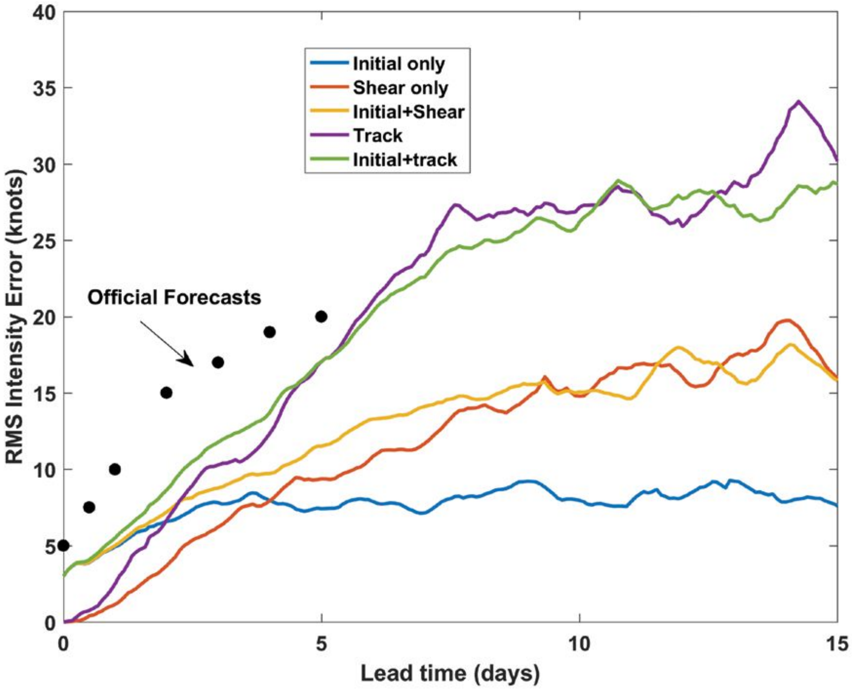


Growth of hurricane wind speed errors (in knots) as a function of forecast time in days. The blue curve shows what happens when the only error is a 3-knot error in the initial hurricane wind speed; the red curve shows errors resulting from errors in forecast wind shear along the hurricane's path; the yellow curve shows what happens when both of the above errors are considered; the purple curve shows errors due only to errors in forecasts of the hurricane's path; and the green curve shows errors due to all of the above. This last, green curve shows our best estimate of what we could do today if our hurricane models were perfect but we still had imperfect measurements and forecasts of large-scale atmospheric conditions. The black dots show current errors in official National Hurricane Center forecasts.

hurricane wind speeds have shown little improvement since records began more than 45 years ago. Why? Our research focused on three sources of error: Inaccurate specification of the initial state of the atmosphere including the hurricane, errors in forecasting the environment through which the hurricane is forecast to move, and errors in forecasting the track of the storm. We assumed that the hurricane model itself is perfect, giving us an estimate of how well we could do if we had better models.

We found that errors in wind speed forecasts out to 3 days are due mostly to incorrect specification of the hurricane itself, including its wind structure and the moisture content of its eyewall. The eyewall moisture is particularly challenging because it is difficult to measure, but we showed that it can be indirectly inferred from careful measurements of the rate of intensification of the hurricane.

Beyond 3 days, intensity errors result mostly from errors in the forecast of the hurricane track and the environment through which it moves.

Our most important result is that there is still a wide gap between the skill with which we could forecast hurricane winds, given the current quality of observations and forecasts of the large-scale atmospheric and oceanic environment, and the actual skill of current forecasts. Thus by improving hurricane models, and the methods by which we incorporate observations into those models, we could make big improvement in hurricane wind forecasts, even if we did not continue to improve observations and forecasts of the hurricane environment. Doing all three might yield greatly improved hurricane forecasts out to 5 days and beyond.—Kerry Emanuel (MIT), and F. Zhang, "Tropical cyclone prediction and predictability: Advances and challenges," presented at the Second Symposium on Multi-scale Atmospheric Predictability, 22-26 January 2017, Seattle, Washington.

Source Attribution of Black Carbon and its Radiative Forcing in China

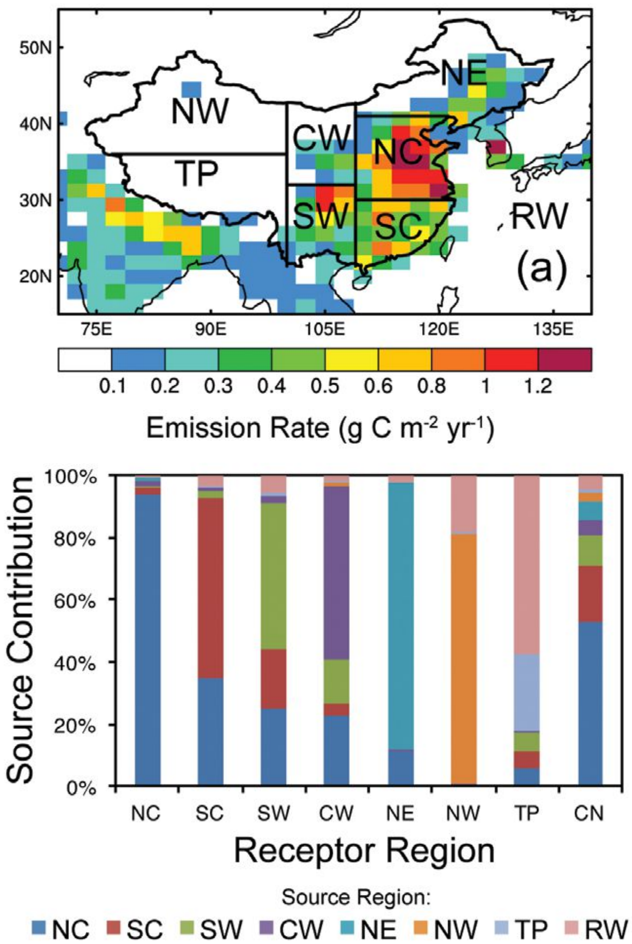
When wood or coal is burned, black carbon (BC, a.k.a. soot) is one of the by-products. Though soot particles can be fine and powdery, they can have a large effect on the environment. Local and nonlocal sources of soot have different influences on radiative forcing—changing the Earth's energy balance—in its destination region. In China, for example, air quality becomes poor because of an increase in tiny atmospheric particles from rapid urban and economic growth in recent years. When more cars hit the road or people use more appliances (powered by coal-generated electricity), more of these particles are released into the atmosphere. But just how much influence these particles from one region have on the air quality of neighboring areas has been uncertain, until now.

Our research used simulations of the Community Earth System Model with emissions for the years 2010–14 and a BC source-tagging technique to quantify the source attribution for mass concentration, haze formation, transport of BC, and its direct radiative forcing in China. They found that in regions with high emissions (e.g., northern and southern China), local emissions predominantly contributed to BC concentrations, while nonlocal emissions more strongly influenced BC over central and western China, which have lower emissions.

The study showed that during polluted days, nonlocal sources played an important role in increasing regional BC concentrations. In the winter haze season, more than 50% of surface BC in China originated from emissions in north China, which contributed more than 90% to local BC and a substantial amount to south, southwest, and central-west China.

The study also showed that local emissions accounted for 65% of BC direct radiative forcing (i.e., atmospheric heating) in China, while emissions from inside and outside China are equally important for BC outflow from East Asia that affects BC over the Pacific Ocean and the western United States. Emissions from China accounted for 8% of BC concentration and 29% of the total air column load of BC in the western United States in spring.

Due to its warming effect in the climate system, BC is potentially important for climate mitigation, and its source attribution is equally important to understand its impacts locally and regionally.—Yang Yang (Pacific Northwest National Laboratory), H. Wang, S. J. Smith, P.-L. Ma, and P. J. Rasch, "Source attribution of black carbon and its direct radiative forcing in China," presented at the 19th Conference on Atmospheric Chemistry, 22-26 January 2017, Seattle, Washington.



Top: **Spatial distribution of BC emissions averaged over the years 2010–14 and the defined source regions (NC: north China, SC: south China, SW: southwest China, CW: central-west China, NE: northeast China, NW: northwest China, TP: Tibetan Plateau, and RW: rest of the world).**

Bottom: **Source attribution of wintertime BC surface concentration in China (CN) and the seven smaller regions.**