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
Emissions (model input):
SO₂, NOₓ, NH₃, CO, NMVOC, Elemental Carbon, Primary Organic Matter, PM₂·₅, CH₄

Model output (non exhaustive):
• PM₂·₅ concentration and impacts on human health
• O₃ and O₃ metrics, impacts on agriculture and health
• Radiative forcing
  CO₂e based on GWPhh and GTPhh
  BC deposition (e.g. Arctic, Himalayas,…)
## Precursor – pollutant dependencies included in TM5-FASST:

<table>
<thead>
<tr>
<th>Pollutant→ Precursor↓</th>
<th>SO₂ gas</th>
<th>NOₓ gas</th>
<th>NH₃ gas</th>
<th>O₃ gas</th>
<th>SO₄ pm</th>
<th>NO₃ pm</th>
<th>NH₄ pm</th>
<th>BC pm</th>
<th>OM pm</th>
<th>SOₓ dep</th>
<th>NOᵧ dep</th>
<th>BC dep</th>
<th>Rad. Forc</th>
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<tbody>
<tr>
<td>SO₂ (g)</td>
<td>XXX</td>
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<td>NOₓ (g)</td>
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<td>NH₃ (g)</td>
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<td>NMVOC (g)</td>
<td>x</td>
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<td>BC (pm)</td>
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<tr>
<td>POM (pm)</td>
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<td>XXX</td>
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<tr>
<td>CO (g)*</td>
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<td>xx</td>
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<tr>
<td>CH₄ (g)*</td>
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<td>x</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>x</td>
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<td></td>
<td></td>
<td>xxx</td>
</tr>
</tbody>
</table>

* source-receptors from HTAP1
Delta concentration footprints from a +20% emission perturbation
**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

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**Population weighted PM2.5**

- PM2.5 (NH₃)
- PM2.5 (NOₓ)
- PM2.5 (SO₂)

For selected source regions:
- EUROPE
- USA
- JAPAN
- CHINA
- INDIA
- GERMANY only
Linearity issues:
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  - USA
  - JAPAN
  - CHINA
  - INDIA
  - GERMANY only
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, no age classes)
- **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
- High resolution gridded population data overlaid with high-resolution interpolated PM2.5 & O₃ fields

**Contribution of air pollution (PM2.5) to total cause-specific mortalities as a function of PM2.5 concentration**

- Anenberg approach
- Burnett et al. (new approach)

**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
Methodology
Health impacts

Urban increment subgrid parameterization

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)

→ 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)

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

![Graph showing primary PM correction factor vs. urban population fraction for N-AM, EUR, and CHINA.](image)
Methodology
Crop impacts

- Based on 2 metrics:
  - AOT40 (least robust)
  - 3 monthly (growing season) daytime O3 mean
- Crop production and growing season gridmaps from GAEZ for year 2000.
### 2030 MIT (low emission scenario)

<table>
<thead>
<tr>
<th>Region</th>
<th>BC</th>
<th>NH3</th>
<th>NOx</th>
<th>POM</th>
<th>SO2</th>
<th>NMVOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASIA</td>
<td>-47%</td>
<td>+19%</td>
<td>-30%</td>
<td>-49%</td>
<td>-61%</td>
<td>-35%</td>
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<tr>
<td>LAM</td>
<td>-45%</td>
<td>+47%</td>
<td>-53%</td>
<td>-27%</td>
<td>-41%</td>
<td>-28%</td>
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<tr>
<td>MAF</td>
<td>-30%</td>
<td>+33%</td>
<td>-40%</td>
<td>-29%</td>
<td>-49%</td>
<td>-30%</td>
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<td>OECD90</td>
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<td>SHIPPING+AVIATION</td>
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<td>-7%</td>
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<td>+30%</td>
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<td>-48%</td>
<td>-35%</td>
<td>-69%</td>
<td>-37%</td>
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</table>

### 2030 FLE (high emission scenario)

<table>
<thead>
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<th>POM</th>
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<th>NMVOC</th>
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<tbody>
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<td>+165%</td>
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<td>-39%</td>
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<tr>
<td>REF</td>
<td>-18%</td>
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<tr>
<td>SHIPPING+AVIATION</td>
<td>+3%</td>
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<tr>
<td>GLOBAL</td>
<td>+45%</td>
<td>+27%</td>
<td>+11%</td>
<td>+7%</td>
<td>+29%</td>
<td>+33%</td>
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</tbody>
</table>
COMPARISON TM5-FASST with FULL TM5-CTM

PM2.5 (µg/m³) prem. mortalities prem. mortalities

FASST CTM

FASST CTM

2005 2005

2030LOW 2030LOW

2030HIGH 2030HIGH

EUR NAM China+ India+ Russia Brazil RSEAS EUR NAM China+ India+ Russia Brazil RSEAS EUR NAM China+ India+ Russia Brazil RSEAS

TM5-CTM TM5-FASST TM5-CTM TM5-FASST TM5-CTM TM5-FASST
COMPARISON TM5-FASST with FULL TM5-CTM

O$_3$ (ppbv)
6 month daily max av

2005

2030 LOW

2030 HIGH

prem. mortalities

prem. mortalities
Typical TM5-FASST applications

• LIMITS: AQ co-benefits of climate scenarios from 6 IAM emission scenario ensemble
  • 6 models x 3 AQ scenarios x 2 climate policy scenarios x 4 years
    ➢ 144 runs (without counting resubmissions)

• UNEP Ozone and BC assessment: Health impact apportionment by region, by SLCP mitigation measure

• WHO Health impact apportionment by country, by sector

• Screening of SSPs scenarios for plausibility and consistency of pollutant levels with storylines (6 models x 5 SSPs x 3 climate scenarios x 3 years)
Few results

Projected man-made PM2.5 levels in 2030 (CLE, no MIT)

Projected decrease in PM2.5 levels in 2030 as a consequence of Climate Mitigation measures only

Projected O3 levels in 2030 (CLE, no MIT)

Projected decrease in O3 levels in 2030 as a consequence of Climate Mitigation measures only

LIMITS project

Air quality co-benefits of climate policies
6 IAMs, air pollutant emissions processed with TM5-FASST
Avoided premature mortalities

Avoided crop losses
TM5-FASST-WEB is now accessible on-line

http://fasst-web.jrc.it/

Regional delta (PM, O3, impacts) between 2 emission sets

✓ Perturbation of baseline emissions
  - By sector
  - By component
  - By region

✓ Library of emission scenarios
✓ Submit own emission scenarios
  (demo during coffee break)
Next steps:

Source-receptors:
• Extend FASST on-line version with HTAP2 S/R
• Ensemble output with statistics

Impact modules:
• Implementation of NO$_y$ and SO$_x$ wet deposition
• Regional forcing and Temp response from SLCP
• Better treatment of crop impacts (flux) – but how?