ITU-CITET Regional Training Workshop on ICT and Climate Change Mitigation and Adaptation in Arab Region

Tunis, Tunisia 12-13 July 2017

Session 2: The Evidence for Climate Change and the Link to ICT

Dr Dave Faulkner

Objectives

This session will introduce the linkage between ICTs and climate change, looking at both the positive and negative effects of ICTs on climate change

STUDENTS

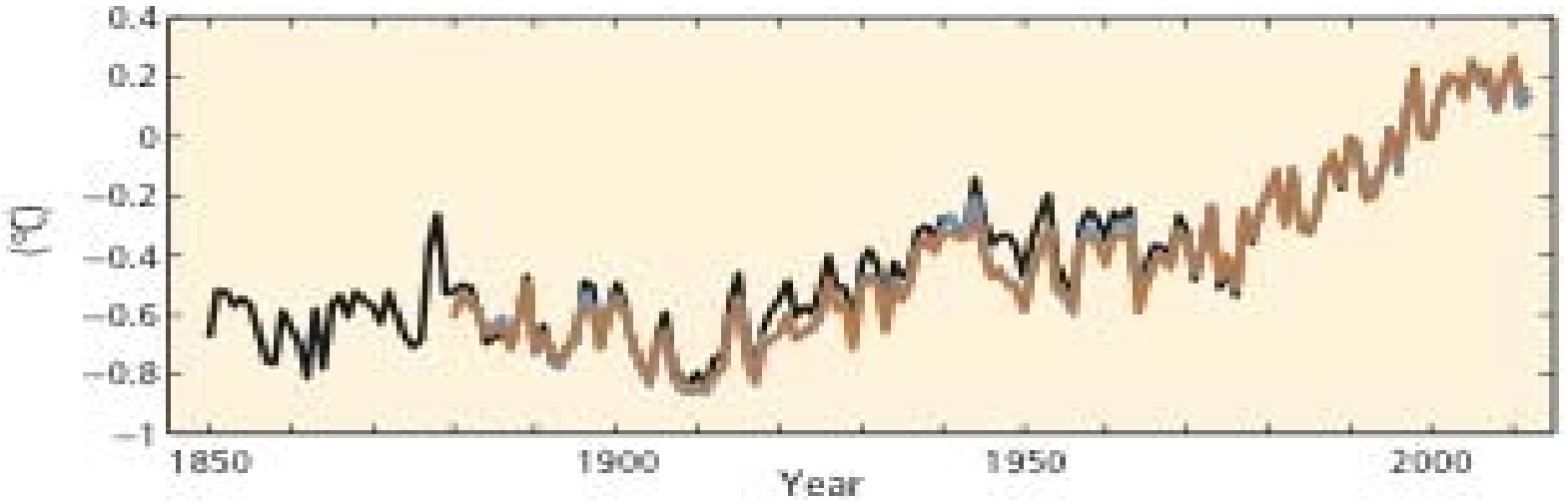
Session topics will discuss

- Evidence for Climate Change
- The linkage between ICT and Climate Change
- Energy efficiency of ICT
  - There will be more detail on this in Session 5
- The role of ICTs in monitoring the environment
- Climate change adaptation using ICTs

To start:
The evidence for climate change

The Evidence for Climate Change (1)

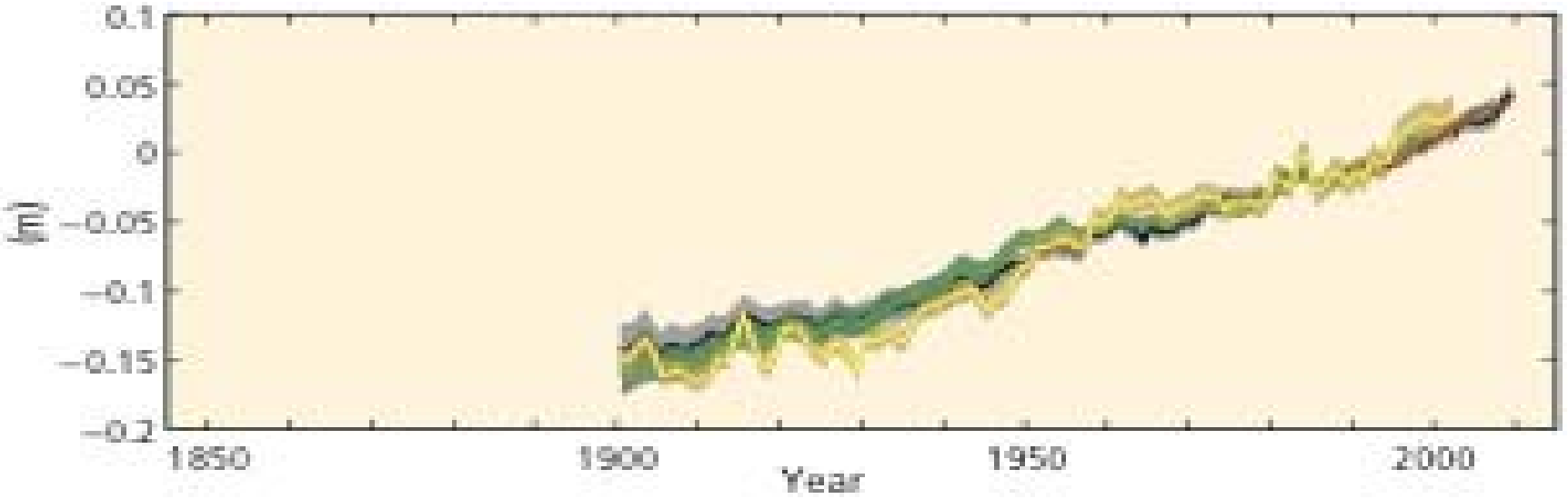
- Globally averaged combined land and ocean **surface temperature**.



Source: IPCC 5th Assessment Report: "Climate Change 2014 Synthesis Report Summary for Policymakers"
www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

The Evidence for Climate Change (2)

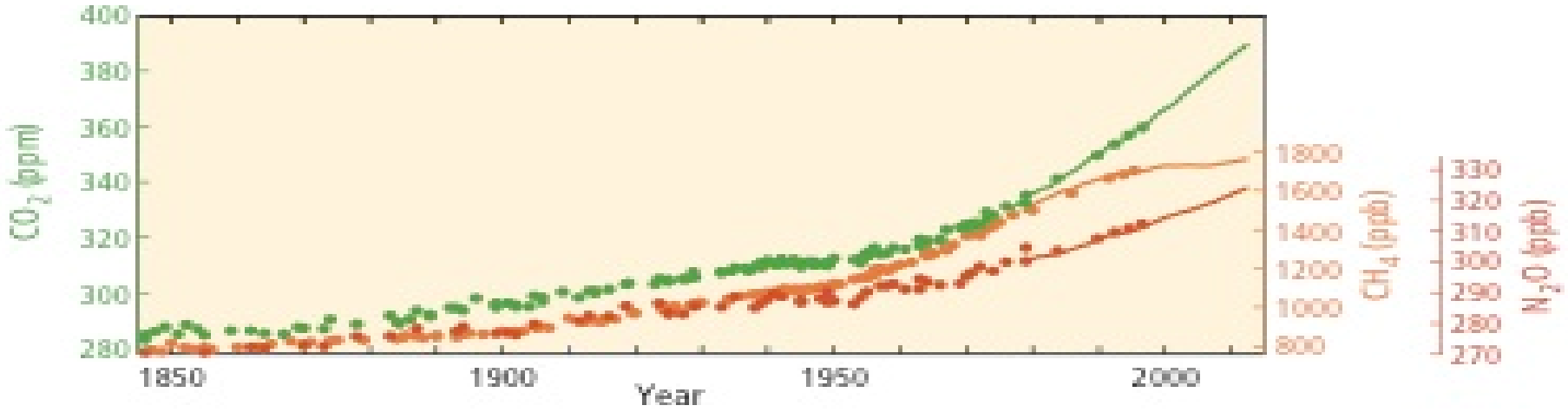
- Globally averaged **sea level change**.



Source: IPCC 5th Assessment Report: "Climate Change 2014 Synthesis Report Summary for Policymakers"
www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

The Evidence for Climate Change (3)

- Globally averaged **greenhouse gas concentrations.**

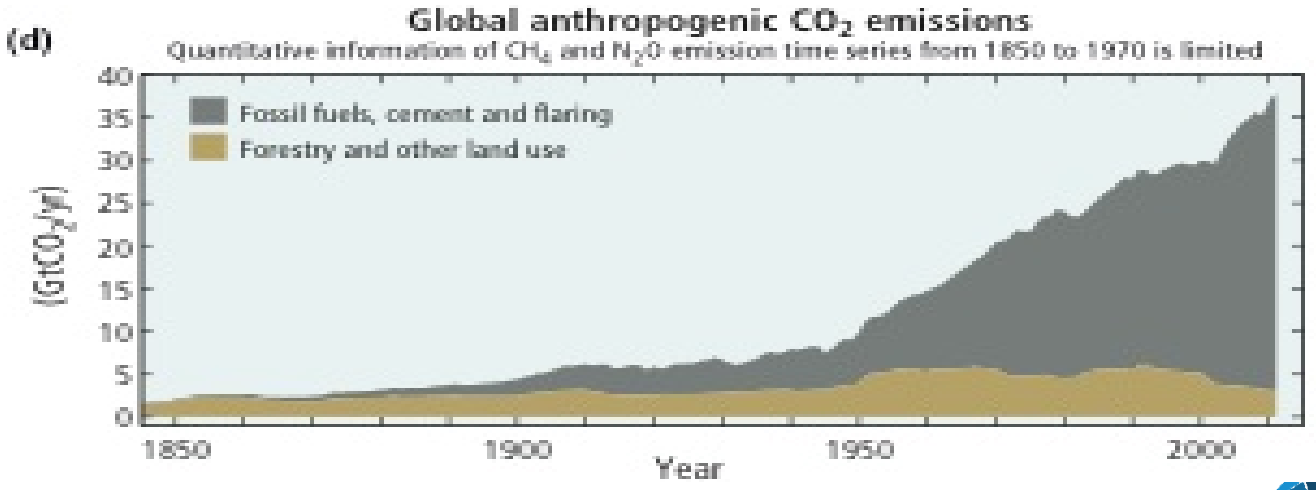


Source: IPCC 5th Assessment Report: "Climate Change 2014 Synthesis Report Summary for Policymakers"
www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

Human Influence on the Climate

SPM 1. Observed Changes and their Causes

- Anthropogenic emissions of greenhouse gases are the highest in history
  - This arises from changes in land use and burning of fossil fuels.



IPCC 5th Assessment Report

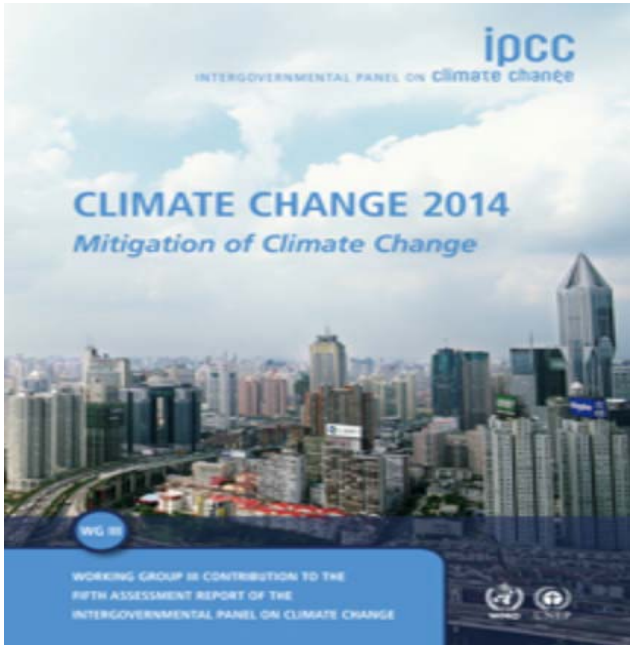
SPM 1.1 Observed changes in the climate system

- 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, and sea level has risen.
- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.

Source: IPCC 5th Assessment Report: "Climate Change 2014 Synthesis Report Summary for Policymakers"
www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

The importance of Mitigation

- Without additional efforts to reduce GHG emissions beyond those in place today, emissions growth is expected to persist
  - driven by growth in global population and economic activities.
- Mitigation scenarios reaching about 450 ppm CO_2e in 2100 typically involve temporary overshoot of atmospheric concentrations, as do many scenarios reaching about 500 ppm to about 550 ppm CO_2e in 2100.



www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

Reductions in GHG emissions are necessary…

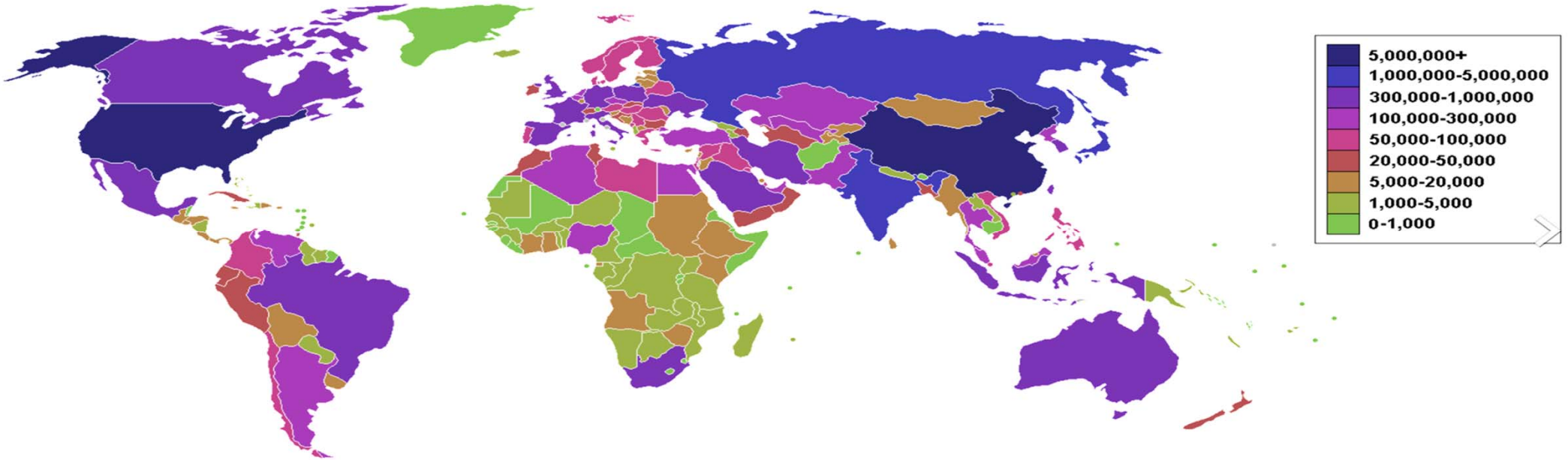
- IPCC 5th Assessment Report:
  - to keep average global temperature rise below 2°C,
  - a reduction in GHG emissions of 40-70% below 2010 levels in needed by 2050.
- Even this may be insufficient to keep food production at current levels when regional and local climate variations are taken into account.
- Submissions of Intended Nationally Determined Contributions (INDCs) have been invited.

www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

Outcomes of COP21 (Paris) -the top 5

- Agreement to limit rise in global temperatures to below 2°C (peak of CO_2e levels around 450ppm).
- First agreement that commits *all* countries to cut carbon emissions.
- Partly legally binding and partly voluntary.
- Promise to raise $100bn a year by 2020 to help poor countries adapt their economies.
- Pathway to a new goal of zero net emissions by later this century.

Countries by CO_2 emissions (in thousands of tonnes per annum)



http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions

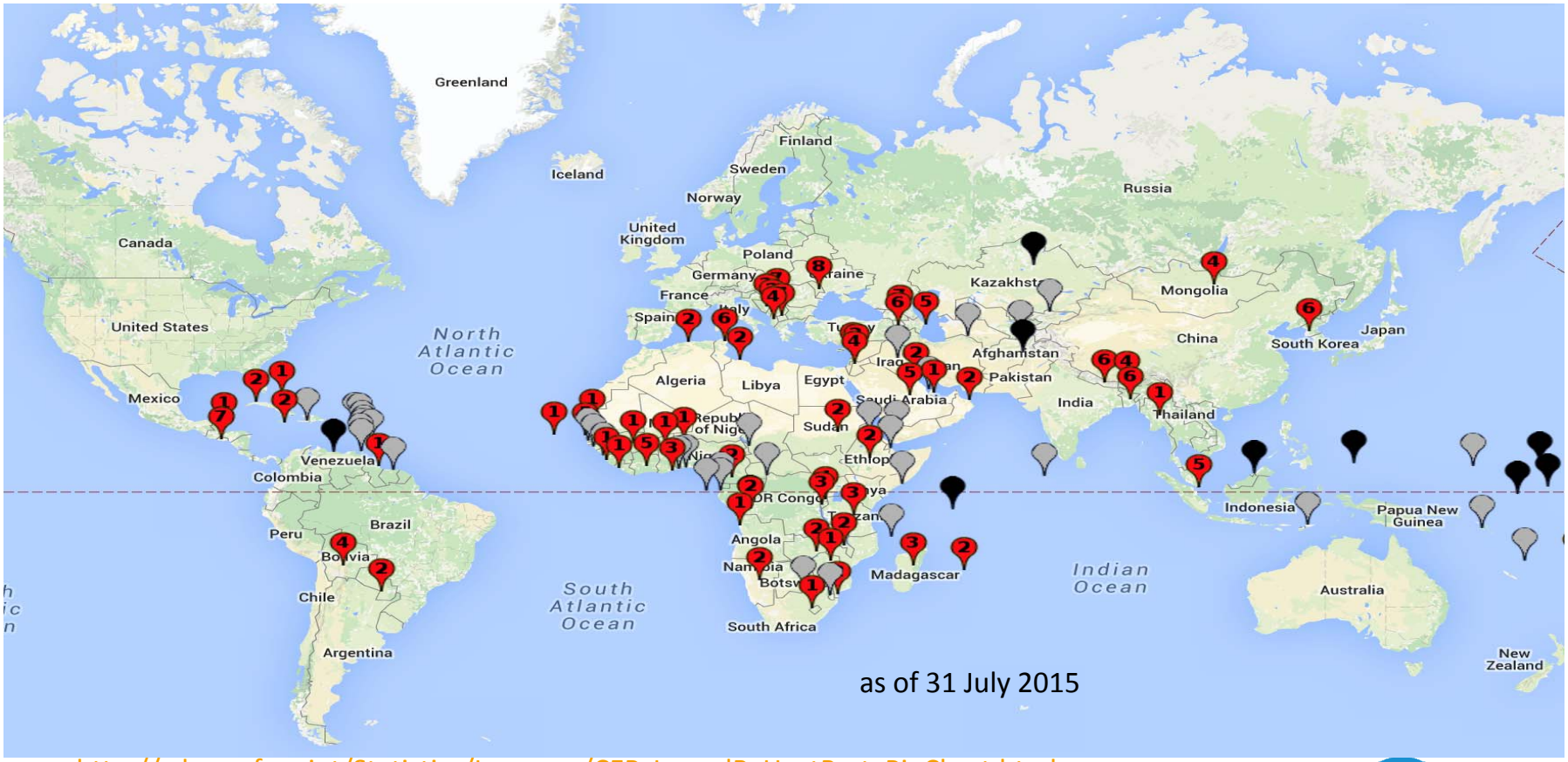
The Kyoto Protocol

- Puts obligation on developed (Annex 1) countries to reduce current GHG emissions as they are historically responsible for current levels of GHGs in atmosphere.
- GHG emission reduction targets (from 1990) levels are listed in Annex B.
- Non-Annex 1 (developing) countries should submit National Appropriate Mitigation Actions (NAMAs).
- Virtually all non-Annex I countries have established a “designated national authority” to manage their Kyoto obligations:
  - specifically the ‘CDM process’ that determines which GHG projects they wish to propose for accreditation by the Clean Development Mechanism (CDM) Executive Board.
- 33 countries have so far submitted INDCs to COP21.
  - The EC submitted an INDC to COP21 stating their intention to reduce emissions by 40% by 2030.

What is a CDM Project?

- A project qualifying for Certified Emission Reductions (CERs or carbon credits) issued by the Clean Development Mechanism (CDM) Executive Board.
- Emission reductions achieved by CDM projects are verified by a DOE (Designated Operational Entity) under rules of the Kyoto Protocol.

Distribution of CDM projects



http://cdm.unfccc.int/Statistics/Issuance/CERsIssuedByHostPartyPieChart.html

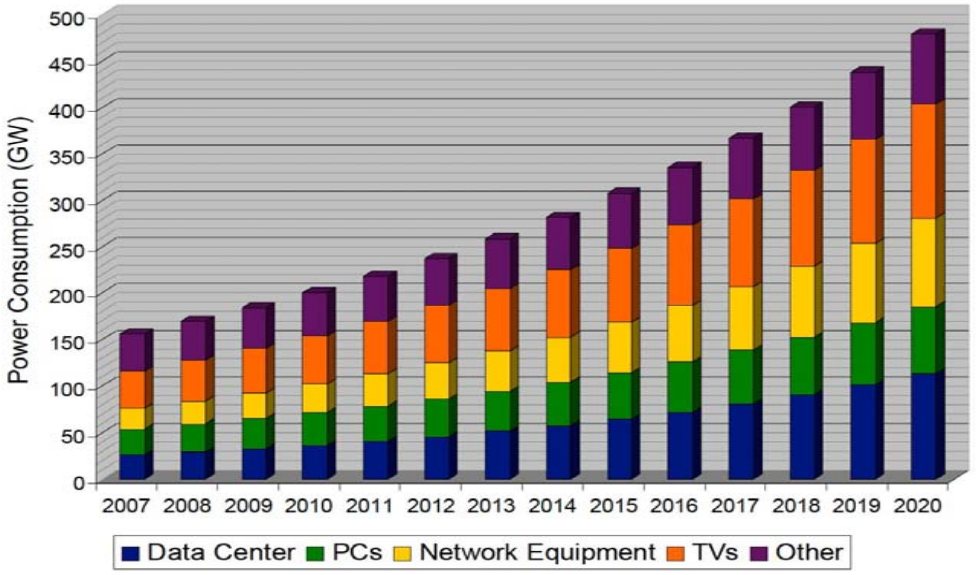
Interim Summary

- Climate change is happening as a result of human activities and will have an impact on all our lives.
  - There may be irreversible changes to the global climate.
- The Kyoto Protocol (and successors) was set up to try to limit GHG emissions.
  - Instruments include emission reduction targets, NAMAs, INDCs and CERs.
- COP21 in Paris in December 2015 achieved first agreement to commit *all* countries to cut GHG emissions.

Next:
The positive and negative effects of ICT on climate change

The downside – Energy footprint of ICT

- The energy footprint of ICT is still growing due to wider use of ICTs in a range of economic sectors, even if the energy consumption of individual devices is reducing.
- Large installations of ICT for the implementation of e.g. Smart Grids and e-services will further increase emissions.



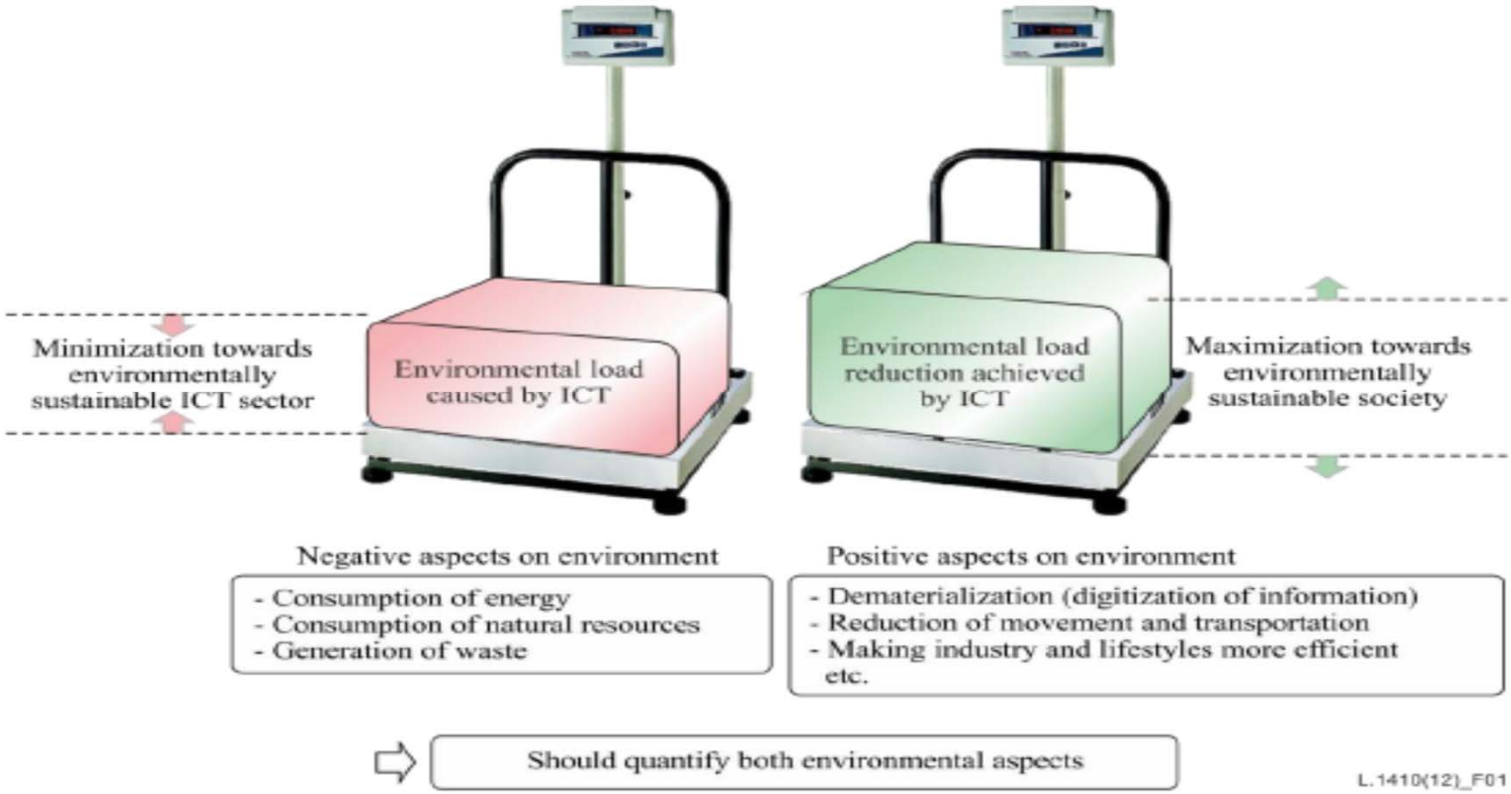
According to Gartner in 2007 the global (ICT) industry accounted for approximately 2% of global carbon dioxide (CO2) emissions energy footprint of ICTs.

The Upside:

- ICTs for Mitigation
  - ICTs improve the energy efficiency in the telecommunications, transportation, construction, and services industries.
  - It is possible to reduce the emissions of CO_2 in a substantial way through ICTs, and make our economic system more sustainable

Source: Sala s. (2010)

Assessing the positive and Negative impacts of ICT

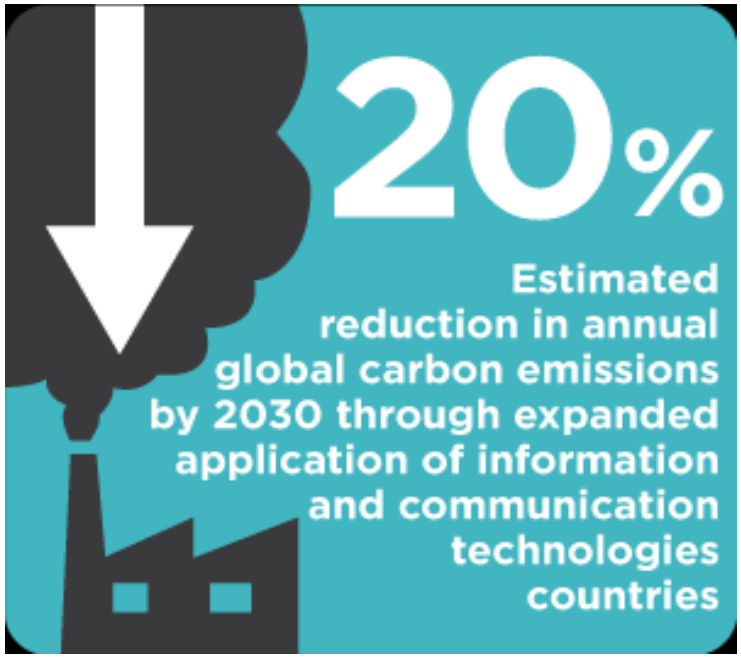


Source: ITU-T(2014,pp vii) https://www.itu.int/rec/T-REC-L.1410-201412-I/en

ICTs @ COP 21 (Paris, 2015)

GeSI(2015)

- ICT emissions are expected to decrease to 1.97% of the global total by 2030, from 2.3% in 2020
- ICTs—including the Internet, mobile phones, geographic information systems (GIS), satellite imaging, remote sensing, and data analytics—could reduce yearly global emissions of carbon dioxide (CO_2) **20% by 2030**, thus holding them at their 2015 level.
- ICTs are also critical for climate change adaptation, providing vital tools for all phases of the disaster risk management cycle.



http://www.worldbank.org/en/topic/ict/brief/connections-note-30

Effects of ICTs in Climate Change

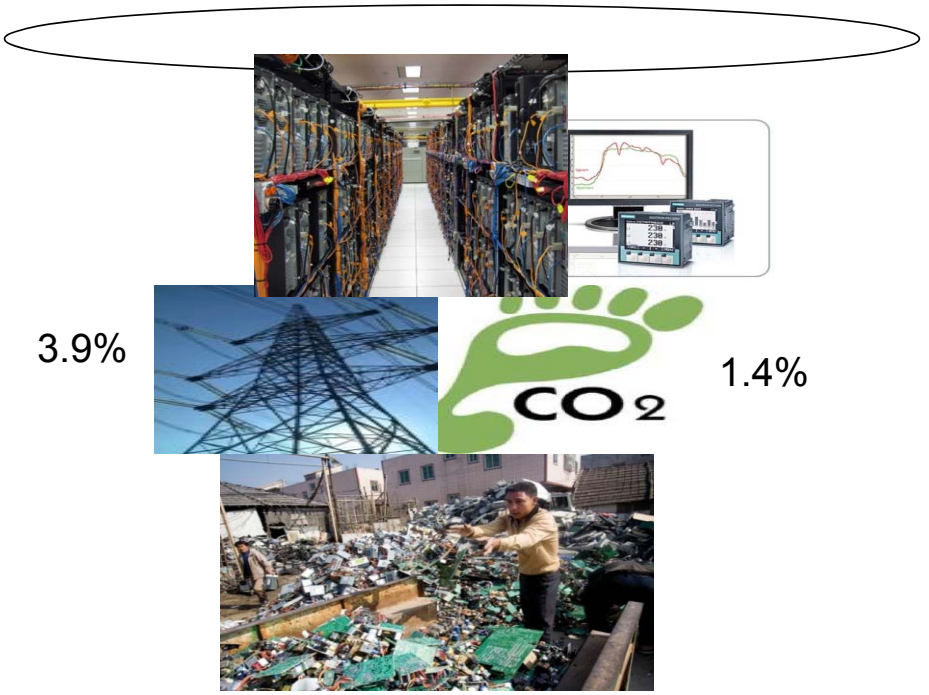
- The role of ICT in climate change can be grouped into three levels of impacts:

1st Order effects	"the impacts created by the physical existence of ICTs and the processes involved, e.g., energy consumption and GHG emissions, e-waste, use of hazardous substances and use of scarce, non-renewable resources. "
2nd Order effects	"the impacts and opportunities created by the use and application of ICTs. This includes environmental load reduction effects which can be either actual or potential, such as travel substitution, transportation optimization, working environment changes, use of environmental control systems, use of e-business, e-government, etc.
Rebound effects	"the impacts and opportunities created by the aggregated effects on societal structural changes by using ICTs; particularly for some ICT services such as teleworking or videoconferencing, the time gained by an end user using an ICT service which then may cause additional impact e.g., a leisurely drive and economic activities, which are difficult to track. ".

Source: ITU-T(2014, pp vi-Viii) https://www.itu.int/rec/T-REC-L.1410-201412-I/en

First order effects of ICTs on GHG emissions

- First order effects include carbon emissions during manufacturing and the disposal of hardware
  - Transportation
  - Factory power (e.g. buildings and furnace heating)
  - Embodied emission from raw materials
- Indirect emissions
  - Emissions from power stations used to run the ICTs



Source: Module developer

ITU's Green Standards Addressing First Order Effects #1

- Reduction of energy consumption by ICT equipment through new standards;
  - E.g. The promotion of Next Generation Networks (reducing power consumption by up to 40%)
  - Better use of spectrum to reduce energy consumption wireless devices – analogue to digital
- Example: Standards for universal power adapter and charger for mobile and stationary ICT devices
  - Saves 382,000 tons of e-waste per year
  - Saves at least 13.6 MtCO2 emissions annually
  - Reduces the energy consumption and GHG emissions of external power supplies by between 25% and 50%

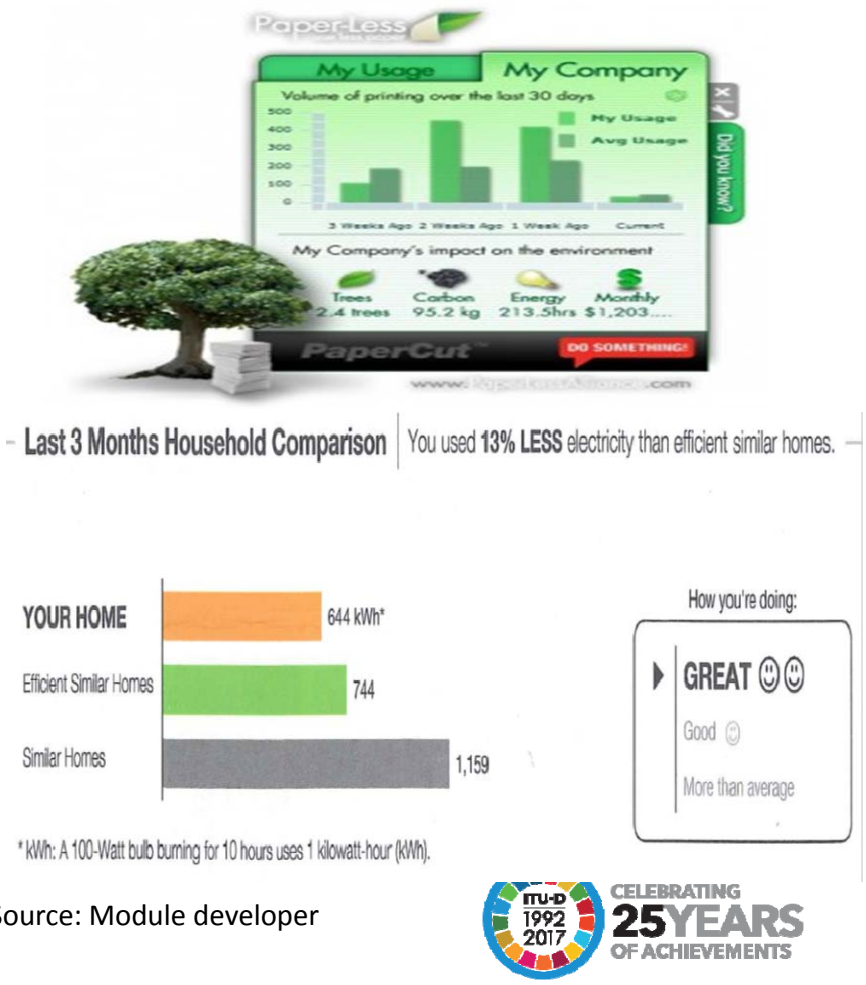
1W saved on 1 billion routers in user premises is equivalent to 1GW not being needed

ITU's Green Standards Addressing First Order Effects #2

- Common set of methodologies for the assessment of ICT carbon footprint
- Without, it will be impossible to provide meaningful comparisons
- Helps to establish the business case to green ICT
- Scope includes: goods, networks, services, organizations, projects, cities and countries
- Developed in cooperation with UNFCCC
- More at https://www.itu.int/rec/T-REC-L.1410-201412-I/en

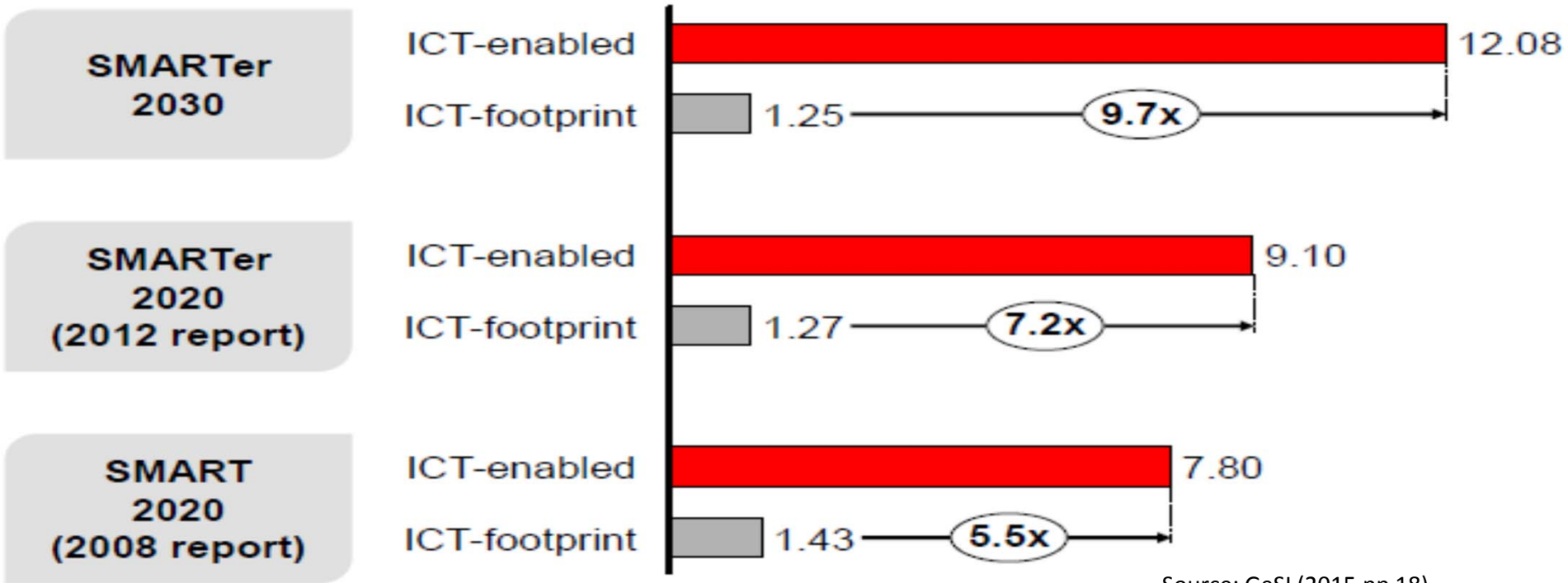
Second order effects of ICTs in Climate Change

- The second-order effect refers to the positive impact of using ICT on business processes.
- Most of the benefits of ICTs lie in the second order effects via increased efficiency, transparency, speed of transactions, rapid market-clearing, long-tail effects and so on.
- By 2030, ICTs could eliminate the equivalent of 12.1 billion tons of CO_2 per year in five sectors—transport (30% of the total reduction), manufacturing (22%), agriculture and food (17%), buildings (16%), and energy (15%) (GeSI, 2015)



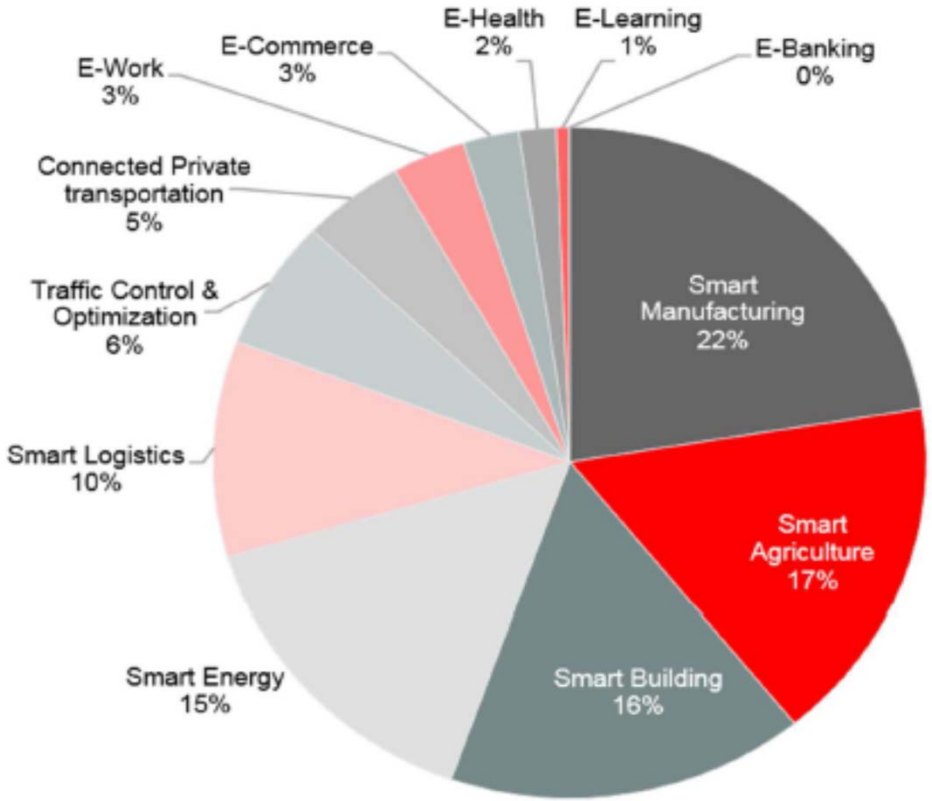
Source: Module developer

2nd order effects: ICTs Benefit Factor 2020 vs 2030 (Gt Co_2e)



Source: GeSI (2015,pp 18)

ICT CO_2e abatement potential (2030) across sectors



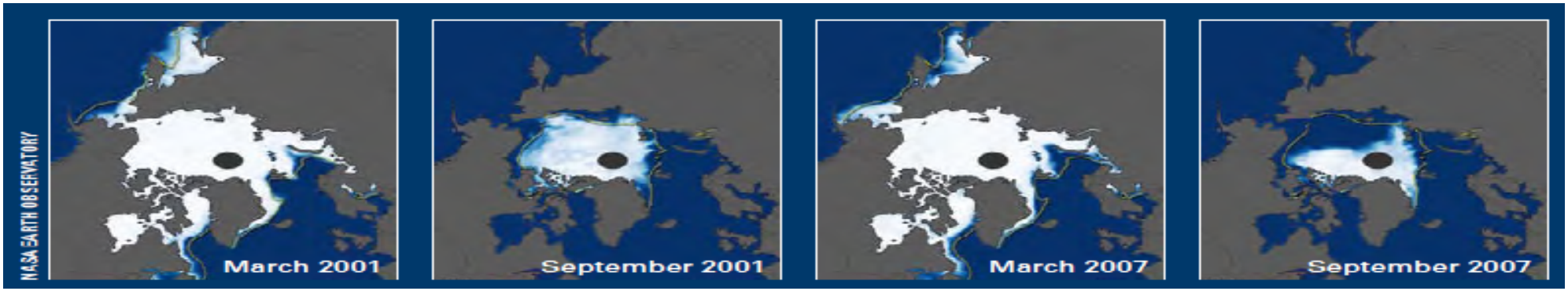
Interim Summary

- ICTs have a significant role in climate change mitigation and adaptation strategies.
- ICT production, use and disposal is one of the contributors to CO2 emissions which needs to be mitigated
  - *We will investigate mitigation can be achieved in session 5*
- ICTs can also be used to mitigate CO2 emissions in other sectors.
  - *We will investigate other important roles of ICT : environmental monitoring and adaptation to climate change*

Next:

The Role of ICTs in Monitoring the Environment

Example: Monitoring the coverage of Arctic Sea Ice



Source: http://earthobservatory.nasa.gov/Features/WorldOfChange/sea_ice.php

Why Monitor the Environment?

- We can forecast weather-related events and make long-term predictions regarding climate patterns
- In the event of a disaster, we can detect, track and enhance the recovery efforts
  - Minimizing the impact on human livelihood and economy
- to identify potential threats to:
  - Transportation networks, Water supply, Electricity and Telecommunications services, Construction activities, Agriculture, Tourism industries
- It allows us to identify suitable areas for development
  - e.g. housing and agriculture

Climate Variables

Domain	Essential Climate Variables (ECVs)
Atmospheric (over land, sea and ice)	Precipitation, upper-air temperature, Wind speed and direction (surface and upper-air), water vapour, cloud properties, Earth radiation budget (including solar irradiance), carbon dioxide, methane, and other long-lived greenhouse gases,[1] ozone and aerosol properties, supported by their precursors[2]
Oceanic	Sea surface temperature, ocean salinity, sea level, sea state, sea ice, ocean colour
Terrestrial	Lakes, snow cover, glaciers and ice caps, ice sheets, albedo, land cover (including vegetation type), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Leaf Area Index (LAI), biomass, fire disturbance, soil moisture

1 Including the six greenhouse gases: N_20, CFCs, HCFCs, HFCs, SF_6 and PFCs.
2 In particular N_20, SO_2, HCHO (formaldehyde) and CO.

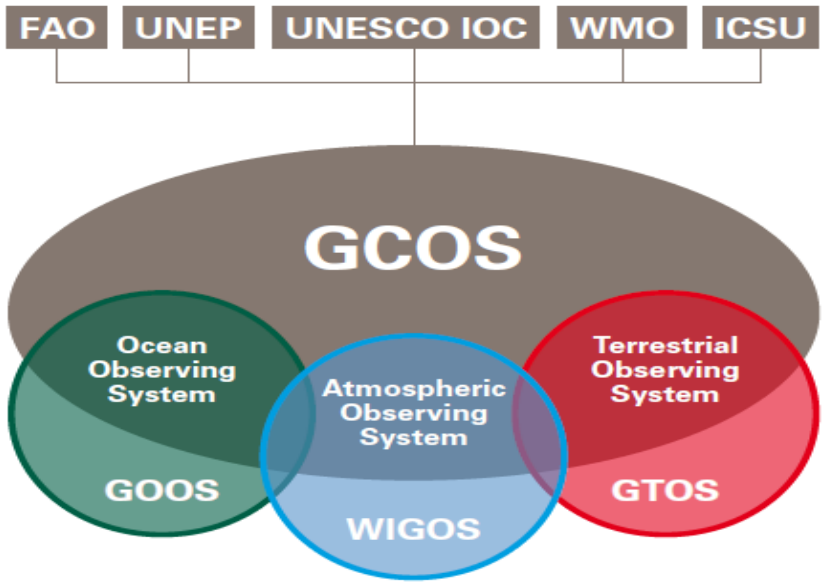
Source: http://www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf

Organisations concerned with environmental monitoring

- World Meteorological Organization (WMO)
- Food and Agriculture Organization of the United Nations (FAO)
- United Nations Educational, Scientific and Cultural Organization Intergovernmental Oceanographic Commission (UNESCO IOC)
- United Nations Environment Programme (UNEP),
- International Council for Science (ICSU)

Observing Systems

- Global Climate Observing System (GCOS)
- Global Ocean Observing System (GOOS)
- Global Terrestrial Observing System (GTOS)
- WMO Integrated Global Observing System (WIGOS)

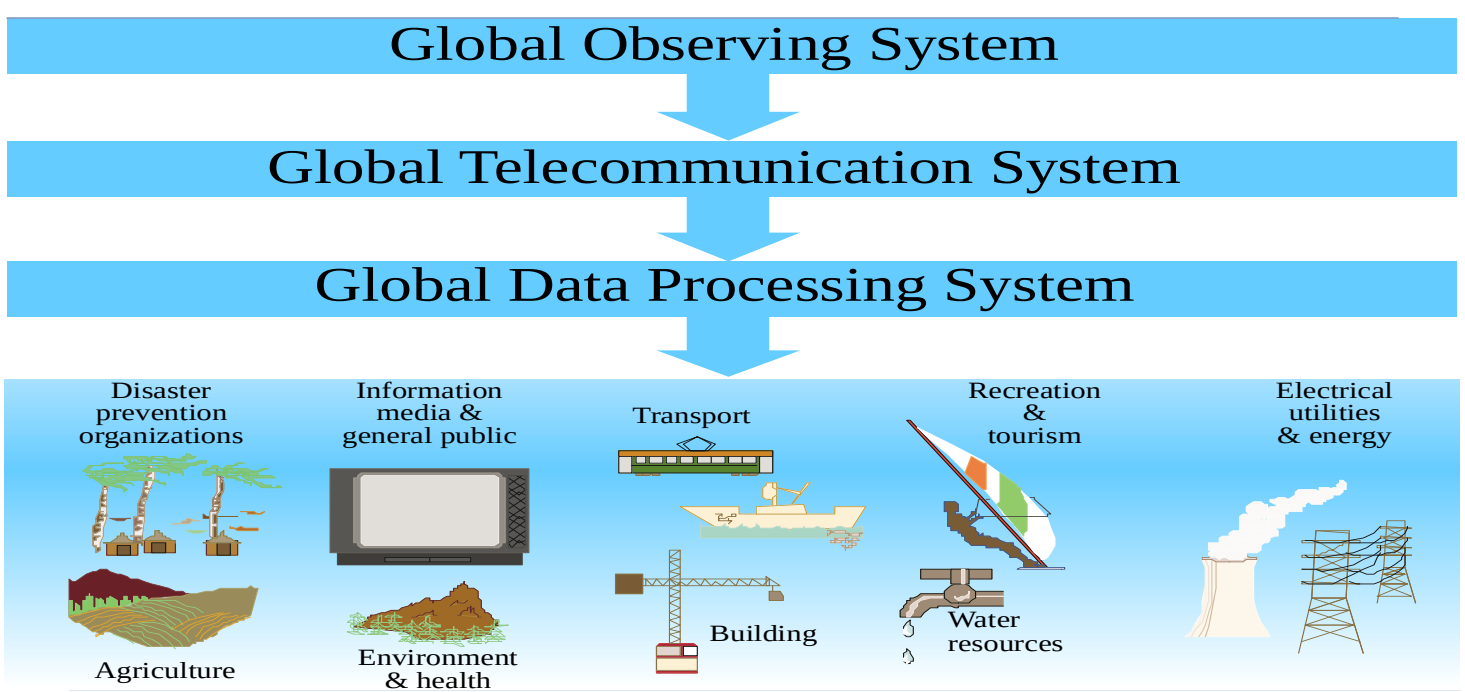


Source: Space and Climate Change, Use of Space-based Technologies in the United Nations System, UNOOSA

World Weather Watch

FIGURE 1-1

World Weather Watch systems

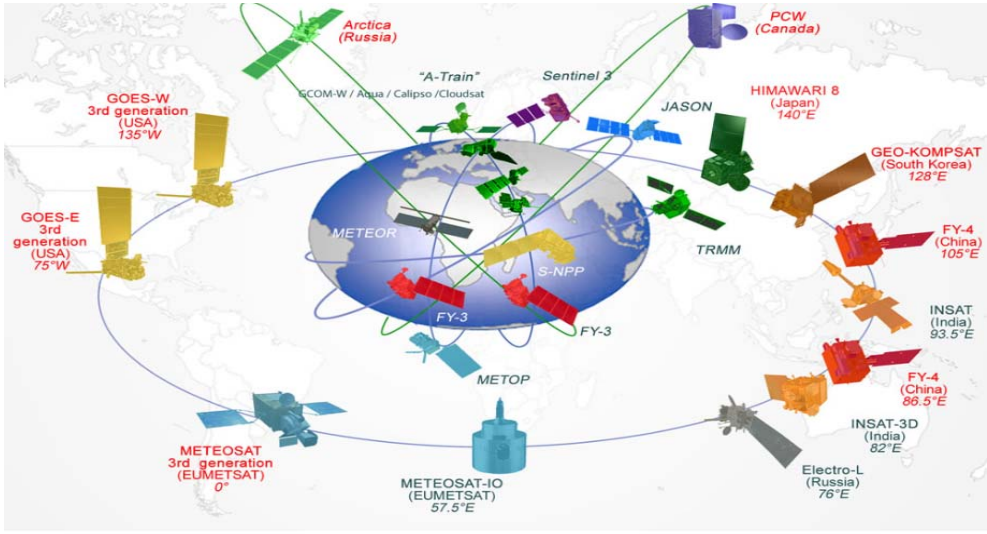


Meteo-01-1

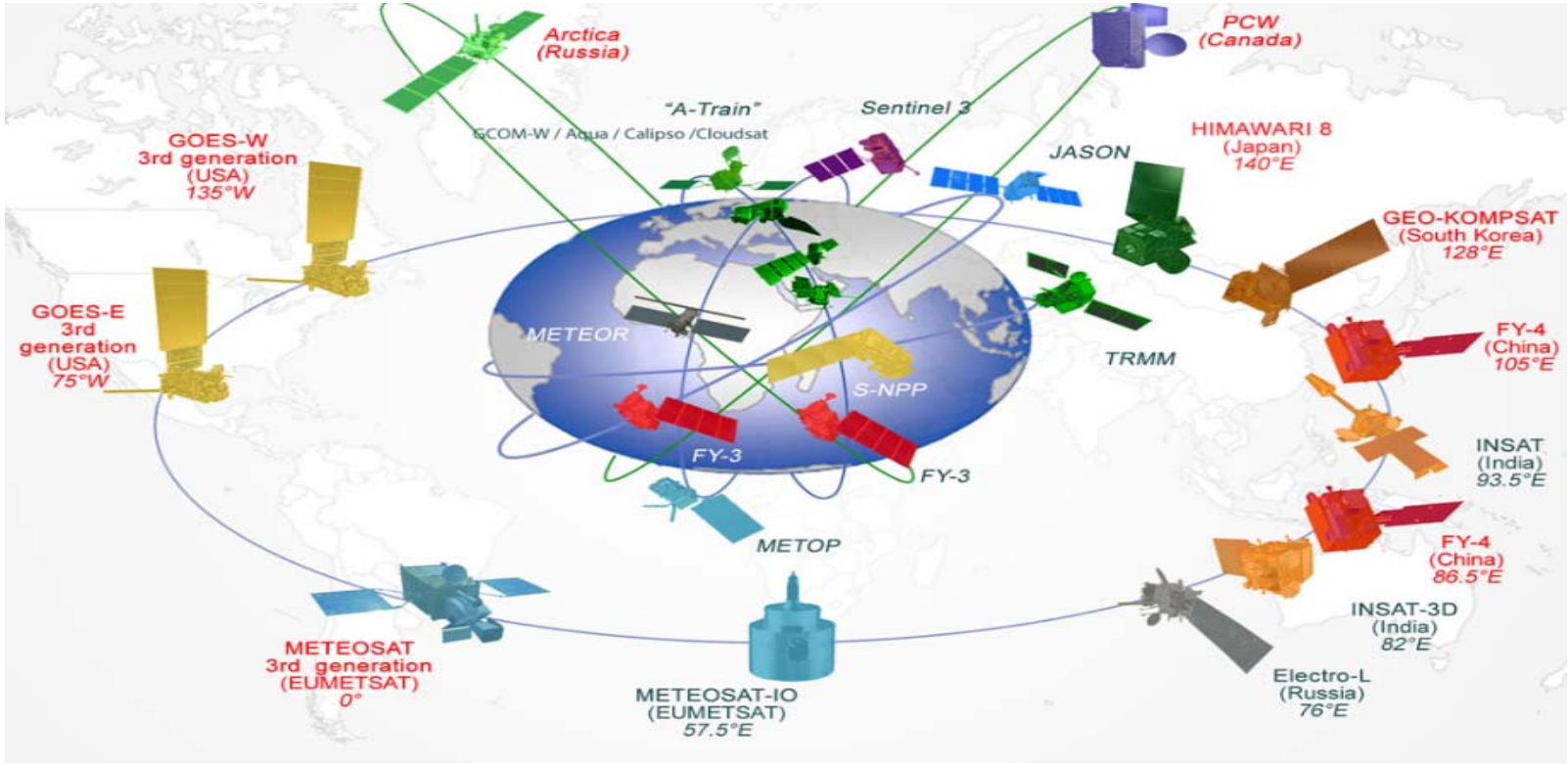
Source: http://www.wmo.int/pages/prog/www/OSY/GOS.html

Spacecraft

- Satellites provide a platform for environmental monitoring sensors.
  - Including communication equipment (transponder and antennas), power supply, propulsion system, etc.
- Satellites operate in a variety of orbits depending on the function (e.g. communication, imaging, weather)
  - Low-Earth orbit (LEO): 160km to 2000km
  - Medium-Earth orbit (MEO): 2000km to 35700km
  - Geostationary orbit (GEO): 35700km
  - Elliptical orbit



Different Satellite Orbits

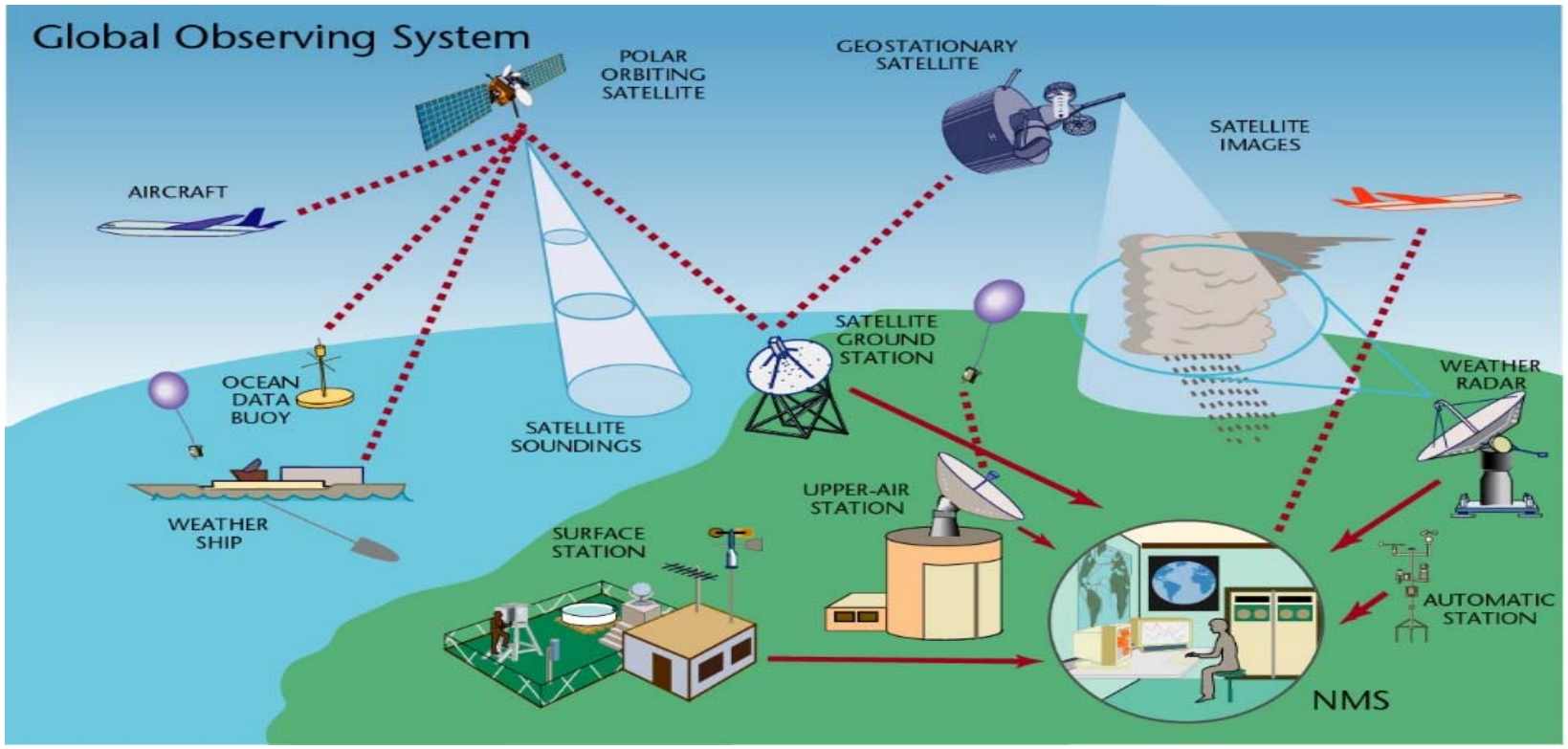


Source: http://www.wmo.int/pages/prog/www/OSY/GOS.html

Geostationary Orbit

- Many satellites used for Earth observation purposes use GEO orbits because of the larger footprint (view of the earth). These orbits are circular, in the equatorial plane and the period of revolution is equal to the Earth's period of rotation.
- About 1/3 of the Earth is visible from GEO orbit, but high latitudes are not covered.
- Larger distance from the Earth implies greater launch cost.
- High-gain antennas are required because of greater signal path loss.
- Therefore, Earth-monitoring satellite systems generally employ a combination of satellites in both GEO and LEO/MEO polar orbits

Global Observing System Components



Source: http://www.wmo.int/pages/prog/www/OSY/GOS.html

Interim Summary

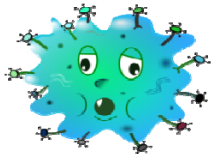
- The GOS comprises an integrated measurement and communication network which acquires, stores, relays and processes data regarding these variables.
- Maintaining a reliable radiocommunication network is important to enabling us to measure, relay, and analyse these sets of data

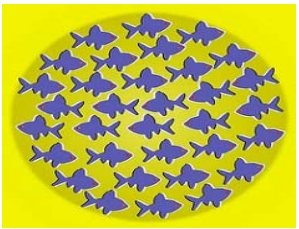
Next

Climate Change Adaptation Using ICTs

ICTs can help other sectors adapt to climate change effects

- Examples
  - Energy sector: control of wind turbines during periods of excessive wind
  - Transport sector: warnings of excessive heat, wind, rainfall affecting transport safety
  - Health sector: gathering information on spread of diseases (Google can now track these by requests for information on a topic)
  - Environmental Protection: tracking species migration (northward migration of fish stocks)





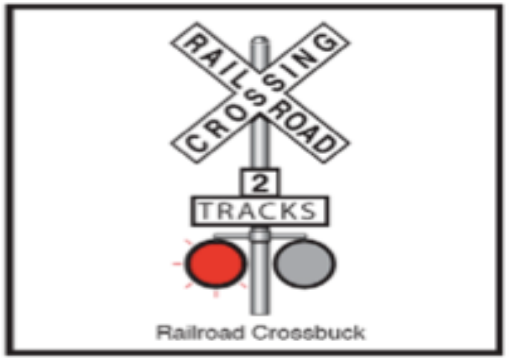
Business Dependencies on ICT

- Customer transactions (including electronic banking)
- Staff to staff communication (email, phone call, video-conferencing)
- Financial management
- E-commerce
- Ticketing and billing systems
- Customer/passenger information systems
- Healthcare provision
- ATMs ('Hole-in-wall', banking)
- Emergency Services

See notes for source

Control System Dependencies on ICT

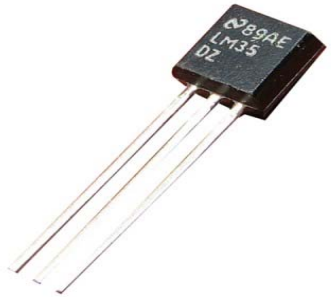
- Traffic Signalling
- Traffic Management
- Navigation (water borne, satellite and land-based)
- Vehicles – road and rail
- Aircraft and Marine Vessels
- Rail Signalling
- Air Traffic Management
- Supply-chain Management
- Logistics (goods despatch and delivery)
- Real-time delivery management and reporting
- Supervisory control and data acquisition (SCADA)
- Remote management of pumps and switches in network
- Water distribution
- Energy generation and distribution (especially nuclear and “smart grid“)



See notes for source

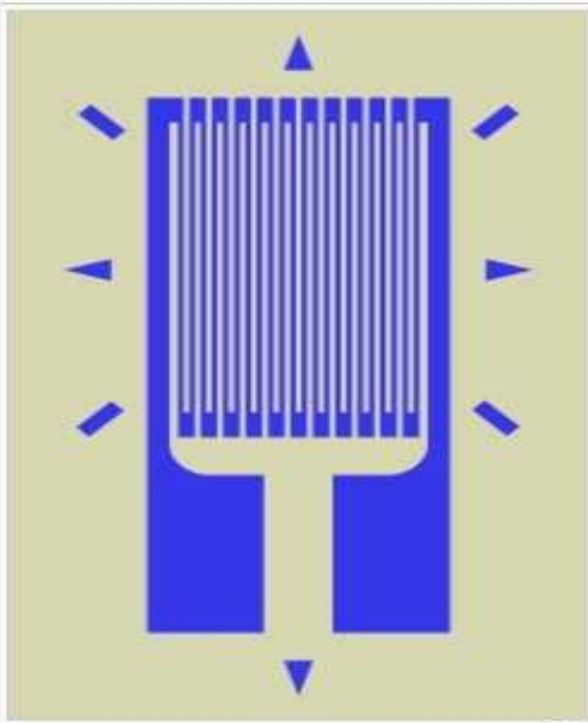
Sensor Layer Network

- A sensor layer network already exists to a large extent in control networks for industrial processes
- Example:
  - structural monitoring of bridges using strain gauges provides early warning of problems
  - sensor layer networks also serve the food production and water sectors



Sensor Layer Network

- A strain gauge, typically glued onto a sample of material to measure its deformation.
- The blue material is a conductor, so current must flow through the narrow vertical channels.
- If the gauge is stretched vertically, the channels get longer and narrower.
- This increases the gauge's electrical resistance, which can be measured to work out the strain.



Typical foil strain gauge. The gauge is far more sensitive to strain in the vertical direction than in the horizontal direction. The markings outside the active area help to align the gauge during installation.

https://en.wikipedia.org/wiki/Strain_gauge

Smart Water Management Objectives

- The OECD report 'Water Security for Better Lives'*, suggests that achieving water security objectives means maintaining acceptable levels for four water risks:
  - risk of shortage (including droughts)
  - risk of inadequate quality
  - risk of excess (including floods) and
  - risk of undermining the resilience of freshwater systems (e.g. by exceeding the capacity of the surface and groundwater drainage systems).

See notes for source

Smart Water Management Tools

- (SWM) tools can be categorized in the six main areas
  - Data acquisition and Integration (e.g. sensor networks, smart pipes, smart meters).
  - Data Dissemination (e.g. radio transmitters, WiFi, Internet).
  - Modelling and Analytics (e.g. Graphical Information Systems).
  - Data processing and Storage (e.g. Cloud computing)
  - Management and Control (e.g. SCADA, Supervisory Control and Data Management)
  - Visualization and Decision Support (e.g. Web-based communication and Information systems tools)

Source: FG-SSC "Smart Water Management in Cities", Page 20
http://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx

Smart Water Management #1/2

- Raw (untreated) water service
  - Diversion of raw water is necessary to facilitate treatment and distribution to a city's population. In some cities, retail water price includes water diversion project costs
- Water supply services
  - Provision of safe treated water to various sectors within the urban environment, including the residential, commercial, and industrial sectors
- Drainage services
  - Provision of urban drainage through pipe networks is important to safeguard public health and prevent flooding

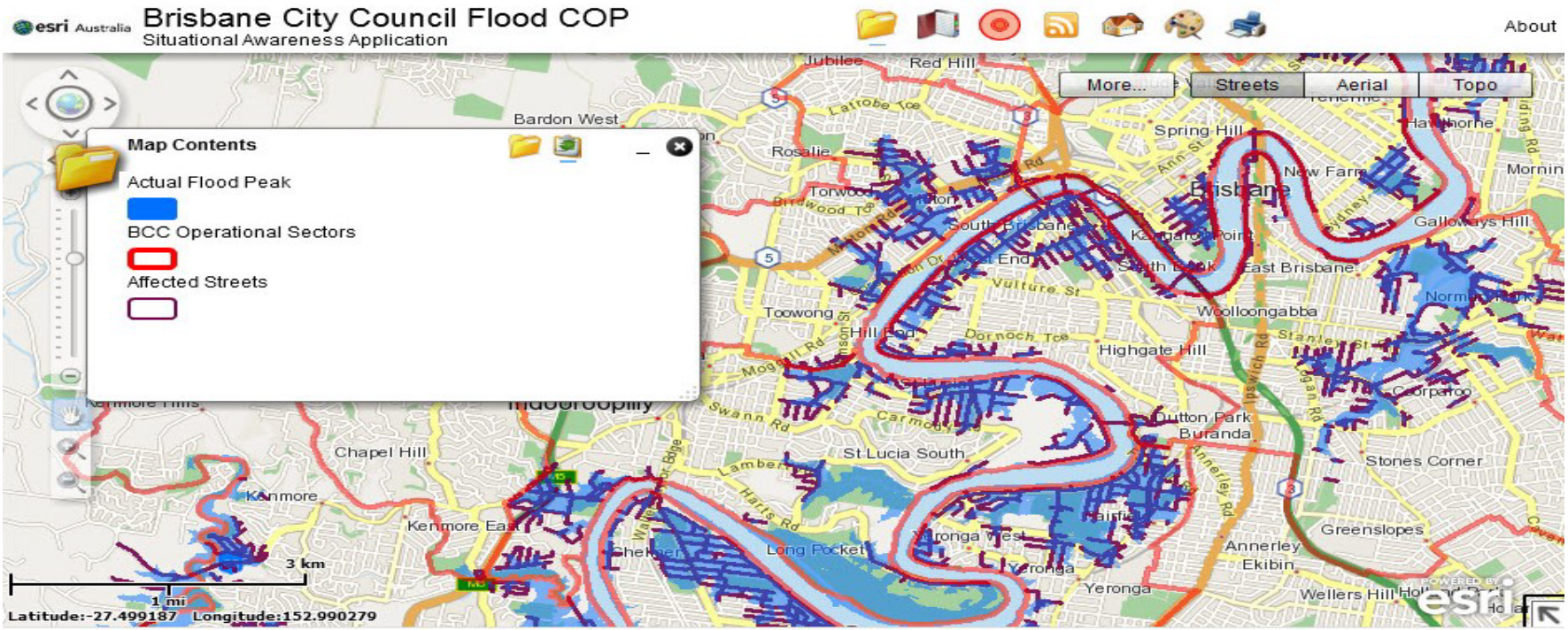
See notes for source

Smart Water Management #2/2

- Wastewater treatment services
  - Provision of wastewater treatment for commercial/marketed services is necessary to ensure environmental protection.
- Reclaimed water service
  - Usually offered by the vast majority of sewage treatment companies as a value-added business to industrial customers/users such as power plants
- Other water supply services
  - The seawater desalination market is in transition from Engineering, Procurement and Construction (EPC) equipment provision to integral investment and operational service.

See notes for source

Smart Water Management Example



- This example provides citizens with an indication of flood risk
  - locations for remedial work or new building avoidance can identified

See notes for source

Conclusion

- Most other sectors depend upon ICT for their operation
  - This is becoming more and more important as new efficiency measures are introduced which depend upon ICT
- It is therefore highly important that the ICT infrastructure is reliable and is adapted to cope with climate change impacts
  - The network must protected against the new extremes weather events brought about by climate change as predicted by the IPCC and regional meteorological offices

References for Further Reading 1

- ITU Technology Watch Report 7: “NGNs and Energy Efficiency”.
- ITU Future Networks Focus Group Report “Overview of Energy-saving of Networks”.
- ITU-T Recommendations: L.1300, L.1310
- The GreenTouch Consortium - www.greentouch.org.

References for Further Reading 2

- IPCC 5th Assessment Report: Climate Change 2014 Synthesis Report Summary for Policymakers www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
- IPCC Climate Change 2014 Mitigation of Climate Change, Summary for Policymakerswww.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf
- ITU-D SG 2 Report Question 24/2 ICT and climate change http://www.itu.int/pub/D-STG-SG02.24-2014
- ITU Reports on ICT & Climate Change including:
  - "Climate Change Adaptation and ICTs: The Case of Ghana".
- National policy documents including UK Climate Change Act 2008.

References for Further Reading 3

- *NASA Earth Observatory*
  http://earthobservatory.nasa.gov/Features/WorldOfChange/sea_ice.php
- Systematic Observation Requirements for Satellite-based Products for Climate, September 2006 GCOS – 107 (WMO/TD No. 1338)
  http://www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf
- *Space and Climate Change - Use of Space-based Technologies in the United Nations System, UNOOSA*
- Global Planning for Operational Geostationary Satellites and Low-Earth Orbiting Satellites
  http://www.wmo.int/pages/prog/sat/globalplanning_en.php
- Evolution of the space-based global observing system, http://www.wmo.int
- Handbook - Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction; Edition 2008; Radiocommunication Bureau; ITU
  http://www.wmo.int/pages/prog/www/OSY/GOS.html

Thank You