

7 Steps to Modelling Climate Impacts on a Network

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Water – an essential resource



Water is like air.

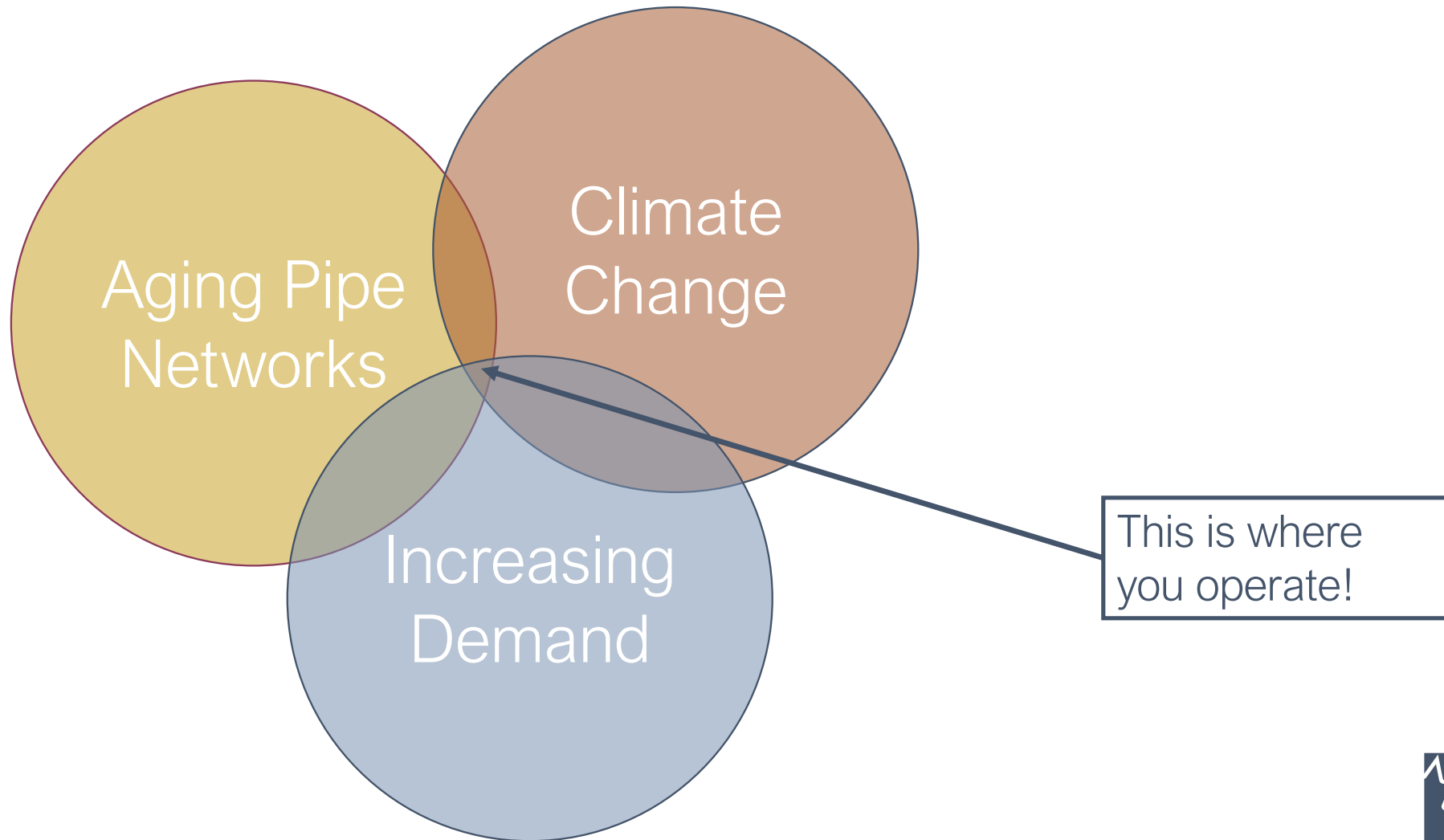
People tend not to
think of it much...

until it is
running out.

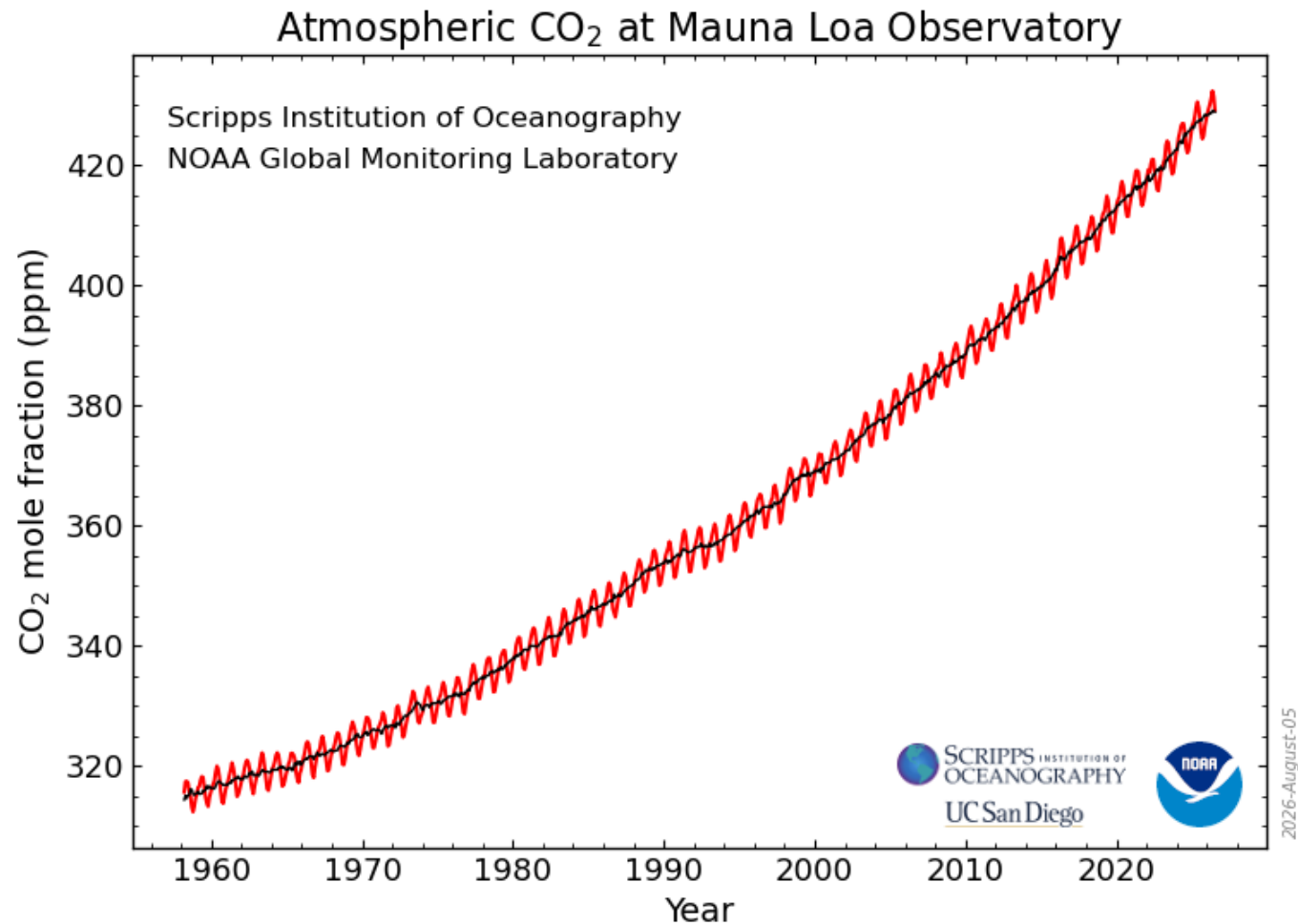


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Water resources under pressure



Climate update – 2026



We continue to add more CO₂ every year to the sky.

Currently almost 430 ppm

Pre-industrial : 280 ppm

~ 53% more

Carbon dioxide (CO₂) keeps us “COsy”!



CO₂ is an important gas in our atmosphere.

Like a **cosy sweater**, CO₂ (and other greenhouse gasses) keep us warm, insulating us from the cold of space.

CO₂ traps heat in the Earth's atmosphere by **absorbing infrared radiation** and **preventing it from escaping into space**



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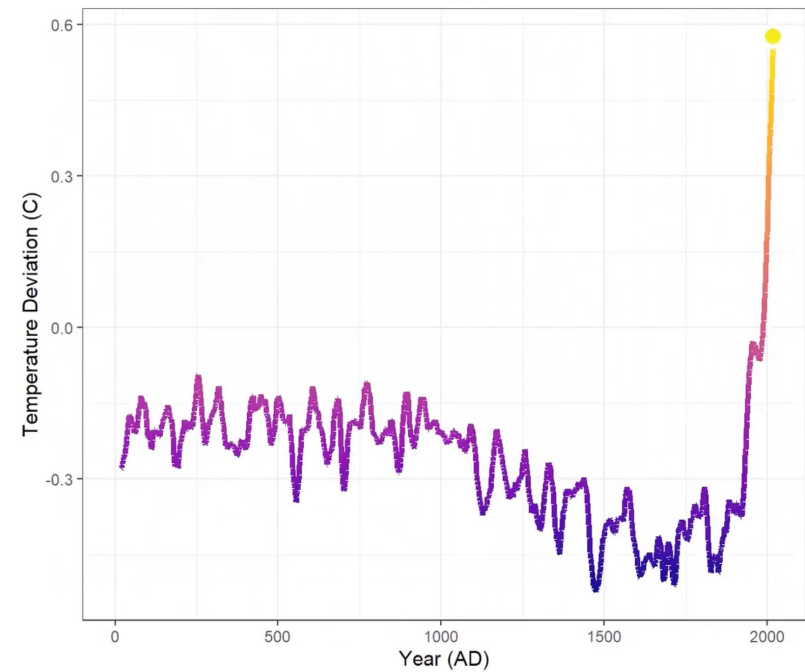
Too many “CO₂y” jumpers



But we have added so much carbon dioxide (CO₂) and other GHGs that the earth is getting **hotter** and **hotter** (and hotter).

Global Temperature Trend from 0 to 2019 AD

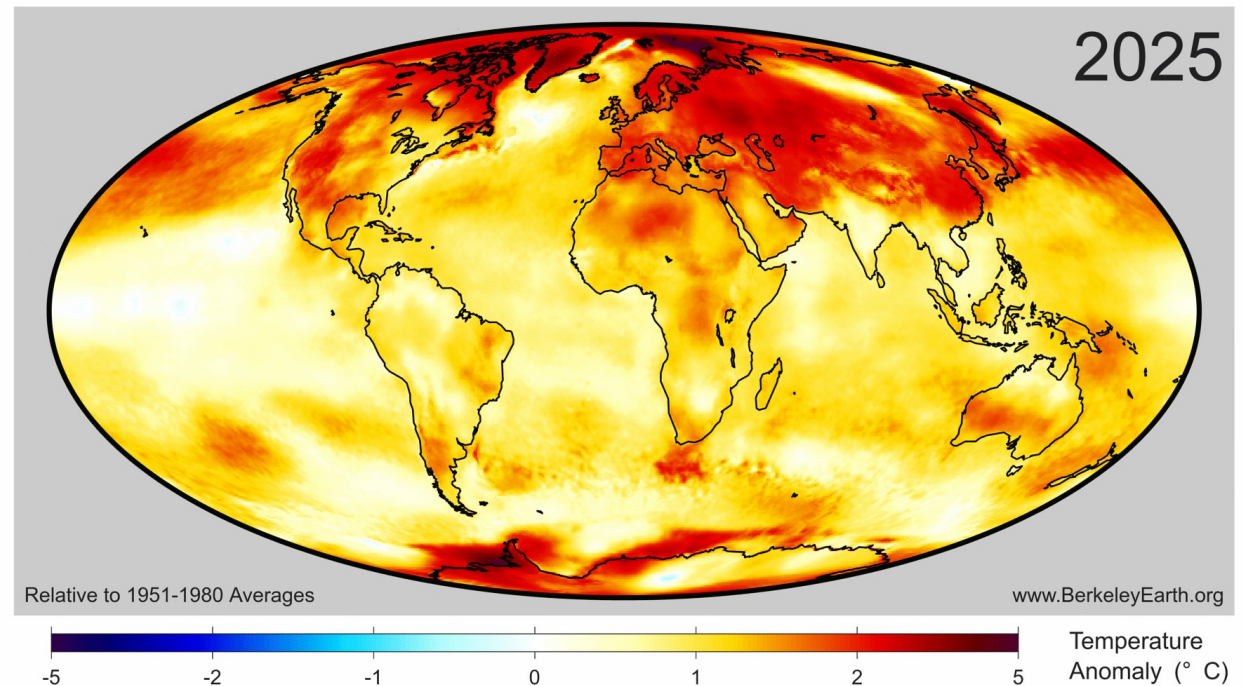
Temperature Deviation (C) from 1961-1990 Average
Year: 2019



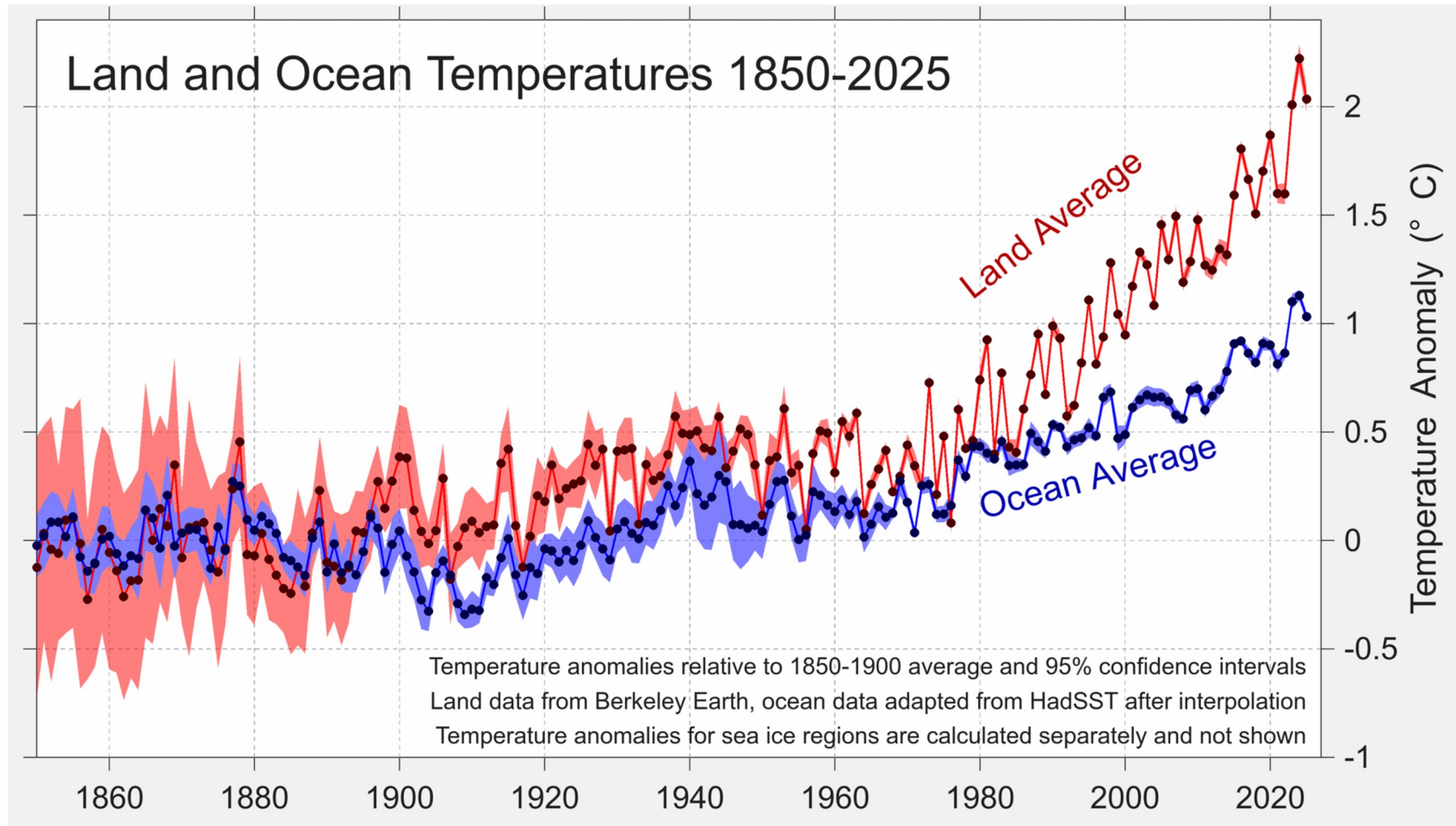
Visualization by Ben Gregory
(benpgregory@gmail.com)

Global climate trends

- Warming almost everywhere, but **most** at poles and inland regions
- Rainfall is more intense but more erratic
- Weather patterns "stick" longer, prolonging heatwaves/droughts



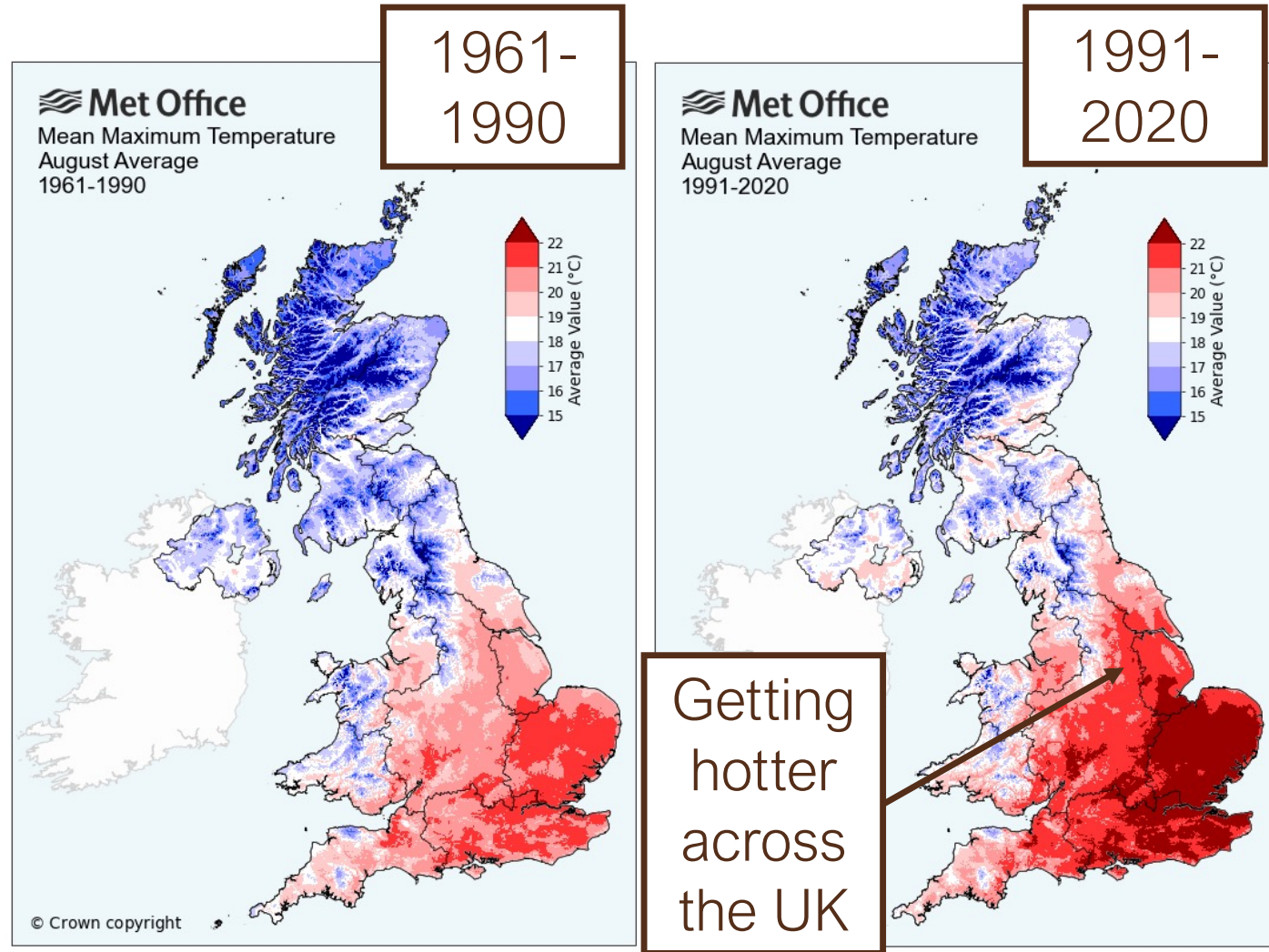
Land temperature rising faster than oceans



<https://www.carbonbrief.org/state-of-the-climate-2025-in-top-three-hottest-years-on-record-as-ocean-heat-surges-9>

UK climate trends

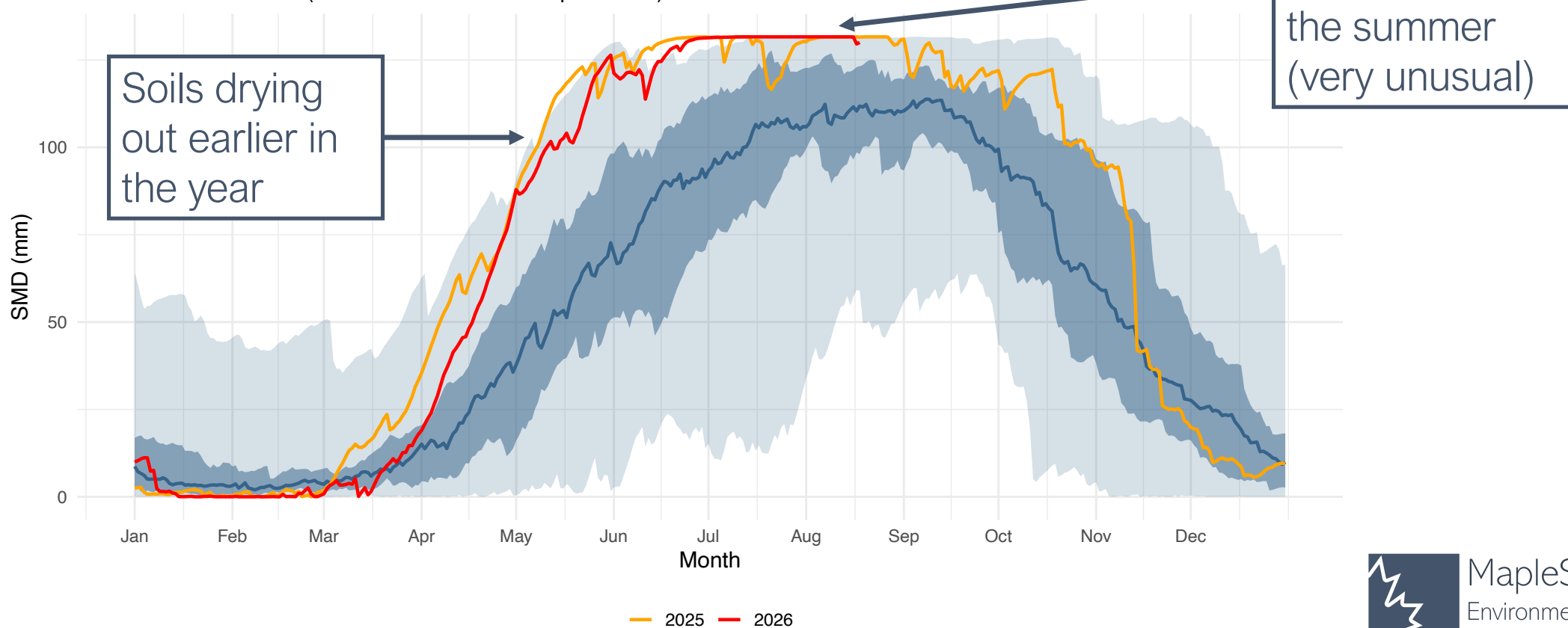
- Hotter drier summers
- Warmer, wetter winters
- More extreme weather events



Soil Moisture Deficit (2026)

Daily SMD: Long-Term Baseline Range vs 2025/2026

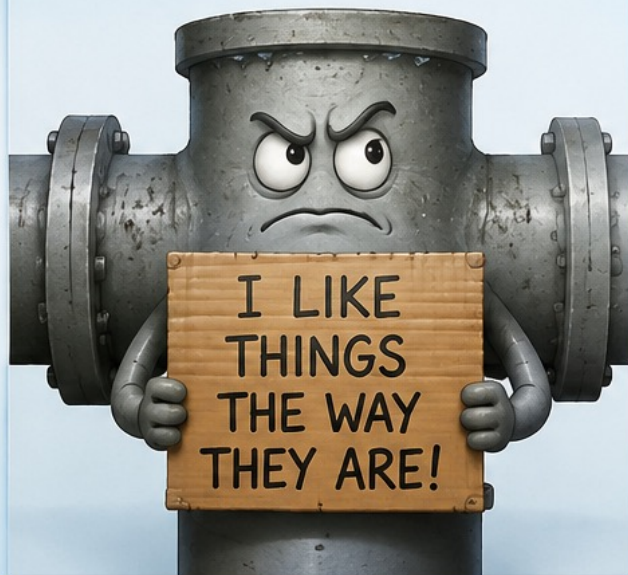
Baseline = 1980–2024 (min–max and 25th–75th percentile)



WATER MAINS HATE CHANGE

Pipe Psychology 101

- Pipes hate change.



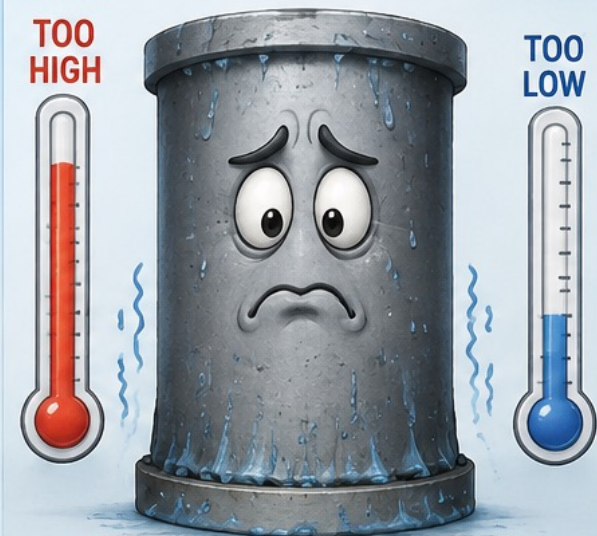
Consistency = Comfort

- They REALLY dislike sudden changes.



Sudden changes = Stress

- They don't like extremes either....



Moderation = Longevity

So... how will our changing climate affect the water industry?

- Changing burst / leakage patterns
- Changing demand patterns
- Changing recharge / rainfall intensity patterns

The MapleSky Team



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We help organisations to **identify** and **mitigate**
environmental risks to the **built environment**

At MapleSky, we help water companies:

Without people like you,
our societies would change
beyond recognition.

So...

Thanks!

Predict and
prevent bursts

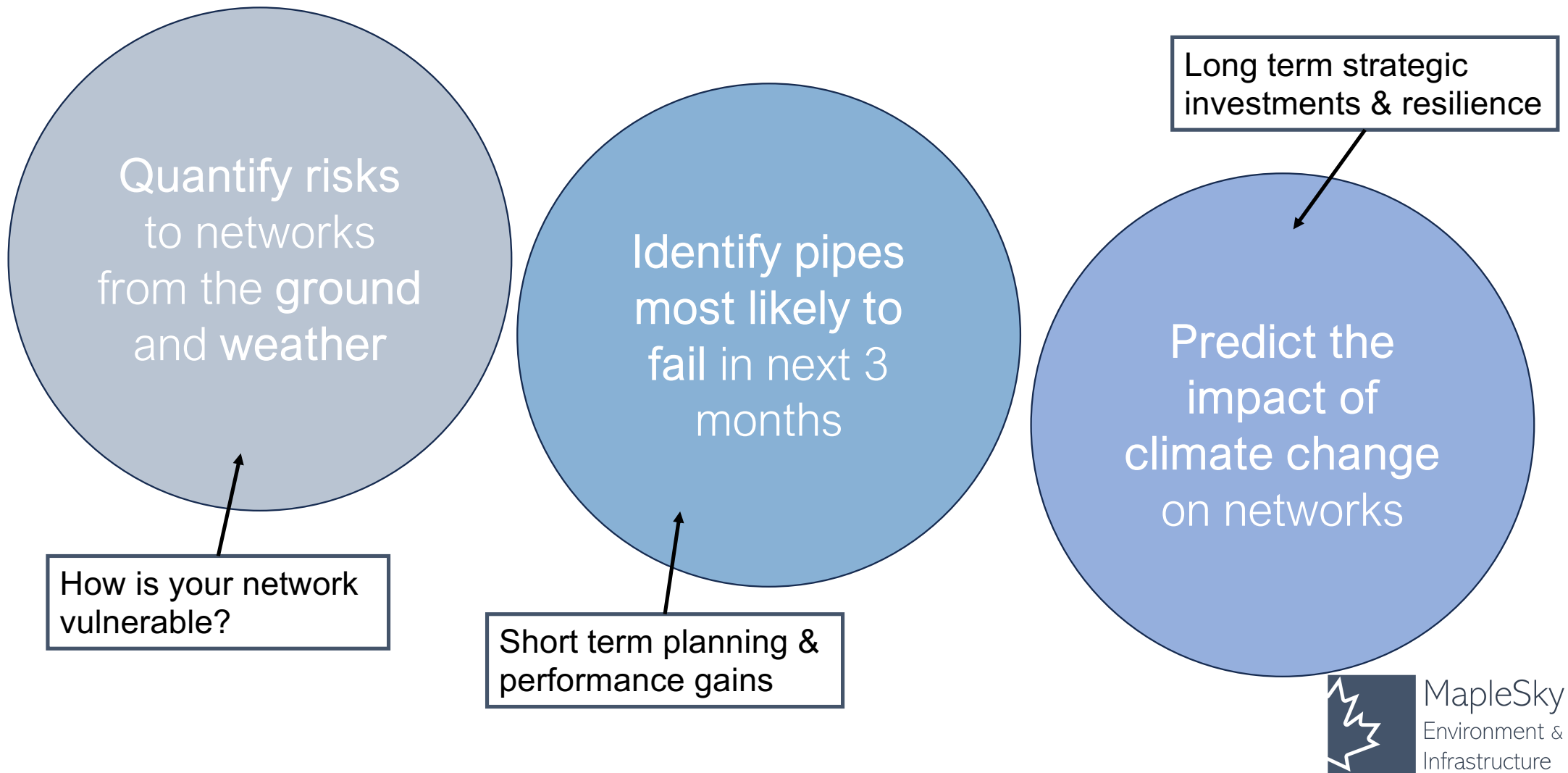
Reduce
leakage rates
& carbon

Increase citizen
satisfaction



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What we do at MapleSky



We help organisations mitigate environmental risks



BANK OF ENGLAND



BANK OF ENGLAND
PRUDENTIAL REGULATION
AUTHORITY

The Institution of
StructuralEngineers



& 25+ insurance companies

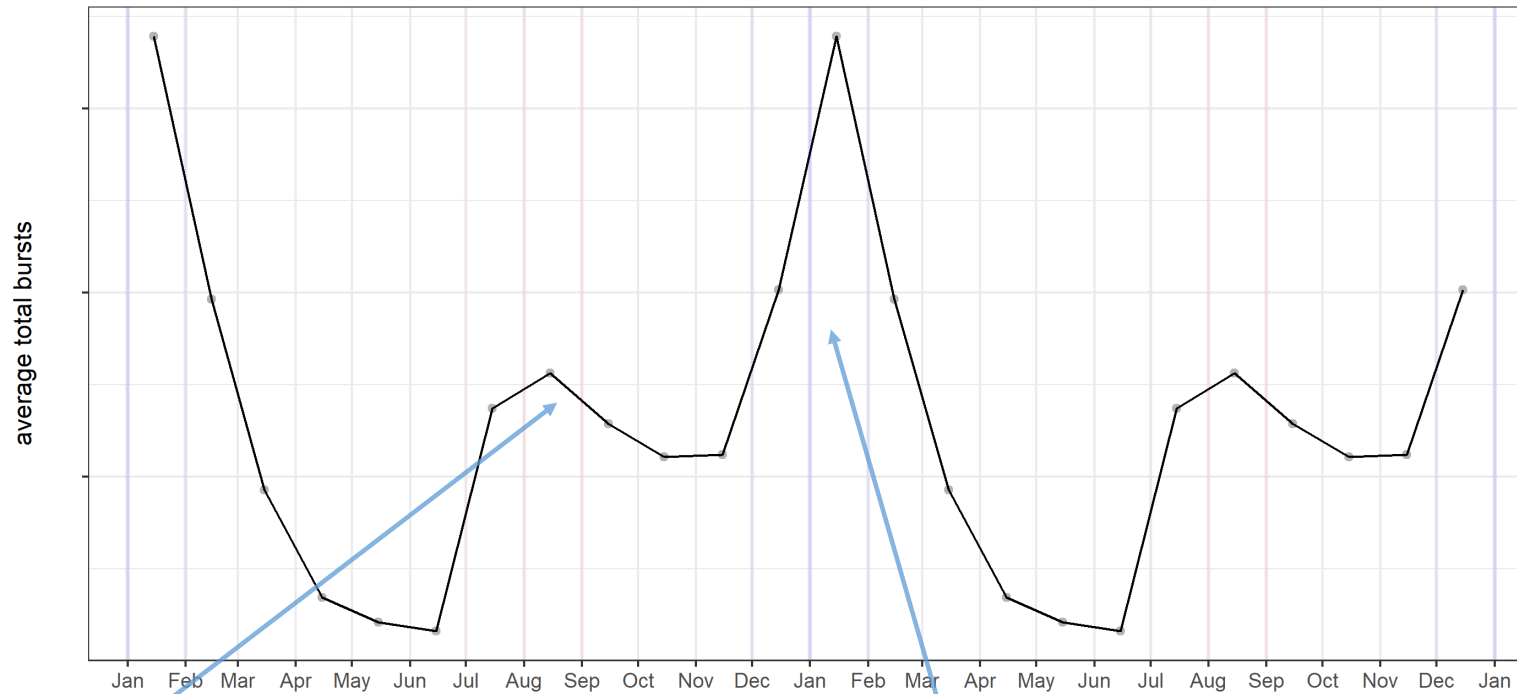


Learning from specific projects



Monthly trends - bursts

average bursts per month (2010-2019) - all materials



Summer peak

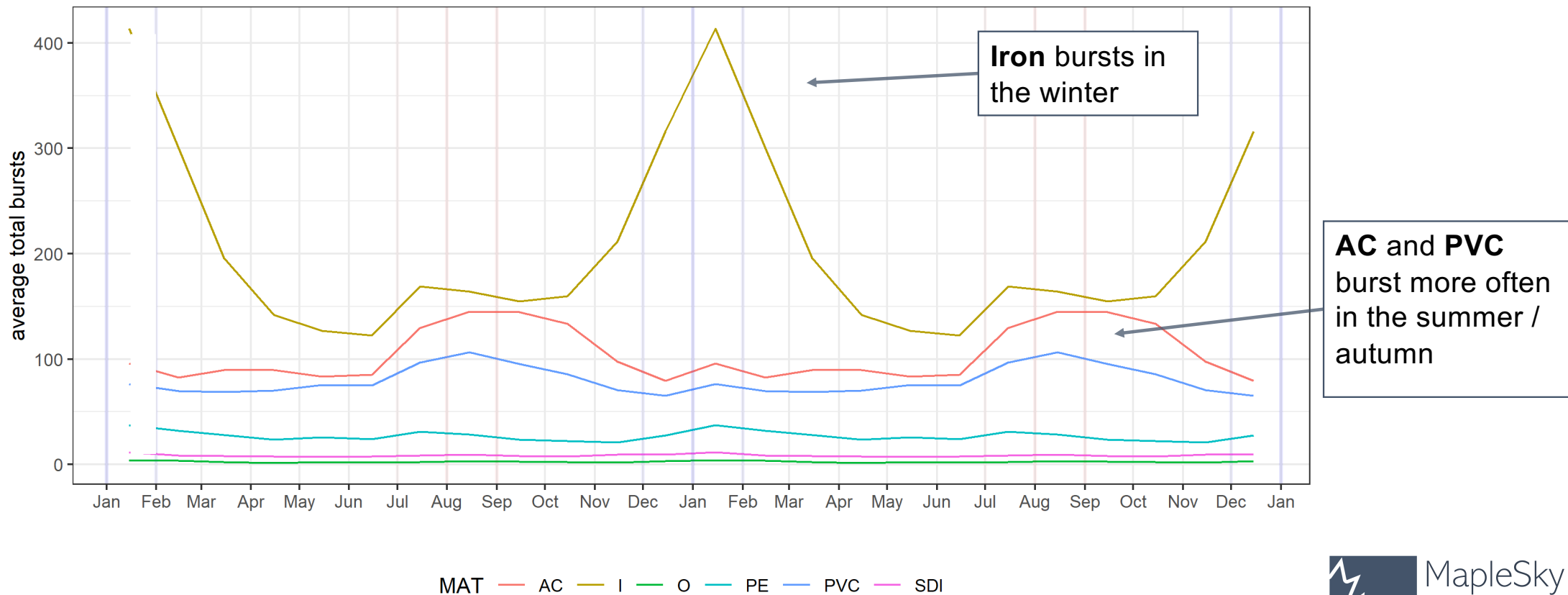
(hot temperature and ground movement impacts)

Winter peak

(Cold weather impacts)

Monthly trends (by material)

average bursts per month (2010-2019) - by material

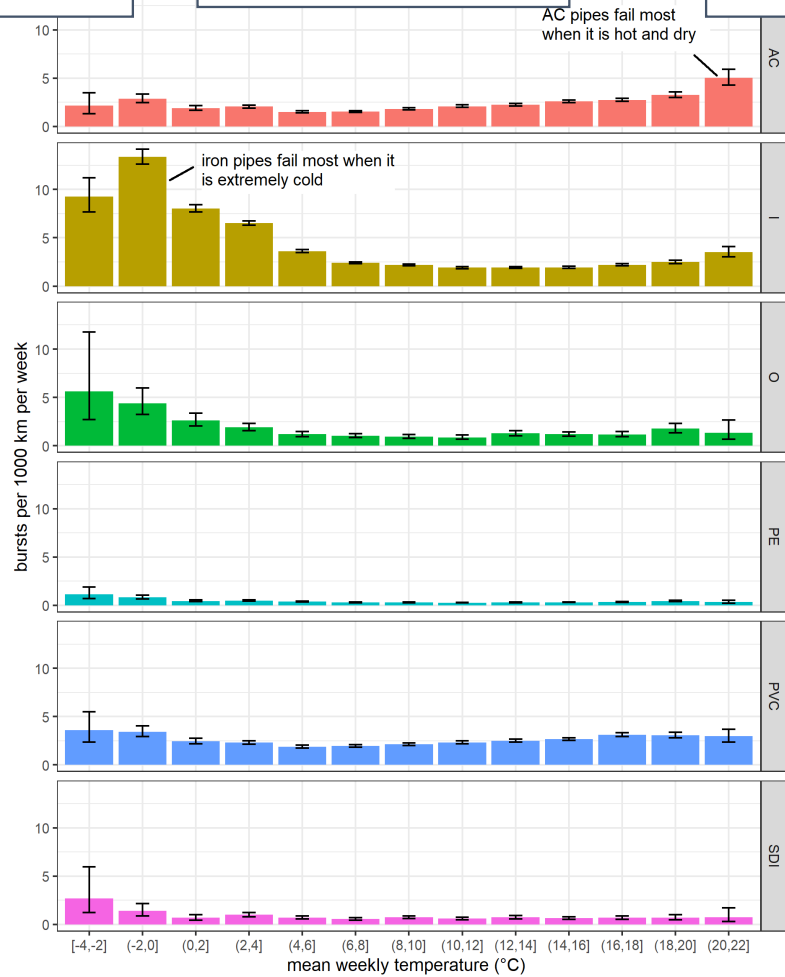


Temperature & Soil Moisture Deficit (SMD)

Cold

Temperature

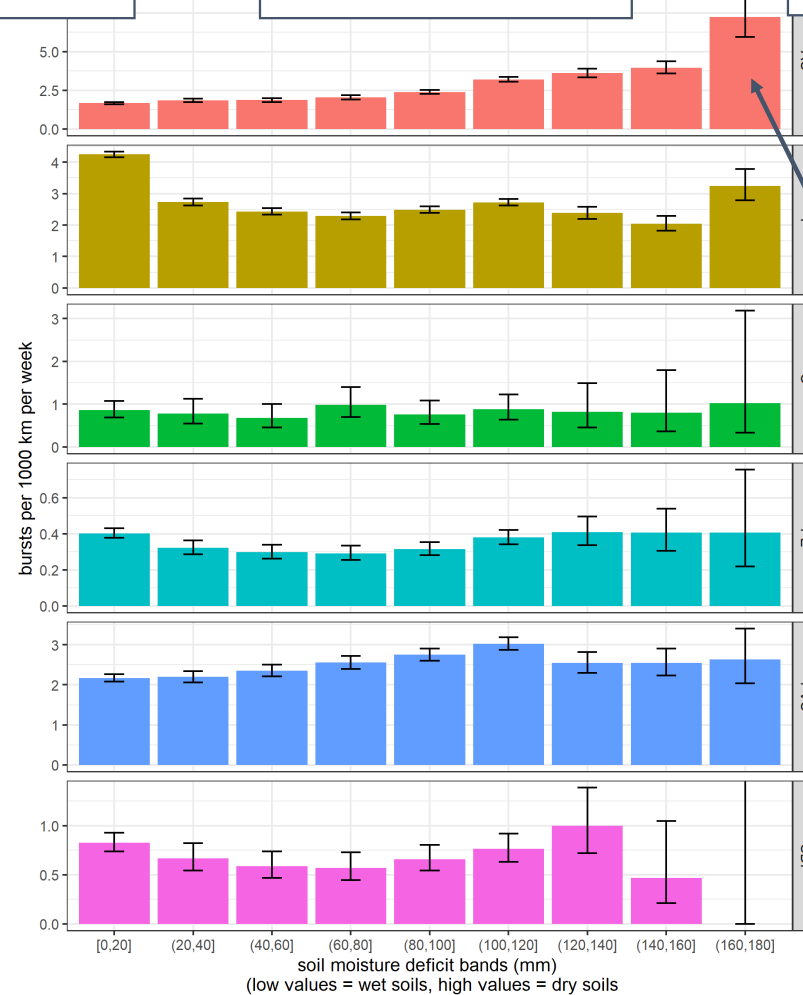
Hot



Wet

Soil moisture

Dry



AC fails most when soils are very dry... and especially where soils are shrinkable

General patterns observed in the UK

Iron pipes fail most in **cold winters**

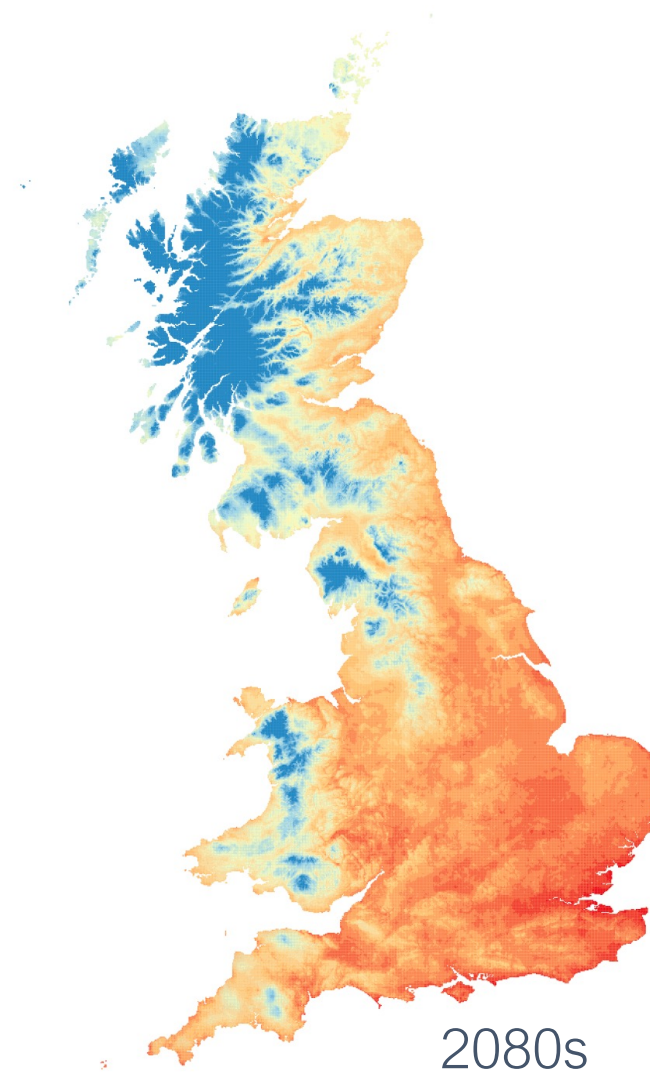
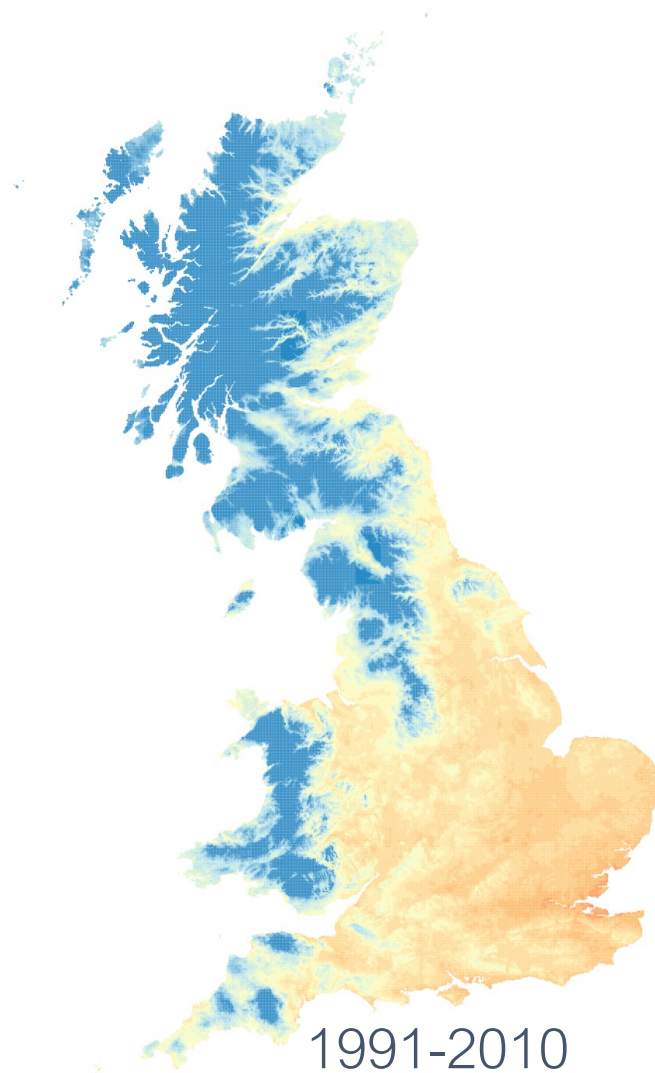
Iron also fails more when summers are **hot and dry** *

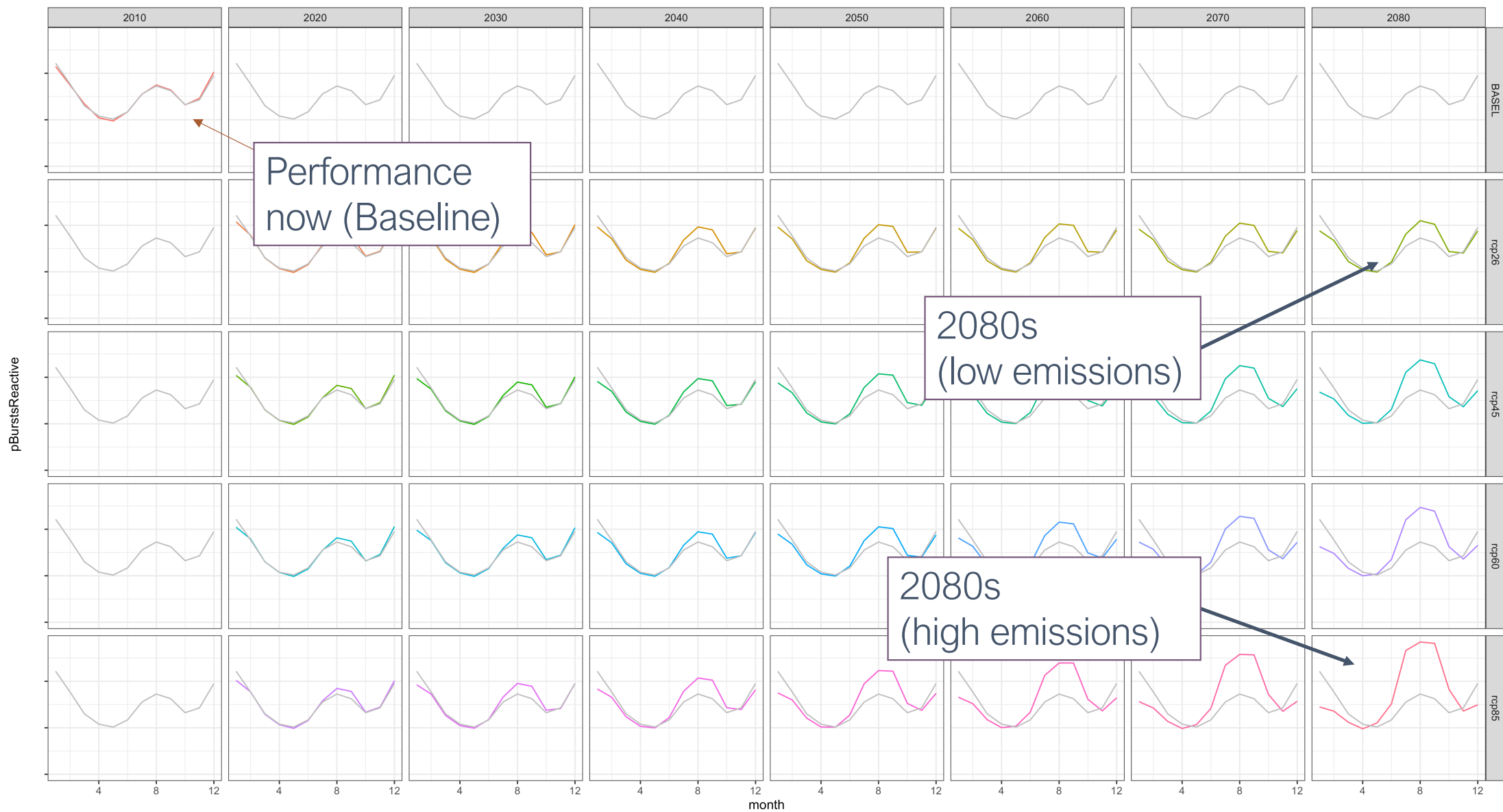
Asbestos Cement pipes fail most in **hot, dry summers** *

* (especially in shrinkable soils)

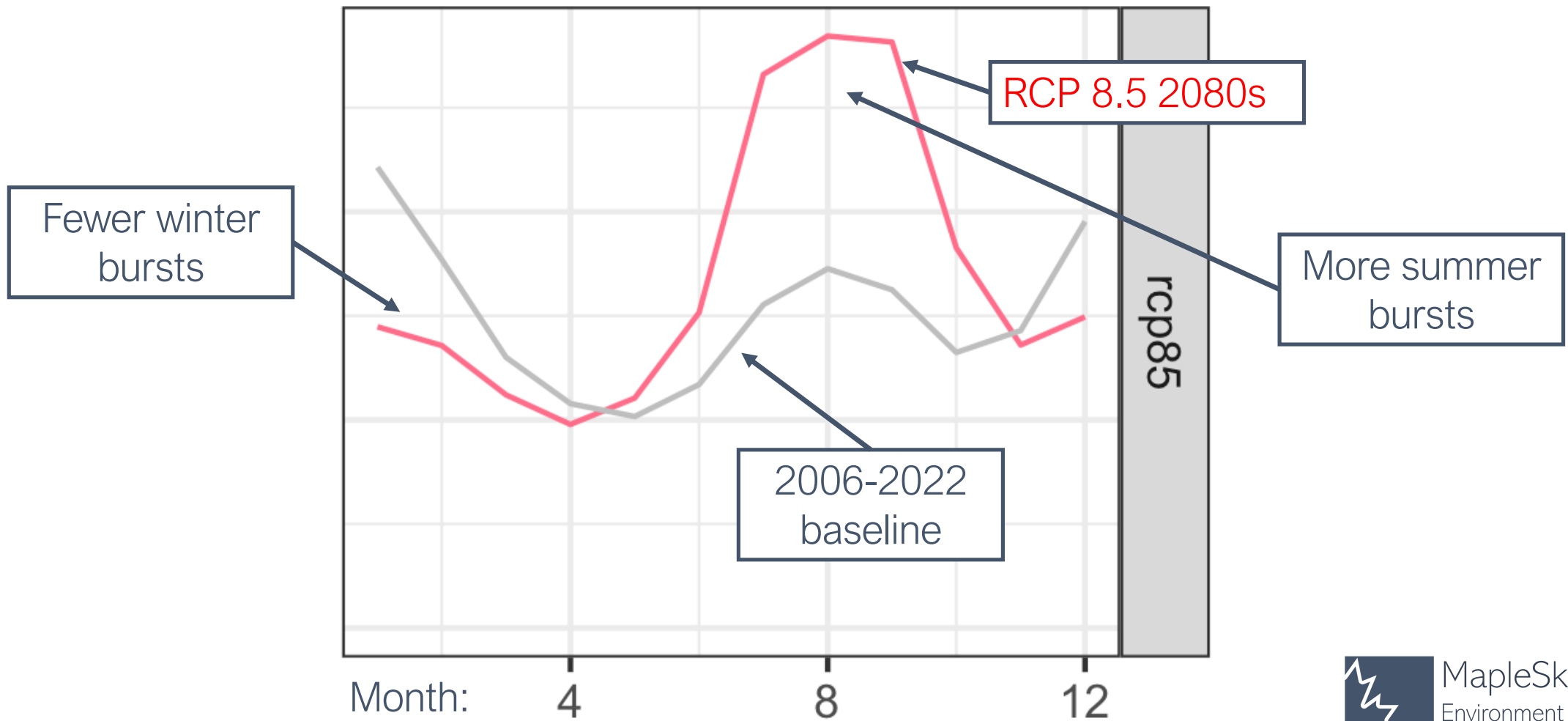
PVC pipes also see increased failures under **very hot conditions**

baseline and future soil moisture deficit (SMD)





2080s (RCP 8.5)



7 Steps to Modelling Climate Impacts on a Network

Clean Data

1. Gather, clean and prepare infrastructure and environmental data

Build Historic Models

2. Build accurate historic models of network performance

Run Models with Future Climate data

3. Integrate future climate data to predict future performance

This is arguably the most important step

Step 1 — Gather Data

Environmental data

Ground hazards

- Shrinkable clays
- Aggressive peats
- Sand (hides leaks)
- Landslides / slope instability
- Historic mines and voids

Weather data

- Rainfall
- Temperature (min / max)
- Soil Moisture Deficit (SMD)
- Consider lagged + derivative data, thresholds, time-since metrics

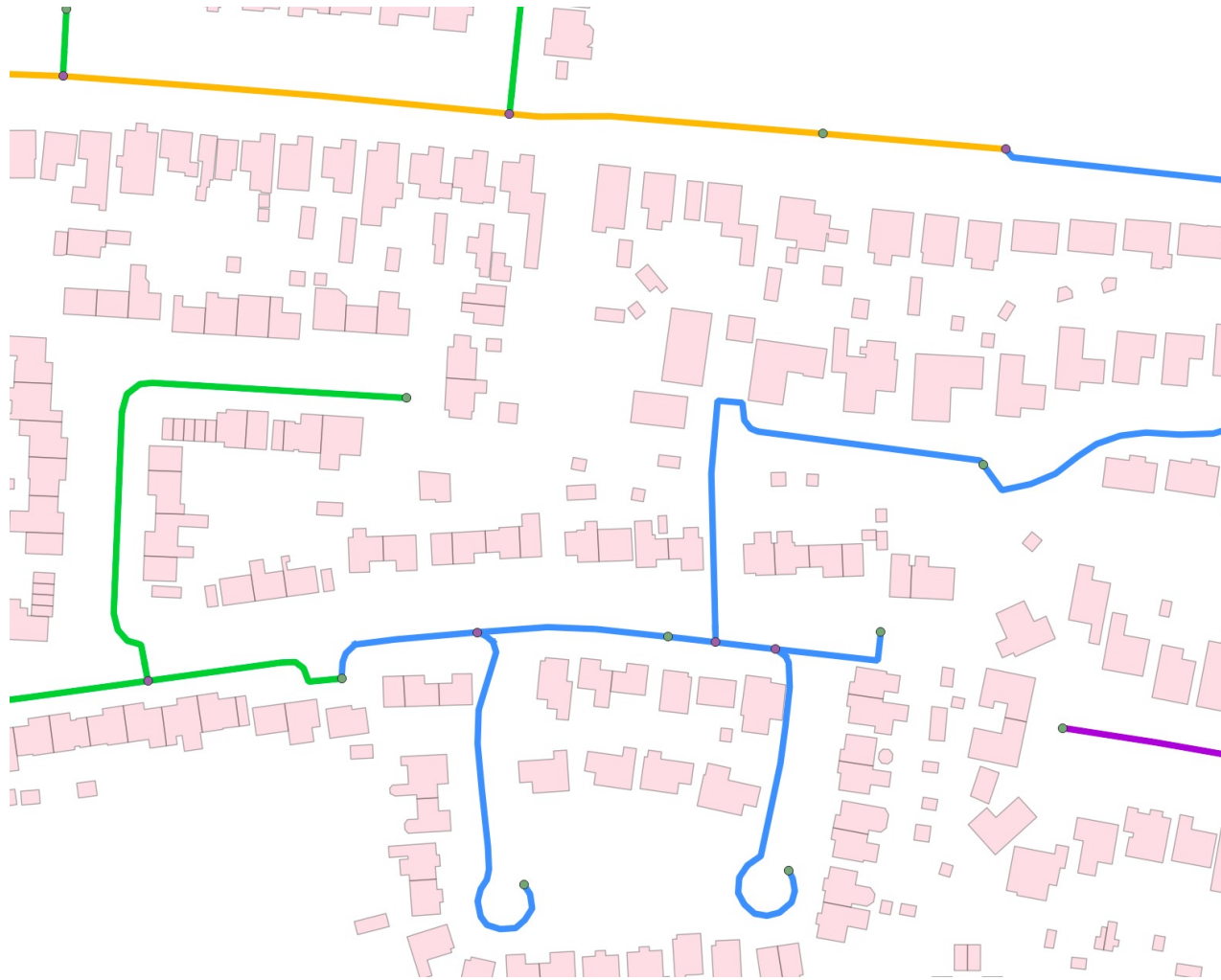
Infrastructure data

Pipes (historic + current)

Bursts

Leakage history

Pipe attributes – essential attributes



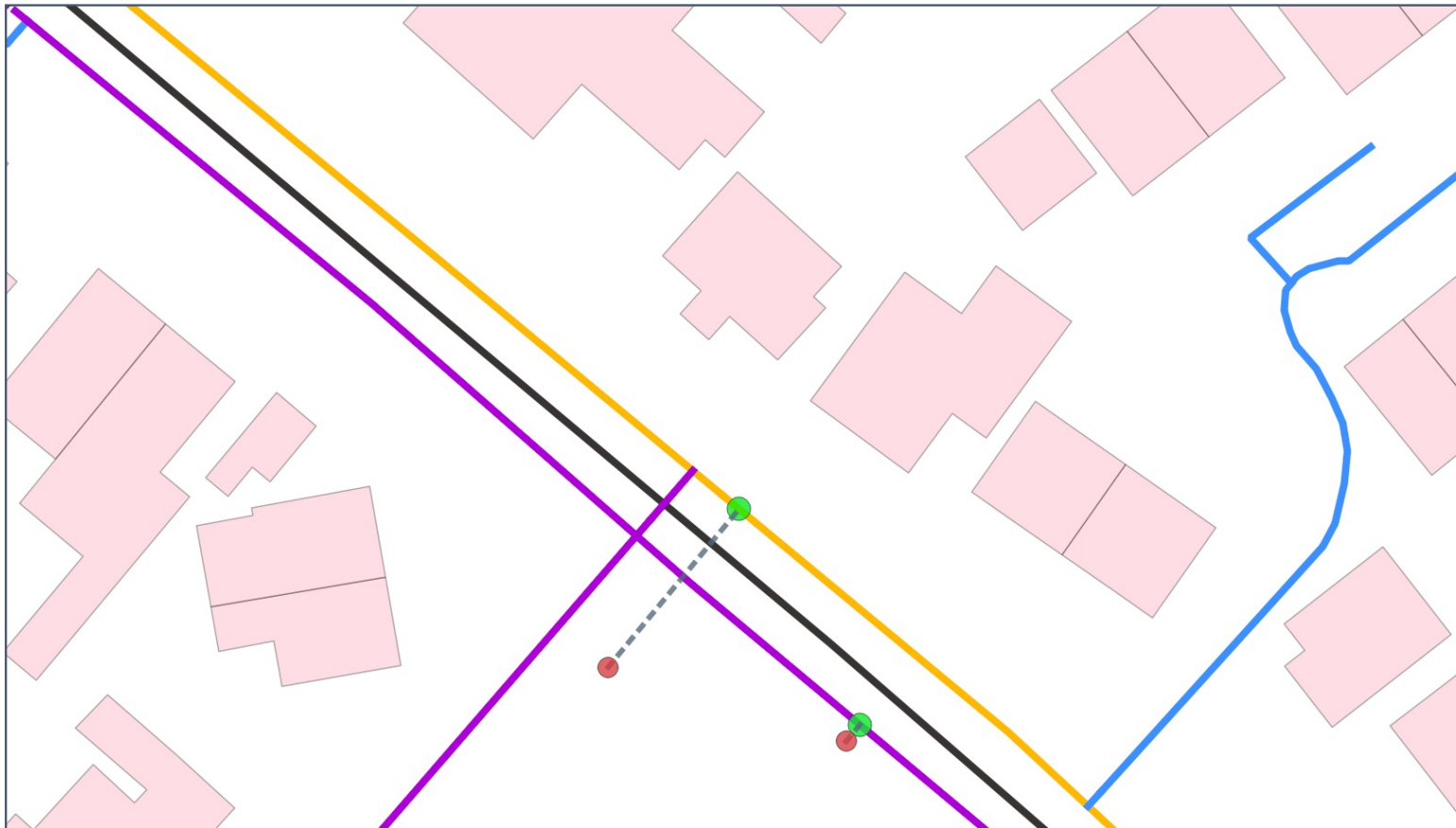
Material

Diameter

Installation date

Decommission date

Bursts / Leakage Jobs / Leakage



Material

Diameter

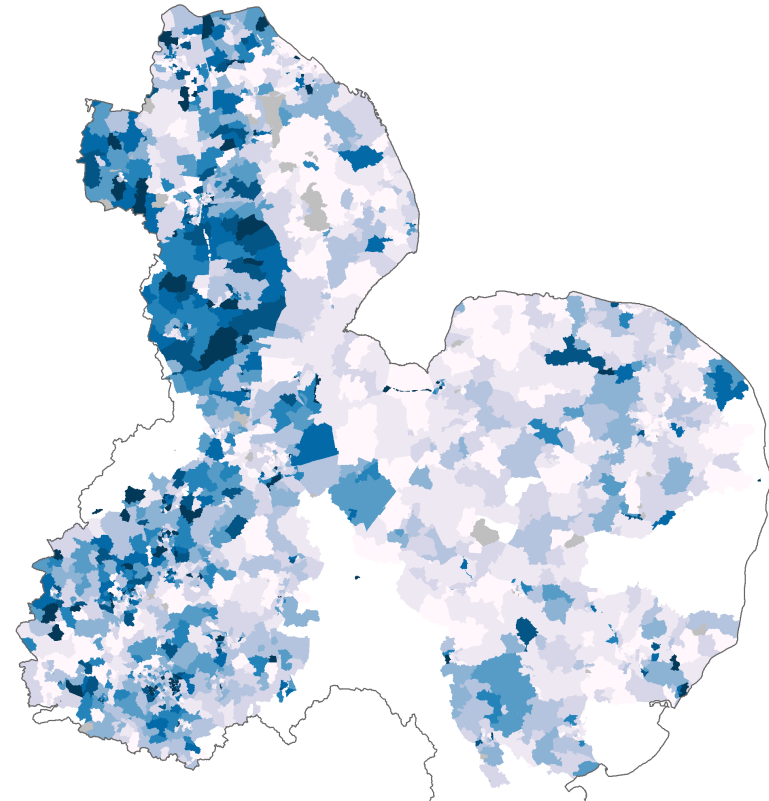
(1st) date of notification

Water source & DMAs / PMAs (supply areas)

DMAs are a useful attribute to tag
operations / other data:

Water source (ground / surface / mixed)
(as surface water is associated with higher

Pressure (min / max / stability)



Environmental data

- Weather data – in a consistent format with climate models – (1, 2, 5 km grids)
- Ground condition data – especially ground movement risk + sandy soil locations
- Tree data
- Topographic data - with height, slope and aspect

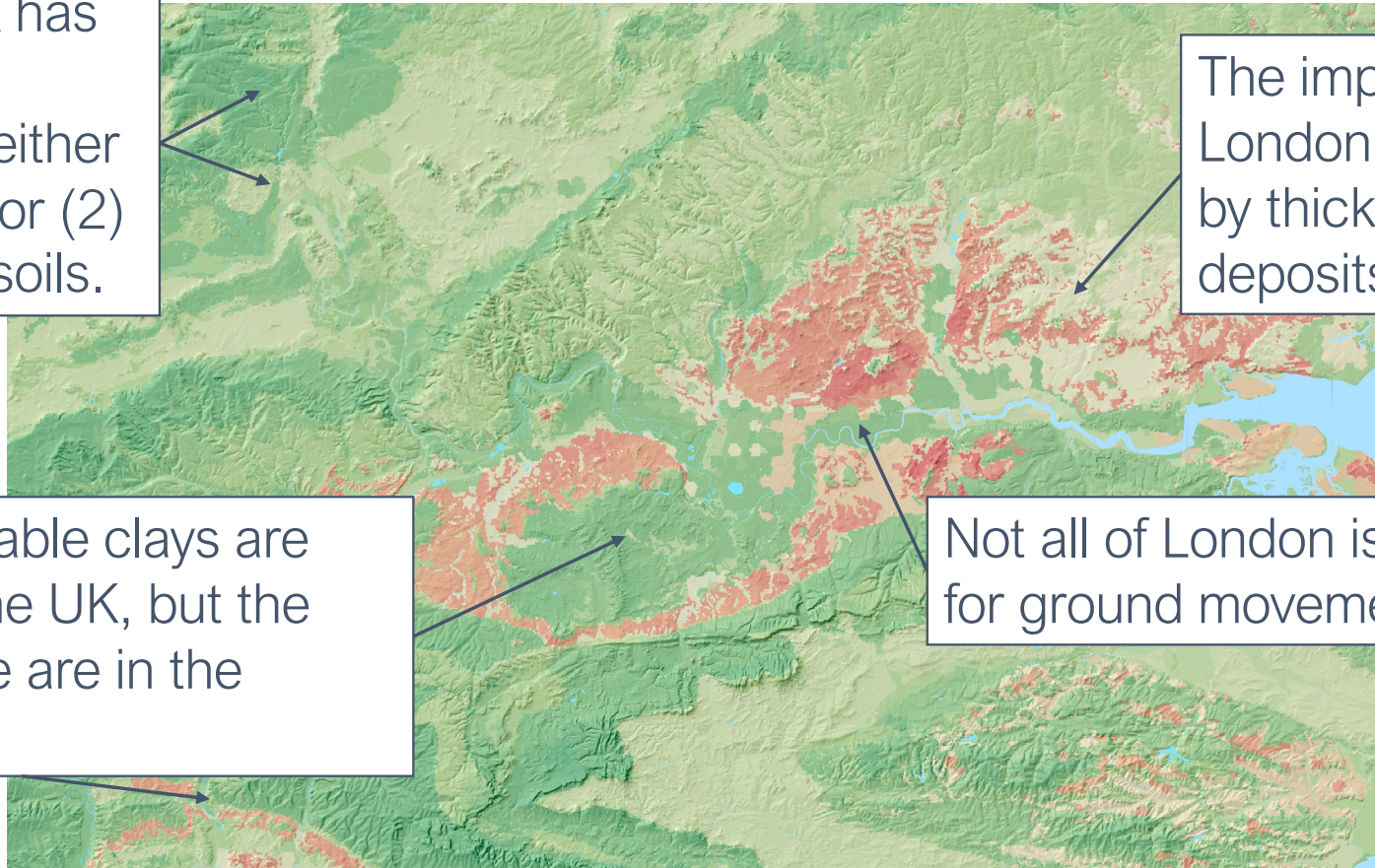
MapleSky Ground Hazard Data – Shrink-swell clays

Much of the UK has low shrink-swell potential given either (1) high rainfall or (2) low-shrinkable soils.

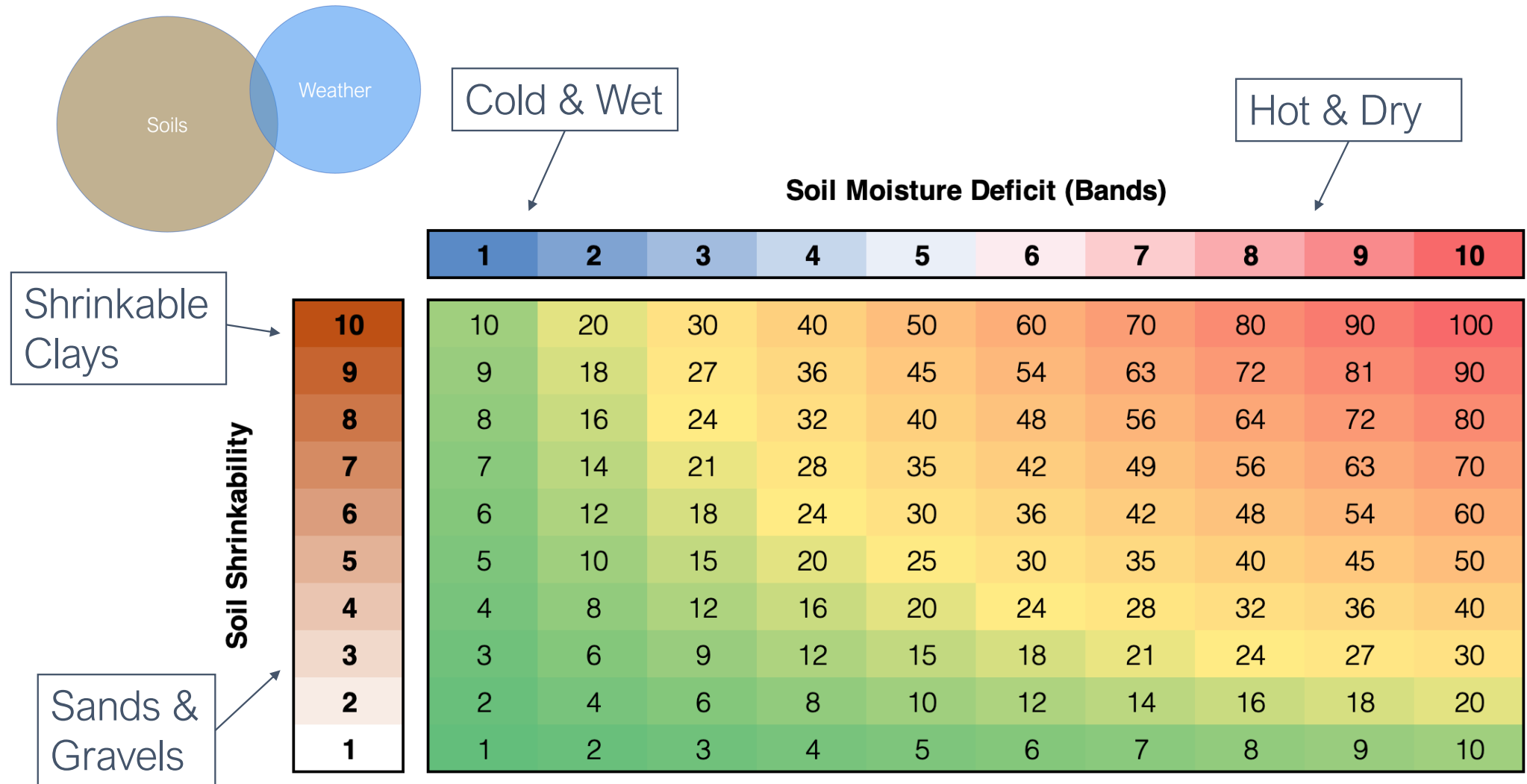
The impact of the London Clay is muted by thicker superficial deposits in some areas

Areas of shrinkable clays are found across the UK, but the most shrinkable are in the south.

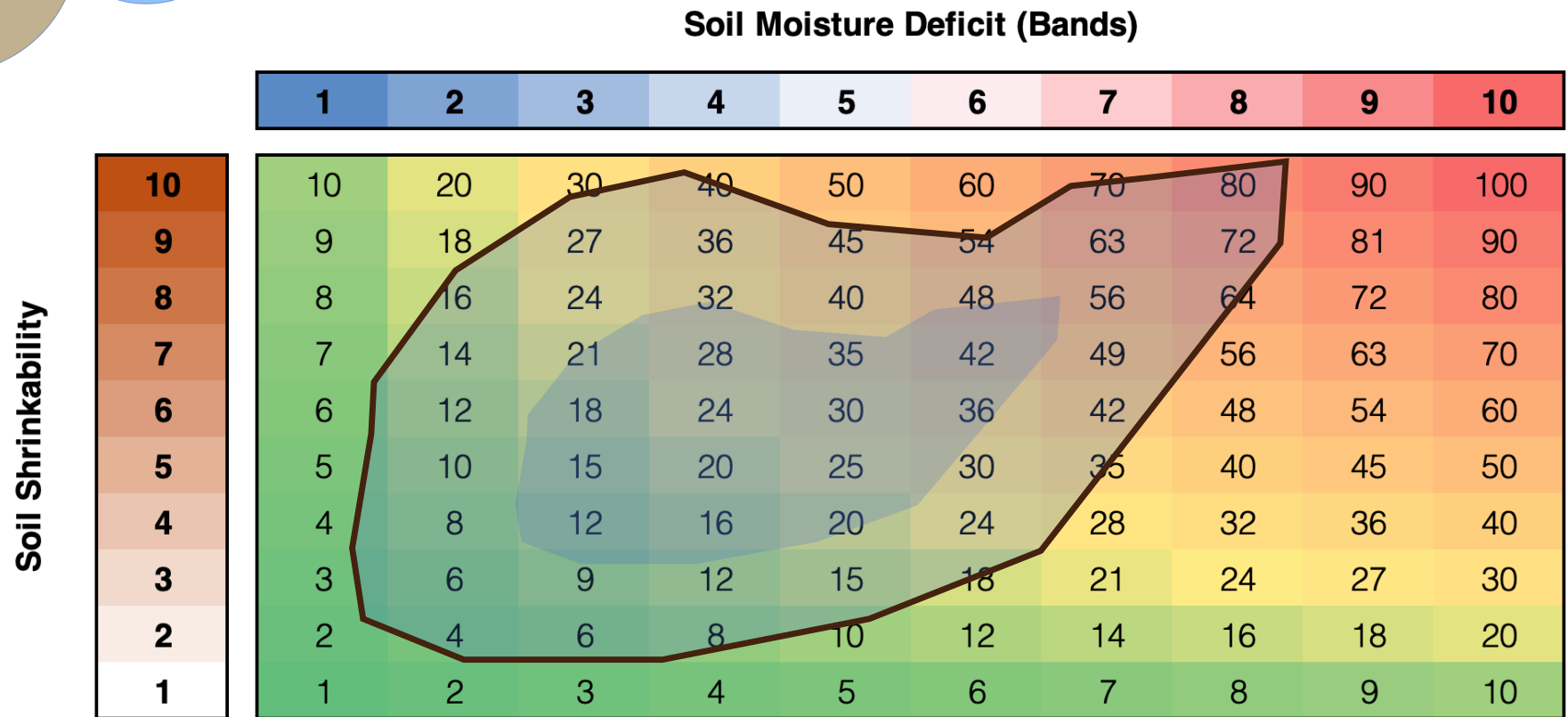
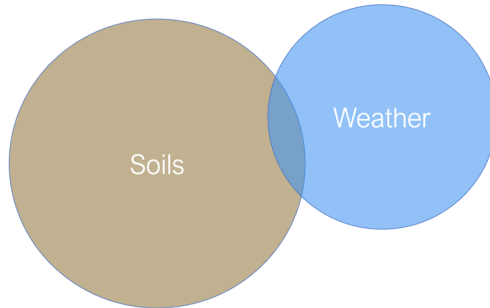
Not all of London is high risk for ground movement



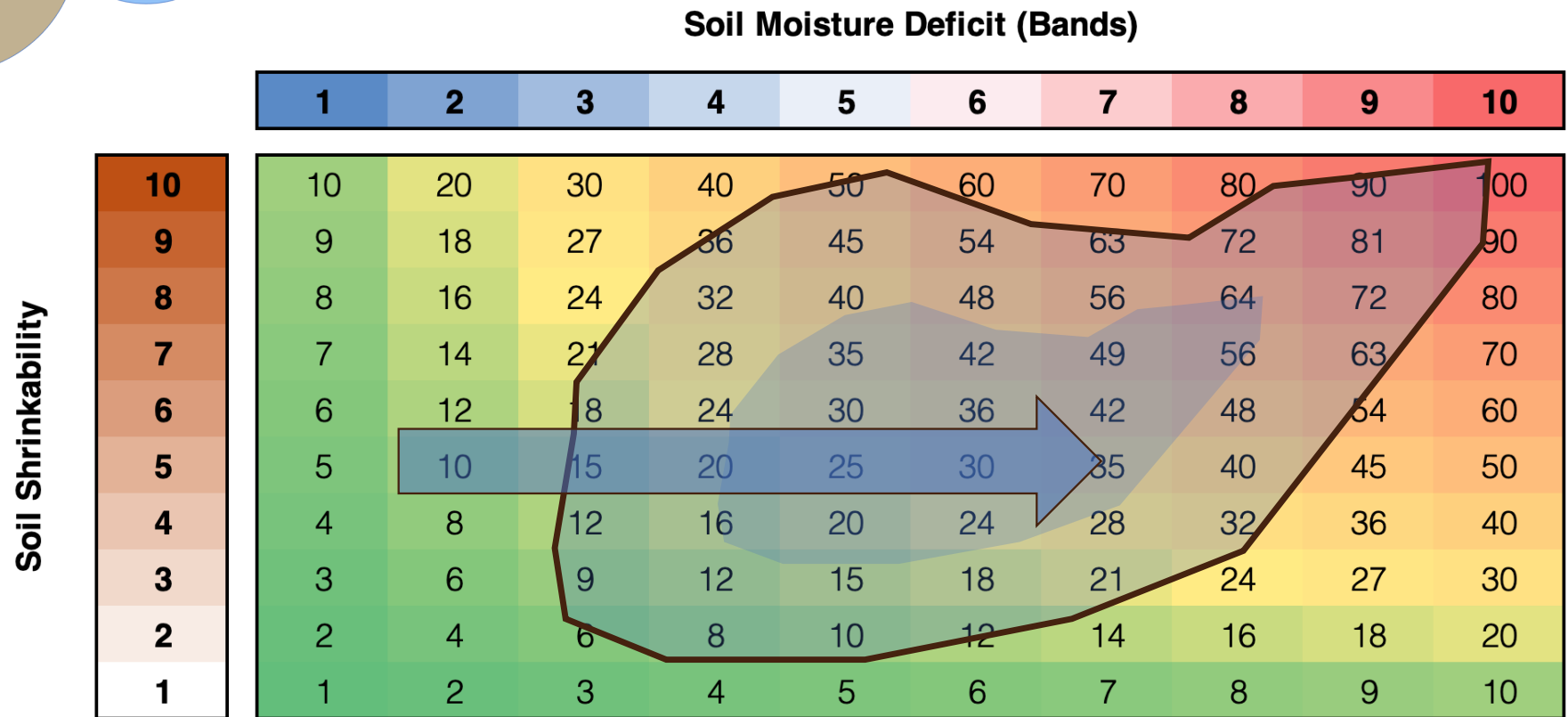
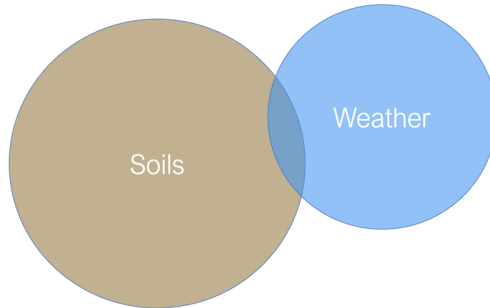
Ground movement matrix



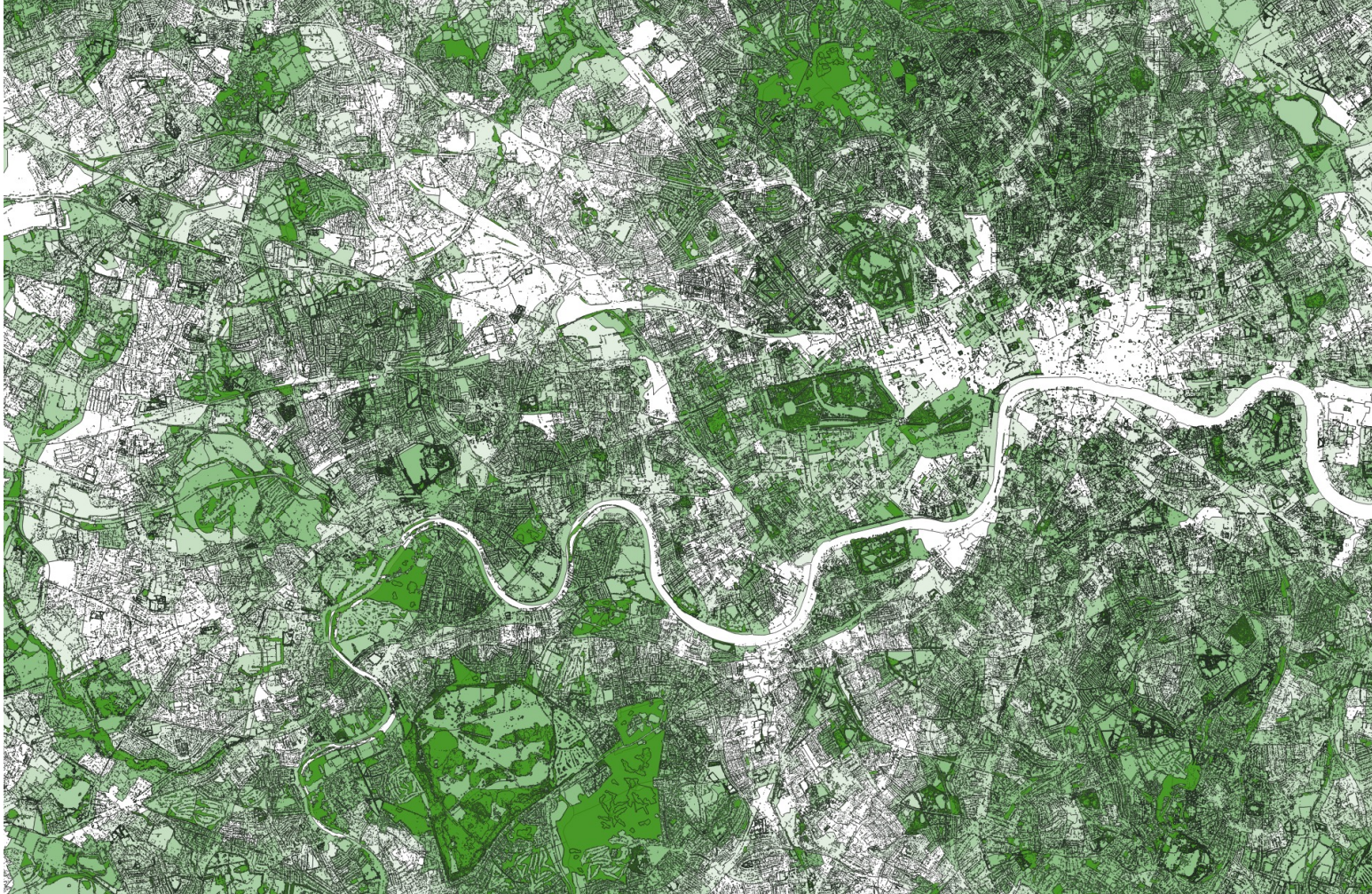
Ground movement matrix



Ground movement matrix



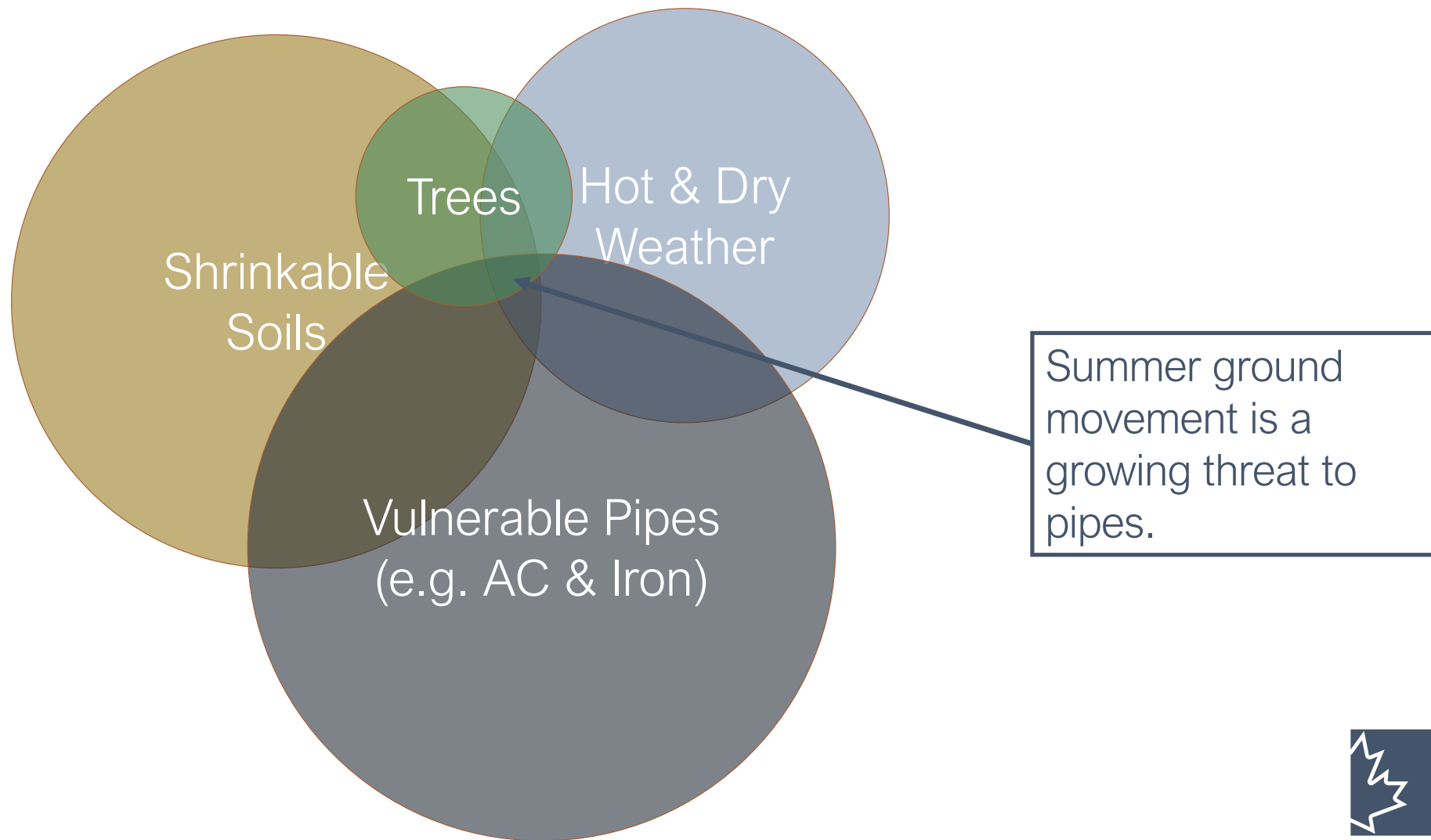
Integrate Tree Data



Combined Tree
canopy +
woodlands data

Filter to trees
over 3 m

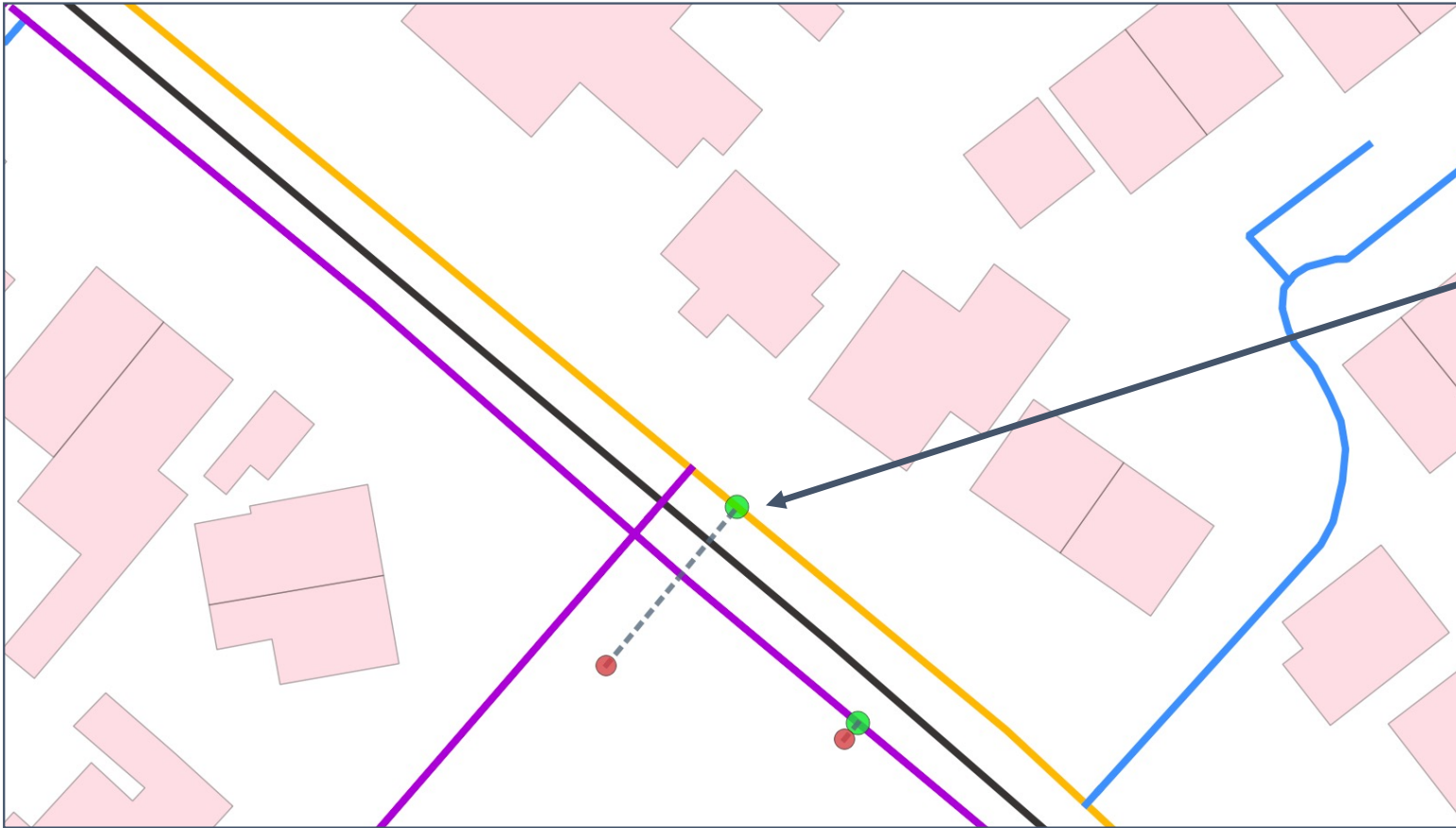
Most “at risk” pipes – summer failures



Step 2 — Clean & Integrate Data

- Pipe assets – fully attributed - harmonised to simple material classes
- Bursts – attributed with date and accurate location
- Choose temporal scale (daily, weekly, monthly)
 - Consider “fuzzy” temporal scales / fuzzy variables.
 - Could the burst have occurred **before** it was reported?
- Data cleaning is THE MOST important part of this workflow.
- Data cleaning takes longer than you think / hope, but is SO important.
- Data cleaning will save you so much money in the end.

Cleaning location - Identify which pipe ACTUALLY burst (and when)



Multi-layered logic to accurately identify the most likely main that burst

Also... day of week, mis-matched dates (MM-DD), typos, out of sequence etc

From WHAT POINT do you trust your data?

A key step is to determine at **what point you begin to trust** your data.

This will start to become clear when you look in detail at your records.

While burst records may go back many years, typically we find records become useable between around **2005 – 2010 onwards**

A key part of our work is helping companies adjust their systems to **collect better quality data in the first place** to minimise future cleaning.

Step 3 — Hypothesis Development

- How do pipe materials respond to:
 - Soil conditions
 - Weather conditions
- Test and quantify these relationships
- Do this for individual materials
- How would you expect an asset / cohort to respond? What is your lived experience?

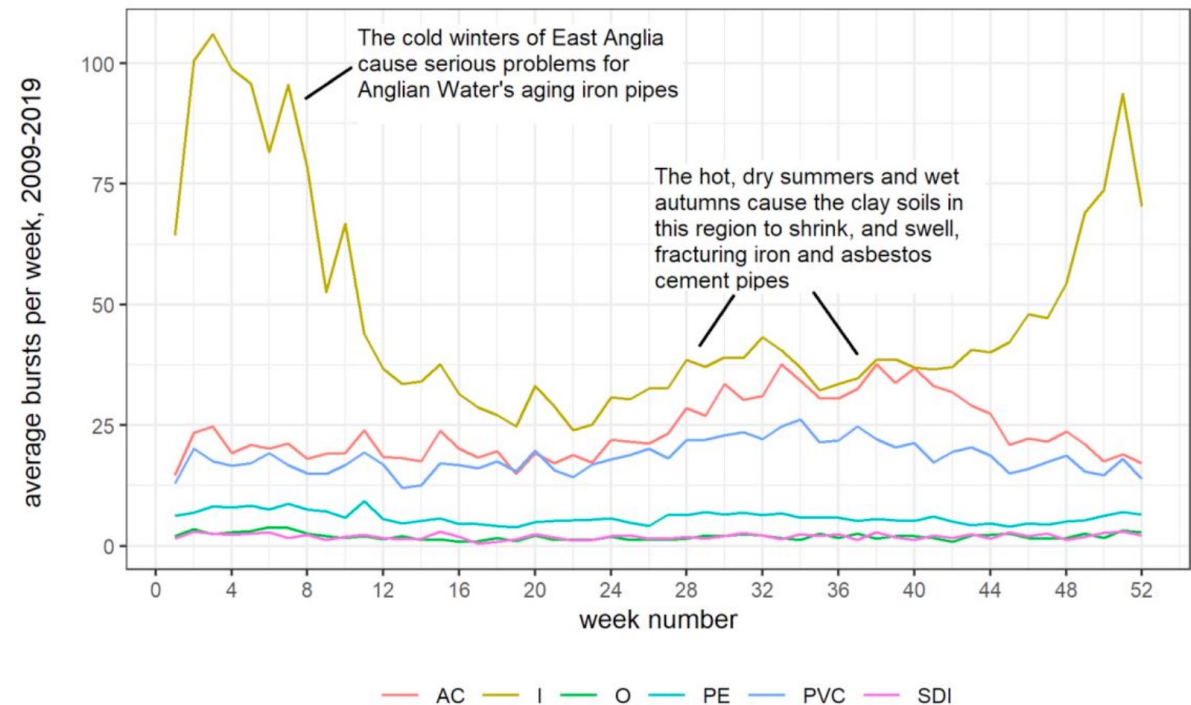
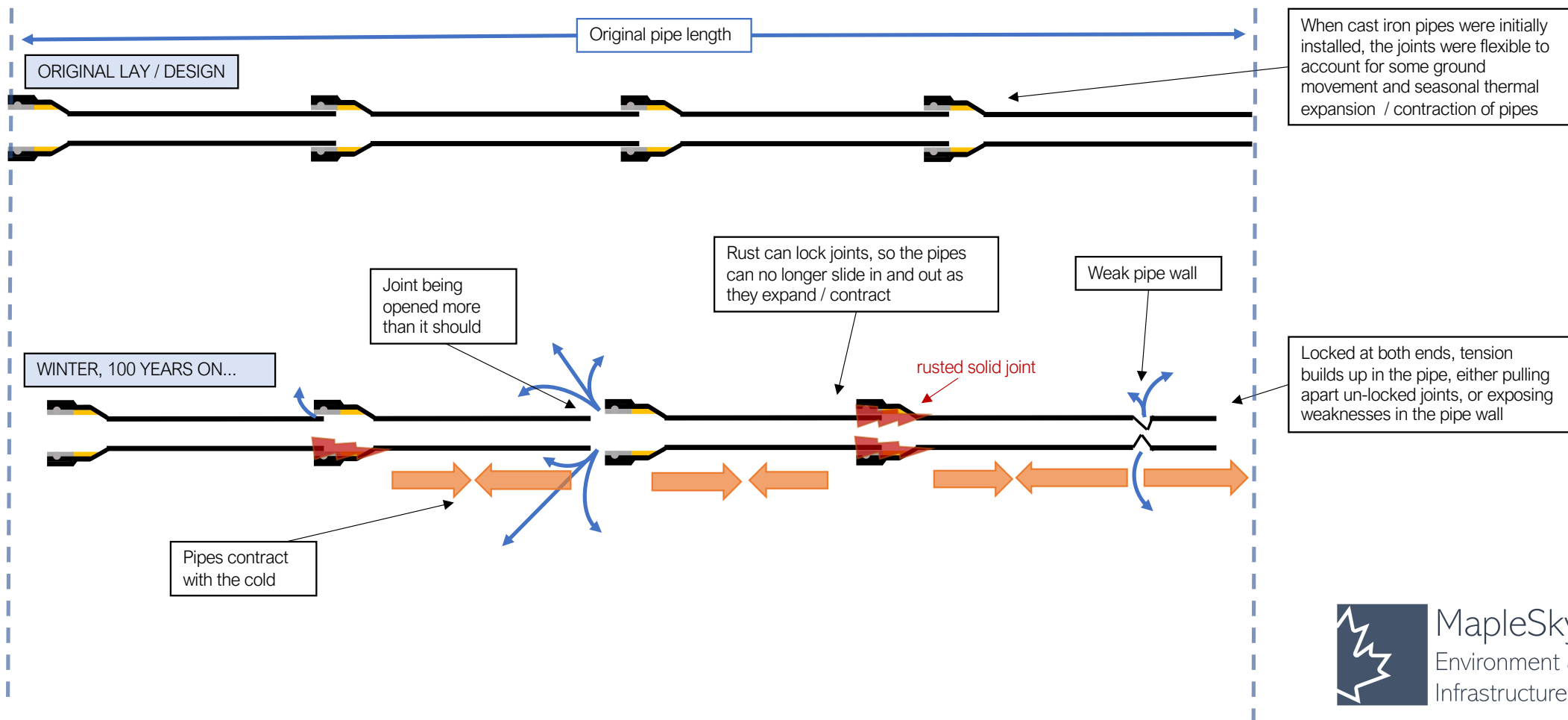
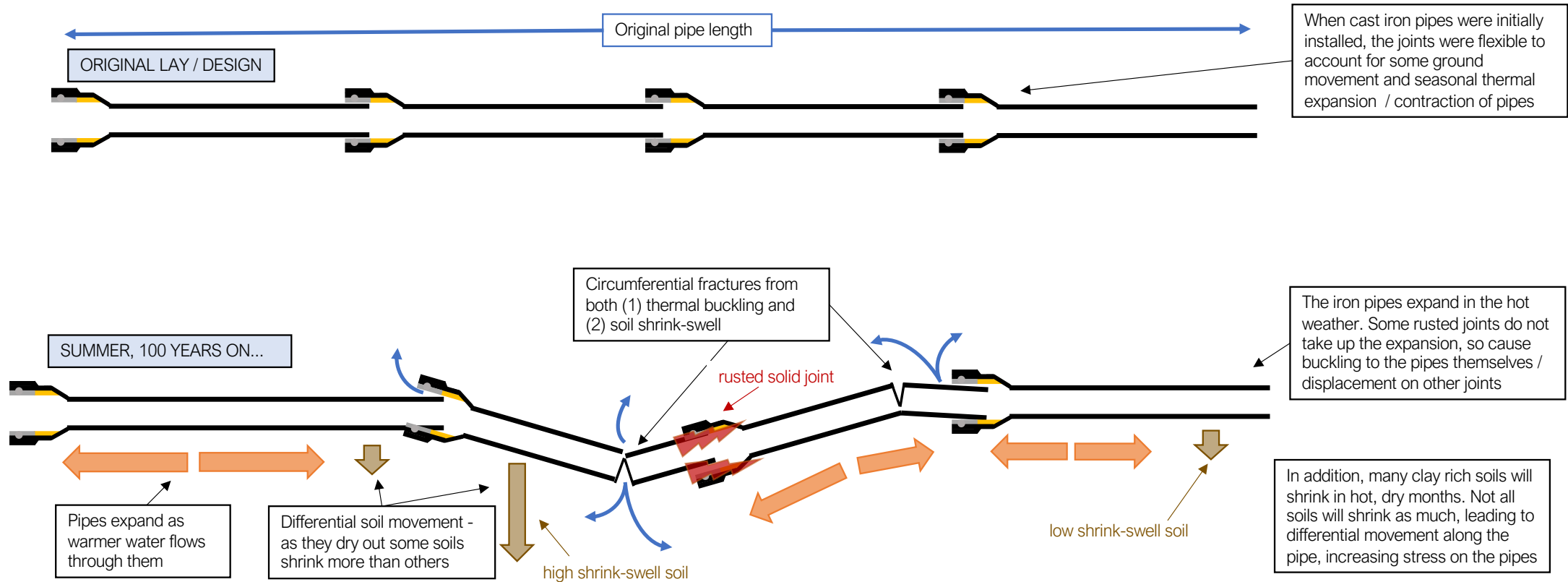


Figure 4 - observed response of Anglian Water's pipe to seasonal weather patterns. AC), iron (I), polyvinyl chloride (PVC), polyethylene (PE), steel and ductile iron (SDI) and "other materials" (O).

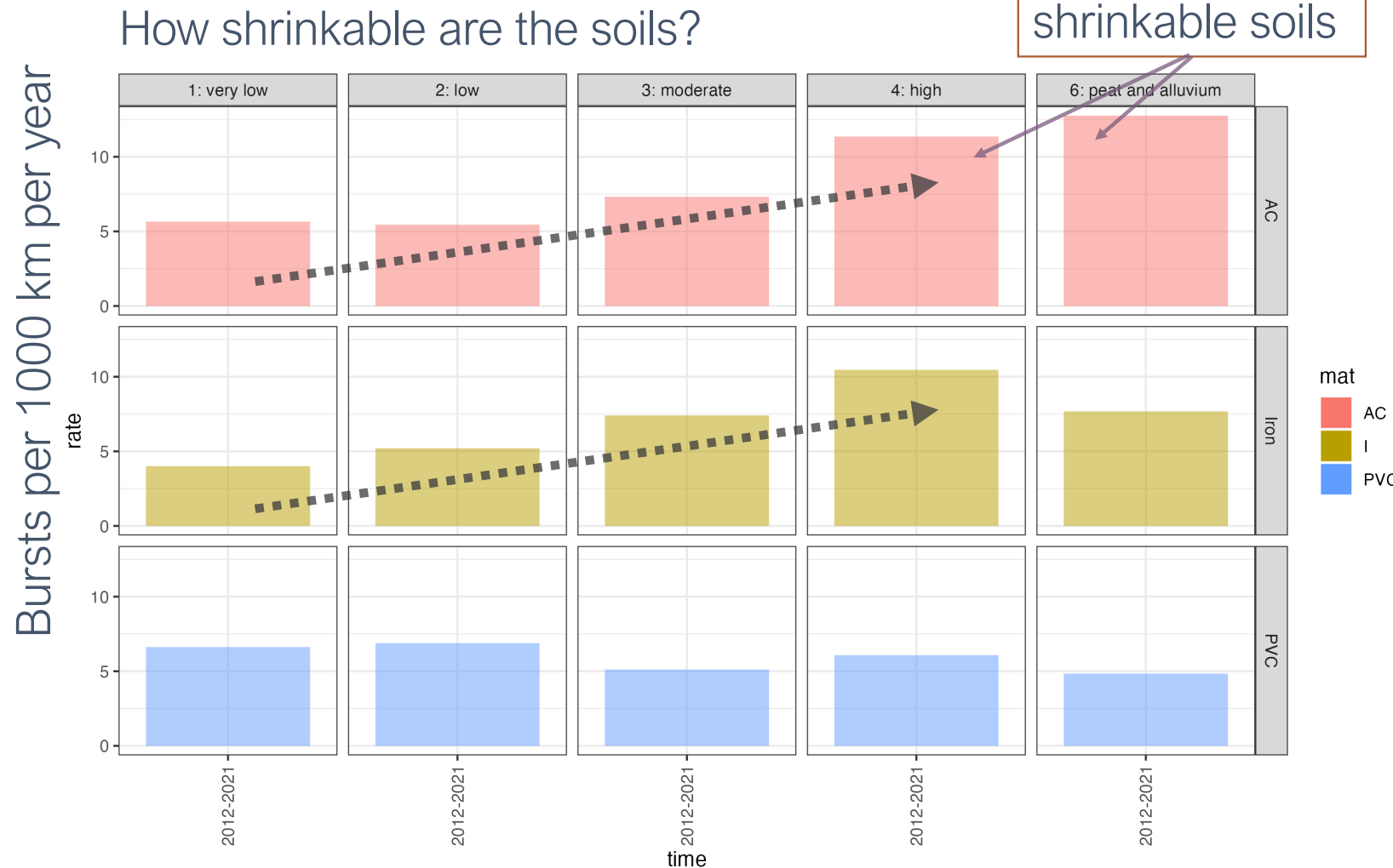
Winter failures (old iron pipes)



Summer failures (iron)



Soil impacts

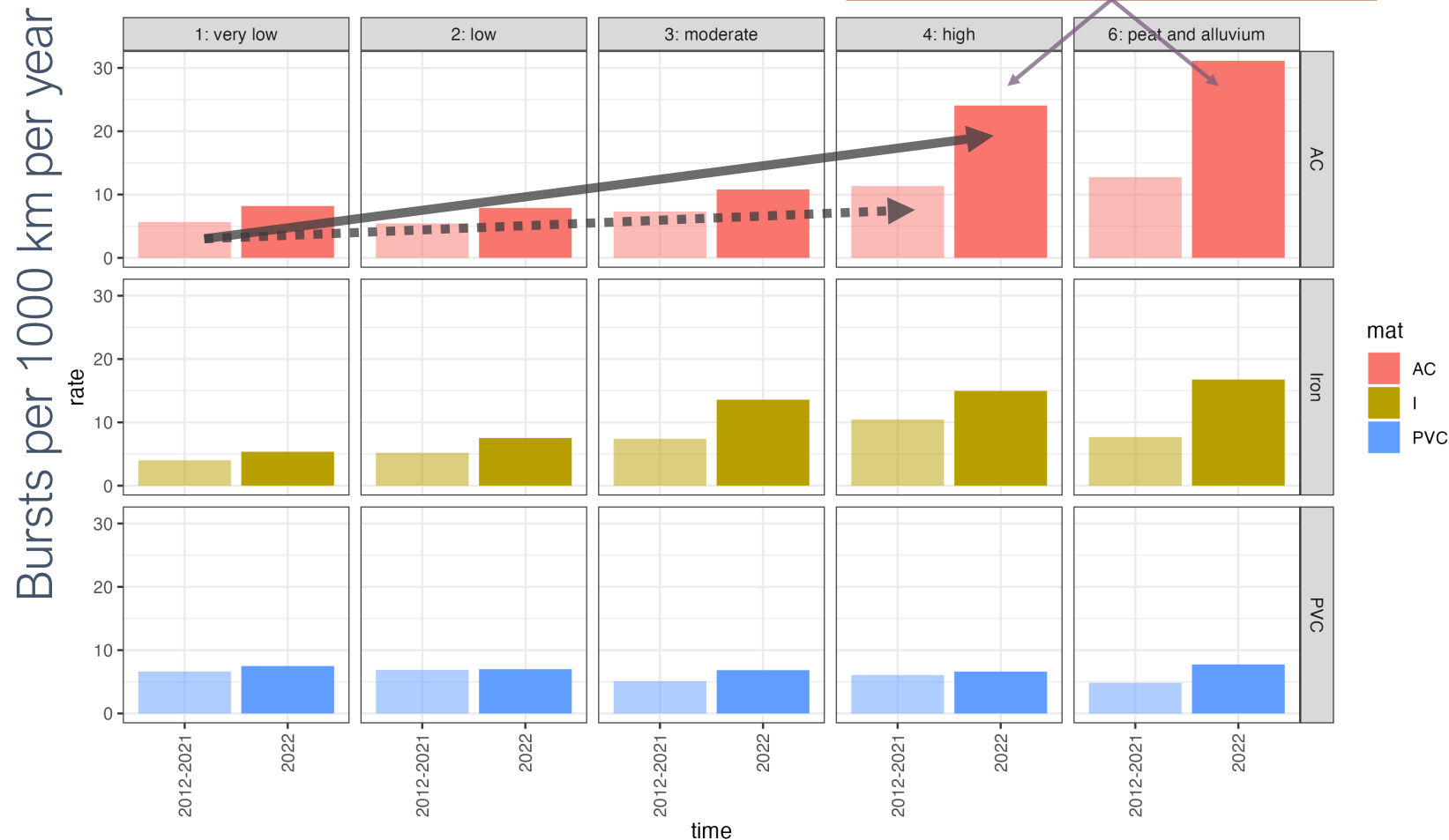


Average summer burst rates in different soils (2012-2021)

Soil impacts

Even more bursts in hot summers!

How shrinkable are the soils?



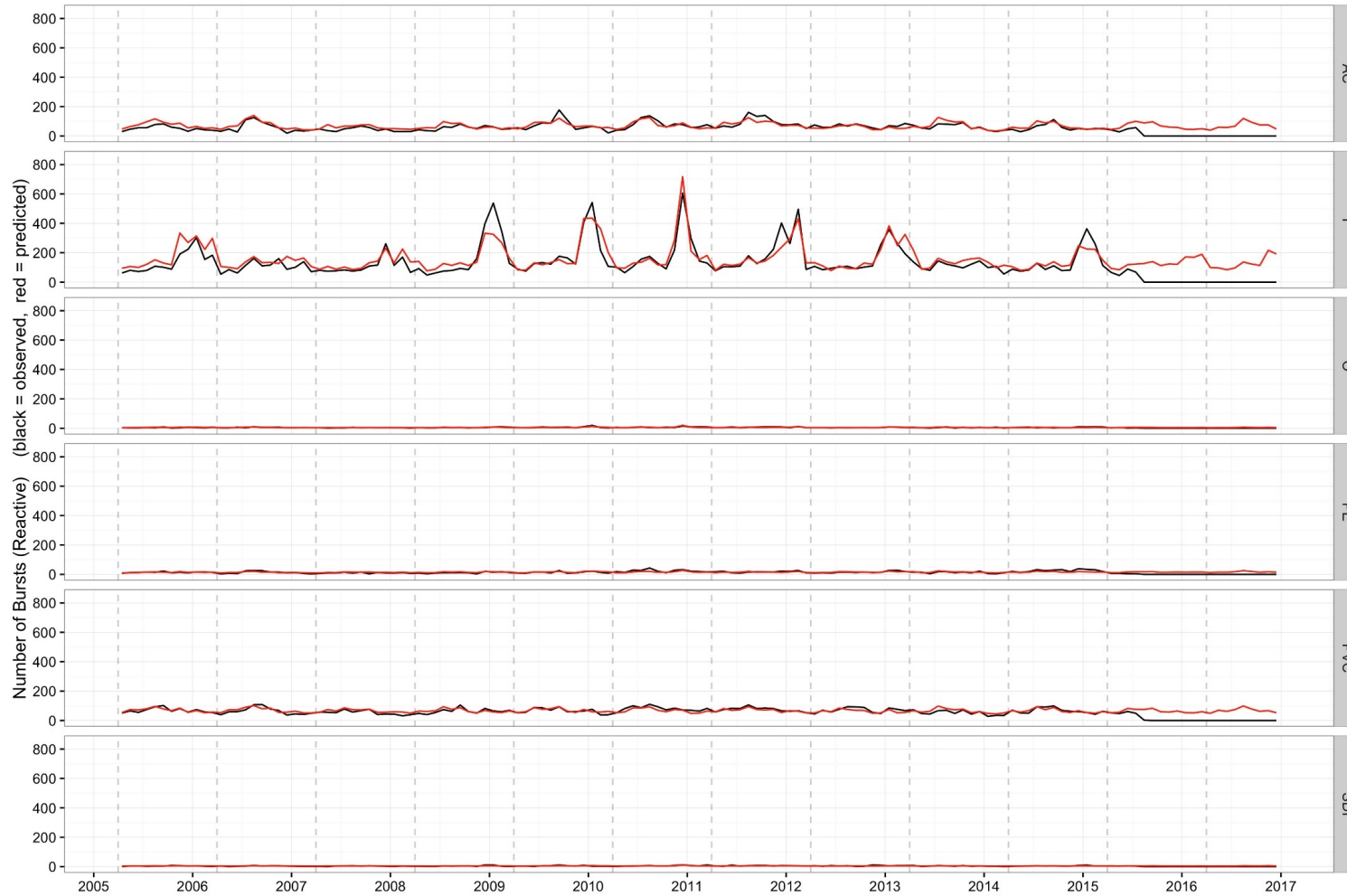
Average summer burst rates in different soils (2012-2021) compared with 2022 (very hot!)

Step 4 — Build Backward-Looking Models (equations)

- Split your data in to training and testing sub-sets
- Do this for individual materials (broad groups):
(e.g. Cast & Spun Iron, AC, PVC, PE, Steel, Ductile, “Other”)
e.g. build 6 or so models, as the different materials respond differently to environmental factors.
- Model historical pipe – soil – weather interactions
 - GLM (poisson regression)
 - Negative binomial
 - Multi-stage model...
 - **The model choice is NOT as important as CLEAN DATA.**
- Consider your hypotheses: - Does this data explain how past conditions have driven:
 - Bursts
 - Leakage
 - Other impacts

Build material specific models

Observed Weather: Reactive Bursts



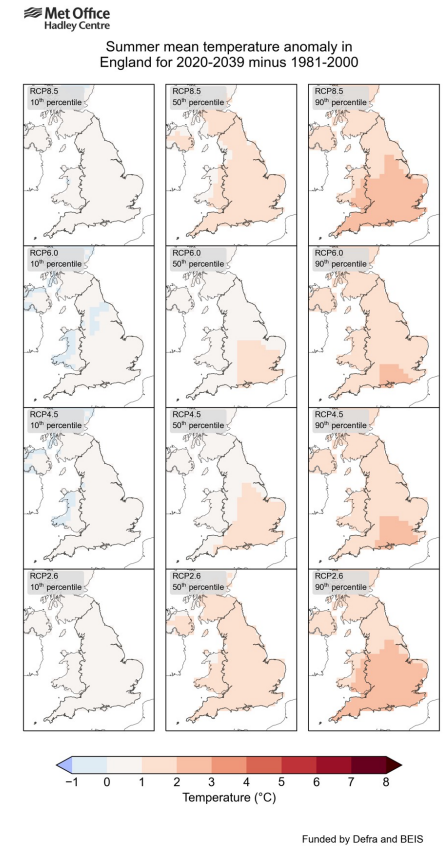
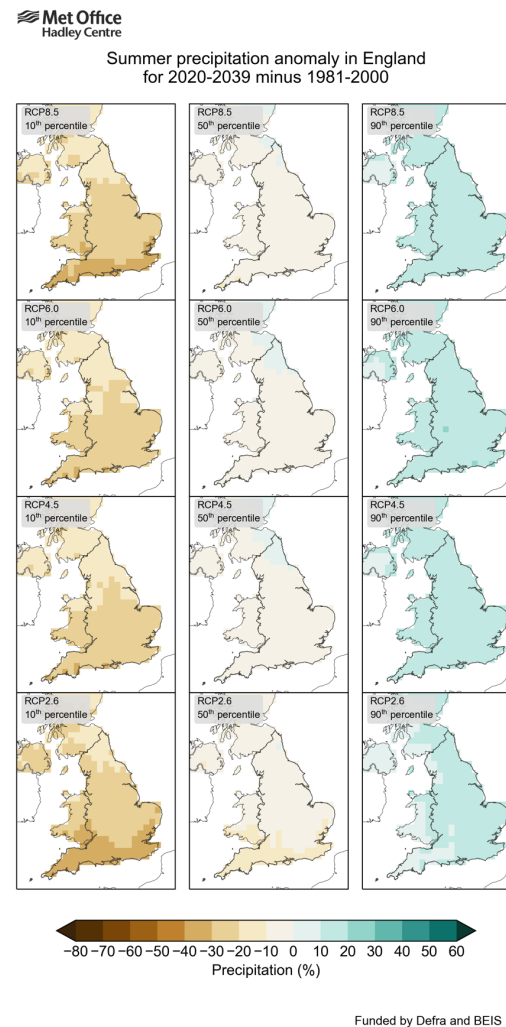
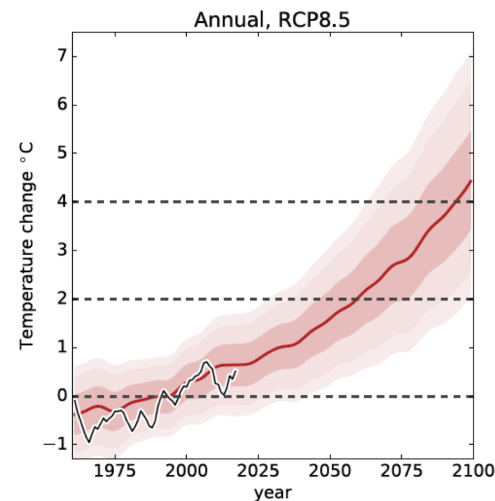
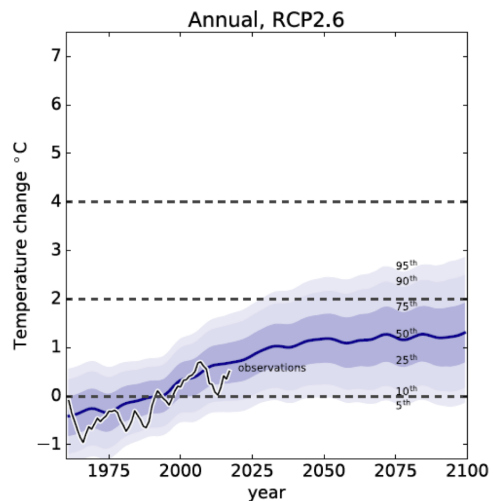
Most bursts are on AC and Iron pipes in this region

Step 5 — Simulate Future Climate Scenarios (build data)

- Typically NetCDF format (annoying)

Key variables:

- Temp: min, mean, max; thresholds,
- SMD (soil moisture deficit)
- Rainfall: accumulation (rolling sum)



Use 50% percentile for climate / weather variables

We suggest working with the 50% percentile data for temperature and rainfall from the climate data

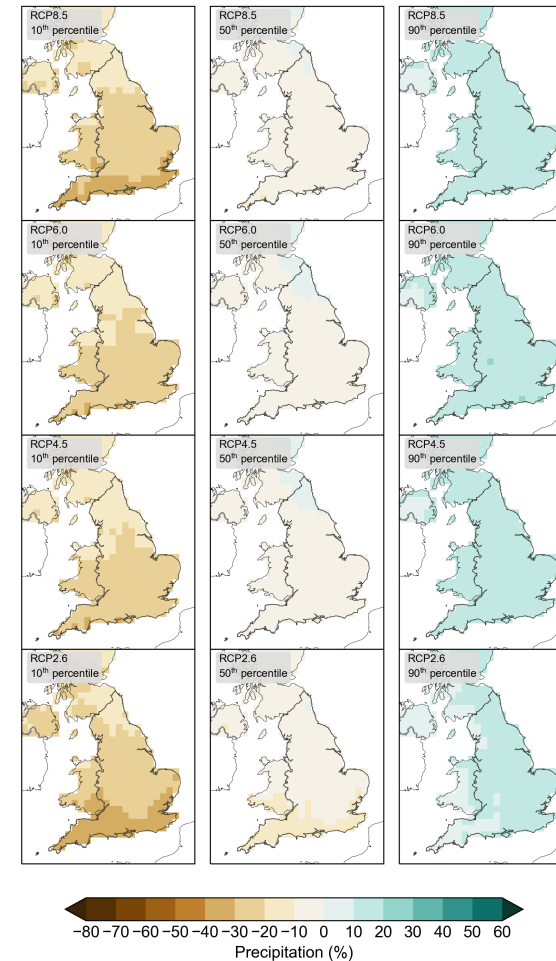
While more extreme scenarios are available (e.g. 90th, 10th), the interactions between the variables are complex.

The trends will be scary enough anyway.

Identify areas where new extremes occur beyond your observed range / experience. Models tend to not extrapolate as well...

Met Office
Hadley Centre

Summer precipitation anomaly in England
for 2020-2039 minus 1981-2000

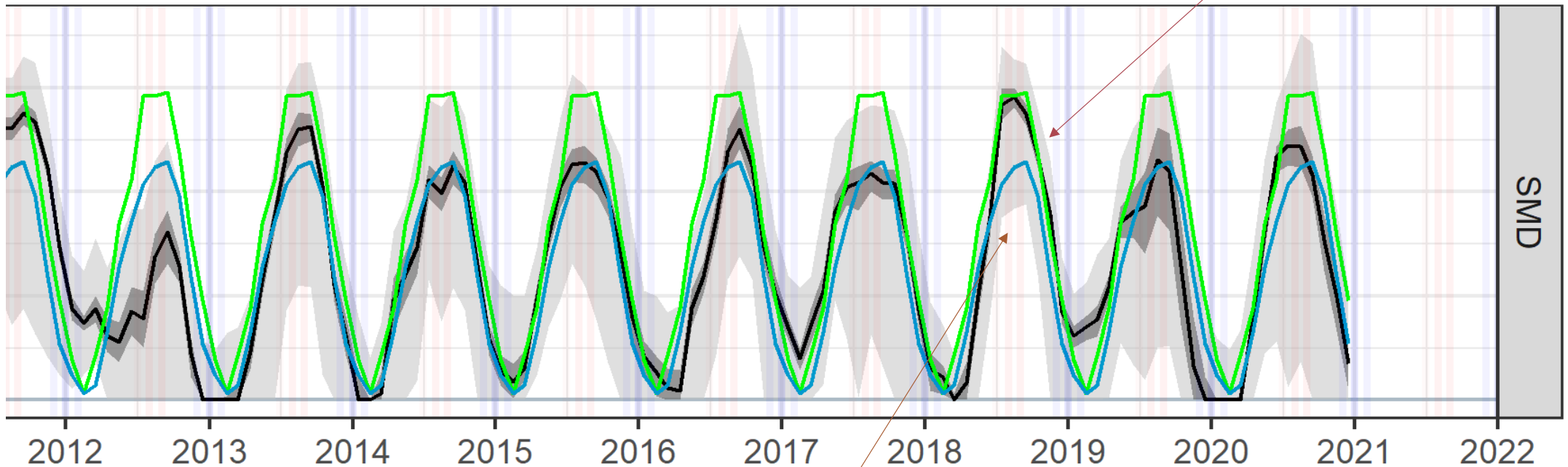


Build future weather simulations / climate variables

Blue line = 2006-2020 average

Green line = 2080s average

Green line – RCP8.5 2080s average



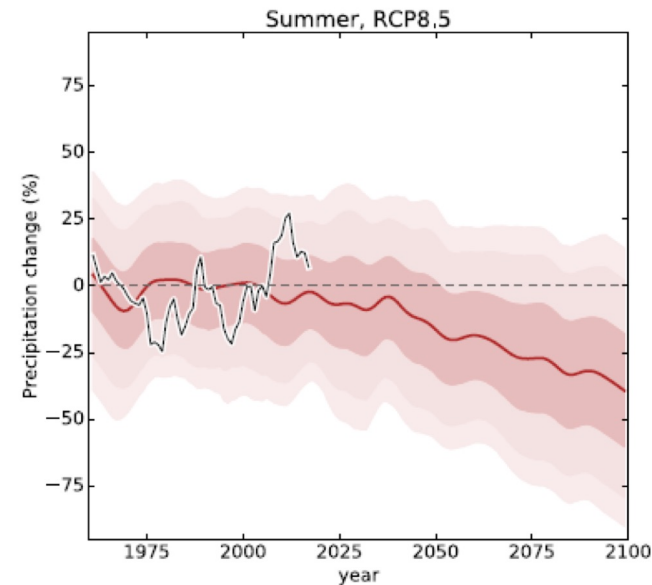
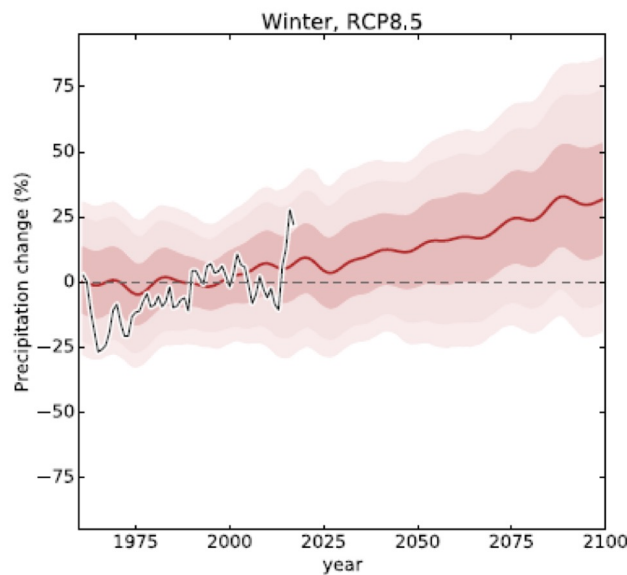
Blue line – 2006-2020 average

Black lines are actual values – not the variations / extremes

Step 6 — Integrate Future Climate Data in the Models (equations)

- Drop out the observed weather data
- Insert the future weather scenarios in your models
- This is why you **must ensure the climate data you use matches the format / structure of your observed / baseline data**

Future UK precipitation



Step 7 — Validate Against Reality / Experience / Expertise

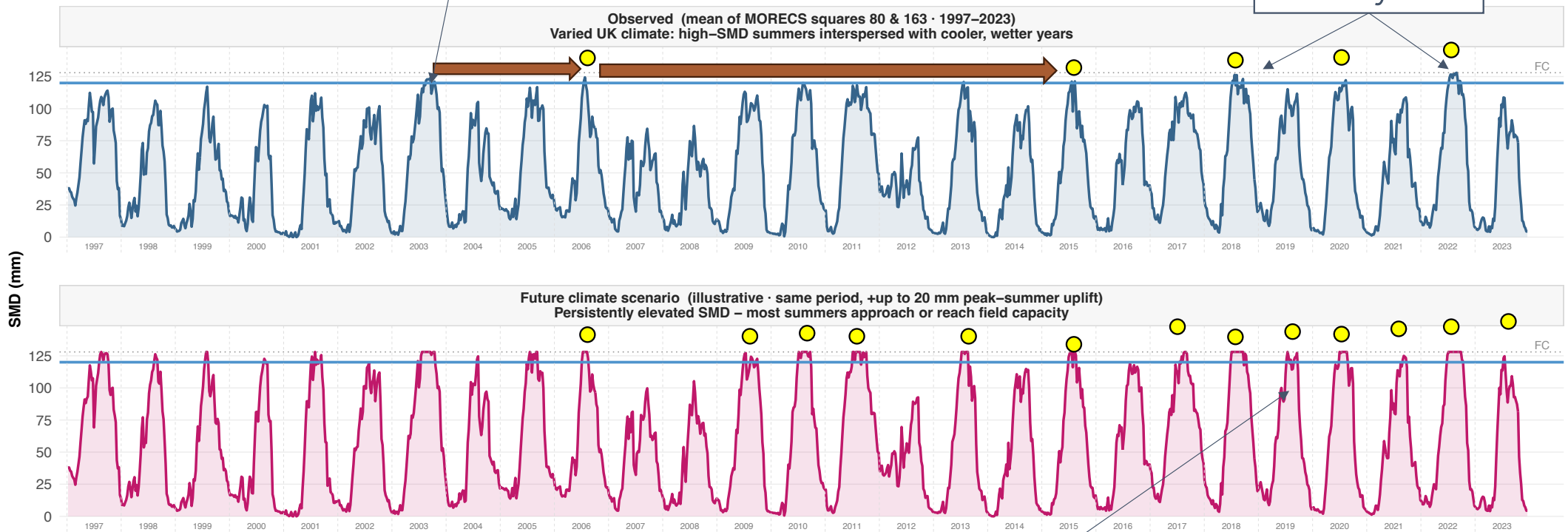
- Check model outputs against real-world observed data
 - What trends are similar to those you see now?
 - What was surprising?
 - Is there anything you fundamentally disagree with?
- Talk with your people on the ground
- You may also want to consider frequency / length of gaps between extreme events



SMD max in successive years

How important is the interval / lag between event years?

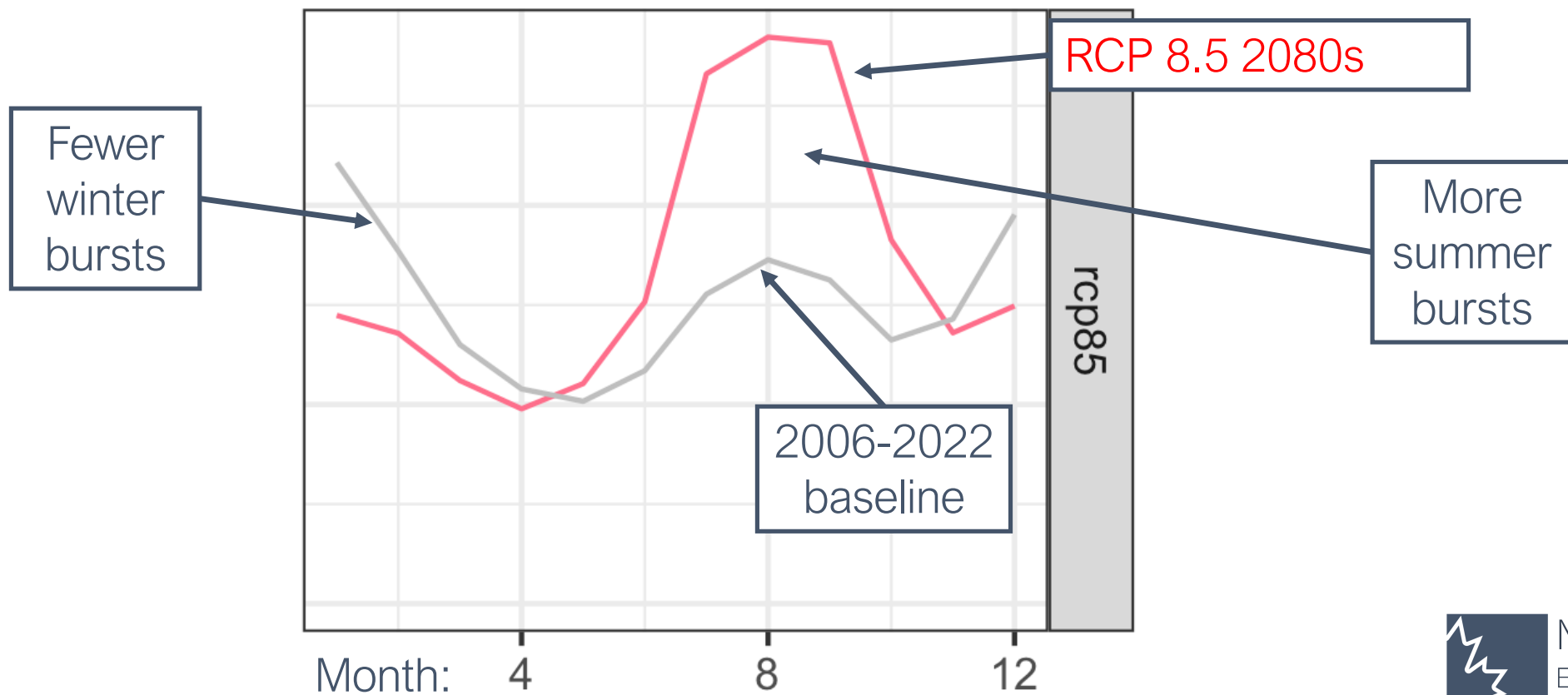
Soil Moisture Deficit – Observed vs Future Climate Scenario



What happens to the pipes when the soils dry out MOST years?

What you are likely to see...

Every region is different but there are some key trends to look out for:



1. Fewer winter bursts

Assuming no further deterioration of the assets...

- Expect fewer iron bursts in winter, on average.
- Winter outbreaks still will occur, but will be less frequent.
- When winters are cold, many bursts, and much leakage will occur.

2. More summer bursts

Assuming no further deterioration of the assets...

- Expect more bursts:
 - AC
 - Iron
 - PVC
- Especially in shrinkable soils



3. Increasing water scarcity

Assuming no further deterioration of the assets...

- **More bursts** and **higher leakage** will occur in summer months, when water demand is greatest.
- *Extreme* years like 2022, 2025, 2026 will become *average* years
- Hose pipe bans and visibly bursting pipes ... PR issues

3 Key things to remember

- 1) Prioritise data cleaning and validation
- 2) Ensure you have a good understanding of WHY pipes fail / leak
- 3) Be aware of model extrapolation beyond observed data range – there is more uncertainty when pipes are exposed to new extremes or more frequent extremes



Let's connect on
LinkedIn for more
details / questions

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