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Christina von Haaren
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Landscape Planning with Ecosystem Services

Theories and Methods for Application in Europe

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To the landscape planners of tomorrow

Preface

In an era where the Internet dominates knowledge acquisition, it seems obvious to ask the question "why a book about landscape planning methodologies?" We decided to write and edit this book for two main reasons:

1. Practitioners and students of landscape planning take in huge amounts of unconnected information. Only with difficulty can students put papers about separate aspects into a context that enables them to use methods critically and in a targeted manner.
2. The question "how to evaluate the landscape?" is often answered by landscape planners and others involved in environmental planning or impact studies across European countries in different ways. However, the purposes and tasks are often very similar, as indeed are many of the relevant methods in a European context.

Thus, the overall motive for this book is to provide orientation in the information jungle. We also feel that many of the pressing environmental challenges can be best addressed by combining the practical orientation of landscape planning with concepts and approaches from the burgeoning literature on ecosystem services and natural capital. In this book, we discuss how these two fields can be integrated and review hands-on methods which, in principle, are applicable in all European countries. A feature of this book is that an emphasis is placed on combing evaluations based on legal norms with those based on public preferences, including economic approaches. Furthermore, over 45 authors from different disciplines have adopted a common framework for discussing their methodologies. This ensures a consistency of material for the reader which, in turn, assists in combining different elements in practical applications.

It has taken a long time to complete this book, and many people have supported our vision with advice, energy, creativity, and sheer hard work. We would particularly like to thank all of the chapter authors and reviewers. Advice from the editors of the Springer Landscape Series and publishing staff (particularly Nel van der Werf) is also much appreciated.

Financial support from several research grants has assisted with our work on a number of chapters in the book. In particular, Andrew A. Lovett would like to acknowledge the support from the UK Economic and Social Research Council (award ES/L011859/1 for the Business and Local Government Data Research

Centre) and the UK Natural Environment Research Council (award NE/M019713/21 for the ADVENT project). Christian Albert has been supported by a grant from the German Federal Ministry of Education and Research (BMBF) for the PlanSmart research group (funding code: 01UU1601A).

We are also very grateful to the team of people in Hannover and Norwich who have helped with tasks such as proofreading, redrawing diagrams, checking references, formatting, and the multiple other tasks that are involved in preparing the final version of a manuscript. Our sincere thanks go to Martha Graf, Judith McAlister-Hermann, Zhiyuan Peng, Sascha Vandrey, Anna-Lena Vollheyde, Louise von Falkenhayn, Eick von Ruschkowski, and Trudie Dockerty. Special thanks are due to Ingrid Albert for acting as coordinator of this team and making sure the plates kept spinning.

An international collaboration of this type has involved considerable travel and visits to our respective universities. We would therefore like to thank the Hotel in Herrenhausen for providing a "home from home" for Andrew A. Lovett during visits to Hannover and to Gilla and Lena Sünnenberg for hosting Christina von Haaren during stays in Norwich.

We hope that readers of this book will gain as much insight from reading it as we have benefited from planning and writing it.

Hannover, Germany — Christina von Haaren
Norwich, UK — Andrew A. Lovett
Hannover, Germany — Christian Albert
September 2018

Contents

Regional Climate Regulation Capacities

13

Hermann Klug and Steffen Reichel

Abstract

In the past decades climate change impacts have become more pronounced, especially in the European Alps. There has been a spatio-temporal diversity of these impacts ranging from east to west, north to south, and with consideration of the orography, from low to high altitudes. The impacts of the present weather conditions and climate change on the environment and on humans show a great variety. As a consequence of dissimilar preconditions, mid-term and short-term adaptation planning approaches cannot simply be transferred from one place to another. They require a local to regional understanding of the drivers, impacts and responses on vulnerable ecosystem services, and regional regulation capacities and adaptation potentials. With respect to climate variables this chapter explores existing climate data repositories and demonstrates how these can be transferred into standardised data offerings, enabling harmonised searching, discovering, assessing, analysing, and processing. Diverse publicly available meteorological datasets, from weather stations in the alpine space, are transferred into an Open Geospatial Consortium Compliant Sensor Observation Service. This standard compliant data repository enables a post-processing with Python scripts which analyses the unified data records and displays them in charts for further interpretation. As a result, readers are able to compile and publicly share standard compliant data repositories and run queries on them for data exploration to estimate impacts on ecosystem services.

Keywords

Climate change · European Alps · Meteorological data · Data synthesis · Python

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13.1 Introduction

The Alps have been highlighted as being affected by climate change in a more pronounced way than other European regions (Nogués-Bravo et al. 2007). These changes are not evenly distributed in space (horizontally and vertically) and time. They depend on the specific landscape structures and patterns. Consequently, climate impacts on humans and the environment are different across the Alps (Auer et al. 2007). Moreover, climate changes are altering the functions of ecosystems (Nelson et al. 2013).

The impacts of, for example, flooding (Beniston 2012), storms (Etienne and Beniston 2012), or water scarcity (Hohenwallner et al. 2011), and the related environmental and human consequences from these hazards, are closely watched by local to national stakeholders. Related transdisciplinary efforts and existing non-alpine climate change platforms, that these stakeholders are working with, were documented within the Alpine Space program project C3-Alps (Klug et al. 2014). The produced online repositories were used in iterative stakeholder interactions for designing layout and functionality of a new user-centred knowledge inventory portal on climate change impacts and adaptation planning, tailored to the Alpine space.[1] Such user-adapted and spatially concrete information about climate change and the adaptation capacities of ecosystems and their services is a precondition for integrating climate change adaptation into landscape and spatial planning.

The need for an integrated information platform is illustrated by the fact that more than 350 datasets on climate change impacts and present adaptation strategies on ecosystem services have been developed across the Alps. However, the content focuses on reports and pictures and neglects detailed climate and weather information services on, for example, precipitation, temperature, wind speed, and wind direction. Furthermore, the information is often provided only offline, scattered across websites, or resides in poorly documented reports and in addition, data are often not internationally standardised. An environmental information system – as landscape planning can provide for regions and municipalities – could either import the relevant data from national platforms, or generate the relevant information and process it for use in planning and land use decision.

In this context, this chapter is about an integration and synthesis approach on climate and weather data. A synthesised cross-Alpine standard compliant inventory method is provided as an example. The approach can be adapted to other regions with some changes. It includes scripts and tools to setup a Sensor Observation Service (SOS) (OGC 2012), to insert datasets from available sources into the SOS, and to analyse and visualise the data using Python scripts. This practical approach provides publicly available datasets in the data formats Observations & Measurements (O&M) (OGC 2011; ISO 19156 2011), and Water Markup Language (WaterML) as a hydrological time-series data specialisation of O&M. This is in congruence with the International Organization for Standardization (ISO) and the

[1] http://www.sbg.ac.at/zgis/landscapelab/c3alps

World Meteorological Organization (WMO). Both are closely cooperating in their effort to facilitate a worldwide establishment of weather station networks.

13.2 Material and Methods

Having outlined the spatio-temporal differences of weather phenomena and climate change impacts and the possible alteration of ecosystem services across the Alps, we start with the setup of the spatial data infrastructure (SDI). A SOS from the 52°North repository is setup (Fig. 13.1). Publicly available datasets are automatically (or manually) downloaded from the accessible web resources. Provided XML and Python scripts transfer the data (semi-)operational into the SOS and visualises the datasets for further interpretation.

13.2.1 Setting up the Sensor Observation Service and Data Structures

The Sensor Observation Services have to be set up, in our case, as discussed in the 52°N SOS community.[2] Consequently, the SOS files[3] are downloaded and the

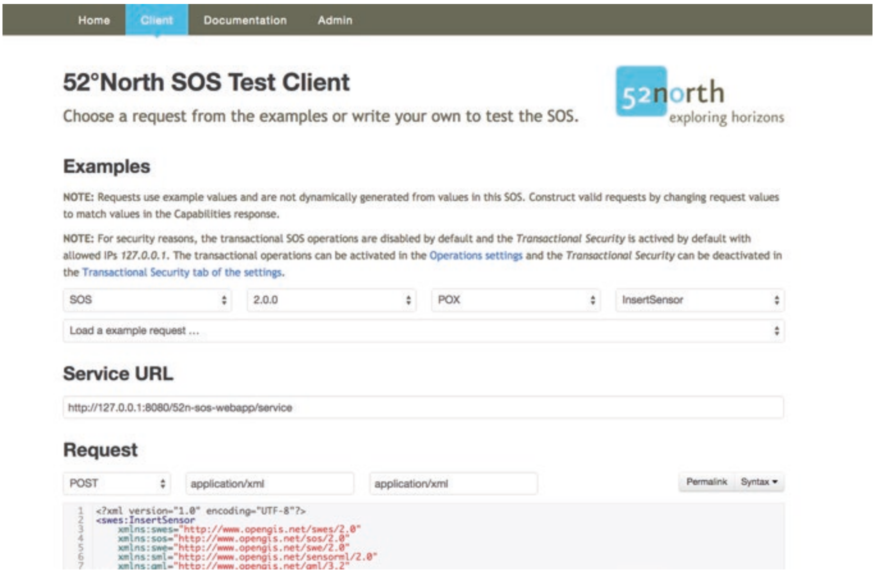

Fig. 13.1 Entering the data structure into the SOS

[2] http://www.52north.org/communities/sensorweb/sos

[3] http://www.52north.org/communities/sensorweb/sos/download.html

'52n-sensorweb-sos-bundle-4.3.0' installed according to the wiki reference.[4] For integration of the data structure into the SOS we set up the sensor metadata using the three examples. Extensible Markup Language (XML) scripts in the 'sensorml' folder.[5] The contents of every file is copy/pasted into input field of the 52°N SOS test client as outlined in Fig. 13.1.[6]

13.2.2 Available Weather Information Services and Datasets

Referring to the flooding, storm, and water scarcity examples in the case study, available precipitation, temperature, and wind speed and wind direction datasets were unified into the O&M 2.0 data format distributed via the SOS. Climate data repositories are organised by diverse data providers and on different organisational levels. National environment agencies, meteorological, and/or hydrological surveys, provide this information. In these repositories, datasets differ from raster, vector to text file representations with a dissimilar monitoring time scale. These may range in time scale from annual to monthly, daily average, or single measurements repeating every 5–15 or 30 min. Further repositories have resulted from joint global (IPCC,[7] NOAA,[8] WorldClim,[9] FAO,[10] NASA,[11] CRU[12]), European (INSPIRE[13]) or Alpine (HISTALP[14]) efforts or have been based on commercial interests (OGIMET,[15] UBIMET,[16] ZAMG[17]). As a result, the selection of data properties, including their temporal resolution, is dependent on the location of the interest and the phenomena under investigation.

4 https://www.wiki.52north.org/bin/view/SensorWeb/SensorObservationServiceIVDocumentation#Installation

5 http://www.sbg.ac.at/zgis/landscapelab/downloads/KlugReichel.zip

6 http://www.YOUR-IP:8080/52n-sos-webapp/client

7 http://www.ipcc-data.org/index.html

8 http://www.ncdc.noaa.gov/data-access

9 http://www.worldclim.org/download

10 http://www.fao.org/nr/climpag/pub/EN1102_en.asp

11 http://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?+s01

12 http://www.cru.uea.ac.uk/data

13 http://inspire-geoportal.ec.europa.eu

14 http://www.zamg.ac.at/histalp/dataset/station/csv.php

15 http://www.ogimet.com

16 http://www.ubimet.com/en_INT

17 http://www.zamg.ac.at/cms/en

13.2.3 Importing Climate Datasets into the SOS

This chapter focuses on the datasets, from which respective information should be extracted, in our case exemplary for the European Alps. Python scripts[5] are useful for transferring the below mentioned datasets into the installed SOS.

The National Oceanic and Atmospheric Administration (NOAA) repository is a global data pool. It is intended to be free and have unrestricted access for research purposes, education, and other non-commercial activities, for 18 surface meteorological parameters (including temperature, precipitation, and wind). Historical data from the global summary of the day (GSOD) repository are available for +9000 single stations from 1929 to present, while data from 1973 to present is almost complete for every station.[18] Within the script, daily average temperature values from GSOD are converted from Fahrenheit (°F) to Celsius (°C) and daily precipitation averages from inch to millimetre.

Meteorological Aviation Reports (METAR) are available at airports in encoded format for reporting weather information – mainly to pilots.[19] In contrast to GSOD the publication interval of the parameters is 30 min.

The freely available Historical Instrumental Climatological Surface Time Series of the Greater Alpine Region (HISTALP) database consists of, for example, monthly homogenised temperature (partly since 1760) and monthly precipitation data sums (partly since 1800) (Auer et al. 2007). We manually downloaded the monthly average datasets as homogenised series CSV export.[20]

13.2.4 Visualisation of Data Entries

The open source Python 2D plotting library 'matplotlib' has proven useful for a simple visualisation of data values.[21] We recommend using the Python Anaconda distribution and following their installation instructions[22] or alternatively, our readme instructions in the KlugReichel.zip.[5]

13.3 Results

The automated climate data assembly and processing provides a complex information base on past and present environmental conditions, which in comparison with ecosystem services might expose local regulation capacity to respond to stress

[18] http://www1.ncdc.noaa.gov/pub/data/gsod/, ftp://ftp.ncdc.noaa.gov/pub/data/noaa/isd-history.txt

[19] http://weather.noaa.gov/pub/data/observations/metar/stations/STATION-CODE.TXT (your station code, e.g. LOWS for Salzburg airport).

[20] http://www.zamg.ac.at/histalp/dataset/station/csv.php

[21] http://matplotlib.org

[22] https://store.continuum.io/cshop/anaconda

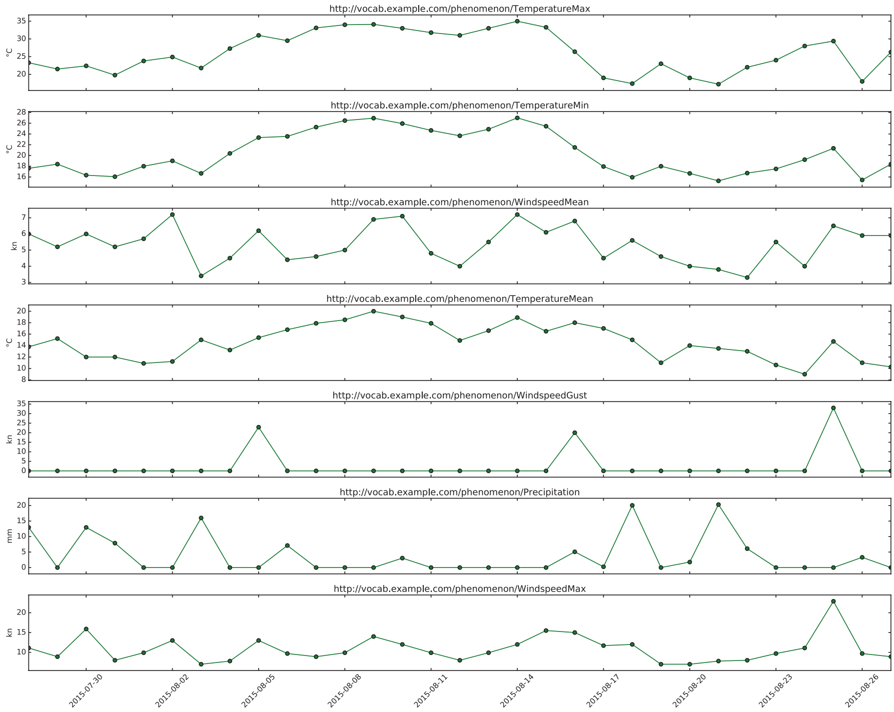

Fig. 13.2 GSOD dataset from Salzburg airport (LOWS)

during flood, storm, and water scarcity times. Targeted temperature, precipitation, wind speed and wind direction dataset are generated. With the unification of the HISTALP data (temperature, precipitation, pressure), GSOD (temperature, precipitation, wind speed), and the METAR datasets (wind speed, wind direction, temperature, and others), a standardised data repository could be established.

There is almost no long-term METAR data repository publicly available but OGIMET hosts information since 2005, which they are willing to share. Actual measurements on the NOAA data repository are discarded after 36 h. Thus, the developed script includes a permanent request on new METRA data every 30 min to set up a larger data repository.

With the 52°N SOS v4.3.0 user interface shown in Fig. 13.1, the values inserted can be retrieved using tailored XML queries. These XML scripts integrated into the provided Python plot script can be used for visualisations in the Python 2D plotting library 'matplotlib' as shown in Figs. 13.2, 13.3, and 13.4.

The visualisations in Figs. 13.2, 13.3, and 13.4 have been kept very simple but can be modified in colour, style, and layout. Especially the representation of the wind direction in Fig. 13.3 is less explorative as it could be with the wind rose extension to 'matplotlib'.[23]

[23] https://pypi.python.org/pypi/windrose/1.5

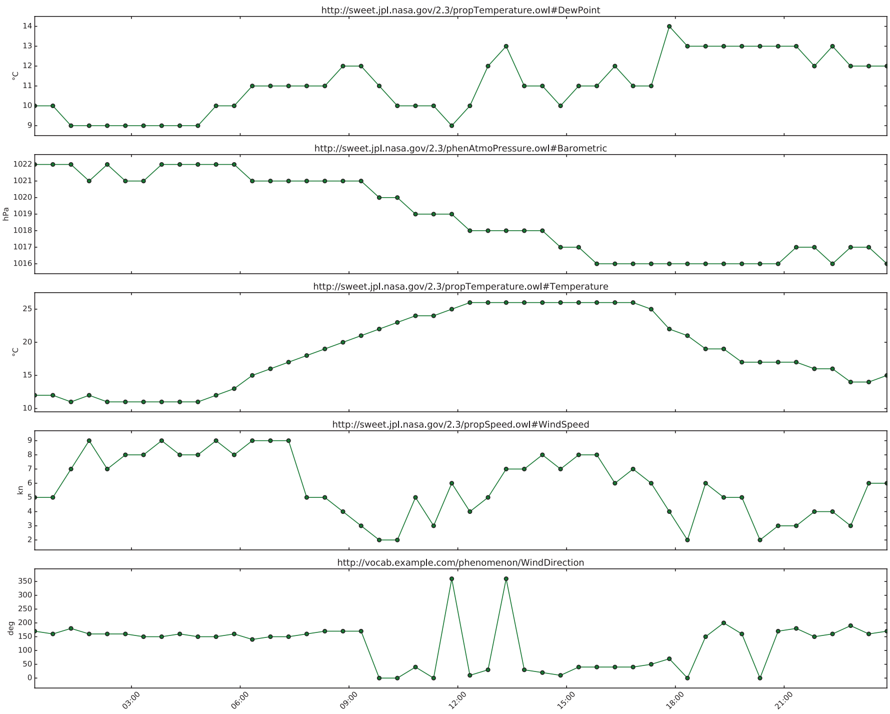

Fig. 13.3 METAR dataset from Salzburg airport (LOWS)

13.4 Discussion and Conclusion

The framework presented here updates existing landscape planning approaches for ecosystem services with an 'Automated Geosynthesis' approach based on climate and weather information. As demonstrated by Kmoch et al. (2015) and Klug and Bretz (2012), other hydrology or soil-related spatio-temporal datasets could also be shared and synthesised in a similar standardised and publicly accessible procedure. This geosynthesis is designed to combine the spatio-temporal components or elements and related processes to form an interconnected whole. As such, it is an entity greater than the sum of its single components. It should provide an improvement in the understanding of the processes and functions operating in landscapes. The automated geosynthesis should deliver locally adapted operational services and products that assemble distributed geospatial information for complex analysis. In turn this will enhance and support the qualified decision making process in landscape planning for ecosystem services.

Critical components in implementing an automated geosynthesis are the many local environmental parameters (e.g. relief, soils, flora, fauna, and hydrology). In the presented case study, only the meteorological information was used. Since neither the local setting nor the impacts and planning approaches are similar across the

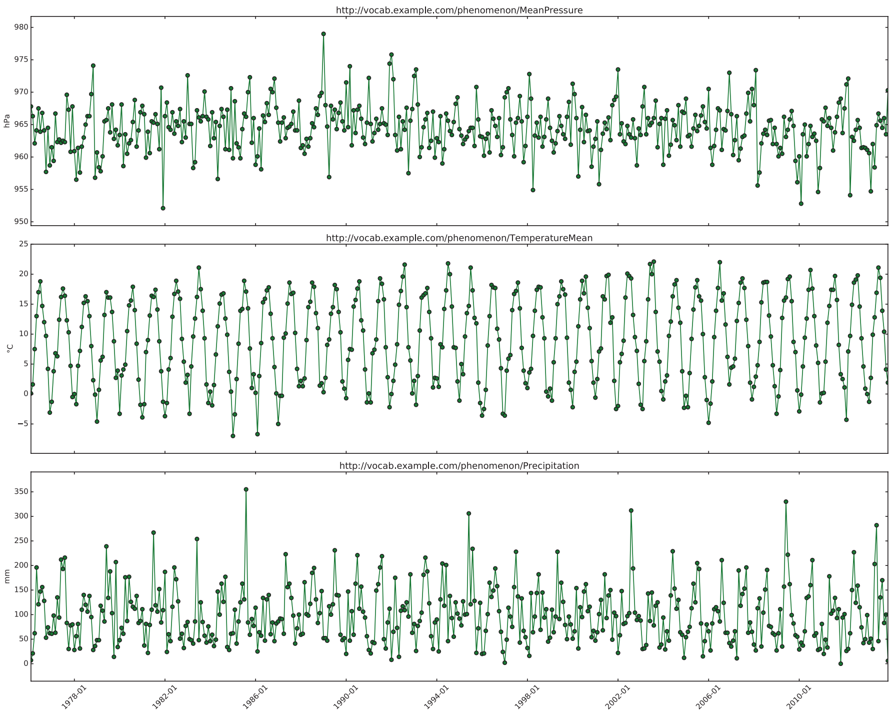

Fig. 13.4 HISTALP dataset from Salzburg airport (LOWS)

Alps, an immediate transfer of the study might be limited. However, the application of a standard compliant concept of connecting geospatial technologies is place independent and has been proven successful. Thus, the described standard compliant geospatial technologies that are independent from computer platforms can be recommended for any further study also outside of the Alps. They enable the interoperable connection of distributed data and metadata services (SensorML; OGC (2007b)) to ensure an exchange of machine- (XML) and human-readable sources (figures) for an increased awareness of past climate change, present weather phenomena, and climate change predictions such as those provided by datasets from EURO-CORDEX or ENSEMBLES (Jacob et al. 2014), which are used for short and mid-term ecosystem service planning approaches. The improved resource allocation and prioritisation, with tailor-made location specific information for mid-term planning support, could then be used as an operational service covering the European Alps.

The HISTALP and GSOD repositories setup include temporal ambiguities. Thus, the interpretation of both datasets is limited in its present form. Post-processing the daily data to average monthly values could help to analyse the datasets on a monthly scale. Nevertheless, temperature measurements are now available in a unique format, not separated into non-comparable degree Fahrenheit (GSOD) and degree Celsius (METAR, HISTALP). The same applies to precipitation information consistently converted from inches (GSOD) into millimetres (HISTALP, METAR). However, the temporal differences of the datasets require post-processing for a consistent daily comparison.

13.5 Outlook

Besides climate datasets, cross-domain environmental monitoring networks across the Alps regularly provide information on the state of the environment (Mirtl et al. 2015). Implemented wireless sensor networks integrating meteorological, hydrological, and pedological observations into a standardised spatial data infrastructure, provide the basis for exposing local to regional vulnerability hot spots in near real-time, for example for flooding (Klug et al. 2015). Immediately available observations from distributed monitoring networks enable forecasting applications incorporating real time *in situ* measurements for validation (Klug and Oana 2015). Coupled with integrated environmental modelling toolkits, installed as a Web Processing Service (WPS) (OGC 2015), they provide information on present and near-future environmental conditions exposing local regulation capacities on stressors such as those mentioned above (Klug and Kmoch 2015; Laniak et al. 2013; Schimak et al. 2010). Hence, the process discussed in this study should be further developed to incorporate spatial data infrastructures and publicly accessible data offerings. This would reduce the number of copied datasets and would enable and strengthen a transparent data holding and sharing within a holistic, transdisciplinary, and integrated analysis. This innovation would further avoid and reduce delay times in data provision and prevent stakeholders and practitioners wasting valuable time and resources in searching, obtaining, and pre-processing of datasets.

For creating the data inventory, services and their access, developers should follow the approach described by Klug and Kmoch (2014), who used a standard compliant web service architecture for inter-operable and thus a multi-purpose use of data and metadata. To ensure the proposed spatial data infrastructure complies with the Infrastructure for Spatial Information in Europe (INSPIRE) further work should follow the INSPIRE theme on Meteorological geographical features.[24] The data repositories should be registered in a Catalogue Service for the Web (OGC 2007a) using the ISO 19115 (2003) metadata standard and possibly extended to the XML schema according to the ISO 19139 (2007) standard. This would enable the transfer of information across platforms; again without copying and pre-processing of datasets but enable an immediate multi-purpose use of available resources.

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[24] http://inspire.ec.europa.eu/theme/mf

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