YYT-C3001 Management of environmental data and information

Lecture 5: Spatial data model technologies



Jussi Nikander

23.9.2020

Contents of this lecture

Data representation formats

Spatial reference systems, temporal data and metadata

Spatial data modeling in databases

GeoPackage

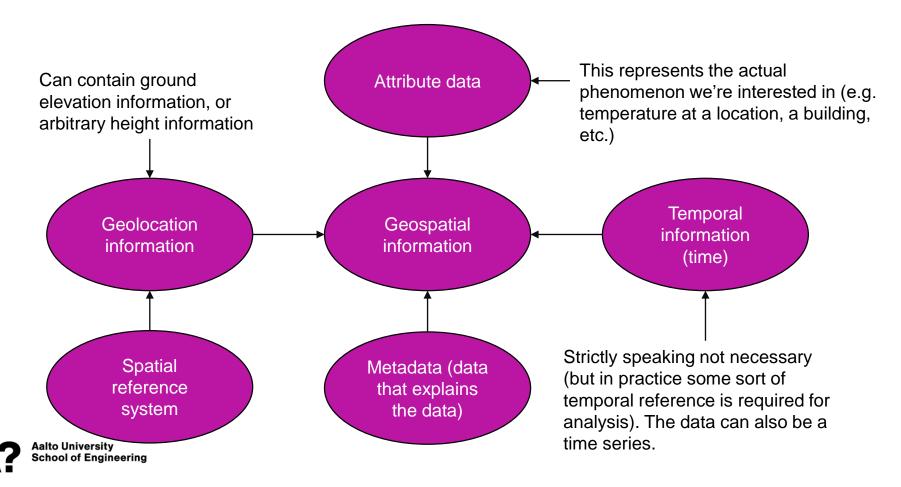


Learning goals for this lecture

- Reiterate your knowledge of raster and vector data (from MAA-C2005 Geoinformation in Environmental Modeling)
- Understand what is required for a spatial dataset that can be provided to other users
- Understand the contributions of the different parts of the data sets to interoperability
- Familiarize yourself with the idea of GeoPackage data format



Structure of geospatial information



Geolocation information and attribute data



Lecture exercise

I will divide you into breakout rooms in Zoom

In breakout rooms consider the following

- What are vector and raster data formats? What sort of data are they
 made to represent? What similarities and differences are there
 between the data formats?
- Consider representing waters (lakes, rivers, the sea) as a raster and as a vector layer. Come up with use cases where vector would be better than raster and vice versa. What in these use cases makes one data representation better than the other?

Let's use 15 minutes for this

https://jamboard.google.com/d/1Lx86vEov4kgrPVEL0cwIX6iWaTEv9eFXoIzTGvpQx0/edit?usp=sharing



Geospatial data example

- Each blue dot in the example represents a building
- The dot is a point data element; a coordinate value pair
- In this dataset, the shape of the building is not stored
- Each building has many attribute data elements
- Together, buildings become a spatial data layer
- In this case the layer is stored as a single file on a computer

spoo_build	dings_2013 - 6674831	
FID	146	
РКОО	6674831	
IKOO	25489989	
KATU	Tietotie	
OSNO1	1	
POSNO	02150	
KAVU	1970	
KATAKER	532	
TILAV	87540	
KERALA	12774	
KORALA	13029	
KOHALA	120	
MP	2	
ASHALA	120	Your State
TOIMALA	0	
RA	9999999999	



Geospatial data representation: vector data

The building data in the example is in vector data format

In vector format the data consists of discrete features that have attributes attached to them

• Features can be points, lines, or areas (polygons)

| Espoo_buildings_2013 × | | | |

 |

 | | | | | |
 | | + |
 | | | | | |
 | |
 |
 | |
 | |
 | | |
 | | | | |
|--|--|--|---
--
--
--
--
--
--
--
--

--|--|---|--|---|--
---|---
---|---|---|---|---
--|--|--
--
---|--|---
--
--|--

---|---|---|---|---|---|---|
| ld: 調 Add 頭 Delete 酮 Calculate The Coom To | | | |

 |

 | | | | | |
 | | |
 | | | | | |
 | |
 |
 | |
 | |
 | | |
 | | | | |
| Shape * | pu | IKOO | KATU | OSNO1

 | 1 POSNO

 | KAVU | KATAKER | TILAV | KERALA | KORALA | KOHALA
 | MP | ASHALA | TOIMALA
 | RA | VSHEN | ASLKM | HU01 | ALA1 | AS1
 | HUO2 | ALA2
 | AS2
 | HUO3 | ALA3
 | AS3 | HUO4
 | ALA4 | AS4 | HUO5
 | ALA5 | AS5 H | HUO6_YLI | AL |
| Point | 6674787 | 25489694 | Tekniikantie | 21

 | / 02150

 | 1987 | 532 | 2622 | 811 | 811 | 0
 | 2 | 0 | 0
 | 3 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | |
| Point | 6674826 | 25489710 | Tekniikantie | 21

 | 02150

 | 1987 | 532 | 2622 | 811 | 811 | 0
 | 2 | 0 | 0
 | 3 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | |
| Point | 6674847 | 25489675 | Tekniikantie | 21

 | / 02150

 | 1987 | 532 | 2622 | 811 | 811 | 0
 | 2 | 0 | 0
 | 3 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | / |
| Point | 6674848 | 25489630 | Tekniikantie | 21

 | 02150

 | 1987 | 532 | 2622 | 811 | 811 | 0
 | 2 | 0 | 0
 | 3 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | |
| Point | 6674671 | 25489827 | Tekniikantie | 17

 | / 02150

 | 1997 | 532 | 100268 | 21481 | 21834 | 0
 | 8 | 0 | 0
 | 1 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | _ / |
| Point | 6674831 | 25489989 | Tietotie | 1

 | 02150

 | 1970 | 532 | 87540 | 12774 | 13029 | 120
 | 2 | 120 | 0
 | 999999999 | 0 | 2 | 0 | 0 | 0
 | 4 | 120
 | 2
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | |
| Point | 6674839 | 25490119 | Tietotie | 1

 | 1 02150

 | 1965 | 613 | 0 | 50 | 0 | 0
 | 0 | 0 | 0
 | 1 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | / |
| Point | 6674767 | 25489989 | Tietotie | 1

 | 1 02150

 | 1985 | 532 | 13335 | 2619 | 2899 | 0
 | 1 | 0 | 0
 | 1 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | _ |
| Point | 6674786 | 25489934 | Tietotie | 1

 | 1 02150

 | 2002 | 941 | 51 | 24 | 24 | 0
 | 1 | 0 | 0
 | 3 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | / |
| Point | 6674461 | 25489888 | Tekniikantie | 13

 | 02150

 | 1979 | 532 | 18950 | 3952 | 5518 | 73
 | 3 | 73 | 0
 | 1 | 0 | 1 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 3 | 73
 | 1 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | / |
| Point | 6674460 | 25489848 | Tekniikantie | 13

 | 3 02150

 | 2003 | 941 | 220 | 65 | 65 | 0
 | 1 | 0 | 0
 | 3 | 0 | 0 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 0
 | 0 | 0 | 0
 | 0 | 0 | 0 | |
| Point | 6674360 | 25489972 | Tekniikantie | 11

 | 02150

 | 2000 | 11 | 580 | 105 | 210 | 89
 | 1 | 89 | 0
 | 1 | 67 | 1 | 0 | 0 | 0
 | 0 | 0
 | 0
 | 0 | 0
 | 0 | 4
 | 89 | 1 | 0
 | 0 | 0 | 0 | / |
| _ | <u> </u> | | |

 |

 | _ | | | | |
 | | |
 | | | 1 | | |
 | |
 | _
 | |
 | |
 | | | | |
 | | | | ÞΨ |
| 1 of 553' | 24 selected | a l | |

 |

 | | | | | |
 | | |
 | | | | | |
 | |
 |
 | |
 | ſ | Filters: 🖑
 | | ál 🗘 | -
 | | + | 100 % 🔹 | - 12 |
| | Add Shape Point Po | Add Delete Shape 20 Point 6674787 Point 6674826 Point 6674847 Point 667481 Point 667481 Point 6674839 Point 667487 Point 6674767 Point 6674767 | Add Peter Catchel Shape 20 IKOO Point 6674827 25489649 Point 6674827 25489679 Point 6674847 25489630 Point 6674837 25489630 Point 6674837 25489630 Point 6674831 25489989 Point 6674837 25489989 Point 6674836 25499119 Point 6674787 25489989 Point 6674780 25489983 Point 6674786 25489848 Point 6674830 25489848 Point 6674861 25489848 Point 6674861 25489848 Point 6674860 25489848 Point 6674600 25489848 | Add Delete Example Calculate Example Calculate Calculate <thcalculate< t<="" th=""><th>Add Delete Calculat Calculat Calculat Calculat Concention <t< th=""><th>Add Delete Exact State Calculate Calculate Calculate Calculate Control Switch Shape 20 IKOO KATU OSNO1 POSNO Point 6674787 25489694 Tekniikantie 21 02150 Point 6674872 25489675 Tekniikantie 21 02150 Point 6674874 25489675 Tekniikantie 21 02150 Point 6674881 25489675 Tekniikantie 21 02150 Point 6674881 25489675 Tekniikantie 21 02150 Point 6674871 25489867 Tekniikantie 10 02150 Point 667481 25489989 Tetotie 10 02150 Point 667477 25489989 Tetotie 10 02150 Point 6674767 25489983 Tetotie 11 02150 Point 6674460 2548988 Tekniikantie 13 02150</th><th>Add Delete Calculate Calculat Calculate Calculat</th><th>Add Delete Calculate Calculate Calculate Delete D</th><th>Add Delet Calcult Calcult Calcult Switch $\Box Clev$ $\Box Delet$ Shape 20 IKO KATU OSNOI POSNO KAVU KATKER TLAV Point 667477 25489694 Tekniikantie 21 02150 1987 532 2622 Point 667487 25489675 Tekniikantie 21 02150 1987 532 2622 Point 667487 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489670 Tekniikantie 21 02150 1987 532 1002 Point 667487 25489949 Tekniikantie 21 02150 1985 532 13335 <</th><th>Add Delet Example Calcult Calcult</th><th>AddDeleteCalculateCalculateControl\mathbb{C}^{1} south\mathbb{C}^{1} south</th><th>Add Delet <thd< th=""><th>Add Belet Belet</th><th>Add Delet Display <thdisplay< th=""> <thdisplay< th=""> <thdispla< th=""><th>AldDeteCalcultCaccultCorontDescriptionDescriptionDescriptionShapeVoKOVKAUSNOIPONOKAVKATAKERTLAVKERALAKORALAKOHALAMPASHALATOIMALAPoint66747725489694Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie21021501987552100262148121481018000Point66746725489807Tekniikantie2102150199755210026214812148101800</th><th>All and any and any and any and any and any any any any any any any any any any</th><th>Note the section of th</th><th>AndBy elseBy Cal - ViewColoreBy SinceElse - ViewDescriptionBin viewColoreDescriptionSince</th></thdispla<></thdisplay<></thdisplay<></th></thd<></th></t<><th>AldBy etcBy classical control actions all control ac</th><th>Alt Belo Example Account @ Zorone Birth Birth</th><th>AldBy etaBy classical control actions all control ac</th><th>Image Image <th< th=""><th>AldBeloCalcularCalcularCalcularSinceCalcularCa</th><th>All endBest - Location of Loc</th><th>Image Image <th< th=""><th>All Big and the second below in the seco</th><th>Image Image <th< th=""><th>All Big and Big and</th><th>All interpretent interpre</th><th>All in the state in the s</th><th>All bits Bits Control <thcontrol< th=""> <thcontrol< th=""> <thcon< th=""><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th></thcon<></thcontrol<></thcontrol<></th></th<></th></th<></th></th<></th></th></thcalculate<> | Add Delete Calculat Calculat Calculat Calculat Concention Concention <t< th=""><th>Add Delete Exact State Calculate Calculate Calculate Calculate Control Switch Shape 20 IKOO KATU OSNO1 POSNO Point 6674787 25489694 Tekniikantie 21 02150 Point 6674872 25489675 Tekniikantie 21 02150 Point 6674874 25489675 Tekniikantie 21 02150 Point 6674881 25489675 Tekniikantie 21 02150 Point 6674881 25489675 Tekniikantie 21 02150 Point 6674871 25489867 Tekniikantie 10 02150 Point 667481 25489989 Tetotie 10 02150 Point 667477 25489989 Tetotie 10 02150 Point 6674767 25489983 Tetotie 11 02150 Point 6674460 2548988 Tekniikantie 13 02150</th><th>Add Delete Calculate Calculat Calculate Calculat</th><th>Add Delete Calculate Calculate Calculate Delete D</th><th>Add Delet Calcult Calcult Calcult Switch $\Box Clev$ $\Box Delet$ Shape 20 IKO KATU OSNOI POSNO KAVU KATKER TLAV Point 667477 25489694 Tekniikantie 21 02150 1987 532 2622 Point 667487 25489675 Tekniikantie 21 02150 1987 532 2622 Point 667487 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489670 Tekniikantie 21 02150 1987 532 1002 Point 667487 25489949 Tekniikantie 21 02150 1985 532 13335 <</th><th>Add Delet Example Calcult Calcult</th><th>AddDeleteCalculateCalculateControl\mathbb{C}^{1} south\mathbb{C}^{1} south</th><th>Add Delet <thd< th=""><th>Add Belet Belet</th><th>Add Delet Display <thdisplay< th=""> <thdisplay< th=""> <thdispla< th=""><th>AldDeteCalcultCaccultCorontDescriptionDescriptionDescriptionShapeVoKOVKAUSNOIPONOKAVKATAKERTLAVKERALAKORALAKOHALAMPASHALATOIMALAPoint66747725489694Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie21021501987552100262148121481018000Point66746725489807Tekniikantie2102150199755210026214812148101800</th><th>All and any and any and any and any and any any any any any any any any any any</th><th>Note the section of th</th><th>AndBy elseBy Cal - ViewColoreBy SinceElse - ViewDescriptionBin viewColoreDescriptionSince</th></thdispla<></thdisplay<></thdisplay<></th></thd<></th></t<> <th>AldBy etcBy classical control actions all control ac</th> <th>Alt Belo Example Account @ Zorone Birth Birth</th> <th>AldBy etaBy classical control actions all control ac</th> <th>Image Image <th< th=""><th>AldBeloCalcularCalcularCalcularSinceCalcularCa</th><th>All endBest - Location of Loc</th><th>Image Image <th< th=""><th>All Big and the second below in the seco</th><th>Image Image <th< th=""><th>All Big and Big and</th><th>All interpretent interpre</th><th>All in the state in the s</th><th>All bits Bits Control <thcontrol< th=""> <thcontrol< th=""> <thcon< th=""><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th></thcon<></thcontrol<></thcontrol<></th></th<></th></th<></th></th<></th> | Add Delete Exact State Calculate Calculate Calculate Calculate Control Switch Shape 20 IKOO KATU OSNO1 POSNO Point 6674787 25489694 Tekniikantie 21 02150 Point 6674872 25489675 Tekniikantie 21 02150 Point 6674874 25489675 Tekniikantie 21 02150 Point 6674881 25489675 Tekniikantie 21 02150 Point 6674881 25489675 Tekniikantie 21 02150 Point 6674871 25489867 Tekniikantie 10 02150 Point 667481 25489989 Tetotie 10 02150 Point 667477 25489989 Tetotie 10 02150 Point 6674767 25489983 Tetotie 11 02150 Point 6674460 2548988 Tekniikantie 13 02150 | Add Delete Calculate Calculat Calculate Calculat | Add Delete Calculate Calculate Calculate Delete D | Add Delet Calcult Calcult Calcult Switch $\Box Clev$ $\Box Delet$ Shape 20 IKO KATU OSNOI POSNO KAVU KATKER TLAV Point 667477 25489694 Tekniikantie 21 02150 1987 532 2622 Point 667487 25489675 Tekniikantie 21 02150 1987 532 2622 Point 667487 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489675 Tekniikantie 21 02150 1987 532 2622 Point 6674871 25489670 Tekniikantie 21 02150 1987 532 1002 Point 667487 25489949 Tekniikantie 21 02150 1985 532 13335 < | Add Delet Example Calcult Calcult | AddDeleteCalculateCalculateControl \mathbb{C}^{1} south | Add Delet Delet <thd< th=""><th>Add Belet Belet</th><th>Add Delet Display <thdisplay< th=""> <thdisplay< th=""> <thdispla< th=""><th>AldDeteCalcultCaccultCorontDescriptionDescriptionDescriptionShapeVoKOVKAUSNOIPONOKAVKATAKERTLAVKERALAKORALAKOHALAMPASHALATOIMALAPoint66747725489694Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie21021501987552100262148121481018000Point66746725489807Tekniikantie2102150199755210026214812148101800</th><th>All and any and any and any and any and any any any any any any any any any any</th><th>Note the section of th</th><th>AndBy elseBy Cal - ViewColoreBy SinceElse - ViewDescriptionBin viewColoreDescriptionSince</th></thdispla<></thdisplay<></thdisplay<></th></thd<> | Add Belet Belet | Add Delet Display Display <thdisplay< th=""> <thdisplay< th=""> <thdispla< th=""><th>AldDeteCalcultCaccultCorontDescriptionDescriptionDescriptionShapeVoKOVKAUSNOIPONOKAVKATAKERTLAVKERALAKORALAKOHALAMPASHALATOIMALAPoint66747725489694Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie21021501987552100262148121481018000Point66746725489807Tekniikantie2102150199755210026214812148101800</th><th>All and any and any and any and any and any any any any any any any any any any</th><th>Note the section of th</th><th>AndBy elseBy Cal - ViewColoreBy SinceElse - ViewDescriptionBin viewColoreDescriptionSince</th></thdispla<></thdisplay<></thdisplay<> | AldDeteCalcultCaccultCorontDescriptionDescriptionDescriptionShapeVoKOVKAUSNOIPONOKAVKATAKERTLAVKERALAKORALAKOHALAMPASHALATOIMALAPoint66747725489694Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie2102150198755226228118110022000Point66746725489675Tekniikantie21021501987552100262148121481018000Point66746725489807Tekniikantie2102150199755210026214812148101800 | All and any and any and any and any and any | Note the section of th | AndBy elseBy Cal - ViewColoreBy SinceElse - ViewDescriptionBin viewColoreDescriptionSince | AldBy etcBy classical control actions all control ac | Alt Belo Example Account @ Zorone Birth Birth | AldBy etaBy classical control actions all control ac | Image Image <th< th=""><th>AldBeloCalcularCalcularCalcularSinceCalcularCa</th><th>All endBest - Location of Loc</th><th>Image Image <th< th=""><th>All Big and the second below in the seco</th><th>Image Image <th< th=""><th>All Big and Big and</th><th>All interpretent interpre</th><th>All in the state in the s</th><th>All bits Bits Control <thcontrol< th=""> <thcontrol< th=""> <thcon< th=""><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th></thcon<></thcontrol<></thcontrol<></th></th<></th></th<></th></th<> | AldBeloCalcularCalcularCalcularSinceCalcularCa | All endBest - Location of Loc | Image Image <th< th=""><th>All Big and the second below in the seco</th><th>Image Image <th< th=""><th>All Big and Big and</th><th>All interpretent interpre</th><th>All in the state in the s</th><th>All bits Bits Control <thcontrol< th=""> <thcontrol< th=""> <thcon< th=""><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th></thcon<></thcontrol<></thcontrol<></th></th<></th></th<> | All Big and the second below in the seco | Image Image <th< th=""><th>All Big and Big and</th><th>All interpretent interpre</th><th>All in the state in the s</th><th>All bits Bits Control <thcontrol< th=""> <thcontrol< th=""> <thcon< th=""><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th></thcon<></thcontrol<></thcontrol<></th></th<> | All Big and | All interpretent interpre | All in the state in the s | All bits Bits Control Control <thcontrol< th=""> <thcontrol< th=""> <thcon< th=""><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th><th>All all all all all all all all all all</th></thcon<></thcontrol<></thcontrol<> | All | All | All |



Discrete objects and geometry types

- In most spatial models, three spatially distinct types of discrete objects are used
- Point has one set of coordinate values and represents single location
- Polyline consists of two or more points that are linked together
- Polygon consist of an area enclosed by a closed polyline





Point data (traffic accidents 2016)



Polyline data (road network)



Polygon data (municipal borders)

Geospatial data representation: vector data

In a vector data set each data element (such as building) can have numerous attribute data elements

Below is a table representation of the data set, showing all the attributes for each building The Shape column contains spatial data, all other columns contain attribute data

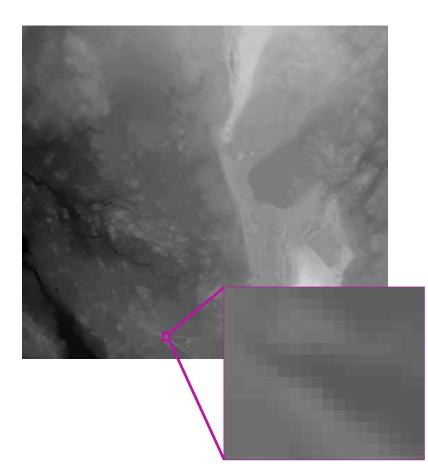
III Esp	Espoo_buildings_2013 ×																																				
Field:	🐺 Add	🕎 Delete	a 🔃 Calcy	ulate Selection: 7	Zoom To	Berne .		tor Ix Delet					-										_	_	_		_	_	_	_	_					7	≡
	D Shape	e PKOO	IKOO	KATU	OSNO1	1 POSNO	KAVU	KATAKER	TILAV	KERALA	KORALA	KOHALA I	MP	ASHALA	TOIMALA	RA	VSHEN	N ASLKN	мн	IUO1 A	ALA1	AS1 H	HUO2	ALA2	AS2	HUO3	ALA3	AS3 I	HUO4	ALA4	AS4	HUO5	5 ALA	.5 AS5	5 HUO6_	YLI A	S
141	11 Point	6674787	25489094	Telefilia antes		1 02150	1987	532	2622	811	811	0	2	0	0	3	<u> </u>	0 /	0	0	0	0	0	0	0	0							<u> </u>	0 0		0	
142	12 Point	6674826	25489710) Tekniikantie	21	1 02150	1987	532	2622	811	811	0	2	0	0	3	1	0 /	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	
143	13 Point	6674847	25489675	j Tekniikantie	21	1 02150	1987	532	2622	811	811	0	2	0	0	3	1 1	0 /	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	1
144	I4 Point	6674848	25489630) Tekniikantie	21	1 02150	1987	532	2622	811	811	0	2	0	0 0	3	1 1	0 /	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	/ /
145	5 Point	6674671	25489827	7 Tekniikantie	17	7 02150	1997	532	100268	21481	21834	0	8	0	0 0	1	(0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	17
146	16 Point	6674831	25489989	Tietotie	1	1 02150	1970	532	87540	12774	13029	120	2	120	0	999999999	1	0	2	0	0	0	4	120	2	0	0	0	0	0	0	0		0 0		0	
147	7 Point	6674839	25490119	Tietotie	1	1 02150	1965	613	0	50	0	0	0	0	0	1	(0 /	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	17
148	18 Point	6674767	7 25489989	Tietotie	1	1 02150	1985	532	13335	2619	2899	0	1	0	0	1	1	0 /	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	
149	9 Point	6674786	5 25489934	Tietotie	1	1 02150	2002	941	51	24	24	0	1	0	0 0	3	1 1	0 /	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	1
150	i0 Point	6674461	25489888	B Tekniikantie	13	3 02150	1979	532	18950	3952	5518	73	3	73	3 0	1	1	0	1	0	0	0	0	0	0	3	73	1	0	0	0	0	1	0 0	1	0	
151	i1 Point	6674460	25489848	B Tekniikantie	13	3 02150	2003	941	220	65	65	0	1	0	0 0	3	1 1	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0	1	0	
152	2 Point	6674360	25489972	? Tekniikantie	11	1 02150	2000	11	580	105	210	89	1	89	9 0	1	1 67	7	1	0	0	0	0	0	0	0	0	0	4	89	1	0	1	0 0	1	0	
																<u> </u>	<u> </u>	_	_	_	1	_					_	_	_								<i></i>
		324 selected																										F	Filters:		Gil \$	-			+ 100	0% •	2

Aalto University

chool of Engineering

Geospatial data example 2

- The raster layer in this example represents elevation
- Each raster cell (pixel) covers a 10m x 10m area
- The cell value represents the elevation at that area
 - Naturally, in real life elevation inside a pixel area can vary
- The layer represents one phenomenon (~attribute value) and covers a large geographical area
- A background map is not visible since the raster covers the whole area



Geospatial data presentation: Pixel value Number of pixels with the given value

In raster data format, the data consists of a regular tessellation that covers an area

A raster layer represents a continuous phenomenon that can be measured

 The area is divided into small, regular polygons, typically squares (triangles and hexagons can also be used)

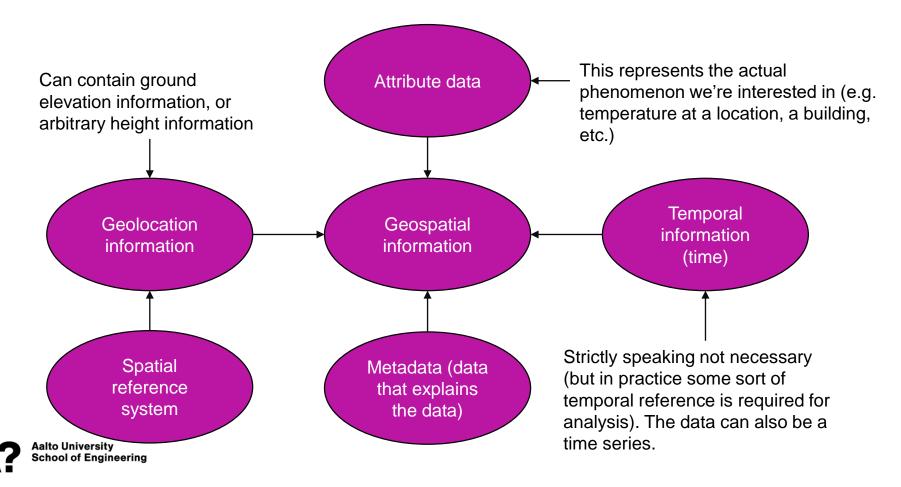
Each cell (pixel) in the raster represents the value of the phenomenon on the area covered by the cell

If many phenomena are to be covered, several raster layers are required





Structure of geospatial information



Spatial references, temporal data, and metadata



Spatial reference systems

Coordinate systems

- Geographic coordinates (spherical surface)
 - E.g. ETRS89
- Projected coordinates (planar surface)
 - E.g. ETRS-TM35FIN

Map projections transform geographic coordinates (lat, lon) into planar coordinates (x, y)

A spatial reference defines the parameters required for using a specific coordinate system



Spatial reference system example: ETRS89 EPSG:4258

A reference system covering Europe, where the Eurasian plate is static

The EPSG number is a Spatial **Reference ID**, which unambiguously identifies this SRS

If you don't know what SRS your dataset has, you have a problem



ETRS89



Unit: degree (supplier to define representation) Geodetic CRS: ETRS89 Datum: European Terrestrial Reference System 1989 Ellipsoid: GRS 1980 Prime meridian: Greenwich Data source: OGP Information source: EPSG. See 3D CRS for original information source.

Revision date: 2018-02-16

Scope: Geographic Information.

Remarks: Has been realized through ETRF89, ETRF90, ETRF91, ETRF92, ETRF93, ETRF94, ETRF96, ETRF97, ETRF2000, ETRF2005 and ETRF2014. This 'ensemble' covers any or all of these realizations without distinction.

Area of use: Europe - onshore and offshore: Albania; Andorra; Austria; Belgium; Bosnia and Herzegovina; Bulgaria; Croatia; Cyprus; Czech Republic; Denmark; Estonia; Faroe Islands; Finland; France; Germany; Gibraltar; Greece; Hungary; Ireland; Italy; Latvia; Liechtenstein; Lithuania; Luxembourg; Macedonia; Malta; Moldova; Monaco; Montenegro; Netherlands; Norway including Svalbard and Jan Mayen; Poland; Portugal; Romania; San Marino; Serbia; Slovakia; Slovenia; Spain; Sweden; Switzerland; Ukraine; United Kingdom (UK) including Channel Islands and Isle of Man; Vatican City State.

Coordinate system: Ellipsoidal 2D CS. Axes: latitude, longitude. Orientations: north, east. UoM: degree

SRS lecture exercise

I'll give you three pictures of a map view containing a background map and a population tile data. I'll also give you three spatial reference systems.

Connect the map view to the correct SRS. Consider why you answer the way you do.

Let's use at 10 minutes for this; it is individual work – after 5 minutes I'll put up a presemo where you can put your answers.









А

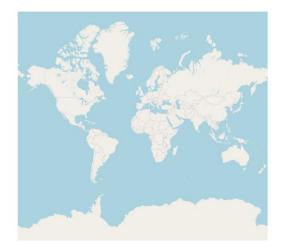
В

С

Spatial reference systems: 1. EPSG 3067 (ETRS-TM35FIN) 2. EPSG 3857 (WGS84 web pseudo-Mercator) 3. EPSG 4258 (ETRS89)

Bonus question: which of the above images represent appropriate use of the corresponding SRS?

Aalto University School of Engineering Fill in your answers at https://presemo.aalto.fi/medi1







A - 2

B - 3

C - 1

Spatial reference systems: 1. EPSG 3067 (ETRS-TM35FIN) 2. EPSG 3857 (WGS84 web pseudo-Mercator) 3. EPSG 4258 (ETRS89)

Bonus question: which of the above images represent appropriate use of the corresponding SRS?

Bonus answer: EPSG 3857 covers the whole Earth, so it is used appropriately.



Temporal data

Spatial dataset should always have a temporal aspect

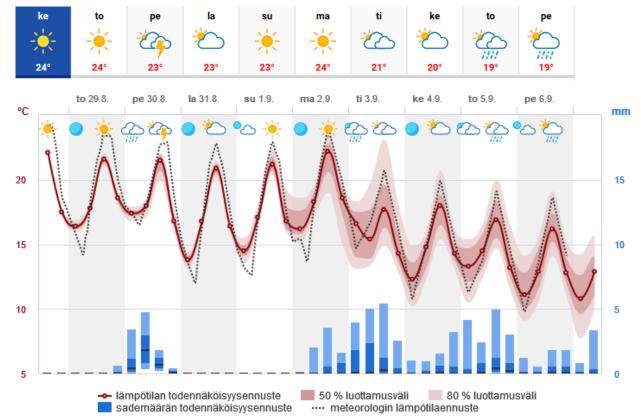
- A dataset can consist of several time steps (e.g. weather forecast)
- A dataset can represent the situation at a specific moment of time
- A dataset that consist of several time steps can be very sensitive to the length of the time step
- Hourly weather forecast vs. daily weather forecast



Temporal data example (nonspatial view)

A weather forecast for a 10-day period on both daily resolution, and on a 6-hour resolution

Notice especially the temperature on daily level compared to temperature in the graph



Aalto University School of Engineering

Temporal data example (spatial view)

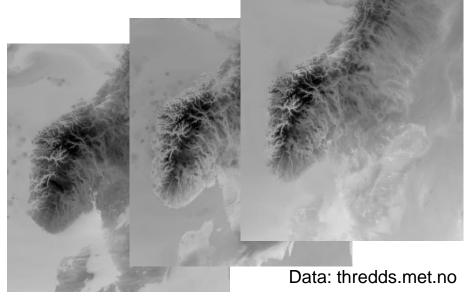


https://www.youtube.com/watch?v=RqmeJCBF_mg



Spatio-temporal data set types

- Change with time in spatial data is typically expressed with several spatial layers that each represent the situation at a given point of time
- One common application are routes, which describe movement and consist of linked locations with associated time stamps







Parent, C., Spaccapietra, S., Renso, C., Andrienko, G., Andrienko, N.,
 Bogorny, V., ... & Theodoridis, Y. (2013). Semantic trajectories
 modeling and analysis. ACM Computing Surveys (CSUR), 45(4), 1-32.

Metadata

- Spatial data typically has a complex structure
- This structure needs to be known (typically in a machine-readable format) in order to exploit spatial data
- In addition, the users need to know what a given spatial dataset represents, and what it therefore can be used for
- Therefore metadata (data about the data) is important for spatial datasets



-<gmd:MD Metadata xsi:schemaLocation="http://www.isotc211.org/2005/gmd ../../../web/geonetwork/xm1/schemas/iso19139/schema.xsd"> -<gmd:fileIdentifier> <gco:CharacterString>a959b07c-16ff-4ed0-9a3b-72d6bbc026ff</gco:CharacterString> </gmd:fileIdentifier> -<gmd:language> <gco:CharacterString>fin</gco:CharacterString> </gmd:language> -<gmd:hierarchvLevel> <gmd:MD ScopeCode codeListValue="series" codeList="http://standards.iso.org/iso/19139/resources/gmxCodelists.xml#MD ScopeCode"/> </gmd:hierarchyLevel> -<gmd:hierarchvLevelName> <gco:CharacterString>Aineisto</gco:CharacterString> </gmd:hierarchyLevelName> -<gmd:contact> -<gmd:CI ResponsibleParty> -<gmd:organisationName xsi:type="gmd:PT_FreeText_PropertyType"> <gco:CharacterString>Maanmittauslaitos</gco:CharacterString> -<gmd:PT FreeText> -<gmd:textGroup> <gmd:LocalisedCharacterString locale="#FI">Maanmittauslaitos</gmd:LocalisedCharacterString> </gmd:textGroup> -<gmd:textGroup> <gmd:LocalisedCharacterString locale="#EN">National Land Survey of Finland</gmd:LocalisedCharacterString> </gmd:textGroup> -<gmd:textGroup> <gmd:LocalisedCharacterString locale="#SV">Lantmäteriverket</gmd:LocalisedCharacterString> </gmd:textGroup> </gmd:PT FreeText> </gmd:organisationName> -<gmd:contactInfo> -<gmd:CI Contact> -<gmd:address> -<gmd:CI Address> -<gmd:electronicMailAddress xsi:type="gmd:PT_FreeText_PropertyType"> <gco:CharacterString>asiakaspalvelu@maanmittauslaitos.fi</gco:CharacterString> -<gmd:PT FreeText> -<gmd:textGroup> <gmd:LocalisedCharacterString locale="#FI">asiakaspalvelu@maanmittauslaitos.fi</gmd:LocalisedCharacterString> </gmd:textGroup> -<gmd:textGroup> <gmd:LocalisedCharacterString locale="#EN">customerservice@nls.fi</gmd:LocalisedCharacterString> </gmd:textGroup> -<gmd:textGroup> <gmd:LocalisedCharacterString locale="#SV">kundservice@lantmateriverket.fi</gmd:LocalisedCharacterString> </gmd:textGroup> </gmd:PT FreeText> </gmd:electronicMailAddress> </gmd:CI Address> </gmd:address> </gmd:CI Contact> </gmd:contactInfo> -<gmd:role> <gmd:CI RoleCode codeList="http://standards.iso.org/iso/19139/resources/gmxCodelists.xml#CI RoleCode" codeListValue="owner"/> </gmd:role> </gmd:CI_ResponsibleParty> </gmd:contact> -<gmd:dateStamp> <gco:DateTime>2018-09-03T15:00:33</gco:DateTime> </gmd:dateStamp> -<gmd:locale> -<gmd:PT Locale id="SV"> -<gmd:languageCode> <gmd:LanguageCode codeList="http://www.loc.gov/standards/iso639-2/" codeListValue="swe"/> </gmd:languageCode> -<gmd:characterEncoding> <gmd:MD CharacterSetCode codeList="http://standards.iso.org/iso/19139/resources/gmxCodelists.xml#MD CharacterSetCode" codeListValue="UTF-8</p> </gmd:characterEncoding> </gmd:PT Locale>

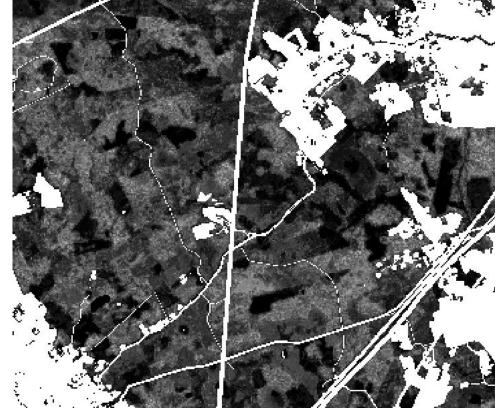
</gmd:locale>

Human-readable metadata: an example

"The estimation errors at pixel level are rather high but decrease when the area in question increases, i.e., when the area of interest consists of several pixels."

- Using this data for analysis on individual pixel level may be a bad idea
- The (potentially) large errors on single pixels will persist through the analysis
- When using larger areas in the analysis, the errors even out

Aalto University School of Engineering



Data: Multi-source national forest inventory 2017, total volume of trees

Geospatial data modeling



Spatial data model

A spatial data model defines how the real world can be approximated on a computer system

A model can be based either on the vector or the raster approach

- Raster models are typically conceptually relatively simple; a raster image and appropriate spatial metadata for spatial reference system, raster position, and data semantics
- Vector data models can be conceptually more complex, as they need to define the various geographic primitives used, as well as their connections, etc.



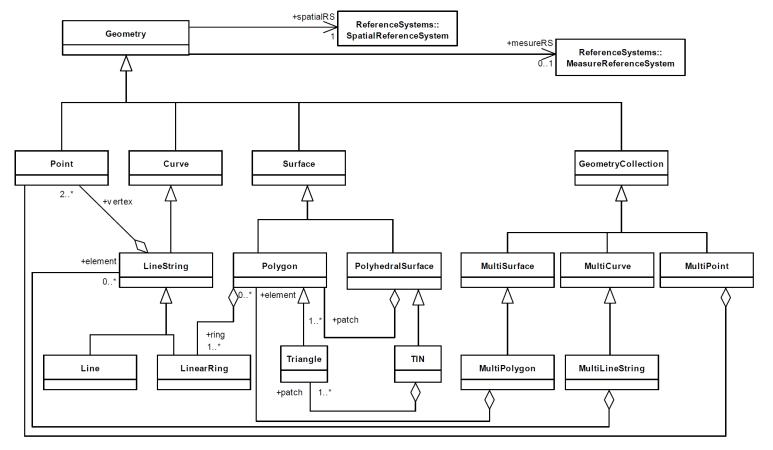
Defining a (spatial) data model

Data models need to be unambiguously and precisely defined

- Everyone using a data model needs to implement it the same way
- A data model needs to be put into the right context
- A spatial data model defines how the real world is approximated on the computer in a specific universe of discourse (a specific domain)
- The model definition method needs to be (sufficiently) formal
- UML (Unified modeling language)
- ER-diagram (Entity-Relationship diagram)
- Etc.

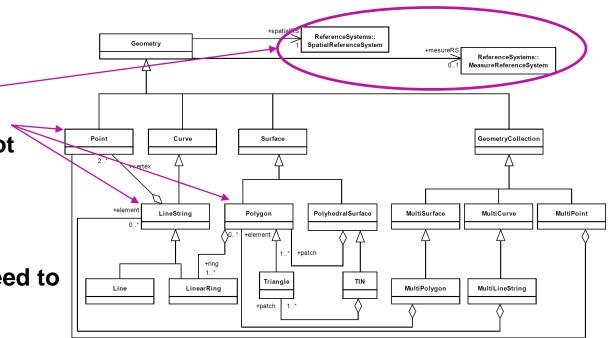


Spatial data model example: OGC Simple Features



Spatial data model example: OGC Simple Features

- Simple features defines
 explicitly
 - Spatial reference
 - Location and shape -
 - Some spatial relations
- Simple features does not define
 - Attribute data
 - Temporal information
 - Metadata
- Implemented models need to include these elements



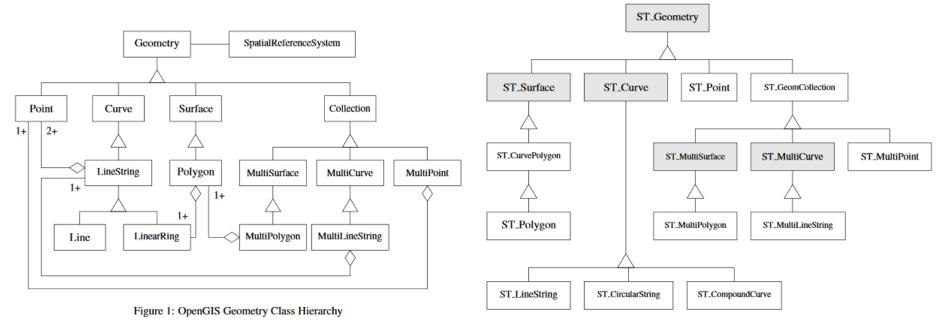


From data models to database schemas

- Spatial data typically resides in (often large) databases
- A vector model (e.g. Simple Features) can relatively easily be transformed into a database model
 - Standardized in the ST_* types
 - ISO/IEC 13249-3
- ER-model (Entity-Relationship) is often used to define SQL database schemas

- The Simple features and ST_* -type hierarchy define what sort of data elements can be used in any database that supports them
- An ER-model describes how a specific database is designed

Vector data in spatial databases: SQL-MM and the ST_* types



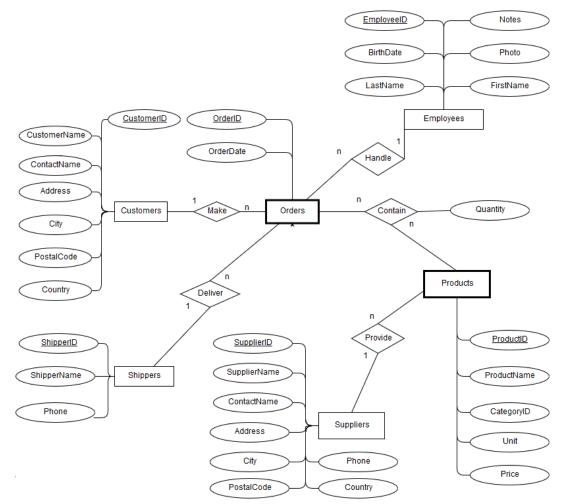
Aalto University

School of Engineering

Figures from Stolze, K., 2003, February. SQL/MM Spatial-The Standard to Manage Spatial Data in a Relational Database System. In *BTW* (Vol. 2003, pp. 247-264).

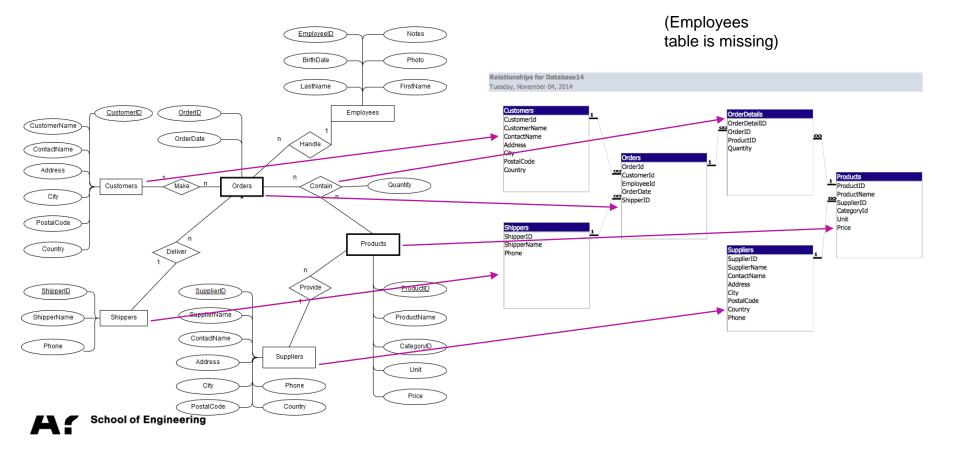
Figure 2: SQL Type Hierarchy

ER Diagram example



- Rectangles are entities
- Diamonds are relationships
- Ellipses are attributes
- Entities (and some relationships) are turned into database tables in a DB implementation
- Attributes are columns in a table
- Some of the attributes may be vector data
- Often in a spatial database there are very few, if any, relationships
- Raster layers can be a bit more complicated

ER-diagram to database schema



Database in practice

CustomerId CustomerName ContactName Address City PostalCode Country

۸

v

Number of Records: 91

CustomerID	CustomerName	ContactName	Address	City	PostalCode	Country
1	Alfreds Futterkiste	Maria Anders	Obere Str. 57	Berlin	12209	Germany
2	Ana Trujillo Emparedados y helados	Ana Trujillo	Avda. de la Constitución 2222	México D.F.	05021	Mexico
3	Antonio Moreno Taquería	Antonio Moreno	Mataderos 2312	México D.F.	05023	Mexico
4	Around the Horn	Thomas Hardy	120 Hanover Sq.	London	WA1 1DP	UK
5	Berglunds snabbköp	Christina Berglund	Berguvsvägen 8	Luleå	S-958 22	Sweden
6	Blauer See Delikatessen	Hanna Moos	Forsterstr. 57	Mannheim	68306	Germany
7	Blondel père et fils	Frédérique Citeaux	24, place Kléber	Strasbourg	67000	France
8	Bólido Comidas preparadas	Martín Sommer	C/ Araquil, 67	Madrid	28023	Spain



Spatial datasets

One or more spatial data layers create a spatial dataset

The layers may be explicitly connected to each other (e.g. database relationships)

Or the layers may have no explicit connections but create a thematic set



- -x_wind
- y_wind
- ---air_temperature
- ----specific_humidity
- mass_fraction_of_cloud_condensed_wate
 - mass_fraction_of_cloud_ice_in_air cloud area fraction
- mass_fraction_of_snow_in_air
- mass_fraction_of_rain_in_air
- mass_fraction_of_graupel_in_air
- Turbulent kinetic energy (TKE)



- ---relative_humidity ----upward air velocity
- ertel potential vorticity



latitude

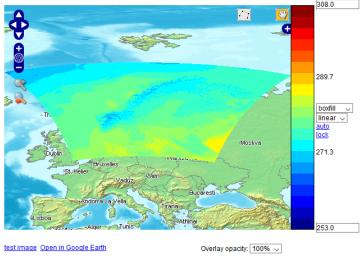
geopotential

<u>User quide</u>



Layer: MET Norway Thredds Service > MEPS 2.5km > air_temperature Units: K Depth (): [0.9955521821975708] Date/time: [2019] 5] 10] [00:00:00] UTC first frame last frame

Fit layer to window



Powered by OpenLayers and OGC standards

Permalink | email

Data: thredds.met.no weather data; air temperature layer shown on map



GeoPackage

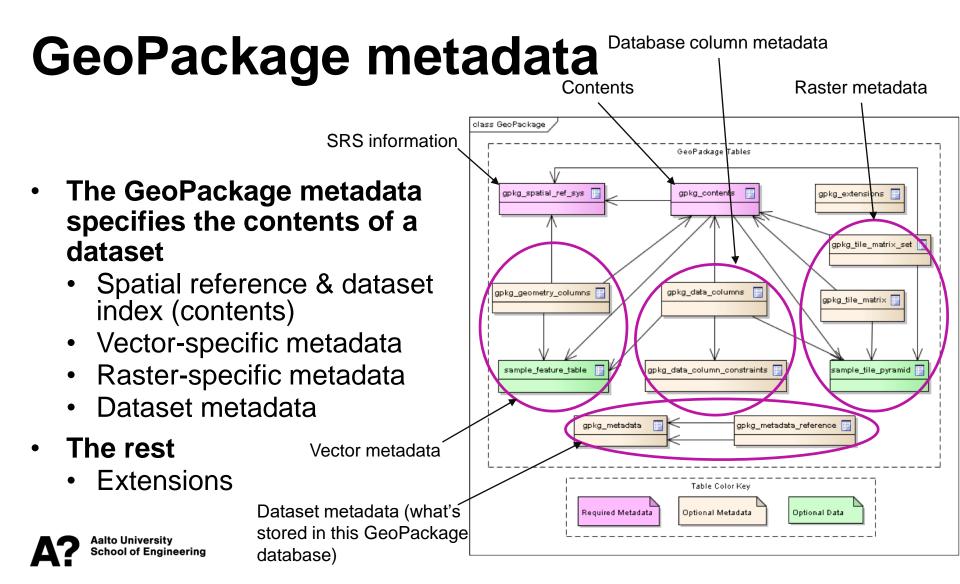


GeoPackage

- An open, non-proprietary standard format for geospatial data storage
- Goal is to be a general format for storing spatial data across different systems
- Can contain both vector and raster data
- Implementation is a SQLite database container
- Contains
 - Metadata that specifies what a specific geopackage contains
 - The data







For the next time...

Third exercise round has been published

Remember, next week you need to submit your learning diary for peer assessment.

Submit your diary on September 30th at the latest!

And remember, your learning diary will not be ready next week, so don't stress about that. Just submit what you have ready, but submit it **on time**, so the diaries can be given for peer assessment.

