Max-Planck-Institut für Biogeochemie

IMPRS gBGC
International Max Planck Research School for Global Biogeochemical Cycles

KIT Karlsruher Institut für Technologie

Thermodynamics of Earth system processes

2-day block course, 01. + 02. March 2018
Max-Planck-Institute for Biogeochemistry, Jena

Lecturers: Axel Kleidon (MPI for Biogeochemistry) and Erwin Zehe (KIT)

Objective of the course:
Water flows downhill, mountains erode, and wood decomposes. In the absence of other processes, sooner or later, water would collect in the world's oceans, mountains would be eroded down to the seafloor, and wood would decompose to its raw ingredients. The outcome would constitute a "dead" state of the Earth system, without atmospheric dynamics, hydrologic and biogeochemical cycling, and it would be unable to sustain life. The present Earth is nowhere near such a "dead" state, and thermodynamics provides the key answer to understand why the Earth is not in such a "dead" state.

This course provides the basics to understand how dynamics are maintained in Earth systems from a perspective of non-equilibrium thermodynamics. It provides the basics for a comparatively non-technical description of the thermodynamic foundations, illustrate quantitatively how these apply to the various processes of the Earth system, describe how thermodynamics links with organization of flows in space and time (such as turbulent structures and fractal networks), and how these shape the interactions with other processes and their boundary conditions within the system. These descriptions are illustrated using examples from atmospheric science, hydrology, and human activity to provide a general appreciation of the general nature of the Earth as a thermodynamic system and its implications.

Audience: The course is aimed at graduate students with a background in geosciences or environmental sciences. Course contents will be accessible to students with a solid physics and math background (min. high-school level).

Format: The course combines lectures with in-class examples and exercises to illustrate concepts.

Contents:

- Introduction and motivation: How do current questions of Earth system science relate to thermodynamics?
- Basic concepts of thermodynamics: What is entropy? Laws of thermodynamics; dissipative processes; entropy budget; thermodynamic limits; thermodynamic optimality principles; linkages between thermodynamics and organization
- Application to the climate system: Energy conversions in atmospheric dynamics; Surface energy balance partitioning; Boundary layer dynamics; Hydrologic cycling
- Application to hydrology: Thermodynamics of hydrologic processes; rainfall partitioning into runoff and infiltration, soil moisture and storage dynamics; catchment dynamics and similarity
- Application to the Earth system: Biotic activity; Geochemical cycles; Human activity; Planetary systems
- Summary and conclusions

Registration: The course is limited to 25 students, and there is no registration fee. To register, please visit the course website at http://www.imprs-gbgc.de/index.php/Courses/Thermodynamics2018. The website also contains further information on travel and accommodation.

More information: Please contact Axel Kleidon (Axel.Kleidon@bgc-jena.mpg.de) or Erwin Zehe (Erwin.Zehe@kit.edu).