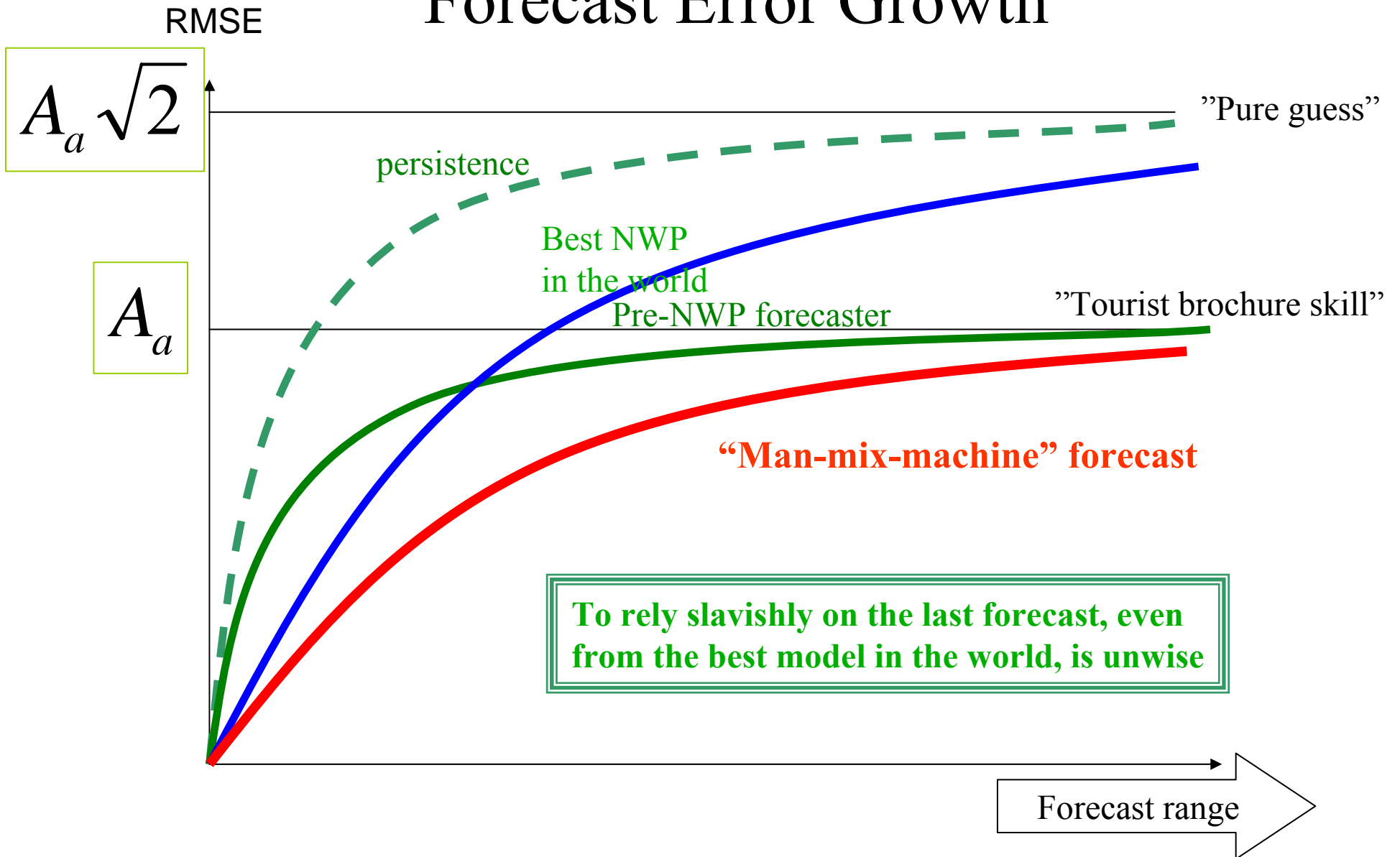


Some topics in medium range weather forecasting

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**Research dept
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Forecast Error Growth

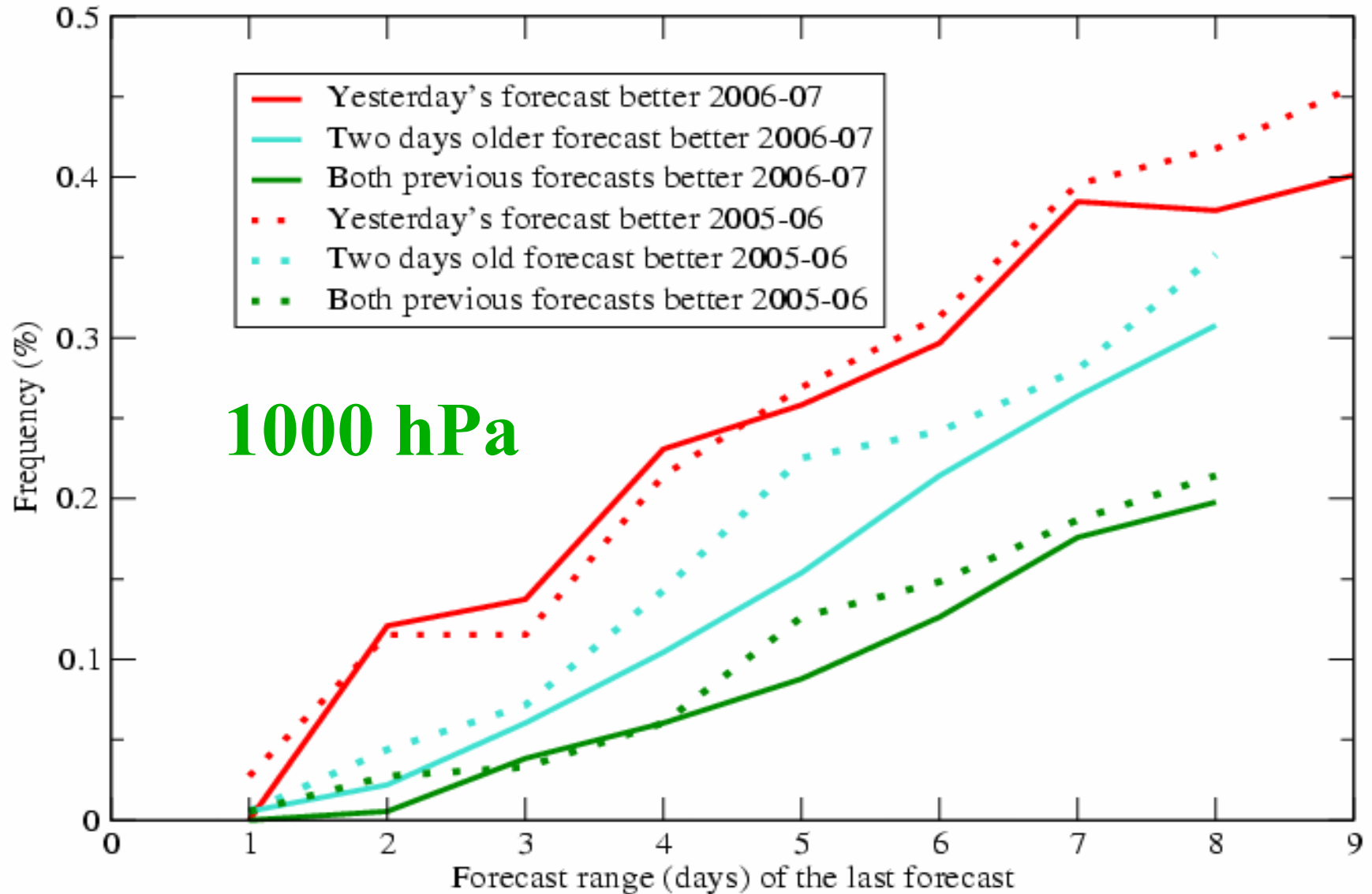


- 1. Is the last ECMWF forecast always better than the previous?**
- 2. Does blending forecasts always work?**
- 3. Updating of the EPS probabilities in light of later observations?**

**1. Is the last ECMWF
forecast always better
than the previous?**

HOW OFTEN IS THE LAST ECMWF FORECAST THE BEST?

Comparison of 1000 hPa forecasts in terms of RMSE 2005-07 over Northern Europe

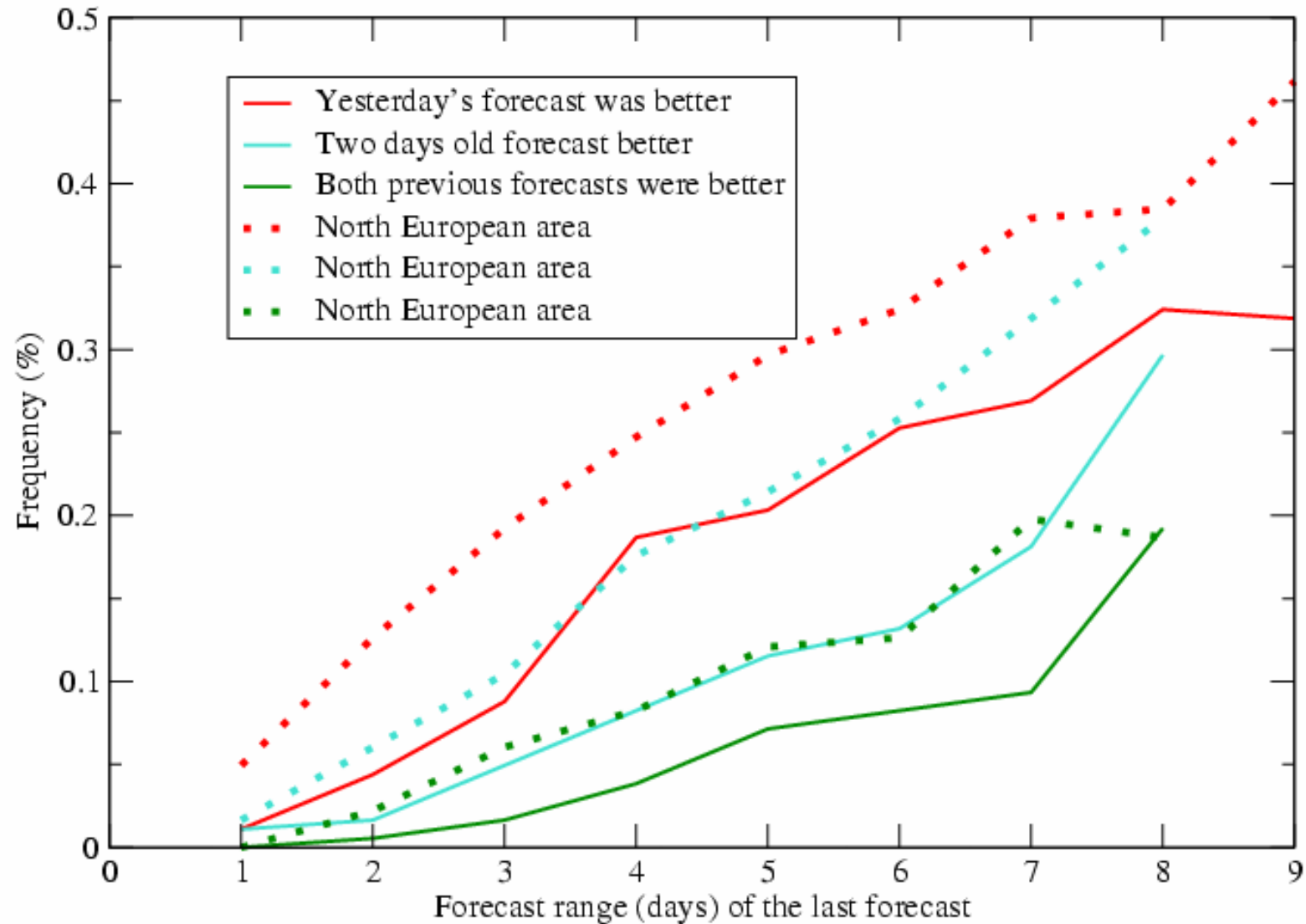


The verifications have so far related to the full European area.

It is expected that the frequencies will increase with a smaller area, like the North European area

HOW OFTEN IS THE LAST ECMWF FORECAST THE BEST?

Comparison of 500 hPa forecasts in terms of ACC 2006-07 over Europe



Conclusions of part 1:

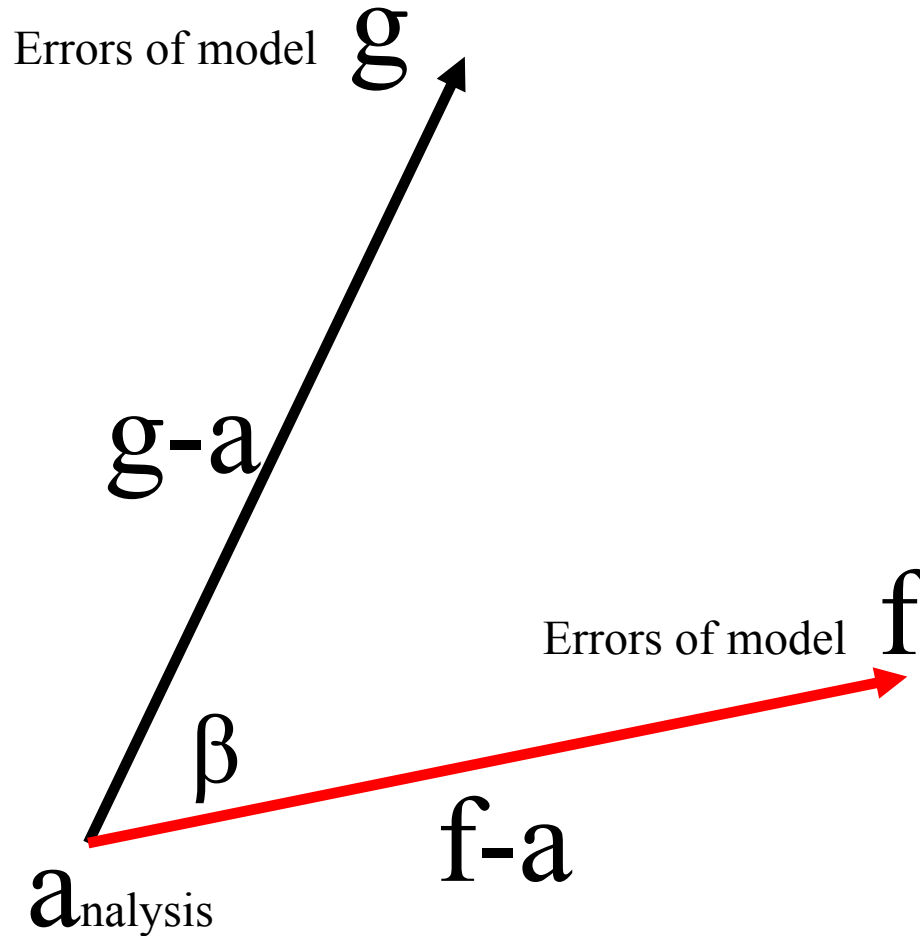
Last ECMWF are worse than the one 12 hours earlier in 20% of the cases at D+3, increasing to 50% at D+9.

For local forecasts the D+3 values might increase to 30%

2. Does blending of forecasts always work?

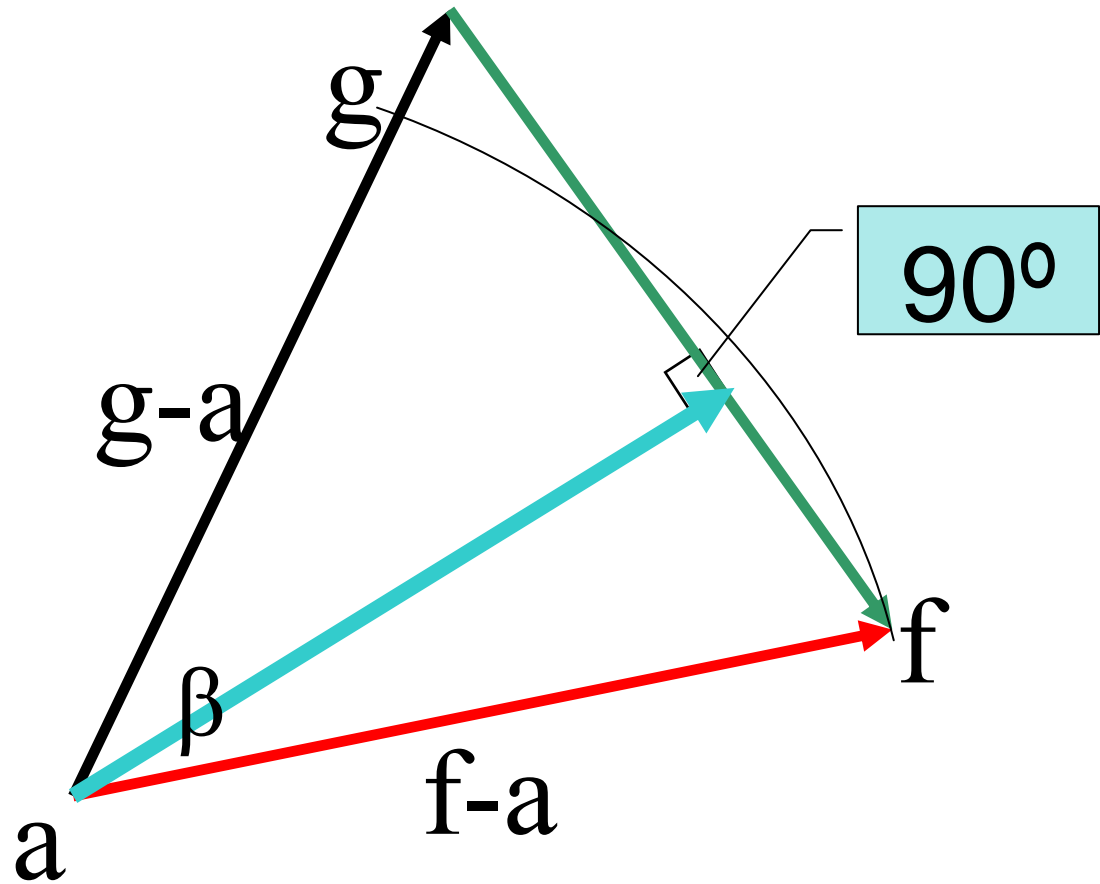
Forecast errors can mathematically be represented by vectors in phase-space, where the cosine of their angle (β) equals their correlation

The image shows correlated, but non-equal errors

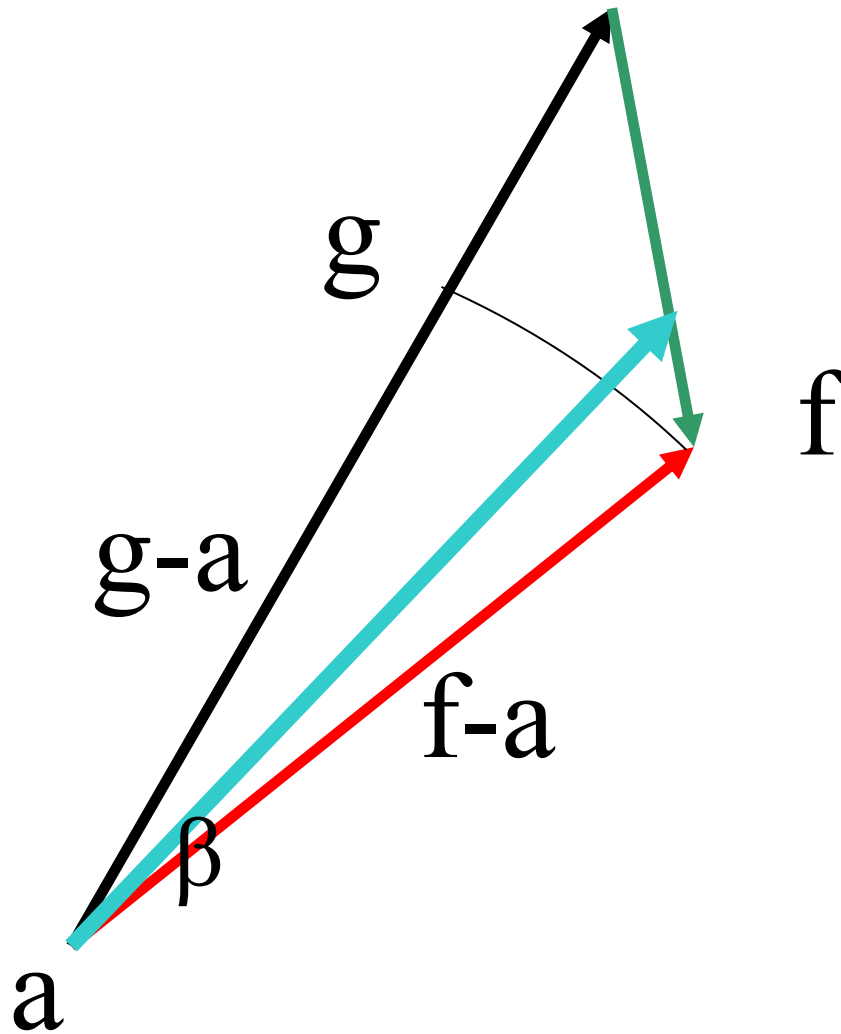


Correlated, but
non-equal errors

Weighted
ensemble mean
minimizes the
error

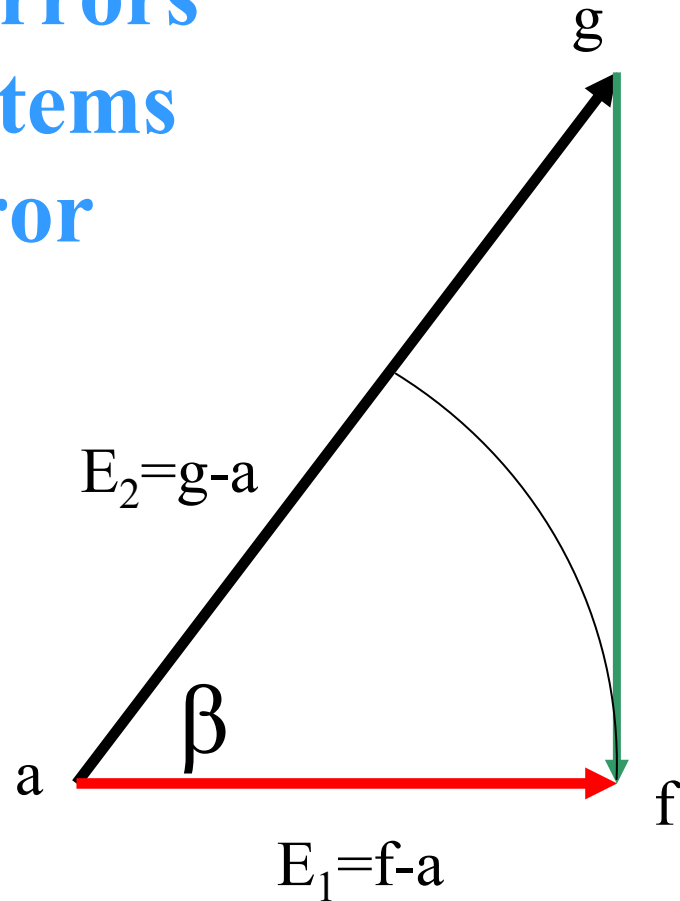


At some stage any weighting will not improve the forecasts



Breaking point:
when the fraction
between the errors
of the two systems
equals the error
correlation

$$\frac{E_1}{E_2} = \cos(\beta) = \text{corr}(E_1, E_2)$$

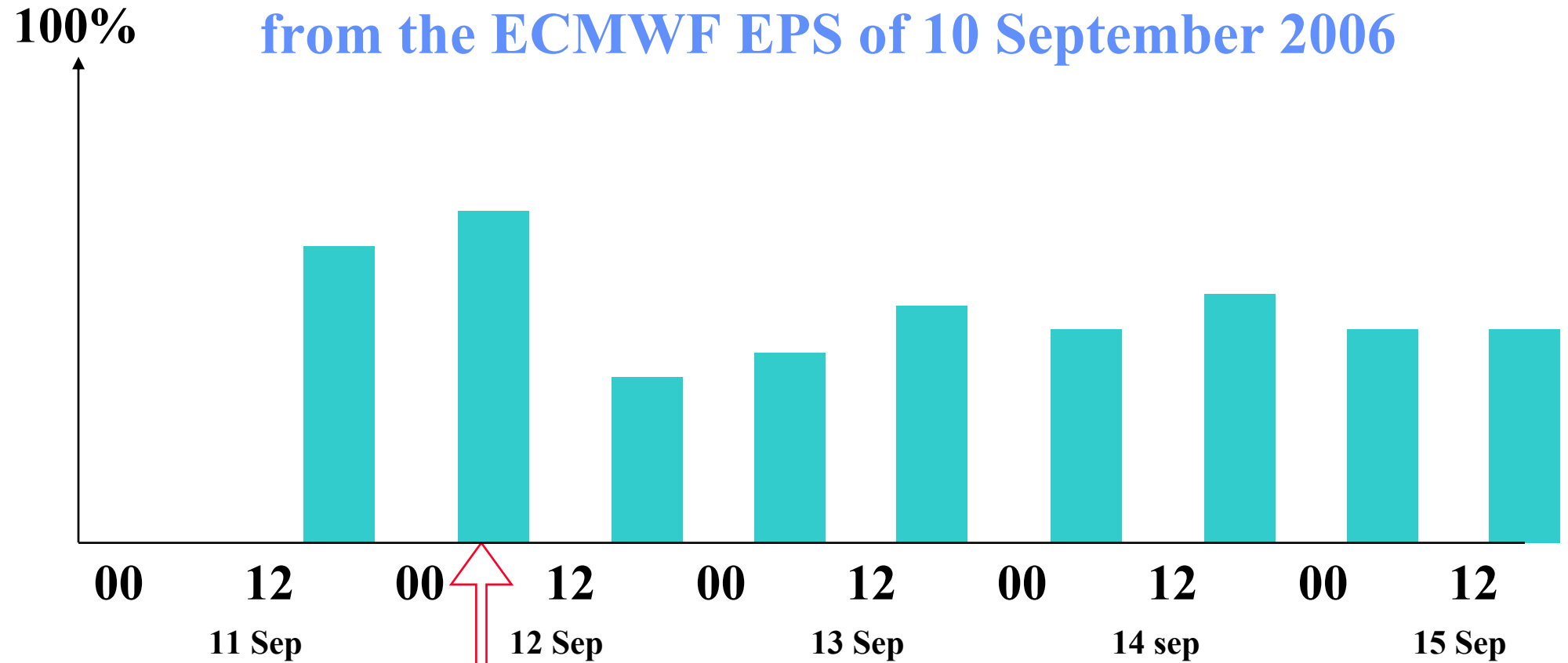


Conclusions of part 2:

Although blending forecasts from different runs (“lagging”) from the same model or the same run from different models (“poor man’s eps”) is a useful alternative to the proper ensemble system, the relation between forecast error magnitude and error correlation might exclude some forecasts.

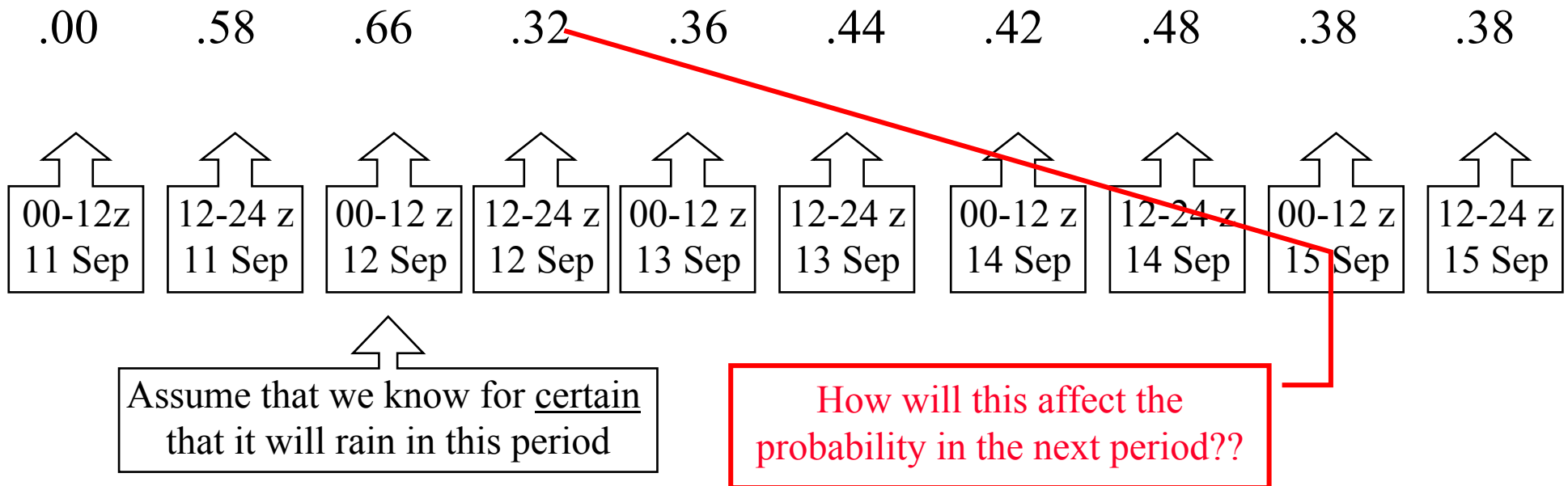
3. Updating of the EPS probabilities in light of later observations?

Probabilities of > 1 mm rain per 12 hours in London from the ECMWF EPS of 10 September 2006



Assume that we know for certain that it will rain in this period

Probabilities of > 1 mm rain per 12 hours in London From the ECMWF EPS of 10 September 2006



0	1	11	33	0	4	4	21	20	97	89	2	15	36	23	4	0	8	1	0
0	0	23	20	9	3	3	5	2	3	13	14	3	18	19	2	0	0	0	1
0	0	36	26	40	5	27	24	63	18	51	0	4	48	81					
0	0	0	6	0	7	70	199	1	41	2	61	54	44	65					
0	0	28	18	0	3	0	2	1	2	29	1	0	0	1					
0	0	8	83	1	52	156	51	18	43	7	5	64	18	0					
0	0	69	24	1	4	20	3	0	2	2	2	13	6	0	1	2	0	0	0
0	0	0	18	35	11	2	55	24	9	0	0	0	0	0	0	0	2	0	1
0	0	0	5	23	23	31	3	152	10	2	55	54	21	4	19	117	2	0	6
0	0	62	47	2	2	1	1	0	4	3	0	0	0	19	113				
0	0	0	34	14	48	55	21	1	0	0	0	0	1	4	1				
0	0	41	10	0	1	0	1	2	1	0	0	0	1	3	0				
0	0	0	28	26	35	9	2	5	11	64	12	2	2	0	0				
0	0	35	11	7	3	0	4	11	1	0	8	13	76	27	0	0	0	76	7
0	0	30	9	0	3	17	32	37	21	61	12	75	69	3	6				
0	0	0	1	10	36	15	7	9	9	1	0	0	0	0	0				
0	0	0	3	4	13	26	3	72	2	1	0	4	22	11	1				
0	0	81	14	0	8	4	2	0	14	0	0	0	0	0	0				
0	0	7	27	15	2	0	24	19	0	1	0	3	47	5	0	0	0	6	5
0	0	56	22	6	0	61	80	0	0	0	0	0	0	0	0				
0	0	48	16	0	2	1	3	5	0	0	4	95	191	6	0				
0	0	0	19	22	46	16	46	52	5	22	1	0	0	0	2				
0	0	33	49	1	2	0	68	6	0	0	0	21	12	1	0	1	2	4	15
0	0	44	65	5	2	5	16	264	1	7	84	22	5	0	0	0	0	2	4
0	0	43	15	5	12	60	76	21	24	72	38	32	6	5	0	9	21	0	19
0	0	0	25	7	5	7	9	0	1	0	0	0	2	100	61	6	0	0	1
0	0	65	7	0	6	11	0	0	0	0	36	10	34	2	30	3	3	0	1

**Rain followed by rain
>10mm/12h**

**Dry followed by
rain >10mm/12h**

**Rain followed by
dry <10mm/12h**

**Dry followed by
dry <10mm/12h**

Number of EPS-members forecasting persistent or changing conditions 12-24z 11 Sep to 00-12z 12 Sep

		12-24z 12 Sep
		R ⊗
00-12z 12 Sep	R	$\left(\begin{array}{cc} 13 & 20 \\ 3 & 14 \end{array} \right)$

⊗ = *dry* **R** = **rain**

From which a transition matrix can be formed

$$\begin{array}{l} \text{Previous} \\ \text{period} \\ \text{12-24z} \\ \text{11 Sep} \end{array} \begin{array}{c} \text{R} \\ \text{R} \\ \otimes \end{array} \begin{array}{c} \text{R} \\ \otimes \end{array} \begin{array}{c} \text{00-12z 12 Sep} \\ \otimes \\ \text{.61} \\ \text{.82} \end{array}$$

Detailed description: The image shows a transition matrix R for a two-state system (dry and rain) over two time periods. The rows represent the previous period (12-24z on 11 Sep) and the current period (00-12z on 12 Sep). The columns represent the states: dry (⊗) and rain (R). The matrix elements are: P(dry|dry) = 0.39, P(rain|dry) = 0.61, P(dry|rain) = 0.18, and P(rain|rain) = 0.82.

$$\otimes = \textit{dry} \quad \mathbf{R} = \textbf{rain}$$

Depending on if rainy or dry conditions proceed the 12-h period the original probability 32% can be updated to 39% or 18%

	00-12z	12Sep
Previous period	R	⊗
12-24z	$\mathbf{R} \begin{pmatrix} .39 & .61 \\ .18 & .82 \end{pmatrix}$	
11 Sep	⊗	

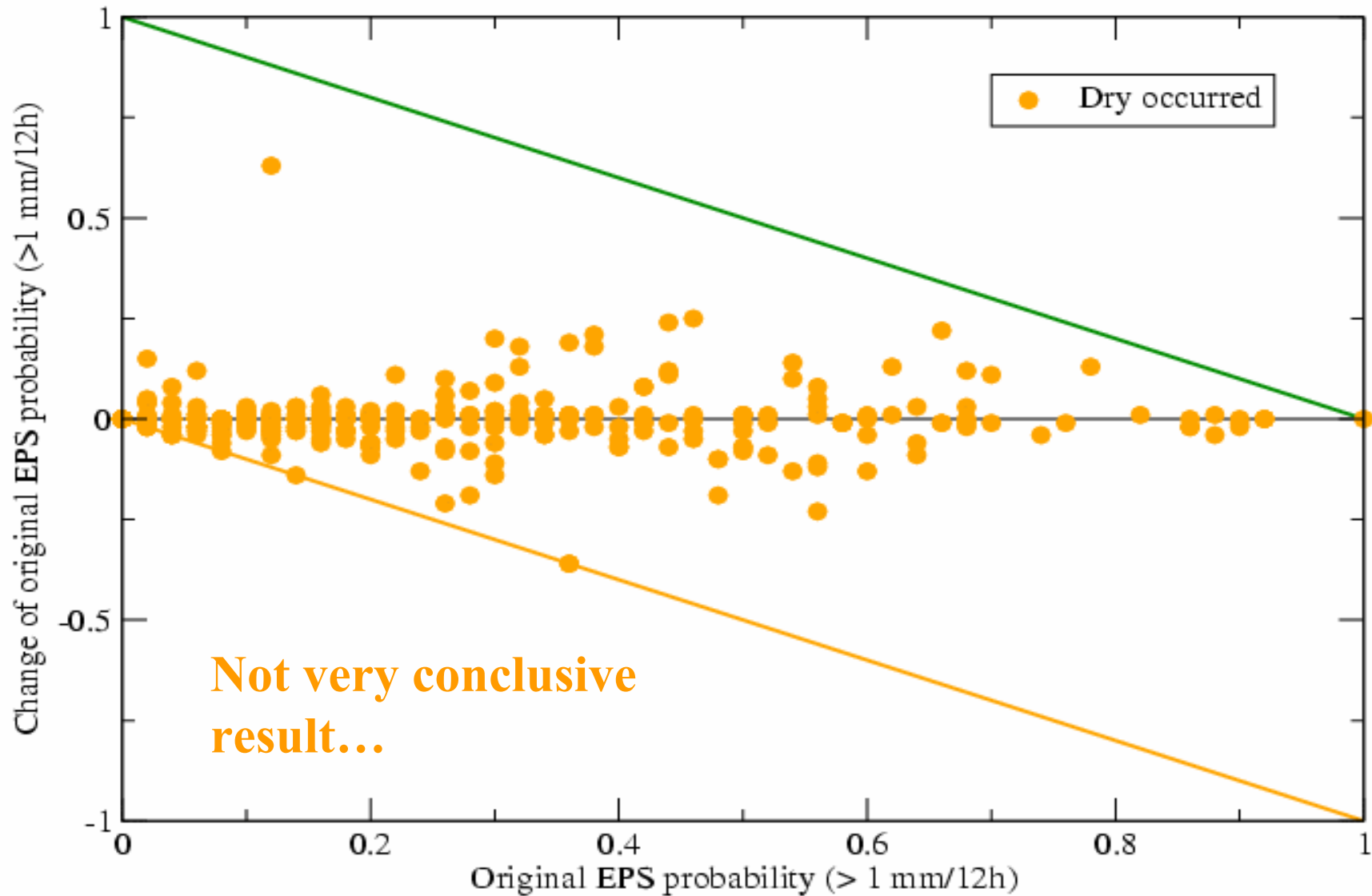
⊗ = *dry* **R** = **rain**

Updated probabilities from knowledge of occurred weather 12 hours earlier

<i>old</i>	.00	.58	.66	.32	.36	.44	.42	.48	.38	.38
	⊗	⊗	●	●	●	●	⊗	⊗	⊗	⊗
	$\begin{pmatrix} 1.0 & .00 \\ .57 & .43 \end{pmatrix}$	$\begin{pmatrix} .72 & .28 \\ .57 & .43 \end{pmatrix}$	$\begin{pmatrix} .39 & .61 \\ .18 & .82 \end{pmatrix}$	$\begin{pmatrix} .62 & .38 \\ .24 & .76 \end{pmatrix}$	$\begin{pmatrix} .72 & .28 \\ .28 & .72 \end{pmatrix}$	$\begin{pmatrix} .55 & .45 \\ .32 & .68 \end{pmatrix}$	$\begin{pmatrix} .62 & .38 \\ .38 & .62 \end{pmatrix}$	$\begin{pmatrix} .58 & .42 \\ .19 & .81 \end{pmatrix}$	$\begin{pmatrix} .47 & .53 \\ .19 & .81 \end{pmatrix}$	$\begin{pmatrix} .73 & .27 \\ .23 & .77 \end{pmatrix}$
<i>new</i>	.00	.57	.57	.39	.62	.72	.55	.38	.19	.19
<i>change</i>	0%	-1%	-9%	+7%	+26%	+28%	+13%	-10%	-19%	-19%

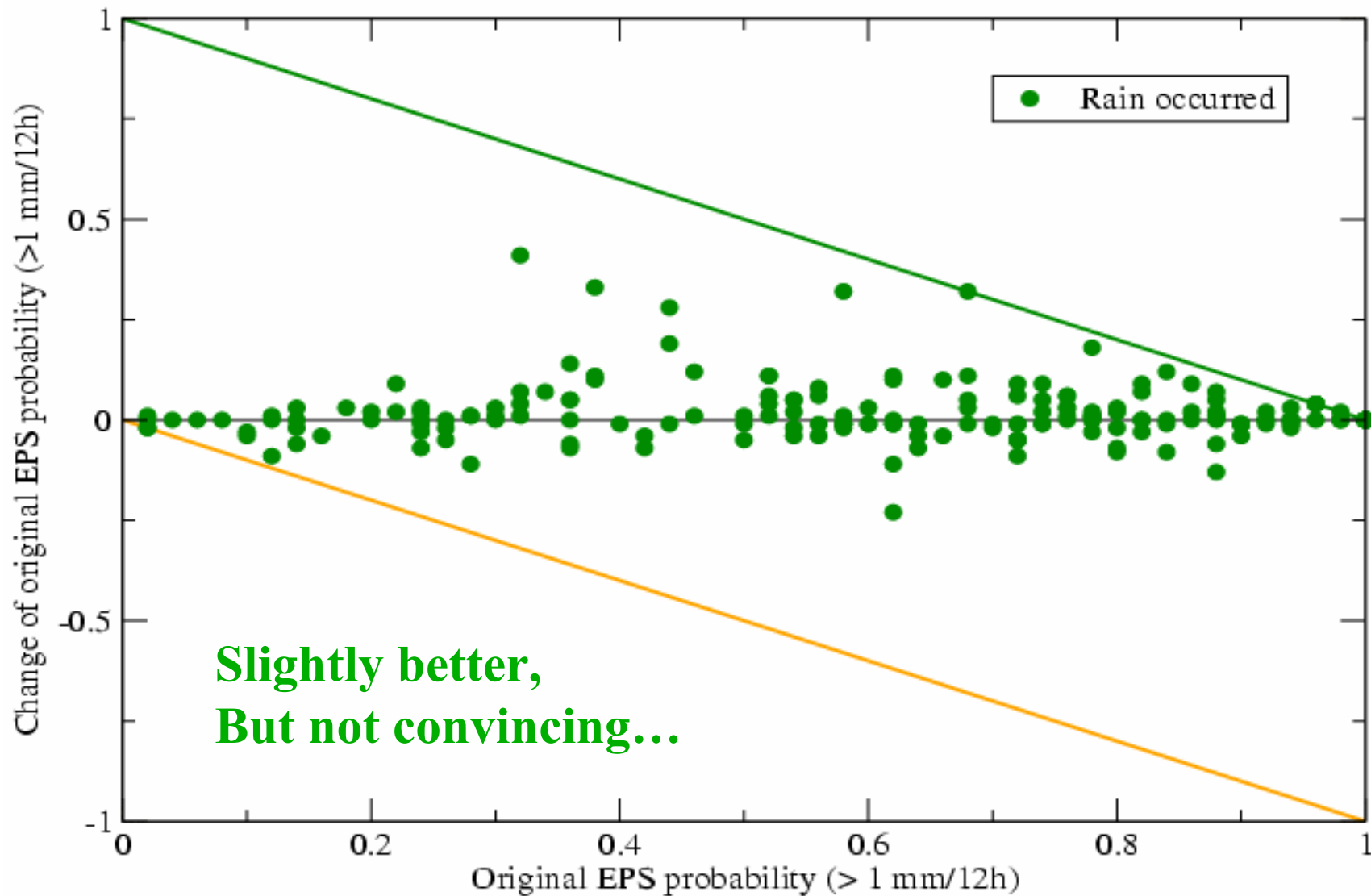
Updating rain probabilities (> 1 mm/12 h)

London-Heathrow 03772 Sep 2006-March 2007 (+36h to +120h)



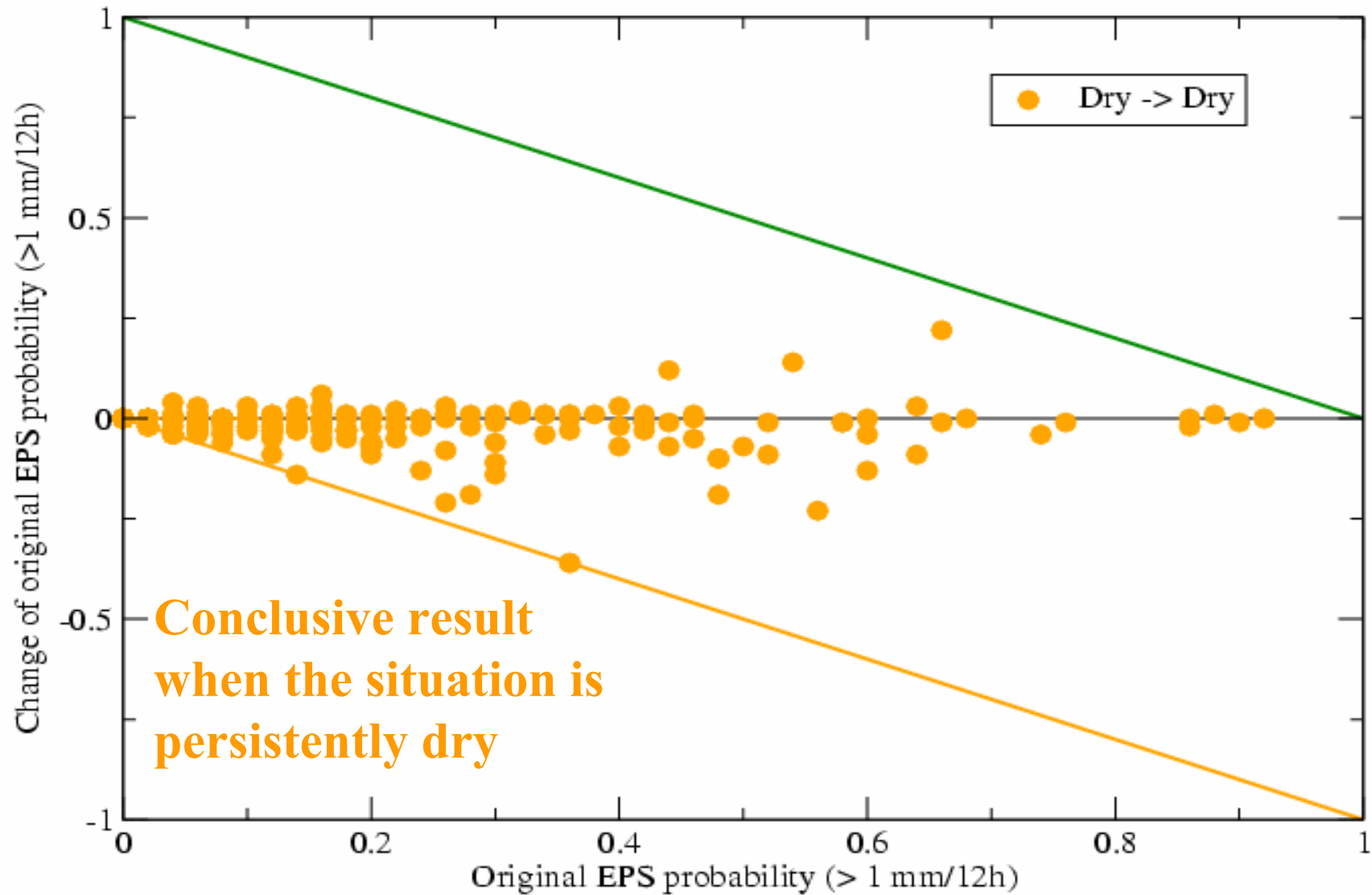
Updating rain probabilities (> 1 mm/12 h)

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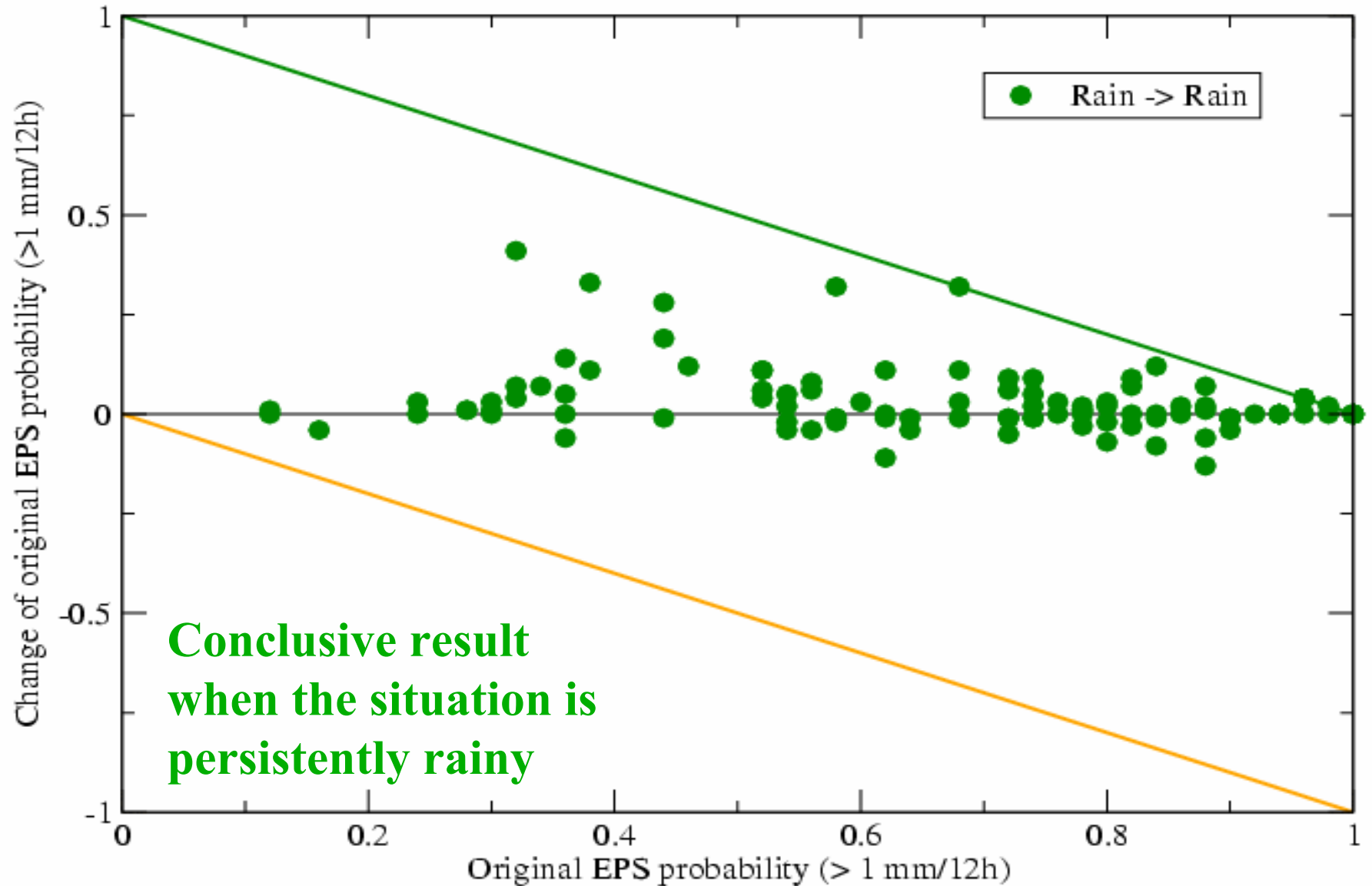
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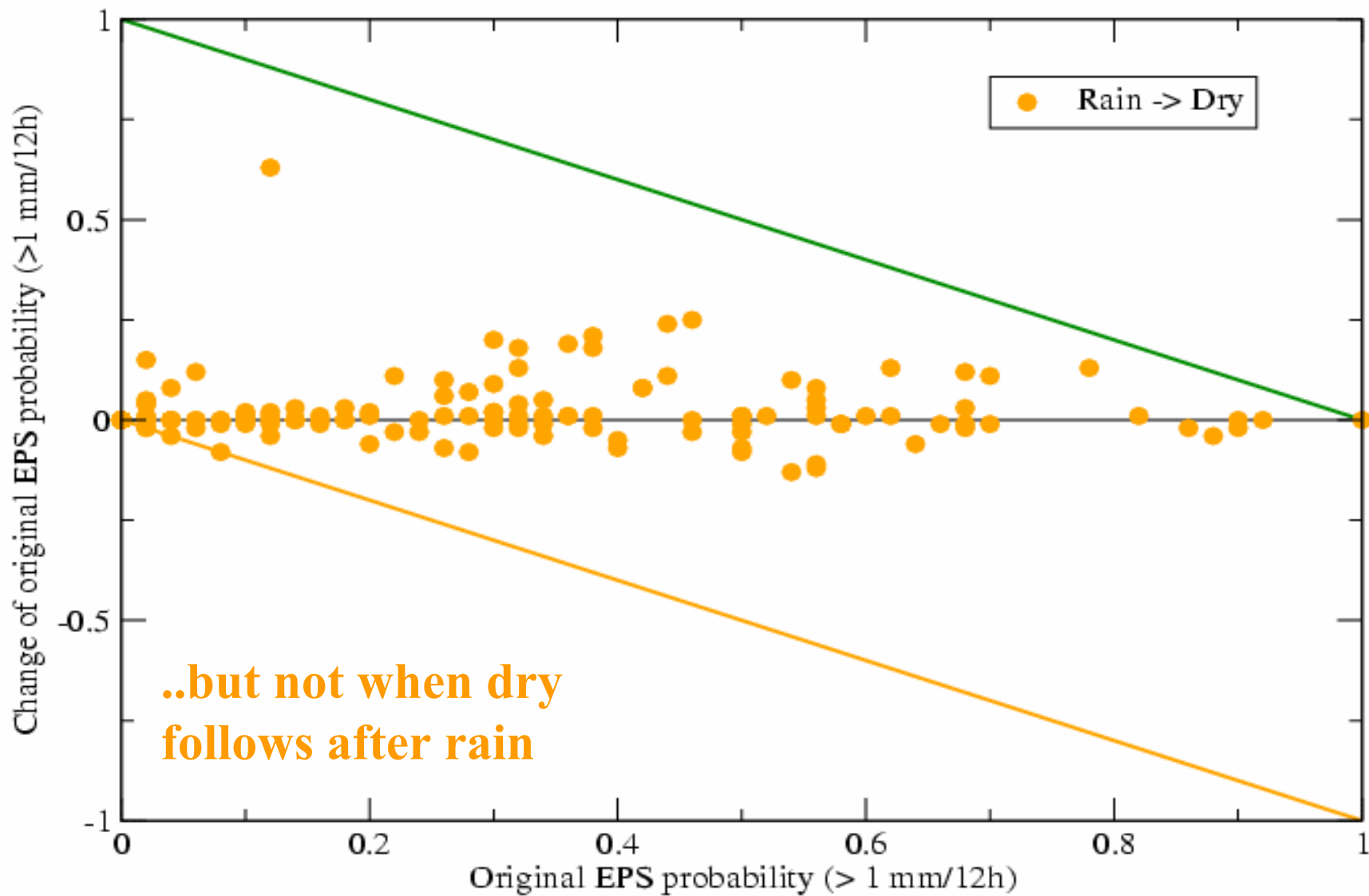
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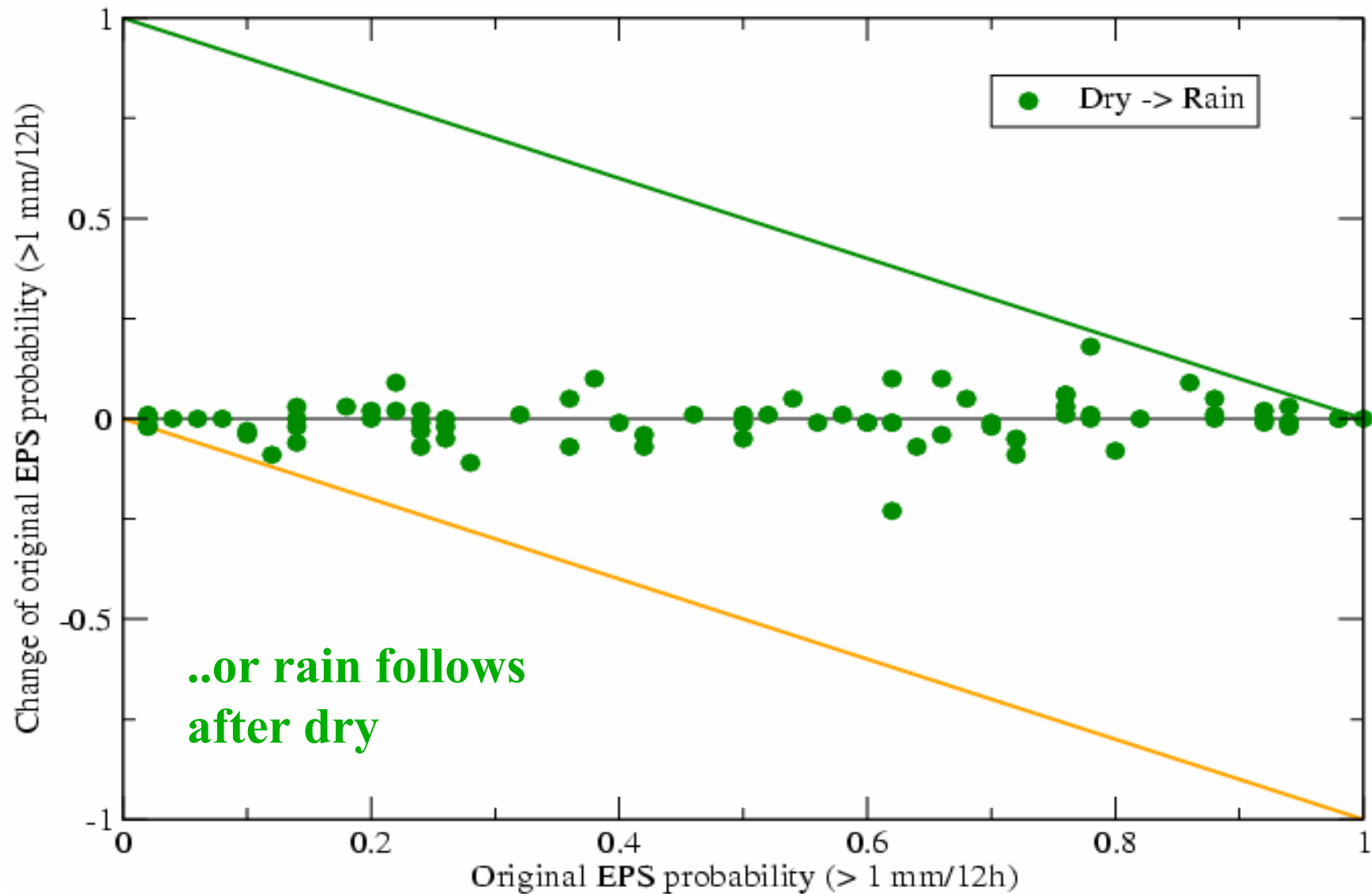
Updating rain probabilities (> 1 mm/12 h)

London-Heathrow 03772 Sep 2006-March 2007 (+36h to +120h)



Updating rain probabilities (> 1 mm/12 h)

London-Heathrow 03772 Sep 2006-March 2007 (+36h to +120h)



Conclusions of part 3:

Updating of EPS rainfall probabilities, at present, seems to work best in persistent (rainy or dry) situations and beyond D+2

End

Andrei A. Markov 1856-1922



**Inventor of the
Markov chains**