



# TM5-FASST

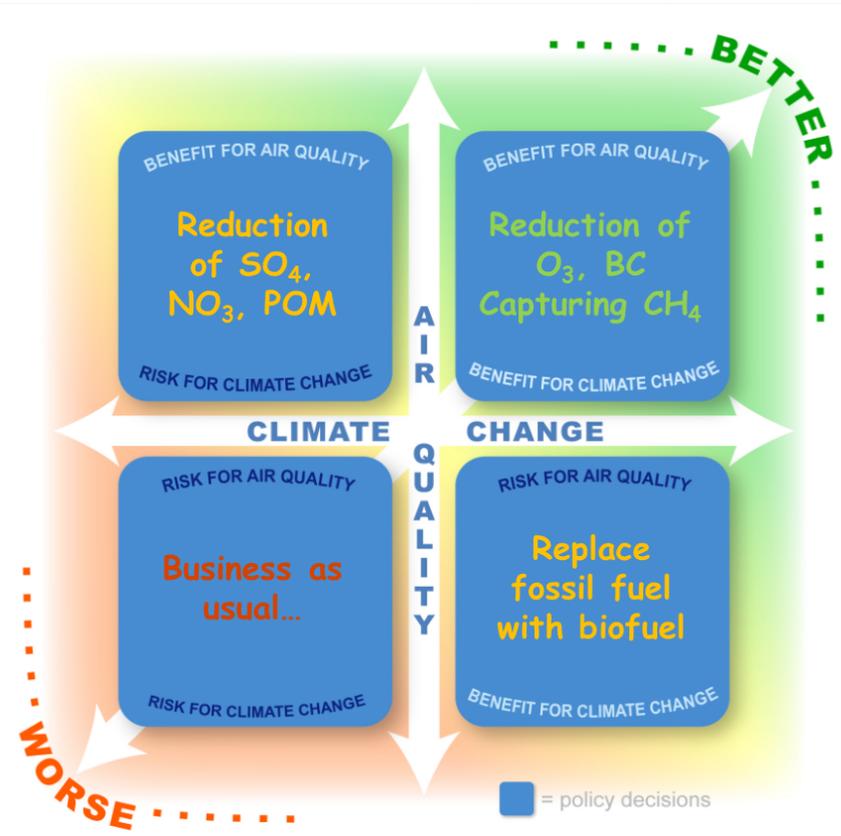
a global multi-metric, multi-impact assessment tool

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# TM5-FASST

## FAst Scenario Screening Tool

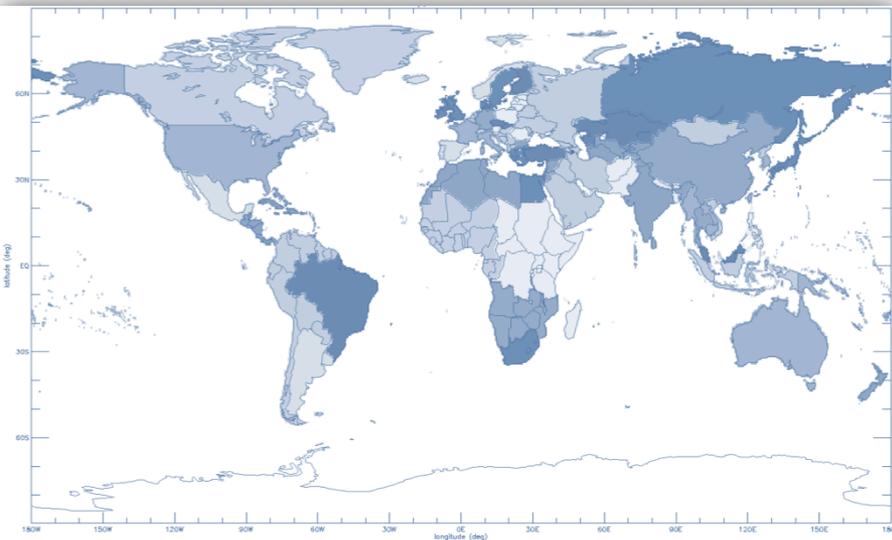


Addresses the need for swift and ad-hoc impact assessment of pollutant emission scenarios (air quality policies, climate policies) in a global framework



## the **FA**st Scenario **S**creening **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):**

SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, CO, NMVOC, Elemental Carbon, Primary Organic Matter, PM<sub>2.5</sub>, CH<sub>4</sub>

### **Model output (non exhaustive):**

- PM<sub>2.5</sub> concentration and impacts on human health
- O<sub>3</sub> and O<sub>3</sub> metrics, impacts on agriculture and health
- NO<sub>y</sub> and SO<sub>x</sub> deposition
- Radiative forcing  
CO<sub>2e</sub> based on GWPhh and GTPhh  
BC deposition (e.g. Arctic, Himalayas,...)

| Pollutant→<br>Precursor↓ | SO <sub>2</sub><br>gas | NO <sub>x</sub><br>gas | NH <sub>3</sub><br>gas | O <sub>3</sub><br>gas | SO <sub>4</sub><br>pm | NO <sub>3</sub><br>pm | NH <sub>4</sub><br>pm | BC<br>pm | POM<br>pm | SO <sub>x</sub><br>dep | NO <sub>y</sub><br>dep | BC<br>dep | Rad.<br>Forc. |
|--------------------------|------------------------|------------------------|------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------|------------------------|------------------------|-----------|---------------|
| SO <sub>2</sub> (g)      | xxx                    | x                      | xx                     | x                     | xxx                   | xx                    | xx                    |          |           | xxx                    |                        |           | xxx           |
| NO <sub>x</sub> (g)      | x                      | xxx                    | xx                     | xxx                   | xx                    | xxx                   | xx                    |          |           | x                      | xxx                    |           | xxx           |
| NH <sub>3</sub> (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 <sub>4</sub> (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, O<sub>3</sub>,...) with base run

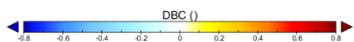
## Applying the source-receptors:

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

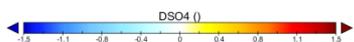
# Delta concentration footprints from a +20% emission perturbation

## CHINA

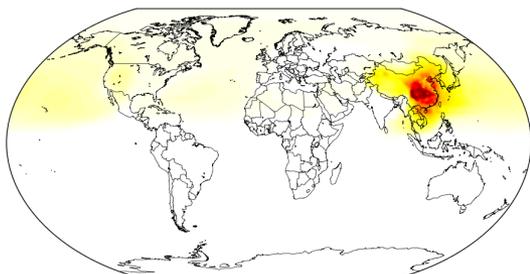
DBC



DSO4



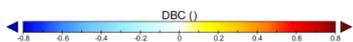
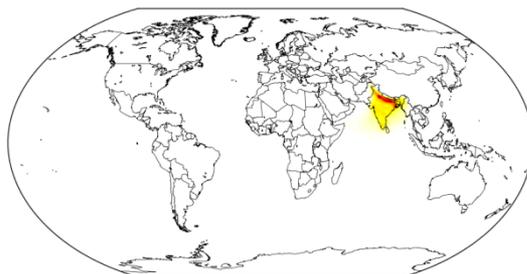
DM6M



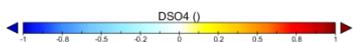
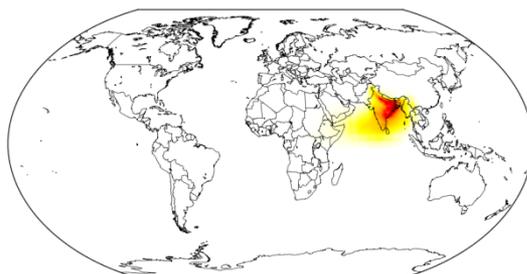
Data Min = -0, Max = 3.8

## INDIA

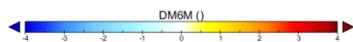
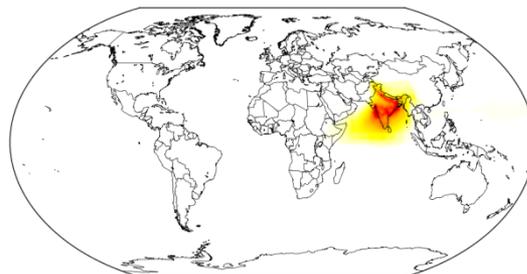
DBC



DSO4



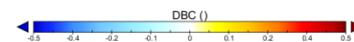
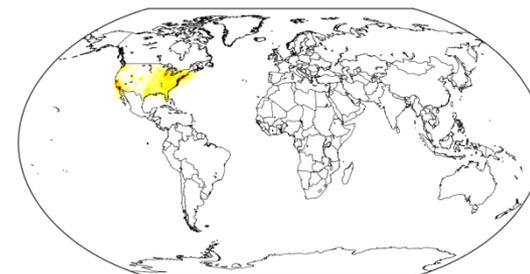
DM6M



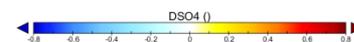
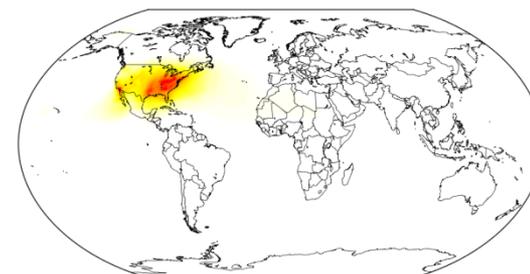
Data Min = -7.6E-08, Max = 4.1

## USA

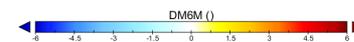
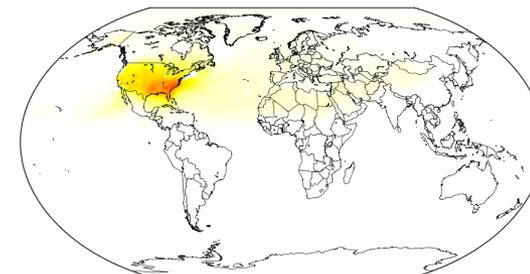
DBC



DSO4



DM6M



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

dBC  
(dBC)

dSO<sub>4</sub>  
(dSO<sub>2</sub>)

dO<sub>3</sub>  
(dNO<sub>x</sub>)

## 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<sub>2.5</sub> (if provided in emissions)
  - Secondary: SO<sub>4</sub>, NO<sub>3</sub>, NH<sub>4</sub>
- Implicitly assumed fixed spatial distribution of emissions per region
- Assumed fixed meteorology (year 2001)

# Linearity issues:

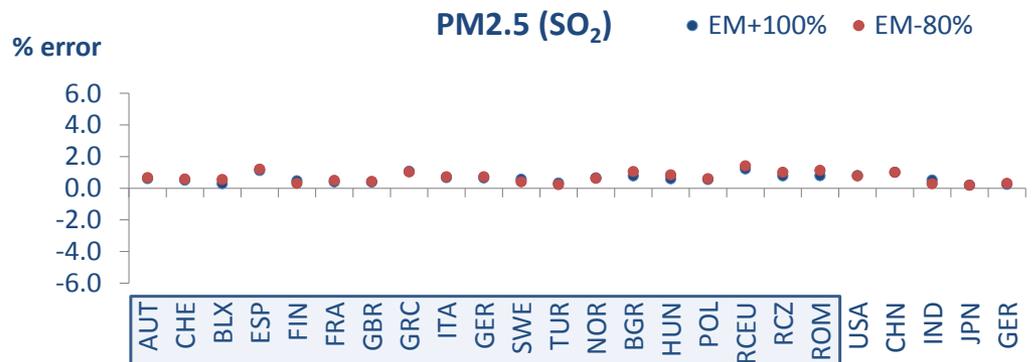
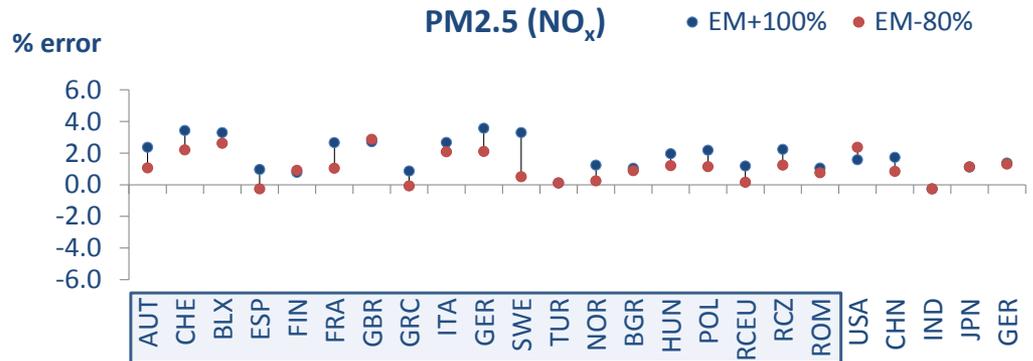
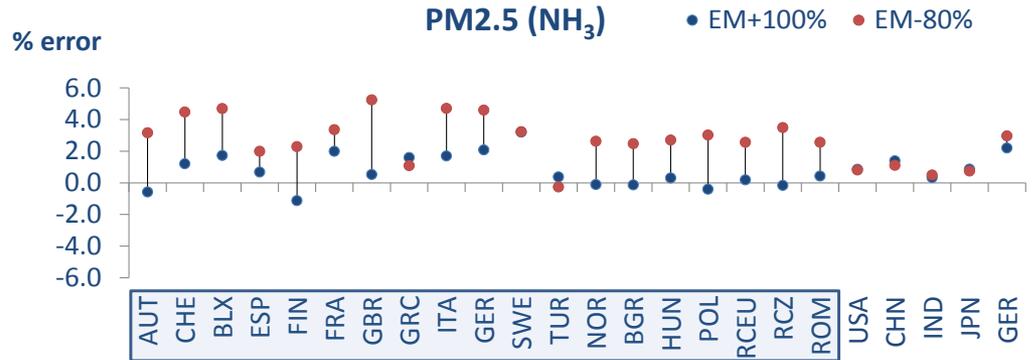
Error when emission changes go beyond -20% perturbation?

- 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:

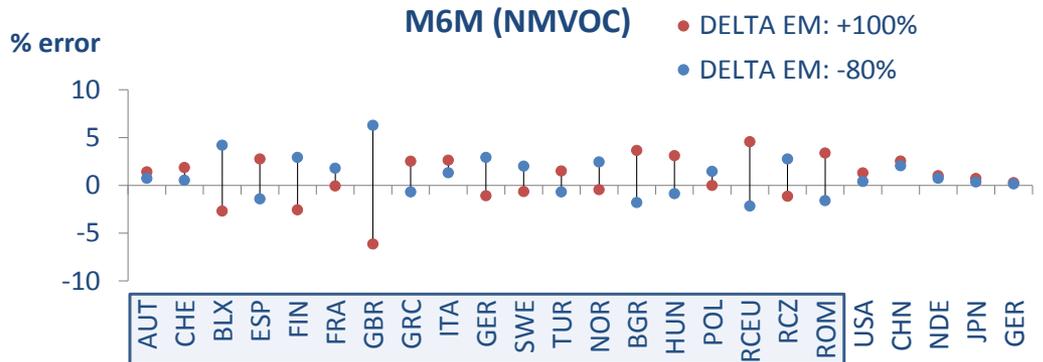
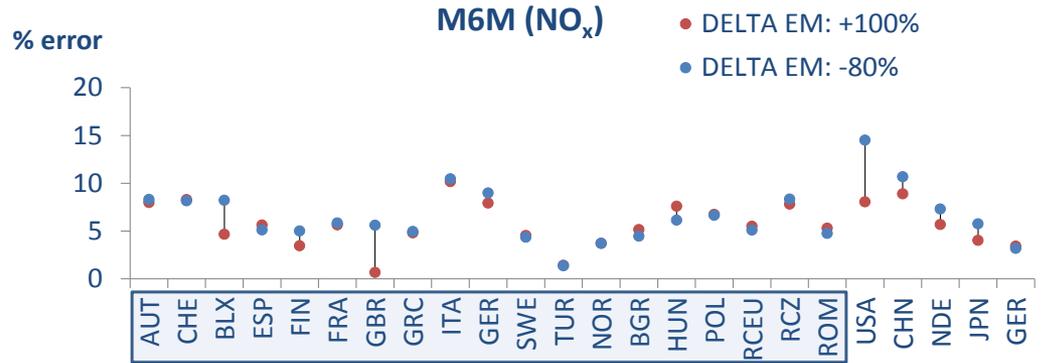
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## Ozone metrics



## 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%        |
| <b>GLOBAL</b>                     | <b>-47%</b> | <b>+25%</b> | <b>-48%</b> | <b>-35%</b> | <b>-69%</b> | <b>-37%</b> |
| 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%         |
| <b>GLOBAL</b>                     | <b>+45%</b> | <b>+27%</b> | <b>+11%</b> | <b>+7%</b>  | <b>+29%</b> | <b>+33%</b> |

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

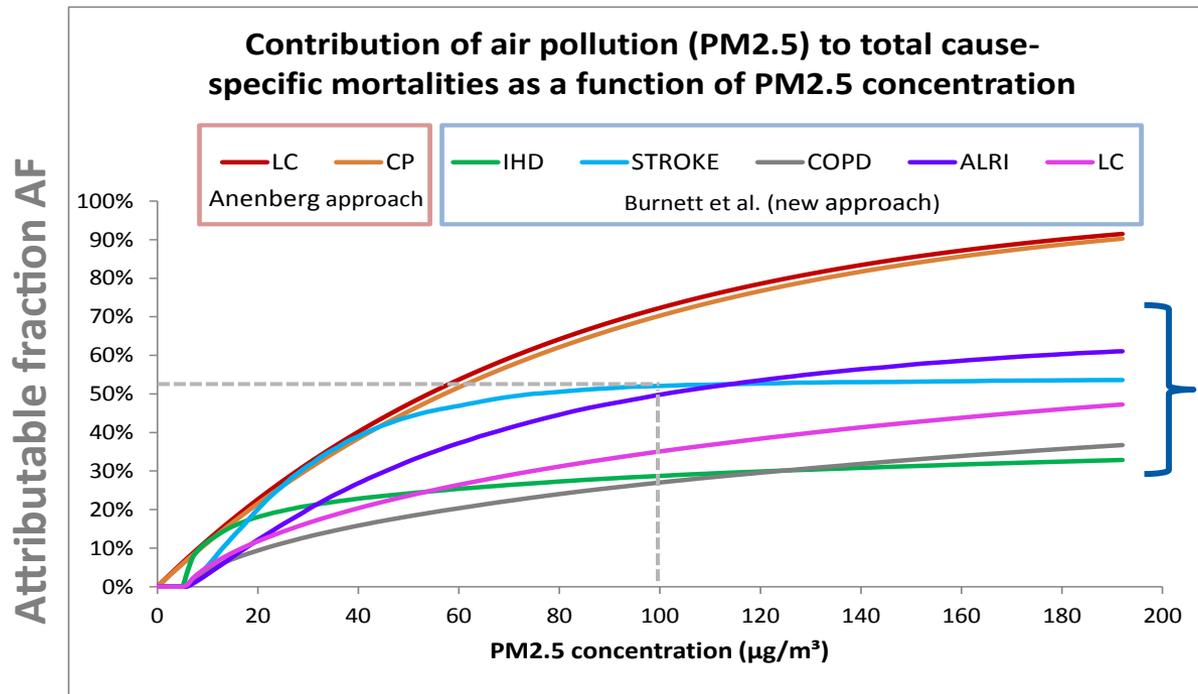
MAF: Developing Countries in Middle East & Africa

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

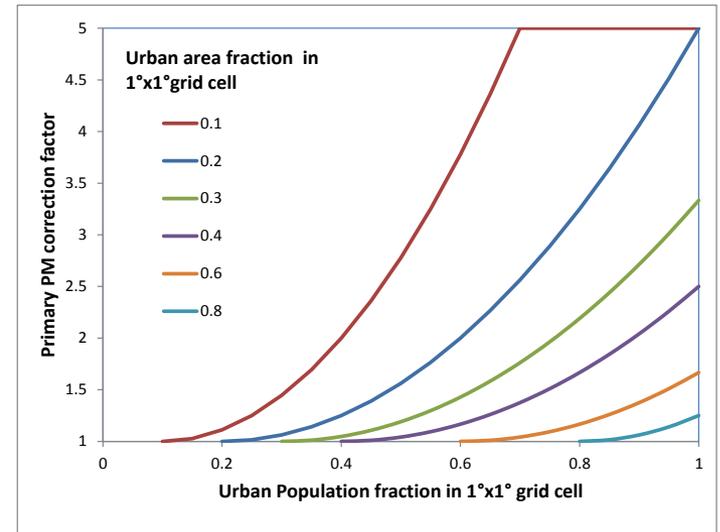
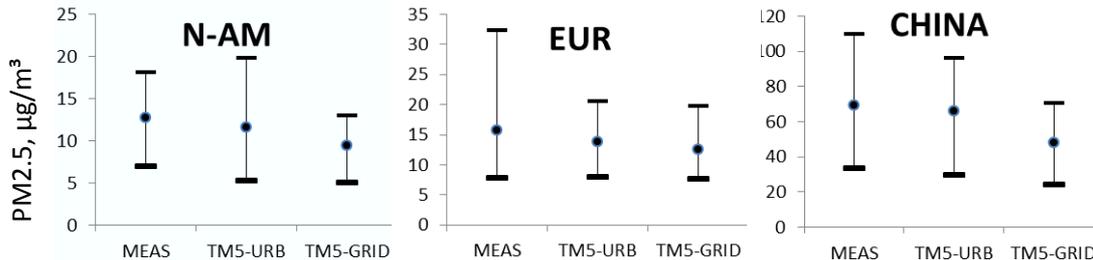
## Urban increment subgrid parameterization

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)

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



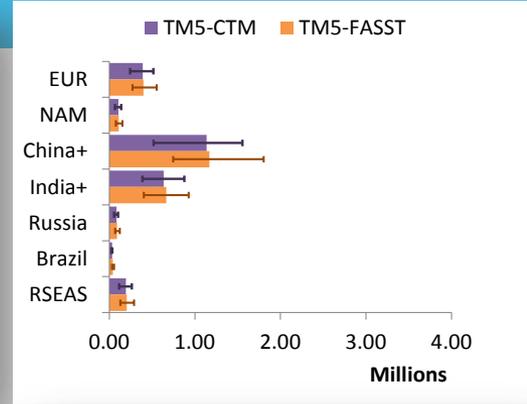
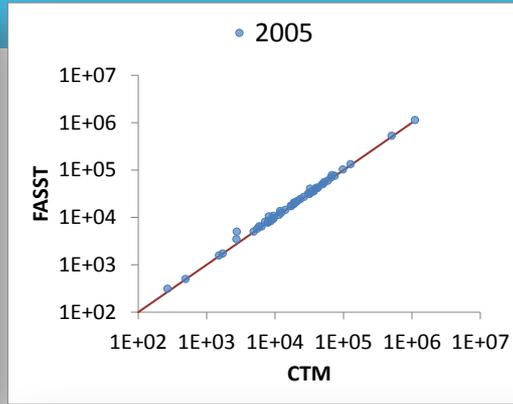
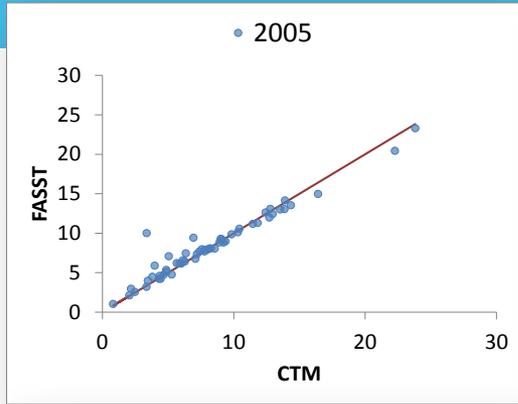
# COMPARISON TM5-FASST with FULL TM5-CTM

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

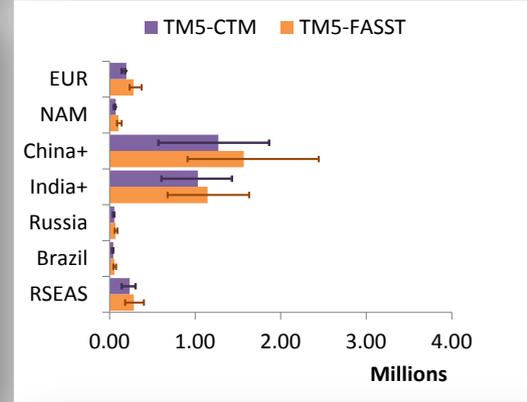
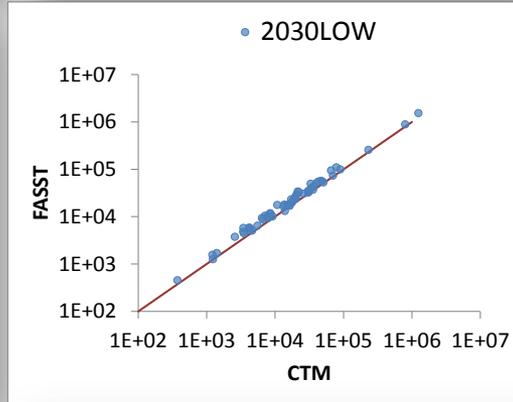
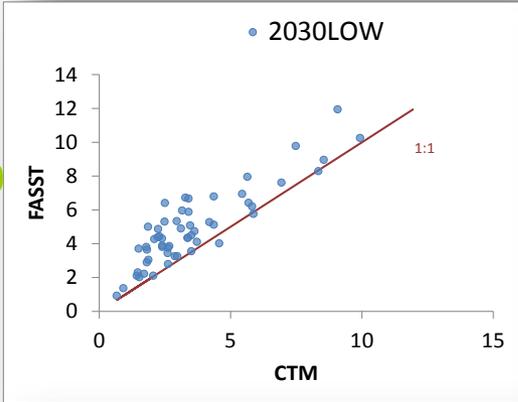
prem. mortalities

prem. mortalities

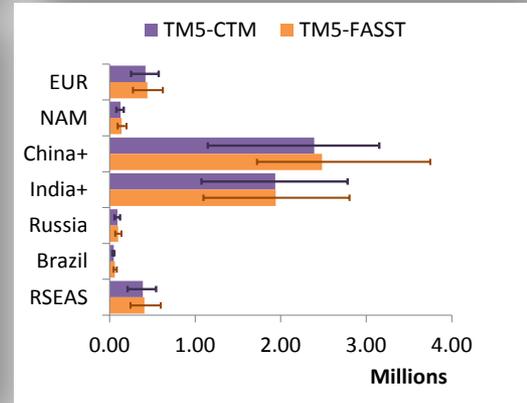
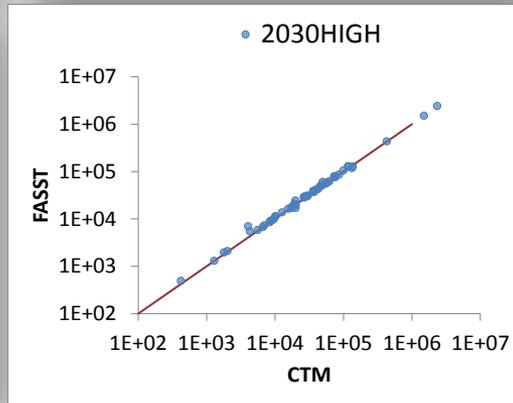
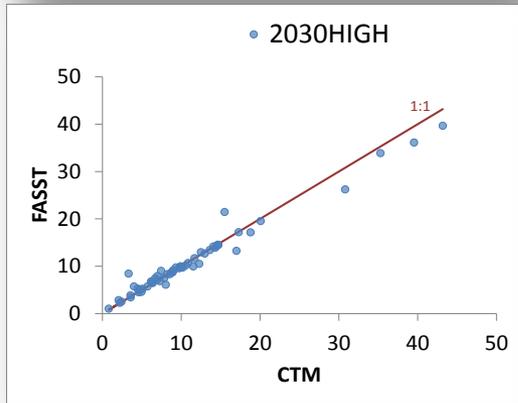
2005



2030  
LOW



2030  
HIGH

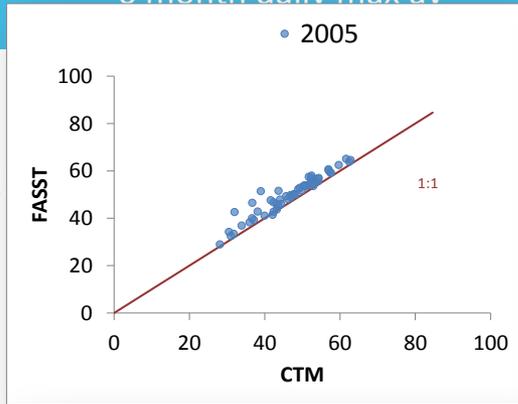


# COMPARISON TM5-FASST with FULL TM5-CTM

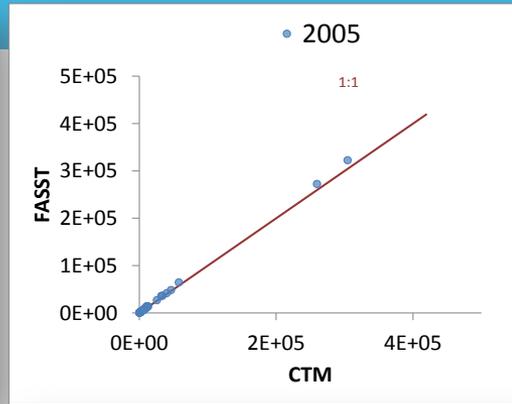
O<sub>3</sub> (ppbv)

6 month daily max av

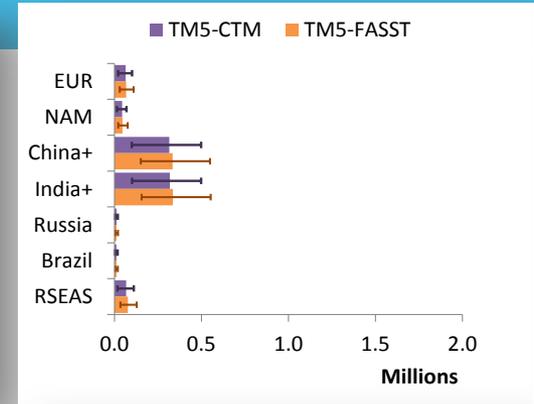
2005



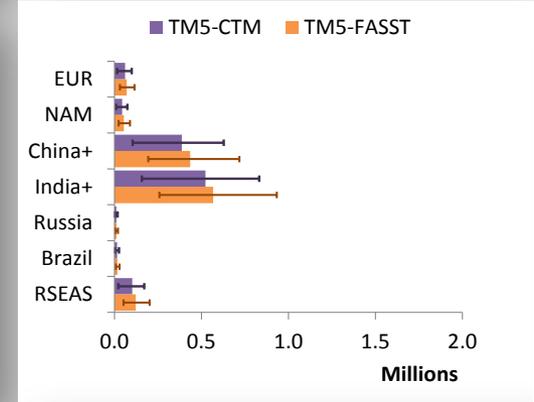
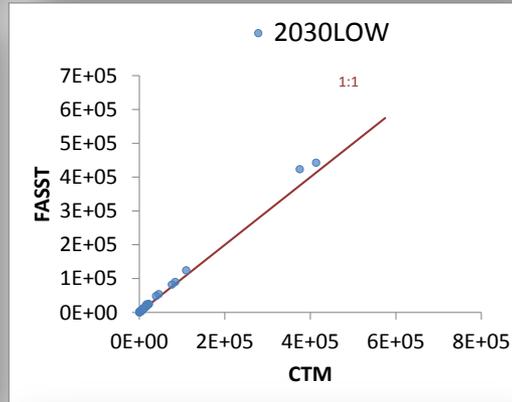
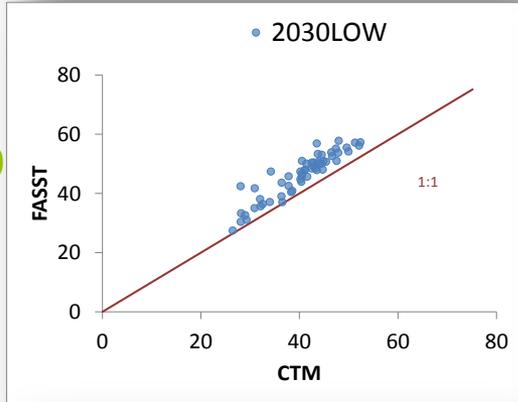
prem. mortalities



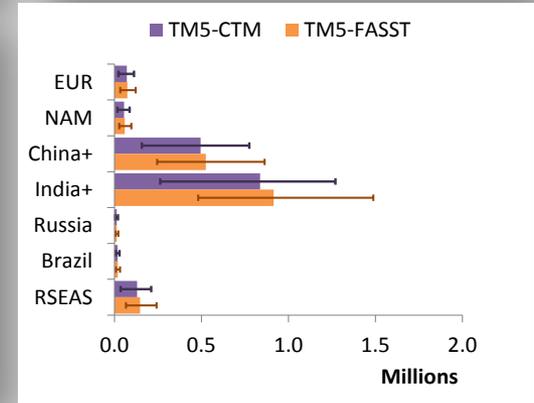
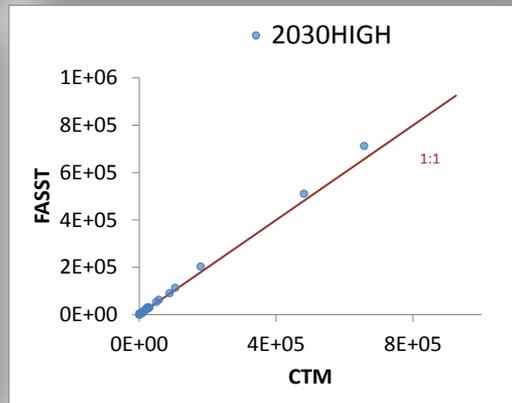
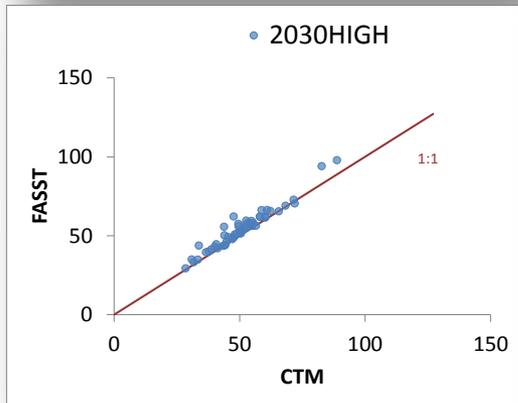
prem. mortalities



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