



TM5-FASST

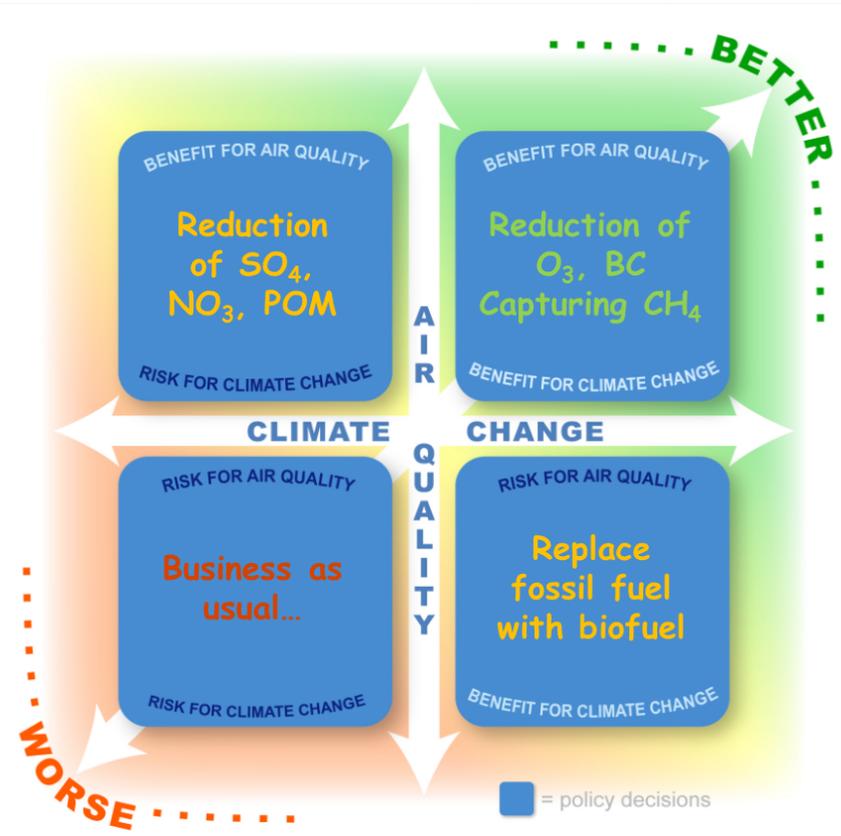
a global multi-metric, multi-impact assessment tool

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TM5-FASST

FAst Scenario Screening Tool

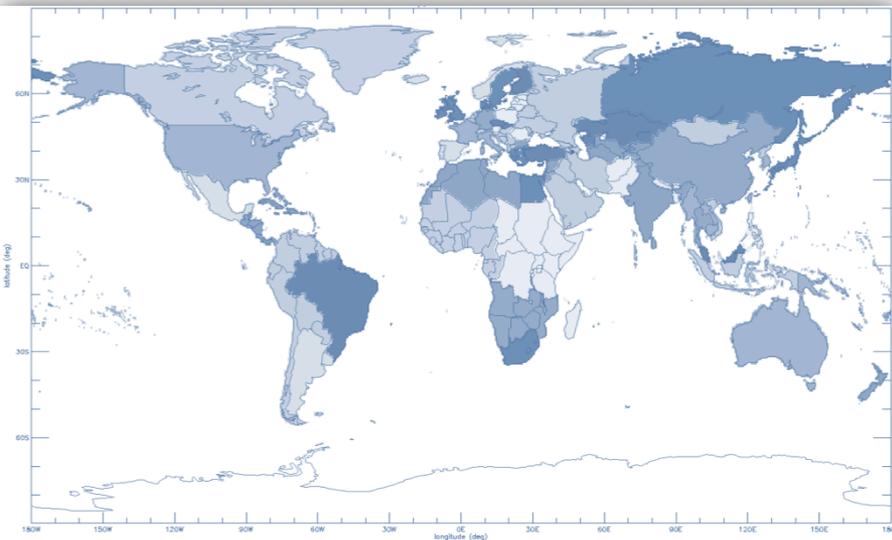


Addresses the need for swift and ad-hoc impact assessment of pollutant emission scenarios (air quality policies, climate policies) in a global framework



the **FA**st Scenario **Sc**reening **T**ool **TM5-FASST**

- 'Emulator' of the full TM5-CTM global chemical transport model
- Source-Receptor model
- Linearized emission \rightarrow concentration relations calculated with TM5-CTM
- 56 source/receptor regions
- EU27: 16 FASST regions
- Fixed natural PM (dust and seasalt) fields



Emissions (model input):

SO₂, NO_x, NH₃, CO, NMVOC, Elemental Carbon, Primary Organic Matter, PM_{2.5}, CH₄

Model output (non exhaustive):

- PM_{2.5} concentration and impacts on human health
- O₃ and O₃ metrics, impacts on agriculture and health
- NO_y and SO_x deposition
- Radiative forcing
CO_{2e} based on GWPhh and GTPhh
BC deposition (e.g. Arctic, Himalayas,...)

Pollutant→ Precursor↓	SO ₂ gas	NO _x gas	NH ₃ gas	O ₃ gas	SO ₄ pm	NO ₃ pm	NH ₄ pm	BC pm	POM pm	SOx dep	NOy dep	BC dep	Rad. Forc.
SO ₂ (g)	xxx	x	xx	x	xxx	xx	xx			xxx			xxx
NO _x (g)	x	xxx	xx	xxx	xx	xxx	xx			x	xxx		xxx
NH ₃ (g)	x	x	xxx	x	xx	xx	xxx			x			xxx
NMVOG (g)	x	x	x	xxx	x	x	x			x			xx
BC (pm)								xxx				xxx	xxx
POM (pm)									xxx				xxx
CO (g)*				xx									xx
CH ₄ (g)*	x	x	x	xx	x	x	x			x			xxx

* source-receptors from HTAP v1



Calculation of Source-Receptor coefficients:

- 1) Base run with RCP base year 2000 emission inventory
- 2) 20% emission perturbation per source region, per precursor
- 3) for each perturbation, calculate DELTA(PM, O₃,...) with base run

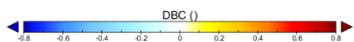
Applying the source-receptors:

- 4) linearly scale the DELTA concentration fields with actual emission changes for each source region

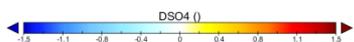
Delta concentration footprints from a +20% emission perturbation

CHINA

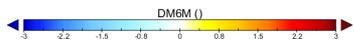
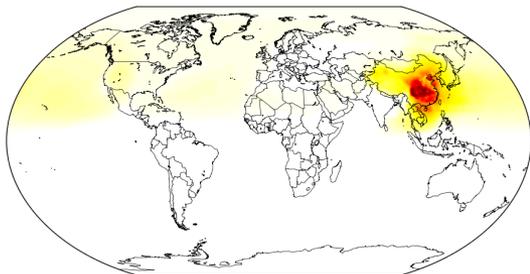
DBC



DSO4



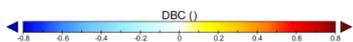
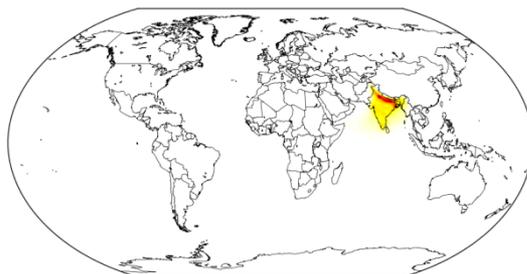
DM6M



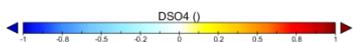
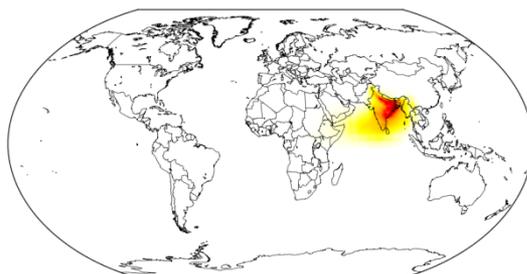
Data Min = -0, Max = 3.8

INDIA

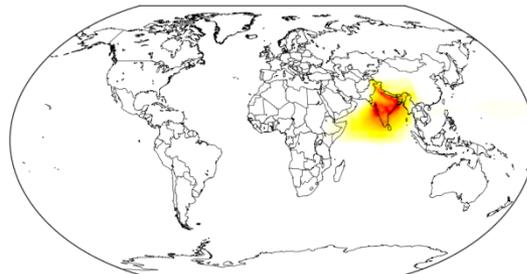
DBC



DSO4



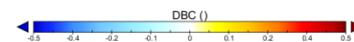
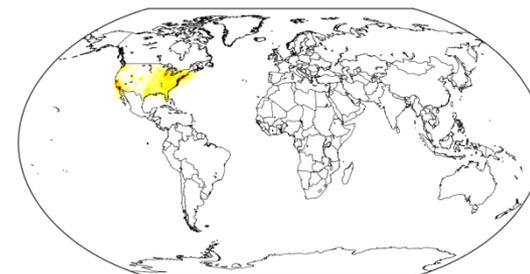
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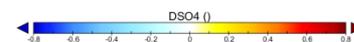
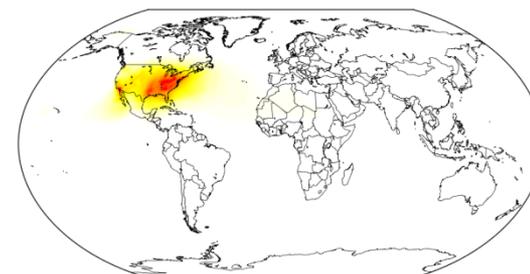
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USA

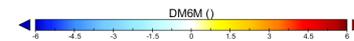
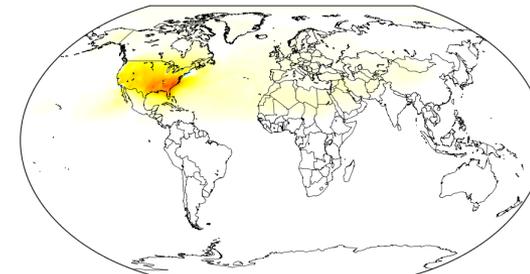
DBC



DSO4



DM6M



Data Min = -1E-01, Max = 3.8

dBC
(dBC)

dSO₄
(dSO₂)

dO₃
(dNO_x)

Specific features of the TM5-FASST model:

- Implemented both as IDL code and as interactive web tool
- Apportionment of pollutants concentrations and impacts
 - By region
 - By sector (provided input emissions are segregated by sector)
 - By precursor
- PM individual chemical compounds are modelled
 - Primary: BC, OM, other primary PM_{2.5} (if provided in emissions)
 - Secondary: SO₄, NO₃, NH₄
- Implicitly assumed fixed spatial distribution of emissions per region
- Assumed fixed meteorology (year 2001)

Linearity issues:

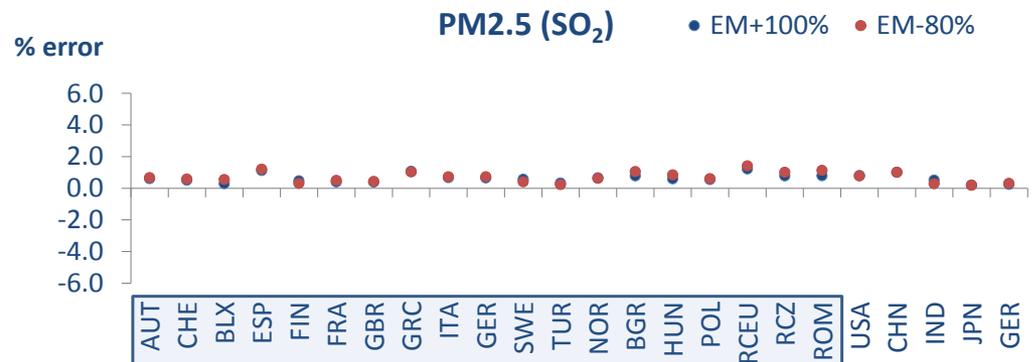
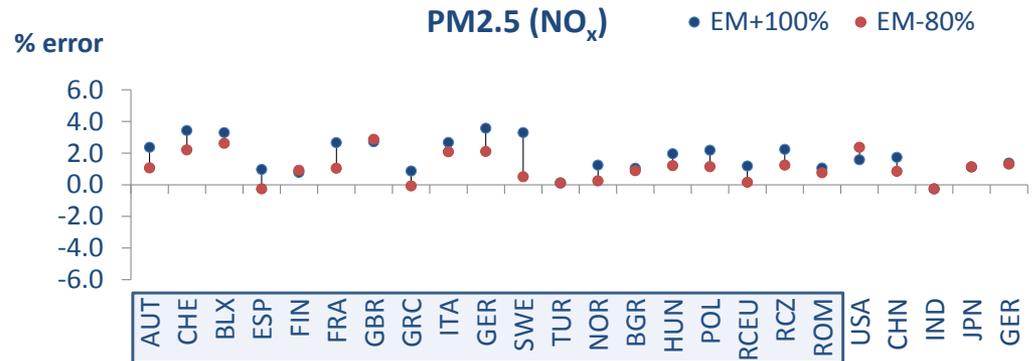
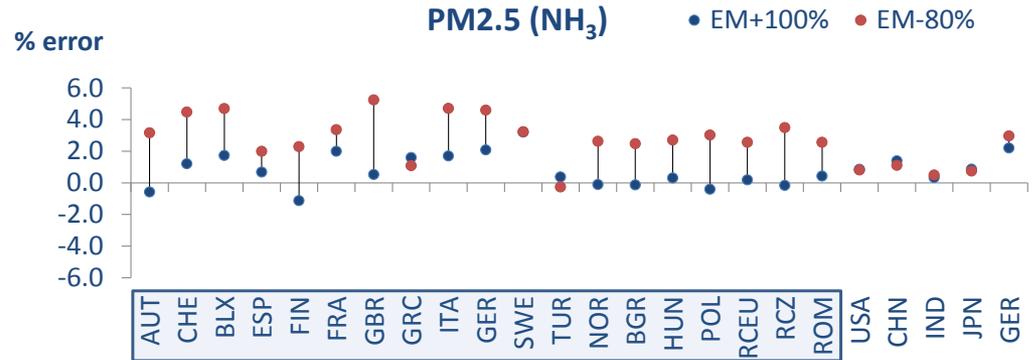
Error when emission changes go beyond -20% perturbation?

- Compare linearized with full CT model for -80%, +100% emission perturbation

- For selected source regions:

- EUROPE
- USA
- JAPAN
- CHINA
- INDIA
- GERMANY only

Population weighted PM2.5



Linearity issues:

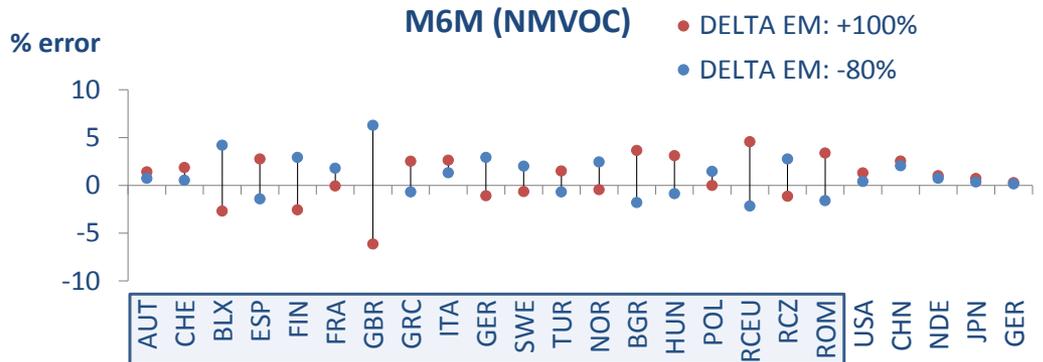
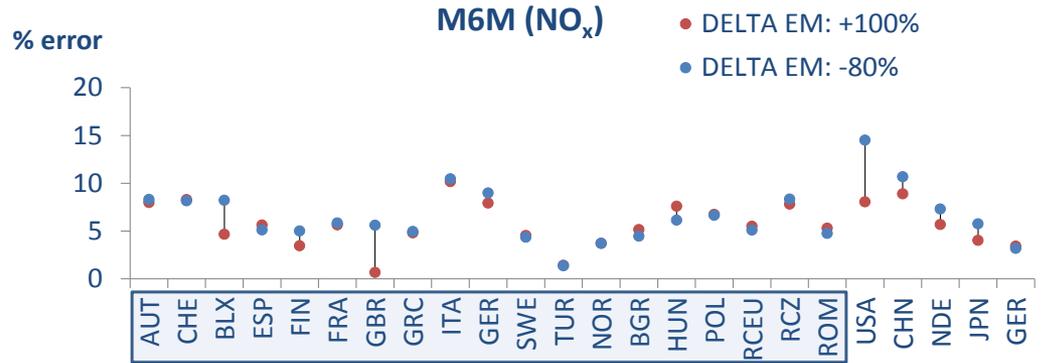
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Ozone metrics



TM5-FASST-CTM Comparison for GEA scenarios:

	BC	NH3	NOx	POM	SO2	NMVOC
2030 MIT (low emission scenario)						
ASIA	-47%	+19%	-30%	-49%	-61%	-35%
LAM	-45%	+47%	-53%	-27%	-41%	-28%
MAF	-30%	+33%	-40%	-29%	-49%	-30%
OECD90	-71%	+14%	-82%	-31%	-89%	-64%
REF	-62%	+34%	-65%	-30%	-80%	-34%
SHIPPING+AVIATION	-10%	+0%	-1%	-7%	-74%	+30%
GLOBAL	-47%	+25%	-48%	-35%	-69%	-37%
2030 FLE (high emission scenario)						
ASIA	+97%	+21%	+165%	+20%	+98%	+53%
LAM	-16%	+47%	+9%	-23%	+17%	+30%
MAF	+71%	+36%	+33%	+23%	+107%	+76%
OECD90	-27%	+17%	-40%	-9%	-22%	-39%
REF	-18%	+35%	-0%	-18%	+10%	+3%
SHIPPING+AVIATION	+3%	+0%	-13%	+7%	+24%	+4%
GLOBAL	+45%	+27%	+11%	+7%	+29%	+33%

OECD90: All countries that belonged to the Organization of Economic Development (OECD) as of 1990

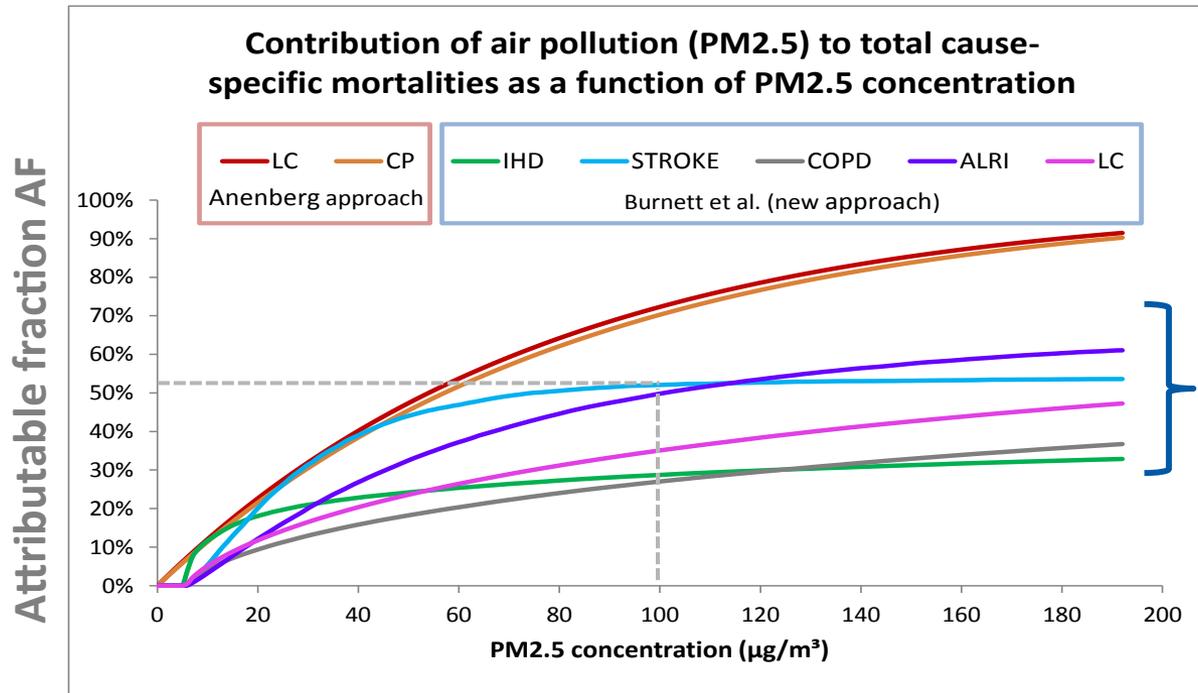
MAF: Developing Countries in Middle East & Africa

LA: All developing countries Latin America

REF: Countries undergoing economic reform - East European countries and the Newly Independent States of the former Soviet Union

ASIA: All developing countries in Asia

- PM2.5: 2-causes mortalities (Krewski et al. 2000, as in Anenberg et al., 2010)
- PM2.5: 5-causes mortalities (Burnett et al., 2013, as in GBD 2010)
- O3: long-term mortalities (Jerett et al., 2009, as in Anenberg et al., 2010)
- Cause-specific base Mortality data (+ projections till 2030) for 14 world regions from WHO



Burnett: Lower impact (benefits) at high PM2.5

e.g. at PM2.5 = $100\mu\text{g}/\text{m}^3$
52% of the "stroke" mortalities are attributable to PM2.5

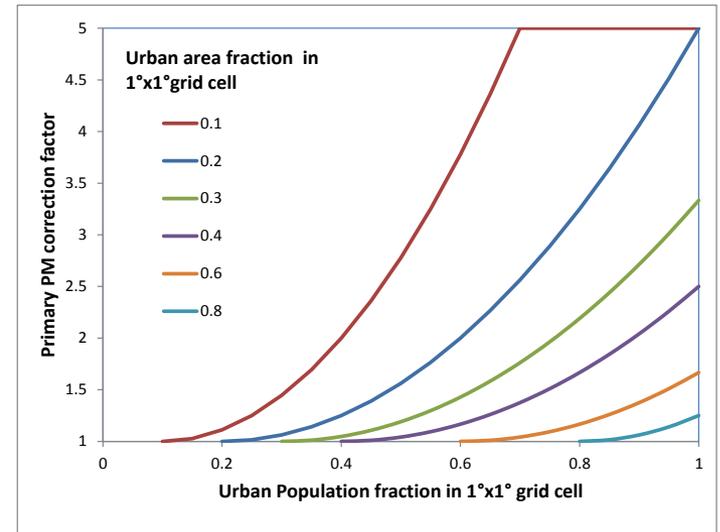
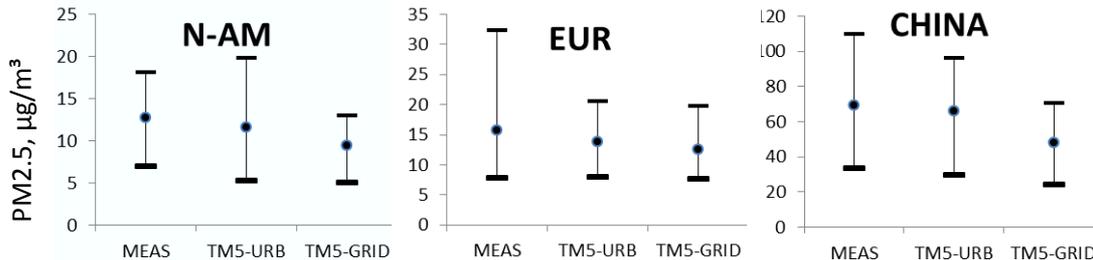
Urban increment subgrid parameterization

FASST-TM5 resolution = $1^\circ \times 1^\circ$

Grid-mean PM not adequately representing population exposure when emission / concentration gradients are present within grid (urban vs. rural area)

- Parameterization adjusting grid-mean concentration to urban incremented population-weighted exposure
- Based on **urban population fraction** f_{up} and **urban area fraction** f_{ua} within gridcell - based on high-resolution gridded population data (UN, CIESIN)

$$C_{BC, TM5}^{pop} = \left[\frac{(f_{UP})^2}{f_{UA}} + \frac{(1-f_{UP})^2}{1-f_{UA}} \right] \cdot C_{BC, TM5}^{area}$$



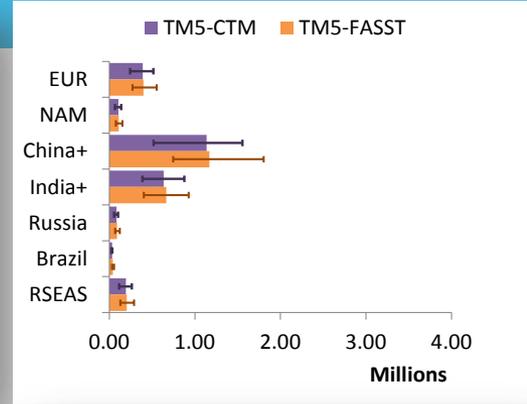
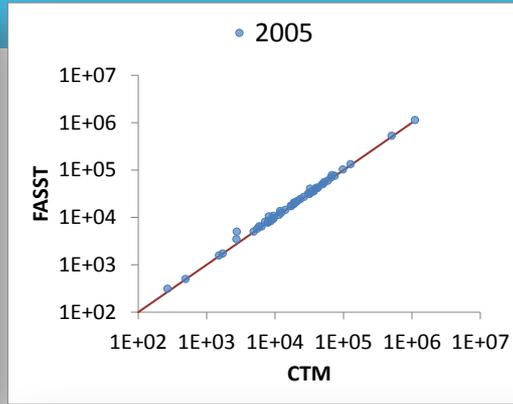
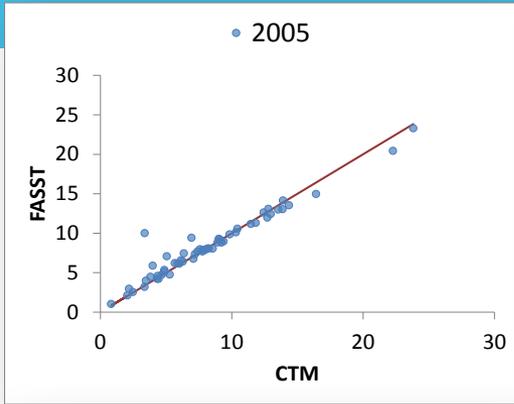
COMPARISON TM5-FASST with FULL TM5-CTM

PM2.5 ($\mu\text{g}/\text{m}^3$)

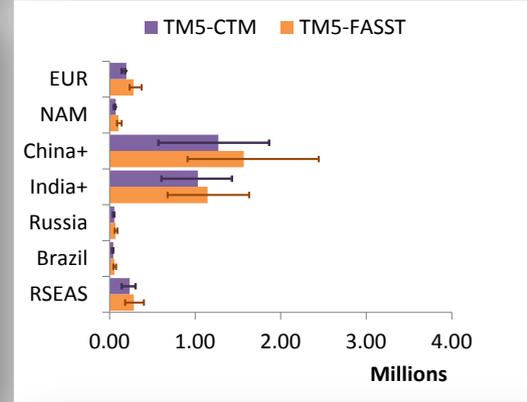
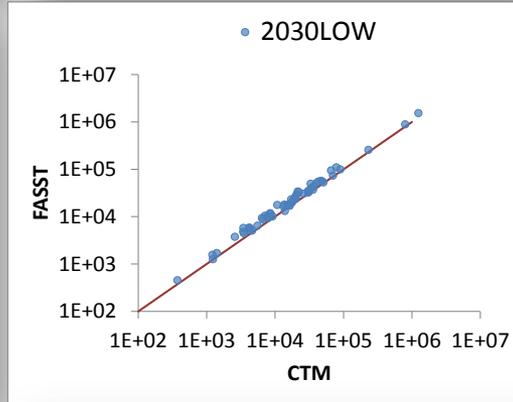
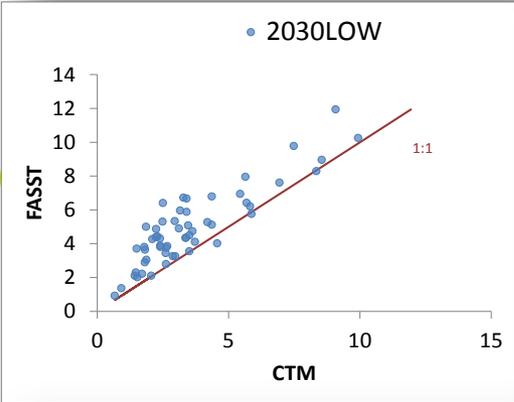
prem. mortalities

prem. mortalities

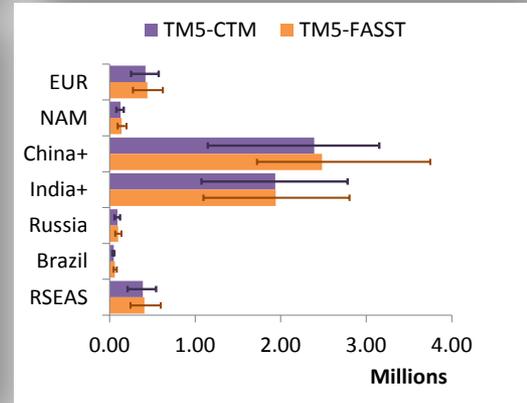
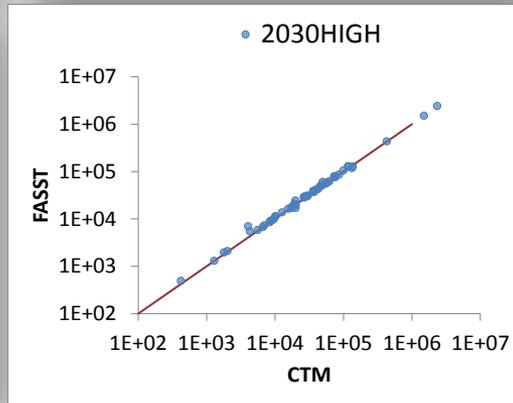
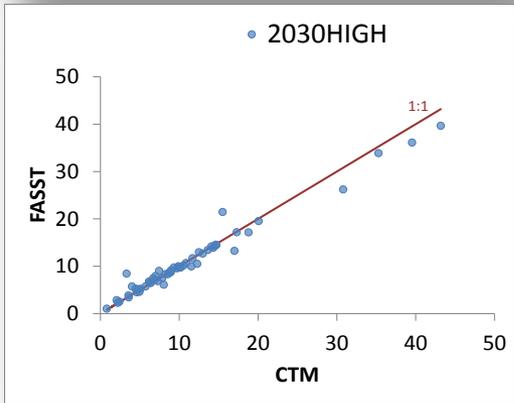
2005



2030
LOW



2030
HIGH

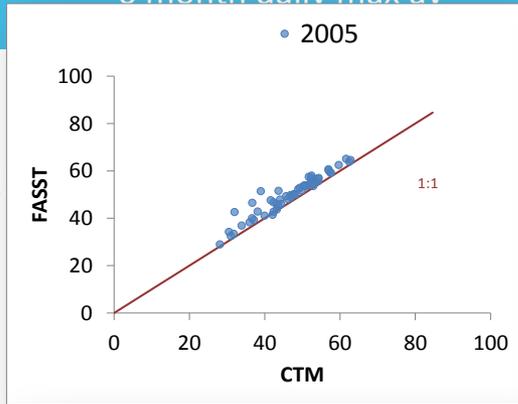


COMPARISON TM5-FASST with FULL TM5-CTM

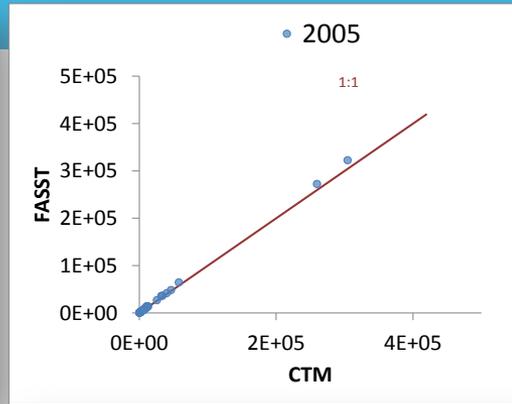
O₃ (ppbv)

6 month daily max av

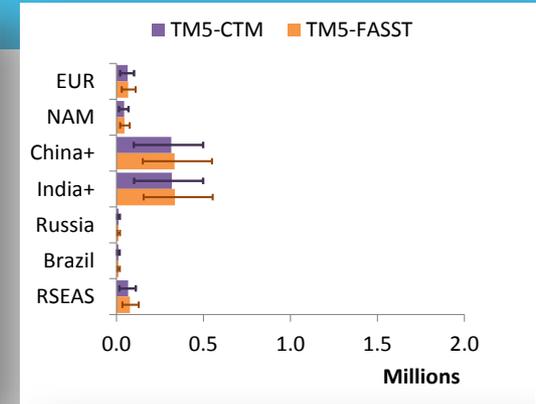
2005



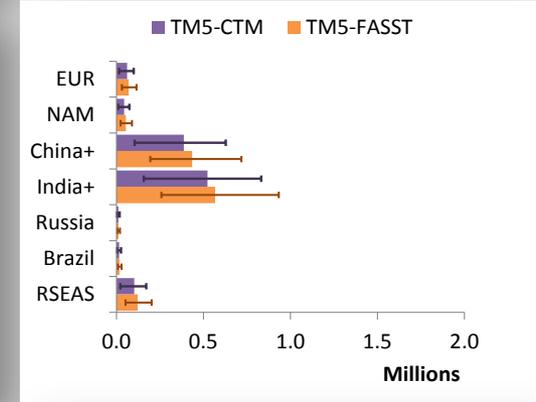
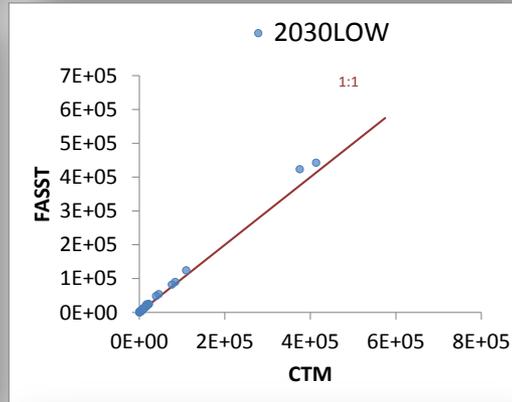
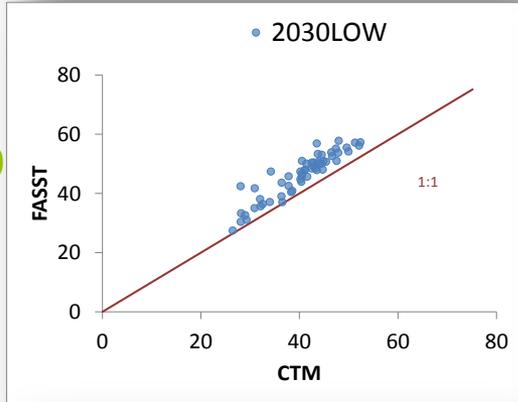
prem. mortalities



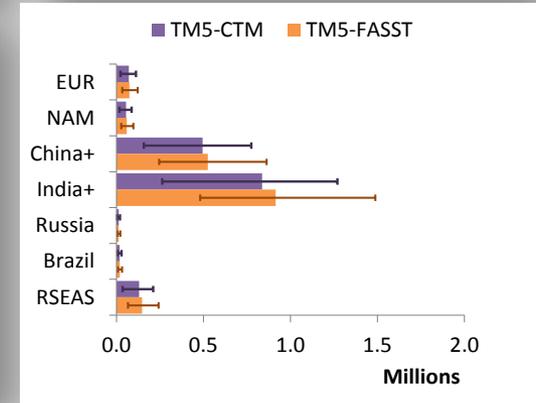
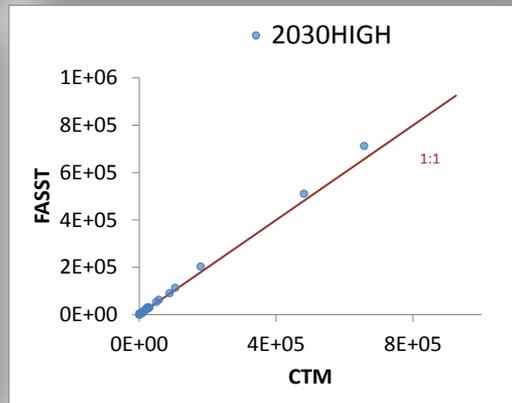
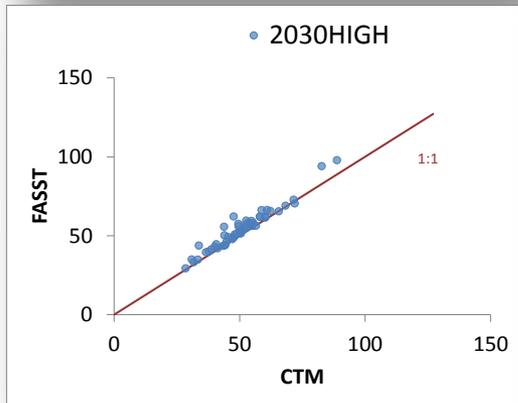
prem. mortalities



2030
LOW



2030
HIGH



Returning issues...

Non-linearity of damage functions

- Including sea-salt and dust in health impacts?
 - need to be included even when making delta's between scenario options
- Attribution of health impact by sector?

Residual water in PM2.5:

- PM2.5 measurements happen according to protocol at fixed RH.
 - EUR: 50%
 - US: 35%
 - CHN:



TM5-FASST applications

Conclusions and outlook