

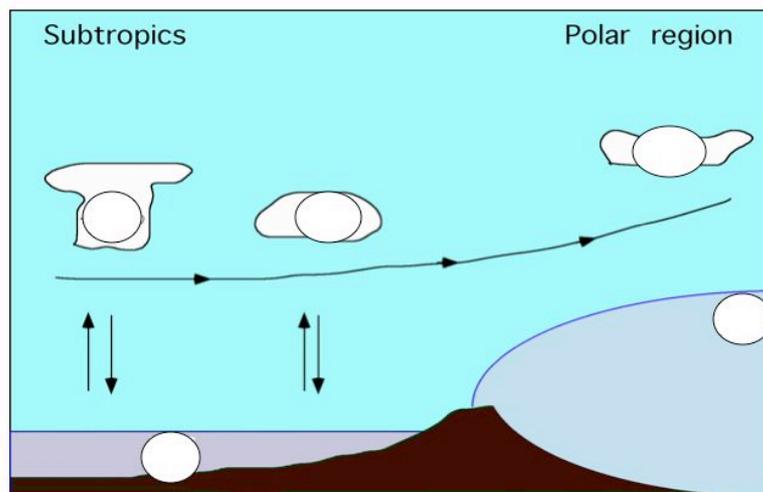
Examination Climate Dynamics Monday 14th of April 2008, 9.00-12.00

1 Climate history

- What are the main forcing mechanisms for climate change on geological time scales?
- Sketch global CO_2 , temperature, ice volume, and benthic marine isotopes over the last 60 Myrs and explain your sketch.
- Explain the Milankovitch theory qualitatively and indicate dominant periodicities, discuss in addition the spectral paradox during the Pleistocene.

2 Stable isotopes in paleoclimatology

- Explain which stable isotopes paleoclimatologist use and what fractionation is.
- Indicate the $\delta^{18}\text{O}$ values in the 5 circles for the present-day climate in the figure below and explain your choices. HAND IN YOUR FIGURE!



- Assume a reasonable N-S temperature gradient and calculate the sensitivity of $\delta^{18}\text{O}$ for a temperature change.
- Explain the differences between marine and ice cores with respect to the interpretation of stable isotopes.

3. Ice in the climate system

- a. Explain the mass balance height feedback.
- b. Why is the temperature field in an ice sheet important for the dynamics of ice?

A general formulation for the thermodynamic equation in ice is:

$$\begin{aligned} \frac{\partial T}{\partial t} = & -u \frac{\partial T}{\partial x} - v \frac{\partial T}{\partial y} - w \frac{\partial T}{\partial z} + \\ & K \frac{\partial^2 T}{\partial x^2} + K \frac{\partial^2 T}{\partial y^2} + K \frac{\partial^2 T}{\partial z^2} + \\ & \frac{1}{\rho C_p} (\dot{\epsilon}_{xx} \sigma_{xx} + \dot{\epsilon}_{yy} \sigma_{yy} + \dot{\epsilon}_{zz} \sigma_{zz}) + \\ & \frac{1}{\rho C_p} (2\dot{\epsilon}_{xy} \sigma_{xy} + 2\dot{\epsilon}_{xz} \sigma_{xz} + 2\dot{\epsilon}_{yz} \sigma_{yz}) + \\ & \frac{L_f M_f}{\rho C_p} \end{aligned}$$

- e. Explain the different terms in the equation.
- f. If you wish to solve this equation at an ice divide, which terms might be neglected and why?
- g. Provide boundary conditions to solve the equation.
- h. Sketch the vertical temperature field for the Robin solution for 2 different values of the mass balance and explain your sketch.