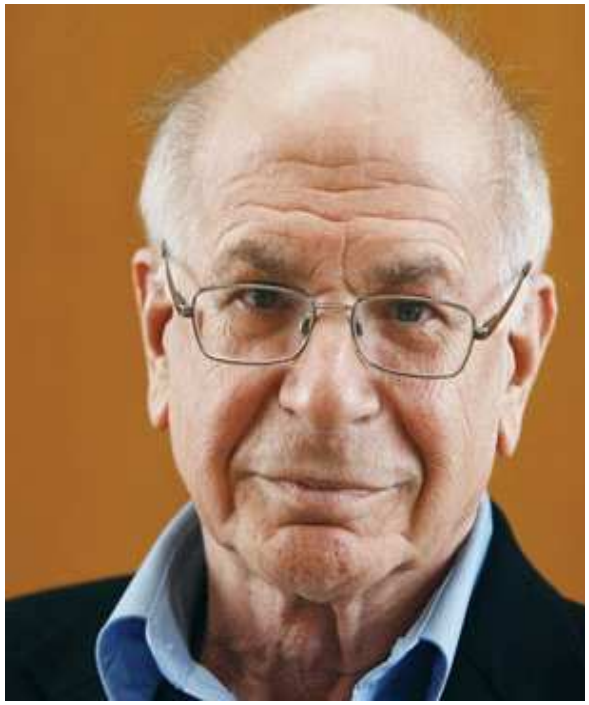
The idea that “forecast experience” to a large degree is *intuitive statistical thinking* developed during my work with the ECMWF User Guide

It was further elaborated in the Bob Riddaway interview
ECMWF Newsletter Autumn 2011


And further in Trento in February 2012

About “intuitive statistics”





Fast and slow thinking really applies to our science

The steadily increasing output of meteorological information meant that any decision has to be made by consulting many of these often conflicting sources

If this work is not made by a meteorological weather forecasters, *somebody else* had to do it!

Our two ways of thinking (Systems 1 and 2):

Fast thinking (System 1):
Meteorologists/hydrologists in the forecast office

Slow thinking (System 2):
Meteorologists/hydrologists attending a seminar

How make this scientific wisdom benefit operational practises?

Time constrains, limited and sometimes misleading information, stress and outside distraction

(Almost) unlimited time, a wide range of reliable information and full concentration

Pitfalls of fast, intuitive thinking

Finnish beer celebration 6-1 victory over Sweden in ice hockey

The beer costs €1 more than the can

What does the can cost?

10 cent is what first comes to most people's minds

Pitfalls of fast, intuitive thinking

The beer costs €1 more than the can…What does the can cost?

10 cent is what first comes to most people's minds

The slow System-2 classified this as a simple problem and left it to the quick System-1 to solve **. . .and System-1 solved it erroneously because correct answer is 5 cent!**

I.1.5 How to turn a disadvantage into an advantage

Turning a disadvantage into an advantage

a)“Everybody” knows that weather forecasts are uncertain

There are no reasons to try to hide that by issuing unrealistically confident or detailed forecasts.

Turning a disadvantage into an advantage

b) Knowing in advance the uncertainty of a particular weather forecast *increases* its value, quantitatively (money wise) and qualitatively (psychologically).

Turning a disadvantage into an advantage

c) The forecasters standing in the public's eye will be enhanced if they give uncertainty information in a way, that allows them to display their knowledge and experience.

END