CORRESPONDENCE

Comment on "Climate Change and the Impact of Extreme Temperatures on Aviation"

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In their recent report, Coffel and Horton (Coffel and Horton 2015) present calculations supporting their hypothesis that temperature changes caused by anthropogenic global warming (AGW) may result in aircraft weight restrictions for takeoffs at certain airports. I have recalculated the performance data the authors rely on referencing the Boeing 737–800 Flight Operations Manual (FOM) (Boeing 2013a). The FOM is the Federal Aviation Administration (FAA) certified document relied on by airline pilots and dispatchers for aircraft performance calculations. The document "Airplane Characteristics for Airport Planning" (Boeing 2013b), used by the authors, provides a more general overview of aircraft performance used by airport administrators for general planning purposes. Following my calculations, I reached the conclusion that the authors overstate any possible effects of AGW on takeoff weight restrictions.

For their calculations, the authors use the aircraft's maximum takeoff weight (MTOW), the maximum weight an aircraft is legally allowed to take off at instead of a takeoff weight (TOW) (the actual weight of the aircraft at takeoff) typical of the route segment. The TOW equals the MTOW only on rare long-range flights, full of passengers, where extra fuel is required for regulatory reasons, such as a Boeing 737 flight operating from Hawaii to the continental United States. The authors base their conclusions on an aircraft operating at MTOW on a daily basis and not at a TOW typical for an airline operating a certain aircraft type on a given city pair. Since aircraft never operate near the MTOW out of La Guardia International Airport (LGA) because of the short-haul flights operated out of LGA, an increase in the number of 10 000-lb weight-restricted days becomes a moot point.

The authors claim that "on a cross-country route, the aircraft will need nearly 100% of its 46 000 lb fuel capacity." The authors base their calculations on the assumption that the Boeing 737–800 often takes off with full fuel on a cross-country route. This is an incorrect assumption. For example, consider a departure from runway-length-critical LGA: the farthest domestic airport from LGA that the Boeing 737–800 regularly could fly into (i.e., a "cross-country route") is Los Angeles (LAX) located 2146 nautical miles from LGA. (It is worth noting that the farthest westerly airport from LGA that is currently serviced by a major airline is Denver). Assuming a 60-kt headwind (1 kt = 0.51 m s^{-1}) at 37 000 feet (the mean headwind for the route) (Hering and Borden 1962) and consulting the cruise performance section of the Boeing 737–800 FOM (Boeing 2013a), the total fuel required for the trip is 30 800 lb (25 300 lb trip fuel + 5500 lb reserve). Assuming a worst-case single class configuration of 189 passengers, with each passenger checking one 40-lb bag, results in a TOW of 165.6k lb for the LGA–LAX flight. At this TOW and LGA's 7000-ft runways, the B737–800 only becomes runway length limited once the temperature reaches 31°C (International Standard Atmosphere +16°C). While the authors are correct that in LGA the "1000-lb weight-restriction level is met every day..." it is important to note that this is an MTOW weight restriction (and not the TOW), a weight that the Boeing 737–800 is never

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subjected to when leaving LGA given its modest fuel load. Determining the exact number of days at which an airline may be maximum takeoff or landing weight restricted would require payload information for a statistically significant number of flights operating out of LGA, which is not publically available. The calculations I conducted out of Denver and Phoenix (not shown) follow a similar pattern to the one shown for LGA.

Second, the authors claim that ''aircraft design changes are unlikely to significantly mitigate the weight restriction problem'' and therefore the aircraft manufacturing industry will have considerable difficulty in adapting aircraft designs to meet operational challenges. There are many small improvements that aircraft manufacturers have already made and will continue to make to meet market demands. These improvements include uprated engines (same engine, different fuel control unit), winglets, and flight control gap seals. For example, Boeing recently offered a Short Field Performance (SFP) modification for the 737–800, which, among other things, seals the leading edge slats providing for increased takeoff performance (Boeing 2015). This modification results in an increase of approximately 2000 lb in weight-restricted aircraft compared to the unmodified Boeing 737–800 (Boeing 2013a).

Last, the authors base their calculations on ''maximum takeoff power.'' Boeing also offers an option of ''bump thrust.'' This software modification in the electronic engine control computer offers an additional 1000 lb of thrust on short and/or high runways (Boeing 2011).

While the authors are indeed correct that climate change may have adverse effects on the airline industry through increased tropical storms and snowfall, the effect of increased temperatures on aircraft takeoff performance is considerably less than the authors predict.

REFERENCES

Boeing, 2011: *Boeing 737 Flight Crew Operations Manual*. The Boeing Aircraft Company, 960 pp.

——, 2013a: *Boeing 737 Flight Operations Manual*. The Boeing Aircraft Company, 410 pp.

——, 2013b: *737 Airplane Characteristics for Airport Planning*. The Boeing Aircraft Company, 682 pp.

——, cited 2015: The Boeing Aircraft Company: Boeing 737 Family. [Available online at http://www.boeing.com/boeing/commercial/737family/background.page.]

Coffel, E., and R. Horton, 2015: Climate change and the impact of extreme temperatures on aviation. *Wea. Climate Soc.*, **7**, 94–102, doi:10.1175/WCAS-D-14-00026.1.

Hering, W., and T. Borden, 1962: Diurnal variations in summer wind field over the central United States. *J. Atmos. Sci.*, **19**, 81–86, doi:10.1175/1520-0469(1962)019<0081:DVITSW>2.0.CO;2.