Projected changes in cold hardiness zones over CONUS

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Introduction

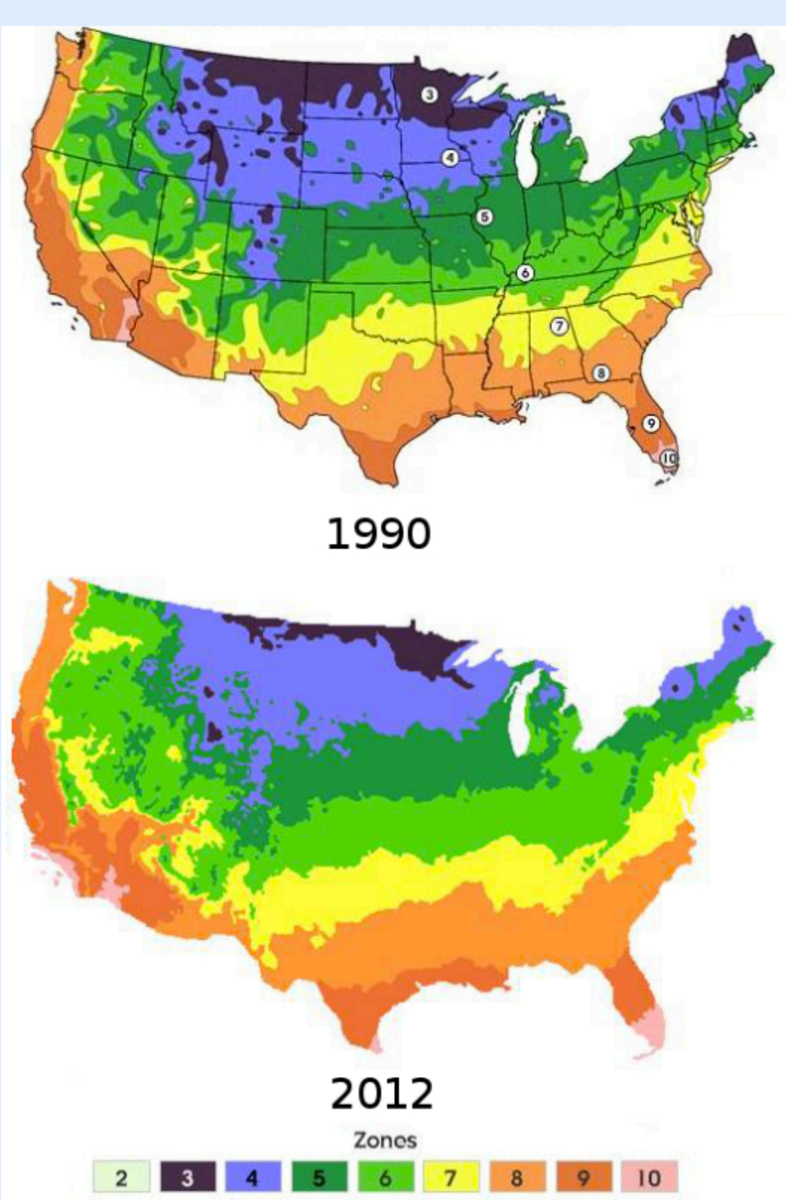
- Cold hardiness is an important factor in the potential distribution and overwinter survival rates of plant species.
- United States Department of Agriculture (USDA) hardiness zones are based on average annual extreme minimum temperatures. Zones range from 1 – 13 and each zone spans ~5.5°C with subdivisions A and B.
- Substantial warming of the coldest nights of the winter under climate change will result in a redistribution of biologically relevant thermoclines.
- Projections of USDA hardiness zones have implications for conventional and alternative crops, native and invasive species distributions and pest-related mortality.

Objective

- Evaluate projected changes in USDA hardiness zones and minimum winter temperatures over the contiguous United States (CONUS), downscaled to locally relevant scales.

Climatological Data and Methods

- Daily minimum temperature from 20 GCMs, statistically downscaled and covering historic (1971-2000) and mid-century (2041-2070) time periods.
- Multi-model means in average coldest daily temperature provide assignment of projected hardiness zones.
- Comparisons between change in coldest night of the winter and change in winter mean minimum temperatures to address differential warming.



Courtesy USDA

Figure 1. Shifts in USDA cold hardiness zones have been recorded over the 20th century. The shifts between the 1990 and 2012 cold hardiness zones may be a function of spatial interpolation methodology and climatological averaging periods (Daly *et al.*, 2012). However, Abatzoglou *et al.* (2014) showed that the coldest night of the year has warmed over the 20th century.

Shifts in Cold Hardiness Zones

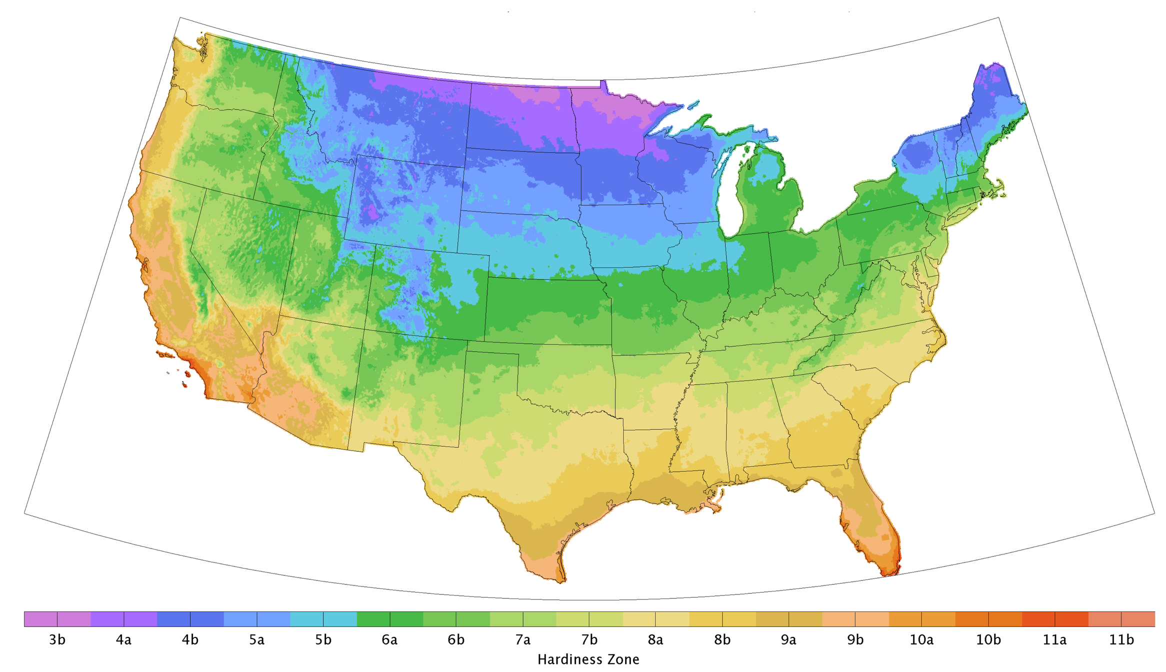


Figure 2. Multi-model mean of cold hardiness zones as defined by the average annual extreme minimum temperature over the period 1971-2000.

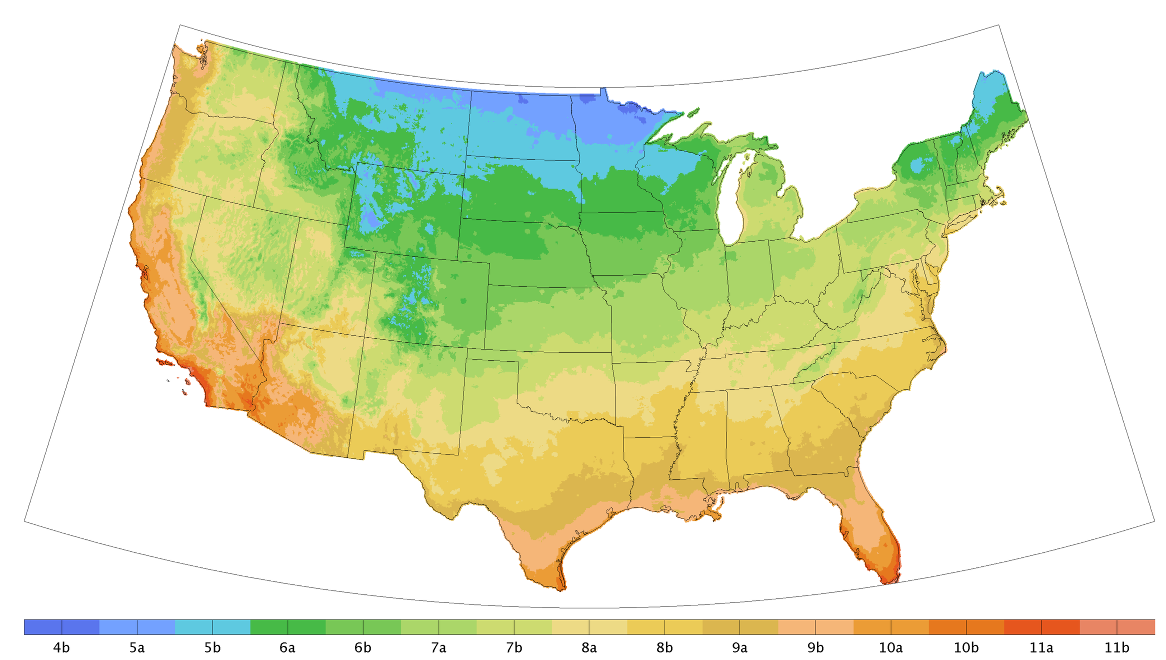


Figure 3. Multi-model mean of cold hardiness zones over the period 2041-2070 shows shifts in hardiness zones over the majority of CONUS.

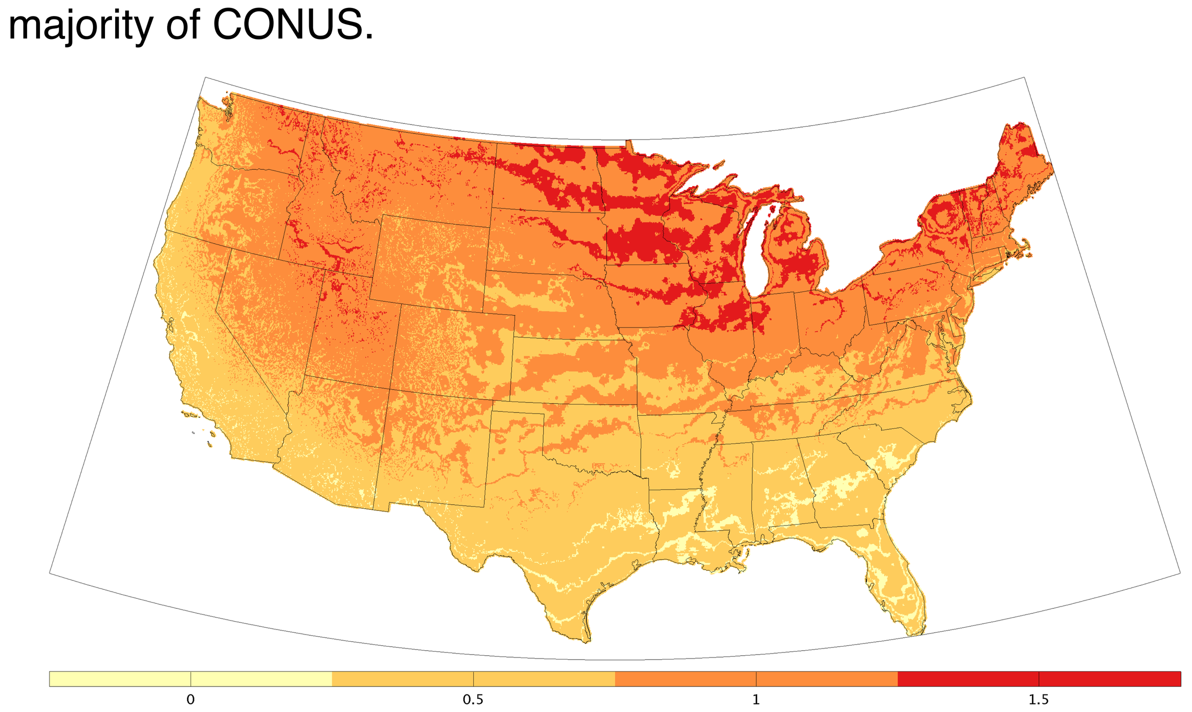


Figure 4. The magnitude of changes in hardiness zones between historic and mid-century periods varies spatially. Generally the largest shifts occur at higher latitude, continental locations. Locations at lower latitude or with maritime influence show less change.

Differential Warming of Extremes vs. Means

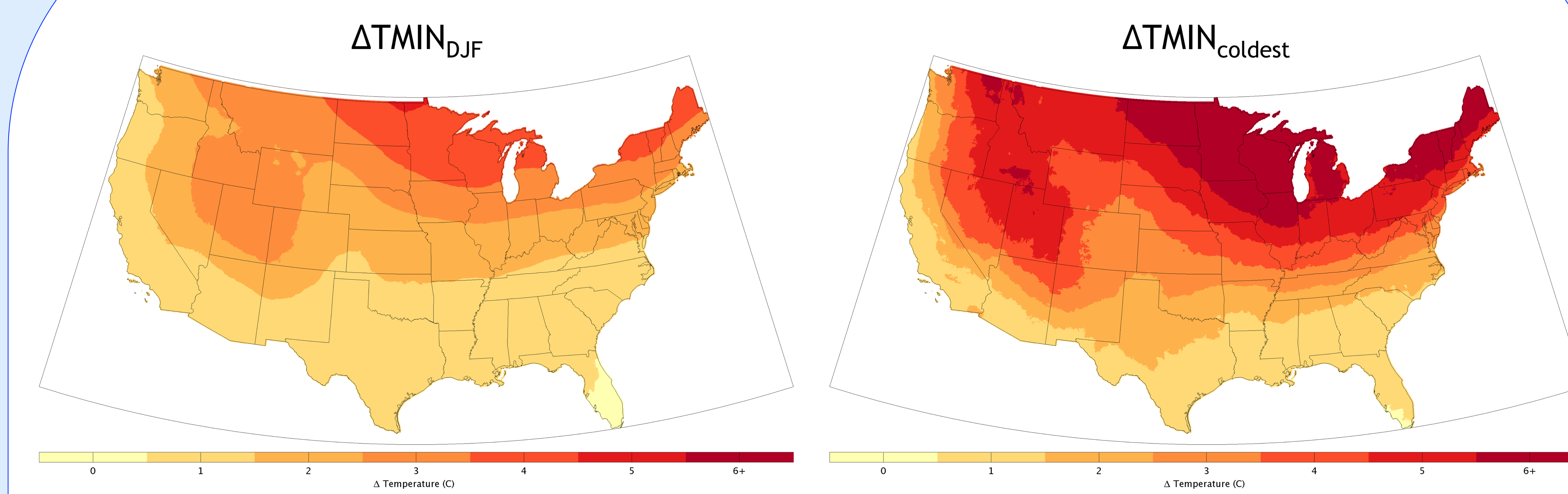


Figure 4. Average winter minimum temperatures (**left**) are projected to warm across CONUS by mid-century, with higher latitudes warming more than lower latitudes. Similarly, average annual extreme minimum temperatures (**right**) are also projected to warm over CONUS, though for the majority of the country the rate of extreme minimum warming will outpace the rate of warming of average winter minimum temperatures.

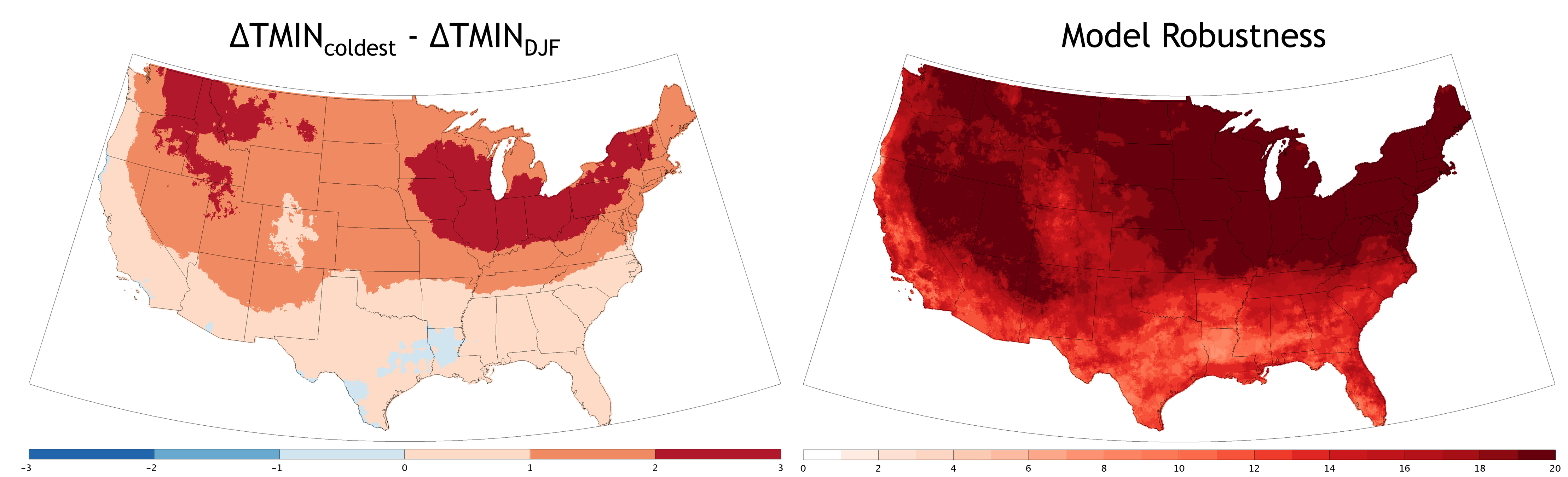


Figure 5. Differential warming (**left**) between average winter minimums and extreme minimum temperatures is greatest across the Upper Midwest and Great Lakes regions, as well as in the Inland Northwest. In small parts of Louisiana and Texas, mean winter temperatures may warm at a greater rate than extremes. These results are robust across models in most locations (**right**). The areas with a larger degree of differential warming are also those regions with strong model agreement.

Conclusions

- Projects increase in minimum winter temperatures (e.g. Abatzoglou and Barbero, 2014) and differential warming underscores importance of examining both extremes and means.
- Difference in warming between mean minima and extreme minima compliment research showing a warming of cold air source regions (e.g. Hankes and Walsh, 2011).
- There may be opportunities under climate change for the production of cultivars in locations that are currently thermally limited.

References:

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Hankes, I. E., & Walsh, J. E. (2011). Characteristics of extreme cold air masses over the North American sub-Arctic. *Journal of Geophysical Research: Atmospheres (1984–2012)*, *116*(D11).

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