

## 2D & 3D integration

### Preview

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The essence of GIS is to query, analyze, process, and display various information based on visual representation of the real world, helping people make decisions scientifically. After more than 10 years' development, the 2D GIS technologies have gained wide recognition of their advantages in managing businesses and improving productivity, and are applied in dozens of industries in China. 2D GIS uses (x, y) to represent a spatial location; whereas 3D GIS uses (x, y, z) to represent a spatial location. Compared to 2D GIS, 3D GIS not only provides 3D visual cognition, but also provides 3D spatial analyses and functions. With the developments in computer technologies and the advanced applications of 2D GIS industry, people have become eager to represent the real world using 3D GIS. 3D GIS also has increasingly significant advantages and is irreplaceable in fields such as combat control in military, electronic sand tables and terrain simulations, digital cities, real estate display, analyses and simulations of environmental and meteorological subjects, urban micro-climates, air pollution modeling, geology and underground pipelines, etc.

Nowadays, 3D GIS is more than a name representing the trend and fashion. It has become practical and is being industrialized. The fast-developing 3D GIS technologies will certainly lead to great innovations in the new generation GIS technologies. However, the data models in 2D GIS are simpler, more abstract, and more synthesized compared to 3D data models. There will be a long period when neither 2D GIS alone or 3D GIS alone can meet the high application requirements in the future. Therefore, to develop GIS software with 2D and 3D integrated, instead of with 3D GIS alone, is the right direction for developing GIS software. It is not comprehensive enough to name such GIS software 2D GIS software or 3D GIS software. Thus a new concept is introduced here--3D GIS.

In this section, the following contents about SuperMap iServer 3D are introduced:

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### 2D and 3D integration

3D GIS is a relative concept to 2D GIS. 3D indicates the 3D geographic space and the 2D map space based on geographical sphere or ellipsoid. So 3D GIS means the GIS based on the 3D geographic space and the 2D map space which based on geographical sphere or ellipsoid.

#### Comparison between 3D GIS and 2D GIS

3D GIS has advantages in visualization, analysis, and decision making that 2D GIS cannot compete with. 3D GIS can represent the real world without projections. It can represent geographic feature and natural phenomena that 2D GIS cannot represent, in a vivid and intuitive fashion. Therefore it is helpful for making GIS popular among general audience. As for spatial analysis, 3D GIS can not only fully incorporate 2D spatial analysis functions, but also break the limitation of the dull display of spatial information on 2D planes. It is a better alternative for information reading and spatial analysis, and can provide industries with more intuitive assistance in decision making.

However, 2D GIS has been developed since 1960s. Its functions, performance, data, applications, etc., are still popular among old and new GIS users. 2D GIS has simple data models, vast amount of spatial data, abundant mapping functions, various methods for querying, analyzing, and decision making, and mature business application flow. All these merits have determined that, in a long period, 2D GIS will not be completely replaced by 3D GIS

which is mainly used for visualization.

Additionally, the retrieval of 3D spatial data is more expensive compared to that for 2D GIS, especially when large 3D scenes are to be modeled. Furthermore, 3D data models are more complicated than 2D data models, making the algorithms for 3D-based spatial queries and analysis functions inefficient. Lastly, 3D GIS has not achieved "real-time" yet due to limitations on network transmission and massive data management.

### **Service with integration of 2D and 3D**

Considering the advantages of 2D and 3D GIS, people often hope a system has 2D and 3D functions at the same time. In most of the current 3D systems, however, the 3D part and 2D part are independent from each other even they are both included in the system. More specifically, they are separated on data, representation methods, and analysis functions. This has made GIS applications very costly and difficult. The major reason for this problem is that most of the 3D systems nowadays are independent from large mainstream 2D GIS platforms. To solve this problem, 2D GIS and 3D GIS must be integrated from the underlying GIS platform technologies.

When designing the framework, SuperMap UGC added a Realspace technology with 2D and 3D integrated. The 2D and 3D integration technology is designed for developing new generation Realspace GIS software which is integrated with 2D technologies. This software should have capacity to manage massive data as well as powerful analysis functions. This more "GIS" framework design will solve the problems in advanced applications of 3D GIS software. Unlike 2D GIS in which the real space is projected onto a 2D plane for representation and analysis, the 2D and 3D integration technology in SuperMap does not need projections. Instead, it directly loads and displays data in longitude and latitude on a 3D globe, thus provides a real 3d display of the geographical space.

SuperMap 3D focuses on the idea of integrating 2D and 3D, and fully considers the organic integration of the two in terms of both design and specific implementation. More specifically, it has realized: integration of 2D and 3D data, integration of 2D and 3D display, and integration of 2D and 3D service publishing.

#### **1. Data storage management integration**

Management integration Realspace adopts the SuperMap SDX+ spatial database technology to store and manage 2D and 3D spatial data in a highly efficient and integrated fashion. The data models and data structures of 2D data and 3D data are integrated. 3D GIS data are compatible with 2D data structures. 2D data have also been adjusted properly so that they can be visualized in 3D scenes with high performance, without the need to convert. The data thus are easier to update and maintain.

#### **2. Display integration**

With the data integration, Realspace allows for efficiently loading massive 2D data into 3D scenes for display without any conversions. It also supports displaying a snapshot of a 3D model in a 2D window.

As for mapping, Realspace incorporates the 2D thematic mapping functions. Thus it supports making most types of the 2D thematic maps in a 3D scene, such as dot density maps, ranges maps, and label maps, as well as columns and pie charts with 3D effects.

#### **3. Analysis integration**

Spatial query and analysis are the basic GIS features. Traditional 2D GIS system is already very mature in terms of those functions, such as buffer analysis, overlay analysis, surface analysis, transportation network analysis, etc. Most of the 3D systems, on the other hand, do not have powerful query and analysis functions due to the lack of support of GIS engines. Many real 3D-based analysis functions have complicated algorithms and low efficiencies, thus are still under development. In this situation, employing 2D-based functions, such as buffer analysis, overlay analysis, network analysis, statistical analysis, etc., in a 3D scene has great practical values.

2D and 3D integration employs spatial analysis and algorithm engines that are integrated with 2D GIS. Most of the query functions (including attribute query and spatial query) and analysis functions of 2D GIS can be used in a 3D system. In the mean time, it also provides some realspace analysis functions such as visibility analysis, flooding analysis, 3D measurements, etc.

#### **4. Service integration**

SuperMap iServer provides an entire integrated scheme for publishing 2D and 3D services. 2D services are published in the same way as 3D services. The configuration and management are completed with the same methods and interfaces. 2D datasets, 2D maps, as well as the maps' cached 2D and 3D data can be directly loaded into a 3D scene. 2D datasets, maps, and the data in a 3D scene can be saved in the same workspace and published in 3D.

## Data and layers of 3D scene

A 3D scene is a scene in which one or more layers of a 3D service are stacked in a certain order and displayed in a window. The main body of a 3D scene is a 3D sphere of simulated earth (with a radius of 6378137 meters). This sphere has a geographic reference. Points on the sphere are positioned with longitudes and latitudes, and can also be easily viewed through the longitude and latitude grid on the sphere provided by the 3D scene. At the same time, it uses global remote sensing image as a background converging the surface of the sphere, simulates the earth's environment, including the universe of the sky, the atmosphere, the fog environment of the earth's surface, etc., to make it more real.

### Data of 3D scene

Based on the OGDC (Open Geospatial DataBase Connectivity) standards, SuperMap 3D has realized zero-difference access to many datasources. It does not only support data formats supported by the SuperMap SDX+ engine, but also support data in standard formats such as WMS, WFS, and KML\KMZ, as well as model data. Overall, 3D data supported in SuperMap Realspace services include: vector data, maps, images, terrain data, models, KML/KMZ data, etc.

| Data type          | Description                                                                                                                                      |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Vector data        | <ul style="list-style-type: none"> <li>Vector datasets (point, line, region, or text datasets)</li> <li>Vector cache (*.scv)</li> </ul>          |
| Image data         | <ul style="list-style-type: none"> <li>Image datasets (images, raster maps)</li> <li>Image cache (*.sci, *.sci3d, *.sit)</li> </ul>              |
| Map data           | <ul style="list-style-type: none"> <li>Configured map (Vector, image layers)</li> <li>Map cache (*.sci, *.sci3d)</li> </ul>                      |
| Terrain data       | <ul style="list-style-type: none"> <li>Raster terrain data (DEM, Grid)</li> <li>Terrain cache (*.sct, *.sci)</li> </ul>                          |
| Model data         | <ul style="list-style-type: none"> <li>3D models (*.3ds, *.sgm), 3D model datasets</li> <li>Model cache (*.scv, *.osgb, *.s3m, *.scp)</li> </ul> |
| KML\KMZ            | <ul style="list-style-type: none"> <li>KML two data formats</li> </ul>                                                                           |
| Raster volume data | <ul style="list-style-type: none"> <li>Raster datasets</li> <li>Raster volume data cache (*.scvo)</li> </ul>                                     |

Currently, SuperMap iServer not only supports publishing these source data, but also supports publishing the cached 3D data generating from pre-processing these source data. The data are split in levels and tiles during the pre-processing for caching. In this section, the data types that are supported in SuperMap Realspace are introduced.

### Vector data

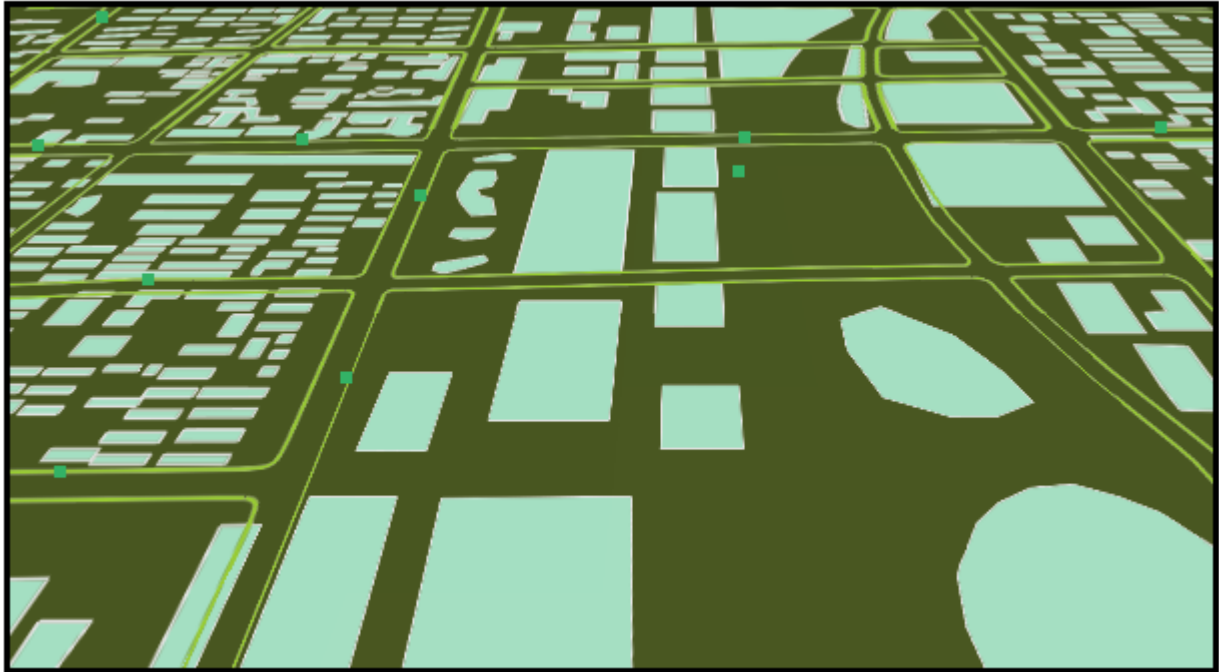
SuperMap 3D supports loading and displaying SuperMap vector (point, line, region, or text) datasets in a 3D scene. The essence is that it places the 2D vector geometries on the sphere according to their coordinates. When loading 2D vector data in a 3D scene, 2D data are converted to 3D layer data. It means that the spatial information of every geometric object adds an additional Z coordinates. And now you can stretch the vector geometries with a height you set. And you also can set a elevation, a display style for them.

The vector datasets supported in 3D scene are: point, line, region, route, network and the geometry objects (point, line and region) in compound datasets.

Vector 3D caches mean the 3D caches generated from vector dataset. The purpose is that, when users view a map or a scene at some scale, the cached images will be automatically loaded for display to ensure the smoothness of the

viewing. And unlike the generation of other types of cache data, the vector 3D caches only generate caches at one specific data, which means it creates only one level caches, because vector data themselves are not affected by resolution, the zooming in/out operations can not affect the display clarity.

After cache is generated from vector data, a cache configuration file \*.scv and a cache index file \*.dat are generated. The \*.scv file is in a plain-code format, and is generated by default when vector cache is generated by the SuperMap desktop product. Cache data can be loaded through this configuration file. This file records the cache version information, the network path and local path of the cache, the cache name, the cache file type, the extent for generating the cache, the longitude and latitude range of the tile on the first level, and the extent for displaying the data at one time.



SuperMap 3D service adopts the following methods to improve the efficiency:

1. Store 2D points instead of 3D points.

During the process of converting 2D vector data to 3D data, a third-dimension coordinate (the elevation value  $z$ ) is added. Thus the data volume is significantly increased. Directly transmitting 2D vector data can effectively reduce the data volume without affecting the data quality.

2. In addition, in order to improve the precision of the storage nodes, SuperMap 3D adopts the method of changing the data types of vector data coordinates for the transmitted vector data. That is, the short (8 bits) integer which is the original format of vector data coordinates is changed as float (32 bits).

### Image data

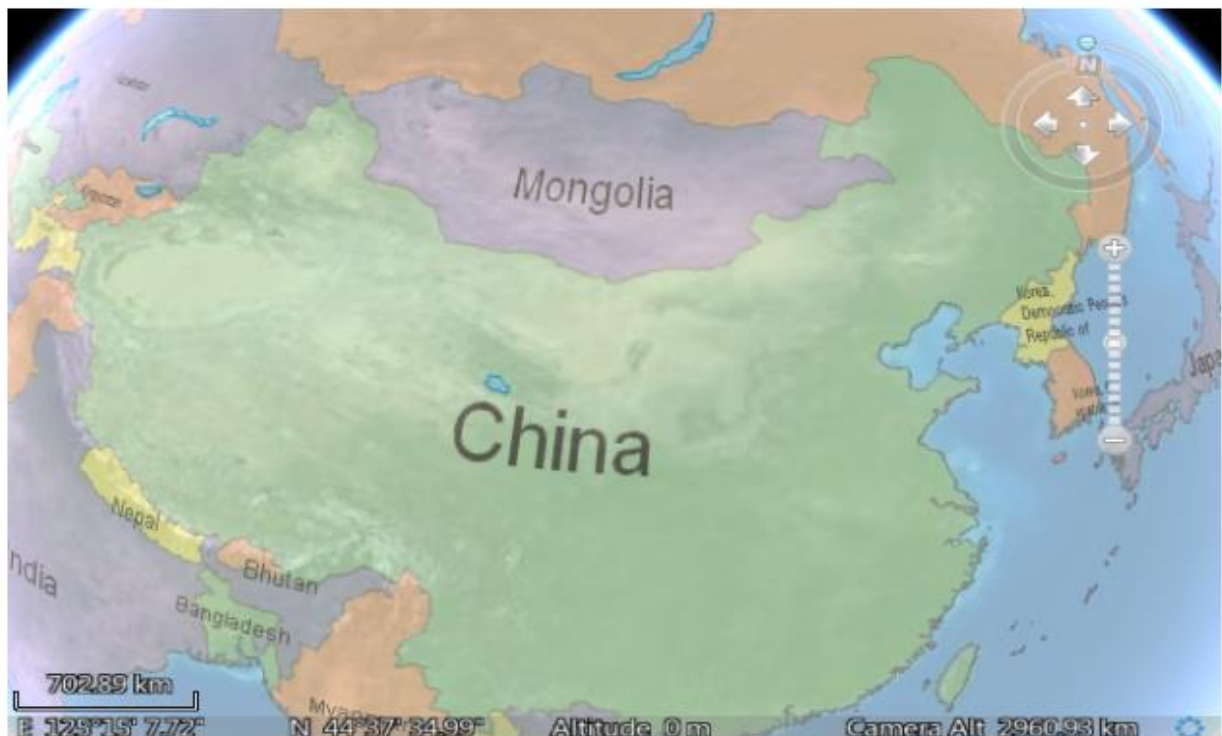
SuperMap Realspce supports preprocessing image files in \*.bmp, \*.gif, \*.jpg, \*.png, and \*.tiff formats to generate image data that can be loaded in a 3D scene. Image data can then be added on the globe surface in a 3D scene according to their coordinate information. The image data here include image datasets (sit), raster map datasets and corresponding 2/3D image cache data (sci, sci3d), and 2/3D map cache data (sci, sci3d). Because the size of image/raster map data is usually large, pre-caching is usually employed when a service containing this type of data is to be published, to improve the efficiency of loading and viewing the data. The idea is that, after pre-caching, the image data saved on the SuperMap iServer server has been preprocessed.

The processes of caching image/raster map data are: first partition the data and generate tile data; save the tile



data into corresponding cache folders after naming the tile data based on certain rules; in the mean time, the system will generate an index file in \*.sci3d format in the root cache directory. The tile data are usually in the PNG, GIF, or JPG format. The \*.sci3d file records the cache information of the map data, i.e., it is the configuration index file of the cache data files of the image/raster map. When adding image/raster map cache data in a 3D environment, users can load data by loading the corresponding index file of the image/raster map cache. Thus the efficiency of loading and viewing massive image data and raster map data can be greatly improved by caching the image/raster map.

The figure below shows the cached image in image format after a remote sensing image and map data are loaded in a 3D scene and published as a realspace service.



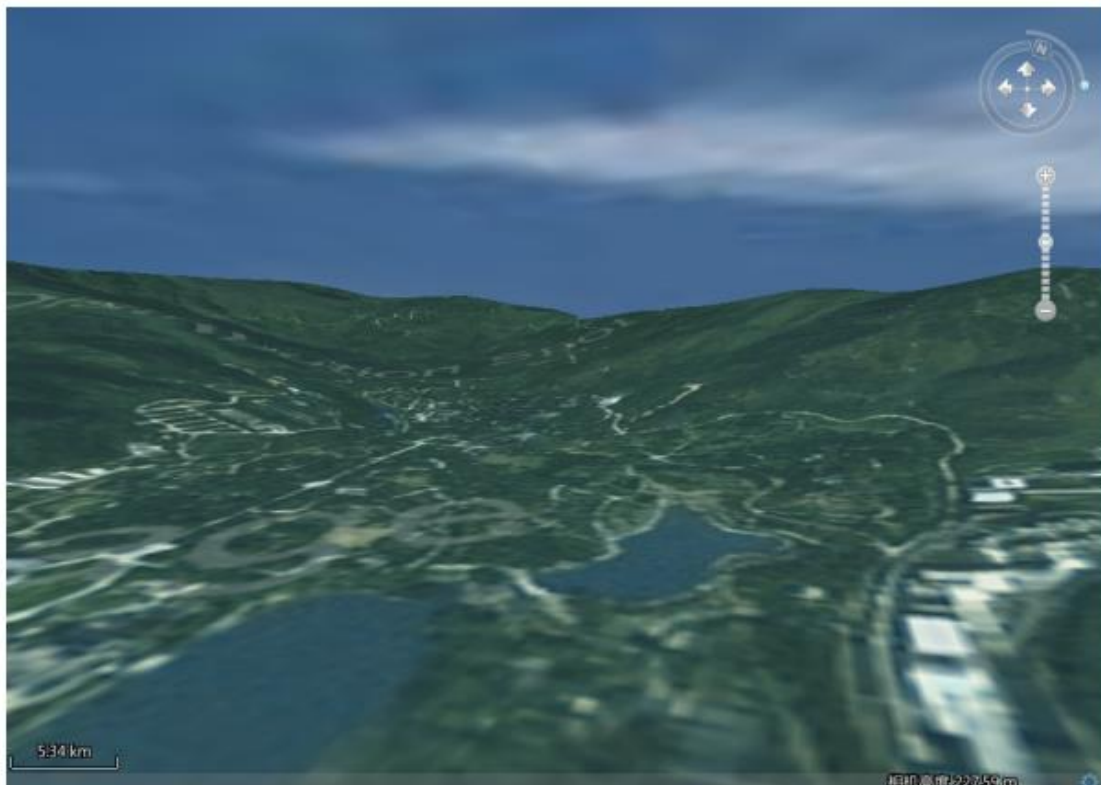
To improve the data transmission speed and lower the data transmission volume, SuperMap Realspace considers the advantages and disadvantages of JPEG and PNG formats when deciding the format for the tile data in an image cache, then a caching scheme with mixed format is designed. The JPEG image format (\*.JPG, \*.JPEG) is a commonly-used image format. It is a format with lossy compression, and can compress an image to a size that fits in very small storage space. Thus it has very powerful compression capability. The PNG format (\*.png) is the most popular format in WEB applications. It supports high level and lossless compression, and can produce compressed image files that are 30% smaller than GIF files without loss of data. Compared to lossy compression by JPEG, PNG offers a smaller compression ratio, but maintains the transparency of edges.

Considering the above characteristics, SuperMap 3D provides a mixed model of JPEG and PNG for caching. It allows users to use tiles in both JPEG and PNG formats for the same cache. Users can employ the JPEG format for tiles in the middle cache blocks to reduce the sizes of corresponding files, and employ the PNG format for the outer cache blocks (because the transparency of tiles in this part need to be maintained). This kind of mixed model has the advantages of both the JPEG and the PNG image formats. Cache files can benefit from the JPEG format and use less disk space. In the mean time the display of the entire image is not affected by the edges of cached tiles. The disk space used by cache files is effectively reduced, and the speed of image data transmission is improved.

## Terrain data

Terrain data are data that represent the ups and downs on the Earth surface, i.e., data containing elevation information. Digital elevation model (DEM) is a continuous representation of spatial variation in elevation. It is a special data model of the DatasetGrid type. The value in every grid is an elevation value, and is represented with a standard color, which is helpful for merging adjacent DEM images.

SuperMap Realspace services support preprocessing DEM and Grid elevation data to generate 3D terrain cache data and publish them. Elevation model are divided into levels and blocks based on a global grid division model. A cache directory is generated accordingly and a SCT file (\*.sct) is generated at the same time. This SCT file contains detailed description on the generated cache, such as the number of cache levels, the cached geographical extent, the cache file type, etc. When loading cached terrain data in a realspace environment, users can load cached terrain data by loading the corresponding index file. Terrain data are added on the 3D globe in a 3D scene according to the coordinate information, so that the globe surface can simulate the ups and downs of the Earth surface realistically.





For transmitting terrain data, SuperMap 3D adopts the following strategies to reduce the transmitted data volume and improve the efficiency of data transmission:

1. The sample points are increased during dividing terrain data to increase the data information volume of each tile. The original tiles are packaged into a big file to decrease the number of tiles and the number of files on the disk. The times of transmission are then reduced, and data with larger size can be published. In addition, the time for creating the cache can also be reduced, and the efficiency of displaying and viewing on a client is improved;
2. Compression and transmission. A server compresses data and then transmits them. The data are then downloaded and decompressed on the client before they are used.

#### Model data Feedback

The SGM (SuperMap Global Model) data format is a whole new format provided by SuperMap for storing 3D models. It allows a model to be quickly loaded in a scene for display and view. In addition, files are encrypted with this format to protect the data. SuperMap supports converting 3D model data (e.g., \*.3ds) that are popular nowadays to model data in \*.sgm format and then loading them in a scene.

SuperMap 3D can generate 3D model cache files from 3D data, and then load them in a 3D scene. After 3D model data are cached, the 3D model cache data include a configuration file \*.scv and an index file \*.dat (replacing the original \*.scm and \*.index). The \*.scv file is in a plain-code format, and is the cache configuration file of the 3D model data. SuperMap loads cached 3D model data via the \*.scv file.



SuperMap Realspace adopts a direct compression method to improve the efficiency of model data transmission. A compression mode is adopted when model cache data are generated. The server then transmits the compressed model data to the client. Data are downloaded and decompressed on the client before they are used. This compression and decompression flow can reduce the data volume during data transmission, and thus improve the transmission performance.

In addition, SuperMap introduced an optimized version of the \*.scv format for 3D model cache. This version was designed to improve the speed of downloading model data, to prevent large individual texture file, and to solve some

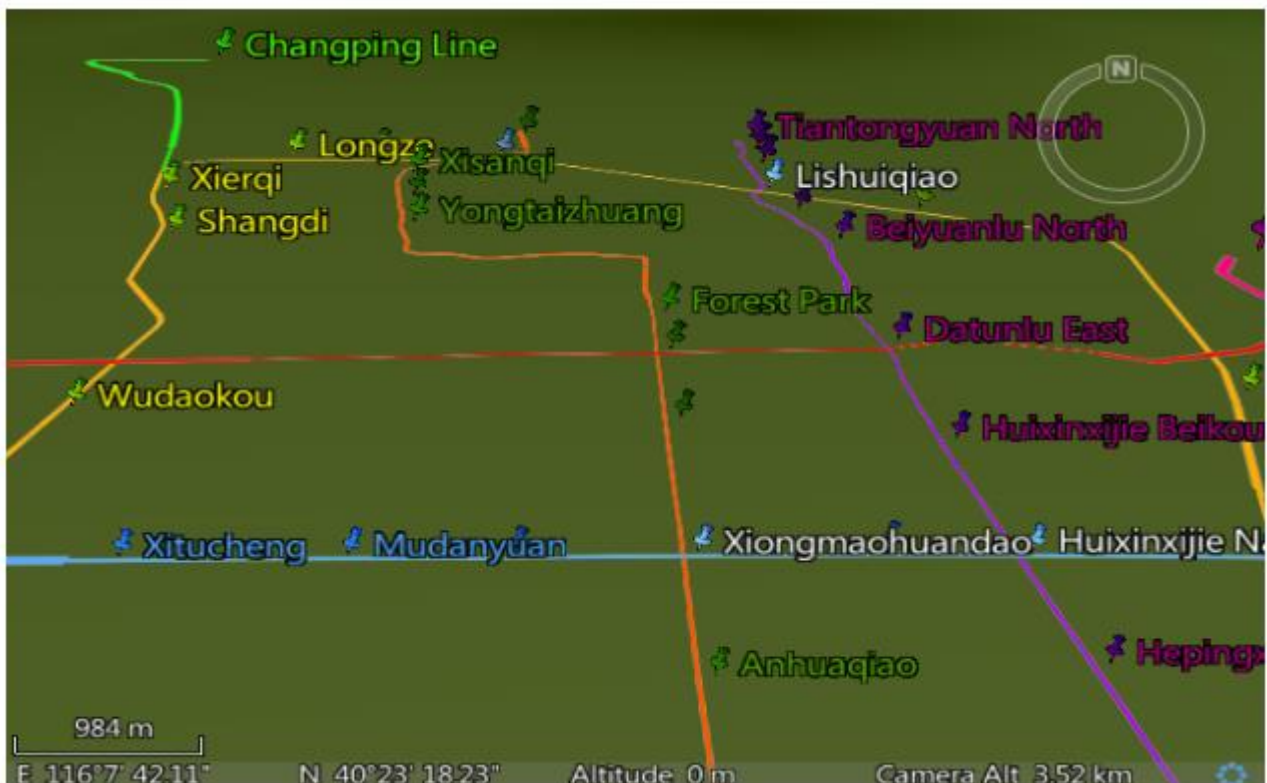
data downloading failures on clients. With the upgraded scv data format, models and texture files are not packaged and sent to clients as a whole as with the original format. Instead, texture files are packaged in groups and sent to clients based on their requirements. The response time the clients have to wait is thus reduced, and the efficiency of data transmission is improved. At the same time, the failure in downloading model data is also solved. SuperMap now uses the upgraded scv format as the standard format for 3D model cache. It still supports loading and publishing data in the original scv format, but does not support generating data in the original scv format anymore.

## KML/KMZ data

KML is a markup language based on the syntax standards of extensible markup language. It adopts the markup structure containing nested elements and attributes, and is used to represent geographical features. Files compiled with the KML language are KML files. The format is also based on XML syntaxes and format. It is used in Google Earth-related software (Google Earth, Google Map, etc.) to display geographic data (including points, lines, regions, polygons, polyhedrons, models, etc.). KML has been adopted by OGC and become one of many OGC standards. KML files have two file extensions: \*.KML and \*.KMZ (a compression set of one or more KML files which are compressed in zip format).

The layer types supported by KML include: images, geometric objects (points, lines, or regions), models, etc. SuperMap 3D supports displaying geographical information recorded in a KML file in a 3D scene as a 3D KML layer. That is, information recorded in a KML file is added on the globe in a 3D scene according to the coordinate information.

If KML file contains models, you need package and compress the KML file, model data and textures with zip format, then change the extension to \*.KMZ format before publishing a SuperMap 3D service.



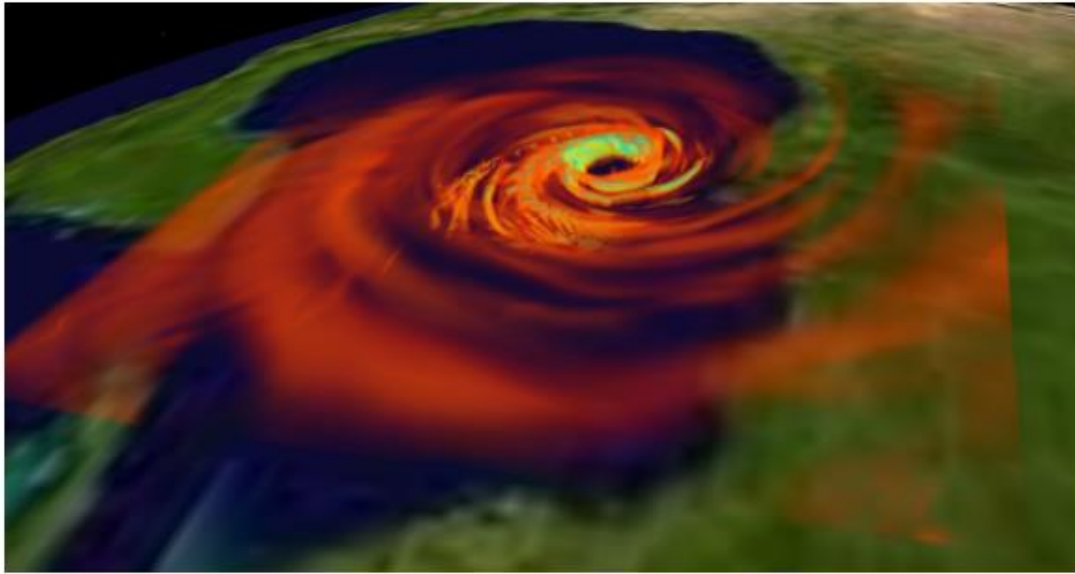
## Raster volume dataset

The raster volume data records the values of the discrete lattices in a three-dimensional or multidimensional space, which is of great use in many fields such as computer graphics, geology, meteorology, etc., and can be used to simulate spatial communication signals strength, haze index, typhoon expression and so on.

Details of the physical spatial body can be displayed. The integrated distribution of a plurality of substances is



displayed in a single image, and the isosurface is represented by the level of the opacity. 3D volume data can be seen as expansion of two-dimensional raster data in the three-dimensional space, so that the details of internal level of the feature can be shown.

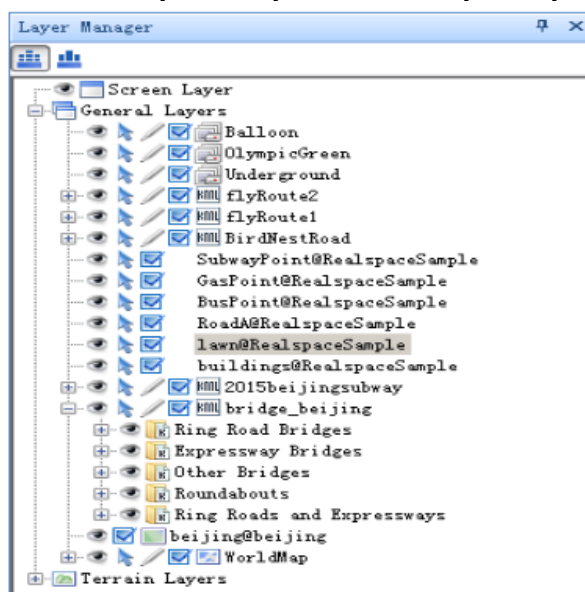


By the Build volume function in SuperMap iDesktop, the raster volume dataset can be generated based on one or more 2D raster dataset; by the Create cache function it can generate the cache for it (\*.scvo). At present, there are two ways to display a raster volume dataset in a three-dimensional scene. One is to load the dataset directly into the scene to express the data information, such as typhoon; the other is to rely on other layers to express the data, which needs to further generate the cache, such as communication signals, haze intensity.

## Layers of 3D scene

As in a 2D map, in a 3D scene, data are loaded onto the 3D globe as layers for display. For example, image data, terrain data, and vector data are all added in different layers for display. In a 3D scene, layers can be divided into four types according to their functions and the data contents contained: general layers, tracking layers, screen layers, and terrain layers.

A 3D scene can contain more than one general 3D layer (Layer3D), and more than one terrain layer (TerrainLayer). The attribute information of each layer includes the basic information of the loaded layer, such as the layer name, the layer description, the visibility of the layer, the selectivity, the layer extent, etc.



## **General layers**

General layers are used to load data for display. There may be multiple general layers in a 3D scene. Styles of general layers can be set and saved in a 3D scene. When the 3D scene is opened next time, the layers will be automatically loaded with the styles saved last time. In a general layer, the object locations relative to the globe are fixed. Thus the scene will be linked and changed with operations on the globe. For example, when the globe is panned, objects in a layer will move with the globe.

General layers can be categorized into five types according to the data contents loaded in them. But since SuperMap has defined terrain layer separately, general layers are categorized into four types: vector 3D layer, image 3D layer, model 3D layer, and KML/KMZ 3D layer.

## **Terrain layers**

A terrain layer in SuperMap Realspace is used for loading terrain data. Terrain data loaded in a 3D scene are managed as a terrain layer. The terrain data are added in a 3D scene as a terrain layer in the form of terrain cache files, i.e., files in \*.sct format. A terrain layer in a 3D scene is managed by the terrain layer set in the 3D scene. Functions such as adding, deleting, and reordering terrain layers are available.

## **3D Tracking layer**

A 3D tracking layer is a temporary layer covering the globe surface in a 3D scene. It is always on the top of other layers in a 3D scene. A 3D tracking layer stores 3D geometric objects added to it. When a 3D scene is closed, the contents of the tracking layer are also cleared.

A 3D scene can only have one 3D tracking layer. A 3D tracking layer cannot be deleted or re-located. Any types of 3D geometric objects can be added to or deleted from a 3D tracking layer. The objects in a tracking layer are not saved. They are only stored in the memory temporarily when a scene is displayed. When the scene is closed, the objects in the tracking layer do not exist anymore. When the scene is re-opened, the tracking layer will be an empty and transparent layer again.

## **Screen layer**

SuperMap Realspace also provides a screen layer. A screen layer is a special layer that is different from a general layer and a 3D tracking layer. Objects in a screen layer are not located on the globe in the 3D scene based on coordinate information. Instead, the objects are located on the screen (the 3D window surface). Therefore, geometric objects in a screen layer do not change with operations on the globe such as rotation and tilt. Instead, they change as the 3D window changes. For example, their locations will change as a 3D window is enlarged or shrunk. In other words, the objects in a screen layer are static relative to the 3D window. Thus a screen layer can be used to store contents that need to be displayed statically in the 3D window, such as Logo, descriptive texts, etc.

A 3D scene has one and only one screen layer. Any 3D geometric objects can be added in a screen layer. The display location and size of the objects can also be set. Geometric objects can also be deleted if they are not needed anymore.

## **How to build a 2D and 3D Integrated B/S application**

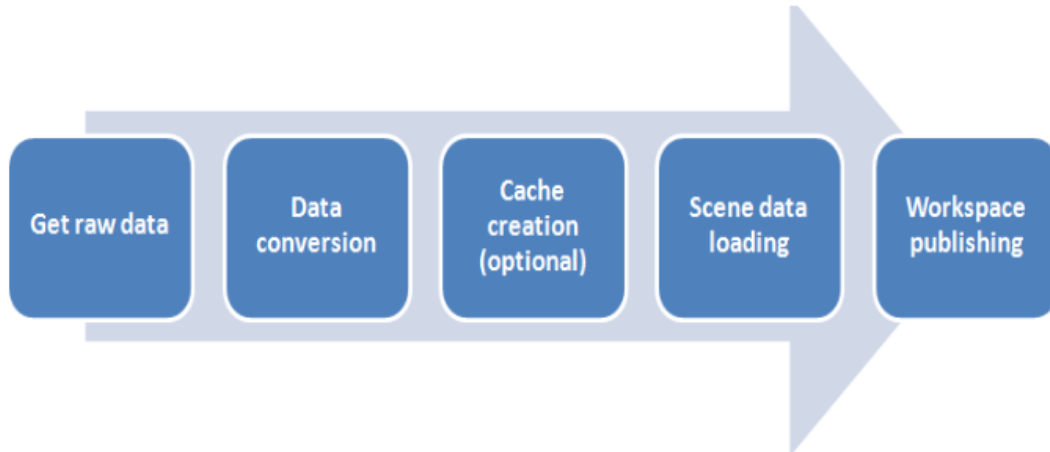
SuperMap iServer 7C publishes and manages 2D services and 3D services using the same methods, and provides a realspace development tool kit for Web clients--SuperMap iClient for 3D. Developers can easily and quickly build B/S structured applications with 2D and 3D GIS integrated, implementing functions such as fast loading of massive data, 2D and 3D map linkage, spatial and attribute query, spatial analyses, simple editing, geocoding, etc.

## **3D service publishing flow**

SuperMap iServer can publish these datasources: SuperMap workspace and remote WMS 1.1.1 datasource and remote WFS 1.0.0 datasource. SuperMap 3D services can publish many types of data. Users' data are usually organized in SuperMap workspaces, i.e., the data are loaded in the 3D scene in the same workspace and then published.

A SuperMap workspace is a working environment for users to store all the datasources of a project (one transaction process) and the organizations of and relationships between maps. SuperMap iServer recommends that users use Oracle Plus datasource, SQL Server Plus datasource, or the UDB datasource to store data (existing SDB datasource can be converted to UDB data or a database datasource in SuperMap iDesktop 9D).

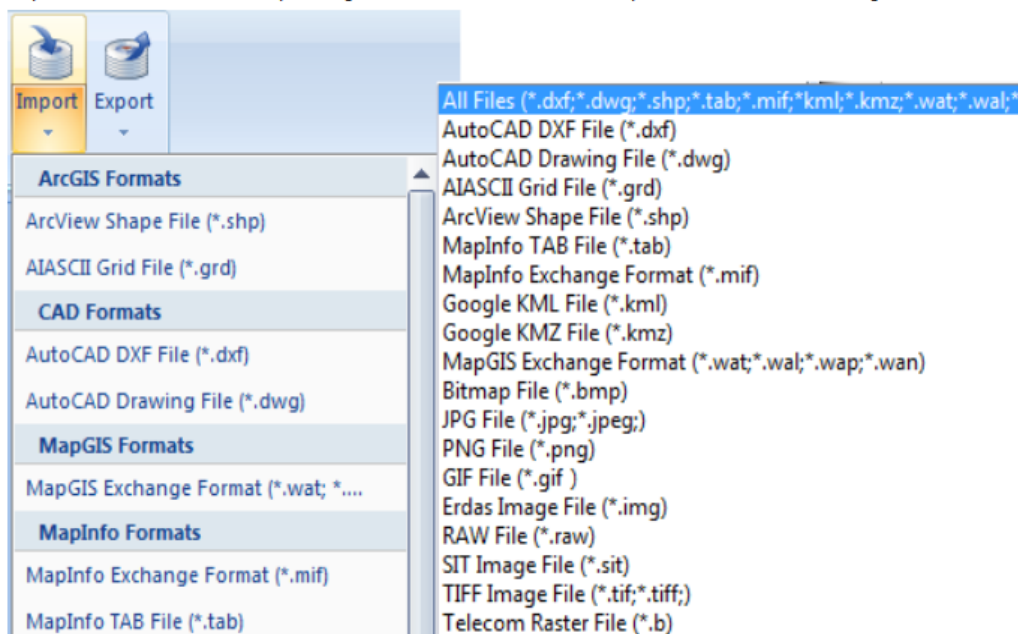
SuperMap iServer provides a complete service publishing scheme with 2D and 3D services integrated. The publishing processes of a 3D service are the same as those of a 2D service. Once the workspace containing the 3D scenes is ready, a user can quickly publish the service via "Quickly publish service(s)".



In many cases, however, users have data coming from various sources with different types. In this case, the data need to be converted and processed to generate corresponding 3D cache data before the data are loaded in a 3D scene. The overall flow of publishing a SuperMap 3D service is:

## 1. Preparing the data

As described in Data in 3D scene, data types that SuperMap 3D services can publish include vector data, maps, images, terrain data, models, and KML data. Some of them are original 2D data, and some are 3D cache data. However, a user's original data come from various sources and they may not be the SuperMap data formats. So SuperMap iDesktop provides the data conversion module to solve this problem. Now the data conversion module supports importing 20 commonly-used data formats, which is located on the drop-down menu of the "Importing data" drop-down button. The corresponding file extensions that can be imported are shown in the figure below.



## 2. Converting the data

It is recommended that the data published in SuperMap 3D services are saved as the file datasource format of SuperMap, i.e., the \*.udb format. The UDB datasource is a file datasource that is cross-platform and supports efficient storage and retrieval of massive data. The maximum data volume a UDB datasource can store is 128TB. Users can create new datasources of the UDB type as needed, and then import datasets into them. The dataset types that can be imported are listed in the figure on the right.

Additionally, image data format SIT, 3D model cache data format scv, map cache data sci, and KML/KMZ data are also commonly-used data formats. They can also be directly loaded in a 3D scene without being converted to the UDB format.

## 3. Generating the cached data

When publishing a SuperMap 3D service, the user can preprocess the data and create a hierarchical cache before loading them in order to improve the performance of the 3D data application. SuperMap 3D provides a mature caching mechanism which can be used to preprocess vector, image, terrain, or model data and create a hierarchical cache. The recommended caches are: 3D vector\model cache (\*.scv), 2/3D image/raster map cache(\*.sci, \*.sci3d), and 3D terrain cache (\*.sct).

Before loading data, the user can click on the dataset for which cache is to be generated in SuperMap iDesktop 9D, and the right click to select generating 3D cache. For map set data, 2D and 3D map caches can be generated for the whole set. About the caching mechanism that a SuperMap 3D service uses to improve its performance, it is described in details in Optimizing the performance of a 3D service about when to generate pre-cache and what kind of data do not need caching or may employ dynamic caching.

## 4. Loading the 3D scene data

A 3D scene is the medium for displaying 3D data. All the 2D and 3D data published in SuperMap 3D services must be first loaded in a 3D scene and then published. In SuperMap iDesktop, it is simple to load data into a 3D scene: After a new 3D scene is created, click on the dataset to be loaded; then right click on it and select "Add to the current scene"; or select "Add cache..." among the scene operations. Additionally, a scene cache can be directly generated for the scene with data loaded. Once the 3D scene is saved and named, the 3D scene containing the data to be published is successfully created.

## 5. Publishing the workspace

After the data are ready and added to a 3D scene, save the workspace and set its path and name. It can be published as 3D service directly, or can be quickly published by SuperMap iServer.

## 3D service publishing example

When a SuperMap 3D service is to be published, the processes may be one of the following three types depending on the specific data type: publishing a datasource, publishing cache data, and publishing model data. In this section, the publishing processes of the three types are described.

### Publishing datasets

The processes of loading datasets or data in standard formats such as WMS, WFS, and KML/KMZ in a 3D scene and then publishing the 3D scene are basically the same. An image dataset Beijing.sit is used as an example here to illustrate the flow of publishing 2D and 3D data.

Step 1. Import the dataset.

In SuperMap iDesktop, right click on Datasources to create a new file datasource. Set its path and file name (test.udb is used here). Then right click on datasource test to import dataset beijing.sit in it. No new datasource is

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created here because a ".sit" file itself is a file type datasource and can be directly opened. If other image formats are used, e.g., a tiff file, the file cannot be opened directly and can only be imported via a datasource.

Step 2. Create a new 3D scene. Right click on Scenes to create a new scene. An empty scene will be generated.

Step 3. Drag the image dataset from the workspace manager into the 3D scene window. Or right click on Beijing to load it in the current scene.

Step 4. Save the 3D scene, and name it as scene1. Save the workspace. Set a path and name (Realspace1.smwu) for the workspace. Select SuperMap UGC 6.0 (i.e., the \*.smwu format) as the workspace version. The password can be empty.

Step 5. Right click the workspace, select the Publish Services. Select the 3D service in the REST service.

In addition, you can also publish the service quickly through WebManager of SuperMap iServer. Please refer to Quickly publishing\_GIS\_Services.

After publishing the service, you can see the new scene1 by accessing its scenes resource. Select View scene with 3D to view the data beijing.sit.

## Publishing cache data

SuperMap iServer allows 2D and 3D cache to be directly added into a 3D scene and then publish the 3D scene, such as image caches, model caches, vector caches and map caches.

When you are using, you can create the scene caches through SuperMap iDesktop for the vector datasets, image data (SIT file), terrain data and model data. Then add the 3D cache files to the 3D scene directly. Of course, for the map, SuperMap supports to load 5.0 Format tile to the 3D scene to publish.

Supported 3D cache types:

Figure 1 Supported 3D cache types

| Cache type | Cache format          |
|------------|-----------------------|
| Vector     | *.scv                 |
| Image      | *.sci3d, *.sci, *.sit |
| Terrain    | *.sct                 |
| Model      | *.osgb, *.scv         |
| Map        | *.sci3d               |

Follow the steps below to generate 3D cache files and load them in a 3D scene:

- (1) Import the data with the original datasource format retained;
- (2) Generate scene (or map) cache (5.0 format);
- (3) Create a new 3D scene;
- (4) Load the cache into the scene. Right click General Layers and click Add XX cache Layer; or click Cache>Load all cache data in the folder under Scenes>Data menu.
- (5) Save the 3D scene and the workspace;
- (6) Publish the workspace where the data are.

For details about operations in each step, please refer to Publishing datasets. Once the workspace is saved, the data preparation is completed. The flow of publishing a workspace is the same for different data, thus is not repeated

here.

## Publishing model data

SuperMap supports loading \*.3ds and \*.sgm models which are popular nowadays in a 3D scene. Either \*.3ds or \*.sgm data can be selected when a model is to be added. However, it is recommended to convert the \*.3ds data format to \*.sgm before adding the data in order to improve the efficiency of adding a model and the display effect. When converting the \*.3ds format to the \*.sgm format, the system filters and extracts the model framework of \*.3ds, and resamples its tiled texture to create a series of images with different resolutions. The images are also indexed. When a model is being loaded, the system will automatically add proper textures for display based on its indexing mechanism.

In SuperMap iDesktop 9D, the operation steps for converting \*.3ds data to \*.sgm data and publishing them are as follows:

1. Click the Model>Model conversion under the Data>3D Data tab. A Model->OSGB/S3M dialogue box will pop up. Set the path of the source 3DS model files (batch conversion is used here), and then set the path for saving the target SGM models after conversion (batch conversion is used here). Click the Convert button to implement the model conversion operation.
2. Create a new 3D scene;
3. Click the Add Model button under the Scenes tab. The Add Model dialogue box will pop up. Select a layer to save the model, or click the New Layer button to create a new layer for storing the model information. It is recommended to select 3D model cache file format (\*.scv) as the layer type. Click the Add Model button. The Open 3D Model File dialogue box will pop up. Select the model file (the converted SGM file) to be added and click on Open. Click the OK button to complete the operation.
4. Save the 3D scene and the workspace;
5. Publish the workspace where the data are.

As mentioned above, for the details about operations in each step, please refer to Publishing datasets.

## Stretching geometries and publishing

Besides model data, users may also need to create simple models. They may not want to use any third-party model-making software, but prefer to directly extend region objects in SuperMap 3D scenes and tile textures on them, realizing simple 3D display. To meet this type of requirements, SuperMap provides complete solutions to vertically extending region objects, tiling textures on them, and publishing them in 3D. In a 3D scene, the geometric objects in a vector dataset will become 3D volume objects after being vertically extended.

The basic flow for realizing extending geometric objects and tiling images on them for publishing are as follows:

Step 1. Prepare the dataset and the geometric region objects to be extended. Fill in the layer attribute table with fields correspond the parameters below, and assign attribute values according to the attribute descriptions in the table below.

Figure 1 The extended attribute of the vector layer

| Attribute       | Description                                                                                                                                                                                                                                                                                      |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Extended height | 2D geometric objects in a 3D layer of the vector dataset type can be vertically extended in a scene. The vertical extended height of objects above the Earth surface can be set in the combo box on the right of the "Extended height:" tag.                                                     |
| Bottom altitude | In a 3D layer of the vector dataset type in a scene, all the objects are displayed at locations corresponding to their longitudes and latitudes. The elevation value at the object locations above the Earth surface can be set in the combo box on the right side of the "Bottom altitude" tag. |

|                   |                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Top texture       | Specifies the texture file used to tile on the top of the model.                                                                               |
| Side texture      | Specifies the texture file used to tile on the side of the model.                                                                              |
| Tiling U/Tiling V | All the objects in a 3D layer of the vector dataset type are rendered using 3D tiling with the same textures repeated horizontally/vertically. |

All of the above parameters are available for setting only when the altitude mode in the Altitude model options is set to non-Clamp to Ground mode.

Step 2. Create a new 3D scene, or load the above vector dataset into an existing 3D scene. Select Styles>Extension, and set the altitude mode to Relative to ground. Then set the parameters in Extension Attribute, i.e., select the proper fields in the combo boxes corresponding to the parameters.

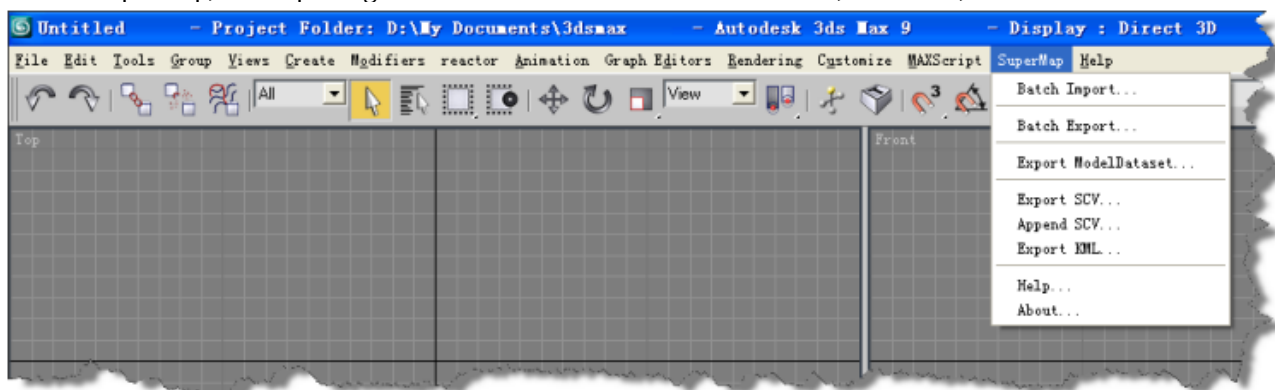
Step 3. Save the 3D scene and the workspace.

Step 4. Publish the workspace where the 3D scene is as a SuperMap iServer realspace service. For details about the operation, please refer to Publishing datasets.

### Publishing animation model data

SuperMap supports animation model data in the scv format to be loaded in a 3D scene for publishing. Users can generate animation model data using a piece of third-party software that makes 3D models (Autodesk 3ds Max 9). The animation model can then be exported to data in the SGM format via a plug-in provided in SuperMap. After that the data can be imported to a workspace via the desktop software. The creation and publishing flow of animation model data is as follows:

1. Installing the plug-in: Get the plug-in file. Extract the file and copy all the file contents into the local 3dsmax9 installation directory. Start 3dsmax9. The SuperMap plug-in menu can then be seen on the interface. Currently this plug-in only supports exporting 3D models (animation and non-animation) to 3D data in the SGM format of SuperMap, and exporting non-animation models to model datasets, SCV data, and KML data.



2. Making the model: Make 3D animation model data, or import existing animation model data to 3ds Max 9.
3. Exporting the model: Export the animation model data to the SGM format of SuperMap. To do this, click on "Save as", and select the SGM format.
4. Importing the model: Open SuperMap iDesktop 9D, and create a new file datasource, i.e., the UDB datasource. Then create a new attribute dataset in the new datasource and add fields representing the path of the model (e.g., MPath), longitude and latitude (e.g., x, y), and model elevation (z). These parameters are required when an animation model is imported.
5. Caching the model: Select the new attribute dataset. Right click on it and select generating 3D cache. Then set the field information of the model in the pop-up dialogue. The required fields are the path and the geographic location of the model, which correspond to the new fields created in the attribute dataset.

6. Loading the model: In a new 3D scene or an existing 3D scene, right click on general layers, and select "Add cached model layer".
7. Publishing the service: Save the 3D scene and the workspace. Publish the workspace.

For details about operations in each step, please refer to Publishing datasets. Once the workspace is saved, the data preparation is completed. The flow of publishing a workspace is the same for different data, thus is not repeated here.

### **3D service security measures**

As mentioned in the integration of 2D and 3D , getting 3D space data is much more expensive than 2D, especially resource-costly modeling. Users will cherish their 3D data in hand and concern the security of 3D data that they published, therefore the security problem of 3D scene and 3D data is very important.

To the security problem of 3D cached data, SuperMap provides two-layer security guarantee, the encryption when producing data and the encryption after data published.

#### **Encrypt when creating cache**

For the security of 3D datasets, SuperMap provides encryption mechanisms of cache files, which can set passwords on cache files. Cache encryption setting is the first protection of cache data. The password is directly written into cache files, and any action using the cache files can be implemented only if the password is provided. When using SuperMap iDesktop to create the caches, you can set the cache file password. After setting the password, the operations about cache should provide the password.

Please refer to Encrypt when creating cache data.

After the 3D service is published, any client that can access the service can get the data. So the cache password doesn't work anymore. Please use Security guarantee after cache is published to make sure of the safety of 3D data.

#### **Security guarantee after cache is published**

##### **Secure access to 3D services**

SuperMap iServer provides good security mechanism to secure the safety of the published data and services. If your GIS server opens security control, then the Role-based access control system can strongly protect 3D services.

Besides, SuperMap iServer provides safety certification that based on RSA for 3D service, ensuring that only iClient and the client who holds the private key can access to 3D service.

##### **3D cache data security**

When the Client is using 3D service, the 3D data will be stored in client local by default. To ensure 3D service and cache data safety, iServer offers the encryption mechanism for cached data generated when the 3D client browsing 3D services.

By this encryption mechanism, only iClient can directly use the downloaded 3D cached data, otherwise you need to provide the password. See: Encrypt for 3D client cache.

### **Performance optimization of 3D services**

Generally speaking, map caching technology is an effective method for quickly accessing the map services. According to certain mathematical schemes, the maps are partitioned into tiles with certain specifications and are deployed into server. When users access map services with the client browser, the server can directly return the right cached images within current map coordinate domain, and thus reduce the server's burden and improve the map



browsing speed efficiently.

Map caching technology can be applied to the large amount of data of which the update frequency is low, to improve the map browsing speed notably, thus improve the users' experiences. For 3D data, SuperMap iServer provides a complete caching system, such as precaching, dynamic caching, etc.

### 3D data optimization

#### Optimization methods

SuperMap 3D takes a series of measures in order to optimize 3D data and improve the data transmission speed and service access efficiency. The optimization methods are different for different types of data, and are introduced detailedly here.

##### 1. Vector data

For the transmitted vector data, SuperMap 3D adopts following methods to improve the data transmission efficiency: storing 2D points, but not 3D points.

A third-dimensional coordinate (elevation z) is added in the process of converting the 2D vector data to the 3D data, and thus the data quantity is notably increased. Therefore, directly transmitting 2D vector data can effectively reduce the data quantity without affecting the quality of the vector data.

In addition, in order to improve the precision of the storage nodes, SuperMap 3D adopts the method of changing the data types of vector data coordinates for the transmitted vector data. That is, the short (8 bits) integer which is the original format of vector data coordinates is changed as float (32 bits).

##### 2. Image data

For the tile data format in the image cache, SuperMap 3D considers the advantages and disadvantages of the JPEG and PNG file formats and thus provides the image cache methods of mixed formats, in order to improve the data transmission speed and reduce the data transmission quantity. Here, the JPEG image format (\*.JPG, \*.JPEG) is a common format of lossy compression, which has powerful compression functionality and can compress the image into a small storage space. The PNG (\*.png) format is the most popular file format in the WEB applications, which supports high-level lossless compression and provides lossless-compression image files that are 30 percent shorter than those of the GIF format. Compared with the lossy compression of JPEG, the compression of PNG is less in amount but can keep edge transparent or semi-transparent.

Based on above features, SuperMap 3D provides the cache of JPEG+PNG mixed mode, which permits users to use the tiles of both JPEG and PNG image formats in the same cache. Users can choose to use JPEG format for the tiles in the centre of the cache area so as to reduce the relevant file size, and use PNG format in the periphery of the cache (i.e. this part of tiles need to keep transparent). This mixed mode considers the advantages of both JPEG and PNG image formats. The cache files maintain the JPEG's advantage of occupying small disk space and make the whole image display not affected by the edge of the cache tiles, thereby effectively reducing the disk space occupied by the cache files and improving the image data transmission speed.

##### 3. Terrain data

For the transmitted terrain data, SuperMap 3D adopts following methods to reduce the data transmission quantity and improve the data transmission efficiency:

- When partitioning the terrain data, the sample points increase a lot, so each blocked data has a large data information. By integrating the blocked data into a large file, the quantity of blocked data, files in the disk reduce a lot. Thus data transmission times and cache creating time are shortened to improve the browsing efficiency on the client side;
- Compressed transmission. That is, the data is compressed by the server before transmission. The client should decompress the downloaded data before using it.

##### 4. Model data

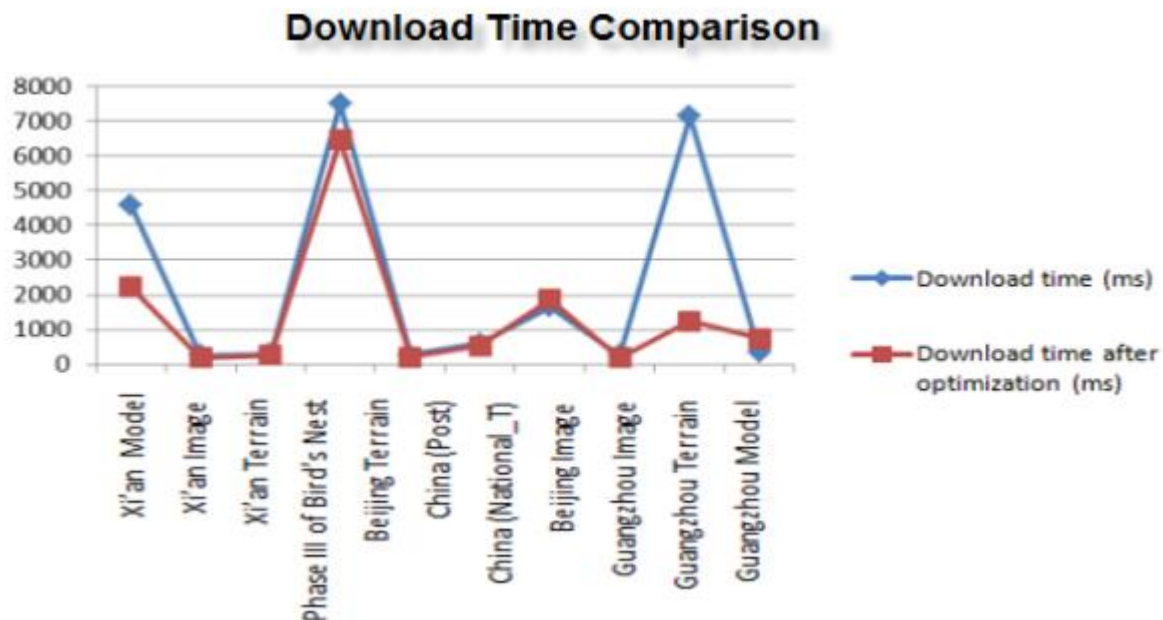
SuperMap 3D adopts the direct compression method to improve the model data transmission efficiency. That is, the server generates the data by compression mode and transmits the compressed model data to the client, and then

the client decompresses the downloaded data before using it. Such a process of compression and decompression can reduce the data transmission quantity and thus improve the transmission performance.

### Comparison of the performances before and after the optimization

Comparison of the download time and rendered frame number before and after the SuperMap 3D client optimizing the downloaded image data, model data, terrain data and vector data.

| Data                     | Download time (ms) | Download time after optimization (ms) | Rendering frames before optimization | Rendering frames after optimization |
|--------------------------|--------------------|---------------------------------------|--------------------------------------|-------------------------------------|
| Xi'an Model              | 4583               | 2232                                  | 20.0527                              | 58.7984                             |
| Xi'an Image              | 267                | 201                                   | 59.3654                              | 59.5047                             |
| Xi'an Terrain            | 297                | 267                                   | 58.9895                              | 59.7332                             |
| Phase III of Bird's Nest | 7499               | 6458                                  | 29.887                               | 41.8329                             |
| Beijing Terrain          | 274                | 210                                   | 59.4215                              | 60.0124                             |
| China (Post)             | 604                | 533                                   | 59.5007                              | 59.7062                             |
| China (National_T)       | 1660               | 1866                                  | 58.8658                              | 59.9854                             |
| Beijing Image            | 258                | 186                                   | 59.2154                              | 59.3754                             |
| Guangzhou Image          | 7132               | 1248                                  | 59.5624                              | 59.5571                             |
| Guangzhou Terrain        | 356                | 748                                   | 60.215                               | 59.6581                             |
| Guangzhou Model          | 58749              | 55381                                 | 19.8974                              | 35.4775                             |



As shown above:

- The compression scale of terrain data is bigger, followed by that of model data and image data. The compression of vector data has few effects.
- For terrain data, the downloaded data and download time change relatively notably before and after the

compression.

### 3D service cache mechanism

In order to improve the overall performance of 3D data application, you should preprocess the data before using it, that is, you should create hierarchical cache. Take the preprocessing of image data for example, you should simplify the image data into the image collection of various resolutions and create a series of layers of different resolutions by resample methods, and then split and store each layer and build corresponding spatial index mechanism, so as to improve the display speed of image zooming and browsing. Such action of preprocessing the vector data, image data, terrain data or model data to create hierarchical cache is called 3D caching.

#### Cache mechanism

SuperMap iServer's 3D service supports general cache mechanism provided by server. For example, HTTP cache, Request cache, and it also supports its special 3D cache, including dynamic cache and manual precache.

#### Dynamic cache

SuperMap iServer supports dynamic cache to increase clients' access speed of 3D scene.

After publishing 3D service, if it is the first time for a client to access service and read data, server will dynamically generate the corresponding layer's 3D. There is no need of generating cache for user's next access. In other words, except loading data and generating cache for use's first time access, server will call cache data in client directly, thereby increasing server's response speed when client is accessing 3D service.

SuperMap iServer's 3D service enables dynamic cache by default, without manual setting. About cache type and format generated by SuperMap 3D service, please refer to: Storage format.

#### Precache

Precache of 3D service means that putting the precache of file or whole scene into SuperMap iServer's corresponding cache directory, i.e, copying cache file to [SuperMap iServer installation directory]\webapps\iserver\output\{scene}.

After stores tiled cache file to above directory in advance, client will use cache data directly when browsing 3D service scene, no long generate dynamic cache. About data type and format of precache supported by SuperMap 3D service, please refer to: Storage format. When using 3D service's precache function, please keep the path and cache name compliant. The advantage of using whole 3D scene cache is that, in SuperMap iDesktop just one operation can tile all data in the scene into cache, and storing whole scene data to 3D service cache directory make it easier to ensure the consistency of every data cache file's name and directory. Therefore precaching for whole scene is recommended.

#### Notice :

- If you load cache layer rather than original file when using SuperMap iDesktop to make workspace or 3D scene, you can publish it directly in SuperMap iServer, and you don't need to copy the cache to SuperMap iServer cache directory manually.
- For the map in 3D scene, although scene cache (\*.sci3d format)is dynamically generated by default when browsing a scene, if the cache file that is stored in advance is map cache file(\*.sci) of SuperMap UGC V5.0 global subdivision,3D service can still recognize and use it when client is browsing maps in scene.

#### Cache format

##### Cache format

SuperMap iServer supports these cache formats: Image cache,terrain cache,vector cache, vector model cache, 2D and 3D map cache and whole 3D scene cache.

| Cache type | Cache format | Description                               |
|------------|--------------|-------------------------------------------|
| Vector     | *.scv        | Cache name:datasetname@datasourcename     |
| Image      | *.sci        | Cache name:datasetname@datasourcename_MIX |

|             |                                          |                                                                                                                                                                                                                             |
|-------------|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Terrain     | *.sct                                    | Cache name:datasetname@datasourcename_Terrain_ZIP                                                                                                                                                                           |
| Model       | *.scv, *.osgb, *.s3m                     |                                                                                                                                                                                                                             |
| Map         | *.sci(map cache)<br>*.sci3d(scene cache) | Cachename:mapname<br>*.sci is Cache of SuperMap UGC V5.0 global subdivision, can be used for precaching of 3D service<br>*.sci3d is the format of scene cache file. Dynamic cache generates scene cache file automatically. |
| Scene cache |                                          | Cachename:3Dscenename<br>Scene cache is a group of files, which is the corresponding 3D cache respectively generated by each type of data mentioned above.                                                                  |

**Notice: for \*.sci format SuperMap UGC V5.0 map cache, only global partitioning can be used for 3D service.**

Storage format: orgional and compact

Original--when the cache storage type is the original type, namely StorageType.Original, the cache files are of original picture formats, and the cache data appears as the picture format in multiple folders. The cache files are of \*.bil format for terrain cache, and of \*.png format for image cache.

Compact--when the cache storage type is StorageType.Compact, the cache files are of large-file cache format, and the cache data is of compact-file format. The cache files are not original cache pictures. Rather, they compact and encrypt all the cache pictures in the folders and store them into a group of files. This group of files can be divided into three parts: index files, a group of data files and lock files. The index files are of \*.sc (SuperMap Cache File) format; the data files are of \*.scXX (SuperMap Cache File Data) format, where the XX are not two letters but two hexadecimal numbers (00 ~ FF). Only two hexadecimal numbers are supported here, that is, 256 data files at most are supported. The number of data files is decided by the size of cache data. The size of a data file is 2G at most. In addition, there may be a lock file (of \*.~ format) in windows, that is used to realize multi-process or multi-threading reading and writing of the cache. Compared with the original type, the compact storage type has following advantages:

- (1) Good for transmitting and copying massive cache files;
- (2) Shortens the time spent on creating cache;
- (3) Improves the performance of getting cache files on the client;
- (4) Supports encryption.

## Features of SuperMap 3D services

3D services support dynamic publishing and massive data publishing, and have strong stability. In addition, they support clients' 3D operations such as 3D query, distance measurement, as well as 3D query and highlighting on raster maps.

### Supporting dynamic publishing

SuperMap iServer supports publishing data without any processing, i.e., without generating cache data. As long as the data can be loaded in a 3D scene, they can be directly published.

Currently, the data types that can be dynamically published in SuperMap iServer 3D services include: images, maps, models, vector data, and terrain data. The description and examples of dynamically publishing the original data of a dataset type are not repeated here. Please refer to Publishing datasets.

### Supporting publishing massive data



As tested, SuperMap iServer 3D services can stably publish massive data. According to the tests so far, the data volume that a service supports is different for different data types.

| Data type | Supported data volume |
|-----------|-----------------------|
| Vector    | 10G                   |
| Image     | 100G                  |
| Map       | No limit              |
| Model     | 10G                   |
| Terrain   | 100G                  |

### Strong stability

#### Automatic updates

SuperMap iServer supports checking a published 3D workspace in real-time. Once any changes are detected, the system will automatically implement synchronization. Thus if a published 3D workspace has experienced any changes from outside (e.g., a layer is added in the 3D scene via SuperMap iDesktop, the changes will be reflected in the published service.

SuperMap iServer provides updates on a published 3D workspace, including updates on the scene and on the data. The table below lists the supported update contents:

| Update content | Supported changes                               |
|----------------|-------------------------------------------------|
| 3D scene       | Adding and deleting a scene                     |
|                | Adding and deleting a layer (layers) in a scene |
|                | Changing layer styles                           |

**Note: Only database-type datasources in the workspace can be edited across processes.**