СТО ГОДИНА
МИЛАНКОВИЋЕВЕ ТЕОРИЈЕ
О КЛИМАТСКИМ
ПРОМЕНАМА

1920 2020 2120

100 YEARS of
MILANKOVIC'S THEORY of
CLIMATE CHANGE

Understanding Climate History to Project Future Climate Change - Importance of Milankovic's Theory

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Introduction - Background

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- United Nations Secretary-General - Climate change is the defining challenge of our time.
- World Economic Forum 2020 Global Risk Report: Climate Action Failure #1 risk by impact and #2 by likelihood. Extreme weather events - #1 - likelihood and 4th - impacts.
- Climate System Science: decades of scientific wisdom and leadership
  - Archimedes, Newton, … 1824 – Fourier –greenhouse effect; 1896 – Arrhenius- theoretical model of Greenhouse
  - 1920 – Milankovic - Théorie Mathématique; 1930 – Milankovic - Mathematische Klimalehre und Astronomische; 1941 - Milankovic, M.: 1941, Canon of Insolation and the Ice Age Problem.
  - 1950's - International Geophysical Year – 1957; carbon cycle and oceans; atmospheric models
  - 1960's - weather satellites; climate models; 1967 – Global Atmospheric Research Program (to 1980)

Earth's variable climate

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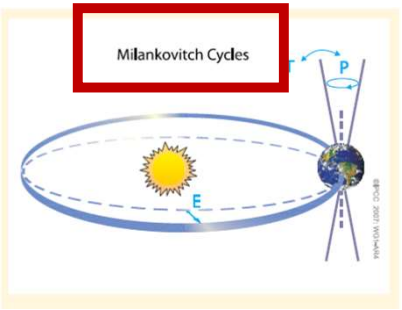
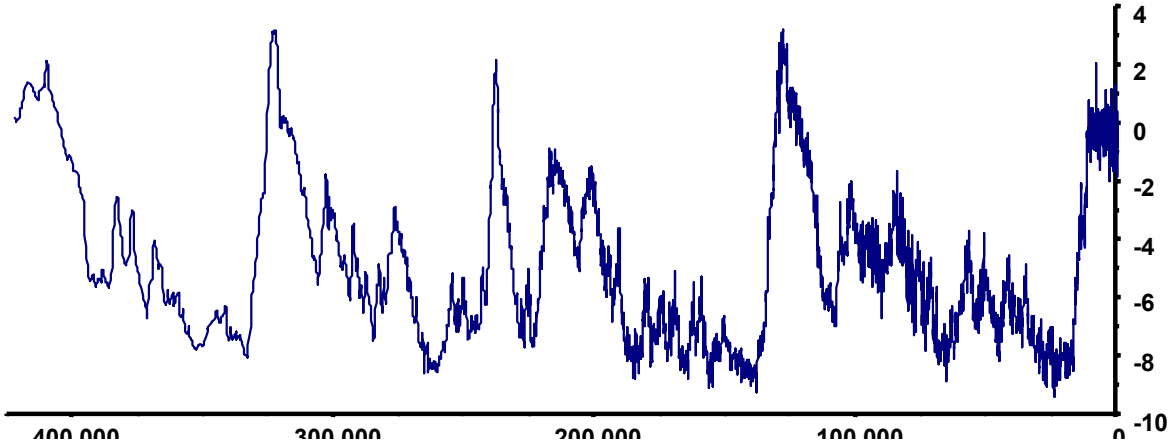
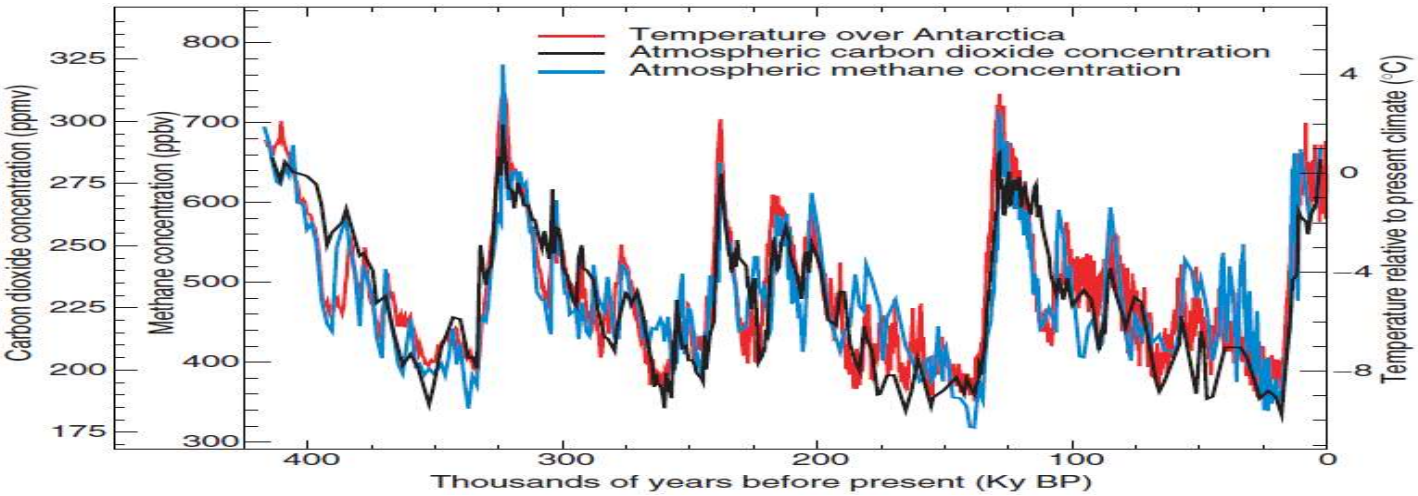
- Ice Ages – Warm Periods
  - Scientific explanations



- Variations of T, CO_2, CH_4
  - Milankovic
  - Greenhouse effect
  - Albedo, ice, snow
  - Oceans





Enhancing Climate Science for Action

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- 1980 –World Climate Research Program
- 1986 –International Geosphere-Biosphere Program (PAGES +) (merged into Future Earth)
- 1988 – IPCC
  - Assessments for Policy –
  - 1990 FAR - 2nd WCC; 1992 UNFCCC; SAR - 1997 Kyoto Protocol; TAR, AR4, AR5 - 2015 Paris Agreement
- 2008 – Integrated Research on Disaster Risk
- 2015 – Future Earth
- 2015 - Sendai Framework
- 2015 – Paris Agreement
- 2015 - Sustainable Development Goals for 2030
- Global Agenda 2030 – Paris, Sendai, SDG, …

Assessments of Climate Science for policy

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- **First Assessment Report – FAR – 1990**
- Radiative Forcing of Climate - climate variability - orbital changes. "*Variations in climate on time-scales ranging from 10,000 to 100,000 years, including the major glacial/interglacial cycles during the Quaternary period, are believed to be initiated by variations in the Earth's orbital parameters which in turn influence the latitudinal and seasonal variation of solar energy received by the Earth (the Milankovic Effect).*"
- Figure 1. "*compelling argument in favour of the Milankovic theory*",
- Milankovic orbital effects (Berger, 1980) "*appear to be correlated with the glacial-interglacial cycle since glacials arise when solar radiation is least in the extra-tropical Northern Hemisphere summer*".
- Has the climate changed - due to human activities? *"The observed increase (in temperatures) could be largely due to natural variability; alternatively this variability and other man-made factors could have offset a still larger man-made greenhouse warming."*

Assessments of Climate Science for policy

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- **Second Assessment Report – SAR – 1995**
- "*to build confidence in the decade-to-century time-scale natural variability simulated by models, there is a need to compare model attempts to mimic the climate of the last 1000 years with variability estimates from paleo-climate data with comparable time resolution. …. the need to identify the forcings, for example solar, volcanoes, deforestation, … phase lags and leads at very large spatial scales which are potentially testable given appropriate paleo-data.*"
- "*Changes in climate have occurred in the distant past as the distribution of continents and their landscapes have changed, as the so-called Milankovitch changes in the orbit of the Earth and the Earth's tilt relative to the ecliptic plane have varied the insolation received on Earth, and as the composition of the atmosphere has changed, all through natural processes.*"
- "*More convincing recent evidence for the attribution of a human effect on climate is emerging from pattern-based studies.*" "*The vertical patterns of change are also inconsistent with those expected for solar and volcanic forcing.*"
- Has the climate changed - due to human activities? "*the balance of evidence suggests a discernible human influence on climate*".

Assessments of Climate Science for policy

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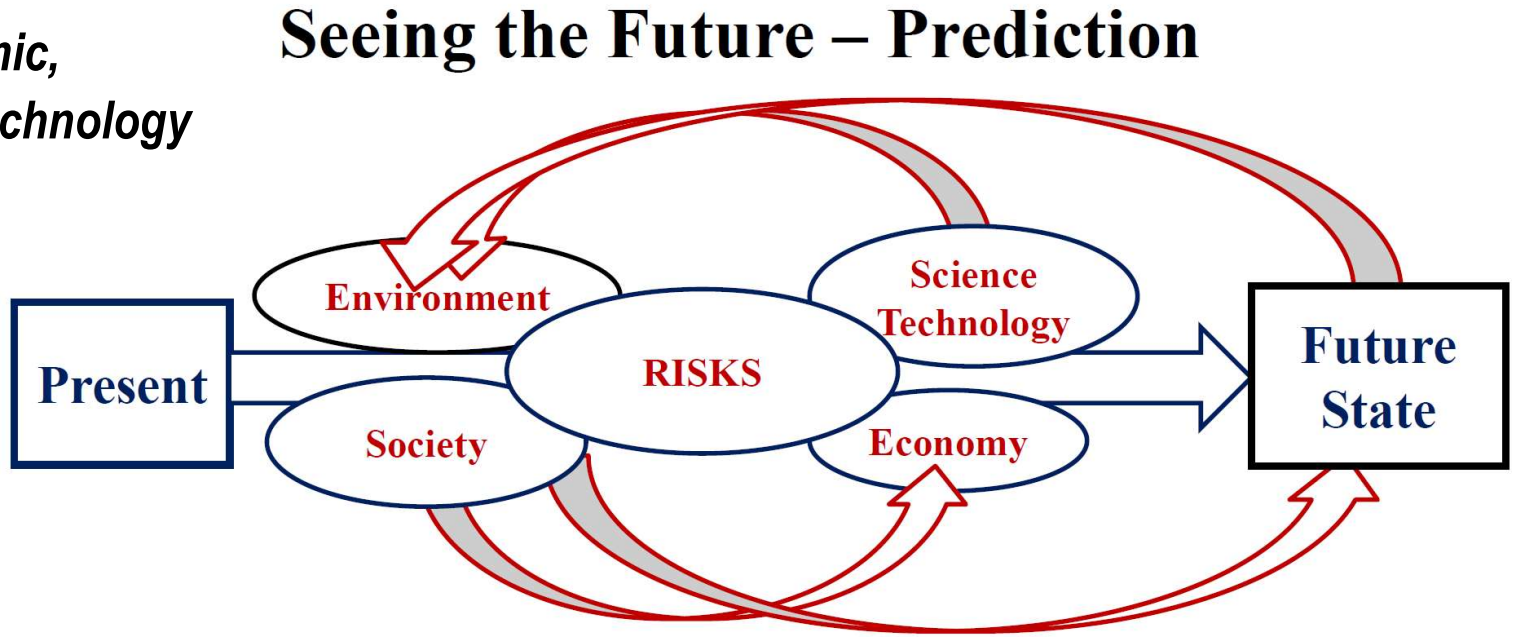
- **Third Assessment Report – TAR – 2001**
- "little ice age", the "Medieval warm period" and the volcanic and solar effects. "*rate and magnitude of global surface warming 20th century warming is likely to have been the largest of the millennium, with the 1990s and 1998 likely to have been the warmest decade and year, respectively in the Northern Hemisphere"*.
- Holocene - northwest Canada (Ritchie) - "*early Holocene Milankovitch thermal maximum*".
- Climate models - present-day versus paleoclimate - Rind et al. (1989) and Berger et al. (1993).
- Has the climate changed - due to human activities? *"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."*
- **Fifth Assessment Report – AR5 - 2013**
- Paleoclimate : "*Recent modelling work provides strong support for the important role of variations in the Earth's orbital parameters in generating long-term climate variability. In particular, new simulations with GCMs support the fundamental premise of the Milankovitch theory that a reduction in NH summer insolation generates sufficient cooling to initiate ice sheet growth".*

Seeing the Future - Prediction

- *Interactions –*
  - *social, economic,*
  - *science and technology*
  - *environmental*
  - *feedbacks*

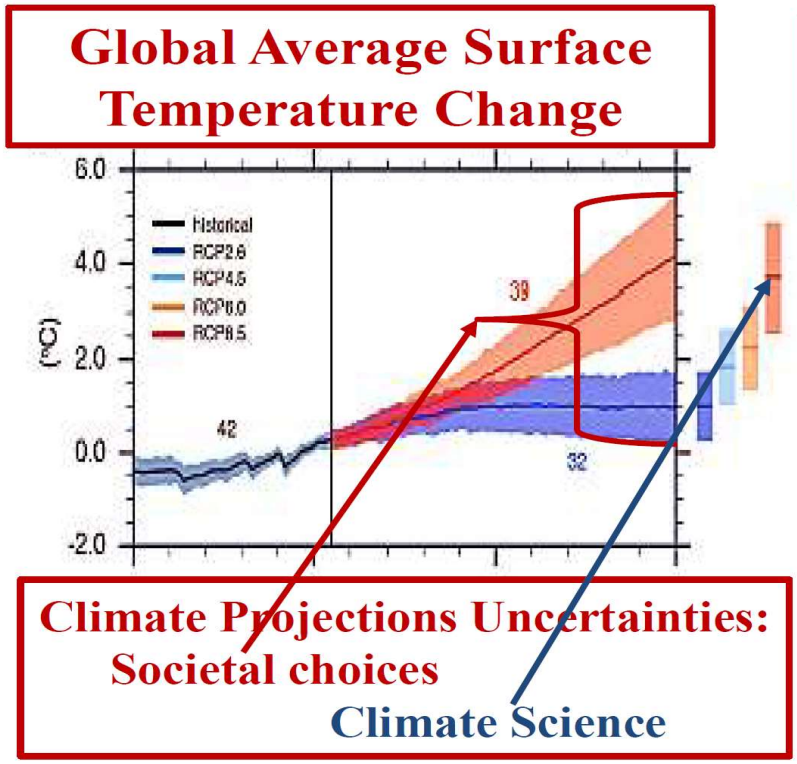


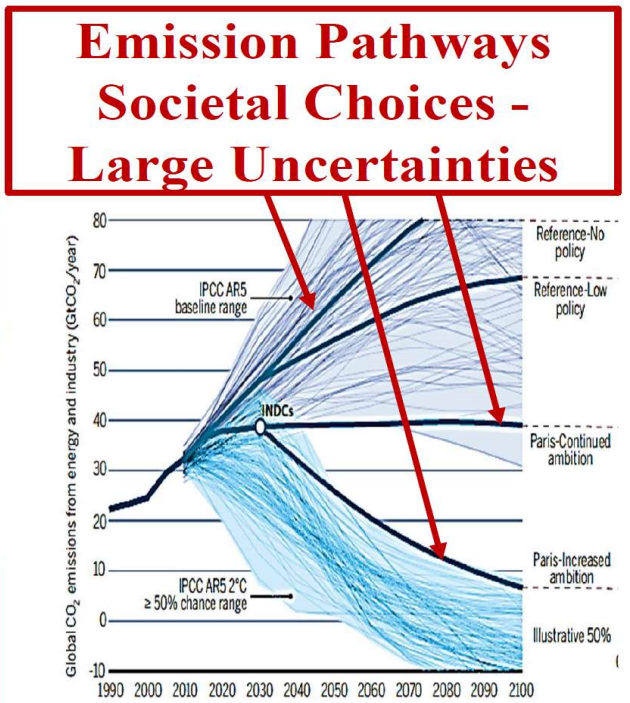
Linking social, economic, technology, science and environmental issues and the future with the present - RISKS AND IMPACTS

Uncertainties in Future Climate

- *Choices in responding to climate change*
  - Uncertainties
  - climate science
  - societal choices
- Importance of "strong" science

GM1





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GM1 Gordon McBean, 2020-11-12

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Over the past century, Planet Earth has seen a changing climate and the scientific understanding of the complex climate system has been greatly enhanced, through leading scientists who applied fundamental scientific thinking to develop and test hypotheses and theories, leading to understanding and predictions of the future. Professor M. Milankovic was one of those scientists. His development of the Milankovic theory and the explanations of the driving forces for the last million plus years of climate and the ice ages provided a basis for climate system scientific understanding. He continued his contributions over decades and his science has provided a basis for many scientists to further develop and extend our global understanding of the complex climate system enabling predictions.

Thank you for your attention!