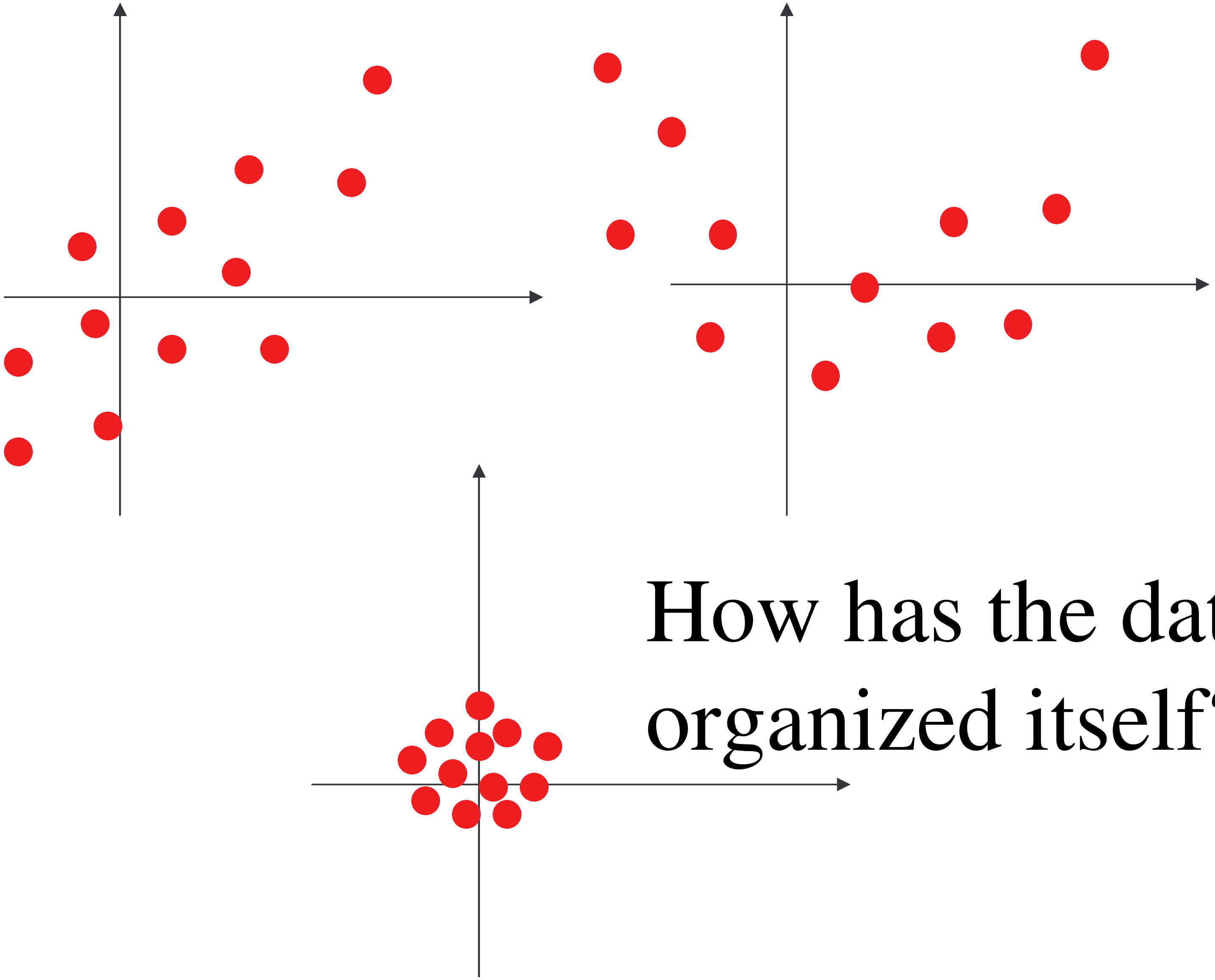
Common (mis) interpretations of statistics in meteorology

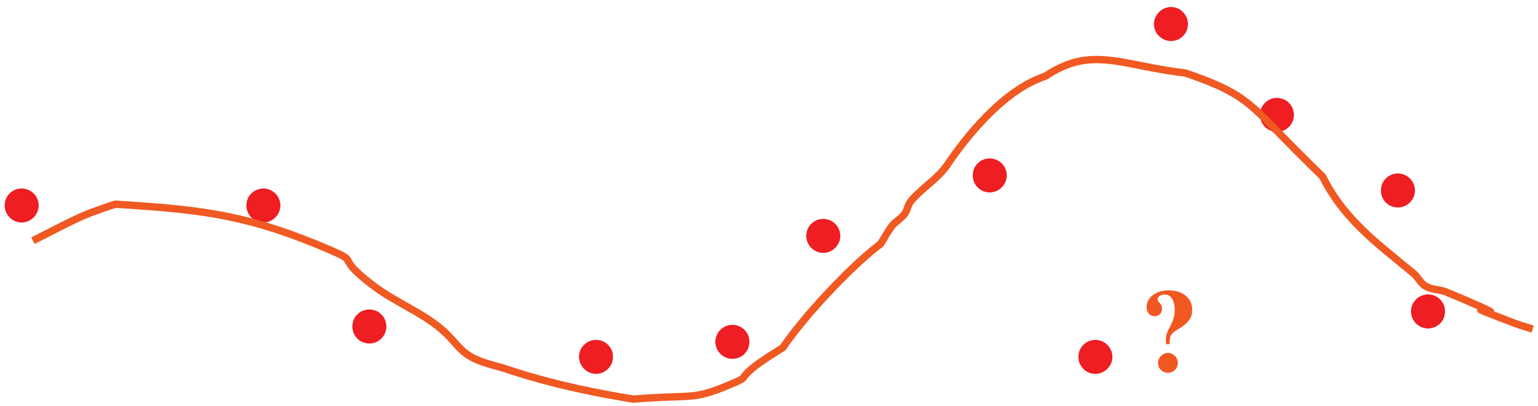
Corso di meteorologia-statistica e comminicazione
Trento, 2 Dec 2005 Anders Persson, SMHI

1. Look at the data



How has the data organized itself?

The forecast is correct but one the observation is wrong



2. Randomness

2. The power of randomness

Number of lottery numbers after one year National Lottery in Great Britain 49 number once a week)

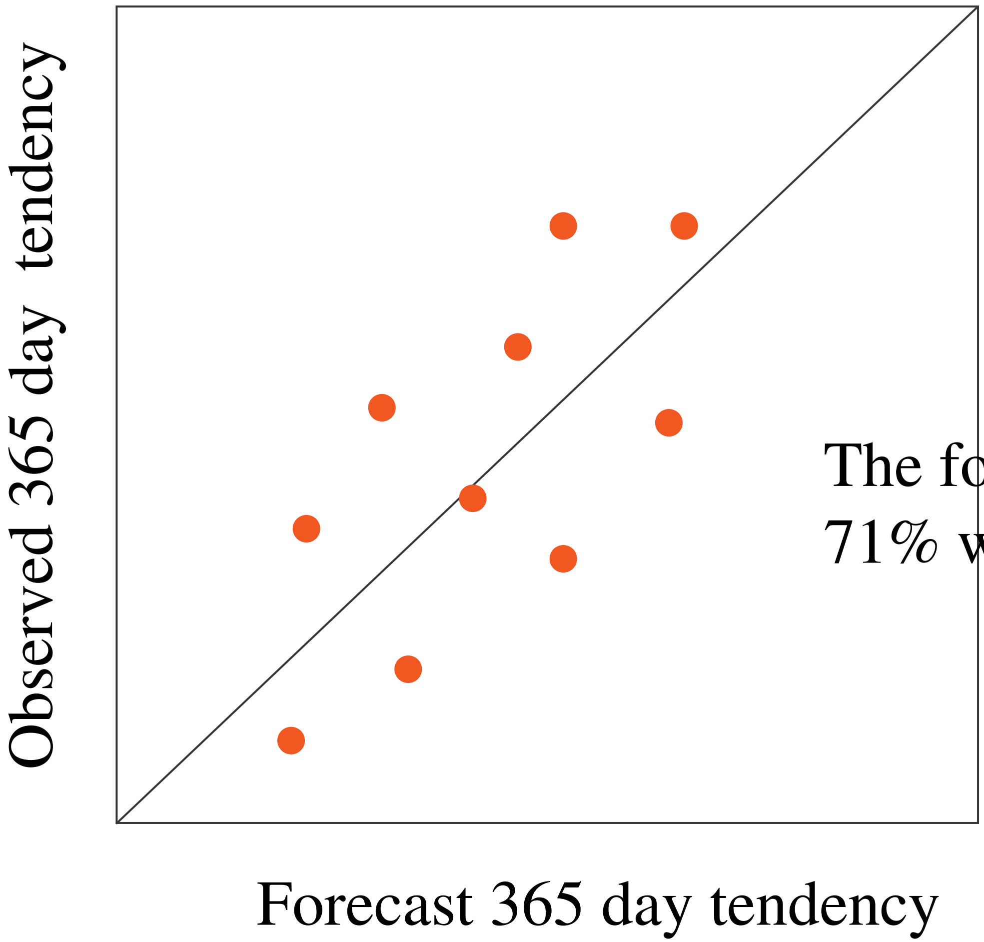
11	16	12	15	21	14	15
9	12	11	17	13	11	16
13	16	16	13	9	12	12
15	12	10	17	15	10	20
13	15	13	13	14	14	10
11	9	15	4	13	16	15
14	23	19	15	13	17	11

What is so special with 39 and 44?

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49

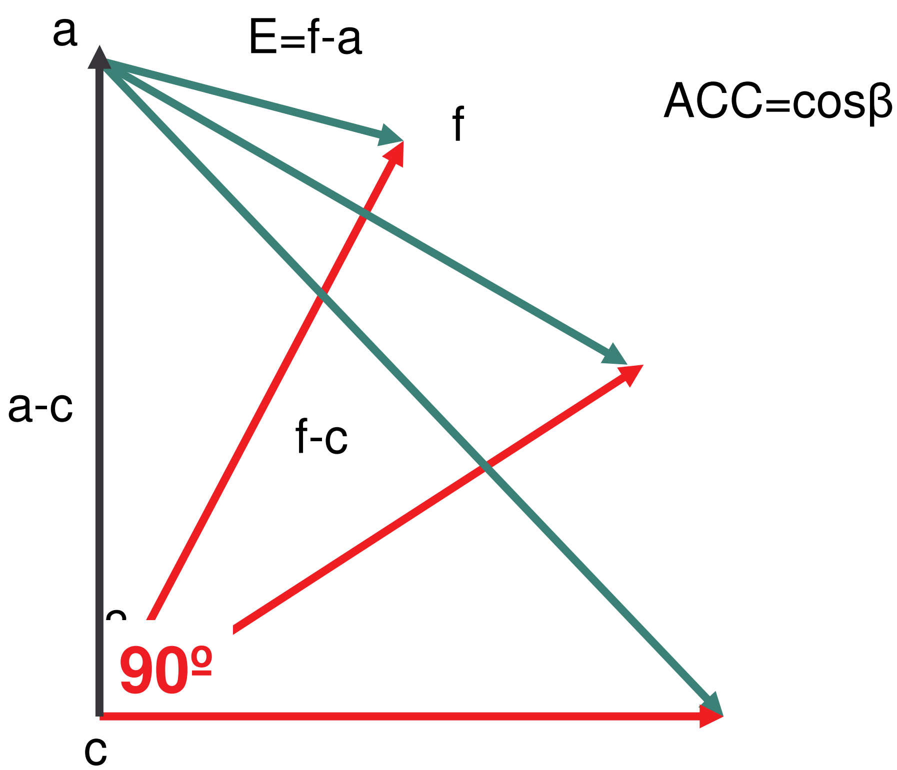
2.2 The dangerous and powerful “Regression to the mean”

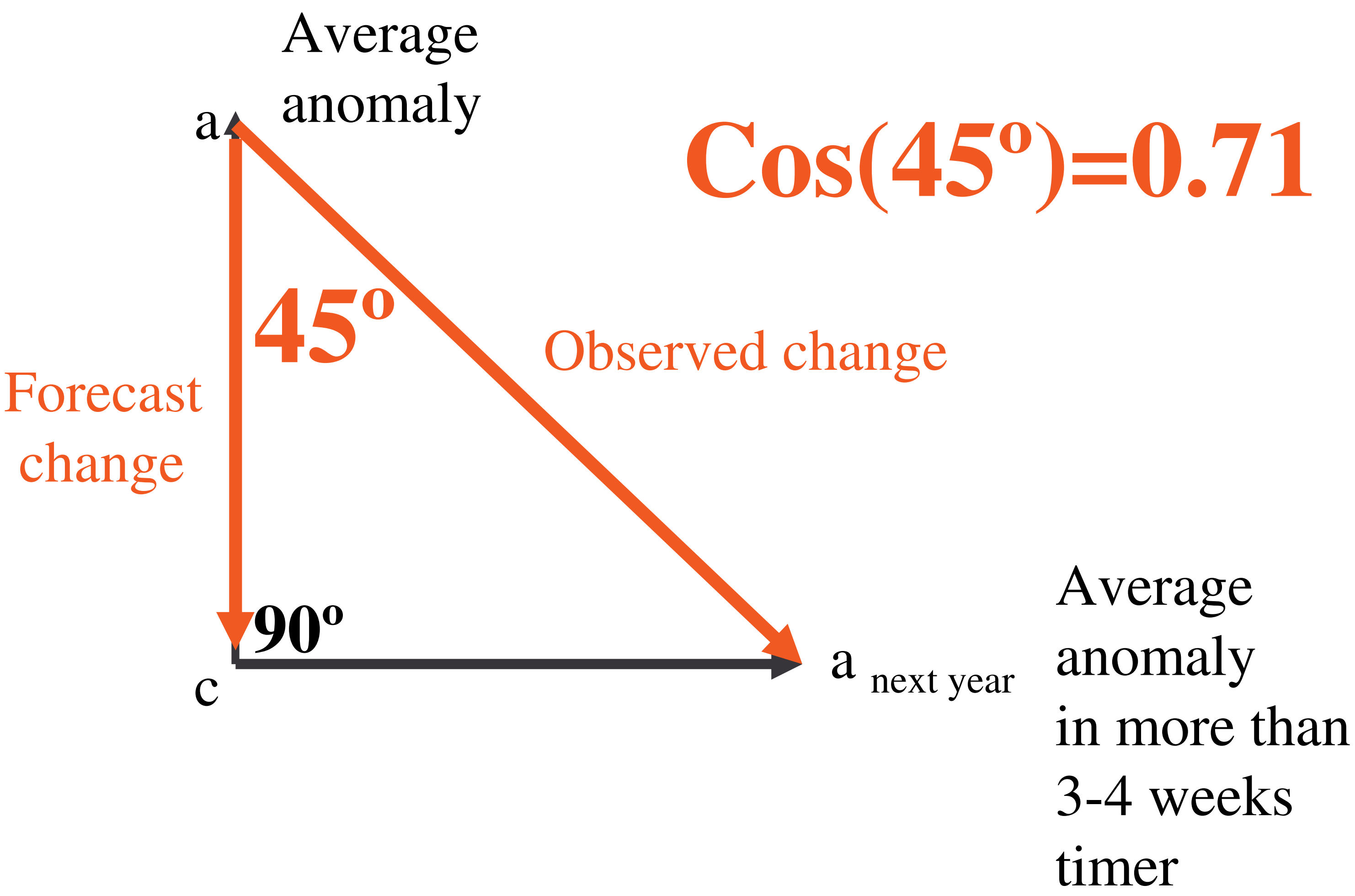
Is it possible to forecast temperature changes 365 days ahead?



The forecasts correlate 71% with the verification

Method: the inverse to the current anomaly

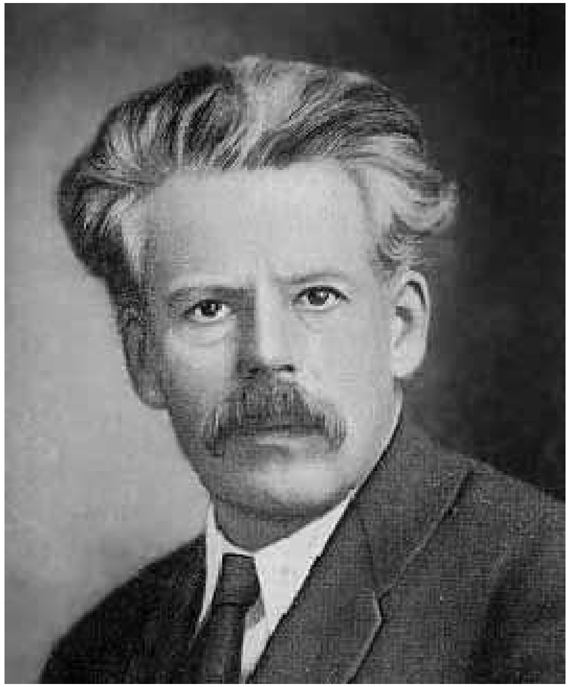

a
E=f-a
f
ACC=cosβ
a-c
f-c
90º
c



$\cos(45^{\circ})=0.71$

2.3 The Slutsky-Yule effect

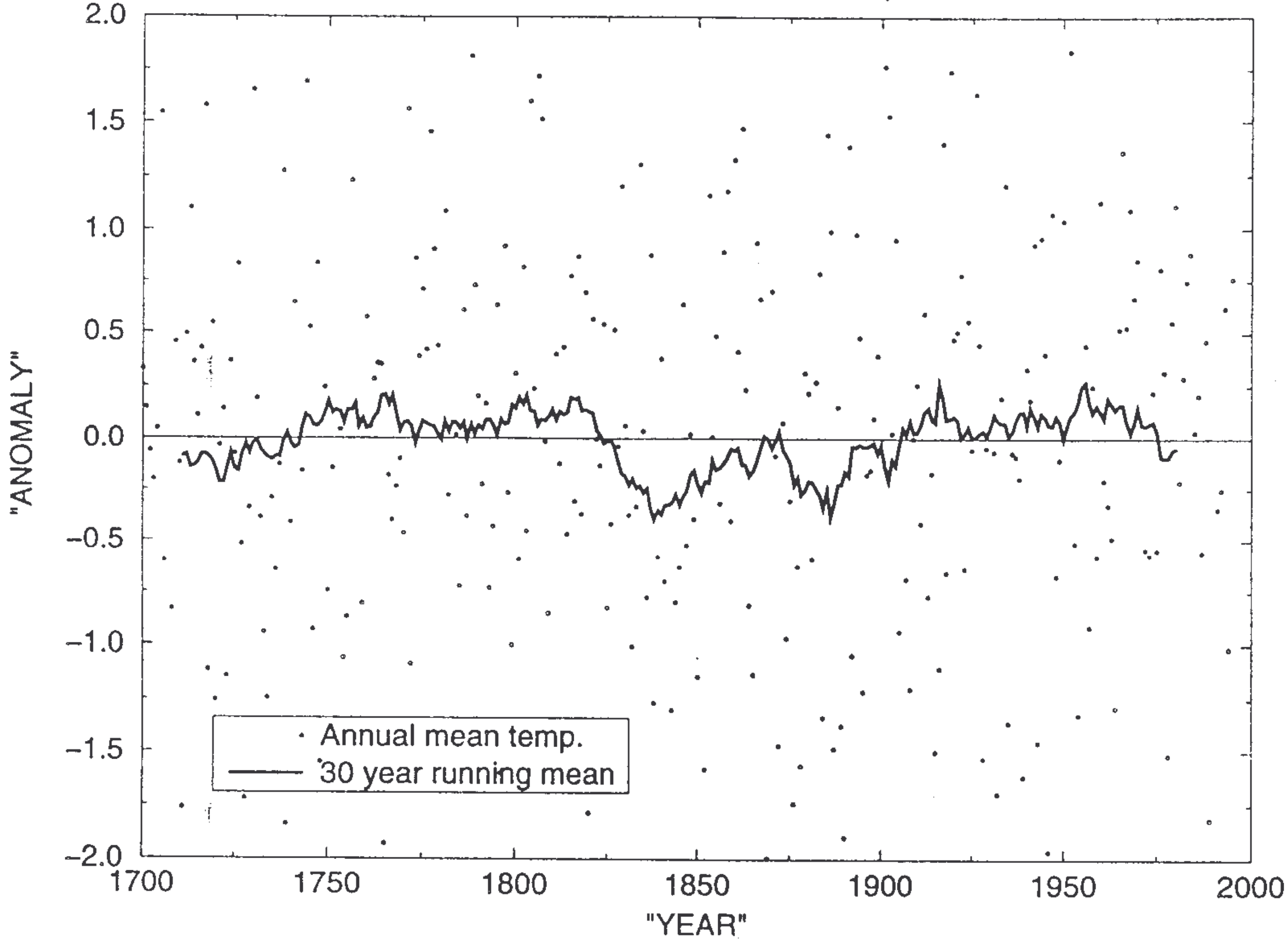
Eugene Slutsky 1880-1948

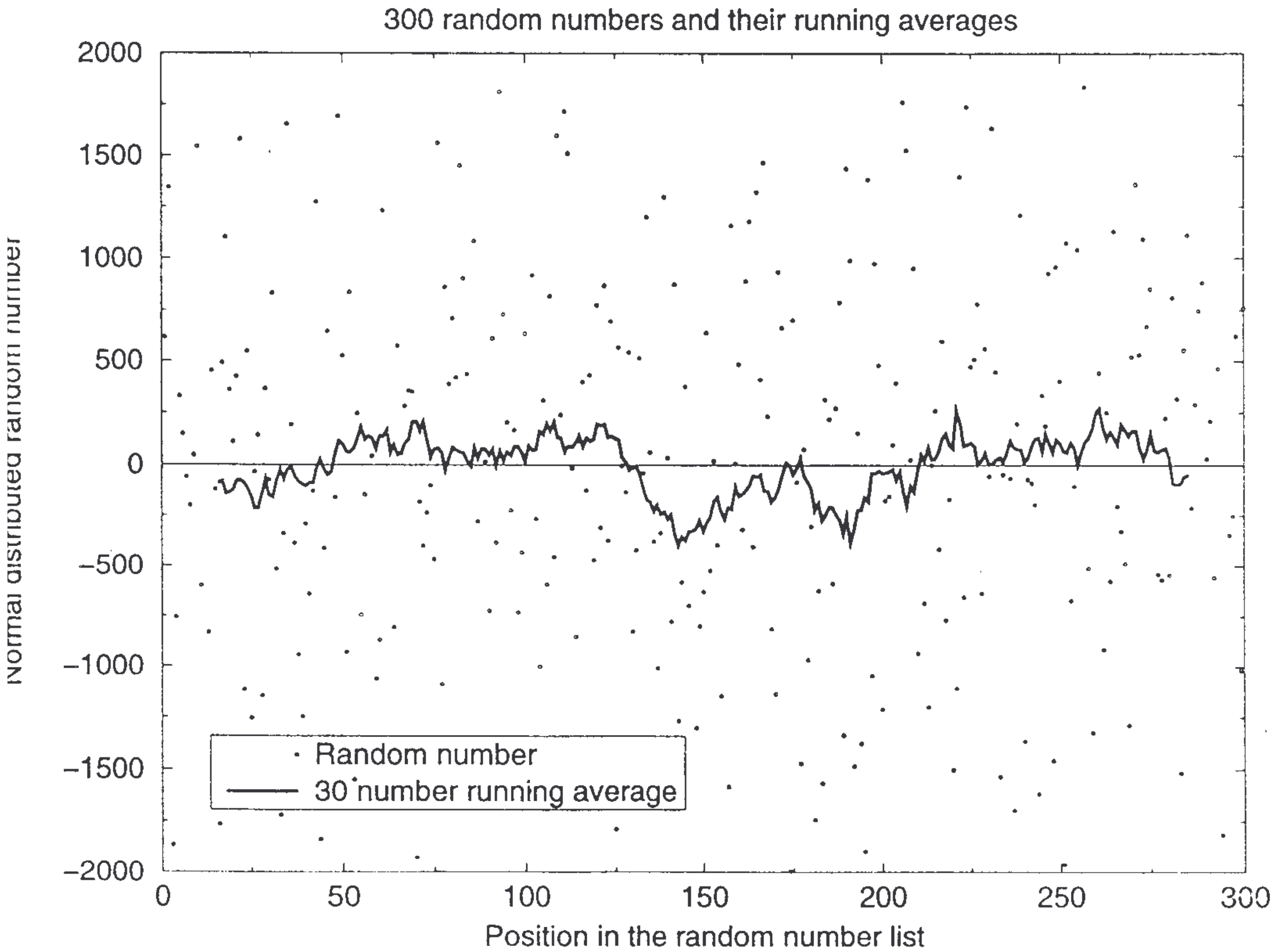


George Yule 1871-1951

GLOBAL CLIMATE CHANGE?

A graph of the changes in annual temperature?

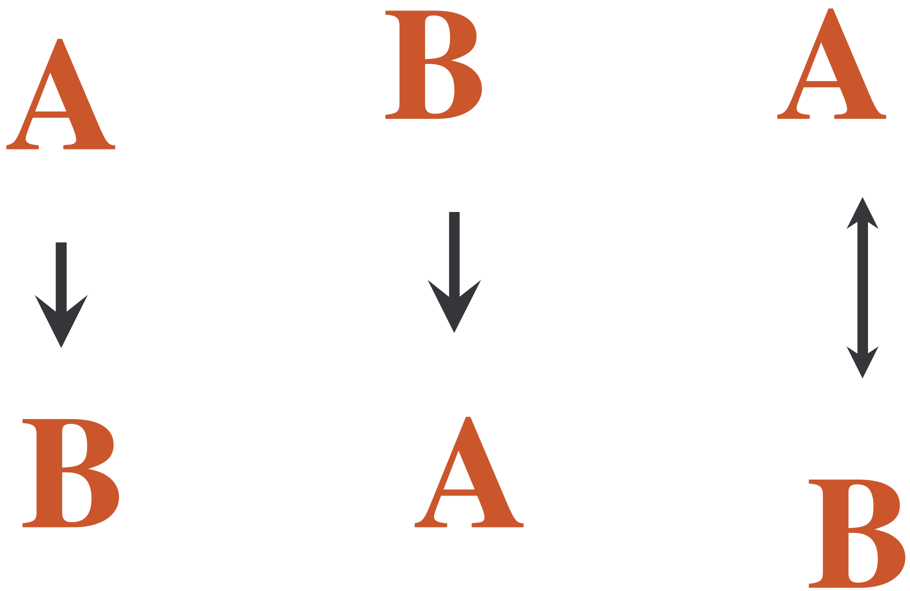



300 random numbers and their running averages
Normal distributed random number
Position in the random number list
Random number
30 number running average
2000
1500
1000
500
0
−500
−1000
−1500
−2000
0
50
100
150
200
250
300

3. Correlations

3.1 What correlations do not mean

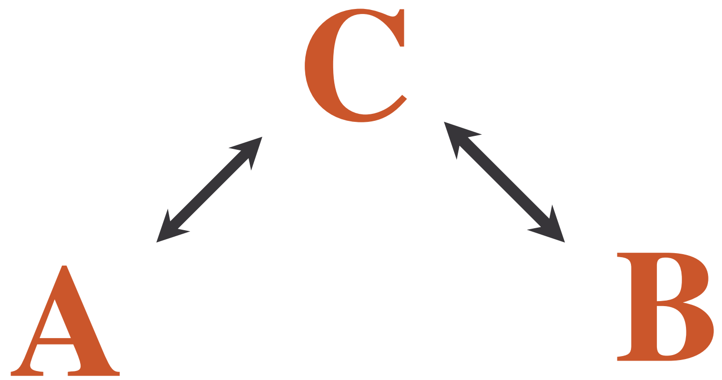
Causality



1. If A and B depend on each other, they also correlate

2. The reverse is not necessarily true

3. A and B might not depend on each other, but on C



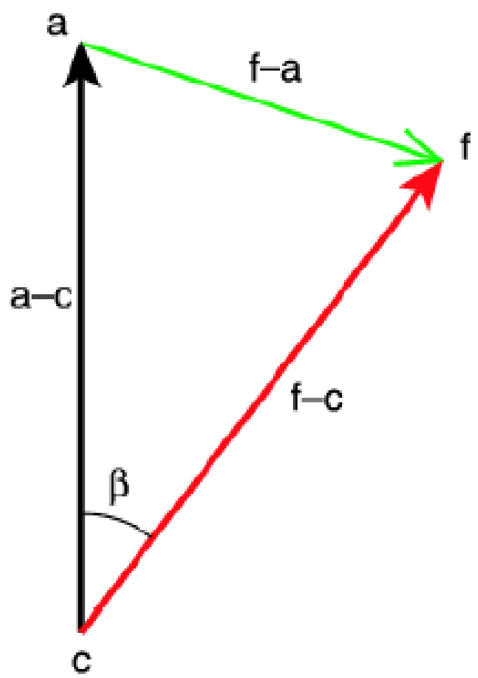
3.2 Forecast error correlation

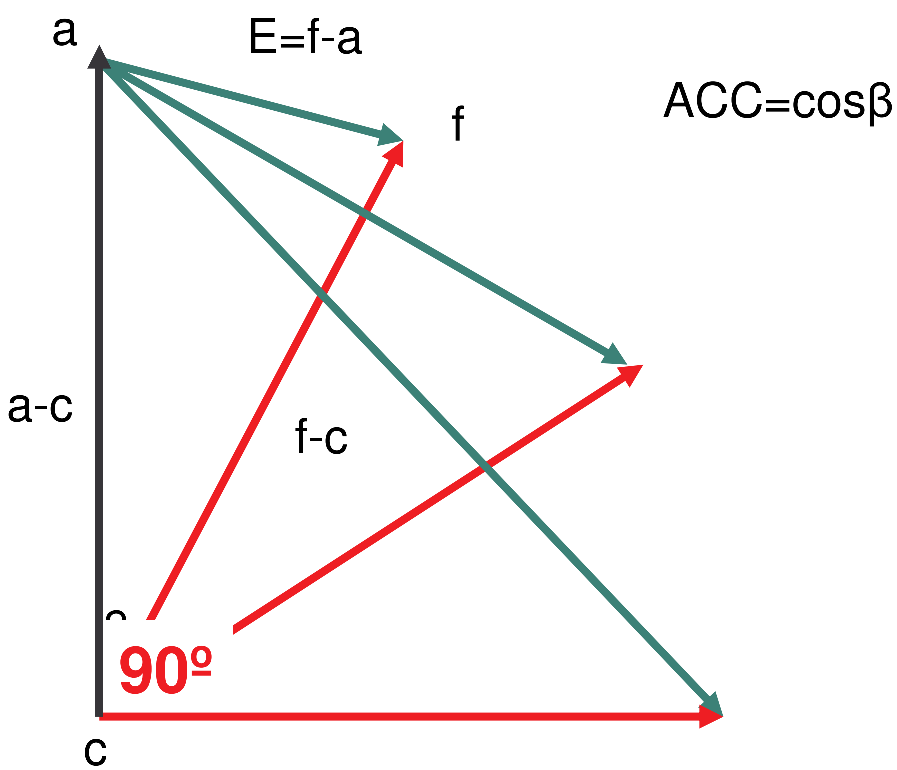
A simple vector-geometrical alternative

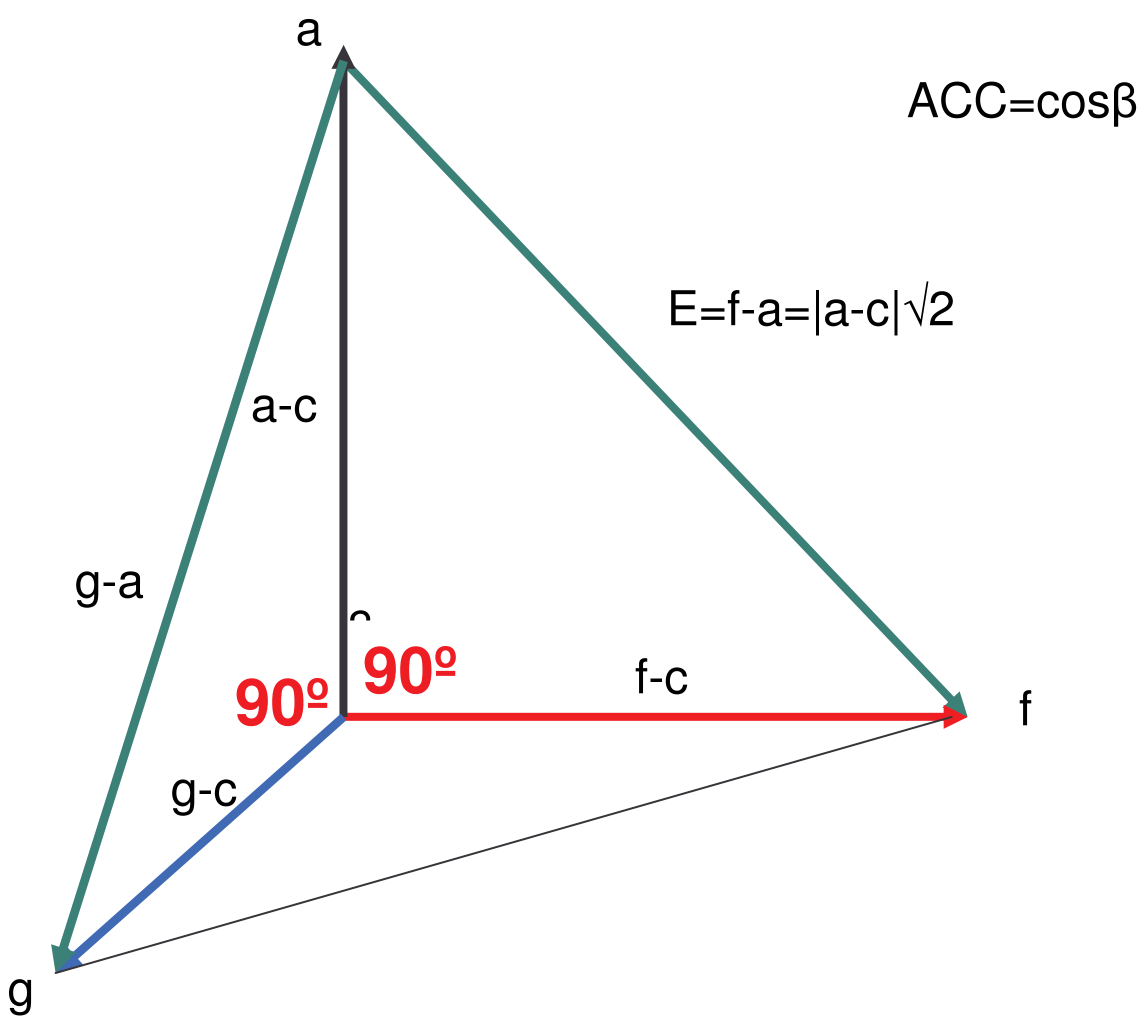
The previous mathematics can also be given a vector algebraic presentation where **a**, **f** and **c** represent states in some phase space

The length of the vectors represent A_a and A_f, and the difference **f-a** is proportional to the RMSE

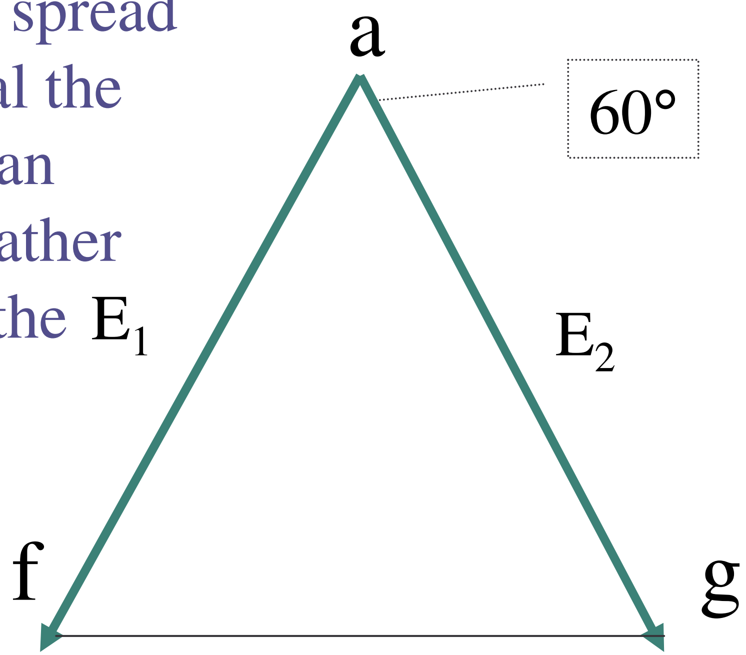
With an underactive model **f-c** will become somewhat shorter. Also **f-a** will decrease and thus the RMSE



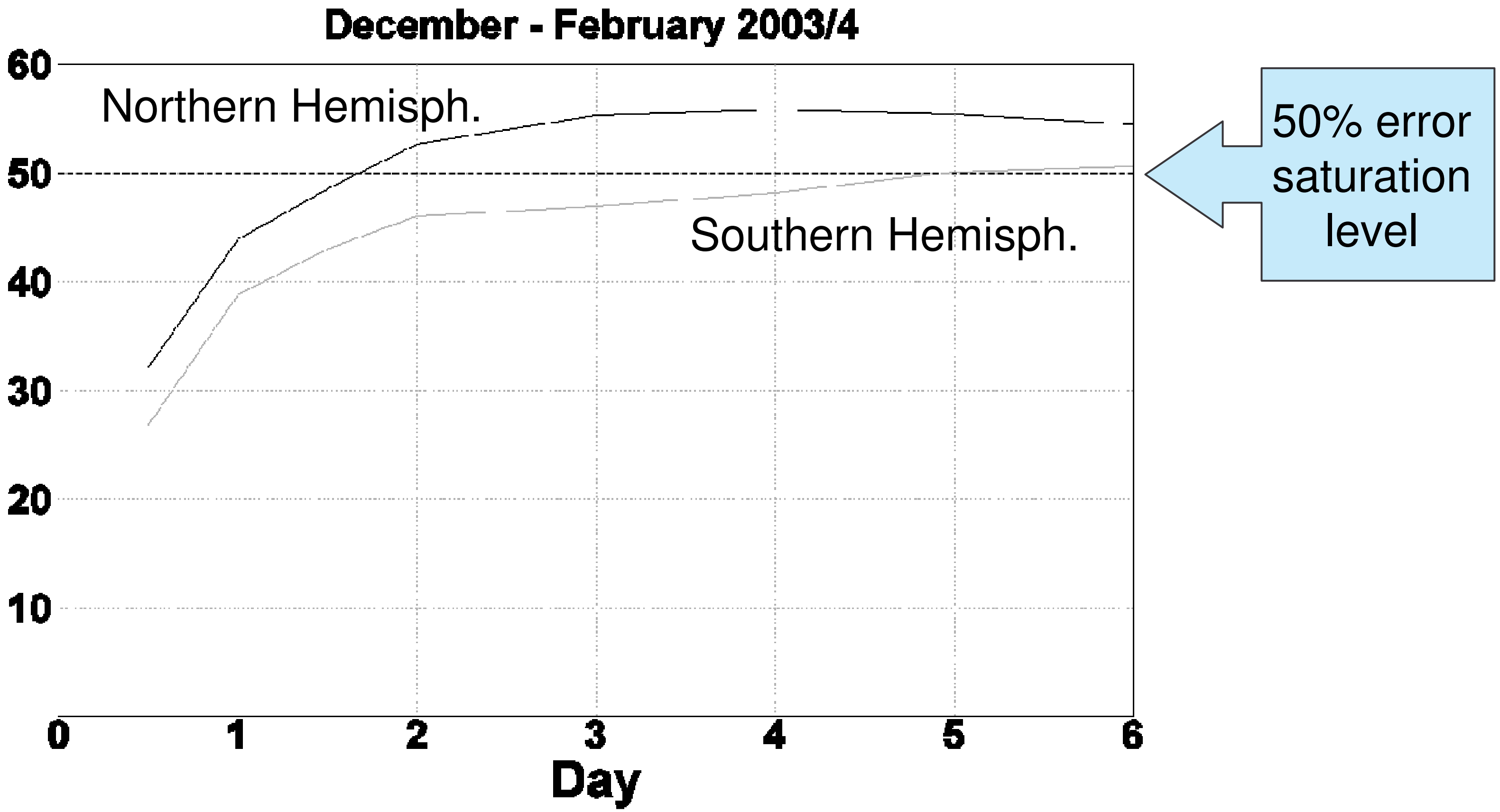

a
E=f-a
f
ACC=cosβ
a-c
f-c
90º
c

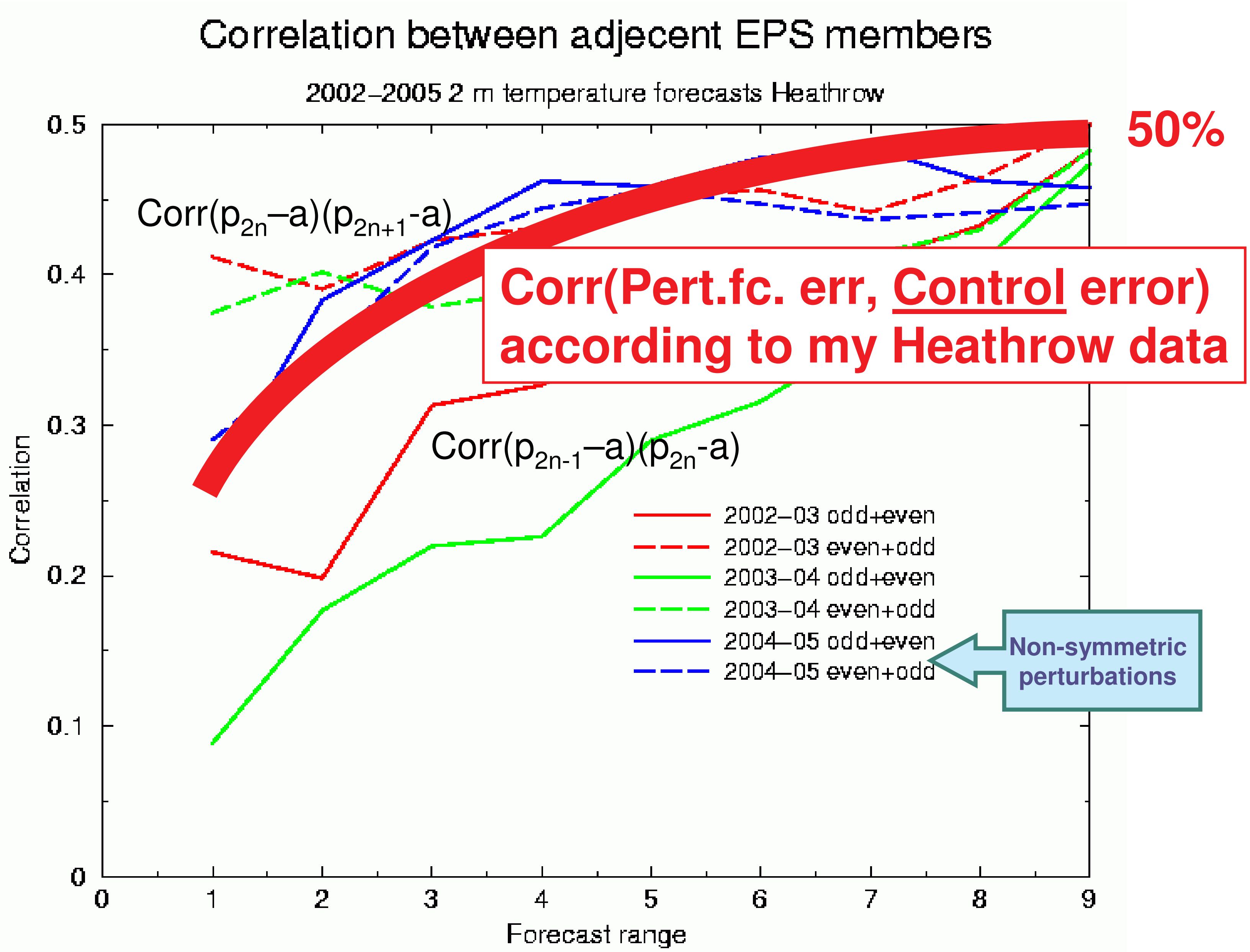

a
ACC=cosβ
E=f-a=|a-c|√2
a-c
g-a
c
90º
90º
f-c
f
g-c
g

For correlated errors the ensemble spread does not equal the ensemble mean error, but is rather smaller than the error

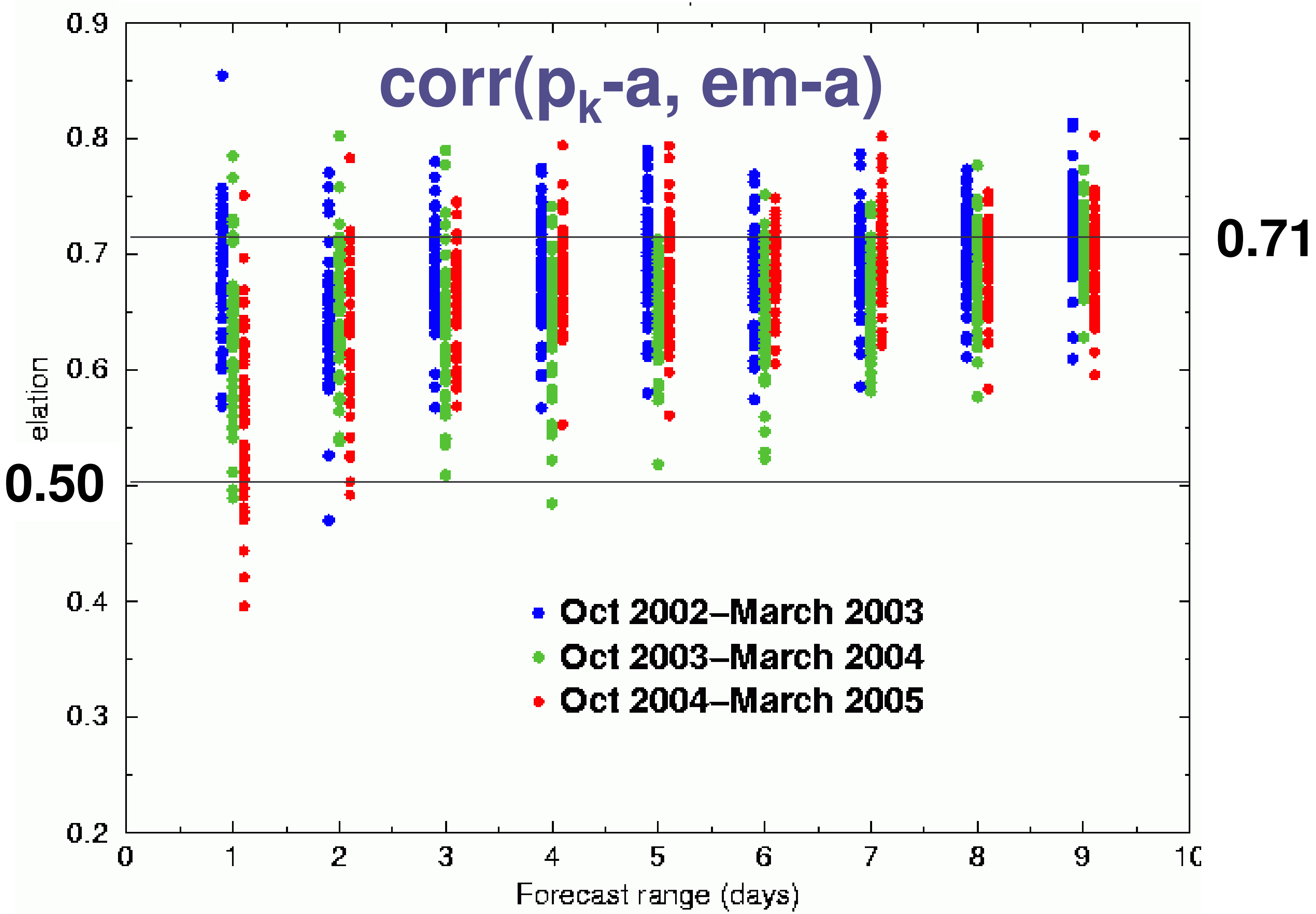


Correlation of 500 hPa forecast errors between the ECMWF and the UKMO global models winter 04-05

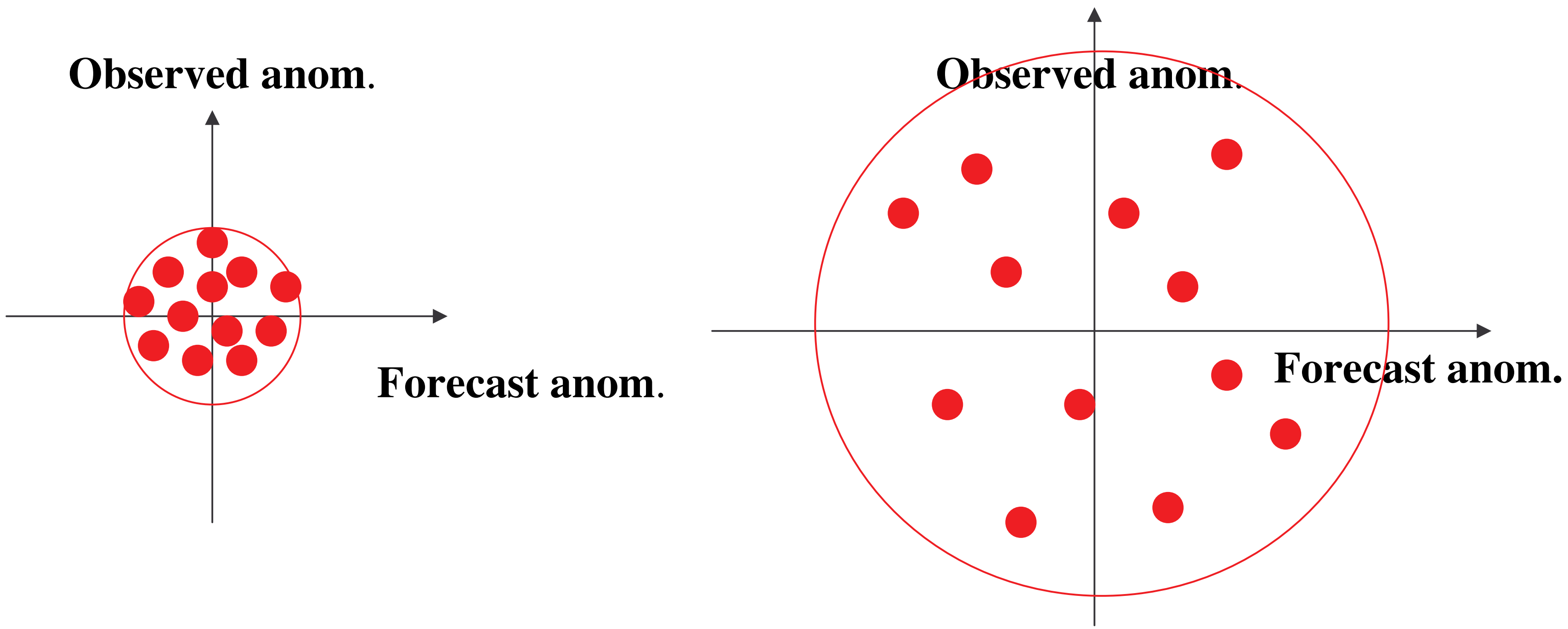



Correlation between adjecent EPS members
2002–2005 2 m temperature forecasts Heathrow
50%
Corr(Pert.fc. err, Control error) according to my Heathrow data
Corr(p2n–a)(p2n+1-a)
Corr(p2n-1–a)(p2n-a)
2002–03 odd+even
2002–03 even+odd
2003–04 odd+even
2003–04 even+odd
2004–05 odd+even
2004–05 even+odd
Non-symmetric perturbations
Correlation
Forecast range
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9

Correlation of perturbed member errors and the *ensemble mean* errors

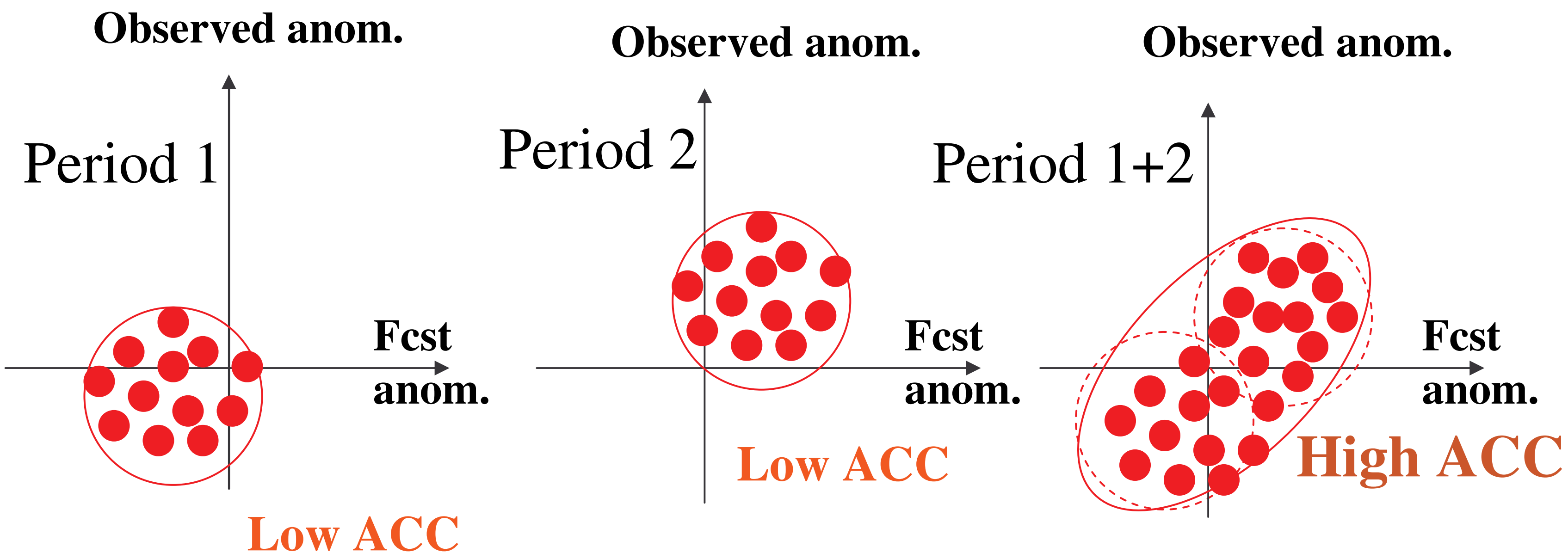


3.3 The danger of correlations

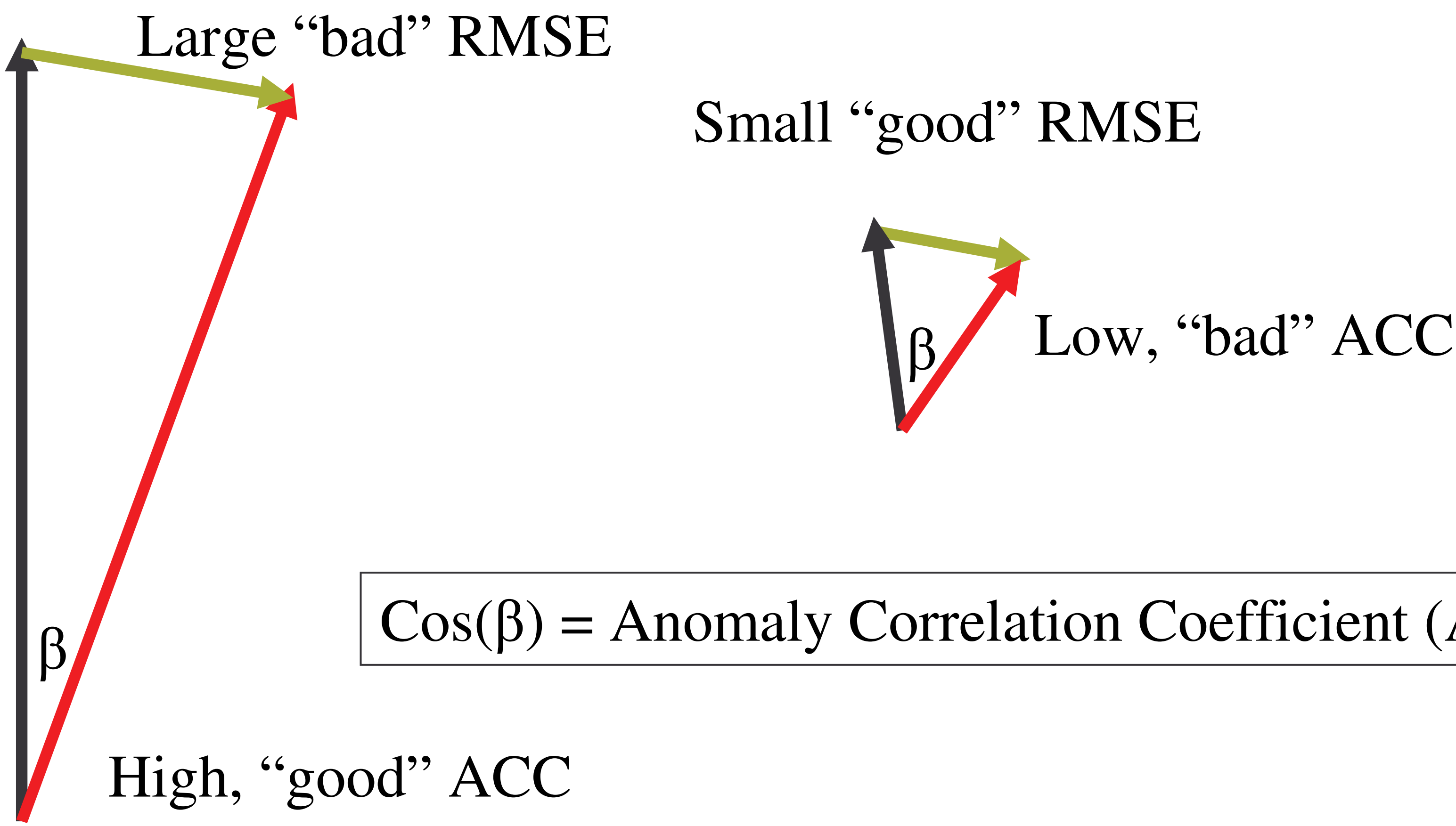


Both sets of forecasts correlate ”badly”,
But only the forecast to the left might be ”bad”

Two short periods can both have correlation =0
If they are combined the correlation increases considerably



RMSE and anomaly correlations

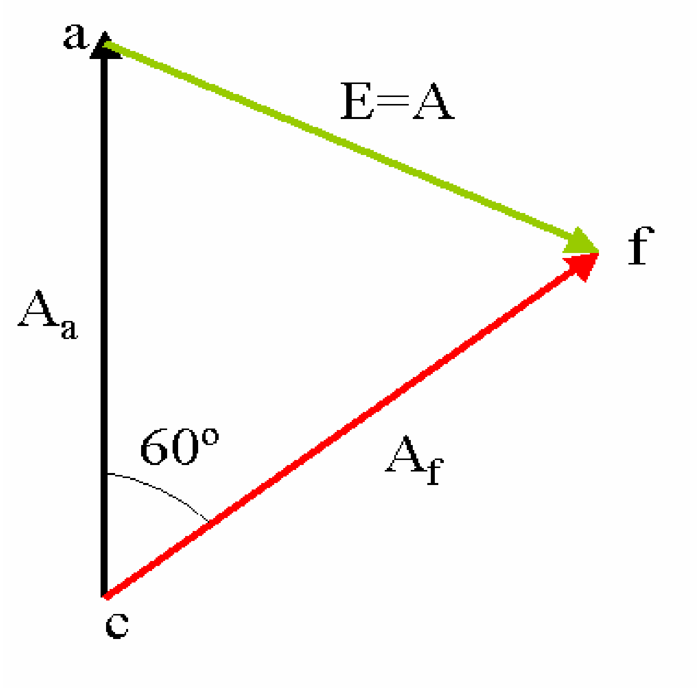


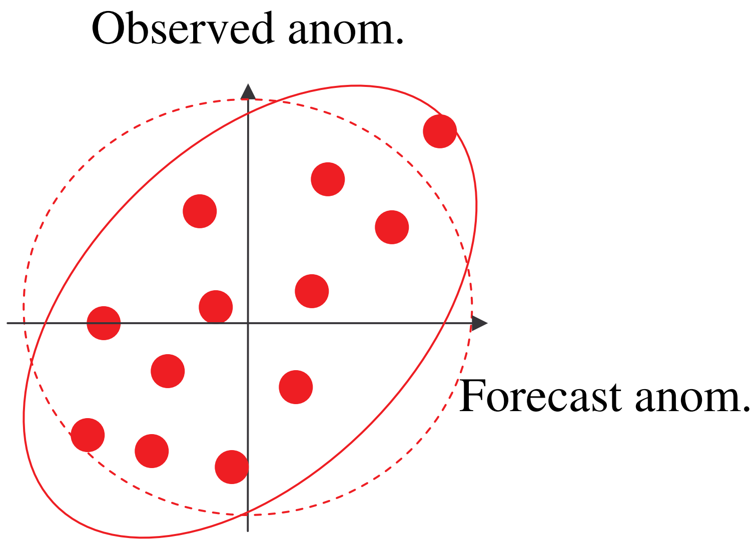
Cos(β) = Anomaly Correlation Coefficient (ACC)

The ACC = 60% limit

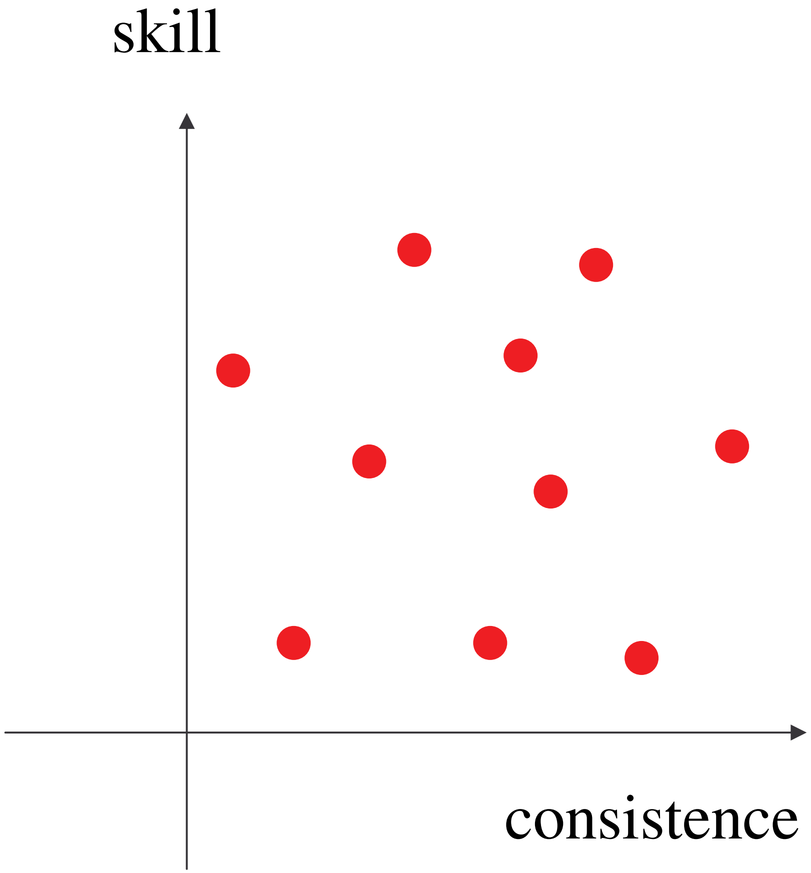
By convention anomaly correlations < 60% are regarded as indicating not useful forecasts

$$If\ \ E = A \quad then \quad ACC = 0.5$$





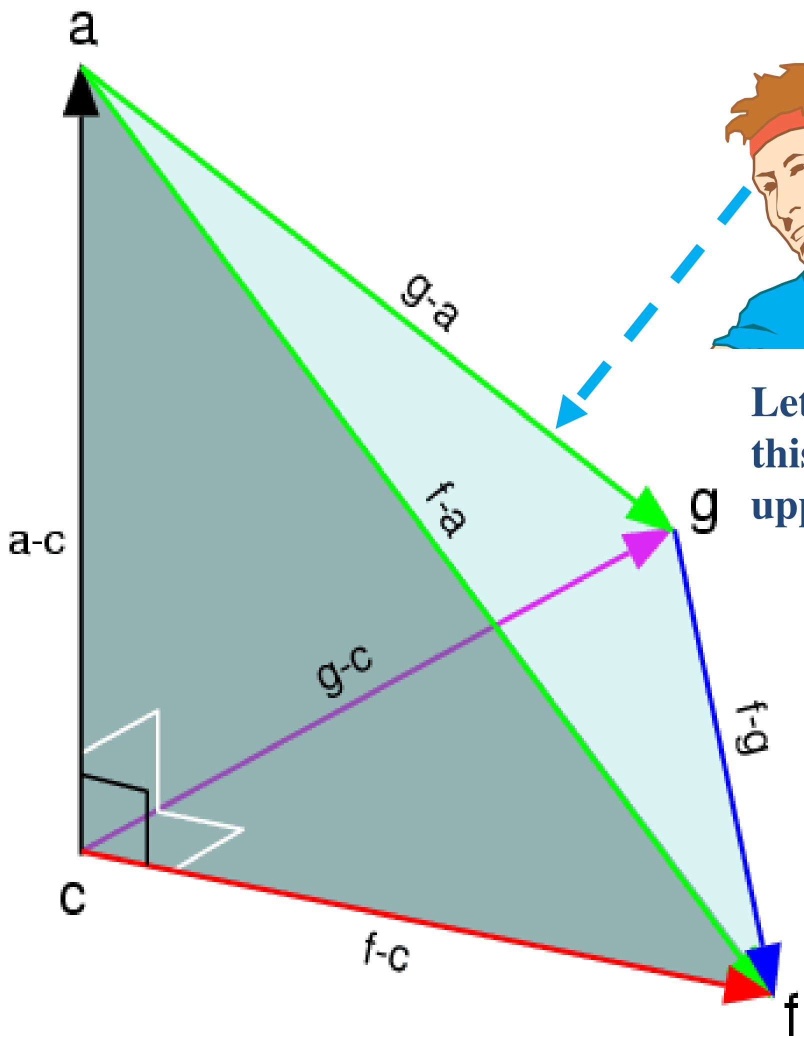
3.4 The consistency-skill artefact


skill
consistence

The consistency-skill correlation

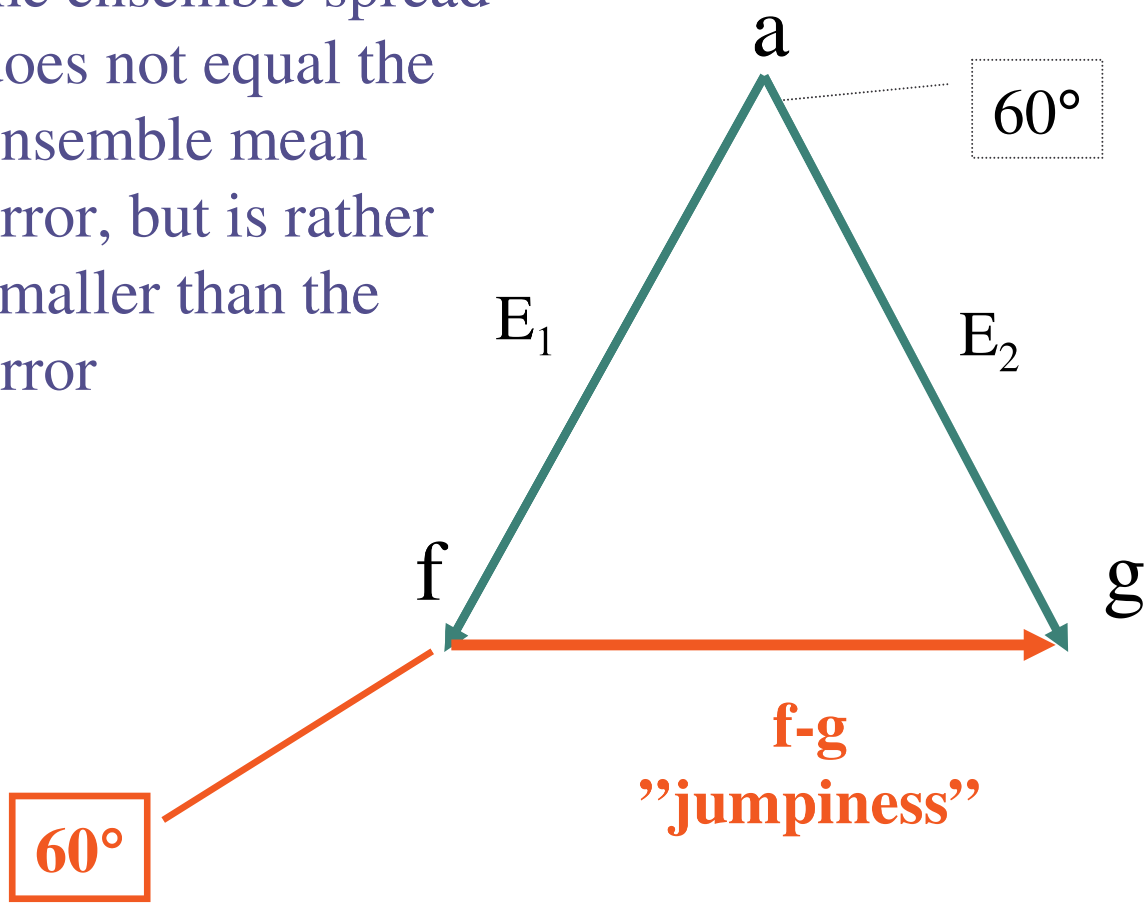
- Two forecasts systems (f) and (g) lack predictive skill and are mutually uncorrelated.

This implies that all three vectors are perpendicular (90°)



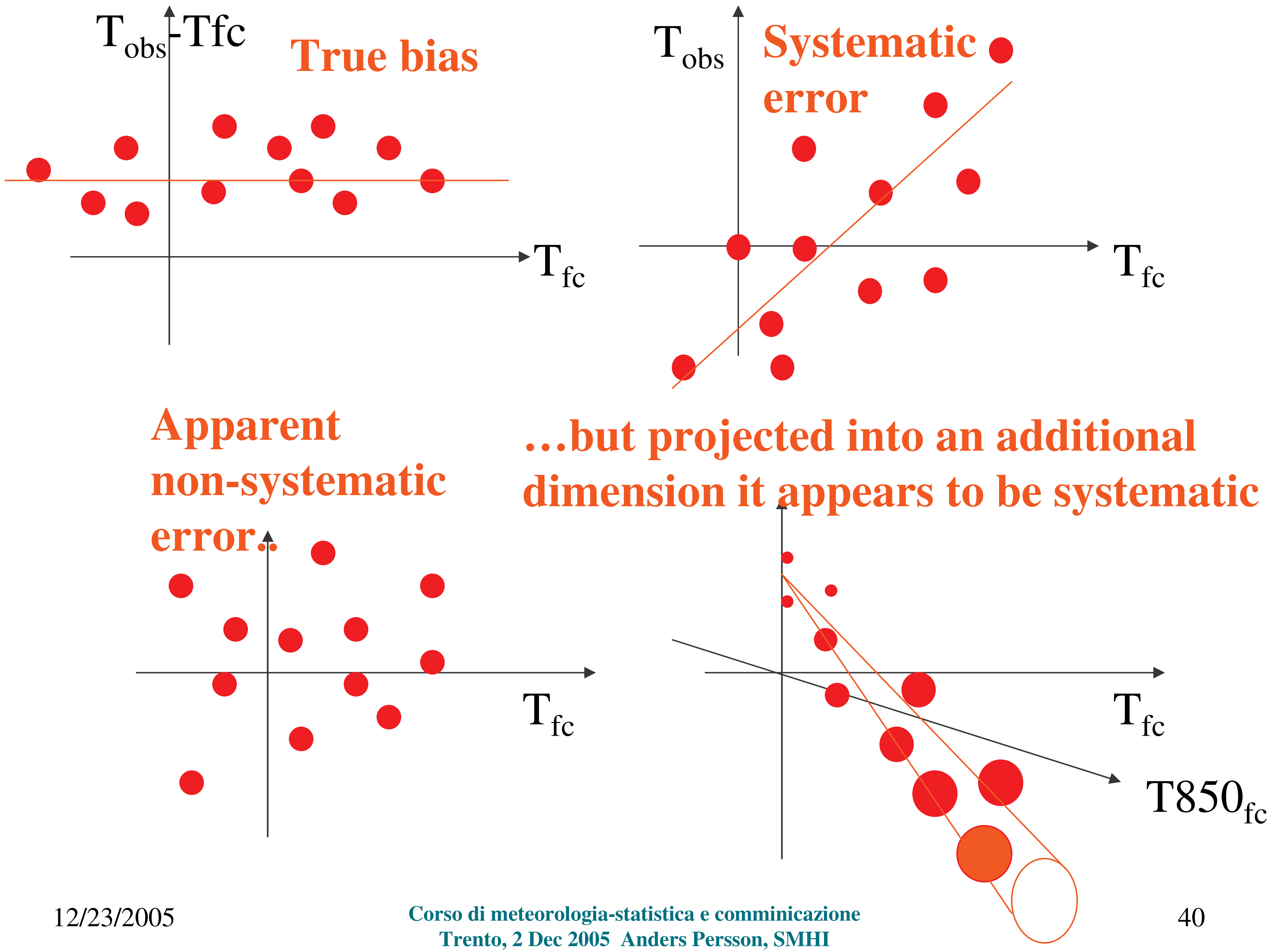
Let us now watch this 3D figure from upper right...

For correlated errors the ensemble spread does not equal the ensemble mean error, but is rather smaller than the error



4. Mean errors

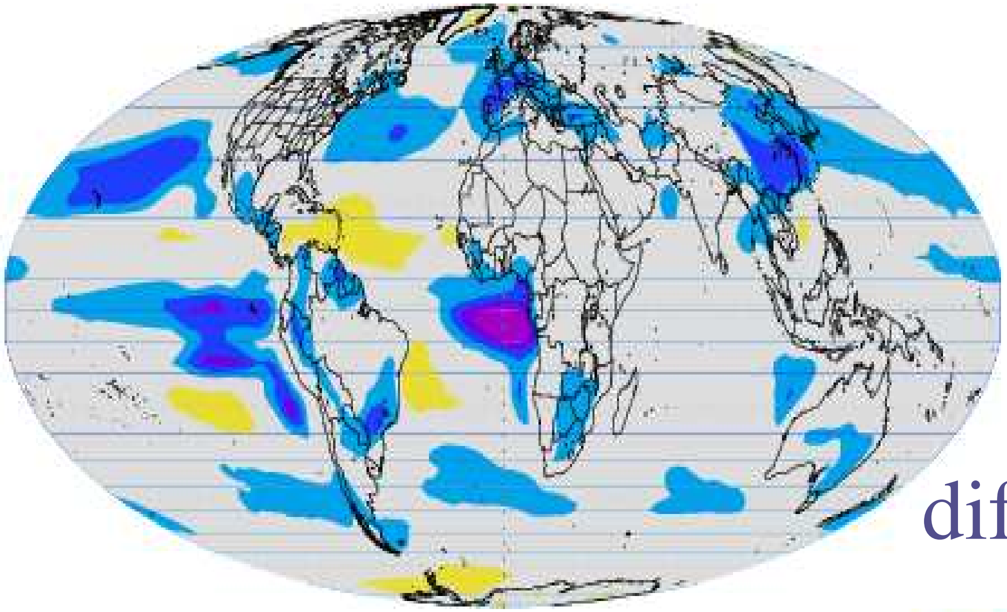
4.1 Biases and systematic errors

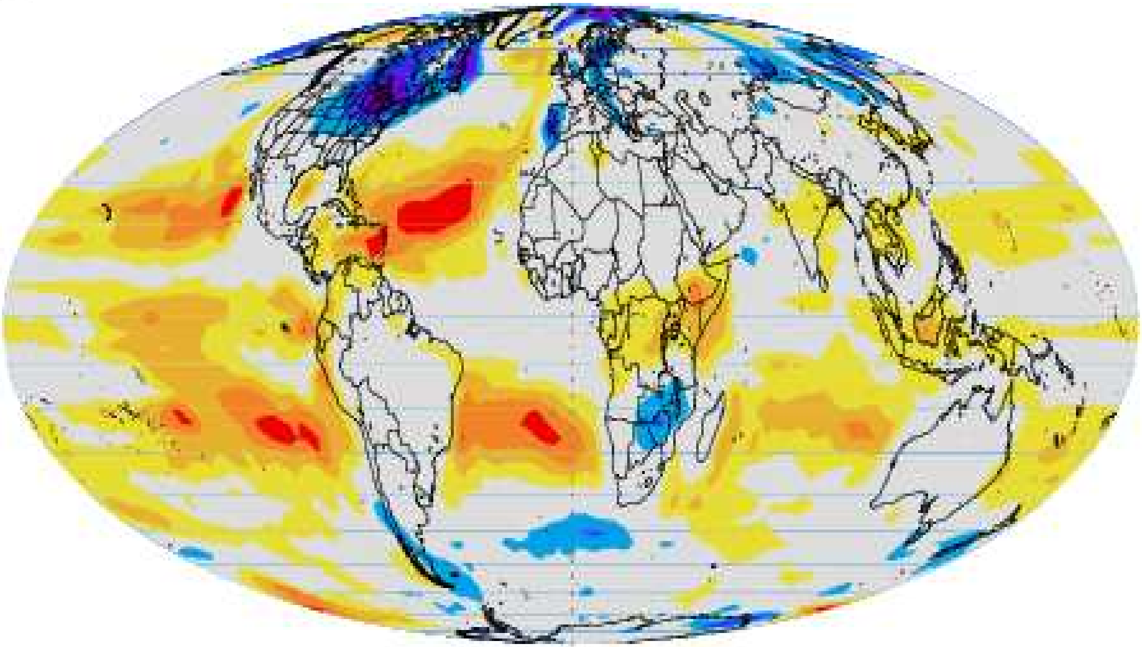


True bias
Tobs-Tfc
Tfc
Systematic error
Tobs
Tfc
Apparent non-systematic error..
Tfc
…but projected into an additional dimension it appears to be systematic
Tfc
T850fc

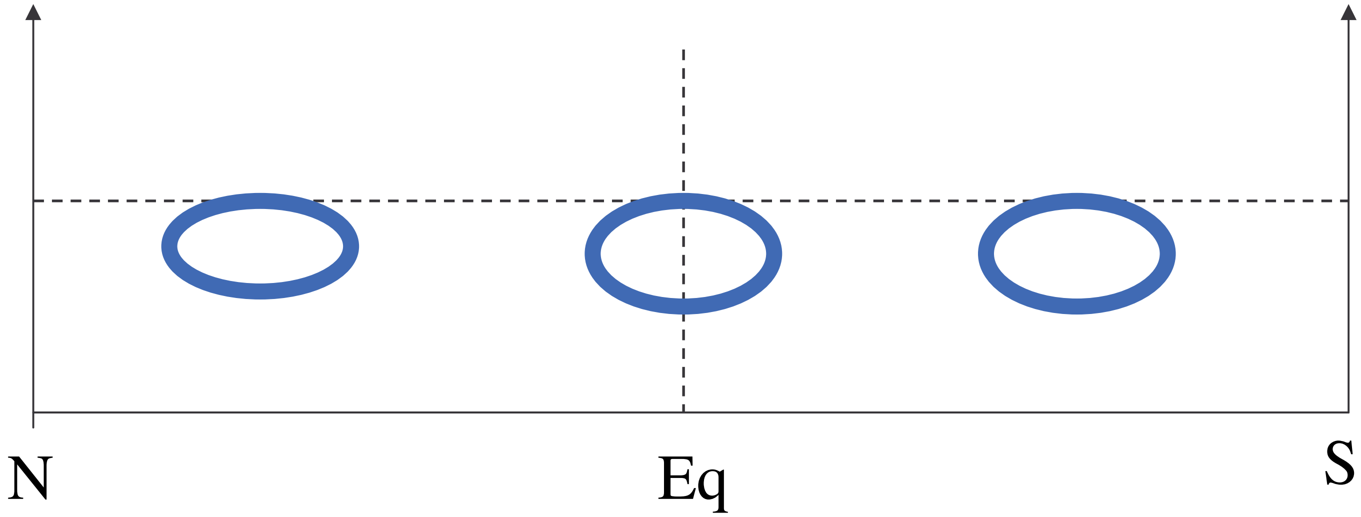
4.2 Systematic errors which look non-systematic

Two global cloud impact simulations which look quite different – or do they?

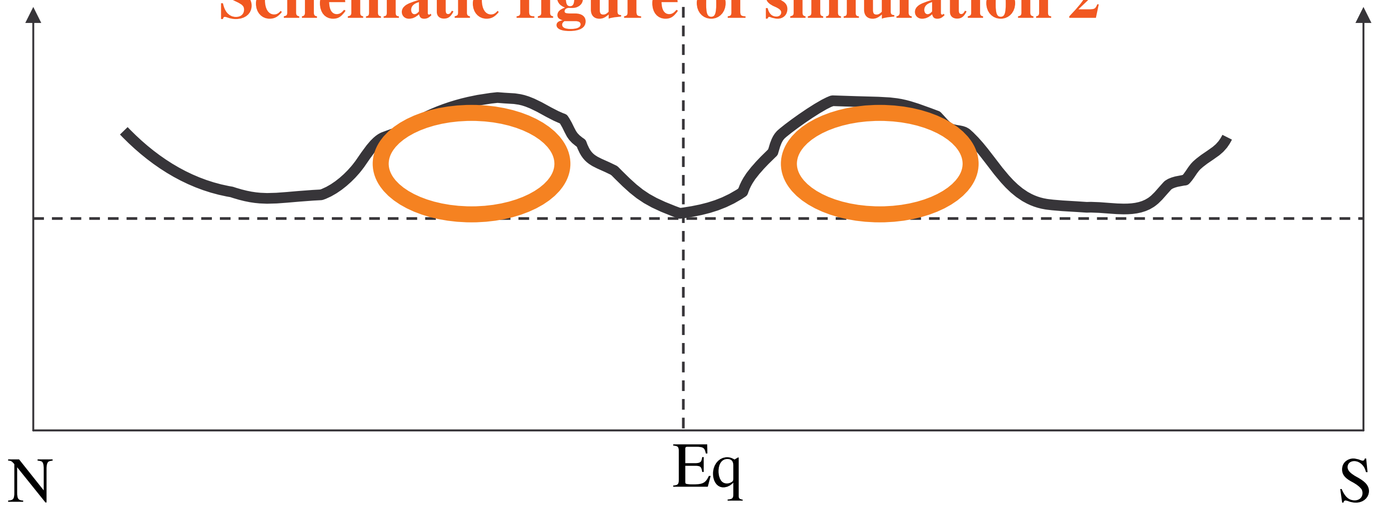


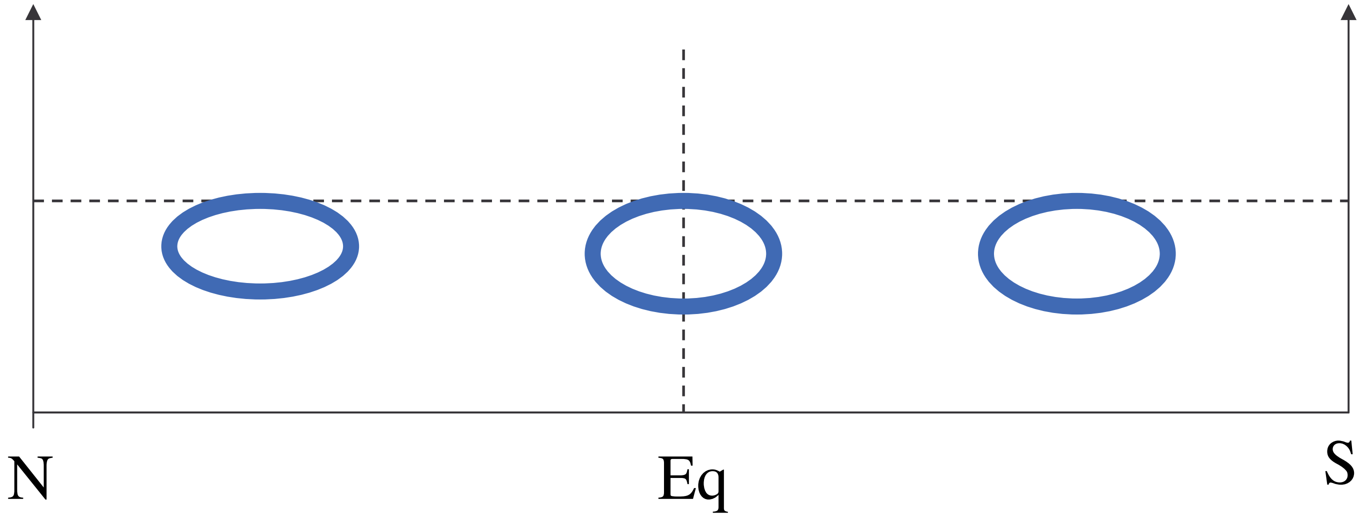


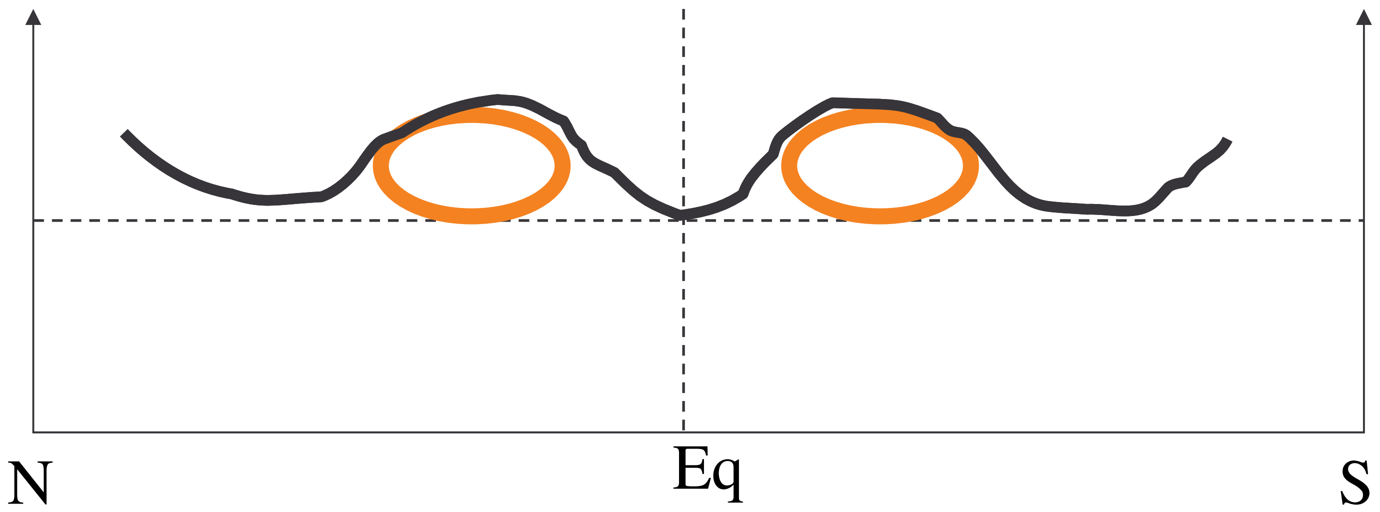
Schematic figure of simulation 1



Schematic figure of simulation 2



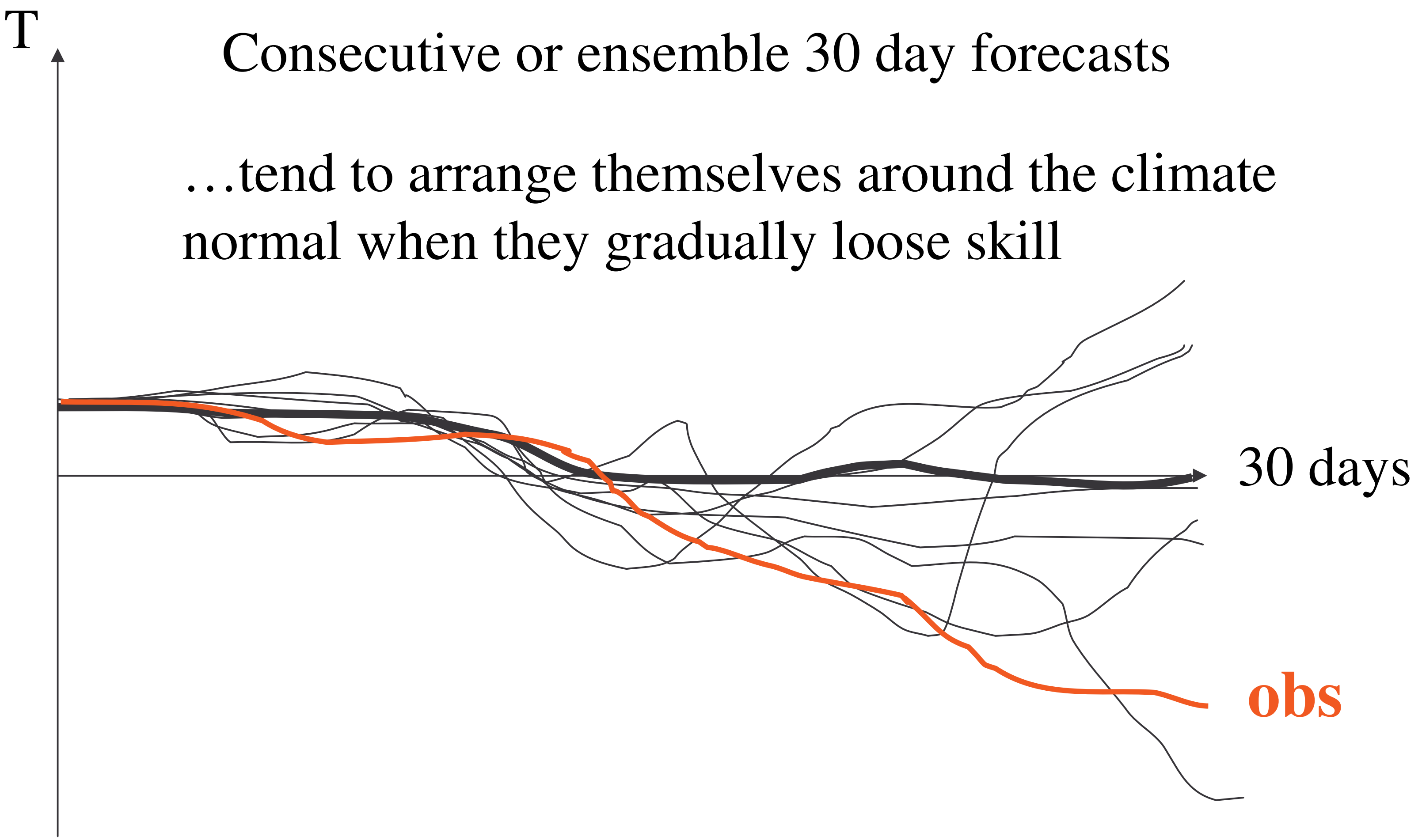

N
Eq
S


N
Eq
S

4.3 Non-systematic errors which look systematic

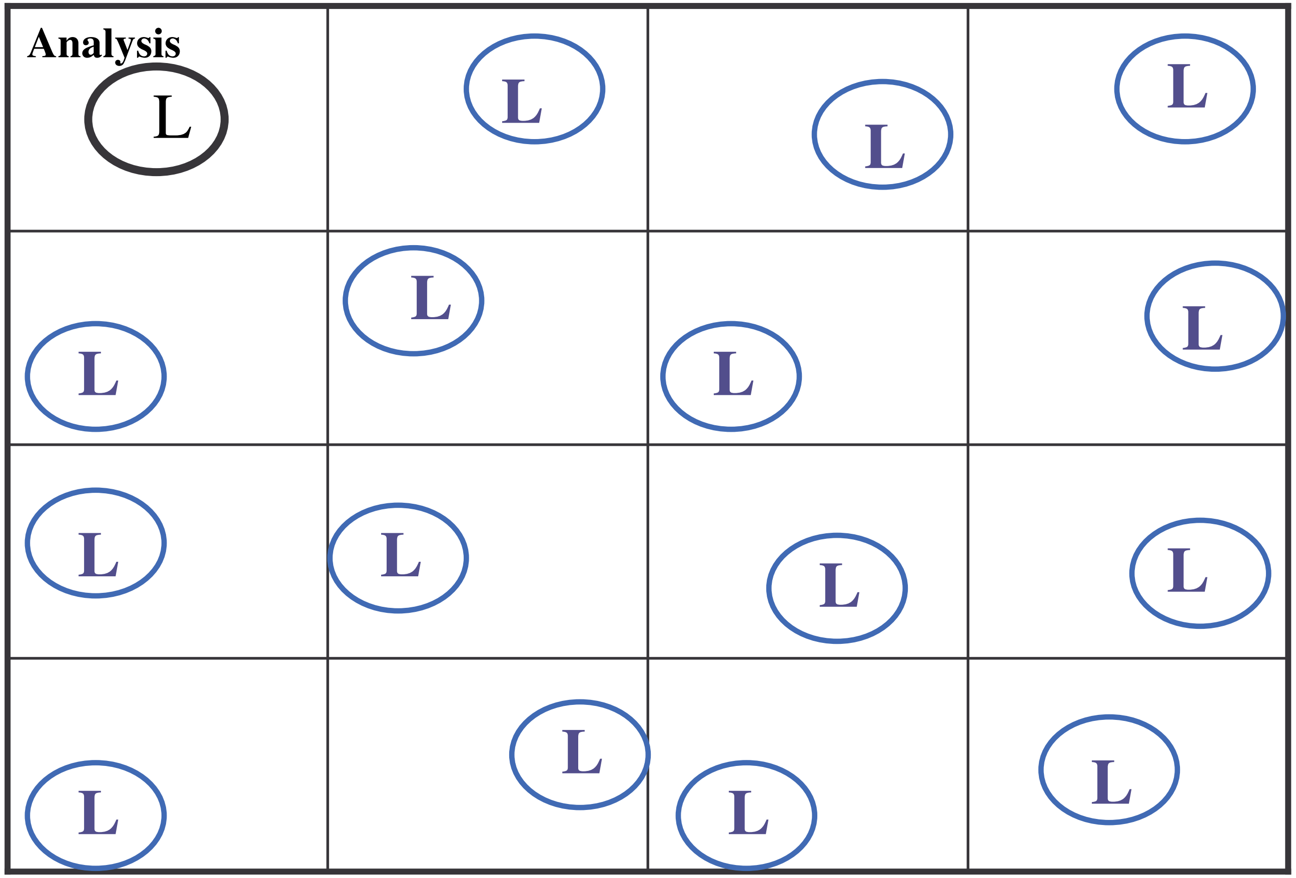
Consecutive or ensemble 30 day forecasts

…tend to arrange themselves around the climate normal when they gradually loose skill

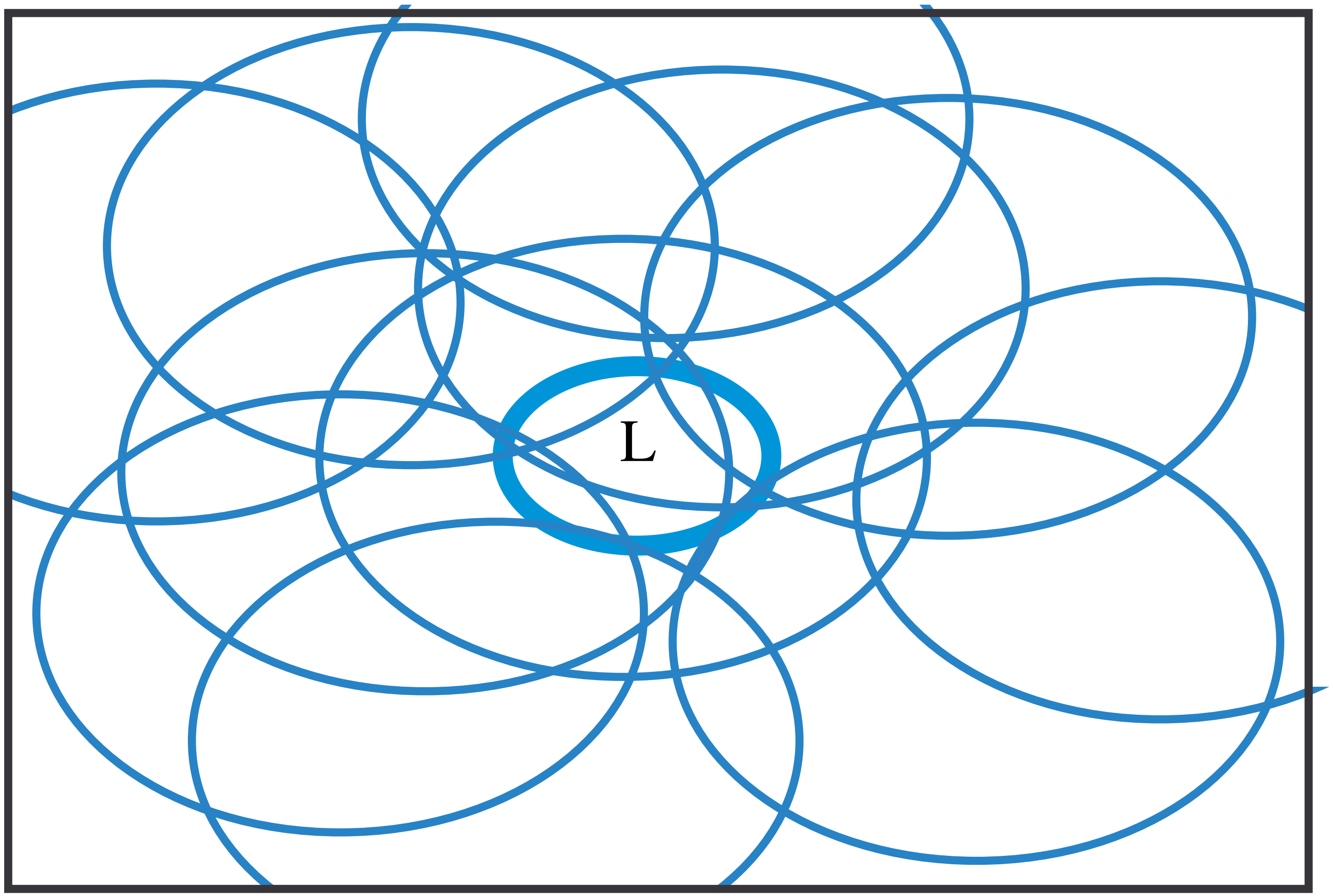


The result gives the impression of a mean error ("bias")

Fifteen different forecast get the intensity right, but not position



The mean of the forecasts look weaker than the analysis although the forecast all had the right intensity



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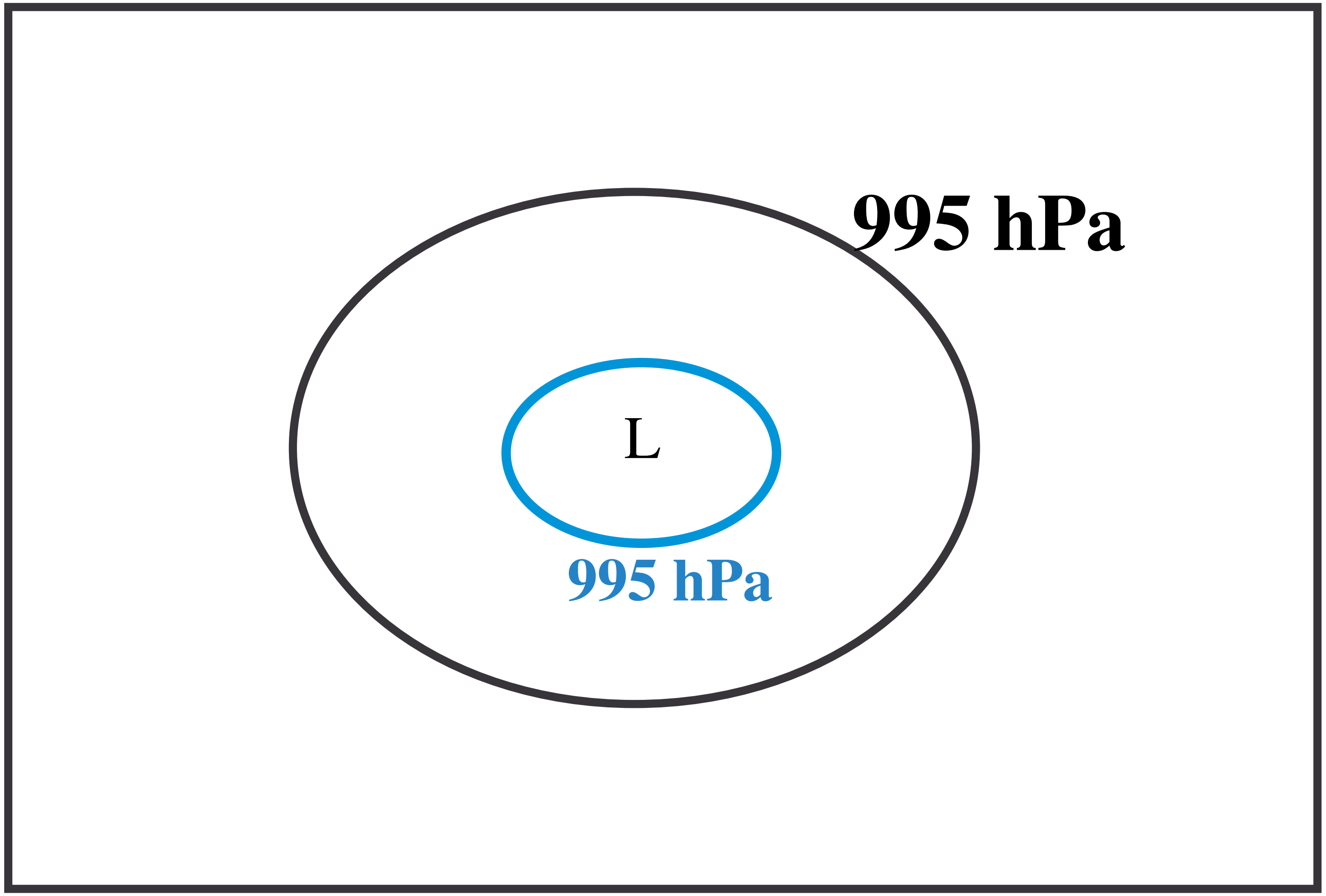


5. Probabilities

5.1 Conditional sampling

A colleague carried out statistics on the weather forecasts and claims that the NWP over forecasts rain:

"When > 10 mm is forecast it rains >10 mm only on ¼ of the cases and then on average only about 7 mm"

Forecasts 48-72 hours ahead	More than 10 mm observed	Less than 10 mm observed
More than 10 mm forecast	5	15
Less than 10 mm forecast	15	65

5.2 Your life might be at risk if you do not understand statistics!

A man was afraid that he suffered from a fatal disease

His doctor applied a test which was said to be “90% accurate”

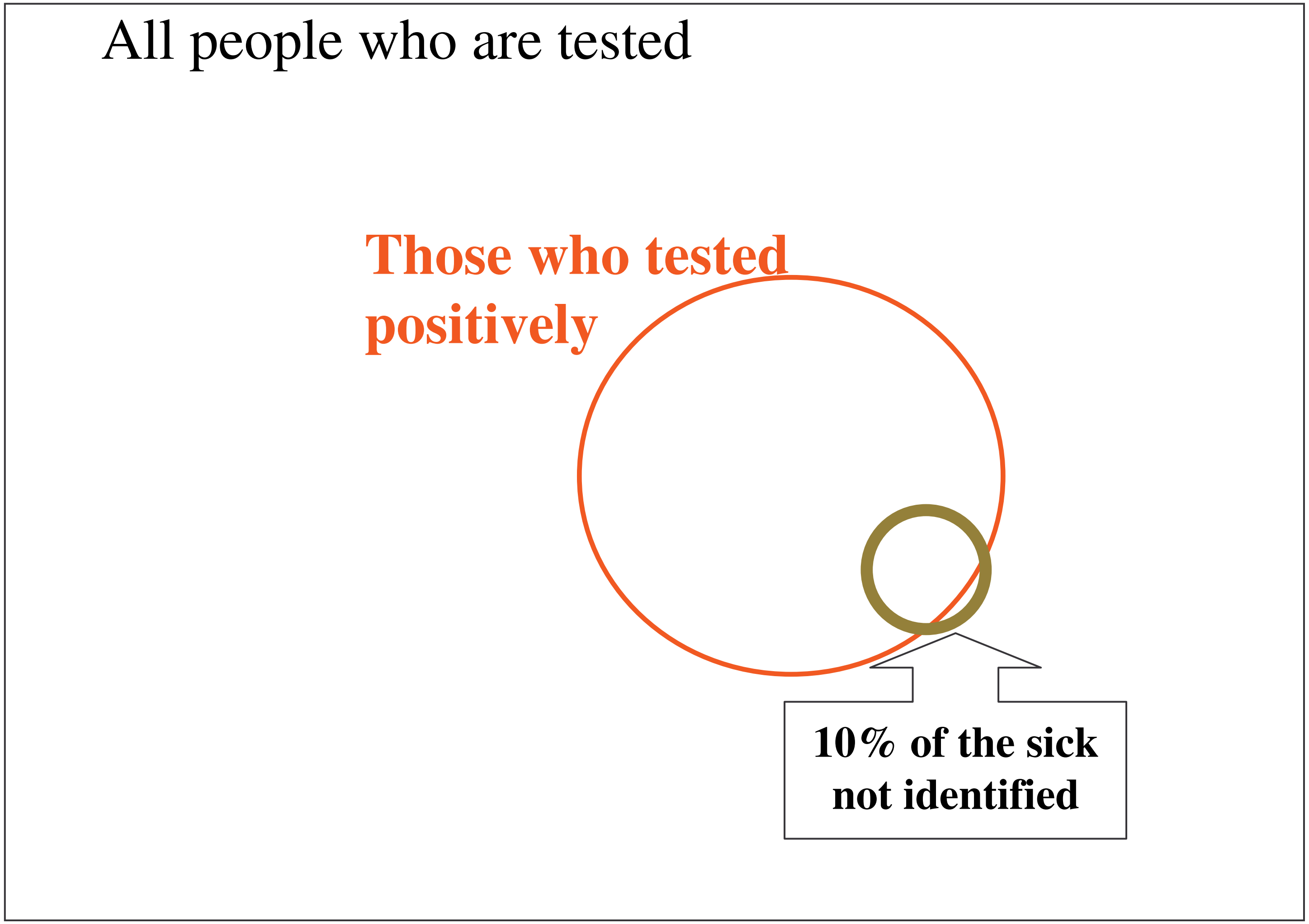
The man tested positively and went home and committed suicide

The risk that he actually had the disease might have been <10%

	Sick	Sound	
Test +	45	455	500
Test -	5	9495	9500
	50	9950	

The test is indeed 90% accurate (catches 45 sick of 50)

Probability that the test+ man is sick = 9%


All people who are tested
Those who tested positively
10% of the sick not identified

Decision-making with probabilities –

Extreme events (ackn. Ken Mylne)

1% risk that a plane will crash - ***would you board it?***

"Climatology" : 1 in 7 million= 0.0014 $^o/_{oo}$ so 1 in 100 is a **HIGH RISK**

Cost protective action = *plane ticket:* ~ €500

Possible loss = *life! ~ €1,000,000+*

C/L = 500/1,000,000 = 0.0005= 0.5 $^o/_{oo}$

Averaged over many occasions, the user's best strategy is to: protect when ***p(event)>C/L***

In this case p > 0.5 $^o/_{oo}$

We have to be prepared to take action even at low probabilities!!

5.3 Do not try to be too smart!

The London waiter

£ 40/day salary when called in

£ 200 extra/day profit for bar when he is called in

EMV = -£40 + risk times £200 = 0
yields
risk = 40/200 = 20%

Conclusion: The waiter should be recruited at time the risk of rain is less than 80%

The London waiter

BUT…..If the waiter should be recruited at any time the risk of rain is less than 80%

Why not employ him permanently?

If the place is London the climatological risk < 80 perhaps 50%

<u>Permanently employed:</u> salary £30/day and give a £100 intake

END