Skoltech

Skolkovo Institute of Science and Technology

“Experimental Data Processing”

Introduction to the course

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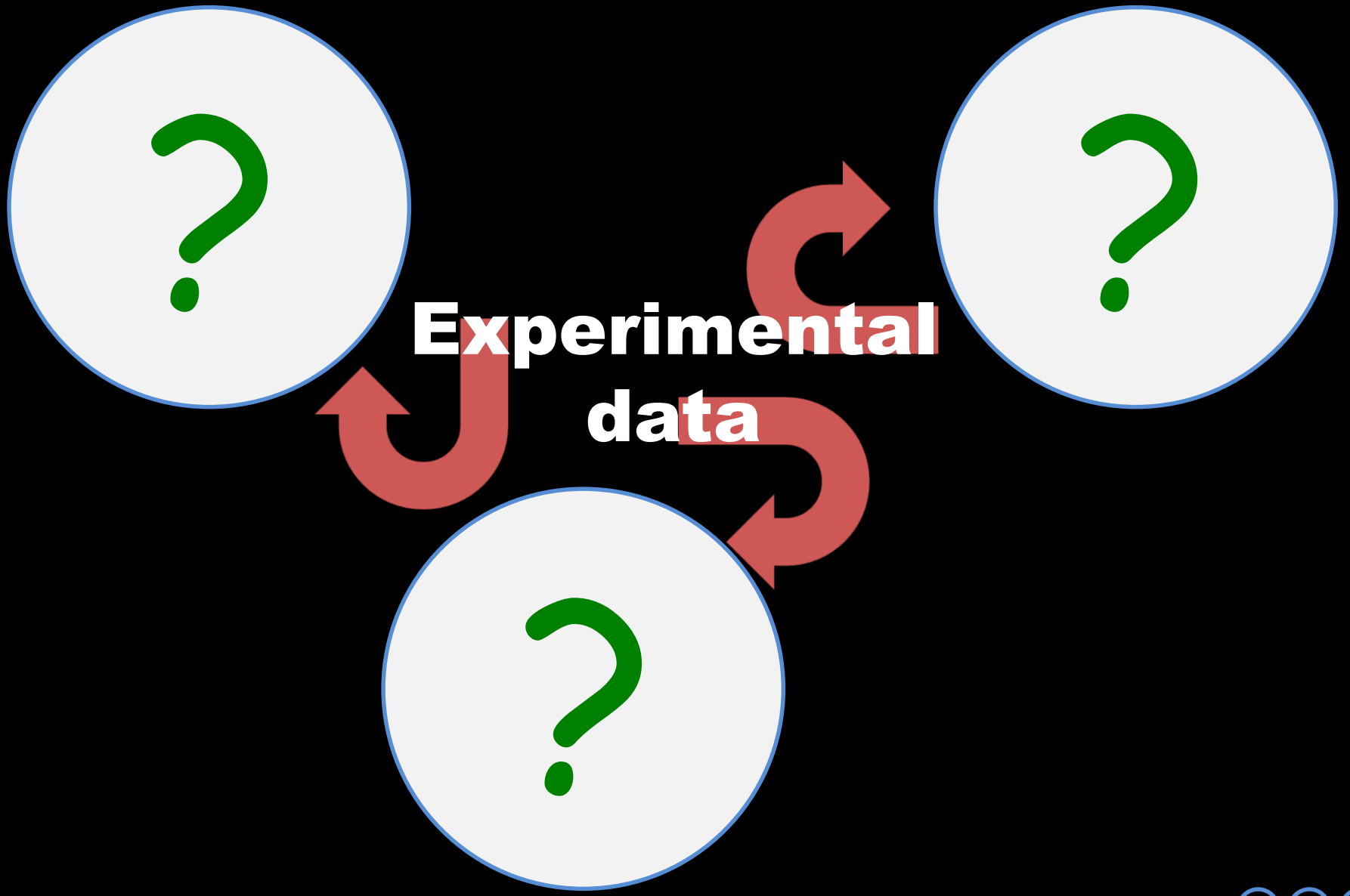
What sense can be made of experimental data?



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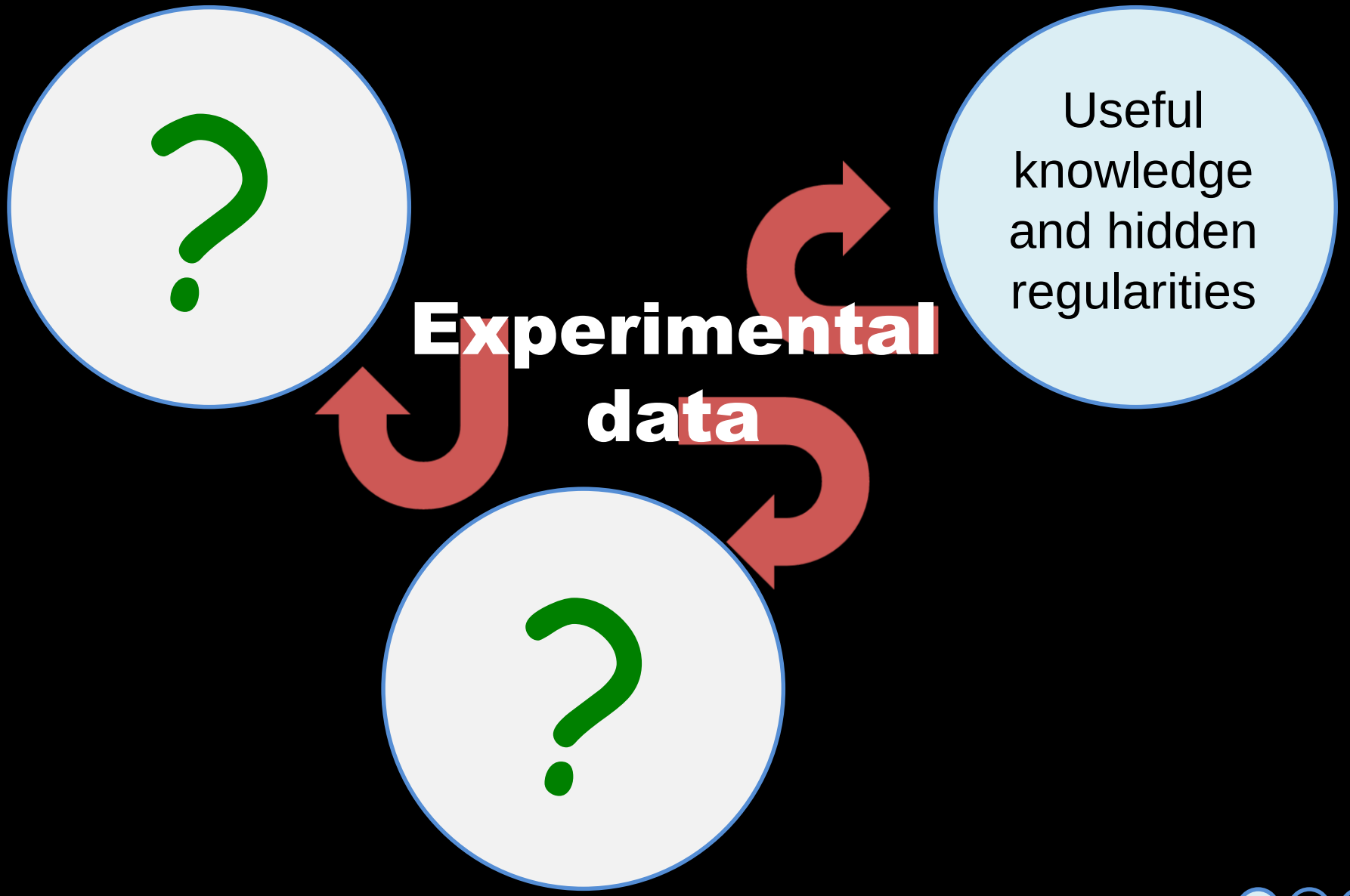

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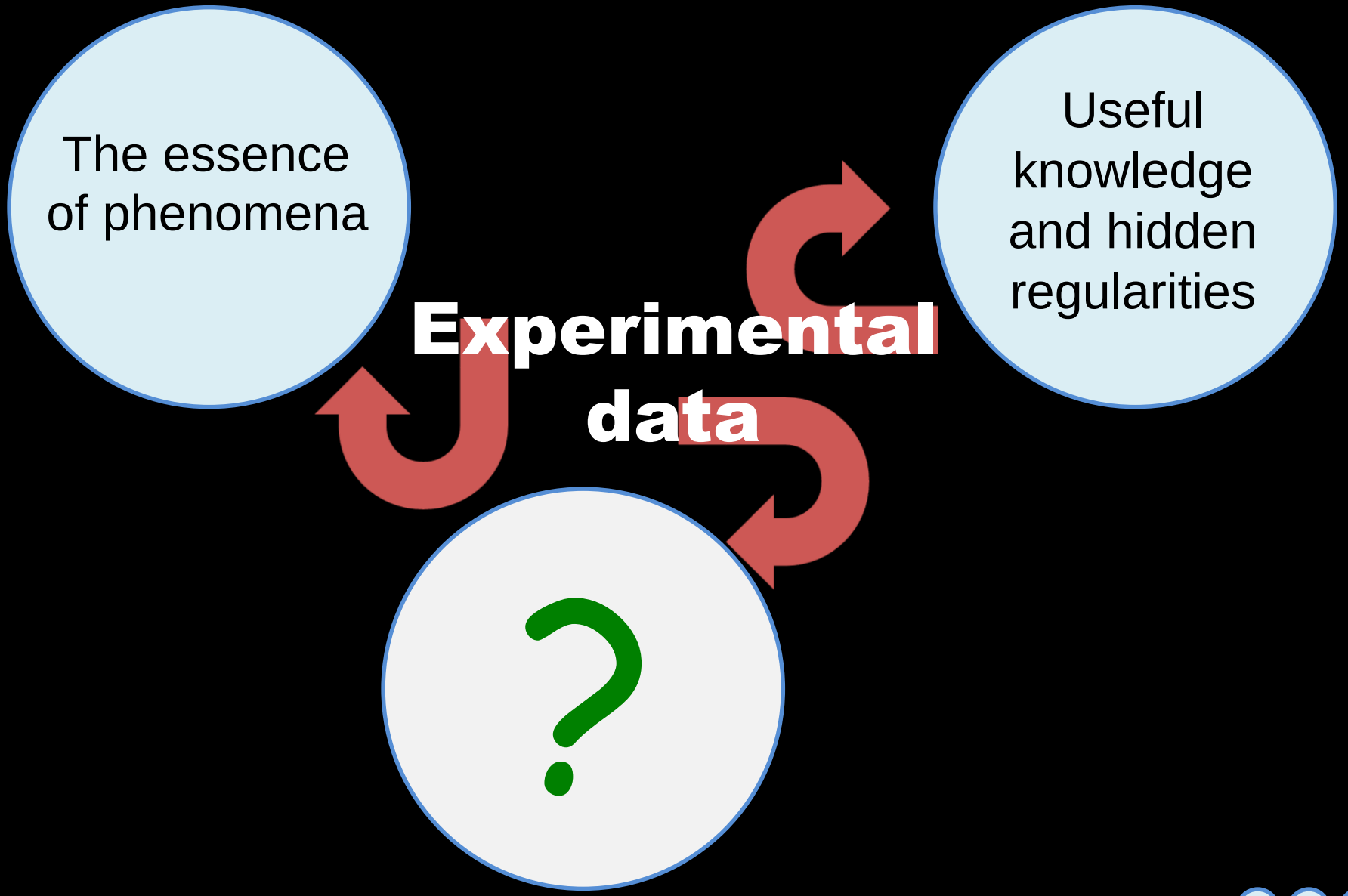

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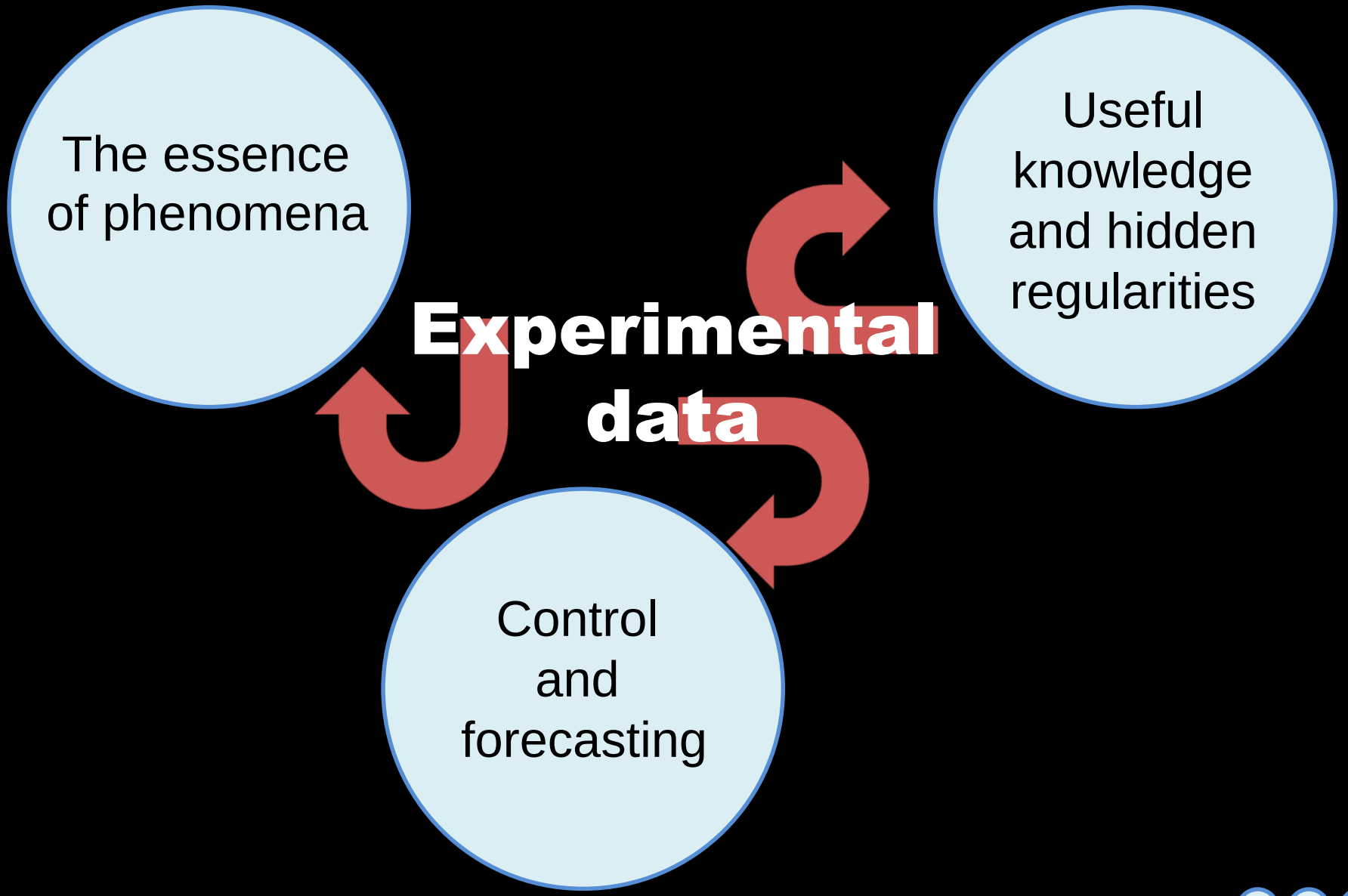
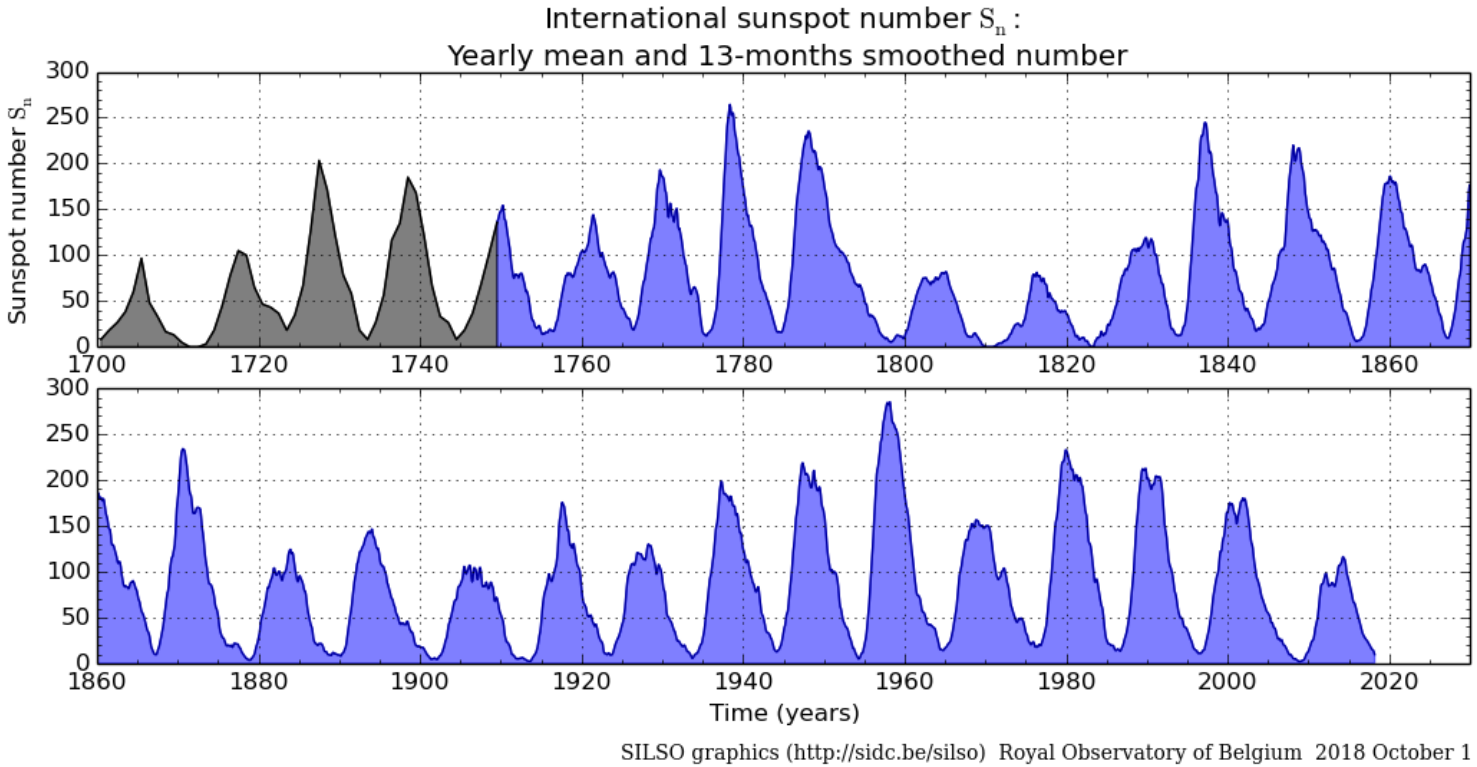


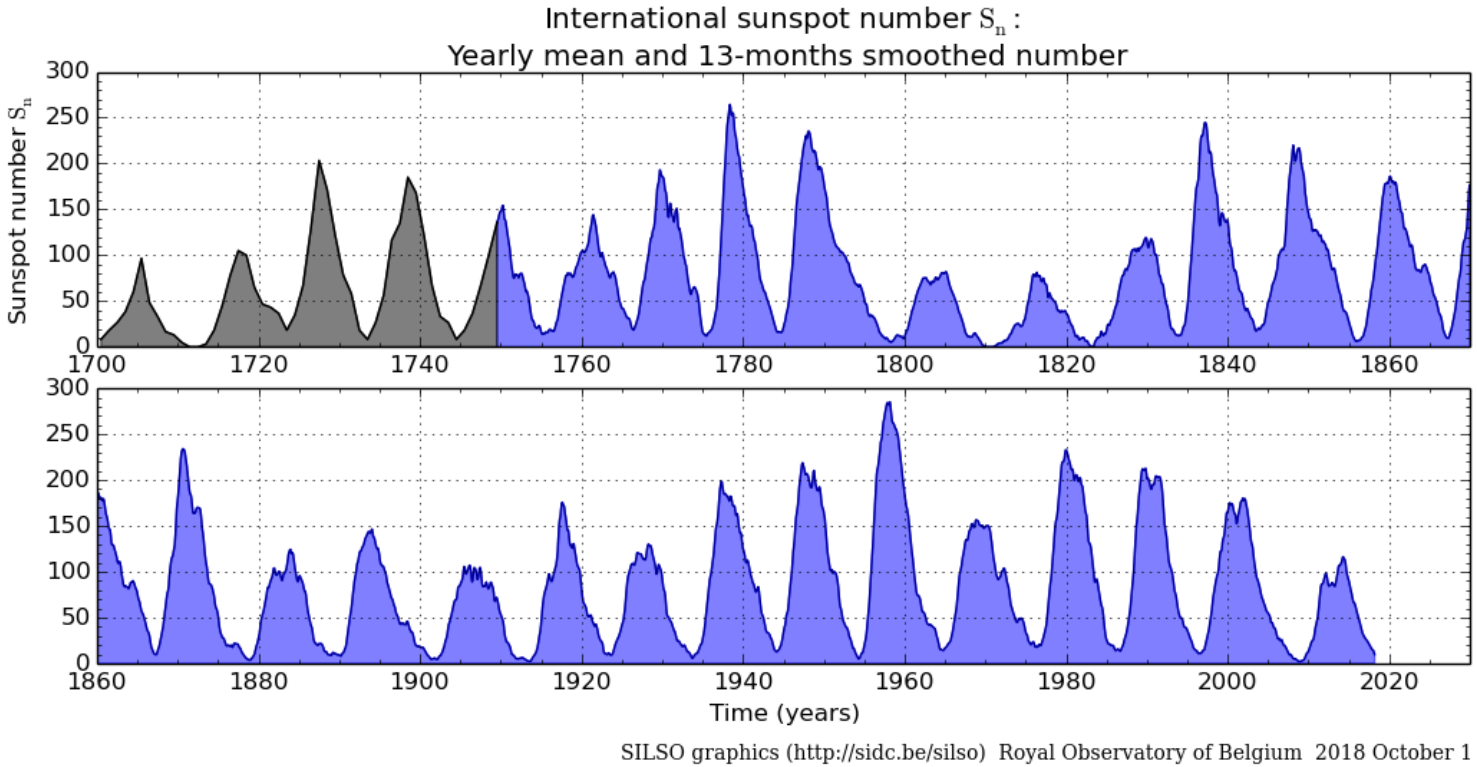
Sunspot number observations 1700-2016

What regularities are visible?



Sunspot number observations 1700-2017

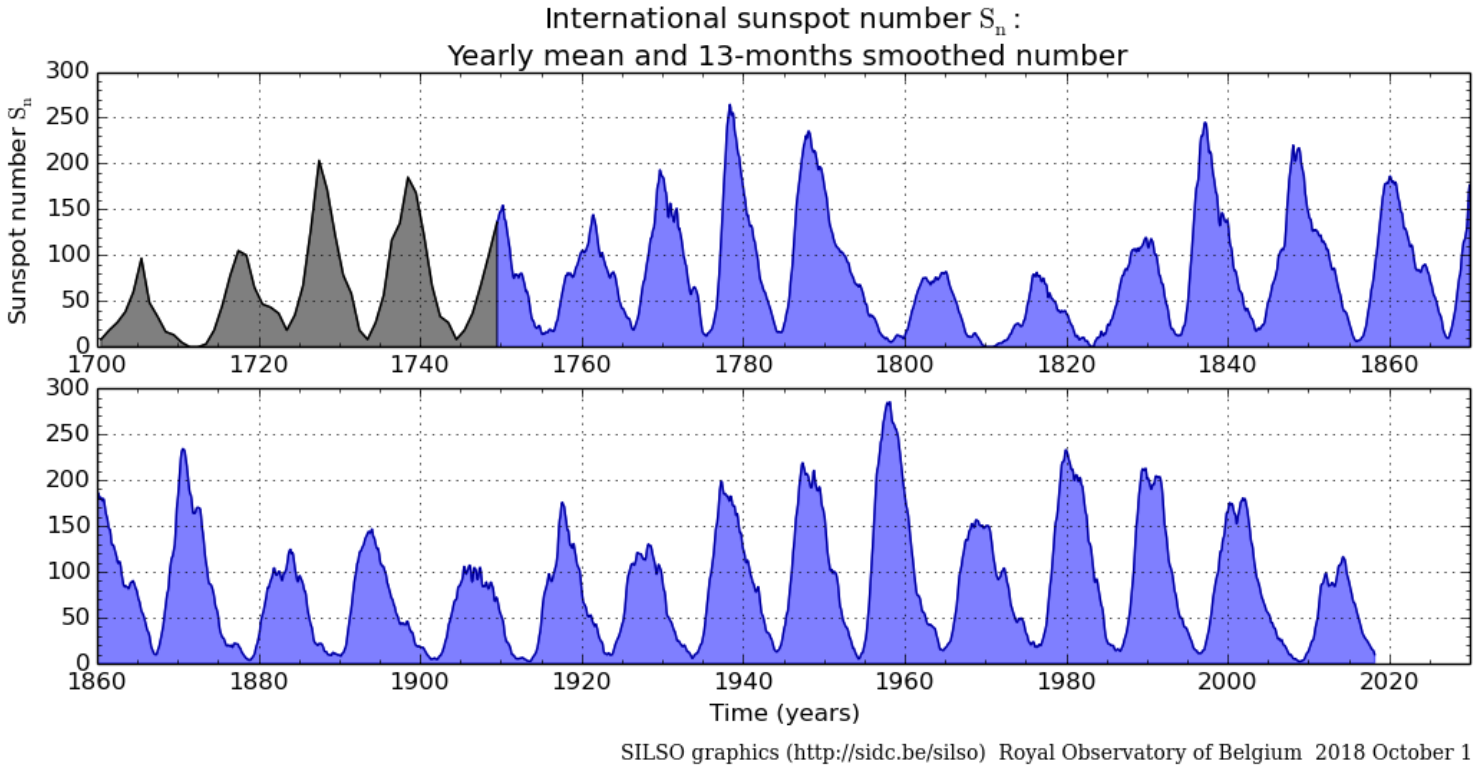
What regularities are visible?



11-year sunspot cycle

Sunspot number observations 1700-2017

What regularities are visible?

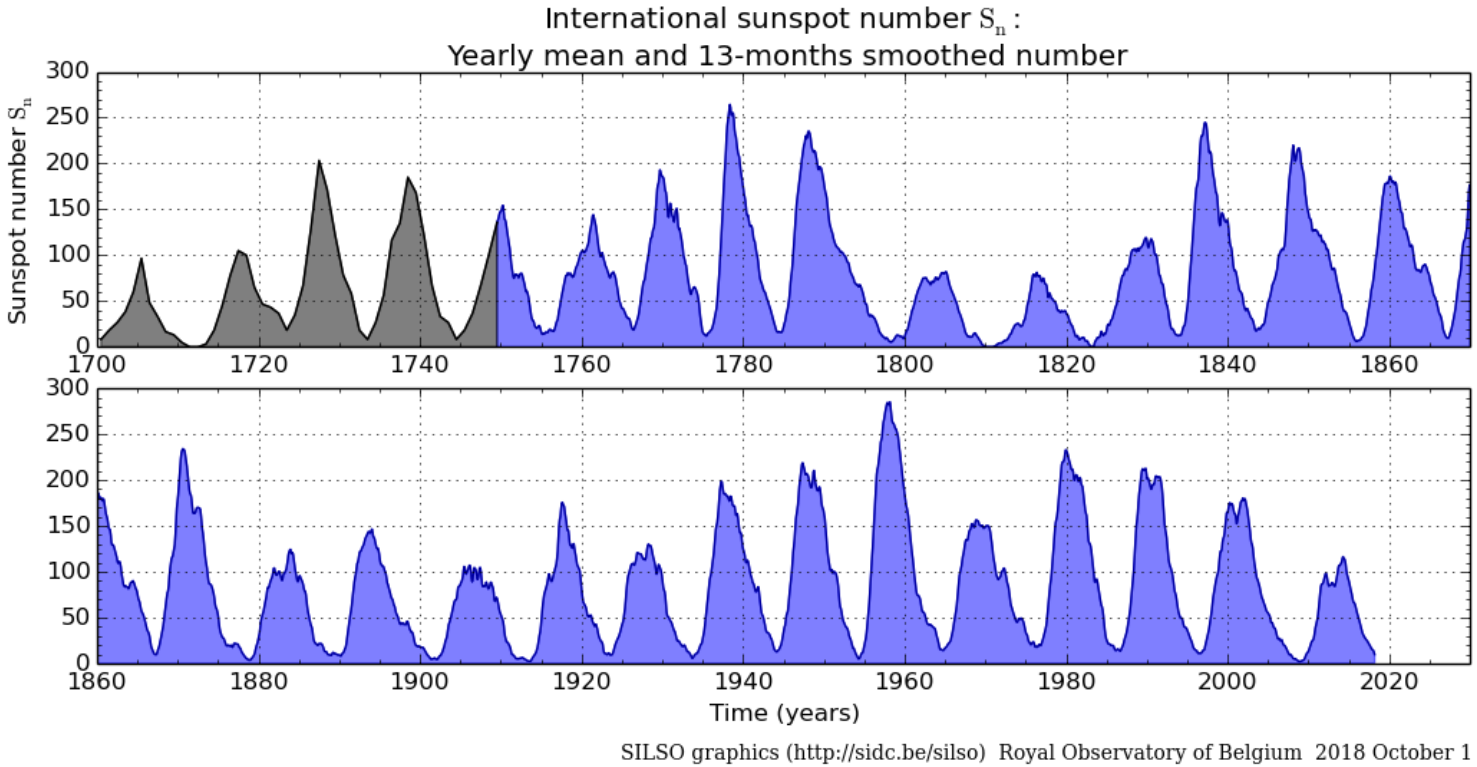


11-year sunspot cycle

The ascent phase is shorter than the decent one

Sunspot number observations 1700-2017

What regularities are visible?



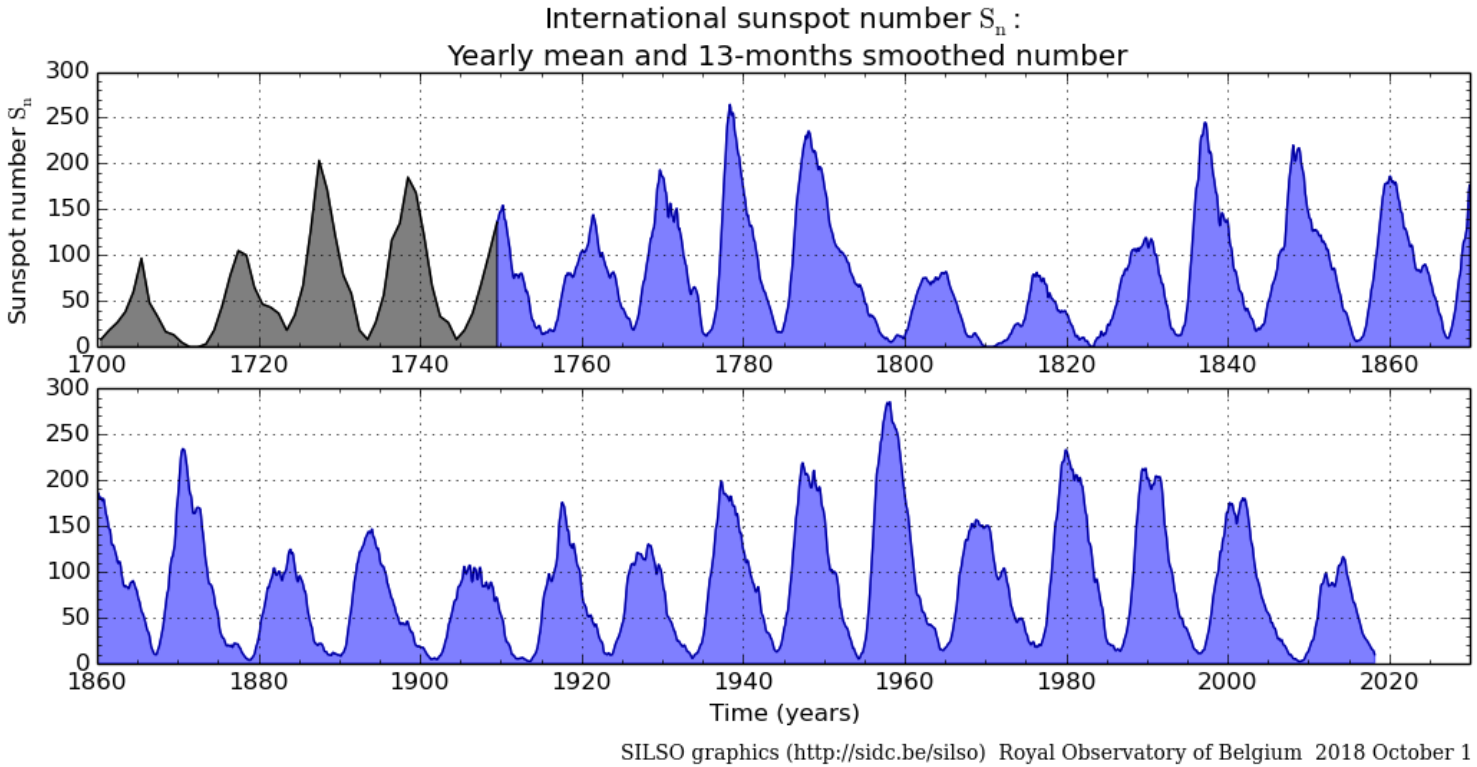
11-year sunspot cycle

The ascent phase is shorter than the decent one

Stronger cycles grow faster in the beginning of ascent phase compared to weaker cycles

Sunspot number observations 1700-2017

What regularities are visible?



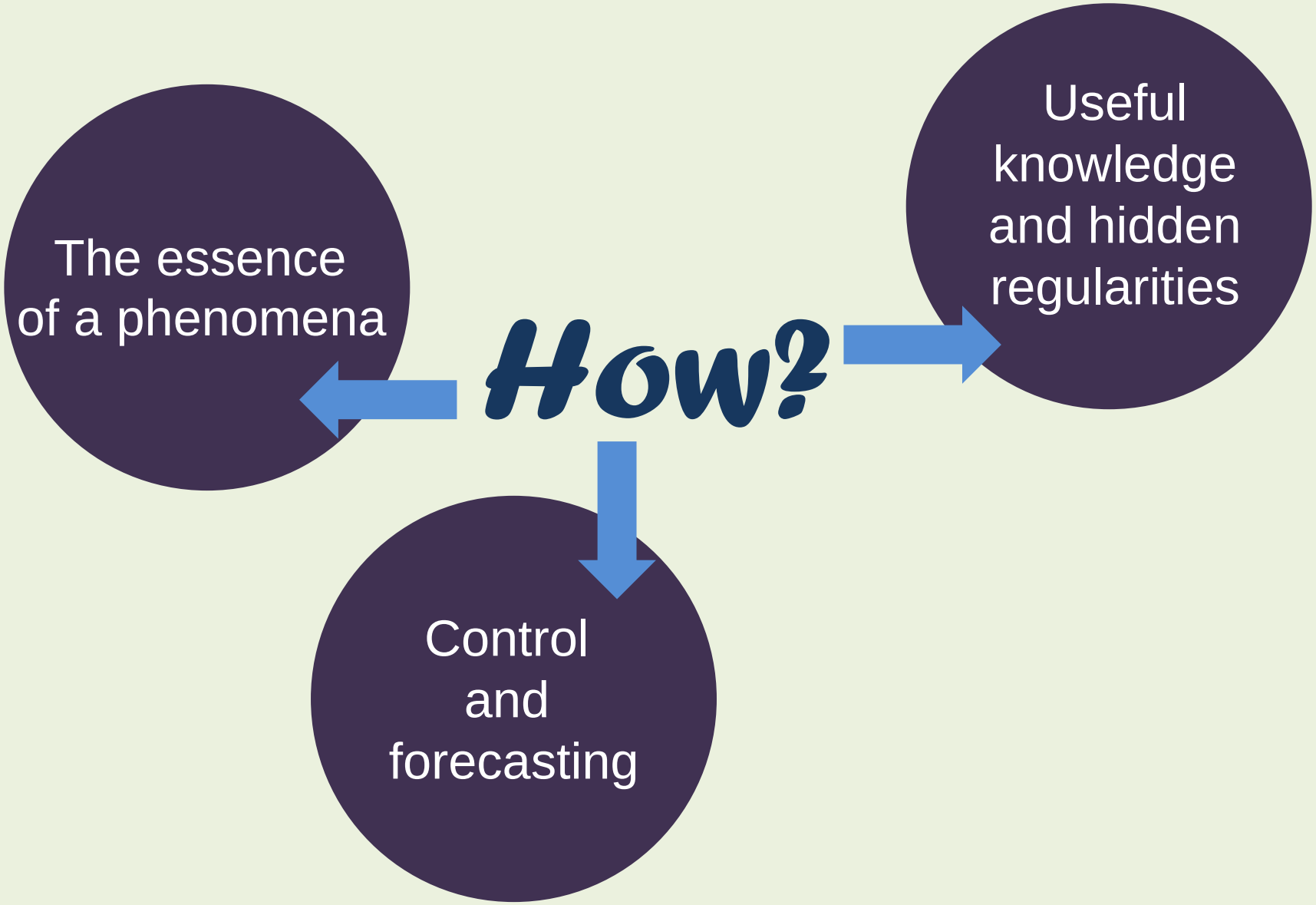
11-year sunspot cycle

The ascent phase is shorter than the decent one

Stronger cycles grow faster in the beginning of ascent phase compared to weaker cycles

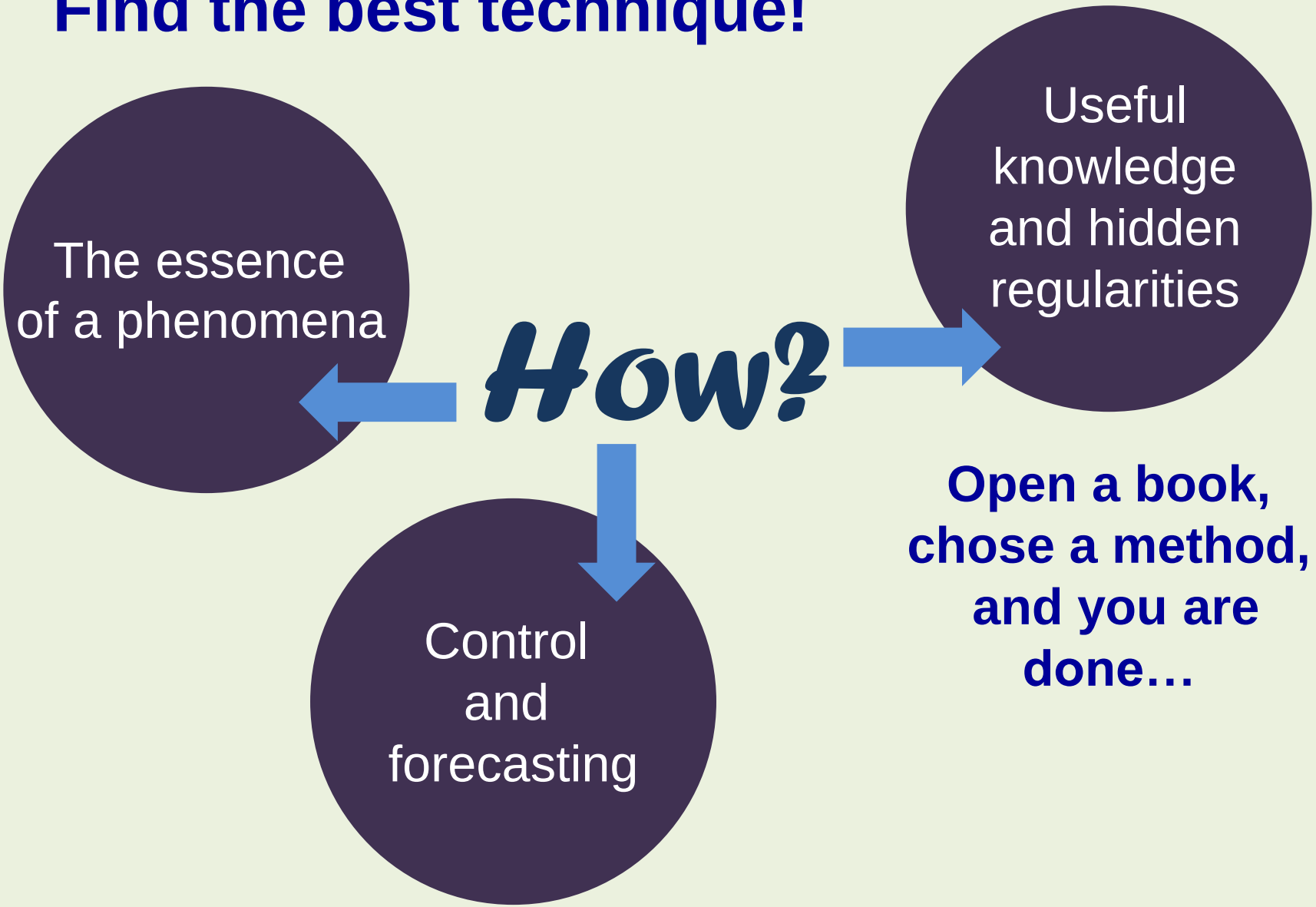
Any regularities to forecast the peak of next cycle 25?

What do we need to accomplish these goals?



What do we need to accomplish these goals?

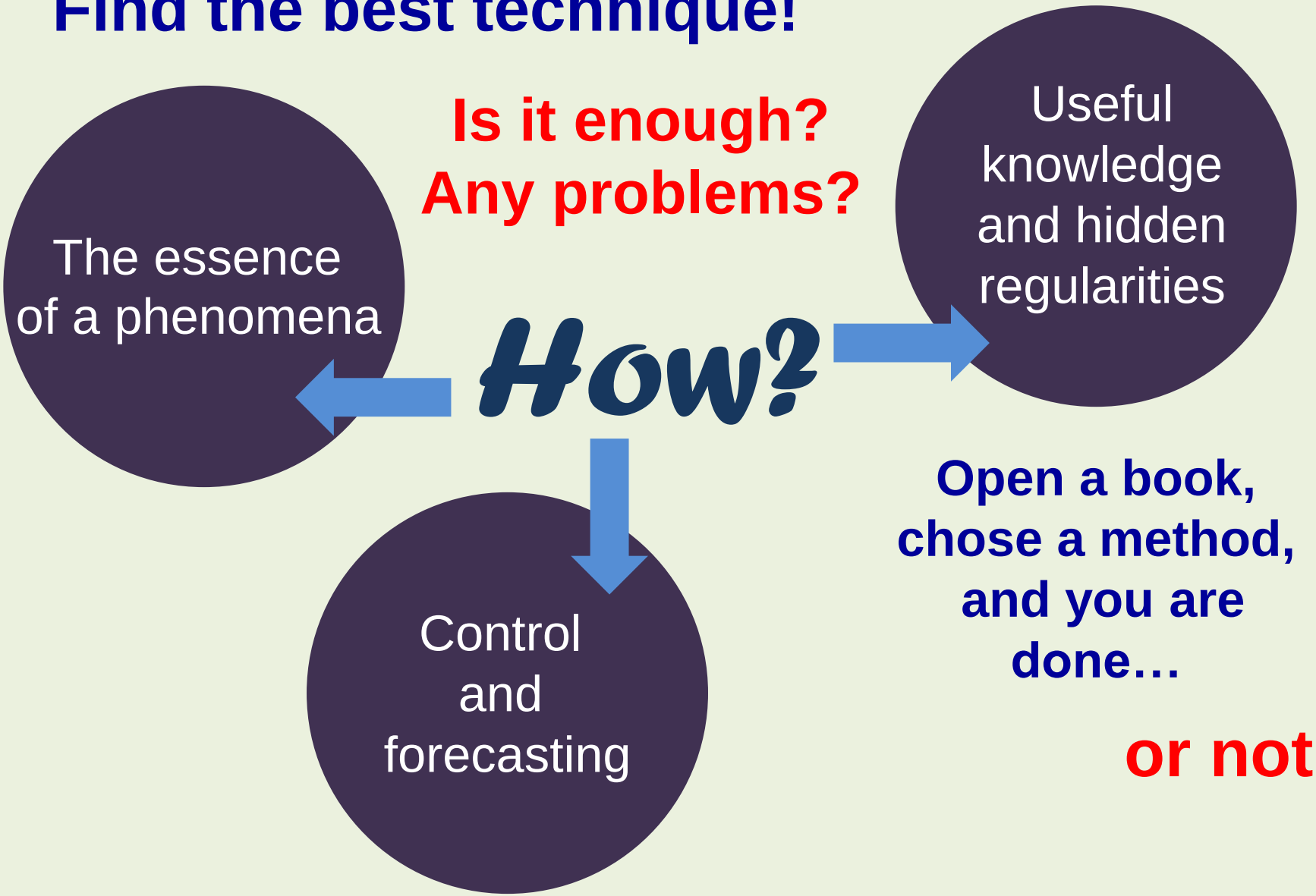
Find the best technique!



Open a book, chose a method, and you are done…

What do we need to accomplish these goals?

Find the best technique!

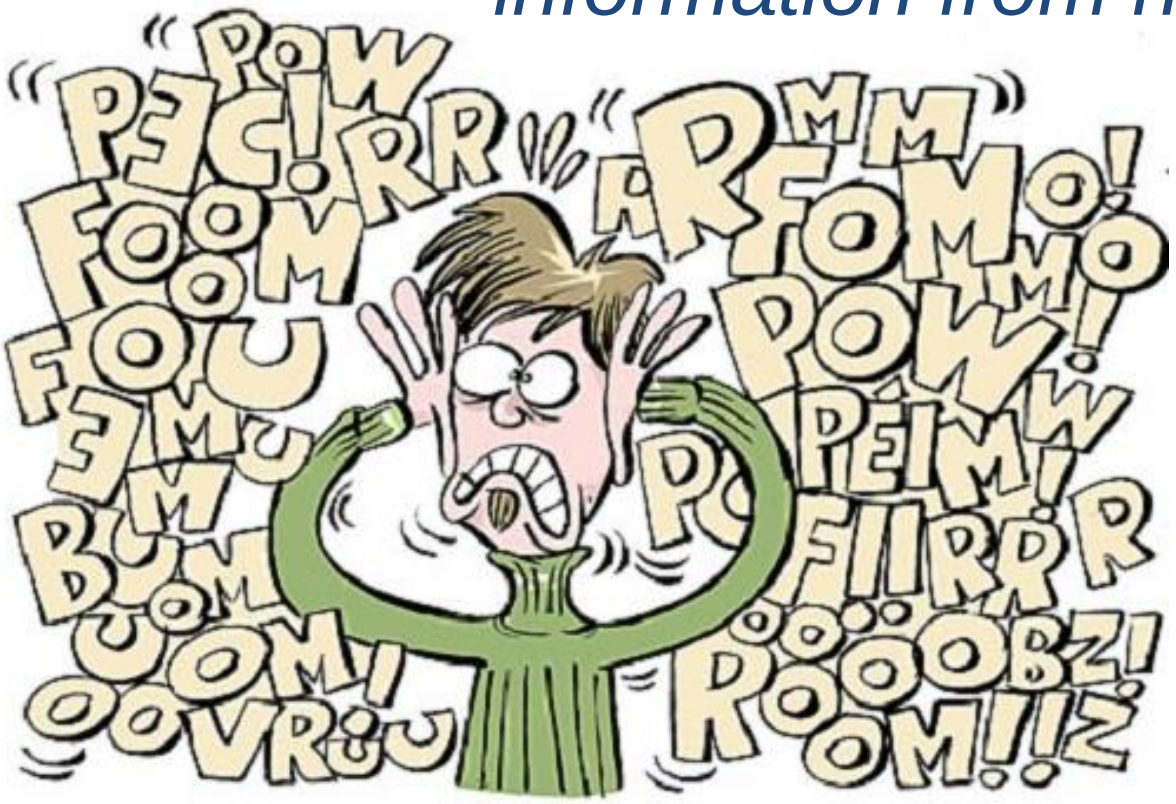


Open a book, chose a method, and you are done…

or not?

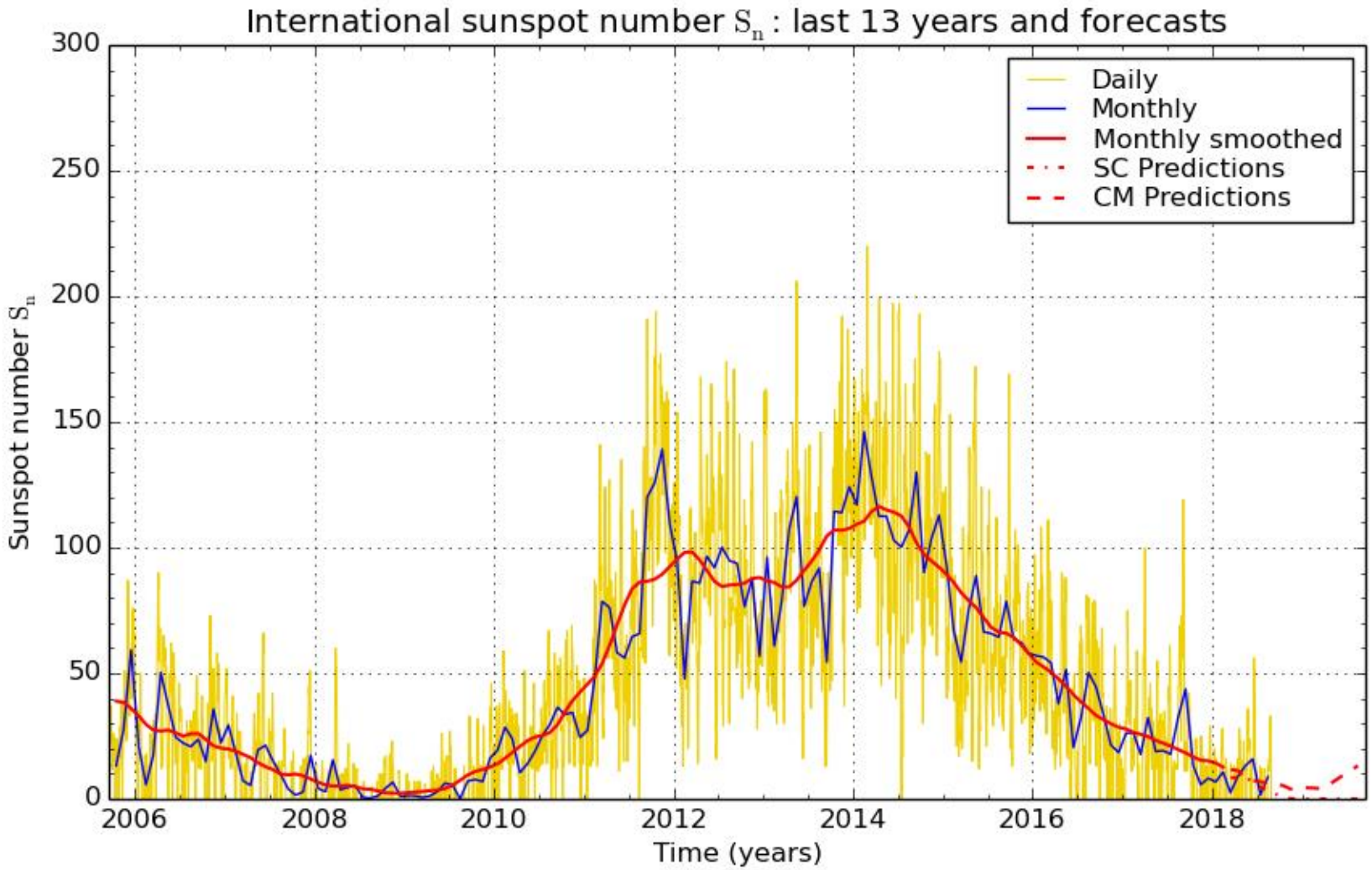
Distortion of information due to random errors

How to extract the useful information from noise?



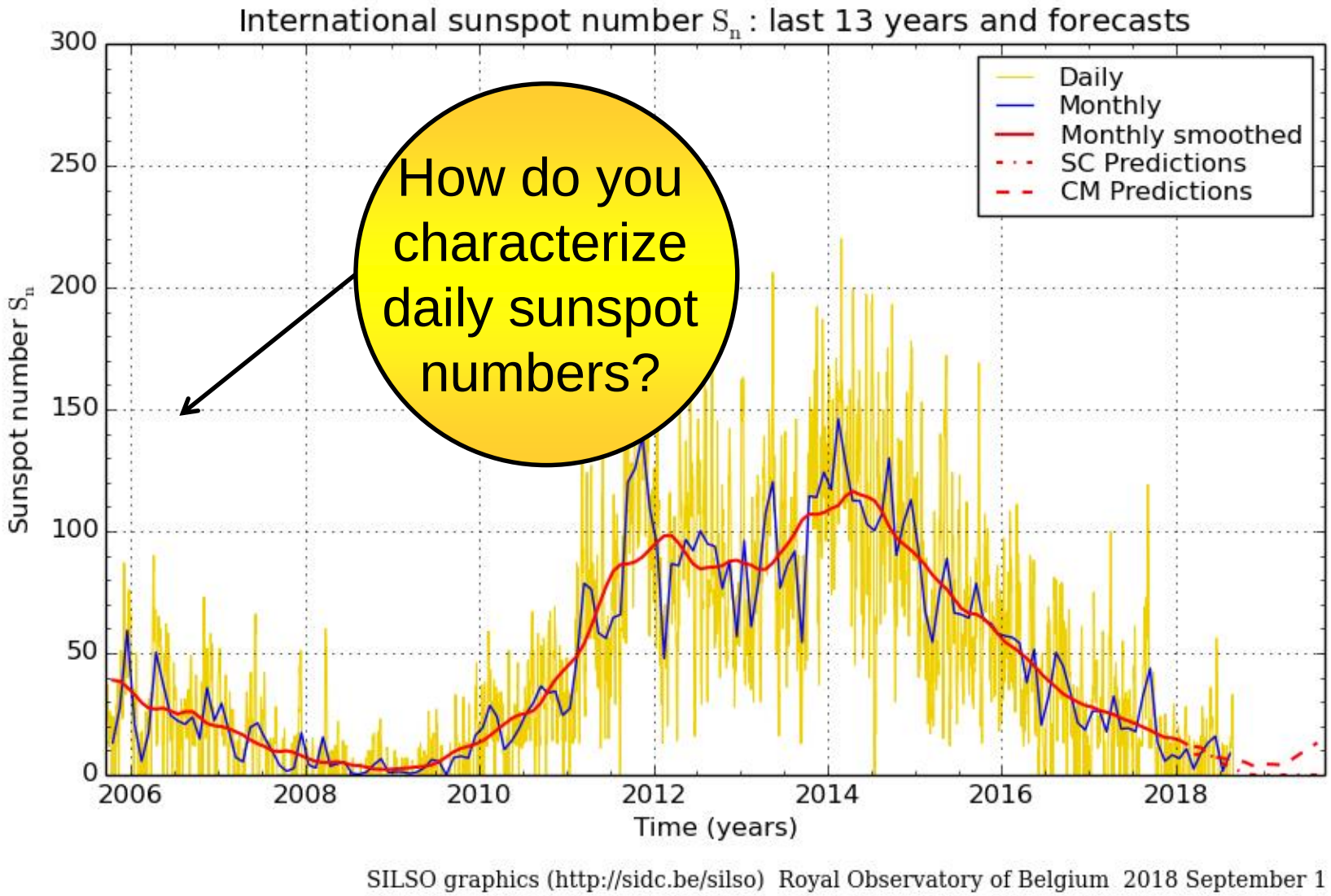
Problem 1: noise

Trend extraction in conditions of random errors



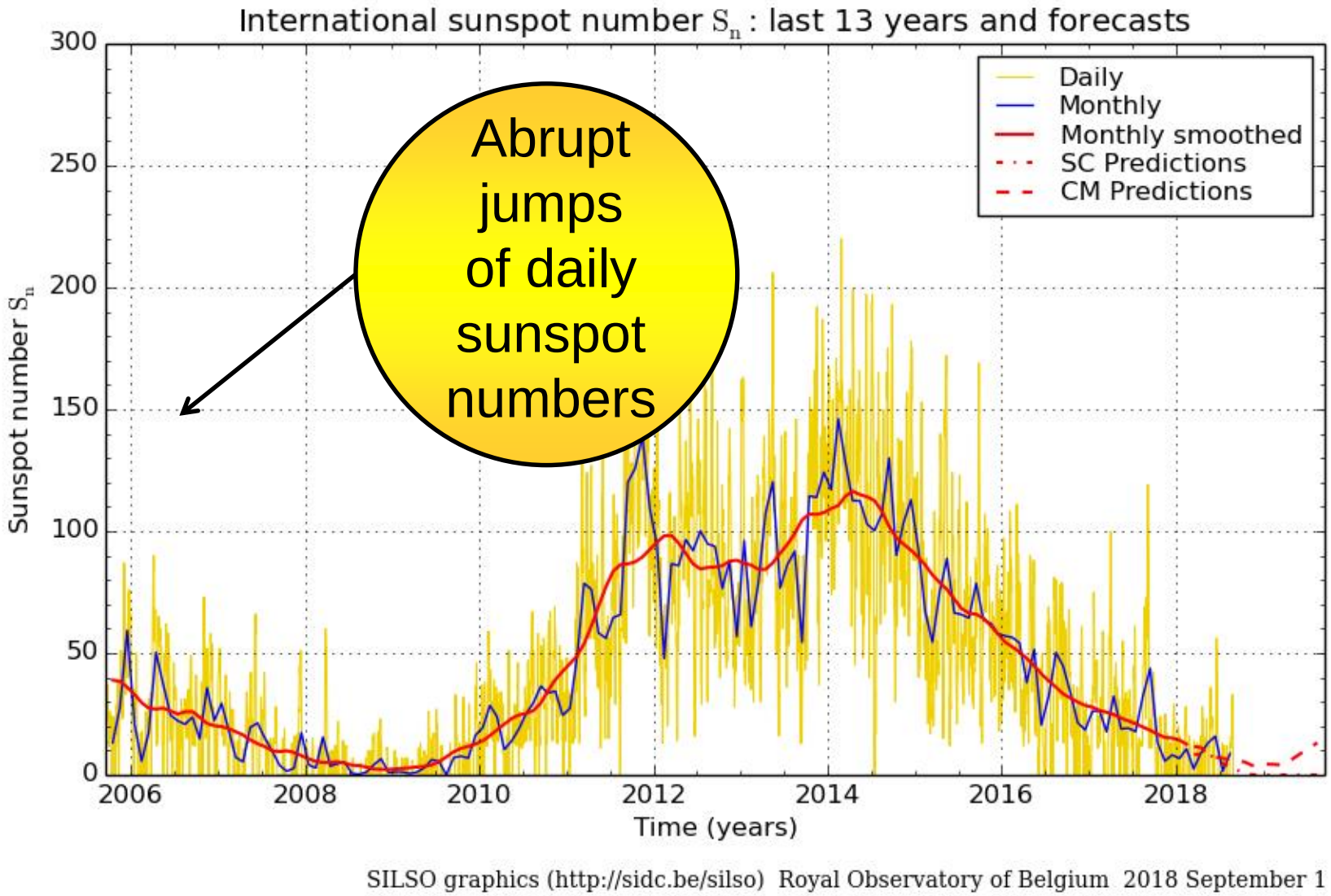
Problem 1: noise

Trend extraction in conditions of random errors



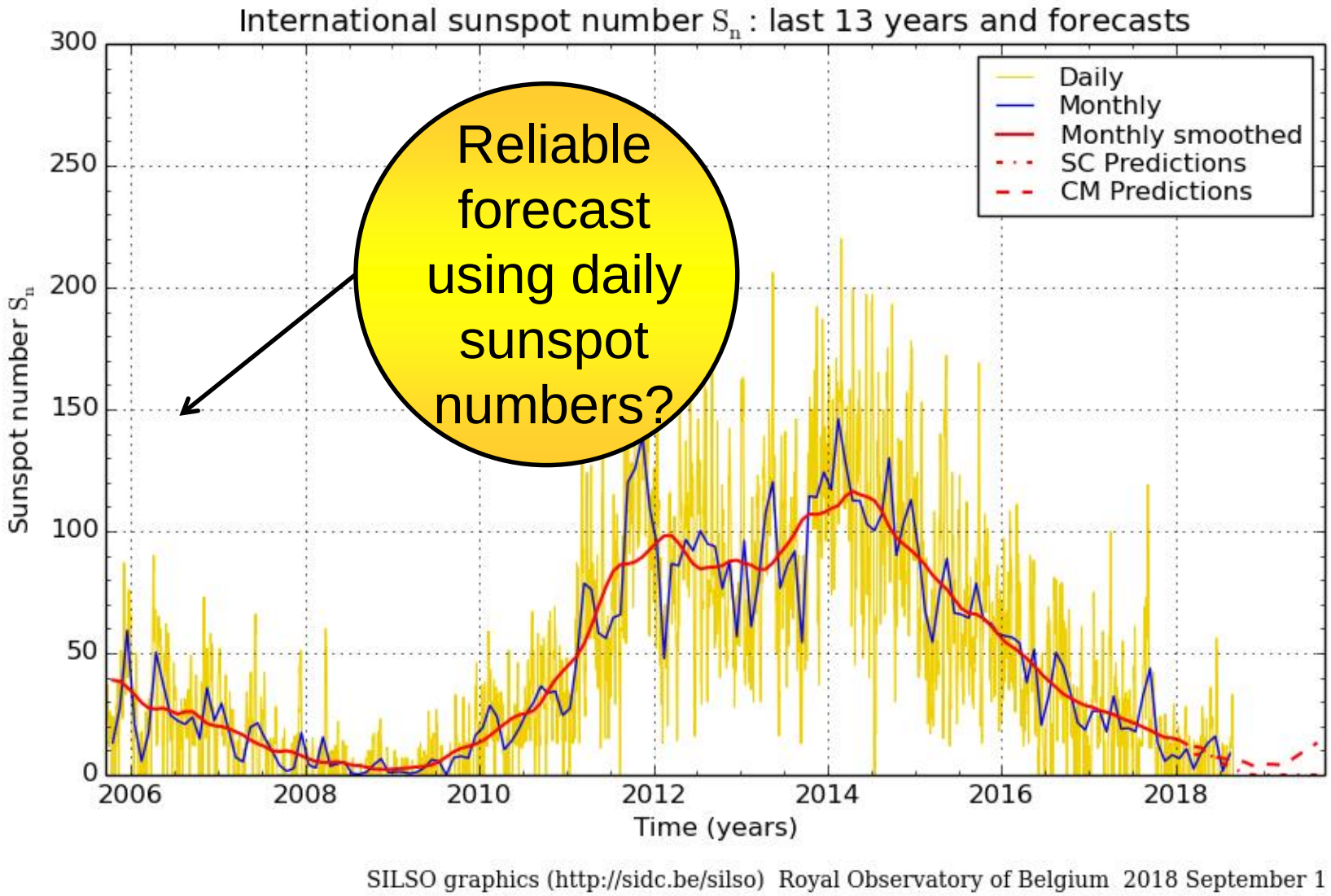
Problem 1: noise

Trend extraction in conditions of random errors



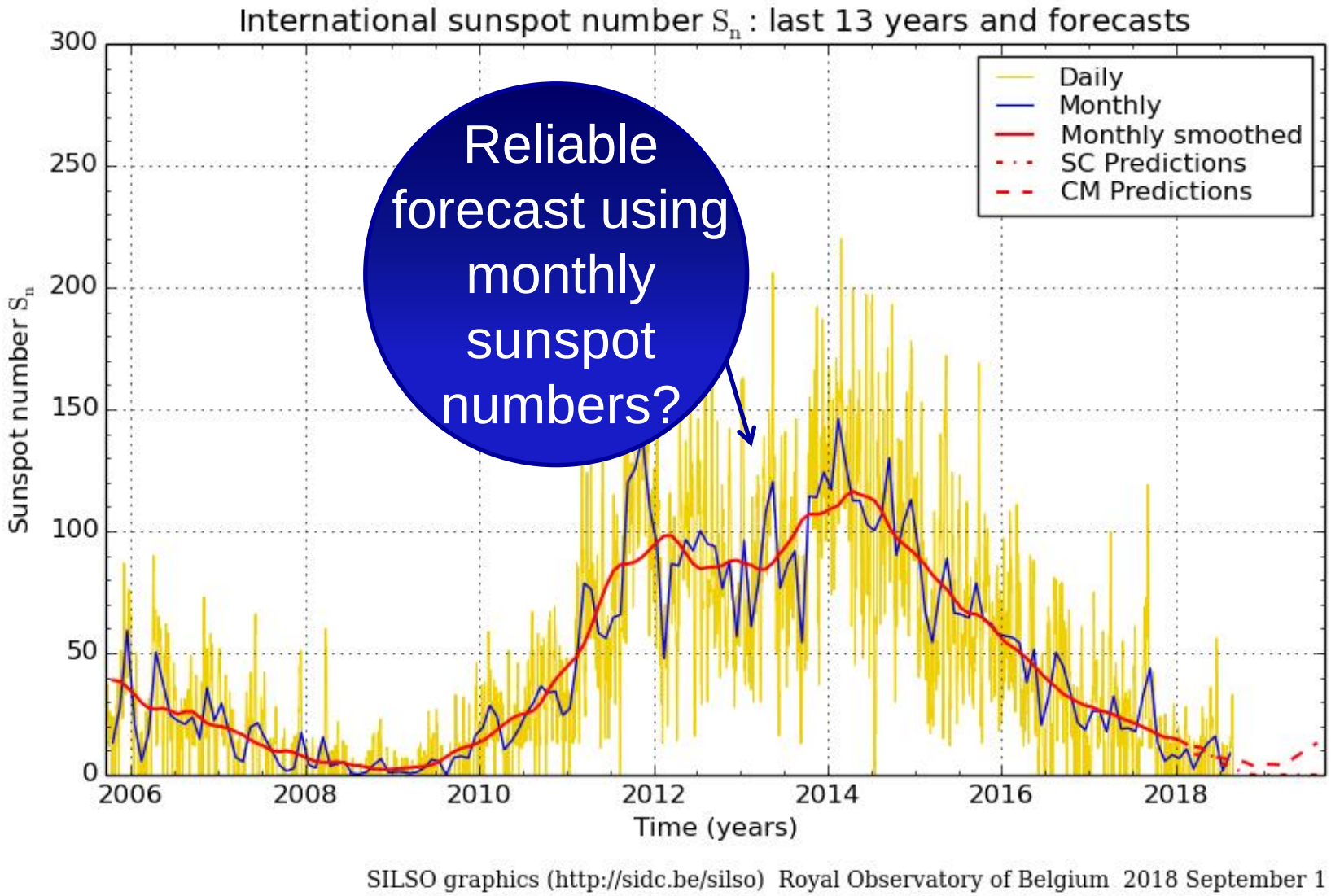
Problem 1: noise

Trend extraction in conditions of random errors



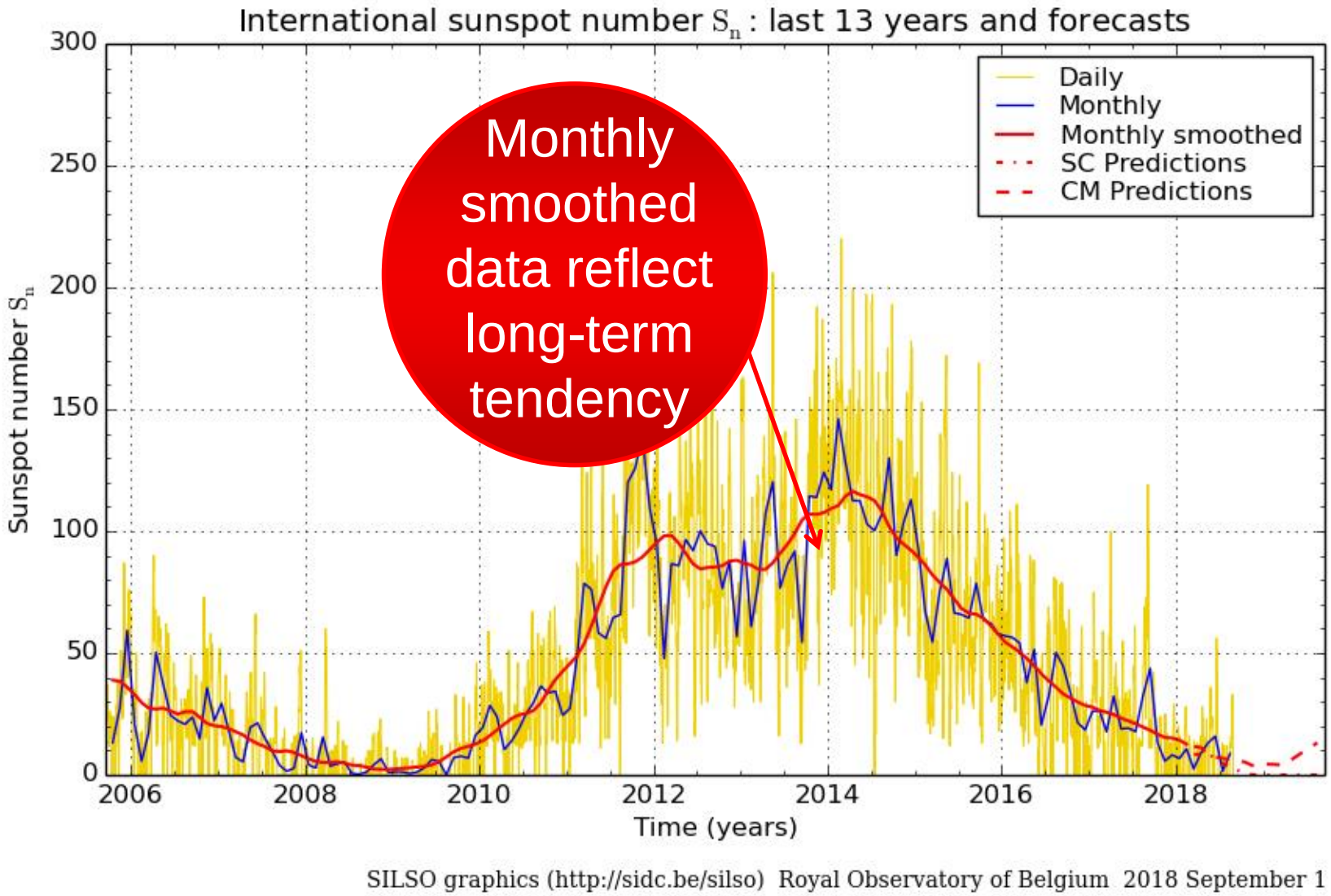
Problem 1: noise

Trend extraction in conditions of random errors



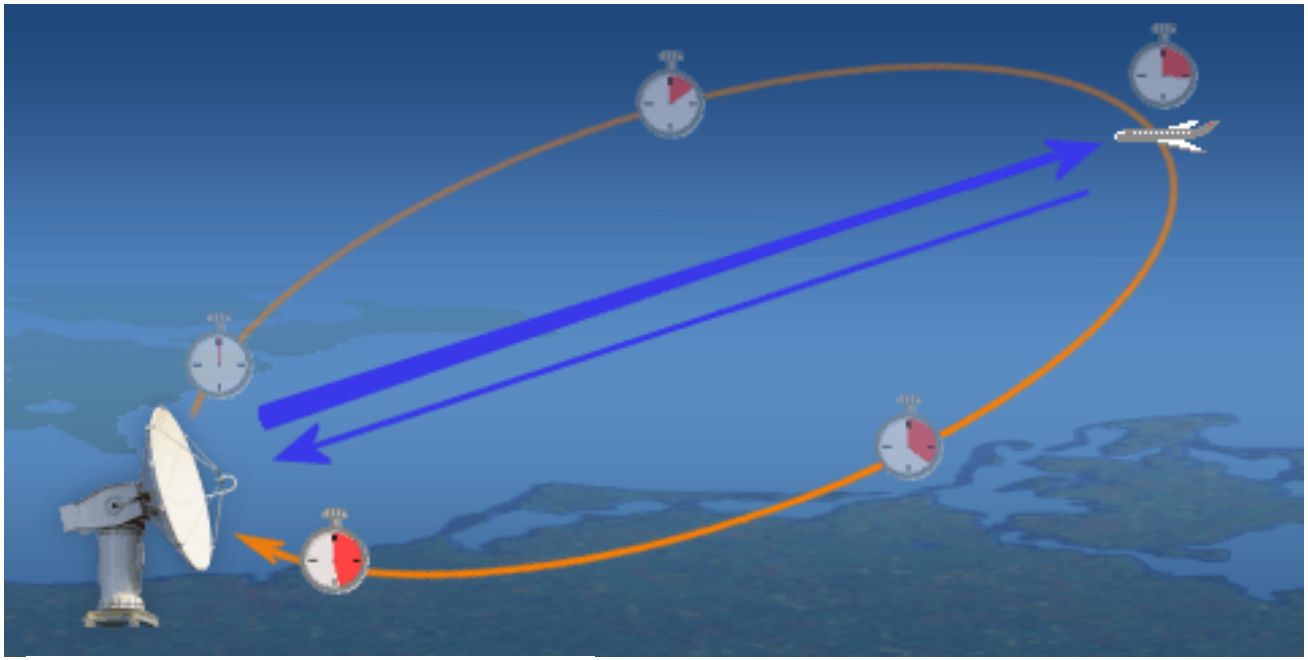
Problem 1: noise

Trend extraction in conditions of random errors



Problem 1: noise

Noise reduction for experimental data is needed



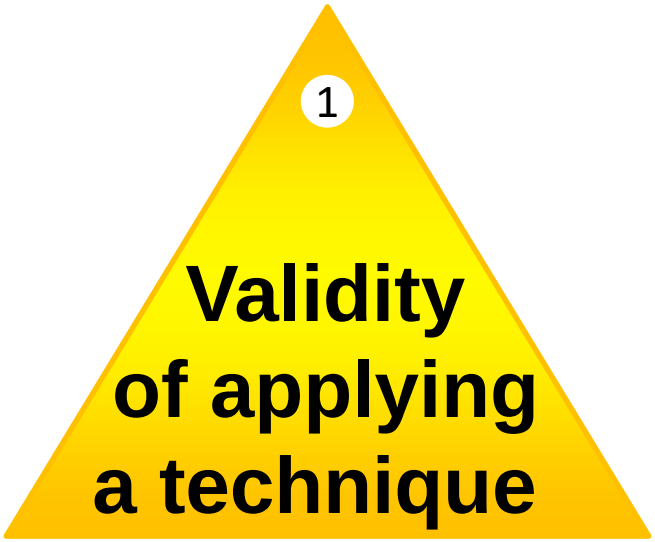
Aircraft might disappear from a radar

Doctor might come up with a misdiagnosis

Business default

Problem 1: noise

How to be sure in the reliability of result?

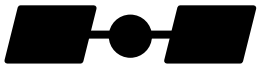


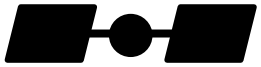
Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique





Man-made satellite

Case 1: valid

How to determine the satellite position?

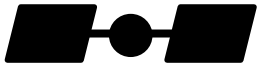
Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique

1



Man-made satellite

Navigation satellite

Case 1: valid

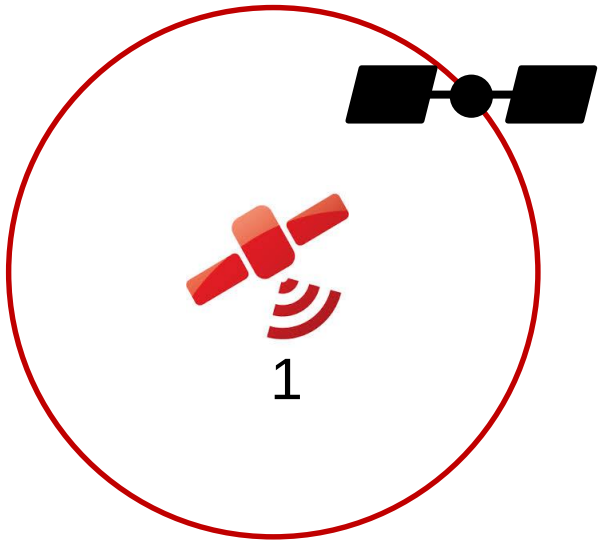
Navigation satellite 1 measures the distance to man-made satellite

Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique



Man-made satellite

Navigation satellite

Case 1: valid

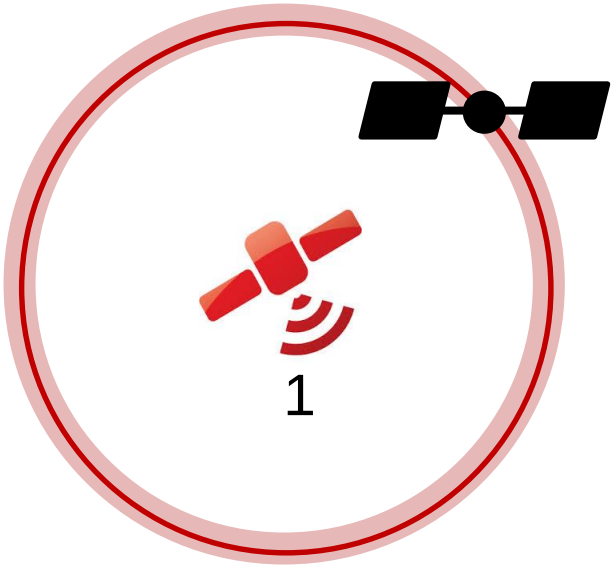
Man-made satellite is somewhere on a circle

Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique



Man-made satellite

Navigation satellite

Case 1: valid

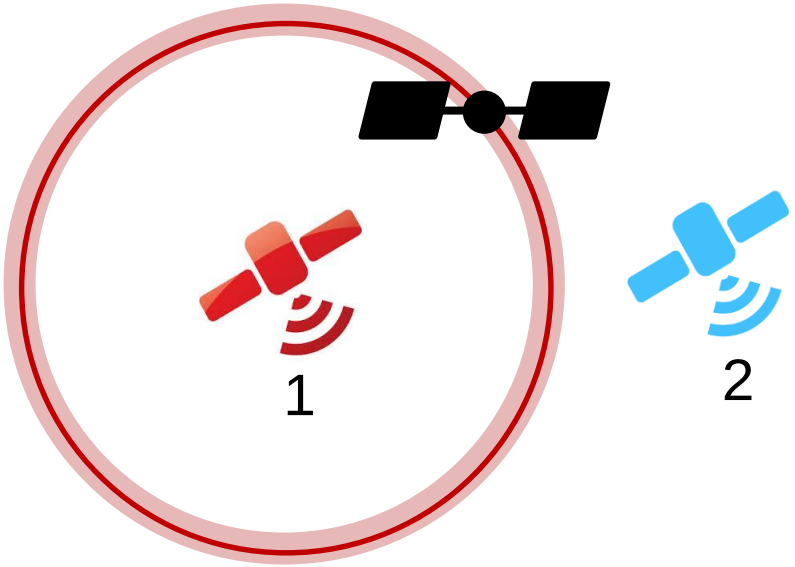
Measurements of distance to man made satellite have errors

Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique



Man-made satellite

Navigation satellite

Case 1: valid

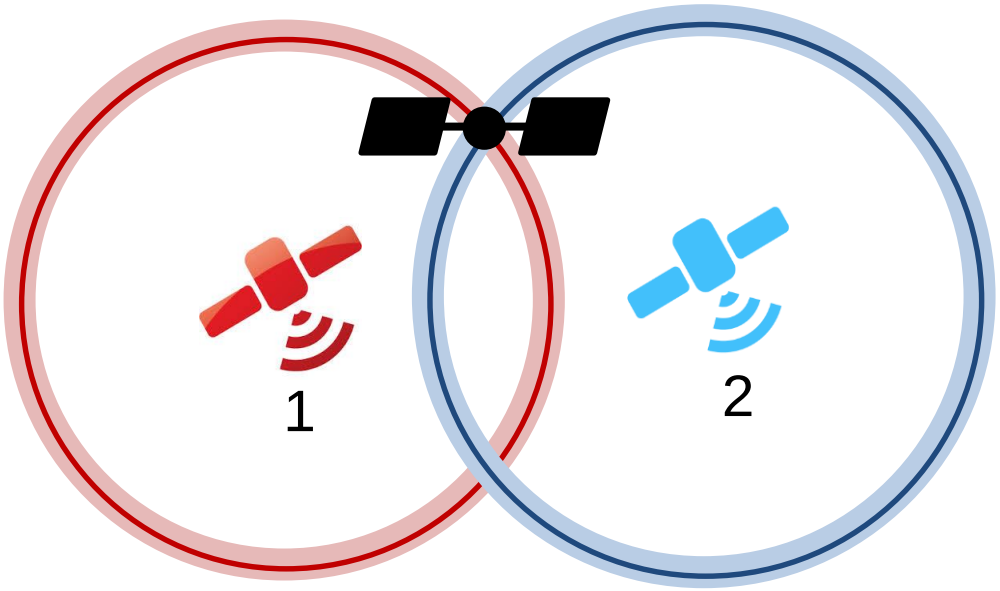
Navigation satellite 2 also measures the distance to man-made satellite

Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique



Man-made satellite

Navigation satellite

Case 1: valid

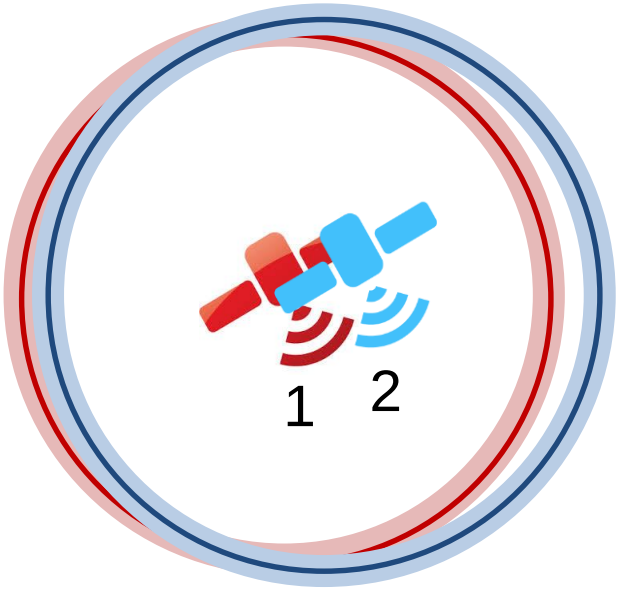
The position of a satellite is at the intersecting points of circles

Problem 2: reliability

How to be sure in the reliability of result?

1

Validity of applying a technique



-?

Man-made satellite

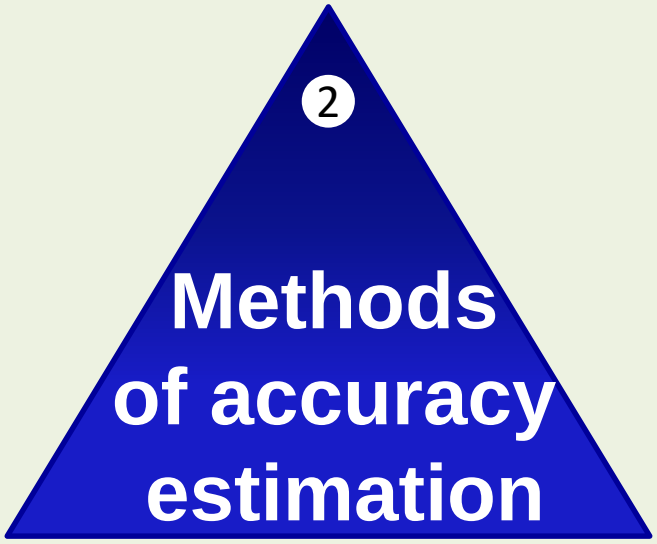
Navigation satellite

Case 2: Not valid:
Ill-conditioned problem

Satellite position is undefined!

Problem 2: reliability

How to be sure in the reliability of result?

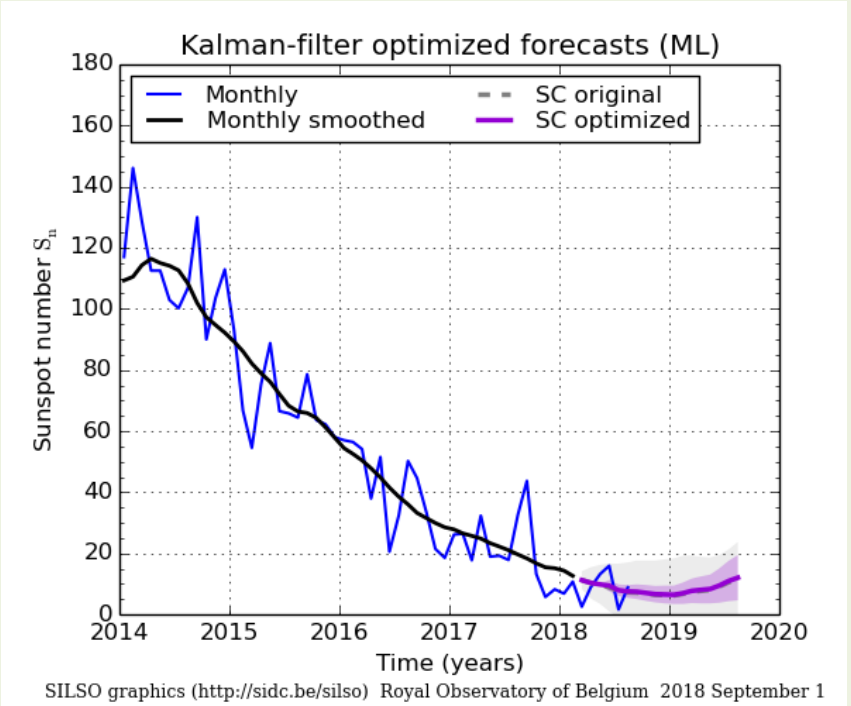


Problem 2: reliability

How to be sure in the reliability of result?

2

Methods of accuracy estimation



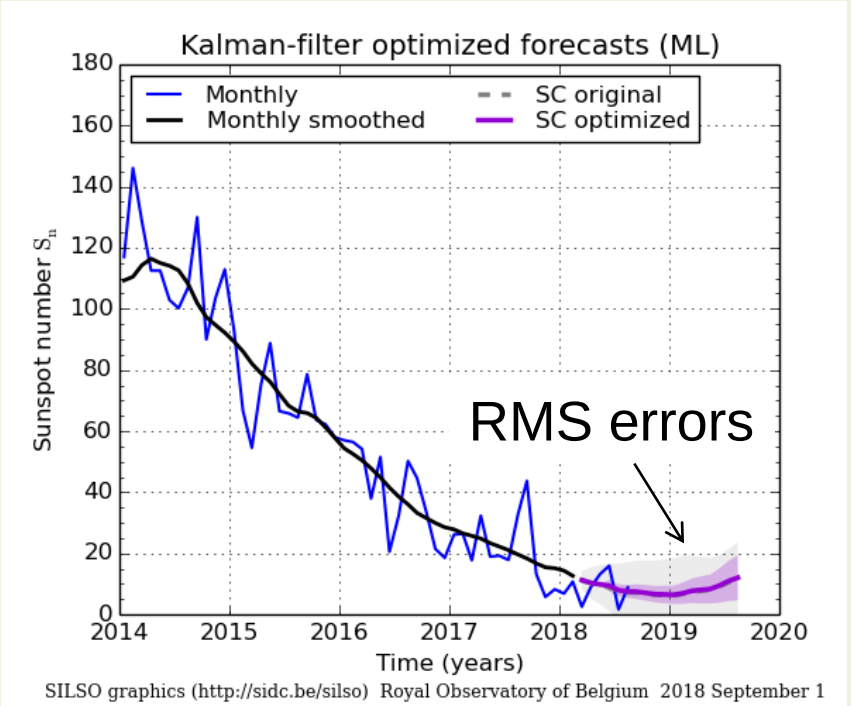
Problem 2: reliability

How to be sure in the reliability of result?

2

Methods of accuracy estimation

Optimal methods usually provide the accuracy of estimation



Problem 2: reliability

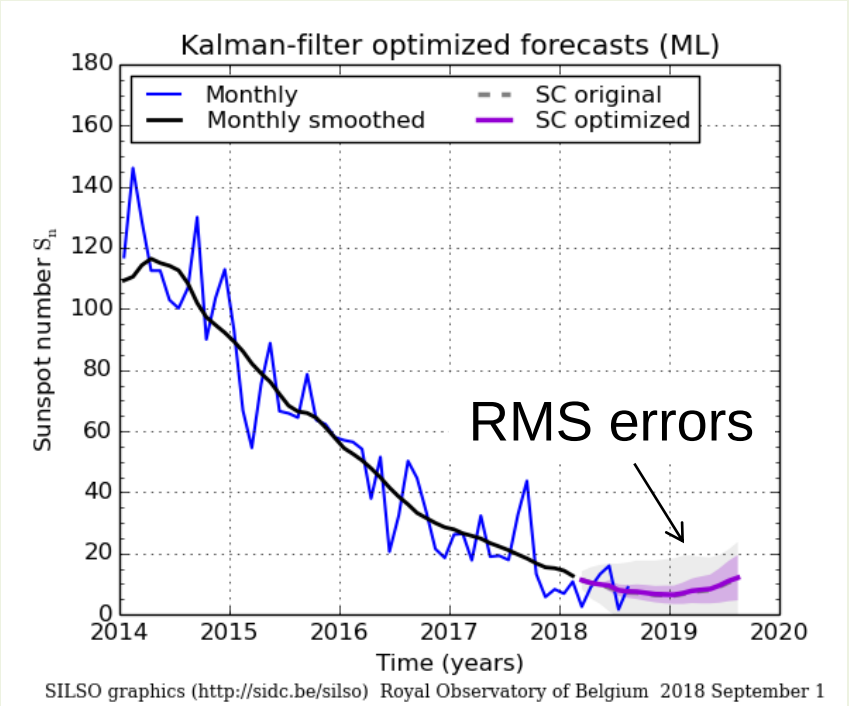
How to be sure in the reliability of result?

2

Methods of accuracy estimation

Optimal methods usually provide the accuracy of estimation

Alternative ways to estimate the accuracy are needed due to great uncertainty and non-optimal estimation



Problem 2: reliability

How to be sure in the reliability of result?

Problem 2: reliability

How to be sure in the reliability of result?

3

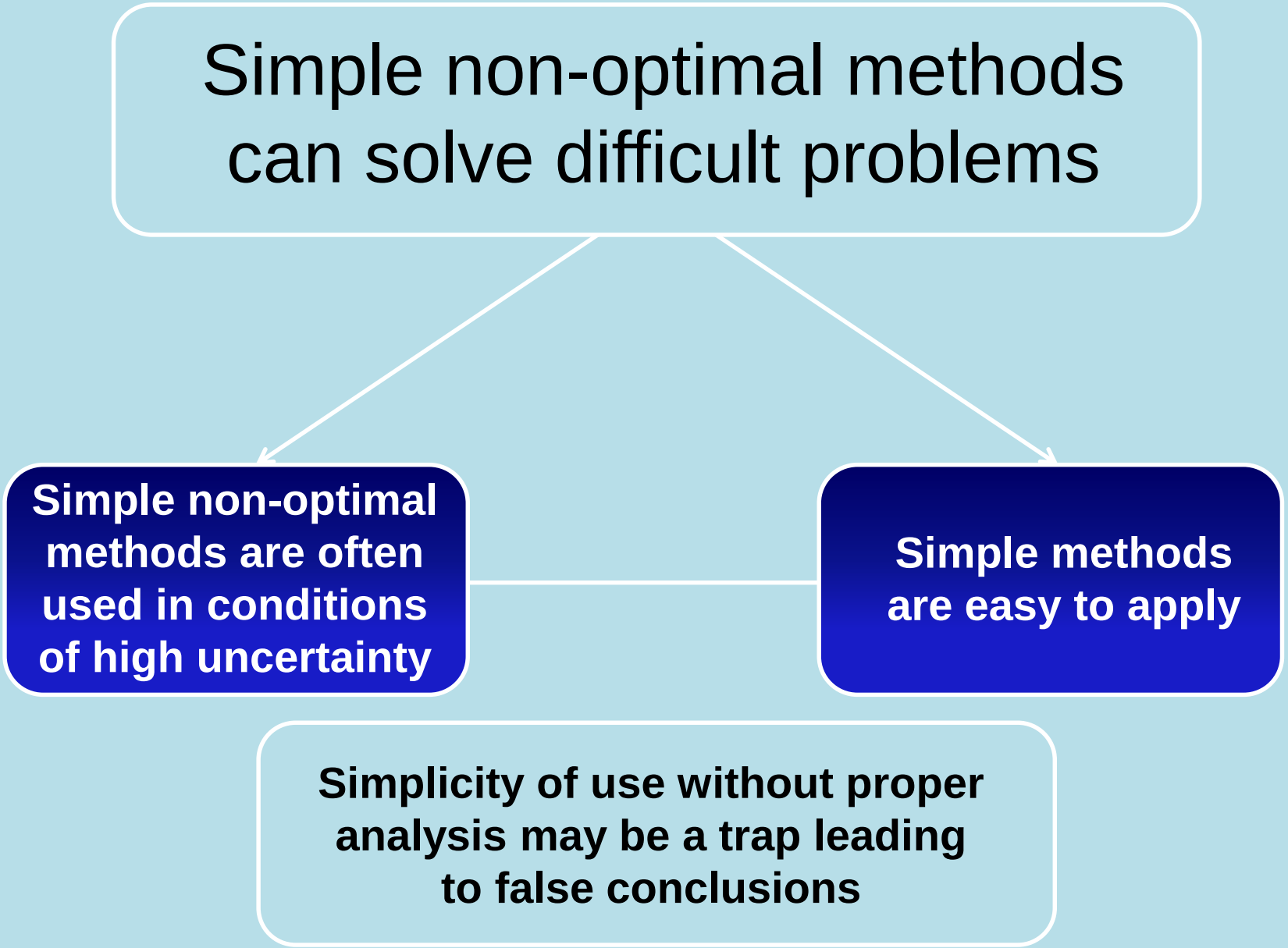
Practical confirmation

Parker Solar Probe Launch, 12 August 2018
A mission to touch the Sun!

- ✓ High costs
- ✓ Sometimes impossible

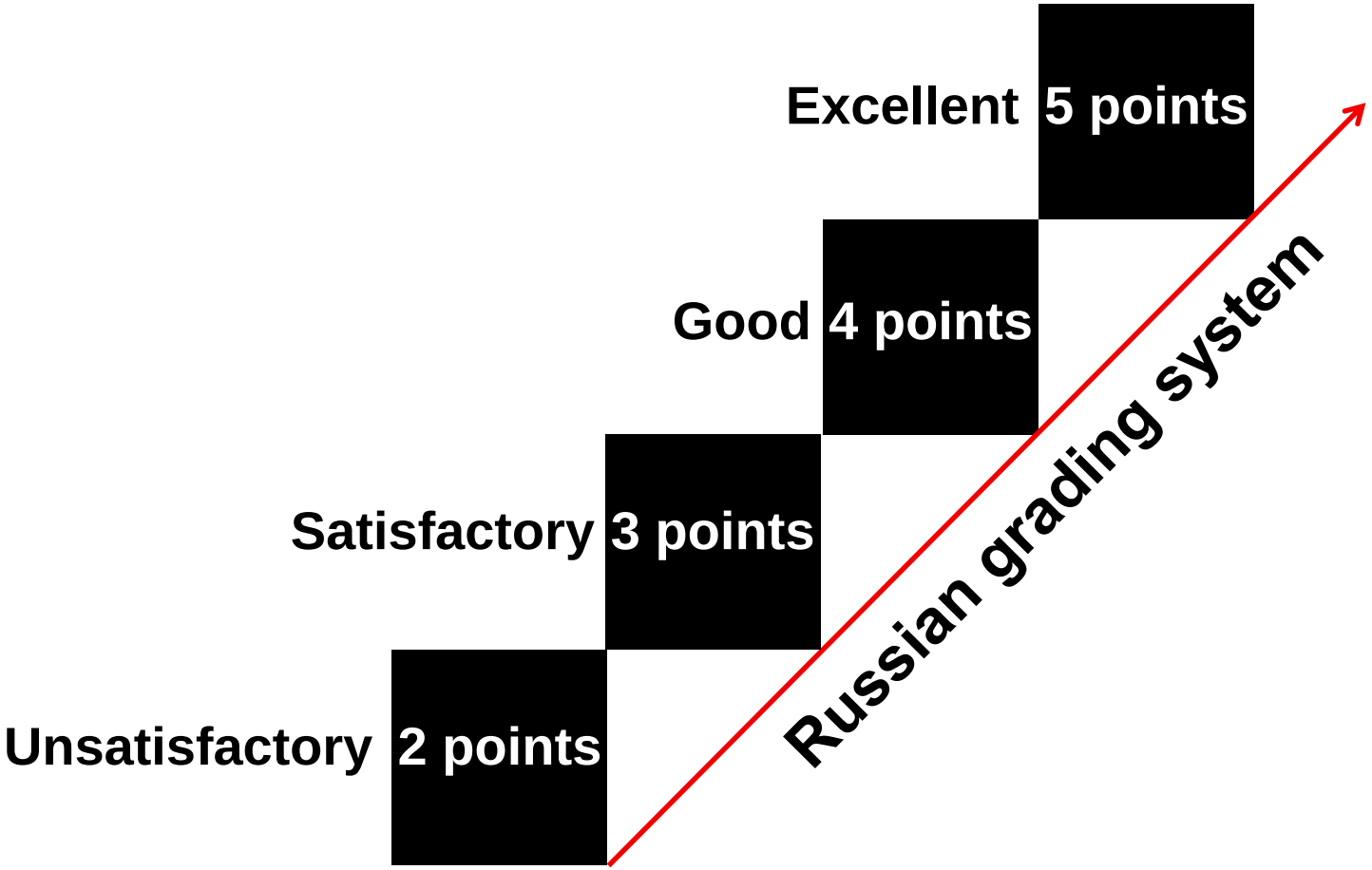
“Practice is the criterion of truth”

Problem 2: reliability



Problem 3: no proper analysis

Simple method to solve difficult problem



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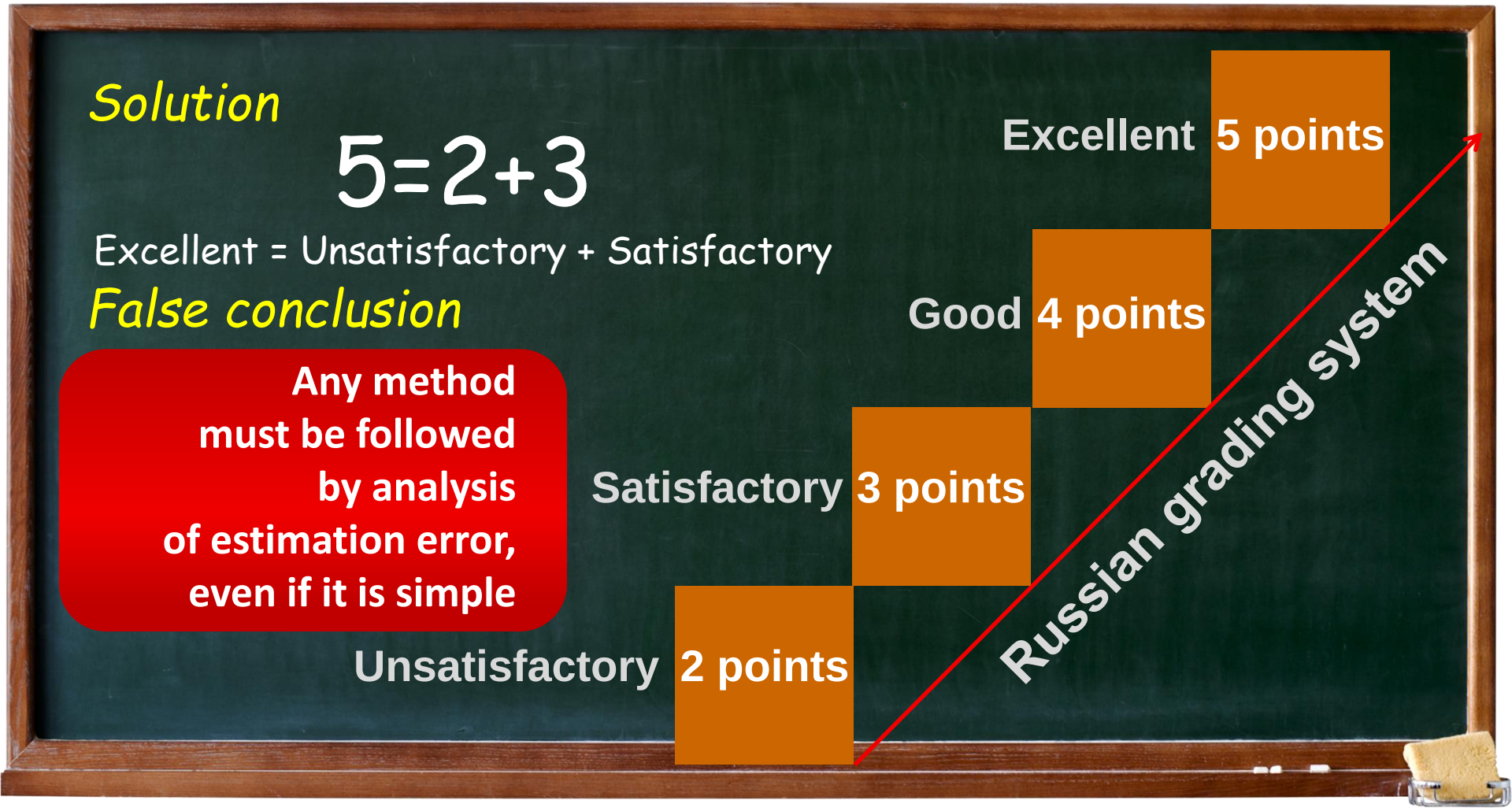
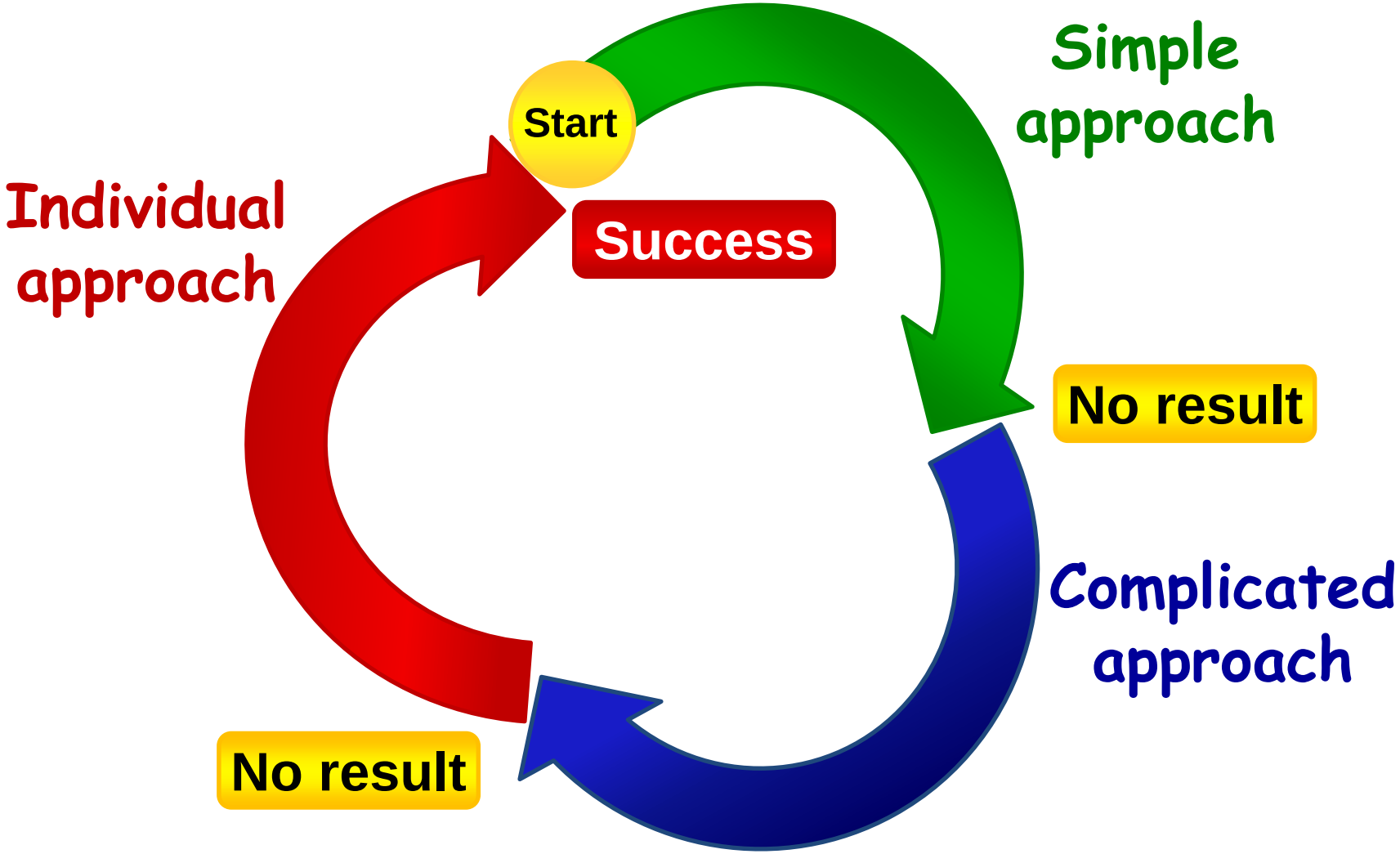
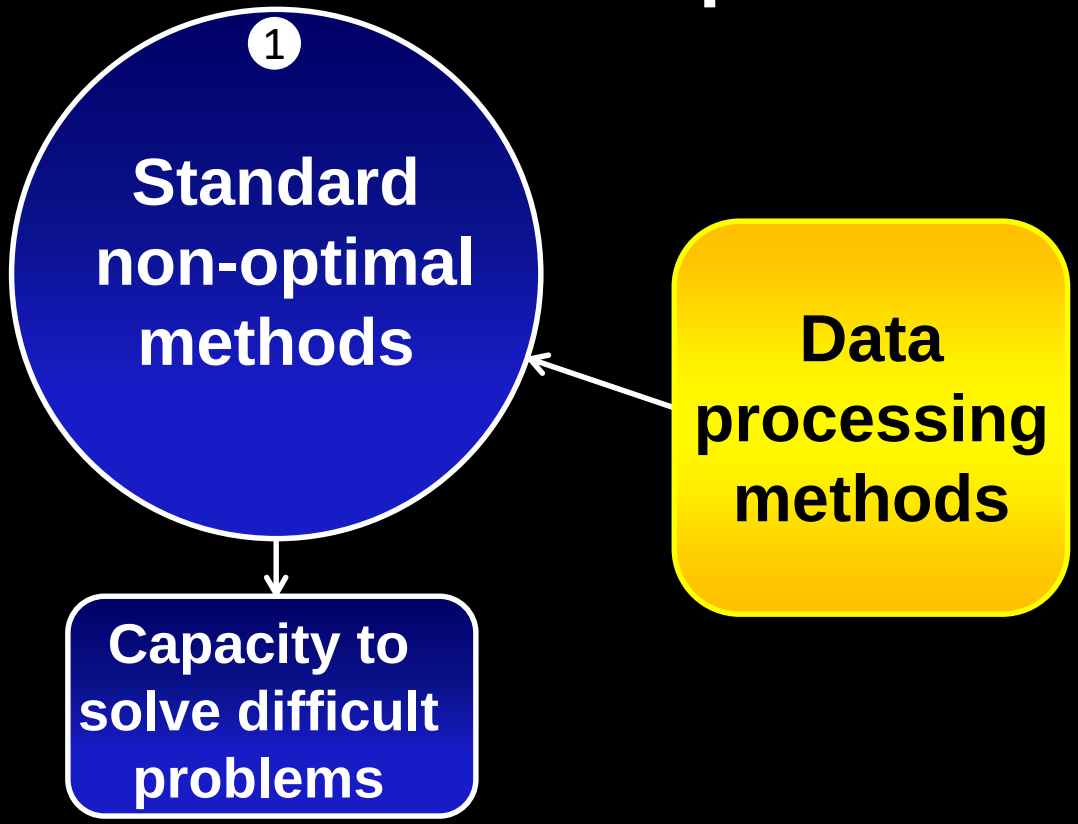


Problem 3: no proper analysis

“Experimental data processing course” is dedicated to the solution of problems mentioned above



Main topics of the course



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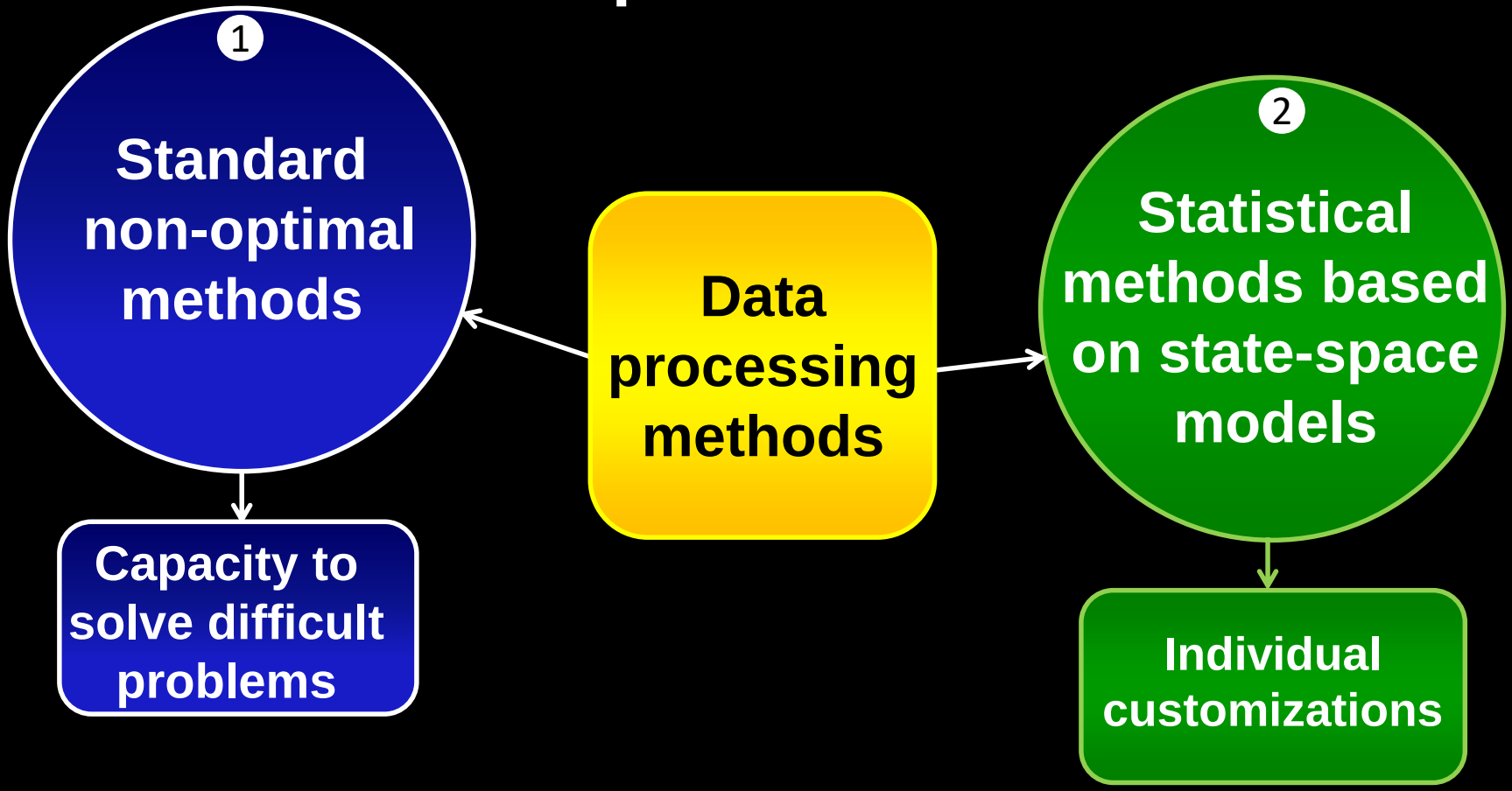

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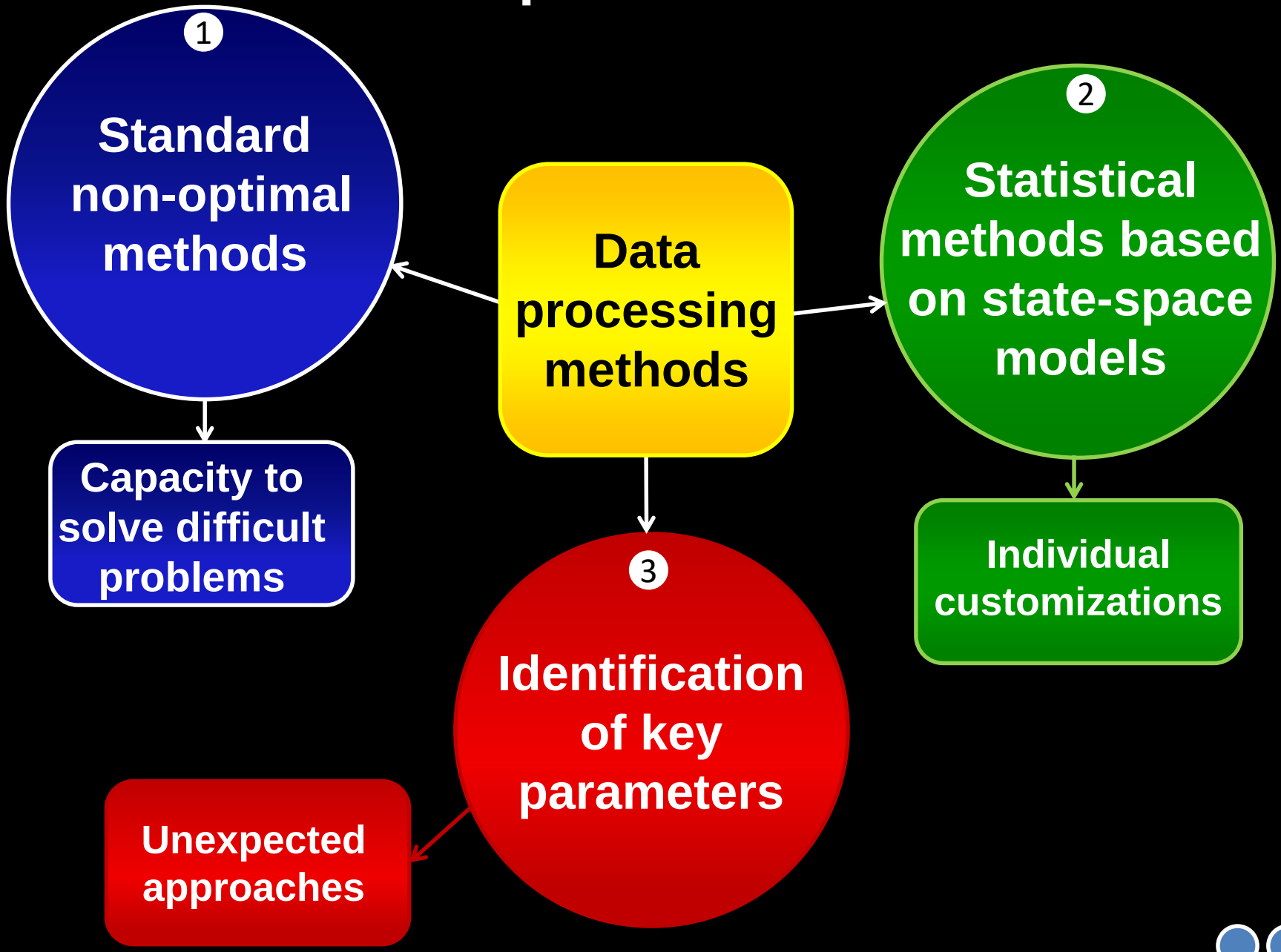
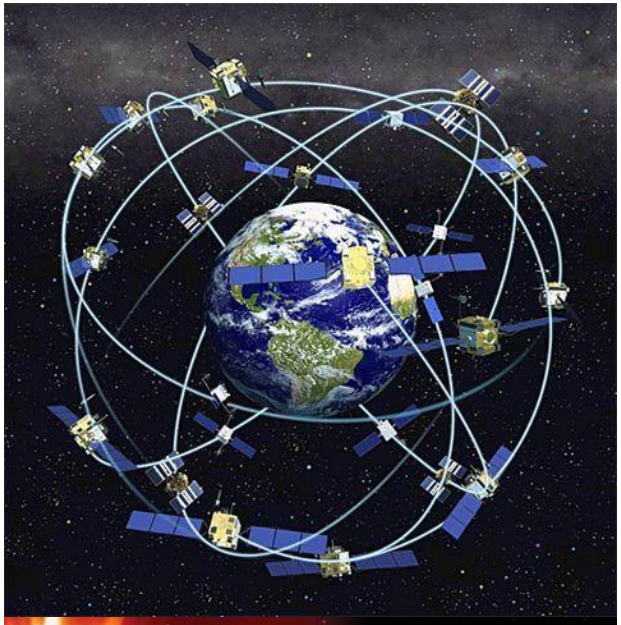




Applications

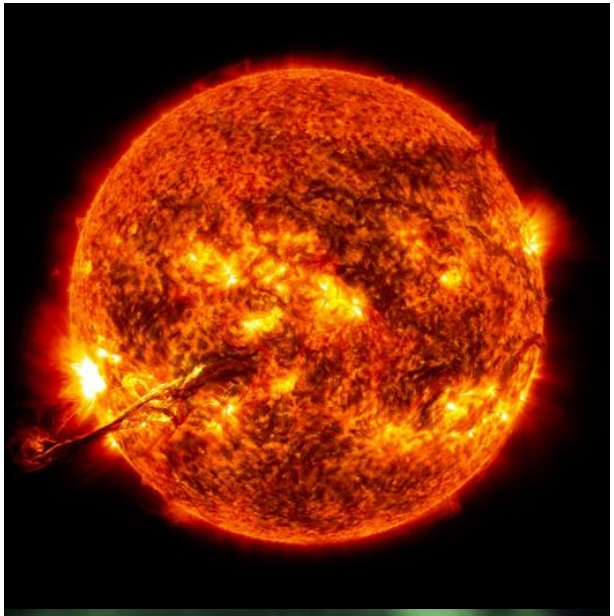
Navigation

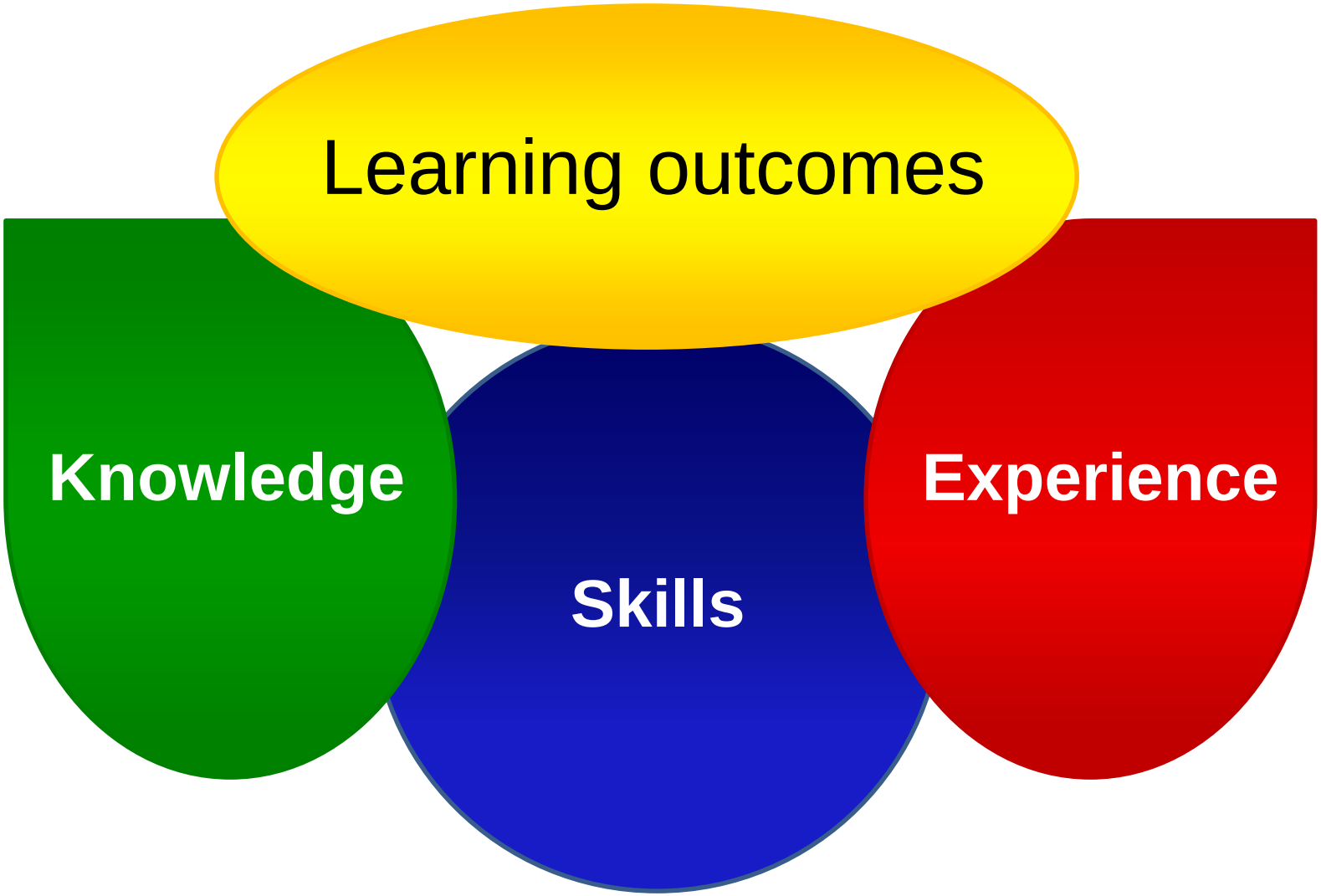
Solar physics

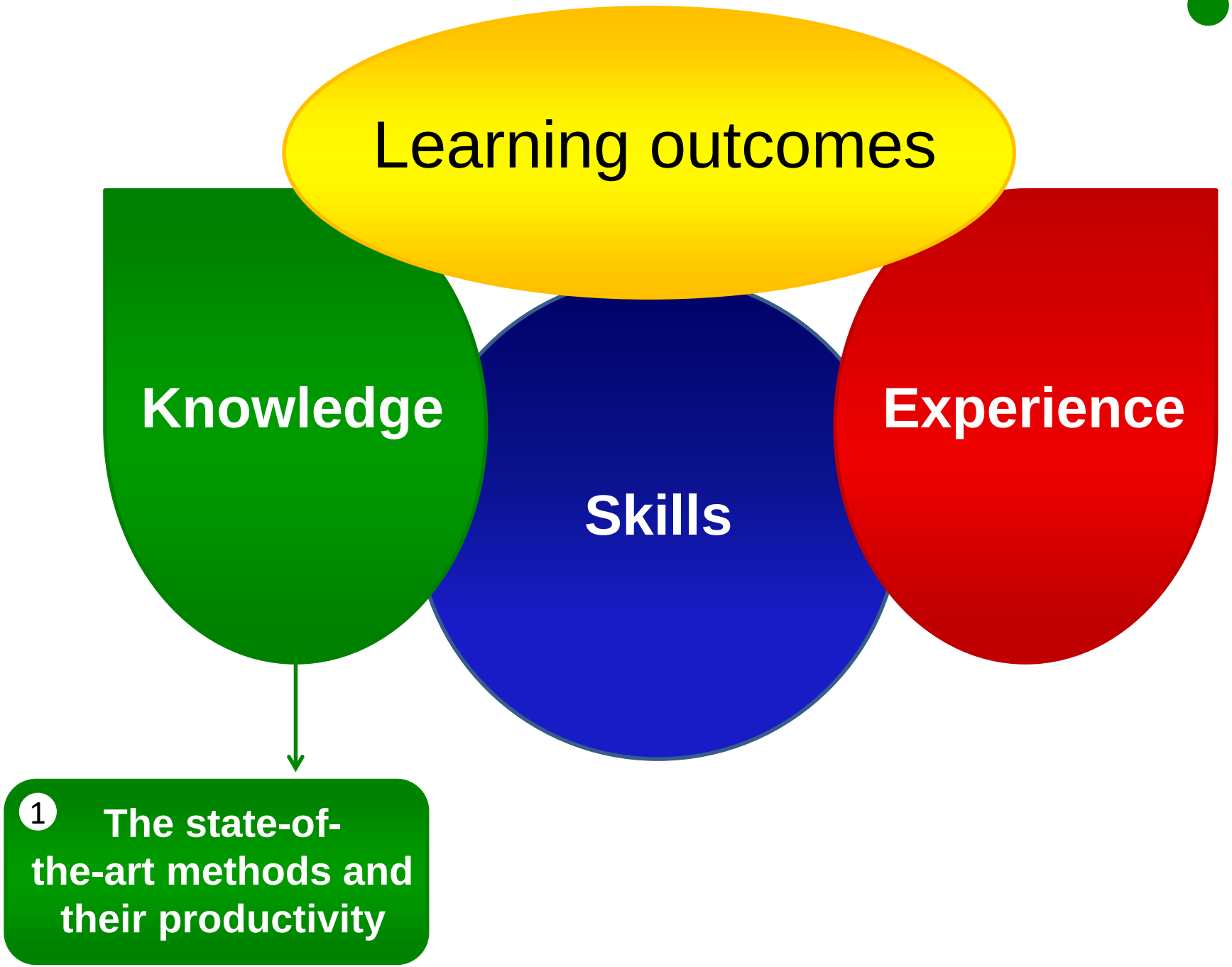
Geomagnetism

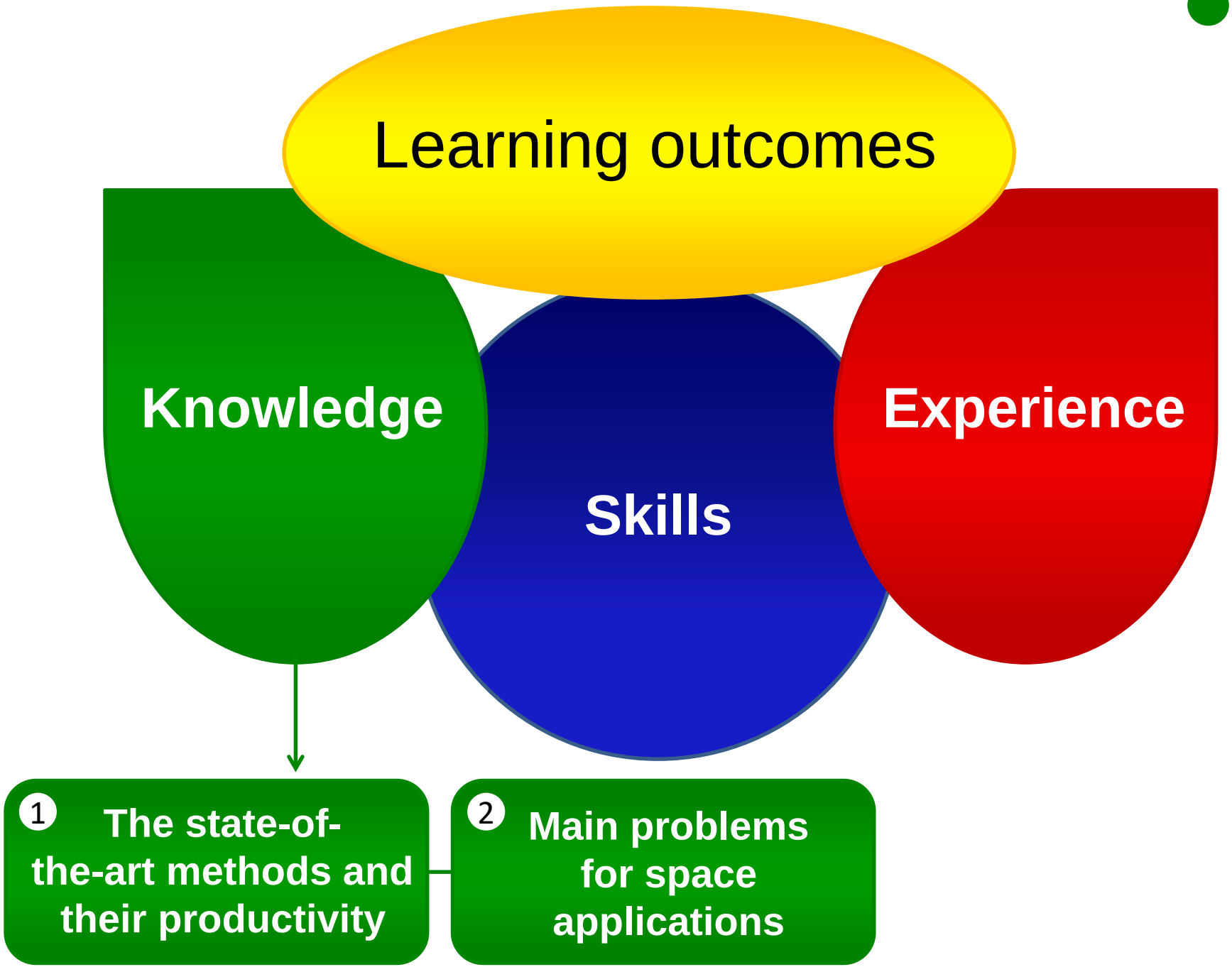
Space weather

Biomedicine

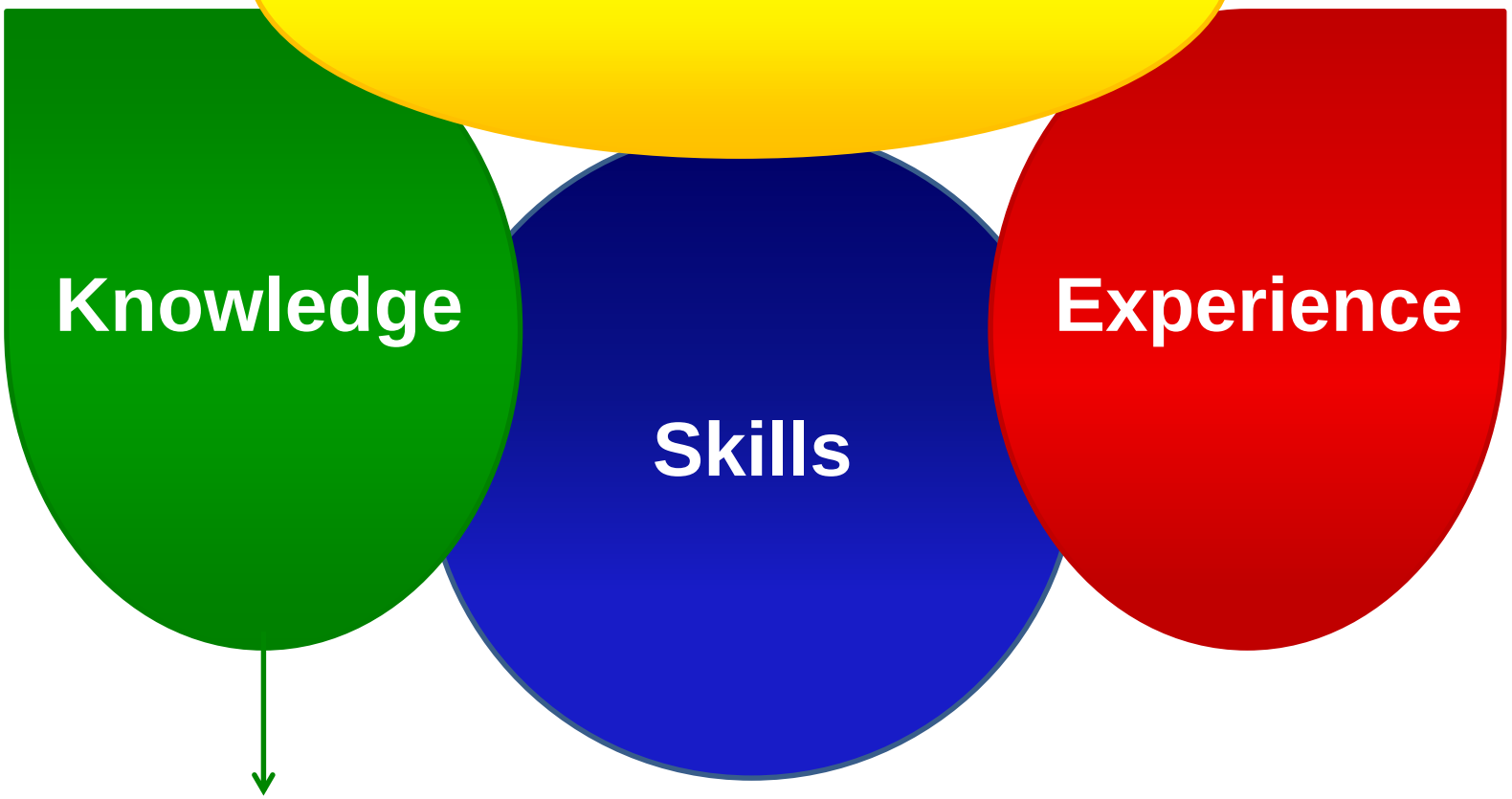



Learning outcomes
Knowledge
Skills
Experience

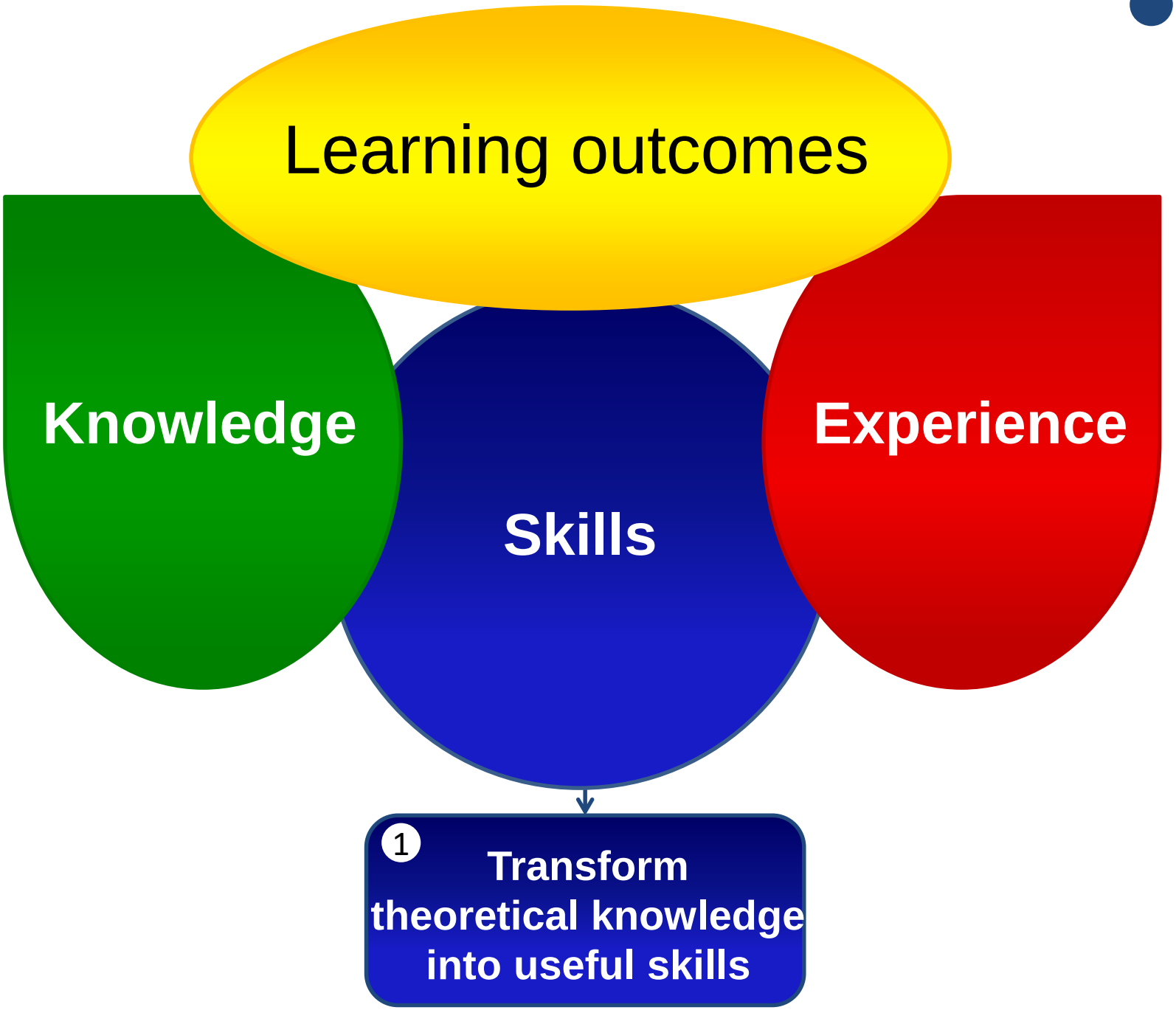

Learning outcomes
Knowledge
Skills
Experience
1
The state-of-the-art methods and their productivity

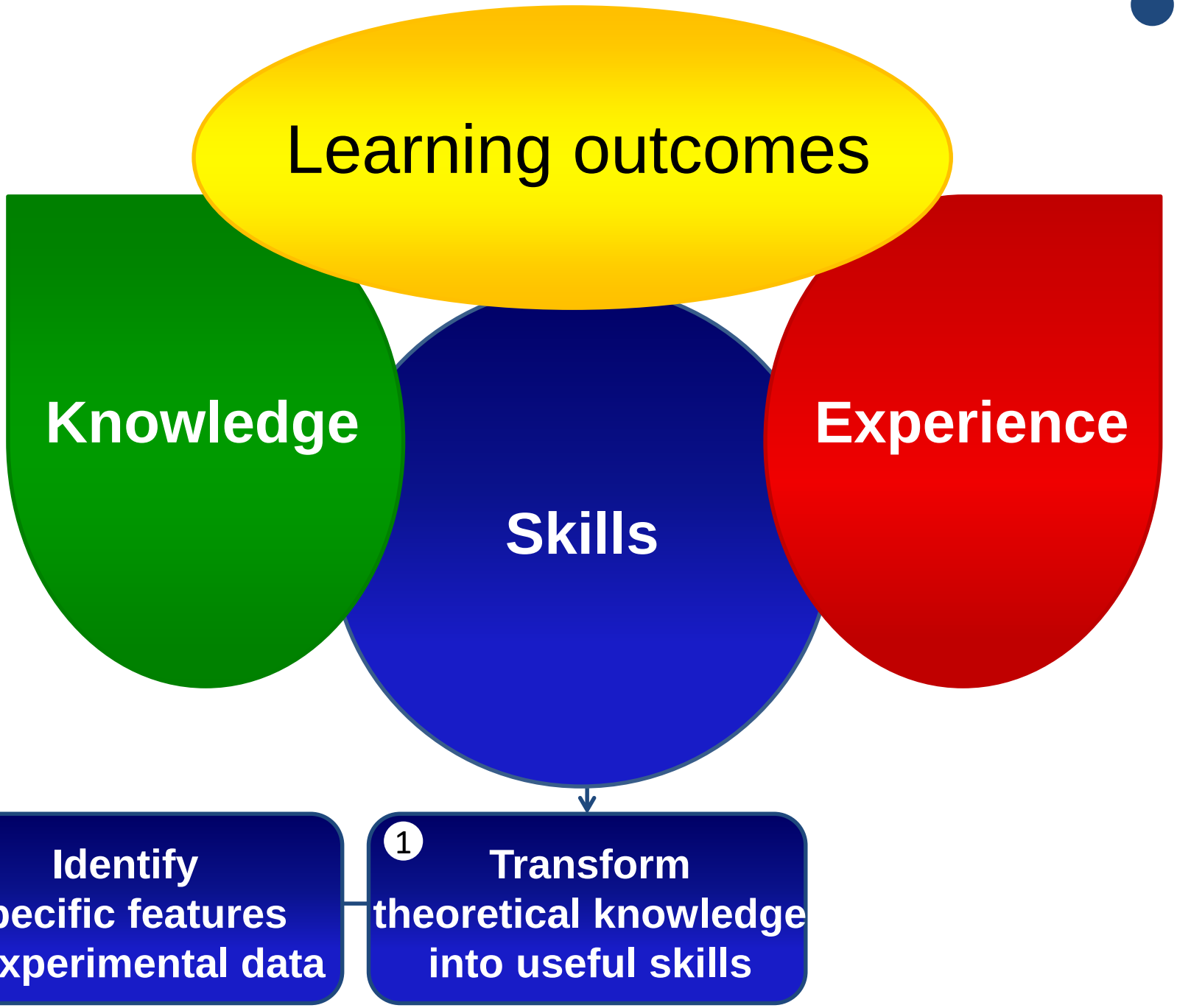

Learning outcomes
Knowledge
Skills
Experience
1 The state-of-the-art methods and their productivity
2 Main problems for space applications

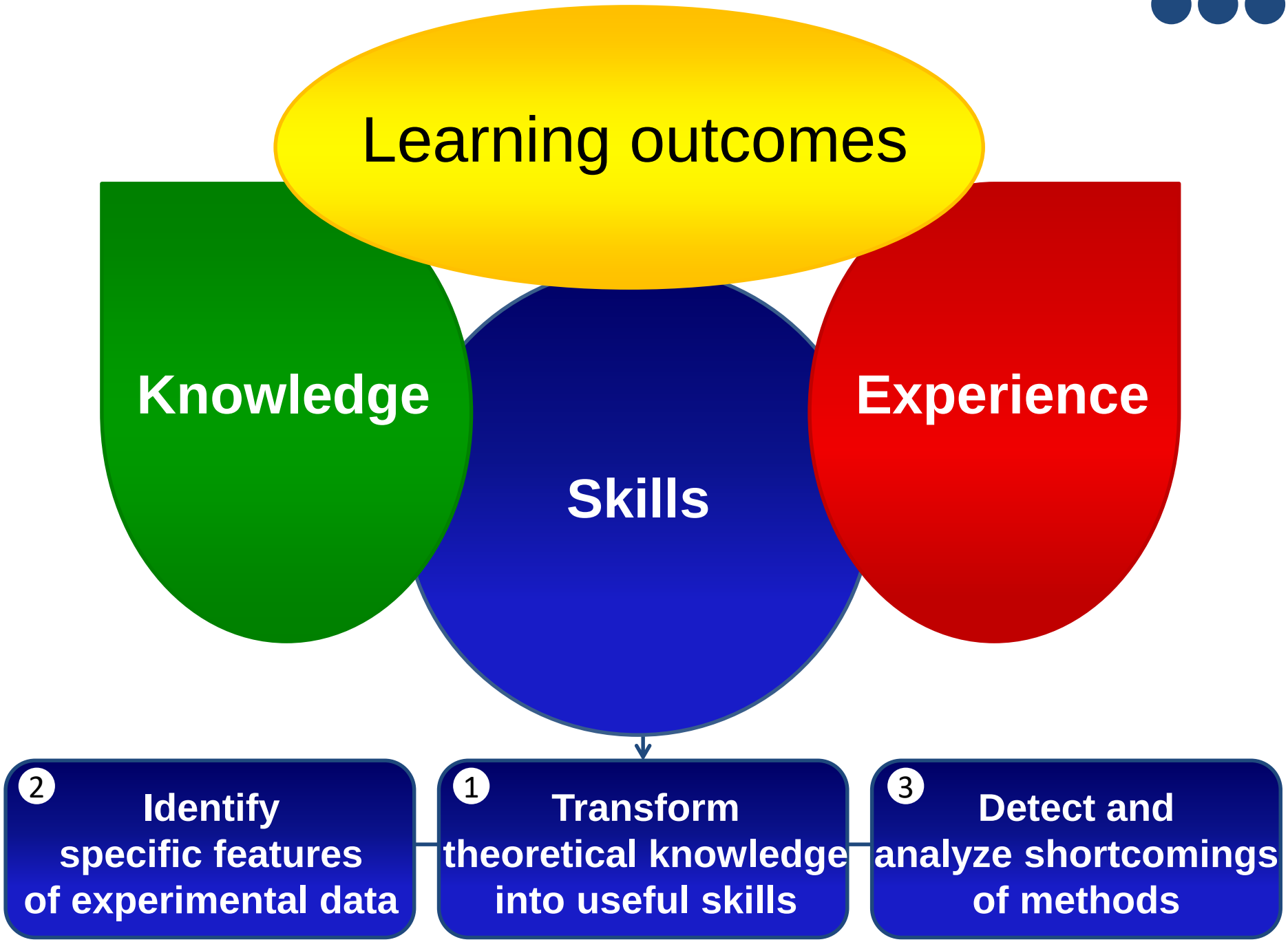
Learning outcomes

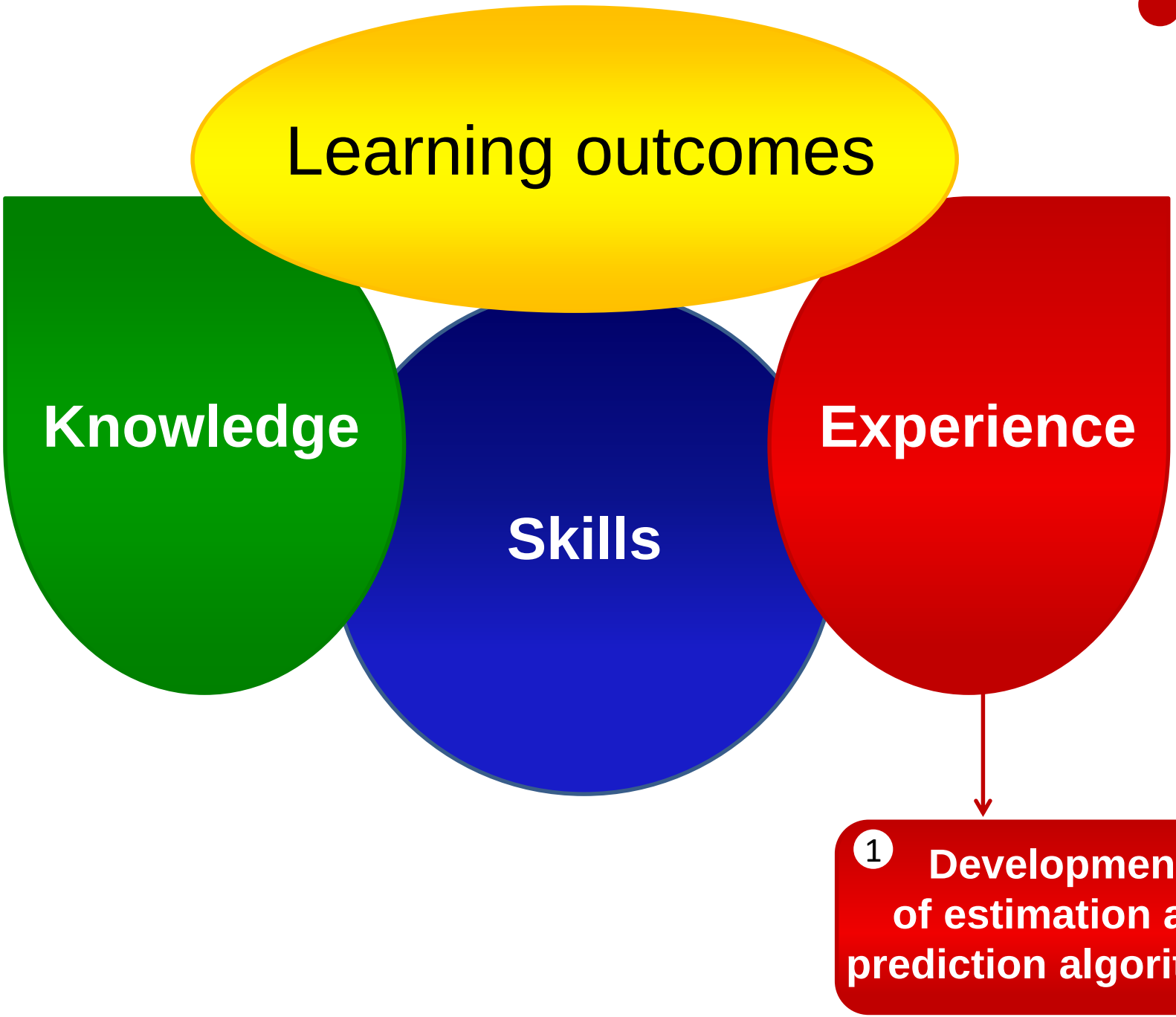


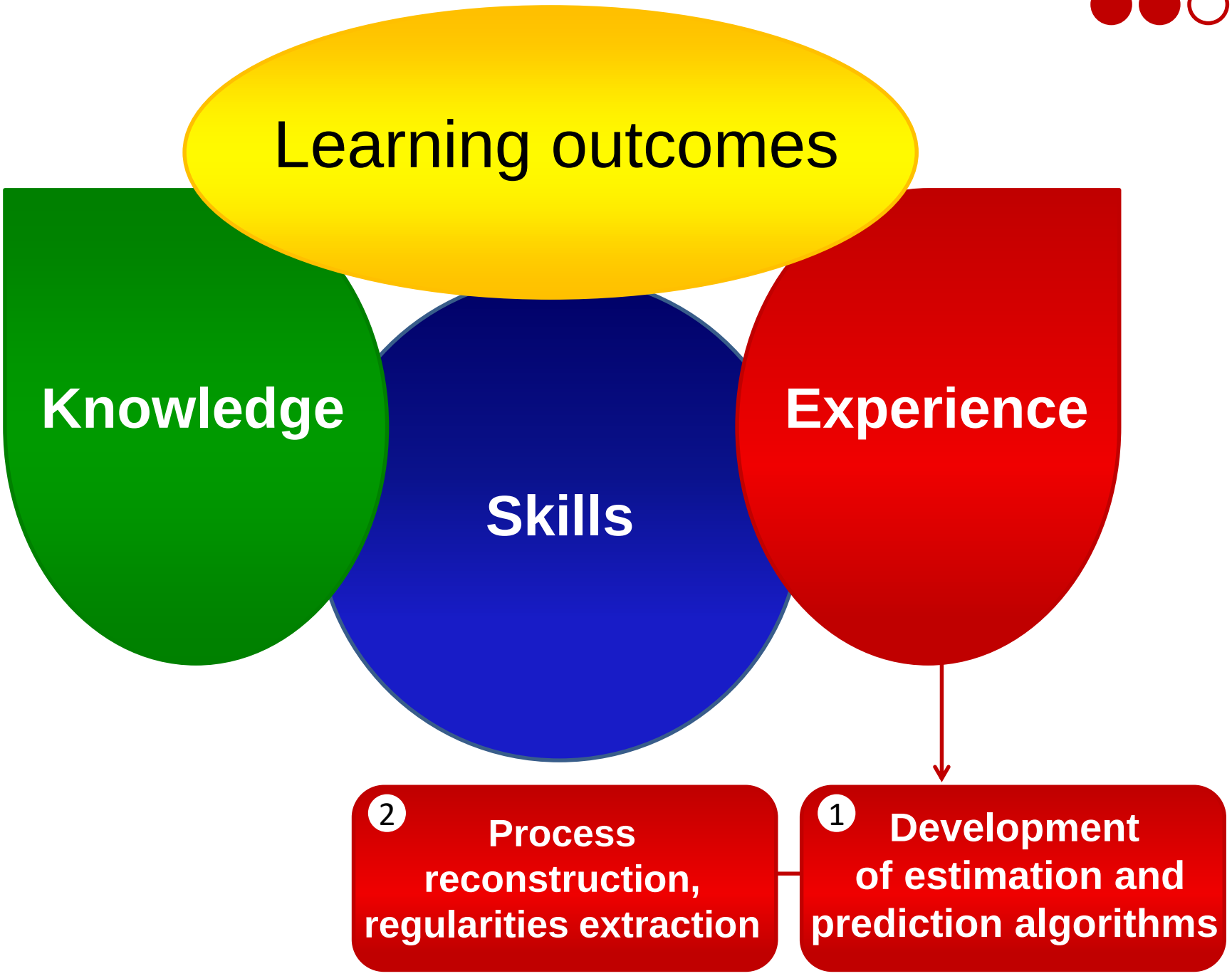
1. The state-of-the-art methods and their productivity
2. Main problems for space applications
3. Estimation of accuracy and reliability

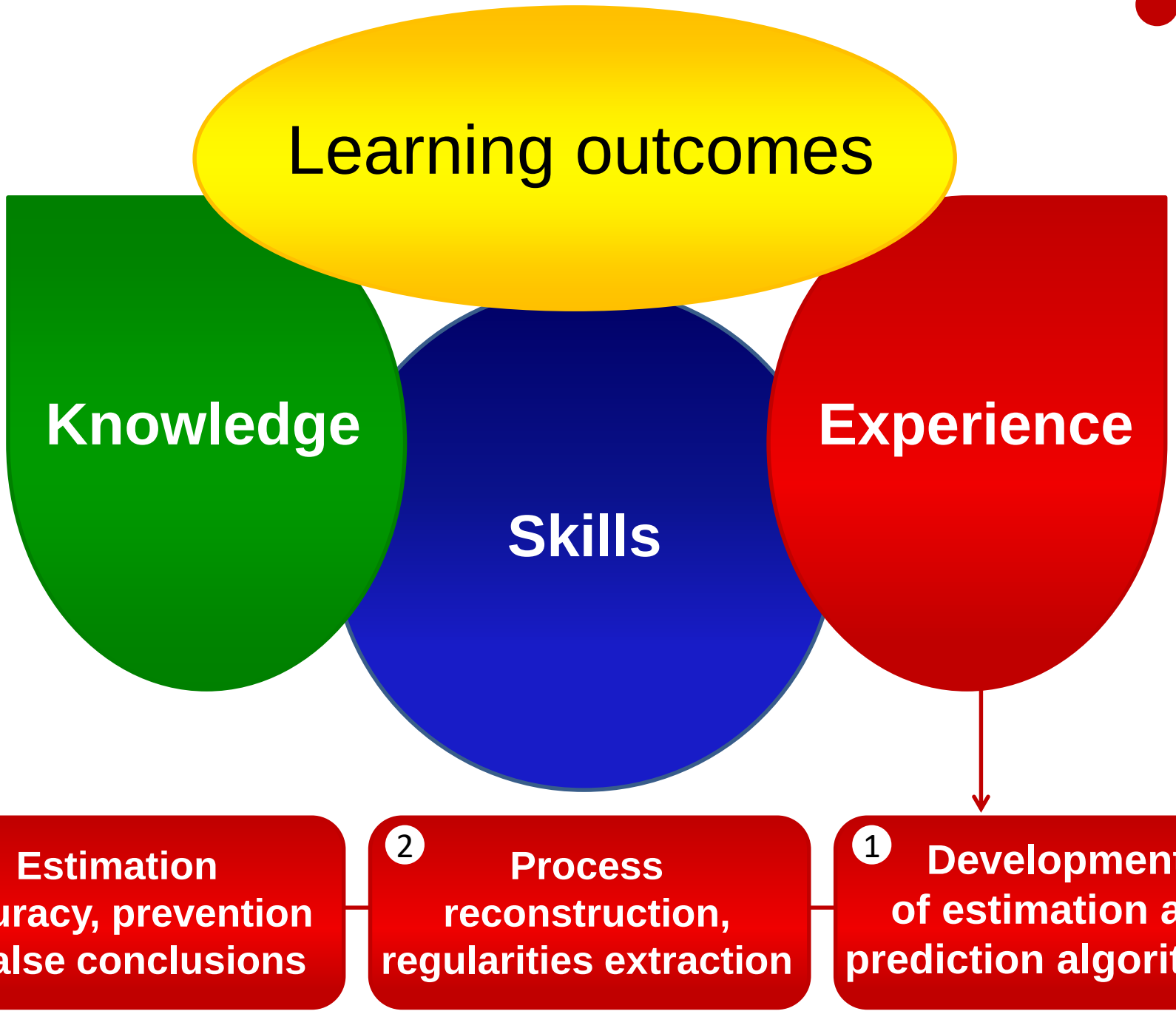

Learning outcomes
Knowledge
Skills
Experience
1
Transform theoretical knowledge into useful skills


Learning outcomes
Knowledge
Skills
Experience
2
Identify
specific features
of experimental data
1
Transform
theoretical knowledge
into useful skills


Learning outcomes
Knowledge
Skills
Experience
2
Identify
specific features
of experimental data
1
Transform
theoretical knowledge
into useful skills
3
Detect and
analyze shortcomings
of methods


Learning outcomes
Knowledge
Skills
Experience
1
Development of estimation and prediction algorithms


Learning outcomes
Knowledge
Skills
Experience
2
Process reconstruction, regularities extraction
1
Development of estimation and prediction algorithms


Learning outcomes
Knowledge
Skills
Experience
3
Estimation accuracy, prevention of false conclusions
2
Process reconstruction, regularities extraction
1
Development of estimation and prediction algorithms

Assignments and laboratory works

Laboratory works in class
Assignments
Final project
Exam

What do you need for laboratory works?

Laptop
Matlab, Python
Inspiration