Approximated Density Altitude Forecasts for Fire Aviation in the Southwest Area

Air density is perhaps the most important factor affecting aircraft performance, as it directly affects the amount of lift generated by an airfoil. This impacts a number of performance elements critical to fire aviation, including cargo weight capacity, takeoff speed and distance, acceleration and service ceiling. Roughly speaking, Density Altitude (DA) is a correction to geometric altitude (elevation) to account for non-standard atmospheric density.

The main factors impacting atmospheric density are temperature and, to a significantly lesser extent, humidity. The Southwest U.S. is notable for exceptionally high DA values during the warm season, when strong surface heating and high terrain combine to create air densities significantly lower than those which would otherwise be observed at the same elevation in the free atmosphere. As an example, aircraft operating out of the Albuquerque International Airport at around 5300 feet on a day with a temperature of 95°F would experience atmospheric density conditions similar to those at 8900 feet in the free standard atmosphere. Density Altitude values above 9000 feet are common across a significant portion of the Southwest where fire operations are conducted in the summer.

To promote situational awareness of Density Altitude conditions, Southwest Predictive Services will be creating a daily graphical DA forecast map and posting it to the SWCC website. Along with this, a static example of DA conditions during a hot summer day (see Figure 1 below) will be provided to give perspective with regard to peak Density Altitudes which could occur during the Southwest fire season. These estimated values will consider only maximum temperature and elevation as predictors, and are accurate to within 500-750 feet. Threshold values of 5000, 7000 and 9000 feet were chosen for the graphic's color scheme as the transition through these thresholds has been shown to relate to performance issues for aircraft used for fire management. GIS layers of elevation and forecast maximum temperature will be used to figure DA using the calculations and assumptions described on the following page.

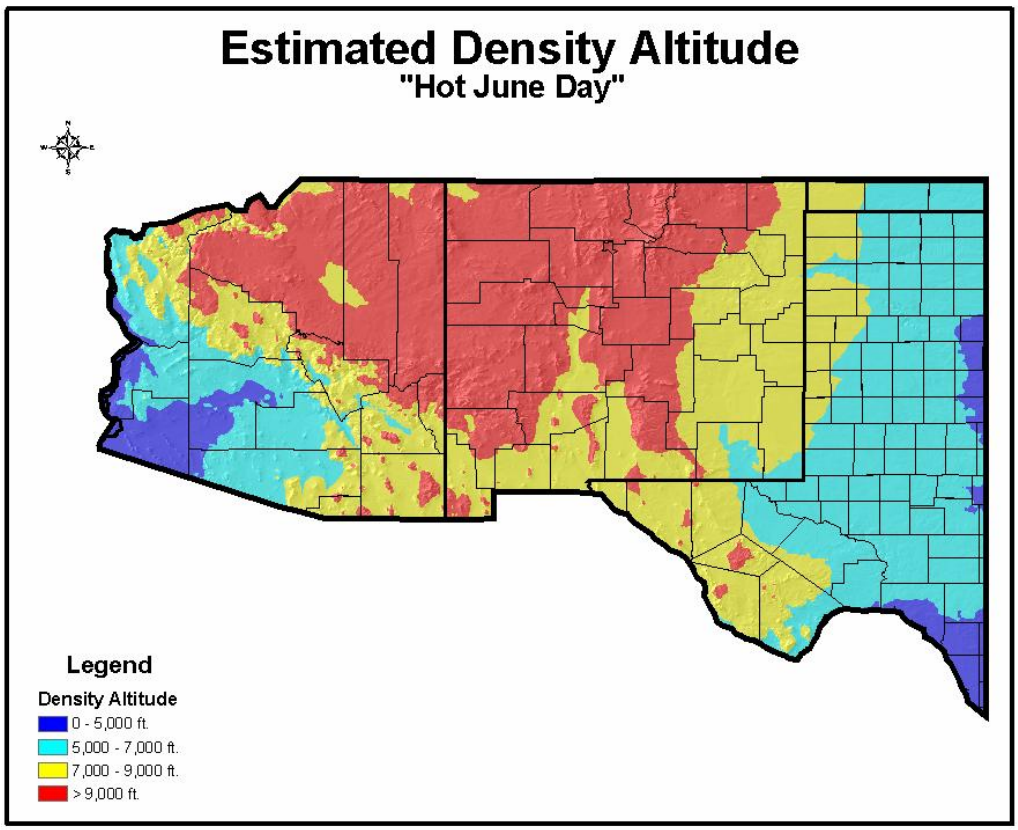

Figure 1 – Estimated Density Altitude using maximum temperatures 10°F above the average June maximum.

Calculation of approximate Density Altitude by Southwest Predictive Services

The following formula for calculating approximate Density Altitude was obtained from the online *Aviation Formulary* (ref. #1) and modified to utilize only station elevation and temperature as inputs. This method does not consider the effect of moisture on air density, which is fairly minimal and not a significant factor in any event during the dry Southwest fire season. Also, station geometric altitude (elevation) is used instead of pressure altitude as day to day changes in atmospheric pressure are an insignificant impact on air density when compared to temperature. Both of these factors combined are within the 500-750 ft. margin of error associated with the calculated values.

DA = SA + 118.6*(T-T_s)

Where:
DA = Density Altitude in feet MSL
SA = Station Altitude in feet MSL for where the DA is being calculated
T = Actual air temperature (° K) at SA
T_s = Standard temperature (° K) at SA

To accept inputs of SA in feet and T in °F and to compute T_s without additional inputs, the formula converts to the following:

DA = SA + 118.6*[((5/9)*(T-32)) + 273) – (288.15 - .0019812 * SA)]

Where:

DA = Calculated approximate density altitude in feet above Mean Sea Level (MSL)
SA = Altitude in feet MSL for where the DA is being calculated
T = Air temperature (° F) for where the DA is being calculated
288.15 = Standard temperature at MSL (° K)
.0019812 = Standard decrease in temperature with altitude (° K/ft.)
((5/9)*(T-32)) + 273) = Conversion of air temperature from ° F to ° K
(288.15 - .0019812 * SA) = Standard atmosphere temperature (° K) at elevation SA

Example: Computation for location at 5300 feet with projected max temperature of 95°F

DA = **5300** + 118.6*[((5/9)*(**95**-32) + 273) – (288.15 - .0019812 * **5300**)]
DA = 5300 + 118.6*[(308) – (277.64964)]
DA = 5300 + 118.6*[30.35036]
DA = 5300 + 3600 = 8900 feet

Note: To create the graphical outlooks, elevation and max temperature data will be sample at a 5-10km resolution across the entire Southwest and interpolated using an inverse distance weighted interpolation scheme to create a seamless image.

References:

1. Aviation Formulary: http://williams.best.vwh.net/avform.htm
2. Density Altitude Definition: http://en.wikipedia.org/wiki/Density_altitude
3. Verbal communication with USFS Southwest Region Fire Aviation Officer and Aviation Safety Officer