Session 5: A Systems Approach to Environmental Challenges

Climate change: we need an approach of complex system modelling

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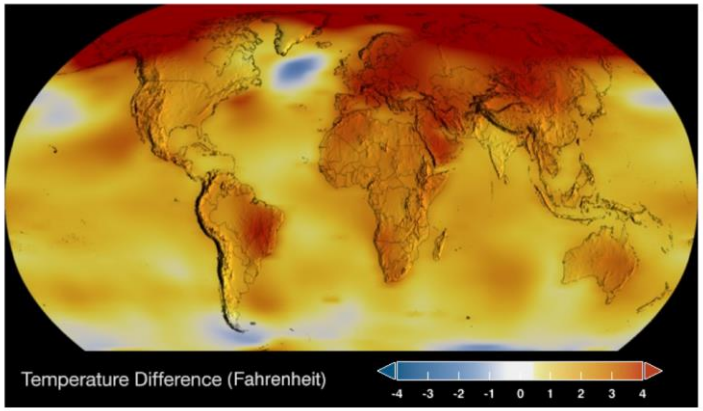
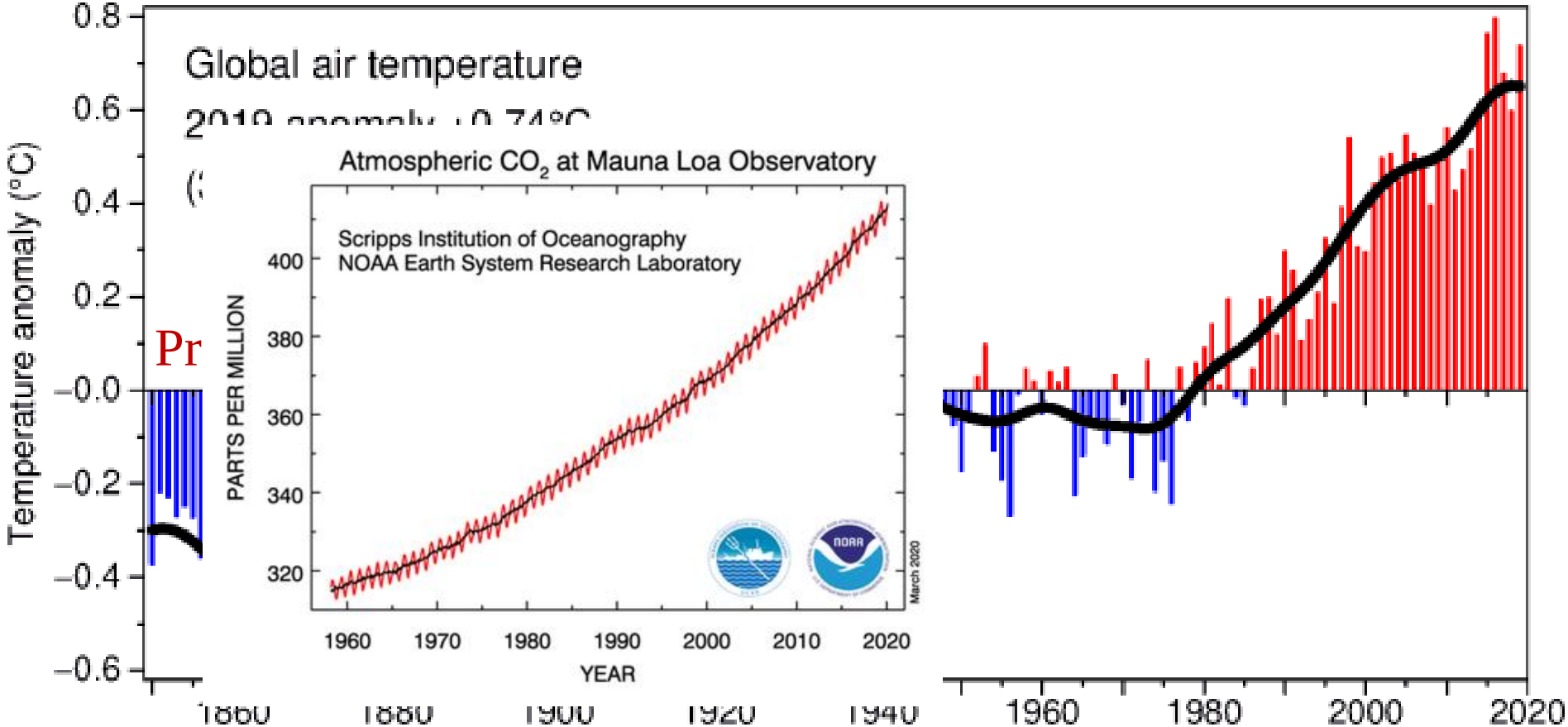
From the point of view of the global mean annual temperature, the situation seems clear

2019



2019: 3rd warmest year
+1°C vs pre-industrial

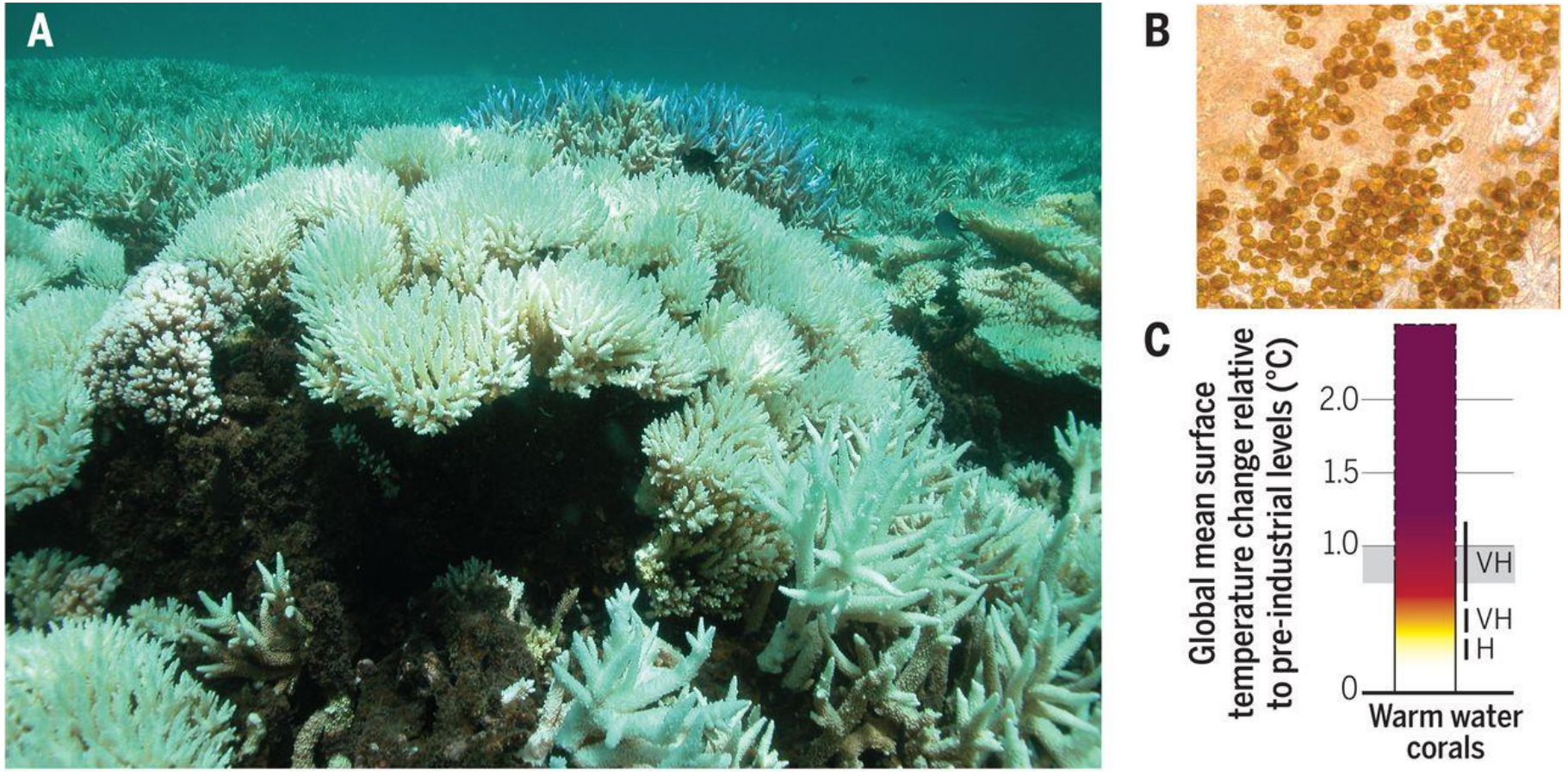
Anomalies vs 1961-1990



Climate is not only temperature and precipitation evolution is already more complex
From the point of view of the impacts, the situation is still more complex (non linearities)

Hoegh-Guldberg, Jacob, Taylor, Guillén Bolaños, Bindi, Brown, Camilloni, Diedhiou, Djalante, Ebi, Engelbrecht, **Guiot**, Hijioka, Mehrotra, Hope, Payne, Pörtner, Seneviratne, Thomas, Warren, Zhou, SCIENCE 2019

The response of the ecosystems is often nonlinear



99% warm coral reefs in danger with +2°C in 2100

O. Hoegh-Guldberg et al. Science 2019;365:eaaw6974

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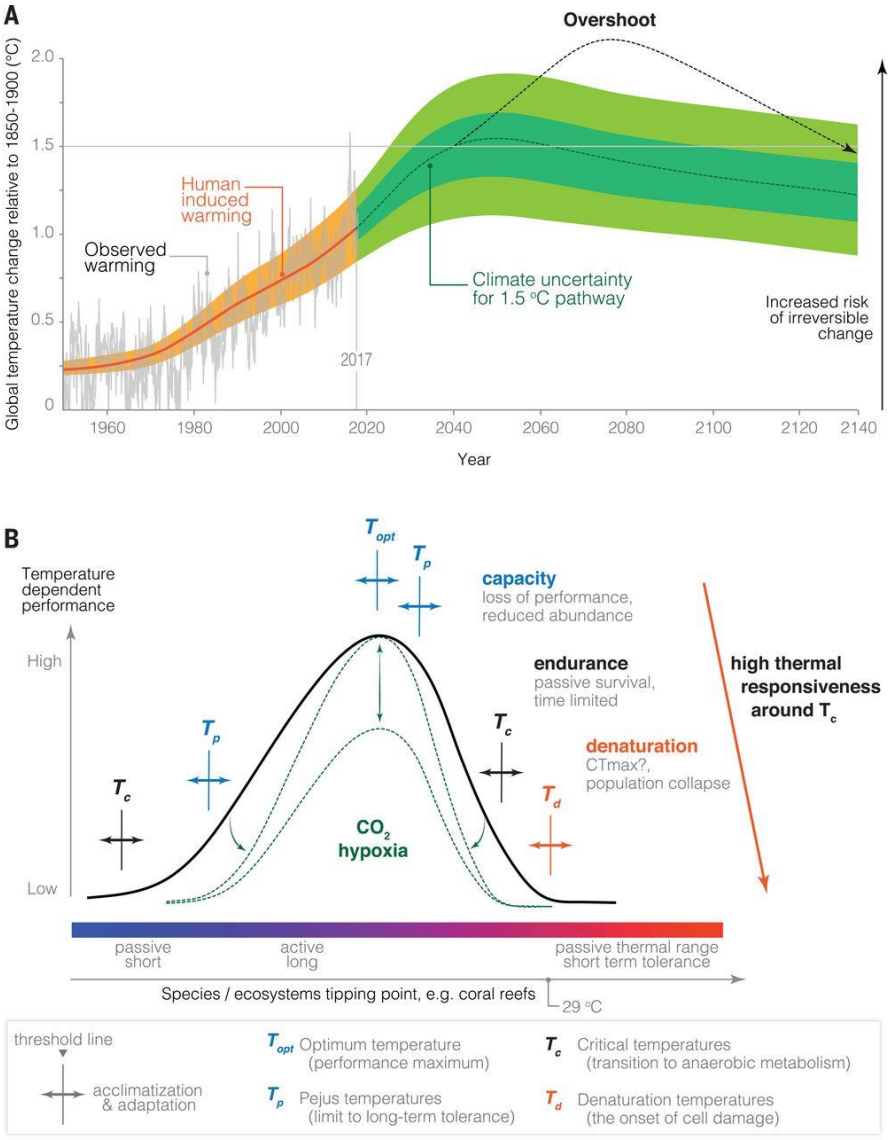
The future +0.5°C warming will have more impact than the past +0.5°C warming: accelerating risk



- The next 0.5°C above today (from 1.0°C to 1.5°C) will involve greater risks per unit temperature than those seen in the last 0.5°C increase.
- This principle of "accelerating risk" is also likely to drive proportionally and possibly exponentially higher risk levels in the transition from 1.5°C to 2.0°C
- Tipping points: a group of organisms or an ecosystem can appear "healthy" right up to the point of collapse
- This suggests caution in extrapolating from measures of ecosystem condition to predict the future (appreciation of organisms' distance from their optimal temperature)

O. Hoegh-Guldberg et al. Science 2019;365:eaaw6974

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Additional complexities: the solutions to mitigate climate change may have negative impacts on other components of the system

- Limiting GHG emissions to **420 Gt CO_2** for a 66% (or +) of not exceeding 1.5°C
- **Reducing** radically the use of **fossil fuel** is necessary but not sufficient
- **Negative emissions** are also necessary, according to the speed of fossil reduction
- Promote **nature-based solutions** (vegetation and soils)
- Likely more **technical solutions** (bioenergy with carbon capture and storage, BECCS)
- But BECCS would require ~18% of global land to sequester 12 Gt CO2/year
- Consequence: **loss of primary forest and natural grassland** → more GHG emissions, less biodiversity, less agriculture
- Preferentially **restoring natural ecosystems** and their ability to sequester carbon
- We need a "**win-win**" scenario in which both climate and biodiversity benefit, contributing to UN Sustainable Development Goal (SDG)
- Important issue of "loss and damage" also highlights the inequity between nations that have largely caused climate change (and have received the greatest benefits) and the others

An example of IAM model to estimate cost and benefits associated with acting in response to climate change

- Cost of 1.5°C scenario and business as usual (+3.7°C) scenario, using PAGE09 model
- BAU : Mean total damages of $550 Trillion (US$2008)
- 1.5°C: Mean total damages of $54 Trillion
- Investments to reach not zero emission by 2050: $1.46 to $3.51 trillion (US$2010) in energy supply and $640 to $910 billion in energy demand --> $71-150 Trillion (US$2010).
- Ratio = 3 to 7 times
- **But all the damages that are difficult to quantify (e.g., disruption and migration of human communities; reductions in ecosystem services associated with biodiversity loss).**
- So, potential economic benefits arising from limiting warming to 1.5°C may be at least 4 to 5 times the size of investments needed until 2050 (in terms of energy)

C. Hope, 2011. The Social Cost of CO2 from the Page09 Model. Economics Discussion
O. Hoegh-Guldberg et al. Science 2019;365:eaaw6974

A new approach based on quantitative ecological-economic modelling is necessary

- **Complexity of the system** needs to integrate climate change, land-use change, loss of biodiversity, and human health and well-being → including monetary and not monetary values,
- We have to find new technological routes to **sustainable economic development** based around restoration and sustainable use of land, and a transport, energy, manufacturing, and agricultural economy that is much less dependent upon fossil fuels.
- Compare policies that **explicitly acknowledge the value of biodiversity**, both in terms of its contribution to the human economy and as the major buffer against climate change.