The inclusion of near-term radiative forcing into a multi-pollutant/multi-effect framework
Air pollutants have also effects on climate change in the near-term

There are concerns about climate effects of air pollutants:

1. Near-term forcing of air pollutants
   - Warming: BC, CH$_4$, O$_3$ (i.e., CH$_4$, CO, VOC, NO$_x$)
   - Cooling: SO$_2$, OC
   - accelerates or delays ongoing climate change at the regional scale,
   - changes regional weather circulation and precipitation patterns.

2. Increases arctic melting through deposition of (black) carbon
BC concentrations in the Arctic from European sources (preliminary GAINS/EMEP calculations)

From wood burning in Norway
Other Norwegian sources
Other European sources
How could near-term climate effects be introduced into GAINS?

- Near-term climate impacts could be included into the GAINS multi-pollutant/multi-effect concept as an additional effect of air pollutants.

- Relevant precursors: $\text{SO}_2$, $\text{NO}_x$, $\text{NH}_3$, $\text{VOC}$, $\text{O}_3$, PM2.5, BC, OC, CO, CH$_4$

- Note that many pollutants are co-emitted, and isolated reductions of single pollutants (e.g., BC) are often not possible in reality. GAINS captures these interdependencies!
Extension of the GAINS multi-pollutant/multi-effect framework to include near-term climate impacts

<table>
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<tr>
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<th>PM (BC, OC)</th>
<th>SO₂</th>
<th>NOₓ</th>
<th>VOC</th>
<th>NH₃</th>
<th>CO</th>
<th>CO₂</th>
<th>CH₄</th>
<th>N₂O</th>
<th>HFCs</th>
<th>PFCs</th>
<th>SF₆</th>
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**Health impacts:**
- PM (Loss in life expectancy)
  - √
- O₃ (Premature mortality)
  - √

**Vegetation damage:**
- O₃ (AOT40/fluxes)
  - √
- Acidification (Excess of critical loads)
  - √
- Eutrophication (Excess of critical loads)
  - √

**Climate impacts:**
- Long-term (GWP100)
  - √
- Near-term forcing (in Europe and global mean forcing)
  - √
- Black carbon deposition to the arctic
  - √
Potential impact indicators

• As there is significant scientific uncertainty on the quantification of actual climate impacts, indicators should refer to physical indicators that can be quantified with reasonable robustness.

• Potential metrics (impact indicators):
  1. Instantaneous radiative forcing of sustained emissions (at regional and global scales)
  2. Deposition of (black) carbon in the arctic.

• These metrics would not interfere with UNFCCC objectives (long-term stabilization, reflected through 100 years GWP)
• As they do not involve CO$_2$, no conflict between control of air pollutants and CO$_2$ mitigation could be constructed
CH$_4$ mitigation potential <40 €/ton CO$_2$eq
2020, by World region (GAINS estimate)
Potential approaches for GAINS optimization for CLRTAP protocol

Starting from an energy scenario that achieves given (long-term) climate objectives (expressed through GWP$_{100}$):

**Option 1:**
- Optimize for environmental targets on
  - health and ecosystems (as before),
  - near-term forcing and BC deposition to the arctic.

**Option 2:**
- Optimize for environmental targets on
  - health and ecosystems (as before),
  - under the condition that near-term forcing and BC deposition to arctic does not deteriorate
Work elements

- Development of cost curves for BC, OC, CO (CIAM)
- Quantification of source-impacts relationships (between national emissions and regional forcing)
  - Calculation of source-receptor relationships between (country) precursor emissions and (grid) column concentrations (MSC-W)
  - Estimation of (regional) radiative forcing from (grid) column concentrations (Uni.Oslo)
- Extension of GAINS optimization routine (GAINS)

Prototype implementation feasible in 2010 (depending on available resources!), full implementation and validation thereafter
Conclusions

• Near-term forcing and carbon deposition to the Arctic could be included as an additional effect of air pollutants into the existing multi-pollutant/multi-effect framework

• Suggested metrics:
  – Instantaneous radiative forcing at the regional/global scale
  – Carbon deposition to the Arctic

• A prototype version could be developed by mid 2010 (if funding is available)

• In a first step, such information could be used to prioritize reductions of precursor emissions to reduce PM2.5 levels