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Summary

Modeling for the Columbia River Gorge

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September 25, 2007

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Today's Presentation

- Modeling tools
- Approach
- Model performance
  - Replicating condition in 2004
- 2004 source attribution to haze
- 2018 haze projections
- 2018 source attribution to haze

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Modeling System

- Emission processing
  - EPA's SMOKE model
- Meteorological modeling
  - Penn State/NCAR MM5 model
- Pollutant transport/chemistry modeling
  - ENVIRON's CAMx model

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Modeling Periods

- Two seasons in 2004:
  - August 10-22
    - Warm, dry, some wildfires in Washington
  - November 3-18
    - Cool, foggy, extreme haze event
  - 10 extra days added before each episode
    - "Spin up" the model

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Modeling Grids

- Horizontally:
  - 3 "nested" grids each with different mesh size
    - 36, 12, 4 km grid spacing
- Vertically:
  - Terrain-following
  - Surface to ~16 km (9.5 miles, 53,000 ft)

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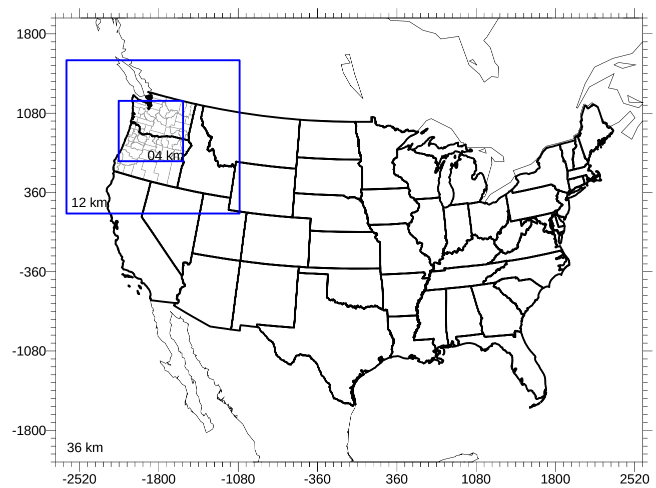
Modeling Grids



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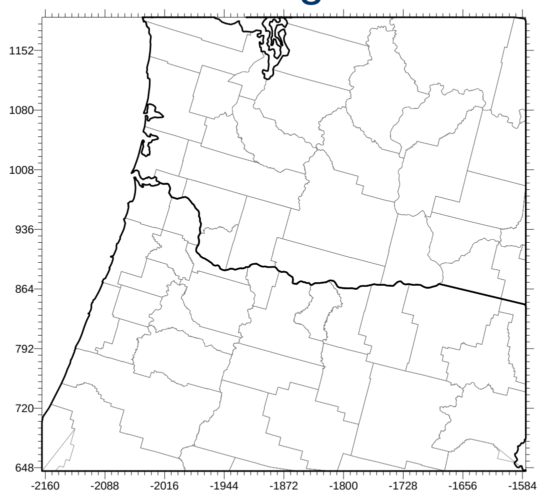
Modeling Grids



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2004 Emission Processing

- Emission inventory (EI)
  - OR/WA from ODEQ/SWCAA
  - Other states, Canada, Mexico from WRAP
  - Annual, county-level, criteria pollutants
    - NOx, SOx, VOC, CO, PM
  - Exceptions:
    - Power plants, some fires, some pulp mills
    - Mt St. Helens estimates from USGS

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2004 Emission Processing

- SMOKE processing
  - Converts from annual to seasonal, monthly, day-of-week, hourly
  - Converts from counties to modeling grid
  - Converts from criteria emissions to compounds tracked by model
    - Many individual gas and PM species needed for chemistry
  - Conversion factors taken from WRAP

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Meteorological Modeling

- MM5 (forecasting model)
  - Used to replicate 2004 episodes
  - Hourly, gridded fields of:
    - Wind
    - Temperature and pressure
    - Humidity, clouds, rainfall
    - Rates and depths of turbulent mixing

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Meteorological Modeling

- MM5 performance
  - Complex terrain added difficulty
  - Stagnation added difficulty
  - August
    - Performed well in simulating wind, temperature, and humidity
  - November
    - Performed well for wind and temperature
    - We needed to add more fog in the basins

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2004 CAMx Performance

- August
  - Dominated by biogenic organic PM and wildfire emissions
  - Secondary PM (sulfate/nitrate) low
    - Episode not sensitive to ammonia emissions
    - Warm and dry
  - Performance was quite good for important compounds
    - Comparable to best performance achieved by WRAP

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2004 CAMx Performance

- November
  - Sulfate/nitrate dominant in this episode
    - Sensitive to ammonia emissions (ammonia-limited)
    - Cool and wet
  - Heavy wood smoke component
    - Over predicted, mostly from Portland
  - Dust components over predicted
  - Performance acceptable on an episode-average basis for all important compounds

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2004 Source Attribution

- "PSAT" probing tool in CAMx
  - Provides source apportionment during model run
  - Stratifies PM contribution by source type and region
    - We used 10 source types and 6 regions
    - CAMx tracked sulfur, nitrogen, primary inert PM
    - Biogenics tracked separately by core model
  - Episode-average conditions are shown

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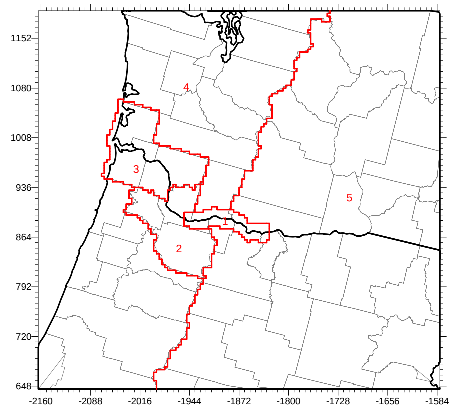
2004 Source Attribution

1. On-road mobile sources
2. Non-road mobile sources (railroad, marine shipping, construction, lawn/garden equipment, etc.)
3. Ammonia sources (livestock operations, agricultural fertilizer application, waste treatment)
4. Other area sources (residential, commercial, industrial, etc. not included above)
5. Electric generating units (EGU)
6. Pulp mills
7. Wildfires
8. Other fires (prescribed and agricultural burns, structural fires)
9. Other point sources (not included in the above);
10. All emissions outside the 4-km grid



Source Region Map - 4km domain
1. In-Gorge
2. Portland
3. NorthWest of Gorge
4. West of Gorge
5. East of Gorge

(LCP Definition: -97, 40, 45, 33)

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2004 Source Attribution

- August results

Mt Zion

Region	Mm^{-1}	Contribution
BC/Outside 4 km domain	7.81	22%
Portland	7.10	20%
NW of Gorge	4.37	12%
Gorge	2.29	6%
East of Gorge	1.64	4%
West of Gorge	1.18	3%
Biogenic SOA	12.00	33%

Wishram

Region	Mm^{-1}	Contribution
East of Gorge	6.44	23%
BC/Outside 4 km Domain	6.26	22%
Gorge	2.58	9%
West of Gorge	1.63	6%
NW of Gorge	0.97	4%
Portland	0.81	3%
Biogenic SOA	9.44	33%

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2004 Source Attribution

- Non-biogenic contributions in August, Mt Zion
  1. Sulfate from super-regional sources (12%)
  2. Soot from Portland non-road sources (5%)
  3. Sulfate from regional sources (5%)
  4. Soot from local Gorge non-road sources (3%)
  5. Sulfate from EGUs northwest of Portland (2%)
- Non-biogenic contributions in August, Wishram
  1. Sulfate from super-regional sources (12%)
  2. POA from eastern OR/WA wildfires (12%)
  3. Soot from eastern OR/WA wildfires (6%)
  4. Sulfate from regional sources (5%)
  5. Soot from local Gorge non-road sources (5%)

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2004 Source Attribution

- November results

Mt Zion

Region	Mm^{-1}	Contribution
Portland	32.00	28%
BC/Outside 4 km domain	22.16	19%
East of Gorge	15.31	13%
Gorge	14.96	13%
West of Gorge	10.30	9%
NW of Gorge	7.72	7%
Biogenic SOA	13.35	11%

Wishram

Region	Mm^{-1}	Contribution
East of Gorge	108.50	57%
BC/Outside 4 km domain	44.01	23%
Gorge	18.02	10%
Portland	4.59	2%
NW of Gorge	3.25	2%
West of Gorge	2.24	1%
Biogenic SOA	9.58	5%

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2004 Source Attribution

- Non-biogenic contributions in November, Mt Zion
  1. Sulfate from eastern OR/WA EGU sources (10%)
  2. Sulfate from super-regional sources (10%)
  3. Nitrate from Portland on-road sources (9%)
  4. Nitrate from western OR/WA on-road sources (4%)
  5. Nitrate from super-regional sources (4%)

- Non-biogenic contributions in November, Wishram
  1. Sulfate from eastern OR/WA EGU sources (27%)
  2. Sulfate from super-regional sources (7%)
  3. Nitrate from eastern OR/WA on-road sources (7%)
  4. Nitrate from super-regional sources (6%)
  5. Nitrate from eastern OR/WA non-road sources (6%)

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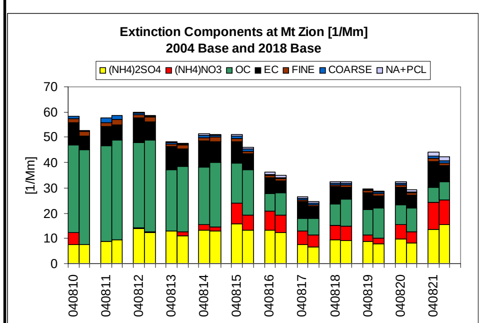
2018 Emission Processing

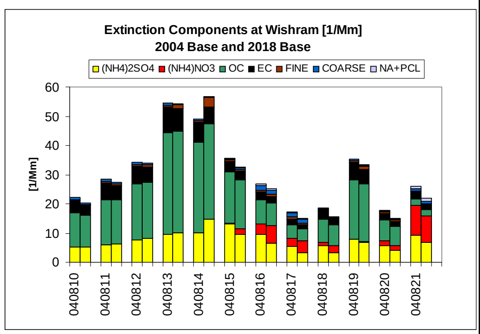
- Emission inventory (EI)
  - Taken mostly from WRAP modeling effort
  - Exceptions:
    - Natural sources held at 2004: biogenic, wind-blown dust, wildfires, agricultural ammonia sources, volcano
    - BART controls on NOx & SOx from PGE Boardman
    - BART controls on NOx, SOx, CO, and PM at Camas Mill

2018 Haze Projections

- CAMx was run with the same:
  - Meteorology
  - Natural emissions
  - Other model configurations/options
- PM projections
  - Reflect changes in man-made emissions
  - Converted to visibility metrics to obtain 2004-2018 trend line

2004-2018 Haze Projections





August Extinction Budget Projections by Day

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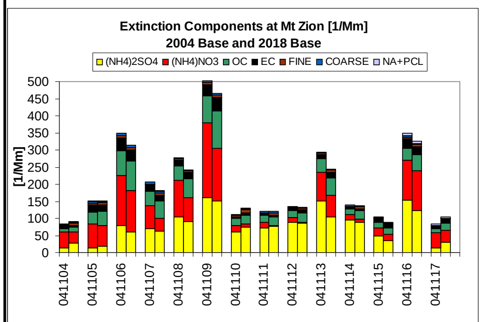
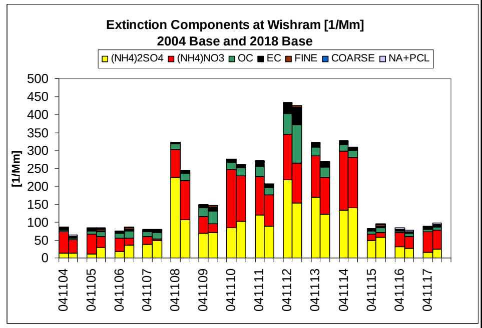
2004-2018 Haze Projections





November Extinction Budget Projections by Day

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2004-2018 Haze Projections

- Average change in worst days of each episode

August Visibility Trends

	Mt Zion	Wishram
Total Extinction Change	-1.9 Mm^{-1} (-3%)	0.4 Mm^{-1} (1%)
Extinction Annual Rate	-0.13 $Mm^{-1}yr^{-1}$	0.03 $Mm^{-1}yr^{-1}$
Total Dv Change	-0.3 (not perceptible)	0.08 (not perceptible)
Dv Annual Rate	-0.02 yr^{-1}	0.006 yr^{-1}

November Visibility Trends

	Mt Zion	Wishram
Total Extinction Change	-35 Mm^{-1} (-10%)	-40 Mm^{-1} (-12%)
Extinction Annual Rate	-2.5 $Mm^{-1}yr^{-1}$	-2.8 $Mm^{-1}yr^{-1}$
Total Dv Change	-1.0 (perceptible)	-1.3 (perceptible)
Dv Annual Rate	-0.07 yr^{-1}	-0.09 yr^{-1}

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2018 vs 2004 Source Attribution

- August results

Mt. Zion – August	2004		2018	
Region	Mm^{-1}	Contribution	Mm^{-1}	Contribution
BC/Outside 4 km domain	7.8	22%	5.8	17%
Portland	7.1	20%	6.7	20%
NW of Gorge	4.4	12%	4.0	12%
Gorge	2.3	6%	1.9	6%
East of Gorge	1.6	4%	1.6	5%
West of Gorge	1.2	3%	1.6	5%
Secondary Organic PM	12	33%	12	35%

Wishram – August	2004		2018	
Region	Mm^{-1}	Contribution	Mm^{-1}	Contribution
East of Gorge	6.4	23%	5.9	20%
BC/Outside 4 km Domain	6.3	22%	4.1	14%
Gorge	2.6	9%	7.0	24%
West of Gorge	1.6	6%	1.9	7%
NW of Gorge	0.97	4%	0.50	2%
Portland	0.81	3%	0.64	2%
Secondary Organic PM	9.4	32%	9.4	32%

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2018 Source Attribution

- November results

Mt. Zion – November	2004		2018	
Region	Mm^{-1}	Contribution	Mm^{-1}	Contribution
Portland	32	28%	28	26%
BC/Outside 4 km domain	22	19%	22	21%
East of Gorge	15	13%	9.0	8%
Gorge	15	13%	25	23%
West of Gorge	10	9%	8.8	8%
NW of Gorge	7.7	7%	2.1	2%
Secondary Organic PM	13	11%	13	12%

Wishram – November	2004		2018	
Source Region	Mm^{-1}	Contribution	Mm^{-1}	Contribution
East of Gorge	109	57%	86	51%
BC/Outside 4 km domain	44	23%	41	25%
Gorge	18	10%	27	16%
Portland	4.6	2%	3.0	2%
NW of Gorge	3.2	2%	0.0	0%
West of Gorge	2.2	1%	0.25	0%
Secondary Organic PM	10	5%	10	6%

2018 “What-If” Scenarios

- Five scenarios run:
  1. Zero PGE Boardman from BART-level emissions
  2. Zero ammonia emissions East of Gorge
  3. Zero on-road mobile emissions in Portland
  4. Zero major industrial (point) emissions Portland
  5. Zero major point emissions in the Gorge

2018 “What-If” Scenarios

- Very little sensitivity seen in these tests
  - Sulfate/nitrate signals are mixed, reflecting complexity of chemistry
  - More influence is seen on worst November days, especially from run (2) and (3)
  - These results not significant to overall conclusions of this study

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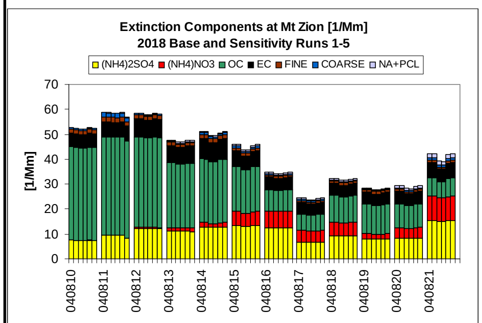
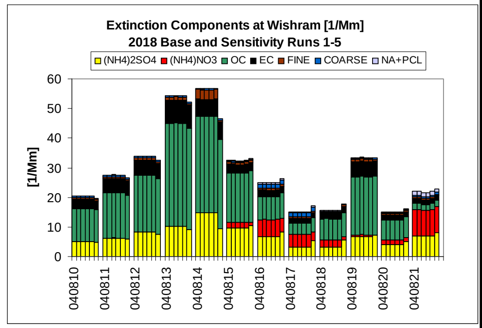
2018 “What-If” Scenarios





August Extinction Budget Projections by Day

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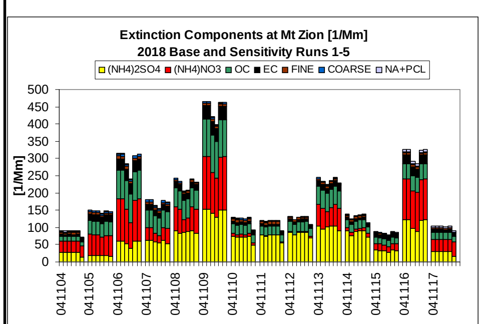
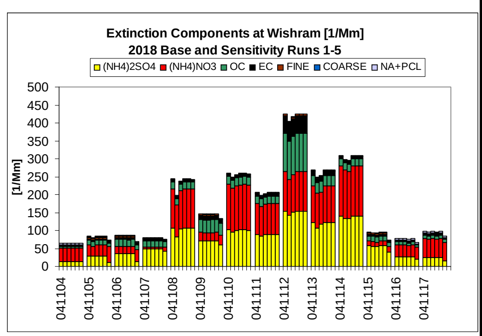
2018 “What-If” Scenarios





November Extinction Budget Projections by Day

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Conclusion

- Modeling system replicated PM and visibility data collected in 2004
  - Established confidence in projecting PM and haze to 2018
- 2018 projections suggest:
  - Little change in summer (1-3%): biogenics and fires are dominant
  - 10% change in foggy fall/winter events: sulfate and nitrate are dominant