Pyregence Spread Modeling during Dixie Fire - Notes from Zeke Lunder, December, 2021.

General Observations

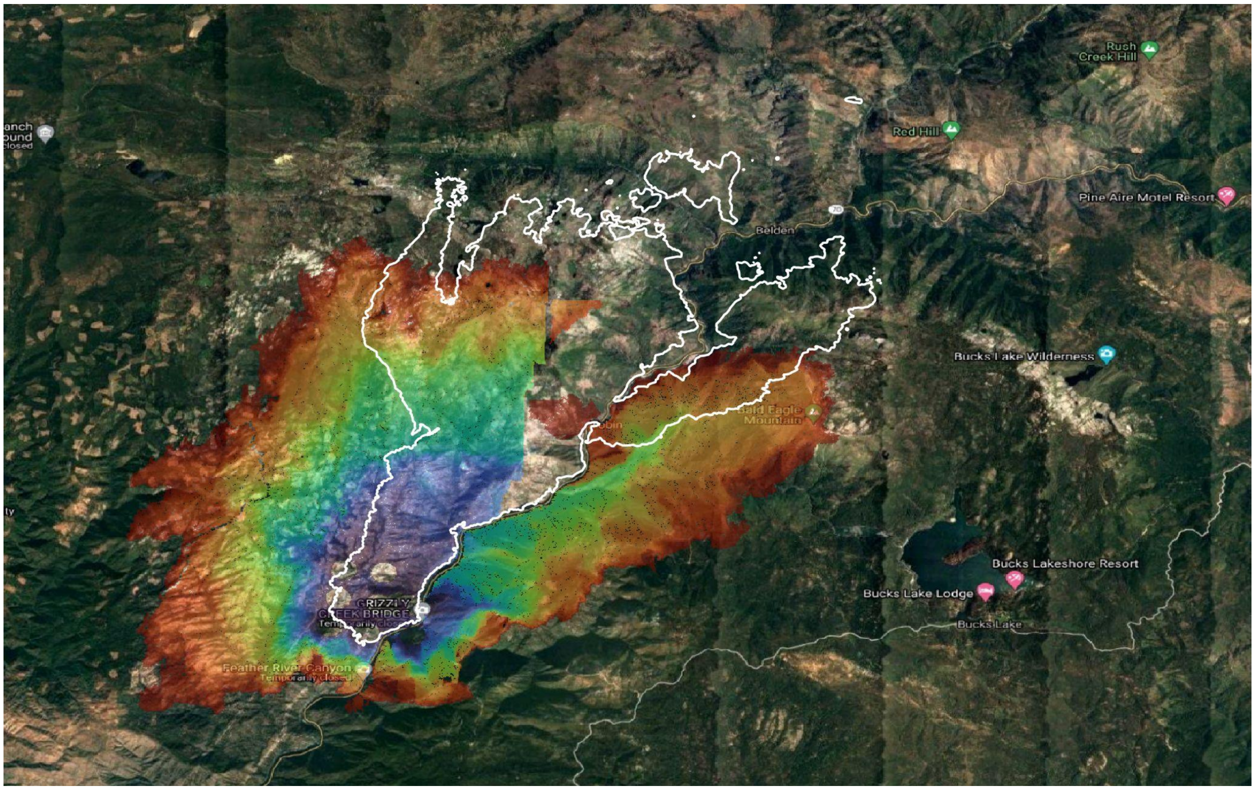
MODIS hits have too many outliers - often over a mile from the edge of the actual fire. Since fires are often holding on ridgelines, these really skew the model runs when they throw a potential ignition point into the bottom of an adjacent watershed where it can make an aligned run. Early in the Dixie Fire, the model was showing potential for the fire to make a major run downcanyon toward Stirling Ciy and Magalia. This was mainly driven by the errant MODIS points.

VIIRS data generally has fewer long outliers, but during PyroCu conditions, heat in the column often creates major errors. I think we should be looking at filtering MODIS by internal accuracy score delivered with the data, and also, do our own filtering based upon distance from other points. The errant points from heat in the column are pretty easy for the trained eye to spot - they tend to be in a pretty rigid grid configuration. It is also often pretty easy to look up the relevant webcam to confirm the errors. I don't see an easy way for us to train a computer to recognize these errors in MODIS.

Downcanyon wind influence seemed to be lacking in areas south of Greenville. We often see torching or crown fire runs on slopes facing directly upcanyon in the steep canyons in the middle of the night due to heavy downcanyon winds.

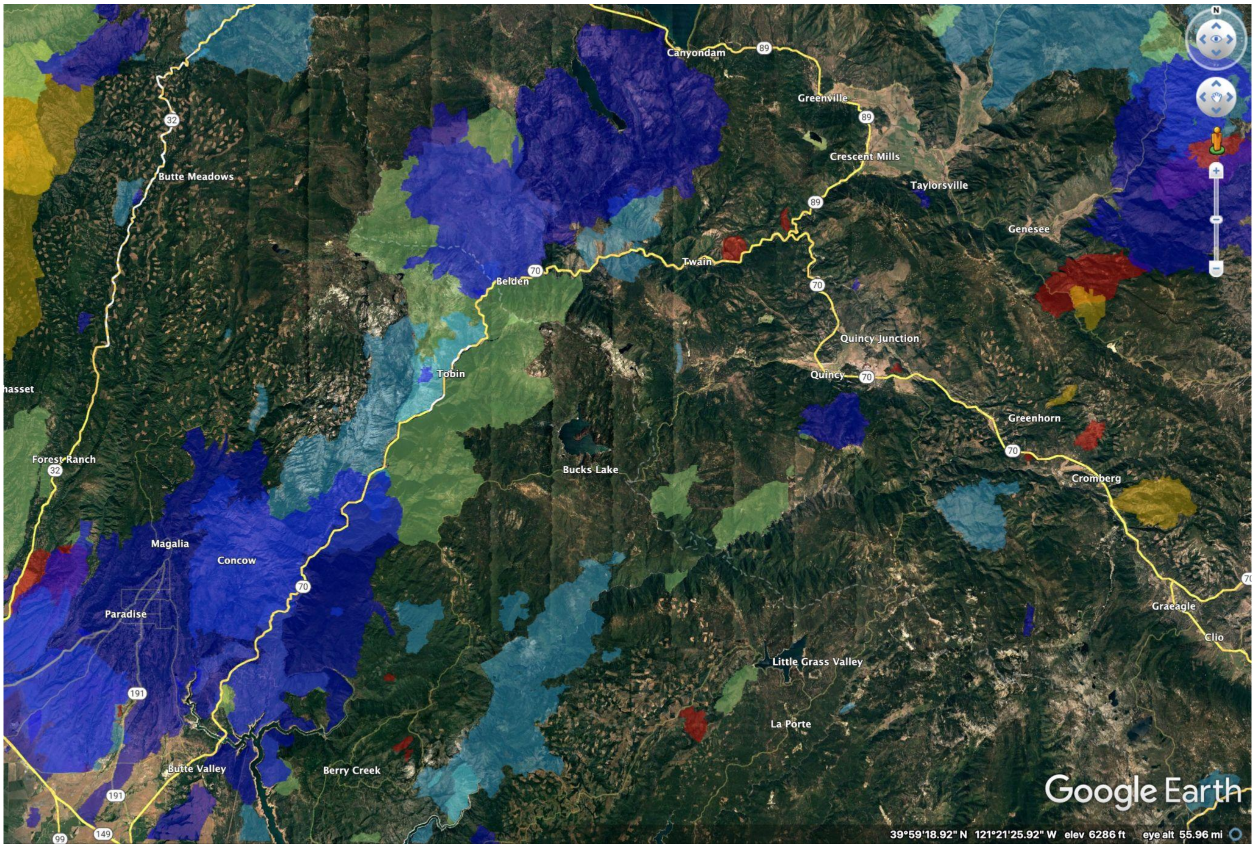
The model overpredicts fire behavior in wet meadows in places like Indian Valley. Maybe incorporate something like the Sentinel Moisture Index into grass/herbaceous fuel models?

Early in the fire, the Pyregence model was dramatically overestimating the lateral spread of the fire to the west and east. This was partly due to MODIS errors which showed heat far to the west of actual fire, and also due to successful (mainly aerial) fire suppression actions on the west flank. The east flank was slowed by sparse fuels in the 2008 fire scars and granite outcroppings to east of fire in Feather River Canyon. The 4-day run below is for 7/14/2021 (18:40 hrs). Actual 4-day fire spread in white.



In general, the dominant direction of spread on the Dixie Fire was toward the NE. Early in fire season before East winds arrive in the fall, this has been the case on other large fires in this area as well (1999 Bucks, 2000 Storrie, 2020 North Complex, and 2012 Chips Fires). We might want to look at ways to incorporate historic trends in fire movement into the model.

Fire History in Dixie Fire Area - Most fires move toward NE.



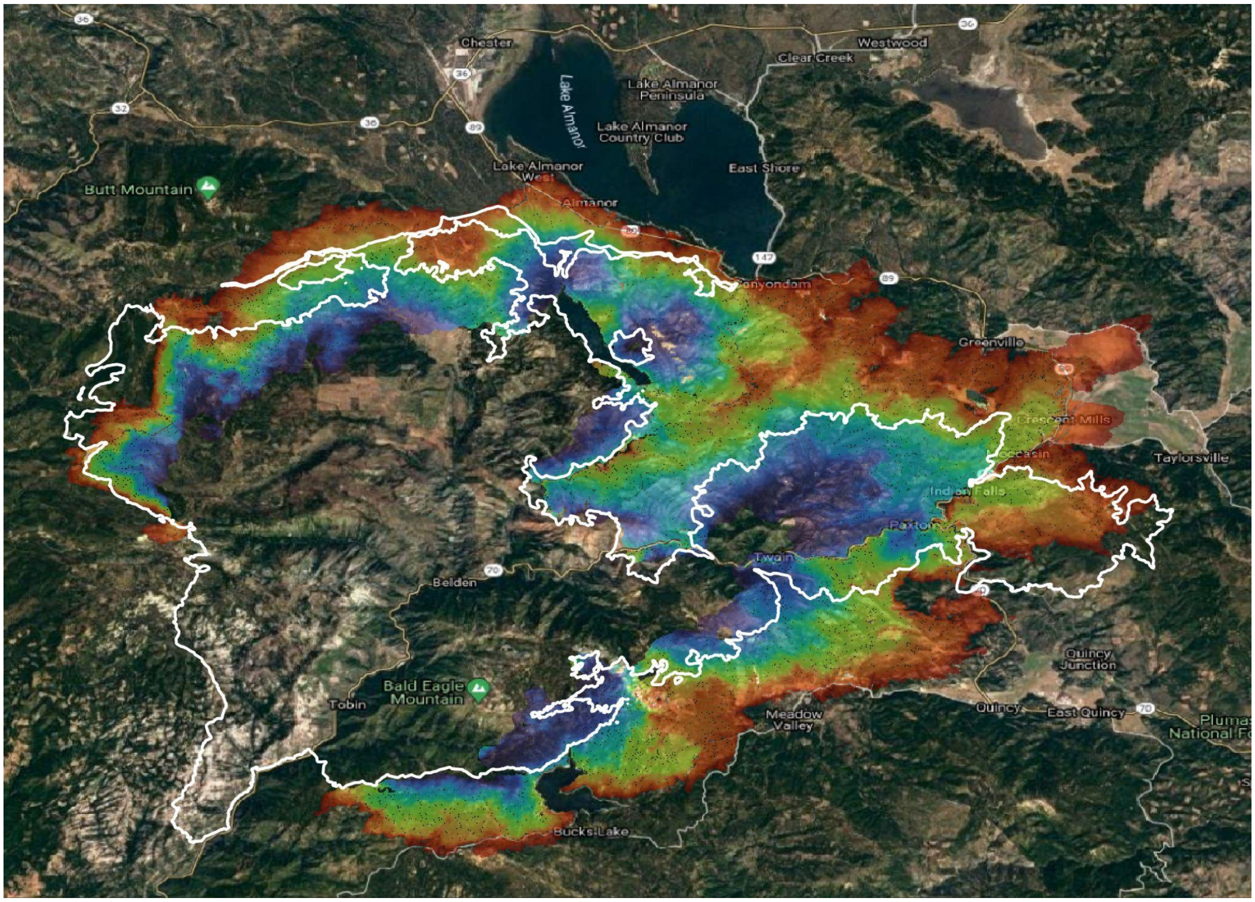
Smoke Inversions

The model is not capturing effects of heavy smoke inversions after fires have escaped initial attack. Generally on the Dixie, frontal passages drove major fire runs, punching up huge amounts of smoke which would smother the fire during the following days of high atmospheric pressure. We often saw very low rates of fire spread under the inversions. A lack of smoke inversions in the model causes a couple major issues:

1. Model is showing spotting too early in the day in valleys where inversions will suppress fire behavior until late in the afternoon. E.g. showing spotting at 14:00 in Indian Valley when inversions weren't lifting until 4pm, if at all. This is a problem because new spots at 14:00 have all afternoon to grow in the model.
2. We had many days on Dixie where fire didn't really spread with still air and heavy smoke.
3. Once the inversion lifts, it is off to the races! Nailing down when this will occur seems like a high priority. Unfortunately, even the IMETs on the Incident Management Teams were having a really hard time getting this right. There were several days on the Dixie where the IMET on the West or East Zone had widely divergent forecasts of when inversions would lift, and in some cases the inversions lasted all day.
4. In mountain valleys, night inversions and general dampening of fire behavior in dawn hours seem underplayed in the model.

An example of the model over-predicting fire spread during periods with heavy smoke packed in under high pressure is shown below. Run is for the 4 days beginning 7/22/2021 (19:30hrs).

Actual 4 day spread shown in white outline. Surface weather during this time was dominated by high pressure, as [documented here]: Much of the fire spread on NW side of this map was from a massive firing operation which spanned over 20 miles along Humboldt Road.



Considerations in Steep Terrain/Canyons
Modeling of backing fire seems realistic on medium-steep slopes, but on steeper slopes in places like the Feather River Canyon, rollout of burning material causes localized crown runs back up aligned slopes, and also moves fire downhill faster than the model is predicting. Rollout is an important part of dynamics of spread in steep canyons, and we might want to look at ways to make fire move faster downhill on slopes over 50%.

Modeling Suppression Effectiveness/Incorporating Incident IR
Modeling, tracking, and mapping fire suppression effectiveness is a massive undertaking, but the models are really limited in their utility if we don’t introduce something on this topic. If flanks have not moved in a 24hr NIROPS scan or VIIRS cycle, we should be turning them off in the model.

During the Dixie Fire, I was reviewing IR intel on a constant basis, and think it would have been nearly impossible to make sense of the various incoming data using an automated process. There were several contractors providing IR data to the incident, including Courtney Aviation, Marine Spill Response Corporation (MSRC), the USFS Firewatch Cobra program, and the

National Guard (DRTI). There is a wide variety of delivery formats amongst the various contractors. The Dixie Fire kind of broke the NIROPS workflow because the interpreters begin their daily interpretation using the most current fire perimeter from the GISS people on the Incident Management Teams. Within the first week or so on Dixie, the perimeter polygon of the fire had too many vertices for use in KML files. Once you get more than 30,000 vertices in a polygon, it won't display as a solid polygon in KML, so the IR contractors had a lot of different ways they were trying to build polygons for their perimeters, but their polygons ended up with lots of geometry errors. Some of the data being posted on NIROPS was actually rasterized polygons converted back to KML.

The current NIROPS/Courtney IR data would need some sort of reprocessing to feed into our models. Courtney is actually streaming their IR data to a network KML file, but CAL FIRE's new Intel Division has refused to share the data to outsiders during the incident. It is good data, but they upload it in chunks to the NIFC FTP site every few hours, and it was being acquired in a kind of chaotic fashion day-to-day during Dixie and Caldor.

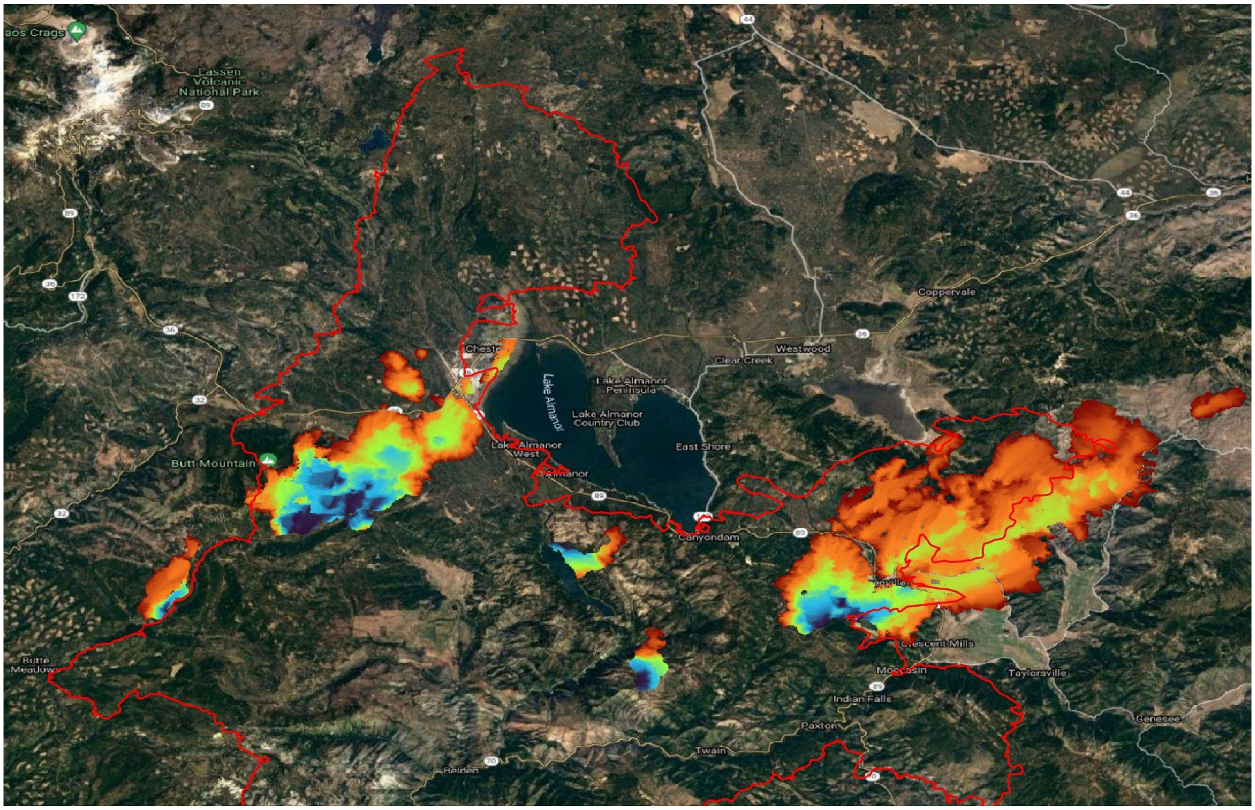
The FIRIS program, based out of SoCal provides their IR as a publicly accessible KML. It also sometimes only covers active parts of the fire which are operational priorities, so wouldn't be something we could necessarily use in an automated fashion.

The DRTI IR program was flying Caldor Fire every day at 1500. The data was pretty reliable for the entire fire footprint. I think we could potentially use DRTI imagery to turn off areas that haven't moved in past 24 hours. More detailed polygons are digitized by the National Guard DRTI program on a haphazard basis, and the quality of this data is a bit hit-or-miss. There were several occasions where I found major errors in the 'realtime' DRTI polygons.

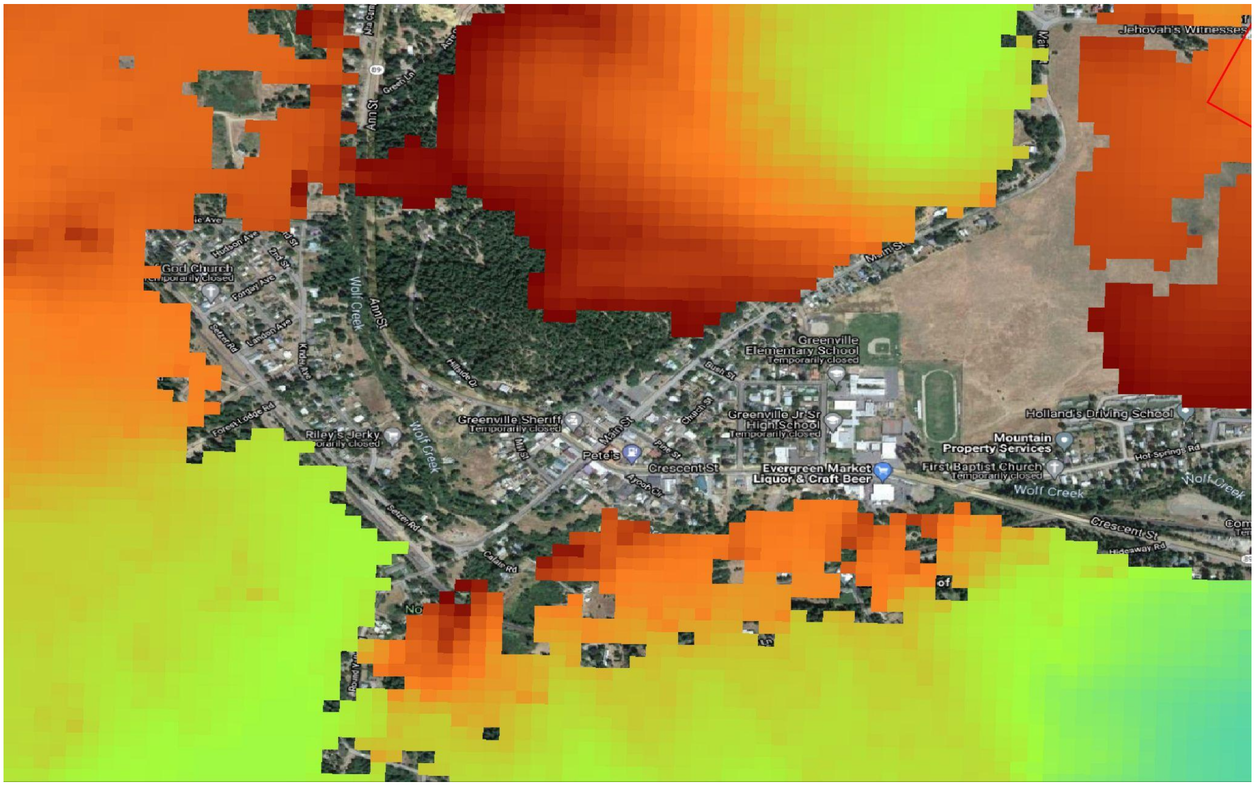
The crux of the problem is that there is not a reliable schedule or delivery format for IR data from fires, and nothing new on the horizon.

Other Dixie Fire Model Runs

The Dixie Fire made some truly spectacular runs. The model did a decent job predicting a couple of them, and often got parts of the fire spread right while failing to predict spread in nearby areas. The example below shows the model was fairly accurate in predicting fire spread to the northeast, but underestimated fire spread by ***15 miles*** on an area of the fire only 20 miles to the west (west of Chester, CA). This particular run was generated for 4 days of spread starting 8/2/2021 at 19:13 hours. The actual fire perimeter after 4 days is shown in red.
This modeling period coincided with a major frontal passage. Surface weather maps for this time period here:



It is worth mentioning that this model run said Downtown Greenville wouldn't burn. We might want to look closer at whether what LANDFIRE calls urban is actually unburnable.



Next Steps

The data archive on the Pyregence website has only 3 archived runs on it for the Dixie Fire. We should identify test-case fires and archive all of the runs from those incidents for later use.

I'd like to talk with Janice Coen about their coupled models, and to get an understanding of what sort of scale of modeling would be most appropriate to better capture the effects of smoke and heavy inversions on predicted fire behavior. The models seemed to predict fire behavior best during unstable weather.

LANDFIRE data is pretty terrible for modeling fire spread, in my experience. I think the SALO forest data is promising, but they still have some issues with calculating crown bulk density. We should be looking at how to better simulate fire in areas currently mapped as urban or unburnable.

We should get the short-term forecast team together to develop an actual quantitative approach to validating the models. There was a huge amount of IR data collected during peak burning hours during the Dixie and Caldor Fires, and this presents good opportunities to calibrate the model.