



Effect of Climate Change on Contaminant Fate and Transport

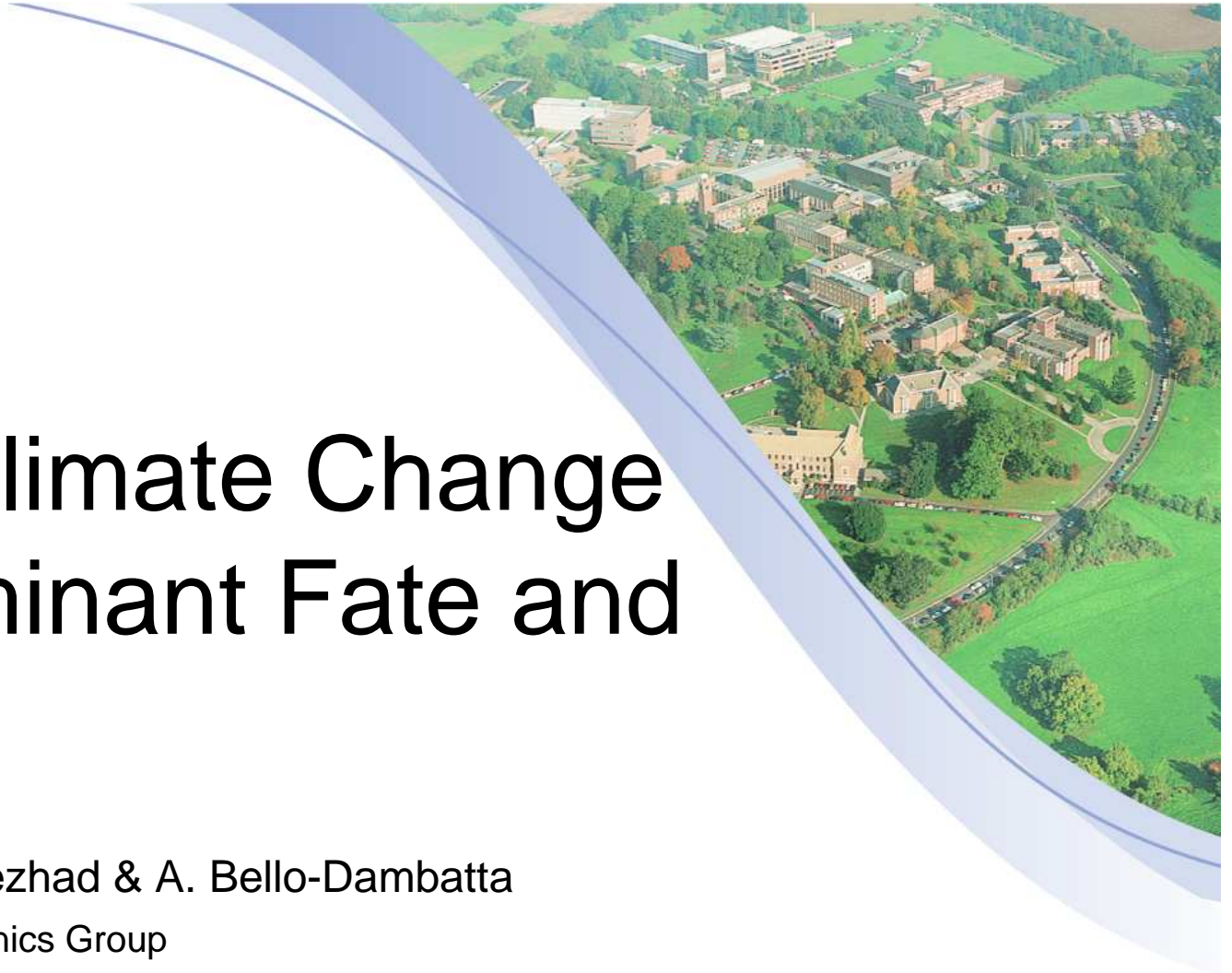
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***Climate Change Impacts and Adaptation: Dangerous rates of change,
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OUTLINE

- Part A
 - Introduction
 - Background
 - Theory
- Part B
 - Model and examples
 - Results
 - Conclusion

Introduction

- Current projects considering the effects and impacts of climate change ...
 - Effect of sea level rise on salt water intrusion
 - Stochastic analysis & time variations of hydrologic properties of soil and random sources of contamination
 - Decision Support Systems, considering the effect of projected climate change on remedial efficacy
- All projects recent and on going

Background: Contaminated land

- Contaminated land problem

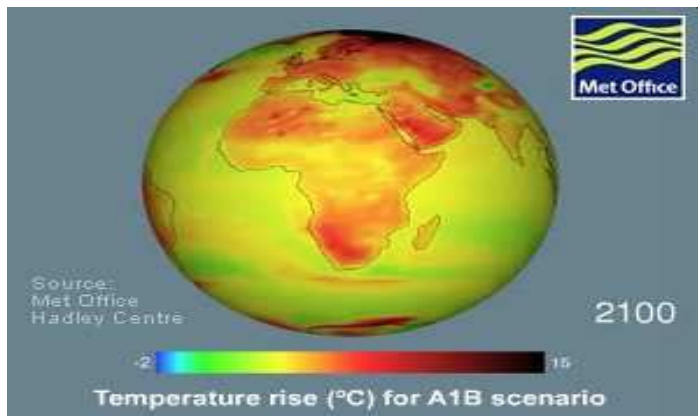


- Hazards posed by contaminated land
 - Human health
 - Water resources
 - Natural habitat
 - Property and infrastructure

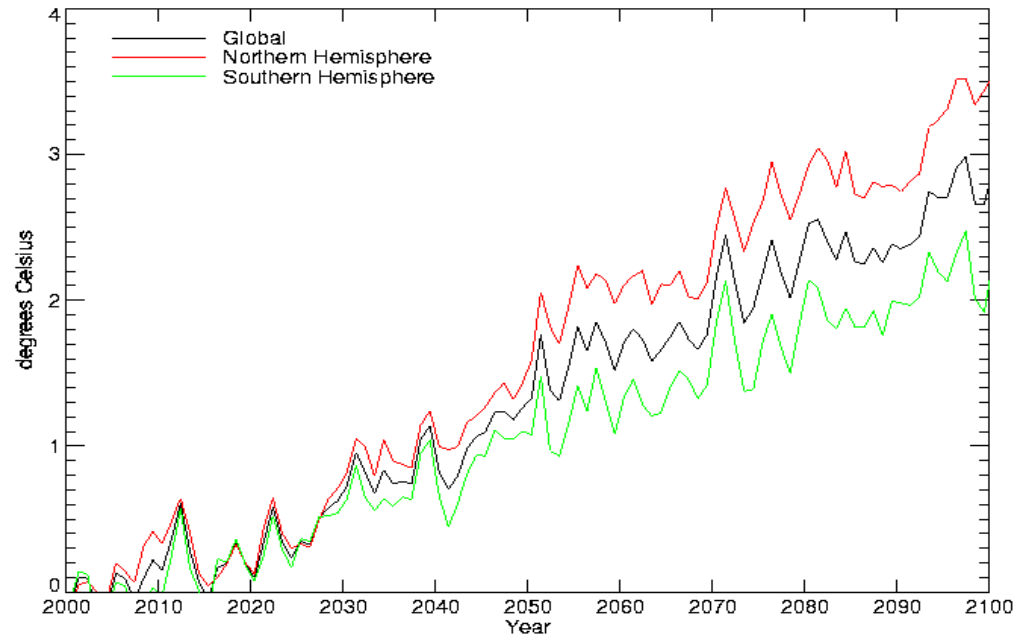
Climate change

- Global climate system is changing
- Feedbacks between the climate system and land surface
- Land-Atmosphere Interactions
- Effects of changes in:
 - Precipitation
 - Temperature
 - Sea-level rise
 - Extreme weather events

Temperature projections



The latest results from the Met Office's climate change research. The data are based on a mid-range IPCC emissions scenario A1B (More integrated world, with a balanced emphasis on all energy sources).

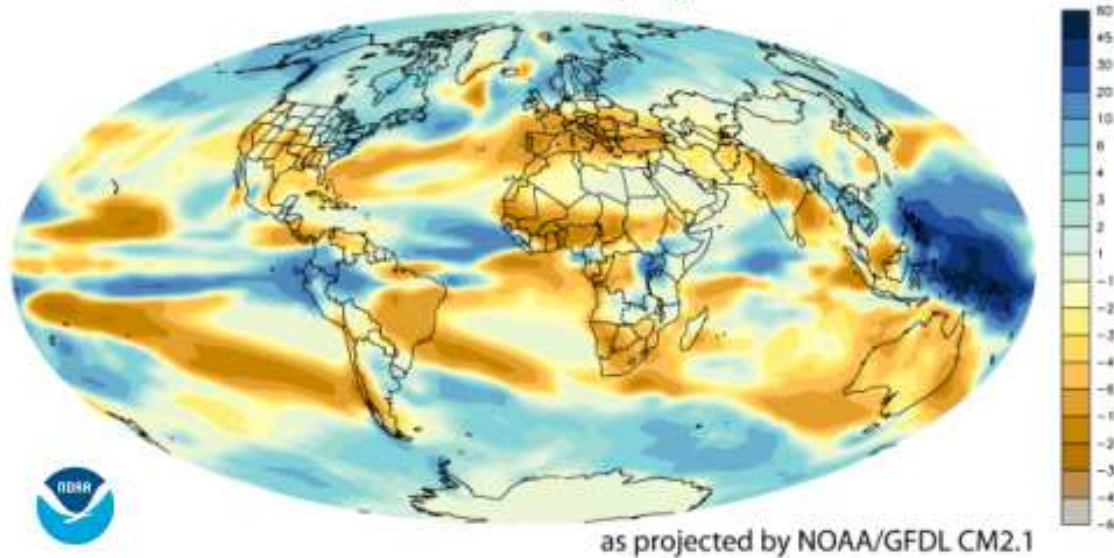


Average annual surface air temperature change from the HadCM3IS9a

Projected changes in: A Decade, Mid-Century and by 2100

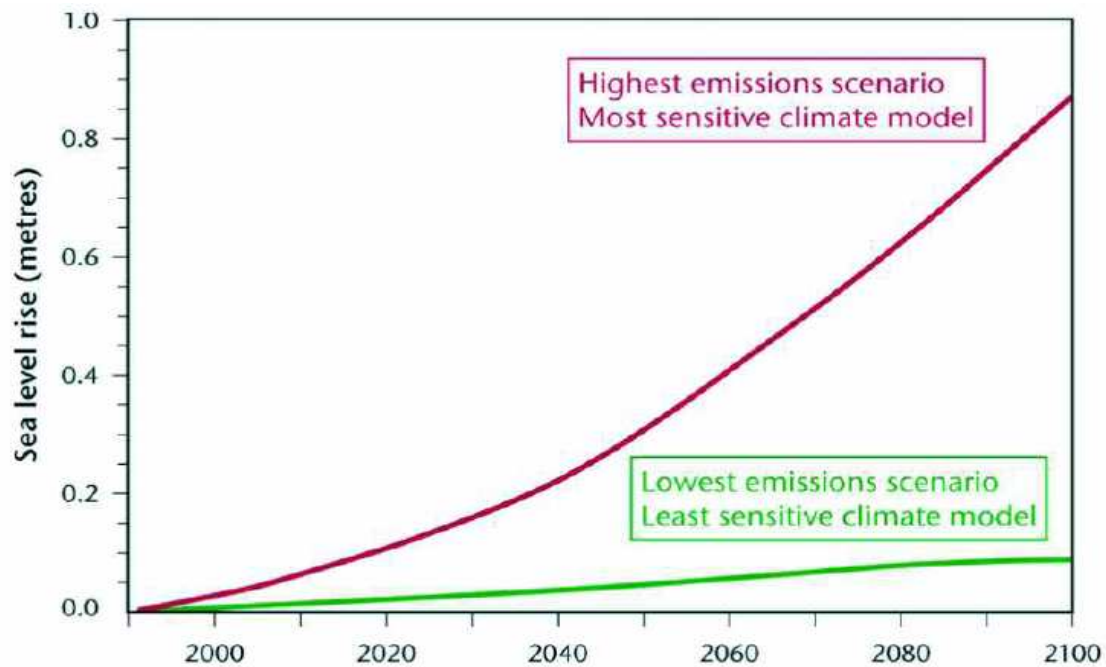
Precipitation projections

CHANGE IN PRECIPITATION BY END OF 21st CENTURY
inches of liquid water per year



Precipitation change for the 21st Century based on SRES A1B scenario. Blue areas are projected to see an increase in annual precipitation amounts. Brown areas are projected to receive less precipitation in the future.

Sea level rise projections



The range of predicted sea-level rise is very large; taking the **lowest emissions scenario** with the least sensitive climate model gave an estimated rise of about 0.1 m over the century. On the other hand, taking the **highest emissions scenario** with the most sensitive climate model gave a rise of almost 0.9 m.

Source: Met office Hadley Centre for Climate Prediction and Research

Extreme weather events

- More intense and frequent
- Great fluctuations in seasonal weather
- Heavy rainfall and storms
- Landslides, run-offs, flooding, erosion etc
- Examples:
 - European heat wave of 2003
 - Recent severe storms and flooding across the UK
 - Land slides in Scotland
 - Australian draught
 - Frequency and intensity of tropical storms, etc

Modelling and example

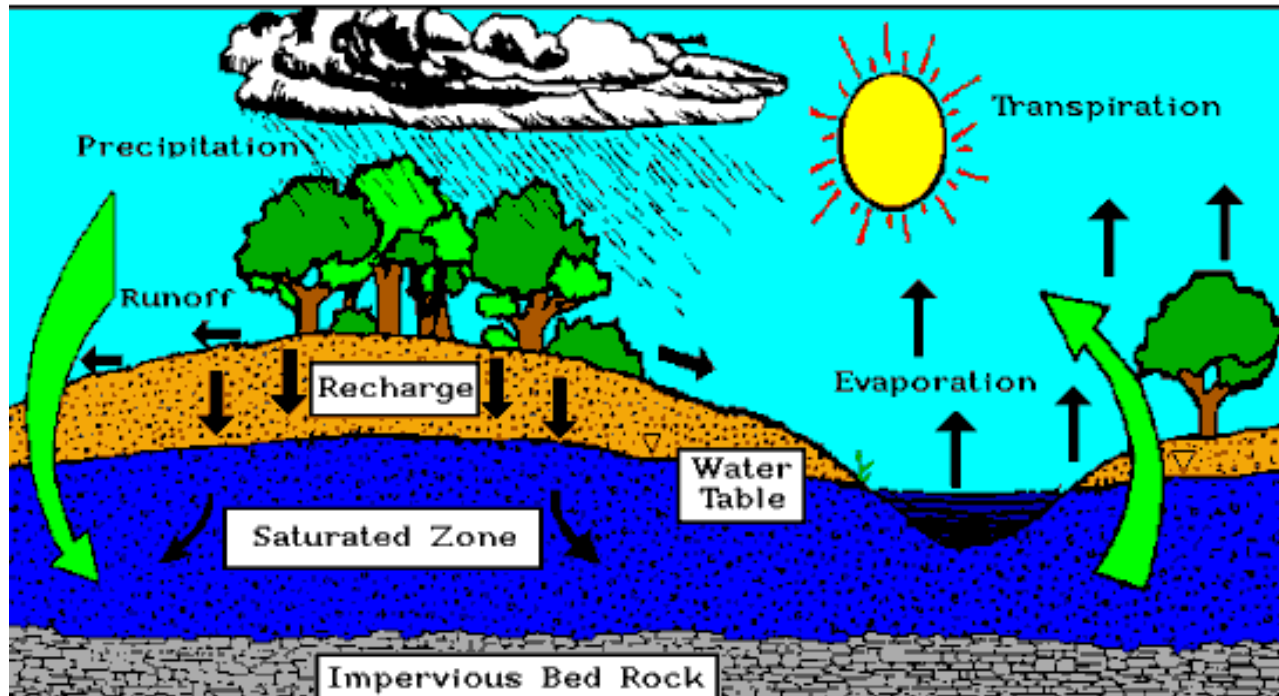
- Importance of contaminant and solute transport modeling
- Governing equation

$$R \frac{\partial (\theta c)}{\partial t} + \nabla (V c) - \nabla (D \nabla c) = F + R_c$$

- Effect of precipitation on [input of contaminant](#)
- Effect of temperature change on
 - [Pore water content & velocity](#)
 - [Chemical reactions](#)

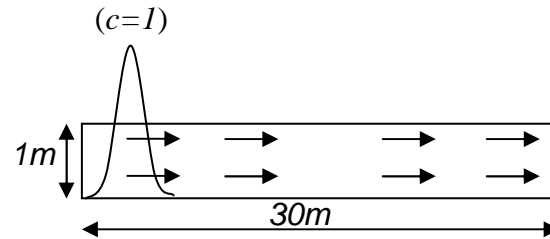
Precipitation change

The Hydrologic Cycle

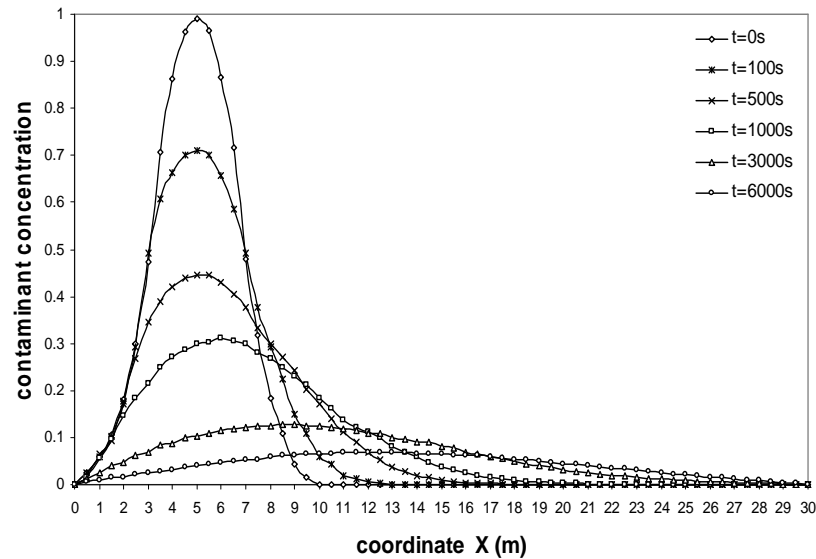


Effect of permeability on velocity

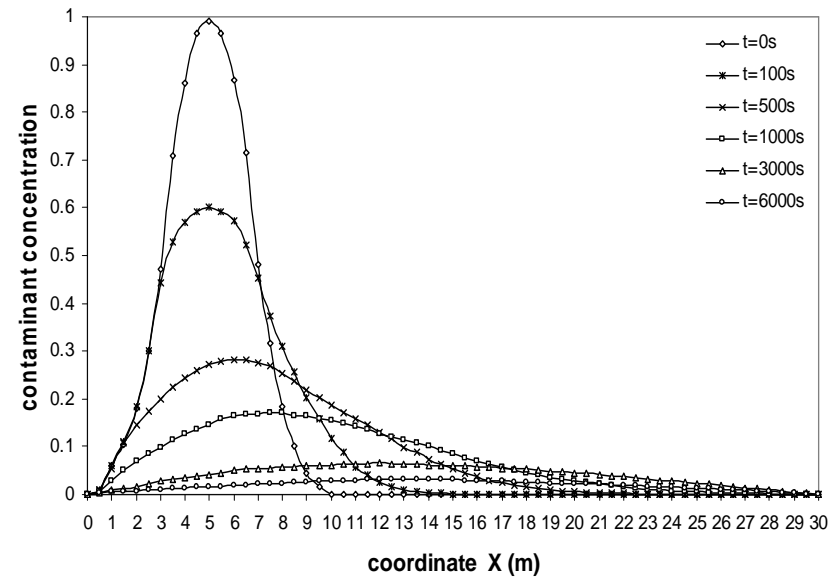
$$V = - \frac{k_w}{\mu_w} \frac{\Delta h_w}{L}$$



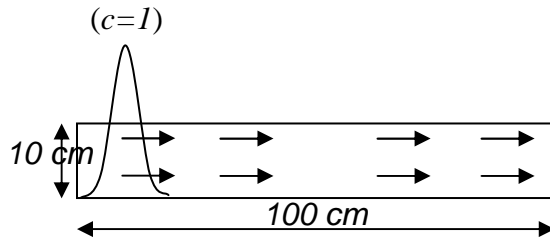
CCD for advection and dispersion through a constant water velocity.



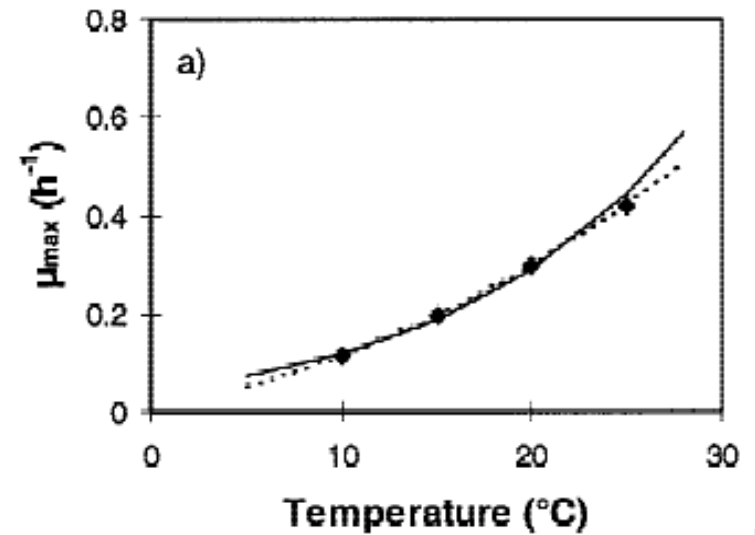
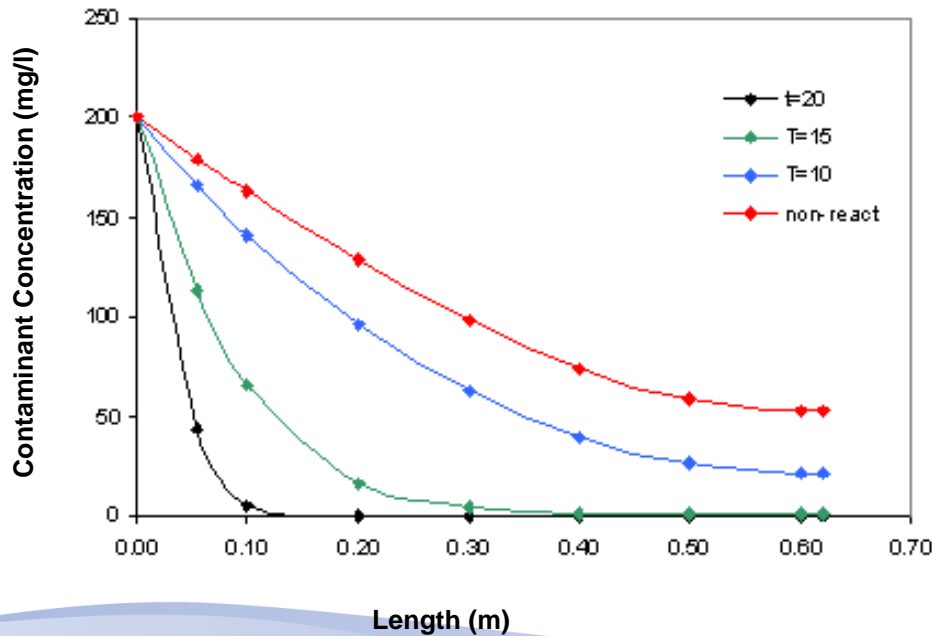
CCD for advection and dispersion through changing water velocity.



Effect of temperature change on chemical reaction rate



$$R_c = \frac{\partial c}{\partial t} = -M_t \frac{\mu_m}{Y} \left(\frac{c}{K_c + c} \right) \left(\frac{c_o}{k_o + c_o} \right)$$



Conclusion

- Global climate system is changing
- Complex interactions and feedback between the climate system and the land system
- Important feedbacks are being affected
- Remedial technologies will be affected
- Contaminant and solute modelling must take these changes into account
- Future policy and regulation must consider these changes.

Thank you