Perubahan Iklim dan Lingkungan Global

Kuliah VI

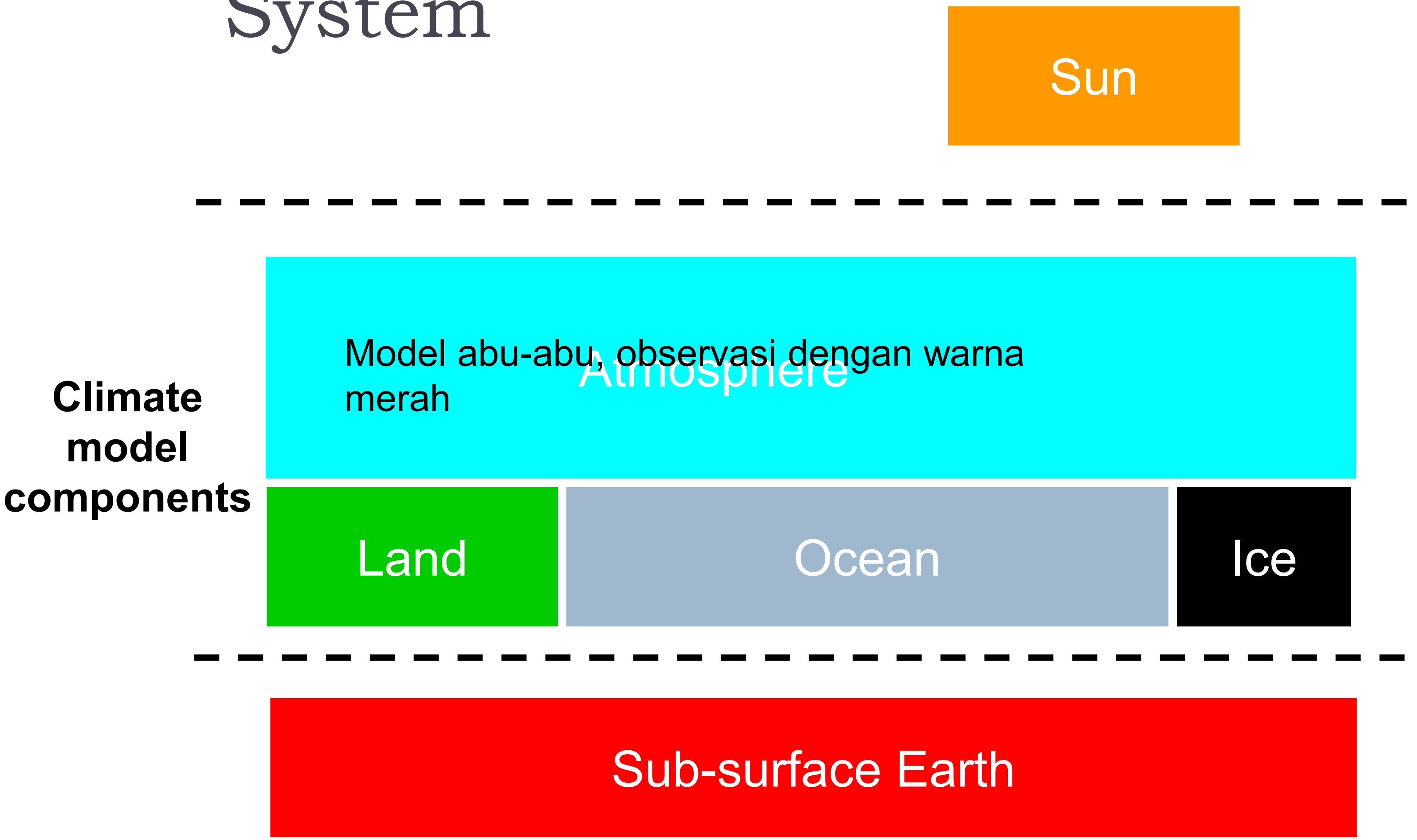
Hendrik Segah, Ph.D

Researcher/Lecturer

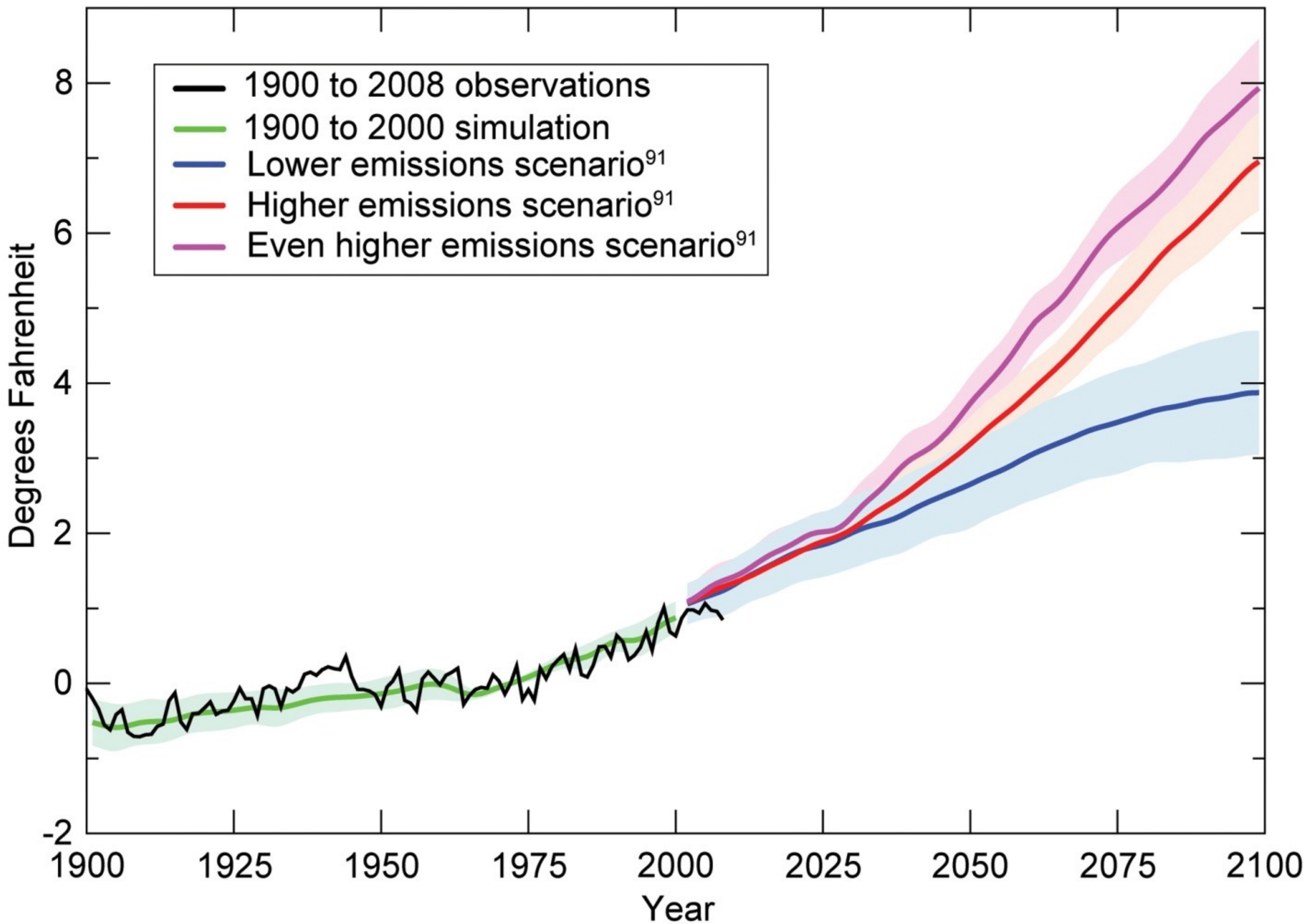
Forest Department, Fac. of Agriculture, Univ. of Palangka Raya

Models of the climate system

Earth’s Climate System



Global mean surface air temperature



Smith *et al.*[72]; CMIP3-A[93]

Atmosphere

- Composition (in particular the greenhouse gases and aerosols) determine radiative and thermodynamic properties
- Passage and absorption of radiation (energy from Sun and back into space) crucial
- Conservation of mass, momentum, energy, and equation of state: general circulation
- Hydrological cycle (evaporation, clouds, rainfall, runoff…)

Ocean

- Surface circulation driven by wind: large scale ocean basin gyres
- Deep overturning circulation driven by 'thermohaline circulation' – competing influences of heat and salt on sea-water density
- Oceans transport ~50% of heat from equator to pole (atmosphere other 50%)
- Most of the climate system's stored heat is in the ocean – it acts as a big flywheel – making the climate system respond over much longer time periods (decades) than if the Earth's surface were all land
- Ocean and atmosphere closely coupled

Cryosphere - Ice

- Mass balance of ice sheets: snow adds material, evaporation/sublimation, ablation, and melting removes
- Rising temperatures don't necessarily imply shrinking ice sheets, as it may mean increased precipitation (snowfall)
- Ice dynamics (e.g. glacier flow rates) important
- Ice albedo – clean snow vs. dirty snow
- Close interaction of ice with atmosphere and oceans

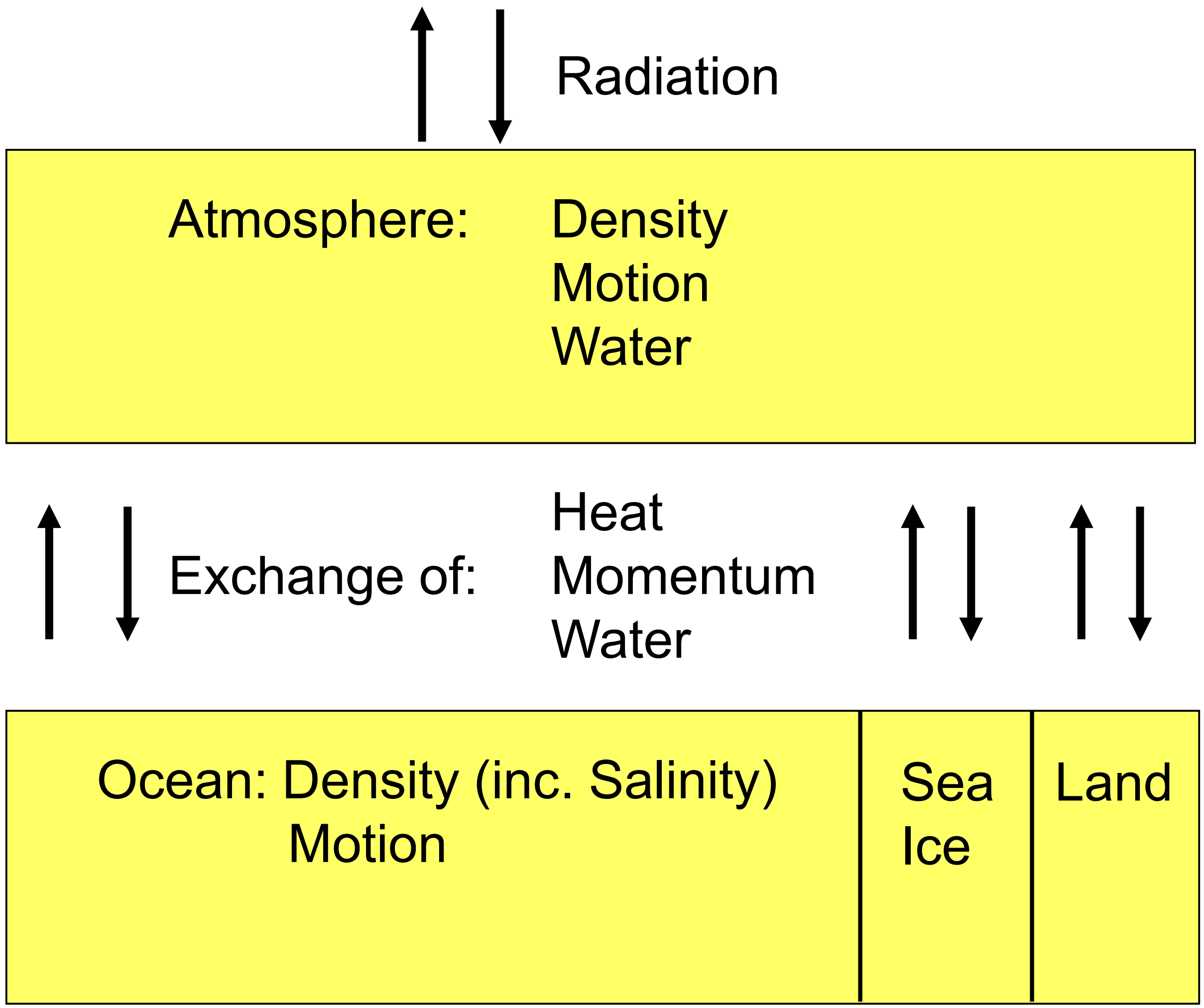
Biosphere

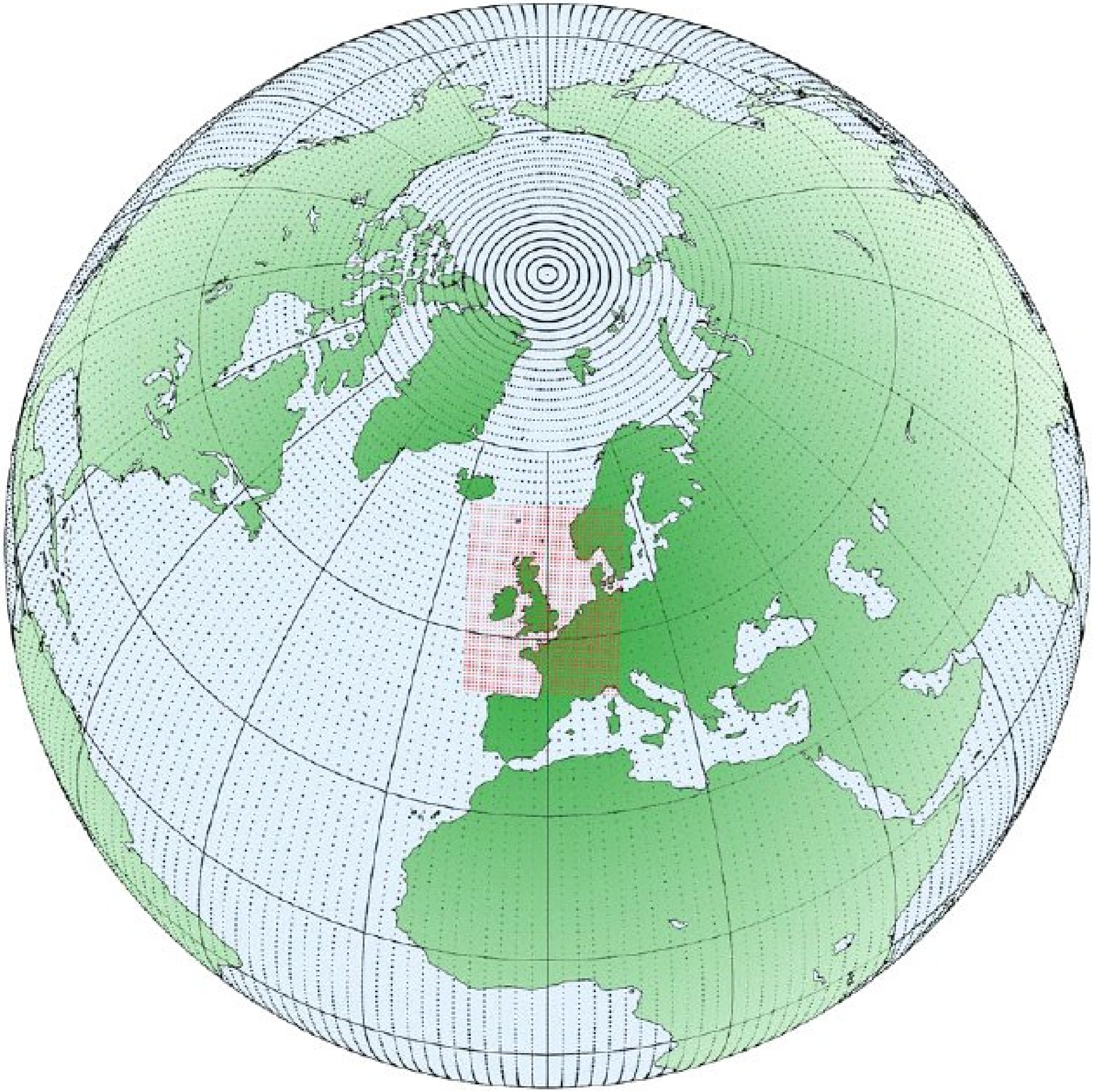
- Models have simplified representations of land and ocean carbon cycles
- Only ½ the emitted CO_2 ends up in the atmosphere – the other ½ is taken up by the oceans and vegetation
- CO_2 uptake by ocean causes acidification:

$$CO_{2(g)} + H_2O_{(aq)} \leftrightarrow H_2CO_{3(aq)} \leftrightarrow H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^{2-}$$

With potential impacts on marine biota – harder to form a calcium carbonate skeleton – high uncertainties

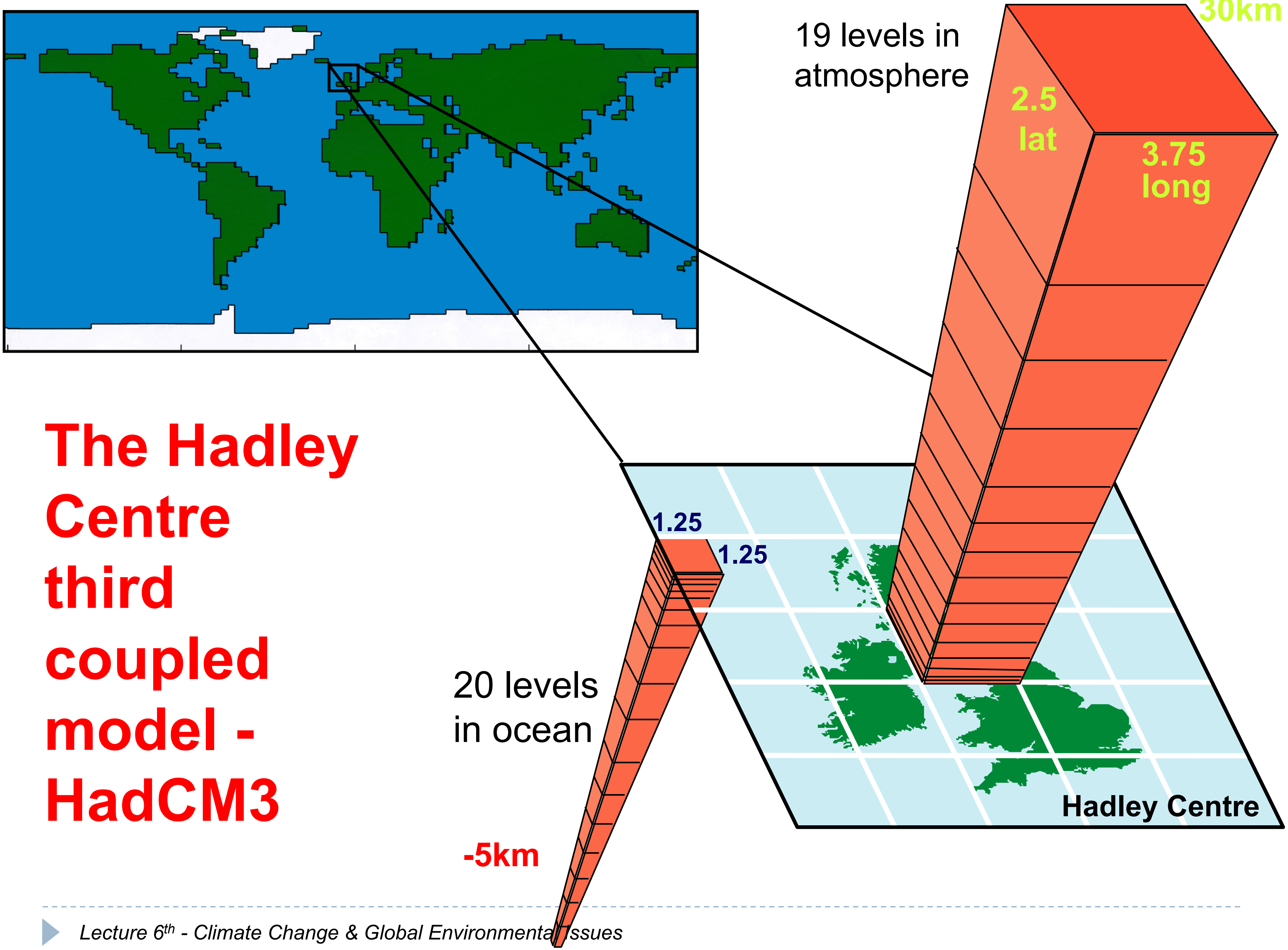
Coupled atmosphere / ocean climate model

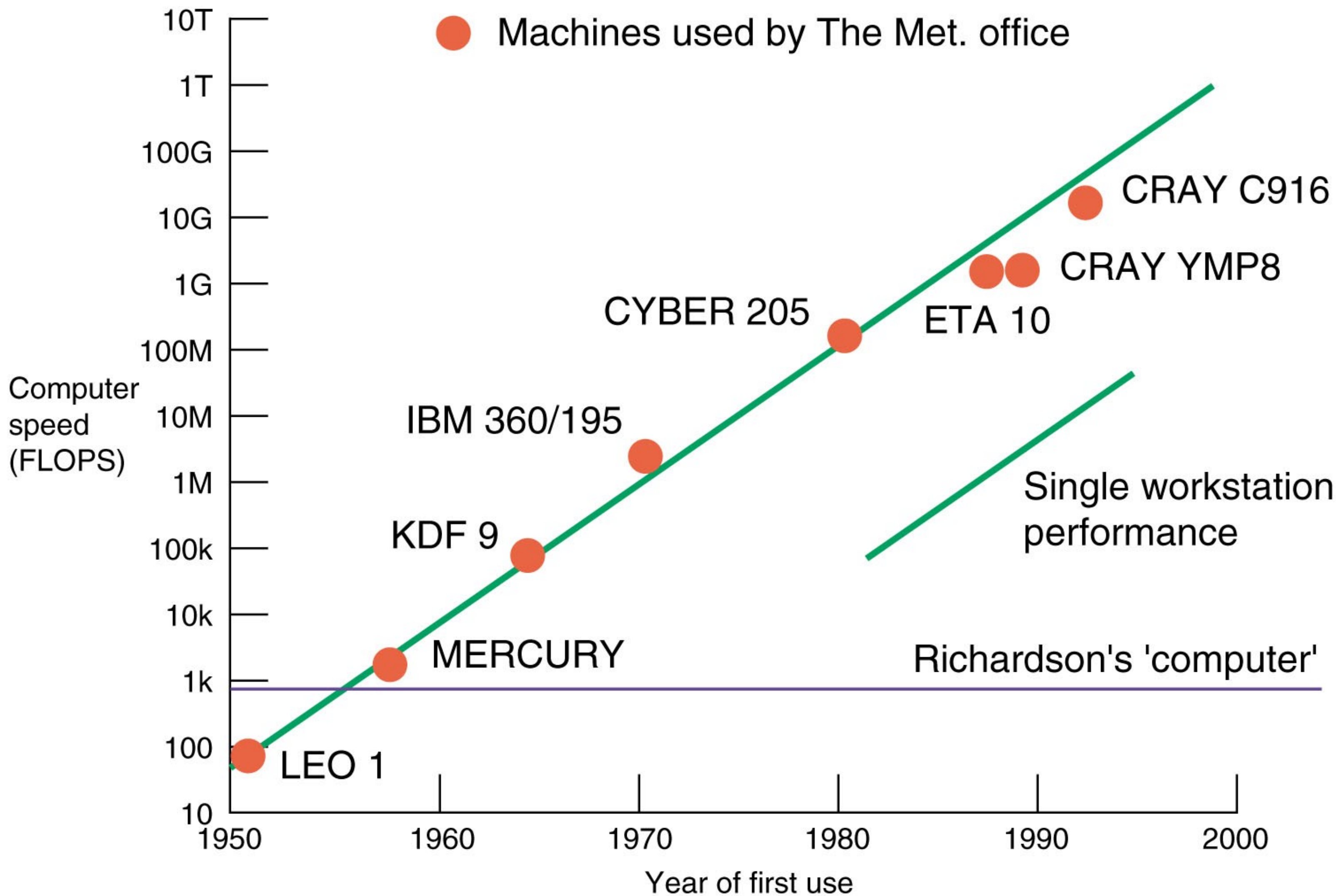




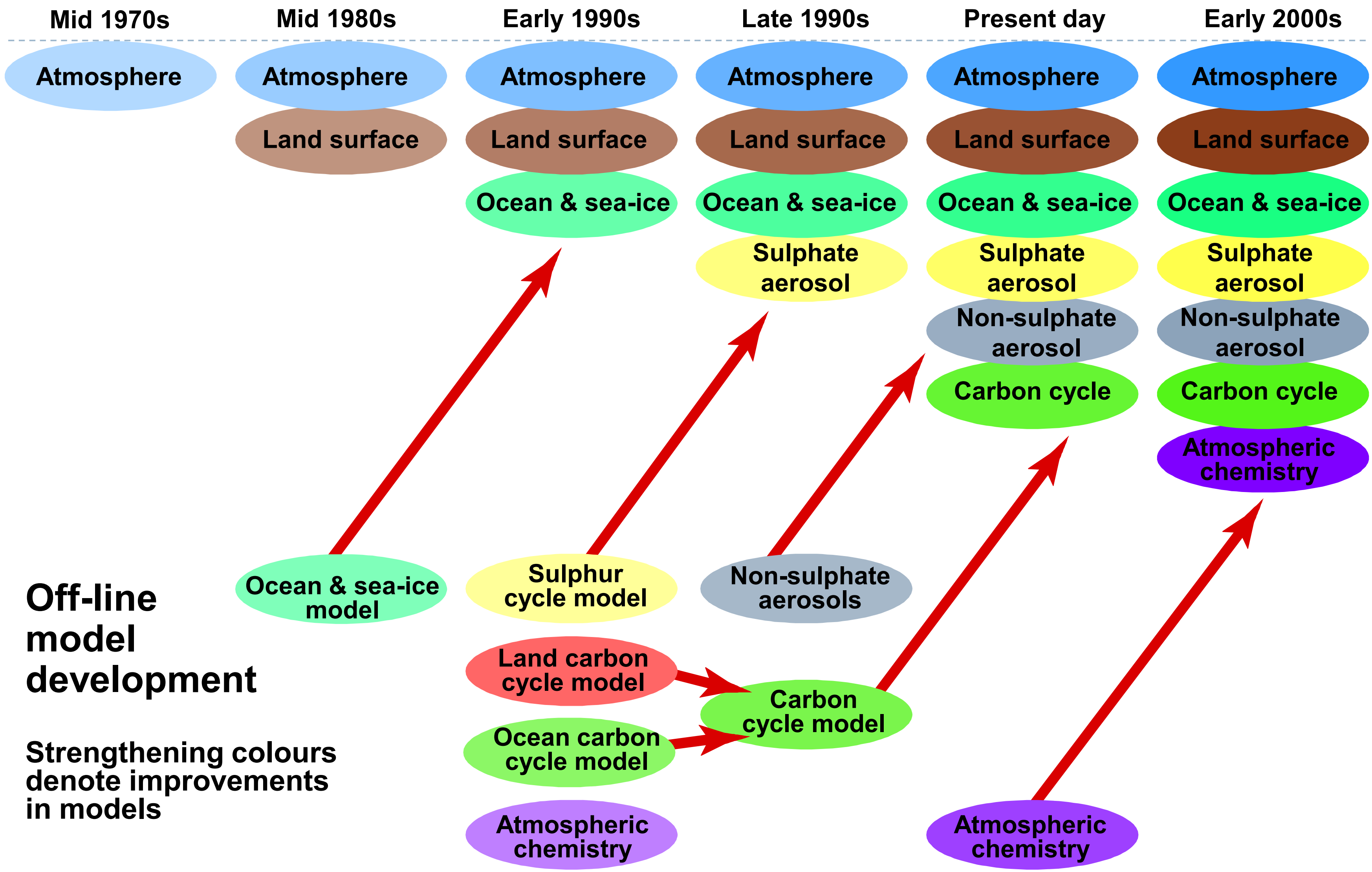
Typical resolution of weather forecast model – 'nested' high resolution region

The Hadley Centre third coupled model - HadCM3




Machines used by The Met. office
10T
1T
100G
10G
1G
100M
10M
1M
100k
10k
1k
100
10
Computer
speed
(FLOPS)
CRAY C916
CRAY YMP8
ETA 10
CYBER 205
IBM 360/195
KDF 9
MERCURY
LEO 1
Single workstation
performance
Richardson's 'computer'
1950
1960
1970
1980
1990
2000
Year of first use

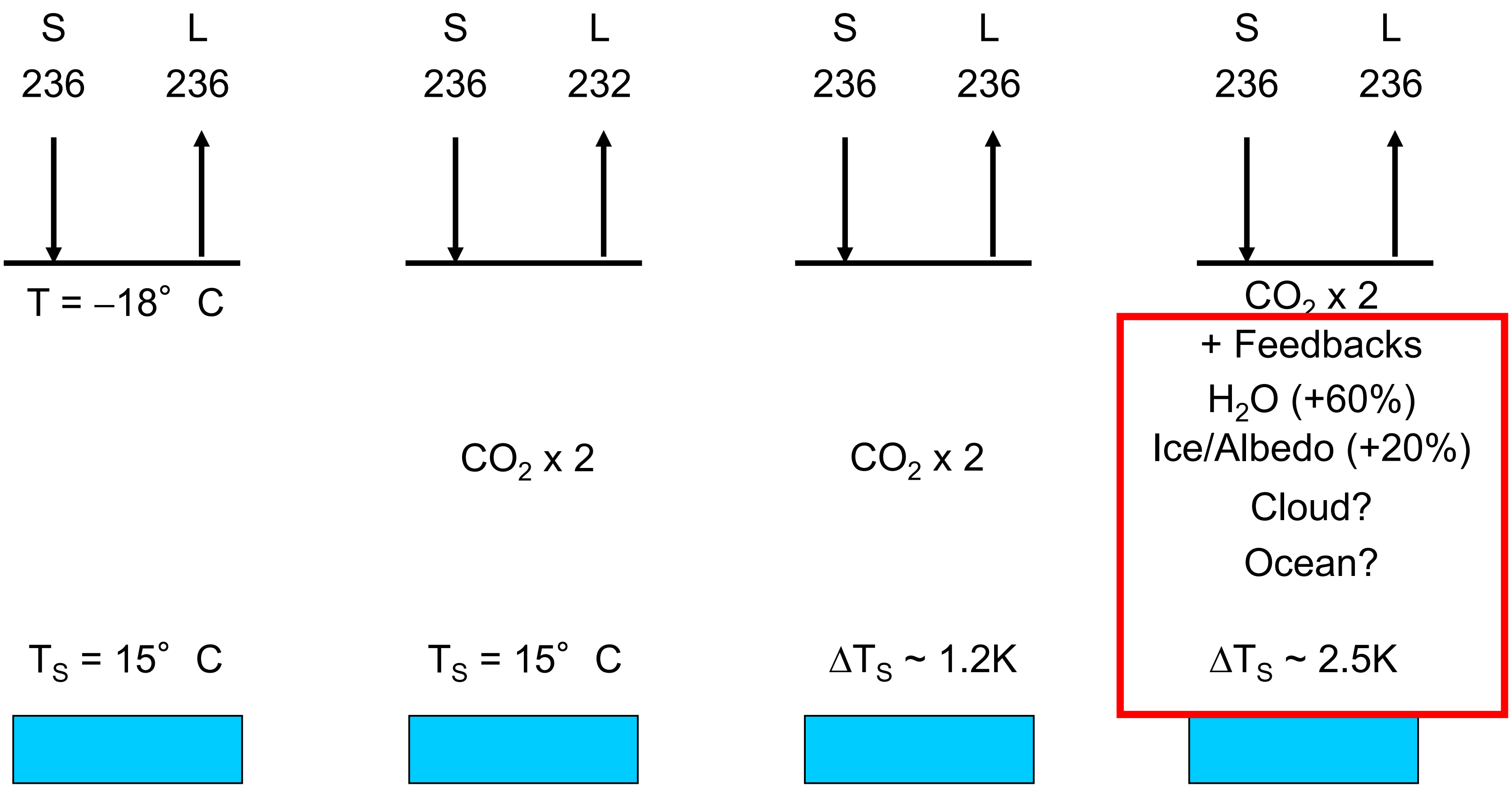
The Development of Climate models, Past, Present and Future



Climate models → Earth System Models

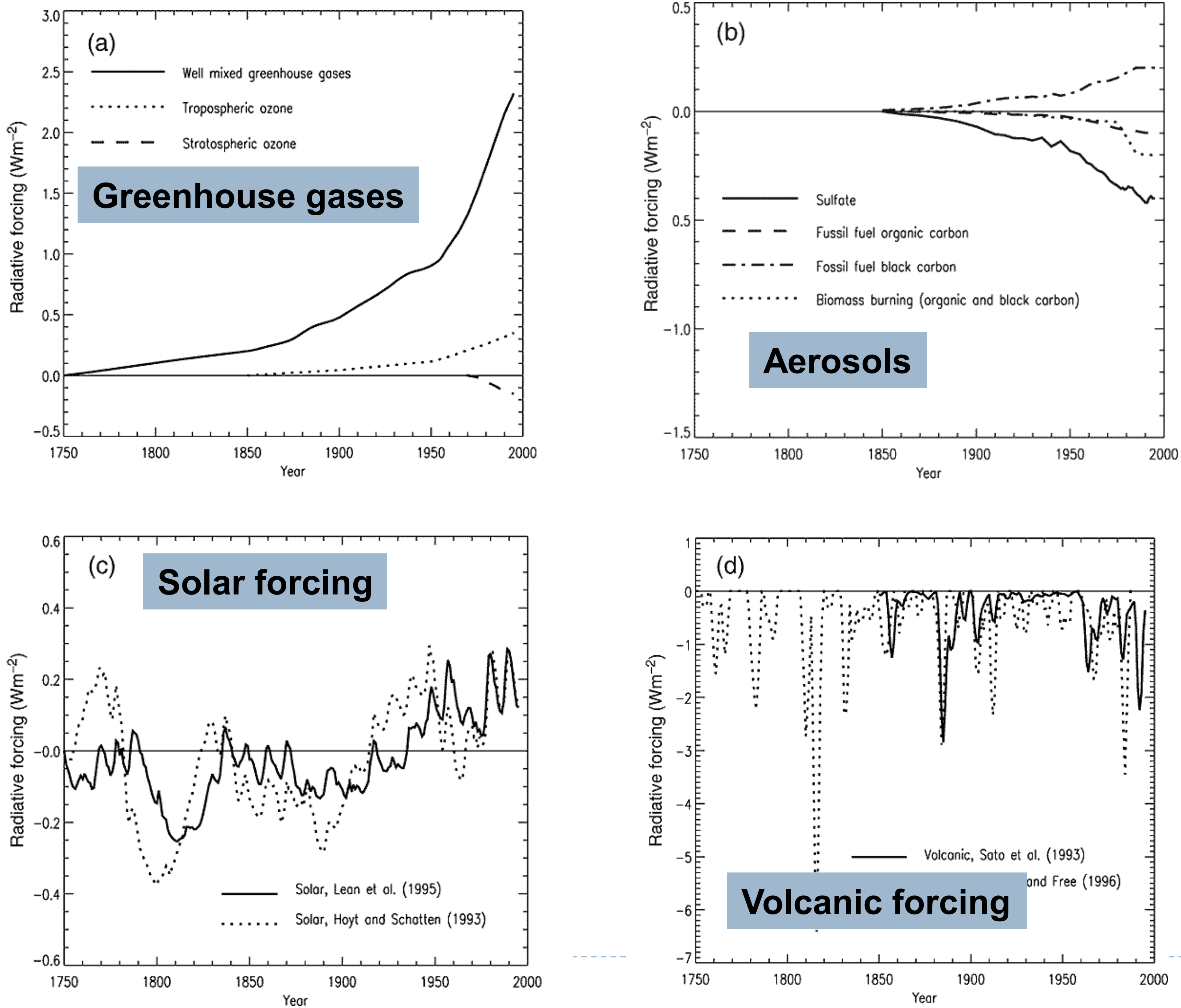
The Enhanced Greenhouse Effect

Solar (S) and longwave (L) radiation in Wm^{-2} at the top of the atmosphere

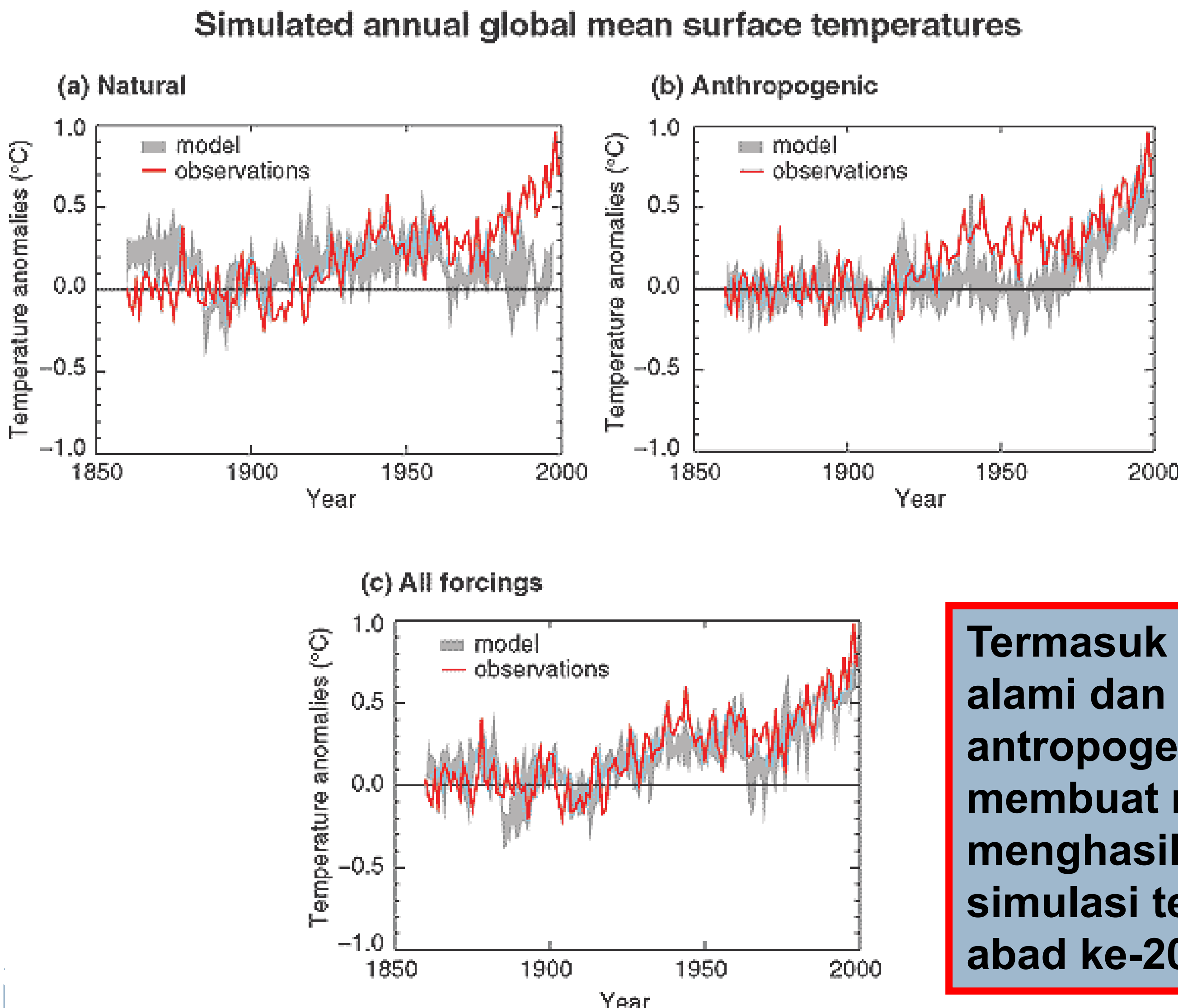


Feedbacks

- There are many important feedbacks in the climate system that can either amplify (positive feedback) or dampen (negative feedback) forcings
- Examples:
- + Water vapour – a warmer atmosphere holds more water, which is a greenhouse gas
- + Ice albedo – a warmer atmosphere has less ice cover, and reduces albedo
- +/- Clouds – a more cloudy atmosphere tends to be warmer at night, but cooler during the day. Cloud height is also important
- Uncertainties in feedbacks lead to uncertainties in future predictions – currently the main source of uncertainty


(a)
Well mixed greenhouse gases
Tropospheric ozone
Stratospheric ozone
Greenhouse gases
Radiative forcing (Wm^{-2})
Year
(b)
Sulfate
Fussil fuel organic carbon
Fossil fuel black carbon
Biomass burning (organic and black carbon)
Aerosols
Radiative forcing (Wm^{-2})
Year
(c)
Solar forcing
Solar, Lean et al. (1995)
Solar, Hoyt and Schatten (1993)
Radiative forcing (Wm^{-2})
Year
(d)
Volcanic, Sato et al. (1993)
and Free (1996)
Volcanic forcing
Radiative forcing (Wm^{-2})
Year

Climate simulations 1860-2000

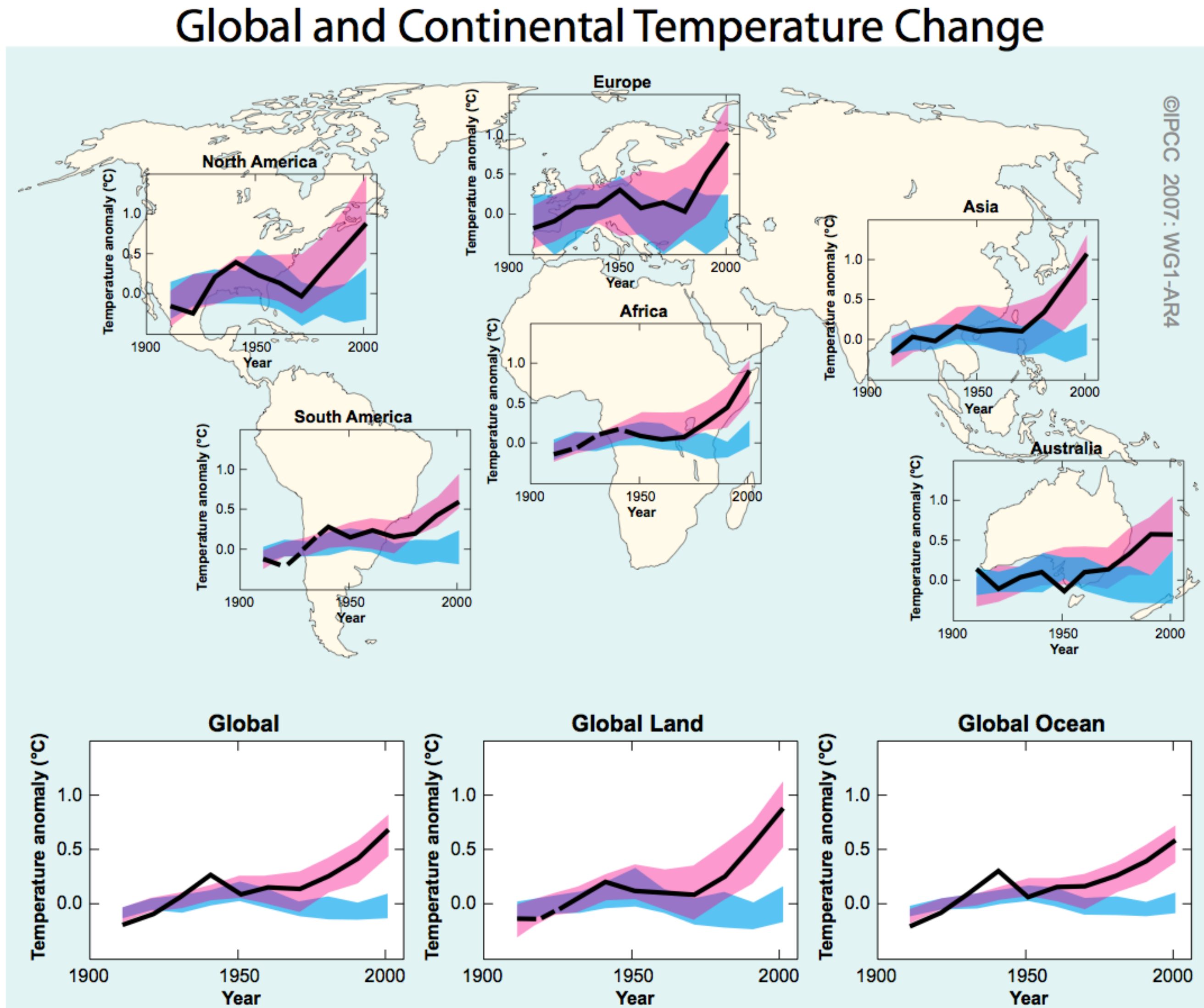


Model warna abu-abu, observasi dengan warna merah

Termasuk ramuan alami dan antropogenik membuat model ini menghasilkan simulasi terbaik iklim abad ke-20

Memahami dan Mengaitkan Perubahan Iklim

- Pemanasan global menunjukkan kontribusi antropogenik yang signifikan selama 50 tahun terakhir



Kesimpulan

- Model iklim mewakili komponen utama dari sistem iklim, dan interaksi dan masukan mereka
- Model iklim memiliki beberapa keterampilan untuk mensimulasikan iklim masa kini, dan juga tren abad ke-20
- Ini memberi kita beberapa keyakinan bahwa mereka dapat memprediksi masa depan.

Additional climate model resources

- Intergovernmental Panel on Climate Change
  - http://www.ipcc.ch/
- Community Climate System Model
  - http://www.cgd.ucar.edu/csm
- IPCC model data distribution
  - http://www-pcmdi.llnl.gov
- Climate data tools (PYTHON)
  - http://esg.llnl.gov/cdat
- SciDAC Earth System Grid project
  - CCSM and PCM data distribution
  - http://www.earthsystemgrid.org

- Michael Wehner, mfwehner@lbl.gov

Kalampangan area, July 2004