Tutorial 04: Landscape-scale fire potential

Tutorials 01 - 03 involved modeling transient fire spread from a point ignition. ELMFIRE can also quantify landscape-scale fire potential (i.e., spread rate, flame length, etc.) assuming each pixel burns as a head fire in a manner similar to FlamMap. In Tutorial 04, we assess how wind speed affects landscape-scale fire potential in part of California's Central Sierra that includes areas burned in the 2013 Rim Fire.

As in Tutorial 03, LANDFIRE 2.2.0 fuel and topography inputs are are obtained from Cloudfire's fuel/weather/ignition microservice. These are used in combination with idealized spatially uniform wind speed/direction and fuel moisture meteorological inputs as specified in the `wx.csv` file:

```
ws,wd,m1,m10,m100,lh,lw
0,0,2,3,4,30,60
5,0,2,3,4,30,60
10,0,2,3,4,30,60
15,0,2,3,4,30,60
20,0,2,3,4,30,60
25,0,2,3,4,30,60
```

In Tutorial 02 and Tutorial 03, each row in `wx.csv` corresponded to a different time. Here, each row can be thought of as specifying different combinations of spatially uniform wind and fuel moisture conditions to drive fire potential calculations. There are six different combinations of input parameters with all inputs held constant across combinations, with the exception of wind speed which is varied from 0 mph to 25 mph at 5 mph increments. Therefore, a total of six separate fire potential calculations will be conducted when Tutorial 04 is executed:

```
cd $ELMFIRE_BASE_DIR/tutorials/04-fire-potential
./01-run.sh
```

The `01-run.sh` script sets up and runs ELMFIRE, including creating multiband meteorological input rasters from the inputs specified in `wx.csv`. Recall that ELMFIRE does not directly read the `wx.csv` file - instead it reads the rasters that are created by `01-run.sh`. Comparing `input/elmfire.data` from Tutorial 03 and Tutorial 04 shows some differences in the `&SIMULATOR` namelist group. Tutorial 03 had this`` &SIMULATOR`` namelist group:

```
&SIMULATOR
NUM_IGNITIONS = 1
X_IGN(1) = 740548.710
Y_IGN(1) = 4147156.024
T_IGN(1)      = 0.0
/
```

which, in Tutorial 04, looks like this:

```
&SIMULATOR
MODE = 2
/
```

ELMFIRE has two primary modes of operation. The first, and default, is `MODE=1` which directs ELMFIRE to run a transient simulation of fire spread across a landscape as in the first three tutorials. Setting `MODE=2` as above directs ELMFIRE to burn every pixel on the landscape as a head fire similar to FlamMap.

Other differences between Tutorial 03 and 04 include elimination of the `&TIME_CONTROL` namelist group (since time step, CFL number, and simulation stop time are not relevant) as well as modifications to the `&MONTE_CARLO` namelist group which now reads:

```
&MONTE_CARLO
METEOROLOGY_BAND_START                  = 1
METEOROLOGY_BAND_STOP                   = 6
METEOROLOGY_BAND_SKIP_INTERVAL          = 1
/
```

This directs ELMFIRE to start in `ws.tif`, `wd.tif` etc. with `METEOROLOGY_BAND_START` (which in this case is 1) and conduct fire potential calculations. ELMFIRE will then increment the meteorology band by `METEOROLOGY_BAND_SKIP_INTERVAL` and conduct fire potential calculations for the next meteorology band. This continues until `METEOROLOGY_BAND_STOP` is exceeded.

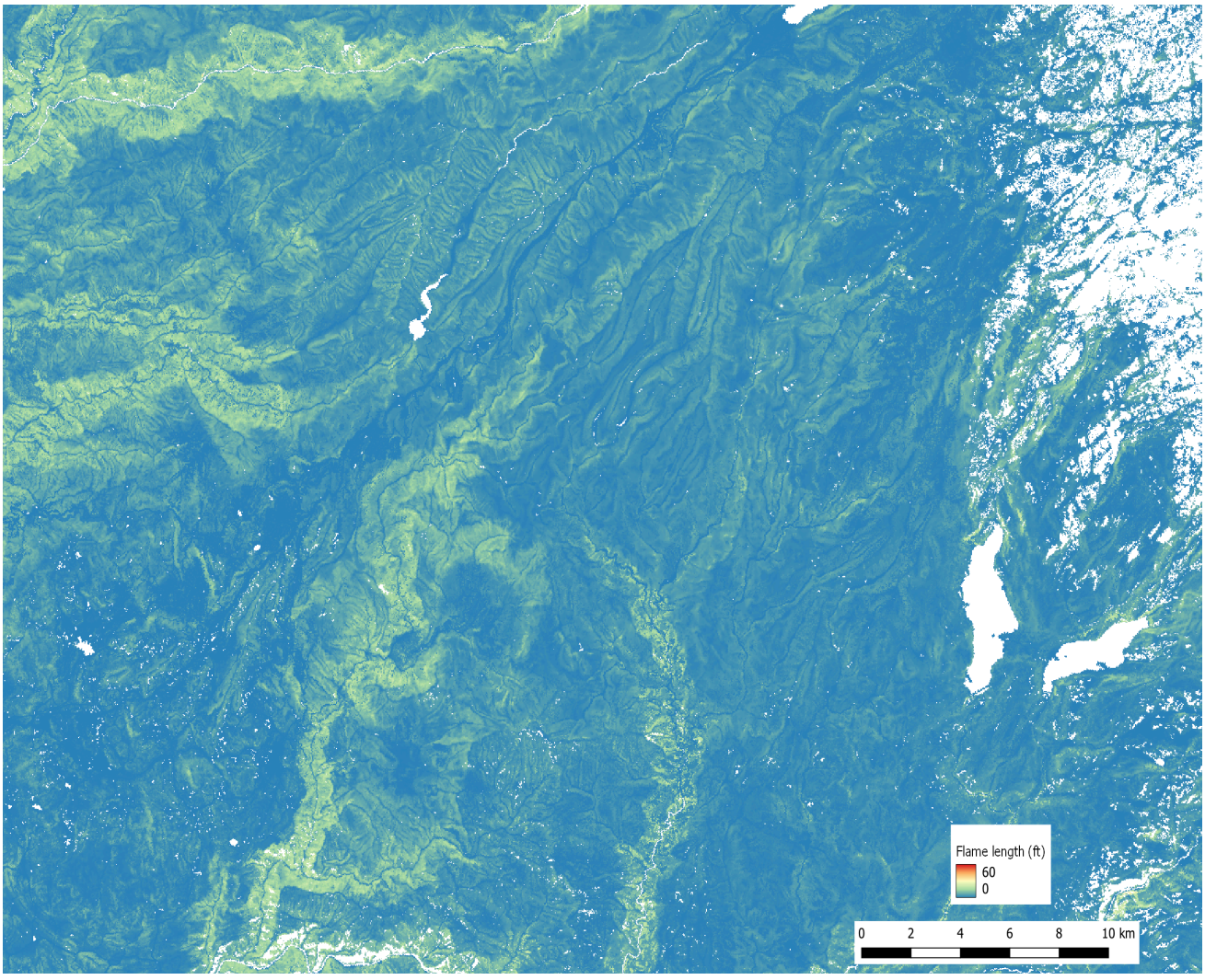
In this case, six separate fire potential calculations (corresponding to wind speed = 0, 5, 10, 15, 20, and 25 mph) are conducted. Outputs (flame length and spread rate) are written to the `outputs` folder with the meteorology band number appended to the quantity name before the `.tif` suffix. For example, `head_fire_flame_length_001.tif` corresponds to the first meteorology band (wind speed = 0 mph), and `head_fire_flame_length_006.tif` corresponds to the sixth meteorology band (wind speed = 25 mph).

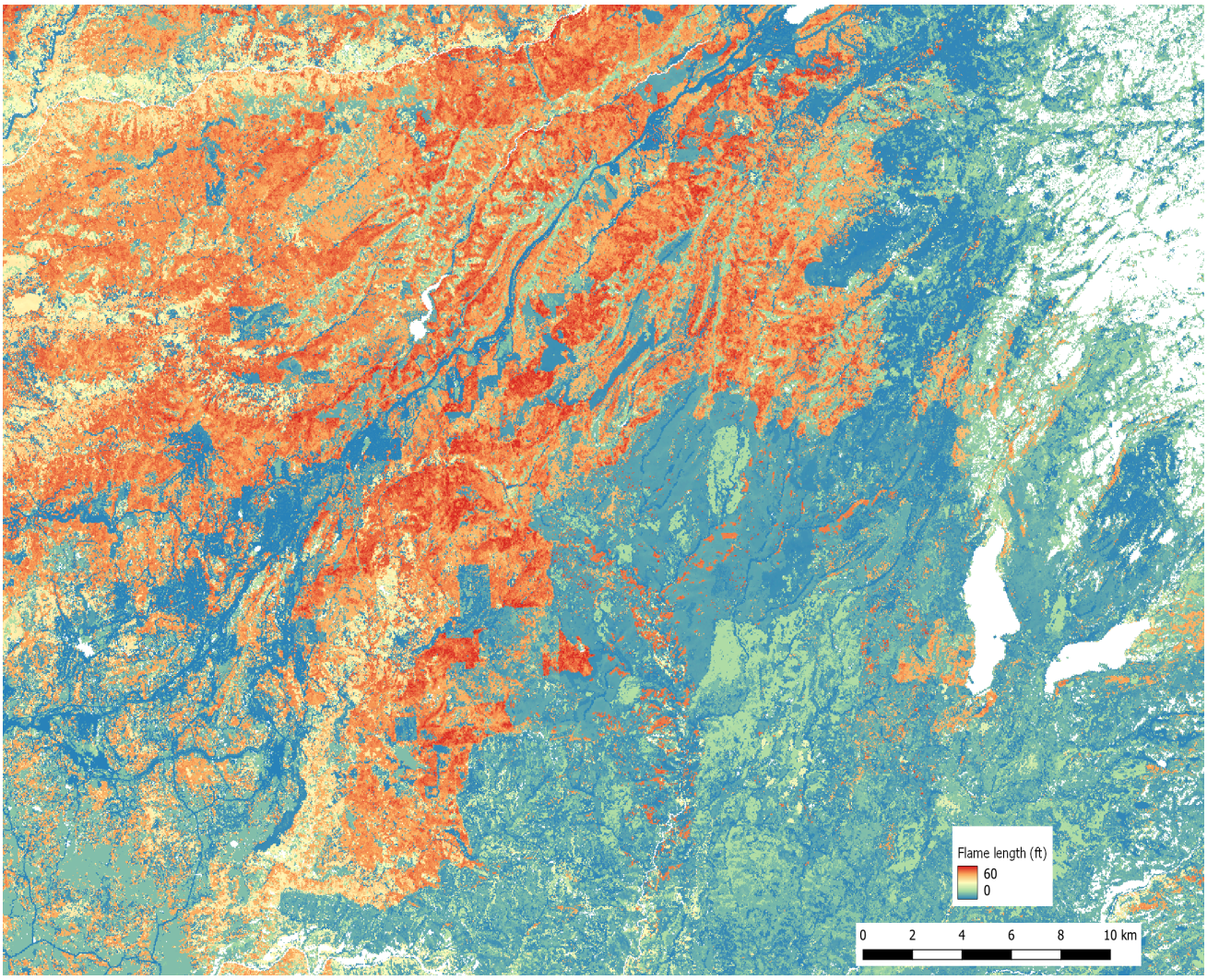
A couple notes:

1. Wind and slope are not assumed to be aligned, meaning wind direction affects potential fire behavior. Running fire potential calculations for the same landscape varying only wind direction will give different results, with the highest spread rate and flame length occurring when wind and slope are aligned, and the lowest occurring when they are opposed.

2. By default, modeled spread rate and flame length include the effect of crown fire. Crown fire can be disabled by adding the keyword `CROWN_FIRE_MODEL = 0` to the `&SIMULATOR` namelist group. Currently, only one crown fire model is implemented and it is disabled by setting `CROWN_FIRE_MODEL = 0` and enabled by setting `CROWN_FIRE_MODEL` to any value greater than 0.

Potential flame length is shown below for the 0 mph (top image) and 25 mph (bottom image) cases.




Flame length (ft)
60
0
0
2
4
6
8
10 km