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University of Birmingham Centre for Railway Research and Education

Contents

- Birmingham Centre for Railway Research and Education
- RRUK
- EURNEX
- Current projects in aerodynamics
- Climate Change and the Railway

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University of Birmingham Centre for Railway Research and Education

- 12 academic staff
- 15 post doctoral researchers
- 20 doctoral students
- MSc in Railway Systems Engineering and Integration
- Research income from Research Councils, EU, UK and European railway industry

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University of Birmingham Team

- Electrical, Electronic and Computer
  - Dr Stuart Hillmansen, Dr Clive Roberts, Dr C Goodman
- Civil Engineering
  - Dr Min An, Prof Chris Baker, Dr Michael Burrow, Dr Gurmel Ghatora, Prof Felix Schmid, Dr D Chapman, Dr A Quinn, Dr M Sterling
- Other Engineering Disciplines
  - Dr Claire Davis (Met & Mat)
  - Prof John Thornes (Geography)
  - Dr Andrew Tobias (Mech Eng)

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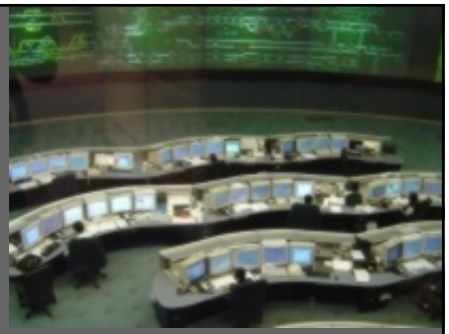
Birmingham Areas of Research



- Aerodynamics and wind
- Asset management
- Environment and climate
- Geotechnical engineering
- Materials and Metallurgy
- Modelling and computation
- Network capacity
- Non-destructive testing
- Power and traction
- Remote condition monitoring
- Risk and safety
- Signalling and train control
- Systems engineering

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Rail Research UK

Railway Research UK

- £7m EPSRC funded virtual research centre comprising of 8 universities
- Led by University of Birmingham and Southampton University
- Together with:
  - Loughborough University
  - University of Leeds
  - Imperial College London
  - Manchester Metropolitan University
  - University of Nottingham
  - University of Newcastle

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Rail Research UK

Railway Research UK

- University of Birmingham – geotechnics, aerodynamics, systems, energy, metallurgy….
- University of Leeds – transport economics
- Imperial College London – metal fatigue, novel technologies
- Loughborough University - mechatronics
- Manchester Metropolitan University – vehicle dynamics
- University of Newcastle – metallurgy, safety, policy
- University of Nottingham – human factors
- University of Southampton – geotechnics, noise and vibration, policy and regulation

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EURNEX: European Rail Research Network of Excellence

- FP6 Integration Activity
- Integrate Research from 36 Universities
- Birmingham leads the UK and Benelux Group and is involved in the following working groups
  - Operations and System Performance
  - Rolling Stock
  - Environment and Energy
  - Infrastructure and Signalling

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Current Projects in Aerodynamics and Wind

- EPSRC - Aerodynamic/Train System Interactions (with MMU)
- RSSB - The behaviour of pantographs in cross winds (with Interfleet Technology)
- Met. Office - Impact of strong winds on transport systems
- *PhD student* - Train slipstream measurements using the rotating rail rig
- MSc student – The flight of ballast under Eurostar trains

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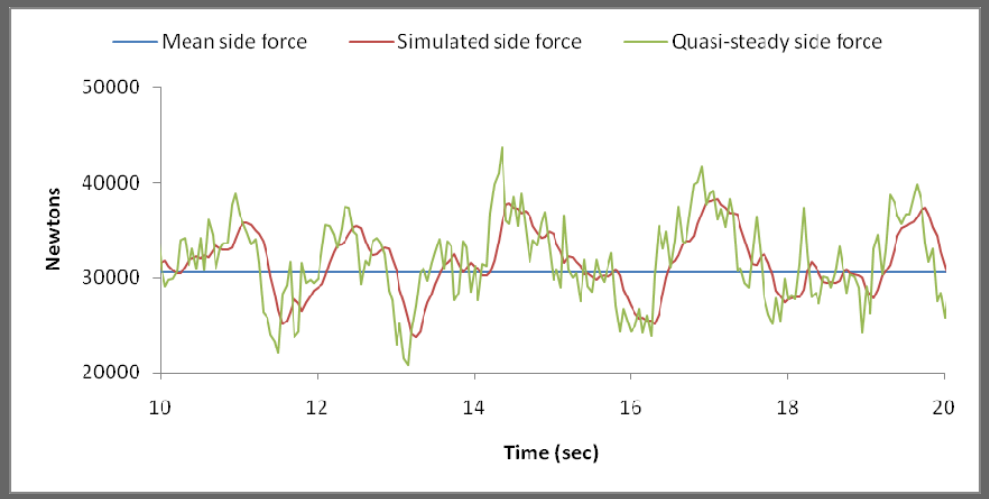

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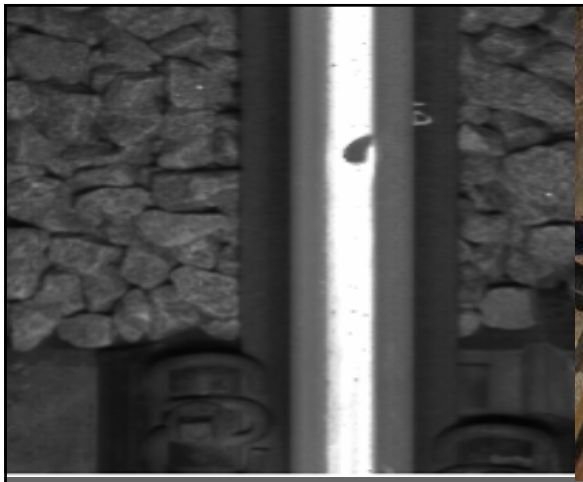

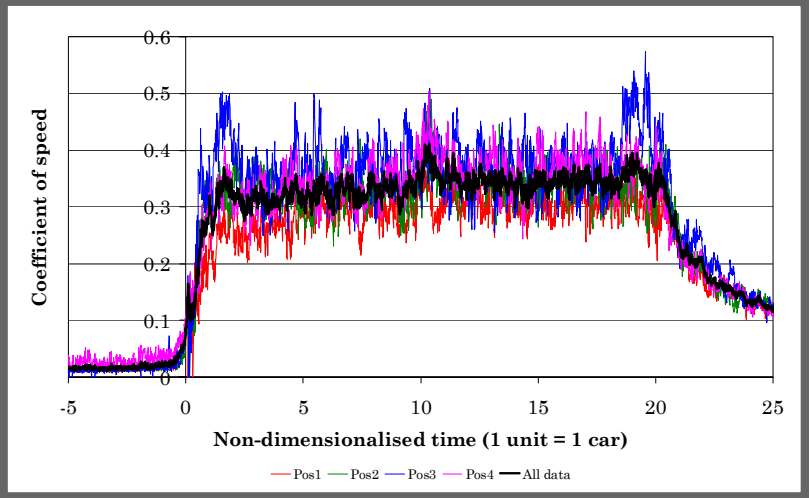

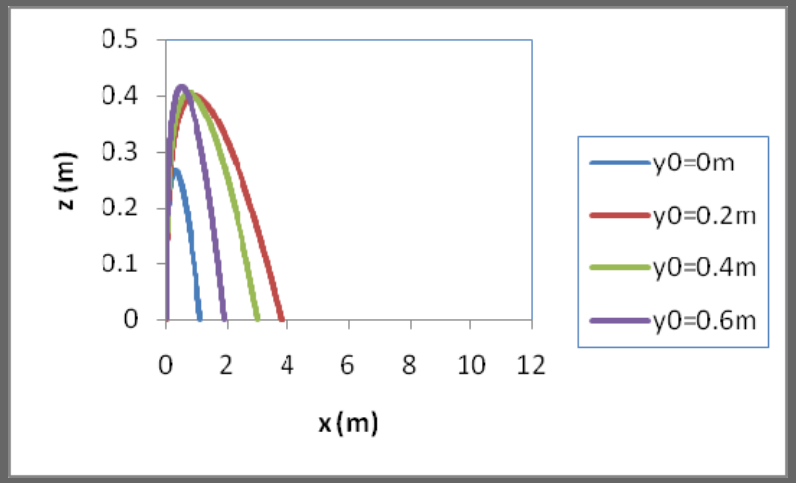

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Climate Change and the Railway

Climate Change and the Railway

- The nature of climate change
- Can railways help to alleviate climate change?
- The effect of climate change on the railway
- A specific example – “Quantifying the Effects of High Summer Temperatures due to Climate Change on Buckling, Broken Rails and Rail Related Delays in the UK.”
- The future - FUTURENET

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The nature of climate change

"Most of the observed increase in global average temperature since the mid-20th century is very likely [more than 90%] due to the observed increase in anthropogenic greenhouse gas concentrations." IPC 2007

Mitigation of climate change

Slow down global climate change by reducing greenhouse gas emissions.

Adaption to climate change

Respond to the predicted impacts of unavoidable global climate change.

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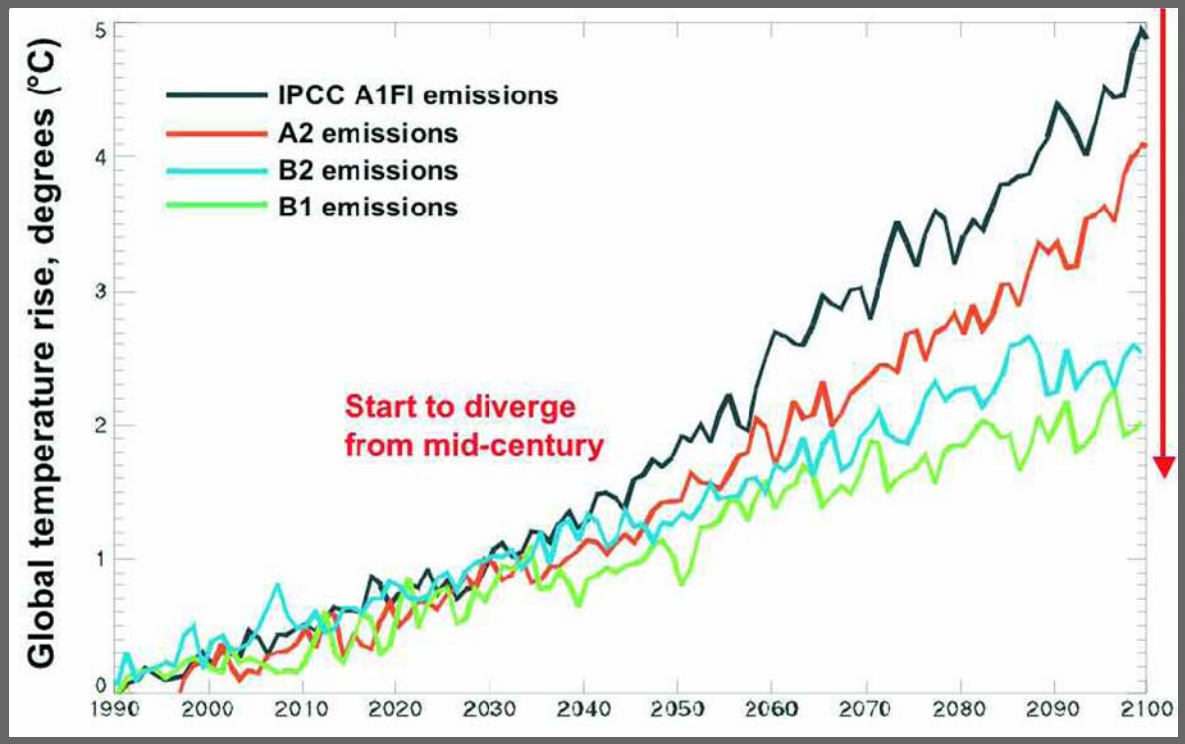
The nature of climate change



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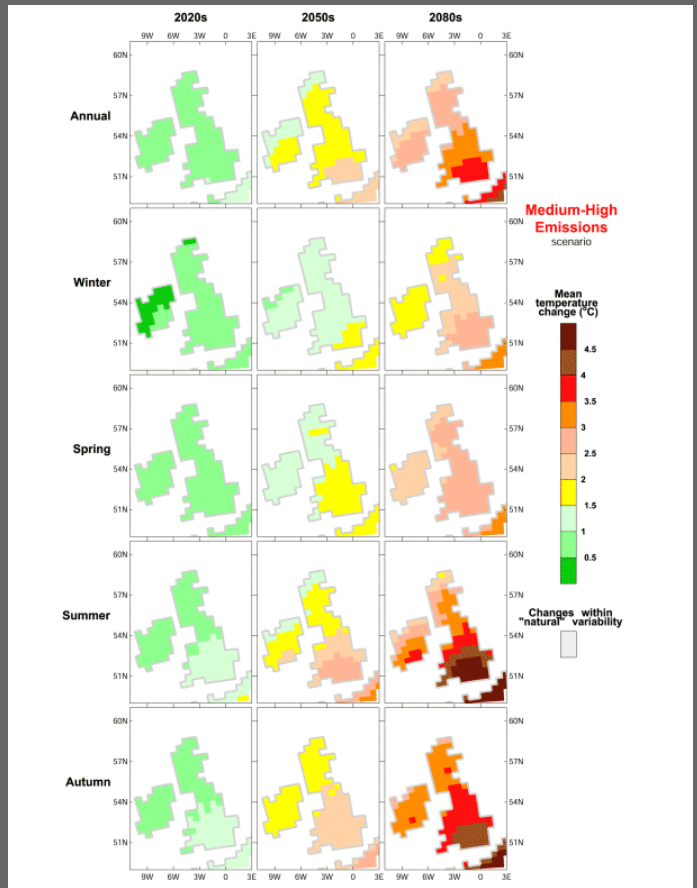
The nature of climate change



Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

Temperature

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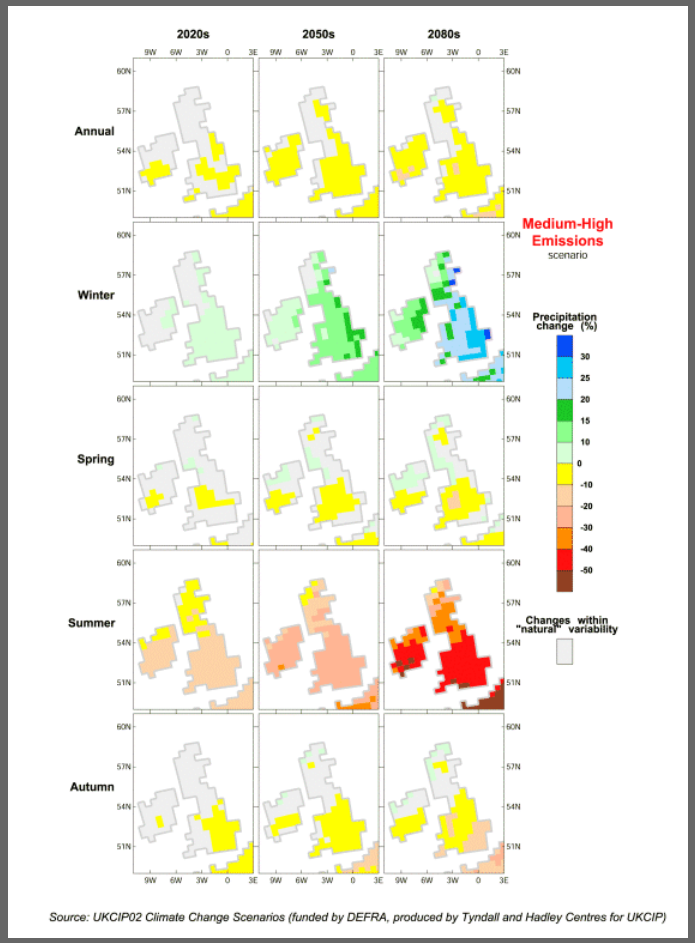
The nature of climate change



Precipitation

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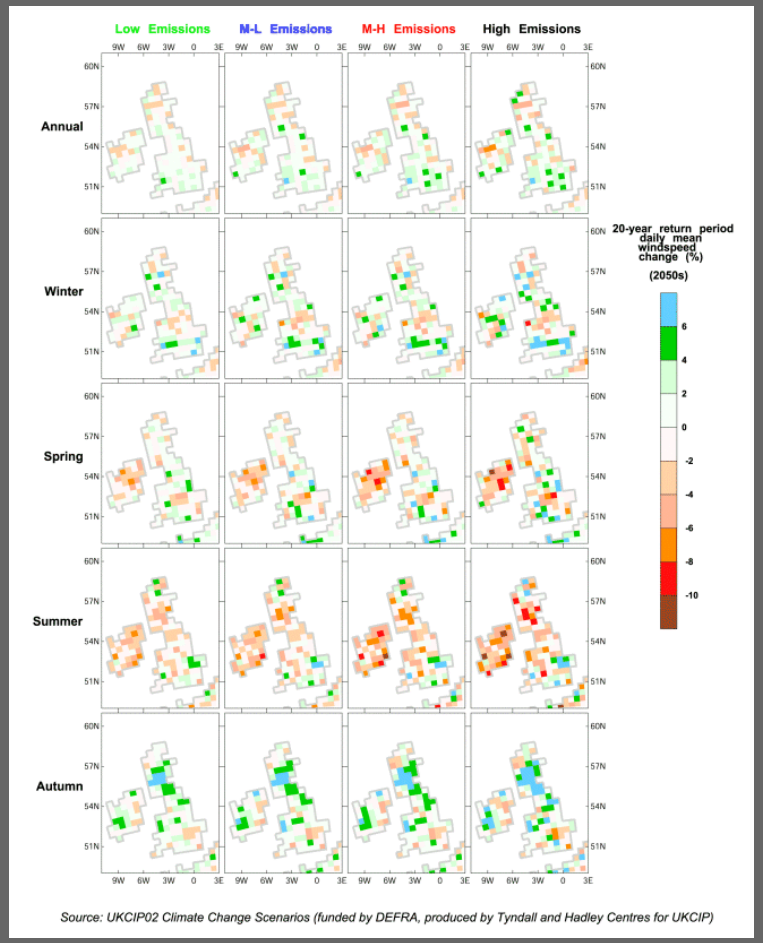
The nature of climate change



20 year wind speed

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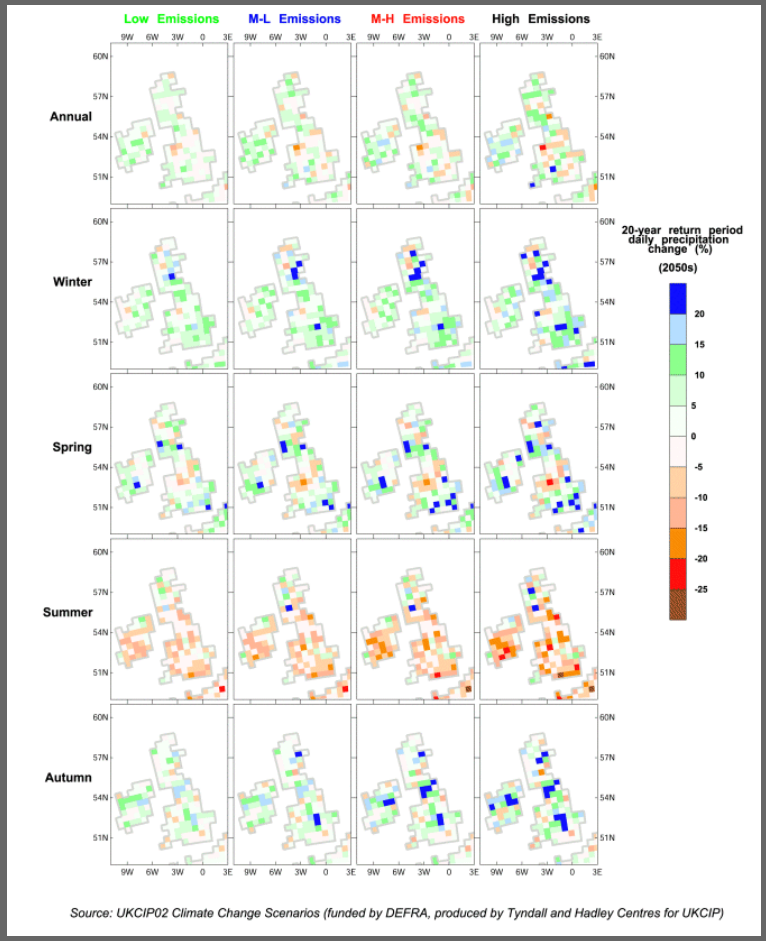
The nature of climate change



20 year rainfall

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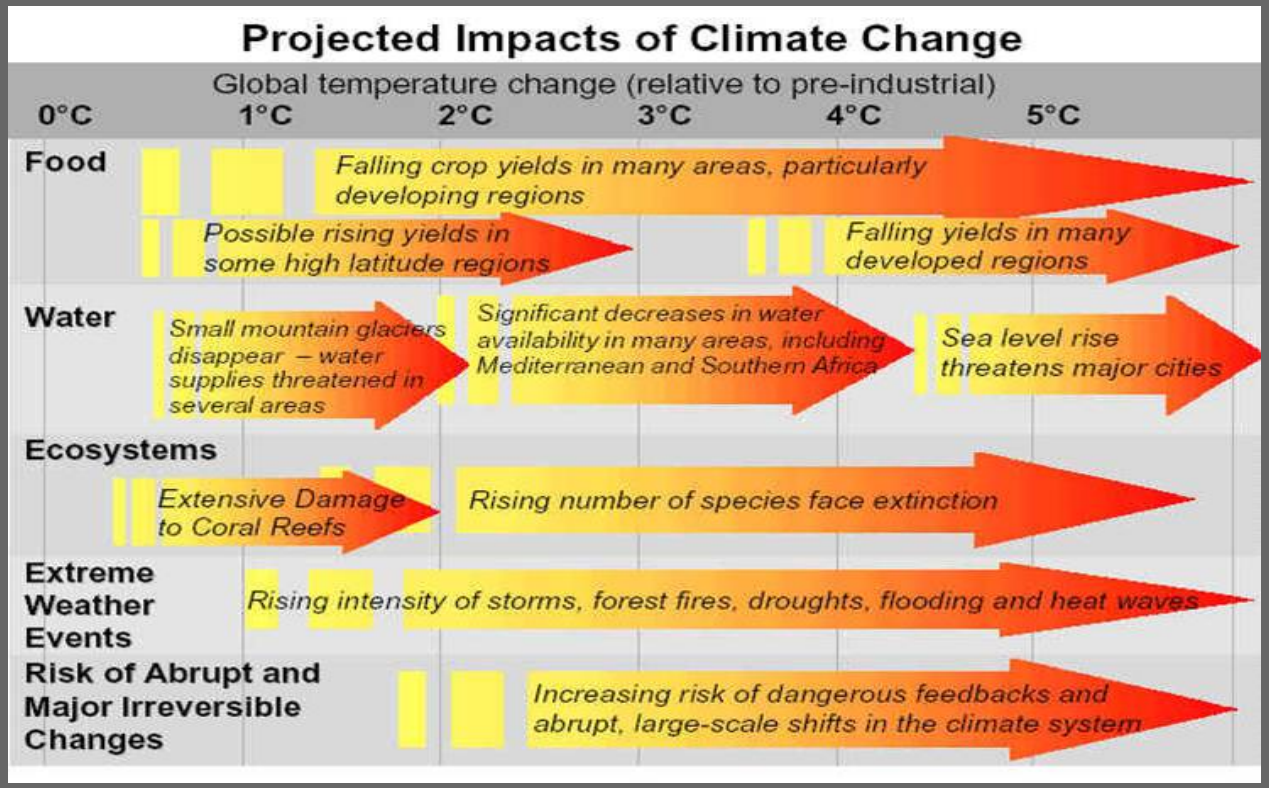
The nature of climate change



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Can railways help to alleviate climate change?

- Arguments are often made that railways are more environmentally beneficial than other modes – particularly when investment decisions are being made.
- This is particularly the case for high speed rail (300kph or above)
- Is this argument sustainable?

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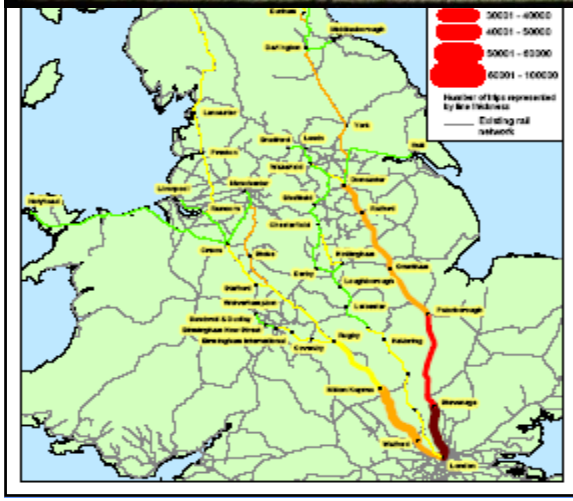
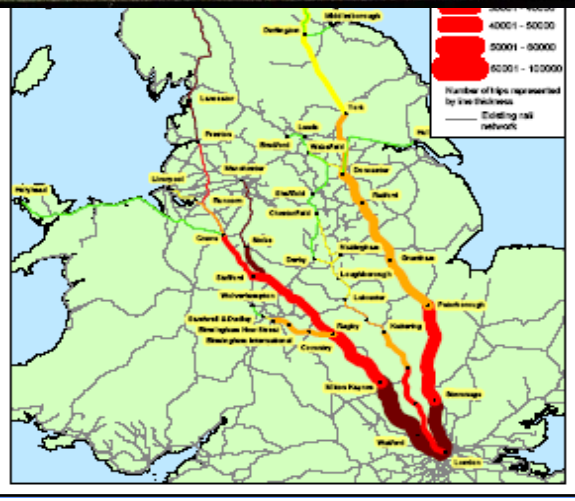
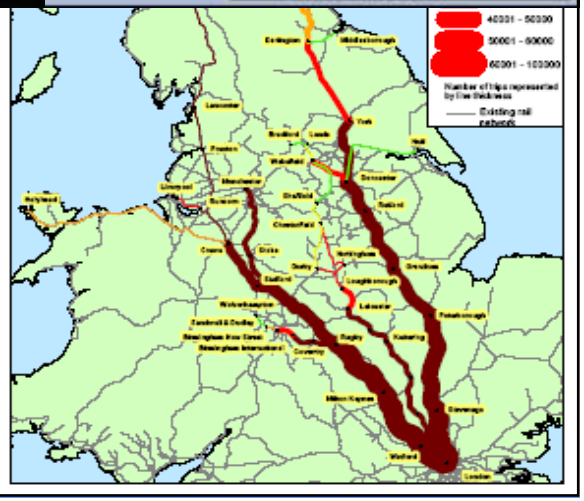
eurostar
3011


POSED HIGH-SPEED ROUTES
Glasgow
Edinburgh
Manchester
Sheffield
Birmingham
UNITED KINGDOM
Cardiff
London
nzance
East coast mainline
West coast mainline
Great Western line
Midlands mainline
Chiltern line







% of emissions by mode

Mode	Percentage of UK CO2 emissions
Passenger cars	12.8
Passenger rail	0.6
Domestic aviation	0.4
Buses and coaches	0.6
Motorcycles	0.1
Total Passenger	**14.5**
International Aviation	**6%**
Road freight	7.9
Rail freight	0.2
Shipping	0.7
Total freight	**8.8**

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Emissions for different modes

Mode	Emissions gCO2/pkm	% change since 1995
Rail diesel	74	-16
Rail electric	54	-26
Rail overall	61	-22
Car and taxi	106	-8
Domestic air	231	+5

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Change in UK electricity mix

Year	Coal	Oil	Gas	Nuclear	Ren.	Other	Carbon intensity gCO2/kWh
1990	68	5	0	20	2	5	718
2005	34	1	37	20	5	4	489

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Emissions for different rail vehicles

Train type	Emissions per passenger km
Class 220 Voyager (diesel 5 car multiple unit – 125mph)	105
Class 390 Pendolino (electric 9 car titling train – 125 mph)	55
Class 43 HST (diesel 10 car – 110mph)	55
Class 91 electric loco + Mk3 coaches (110-mph)	45
Class 373 Eurostar – 18 coach 225mph	12

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Rail and air emissions for different journeys

CO2 emissions per passenger...		
Journey:	**Out & back by plane...**	**Out & back by train...**
London to Paris	3.5 hours, **244** Kg/CO2	2.75 hours, **22** Kg/CO2
London to Edinburgh	3.5 hours, **193** Kg/CO2	4.5 hours, **24** Kg/CO2
London to Nice	4 hours, **250** Kg/CO2	8 hours by Eurostar+TGV, **36** Kg/CO2
London to Barcelona	4.5 hours, **277** Kg/CO2	Eurostar then overnight sleeper, **40** Kg/CO2
London to Tangier	5 hours, **435** Kg/CO2	48 hours by Eurostar, sleeper trains & ferry, **63** Kg/CO2

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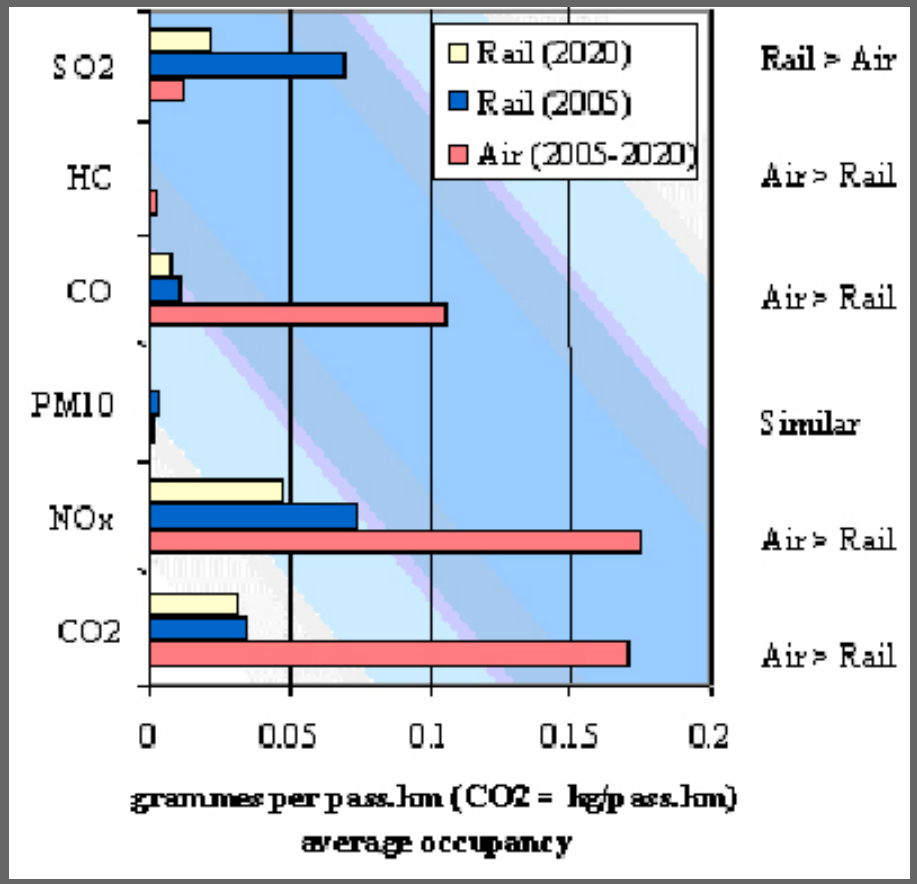
Emissions for different pollutants



Air versus High speed rail

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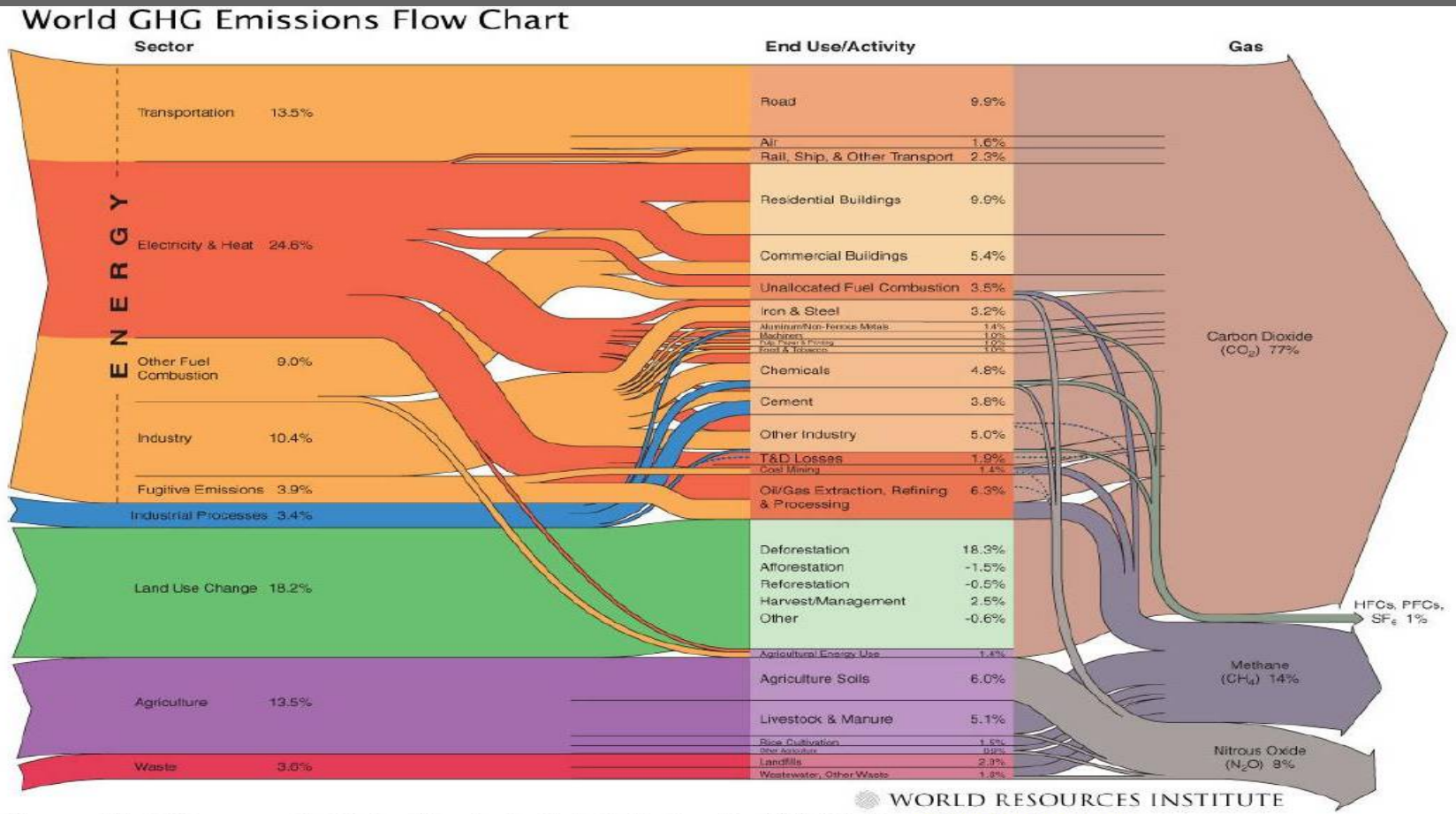
Can railways help to alleviate climate change?



Source: World Resources Institute, Climate Analysis Indicators Tool (CAIT). See: http://cait.wri.org

Can railways help to alleviate climate change?

- Rail has significantly lower carbon emissions than cars or domestic air
- All modes are reducing CO2 emissions – but rail more than most
- A modal shift to rail could reduce emissions significantly

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Can railways help to alleviate climate change?

- Can railways help to alleviate climate change?
- Maybe – but many caveats
  - Overall % emissions produced by trains is small
  - Long life of trains mitigates against rapid adaptation of rolling stock
  - Emissions from different train types vary significantly
  - Energy mix for electric trains is crucial
- Decreased emissions are likely to be a useful by-product of new high speed rail links – but the primary reasons for construction will be economic and a need for increased capacity

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Vittel
PAUDOCK
PRÉSIDENT

The effect of climate change on the railway

Warm, wet winters

Higher wind - effects on OH lines, Pansway, tree fall onto track and overhead
Higher rainfall – damage to bridges, earthworks
Longer vegetation growth periods – leaf fall
Drainage problems

The effect of climate change on the railway

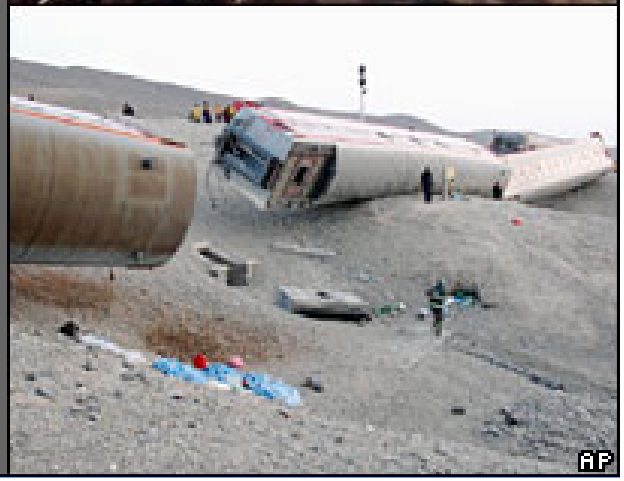
<u>Hot, dry summers</u>
Rail buckling, subsidence
Thunderstorms (lightening),
Thermal comfort problems
Equipment overheating and line side fires
OH lines stretching

The effect of climate change on the railway

Extreme events

Higher extreme storms resulting in problems due to

- Driven rain
- Extreme winds
- River flooding
- Storm surge – coastal flooding
- Tree fall
- Bridge pier scour



The effect of climate change on the railway

<u>Positive effects and complacency</u>

Modal shift,
Reduced low temperature effects
(less ice, icicles, freezing, snow)
Reduced winter delays

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Quantifying the Effects of High Summer Temperatures due to Climate Change on Buckling, Broken Rails and Rail Related Delays in the UK.

Kay Dobney,
Professor Chris Baker,
Dr Andrew Quinn,
Dr Lee Chapman.

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Rail Research UK

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Methodology

1. Map the rail network (GIS)
2. Impact of baseline weather on buckling and rail related delays. (Network Rail's Alterations Database, Met Office data)
3. How climate change may alter temperature patterns (UKCIP, EARWIG)
4. Use 1 to 3 to assess the possible impact that temperature changes due to climate change may have on buckles and rail related delays.

To test the methodology the South East region in the UK has been used.

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The Science of Rail Buckles

Track condition	On standby	Impose 30/60mph speed restriction	Impose 20mph speed restriction
Good condition	SFT + 32	SFT + 37	SFT + 42
Inadequate ballast	SFT + 10	SFT + 13	SFT + 15

[SFT = stress free temperature (normally 27 °C in UK)]
Table 1: UK Critical Rail Temperature (CRT) values for standard track in good and poor states of repair.

$$T_{air} \approx \frac{2}{3} T_{rail}$$

Formula showing the "rule of thumb conversion between ambient air temperatures and rail temperature.

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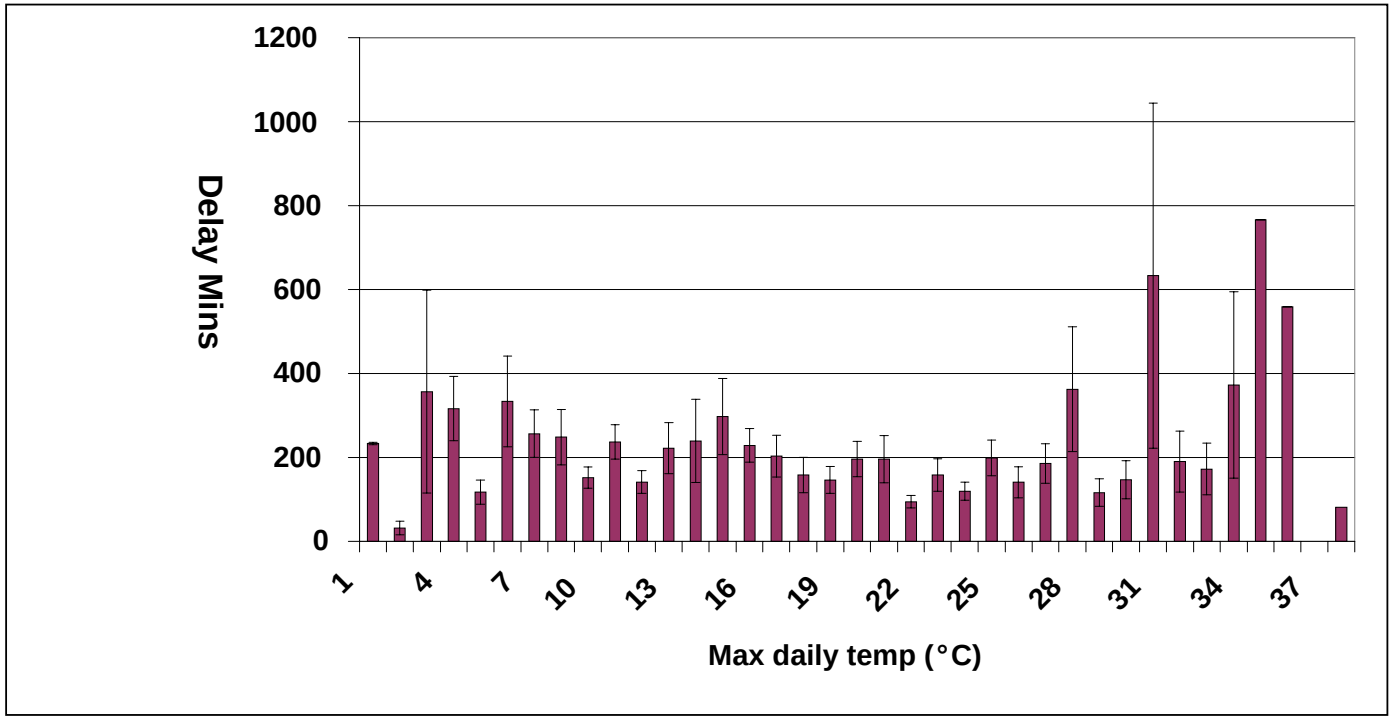
How heat affects railway operations in the South East: rail related delays



Average delay minutes per day for maximum daily temperatures in the range 1°C to 38°C, showing variability bars for each 1°C interval.

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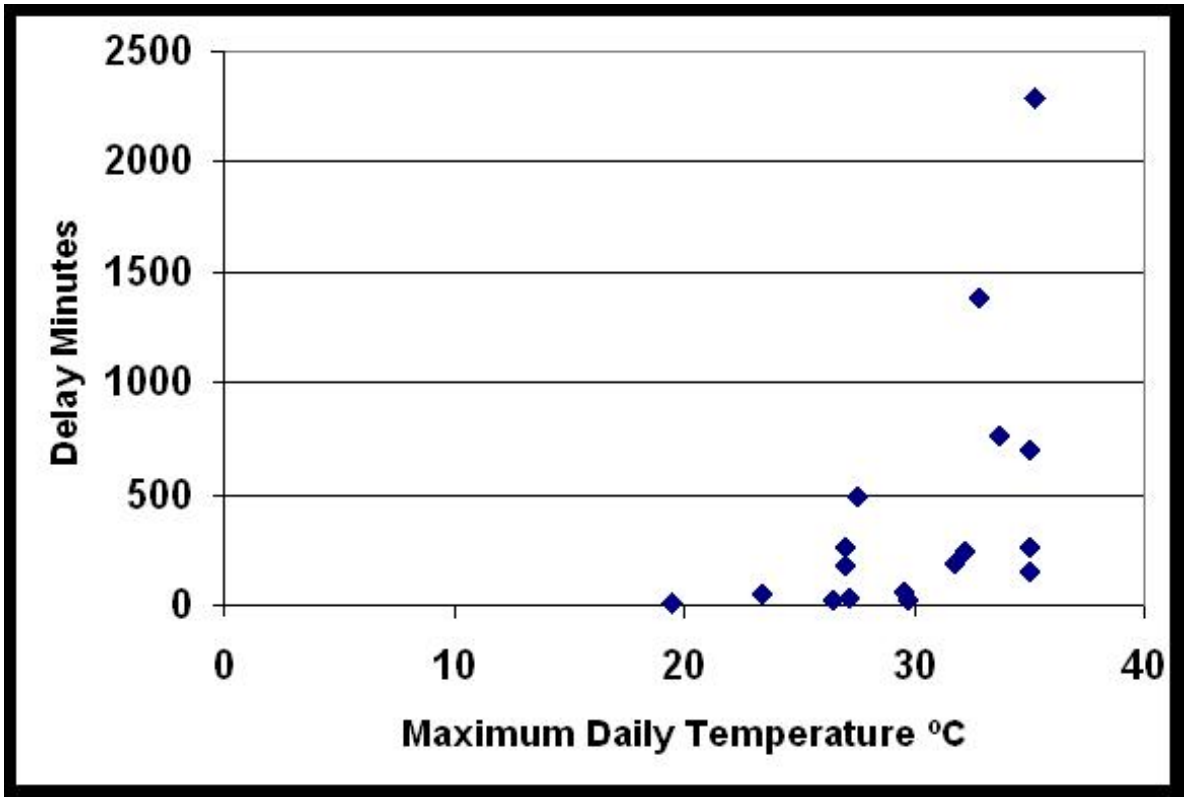
How heat affects railway operations in the South East: Buckles



Maximum daily temperature on days when a buckle occurred compared with the severity of the buckle.

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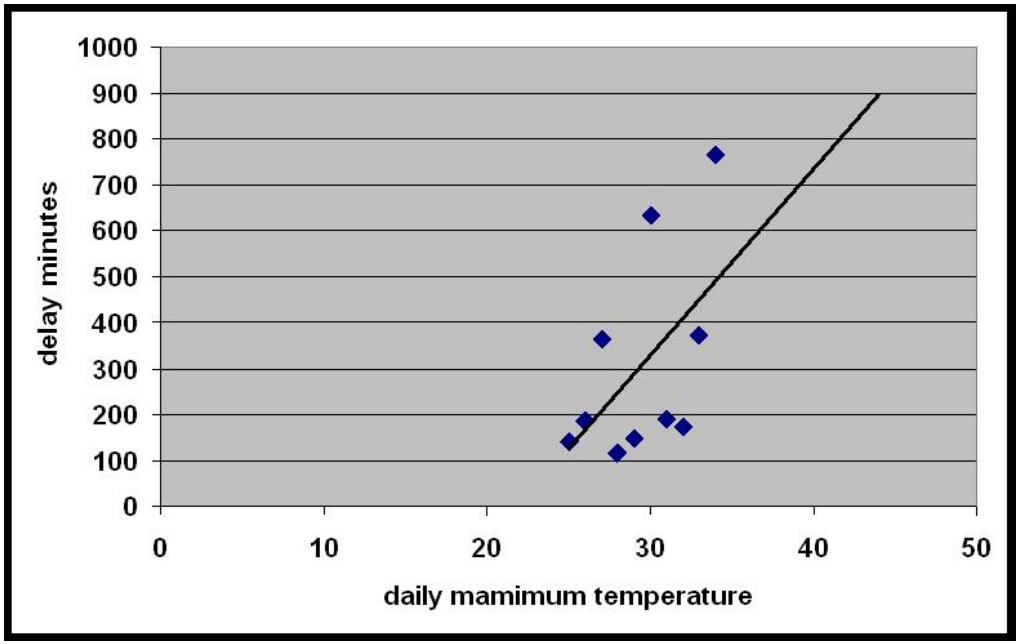
Costing Delays in the South East

The trend between maximum daily temperature and the number of delay minutes.



$$m = 42t - 923$$

Where:
m is the estimated delay minutes
t is the maximum daily temperature.

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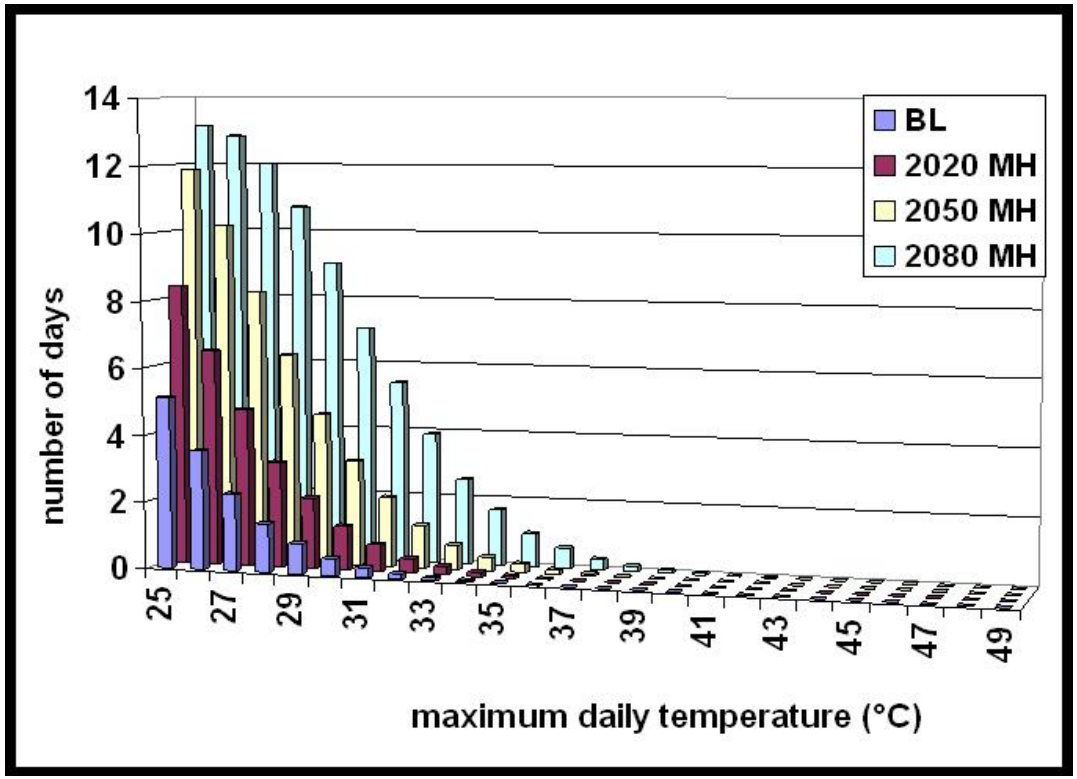
EARWIG's Future Weather Predictions for the South East



Number of days occurring per year that fall within 1°C intervals.

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Costing Delays (SE)

Cumulative cost of rail related delays caused by heat (US$m)

Time series and cause of delay	BL MH av delay mins	2020 MH av delay mins	2050 MH av delay mins	2080 MH av delay mins
C'lative cost US$m	2.2	4.4	8.4	16.4

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Future Work

The focus of the rest of this project will continue to be temperature related.

1. **<u>Hot summers</u>:**
   Rail buckling, Rail related delays, Thermal comfort.
2. **<u>Warm winters</u>:**
   Low temperatures (ice, icicles, freezing) Snow, Reduced winter delays, Modal shift, Complacency.

Work from other groups include:

- Sea level rise
- Earthworks failure
- Flooding
- Urban heat island

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Rail Research UK

The future – the FUTURENET project

- Project Partners
  - Universities of Birmingham, Nottingham and Loughborough
  - Hydraulics Research, British Geological Survey, Transport Research Lab
  - Network Rail, Highways Agency, WSP, IMechE
- Aims
  - What will be the nature of the UK transport system in 2050 (taken as the mid-point of the UKCIP scenarios), both in terms of its physical characteristics and its usage?
  - What will be the shape of the transport network in 2050 that will be most resilient to climate change?

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The future – the FUTURENET project

- Objectives
  - The development of a number of possible UK transport scenarios for 2050
  - The identification of a route corridor for the study together with an inventory of infrastructure assets for that route corridor
  - The development of conceptual models of weather / climate induced failure mechanisms of transport systems, together with meteorological and climatic trigger levels

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The future – the FUTURENET project

- Objectives
  - The development of a modelling methodology that will integrate the work of the first three objectives, and allow the effect of climate change on the resilience of transport networks to be systematically studied
  - The development of generic tools that can be applied to other transport corridors and the wide dissemination of the results amongst stakeholders

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