How do Clean Energy and Autonomous Vehicles impact the climate risk profile of road transportation?

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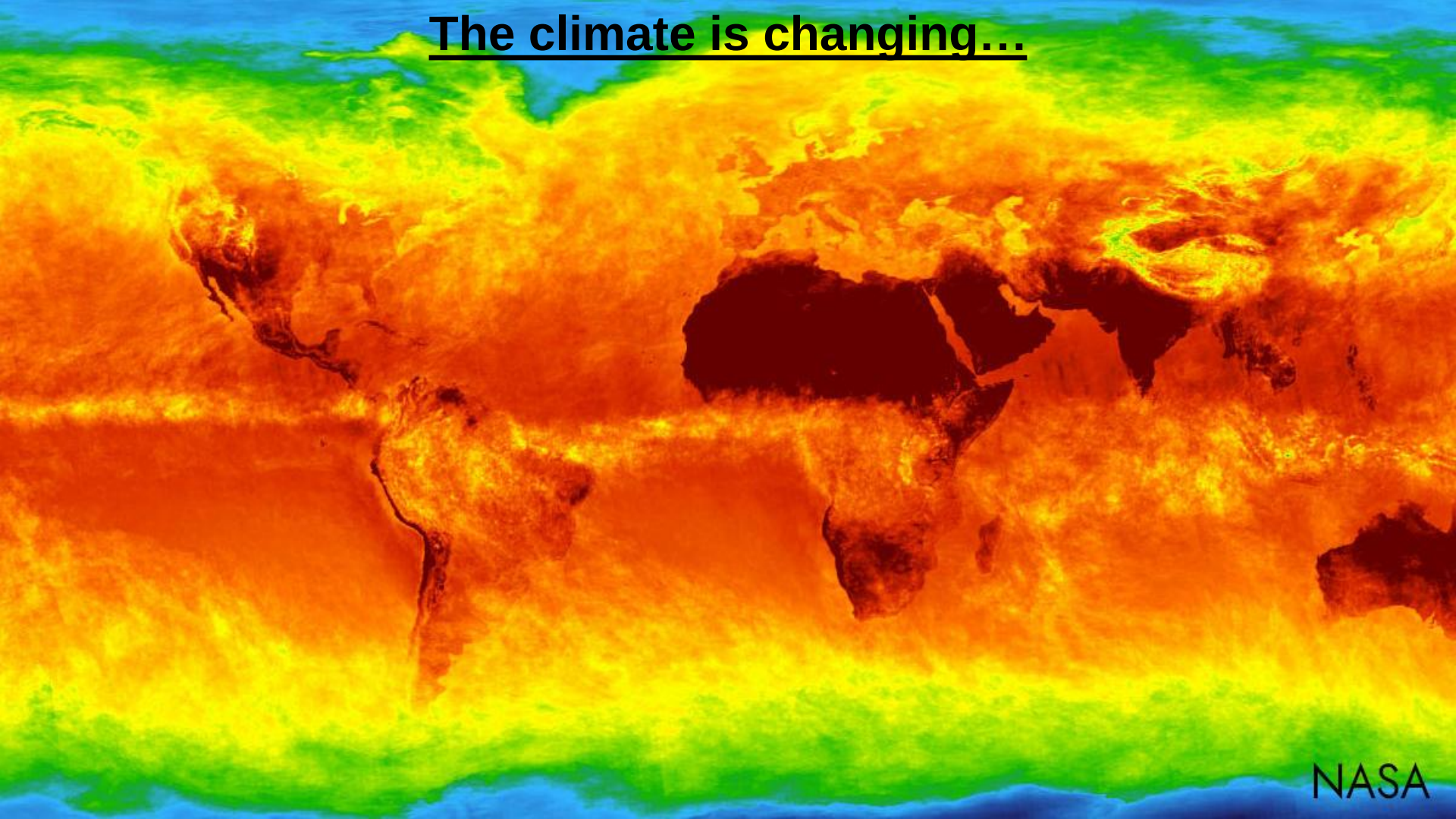
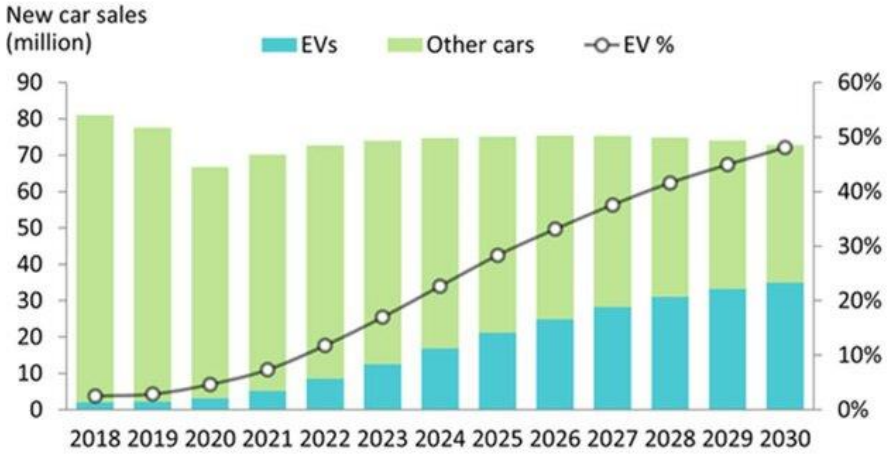
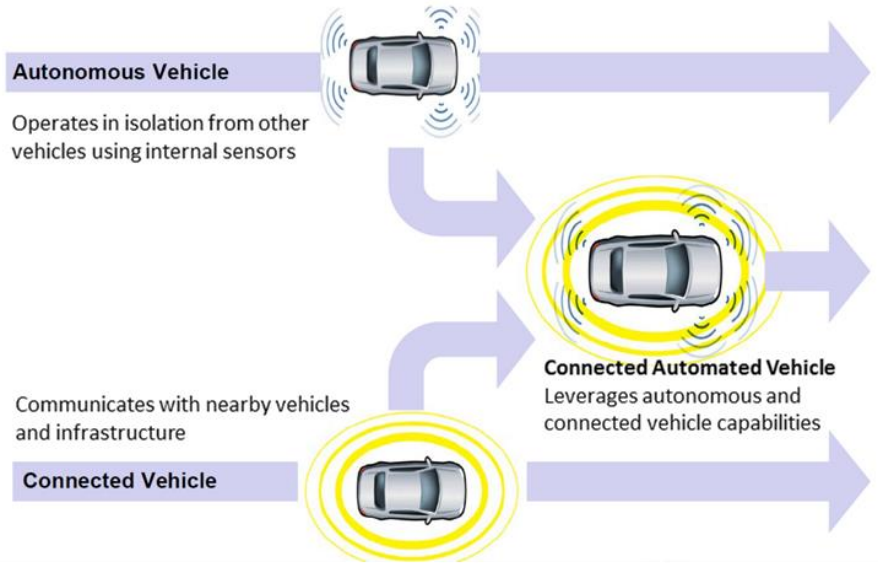
The climate is changing…



…but so are our vehicles



Latyshev et al (2021)



https://www.nevadadot.com/mobility/avcv

"As of the end of April 2024, there are now 1,100,000 fully electric cars on UK roads and a further 655,000 plug-in hybrids."
https://www.zap-map.com/

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What does this mean?

- The climate will undoubtedly be more variable and extreme
- The capabilities of vehicles is markedly different to today
- Taken together – the management of the risk is going to need to evolve…

Are electric and autonomous vehicles more or less resilient to the weather than their fossil fuel predeccesors?

CLEETS

- That is one of the questions that we are aiming to answer in the CLean Energy and Equitable Transportation Solutions (CLEETS) project.
- A £6m + $5m project to establish a global center for climate change, clean energy and clean transportation research.
- Three main themes:
  1. Clean & Equitable Transport: Studying the impact of transportation choices and equitable clean energy transportation adoption
  2. Transport Energy Infrastructure: Investigating the coupling of electricity, transportation, water, petrochemical, and mineral resources, to optimize resource allocation and reduce emissions
  3. Climate Change: Exploring the implications of climate change on the adoption of new transportation solutions along with related consequences (e.g. air quality)

Home - CLEETS Global Center

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CLEETS Clean Energy and Equitable Transportation Solutions NSF-UKRI Global Center

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Weather Risks on ECAV's

	Electric / Connected Vehicle Risks	Additional Issues for AV	Considerations / Mitigations *
High Temperatures	• Reduced range due to cabin cooling • Melting roads will impact roll resistance also reducing range • Increased cooling of components requiring further drain (overheating risks) • Battery degradation in heat, reducing their lifespan • Increased demand on energy grid for cooling may impact supply.		• Battery thermal management systems may help, but will also require increased power. • Parking / charging in covered areas during extreme weather, • Preconditioning to cool the vehicle while it's plugged in • Ecological driving to increase range in adverse conditions.
Rain / Fog / Visibility	• Communication challenges in poor weather	• Reduced sensor performance (especially LIDAR) • Extreme rainfall (e.g. Freezing Rainfall) may be beyond training envelopes. • Hail can damage on-board vehicle sensors	
Flooding	• Water ingress into electric systems. • Charging infrastructure and substations susceptible to flooding.	• Shallow floodwater can obscure lane markings, deep floodwater can hide hazards.	• Lack of an air-intake potentially increases wading depth, therefore increasing resilience
Wind & Storms	• Impact on aerodynamics and energy consumption • Gusts may impact vehicle stability • Charging infrastructure susceptible to flying debris • Storms may impact electricity supplies • Low winds will impact on renewable generation		

Winter Risks for ECAV's

	Electric / Connected Vehicle Risks	Additional Issues for AV	Considerations / Mitigations *
Low Temperatures	• Reduced battery performance and range (up to 36%). Compounded by the increased need for cabin heating. • Batteries take longer to charge • Heavier vehicles can cause more damage to the road in freeze-thaw cycles (potholes) • Increased demand on energy grid for heating may impact supply.		• Preconditioning to warm the vehicle while it's plugged in • Ecological driving to increase range in adverse conditions.
Snow and Ice	• Accretion of snow on wheel arches may reduce efficiency and range • Frozen charging infrastructure. • Accretion of snow and ice may impeded energy generation and supply. • Communication challenges in poor weather	• Snow obscure / obstruct sensors • Snow on road infrastructure can impact navigation (lane markings and signs) • Interactions with winter maintenance fleet may be challenging. • Rapidly changing weather conditions can be challenging for AV algorithms	• Trends to move to AWD by manufacturers will increase resilience • Heavier vehicles with a lower centre of gravity will increase traction • Better engine torque • Reduced risk of skidding from regenerative breaking • Simpler mechanics promote resilience. • Data from sensors will facilitate improved real-time decision making

Implications for winter road maintenance delivery?

- Does the risk actually decrease?
  - Heavy vehicles with a lower centre of gravity
  - Improved torque and regenerative braking
  - Driver assistance systems
- All reduce skid risk and improve safety
- Are we confident to move to a white road policy if this is case?

- Greater autonomy does lead to problems though:
  - Obscuring of lane markings and signage (i.e. white road!)
  - This can be fixed with quantum sensing / positioning

- Reduced ranges in cold weather will lead to more stranded vehicles
- Does a duty of care extend to charging infrastructure?

Implications for winter road maintenance support systems?

- Data from connected vehicles already underpinning significant progress here:
  - Real time friction measurements
  - Communications between vehicles, re-routing algorithms etc

- Artificial Intelligence has the capability to make sense of noisy data from
  - Connected vehicles
  - Dense distributed sensor networks (IoT)
  - Real time treatment updates
  - Pattern / object recognition from sophisticated sensors

- What does ECAV technology mean for the winter service fleet / service delivery?

Electric & Connected Gritters

- Connected Gritters have long been used since the advent of GPS
  - Tracking & Logging
  - Dynamic Routing
- Electric Gritters are also starting to enter service:
  - ECON E-QCB
  - Range: 170 miles
- Range suitable for average use
  - Operating in non-optimal conditions (i.e. cold)
  - Resilience issues for extreme events

WARNING: FLASHBACK TO 2022!

The decreasing importance of road weather forecasts

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Autonomous Vehicles

- Not a case of if, but when…
  - Change will be quick – like flipping a switch

- A lack of data will no longer be a problem
  - Every vehicle on the road will be a data goldmine
- Think how great the weather forecasts will be with all that to assimilate…
- …but, by this time weather forecasts will no longer exist.

Autonomous Gritters

- It isn't data from autonomous cars that will be transformative, it will be autonomous gritters.

- An autonomous gritter short circuits the entire system:
  - Collects it's own on-board road weather data
  - Takes real-time actions based on what it is sensing
  - No forecast required!
  - No decision maker required!

- The only reason weather forecasts are issued at midday is due to working time directives and forward planning
- A fleet of autonomous gritters can patrol 24/7 with no issues.

It’s already happening (at least on sidewalks)…

https://www.swaprobotics.com/snow-plowing

Conclusions

- Winter service will need to evolve to both the changing climate and the changing vehicle fleet
- The latest fleet of ECV's has the potential to reduce the burden of winter maintenance
  - Increased safety
  - White Roads are perhaps a step too far…
- A connected and more autonomous future is already here
  - AV's complicate the risk profile significantly and much research is still needed
- The sector has the chance to show leadership in embracing the benefits, even if it does mean ripping up the rule book.