

Climate change and the railways

Chris Baker

Professor of Environmental Fluid Mechanics

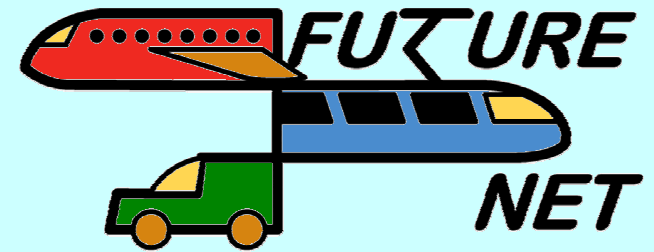
University of Birmingham

Director of the Birmingham Centre for Railway Research and Education



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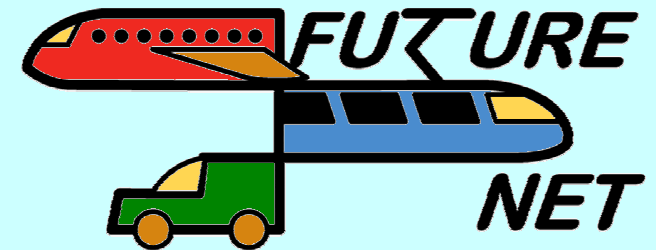


- The nature of climate change
- Climate change and transport systems
- Climate change and the railways
- Current work at the University of Birmingham
 - Climate change effects on the railway network
 - FUTURENET
- Other projects in Europe



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The nature of climate change

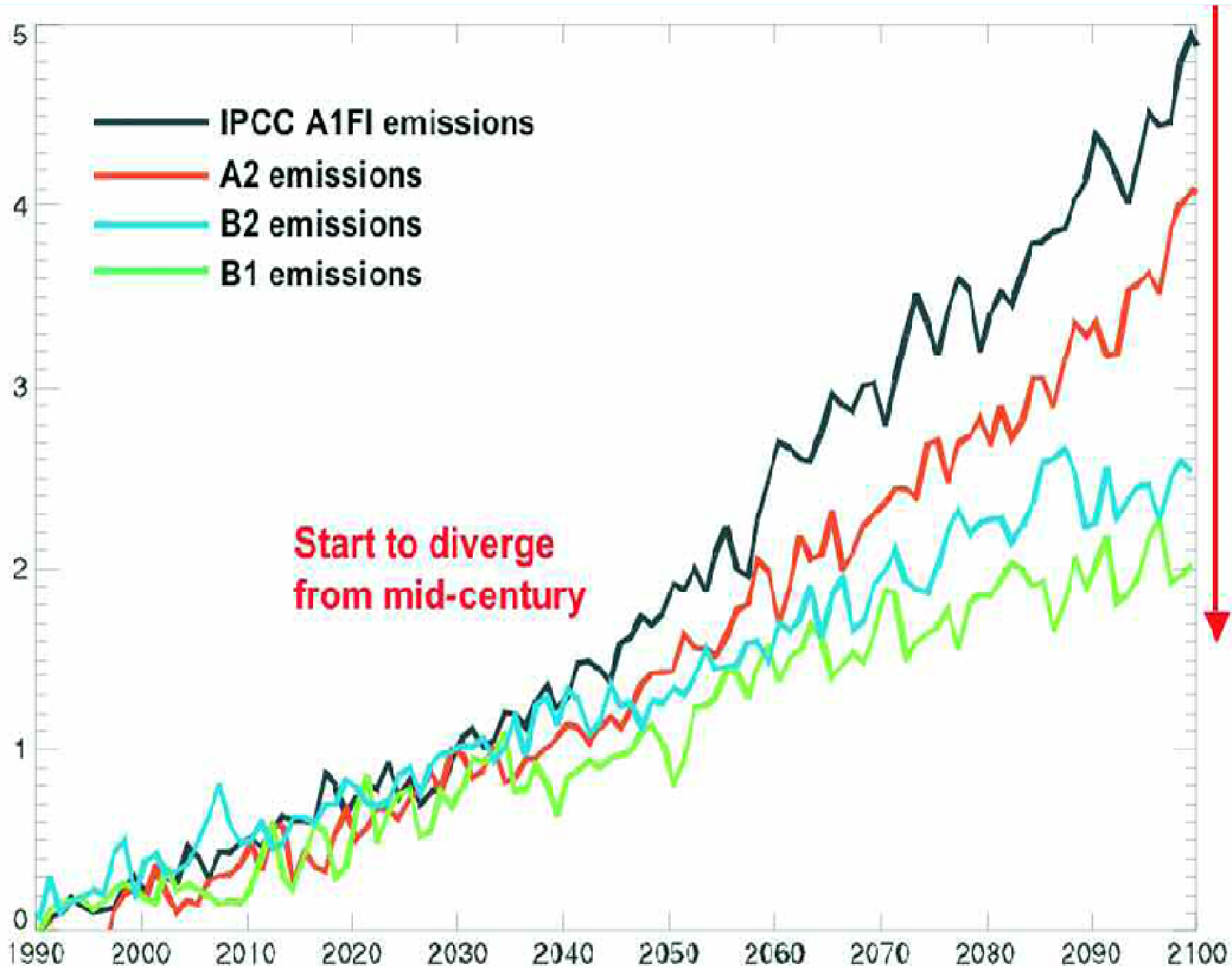


- Future climate predicted through the use of global climate models, calibrated using climate trends from the last half century
- Different GHG emission scenarios are considered (high, medium and low) for different time slices (2020, 2050, 2080)
- Most current work based on UKCIP02 predictions
- More accurate predictions from UKCP09



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Global temperature rise, degrees (°C)



- IPCC A1FI emissions
- A2 emissions
- B2 emissions
- B1 emissions

Start to diverge from mid-century



Plot Details:

Data Source: Probablistic Land
Future Climate Change: True
Variables: temp_dmax_tmean_abs
Emissions Scenario: High
Time Period: 2070-2099
Temporal Average: JJA
Spatial Average: Grid Box 25km
Location: -10 000, 48 000, 4 000, 61 000
Resamples: 50.0
Probability Data Type: cdf



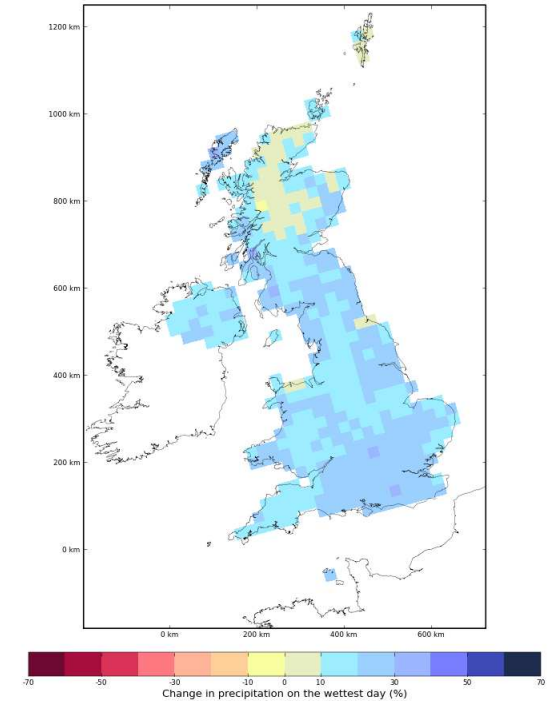
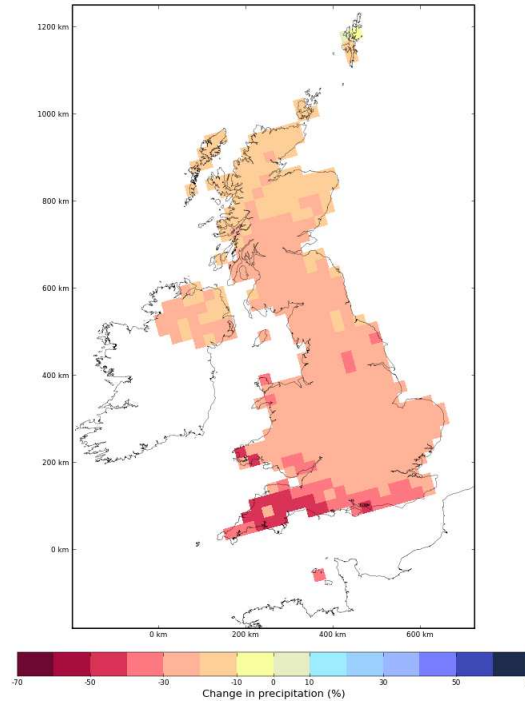
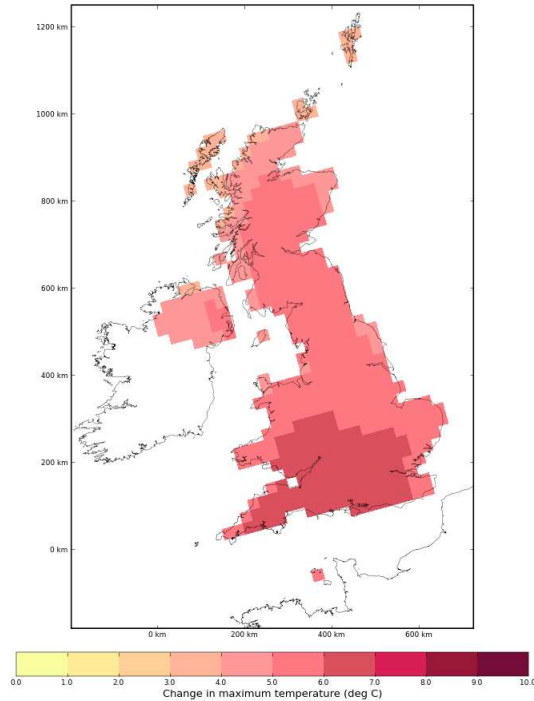
Plot Details:

Data Source: Probablistic Land
Future Climate Change: True
Variables: precip_dmean_tmean_perc
Emissions Scenario: High
Time Period: 2070-2099
Temporal Average: JJA
Spatial Average: Grid Box 25km
Location: -10 000, 48 000, 4 000, 61 000
Resamples: 50.0
Probability Data Type: cdf



Plot Details:

Data Source: Probablistic Land
Future Climate Change: True
Variables: precip_dmean_95_perc
Emissions Scenario: High
Time Period: 2070-2099
Temporal Average: DJF
Spatial Average: Grid Box 25km
Location: -10 000, 48 000, 4 000, 61 000
Resamples: 50.0
Probability Data Type: cdf

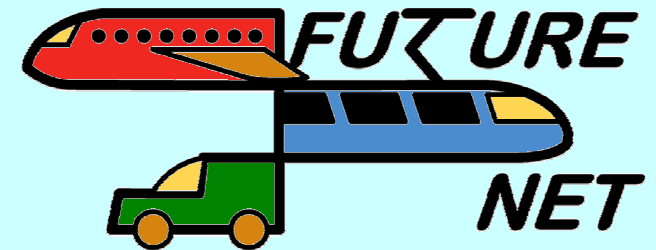


50% probability level predictions for the period 2070-2099 under the High emissions scenario. From left to right (a) Change in summer mean maximum temperature (b) Change in summer mean precipitation (c) Change in wettest days of winter. [UK Climate Projections 2009]



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The nature of climate change

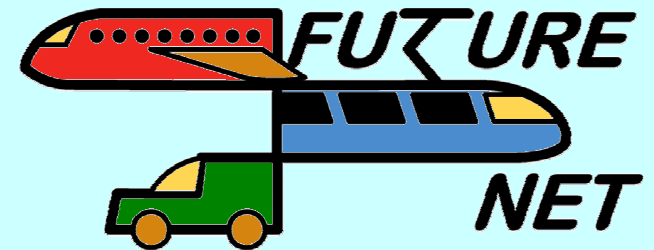


- For the medium / high emissions scenarios
 - A rise of about 1.5 degrees Celsius in the average winter temperature and of 2.5 degrees Celsius for the average summer temperature.
 - Average winter rainfall to increase by around 15% and average summer rainfall to decrease by around 25%.
 - The 20 year return period daily rainfall will increase by around 10% to 15% in the winter and decrease by about the same amount in the summer.
 - The 20 year daily wind speed will increase by around 5% in the winter and decrease by the same amount in the summer.
 - Effects become less severe further north, and more severe for the later time slices
 - Sea level rise of 0.4m in 2050



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Climate change and transport systems

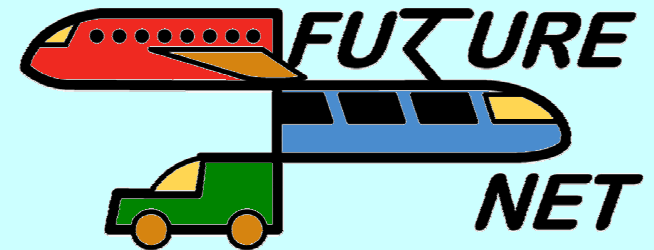


- Hotter, drier summers
 - Pavement deterioration and melting / Rail buckling
 - Ground shrinkage
 - Passenger thermal comfort
- Warmer, wetter winters
 - Increased surface water and flooding
 - Fewer cold weather events
 - Increased frequency of landslip
 - Scour and washout
- Increased frequency of extreme events
 - Wind / storm induced accidents
 - Tree fall
- Sea level rise



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The effect of climate change on the railways

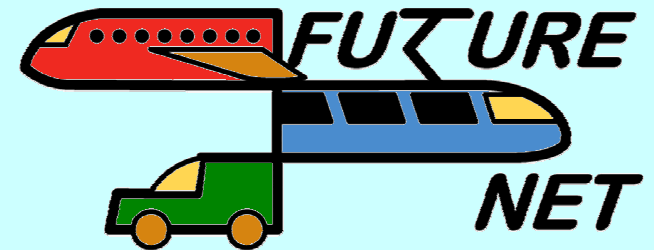


- 2003 RSSB report identified four major effects
 - The effects of high temperatures on track (buckling etc).
 - The effects of high rainfall on earthworks.
 - The effects of extreme precipitation levels on current drainage systems, and the effects of extreme winds on the overhead system
 - Sea level rise



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Hotter drier summers

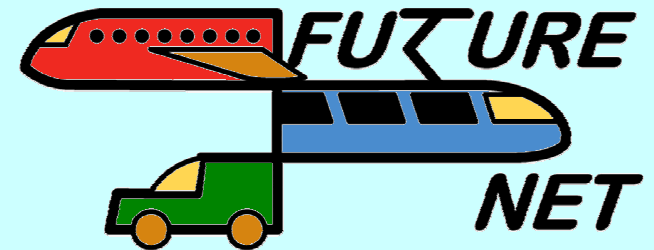


- Increased buckling of train track
- Desiccation of track earthworks
- Greater need for air conditioning systems
- Increased ventilation problems on underground railway systems
- Increased vegetation due to longer growing season – leaf fall issues



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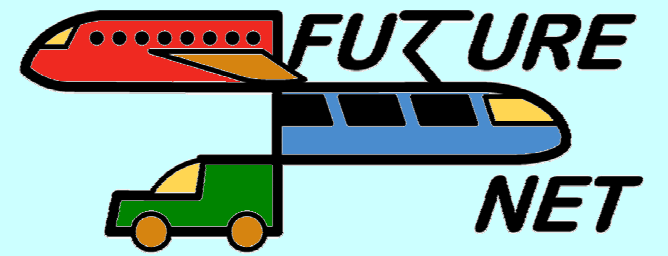
Hotter drier summers



- *“High temperatures are regularly experienced by passengers in hot weather on the Underground, particularly during summer evening peak time. On stations such as King’s Cross, Waterloo, Victoria and Oxford Circus, the temperature can be 11 deg C above ambient temperature above ground. In some instances recorded temperatures have reached 40 deg C. Temperature is the main factor affecting passenger thermal comfort, although air movement is also significant. Survey work in summer 2003 commissioned by LUL [23] identified the average temperature range for thermal comfort as between 21 deg C and 26 deg C in trains and between 17 deg C and 25 deg C in stations. This compares with average observed temperatures over the same period of 28 deg C in trains and 26 deg C in stations.”*

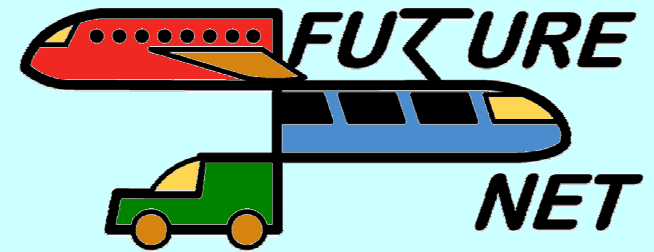


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Warmer, wetter winters



- Increased flooding of the network, and strain on drainage systems.
- Damage to earthworks - failure of saturated embankments
- Track circuit problems

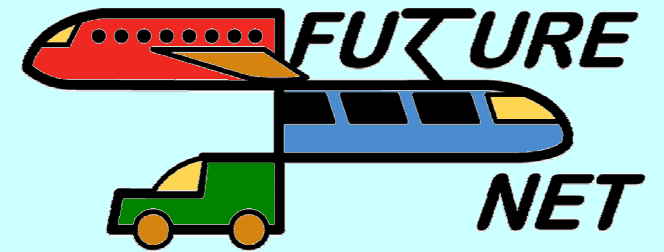


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Glanryhd Oct, 1987



Inverness, Feb 1989



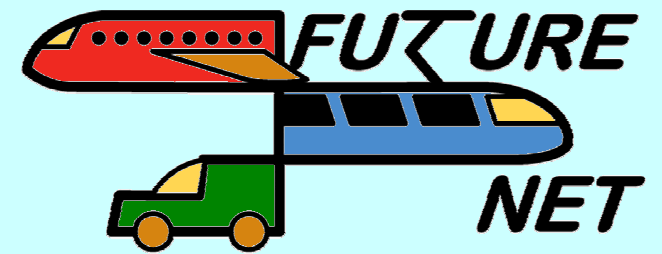
Ramsbottom, Jun 2002



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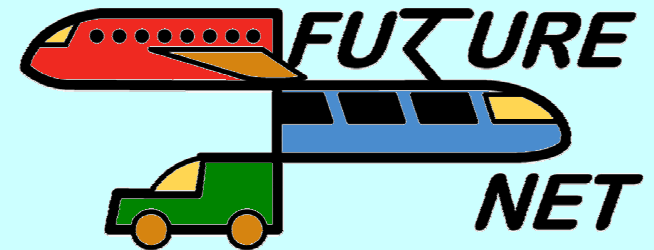


Slope failure at Carmuir's Tunnel



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More extreme events



- Increased likelihood of dewirement (the pantograph losing contact with the overhead wire)
- Increased possibility of train overturning and derailment
- Accidents or network disruption due to trees and building debris being deposited on the track.

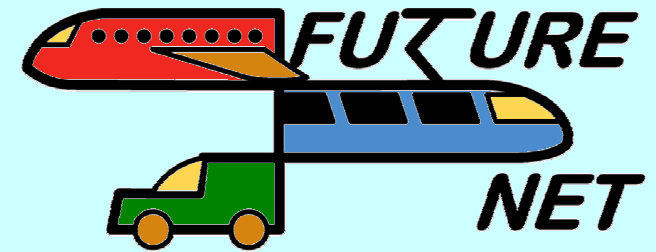


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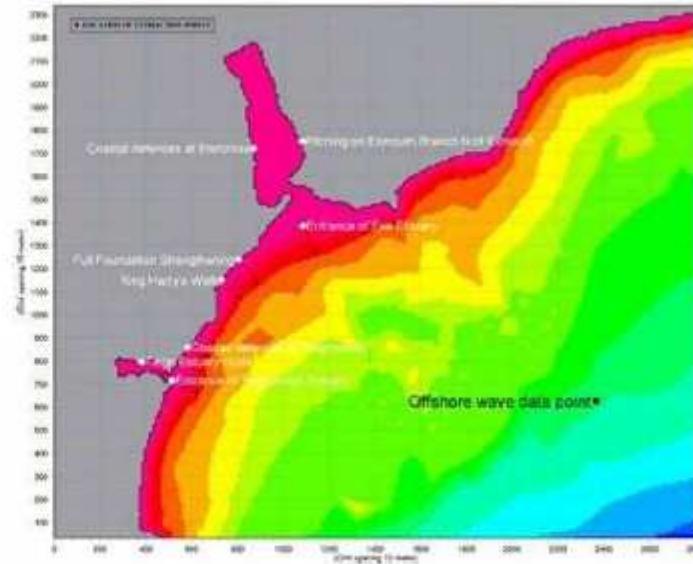


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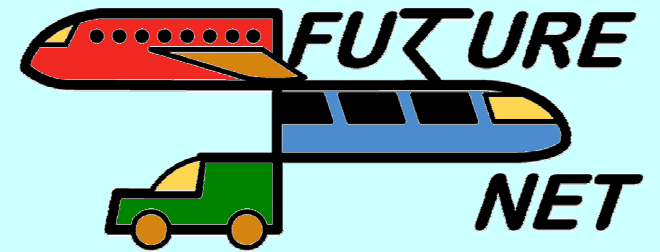
Sea level rise - Dawlish



- Extreme conditions estimated
- Transferred from offshore point to nearshore locations



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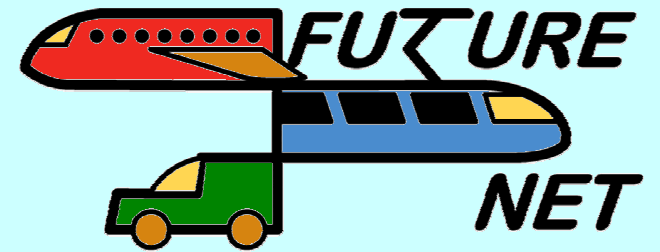
Sea level rise - Dawlish



	Typical % Increase In Overtopping	Events Resulting In Both Lines Being Shut
2006	0	1 in 6
2020	50%	1 in 3.5
2050	125%	1 in 2
2080	250%	1 in 1



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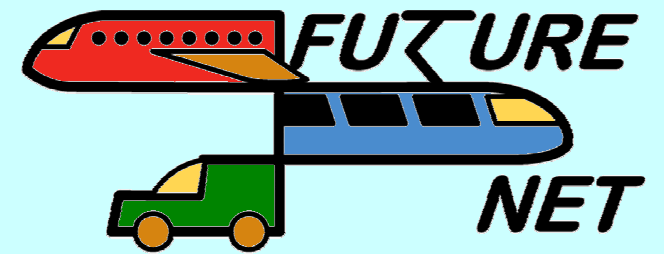


Current work at Birmingham University

- The effect of climate change on railway operation
- FUTURENET



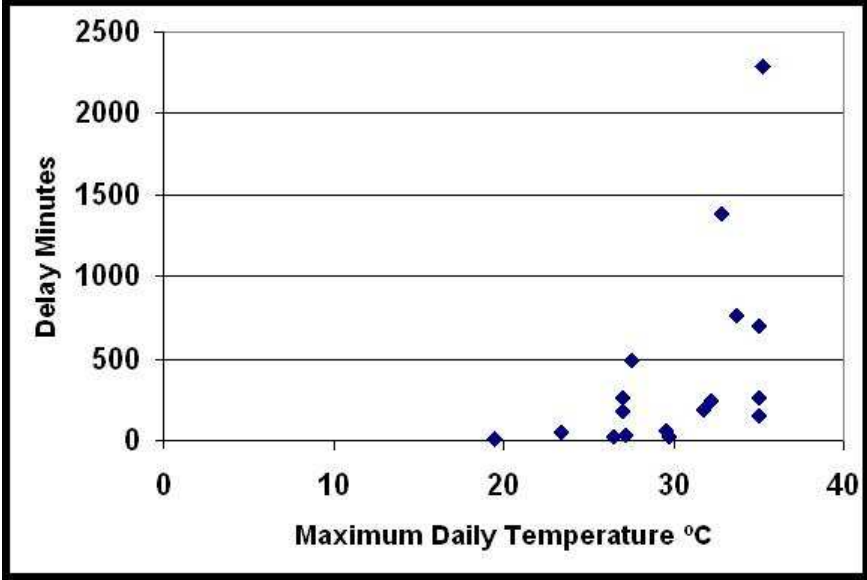
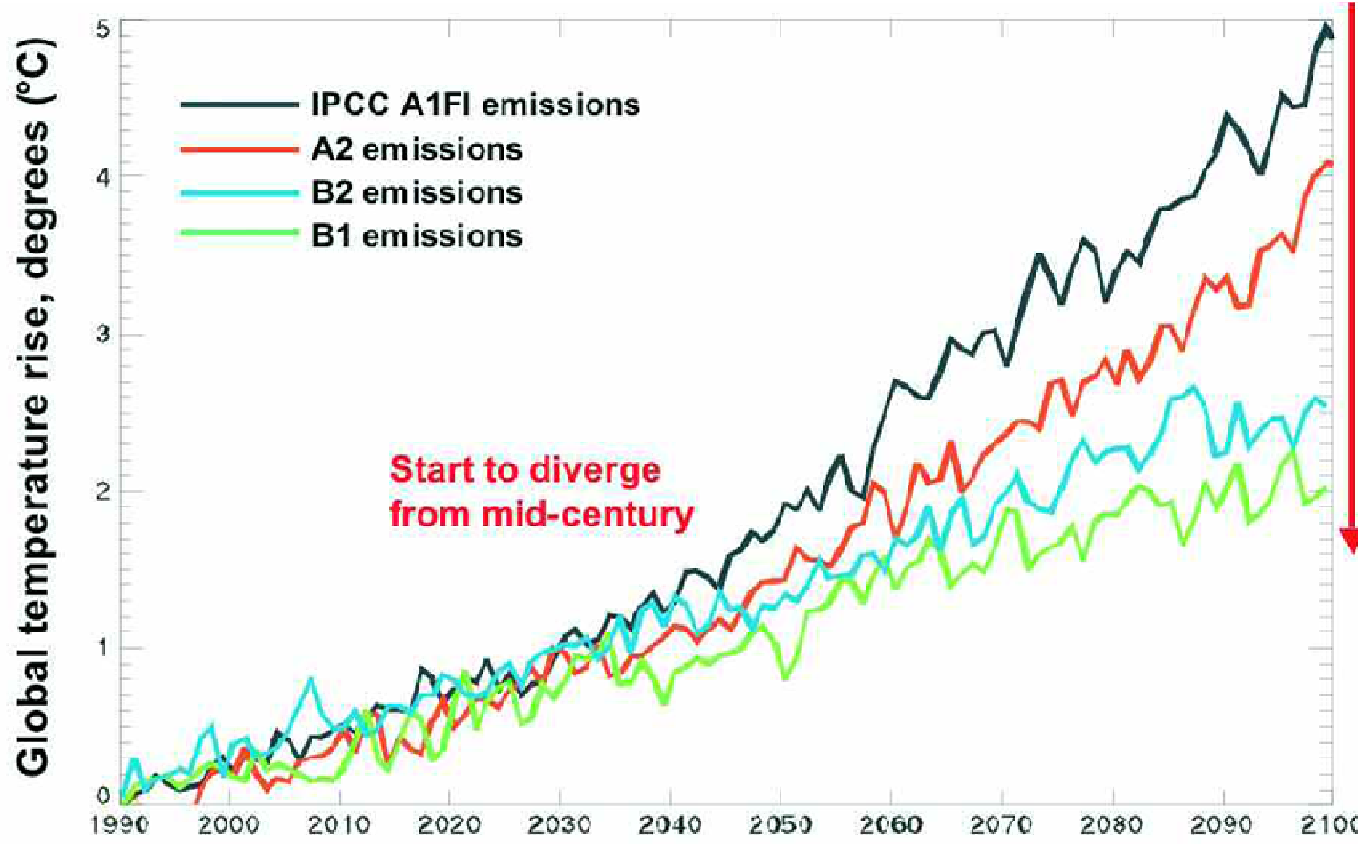
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The effect of climate change on rail operation



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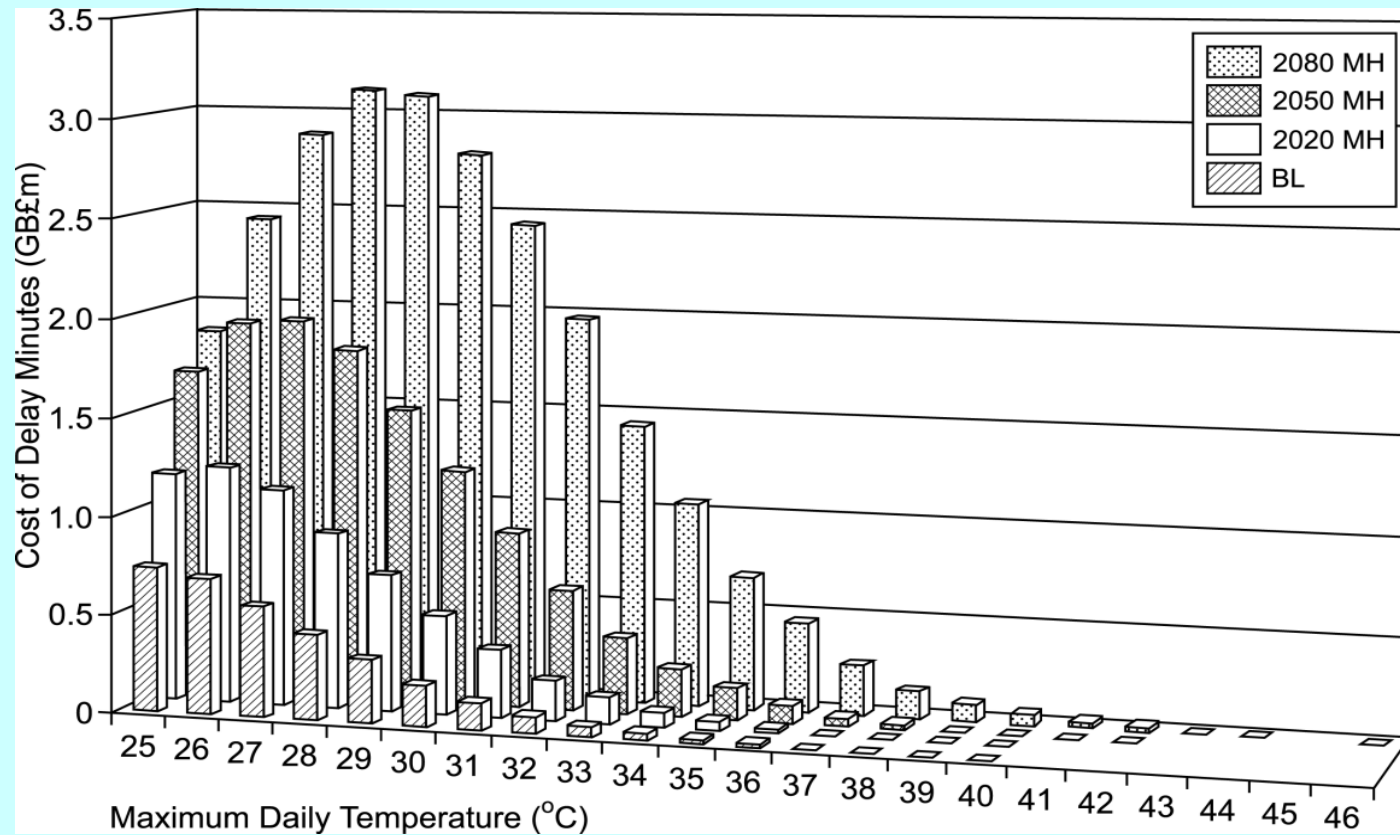
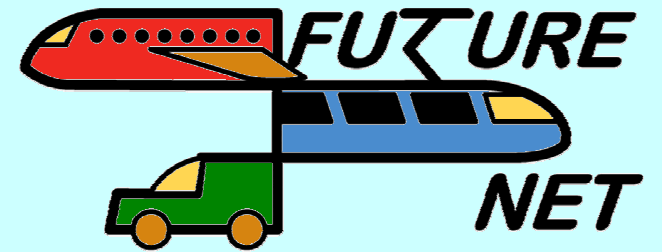
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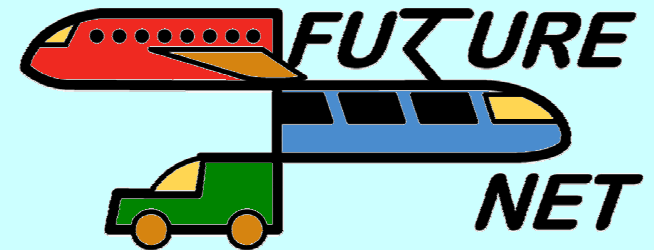
Number of delay minutes attributable to “buckle” events recorded in the ADB against the maximum daily temperature on the date recorded for each region.



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FUTURENET

Future resilient transport networks

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Loughborough
University

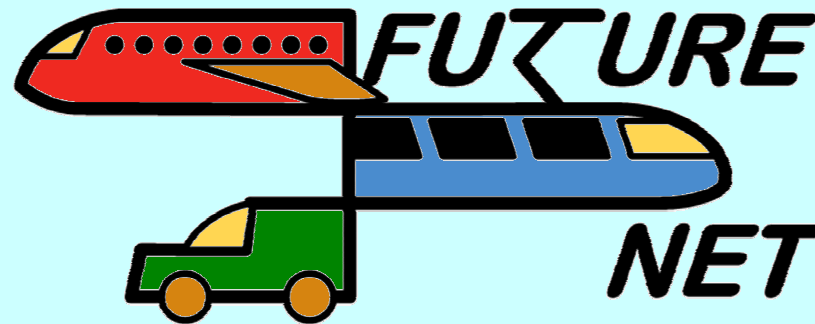


The University of
Nottingham

HIGHWAYS
AGENCY



HR Wallingford
Working with water



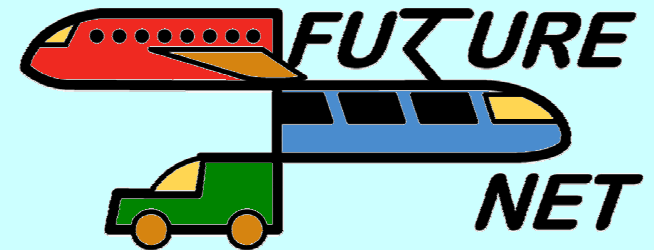
British
Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL



Institution of
**MECHANICAL
ENGINEERS**

EPSRC

The key questions

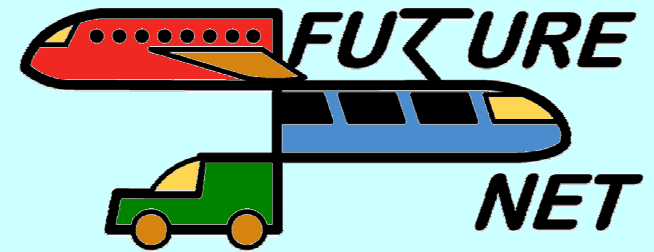


- What will be the nature of the UK transport system in 2050 both in terms of its physical characteristics and its usage?
- What will be the shape of the transport network in 2050 that will be most resilient to climate change?



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The project objectives and deliverables

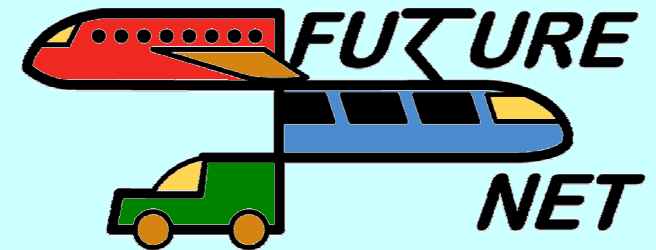


- The development of a number of possible UK transport scenarios for 2050. (WG1)
- The identification of a route corridor for the study together with an inventory of infrastructure assets for that route corridor. (WG2)



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The project objectives and deliverables

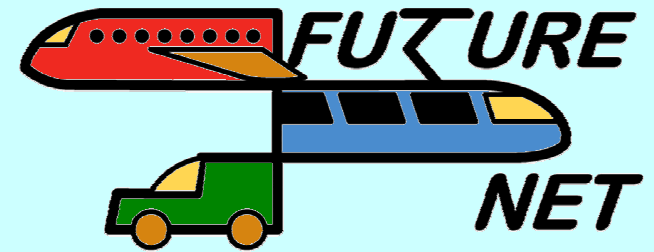


- The development of conceptual models of weather / climate induced failure mechanisms of transport systems, together with meteorological and climatic trigger levels. (WG3)
- Travel behaviour survey including discussion of effect of infrastructure reliability on travel choice (WG4)



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The project objectives and deliverables

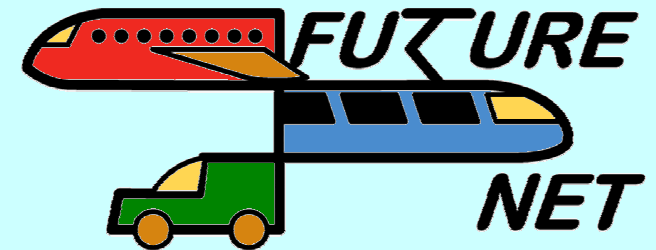


- The development of a modelling methodology that will integrate the work of the earlier objectives, and allow the effect of climate change on the resilience of transport networks to be systematically studied. (WG4)
- The development of generic tools that can be applied to other transport corridors and the wide dissemination of the results amongst stakeholders. (WG5)



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Selected corridor

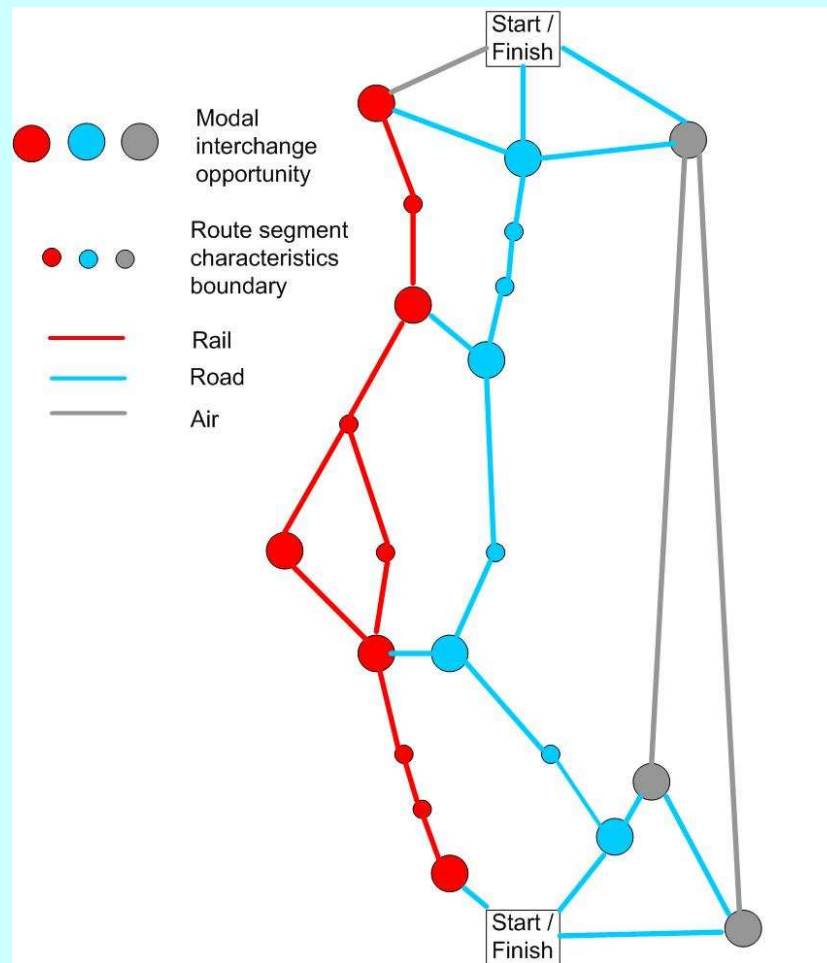
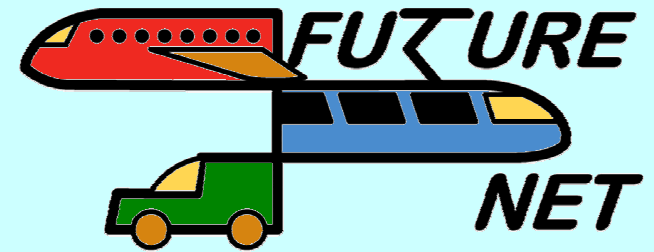


- London to Glasgow along the west coast
 - high volume of road, rail and air traffic
 - large variation in climate by choosing south east to north west route
 - variety of climate change impacts
 - strategically important route



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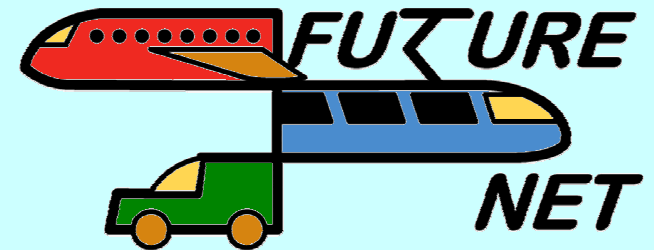
FUTURENET: Modelling context



Development of
Network



Other projects in Europe

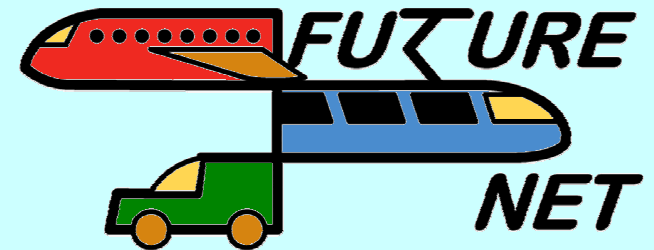


- Network Rail – Tomorrow’s Railway and Climate Change Adaptation (TRaCCA)
- UIC – Adapting Rail Infrastructure to Climate Change (ARICC)
- FP7 projects
 - EWENT
 - WEATHER



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TRaCCA



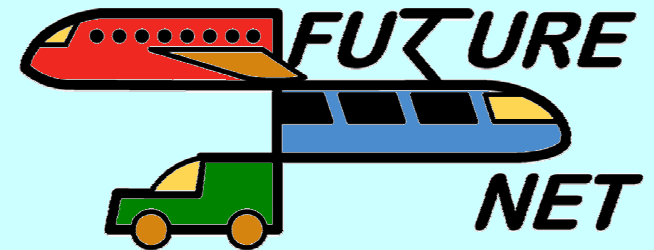
- Series of seven workshops to identify major issues in the UK and find priorities
- Ongoing work to establish correlations between climate parameters and impacts – based on delay minutes.
- West Coast Main Line case study
- Feeds into
 - Adaptation reporting to government
 - Regulatory timescale
 - Development of tool for policy options for adaptation
 - Development of new codes and standards
 - Major issues with asset registers and databases



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Climate Impact Group	Cluster	Consequence
Heat	Track	Management of track buckle risk
Heat	Track	Reduced window of opportunity to carry out maintenance/ renewals work due to heat
Heat	People	Passenger health and impact on freight from train failure in extreme temperatures, including heat and cold
Heat	People	Staff working conditions, eg: use of heat watchmen
Heat	Power/ Telecoms/ Signalling	Floating electrical earth leading to stray earth currents caused by dry ground/ low groundwater; heat (solar gain) affecting lineside equipment; sag in tethered overhead line systems at terminal stations
Rainfall	Fluvial flood	Track and lineside equipment Failure
Rainfall	Groundwater flood	Track and lineside equipment Failure
Rainfall	Pluvial flood	Track and lineside equipment Failure
Rainfall	Fluvial flood	Scour and water effects at bridges
Rainfall	Fluvial flood	Scour at embankments due to high river levels and culvert washout
Rainfall	Fluvial flood	Safety of workforce carrying out inspections during an extreme flood event
Rainfall	Pluvial flood	Landslips
Rainfall	Fluvial flood	Accessibility of fleet and of maintenance depots
Insolation/ heat/ rainfall/ wind	Vegetation	Change in type, falling trees causing obstructions, poor adhesion, and track-circuit non-activation
Sea level rise and storms	Coastal and estuarine defences	Wave overtopping and flooding at defended coastal and estuarine railways

ARICC - deliverables

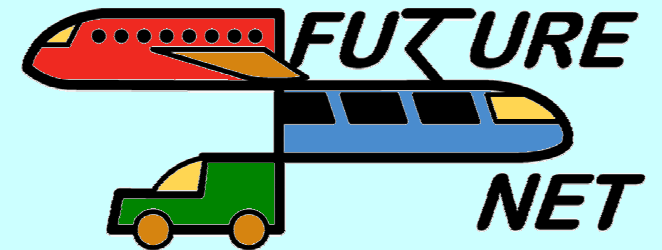


- D1 Solutions and Examples for Natural Hazard Management & Early Warning Systems (monitoring, impact assessment, vulnerability mapping, early warning, risk assessment)
- D2 Knowledge Base & Exchange Platform (good practice, pilot projects, competence mapping, country profiles, contacts...)
- D3 Case Studies: UK West Coast, Rhine Valley, Global Case Study (mapping, risk & costs assessment, cost scenarios 2030 with/without adaptation)
- D4 Guidance Document: Risk Analysis & Adaptation Measures(guidance for integrated natural hazard management, easy to use document, example for concrete line)
- D5 Standards for new and existing Infrastructure(integration of climate change into standards, different procedures in Europe)



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EWENT

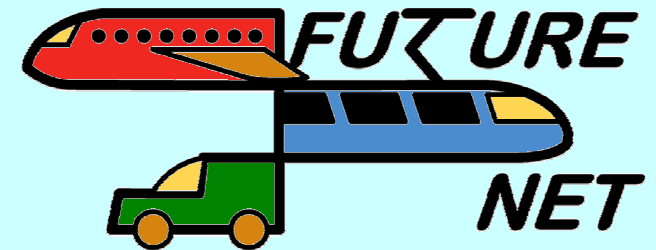


- Overall objective is to estimate and monetise the disruptive effects of extreme weather events on the operation and performance of the EU transportation system.



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EWENT



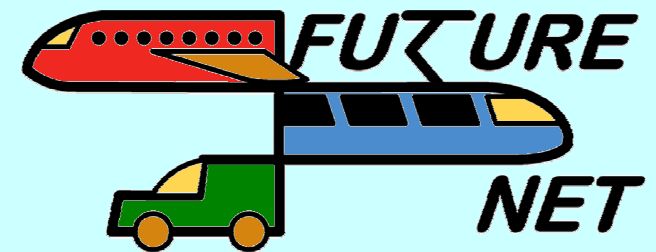
➤ Methodology

- Identify and define the hazards on EU transportation systems caused by extreme weather phenomena and develop relevant scenarios.
- Estimate the probabilities of harmful scenarios caused by extreme weather
- Estimate the consequences of extreme weather events based on developed scenarios - first on EU transport infrastructure, then on operations and finally on supply chains and mobility.
- Monetise the harmful consequences per transport mode both on infrastructure and operations (including mobility and supply chain impacts).
- Evaluate measures and options for negative impact reduction, control and monitoring in short and long-term.



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WEATHER

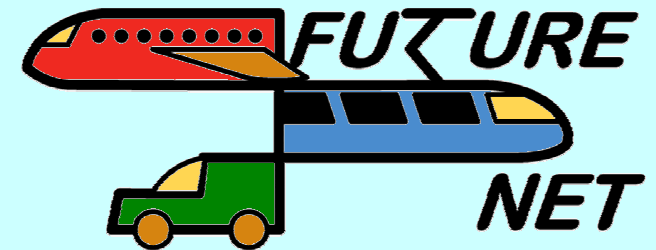


- Core objective is to "determine the physical impacts and the economic costs of climate change on transport systems and identify the costs and benefits of suitable adaptation and emergency management strategies".



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WEATHER

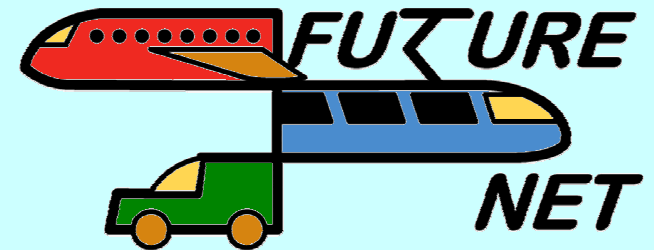


- Develop a dynamic model on the causal relations between the severity and frequency of extreme events, the functionality of critical sectors and social welfare.
- Detailed assessment of the vulnerable elements and damage costs in transport systems.
- Work out efficient and innovative mechanisms of managing disastrous events, focussing on maintaining the function of transport systems.



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WEATHER



- Identify appropriate and efficient adaptation strategies for transportation infrastructures and services to ease the impacts of extreme events in the future.
- Clarify the role of governments, companies and industry associations.
- Check the applicability of theoretical concepts of vulnerability assessment, crises prevention and adaptation strategies with practical experiences and local conditions
- Dissemination of project findings to a wider audience to fostering the debate on the costs and implications of more frequent and severe weather conditions on transport systems



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