Prospects for a Low Carbon Economy: Climate Change, Agriculture and the Rest

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Policymaking under Wicked Uncertainty

Climate Change, Climate Science and Economics

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Outline

1. Mitigate or Adapt?
   - Can we lower global carbon dioxide emissions?
   - Energy sector: What are the prospects for a carbon neutral economy?
2. Agricultural mitigation: Should the agricultural sector produce carbon offset credits?
3. Agricultural Adaptation:
   - Relationship between climate variables and yields (e.g., impact of fast-moving climate factors, such as ENSO and PDO, and slow-moving average changes in climate factors related to warming)
   - development of financial instruments relating to climate and weather.

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Mitigate or Adapt?

- Global emissions of greenhouse gases are rising at unprecedented rates on account of development in places like China.
- Consider the following graphs:

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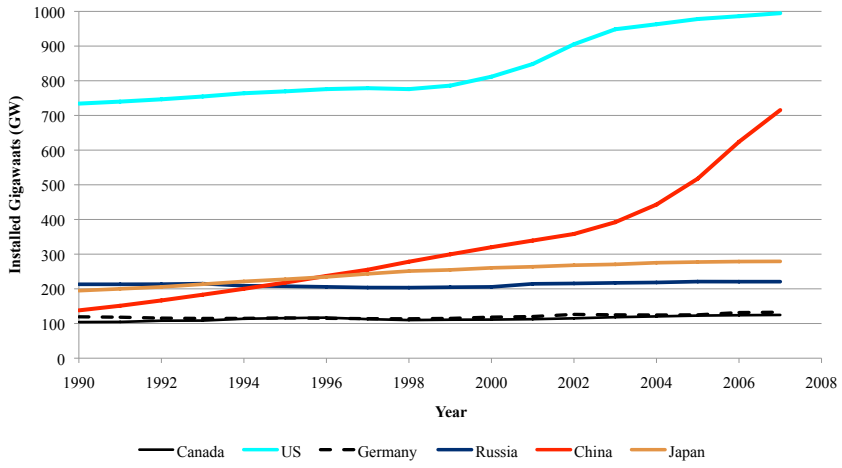
Installed Generating Capacity, 1990-2007



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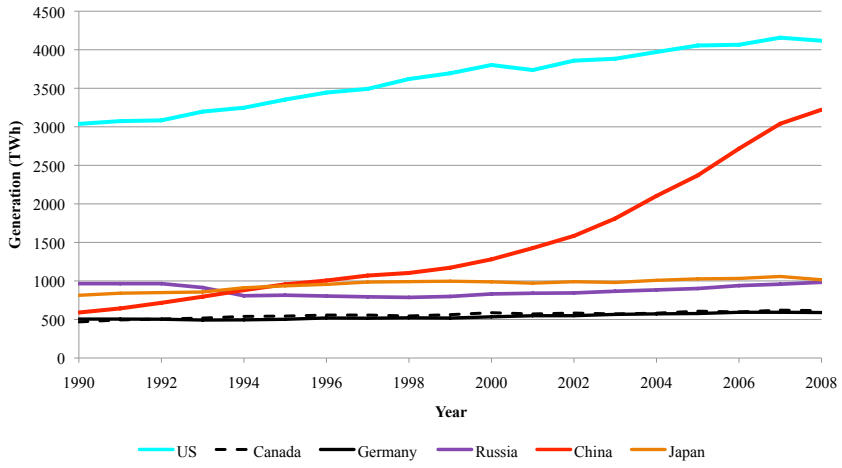
Power Generation, 1990-2008



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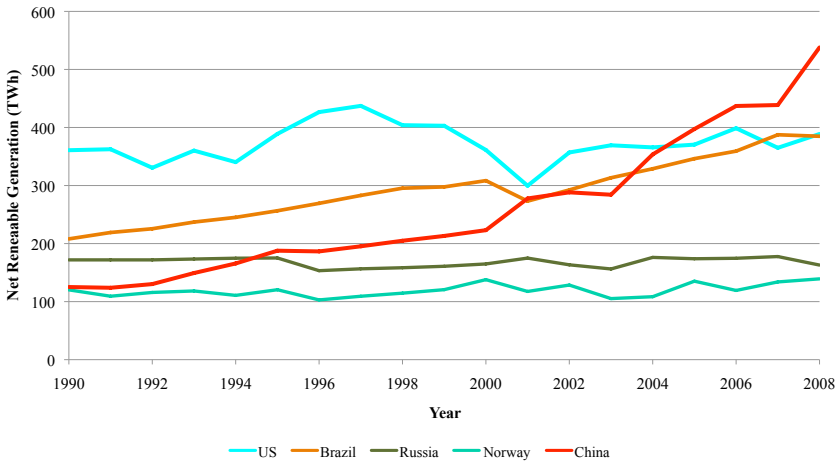
Net renewable generation, 1990-2008



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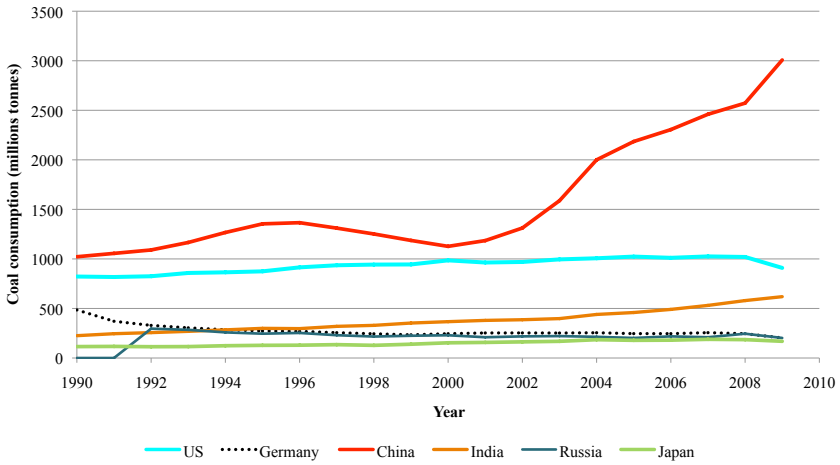
Coal Consumption, 1990-2009



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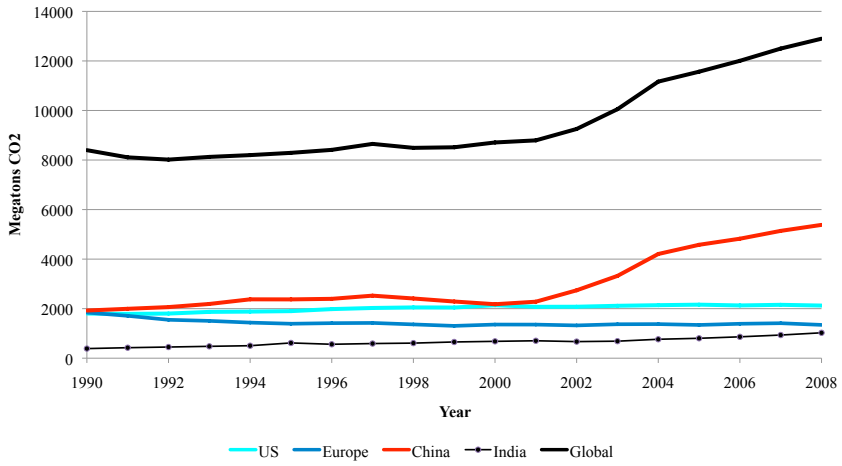
CO_2 Emissions from Coal, 1990-2008



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SUMMARY

- China is currently adding 1000 MW of installed coal-fired generating capacity every week (**max** Ontario load 27,500 MW)
- Chinese consumption of coal in 2009 exceeded the total consumption of Germany, Russia, India, Japan & the U.S. combined!
- Nothing the Americans do, nothing the Europeans do, nothing the Japanese or Russians do can prevent global warming.

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United Nations' Dilemma

Growth Objective:

UN's Millennium Development Goal (MDG) aims to halve number of people living below $1.25 per day by 2015. Target appears within reach because of economic growth in China.

Rich countries have agreed to pursue policies of economic development in poor countries so that their standards of living converge to those of the developed world.

UN FCCC's Special Report on Emissions Scenarios reflects this, and so do climate change predictions

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United Nations' Dilemma (cont)

Emissions Reduction Objective:

Rich countries have agreed via the Kyoto Process to de-carbonize the global economy.

Emissions of carbon dioxide are to be reduced by 50% by 2050, with rich countries agreeing to reduce their emissions by 80%.

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PROBLEM:
Energy is needed for economic development

- Fossil fuels are cheap and ubiquitous; mainly environmental regulations in rich countries prevent poor countries from accessing cheaper energy
- Renewable energy is not the answer. Problems include:
  - Intermittency
  - Low energy density of alternatives (e.g., weight of gasoline is 1% of battery for same energy; gasoline to hydrogen fuel is 10%)
  - Very high costs (coal, gas and oil are much cheaper than alternatives; even nuclear is much less costly than wind and solar)

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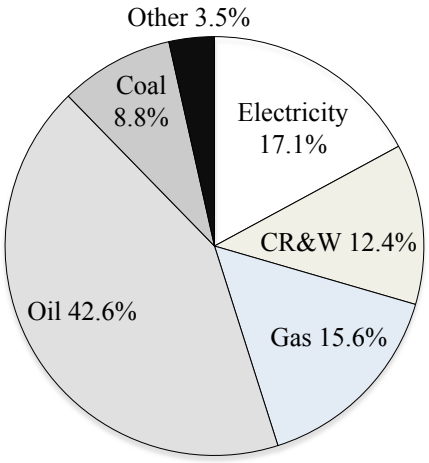
Final energy consumption comes from:



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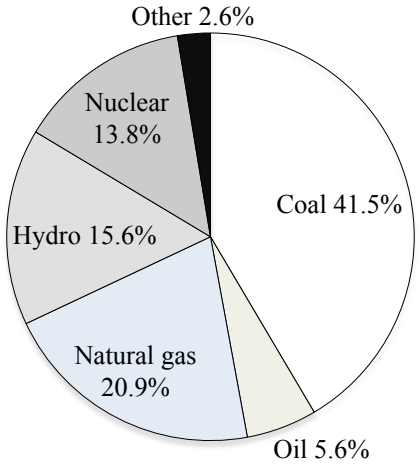
Global electricity is produced from:



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Energy Densities: Comparison of the Physical Area Required to Produce Energy from Selected Sources

Energy Source	Energy Density (W/m^2)	Index
Corn ethanol	0.05	1.0
Biomass-fuelled power plant	0.4	8.1
Wind turbines	1.2	24.6
Oil stripper well producing 2 barrels per day	5.5	115.4
Solar PV	6.7	138.5
Oil stripper well producing 10 barrels per day	27.0	577.0
Gas stripper well producing 60,000 ft^3/day	28.0	590.4
Average U.S. natural gas well, 115,000 ft^3/day	287.5	1105.8
Nuclear power plant[a]	56.0	1153.8

Source: Bryce (2010). [a] Based on a 4860 ha location in Texas

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Some Programs

- Europe requires countries to meet a 20% Renewable Energy Standard (RES) in generation of electricity by 2020.
- U.S. Senate attempted to pass a RES that would require 3% of electricity to be generated from renewable sources by 2012 and 15% by 2021
- Cost to Ontario of its feed-in tariff (FIT) program estimated at $2.4-$2.6 billion per year
- BC moving toward a carbon tax of $30 per tCO_2

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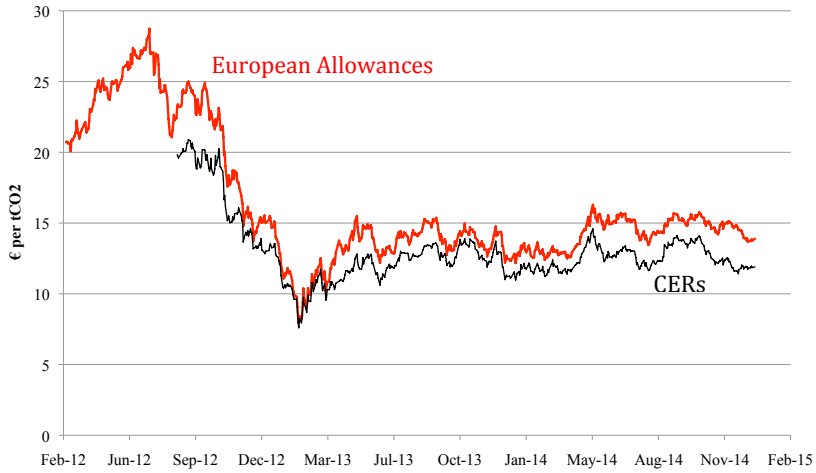
Carbon Prices (Before collapse of CCX: $0.10/$tCO_2$)



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Role of Agriculture in Mitigating Climate Change

- Does agriculture have anything to contribute to mitigation?
- If so, what form should such a contribution take?
- What are the potential costs to farmers?
- Consider
  - Reduced/conservation tillage (soil organic carbon)
  - Energy crops

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Consider conventional vs conservation tillage

Manley et al. (2005, *Climatic Change*): Two meta-analyses

1. Difference in carbon between conventional and no till agriculture (51 studies, 374 observations).
   Conclusion: it depends on depth to which soil carbon is measured; no real gain on Great Plains

2. Costs of practicing no till vs conventional tillage (52 studies, 536 observations): There are costs and, as a result, carbon uptake is expensive.

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Estimated net cost of sequestering carbon with no-till agriculture assuming permanent carbon storage (US$ 2010 per tCO_2)

		At Measured Depth of Soil	
Region	Crop	Shallow	Deep
South	Wheat	$3.4	$4.3
	Other crop	$0.7	$0.7
Prairies	Wheat	$127.2	∞
	Other crop	$49.8	$70.3
Corn belt	Wheat	$48.0	$63.0
	Other crop	$28.4	$29.2

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- Numbers in previous slide should be multiplied by a factor of 10 or more
- Why?
  - Values do not take into account ephemeral nature of sinks
  - Transaction costs of monitoring, contracting, etc. are not taken into account
  - Consider: Write a contract that pays a subsidy of $\$x$/ac if farmer goes to no-till but requires farmer to pay $\$x$/ac the moment tillage occurs. How many farmers would sign up?

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Energy Crops

Fuel type	Crop	Location	Kg C per GJ
Biodiesel	Rapeseed/canola	Europe	150.3
Ethanol	Sugar beet	Europe	100.3
Ethanol	Sugar cane	Latin America	82.3
Ethanol	Palm oil	SE Asia	73.6
Conventional diesel/gasoline (from refining process)			85.0

Increased demand for energy crops reduces cultivated area devoted to food production and increases conversion of forest/pasture to crops -- Searchinger et al. *Science* 319(2008): 1238-1240.

Leakages average 25% but as high as 93%

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Net Climate Warming Relative to Fossil Fuel CO_2 Savings

Crop	Biofuel	Nitrogen use efficiency 0.4	Nitrogen use efficiency 0.6	50% of N harvested for biofuels production replaces crops that need N fertilizer
Rapeseed (canola)	Bio-diesel	1.0-1.7	0.7-1.2	0.5 – 0.9
Maize (corn)	ethanol	0.9-1.5	0.6-1.0	0.4 – 0.7
Sugar cane	ethanol	0.5-0.9	0.4-0.6	0.3 – 0.4

Notes:
Climate warming occurs if values >1.0. Current nitrogen use efficiency is around 0.4.
Source: Derived from Crutzen et al. (2008)

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Adaptation in the Agricultural Sector

- Ricardian rent studies assumed adaptation on the part of farmers, but were used to examine costs of climate change
- Studies by Louise Arthur and her colleagues were among first to examine adaptation to climate by prairie farmers in Canada
- Studies ongoing but emphasis has been on mitigation:
  - global politics focused on mitigation
  - We do not know what to do

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How do we address adaptation in agriculture?

- Results from highly complex, highly speculative, General Circulation Models:
  - 32,000 grids (5° latitude × 2° longitude)
  - 20-50 atmospheric layers; 10 ocean / 3-5 terrestrial
  - 20 minute time intervals
  - Ad hoc surface interface between atmosphere and the ocean/terrestrial components
- GCM results are adjusted to obtain regional predictions of temperature/precipitation
- The better models are able to track past climate, less suitable they are for predicting future climate

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- Regional climate models disagree on regional temperature and especially precipitation predictions
- Climate models are driven by emission scenarios derived from economic models that include projections of future developments in agriculture
- Then agricultural economists design models that take predictions of future regional temperatures & precipitation, develop various potential scenarios for 2020, 2050, etc. and suggest ways we might adapt (e.g. encourage more irrigation works, plant corn not wheat)

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A suggested research agenda

- Past climate in Canada can be our guide
- Certain non-global warming climate events already impact Canadian agriculture, but these have hardly been investigated
  - CWB has done some work showing that yields can be predicted by El Niño events
  - Alberta Environment commissioned a report (2004)
  - Even a 2010 paper linking El Niño type of events to futures grain prices (*J of Materials & Processes*?)
  - Cal Turvey has written about weather derivatives that can also help in adaptation

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What are the climate events that have nothing to do with anthropogenic emissions of greenhouse gases? OR
Why does the Farmers' Almanac outpredict the UK Met Office?

- Pacific Decadal Oscillation (PDO)
- Southern Oscillation Index (SOI)
- El Niño and La Niña
- North Atlantic Oscillation (NAO)
- Teleconnectivity index

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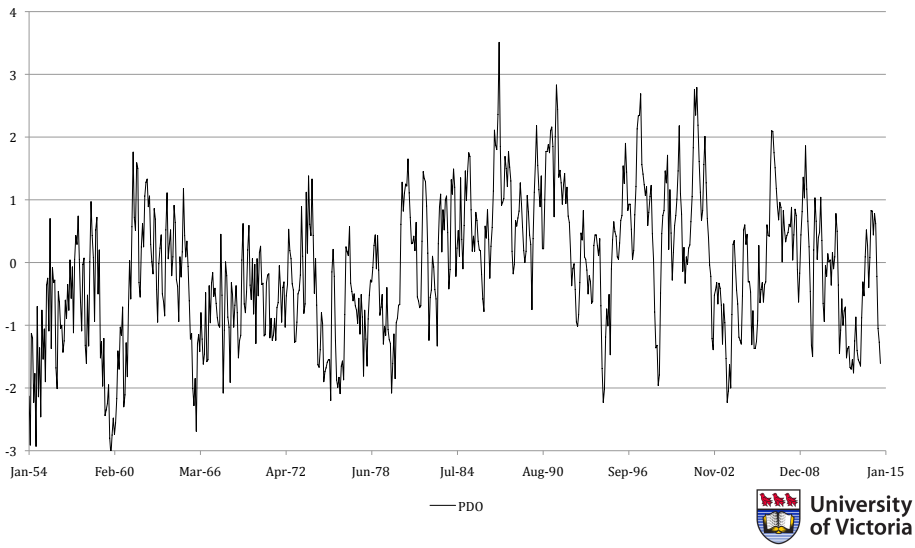
PDO by Month (Anomaly deg C)



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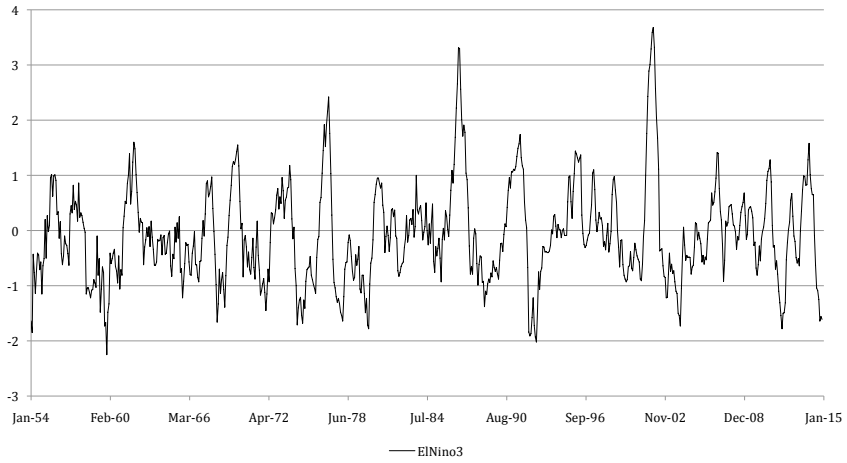
El Nino3 (anomaly deg C)



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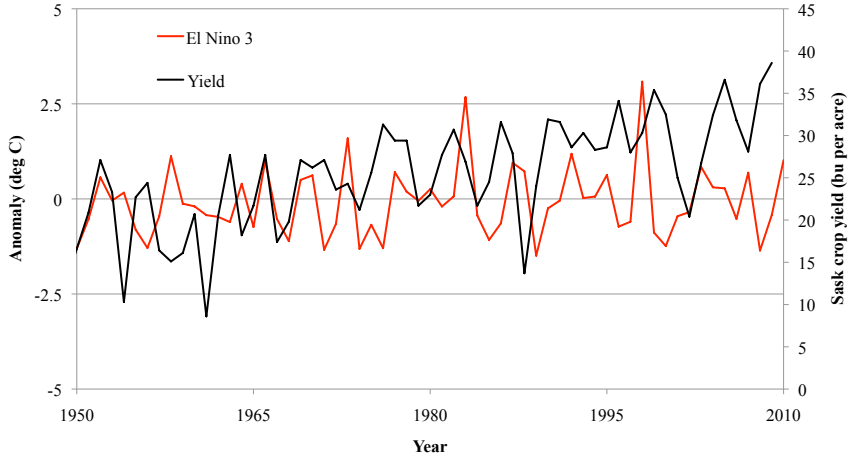
October through March ElNino3 plotted with Average Saskatchewan Crop Yields



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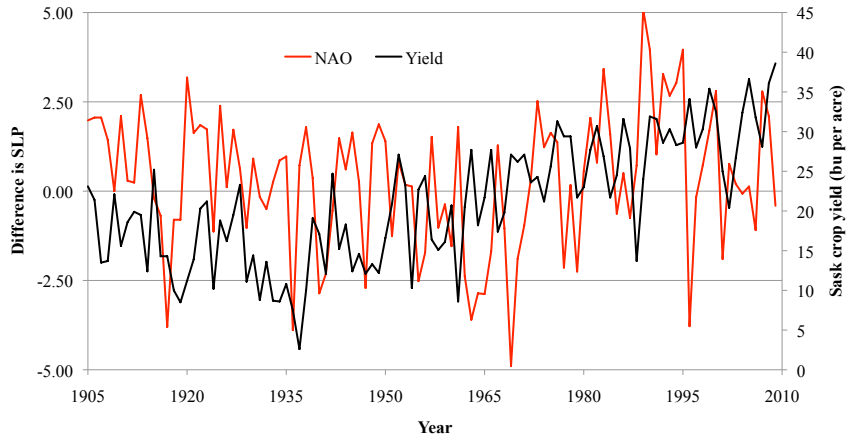
December through March (Winter) index of the NAO: Difference of normalized sea level pressure (SLP) between Lisbon, Portugal & Stykkisholmur/Reykjavik, Iceland.



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What needs to be done? (Partial list)

- Determine if climate indices affect yields.
  - If so, how can we use that information in management (e.g., whether to plant winter wheat)
- Determine if climate indices affect futures prices of grains
- Do climate indices impact the available weather derivatives (e.g., cooling/heating degree days traded on CME)?
- Can climate indices be used for crop insurance or weather derivatives?

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QUESTIONS?

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