Forest Research
The Research Agency of the Forestry Commission

Understanding impacts of climate change on our forests

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FR, Alice Holt, Farnham

FCW Seminar on "*Combating Climate Change*"

Outline

- Causes of anthropogenic climate change
- Changes in climate so far
- Examples of impacts so far
- Future climate projections for Wales
- Uncertainties
- Possible impacts
  - direct, e.g. temperature and tree growth
  - indirect, e.g. management, policy, global trade

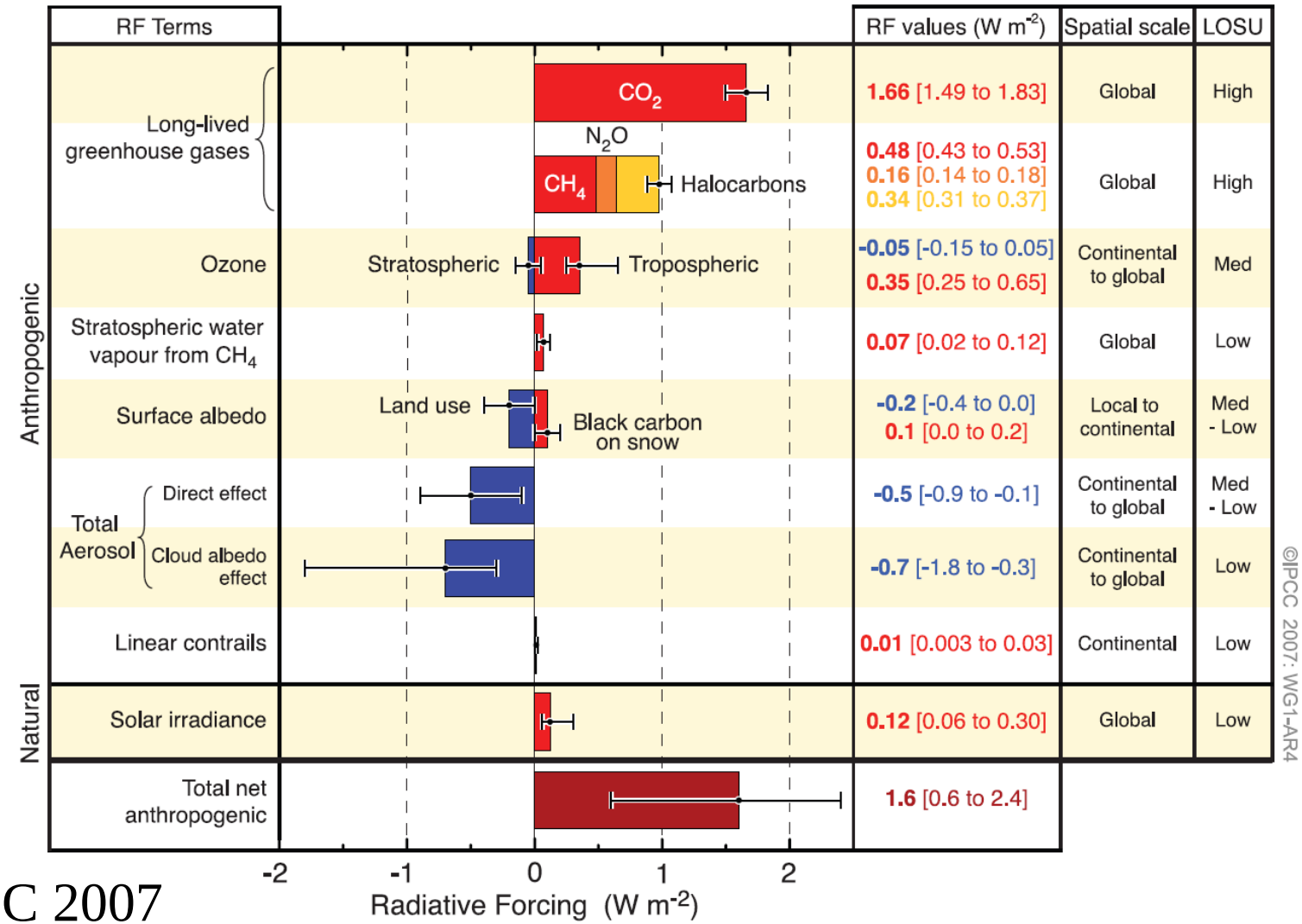
Climate change causes

- Increase in GHG changes the radiation balance
  - CO_2, CH_4, N_2O, O_3 and Halocarbons
- sources
  - industrial uses
  - fossil fuel combustion (coal, gas & oil)
  - deforestation
  - land use change (rice paddies, wetland drainage, livestock, fertiliser use)
- other changes:
  - aerosols & albedo (land use change)
- uncertainties

Not just carbon !

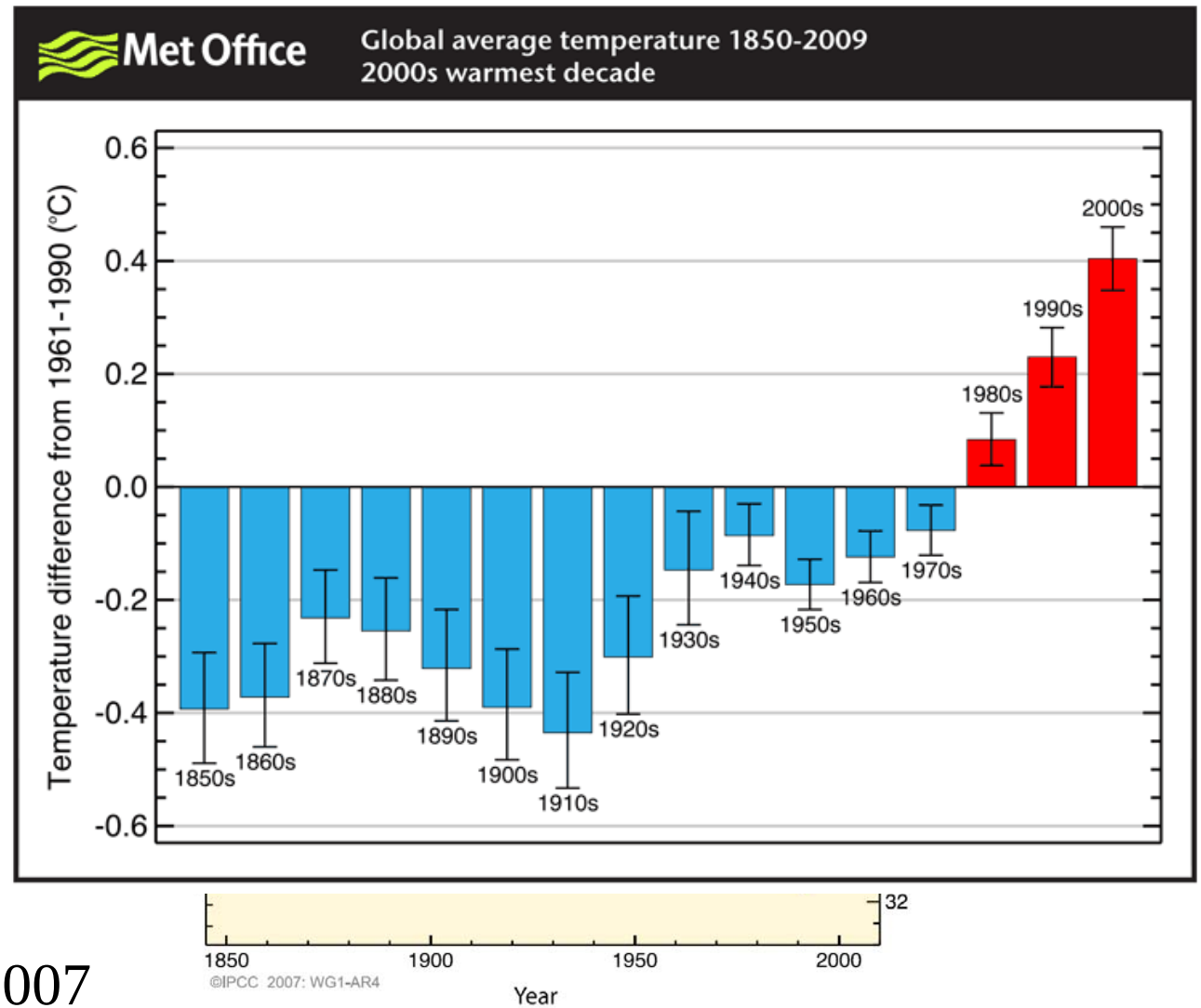
See IPCC 4th Assessment Report, http://www.ipcc.ch/

Present "Radiative Forcing"



IPCC 2007

Causing *global* changes



IPCC 2007

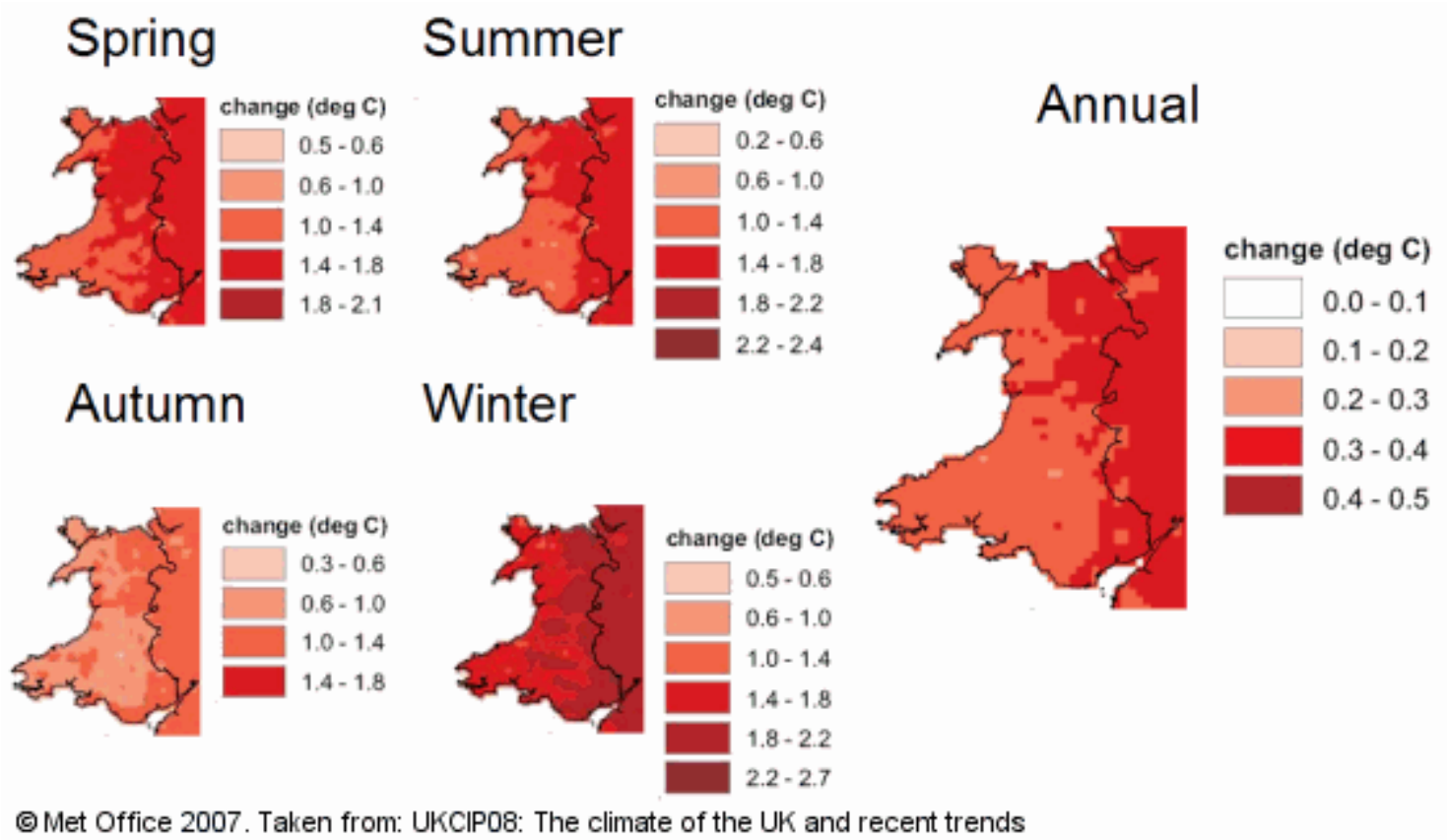
Recent climate trends in Wales

Measured changes in selected climate variables between 1961-2006
after Jenkins *et al.* (2007)

	Spring	Summer	Autumn	Winter	Annual
Daily mean temperature change (°C)	1.4	1.4	1.0	1.7	1.3
Daily maximum temperature change (°C)	1.7	1.6	1.1	1.8	1.5
Daily minimum temperature change (°C)	1.2	1.2	0.9	1.6	1.2
Mean change air frost days (number of days)	-6	-0.2	-2	-13	-22
Percent change in total precipitation (%)	8	-6	22	27	14
Mean change in rain days > = 1mm (no of days)	0.5	-0.7	2.9	4.6	5.7

See: www.ukcip.org.uk, Jenkins et al. (2007), based on linear trend,
see also: www.forestry.gov.uk/climatechange/wales

Recent climate trends in Wales



Change in average daily mean temperature (°C), 1961 to 2006

See: www.ukcip.org.uk, Jenkins et al. (2007), www.forestry.gov.uk/climatechange/wales

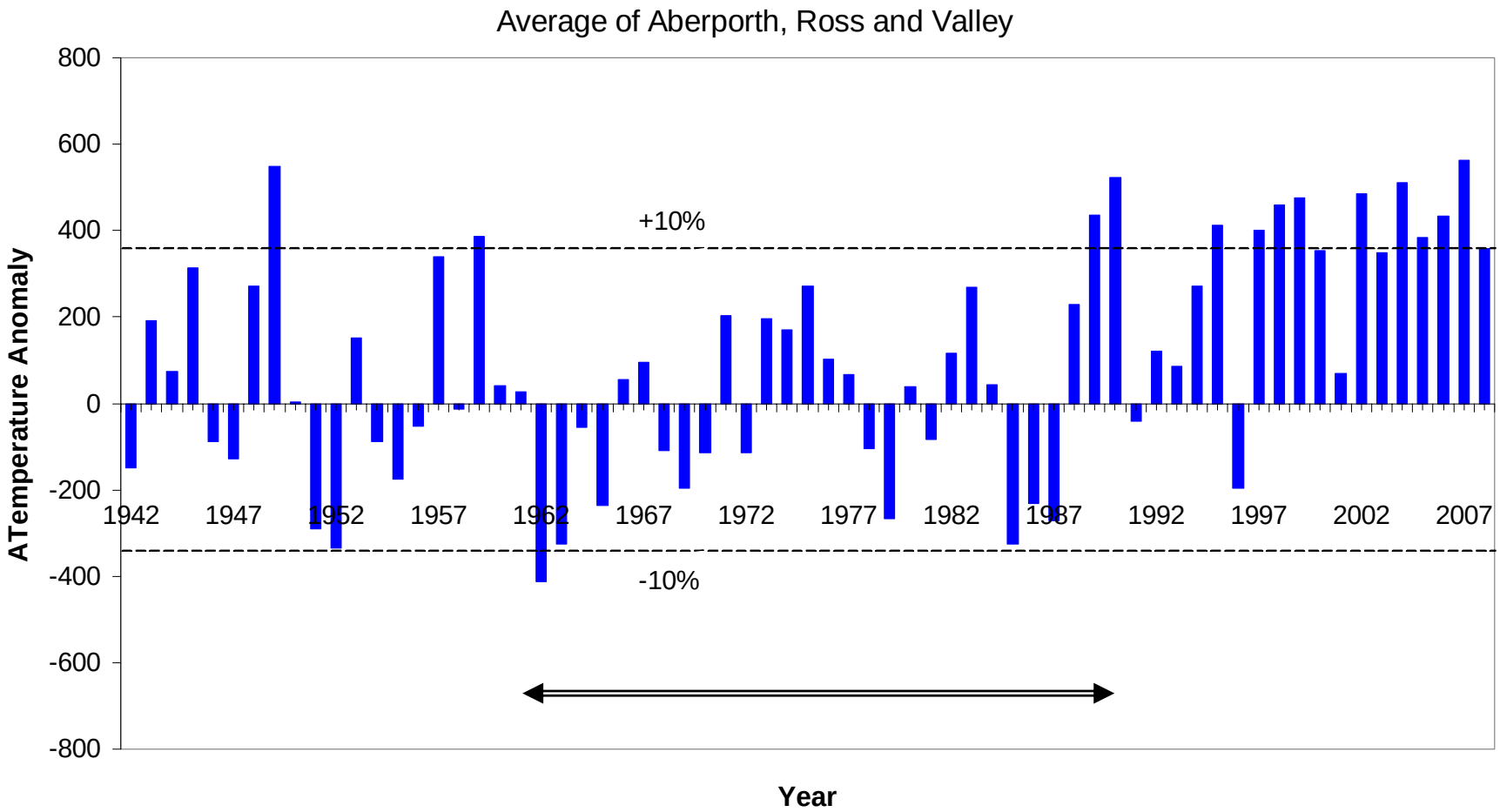
Climate changes so far in Wales

- A significant *increase* in seasonal and annual daily mean, maximum and minimum temperature
- A significant *reduction* in the annual number of frost days, with a significant decrease in the number of late frosts in spring
- A trend of changing seasonal distribution of rainfall, with slightly *less* in the summer, and *fewer raindays* and more in other seasons, with an increase annually

impact on forestry ?

See: www.ukcip.org.uk, Jenkins et al. (2007), www.forestry.gov.uk/climatechange/wales

Growing season temperature change

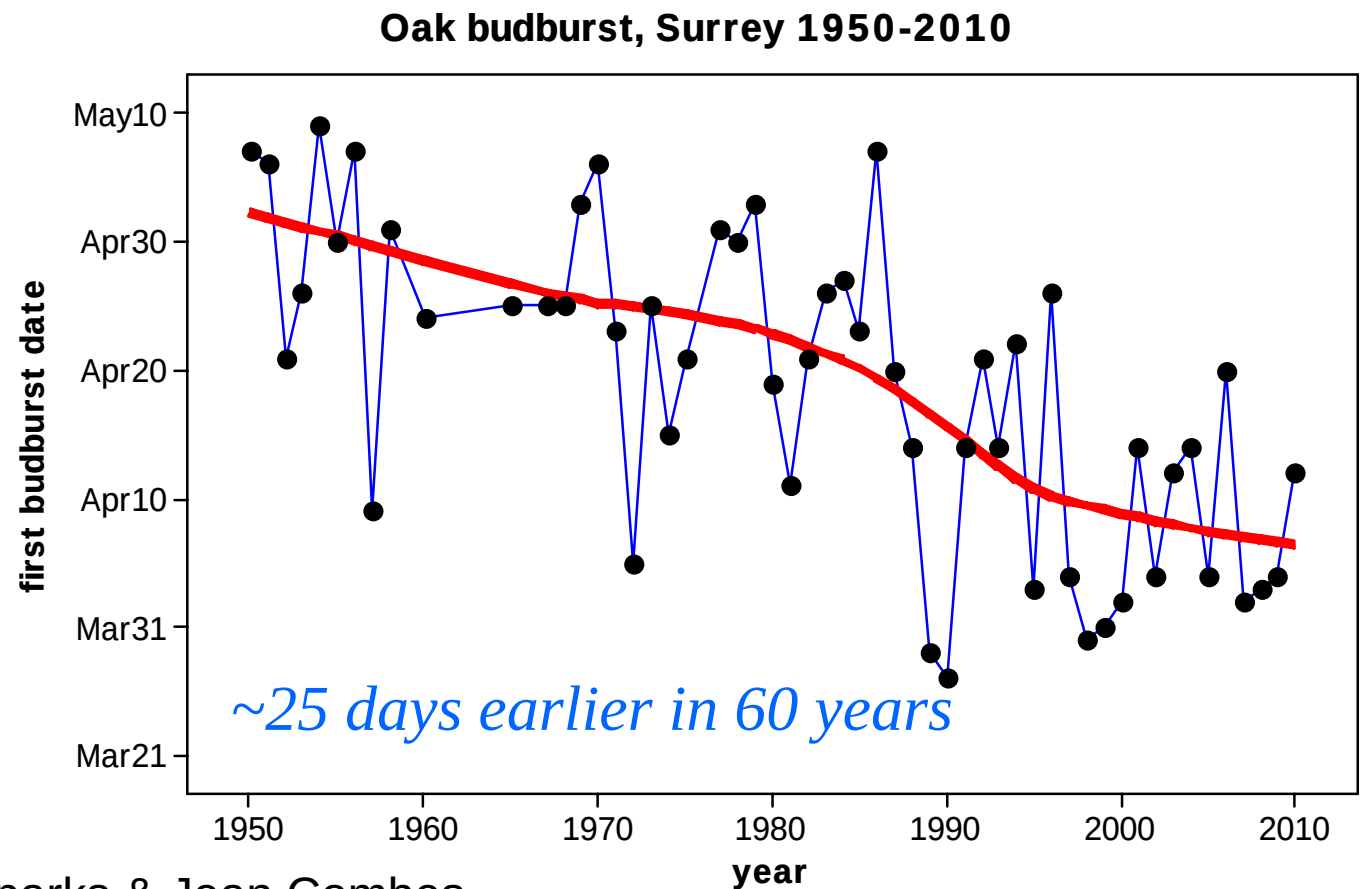


(accumulated temperature anomaly relative to 1961-1990 year mean)

Duncan Ray, FR

Impacts so far

- Changes in seasonal development



Tim Sparks & Jean Combes
http://www.naturescalendar.org.uk/survey/jeancombes.htm

Impacts so far

- Changes in seasonal development
  - e.g. leafing date, flowering, senescence
- Difficult to find clear evidence of changes in productivity, vegetation composition etc
- Confounded by site differences, stand age, changes in management, deer, pollution etc.
- Some clear effects of ‘extremes’ e.g. drought years of 1976, 2003
- Some noted changes e.g. birds, butterflies and moths in abundance, timing and species

(see Read Report, Chap. 4)

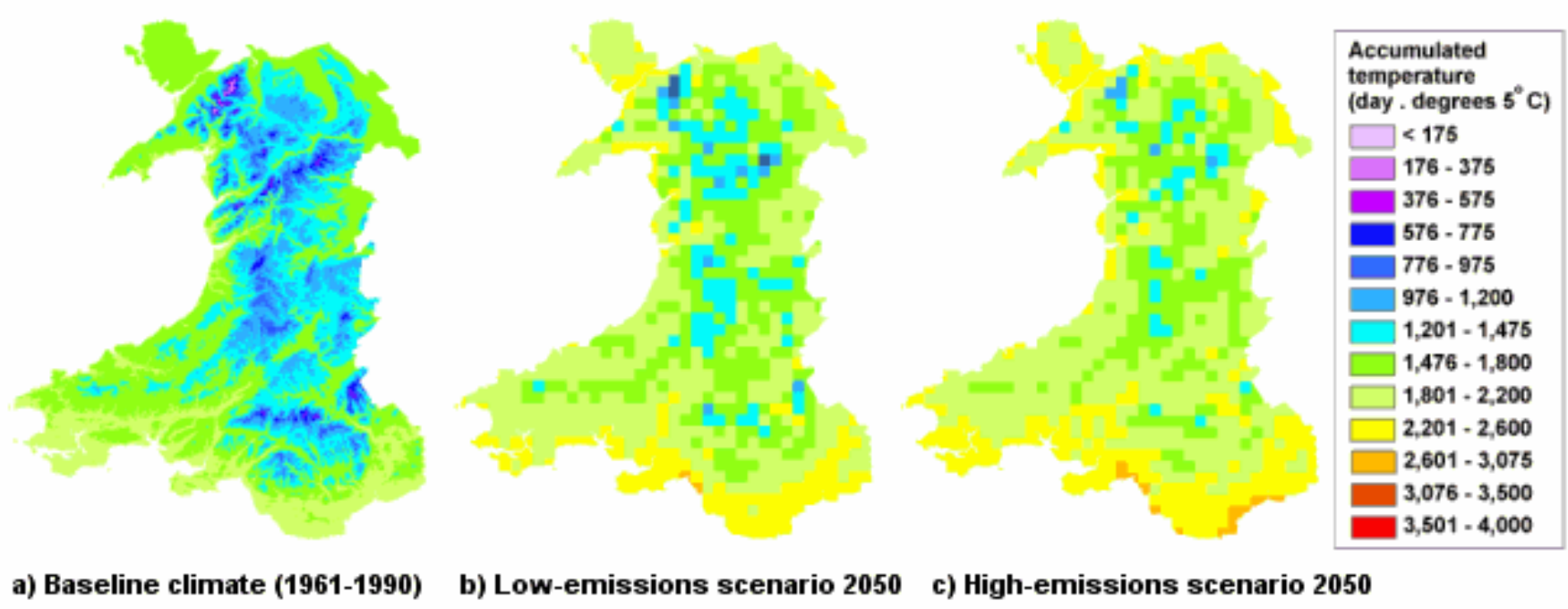
Future climate projections for Wales

- Summers will become warmer and winters will become milder
- Changed seasonal rainfall distribution, with drier summers, particularly in eastern and southern areas, and wetter winters
- Increased frequency of drought throughout Wales, particularly in the south
- Increased frequency of high-intensity rainfall in winter
  - leading to a greater likelihood of flooding, landslips, wetter soils, and risk of soil erosion and sedimentation of watercourses
- Less winter cold and fewer frost days

See: www.ukcip.org.uk

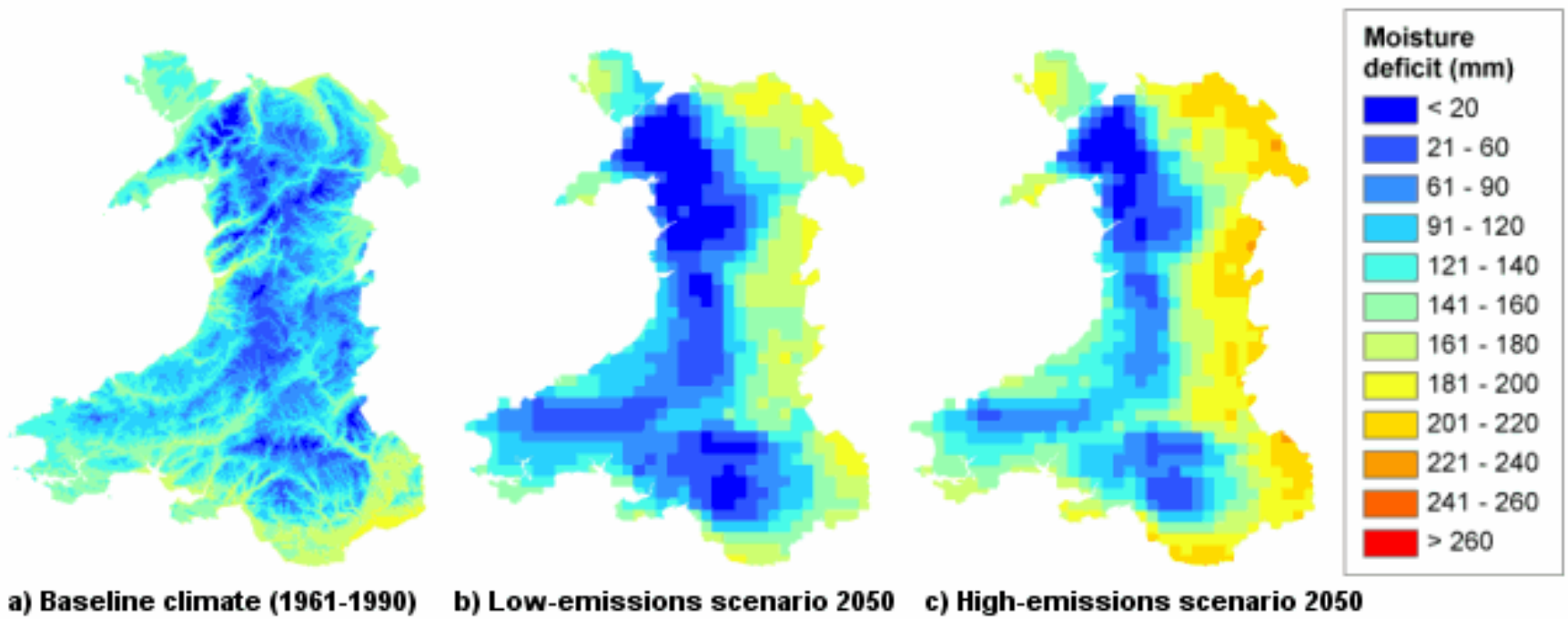
'translate' these into forestry

Growing season temperature projections (UKCP02)



Duncan Ray, FR, www.forestry.gov.uk/climatechange/wales

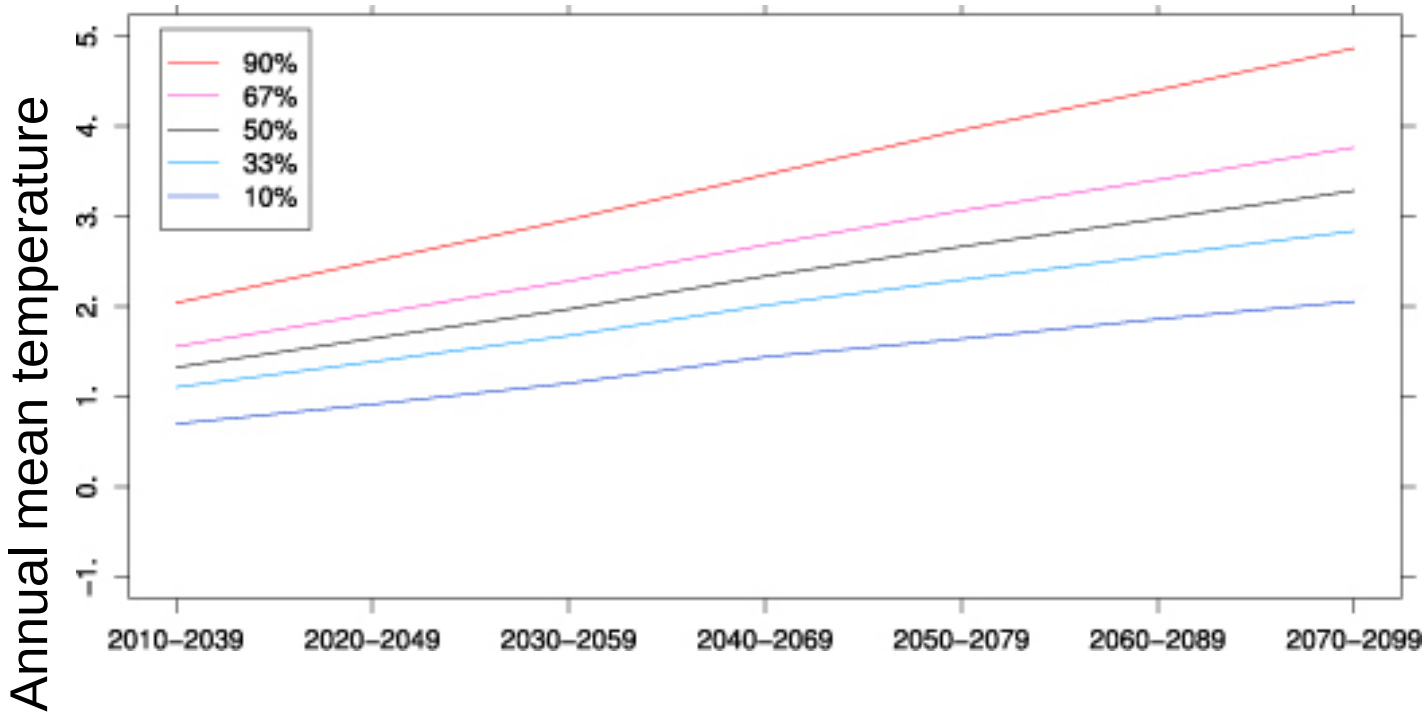
Soil Moisture Deficit Projections
(UKCP02)



But which scenario and what is our confidence in these ?

Duncan Ray, FR, www.forestry.gov.uk/climatechange/wales

Probabilistic climate projections: UKCP09 (Wales, medium emissions)



Uncertainty due to our understanding (different climate models) and natural variability

See: www.ukcip.org.uk, http://ukclimateprojections.defra.gov.uk/

Probabilistic climate projections (2050, medium emissions)

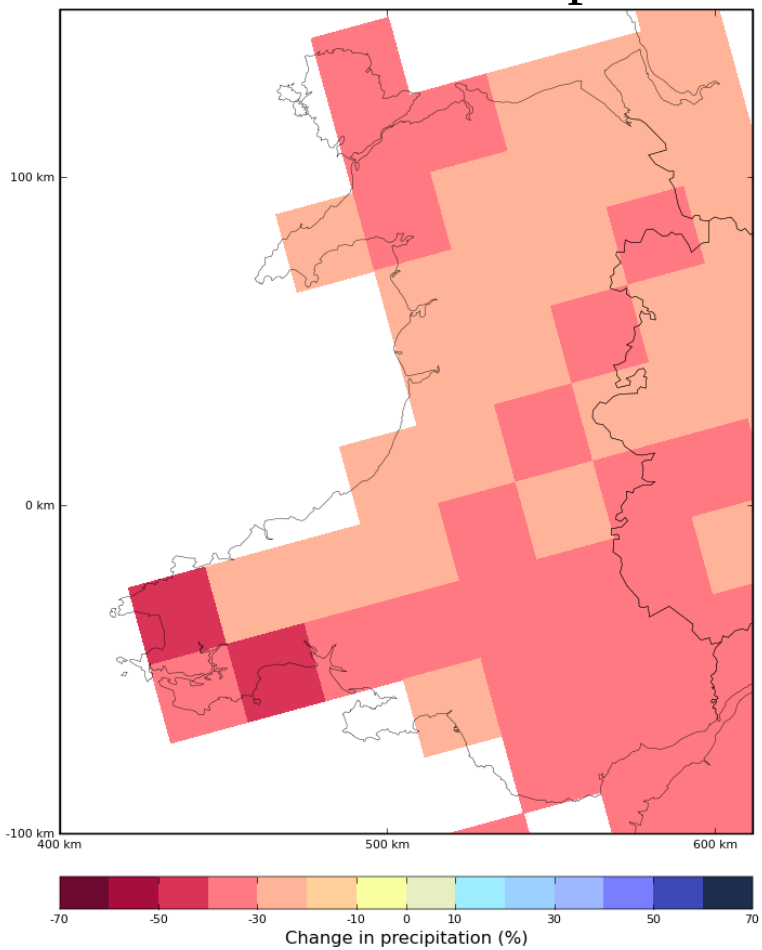
- the central estimate of increase in **summer mean temperature** is 2.5ºC;
  - it is very unlikely* to be less than 1.2ºC and is very unlikely to be more than 4.1ºC. A wider range of uncertainty is from 1ºC to 4.6ºC.
- the central estimate of change in **summer mean precipitation** is –17%;
  - it is very unlikely to be less than –36% and is very unlikely to be more than 6%. A wider range of uncertainty is from –38% to 13%.

*P< 10%

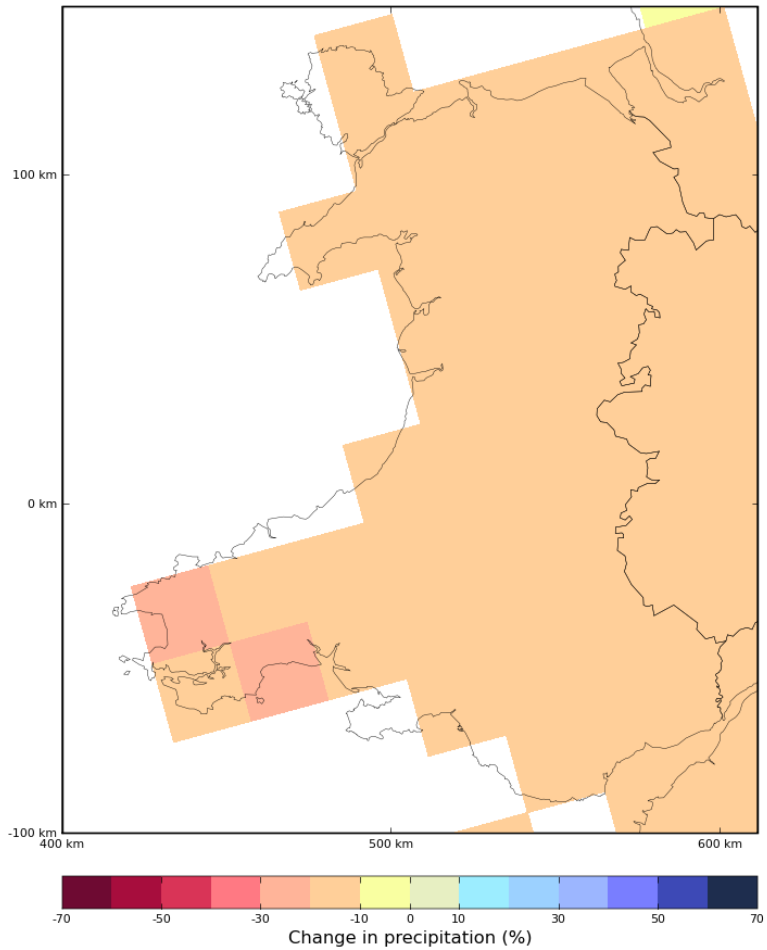
See: www.ukcip.org.uk, http://ukclimateprojections.defra.gov.uk/

Climate projections

33% Summer Precipitation, 2080



67%



Such probability information is key to managing uncertainty

Risk management

Risk = Probability of event x Impact of event

and

Impact of event = f(Vulnerability, Exposure)

Example – developing drought risk assessment

- Vulnerability = f (site characteristics, species sensitivity)
- Exposure = f (exceeding a threshold, e.g. Moisture Deficit)
- Probability = likelihood of exposure

Components of drought risk assessment

Assessing vulnerability and sensitivity

1. Identify vulnerable (droughty) sites
2. Assess sensitivity of species (e.g. using ESC information)

	Moisture deficit (mm)								
	Wet			Moist			Dry		
Species	<20	20–60	60–90	90–120	120–140	140–160	160–180	180–200	>200
SP	WEST		NATIVE						
CP									
LP	COASTAL		COASTAL		KLP	KLP, CLP	CLP	CLP	CLP
MCP									
SS									
NS									

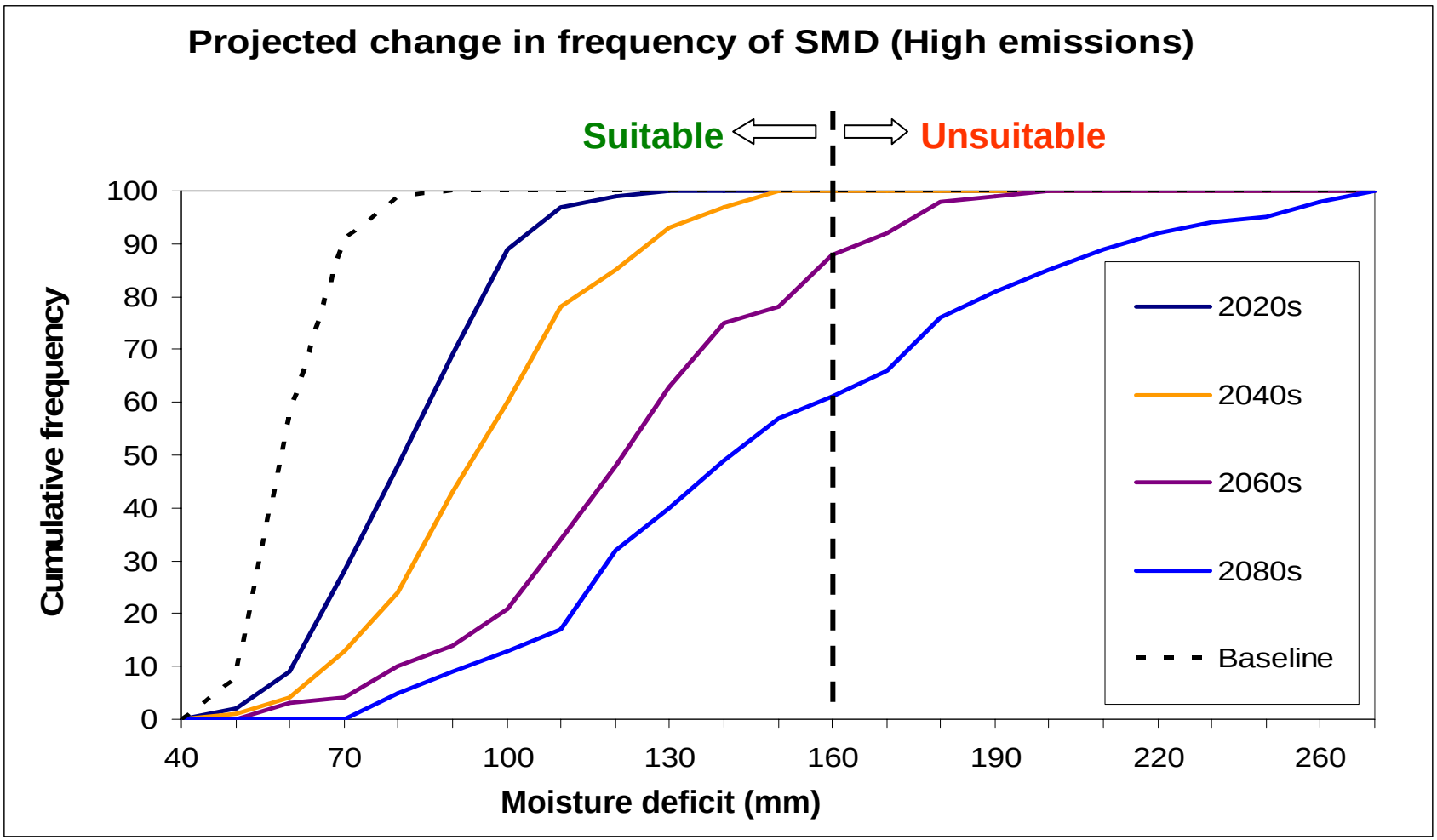
KEY: Very suitable; Suitable; Unsuitable

Sitka spruce changes from Very Suitable to Suitable at 120mm

Sitka spruce becomes Unsuitable at 180mm

Calculating probability of exposure to risk from climate projections

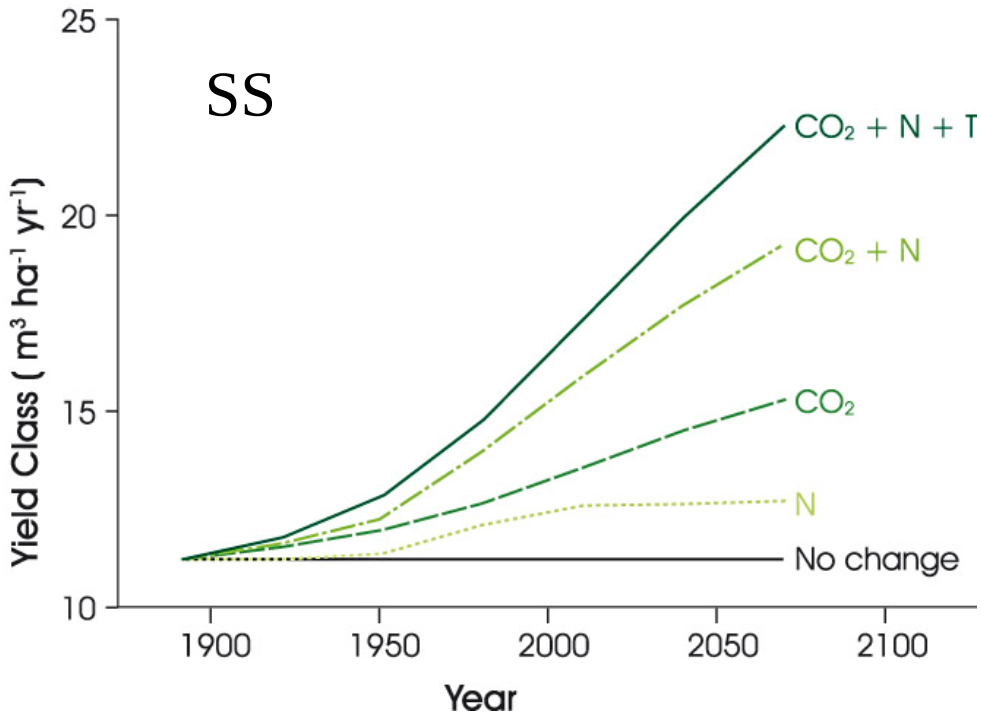
Calculating probability



(Duncan Ray, FR)

Direct effects of climate change

- Increases in tree growth with increased temperature & increased CO_2



(After Cannell et al. 1998,
see Read Report, Chap. 3, p. 39)

Increase in T of 2.5°C,

Increase in CO_2 to 510 ppm

N deposition of 20 kg N ha^{-1}

Direct effects of climate change 'abiotic'

- Increases in tree growth with increased temperature & increased CO_2
  - particularly in cooler areas
- But altered seasonality will have multiple impacts
  - affecting development, winter hardening, chilling requirements, seed dormancy, timber quality
- Drier conditions will lead to reductions in growth
  - particularly drier areas, light soils
- Changes in soil nutrient availability and carbon stock
- Seasonal rainfall changes may lead to waterlogging & rooting depth changes

(Read Report, Chap. 5; and UKFS Climate Change Guidelines)

Direct effects of climate change 'biotic'

- Increased fire risk
- Changes to pests and diseases
  - types, species, incidence, severity, timing
- Changes in invasive species
- Operational consequences
  - timing of operations,
  - altered infrastructure requirements

(Read Report, Chap. 5; and UKFS Climate Change Guidelines)

Indirect effects of climate change

- Measures introduced for mitigation and adaptation reasons
- Modified management
  - species and provenance choice,
  - silvicultural systems…
- Changes in policy because of different drivers
  - carbon, biodiversity, biosecurity, water, landscape, recreation…
- Different markets & economics

(Read Report, Chaps. 5 & 6; and UKFS Climate Change Guidelines)

Summary

- Climate is changing rapidly because of human activities
- The projected changes in our climate are likely to lead to a wide range of direct and indirect effects on trees, woodlands and forests
- Indirect effects include changes through global and local mitigation and adaptation measures because forestry has a significant role to play in both
- Future climate and impacts are uncertain – we need to adopt new ways to deal with uncertainty

Thank you !

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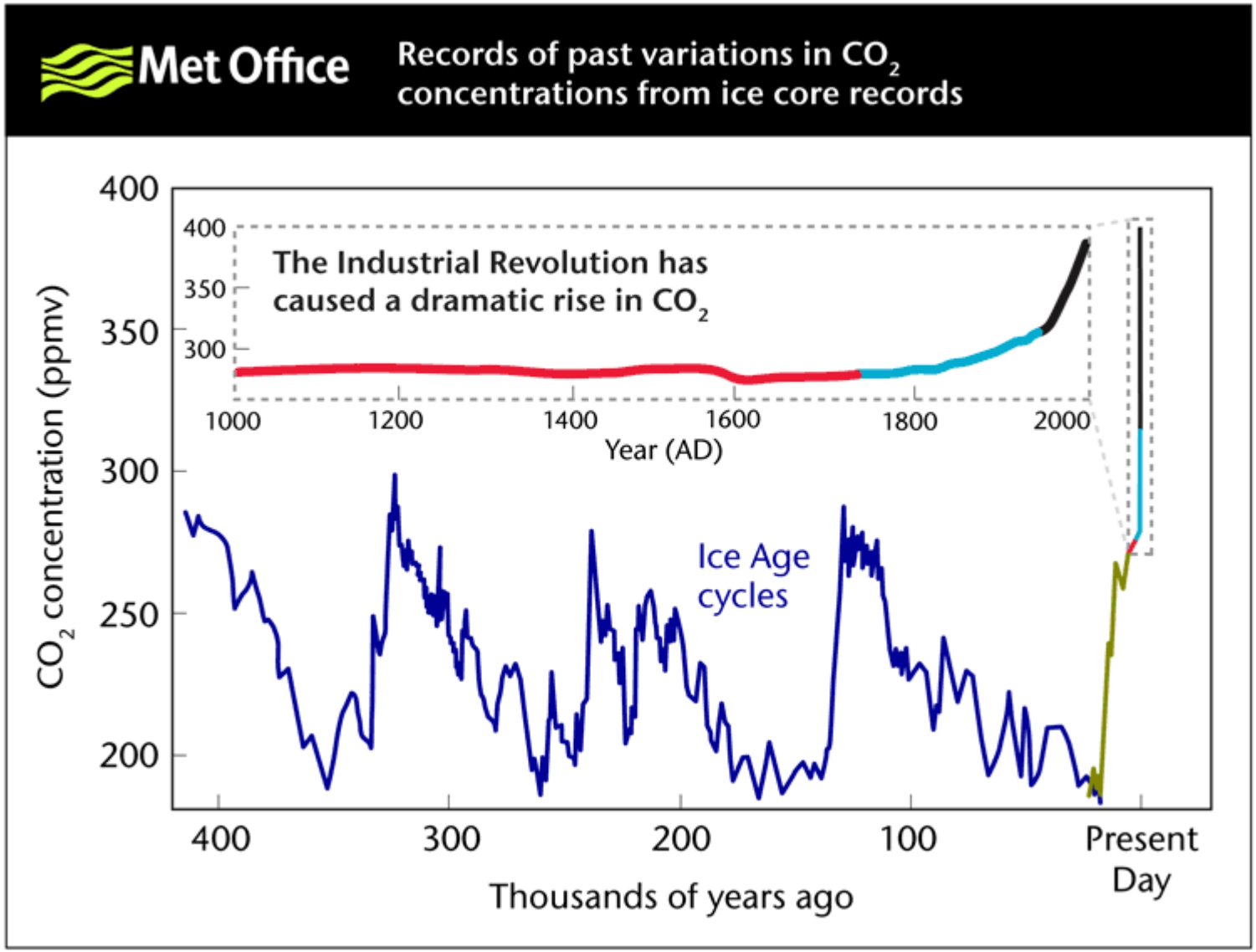
Climate change causes

Global atmospheric concentrations of CO_2, CH_4 & N_2O have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in CO_2 concentration are due primarily to fossil fuel use and land use change, while those of CH_4 and N_2 O are primarily due to agriculture

See IPCC 4th Assessment Report



climate change impacts