Climate change: the science and the predictions

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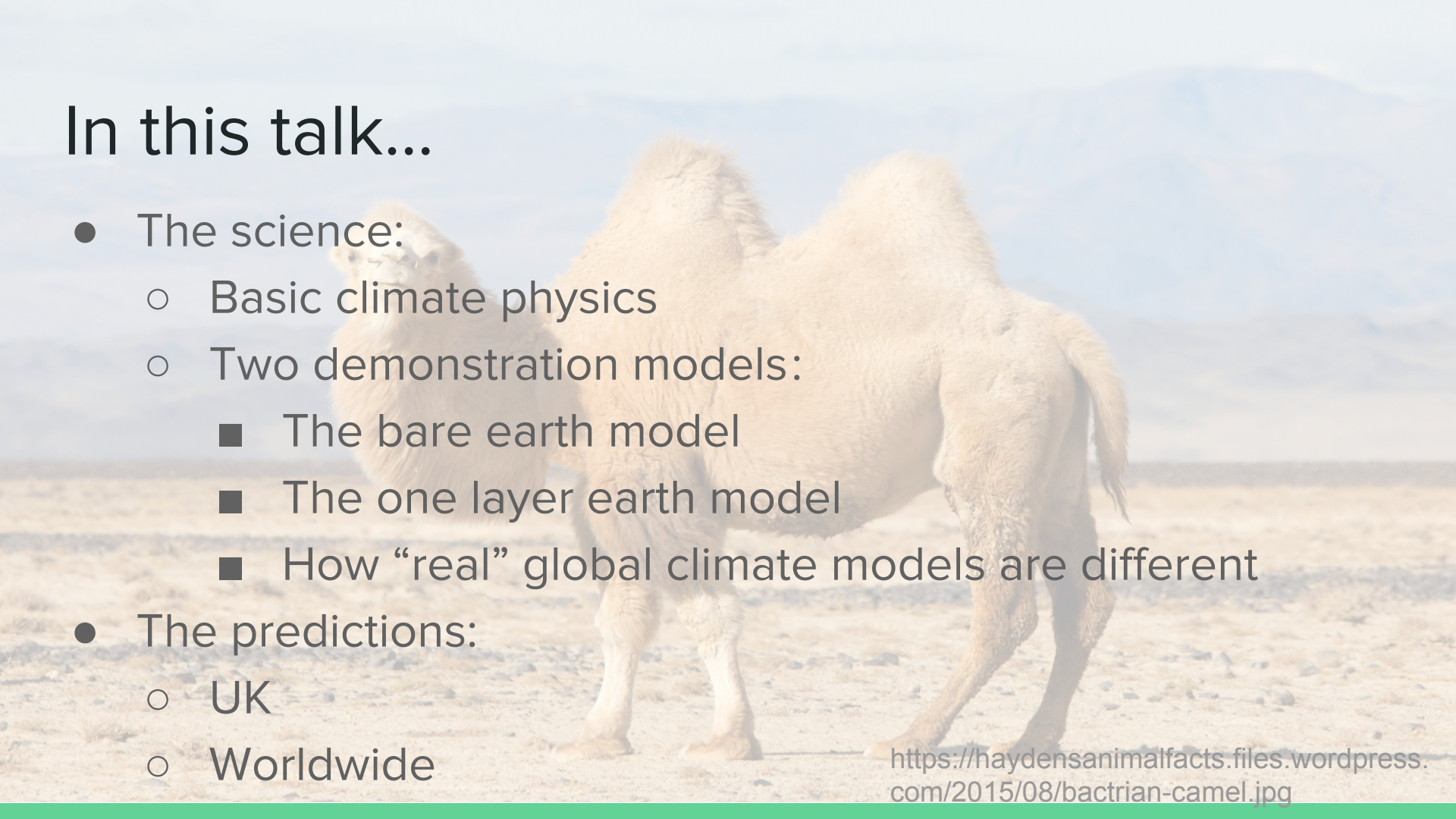
That inevitable disclaimer…

This talk is the result of my research and huge amounts of other people's research. This is at the forefront of science, hence inevitably there are uncertainties. Any and all decisions should be made in response to the original literature, the speaker and the university will not be liable for any correct or incorrect information in this talk.

http://s2.quickmeme.com/img/e8/e8e18

In this talk...

- The science:
  - Basic climate physics
  - Two demonstration models:
    - The bare earth model
    - The one layer earth model
    - How “real” global climate models are different
- The predictions:
  - UK
  - Worldwide



https://haydensanimalfacts.files.wordpress.com/2015/08/bactrian-camel.jpg

The science of climate change

In a nutshell...

Climate change is about a change in energy of our planet.

Change in energy = amount of energy in - amount of energy out

Hot things emit energy by radiation

https://upload.wikimedia.org/wikipedia/commons/thumb/a/a9/Hot_metalwork.jpg/

Hot things emit energy by radiation

https://upload.wikimedia.org/wikipedia/commons/c/cf/Ir_girl.png

Hot things emit energy by radiation

$$E = \varepsilon \sigma T^4$$

https://upload.wikimedia.org/wikipedia/commons/c/cf/Ir_girl.png

Hot things emit energy by radiation

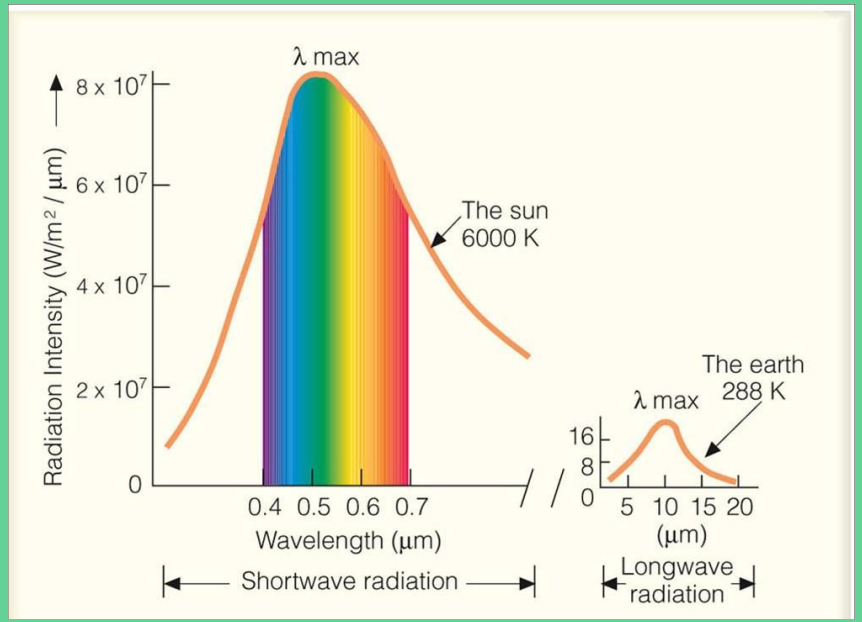
Energy emitted

$$E = \varepsilon \sigma T^4$$

Hot things emit energy by radiation

Energy emitted “Blackbody-ness”

$$E = \varepsilon \sigma T^4$$



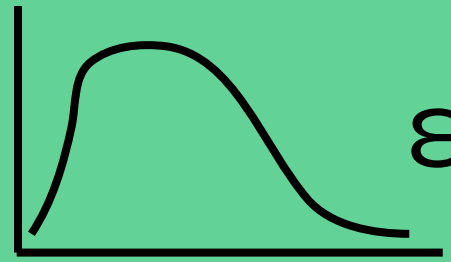
http://apollo.lsc.vsc.edu/classes/met130/notes/chapter2/graphics/earth_sun_plank.jpg

Hot things emit energy by radiation

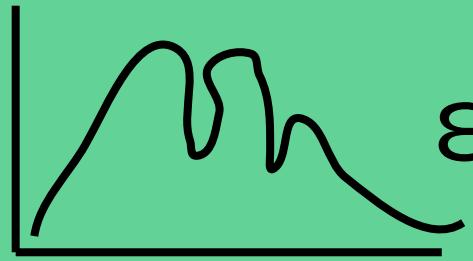
Energy emitted

“Blackbody-ness”

$$E = \varepsilon \sigma T^4$$

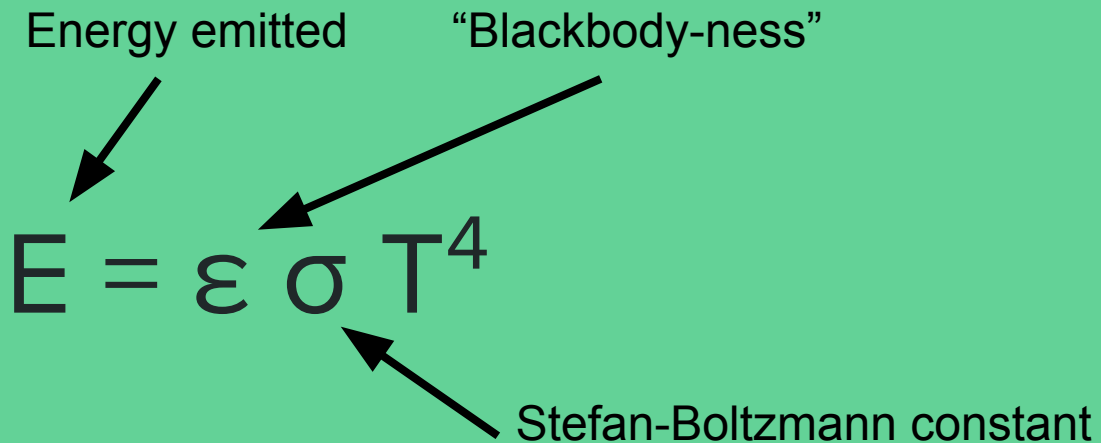


$\varepsilon=1$



$\varepsilon<1$

Hot things emit energy by radiation



Hot things emit energy by radiation

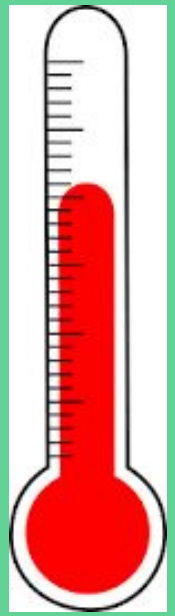
Energy emitted

“Blackbody-ness”

$$E = \varepsilon \sigma T^4$$

Temperature

Stefan-Boltzmann constant



We can already make a simple climate model...

Change in energy = energy in - energy out

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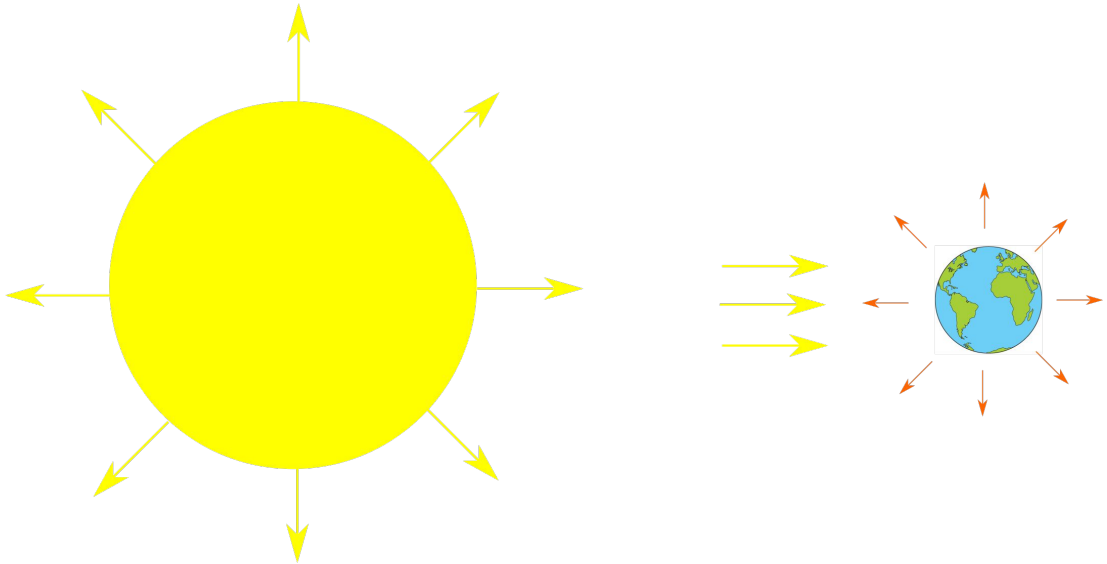

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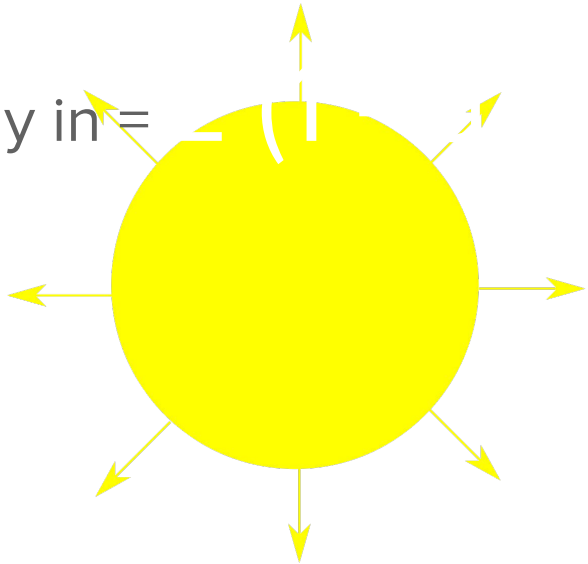
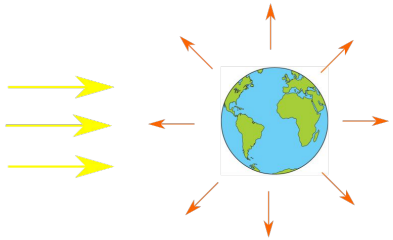
Energy in =





Energy out =

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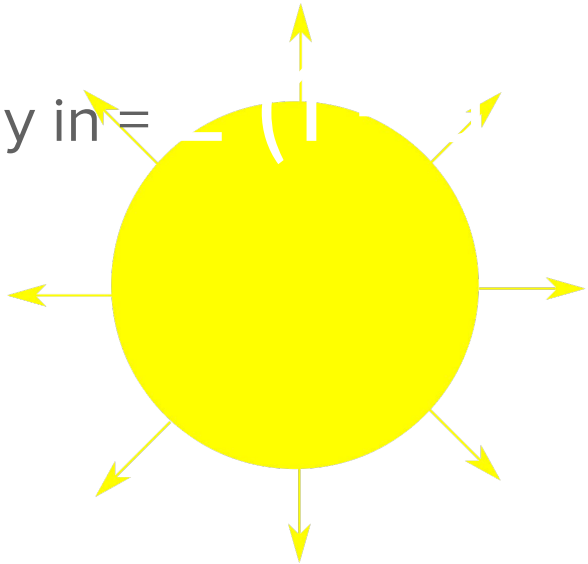
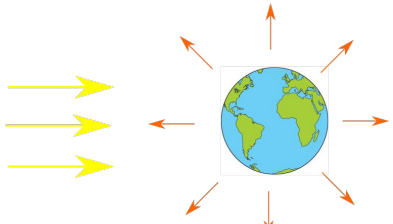


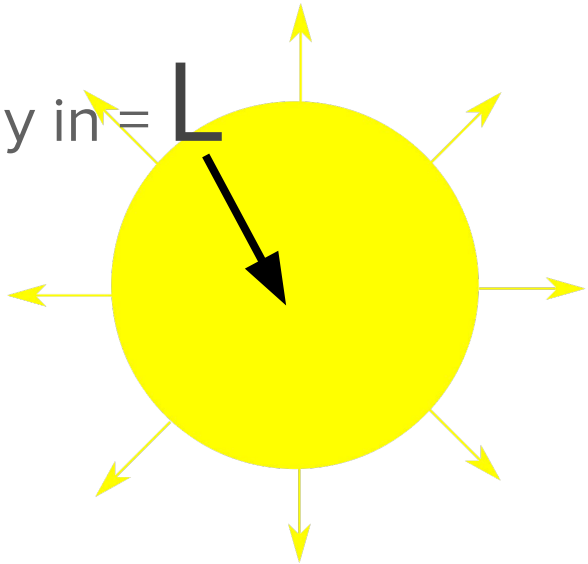


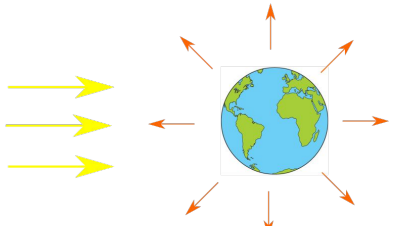
Energy out = $\varepsilon \sigma T^4 A_1$

We can already make a simple climate model...

Change in energy = energy in - energy out

Energy in = L



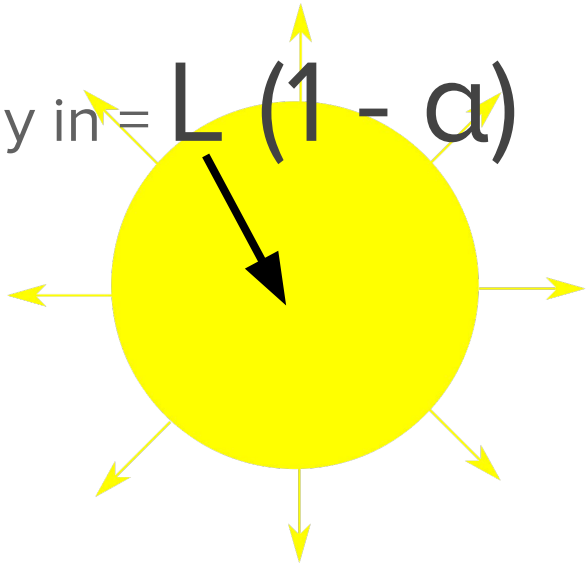


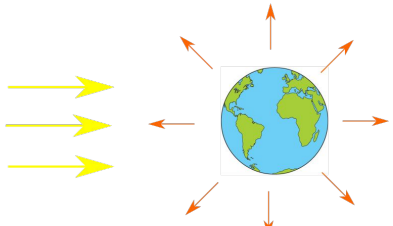
Energy out = $\varepsilon \sigma T^4 A_1$

We can already make a simple climate model...

Change in energy = energy in - energy out

Energy in = $L\ (1 - \alpha)$



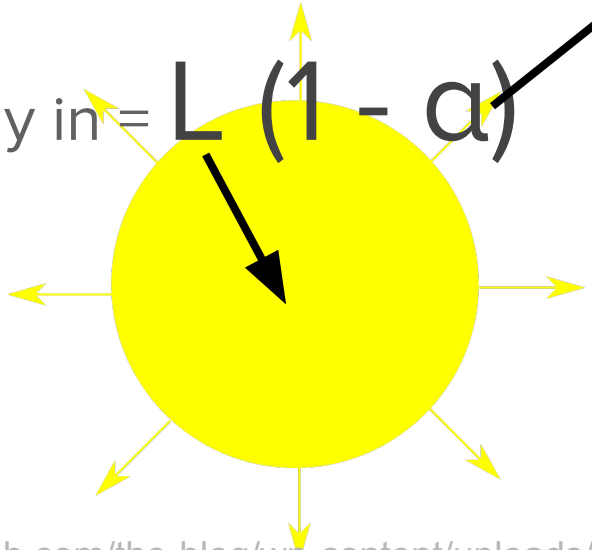


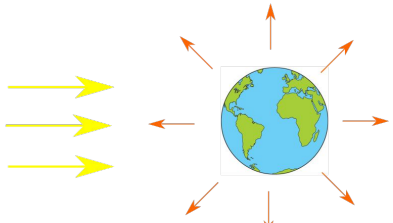
Energy out = $\varepsilon\ \sigma\ T^4\ A$

We can already make a model...

Change in energy = energy in - ene

Energy in = $L_{\odot}(1 - \alpha)$





Energy out = $\varepsilon \sigma T^4 A_1$

http://www.pmslweb.com/the-blog/wp-content/uploads/2014/12/1-so-my-friend-works-in-Antarctica-meme.jpg

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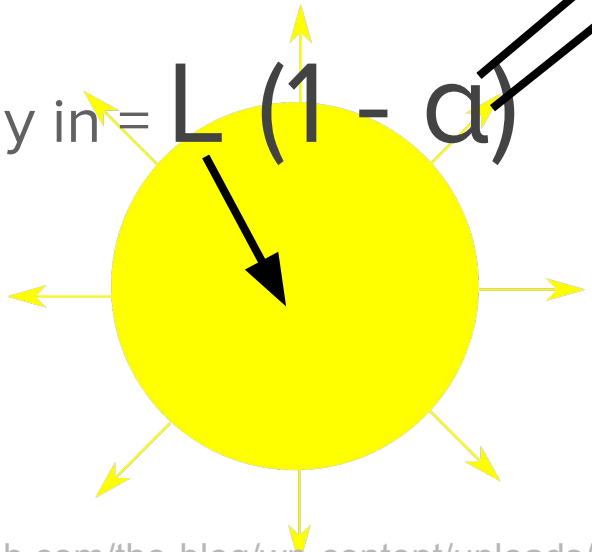

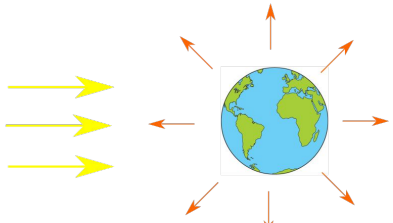

Energy out = $\varepsilon \sigma T^4 A_1$

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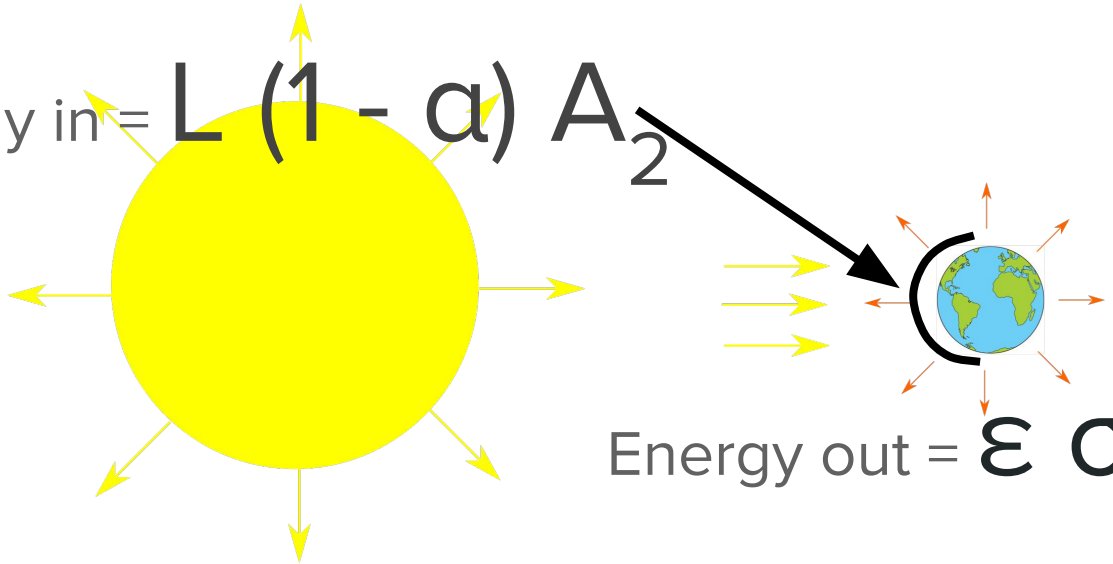
We can already make a simple climate model...

Change in energy = energy in - energy out

Energy in = $L\,(1 - \alpha)\,A_2$



Energy out = $\varepsilon\,\sigma\,T^4\,A_1$

We can already make a simple climate model...

Change in energy = energy in - energy out

Change in energy = $L\,(1 - \alpha)\,A_2 - \varepsilon\,\sigma\,T^4\,A_1$

We can already make a simple climate model...

Change in energy = energy in - energy out

$$0 = L\,(1 - \alpha)\,A_2 - \varepsilon\,\sigma\,T^4\,A_1$$

We can already make a simple climate model...

Earth’s modelled temperature = 255 K

Earth’s real temperature = 295 K

We can already make a simple climate model…

Earth's modelled temperature = 255 K

It's a bit too cold!

Earth's real temperature = 295 K

http://www.dailyhaha.com/_pics/let_the_cat_in.jpg

This model is overly simple

You don’t say….!

It doesn’t have:

- An atmosphere
- An ocean
- A biosphere

And yet it predicts the mean earth temperature to within 40 degrees C. Impressive….

Expanding the model a tiny bit...

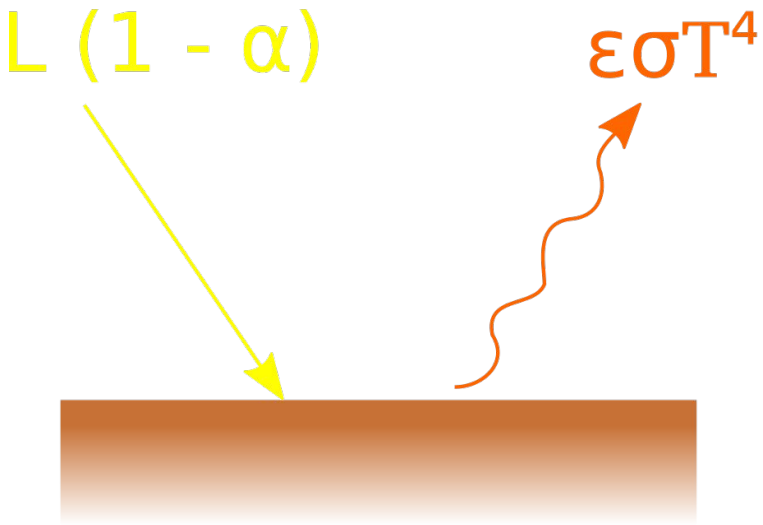
How might an atmosphere absorb and emit energy?

Expanding the model a tiny bit...

How might an atmosphere absorb and emit energy?

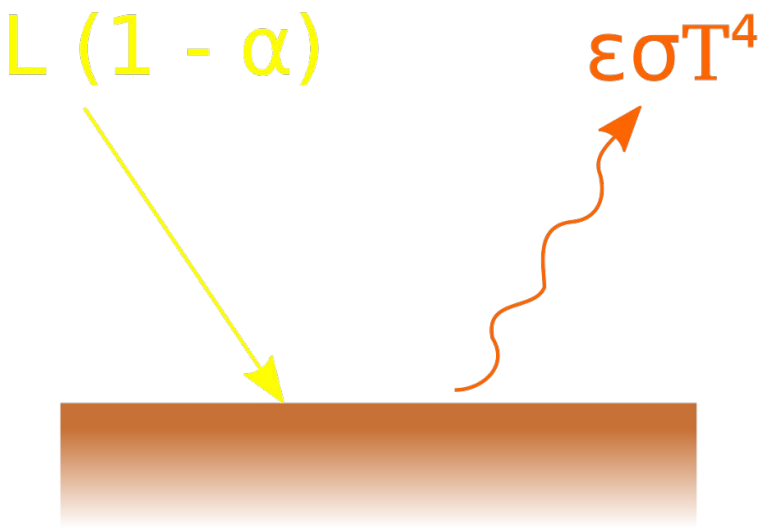
Exactly the same way! $\varepsilon \sigma T^4$

Expanding the model a tiny bit...



Our first model

Expanding the model a tiny bit...



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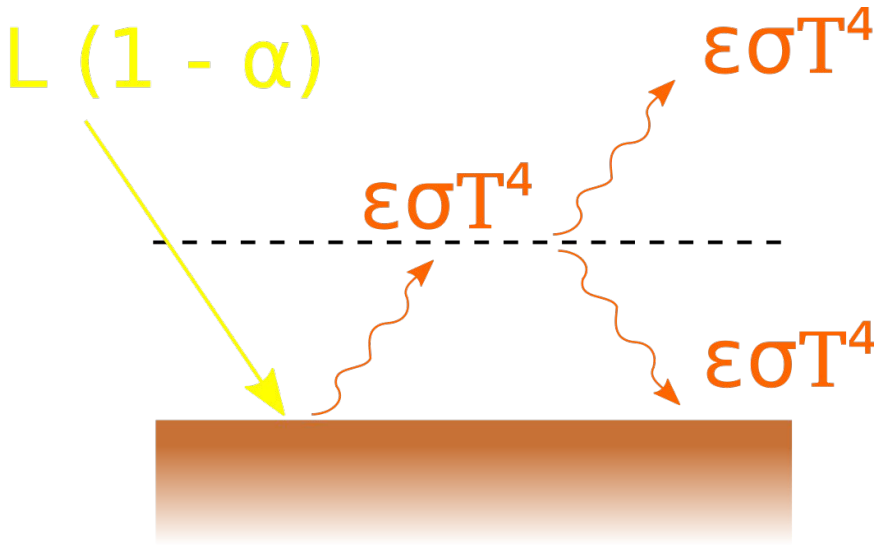

Our new model

Expanding the model a tiny bit...

Earth’s modelled temperature = 303 K

Earth’s real temperature = 295 K

Expanding the model a tiny bit…

Earth’s modelled temperature = 303 K

Now it’s a bit too warm!

Earth’s real temperature = 295 K

http://themetapicture.com/media/funny-bear-swimming-pool.jpg

Our model is still much too simple

But regardless, lets recap

- The energy change = energy in - energy out
- Any hot “thing” emits energy as a blackbody
- Adding in an atmosphere means energy is absorbed and emitted before being lost to space - like earth wearing a coat.

When does a gas absorb energy?

When the frequency of the light is close to the frequency of vibration of the gas molecule

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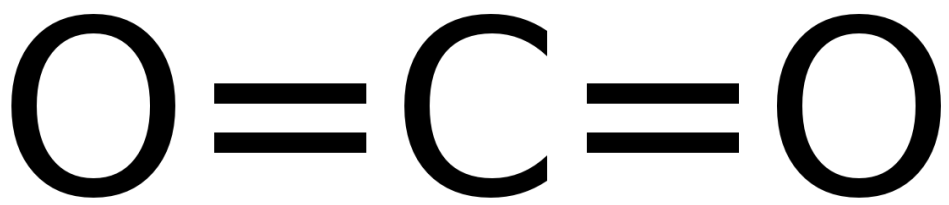
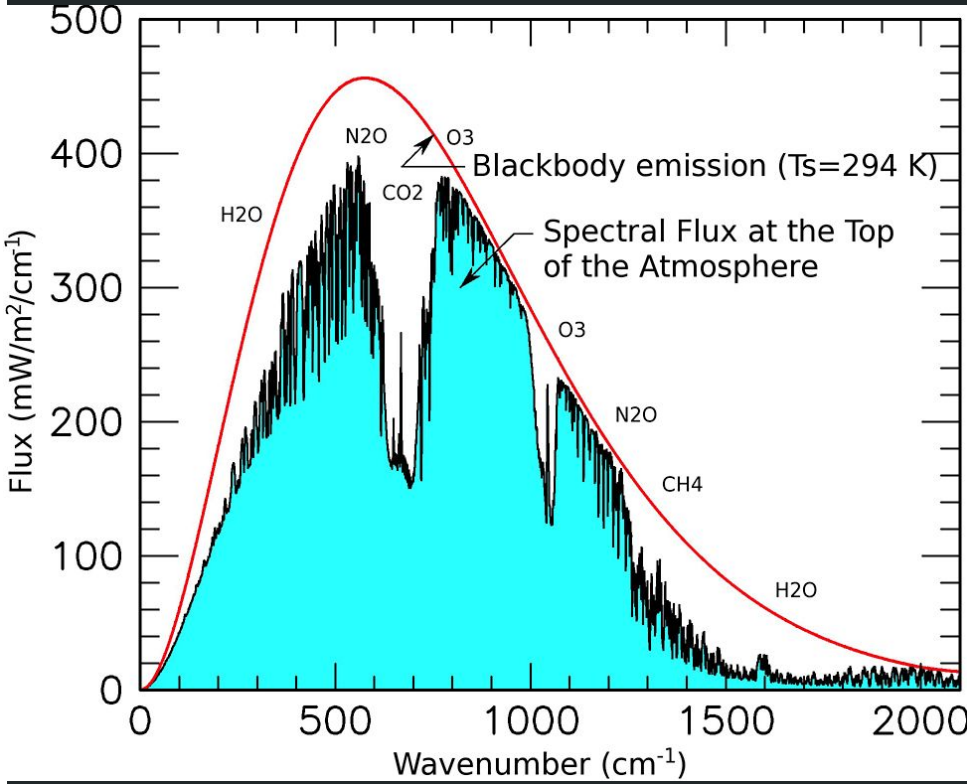
When the frequency of the light is close to the frequency of vibration of the gas molecule

E.g CO_2 H_2O and CH_4

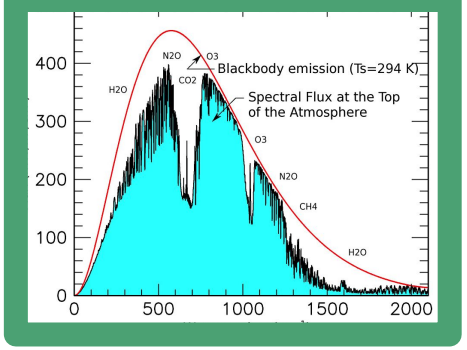


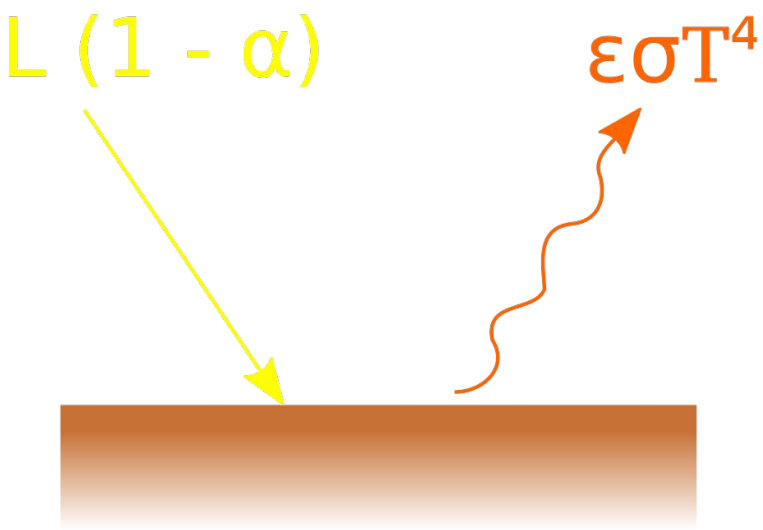
Blackbody curves

Area under the curve is proportional to the energy lost to space

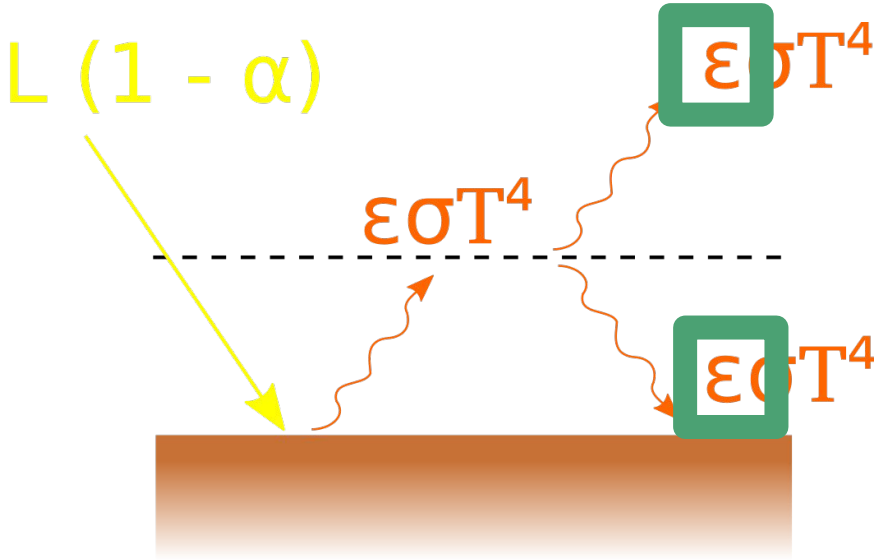


NASA.gov





Our first model



Our new model

These other factors go into proper climate models

- Atmospheric convection
- Clouds
- Aerosols
- Global distributions of gases
- Oceans
- Permafrost
- Albedo changes
- Biosphere interaction
- Volcanoes
- Solar activity
- Earth’s precession / obliquity / eccentricity
- Feedback loops….

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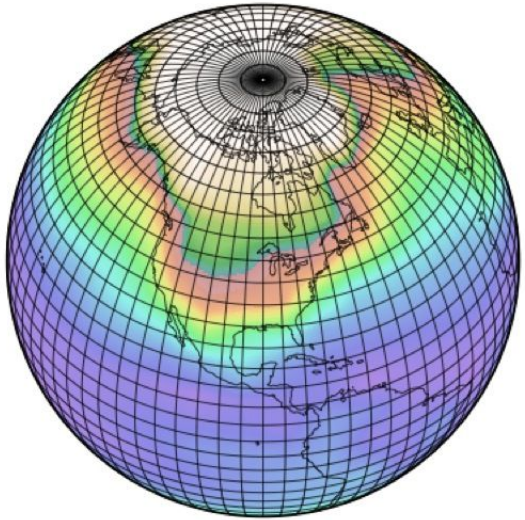

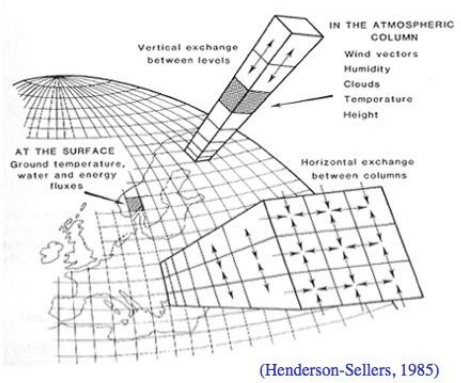

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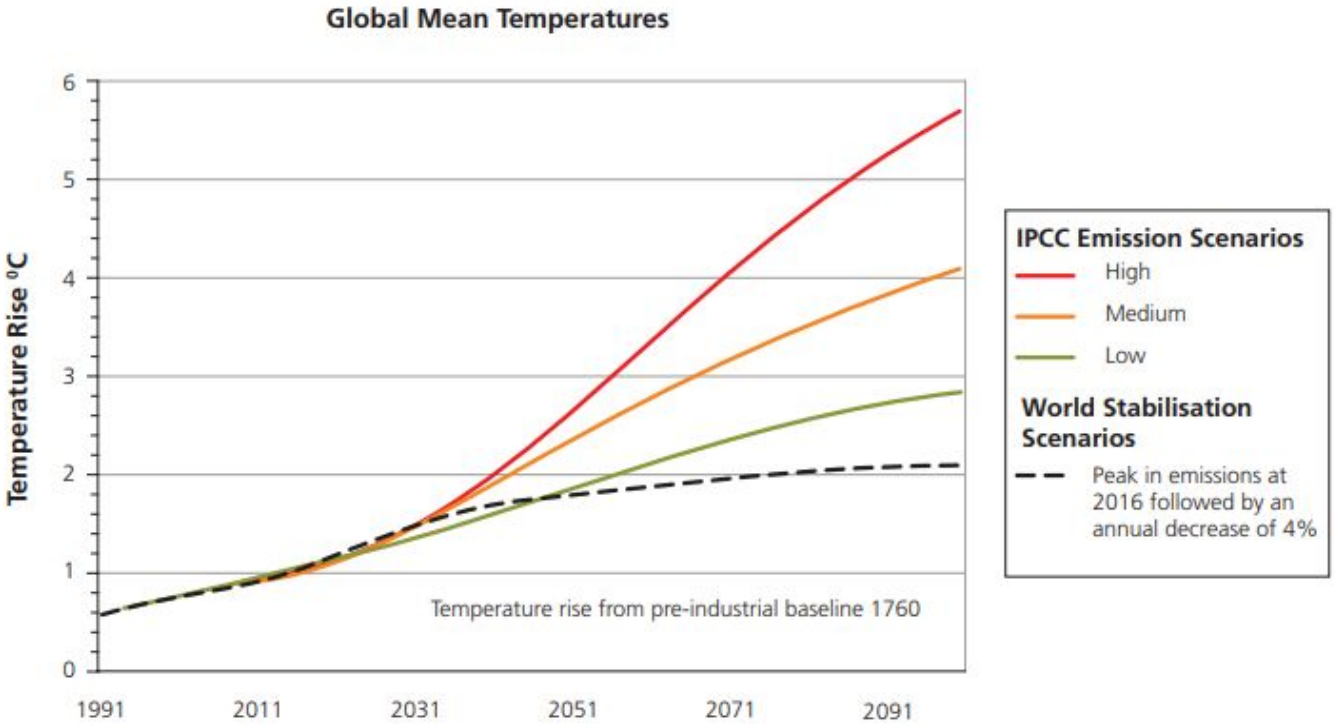
The forecast

The forecast

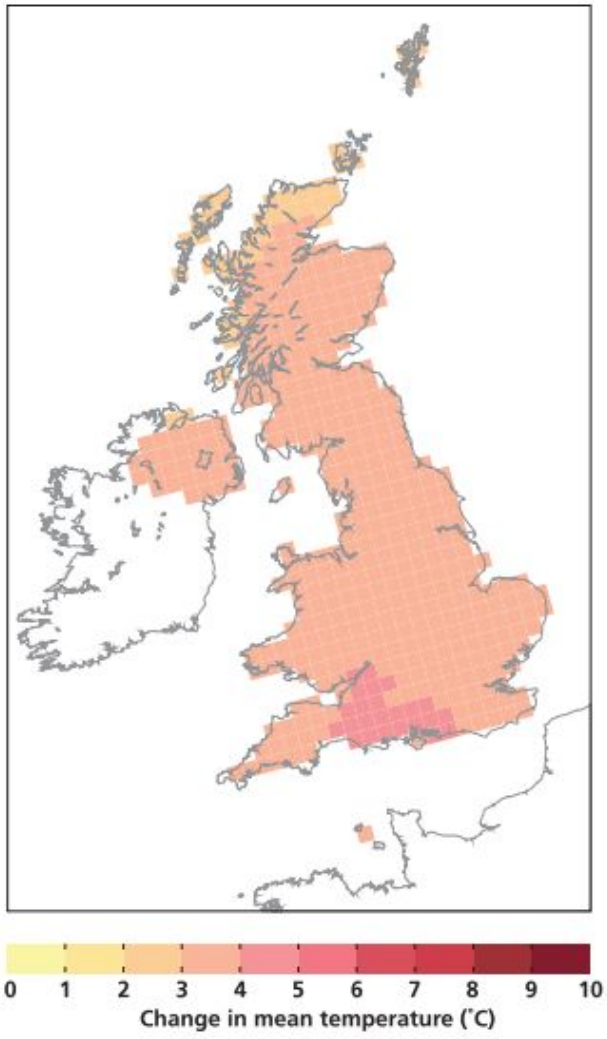


http://ukclimateprojections.metoffice.gov.uk/21708

The forecast

Medium emissions scenario

Annual mean temperature



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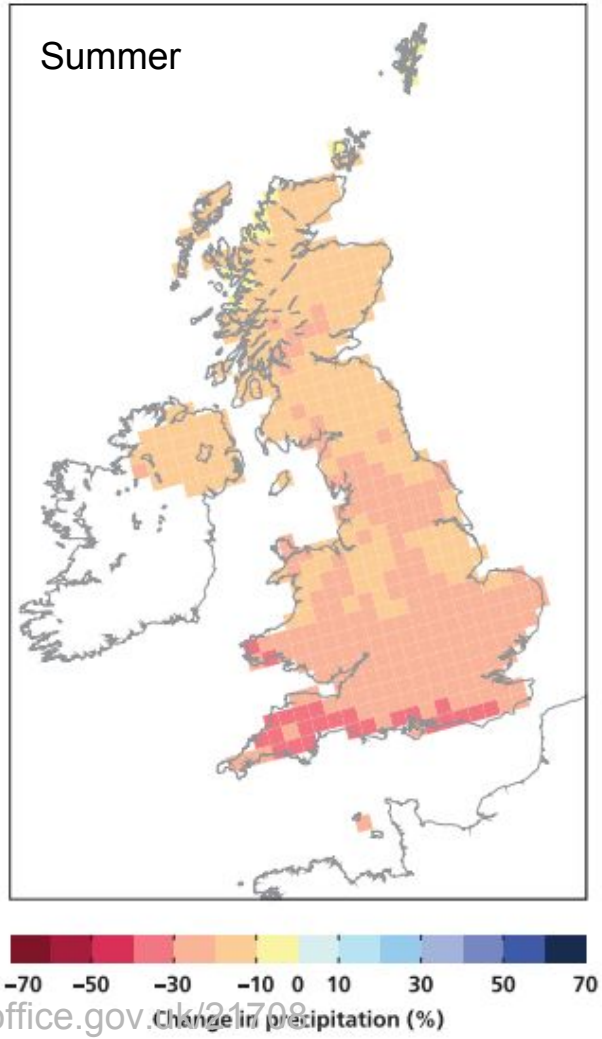
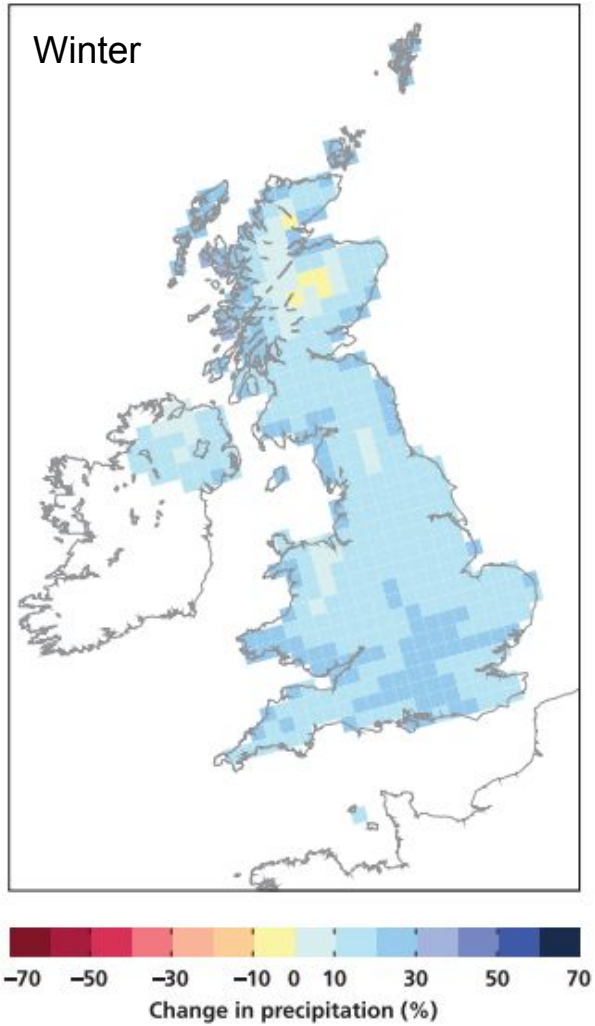
The forecast

Medium emissions scenario

Summer and winter precipitation





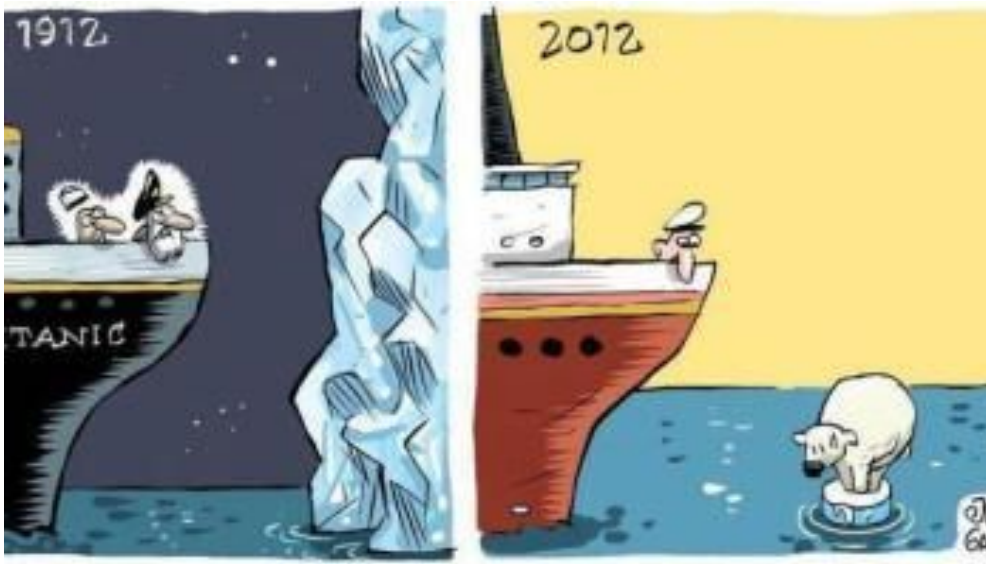
http://ukclimateprojections.metoffice.gov.uk/21708

UK summary

- A few degrees of warming throughout the UK may only normally be noticeable in the heights of summer.
- Increases in rain, and more extreme weather (storms, higher windes and worse flooding) may be the biggest threat in the short to medium term.
- But the UK does not exist in isolation. Must be considered in the context of the rest of the world.

http://harry.enzoverder.be/cats/

The global forecast

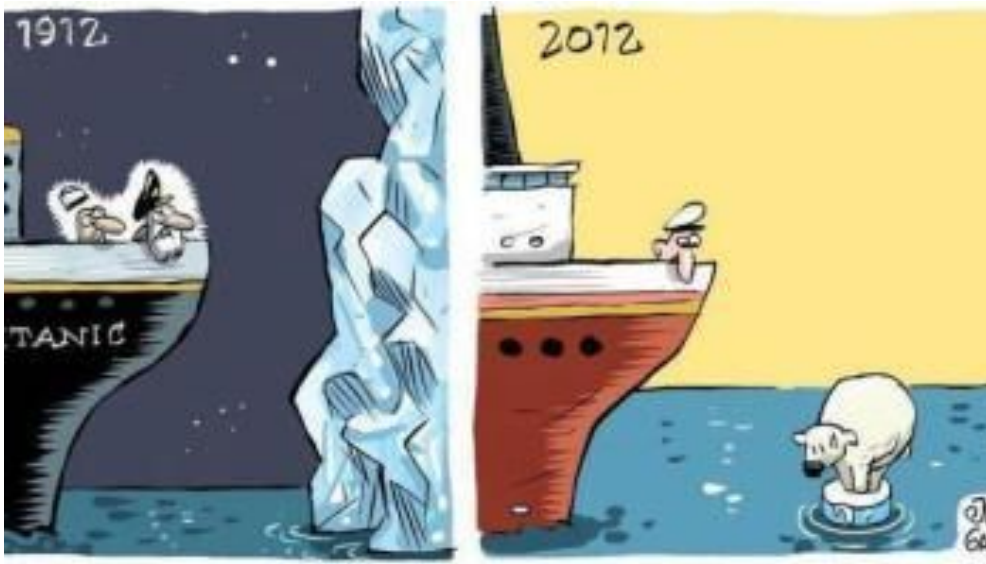


https://i.pinimg.com/originals/c8/fc/c5/c8fcc5c8869a95ed10339de6cf937c2f.jpg

The global forecast - 1°C

Droughts in the American dustbowl causing grain and meat shortages - predictions range from arid to hyper arid. Ecological change in Amazon, coral reefs mostly wiped out. More hurricanes, inc. in the south Atlantic. Several million people displaced in the Bay of Bengal.

On the bright side, good for growing wine in the south of England!



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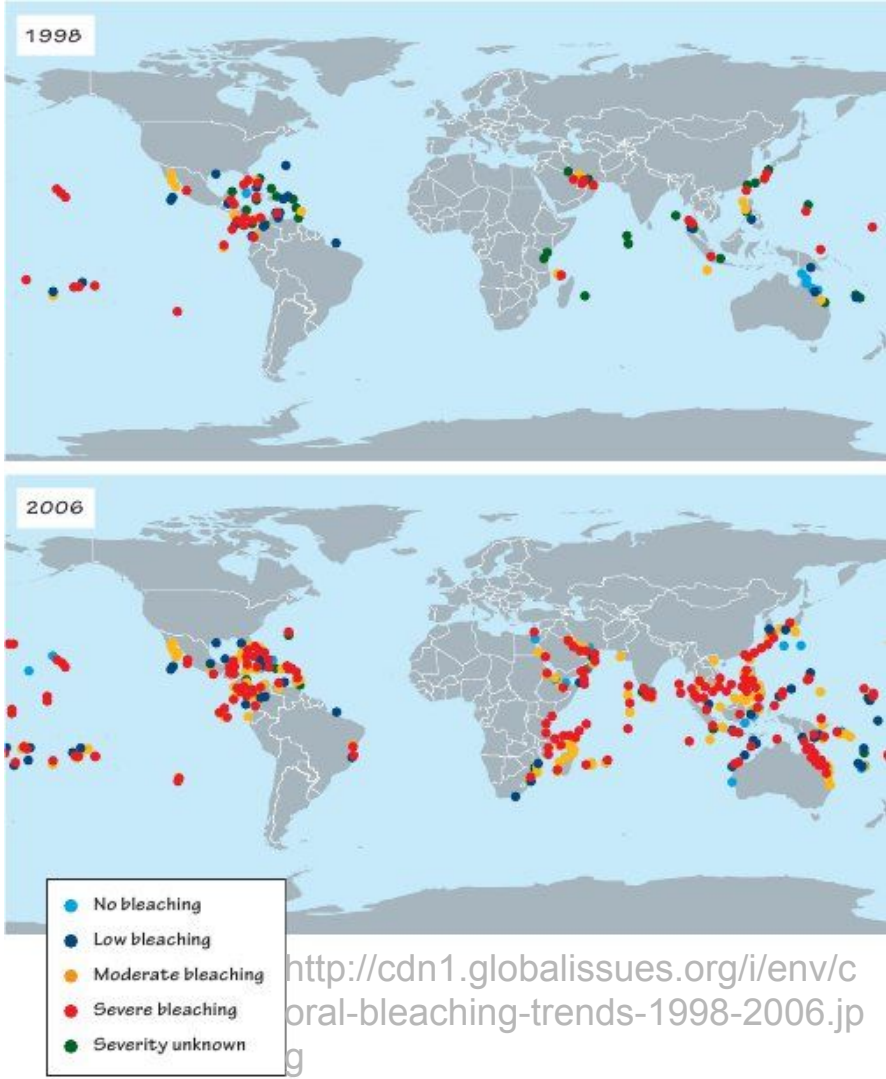
The global forecast - 1°C

This is happening already:

70% of coral reefs worldwide are already dead.



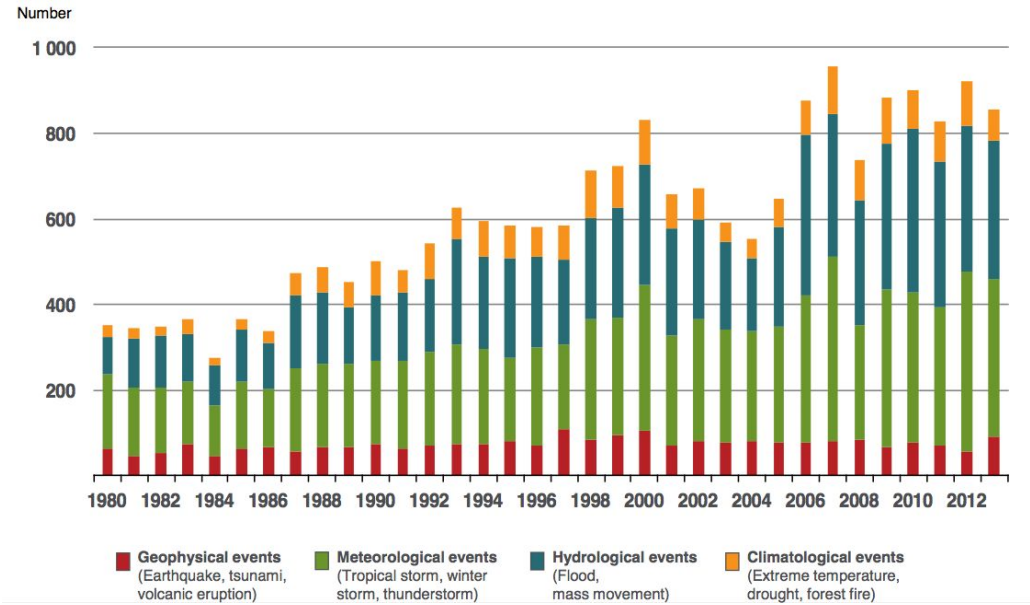
http://cdn1.globalissues.org/i/env/coral-bleaching-trends-1998-2006.jpg

The global forecast - 1°C

This is happening already:

70% of coral reefs worldwide are already dead.

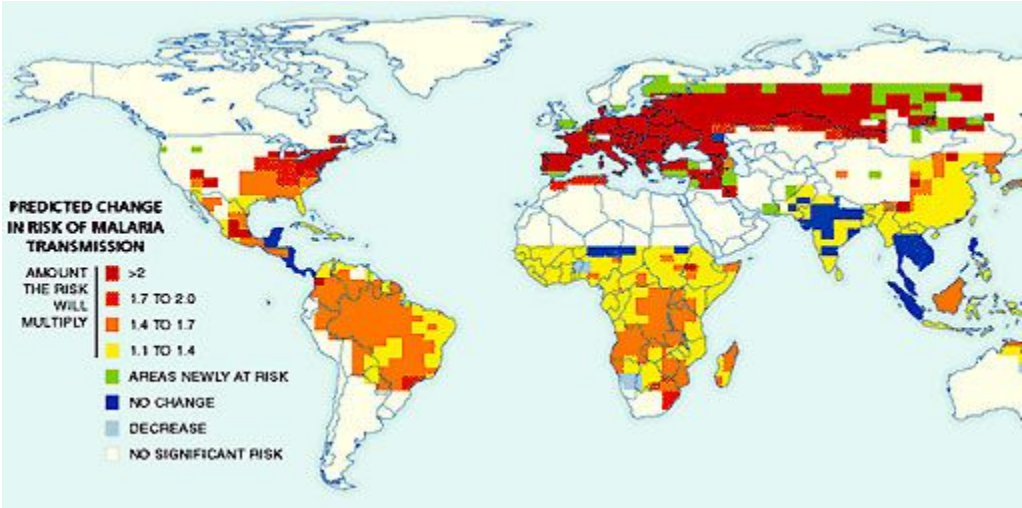
Climate related natural disasters are increasing, while geological disasters are relatively constant.



https://skepticalscience.com/pics/MunichReDisasterFrequency.png

The global forecast - 2°C

Polar bears likely wiped out, South Europe and USA heatwaves cause large scale migration. Insects migrate in new directions, including malaria bearing mosquitoes in most of Europe including southern Britain. Serious increases in forest fires in the Western USA, Australia, and eastern Europe.



https://www.exploratorium.edu/climate/global-effects/data/risk6-3.jpg

The global forecast - 3°C

Manhattan and Holland under water. The arctic is fully ice free all year. Alpine glaciers are all gone. Amazon is mostly dry. El nino extreme is the norm. The mediterranean is mostly desert - summer is like North Africa and the Middle East. Truly violent storms become the norm.

The global forecast - 4°C and beyond

London has climate similar to Marakesh. Most of southern Europe is semi desert to full desert. The world's most productive farmlands are Northern Canada. Oceans rise displacing around a billion people. Venice / Egypt / Bangladesh / Holland entirely lost. London and New York mostly lost. Gigantic mass scale migrations as food forecasts cannot support the world’s population. The Amazon and most of Brazil is desert.

https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcRoN3POT_zIw4QorUz6Izy8_bVDsw4wAaTRv8mIIRGliS4GtYc4sA

Is there any hope?

Is there any hope?

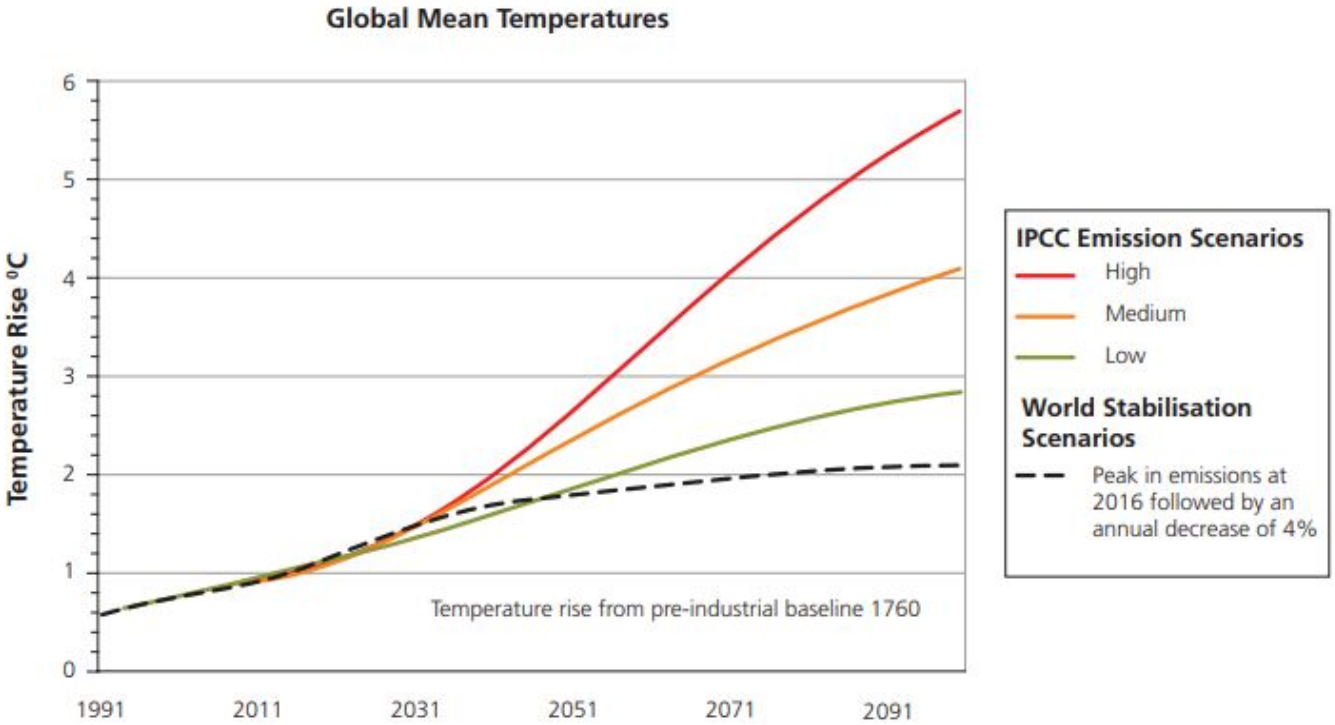
Yes

Is there any hope?

Yes

- Energy proof your home. Get plugs that turn off things sitting on standby (“vampire loads”). Get better insulation. Change to LED bulbs. Recycle. Etc.
- Use your vote for politicians who are trying to do something about climate change.
- Change your energy supplier to a renewable one.
- Walk / cycle / use public transport where possible.

It’s not too late…



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Thank you for listening!

Any questions?

Murrayhoggett@gmail.com