



Challenges in Near Real Time Operational Smoke Forecasting Using Satellite Data

7th International Workshop on Air Quality
Forecasting Research

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Challenges in Near Real Time Operational Smoke Forecasting Using Satellite Data

- Smoke forecast models are running at higher temporal and spatial resolution
- This implies higher accuracy on finer scales from regional to local forecasts of smoke
- Details of smoke sources need to correspondingly improve in detail
- Will present examples of impediments to an increase in accuracy



Challenges in Near Real Time Operational Smoke Forecasting Using Satellite Data

From the Final Report to the Joint Fire Science Program -
Smoke and Emissions Model Intercomparison Project:

- For smoke concentrations from a single fire, overall sensitivity as found here is dominated by (in descending order)
 - a. Time profile (the timing of consumption throughout the day and its relation to meteorological conditions);
 - b. Plume rise (the number of assumed plume heat cores); and
 - c. Uncertainties in fire emissions



Challenges in Near Real Time Operational Smoke Forecasting Using Satellite Data

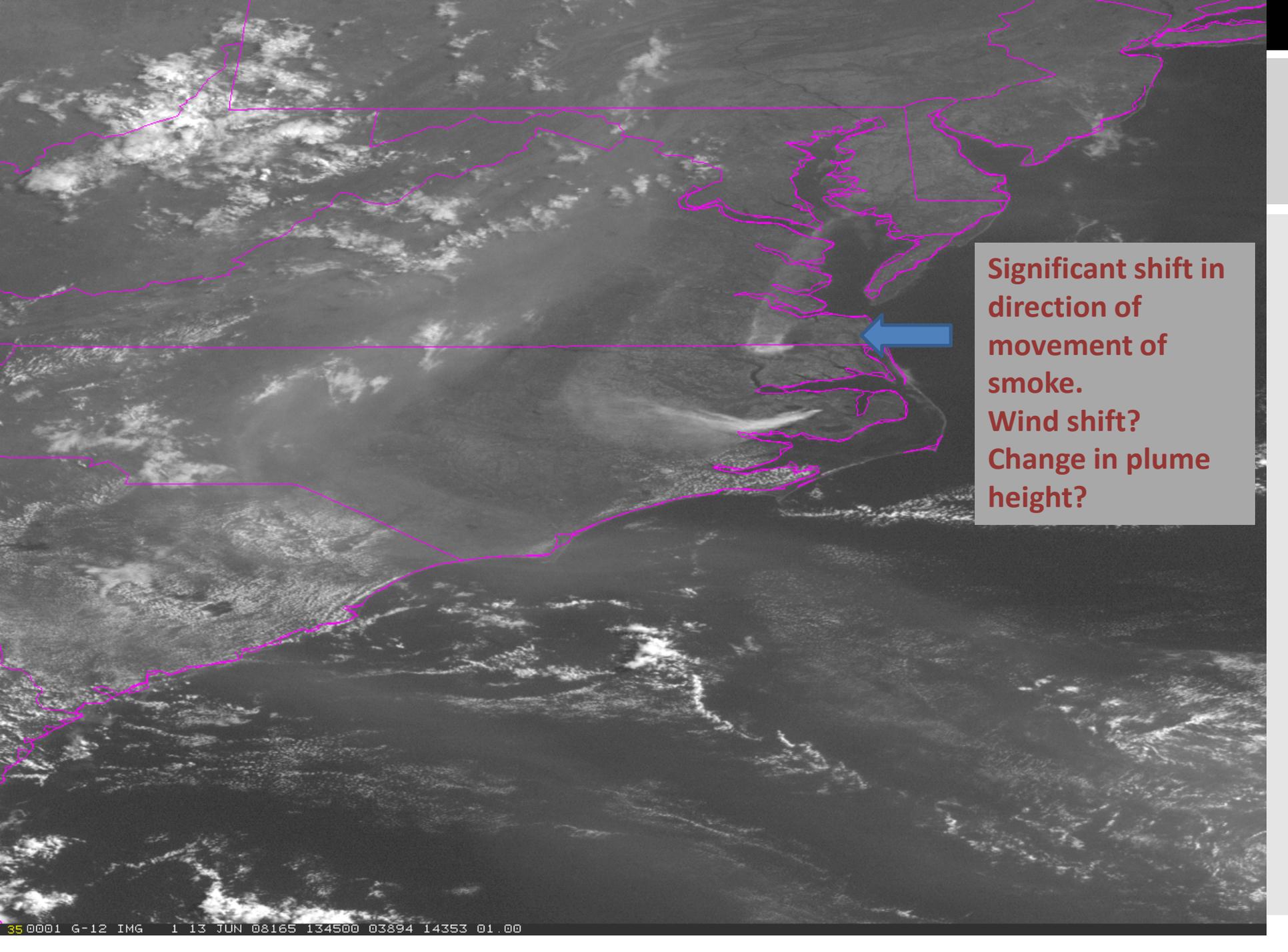
Additional challenges include

- Life of the smoke once in the model: what is the objective of the smoke forecast?
- Navigational accuracy: displacement can locate fire in different land type/fuel load
- False detections: myriad causes, including clouds, land features, volcanoes, solar panels, etc.
- Prescribed/control burns designed to minimize smoke emissions

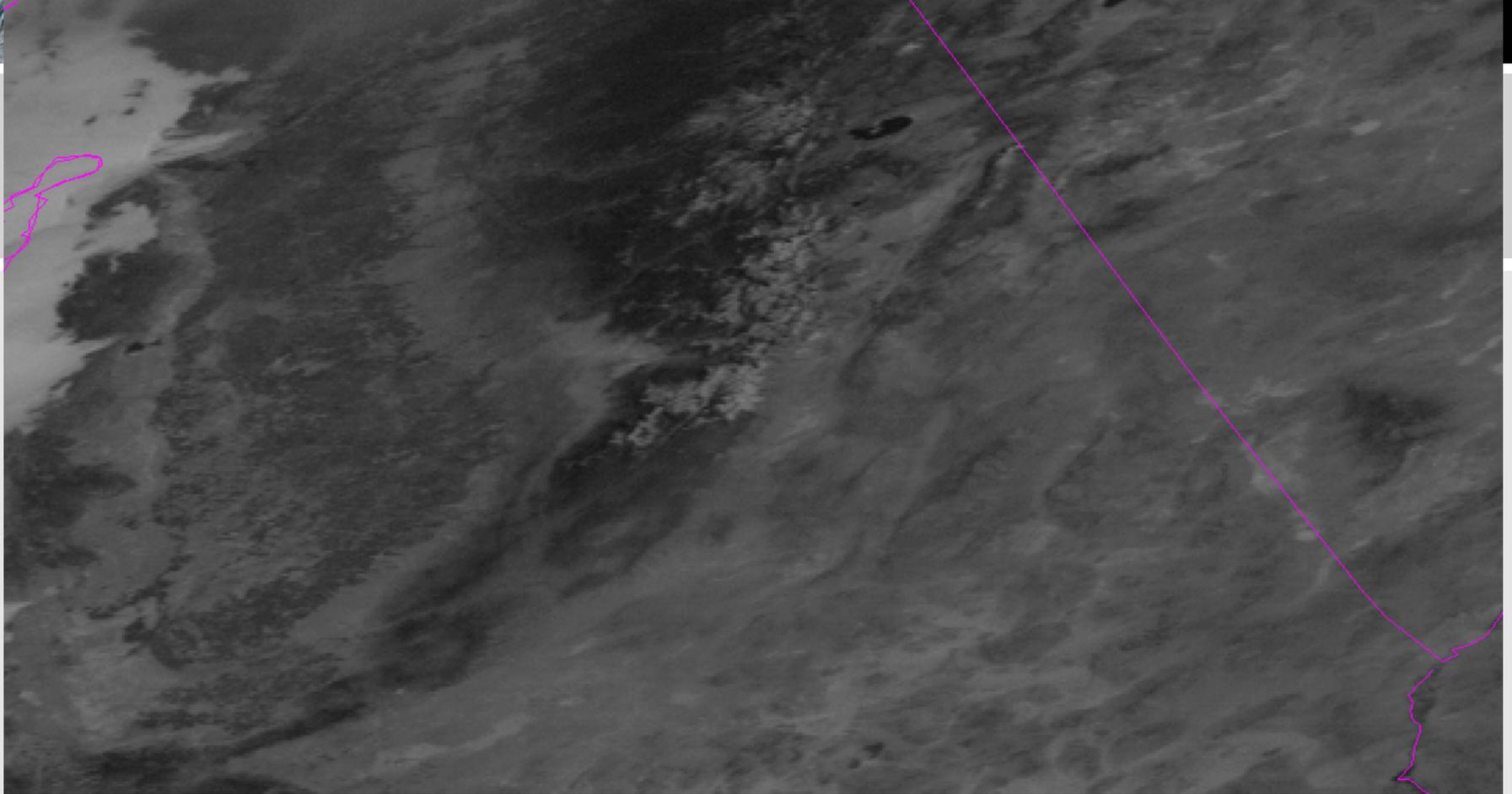


Challenges in Near Real Time Operational Smoke Forecasting Using Satellite Data

- Can't detect fire due to tree canopy (little/no hotspot signal; manual detection)
- Hotspots that don't produce smoke (engineered that way, gas flaring, little biomass, etc)
- Hotspots that don't produce smoke that corresponds to the duration of the fire or the intensity
- Clouds move over a fire – how much longer will the fire burn?
- Clouds clear a fire – when did it begin?
- How quickly is fire moving / % of area burned (grassland fire vs forest)

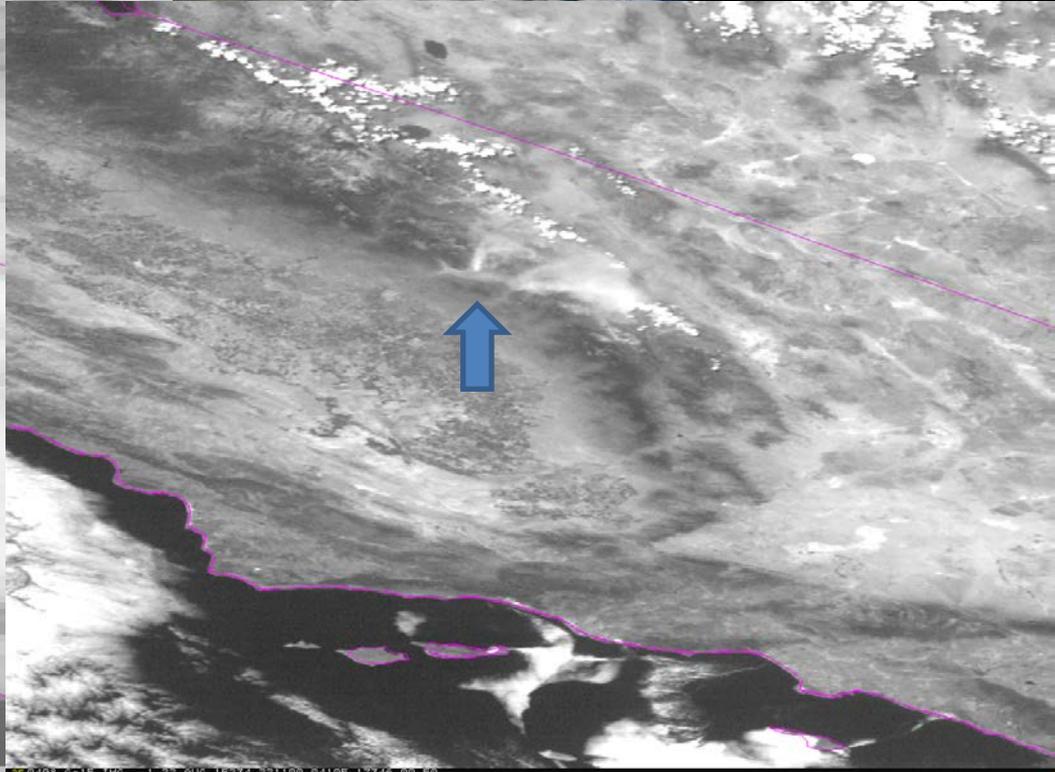
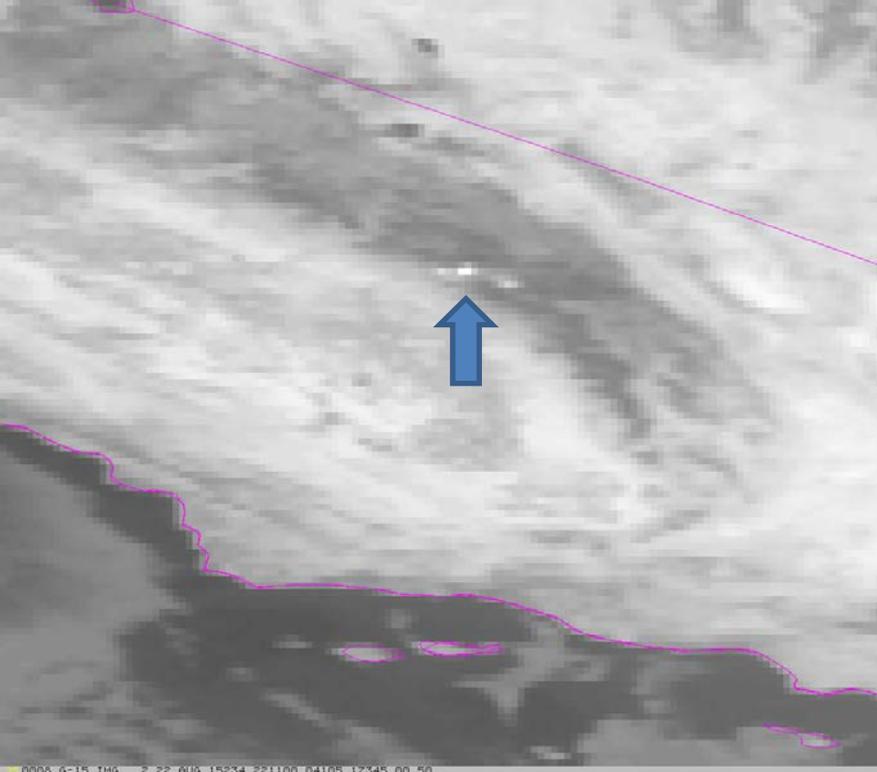


**Significant shift in direction of movement of smoke.
Wind shift?
Change in plume height?**

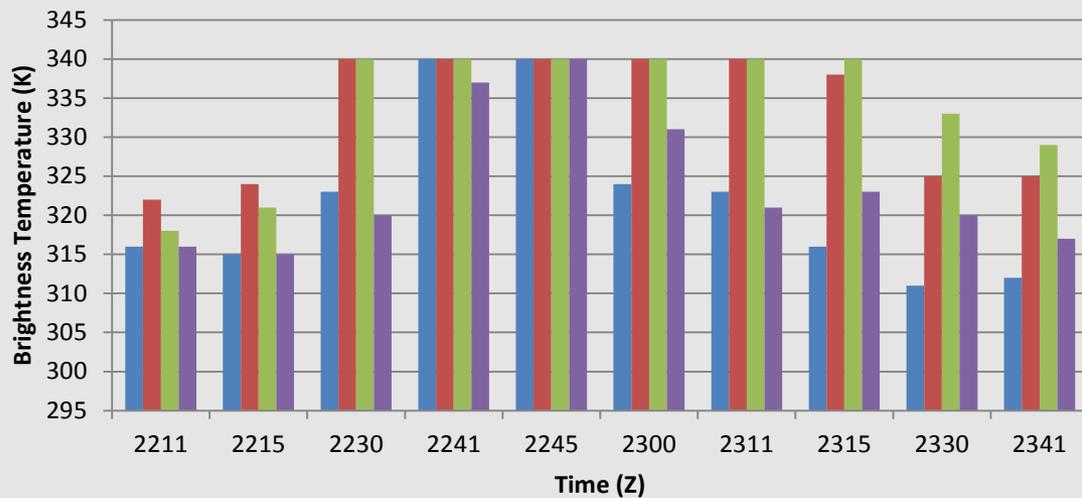


Typical activity observed:

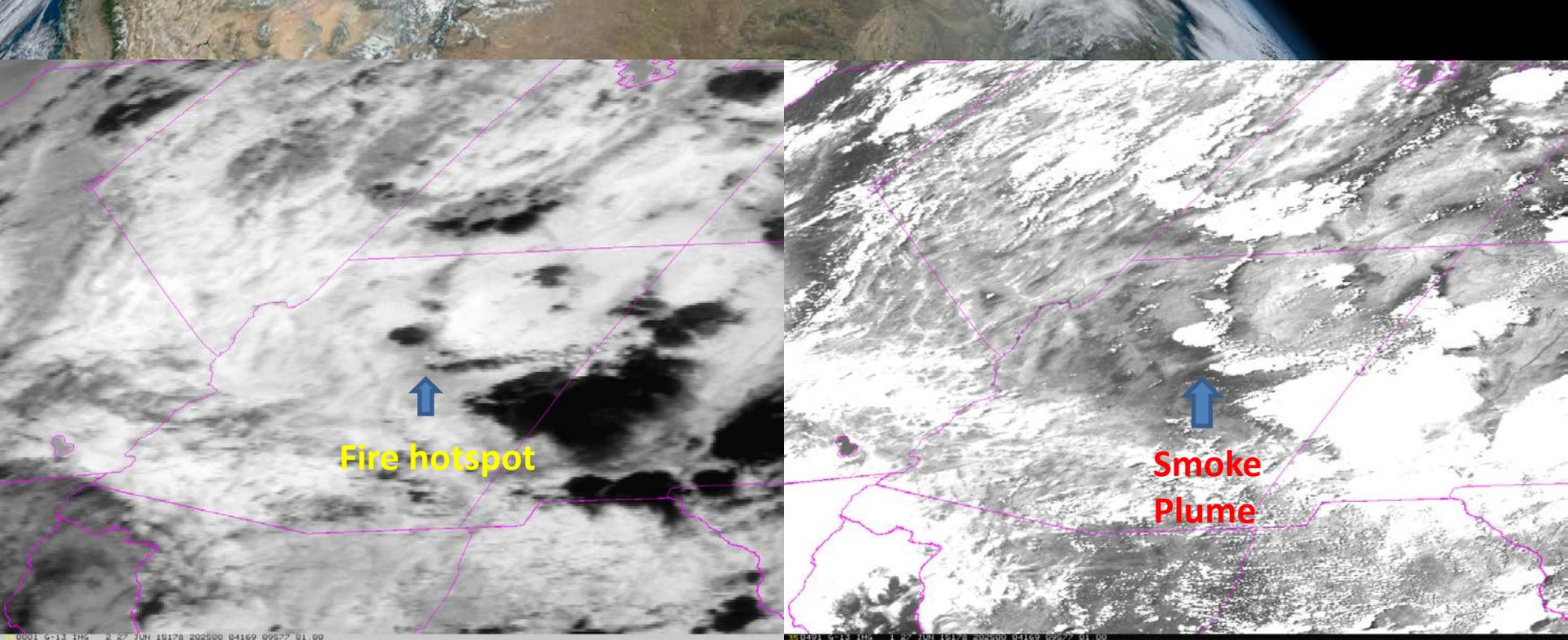
- **Fires 'lie down' at night**
- **Inversion traps smoke in boundary layer**
- **Smoke settles in valleys**



Pixel T Change



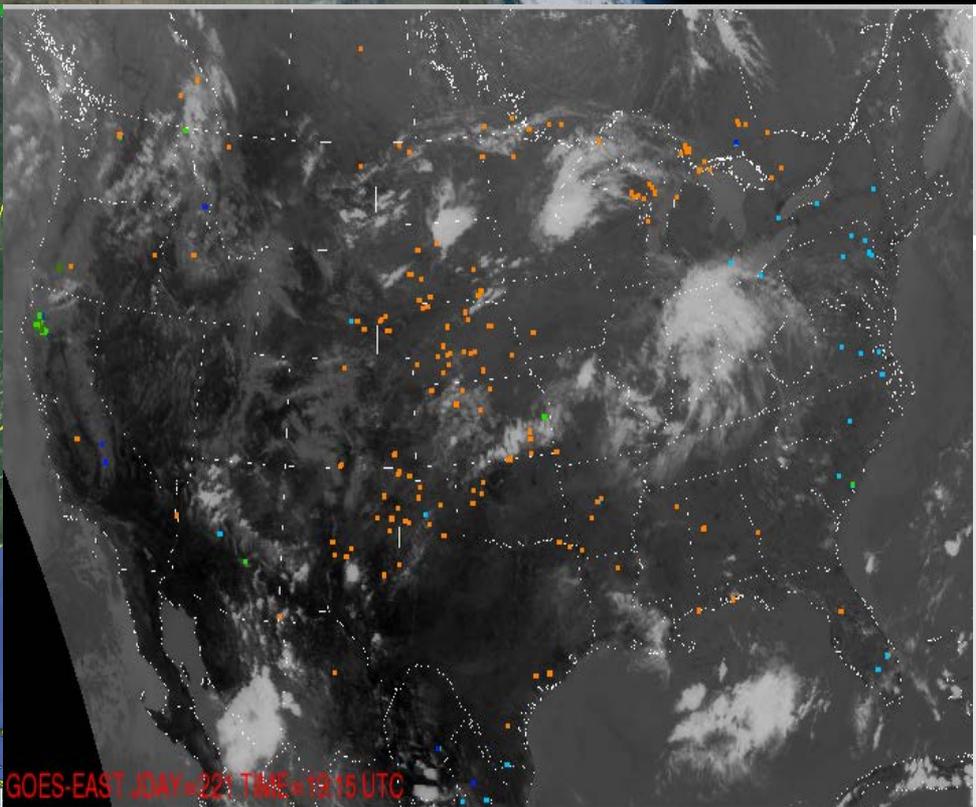
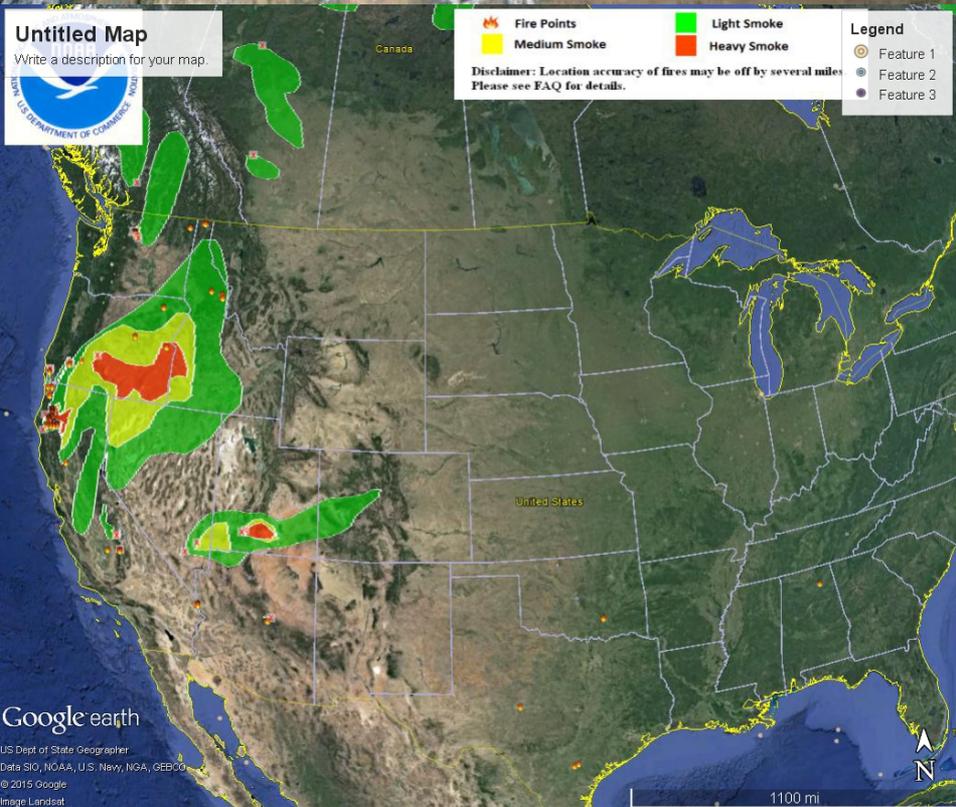
Short burst in fire intensity corresponds to increase in smoke emissions. Time span is 1.5 hours.



Fire is already burning and producing smoke emissions.

How much longer will it burn after getting obscured by clouds?

Will rain extinguish the blaze?

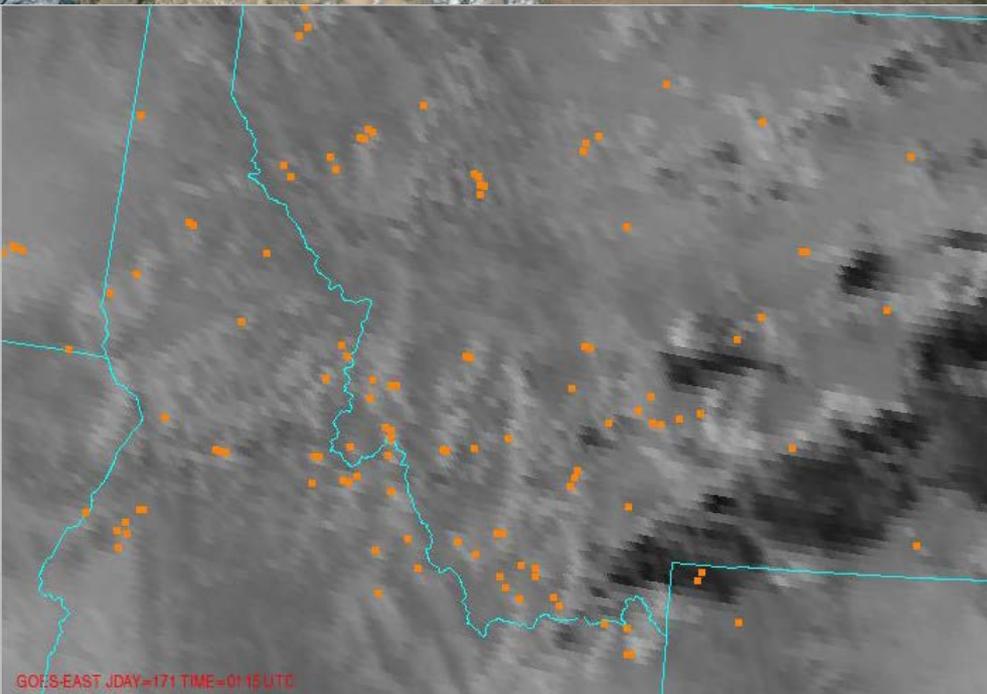


HMS analysis (quality controlled) for 9 Aug 2015 showing locations of fire and smoke

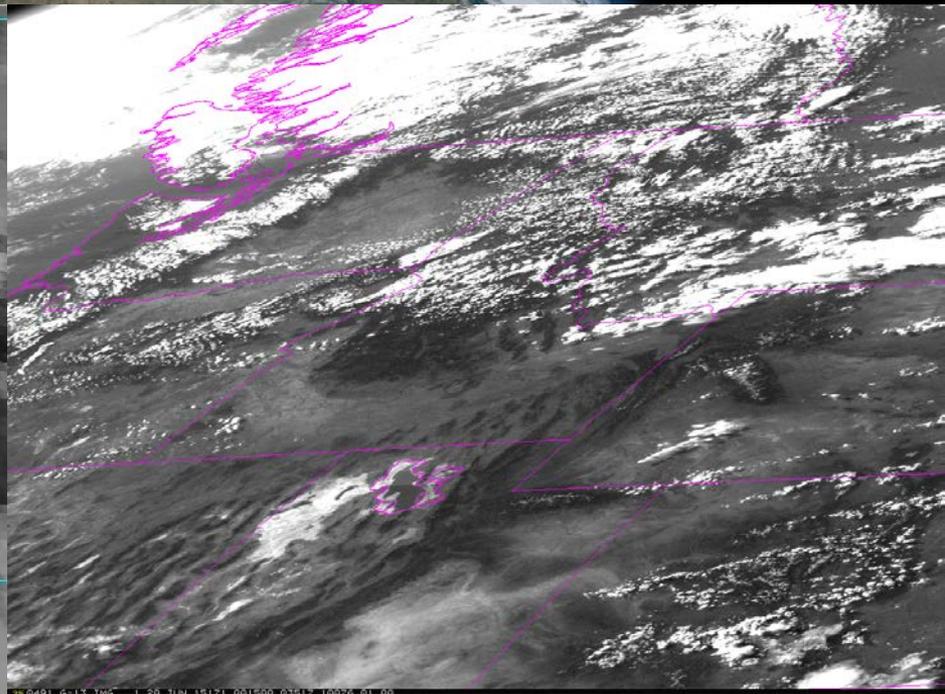
Automated fire detections from GOES, MODIS and AVHRR corresponding to HMS analysis.

Numerous false detects in the automated fire products for a variety of reasons.

Examples of some of the more common causes to follow



HMS display showing GOES-E band 2 with automated WFABBA detections overlaid

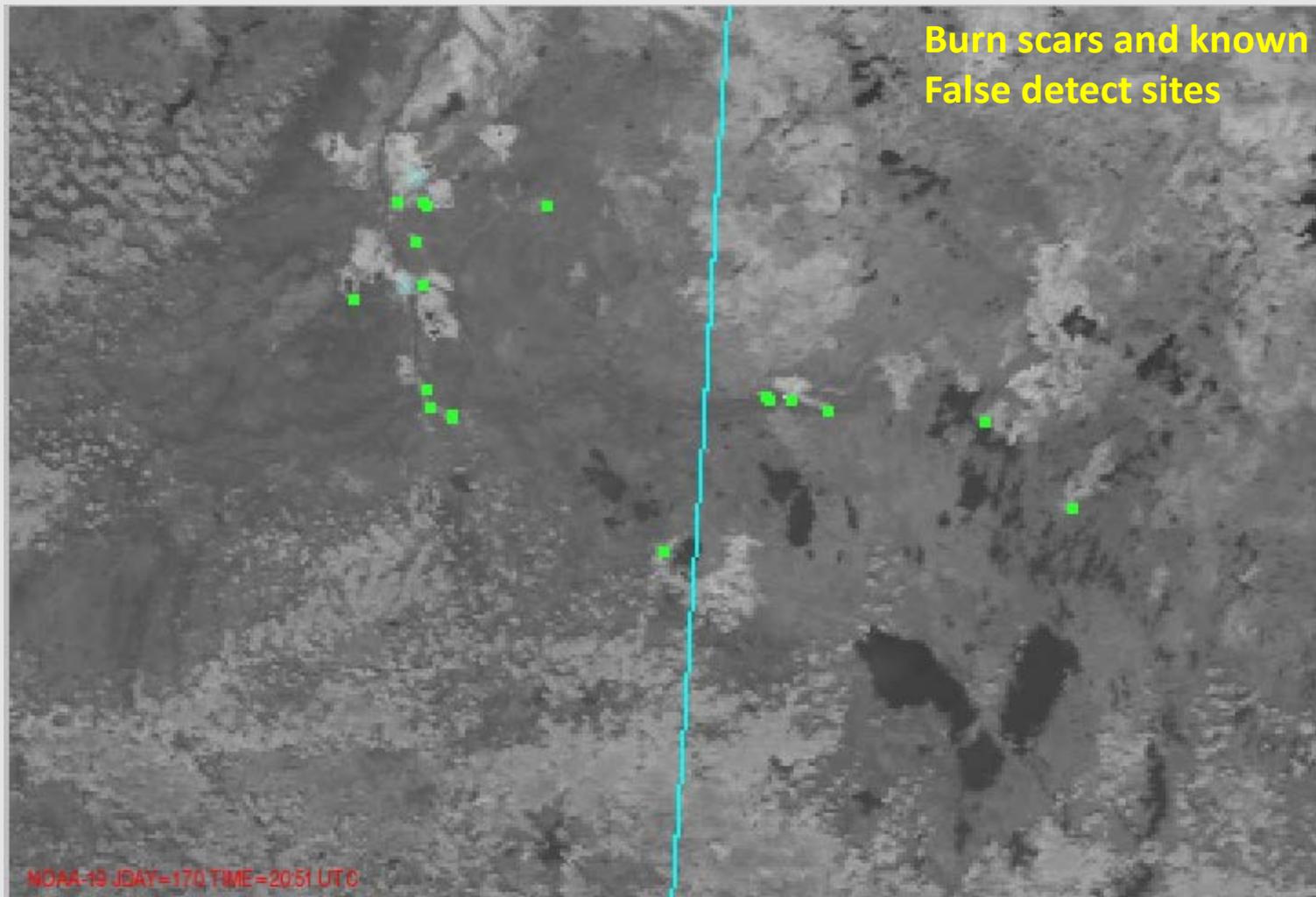


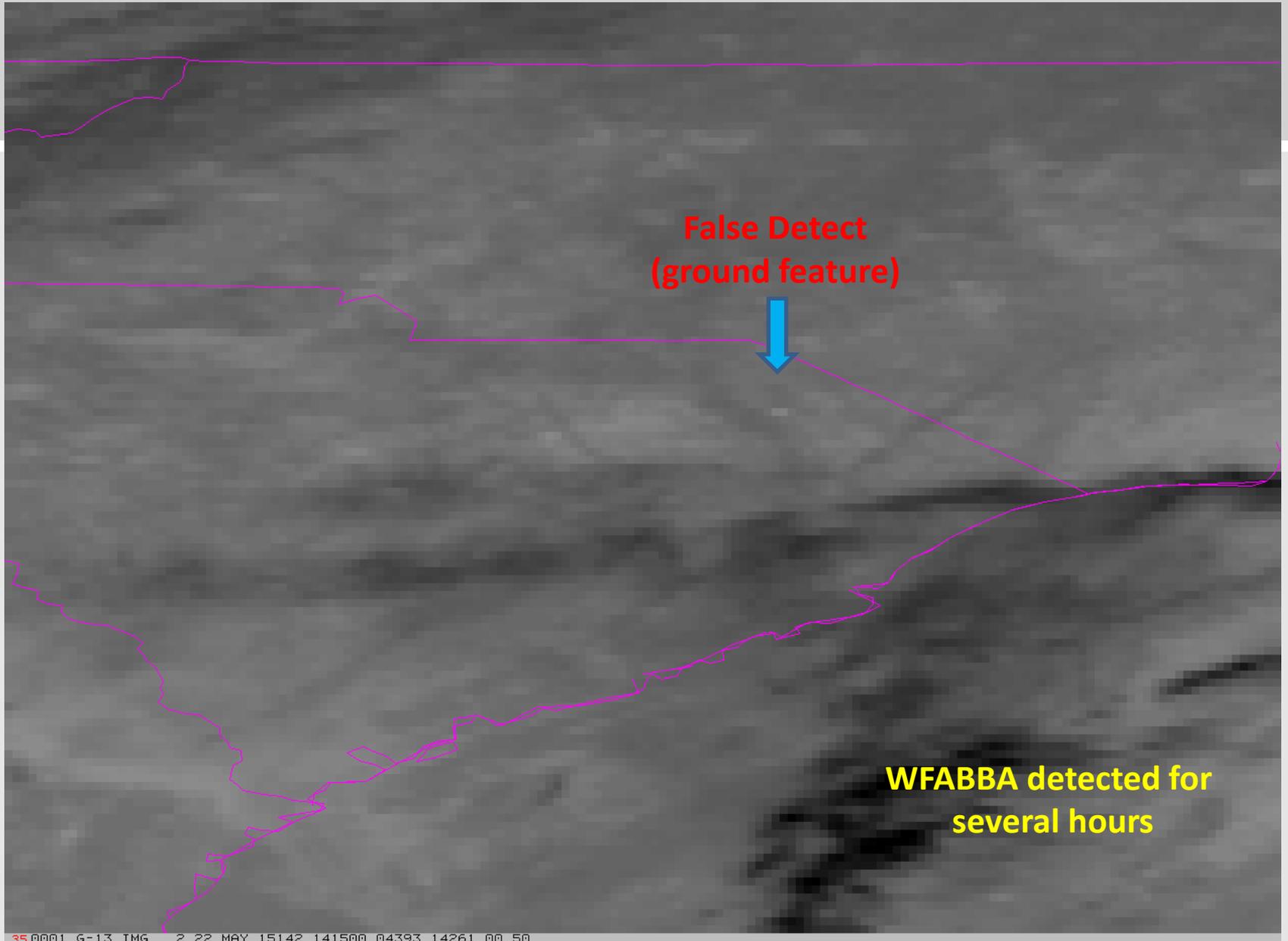
GOES-E VIS animation at corresponding time. Note smoke from fires in California.

There are a significant number of WFABBA false detects due to clouds near sunrise (from GOES-W) and sunset (from GOES-E)

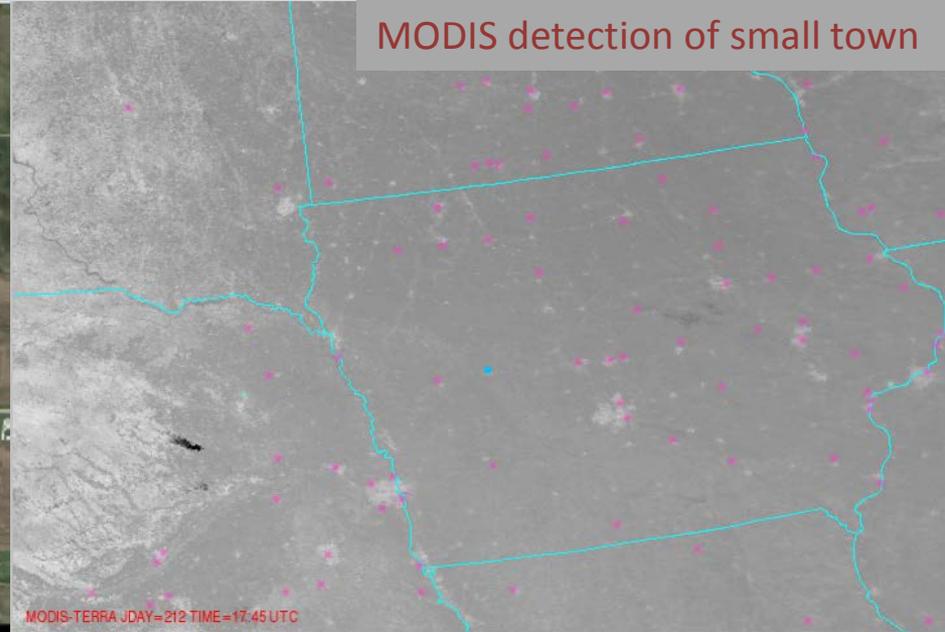
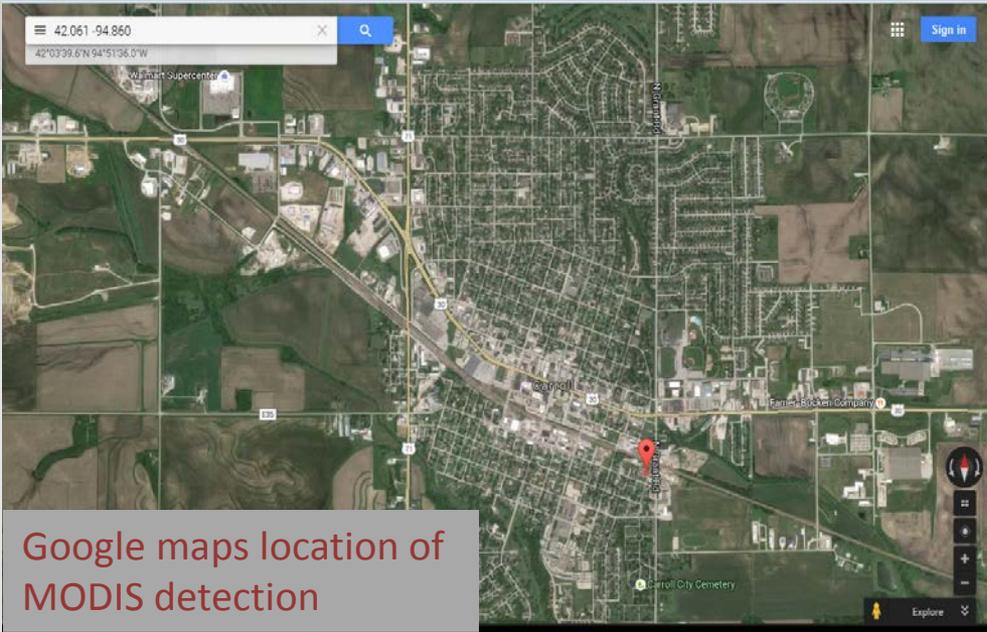
Problem is exacerbated during times of Rapid Scan Operations (RSO)

False Detects





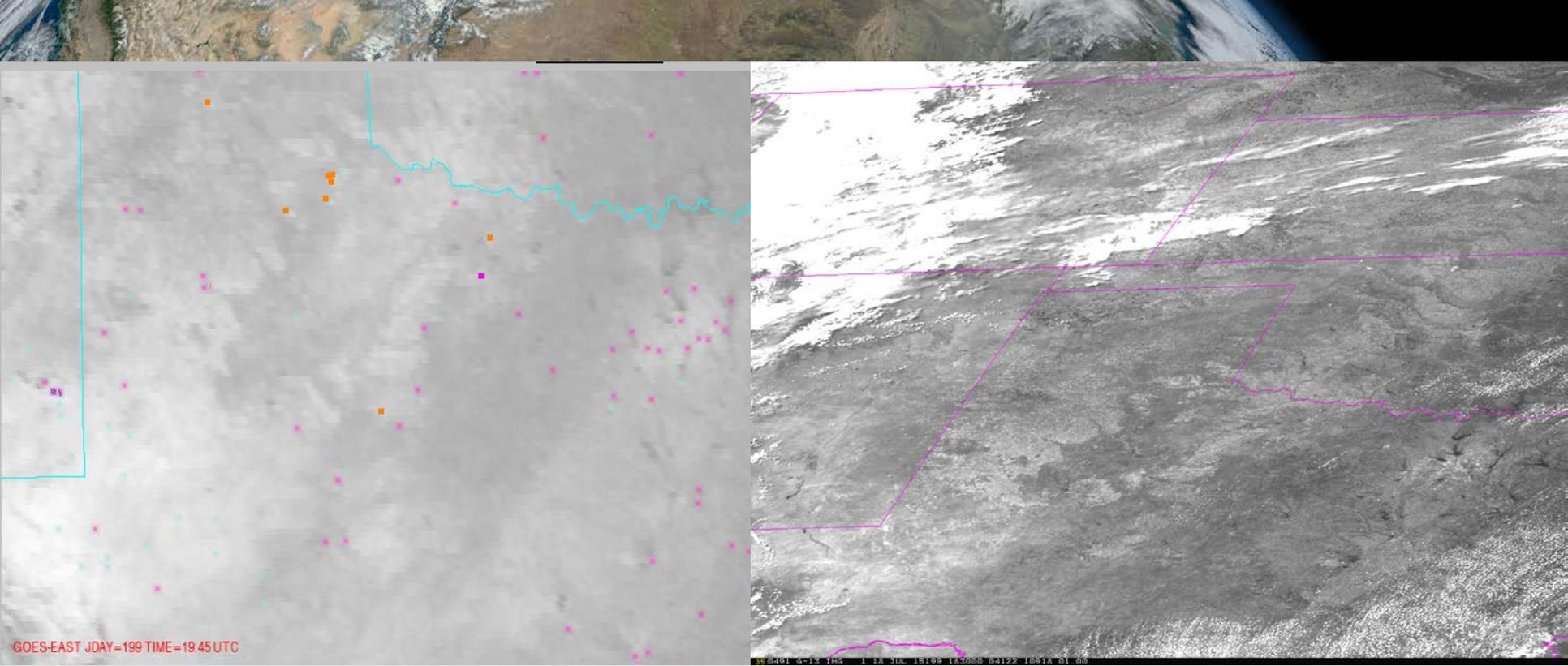
False Detects



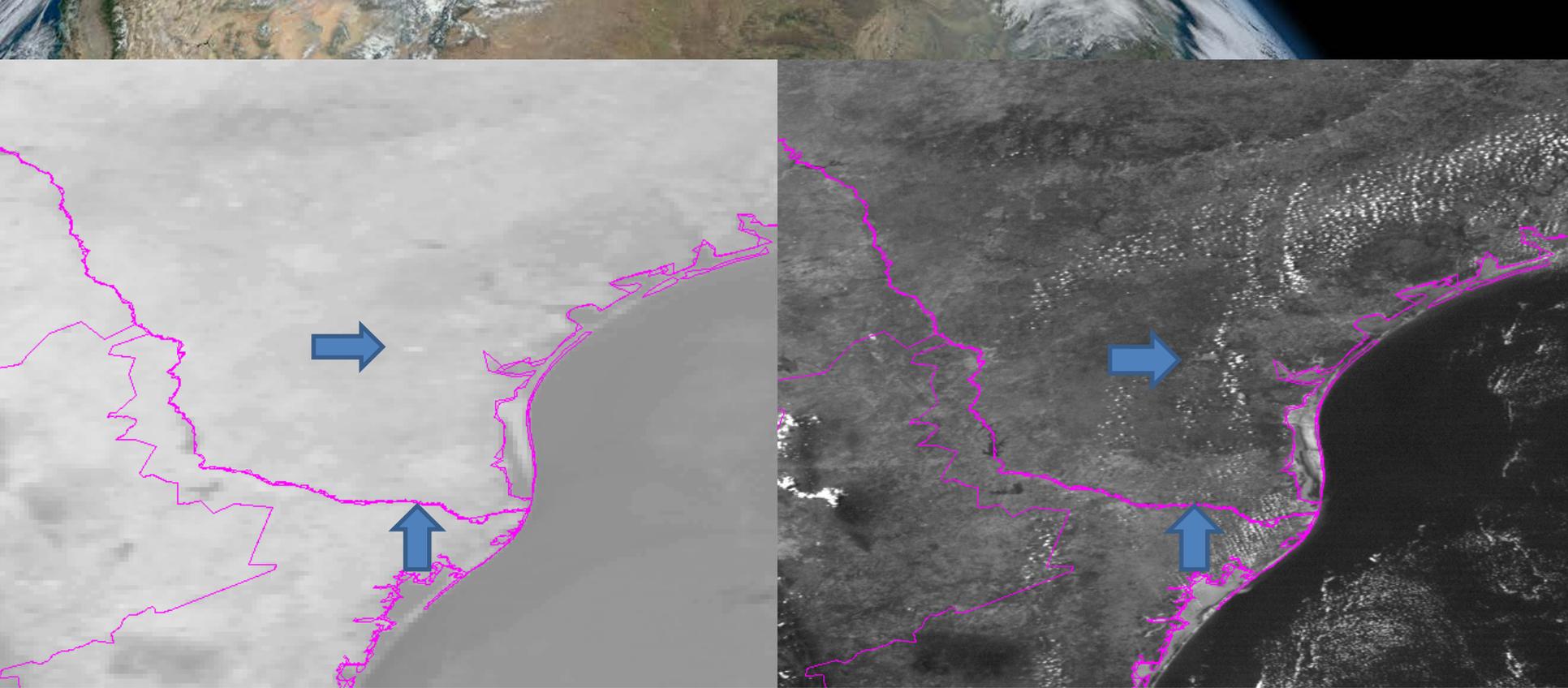
Numerous false detects due to industrial facilities, urban heat islands, shopping centers, solar panels, etc.

More numerous in warm season with higher background temperature and greater solar reflectivity



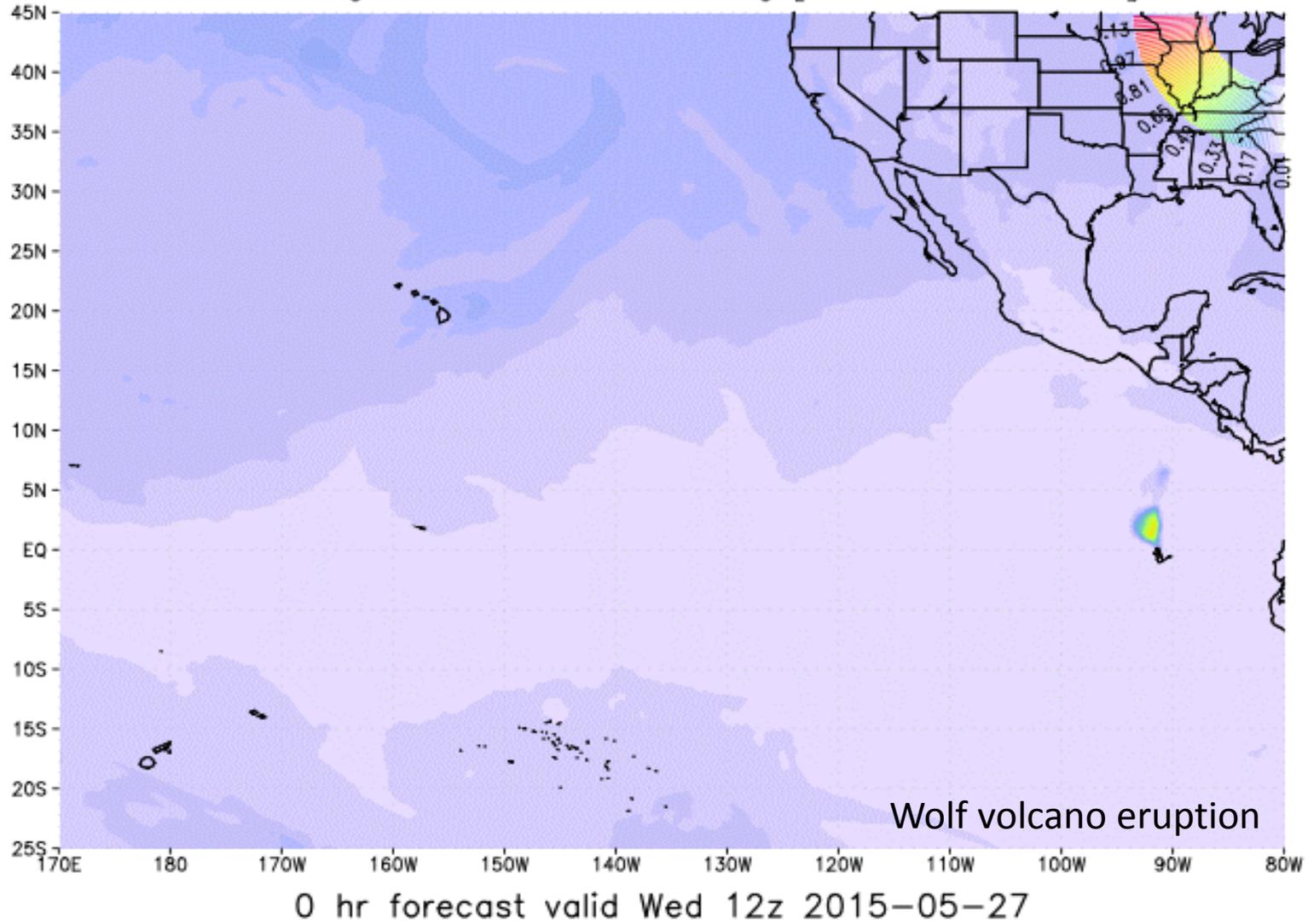


Multiple GOES false detects due to ground features

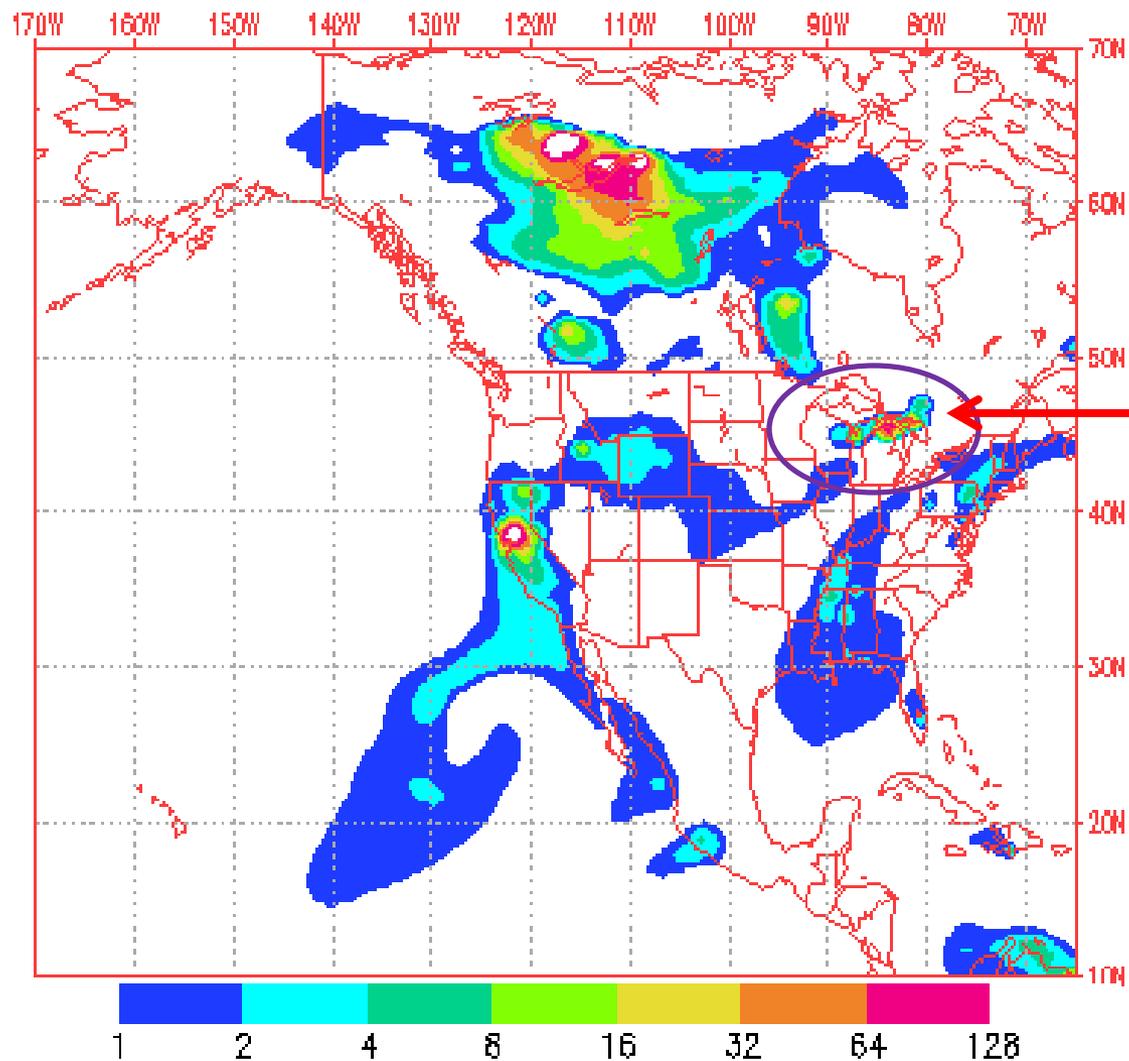


Actual fires with emissions can occur in proximity to false detect land features

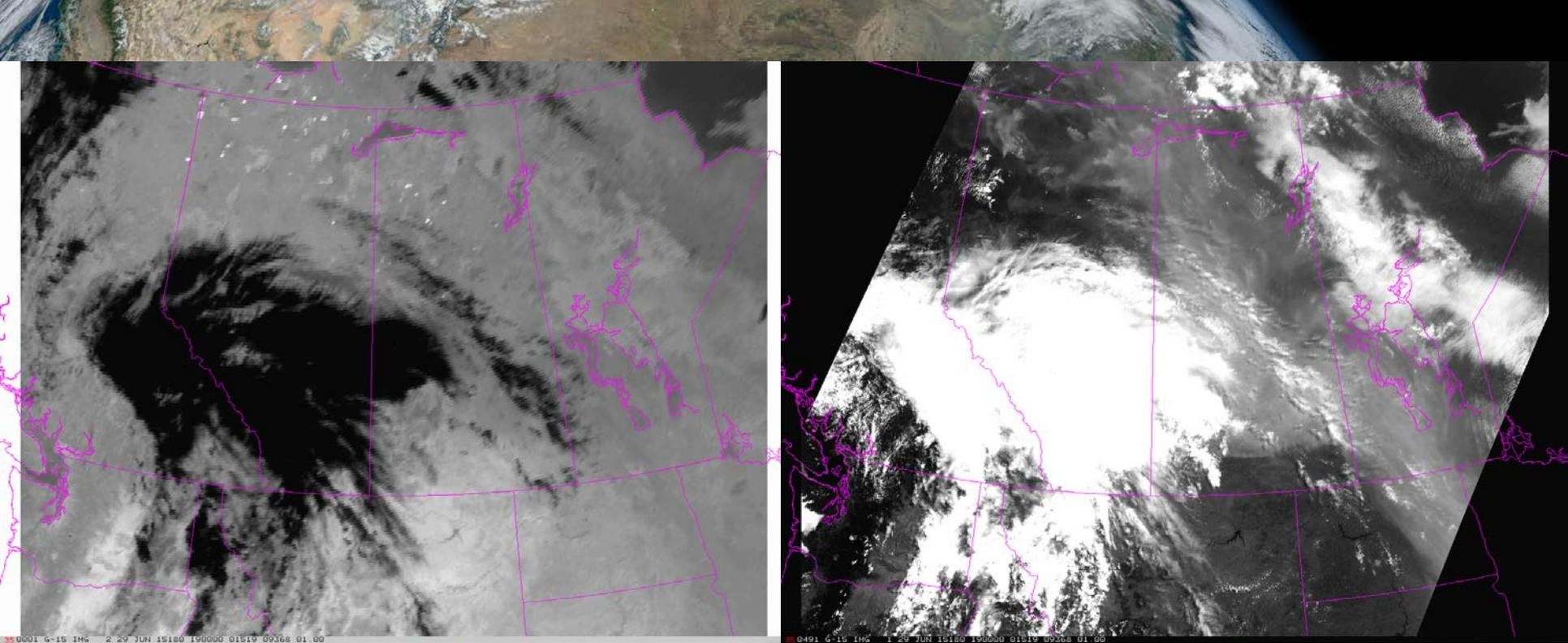
NASA/GMAO - GEOS-5 Forecast Initialized on 12z 2015-05-27
Other Regions CO Biomass Burning [10^{16} molecules cm^{-2}]



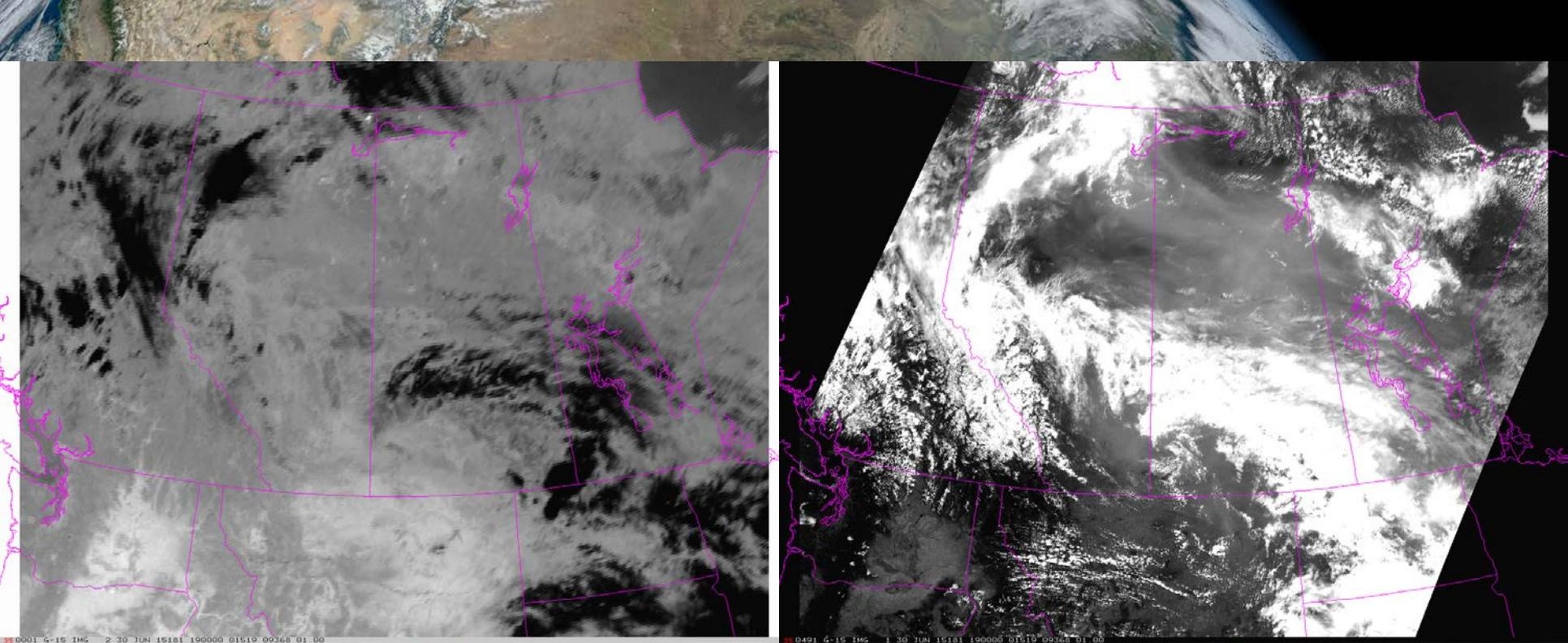
Smoke Surface Concentration ($\mu\text{g}/\text{m}^3$) for 2014070712



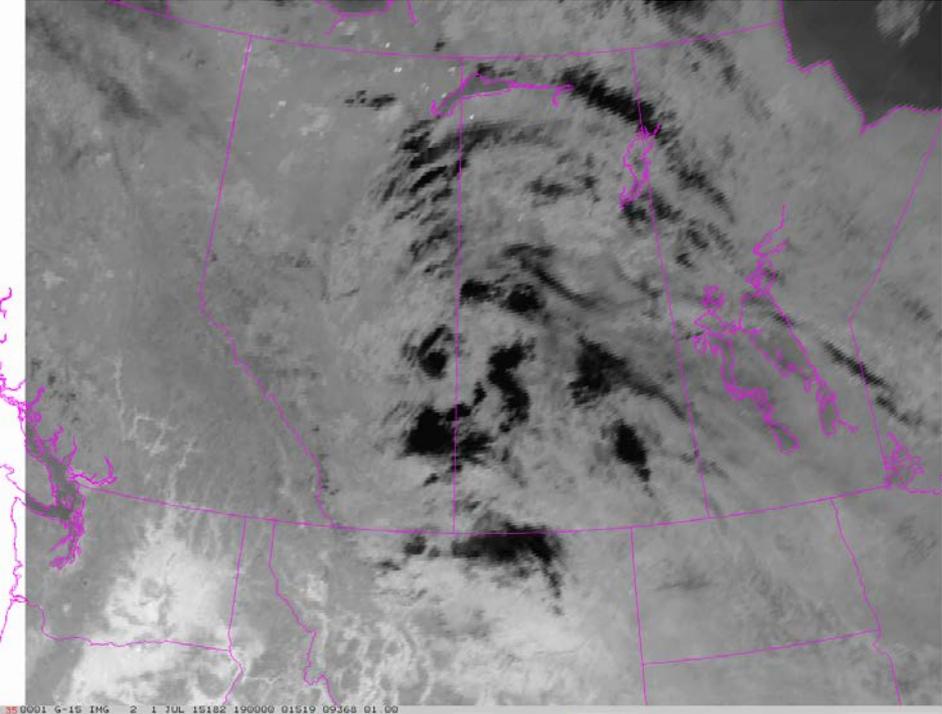
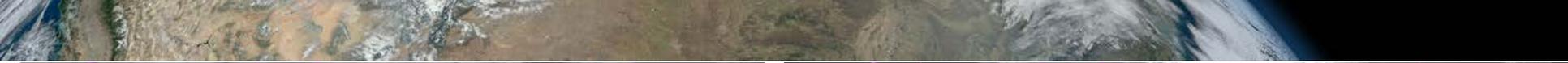
Smoke emissions
From spurious WFABBA
detects



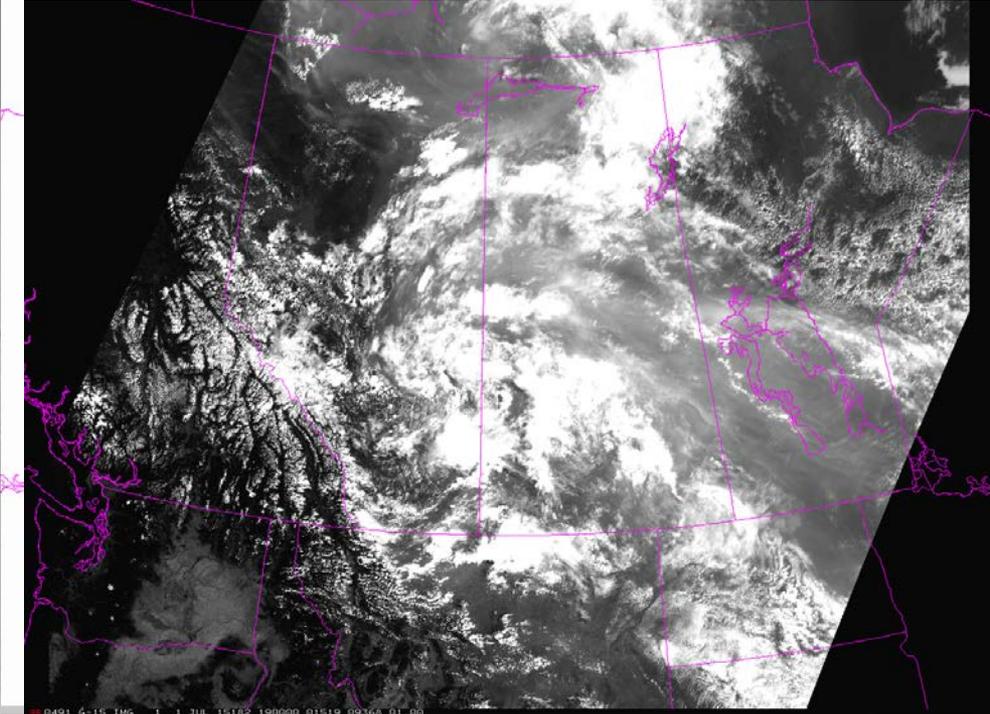
29 June 2015



30 June 2015

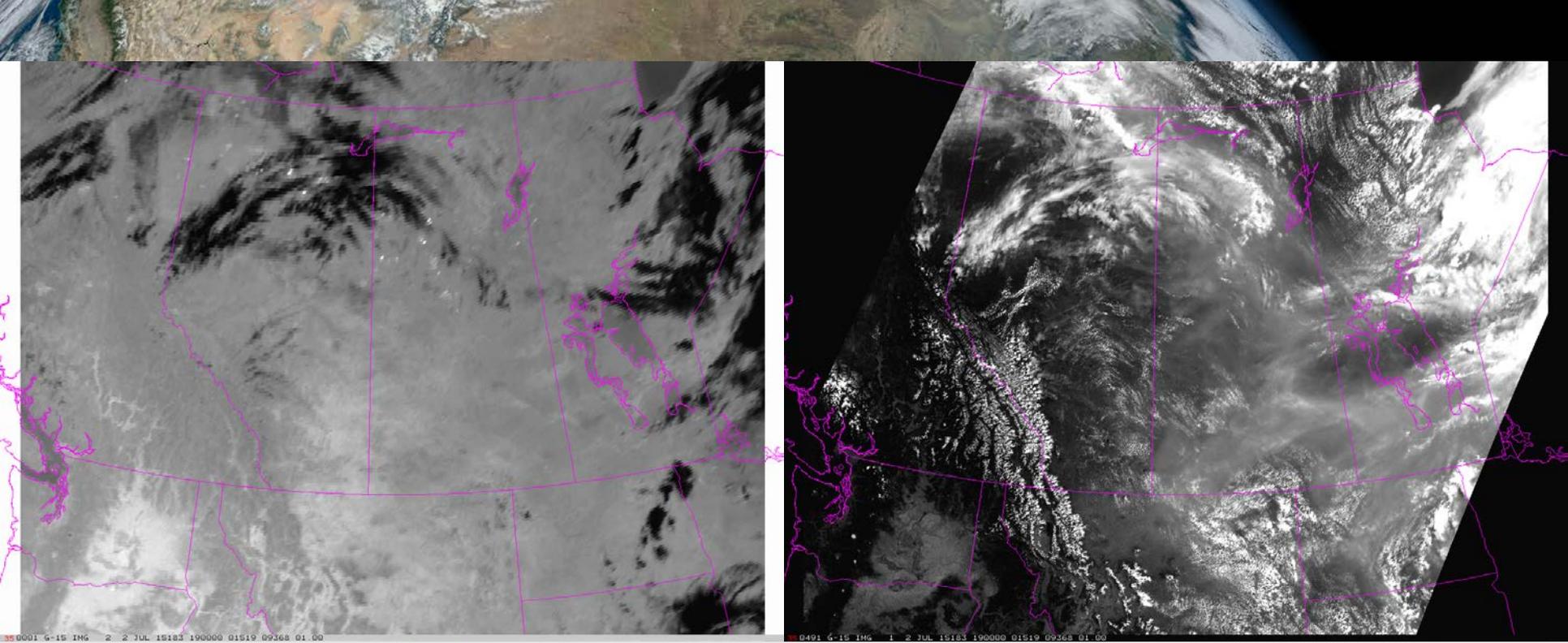


350001 6-15 IMG 2 1 JUL 15182 190000 01519 09368 01.00

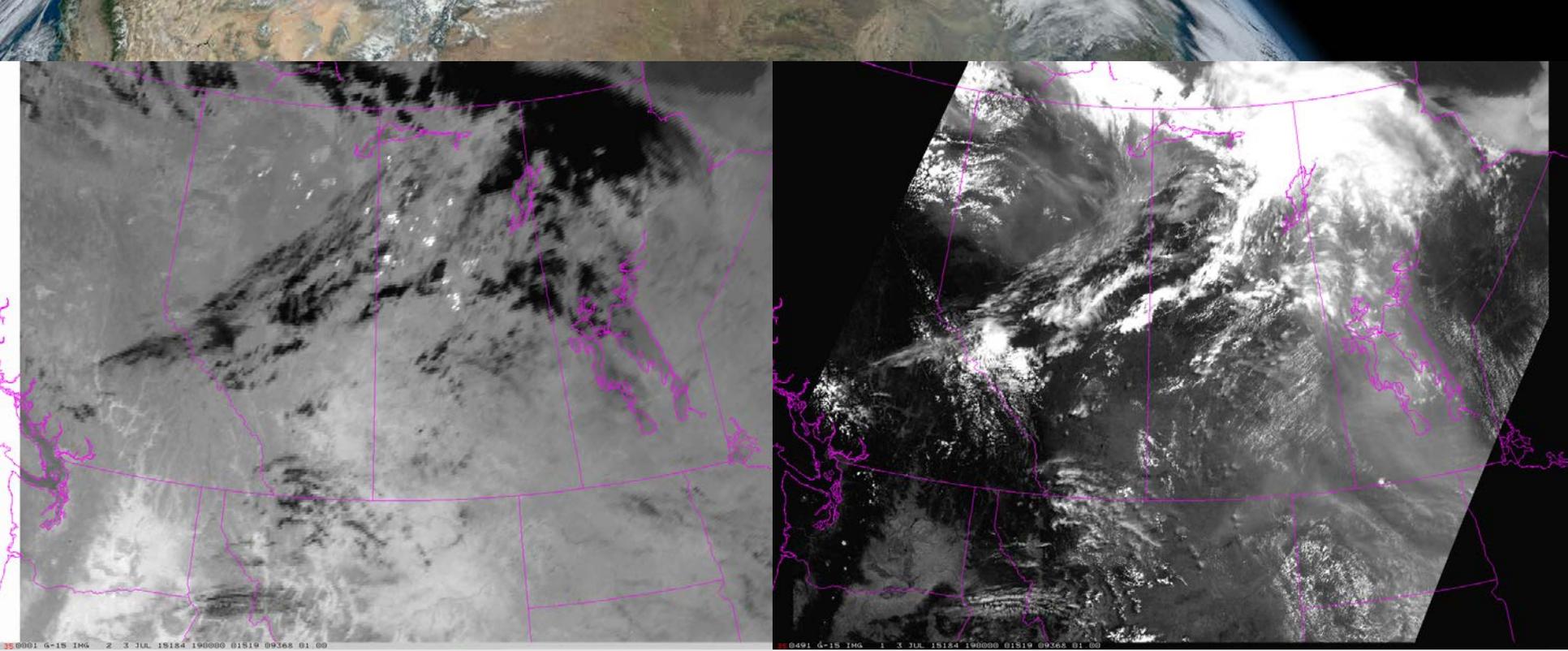


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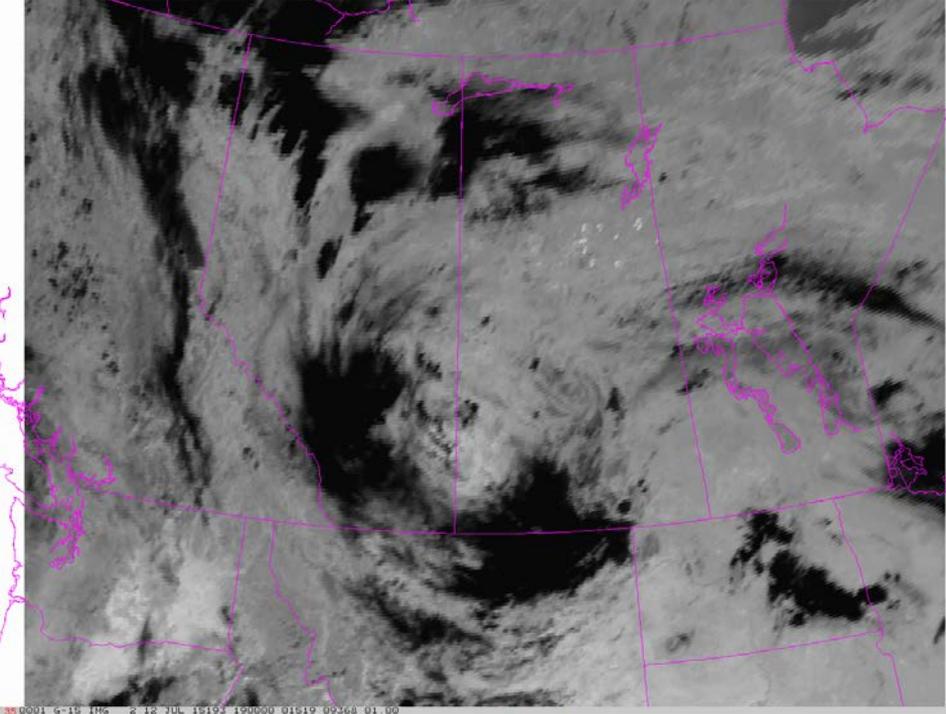
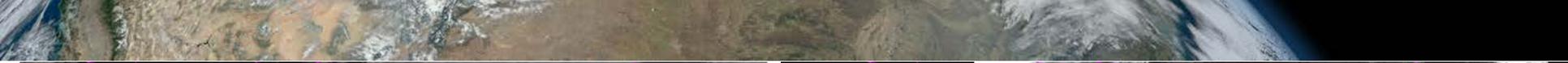
1 July 2015



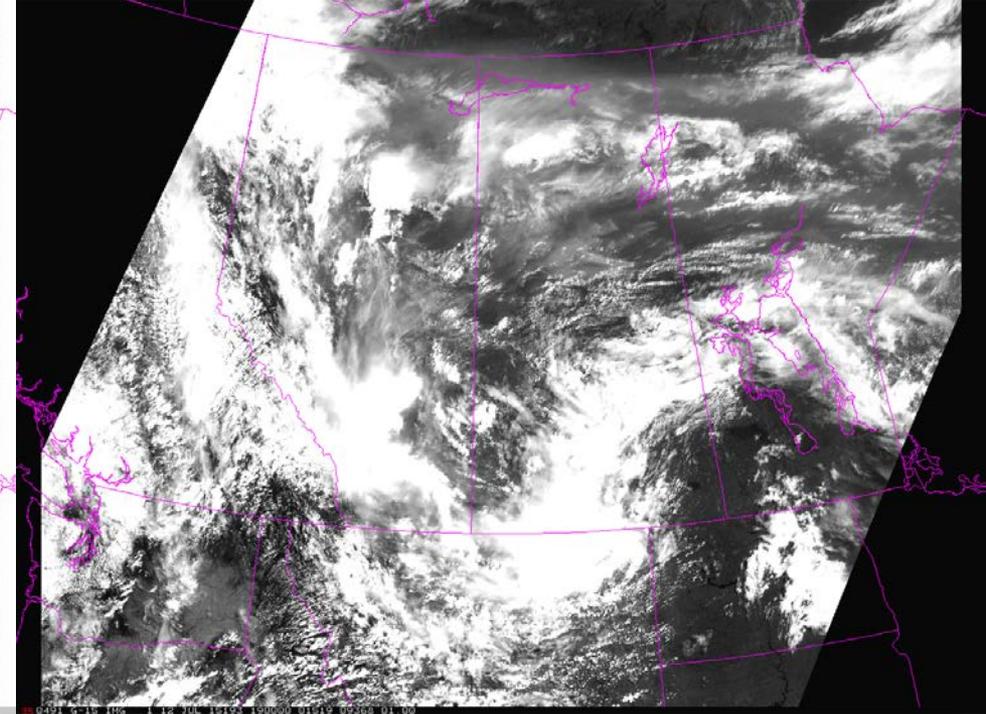
2 July 2015



3 July 2015

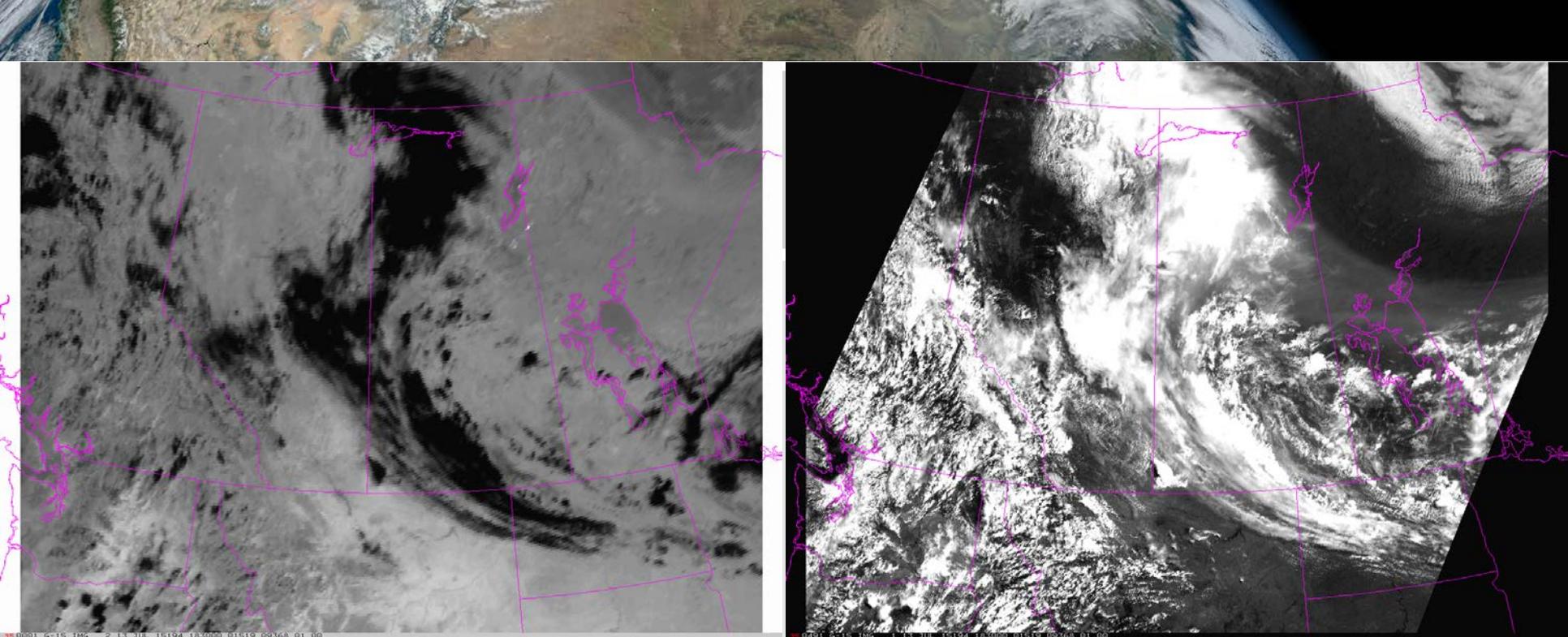


35 0001 6-15 146 2 12 JUL 15193 190000 01519 09368 01.00

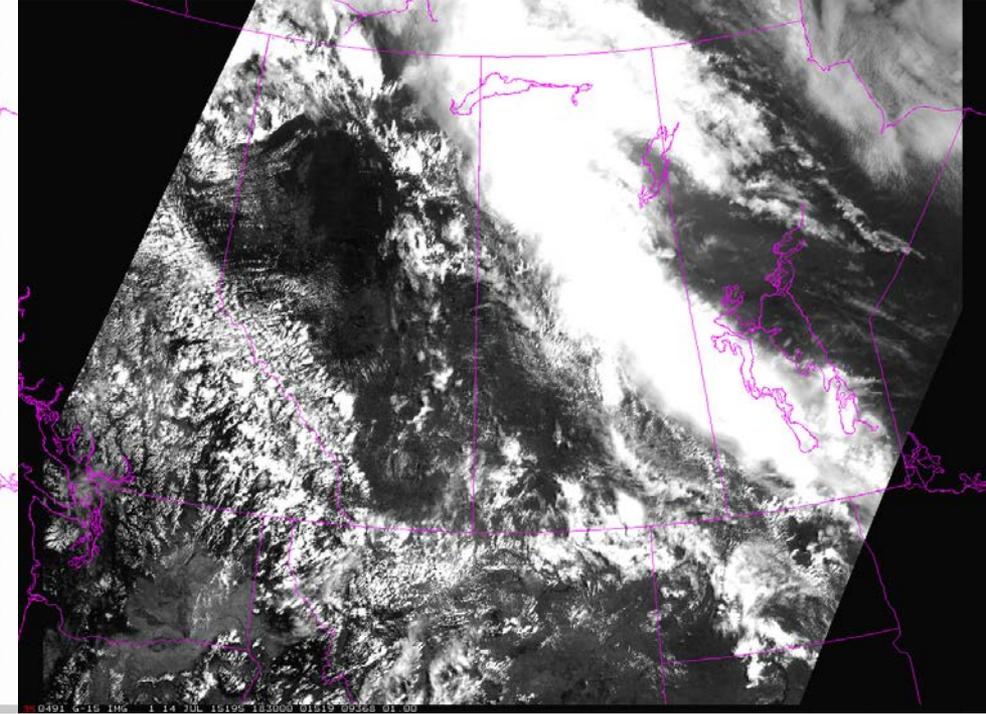
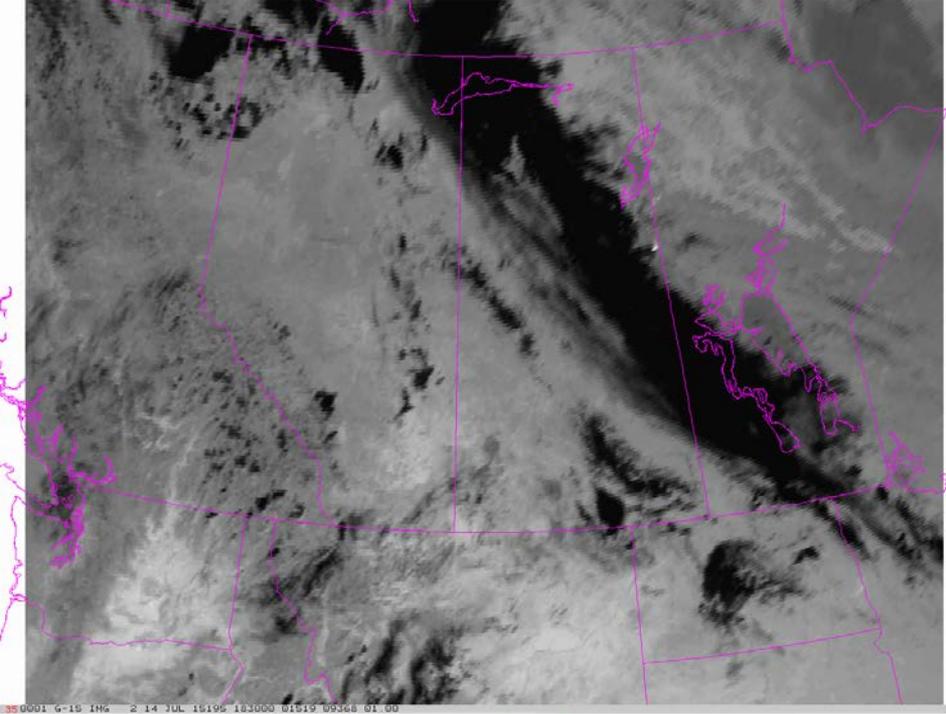
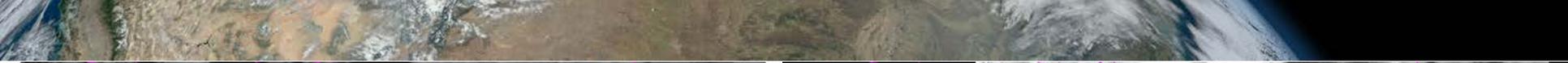


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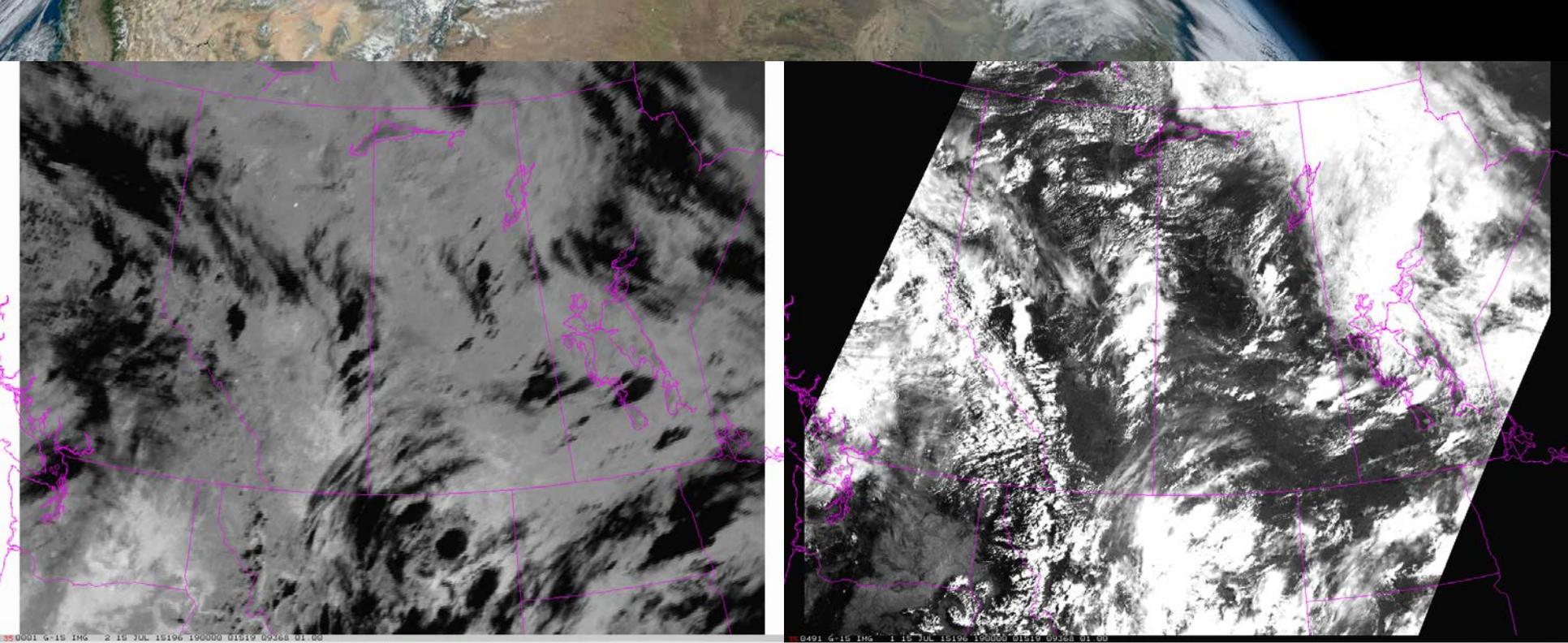
12 July 2015



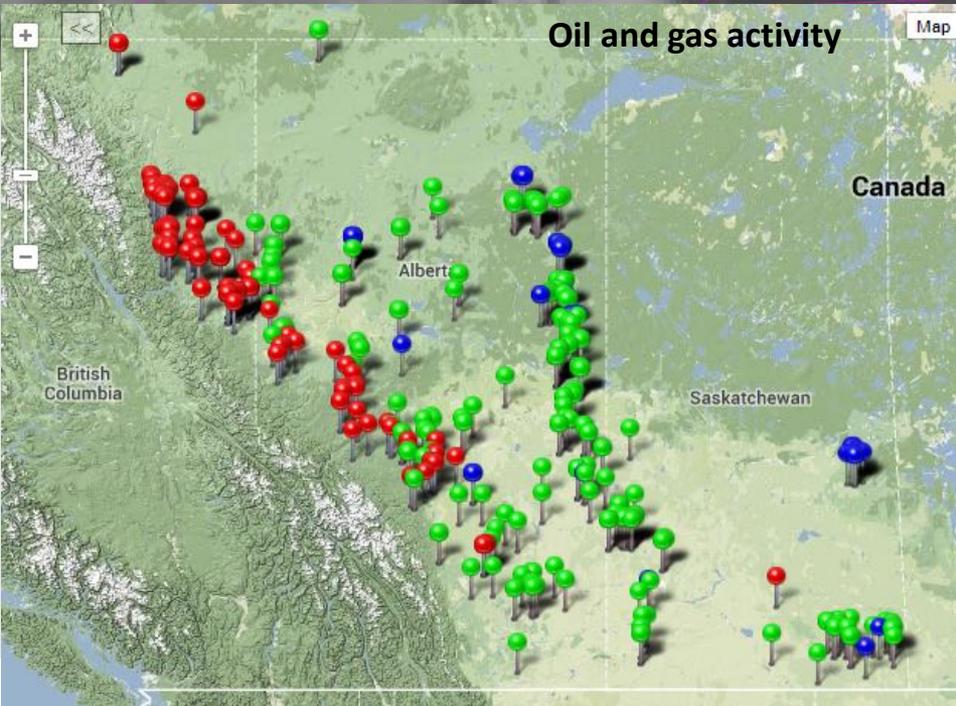
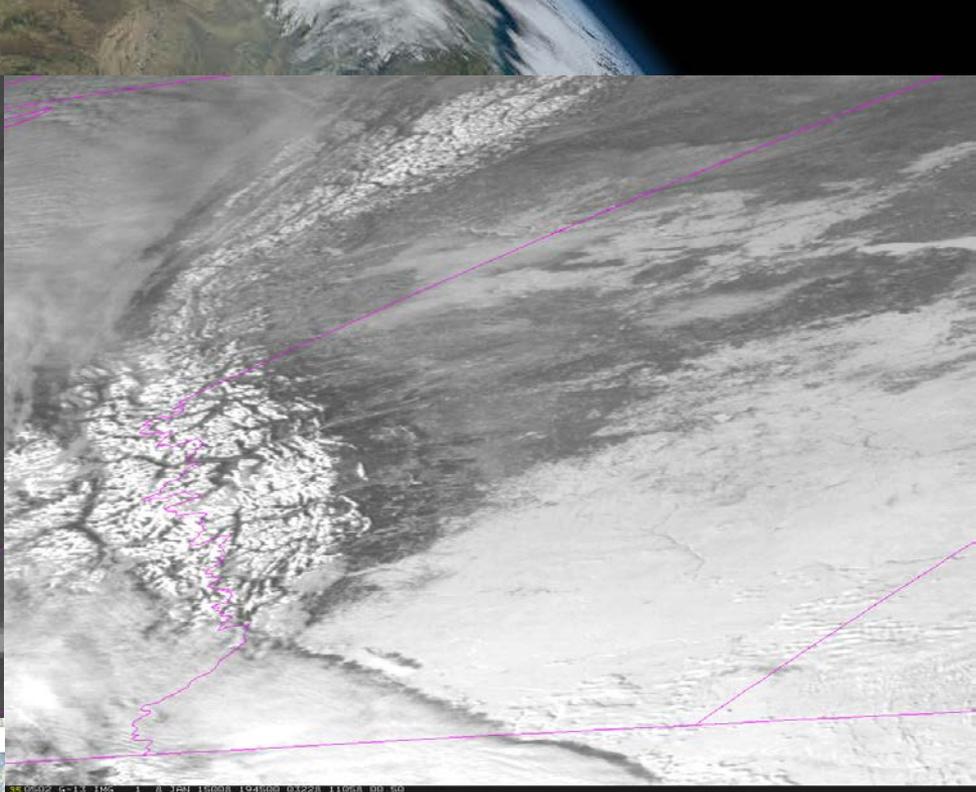
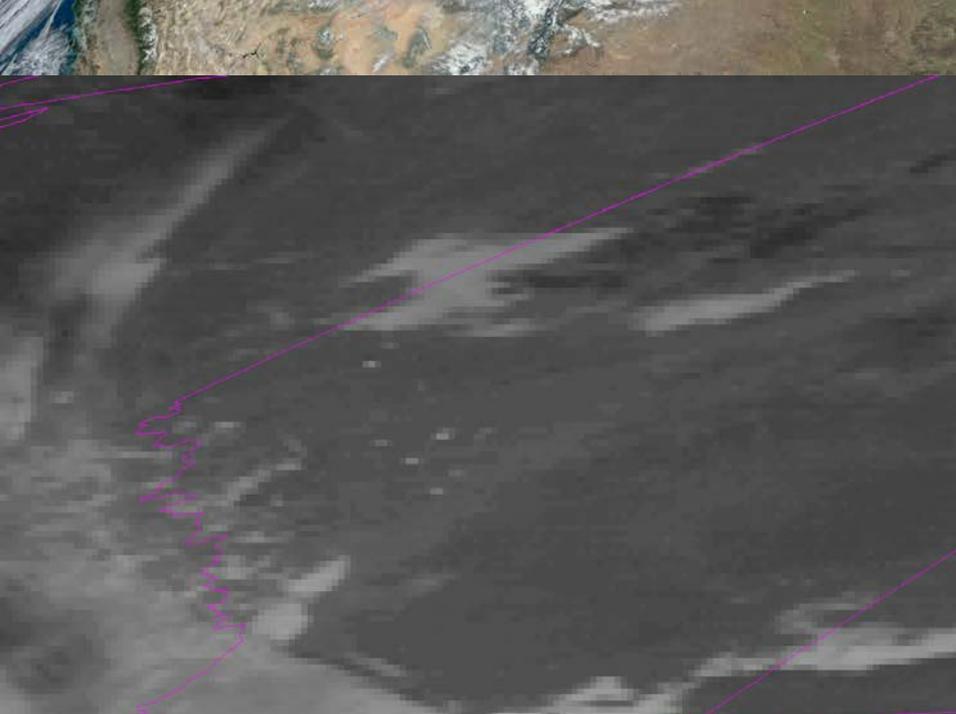
13 July 2015



14 July 2015



15 July 2015



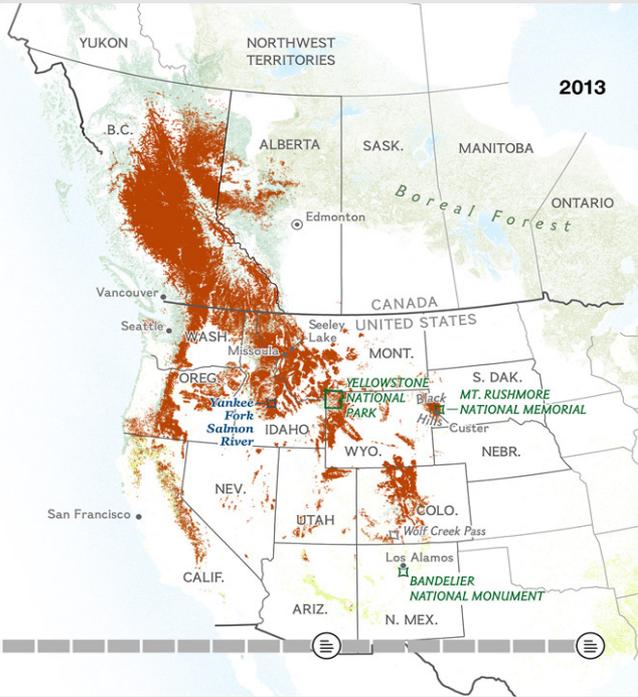
Are the hotspots due to gas flaring?

Or burning due to pine bark beetle?

Either way, smoke emissions much less than with wildfires



Source: National Geographic

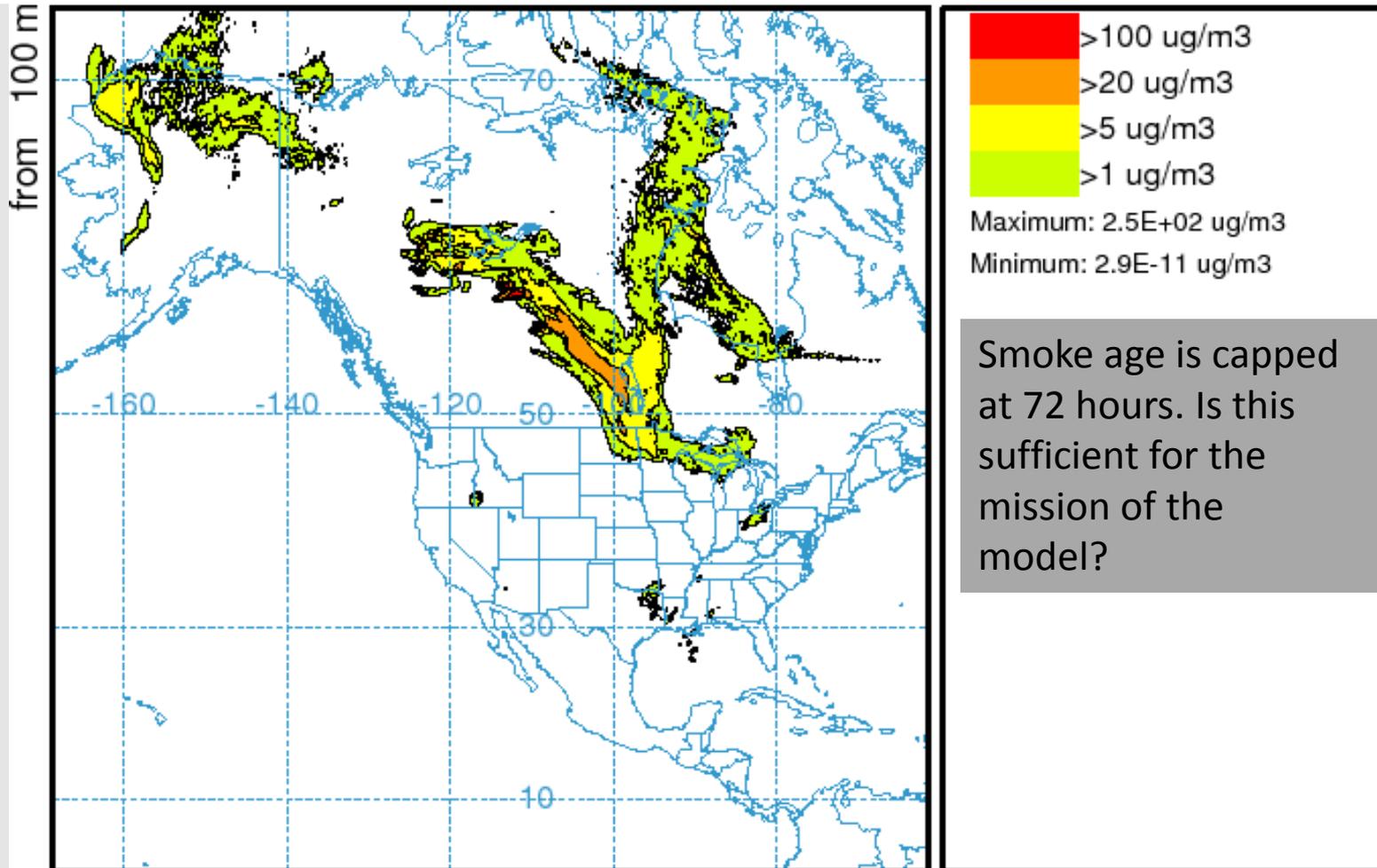


ARL/NESDIS EXPERIMENTAL SMOKE FORECAST

Air Concentration (ug/m³) Layer Average 0 m and 5000 m

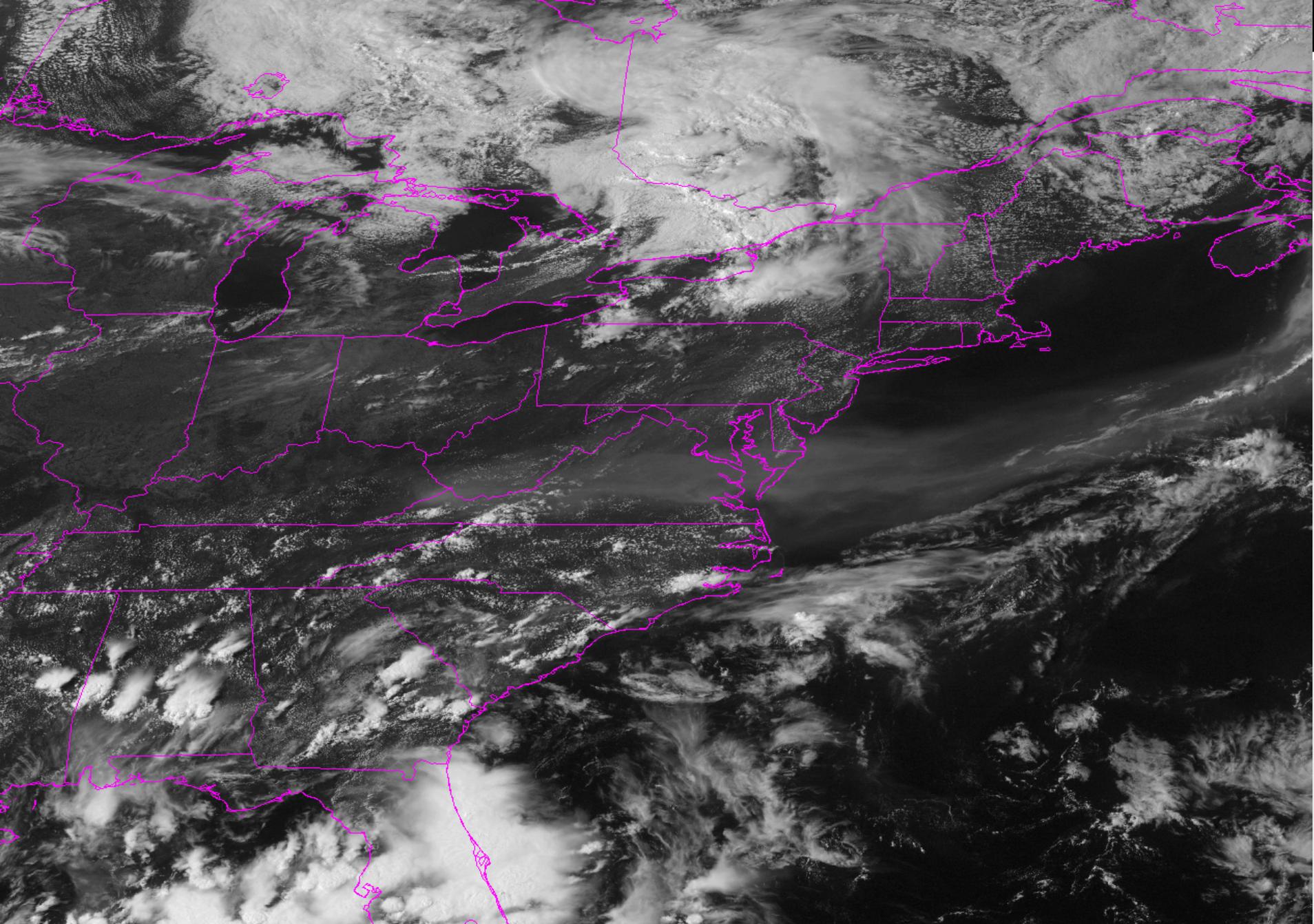
Integrated from 0600 08 Jun to 0700 08 Jun 15 (UTC)

PM25 Release started at 0600 08 Jun 15 (UTC)

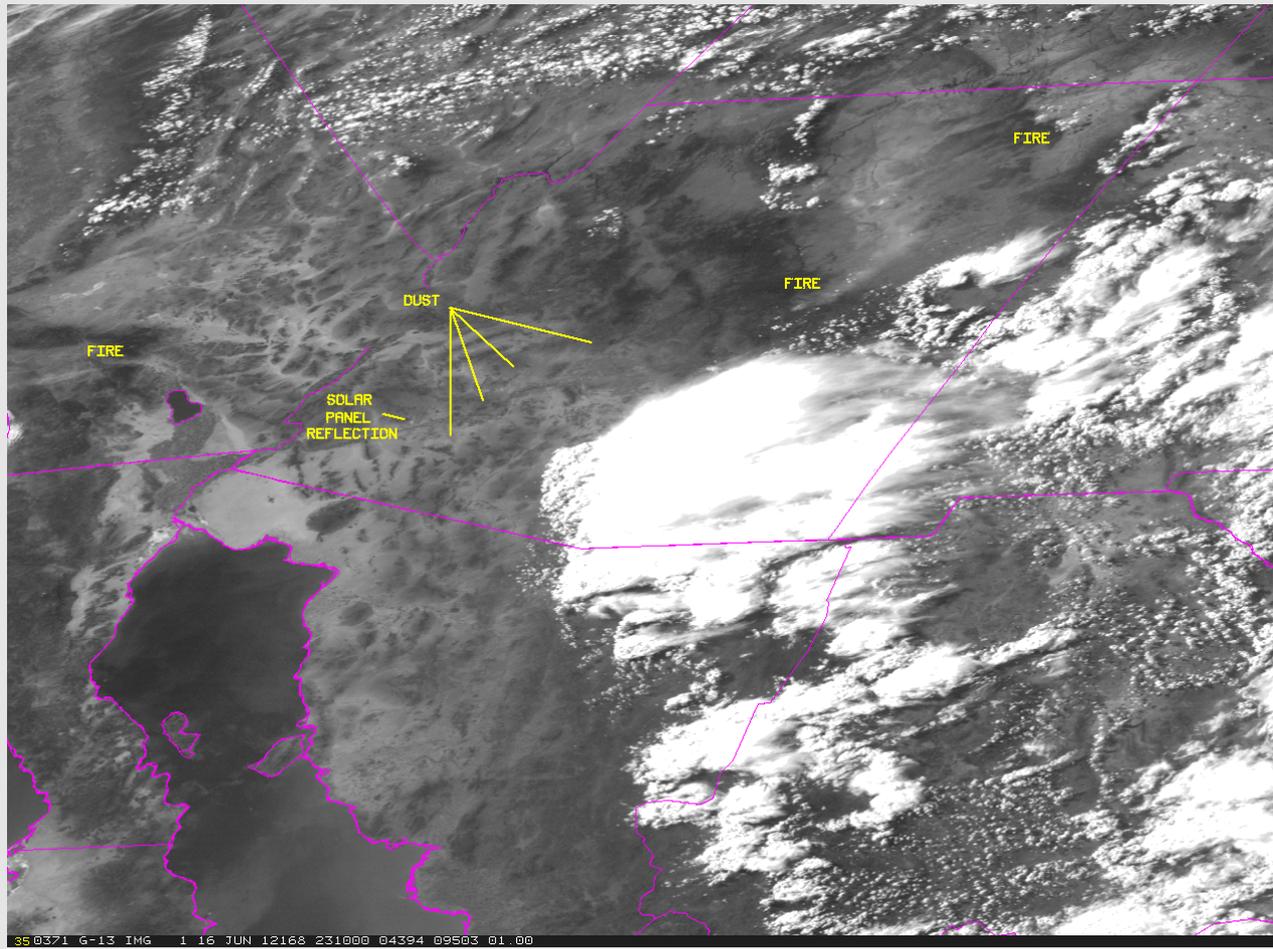
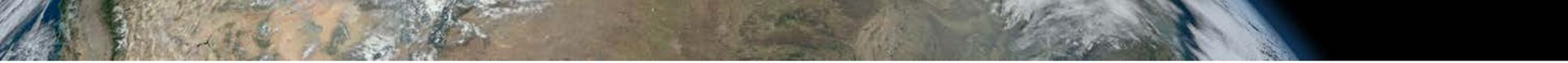


Smoke age is capped at 72 hours. Is this sufficient for the mission of the model?

NAMS METEOROLOGICAL DATA



35 0503 G-13 IMG 1 10 JUN 15161 201500 03364 13016 02.00





THANK YOU

QUESTIONS OR COMMENTS?