

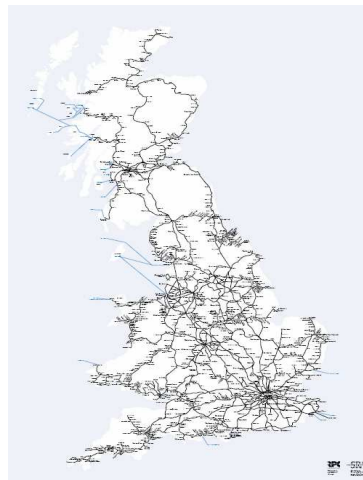
■
■ Outcomes and observations from the
■ CRANIUM railway embankment study



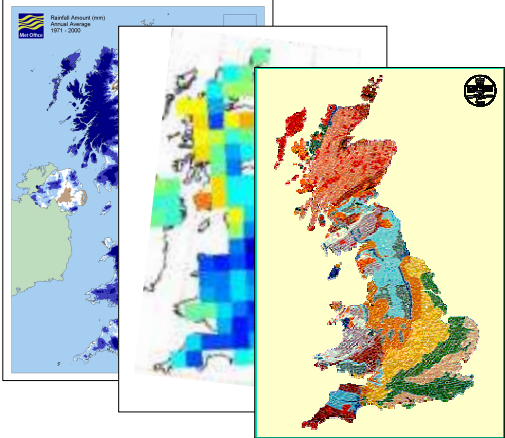
Lucy Manning,
Jim Hall,
Chris Kilsby,
Stephanie Glendinning

■
■ Need for reliability analysis in the face of
■ climate change


- n Quantify the extent to which a system is at risk from failures at different geographical locations
- n Identify locations of potential weaknesses
- n Derive a methodology to prioritise areas for management maintenance work
- n Illustrate how this might change with changing climate



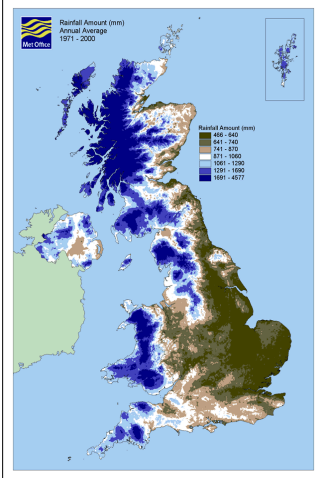
Input data



- n Rainfall
- n Climate change
- n Geology
- n System model



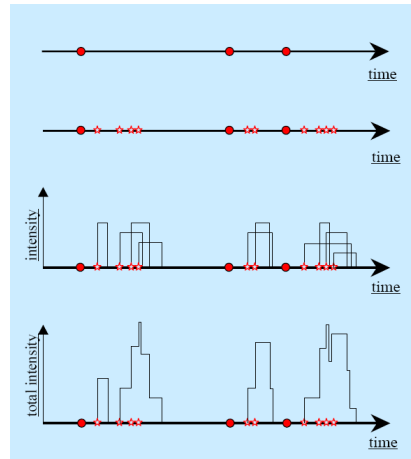
Rainfall



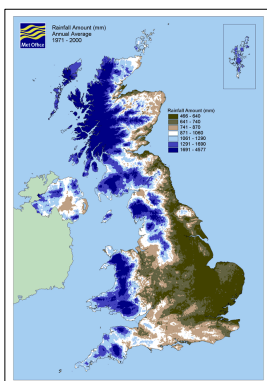
Weather generator (EARWIG)

Rainfall generation process

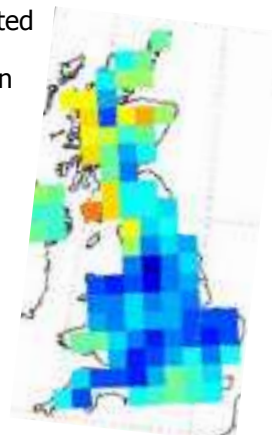
- n based on historical record
- n 5 key variables (daily/hourly distributions)
- n Set of variables for each location, and month
- n Other weather variables depend on whether it is raining



Representation of climate change (EARWIG)

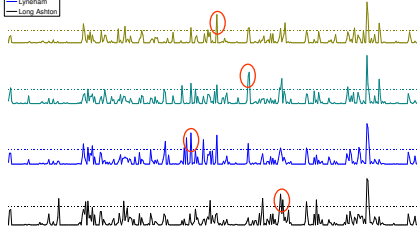


- n Use detailed knowledge of current climate
- n Superimpose the predicted change
- n Limited spatial resolution of predicted climate precludes conclusions about changing spatial rainfall scaling



Daily rainfall records: joint coincidence

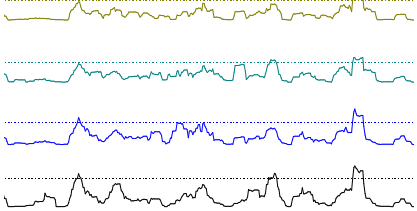
— Heathrow
— Oxford
— Lyntonham
— Long Ashton



One year daily rainfall record

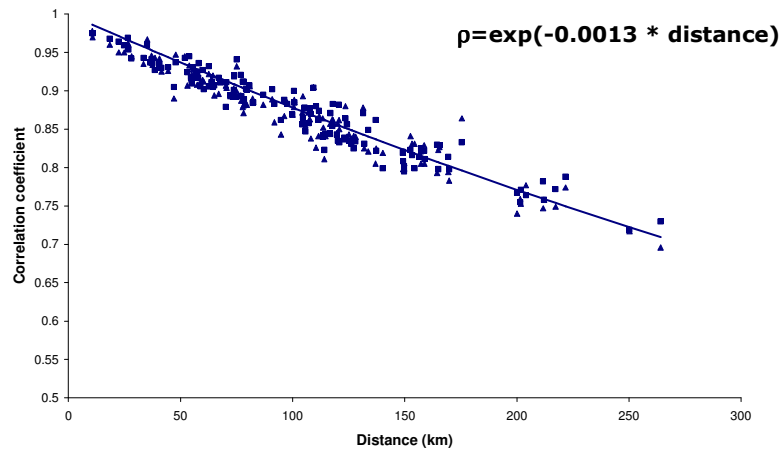
Four locations

— Heathrow
— Oxford
— Lyntonham
— Long Ashton

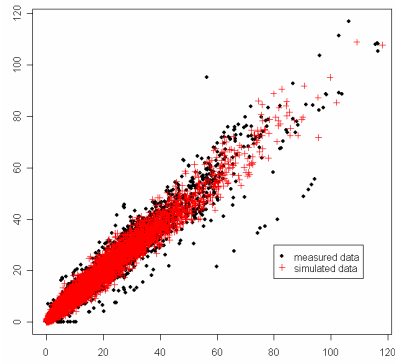


One year 10-day rainfall record

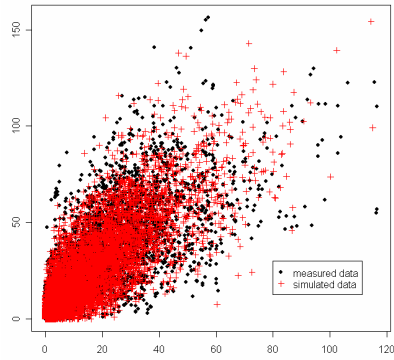
Rainfall spatial model



Simulated rainfall records



11 km separation



154 km separation

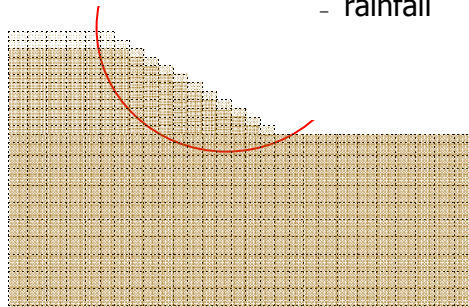
Geology





Slope model

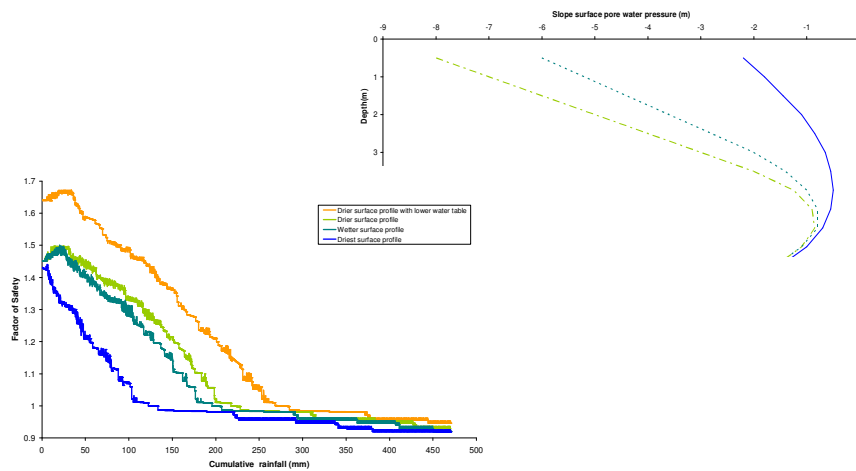
- Stability depends on:
 - slope geometry
 - material properties
 - rainfall



- Six-month simulations
- Not sensitive to short-term rainfall pattern
- Sensitivity not to extremes, but to total rainfall loading

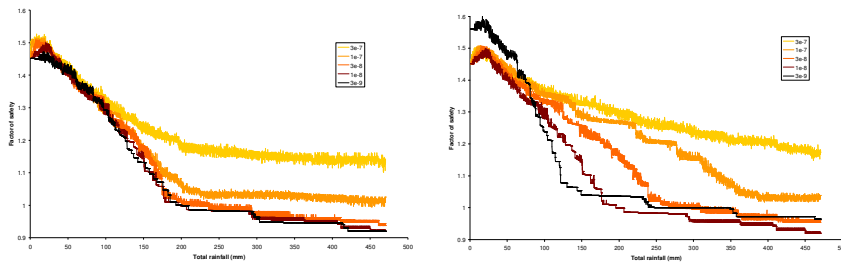


Effect of continuous rainfall on slope model

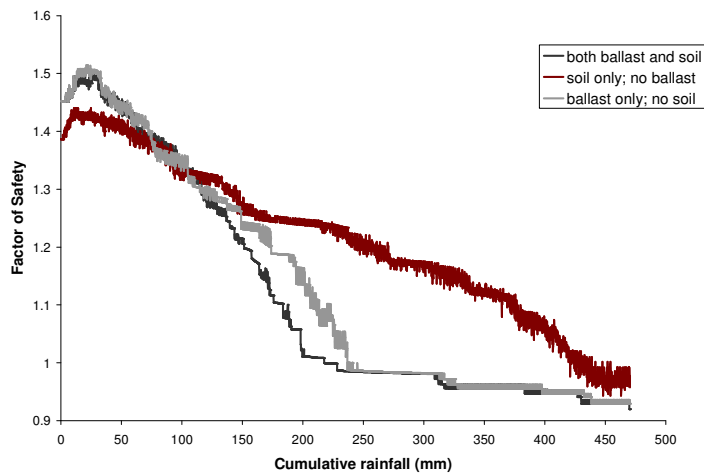




Effect of variation of permeability and soil moisture curve

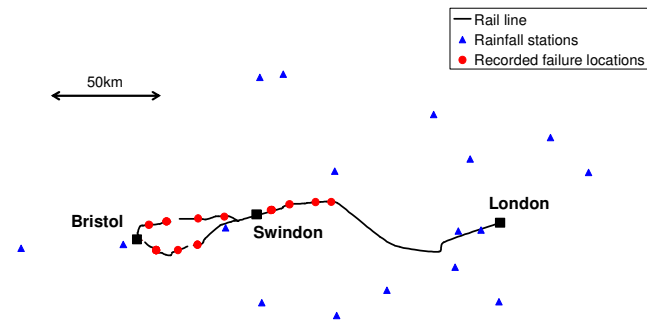


Effect of ballast and soil layers on rainfall infiltration

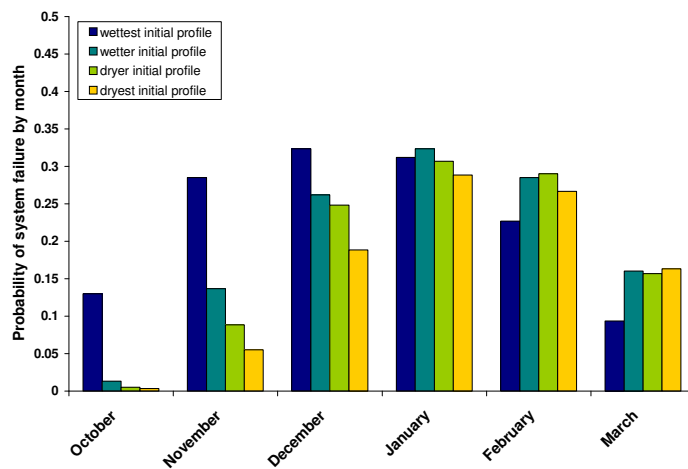




System model

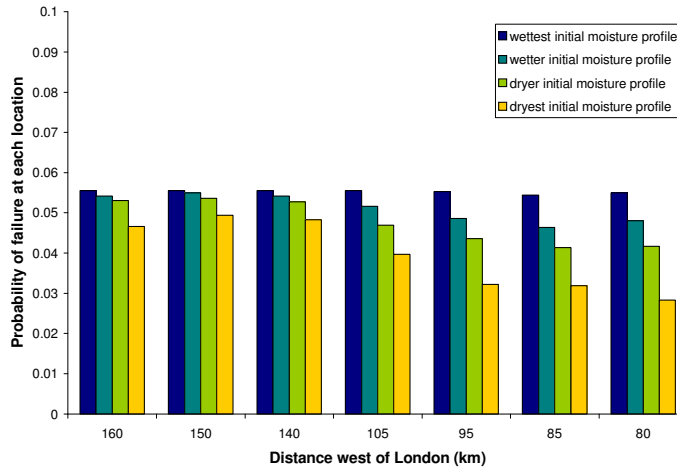


Dependence of stability on initial profile

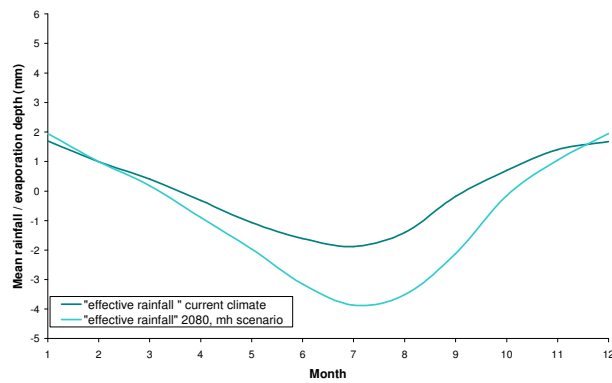




Contribution of different parts of the system

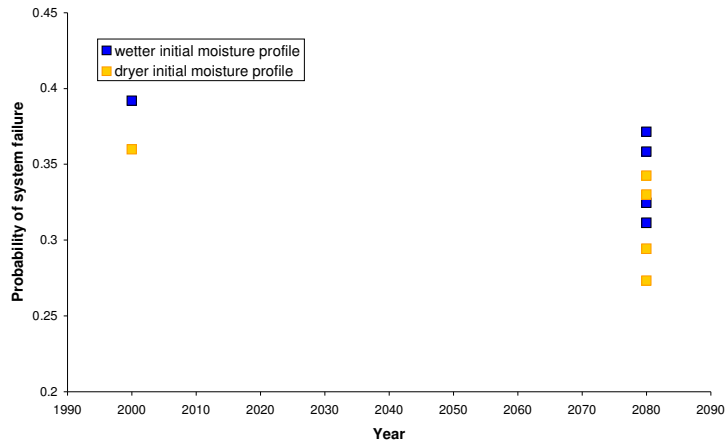


Effect of climate change on mean rainfall / potential evaporation

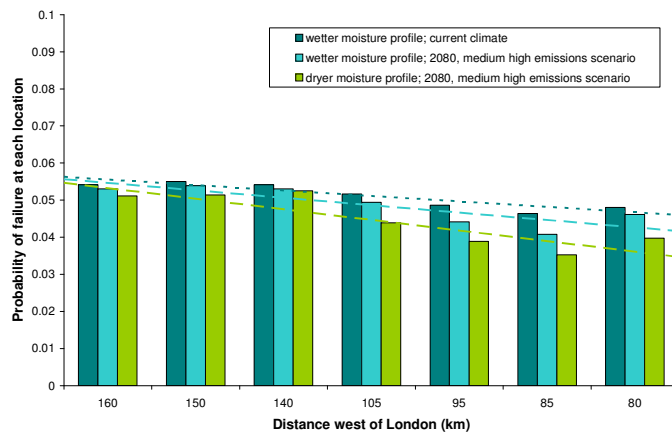




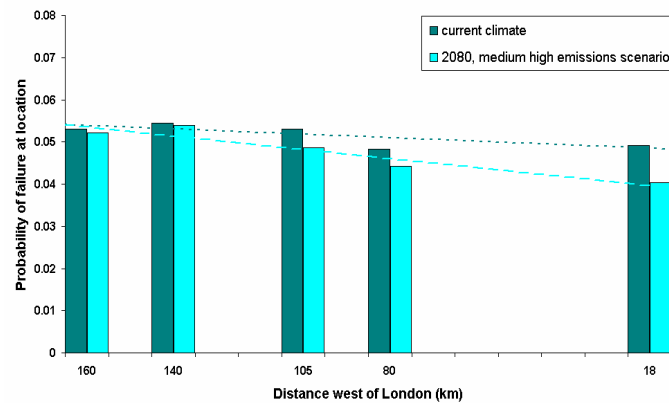
Changing probability of system failure with climate change



Changing importance of different parts of the system



Changing importance of different parts of an extended line



Comparison of failure dates with antecedent rainfall record

Failure date	Aggregation period (days)									Slope angle
	1	2	5	10	20	30	60	90		
26/10/2001	95	92	92	91	81	79	56	65	Embankment	25.0°
02/12/2001	50	79	68	59	27	14	43	31	Embankment	25.0°
08/12/2001	40	25	71	68	47	25	42	42	Embankment	25.0°
07/02/2002	60	62	92	97	99	96	59	37	Embankment	35.0°
09/02/2002	72	70	85	97	99	97	63	38	Cutting	50.0°
14/03/2002	46	72	72	50	77	76	99	89	Cutting	60.0°
20/03/2002	87	86	81	82	55	87	100	93	Cutting	60.0°
21/03/2002	80	83	79	77	59	88	100	94	Cutting	50.0°
25/03/2002	46	31	37	60	58	80	98	94	Embankment	26.0°
20/10/2002	59	41	95	98	84	65	44	60	Cutting	50.0°
14/11/2002	97	98	98	99	98	100	94	86	Embankment	31.0°
31/12/2002	94	94	94	96	88	73	97	98	Cutting	40.0°
10/03/2003	46	55	98	97	76	73	65	88	Embankment	25.0°
04/12/2003	40	48	95	94	94	81	62	21	Embankment	31.0°
12/12/2003	65	71	42	22	88	80	65	22	Embankment	35.0°
11/01/2004	88	79	89	70	69	63	80	68	Cutting	
13/01/2004	84	94	90	88	83	61	90	80	Cutting	50.0°
27/01/2004	40	25	51	27	71	57	62	79	Cutting	40.0°
13/02/2004	48	32	12	59	73	64	67	88	Embankment	45.0°



Summary

- n Incidence and timing of landslides is critically dependent on previous season's rainfall
- n System stability is expected to increase with climate change, but
 - n stability analysed with constant initial conditions – summers expected to be dryer in future
 - n hotter, dryer summers are expected to affect slope material properties
 - n more research needed into slope behaviour after dry season
- n Expect differentiation in landslide risk to increase



Use of multiple climate predictions

