International Cryosphere Climate Initiative

Increased Agricultural Burning in Tula Oblast Spring 2014—Notes on Methodology and Causes

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For a number of years the Laboratory of Soil Informatics of the Soil Institute has monitored emissions of black carbon from agricultural holdings in Russia with the support of the International Cryosphere Climate Initiative (ICCI). The primary source is data from the EOS MODIS satellites (Terra and Aqua). These satellites provide daily coordinates of the status of burning for the entire planet to 1 km. precision for MODIS. Another MODIS product, maps that match to land use, is used to separate the fires into agricultural and other lands. The work of recent years has demonstrated that the land use maps used previously were full of errors. Comparison with satellite data shows the margin of error fluctuates from 20-30% in southern Russia up to 100% in the north of the country, depending on the geographic width of the territory. We had to use field maps in order to decrease this margin of error in calculating black carbon emissions.

Field maps are to the scale of 1:10,000. The map is made by remote sensing data with a spatial resolution of about 1 meter, topographical maps in the scale of 1:25,000 and many other sources. The map displays the borders of all working agricultural lands and cartographic territories. The key includes three types of land: cultivated field, garden, and unused land overgrown with growth, brush, and other. At this time the mapping of fields has been created for some of the subjects of the Russian Federation [i.e., oblasts and other—trans.]. Black carbon emissions work based on the field mapping has been done for Rostov, Moscow and Kostroma oblasts, which captures a transect of the entire agricultural territory of the country. In addition to the three base oblasts, Leningrad and Tula oblast have been added. The MODIS archives allow for a uniform calculation for all five oblasts for the past decades.

Using the field maps actually allows for fewer calculations in determining black carbon emissions on Russian territory. Several assumptions were made in the calculations:

1. If the burning centroid in MODIS is less than 0.5 km. from the nearest field on the field mapping, that field is considered burned.
2. The field is considered completely burned to the cartographic borders.
3. If the MODIS data are close to the dates and coordinates, then one field is considered burned.
4. Emissions were calculated on stubble.

5. The amount of stubble is calculated based on regional grain yield.
6. In the course of our work it became clear no one had ever verified the accuracy of MODIS determination of the burning facts for agricultural lands in Russia, i.e., it was not known how many fires according to MODIS were determined in error, or how many actual fires were not registered.

The MODIS theoretical determination of fire points is based on the following: if 1 ha. of surface is burned with a temperature of at least 300° C. and the surface of the earth is usually not more than 25° C., the pixel with a resolution of 1 km. will double its spectral clarity. This is the fact of burning. But one can assume that the edge of the agricultural burn may not have an area of 1 ha. So with a field 500 meters wide, there must be a strip at least 20 meters deep that is burning all at once. The actual swath of burning stubble could be 20 meters in a mild wind, so one can assume that part of the burning stubble will not be registered by MODIS.

The MODIS thermal sensors are obscured by cloud cover. As stubble burn is a quick process lasting only a few hours, so the fire will not be registered if there is cloud cover. Moreover, the fire can begin and end between MODIS flyovers, which also means it will not be registered.

In order to ground-truth the fire data provided by MODIS, an expedition to Tula oblast was organized in spring 2014, the goals of which were to:

1. Visit as many places as possible where MODIS had determined burning up to the moment of the expedition.
2. Explore the territory with a radius of 1 km. from the MODIS burn coordinate and identify burned plant residue.
3. Establish the coordinates of the identified fires and photograph them.
4. Along our path, visually establish burned plant residues, regardless of whether they had been determined by MODIS or not.
5. Along our path, establish actual burning.

The expedition results were to be the establishment of coordinates and photographs of fields where the burning of agricultural residues or the coordinates of actual fires had been observed.

Right at the time of the expedition data from another satellite became available—NPP, launched by NASA. Analogous to MODIS, the satellite has sensors that allow clarification of the burn factors. It was decided to also verify the NPP data.

The expedition took place in the second half of April and, altogether, covered about 1290 km. in Tula oblast. Four people worked in two cars. All in all MODIS had established 458 fires in Tula oblast by the end of the expedition. Over the course of the expedition 104 points (coordinates) of these were inspected. In the region of 9 MODIS burn coordinates with a radius of 1 km., no signs of burning were in evidence, and there was also no evidence of ploughing or tilling of the fields this year. Traces of agricultural fires were evident in the region of the remaining MODIS coordinates. Thus, it is possible to confirm that MODIS correctly identified burning in 94% of the cases, and in 6% the thermal sensors were in error.

Along the route of the expedition more than 245 active fires or clear evidence of the results of burned plant residue were established. As MODIS had established 104 fires along the route of the expedition, of which 9 were inaccurate, then it may be concluded that the number of actual fires as calculated by MODIS is understated by 2.5 times. Additional results of the study are in progress and will determine not only actual burning, but also the actual area burned.

According to MODIS data, 1470 incidences of burning were established in Tula oblast agricultural lands in 2014. If we take into account the corrective coefficients from the field expedition, in Tula oblast in 2014 stubble or dry grass was burned on the territory of 4500 fields. In the period 1985-1990 in Tula oblast there were 26, 826 agricultural fields with an area of 1,489,577 ha. Statistical data from the former USSR put the area at 1,448,000 ha. Thus it is possible to conclude that on the order of 17% of agricultural holdings were burned.

It is worth mentioning that fires were three times less in 2013. During the entire observation period the largest number of fires was observed in 2009, when we calculate about 50% of agricultural holdings burned.

The primary reasons to burn crop residues in Tula in 2014 are the traditional ones:

1. Extra straw (stubble). In general, this is caused by the absence of large animals (cattle). The introduction of pig and poultry farms does not address this problem as their food is not grain-based.
2. Absence of crop rotation so as to increase tilled and grain crops. i.e., there is no precursor crop that during cultivation would use the surplus straw.
3. Herbicides. The absence of crop rotation and fewer agrotechnical treatments (ploughing, disk tillage, etc.) leads to a battle against pests only won with chemical additives. Consequently, the straw has to be ploughed under only for the sake of the straw itself, which is not economical.
4. Straw decomposition requires the addition of nitrogen fertilizer. With the limited agrotechnical treatments we currently observe, it is expensive and complicated to add nitrogen fertilizer to facilitate decomposition.
5. The maintenance and tilling of straw requires that it be chopped at the time of harvest. There may be no chopper or it can be unused as the chopper requires increased fuel expense.

The specifics of 2014:

1. Dry winter. Decomposition of crop residues requires moisture (wet conditions). The winter of 2013-2014 in Tula oblast was so dry that the previous year's grass did not even lie flat, so the result was dry, vertical grass standing in the fields, which practically has to be mowed and chopped to be used. No one has ever done this—it is much cheaper to burn.
2. Southern Russia has been experiencing a dry period since 2010. Some of the fields are discarded or not cultivated in a given year, which means that the quantity of dry grass increases by orders of magnitude. If the decision is made to cultivate the field anew, it has to be burned. The alternative is very expensive ploughing with heavy equipment.
3. The introduction into crop rotation of certain crops (such as soya) requires suppressing certain pests and diseases. Burning the field allows for fewer expenses for treating the field before planting and for herbicides.

The drop in burning since 2010 is largely connected to fewer working lands as a result of the drought. On the other hand, the large impact of the dry period on the harvest is a result of fires before 2010. In 2009 up to 50% of the fields were burned. Burning lessens the ability of the soil to retain moisture, which promotes arid soil. This in turn means that straw does not decompose. If it does not decompose, then it is burned, which creates a vicious circle.

This circle cannot be broken without improved cultivation techniques.

When we met with farmers before their study tour to Sweden, we found one who does not burn and who suffers from dryness less than others. He has other problems that are more associated with the market price. It turns out that the market does not pay more for high-quality grain in Russia, so the best producers have a hard time recouping their expenses.

--Translated by Gail Stevenson, ICCI Russia Program Director

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