Global ICCT scenarios for road transport…
…and other ongoing activities

Susan Anenberg, PhD

Environmental Health Analytics

Task Force on Integrated Assessment Modeling and Task Force on Hemispheric Transport of Air Pollution

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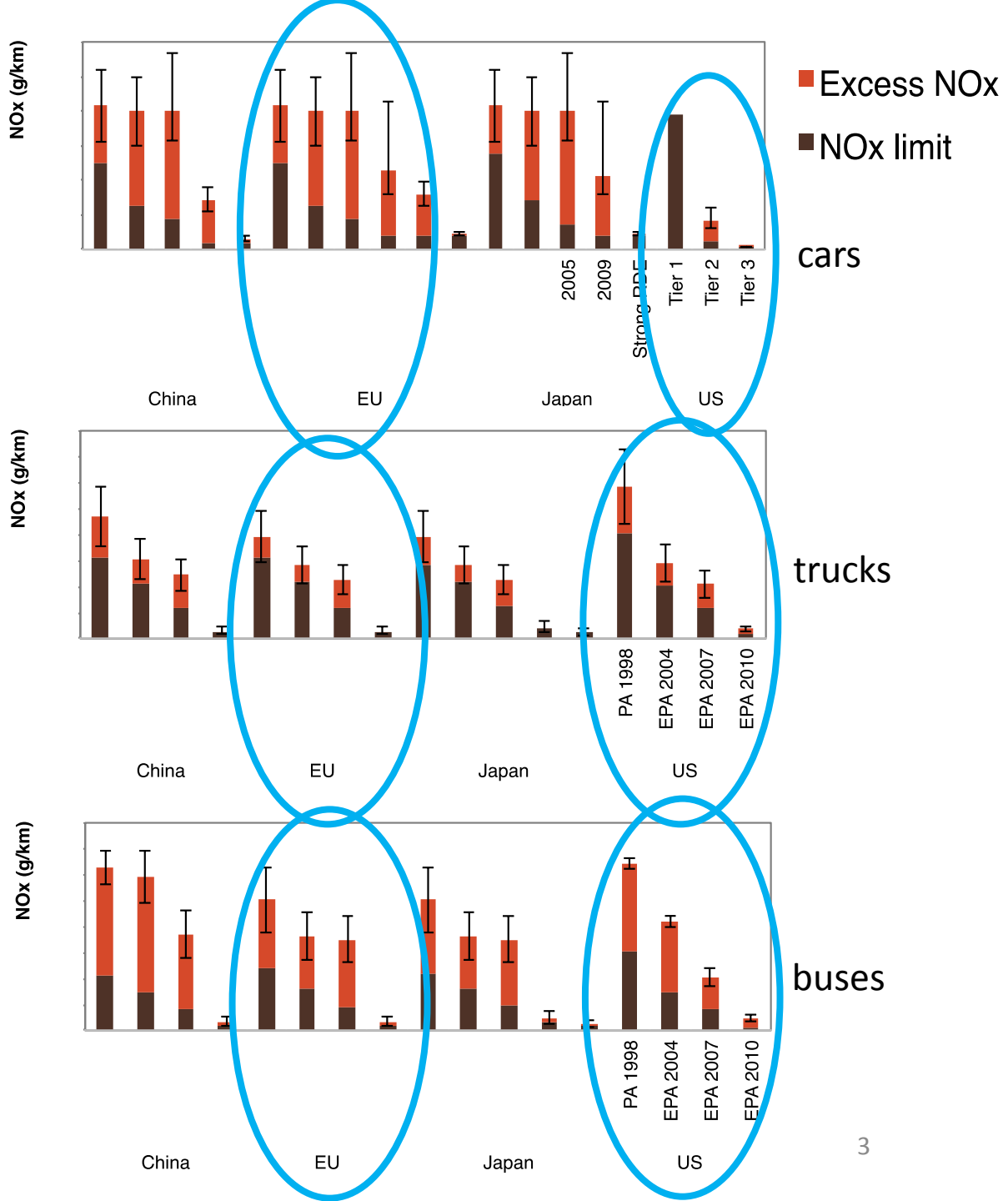
Outline

- Impacts and mitigation of real-world diesel NOx emissions in 11 major world regions
- Global burden of disease from transportation-related air pollution in 2010 and 2015
- Global impacts of ambient air pollution on non-fatal health outcomes
- Climate and Clean Air Coalition Summit on combined cooking and heating and coal heating stoves

Impacts and mitigation of excess diesel NOx emissions in 11 major vehicle markets

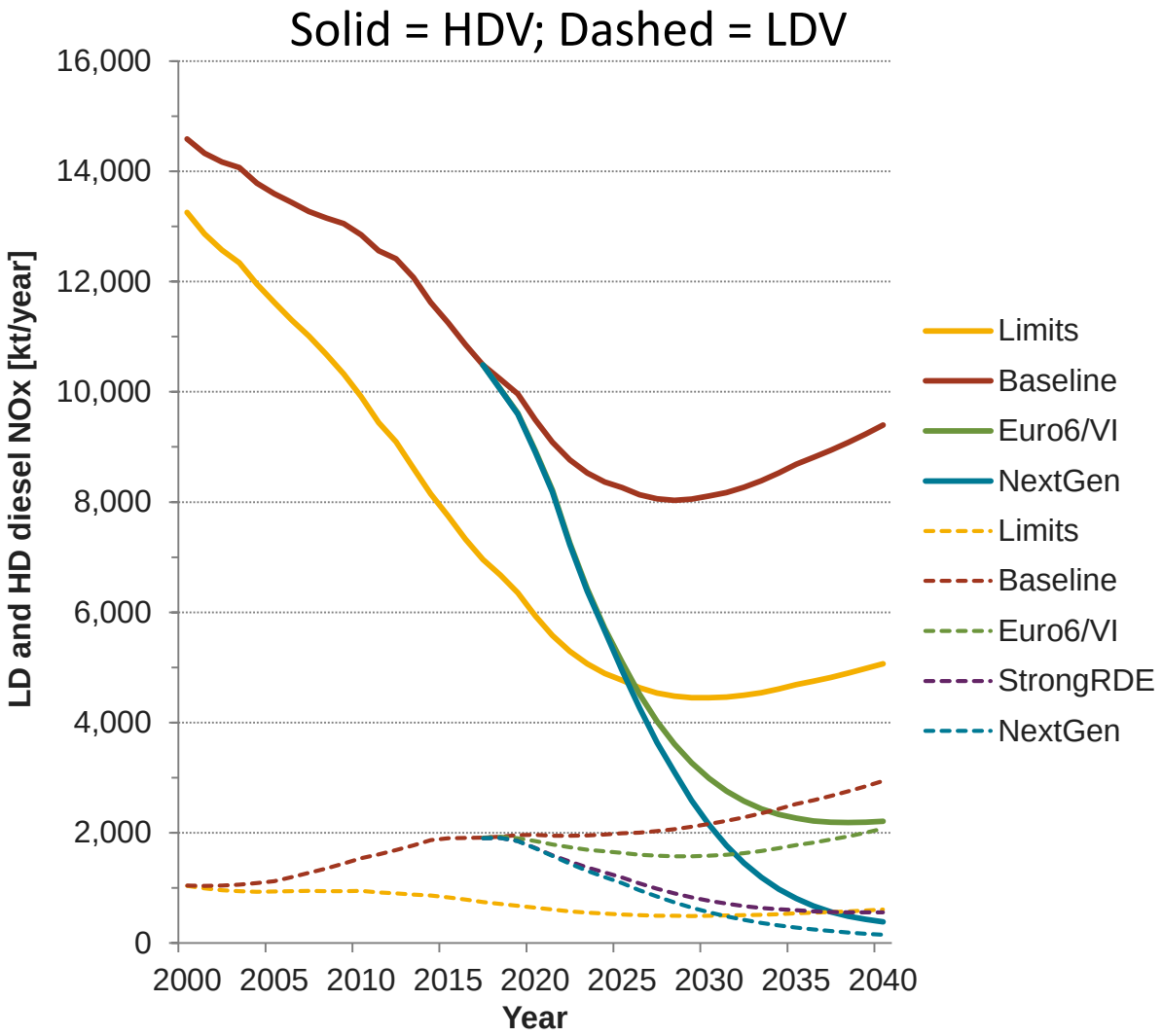
New diesel NOx emission factors based on review of >30 in-use emissions tests

Review conducted by the International Council on Clean Transportation (ICCT)



Anenberg et al., Nature, forthcoming
Embargoed until May 15; Do not cite or quote.

Tighter policies can nearly eliminate future diesel NOx emissions



- **Limits:** Counterfactual where real-world NO_X emissions are equivalent to certification limits.
- **Baseline:** Best estimate of how adopted NO_X emission standards perform in the real world.
- **Euro6/VI:** Countries that haven't yet done so adopt Euro 6/VI equivalent standards "as is"
- **StrongRDE:** Euro 6/VI scenario + idealized LDV Real Driving Emission (RDE) programs that test in-service vehicles, monitor in-use emissions, cover a broad set of driving conditions, and allow for independent verification.
- **NextGen:** StrongRDE scenario + standards equivalent to US Tier 3 and CA voluntary HDV NO_X rule in all markets

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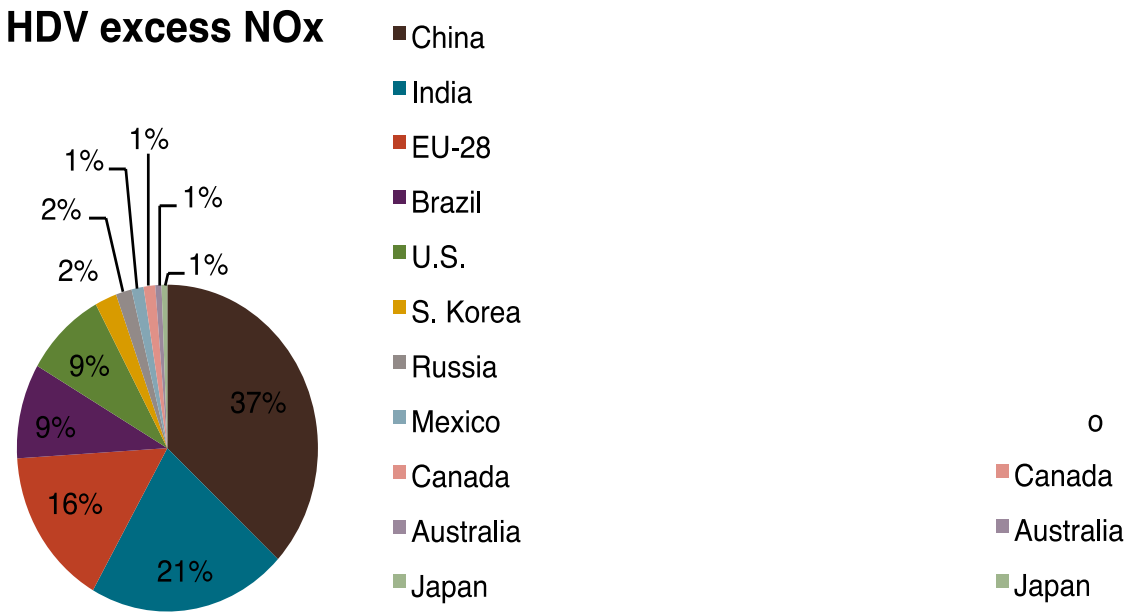
Baseline–Limits 2015: Excess NOx is not just a Dieselgate problem.

Most “excess NOx” is from HDVs.

Five markets—China, India, EU, Brazil, US—contribute ~90% of HDV excess NOx.

Most LDV excess NOx emitted in EU, China, India—all are in need of strong RDE programs.



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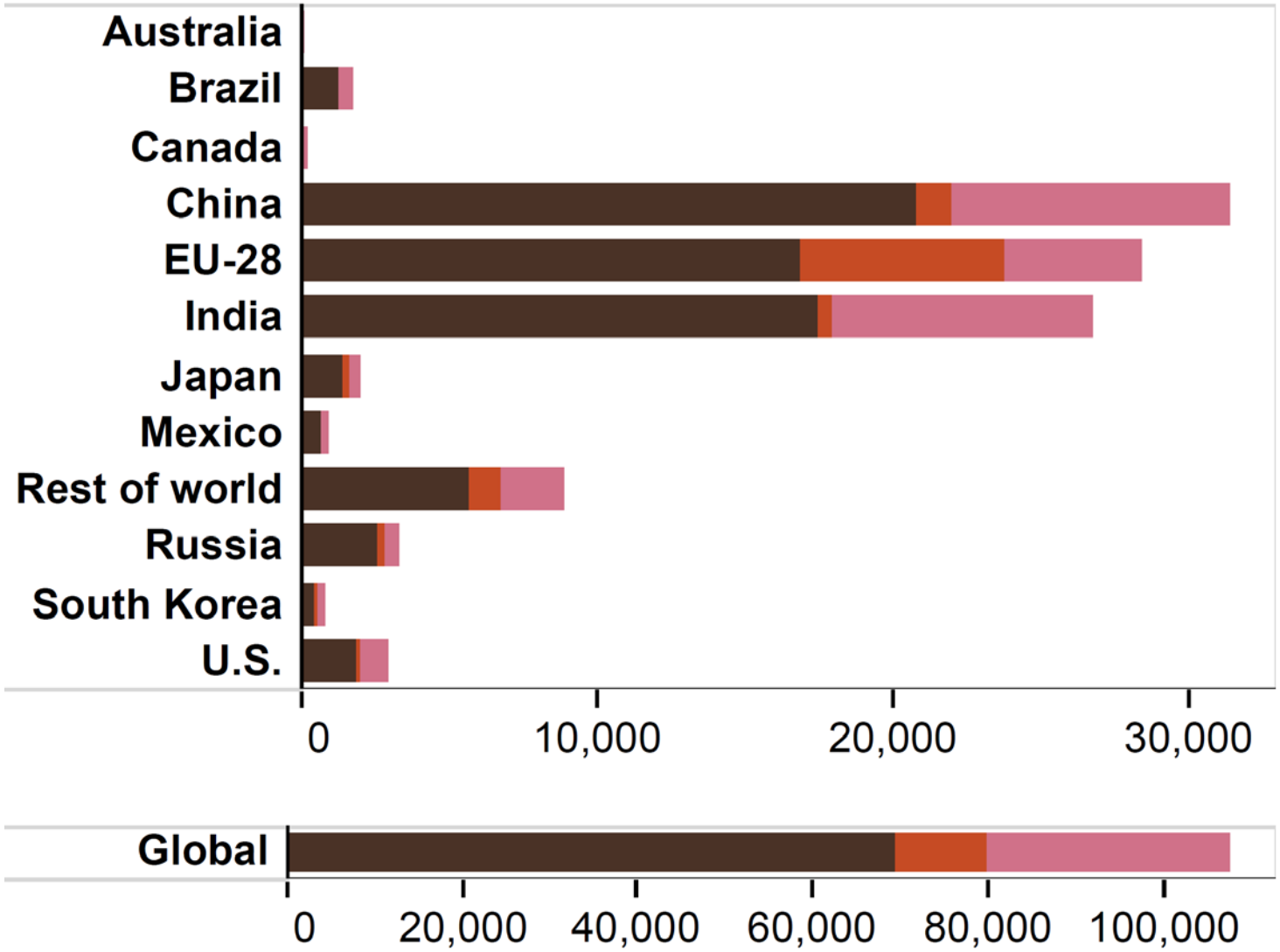
$PM_{2.5}$ and ozone-related premature deaths from excess diesel vehicle NOx emissions



Source of on-road diesel NOx

- excess HDV
- excess LDV
- Limit-2015

38,000 $PM_{2.5}$ and ozone-related premature deaths associated with excess diesel NOx emissions in 2015

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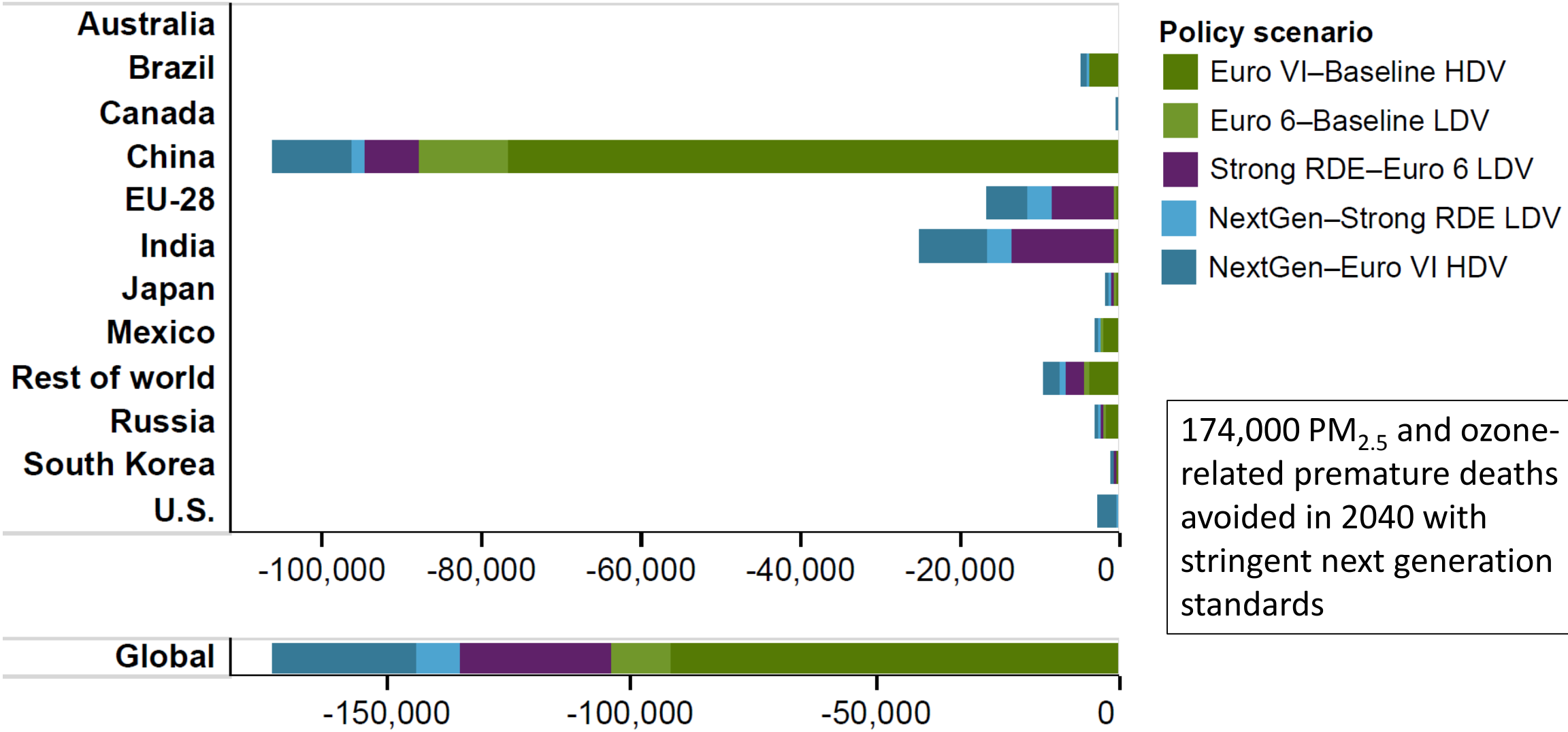
Premature deaths avoided with tighter NOx standards in 2040



174,000 $PM_{2.5}$ and ozone-related premature deaths avoided in 2040 with stringent next generation standards

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See forthcoming paper for additional results

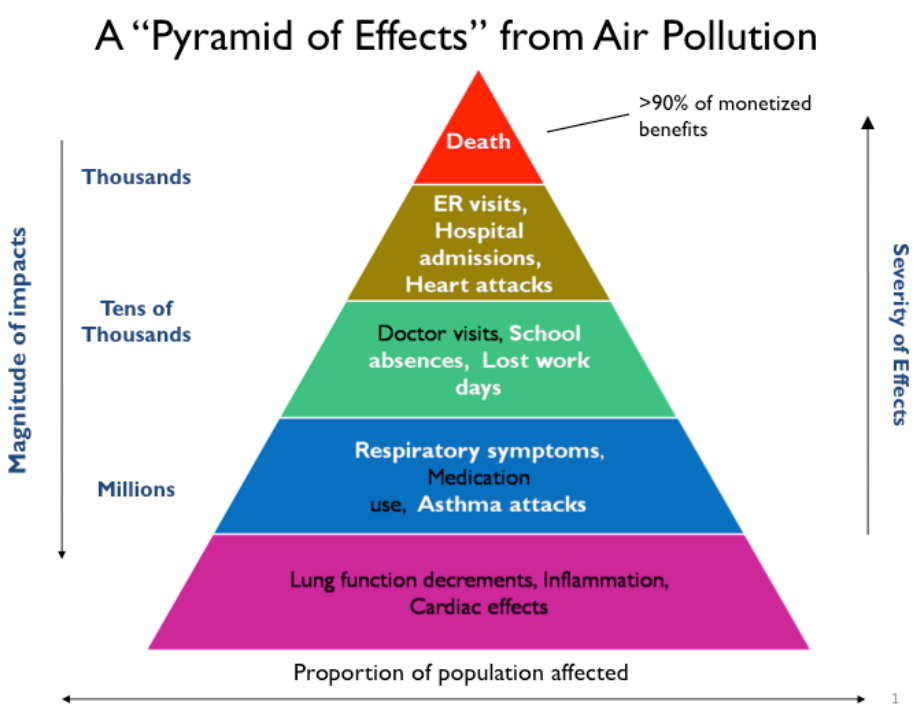
- Ozone impacts on global yields of soy, maize, and wheat
- Ozone and aerosol impacts on global radiative forcing

New project: Burden of disease from transportation-related air pollution

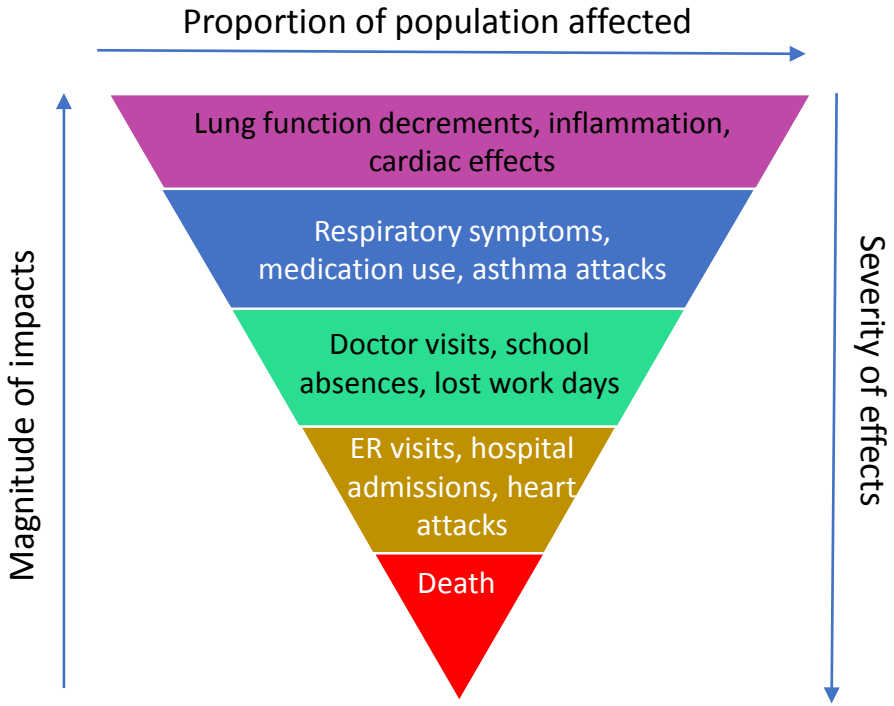
CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

- How many $PM_{2.5}$- and ozone-related premature deaths have resulted from transportation emissions globally in 2015?
- How has this burden of disease changed over time?
- What is the distribution of health impacts around the world?
- Which types of vehicles contribute most to the transportation burden of disease?
- Sponsored by Climate and Clean Air Coalition and International Council on Clean Transportation

New project: Impacts of ambient air pollution on asthma and other non-fatal health outcomes



Inverted pyramid of perceived effects from air pollution



Leading causes of years lost due to disability, 2015

Leading causes 2015	% change number of YLDs 2005–15	% change all-age YLD rate 2005–15	% change age-standardised YLD rate 2005–15
1 Lower back and neck pain	18·6	4·9	−2·1
2 Sense organ diseases	25·2	10·8	0·6
3 Depressive disorders	18·2	4·5	1·0
4 Iron-deficiency anaemia	−3·8	−14·9	−11·6
5 Skin diseases	11·7	−1·2	0·4
6 Diabetes	32·5	17·2	5·4
7 Migraine	15·3	2·0	0·8
8 Other musculoskeletal disorders	20·5	6·6	1·3
9 Anxiety disorders	14·8	1·5	1·0
10 Oral disorders	22·4	8·2	−0·2
11 Asthma	9·4	−3·3	−2·3
12 Schizophrenia			
13 Osteoarthritis			
14 COPD	16·2	2·8	−5·9
15 Falls	11·3	−1·5	−8·6
16 Autistic spectrum	12·3	−0·7	0·6
17 Gynaecological diseases	10·7	−2·1	−3·3
18 Drug use disorders	23·6	9·4	8·2
19 Other mental and substance	18·7	5·0	0·3
20 Medication overuse headache	18·9	5·2	0·6
21 Bipolar disorder	14·9	1·6	0·5
22 Congenital anomalies	28·5	13·7	14·7
23 Haemoglobinopathies	4·3	−7·7	−4·9
24 Chronic kidney disease	23·8	9·5	0·1
25 Ischaemic heart disease	30·2	15·2	−0·3
26 Alzheimer's disease	38·8	22·8	1·1
27 Cerebrovascular disease	20·7	6·8	−4·2
28 Alcohol use disorders	11·1	−1·7	−4·5
29 Epilepsy	−6·4	−17·2	−16·3
30 Other cardiovascular	23·9	9·6	0·5
33 Conduct disorder			
34 Other unintentional			
35 Diarrhoeal diseases			
46 Intestinal nematode			

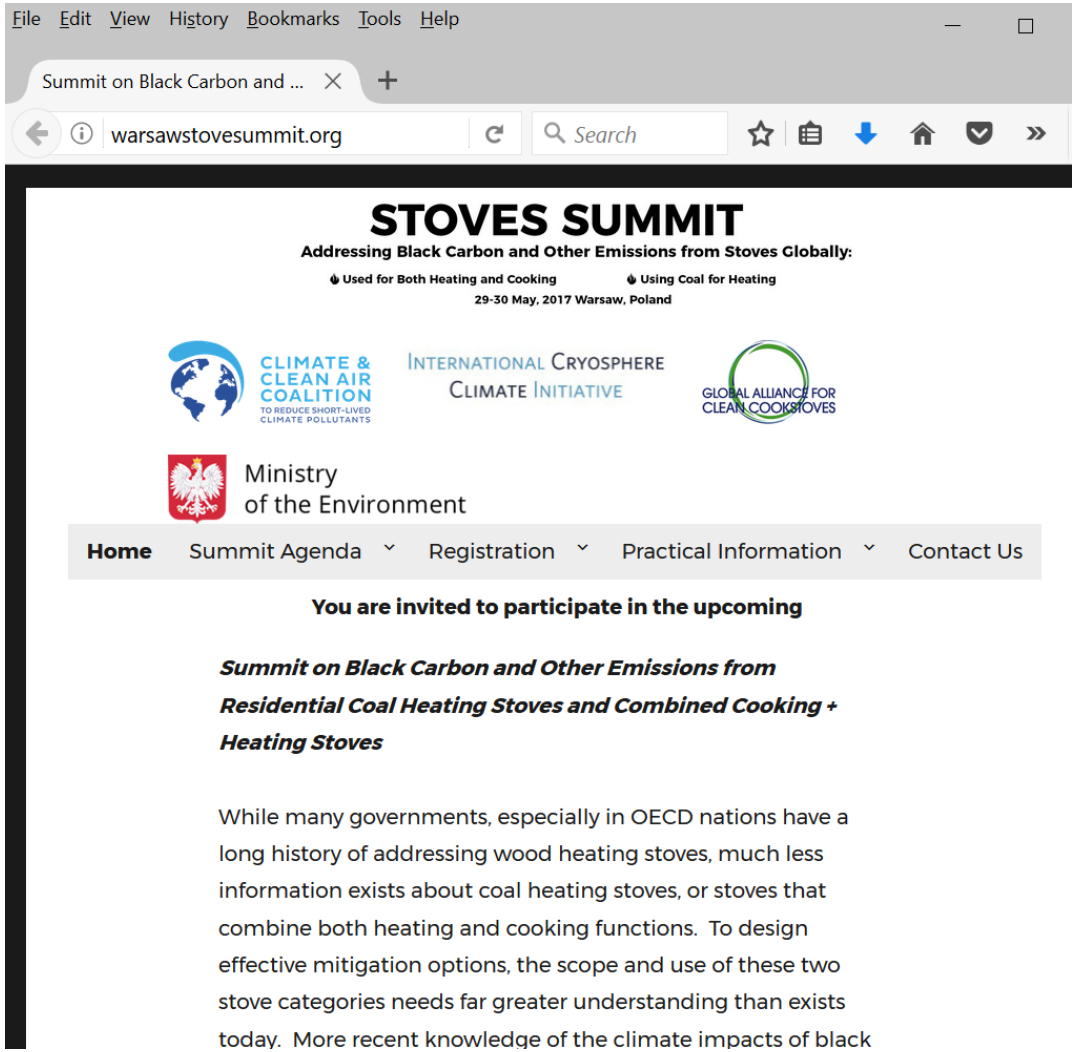
Asthma: #11 cause of YLDs globally

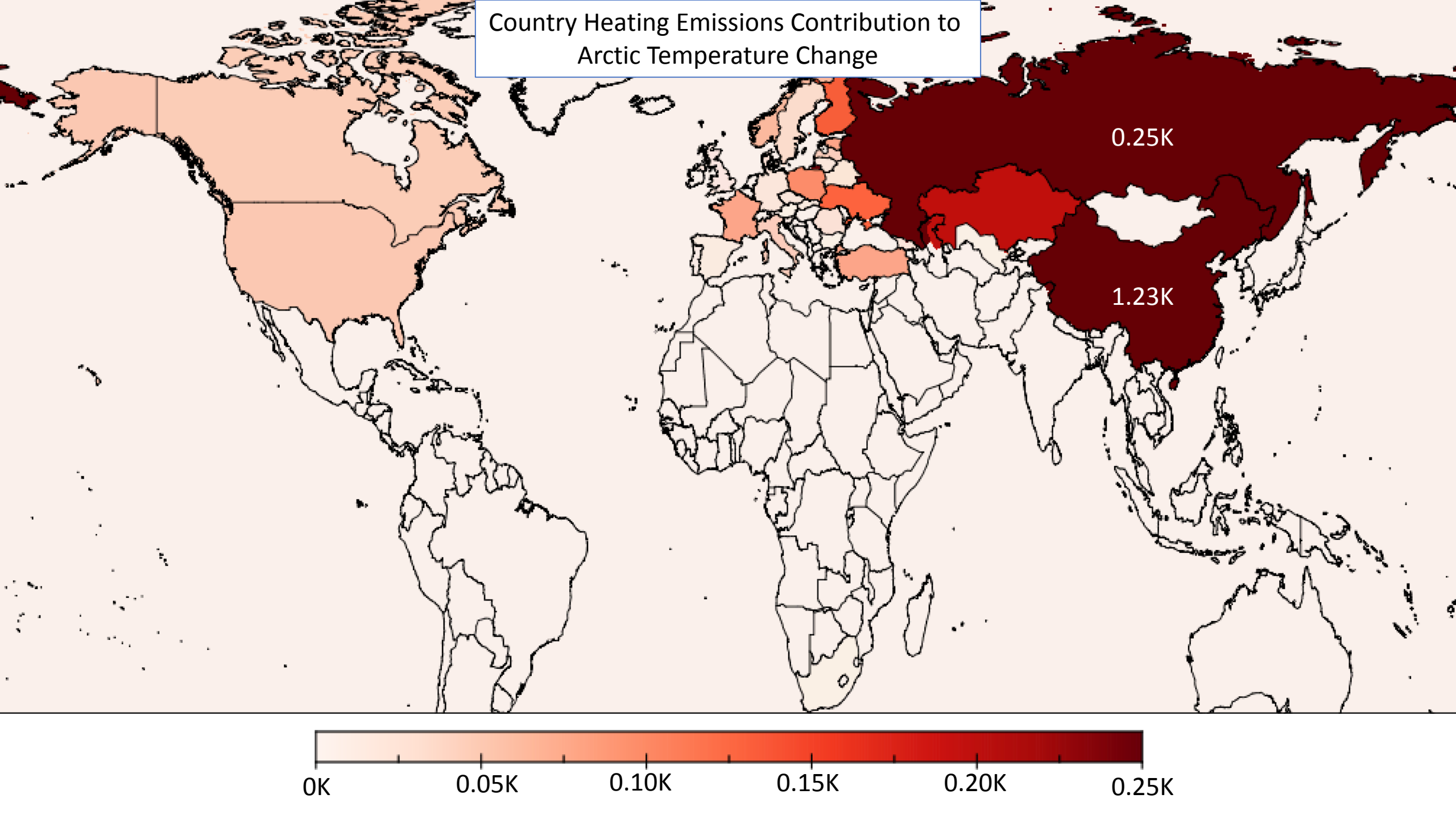
Communicable, maternal, neonatal, and nutritional
Non-communicable
Injuries

IHME, 2017

Summit on black carbon and other emissions from residential coal heating stoves and combined cooking+heating stoves

- May 29-30, 2017 in Warsaw, Poland
- Goal: Enable scaled-up action to reduce short-lived climate pollutants from coal stoves and combined cooking/heating stoves by:
  - Characterizing the **unique challenges posed by short-lived climate pollutant emissions** from these sources
  - Identifying the scale of the problem and **key knowledge gaps**
  - **Fostering connections** among communities of experts working towards developing and disseminating cleaner burning heatstoves and cookstoves
  - Sharing **technological and policy options** for reducing emissions
  - Raising **awareness** through public communication on the conference and its outcomes
  - Developing **next steps** to overcome key knowledge gaps and challenges.




Country Heating Emissions Contribution to Arctic Temperature Change
0.25K
1.23K
0K
0.05K
0.10K
0.15K
0.20K
0.25K

Preliminary gaps, data needs, and next steps from Warsaw Stove Summit white papers

1. Who is using coal heating stoves and combined cooking/heating stoves around the world?
2. How much do coal heating stoves and combined cooking/heating stoves contribute to household air pollution, ambient air pollution, and associated health, climate, and environmental impacts?
3. How much do solid fuel heating stoves contribute to the global burden of disease from household and ambient air pollution?
4. Under development: gaps, needs, and next steps for developing technological, policy, and finance solutions

Register at www.warsawstovesummit.org to participate in this discussion!

Thank you!

- Contact me at: susan.anenberg@envhealthanalytics.com

Extra slides

Policy scenarios consider region-specific implementation timelines.

Region	Type	Baseline[2]	Euro 6/VI	Strong RDE[3]	Next Gen
EU-28	Light	Euro 6 in 2014; adopted RDE phase-in 2017-2020	–	Strong RDE phase-in 2017-2020	Euro 7 in 2021
	Heavy	Euro VI in 2014	–	–	Euro VII in 2025
S. Korea	Light	Euro 6 in 2014	–	**1 year** after EU	**1 year** after EU
	Heavy	Euro VI in 2015	–	–	
Australia	Light	Euro 6 in 2018	–	**3 years** after EU	**3 years** after EU
	Heavy	Euro V in 2011	Euro VI in 2018	–	
India	Light	Bharat 6 in 2020[4]	–	**6 years** after EU	**6 years** after EU
	Heavy	Bharat VI in 2020	–	–	**4 years** after EU
Brazil	Light	Euro 4 in 2009	Euro 6 in 2018	**4 years** after EU	**4 years** after EU
	Heavy	Euro V in 2012	Euro VI in 2018	–	
Russia	Light	Euro 5 in 2016	Euro 6 in 2020	**5 years** after EU	**5 years** after EU
	Heavy	Euro V in 2016	Euro VI in 2020	–	
Mexico	Light	Euro 4 in 2009	Euro 6 in 2018	–	Tier 3 2021-2025
	Heavy	Euro IV in 2008	Euro VI in 2018	–	Same as U.S.
China	Light	China 5 in 2018[5]	China 6a in 2020; China 6b in 2023[6]	Strengthened RDE with China 6b	China 6b equivalent to U.S. Tier 3
	Heavy	China V in 2017	China VI in 2021	–	**2 years** after EU
United States	Light	Tier 3 phase-in 2017-2025	–	–	–
	Heavy	Tier 3[7]/EPA 2010	–	–	Next generation in 2025
Canada	Light	Harmonized with U.S.	–	–	–
	Heavy		–	–	Same as U.S.
Japan	Light	PNLTES[8] 2009	–	Same as EU	Same as EU
	Heavy	PNLTES 2016	–	–	Same as EU

Dash indicates no change from previous scenario.

Grey fill indicates regions that have developed their own emission control programs from the ground up.

Results embargoed; Do not cite or quote.

Meta-analysis of real-world NOx considers studies of PEMS, remote sensing, chassis testing, and emission factor models

Key data sources for real-world NOx emission factors:

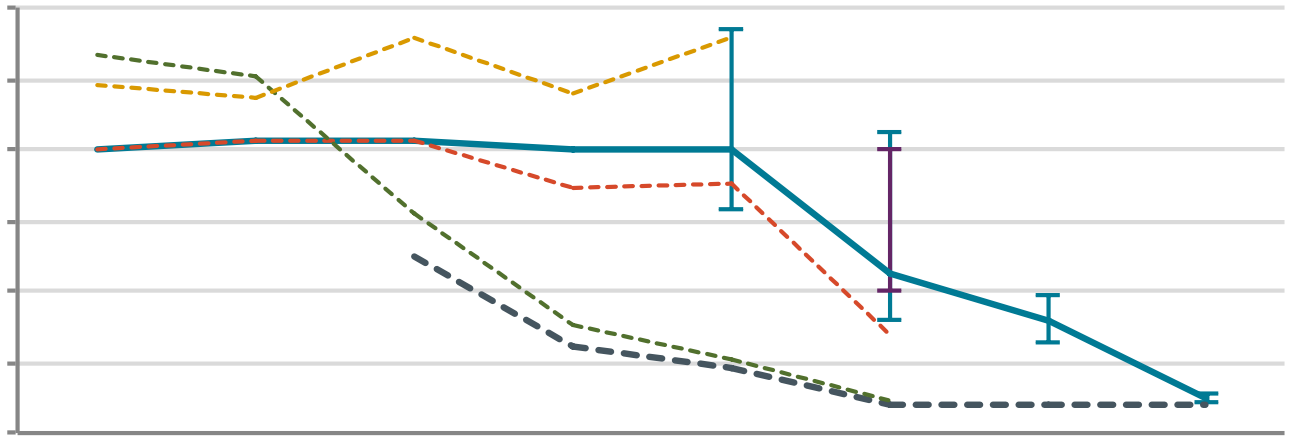
HDV

- EU: COPERT, VTT chassis testing
- US: MOVES, remote sensing (trucks), WVU IBIS (buses)
- China: PEMS testing
- Japan: Comparison with EU regs

LDV

- EU: ICCT PEMS, RDE analysis (Miller & Franco, 2017)
- US: WVU PEMS (Dieselgate), remote sensing
- China: Comparison with EU regs
- S. Korea, Japan: based on EU (confirmed by official PEMS tests)

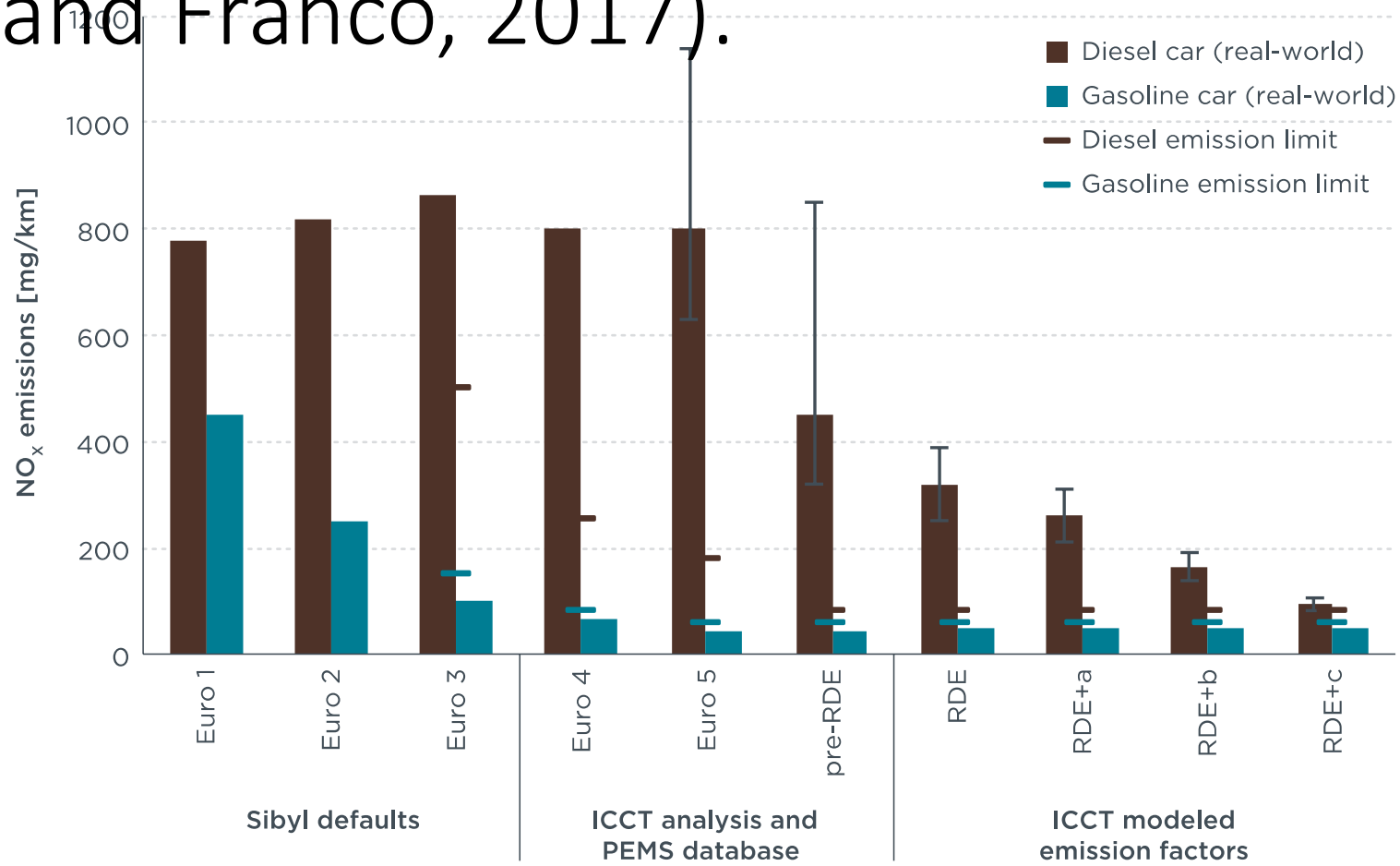
Example: diesel passenger car NO_x emission factors in the EU-28



Results embargoed; Do not cite or quote.

Baseline RDE and Strong RDE emission factors from recently released analysis of EU RDE regulation (Miller and Franco, 2017).

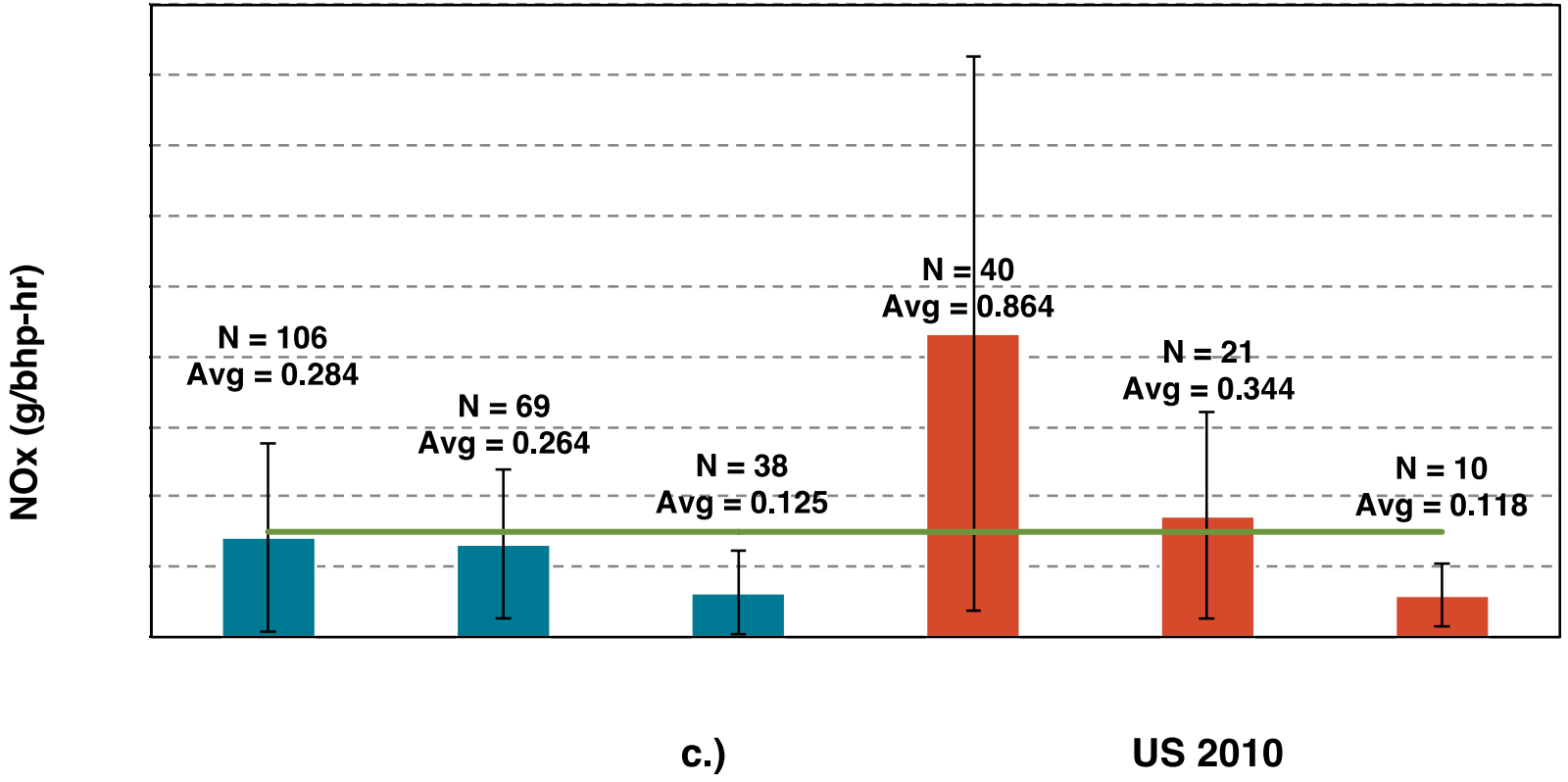
- Baseline RDE (‘RDE’)
  - 1st and 2nd RDE packages
  - Real-world NOx: **4x Euro 6 limit**
- Strong RDE (‘RDE+c’)
  - 3rd and 4th RDE packages and more
  - Cold-start provisions
  - In-service conformity testing
  - Market surveillance using remote sensing
  - Independent verification
  - Expanded RDE test boundaries
  - Tightened conformity factor
  - Real-world NOx: **1.2x Euro 6 limit**



Results embargoed; Do not cite or quote.

US EPA 2010 HDVs may emit more excess NOx in urban driving conditions than equivalent Euro VI vehicles in the EU.

- Data gathered from a literature review of vehicle testing (PEMS and chassis dyno) in EU and US
- US and EU real world emissions diverge at lower vehicle speeds (~lower engine loads)



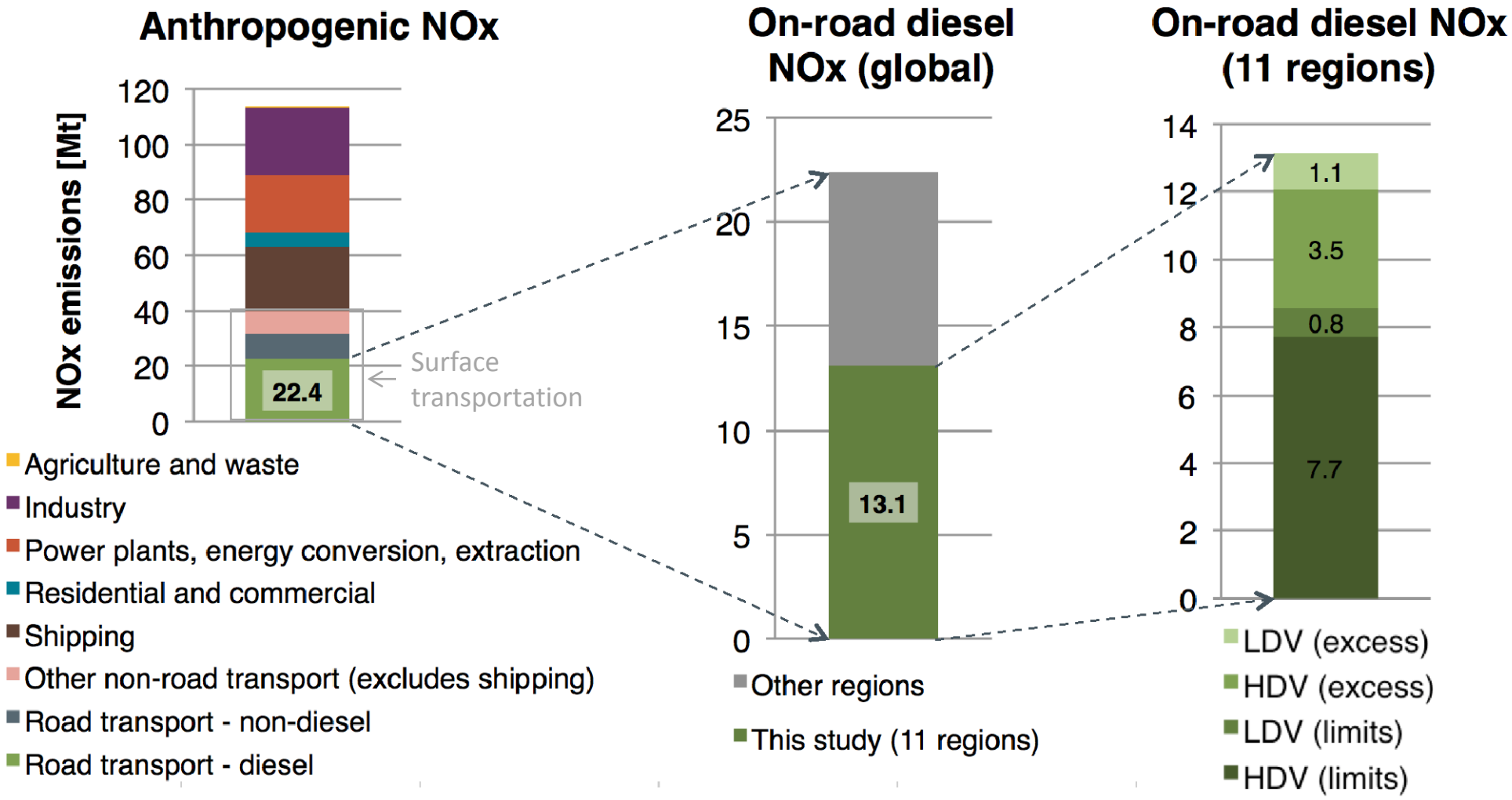
EU Data sources: TNO, VTT, TfL. US Data sources: CARB, EPA, WVU, UCR. Note: Some conversion assumptions had to be made in cases where the NOx emissions were not reported in units of g/bhp-hr

Green: US NTE NOx limit (1.5x certification limit)

Error bars indicate one standard deviation.

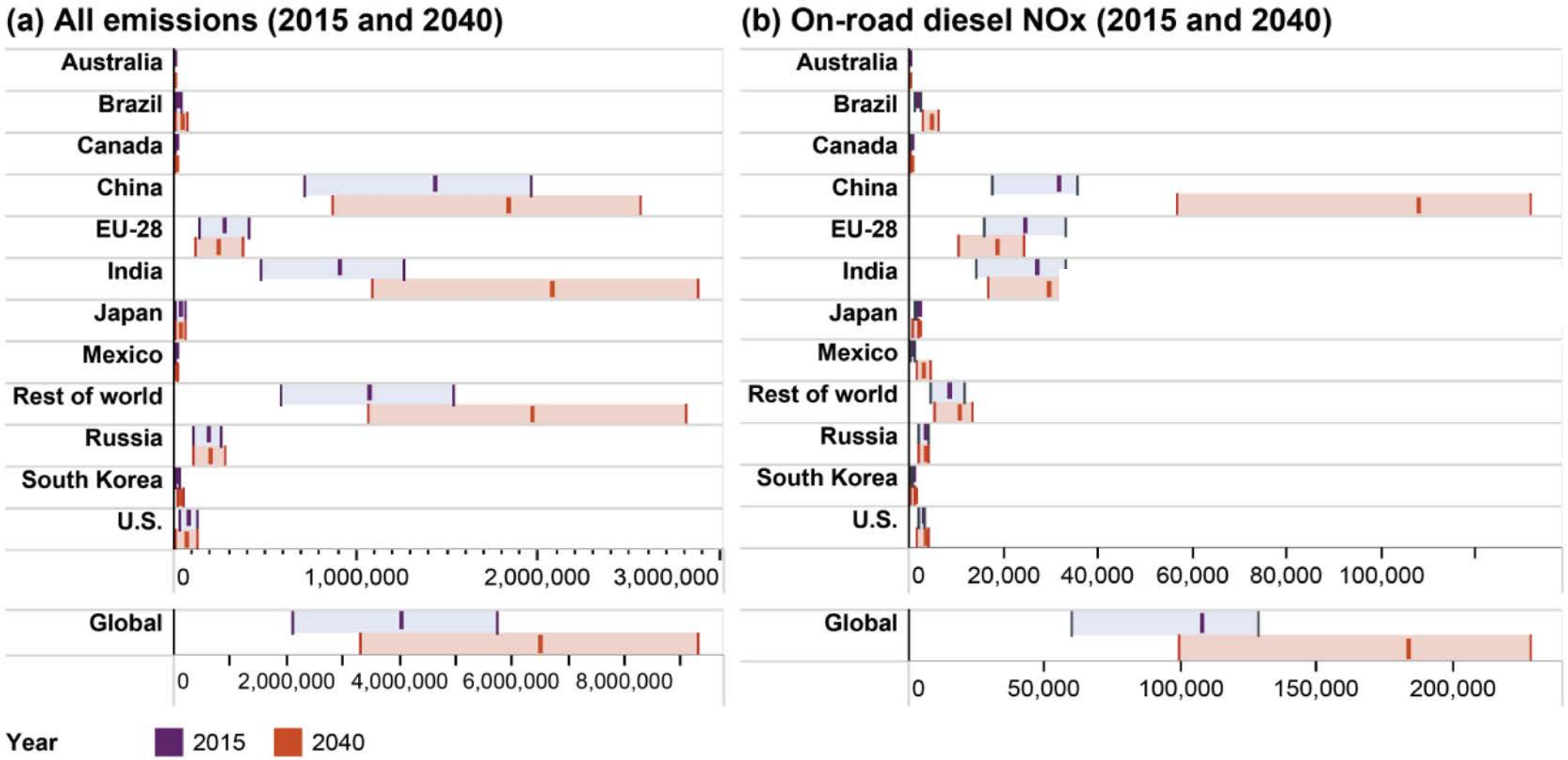
Results embargoed; Do not cite or quote.

Baseline 2015: on-road diesel vehicles contribute 55% of global surface transportation NOx emissions.



Results embargoed; Do not cite or quote.

$PM_{2.5}$ and ozone mortality – all sources and on-road diesel NOx



Results embargoed; Do not cite or quote.

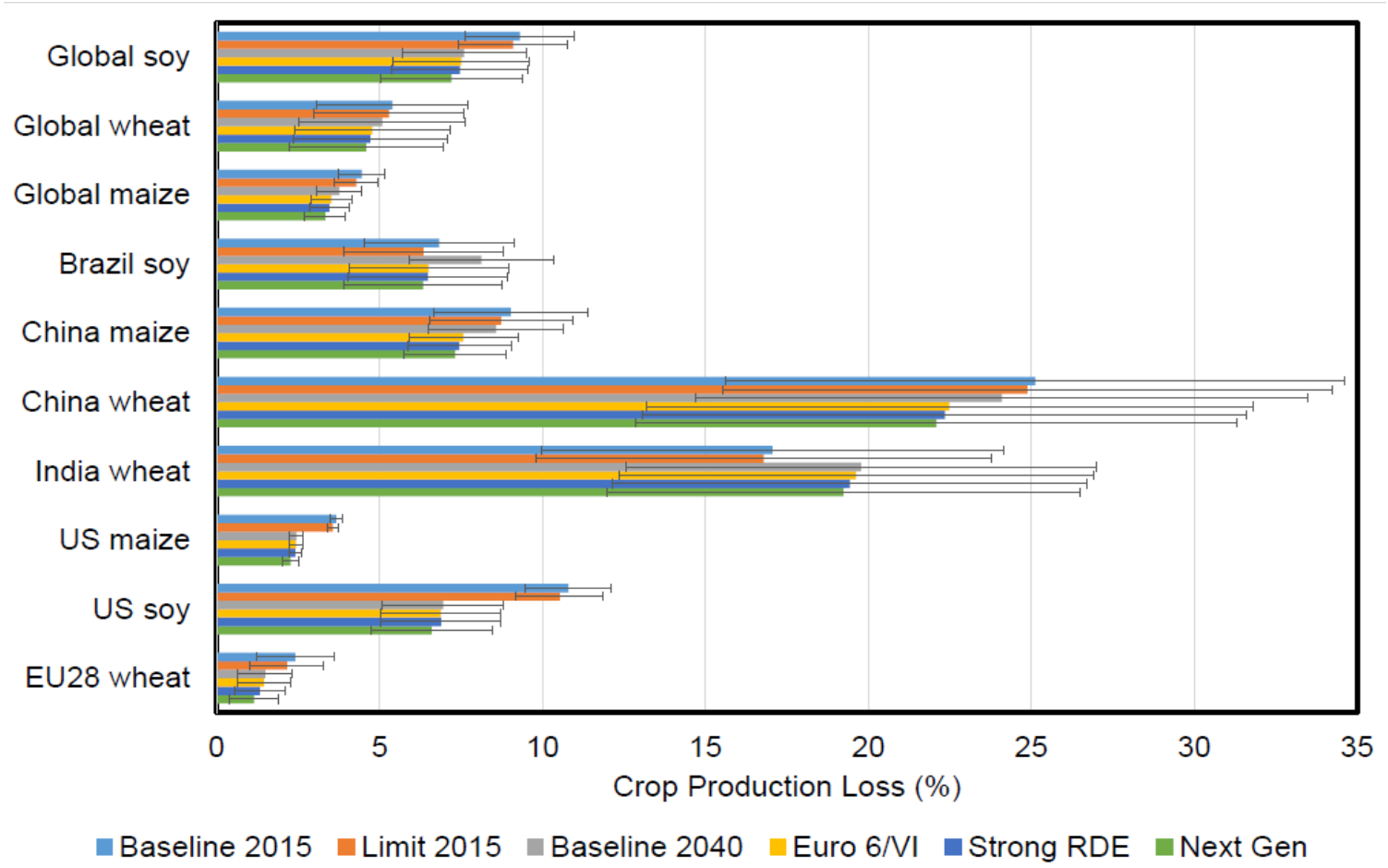
Crop impacts

Ozone is associated with damages to vegetation, including crops and ecosystems.

In EU-28, excess NOx in 2015 exacerbated ozone-related wheat production loss by 0.2-0.3%, translating to 0.2-0.4 Mt of wheat at year 2000 production levels).

Largest crop benefits of the more stringent policies in 2040:

- Chinese wheat and maize (1-2% crop production loss avoided, 4-8 Mt)
- Brazilian soy (1-2%, 0.4 Mt)



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