“CHALLENGES ASSOCIATED WITH THE USE OF SPACE APPLICATIONS FOR MONITORING AIR POLLUTION RESULTING FROM ENERGY USE, PRODUCTION and GENERATION”

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PRESENTATION OUTLINE

- Introduction
- Energy Production, Generation and Use
- Air Pollution from Energy Sources
  - Sources and components of energy-related air pollution
  - Effects of air/atmospheric pollution
- Space Technology for Monitoring and Management of Air Pollution
  - Challenges of space technology advances in air pollution monitoring
- Conclusions

1.0 INTRODUCTION

The basic needs of any nation to support long life expectancy and sustainable livelihood include:

- unpolluted air and water
- food
- wholesome environment
- education
- shelter
- health
- energy.

Among these needs

- Energy is unique and fundamental to the speedy realisation of the other basic needs, it drives the world economy and sustainable development.
- Globalisation and industrialization are also major drivers of the ever-increasing need for energy
- Yet the production, generation and use of energy can jeopardize the safety of the environment, including human living condition and health, if not duly monitored and put into sustainable exploitation

INTRODUCTION contd.

Implications of unregulated energy production, generation and use include the following

- Varied health problems, including
  - lungs diseases and cancer
- Environmental (including air) pollutions, issues of global concern, include:
  - ozone layer depletion, global warming and climate change phenomena with associated disasters such as floods, hurricanes, drought, etc.
  - oil spillage and environmental degradation (including floral and fauna)
  - acid rain and agricultural soil and water pollution
  - industrial and technological disasters with effects on lifes and properties e.g. Chernobyl nuclear disaster in former USSR

Challenges of monitoring/management of these problems are enormous and include in-situ measurements and use of space technology:

2.0 ENERGY PRODUCTION, GENERATION AND USE

- Energy sources can be classified into two categories:

  (i) renewable energy sources: that produces energy without depleting resources e.g. solar, wind, water, earth, biomass, waste.

  (ii) non-renewable sources: e.g. fossil fuel from oil and gas, coal, geo-thermal

- Energy production in developing countries such as China, India, South Korea and Brazil is increasing due to large-scale industrialization and socio-economic growth.
  - current energy production is from coal and oil, which has impacted negatively on the human environment and health as a result of pollution of air, water, soil, flora and fauna

  .
- In Africa, including Nigeria, most energy production and generation is from hydropower, biomass, coal, oil and gas. Africa is endowed with huge confirmed reserves, with petroleum put at 120 years of supplies.
  - However, only a few countries can boast of un-interrupted energy supply to support provision of basic needs, small and medium scale enterprises, industrial growth and development, due to poverty to develop the energy potentials in some countries and misplaced priorities and waste in others.

ENERGY PRODUCTION, GENERATION and USE contd

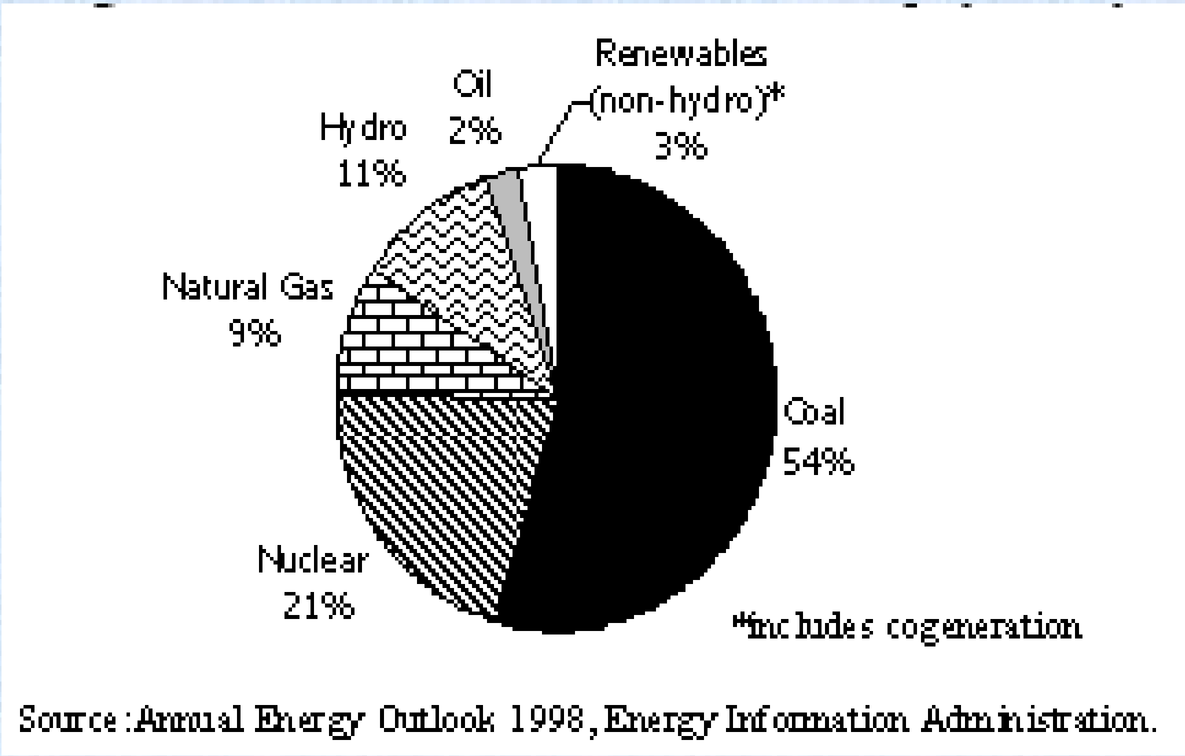
- Energy Generation involves the development of infrastructure such as power plants (hydro, thermal, nuclear and solar), refineries and generators.

- The generation of energy is capital intensive, constituting a hindrance to the development of the huge energy reserves in Africa. A typical thermal station in Lagos is shown below

- Population increase should keep pace with energy generation and use to meet the demand and supply and the needs for rapid growth in the small/medium scale enterprises sector of the economy, industrialization, poverty reduction and sustainable socio-economic development.

A Typical Thermal Power Station in Lagos, Nigeria
Source: Lahmeyer International, 2004. http://www.lahmeyer.de/projects/ge/nigeria_e.pdf

In the US, sources of energy generation are illustrated in the pie-chart below



Source: http://www.ucsusa.org/clean_energy/renewable_energy_basics/public-benefits-of- renewable-energy-use.html

3.0 AIR POLLUTION FROM ENERGY SOURCES

Sources of Energy-related Air Pollution

- Gas flaring
- Burning of fossil fuels/refined petroleum such as kerosene, gasoline, diesel; e.g. exhausts from motor-/auto- vehicles
- Energy generating plants such as thermal stations, refineries
- Exhausts from Industrial/Technological Plants; e.g. the Chernobyl nuclear disaster in former USSR
- Domestic use of coals and biomass
- Forest fire and Bush burning
- Burning of industrial and domestic wastes
- Fumes from dump site decay
- Pipeline and oil facilities vandalization resulting in fire outbreaks
- Contribution from nature such as gaseous emissions from volcanic eruptions e.g. the Pinatubo volcano in Philippines.
- Pollution of soil, water, floral and fauna from acid rain and oil spills (with environmental degradation).
- Air pollution (smoke plumes) associated with rocket and satellite launching
- {Haze and Dusty weather from North East Trade wind blowing from the Saharan desert during the dry season}

AIR POLLUTION FROM ENERGY SOURCES contd.

- Components of air pollution
  - Sulphur dioxide
  - Carbon monoxide
  - Carbon dioxide
  - Nitrogen oxides
  - Hydrocarbons from unburned fossil fuels
  - Dust particles
  - Soot and smoke
  - Chlorofluorocarbons (CFCs)
- Acid rain falls on about 30% of China's total land area
- Industrial boilers and furnaces consume almost half of China's coal and are the largest single point sources of urban air pollution
- CFCs, carbon and nitrogen emissions form the bulk of greenhouse gases released into the atmosphere from oil exploration and gas flaring; vehicular and industrial exhausts and generators
- Acidic water and soot form acid rain (contains Nitric acid, Sulphuric acid, Carbonic acid, e.t.c

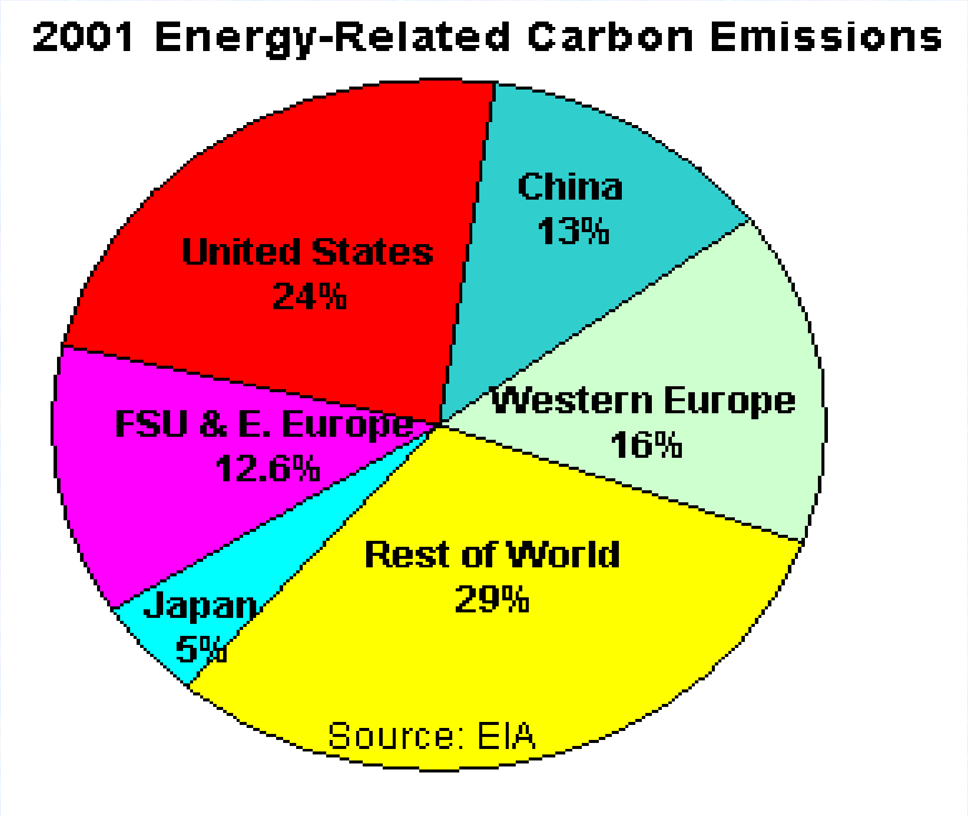
Estimated Air Pollution from a 500MW Coal Plant

- 10,000 tons of sulphur dioxide
- 10,200 tons of nitrogen oxide, equivalent to half a million late-model cars
- 3.7 million tons of carbon dioxide, equivalent to cutting down 100 million trees
- 500 tons of small particles
- 220 tons of hydrocarbons
- 720 tons of carbon monoxide
- 125,000 tons of ash and 193,000 tons of sludge from the smokestack scrubber
- 170 pounds of mercury, 225 pounds of arsenic, 114 pounds of lead, 4 pounds of cadmium, and other toxic heavy metals
- Trace amounts of uranium

Source: Public Benefits of Renewable Energy Use. : http://www.ucsusa.org/clean_energy/renewable_energy_basics/public-benefits-of-renewable-energy-use.html

World's Energy-Related Carbon Emissions in 2001

- Energy- related carbon emissions come mainly from activities of both the developed and developing countries, many of which, are yet to agree to the Kyoto emissions reduction



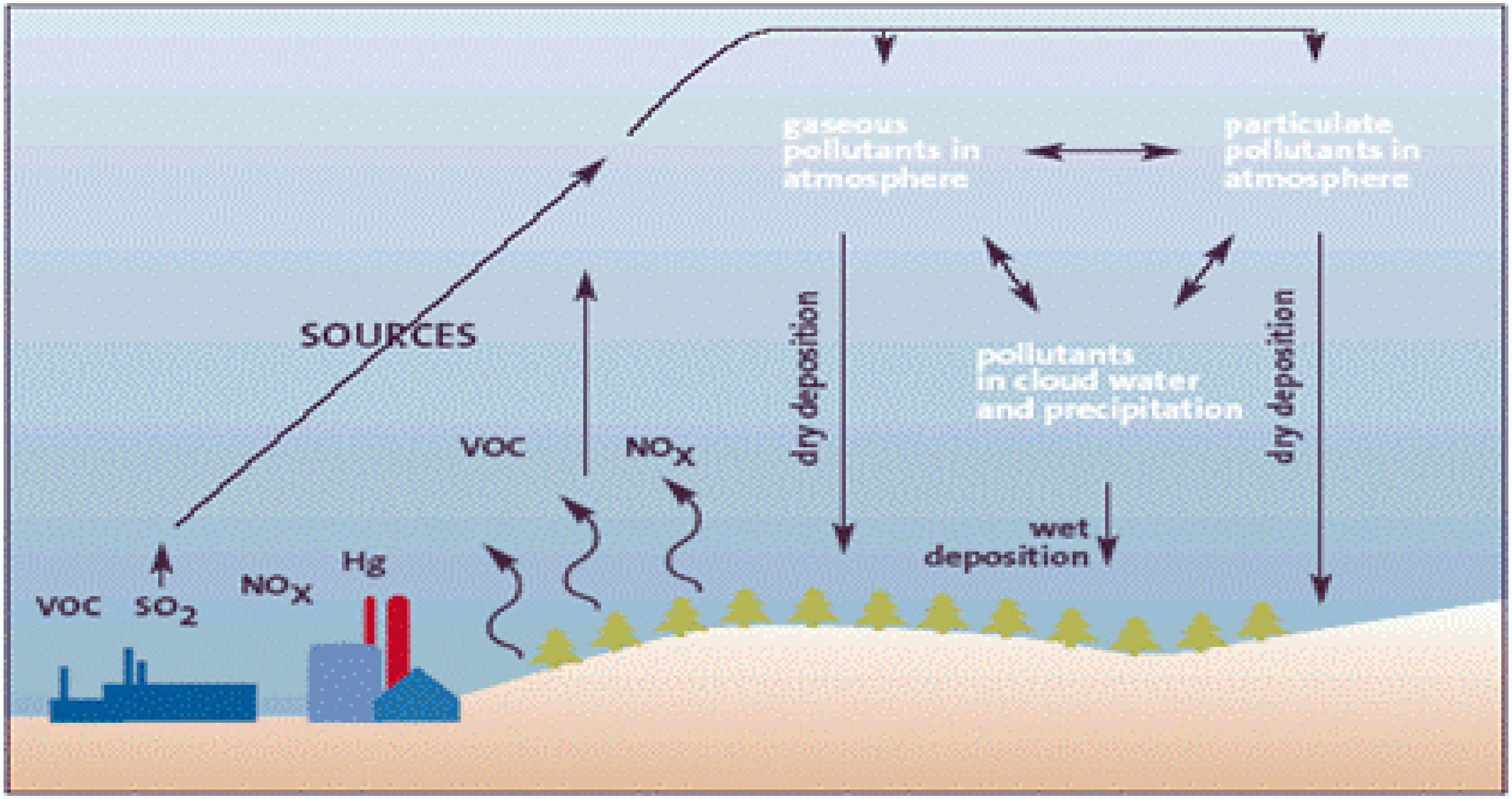
Source: http://www.eia.doe.gov/emeu/cabs/chinaenv.html

In Nigeria major sources of atmospheric pollution are

- Gas flaring from oil and gas exploration (77% of naturally endowed gas is flared),
- Burning of fossil fuel/refined petroleum
- Industrial and domestic plants/generators,
- Fuel woods for domestic use (cooking): major contribution to deforestation and desertification in Nigeria and Africa
- Coal combustion,
- Exhausts from motor-/auto-vehicular, (contribute 36% of air pollution)
- Dust plumes raised by heavy construction works
- (North Easterly winds blowing from the Sahara desert into Nigeria during the dry season).

- **Nigeria's loss to gas flaring is estimated at about $2.5b annually. This contributes about 52% of carbon dioxide emissions in the Niger Delta region of the country and over 250 identified toxins are relelated to gas flaring.**

PHOTO: © Israel Aloja, Environmental Rights Action, March 2004



Formation of Acid rain

Source: Climate Justice 7-Gas flaring poison communities

World Gas flare rankings

TABLE 4.3 "BEST ESTIMATE" OF GAS-FLARING TRENDS IN SELECTED COUNTRIES (2000)

COUNTRY	FLARED GAS	SHARE OF WORLD TOTAL(%)[a]	RATIO GAS FLARED TO OIL PRODUCED (m^3/toe)[b]	
			1990	**2000**
Algeria	6.8	6	79	101
Angola	4.3	4	n/a	118
China	3.2	3	n/a	74
Egypt	0.9	1	37	23
Indonesia	4.5	4	66	66
Iran	10.5	10	70	56
Nigeria	17.2	16	250	166
Mexico	5.6	5	n/a	33
North Sea[c]	2.7	3	18	9
Russia	11.5	11	n/a	77
Venezuela	4.5	4	30	27
United States	2.8	3	10	22
Other countries	33	30	-	-
WORLD[a]	**107.5**	**100**	-	-

Source: Cedigaz, US EIA, OPEC, IEA, World Bank, IHS Energy Group
[a] Shares rounded.
[b] Oil data from BP Statistical Review of World Energy (2001)
[c] North Sea - Denmark, Norway, and the United Kingdom, as Germany and the Netherlands do not flare according to Cedigaz 2000
n/a Not available

Carbon Dioxide Emissions in 1998

Carbon Dioxide (CO_2) Emissions {a} (in thousand metric tons of CO_2)	Nigeria	Sub-Saharan Africa	World
Total Emissions, 1998	78,455	515,001	24,215,376
Percent change since 1990	-12%	10%	8%
Emissions as a percent of global CO_2 production	0.3%	2.1%	
Emissions in 1998 from:			
solid fuels	172	292,852	8,654,368
liquid fuels	25,410	151,843	10,160,272
gaseous fuels	11,325	16,330	4,470,080
gas flaring	40,203	42,110	172,208
cement manufacturing	1,345	11,865	758,448
Per capita CO_2 emissions, 1998			
(thousand metric tons of CO_2)	0.7	0.8	4.1
Percent change since 1990	-28%	-12%	-2%
CO_2 emissions (in metric tons) per million dollars Gross Domestic Product {b}, 1998	2,537	X	773
Percent change since 1990	-29%	X	-10%
Cumulative CO_2 emissions, 1900-1999			
(in billion metric tons)	2,162	16,887	933,686
CO_2 Emissions by Sector, 1999 {c} (in million metric tons of CO_2)			
Public electricity, heat production, and autoproducers	6	X	8,693
Other Energy Industries	6	X	1,205
Manufacturing Industries and Construction	9	X	4,337
Transportation	16	X	5,505
Residential	3	X	1,802
Other Sectors {d}	2	X	5,640
Total Emissions All Sectors:	43	X	27,180
CO_2 Intensity, 1999			
Emissions per total energy consumption			
(metric tons CO_2 per terajoule energy)	11	32	56
Emissions per Gross Domestic Product {e}			
(metric tons of CO_2/million \$PPP)	387 X		582

Source: http://earthtrends.wri.org/pdf_library/country_profiles/cli_cou_566.pdf

Non-carbon dioxide emissions in 1995

	Nigeria	Sub-Saharan Africa	World
Non-CO2 Air Pollution, thousand metric tons			
Sulfur dioxide emissions, 1995	764	5,345	141,875
Nitrogen oxide emissions, 1995	835	9,309	99,271
Carbon monoxide emissions, 1995	21,424	177,268	852,415
Non-methane VOC emissions (f), 1995	3,424	17,375	159,634

Source: http://earthtrends.wri.org/pdf_library/country_profiles/cli_cou_566.pdf

Major sources of air pollution in the US

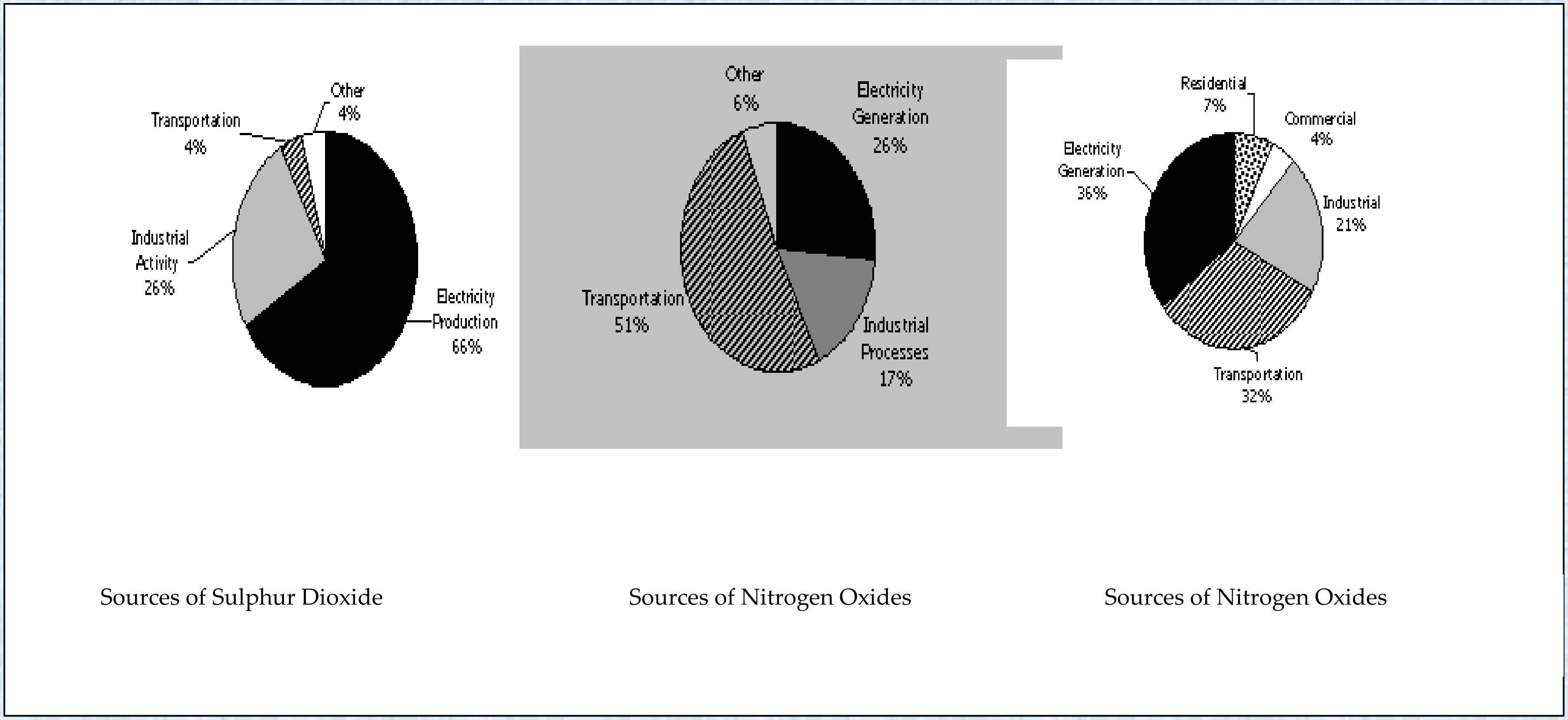
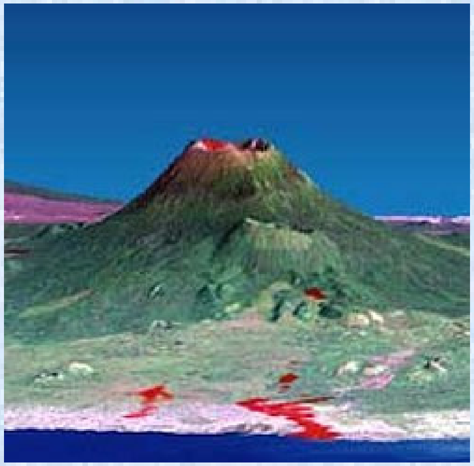
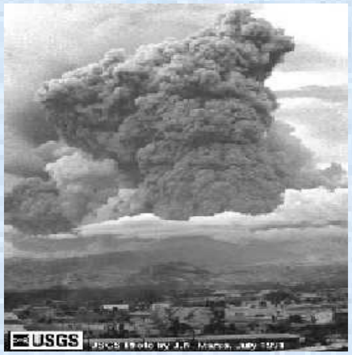


Figure 7: Sources of major air pollution in the United States
Source: EPA National Air Quality and Emissions Trends Report, 1996

AIR POLLUTION FROM ENERGY SOURCES contd.

Nature's contributions and associated disasters





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Goma Volcanic eruption January and July, 2002

1991 Mount Pinatubo volcanic eruption

Natural Disasters:

- **Floods, land-slide etc;**
- **Hurricanes**
- **Earthquake and tsunamis;**
- **Volcanic eruptions**
- **Drought**
- **Forest fires: Exacerbated by major climate change, prolonged dry spells, and traditional practices, e.g. 2001 Indonesia and the Philippines Forest fires**

4.0 SPACE TECHNOLOGY FOR MONITORING AND MANAGEMENT OF AIR POLLUTION

- The advent of Earth observation and meteorological satellites has brought about a great improvement in the monitoring and management of air pollution and air quality assessments

- These satellites carry sensors that are able to monitor pollutants – gases and particulates, in the atmosphere over large areas

  Examples of such satellite systems are:

  - Terra satellites: measure global levels of land surface temperatures, snow cover, atmospheric aerosol levels, cloud properties, methane, vegetation density. These include Moderate Resolution Imaging Spectra-radiometer (MODIS) and Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER)

  - Integrated Computational Assessment of urban air quality via Remote Observation Systems NETwork (ICAROS-NET) measures the concentration of particulate matter in urban air pollution using satellite-borne sensors.

  - NOAA's Advanced Very-High Resolution Radiometer (AVHRR) and ESA's Environmental Satellite, ENVISAT, that carries an array of sensors including Schimachy for ozone layer monitoring and climate change phenomena.

SPACE TECHNOLOGY FOR AIR POLLUTION MONITORING contd.

Space Technology-related International Protocols and Regulations

- ***Remote Sensing Principle X*** provides a basis for the practical implementation of ***GA Resolution A/RES/1721(XVI) of December 20, 1961*** which called for a study on measures to advance the state of atmospheric sciences and technology in order to improve weather forecasting capabilities and to further the study of the basic physical processes that affect climate.

- ***The 1987 Montreal Protocol on ozone destroying pollutants***. Results of research on stratospheric ozone layer conducted under the auspices of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) provided the scientific guidance for formulating this Protocol and its Amendments, as well as ***the 1997 Kyoto Protocol on Climate Change,*** as a result of contributions from **the Upper Atmosphere Research Satellite (UARS), and the array of Total Ozone Mapping Spectrometers (TOMS) aboard Nimbus-7 and Earth probe, Meteor-3 & -3M and ADEOS satellites.**

SPACE TECHNOLOGY FOR AIR POLLUTION MONITORING contd.

UNDERSTANDING PLANET EARTH THROUGH PLANETARY EXPLORATION

- **Planetary exploration has also enriched human understanding of what could befall planet Earth and its life support systems as a result of (i) its abuse and mismanagement by human beings including the non-sustainable exploitation of its natural resources, and (ii) its possible collision with Near Earth Objects (NEO) in the future. Our knowledge of conditions on other planets offers enough lessons and cautions as shown by the following examples:**

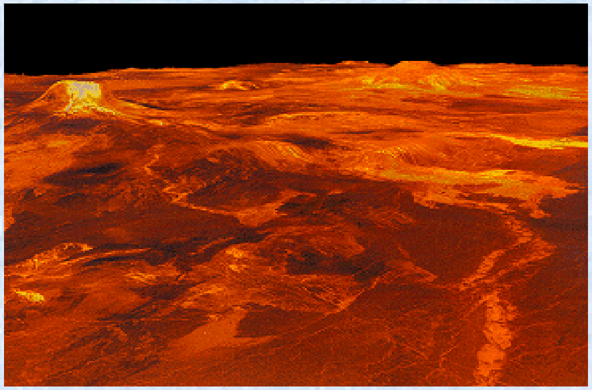
1. **The "runaway" greenhouse effect on Venus, caused by an excess of carbon dioxide in its atmosphere, has led to an understanding of the dangers of carbon dioxide build-up on Earth and the resulting global climate change;**

2. **The antiseptic surface of Mars, clean of any life or organic material because there is no ozone layer to protect it, provides a bleak description of what might happen if Earth's ozone layer were destroyed;**

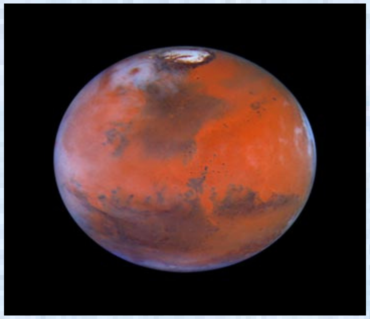
SPACE TECHNOLOGY FOR AIR POLLUTION MONITORING contd.

UNDERSTANDING PLANET EARTH THROUGH PLANETARY EXPLORATION

3. Finding aerosols in the atmosphere of Venus and observing how they interact with the molecules there has led to a better understanding of what happens when aerosols are introduced into Earth's atmosphere;



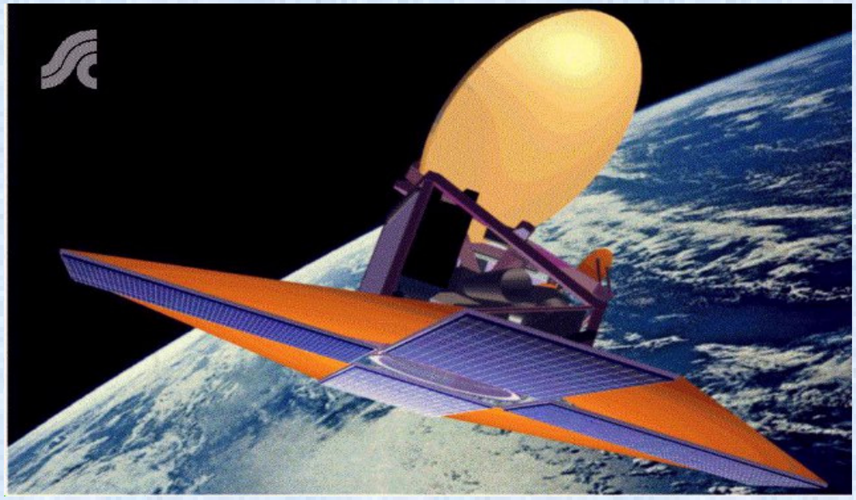
4. Observing and analyzing the dust storms on Mars have provided scientists with models of what happens to a planet's climate if massive amounts of dust are blown into the atmosphere, as would happen on Earth from a volcano, such as the eruption of ashes from Mt. Pinatubo, in the Philippines, in 1991, or from the large impact of an extraterrestrial object such as an asteroid or a comet;



SPACE TECHNOLOGY FOR AIR POLLUTION MONITORING contd.

The oneness of our world

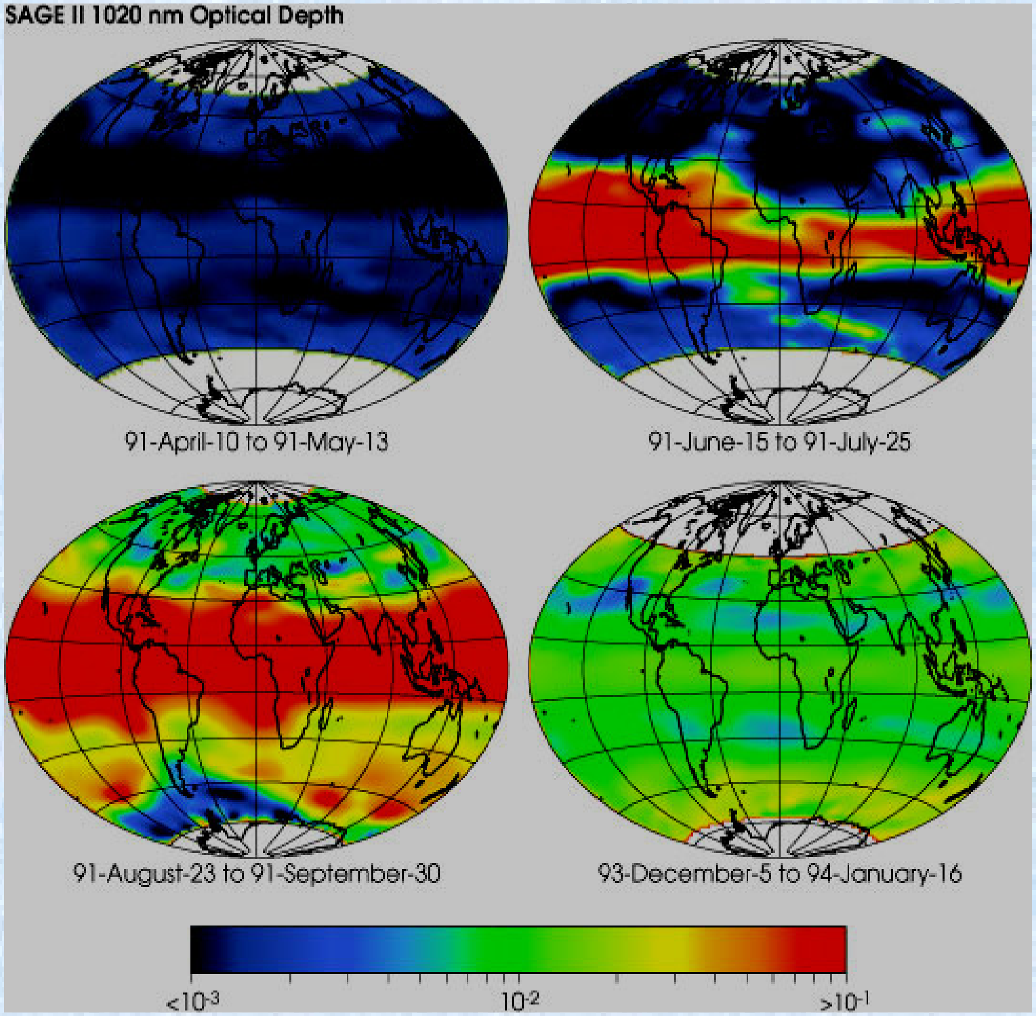
- Odin is an international satellite project (Sweden-France-Canada-Finland) destined, among other objectives, to observe chemical species like H_2O, CO_2, O_3 in the sub-millimetre domain (around 500 GHz) and O_2 in the millimetre range (119 GHz).



SPACE TECHNOLOGY FOR AIR POLLUTION MONITORING contd.

Inpact of the 1991 Mt. Pinatubo Volcanic Eruption on the Global Community

The Oneness of our world



SPACE TECHNOLOGY FOR MONITORING AND MANAGEMENT OF AIR POLLUTION contd.

- **Challenges of Space Technology Advances in Air Pollution Monitoring**

  - **Measurements of air pollution from satellite imageries are usually inferred and require very tasking image processing using high-level computer programming techniques. Therefore availability of experts through capacity building in air pollution research and knowledge of digital image processing for accurate and relevant data acquisition pose a big challenge.**

  - **Spatial resolution of most meteorological satellites and atmospheric monitoring sensors are very low and mostly useful at the regional and global levels, but has limited relevance at the local level where high resolution payloads are required**

  - **Temporal resolution or revisit time of satellites also contribute to the challenges especially where regular monitoring of air pollution is required. The advent of micro-satellites, such as NigeriaSat-1 and the Disaster Monitoring Constellation (DMC) Satellites, have provided great opportunity for the achievement of a dynamic remote sensing or daily revisit of fast changing phenomena on the Earth surface. Payloads of such systems can be modified for air pollution monitoring purposes**

  - **Access to relevant and reliable datasets through internet and fast data communication and transfer facilities can improve access to real-time satellite data, which can readily be downloaded speedily or deployed for air quality assessment. The present effort to launch a communication satellite and also develop a national geospatial data infrastructure in Nigeria, for example, will go a long way in addressing these problems.**

  - **High cost of developing space technology with relevant payload for air pollution/quality monitoring; alternatively, low cost satellite receiving stations can be established and dedicated to weather data capture and air pollution/quality monitoring**

SPACE TECHNOLOGY FOR MONITORING AND MANAGEMENT OF AIR POLLUTION contd.

- Other remedial measures

  i. Development of environmental-friendly energy sources and measures which include renewable energy generation from hydropower, wind and solar energy, renewable bio-energy from energy crops which are able to fix carbon and act as carbon sinks

  ii. Awareness and legislation in support of environmental-friendly energy sources and uses and air pollution regulations: Legislators are getting more aware of their responsibilities to enact and pass bills that will ensure a safer society in many developing countries including Nigeria. For example, it is now an offence to import vehicles older than eight (8) years to Nigeria in view of the air pollution and other problems associated with such vehicles.

On-going Research In Nigeria:

i. Satellite-based integrated environmental change research in the Niger Delta, in collaboration with UMKC, USA, including a PhD study in air pollution monitoring

ii. Nigeria is participating in the PUMA/AMESD project and GEOSS initiatives

iii Deforestation in Nigeria and its implication on biodiversity, etc.

5.0 CONCLUSIONS

- Energy is fundamental to the quick realisation of the basic needs of life, yet it's unsustainable and unregulated use portends danger to human health and environment.

- The growing needs for air pollution-free energy to meet human development can be achieved through the development and use of alternative clean energy sources, which are more environmental friendly and renewable, to reduce the environmental risks currently being faced by both the developed and developing countries.

- All countries, most especially the developed countries, are called upon, to ratify and abide by the resolutions of the Kyoto Protocol for emission reduction.

- Space Science and Technology has offered an avenue for a more accurate monitoring and management of air pollution

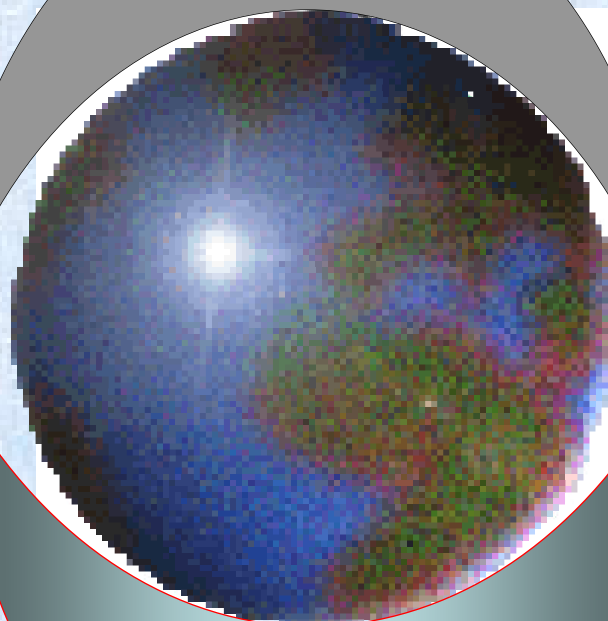
- The development of space technology and the capacity for its utilisation in developing countries has become imperative, to assist in the management and monitoring of environmental pollution to keep pace with the growing needs for energy production, generation and use.

- This development will require international cooperation in research and development with relevant capacity building and technology transfer, as well as provision of low-cost ground stations for relevant satellites data acquisition.

5.0 CONCLUSIONS contd

- **The awareness programmes and political will on the part of the individual countries particularly at the various arms of government, executive, legislative and judiciary, to develop and support the implementation of relevant space technology policies and air pollution regulatory/control measures cannot be over-emphasised**

I Thank You all



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