European Commission

FAst Scenario Screening Tool

TM5-FASST

Addresses the need for swift and ad-hoc impact assessment of air pollutant emission scenarios in a global framework

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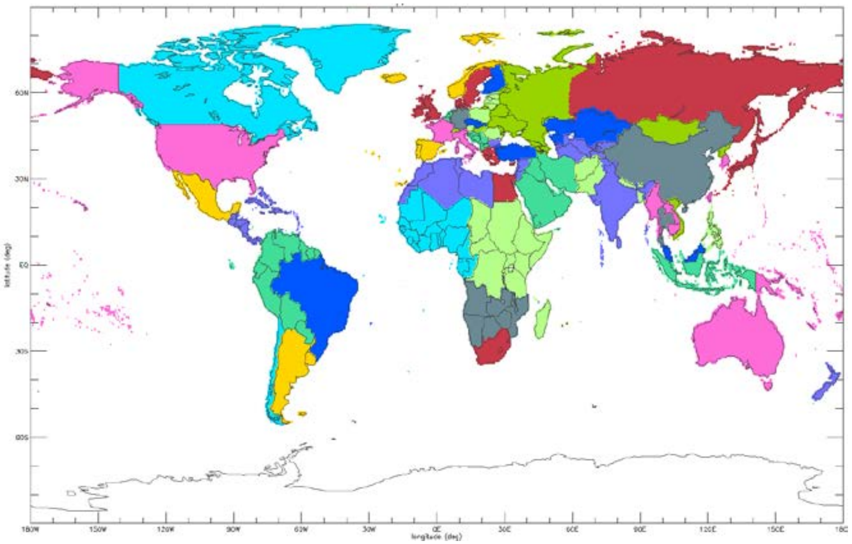
Joint Research Centre

the FAst Scenario Screening Tool

TM5-FASST



- 'Emulator' of the full TM5-CTM global chemical transport model
- Source-Receptor model
- Linearized emission → concentration relations calculated with TM5-CTM
- 56 source/receptor regions
- EU27: 16 FASST regions

Emissions considered:

SO_2, NO_x, NH_3, CO, NMVOC, Elemental Carbon, Primary Organic Matter, $PM_{2.5}$, CH_4

Impacts considered:

$PM_{2.5}$ concentration and impacts on human health

O_3 and O_3 metrics, impacts on agriculture and health

NO_y and SO_x deposition (to be implemented)

Radiative forcing

CO_{2e} based on GWP and GTP

BC deposition to Arctic

Methodology SR calculations

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Calculation of Source-Receptor coefficients:

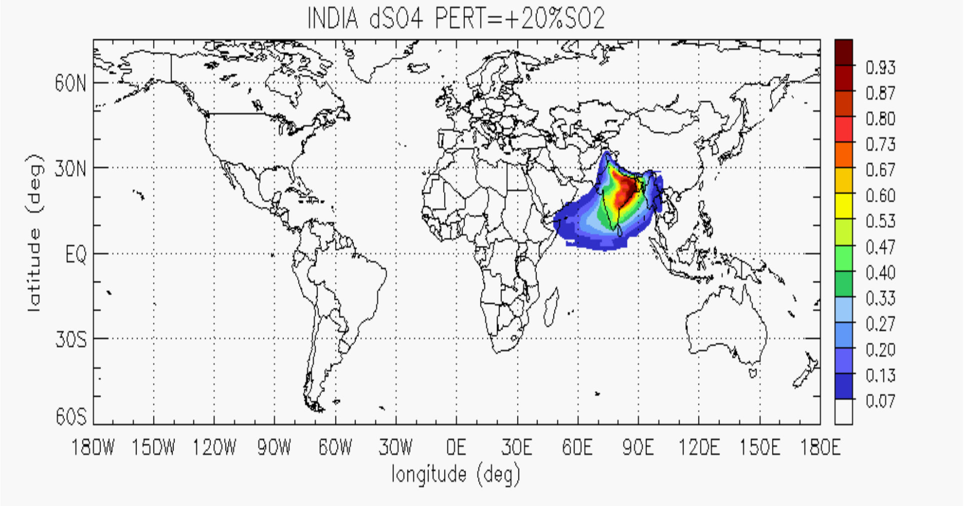
1) Base run with year 2005 Base inventory

2) 20% emission perturbation per source region, per precursor

3) DELTA(PM, O3,...) with base run

4) **SR coefficient** = DELTA normalized per kg delta emission

$A_{i \rightarrow j,y,x} = \Delta C_j(y) / \Delta E_i(x)$ with $\Delta E_i(x) = 0.2 \mathrm{x} E_{i,base}(x)$



Calculation of pollutant concentrations with linear relation and SR coefficient

$$C_i = C_i^b + 5 \sum_k \sum_j \Delta C_{j,k}^i \frac{E_{j,k} - E_{j,k}^b}{E_{j,k}^b}$$

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Specific features of the TM5-FASST model:

Implemented both as IDL code and as interactive MS-Excel spreadsheet tool

- IDL code: gridded maps as output
- Excel: tables and bar plots

Apportionment of pollutants concentrations and impacts

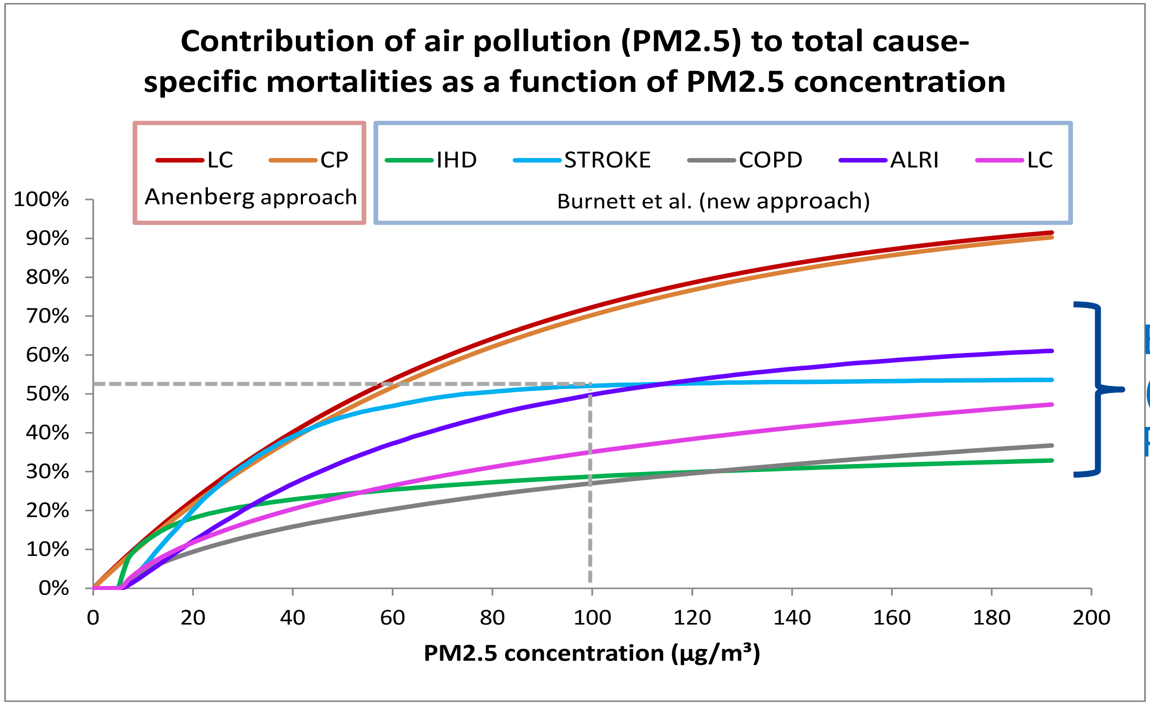
- By region
- By sector (provided input emissions are segregated by sector)
- By precursor

PM individual chemical compounds are modelled

- Primary: BC, OC, other primary PM
- Secondary: SO_4, NO_3, NH_4

Methodology
Health impacts

- 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



AF=(RR-1)/RR
Mort=M0*AF*POP

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

e.g. at PM2.5 = 100µg/m³
52% of the "stroke" mortalities
are attributable to PM2.5

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Urban increment subgrid parametrization

Issue:

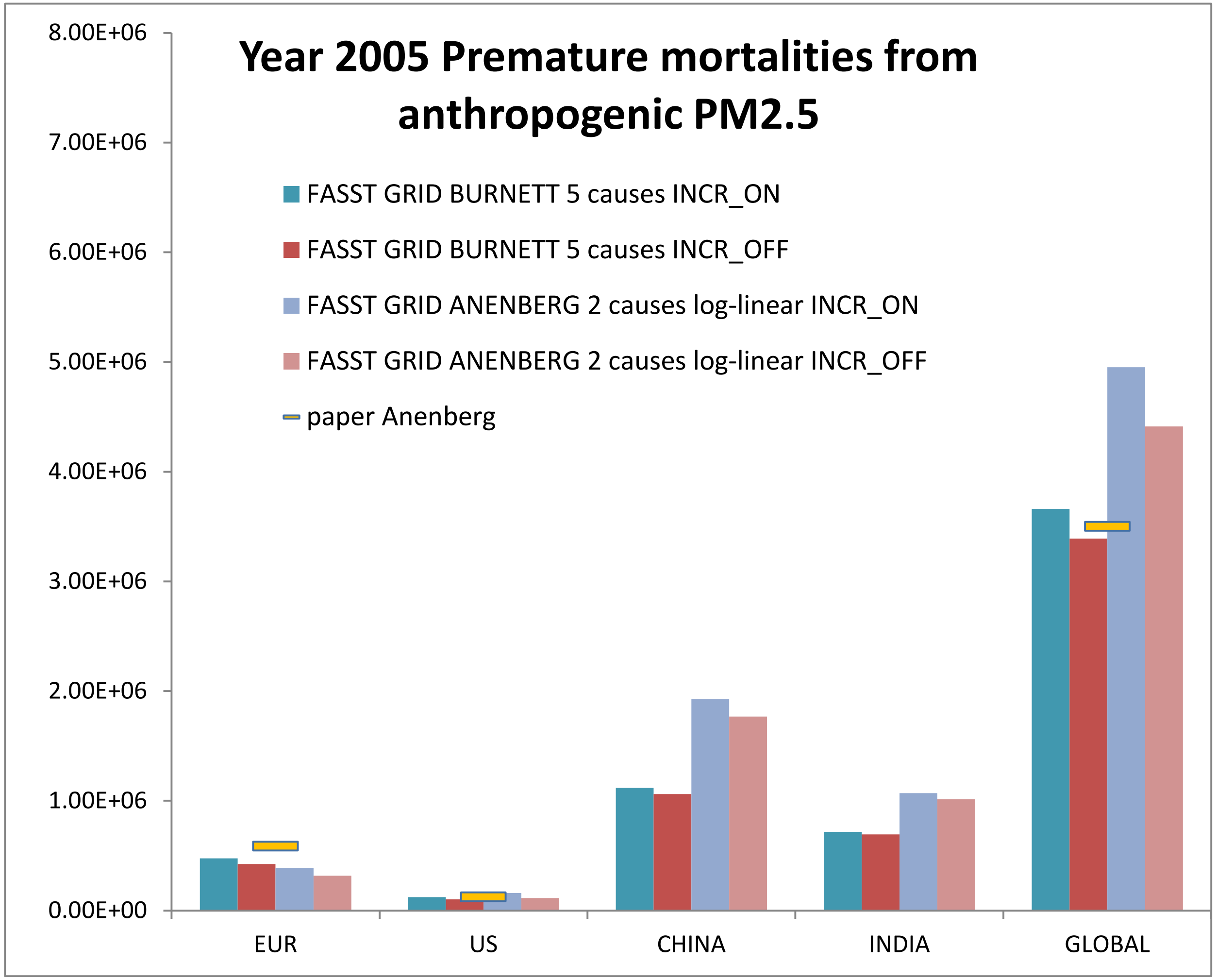
FASST-TM5 resolution = 1°x1°

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

→ Parametrization 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

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



Issues:

- Include / exclude natural aerosol?
- If excluded, use threshold for Burnett functions?

Methodology
Crops

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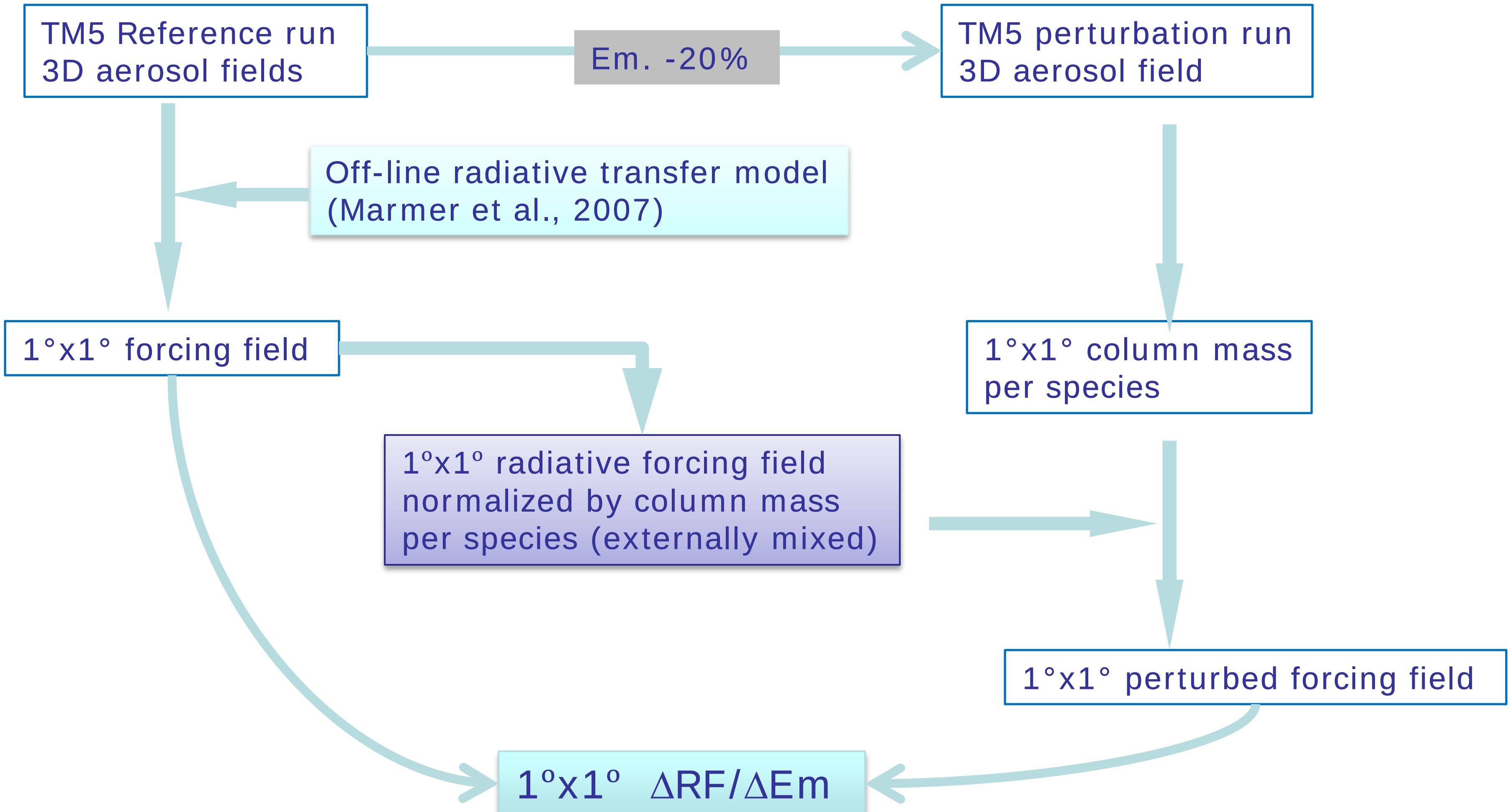
Based on 2 metrics: AOT40 and seasonal daytime mean O_3 (M7, M12). Source-receptor matrices for AOT40 and M7,M12 calculated for 4 crops (wheat, rice, maize, soybean)

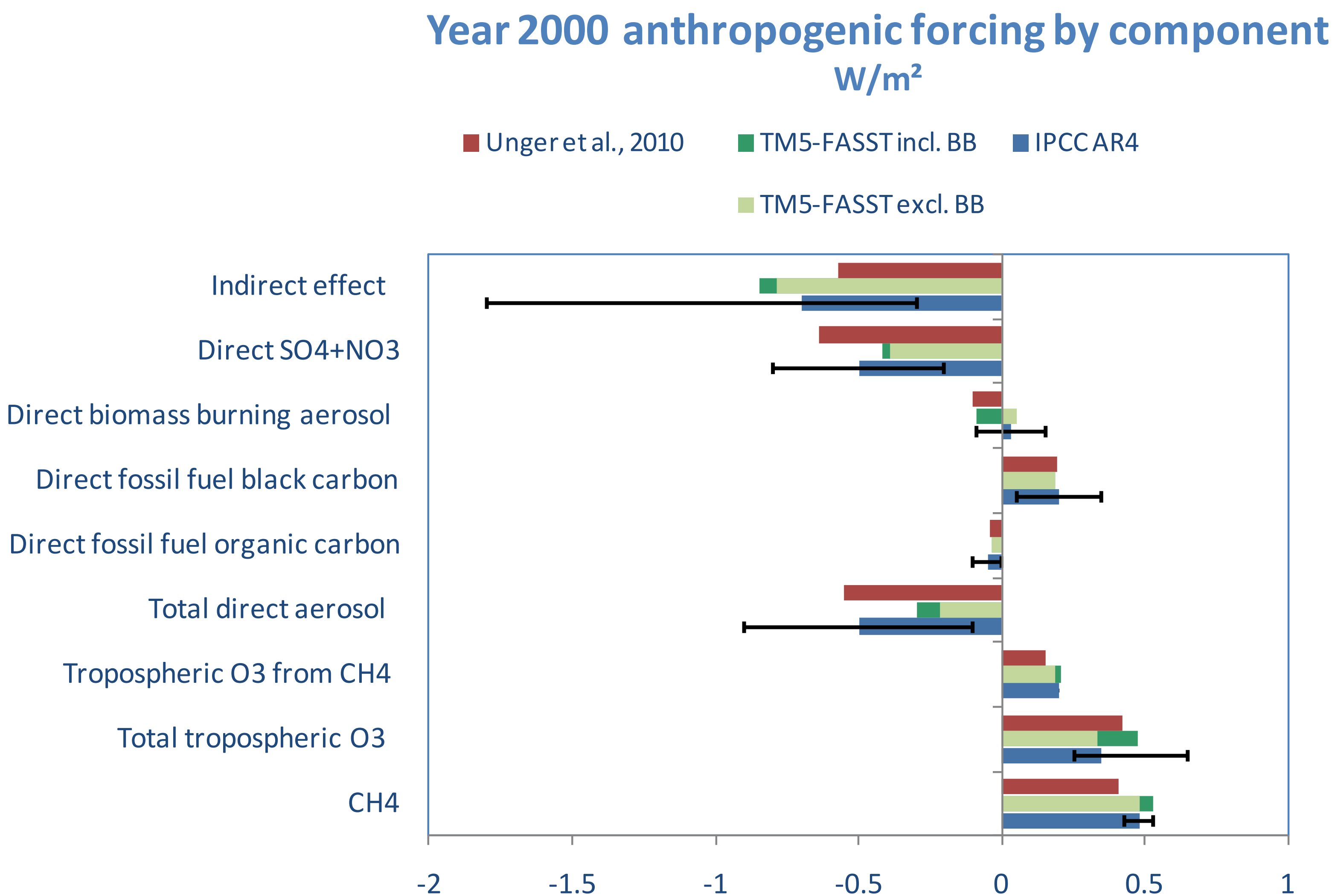
- Based on 3 month growing season
- Crop growing season, spatial distribution, production from GAEZ v.3 (IIASA & FAO) http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/
- AOT40: threshold metric, linear concentration-response function
- Mi: O_3 mean without threshold; non-linear concentration-response function with built-in threshold (20 – 25 ppbV)
- Note: in general different metrics lead to different results!

Methodology
Climate metrics

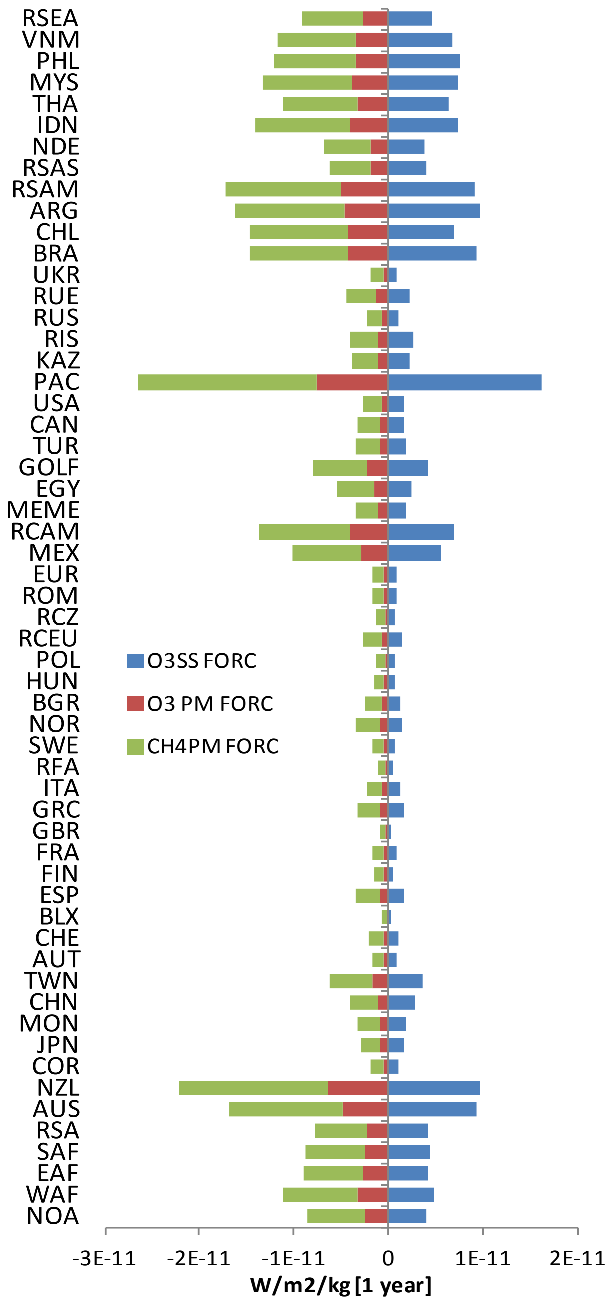


Ozone: similar approach

FASST Forcing comparison with literature



NOx forcing efficiency for FASST emission regions (W/m²/kg)



South & South-East Asia

Latin America

Russia + former Russian

Middle East

Central America

Europe

East-Asia

Australia + NZL

Africa

(A)GWP & (A)GTP (1 year pulse emission)

- (Absolute) GWP and GTP calculated for various time horizons H following Fuglestvedt et al., 2010
- Including long-term feedbacks of NOx, NMVOC and SO2 on CH4 and hemispheric O3

FASST also calculates change in temperature dT(H) from AGTP(H) following Fuglestvedt et al., 2010 (i.e. sum of 1 year emission pulses with moving time horizon)

Regional GWP100 values obtained from FASST

	Literature Global mean value (range)	TM5-FASST Global mean (uncertainty range from forcing uncertainty)	TM5-FASST Africa	TM5-FASST East Asia, SE Asia & Pacific	TM5-FASST Latin America & Caribbean	TM5-FASST N. America & Europe	TM5-FASST South, West & Central Asia
CO[a]	1.9 (1 → 3)	2.8 (2.0→3.4)	2.4	3.0	2.5	2.5	3.1
NMVOC[a]	3.4 (2 →7)	7.5 (5.3→9.3)	7.0	7.7	7.3	6.9	8.1
BC	680 (210 → 1500)	970 (0 → 1600)	1300	630	720	920	1200
SO_2 →SO_4	-40 (-24 → -56)	-48 (-34→-62)	-82	-31	-57	-39	-71
OC	-69 (-25 →-129)	-91 (-43 → -139)	-116	-58	-76	-61	-107
NO_x → O_3[a]	-11 [b] (-36 → 1.6 [b])	-12 (-9→-15)	-15	-12	-21	-5	-10

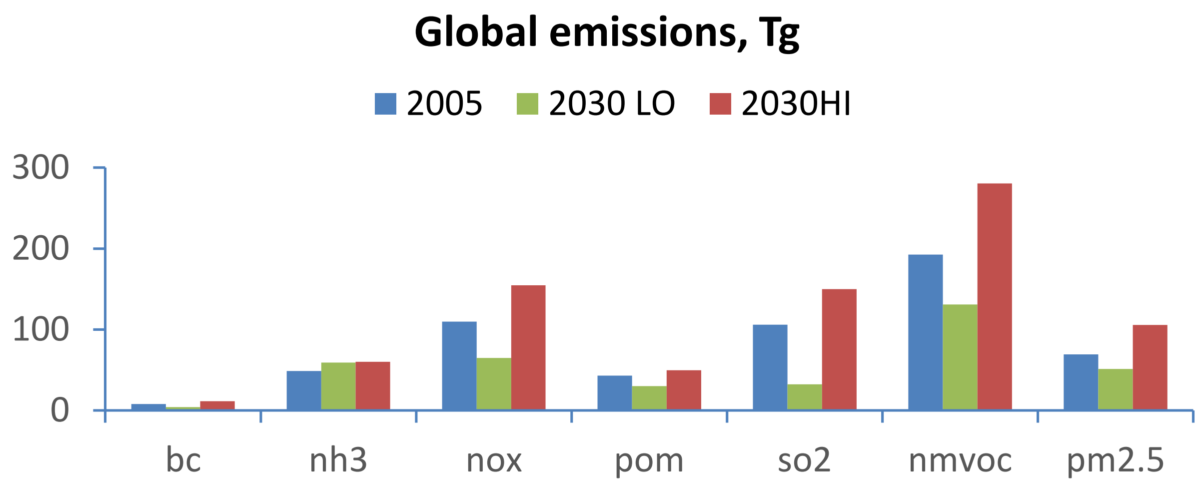
Overview of GWP_{100} values (mW/m^2) from literature (as used in the UNEP/WMO (2011) assessment) together with FASST mean value and range obtained for the 56 countries/regions.

a Including short term O_3, long-term feedbacks on CH_4 lifetime and background O_3. Value in brackets: inorganic aerosol

b GWP(NO_x) was assumed to be 0 in UNEP report (without range). Global mean and range reported here are from Fuglestvedt *et al.*, 2010.

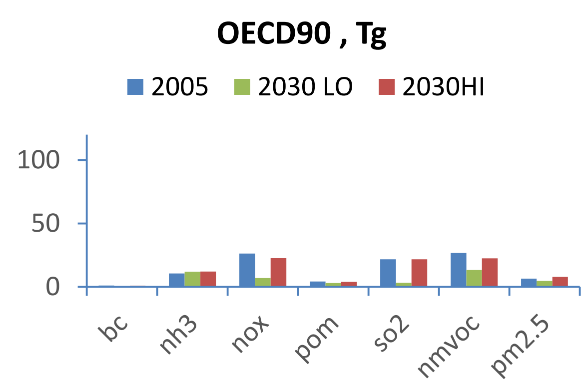
Validation of TM5-FASST:

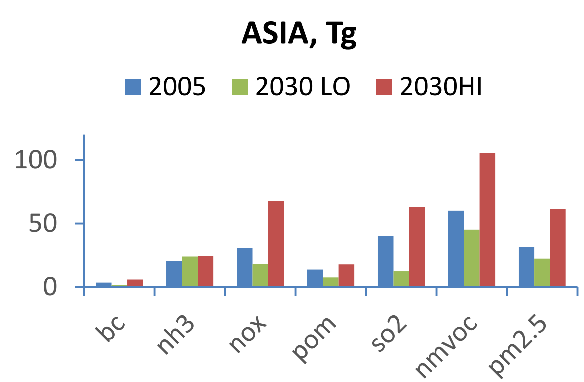
Compare TM5-FASST with full TM5-CTM runs using the same set of emission scenarios as input

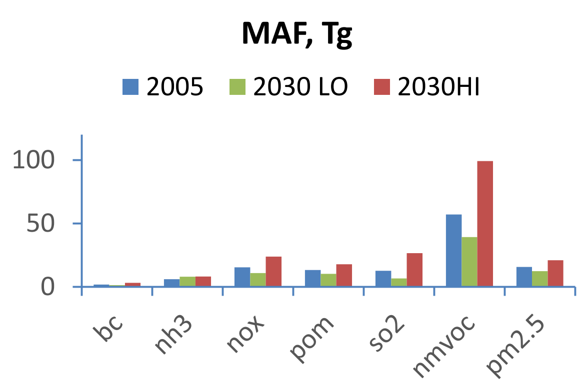


Global Energy Assessment emission scenarios

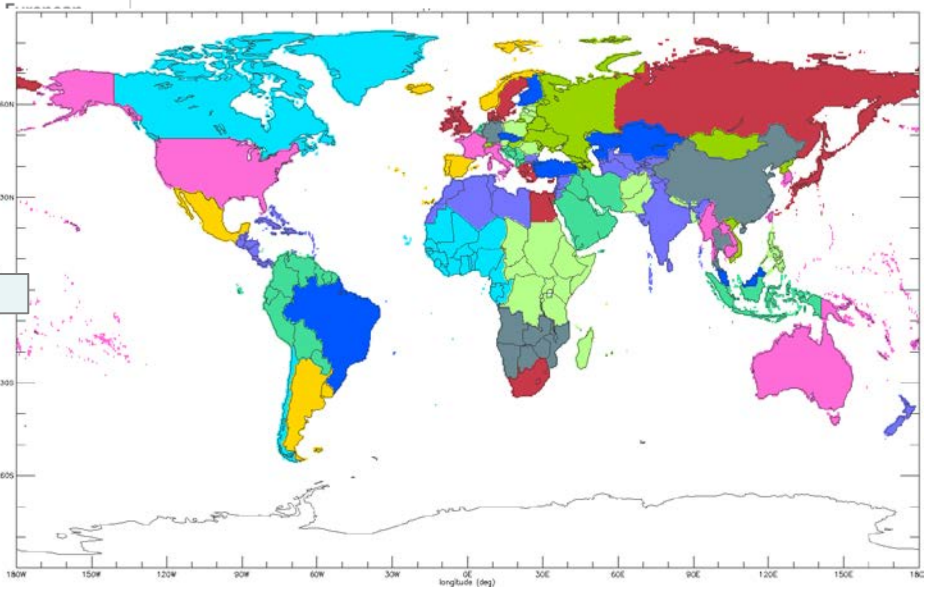
- Year 2005
- Year 2030 CLE - LOW
- Year 2030 CLE - HIGH





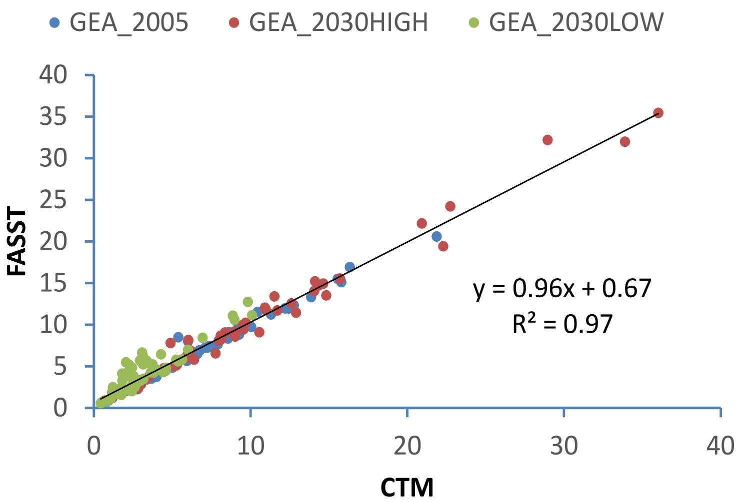


Validation of TM5-FASST vs. full TM5 model

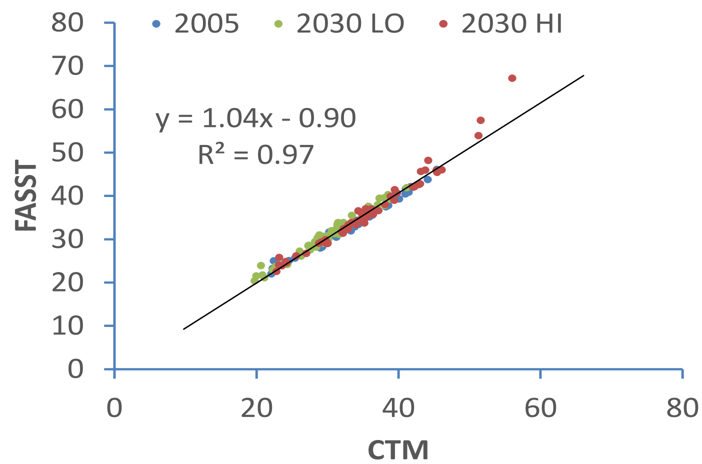


1 dot = 1 averaged region

TM5-FASST vs TM5-CTM
area-weighted anthropogenic PM2.5 (µg/m³)

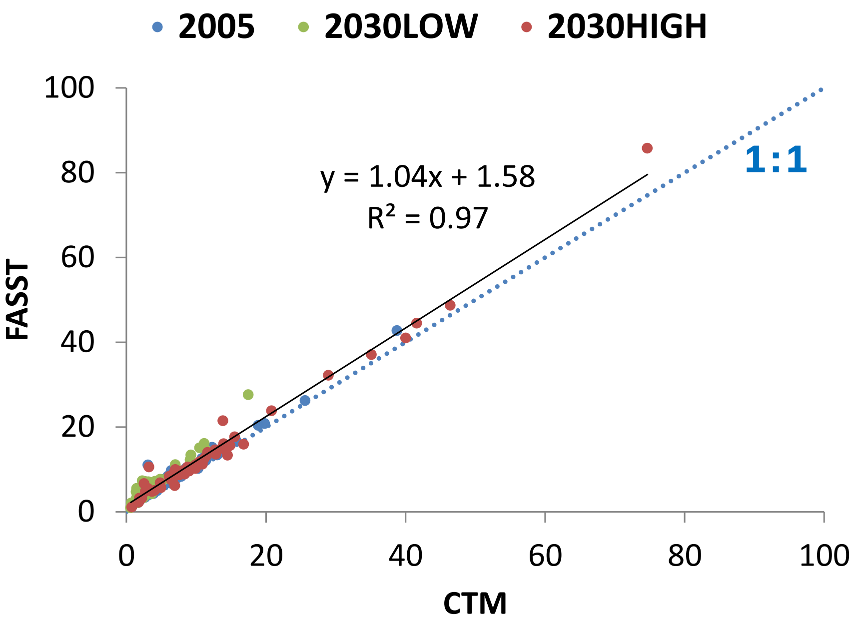


TM5-FASST vs TM5-CTM
annual mean O3 (ppbV)

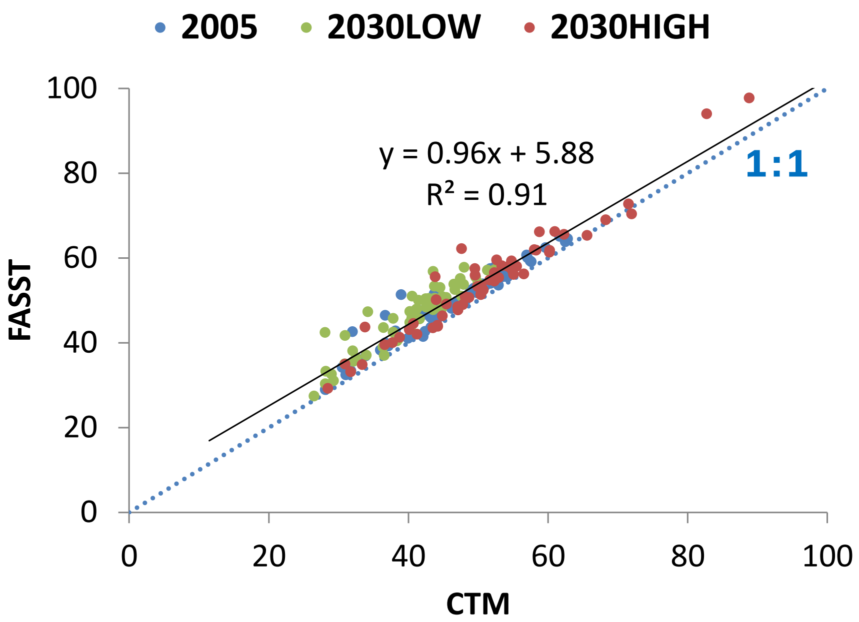


Validation health metrics

Pop-weighted annual PM2.5 (µg/m³)



6-monthly mean of daily max. O3



Validation health impacts (mortalities)

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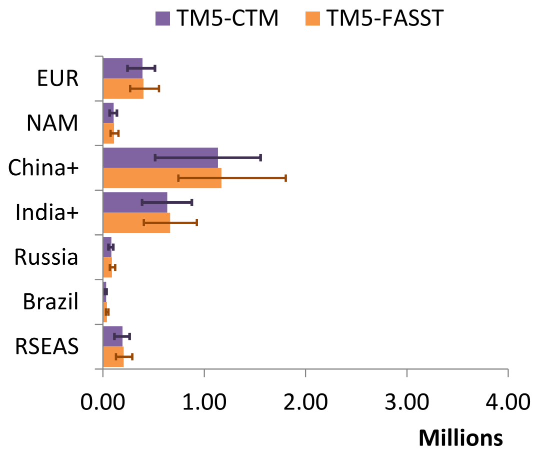
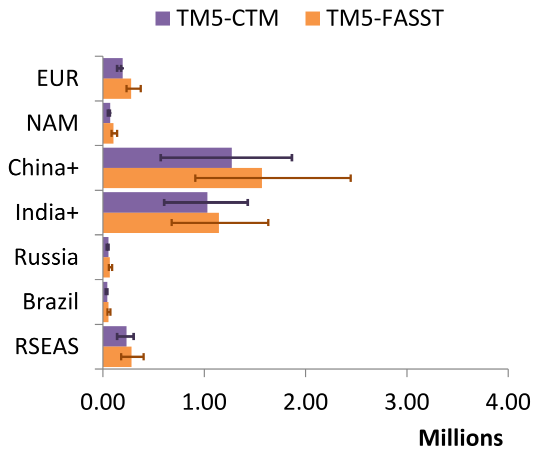
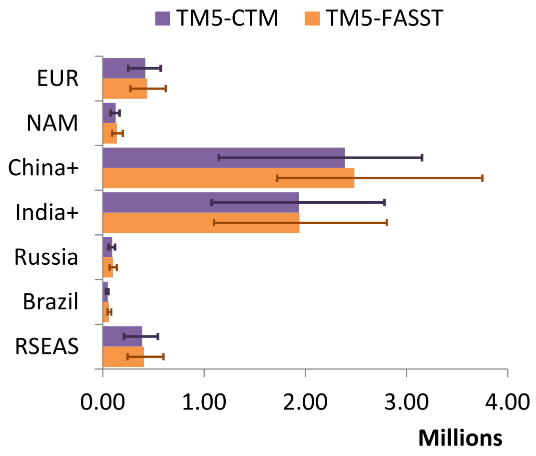
Total of 5-causes PM2.5 mortalities (Burnett et al., 2013)



2005



2030 LOW



2030 HIGH

FASST is relatively strong in

- Global coverage and global consistency in calculating impacts
- Speed of calculation: ideal for assessments requiring many scenario evaluations (optimization, impact attribution by region, by sector,…)
- Internal consistency between various impact categories (health, vegetation, deposition, climate)

FASST is relatively weak in

- Describing non-linear processes (O_3 chemistry, NO_3-NH_4 system)
- Crops impacts less robust due to use of treshold statistics
- Role of inter-annual variability/climate change: current emission-concentration coefficients based on one meteorological year (2001)

OUTLOOK

- Address non-linearities with additional perturbation runs
- Web-based public version scheduled for 2014
- Include flexibility on source-receptor region definition (remapping tool to FASST source regions)
- Include multiple source-receptor models (EMEP, HTAP,...)
- Until now one model- in future ensemble approach
- Additional impact modules
  - Deposition of N and S
  - Biosphere – pollution - climate interactions

Thank you !