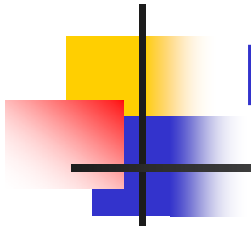


Methodological problems

- Overview:
  - Physics in a complex environment,
  - Measurement problem,
  - Data interpretation problem,
  - Modeling problem.

Physics in a complex environment

- System influenced by a large number of quantities:
  - Often not even all these influences have been identified,
  - Not all influences can be measured.

- Relations between different quantities are non-linear.

- Scientific method (e.g. Popper)
  - (in principle) a hypothesis can be falsified,
  - A hypothesis must be based on objective tests, and
  - The results must be repeatable,

  can be applied only in a rudimentary form.

- Similar problem in all earth science (earthquakes, volcanos)

Measurement problem

- No laboratory measurements under well defined conditions; each parameter can be modified independently, no two must be modified together.

- Measurement in space plasmas:
  - **Noisy data:** instrument influenced by its surroundings,
  - **Incomplete data:**
    - Incomplete time series,
    - 1 point measurements in a temporally and spatially variable moving medium,
    - Unknown/unobserved parameter.
  - **Drift in instrument response.**

- Long term measurements give average parameters – do they have any physical meaning?

Data interpretation problem

- Data interpretation often comparison of different data sets.

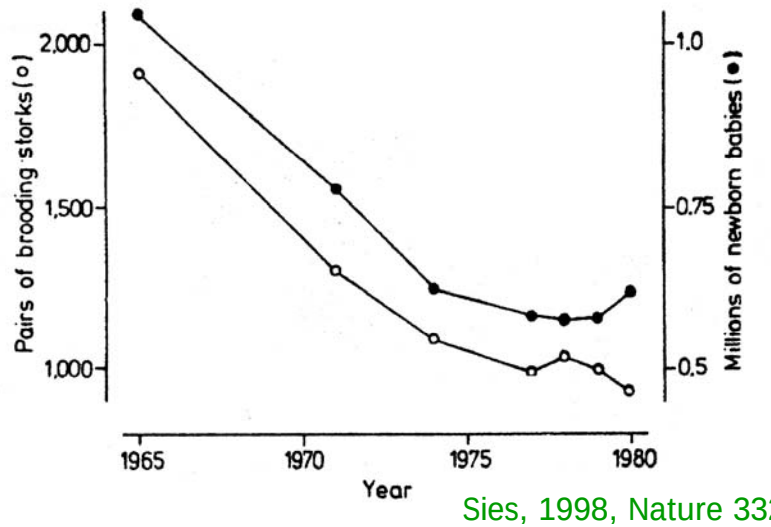
- Correlation (95% significance level as quality criterion):
  - 95% implies error probability at most 5%: 1 out of 20 correlation are accidental.
  - If one correlation id performed, 95% is fine.
  - In 100 correlations, 5 correlations at the level of significance are useless:

The author comments this figure:

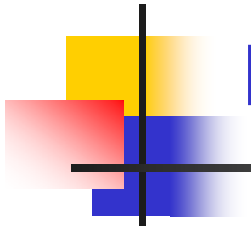
There is concern in West Germany over the falling birth rate. The accompanying graph might suggest a solution that every child known makes sense.

Beck-Bornholt and Dubben (2001) point out:

In addition, it is obvious that storcks do not start in their job before the age of two.



Sies, 1998, Nature 332



Modeling problem

- Complex environment also implies the lack of clear cause-consequence chains.

- Deterministic models:
  - All relevant influences must be known,
  - All relevant influence must be quantified at least approximately,
  - If that not possible parametrization.

- Stochastic modeling:
  - A large number of measurements required to determine probability distributions,
  - Many runs required to get a probability.
  - Stochastic models reflect the underlying nature of complex environments more adequately.