Parallel second order conservative remapping on the sphere

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1. Introduction

We present an implementation of a conservative 1st/2nd interpolation between arbitrary spherical meshes with convex elements, in particular meshes used by IFS model: structured grids such as octahedral or reduced Gaussian grids of IFS, quasi-structured grids such as ORCA of NEMO, or fully unstructured grids of FESOM2. For his work shares a lot in common with an earlier work in [3]. Here, we used a different approach for typical ingredients of remapping process, namely that of spherical polygon intersections (Sutherland-Hodgman) and that of a fast search of potential intersectors (kD-tree) for a given polygon. For these two we rely on available tools of our in-house numerical library for weather simulations – Atlas (see [1]). On top of the traditional cell-to-cell remapping, we extended the remapping to allow staggering of data – data can be either in cell centres or cell vertices on a source mesh, and, independently of the source data localisation, remapped to the cell centres or to the cell vertices of target mesh.

2. Staggering

We support remapping of staggered data. Data points can be located in the cell centres **or** in the nodes/vertices of a given mesh (again, structured or unstructured). This is achieved through construction of sub-quadrilaterals as in Fig. 1. around each node as in [2]. Staggering effects are best seen in Fig. 2. for the 1st order remap from CubedSphere grid CS-LFR-8 to a much higher resolution O256. The imprinting of a lower resolution into O256 is clearly visible in case of the 1st order. The advantage of the 2nd order is substantial for source meshes of lower resolution to the target mesh as seen in Fig. 5.

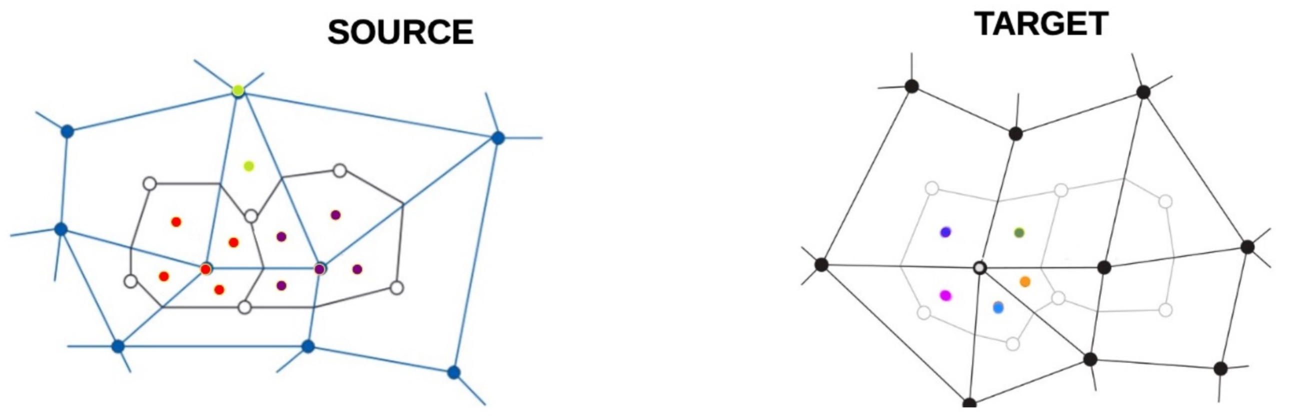


Fig 1. The idea of delegating conservative remapping from nodes to polygons on a source mesh and back on a target mesh. Based on [2].

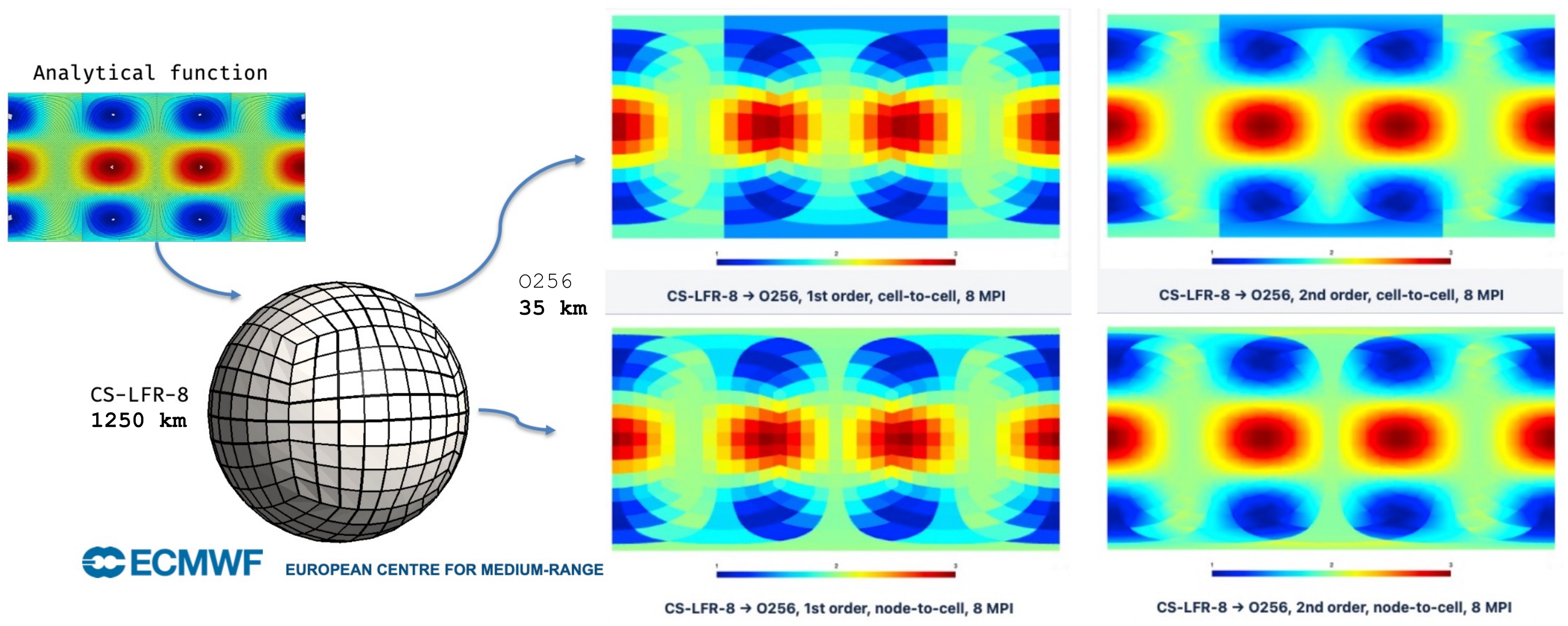


Fig 2. A staggered 1st/2nd remapping for node-to-cell and cell-to-node. Other combinations, such as node-to-node are possible as well (not shown).

3. At ECMWF

The new parallel 2nd order conservative remapping has a potential in a wide range of application at ECMWF, for instance projecting IFS vertex data to any grid (here, cell data on HEALPix - H640) in Fig. 3.

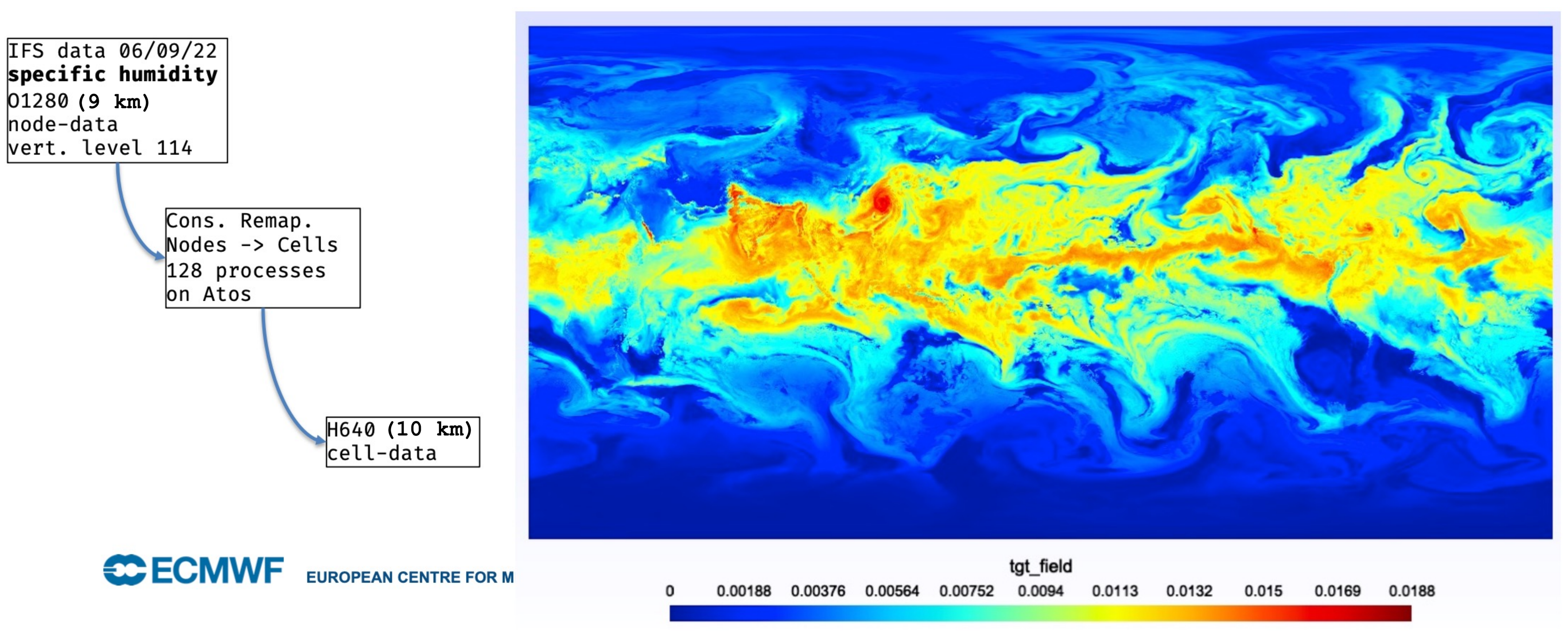
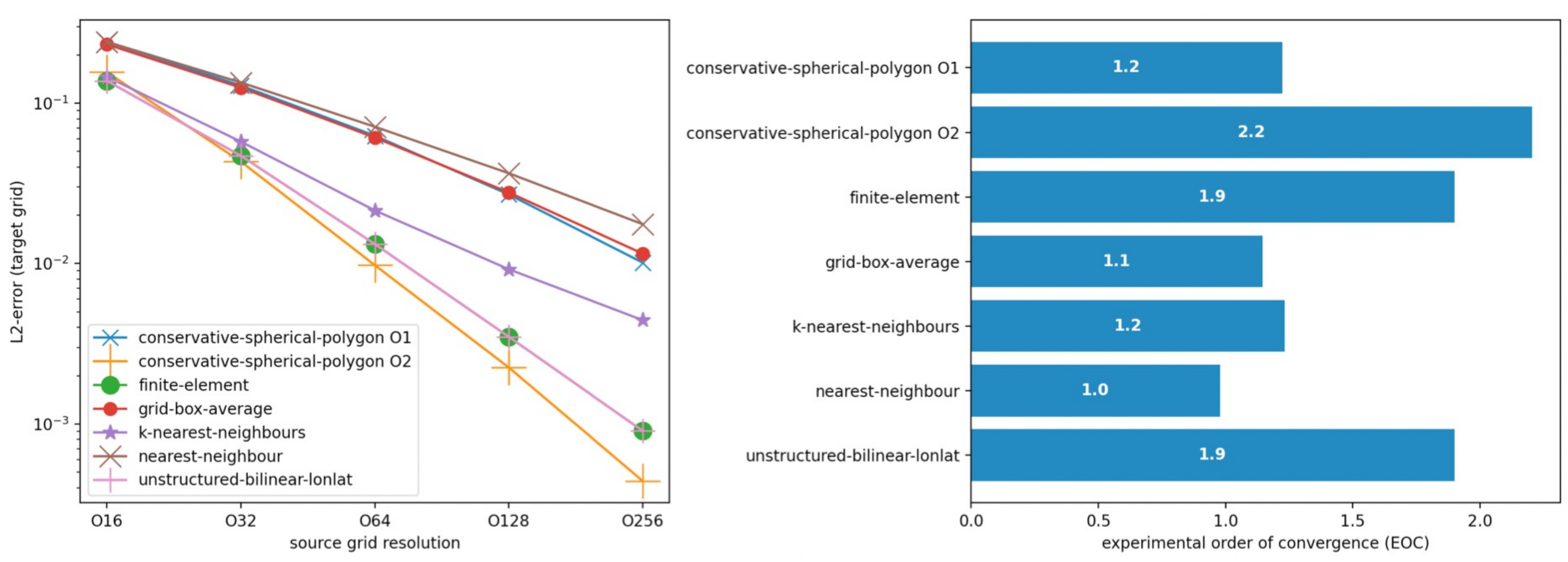


Fig. 3. (UP) Parallel 2nd order projection of IFS reanalysis vertex data to the cell centres of a new HEALPix grid.

Fig. 4. (DOWN) Experimental error of convergence for different Atlas interpolators for a smooth initial condition. The target grid is O512.



4. Diffusion property of Atlas interpolators

Consecutive remapping between a source and a target grid, can give an insight of how diffusive interpolators are. Here we are remapping between O16 and O32 for 400 times as O16->O32->O16->…->O32. It turns out that the conservative 2nd order and the nearest-neighbour are lest diffusive methods as seen in Fig. 5

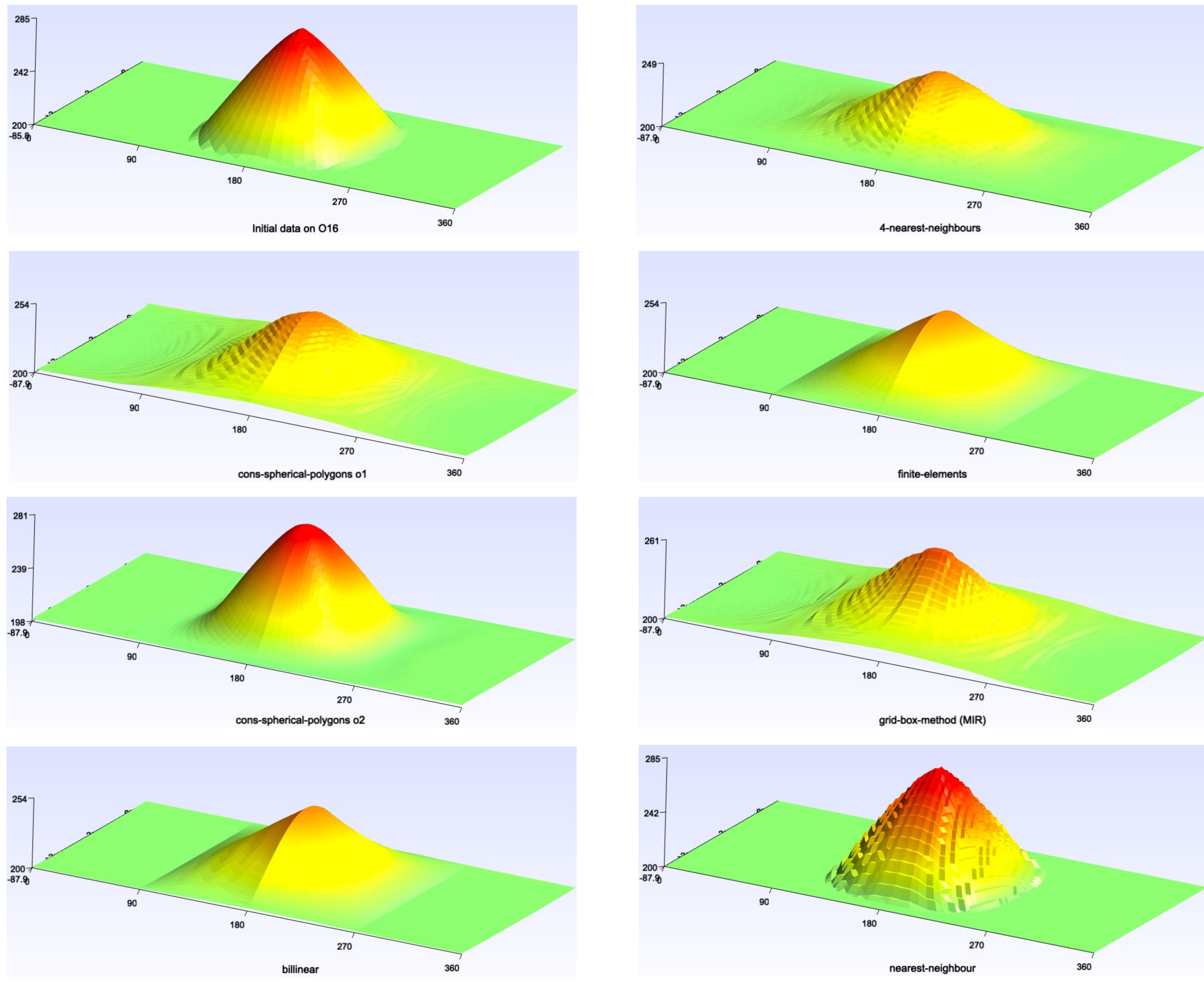


Fig. 5. Diffusion effects of various Atlas interpolators after 400 repetitive interpolations. Top left is the initial data.

5. A very high-resolution example

We remap a cell-centred orographic data on regular latitude-longitude grid 43200 x 21600 to ECMWF's operational O1280 (9 km), O2560, O4000 (2.9 km) and O8000 (1.5 km). The results are in Fig 6.

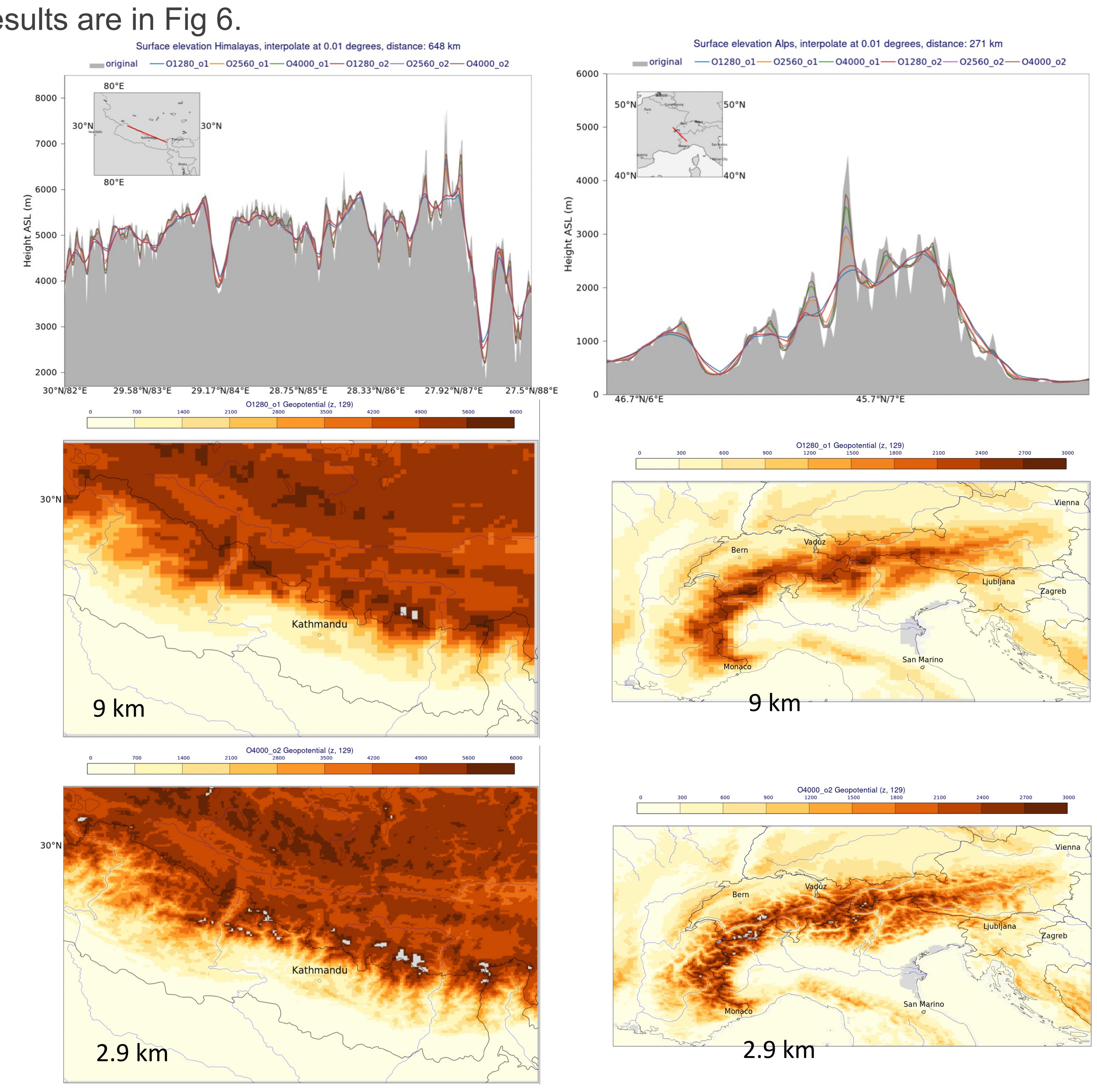


Fig 6. Remapping of regular lat-lon cell data on 43200 x 21600 (0.9 km at the equator) to the node data on O1280 (9 km, in the second row) and O4000 (2.9 km, in the third row). The efficacy of the Atlas' conservative remapping is shown in cross-sectional plots in the first row. Left column are data over Himalaya, the right column are data over Alps.

5. Acknowledgents

We are thankful to Birgit Sützl for preparing the visualisation script for Fig. 6.

6. References

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[3] E. Kritsikis et al. *Conservative interpolation between general spherical meshes,* 2017

[4] P. Maciel et al. *The new ECMWF interpolation package MIR*, ECMWF Newsletter 152, 2017

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