Task Force on Hemispheric Transport of Air Pollution

Hemispheric Transport:

Progress on 2020-2021 WGSR Work Plan Items

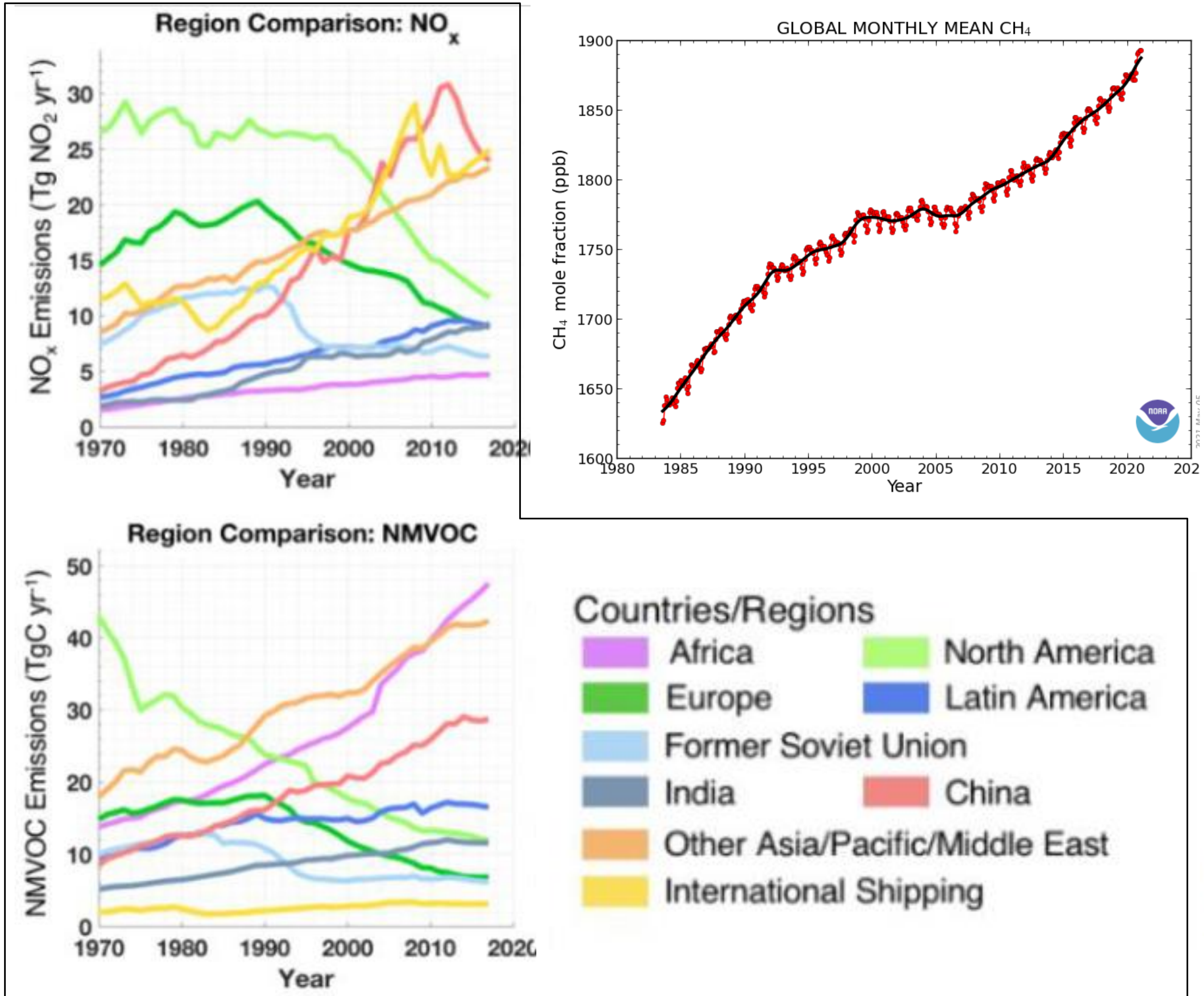
Terry Keating, Rosa Wu, Jacek Kaminski, and Tim Butler

59th Session of the Working Group on Strategies and Review
Online, May 2021

Outline

- [2.1.4] Discussion of hemispheric transport informing the review of the Gothenburg Protocol
    - Contribution of hemispheric transport to observed trends in air quality and its impacts, and future projections
        - Questions 2.1 and 3.2
    - Projected trends in methane, contribution to ground-level ozone, and mitigation potential
        - Question 3.3
    - Projected trends in international shipping, contribution to ground-level ozone and N deposition, and mitigation potential
        - Question 3.4
    - Sufficiency of atmospheric modelling for understanding hemispheric transport of air pollution, and the main requirements for improving simulation of hemispheric transport
        - Questions 2.6 and 2.7
- [2.1.3] Control strategies for use by TF-HTAP in future scenarios
- [1.1.4.3] TF-HTAP activities on Mercury and POPs

Trends in ozone precursors



McDuffie et al. (2020) https://doi.org/10.5194/essd-2020-103

Trends in European background ozone

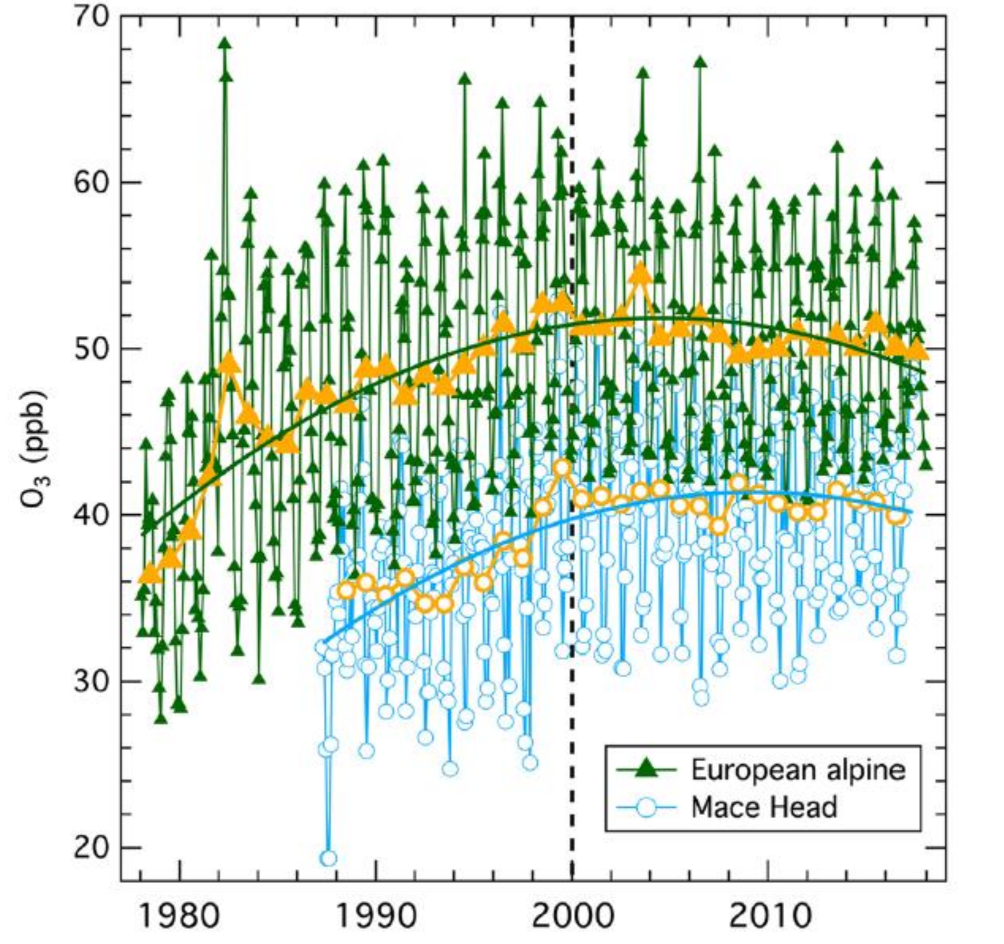


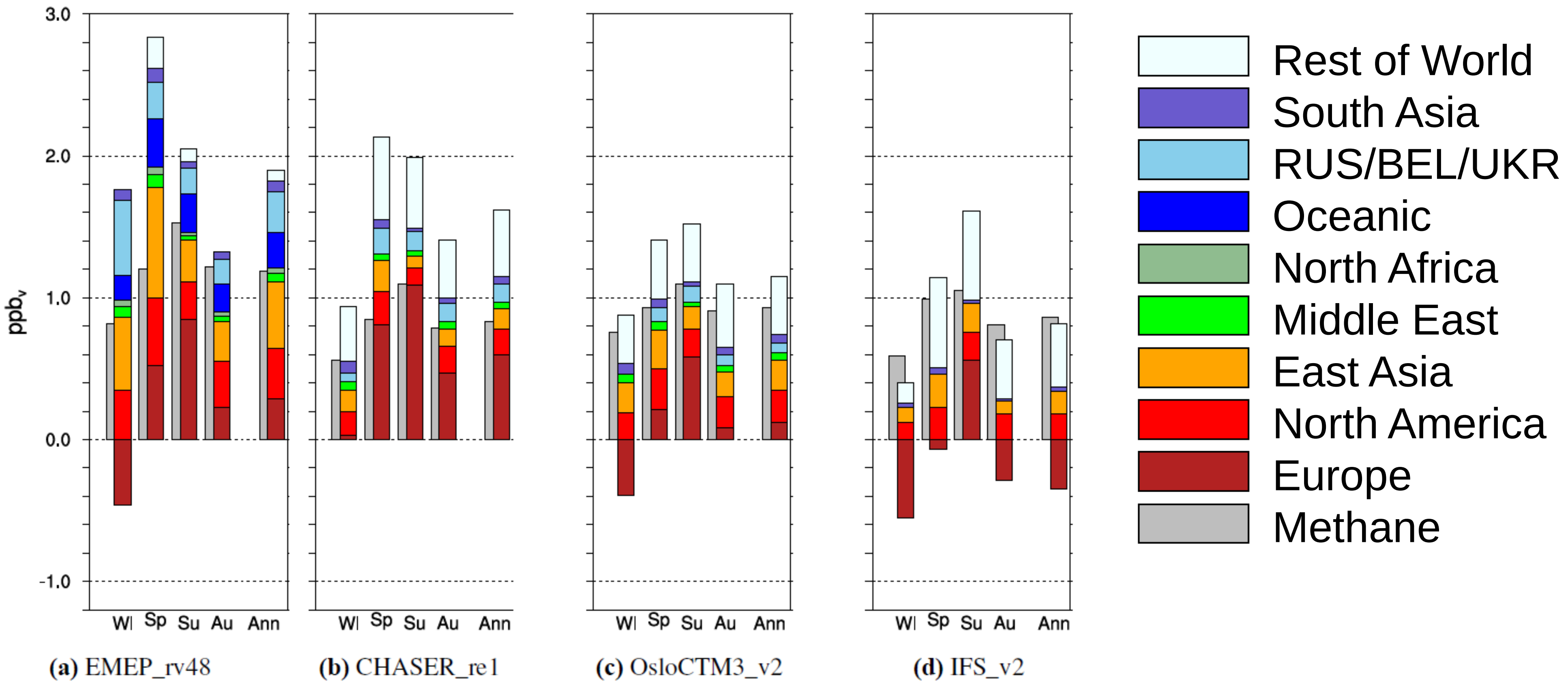
Figure 2. Time series of monthly and annual (orange symbols) mean ozone mixing ratios from two example data sets. The solid curves give the

Parrish et al. (2020) doi: 10.1029/2019JD031908

The effects of intercontinental emission sources on European air pollution levels

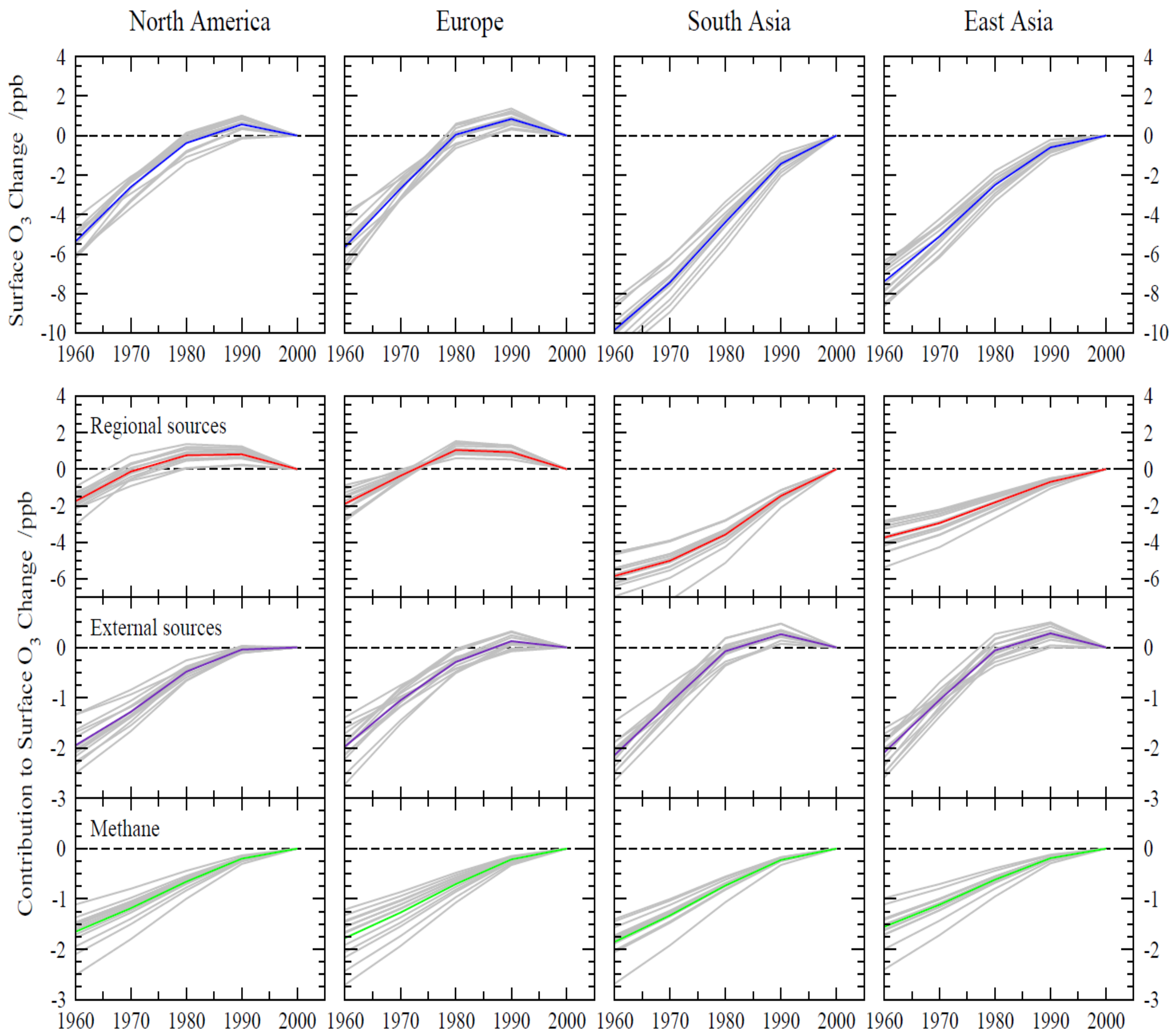
Atmos. Chem. Phys., 18, 13655–13672, 2018
https://doi.org/10.5194/acp-18-13655-2018
© Author(s) 2018. This work is distributed under the Creative Commons Attribution 4.0 License.

Jan Eiof Jonson[1], Michael Schulz[1], Louisa Emmons[2], Johannes Flemming[3], Daven Henze[4], Kengo Sudo[5], Marianne Tronstad Lund[6], Meiyun Lin[7], Anna Benedictow[1], Brigitte Koffi[8], Frank Dentener[8], Terry Keating[9], Rigel Kivi[10], and Yanko Davila[4]



- Anthropogenic emissions of NO_x and VOCs outside of Europe contribute between 2-12 ppb of seasonal average ozone depending on the season
- Methane drives ozone formation in Europe to the same extent as non-European NO_x and VOCs
- International shipping contributes a similar amount as remote continental regions (where included)

Attribution of historical trends in ground-level ozone



- Since 1990: declines in Europe and North America, with increases in East and South Asia.
- In Europe
  - Regional and extra-regional contribution declined between 1990 and 2000
- In North America
  - Regional contribution declined, but extra-regional contribution remained relatively constant.
- Methane contribution increased, offsetting some of the benefits of regional emission control

Results from HTAP phase 1

Projected trends

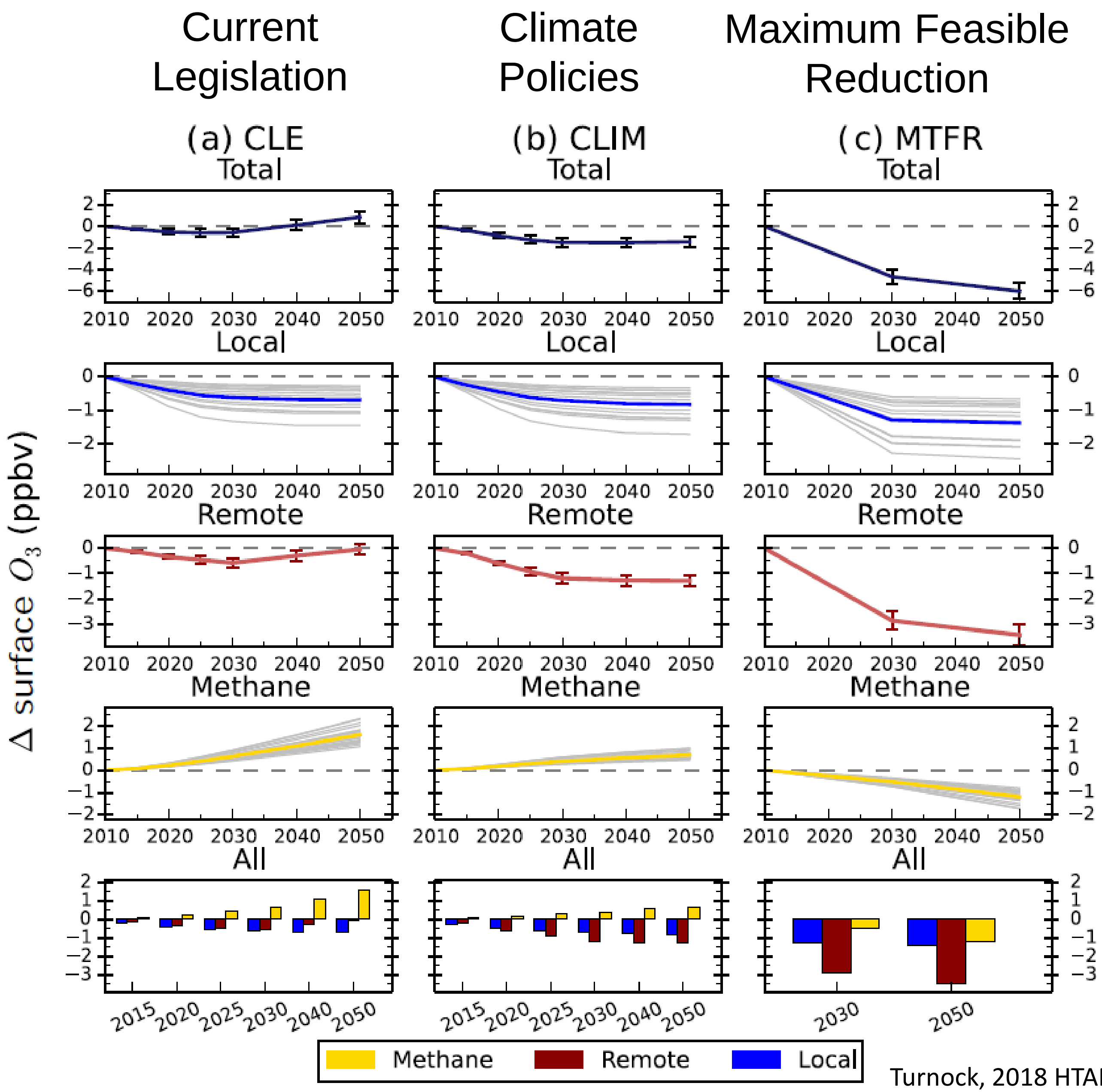
- CLE: O_3 in Europe will decrease as a result of European and (mainly) North American air pollution legislation. Increasing CH_4 will more than offset other emissions decreases after 2030.

- CLIM: Decreased CH_4 emissions and cobenefits from the energy sector will help to stabilize the O_3 concentrations after 2030.

- MTFR: Enhanced technologies inside and outside Europe will decrease emissions of O_3 precursors, including CH_4, and have strong benefits for air quality.

Future Scenarios

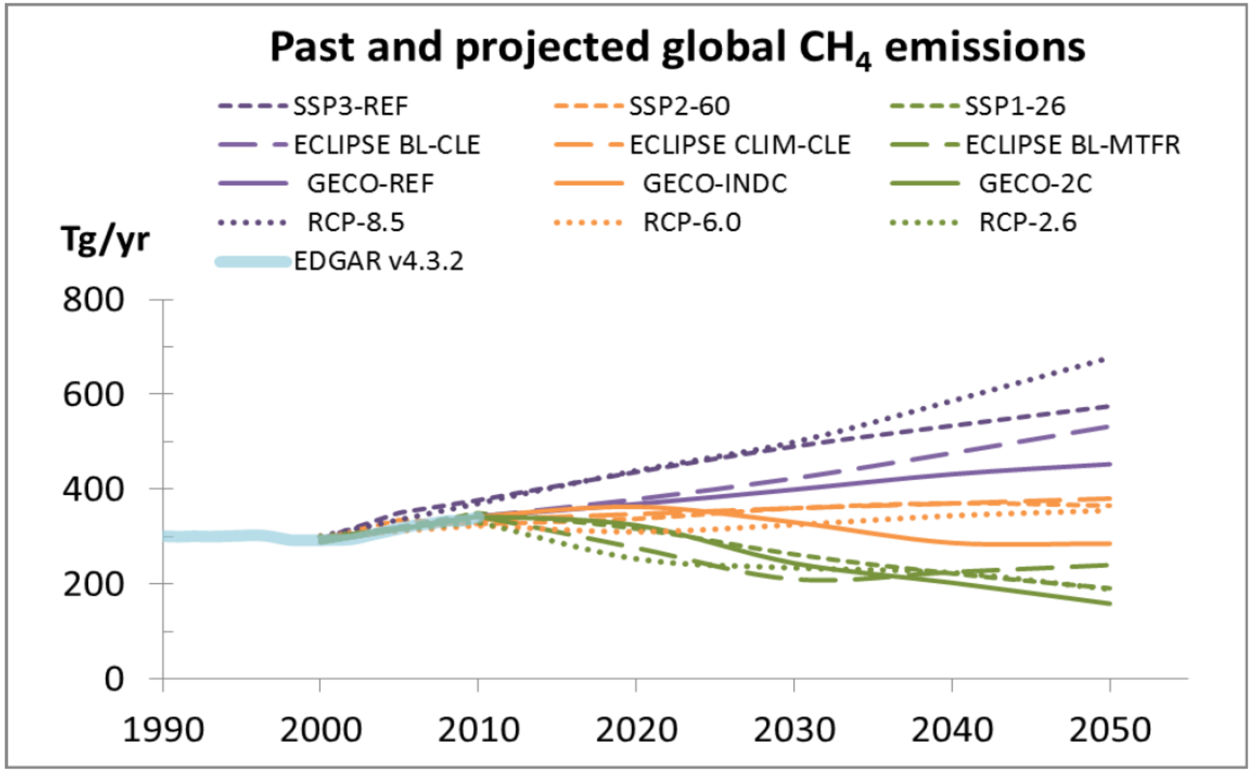
Regional and Extra-Regional Components of Change in Europe



Turnock, 2018 HTAP2 Special Issue

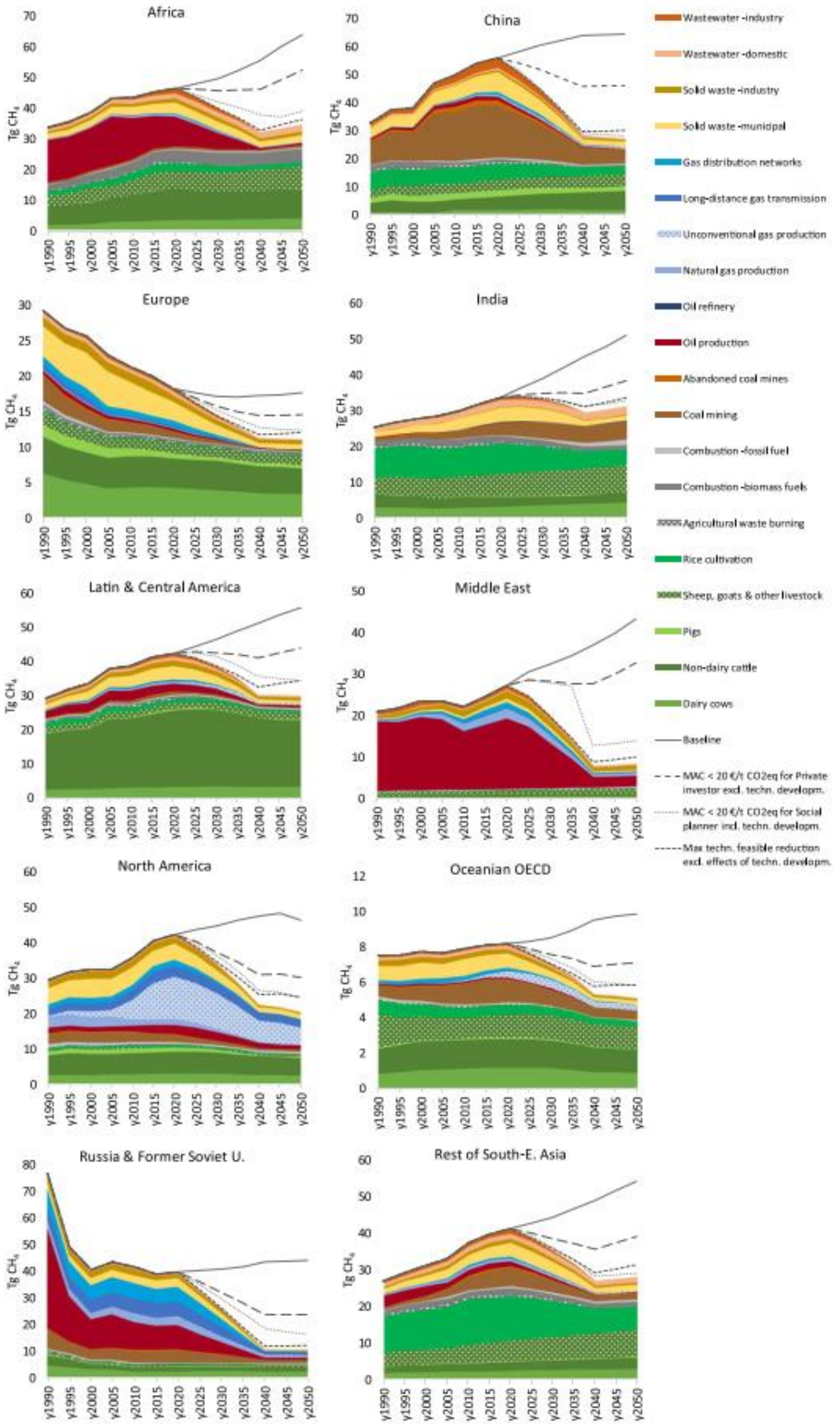
Projected trends and mitigation potential: methane

Figure 3.12. Historical (1990 – 2010) global anthropogenic CH_4 emission trends from EDGAR v4.3.2 and projected (2000 – 2050) trends from four scenario families. Scenarios have been colour-coded to easily distinguish the "high emission", "middle of the road" and "low emission-high mitigation effort" members in each family.



Source: JRC elaboration of emission data

Van Dingenen et al. (2018)



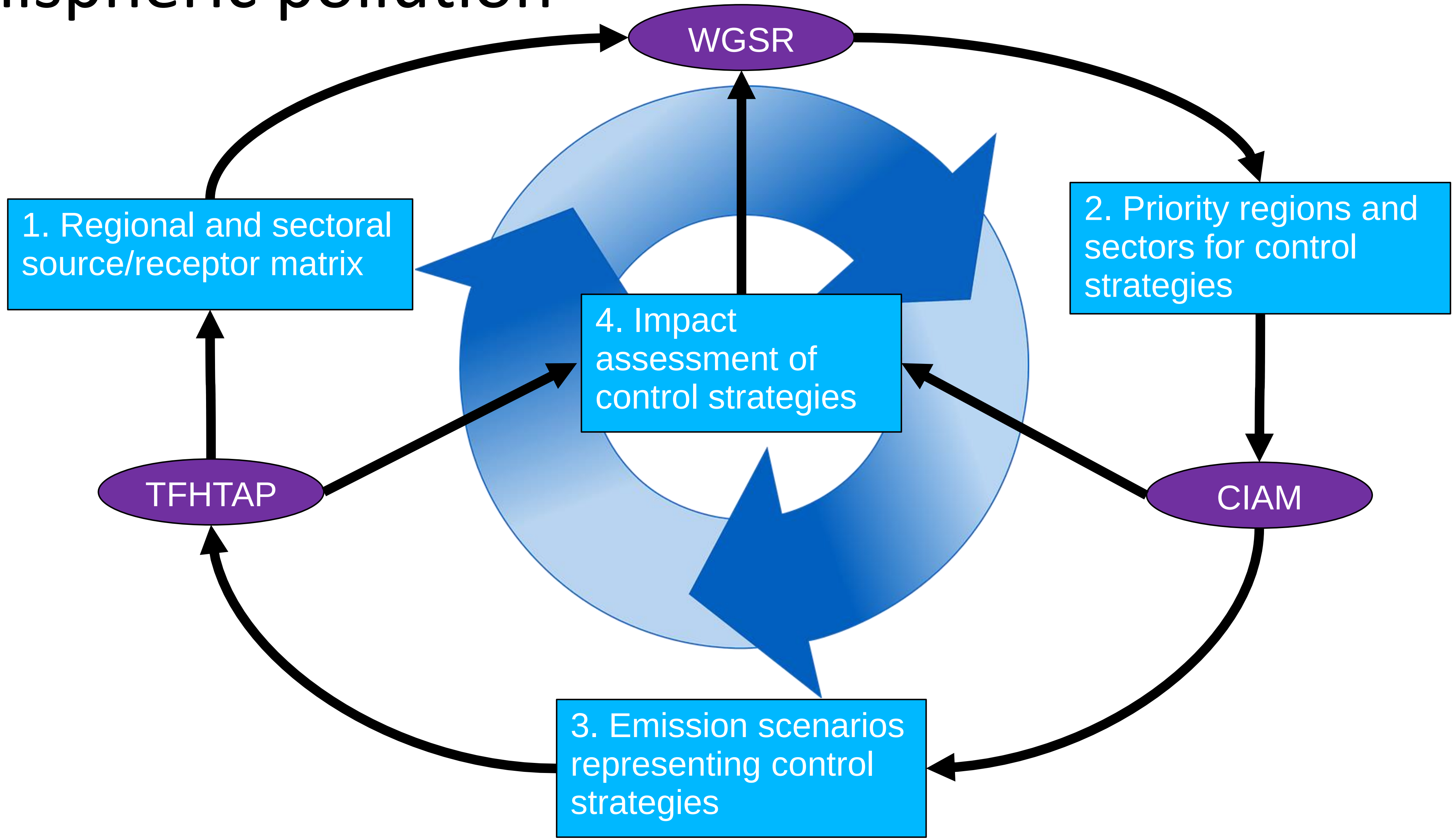
Höglund-Isaksson et al. (2020)

International shipping: technical potential for NOx reductions

Reduction techniques :	SO_2	NO_x	PM	BC	fuel penalty	Investments costs (€/kW)	Operation & maintenance costs
Primary measures:							
- Switch to low sulphur fuels	up to 97%[1]	-	50-90%	0-80%[2] (median: 30%)	-	-	88-223 €/t fuel
- Switch to LNG	90-100%	64-90%	60-98%	75-90%	- 5-10%	219-1603	- 43 €/t fuel (+ fuel savings)
- Switch to water-in-fuel emulsions	-	1-60%	20-90%	0-85%	+ 0-2%	11-44	33-271 k€/year[6]
- Switch to biodiesel and biofuels	-	-	12-37%	38-75%	+ 8-11%	-	-
- Switch to methanol	100%[3]	55%	99%	97%[4]	+ 9%	150-450	10-15 €/MWh for fuel and 3-4 €/MWh for other O&M
- Slow steaming	13-50[5]%	21-64%	18-69%	0-30%	- 15-50%	71	- 42-77% (fuel savings)[7]
- Slide valves	-	20%	10-50%	25-50%	+ 2%	0.33-1.43	(assumed to be null)
Secondary measures:							
- Exhaust Gas Recirculation (EGR)	-	25-80%	-	0-20%	+ 0-4%	36-60	17-25€/kW, so 2-3 €/MWh assuming 8,000 hours/year
- Selective Catalytic Reduction (SCR)	-	70-95%	10-40%	-	0-2%	19-100	3-10 €/MWh
- PM filters (DPFs)	-	-	45-92%	70-90%	+ 1-4%	30-130	+1-4% in fuel penalties
- Scrubbers	90-98%	-	0-90% (median: 14-45%)	0-70% (median: 16-37%)	+ 0.5-3%	100-433	0,6[8]-12 €/MWh (~2% of capital investments)

TFTEI background informal technical document, December 2020

Design and assessment of control strategies for hemispheric pollution

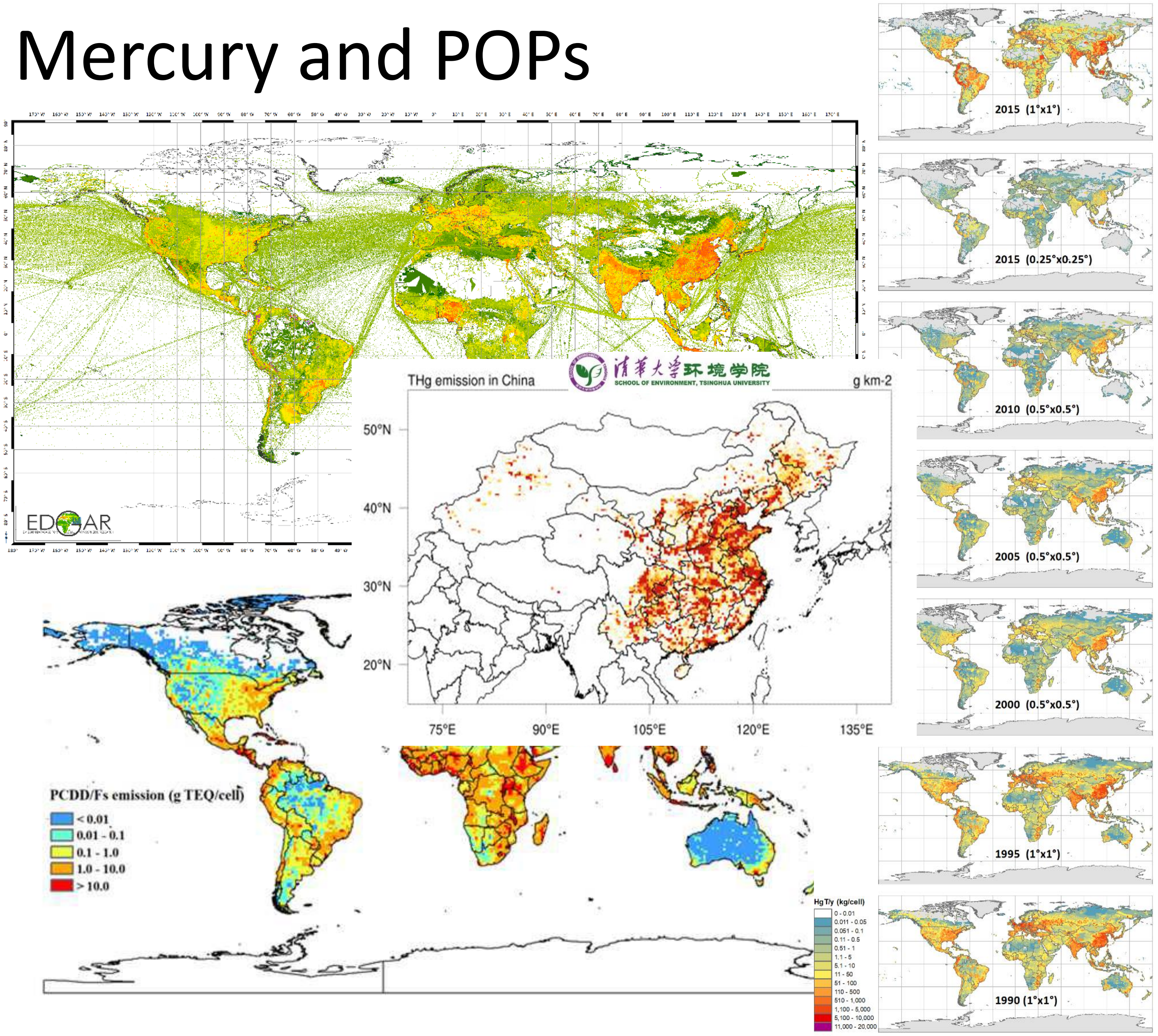


TF-HTAP activities on Mercury and POPs

Workshops on April 13 and 15

Identified Potential For

1) Extending the Global HTAP Emissions Mosaic to Mercury and Combustion-related POPs
2) Mercury Multi-Model Evaluation
   a) 2013-2015
   b) Long Term Trends
3) POPs/Aerosol Multi-Model Evaluation
   a) B(a)P Experiments at Global Scale to Compliment TFMM EuroDelta-Carb
   b) Wildfires



Plots Courtesy of
Jianmin Ma (Peking University)
Marilena Muntean (JRC-Ispra)
Frits Steenhuisen (Arctic Centre, University of Groningen)
Shuxiao Wang (Tsinghua University)