Sustainable control, the implications of climate change for controlled environment research.

- 1. The problem
- 2. Some relevant research
- 3. What we need to do

Wood anemone *Anemone nemosa* flowering 2 months early

Redshanks *Tringa totanus* are moving north

Sustainable control, the implications of climate change for controlled environment research.

Seven salient facts

1. Climate Change is happening now!
2. Too much CO_2 goes into the atmosphere
3. Plants and animals are being affected
4. We and they need to be prepared & adapt
5. We need to know more about the consequences
6. We need to develop CE technology to investigate it
7. This technology should not contribute to the problem

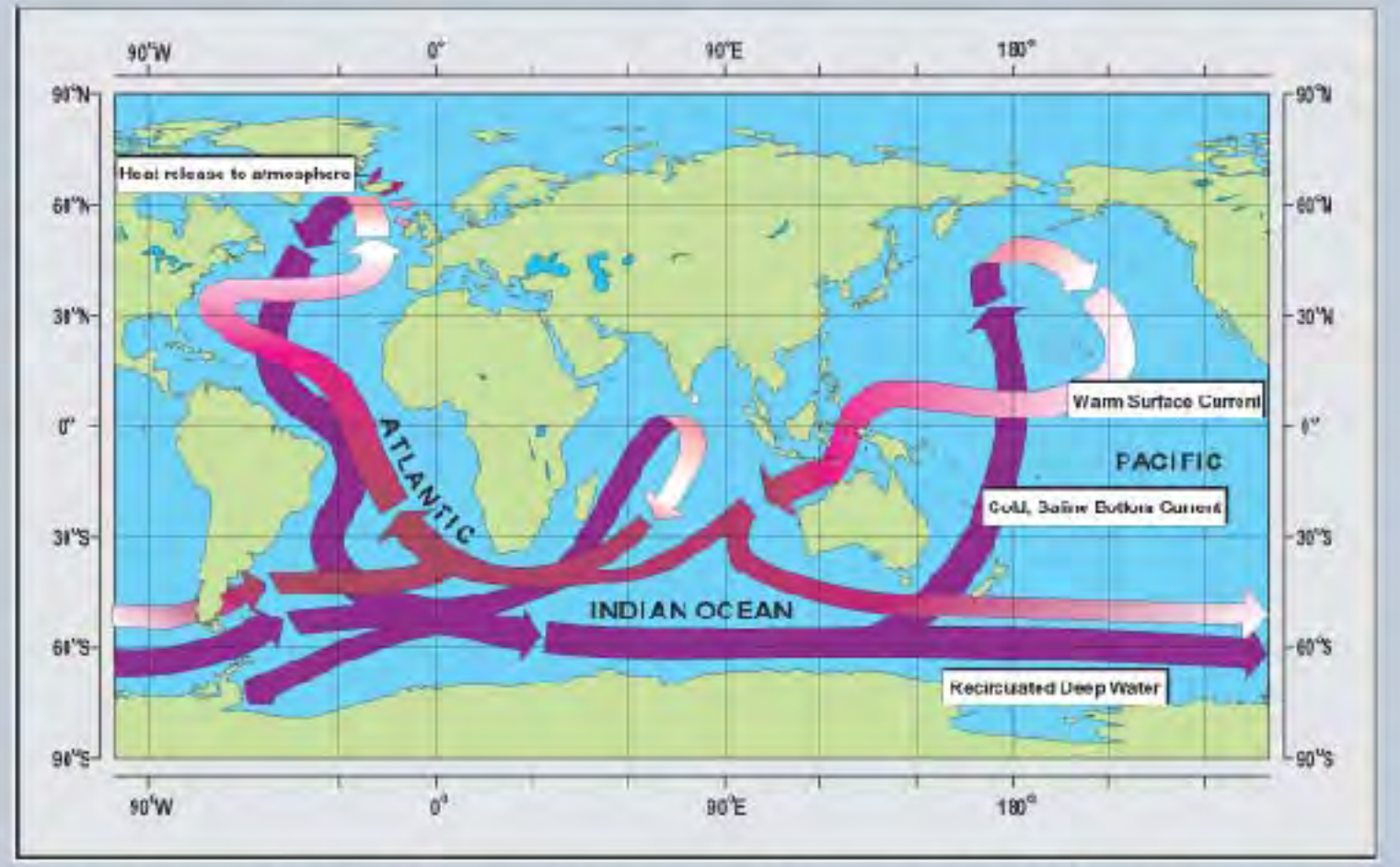
Little egrets *Egretta garzetta* moving north

Warmer or colder?

- Land temperature in some regions is governed by ocean currents
- E.g. UK
- Ocean currents are predicted to change with climate
- leading to cooling in some places & heating in others
- The *global* climate is out of control!

The Atlantic Thermohaline Circulation

- A key Element of the Global Oceanic Circulation -



Schematic diagram of the global ocean circulation pathways, the 'conveyer belt (after W. Broecker, modified by E. Maier-Reimer).

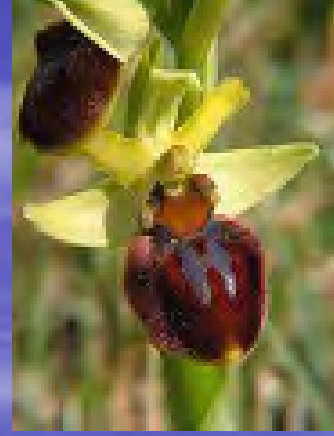
AWI/D3/99-2

The Gulf Stream and other concerns

- The Atlantic Conveyer (Gulf Stream) - heating power of 1 million power stations
- The UK is between 50 & 60 parallel so is Moscow and Saskatoon, temp -25°C & below
- The North polar ice cap is shrinking
- Greenland ice is melting faster than expected
- Is predicted to switch off sometime this century!

Polar bears *Ursus maritimus* drowning from lack of ice

Consequences



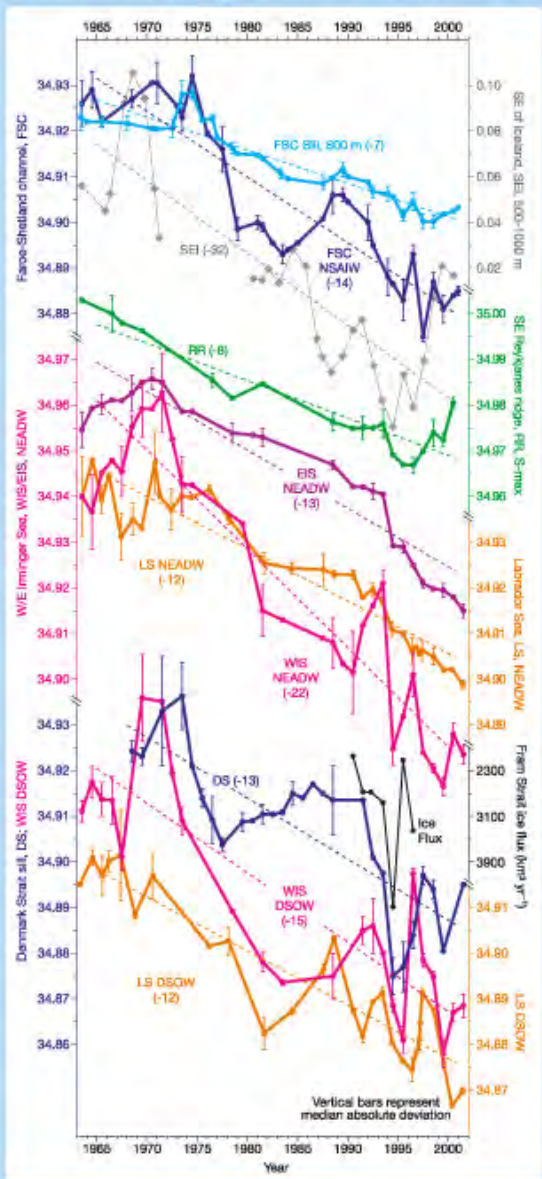
Early spider orchid
Ophrys sphegodes
flowering 2 weeks earlier

- Humid atmosphere
- Storm flooding
- Animals & plants moving north
- Global average sea level rise is about 3.1mm/year 1993 – 2003 & accelerating
  - (**Intergovernmental Panel on Climate Change)**

- "measures for adapting to the impacts of climate change are urgent and inevitable"!
  (Rajendra Pachauri, IPCC Chairman, January 2008)

- North Atlantic
- Desalination
- 40 years decline

Water Mass Changes in the Nordic Seas



Evidence that the following change in the upper Nordic Seas, the entire system of overflow and entrainment that ventilates the deep Atlantic has steadily changed in character over the past four decades, resulting in a sustained and widespread freshening of the deep and abyssal ocean (Dickson et al., 2002).

AV_D3_0301

The Atlantic Conveyer

8 points

1. Gulf Stream - slowing down
2. Arctic water - getting less salty
3. Less salt = less density
4. Does not drop to ocean floor
5. Does not flow back to the Gulf of Mexico
6. No warm water to heat the British Isles
7. Much colder winters
8. We need to model the consequences of this
   - Using CE

The Atlantic Conveyer

- Dr Terry Joyce (Woods Hole Oceanographer)
- "It will be quick, Suddenly one decade we're warm, and the next decade we're in the coldest winter we've experienced in the last 100 years, but we're in it for a 100 years."

Some Consequences

- c. 15 million species globally
- A quarter of animals and plants may go extinct by 2050
- A minimum of 9%
- Over 1 million species

Cod *Gadus Morhua* – moving north

Northern Butterflies at Risk

- Not only are they moving further north
- They are also moving up hillsides
- Northern species set to decline by 65%
- Southern species by 24%




Mt Kilimanjaro

- February 1993

- February 2000

CE research on climate change

- Problem for plants with photoperiod triggers for flowering
  - lettuce (*Lactuca*)
  - potato (*Solanum*)
  - barley (*Hordeum*)
  - spinach (*Spinacia*)
- range limited by day-length but may overheat.

CE research on climate change

- Not so important for plants requiring temperature cues
  - daffodils (*Narcissus*)
  - tulips (*Tulipa*)
  - hyacinths (*Hyacinthus*)
  - bulb iris (*Iris reticulata*)
- They can move north
  - But takes time

Wood anemones
Anemone nemorosa
an English April flower
are now flowering in
February!

CE research on climate change

- Some such as:
  - lilac (*Syringa*)
  - quince (*Chaenomeles*)
- require both specific light and temperature cycles.

CE research on climate change

- Some tropical plants respond to neither photoperiod or temperature, but have evolved responses to humidity, or frankly – rain before they will flower i.e.:
  - trees in the bean family (Fabaceae)
  - trumpet vine* (Bignoniaceae)
  - dogbane (Apocynaceae)
  - cola nut (Sterculiaceae)
  - and kapok (Bombacaceae)

*

CE research on climate change

- Will olives will be able to crop successfully in more northern latitudes even if the temperature is high enough?
- ***We need research using controlled environments to determine appropriate translocation of crops as global warming progresses.***

Olive *Olea europea*

CE research on climate change

Solar Domes at Bangor, Wales, UK

CE research on climate change

- Buse *et al.* (1999) grew oaks & caterpillars in solar domes (sunlit controlled environment chambers)
- Birds need caterpillars to feed chicks
- Caterpillars need young oak leaves to feed themselves
- At elevated temperature, oak budburst and caterpillar hatching remained synchronised but were earlier

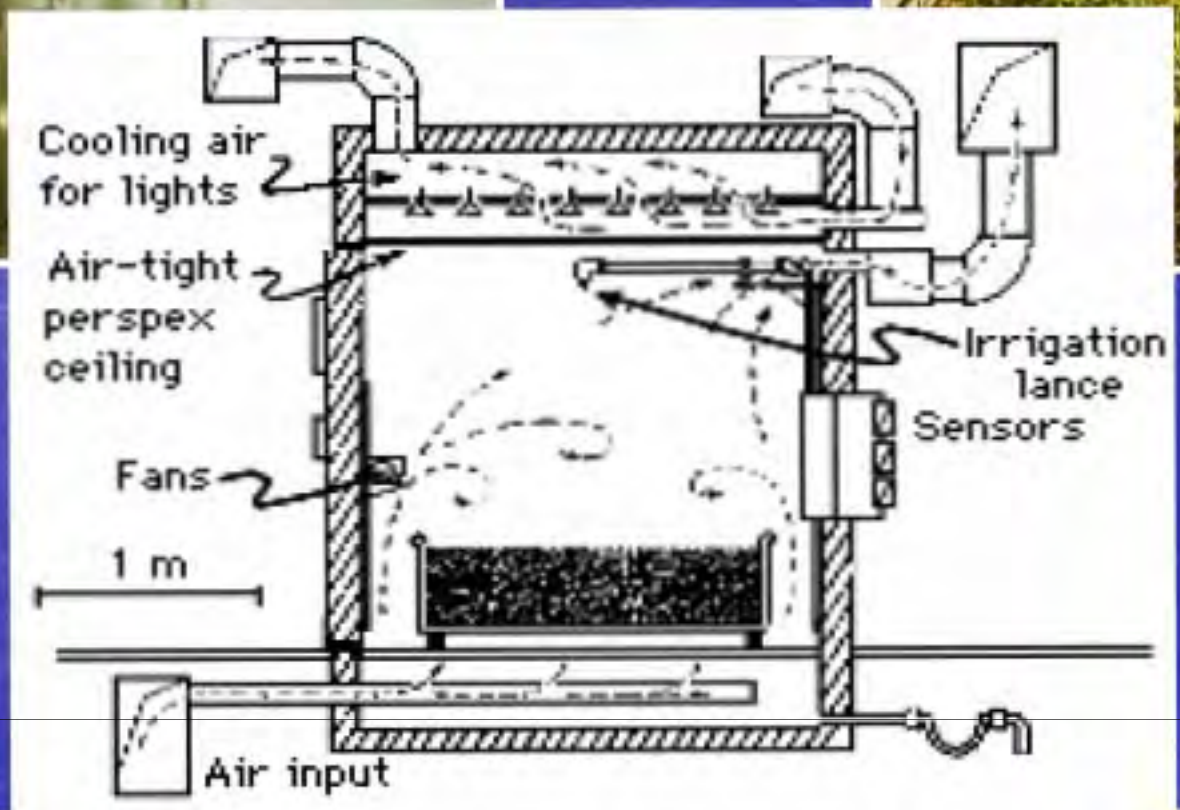
CE research on climate change

- Laying date in birds is genetically constrained (Stenning 1984)

- Buse *et al.* (1999) Delayed hatch time in birds to simulate conditions of elevated spring temperatures - results:
  - asynchrony with caterpillar peak
  - reduced chick mass, body size & fledging success.

- Experiments by Professor Marcel Visser in Holland with birds in temperature controlled aviaries to investigate this problem further (Visser *et al*. 2008)

The Ecotron


Cooling air for lights
Air-tight perspex ceiling
Fans
1 m
Air input
Irrigation lance
Sensors

CE research on climate change Results

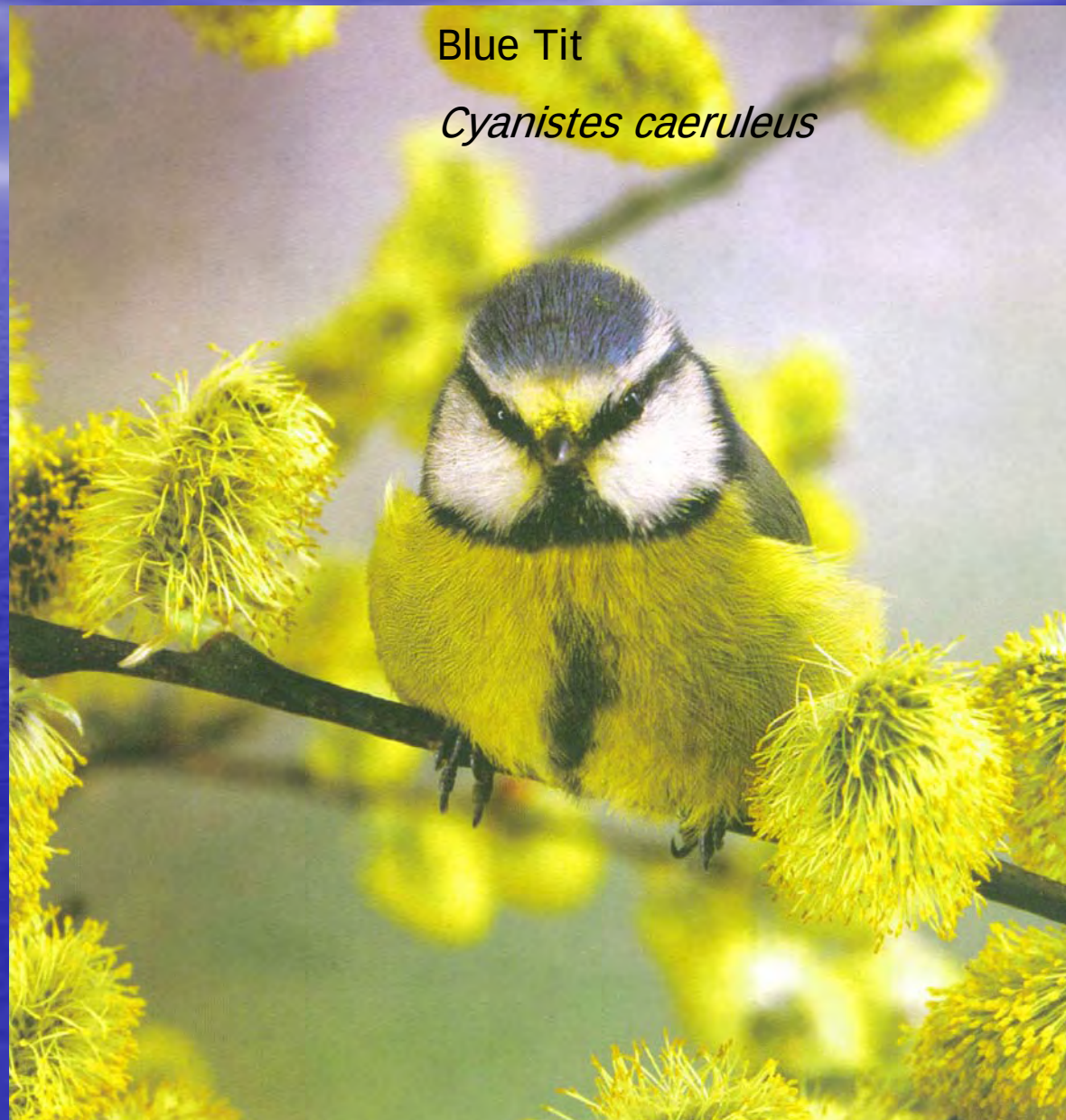
- The effect of elevated CO_2 on plant biomass and carbon and nitrogen content was complex
- The effects were species and generation specific
- Components affected included:
  - enzymes (Phenylanaline Ammonia Lyase)
  - phenols (phenolic biosynthesis)
  - lignin (the substance that makes trees woody)

CE Carbon Footprint

- We need machines that can control temperature from about -20^{0}C to about 50^{0}C with ramping
- We need energy efficient light sources
  - Perhaps development of LED technology
- We need efficient insulation
  - Maybe a case for using sheep wool
- Energy efficient cooling
- Energy capture mechanisms
- Materials with a low carbon footprint

Acknowledgements

- To blue tits for helping me with my research
- To UK Controlled Environment Users Group for a travel bursary
- To University of Sussex for further funding and leave to attend




THANK YOU FOR LISTENING.