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Cross-domain interoperability in geosciences for data integration and decision support via Semantic Web technologies

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The research and understanding of complex geoscience phenomena, such as e.g. climate change, space weather or earth plate dynamics require an integrated approach for the combination of data covering different earth and space science domains. The results must be comprehensible for the scientific community, for the interested public as well as high-level decision-making purposes and therefore prepared and presented in very different ways. At present most of the geoscience data which are generated within one domain, e.g. earth gravity data in the geodetic domain are not usable or at least are only difficult to use within other domains, e.g. in seismology, geophysical domain. The problem is even bigger. Sometimes, within one domain, the ”same” data just measured by different instruments are not capable of being integrated. Just think, how difficult it is to combine in-situ earth gravity data measured by e.g. superconducting gravimeters with global gravity field data derived from specific satellite missions such as GRACE or GOCE.

Obstacles for the integration of data are the usage of different data and file formats provided by proprietary data management and information systems using different services. Therefore a lot of effort for the search of data, the understanding of data management systems and services as well as the transformation of data and file formats often done by scientist is necessary. Another challenge for the integration of data often is the lack of information about data provenance and governance. This context of the data and information are absolutely necessary in order to judge whether the specific data can be used in a specific application within a specific field of research. What else prevents data from being used in the same or different scientific domains? Cultural and linguistic differences of scientific work in geoscience and neighboring disciplines often lead to the use of different vocabularies, different understanding of terms for data description and data retrieval purposes.

The Semantic Web, an extension of the World Wide Web possesses the capability for the solution of many questions touched on in the first part of this abstract. First, the Semantic Web is based on standards for domain models and data as well as for vocabularies used for the terminological interoperability. Domain models formed as ontologies related to earth and space sciences conceptualize a specific field, e.g. virtual observatories in space physics (VSTO ontology), the measuring process itself (SSN ontology) or the lifecycle of geoscience data (ISDC ontology). Upper ontologies (SWEET) for the geoscience domain are often the umbrella of the appropriate domain ontologies. Classification, taxonomy or thesaurus vocabularies consist of domain specific keywords and relations between keywords. Within the Semantic Web these vocabularies are modeled as terminological ontologies. Examples for terminological ontologies in the earth and space science domain are GCMD scientific keywords and SPASE ”allowed values”. The GEMET thesaurus ontology also relates to environmental and social sciences. The merging of domain and terminological ontologies enables both to bridge the gap between different scientific fields and different linguistic comprehension. In the Semantic Web realm, the integration of geoscience data, modeled as individuals and/or at least described by all required context information in the domain ontologies is realized ”just” by networking the specific and appropriate ontologies. An example for such an approach is the ISDC ontology network linking domain ontologies, such as FOAF, GeoNames, Bibo, DBpedia and terminological ontologies, such as GCMD science keywords, SPASE ”allowed values” and GEMET thesaurus. Within the near-earth space domain, it is planned to connect Japanese IUGONET, EU-ESPAS and German ISDC data and appropriate data management systems using the same terminological ontology based on an extended SPASE thesaurus.

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