

BLENDING WORLD MAP PROJECTIONS

JENNY B.(1), PATTERSON T.(2), HURNI L.(1)

(1) Institute of Cartography, ZURICH, SWITZERLAND ; (2) US National Park Service, HARPERS FERRY, WV, UNITED STATES

ABSTRACT

The idea of combining existing map projections to create new projections has been applied in the past by various authors. Many of the commonly used world map projections are such hybrid projections, for example, the Goode Homolosine projection or the Winkel Tripel projection. This paper discusses three digital methods for blending existing projections to create new projections for world maps at small scales. The three methods are implemented in Flex Projector, a software application specifically designed for the creation and evaluation of new world maps projections.

INTRODUCTION: VISUAL DESIGN OF WORLD MAP PROJECTIONS

The most comprehensive collection of map projections lists more than 300 varieties (Anderson, s.d.). Despite this plethora of available projections, the reader of world atlases will only encounter a very limited number of projections in common use for small-scale world maps. Typically these are Eckert IV, Goode Homolosine, Mercator, Miller Cylindrical, Mollweide, Robinson, Winkel Tripel and a limited number of other small-scale world projections (Bugayevskiy and Snyder, 1995, p. 243). A variety of reasons exist for this lack of diversity. For example, many projections are designed for large and medium-scale maps, not small-scale world maps. Also, some projections were only created for purely mathematical reasons and never intended for everyday mapmaking. Some projections are too whimsical or uncommon in graphical appearance to be used in small-scale mapping, or are too similar to other projections. Finally, personal taste is also a major selection criterion; a cartographer may or may not like an otherwise appropriate projection favored by others. These are some of the reasons why the number of available projections for making world maps for general audiences is small.

The design of new map projections has thus far required mathematical and cartographic expertise, and has therefore been reserved to a small group of specialists. There exists, however, a complementary visual approach for the definition of map projections, where graticules are defined in a graphical, non-mathematical way. This hitherto seldom-used approach was pioneered by Arthur Robinson in 1961, while commissioned by the Rand McNally publishing house to create a world map projection (Robinson, 1974). Robinson proceeded through an iterative process to create his pseudocylindrical projection, graphically evaluating the appearance and relative relationships of landmasses. He first estimated the values for parallel lengths and spacing, then 'the projection was drawn and the continents plotted. Less than satisfactory relationships appeared, of course, and compensating adjustments were made [...], a new projection derived and the continents again plotted. This iterative process, a sort of graphic successive approximation, was repeated until it became obvious that further adjustments would produce no improvement, at least to the eyes of the author' (Robinson, 1974, p. 151-152).

With Robinson's manual-visual approach, the design of equal-area projection would be extremely tedious. Yet, world map projections are typically intermediate projections that are neither conformal nor equal-area. Indeed, as Frank Canters (2002, p. 57) writes: '[...] cartographers have always agreed that conformal projections are not suited for world maps. This has not been the case for equal-area projections. On the contrary, the equal-area property has for a long time been considered as the most important property for world maps, especially for the mapping of statistical data. [...] More recently, map projections with intermediate distortion characteristics (neither conformal, nor equal-area) have become increasingly popular for global mapping purposes. Because these maps have more balanced patterns of distortion than equal-area graticules, the shape of large areas is better preserved.' Accordingly, Robinson's intermediate projection was very well received by cartographers and widely used, for example by the National Geographic Society (Garver, 1988).

FLEX PROJECTOR

Robinson's visual method has been brought to the digital realm, resulting in Flex Projector, a software application that can adjust the length of parallels and their distance from the equator via a graphical user interface. Robinson's approach has been extended with the option to bend parallels and to adjust the distance between meridians. The goal of this graphical method is to make the design of world map projections approachable for those without expert knowledge in mathematics. Upon opening Flex

Projector, the user sees a graphic user interface comprised of three components (Figure 1). The panel in the upper left is a world map in the Robinson projection. To the right of the map is the panel with sliders that control the shape of the projection, and which invite the user to experiment. Moving any of the sliders results in an immediate change to the Robinson projection, which then ceases to be a Robinson projection and starts on its way to becoming an entirely new projection. Below the map is the Distortion Table, which reports in real-time the amount of distortion contained in the modified projection, including comparisons to common world map projections.

The heart of Flex Projector are the sliders in four panels for adjusting (1) the length of parallels (see the panel on the right border of Figure 1), (2) the distances of parallels from the equator, (3) the convex or concave bending of parallels, and (4) the distribution of meridians. The Linked Sliders option at the bottom of Figure 1 allows the movement of multiple sliders simultaneously. Increasing the number of linked sliders generally produces projections with smoother, more uniform shapes. An additional slider on the top of the same panel, the Proportions slider, offers a quick method to alter the height-to-width ratio of a projection.

With the basic controls described above a user can adjust a projection to an almost infinite variety of shapes, including adjusting the position of central meridian to any longitude. However, it is not possible to design every type of projection. Flex Projector is limited to map projections that show the entire world, have an equatorial aspect (the latitude of origin is always the equator), that are symmetrical relative to the central meridian and the equator, and uninterrupted. All projections designed in Flex Projector use a spherical earth model. A more complicated ellipsoidal model would not significantly enhance the geometry of small-scale world maps of the type that Flex Projector was conceived to create.

Jenny et al. (2007; 2008) provide an overview of the functionality and interface of this cross-platform and open-source application from a user's point of view; and Jenny et al. (2010) detail the mathematics and algorithms that convert user settings to formulae for projecting digital data. Flex Projector can be downloaded from www.flexprojector.com. This article introduces methods for blending projections, allowing the user to selectively combine properties of two projections. This is a new tool in Flex Projector that further simplifies the creation of new projections for world maps.

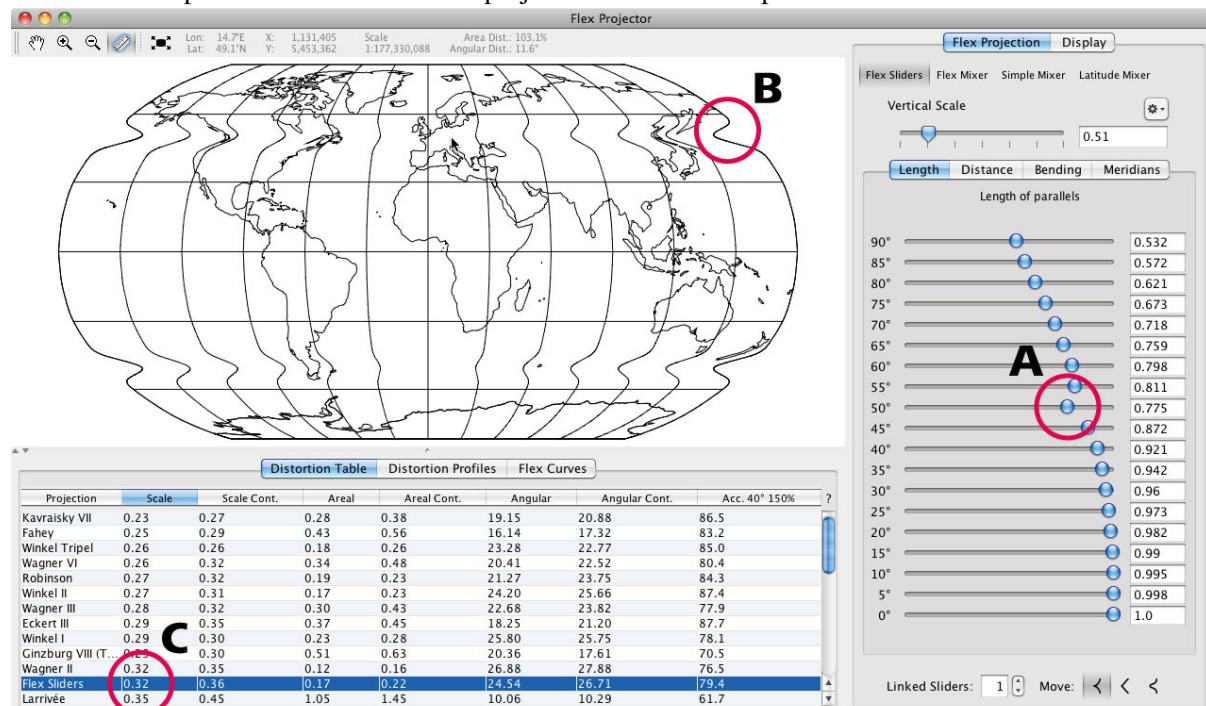


Figure 1. Screenshot of Flex Projector: Moving the sliders controlling the length of parallels for every 5 degrees (A) changes the projection (B) and the projection ranking (C)

THREE METHODS FOR BLENDING PROJECTIONS

The latest version of Flex Projector currently offers three options for combining projections to create non-interrupted blended world map projections:

1. Non-continuous combinations of projections: Non-continuous combinations of projections fuse two map projections along a parallel. This results in new pseudocylindrical or cylindrical projections. An example

of such a projection created in the past is the Goode Homolosine, which is mainly used in its interrupted form. It combines Sanson's sinusoidal projection and the Mollweide projection.

2. Arithmetic means of projections: This projection family is composed of projections that are defined by a weighted arithmetic mean of two projections. In the past, this method was used, for example, by Eckert, Winkel and Putnin to create some of their projections.

3. The Flex Projector Mixer: This is a new type of projection blending allowing the designer of a new projection to combine specific characteristics of two existing projections, such as the bending of parallels or the distribution of meridians and parallels. For this approach, existing projections are first approximated by a generic mathematical expression. This expression separates the mathematical description of four geometrical characteristics: the length of meridians, the vertical distribution of parallels, the bending of parallels, and the horizontal distribution of meridians. The author of a new projection can then selectively blend these four characteristics of two projections to create a new one (Figure 2).

Flex Projector offers a graphical user interface for all three blending methods, permitting the user to adjust the blending options and providing immediate visual feedback. For a numerical comparison, Flex Projector also computes various distortion indices for the new projection, as well as for a series of existing projections.

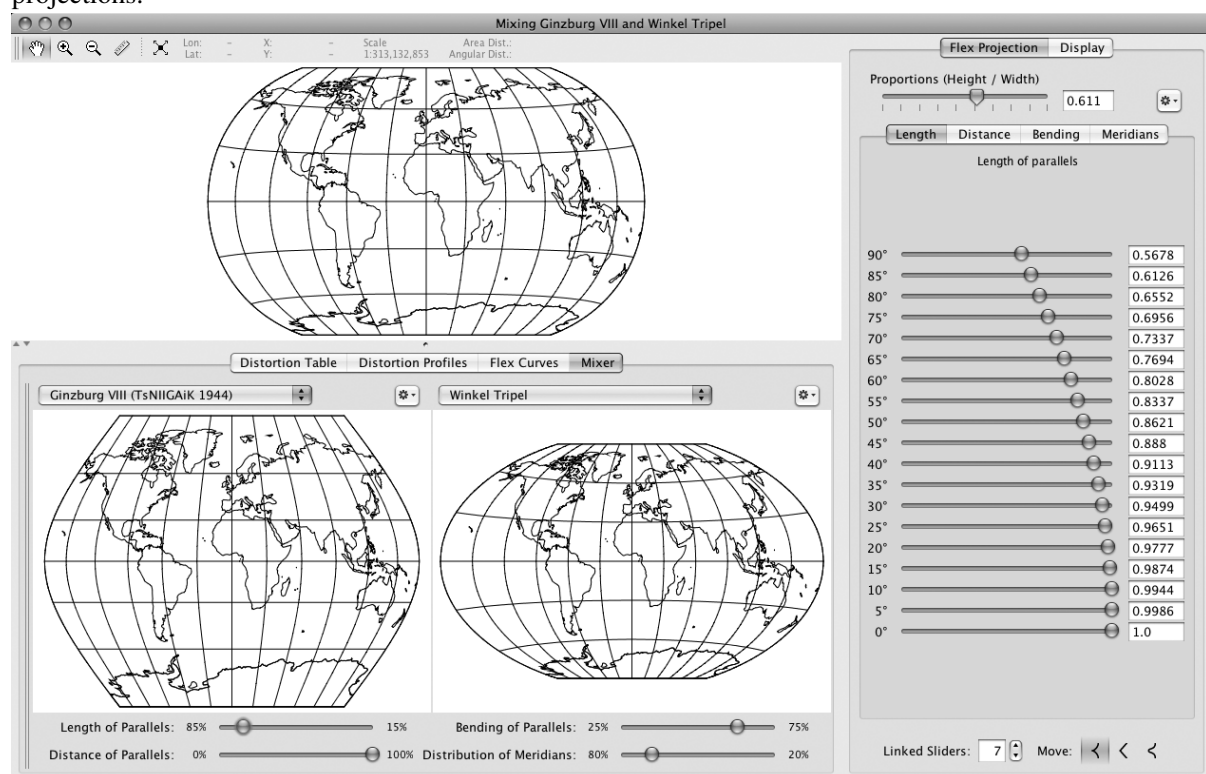


Figure 2. Screenshot of Flex Projector: Blending the Ginzburg VIII (bottom left) and the Winkel Tripel (bottom center) projections. Sliders below these two parent projections control the blending of the four curves that define the new projection above.

CONCLUSION

Flex Projector simplifies the blending of two existing projections to design a new hybrid projection, providing three different methods. If necessary, the blended projection can be fine-tuned further using the graphical user interface for adjusting the curves and other options (as shown on the right of Figure 1).

It is the authors' hope that the various tools in Flex Projector for the design and evaluation of projections for small-scale world maps will lead to a variety of new projections that are aesthetic and have low distortion characteristics. According to Anderson and Tobler (s.d.) 'blended map projections are splendid projections' – we hope that users of Flex Projector come to the same conclusion.

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