UNITED NATIONS STATISTICS DIVISION (UNSD)

Workshop on Environment Statistics in support of the implementation of the Framework for the Development of Environment Statistics (FDES 2013)

Balaclava, Mauritius

26-29 January 2015

Climate change and GHGs

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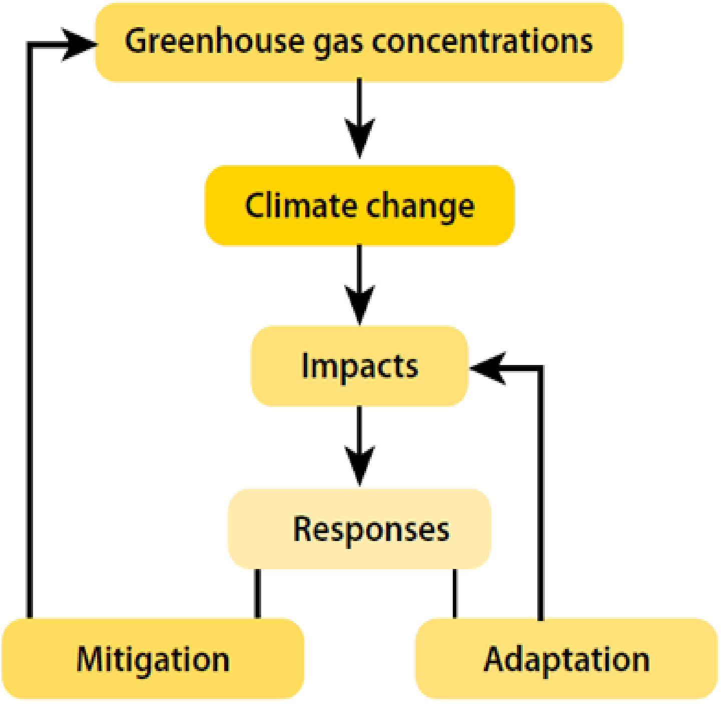

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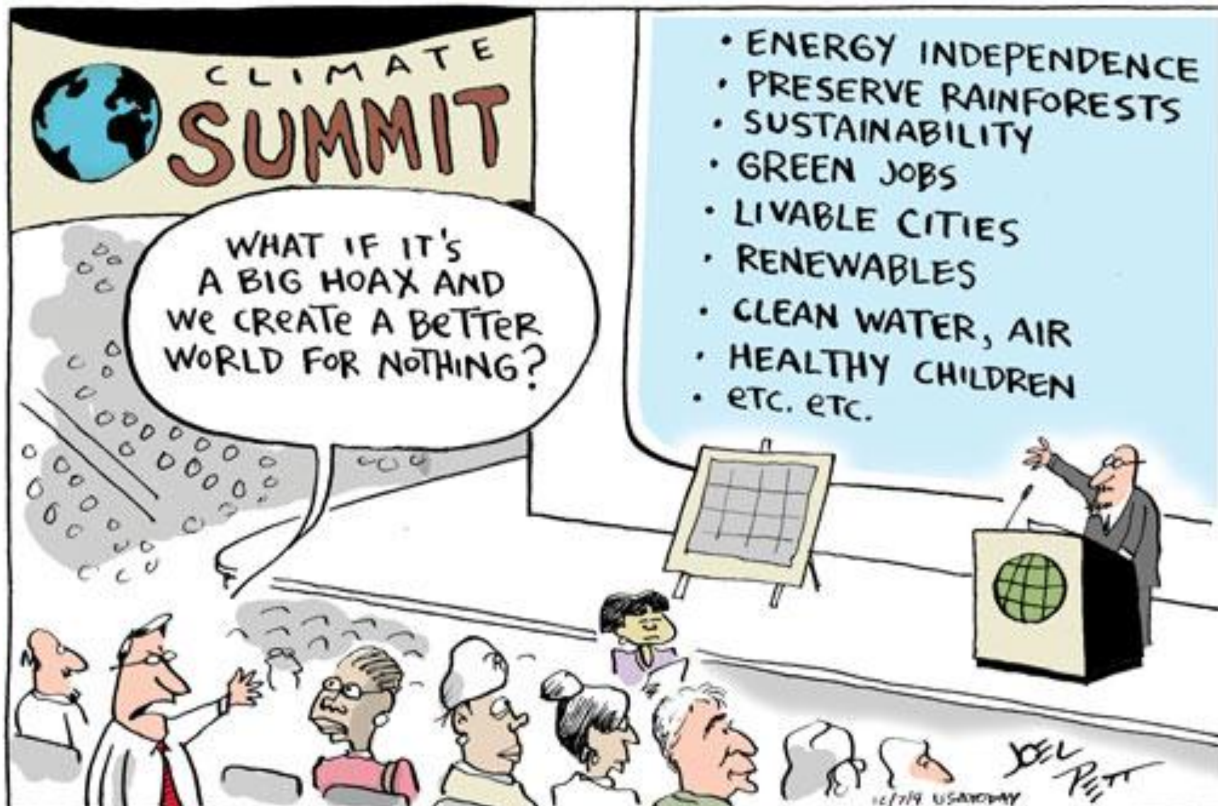
Part I

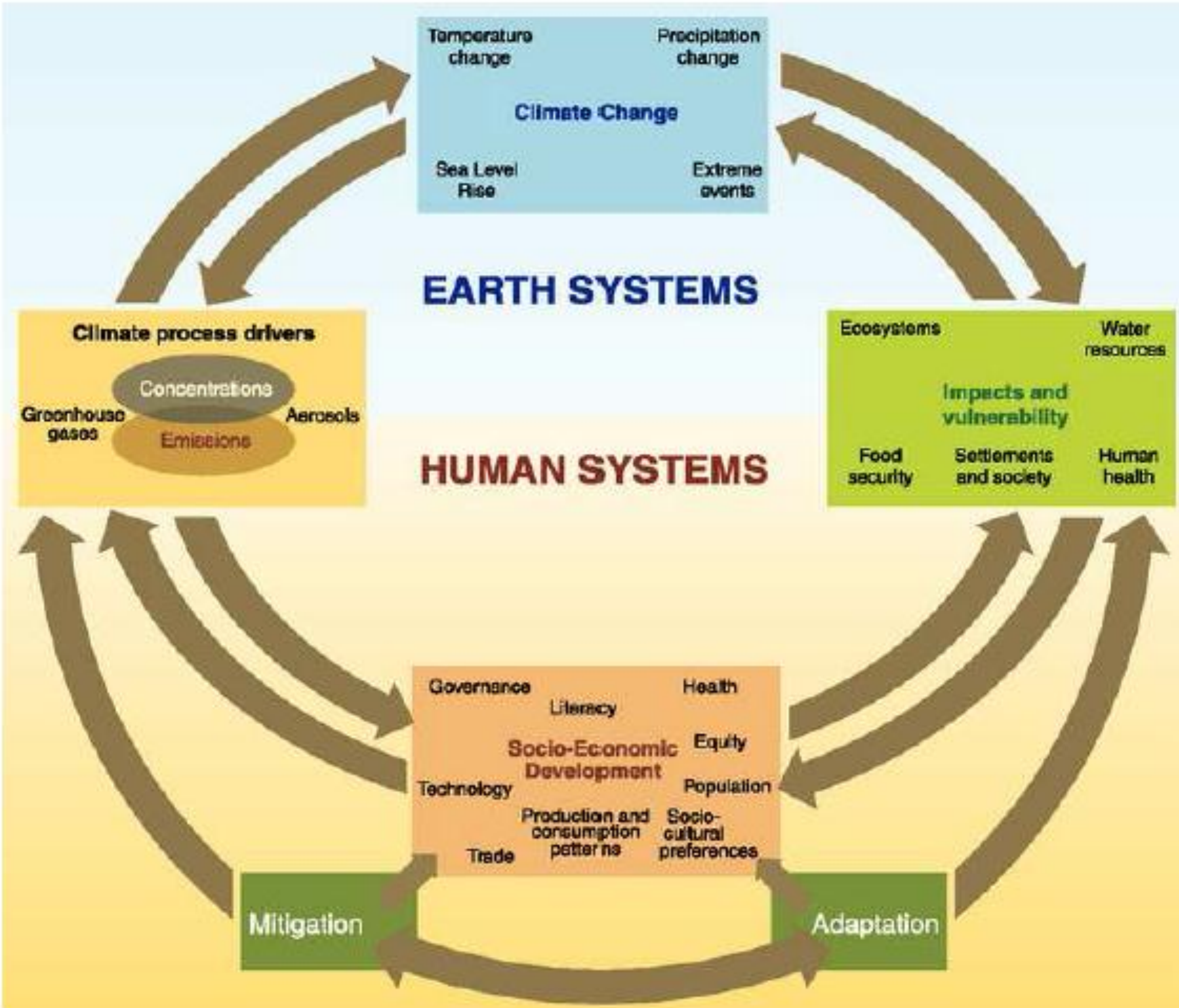
Understanding Climate Change



Definition of Climate Change

- Refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land-use. *(IPCC TAR, 2001)*
- A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods *(UNFCCC Article 1)*
- The climate of a place or region is changed if over an extended period (typically decades or longer) there is a statistically significant change in measurements of either the mean state or variability of the climate for that place or region. *(UN/ISDR, 2004)*

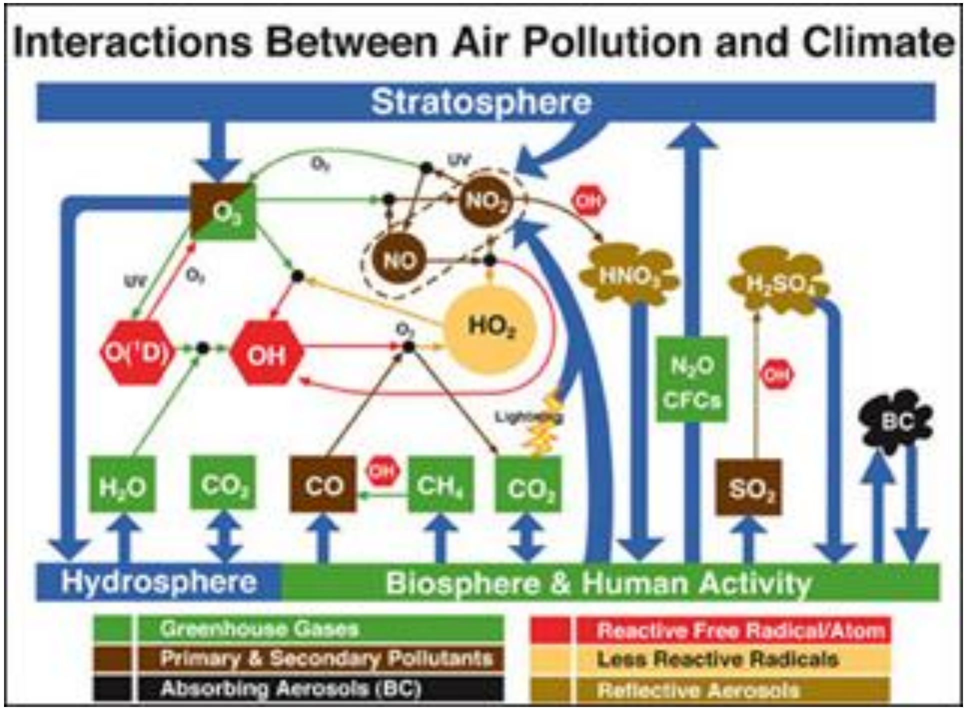
Framework on CC



Source FDES 2013

Causes of CC

- As the Earth depends on its atmosphere, a change in the atmosphere's chemistry causes changes in the climate
- Changes in the atmosphere are caused by burning coal, oil, and gas which results in emissions of Greenhouse gases (GHGs)
- GHGs are any of various gaseous compounds (such as carbon dioxide) that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse effect



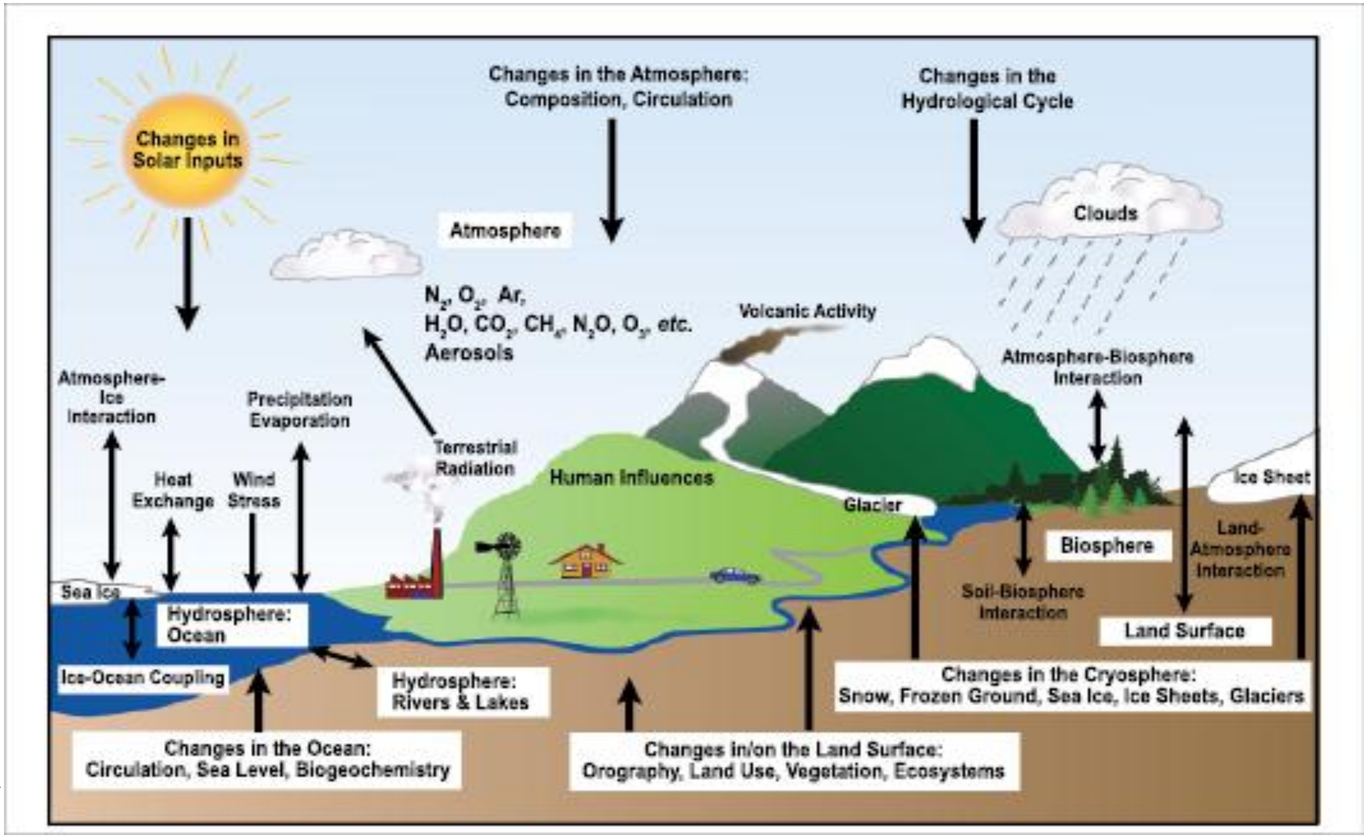
GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases (F- Gases) such as chloro fluorocarbon (CFC) and hydro-chloro fluorocarbon (HCFC).

Causes of CC?

Where does that annual release of carbon go? Approximately 4 billion tons of carbon per year are accumulated in the atmosphere. Ocean modelers find that the oceans take up approximately 25% of emissions per year (2.3 billion tons), and the land takes up about 3 billion tons (or 33% of total emissions). These flows or "fluxes" within the Global Carbon Cycle may be summarized using the formula:

Atmospheric increase = Emissions from fossil fuels + Net emissions from changes in land use - Oceanic uptake - Terrestrial carbon sink

(Source: http://www.whrc.org/resources/primer_human.html#sthash.BwYJkcRV.dpuf)



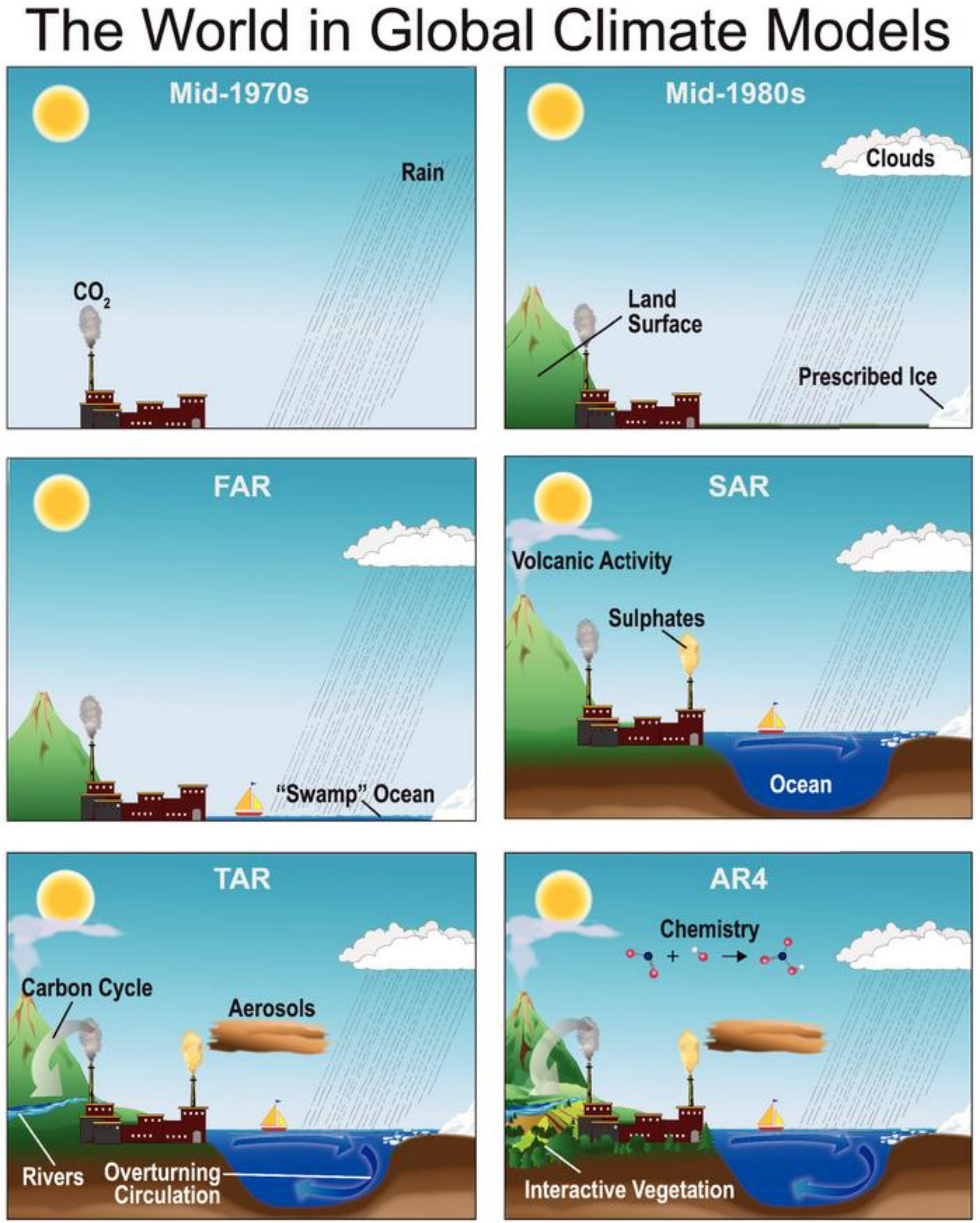
Schematic view of the components of the climate system, their processes and interactions.

- Human beings are causing the release of carbon dioxide and other greenhouse gases to the atmosphere at rates much faster than the earth can cycle them. Fossil fuels - oil, coal, natural gas, and their derivatives - were formed through the compression of organic (once living) material for millions of years, yet billions of tons of these fuels are now being burned per year.
- The CO2 expelled into the atmosphere through these activities will remain in the atmosphere on the order of decades to centuries. This means that the CO2 emitted today will likely be affecting the climate for generations.

It is clear that <u>statistics</u> will improve the understanding of the CC processes

Reports on CC

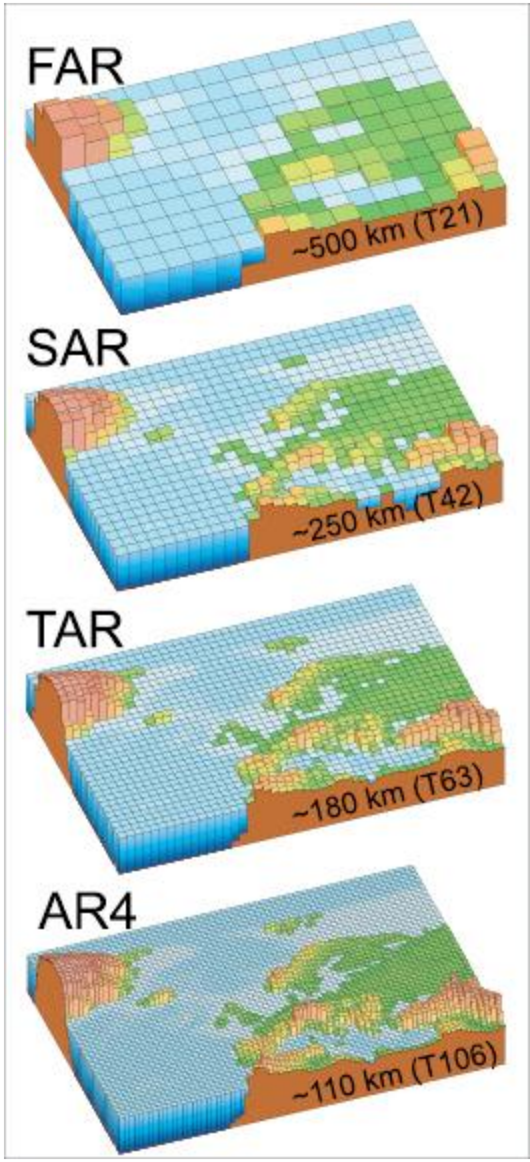
- The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change
- The different IPCC Reports on CC highlighted the progress made in understanding global warming
- FAR=First Assessment Report; SAR= Second; TAR= Third etc and recent = AR5
- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.



Reports on CC

- In IPCC reports, geographic resolution (details about the areas/regions having CC impacts as well as factors driving CC) have been improved
- This is reflected in the characteristic of the generations of climate models used in the IPCC Assessment Reports: FAR (IPCC, 1990), SAR (IPCC, 1996), TAR (IPCC, 2001a), and AR4 (2007) + AR5 2014 which reveal changes in
  - Atmosphere: e.g. temperature, rainfall, land and ocean surface temperature
  - Ocean: e.g. ocean warming, acidification/PH
  - Cryosphere: e.g. snow cover
  - Sea level: e.g. rate of sea level rise...
  - Carbon and Other Biogeochemical Cycles: e.g. atmospheric concentrations of carbon dioxide, methane, and nitrous oxide

AR5



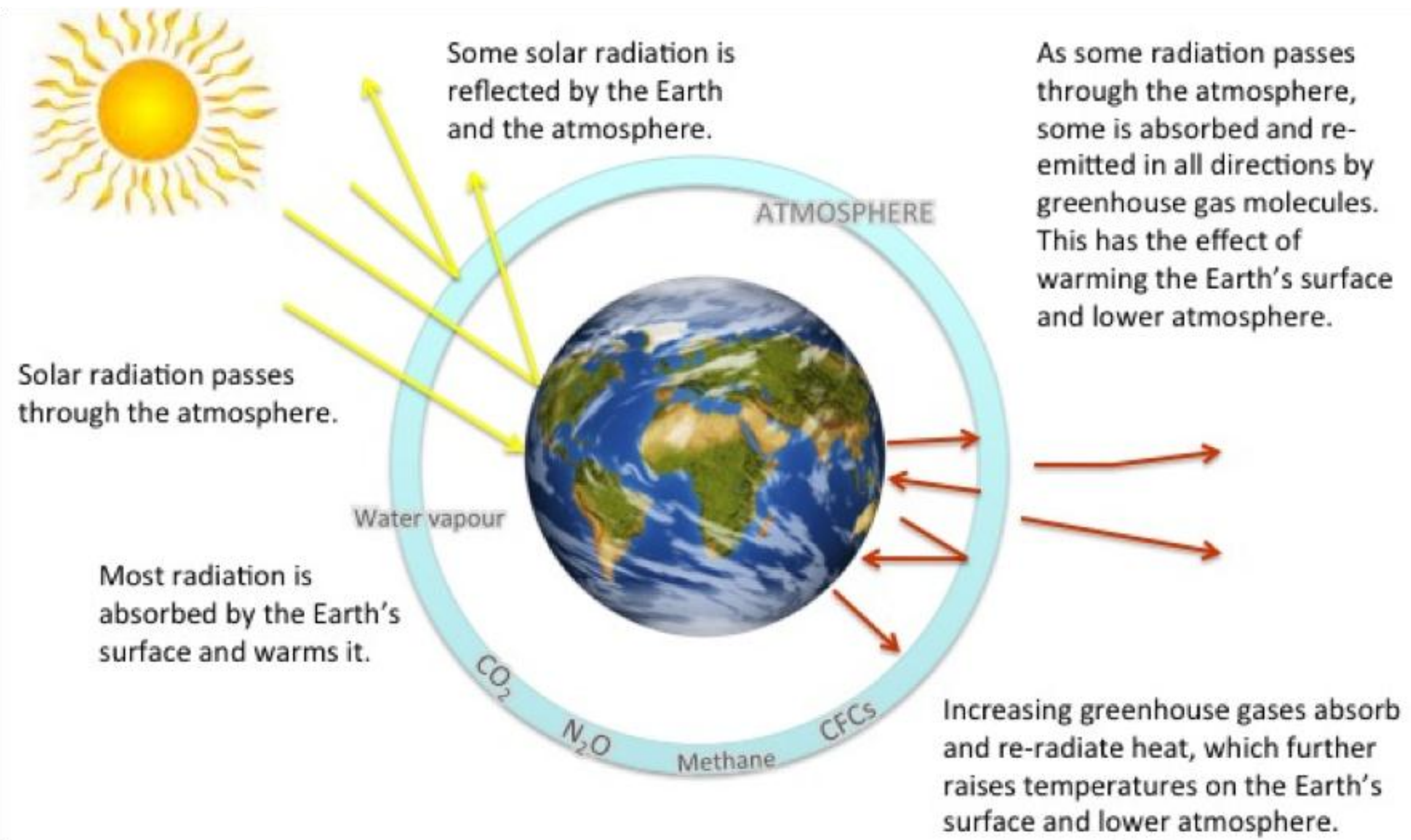
Climate change mechanism and global warming – Drivers of Climate Change

- Natural and anthropogenic substances (e.g GHGs) and processes (e.g. deforestations) that alter the Earth's energy budget are drivers of climate change.
- Radiative forcing (RF) quantifies the change in energy fluxes caused by changes in these drivers, e.g. for 2011 relative to 1750.
- Positive RF leads to surface warming, negative RF leads to surface cooling.
- RF is estimated based on in-situ and remote observations, properties of greenhouse gases and aerosols, and calculations using numerical models representing observed processes.
- Some emitted compounds affect the atmospheric concentration of other substances.
- The RF can be reported based on the concentration changes of each substance. Alternatively, the emission-based RF of a compound can be reported, which provides a more direct link to human activities and includes contributions from all substances affected by that emission.
- The total anthropogenic RF of the two approaches is identical when considering all drivers.

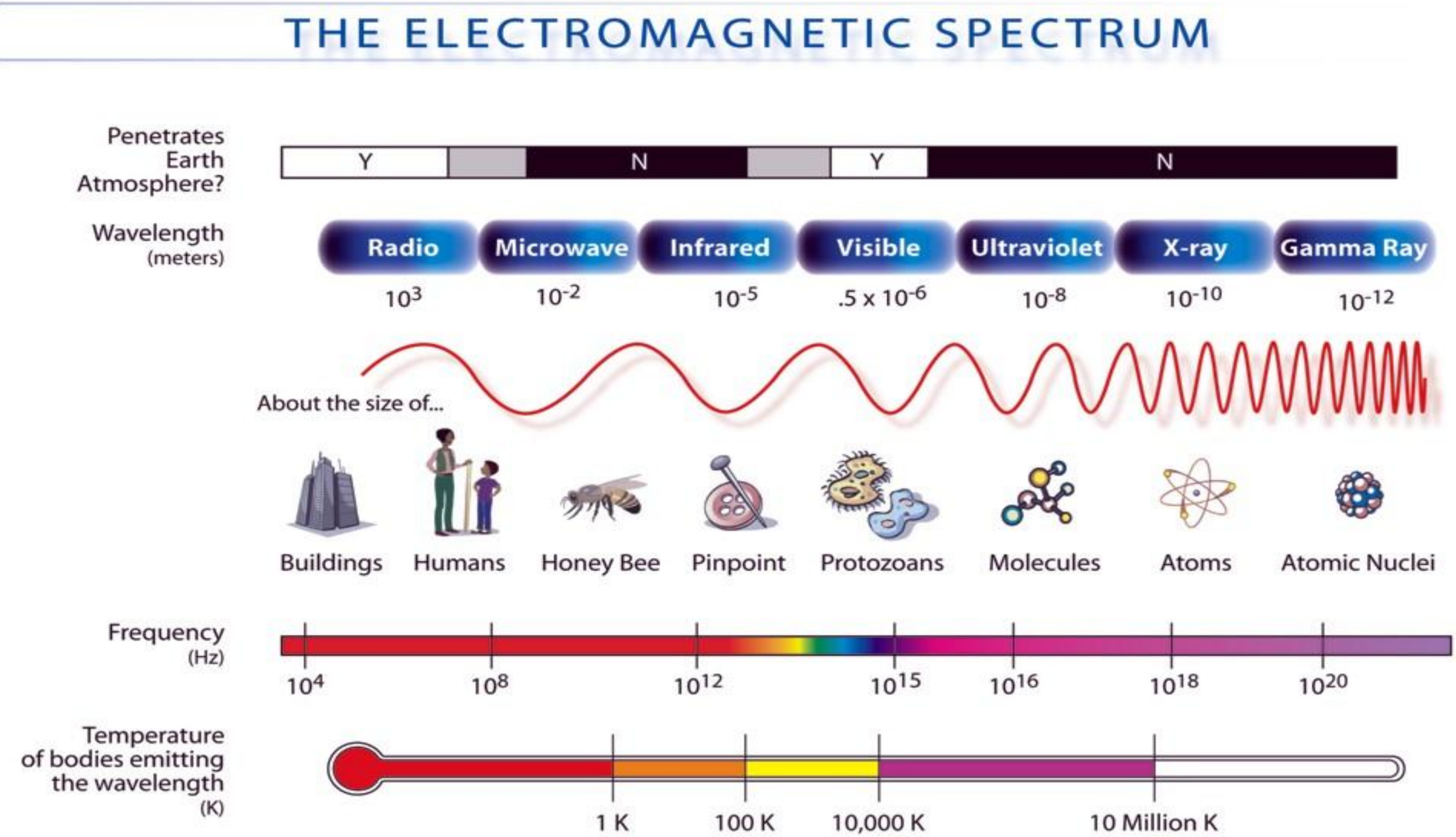
Climate change mechanism – The greenhouse effect

Climate change mechanism
Role of Greenhouse gases in CC

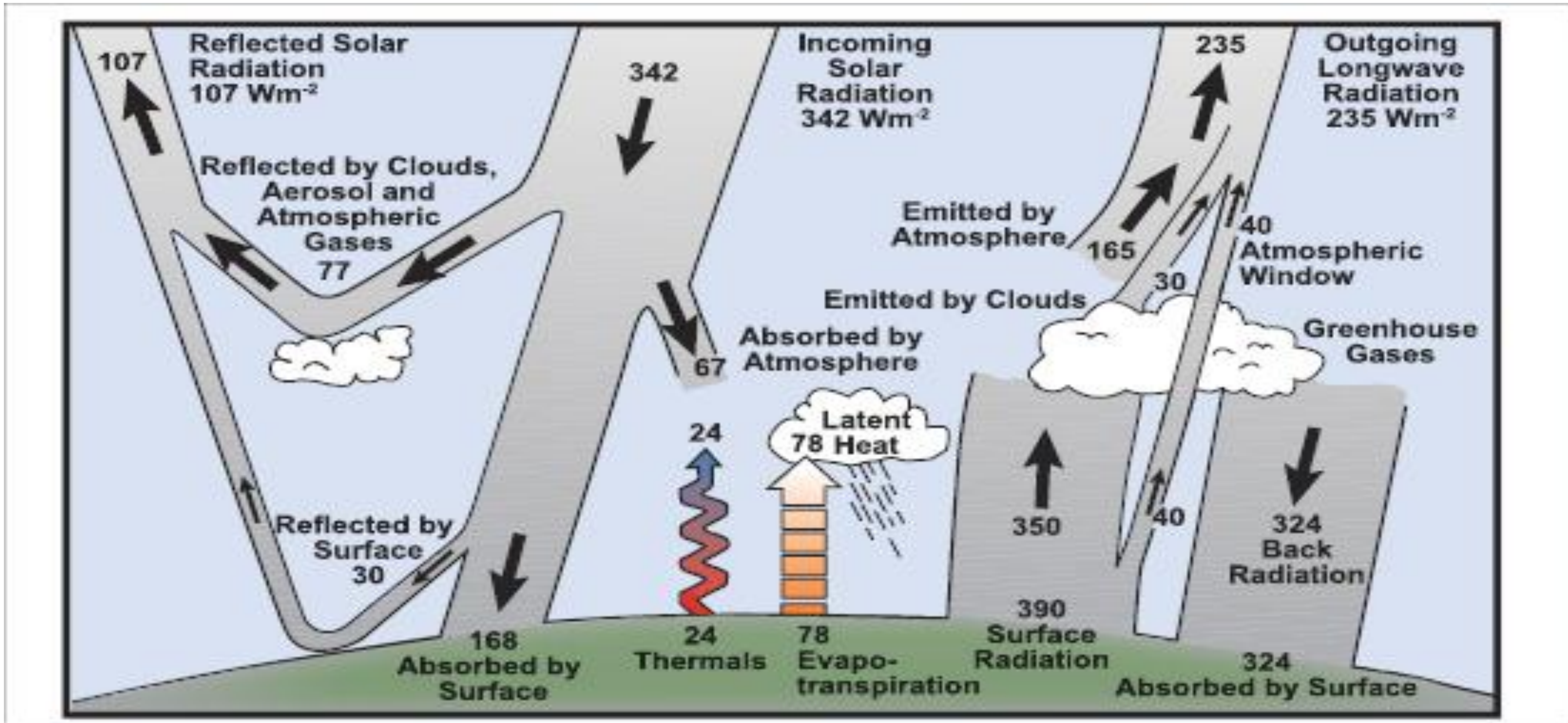
- GHGs cause CC and global warming
- The surface energy balance is the resultant of radiative components such as incoming and outgoing short-wave and long-wave radiation, and also non-radiative components such as sensible heating, latent heating, and the change in energy storage in water or substrate on land.



CC mechanism and global warming – Radiations driving CC



CC mechanism and global warming - Earth's Energy Balance

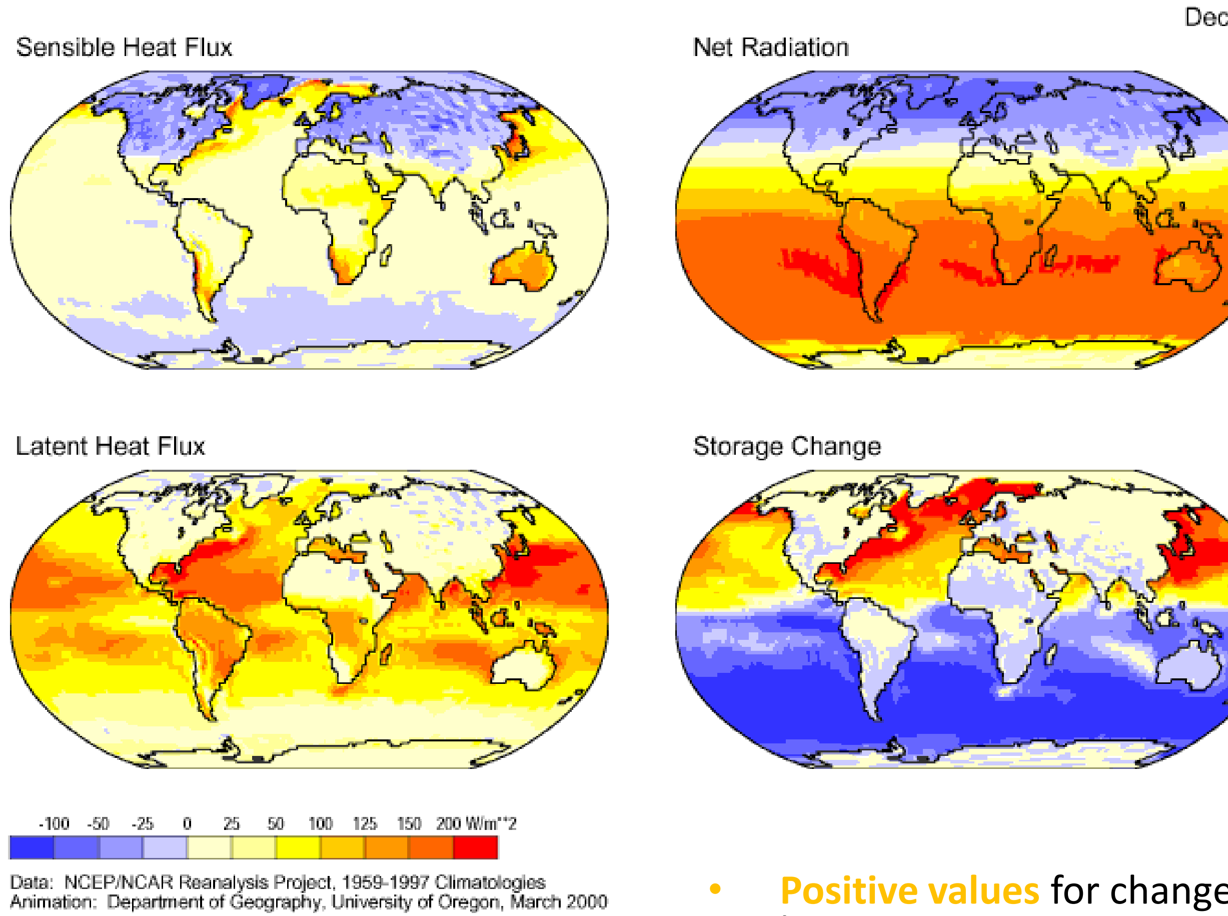


- Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation.
- About half of the incoming solar radiation is absorbed by the Earth's surface. The atmosphere in turn radiates longwave energy back to Earth as well as out to space.
- The energy that is not reflected back to space is absorbed by the Earth's surface and atmosphere. This amount is approximately 240 Watts per square metre (W m^{-2}).

(Source: Kiehl and Trenberth (1997).

CC mechanism and global warming – Non-Radiative Components

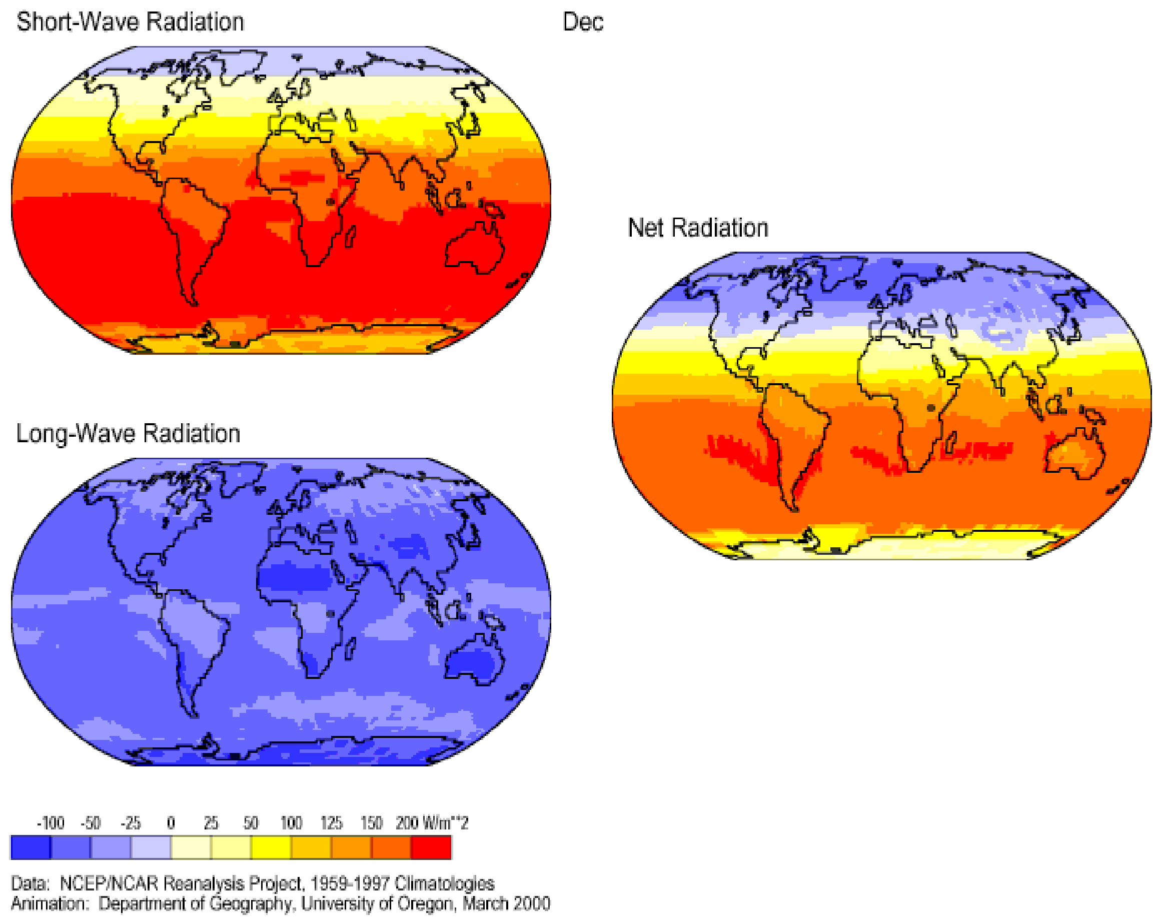
- Positive values for sensible and latent heat flux represent energy moving towards the atmosphere,
- Negative values represent energy moving away from the atmosphere.



- Positive values for change in heat storage represent energy moving out of storage,
- Negative values represent energy moving into storage.

CC mechanism and global warming - Radiative Components

- **Positive values** represent energy moving towards the surface,
- **Negative values** represent energy moving away from the surface.



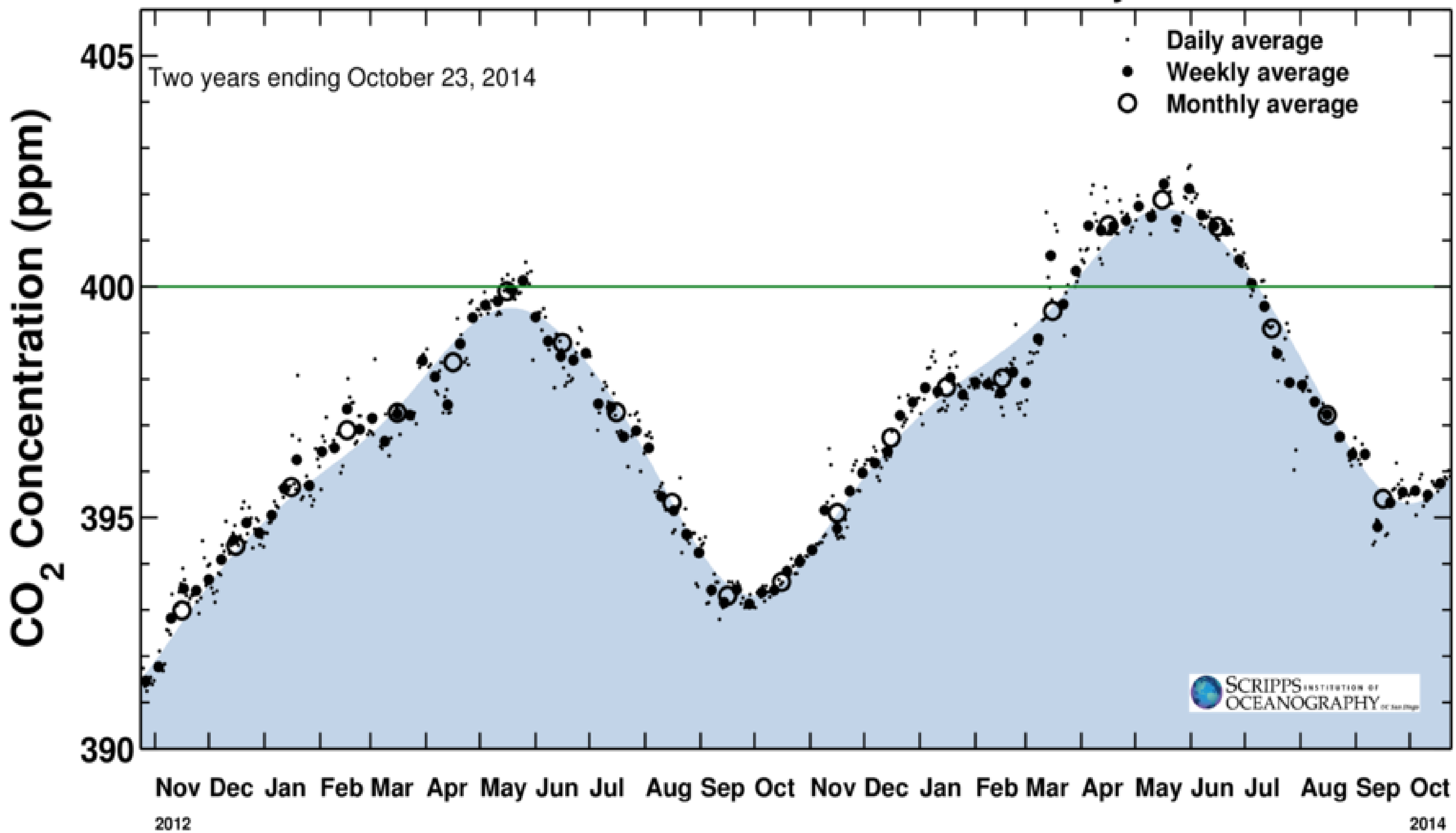
CC mechanism and global warming

CO_2 concentration

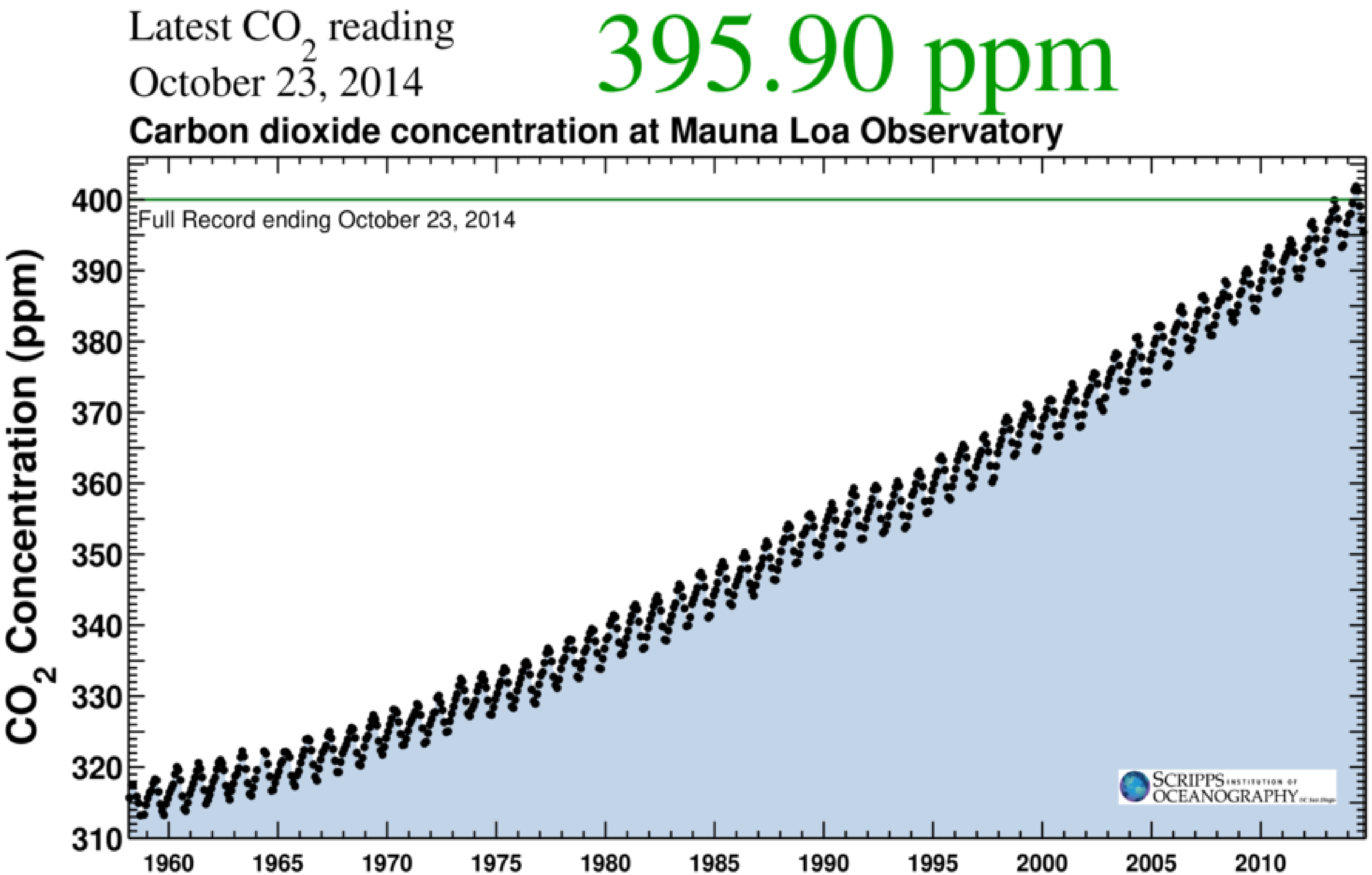
Latest CO_2 reading
October 23, 2014

395.90 ppm

Carbon dioxide concentration at Mauna Loa Observatory



CC mechanism and global warming - CO_2 concentration - The KEELING Curve

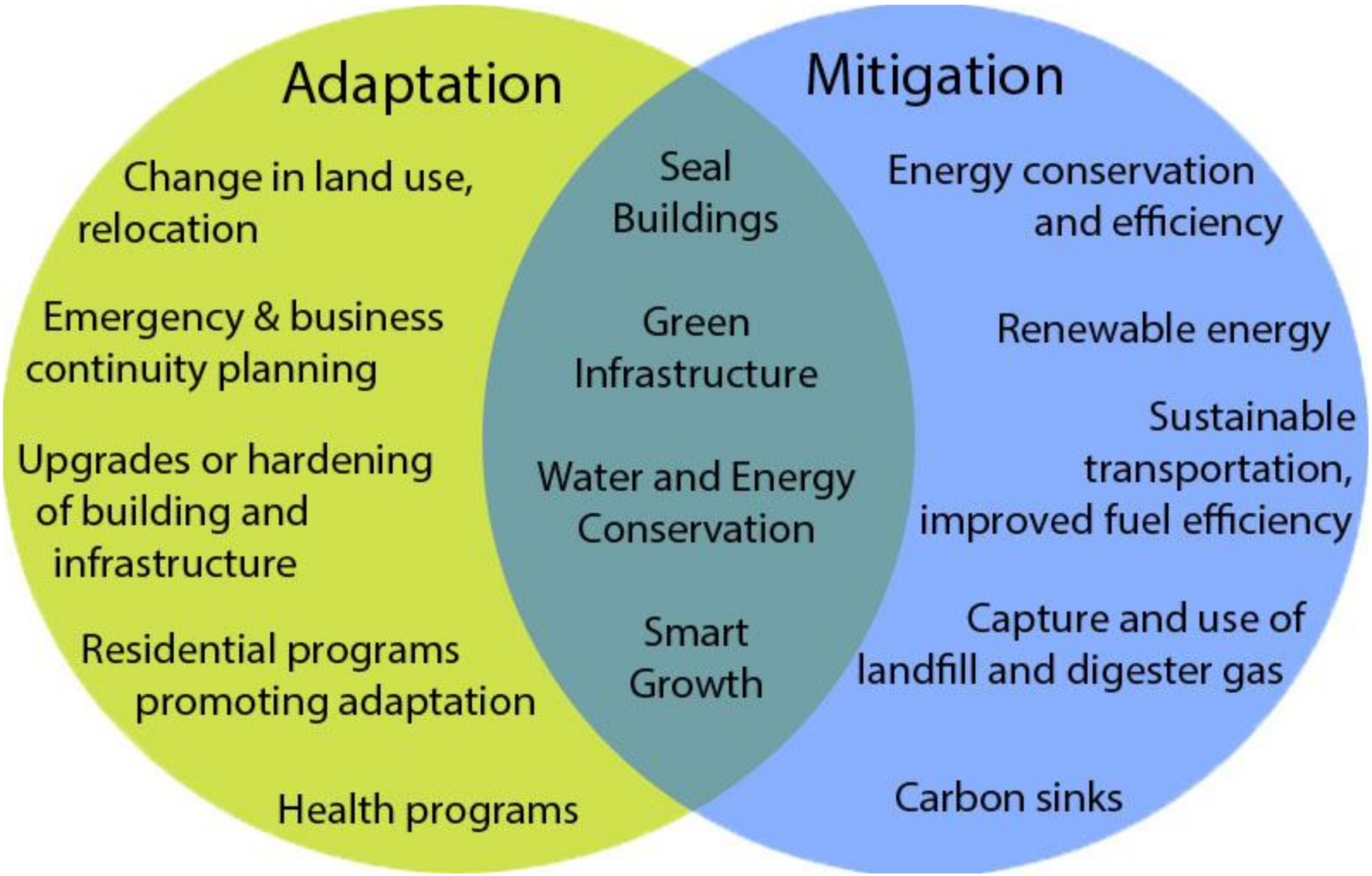


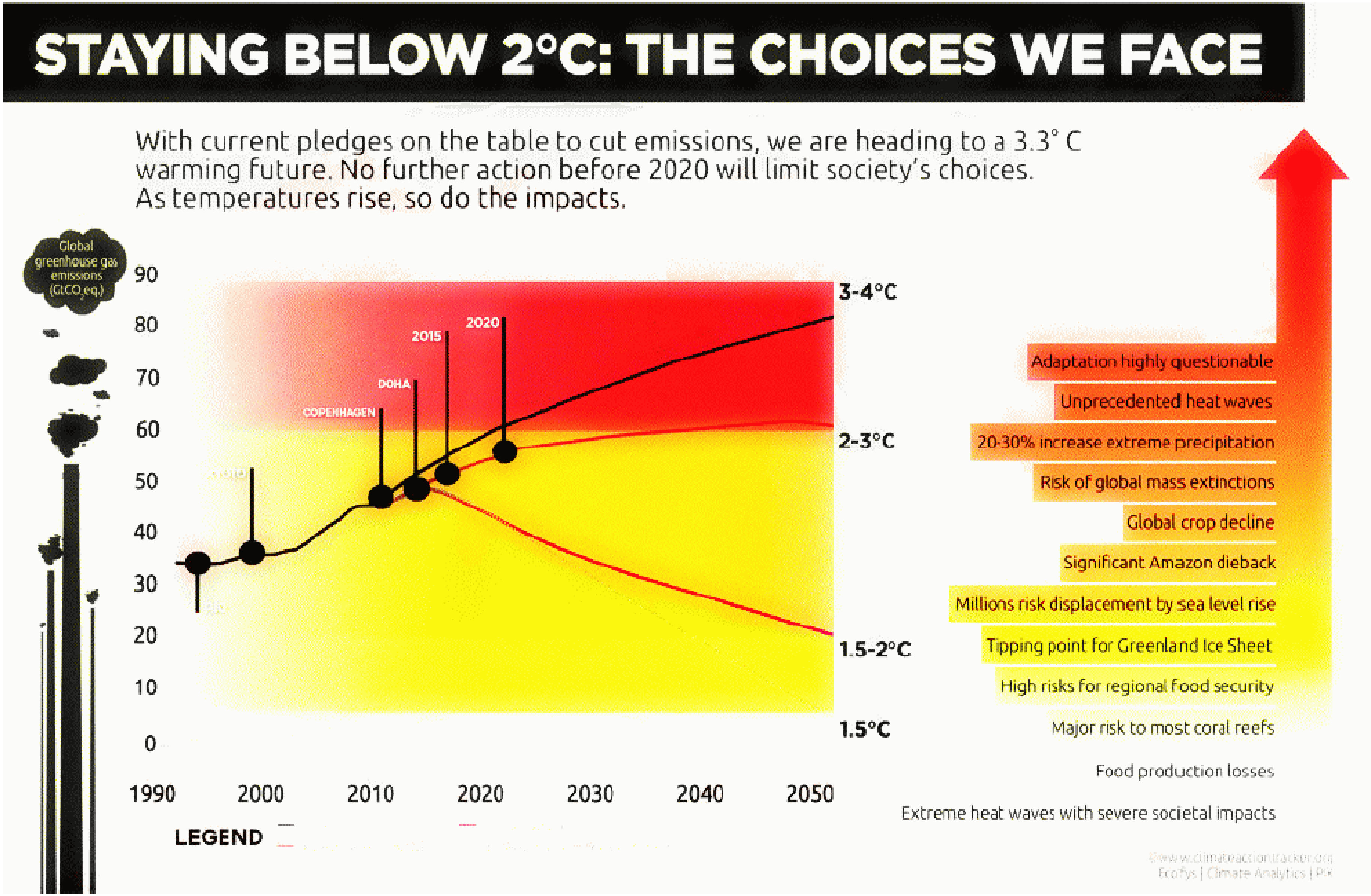
CC Adaptation and Mitigation

- **Climate mitigation** is any action taken to permanently eliminate or reduce the long-term risk and hazards of climate change to human life, property. It is an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.
- **Climate adaptation** refers to the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences. It is an adjustment in natural or human systems to a new or changing environment.

Source: http://www.global-greenhouse-warming.com/climate-mitigation-and-adaptation.html

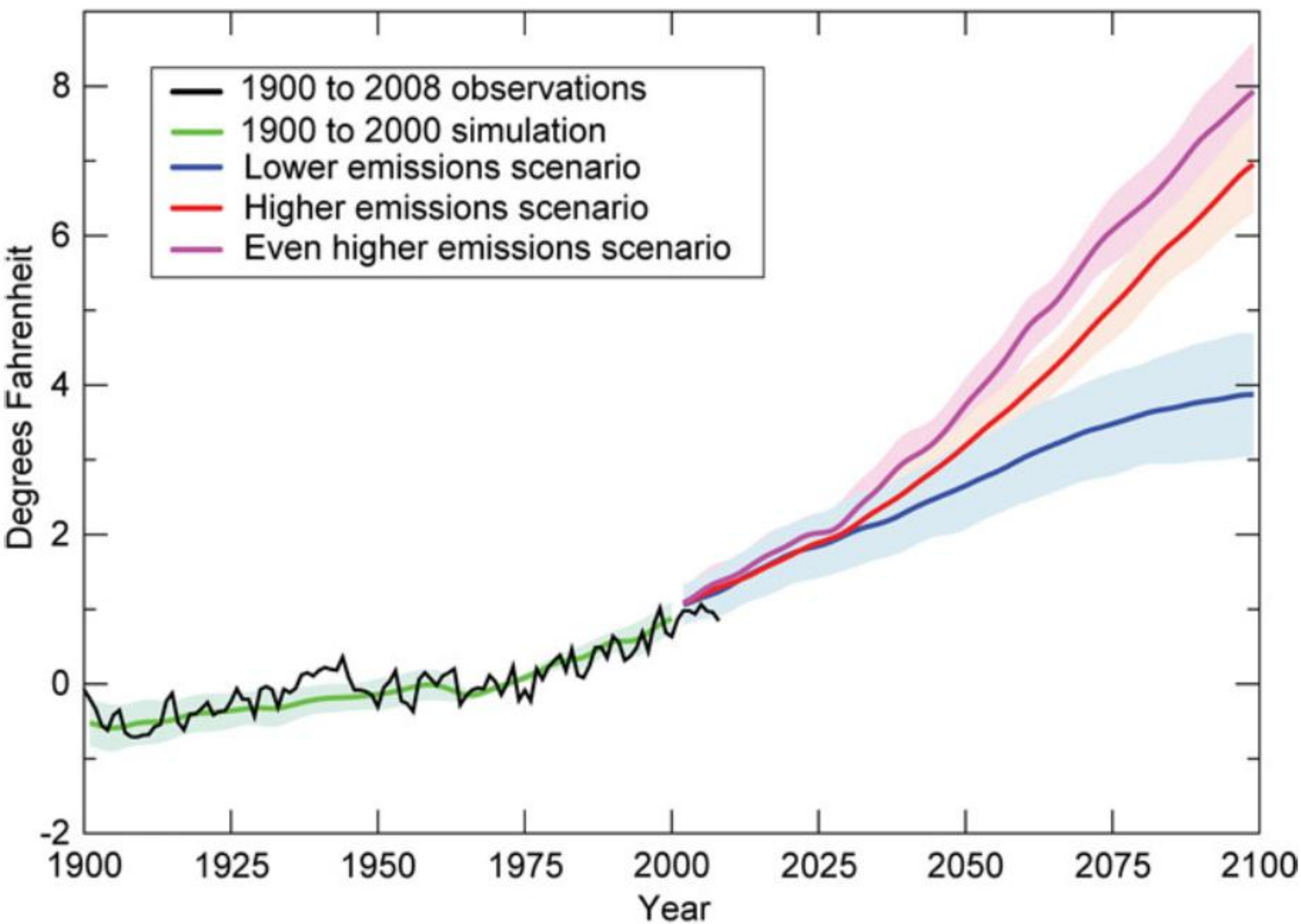
CC Adaptation and Mitigation





The New York Times

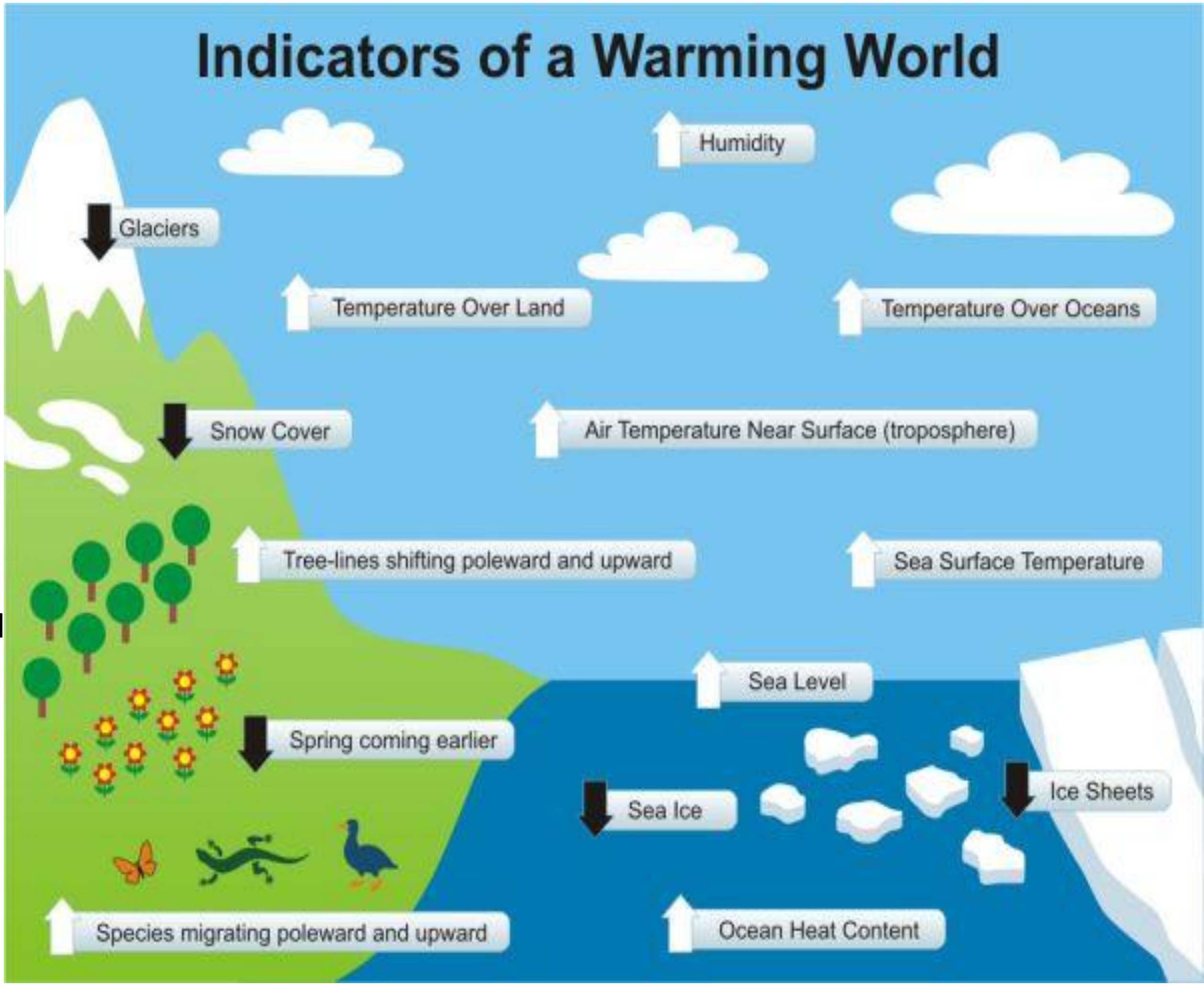
February 23, 2009



1900 to 2008 observations
1900 to 2000 simulation
Lower emissions scenario
Higher emissions scenario
Even higher emissions scenario
Degrees Fahrenheit
8
6
4
2
0
-2
1900
1925
1950
1975
2000
2025
2050
2075
2100
Year

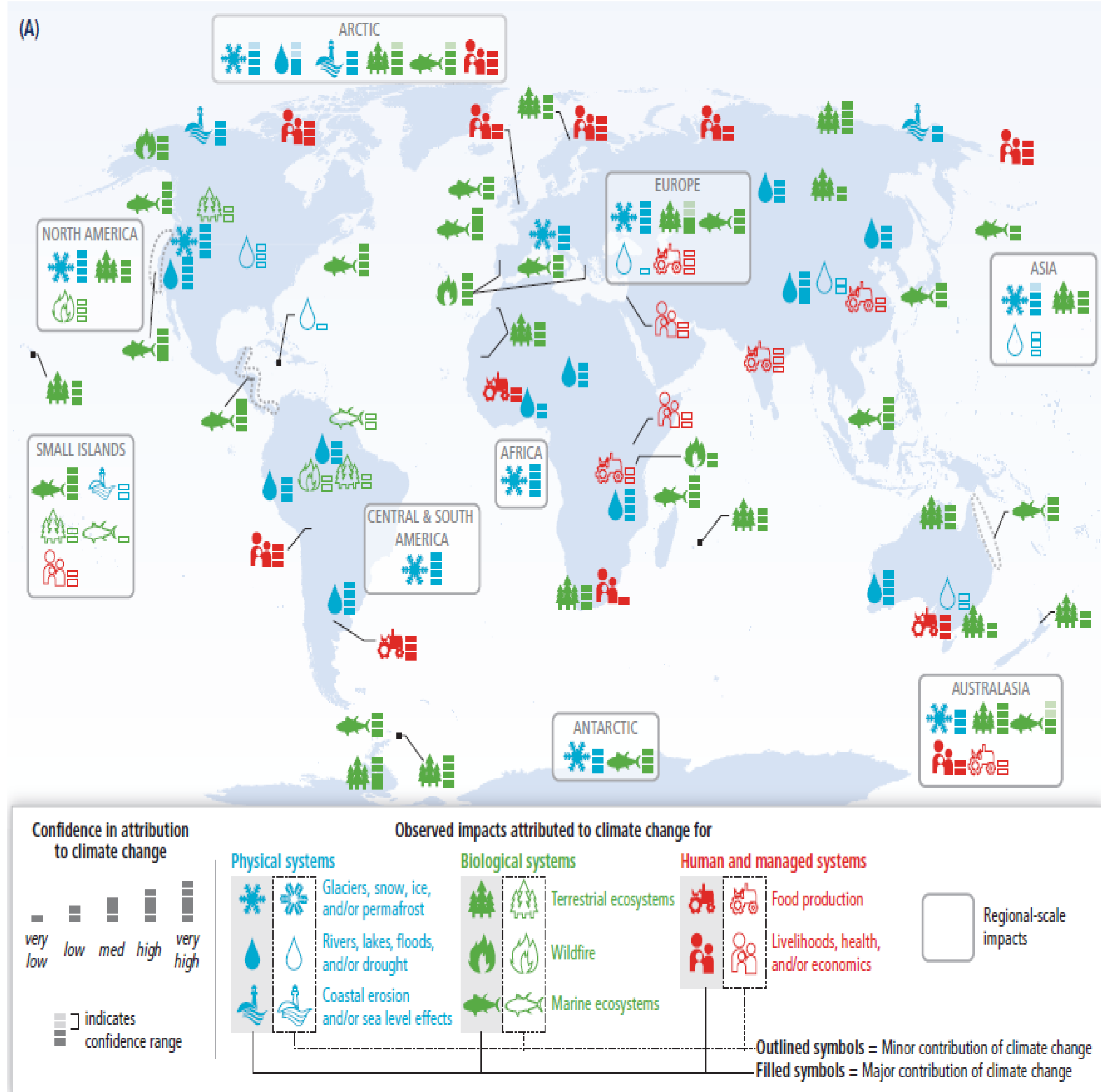
Evidence of CC - Impacts

- Growing world population and expanding world economy are pressing against the planetary boundaries (capacity of the planet) and is a threat;
- CC induces
  - rising ocean levels or changes in the chemistry of the oceans
  - Warming atmosphere and ocean
  - Diminishing amounts of snow and ice, and
  - Increased concentrations of greenhouse gases
  - changes in storm patterns; drought frequency, and flood frequency;



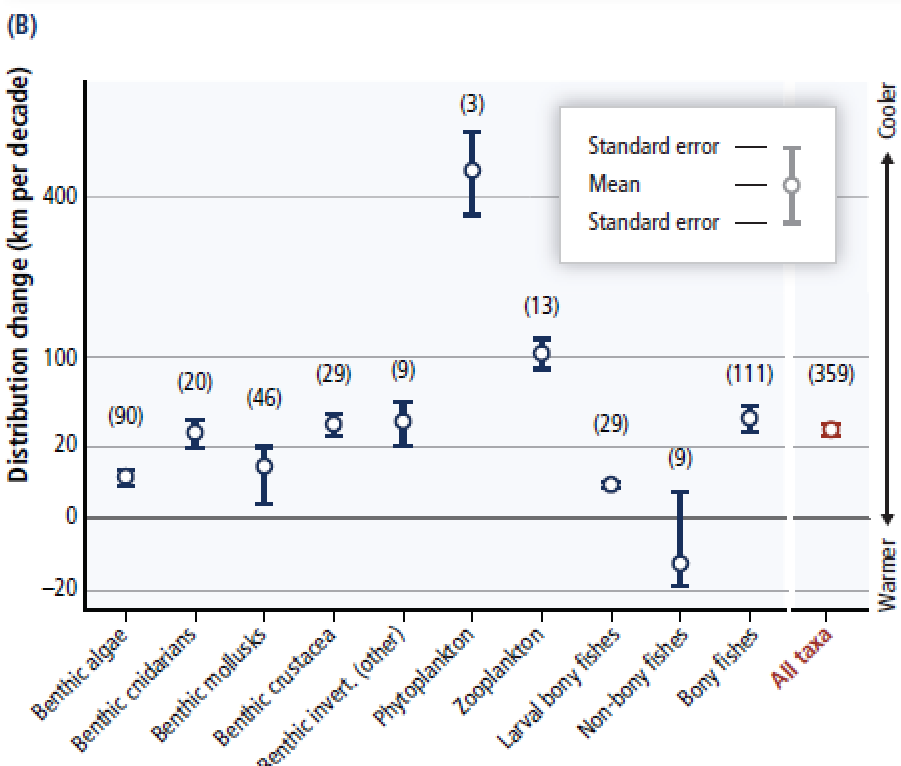
Evidence of CC - Impacts

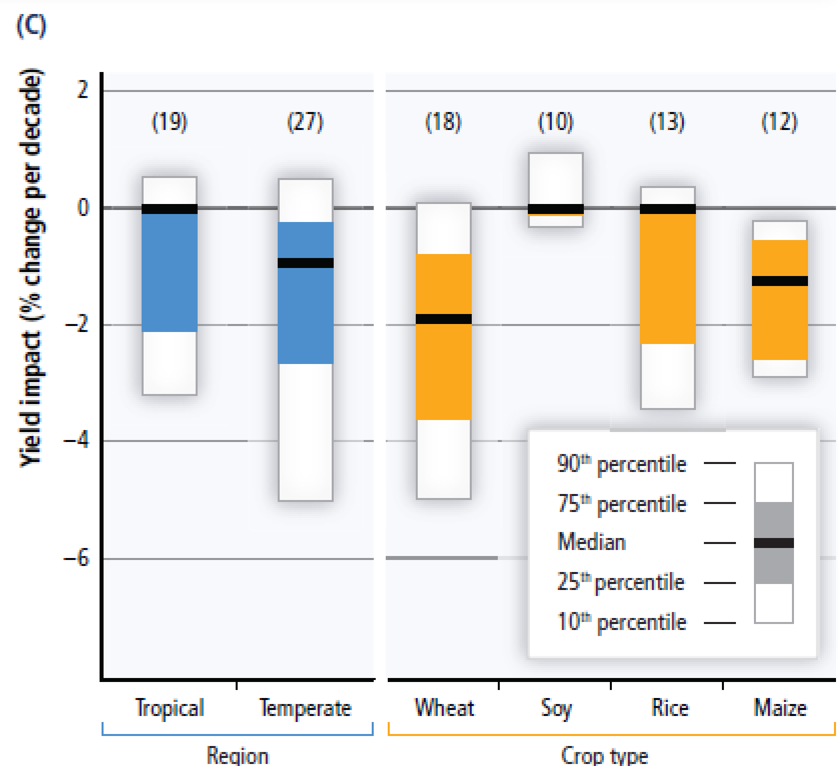
- Widespread impacts in a changing world. (A) Global patterns of impacts in recent decades attributed to climate change, based on studies since the AR4.
- Impacts are shown at a range of geographic scales. Symbols indicate categories of attributed impacts, the relative contribution of climate change (major or minor) to the observed impact, and confidence in attribution.



Evidence of CC - Impacts

- (B) Average rates of change in distribution (km per decade) for marine taxonomic groups based on observations over 1900–2010. Positive distribution changes are consistent with warming (moving into previously cooler waters, generally poleward). The number of responses analyzed is given within parentheses for each category.
- (C) Summary of estimated impacts of observed climate changes on yields over 1960–2013 for four major crops in temperate and tropical regions, with the number of data points analyzed given within parentheses for each category.





Evidence of CC – Accuracy of predictions

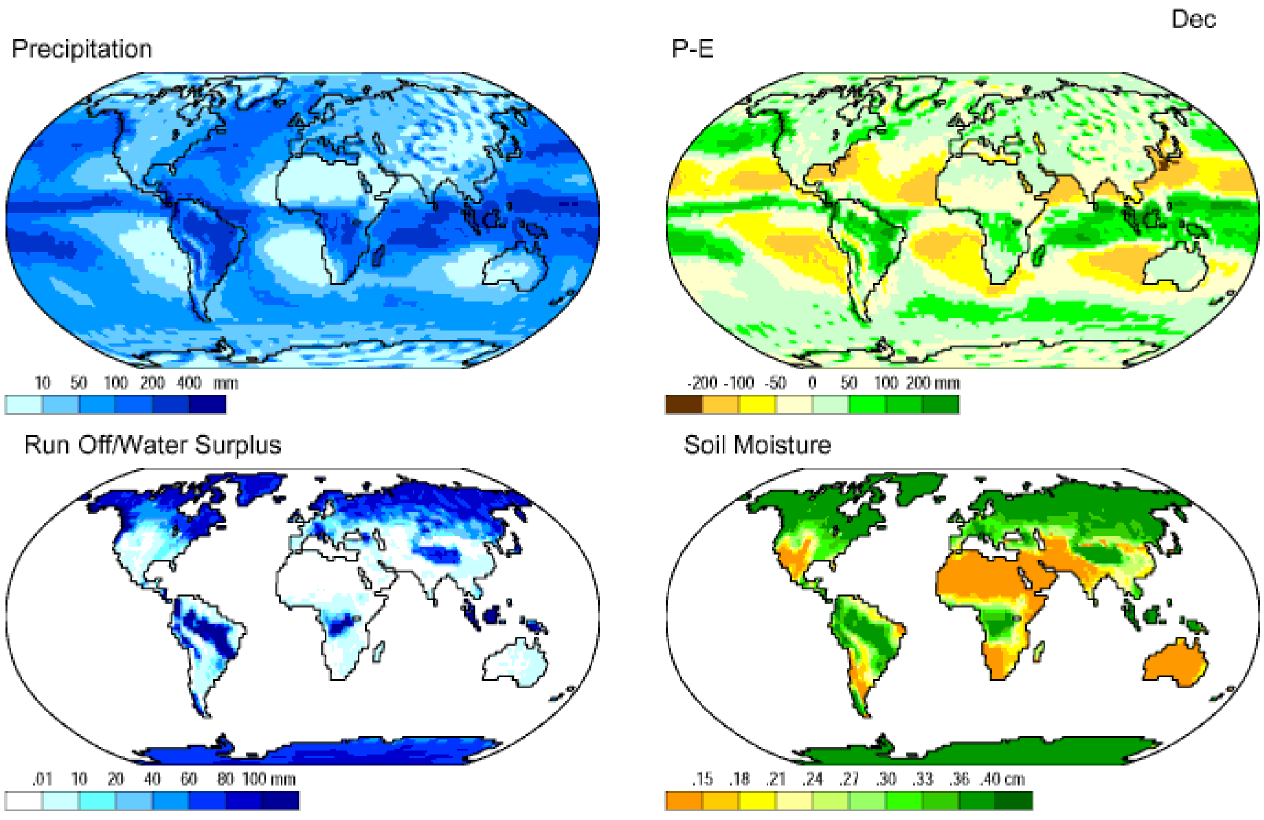
Confidence Terminology	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than 1 out of 10 chance

The standard terms used to define levels of confidence in IPCC report are as given in the IPCC Uncertainty Guidance Note (IPCC AR4)

Likelihood Terminology	Likelihood of the occurrence/ outcome
Virtually certain	> 99% probability
Extremely likely	> 95% probability
Very likely	> 90% probability
Likely	> 66% probability
More likely than not	> 50% probability
About as likely as not	33 to 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Extremely unlikely	< 5% probability
Exceptionally unlikely	< 1% probability

Predicted CC –
Impact on Global Water Balance

- **The impacts due to CC can be visible and the following indicators illustrates this fact**
- **Precipitable water vapor is a measure of available moisture in the atmosphere.**
- **Precipitation rate is the actual measurement of precipitation at the surface.**
- **Precipitation-Evaporation (P-E) represents the difference between precipitation and evaporation.**
- **Runoff/Water surplus are measurements of outflow of moisture.**
- **Soil moisture represents the pattern of storage of moisture at the surface.**

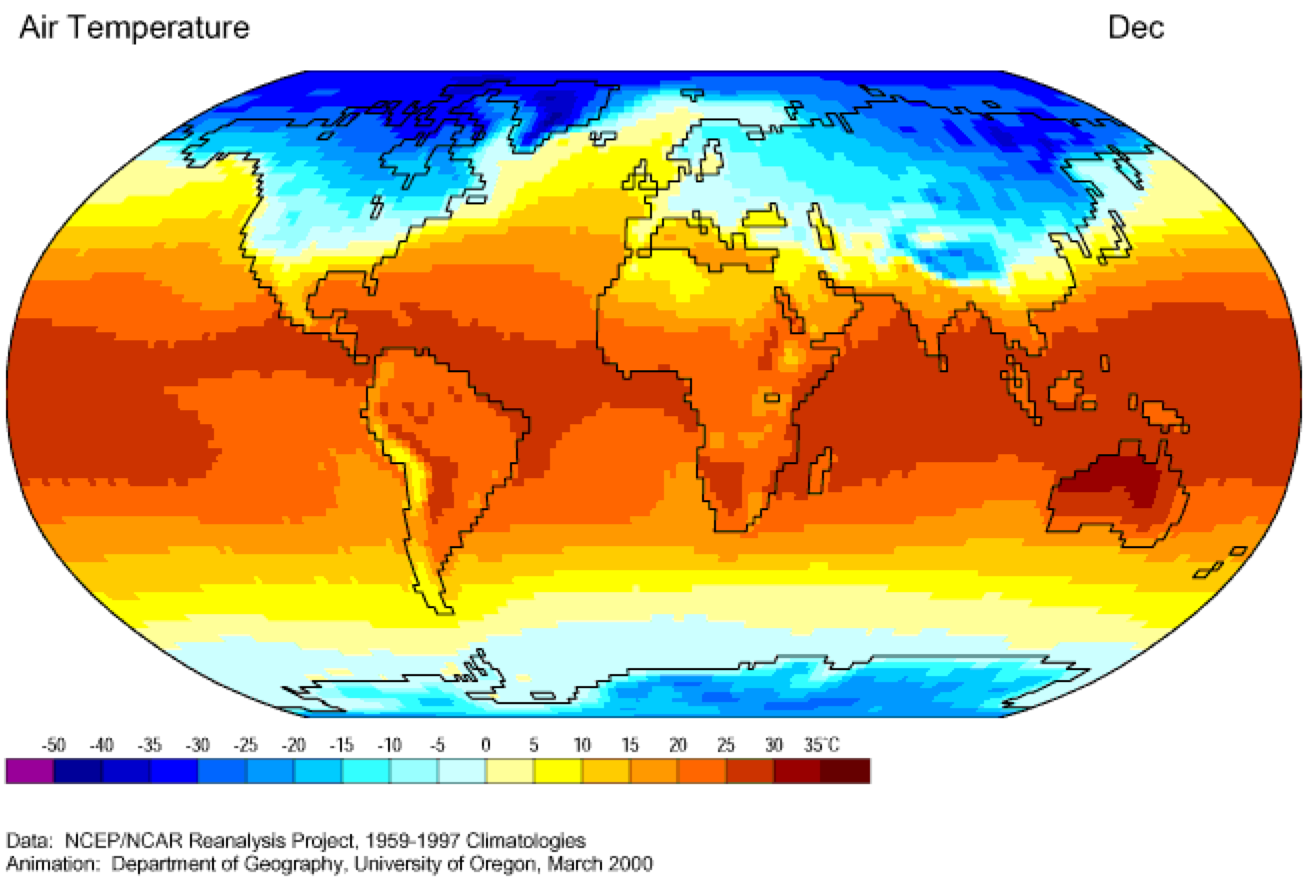


Data: NCEP/NCAR Reanalysis Project, 1959-1997 Climatologies
Animation: Department of Geography, University of Oregon, March 2000

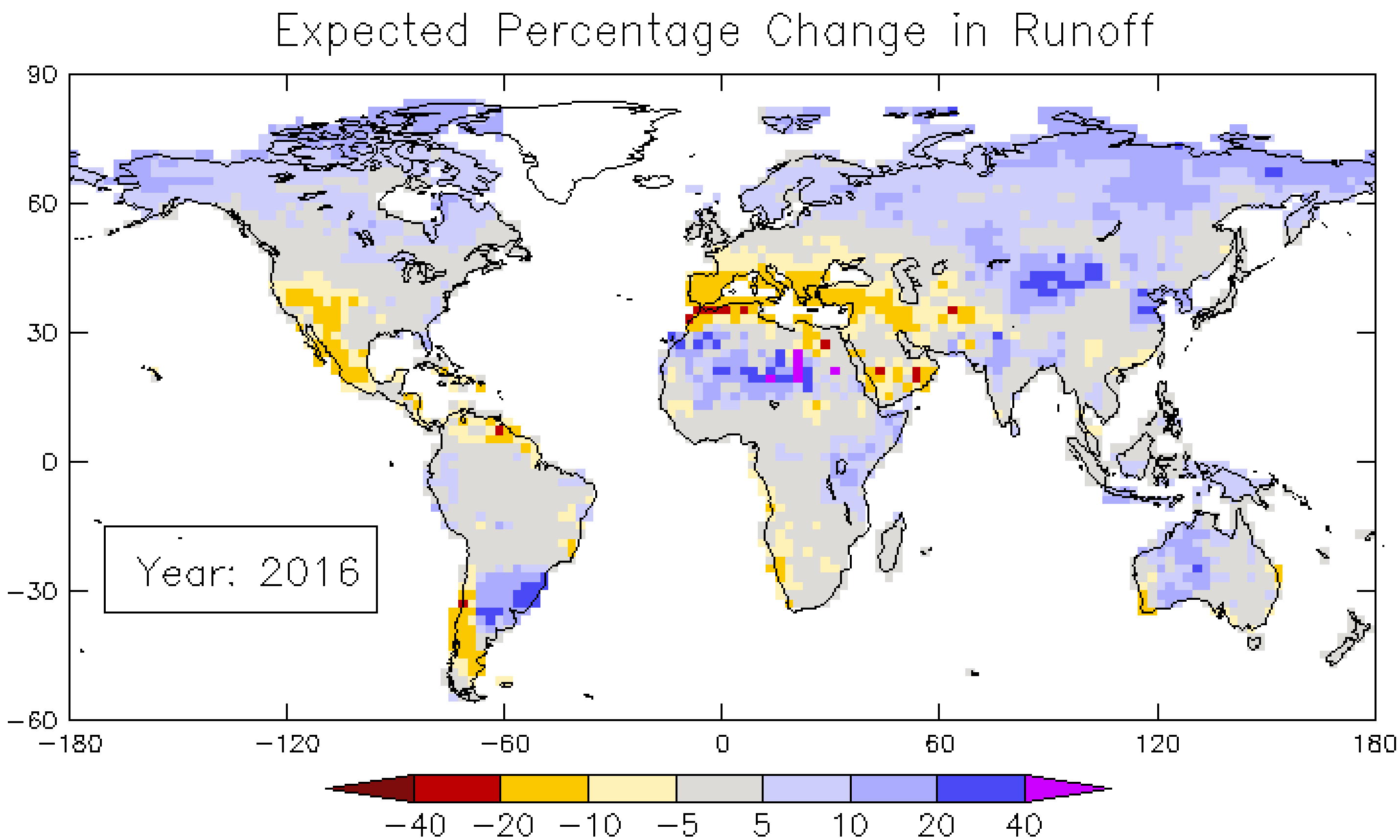
Predicted CC – Impact on Temperature

- Temperature changes are obvious around the globe
- Seasonal temperature variations can be explained in terms of the latitudinal and seasonal variations in the surface energy balance.
- The pattern of temperatures are a function of net short-wave radiation, net long-wave radiation, sensible heat flux, latent heat flux and change in heat storage.

(Source: University of Oregon http://geog.uoregon.edu/envchange/clim_animations/index.html)



Predicted CC – Impacts on surface runoff



- P.C.D. Milly (USGS) and K.A. Dunne

Responses to CC – Main International commitments

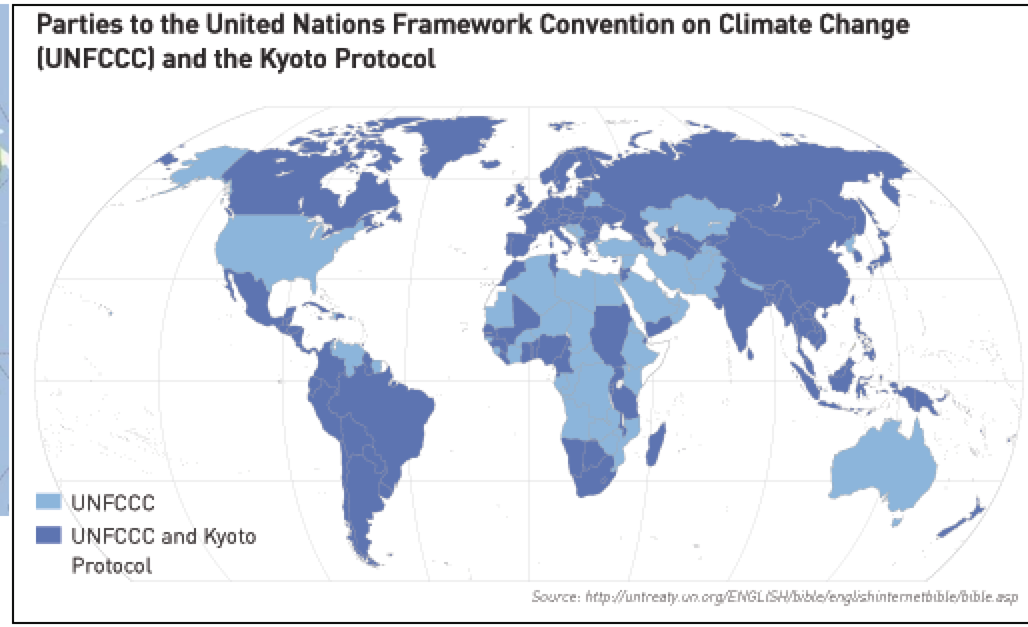
- Understanding human-induced climate change is a very important scientific process and the Intergovernmental Panel on Climate Change (IPCC) was created together with the UN Framework Convention on Climate Change (UNFCCC) to manage and monitor CC with parties (countries) which are UN signatories to agreements and commitments.
- UNFCCC is the legally binding framework that the world's governments agreed to in 1992 in Rio, Brazil.
- In this agreement is an annex that is attached to the document –
- **Annex 1 countries:** basically the rich countries and the post-communist countries of Central Europe and the former Soviet Union where rich countries can help poor countries (**Non Annex I**) to face the challenge of climate change and that countries should give regular reports on CC and GHG emissions.

Responses to CC – main UN Conventions

- UNFCCC manages CC and IPCC (e.g. AR5) reveals facts about CC.
- Convention on Biological Diversity (CBD) builds on biological diversity - on the growing realization that human-induced climate change, pollution, deforestation, ocean acidification, and other human-caused factors were threatening the survival of other species.
- UN Convention to Combat Drought and Desertification (UNCCD) - a response to human devastation of droughts in Africa in the 1980's, was the challenge of <u>the spreading deserts in the world as dry land regions became </u>less and less hospitable in many places in the world and that is the challenge of combating desertification.

Responses - Parties to the UNFCCC

- Parties to the UNFCCC   Annex I and II and Kyoto Protocol

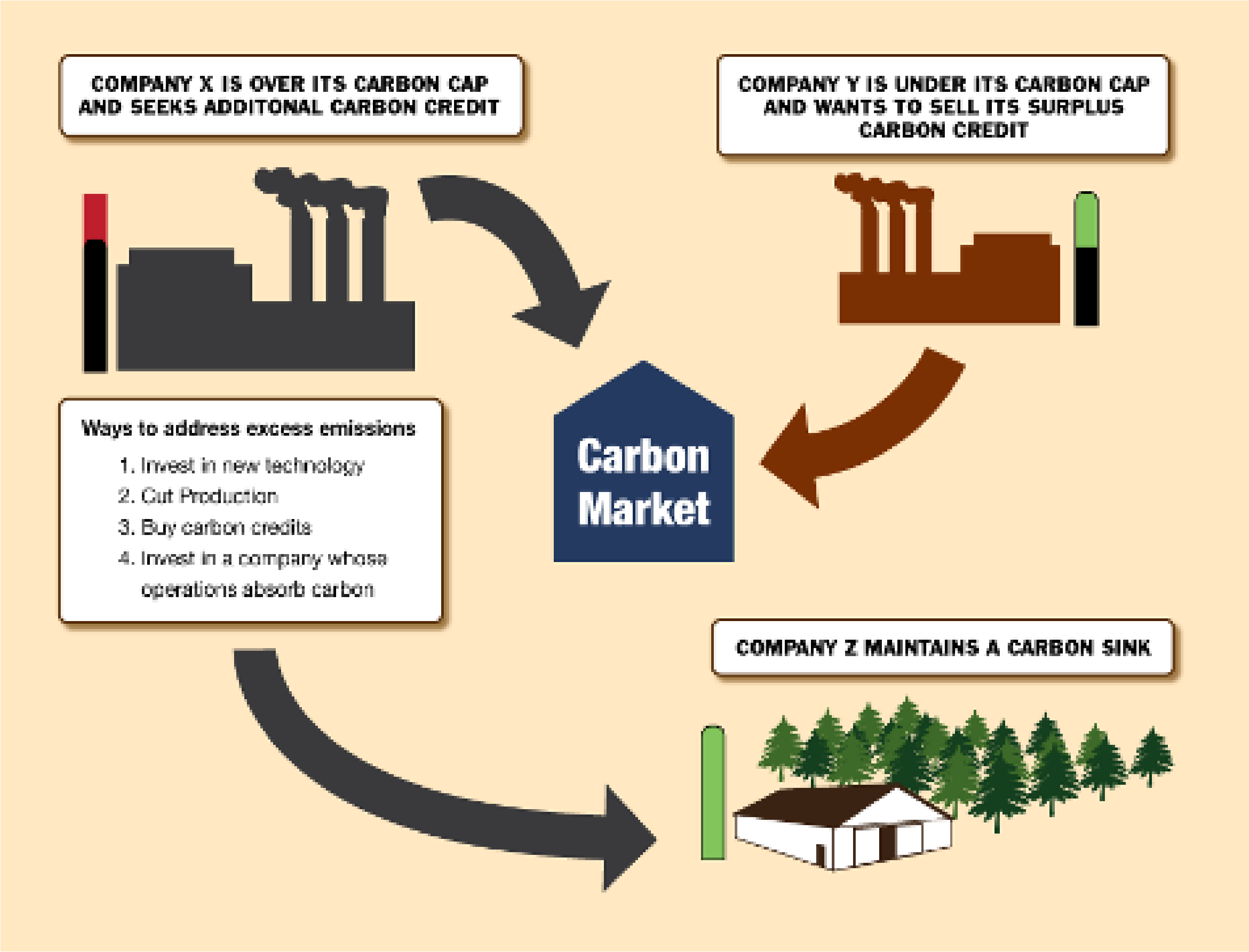


Responses - Kyoto Protocol and beyond

- The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and
- in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.
- In 2012, the Doha Amendment (to the Kyoto Protocol) was adopted. This amendment further reduced the GHG emissions assignments by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020. It also expands the list of GHGs regulated by the Kyoto Protocol.

Responses - Carbon trading

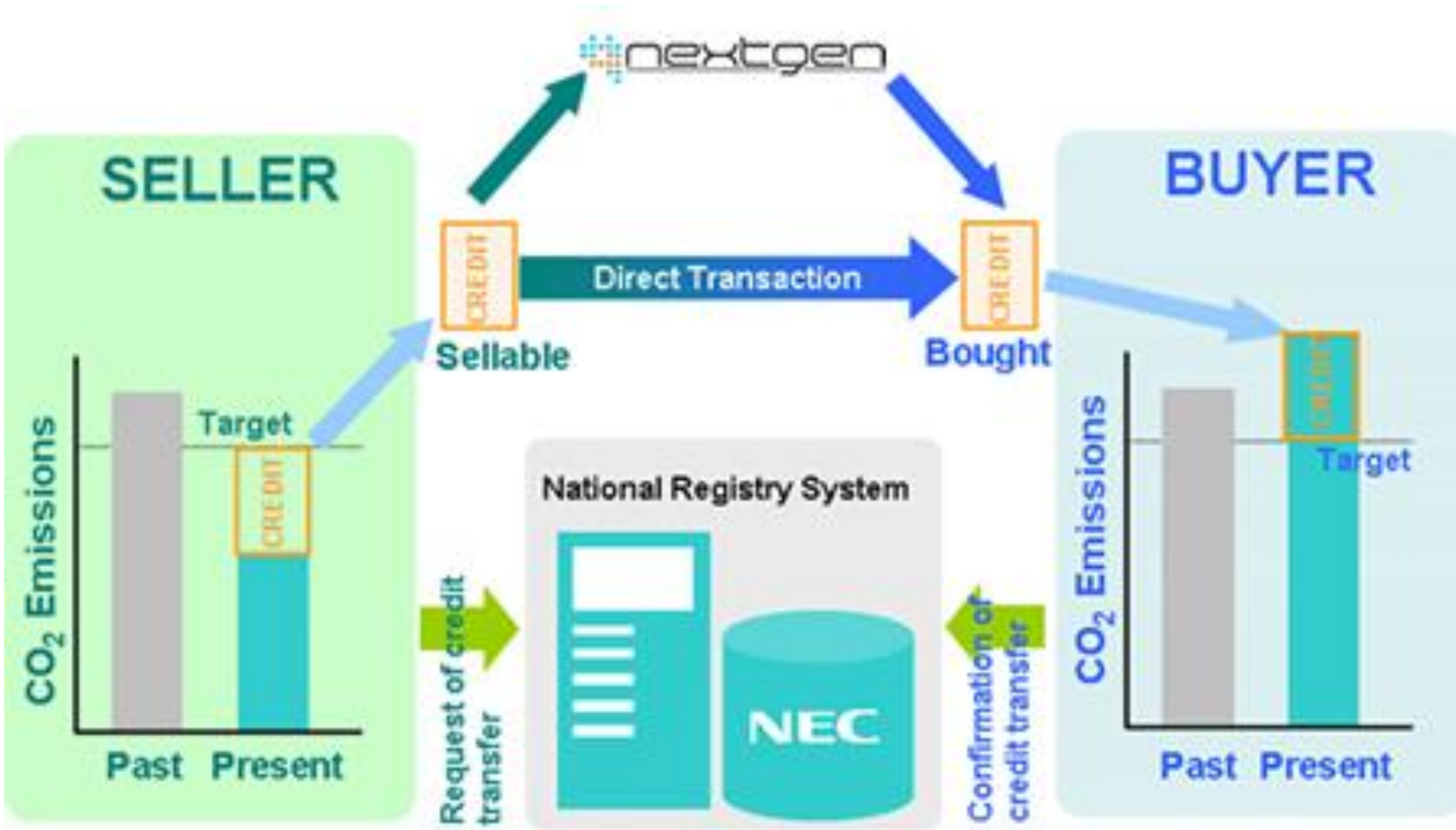
- Clean Development Mechanism (CDM)
- REDD+
- NAMAs
- Etc
- More info:
  (1) http://www.general-carbon.com/gc/index.php/carbon-credits-cdm,-vcs,-poa,-gs-energy-and-sustainability-services.html
  (2) http://unfccc.int/2860.php



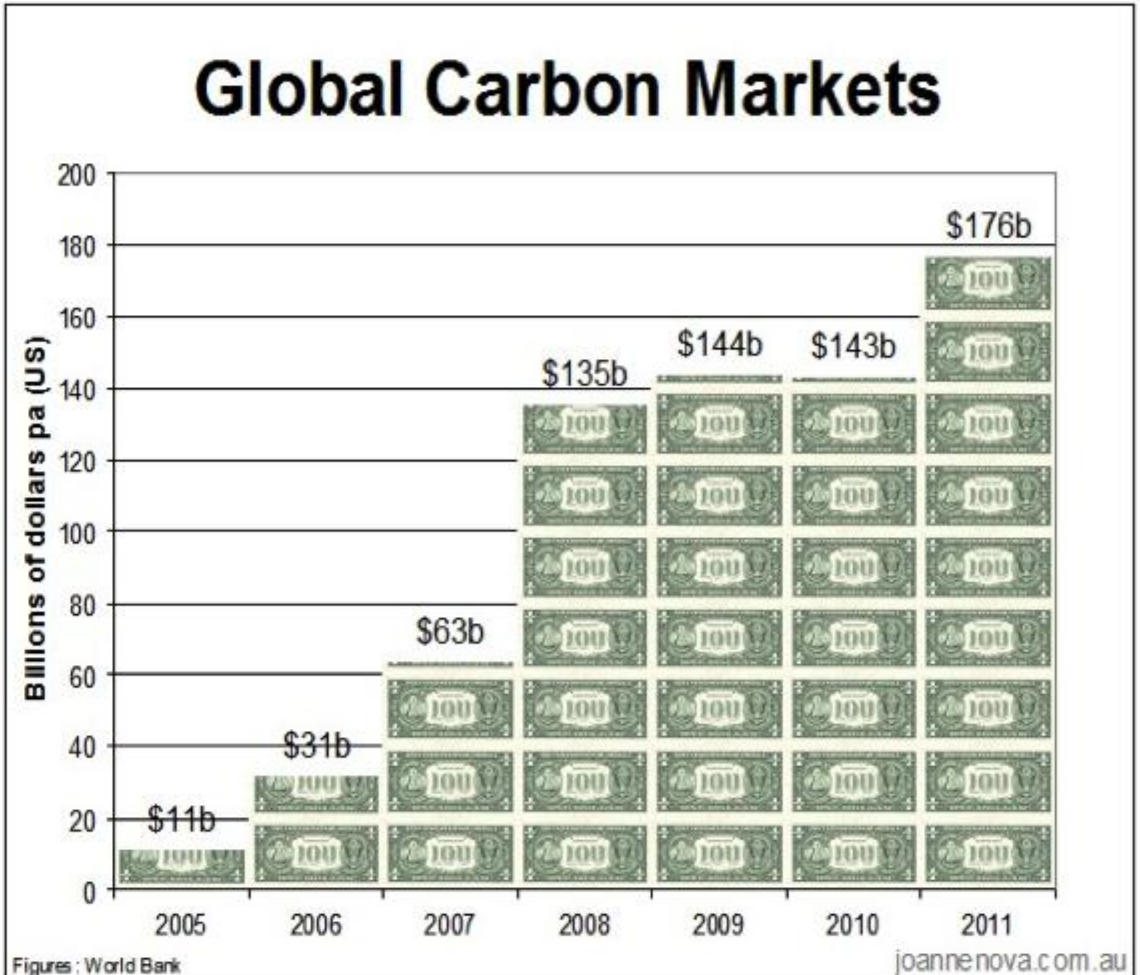
Carbon Trading

- https://www.youtube.com/watch?v=YfQyPl6BkP4

Carbon Trading



Carbon Trading



- Source: Harvard Kennedy School

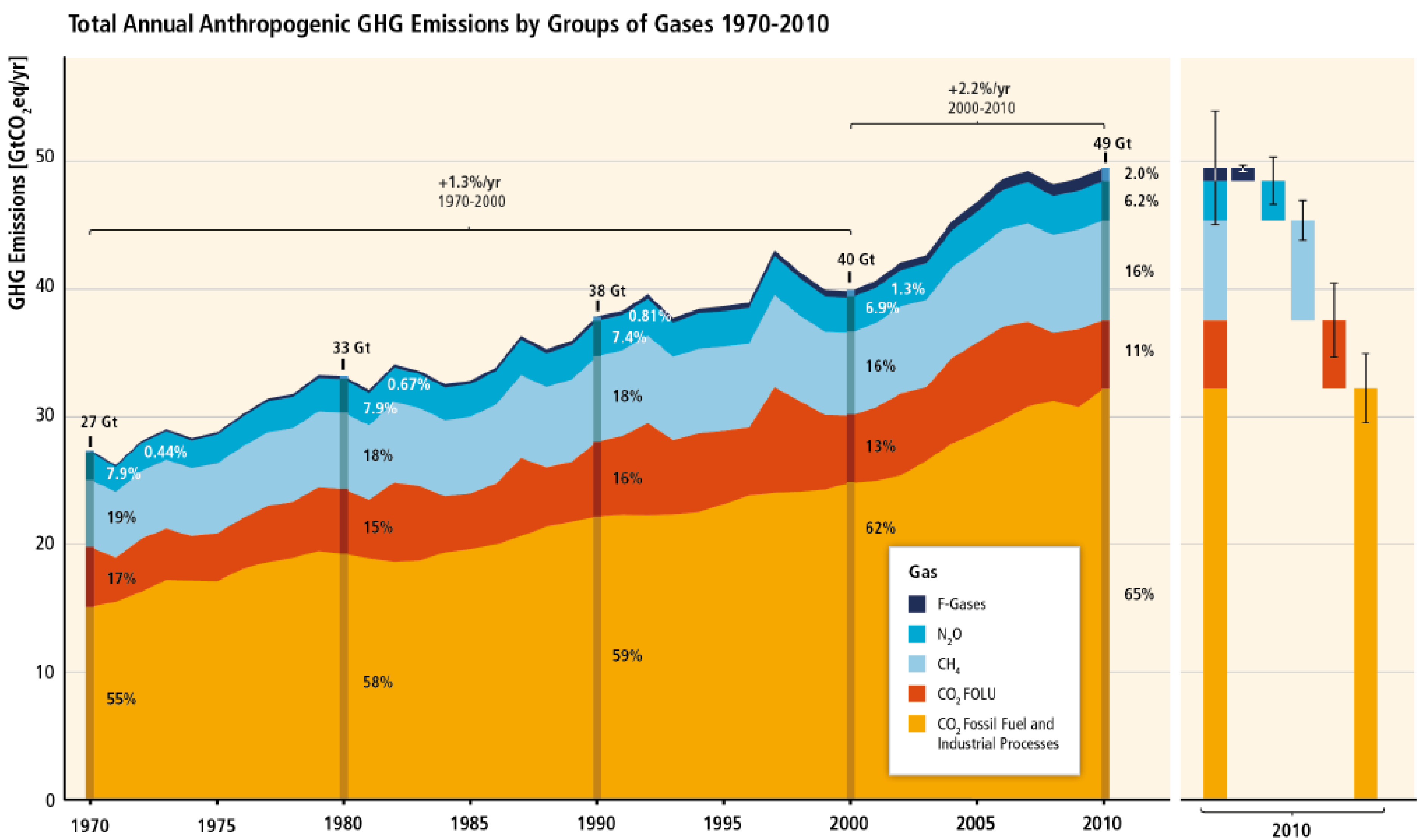
Responses - CC Reporting

- Reporting is required from all parties and comprises:
  - National circumstances
  - National greenhouse gas inventories
  - General description of steps taken or envisaged to implement the Convention
  - Measures to facilitate adequate adaptation to climate change
  - Measures to mitigate climate change
  - Other information (e.g awareness raising)
  - Constraints and gaps, and related financial, technical and capacity needs

Part II

GHG Inventories

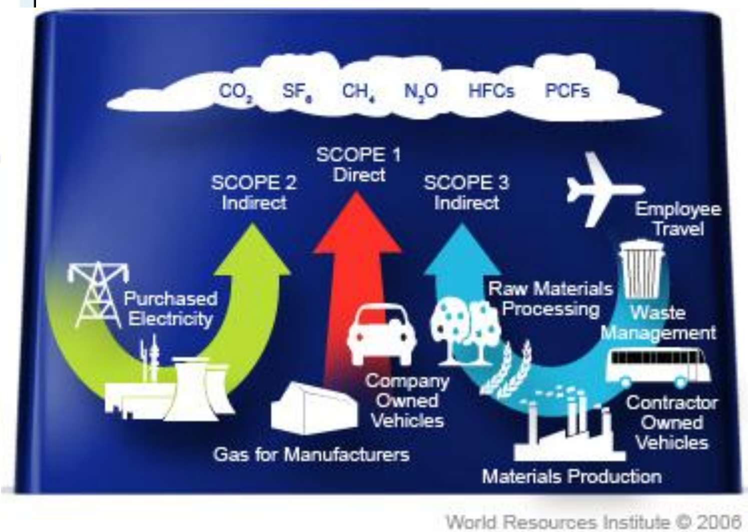
CC and Emissions of GHGs



GHG inventories

- GHG and carbon footprint

Inventory process



Carbon Footprint

GHG calculations

- Calculations
  - Simplest (Tier 1):

$$CO_2e = \sum_{i=1}^{n} GHG_i \times GWP_i \quad (Eq. A-1)$$

Emissions (E)= Activity data (AD) x Emission factor (EF)

  - Complex (Tier 2, 3):

$$Total\ Emissions = \sum_{1}^{i}(E_{CO_2} \times GWP_{CO_2})_i + \sum_{1}^{i}(E_{CH_4} \times GWP_{CH_4})_i + \sum_{1}^{i}(E_{N_2O} \times GWP_{N_2O})_i + \sum_{1}^{i}(E_{PFC} \times GWP_{PFC})_i + \sum_{1}^{i}(E_{HFC} \times GWP_{HFC})_i + \sum_{1}^{i}(E_{SF_6} \times GWP_{SF_6})_i$$

Annual emissions · Monthly share · Daily share · Hourly share

$$E_{i,s,h} = \sum_{c=1}^{244} \left(E_{i,c,s,j} \frac{x_{c,s,j,m}}{\sum_{m=1}^{12} x_{c,s,j,m}} \frac{7}{n_{m,j}} \frac{y_{c,s,d}}{\sum_{d=1}^{7} y_{c,s,d}} \frac{z_{c,s,d,h,t}}{\sum_{h=1}^{24} z_{c,s,d,h,t}} \right)$$

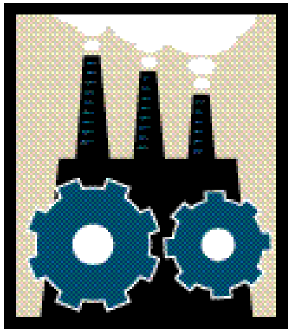
Where:

E = Emissions; x = Country, sector, year and month specific activity; y = Country, sector and day specific activity;

z = Country, sector, day, hour and time zone specific activity; n = month and year specific numbers of days

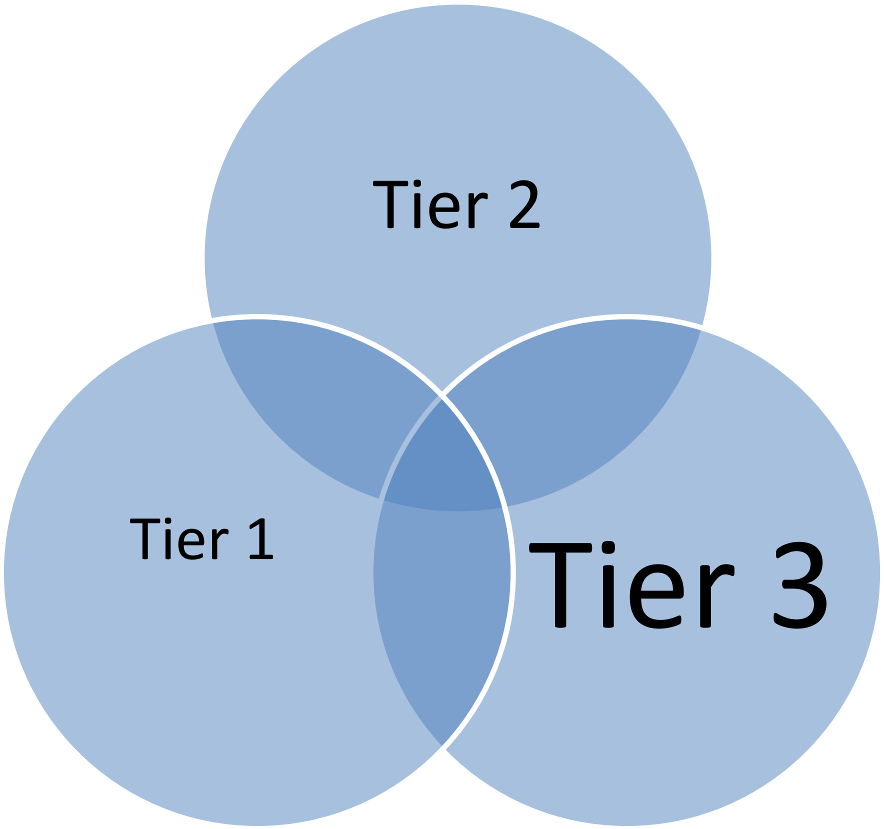
i = Grid code (lon/lat); s = Sector; h = hour (plus referenced to 1970); c = Country; j = Year; m = Month; d = Weekday

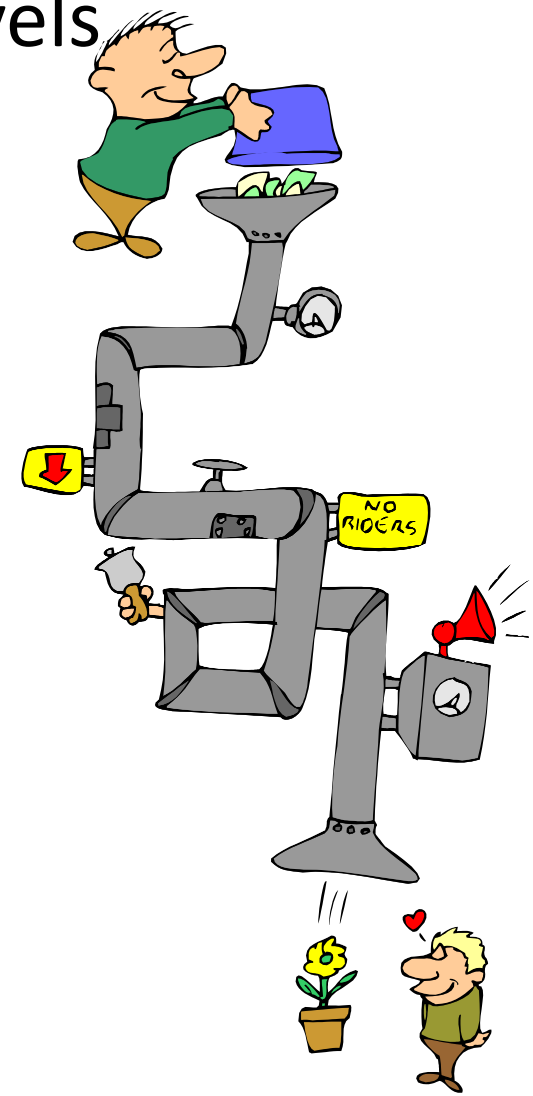
t = Time zone



GHG calculations

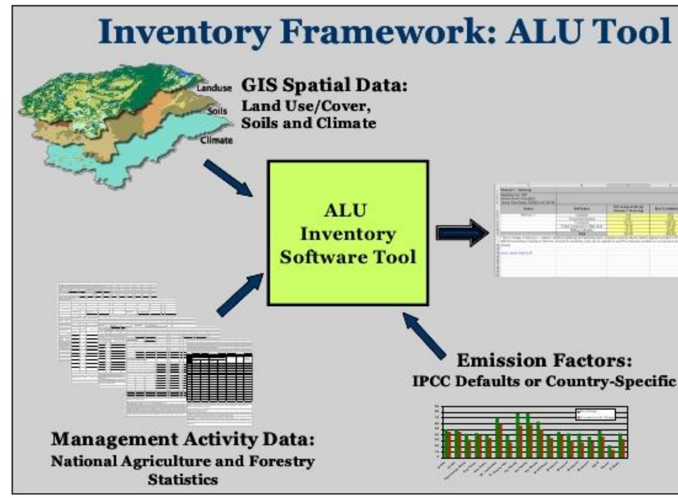
- Complexity of calculations and data needs increases with increase in Tier levels



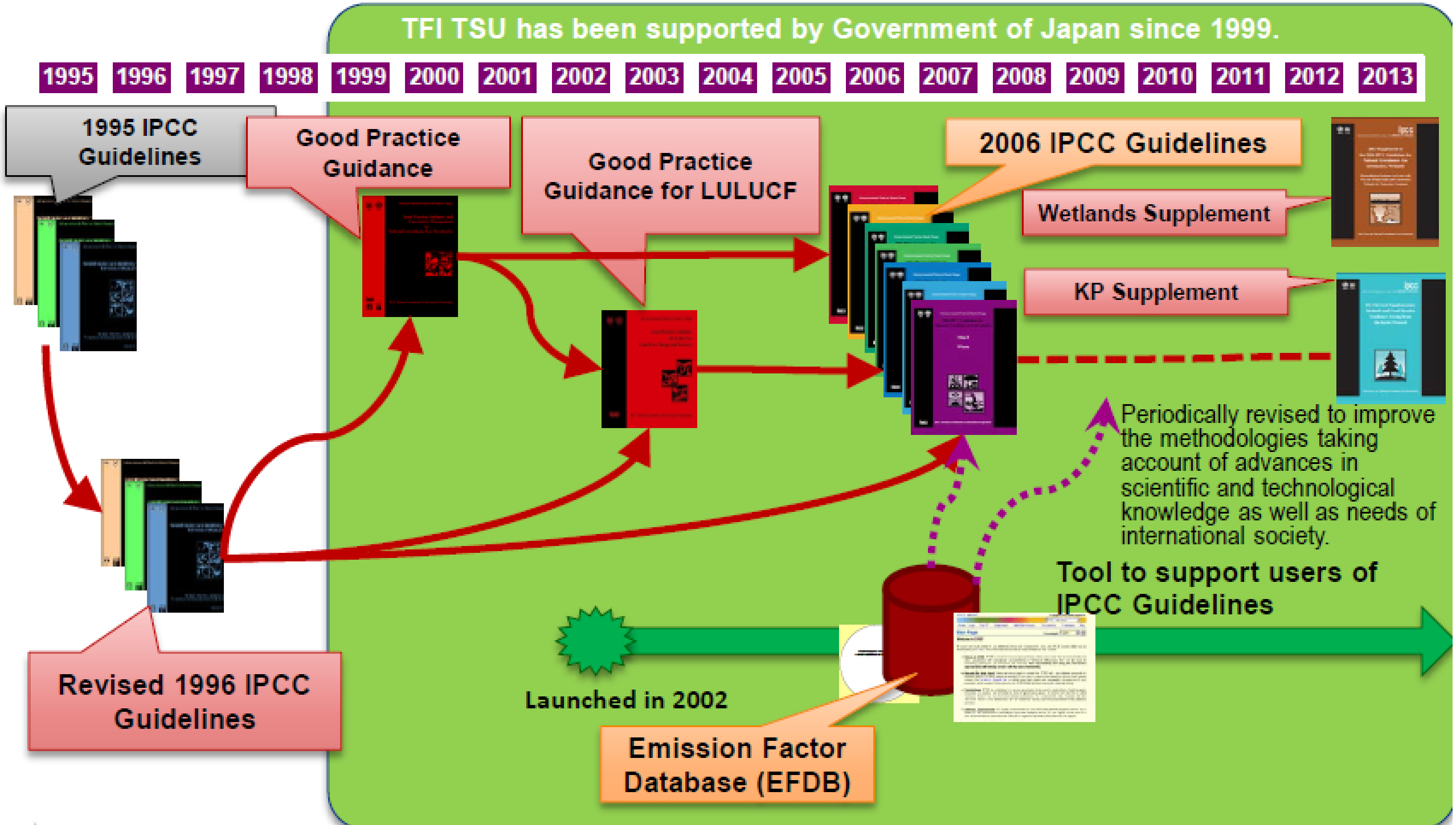


GHG inventory manuals and Software

- IPCC Guidelines



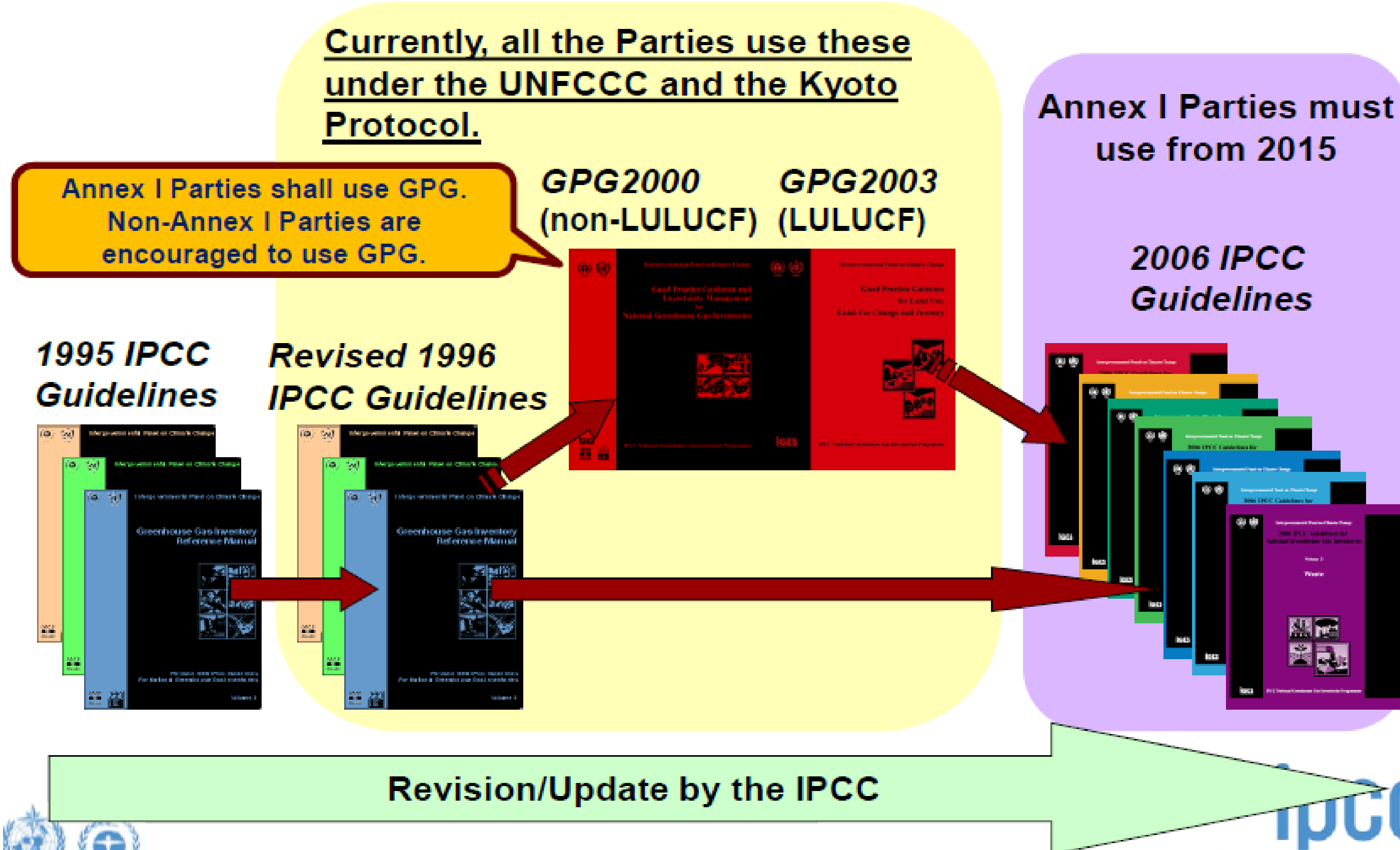
Evolution of IPCC Guidelines & other tools



WMO UNEP

INTERGOVERNMENTAL PANEL ON climate change

UNFCCC and IPCC TFI (4)



GHG sectors – Current for Non Annex I countries

Energy

Electricity

Transport

Manufacturing

Commercial

Households Others

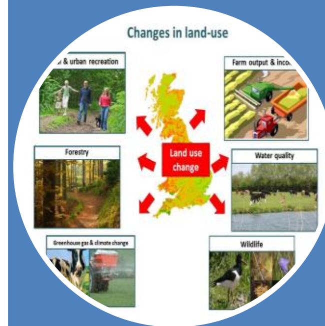
Industrial processes

Agriculture

Livestock

Soils

etc



Land Use, Land Use Change and Forestry

Waste

Solid

Liquid

Example worksheet

This spreadsheet contains sheet 1 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

This spreadsheet contains sheet 2 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

This spreadsheet contains sheet 3 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

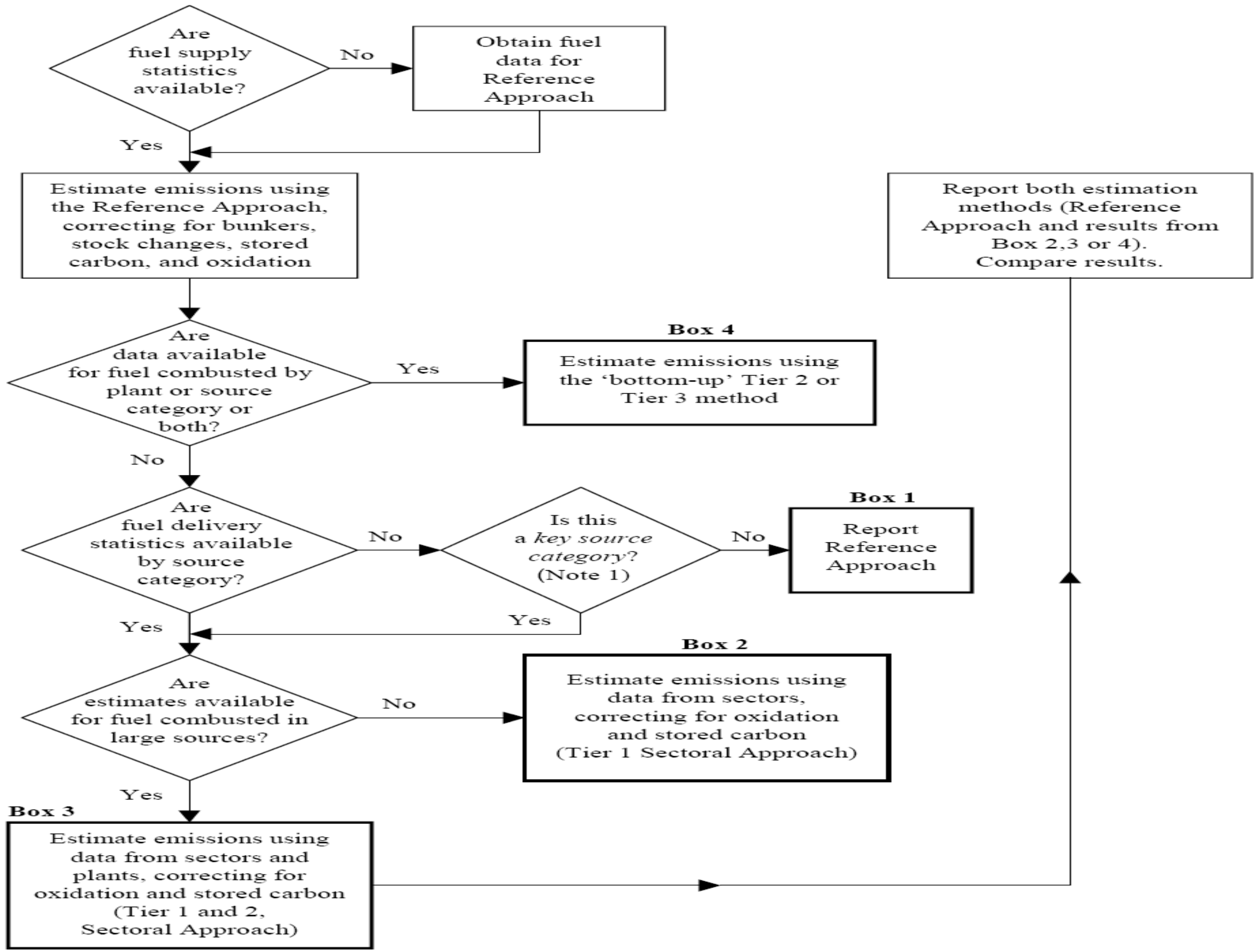
MODULE	**ENERGY**	**ENERGY**	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**	**1-1**	**1-1**
SHEETS	**1 OF 5**	**2 OF 5**	**3 OF 5**
COUNTRY	**0**	**0**	**0**
YEAR	**0**	**0**	**0**

			A Production	B Imports	C Exports	D International Bunkers	E Stock Change	F Apparent Consumption	G [b] Conversion Factor (TJ/Unit)	H Apparent Consumption (TJ)	I Carbon Emission Factor (t C/TJ)	J Carbon Content (t C)	K Carbon Content (Gg C)	L Carbon Stored (Gg C)	M Net Carbon Emissions (Gg C)	N Fraction of Carbon Oxidised	O Actual Carbon Emissions (Gg C)	P Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES								F=(A+B-C-D-E)		H=(FxG)		J=(HxI)	K=(J/1000)		M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Orimulsion						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Natural Gas Liquids						0.00		0.00		0.00	0.00		0.00		0.00	0.00
	Secondary Fuels	Gasoline						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Jet Kerosene						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Other Kerosene						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Shale Oil						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Gas / Diesel Oil						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Residual Fuel Oil						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		LPG						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Ethane						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Naphtha						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Bitumen						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Lubricants						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Petroleum Coke						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Refinery Feedstocks						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Other Oil						0.00		0.00		0.00	0.00		0.00		0.00	0.00
Liquid Fossil Totals										0.00		0.00	0.00	0.00	0.00		0.00	0.00
Solid Fossil	Primary Fuels	Anthracite [a]						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Coking Coal						0.00		0.00		0.00	0.00	0.00	0.00		0.00	0.00
		Other Bit. Coal						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Sub-bit. Coal						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Lignite						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Oil Shale						0.00		0.00		0.00	0.00		0.00		0.00	0.00
		Peat						0.00		0.00		0.00	0.00		0.00		0.00	0.00

Example calculation process

Decision tree

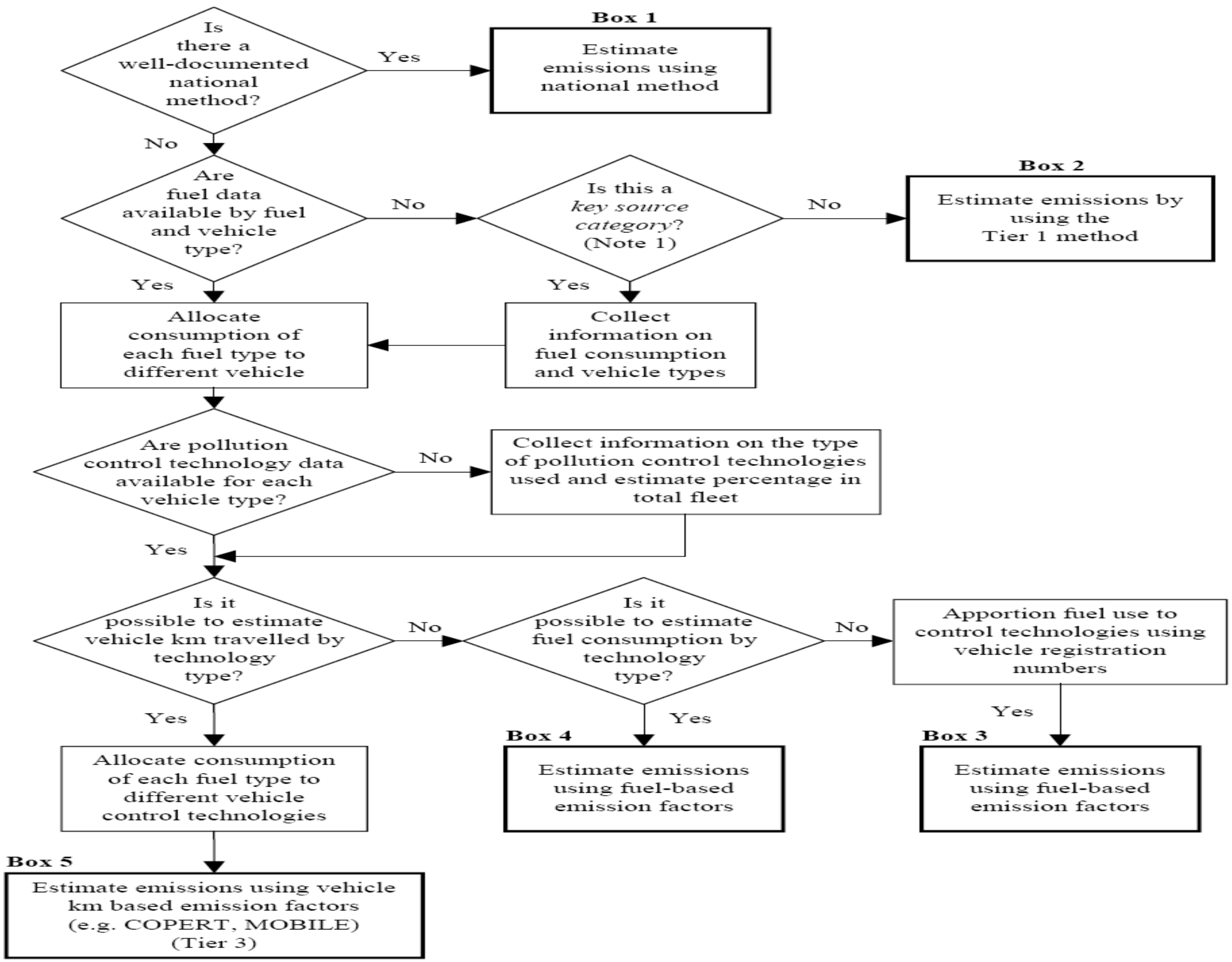
Figure 2.1 Decision Tree for Selecting the Method for Estimation of CO_2 Emissions from Stationary Combustion



Calculation process for complex calculations

- Example from road transport sector

Figure 2.5 Decision Tree for CH_4 and N_2O Emissions from Road Vehicles



GHG results

- Example emissions targets and related data

Country	Kyoto target	Existing policies and measures	Additional policies and measures	Use of carbon sinks	Use of Kyoto mechanisms	Existing and additional measures, use of carbon sinks and Kyoto mechanisms	
		Projections for 2010	Projected effect in 2010			Projections for 2010	Gap between projections and target
	% of base year	% of base year	% of base year	% of base year	% of base year	% of base year	% of base year
Austria	− 13.0 %	17.2 %	− 18.2 %	− 0.9 %	− 11.4 %	− 13.4 %	− 0.4 %
Belgium	− 7.5 %	− 3.6 %			− 4.8 %	− 8.4 %	− 0.9 %
Bulgaria	− 8.0 %	− 37.0 %	− 4.6 %			− 41.7 %	− 33.7 %
Cyprus	n.a.	101.6 %				87.9 %	n.a.
Czech Republic	− 8.0 %	− 25.8 %	− 3.1 %			− 28.8 %	− 20.8 %
Denmark	− 21.0 %	-9.7 %		− 3.3 %	− 6.1 %	− 19.0 %	2.0 %
Estonia	− 8.0 %	− 56.6 %	− 3.3 %			− 59.9 %	− 51.9 %
Finland	0.0 %	19.6 %	− 17.4 %	− 0.8 %	− 3.4 %	− 2.0 %	− 2.0 %
France	0.0 %	0.9 %	− 4.3 %			− 3.4 %	− 3.4 %
Germany	− 21.0 %	− 22.4 %	-3.3 %			− 25.7 %	− 4.7 %
Greece	25.0 %	34.7 %	− 9.8 %			24.9%	− 0.1 %
Hungary	− 6.0 %	− 28.5 %	− 0.2 %			− 28.7 %	− 22.7 %
Ireland	13.0 %	22.6 %	− 0.2 %	− 3.7 %	− 6.5 %	12.3 %	− 0.7 %
Italy	− 6.5 %	13.1 %	− 12.2 %	− 3.2 %	− 3.7 %	− 6.0 %	0.5 %
Latvia	− 8.0 %	− 46.2 %	− 2.4 %			− 48.6 %	− 40.6 %
Lithuania	− 8.0 %	− 30.2 %				− 30.2 %	− 22.2 %
Luxembourg	− 28.0 %	11.9 %	− 2.7 %		− 37.3 %	− 28.0 %	0.0 %
Malta	n.a.	123.5 %				123.5 %	n.a.
Netherlands	− 6.0 %	− 0.6 %		− 0.1%	− 9.4 %	− 10.1 %	− 4.1 %
Poland	− 6.0 %	− 28.4 %				− 28.4 %	− 22.4 %
Portugal	27.0 %	44.3 %	− 4.0 %	− 7.6 %	− 9.5 %	23.1 %	− 3.9 %
Romania	− 8.0 %	− 31.9 %	− 3.9 %			− 35.8 %	− 27.8 %
Slovak Republic	− 8.0 %	-20.2 %	− 3.1 %			− 23.3 %	− 15.3 %
Slovenia	− 8.0 %	6.8 %	− 8.2 %	− 8.3 %	− 3.0 %	− 12.7 %	− 4.7 %
Spain	15.0 %	42.3 %		− 2.0 %	− 11.0 %	29.2 %	14.2 %
Sweden	4.0 %	− 3.4 %		− 2.9 %		− 6.4 %	− 10.4 %
United Kingdom	− 12.5 %	− 23.2 %		− 0.5 %		− 23.7 %	− 11.2 %
EU-15	**− 8.0 %**	**− 4.0 %**	**− 3.9 %**	**− 0.9 %**	**− 2.5 %**	**− 11.4 %**	**− 3.4 %**
Croatia	− 5.0 %	0.4 %	− 11.1 %			− 10.8 %	− 5.8 %
Iceland	10.0 %	2.4 %				2.4 %	− 7.6 %
Liechtenstein	− 8.0 %	3.8 %				3.8 %	11.8 %
Norway	1.0 %	18.9 %			− 20.1 %	− 1.1 %	− 2.1 %
Switzerland	− 8.0 %	− 3.2 %	-2.4 %		− 3.1 %	− 8.7 %	− 0.7 %
Turkey	n.a.	99.7 %				99.7 %	n.a.

Example result of emissions/removals

Example from Taiwan

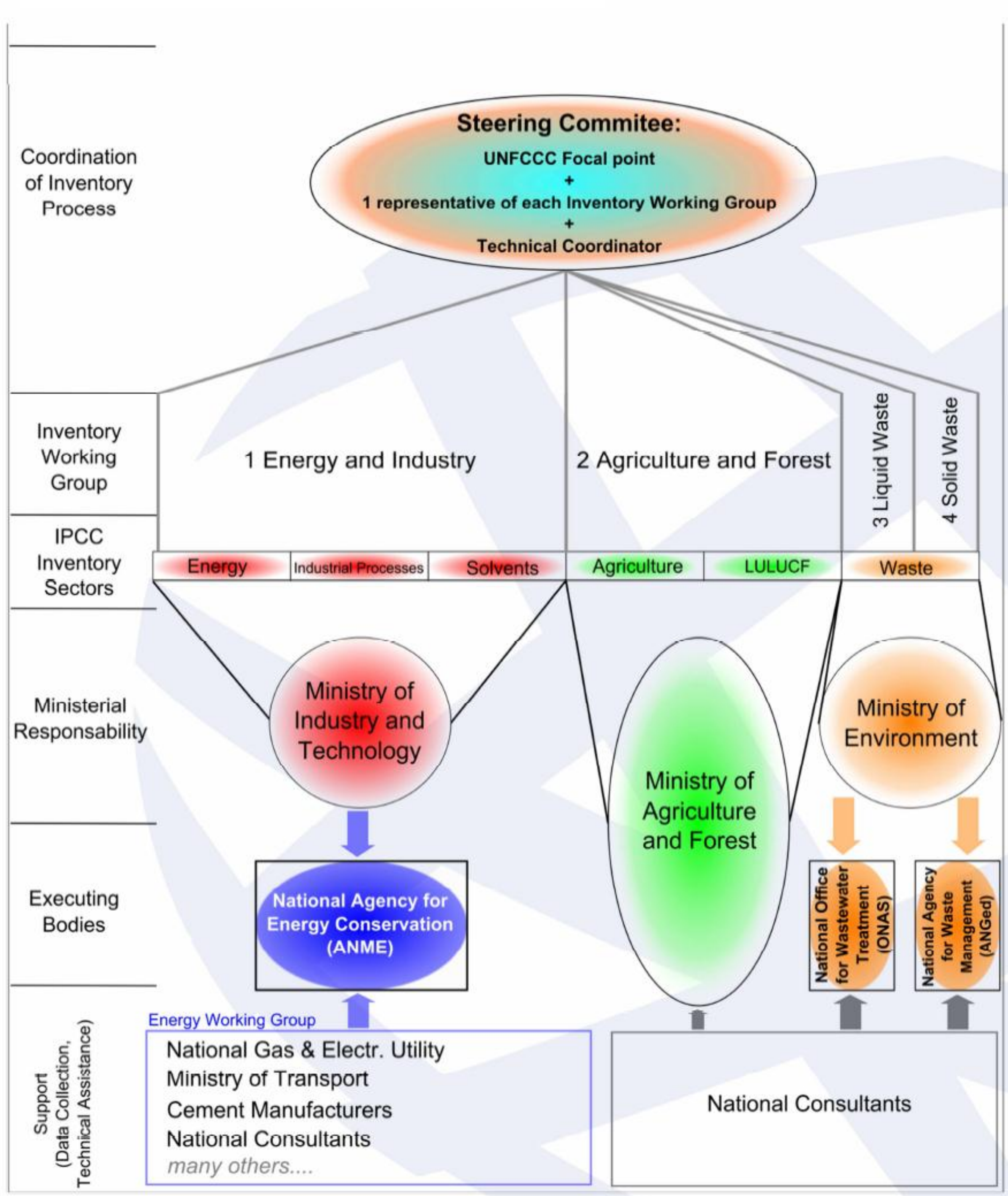
Unit: kilotons of carbon dioxide equivalents

Year	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	CO_2 absorption	Total GHG emission	Net GHG emission
1990	122,399	11,974	12,736	NE	NE	NE	-18,704	147,109	128,406
1991	131,853	11,219	13,537	NE	NE	NE	-16,947	156,609	139,661
1992	141,259	12,116	13,383	NE	NE	NE	-18,979	166,759	147,780
1993	152,725	13,424	13,679	1,592	NE	NE	-19,107	181,420	162,313
1994	160,162	14,000	13,937	1,802	NE	NE	-19,173	189,900	170,727
1995	167,308	15,545	13,902	1,689	NE	NE	-19,206	198,445	179,239
1996	175,754	15,495	14,217	2,752	NE	NE	-19,133	208,218	189,085
1997	188,951	15,447	12,360	3,115	NE	NE	-19,283	219,873	200,590
1998	198,340	15,149	11,908	4,391	NE	NE	-19,298	229,788	210,490
1999	207,130	14,660	12,258	3,392	NE	NE	-19,301	237,440	218,139
2000	224,661	11,028	12,443	5,639	2,386	494	-19,360	256,651	237,291
2001	230,576	9,200	12,437	5,412	2,021	546	-18,601	260,193	241,592
2002	239,593	7,250	12,205	5,415	2,509	593	-19,554	267,565	248,011
2003	248,599	6,196	11,205	4,920	2,776	969	-19,624	274,665	255,041
2004	257,279	5,920	11,734	4,494	2,852	1,285	-19,672	283,565	263,893
2005	263,819	4,979	11,461	1,647	2,505	2,893	-19,628	287,303	267,676
2006	271,774	4,486	11,674	1,028	2,657	2,993	-19,738	294,611	274,873
2007	274,973	4,127	11,429	1,031	2,309	2,933	-19,730	296,801	277,071
2008	263,606	4,727	10,839	1,001	1,498	2,844	-19,807	284,515	264,707

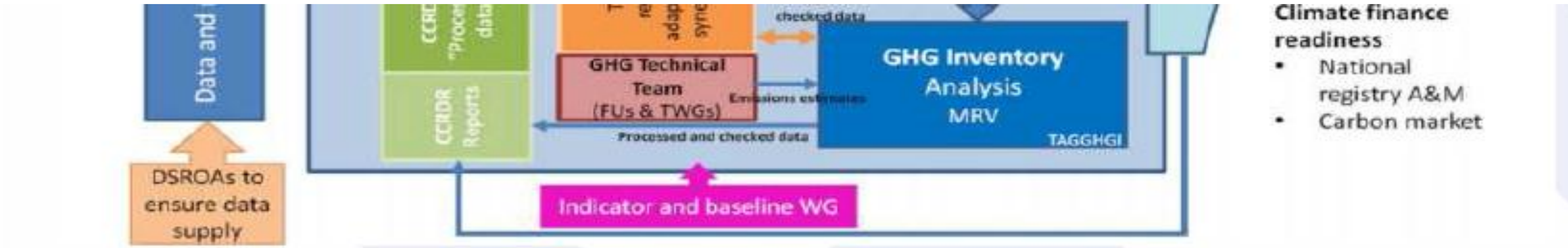
Notes:
1. NE means Not Estimated due to insufficient data or incomplete statistical work.
2. Data source: EPA Executive Yuan (except data of carbon dioxide emission due to fuel combustion by energy sector came from Bureau of Energy Ministry of Economic Affairs).

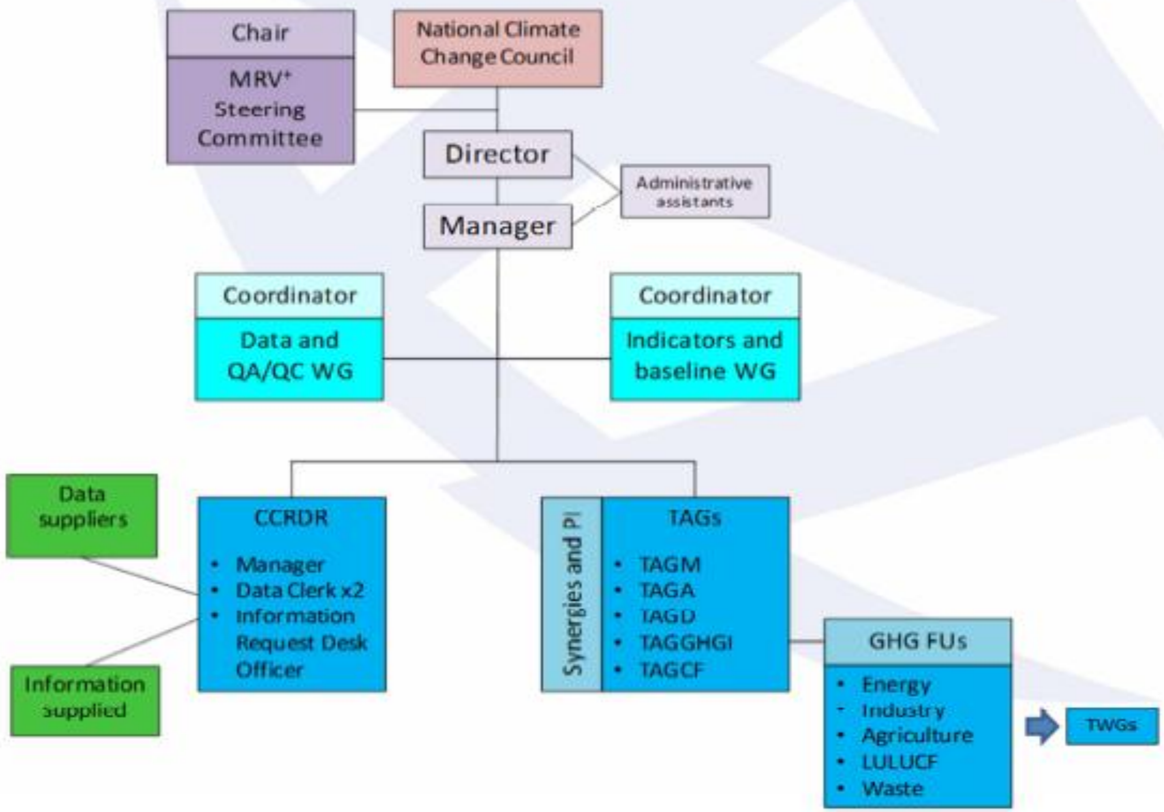
Institutional set ups and GHG MRV – Monitoring, Reporting and Verification

- Measurable
- Reliable
- Verifiable



Institutional set ups and GHG MRV





Quality Of GHG Inventories

- National GHG inventories must produce emission/removal data which are neither far over nor below real values as far as can be judged according to the available data and information

- National GHG inventories must be prepared in accordance with the **TACCC principles**:
  - **Transparency**
  - **Accuracy**
  - **Completeness**
  - **Comparability**
  - **Consistency.**

- Source: UNFCCC

GHG Inventory Preparation

- Identify **key categories** and significant subcategories (see IPCC good practice guidance (2000) chapter 7 and IPCC good practice guidance (2003) chapter 5).
- Select **methods** and **emission factors** (GPG decision trees at sector category level).
- Collect **activity data** (both statistical and parametric).
- Manage **recalculations** (if needed) (see IPCC good practice guidance (2000) chapter 7 and IPCC good practice guidance (2003) chapter 5).
- Implement **QA/QC plan**: (see IPCC good practice guidance (2000) chapter 8 and IPCC good practice guidance (2003) chapter 5)
  - **Basic checks** should be completed on entire inventory (Tier 1)
  - **More in-depth investigations** into key categories (Tier 2).
- Documentation.

National Inventory Management Team

Role	Name	Organization	Contact Information	Comments
Inventory Director/Coordinator				
Energy Sector Lead				
Industrial Processes Lead				
Agriculture Sector Lead				
LULUCF Sector Lead				
Waste Sector Lead				
Archive (Data and Document) Manager/Coordinator				
QA/QC coordinator				
Uncertainty Analysis coordinator				
Other: e.g., GHG Policy Specialist who tracks capacity building efforts and IPCC processes				

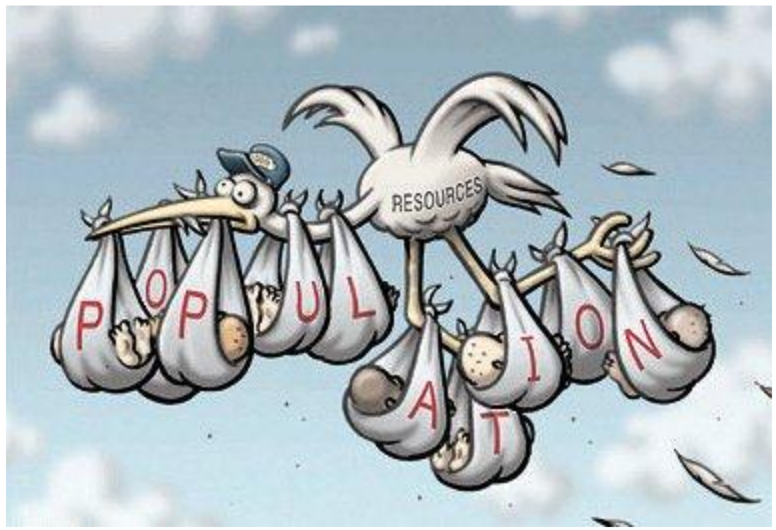
Steps for planning of GHG inventory

[1] "UNFCCC resource guide for preparing the national communications of non-Annex I Parties" - Module 3: National greenhouse gas inventories, p. >.

The GHG inventory cycle

Part III

Scope of CC related statistics



Some examples of Statistics required for CC

Include environmental, social and economic data that measure…

- Drivers: human caused sources and causes of emissions
- Greenhouse gas emissions
- Mitigation: efforts of humans to avoid the consequences
- Adaptation: efforts to adapt to these consequences
- Impacts: on human and natural systems

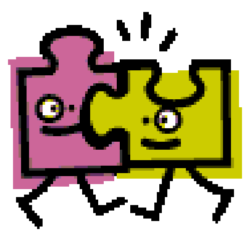



Some examples of Specific Statistics required for CC

- Re-occurrence of diseases
- New diseases

- Changes in current trends "Extreme events" (heat waves, storms, etc.)
- Water
- Land use, land cover changes, and soil degradation.
- Crop production patterns
- Jobs…**"Green Jobs"**

- Population / Demographics / Migration
  Types of "households"
- Need to be able to connect/combine different data sets



The Linkages to FDES

- As a cross-cutting issue, climate change statistics are spread over a large proportion of the domain of environment statistics.
- The very real challenge that this poses to environment statistics should not be underestimated.
- It is essential that the scientific approach to climate change be addressed, with the provision of well-structured, relevant, reliable and timely information; but the policy aspect and the supporting information that must inform it also remain pressing requirements that need to be confronted with a view to integration and coherence.

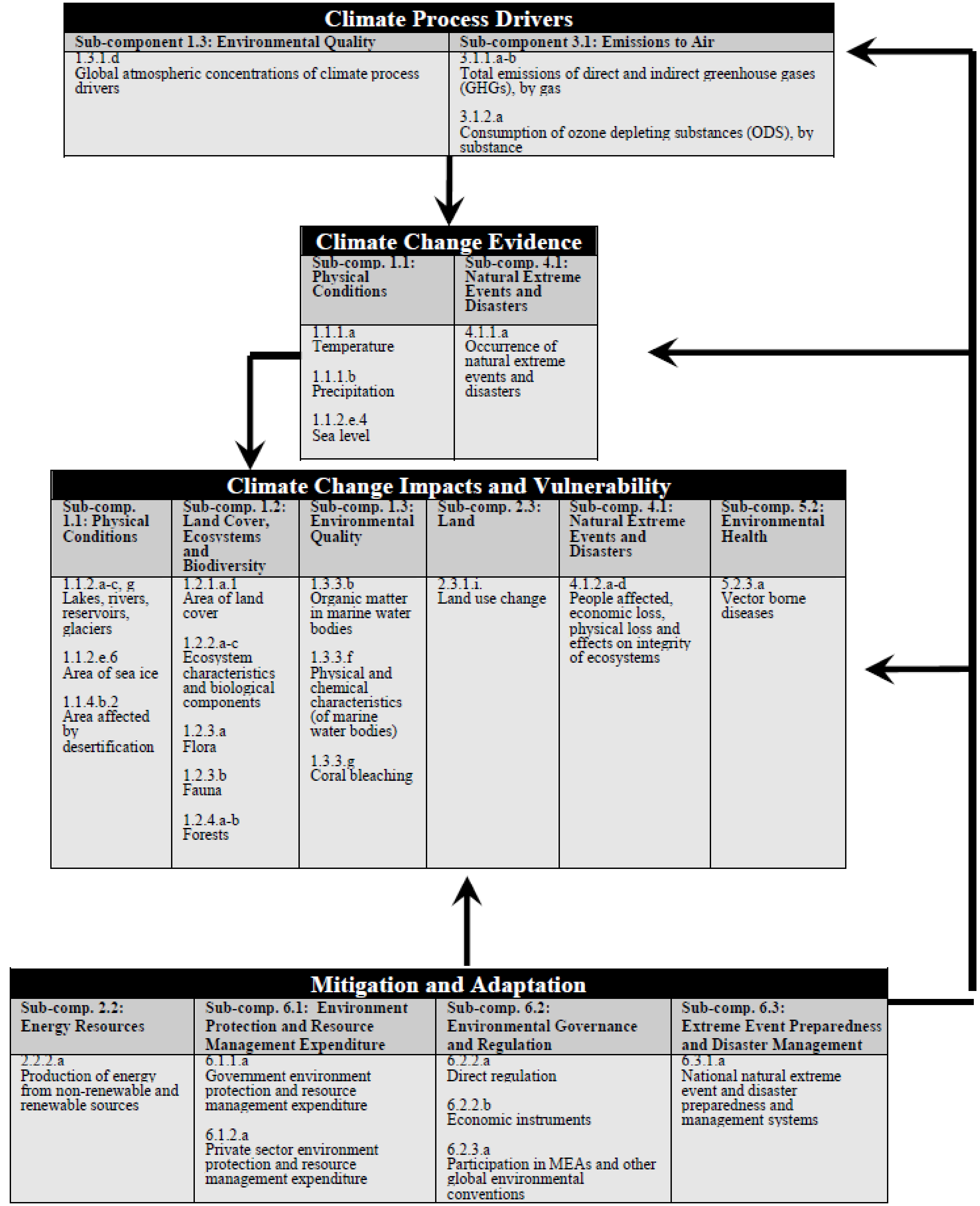
The Linkages to FDES

- The FDES provides a very comprehensive and structured way to collect and build statistics for components of the environment that will be crucial in climate change studies, policies and strategies.
- The issues presented so far can therefore be tracked by applying the FDES

FDES 2013

- The process for CC Stats is well elaborated in the FDES.
- Being a comprehensive framework, the FDES contains topics that are cross cutting to CC
- Cross-cutting issues of climate change is well-represented through the FDES

Figure 5.8: Topics in the FDES that relate to climate change



Thank you

FOR YOUR KIND
ATTENTION