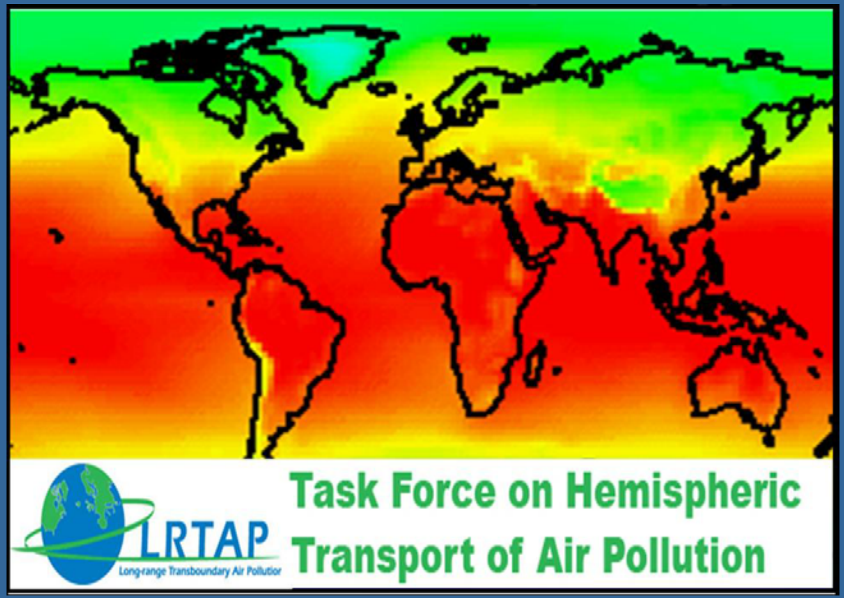
Model intercomparison under HTAP



Kees Cuvelier
The TF HTAP Modelling Team

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION
Institute for Environment and Sustainability

MICS, Vienna, 26-27 Feb 2009

While local and regional emission sources are the main cause of air pollution problems worldwide, many air pollutants are transported on a hemispheric or global scale, including:

- Ozone and its precursors
- Fine particles
- Acidifying substances
- Mercury
- Persistent organic compounds

The Task Force on HTAP (UNECE Convention on LRTAP) is conducting a series of multi-model evaluation and intercomparison experiments

- Created in December 2004 by the UNECE Convention on Long-Range Transboundary Air Pollution
- US and EC are the Lead Parties
- To improve the scientific understanding of intercontinental transport and hemispheric air pollution in the Northern Hemisphere.
- Participation is open to all interested experts.
- Focus on the "7 science questions"
- Coordinated model studies to provide harmonized information to the HTAP interim and final reports
- Contribute to the review of protocols to the Convention

Policy-Relevant Science Questions

1. How does hemispheric transport affect air pollution?
2. How much do emissions in one country or region affect air pollution in another country or region? (SR)
3. How confident are we of the results and what is our best estimate of the uncertainties?
4. How will changes in emissions in one country or region affect air pollution in another country or region?
5. How may the source-receptor relationships change over the next 20 to 50 years due to changes in emissions?
6. How may the source-receptor relationships change due to climate change?
7. What efforts are needed to develop an integrated system of observation data and models?

➔ <u>Call for a model intercomparison study</u>

HTAP Model Overview (1)

NR	MODEL	RESOLUTION	RESPONSIBLE
01	GEOSChem-v07	144 x 91 x 30	Rokjin Park
02	MOZARTGFDL-v2	192 x 96 x 28	Arlene Fiore
03	STOCHEM-v02	96 x 72 x 20	Kirsty Pringle, Michael Sanderson
04	CAMCHEM-3311m13	144 x 96 x 28	Peter Hess
05	INCA-vSSz	96 x 72 x 19	Michael Schulz, Sophie Szopa
06	LLNL-IMPACT-T5a	144 x 91 x 48	Cynthia Atherton, Dan Bergmann
07	MSCE-HM-v4.5 (NH)	144 x 37 x 8	Oleg Travnikov
08	MSCE-POP-v2.2 (NH)	144 x 37 x 8	Alexey Gusev
09	EMEP-rv26 (NH)	360 x 90 x 20	Jan Eiof Jonson, Peter Wind
10	OsloCTM2	128 x 64 x 40	Michael Gauss
11	FRSGCUCI-v01	128 x 64 x 37	Oliver Wild
12	UM-CAM-v01	96 x 73 x 19	Guang Zeng
13	TM5-JRC-cy2-ipcc-v1	360 x 180 x 25	Elina Marmer
14	MOZECH-v16	192 x 96 x 28	Martin Schultz, Sabine Schröder
15	GEOSChem-v45	72 x 46 x 30	Marta Garcia Vivanco
16	GOCART-v4p1	144 x 91 x 30	Thomas Diehl
17	GEMAQ-v1p0	180 x 90 x 28	Alexander Lupu
18	GEMAQ-EC	96 x 72 x 20	Sunling Gong
19	ULAQ-v03 (v02)	64 x 37 x 28	Veronica Montanaro
20	SPRINTARS-v356	320 x 160 x 20	Toshihiko Takemura
21	ECHAM-HAMMOZ-v21	128 x 64 x 31	Gerd Folberth
22	STOC-HadAM3-v01	72 x 36 x 19	Ian MacKenzie
23	INCA-v2MS	96 x 73 x 19	Michael Schulz
24	GISS-PUCCINI-modelE	72 x 46 x 23	Drew Shindell

HTAP Model Overview (2)

NR	MODEL	RESOLUTION	RESPONSIBLE
25	GISS-PUCCINI-modelA	72 x 46 x 23	Drew Shindell
26	GMI-v02a	144 x 91 x 42	Huisheng Bian
27	GOCART-v4p2	144 x 91 x 30	Thomas Diehl
28	GMI-v02f	144 x 91 x 42	Bryan Duncan
29	HADGEM2-A-v01	192 x 145 x 38	Shekar Reddy
30	CAMCHEM-3514	144 x 96 x 28	Peter Hess
31	GEMAQ-v1p0R1p5x1p5	(only vertprof)	Alexander Lupu
32	CHASER-v03	168 x 64 x 32	Sudo Kengo
33	IFS-CY32R3	320 x 160 x 25	Johannes Flemming
34	GRAHM-1.1	180 x 90 x 28	Didier Davignon
35	EMEPGLOB-rv3	360 x 180 x 20	Jan Eiof Jonson
36	ECHMERIT-V1	128 x 64 x 19	Gerlinde Jung
37	GLEMOS-v1.0	360 x 180 x 20	Oleg Travnikov
38	GFDL-AM3	144 x 90 x 24	Arlene Fiore
39	GISS-PUCCINI-ModelEaer	72 x 46 x 23	Drew Shindell
40	MOZARTGFDL-v4	192 x 96 x 64	Arlene Fiore
41	STOC-HadAM3-v02	72 x 36 x 19	Ian MacKenzie
42	TM5-JRC-cy2-ipcc-v1-glv3x2	360 x 180 x 25	Frank Dentener
43	TM5-JRC-cy2-ipcc-v1-glv6x4	360 x 180 x 25	Frank Dentener
44	TEST	xx – xx - xx	To test your own model

Current defined experiments:

SR: **Source-Receptor Emission Sensitivity Studies**

- Initially, this set of simulations consisted of a reference simulation (2001) and simulations reducing anthropogenic emissions by 20% in EU, NA, EA, and SA.

- These simulations are defined for reductions of NOx, VOC, CO, Hg, specific POPs, and combined reductions of NOx, VOC, CO, SO2, and aerosols.

- After analysis of these results, additional simulations were defined reducing anthropogenic emissions by 20% globally and zero-ing out anthropogenic, biomass, and dust sources of aerosols, and shipping and aviation emissions.

TP: Tracer and Process Studies

- These experiments are designed to test the transport parameterizations in the models and to allow a meaningful diagnosis why differences occur between the various chemistry transport models.
- The simulations consist of a simple passive tracer experiment with tracers of different lifetimes, pulse studies to examine continental outflow episodes (related to the ES experiment series), and a series of simulations that transition to a realistic CO simulation.

ES: Event Simulations

- These experiments explore the ability to reproduce specific events of intercontinental transport observed during the ICARTT campaign and their impacts on atmospheric composition

FC: Future Climate and Emission Scenarios

- A fourth set of simulations examining the impacts of future changes in emissions and climate are being considered.

VARIABLE	UNITS	DESCRIPTION
vmr_o3_m24	mole/mole	Monthly mean values of the daily mean values (equal to monthly mean).
vmr_o3_m12	--	Monthly mean values of the day-time (8H-20H) mean values.
vmr_o3_m7	--	Monthly mean values of the reduced day-time (9H-16H) mean values.
vmr_o3_max	--	Monthly mean values of the daily maxima of the 8-hr running averaged concentrations.
vmr_o3_somo35	(mole/mole) x days	Monthly accumulated daily concentrations of the maxima of the 8-hr running average concentration in excess of 35 ppb.
vmr_o3_aot40	(mole/mole) x hours	Monthly accumulated hourly concentrations in excess of 40 ppb.
vmr_o3_aot60	(mole/mole) x hours	Monthly accumulated hourly concentrations in excess of 60 ppb.
vmr_o3_exc60	days	Monthly number of days of exceedances over 60 ppb of the 8-hr running averaged daily maximum ozone concentration.
vmr_o3_sumo6	(mole/mole) x hours	Monthly accumulated hourly concentrations larger than or equal to 60 ppb.
vmr_o3_w126	(mole/mole) x hours	Monthly accumulated hourly concentrations with the following sigmoidal weighting function: { 1. + 4403. * exp(-0.126 * 10^9 * O3) }$^{-1}$, with O3 in mole/mole (this means 10^9 * O3 is in ppb)
vmr_no2_m24	mole/mole	Monthly mean values of the daily mean values (equal to monthly mean).

U,NA,SA,GL
E,SW
eptember
2004
ber 2004

Gas	65	-	
Aerosol	12	-	
Deposition	58	-	
Aero-aod	11	-	
Budgets	6	-	production/loss
Vert Profs	12	-	
SFC	16	-	(or indicators)

Data base at FZ-Juelich server

- Directories:

DVS: All monthly results of all models,
Daily (0,6,12,18 hr) vertical profiles

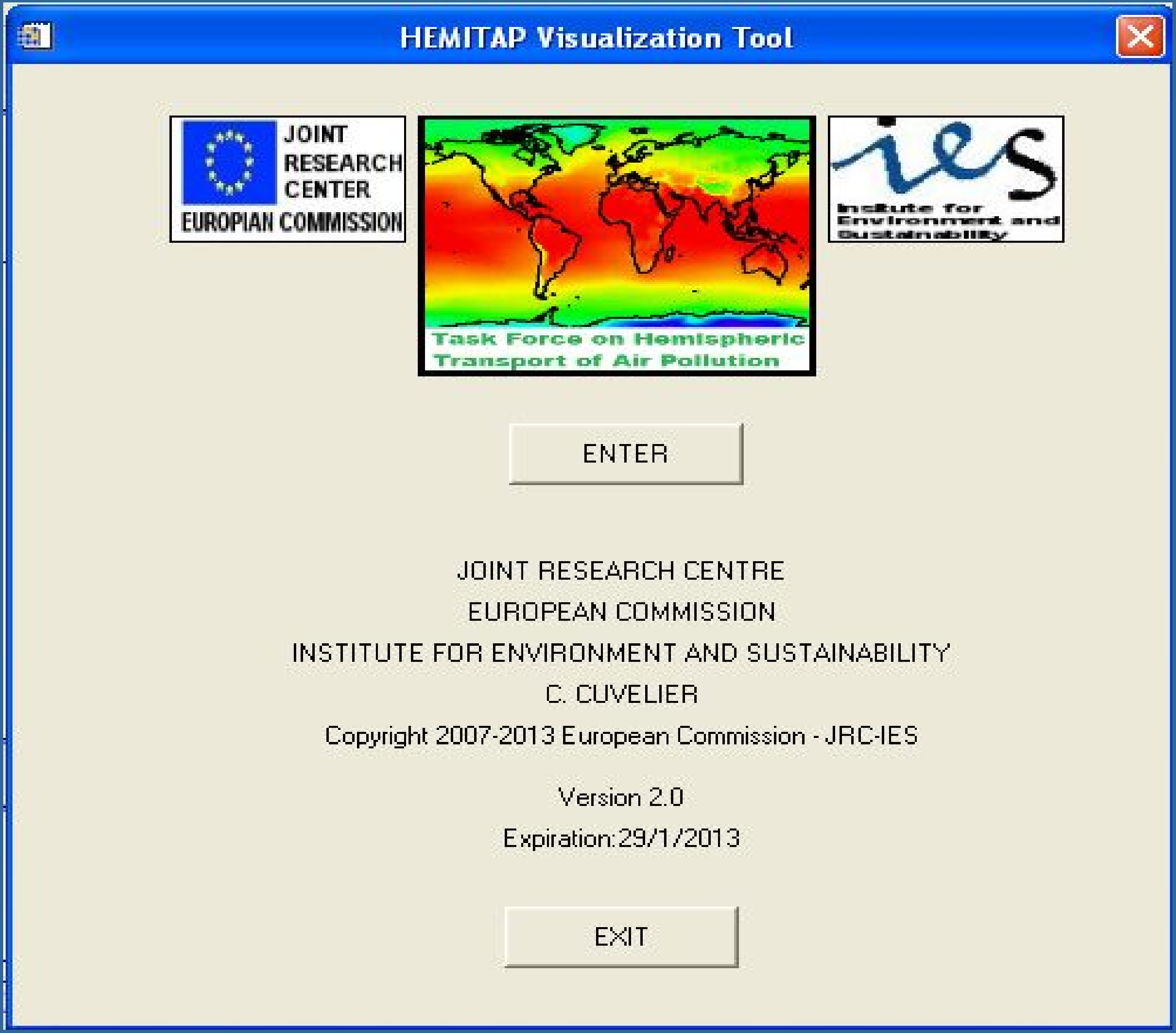
HOURLY-DAILY: All hourly and daily results
(sfc, aod, vertprofs)

DVS_SEP2007: DVS frozen in Sep 2007

HOURLY-DAILY_SEP2007: All hourly and daily results up to Sep 2007

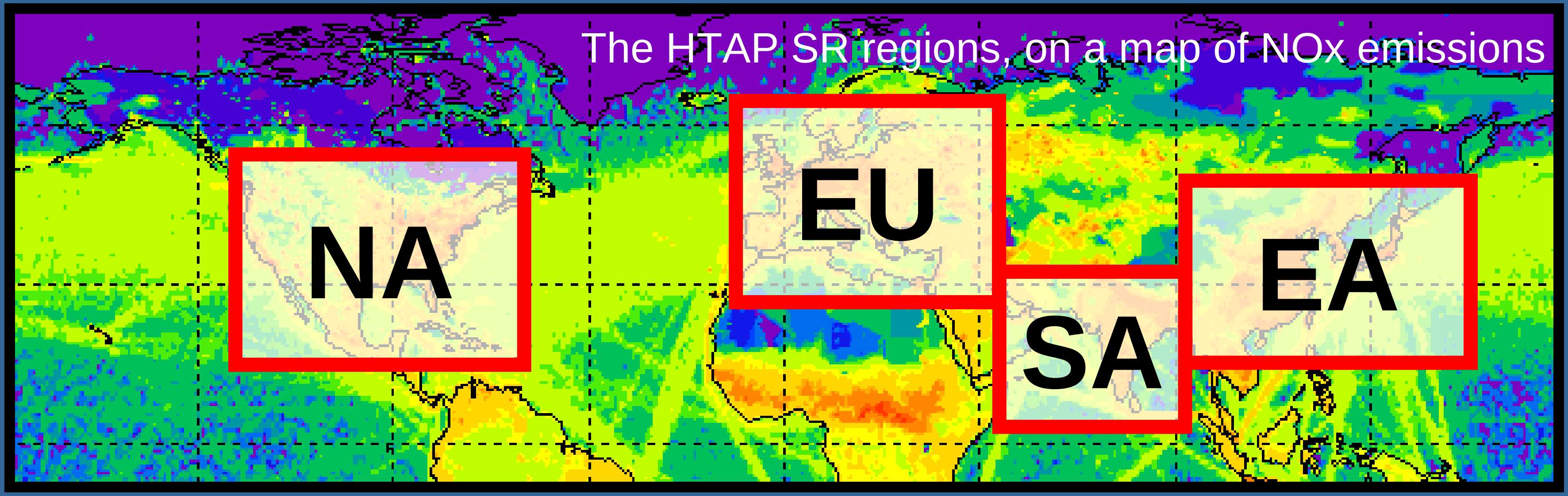
DVS: **175 Gb** ➔ Need for a visualisation Tool

HOURLY-DAILY: **400 Gb**



The Tool can be run remotely on the Juelich server

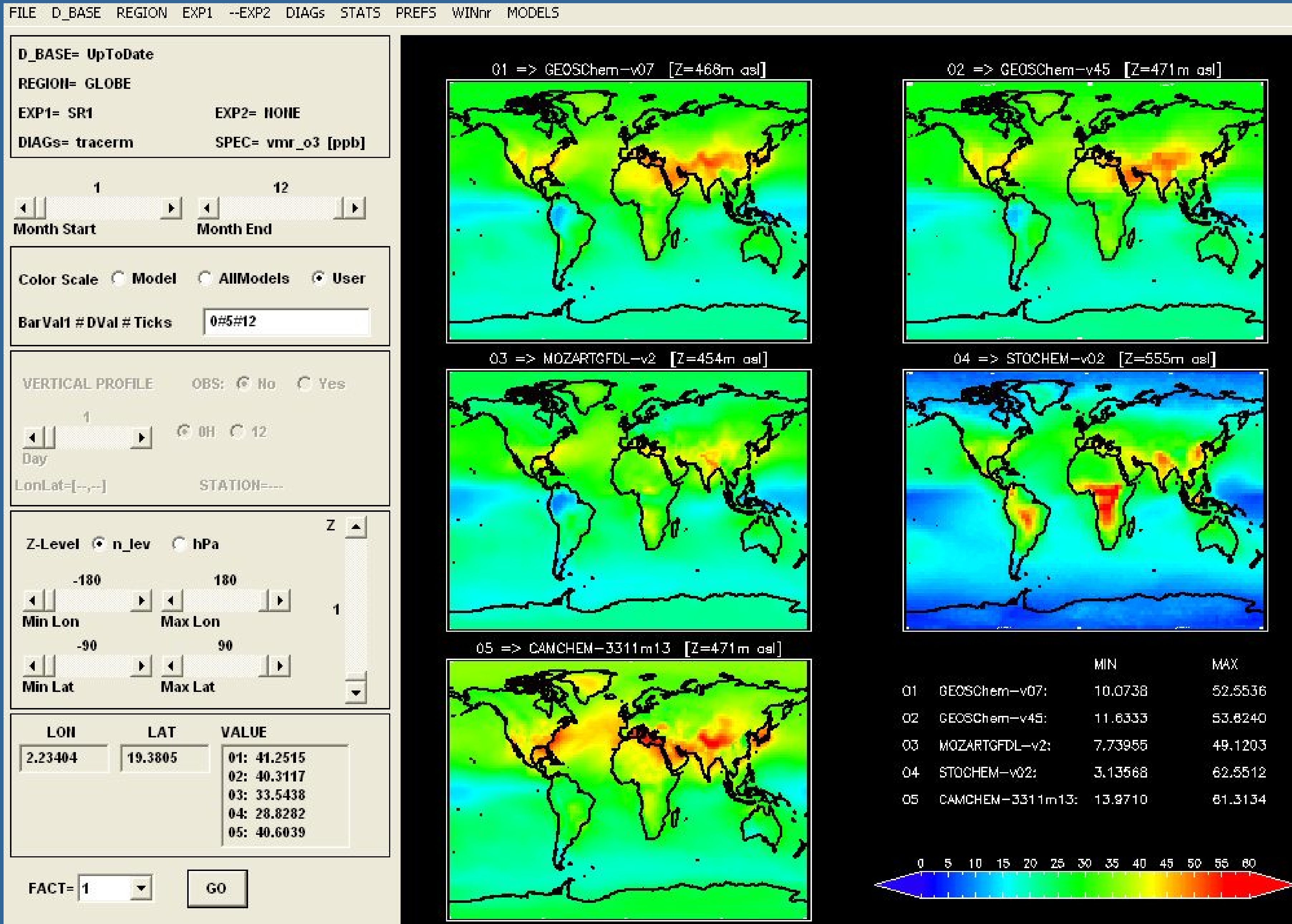
SR: Source-Receptor Emission Sensitivity Studies



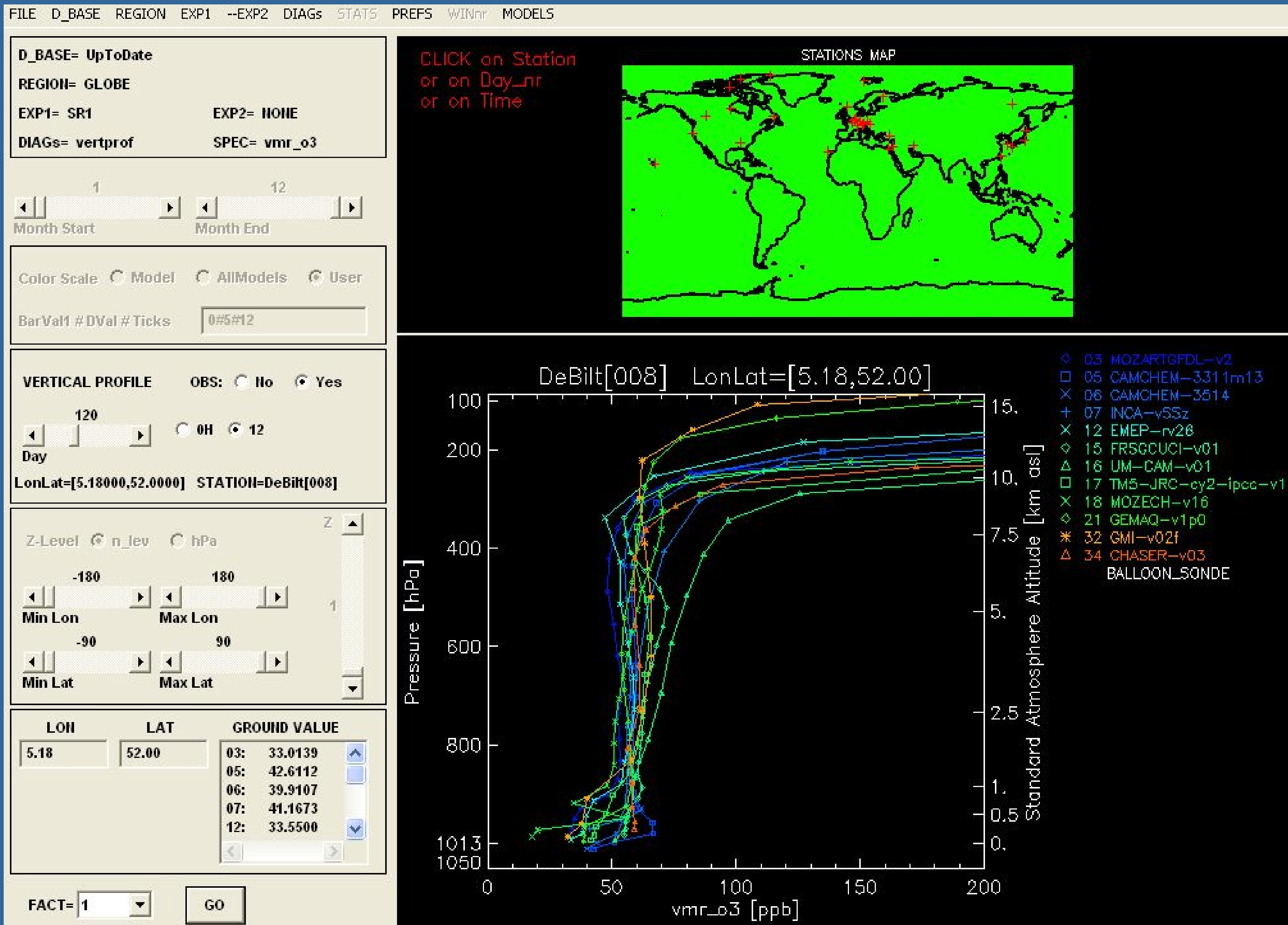
The global/hemispheric models ran a series of experiments:

- Year 2001 base case
- -20% global [CH_4]
- -20% regional NO_x, CO, VOC emissions (or all)
- -20% regional Hg, POP

SR1: surface vmr_o3, annual mean, 5 models/page



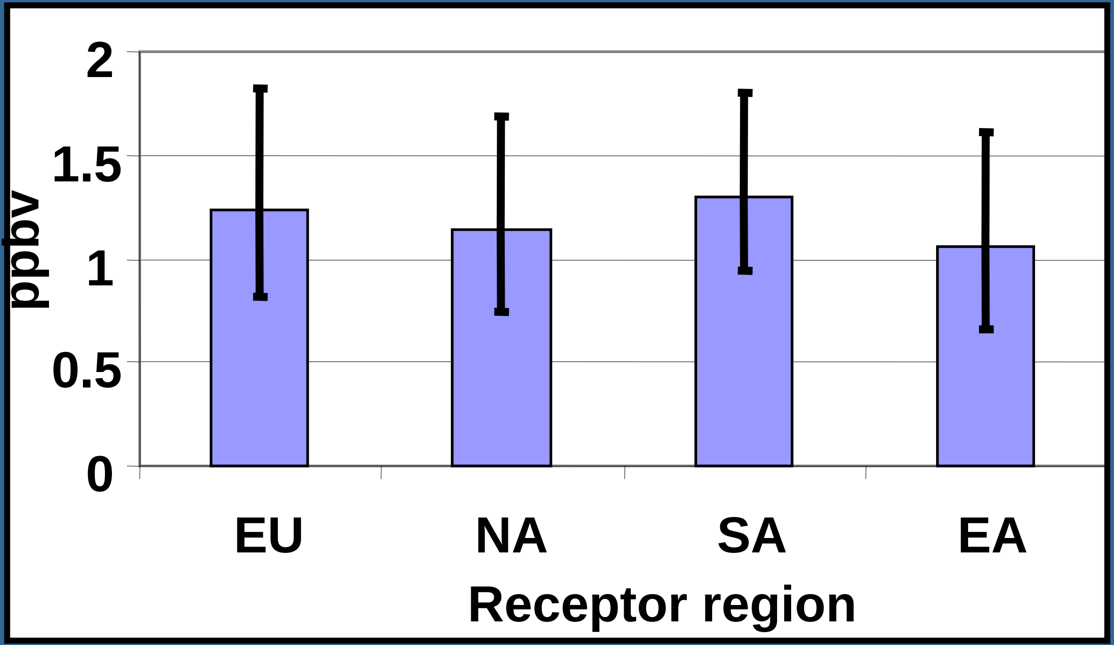
SR1: VertProf of vmr_o3, De_Bilt (NL), day=120, Time=12H



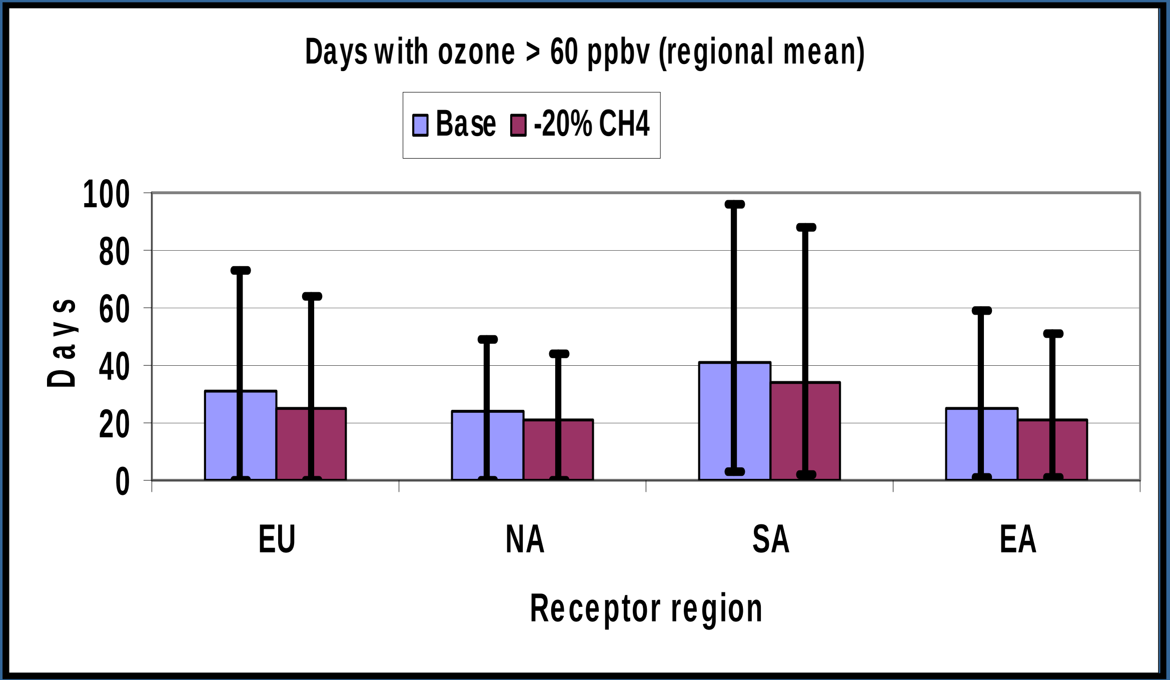
vmr_o3_exc60:
SR2-SR1 (impact of 20% CH4 reductio[illegible]

14 Models:
GEOSChem-v07
GEOSChem-v45
MOZARTGFDL-v2
CAMCHEM-3311m13
INCA-vSSz
LLNL-IMPACT-T5a
OsloCTM2
FRSGCUCI-v01
UM-CAM-v01
TM5-JRC-cy2-ipcc-v1
MOZECH-v16
GEMAQ-v1p0
GISS-PUCCINI-modelE
GMI-v02f

	Global	NH	SH	EU	NA	SA	[illegible]	[illegible]
Model 01	-1.11625	-2.12024	-0.112270	-6.54866	-3.12102	-8.80369	[illegible]	[illegible]
Model 02	-1.01347	-1.87848	-0.148459	-4.50001	-3.01541	-9.79700	[illegible]	[illegible]
Model 03	-0.973993	-1.74998	-0.198008	-4.87617	-3.10410	-7.16855	[illegible]	[illegible]
Model 04	-1.63836	-3.17798	-0.0987463	-9.36367	-4.21813	-10.8364	[illegible]	[illegible]
Model 05	-0.796927	-1.52099	-0.0728596	-4.09890	-2.65286	-5.08874	[illegible]	[illegible]
Model 06	-1.93816	-3.34347	-0.532850	-8.68751	-4.06290	-13.1053	[illegible]	[illegible]
Model 07	-1.57871	-2.66359	-0.493824	-7.96894	-3.00876	-13.0339	[illegible]	[illegible]
Model 08	-2.17086	-4.08325	-0.258465	-14.7566	-6.24371	-9.26062	[illegible]	[illegible]
Model 09	-1.09275	-2.10431	-0.0811938	-7.75694	-1.87516	-3.01587	-3.79504	-1.09275
Model 10	-1.35677	-2.44762	-0.265932	-9.44730	-5.33169	-6.74955	-3.29221	-1.35677
Model 11	-1.21480	-2.19540	-0.234205	-5.30648	-4.69035	-8.43970	-4.25391	-1.21480
Model 12	-1.66631	-2.97148	-0.361139	-7.88000	-4.87706	-7.59270	-4.55789	-1.66631
Model 13	-0.503199	-0.792169	-0.214230	-0.0907736	-0.526155	-6.16189	-1.84439	-0.503199
Model 14	-1.97204	-3.85789	-0.0861801	-11.7151	-5.82843	-12.6530	-6.19091	-1.97204
MeanValue	-1.35947	-2.49335	-0.225597	-7.35693	-3.75398	-8.69335	-4.50203	-1.35947
Stddev	0.484980	0.919463	0.148556	3.58747	1.58176	3.02736	1.52634	0.484980

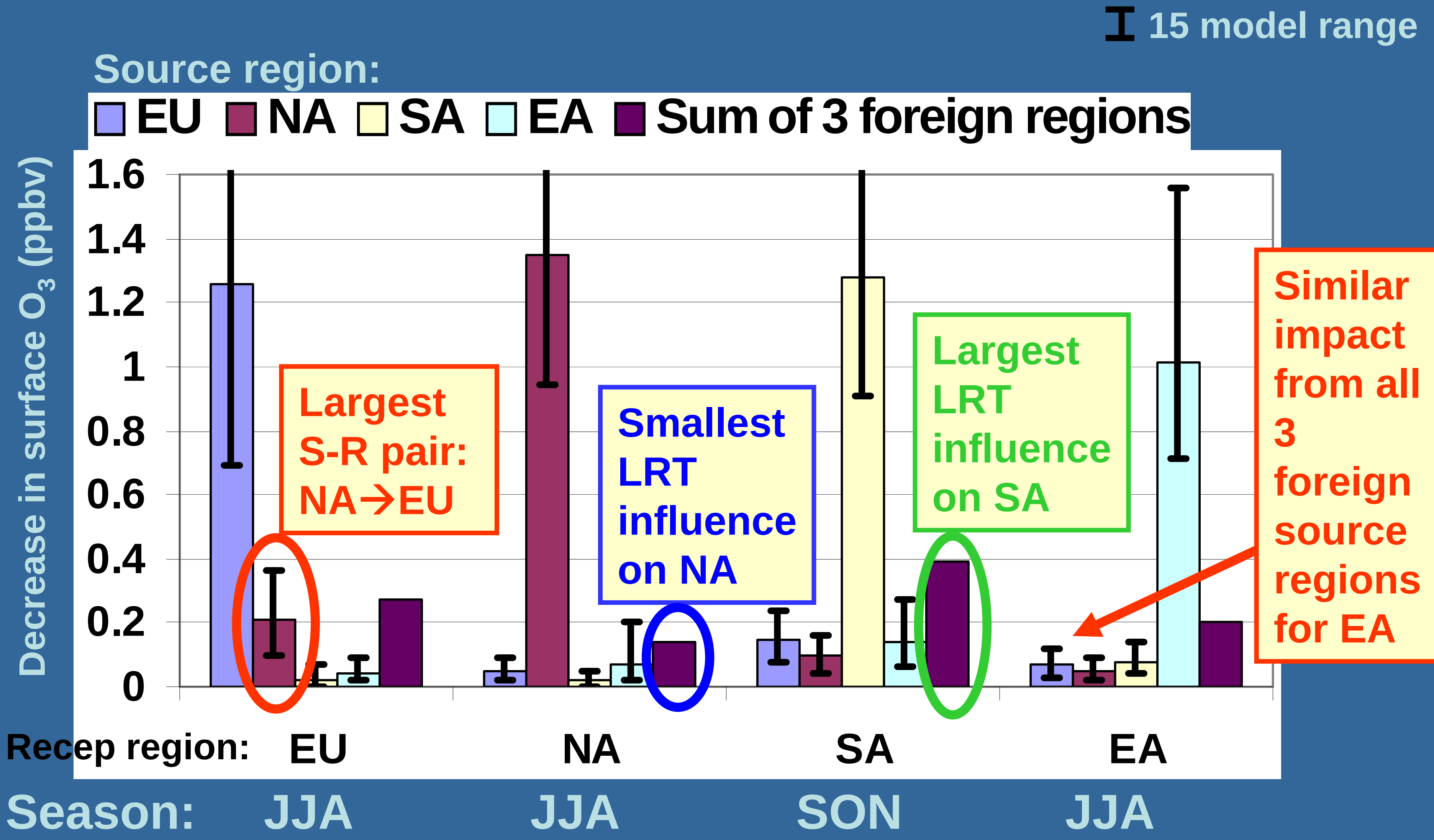


Annual mean surface O3 decrease due to a 20% global [CH4] reduction



O3 AQ improvement for -20% [CH4] Exc Days (60 ppb 8-hr)

from: A.M. Fiore et al.



Sensitivity of surface O3 to NOx sources during season of maximum domestic O3 production

from: A.M. Fiore et al.

2007 Interim Report

• Focus on Ozone and Aerosols
• http://www.htap.org/activities/2007_interim_report/
• Serves as basis for 2010 Report
• Includes measurement- and model-based analysis

Major Findings (1)

• "Observations from the ground, aircraft, and satellites provide a wealth of evidence that ozone and fine particle concentrations in the UNECE region and throughout the Northern Hemisphere are influenced by intercontinental and hemispheric transport of pollutants."

• "The processes that determine the overall patterns of transport at this scale are relatively well understood and our ability to quantify the magnitude of transport is improving."

Major Findings (2)

- "The HTAP model intercomparison has provided the first set of comparable estimates of intercontinental source-receptor relationships from multiple models."

- "For ground-level ozone, there is a hemispheric background concentration of 20-40 ppb that includes a large anthropogenic and intercontinental component. …changes in intercontinental transport can have small, but significant, impacts on surface concentrations."

- "For fine particles, the impact of intercontinental transport on surface air quality is primarily episodic, especially associated with major emission events such as fires or dust storms.
The intercontinental transport of both ozone and fine particles has large impacts on total atmospheric column loadings, which have significant implications for climate change."

The Ensemble-model (or multi-model) approach is a useful tool in the frame of the Harmonisation of the individual model results.

It is often more robust and looks therefore more appropriate for policy purpose

Procedure for MI (cf CityDelta, EuroDelta):

- Analysis of individual Modelling results (Validation against Obs)
- Intercomparison of Modelling results (Central data base)
- Ensemble approach (mean/median of the Models)
- Analysis of the variability around the Ensemble
- Validation of the Ensemble model
- Spin-off: improvement and further development of models

Some Publications:

- A.M. Fiore et al.: Multi-model estimates of intercontinental SR relationships for ozone pollution.

- M.G. Sanderson et al.: A multi-model SR study of the hemispheric transport and deposition of oxidised nitrogen.

- D.T. Shindell et al.: A multi-model assessment of pollution transport to the Arctic.

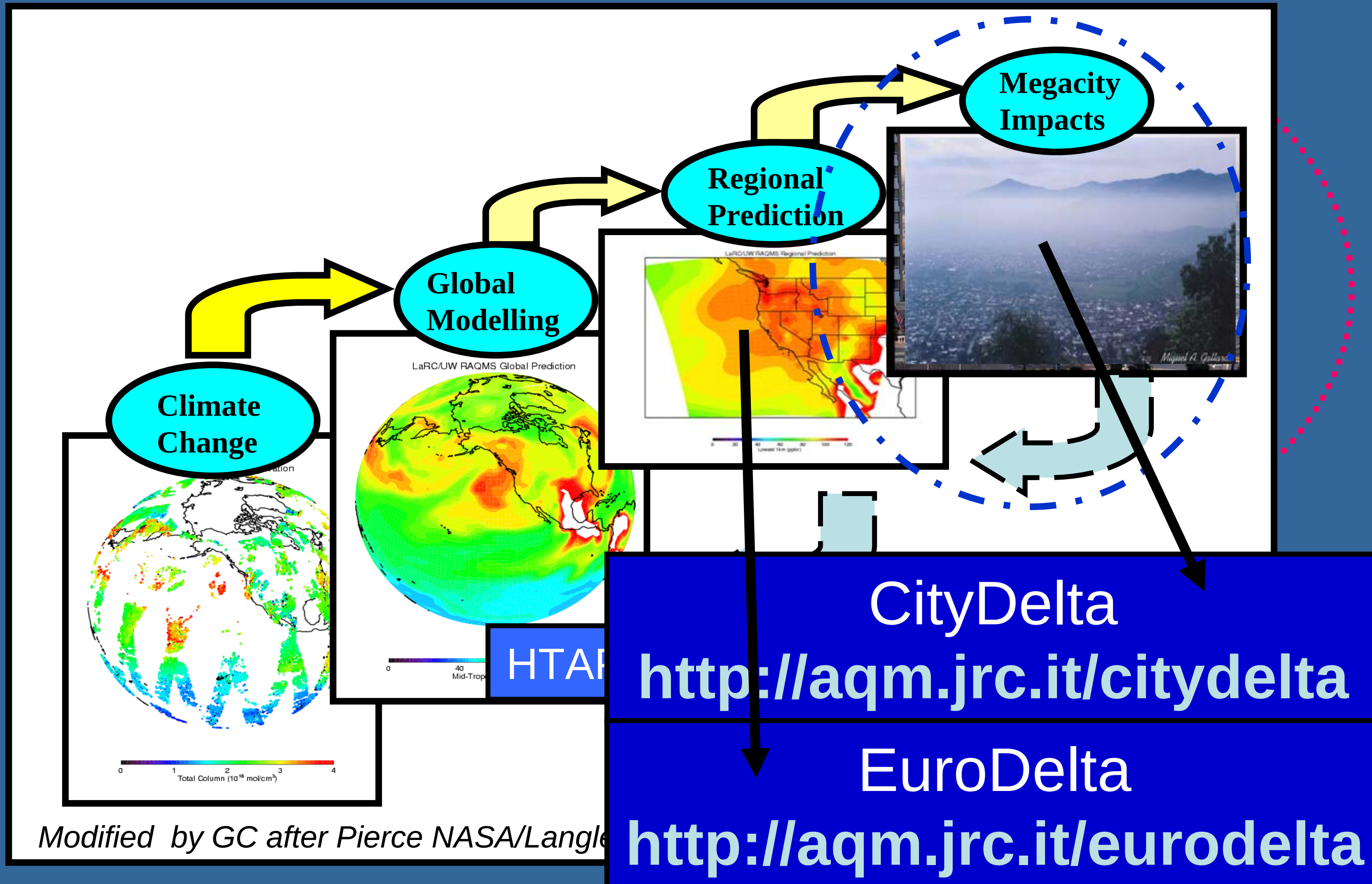
- J.E. Jonson et al.: A multi-model analysis of vertical profiles.

- S. Casper-Anenberg et al.: Impacts of intercontinental SR relationships for ozone pollution on human mortality

- 2007 Interim Report

- C. Cuvelier: Users guide to the HemiTap visualization Tool

Air Quality Prediction: A Challenge of Scales and Integration



The EuroDelta project

KC, PT,
PR, LW, LP, LT, ST, RS, AK, LR, BB, RB, MS, GB, PB

ED Phase I (2003-2005):

- Examination of common performance of Regional AQ models in predicting recent (2000; for validation) and future (2020) AQ in Europe.
  AQ models: CHIMERE, REM, EMEP, MATCH, LOTOS

- Investigation of 2020 emission reductions for
  - NO_x, SO_2, VOC, NH_3, PPM2.5 independently in FR, GE, IT
  - NO_x and SO_x in sea areas (NS, MS).

- The model Ensemble was used to measure robustness of the predictions.

In the Source-Receptor relationships, emission changes are distributed over all emission sources in proportion to their contribution. This type of SRR is used in the IIASA/RAINS approach to Integrated Assessment (IA).

ED Phase II (2005-2009):

- Study of the impact of emission reductions in individual emission sectors.
- First look at whether there are differences in the impact of emission reductions if they are applied to single sectors compared with all sectors.
- Aims to assess the usefulness of introducing sectoral SRR in IA.
- Total of 70 scenarios for FR, SP, GE, UK, PL, BNL, It, PO and 10 scenarios for the Mediterranean Sea

Emission reduction overview (1)

				Emissions Reductions in ktonnes/year with Percent of Total 2020 Emissions Remaining Shown in Parenthesis				
Scenario	Country	Sectors	Pollutant(s)	NOx	PM2.5	SOx	VOC	NH3
0	BASE CASE 2020 CLE							
1	France	All	NOx+PM2.5	230 (71.9%)	62 (62.8%)			
2		All	SOx+VOC			110 (68.1%)	150 (83.8%)	
3		SNAP 1	NOx+PM2.5	40 (95.1%)	3 (98.2)			
4		SNAP 1/4	SOx+VOC			40 (88.4%)	30 (96.8%)	
5		SNAP 2	PM2.5		45 (73.0%)			
6		SNAP 3	NOx+PM2.5	100 (87.8%)	2 (98.8%)			
7		SNAP 3/6	SOx+VOC			70 (79.7%)	120 (87.0%)	
8		SNAP 4	PM2.5		10 (94.0%)			
9		SNAP 7	NOx+PM2.5	90 (89.0%)	2 (98.8%)			
10		SNAP 10	NH3					250 (63.8%)
11		Combined	NOx+PM2.5	40/100/90 (71.9%)	3/45/2/10/2 (62.8%)			

Emission reduction overview (2)

51	MED SEA	Base Case 2010 With 2.7% RFO and 0.1% Gasoil
52		Base Case 2010 But 1.5% S On Ferries
53		Base Case 2010 But 0.1% S on all ships at berth in all EU ports
54		Base Case 2020
55		Base Case 2020 With Only 2% Growth
56		Base Case 2020 + Mediterranean as 1.5% SECA
57		Base Case 2020 + 12m limit as 1.5% SECA in EU Inc Gibraltar straits
58		Base Case 2020 + 12m limit as 1.5% SECA in EU Excl Gibraltar straits
59		Base Case 2020 +Aegean Sea alone as a 1.5% SECA
60		Base Case 2020 with 40% NOx Reduction

Report ED II
+
3 DVDs

JRC Scientific and Technical Reports

EURODELTA – II

Evaluation of a Sectoral Approach to Integrated Assessment Modelling including the Mediterranean Sea

by

P. Thunis & C. Cuvelier (editors)
European Commission, Directorate General JRC, Joint Research Centre
Institute for Environment and Sustainability
I-21020 [illegible], Italy

P. Roberts, L. White, L. Post
CONCAWE
Boulevard du [illegible] 165, B-1160 [illegible]

L. Tarrasón, S. Tsyro
Air Pollution Section Research Department, Norwegian Meteorological Institute [illegible]
P.O. Box 43, Blindern, N-0313 Oslo, [illegible]

R. Stern, A. Kerschbaumer
Freie Universität Berlin, Institut für Meteorologie [illegible] Umweltforschung
Carl-Heinrich-Becker Weg 6-10, D-12165 Berlin, Germany

L. Rouïl, B. Bessagnet
INERIS, Institut National de l'Environnement Industriel et des Risques
[illegible] ALATA, F-60550 [illegible], France

R. Bergström
SMHI – The Swedish Meteorological and Hydrological Institute
SE-601 76 [illegible], Sweden

M. Schaap, G.A.C. Boersen, P.J.H. Builtjes
TNO Built Environment and Geosciences, Dept. of Air Quality and Climate
P.O. Box 80015, NL-3508 TA Utrecht, The Netherlands

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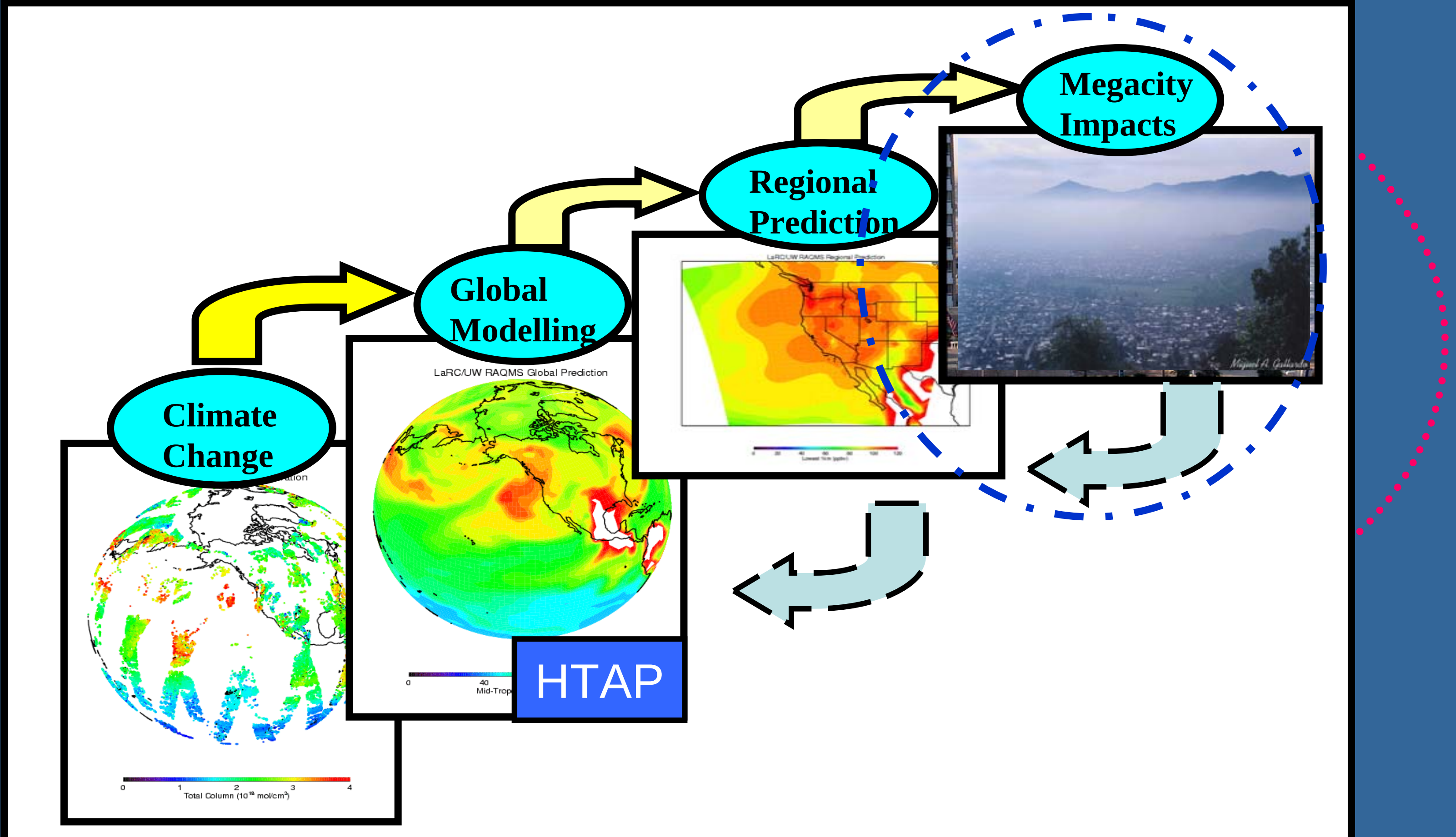
Air Quality Prediction: A Challenge of Scales and Integration



Modified by GC after Pierce NASA/Langley

Propagation of the variability of model results

➔ Uncertainty in AQ Policy advice