A Hexagonal Box Spline Wavelet for Level of Detail Visualization of Digital Earth Data

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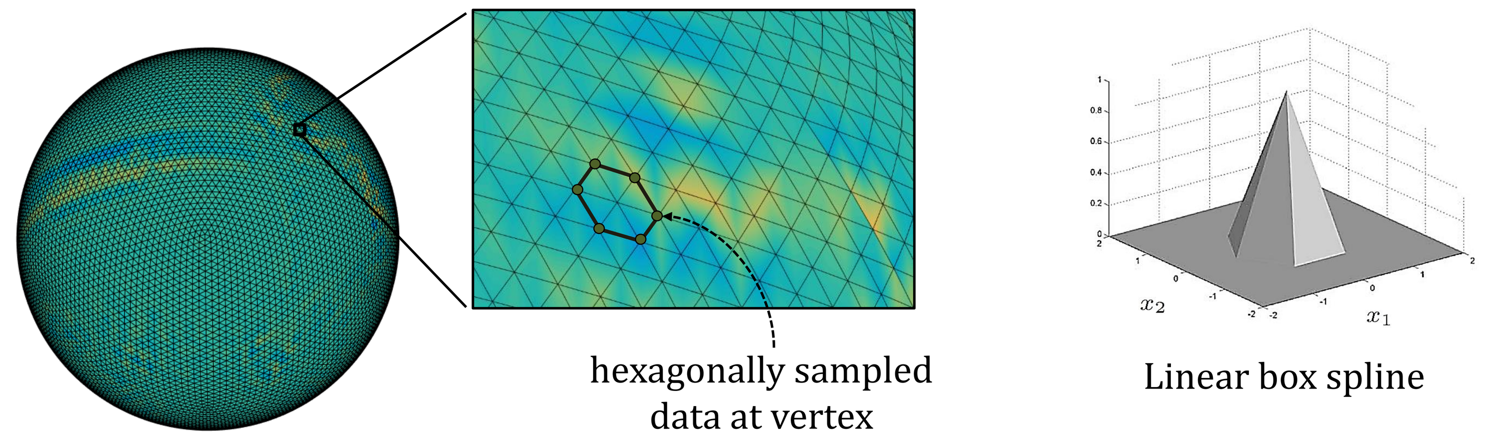
Introduction

Motivation

- Multiresolution analysis provides facilities to visualize large data at different levels of detail (LoD) while providing the advantages of efficient data compression and transmission.

Contribution

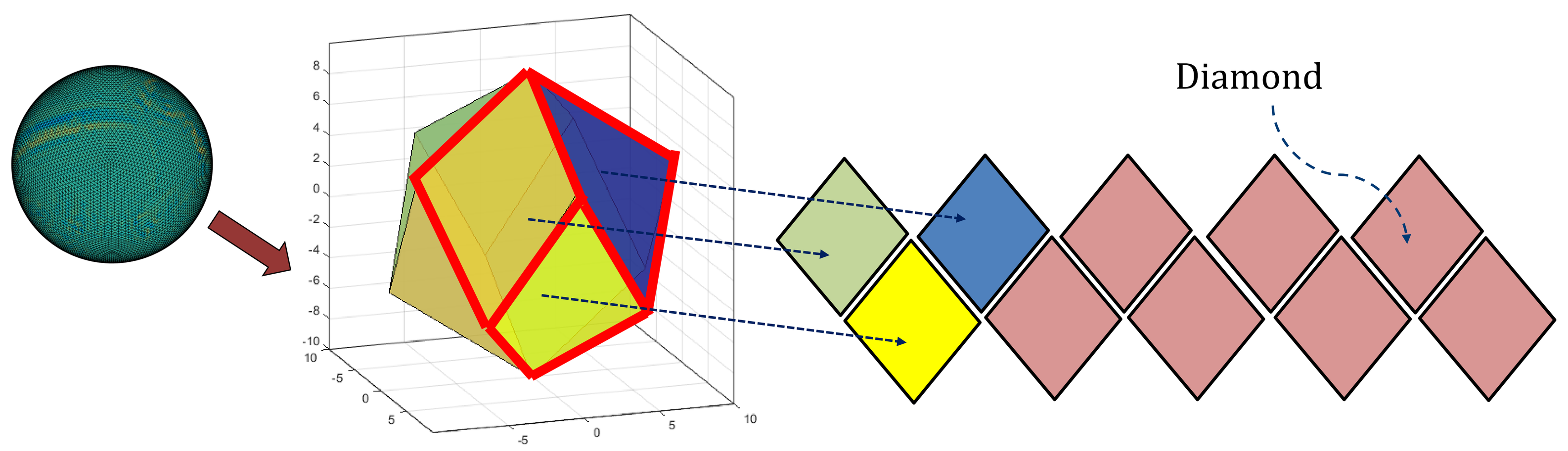
- In this work, hexagonally sampled geospatial data on Digital Earth at a fine level is taken as an input and a hierarchical traversal is applied by applying decomposition and reconstruction methods.
- Multiresolution filters are designed based on the three directional linear box-spline which is natively supported by modern GPUs.



Method

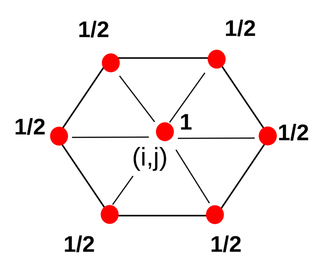
Data Structure: *Atlas of Connectivity Maps* [1]

- Connectivity information of the vertices on Digital Earth surface is stored in two dimensional array.



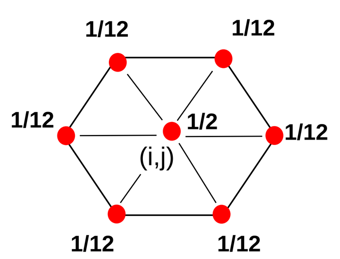
Method

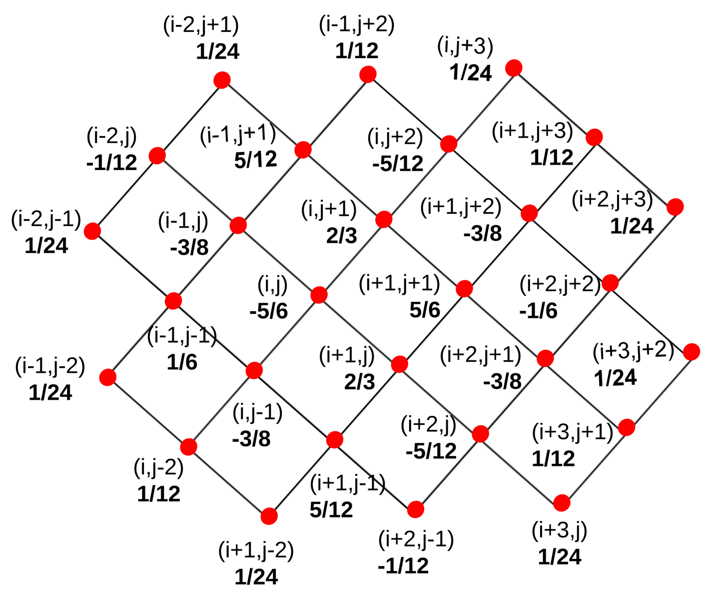
Multiresolution Filters:



Scale Filter (u):
The hexagonal linear box spline is self similar, i.e. shifts of a dilated version can provide the fine version, and the necessary coefficients are given by the scale filter.

Auto-Correlation Filter (b):
The auto-correlation and its inverse are needed because we are orthogonally projecting a fine level down to a coarse level.





Weight Filter (w):
From the orthogonality constraint:
In spatial domain-

$$[w * u_2^n * b^{2n+1}]_{\downarrow 2}(k) = 0, \qquad k \in \mathbb{Z}$$

In z-transform domain-

$$\frac{1}{2}[W(z)U_2^n(z)B_1^{2n+1}(z) + W(-z)U_2^n(-z)B_1^{2n+1}(-z)] = 0$$

Multiresolution Scheme:

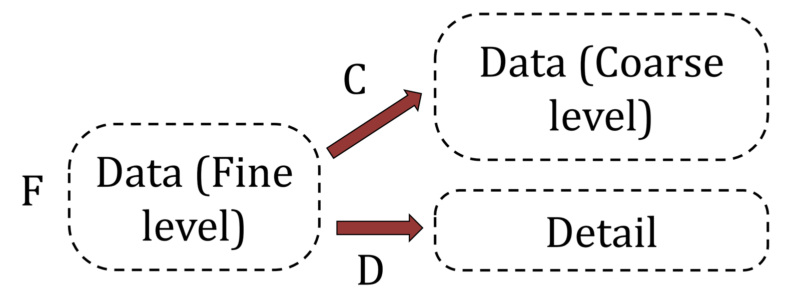
Decomposition:

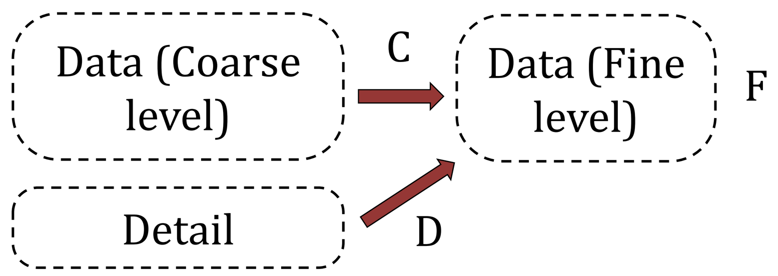
$$C = (((F * u) * b)_{\downarrow 2}) * b^{-1}$$
$$D = ((F * w)_{\downarrow 2}) * b^{-1}$$

Reconstruction

$$F = (C_{\uparrow 2}) * u + (D_{\uparrow 2}) * w$$

Where, F is the data at fine level. C and D are coefficient and detail at coarse level respectively.

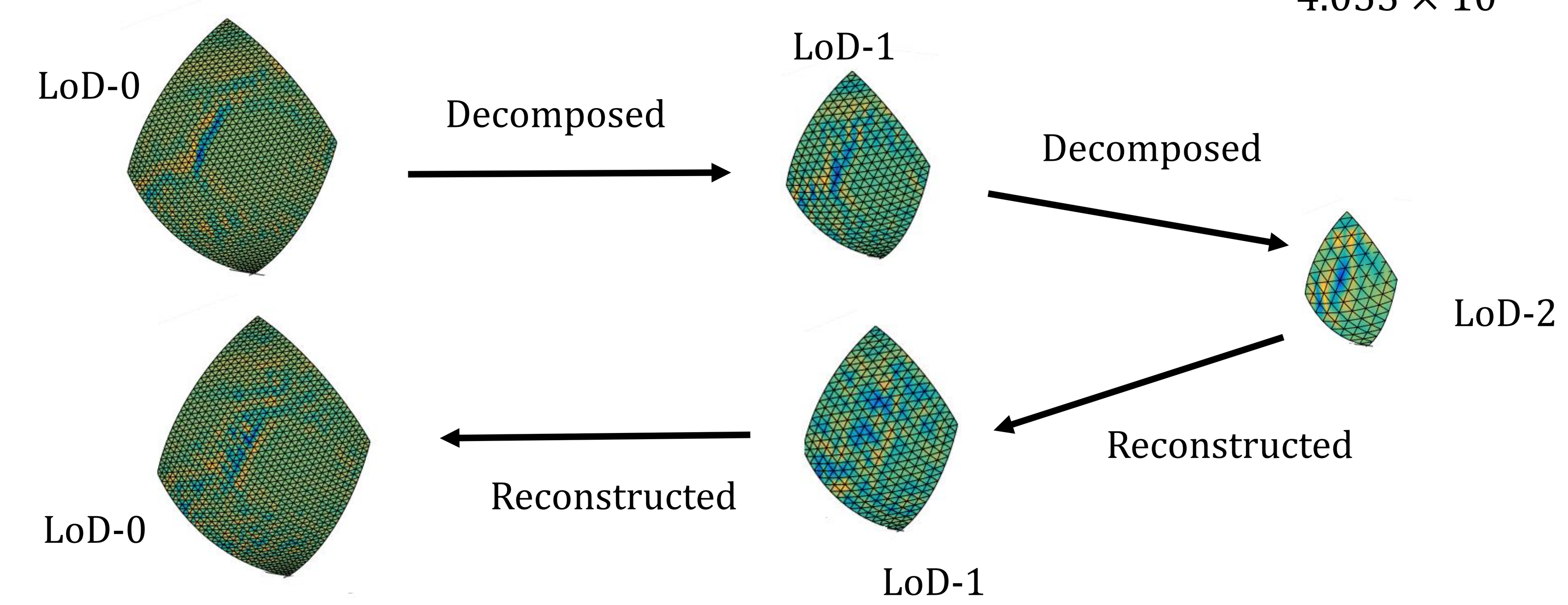


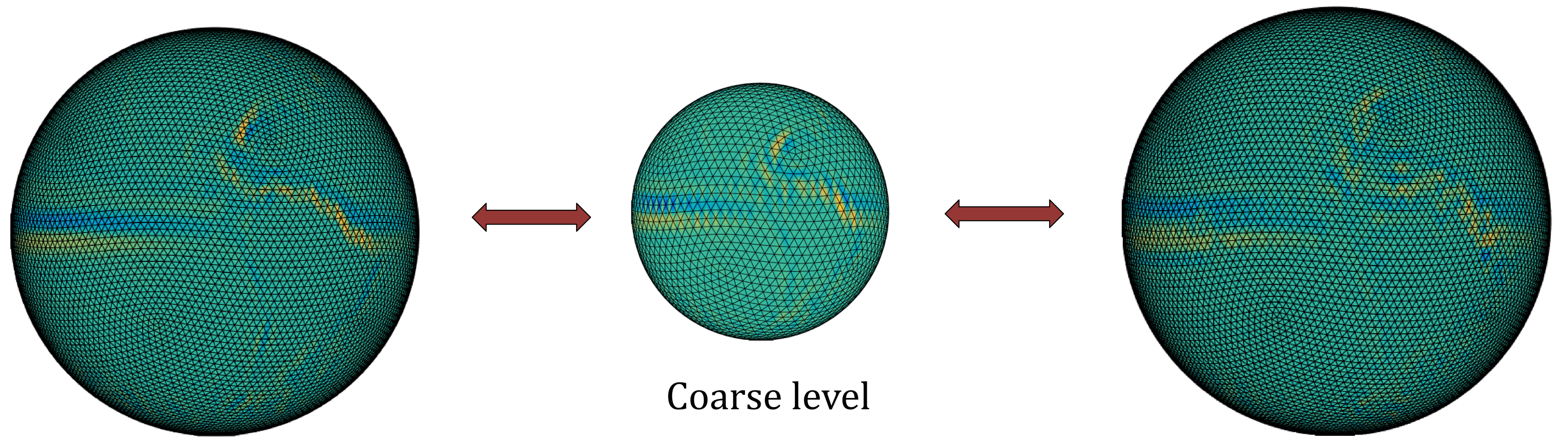


Results

Data set : ICON (ICOsahedral Non-hydrostatic)

Mean Square Error: 4.053×10^{-12}





Future Work

- Applying the multiresolution scheme on larger scale data set.
- Investigating the error occurred during reconstruction.

References

[1] Mahdavi-Amiri, Ali., and Samavati, Faramarz., "Atlas of Connectivity Maps for Semiregular Models", Proceedings of Graphics Interface, 2013, pp. 99-107.
[2] Unser, M., Aldroubi, A., Eden, Murray., "A family of polynomial spline wavelet transforms", Signal Processing, Elsevier, 1993, Volume 30, Issue 2, pp. 141–162
[3] Condat, L., Van De Ville, D., and Unser, M., "Efficient Reconstruction of Hexagonally Sampled Data using Three-Directional Box-Splines", IEEE International Conference on Image Processing, 2006, pp. 697-700.