

Universiteit Utrecht Faculty of Geosciences

River and delta morphodynamics

Biogeomorphic systems? Knowing the whole world from the top of a mountain

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Applied and Engineering Sciences



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"Everything in nature is interconnected"

<u>https://www.nature.com/collections/ceaeaabjia/</u>



Humboldt's legacy

Explorer-naturalist Alexander von Humboldt's contributions to the fields of ecology, global change and geoscience fundamentally altered the way we view the natural world and our place in it. On the 250th anniversary of his birth, we look back over his life and compile a collection of articles inspired by his legacy.

NATURE ECOLOGY & EVOLUTION | VOL 3 | SEPTEMBER 2019 | 1265-1266 | www.nature.com/natecolevol

Writing Heroes into ahistoric history ...

The emergence and evolution of Earth System Science

Will Steffen, Katherine Richardson, Johan Rockström, Hans Joachim Schellnhuber, Opha Pauline Dube, Sébastien Dutreuil, Timothy M. Lenton and Jane Lubchenco

Abstract | Earth System Science (ESS) is a rapidly emerging transdisciplinary endeavour aimed at understanding the structure and functioning of the Earth as a complex, adaptive system. Here, we discuss the emergence and evolution of ESS, outlining the importance of these developments in advancing our understanding of global change. Inspired by early work on biosphere–geosphere interactions and by novel perspectives such as the Gaia hypothesis, ESS emerged in the 1980s following demands for a new 'science of the Earth'. The International Geosphere-Biosphere Programme soon followed, leading to an unprecedented level of international commitment and disciplinary integration. ESS has produced new concepts and frameworks central to the global-change discourse, including the Anthropocene, tipping elements and planetary boundaries. Moving forward, the grand challenge for ESS is to achieve a deep integration of biophysical processes and human dynamics to build a truly unified understanding of the Earth System.

2020, Nature Reviews Earth & Environment, https://doi.org/10.1038/s43017-019-0005-6

science in the 1980s, global expansion in the 1990s and present-day ESS. A timeline of key events, publications and organizations that characterize the evolution of ESS is shown in FIG. 1.

Beginnings (pre-1970s). Past conceptualizations of the Earth formed important precursors to the contemporary underster ung of the Earth Sp. ym. Examples include J. Hutton's 1788 heory Earth, Humboldtian science in the of th 19th entury and V. Vernadsky's 197 "The Losphere". Understanding the histories, pots of ESS 1, wever, requires a focus on the second half of the 20th century when, in a Cold War context, important shifts occurred in the Earth and environmental sciences8. Thanks to military patronage taking precedence over traditional sources of funding for Earth sciences, geophysics experienced unprecedented growth9. Moreover, surveying and monitoring the global environment became a strategic imperative, providing information that would later be useful for contemporary ESS10,11.

Von Humboldt (1807) at first sight:

"This science, ... can progress only ... by connecting together all the phenomena ... on the surface of the earth.

In this great chain of causes and effects, no single fact can be considered in isolation.



This talk ... from the humanities NIAS

Netherlands Institute for Advanced Study in the Humanities and Social Sciences

Alexander von Humboldt as the hero of ecosystem and earth system science?

Did Humboldt mean the same thing with 'system' as we do?

 What is a complex system?
 Did AvH do orderly systematization or complex explanatory systems in Plant Geography and Cosmos?

Chapter under review: Earth ArXiv https://doi.org/10.31223/X5DK81



Alexander von Humboldt

- Berlin, 1769 1859, lived long in Paris
 - Göttingen, met Kant, Goethe, Volta, Darwin, ...
 - Allowed huge public to see through his eyes with poetic descriptions: a view from the mountain
- Great insights, lots of data, some nonsense
 - Vital force? Galvanic experiments
 - Expeditions, more than botany
 - Geography of plants 1807
 - 'vegetable bands' on a mountain and on Earth
 - Cosmos 1845-1862
 - $\blacksquare \rightarrow$ Muir's national parks



Primary sources

Von Humboldt, A. and Bonpland, A. (1807). Essay on the geography of plants and the <u>Tableau</u> Physique.

» Paris: Fr. Schoell. Translated from the original **French**, first edition by S. Romanowski, The University of Chicago Press 2009, Chicago, USA.

» pdf online

■ Von Humboldt, A. (1845).

<u>Cosmos</u>: a sketch of a physical description of the universe.

- » Translated in 1858 from German by E.C. Otté, Harper and Brothers, New York.
- The first edition is also used here; this was printed in German in Fraktur by Cotta, Stuttgart (Tübingen) and scanned in 2013 by the Deutsches Textarchiv, <u>http://www.deutschestextarchiv.de/book/show/humboldt_kosmos01_1845</u>.

translation from German by DeepL



Geographie der Planzen in den Tropen-Kändern;

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System and systematics

- Σύστημα: a whole compounded of several parts
 - soul and body,
 - organization or company of people,
 - intervals and scales in music,
 - literary or logical composition,
 - group of buildings,
 - metrical and mathematical systems including the solar system,
 - physiological phenomena including circulation,
 - machines

H.G. Liddell and R. Scott (1940), A Greek-English Lexicon, Oxford Clarendon Press. 1940, http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.04.0057%3Aentry%3Dsu%2Fsthma

Complex system (after 1920s/1950s)

- ensemble of many elements which are *interacting* in a disordered way resulting in robust organization and memory
 - organization is hierarchical at several levels and scales
 - state dependent on the recent past
 - Open: energy or matter is exchanged with environment
 - emergent properties and behavior, holistic and not reductionistic
 - e.g. organism: stable organization and dynamics works against tendency of environment to disorganize it
 - opposing second law of thermodynamics

Ladyman, J., Lambert, J. and Wiesner, K. (2013). What is a complex system? Euro Jnl Phil Sci 3, 33-67



Ordering principles 18th century

Encyclopedia: alphabet

Diderot & d'Alembert (eds) 1751-1772

ENCYCLOPEDIE,

DICTIONNAIRE RAISONNÉ DES SCIENCES, des arts et des métiers,

PAR UNE SOCIÈTE DE GENS DE LETTRES.

Mis en ordre & publié par M. DIDEROT, de l'Académie Royale des Sciences & des Belles-Lettres de Pruffe; & quant à la PARTIE MATHÉMATIQUE, par M. D'ALEMBERT, de l'Académie Royale des Sciences de Paris, de celle de Pruffe, & de la Société Royale de Londres.

> Tantùm series juncturaque pollet, Tantùm de medio sumptis accedit honoris! HORAT.

TOME PREMIER.

Diderot & d'Alembert (eds) 1751-1772



A PARIS, BRIASSON, rue Saint Jaques, à la Piane d'ar. DAVID Linié, rue Saint Jaques, à la Piane d'ar. LE BRETON, Impineur ordinaire du Roy, rue de la Harpe. DURAND, rue Saint Jaques, d'auto Lady, 6 rue Griffin.

M. DCC. LI. AVEC APPROBATION ET PRIVILEGE DU ROY.

Ordering principles 18th century

- Encyclopedia: alphabet
 - Diderot & d'Alembert (eds) 1751-1772
- Systema Naturae: taxonomy
 - Numerical and morphological similarities
 Linnaeus 1735-1758



Ordering principles 18th century

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 - Linnaeus 1735-1758
- Système du monde: (Newtonian) forces
 Laplace 1796







How does Humboldt use 'system'?

Plant Geography:

■ 5x French,11x German, 6x English

Nerve system, solar system

Cosmos: ~100x

- Solar system
- Isolines
- Groupings and taxonomies
- Theology and philosophy

 \blacksquare \rightarrow no complex system. So what brings parts into a whole?

Climate related to 'vegetable bands', globally: most important physical/chemical influences on vital functions of plants



What orders matter in lifeforms?? Vital force



Bildungstrieb: vital force, drive of life

- Blumenbach 1791, taught Humboldt
- Goethe: used it as ordering principle

Humboldt: experiments
 galvanic action in (his) muscles
 horses thrown into pond with electrical eels
 Volta: animal electricity, not galvanic

$\blacksquare \rightarrow$ Humboldt remains vague but refers to vital/life forces

Why does Humboldt not call it a system?

"A physical description of the world must therefore not be confused with the so-called encyclopaedia of the natural sciences (a broad/wide-ranging name for a poorly defined discipline)."

- Humboldt does not like the *a priori* ordering principles in older systems, so avoids the word 'system'
 - Instead, 'leitenden Ideen' = guiding ideas, 'Reihenfolge' = ordering of data in a sequence in time or space by 'Intensität' = intensity
 - \rightarrow in a graphic of a mountain as a model for the world

Conclusions

Humboldt did not coin system science
 did not like 'systematic'

 Humboldt explained the ordering of global patterns
 perceived a balance, a web of life, how all hangs together
 Humboldt needs and invokes vital forces to explain vegetation patterns

We need to teach our students what a system is
 And hero history is bad history of science

Chapter under review: Earth ArXiv https://doi.org/10.31223/X5DK81





When did 'system' become 'system'?

- Later: gradual emergence of 'complex system'
 - Vernadsky biosphere
 - Lottka–Volterra predator-prey relations
 - Von Bertalanffy 1920s / 1950s, response to reductionism
 - Control systems: cybernetics: Wiener 1950s
- But 'system' as in 'systematic' still in use today!
 Do we teach our students the difference?