Storybook of Workshops

Physical climate system (coordinators: Christoph Raible and Jörg Franke)

El Niño Southern Oscillation is a phenomenon in the tropical Pacific where the atmospheric dynamics is coupled to the ocean. The positive phase of ENSO called El Niño is characterized by reduced trade winds in the equatorial Pacific and a positive SST anomaly in the eastern equatorial Pacific and vice versa for the negative phase of ENSO called La Niña (Fig. 1). This phenomenon is the most important mode of climate variability with worldwide implications, link reduced precipitation over the India and Indonesia for El Niño conditions. Thus, predicting the phases of ENSO is of high socio-economic relevance and has received high attention in the scientific community since the late 1960s.

Given its relevance this phenomenon, in particular the predictability and the methods to generate prediction, will be the focus of the three interlinked workshops of the 'physical climate system' part.

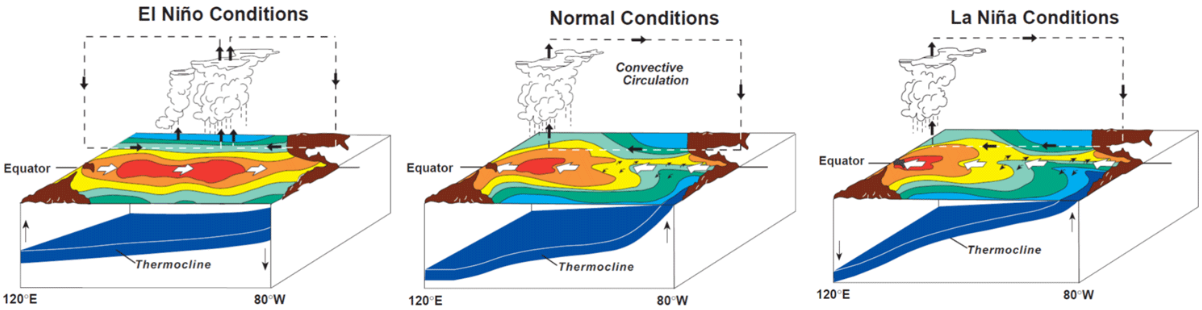

Fig. 1: Sketch of the three phases of ENSO.

1. WS1: Programing a numerical model to predict ENSO (C. Raible)

In this workshop a numerical model will be programed to forecast ENSO.

Tasks:

- Understand the references below.
- Find necessary data in the internet.
- Program the simple model introduced in McGregor et al. 2012
- Extend the model by the combination mode of the annual cycle and the El Niño/Southern Oscillation (Stuecker et al. 2013)
- Perform predictions.

The students will learn to find data via the internet. Under supervision of the advising person they will explore the relevant literature. Further, the students will learn how to program a dynamical model using the language R.

References:

McGregor, S., A. Timmermann, N. Schneider, M. Stuecker, and M. England, 2012: The effect of the South Pacific Convergence Zone on the termination of El Niño events and the meridional asymmetry of ENSO, Journal of Climate, 25, 5566–5586.

Stuecker MF, Timmermann A, Jin F-F, McGregor S, Ren H-L (2013) A Combination mode of the annual cycle and the El Niño/Southern Oscillation. Nat Geosci 6:540–544.

2. WS2: Programing several statistical of different complexity to predict ENSO (C. Raible)

In this workshop statistical models are programed to forecast ENSO.

Tasks:

- Find statistical models predicting ENSO variability for the next months and seasons and the relevant literature
- Find ENSO related data on the web
- Search for indices, sea surface temperature, sub surface ocean data, pressure and surface wind data in the tropical Pacific, etc.
- Program several statistical models to predict the Nino3.4 index
    - Start with simple approaches – the climate model and the persistence model
    - Develop a Markov chain model
    - Develop a multivariate regression model including the data sets identified. Ensure that overfitting is prevented.
    - Develop an analog technique to predict ENSO.
- Combine the models to one forecast. [e.g., Raible et al. 1999].

The students will learn to find data via the internet. Under supervision of the advising person they will explore the relevant literature. Further, the students will learn how to program a statistical model using the language R.

3. WS3: Programing a set of verification measures to verify ENSO forecasts (J. Franke / C. Raible)

Basis for the verification workshop are ENSO forecasts done with various approaches described in WS1 and WS2.

Tasks:

- Find several observations data sets online
- Program R-functions for several statistical measures to compare forecasts with observations
    - Bias
    - Correlation
    - root-mean-square error
- Find functions for more sophisticated measure on the web
- Calculation of various verifications measures for multiple combinations of forecasts and observations
- Interpretation of results and decision which models gives the best forecast

The students will learn how and where to find climate data on the internet, program own functions in R, and how to use pre-written function from existing R-packages. Additionally, they will develop a feeling for the specific advantages and disadvantages of a range of verification measures and how to critically interpret them.

Climate Governance (coordinator: Manfred Elsig)

Climate Governance is strongly shaped by law, economics and politics. Three sets of workshops will focus on various aspects of climate governance. The economics part focuses on new ways of carbon-accounting in light of ever increasing global and regional value chains. It allows students to better understand the need for accurate measures to allow to design international treaties. The law workshop focuses on a key case in WTO law and shows how disputes arise if countries have different domestic support policies for climate-related products. It will help students to get a first exposure to how disputes are handled in the inter-governmental organization and how trade and climate concerns are balanced. It also includes a role-play. The political science workshop allows students to explore the students the world of preferential trade agreements (PTAs). They will be asked to carry out certain research activities such as coding climate-related obligations and attempting to explain why there is widespread variation across different treaties.

4. **WS4: Climate and agricultural trade policy** (Manfred Elsig, Georgina Roskell)

This workshop will focus on the relationship between climate and agricultural trade policy. In preparation for the student presentation on the topic, this workshop will have sessions covering the following aspects relating to climate change and agricultural trade policy: (i) a general overview of agricultural trade under the WTO, the WTO rules relating to agriculture trade under the various agreements, with particular emphasis on the Agreement on Agriculture, and it's three pillars; (ii) a discussion on the inter-relationship between climate change and agricultural trade, and how they both not only can adversely affect one another, but can also be mutually beneficial to achieving advancements in reaching their objectives; (iii) a brief discussion on how non-trade concerns, food security and climate related matters are becoming of increasing importance in agricultural trade negotiations; (iv) a discussion on the rules of agricultural trade that could be applicable to achieving climate-related obligations; and (v) examples will be given of domestic agricultural trade policies which are beneficial to the achievement of climate change objectives.

5. **WS5: Law and Economics of Climate-related Regulation** (with a WTO case) (Law, P. van den Bossche)

This workshop, which focuses on the complex relationship between international economic law and environmental policy, will culminate with a student presentation of the significant issues raised in a particular international trade dispute decided by the WTO Appellate Body: *India – Solar Cells* (2016) (A case featuring a complaint by the United States against India regarding requirements, imposed by the latter, that Indian solar power producers use Indian-made solar cells and modules). In preparing to present this case, a number of foundational issues will necessarily be discussed. These include: (i) the history and structure of the WTO (ii) the primary avenues through which environmental issues (such as climate change) interact with WTO law; (iii) the procedural law governing how, and under what circumstances, a dispute may be brought within the WTO dispute settlement system; and (iv) an introduction to some of the major substantive provisions of the GATT (including National Treatment, MFN, and the General Exceptions). Provided with this framework, students will be prepared to study and discuss the Appellate Body report (i.e. judgment) issued in *India-Solar Cells* (2016) (and other relevant documents), and similarly, will have the ability to provide the principle arguments/reasoning set forth in the case by each of: the United States, the complainant; India, the respondent; and the Appellate Body, the appeals court.

6. WS6: Trade Agreements and Climate-related obligations (Political Science, M. Elsig)

This workshop will focus on how climate-related obligations have been negotiated and inserted in preferential trade agreements (PTAs). The workshop will start out with an initial session on the role and spread of PTAs in recent years and how they are also used for non-trade or trade-related issues (see figure below). Students will have the chance to qualitatively assess a selected number of PTAs and screen them for climate-related obligations. Students will also get the opportunity to analyze and visualize PTAs and their design features over time. Finally, students will be asked to provide theoretical explanations for their observations and focus, in particular, on where certain climate-related features originate and how they diffused across treaties.

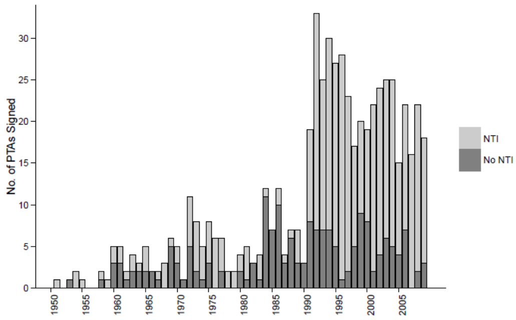

Figure 1. Number of PTAs signed with and without NTIs by year.
Only NTI references in main text are included (not references in preamble).

Source: Milewicz et al. 2015

Climate Economics (coordinator: R. Winkler)

International treaties on the provision of global public goods are plagued by the fundamental free-riding problem: each country's contribution will benefit all countries in a non-exclusive and non-rival manner. This prisoner's dilemma aspect and the absence of a supranational authority makes international coordination both crucial and exceptionally difficult to achieve. Countries may either lack the incentive to sign an agreement and benefit from the signatories' contributions or have incentives not to comply with promises made in an agreement. The three climate economic workshops tackle the design of international environmental agreements from an empirical, experimental and theoretical economic perspective.

7. **WS7: Simulating and understanding carbon policy effects in the electricity market using the energy market game (**Doina Radulescu, Patrick Bigler)

Effective pathways to net-zero carbon emissions require an overhaul of electricity production. Globally, coal and natural gas remain the biggest resources for electricity production with shares of 36% and 22% respectively (IEA, 2021). In this workshop we will use the energy market game (Thurber and Wolak, 2013) to better understand the mechanism of electricity markets. Each session will include short introductions into relevant concepts such as the merit-order curve, bid auctions and price formation as well as carbon taxation and carbon permit markets. Students will learn how different market settings and policy instruments influence both electricity wholesale prices and the electricity production mix.

Students will be assigned a selected portfolio of electricity generation technologies alone or in teams. The relevant settings and market rules are explained and discussed and different hours of the day representing different demand structures as well as different generation circumstances will be played given one set of rules. Afterwards the rules will be changed, or additional policies will be introduced. The different market outcomes help student understand challenges and pathways to a cleaner, less-fossil fuel dependent electricity generation world. They will learn about and understand concepts such as uniform price auctions, pay-as bid auctions, carbon taxation and carbon cap and trade. We will also simulate a scenario with higher renewable generation capacities and illustrate potential problems with regards to congestion and supply – demand timing mismatches.

References:

IEA (2021), Electricity market report.

Thurber, M. C., & Wolak, F. A. (2013). Carbon in the classroom: lessons from a simulation of California's electricity market under a stringent cap-and-trade system. The Electricity Journal, 26(7), 8-21.

Thurber, M. C., Davis, T. L., & Wolak, F. A. (2015). Simulating the interaction of a renewable portfolio standard with electricity and carbon markets. The Electricity Journal, 28(4), 51-65.

https://www.energymarketgame.org

8. **WS8: Climate change and the economics of extreme weather events** (Dino Collalti/Eric Strobl)

Quantifying economic damages from climate change is an extremely difficult endeavor. Most often, economists think of climate change as a global public good with a "shadow price", the social cost of carbon (SCC, Nordhaus, 2019). The SCC should price in all externalities that carbon emission causes. To derive this shadow price, both the counterfactual regarding future climate and the counterfactual for identifying the damage or dose response function is crucial (Auffhammer, 2018). In other words, we not only need to know scenarios for future climate but also a counterfactual future economy to extrapolate from current climate to future climate. Unfortunately, there is a fundamental lack of comparability of today's economies with economies in the future with a warmer climate. Nonetheless, recent empirical strategies that use panel data weather variation and interannual variability have successfully provided more reliable estimates of economic impacts (Kolstad & Moore, 2020). One strand of the literature specifically focuses on the economic response to extreme weather events and natural hazards (Botzen et. al. 2019). The main advantage of this approach is that, by estimating the aggregate response in some way or another, one avoids modelling all micro-level reactions into an aggregate via economic models.

The aim of this workshop is to bring students into contact with real data that links weather anomalies to economic outcomes. The workshop has three objectives. First, students will deepen their conceptual understanding of the damage function. This includes questions relating to weather vs. climate, short-run vs. long-run effects and the speed of adjustment and adaptation in the economy. Second, students will analyze data on weather anomalies and their economic impact by using the GAME-LIGHTS database (Felbermayer et. al. 2022). For the analysis of the data, students will learn to use pre-written functions from existing R-packages to import data, create plots and run regressions. Lastly, students will evaluate their work with the related literature and discuss implications of the current scientific evidence regarding weather and climate extremes in a changing climate (AR6, Chapter 11).

References:

Nordhaus, William. "Climate change: The ultimate challenge for economics." American Economic Review 109.6 (2019): 1991-2014.

Auffhammer, Maximilian. "Quantifying economic damages from climate change." Journal of Economic Perspectives 32.4 (2018): 33-52.

Kolstad, Charles D., and Frances C. Moore. "Estimating the economic impacts of climate change using weather observations." Review of Environmental Economics and Policy (2020).

Botzen, WJ Wouter, Olivier Deschenes, and Mark Sanders. "The economic impacts of natural disasters: A review of models and empirical studies." Review of Environmental Economics and Policy (2019).

Felbermayr, Gabriel, et al. "The economic impact of weather anomalies." World Development 151 (2022): 105745.

Seneviratne, Sonia I., et al. "11 Chapter 11: Weather and climate extreme events in a changing climate." (2021).

9. WS9: Carbon-accounting, value chains, and defining climate targets (Economics, J. Francois)

Effective environmental policy requires precise pollution and resource accountancy. This allows for tracking target variables, such as CO2 or methane emissions. In the case of greenhouse gasses, a producer perspective is usually taken. Accordingly, national pollutant and resource use inventories are based on production activities within national territories and environmental policy targets local producers according to the "polluter pays" principle. This principle is also enshrined in the national abatement targets of the Kyoto Protocol (see e.g. Fernández-Amador et al., 2016a,b, 2017). However, recent literature (see Hoekstra and Janssen, 2006 for an overview) argues we should also hold consumers responsible for reducing environmental pressure (see e.g. Ahmad and Wyckoff, 2003, Peters et al., 2012 or Fernández et al., 2016). Such a "consumer pays" view is justified where consumption patterns increase environmental pressure in other geographical regions via geographically fragmented supply chains (aka global value chains, see e.g. Baldwin and López-Gonzáles, 2013). Consumption-based environmental accounting has also become prominent among policy makers. Using input-output (IO) methodology, a literature on construction of production- and consumption-based national pollution inventories for single countries has emerged (see e.g. Fernández-Amador et al., 2016a,b, 2017).

Final production- and final consumption-based inventories account for pollution and resources usage, assigning emissions to the country where the good is where it leaves the factory (final production) or finally consumed (final consumption). In this workshop, students will learn methodologies for quantitative analysis of the situation of national economies in terms of indicators for sustainability footprints. For that purpose, they will be guided through construction and analysis of databases on sustainability footprints defined in terms of carbon dioxide emissions and methane. The extension of these methods to cover other sustainability indicators (water, rainforest resources, etc.) will also be discussed. The students will learn through application, differences between inventories based on territorial or geographic-based production activities, final production activities, and consumption patterns. They will also be led through analysis of how important these differences are when designing international climate treaties that include defined national targets of objectives, and that at the same time may conflict with other existing international treaty frameworks (like the WTO, the EC, etc.).

References:

Baldwin, R., & Lopez-Gonzalez, J. (2015). "Supply-chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses." The World Economy, 38(11), 1682-1721.

Fernández-Amador, O., Francois, J. and P. Tomberger (2016a): Carbon Dioxide emissions and international trade at the turn of the millenium, Ecological Ecoomics. 126. 14-26.

Fernández-Amador, O., Francois, J. and P. Tomberger (2016b): MRIO linkages and Switzerland's CO2 Profile, Journal Aussenwirtschaft. 67-III. 47-67.

Fernández-Amador, O., Francois, J., Oberdabernig, D. and P. Tomberger (2017): Carbon dioxide emissions and economic growth: An assessment based on production and consumption emission inventories, Ecological Economics. 135. 269–279.