THE GRADUATE INSTITUTE | GENEVA

INSTITUT DE HAUTES ETUDES
INTERNATIONALES ET DU DÉVELOPPEMENT

GRADUATE INSTITUTE OF INTERNATIONAL
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Climate Change and Socio Economic Data

Urs Luterbacher

The inclusion of socio-economic data with climate and hydrological data seems essential

- To assess the socio-economic impact of climatological or extreme hydrological events

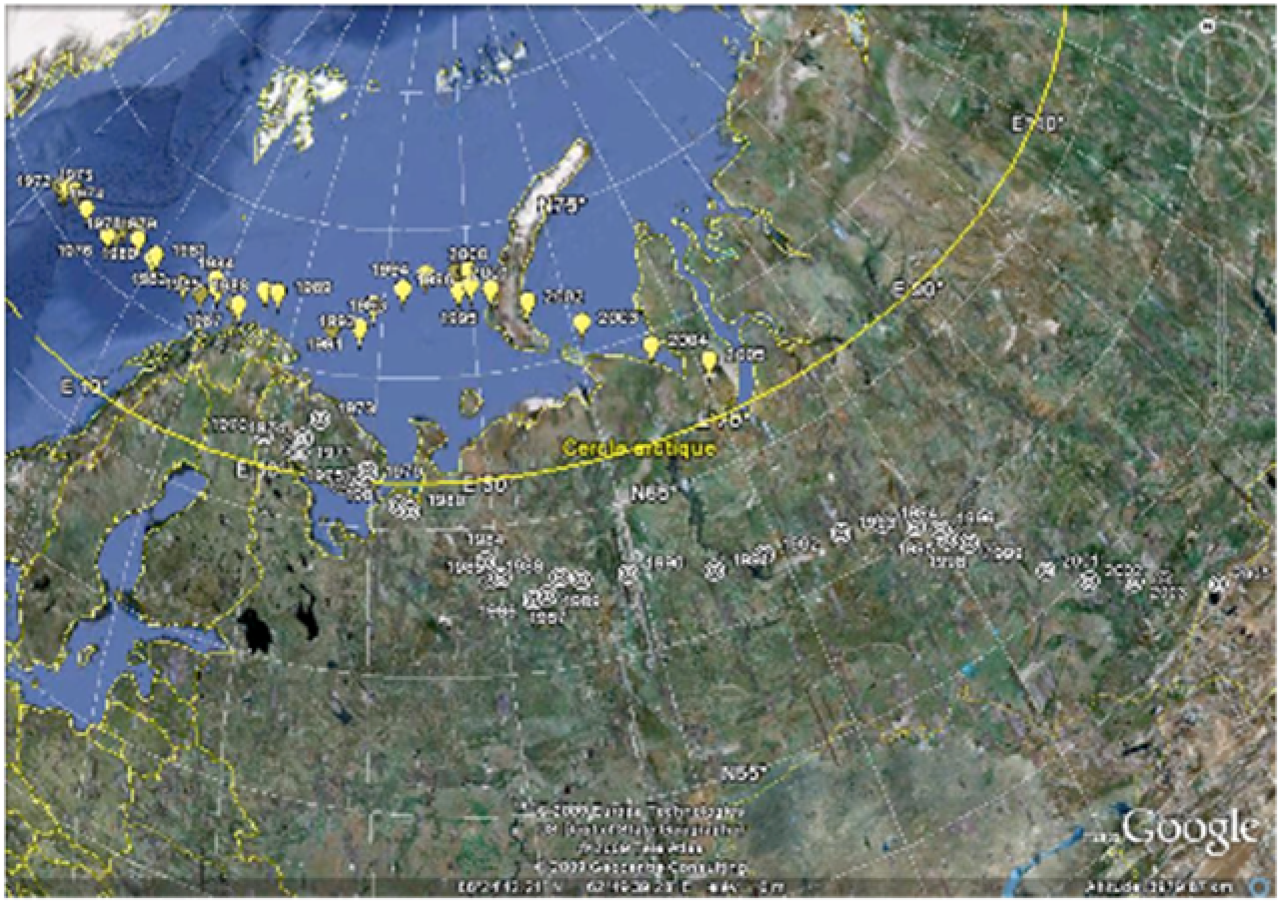
- To establish feedback relationship between socio-economic development and climate trends

- The following map constitutes an illustration of the importance of such relations

- However such correspondences an inclusions raise many difficulties

Location and greenhouse gas emissions

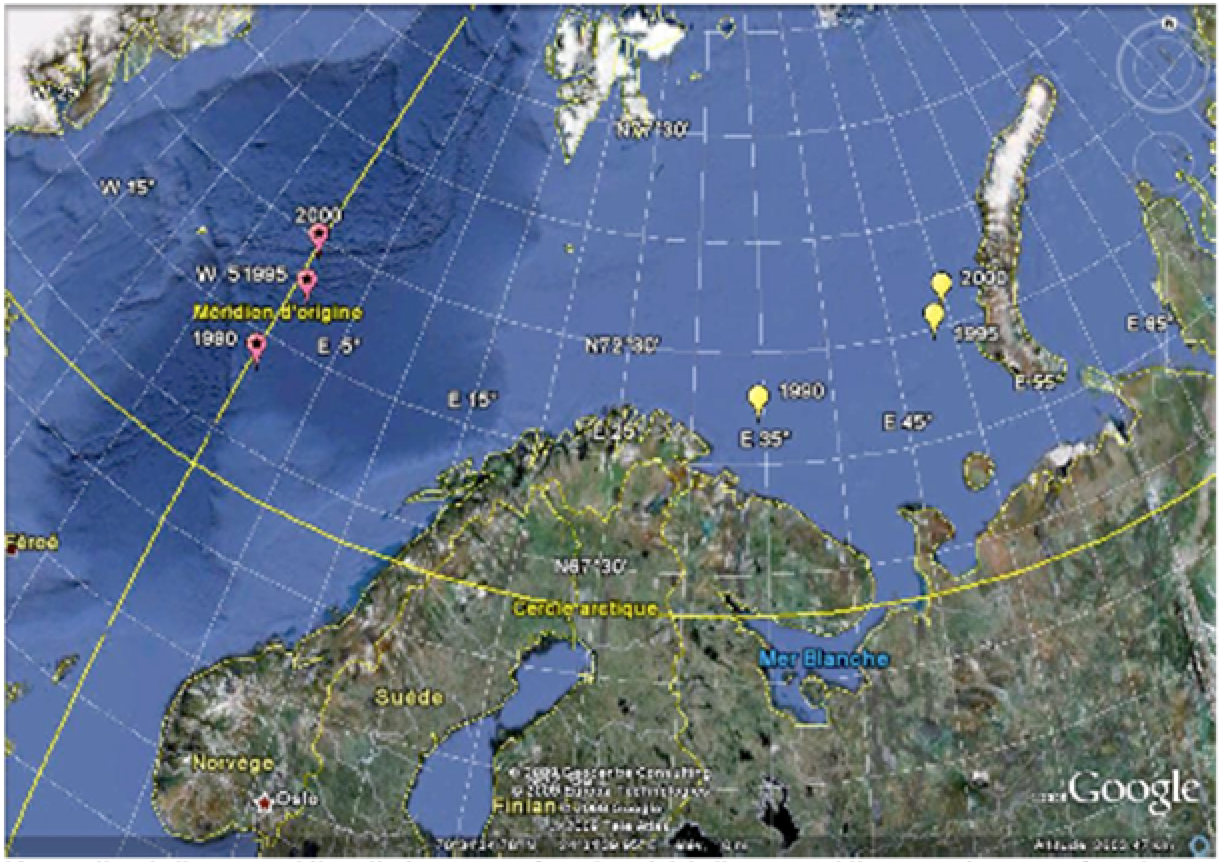
Figure 1: Projection of the world's pollution center of gravity on the Earth's surface



Note: yellow balloons: total CO_2 anthropogenic emissions (organic carbon excluded), grey circles: CO_2 emissions from industrial processes

Comparing economic and emissions' center of gravity

Figure 2: Comparison between the world's pollution and economic centers of gravity



Note: yellow balloons: world's pollution center of gravity, pink balloons: world's economic center of gravity

Theses Maps illustrates that:

- The center of gravity of CO_2 emissions is shifting eastward
- The center of gravity of CO_2 emissions is farther East than the economic center of gravity which suggest less efficient production processes (more CO_2 intensive) there
- This suggests particular policies

Climate change presents challenges for a fruitful collaboration between natural and social scientists

- Two difficulties are present in terms of quantitative analysis:
  - Time consistency questions: The time horizon of the climatologist is often much longer than the one chosen by the social scientist or the economist. This makes the construction of socioeconomic models combined with climate change extremely difficult to interpret correctly: e.g. the Nordhaus and Tulkens Eyckman models that represent complete feedback cycles between the two extend over hundreds of years
  - Space consistency: The climatologist or hydrologist works in terms of a geographic unit such as cell in a grid or a catchment area, the social scientist works with data gathered at the level of a socio-economic entity

Attempts have been made to simulate climate society interactions at the global level

- Nordhaus proposed the DICE model in 1993
- It is an aggregated economic world model which estimates the impact the economy has on climate and climatic feedbacks in terms of damages to the economy
- A more disaggregated model called RICE was proposed in 1996.
- It incorporates 6 world regions interacting with each other US, EU, Japan, Former Soviet Union, China, Rest of the World: One can then compute coalition outcomes
- Tulkens and Eyckman propose a modified version of it

Variables in the Rice and Eyckmans Tulkens Model

$Y_{i,t}$	Production (billion 1990 US$)
$A_{i,t}$	Productivity
$Z_{i,t}$	Consumption (billion 1990 US$)
$I_{i,t}$	Investment (billion 1990 US$)
$K_{i,t}$	Capital stock (billion 1990 US$)
$L_{i,t}$	Population (million people)
$C_{i,t}$	Cost of abatement (billion 1990 US$)
$D_{i,t}$	Damage from climate change (billion 1990 US$)
$E_{i,t}$	Carbon emissions (billion tonnes of C)
$\sigma_{i,t}$	Emission–output rate
$\mu_{i,t}$	Emission abatement
M_t	Atmospheric carbon concentration (billion tonnes of C)
F_t	Radiative forcing (W/m^2)
ΔT_t	Temperature increase atmosphere (°C)
T_t^0	Temperature increase deep ocean (°C)

General structure of the Nordhaus Yang and Eyckmans Tulkens model

Appendix A

Equation listing of the CWS model:

$$U_i(Z_{i,t}) = Z_{i,t}$$

$$Y_{i,t} = Z_{i,t} + I_{i,t} + C_i(\mu_{i,t}) + D_i(\Delta T_t)$$

$$Y_{i,t} = A_{i,t} K_{i,t}^{\gamma} L_{i,t}^{1-\gamma}$$

$$C_i(\mu_{i,t}) = Y_{i,t} b_{i,1} \mu_{i,t}^{b_{i,2}}$$

$$D_i(\Delta T_t) = Y_{i,t} \theta_{i,1} \Delta T_t^{\theta_{i,2}}$$

$$K_{i,t+1} = (1 - \delta_K) K_{i,t} + I_{i,t} \quad (K_{i,0} \text{ given})$$

$$E_{i,t} = \sigma_{i,t}(1 - \mu_{i,t}) Y_{i,t}$$

$$M_{t+1} = (1 - \delta_M) M_t + \beta \sum_{i \in N} E_{i,t} \quad (M_0 \text{ given})$$

$$F_t = \frac{4.1 \ln(M_t / M_0)}{\ln(2)} + F_t^x$$

$$T_t^{\circ} = T_{t-1}^{\circ} + \tau_3 [\Delta T_{t-1} - T_{t-1}^{\circ}]$$

$$\Delta T_t = \Delta T_{t-1} + \tau_1 [F_t - \lambda \Delta T_{t-1}] - \tau_2 [\Delta T_{t-1} - T_{t-1}^{\circ}]$$

Eyckmans Tulkens results

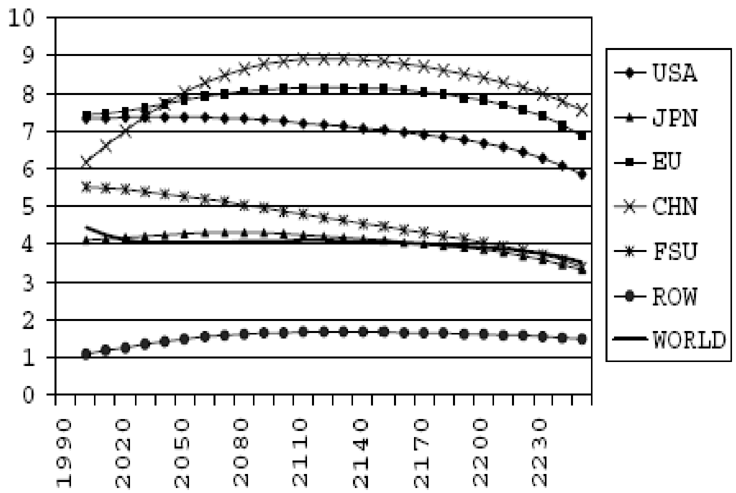


Fig. 4. NASH emissions abatement (%).

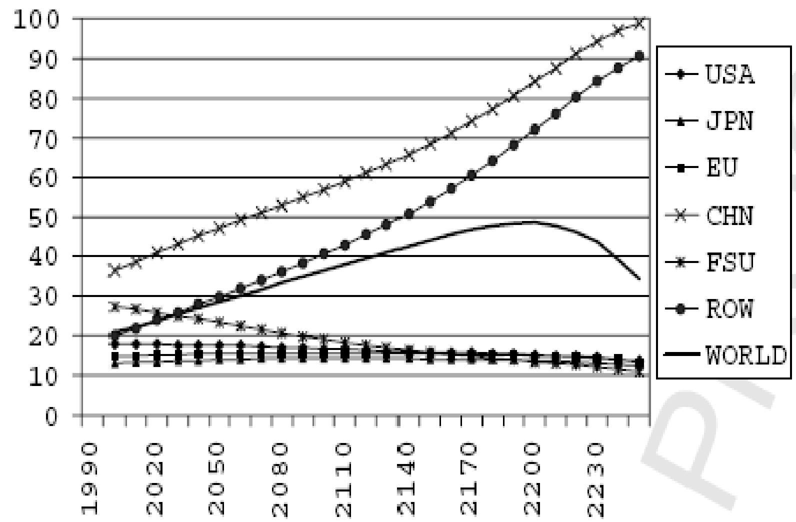


Fig. 5. EFF emissions abatement (%).

Another Example: A socio-economic model connected to hydrological factors

➔ Model Climsocwater
➔ System SPARE

Will built a **socio-economic model** that includes:

- Industrial sector: Value added
- Agricultual sector: Value added
- Demography
- Energy
- Services
- Trade
- Government expenses and revenues

RESULTS – We want to determine:

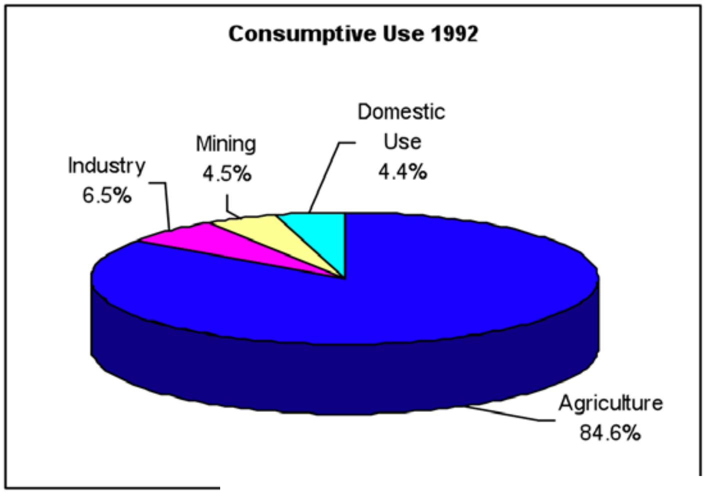
- Supply of water based upon hydrological data
- Demand and consumption of water by the diverse economic activities represented in the model over a territory, Space concistency: We clearly have to distinguish between the consumptive and non consumptive uses of water
- Fror this we need total water availability in terms of annual flows available for withdrawals : Time consistency problem

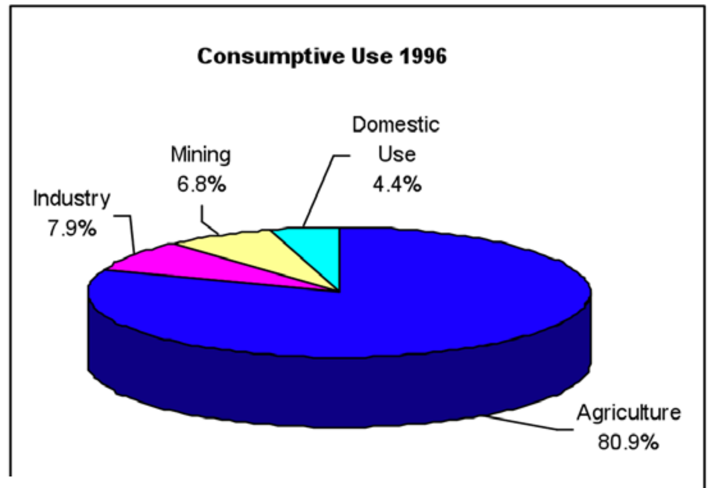
Water Availability and Withdrawals

- Water Availability: Data provided by a hydrological team (ETHZ) in terms of monthly flows which are then annualized
- Water Withdrawals: our own research plus the elements of information provided by a team of hydro-geologists on the consumptive use of water by hydroelectric dams
- Problem: Socio-economic data are gathered a the level of administrative units and not physical surfaces (such as catchment areas). Moreover some data at the local level are very difficult to get, thus necessity often to resort to higher levels of resolution: National Level

Example: Chili where competitive aspects of water use are important

- In Chili competitive aspects especially between agriculture and mining dominate in the Aconcagua region:

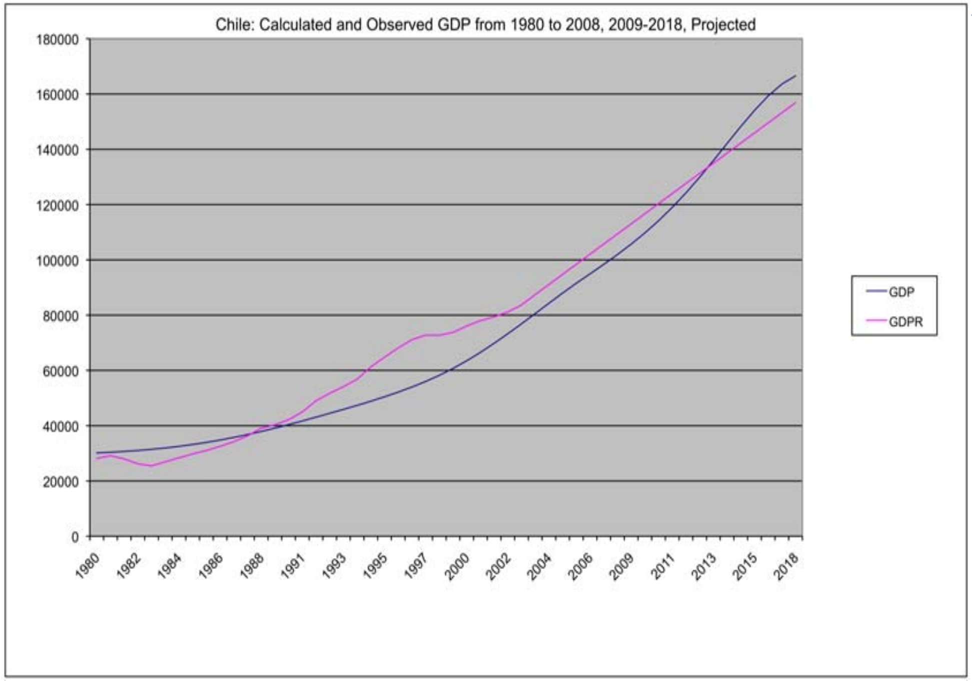


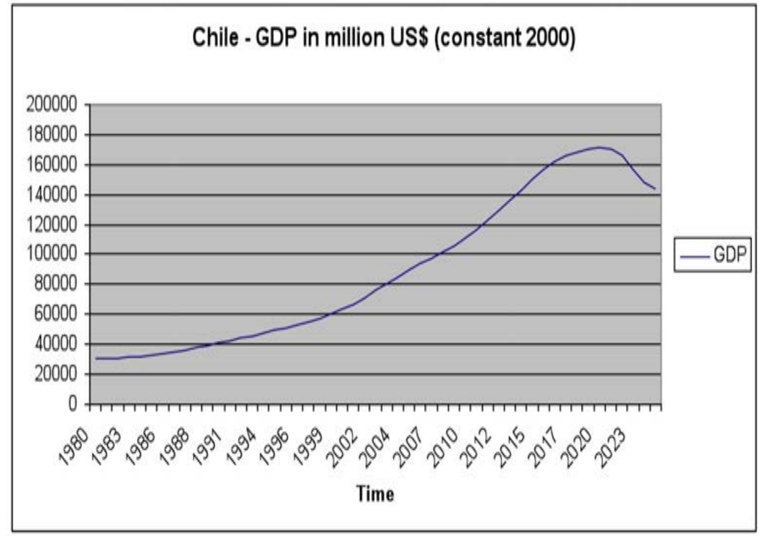


	2010	2020	2030	2040	2050
INE	17.1 Mio	18.5 Mio	19.6 Mio	20.1 Mio	20.2 Mio

Growth of Chilean Population as projected by INE of Chile

Example of Competitive Aspects between Agriculture, Hydro and Mining





This simulation is based upon water data provided by the ETHZ hydrological group. Water is an input to value added in industry and agriculture in our model.

In addition water used by households and the consumptive aspect of dam use has been incorporated. How does the competition for water between sectors work itself out over time? Our simulation shows that it will eventually weigh on income as water shortages will continue and require a drastic increase in water pricing and lead to a reduction in Chilean GDP.

Conclusions

- We have demonstrated that integrated hydrological climatological and socio-economic modeling of precise processes can work at a country level
- We showed how climatological and hydrological data can be introduced into socio-economic models and show its influence on all kinds of processes
- We generated simulations of water demand by different sectors which can then again be used by hydrologists because withdrawals modify hydrological conditions
- The description and analysis of these mutual feedback effects needs to be improved-> ACQWA project
- However, our project shows how some of the problems can be overcome

Thank you for your attention !