

Workshop on Thermodynamic optimality principles

Date: 8 – 10 November 2016

Location: Vrije Universiteit (VU) Amsterdam, The Netherlands

Who: Scientists interested in thermodynamic optimality principles applied to land-surface atmosphere interactions and hydrological processes.

Maximum number of participants: 20

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The combined use of the first and second laws of thermodynamics (conservation of energy and the entropy balance) leads to physical limits or constraints to fluxes of mass and energy. A well-known limit is the Carnot limit stating that the theoretical maximum amount of work that can be subtracted from a heat engine (two connected reservoirs with a clear temperature difference) is by definition less than the energy put into the system.

It appears that the atmosphere operates close to these limits. For example: vertical turbulent heat fluxes (sensible and latent heat) could be predicted by maximizing the rate of work needed to lift the air from the (warm) surface to the (cold) atmospheric boundary layer with only solar radiation and surface temperature as input. The lifting of the air particles is caused by the temperature difference between the surface and boundary layer, while at the same time the temperature difference decreases due to the vertical transport of air. This temperature difference is even further decreased when evaporation increases. These feedbacks form the basis to obtain a maximum in work.

There is high potential to apply these principles to less idealized cases, or to vegetation or hydrological systems. Several successful attempts have been made by applying these principles to e.g. predict net primary production of trees, to predict macropore density in the unsaturated zone enhancing infiltration or to predict surface and subsurface drainage characteristics. However, these studies all use different objective functions which were optimized, while terminology, perceptions and methodology are still not uniform and clear.

This workshop aims to bring a small group of scientists together who are working in this subfield. The aim is to come to a better understanding of thermodynamic optimality principles and to share ideas and develop combined research ideas. The main focus will be on the land-surface atmosphere interactions and hydrological processes.

Tentative program

8 November Introduction to thermodynamics

9:15 – opening by Chairman

9:30 – Introduction of participants

Participants include their specific interest in thermodynamics and their expectations for the workshop, e.g., by addressing these questions:

- *Why are you interested in thermodynamics?*
- *What do you expect to learn/get out from thermodynamics?*

10:30 – Coffee break

11:00 – Erwin Zehe: From heat engine to hydrological processes

Link between entropy/temperature and fluxes of mass/free energy.

12:30 – lunch

13:30 – Hisashi Ozawa: thermodynamics & fluid dynamics

15:00 – Coffee break

15:30 – Axel Kleidon: Thermodynamics and optimality.

From thermodynamic equilibrium (TE) to systems far from TE. Is there a physical basis for optimality or is their only empirical evidence? What are minimum requirements for a system to 'optimize'?

17:00 – Discussion

17:30 – end

9 November Unifying the different optimality principles

9:15 – 17:30

The second day will be devoted to unifying the different optimality principles. During this day all participants can bring in their case studies with respect to thermodynamic optimality after which we can discuss what is optimized and how this relates to

other optimization principles (e.g. maximum entropy production, maximum power, maximum free energy dissipation ...). Depending on the number of presentation requests each speaker will have 45 to 60 minutes including discussion.

If you are willing to present something, please send an email to m.c.westhoff@vu.nl with a title and a short summary of your presentation

In the afternoon we summarize all principles to see if these fall under the same umbrella. What are the commonalities and differences between the different principles?

10 November How to proceed in the near future?

9:15 – 12:30

We will use the last morning to discuss on how to proceed. What are open questions? Can we come to common research goals/project for which we may write a research proposal? What about organizing a summer school? Can we 'summarize' the findings of this workshop into a joined opinion paper?