Optimisation of Storage Structure to Enable Efficient File Access and Processing on Massive Time-series of EO Data

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1 Introduction

The HDF5 file format enables users to build highly tunable data access and storage solution tailored to meet their everyday needs and requirements. This report examines the comparison of differing chunksizes for both a 2D spatial domain (x & y axis), as well as 3D (z axis) storage blocks, and at varying compression levels in relation to storing Earth Observation imagery.

2 method

14 spatial cells, approximately 1.0 degrees by 1.0 degrees with a 25 metres pixel resolution, were selected because of their spatial position relative to the WRS2 Landsat grid. These cells contain varying amounts of data coverage, ranging from sparse (mostly null data) to complete valid data coverage.
Imagery acquired by Landsat 5 from the year 2008 was used due to SLC-OFF issues with Landsat 7.
The spatial dimensions of each cell were 4000 by 4000 pixels, whereas the z-axis differed from cell to cell but within the range of 13 to 23 slices.
The z-axis chunk sizes used were 5, 10 & 20, and for each z-axis chunk size, each of the follwoing spatial chunks were applied:

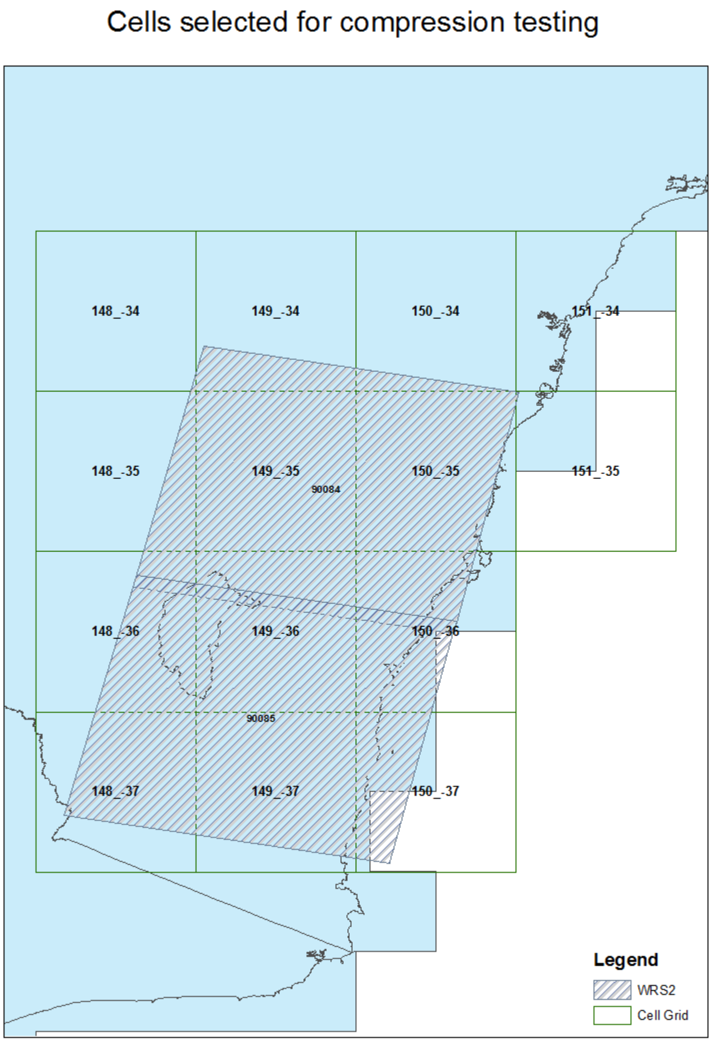
- 50
- 75
- 100
- 150
- 200
- 300
- 400

For each chunksize combination, a different compression filter from the following list was applied:

- GZip level 1
- GZip level 4
- GZip level 8
- LZF

To add to the combinations, each compression filter was set with and without a shuffle filter in order to evaluate any additional compression gains that a shuffle filter may provide.
The total number of combinations resulted in 2352 files, and for further comparison of read acces, raw uncompressed files were also generated.
The following figure displays the area selected for the storge uints compression testing. Cells that interesected the geometries of Path 90 and Rows 84/85

from the WRS2 *descending* grid, were then used to form the data basis of this report. As one can see, the cell grid data layout results in sparse data as well as dense data, within a given cell, for a given acquisition date.



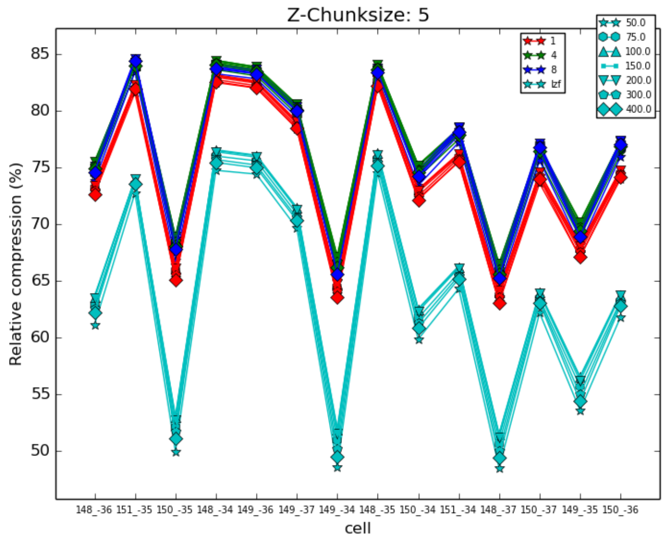
3 Results

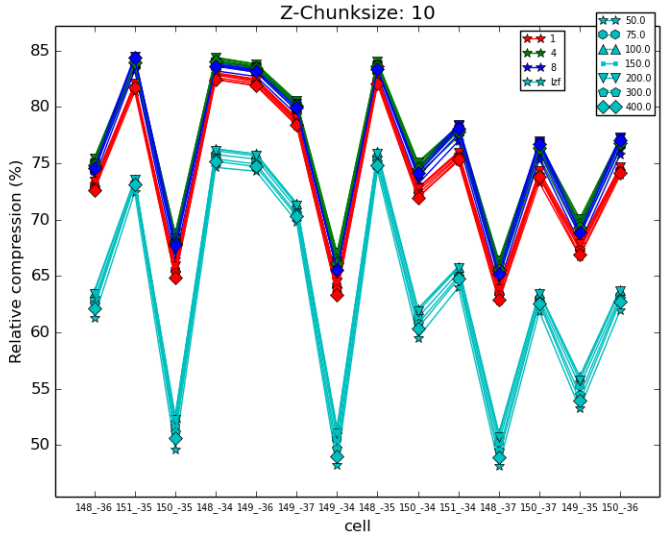
The shuffle filter didn't have the desired affect reducing the filesize, most likely due to the variabiity of the data contained within a given chunk. As such it was excluded early on in the comparative analysis.
The conducted read test was simply to read all the data for a given *compression xy chunk z chunk* setting for each cell. This was simply to emulate a workflow processing all data.
It has already been noted in a previous report that processing data using a chunksize smaller than the storage chunksize can have significant impacts on an algorithmic workflow.
With so many differing chunksizes, this was undesireable to test, and could result in highly skewed results.

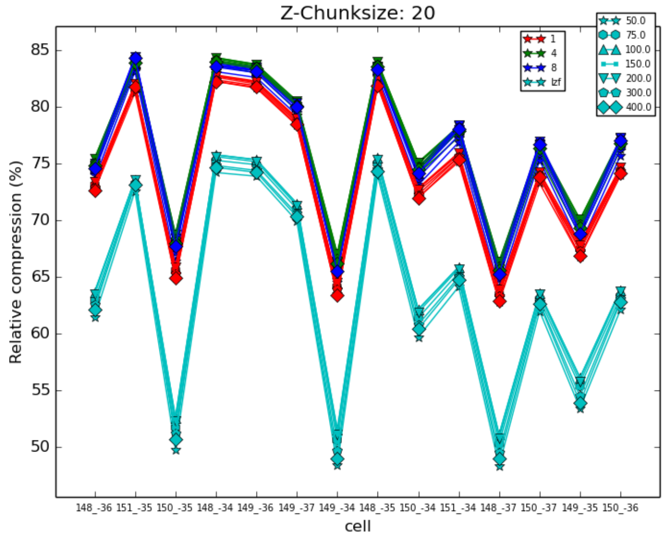
3.1 Compression Ratios

Compression ratios of each cell, at varying spatial chunksizes.

There is slight variation in filesizes between cells, but this is expected due to the WRS2 swath locations, thereby depending on the acquisition date, some cells have partial data, while others have more complete coverage.
For the data used in this comparison overview, it was observed that chunksizes not being an exact multiple of the array dimensions had a small but fairly negligible affect on overall filesize.





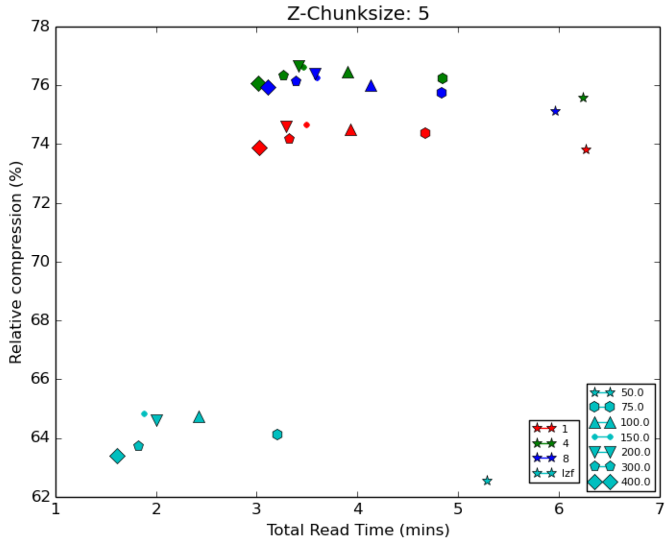


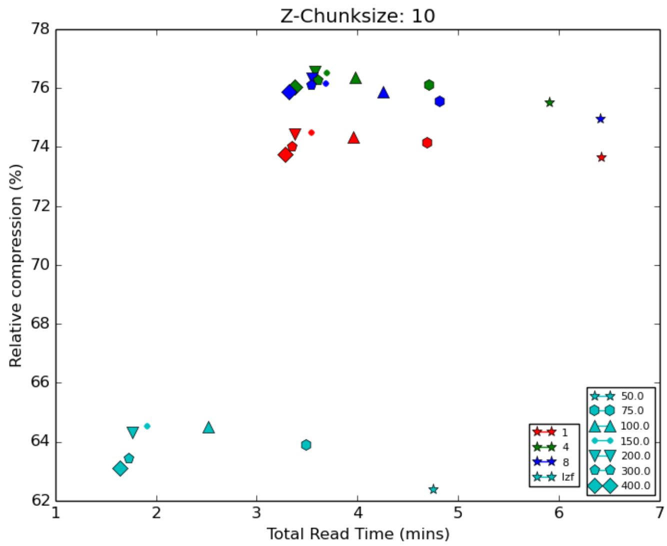
3.2 Read Times

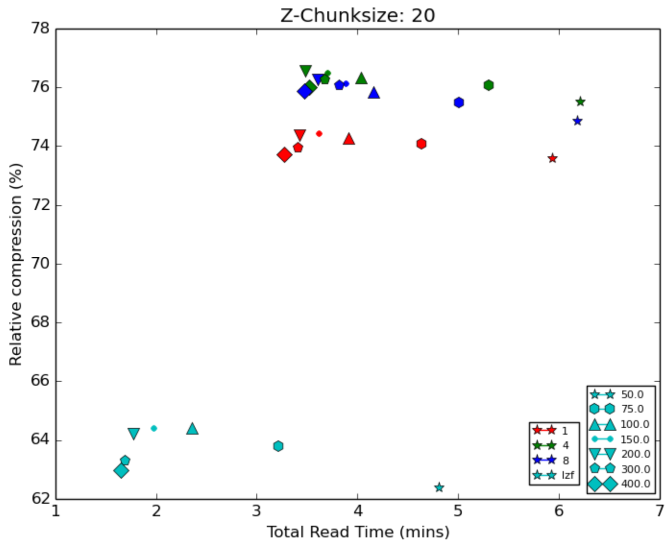
Total read time vs compression ratio

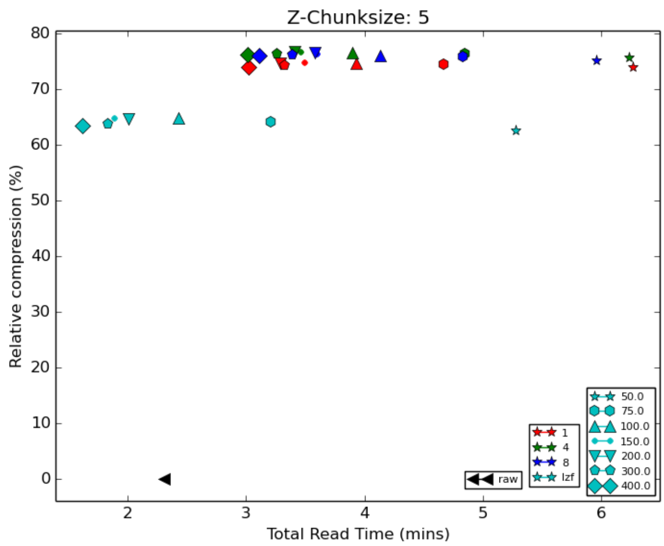
It is interesting to note that while the filesize decreased with an increasing spatial chunksize, at the 300 & 400 chunksize, the filesize increased. This trend hasn't been investigated further, but one could make the assumption that due to the nature of the data, that the spatial variability has some influence on the overall compression. The hypthesis is that less homogenous data compresses poorly compared to data of a more homogenous state.
For a further comparitive investigation, raw uncompressed files were also

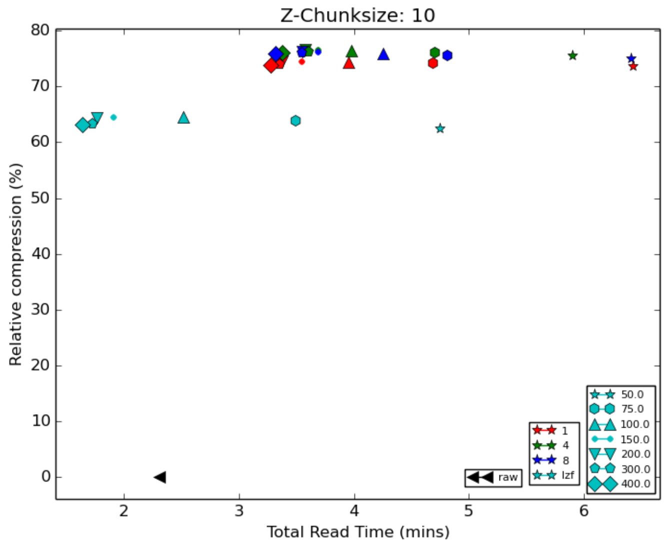
generated. The raw files were written using a natural scanline blocksize. In terms of total read time, only some files compressed using the LZF algorithm outperformed the raw binary files.

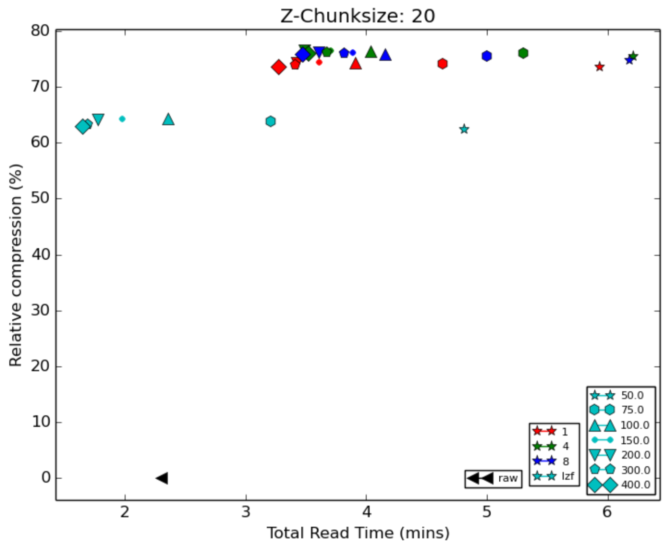





Z-Chunksize: 20
Relative compression (%)
Total Read Time (mins)
1
4
8
lzf
50.0
75.0
100.0
150.0
200.0
300.0
400.0


Z-Chunksize: 5
Relative compression (%)
Total Read Time (mins)
raw
1
4
8
lzf
50.0
75.0
100.0
150.0
200.0
300.0
400.0





4 Summary

Overall, the spatial blocksize of 200 performed well alround for each compression setting, and z chunksize. This is not to say that a spatial blocksize of 200 will be performant for all workflows. As previously noted reading a block smaller than 200 will incurr performance penalties if the goal is to process the entire spatial dimension. This will also be true for any blocksize. The filesizes for a given *spatial* chunksize and compression filter differed slightly between the thre z axis chunksizes. A z chunksize of 5 tended to have better better compression ratios, potentially due to more complete chunks

being written to disk as opposed to partial chunks. However, the total read times tended to be longer.
As for the compression algorithms, in terms of raw speed, the LZF algorithm significantly performed better at all *spatial* and z chunksize than the other compression settings. The compression ratios were slightly lower in the range of 10-15% than the GZip equivalents.
The default setting of *4* for the GZip algorithm, tended to get higher compression ratios than even the level *8* GZip setting. In some instances GZip level *4* also had better read times than levels *1* or *8*.