

**E.G.:** *Do you think black carbon is having a worse effect today than it might have had during the mid-century, as we are now seeing the effects of climate change?*

**S.K.:** It depends on which effect you're talking about. You've got the effect of atmospheric warming, you have the effect happening with black carbon when it gets deposited on snow and glaciers, and then you also have the health effect of people breathing those aerosols in, which cause a lot of respiratory problems and can be carcinogenic.

Even though concentrations have dropped, everything is compounded by the atmospheric warming that's happening as a result of all the other activities that we're doing.

**E.G.:** *Do you know, globally and regionally, where the highest concentrations of black carbon are, and what is the result?*

**S.K.:** The largest emissions right now are in Asia – in India and eastern China where you have rapidly growing economies and large populations, so that's the largest source. From natural sources, places where you can get a lot of biomass burning like the Siberian forest or the wildfires that we're having in the western part of United States today, those can be big sources also.

If you take the studies done in Asia, the black carbon in the atmosphere ends up absorbing the solar radiation. Some of that energy that would have otherwise made it to the surface doesn't make it there, so there is some indication that black carbon and other pollutants are causing atmospheric warming higher up in the atmosphere, but the surface can actually end up cooling because that energy is getting absorbed higher up.

In the Pacific Northwest, when I first started this work, I had no idea what it was going to look like. What we found so far is that during the wintertime it snows so much in this region that the black carbon ends up being really diluted in the snowpack. As we move into the springtime, we start to get less precipitation and the snowpack starts to melt. Then black carbon ends up either just falling out of the atmosphere and onto the snowpack, or as the snow starts to melt, the black carbon can get trapped on the surface and get consolidated into higher and higher concentrations.

But the highest concentrations are related to when we have wildfire activity. There are only so many areas that still have snow when the wildfire season is happening, and so more high-elevation snowpacks on the glaciers is where those fire emissions are going to end up.

**E.G.:** *As you know, 2012 and 2013 were the worst fire seasons on record for the Pacific Northwest. What kind of impact did that have, and do you know what the impact might be if we continue to see more than a million acres go up in flames every fire season in this region?*

**S.K.:** From the work I did on the Olympic Peninsula, we saw that there was a fire out there that ended up resulting in a deposition on Mount Olympus, and the work that we've done indicates that fire would have accelerated melt on those glaciers somewhere on the order of two to four times higher than if you didn't have



*Susan Kaspari, professor at Central Washington University, collects samples in a snow pit on Table Mountain, located on the north side of the Columbia River in Washington. The area was burned during a fire in 2012.*

PHOTO BY CHRISTI TURNER

wildfires. So from the perspective of how quickly our snowpack and our glaciers melt, it's something that we should definitely be paying attention to.

**E.G.:** *Tell me a little bit more about the research you've been conducting in the Cascades. What kinds of things have you discovered that may have been a surprise to you or that people should take into account because it could be a warning sign of trouble ahead?*

**S.K.:** I thought that we were going to see the highest concentrations associated with human activity, and we have more work to do to geochemically trace where all the black carbon is coming from, but in the case of what we did on Mount Olympus, we know that it's from fire.

When we compare what we saw with one active forest fire, concentrations were way higher than what we were naturally seeing just build up on the glacier during the summertime. So the wildfire story is really important around here.

Black carbon is not the only thing that's getting deposited on the glaciers. You get dust, and some of that dust is coming from natural sources and some dust is being emitted in increased concentrations because of land use change, agriculture and that sort of thing, and then there is also a lot of organic matter that gets deposited on the glaciers.

**E.G.:** *Is black carbon the worst of the three or is that something you're still looking into?*

**S.K.:** In terms of how much energy it absorbs, definitely, black carbon is way more absorptive than either organic matter or dust. Where it gets complicated is that

there is way more dust than there is black carbon, so you have to take into account both the properties and how much is actually getting deposited, but defining properties of dust is not that easy to do.

**E.G.:** *What are some of the things we don't know about yet that you would like to figure out or see someone else figure out?*

**S.K.:** Ultimately the question comes down to: If this is affecting climate or if it's affecting water resources, what can we do

to mitigate it? But there are enough uncertainties right now in terms of being able to ask, "Is black carbon really contributing that much to the melt, or is there so much dust naturally in the environment that the black carbon isn't really adding that much more to it?"

**E.G.:** *So in the Northwest, it sounds like most of the black carbon is coming from fire. Where is all the dust coming from?*

**S.K.:** If you go on any mountain you have some rocky outcrops but some of it is agricultural. In Washington most of the agricultural land is on the east side, where it's drier, but sometimes when the wind changes direction you can end up with dust that can move back toward the west where the mountains are. Roads that exist in the mountains can be a big source. Some of it is definitely natural, and then some of it's the amount of dust that being put into the atmosphere that is increasing as we continue to modify the landscape.

**E.G.:** *What hypothesis are you working on with your next project examining the linkage between wildfires and accelerated snowmelt?*

**S.K.:** We know that we're left with these

charred stands of trees that are basically just snags covered with this black material after a wildfire. My simple hypothesis is that those trees are acting as a source of black carbon to the snowmelt post wildfire. And then within that, the questions I'm wanting to ask are: How large of a scale is that effect? And how does that effect vary with burn severity or the age of the burn? We've done sampling over the last couple winters, after that 2012 Table Mountain fire burn. The past two springs I've gone up and made some measurements within that burn area, but this past fall we also had the Snag Canyon fire, which was also near my university. This spring we'll be doing fieldwork comparing the amount of black carbon deposited on the snowpack in that 2012 fire, the 2014 fire and some other fires that are a little bit older.

**E.G.:** *You're the expert on black carbon. What's important? What should people know about?*

**S.K.:** I think more people are hearing about black carbon, but they haven't really known what it is. And now people recognize in the climate community that black carbon is second only to carbon dioxide in terms of what it's doing for warming, but compared to cleaning up greenhouse gases it's a lot easier to be able to reduce black carbon emissions. I don't want you to leave thinking forest fires are the only concern around here, because that's not the case at all. I mean especially in places like Seattle and Portland, and the ports. There's a lot of black carbon that's getting emitted in those areas, everything from transitioning to more efficient wood stoves, more efficient diesel engines, they've cleaned up the type of fuel being used in some of the ships, that type of thing.

**E.G.:** *What are the effects of the increased snowmelt? Why should we be concerned?*

**S.K.:** The seasonal snowpack is getting hit hard by temperature as it is. There's a couple different things that drive the energy balance of the snowpack, that drive whether or not it melts, and temperature is part of it, but for mid-latitude, albedo (reflection of solar energy from the Earth and back into space, in this case, the whiteness of the snow) can be the dominant factor in terms of what's driving melt. In Colorado there's an area that gets a lot of dust, and they've been able to show that the snowmelt there is getting way more impacted by dust deposition than it is by temperature increases. That's really important.

We're already getting less snow in the wintertime, snowpack is disappearing sooner, so you can think of it as well, if we're having more black carbon and dust deposited on our snow, it's just going to affect the snowmelt that much sooner. We have a couple drainages in Washington where melt water from glaciers can provide up to 50 percent of the summertime stream flows, and those glaciers are retreating rapidly. Right now we continue to rely on them as a source of water, but once they're gone, we no longer have that buffer during the summer time.