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sos4R is **an OGC Sensor Observation Service client** written for the R software environment for statistical analysis. It supports (near) realtime querying of data from SOSs and subsequent analysis and visualization with the manifold capabilities of R.

Development supported by the **52°North Student Innovation Prize for Geoinformatics 2010**

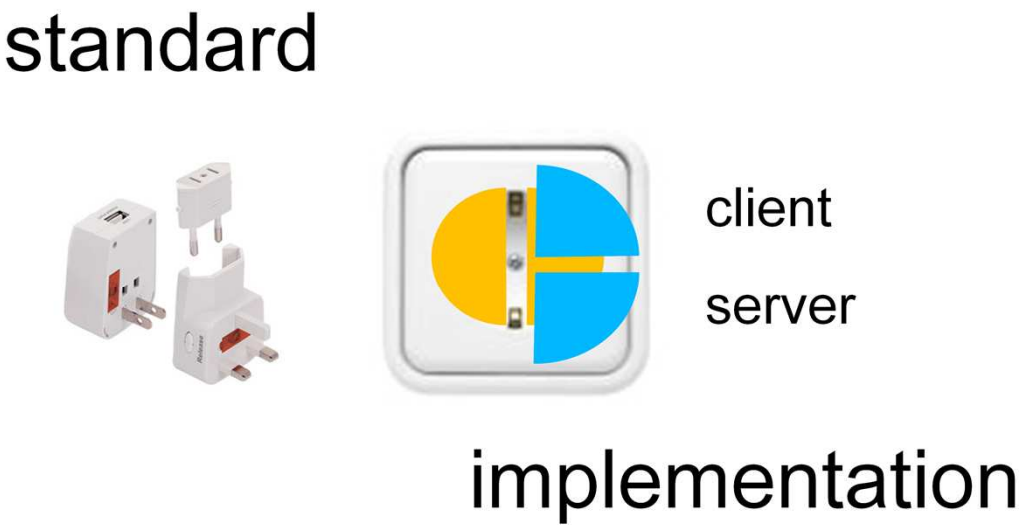
Thanks to Centre for Research into Statistical Methodology (CRiSM) for granting the conference bursary.

Personal motivation: Something that **should be done**, a project that is of great use to other people. Don't want to implement/work with standards for the standards sake only, but **use what I learned for interdisciplinary purposes.**

Program in R ☺.

More and more governments and organisations provide their data (sometimes via APIs, which are often proprietary), specific solutions for download and analysis exist, but also often csv/xls format, **Reproducible Research** well supported by R – **SOS could play a role in that**.

Spread SWE, R



Another motivation: Standard is only **half the solution**, implementations are needed… **OGC is a different world than R** – policy is (currently) standards before implementations. OGC realizes that standards are not always taking off as hoped.

Argument coming from a recent discussion in the SOS standards working group in the voting phase about lack of demand for implementation in OGC specification process. Only server side mentioned, or meant? IMHO the discussion was only about server side implementations, not clients...

*… but then also on the **client side**, not only the server side!*

I would like to **add a viewpoint**: t's worth worrying more about the **endpoints** rather than the service itself, i.e. Provide libraries for Java, C, Python and of course R and then the actual possibly complicated protocol is not that big of an issure anymore: **Develop libraries** rather than worry to much about interfaces

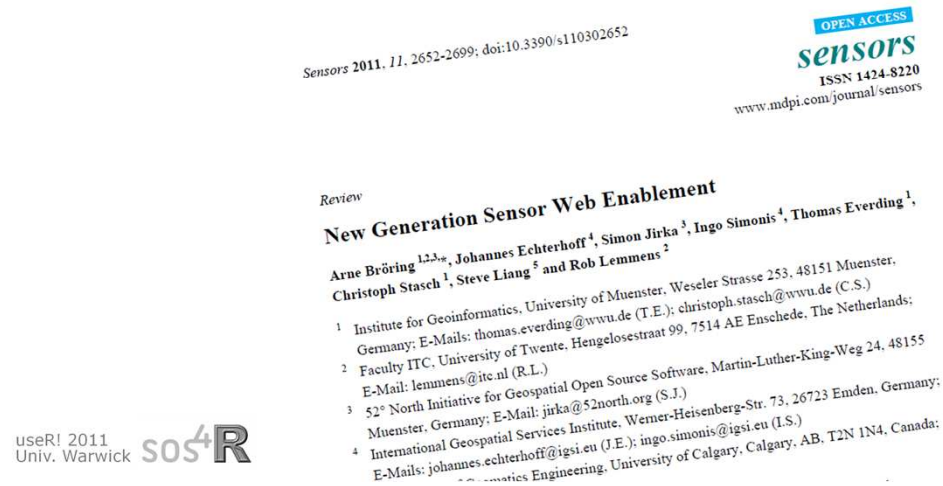
http://blog.programmableweb.com/2011/02/03/should-cloud-apis-focus-on-client-libraries-more-than-endpoints

http://us.cdn1.123rf.com/168nwm/winterling/winterling0606/winterling060600221/433375-white-power-outlet-w-path.jpg

http://www.bytelove.de/images/uploads/Gadgets/tools/world-travel-adaptor-img1.jpg

No dedicated, **generic open source SWE clients for** statistical **analysis**. There are **viewers** of varying abilities (OpenOOIS.org Map Viewer, SOS client for OpenLayers), **advanced viewers** visualize sensor positions on map and have tabular and graphic display of data (partly map overlays) like 52°North Clients, GeoCENS Sensor Web Browser, **plug-ins** to geographic information systems allow **importing** and subsequent **processing** with the respective software, but most importantly **data combination** with a large number of other data sources, like ArcGIS and uDig, gvSIG – **none of which is R**.

sensor web



What is the Sensor Web? **My short defintion**: Bringing sensors to the internet in an interoperable/standardized way. Required fuctionality: **Data access, data encoding, sensor tasking, eventing (**Subscription/Publishing**), discovery (**catalogues**).**

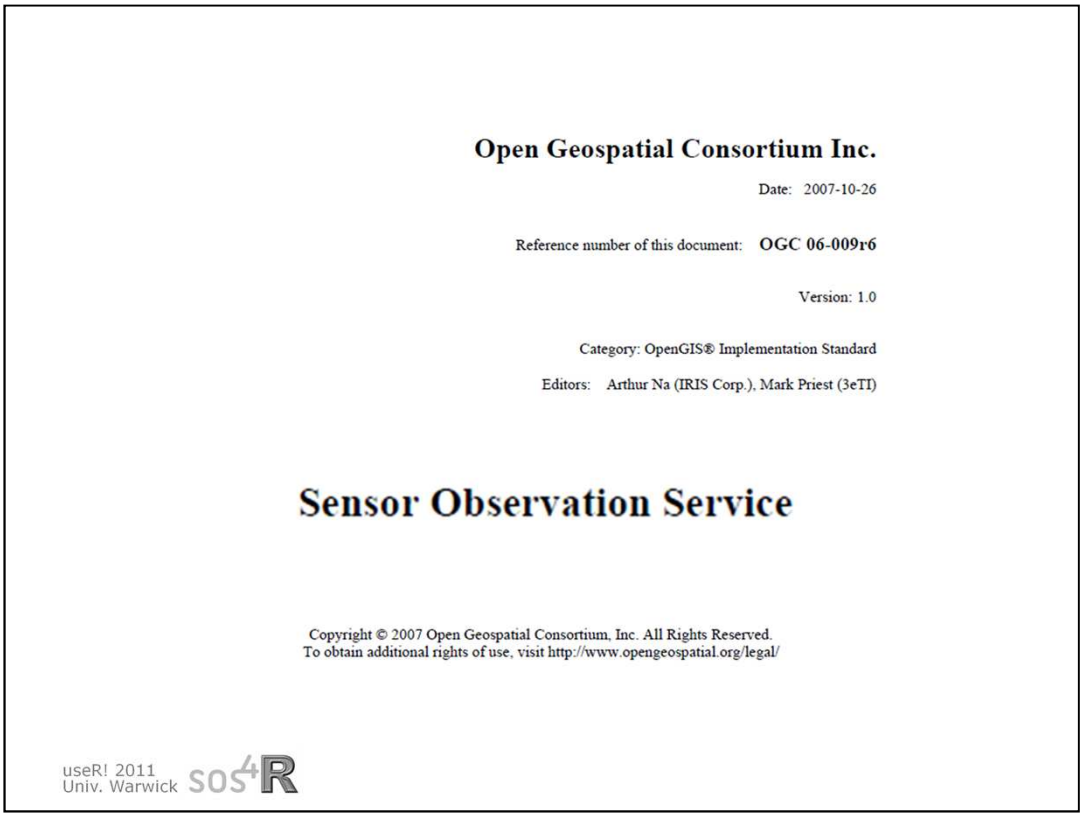
MOTIVATION: world full of sensors.

Service Model and **Information Model**

Wikipedia: *A Sensor Web is a type of sensor network or geographic information system (GIS) that is especially well suited for environmental monitoring.*

OGC: *A Sensor Web refers to web accessible sensor networks and archived sensor data that can be discovered and accessed using standard protocols and application program interfaces (APIs). (OGC 07-165)*

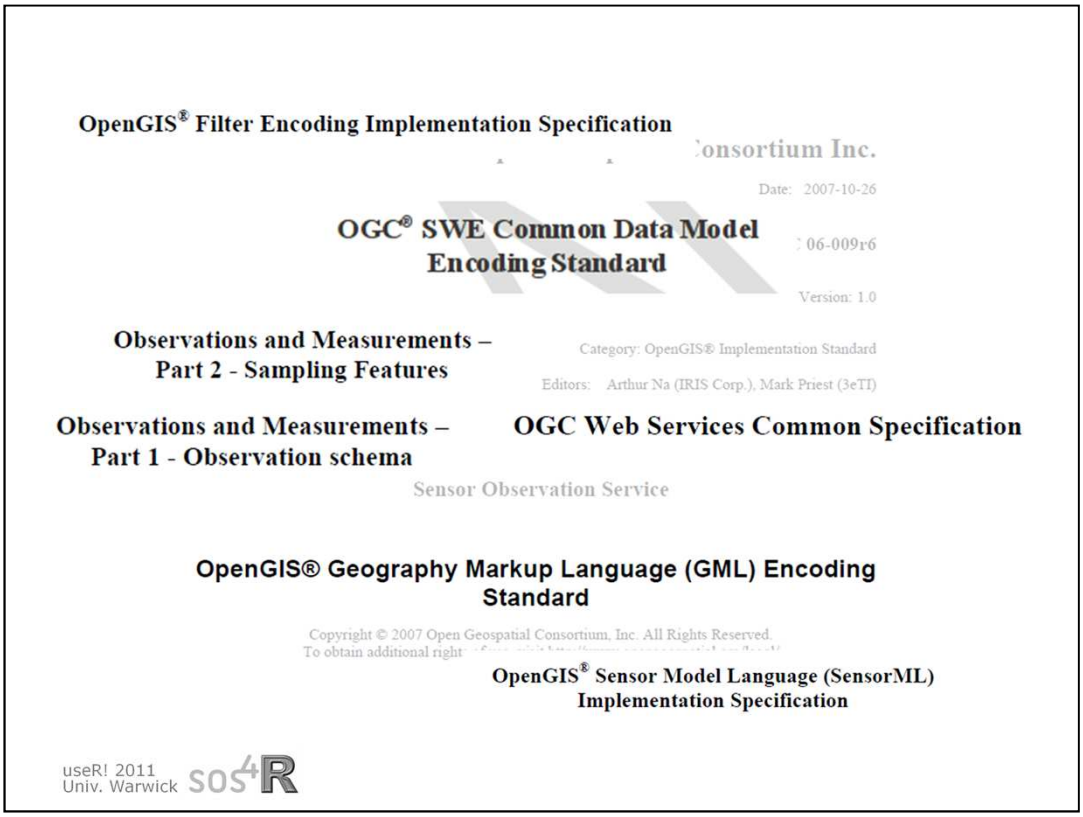
Great overview: Recent open access paper **„New Generation Sensor Web Enablement“**, valuable history and state of the art analysis to understand what was/is/will be going on, 48 pages and **154** (!) references: http://www.mdpi.com/1424-8220/11/3/2652/



A standardized data storage service for observations made by sensors.

Advanced **spatial**, **temporal** and **value based** filtering.
Who has heard of SOS before?

Problem: It comes with an **entourage**...

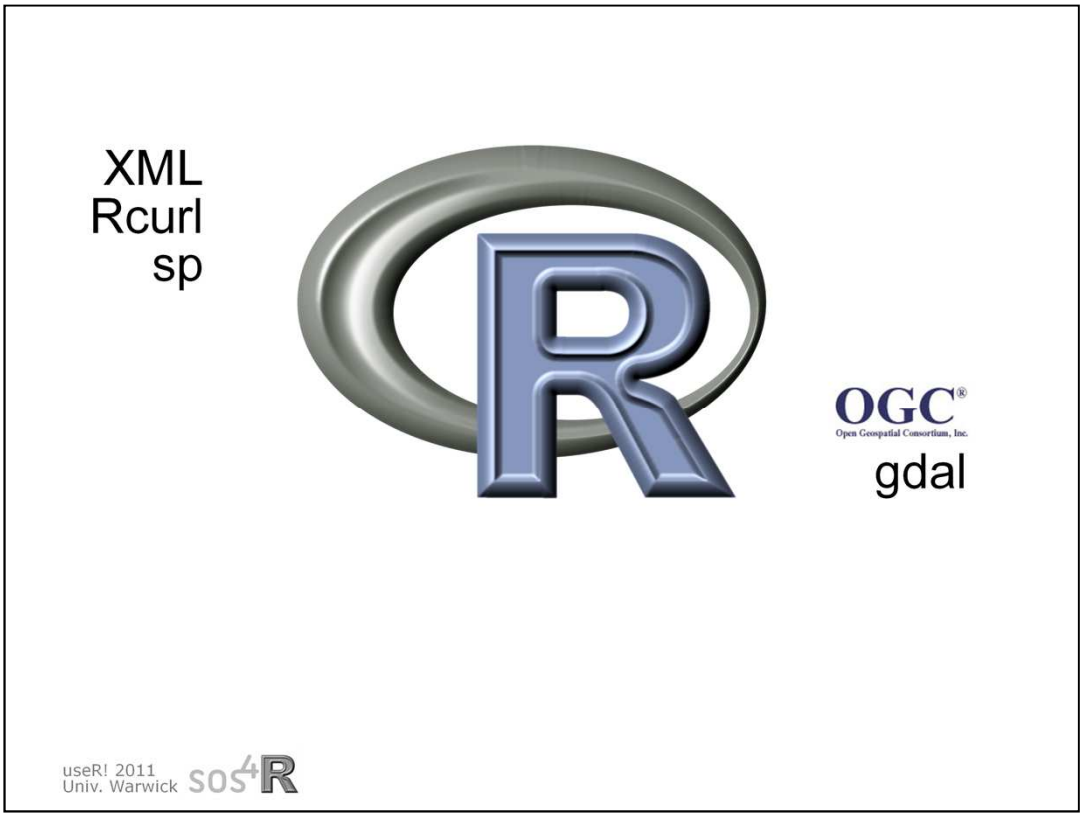


Known to SWE community, but (my guess/opinion/impression) not to many statisticians **– is that the reason for lack of applications and low number of service deployements?**

Who would like to work with close to real time environmental data?

Goal/Idea: keep this away from a user! Possible for „usual“ use cases.

Only possible so far, some terms and definitions needed. More on that in the example.



What packages do I rely on:

XML and for XML parsing/creation (still manual though!), **Rcurl** for transfer, **sp** for output as spatial classes

The one **limitation**: O&M Data Model… → ISSUES

OGC Integration in R so far: WFS, WCS, WMS possible via *gdal package* (Geospatial Data Abstraction Library), however, does not directly support typical sensor data, like in situ measurements, but vector and raster ("image") data.

client

exchangeability

filtering

classes and methods

Client: XML decoding, XML encoding, KVP encoding

Interactive creation of GET and POST request, with sensible defaults et cetera, encoding of requests and automatic decoding/parsing of responses to R objects for subsequent analysis

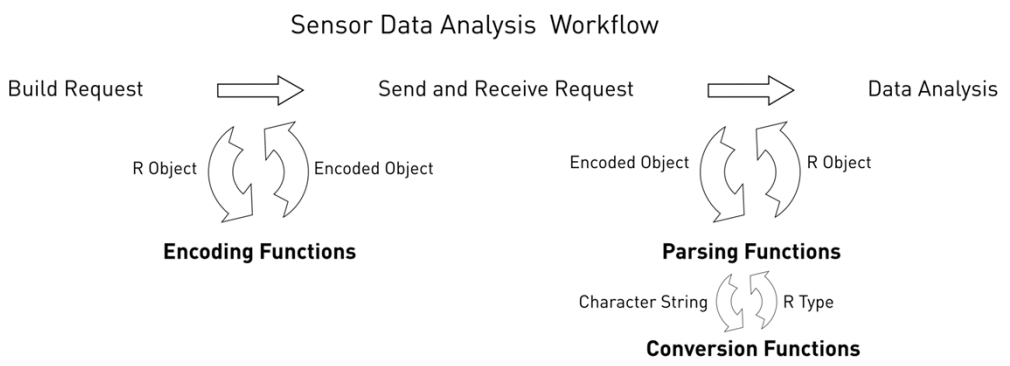
Exchangeability in the code for **Parsers**, **Encoders**, **Converters**

Filtering: temporal and simple bounding box filtering are **supported**, spatial and complete filtering only via manual creation (so far)

Classes and methods for SOS Core Profile: O&M (Support profile of 52N SOS), GML, SensorML - Could also have done that with *templates* and replacing, but that is just **messy**!

Also support for **CSV values by NOAA SOS**

Tested with SOS by 52°North, OOTethys and Degree (see list on website)



Exchangeability in a common workflow

Functions can be „overridden“ at all important points in the process: encoding, decoding (with conversion)

Ensures **forward compatibilty**

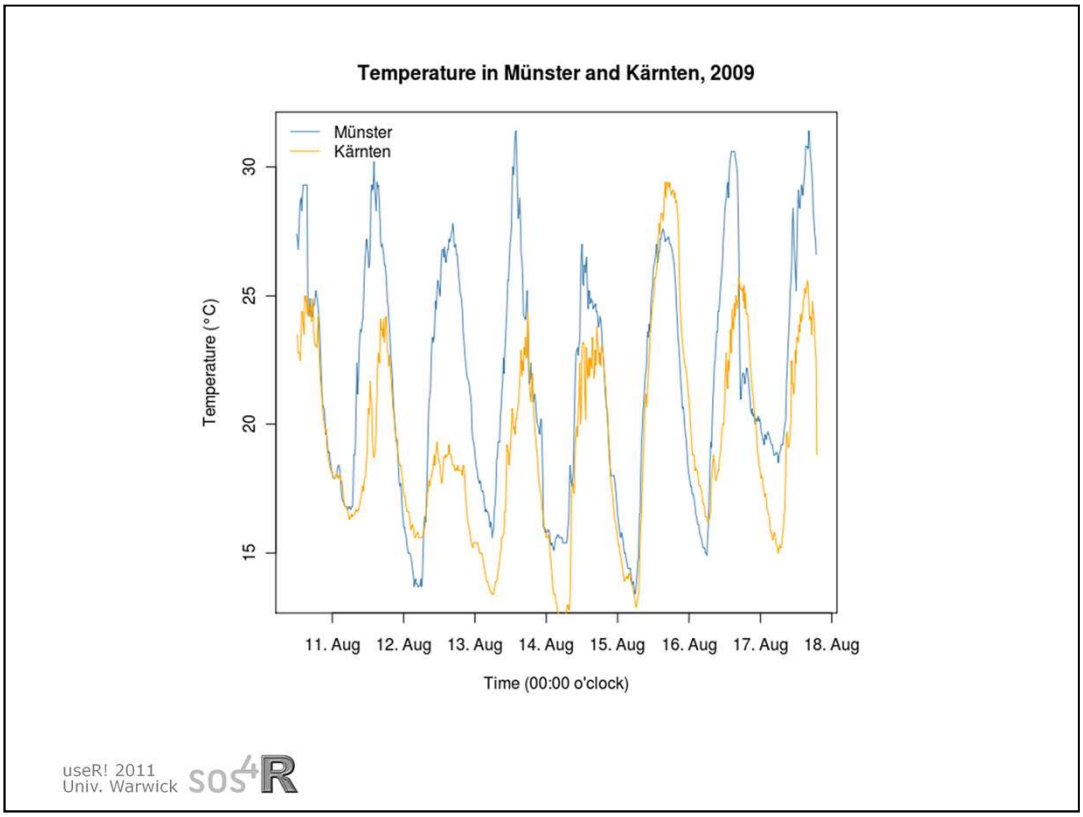
demo

Live demo

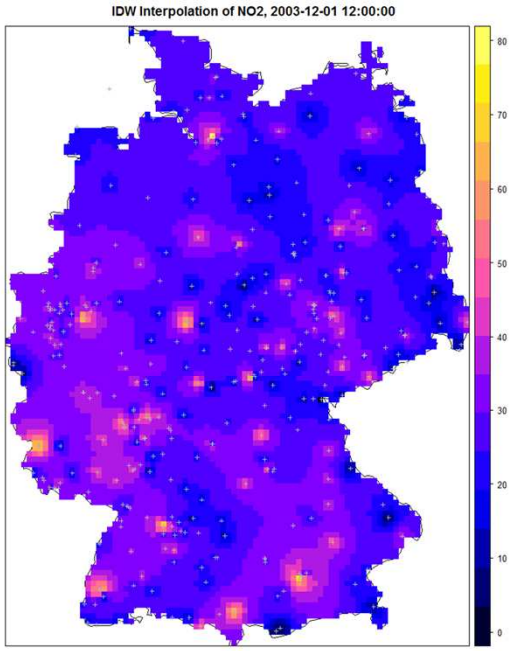
```
6  # establish a connection to a SOS instance with default settings
7  weathersos <- SOS(url = "http://v-swe.uni-muenster.de:8080/WeatherSOS/sos")
8
9  ##############################################################################
10 # Request two procedures
11 obs <- getObservation(sos = weathersos, offering = off,
12         procedure = sosProcedures(off),
13         eventTime = sosCreateEventTimeList(sosCreateTimePeriod(sos = weathersos,
14                         begin = as.POSIXct("2009-08-10 12:00"),
15                         end = as.POSIXct("2009-08-20 12:00"))))
16 obs
17
18 # Create plot
19 # Attention: plots ignore the fact that the times do NOT perfectly match!
20 x <- 800
21 plot(x = obs[[1]]@result[[1]][1:x], y = obs[[1]]@result[[3]][1:x], type = "l",
22         col = "steelblue", main = "Temperature in Muenster and Kaernten, 2009",
23         xlab = "Time (00:00 o'clock)",
24         ylab = "Temperature (°C)",
25         xaxt="n") # do not plot x-axis
26 r <- as.POSIXct(round(range(obs[[1]]@result[[1]]), "days"))
27 axis.POSIXct(side = 1, x = obs[[1]]@result[[1]][1:x], format = "%d. %h",
28         at = seq(r[1], r[2], by="day"))
29 lines(x = obs[[2]]@result[[1]][1:x], y = obs[[2]]@result[[3]][1:x],
30         col = "orange")
31 legend("topleft", legend = c("Muenster", "Kaernten"),
32         col = c("steelblue", "orange"), lty = 1, bty="n")
33
```


Code for plot WeatherSOS, **only lines 7 and 11 to 15 are actually sos4R code for the request**, the rest is plotting

52N SOS, so all the defaults work quite well…



Based on ifgi WeatherSOS, backup slide for live demo



useR! 2011
Univ. Warwick SOS4R

demo("airquality")

EEA Air Quality Data, **AirBase**, NO2

http://www.eea.europa.eu/themes/air/airbase/

IDW interpolation for one point in time (package **gstat**), by Edzer Pebesma

YOU are NOT the issue, but the future work!

Extended implementation of **GML/SWE schemas**, both ways – GENERAL MODEL FOR SPATIO-TEMPORAL DATA (SQLite?)
Transactional profile
Arbitrary filtering

spacetime for spatio-temporal data – model?

Question for all: Do or do not use SWE/SOS terms?

Missing a **implementable_ observation profile!** So interoperability goal is not reached. But it is in the works.

Missed a **public directory of SOS** for testing (apart from GEOSS registry), and a lot more services… INSPIRE II?

Read more or get in touch!

References:

- http://www.warwick.ac.uk/statsdept/user-2011/abstract_booklet.pdf, page 80
- *Nüst, D.*, Stasch, C. & Pebesma, E. J. (2011): **Connecting R to the Sensor Web** in Geertman, S.; Rei
- Websites:
    - www.nordholmen.net/sos4r
    - 52north.org/geostatistics