# The challenge of sensor selection, long term-sensor operation and data evaluation in inter- -institutional long term monitoring projects

## - lessons learned in the MOSES project -

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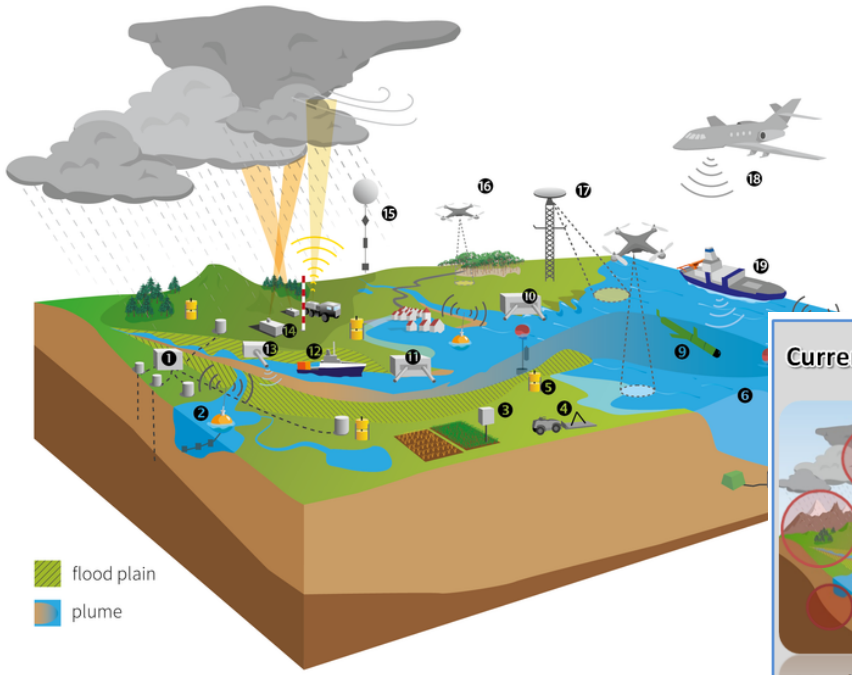
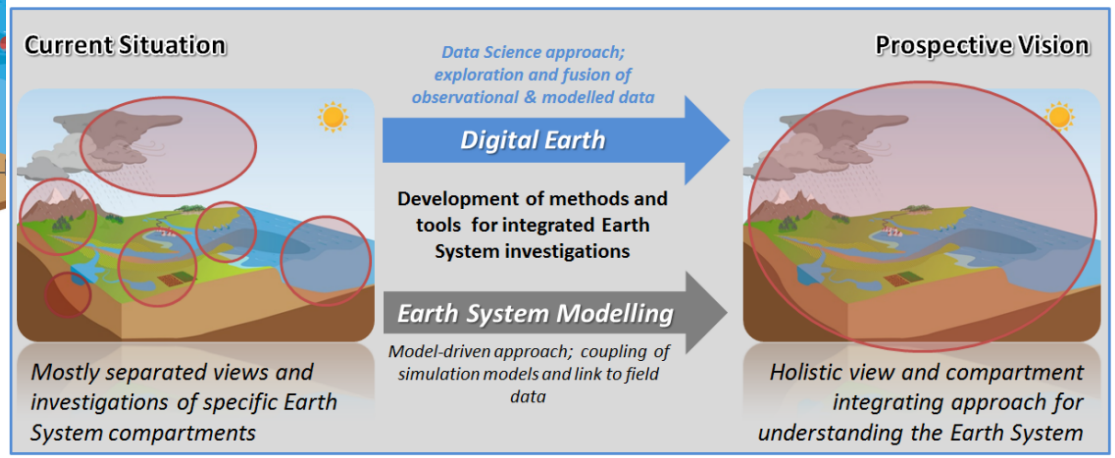
- Today, **Sciences Across Disciplines**...is a „buzz"-term in many national and international science programs.

- The motivation of such “across disciplines” projects is the scientific awareness that functions and processes in most marine and terrestric ecosystems are highly complex and interact across our human definitions of scientific disciplines.

# Cross discipline approaches are “en vogue”

MOSES and Digital Earth are two novel observing „systems“ and „strageties“ of the German Helmholtz Association specifically designed to investigate the interactions of short-term events and long-term trends **across Earth compartments**.



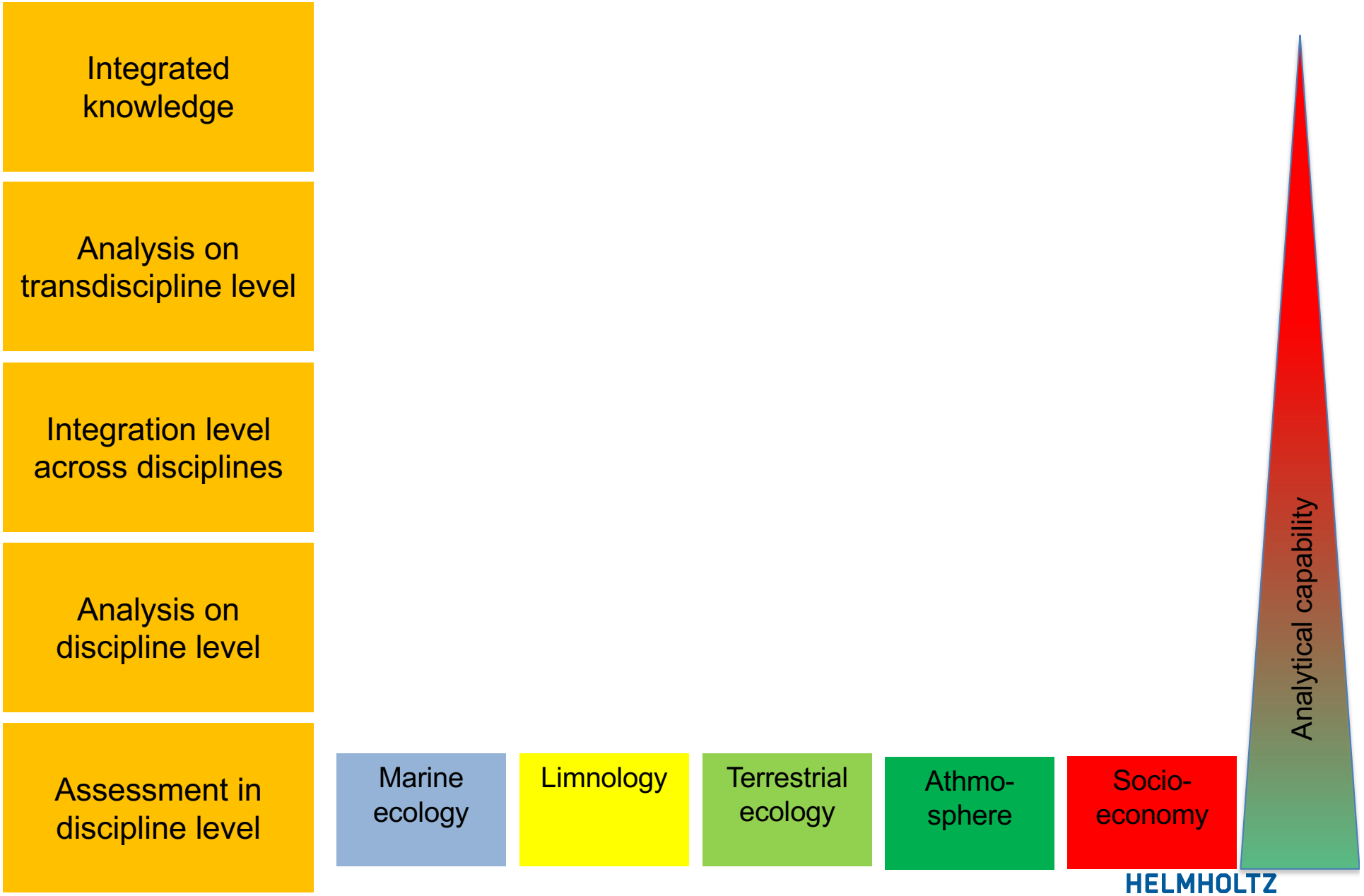
# Digital Earth / MOSES



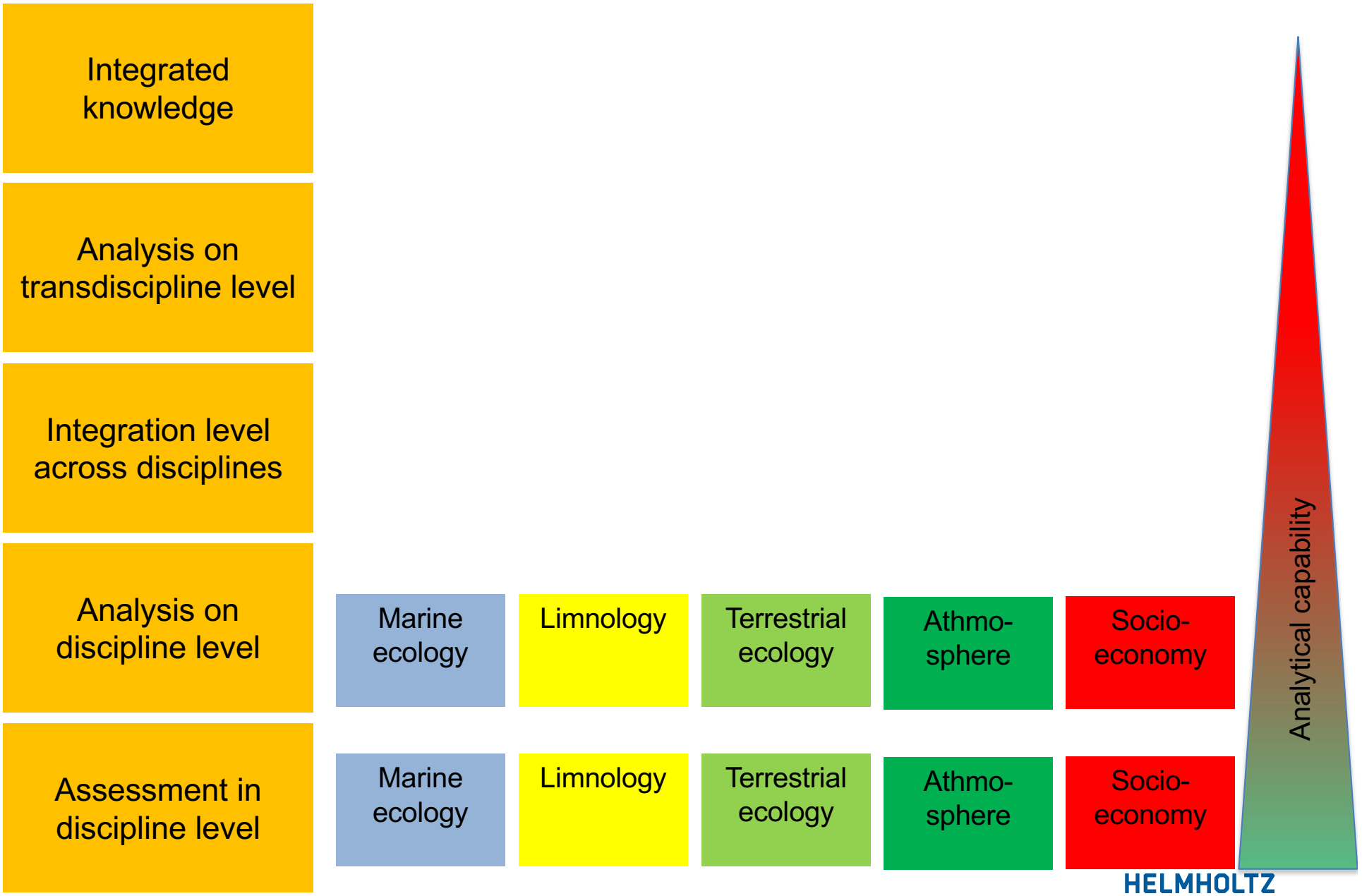
The term “across disciplines” itself however implies that we go beyond our scientific knowledge…. and it is not always very clear…

how to do this?

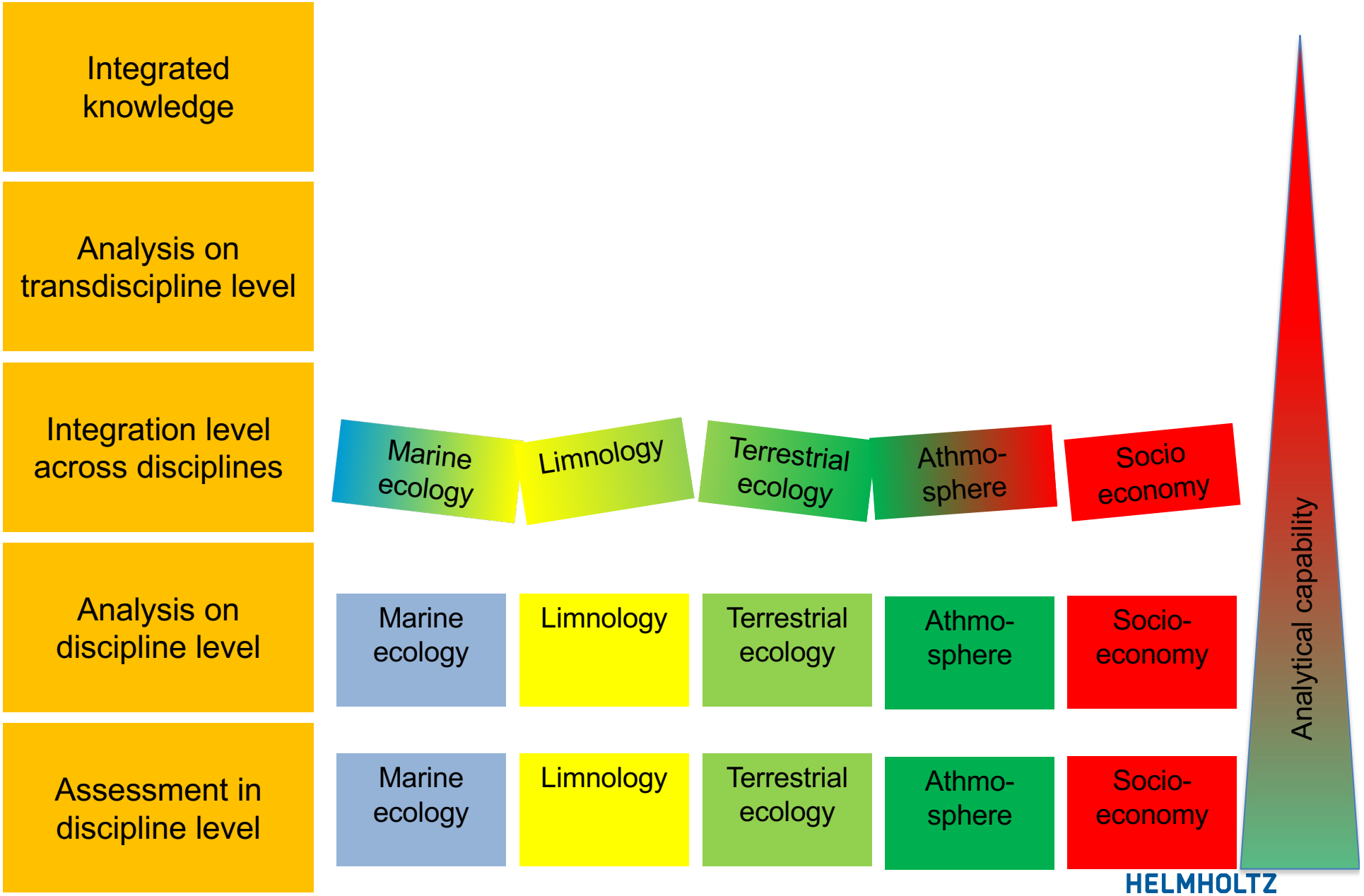
# Ideal workflow



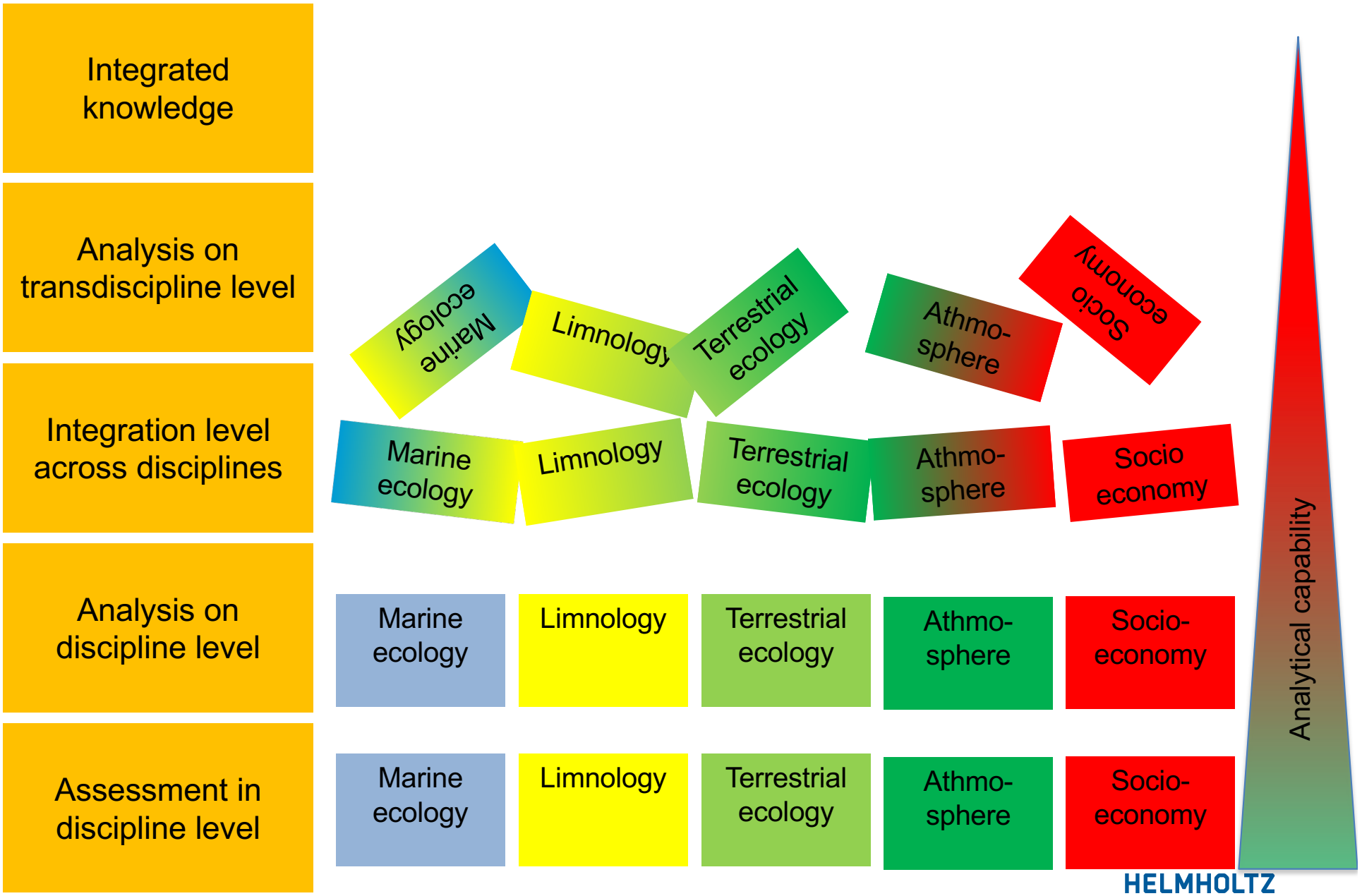
# Ideal workflow



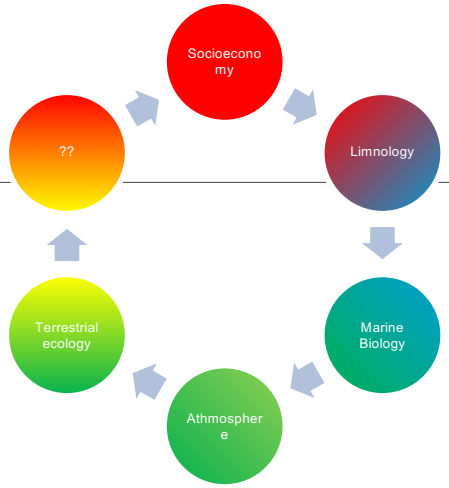
# Ideal workflow



# Ideal workflow

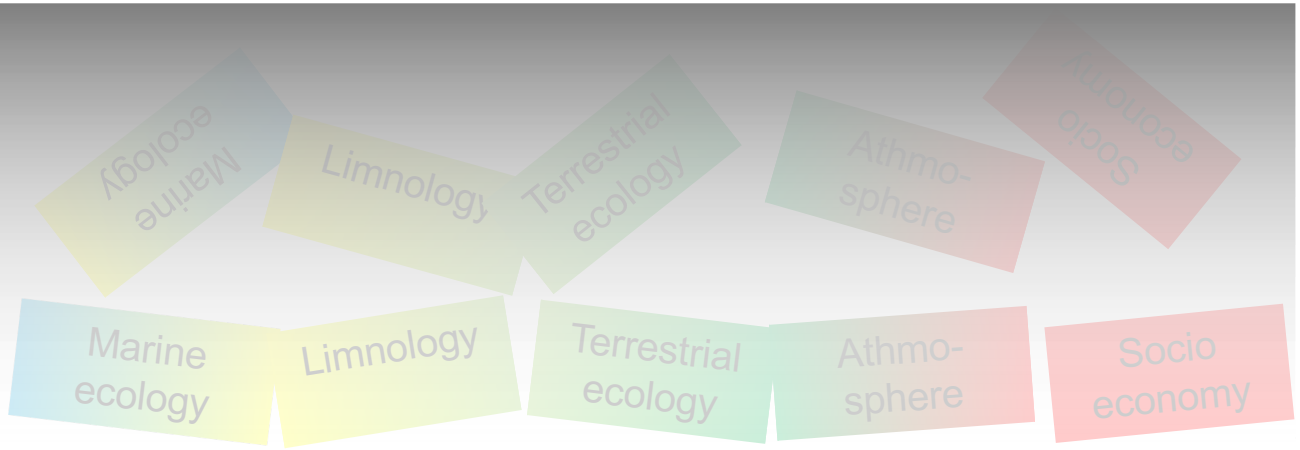


# Ideal workflow




Integrated knowledge

Analysis on transdiscipline level



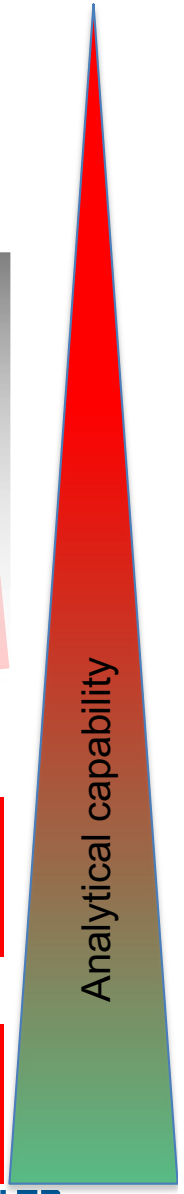

Integration level across disciplines

Analysis on discipline level

| Marine ecology | Limnology | Terrestrial ecology | Athmo-sphere | Socio-economy |
|---|---|---|---|---|

Assessment in discipline level

| Marine ecology | Limnology | Terrestrial ecology | Athmo-sphere | Socio-economy |
|---|---|---|---|---|

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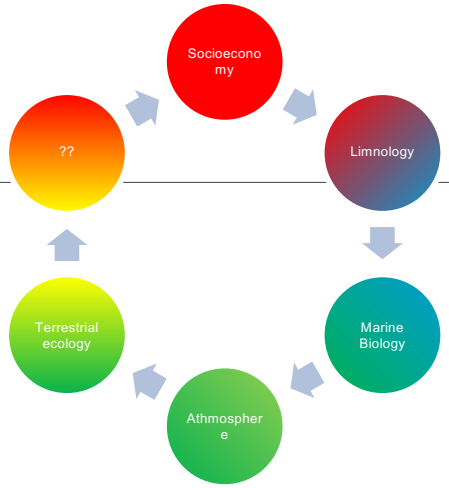
# Ideal workflow




Integrated knowledge

Analysis on transdiscipline level

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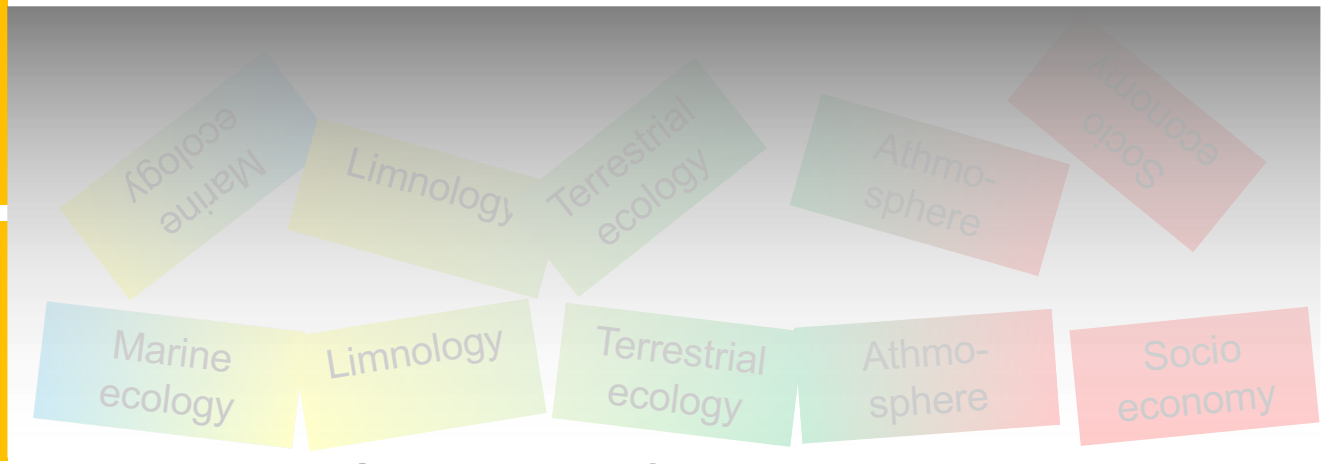


Our comfort zone

| Marine ecology | Limnology | Terrestrial ecology | Athmo-sphere | Socio-economy |
|---|---|---|---|---|
| Marine ecology | Limnology | Terrestrial ecology | Athmo-sphere | Socio-economy |

Analytical capability

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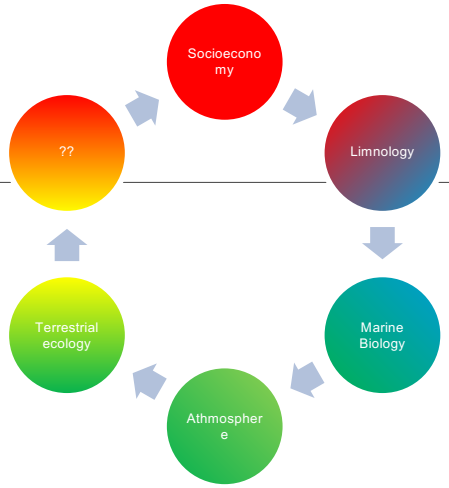
# Ideal workflow




Integrated knowledge

Analysis on transdiscipline level

Integration level across disciplines

Analysis on discipline level

Assessment in discipline level

Our comfort zone

| | | | | |
|---|---|---|---|---|
| Marine ecology | Limnology | Terrestrial ecology | Athmo-sphere | Socio-economy |
| Marine ecology | Limnology | Terrestrial ecology | Athmo-sphere | Socio-economy |

Analytical capability

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# Cross-cutting problems

- Independent of the scientific discipline, the same problems emerge in almost any discussion.
  - Data processing with respect to data quality.
  - Stable data assessment in (near-realtime).
  - Integration, aggregation & analysis of simple and complex data.

## Data processing with respect to data quality….

**In July 2018 and November 2019, two joint workshops of the AWI, HZG, GEOMAR, UFZ and GFZ were orgnized.**

**The main goals of these workshops were:**

- to test the comparability of different sensors measuring the same parameters (e.g., water temperature, oxygen, etc.)
- to test the MOSES data flows from the sensors to the database with respect to an inter-institutional availability of the obtained sensor data,
- to test new MOSES sensors under controlled conditions and to development a MOSES concept (Standard Operational Procedures - SOPs) for the intercalibration of sensors before joint measurement campaigns.

# Data processing with respect to data quality….

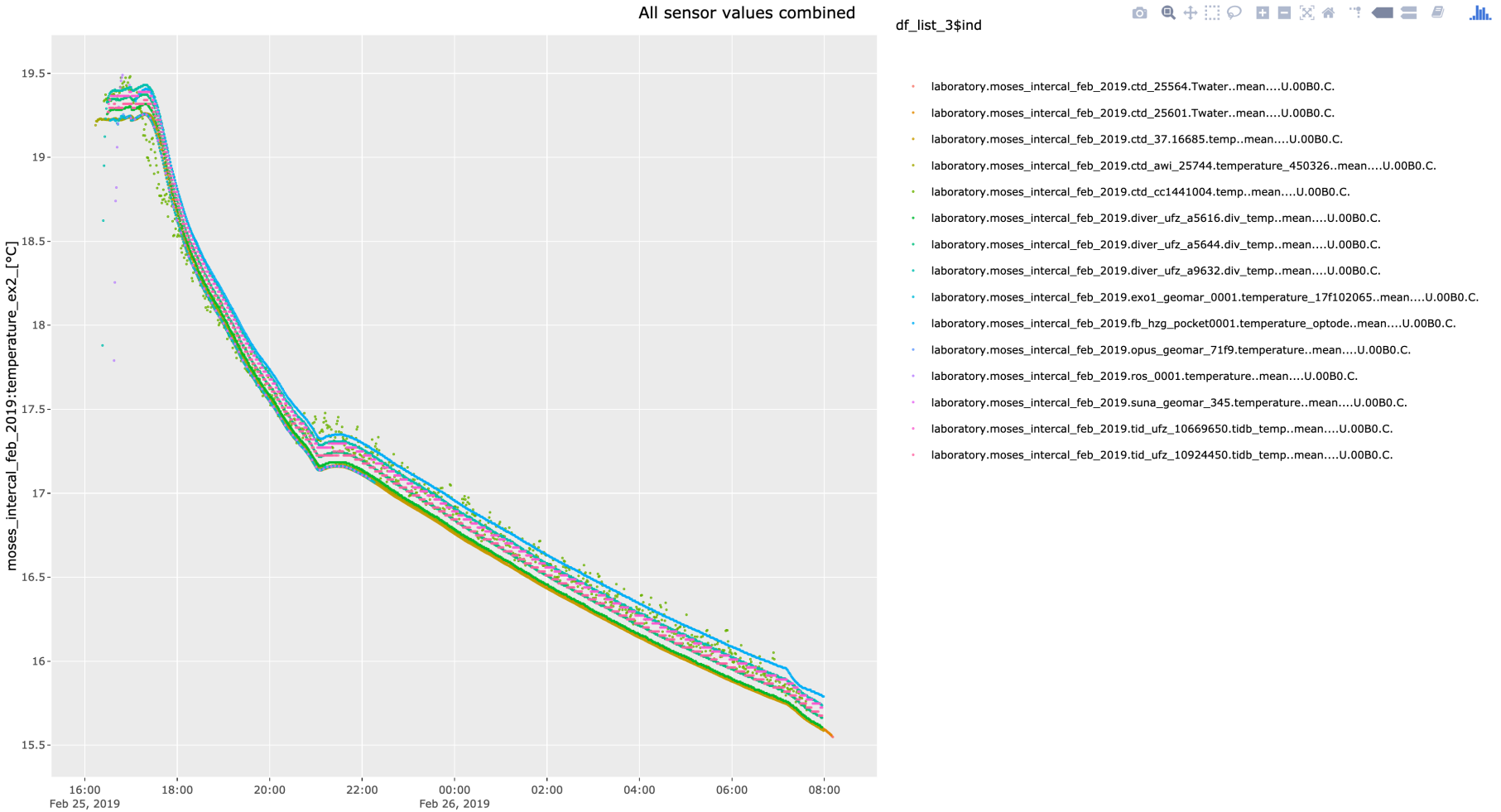
**A total of 15 sensors with different parameters were tested in a simultaneous approach.**

| | |
|---|---|
| AWI | laboratory.moses_intercal_feb_2019.ctd_25564.Twater..mean....U.00B0.C. |
| AWI | laboratory.moses_intercal_feb_2019.ctd_25601.Twater..mean....U.00B0.C. |
| AWI | laboratory.moses_intercal_feb_2019.ctd_37.16685.temp..mean....U.00B0.C. |
| AWI | laboratory.moses_intercal_feb_2019.ctd_awi_25744.temperature_450326..mean....U.00B0.C. |
| HZG | laboratory.moses_intercal_feb_2019.ctd_cc1441004.temp..mean....U.00B0.C. |
| UFZ | laboratory.moses_intercal_feb_2019.diver_ufz_a5616.div_temp..mean....U.00B0.C. |
| UFZ | laboratory.moses_intercal_feb_2019.diver_ufz_a5644.div_temp..mean....U.00B0.C. |
| UFZ | laboratory.moses_intercal_feb_2019.diver_ufz_a9632.div_temp..mean....U.00B0.C. |
| GEOMAR | laboratory.moses_intercal_feb_2019.exo1_geomar_0001.temperature_17f102065..mean....U.00B0.C. |
| HZG | laboratory.moses_intercal_feb_2019.fb_hzg_pocket0001.temperature_optode..mean....U.00B0.C. |
| GEOMAR | laboratory.moses_intercal_feb_2019.opus_geomar_71f9.temperature..mean....U.00B0.C. |
| ROSTOCK | laboratory.moses_intercal_feb_2019.ros_0001.temperature..mean....U.00B0.C. |
| GEOMAR | laboratory.moses_intercal_feb_2019.suna_geomar_345.temperature..mean....U.00B0.C. |
| UFZ | laboratory.moses_intercal_feb_2019.tid_ufz_10669650.tidb_temp..mean....U.00B0.C. |
| UFZ | laboratory.moses_intercal_feb_2019.tid_ufz_10924450.tidb_temp..mean....U.00B0.C. |

n = 15

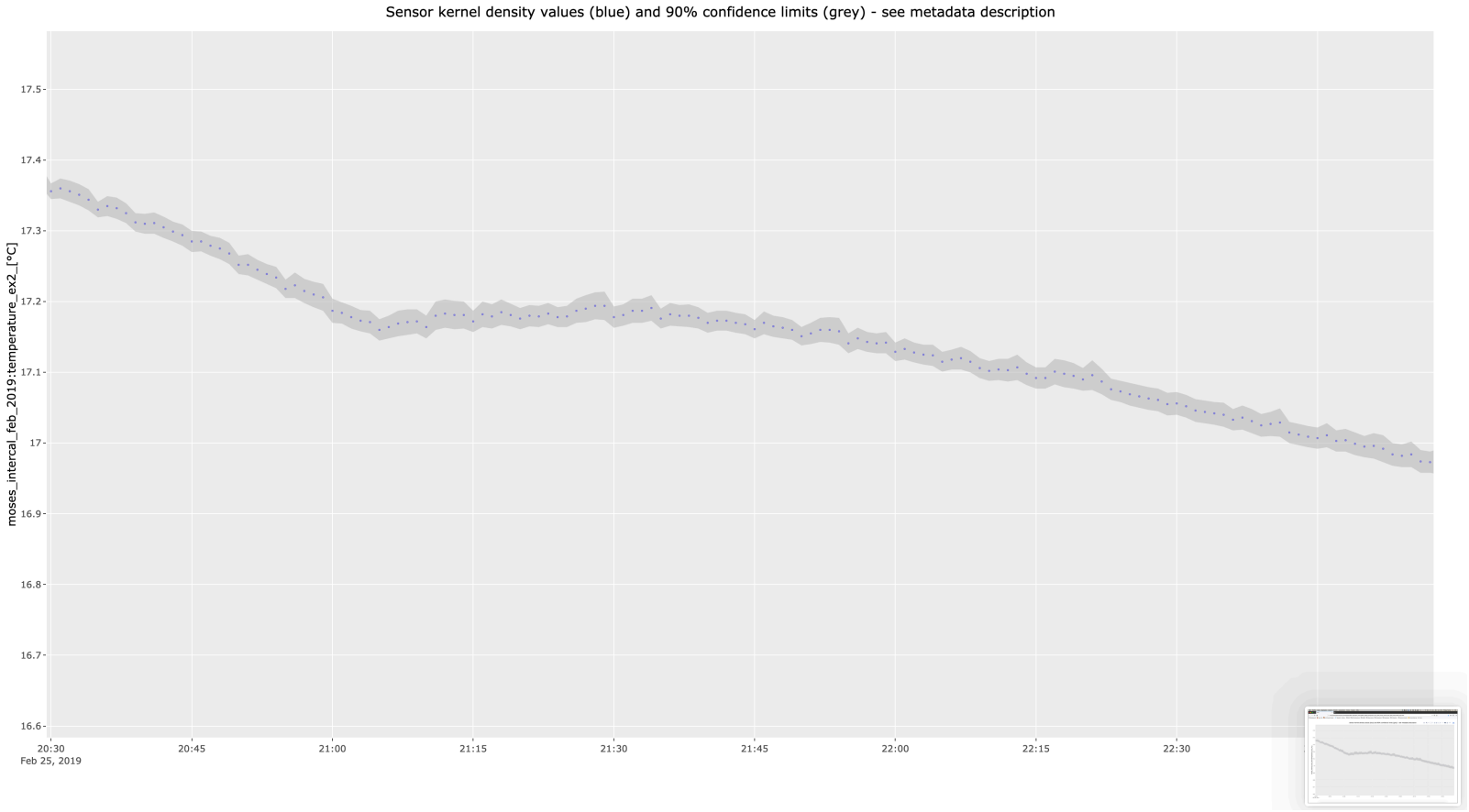
# Data processing with respect to data quality….

## Focussing on temperature:



# Data processing with respect to data quality….

Intelligent data compilation by statistical procedures like kernel density estimates and / or auxiliary sensor use allow for modelling / predicting missing data, sensor drift **AND most important Accuracy and Precision information.**



# Data processing with respect to sensor plausability…

## Applying ARGO plausability checks:

| par_id | All checks passed | Failed at quality check level 11 (Gradient test) | Failed at quality check level 7 (Regional range test) | Total |
|---|---|---|---|---|
| laboratory.moses_intercal_feb_2019.ctd_25564.Twater..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.ctd_25601.Twater..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.ctd_37.16685.temp..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.ctd_awi_25744.temperature_450326..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.ctd_cc1441004.temp..mean….U.00B0.C. | 99.78190 | 0.1090513 | 0.1090513 | 100 |
| laboratory.moses_intercal_feb_2019.diver_ufz_a5616.div_temp..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.diver_ufz_a5644.div_temp..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.diver_ufz_a9632.div_temp..mean….U.00B0.C. | 99.78678 | 0.1066098 | 0.1066098 | 100 |
| laboratory.moses_intercal_feb_2019.exo1_geomar_0001.temperature_17f102065..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.fb_hzg_pocket0001.temperature_optode..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.opus_geomar_71f9.temperature..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.ros_0001.temperature..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.suna_geomar_345.temperature..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.tid_ufz_10669650.tidb_temp..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| laboratory.moses_intercal_feb_2019.tid_ufz_10924450.tidb_temp..mean….U.00B0.C. | 100.00000 | 0.0000000 | 0.0000000 | 100 |
| Total | 99.96106 | 0.0194723 | 0.0194723 | 100 |

The real data

# Data processing with respect to sensor plausability…

## Additional statistical procedures…

laboratory:moses_intercal_feb_2019

| Sensor URN | Adjusted R-squared of regression between measures value - expected value | Statistical significance that measured and expedcted variables are correlated | Slope of regression of measured values against expected value | Statistical significance of difference in slope of measured values and expected values | Median accuracy (difference between measured value and expected value = median residuen) | Mean accuracy (difference between measured value and expected value = mean residuals) | Statistical significance of accuracy (mean difference between measured values and expected value) | Precicion (+/- spread around measured value (95pct confidence limit)) | Coefficient of variation (pct) of precicion to accuracy |
|---|---|---|---|---|---|---|---|---|---|
| moses_intercal_feb_2019:ctd_awi_25744:temperature_450326 | 0.9996052 | *** | 1.0053909 | *** | -0.0009073 | -0.0091557 | *** | 0.0015644 | 17.0867988 |
| moses_intercal_feb_2019:diver_ufz_a9632:div_temp | 0.9976658 | *** | 1.0080419 | *** | 0.0016729 | 0.1140364 | *** | 0.0032114 | 2.8161484 |
| moses_intercal_feb_2019:ctd_cc1441004:temp | 0.9926212 | *** | 0.9562691 | *** | -0.0020758 | 0.0767775 | *** | 0.0061902 | 8.0624610 |
| moses_intercal_feb_2019:diver_ufz_a5616:div_temp | 0.9999524 | *** | 1.0165609 | *** | 0.0005371 | -0.0082756 | *** | 0.0011634 | 14.0582718 |
| moses_intercal_feb_2019:diver_ufz_a5644:div_temp | 0.9999473 | *** | 1.0169230 | *** | 0.0003625 | 0.0469419 | *** | 0.0011941 | 2.5437916 |
| moses_intercal_feb_2019:tid_ufz_10924450:tidb_temp | 0.9999064 | *** | 1.0038544 | *** | -0.0003160 | 0.0452123 | *** | 0.0006742 | 1.4912897 |
| moses_intercal_feb_2019:ctd_25564:Twater | 0.9999425 | *** | 1.0028887 | *** | -0.0006834 | -0.0244798 | *** | 0.0005239 | 2.1399671 |
| moses_intercal_feb_2019:ctd_25601:Twater | 0.9999401 | *** | 1.0032472 | *** | -0.0006723 | -0.0244912 | *** | 0.0005417 | 2.2118492 |
| moses_intercal_feb_2019:tid_ufz_10669650:tidb_temp | 0.9999089 | *** | 1.0067264 | *** | -0.0000784 | 0.0991877 | *** | 0.0007551 | 0.7612485 |
| moses_intercal_feb_2019:exo1_geomar_0001:temperature_17f102065 | 0.9997965 | *** | 0.9938749 | *** | -0.0002065 | -0.0323417 | *** | 0.0012814 | 3.9620727 |
| moses_intercal_feb_2019:ros_0001:temperature | 0.0524740 | ns | -69.8181698 | *** | -0.0848775 | -0.1951538 | ns | 0.3217956 | 164.8933121 |
| moses_intercal_feb_2019:opus_geomar_71f9:temperature | 0.9998785 | *** | 0.9963838 | * | 0.0008304 | -0.0207693 | *** | 0.0021471 | 10.3380232 |
| moses_intercal_feb_2019:ctd_37:16685 | 0.9999204 | *** | 1.0010742 | *** | 0.0001192 | -0.0384071 | *** | 0.0005576 | 1.4518944 |
| moses_intercal_feb_2019:suna_geomar_345:temperature | 0.9998968 | *** | 0.9942930 | *** | -0.0000331 | -0.0220024 | *** | 0.0020931 | 9.5131915 |
| moses_intercal_feb_2019:fb_hzg_pocket0001:temperature_optode | 0.9998817 | *** | 0.9921091 | *** | 0.0011739 | 0.1568924 | *** | 0.0008014 | 0.5107953 |

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# Data processing with respect to sensor plausability…

## Additional statistical procedures and their possible application…

laborator

I need to determine the “real” temperature as accurate as possible and have less strict requirements for the variability of the measurements due to sensor specifications

| Sensor URN | value | correlated | value | Statistical significance of difference in slope of measured values and expected values | Median accuracy (difference between measured value and expected value = median residuen) | Mean accuracy (difference between measured value and expected value = mean residuals) | Statistical significance of accuracy (mean difference between measured values and expected value) | Precicion (+/- spread around measured value (95pct confidence limit)) | Coefficient of variation (pct) of precicion to accuracy |
|---|---|---|---|---|---|---|---|---|---|
| moses_intercal_feb_2019:ctd_awi_25744:temperature_450326 | 0.9996052 | *** | 1.0053909 | *** | -0.0009073 | -0.0091557 | *** | | |
| moses_intercal_feb_2019:diver_ufz_a9632:div_temp | 0.9976658 | *** | 1.0080419 | *** | 0.0016729 | 0.1140364 | *** | 0.0032114 | 2.8161484 |
| moses_intercal_feb_2019:ctd_cc1441004:temp | 0.9926212 | *** | 0.9562691 | *** | -0.0020758 | 0.0767775 | *** | 0.0061902 | 8.0624610 |
| moses_intercal_feb_2019:diver_ufz_a5616:div_temp | 0.9999524 | *** | 1.0165609 | *** | 0.0005341 | -0.0082756 | *** | | |
| moses_intercal_feb_2019:diver_ufz_a5644:div_temp | 0.9999473 | *** | 1.0169230 | *** | 0.0003625 | 0.0469419 | *** | 0.0011941 | 2.5437916 |
| moses_intercal_feb_2019:tid_ufz_10924450:tidb_temp | 0.9999064 | *** | 1.0038544 | *** | -0.0003160 | 0.0452123 | *** | 0.0006742 | 1.4912897 |
| moses_intercal_feb_2019:ctd_25564:Twater | 0.9999425 | *** | 1.0028887 | *** | -0.0006834 | -0.0244798 | *** | 0.0005239 | 2.1399671 |
| moses_intercal_feb_2019:ctd_25601:Twater | 0.9999401 | *** | 1.0032472 | *** | -0.0006723 | -0.0244912 | *** | 0.0005417 | 2.2118492 |
| moses_intercal_feb_2019:tid_ufz_10669650:tidb_temp | 0.9999089 | *** | 1.0067264 | *** | -0.0000784 | 0.0991877 | *** | 0.0007551 | 0.7612485 |
| moses_intercal_feb_2019:exo1_geomar_0001:temperature_17f102065 | 0.9997965 | *** | 0.9938749 | *** | -0.0002065 | -0.0323417 | *** | 0.0012814 | 3.9620727 |
| moses_intercal_feb_2019:ros_0001:temperature | 0.0524740 | ns | -69.8181698 | *** | -0.0848775 | -0.1951538 | ns | 0.3217956 | 164.8933121 |
| moses_intercal_feb_2019:opus_geomar_71f9:temperature | 0.9998785 | *** | 0.9963838 | * | 0.0008304 | -0.0207693 | *** | 0.0021471 | 10.3380232 |
| moses_intercal_feb_2019:ctd_37:16685 | 0.9999204 | *** | 1.0010742 | *** | 0.0001192 | -0.0384071 | *** | 0.0005576 | 1.4518944 |
| moses_intercal_feb_2019:suna_geomar_345:temperature | 0.9998968 | *** | 0.9942930 | *** | -0.0000331 | -0.0220024 | *** | 0.0020931 | 9.5131915 |
| moses_intercal_feb_2019:fb_hzg_pocket0001:temperature_optode | 0.9998817 | *** | 0.9921091 | *** | 0.0011739 | 0.1568924 | *** | 0.0008014 | 0.5107953 |

Unit price: 15 000 €

Unit price: 250 €

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# Data processing with respect to sensor plausability…

## Additional statistical procedures and their possible application…

laboratory:moses_intercal_feb_2019

I need to determine very small scale temperature changes over time without having the need of an accurate absolute temperature (climate change questions).

| Sensor | Adjusted | Statistical | | Statistical significance of difference in slope of measured values and expected values | Median accuracy (difference between measured value and expected value = median residuen) | Mean accuracy (difference between measured value and expected value = mean residuals) | Statistical significance of accuracy (mean difference between measured values and expected value) | Precicion (+/- spread around measured value (95pct confidence limit)) | Coefficient of variation (pct) of precicion to accuracy |
|---|---|---|---|---|---|---|---|---|---|
| moses_i | | | 3909 | *** | -0.0009073 | -0.0091557 | *** | 0.0015644 | 17.0867988 |
| moses_i | | | 0419 | *** | 0.0016729 | 0.1140364 | *** | 0.0032114 | 2.8161484 |
| moses_intercal_feb_2019:ctd_cc1441004:temp | 0.9926212 | *** | 0.9562691 | *** | -0.0020758 | 0.0767775 | *** | 0.0061902 | 8.0624610 |
| moses_intercal_feb_2019:diver_ufz_a5616:div_temp | 0.9999524 | *** | 1.0165609 | *** | 0.0005371 | -0.0082756 | *** | 0.0011634 | 14.0582718 |
| moses_intercal_feb_2019:diver_ufz_a5644:div_temp | 0.9999473 | *** | 1.0169230 | *** | 0.0003625 | 0.0469419 | *** | 0.0011941 | 2.5437916 |
| moses_intercal_feb_2019:tid_ufz_10924450:tidb_temp | 0.9999064 | *** | 1.0038544 | *** | | | | 0.0006742 | 1.4912897 |
| moses_intercal_feb_2019:ctd_25564:Twater | 0.9999425 | *** | 1.0028887 | *** | | | | 0.0005239 | 2.1399671 |
| moses_intercal_feb_2019:ctd_25601:Twater | 0.9999401 | *** | 1.0032472 | *** | -0.0006723 | -0.0244912 | *** | 0.0005417 | 2.2118492 |
| moses_intercal_feb_2019:tid_ufz_10669650:tidb_temp | 0.9999089 | *** | 1.0067264 | *** | -0.0000784 | 0.0991877 | *** | 0.0007551 | 0.7612485 |
| moses_intercal_feb_2019:exo1_geomar_0001:temperature_17f102065 | 0.9997965 | *** | 0.9938749 | *** | -0.0002065 | -0.0323417 | *** | 0.0012814 | 3.9620727 |
| moses_intercal_feb_2019:ros_0001:temperature | 0.0524740 | ns | -69.8181698 | *** | -0.0848775 | -0.1951538 | ns | 0.3217956 | 164.8933121 |
| moses_intercal_feb_2019:opus_geomar_71f9:temperature | 0.9998785 | *** | 0.9963838 | * | 0.0008304 | -0.0207693 | *** | 0.0021471 | 10.3380232 |
| moses_intercal_feb_2019:ctd_37:16685 | 0.9999204 | *** | 1.0010742 | *** | | | | 0.0005576 | 1.4518944 |
| moses_intercal_feb_2019:suna_geomar_345:temperature | 0.9998968 | *** | 0.9942930 | *** | -0.0000331 | -0.0220024 | *** | 0.0020931 | 9.5131915 |
| moses_intercal_feb_2019:fb_hzg_pocket0001:temperature_optode | 0.9998817 | *** | 0.9921091 | *** | 0.0011739 | 0.1568924 | *** | 0.0008014 | 0.5107953 |

Unit price: 250 €

Unit price: 15 000 €

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# Stable data assessment in (near-realtime).

In ecology, data handling and verification procedures are by far not accurate and precise.

- Our data handling and verification procedures are only a first step towards a convincing quality control.
  - The state-of-the-art data handling procedures (flagging) are by far not sufficient for a high scientific level. What are probably good data?
  - How are missing data or data gaps filled?
  - We do not use state of the art capabilities of online sensor technology to countercheck data against other probes.
  - We do not use forecasting methods for online sensor control.
  - **We MUST provide Accuracy and Precision for each data point**.

We need more intelligent and automated data control and data verification procedures to achieve a higher data quality within a reasonable effort.

# Cross-cutting problems

- Independent of the scientific discipline, the same problems emerge in almost any discussion.
  - Data processing with respect to data quality.
  - Stable data assessment in (near-realtime).
  - Integration, aggregation & analysis of simple and complex data.

# Integration & analysis of simple and complex data.

**A real world example:** Master thesis (#### University – Department Computational Science) on the effects of low water years on the water quality of the Southern North Sea.

The Task: To visualize existing MOSES data on the Elbe discharge on the water quality (Temperature, Salinity, Turbidity) in the Southern North Sea:

The target data dources :

- **Cuxhaven Ferrybox, Helgoland Ferrybox... (TS data).**
- **Helgoland Reede Data (PANGAEA)**.
- **German bight, FINO3, NSB II and NSB III** (**BSH Data Base**).
- **Cuxhaven Water Level (OPENDAP Data Base):**
- **River Discharge (Datenportal FGG Elbe)**:

# Integration & analysis of simple and complex data.

**A real world problem:** The student needed about 2 month to successfully retrieve the data from the respective databases and to bring them in a form to use them for analysis:

- 11 R scripts with up to 1000 lines of code were necessary to convert the database data.

## *A non representative poll…*

1. 70% of the biological scientists are not able to use R or Matlab…
2. 90% of the biologists are not prepared / trained to use NETcdf, JSON, XML etc. etc.
3. 90% of the scientist use Excell and standard calculation programs.
4. 90% of the ecological oriented biological scientists think that the term FAIR is related to fair trade products.

## *A real-world problem…*

Access to data repositories like below in NOT feasable for most ecologists! -> (and will not be in the future):

http://sos.[redacted]/sos.py?request=GetObservation&service=SOS&eventTime=2019-04-16T08:46:10Z/2019-04-16T10:08:10Z&offering=Prandtl&observedProperty=Sal_Teledyne_Citadel_TS-NH

https://dashboard.[redacted]/data-xxl/rest/data?beginDate=2019-05-18T00:00:00&endDate=2019-05-19T23:59:59&format=application/json&aggregate=hour&aggregateFunctions=MEAN&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:pH_meinsberg_ega&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:relative_humidity_0001&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:salinity&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_aanderaa_optode&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_citadel&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_turner_scufa_0001&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:total_alcalinity_contros_fia_ta&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:turbidity&sensors=laboratory:moses_stern_1:fb_hzg_pocket0001:xco2_corr_contros_hydroc

# *The real world…☺*

Standard access of ecologists to the institutes ecological databases **IS** via “click and download”:

## Available sensors

Filter sensors: ›_hzg_pocket0001:xco2_corr_contros_hydrocmp

Deselect all sensors

| | Sensor code | | Sensor description |
|---|---|---|---|
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:pH_meinsberg_ega | pH | laboratory:moses_stern_1:fb_hzg_pocket0001:pH_meinsberg_ega |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:relative_humidity_0001 | % | laboratory:moses_stern_1:fb_hzg_pocket0001:relative_humidity_0001 |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:salinity | PSU | laboratory:moses_stern_1:fb_hzg_pocket0001:salinity |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_aanderaa_optode | °C | laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_aanderaa_optode |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_citadel | °C | laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_citadel |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_turner_scufa_0001 | °C | laboratory:moses_stern_1:fb_hzg_pocket0001:temperature_turner_scufa_0001 |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:total_alcalinity_contros_fia_ta | µmol/kg | laboratory:moses_stern_1:fb_hzg_pocket0001:total_alcalinity_contros_fia_ta |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:turbidity | FTU | laboratory:moses_stern_1:fb_hzg_pocket0001:turbidity |
| ☑ | laboratory:moses_stern_1:fb_hzg_pocket0001:xco2_corr_contros_hydroc | µatm | laboratory:moses_stern_1:fb_hzg_pocket0001:xco2_corr_contros_hydroc |

9 / 1284 sensor(s) are registered for this data service.

## Request data

Begin 2019-05-18

End 2019-05-19

Format JSON

Aggregate hour ☐ minimum ☐ 0.25-percentile ☑ mean ☐ median ☐ 0.75-percentile ☐ maximum ☐ standard deviation ☐ count

Build request...

We often discuss that we need a good public outreach and that we must provide our data, if possible open access, to the relevant “Stakeholders”.

We fully agree with this ☺

**but**

With respect to data, ecological scientists, which often do not have much computational competences in data-mining and large-scale data exploration, are most important stakeholders using the data for real science.

HELMHOLTZ