University of Leicester

EOS

Observing climate 3: Integrated observations

John Remedios

Earth Observation Science and NCEO
Dept. of Physics and Astronomy
U. Leicester

AATSR

ENVISAT

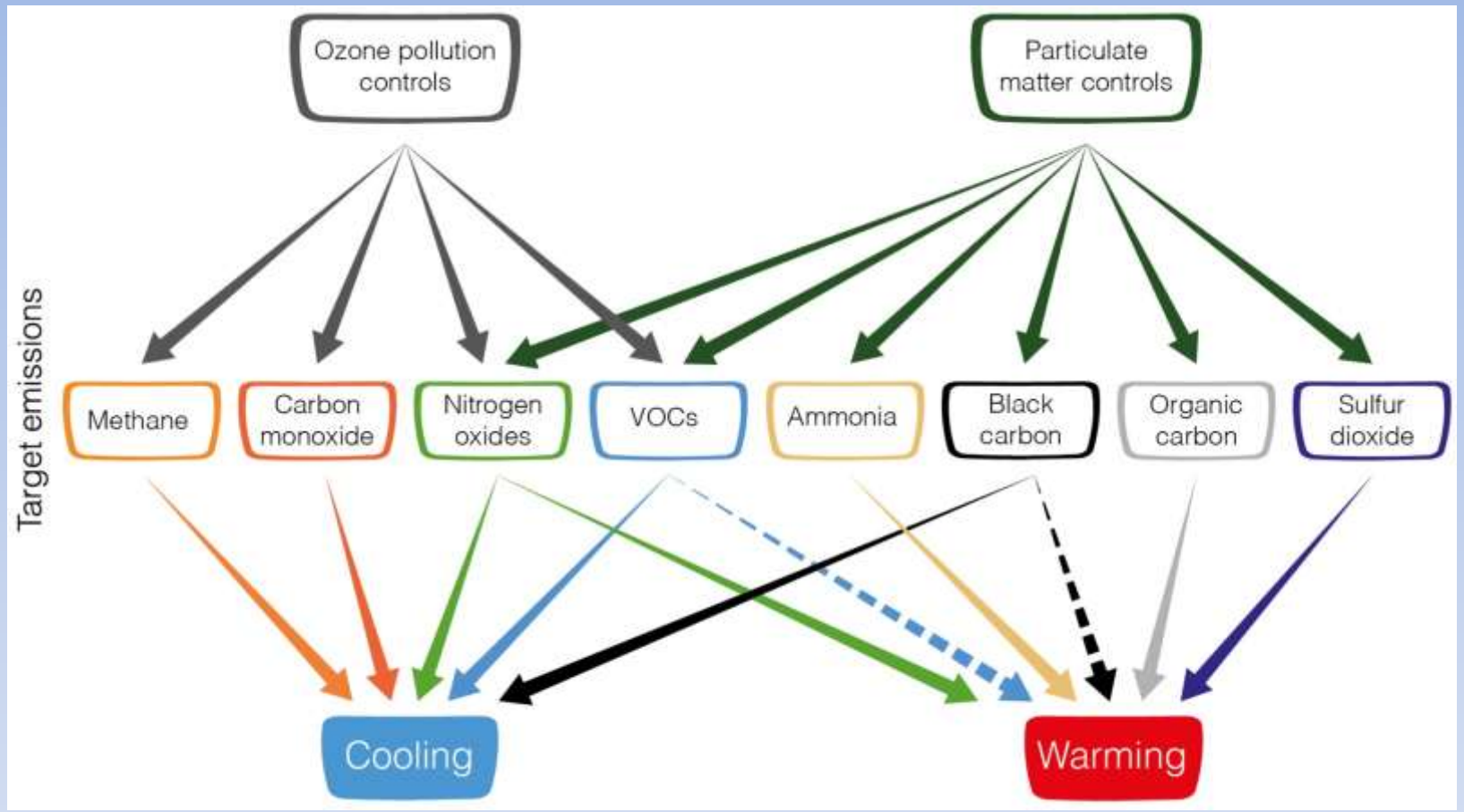
G-STEP
Innovating / Training / Collaborating

IPCC figures from Ch.2, 8, SPM; WG I report 2013

Hartmann, D.L., A.M.G. Klein Tank, M. Rusticucci, L.V. Alexander, S. Brönnimann, Y. Charabi, F.J. Dentener, E.J. Dlugokencky, D.R. Easterling, A. Kaplan, B.J. Soden, P.W. Thorne, M. Wild and P.M. Zhai, 2013: Observations: Atmosphere and Surface. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 159–254, doi:10.1017/CBO9781107415324.008.

IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–30, doi:10.1017/CBO9781107415324.004.

IPCC: Climate and other controls



FAQ 8.2, Figure 1: Schematic diagram of the impact of pollution controls on specific emissions and climate impact. Solid black line indicates known impact, dashed line indicates uncertain impact.

IPCC: Land Surface Air Temp

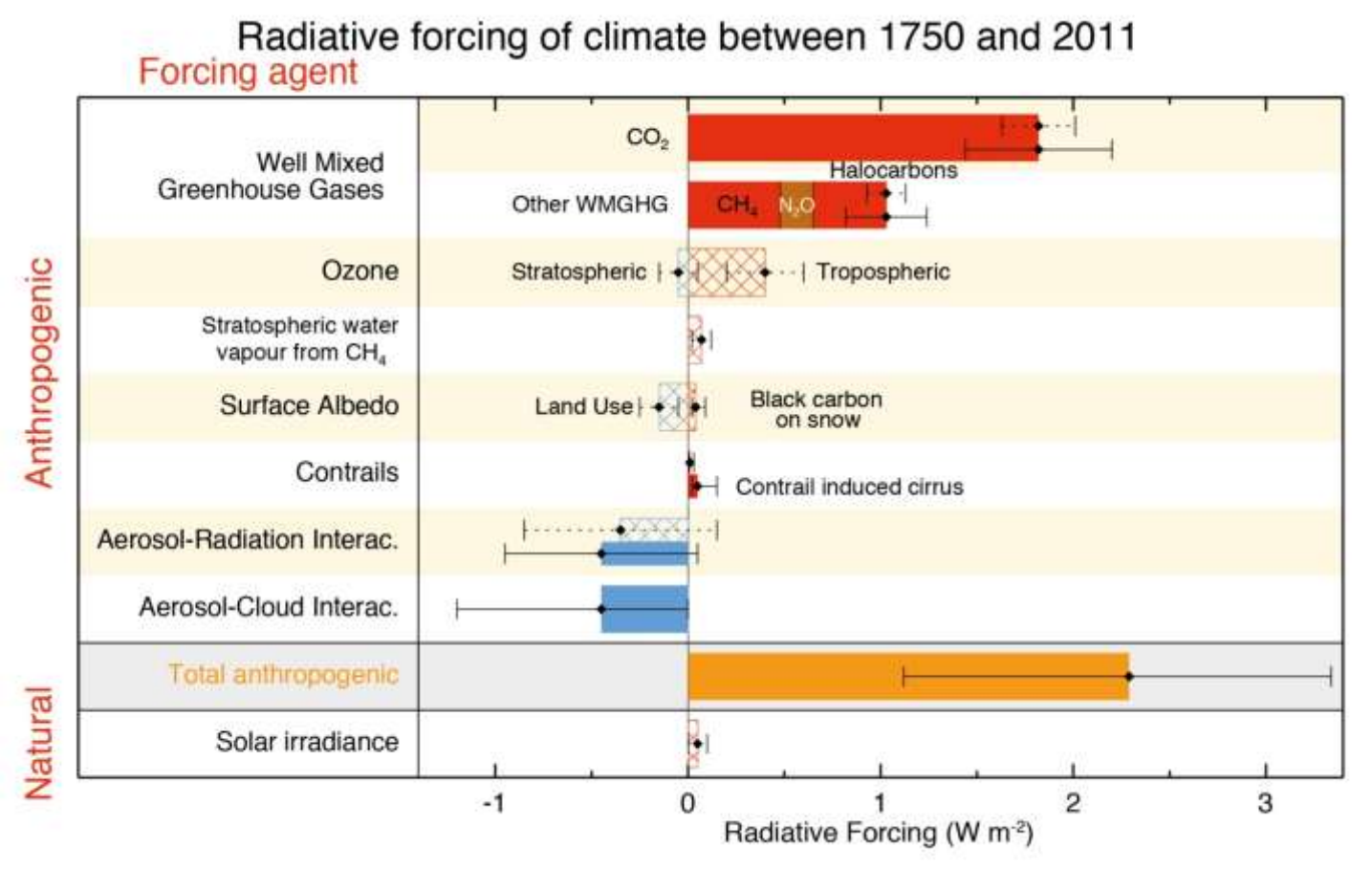


Figure 8.15: Bar chart for RF (hatched) and ERF (solid) for the period 1750–2011, where the total ERF is derived from Figure 8.16. Uncertainties (5–95% confidence range) are given for RF (dotted lines) and ERF (solid lines).

IPCC Summary WG1 2013

- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.
- The atmosphere and ocean have warmed,
- the amounts of snow and ice have diminished,
- sea level has risen,
- the concentrations of greenhouse gases have increased

IPCC: Coherence

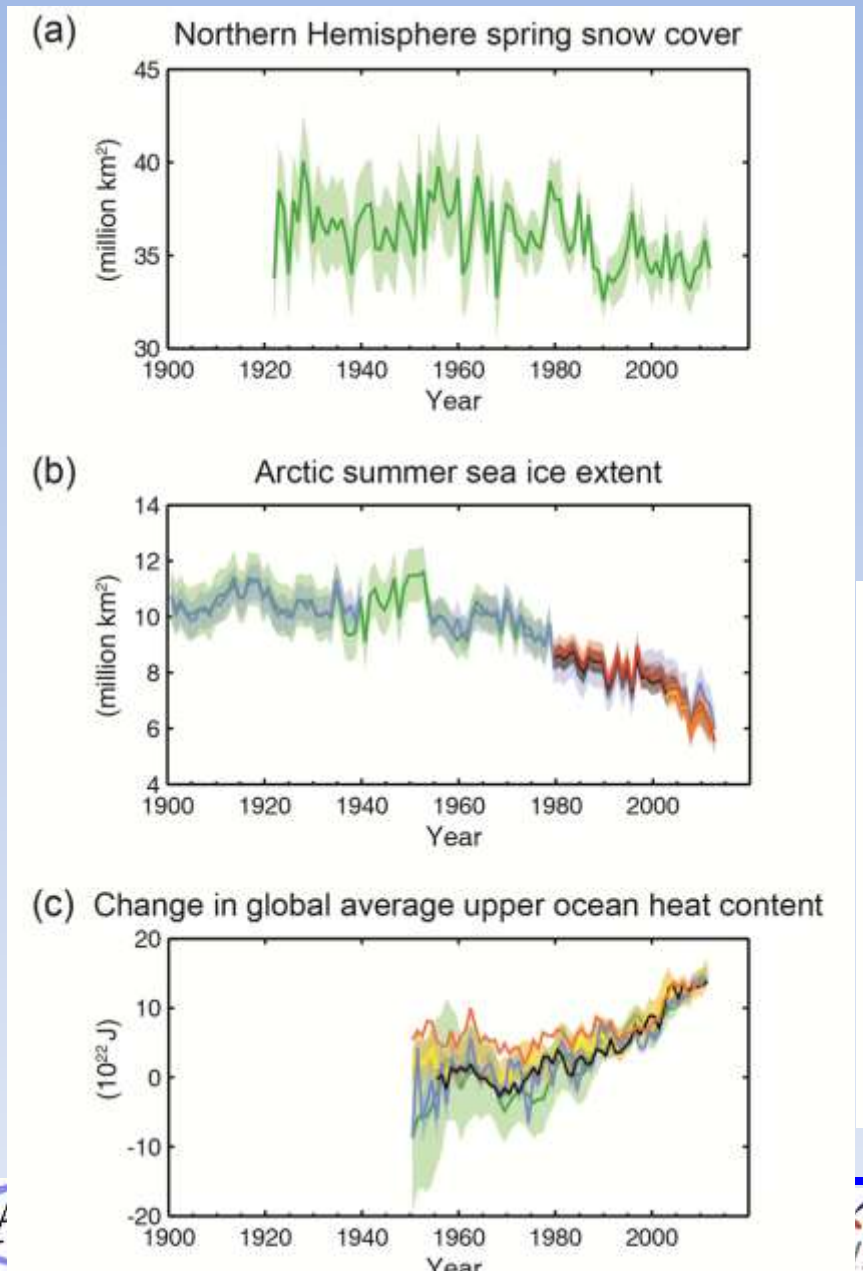
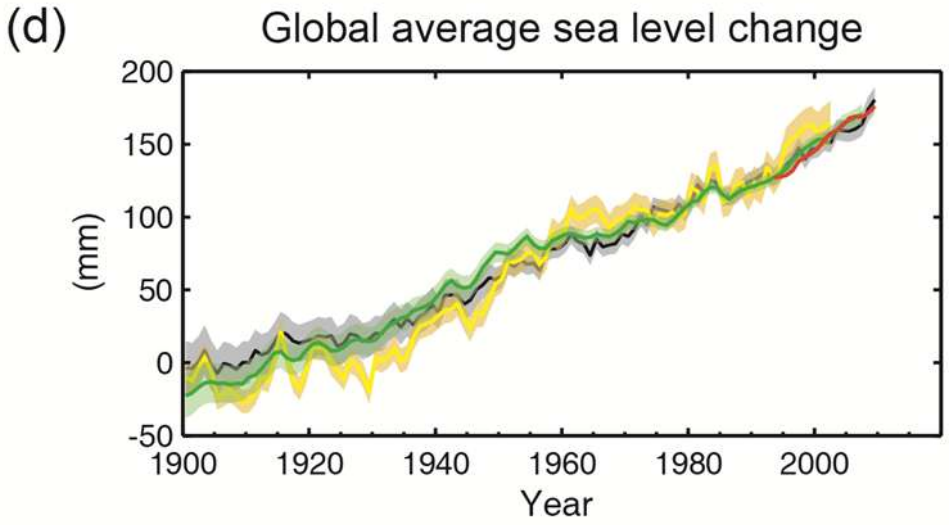
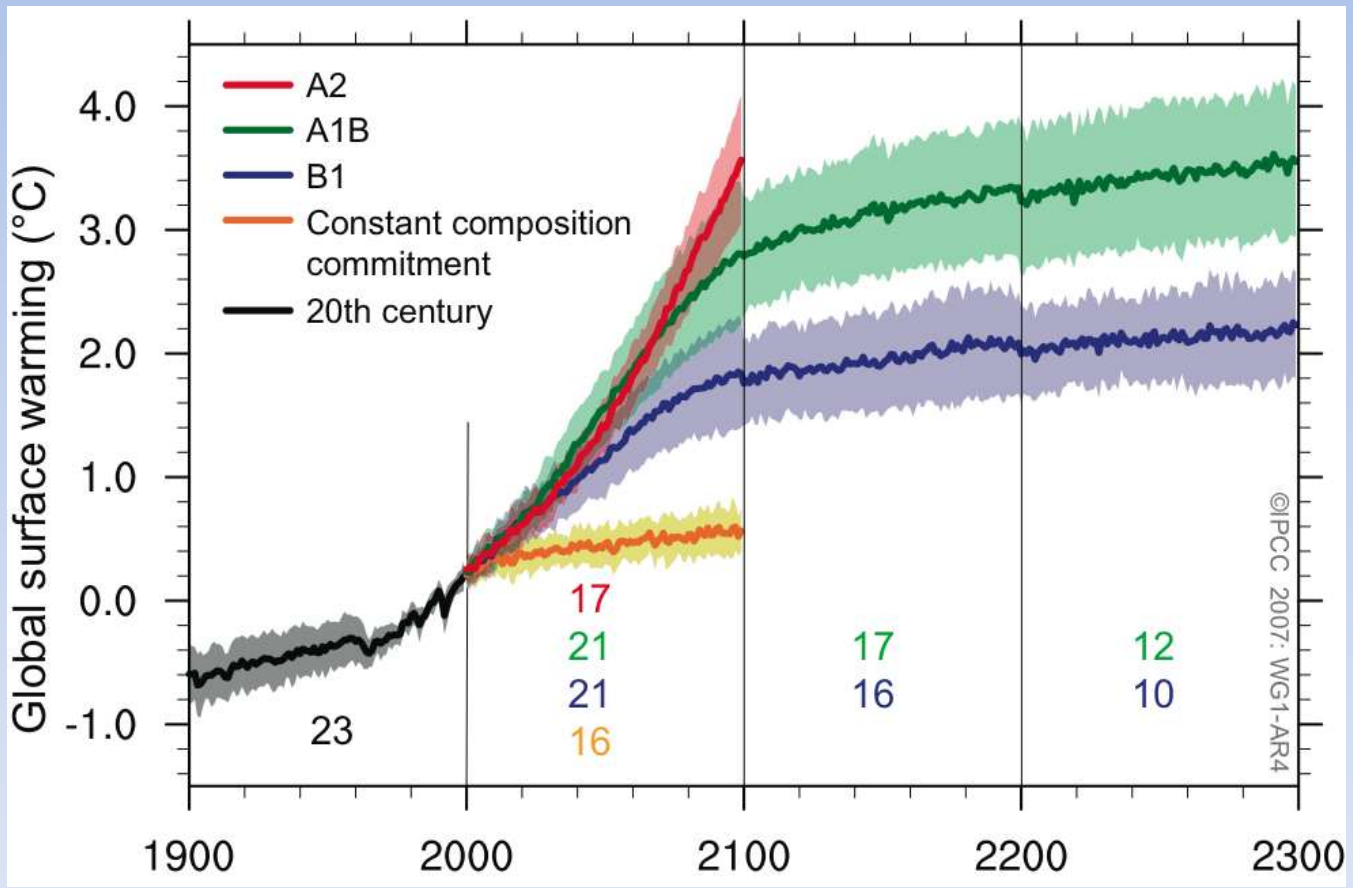


Figure SPM.3: Multiple observed indicators of a changing global climate: (a) Extent of Northern HemisphereMarch-April (spring) average snow cover, (b) Extent of Arctic July-August-September (summer) average sea ice, (c) change in global mean upper ocean (0–700 m) heat content aligned to 2006–2010, and relative to the mean of all datasets for 1971, (d) global mean sea level relative to the 1900–1905 mean of the longest running dataset, and with all datasets aligned to have the same value in 1993, the first year of satellite altimetry data. All time-series (coloured lines indicating different data sets) show annual values, and where assessed, uncertainties are indicated by coloured shading. See Technical Summary Supplementary Material for a listing of the datasets. {Figures 3.2, 3.13, 4.19, and 4.3; FAQ 2.1, Figure 2; Figure TS.1}



DEPENDENCY ON CO_2 LEVELS
[From the IPCC 2007 report, http://www.ipcc.ch]

Orange = constant at current levels
B1 = stabilisation at 600 ppmv
A1B = Business as usual
Taken from Susan Solomon IPCC presentation



Scenario Equilibrium CO_2 concentrations

850 ppmv

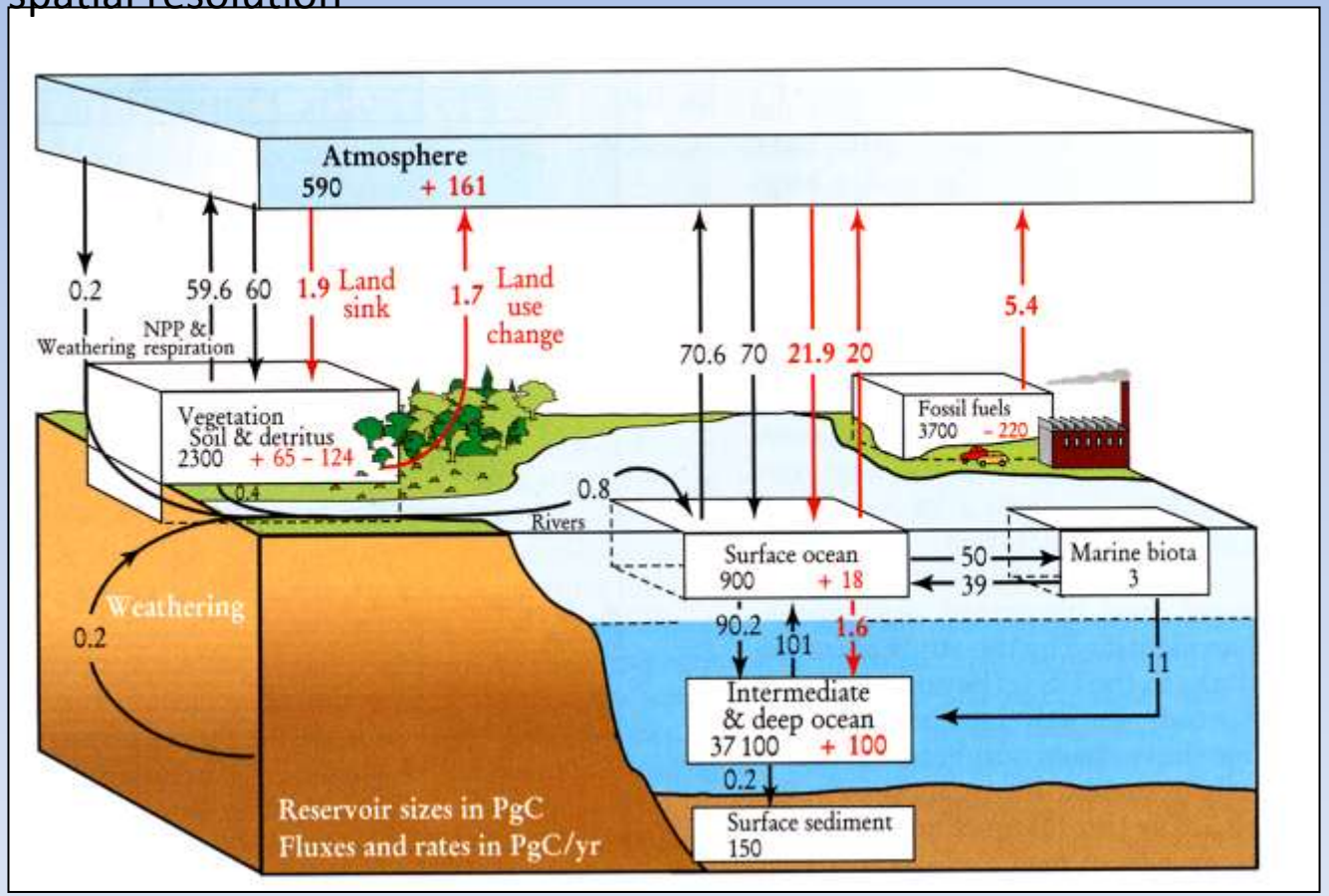
600 ppmv

400 ppmv

Missing aspects: The Carbon cycle and feedbacks for future Earth system understanding

Will be included fully in next generation climate models of the Earth system, e.g. UKESM1

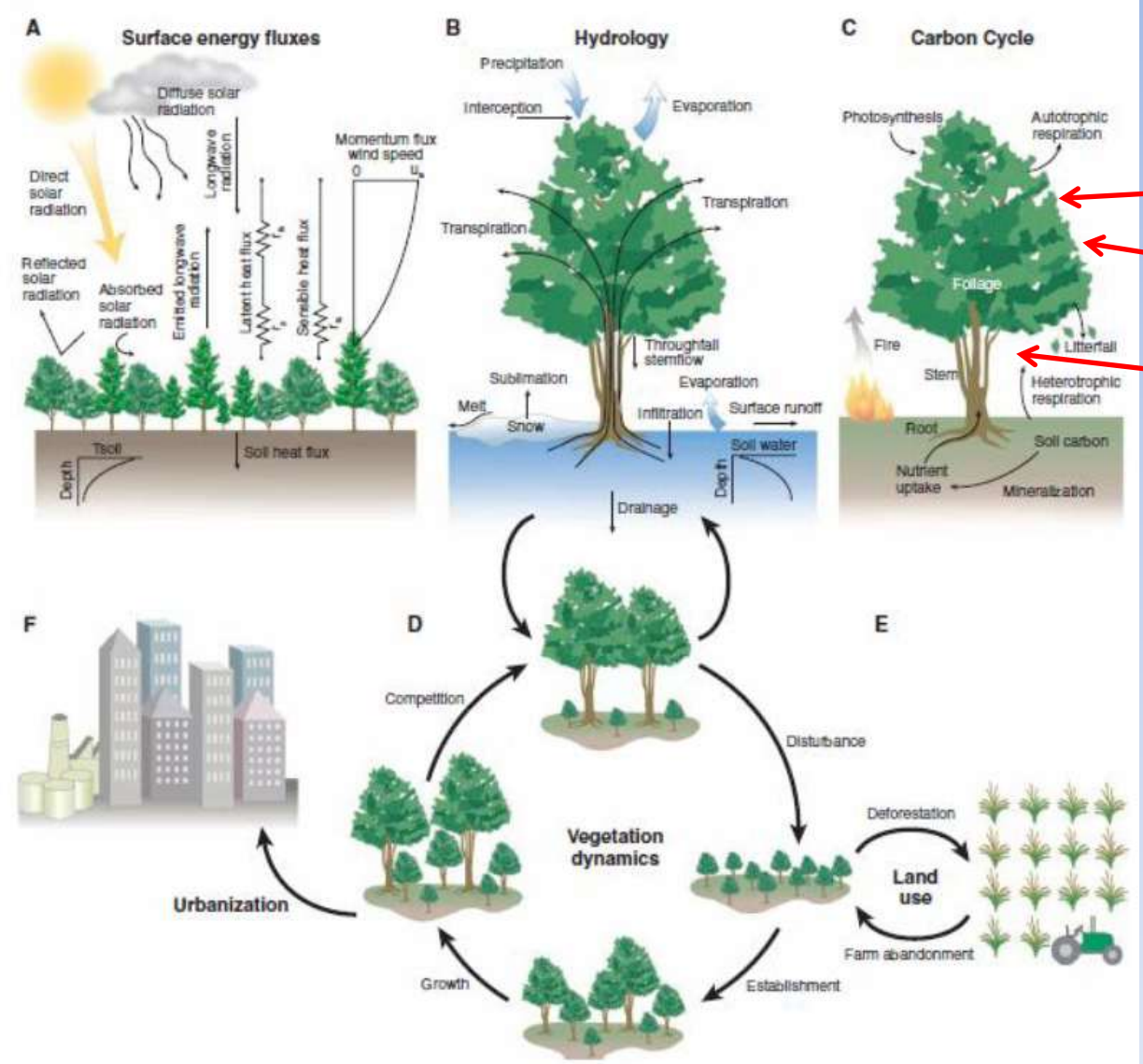
Currently some cycles in Earth system models of intermediate complexity (EMICS) but limited spatial resolution



BOXES = RESERVOIRS
ARROWS = FLUXES
BLACK = NATURAL PROCESSES,
RED=ANTHROPOGENIC INFLUENCES

Sarmiento and Gruber, Physics Today, 2002

Forest cycles



LAI

Height

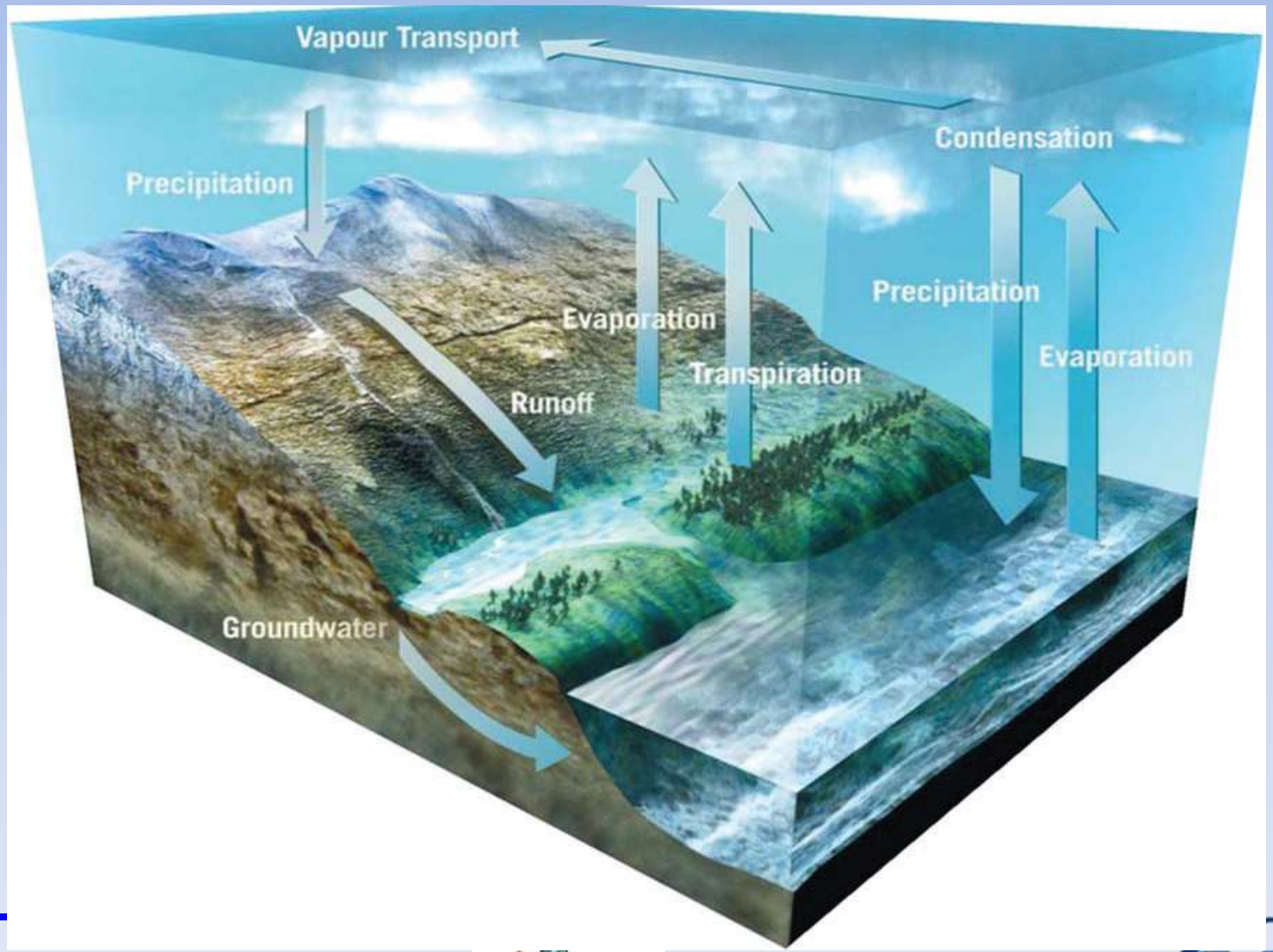
Biomass

Bonan (2008)

Global water cycle

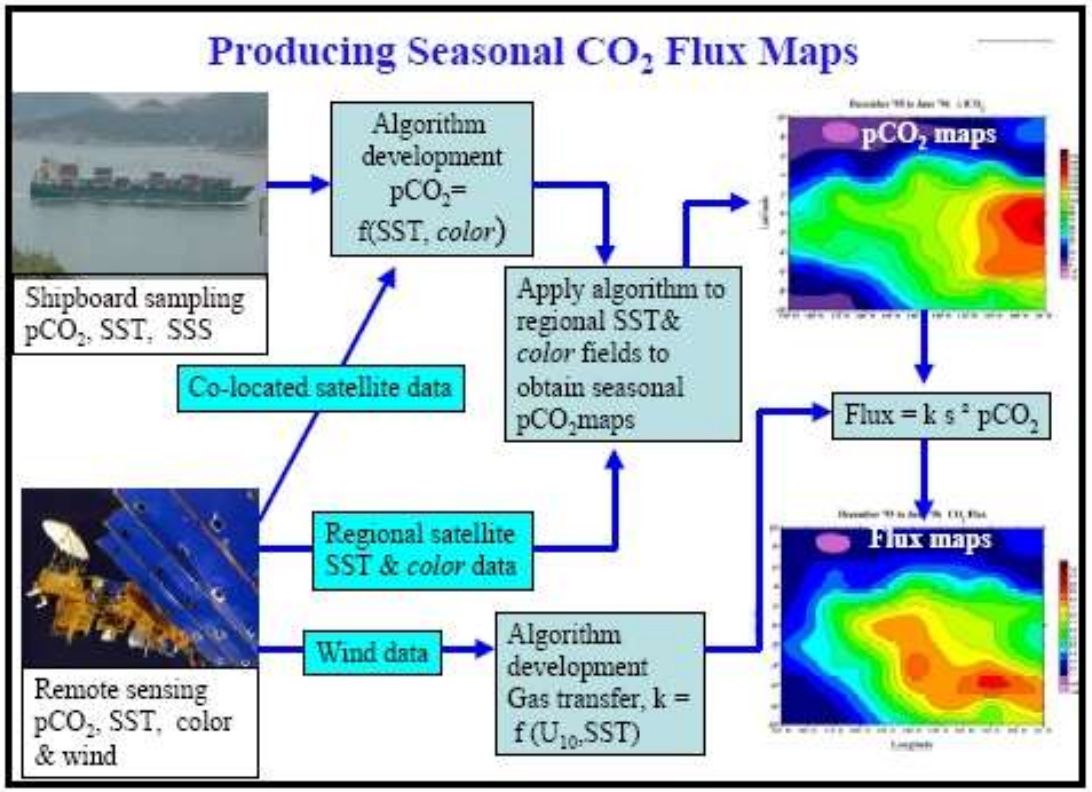
Courtesy ESA; GEO Integrated Global Water Cycle Observations

GPM
Met systems
SWOT
GRACE



Illustrative ocean carbon flux process

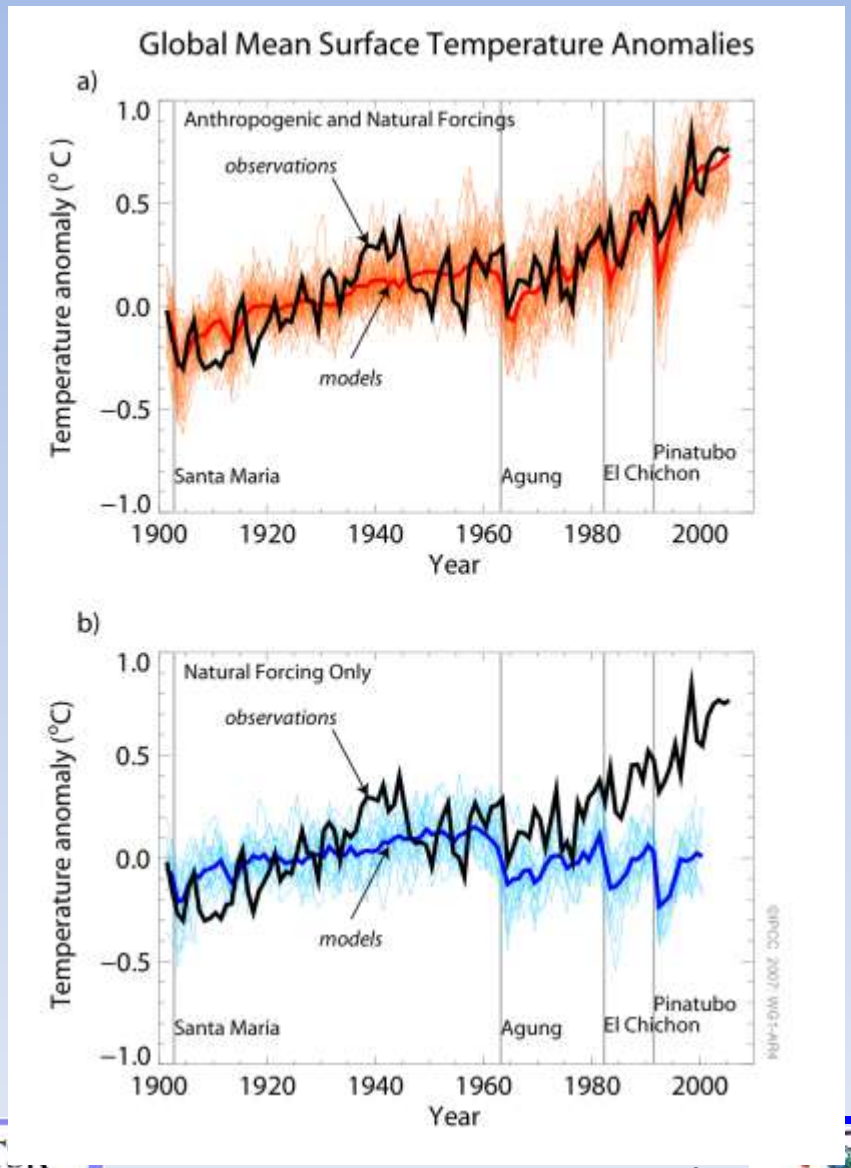
- http://www.oco.noaa.gov/oceanAtmosCarbonFluxProduct.html



Schematic of steps involved to create flux maps. From ship data and co-located satellite data we create algorithms. These algorithms are applied to regional fields of remotely sensed parameters such as sea surface temperature (SST) and color. Using relationships of wind speed and gas exchange the gas transfer velocities are determined. The gas transfer velocities and Δ pCO_2 fields are then used to determine regional fluxes.

Disruptive events

TESTING THE MODELS WITH DATA
[From the IPCC 2007 report, http://www.ipcc.ch]



Since we cannot test models in the future, the best way to test GCMs is against past climate – need long-term observations for this.

Example shows that a model, although it has uncertainties, can reproduce large elements of the temperature rise through the 20th century – there is a consistency between models and observations.

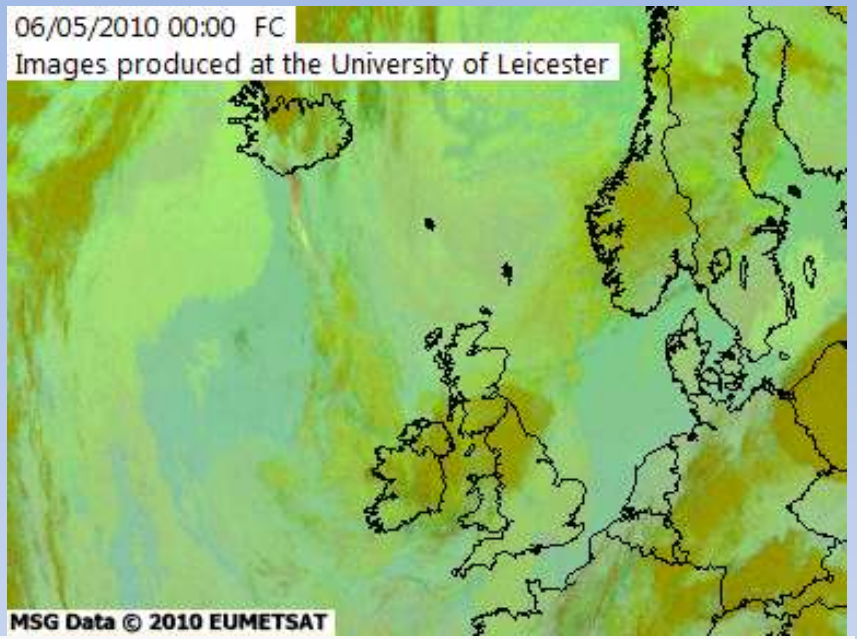
Natural forcings include solar, volcano.

Taken from Susan Solomon IPCC presentation for IPCC WGI

Mt Pinatubo eruption, 1991

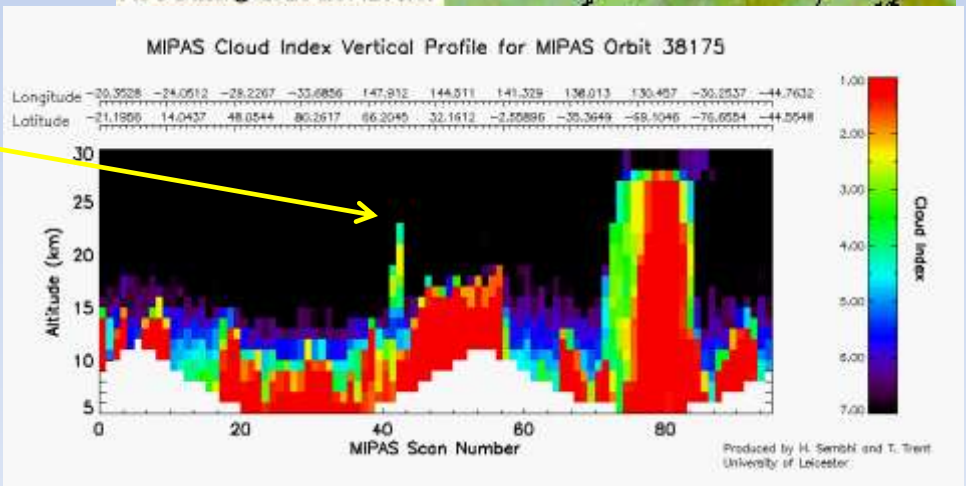
Volcanoes and T (surface)

Mt. Pinatubo



Eyjafjallajokull

Sarychev



Stratospheric aerosol: SPARC 2006; Figure from SPARC CCMVal 2010

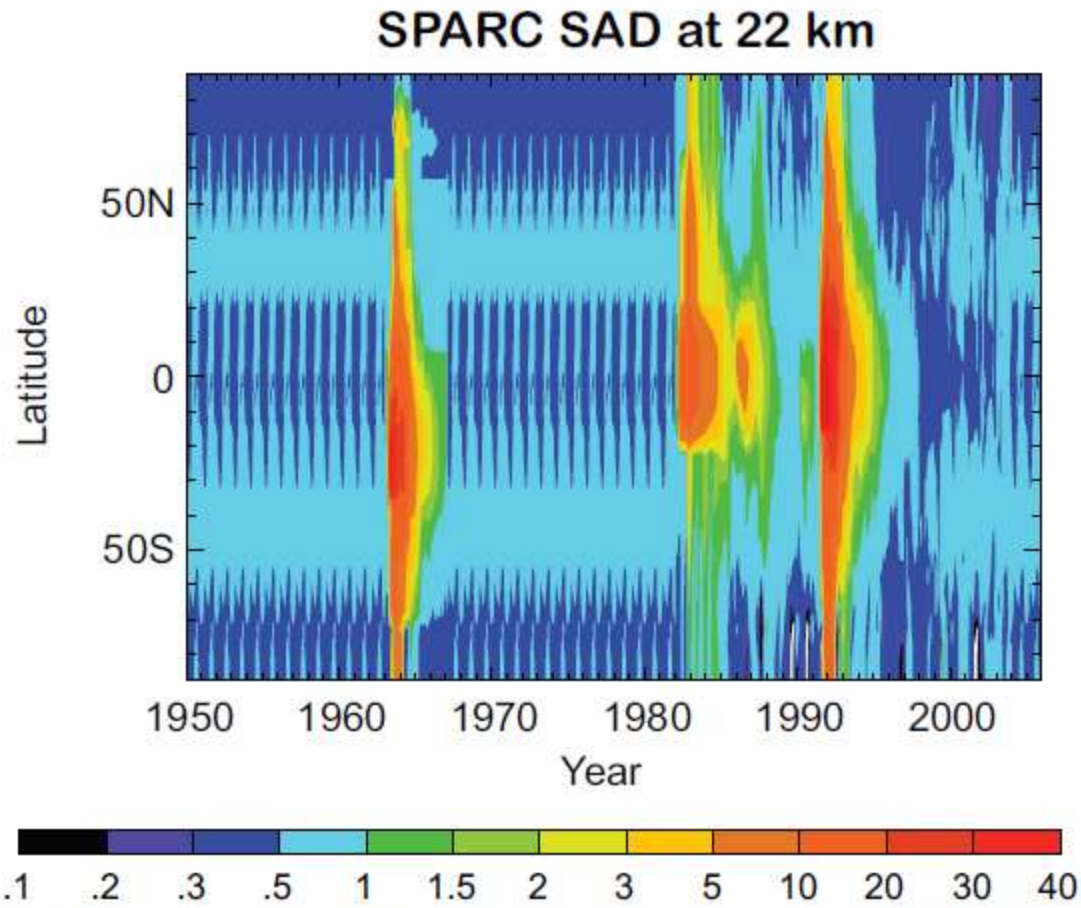


Figure 2.5: Aerosol surface area density ($\mu m^2/cm^3$) at 22 km, reconstructed from SAGE data.

IPCC ATSR SST vs HadSST3

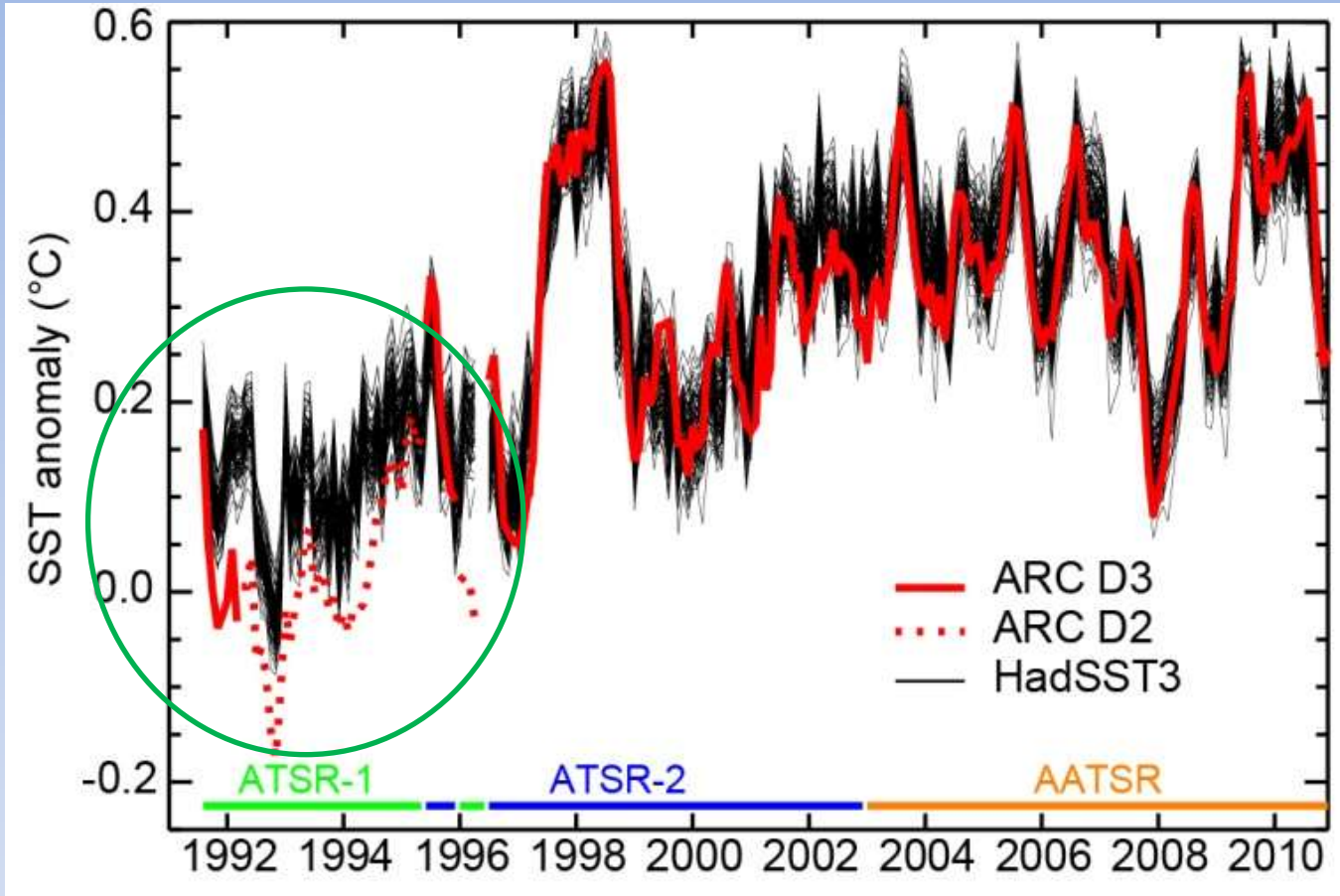


Figure 2.17: Global monthly mean Sea Surface Temperature (SST) anomalies relative to a 1961–1990 climatologyfrom satellites (ATSRs) and in situ records (HadSST3). Black lines: the 100-member HadSST3 ensemble. Red lines: ATSR-based night-time subsurface temperature at 0.2m depth (SST0.2m) estimates from the ATSR Reprocessing for Climate (ARC) project. Retrievals based on three spectral channels (D3, solid line) are more accurate than retrievals based on only two (D2, dotted line). Contributions of the three different ATSR missions to the curve shown are indicated at the bottom. The in situ and satellite records were co-located within 5° × 5° monthly grid boxes: only those where both datasets had data for the same month were used in the comparison. Adapted from Merchant et al. (2012).

Volcanoes and climate

- Some large volcanoes cause falls in global temperature
- Heating effect of volcanic aerosols can cause changes in atmospheric circulation
- Heterogeneous chemistry in stratosphere results in ozone decreases
- How often does a large volcanic eruption occur which is large enough to perturb climate?
- How often do volcanic eruptions perturb the EO observing system?

Reflections: the human dynamic

Entering the Anthropocene

Science (and Society)

Decadal Survey (NRC, 2007)

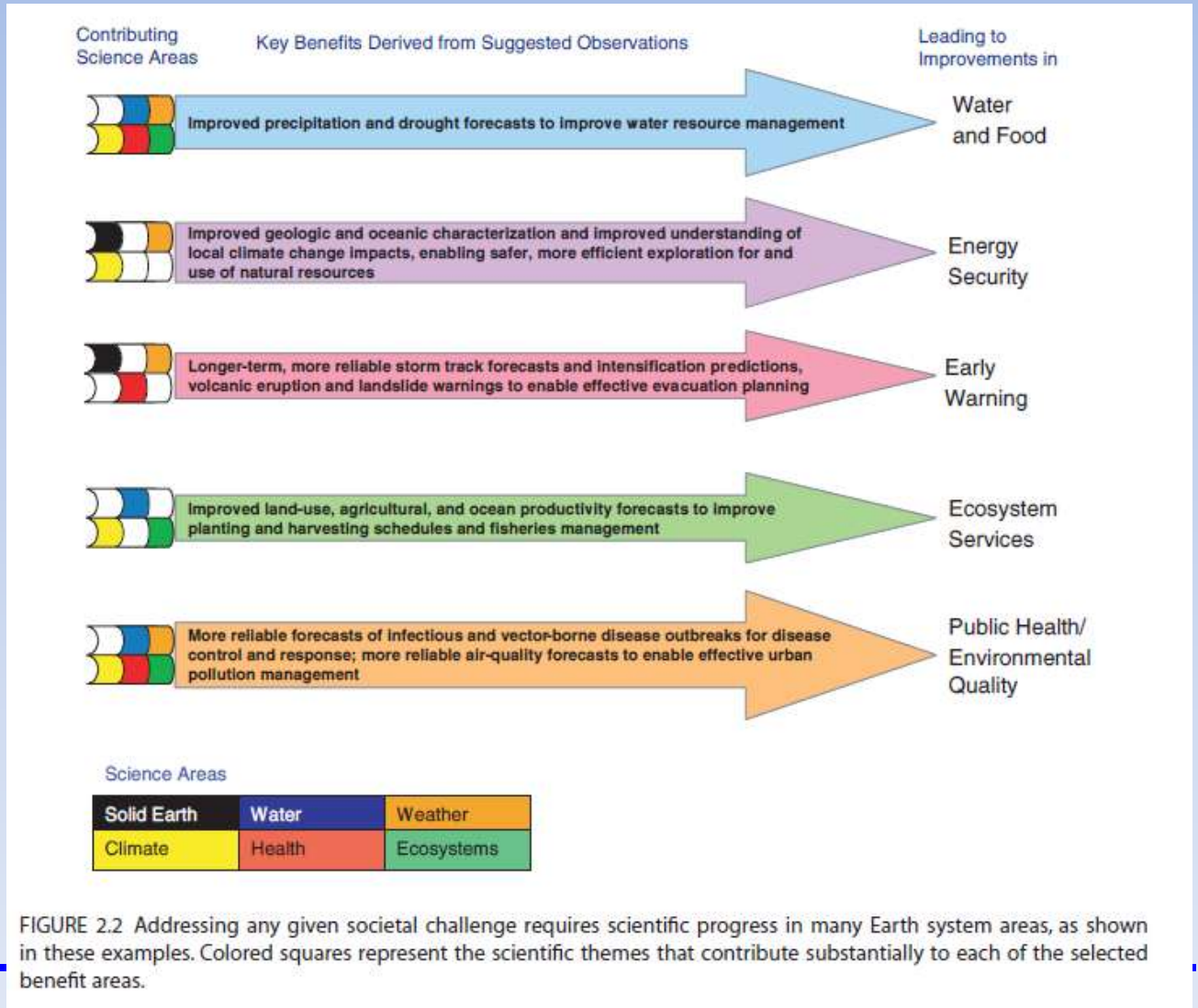
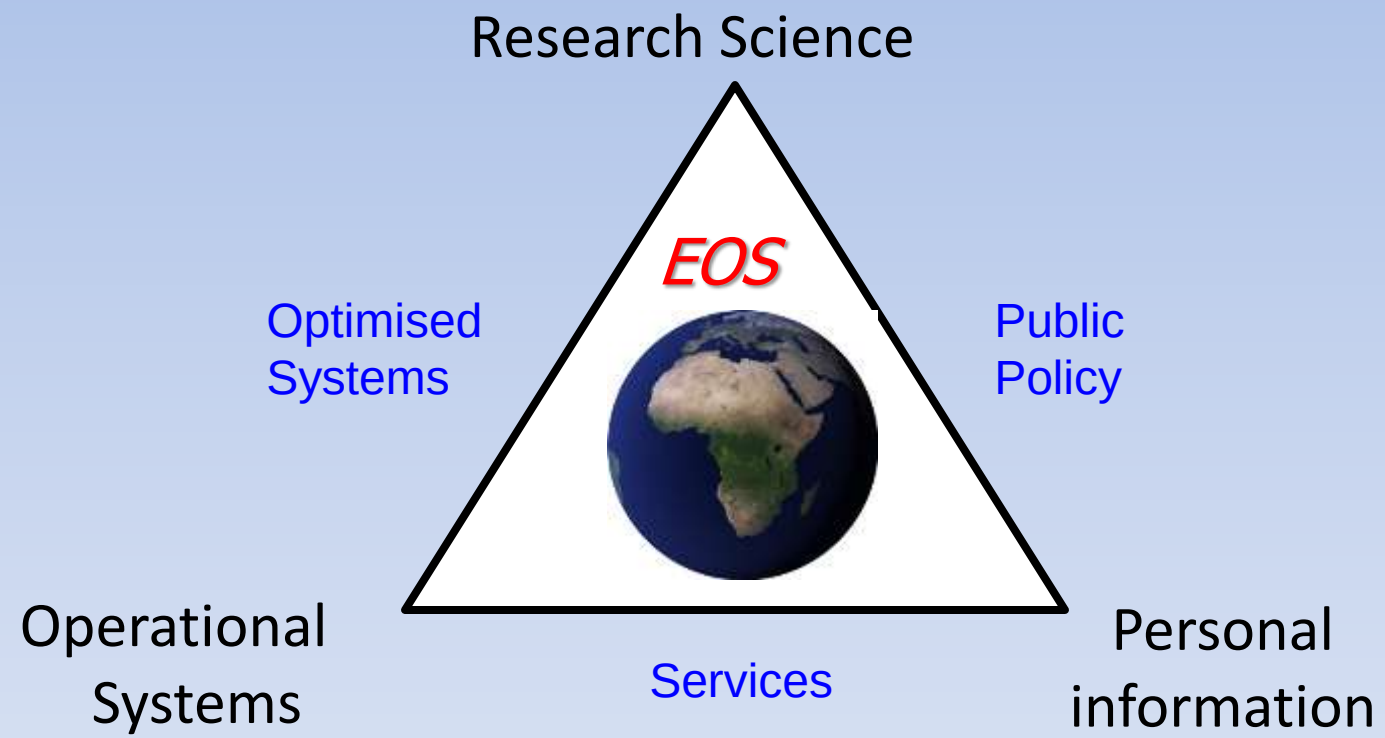


FIGURE 2.2 Addressing any given societal challenge requires scientific progress in many Earth system areas, as shown in these examples. Colored squares represent the scientific themes that contribute substantially to each of the selected benefit areas.

50 years forward

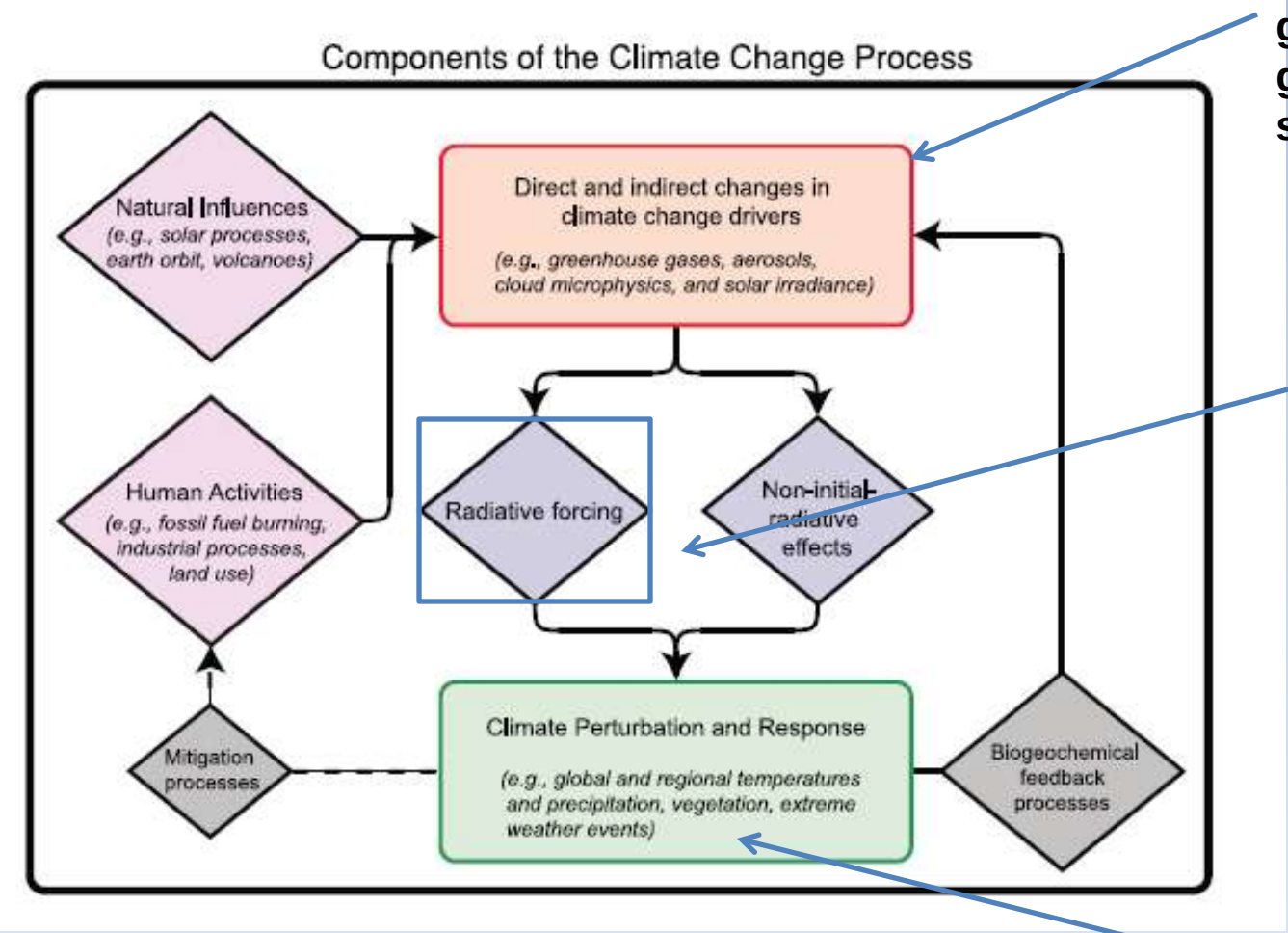
EO embedded in society



What will this system look like and how will we build it?

CONCEPT DIAGRAM
[From the IPCC 2007 report, http://www.ipcc.ch]

Radiative forcing concept diagram (Figure 2.1) from the IPCC 2007 AR4 report



Change in greenhouse gas, clouds, sun

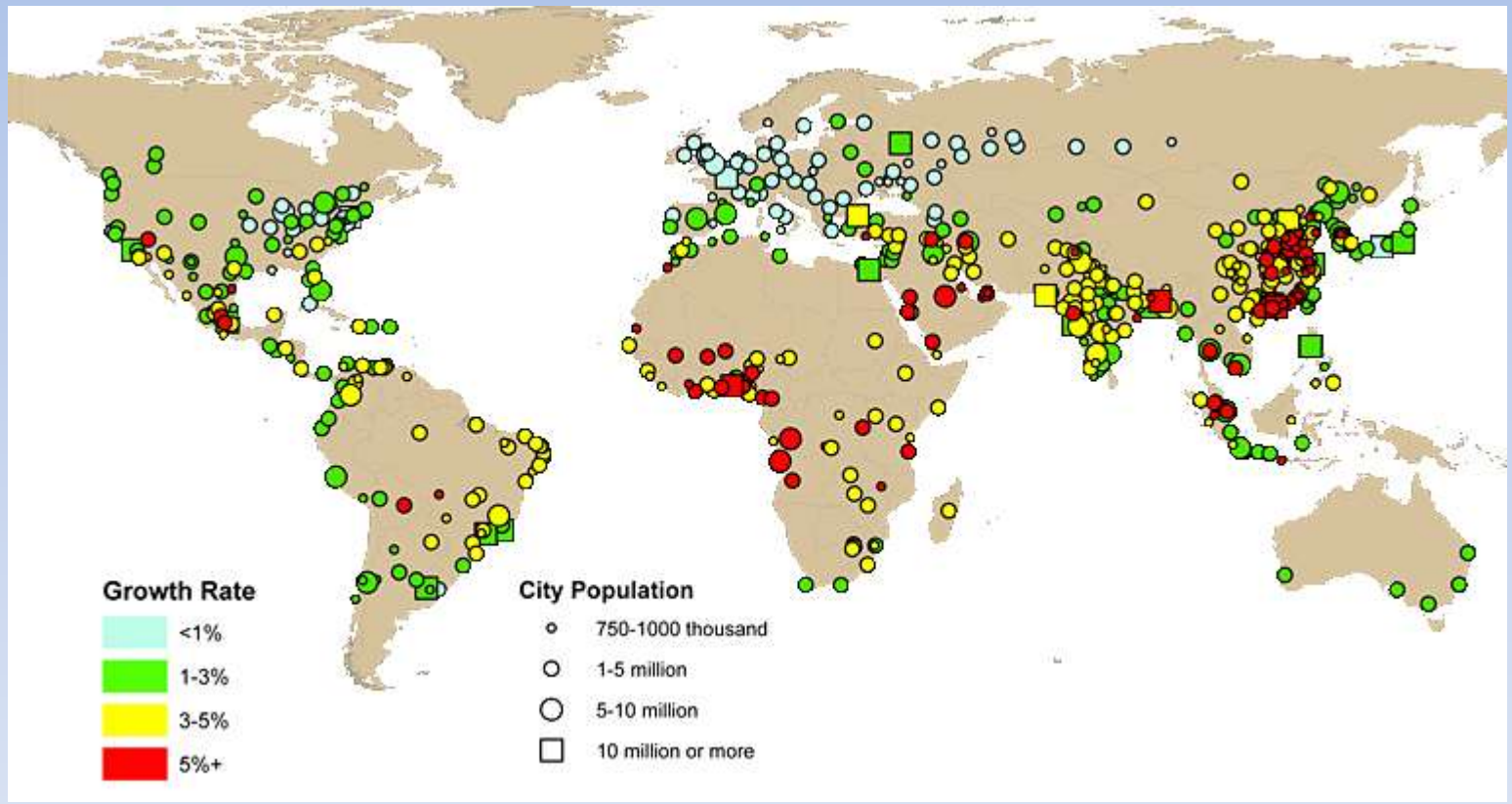
Changes in atmosphere or sun change the forcing of the climate system

Change in surface temperature or other climate parameter
N.B. feedback!!

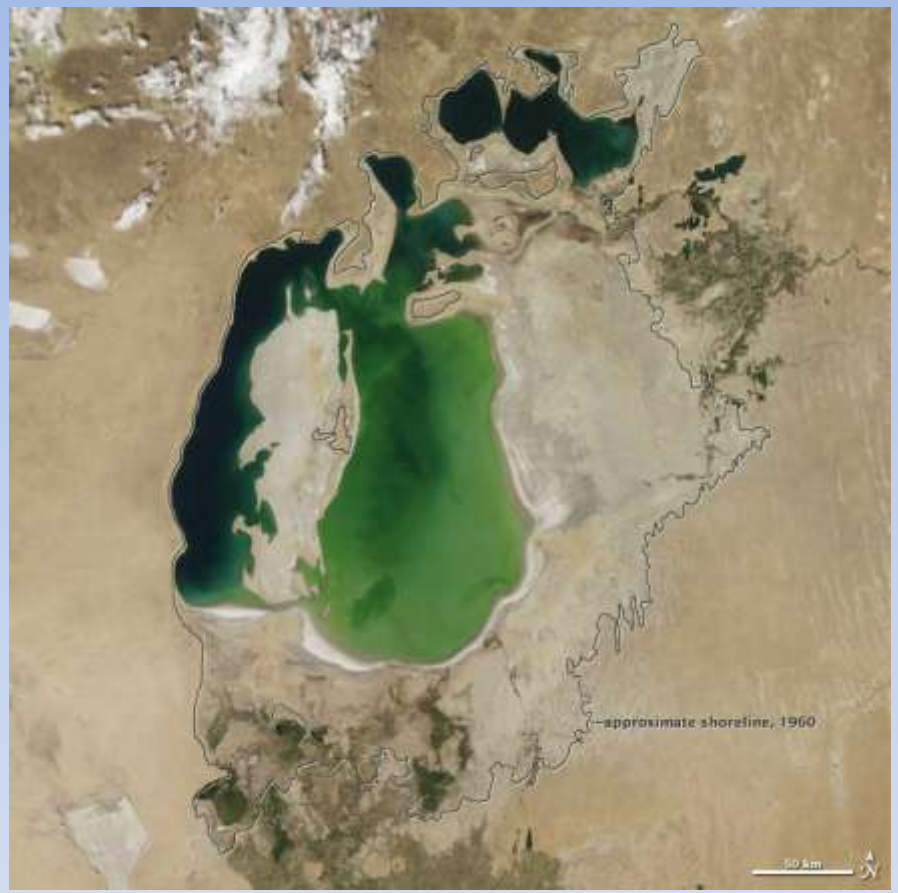
Urban change

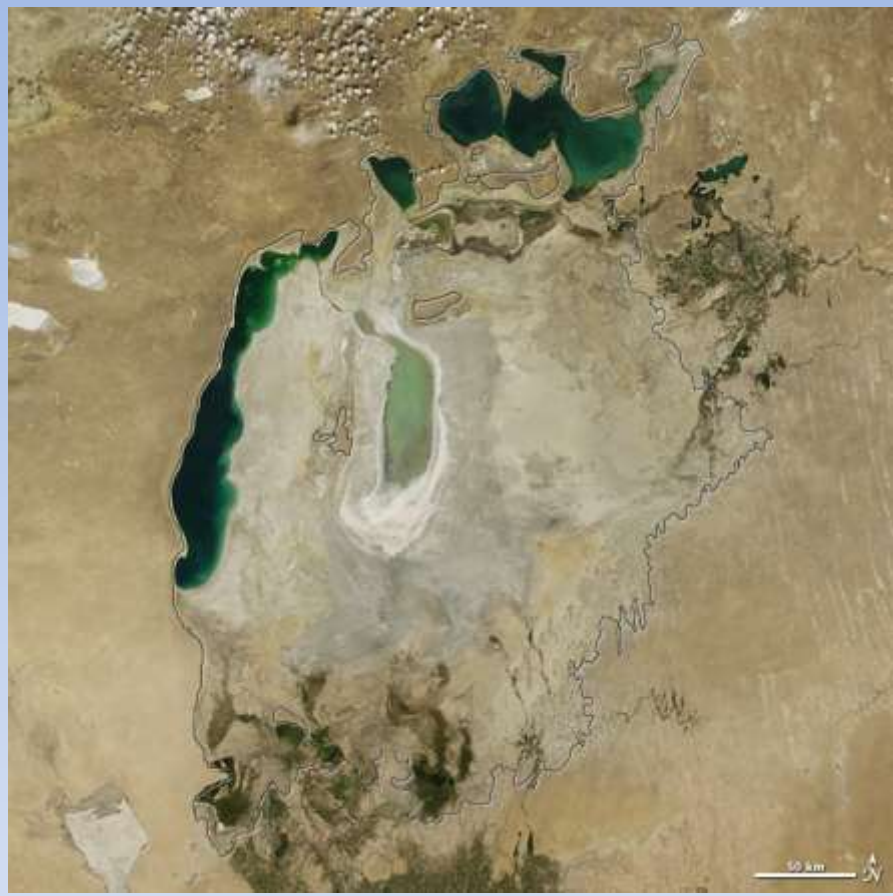
- http://esa.un.org/unup/Maps/maps_1970_2011.htm

Source: United Nations, Department of Economic and Social Affairs, Population Division: World Urbanization Prospects, the 2011 Revision, New York 2012



Aral Sea changes: MODIS





25/8/2000 25/8/2013

http://earthobservatory.nasa.gov/Features/WorldOfChange/aral_sea.php

Beyond Climate Services

- Climate information and knowledge to policy and market
- Personal apps
- Citizen science
- Model/data integration and model robustness.
- A world of change!
  http://www.earthobservatory.nasa.gov/Features/WorldOfChange/

… the human dimension…..

- Social “human” dynamics in Earth system models: economic analyses; migrations; disruptive land change
- New descriptions of cause, risk and impacts
- Environmental trade-offs vs a regulated Earth
- Environmental choice.