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# R in the Sensor Web

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**Abstract:** The sensor web enablement initiative designed services for sensor data handling, discovery and eventing, but did not cover the processing of it. Independent but at the same time the R community developed an interoperable platform for data analysis. We present novel technologies that connect the sensor web with R and vice versa, enabling the processing of sensor web data and dissemination of the results.

**Keywords:** R; sensor web; spatio-temporal;

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The SWE or sensor web enablement movement is mostly worried with interoperable, web service based ways of accessing data (sensor observation service, SOS), storing data (transactional sensor observation service, SOS-T), discovering sensors or sensor data (the sensors instance and observation registries, SIR/SOR), and defining events as a function of observed values (sensor event service, SES) and the notification sequence after that (web notification service, WNS). Surprisingly little effort has been put into analyzing sensor data, and serving or providing analyzed values. From a web service based perspective, analyzing data implies the computation of new values based on observed ones, and could be accomplished in the OGC realm by a web processing service (WPS). An example of such a WPS is the INTAMAP service (www.intamap.org, Pebesma et al., 2011). In an attempt to consider any numerical value, observed or generated, as a sensor, the SANY project (Havlik et al., 2009) extended the SWE to include aggregations, model predictions, and interpolations. Although they might rightly claim that some modelling (e.g. the conversion of an electric current to a temperature value in a sensor device does use a calibration curve) is usually hidden behind observations, the generalization that all information essentially is sensor information did not replace the mainstream paradigm of considering "observation", "modelling" and "prediction" as three distinct activities. One reason for not succesfully covering the data analysis field might be that the SWE and OGC communities largely consisted of informaticians who either thought that data analysis was uninteresting, or considered it an activity from another domain. Recent developments in the SWE community recognize the obstacles of complex data models and services when they suggest profiles that subset existing standards to a typical use case (Jirka et al., 2011), eventually supporting the desired interoperability.

In the meantime, during the same period that SWE was born and came to flourish, data analysis communities massively agreed upon an interoperable platform for exchanging data, software, and analysis scripts, and instead of needing a myriad of three letter acronyms, they only used R, which is not even an acronym. According to a New York Times article (Vance, 2009), R is the *lingua franca* of

data analysts inside corporations and academia. Although originally meant to be compatible with the commercial software S-Plus, the open source platform for statistics R has for more than a decade gained so much momentum that S-Plus compatibility no longer played a role. The ability to quickly exchange research findings, partly by using one of the 4000 add-on packages developed by a similar number of developers, has demonstrated to be a successful and growing model for communication.

This paper discusses three technologies currently in development at 52°North and the Institute for Geoinformatics, that bind R to the sensor web:

- the R package sos4R (Nüst et al., 2011), which allows R users to directly import sensor data from a sensor observation service
- the R package spacetime (Pebesma, 2011), which provides classes and methods for spatio-temporal data to R, and which opens the way for a structured and referenced way of analyzing spatio-temporal data (e.g. spatio-temporal interpolation, analysis of spatio-temporal point processes)
- the WPS4R package/WPS processing backend, which allows the exposure of arbitrary R scripts through a WPS interface

These three package acknowledge for instance that people with different backgrounds typically use different environments to solve problems. Domain specialists (hydrologists, soil scientists, climate modellers, ...) often do not program in Java or design data bases. They often use R. Still, for disseminating data, for coupling larger data bases with models, or for near real time data analysis systems, a solution consisting of a single R script may not be sufficient. Building bridges between the SWE technology and the R community might enable the means to build scalable and sustainable information systems, where dynamic sensor information and complex modelling are integrated in a sound and robust way and where specialists from different domains can work together.

**References and Notes**

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