Special OFCM Session 3

DTRA Modeling for Smoke, Dust, Volcanic Ash

1. *Calbuco Volcano Eruption in Chile*
2. *Crude Oil Fire in La Crosse, WI*

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DTRA Reachback Division

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Summary of Volcano Parameters

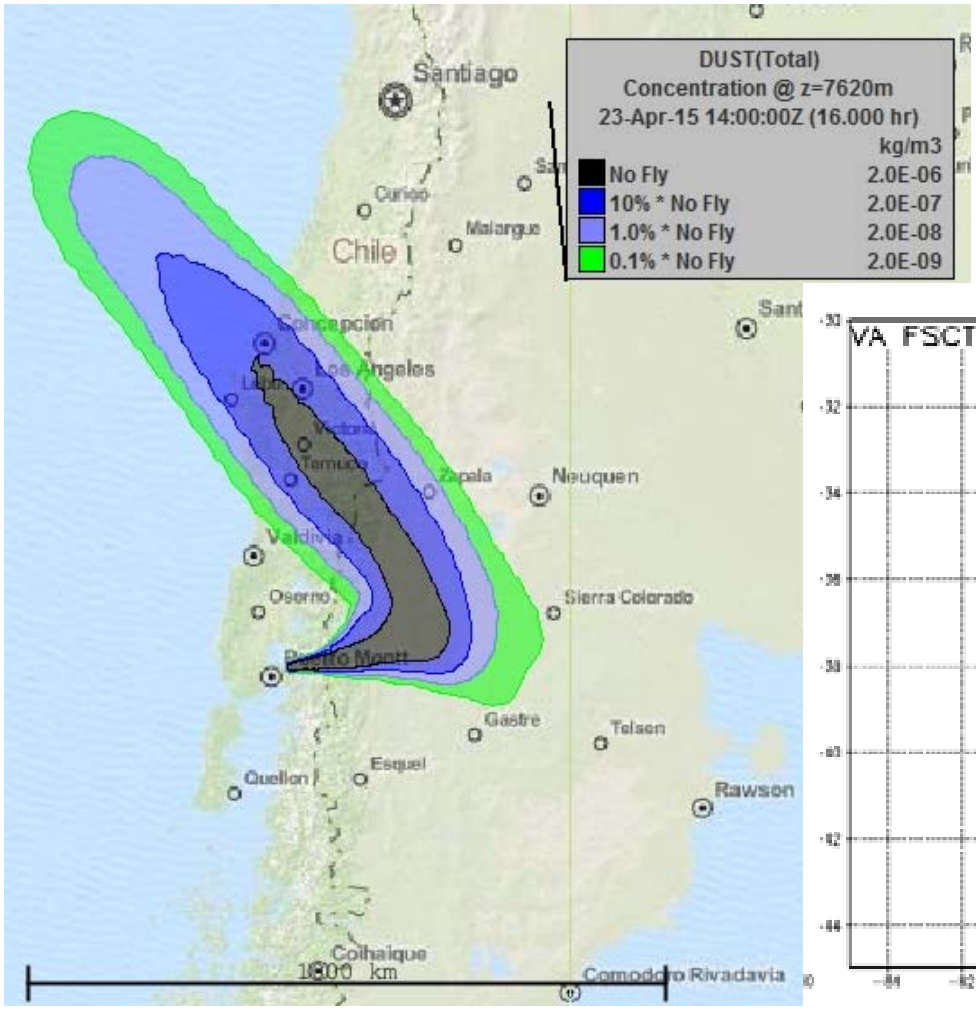
- **(U) Volcano Details**
  - **Calbuco is classified as an stratovolcano of eruption classification S2 by the Smithsonian Volcanoes of the World Atlas.**
  - **Altitude of the volcano is ~ 1500 meters**
  - **According to the USGS Open File Report 2009-1133 (*Preliminary Spreadsheet of Eruption Source Parameters for Volcanoes of the World*), an S2 eruption generally has the following characteristics:**
    - **Approximately 11 km plume height (above volcano source)**
    - **A mass flow rate of about 1E5 kg/s for fine particles**
    - **Mean aerodynamic size of particles of 20 microns with lognormal sigma of 2**
    - **Assumed volcano eruption lasted 24 hours**
    - **Note: All of the above values should be taken as extremely approximate or (in case of duration of eruption) a guess about the future.**

Comparison of Effects

- **(U) Comparison**
  - **Outputs were compared at nearest available time in HPAC run with nearest available output time from the Buenos Aires Volcanic Ash Advisory Center (note: output times do not match up perfectly)**
  - **Volcanic Ash Advisory Center is the official guidance for air travel as it relates to volcanic ash. Reachback modeling does not supersede the legal authority of the VAAC as the official model of the ash effects.**
- **(U) Outputs**
  - **Concentration outputs are based on official no fly criterion for air flight (2 mg/m^3), with 10%, 1%, and 0.1% of the threshold concentration also shown.**
  - **Horizontal outputs of concentration are shown at 25,000 ft. Vertical cross-sections are also provided to show behavior at altitude.**
  - **VAAC outputs show (red box) forbidden flight locations for the listed time period.**

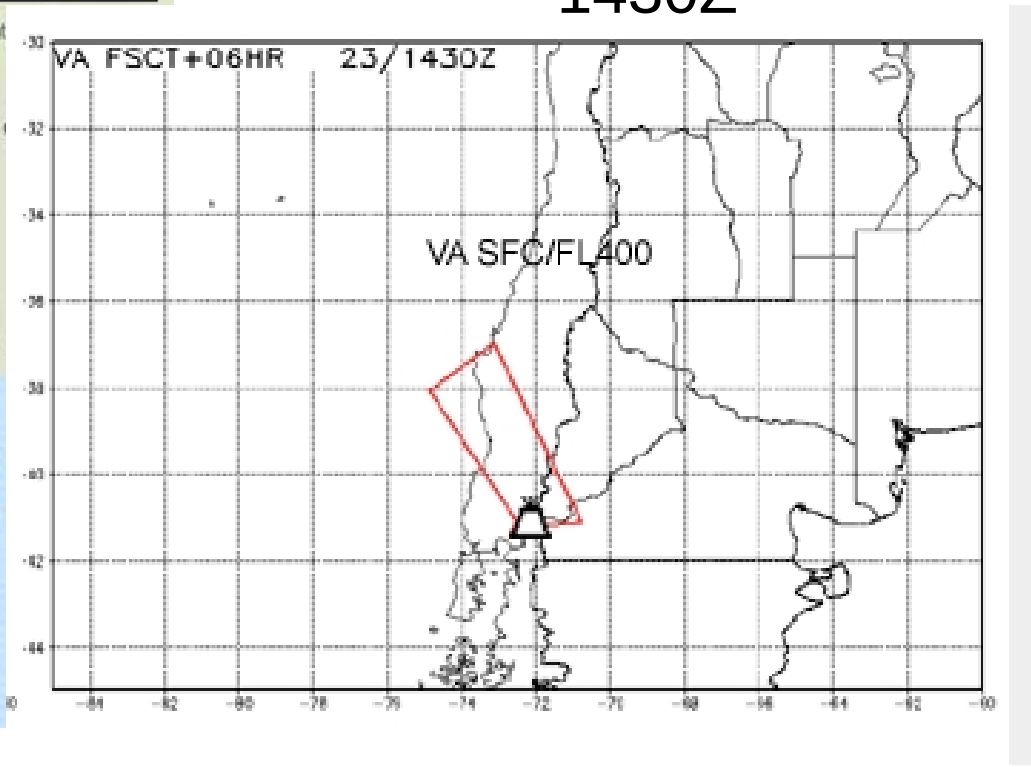
Comparison VAAC and HPAC; 1400Z 23APR2015

1400Z



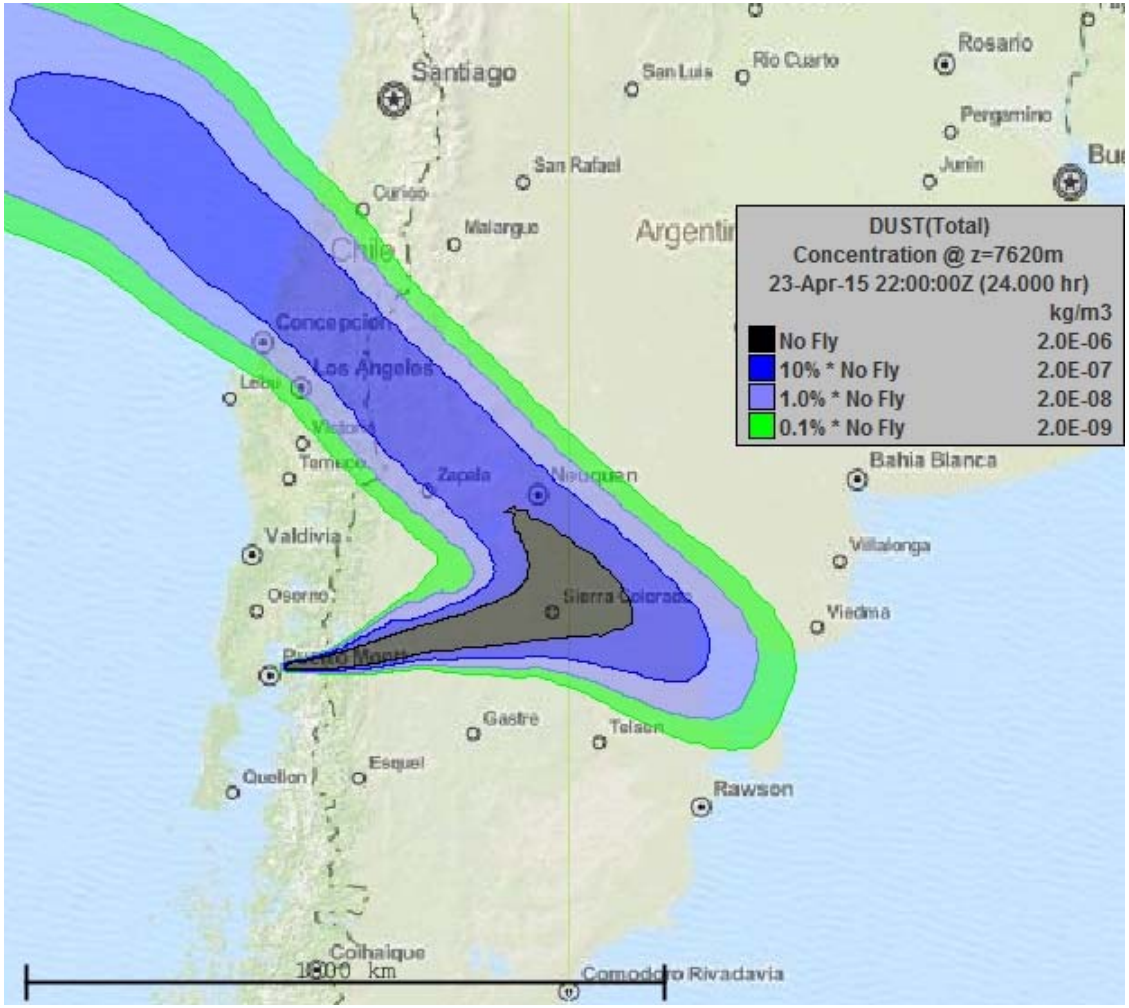
Note: Comparison between two methods give very consistent results. Reachback modeling does not supersede legal authority of the VAAC, which is the official guidance on air flight restrictions.

1430Z



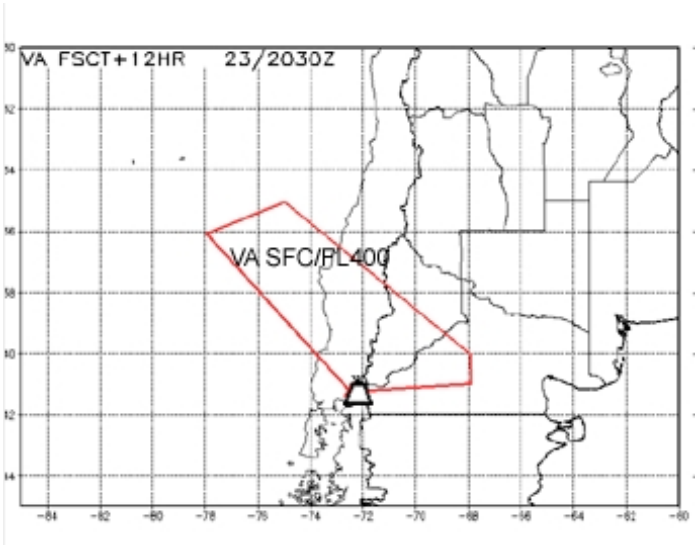
Comparison VAAC and HPAC; 2200Z 23APR2015

2200Z

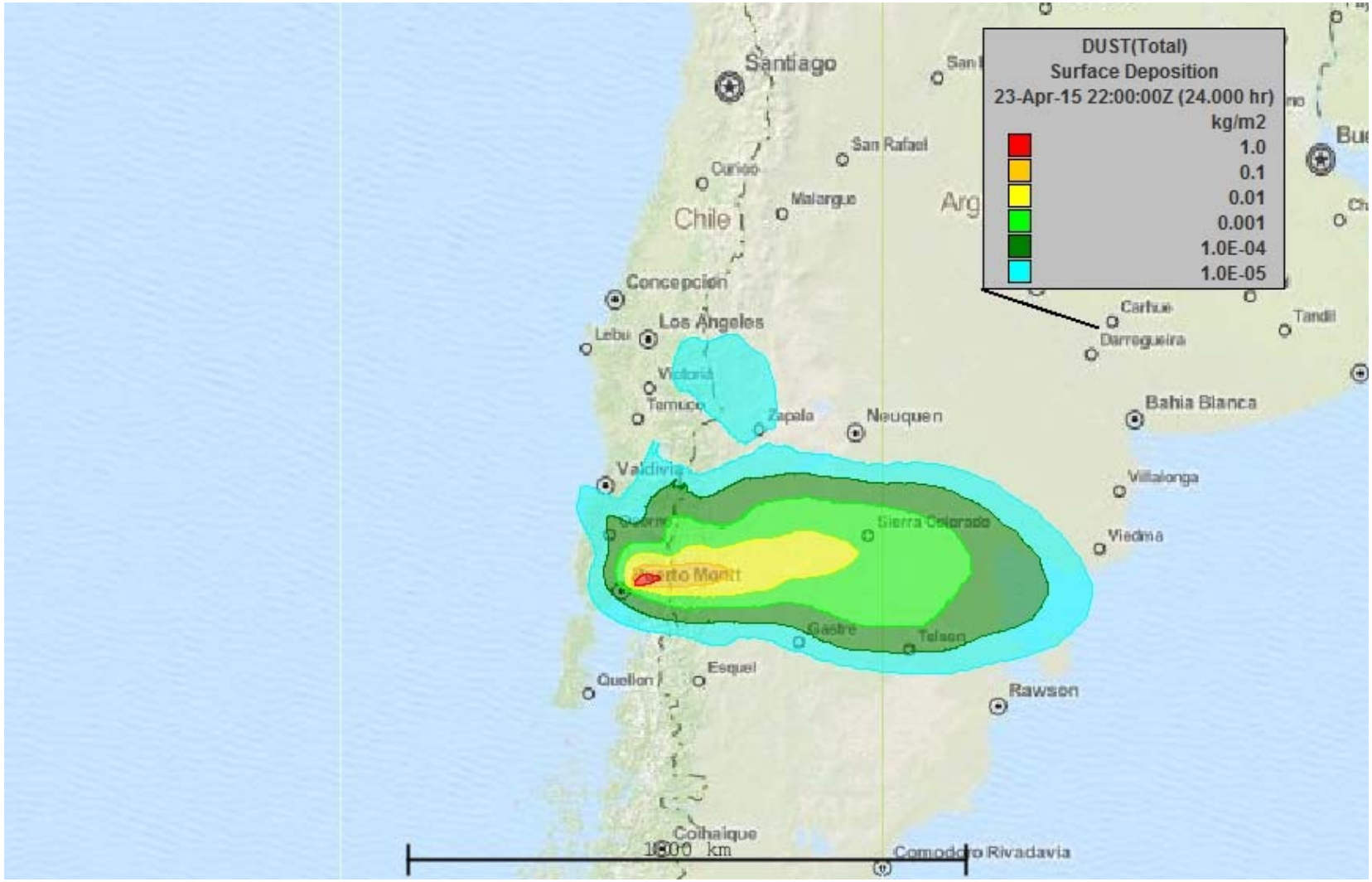


Note: Comparison between two methods give very consistent results. Reachback modeling does not supersede legal authority of the VAAC, which is the official guidance on air flight restrictions.

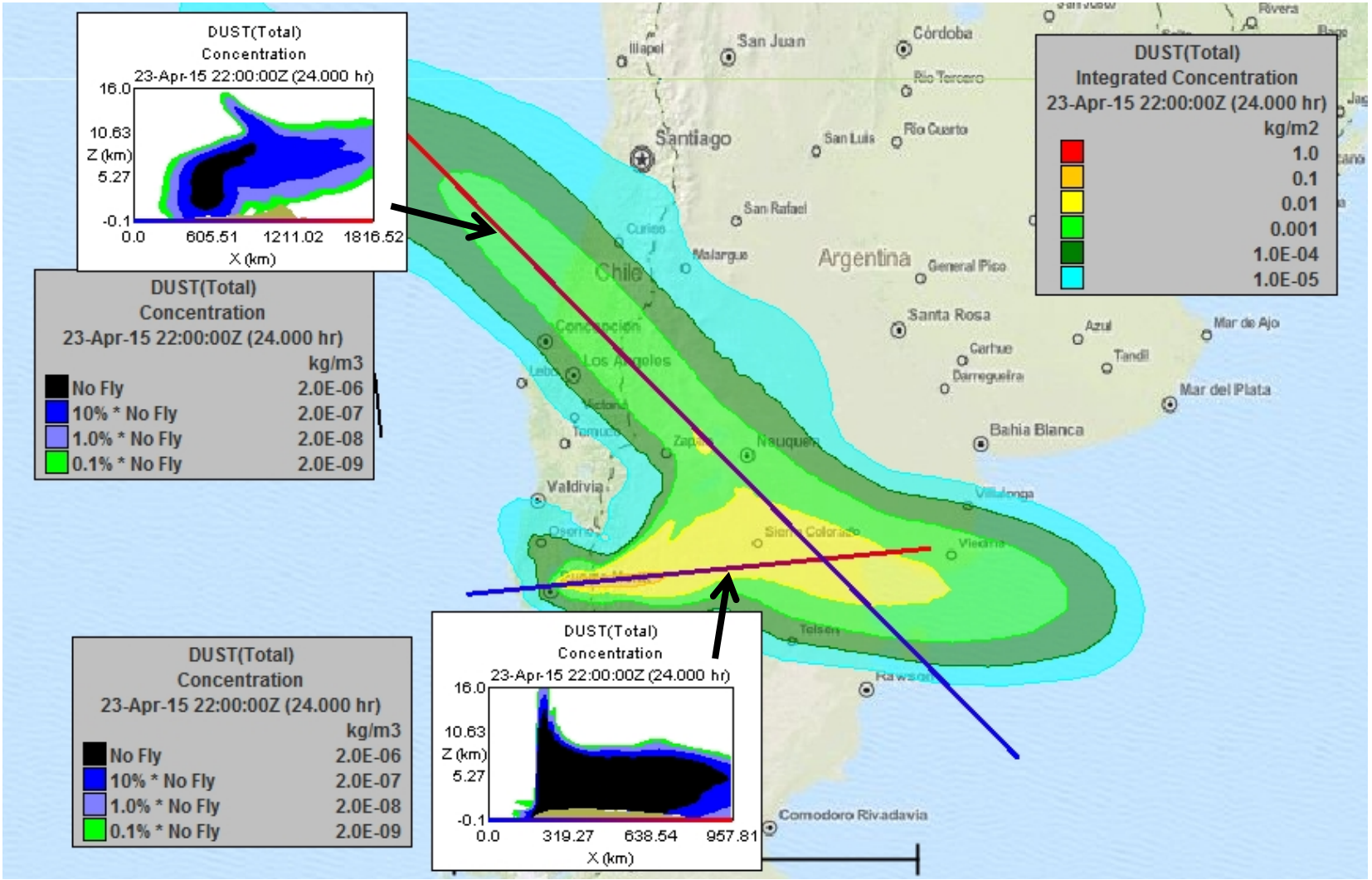
2030Z



Ground Deposition; 2200Z 23APR2015



Vertical Cross-Sections; 2200Z 23APR2015



Notional Crude Oil Fire in La Crosse, WI

Scenario Description

- **(U) Scenario Description**
  - **A 90-car train (each car containing approx. 30,000 gallons of Bakken crude oil) involved in accident.**
  - **Assumed oil density of 825 kg/m^3 (note: density of any particular crude is specific to the well it was pumped from, so this is an approximate value only)**
  - **Derailment resulted in 100,000 gallon pool that immediately ignites.**
  - **The fire causes lighter components (propane, etc.) in the crude in a single car to create a BLEVE**
  - **An additional 450,000 gallons of crude are consumed in a longer-running oil fire**
  - **Assumed a burn time for the first 100,000 gal spill of 1 hr**
  - **Second fire (450,000 gallons) assumed to start at end of 1st hour, run for 11.5 additional hours.**

Fire Assumptions

- **(U) Two Fires**
  - **First fire (100,000 gal) assumed to burn for 1 hour (requires an effective pool diameter of 45 meters).**
  - **Second fire (225,000 gal) was assumed to start at the end of the first fire, was assumed to be at the same location, and assumed to burn for about 11.5 hours; this requires an effective pool diameter of only 20 meters (may reflect slower leaking of the crude from trains).**

- **(U) Plots Shown**
  - **Plots are shown at 1 hour (which reflects effects from the first fire) and 4 hours (which reflects effects from the second fire).**

Oil Fire Modeling and Hazard Caveats

- **(U) Caveats**
  - **Oil will almost certainly pool in an irregular shape, as dictated by the terrain, not circular pools as assumed in model (see also next slide).**
  - **Modeling assumed burning occurred at a constant rate. In reality, rate will almost certainly vary unless the burn area remains constant.**
  - **Much of the soot will end up suspended above ground level due to rise induced by the fire's hot air – the hazard for ground level is mostly proximate to the release location. High-rise buildings downwind will be more likely to experience smoke exposure.**
  - **Outputs from the second fire are shown at 4 hours. Due to the lack of change in the weather and fuel burn rate, outputs at other times should be fairly similar (some changes based on boundary layer and stability changes do occur – see 8 hour cross-section, but ground effects do not change appreciably).**

Pool Fire Effects

- **(U) Effects Shown**
  - **Effects estimated from sources 2 and 3 (see below)**
  - **Fire from pool was assumed to have a radius of 22.5 meters and burn for approximately 1 hour**
  - **Radii for the pool dimensions (assuming circular pool), distance to blistering, and distance to pain provided**
  - **Methodology does not explicitly calculate 1st, 2nd, and 3rd degree burns. However, distance to pain is approximately a 1st degree burn distance, distance to blistering is somewhat larger than the second degree burn distance (see BLEVE slides for example)**
  - **Keep in mind that <u>these effects are based on 30-second exposures</u> – individuals who spend a larger period of time will receive more serious effects, as will individuals with darker skin tones who (may be able to) can absorb radiant heat more efficiently.**
  - **<u>Heat is less intense but longer-lasting than for the BLEVE</u>**

2. D. Drysdale, "An Introduction to Fire Dynamics", 2d ed.
3. Center for Chemical Process Safety, "Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs", Figure 6.10

Fire Plumes

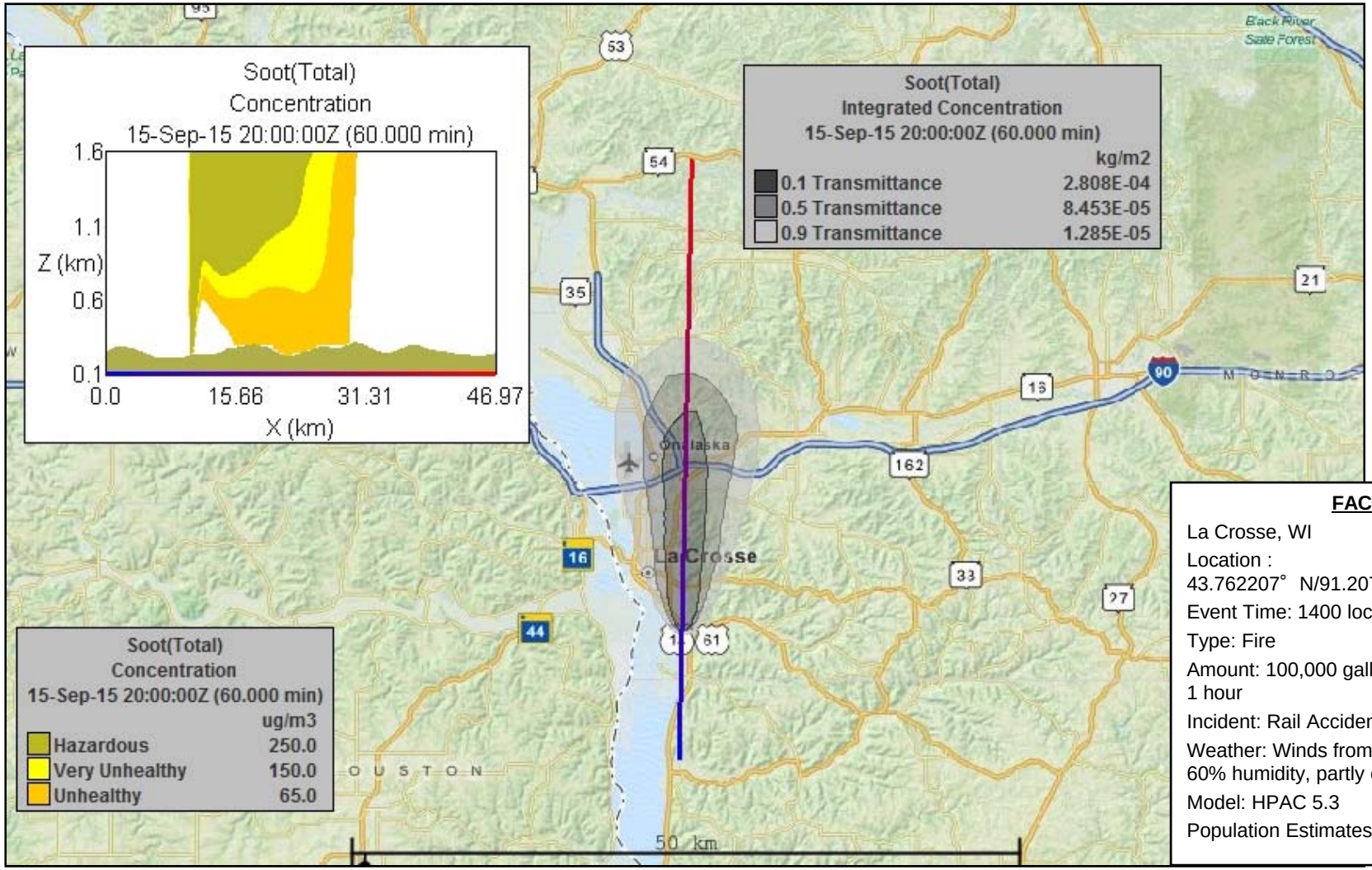
- **(U) Fires Simulated and Outputs**
  - **Two fires were simulated:**
    - **First fire burned 100,000 gallons of crude over 1 hour (this was the source of the pool fire radiant heat plots in previous section)**
    - **A second fire, starting at the end of the first fire, burning 225,000 gallons over approx. 12 hours.**
  - **Ground effects are provided at both 1 hour (indicative of the faster burning fire's effects) and 4 hours (indicative of the slower fire's effects)**
  - **Vertical cross-sections are shown at 1, 4, and 8 hours. The eight-hour plot indicates that nightfall is lowering the boundary layer, but despite this effect no hazardous concentrations reach ground level (ground effect plots at 8 hours are identical to at 4 hours).**
  - **Cross-section concentrations are shown based on the EPA soot criteria, which are lower than the visibility criteria (due to relatively low concentrations, this showed up better in the plots)**
  - **Vertical cross-sections could not be shown with lat/long or national grid due to program limitations**

Effects Levels

- **(U) Human Effects**
  - **Human effects levels for soot/smoke are taken from:**
    - *Guidelines for Reporting of Daily Air Quality – Air Quality Index (AQI),* USEPA, EPA-454/B-06-001, May 2006.
    - See Table *Pollutant-Specific Sub-indices and Health Effects Statements for Guidance on the Air Quality Index (AQI)*
    - Levels are taken from 24-hour exposure to 2.5 µm particles (actual soot particles will cover a range of sizes).

  - **Effects shown are only officially hazardous with an exposure lasting 24 hours, which is unlikely given this scenario. However, shorter exposures can sometimes cause effects, so these levels are provided as a conservative estimate of human effects.**

Vert. Int. Conc. & Vertical X-Section; 1 Hour



FACTS

La Crosse, WI

Location : 43.762207° N/91.207461° W

Event Time: 1400 local, 15SEP2015

Type: Fire

Amount: 100,000 gallons burning over 1 hour

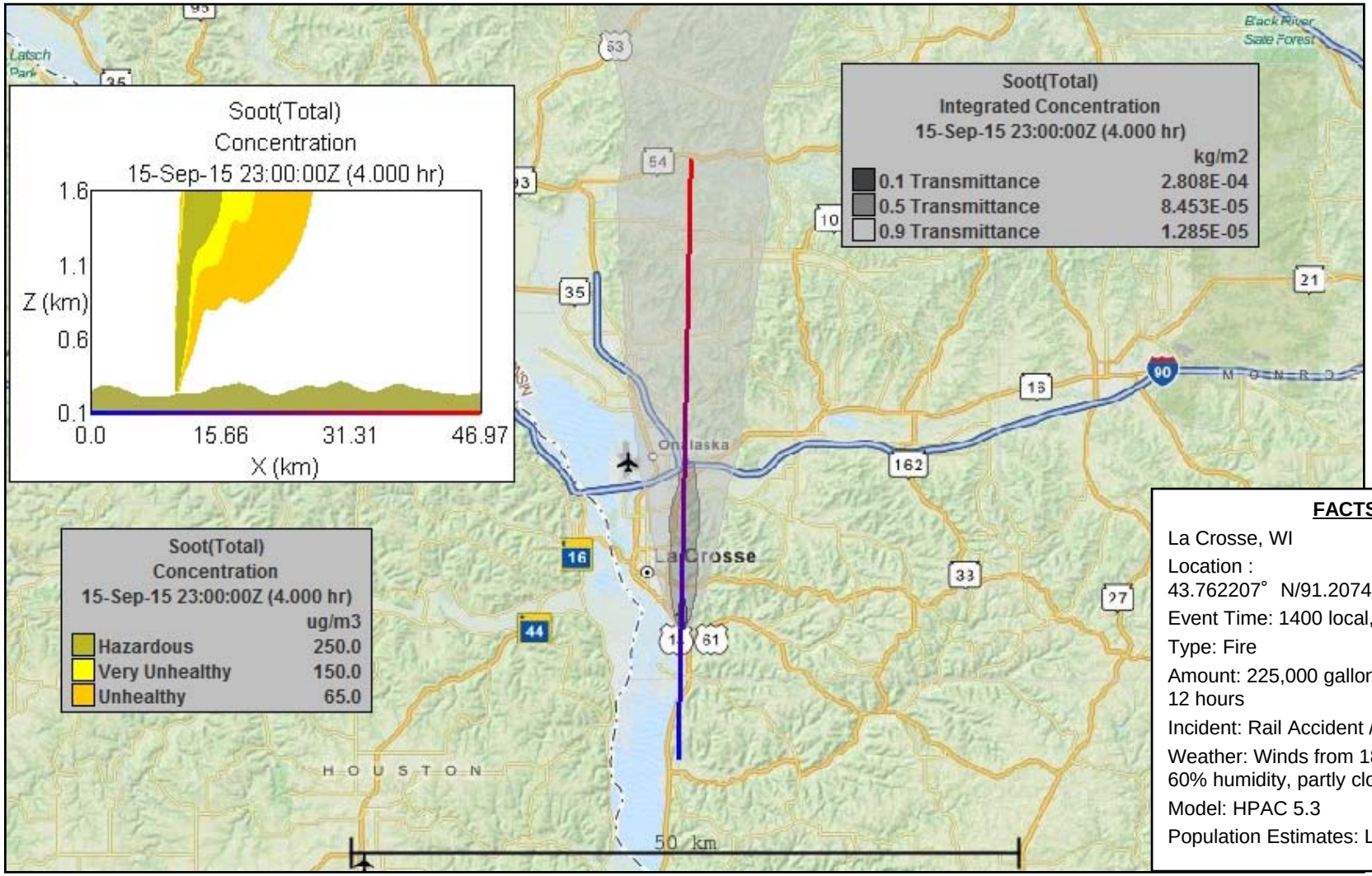
Incident: Rail Accident /Fire/BLEVE

Weather: Winds from 180° at 9 mph; 60% humidity, partly cloudy

Model: HPAC 5.3

Population Estimates: Landscan 2013

Vert. Int. Conc. & Vertical X-Section; 4 Hours



FACTS

La Crosse, WI

Location : 43.762207° N/91.207461° W

Event Time: 1400 local, 15SEP2015

Type: Fire

Amount: 225,000 gallons burning over 12 hours

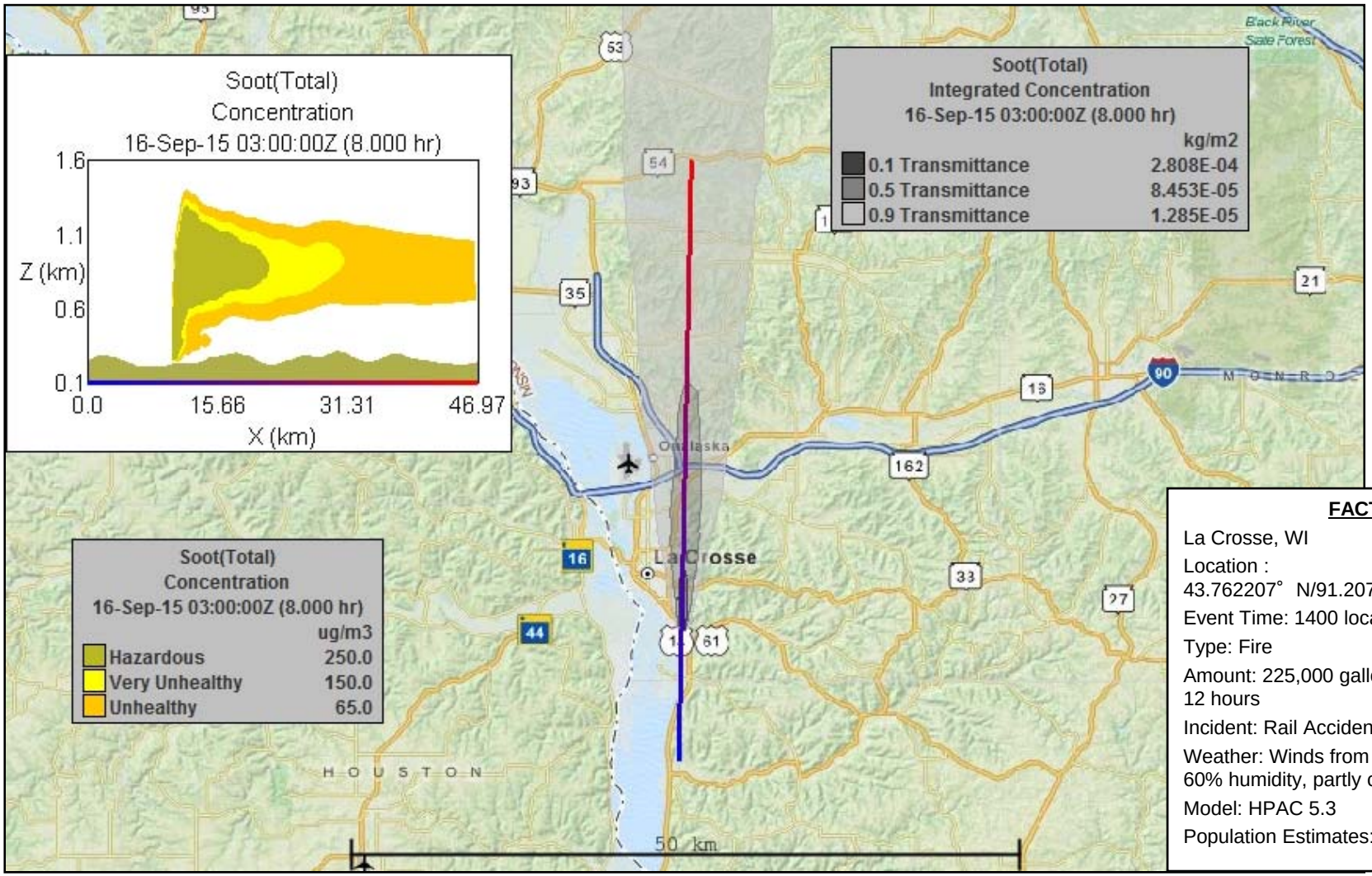
Incident: Rail Accident /Fire/BLEVE

Weather: Winds from 180° at 9 mph; 60% humidity, partly cloudy

Model: HPAC 5.3

Population Estimates: Landscan 2013

Vert. Int. Conc. & Vertical X-Section; 8 Hours



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Soot – Surface Dosage

Value	Description
Hazardous	Serious aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; serious risk of respiratory effects in general population. Everyone should avoid all physical activity
Very Unhealthy	Significant aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; significant increase in respiratory effects in general population. People with heart or lung disease, older adults, and children should avoid all physical activity outdoors; everyone else should avoid prolonged or heavy exertion.
Unhealthy	Increased aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; increased respiratory effects in general population. People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion; everyone else should reduce prolonged or heavy exertion.

Cumulative dosage values based on exposure to 2.5mm particulate matter. Concentration values and descriptions taken from Pollutant-Specific Sub-indices and Health Effects Statements and Cautionary Statements for Guidance on the Air Quality Index tables, in *Guidelines for Reporting of Daily Air Quality – Air Quality Index (AQI)*, USEPA, EPA-454/B-06-001, May 2006.