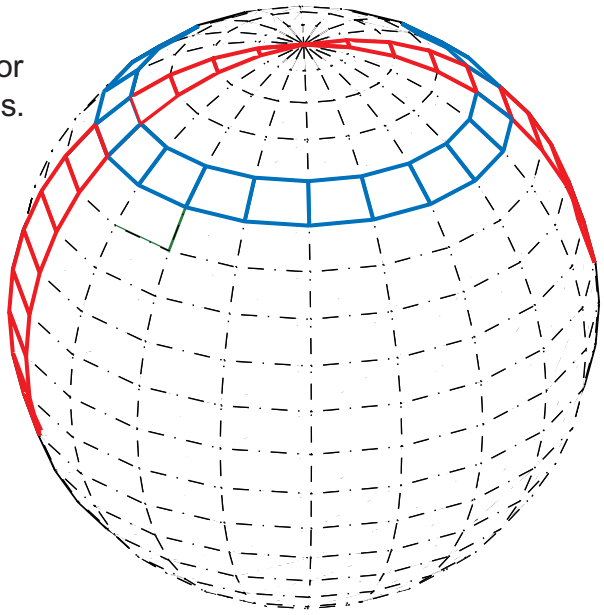
UCIrvine Chemistry-Transport Model: Tracer Advection with Second-Order Moments on a Spherical Grid

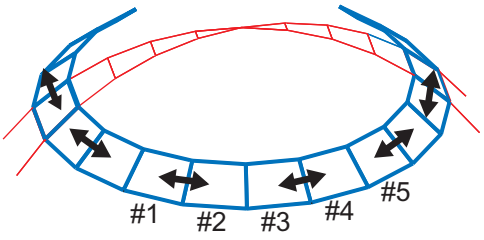
(OpenMP, vectorized version 5.0, Apr 2003)

Both **U** and **V** advection are calculated separately for continuous 360-degree latitudinal & meridional rings.

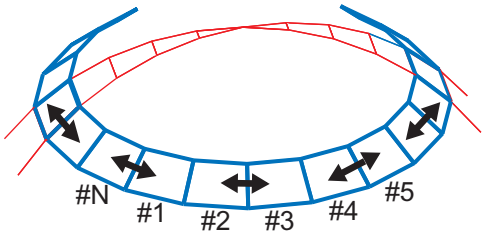


All advection (U, V & W) is calculated on a continuous loop with an even number of boxes.
The advection step is two-part to avoid dependencies and allow for large vector ops.
(1) all the even boundaries (i.e., between boxes 1 & 2, 3 & 4) are calculated, then
(2) all the odd boundaries (i.e. between 2 & 3, 4 & 5, N & 1) are calculated.

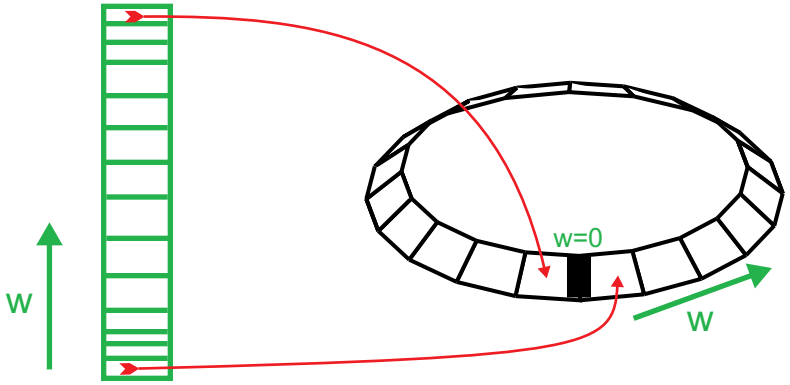
(1)



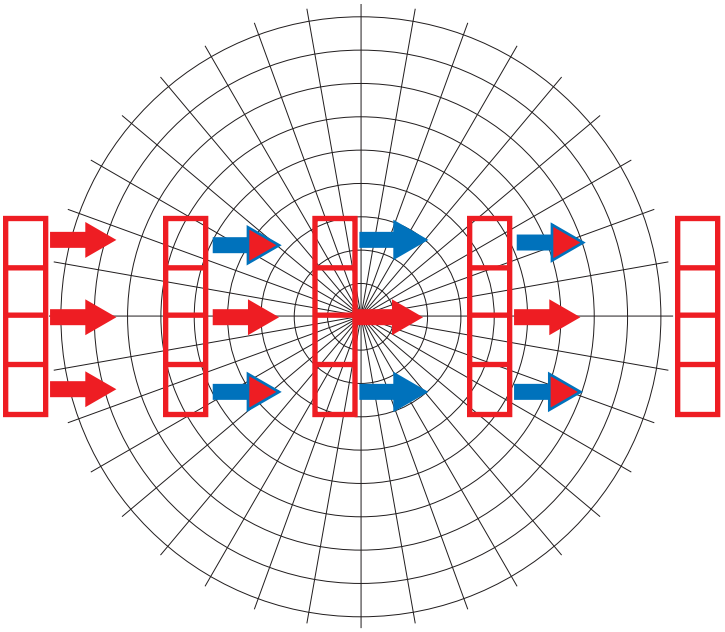
(2)



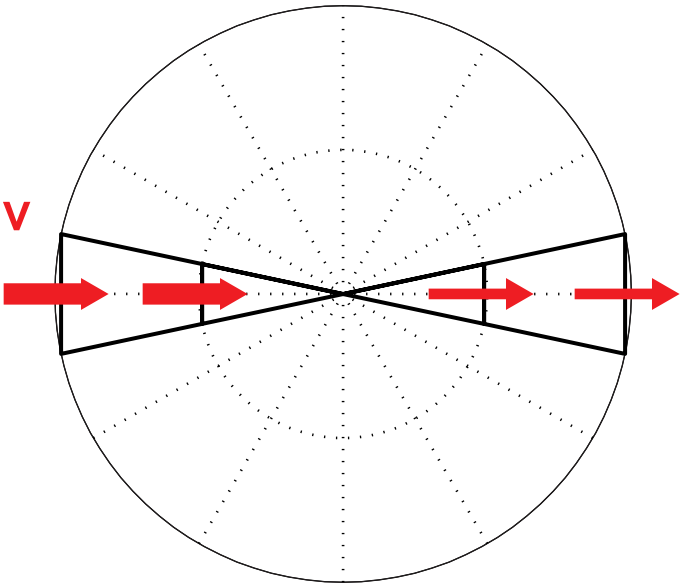
Vertical advection (W) is calculated by joing the top & bottom boxes with W=0 between. If longer vectors are needed then several columns of boxes from adjacent geographic grids can be stacked (W=0 between)

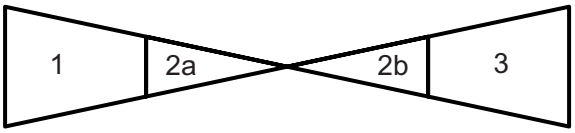


Tracer advection across a polar grid presents a very difficult numerical problem: that of preserving the shape of the tracer distribution as the flow shifts direction (e.g., from **V** to **U**) and the original grid boxes expand across many polar boxes.

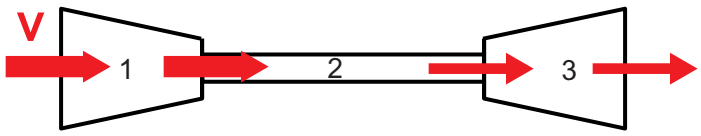


Meridional flow (V) over the pole assumes that the two opposite, pie-shaped polar sections 2a & 2b are combined into a single box 2, *preserving all second-order moments including the V-moments*. The V advection is calculated as a meridional belt over both poles. After this step, the moments in box 2 are used to split it back into two equal boxes 2a & 2b. In general, this pair will be too large(small) compared with the expected air mass and an inferred U-flow within the polar cap is then calculated as for any latitude belt. The W-flow, needed to infer the U-flow, is assumed to be uniform over the polar cap and is calculated from the integrated convergence of V into the polar cap.

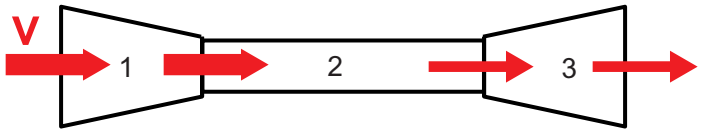




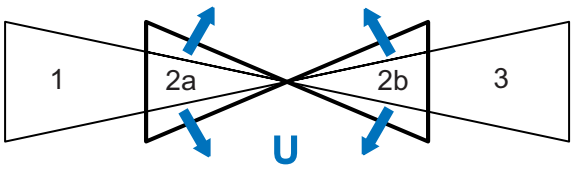
Combine polar pie-wedges



Advect tracer and air



Split into equal polar pie-wedges



Advect in U to offset convergence

Solid body rotation (2-D) on a polar grid with the UCI CTM versions 3.3 and 5.0.
A 6x6 block of tracer with mixing ratio 100 on a background of 0 (thick rectangle) is advected for one full rotation with the flow at an angle of 30, 80 and 90 degrees relative to the equator. The second-order moments algorithm used limiter 2 (positive monotonic). The new CTM 5.0 algorithm has different ordering due to vectorization (i.e., 30 deg) and greatly improved over-the-pole transport (i.e., 80 and 90 deg).