Core-mantle boundary flows obtained purely from Swarm secular variation gradient information

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The Swarm constellation provides information on both along- and across-track magnetic field gradients. Spatial changes of the magnetic vector field elements are described by a magnetic field gradient tensor, whose elements and their uncertainties can be estimated using the Virtual Observatory (VO) concept, whereby data within a cylinder centred on the VO with axis perpendicular to the Earth’s surface are reduced to a central point at satellite altitude. Recent experiments have shown that analysing data collected over a 4 month window provides the best compromise between reducing bias from the way the satellite orbits sample each VO cylinder and preserving information sufficient to resolve 300 non-overlapping VOs. We invert annual first differences of the 5 independent gradient tensor elements (providing estimates of secular variation, SV, gradients) at these 300 VOs over the Swarm era for advective velocity at the core-mantle boundary, forcing the flow to have minimal acceleration while providing an adequate fit to the data. We obtain flows similar to those from previous SV inversions but purely from the gradient information. The resolution of the SV gradients is higher than that of the SV itself, resulting in a ~30% increase in the number of effective flow parameters; this is thought to be because the gradients are less affected by long period external signals that are difficult to remove from the data, resulting in an improved signal to noise ratio. Although very little temporal change in the flow is required to reproduce even rapid changes in the magnetic field, we are able to isolate some robust flow changes, in particular regarding changes in the azimuthal flow acceleration, associated with the geomagnetic impulse in the Pacific region in around 2016.