

# LERC Benchmarks

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## General Remarks

The benchmarks shown here are not meant to be complete. Compression is always data dependent, often strongly. By increasing Lerc's MaxZError parameter almost any compression factor can be achieved. Lerc can be used on any pixel or data type, from char all the way up to double. The main playground for Lerc is higher pixel depth meaning 16 bit or larger. This is what we will focus on here. We will compare it to LZW, the classical lossless compression method used when jpeg or png does not fit or cannot be used at all.

Use this document to get an idea what you can expect from Lerc, roughly. In the end, nothing can replace your own experimenting on your own data and compressing at the precision you need for your application or use case.

For LZW compression, we call the function `compress2(...)` in `ZLibAccess.h`. We use level 9 for best possible compression. We also tried level 6 resulting in similar, sometimes worse compression, and sometimes reduced cpu time but mainly for those cases where cpu time peaked with level 9. The overall picture was pretty much the same.

Large rasters are compressed tile by tile using a max tile size (width, height) of 1024.  
LERC (0.01) means Lerc encoding with a MaxZError = 0.01.

## 1) Float scientific data

Datasets used:

1. 2009129biomassProduction.tif, 4600 x 4300, [0 ... 455.8]
2. 2009129evaporation.tif, 4600 x 4300, [-4.1 ... 9.2]
3. 2009129transpiration.tif, 4600 x 4300, [0 ... 7.8]
4. AirTemperature\_2009129.tif, 4600 x 4300, [-10.7 ... 28.5]

Although not elevation data, these scientific data (biomass production, evaporation, transpiration, air temperature) are to some degree correlated with the land and therefore also correlated with elevation. These are 2D float rasters from a single winter day in China. Original format is float tif.

| Compression factor       | LZW  | LERC (0.01) | LERC (0.1) | LERC (1.0) |
|--------------------------|------|-------------|------------|------------|
| -----                    |      |             |            |            |
| 2009129biomassProduction | 3.4  | 7.3         | 9.8        | 14.8       |
| 2009129evaporation       | 1.4  | 12.5        | 25.8       | 112.0      |
| 2009129transpiration     | 1.7  | 12.1        | 20.4       | 49.0       |
| AirTemperature_2009129   | 2.5  | 9.6         | 17.0       | 43.9       |
| average                  | 2.3  | 10.4        | 18.3       | 54.9       |
|                          |      |             |            |            |
| Encoding time (sec)      | LZW  | LERC (0.01) | LERC (0.1) | LERC (1.0) |
| -----                    |      |             |            |            |
| 2009129biomassProduction | 4.2  | 0.3         | 0.3        | 0.3        |
| 2009129evaporation       | 5.8  | 0.4         | 0.3        | 0.3        |
| 2009129transpiration     | 18.3 | 0.3         | 0.3        | 0.3        |
| AirTemperature_2009129   | 4.0  | 0.3         | 0.3        | 0.3        |
| average                  | 8.1  | 0.3         | 0.3        | 0.3        |
|                          |      |             |            |            |
| Decoding time (ms)       | LZW  | LERC (0.01) | LERC (0.1) | LERC (1.0) |
| -----                    |      |             |            |            |
| 2009129biomassProduction | 325  | 67          | 61         | 59         |
| 2009129evaporation       | 503  | 73          | 68         | 50         |
| 2009129transpiration     | 493  | 65          | 64         | 59         |
| AirTemperature_2009129   | 375  | 67          | 65         | 53         |
| average                  | 424  | 68          | 65         | 55         |

## 2) Float elevation surfaces from interpolated DTED elevation raster

Datasets used:

1. grdn35w118, 3612 x 3612, 62 - 3068 m
2. n35w118\_13, 10812 x 10812, 65 - 3068 m

| Compression factor  | LZW  | LERC (0.01) | LERC (0.1) | LERC (1.0) |
|---------------------|------|-------------|------------|------------|
| -----               |      |             |            |            |
| grdn35w118          | 1.3  | 3.1         | 4.5        | 7.9        |
| n35w118_13          | 1.4  | 3.7         | 5.7        | 11.1       |
| Encoding time (sec) | LZW  | LERC (0.01) | LERC (0.1) | LERC (1.0) |
| -----               |      |             |            |            |
| grdn35w118          | 4.3  | 0.4         | 0.4        | 0.4        |
| n35w118_13          | 40.5 | 3.4         | 3.3        | 2.9        |
| Decoding time (ms)  | LZW  | LERC (0.01) | LERC (0.1) | LERC (1.0) |
| -----               |      |             |            |            |
| grdn35w118          | 371  | 78          | 67         | 63         |
| n35w118_13          | 3346 | 635         | 602        | 527        |

## 3) 16 bit integer DTED-1 images, 1201 x 1201 pixel, covering 100 km x 100 km

Datasets used:

1. dted1\_w156n19, volcano with some ocean, Hawaii.
2. dted1\_w157n20, Hawaiian islands with mostly ocean.
3. dted1\_w112n34, all land 600 - 2600 m, Arizona.
4. dted1\_w82n31, mostly flat land 0 - 75 m, Georgia.

We use MaxZError = 0 (lossless) and 5 (lossy).

DTED is the classical format for elevation data. In the past, 1 meter vertical resolution was sufficient for most purposes. The data does not contain floating point noise. This helps LZW achieve better results, especially when the range of z is in [-128, +127], i.e., char. This is ideal for symbol based compression algorithms such as LZW. See the fourth example, some flat coastal area in Georgia.

| Compression factor | LZW | LERC (0) | LERC (5) |
|--------------------|-----|----------|----------|
| -----              |     |          |          |
| dted1_w156n19      | 2.2 | 3.1      | 5.6      |
| dted1_w157n20      | 7.9 | 10.4     | 17.5     |
| dted1_w112n34      | 1.8 | 2.3      | 4.1      |
| dted1_w82n31       | 4.9 | 4.6      | 11.5     |
| average            | 4.2 | 5.1      | 9.7      |

  

| Encoding time (ms) | LZW | LERC (0) | LERC (5) |
|--------------------|-----|----------|----------|
| -----              |     |          |          |
| dted1_w156n19      | 173 | 22       | 36       |
| dted1_w157n20      | 94  | 11       | 14       |
| dted1_w112n34      | 215 | 28       | 45       |
| dted1_w82n31       | 612 | 30       | 46       |
| average            | 274 | 23       | 35       |

  

| Decoding time (ms) | LZW | LERC (0) | LERC (5) |
|--------------------|-----|----------|----------|
| -----              |     |          |          |
| dted1_w156n19      | 17  | 7        | 7        |
| dted1_w157n20      | 11  | 4        | 4        |
| dted1_w112n34      | 20  | 8        | 8        |
| dted1_w82n31       | 16  | 7        | 6        |
| average            | 16  | 7        | 6        |

#### 4) 16 bit integer DTED-2 images, 3601 x 3601 pixel, covering 100 km x 100 km

Datasets used:

1. dted2\_w156n19, volcano with some ocean, Hawaii.
2. dted2\_w157n20, Hawaiian islands with mostly ocean.
3. astgtm\_w112n34, all land 550 - 2600 m, Arizona.
4. astgtm\_w82n31, mostly flat land 0 - 110 m, Georgia.

| Compression factor | LZW  | LERC (0) | LERC (5) |
|--------------------|------|----------|----------|
| -----              |      |          |          |
| dted2_w156n19      | 3.5  | 3.9      | 8.3      |
| dted2_w157n20      | 10.1 | 12.7     | 23.9     |
| astgtm_w112n34     | 2.6  | 2.8      | 5.8      |
| astgtm_w82n31      | 7.1  | 5.3      | 15.0     |
| average            | 5.8  | 6.2      | 13.3     |

| Encoding time (ms) | LZW  | LERC (0) | LERC (5) |
|--------------------|------|----------|----------|
| -----              |      |          |          |
| dted2_w156n19      | 1350 | 224      | 343      |
| dted2_w157n20      | 748  | 108      | 140      |
| astgtm_w112n34     | 1788 | 273      | 426      |
| astgtm_w82n31      | 6051 | 317      | 390      |
| average            | 2484 | 231      | 325      |

| Decoding time (ms) | LZW | LERC (0) | LERC (5) |
|--------------------|-----|----------|----------|
| -----              |     |          |          |
| dted2_w156n19      | 143 | 55       | 53       |
| dted2_w157n20      | 88  | 29       | 26       |
| astgtm_w112n34     | 170 | 64       | 64       |
| astgtm_w82n31      | 118 | 54       | 49       |
| average            | 130 | 51       | 48       |

## 5) Multi spectral images

Datasets used:

1. Lvl02-00601-Col1.tif (UltraCam Graz Color), 5770 x 3770, 4 bands, 16 bit
2. Lvl02-00601-Pan1.tif (UltraCam Graz Pan), 17310 x 11310, 1 band, 16 bit
3. 09DEC25092217-M2AS\_R2C2-052490196030\_01\_P0011.tif (QuickBird Libya Color), 3584 x 3584, 4 bands, 11 bit
4. 09DEC25092217-P2AS\_R2C2-052490196030\_01\_P0011.tif (QuickBird Libya Pan), 14336 x 14336, 1 band, 11 bit
5. 2010-05-14T200550\_RE3\_3A-NAC\_6330262\_1110971.tif (RapidEye Portland), 5000 x 5000, 5 bands, 16 bit
6. 2010-05-14T200551\_RE3\_3A-NAC\_6332757\_1110971.tif (RapidEye Portland), 5000 x 5000, 5 bands, 16 bit

With this last section of sample data we have clearly left the realm of elevation data. Multi spectral images can come in many different flavors: Different number of bands, typically bands that represent red, green, and blue, plus infrared or near infrared channels, plus potentially other frequencies. Often these “color” bands come in lower resolution, with an added gray value or pan chromatic single high resolution band which allows for the application of so called pan sharpening methods to create higher resolution color images by combining all bands. Another variable is the pixel or bit depth: Often 11 or 12 bit, sometimes up to 16 bit.

If the goal is to only transmit a 24 bit RGB image for display, then simply convert to 24 bit RGB first and jpeg compress the result. The use case of interest here is that these multi spectral images must be transmitted either lossless or with a small, controlled loss.

The numbers below show that 11 bit images can be better compressed than 16 bit images (no surprise), and that LERC lossless is only somewhat better than LZW. The main advantage of LERC over LZW is again the much faster encoding speed of 5-10x. If, however, a small controlled loss is tolerable, then LERC allows for easy control resulting in higher compression. The values 2 and 4 for MaxZError correspond to the last 2 and 3 bit being discarded. As can be seen from the pictures, such a small error is still not visible when the decompressed multi band images are rendered.

| Compression factor    | LZW | LERC (0) | LERC (2) | LERC (4) |
|-----------------------|-----|----------|----------|----------|
| -----                 |     |          |          |          |
| UltraCam Graz Color   | 1.5 | 1.8      | 2.3      | 2.7      |
| UltraCam Graz Pan     | 1.6 | 2.0      | 2.6      | 3.0      |
| QuickBird Libya Color | 2.6 | 2.9      | 4.3      | 5.6      |
| QuickBird Libya Pan   | 2.5 | 2.9      | 4.3      | 5.7      |
| RapidEye Portland (1) | 1.3 | 1.5      | 1.8      | 2.1      |
| RapidEye Portland (2) | 1.2 | 1.4      | 1.7      | 1.9      |

|         |     |     |     |     |
|---------|-----|-----|-----|-----|
| average | 1.8 | 2.1 | 2.8 | 3.5 |
|---------|-----|-----|-----|-----|

| Encoding time (sec) | LZW | LERC (0) | LERC (2) | LERC (4) |
|---------------------|-----|----------|----------|----------|
|---------------------|-----|----------|----------|----------|

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|                       |      |     |     |     |
|-----------------------|------|-----|-----|-----|
| UltraCam Graz Color   | 15.2 | 1.6 | 2.8 | 2.7 |
| UltraCam Graz Pan     | 37.4 | 3.5 | 6.3 | 5.9 |
| QuickBird Libya Color | 19.8 | 1.0 | 1.7 | 1.6 |
| QuickBird Libya Pan   | 71.2 | 3.8 | 6.6 | 6.3 |
| RapidEye Portland (1) | 20.0 | 2.3 | 4.0 | 3.8 |
| RapidEye Portland (2) | 19.4 | 2.3 | 4.0 | 3.8 |

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| average | 30.5 | 2.4 | 4.2 | 4.0 |
|---------|------|-----|-----|-----|

| Decoding time (sec) | LZW | LERC (0) | LERC (2) | LERC (4) |
|---------------------|-----|----------|----------|----------|
|---------------------|-----|----------|----------|----------|

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|                       |     |     |     |     |
|-----------------------|-----|-----|-----|-----|
| UltraCam Graz Color   | 1.2 | 0.5 | 0.5 | 0.5 |
| UltraCam Graz Pan     | 2.7 | 1.0 | 1.0 | 1.0 |
| QuickBird Libya Color | 0.7 | 0.3 | 0.3 | 0.2 |
| QuickBird Libya Pan   | 2.6 | 1.0 | 1.0 | 1.0 |
| RapidEye Portland (1) | 1.8 | 0.7 | 0.7 | 0.7 |
| RapidEye Portland (2) | 1.8 | 0.7 | 0.7 | 0.7 |

|         |     |     |     |     |
|---------|-----|-----|-----|-----|
| average | 1.8 | 0.7 | 0.7 | 0.7 |
|---------|-----|-----|-----|-----|