

THE ROLE OF GIS AND REMOTE SENSING IN MAPPING THE DISTRIBUTION OF GREENHOUSE GASES

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Abstract

Technology offers a means to assess, plan, and implement sustainable programmes that can affect us into the future. A GIS-based framework helps gain a scientific understanding of the earth at a truly global scale. GIS with updated data helps people to know what happens in our planet, how climate takes place and where impacts of climate change affect people. Remote sensing was also identified as a foundational technology. Tying in remote sensing technologies and data with GIS is a powerful combination of understanding spatial patterns in the earth's ever changing surface. Combining Remote sensing information in a GIS allows us to track, model, and observe climate trends across the planet's surface. (Jack Dangermond, 2010).

Keywords: Geographic information system, remote sensing, greenhouse gases, carbon dioxide, methane, ozone

Introduction

The increase of carbon dioxide and greenhouse gases (GHGs) in the atmosphere, combine with climate variability will likely bring about more extreme weather events, such as tropical storms, floods and droughts (Jack Dangermond, 2010). Using GIS and Remote sensing techniques allows us to utilize complex statistical methods to view trends and change at specific times or over periods of times (Jack Dangermond, 2010). GIS can help us study potential solutions to problems and potential outcomes of implementing the potential solutions. It can help us become visionary rather than reactionary.

The first application of geospatial technologies to climate science is in assessing the current state of greenhouse gas emissions, land use, forestry

and other critical factors. GIS is often seen primarily as a tool for educated analysis of causes and impacts of phenomena related to climate change. However, it can also have an operational role in mitigating global warming, especially when integrated with the internet for information collection and dissemination. The process merges field measurements with airborne laser scanning and satellite images into a seamless information flow that collects, distills and disseminates detailed, high-resolution carbon offset estimates to all parties concerned in near real time (Jack Dangermond, 2010).

Background

A greenhouse gas is a gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide (CO₂), methane (CH₄), nitrous oxide, and ozone. Greenhouse gases greatly affect the temperature of the Earth, without them, Earth's surface would average about 33°C colder than the present average of 14°C.

Since the beginning of the industrial Revolution, the burning of fossil fuels has contributed to 40% increase in the concentration of carbon dioxide in the atmosphere from 280ppm (parts per million) to 397ppm, despite the uptake of a large portion of the emissions by various natural “sinks” involved in the carbon cycle. Human activities (anthropogenic) that produce GHGs emissions are modifying the Earth's energy balance between incoming solar radiation and the heat release back into space, resulting in climate change.

The 2007 fourth Assessment Report compiled by the Intergovernmental panel on climate change (IPCC) (AR4) noted that “changes in atmospheric concentrations of greenhouse gases and aerosols, land cover and solar radiation alter the energy balance of the climate system”, and concluded that “increases in anthropogenic greenhouse gas concentration is very likely to have caused most of the increases in global average temperatures since the mid-20th century”.

Between the periods of 1970 to 2004, GHG emissions increase at an average rate of 1.6% per year, with carbon dioxide emissions from use of fossil fuels growing at a rate of 1.9% per year. Total anthropogenic emissions at the end of 2009 were estimated at 49.5 giga tons carbon dioxide-equivalent. These emissions include CO₂ from fossil fuel use and from land use, as well as emissions of methane, nitrous oxide and other GHGs covered by Kyoto protocol. In 2004, total global anthropogenic GHG emissions were 49GtCO₂ (IPCC, 2007). Emissions from fossil fuel combustion account for a majority of anthropogenic CO₂ emissions. In 2008, global emission of CO₂ from energy use totaled 32GtCO₂ (US Dept.of

Energy, 2012, UNEP, 2003, Earth Trends, 2005). From 2000 to 2010, global CO₂ emissions from energy use increased 34%. In 2006, china became the world's largest contributor of GHG emissions surpassing the U.S. U.S. was responsible for more than 14% of the total anthropogenic GHG emissions in 2004(U.S. EPA, 2012). Fossil fuel combustion is the largest source of U.S. GHGs, currently accounting for 79% of total emissions. The electric power industry accounts for about one-third of total U.S. GHGs. Transportation is the second largest contributor to total U.S. GHG emissions responsible for 27% of total emissions in 2010(U.S. EPA,2012).

The Gis And Remote Sensing Evolution

A geographic information system (GIS) is a computer –assisted system for handling spatial information. GIS software can be considered as a collection of software programs to acquire, store, analyze, and display information. The input data can be maps, charts, spreadsheets, or pictures (Robert Sanderson, 2010).

GIS was born when the virtues of classical map are wedded to the power of computers. It originated in the early 1960s from two independently functioning organizations; the Harvard laboratory for computer Graphics (HLCG) and the Canadian Geographic information system (CGIS). HLCG was set up in 1965. It was to develop automated procedures capable of using line printer to create maps quickly and cheaply. It produced the mapping package SYMAP (Synagraphic mapping system) that could generate a variety of maps including chrolopleths and isolines (Tasneem Abbasi and S.A.Abbasi, 2010).

The Canadian Geographic information system (CGIS) is commonly acknowledged as being the first time GIS. The Canadian Government was planning the Canadian land inventory (CLI) to map the land capability of settled canada. By the end of the 1960s this idea had been turned into a working system that held maps and associated attribute information for the whole canada (Tasneem Abbasi and S.A.Abbasi, 2010).

The 1970s saw increase in the processing power of the computers. This coupled with increasing awareness of the environmental issues, spurred the growth of GIS, with developments spreading to private software companies in North America and Europe.

In the 1980s Arc Info was launched. It was the first GIS software package that was to become the industry standard for the next decades. The software was developed by Environmental Systems Research Institute (ESRI). The first widely used software package which also had the ability to digitize images was MapInfo from the Map Info corporation. ESRI responded by launching Arc view as a sister product to Arc Info. They were

later merged into a single product; ArcGis (Tasneem Abbasi and S.A.Abbasi, 2010).

Remote sensing is the science of deriving information about an object from measurements made at a distance from the object without actually coming in contact with it. The quantity most frequently measured in present-day remote sensing systems is the electromagnetic energy emanating from the objects of interest and although there other possibilities such as seismic waves, sonic waves and gravitational force.

A great deal of stimulus was provided to GIS by the almost parallel advancements in remote sensing, in the late 1960s and early 1970s as a potentially cheap and effective source of earth observations. Prior to the 1960s, remote sensing was dependant on aerial photography which is very useful in many ways but doesn't have the kind of wide and frequent coverage of earth that is possible with satellites in space.

The launching of the first-ever remote sensing satellite (TIROS-1) coincided with the birth of GIS even though the two events occurred independently of each other (Tasneem Abbasi and S.A.Abbasi, 2010).

In years to come remote sensing and GIS were to converge towards each other. As remote senses images greatly strengthen GIS, the two developments fuelled the growth of each other. The relationship further strengthened with the launching of LANDSAT (1,2,3,4,5,6 and 7), National oceanic and Atmospheric Administration (NOAA) satellite, Seas at, Geographic Operation Environmental Satellite (GOES), Television Infrared Observation Satellite (TIROS), Heat capacity mapping mission satellite (HCMM), the SKYLAB to mention but few (Tasneem Abbasi and S.A.Abbasi,2010).

Gis and Remote Sensing in Mapping the Distribution of Greenhouse Gases

Carbon dioxide (CO₂) and Methane (CH₄) are the two major important anthropogenic greenhouse gases and contribute to global warming. Satellite measurements of vertical columns or column averaged mixing ratios of CO₂ and CH₄ have the potential to improve this situation. This is because satellites produce large amounts of data which cover the entire Earth in short time periods. The first satellite instrument which provides this type of information is Scanning Imaging Absorption spectrometer for Atmospheric cHartographY (SCIAMACHY) on board the European environmental satellite (ENVISAT). This is because SCIAMAHY measures spectra of reflected solar radiation in the near-infrared spectral region in nadir (down looking) observation mode. These measurements are sensitive to greenhouse gas concentration changes at all atmospheric altitude levels including the

lowest layer of the atmosphere where the sourced sink signals are largest (Michael Buchwitz, 2008).

At the Institute of Environmental Physics/Remote sensing (iup/ife) of the university of Bremen, located in Northern Germany, a retrieval algorithm called WFM-DOAS has been developed to retrieve information on greenhouse gas columns from the spectra measurements of the SCIAMACHY instrument. Recently, three years of data (2003-2005) have been processed using WFM-DOAS. For each month a global map has been produced which displays the spatial distribution of the corresponding greenhouse gas during this month. These maps have been combined to an animation to show how the greenhouse gas distributions are changing with time. The satellite data have been filtered using a number of criteria in order to make sure that only good measurements are considered. The greenhouse gas distributions are shown as column-average volume mixing ratios (VMRs) also called column-averaged dry air mole fractions. The units are ppm (parts per million) for CO₂ and ppb (parts per billion) for CH₄ (Micheal Buchwitz, 2008).

The periodic monitoring of methane gas emissions from agricultural activities in US using GIS is indispensable in the formulation of policies. As a decision support tool, it is essential in tracking the threats of greenhouse gas emission at both national and state level. The GIS mapping highlighted the spatial distribution of rice production and climate change prediction and the surround ecology of the state as well. GIS technique as used here in contributing to the literature stands as a relevant decision support tool that pinpoints high risk areas and counties vulnerable to the concentration of methane gas in the atmosphere. This involved the generation of maps that identified rice producing counties known for methane gas emission, visualizing counties and natural areas prone to greenhouse gas concentration. In these settings, not only help focus the scope of GIS and environmental planning with records of change in affected areas, but it furnished information on pace at which rice farming activities can influence climate change (Edmund C. Merem, Chandra Richardson, Corney Romarno, Joan Wesley and Yaw Twumasi, 2012).

GIS technology upholds base-level information requirement and provide emergence management workflow support through data management, situation awareness, planning, and field operations. In Germany, the topography impact on the carbon sequestration, different topographical indices were derived from Digital elevation model (DEM). The indices were calculated with the help of Arc view GIS 3.3. The data on the carbon storage were intersected with the available raster data on the predicting variables in a geographic information system using regression

kriging, a spatial interpolation technique that combines linear regression analysis with geo-statistics (Winfried Schroder and Roland Pesch, 2011).

GIS can be used to overlay the best available spatially disaggregated global data on critical impact elements. With the inundation zones projected for 1-5m SLR. Studies reveal that tens of millions of people in the developing world are likely to be displaced by sea level rise within this century; and accompanying economic and ecological damage will be severe for many (Tasneem Abbasi et al, 2010). Studies by Craft (2008) using field and laboratory measurements, GIS and simulation modeling have been done to assess the potential effects of accelerated sea-level rise on tidal marsh area and delivery of ecosystem (Tasneem Abbasi and S.A.Abbasi, 2010).

Recommendation

As a decision support tool, it is essential in tracking the threats of greenhouse gas emissions at both the National and State level. GIS and Remote sensing in cooperation unable us to understand events that are inaccessible, yet significant in regards to climate pollution.

Conclusion

Sustainable land management is essential for effective greenhouse gas management, hence it is important to acquire data on land cover. Remotely sensed land cover changes are used in calculations of emission levels, and data collected on a national scale will enable Government to develop response measures.

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