

Kostas Alexopoulos

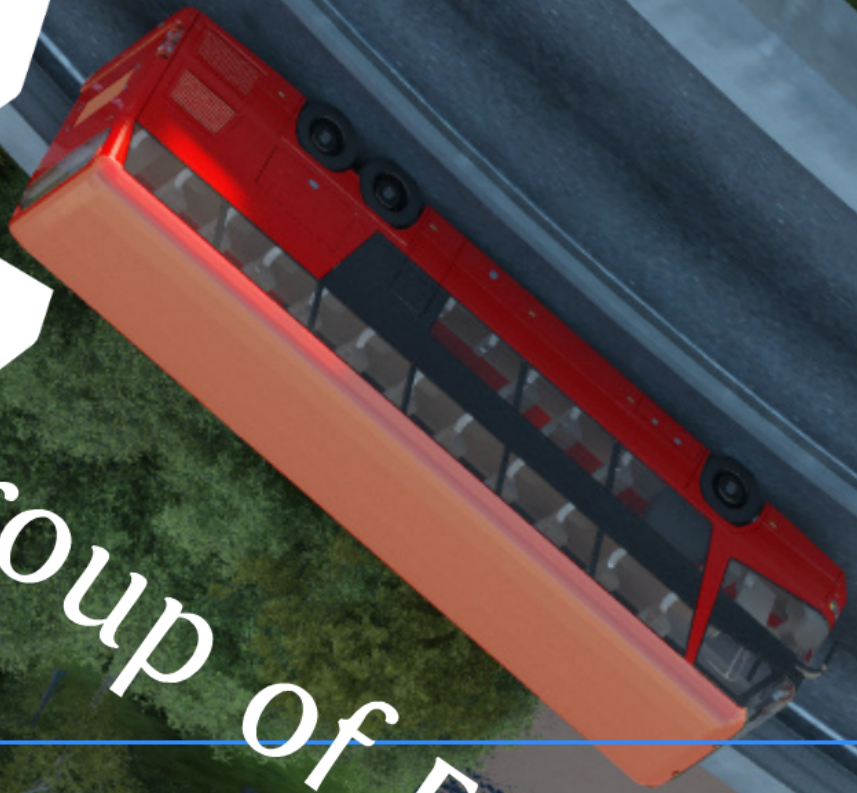
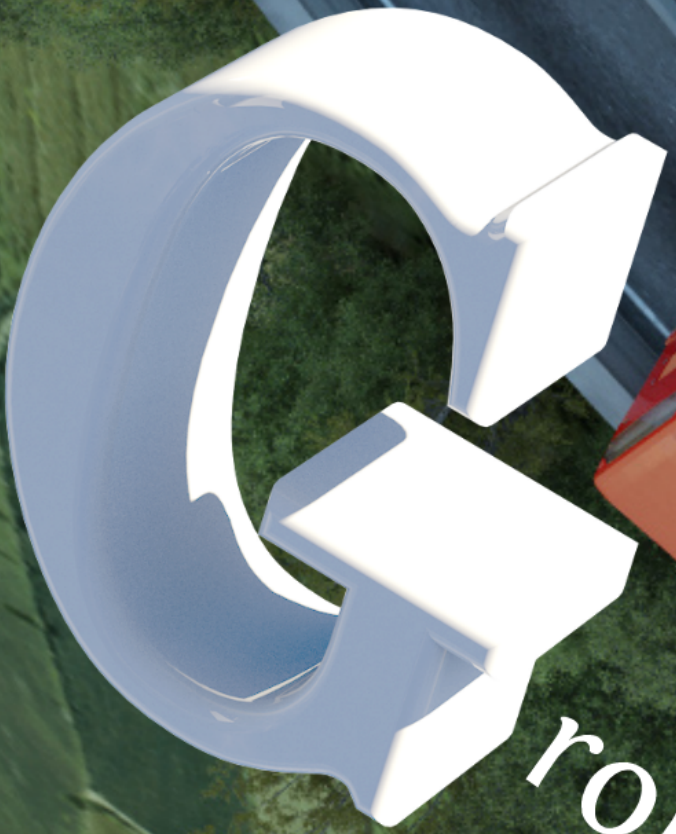
Secretary

Working Party on Rail Transport

Working Party on Transport Trends and Economics

Focal Point for Climate Change

UN ECE Transport Division



Group of Experts



DAPTATION

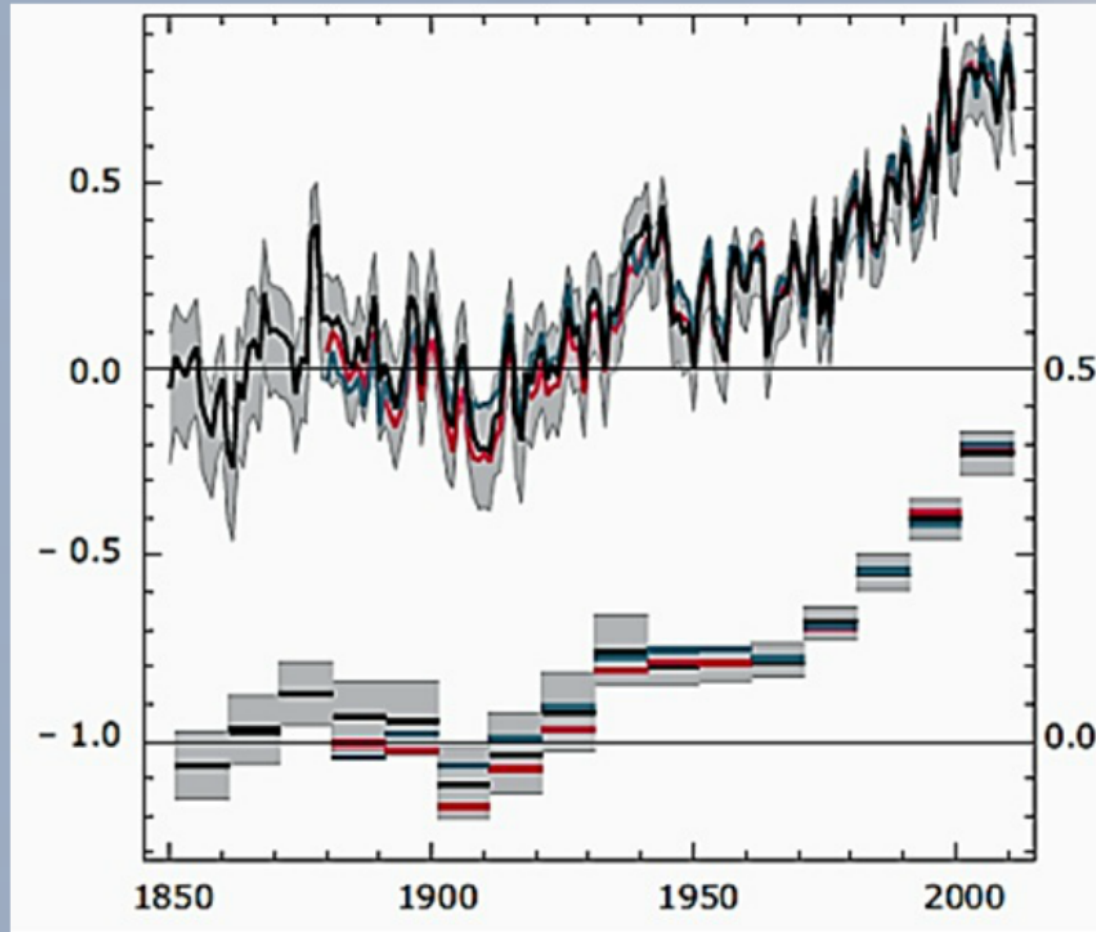
Monitoring and restrictions

- Rail temp. gauge
- Snow gauge
- Scouring detector
- Seismograph
- Speed restrictions
- Traffic suspension

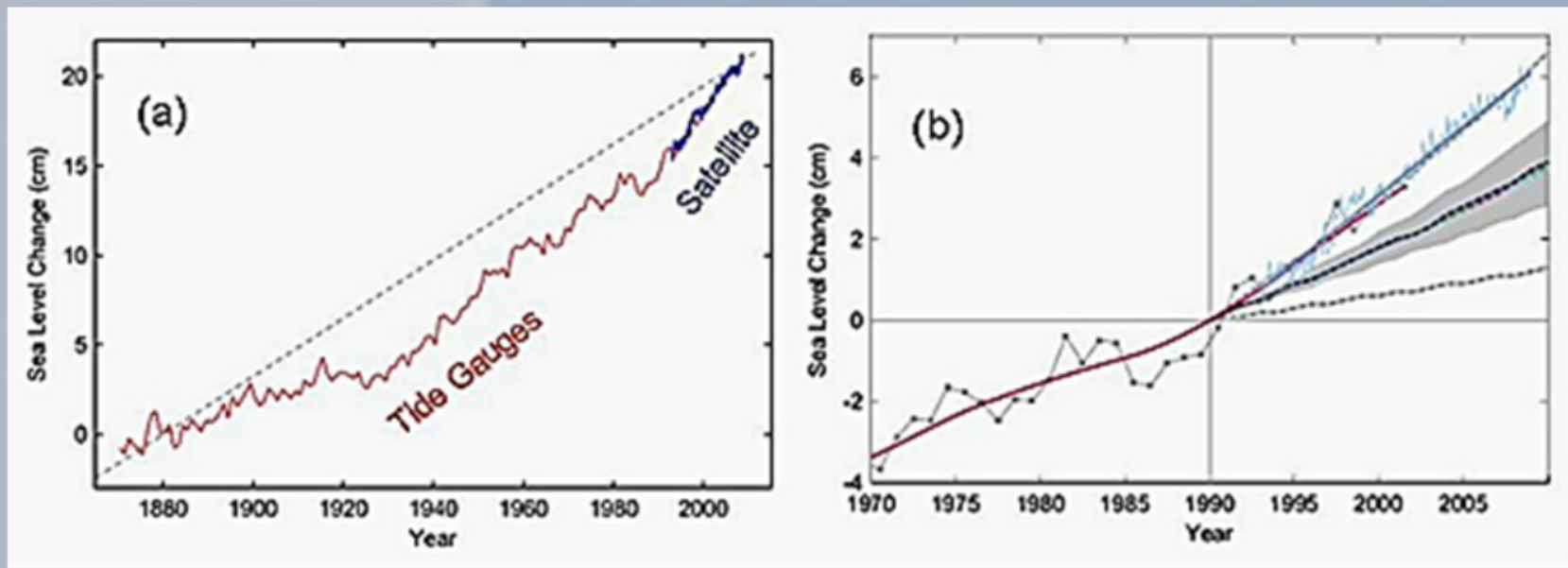


Climate is changing

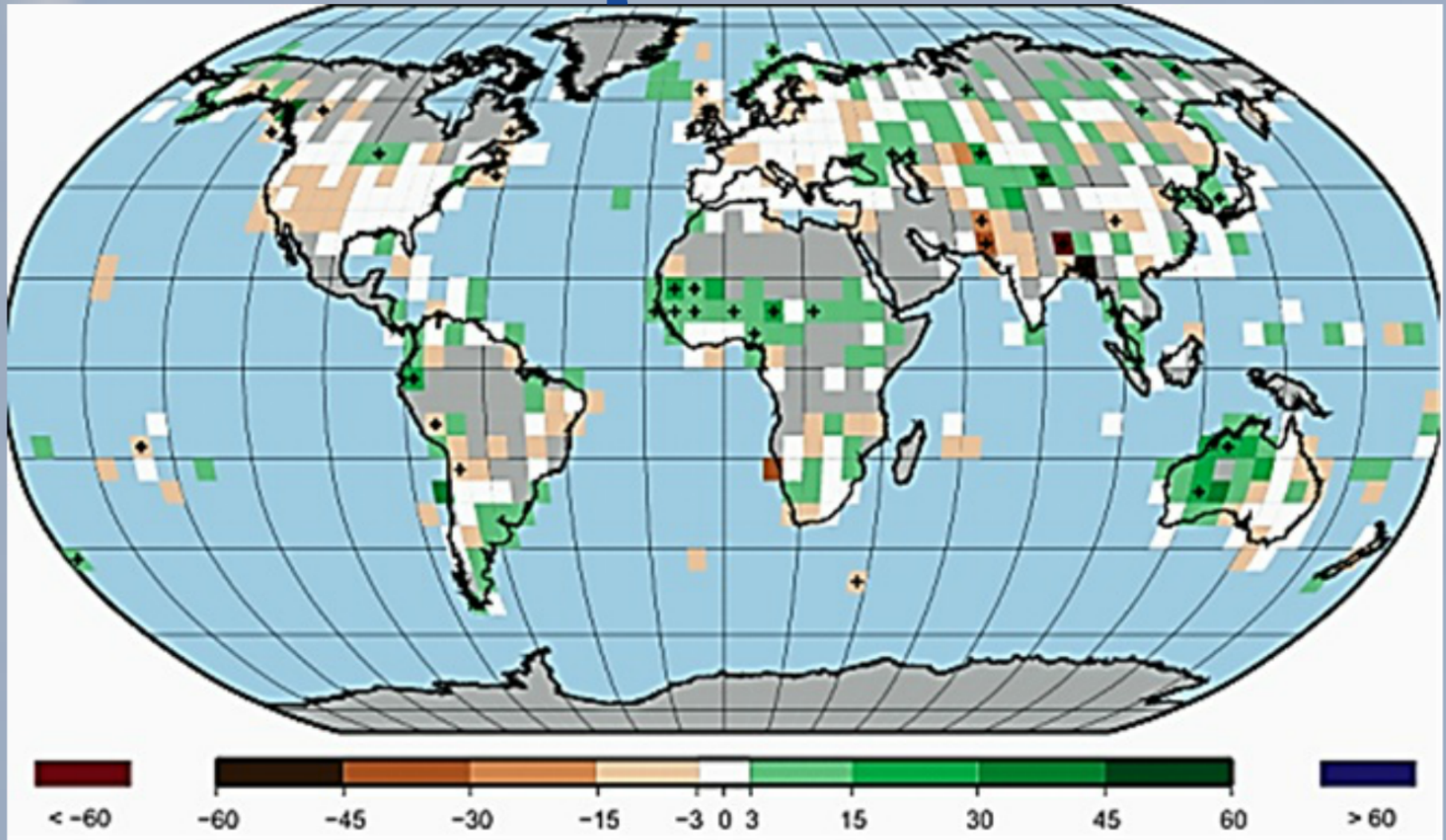
Temperature



Sea Level



Precipitation

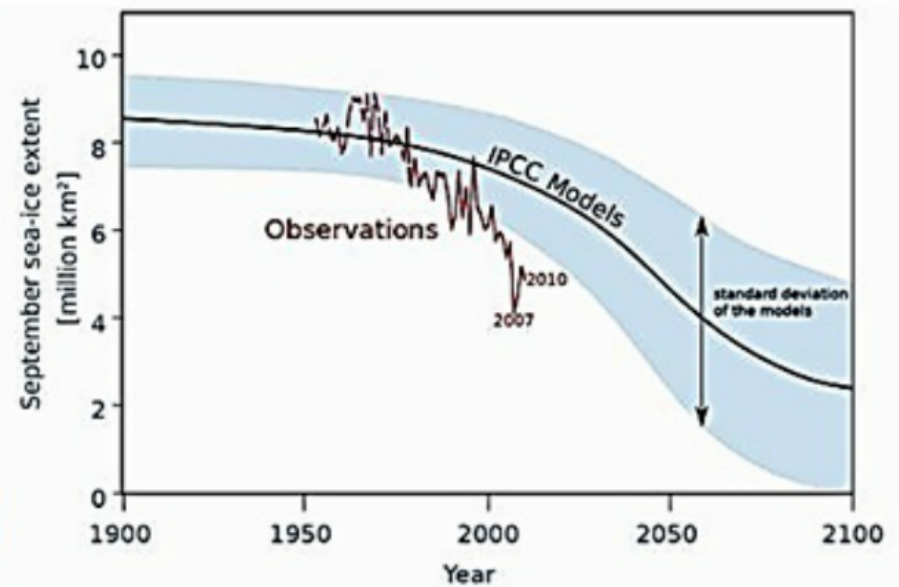


Polar Ice Loss

Trends

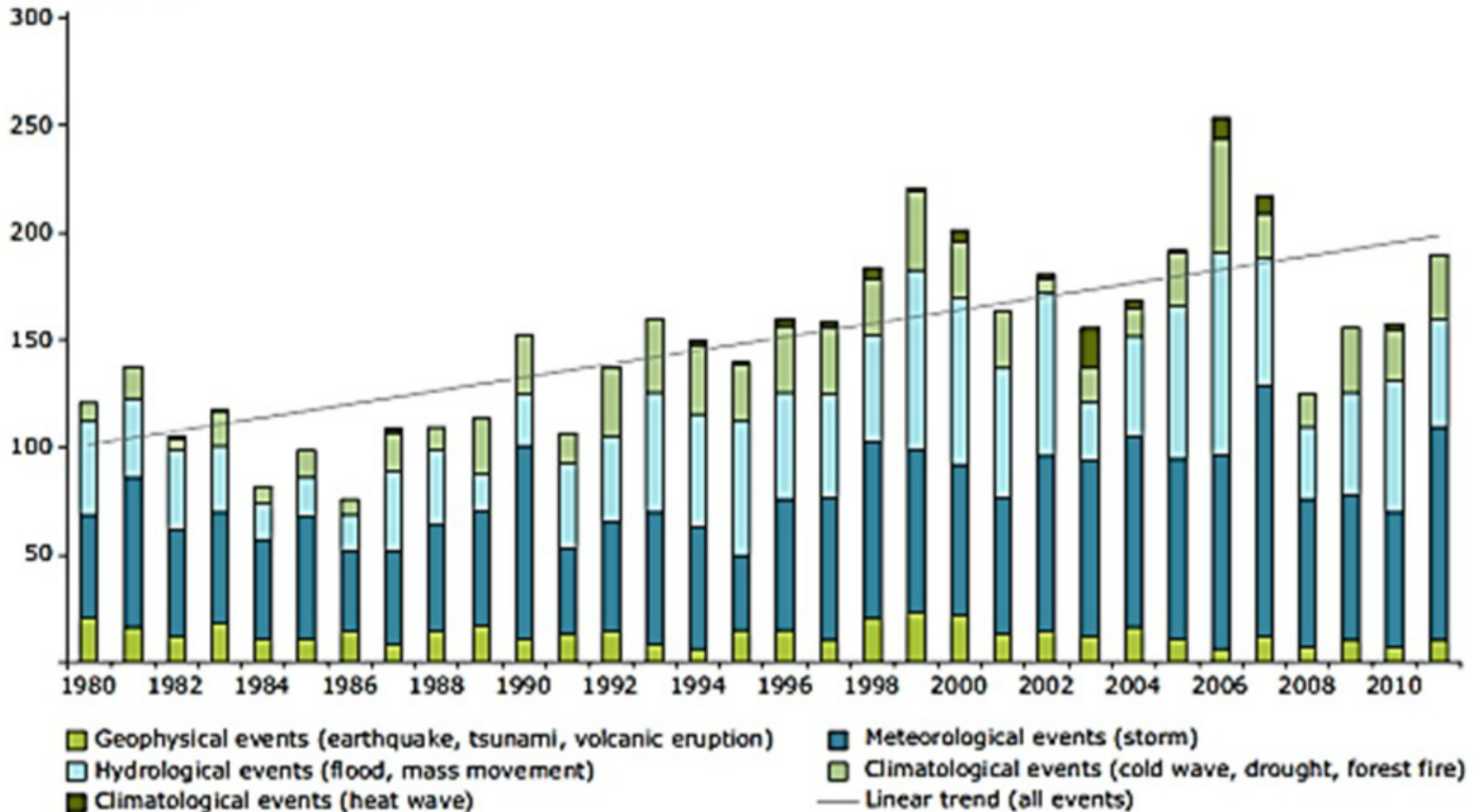


Projections



Extreme Climate Events

Number of events





Impacts for Transport

Factor	Impacts		
Temperature	Road	Rail	Ports, inland navigation and airports
Higher mean temperatures, Heat waves and Droughts	Thermal pavement loading/degradation; asphalt rutting; thermal damage of bridges; increased landslide risks in mountainous roads; asset lifetime reduction; increased needs for cooling (passenger and freight) and fuel consumption; shorter windows for maintenance work; increased construction and maintenance costs; changes in transport demand	Track buckling; infrastructure and rolling stock overheating/failure; slope fires and failures; electronic equipment and signalling problems; speed restrictions; asset lifetime reduction; higher needs for cooling/fuel; shorter maintenance work windows; increased construction and maintenance costs; changes in demand	Damage to infrastructure, equipment and cargo; higher energy consumption for cooling cargo; lower water levels and restrictions for inland navigation; air transport payload restrictions; warmer weather will reduce snow/ice removal costs and extend the construction season
Increased spatio-temporal variability in warm/cool days			
Permafrost degradation and thawing, Reduced arctic ice coverage	Road buckling; decreases in the number of travelling days; slope instability and embankment failures; coastal erosion affecting coastal roads	Rail track damages; slope instability and embankment failures; freight and passenger restrictions	Major damages in port and airport infrastructure; longer shipping seasons-NSR; new shorter shipping routes-NWP/less fuel costs, but higher support service costs
Precipitation	Road	Rail	Ports, inland navigation and airports
Changes in the intensity/frequency of extremes (floods and draughts)	Network inundation; increased landslides and slope, earthwork and lineside equipment failures; impacts on vital nodes e.g. bridges due to scouring and inundation; poor visibility	Submersion, Bridge scour, Drainage systems, tunnels and bridges landslides, Underground flooding, Embankments/Earthwork	Land infrastructure inundation; damage to cargo and equipment; navigation restrictions in inland waterways due to droughts;

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Reduced arctic ice coverage			
Precipitation	Road	Rail	Ports, inland navigation and airports
Changes in the intensity/frequency of extremes (floods and draughts)	Network inundation; increased landslides and slope, earthwork and lineside equipment failures; impacts on vital nodes e.g. bridges due to scouring and inundation; poor visibility and increased accident risk; more frequent slush flow avalanches; delays; changes in demand	Submersion, Bridge scour, Drainage systems, tunnels and bridges landslides, Underground flooding Embankments/Earthwork damage, Operational assets, Delays risk	Land infrastructure inundation; damage to cargo and equipment; navigation restrictions in inland waterways due to droughts;
Winds and thunderstorms	Road	Rail	Ports, inland navigation and airports
Changes in the frequency/intensity of events	Damages to fence; road accidents	Damages to installations, catenary; overvoltage; disruption to operations	Problems in vessel navigation and berthing in ports
Sea level (mean and extreme)	Road	Rail	Ports and Inland navigation
Mean sea level changes	increased risks of coastal inundation and erosion affecting coastal roads; temporary inundation, Unusable roads during storm surge	Bridge scour, Installations/Catenary damage, Restrictions/Disruption of train operation,	Increased damages in port infrastructure/cargo from inundation and wave energy changes; higher port construction/maintenance costs; sedimentation issues in port/navigation channels; effects on key transit points (e.g. The Panama Canal); relocation of
Increased destructiveness of storms/storm surges		Embankments/Earthwork flooding	

	and increased accident risk; more frequent slush flow avalanches; delays; changes in demand	flooding Embankments/Earthwork damage, Operational assets, Delays risk	
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Increased destructiveness of storms/storm surges			
Changes in the wave energy and direction			



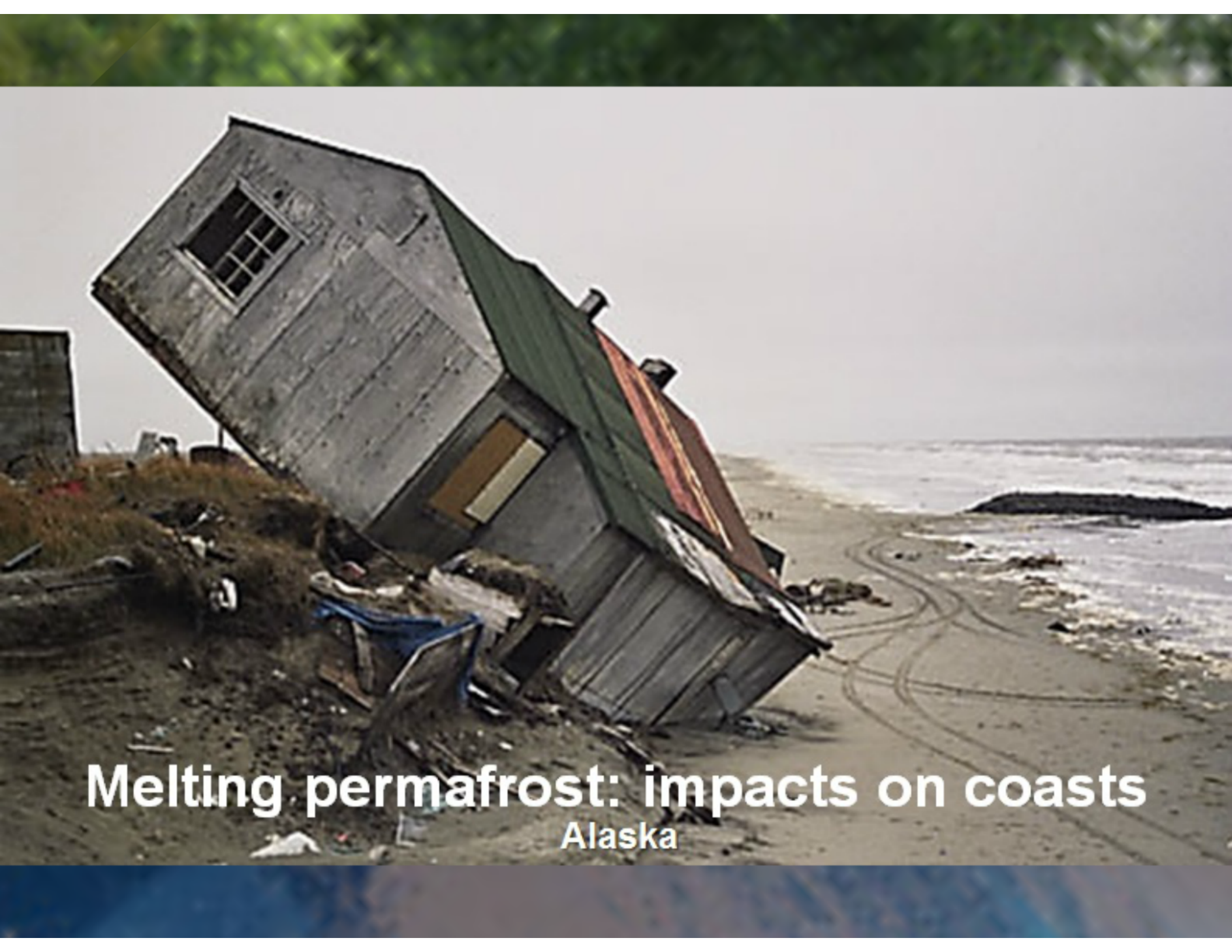
Drought & inland waterway transport





Melting permafrost: impacts on roads

Alaska



Melting permafrost: impacts on coasts

Alaska





Technical adaptation measures
to climate change impacts

A. Flood protection and management

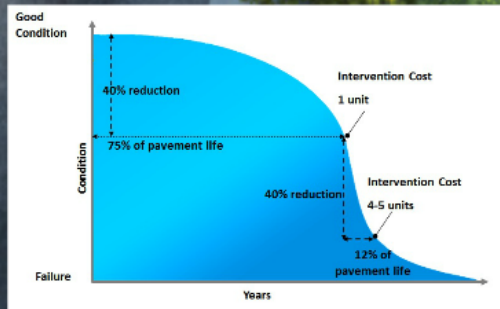
1. Construction of extensive sewerage and flood protection works for collecting the superficial runoff;
2. Construction and Maintenance of flood protection works to collect water runoff and improve the overall flood protection



B.



B. Pavement Maintenance



Falling Weight Deflectometer (FWD)



Laser Profiler



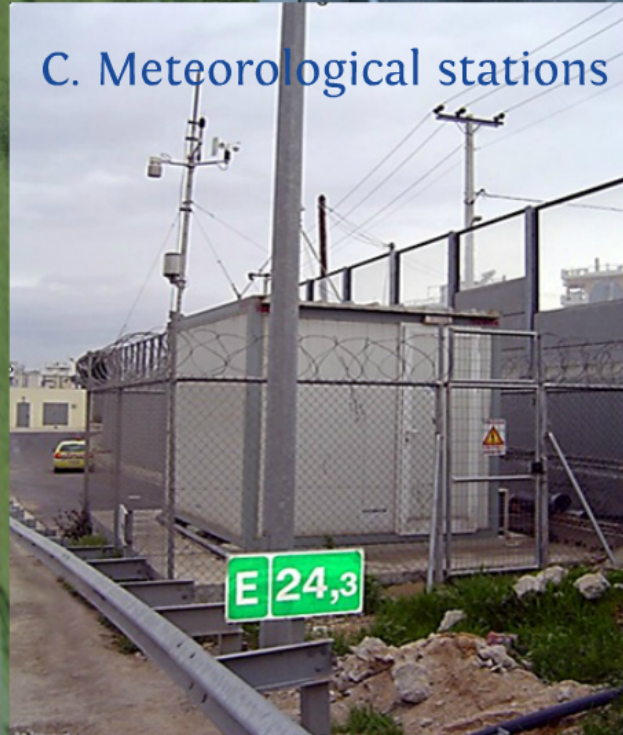
Ground Penetrating Radar (GPR)



Grip Tester

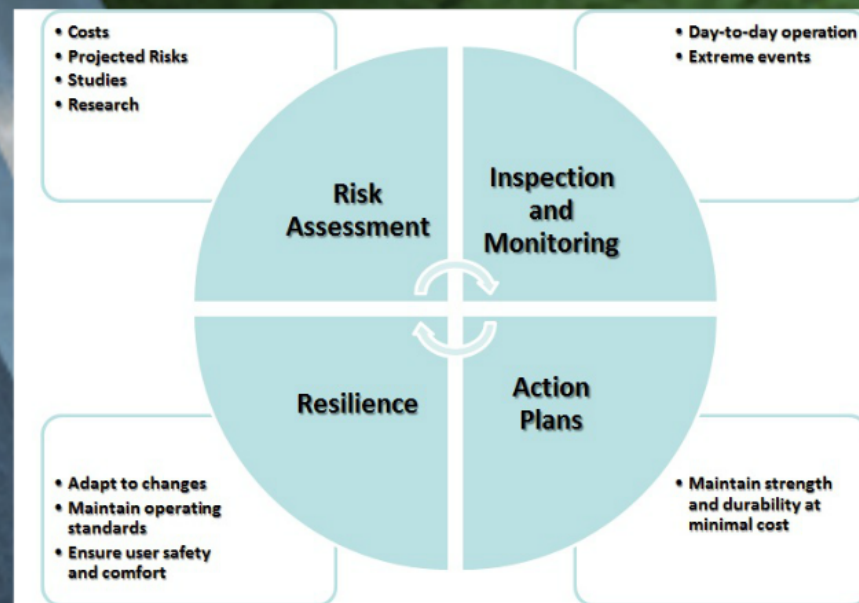


C. Meteorological stations



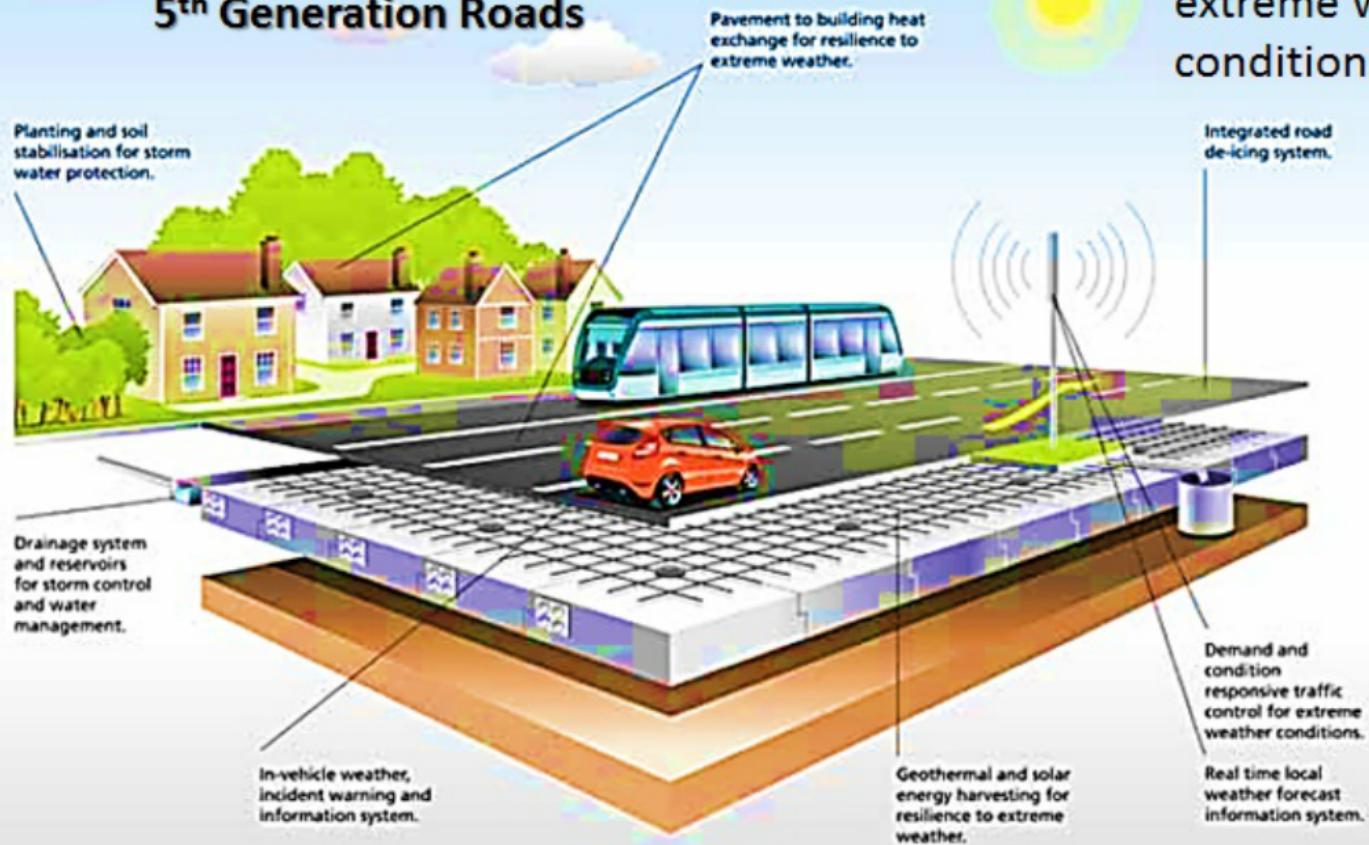
D. Proactive
Monitoring /

D. Proactive Management / Action Plans/ Monitoring / Inspections





The Resilient Road 5th Generation Roads



The Resilient Road:
Fully adaptable to
extreme weather
conditions



RAILWAYS

Greater resilience of network: ra

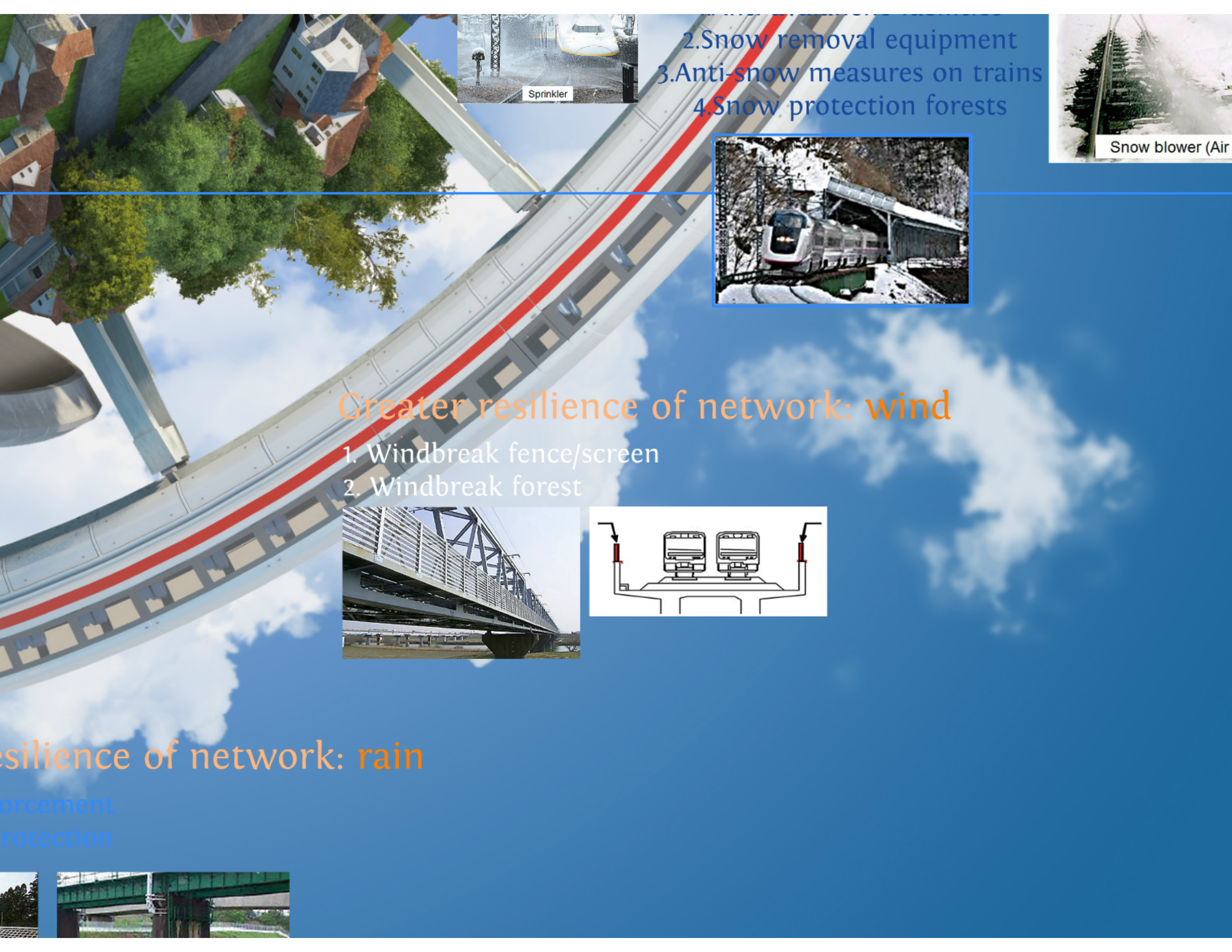
1. Slope reinforcement
2. Scouring protection



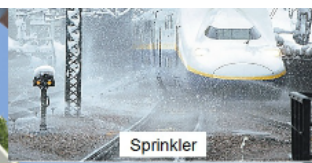
Greater resilience of network: rain

1. Slope reinforcement
2. Scouring protection





- 2.Snow removal equipment
- 3.Anti-snow measures on trains
- 4.Snow protection forests



Greater resilience of network: wind

- 1. Windbreak fence/screen
- 2. Windbreak forest



Resilience of network: rain

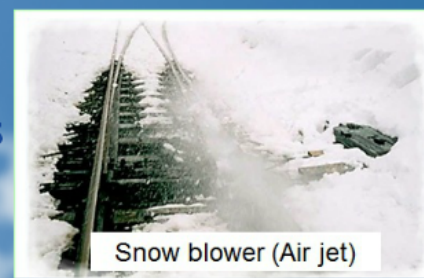
Reinforcement
Protection





Greater resilience of network: snow

1. Anti-avalanche facilities
2. Snow removal equipment
3. Anti-snow measures on trains
4. Snow protection forests

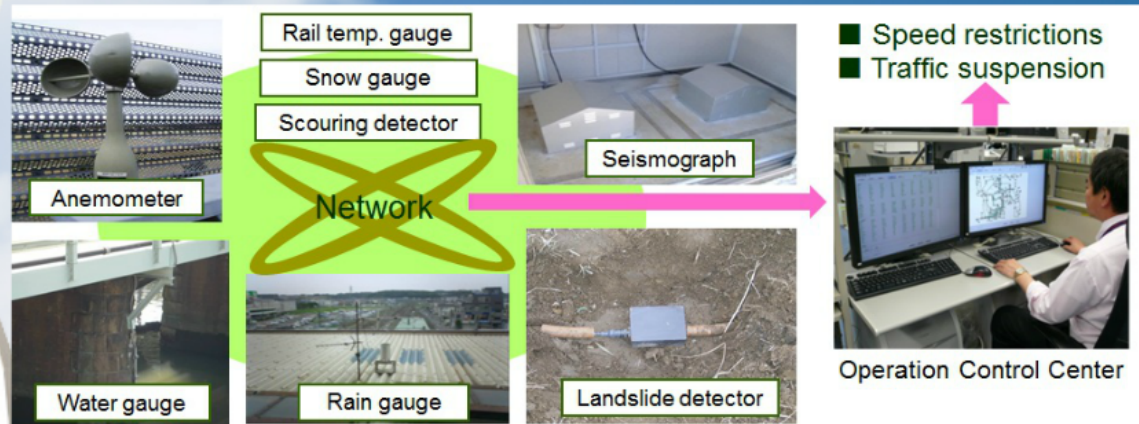


Greater resilience of network: wind

1. Windbreak fence/screen
2. Windbreak forest



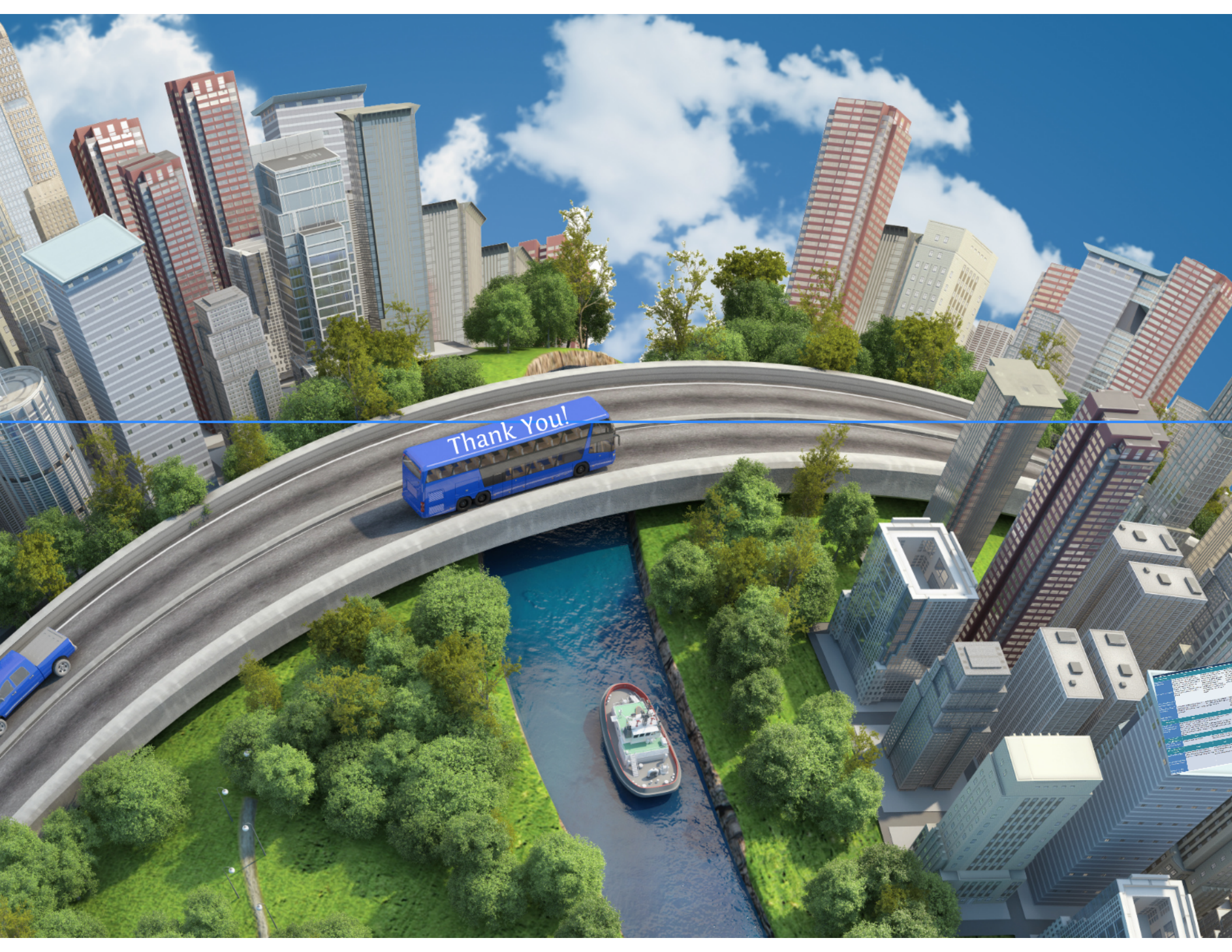
Monitoring and restrictions



water resilience of network: snow



ext steps



Thank You!