Climate change: Overview of the scientific background and the potential impacts affecting transportation

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Scope of the work

- To assist the UNECE Group of Experts, in accordance with its agreed work programme and objectives

- Effective adaptation action for International Transport Networks (ITN) requires an understanding of the potential climate change (CC) impacts, that may vary in type, range and distribution, depending on climate change factors as well as on

  - Region/local vulnerability
  - Mode of transport
  - Infrastructure, operation, services

- It represents a first step to take stock of the available information on CC impacts on international transportation infrastructure

  - in the ECE region and beyond
  - including their type, range and distribution across different regions and transport modes

Work in progress

Update the draft report (November 2011), which

- presents a short review of the scientific background of Climate Change and its implications on a global scale and in the UNECE region

- reviews potential CC impacts on international transport networks

  - identifying particularly issues pertinent to transport infrastructure in the UNECE region;
  - taking into account the different modes of transportation.

- reviews briefly some of the particularly pertinent studies relating to different modes of transportation and Identifies additional literature of relevance

Collation and analysis of the answers to a relevant questionnaire sent out to pertinent public and private entities (answers expected by 15th of July)

Presentation Synopsis

Climate Change: The Physical Basis

- Phenomenology: in which way is the climate changing?
  - Temperature, sea level rise and precipitation trends
  - Extreme events
- Mechanism: which are the processes involved?
- Feedbacks and tipping points: concerns about <u>dangerous</u> climate change

Climate Change Implications for Transport

- Impacts on coastal areas
- Riverine floods
- Heat waves and Droughts
- Impacts in polar areas (opening arctic routes and permafrost melt issues)

Select studies on climate change impacts on transport

Phenomenology: how the climate is changing?

Climate Change (CC): change of climatic conditions relative to a reference period, i.e.:

- the first period with accurate records (1850s-1860s) or
- the average climate of periods with accurate climatic information and infrastructure used today (e.g. 1961-1990 1980-1999)

Temperature, sea level and precipitation trends →

Polar Ice loss →

Extreme climate events →

There are also feedbacks/tipping points. i.e trends can be changed by reinforcing (or negative) feedbacks and if thresholds are crossed trends will not be linear and reversible, but abrupt, large and (potentially) irreversible in human temporal scales.

Climate controls: what are the processes involved?

Climate is controlled by solar heat inflows/outflows →

The observed increase in heat content is probably due to the increasing atmospheric concentrations of greenhouse gases (GHGs), that absorb heat reflected back from the Earth's surface →

Variability both natural (Milankovich cycles, sunspot activity) and human-induced →

Potential CC factors affecting transportation

The most important factors are IPCC (2007):

- rising mean sea levels and higher storm surges
- more intensive precipitation events
- increase in very hot days/frequency of heat waves
- Higher arctic temperatures (opening routes but, also, permafrost melt) and
- increase in hurricane destructiveness (winds, precipitation and storm surge extremes) in some regions

International transport network vulnerability to Climate Change

Long lifetimes of key assets, sensitive to climate →

Location of assets at areas exposed to climate impacts (ports, inland waterways, road and rail networks in flood plains etc)

Interdependence of transport and trade: transport is demand driven (indirect impacts, e.g. agriculture, tourism)

Relatively few studies, particularly in terms of adaptation measures, although large costs are expected →

Important: Understanding of key vulnerabilities to CC

Climate Change Implications for Transport

Significant impacts on transport infrastructure/operations expected

In coastal areas

In river flood plains

Due to heat waves and droughts

Due to permafrost melt

In polar areas

longer shipping season in Arctic, shorter shipping routes-NWP/less fuel costs, but, possibly, higher costs for new support services

Coastal areas

Increased coastal flood and inundation risks

Coastal erosion and damages to port infrastructure, equipment and cargo

Increased port construction and maintenance costs

Changes in port/navigation channel sedimentation patterns;

Relocation of people/business, labour shortages and insurance issues

Impacts on coastal areas: roads

Source: P. Peduzzi, 2011

Impacts on coastal areas: roads

Impacts on coastal areas: airports e.g. Kingston (Jamaica)

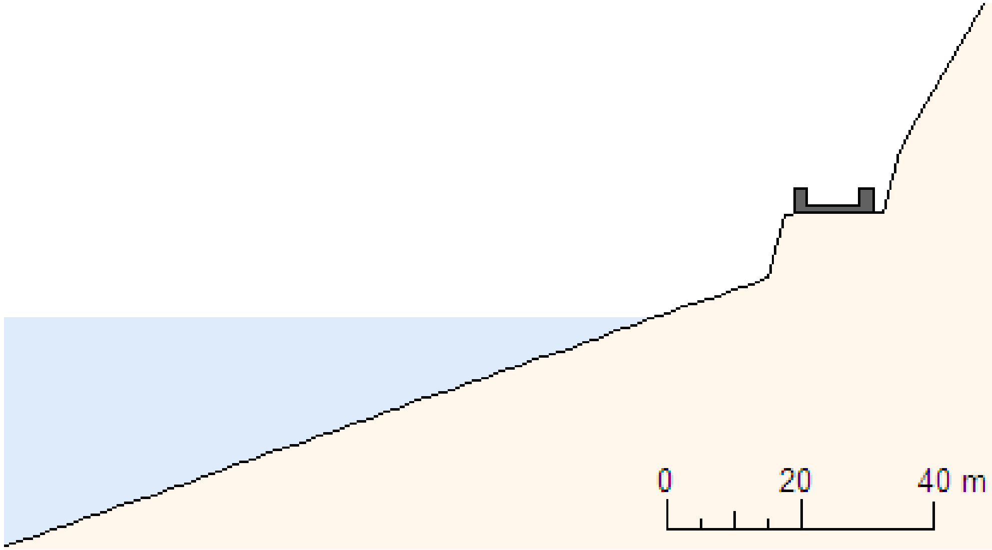
Inundation risks in both the runway/airport facilities and the causeway

Impacts on coastal areas: railways

Coastal transport infrastructure

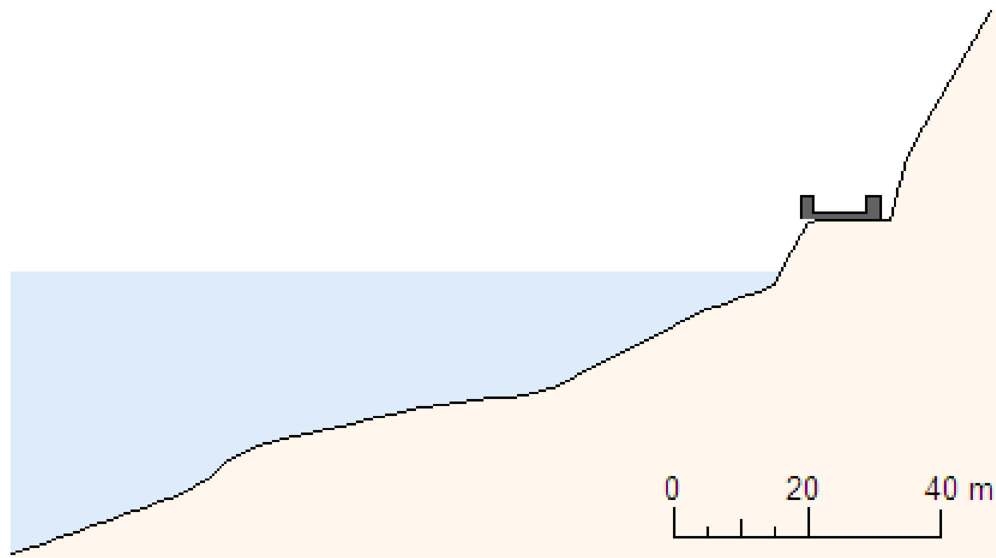
The main railway line to Sochi (Black Sea), that is threatened by the erosion of the fronting beach – which, will be (red line) under 1 m storm surge and offshore waves with height (H) = 4 m and period (T) = 7.9 sec.

Leont' yev Model



Present normal conditions

Storm surge 1 m



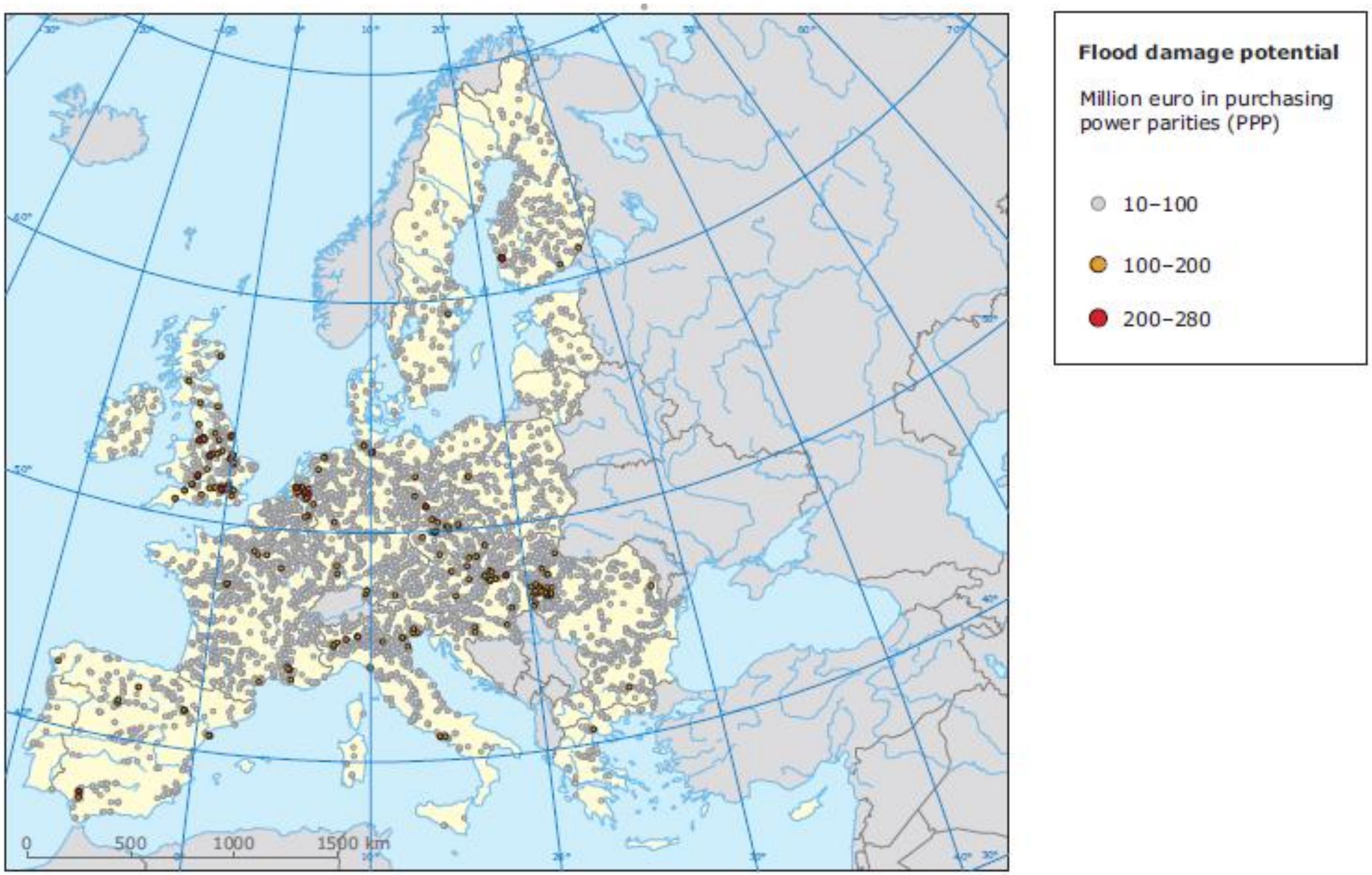
River flood plains

Increased flooding/inundation risks for transport networks

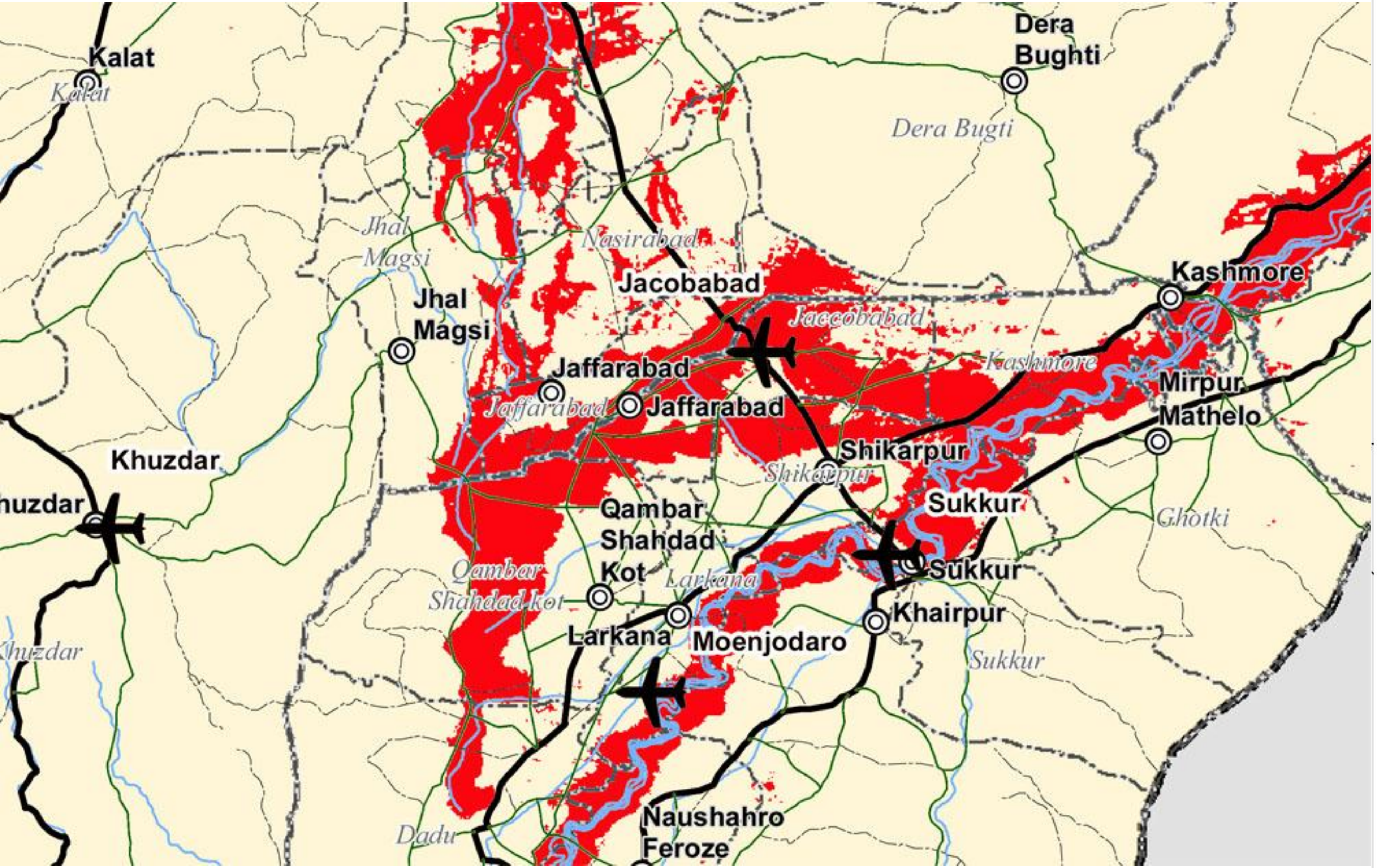
Impacts on inland waterway navigation;

Damages and/or destruction of vital transport nodes (e.g. bridges)

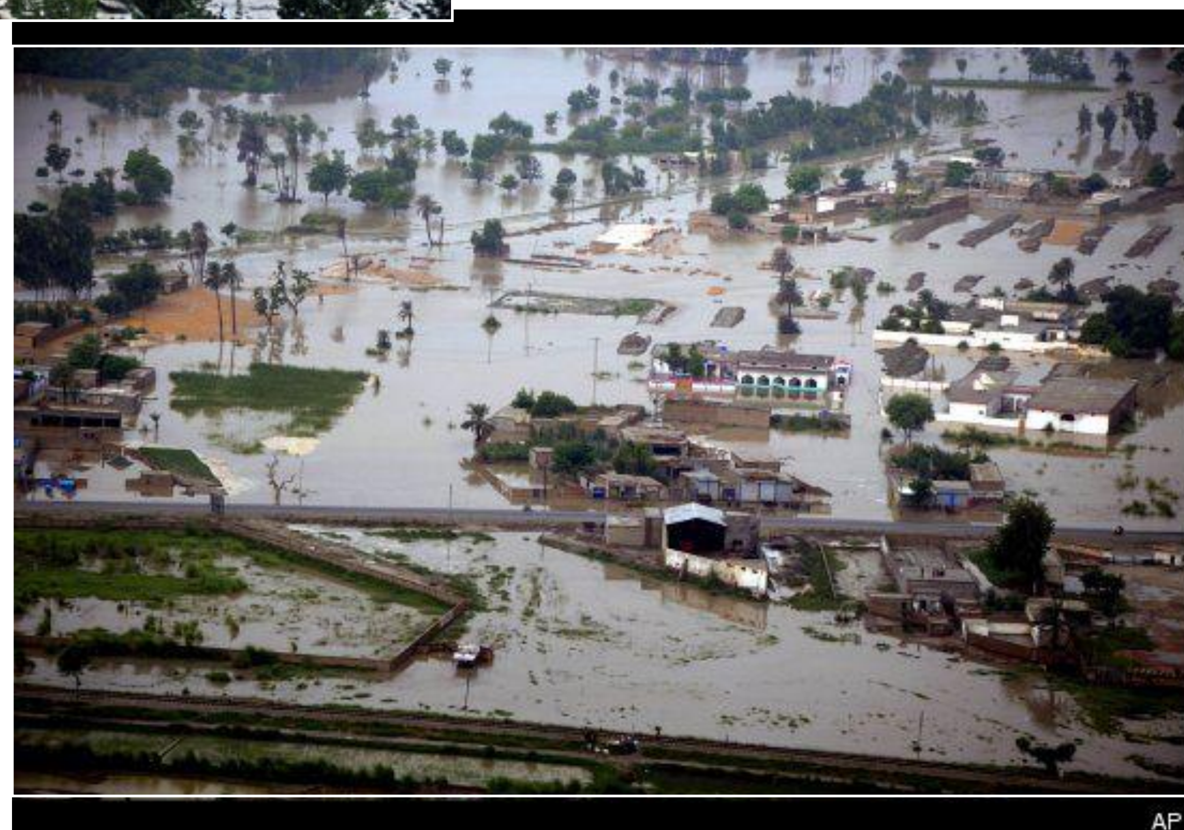
Impacts on river flood plains



Flood damage potential in Europe (EEA, 2010). Estimations are for the 100-year return period event (i.e. the record flood in 100 years), present climate and no defences. Catchments of less than 500 km^2 are not included.



Source(s): MapAction; United Nations Office for the Coordination of Humanitarian Affairs (OCHA)
P.l Peduzzi, UNEP (2010). UNECE-UNCTAD Workshop



Source: P. Peduzzi, 2010 UNECE-UNCTAD Workshop presentation.

Due to heat waves and droughts

Dilatation of badly designed railways

Forest fire impacts on land and air transport

Increased landslide risks affecting mountainous road and rail networks

Damage to infrastructure, equipment and cargo and increased construction and maintenance costs

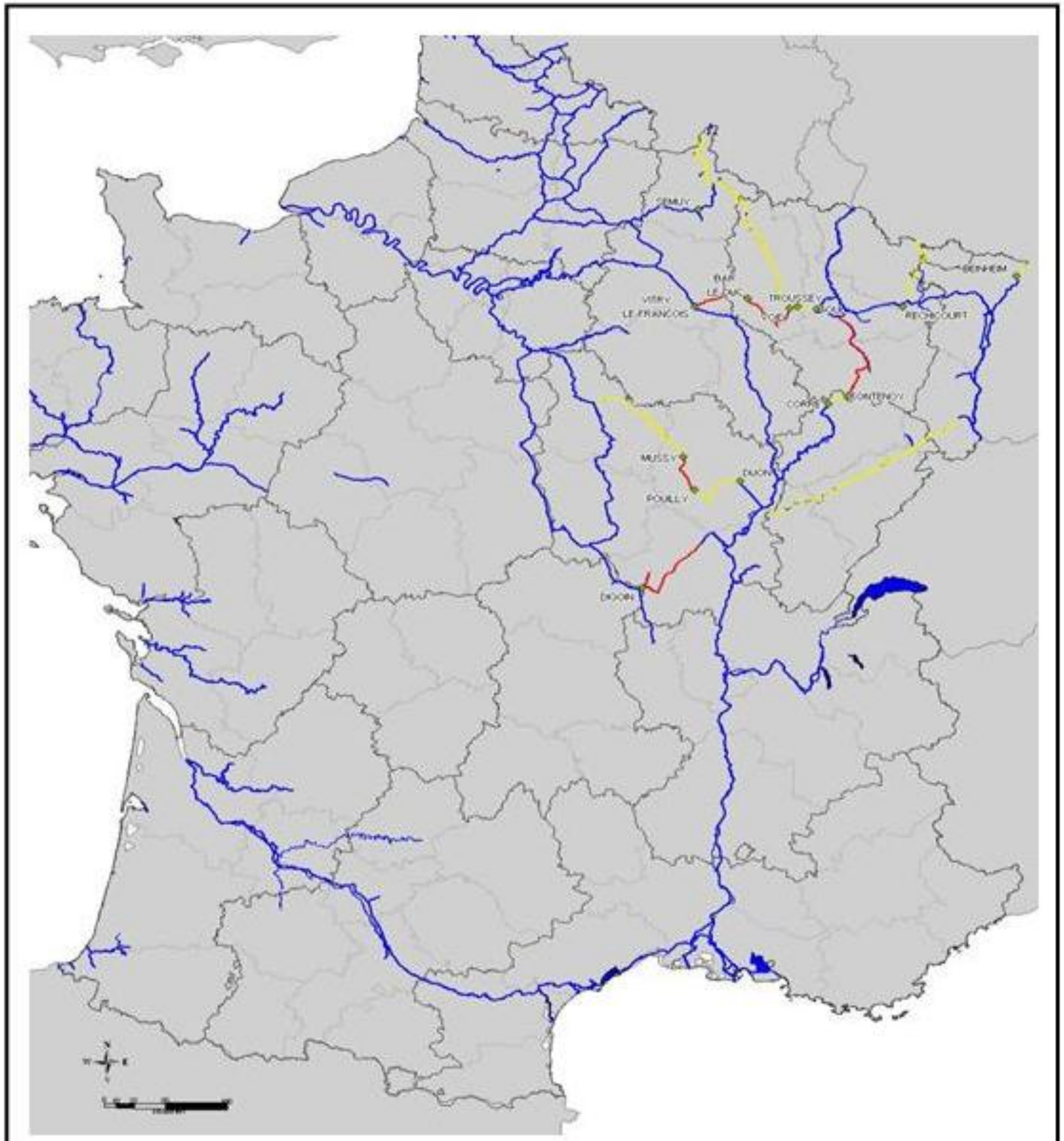
Higher energy consumption in ports and other terminals

Challenges to operations in inland waterways and service reliability

Impacts due to heat waves: rail dilatation

Drought & inland waterway transport

Drought & inland waterway transport



Impacts of the 2003 drought on the French inland waterways.

Red shows waterways where navigation was closed and

Yellow shows waterways where navigation was restricted on late August 2003

(Leuxe, 2011)

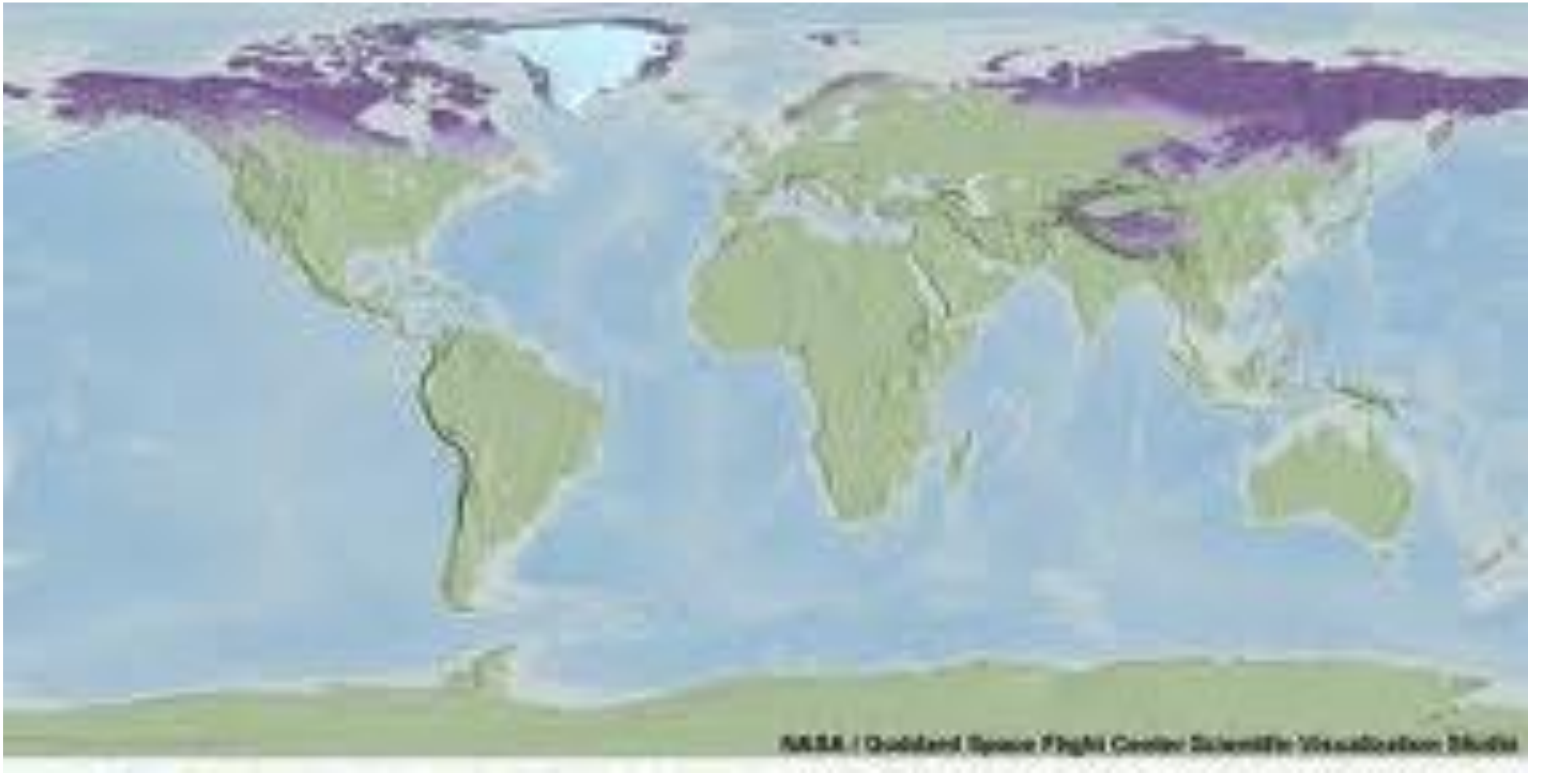
Permafrost areas

Permafrost degradation will cause damages to

- railways, roads, bridges and pipelines;
- building foundations and airports;
- coastal infrastructure

and lead to increased construction and maintenance costs

Permafrost distribution



Melting permafrost: impacts on roads

Alaska

Melting permafrost: impacts on coasts

Alaska

Select studies on CC impacts on transport

The US Gulf Coast Study (Phases I & II)

PIANC Study

Scottish Road Network Climate Change Study

Climate change and the railway industry: a review

Future Resilient Transport Networks (FUTURENET)

Rail safety implications of weather, climate and climate change

Climate Adaptation of Railways: Lessons from Sweden

Railway construction techniques in permafrost regions

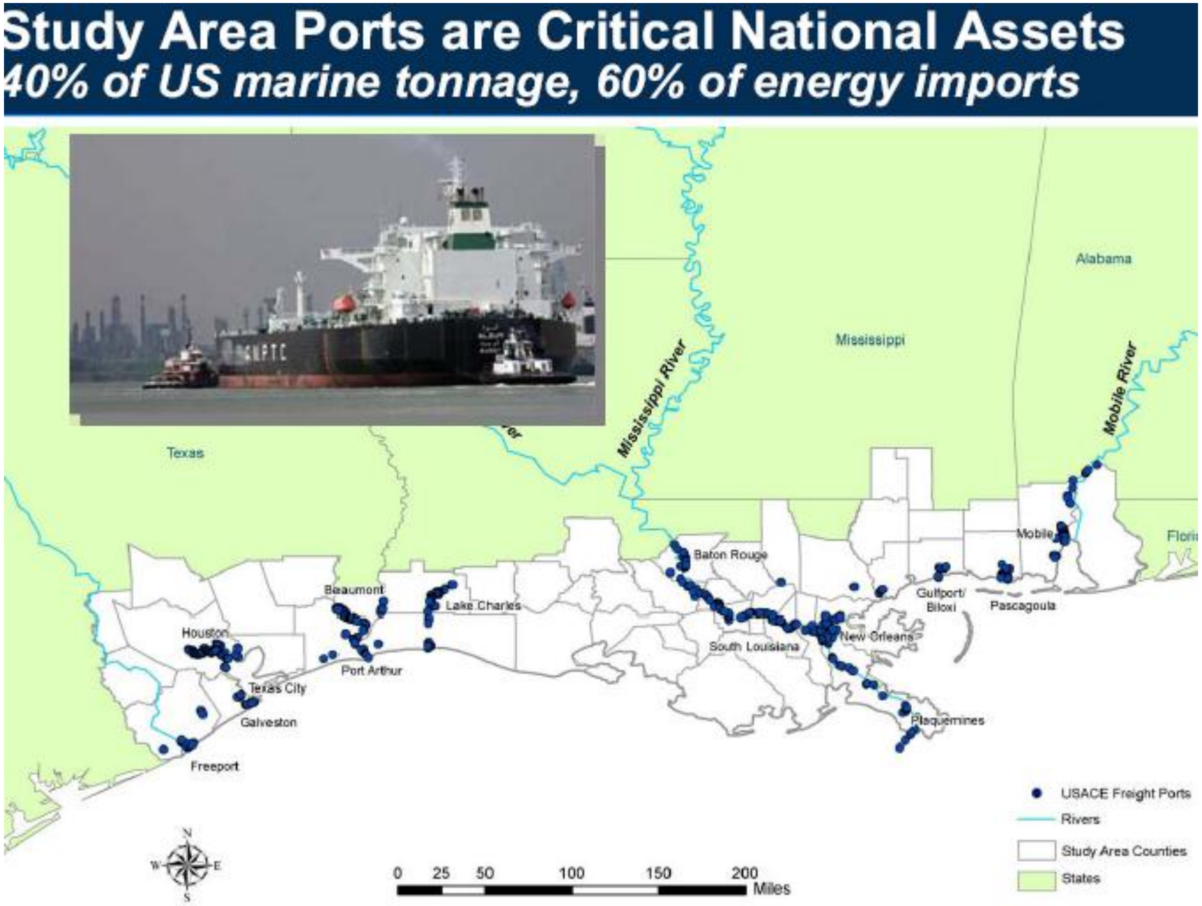
Quantifying the effects on rail of high summer temperatures

ARISCC Adaptation of Railway Infrastructure to Climate Change

Climate Risk and Business: Ports

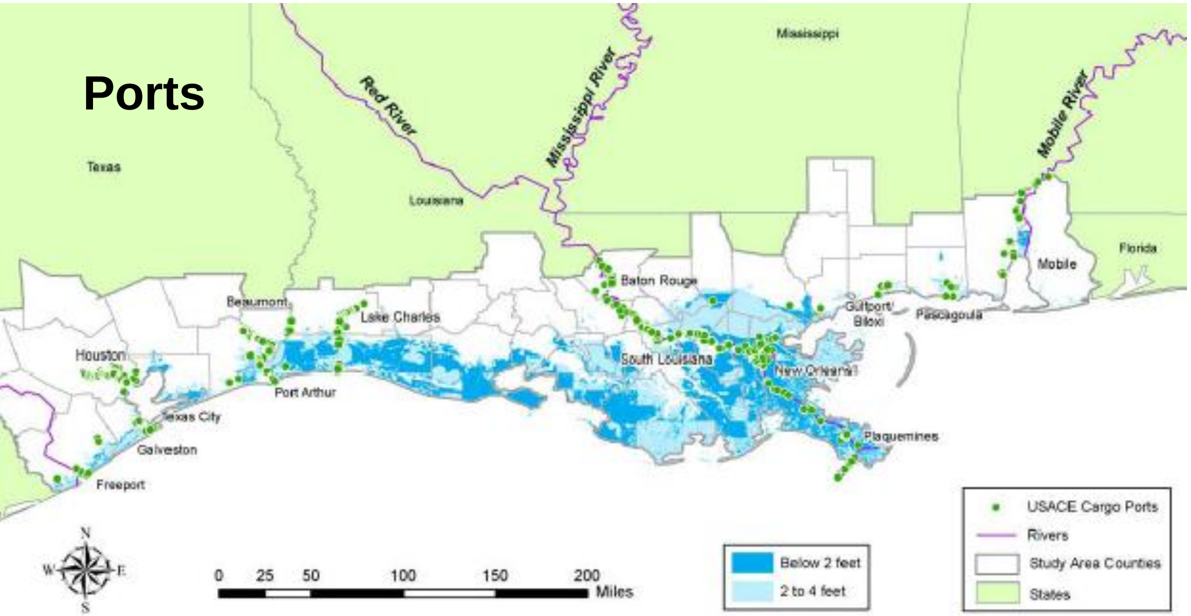
French studies on CC impacts on transportation

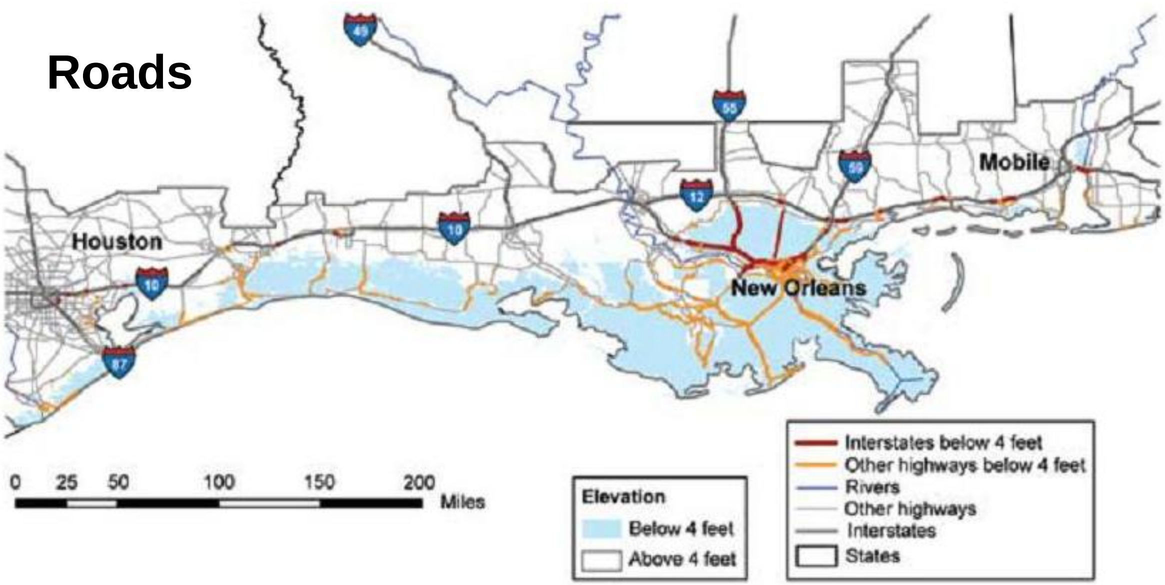
US Gulf Coast study



Ports and other infrastructure assets at risk along the US Gulf coast (US Gulf Coast Study)

US Gulf Coast study

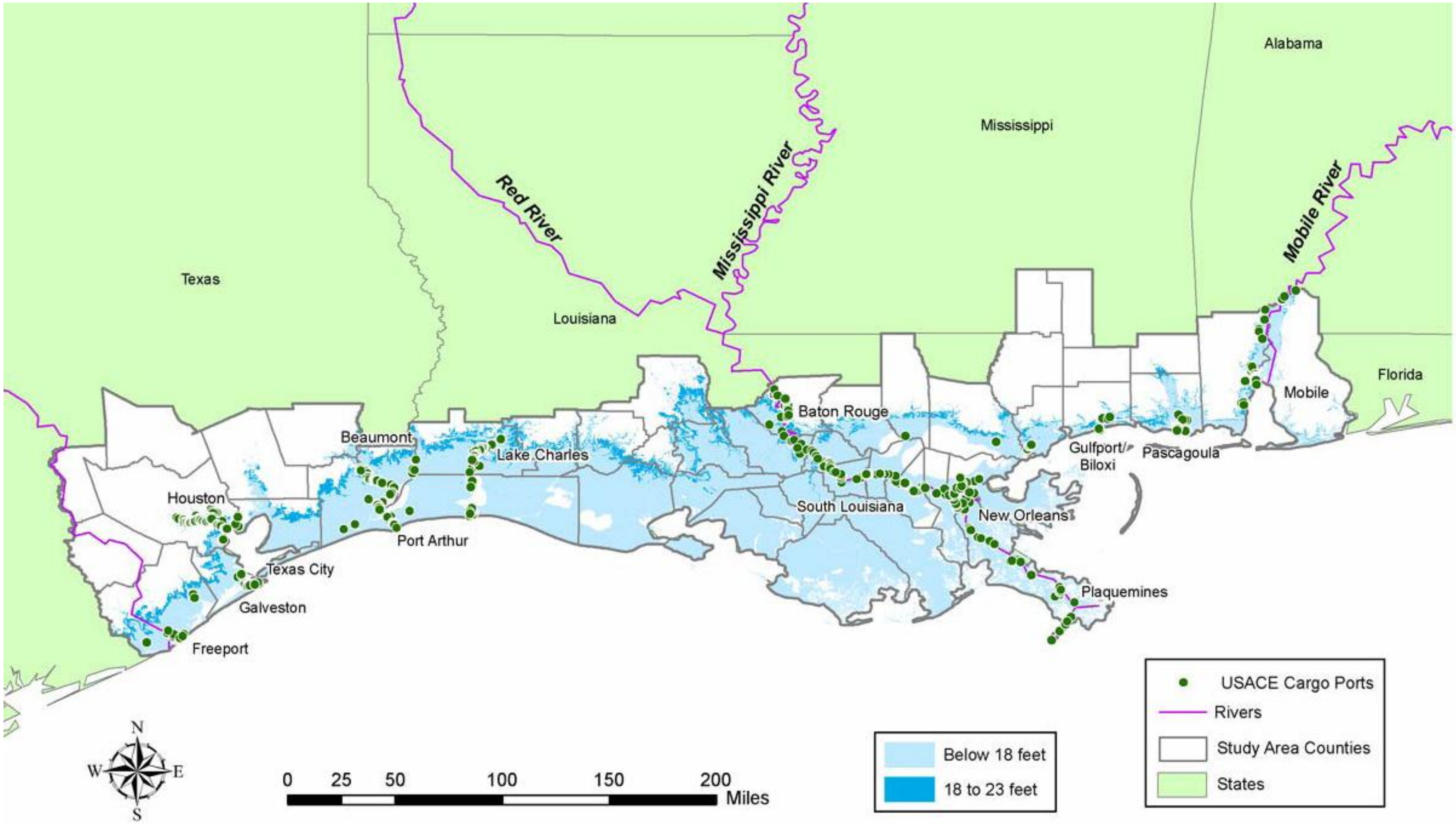




Flood risk at US Gulf coast under SLR 0-6-1.2 m (MSL + storm surge).

Relative SLR of <u>~1.2 m</u> (4 feet) <u>could inundate more than 2400 miles of roads, over 70% of the existing port facilities, 9% of the railway lines and 3 airports</u>

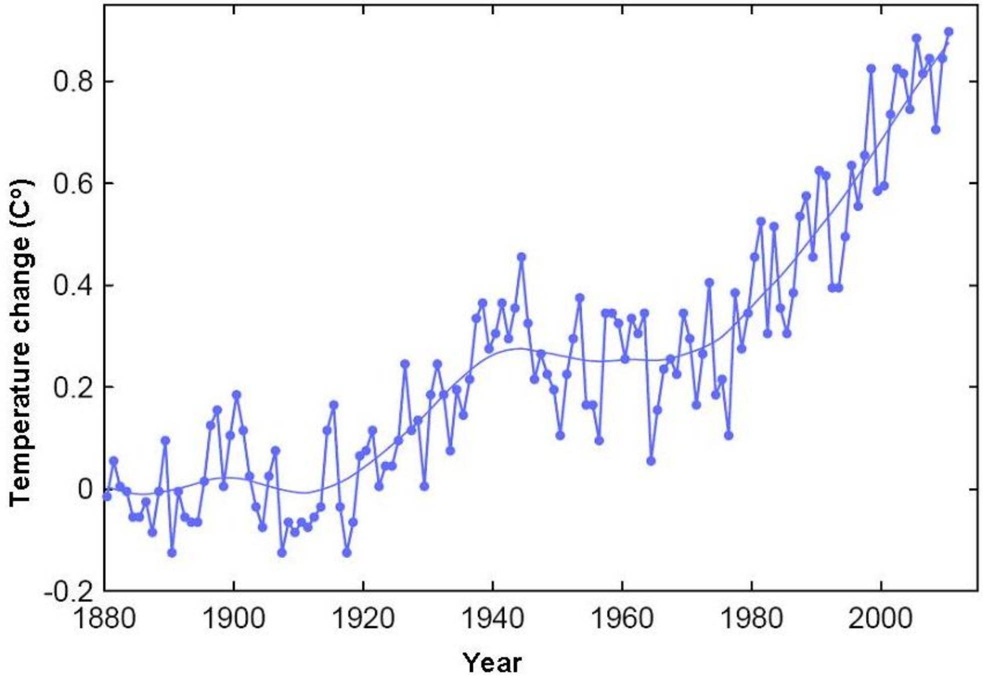
US Gulf Coast study



In the case of a ~5.4-7 m storm surge, more than 50% of interstate and arterial roads, 98% of port facilities, 33% of railways and 22 airports in the US Gulf coast would be affected (CCSP, 2008).

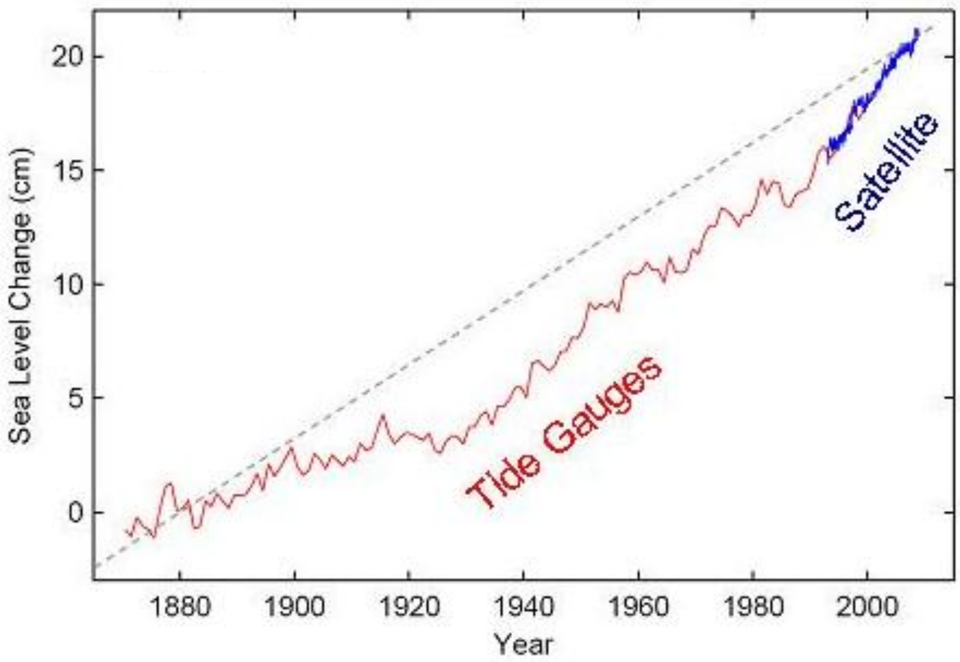

International Conference on
Adaptation of Transport Networks to Climate Change
25 - 26 June 2012, Alexandroupolis, Greece
UNITED NATIONS
ECONOMIC COMMISSION FOR EUROPE
Hosted by Evros Chamber of Commerce and Industry and the Hellenic Chambers Transport Association
Under the auspices of the Ministry of Infrastructure, Transport and Networks and
the Ministry of Environment, Energy and Climate Change of Greece

Thank you!



Mean temperature 1880-2010. NASA Data (Rahmstorf, 2011).

Projections for 2100:
- Increase 0.5 - 4.0 ºC, depending on the scenario (IPCC, 2007)



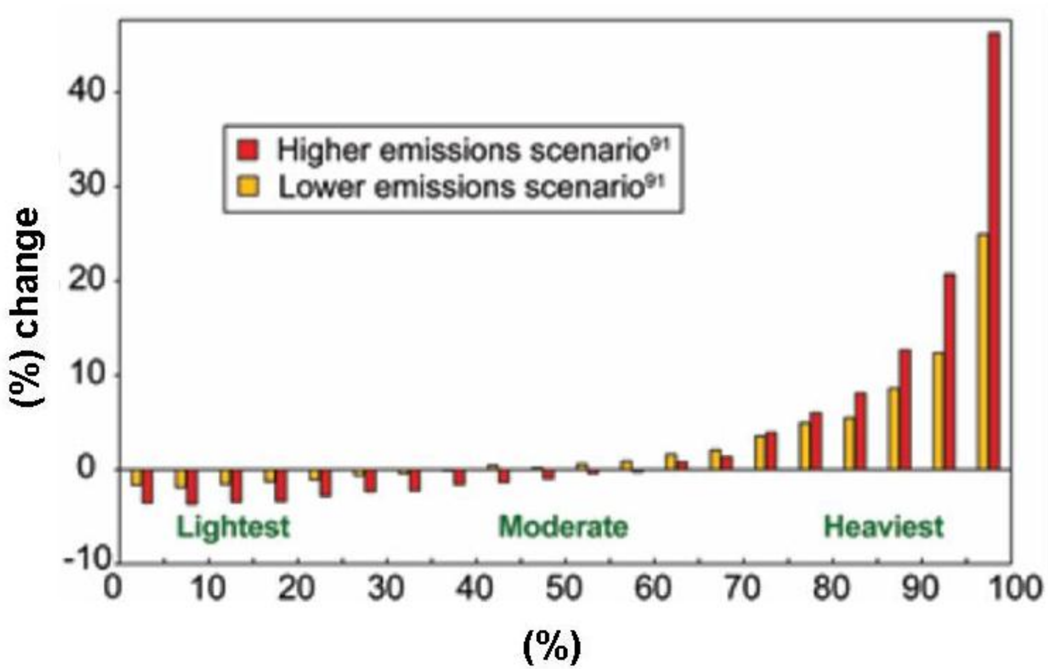
Global sea level changes 1860-2010 (Rahmstorf, 2011).

Projections for 2100:

- 0.22 - 0.50 m (IPCC, 2007)
- > 1 m if ice sheet melt is included (Rahmstorf, 2007)

above the mean sea level of 1980-1999

Precipitation changes



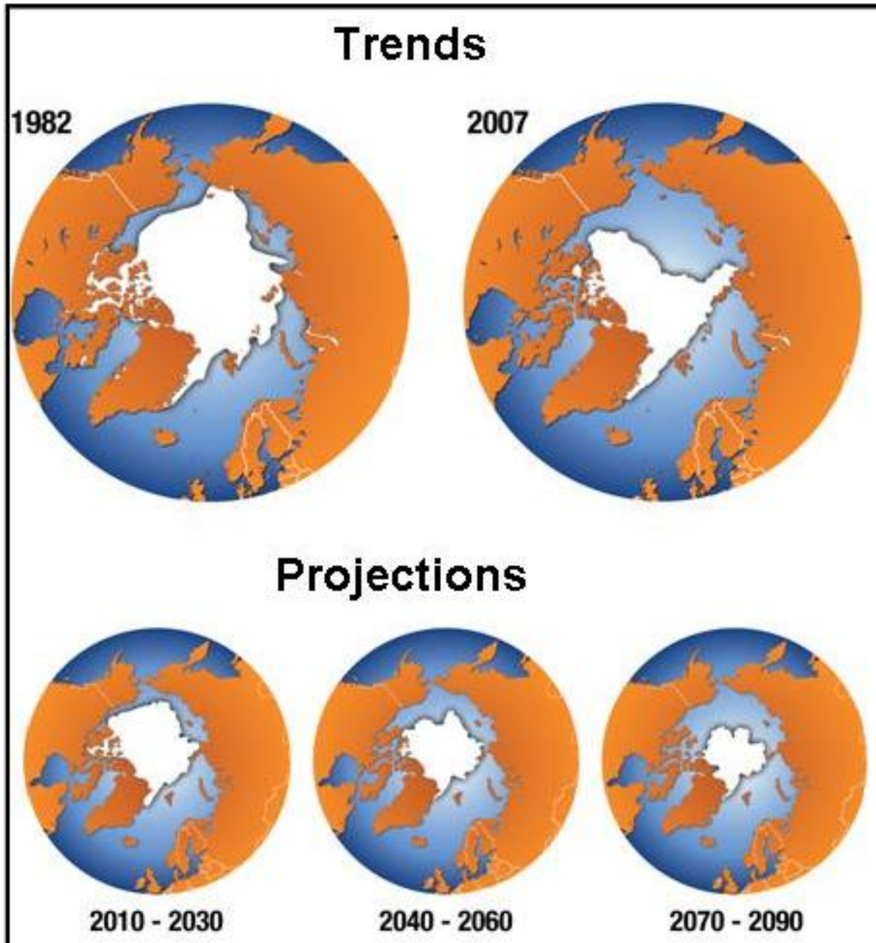
***Projected changes in precipitation between 1990-1999 and 2090-2099 (N. America). Light, moderate and heavy events (Karl et al., 2009*).**

Spatial Variability (IPCC, 2007)

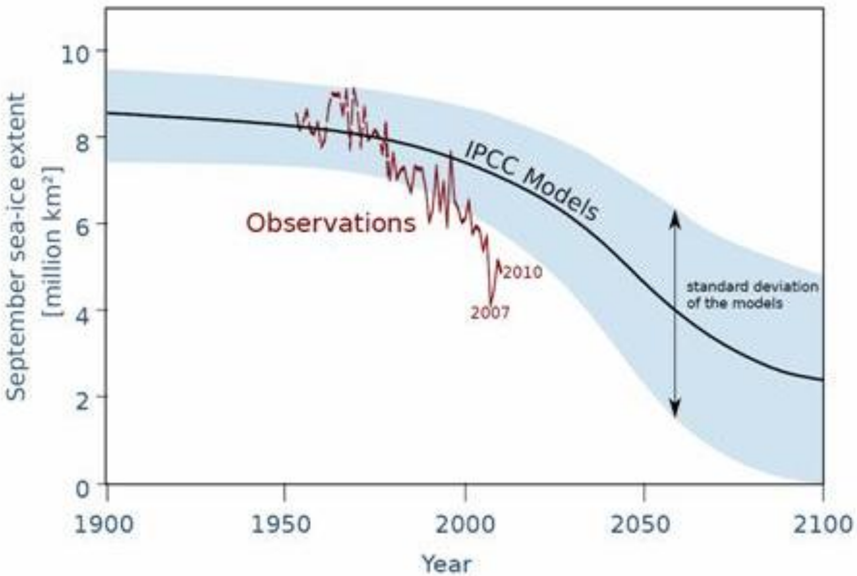
Mostly wetter to the north and dryer to the south of the UNECE region

- <u>Very likely (> 90%)</u> increase in N. Europe, Canada, NE USA and N. Asia and decrease in S. Europe
- <u>Likely (> 66%)</u> increase in extreme rainfall events in N. Europe and N. Asia and
- LIkely <u> (> 66%)</u> increase in draughts in S. Europe
- <u>Very likely (> 90%)</u> snowfall decrease in Europe and N. America

Trends and projections of summer Arctic ice loss



Model results and observations of sea ice loss (Rahmstorf, 2011).



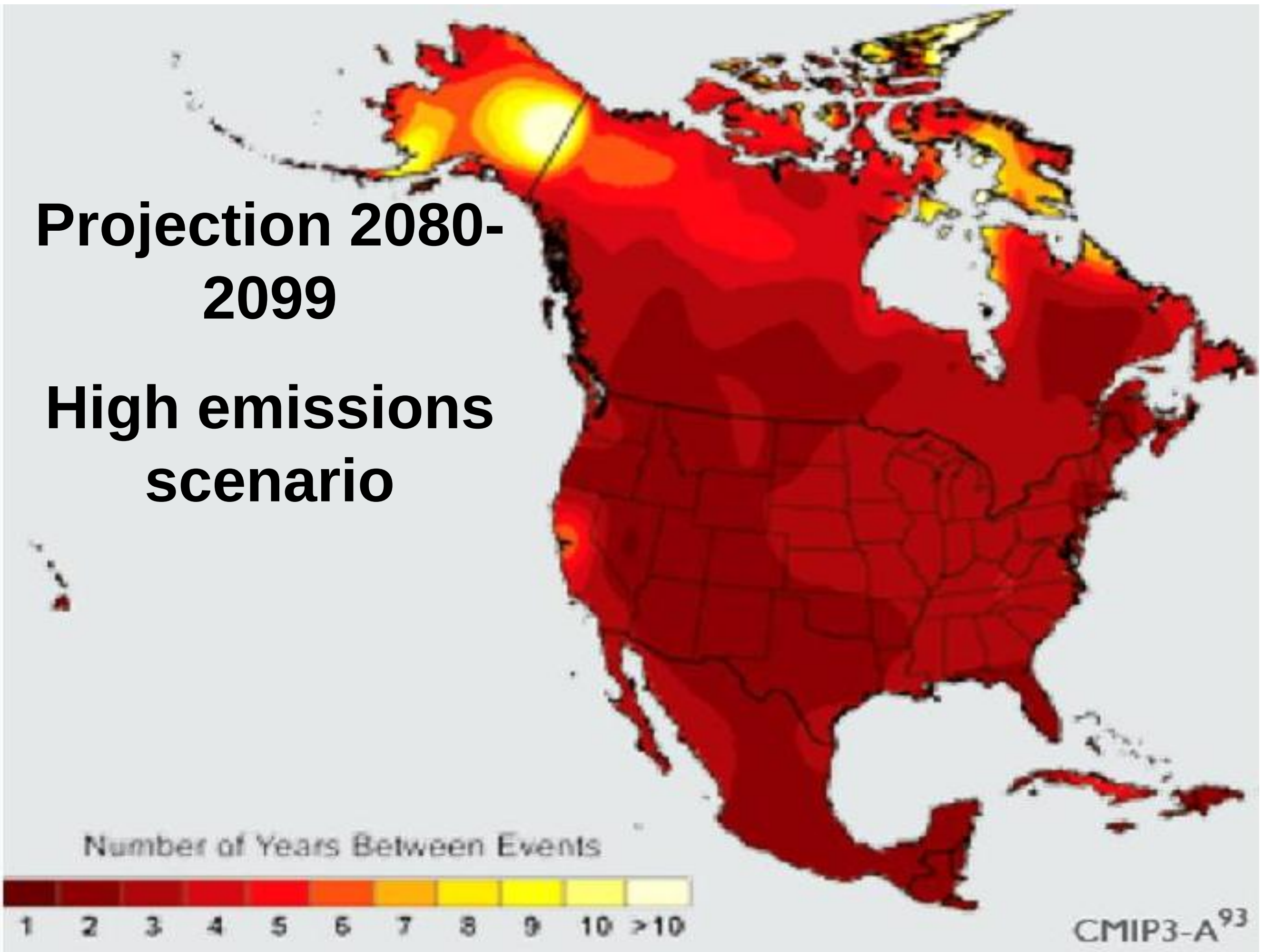
Likelihood of extreme events (IPCC, 2007)

Phenomenon/ trend	Likelihood that trend occurred in late 1900s (post 1960)	Likelihood of a human contribution to observed trend	Likelihood of future (2100) trends based on IPCC scenarios
Fewer cold days/nights over most land	Very likely	Likely	Virtually certain
More frequent hot days/nights over most land	Very likely	Likely (nights)	Virtually certain
Warm spells/heat waves frequency increases over most land	Likely	More likely than not	Very likely
Heavy precipitation event frequency increases over most areas	Likely	More likely than not	Very likely
Area affected by droughts increases	Likely in many regions since 1970s	More likely than not	Likely
Intense tropical cyclone activity/storm surge increases	Likely in some regions since 1970	More likely than not	Likely

Projections: More frequent extreme heat waves

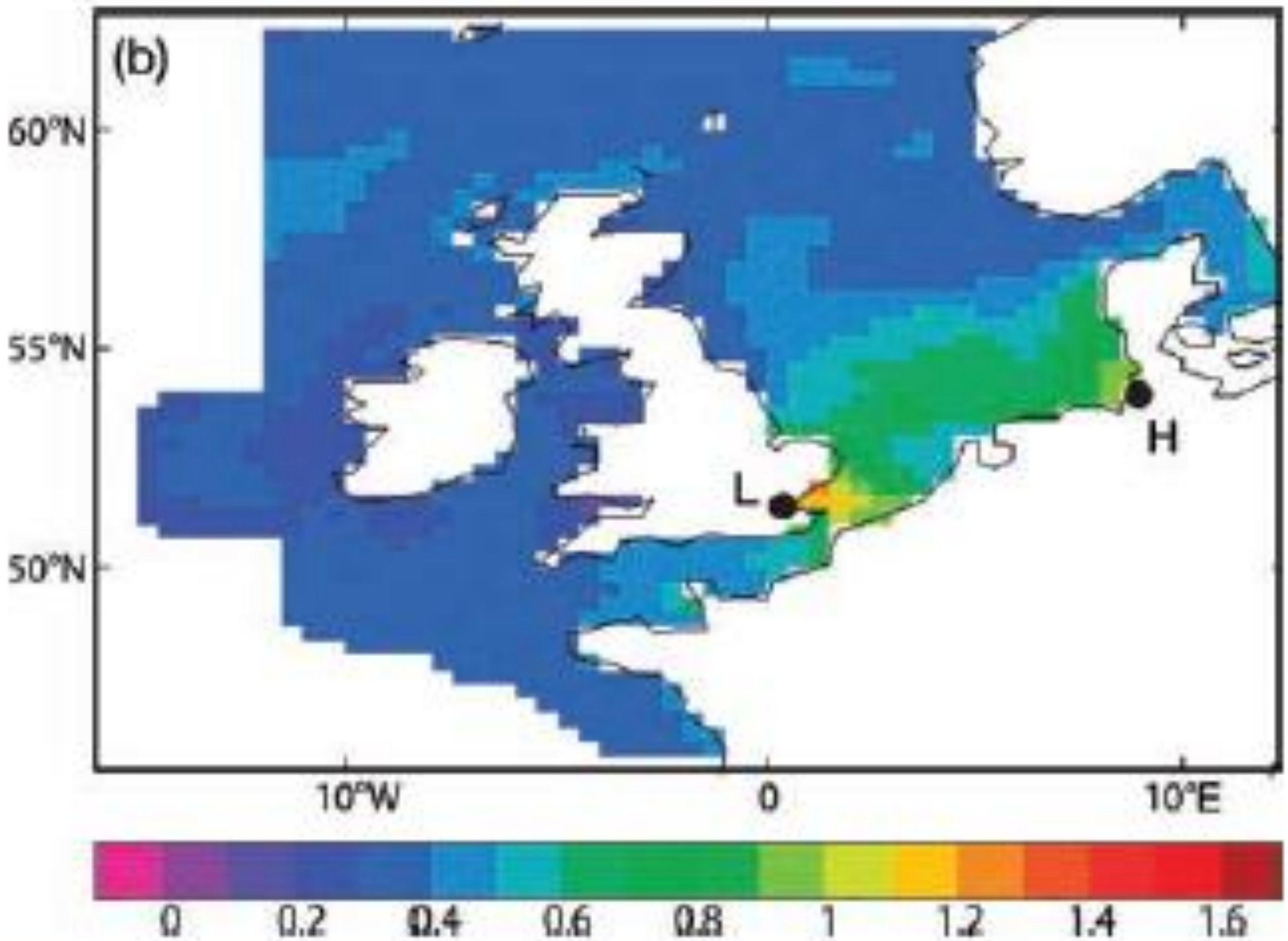
Projection 2080-2099

High emissions scenario



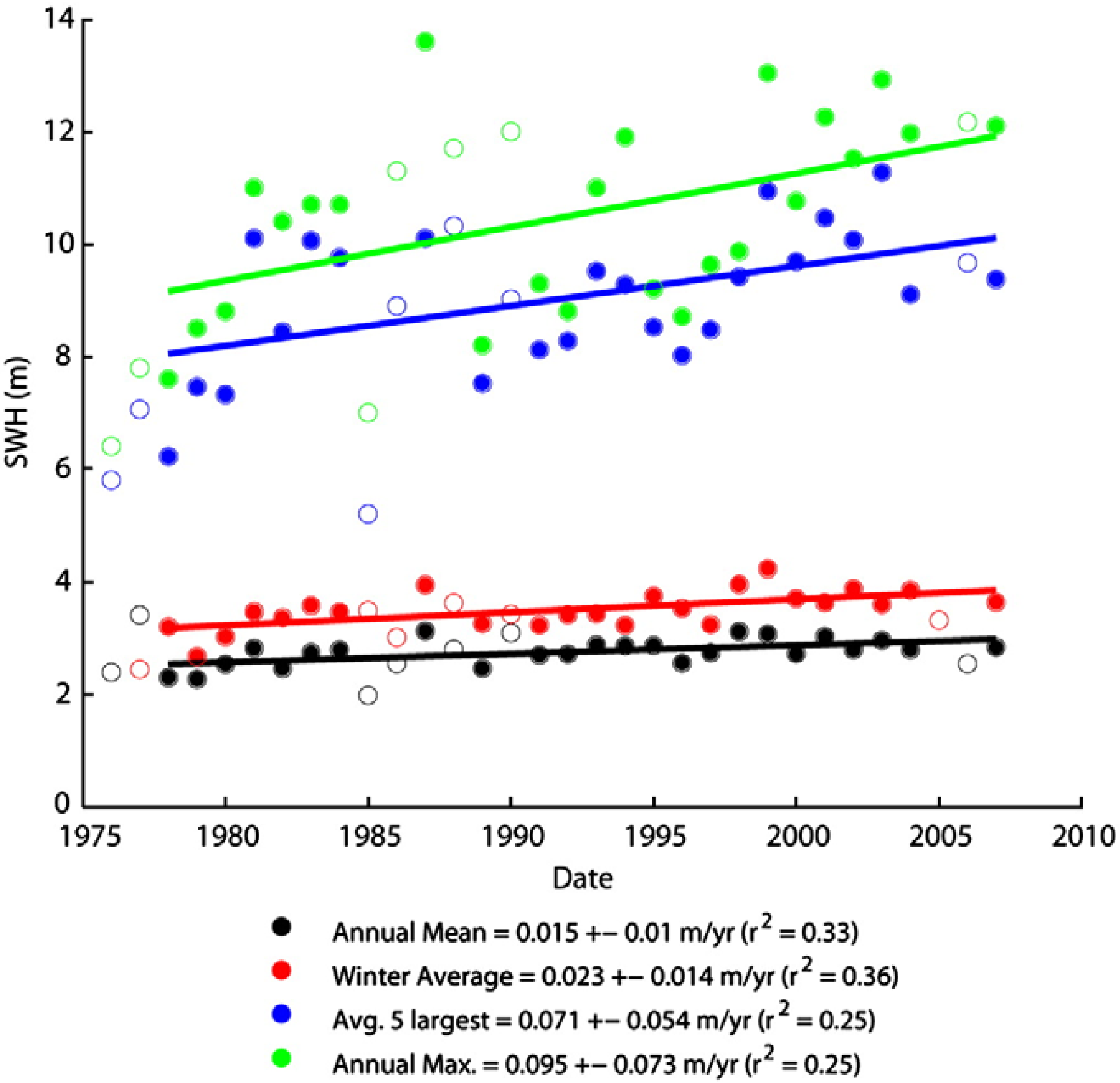
Extreme heat waves (1-in-20-year events) are projected to be more frequent in N. America (Karl et al., 2009)

Projections: More frequent extreme sea levels



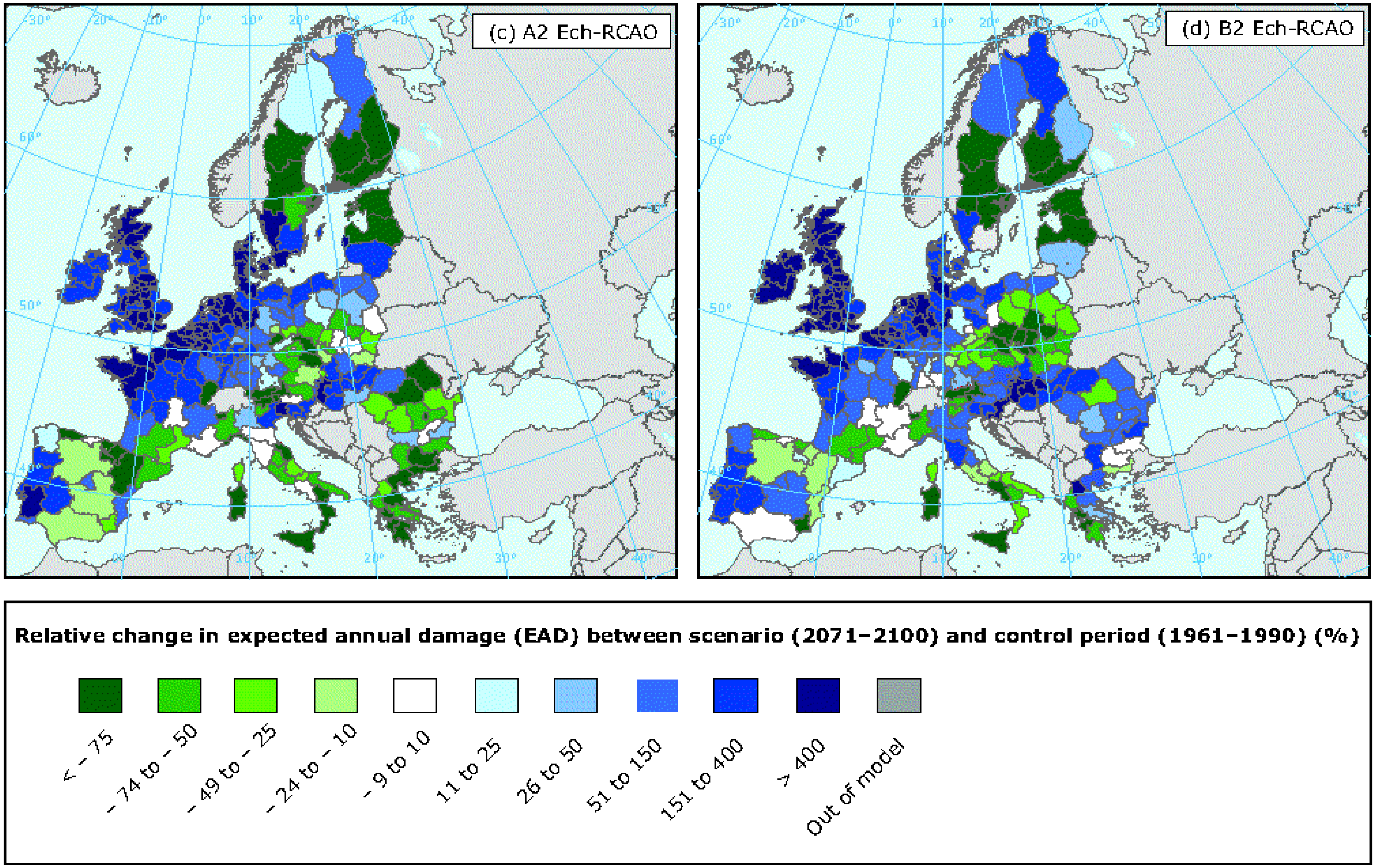
Projected increase in the 1-in-50-year extreme sea level in 2080 (A2 scenario) (L – London; H – Hamburg) (after Lowe and Gregory, 2005).

Current trends: More energetic extreme waves



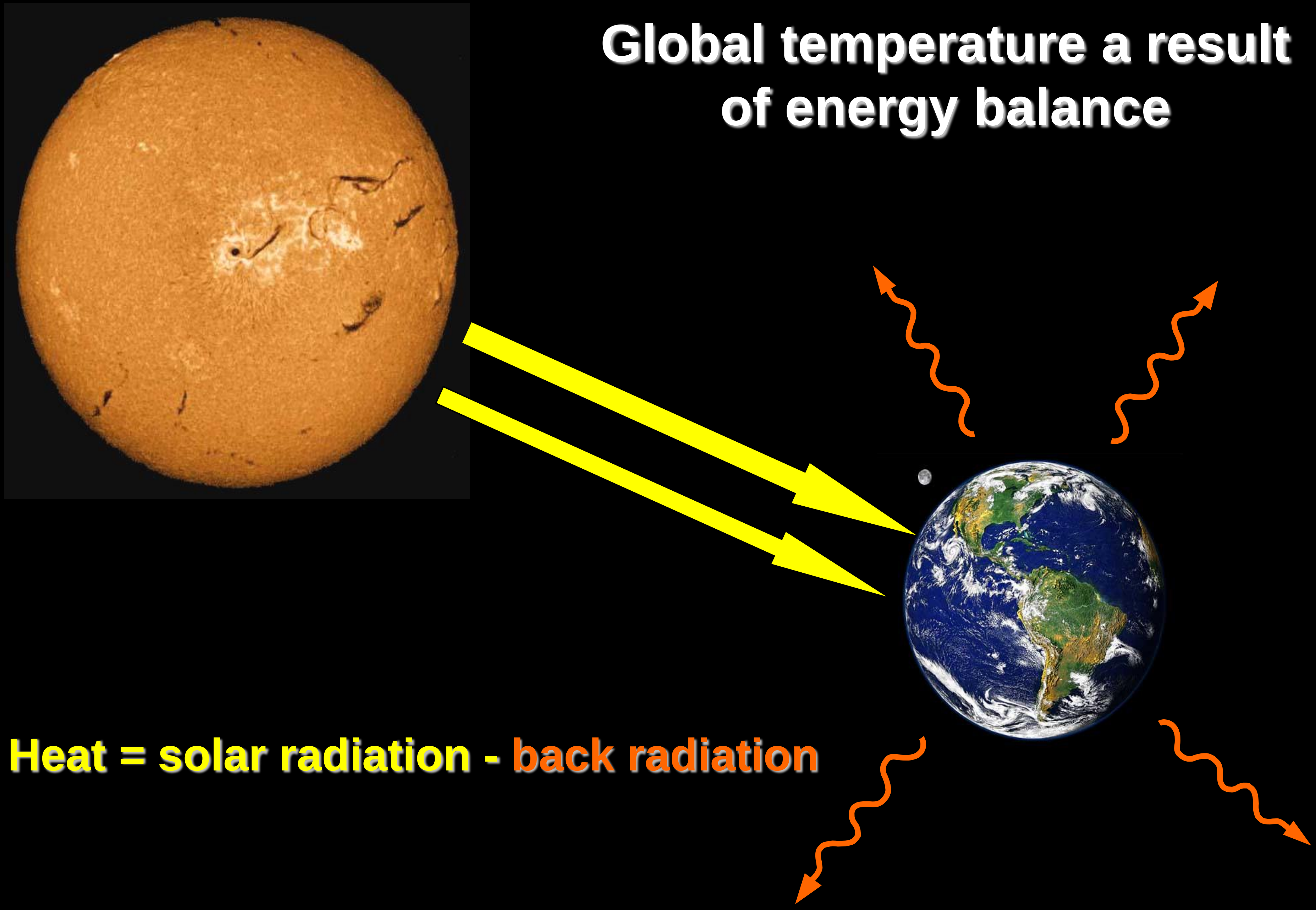
Increases in the annual mean, winter averages, mean of the highest annual waves and annual maxima significant wave heights at the NDBC #46005 platform (NE Pacific). The annual maximum significant wave height has increased 2.4 m! in the last 25 years. (Ruggiero et al., 2010).

Projections: Riverine Floods



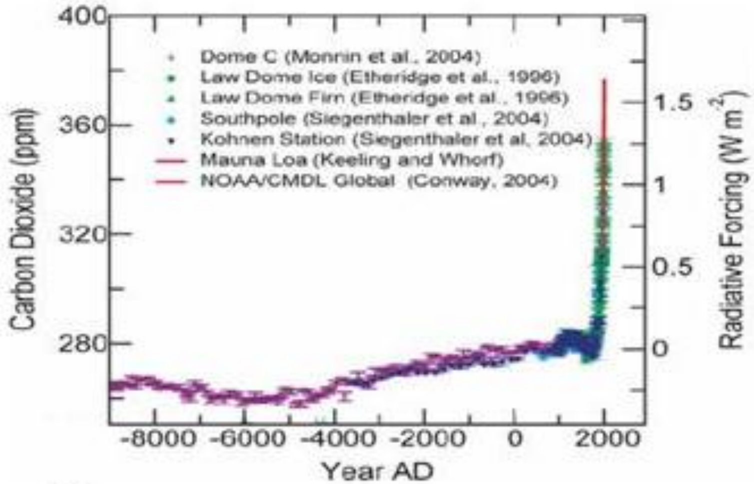
Relative changes in Expected Annual Damage (EAD) from riverine floods, between 2071–2100 and 1961–1990 in Europe (EC JRC, 2010)

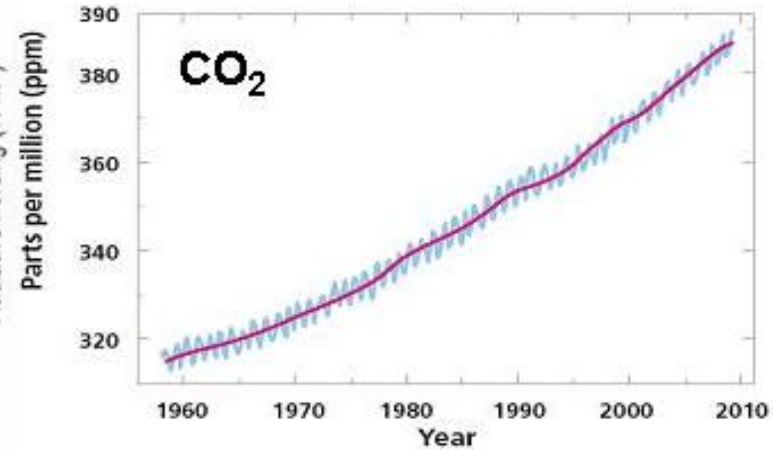
Global temperature a result of energy balance

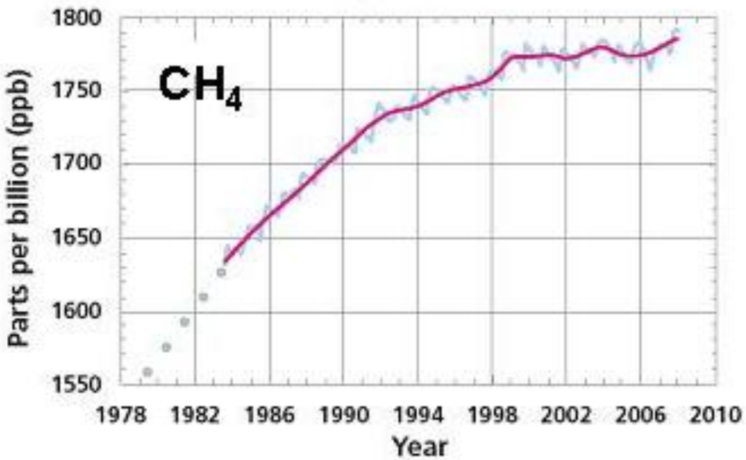


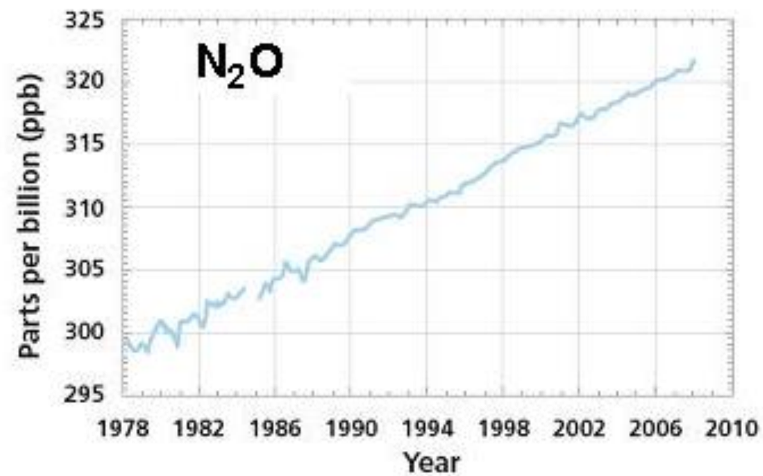
Heat = solar radiation - back radiation

Trends in GHG atmospheric concentration



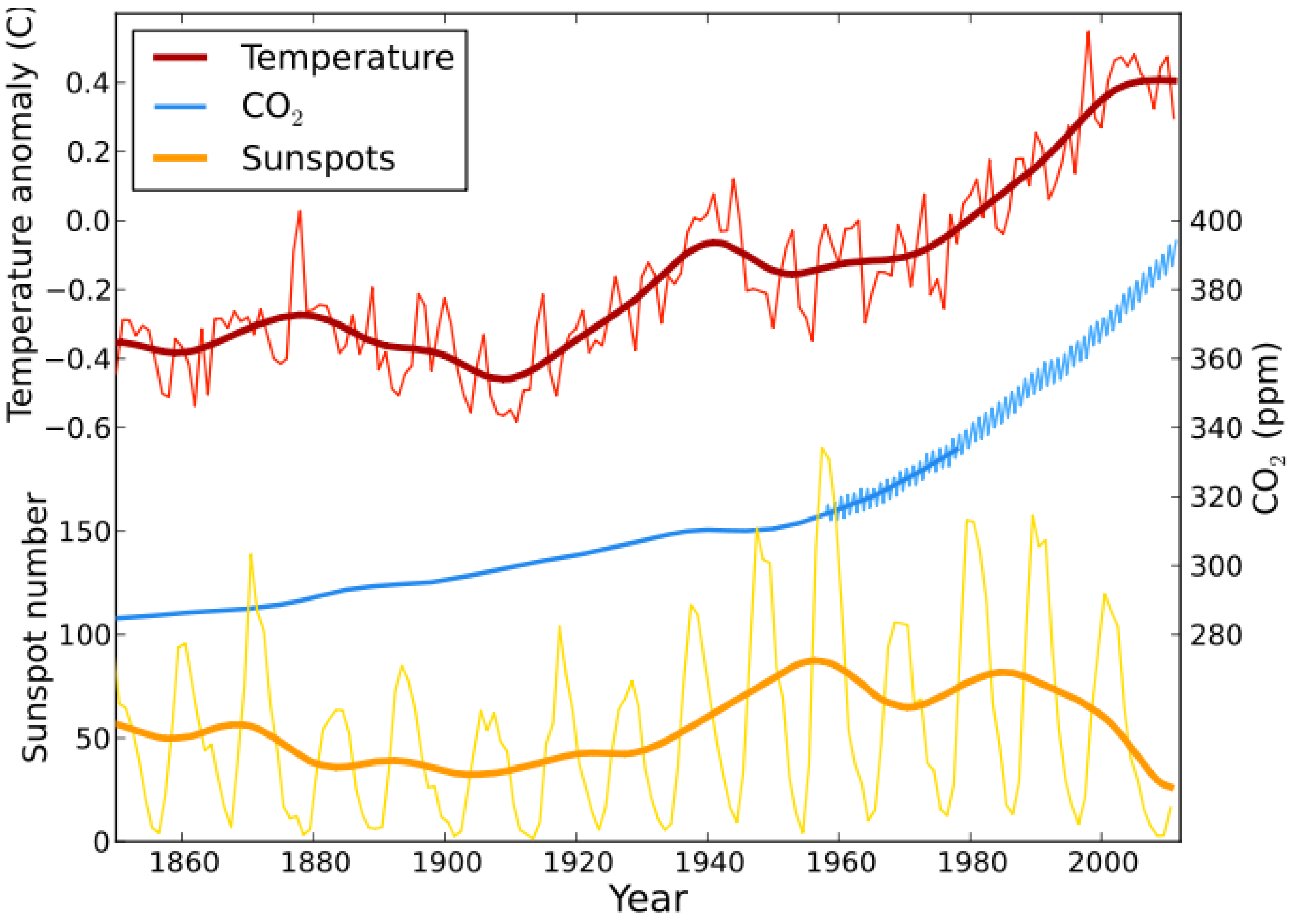






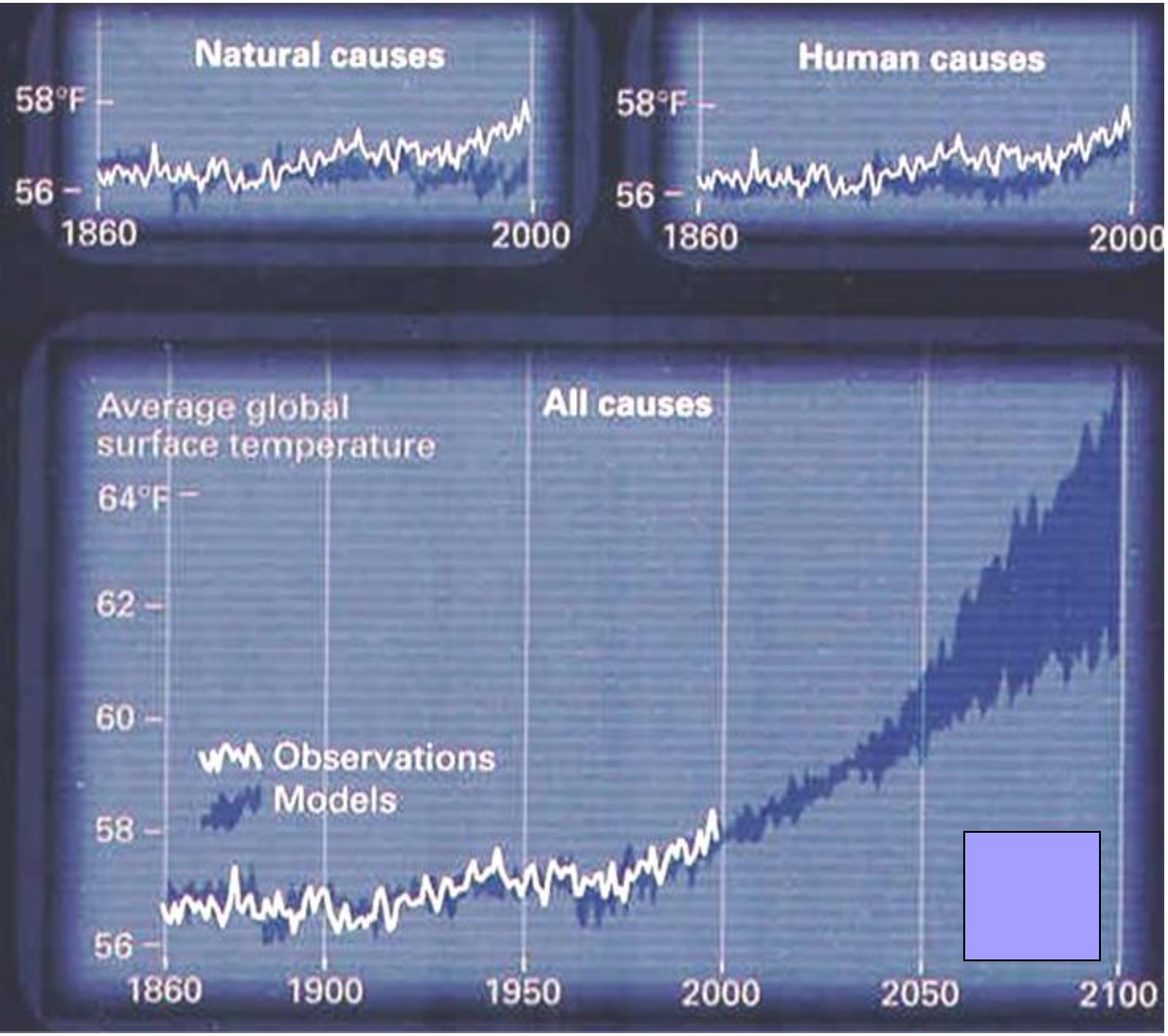
Atmospheric CO2 concentration (in parts per million) during the last 11000 years (Rahmstorf, 2011) and the last 50 years. The concentrations of the CH4 and N2O (in ppb-parts ber billion) since 1978 are also shown (Richardson et al., 2009).

Natural CC: solar activity:



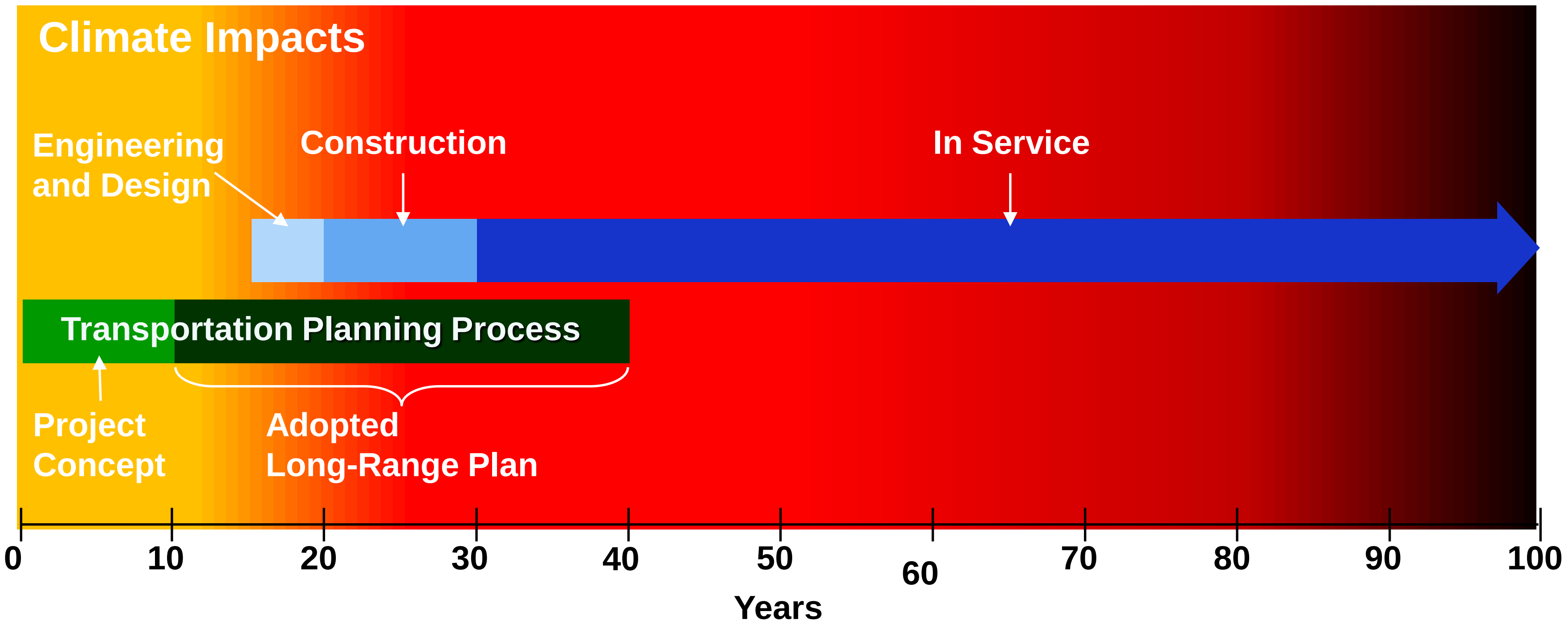
Correlation between temperature (red), CO2 concentation (blue) and sunspot trends (yellow) (1850-2010, Data from NOAA, UEA), showing a recent (30 year) decoupling between temperature and sunspot trends.

Climate Change: Both natural and human-induced



Diagnosis and prognosis from climatic models (Hadley Centre for Climate Prediction, UK), showing temperature controls by both naturla and human-induced processes. Only coupled model results honour the observations

Transportation Timeframes vs. Climate Impacts



Source: Savonis, 2011

CC Change impacts study Coverage for European sectors

Sector	Coverage	Cost estimates	Benefit estimates
Coastal zones	Very high — infrastructure/erosion for Europe, regions, several countries as well as cities/local examples.	√√√	√√√
Energy	Medium — cooling/heating demand (autonomous adaptation) for Europe, some countries. Less on planned adaptation and supply *.	√√	√√
Infrastructure	Medium — adaptation cost estimates in several countries for flooding, but lower coverage of other infrastructure risks.	√√	√
Agriculture	High — coverage of farm-level autonomous adaptation benefits, but much less on costs and on planned adaptation.	√	√√
Health	Low/medium — adaptation costs for heat alert systems and food-borne disease, but less coverage of other health risks.	√	
Water	Low/medium — limited number of national, river basin or sub-national studies on water supply.	√	
Transport	Low/medium — some national and individual sector case studies.	√	
Tourism	Low — studies of winter tourism (Alps) and some of autonomous adaptation from changing summer tourism flow *.	√	√
Forestry and fisheries	Low — limited number of quantitative studies.	√	
Biodiversity/ecosystem services	Low — limited number of quantitative studies.	√	
Business and industry	Very low — no quantitative studies found.		
Building adaptive capacity	Low — selected studies only and only qualitative descriptions of benefits.	√	

Note: * can be considered an impact or an adaptation. See Watkiss and Hunt (2010) for extra notes and caveats.

Key: √ Low coverage with a small number of selected case studies or sectoral studies.
√ √ Some coverage, with a selection of national or sectoral studies.
√ √ √ More comprehensive geographical coverage, with quantified cost or benefit estimates at aggregate levels.

Source EEA, 2010