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Modelling the Effects of E10 Fuels on Air Quality in Canada

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Background

May 2003



Health
Canada

Santé
Canada

- Health Canada held an expert panel on ethanol blended gasoline and its effects on air quality
- Initiated a detailed study of the health effects associated with the widespread use of E10 fuels in Canada (10% ethanol blended gasoline)

Project Overview

I Emission Inventory Preparation

- MOBILE6.2C

II Air Quality Modelling

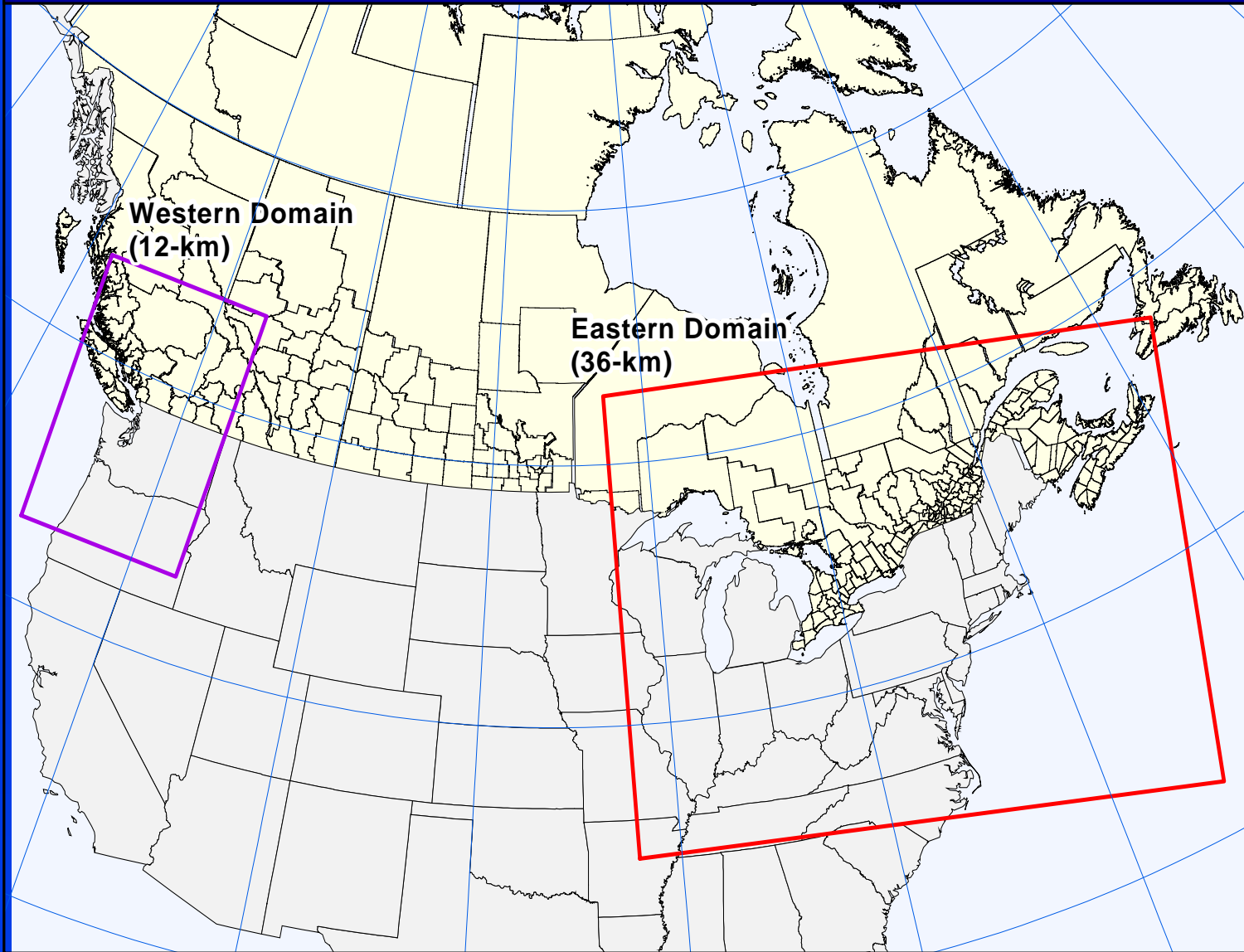
- MC2, MM5, SMOKE 2.0*, CMAQ 4.3*
- CO, NO_x, VOC, PM_{2.5}, SO₂, NH₃, Ozone, PAN, Benzene, 1,3-Butadiene, Acetaldehyde, Formaldehyde

III Human Health Risk Assessment

- Health Canada

* Modified by RWDI & UCR to handle toxic species

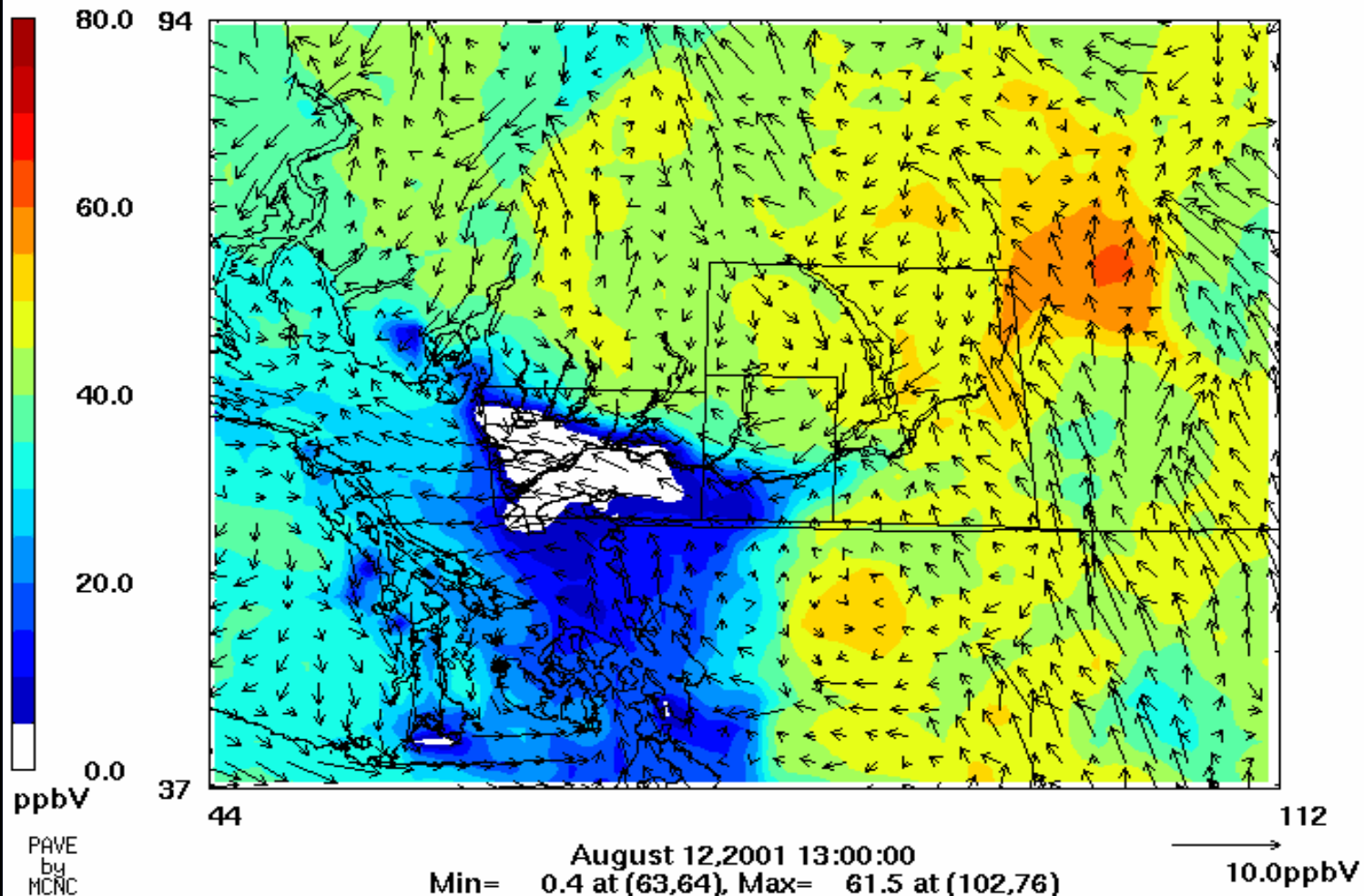
Modelling Domains



Western Domain: Base Case

Wind Field & O3

Ground Level
4km Grid



Presentation Overview

Emission Inventory Preparation

1. About Ethanol

- Oxygenates
- Ethanol Blending

2. MOBILE6.2C

- Canadian Updates
- Model Inputs

3. Preliminary Results

- Emission Estimates
- Comparisons



About Ethanol

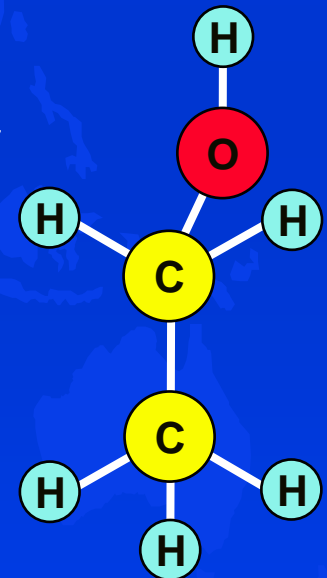
Ethanol is an alcohol made from biological resources such as agricultural crops and forestry by-products



<http://www.hybridfuels.ca/images/pics/ethanol.jpg>

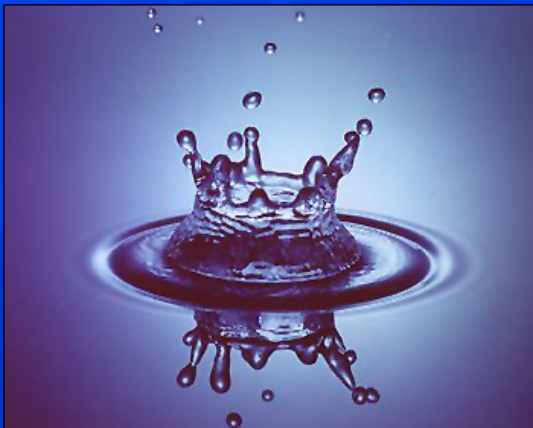
Oxygenates

- Compounds that contain oxygen in their molecular structure
- Enhance octane when blended with gasoline
- Improve combustion efficiency, thereby reducing most pollutant emissions



Ethanol
 $\text{CH}_3\text{CH}_2\text{OH}$

Ethanol Blending



Splash Blend

- Conventional gasoline blended with ethanol, which increases fuel volatility
- Permitted by waiver in select areas



Tailor Blend

- Specially tailored gasoline blended with ethanol to account for increased fuel volatility
- Complies with gasoline volatility standards



Ambient Air Quality

Secondary Pollutant Formation

Direct Emissions from Vehicles

Canadianization of MOBILE6.2

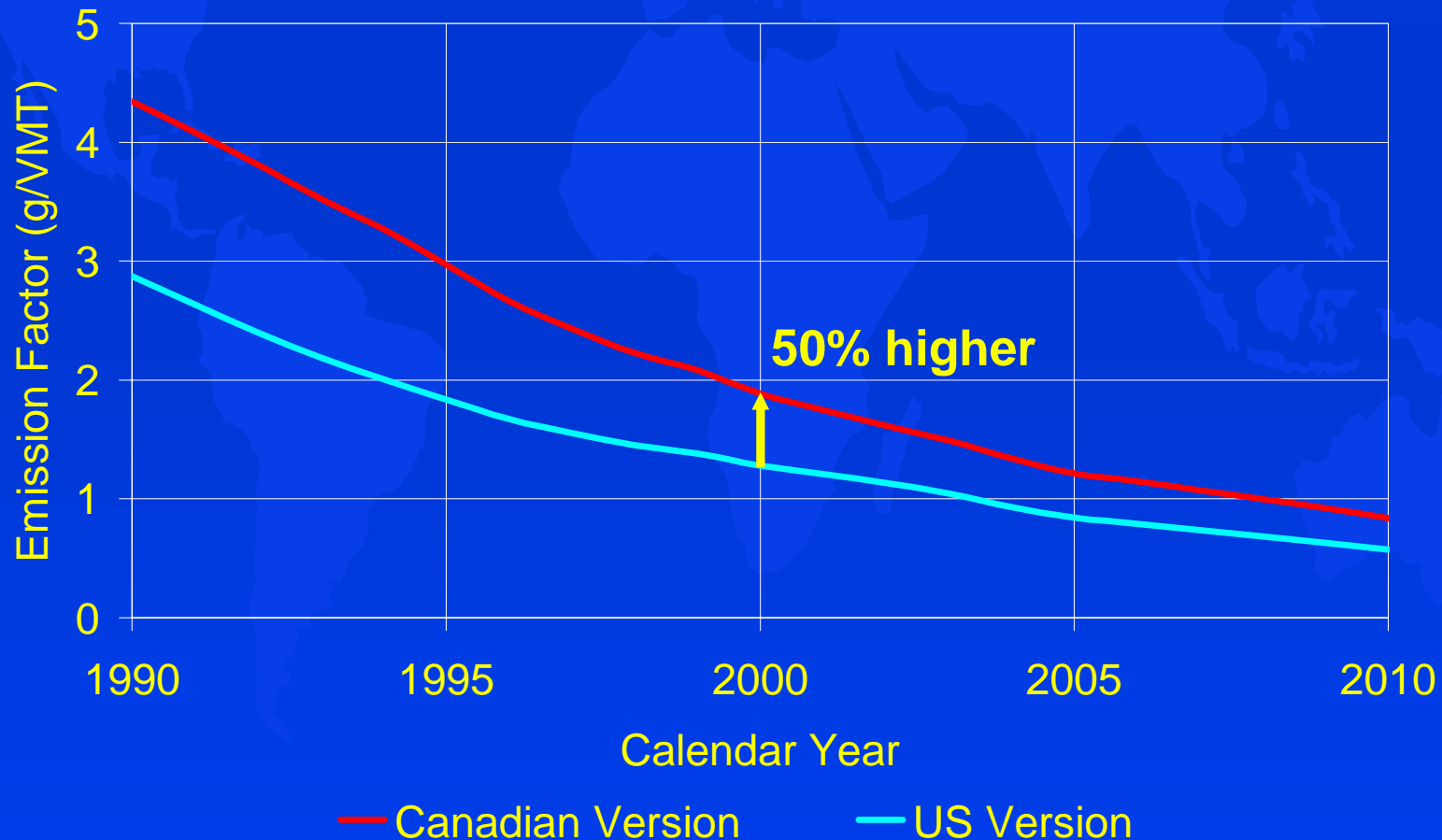


MOBILE6.2C

WHY Were Updates Needed?

- Fleet Differences, Fuel Characteristics

LDGV - VOC Emissions



MOBILE6.2C Inputs (West)

Parameter	Base Case	Splash Blend	Tailor Blend
Oxygenate (Ethanol)	0% Volume 0% Market	10% Volume 100% Market	10% Volume 100% Market
Aromatics (%)	23.6	21.2	20.3
Olefins (%)	10.1	9.1	7.6
Benzene (%)	0.7	0.6	0.7
E300 (%)	86.6	87.9	86.6
E200 (%)	48.6 (summer) 55.6 (winter)	53.7 (summer) 60 (winter)	48.6 (summer) 55.6 (winter)
Fuel RVP	7.9 (summer) 13.7 (winter)	8.9 (summer) 14.7 (winter)	7.9 (summer) 13.7 (winter)
Gasoline Sulphur	225 (year 2000) 30 (year 2010)	203 (year 2000) 30 (year 2010)	225 (year 2000) 30 (year 2010)
Vehicle Reg. Dist.	British Columbia, 2000		
Average Speed	50 km/h, 80 km/h, 100 km/h		
Calendar Year	2000, 2010		
Min/Max Temp. (F)	January: 33/43, April: 42/56, July: 56/71, October: 44/56		

MOBILE6.2C Results

(E10 Relative to Base Case)

Emissions Affected by E10

- CO
- VOC
- Benzene
- 1,3-Butadiene
- Acetaldehyde
- Formaldehyde

Emissions Not Affected by E10

- NO_x
- PM_{2.5}
- NH₃
- SO₂

MOBILE6.2C Results

(E10 Relative to Base Case)

All Modelled Pollutants	<ul style="list-style-type: none">• Minor differences between Splash & Tailor results• Percent change not affected by travel speed/season
CO, VOC, Benz. 1,3-Butadiene	<ul style="list-style-type: none">• Lower emissions• Varies by calendar year and vehicle type
Acetaldehyde	<ul style="list-style-type: none">• Much higher emissions• Varies by calendar year and vehicle type
Formaldehyde	<ul style="list-style-type: none">• Higher emissions for year 2000• Lower emissions for year 2010 (except HDGV)

MOBILE6.2C

Percent Change

E10 Splash – Year 2000

(West, July, LDGV)

132%

3%

-5%

-20%

-26%

-24%

CO

VOC

Formaldehyde

Acetaldehyde

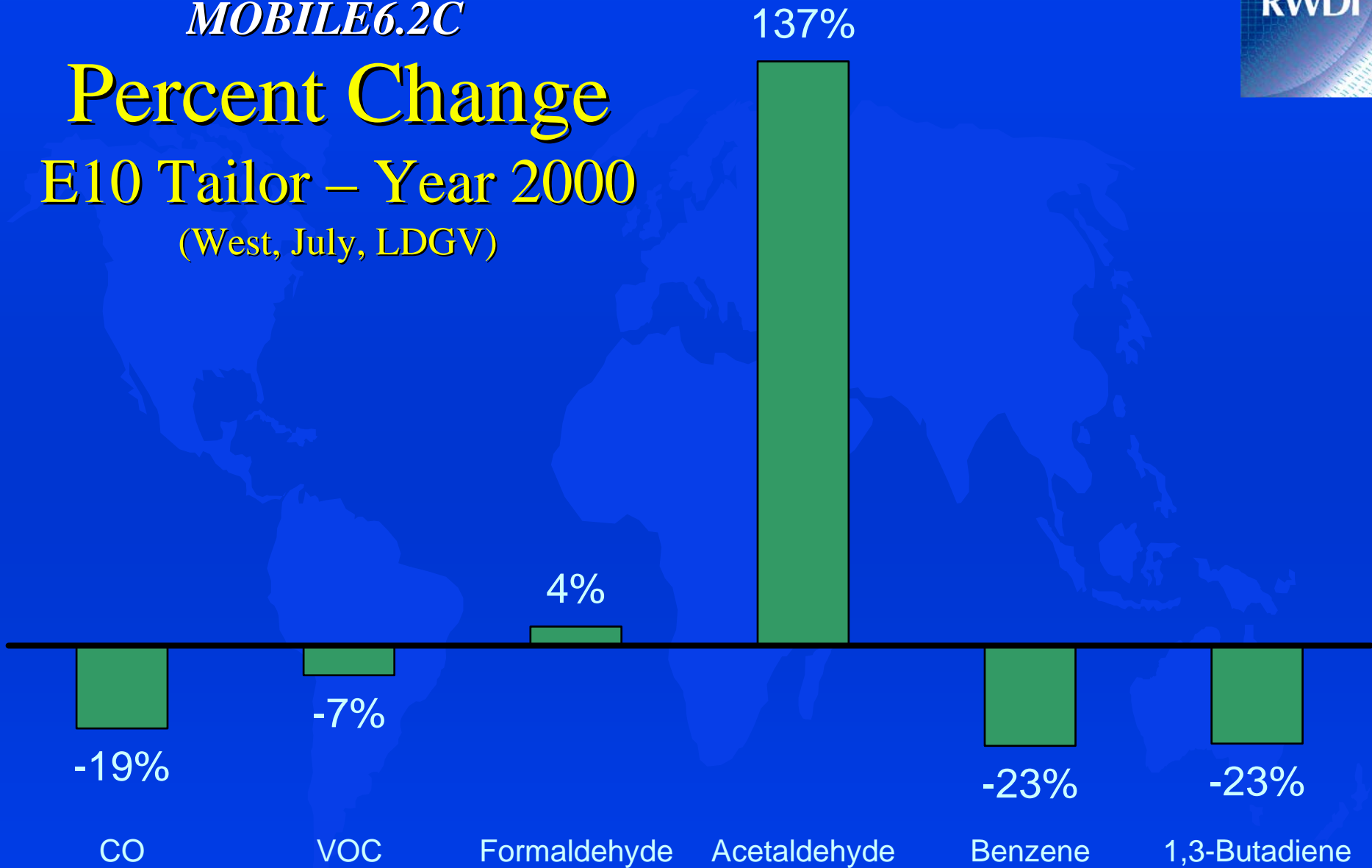
Benzene

1,3-Butadiene



MOBILE6.2C

Percent Change E10 Tailor – Year 2000 (West, July, LDGV)



Emissions by Sector (West)

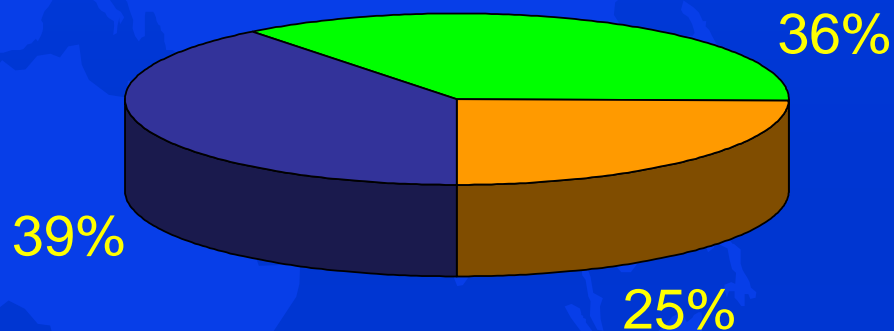
(Emissions from Human Activities)

■ Mobile Sources

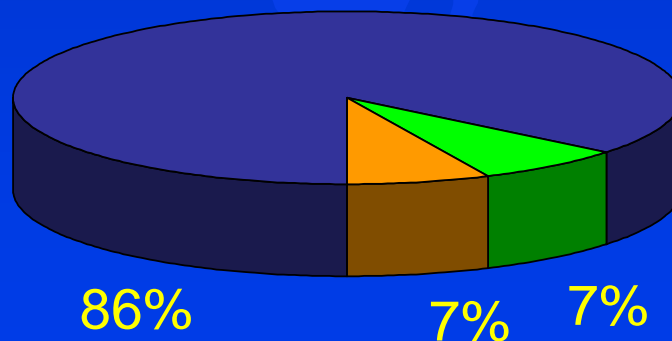
■ Area Sources

■ Point Sources

Volatile Organic Compounds



Acetaldehyde (and higher aldehydes)



Comparison to Other Studies

(LDGV, E10 Splash, Emissions)

	Present Study ^[1]	NRC Canada (1997) ^[2]
NO _x	<ul style="list-style-type: none"> • Unchanged 	<ul style="list-style-type: none"> • Unchanged
CO	<ul style="list-style-type: none"> • Down 20% 	<ul style="list-style-type: none"> • Down 15%
VOC	<ul style="list-style-type: none"> • Evap. Up 8% • Exh. Down 10% • Combined Down 5% 	<ul style="list-style-type: none"> • Evap. Up 30% • Exh. Down 3% • Combined Up 9%

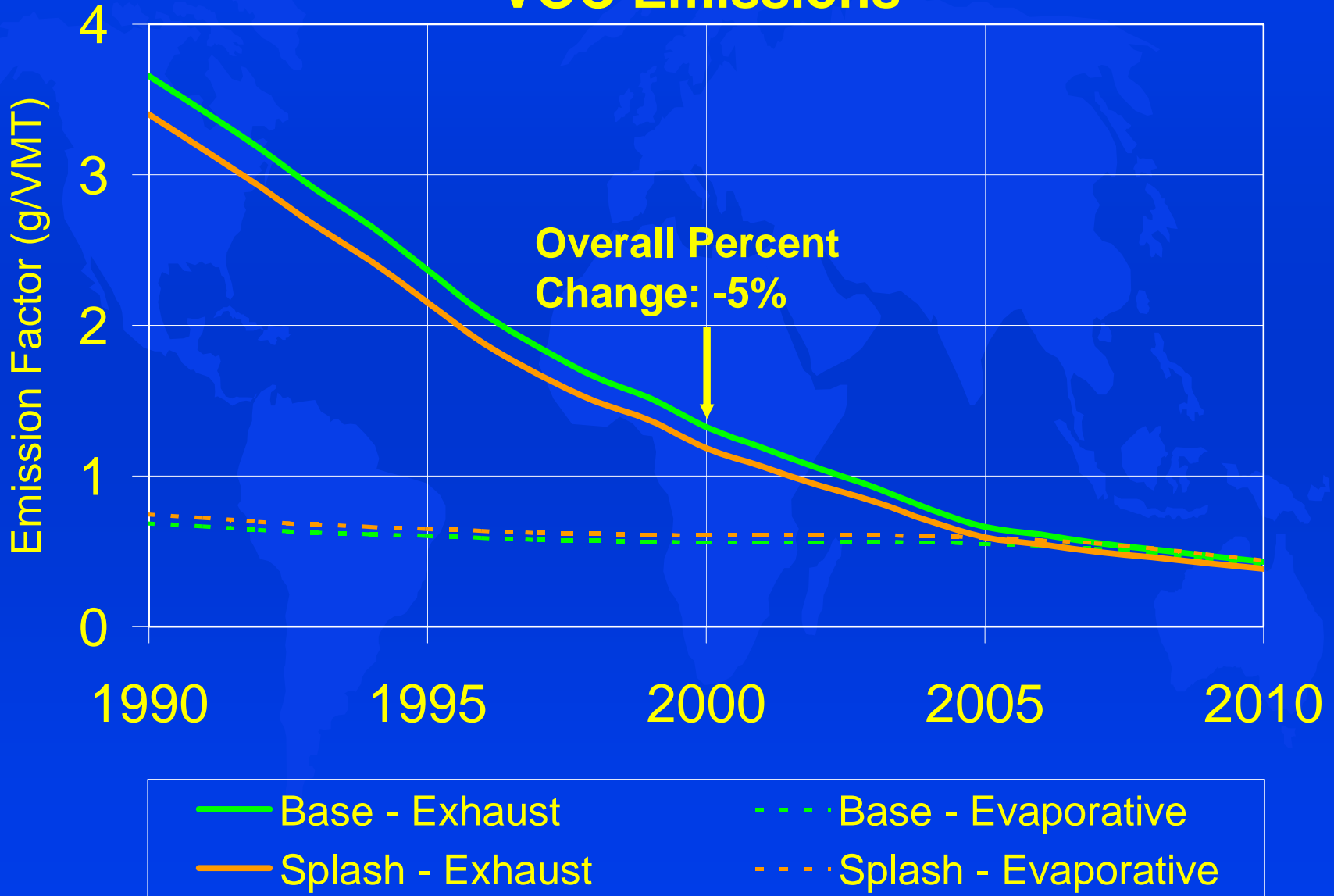
[1] Based on MOBILE6.2C results, year 2000, West, July

[2] Based on MOBILE5C results and 1989 emission data

E10 Splash (West, July, LDGV)



VOC Emissions



Summary of Key Points

1. E10 improves the combustion efficiency of gasoline thereby reducing most exhaust emissions
2. E10 increases acetaldehyde emissions significantly due to the higher oxygen content of ethanol blends
3. Percent change in vehicle emissions are not affected significantly by travel speed or season
4. Cooler ambient temperatures minimize the effect of splash blends on evaporative VOC emissions

Next Steps

I Emission Inventory Preparation

- MOBILE6.2C

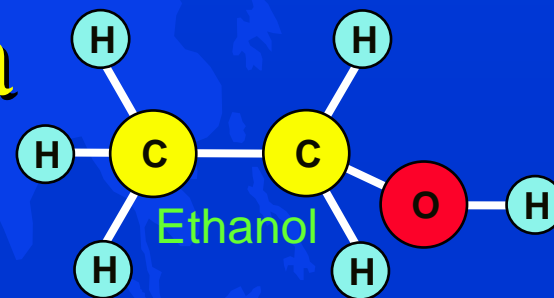
II Air Quality Modelling

- Perform toxic and photochemical modelling

III Human Health Risk Assessment

- Provide Health Canada with modelling results

Modelling the Effects of E10 Fuels on Air Quality in Canada



Acknowledgements:

- Oil, Gas & Energy Branch of Environment Canada
- Meteorological Service of Canada
- National Research Council of Canada
- U.S. EPA Office of Transportation & Air Quality
- University of California, Riverside
- Air Health Effects Division of Health Canada