7.1 DERIVATION OF FACET GRIDS FOR USE WITH THE PRISM MODEL

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PRISM (Parameter-elevation Regressions on Independent Slopes Model) is an analytical model that uses point data and a digital elevation model (DEM) to generate gridded estimates of monthly and annual climate (Daly et. al. 1994). PRISM is uniquely suited to regions with mountainous terrain, because it incorporates a conceptual framework that allows the spatial scale and pattern of orographic processes to be quantified and generalized.

In the case of precipitation, primary effect of orography on a given mountain slope face is to cause precipitation vary strongly with elevation. Orographic effects typically operate at large spatial scales, responding to smoothed topographic features rather than detailed variations in terrain. A landscape can be divided into a mosaic of topographic faces, or "facets", each assumed to experience a different orographic regime. It is the derivation of facet orientations on smoothed and unsmoothed DEMs that are of interest in this paper.

In complex terrain, it is apparent that simplification of facet grids is not a trivial matter. If it were, then less than a user-defined constant, then the cell is considered flat. Otherwise, an orientation is assigned based on an 8 point compass (NNW, NNE, ..., etc.).

2) A distribution of orientations is then created for the single cell by calculating the orientations of all neighboring cells within a user-specified radius.

3) The frequency distribution of those bins are simplified using a set of 15 rules, as illustrated in Figure 1. The rule that best matches the distribution is used to assign an orientation to that single facet grid cell.

4) The process is repeated for every grid cell in the domain.

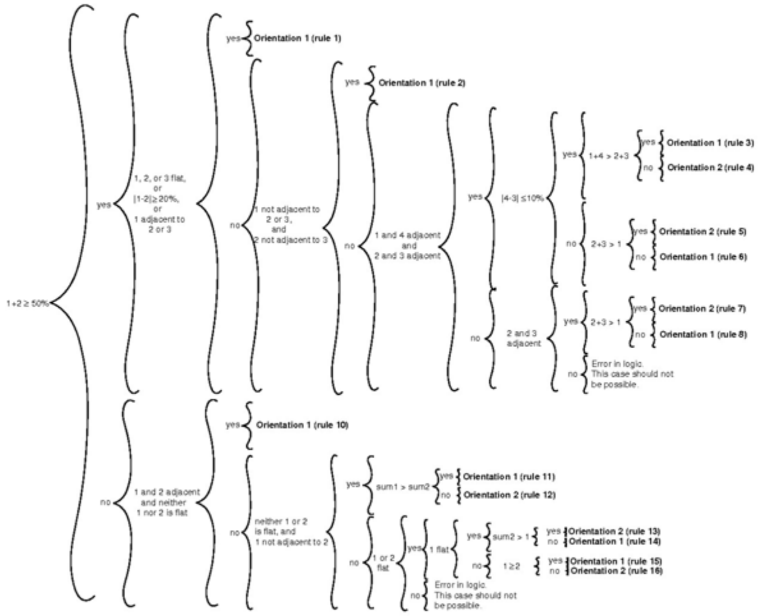
The grid cell facets can be derived from the original DEM or from a DEM that has been smoothed at a variety of scales. PRISM uses facet grids derived from DEMs smoothed at six different scales, choosing more detailed facet grids when data density is high and more generalized representations where data are sparse.

It was hypothesized that most of the facet distributions would be fairly easy to characterize with some basic rules, and more a vector average of the east-west and north-south components would yield averaged vector components from which orientations could be calculated. A simple test using complex terrain demonstrates that vector solutions produce unacceptable results, such as anomalous linear facets centered along ridge lines and valley bottoms. The approach described in this paper can be broken into 4 basic steps : 1) calculate a single grid cell orientation, 2) generate a distribution of orientations for neighboring cells, 3) apply a set of rules to find the best orientation for the given distribution, and 4) repeat the process for every grid cell in the domain. Each of the steps is now discussed in further detail.

1) An orientation for a single grid cell is computed from the 4 adjacent cells in the north-south and east-west direction. Assuming a Cartesian coordinate system, the east-west gradient is calculated as a difference in elevation between the adjacent cells to the east (i+1,j) and to the west

(i-1,j). Similarly, the north-south gradient is the difference between the adjacent cells to the north (i,j+1) and to the south (i,j-1). If both gradients are

complex decision trees would be required for less obvious distributions. From this supposition, a set of 15 rules was created. It was apparent that most of the orientations could be found in 3 or fewer bins, and the 2 dominant orientations generally accounted for 50% or more of the distribution. The set of rules was divided based on whether the orientations for the two dominant frequencies accounted for 50% or more of the distribution. Each decision tree was further divided into additional branches, with more complex decisions required for more complex frequency distributions. For example, if the 2 highest frequencies account for more than 50% of the frequency distribution, the highest frequency of orientation is NNW and the next 2 highest frequencies are WNW and NNE, then it would be reasonable to assign an orientation of NNW to that cell. Obviously the logic for such a case is rather simple and intuitive. Another case might be one for which SSE accounts for 40%, ESE 16%, ENE 22%, and NNE 18%, with the remainder of the orientations distributed evenly. Referring to Figure



Notes : The numbers like 1, 2, ... represent the orientation with the highest frequency of occurrence, the 2nd highest ...
|1-2| represents the absolute value of the difference in frequencies for orientations 1 vs 2
sum1=max(1+orientation left, 1+ orientation right)
sum2=max(2 +orientation left, 2+ orientation right)

Figure 1. Algorithm for Determination of Facet Orientations

1, this case corresponds to rule 3. This distribution is one in which the dominant orientations are fairly clustered but the frequency of the dominant orientation is higher than those of the next 3 orientations. As expected, facet grids from more highly smoothed DEMs yield larger clusters of similar facet orientations.

The logic illustrated in Figure 1 may seem fairly convoluted. However, tests over a 3 year period at resolutions of 500 m to 80 km have shown the algorithms to be fairly robust. The grids also make intuitive sense when evaluated subjectively.
The primary motivation for development of a faceting algorithm was to simplify facets for complex terrain at a variety of scales. Without such smoothing and simplification of facets, the very complicated topography in products by the scientific community following extensive reviews clearly demonstrates the viability of the faceting scheme in simplification of topographic facets.

Reference

Daly, C., R. P. Neilson, and D. L. Phillips, 1994: A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountainous Terrain. *J. Appl. Meteor.*, **33**, 140-158

regions like the western U.S. would lead to very complex precipitation distributions which are not evident in observed data. The acceptance of PRISM-generated map