Task Force on Hemispheric Transport of Air Pollution

TF-HTAP

Update on 2022-2023 work plan items with focus on methane

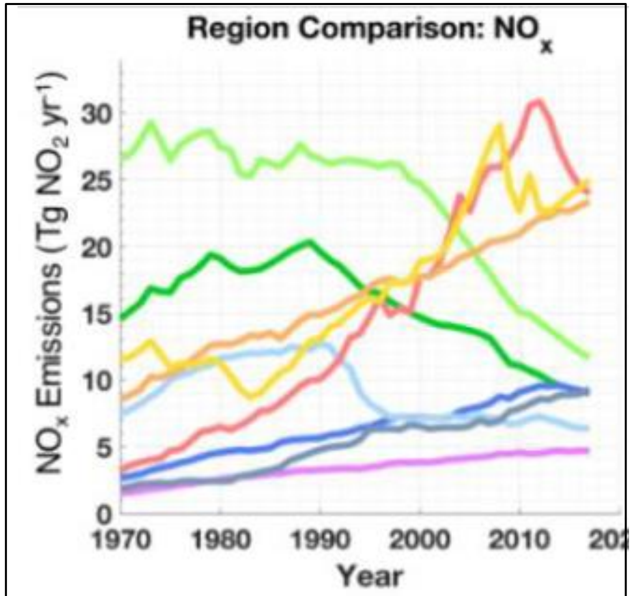
Terry Keating, Rosa Wu, Jacek Kaminski, and Tim Butler

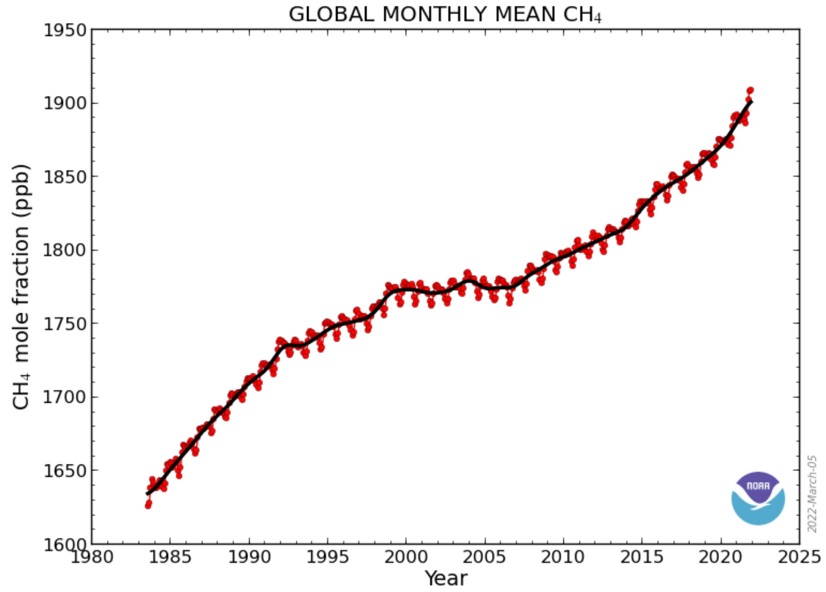
60th Session of the Working Group on Strategies and Review
Geneva, 11-14 April 2022

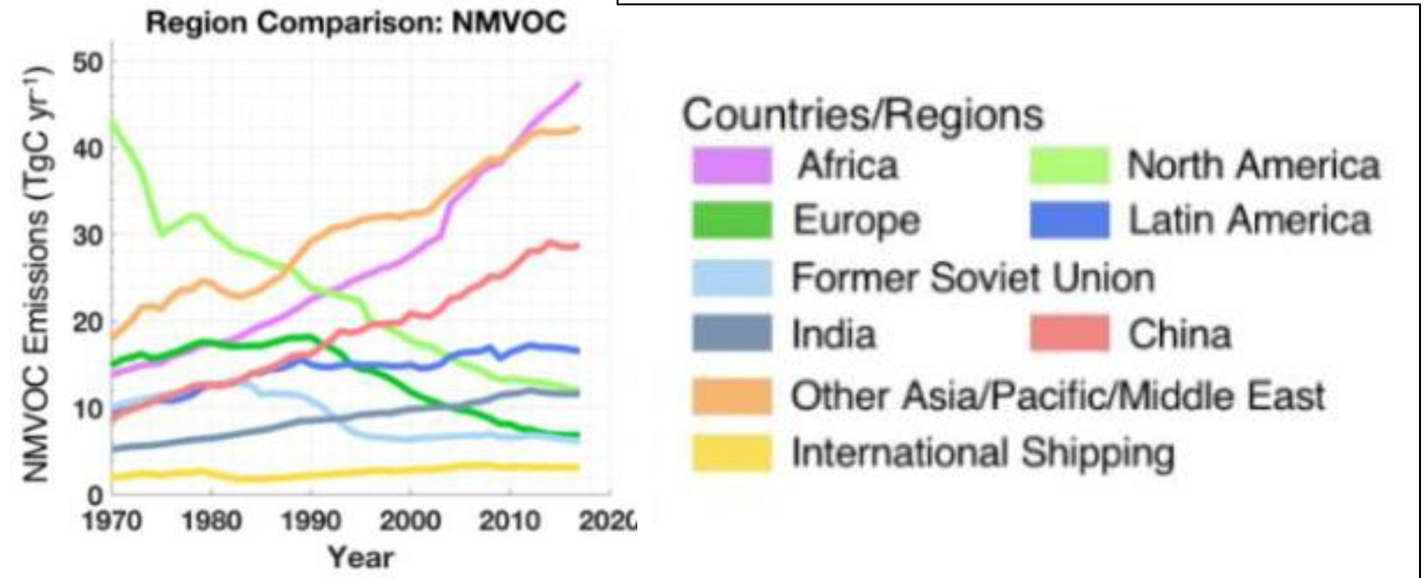
Selected items from the 2022-2023 workplan

Item	Activity description/ objective	Expected outcome/ deliverable	Lead body(ies)	Status
1.1.3.3	**Assessing observed trends in air pollution at the various scales. Linkages between global and regional air pollution.**	**Contribution to the review of the Gothenburg Protocol (2022)**	**TFMM, TFHTAP, TFIAM and MSC- W**	**Input provided in 2021. Feedback on this input is welcome.**
1.1.3.7	**Perform an evaluation of the impact of potential methane mitigation measures on regional ozone**	**Report and workshop organized in 2023**	**TFMM, TFHTAP, MSC-W, TFIAM**	**TFMM currently leading this activity.**
1.1.4.2	Attribution of long-term changes of Hg and POP pollution to regional and extra- regional (global, secondary) sources	Analysis of available global Hg and POP emissions inventories. Model assessments. Technical Report.	MSC-E, TFHTAP, AMAP, UNEP, Stockholm and Minamata Conventions	Workshops in May 2022.
1.1.4.3	**Development and design of global emission scenarios to explore the mitigation potential in comparison to the baseline with a data set for use in Convention modeling tools**	**Report (2022–2023)**	**TFIAM (CIAM) and TFHTAP**	**Drawing on prior TFHTAP modeling to examine impacts of CIAM scenarios**
1.1.4.4a	Complete the updated global emissions mosaic for traditional air pollutants (HTAPv3, 2000–2018)	Updated data set (2023)	TFHTAP in cooperation with JRC, CAMS, CIAM, TFEIP, other international partners	Initial public release of dataset on 1st of April 2022. Workshop in May 2022.
1.1.4.5	**Continue development of the openFASST tool for screening analysis of future scenarios and implications of global and regional model uncertainties**	**Tool updates (2022,2023)**	**TFHTAP**	**Support from US EPA.**

Global trends in ozone precursors



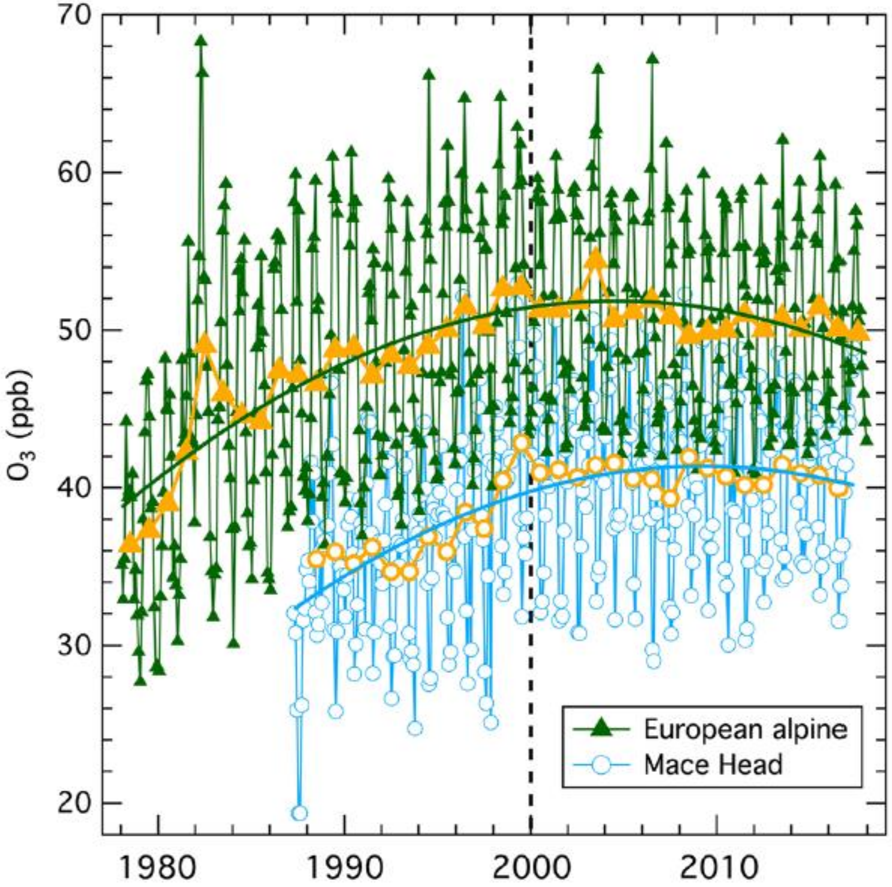




McDuffie et al. (2020) http://doi.org/10.5194/essd-2020-103

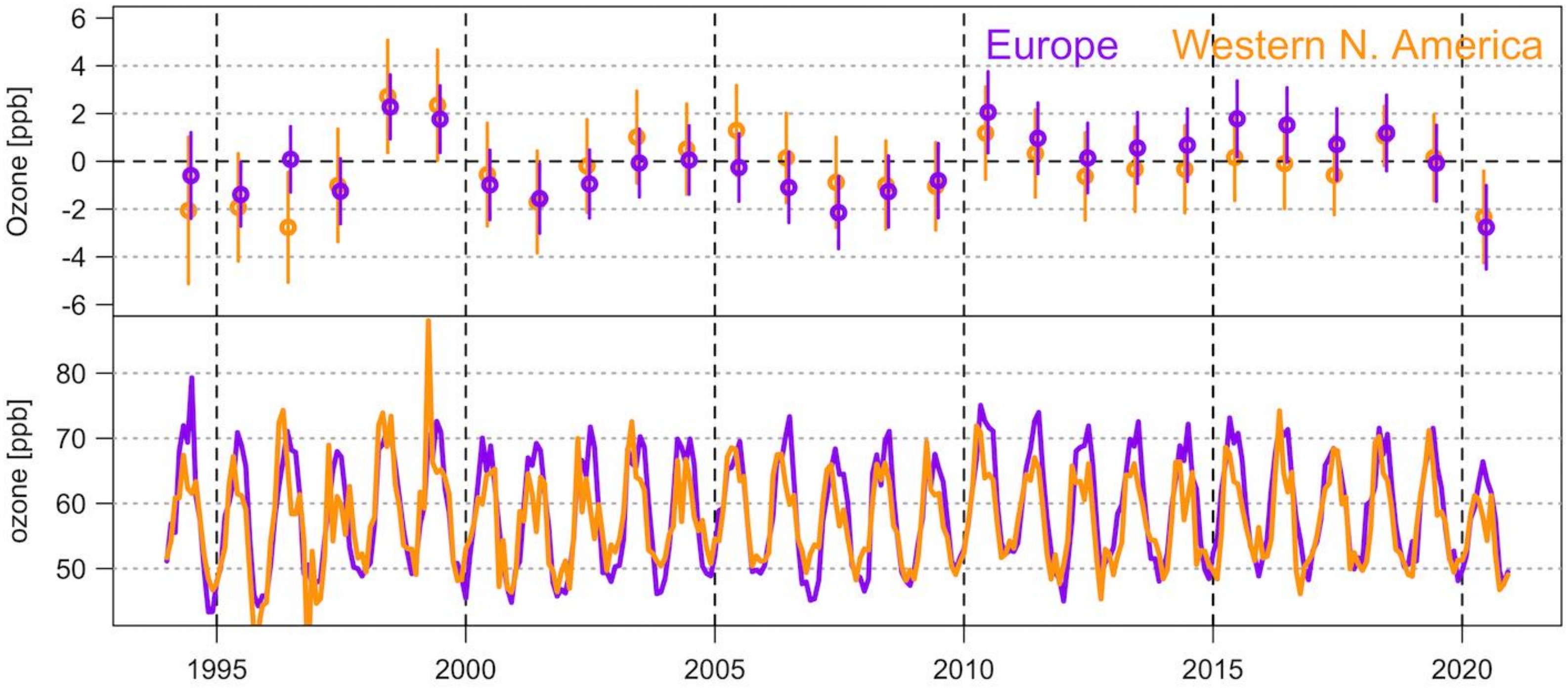
- Consistent downward trends in NOx and NMVOC emissions in the UNECE
- Recent reversal in NOx trend from China and stabilisation in NOx from international shipping
- Continuing increase in NMVOC emissions from several regions
- Accelerating increase in global methane concentration

Trends in background ozone: how to measure this?



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

Ozone anomalies and weighted observations in the free troposphere from ozone sondes, lidar, and commercial aircraft.



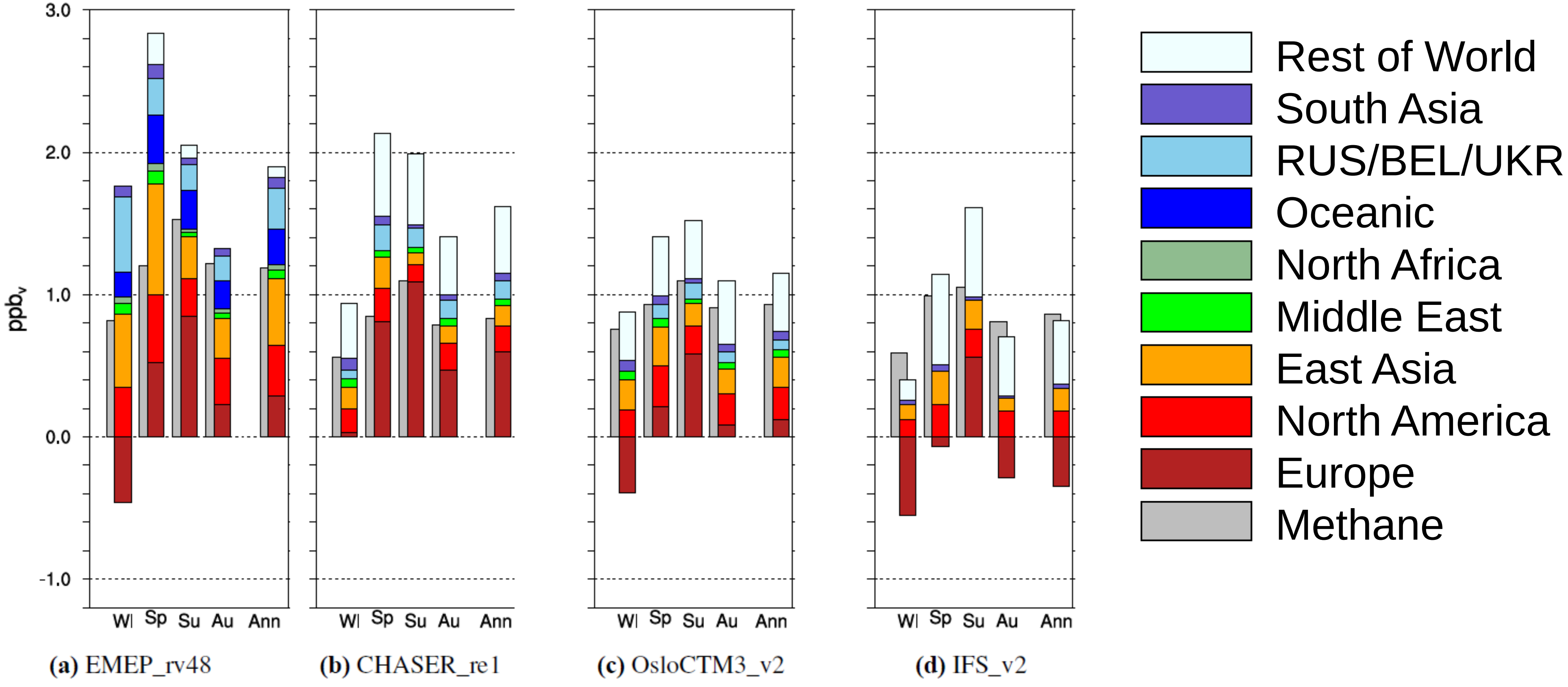
Chang et al. (in press)

- Ozone concentrations at some sites selected to represent the inflow to Europe and North America (on the left) appear to have peaked in the mid-2000s and have begun to decline [Parrish 2020].
- However, a broader analysis of remote surface sites has shown both increasing and decreasing trends over this period [Cooper 2020].
- Moreover, observations in the free troposphere from sondes, lidar, and commercial aircraft (on the right) show an increasing trend, except in 2020 due to the effects of the pandemic [Chang in press].

The effects of intercontinental emission sources on European air pollution levels

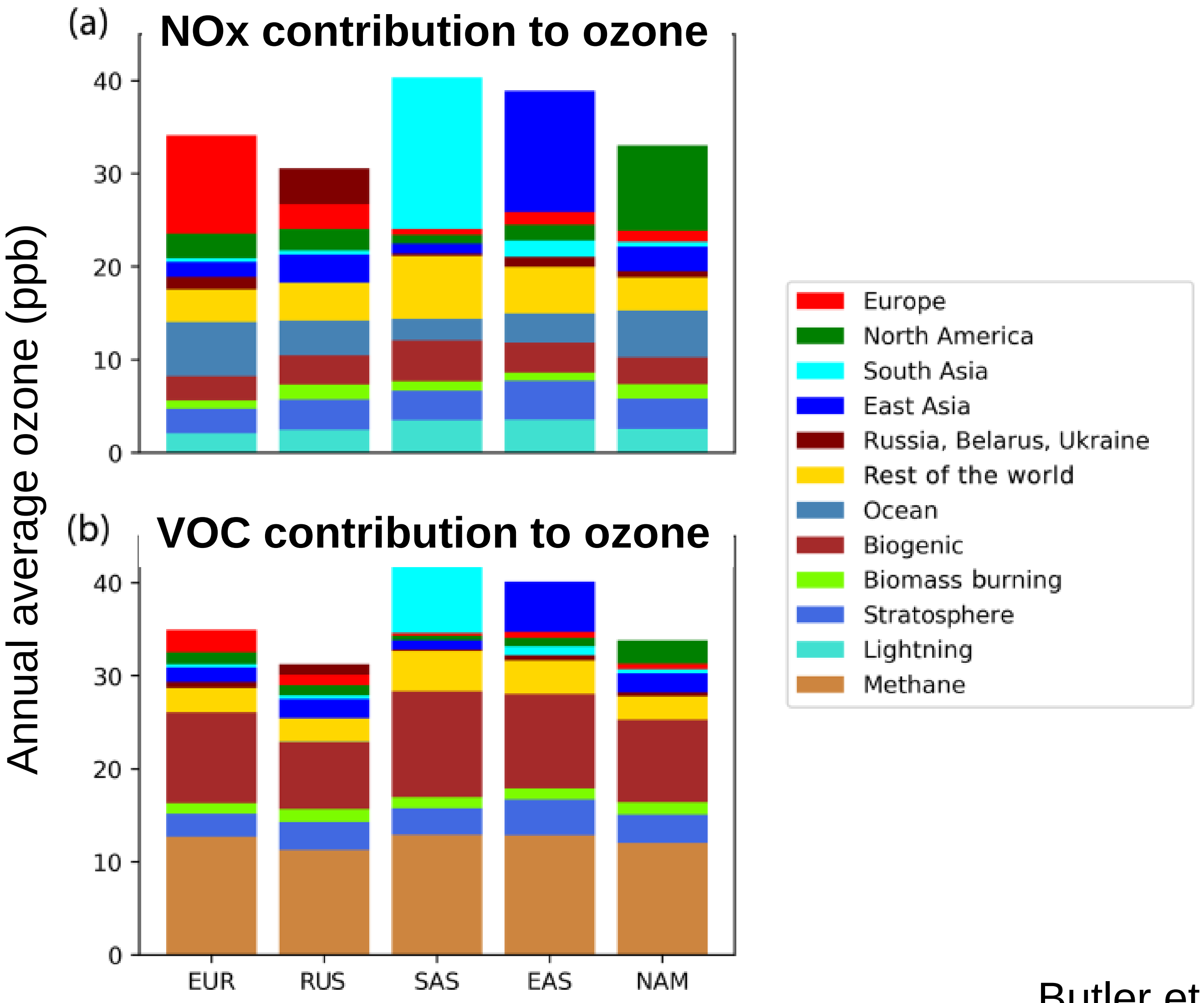
Atmos. Chem. Phys., 18, 13655–13672, 2018
https://doi.org/10.5194/acp-18-13655-2018

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]



- Large inter-model variability
- Anthropogenic emissions of NO_x and VOCs outside of Europe contribute a comparable amount of ozone as local emissions
- 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)

Detailed source attribution of ozone: effect of NOx and VOCs

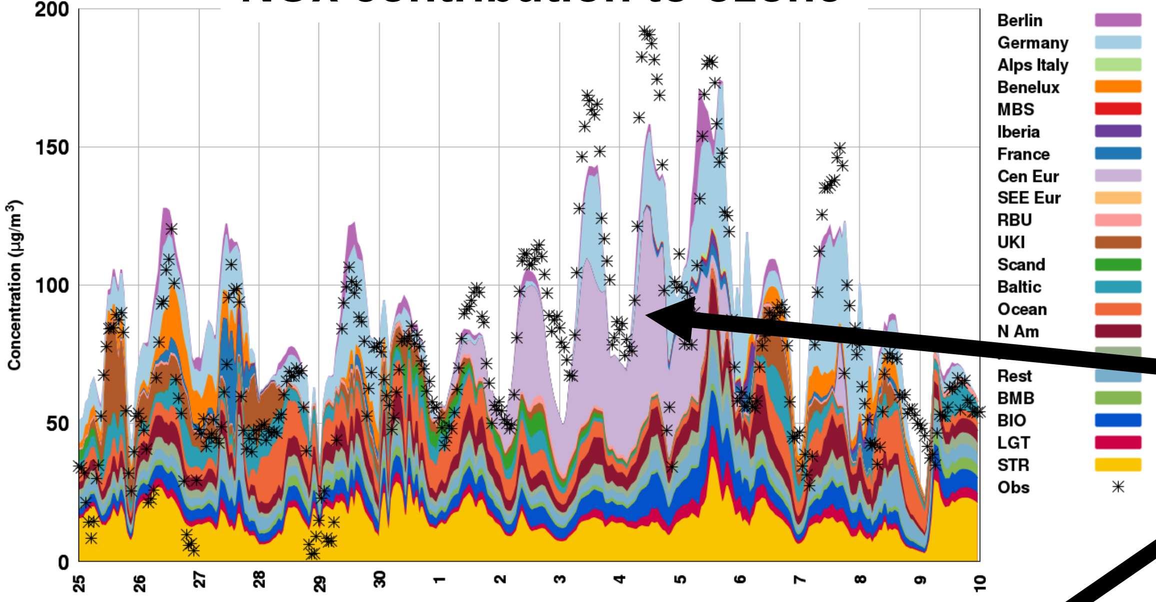


- Some individual models can do more detailed source attribution
- Local NOx contribution to ozone is comparable to long-range component
- International shipping is the single largest NOx source for transboundary ozone
- Biogenic NMVOCs are more important than anthropogenic NMVOCs in most regions
- Methane contributes about 1/3rd of annual av. ozone

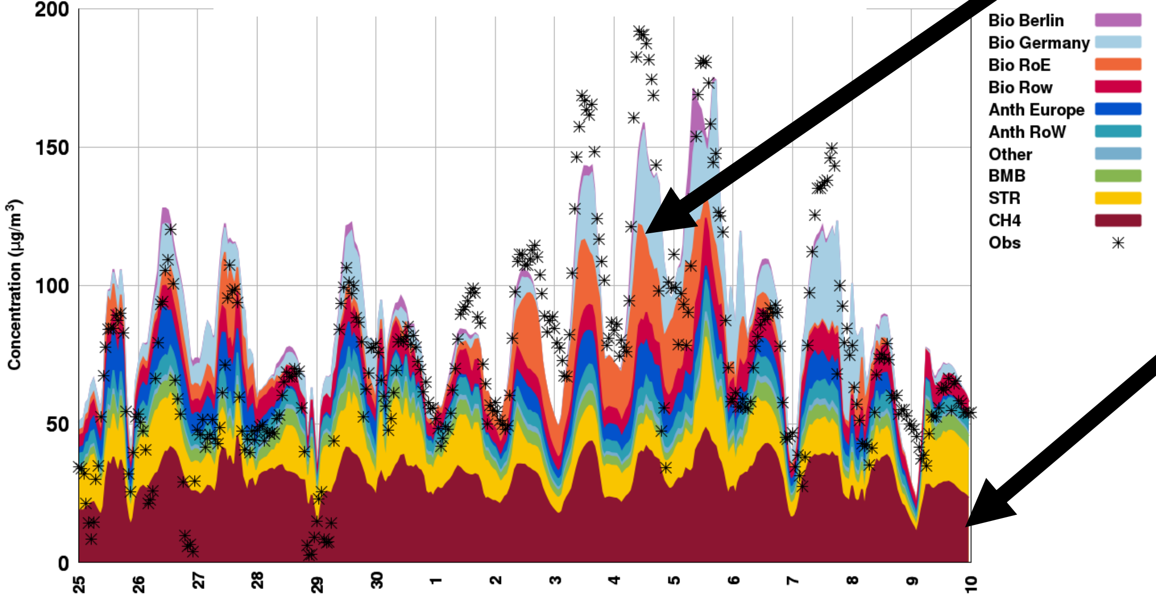
Butler et al. (2020) https://doi.org/10.5194/acp-20-10707-2020

Source attribution for ozone in Berlin: June-July 2015

NOx contribution to ozone



VOC contribution to ozone

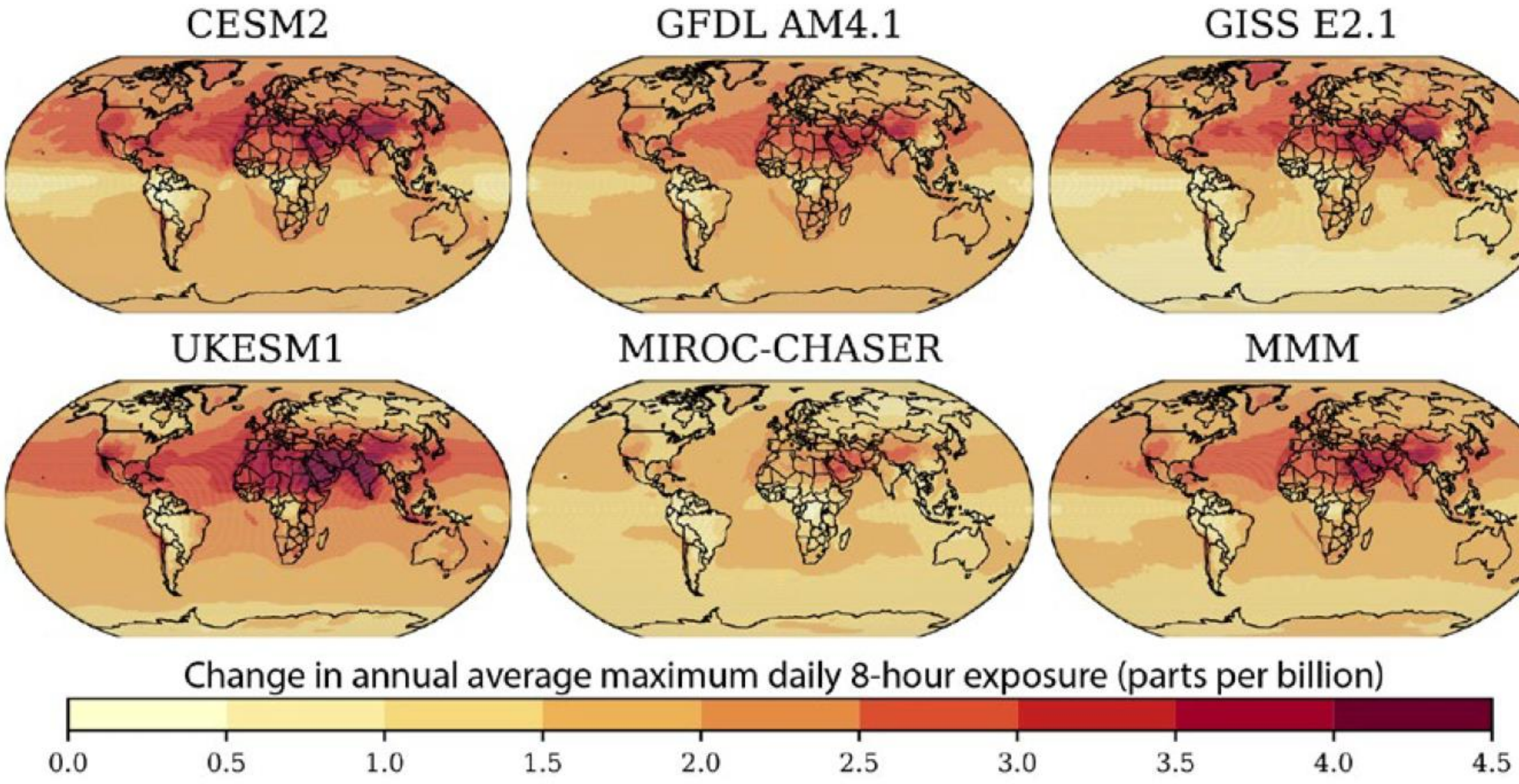


Peak ozone episodes attributable to regional anthropogenic NOx and biogenic VOC

Consistent baseline contribution from methane: important for accumulated exposure

Lupascu et al. (2022) https://doi.org/10.5194/acp-2022-189

Spatial variability in the surface ozone response to methane



- Large spread between different global models
- Clear general pattern
- Regional response related to local photochemical activity and NOx emissions
- TFMM multi-model study will provide more detail for Europe

CCAC/UNEP Global Methane Assessment (2021)

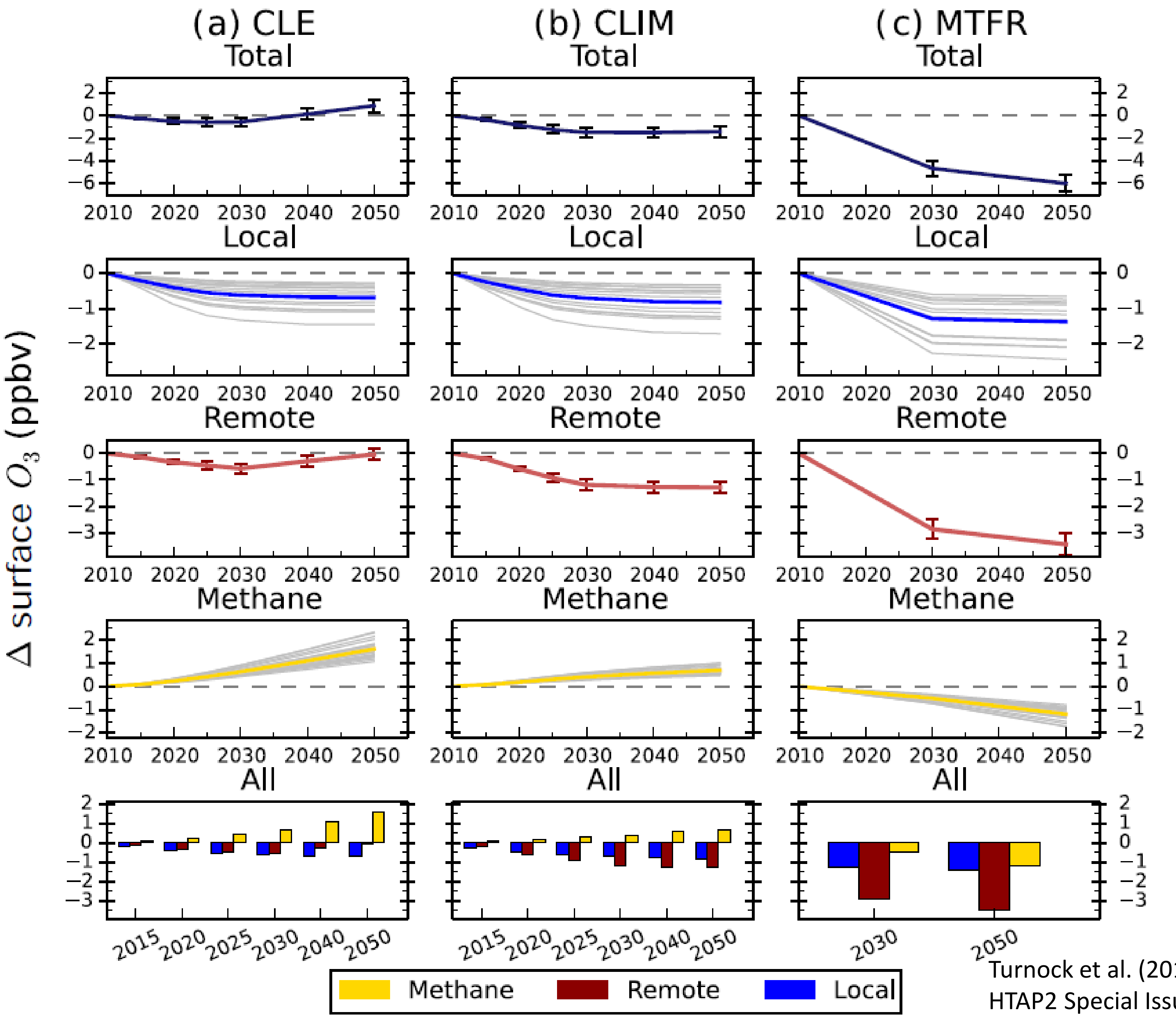
Regional and extra-regional components of change in Europe

- 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.

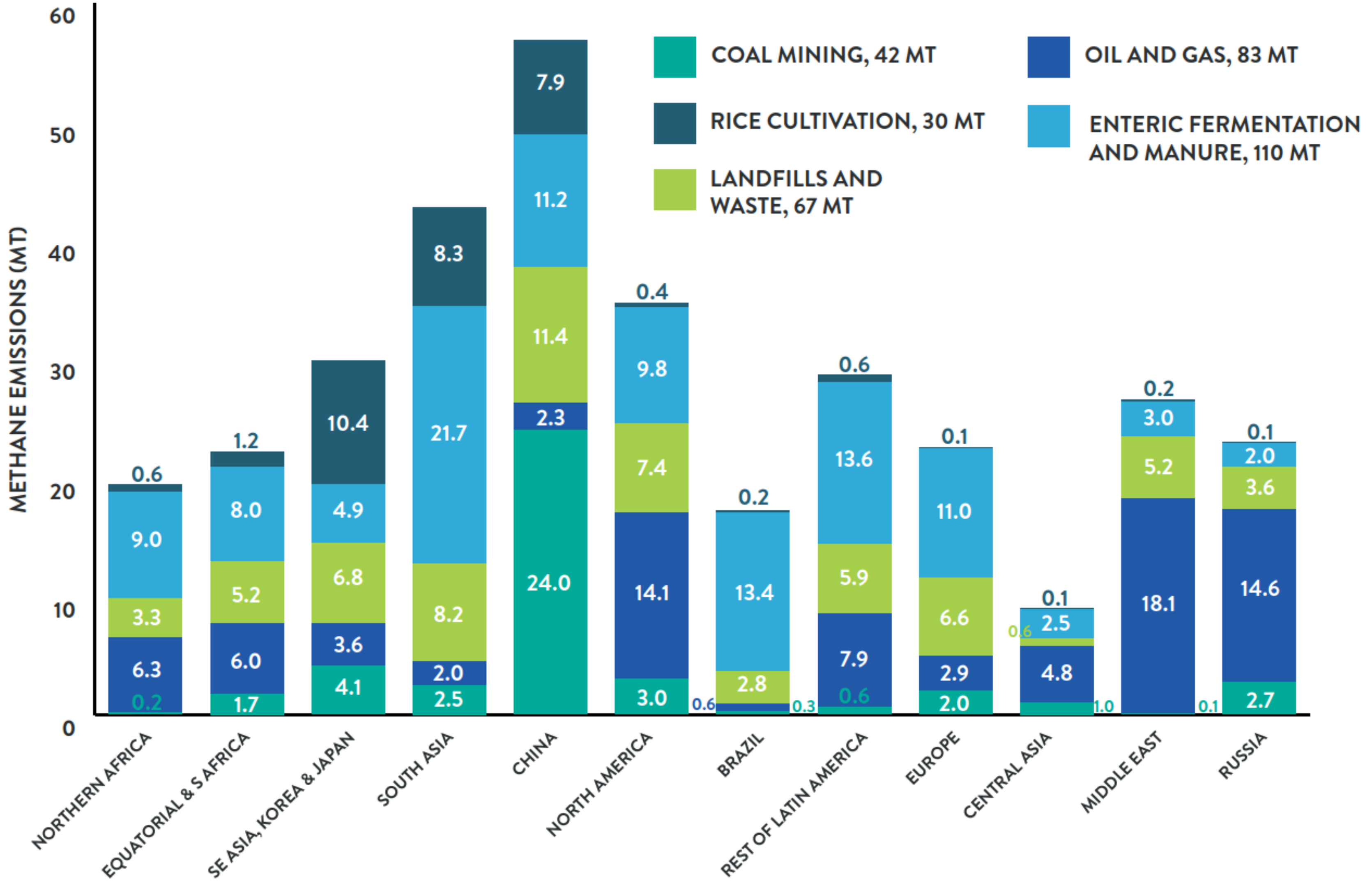
- MTFR: Enhanced technologies inside and outside Europe will decrease emissions of O_3 precursors, including CH_4, and have strong benefits for air quality.

ECLIPSEv5a Scenarios



Turnock et al. (2018)
HTAP2 Special Issue

Anthropogenic methane emissions by region

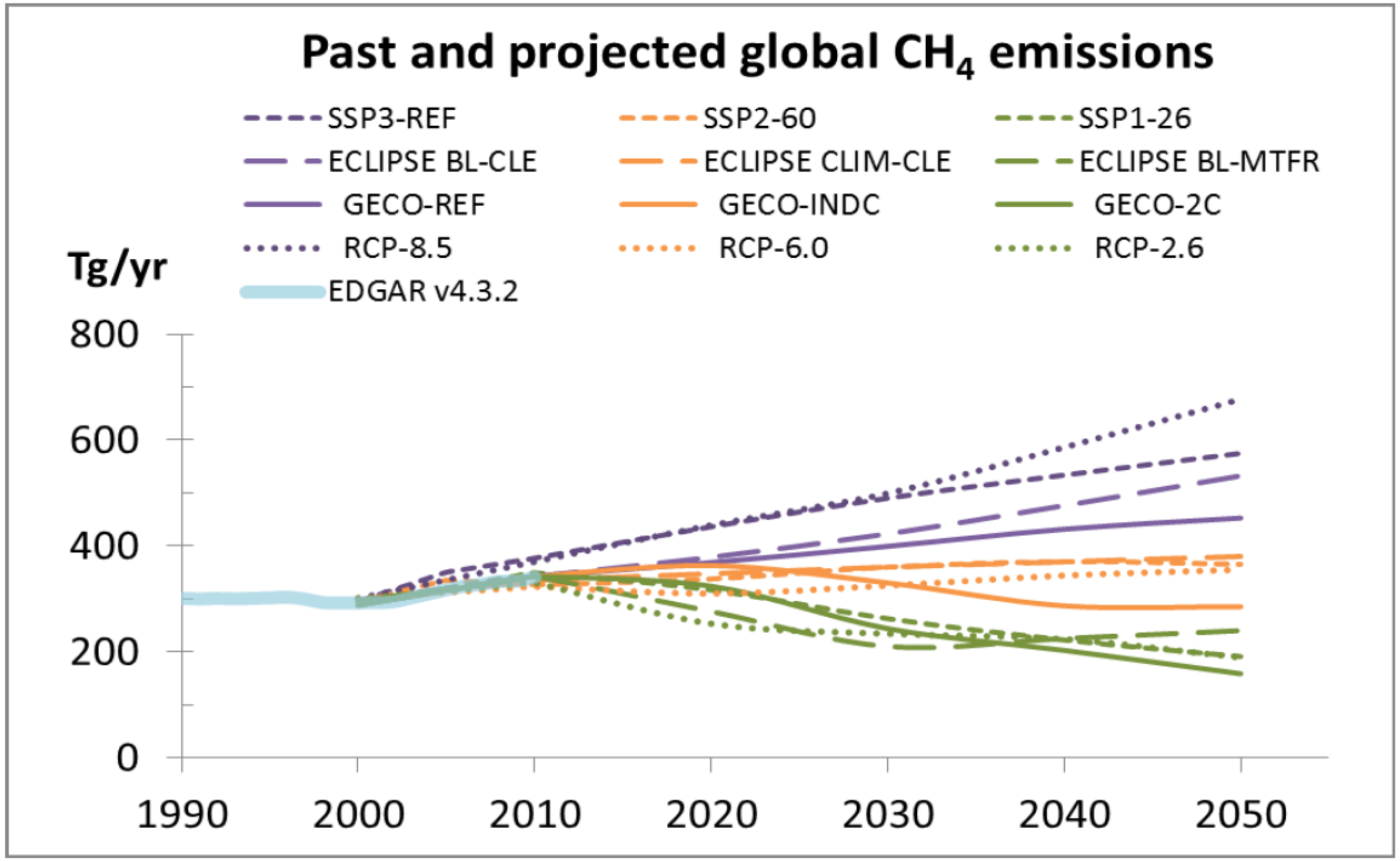


- Anthropogenic emissions are approximately equal to natural emissions globally
- Large methane emissions outside of the UNECE
- Methane is globally well-mixed, so emission cuts in any source region will have the same local benefits in each receptor region

CCAC/UNEP Global Methane Assessment (2021)

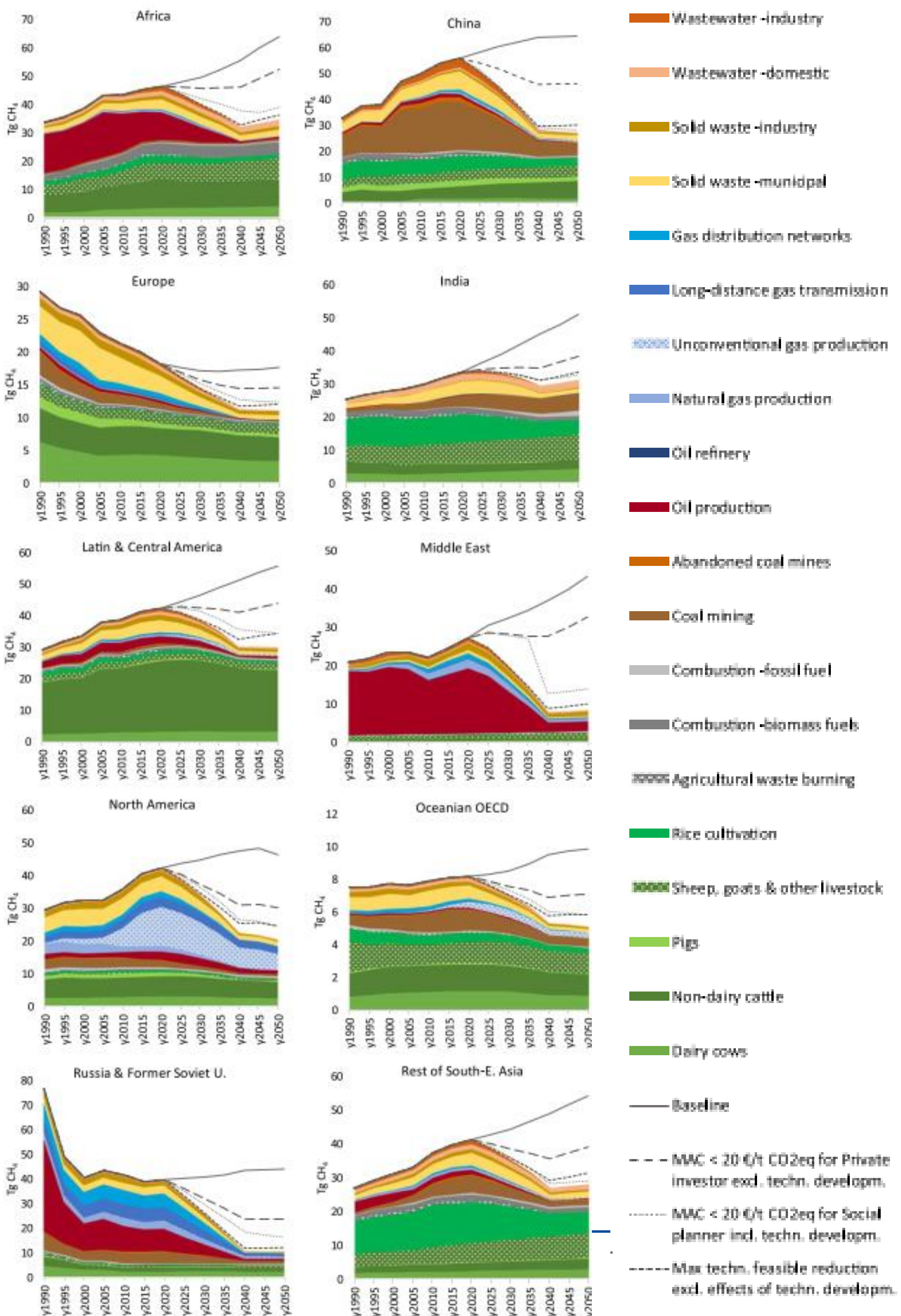
Projected trends and mitigation potential: methane

Van Dingenen et al. (2018)



Source: JRC elaboration of emission data

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

Key messages from the TF-HTAP contribution to the GP review

- Expected increases in global CH_4 are expected to more than offset projected reductions of NO_X and VOC emissions in Europe and at least partially offset reductions of NO_X and VOC emissions in North America.
- The fossil fuel (production and distribution) and waste sectors have the highest technical potential for reduction of methane emissions. The agricultural sector is a major source of methane emissions but has a low technical potential for reductions in methane emissions.
- The share of global shipping NOx as a proportion of global anthropogenic NOx emissions (currently at about 30%) is projected to vary between 10% and 60% by the end of the century, depending on the effectiveness of land-based NOx emission control.
- Significant technical potential for the mitigation of global NOx emissions from shipping exists from a range of primary and secondary measures, but the impacts of these measures on reducing ozone and N deposition in the UNECE region has not been fully assessed.