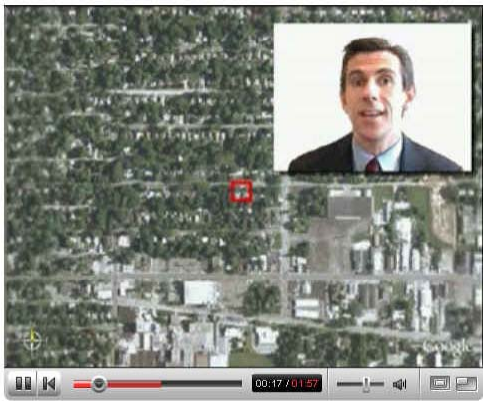
Understanding Data Quality

IST400/600

JIAN QIN

Why are we concerned about data quality?

2



Why are we concerned about data quality?

3

- Protect potential data consumers from unintended consequences resulting from
  - Misinformation
  - Mistaken assumptions about data collection methods, measurement precision, or scale

What is data quality?

4

Quality Dimensions	Strategic Goals
Relevance	Relevance
Accuracy	Quality
Timeliness	Timeliness
Accessibility	Utility
Interpretability	Completeness
Coherence	Comparability

Burns, E.M. et al. (2002). Data quality assessment methodology: A framework. In: Proceedings of the Survey Research Methods Section, ASA (2002). http://www.amstat.org/Sections/Srms/Proceedings/y2002/Files/JSM2002-000347.pdf

Data quality glossary

5

- **Accuracy:** the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.
- **Assessment:** the evaluation process used to measure the performance or effectiveness of a system and its elements, used to denote any of the following: audit, performance evaluation, management systems review, peer review, inspection, or surveillance
- **Comparability:** the degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator.

For more terminology on data quality, see:
http://www.hanford.gov/dqo/glossaries/Glossary_of_Quality_Assurance_Terms1.pdf

The two sides of quality

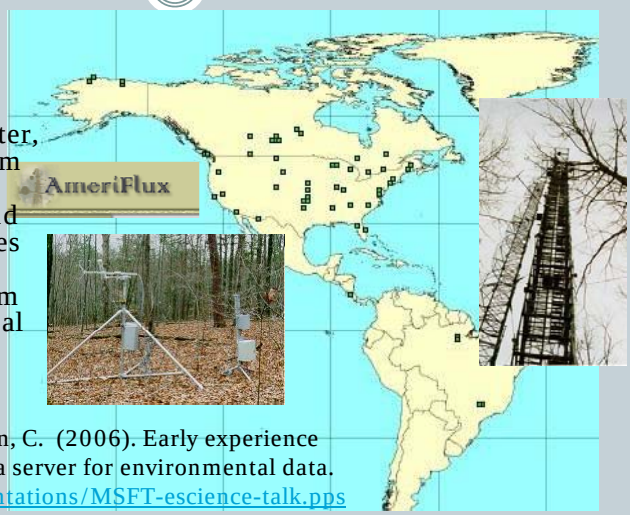
6

Target data system	Metadata for users
• Background • Frames and Sampling (if • applicable) • Data Collection • Data Preparation • Data Dissemination • Sponsor Self-Evaluation • Data Analysis Results	• Lineage • Positional accuracy • Attribute accuracy • Logical consistency • Completeness • Currency • Status

Target data systems: An example (1)

7

- AmeriFlux network provides continuous observations of ecosystem level exchanges of CO_2, water, energy and momentum spanning diurnal, synoptic, seasonal, and interannual time scales and is currently composed of sites from North America, Central America, and South America.

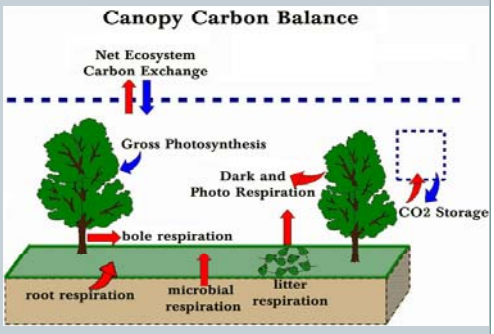


Agarwal, D. and van Ingen, C. (2006). Early experience prototyping a science data server for environmental data. http://bwc.lbl.gov/Presentations/MSFT-escience-talk.pps

Target data systems: An example (2)

8

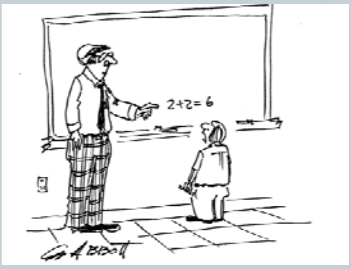
- 149 Sites across the Americas
- Each site reports a minimum of 22 common measurements.
- Communal science – each principle investigator acts independently to prepare and publish data.
- Data published to and archived at Oak Ridge.
- Total data reported to date on the order of 150M half-hourly measurements.



- http://public.ornl.gov/ameriflux/

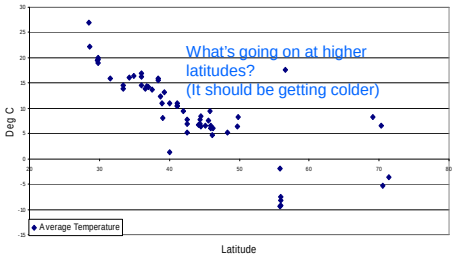
Target data systems: An example (3)

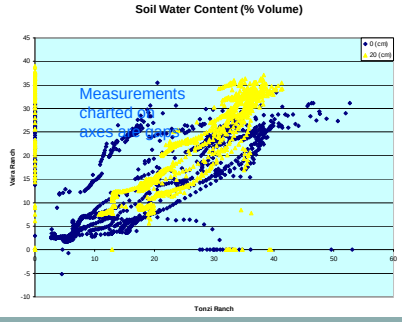
- Data quality problems:
  - Measurements Are Not Simple or Complete
  - Gaps in the data
    - Quiet nights
    - Bird poop
    - High winds
    - ….
  - Difficult to make measurements
    - Leaf area index
    - Wood respiration
    - Soil respiration
    - …
  - Localized measurements – tower footprint
  - Local investigator knowledge important
  - PIs' science goals are not uniform across the towers

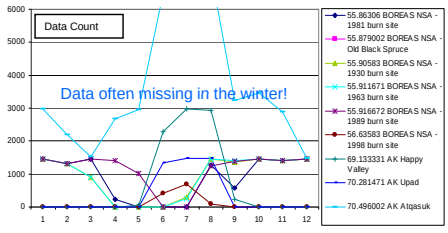


Checking for data quality

- Real field data has both short term gaps and longer term outages
  - The utility of the data depends on the nature of the science being performed
  - Browsing data counts can give rapid insight into how the data can be used before more complex analyses are performed



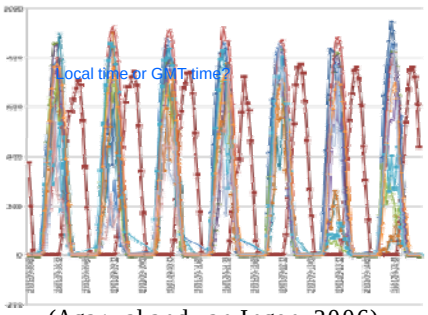




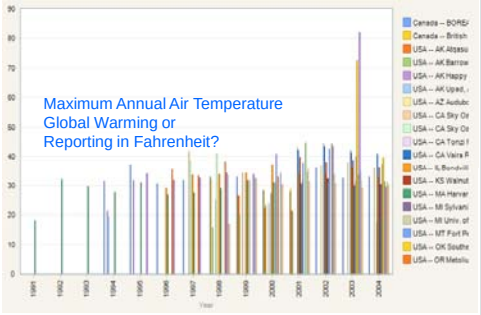
(Agarwal and van Ingen, 2006).

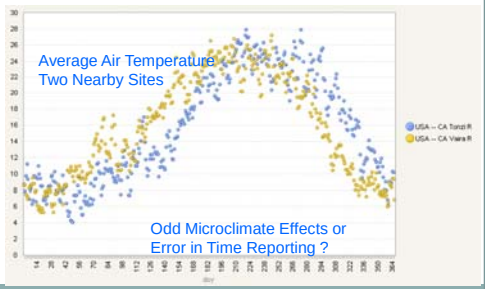
Checking for data quality

- Real field data has unit and time scale conversion problems
  - Sometimes easy to spot in isolation
  - Sometimes easier to spot when comparing to other data
  - Browsing data values can give rapid insight into how the data can be used before more complex analyses are performed



(Agarwal and van Ingen, 2006).



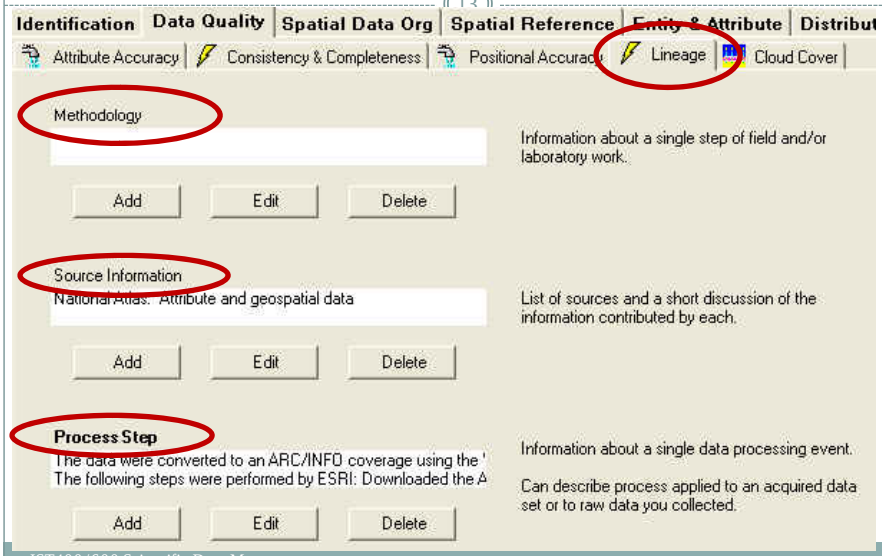


Metadata for users (1)

12

- Describing data quality in metadata (FGDC metadata standard, see example record in handout)
  - Lineage
    - *Methodology*: Information about a single step of field and/or laboratory work.
    - *Source of Data*: List of sources and a short discussion of the information contributed by each.
    - *Processing steps*: Information about a single data processing event. Can describe process applied to an acquired data set or to raw data collected.

Lineage (1)



Lineage (2)

- Data quality benefits of lineage
  - Communicates suitability, reliability, accuracy, currency, redundancy
  - Enhance interpretation, prevents misinterpretation, misuse of environmental data
  - Enhance a user's justification for using data
  - Reduces possible false sense of data precision
  - Facilitate integration of data
  - Allows non-expert data user to understand processing steps
  - Communicates processing steps leading to creation of scientific data product
  - …

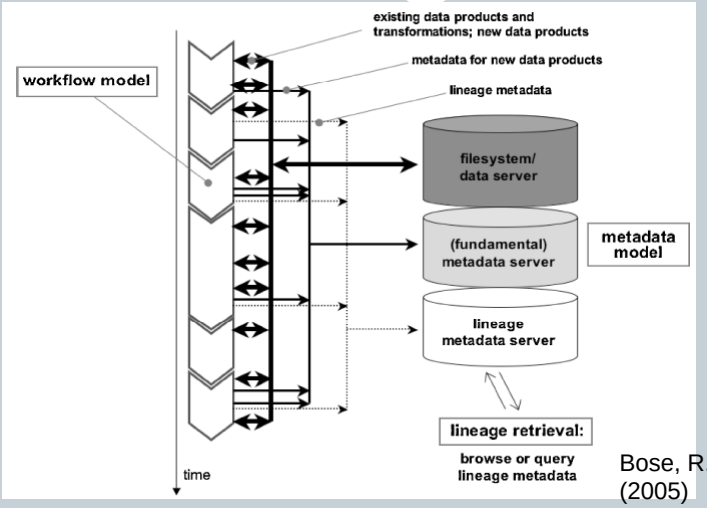
Lineage (3)

15

- Scientific processing benefits of lineage
  - Records processing history for internal records, audit, quality control
  - Records computational history for judging statistical validity of future operations
  - Reduces data provider liability
  - Provides consistent documentation for distributed datasets
  - Finds the sources of faulty, anomalous processing inputs
  - Saves processing "recipes"; modifies and reruns processing sequence
  - …

Lineage (4)

16



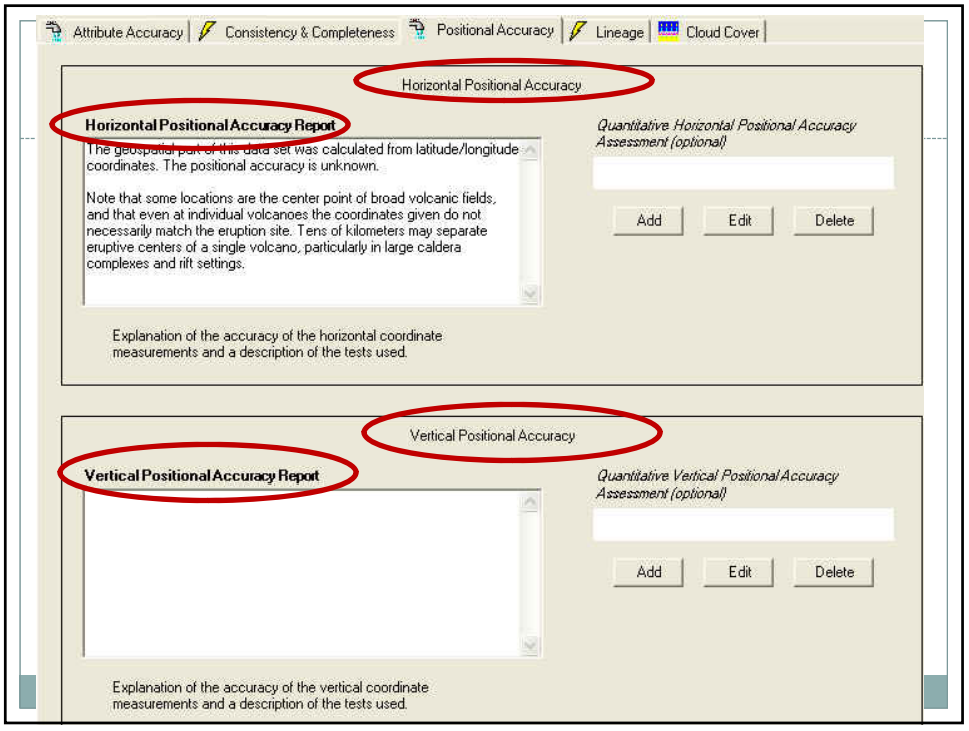
Bose, R. and J. Frew (2005)

Metadata for users (2)

17

- Positional accuracy
  - Determining accuracy requires comparison of a recorded position against the actual position as defined by a known datum. Positional accuracy would be determined by how close the represented position of a feature is in relationship to its actual position on the earth.

Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: As for PRISM maps, accuracy of this data set is based on the original specification of the Defense Mapping Agency (DMA) 1 degree digital elevation models (DEM). The stated accuracy of the original DEMs are 130 m circular error with 90% probability
Quantitative_Horizontal_Positional_Accuracy_Assessment:
Horizontal_Positional_Accuracy_Value: 130 m with 90%
Horizontal_Positional_Accuracy_Explanation: The broad DMA production objective for 1-degree DEM's.



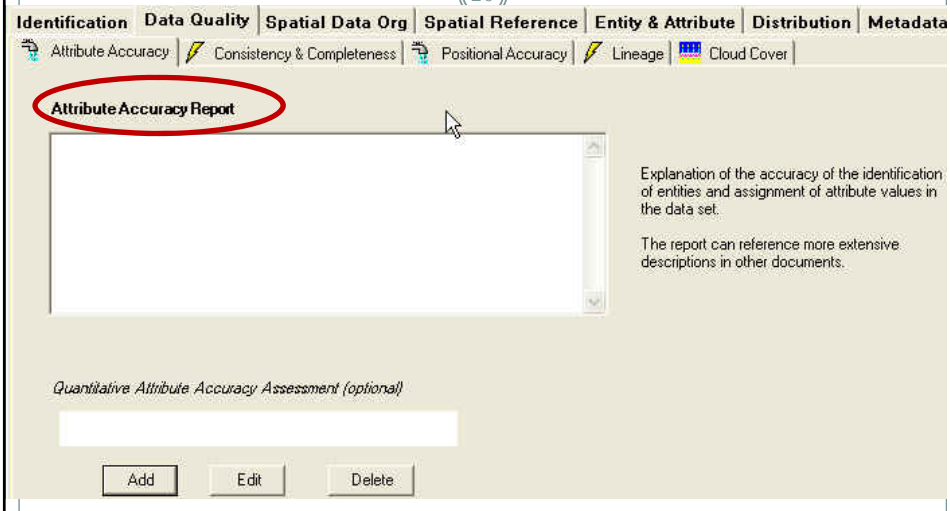
Metadata for users (3)

19

- Attribute accuracy
  - Determining accuracy requires comparison of recorded entry against the actual as defined by predefined standards.

Metavist interface for data quality

20



Metadata for users (4)

21

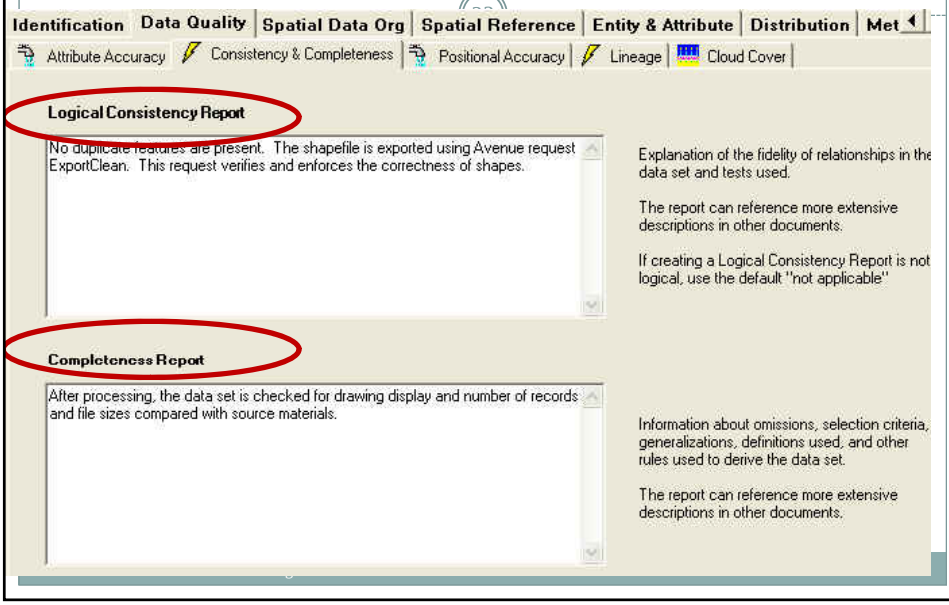
- Logical consistency
  - How well does the data fit within logical rules of data structure.
  - Attribute logical consistency entails the testing of two or more functionally related attributes. The value for one attribute determines the valid values for its related attributes. (If X then Y)
  - Feature logical consistency is the testing for feature to feature relationships that are consistent with known or expected rules.

Metadata for users (5)

22

- Completeness
  - Completeness of spatial coverage tests expected spatial coverage against actual coverage either as areas missed or stations covered
  - Completeness of temporal coverage is for time series data when there are gaps in the time recordings
  - Completeness of classification examines how exhaustive is the classification system and are there generalizations
  - Completeness of verification examines the verification method for the data
  - Completeness of attribution examines if each record is complete

Metavist interface for data quality



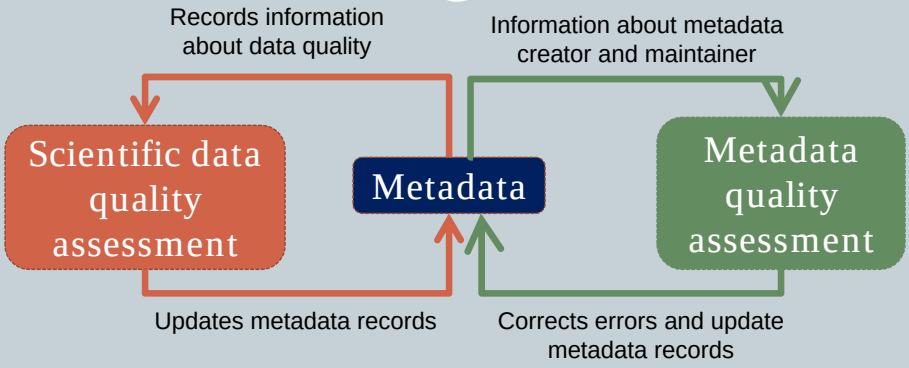
Metadata for users (6)

24

- Other metadata elements for data quality
  - Currency
    - Beginning date
    - End date (processing time between collection and storage if ongoing collection)
  - Status
    - Maintenance and update frequency
    - Progress

Assessment of data quality

25



Quality dimensions

26

For scientific data	For metadata
• Relevance • Accuracy • Timeliness • Accessibility • Interpretability • Logical consistency • Coherence	• Completeness • Accuracy • Provenance • Conformance to expectations • Logical consistency and coherence • Timeliness • Accessibility • Proper context • Use of standard vocabularies