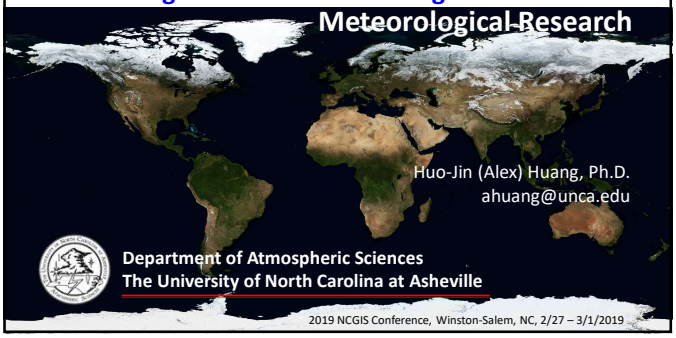
Using GIS to Conduct Undergraduate Meteorological Research

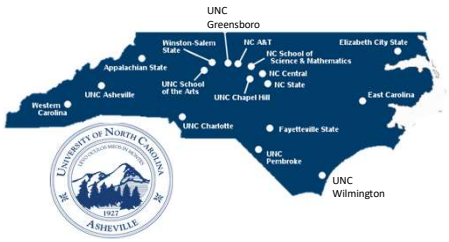


Huo-Jin (Alex) Huang, Ph.D.
ahuang@unca.edu

Department of Atmospheric Sciences
The University of North Carolina at Asheville

2019 NCGIS Conference, Winston-Salem, NC, 2/27 – 3/1/2019

The University of North Carolina Asheville (UNCA) is part of UNC System since 1969



The University of North Carolina Asheville (UNCA) is the only public liberal arts university in North Carolina. It was established in 1927 and is located in the heart of Blue Ridge Mountains.

UNIVERSITY of NORTH CAROLINA ASHEVILLE

90 YEARS 1927 - 2017

Asheville, North Carolina

The UNCA Department of Atmospheric Sciences (ATMS) is a **meteorology department** to educate students to become a professional meteorologist working in the private sector, academia, or government.

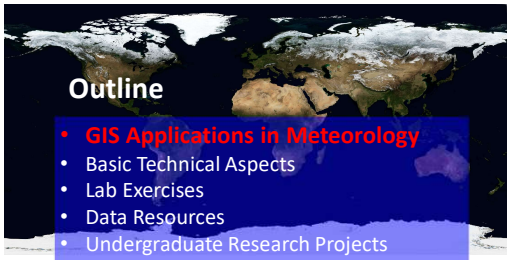
www.atms.unca.edu

Why do Meteorology Students Need to Learn GIS?

- GIS is Ubiquitous
- Government and private sectors use GIS
- NOAA NWS uses GIS
- Professionalism
- Employability
- Powerful **tool** for visualization of data

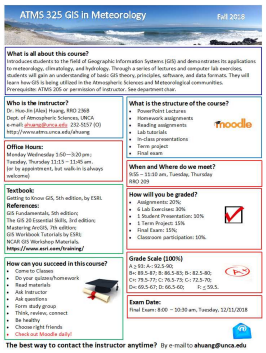
Challenges:

- Powerful and complex
- Data accessibility and quality
- May require programming
- Additional learning for students

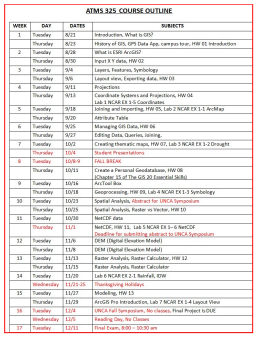


ATMS 325 GIS Applications in Meteorology

Goals: To educate students to learn basic skills of ArcGIS and to help them to conduct undergraduate research.



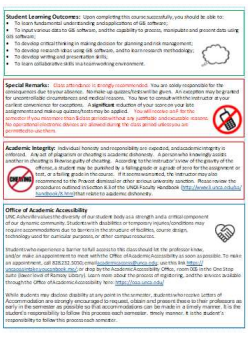
ATMS 325
Syllabus, Page 1



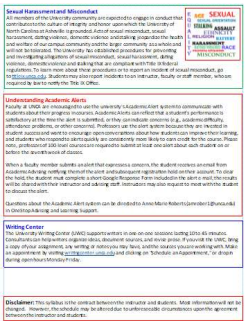
ATMS 325 COURSE OUTLINE

WEEK	DAY	DATES	SUBJECTS
1	Tuesday	8/21	Introduction, What is GIS?
	Thursday	8/23	History of GIS, GPS Data App, campus tour, HW 01 Introduction
2	Tuesday	8/28	What is ESRI ArcGIS?
	Thursday	8/30	Input X-Y data, HW 02
3	Tuesday	9/4	Layers, Features, Symbology
	Thursday	9/6	Layout view, Exporting data, HW 03
4	Tuesday	9/11	Projections
	Thursday	9/13	Coordinate Systems and Projections, HW 04 Lab 1 NCAR EX 1-5 Coordinates
5	Tuesday	9/18	Joining and Importing, HW 05, Lab 2 NCAR EX 1-1 ArcMap
	Thursday	9/20	Attribute Table
6	Tuesday	9/25	Managing GIS Data, HW 06
	Thursday	9/27	Editing Data, Queries, Joining,
7	Tuesday	10/2	Creating thematic maps, HW 07, Lab 3 NCAR EX 1-2 Drought
	Thursday	10/4	Student Presentations
8	Tuesday	10/8-9	FALL BREAK
	Thursday	10/11	Create a Personal Geodatabase, HW 08 Chapter 15 of The GIS 20 Essential Skills
9	Tuesday	10/16	ArcToolBox
	Thursday	10/18	Geoprocessing, HW 09, Lab 4 NCAR EX 1-3 Symbology
10	Tuesday	10/23	Spatial Analysis, Abstract for UNCA Symposium
	Thursday	10/25	Spatial Analysis, Raster vs Vector, HW 10
11	Tuesday	10/30	NetCDF data
	Thursday	11/1	NetCDF, HW 11, Lab 5 NCAR EX 1-6 NetCDF Deadline for submitting abstract to UNCA Symposium
12	Tuesday	11/6	DEM (Digital Elevation Model)
	Thursday	11/8	DEM (Digital Elevation Model)
13	Tuesday	11/13	Raster Analysis, Raster Calculator, HW 12
	Thursday	11/15	Raster Analysis, Raster Calculator
14	Tuesday	11/20	Lab 6 NCAR EX 2-1 Rainfall, IDW
	Wednesday	11/21-25	Thanksgiving Holidays
15	Tuesday	11/27	Modeling, HW 13
	Thursday	11/29	ArcGIS Pro Introduction, Lab 7 NCAR EX 3-4 Layout View
16	Tuesday	12/4	UNCA Fall Symposium, No classes, Final Project is DUE
	Wednesday	12/5	Reading Day, No Classes
17	Tuesday	12/11	Final Exam, 8:00 – 10:30 am

ATMS 325
Syllabus, Page 2



ATMS 325
Syllabus, Page 3



ATMS 325
Syllabus, Page 4

ATMS 325 GIS Applications in Meteorology

Technical Aspects:

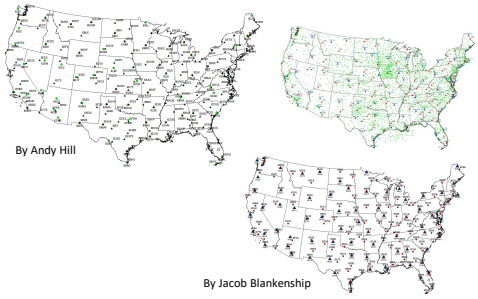
- Input X Y data
- Joining
- Inquiry/Selecting
- Clip/Intersect
- Overlapping
- Symbology
- Projections
- Editing tables
- Layout view
- Vector calculator
- Raster calculator
- Contouring
- Conversion
- Spatial analysis
- Modeling
- Georeferencing
- Geocoding
- NetCDF
- Introduction to ArcGIS Pro

ATMS 325 GIS Applications in Meteorology

Knowledge Aspects:

- Acquiring data
- Quality of data
- Data analysis
- Assessment
- Correlation
- Insightful observation
- Literature review
- Oral presentation
- Poster presentation

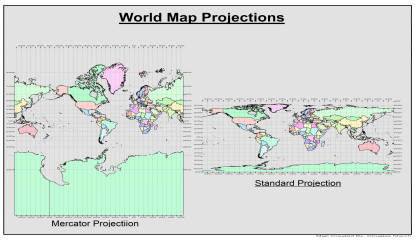
Lab Exercise Example: Input X Y Data



By Andy Hill

By Jacob Blankenship

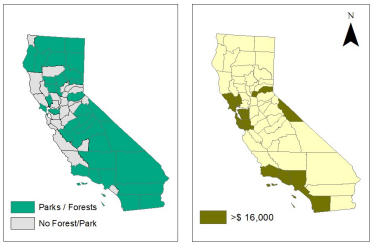
Lab Exercise Example: Map Projection



By Doug March

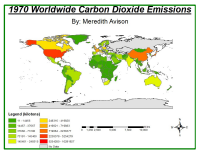
Lab Exercise Example: Join and Classification

Parks/Forests and Income in California

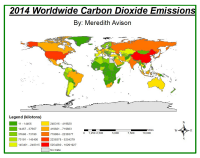


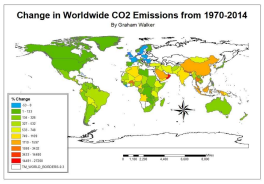
By Meredith Avison

Lab Exercise Example: Join and Symbology



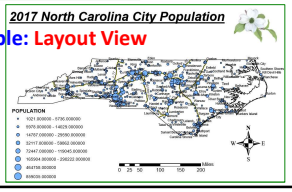
By Meredith Avison



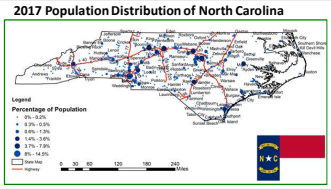


By Graham Walker

Lab Exercise Example: Layout View

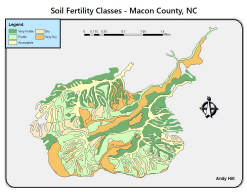


By Meredith Avison

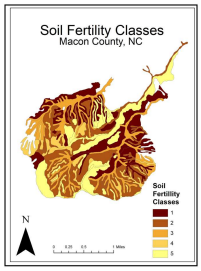


By Jacob Blankenship

Lab Exercise Example: Editing Tables

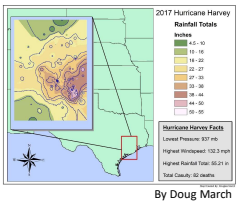


By Andy Hill

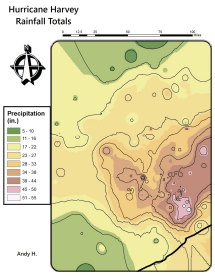


By Doug March

Lab Exercise Example: Contouring

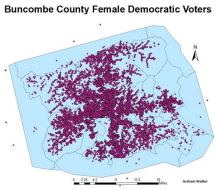


By Doug March

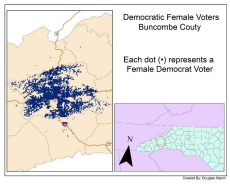


By Andy Hill

Lab Exercise Example: Geocoding



By Graham Walker



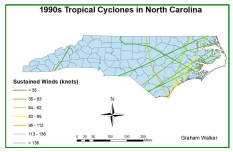
By Doug March

Lab Exercise Example: Georeferencing

By Jacob Blankenship

By Graham Walker

Lab Exercise Example: Selection and Symbology



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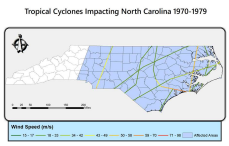
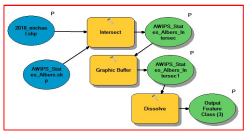


By Andy Hill

Lab Exercise Example: Modeling



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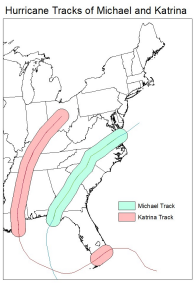
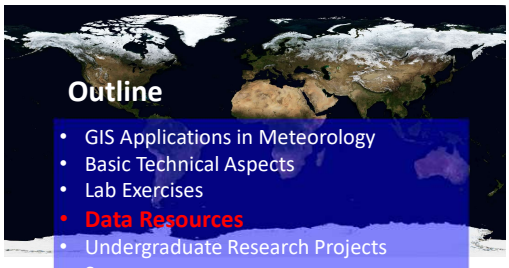
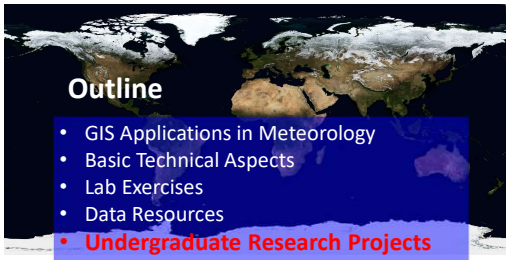




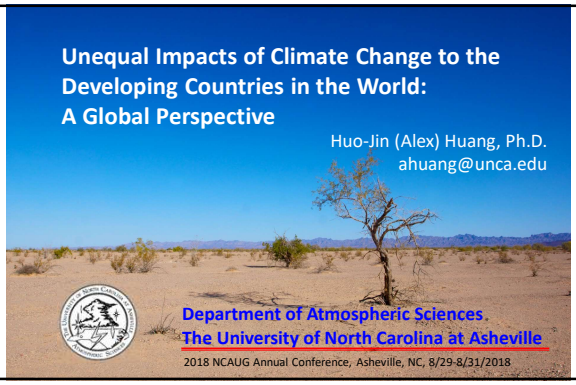
Data Sources:

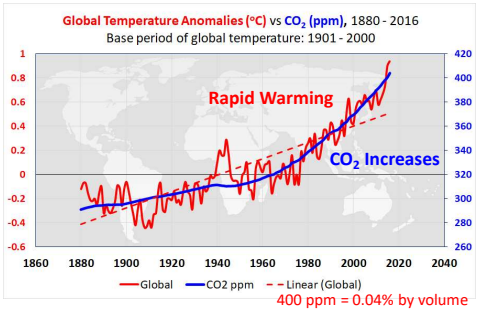
- World Bank: Population, Economy, Energy, Agriculture
- International Monetary Fund: Global economy
- US Energy Information Administration: Energy data
- International Energy Agency: Energy data
- Berkeley Earth: Climatic data of nations
- CIA: Background data of nations
- USGS: US satellite and DEM data
- National Weather Service GIS Portal: Maps and data
- NCEI: IBrTCS (Global tropical cyclone data)
- SPC: US storm data (tornadoes, hails, and strong winds)
- WorldClimate: IPCC Climate Model Forecast data
- Drought Monitor: US drought data and maps
- National Snow and Ice Data Center: Iceberg data
- NCSU Library: NC County DEM data
- GSFC/NASA: NDVI data
- Open Source GIS data/Maps



Research Projects:

- Global economy
- Global carbon dioxide emission
- Global Climate Change Vulnerability Index (CCVI)
- Global energy production and consumption
- Tropical cyclone statistics
- Storm data statistics
- Rainfall patterns in Western North Carolina
- Case studies of individual tropical cyclones
- Mapping of US droughts
- Iceberg distribution and its relationship with NAO
- Changes in NDVI (greenness) in Western North Carolina
- Rainfall patterns in Taiwan by typhoons
- Climate change in North and South Carolina

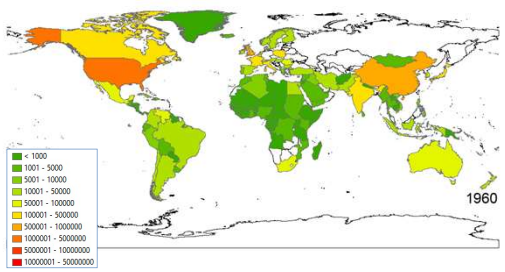




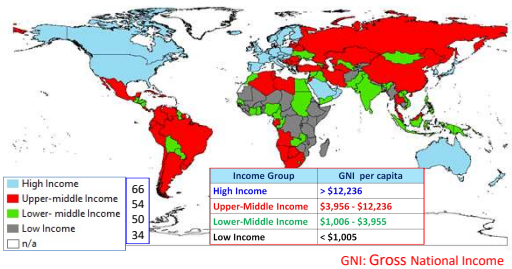
400 ppm = 0.04% by volume

Data from http://www.ncdc.noaa.gov/monitoring-references/faq/anomalies.php#anomalies

Annual Carbon Dioxide Emissions (kilo tons), 1960 - 2014



Income Groups of World's Countries

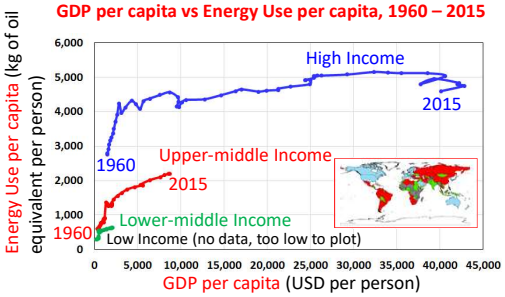


Income Group	GNI per capita
High Income	> $12,236
Upper-Middle Income	$3,956 - $12,236
Lower-Middle Income	$1,006 - $3,955
Low Income	< $1,005

GNI: Gross National Income

Most poor countries are in Africa and Southeastern Asia.

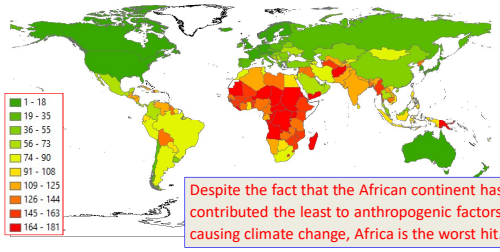
GDP per capita vs Energy Use per capita, 1960 – 2015



High Income countries become more energy-efficient in growing economy but the trend has **plateaued out**. Upper-middle Income countries grow rapidly in economy and **demand** more energy.

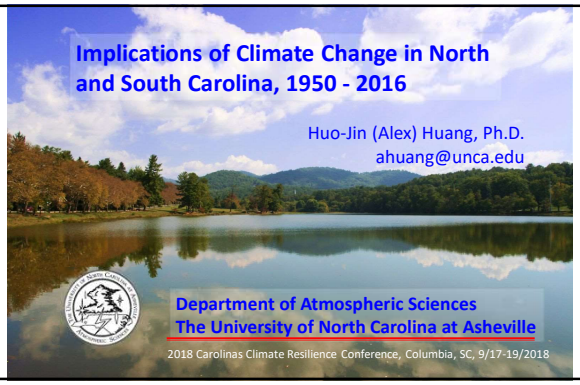
Climate Change Vulnerability Index (CCVI) Ranking

African and developing countries are most vulnerable

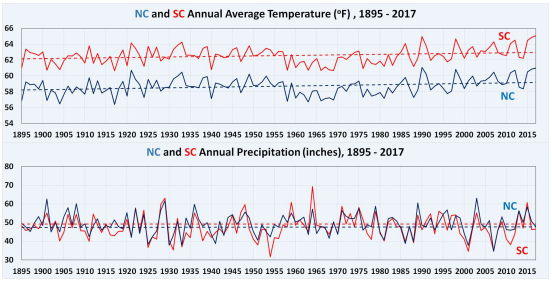


Despite the fact that the African continent has contributed the least to anthropogenic factors causing climate change, Africa is the worst hit.

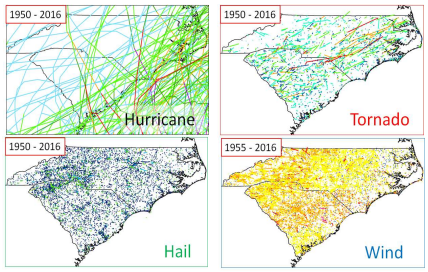
Data from the University of Notre Dame Global Adaptation Initiative (ND-GAIN)
https://gain.nd.edu/our-work/country-index/

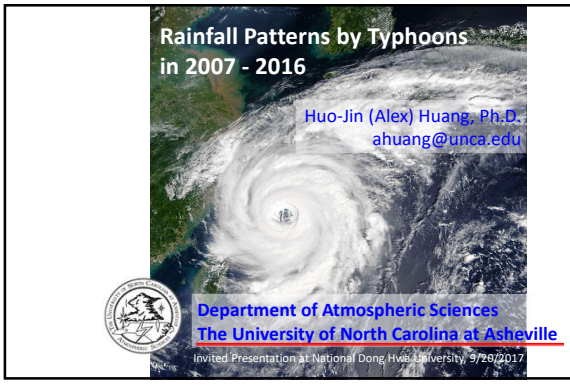


Annual Temperature and Precipitation in North and South Carolina, 1895 - 2017



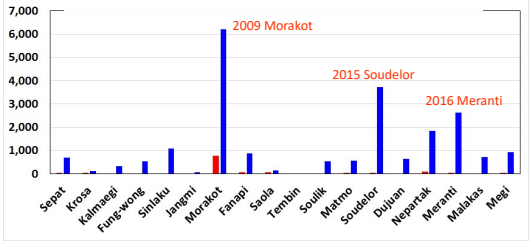
Severe Weather Events in North and South Carolina 1950 - 2016



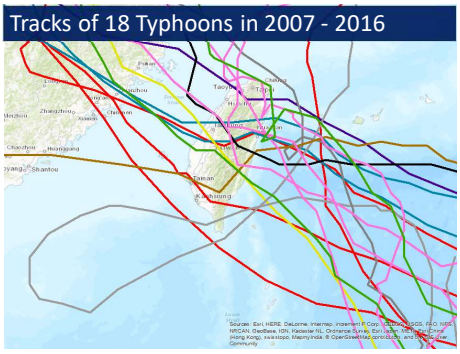


18 Landfalling Typhoons during 2007 – 2016 were selected for the study

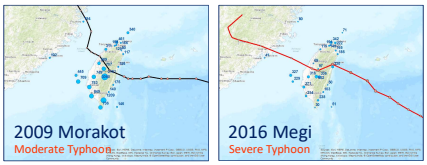
Fatalities and Property Damage (in millions of USD)



Tracks of 18 Typhoons in 2007 - 2016



Rainfall Patterns by Typhoons in 2007 - 2016

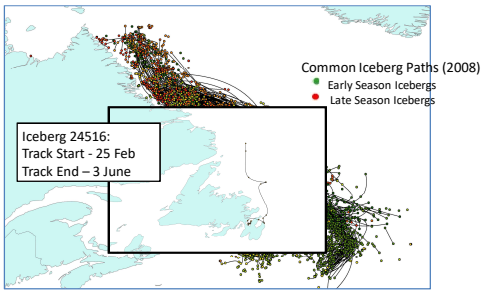


- **Slow-moving** typhoons cause most destruction and fatalities;
- Due to the counterclockwise circulation of a typhoon, the **windward side** (the side facing the wind) of mountains receive most precipitation; and
- The **Central Mountain Range** plays a critical role in producing precipitation.

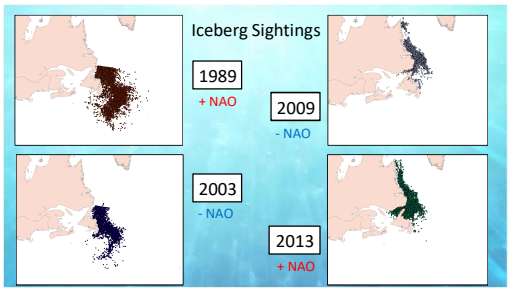
Inter-Relationship of Labrador Iceberg Data To Northern Atlantic Oscillation

Douglas March
Department of Atmospheric Sciences
University of North Carolina at Asheville

2018 UNCA Fall UGR Symposium, December 4, 2018



Data from NSIDC 2018



Data from NSIDC 2018

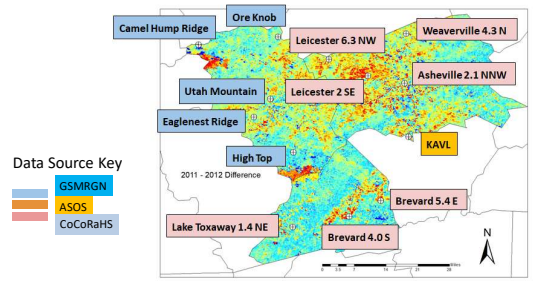
Change in Vegetation Growth and its Correlation with Precipitation Types in Western North Carolina Counties

Meredith Avison, Jacob Blankenship, Andrew Hill, and Graham Walker*

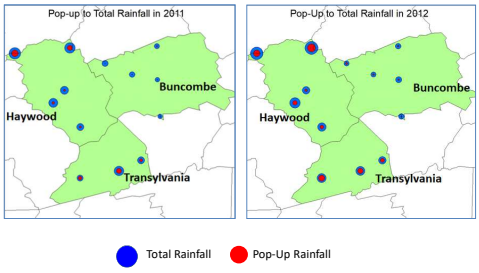
Departments of Atmospheric Sciences and Environmental Studies*
University of North Carolina at Asheville

2018 UNCA Fall UGR Symposium, December 4, 2018

2011-2012 change of the NDVI differences (for site selection)



More pop-up thunderstorms occur in Haywood and Transylvania counties



Reflections

- **GIS** is **powerful** and **complex;**
- **Time demanding** and **labor intensive**;
- **Lab assignments** together with lectures are a must;
- Integrating both **MS Excel** and **ArcGIS** in teaching undergraduate research is critical.

Summary

- **Student learning** experience;
- Incorporating **MS Excel** and ArcGIS;
- Additional training (**Python** programming and statistics);
- A sequence of **two GIS courses** may be more beneficial to students;
- Collecting more **applicable data** and re-designing **lab assignments.**

Using GIS to Conduct Undergraduate Meteorological Research

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