SYSTEMS AND SUSTAINABILITY IN TIME AND SPACE

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Introduction
"May you live in interesting times"
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Population Growth

World Population Growth

After taking all of human history for population to reach one billion, it took only a little over a century to reach two billion in 1930. The third billion was added in just 30 years, the fourth in only 15 years.
The Annihilation of Nature

- 50% of all wildlife has been lost in the last 40 years
- 70% in South America.
- Since 1500, eight mammals have gone extinct,
- Another 27 “possibly extinct”
- 188 mammals are critically endangered, and 493 are threatened with extinction.

Gerardo Ceballos

*The Annihilation of Nature – Human Extinction of Birds and Mammals*
Climate change

- Within a few decades, climate change will have “massively disruptive consequences to societies and ecosystems,” including widespread famines, lethal heat waves, more frequent and destructive natural disasters, and social unrest.
- Despite the litany of warnings, governments have failed to take meaningful action.

http://whatweknow.aaas.org/get-the-facts/
Inequality

- **62 INDIVIDUALS**
  - Have the same wealth as the poorest 3.6 billion people in the world

- **$542 BILLION**
  - The increase in wealth of the richest 62 individuals since 2010

- **$1 TRILLION**
  - The fall in wealth of the poorest 3.6 billion people since 2010

- **1%**
  - Since 2000, the poorest half of the global population received only 1% of the increase in global wealth

- **50%**
  - The amount of the global wealth increase since 2000 received by the top 1%

- **$3**
  - Rise in the average annual income of the poorest 10% of people in the world

http://oxf.am/Znhx
“All of our exalted technological progress, civilization for that matter, is comparable to an axe in the hand of a pathological criminal.”

— Albert Einstein - Letter to Heinrich Zangger (1917)
“I look forward with great optimism. I think that we undergo not only a historical, but a planetary change as well. We live in a transition to the noosphere.”

Vladimir Vernadsky, *The Biosphere and the Noosphere*, 1945
European aviation industry
345,000 tons

Volcano Eyjafjallajoekull
150,000 tons*

205,000 tons
CO2 saved by 60% cancelled flights across Europe
Solar panels on the roof of greenhouses growing mushrooms in Neihuang county, Henan province
Photograph: China stringer network/Reuters
New Investments in Clean Energy ($BN)

- OECD
- Non OECD

Q3 2015

$37.6bn

$32.4bn
Systems and models
World Dynamics Model
Jay Forrester World 2, 1971
World3 model
Lake Balaton Model

- 11 state variables (biota, nitrogen, phosphorus, oxygen)
- 16 segments (compartments)
- 100+ parameters
- Hydrodynamics - wind induced currents
Simplification in modeling

- Simplification is a must
- How is it done?
- Science is value neutral and is supposed to provide information for policy and decision-making: only the latter have to account for societal values and preferences

Values in science do matter

- What are the assumptions we make?
- What are the boundaries of the system?
- What spatio-temporal resolution we choose?
- What models we use?
- What are the experts we invite?
- What accuracy we allow?
- How do we collect, process and use data?
- How do we report our results?
- What objective functions we define?
Values in science do matter

- Who pays my salary? Will they like it?
- What are the credits from this research?
- What impact factor my research will have?
- How many citations will I get?
- Does this help with my tenure?

“A scientific man ought to have no wishes, no affections, a mere heart of stone.”

Charles Darwin
Spatial modeling

Photosynthesis
- Photosynthetic Biomass
- Translocation
- Non-Photo Biomass
- Mortality
- Detritus

Surface Water
- Precipitation
- Evaporation
- Runoff

Unsaturated Water
- Infiltration
- Transpiration
- Percolation & upflow

Saturated Water
- Surface - Saturated exchanges
- Groundwater flow

Horizontal fluxes between cells

Biomass
- Growth
- Mortality

Consumers
- Uptake
- C Grow

C Mort

Con Mort

Unit Model
The complexity curse

- We seem to be treating complexity with complexity
- Oreskes: “A complex model may be more realistic yet at the same time more uncertain”*
- Complex models are hard to test
- Complex models are hard to communicate
- Complex models are hard to trust
- Complex models are hard to calibrate
  - In environmental modeling calibration is a must.


Library of Hydro-Ecological Modules

Local Dynamics
- Physical Conditions
- Hydrology
- Nutrient Cycling
- Plant Growth
- Dead Organic Decomposition

Spatial Dynamics
- Surface Hydrology & Nutrient Transport
- Groundwater Hydrology & Nutrient Transport
- Crop Rotation
- Landuse Change

Simulation Module Markup Language

Spatial Modeling Environment - SME
COMPLEX model space

Open-source or available for COMPLEX members

- MADIAMS – WP5
- Energy Market Model – WP5
- FUND – WP5
- D2gen – WP2

Contextual Interaction Model – WP3

- ICHM – WP2
- DHYMAS – WP2
- ENKI – WP2

Other mental models from stakeholder workshops

Regional model of land use in Malar region – WP4

- PLUS4-CMP – WP3
- RHOMOLO – WP5
- ProdRisk – WP2
- EXIOPOL – WP5
- EMPS – WP2
- CREEA – WP5
- EXIOMOD – WP5

Integrated assessment, Hydro and CRE, Landuse, Climate, ABM, CGE, Data, Conceptual
Semantic integration agent

- Technical Integration Agent
  - Message from source model
  - Meta-model info of source model
  - Meta-model info of destination model
  - Semantic Integration Agent
    - Semantically amended message
    - Dataset Integration Agent
      - Exchanged message
      - Ontology
      - Units
      - Other Ontologies
```cpp
//                    Class
// -------------------------------------------------------
PLM_module * PLM_module::fInstance = NULL;
PLM_module * PLM_module::kNullModel = (PLM_module*)0x1;
int PLM_module::InitVars() {
    TIME.SSInit(this);
    fVarList.Alphabetize();
    return 0;
}

Module GLOBALS_module{
    aux Variable AIR_TEMP_DEGC {
        update Command u0 { Variable = AIR_TEMP_DEGF-
                        Value = ( ( (AIR_TEMP_DEGF-
                                    32)*5 )/9 )};
    }
}
```

**Spatial Modeling Environment (SME)**
ilwis 4
INTEGRATED LAND AND WATER INFORMATION SYSTEM

THE NEXT GENERATION TOOL FRAMEWORK
FOR GIS AND REMOTE SENSING
Water - Energy Nexus

- Energy to build and maintain machinery
- Energy to mitigate land erosion and soil depletion
- Energy to produce and deliver F & P
- Fertilizers Pesticides (F & P)
- Energy to apply F & P
- Energy for crop yield and transportation
- Net Energy Output
- Energy for delivery, storage and distribution of fuels

- Land cultivation
- Trucks and tractors (Horses?)
- Energy for machines
- Energy for surface and groundwater treatment
- Water runoff
- Crop growth
- Water supply
- Water for refinery
- Canals and pipelines
- Energy for pumps
- Refinery
- Energy for refinery
- Energy for refinery
- Energy for refinery
- Main flows of energy
- Flows of water
- Flows of auxiliary energy

Friday, February 19, 16
EROEI

EROEI (Energy Return on Energy Invested)

\[ e = \frac{e_{out}}{e_{in}} \]

- \( e_{out} \) – is the amount of energy produced,
- \( e_{in} \) – is the amount of energy used in production

It requires about 750 kilojoules to lift 15 kg of oil 5 km out of the ground - a physical fact that will not change with S&P or NASDAQ.
Scooters in Enschede (and elsewhere)
Modeling human society

Methodological approach spatially explicit Agent-Based modeling

- Represent cooperative agricultural networks/clusters within ecological spatial framework
- Shift to environmental sustainability, efficiency and self-sufficiency
Sustainability
Brundtland Commission (1987): Sustainable development is the “ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.”
Maslow's Hierarchy of Needs

Abraham Harold Maslow (April 1, 1908 - June 8, 1970) was a psychologist who studied positive human qualities and the lives of exemplary people. In 1954, Maslow created the Hierarchy of Human Needs and expressed his theories in his book, Motivation and Personality.

Self-Actualization - A person's motivation to reach his or her full potential. As shown in Maslow's Hierarchy of Needs, a person's basic needs must be met before self-actualization can be achieved.

WiFi
Changing needs

“At the beginning of this century, the average American had 18 wants and considered 72 of them important. By the end of the century, the average American had 496 wants and considered 96 of them as genuine necessities for happiness.” (Miller)
Changing needs

www.HealthAim.com
"...it's naive to project our values, preferences and capabilities (maybe even our anatomies and physiologies) into an unknowable future and seek to impose them on our successors... Most of us are so decoupled from even the previous two or three generations to have much more than the most general idea what futures they were hoping for on our behalf. It isn't clear what ought to be sustained. It's even less clear what CAN be sustained."

Matthew Chew (ASU)
Needs and values

- Needs are different for different mindsets, cultures, traditions, priorities
Heterogeneous needs

- Needs are different between the ‘haves’ and the ‘have-nots’
Sustainability

- Wimberly (1999): “to be sustainable is to provide for food, fiber, and other natural and social resources needed for the survival of a group – such as a national or international society, an economic sector or residential category – and to provide in a manner that maintains the essential resources for present and future generations.”
Sustainability

- Solow (1991): “…the system is sustainable as long as the total capital of the system is equal or greater in every next generation”.

- Costanza and Daly (1992): “..sustainability only occurs when there is no decline in natural capital”.

- Costanza (1992): ”Sustainability... implies the system's ability to maintain its structure (organization) and function (vigor) over time in the face of external stress (resilience)”
Sustainability key words

- persist
- maintain
- no decline
- continue indefinitely
- greater longevity
Holling’s renewal cycle

Holling (1986)
Gumilev’s ethnogenesis

Passion (vigor)

implicit  growth  explicit  acme  break down  inertia  obscurity  regeneration  relict

Time
The life cycle of the Columbia River canned salmon industry
"The very success in managing a target variable for sustained production of food or fiber apparently leads inevitably to an ultimate pathology of less resilient and more vulnerable ecosystems" (Holling, 1996).
Systems and hierarchies

- “The whole is more than the sum of parts” (Bertalanffy, 1968)
- “Evolution cannot occur unless there is limited longevity of the component parts so that new alternatives can be selected” (Costanza and Patten, 1995)
Scale and sustainability

- Sustainability of a system borrows from sustainability of a supra-system and rests on lack of sustainability in subsystems
- Sustainability is misleading in any other scale except the global one

Local sustainability

- Calvert County, MD 1997 Comprehensive plan - “Towards more sustainable community”
- “Sustainable Burlington”
- “Sustainable Raleigh project”
- “Sustainable and Desirable America”
- “Stable Regions of Russia”
- "Duurzaam Dalfsen" and "Duurzaam Hoonhorst"
Local vs. global sustainability

- Are we further destroying the whole (the biosphere) by sustaining the elements, perhaps, beyond their life spans?
- Should elements be allowed to fail?
- Who decides which elements to sustain?
Sustainability is the social compromise about the size of the human enterprise on planet Earth.

- Sustainable development is development within these socially accepted limits.
- Ability to stay on track within certain conditions.
- How to reach this social compromise?
Participatory modeling
Participatory modeling

- Companion modeling, mediated modeling, shared vision planning...
- Participatory modeling is the process of incorporating stakeholders, including the public and decision-makers, into the modeling process
- Soliciting information from stakeholders: integrating scientific knowledge with local knowledge
- Leveling the playing field: co-learning, co-understanding
- Goal driven: you know how the model will be used

The Process

- Identify project goals
- Identify and invite stakeholders
- Choose modelling tools
- Collect and process data
- Discuss system, build conceptual model
- Run model, discuss results
- Discuss and define scenarios
- Analyze model, discuss improvements
- Present results to other stakeholders and decision makers

"We no longer have the money to do it."
"I'm out of here. This is just a waste of time!"
"I'm convinced. Let's make it happen."
"Now I see why they are unhappy. But there should be a compromise."
"This can't be right. We need another model."
"This is not going to work and is too expensive. Let's find a better solution."
"That's how it works! But we never thought about this."
"We don't know what this means. Can we invite somebody else?"

Environmental Modelling & Software 53: 207–212.
But...

- It's really hard to design products by focus groups. A lot of times, people don't know what they want until you show it to them.

— Steve Jobs
Biases

- ‘Temporal insensitivity’
- ‘Steady-state’
- ‘Man versus Nature’
- Anthropomorphic bias
- ‘Single species’
- Cognitive perceptions and the ‘visible is credible’
- ‘Creeping normality’
- Disciplinary biases
- ‘Dominant stature’
- ‘Managed expectations’
- ‘Confirmation bias’ or ‘myside bias’

Set (or Revise) Goals → Get Facts & Information → Evaluate, Reevaluate Results → Judge, Decide, Act! → Acquire Knowledge → Process Information

System 1 reasoning:
- Preconceived notions, Biases, Beliefs

System 2 reasoning:
- Affect, Reconcile
New Trends in PM

- Quantitative and qualitative growth of social media
- Increasing popularity of mobile applications
- Use of web services
- Broad ‘popular’ access to data and information
- Wider social participation in creating these data and information
- Citizen science

"...it often happens, that if a Lie be believ’d only for an Hour, it has done its Work, and there is no farther occasion for it. Falsehood flies, and the Truth comes limping after it; so that when Men come to be undeceiv’d, it is too late; the Jest is over, and the Tale has had its Effect…"

Jonathan Swift (1710)
How to do PM over social media?

- Could we engage the society in crafting our models?
- Can we track human decisions while they play with the model?
- Can they jointly choose the most appropriate behavior?
- Can we use the social media to engage the society in making some important decisions about our preferred futures?
- Can the stakeholders help to choose the most appropriate pathways to these futures?
To Conclude
It is all about values, norms and preferences prevailing in a society, and the corresponding choices we as individuals make. These are very different and do change.
P.P. Rubens. The Judgement of Paris 1632
Heterogeneous tastes
Dynamics of fashion
February 2007 News Map

Based on an analysis of data from the Vanderbilt University Television News Archive

Source: Worldmapper.org
NASA Confirms Earth Will Experience 15 Days Of Complete Darkness in November 2015

"Is it hypocrisy to **honestly believe** in something that is not true? Furthermore, if people honestly believed in something and if they **acted upon such belief**, can one consider such a belief to be a real cause of an ensuing historical event, even if it is not true?... **Human beings create history on the basis not of reality but their perceptions of reality**, perceptions that are often far removed from what actually occurred. But what actually occurred... is visible only from the hindsight that the study of history presents."

University professors, researchers and teachers, we have the luxury and ultimate responsibility of access to the bright young minds of future generations, and it is up to us to help them understand the present to be prepared for the future.
High Tech, Human Touch

- $HT + HT$
- $HT \times HT = HT^2$
ATLAS

- A unique educational programme in Technology and Liberal Arts & Sciences (ATLAS) focuses on science, mathematics, engineering and social sciences.

- Project based
- Student centered
Modeling sub-domain is designed to make sense of geoinformation amongst the deluge of data by building new and using existing simplified representations of reality, models that help us to analyze systems in time and space, guide our efforts in collecting data, and communicate knowledge with stakeholders.
Crowd-sourcing tools and use of social media, which is key for modeling in a participatory framework;
Visualization tools in the spatial and temporal contexts to make models useful and used;
Smart systems and applications as components of decision support systems;
Data and model standards, semantics and ontologies to facilitate model integration;
Web applications to simplify access to models and modeling results
Web services and ontologies for model integration
Generation Y

Millennials really want to transition to clean energy, says new poll

(http://grist.org/article/millennials-really-want-to-transition-to-clean-energy-says-new-poll/)
According to European Millennials, education and technology are key factors in making a real difference in the world and ensuring personal future success.

Their Use of Technology
European Millennials are highly comfortable with technology and believe it has been influential in their lives.

78% Western European Millennials
92% Central & Eastern European Millennials

23% Western European Millennials
30% Central & Eastern European Millennials

believe that technology has made it easier to get a job, compared to 83% of Millennials worldwide.

are most likely to say that technology (followed by economics) is the field of study most important for ensuring personal future success, rather than math or science.

http://survey.telefonica.com/meet-the-millennials/europe/
Different type of students

- ‘Great instability causes great emotional distress’
- Expectation of climate-change disasters is causing “pre-traumatic stress disorder”
- ‘I will not do nothing’

Daddy, what did YOU do to stop global warming?

http://www.climateconviction.org/refs.html
“I have come to the conclusion that politics are too serious a matter to be left to the politicians.”

Charles De Gaulle
Do something

- Give a talk at a school
- Start a campaign
- Write a newspaper article
- Call your senator
- Practice what you preach
- Grow your food
- Switch off the light
- Take the stairs
"The University of Twente is dedicated to research in order to actually make a difference: to ensure that our findings are used in society, to help to improve the lives of people, and perhaps even to save lives".

UT Vision 2020
My thanks go to...
Thanks...
"I know you think you understand what you thought I said but I'm not sure you realize that what you heard is not what I meant."

Alan Greenspan