ArcGIS® 3D Analyst™—
Designing Interactive ArcGlobe™ Documents

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An ESRI Technical Paper

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Document Overview

This document outlines best practices and recommended usage in building interactive ESRI® ArcGlobe™ documents. ArcGlobe is ArcGIS® 3D Analyst™ software's newest addition at version 9.0 for three-dimensional visualization of multiresolution global data. This document discusses data preparation guidelines, including usage for handling large and small data sets, display optimization techniques, and hardware and graphics card settings options. General tips and guidelines to achieve maximum usability will be suggested.

Helpful tips for displaying with different data types are also presented in the last sections.

Data Preparation Guidelines

ArcGlobe appeals to most users because of its ability to handle massive amounts of GIS data (rasters, features, and surfaces). As a result, data preparation is a first and important step that should be taken when authoring ArcGlobe documents.

As a prerequisite, any data set intended to be used in ArcGlobe needs to have a projection system associated with it. ArcGlobe is able to display data that is in any projection system supported in ArcGIS.

ArcGlobe uses the Geographic Coordinate System (GCS) for any data within the range of 45°N–45°S latitudes. Hence, GCS is the optimal projection system for data sets in these regions. However, it should be noted that it is not required to reproject a data set in non-GCS projection before visualization can occur; the application will automatically reproject the data on the fly.

ArcGIS 9 has introduced a new projected coordinate system, World_Cube (Figure 1). This projection system, which is identical to GCS within the range of 45°N–45°S, is the native coordinate system for ArcGlobe. Data sets in World_Cube projection in these "Expanded Polar" regions (45°N–90°N or 45°S–90°S) will help avoid on-the-fly reprojection. In addition, data sets in this coordinate system also have the added benefit of having pyramids that are specifically conformant to ArcGlobe software's cell size requirement, which avoids further resampling operations. World_Cube projection is supported for file-based rasters as well as in the geodatabase (both in a personal geodatabase and ArcSDE®).

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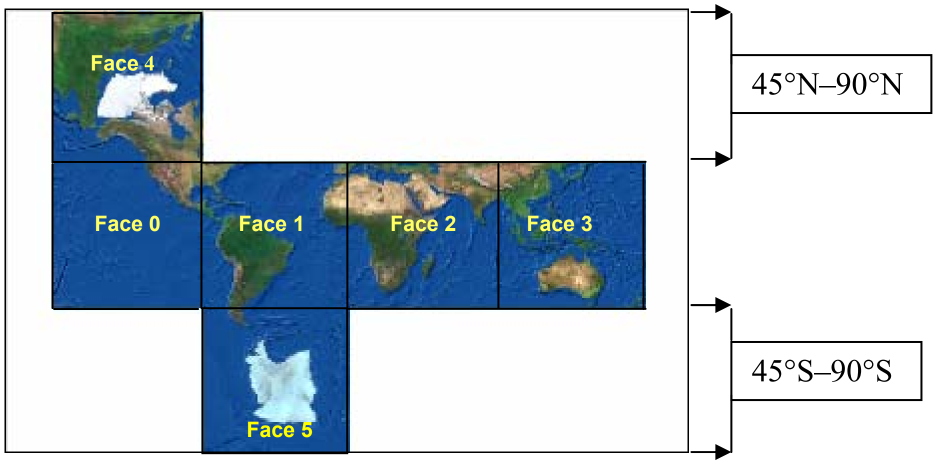
Figure 1
World Cube Projection and Globe Face Subdivision



Note: At ArcGIS 9 there are *no* transformations available from World_Cube to any other coordinate system. As a result, due consideration should be given before storing data sets with this projection if the data is also intended to be used in other ArcGIS applications.

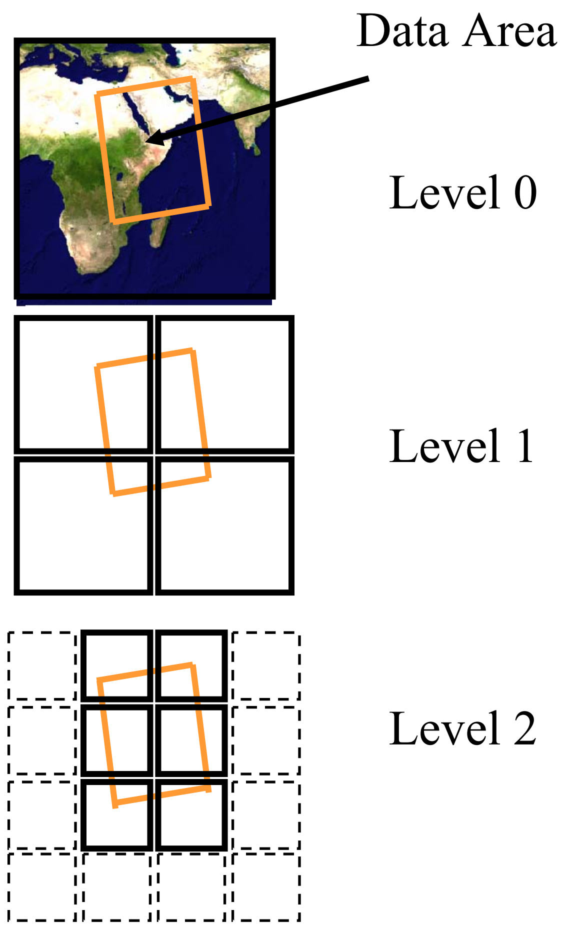
The following are recommended guidelines for preparing data for use in ArcGlobe:

- Define projection system for your data set.
- Build raster pyramids for data sets that support them.
- Geographic Coordinate System is the optimal projection system for data sets that lie between 45°N and 45°S latitudes.
- Storing raster data sets in the World_Cube projection system will boost on-demand data visualization performance (see On Demand or Just in Time Mode of Data Caching).
- Image formats that have less compression (lossy or nonlossy) have a better performance for on-demand navigation.

Display Optimizations in ArcGlobe

In ArcGlobe, the globe area is subdivided into six major faces (Figure 1). Each of these faces is then divided into multiple tiles at different levels of detail (see Figure 2). This data organization is termed Data Tiling.

Figure 2
ArcGlobe Data Tiling Scheme



Each of the six major faces is subdivided into multiple tiles at different levels of detail. Each tile is further subdivided into four tiles at each successive level of detail to a maximum of 31 levels of detail.

Data Caching

The storing of data tiles for future use is termed Data Caching. Data tiles are always stored in a memory cache and optionally also in a disk cache.

The main advantage of data caching is to improve the visualization performance as well as to reduce repetitive data requests from data sources (Figure 3).

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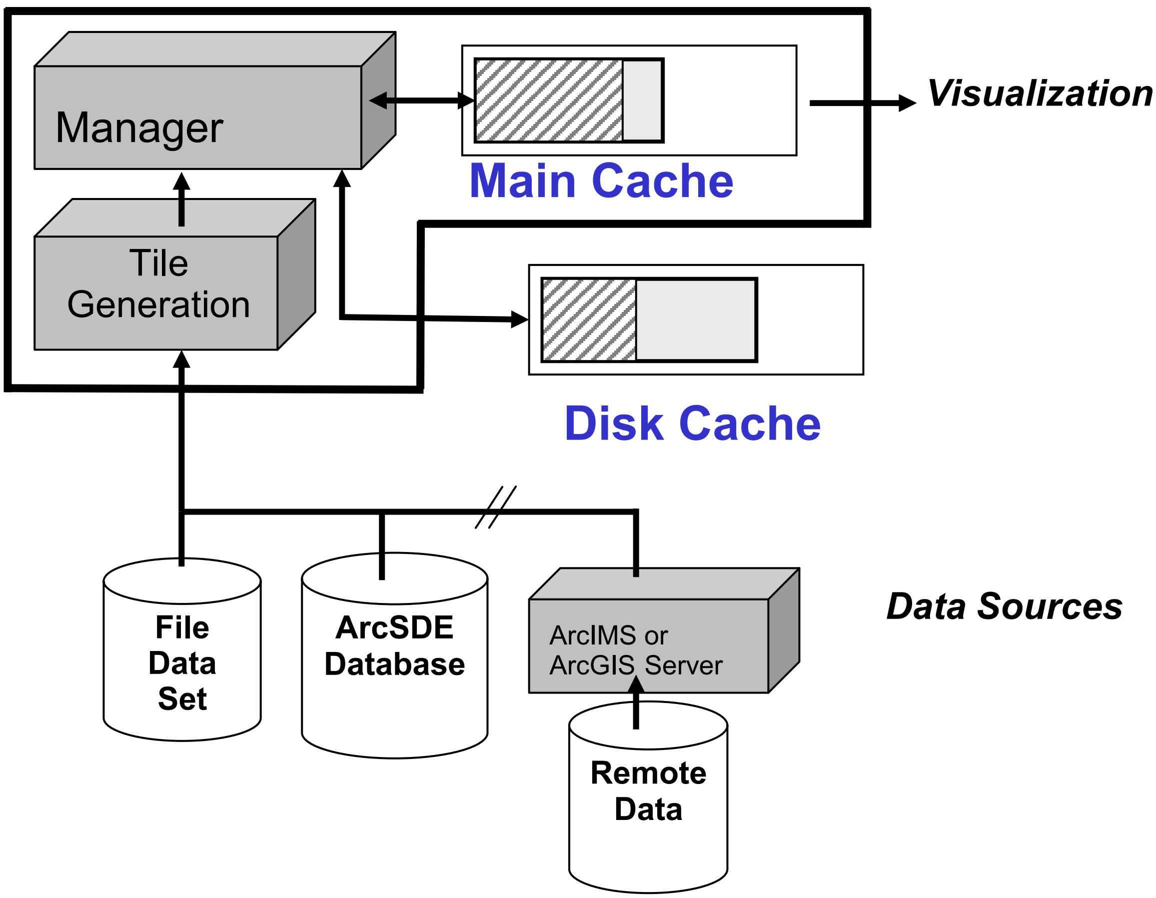
Figure 3
ArcGlobe Data Caching Structure



Each data tile will be stored into memory and optionally onto disk for future use. Using data caching improves visualization performance.

Memory Data Caching

Whenever data is displayed in ArcGlobe, data tiles are stored into memory for faster access. The default size of the tile memory cache will be set by the application the first time it is launched, depending on available physical memory.

If you have ample free physical memory, bumping up the cache memory size may help when displaying large amounts of data. You can do that in the Cache property page of the application's Options dialog.

The tile memory cache is not the total memory required by the application as other subsystems of the application allocate their own memory usage (layers, data connections, etc.).

For good interactive performance, it is recommended to keep the total memory usage below the physical memory limit.

Disk Data Caching

There are three methods of disk caching: on-demand (just-in-time), full, and partial data caching.

On-Demand or Just-in-Time Mode of Data Caching

This is the default mode of disk caching. The application will generate only the data tiles required to display the area and levels of detail of interest for the user. The generation and storage of these tiles will happen as the user interactively navigates around or zooms in and out of the globe. This mode of data caching is termed On-Demand or Just-in-Time data caching, because only areas visited within an ArcGlobe session will be cached to disk. The distance, from which the observer is observing the data set, determines the level of detail of the disk cache.

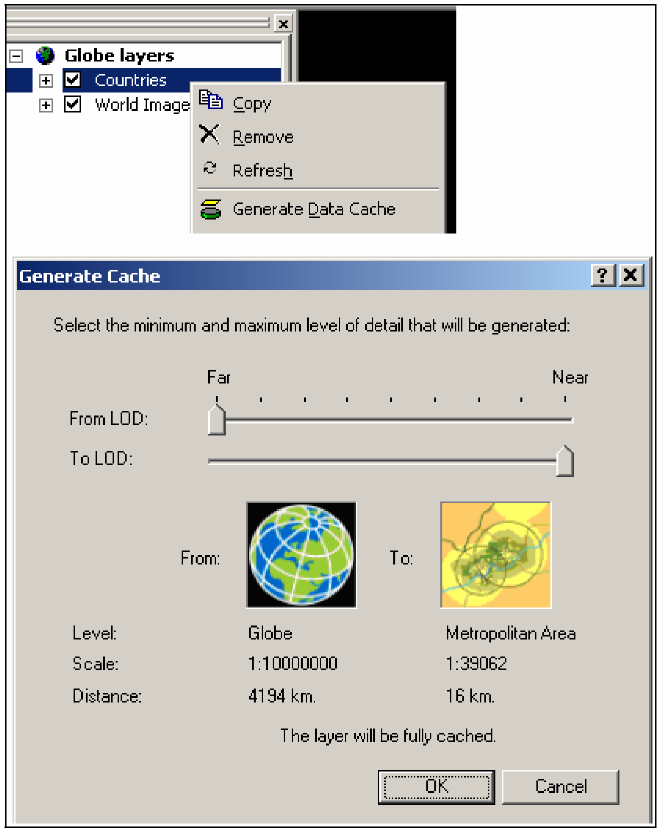
In this mode of data caching the data format, projection system, and availability of pyramids (for rasters) as discussed under Data Preparation will affect the performance of the application.

Full Data Caching

Full data caching means generating and saving the data tiles for all areas to the maximum level of detail of a given data set.

Full data caching can be accomplished for any layer—exceptions being ArcIMS® and ArcGIS MapServer layers. Note that both raster and feature data sets treated as vectors support the generation of full data caching. However, generating full data caches for rasterized features is not recommended because the maximum level of detail can be extremely high. Full data caching can be done by invoking the Generate Data Cache context menu command of a layer (Figure 4).

Figure 4
Generate Data Cache Dialog

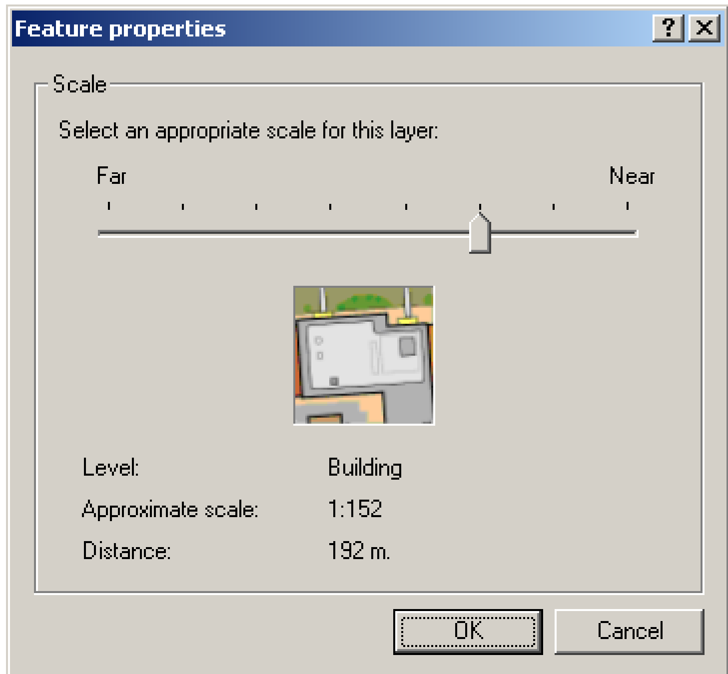


Note that there are two levels of detail that can be set—the From LOD and To LOD options. If both are set to the minimum (From LOD) and maximum (To LOD), the data is said to be fully cached.

The From LOD in the Generate Cache dialog defines the minimum level of detail (for rasters and rasterized features, it translates to cell size) the data cache should be generated from. The To LOD defines the maximum level of detail the data cache should be generated to. When both the From LOD and To LOD are set to the minimum and maximum values, respectively, the data set will be referred to as full data cache. Generating full data cache guarantees that all possible levels of detail for the entire data extent will be previsited/captured in the data cache. This method is the preferred/optimal method if smooth interaction and performance are the main goals of an ArcGlobe document.

For raster data sets the maximum and minimum LOD values offered in the Generate Data Cache dialog are constricted by the raster cell size—these values are fixed and cannot be changed. However, for feature data sets, the scale level chosen in the Feature properties dialog constricts the maximum values of the From LOD and To LOD (Figure 5). As a result, you may not always see the lowest level of detail (globe level) and/or the highest level of detail (room level) offered as an option to select.

Figure 5
Level of Detail for Feature Layers



Note that the maximum and minimum values shown on the slider depend on the data extent and feature count. This slider is an adaptive slider that will change the range when it is set at the maximum (nearest) or minimum (farthest) level of detail.

The first step before proceeding to Generate Data Cache (or even display in the case of feature data treated as vectors) for a feature layer is to determine the scale (level of detail) at which you want to view your data set.

When opening the Feature properties dialog (the Scale) of a feature layer (located on the Globe General layer property page), the slider is set at a scale at which the application has estimated to be appropriate for the data set. The default scale is appropriate for most data sets. However, if the application suggested value is not the appropriate display scale for a particular data, change the value before accepting the dialog. Setting this value will also by default set a layer visibility threshold—the range of distances the layer will be visible or not. At any level of detail the layer distance visibility threshold can be set to be visible at all times or at a different value.

As a rule of thumb, start with the application suggested (default) scale and progressively increase it (to the right) or decrease it (to the left) to fit your display requirement (Figure 5). Also note that, for feature data sets, the scale range offered on the slider depends on the data extent and number of features. The Feature properties dialog has an adaptive scale slider (i.e., if the slider value is set to the maximum–minimum position, it will expose one more additional level of detail upon returning back to the dialog until the absolute maximum or minimum scale values are reached).

These "caps" on the maximum–minimum levels of detail are incorporated to prevent the user from selecting a level of detail too low or too high for any feature data set.

Partial Data Caching

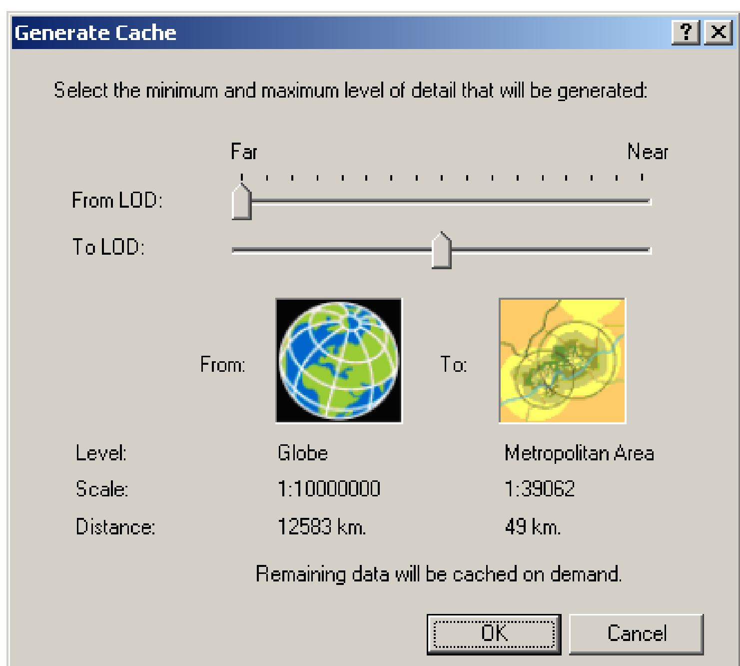
It is also possible to generate a data cache up to a level of detail of your choice and then allow the application to generate higher or lower levels of detail as needed while interacting (on-demand mode of data display).

This mode of data caching is termed Partial Data Caching and is available for feature data sets that are rasterized (all non-3D feature data sets are treated as rasterized features by default) and for rasters only.

Features as vectors have only one level of detail per layer so generating data cache always produces fully cached data. With rasterized features, however, generating partial data caches is more practical, especially at low levels of detail. If higher levels of detail are required, they can be further generated by an on-demand mode of data caching.

The maximum value of the To LOD slider offered in the Generate Cache dialog depends on the level of detail/scale selected on the Feature properties dialog (Figure 5). Although the application does not enforce setting the scale value for rasterized features as it does for features treated as vectors, it is a good practice to make sure the application–selected default value is appropriate before generating partial caches for rasterized features (Figure 6).

Figure 6
Partial Data Caching



When the slider values in the From LOD and To LOD are not set to the minimum and maximum values, respectively, the data is said to be partially cached. All remaining levels of detail will be generated on the fly in the on-demand data caching mode.

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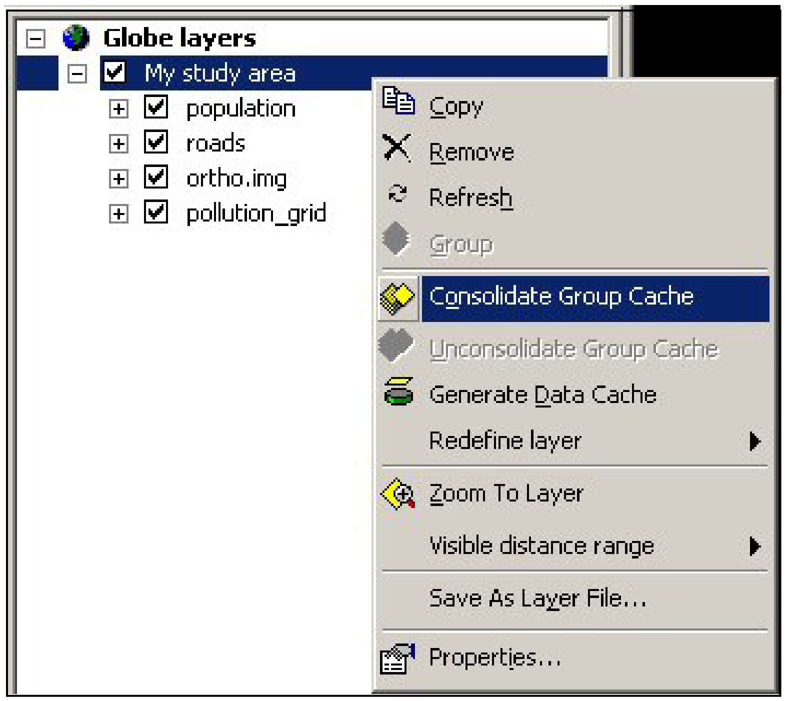
Consolidating Group Caches

If your study area involves many draped rasters and/or rasterized features that overlap in extent, consolidating the caches of these individual data sets into a group can improve performance when displaying. This is termed as Group Cache Consolidation. The idea is similar to IMS layers in which most of the properties of the sub-images are defined by an image service. Here, the group layer will be used as the consolidating layer for the children layers (Figure 7).

Figure 7
Cache Consolidation



Cache consolidation is available through group layers. Consolidating layer caches when many rasterized features and rasters overlap in extent improves display visualization performance.

Before consolidating a group layer, make sure you have set the desired symbology, display properties, and visibility of all the children layers. Changing any of those properties after cache consolidation will require rebuilding the cache.

Although layer consolidation is available for rasters and rasterized features in a group, elevation and features as vectors can stay in the consolidated group without being affected.

If consolidating coarse resolution rasters with high-resolution data, coarse resolution images will be magnified to blend with the high-resolution data. Set the texturing mode property (in the GlobeDisplay page of a layer) to smooth to avoid pixelation.

Data Compression

ArcGlobe has different compression schemes that come in handy when displaying different data types.

The default setting uses 16-bit radiometric compression for color resolution. This is sufficient for most raster data sets with wide range in color variation. However, when using especially monochromatic rasters and true color images that have subtle color differences, the default 16-bit color resolution can result in gradation artifacts. Compare Figure 8 and Figure 9.

Figure 8
Monochromatic Image With 16-Bit Radiometric Color Resolution
(also with 60% lossy spatial compression)

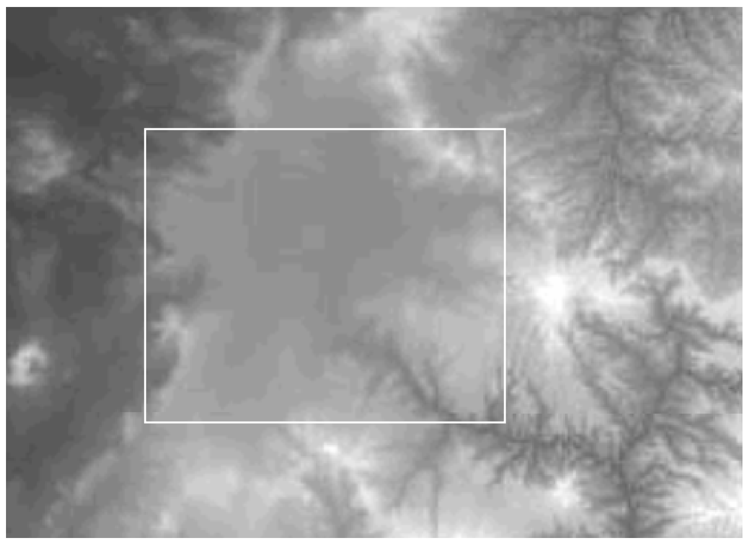


Figure 9
Monochromatic Image Without Radiometric Color Compression
(also with 60% lossy spatial compression)

As can be seen in the white square regions in the above snapshots, if a smooth color transition is required for a monochromatic image, 24-color has a better result (Figure 9). This can be achieved by turning off the "Use radiometric compression of colors to 16 bits" option on the Compression tab of the Options dialog for any newly added layers or from the cache property page of the layer.

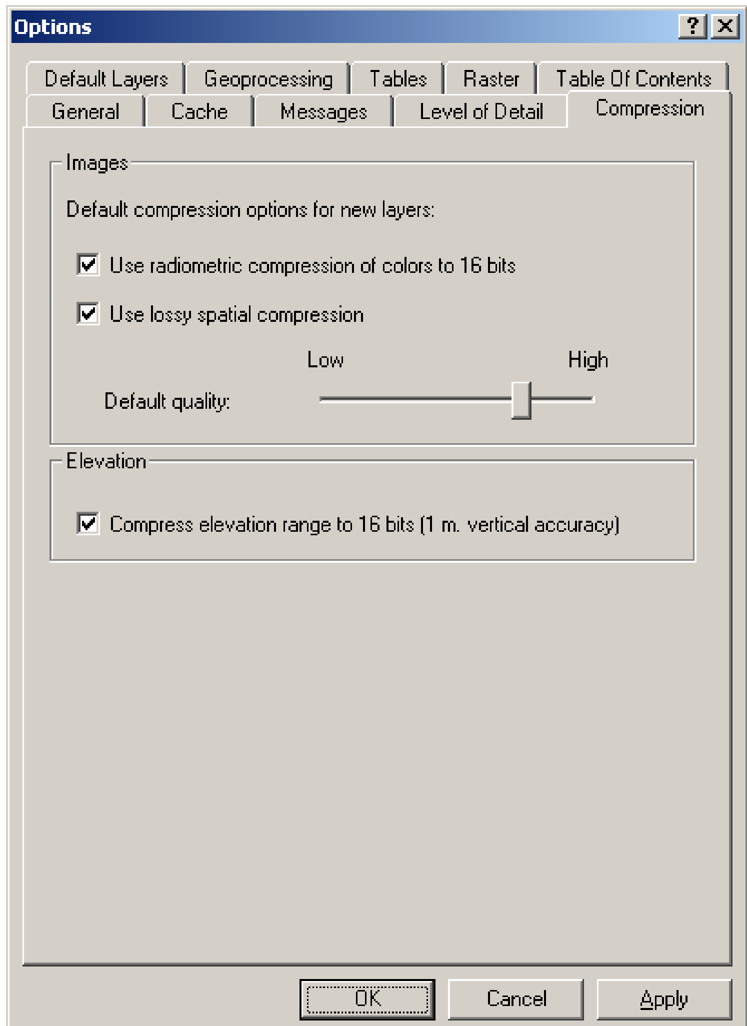
The maximum amount of color variation that can be attained while using a single band (monochromatic) image using the 16-bit radiometric color compression is 32 (2^5 for each R, G, and B band—for a total of 32,768 colors in a 3-band image).

When using 24 bits, one can expect to get up to 256 colors per band for a total of more than 16 million colors.

ArcGlobe also uses a lossy spatial compression by default. This is a standard JPEG compression that may result in losing some resolution to image data (the level of compression required can be adjusted).

Figure 10 shows image and elevation compression schemes available in ArcGlobe. Note that these values can be applied as a global setting or individually per layer. Compression values set on a layer's cache property page take precedence over global defaults set in the Compression tab of the Options dialog.

Figure 10
Compression Tab of Options Dialog Showing the Various Compression Schemes Available in ArcGlobe



Hardware and Graphics Card

ArcGlobe is an interactive three-dimensional GIS visualization application and, hence, can benefit from appropriate hardware and graphics card combinations. Hardware that has good/high disk access rates and graphics cards that are at least OpenGL 1.1 compliant with +64 MB of onboard memory are recommended.

It is also recommended that you obtain the latest graphics drivers from your graphics card manufacturer Web site. Note that graphics drivers get updated on a regular basis so it is worth checking every few months for updates. Also note that some laptops might have specific drivers released by the equipment manufacturer—so check to see if the laptop vendor/manufacturer has specific drivers available before updating directly from the graphics card manufacturer.

Different settings on the graphics card can affect the performance/quality of an ArcGlobe session.

To avoid flickering artifacts in the view background when in oblique perspective view, it is recommended that Anisotropic Filtering be set to the maximum supported by the card. Aliasing is an artifact that commonly appears as edges of lines being zigzagged. Setting the antialiasing to a higher level may help avoid or prevent this. However, note that this might have an adverse effect on performance. Turning off the vertical sync option might also result in better performance.

Antivirus Software

We have noticed that some antivirus software that uses real-time protection might dramatically slow ArcGlobe software's performance when viewing data sets in an on-demand mode. If possible, exclude the GlobeCache folder, where the ArcGlobe disk cache resides, from being monitored by the real-time monitoring software.

Tips and Recommended Usage

Raster Tips

- Always opt to generate pyramids if they do not exist.
- On-demand performance of raster data decreases in formats with high wavelet compressions—such as MrSID and JPEG 2000 formats.
- Storing data sets in ArcSDE using cube projection will give you an additional benefit by avoiding pyramid resampling and data reprojection.
- Generate the full disk cache whenever possible.

Tips for Features as Vectors

- Remember that data tiles of feature layers as vectors are defined only for a single level of detail. Hence, organize your vector data into multiple features/ representations if a multiple level of detail is required.
- Do not attempt to display a large amount of vector features (more than 64K vertices in a single tile) at a very low level of detail (it may result in vector overflow error).
- When using feature data as vectors, each tile has a storage limit of 65,536 vertices; increase the target LOD or Scale if your data contains more than 64K vertices per tile.
- Avoid attempting to display vector features at a very high level of detail, which might result in sparsely populated tiles.
- Partial caching is not defined for feature layers as vectors, but full caching exhibits good performance.
- If vector data (points/lines) is intended to be "draped" on the globe surface, use the rasterize option, especially if there are many features.

- When navigating close to line features as vectors, you might experience performance issues.

  - Set the layer LOD or Scale close to the distance range at which you intend to navigate. For example, do not set a global feature scale and attempt to navigate at street level distances (close to the feature).

  - Consider rasterizing the feature.

- The elevation values of three-dimensional feature data are limited to ±16 km. If you have a data set that exceeds this elevation range:

  - Use the unit conversion layer property to scale the data within the ±16 km range.
  - Compensate the overall vertical exaggeration factor by an appropriate amount.

Tips for Rasterized Features

- While attempting to use large data sets (e.g., ArcGIS StreetMap™)

  - Use layer visibility to limit display at lower levels of detail.

  - Prepare alternative representations to display at lower levels of detail.

  - Generate partial cache for the lowest levels you intend to visit.

  - Use the layers' Visible Distance Range to set a visibility threshold to avoid tile generation at distances/scales not appropriate to view the layer.

- Set the desired symbology before generating the data cache.

- Be cognizant of point size and real-world size conversion factor when dealing with rasterized features. All rasterized features (points, lines, and polygons) have a point to real-world conversion factor.

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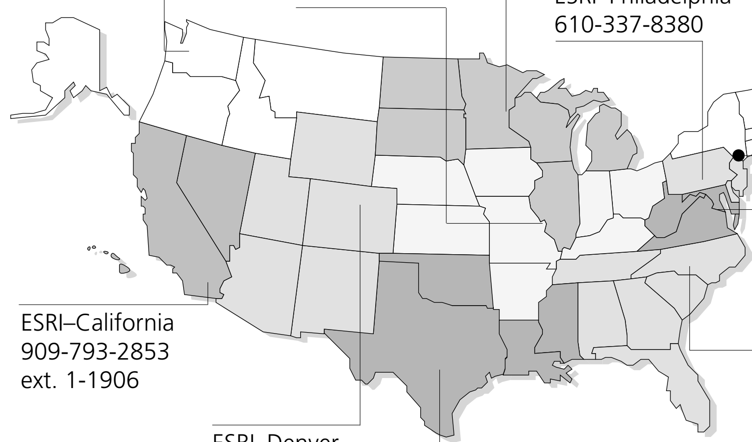

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