Effect of climate change on dose impact assessments

–

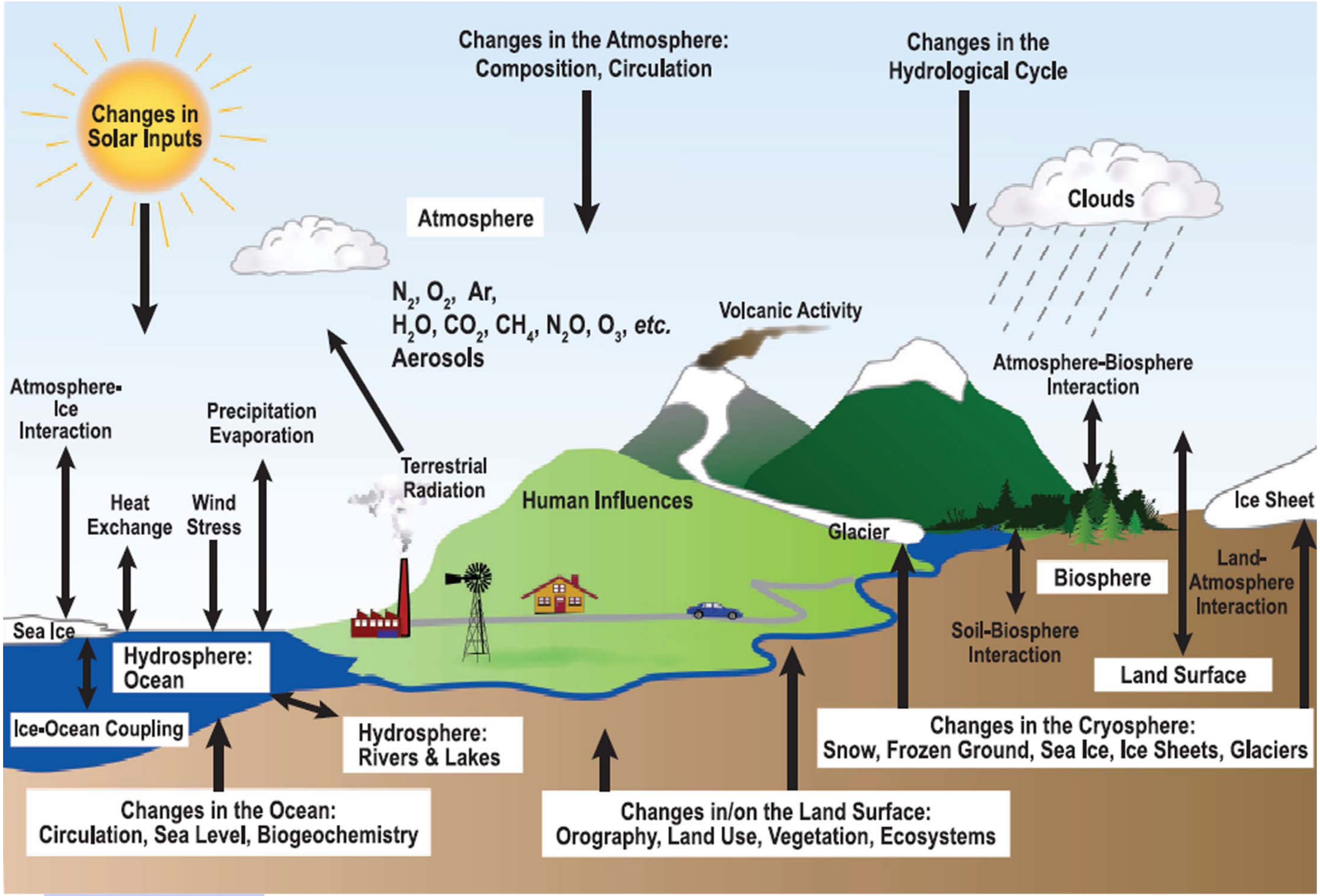
How to proceed ??

Geert Olyslaegers

Biosphere Impact Studies

golyslae@sckcen.be

EMRAS II meeting
Munich, 5 – 7 October 2010


Changes in Solar Inputs
Changes in the Atmosphere: Composition, Circulation
Changes in the Hydrological Cycle
Clouds
Atmosphere
N2, O2, Ar, H2O, CO2, CH4, N2O, O3, etc. Aerosols
Volcanic Activity
Atmosphere-Biosphere Interaction
Atmosphere-Ice Interaction
Precipitation Evaporation
Terrestrial Radiation
Heat Exchange
Wind Stress
Human Influences
Ice Sheet
Glacier
Biosphere
Land-Atmosphere Interaction
Sea Ice
Hydrosphere: Ocean
Soil-Biosphere Interaction
Land Surface
Ice-Ocean Coupling
Hydrosphere: Rivers & Lakes
Changes in the Cryosphere: Snow, Frozen Ground, Sea Ice, Ice Sheets, Glaciers
Changes in the Ocean: Circulation, Sea Level, Biogeochemistry
Changes in/on the Land Surface: Orography, Land Use, Vegetation, Ecosystems

(IPCC, 2007)

Climate predictions for Northern Europe on a short term

- Annual mean **temperatures** in Europe are likely to increase more than the global mean. The warming in northern Europe is likely to be largest in winter.
- Annual **precipitation** is very likely to increase in most of northern Europe. Extremes of daily precipitation are very likely to increase in northern Europe. Summer precipitation is projected to decrease slightly.
- Confidence in future changes in **windiness** is relatively low, but it seems more likely than not that there will be an increase in average and extreme wind speeds in northern Europe.
- The duration of the **snow** season is very likely to shorten in all of Europe, and snow depth is likely to decrease in at least most of Europe.

(IPCC, 2007)

Impact of climate change on (managed) ecosystems in Northern Europe (1/2)

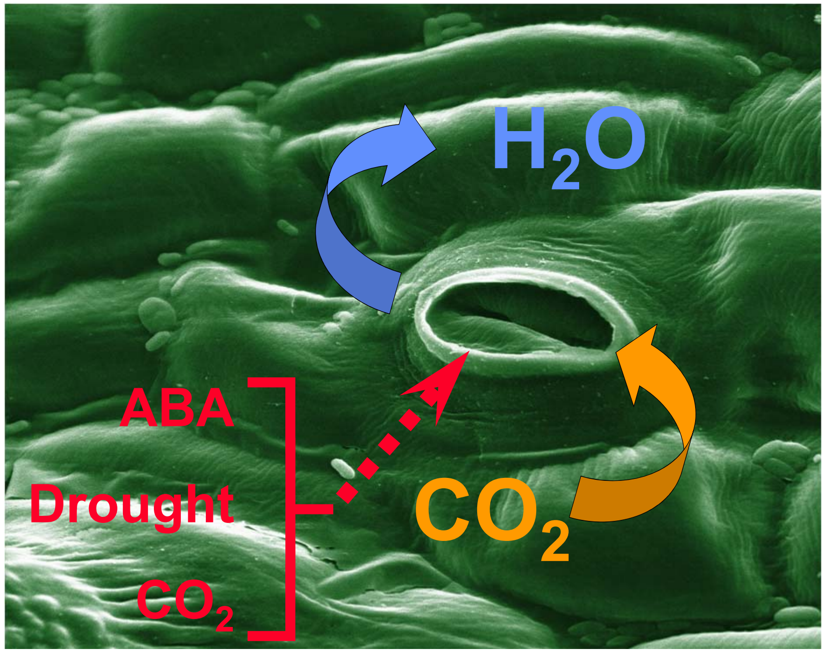
- Crop production will be affected differently according to the regional variations in **adaptive capacity** such as adjustment of planting dates and crop variety, crop relocation, improved land management, pest and diseases control.

- In northern Europe, runoff, water availability, and soil moisture are likely to increase in **winter**. An increase in rainfall during periods when soils will be saturated (winter, spring) could increase the frequency and severity in **floods**. There could be a slight increased **summer** drying, with **additional** consumption of water for **irrigation** (might affect hydrogeological gradient).

Impact of climate change on (managed) ecosystems in Northern Europe (2/2)

- There will be some broadly positive effects on agriculture. For average management conditions, wheat yields might increase by 5-7% for a doubled current CO_2 concentration. This increase in yield due to **CO_2 fertilisation** might be **offset by an increase in temperature and a decrease in water resources**. A rise in mean temperature tends to speed up the development, increase transpiration and respiration rates, which in turn affects biomass production.

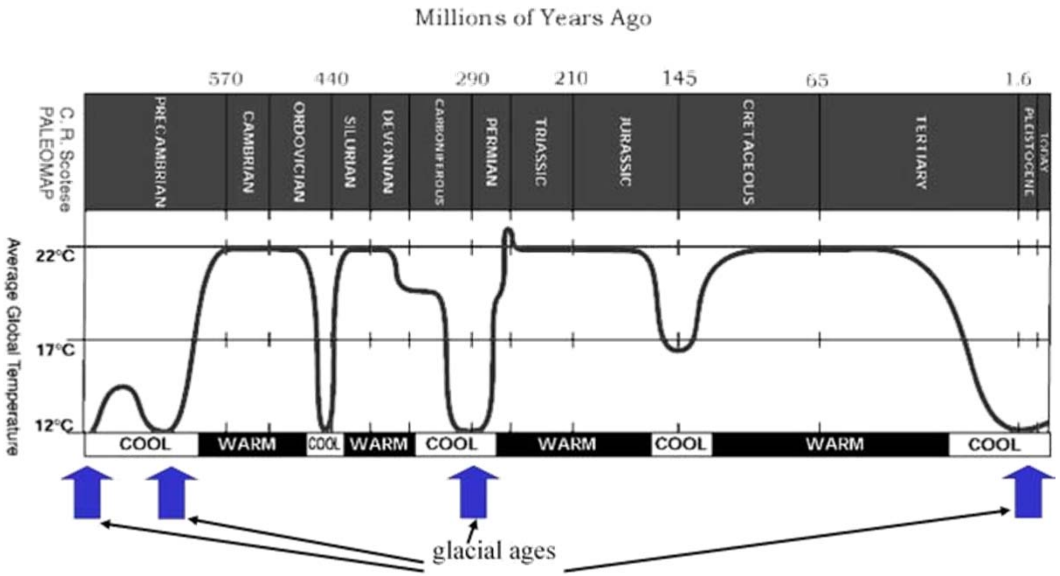
- A decrease in water resources might however be counter balanced by an **increase in water use efficiency** of the crop under elevated CO_2 (stomatal closure -> decreasing transpiration rate).



(Bazzaz and Sombroek, 1996; Kimball *et al.*, 2002; Ainsworth and Long, 2005; IPCC, 2007)

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

However, for deep disposal predictions at longer timescales are required



- Till 2000 → Milankovitch
  - Orbital shape (eccentricity)
  - Axial tilt (obliquity)
  - Precession (wobble)
  - Orbital inclination

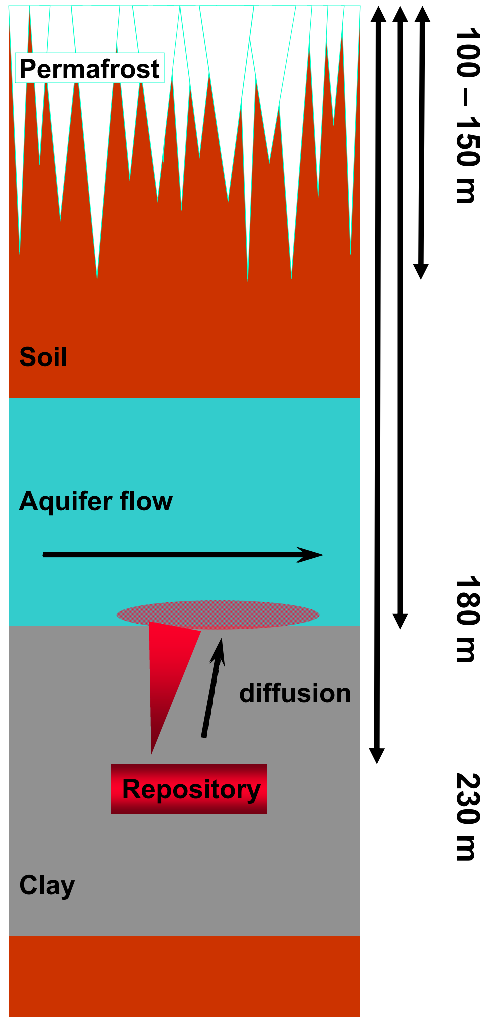
    (natural forcings)

→ Colder period from 50 kyr till max 100 kyr

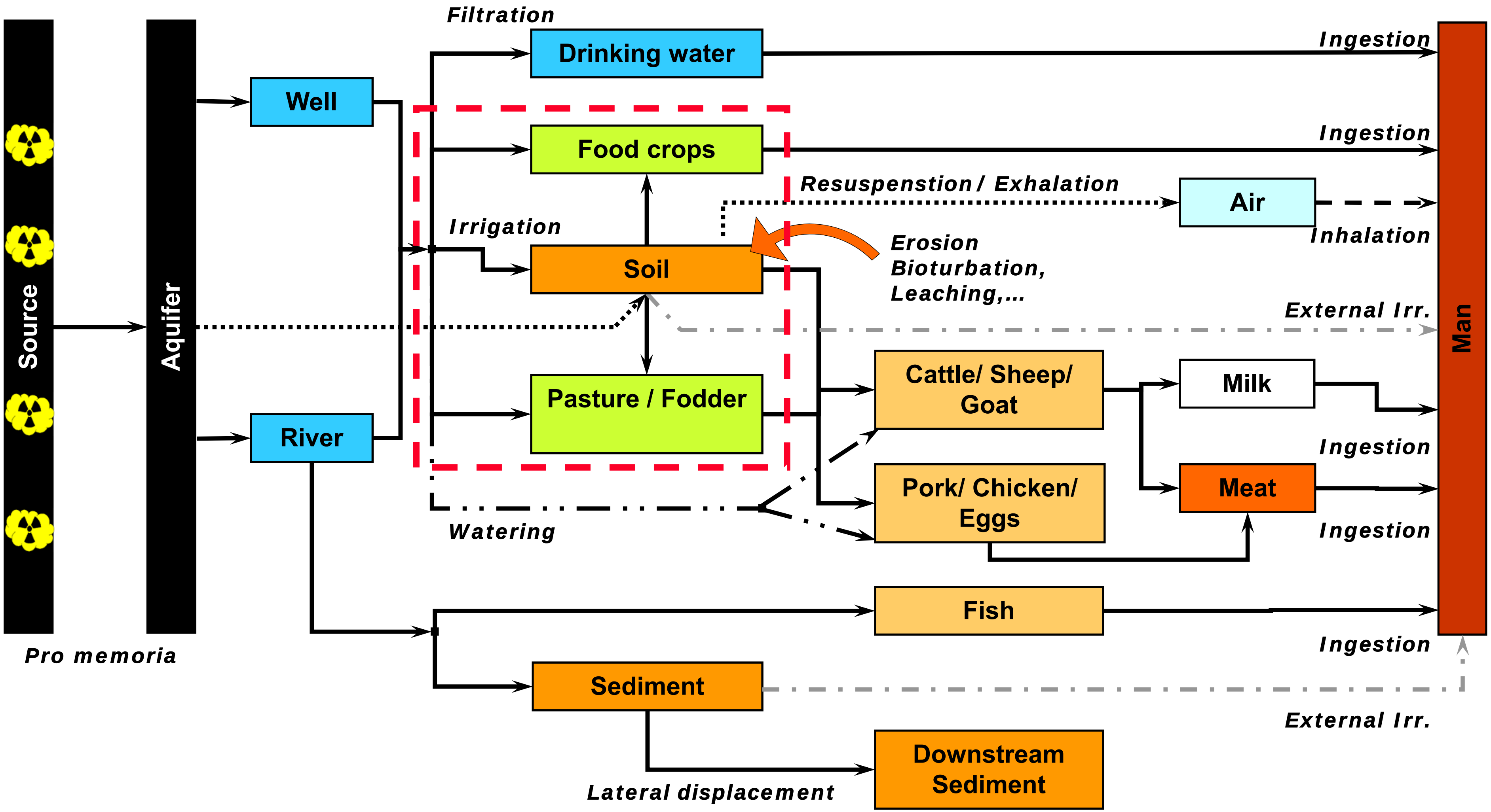
- After 2000 → Berger and Loutre (1991)
  - If CO_2 ↗ by 240 ppm → no glacial period is expected in the next 175 kyr

For the geosphere the consequences are probably limited

- Repository at 230 m in the Boom Clay (180 m)
- Glacial period → ?
  - Permafrost (100 – 150 m)
    - → Limited infiltration and groundwater flow
    - → Low transfer of RN in clay since migration mainly through diffusion
    - → Possible local accumulation of RN due to diffusion out of the Boom Clay
  - See level change
    - → Presumably no effect
  - Injection of O_2-rich water in subsurface
    - → change in redox-state



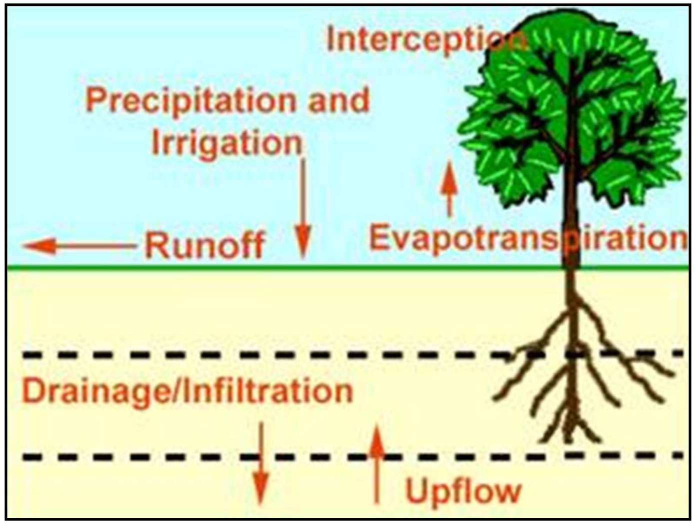
The biosphere will be strongly affected by climate/environmental change



Many biosphere components might be affected

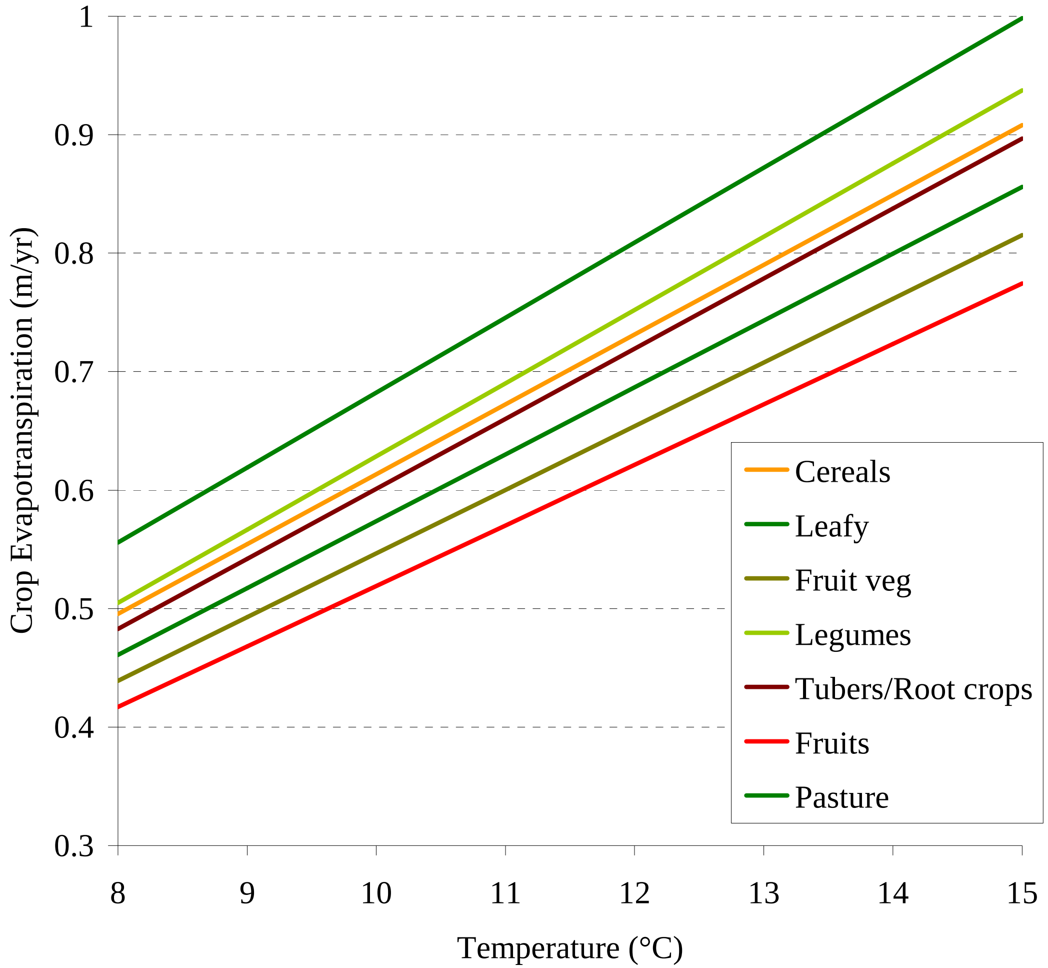
- **Effect at *plant level***
  - Soil-plant TF
  - Biomass, partitioning, transpiration rate, seasonality and species
- **Effect at *animal level***
  - Water consumption and food composition
  - Soil-plant and animal TF (uptake RN)
  - Species
- **Effect on *agricultural practices***
  - Irrigation regime
- **Effect on *humans***
  - Food composition
- **Other**
  - Erosion / Bioturbation
  - Infiltration

Change in irrigation regime due to change in temperature



$$P - I - E + U - R - D = \Delta S$$

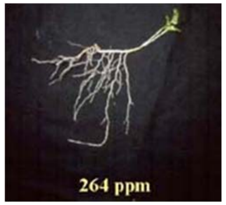
P	:	precipitation (and irrigation)
I	:	intercepted
E	:	evapotranspiration
U	:	up-flow (*e.g.* capillary flow)
R	:	runoff
D	:	drainage/infiltrations
ΔS	:	storage

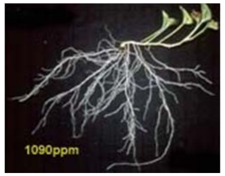


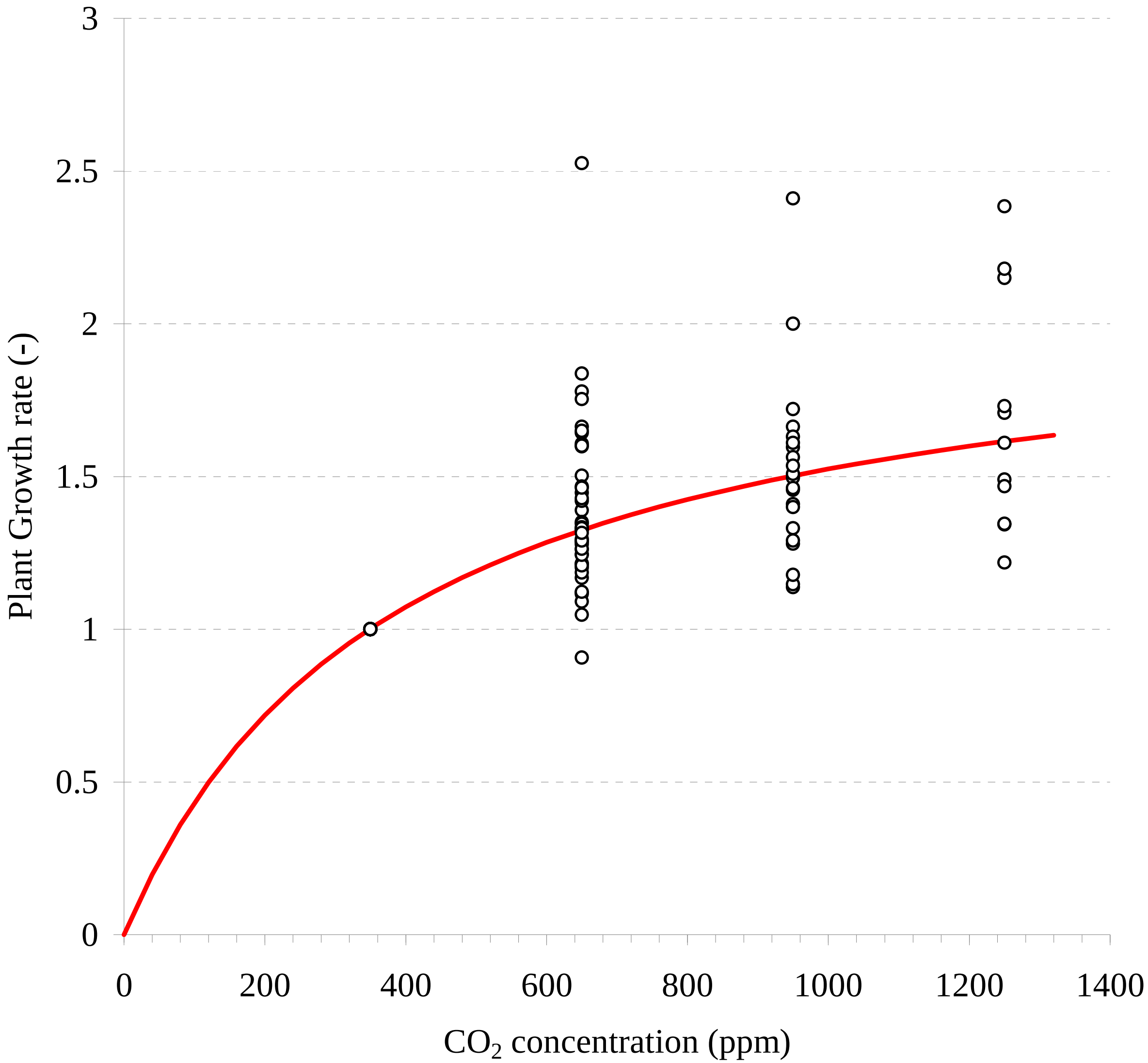
Average crop evapotranspiration with different air temperature calculated according to FAO

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

CO_2 has an effect on biomass production





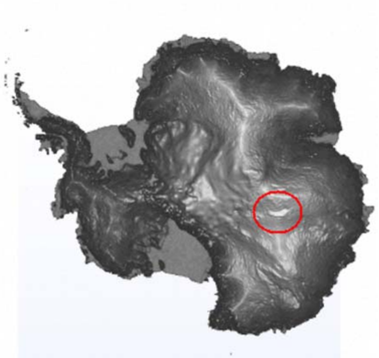


Also influence of a changing soil-to-plant transfer factor was incorporated

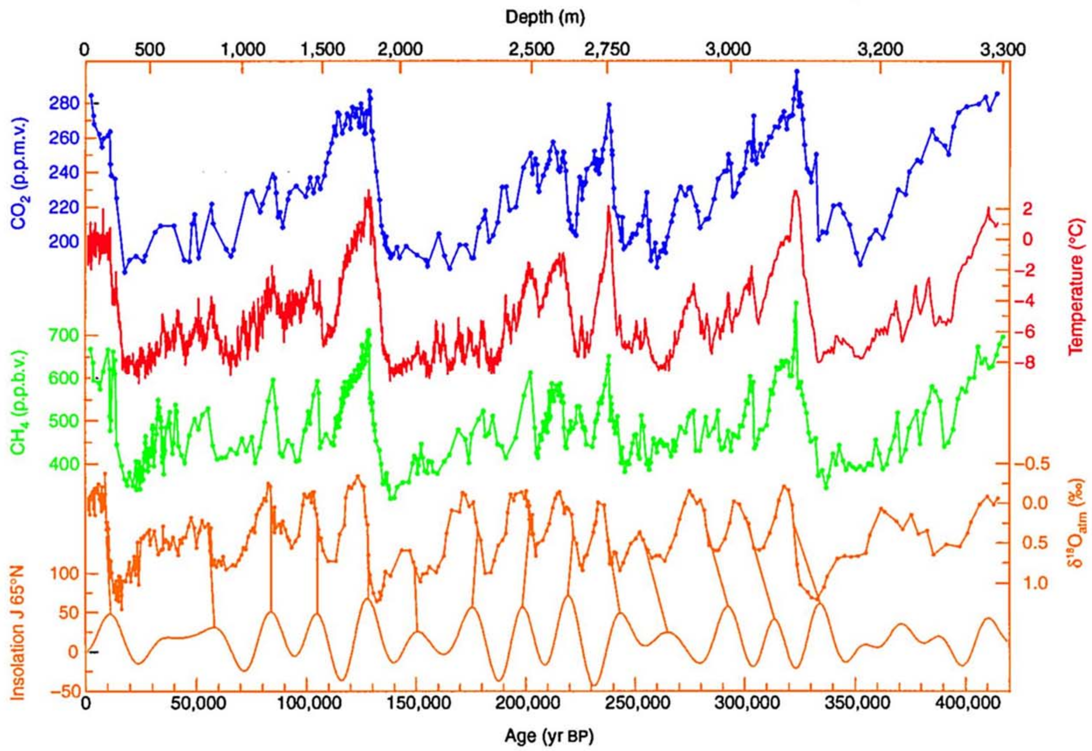
- Determination of a diffusion parameter (DP)
  - DP > TF → Passive transport
  - DP < TF → Active transport
- Active transport
  - no CO_2 effect
  - Edible parts above ground level are corrected for ET_c
    - pasture, leafy vegetables, fruit vegetables,…
  - Edible parts under ground level are not corrected for ET_c
    - tuber and root crops
- Passive transport
  - CO_2 effect (higher CO_2 → dilution)
  - Edible parts above ground level are corrected for ET_c
    - pasture, leafy vegetables, fruit vegetables,…
  - Edible parts under ground level are not corrected for ET_c
    - tuber and root crops

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

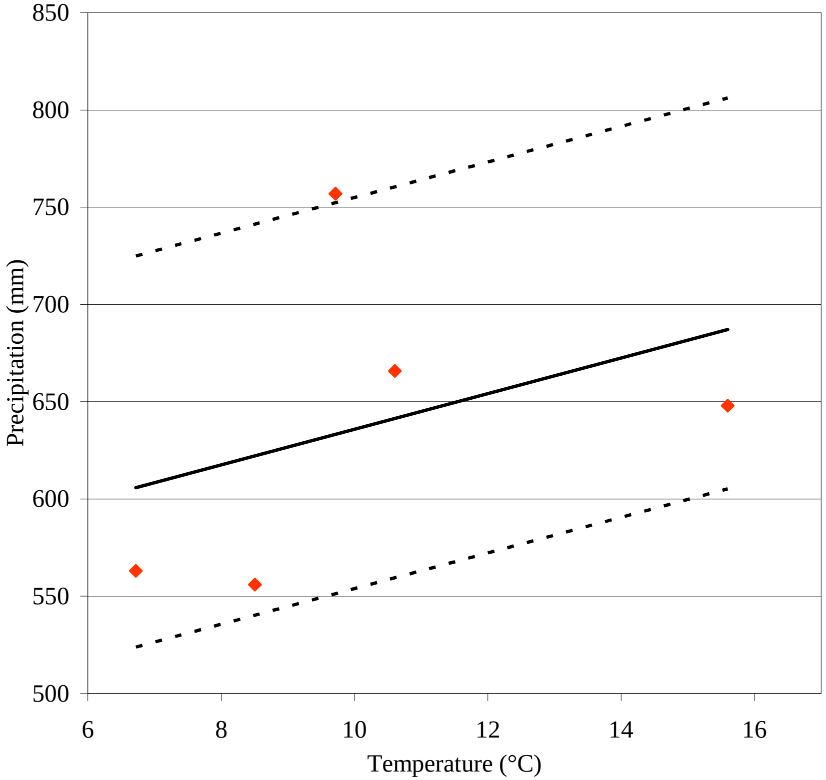
Paleodata were used as input data

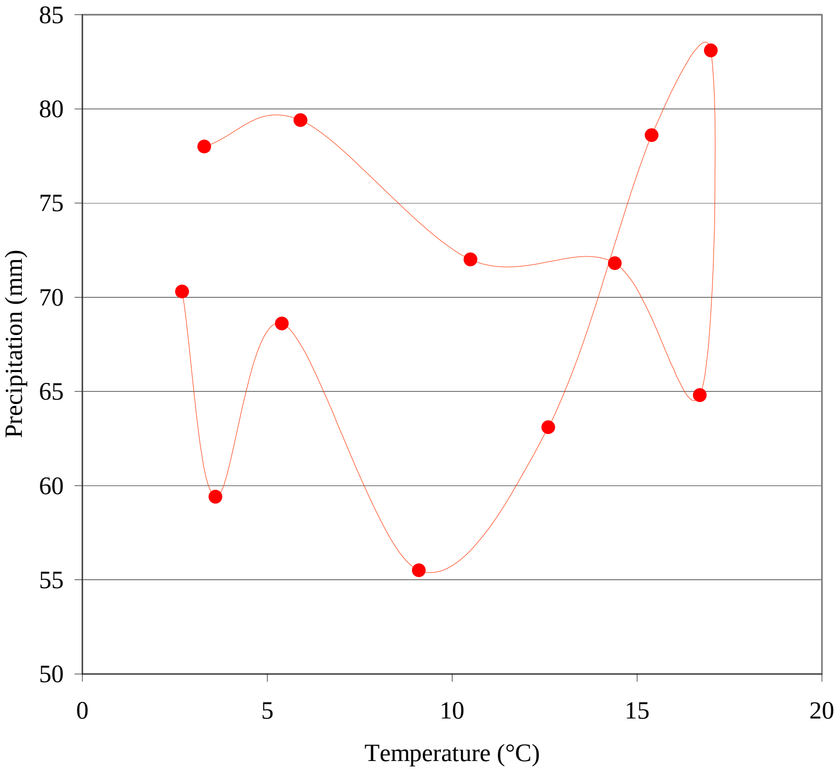


- Vostok ice core data
  - Antarctica
  - reached back 420,000 years
  - revealed 4 past glacial cycles

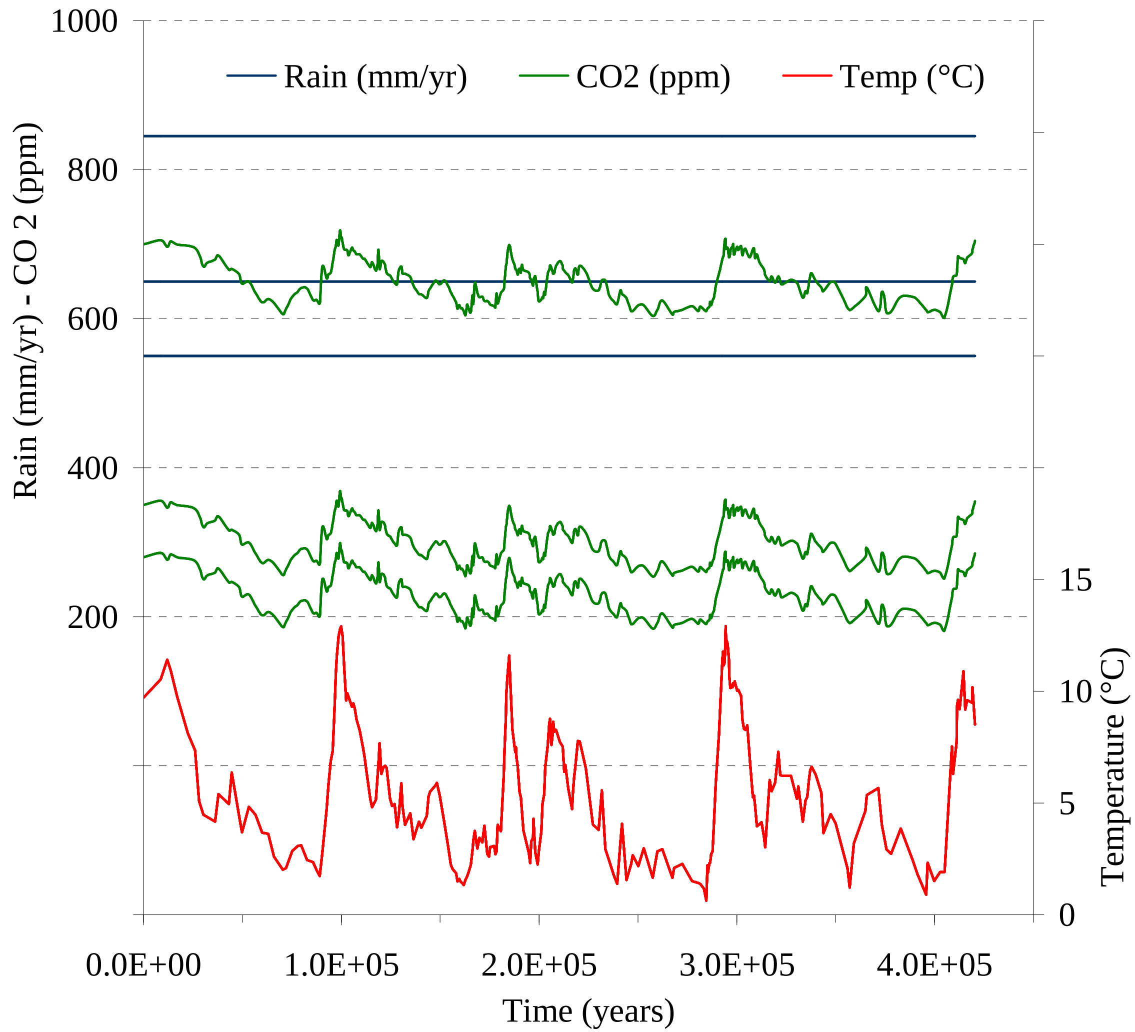


Predicting precipitation is rather difficult

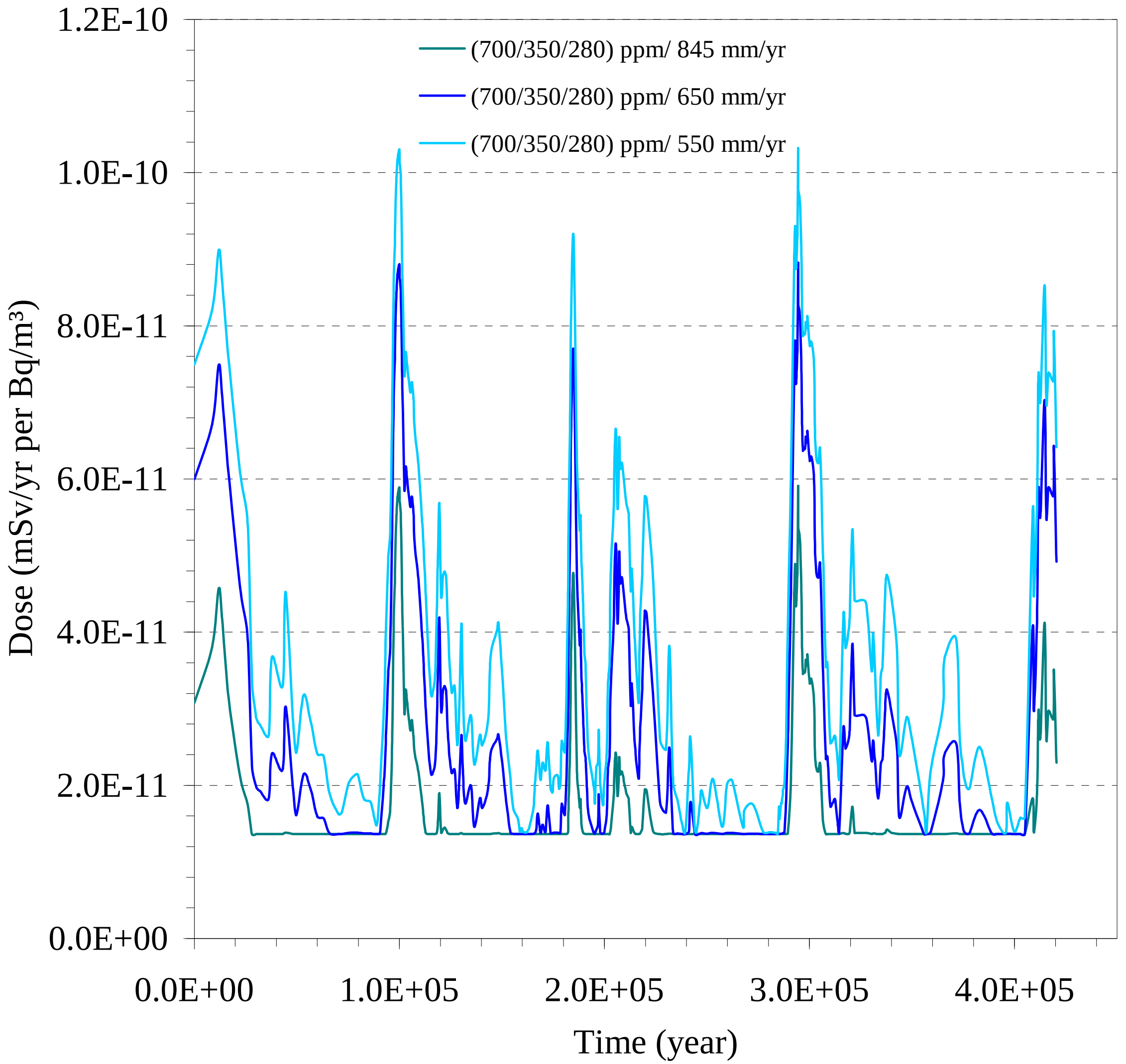




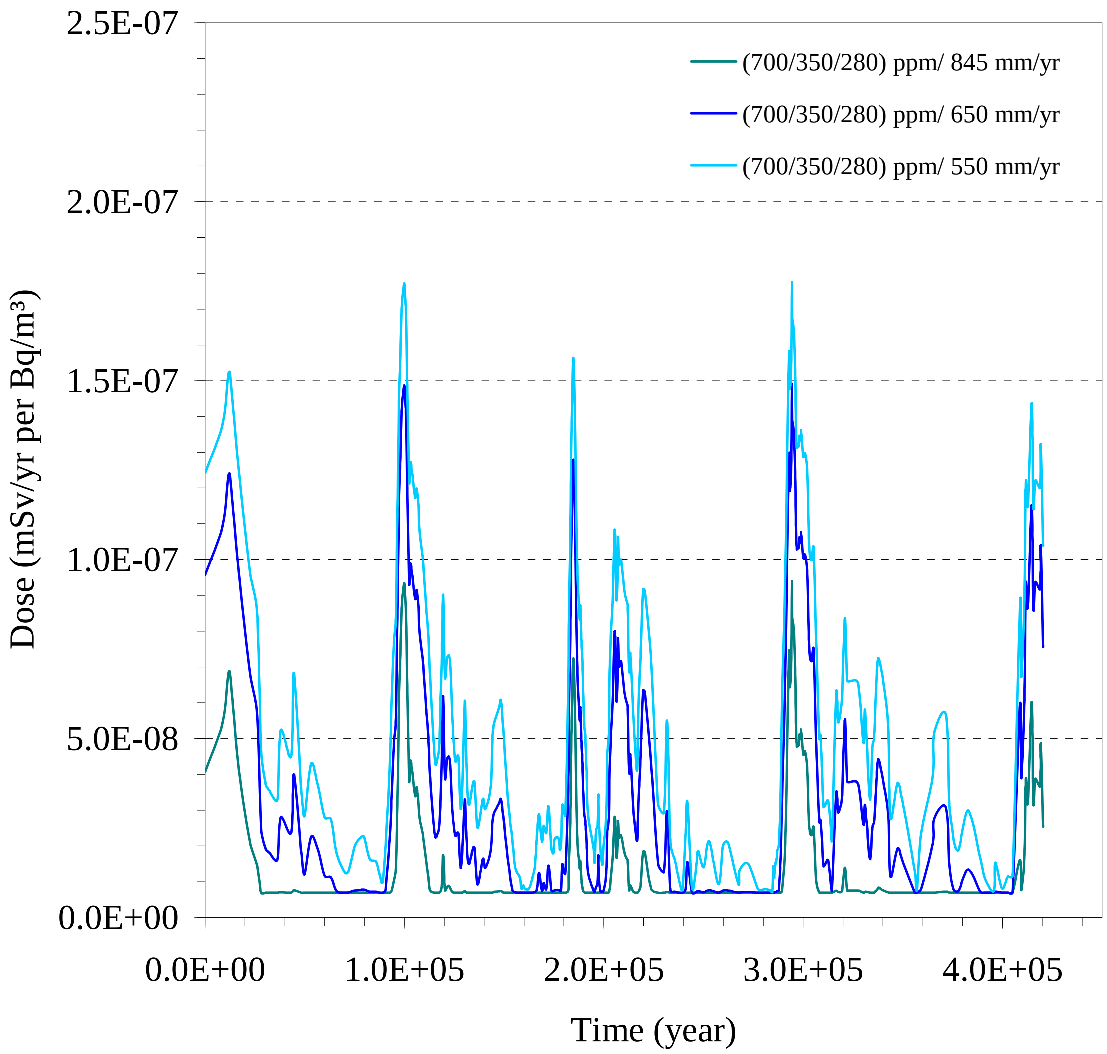
CO_2 and temperature data were used combined with arbitrary precipitation rates



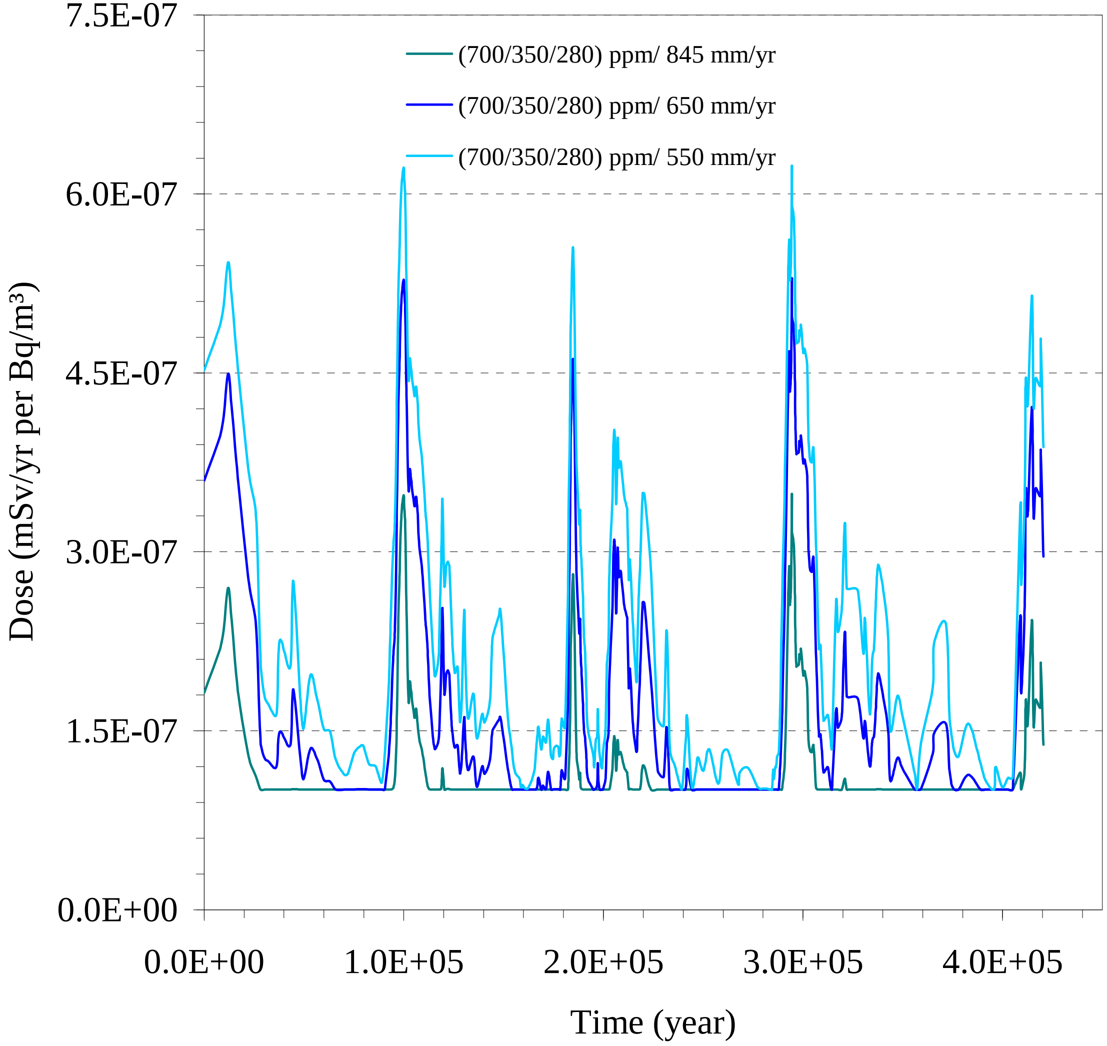
preliminary results for H^3



preliminary results for Cs^{137}

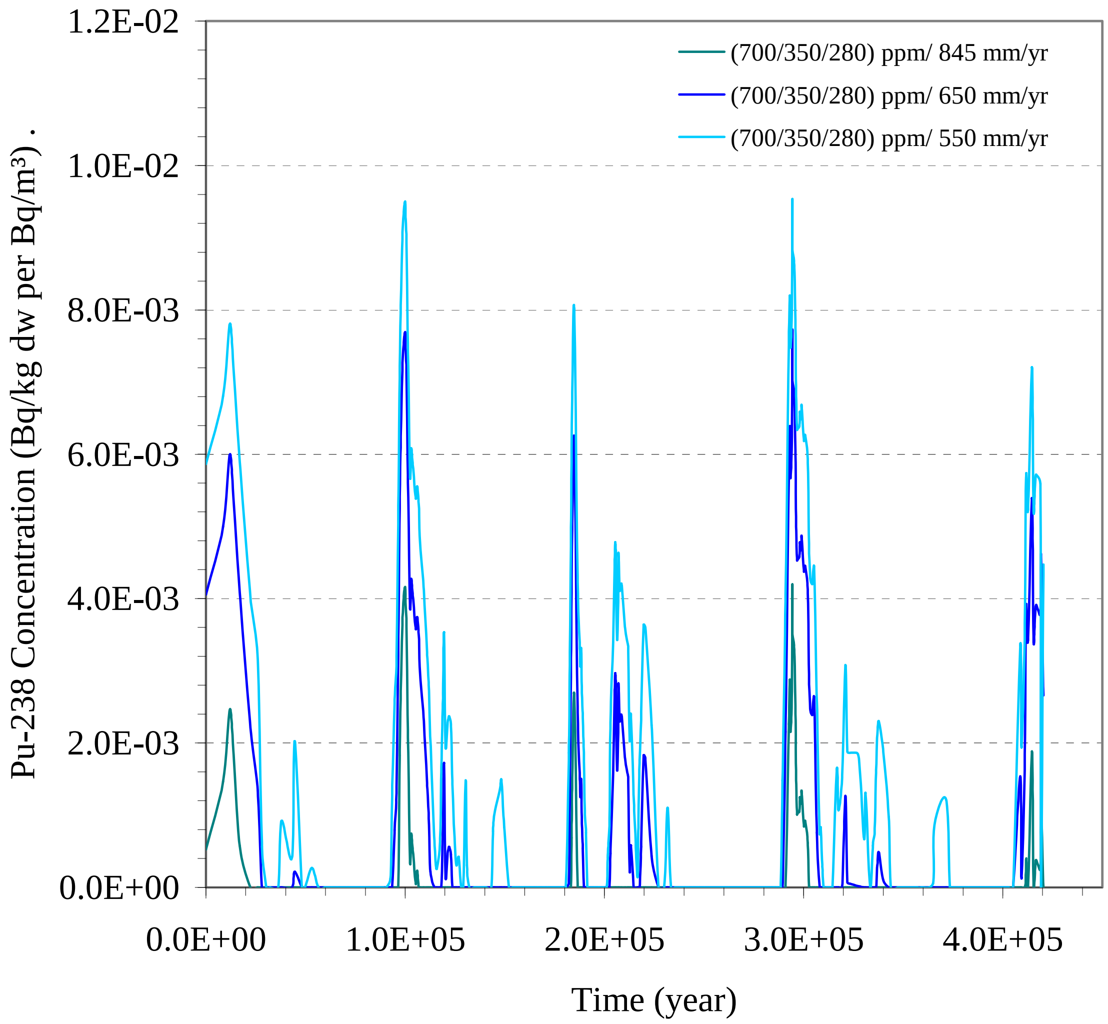


preliminary results for Pu^{238}

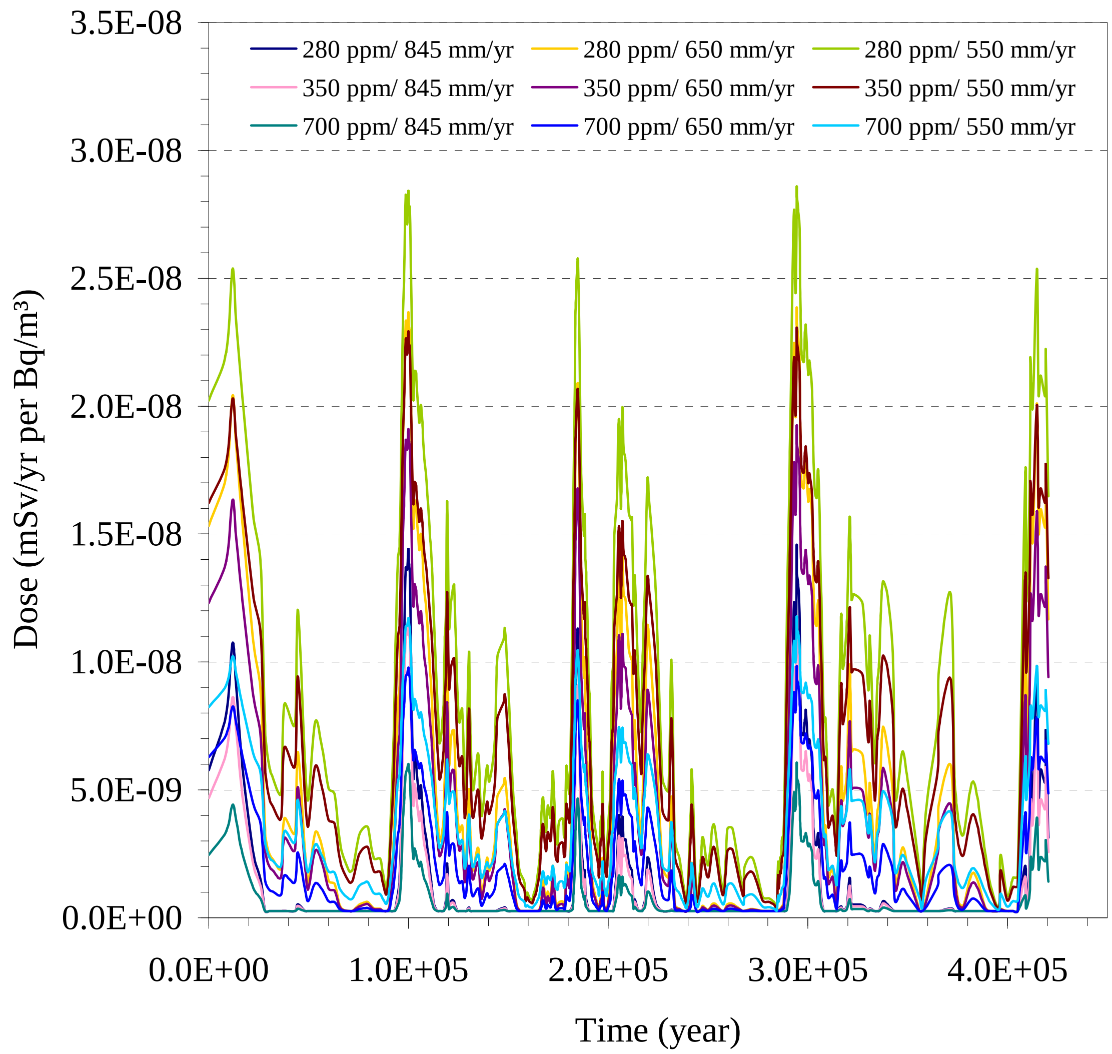


SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

preliminary results for Pu^{238}

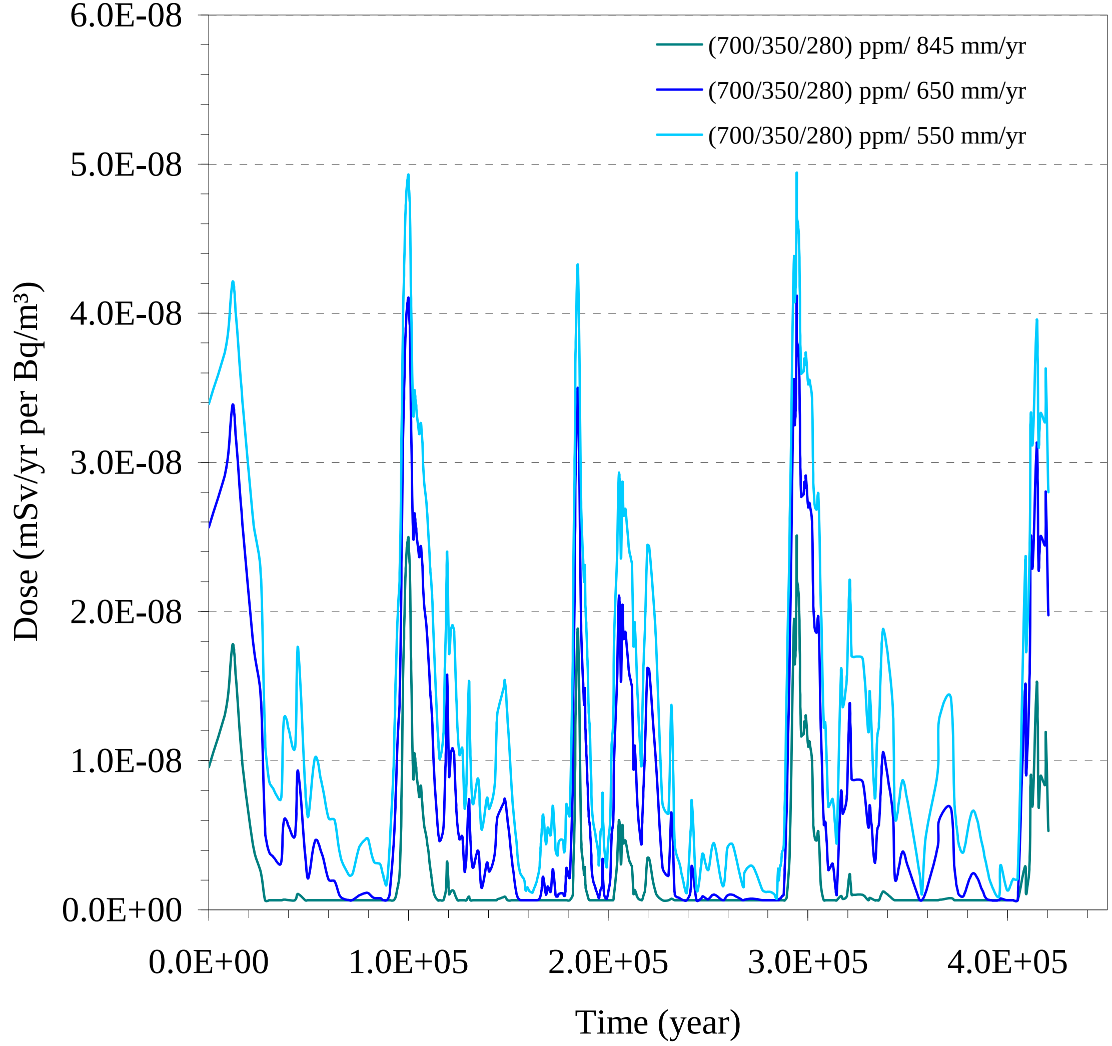


preliminary results for C^{14}

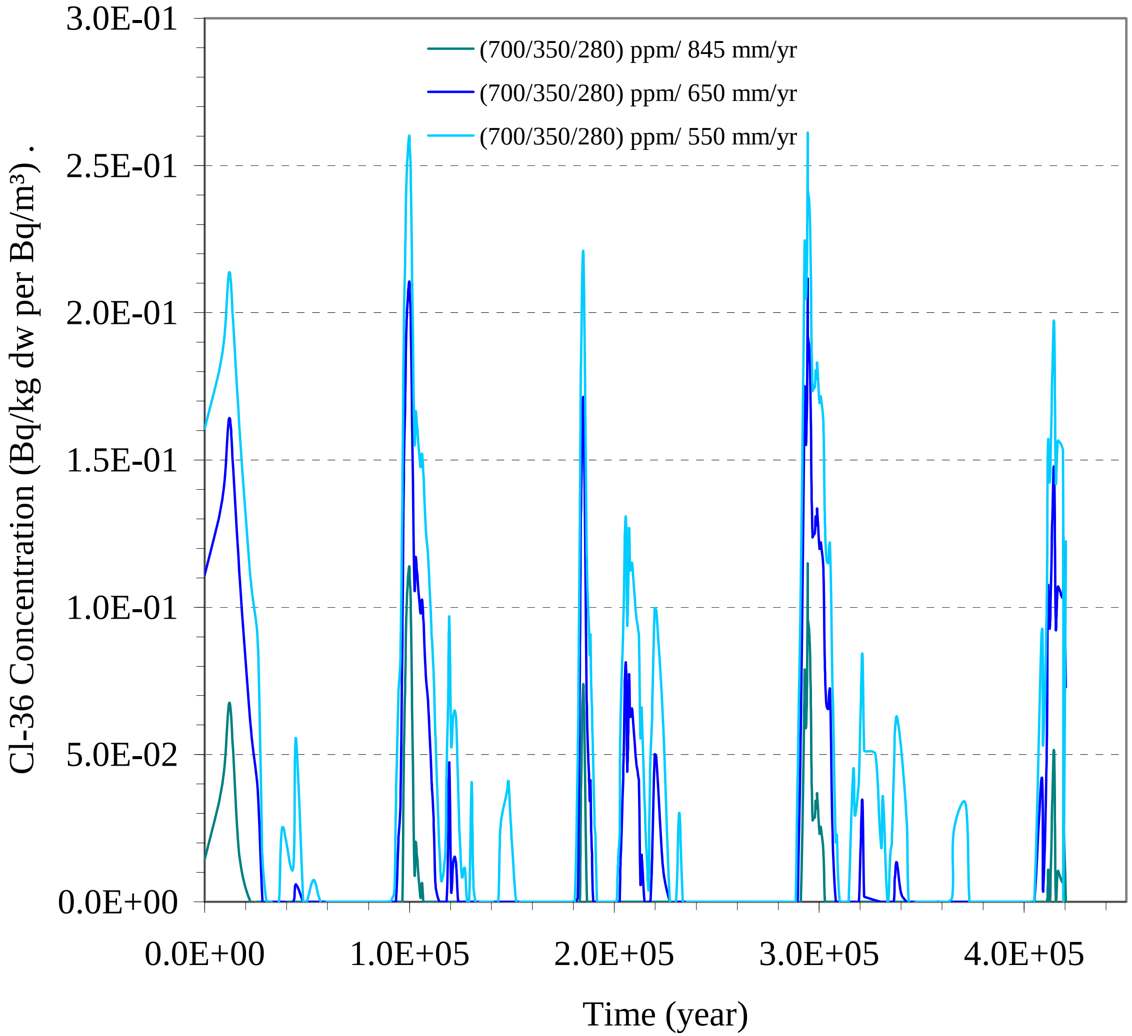


STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

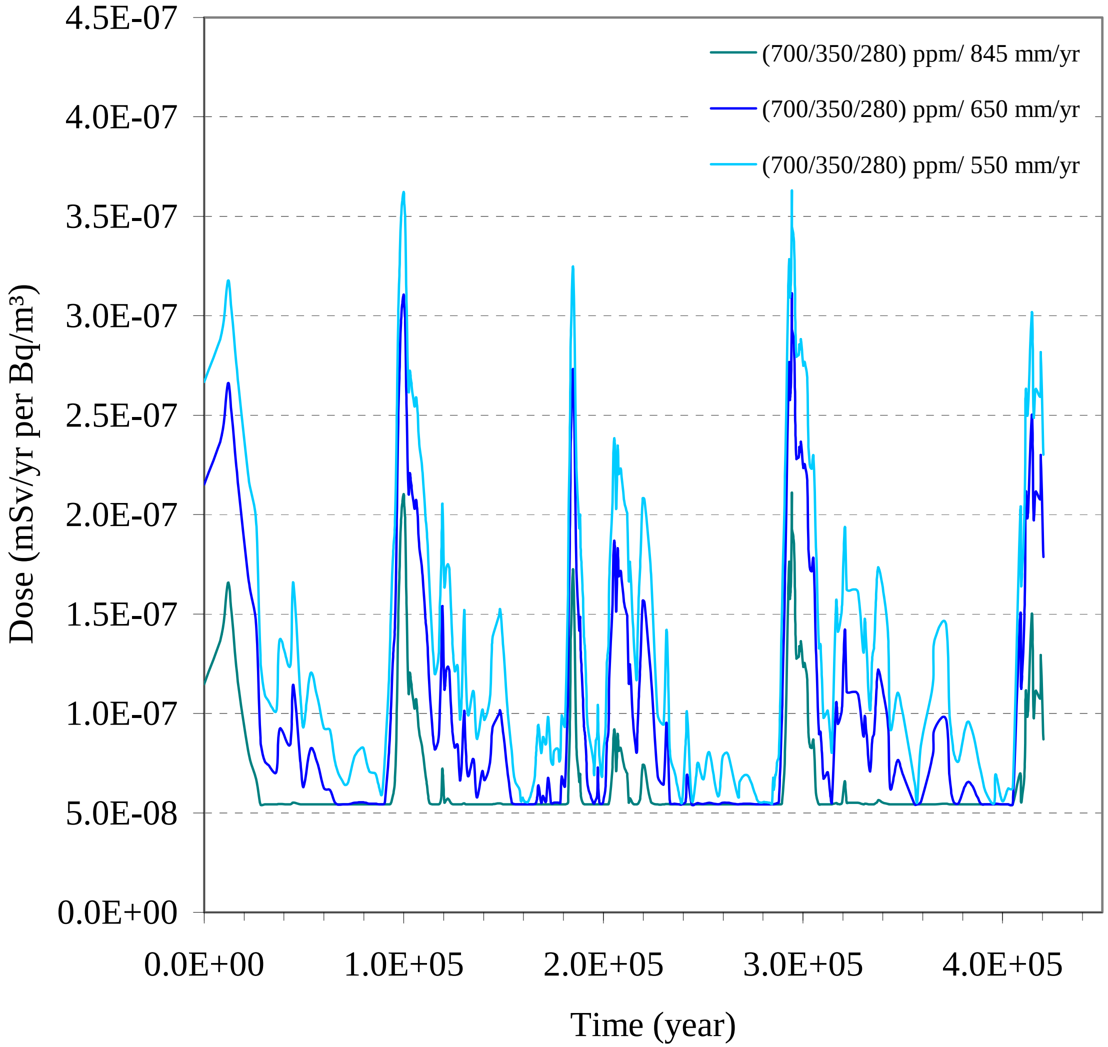
preliminary results for Cl^{36}



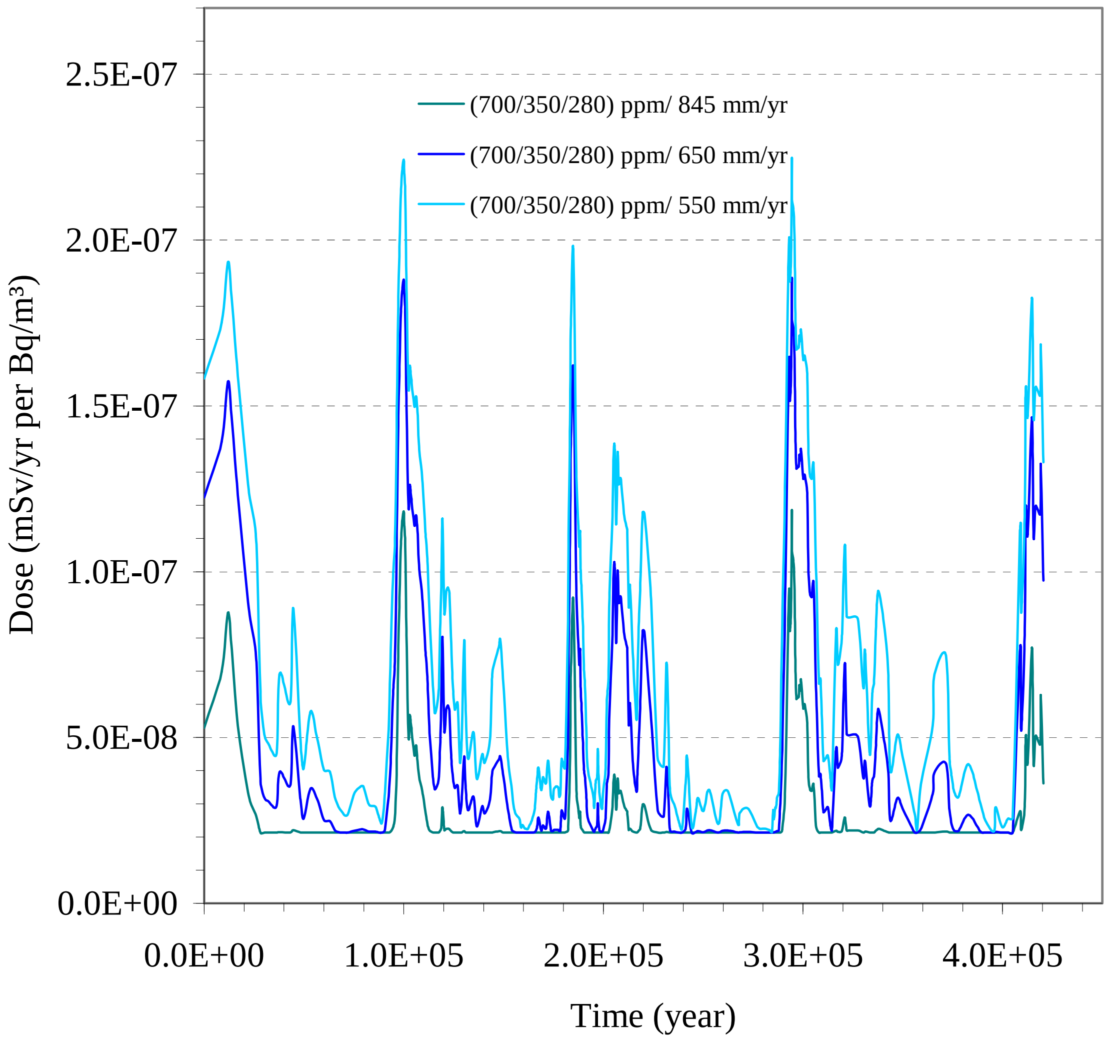
preliminary results for Cl^{36}



preliminary results for I^{129}

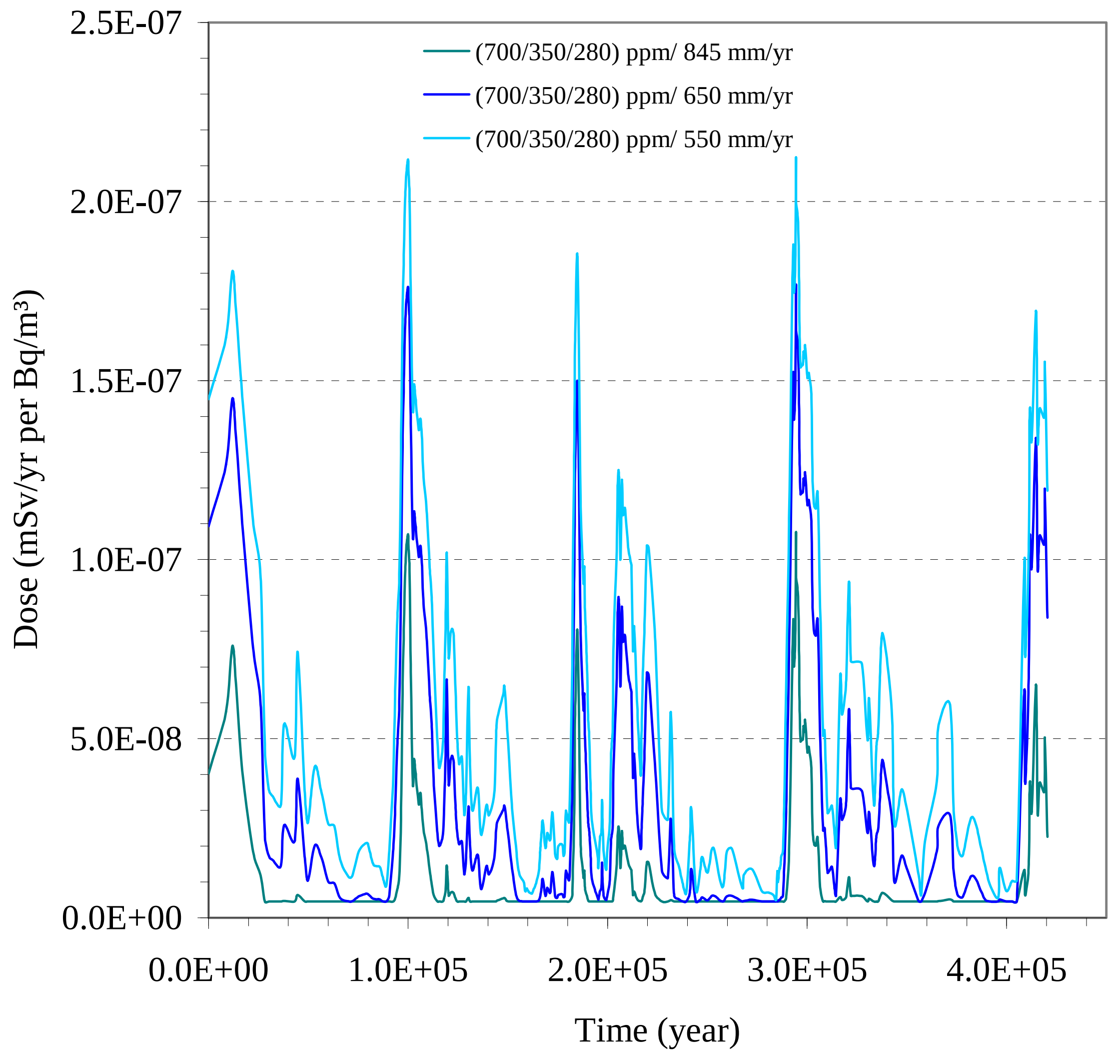


preliminary results for U^{235}



SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

preliminary results for Se^{79}



STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Interesting reading

Journal of Environmental Radioactivity 99 (2008) 1736–1745

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

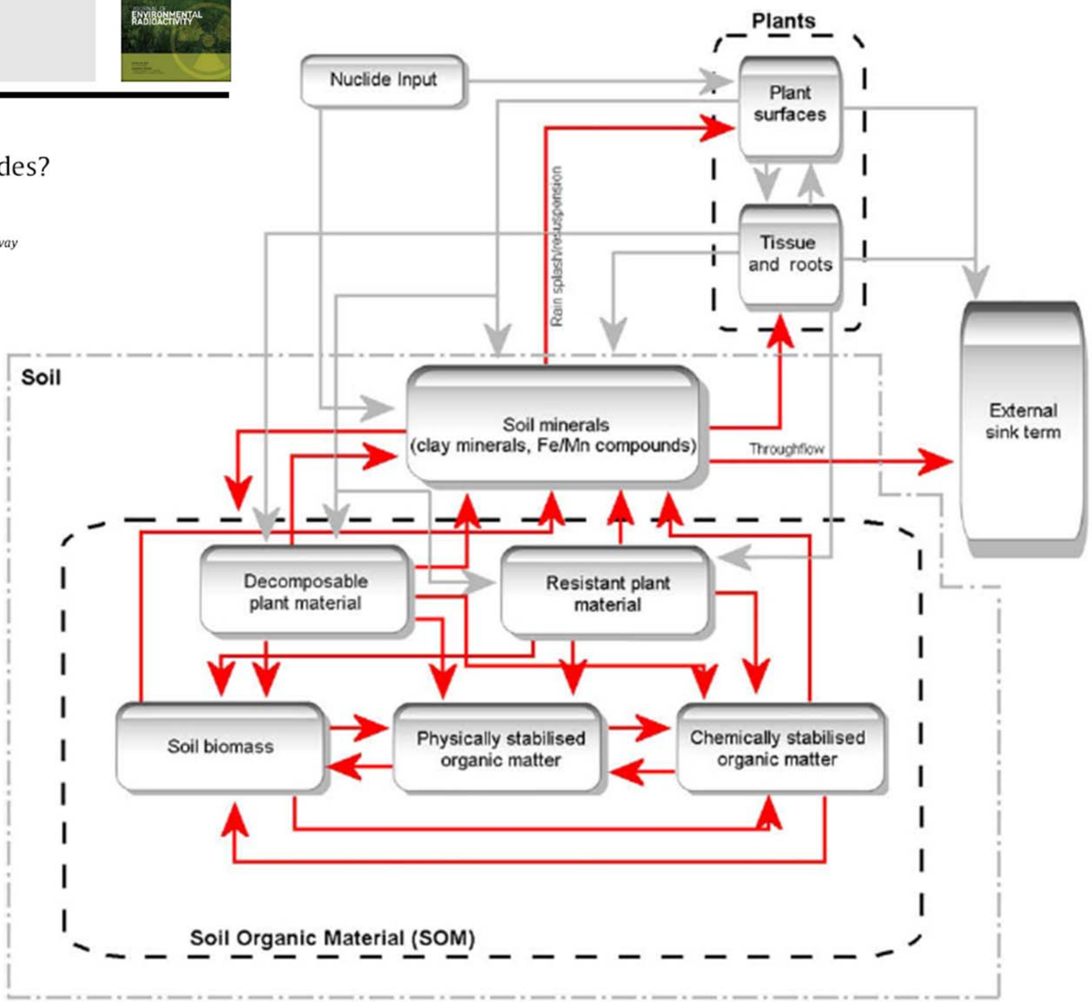
journal homepage: www.elsevier.com/locate/jenvrad

ELSEVIER

Will global warming affect soil-to-plant transfer of radionuclides?

M. Dowdall[a,*], W. Standring[b], G. Shaw[c], P. Strand[b]

[a] Norwegian Radiation Protection Authority, Environmental Unit, Polar Environmental Centre, Hjalmer Johansens Gt., 9296 Tromsø, Norway
[b] Norwegian Radiation Protection Authority, PO Box 55, N-1332 Østerås, Norway
[c] School of Biosciences, Faculty of Science, University of Nottingham, University Park, Nottingham NG7 2RD, UK



Interesting reading

Journal of Environmental Radioactivity 99 (2008) 1736–1745

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Will global warming affect soil-to-plant transfer of radionuclides?

M. Dowdall[a,*], W. Standring[b], G. Shaw[c], P. Strand[b]

[a] Norwegian Radiation Protection Authority, Environmental Unit, Polar Environmental Centre, Hjalmer Johansens Gt., 9296 Tromsø, Norway
[b] Norwegian Radiation Protection Authority, PO Box 55, N-1332 Østerås, Norway
[c] School of Biosciences, Faculty of Science, University of Nottingham, University Park, Nottingham NG7 2RD, UK

Parameter	Possible change	Arid/dryland soil	Organic soil	Clay soil
Precipitation	Increase in total amount	↓ Long term – loss of radionuclides via runoff/migration out of soil/rooting zone	↔ Assuming water retention properties sufficient to reduce impact on runoff	↓ Long term – migration out of rooting zone, increased runoff
	Increase in event freq./intensity	↑ Increased resuspension	↔	↑ Increased resuspension
Organic matter	SOM loss	↑ Cs, Sr, U, Pu	↑ For I, ↓ or ↔ for Cs, Pu, Sr	↑ For I, ↓ or ↔ for Cs, Pu, Sr
	CEC reduction	↑ For Cs, Sr, U, Pu	↑ For Cs, Sr, U, Pu	↑ For Cs, Sr, U, Pu
	Moisture reduction		↓ For Cs, Sr, I, Pu as pH increases	
	DOC discharge	↔	↑ For Cs, Sr, U, Pu due to colloidal increases ↓ For Cs, Sr, I, Pu long term due to inventory loss	↑ For Cs, Sr, U, Pu due to colloidal increases ↓ For Cs, Sr, I, Pu long term due to inventory loss
Temperature	General increase	↔		
	Structural changes in soil	↔	↓ Long term – loss of radionuclides via runoff/migration out of soil/rooting zone	↓ Long term – migration out of rooting zone, increased runoff

Copyright notice

SCK•CEN
Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire

Stichting van Openbaar Nut
Fondation d'Utilité Publique
Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSEL
Operational Office: Boeretang 200 – BE-2400 MOL