Climate Change Risk Analysis (Spring 2016)

16:460:571 / 16:107:571 / 34:970:663

Thursdays, 1:10pm-4:10pm, Civic Square Building 168

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Catalog Course Description: Science, economics and public policy of climate change risks. Extreme events, sea-level rise, agriculture, energy, health, labor, crime and violence, supply chain disruptions, ecosystem services, tipping points. Global and regional climate modeling, integrated assessment modeling, decision-making under uncertainty and with long time horizons. Climate change adaptation and resilience.

Extended Course Description (subject to revision)

From Superstorm Sandy to the most extensive drought since the 1930s: in 2012, the hottest year on record in the contiguous United States, weather- and climate-related disasters cost Americans more than $110 billion. As climate change intensifies over the course of the century, climate models project that heat waves will become more frequent and intense and that intense downpours will become more common. Sea level rise will increase the flooding associated with storm events. If greenhouse gas emissions continue unabated through the end of the 22nd cenutry, significant parts of the eastern United States may become physiologically uninhabitable during the hottest days of the summer. This graduate course will examine the natural science, impact science and economic literature on the uncertainties and risks associated with climate change, and the challenges of linking together research in these disciplines.

Student Expectations (subject to revision)

Students are expected to (1) attend all class sessions and participate in discussions; (2) rotate through leading discussions; and (3) contribute to a team preparing a proposal for a climate risk assessment.

Grading (subject to revision): 30% final proposal, 40% discussion participation, 30% discussion leading

Academic Integrity

All students are responsible for upholding the highest standards of student behavior, as specified under the University Code of Student Conduct (http://studentconduct.rutgers.edu/), including but not limited to strict adherence to the terms of the University's Academic Integrity Policy (http://academicintegrity.rutgers.edu/). Plagarism is not acceptable on any assignment; on collaborative assignments, all group members are responsible for ensuring the integrity of all group products.

Course Topics (subject to revision)

This list of subjects will be revised based upon student interests.

1. Introduction

2. Socio-economic projections
3. Global and regional climate modeling
4. Extreme events
5. Sea level rise and coastal climate change impacts
6. Energy
7. Agriculture and forestry
8. Benefit-cost analysis and decision-making under uncertainty
9. Civil conflict and human migration
10. Adaptation and resilience
11. Ecosystem services
12. Tipping points and the long-term

Not covered in 2016:

13. Health and labor
14. Supply chains
15. Financial risk
16. Concepts of risk
17. Climate risk communications

Readings

The leaders of each class session should look over these and other candidate readings two weeks before their assigned date, and confer with the instructors to finalize the list. Note that the final list of selected readings should strike a balance between review articles and articles describing specific analyses. Please see also the list of additional possible references later on in the syllabus.

January 28 - Introduction

Risky Business Project (2014) report. www.riskybusiness.org

Houser et al. (2015). *Economic Risks of Climate Change: An American Prospectus*. Columbia University Press.– Preface and ch. 1-5. (Available online at climateprospectus.org)

Dell, M., Jones, B. F., & Olken, B. A. (2014). What Do We Learn from the Weather? The New Climate–Economy Literature. *Journal of Economic Literature*, *52*(3), 740-798.

February 4 - Socio-economic projections

Edmonds, J., & Reilly, J. (1983). Global Energy and CO2 to the Year 2050. The Energy Journal, 4(3), 21-48. (and skim Edmonds, J., & Reilly, J. (1983). A long-term global energy-economic model of carbon dioxide release from fossil fuel use. Energy Economics, 5(2), 74-88.)

Nordhaus, W. D. (1992). An Optimal Transition Path for Controlling Greenhouse Gases. Science, 258, 1315-1319.

Moss, R. H., Edmonds, J. A., Hibbard, K. A., Manning, M. R., Rose, S. K., van Vuuren, D. P., ... & Wilbanks, T. J. (2010). The next generation of scenarios for climate change research and assessment. Nature, 463(7282), 747-756.

O'Neill, B. C., Kriegler, E., Riahi, K., Ebi, K. L., Hallegatte, S., Carter, T. R., ... & van Vuuren, D. P. (2014). A new scenario framework for climate change research: the concept of shared socioeconomic pathways. *Climatic Change*, *122*(3), 387-400.

Raupach, M. R., Marland, G., Ciais, P., Le Quéré, C., Canadell, J. G., Klepper, G., & Field, C. B. (2007). Global and regional drivers of accelerating CO2 emissions. *Proceedings of the National Academy of Sciences*, *104*(24), 10288-10293.

Play with https://insightmaker.com/insight/30045/Simple-Climate-Carbon-Economic-Model

February 11 - Global and regional climate modelling

NAS (2016). SCC Phase 1 report, chapters 3-4

Hansen, J., Johnson, D., Lacis, A., Lebedeff, S., Lee, P., Rind, D., & Russell, G. (1981). Climate impact of increasing atmospheric carbon dioxide. Science, 213(4511), 957-966.

Hawkins, E., & Sutton, R. (2009). The potential to narrow uncertainty in regional climate predictions. *Bulletin of the American Meteorological Society*, 90(8), 1095-1107.

Sunyer, M. A., Hundecha, Y., Lawrence, D., Madsen, H., Willems, P., Martinkova, M., ... & Loukas, A. (2015). Inter-comparison of statistical downscaling methods for projection of extreme precipitation in Europe. *Hydrology and Earth System Sciences*, *19*(4), 1827-1847.

Kay, J. E., Deser, C., Phillips, A., Mai, A., Hannay, C., Strand, G., ... & Holland, M. (2015). The Community Earth System Model (CESM) large ensemble project: A community resource for studying climate change in the presence of internal climate variability. *Bulletin of the American Meteorological Society*, *96*(8), 1333-1349.

Sriver, R. S., C. E. Forest, and K. Keller: Effects of initial conditions uncertainty on regional climate variability: An analysis using a low-resolution CESM ensemble. *Geophysical Research Letters* 42 (13), 5468–5476, doi: 10.1002/2015GL064546 (2015).

February 18 - Extreme Events

Focus on:

Horton, D. E., Johnson, N. C., Singh, D., Swain, D. L., Rajaratnam, B., & Diffenbaugh, N. S. (2015). Contribution of changes in atmospheric circulation patterns to extreme temperature trends. *Nature*, *522*(7557), 465-469.

Trenberth, K. E., Fasullo, J. T., & Shepherd, T. G. (2015). Attribution of climate extreme events. *Nature Climate Change* 5, 725-730.

Nancy H. Mantell, Joseph J. Seneca, Michael L. Lahr and Will Irving (2013). The Economic and Fiscal Impacts of Hurricane Sandy in New Jersey. Rutgers Regional Report Issue Paper 34.

Lightly read:

Francis, J. A. and S. J. Vavrus, 2012: Evidence Linking Arctic Amplification to Extreme Weather in Mid-Latitudes, Geophys. Res. Lett., Vol. 39, L06801, doi:10.1029/2012GL051000

Morss, R. E., Wilhelmi, O. V., Meehl, G. A., & Dilling, L. (2011). Improving societal outcomes of extreme weather in a changing climate: an integrated perspective. Annual Review of Environment and Resources, 36(1), 1.

Cohen, J., Screen, J. A., Furtado, J. C., Barlow, M., Whittleston, D., Coumou, D., ... & Jones, J. (2014). Recent Arctic amplification and extreme mid-latitude weather. *Nature geoscience*, *7*(9), 627-637.

R. Kopp, J. Buzan and M. Huber. The deadly combination of heat and humidity. *New York Times* Sunday Review, 7 June 2015.

Play with http://cci-reanalyzer.org

February 25 - Sea-level rise and coastal climate change impacts

Jones (2013). Climate science: Rising tide. Nature 501, 301–302, doi:10.1038/501300a

Houser et al. (2015) – ch. 11

Kopp et al. (2014). Probabilistic 21st and 22nd century sea-level projections at a global network of tide gauge sites. *Earth's Future* 2: 287-306.

Aerts, J. C. J. H., Lin, N., Botzen, W., Emanuel, K. and de Moel, H. (2013), Low-Probability Flood Risk Modeling for New York City. Risk Analysis, 33: 772–788. doi: 10.1111/risa.12008

Psuty, N. P., & Silveira, T. M. (2010). Global climate change: an opportunity for coastal dunes??. *Journal of Coastal Conservation*, *14*(2), 153-160.

Hsiang, S. M., & Jina, A. S. (2014). *The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones* (No. w20352). National Bureau of Economic Research.

Play with http://sealevel.climatecentral.org/

March 3 - Benefit-Cost Analysis and Decision Making Under Uncertainty

Arrow, K., Cropper, M., Gollier, C., Groom, B., Heal, G., Newell, R., ... & Weitzman, M. (2013). Determining benefits and costs for future generations. Science, 341(6144), 349-350.

Heal, G., & Millner, A. (2014). Reflections uncertainty and decision making in climate change economics. *Review of Environmental Economics and Policy*, *8*(1), 120-137.

Skim: Interagency Working Group on Social Cost of Carbon, United States Government (2010). Appendix 15a. Social cost of carbon for regulatory impact analysis under Executive Order 12866. In: Final Rule Technical Support Document (TSD): Energy Efficiency Program for Commercial and Industrial Equipment: Small Electric Motors, U.S. Department of Energy. - Focus on section on discounting

Revesz, R. L., P. H. Howard, K. Arrow, L. H. Goulder, R. E. Kopp, M. A. Livermore, M. Oppenheimer, and T. Sterner (2014). Global warming: Improve economic models of climate change. Nature 508, 173–175, doi:10.1038/508173a.

R. Leichenko et al. (2011). An Economic Analysis of Climate Change Impacts and Adaptations in New York State. In: Responding to Climate Change in New York State. NYSERDA Technical Report 11-18 [ClimAID].

Dittrich, R., Wreford, A., & Moran, D. (2016). A survey of decision-making approaches for climate change adaptation: Are robust methods the way forward?. *Ecological Economics*, *122*, 79-89.

Podcast: "How do you put a price tag on nature?", Radiolab, http://www.radiolab.org/story/what-dollar-value-nature/.

March 10 – Energy

Houser et al. (2015) – ch. 10

Department of Energy (2013). U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather. http://energy.gov/sites/prod/files/2013/07/f2/20130710-Energy-Sector-Vulnerabilities-Report.pdf -- read Executive Summary

Schaeffer, R., Szklo, A. S., de Lucena, A. F. P., Borba, B. S. M. C., Nogueira, L. P. P., Fleming, F. P., ... & Boulahya, M. S. (2012). Energy sector vulnerability to climate change: a review. *Energy*, *38*(1), 1-12.

S. A. Hammer et al. (2011). Energy. In: Responding to Climate Change in New York State. NYSERDA Technical Report 11-18 [ClimAID].

Ruth, M., & Lin, A. C. (2006). Regional energy demand and adaptations to climate change: methodology and application to the state of Maryland, USA. Energy policy, 34(17), 2820-2833.

Davis, L. W., & Gertler, P. J. (2015). Contribution of air conditioning adoption to future energy use under global warming. *Proceedings of the National Academy of Sciences*, *112*(19), 5962-5967.

March 24 – Agriculture (Karl, Justin, and Natalie)

Houser et al. (2015) – ch. 6

McGrath, J. M., & Lobell, D. B. (2013). Regional disparities in the CO2 fertilization effect and implications for crop yields. Environmental Research Letters, 8(1), 014054.

Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A., ... & Jones, J. W. (2013). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. Proceedings of the National Academy of Sciences, 201222463.

Nelson, G. C., Valin, H., Sands, R. D., Havlík, P., Ahammad, H., Deryng, D., ... & Kyle, P. (2014). Climate change effects on agriculture: Economic responses to biophysical shocks. *Proceedings of the National Academy of Sciences*, *111*(9), 3274-3279.

Marshall Burke and Kyle Emerick. 2015. "Adaptation to climate change: Evidence from US agriculture". *Accepted*, American Economic Journal -Economic Policy.

March 31 - Civil Conflict and Human Migration

Hsiang, S. M., Burke, M., & Miguel, E. (2013). Quantifying the influence of climate on human conflict. Science, 341(6151), 1235367.

Hsiang, S. M., & Burke, M. (2014). Climate, conflict, and social stability: what does the evidence say?. *Climatic Change*, *123*(1), 39-55. [Read 1. 1 and skim]

Kelley et al. (2015). Climate change in the Fertile Crescent and implications of the recent Syrian drought. *PNAS* 112: 3241-3246. 10.1073/pnas.1421533112

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global Environmental Change*, *21*, S3-S11.

Gray, C. L., & Mueller, V. (2012). Natural disasters and population mobility in Bangladesh. *Proceedings of the National Academy of Sciences*, *109*(16), 6000-6005.

Mueller, V., Gray, C., & Kosec, K. (2014). Heat stress increases long-term human migration in rural Pakistan. *Nature climate change*, *4*(3), 182-185.

April 7 – Adaptation and resilience

Houser et al. (2015) – ch. 22

Bierbaum, R., Smith, J. B., Lee, A., Blair, M., Carter, L., Chapin III, F. S., ... & Wasley, E. (2013). A comprehensive review of climate adaptation in the United States: more than before, but less than needed. *Mitigation and adaptation strategies for global change*, *18*(3), 361-406.

New York City Panel on Climate Change 2015 Report Executive Summary. Annals of the New York Academy of Sciences, 1336: 9–17. doi: 10.1111/nyas.12591.

New York City (2015). Vision 4: Our Resilient City. In: *One New York: the plan for a just and strong city*. http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf

Kerr, R. A. (2011). Time to adapt to a warming world, but where's the science?. *Science*, *334*(6059), 1052-1053.

Bosello, F., Carraro, C., & De Cian, E. (2010). Climate policy and the optimal balance between mitigation, adaptation and unavoided damage. *Climate Change Economics*, *1*(02), 71-92.

Explore http://www.georgetownclimate.org/adaptation/clearinghouse

April 14 - Ecosystem Services

Houser et al. (2015) – ch. 18

Chapin III, F. S., Zavaleta, E. S., Eviner, V. T., Naylor, R. L., Vitousek, P. M., Reynolds, H. L., ... & Díaz, S. (2000). Consequences of changing biodiversity.Nature, 405(6783), 234-242.

Cheung, W. W.L., Lam, V. W.Y., Sarmiento, J. L., Kearney, K., Watson, R. and Pauly, D. (2009), Projecting global marine biodiversity impacts under climate change scenarios. Fish and Fisheries, 10: 235–251. doi: 10.1111/j.1467-2979.2008.00315.x

Hackett, S. B., & Moxnes, E. (2015). Natural capital in integrated assessment models of climate change. *Ecological Economics*, *116*, 354-361.

Craft, C., Clough, J., Ehman, J., Joye, S., Park, R., Pennings, S., ... & Machmuller, M. (2008). Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. *Frontiers in Ecology and the Environment*, *7*(2), 73-78.

April 21 - Tipping Points

Houser et al. (2015) – ch. 16

R. E. Kopp, R. Shwom, G. Wagner, J. Yuan (in rev.) Tipping Elements, Tipping Points and Economic Catastrophes: Implications for the Cost of Climate Change.

Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S., & Schellnhuber, H. J. (2008). Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences*, 105(6), 1786-1793.

Lenton, T. M. (2011). Early warning of climate tipping points. *Nature Climate Change*, 1(4), 201-209.

Nordhaus, W. D. (2011). The economics of tail events with an application to climate change. *Review of Environmental Economics and Policy*, 5(2), 240-257.

April 28: Proposal presentation

Final Project

Request for Proposals: Regional Climate Change Risk Assessment Grants

The Curchitser-Kopp Foundation is pleased to announce the Regional Climate Change Risk Assessment Competitive Grant Program, which will support projects to assess growing climate risks in regions of interest to the Foundation.

There is $3 million in funding available to support proposals under this RFP. Applicants may request funding of up to the full $3,000,000. We expect to make between one and three awards. Proposals will be reviewed, evaluated and scored on the extent to which they:

- Identify key climate change risks to the region
- Describe a plausible suite of physical and socio-economic scenarios of relevance to the region, incuding projected physical changes associated with each scenario
- Generate knowledge to guide climate adaptation and motivate greenhouse gas mitigation in the region of interest
- Have a clear plan for engaging key stakeholders both in the initial and final stages of the analysis
- Are technically sound and feasible, and set forth a clear, logical, and achievable work plan

Your proposal will be reviewed by the Foundation's Board of Director and its Scientific Advisory Board. Successful proposals must be highly ranked by both boards.

Proposals must be fully cited and are encouraged to be well-illustrated with explanatory figures. Proposal should include:

1) A 1-page project summary
2) A 15 page project description
3) A list of references cited, with full authors, title, and journal names
4) A budget and budget justification
5) 1-2 page CVs for each team member

The proposal should be in 11 pt Times New Roman font with 1" margins, single-spaced. They must be submitted via Sakai as a single PDF file. Proposals not meeting the formatting and style specifications will be automatically rejected without review.

Proposals are due by COB on **April 25, 2016**. Each applicant will also have the opportunity to present their proposals to a joint meeting of the Boards and the Board of Visitors on **April 28, 2016**. Presentations should be limited to 20 minutes of prepared remarks and 20 minutes for discussion.