P1.44 **Implementing Weather Studies in Multiple Formats for Non-Science and Science Majors**

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1. ABSTRACT

Wesley College, a small 4-year liberal arts college in Dover, Delaware, has approximately 1200 full-time undergraduate resident students, and there is an evening program for the alternative student. Wesley College offers a degree in environmental studies (ES) and a non-majors course in ES. While the ES degree and non-majors course in ES rely on climate concepts, there currently is no course offered at Wesley College that is devoted specifically weather studies (WS). The Online Weather Studies Resources developed by the American Meteorological Society (AMS) and a text published by the AMS will be used to develop a course for non-majors and to supplement two environmental science courses for first year environmental science majors. The objectives of this paper are:

- To describe how WS will be implemented at Wesley College
- To describe common content areas that will drive the three distinctively different weather studies courses.

The WS course for non-majors will be taught in two formats and initially will be taught without a lab. The online resources will be used to supplement the lecture material. One course will be face-to-face and it will be offered spring semester 2008. The second format will be a hybrid and it will be offered at a later time. Wesley is relatively new to distance learning and the Online Weather Studies Resources will play a key role in advancing online education. With the hybrid format, there will be occasional class meetings. The remainder of the course will be handled through the Internet, discussion groups, and CD material, which will use Online Weather Studies Resources.

The Online Weather Studies Resources also will be used to supplement two existing courses for the environmental science majors. Selected WS content areas will be used to enhance sections that focus on human-environment interaction, climate change, environmental hazards and watersheds and their management. These courses will be taught in a traditional face-to-face format.

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2. INTRODUCTION

The AMS co-sponsored with National Weather Service (NWS) an Online Weather Studies Diversity Project workshop in Kansas City, 20-25 May 2007. A primary goal of the Diversity Project is to offer to eligible institutions the opportunity to implement and offer an introductory geosciences course with the assistance of AMS mentors and online AMS resources. Two of the objectives of the Diversity Project workshop were to:

1. To share ideas in science content and teaching strategies related to offering the *Online Weather Studies* course
2. To present a paper or poster at the Education Symposium at the AMS Annual Meeting.

One of the underlying reasons for AMS to engage in the Diversity Project was to encourage the participation of underrepresented undergraduate students in a geosciences course. The introduction to the AMS Online Resources and workshop training provided an excellent framework to begin this initiative at Wesley College. Wesley College is part of the Delaware EPSCoR/NSF grant, and a significant part of the grant is to develop an outreach program to encourage students to enter the STEM tracking in college. Both the AMS Diversity project and the EPSCoR/NSF grant have and will provide the foundation to improve enrollment in the sciences at Wesley College.

Even though the students (ES majors and non majors) and the content for the three courses will be different, there will be some common content themes that will drive all courses. There are four content areas that will be common to all students and courses, and these will be used to relate weather and climate to multiple disciplines. These areas are:

1. Global climate change
2. Environmental hazards
3. Watersheds and their management
4. Human-environment-weather interaction

Global climate change will be at the core of the courses, and this topic will be used to begin all courses. This approach was chosen because climate change:

- Influences ecosystem and watershed processes and functionality,
- Will influence business and economic decisions,
- Is a hotly debated political topic
- Will influence food and water security
- Has been and is influenced by human activities
- Will cause irreversible changes to the earth system
- Is not well understood by the public

- Is a global phenomenon that is likely to cause environmental hazards
- Influences global human health

Scientists agree on the major causes of climate change; however the general public does not understand the significance of climate change. The scientific community has not conveyed a clear understandable message. Generally the pubic rank the risk of climate change on ecology and human welfare as being low; while many if not all scientists rank climate change as the leading environmental issue facing our global society.

The effect of climate change on water resources is global. Loaiciga et al. (2000) concluded that the quantity of water in the Edwards Aquifer in Texas would be reduced by increases in CO_2 and a subsequent increase in temperature. Correia (1999) stated that climate change would influence water resources in the Mediterranean region, and that a holistic approach to water management would be imperative to ensure that water shortages did not occur. The fact that land use and water resources were linked would only compound the effect of climate change on water management (Correia, 1999). Abler et al. (2000) investigated the effect of different climate change scenarios on maize production. They concluded that farmers would need to understand the link between agricultural commodity policies and climate change and the subsequent impact on water quality in the Chesapeake Bay watershed.

The impact of climate change on human health is globally important, and there are complex weather variability, water management, economic, and social interrelationships. Simpson (2006) noted that health sensitive groups of people from less industrialized countries as well as people who do not have adequate economic means would be disproportionately affected by climate change. McMichael (2007) discussed how climate change was likely to affect a growing population by altering global food production systems, fisheries and the stratospheric O_3 layer to name a few. The health of people in South and Central America will be adversely affected by climate change (Moreno, 2006). The human health aspect of climate change will hopefully guide national and international leaders to adopt new policies that will reduce health impacts.

The impact of climate change is broad, even within a discipline such as WS. It is not the intent of this paper to have a comprehensive review of climate change and its effect on environmental, biological, political and social systems. Weather studies in general is strongly grounded in the physical sciences, and the approach to integrating WS into the Wesley College curriculum will still have the physical and atmospheric sciences, but there will be initial and additional emphasis on environmental and human systems.

The objectives of this paper are:

- To describe a path forward regarding implementation of weather studies at Wesley College
- To discuss and illustrate some selected materials, which are not available as part of the AMS Online Weather Studies Resources, that will be used to drive the three distinctively different weather studies courses.

3. PATH FORWARD: COURSE IMPLEMENTATION

WS concepts were integrated into an ES course at Wesley College fall 2007 and integration of WS as a course will begin spring semester 2008. The courses are distinctively different and course content is and will be different. The fall 2007 course is required of all incoming first year ES studies students and will be supplemented with AMS Online Resources. The spring 2008 courses will be offered as a classical WS course and the second course is the first year laboratory course for ES students.

3.1 *Fall 2007*

Seminar on the Environment is offered as a one credit hour required course for all first year ES students. After completing the Online Weather Studies Diversity Project workshop, I decided an excellent way to begin integrating WS concepts into the overall curriculum was to introduce a major WS topic that overlapped with ES. Global climate change was the topic selected. Students were introduced to the scientific aspects of climate change the second half of the semester. Students were then required to work in teams and make a presentation quality poster. Topics chosen for the posters were:

- The impact of global warming on coastal water levels
- The impact of global warming on water pollution
- The impact of global warming on water scarcity

The posters were part of a Wesley College globalization initiative program and the posters were displayed in a morning session devoted to global environmental issues.

The posters served to introduce first semester students to college level scientific content, to relate climate change to familiar but complex issues and to introduce students to making scientific posters. The students quickly recognized that climate change certainly had an effect on their topic, but more importantly that climate change had an effect on food production systems, human health, economics, environmental degradation, ecosystem functionality and sustainable development. The issue of climate change was not localized, but it was a global phenomenon.

3.2 *Spring 2008*

Two courses will be offered that include a three credit hour non-laboratory WS course for non-science majors. This course offering is the first WS course at Wesley College. As a first time offering, I will generally follow the text published by AMS (Moran, 2006). Selected AME Online Resources will be used to supplement the lecture material. I have chosen to modify the order of topics by beginning with climate and climate change, which is found in chapter 15. Climate change will be expanded and will be used to cultivate an interest in WS. Additionally, watersheds and their management, hydrologic cycle and environmental-weather hazards will be expanded and introduced at appropriate times in the semester.

A second course is a laboratory course required for first year ES students. WS topics that will be integrated into this course include climate and climate change, watersheds and their management, hydrologic cycle and environmental-weather hazards. From an environmental science standpoint, these topics comprise a significant portion of this course, and the content will be somewhat different than the WS course for non-majors. Regardless of the spring 2008 course, these four topic areas will be discussed from a human-environment-weather interaction point of view.

In order to create intellectual excitement in all students, outside speakers from the NWS will be used, student presentations and posters will be required and field trips to state and local agencies that routinely use weather information will be scheduled. Lectures will be structured to make the content relevant to broad areas of study at Wesley College, and the courses will offer a personal side of interest for all students i.e. marine weather in the Chesapeake Bay or business decisions and weather.

4. SUPPLEMENTAL WS RESOURCES: CLIMATE CHANGE RESOURCES

One of the major topic areas that will be expanded is climate and climate change. Climate change not only is a WS topic, but it is also a major content area in environmental science. Therefore, I would like to summarize some of the additional resources I will use for discussions and student projects. The majority of these resources can be found on the Internet and are appropriate for a first or second year student.

4.1 *Ecological Footprints*

I have found an excellent entry to discussing climate change is to introduce students to online or spreadsheet assessments of their ecological footprint and their personal greenhouse emissions. There are Internet based ecological footprints available, and one such tool can be found at the following URLs:
http://www.rprogress.org/ecological_footprint/about_ecological_footprint.htm

http://www.myfootprint.org/

This footprint calculation has only 14 questions, and individuals are asked about housing, food consumption and transportation. This activity fits well as a first day assignment and it will provide the foundation to begin a more rigorous treatment of climate change. The Web link for the footprint calculation is part of a Web resource devoted to information on sustainable economies. There are additional hyperlinks that can be accessed for information on environment and the economy. Generally, students find this to be an interesting point of discussion, and they often remark that they view themselves just as an "average American". That comment can be used to set the stage for many future discussions.

4.2 *Greenhouse Emission Databases and Calculators*

One of the causes of climate change is human activity. There are Web based resources that can be used to facilitate this discussion. Two general diagrams showing how energy in used in the United States and globally are shown in figure 1 and figure 2. Major areas of energy use provide the inputs, and then the energy is allocated across end use and activity categories. The outputs are shown in terms of greenhouse emissions relative to the type use. This figure provides the beginning of a climate change discussion from a human-weather-environment standpoint.

The World Resources Institute (WRI) Web page has a number of resources that can be used. The Climate Analysis Indicator Tools (CAIT), which was developed by WRI, can be quite effective in providing supplemental information on climate change. Refer to the Web page, http://cait.wri.org/cait.php, for more information (Washington, DC: World Resources Institute, 2008). A user must register, but once that is completed access to a Web based library of mapping, database, graphic projection tools and information is available. An example of data available from the WRI/CAIT database is shown in table 1. This data can be accessed for an individual country, regions of the globe or less and more industrialized countries. An example database query is shown in table 2. Data is also available across time periods for 1900-2003. A part of the WRI information portal, Earth Trends, provides additional information for countries or regions (World Resources Institute, 2007). Example profiles for China and the United States are shown in figure 3.

The ability to access the type information that WRI has available simplifies data gathering for lectures, lab or student reports. Within the CAIT databases, greenhouse gas (GHG) data and other relevant climate change indicators are available. Indicators include greenhouse gas emissions, socio-economic and natural factors. Each category is subdivided as follows:

- GHG Emissions: Yearly Emissions, Cumulative Emissions and Emissions Intensities
- Socio-Economic: Health, Education, Income/Size of Economy, Energy Use and Governance
- Natural Factors: Climate (Heating and cooling Needs), Fossil Fuel Reserves, Energy Use Mix, Land Area and Population

These data can then be used to complete comparative analyses of GHG, sectors and countries. Trends can be calculated and graphed. The individual country profiles are formatted to have a quick but comprehensive view of a country from a climate and atmosphere standpoint. Students can be creative in comparative analysis of countries and the data output is user friendly for presentations and posters.

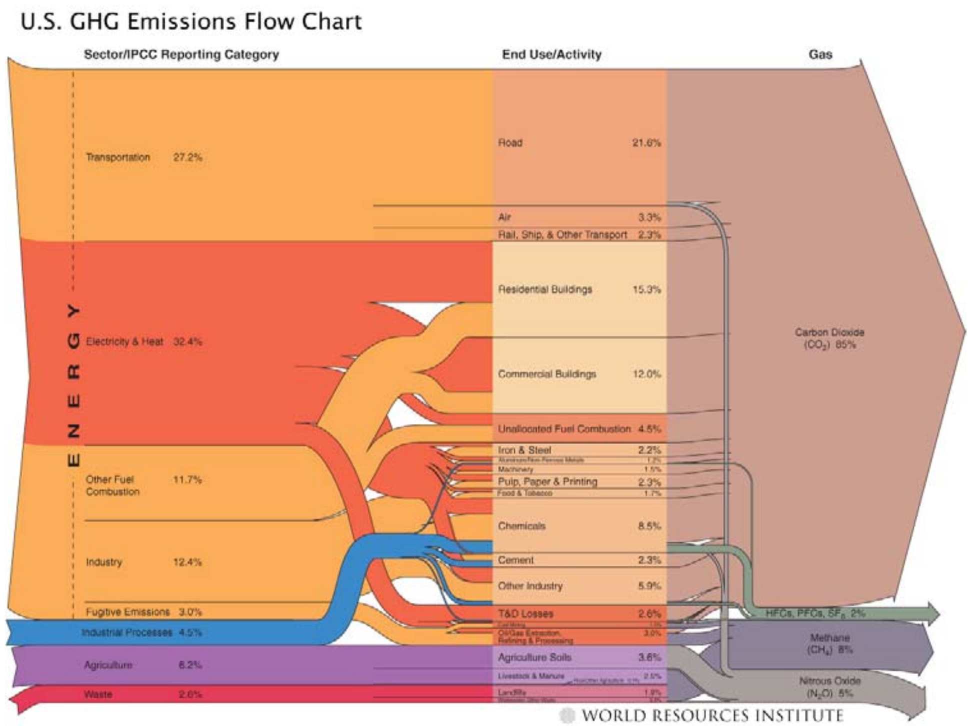


Figure 1: United States energy use and greenhouse emissions (source, World Resources Institute, Web page http://cait.wri.org/figures.php)

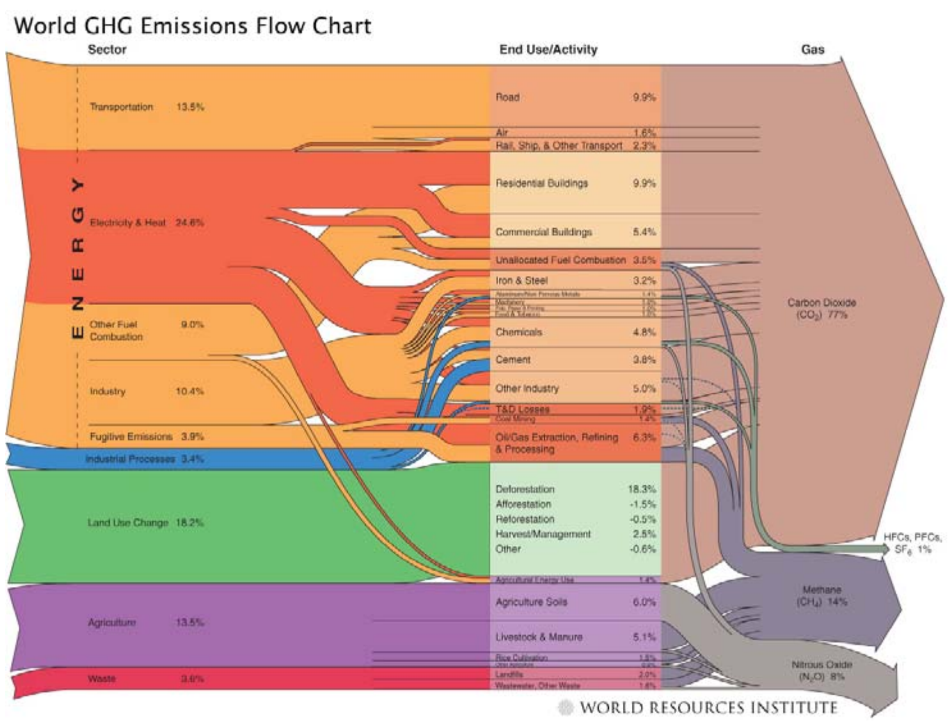
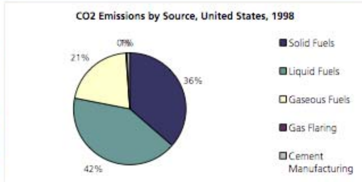


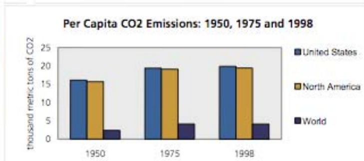
Figure 2: Global energy use and greenhouse emissions. (source, World Resources Institute, Web page http://cait.wri.org/figures.php)

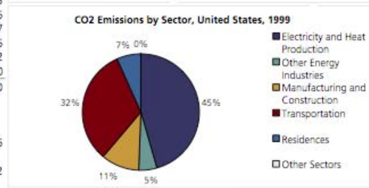
Climate and Atmosphere-- United States

EarthTrends Country Profiles

Carbon Dioxide (CO2) Emissions {a} (in thousand metric tons of CO2)	United States	North America	World
Total Emissions, 1998	5,447,640	5,915,907	24,215,376
Percent change since 1990	13%	13%	8%
Emissions as a percent of global CO2 production	22.5%	24.4%	
Emissions in 1998 from:			
solid fuels	1,982,264	2,085,772	8,654,368
liquid fuels	2,273,622	2,467,484	10,160,272
gaseous fuels	1,137,375	1,298,217	4,470,080
gas flaring	12,555	16,599	172,208
cement manufacturing	41,823	47,835	758,448
Per capita CO2 emissions, 1998 (thousand metric tons of CO2)	19.9	19.4	4.1
Percent change since 1990	5%	5%	-2%
CO2 emissions (in metric tons) per million dollars Gross Domestic Product {b}, 1998	679	X	773
Percent change since 1990	-11%	X	-10%
Cumulative CO2 emissions, 1900-1999 (in billion metric tons)	283,302	304,687	933,686
CO2 Emissions by Sector, 1999 {c} (in million metric tons of CO2)			
Public electricity, heat production, and autoproducers	2,397	2,515	8,693
Other Energy Industries	272	326	1,205
Manufacturing Industries and Construction	556	646	4,337
Transportation	1,693	1,844	5,505
Residential	352	392	1,802
Other Sectors {d}	X	449	5,640
Total Emissions All Sectors:	X	6,172	27,180
CO2 Intensity, 1999			
Emissions per total energy consumption (metric tons CO2 per terajoule energy)	59	58	56
Emissions per Gross Domestic Product {e} (metric tons of CO2/million $PPP)	650	649	582





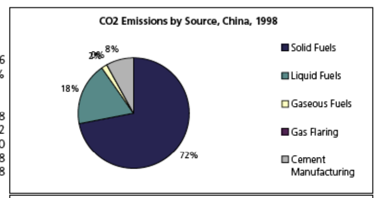


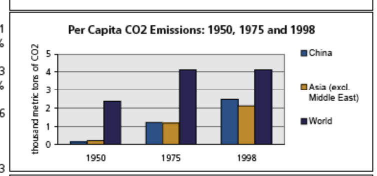
View more Country Profiles on-line at http://earthtrends.wri.org

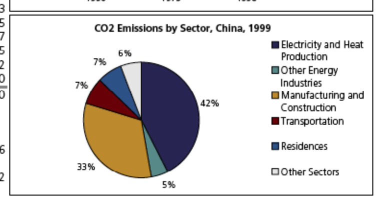
Climate and Atmosphere-- China

EarthTrends Country Profiles

Carbon Dioxide (CO2) Emissions {a} (in thousand metric tons of CO2)	China	Asia (excl. Middle East)	World
Total Emissions, 1998	3,316,760	7,360,942	24,215,376
Percent change since 1990	31%	38%	8%
Emissions as a percent of global CO2 production	13.7%	30.4%	
Emissions in 1998 from:			
solid fuels	2,386,913	4,020,885	8,654,368
liquid fuels	609,001	2,304,231	10,160,272
gaseous fuels	55,231	580,898	4,470,080
gas flaring	0	22,391	172,208
cement manufacturing	265,615	432,537	758,448
Per capita CO2 emissions, 1998 (thousand metric tons of CO2)	2.5	2.1	4.1
Percent change since 1990	17%	19%	-2%
CO2 emissions (in metric tons) per million dollars Gross Domestic Product {b}, 1998	3,454	X	773
Percent change since 1990	-43%	X	-10%
Cumulative CO2 emissions, 1900-1999 (in billion metric tons)	65,168	161,972	933,686
CO2 Emissions by Sector, 1999 {c} (in million metric tons of CO2)			
Public electricity, heat production, and autoproducers	1,281	2,697	8,693
Other Energy Industries	139	312	1,205
Manufacturing Industries and Construction	979	1,915	4,337
Transportation	221	943	5,505
Residential	211	471	1,802
Other Sectors {d}	176	580	5,640
Total Emissions All Sectors:	3,007	6,918	27,180
CO2 Intensity, 1999			
Emissions per total energy consumption (metric tons CO2 per terajoule energy)	66	56	56
Emissions per Gross Domestic Product {e} (metric tons of CO2/million $PPP)	700	540	582







View more Country Profiles on-line at http://earthtrends.wri.org

Figure 3: Country profiles for the United States and China regarding climate and atmosphere. (source, World Resources Institute Web page http://earthtrends.wri.org/country_profiles/index.php?theme=3)

Emissions information can be personalized by using an Environmental Protection Agency (EPA) Web site that calculates greenhouse emissions for an individual. This calculation can be completed online or a spreadsheet version can be downloaded (refer to the following URL http://www.epa.gov/climatechange/emissions/ind_calculator.html). An estimate of personal emissions is based on transportation habits, home energy, recycling and waste generated. Once that estimate is calculated, an individual has the option to investigate what can be done to reduce emissions. A part of the EPA emission calculator is devoted to assumptions of the calculations as well as the actual formulas.

Table 1: Examples of climate and atmosphere data available from WRI/CAIT (data sources available at http://cait.wri.org/cait.php).

Select the variable you wish to view from the list.
Air Pollution: Carbon monoxide emissions
Air Pollution: Nitrogen oxides emissions
CO_2 Emissions by Source: CO_2 emissions from liquid fuels
CO_2 Emissions by Source: Cumulative emissions from land use change (source: WRI)
CO_2 Emissions: CO_2 emissions per capita (source: WRI)
CO_2 Emissions: Cumulative CO_2 emissions, 1900-2000 (source: WRI)
CO_2 Emissions: Total CO_2 emissions (source: WRI)
CO_2 Emissions: Total CO_2 emissions including land use change (source: WRI)
CO_2 Intensity: CO_2 emissions per GDP (source: WRI)
Global Gas Concentrations: CFC-11
Global Gas Concentrations: CO_2
Global Gas Concentrations: Methane

4.3 *Land Cover and Climate Change Resources*

One factor of many that contributes to climate change is a change in land use and land cover (LULC), and there are complex feedback mechanisms that are not well understood. A research element of the US Global Change Research Program (www.usgcrp.gov) is devoted to land use and land cover change. Two questions they posed are:

1 "How do climate variability and change affect land use and land cover, and what are the potential feedbacks of changes in land use and land cover to climate?"

2 "What are the environmental, social, economic, and human health consequences of current and potential land-use and land-cover change over the next 5 to 50 years?"

A discussion about LULC and its interrelationship with climate change is facilitated with easily accessible data. The WRI (World Resources Institute, 2007) has complied useful LULC information. In figure 4, a global map of carbon storage in vegetation and soils is shown. There are differences in carbon storage among land use categories, and scientists agree that there are significant geographical differences in stored terrestrial carbon. There is approximately twice the amount of carbon stored in grasslands than in agricultural lands, and about 25% of the carbon entering the atmosphere is attributed to land use change activities (WRI, 2003). In figure 5, cumulative carbon emissions over 50 years are shown. This value represents a net change in total carbon, which has resulted from urbanization, deforestation, or conversion of wildlands to agricultural lands. Figures 4 and 5 show the geographical variation of carbon, but more importantly the information assists

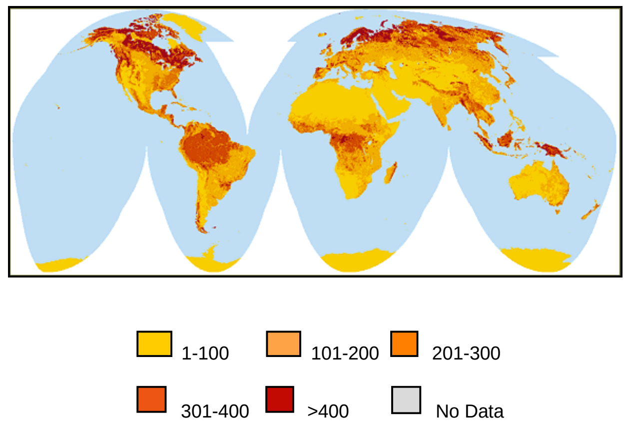


Figure 4: Global terrestrial carbon storage (mt ha^{-1}). Source World Resources Institute - PAGE, 2000.

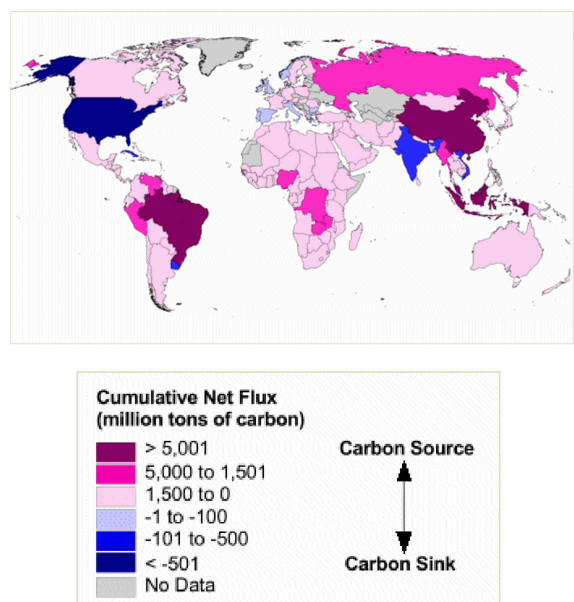


Figure 5: Cumulative net carbon flux from land to the atmosphere from 1950-2000 (source WRI, 2003)

in extending a discussion centered on land use and climate change.

A discussion can now be directed toward the complex interaction between LULC and global climate change, the temporal and spatial changes in LULC and climate change and feedback mechanisms. Topics that can be explored include:

- Primary mechanisms by which land-use and land-cover change affect climate change
- Climate change affects the way land is used
- Geographical differences in stored carbon i.e. humid tropics, dry tropics and boreal regions

At some point, the discussion can be directed toward the second question posed by the US Global Change Research Program (www.usgcrp.gov):

> ***"What are the environmental, social, economic, and human health consequences of current and potential land-use and land-cover change over the next 5 to 50 years?"***

There are additional sources of information about LULC and climate change. The United States Geological Society (USGS) and the United States Department of Agriculture (USDA) have readily available online data in text, database and digital formats. The USGS provides two current versions of the global land cover characterizations database. Information regarding this data can be found at: http://edcsns17.cr.usgs.gov/glcc/. The USDA has LULC data available at http://datagateway.nrcs.usda.gov/.

5. SUMMARY

After completing the AMS Diversity Workshop, a plan to integrate WS into the Wesley College curriculum was developed. As Director of the ES Program at Wesley College, I gave consideration to how WS could be effectively integrated into the ES program as well as developing a stand alone WS course for non science majors. The primary objectives of this paper are:

- To describe how weather studies is being implemented at Wesley College
- To discuss and illustrate some selected new resource materials that will be used to drive the WS initiative.

The addition of WS as a course and WS content areas into existing courses was initiated fall 2007 and is continuing spring 2008. During fall 2007, WS studies concepts were introduced into a first year ES seminar course. Climate change as a topic was chosen because it has a significant effect on environmental, ecological, human and economic systems. As a culminating project, students were required to make a professional poster on how global climate change affects some aspect of water. For spring 2008, a stand alone course is being offered, and WS concepts are also incorporated into a first year ES laboratory course. The one common thread for all courses is global climate change and this topic will be used to begin all courses.

New resources have been identified and have been and will be used in WS and WS related courses. These resources focus on online information about climate change, emissions calculators, and LULC. Searchable databases, image files, and online calculators are available, and they are easily accessible by students. The data and information can be used for classroom discussions, outside projects or posters. The description of the new resources in this paper is not designed to be exhaustive. There are other excellent sources, but I believe the ones described in this paper provide enrichment to WS.

Table 2: Thousand metric tons of carbon dioxide emitted from 1940-2000 for selected regions

	Year			
	1940	1960	1980	2000
	Carbon Dioxide Emitted (Thousand metric tons)			
World Total	4800089	9600178	18816059	24020632
Region/Classification				
Asia (excluding Middle East)	420369	1523446	3908932	7780890
Central America & Caribbean	26701	89696	342558	512077
Europe	2264051	3952086	7462137	6049385
Middle East & North Africa	28174	125204	714872	1612584
North America	1977275	3060741	5255769	6292841
Oceania	41747	105869	235781	369618
South America	48248	205264	520694	811917
Sub-Saharan Africa	52652	130379	353177	546503
Developed Countries	4573017	7761493	14733339	14730232
Developing Countries	299709	1471965	4151957	9304992
High Income Countries	3743462	5679464	10250432	12004630
Low Income Countries	122926	336775	950110	2014233
Middle				

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