



Patterns in Nature

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Course material: www.stephan-matthiesen.de

More examples (in German): www.science-texts.de

About me



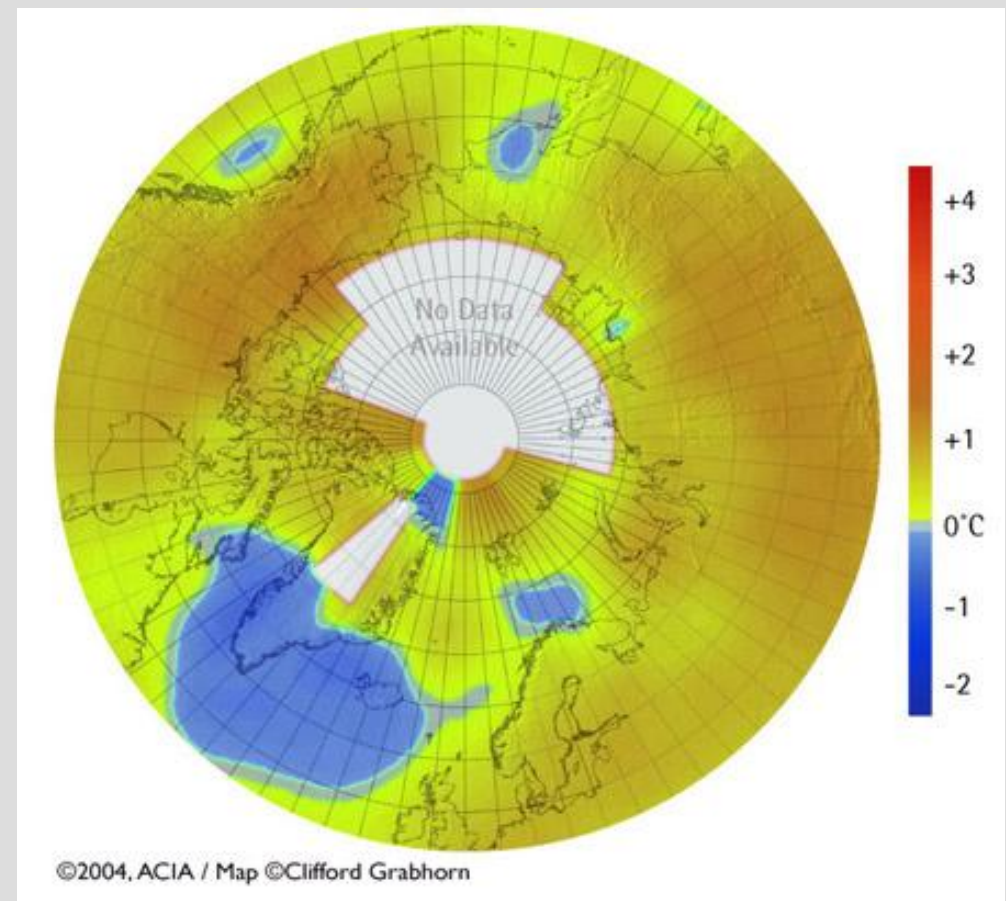
Fieldwork in Sweden, Aug 2007



Arctic Change

- Considerable warming observed in Arctic regions
- How will the plants and the soil react?
- Will they take up more carbon dioxide from the air, or release more?

Observed temperature changes 1954-2003



EarthTemp: Understanding Earth's surface temperatures

Surface Temperature means different quantities

- surface air temperature (SAT)
- skin temperature (skin=top layer of land, water etc.)

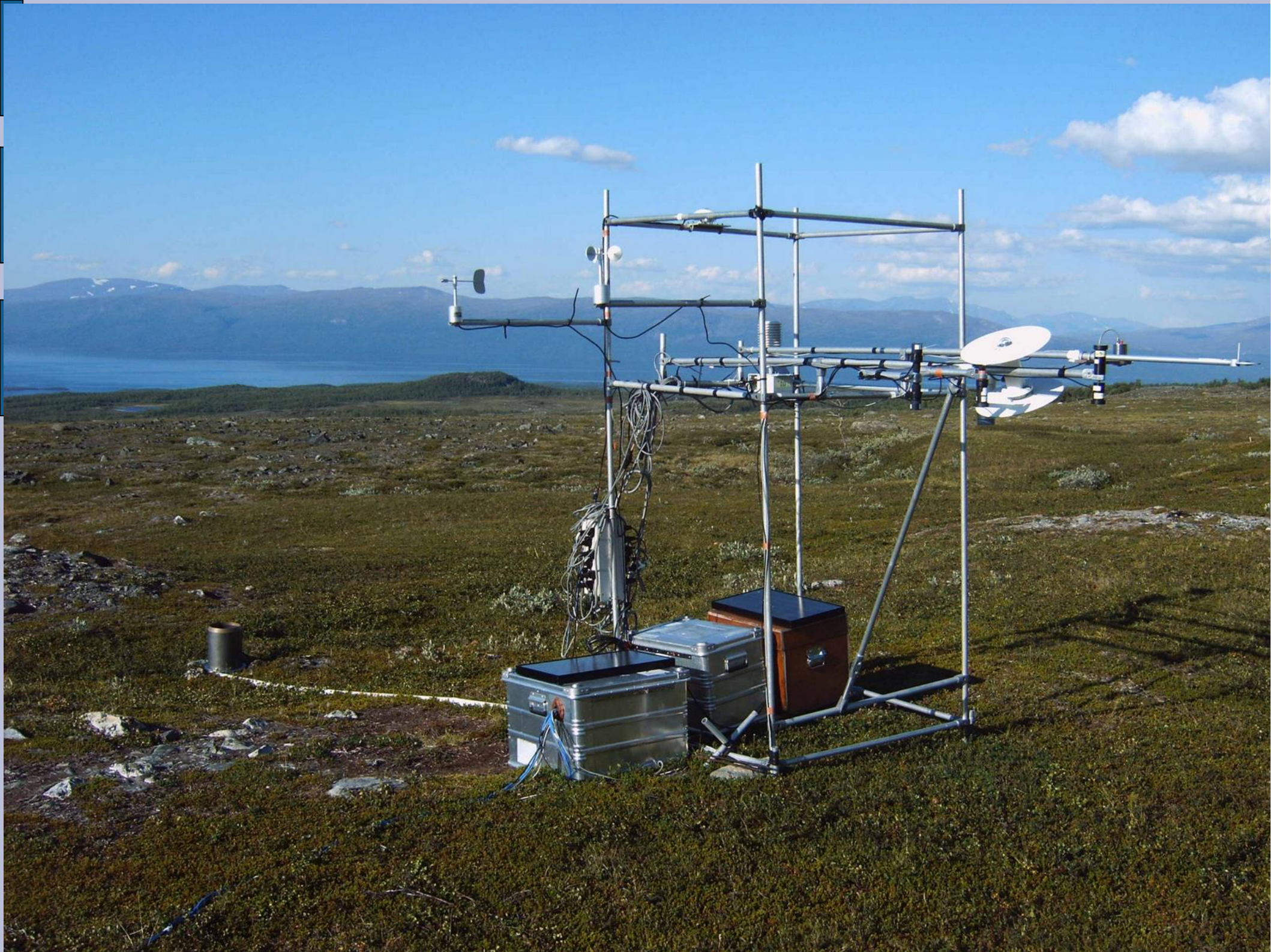
They are measured with different methods

- thermometers (= in situ)
- satellites

How do they all relate to each other?

Where are gaps in our understanding?

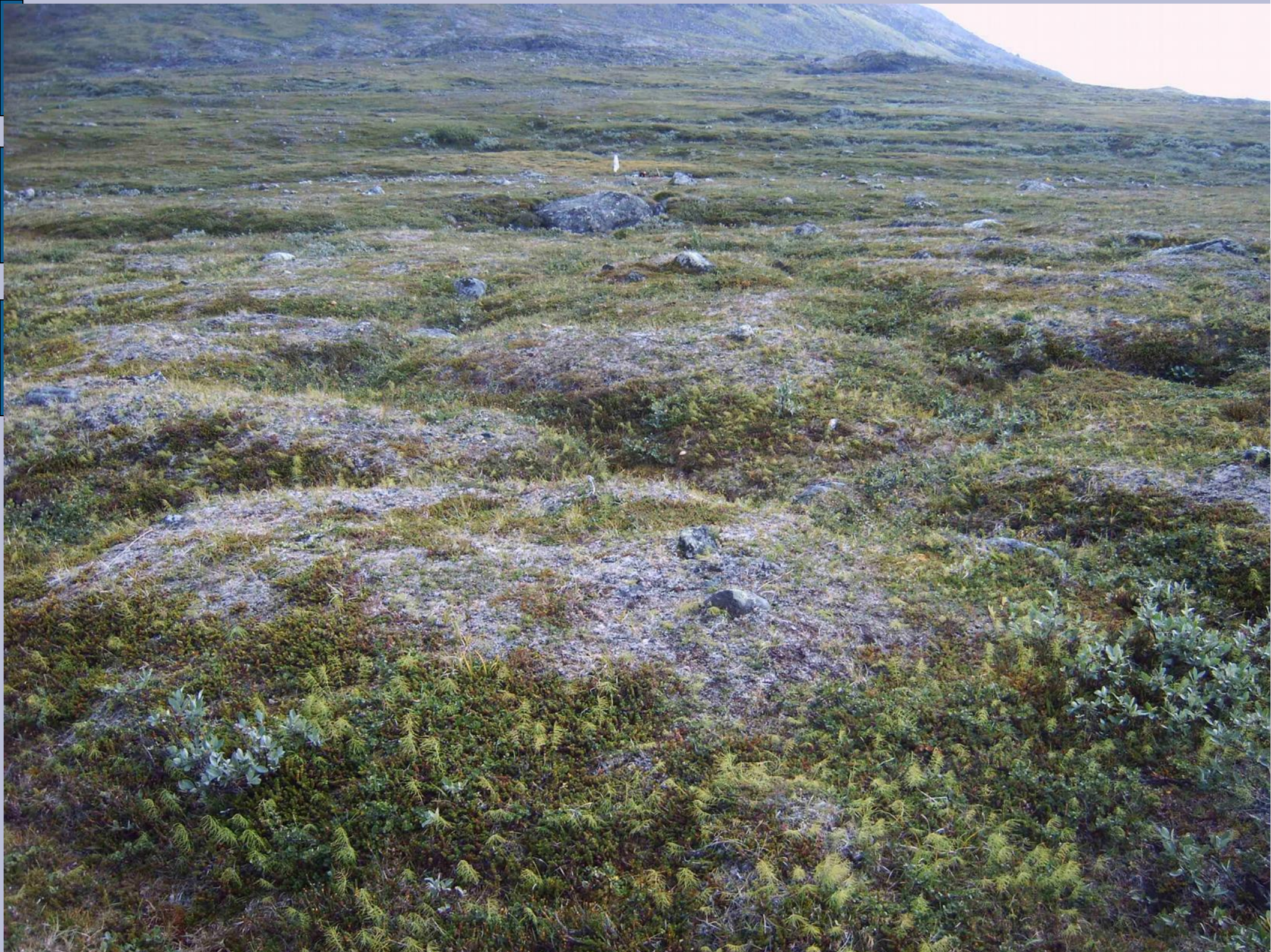
(more details: <http://EarthTemp.net>)















About you

Take 5 minutes to discuss with your neighbour:

- Why are you interested and what do you expect from this course?
- Which patterns have you noticed in nature?





























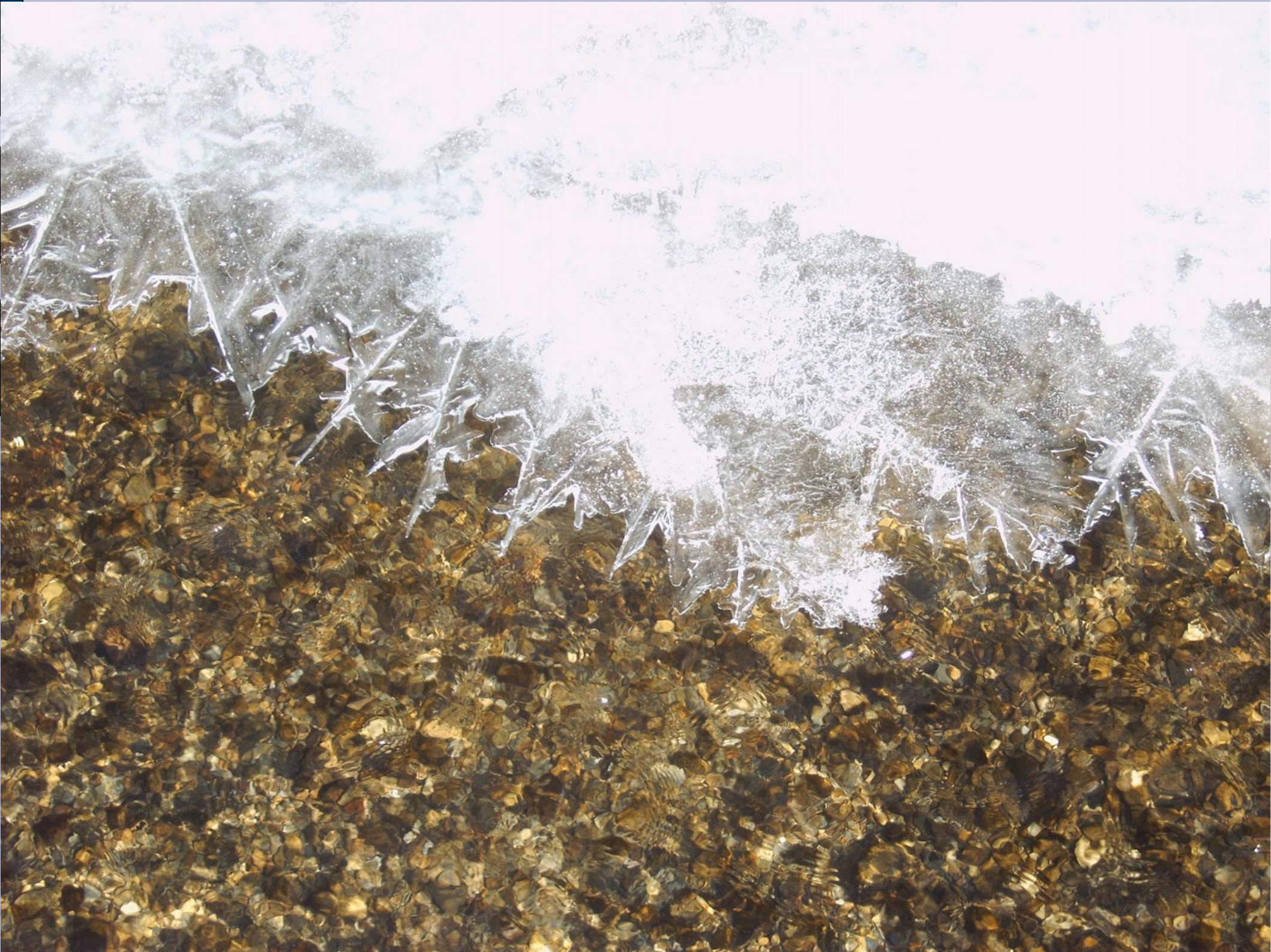
















Order from chaos in the human world

Discuss with your neighbour how humans achieve the following activities:

- an orchestra playing a symphony?
- a construction crew building a bridge?
- baking a cake?
- soldiers marching?
- a ballet performance?
- tourists choosing a pub in Grassmarket?

(Well-informed) leader

A key individual (leader) that directs the activity of the group and gives (detailed) instructions.

Examples:

- officer – soldiers
- conductor – orchestra
- tour guide – tourist group

Building by blueprint

A compact representation of the temporal or spatial relationships of the pattern.

Examples:

- construction crew building the bridge

Following a recipe

Sequential instructions that specify the actions of the individual's contribution to the global pattern.

Examples:

- cooking – recipe
- ballet dance – choreography

Templates

A full-size guide that steers the pattern formation process.

Examples:

- sewing pattern for making clothes

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Examples:

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Mechanisms in comparison

- Well-informed leader
- Building by blueprint
- Following a recipe
- Templates

Usually, several of these mechanisms interact.

The instructions are “external”.

Stygmergy

Modifying the process through feedback from the emerging pattern.

Examples:

- A cook tasting the dish and modifying the recipe.
- Tourists going into the pub where there is already a crowd.

Self-organization Definition

Self-organization is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system's components are executed using only local information, without reference to the global pattern.
(Camazine et al 2001, p. 8)

Patterns

Definition

The best I can do is to say that a pattern is a form in which particular features recur recognizably and regularly ... the repeating elements may be similar but not identical, and they will repeat in a way that could be called regular without following a perfect symmetry. Yes, I know it's vague – but I believe we usually know such patterns when we see them.

(Philip Ball, *Shapes*, p. 18)

Something to think about: Dwarves and hats



The most important event in the life of a dwarf is the hat-giving ceremony. Once a year, all the young dwarves who have reached the age of 50 are led into a completely dark cave. From a big heap of red and green hats, they have to pick one and put it on. One by one they then enter the big, well-lit ceremonial hall and have to form a line in front of the Elders, but such that all dwarves with red hats form the left half of the line, the ones with green hats form the right half.

It's your turn. But: As the cave was so dark, you don't know the colour of your own hat. There are no mirrors, you are not allowed to take the hat off, and nobody is allowed to tell you the colour of your hat (or signal it to you). If you end up between the dwarfs of a different colour, you get thrown out of the mountain.

What would YOU do in order to be on the correct side?

(story adapted from: *Wurzel* 6/2007)

“But how do I get into the mountain?’ the young dwarf asked.” by John Bauer (1909)

Literature

- Ball, Philip (2001): *The self-made tapestry. Pattern formation in nature*. Oxford University Press.
- Ball, Philip (2009): *Branches/Flows/Shapes* (3 parts). Oxford University Press
- Camazine et al. (2001): *Self-Organization in Biological Systems*. Princeton University Press.
- Adam, John (2003): *Mathematics in Nature. Modeling Patterns in the Natural World*. Princeton University Press.

Patterns in Nature Outline

1. Introduction

2. Waves and oscillations
3. Regularity and chaos
4. Animal cooperation
5. Spatial patterns
6. Aggregation and growth processes
7. Cellular automata
8. Fractals
9. Miscellaneous topics
10. Concluding session

