Using economics and climate science as instruments for climate change education (CCE) in rural communities: learnings from Tennessee and Kentucky

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Agenda

- ✓ Introduction
- ✓ Climate change – what's the big concern about?
- ✓ Climate change Education (CCE): existing gaps and solutions
- ✓ The Takeaways

Problem statement

- Pressure on current agricultural production systems in the event of a changing climate.

- U.S agricultural industry a major player in the world food market – climate related implications for both domestic and the global food supply and security.

- Existing situation in the U.S regarding climate change understanding and knowledge – lack of clear understanding of the basics of climates and climate change.

The role of Ag. Universities

- Climate change education emerges a crucial area for K-12 educators, students, college students and agricultural communities.

- Initiatives in climate change education at strategically located universities in rural areas is of profound importance to design adaptive strategies to adjust to a changing climate in the respective regions.

Past efforts: The UTM-Mobile Energy Classroom

Current focus

UT Martin-Murray State CCE Initiative

Education

- Curriculum Design, Materials Development, Library Resources and Instruction Delivery Systems
- Student Recruitment and Retention
- Student Experiential Learning
- Professional Development for Educators

Research

- Studies and Experimentation in Food and Agricultural Sciences
- Collaborative Interaction with Other Institutions for Research on Climate Change Impacts on Rural Communities
- Research Opportunities for Students in the Area of Climate Change

Outreach

- Leadership Development
- Community and Economic Development
- Increase awareness about the science of climate and climate change in rural communities via presentations, club meetings, and workshops

Purpose and objectives

- Designed to **introduce climate science to agricultural interests** in West Tennessee and Western Kentucky
- Designed to **introduce climatology and meteorology curriculum** to area high schools, colleges, and universities
- Designed to provide **workshops in climate education** for educators, people involved in agribusiness, and the general public
- Designed to build **capacity for future research** in climate science in the region

Program Sponsor: USDA: National Institute of Food and Agriculture
Program Name: Capacity Building Grants for Non-Land Grant Colleges of Agriculture

What the curricula is *not* about

Arguing for or against "global warming"

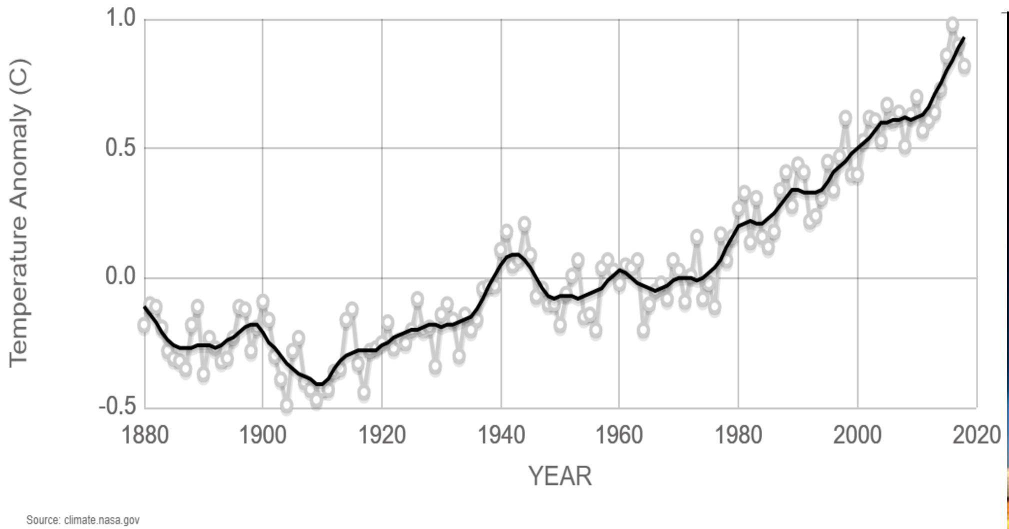
Pushing any sort of political agenda

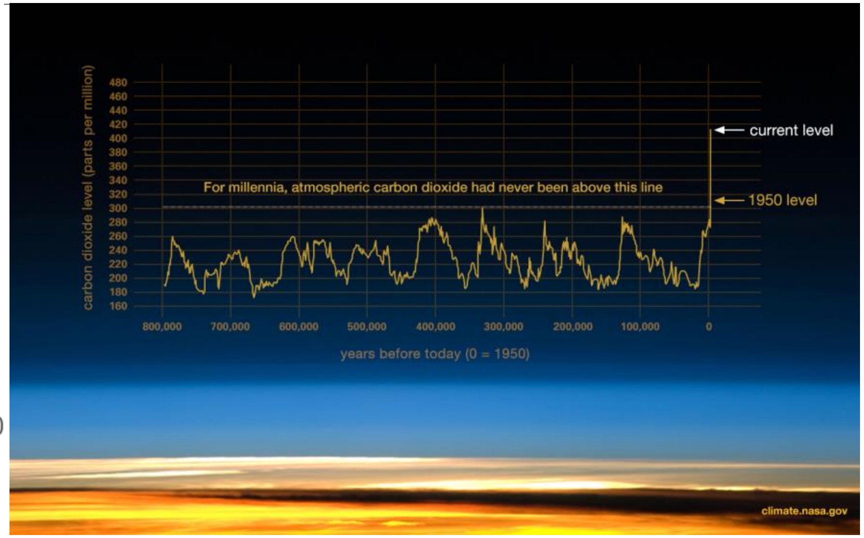
"It was commissioned in the 1890s by climate scientists."

http://capewest.ca/cartoon_commentary.html

Thompson, 2016 in: http://www.globalwarming.mamorllc.com/climate-change-debate-clinton-trump-differ-on-global-warming-special-report/

Climate is a bit trendy….what's the big concern?





Relative to the 1951-1980 average, 18 of the 19 warmest years all have occurred since 2001

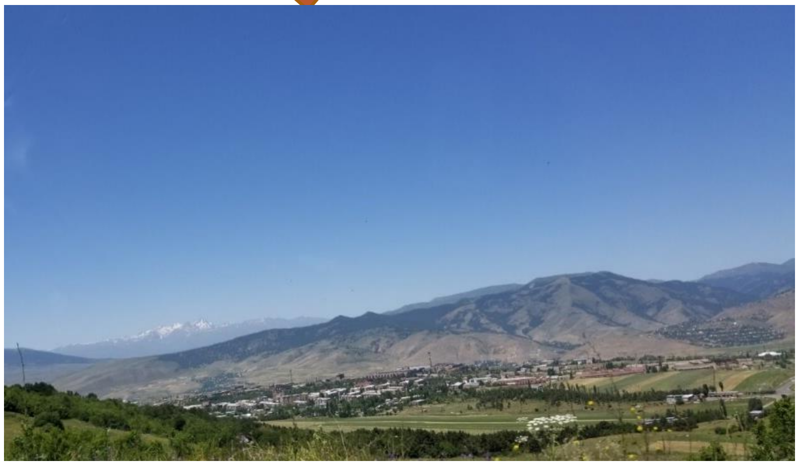
2016 ranks as the warmest on record (Source: NASA/GISS)

Stark increase in CO_2 concentrations attributed to human/anthropogenic activity particularly after 1950

Meeting the National Standards

Agriculture

- NRS.01.03. Apply ecological concepts and principles to atmospheric natural resource systems.
- NRS.01.03.01.a. Classify different kinds of biogeochemical cycles and the role they play in natural resources systems.
- NRS.01.03.01.b. Assess the role that the atmosphere plays in the regulation of biogeochemical cycles.
- NRS.01.03.01.c. Evaluate and make recommendations to lessen the impact of human activity on the ability of the atmosphere to regulate biogeochemical cycles.
- **NRS.01.03.02.a.** Research and summarize how climate factors influence natural resource systems.
- **NRS.01.03.02.b.** Analyze the impact that climate has on natural resources and debate how this impact has changed due to human activity.
- **NRS.01.03.02.c.** Assess the primary causes of climate change and design strategies to lessen its impact on natural resource systems.



Kentucky Includes Climate Change as a Standard

Kentucky wants students to critically assess geoscience data and results from climate models to *"make an evidence-based __forecast__ of the rate of global or regional climate change and associated future impacts to Earth systems"*

Kentucky Department of Education

HS. Weather and Climate – Continued

HS. Weather and Climate

Students who demonstrate understanding can:

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS3-5) --------------------------------------- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5) • New technologies advance scientific knowledge. (HS-ESS3-5) **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. (HS-ESS3-5) • Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4), (HSESS3-5)	**ESS1.B: Earth and the Solar System** • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary to HS-ESS2-4)* **ESS2.A: Earth Materials and Systems** • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4),*(secondary to HS-ESS2-2)* • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4) **ESS3.D: Global Climate Change** • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4) **Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-5)

Connections to other DCIs in this grade-band: **HS.PS3.A** (HS-ESS2-4); **HS.PS3.B** (HS-ESS2-4),(HS-ESS3-5); **HS.PS3.D** (HS-ESS3-5); **HS.LS1.C** (HS-ESS3-5); **HS.LS2.C** (HS-ESS2-4); **HS.ESS1.C** (HS-ESS2-4); **HS.ESS2.D** (HS-ESS3-5); **HS.ESS3.C** (HS-ESS2-4); **HS.ESS3.D** (HS-ESS2-4)

Articulation of DCIs across grade-bands: **MS.PS3.A** (HS-ESS2-4); **MS.PS3.B** (HS-ESS2-4),(HS-ESS3-5); **MS.PS3.D** (HS-ESS2-4),(HS-ESS3-5); **MS.PS4.B** (HS-ESS2-4); **MS.LS1.C** (HS-ESS2-4); **MS.LS2.B** (HS-ESS2-4); **MS.LS2.C** (HS-ESS2-4); **MS.ESS2.A** (HS-ESS2-4),(HS-ESS3-5); **MS.ESS2.B** (HS-ESS2-4); **MS.ESS2.C** (HS-ESS2-4); **MS.ESS2.D** (HS-ESS2-4),(HS-ESS3-5); **MS.ESS3.B** (HS-ESS3-5); **MS.ESS3.C** (HS-ESS2-4),(HS-ESS3-5); **MS.ESS3.D** (HS-ESS2-4),(HS-ESS3-5)

Kentucky Academic Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-5)

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. *(HS-ESS3-5)*

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ESS3-5)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-ESS2-4)*

Mathematics –

MP.2 Reason abstractly and quantitatively.(HS-ESS2-4),(HS-ESS3-5)

MP.4 Model with mathematics. (HS-ESS2-4)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-4),(HS-ESS3-5)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4),*(HS-ESS3-5)*

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-4),(HS-ESS3-5)

Tennessee Includes Climate Change as a Standard(!)

- Note that Tennessee's standards regarding Climate Change
  are not as specific as Kentucky's

- Tennessee Science Standards – especially for High School students are **environmental science-course** based

ENVIRONMENTAL SCIENCE: COURSE OVERVIEW

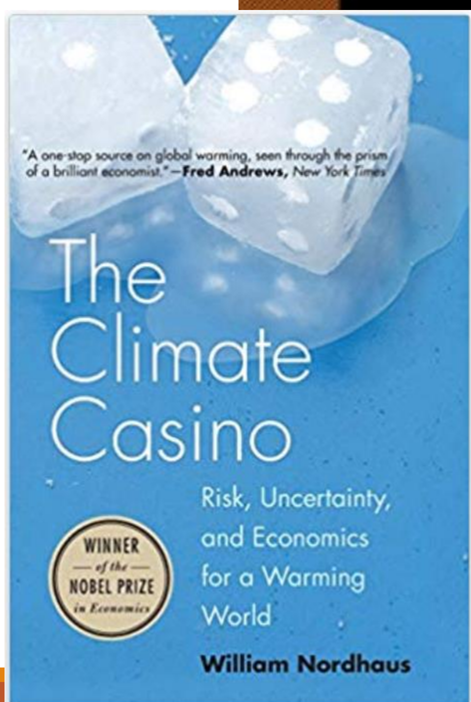
The academic standards for Environmental Science establish the content knowledge and skills for Tennessee students necessary to prepare them for the rigorous levels of higher education and future job markets. The course provides students with an opportunity to develop an understanding of interrelationships in the natural world. In addition, it allows them to identify natural and man-made environmental problems and design and evaluate possible solutions for these problems. The academic standards for Environmental Science are research-based, supported by the National Research Council's *Framework for K-12 Science Education*. The standards establish the core ideas and practices of science and engineering that will prepare students to use scientific thinking to examine and evaluate knowledge encountered throughout their lives.

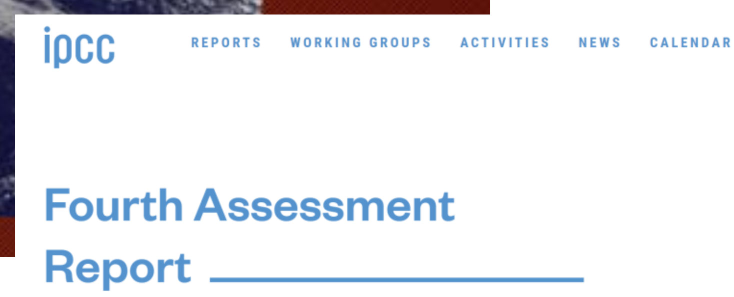
The major disciplinary core ideas utilized for Environmental Science include:

Environmental Science (EVSC)		
Life Sciences (LS)	Earth and Space Sciences (ESS)	Engineering, Technology, and Applications of Science (ETS)
From Molecules to Organisms: Structures and Process	Earth's Place in the Universe	Engineering Design
Ecosystems: Interactions, Energy, and Dynamics • Interdependent relationships in ecosystems • Cycles of matter and energy transfer in ecosystems • Ecosystems dynamics, functioning, and resilience	Earth's Systems • Earth materials and systems • Plate tectonics and large scale system interactions • The roles of water in Earth's surface processes • Weather and climate	Links Among Engineering, Technology, Science, and Society • Interdependence of science, engineering, and technology • Influence of engineering, technology, and science on society and the natural world
Heredity: Inheritance and Variation of Traits	Earth and Human Activity • Natural resources • Natural hazards • Human impacts on Earth systems • Global climate change	Applications of Science • Importance of science practices in understanding the natural world
Biological Change: Unity and Diversity • Natural selection • Adaptation • Biodiversity and humans		

Addressing the gap through curriculum development….

Derived information from resources such as…





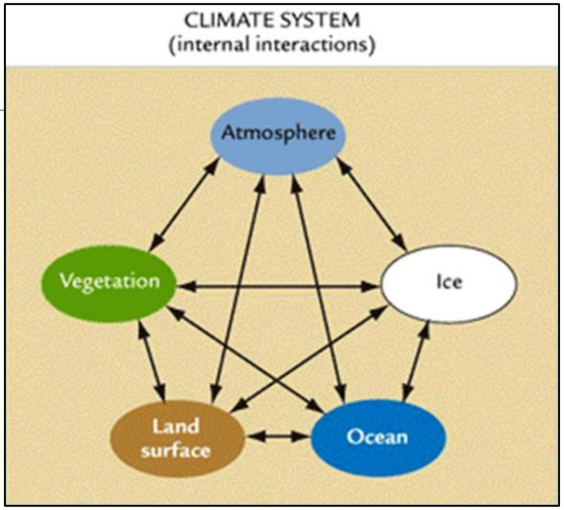
to create web-based courses in…

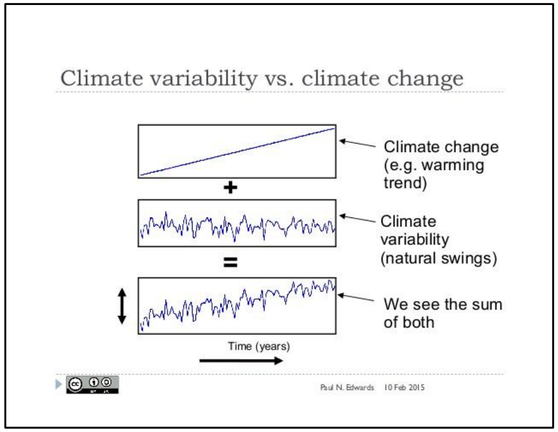
Climate science

- Describes the climates that we currently have
- Explains and discusses the factors controlling the climates that we have
- Describes the basic chemistry and physics behind the factors controlling the climates that we have

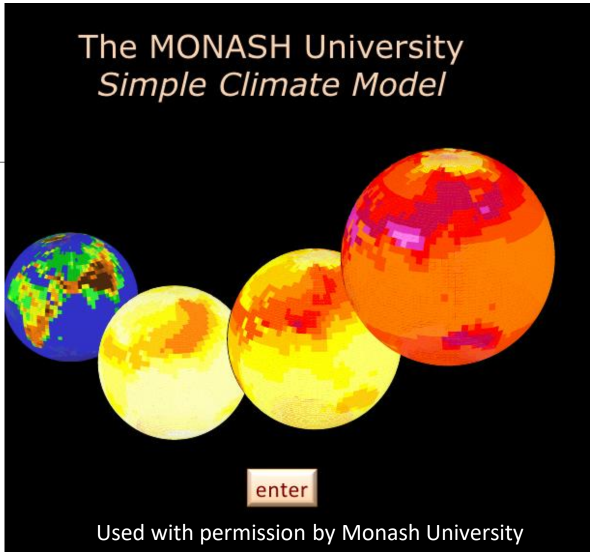
Climate change VS climate variability

- Describes the difference between climate change and climate variability
- Explains the natural and anthropogenic causes of climate change
- Explains what “teleconnections” are and describes and explains many of the major ones and their contributions to overall climate variability





to create web-based courses in…

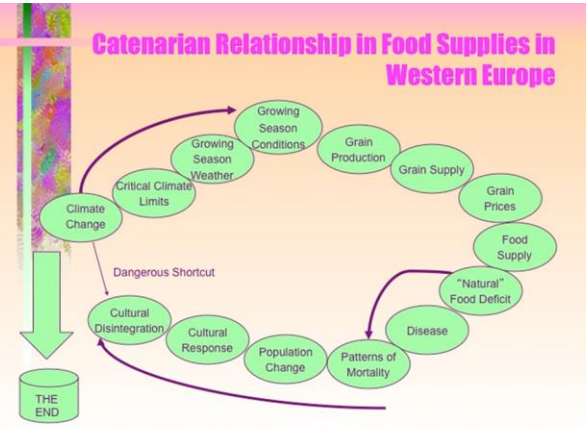


Climate modeling

- Describes different types of models
- How the models are constructed
- How the models are used
- In more advanced courses, this content will include having students build a simple climate model

Economic impacts of climate change

- An applied approach to the use of climate information on agricultural interests
- How climate models are applied to the assessment of the future of agricultural interests



Climate change mitigation and policy

- Strategies on developing mitigation strategies in agriculture in the event of climate variability VS climate change

Voice over modules with learning assessments

Course Title:
Economic impacts of climate change

Module 1: Observed and projected climate changes in Southeast U.S (including Tennessee/ Kentucky)

Dr. Rachna Tewari

The University of TN- Martin

The UT Martin-Murray State Climate Change Education Initiative is funded by the Capacity Building Grants for Non-Land Grant Colleges of Agriculture Program (NLGCA), United States Department of Agriculture, National Institute of Food and Agriculture (PROJ NO: TENW-2016-06721).

Curriculum progress

- **Dual-credit course modules delivered online** via Racer Academy and the traditional Agriculture 199 course on Murray State's Campus (2018)

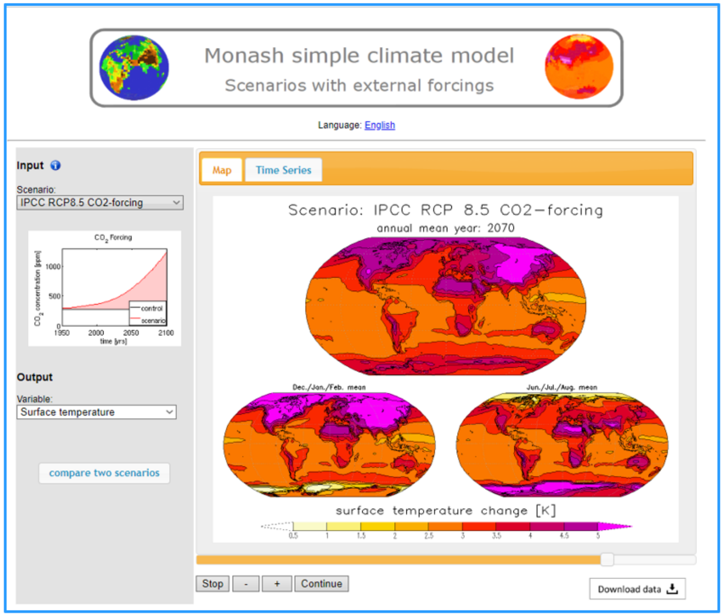
- **Curriculum revision** (2018) - Geoscience Major/Meteorology Concentration at UTM to include 2 new courses designed as electives to Ag, Geosciences, and Natural Resources UG programs:
  - METR 160 – AgriWeather
  - METR 425 – Agricultural Meteorology and Climatology

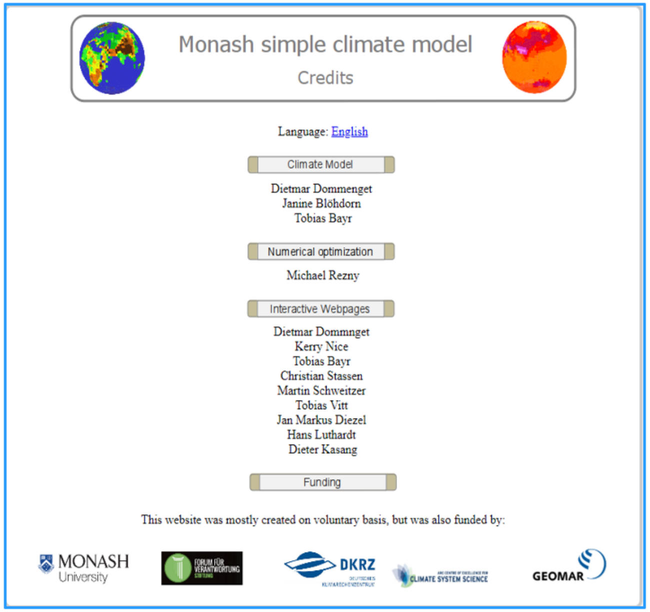
- NRM 755 – **Graduate level Global Climate Change Course** as elective in the Master of Science in Agriculture and Natural Resources at UTM (2018)

Workshops

- Designed to walk participants through the five areas of climate change analysis
  - Science
  - Variability vs Change
  - Climate Modeling
  - Economic Impacts
  - Mitigation Strategies
  - Policy Development
- Open to High School and University Educators, Agricultural Specialists, General Public
- Climate change related educational activities, stabilization wedges games

Workshops on climate models





- Course Material and Information on Climate Change Information provided to high school educators at the **Kentucky Agriculture Teacher's Conference** (2018)
- Climate Change Workshop for Agriculture Educators during the **West Tennessee FFA Livestock Evaluation Contest** (2018)

Highschool events – climate wedges game

Wedge Stabilization Strategies:
They don't include agriculture (except maybe soil storage)!

Wedge Strategies Currently Available

The following pages contain descriptions of 15 strategies already available that could be scaled up over the next 50 year to reduce global carbon emissions by 1 billion tons per year, or **one wedge.** They are grouped into four major color-coded categories:

Efficiency & Conservation
- Increased transport efficiency
- Reducing miles traveled
- Increased building efficiency
- Increased efficiency of electricity production

Fossil-Fuel-Based Strategies
- Fuel switching (coal to gas)
- Fossil-based electricity with carbon capture & storage (CCS)
- Coal synfuels with CCS
- Fossil-based hydrogen fuel with CCS

Nuclear Energy
- Nuclear electricity

Renewables and Biostorage
- Wind-generated electricity
- Solar electricity
- Wind-generated hydrogen fuel
- Biofuels
- Forest storage
- Soil storage

Each strategy can be applied to one or more sectors, indicated by the following symbols:

= Electricity Production, =Heating and Direct Fuel Use, =Transportation, = Biostorage

3

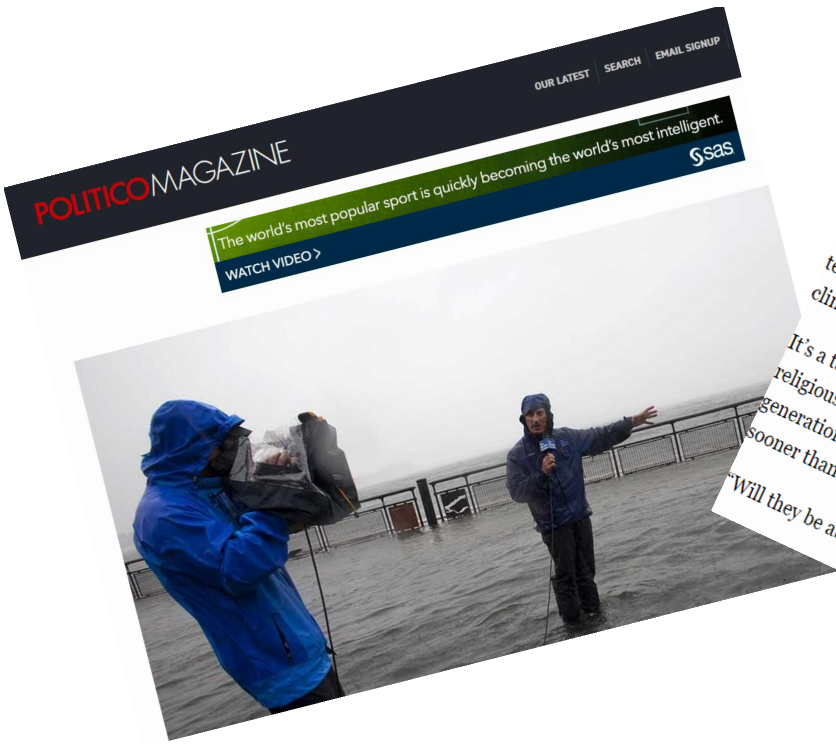
Local/regional/national events

Student involvement

Student workers to assist with research, course development and workshops focusing on climate change.

Media

- Media interviews on the grant and climate change



"They see it firsthand," Robert Mark Simpson, a professor of geography at the University of Tennessee at Martin, told me. "There is a sort of acknowledgment that the climate is changing. They just don't think humans are that impactful. [They think blaming humans is] a conspiracy to overthrow the U.S. economy."

Simpson attended the conference at the Phoenix Convention Center to outline his three-year effort to educate farmers about climate change in western Tennessee and eastern Kentucky, where at some dinner tables the term remains a political curse word. Tennessee just elected a leading climate change doubter, Marsha Blackburn, to the U.S. Senate.

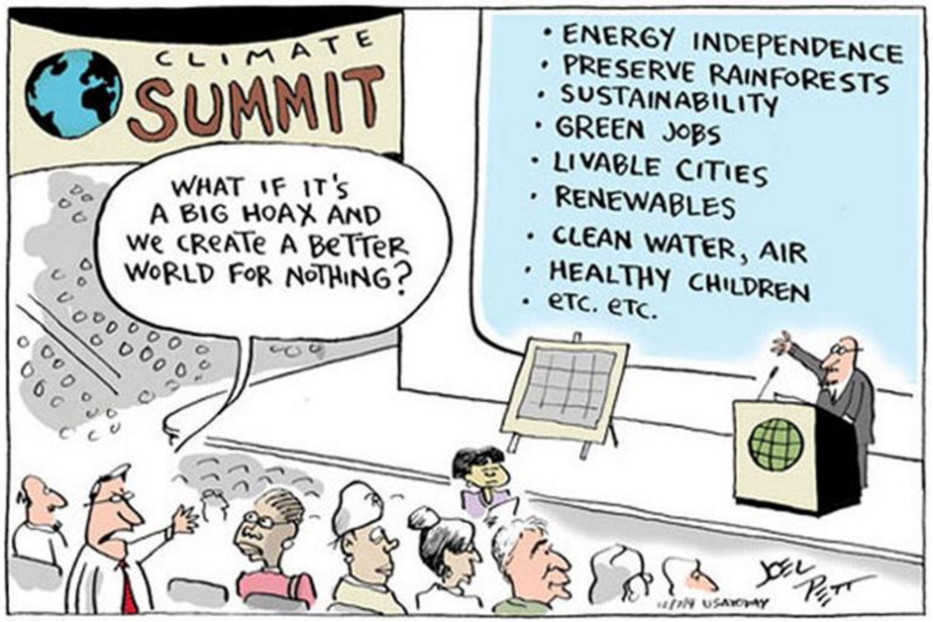
It's a tall order. So, he is also trying another tack to reach the political and religious conservatives for which farming has been in the family for generations: warning that the family business might be in jeopardy—sooner than they might think.

"Will they be able to farm here 30 to 40 years from now?"

Potential Research Questions

- How does climate change impact west Tennessee and western Kentucky farmers in terms of expected yields, etc.?
- What is the **willingness to pay** for projects to reduce carbon emissions?
- How does global climate variability and change affect **crop and livestock prices** of interest to this region?
- How does climate change affect **water resource availability and associated costs and benefits**?
- Do air quality changes (ozone, particulates, etc.) play a role in the quality and quantity of crop yields and in livestock health?

The Takeaways



- *Be a resource for info on climate and climate change*
- *Enhance school and college curriculum in climate change*
- *Build research capacity for answering fundamental questions on climate change to agricultural and general interests in our region*

Thank you!

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