Update on Blosc2

New Features And What We Are Working On

Francesc Alted / @FrancescAlted

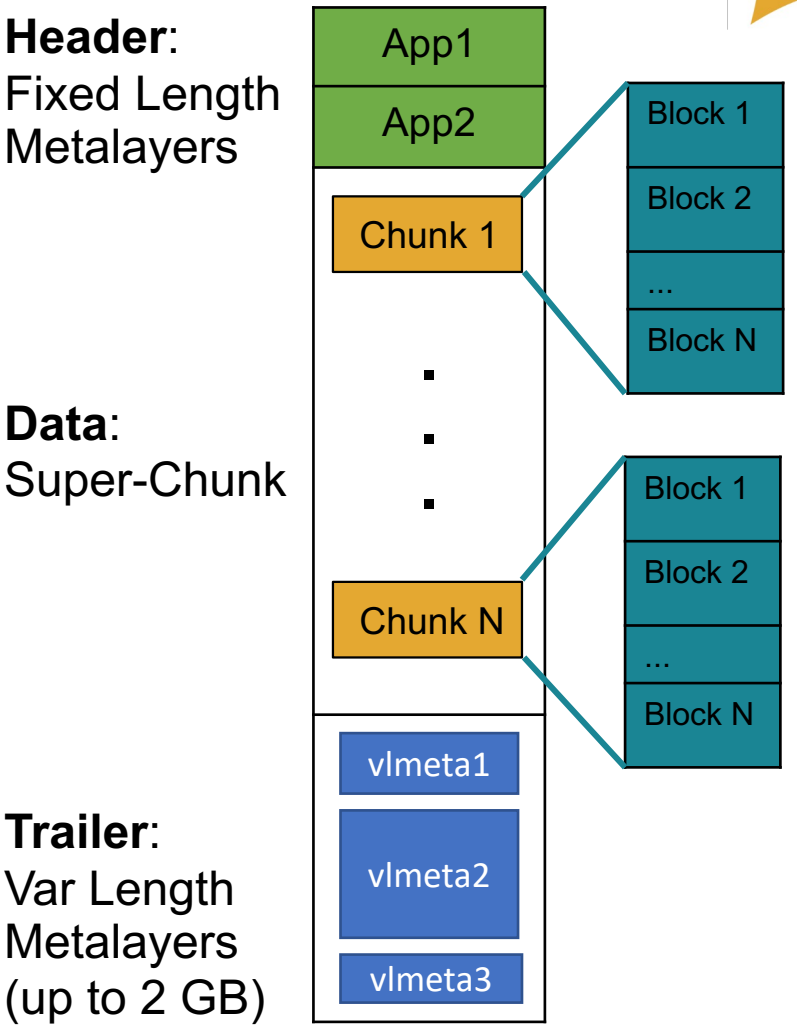
The Blosc Development Team / @Blosc2

CEO ironArray / @ironArray

LEAPS Innov WP7 (data reduction and compression) meeting
March 29th 2023

What is Blosc2?

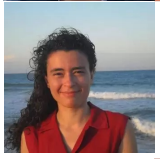
- Next generation of Blosc(1), a high performance compressor.
- Blosc2 adds 63-bit containers that expand over the existing 31-bit containers (chunks) in Blosc1.
- Metalayers for adding info for apps and users.



The Blosc Development Team


Aleix Alcacer


Oscar Guiñón


Marta Iborra


Alberto Sabater


Nathan Moinvaziri


Francesc Alted (BDFL)

Agenda

The second partition in Blosc2/HDF5: what's it providing?

New Blosc2 NDim and NDArray objects

Bytedelta: enhancing your compression toolset

Ongoing Work

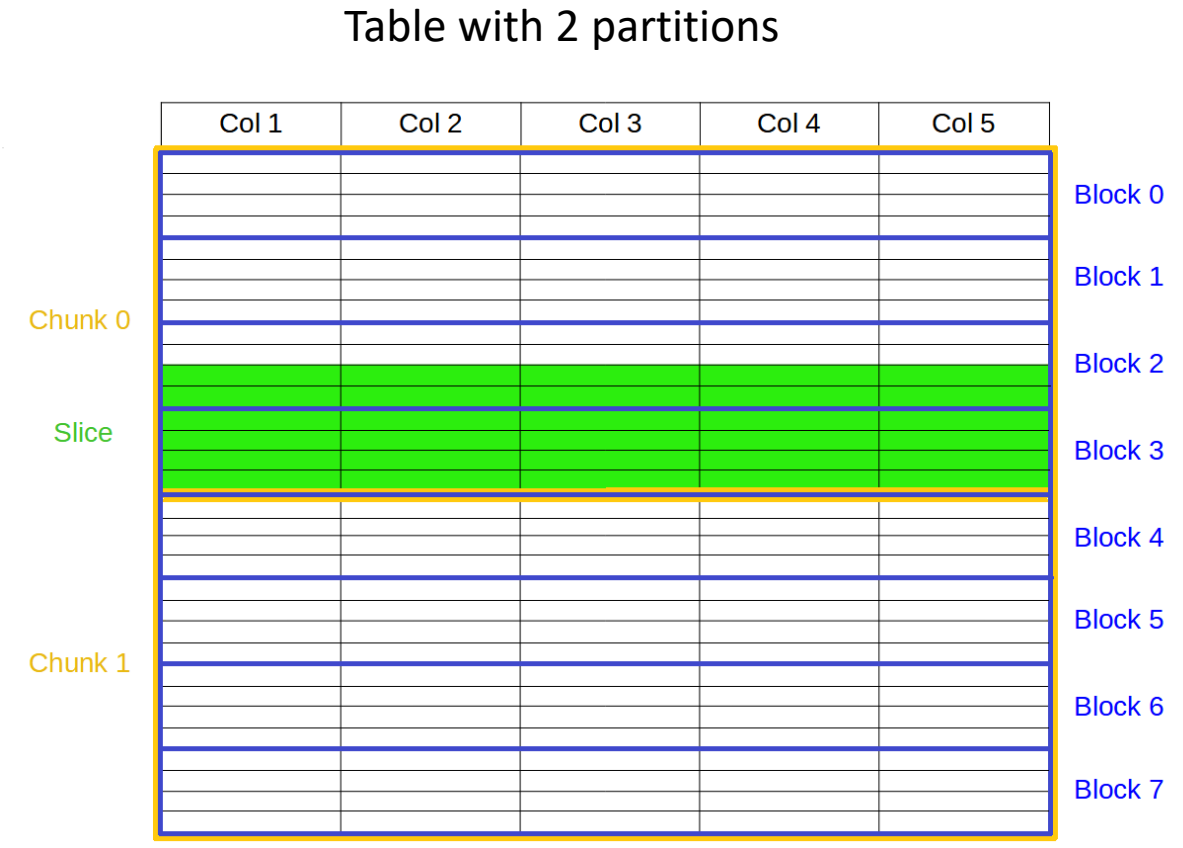
The second partition in Blosc2/HDF5

What is it providing?

Implementation of a second partition in HDF5/PyTables

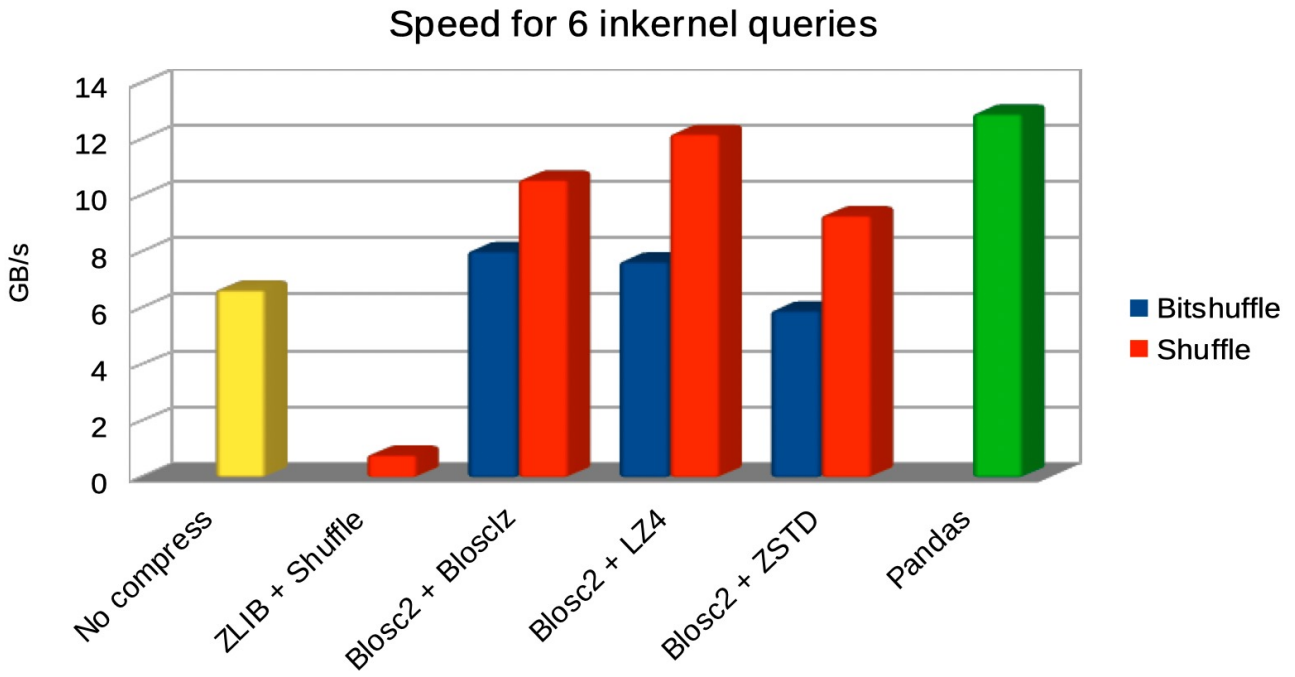
- Chunks and Blocks: allow better granularity during compression/decompression
- Modern processors work best when workloads fit in internal caches
- Chunks can be set to fit in L3 cache, and blocks to fit in L1/L2

Better performance!



Second partition at work

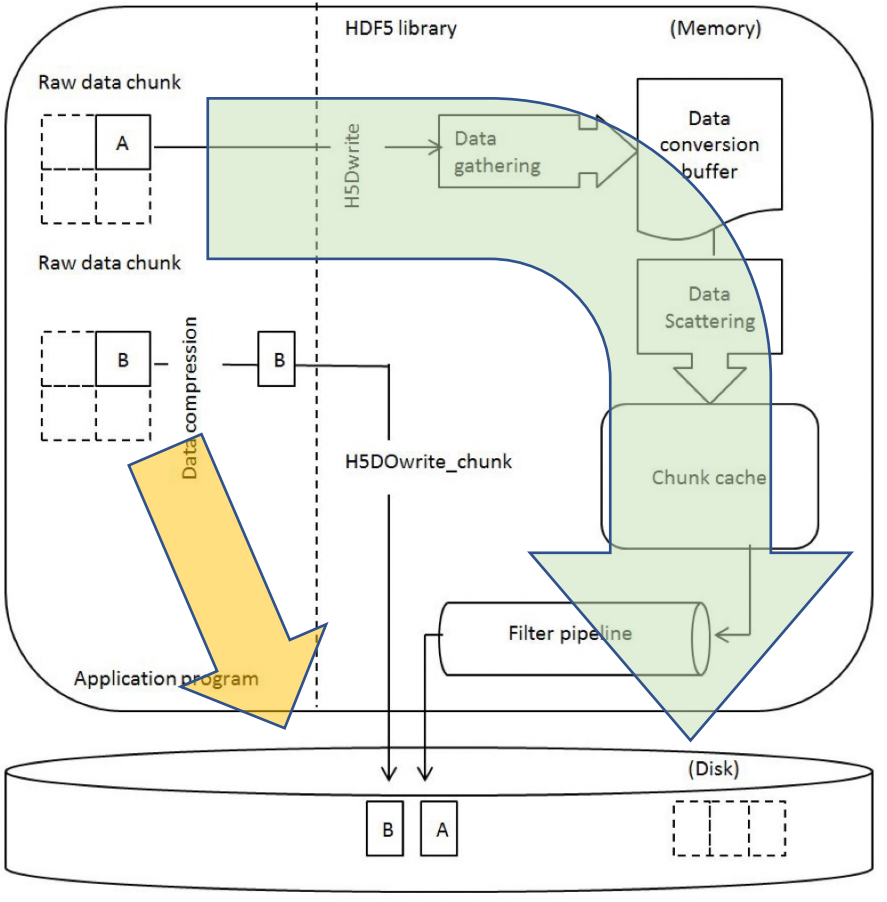
- Using data from ERA5 datasets
- Inkernel queries
  => full scan on disk



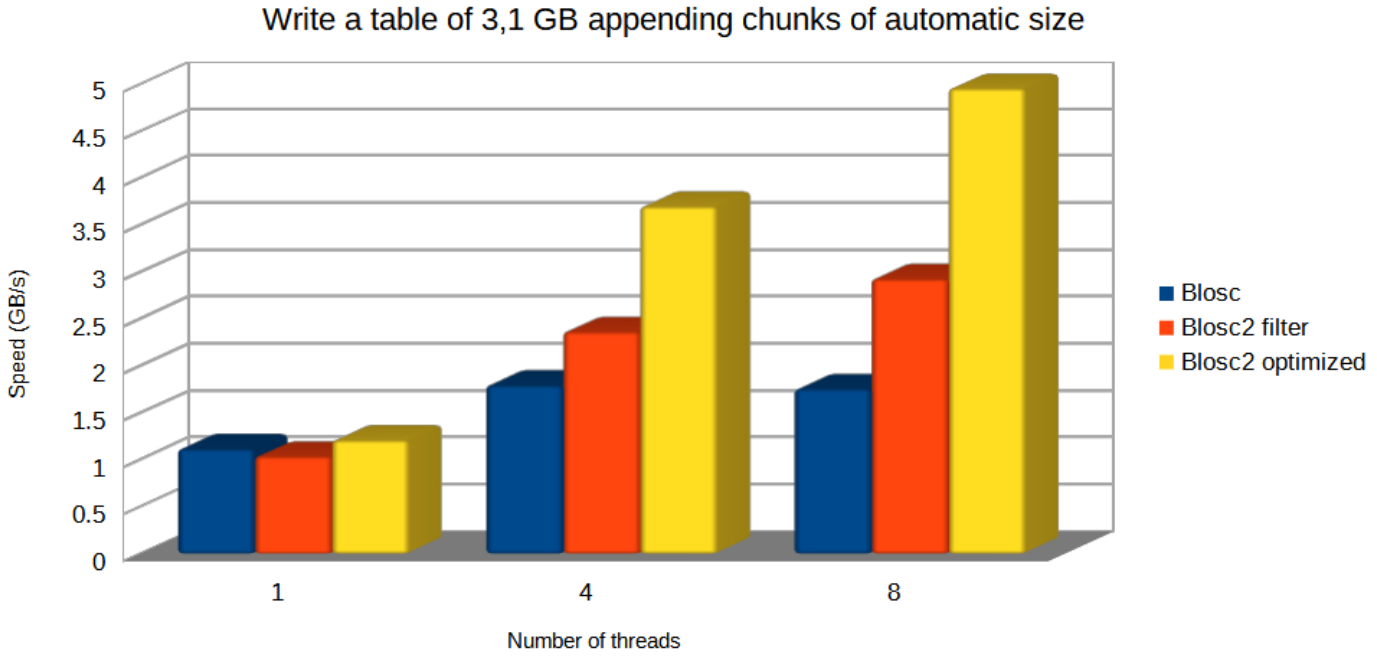
- Much higher speed than default ZLIB + shuffle in HDF5
- 2x performance than plain HDF5 with no compression
- Almost reaching perf of efficient, pure in-memory libraries like pandas

Bypassing the HDF5 pipeline

- HDF5 pipeline implementation is powerful but slow
- PyTables has support for bypassing it via the H5Dwrite_chunk / H5Dread_chunk
- Unleash the full I/O parallel in Blosc2

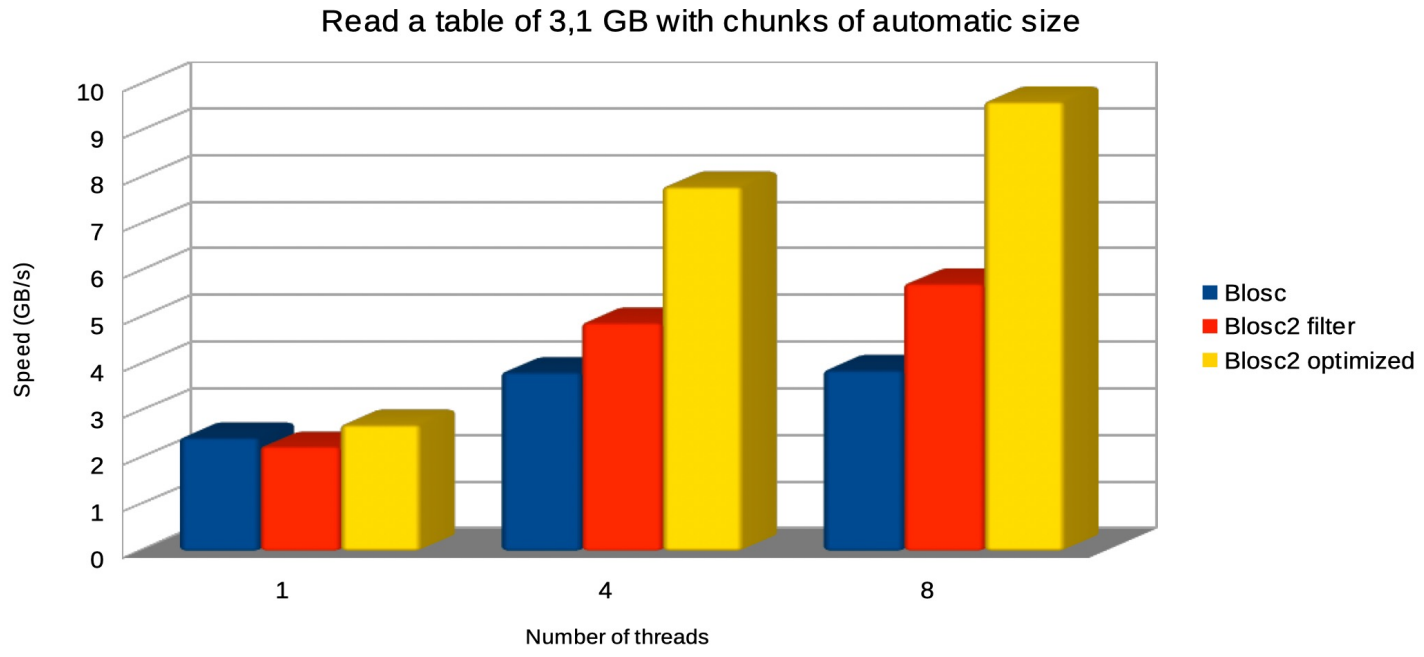


Bypassing the HDF5 pipeline: Writing



Blosc2 optimized -> bypass the HDF5 pipeline. Almost 2x faster!

Bypassing the HDF5 pipeline: Reading



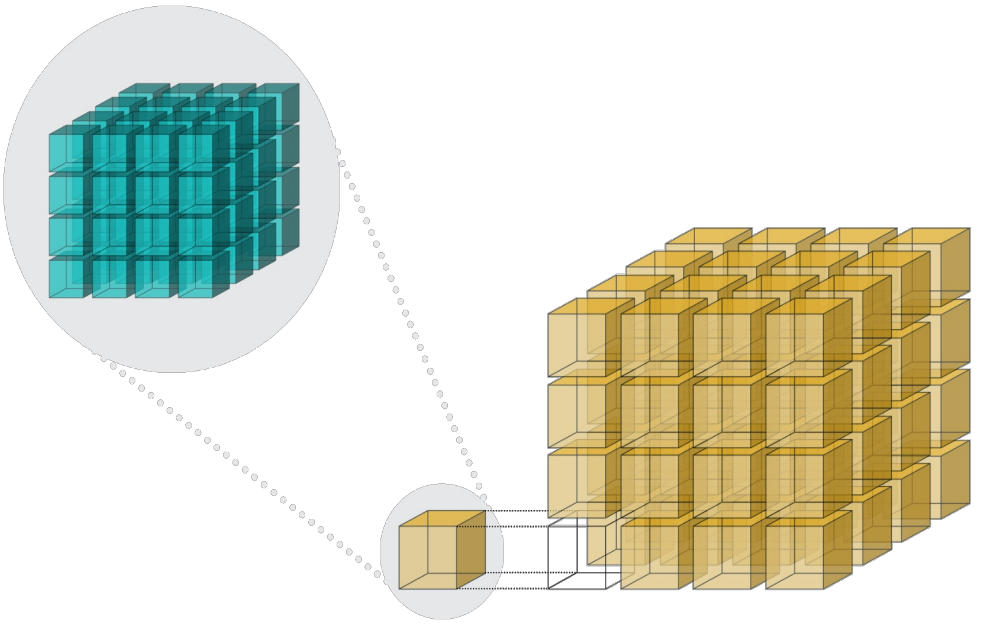
Blosc2 optimized -> bypass the HDF5 pipeline. Almost 2x faster!

NDim And NDArray

Blosc2 Goes Multidimensional

C-Blosc2 NDim: Multidimensions for C

- Each NDim array is split in chunks
- Each chunk is split in blocks
- All the partitions are multidimensional!
- Metalayer representing both multidimensionality and **data types** (new!)



https://www.blosc.org/c-blosc2/reference/b2nd.html

NDArray: Blosc2 NDim for Python

```python
import blosc2

a = blosc2.full((4, 4), fill_value=9)
a.resize((5, 7))
a[3:5, 2:7] = 8
print(a[:])
```

Output:

```
[[9 9 9 9 0 0 0]
 [9 9 9 9 0 0 0]
 [9 9 9 9 0 0 0]
 [9 9 8 8 8 8 8]
 [0 0 8 8 8 8 8]]
```

Features:

- Create arrays in memory or on disk
- Flexible resize (including shrinking)
- Support for all NumPy data types
- Efficient conversion from/to NumPy
- Mimic NumPy API
- Version 2.1 out; meant for production

https://www.blosc.org/python-blosc2/reference/ndarray_api.html

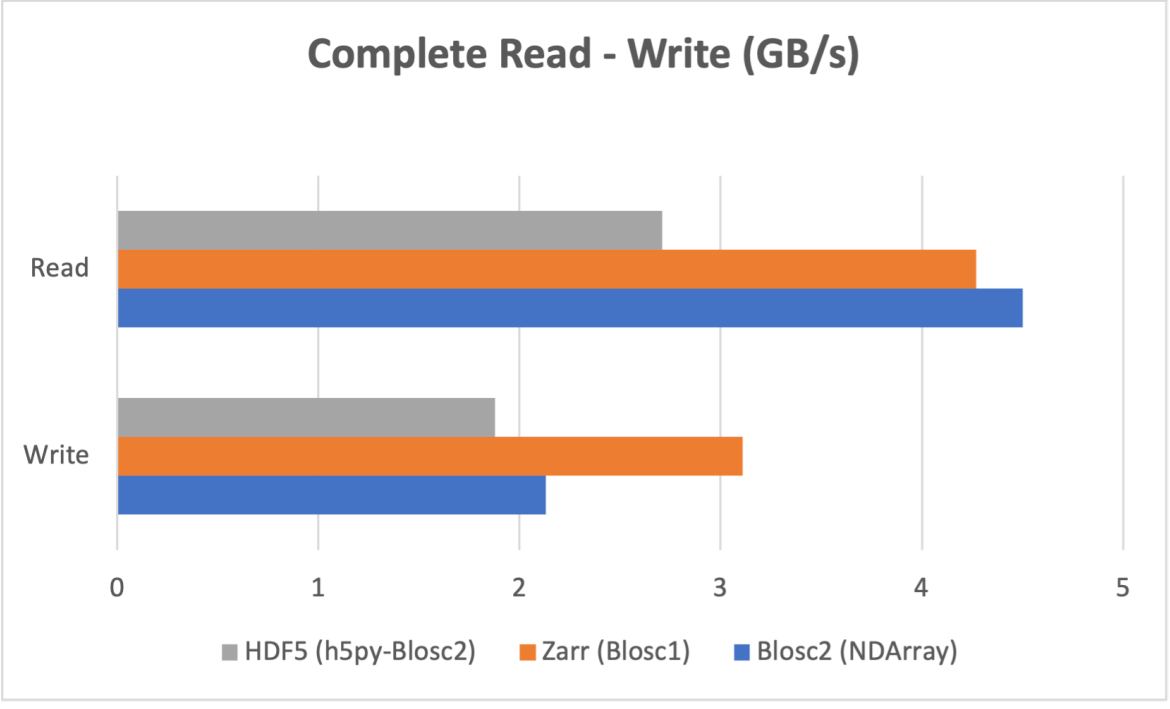
Blosc2 NDim read/write performance

4-d array:

- shape: (50, 100, 300, 250)
- chunk shape: (10, 25, 50, 50)
- block shape: (3, 5, 10, 20)
- data type: *float64*

- Doing a complete read is generally faster

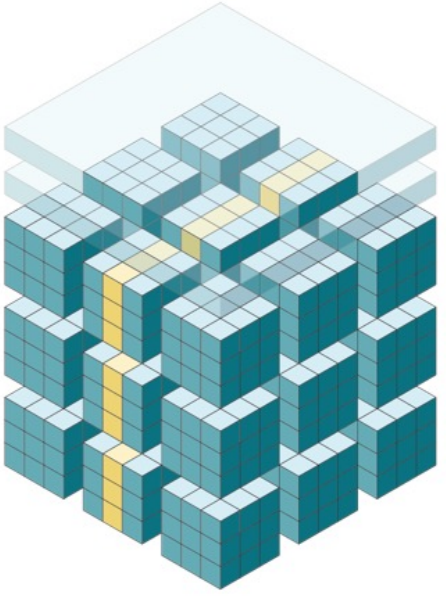
- Writing is more expensive because of the overhead of double partitioning



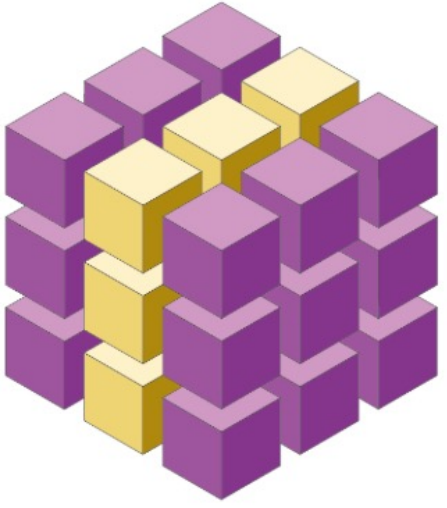
https://www.blosc.org/posts/blosc2-ndim-intro/

Leveraging the second partition in Blosc2 NDim

Much more selective and faster queries!

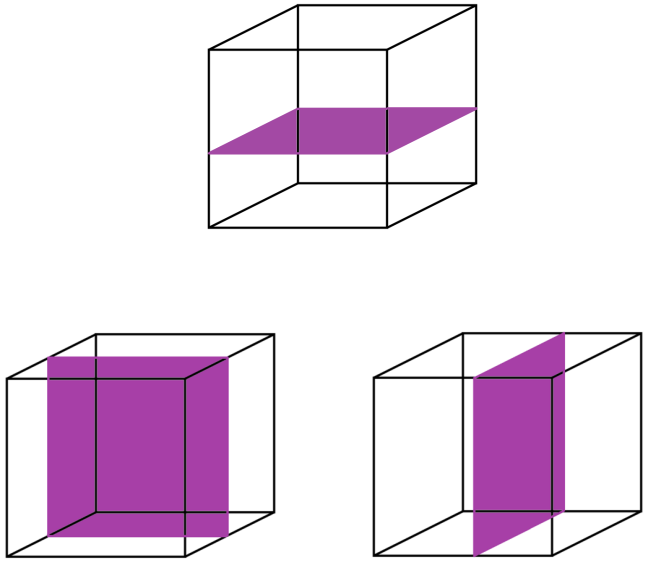


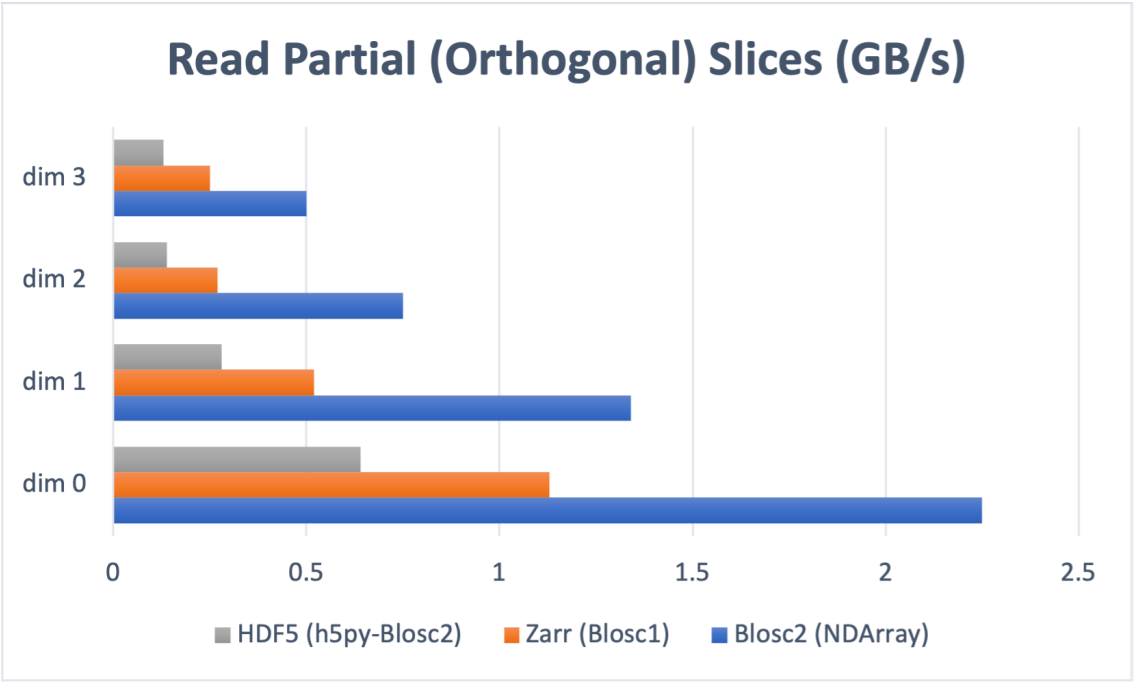
Blosc2 NDim



HDF5 / Zarr / others

Blosc2 NDim partial read performance





Faster slicing due to higher data selectivity in double partitioning

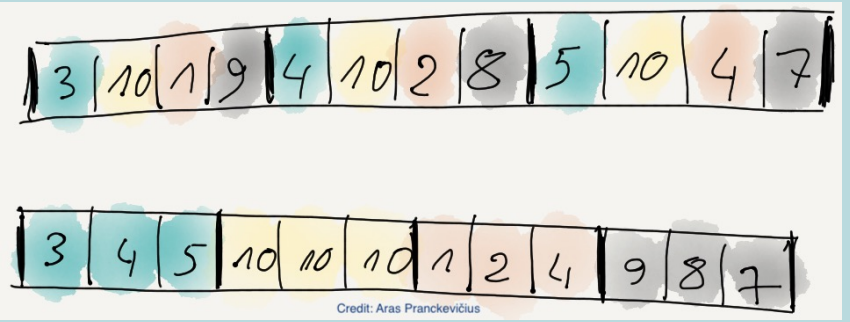
Bytedelta

A new filter for Blosc2

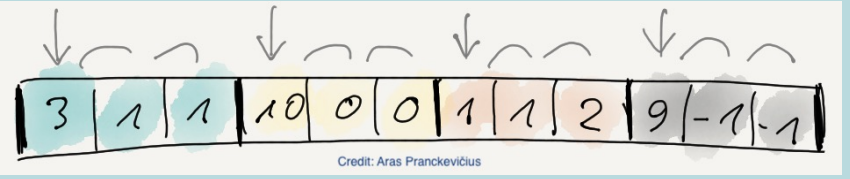
Bytedelta: How it works

Blosc2 Filter Pipeline

shuffle ->



bytedelta ->



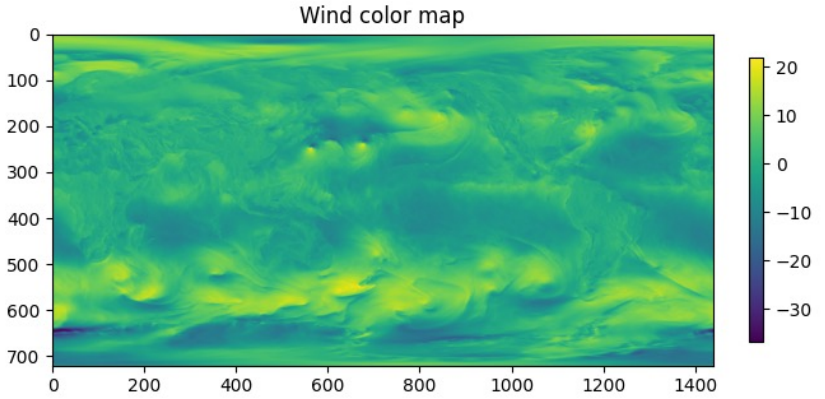
Based on initial work by Aras Pranckevičius

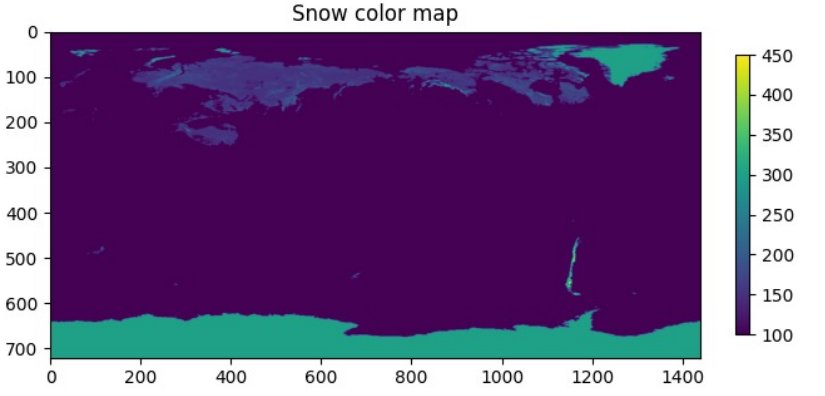
https://www.blosc.org/posts/bytedelta-enhance-compression-toolset/

Bytedelta: How does it perform?

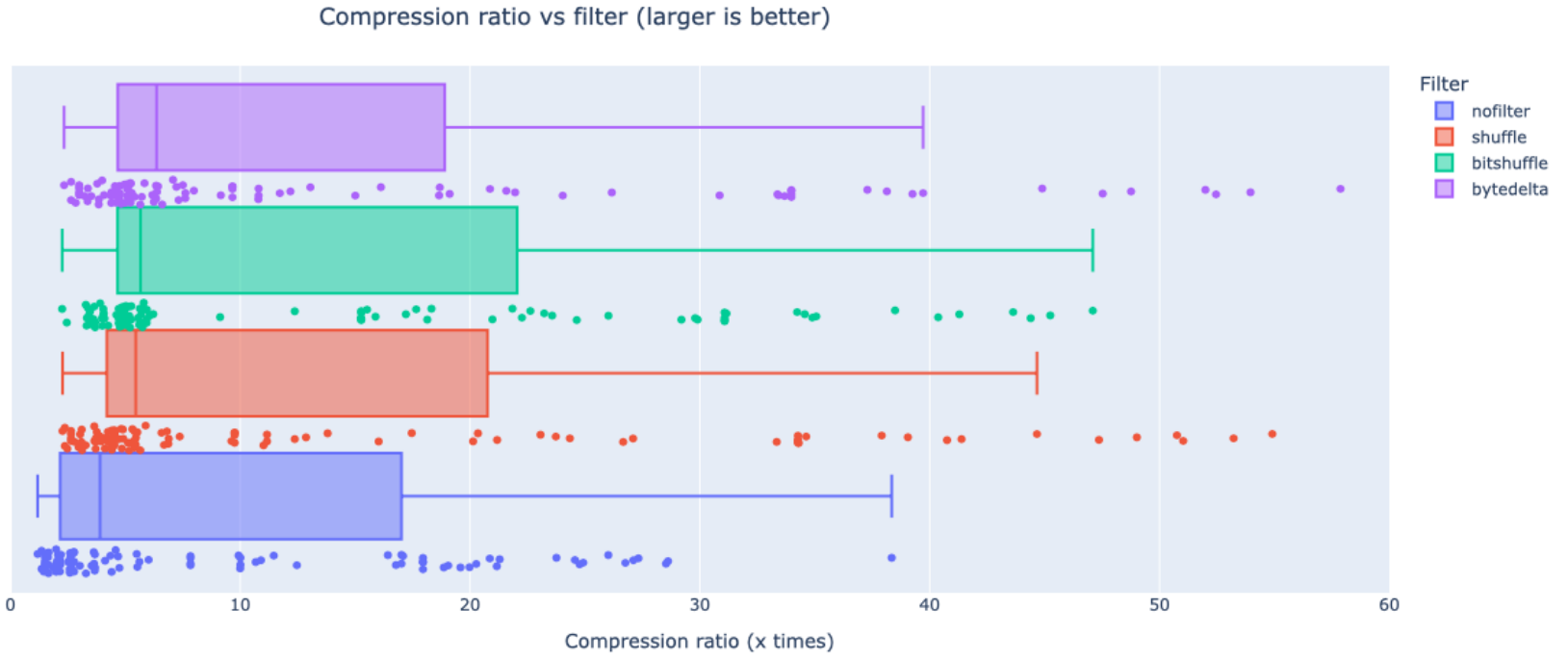
Tested on 5 different ERA5 datasets
(atmospheric reanalysis of the global climate):
wind, snow, flux, precip and pressure

- Some show some complex structure (wind)
- Others are simpler (snow)





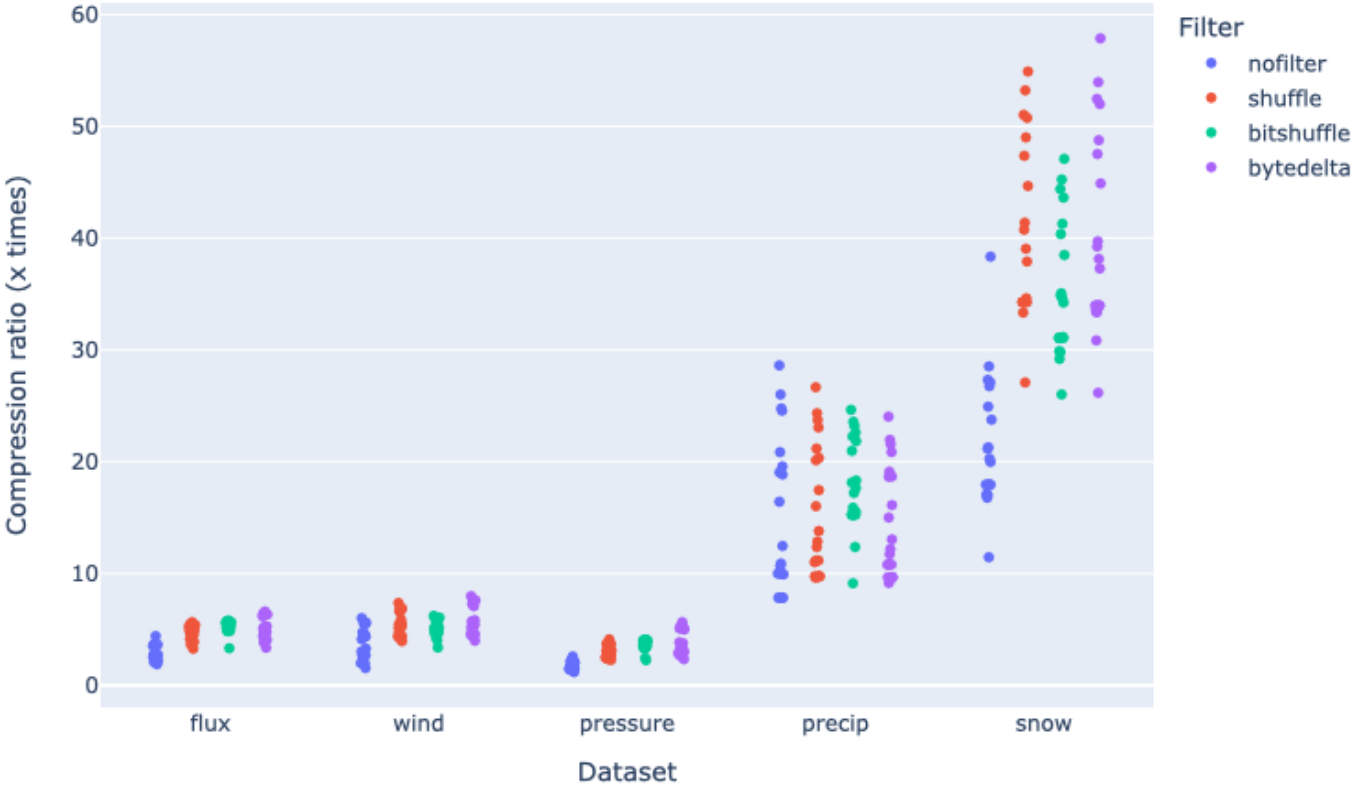
Bytedelta: How does it perform?



Bytedelta compress better than shuffle or bitshuffle on average
Median for bytedelta (best): 6.36 x
Median for bitshuffle (second best): 5.66 x

Bytedelta: How does it perform?

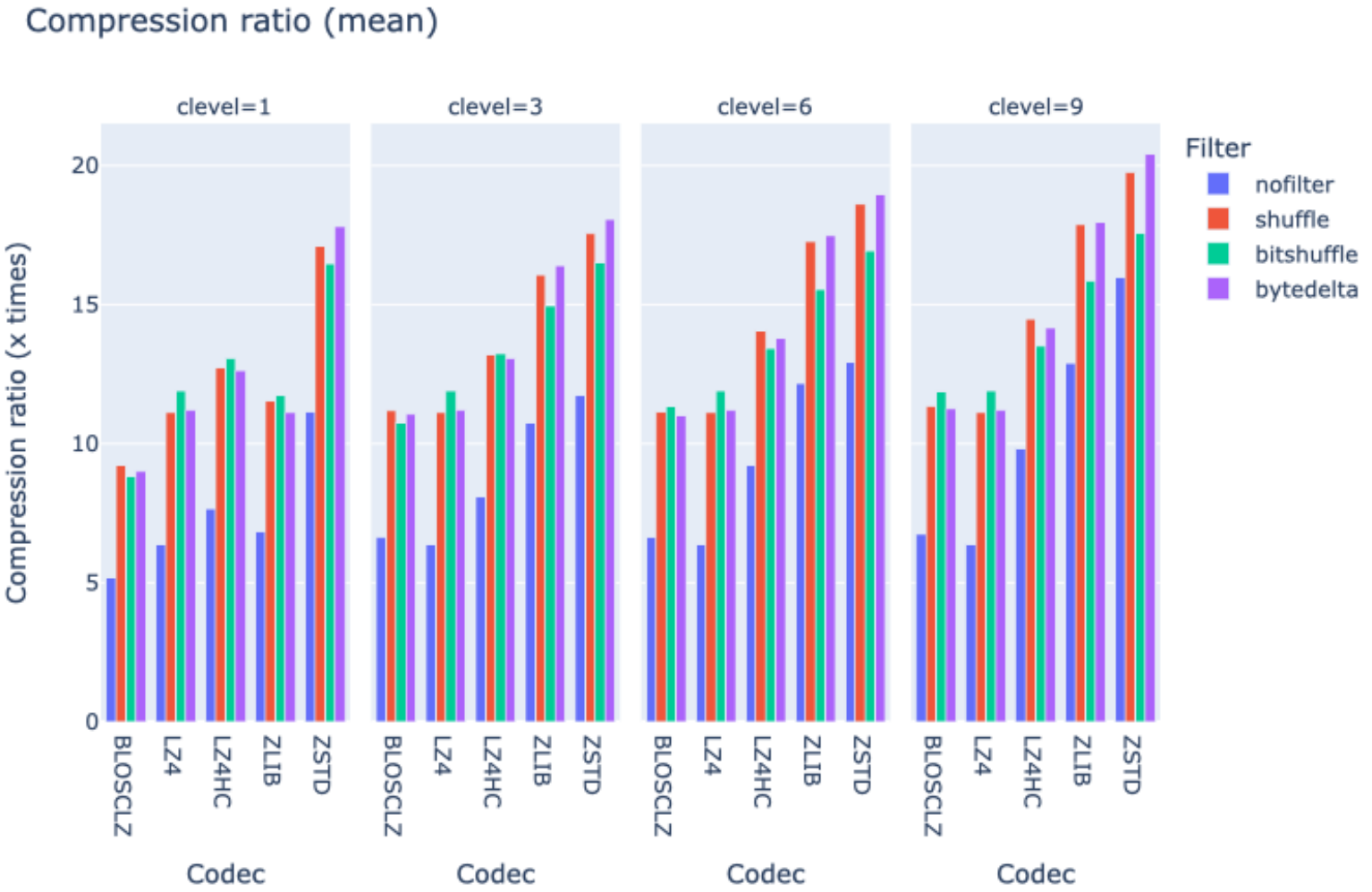
- Compression ratio versus dataset
- Points for all the general codecs in Blosc2 (BLOSCLZ, LZ4, LZ4HC, ZLIB, ZSTD), and for different filters



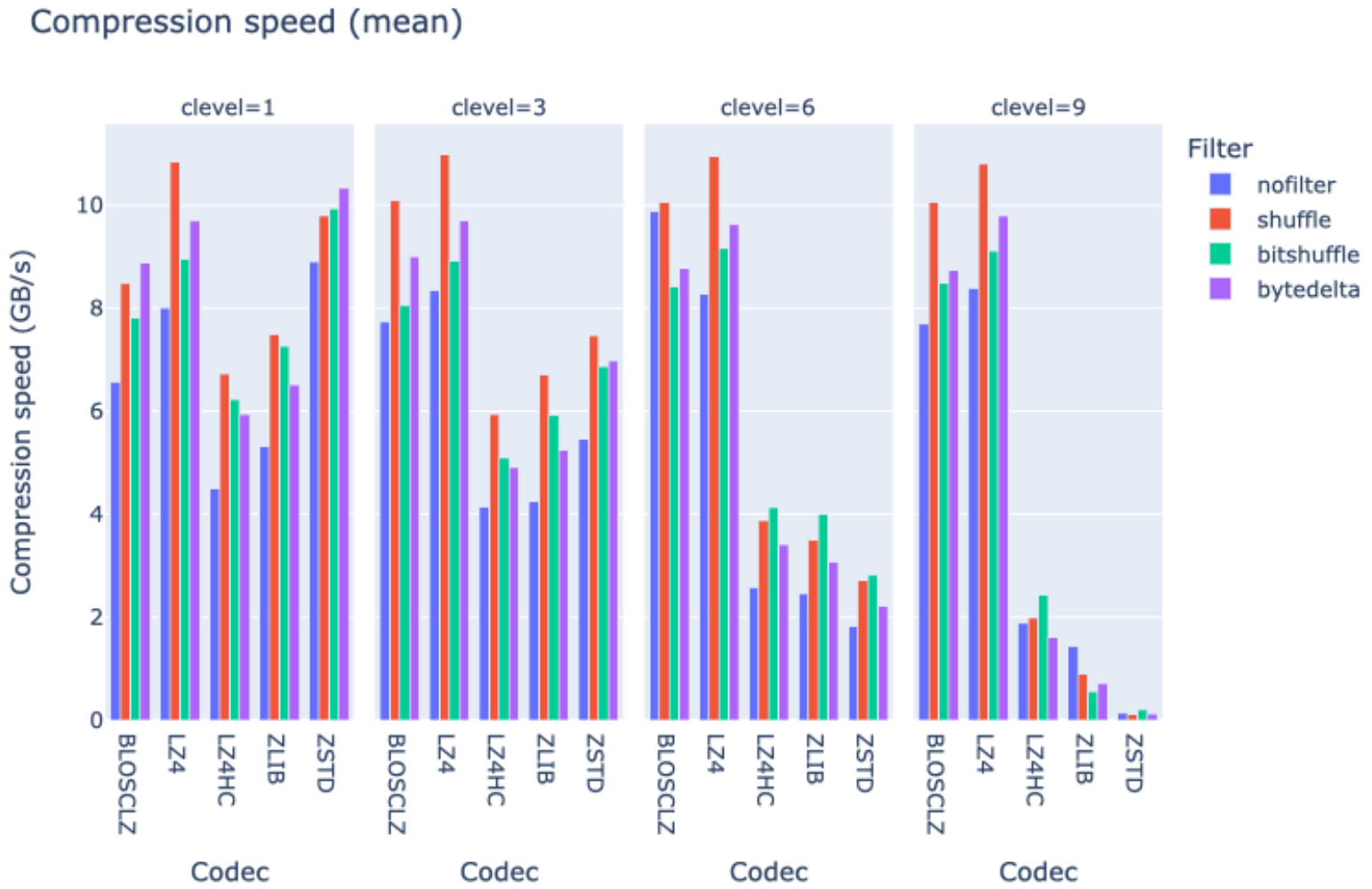
Bytedelta: How does it perform?

Compression ratio for the datasets with more complexity (entropy)

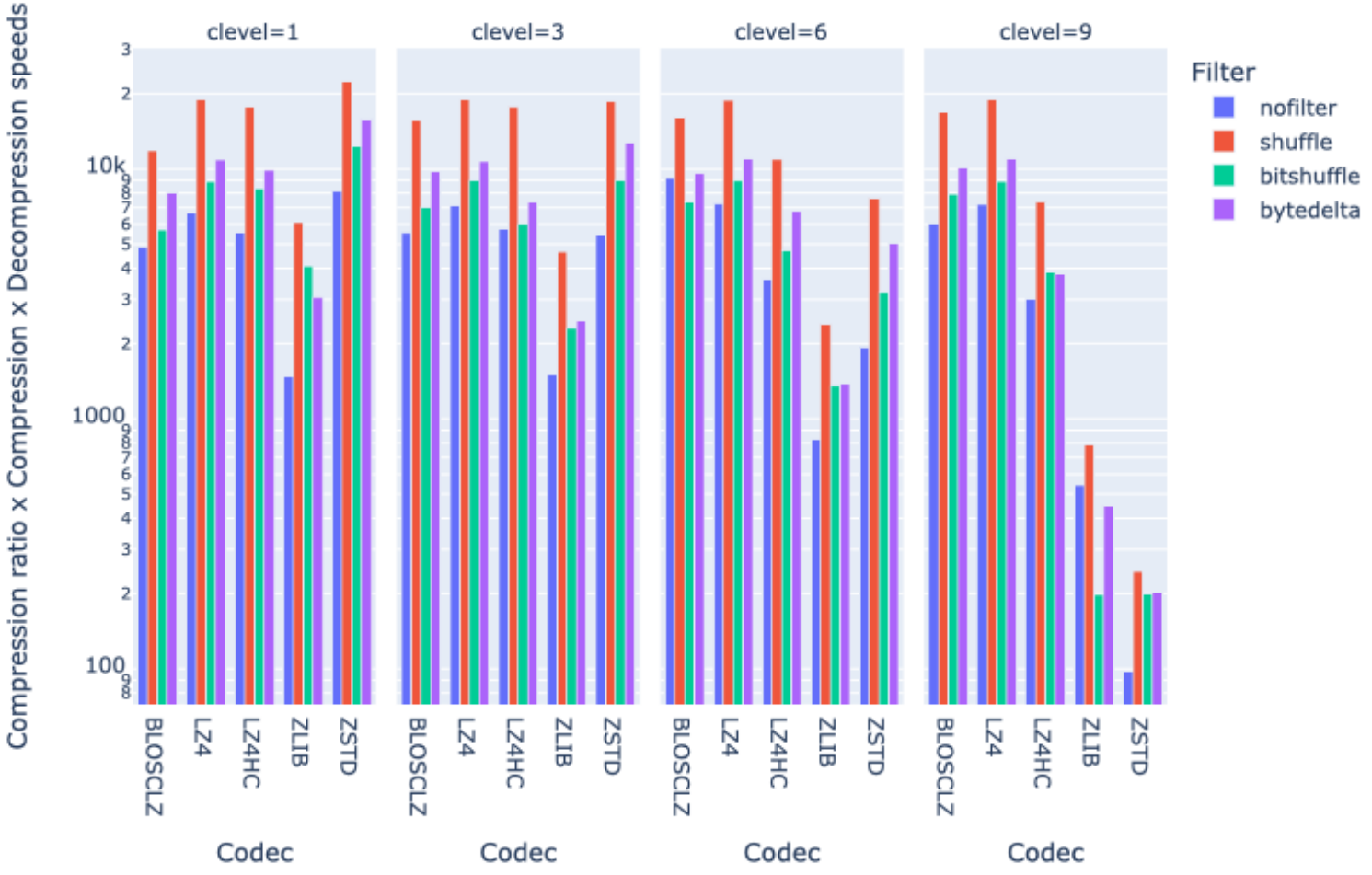
For *pressure*, bytedelta achieves up to 37% better results than second best (!)



Bytedelta works best in combination with ZSTD codec (and high clevels of ZLIB)



Bytedelta shows excellent compression speed when using ZSTD with clevel 1



Bytedelta + ZSTD level 1: a good default

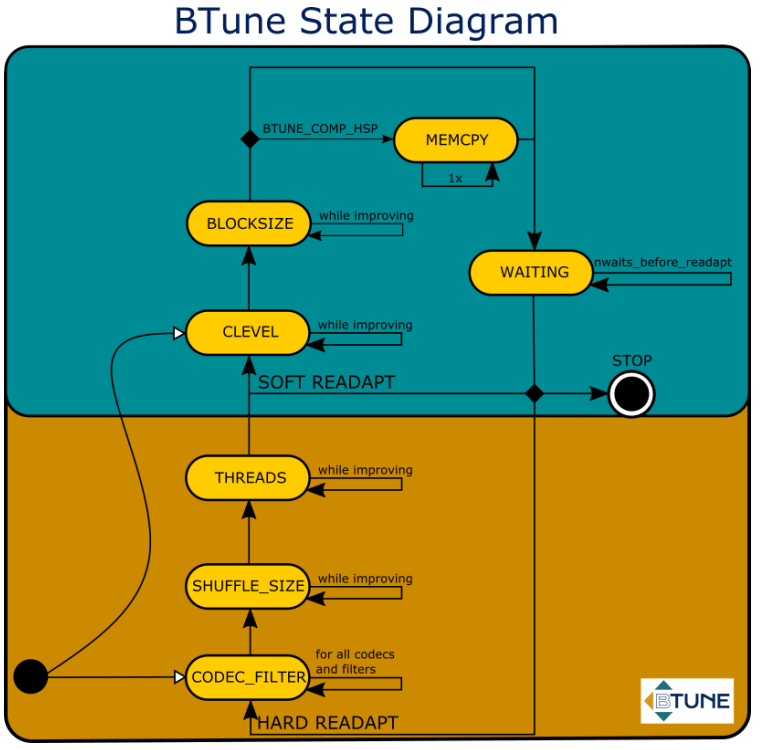
(specially for complex datasets)

Ongoing Work

Fine Tuning Performance with BTune

https://btune.blosc.org

- BTune can fine tune the different parameters of the underlying Blosc2 storage to perform as best as possible.
- Can be trained to find the best codec & filter with deep learning.
- **Looking for beta testers!**



Support for High Throughput JPEG 2000 (HTJ2K)

- Experimenting with OpenHTJ2K, an open source HTJ2K implementation by Osamu Watanabe.
- We already have a working implementation, but:
    - It cannot leverage Blosc2 multithreading
    - Big library: cannot be included straight in C-Blosc2

Proposal:

Use a smarter plugin system that can load plugins dynamically in runtime. Already working on that, but need more resources.

Conclusion

Blosc2 is making rapid progress

The Blosc2 development team has recently:

- Implemented **native support for Blosc2 in HDF5**, bypassing the HDF5 pipeline
- **New Ndim and NDArray** objects for easy handling of multidimensional data containers
- **New bytedelta** filter
- **BTUNE,** a tool for automatically select best Blosc2 parameters, is **in beta**
- Prospective work done for High Throughput JPEG 2000

Blosc2: a highly efficient and flexible tool for
compressing your data, your way

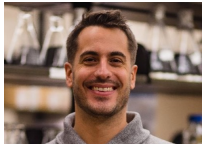
Proposals

1. Use Blosc2 in combination with HDF5 direct chunking mechanism for efficient compression and parallel I/O.

2. Help in determing optimal compression pipelines by adapting to user data and using machine learning techniques.

3. Support for High Throughput JPEG 2000

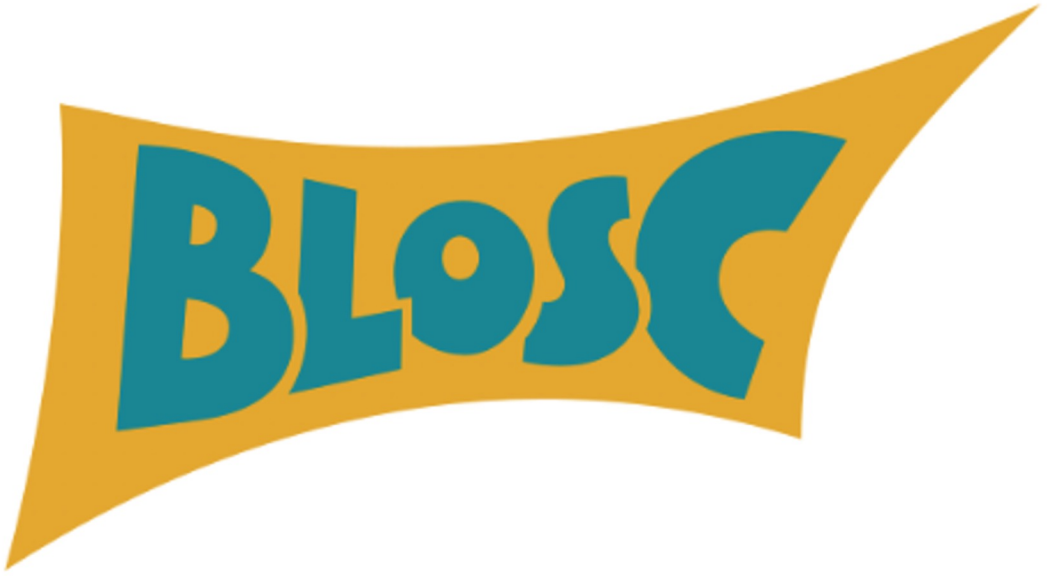
Thanks to donors & contracts!



Jeff Hammerbacher

Without them, we could not have possibly put Blosc2 into production status: Blosc2 2.0.0 came out in June 2021; now at 2.8.0.

Enjoy data!



https://blosc.org/