

## Converting winds from map coordinates to earth coordinates

Because a map projection is a flattened version of the earth which distorts geometry, its coordinate system is different than true north, south, east, and west. This impacts the values of wind vector components  $u$  and  $v$  in numerical models.

To convert from map coordinates to earth coordinates for  $u$  and  $v$  (sometimes called “wind rotation”), the following equations are used:

$$u = -v_{map} \sin \alpha + u_{map} \cos \alpha$$

$$v = v_{map} \cos \alpha + u_{map} \sin \alpha$$

where  $\alpha$  is the angle between the map wind vector and true earth wind vector.  $\alpha$  is determined from the map projection equations, and usually provided by a subroutine.  $\alpha$  is smallest near the center of the model grid and becomes larger away from the center.

It is common for numerical models to only output the map projection wind vectors. Since observations are relative to earth coordinates, the conversion is necessary when comparing to observations. The above equations are easy to implement, but obtaining  $\alpha$  sometimes is challenging. There are three ways to learn how to compute  $\alpha$ : 1) check the model documentation; 2) look for a subroutine with the terms “rotate” and “winds”; or 3) contact one of the model developers.

To convert winds from earth coordinates to map coordinates, the following equations are used:

$$u_{map} = v \sin \alpha + u \cos \alpha$$

$$v_{map} = v \cos \alpha - u \sin \alpha$$

As always, make sure  $\alpha$  is in radians before doing the computations.