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Short Note
Correcting GIS-based slope aspect calculations for the Polar Regions

GEOFF J.M. MORET and AUDREY D. HUERTA

Department of Geosciences, Penn State University, University Park, PA 16802, USA
gmoret@geosoc.psu.edu

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Introduction

Slope aspect is an important geomorphic parameter. The aspect of a slope controls its solar irradiation, thus affecting a wide diversity of processes (for a partial review see Moore *et al.* 1991). Slope aspect can be calculated from a digital elevation model using one of several GIS-based algorithms (e.g. Moore *et al*. 1991, Burrough & McDonnell 1998). These algorithms are designed for mid-latitude regions, calculating slope aspect as an angle relative to grid north. In polar regions, however, this approach suffers from two problems:

1. In the commonly-used polar stereographic projections, grid north is parallel to either the prime meridian (for the south pole) or the meridian at 180° (for the north pole) while geographic north varies with longitude.
2. In the polar regions, the direction of geographic north can vary significantly over a relatively small area.

As a result, GIS-based slope aspect calculations do not give correct values when using polar projections.

The method we present here provides a simple technique for correcting GIS-calculated slope aspect to determine the true, geographic slope aspect. This technique is critical for work using slope aspect in the polar regions.

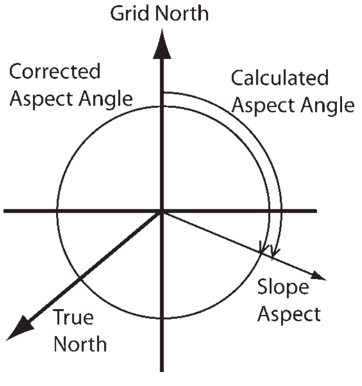

Fig. 1. Diagram demonstrating the problem with GIS-based aspect calculations. Grid north, which runs parallel to the prime meridian (0°), can be far from geographic north (in this case, -140°). Thus, the calculated slope aspect (in this case, 110°) can be far from the true slope aspect (250°).

Aspect correction

To obtain a corrected slope aspect map, we must subtract each grid cell's longitude from the GIS-calculated aspect (Fig. 1). In the South Pole Stereographic Projection (see Snyder 1987, p. 154) the longitude, λ, of a data point in this projection is independent of the ellipsoid used and is given

$$\lambda = \arctan\left(\frac{x}{y}\right)$$

where the four-quadrant arctangent is used. In this equation x and y are the coordinates of the data point after the removal of false easting and false northing (i.e., when the coordinates of the pole are 0,0). In the North Pole Stereographic Projection, the longitude is given by

$$\lambda = \arctan\left(\frac{x}{-y}\right).$$

ESRI states that incorrect slope aspects in the polar regions represent "a known limit for our software" (personal communications, ESRI support, February 2006). Thus, we have written a Matlab function (Appendix A) to convert the ESRI-determined slope aspect into slope aspects that are referenced to geographic north. This function uses the GIS-calculated aspect data, the grid spacing, and the (x,y) coordinates of the lower left-hand corner of the grid as inputs. The data can be transferred between ArcGIS and Matlab in the form of ASCII files.

The Matlab function (Appendix A) allows the user to choose output ranges of 0° to 360° or -180° to 180°. The code also addresses the two special cases of 1) grid cells that do not have an elevation in the DEM ("NoData" cells in ArcGIS), and 2) cells that are flat, and thus have no aspect. By convention, the "NoData" cells are set to a value of -9999 and the flat cells are set to a value of -1. If the user chooses an output range of -180° to 180° the flat cells are set to a value of 9999.

Acknowledgements

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References

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Moore, I.D., Grayson, R.B. & Ladson, A.R. 1991. Digital Terrain Modelling: a review of hydrological, geomorphological, and biological applications. *Hydrological Processes*, **5**, 3–30.

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Appendix A: Matlab Function

```
function newdata=trueaspect(data,dx,xll,yll,hemi,range);
%TRUEASPECT corrects slope aspect data so that angles
are relative to
%geographic north instead of grid north. The inputs are:
%data: a matrix of slope aspect data, with NoData cells set
to -9999 and
%cells without an aspect set to -1
%dx: the cell size
%xll: The x-coordinate of the lower left hand grid cell. This
should be in
%a polar stereographic projection, with false easting
removed.
%yll: The y-coordinate of the lower left hand grid cell. This
should be in
%a polar stereographic projection, with false northing
removed.
%hemi: Use hemi = 1 for the south pole and hemi = 2 for the
north pole.
%range: If range = 1, the output values will be between 0
and 360 degrees.
%If range has any other value, they will be between -180
and +180 degrees.
[nrows,ncols]=size(data);
for m=1:nrows
    for n=1:ncols
        if data(m,n)==-1
            data(m,n)=9999;
        end
    end
end
x=xll+[0:(ncols-1)]*dx;
y=yll+[0:(nrows-1)]*dx;
newdata=zeros(nrows,ncols);
for i=1:nrows
    for j=1:ncols
        if hemi==1
            lon=atan2(x(j),y(i))*180/pi;
        elseif hemi==2
            lon=atan2(x(j),-1*y(i))*180/pi;
        else
            error('hemi must be 1 or 2')
        end
        newdata(i,j)=data(i,j)-lon;
        if newdata(i,j)<-1000
            newdata(i,j)=-9999;
        elseif newdata(i,j) >1000
            if range==1
                newdata(i,j)=-1;
            else
                newdata(i,j)=9999;
            end
        elseif newdata(i,j)<0
            newdata(i,j)=newdata(i,j)+360;
        elseif newdata(i,j)>360
            newdata(i,j)=newdata(i,j)-360;
        end
        if and(range~=1,newdata(i,j)>180)
            newdata(i,j)=newdata(i,j)-360;
        end
    end
end
```

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