

## WebGIS-based data center design for polar science studies: simulation of Türkiye

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**Abstract:** Scientific studies concentrated in Antarctica hold great value and importance for humanity. Research projects are conducted in various disciplines on the continent, where nearly 100 research stations from 30 countries are established. Despite the challenges posed by Antarctica's natural structure, unique environment, difficult working conditions, and limited logistics opportunities, scientific research conducted there is indispensable due to the valuable information it offers. In pursuit of accessing this information, Turkish Antarctic expeditions have been organized since 2017. In this study, a polar data center was established through a web-based geographic information system (WebGIS), a significant infrastructure for the continuity of scientific studies. The implemented projects and raw/processed data from previous expeditions in diverse subjects and disciplines, including geology, geophysics, geography, hydrology, meteorology, oceanography, glaciology, atmospheric physics, chemistry, microbiology, and remote sensing, were incorporated into this information system. Studies in Antarctica have primarily focused on observing the effects of global warming, necessitating the monitoring of past and current data related to sea ice, sea level, and coastal changes. The data also encompasses seismic, volcanic, tectonic, and Global Navigation Satellite System (GNSS) monitoring. As suggested by the Antarctic Treaty, a user-friendly website was designed and made accessible for research projects, data, and publications. An entity relationship diagram was created for the fields to be included in the database. These fields were structured as tables using structured query language (SQL) queries in PgAdmin. A workspace and storage area were created in GeoServer, and a connection was established with PostGIS. Layers of spatial and nonspatial data from the PgAdmin application were added to the GeoServer workspace. The data transferred to GeoServer were presented in an OpenLayers web map with Web Map Service (WMS) and Web Feature Service (WFS) according to Open Geospatial Consortium (OGC) standards. Additionally, a mini web map was designed using the desktop Quantum GIS (QGIS) application and GIS Cloud collaboration, displaying GNSS and meteorological (weather) observation stations on the continent. A dynamic web project was employed for coding in Eclipse software, where backend coding was done with JavaScript. SQL was used as a part of the backend to integrate data from the database per request. Frontend coding for the website's visual side was completed with HTML, CSS, and JavaScript. As a result, a WebGIS platform was developed where researchers can register, add projects, and publications, and view data on a map. Users can download, analyze, and utilize the available data. The data center's existence underscores the importance of polar science and serves as an incentive for further research.

**Key words:** Polar science, Antarctica, data center, QGIS, WebGIS

### 1. Introduction

Antarctica is the coldest continent and the world's largest scientific research laboratory. There are parts of the continent that have not received rainfall for millions of years, making Antarctica the driest place on Earth (Gould, 1971). It is approximately 18 times the size of Türkiye and is protected by a series of treaties and conventions. According to the treaty signed in 1959, Antarctica is open only to scientific research (Lamus, 2013). Countries built research stations there in order to continue their scientific studies in the 19th century. (Dodds and Collis,

2017). These research stations play a crucial role in facilitating sustainable scientific work in Antarctica. The progress of scientific studies in Antarctica is influenced by its geographical location, climatic conditions, and topographic structure. To maintain control and ensure the sustainability of these scientific studies, a committee called the Special Committee on Antarctic Research was established, later renamed the Scientific Committee on Antarctic Research (Elzinga, 2011; Spiller, 2020). Short-term expedition-oriented projects and long-term monitoring projects are carried out in Antarctica in many

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disciplines, such as geography, oceanography, astronomy, hydrology, geology, geophysics, meteorology, chemistry, and physics, in temporary camps and research stations (Hughes et al., 2013). Most countries with research stations on the continent store the data about the expeditions they organize extensively in the databases they create and present on their websites. Individual studies of different disciplines produce input data for other disciplines. For example, the effects of climate change can be observed by monitoring glacier movements and coastline changes (Parkinson and Cavalieri, 2012). The ecology of the continent and its surrounding waters is also a subject of significant research and is studied by various disciplines. Weather observation and Global Navigation Satellite System (GNSS) stations are located in different parts of the continent to support geodetic studies, climate change research, and tectonic studies. Countries with scientific goals for the polar regions need to ensure project and research follow-up, effective management of expedition processes, creation of an area for efficient budget utilization, and prevention of project duplications and data waste. Integrating the data center with a geographic information system (GIS) is necessary to visualize data through maps. Certain countries operating in Antarctica, such as the USA, UK, Canada, Australia, and Korea, have web-based GIS (WebGIS)-based data centers accessible through any browser (Parsons, 2009; Cheng et al, 2013; Friddell et al. 2014; Jin, 2014; Fremand, 2021). Datasets can be accessed, and metadata can be explored through these polar data centers. Additionally, the data are displayed on a web map. Other countries have also established polar data centers for various purposes. Norway has made a JavaScript API available for developers in the Norwegian Polar Data Center, along with various map products and mapping services for the Antarctic and Arctic regions. In the polar data centers of the Netherlands, India, and Japan, there are datasets available, but they are not displayed on the web map. Equipping data with spatial information allows all activities to be displayed on maps and establishes a connection between information and location. The most up-to-date tool used for this purpose is the GIS. The GIS stores and allows the processing of collected and integrated data (Zhinong et al., 2004). Information is obtained through analyses and queries using various algorithms, programming languages, and models (Hutzinger and Fiedler, 1991). In a system where all of the information is stored on a central server, one or more users can access the same database and utilize the same services. A well-coded web application with backend and frontend components is required for this. There are quite a number of tags or functions for the programming, markup, and styling languages. Cascading style sheets (CSS) is the phenomenon that designs the shape and/or appearance of a hypertext markup language (HTML)

document (Henick, 2010; Meyerovich and Rabkin, 2013). In other words, CSS is a text-shaping language that saves HTML from being a simple skeleton. JavaScript is actually a programming language. It is used on websites and some game engines. More dynamic web interfaces or calculations can be made with JavaScript. In other words, operations such as what to do when a button is used are done with JavaScript. When a tool created by the frontend is used, the results are produced using tool algorithms created and coded from the databases provided by the back end. When it is desired to run a web page, the frontend and the backend work together (Henick, 2010). The frontend page is managed by the backend which renders or redirects the page (Gong et al., 2020). Web-based GIS applications have three components: the user, the server, and the network. The WebGIS system that depends on Open Geospatial Consortium (OGC) services provides users with the ability to explore, access, and visualize geospatial data (Zhinong et al., 2004; Wei et al., 2009). In this study, based on similar data centers, the required features were determined by creating a relational database that included user and project information. Server connections were established, and a polar data center with maps was visualized through frontend and backend coding.

## 2. Materials and methods

A WebGIS application requires a configuration diagram to progress properly (Figure 1). Data collection is the first step in this diagram. The necessary vector and raster data were organized for use in the desktop GIS application. The Quantum Geographic Information System (QGIS) is represented by the desktop database, the second step of the diagram. The spatial database was created after the data were collected and stored in the desktop database. PostgreSQL (PgAdmin) and its extension, PostGIS, were used for this. Data and geometry information to be presented to the user in the WebGIS application were included in this database. An entity relationship diagram was used to set up this data as a relational database. A database connection was made with GeoServer for web mapping. GeoServer is basically a map server and is the third step in the diagram. In GeoServer, geometry data were published as point locations with Web Map Service (WMS) and project information as Web Feature Service (WFS). Moreover, NASA's Antarctica shapefile was used in the QGIS desktop software. A mini-map was obtained by connecting QGIS to the GIS Cloud. The mini-map was included in the GNSS and meteorological observation stations. The data of these stations were retrieved from Quantarctica. Finally, in the fourth step, to develop the WebGIS application, a dynamic web project was created in Eclipse software, the backend codes were made with JavaScript using structured query language (SQL) query connections, and the frontend

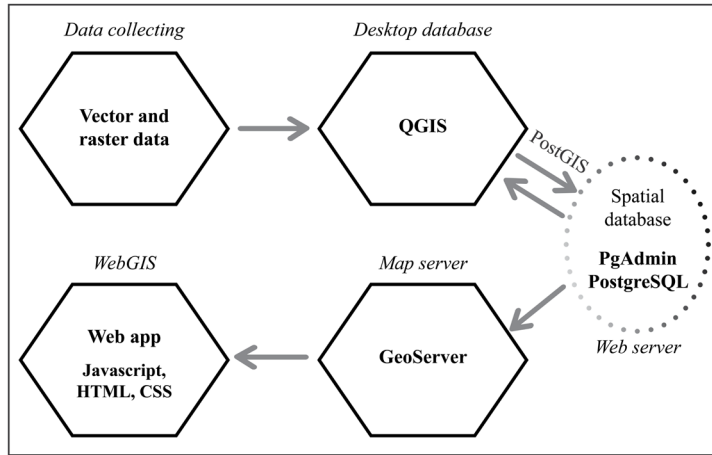


Figure 1. WebGIS configuration diagram.

codes were made using JavaScript, HTML, and CSS. The website interface was styled with CSS, and the text profiles were designed with HTML. Dynamic actions such as popup windows and click-on operations were determined by JavaScript. OpenStreetMap (OSM)-based world map and clustering, measuring, and zooming features taken from OSM's open-source library were used in the WebGIS application, which can be accessed on a local computer via the Tomcat server.

### 2.1. Spatial database creation

There are certain stages in the process of establishing the database and transferring it to the web environment. In the local server systems, if authorized users want to change any data, they can access the database on the server and add, update, or delete the relevant rows. This change occurs simultaneously for all users. The WebGIS technique is frequently used to share data in databases created in GIS software with users (Sandinska, 2016). In this way, web mapping and data visualization are done. Static data become real-time (Bendib et al., 2016). WebGIS is defined as a geographic information system that uses web technology to communicate between a server and a client (Mathiyalagan et al., 2005). A web-based GIS application basically consists of 2 units: a server (service unit): GIS server, and a client (user): web browser (Sahin and Yakar, 2021). A spatial database is a database where geospatial data are stored. The desktop GIS application accesses the database and allows certain operations on the data (Rigaux et al., 2002; Swift and Goldberg, 2019). Points, lines, and polygons marked on the map indicate spatial data. Data accessed by users in a polar data center can be listed as follows:

- Project information (ID, managers, field of study, discipline)
- Research locations
- Datasets

- Publications

Special extensions are required to keep them in the database. The data stored in the QGIS are migrated to the PostgreSQL-configured database PostGIS extension. Then, with the Query tool, the 'create extension postgis;' command is executed. In this way, the PostGIS extension is connected to the created database. PostgreSQL is a database management system where spatial data can be kept, and its extension PostGIS is run in the PgAdmin application. Data entries were made with SQL queries in the PgAdmin application. Database management systems mostly rely on data models. Database modeling begins with data modeling since it is a technique that organizes and documents the data of the system. The entity relationship diagram (ERD) defines the data with regard to the entities and relationships represented by the data (Li and Chen, 2009). The relationship between the tables containing these data is shown in the ERD (Figure 2).

In addition to these tables, two more independent tables were created. These tables were Users and Pending. In this way, when the user creates a record on the website, it is put in the Pending table. It is thought that the project name, a branch of science, and project coordinator at a point on the map (latitude, longitude) can take different values.

- The same project may be working in different branches of science.
- The same project may be located in different locations.
- The same project may be run by different project managers.
- Different projects may have the same discipline, the same project manager, and the same location.

Briefly, one of these four values must be different. Accordingly, primary keys and unique assignments were made. If similar data are entered into fields that are

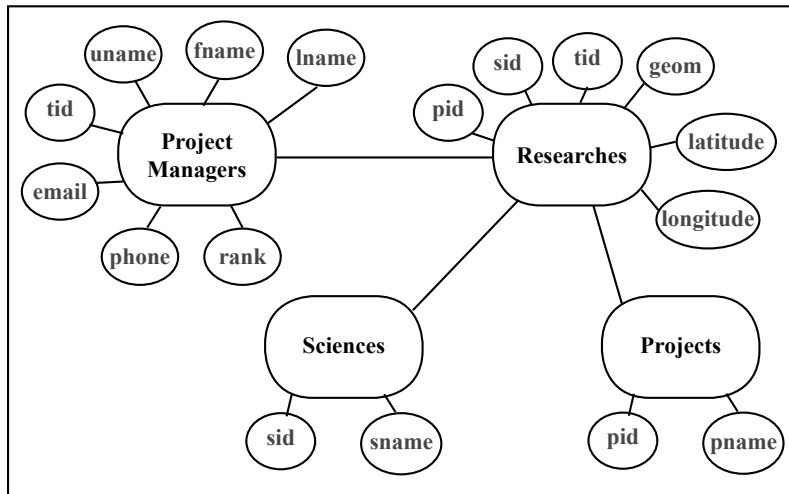


Figure 2. Entity relationship diagram.

specific to a single data, the 'unique' definition does not add that data to the database. Therefore, it is important to define 'unique'. The tables were created according to the ERD (Table). SQL queries are made after the identifiers are determined. All queries express a statement. A SQL statement basically consists of identifiers, parameters, keywords, and variables. (Melton and Simon, 1993). Identifiers are the names of database objects such as tables, columns, aliases, indexes, and views (Fehily, 2014). Data can be added to or deleted from the created tables. The research table in a PostgreSQL database with geometry field (geom) data are given in Figure 3, as an example. The spatial reference system identifier (SRID) of the geom data in the research table is 4326. All of the required tables were created in the PgAdmin application. The Projects, Sciences, Research, Project Managers, Pending, and Users tables were inserted. Thus, the database was created.

## 2.2. Web mapping process

Web mapping is a technique for using maps that are acquired by an information system for spatial data (Neumann, 2008). Figure 4 shows the process of publishing maps on the web. The QGIS was used as a desktop GIS application. GeoServer was used as a publishing engine, and the OpenLayers library and GIS Cloud were used as web mapping applications. The publishing engine accessed the spatial database and published the data as web services. These services were used by the web mapping application and made the blank data in the geom column of the database appear. The web mapping application is the end product where users interact with these services. First, a workspace was defined in GeoServer. Then, the PostGIS database connection in the vector data sources section was made in the storage space. In this way, layers of spatial and nonspatial data from the PgAdmin application were added

to the workspace (Figure 5). The PostGIS connection ensures that changes made in the PgAdmin application are reflected in the data added to the GeoServer as a layer. GeoServer supports publishing web services according to OGC standards (WFS, WMS, and WCS). GeoServer enables users to access and work with geographic data from different environments. GeoServer can use vector (Oracle Spatial, MySQL, PostGIS, Shapefiles, and Web Services) and raster (GeoTiff, 51 Jpeg2000, etc.) data as a data source, and KML is produced in standard protocols. It can also read formats such as GML, GeorSS, and GeoPDF (Chunithipaisan and Supavetch, 2009; Iacovella, 2017). By means of OpenLayers integration in GeoServer, the data served can be instantly queried and viewed over the internet. GeoServer is a service that runs Java code in the background (Kommana, 2013). For this, the computer, or servers where GeoServer is located, must have Java. GeoServer should run continuously on the specified port, such as 8080. The data stored in GeoServer consist of layers. A new layer can be created by extracting the desired sections from these data. A new virtual table was created with a SQL query that displays specific data on the map in GeoServer. The details are given below:

```
SELECT p.pname, s.sname, t.rank, t.fname, t.lname,
t.email, t.uname, r.geom
```

```
FROM public."Project_Managers" t, public."Projects"
p, public."Sciences" s, public."Researches" r
```

```
WHERE t.tid = r.tid AND p.pid = r.pid AND s.sid =
r.sid AND r.geom IS NOT NULL
```

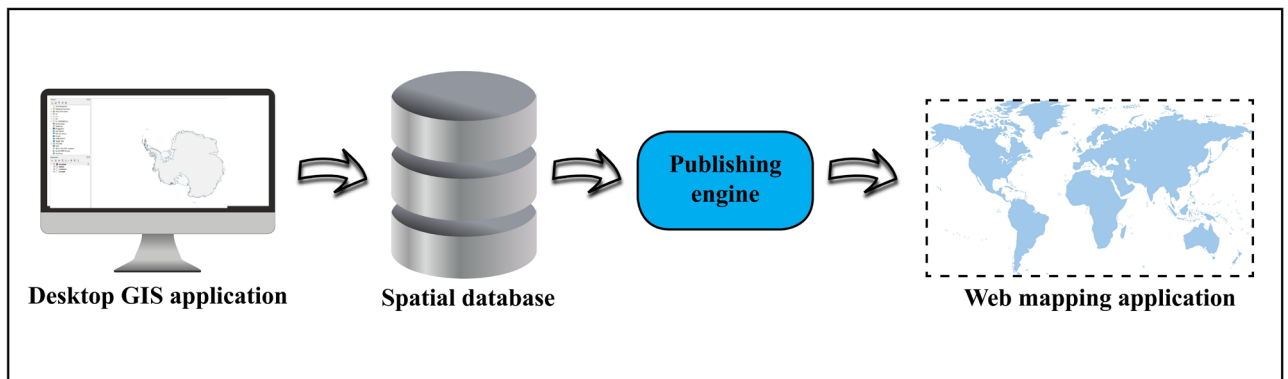
The locations of the projects on the Antarctic continent were added. In GeoServer, ready-made styles can be used, or the desired style can be created to change the appearance of the data in the layer preview (Jiang, 2020). The styled layer descriptor (SLD) codes of the styles in the QGIS software were used to change the appearance of the

**Table.** Tables and their identifiers created in the PostgreSQL database.

Table name	SQL identifiers
Projects	<u>pid</u> , pname
Sciences	<u>sid</u> , sname
Project Managers	<u>tid</u> , fname lname, email, phone, uname character varying, rank
Research	<u>pid</u> , <u>sid</u> , <u>tid</u> , geom, latitude, longitude
Users	<u>userid</u> , fname, lname, email, password, auth
Pendings	<u>id</u> , pname, <u>sid</u> , fname, lname, email, phone, uname, rank, geom, latitude, longitude

Data Output Messages Notifications								
	<u>pid</u> [PK] integer	<u>sid</u> [PK] integer	<u>tid</u> [PK] integer	geom geometry	latitude double precision	longitude double precision		
1	1	1	1	0101000020E610000040A4DFBE0E684EC04C6E14596B0F50C0	-64.240927	-60.81295		
2	2	2	2	0101000020E61000000070ECD973F94DC0419AB1683AF54FC0	-63.915845	-59.948848		
3	3	3	3	0101000020E6100000446CB07092DA4EC0E753C72AA52250...	-64.541331	-61.707594		
4	4	4	4	0101000020E610000097E2AAB2EF0E4DC004543882541650C0	-64.348908	-58.11669		
5	5	4	5	0101000020E61000008CDB68006F294CC0E02D90A0F8894FC0	-63.0779	-56.3237		
6	6	1	6	0101000020E61000008CDB68006F294CC0E02D90A0F8894FC0	-63.0779	-56.3237		

**Figure 3.** Researches table in PostgreSQL (PgAdmin).



**Figure 4.** Map publishing scheme.

points. The styles of these points were saved with an .sld extension and transferred to GeoServer. Point data were published as WMS by clicking on OpenLayers in the layer preview section (Figure 6).

OpenLayers is an open-source JavaScript library. An OpenLayers map was defined using the link <http://tile.openstreetmap.org/{z}/{x}/{y}.png>. The points of the projects were displayed on this map (Figure 7). In addition, a mini Antarctic map was designed in the QGIS desktop app. NASA's Antarctic shapefile was used for that. It was embedded and published via the GIS Cloud web app

(Figure 8). With the latest GIS technology improvements, it is required to integrate GIS with the cloud (Alfaqih and Hassan, 2016). GIS Cloud stores and publishes raster and vector datasets uploaded from desktop QGISs. It enables the creation, styling, and editing of the maps. While the mini map was defined with a stereographic projection, the OpenLayers map was defined with an equirectangular projection. Tools were added to the OpenLayers web map through the open-source library. These tools are used for layer filtering, coordinate display, line-polygon measurement, and feature clustering purposes.



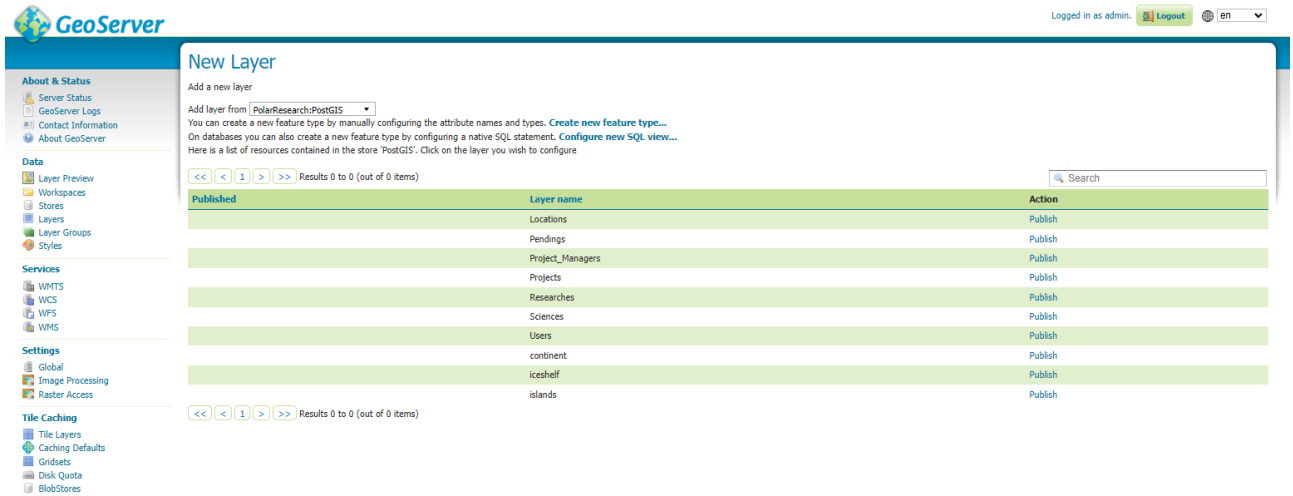


Figure 5. Layer interface in GeoServer.

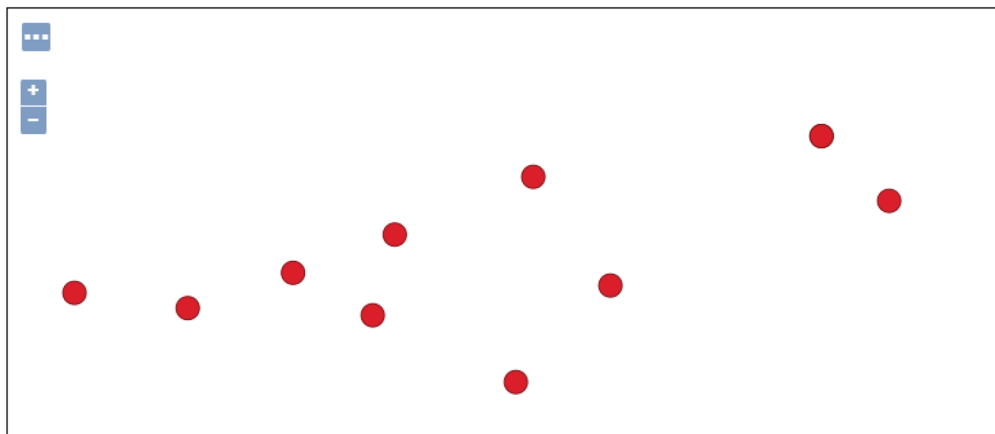


Figure 6. Published points in GeoServer.

### 2.3. WebGIS site development

WebGIS is a distributed information system that contains a GIS server and client (web browser, desktop application, or mobile application). A GIS system spreads information and functions and enables communication between the different components of the system using web technologies (Kuria et al., 2019). After the web mapping process, a user-friendly web application was developed with various programming languages. The backend included the map server and web server (spatial database). When users enter the website and create a record, they interact with the frontend. The application takes the information and stores it in the database set up on the server. The backend is the place that provides the infrastructure and technology required for the frontend to work (Smith, 2012; Noskov and Ziph, 2018). In order to display the data on the map

on the website, the configuration code was added to the web.xml file in the folder where GeoServer was installed. The software used for backend and frontend coding was Eclipse, and the server host was Apache Tomcat. The server port had to be different than that of GeoServer. Therefore, it was assigned 9080. HTML, CSS, and JavaScript were used for the interface of the website shown to the users. JavaScript was also used for backend coding. SQL was part of the backend to query, store, and retrieve data from the database. In Eclipse, there are files called src. These files containing the Java encodings were divided into three parts: connection, map, and objects. They enable the desired data to be interacted with by connecting them to the database. Users first interact with the frontend when they register to the system and add projects. Then, the frontend works with the backend to add data to the database. Data are

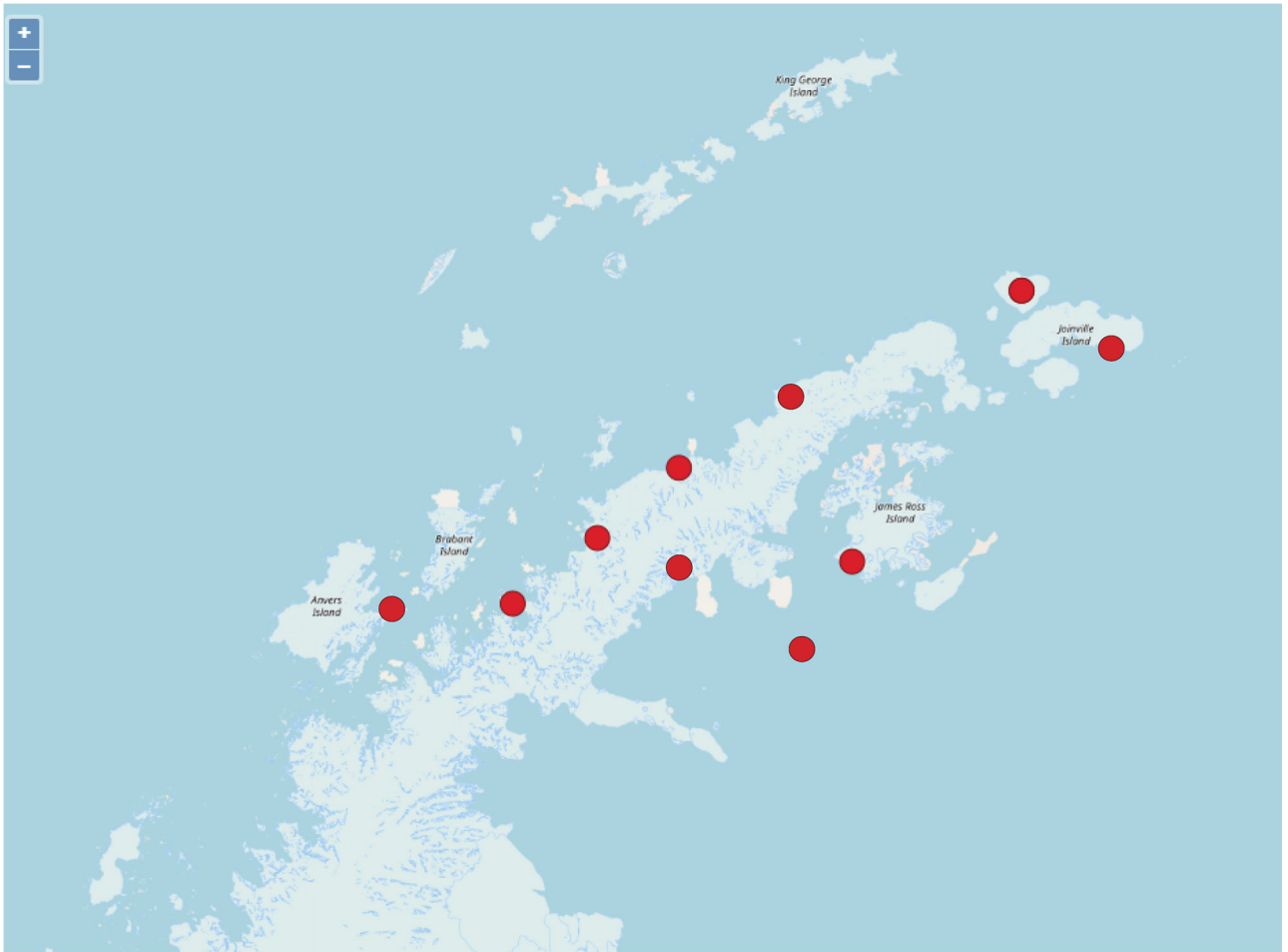


Figure 7. OpenLayers map with the published points.

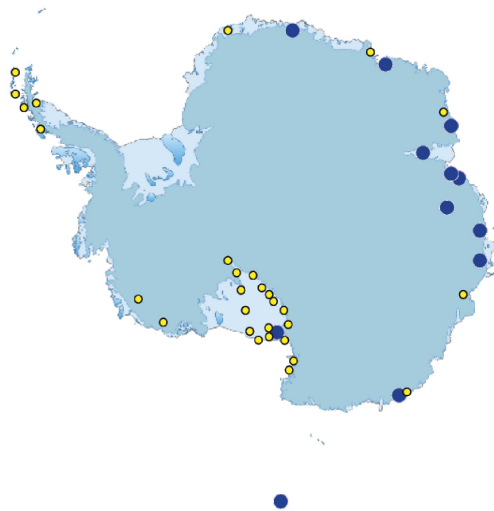


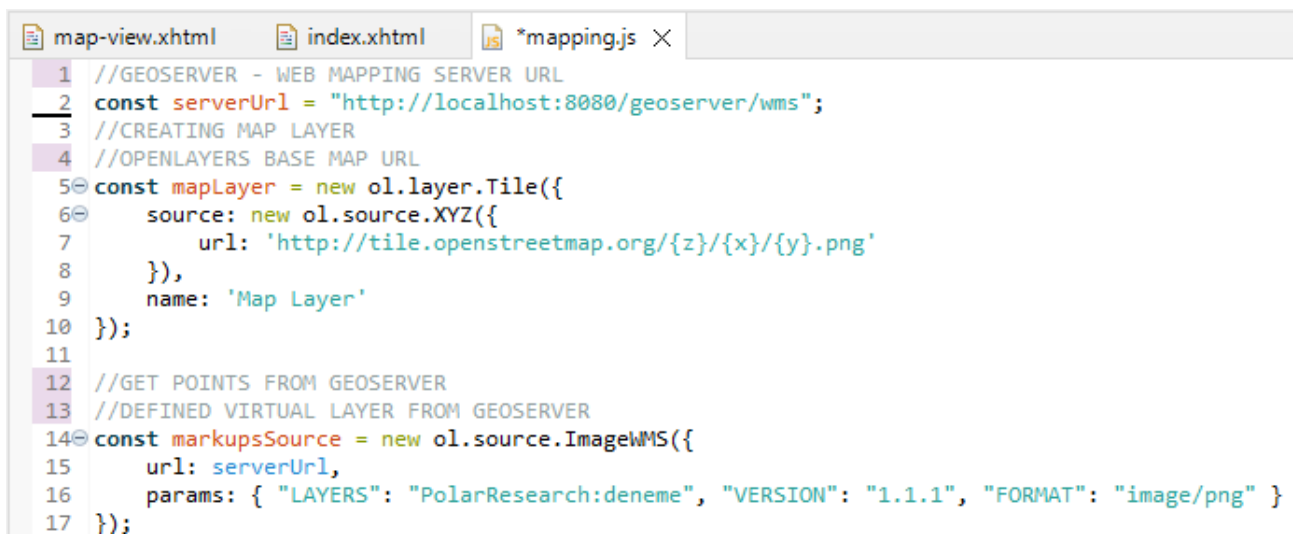
Figure 8. GIS Cloud mini map.

returned to the backend and then the frontend through interconnections. This makes all of the information visible, including the geometry data. CSS, JavaScript, and images were filed as resources while coding the frontend. The CSS files contained the styles of images, texts, forms, and maps. The JavaScript files contained OpenLayers application programming interface (API) coding. Clustering points, identifying popups, measurement tools, and zooming in and out through the map functions were provided from JavaScript codes from the OpenLayers API library. In the study by Gupta et al. (2014), popups and measurement tools were implemented similarly. A part of the codes and their explanation in the mapping.js file is given as an example in Figure 9. Then, HTML, CSS, and JavaScript were combined in XHTML files (Figure 10). The website can be viewed in any browser via localhost, assigned to port 9080. XHTML files are the pages that compose the website. This website basically consists of Map View, Add Project, Deposit Data, and About-Contact Pages. Every single one has an XHTML file related to them.

### 3. Results and discussion

The data were presented in a queryable, manageable, and actionable form in a web-based GIS application. As stated by Damiani et al. (2008), the main purpose of the data center is to gather information about the research activities carried out in the polar regions, provide coordination, and allow for effective planning. The national data center, which was named the Turkish Polar Data Center (TPDC), was planned to include projects carried out by scientists, publications (reports, papers, and articles), and processed or raw datasets. The TPDC's main page includes Map View, Add Project, Deposit Data, and About-Contact

buttons (Figure 11). Each button refers to a page on its own. When the Add Project and Deposit Data buttons are clicked on, first the user registration subpage opens. The user's information is kept in the Pendings table in the PostgreSQL database. After the user's information is verified, they can reach the Add Project and Deposit Data pages. Users first mark the location of the project on the map, and then enter other information to add the project (Figure 12). Due to the unique definitions in the database, the same projects cannot be uploaded to the website. Users are also able to upload data about their projects from the Deposit Data tab (Figure 13). Datasets and publications added by a user can be viewed after the administrator approves them. User registration requires Open Researcher and Contributor ID (ORCID) verification as well as an email and password. ORCID allows researchers to register for a unique identifier (Sprague, 2017). The Map View tab is where many functions can be performed (Figure 14). Project information is filtered in the search section, and project locations are clustered on the map at the same time. Filtering can be done according to the branch of science, project name, and project manager's name. Earth science, life science, physical science, and social and human sciences are the main disciplines of the projects. Project information and a mini map are located in the left pane of the page (Figure 14). The mini map shows Antarctica in a stereographic projection. Here, layers of the continent, islands, ice shelf, GNSS, and weather observation stations can be filtered. In the OpenLayers map, polygon and line measurements can be made, and project information can be displayed in popup windows by clicking on the points. When clicking on a point on the map, if there is more than one project at the same point, all of the projects at



```

1 //GEOSERVER - WEB MAPPING SERVER URL
2 const serverUrl = "http://localhost:8080/geoserver/wms";
3 //CREATING MAP LAYER
4 //OPENLAYERS BASE MAP URL
5 const mapLayer = new ol.layer.Tile({
6   source: new ol.source.XYZ({
7     url: 'http://tile.openstreetmap.org/{z}/{x}/{y}.png'
8   }),
9   name: 'Map Layer'
10 });
11
12 //GET POINTS FROM GEOSERVER
13 //DEFINED VIRTUAL LAYER FROM GEOSERVER
14 const markupsSource = new ol.source.ImageWMS({
15   url: serverUrl,
16   params: { "LAYERS": "PolarResearch:deneme", "VERSION": "1.1.1", "FORMAT": "image/png" }
17 });

```

Figure 9. JavaScript coding for mapping.



```

*map-view.xhtml × index.xhtml *mapping.js
1 <?xml version="1.0" encoding="UTF-8" ?>
2 <!DOCTYPE html
3 PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
4 <html xmlns="http://www.w3.org/1999/xhtml"
5 xmlns:ui="http://xmlns.jcp.org/jsf/facelets"
6 xmlns:h="http://xmlns.jcp.org/jsf/html"
7 xmlns:f="http://xmlns.jcp.org/jsf/core"
8 xmlns:p="http://primefaces.org/ui">
9
10 //CSS RESOURCES FOR STYLING
11 <h:head>
12 <meta http-equiv="X-UA-Compatible" content="IE=edge" />
13 <meta name="viewport" content="width=device-width, initial-scale=1.0" />
14 <title>Turkey Polar Data Center</title>
15 <h:outputStylesheet name="map-view-style.css" library="css"/>
16 <h:outputStylesheet name="ol.css" library="css"/>
17 //JAVASCRIPT RESOURCES FOR OPERATIONS AND FUNCTIONS
18 <h:outputScript library="js" name="jquery-3.6.0.min.js" target="head"/>
19 <h:outputScript library="js" name="ol.js" target="body"/>
20 <h:outputScript library="js" name="mapping.js" target="body"/>
21 <h:outputScript library="js" name="info.js" target="body"/>
22 <h:outputScript library="js" name="functionality.js" target="body"/>
23 <h:outputScript library="js" name="layer-selector.js" target="body"/>
24 <h:outputScript library="js" name="measure-tools.js" target="body"/>
25 <h:outputScript library="js" name="coordinate-func.js" target="body"/>
26 </h:head>

```

Figure 10. Map View XHTML file.



Figure 11. Main page of the TPDC.

that point are displayed in the popup window. Moreover, clicking on any of the projects in the left pane navigates to the project locations by clustering. The left pane also includes the publications and datasets for the projects. The

uploaded files are stored in a specified file on the computer. Researchers can download publications and data uploaded to the site, even without creating a user registration, from the Map View page. These data may include satellite

1  
Choose Coordinate

2  
Enter Project Name

3  
Enter Science

4  
Enter Project Manager

Enter Coordinate

X-Y Coordinates  Latitude-Longitude (Decimal)  Latitude-Longitude (DMS)

-67.3809 -68.5580

Sonraki

Figure 12. Add Project page.

Choose File

Upload

.xlsx, .csv, .pdf, .doc, .docx, .txt, .jpg, .jpeg, .png, .mcw, .mdb, .mmr, .shp, .dgn, .kml, .geojson, .gmt, .gdb, .gxt, .wfs, .svg, .sxf, .mct extension files can be upload.

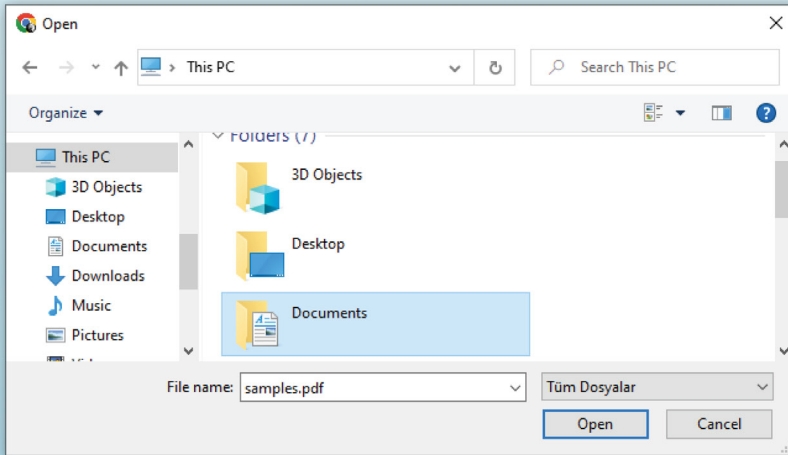


Figure 13. Deposit Data page.

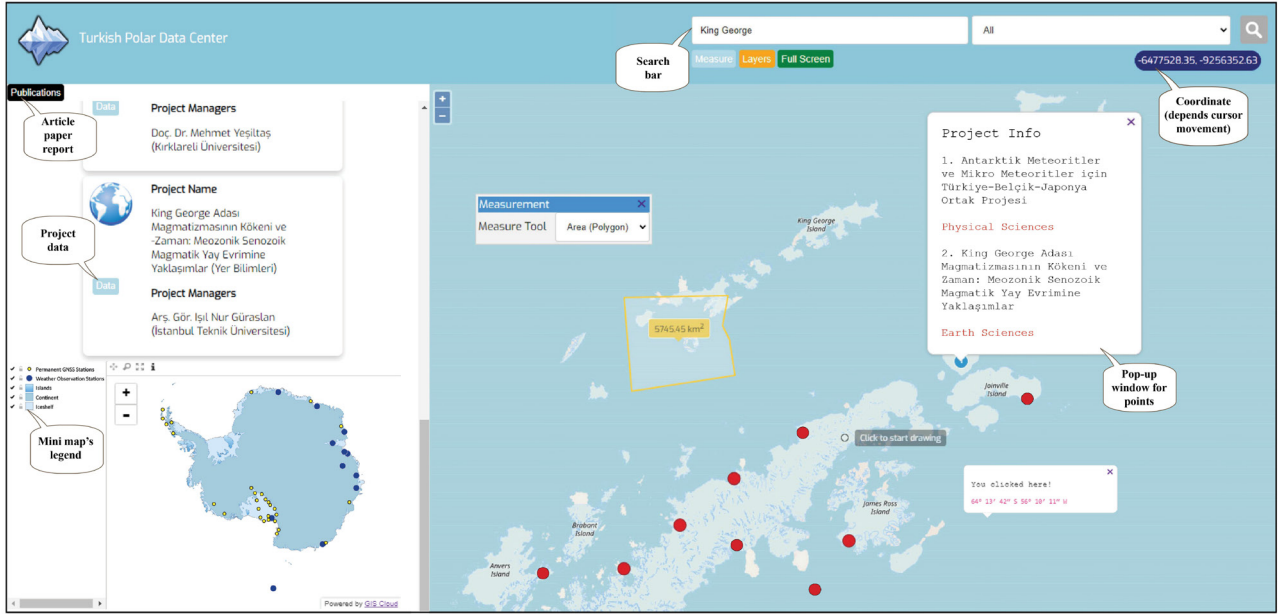


Figure 14. Map View page.

images, meteorological parameters, GNSS data, and geological samples. As the cursor moves on the map, the coordinate bar in the upper right changes accordingly. If anywhere on the map is clicked, the coordinates of that point appear in the popup window. The TPDC acts as a project and data warehouse for polar studies. Researchers visiting the data center can avoid project duplication by having ideas for their new projects. In addition, they can do research and study by downloading the datasets of the projects. Some of the projects included in the TPDC are listed below:

- A new approach to the origin of evaporate formations in Antarctica: implication of Mars
- DEAIS: A history of decline of the east Antarctic ice sheet
- Tracking the evolution of a magmatic arc on the plutonic and volcanic complexes of Livingston Island (South Shetland Archipelago, Antarctica)
- Sedimentological, geochemical, and magnetic susceptibility properties of permafrost and soil deposits in the King George Island (West Antarctica): Paleoenvironmental implications
- Landscape-geochemical determination of Marguerite Bay Islands, Antarctic Peninsula
- Monitoring troposphere and snow depth/thickness in Antarctica with GNSS meteorology and GNSS reflectometer methods
- Ecology, diversity, taxonomy, and biogeography of diatoms (Bacillariophyta)
- Bioprospecting with new scientific approaches being undertaken on Antarctic organisms

As these projects reveal information about Antarctica, they contribute to polar science and reach researchers through the data center.

In this simulation, data are set to be stored in a folder on a local computer. As the number of polar expeditions increases, so do the projects, data, and publications. Therefore, the stored data will take up more space. The data must be stored on a cloud platform when this simulation is implemented as an official website. Emara and Huang (2020) indicated that the cloud storage of Amazon Web Services (AWS) is suitable for large-scale data. There are three separate data pages in the Korean Polar Data Center (KPDC): Metadata, Live Data, and Science Data. A system can be developed for the live data in further operations. Real-time data from weather observation and permanent GNSS stations in Antarctica can also be presented to the user as live data. The increase in the number of projects will also increase the number of points on the map. The data can be reviewed periodically if the date-time filtering feature is added. When downloading the datasets from the site, it was observed that some of them also included metadata. However, it is necessary to allow users to define their own metadata. To address this, a dropdown menu can be created by adding a metadata filtering feature. WebGIS applications have eight significant functions (Kong et al., 2015):

- Base map availability
- Legend customization
- Map elements
- Map products
- Information query

- Location search
- Reporting
- Selected sets of spatial analysis.

The TPDC has each of these, but if some functions are intensified, it will have a much more efficient use. Spatial analysis such as density calculation, point interpolation, and finding hotspots/outliers can be added. While structuring this data center, precedents were evaluated and making the Map View page more user-friendly and comprehensible compared to others was focused on. The Map View page allows for the easy filtering and examination of projects, while also providing the option to download data and publications simultaneously. In summary, unlike other polar data centers, the aim was to create an integrated structure on a single page.

#### 4. Conclusion

In this study, a simulation of the Turkish Polar Data Center was developed with WebGIS technology. All of the essential components and functions of a WebGIS application were combined. It is remarkable that PostgreSQL is an easy-to-use database that works seamlessly and is compatible with GeoServer. The OpenLayers JavaScript library offers many tools and features for web maps. Backend and frontend coding in the dynamic web project of Eclipse was created using open-source libraries in an understandable and easy-

to-manage manner. This simulation was established to be the base of Türkiye's official polar data center. It was built to avoid data waste and project duplication, effectively manage polar expeditions, and reach more researchers. The datasets it contains can allow researchers who could not participate in Antarctic expeditions to conduct virtual research on the samples brought from there and the data obtained. Social consciousness and scientific knowledge about polar regions are strengthened by polar data centers. The willingness to participate in expeditions, receive project support, and contribute to national and international literature will increase. Additionally, infrastructure and ease of management are provided for new research stations and camps. The aim of the Turkish Polar Data Center is to provide comprehensive guidance for the establishment of a polar data center, utilizing open-source software from start to finish. If all countries operating on the continent establish their own polar data centers, the visibility of the work being done will increase worldwide. Researchers will have easier access to projects and data within these data centers, encouraging them to produce new and original studies and contribute to the development of polar science. In conclusion, the polar data centers of countries with scientific goals in Antarctica should be checked regularly, and new technologies should be followed and kept up to date.

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