CLIMATE IMPACT OF FINNISH AIR POLLUTANTS AND GHGs WITH DIFFERENT EMISSION METRICS

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Aims of the work

- Assess the climate impact of Finnish air pollutant and GHG emissions from 2010 until 2030
  - global warming potential (GWP)
  - global temperature change potential (GTP)
  - Multiple pollutants were assessed: SO_2, NO_X, NH_3, VOC, BC, OC and CO as well as CO_2, CH_4 and N_2O
- Multi-pollutant approach that gives important insight into:
  - The net-effect of “cooling” and “warming” components
  - The relative impacts of the short-lived and long-lived components
  - Formulating national policies and opinions to mitigate air pollution and GHGs

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Data sources – historical emissions

Pollutant	Data source
Black carbon (BC), organic carbon (OC)	FRES model (*SYKE*)
CO	GAINS model (*IIASA, http://gains.iiasa.ac.at*)
CO_2, CH_4 and N_2O from combustion sources	FRES model (*SYKE*)
CO_2, CH_4 and N_2O from other sources than combustion	National inventory of greenhouse gases specified in the Kyoto Protocol to the Secretariat of the UNFCCC (*Statistics Finland*)
NH_3 and VOC	National emission inventory to the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) and to the European Environment Agency EEA (*SYKE*)

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Future emission scenarios

- Finland's current National Climate and Energy Strategy that was updated in the beginning of 2013.
- The strategy includes two scenarios:
  1. a Baseline scenario that fulfils the agreed EU targets and specific national targets for share of renewables and emission reductions in the non-ETS sector; and
  2. The With-Additional-Measures scenario (WAM) accelerates measures to reach the non-ETS sector goal compared with baseline and anticipates a 80 percent reduction in CO_2 emissions by 2050 via traffic mode changes and ”eco-driving” as well as stricter regulation of energy efficiency of buildings.

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Metrics

Earth Syst. Dynam., 4, 145–170, 2013
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Earth System Dynamics
Open Access

Simple emission metrics for climate impacts

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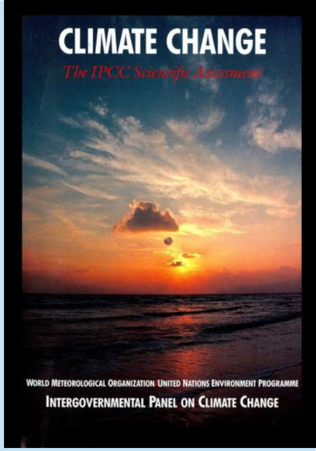
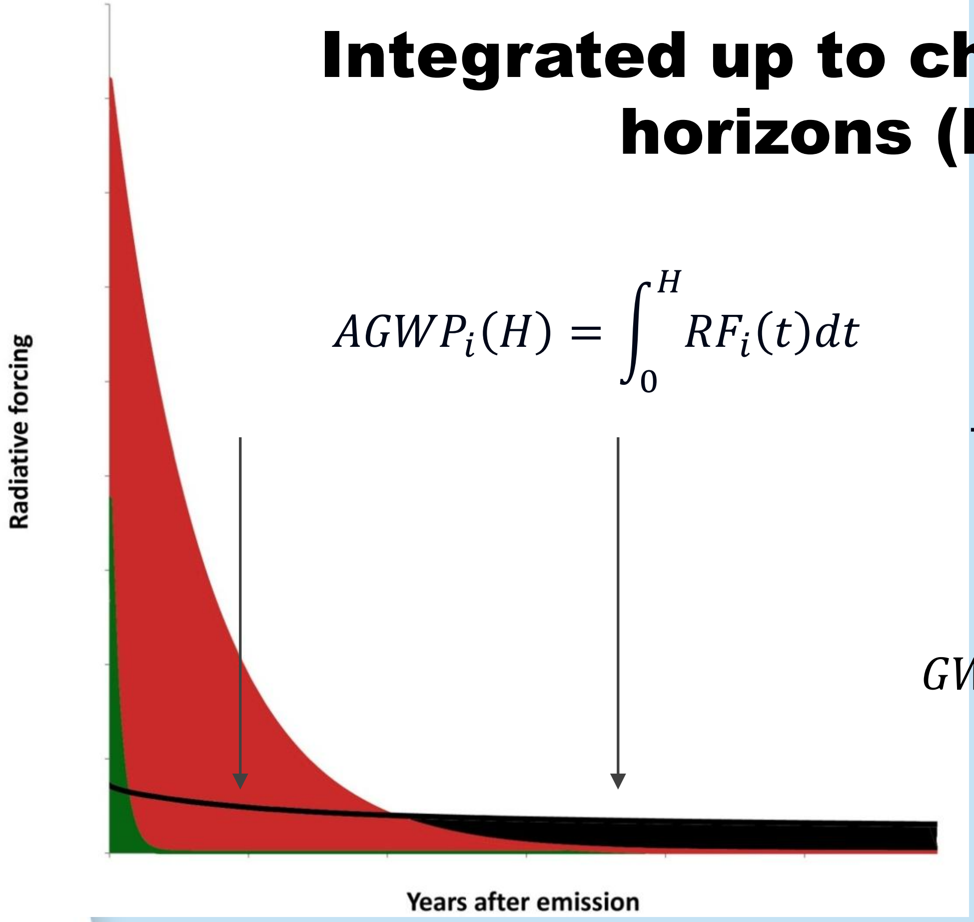


GWP: Based on pulses of different pollutants

Integrated up to chosen time horizons (H)

$$AGWP_i(H) = \int_0^H RF_i(t)dt$$



Adapted from Shine et al., 2005

Then normalized to AGWP for CO_2:

$$GWPi(H) = \frac{AGWP_i(H)}{AGWP_{CO_2}(H)} = \frac{\int_0^H RF_i(t)dt}{\int_0^H RF_{CO_2}(t)dt}$$

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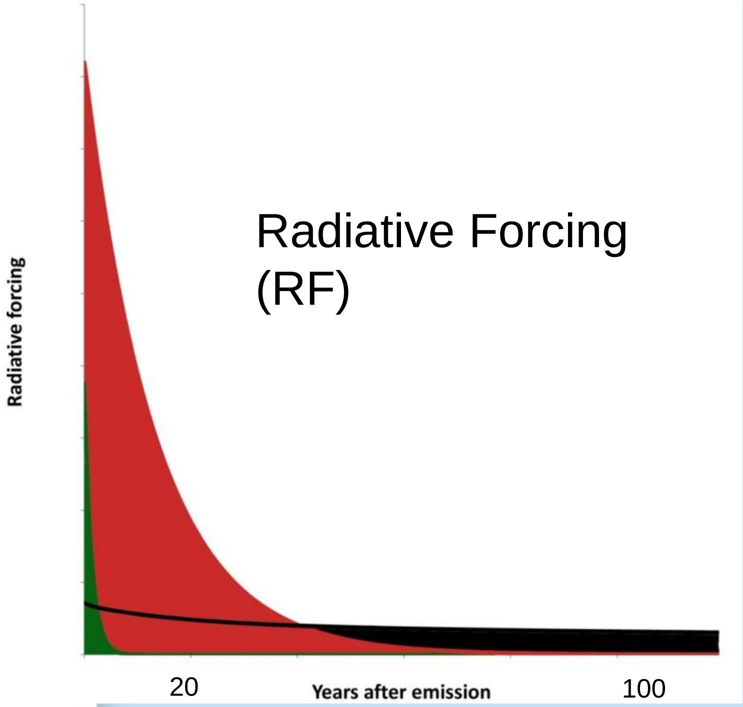
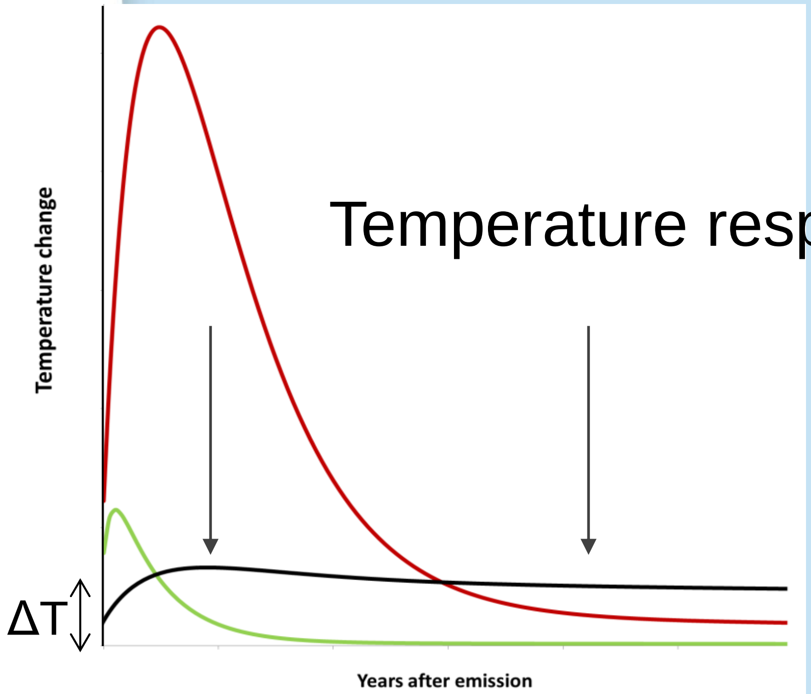


$$GWP_i(H) = \frac{\int_0^H RF_i(t)dt}{\int_0^H RF_{CO_2}(t)dt} = \frac{AGWP_i(H)}{AGWP_{CO_2}(H)}$$

➔ strong memory
(often misunderstood; no climate response included)

Temperature response



$$GTP_i(t) = \frac{AGTP(t)_i}{AGTP(t)_{CO_2}} = \frac{\Delta T(t)_i}{\Delta T(t)_{CO_2}}$$

Large differences between GTP and GWP for short-lived components

Metrics for emission scenarios

- A pulse emission assumes that the emissions are stopped instantaneously, usually not realistic
- Emission metrics for pulse emissions can serve as building blocks for emission scenario assessments
- For emission scenarios, the AGWP and AGTP values can be calculated with a convolution
- Convolution is a mathematical operation in which 2 mathematical functions are combined to make a modified version of those 2

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Metric values

- Species: SO_2, NO_X, NH_3, VOC, BC, OC and CO as well as CO_2, CH_4 and N_2O
- Input consistent with IPCC(2007) and the ATTICA assessment (Fuglestvedt et al., 2010)
- The Impulse Response Function for CO_2 is based on the Bern Carbon Cycle Model (Joos et al., 2001)
- The temperature response is based on the Hadley CM3 climate model (Boucher & Reddy, 2008)
- BC on snow included, 20 % of the direct effect (Bond et al., 2013)
- The aerosol indirect effect included, factor 1.75 of the direct sulfate aerosol effect

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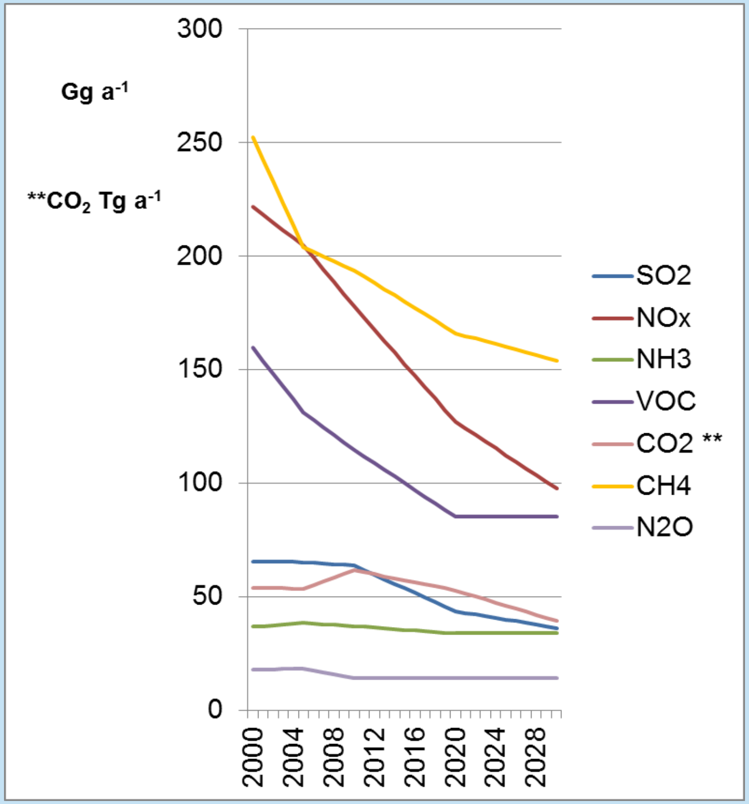
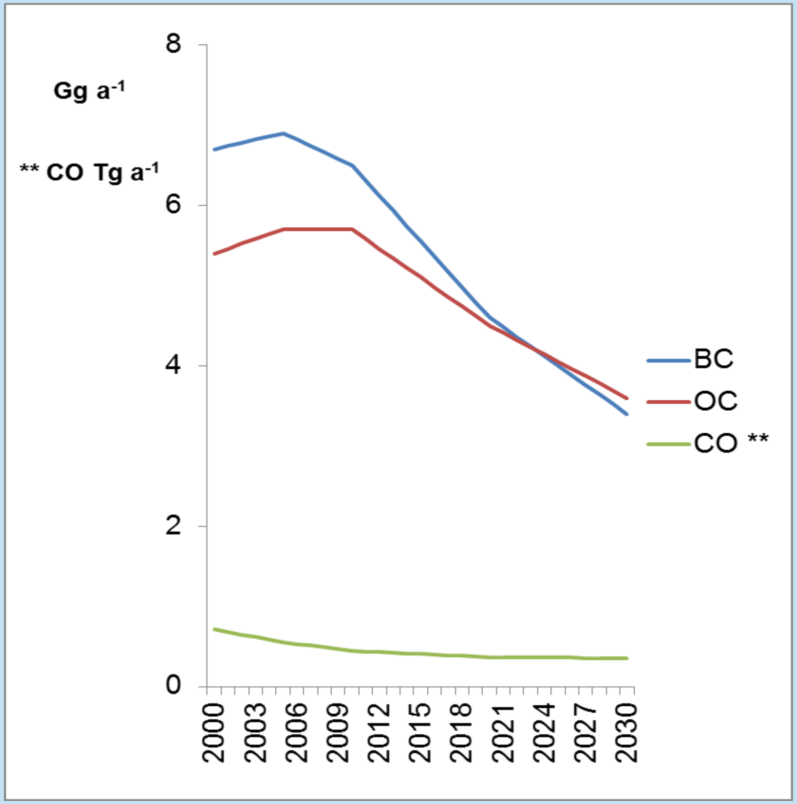
Results

Emissions in the baseline scenario of Finland's current National Climate and Energy Strategy (2013)





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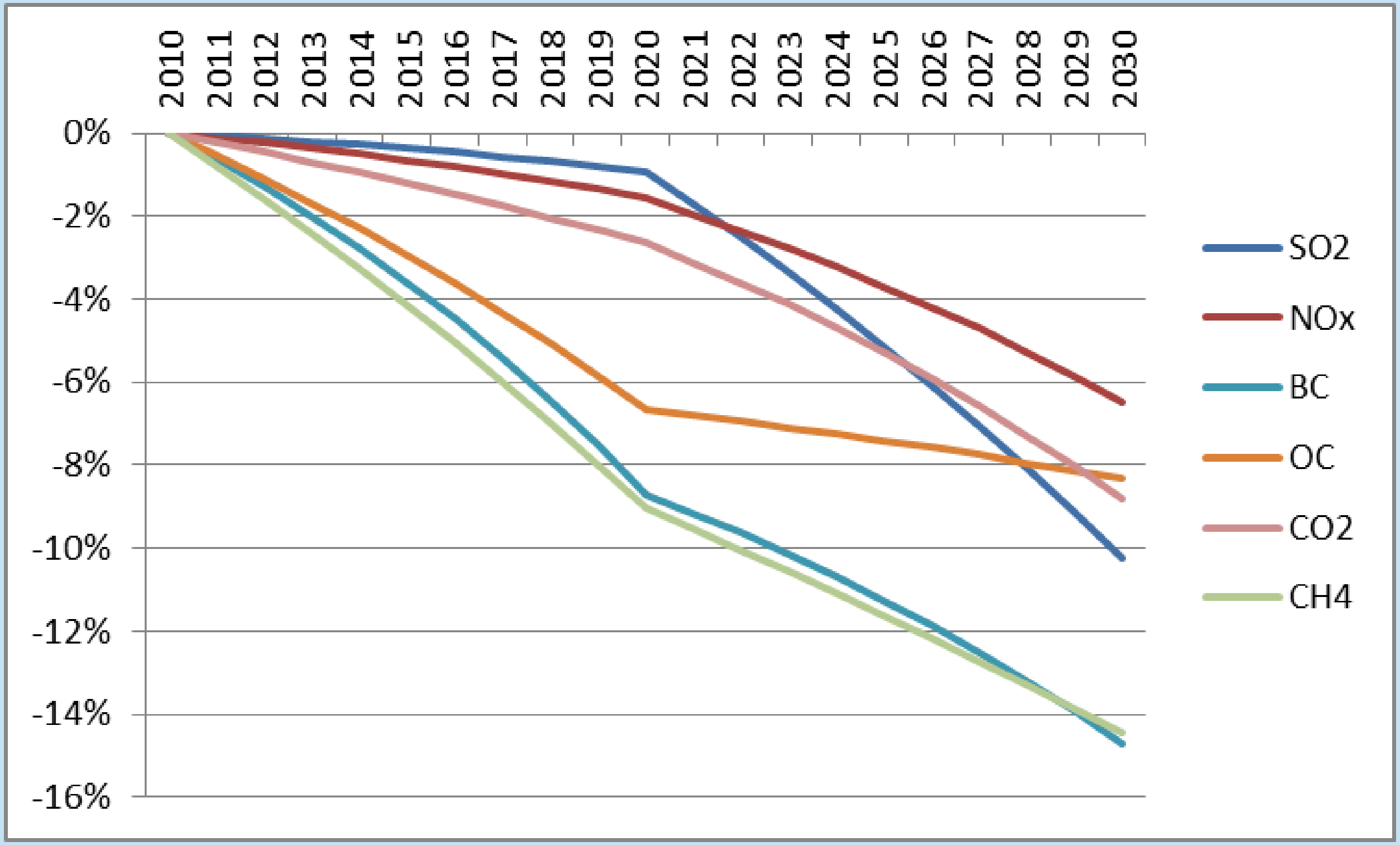
Relative emission changes - WAM scenario vs. the baseline scenario



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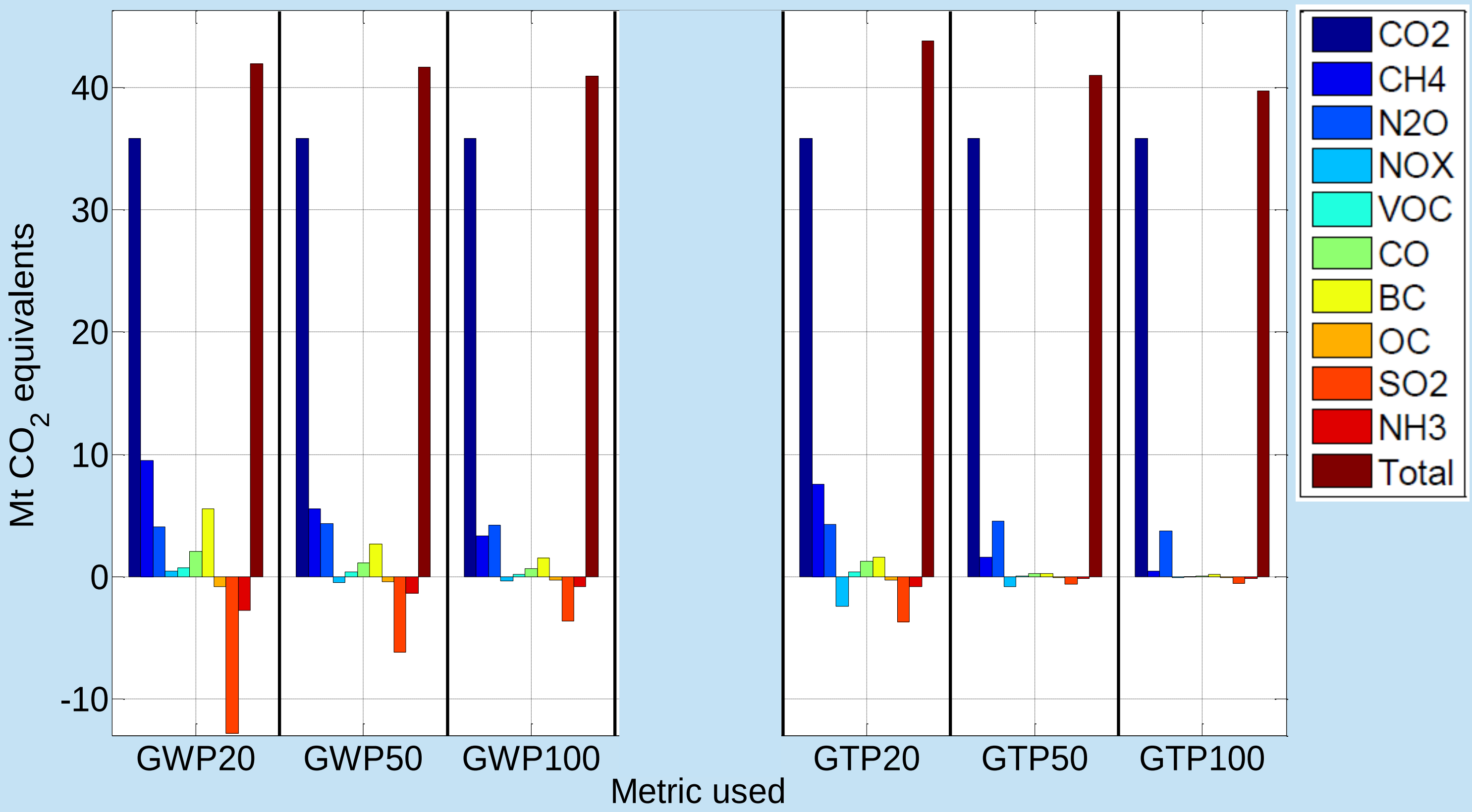
2030 WAM emissions as CO_2 eq



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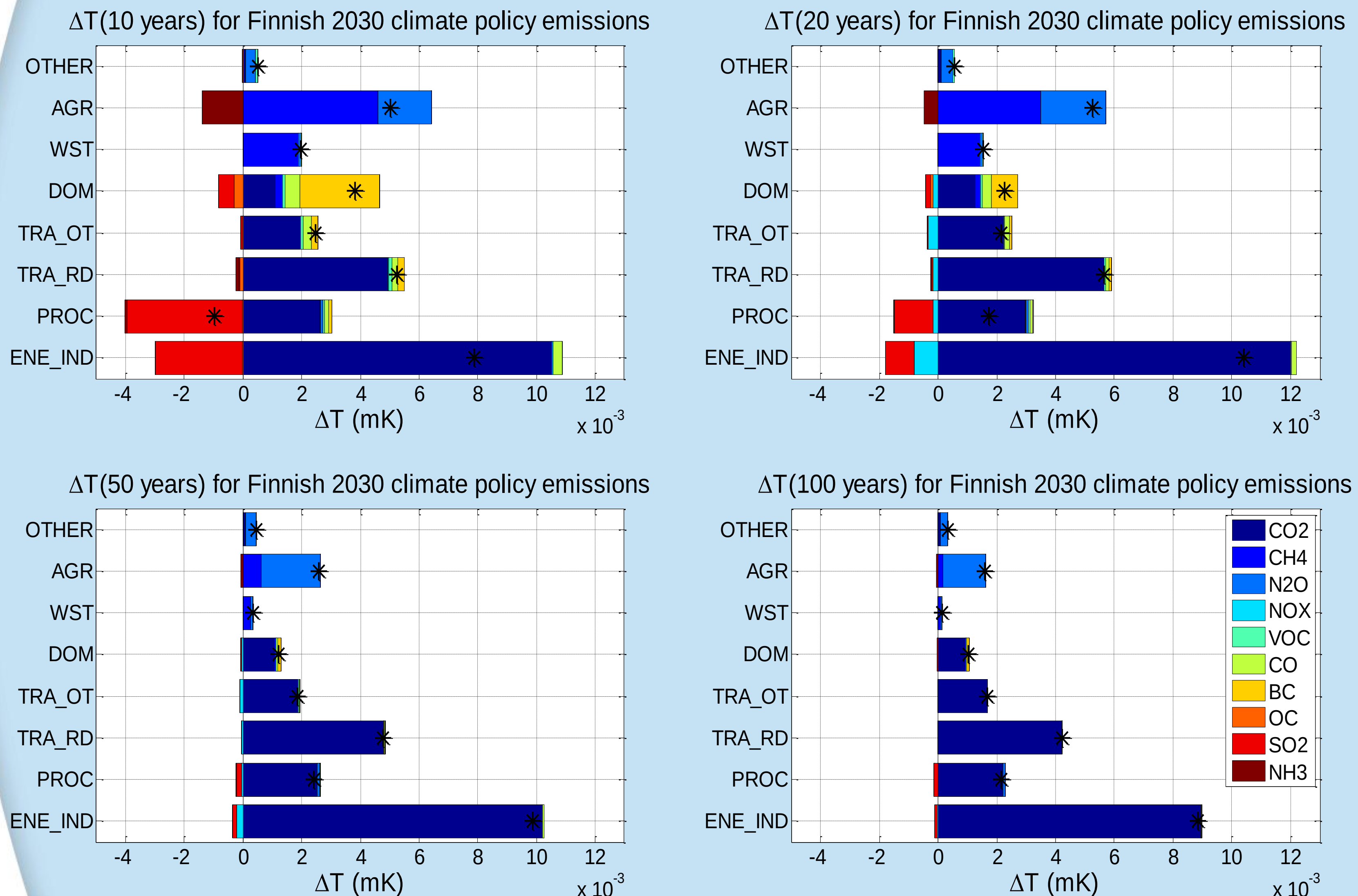
Sector specific temperature differences by pollutants for different time horizons



AGR= agriculture, WST=waste, DOM=residential combustion, TRA_OT=off-road transport, TRA_RD=on-road transport, PROC=industrial processes, ENE_IND=combustion in energy production and industry

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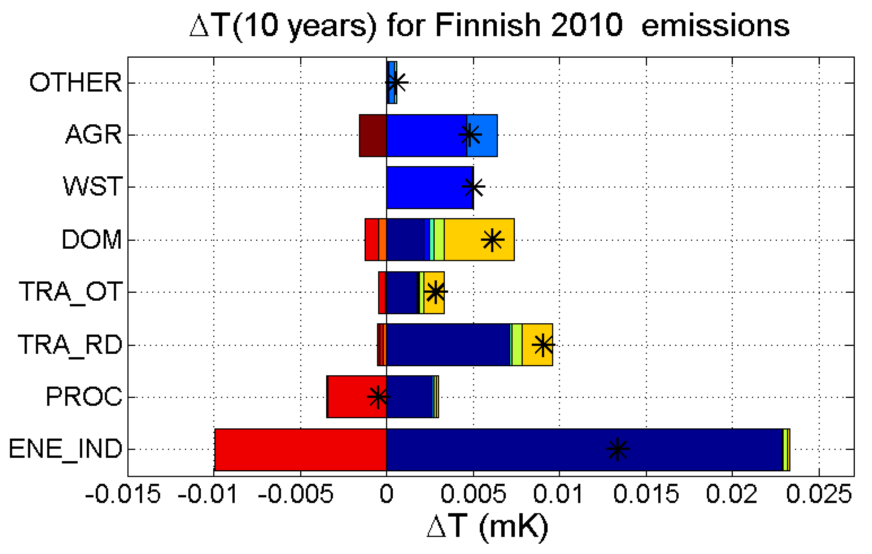
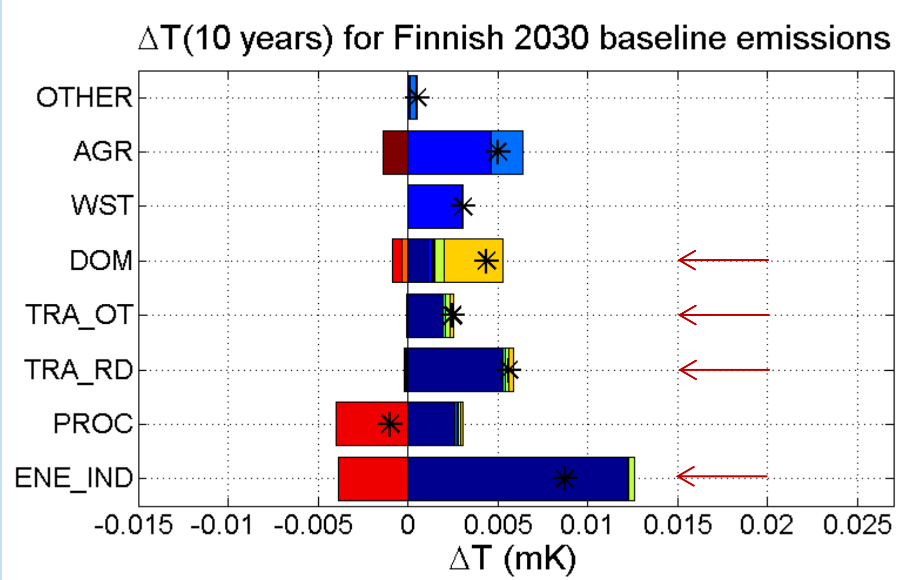
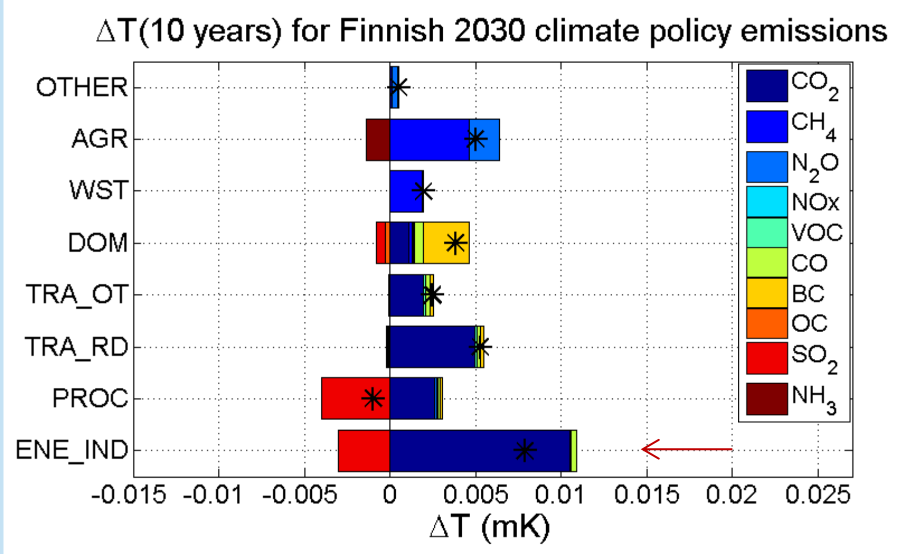
2010 vs 2030 policy analysed with GTP10







- Both baseline and WAM policies reduce the temperature response in 2030 compared with 2010
- Additional reductions via WAM are only marginal until 2030 time horizon

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Results demonstrate that…

- Policy analyses using climate metrics should include multiple pollutants
- Analyses should be conducted and presented utilizing different metrics and several time scales in order to avoid biased policy messages
- Sector specific policies can be designed based on sector specific analyses
- The Finnish climate policies seem to lead to climate benefits with all metrics. It is important to assure that the policies in the scenarios take place as planned.

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Thank you!

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