



Koninklijk Nederlands
Meteorologisch Instituut

Online coupling of TM5 in EC-Earth

Twan van Noije



Integrated Forecasting System (IFS)

GCM: ECMWF

Land surface: H-TESSEL

OASIS

Atmospheric chemistry:
TM5



Nucleus for European Modelling
of the Ocean

GCM: OPA

Louvain-la-Neuve sea-ice model (LIM)

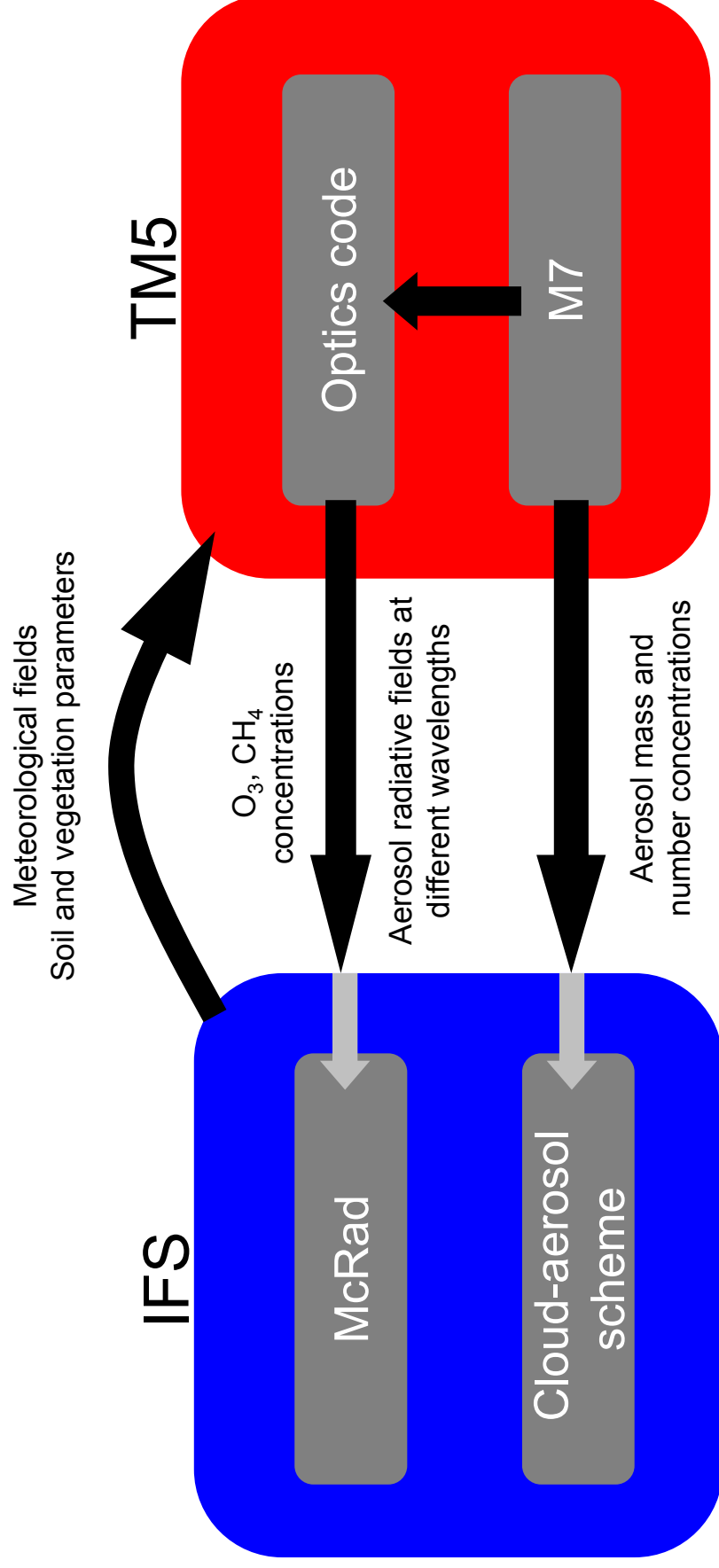
Dynamic vegetation:
Lund-Potsdam-Jena model
(LPJ-GUESS)

Performance metrics

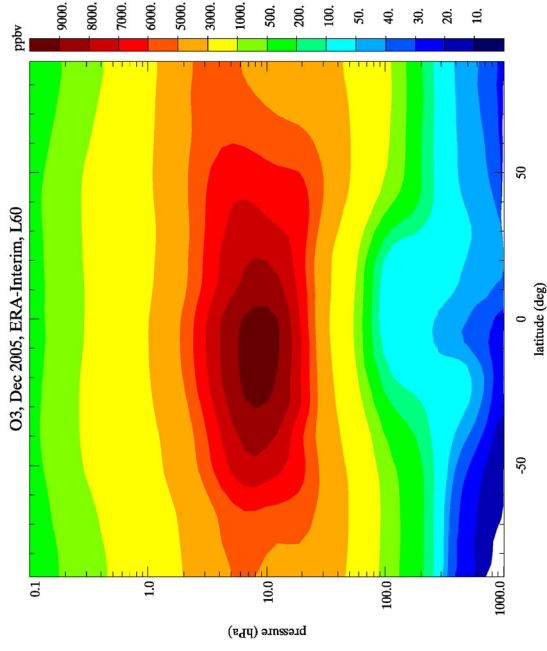
- EC-Earth is in CMIP5 (input IPCC AR5)
- Current performance (IFS-NEMO-LIM) is better than the CMIP3 (AR4) mean

Model	2-m T	MSLP	Precip	Qnet	U-wind stress	V-wind stress	T	U	V	Q	SST	SS Salinity	Sea Ice extent	Total
Mean CMIP3	25.1	11.7	38.9	14.2	4.03	3.10	39.0	12.1	8.25	29.4	17.2	0.22	0.34	1.0
Best CMIP3	16.7	2.76	15.1	12.5	2.69	2.28	41.7	7.08	4.58	19.5	8.53	0.10	0.23	0.64
Worst CMIP3	97.6	5.57	41.0	13.0	4.84	3.96	46.8	8.64	10.2	30.3	18.5	0.09	0.98	1.30
EC-Earth	34.4	1.74	30.8	28.8	7.70	4.63	28.2	2.03	1.68	13.8	14.9	0.12	0.03	0.83

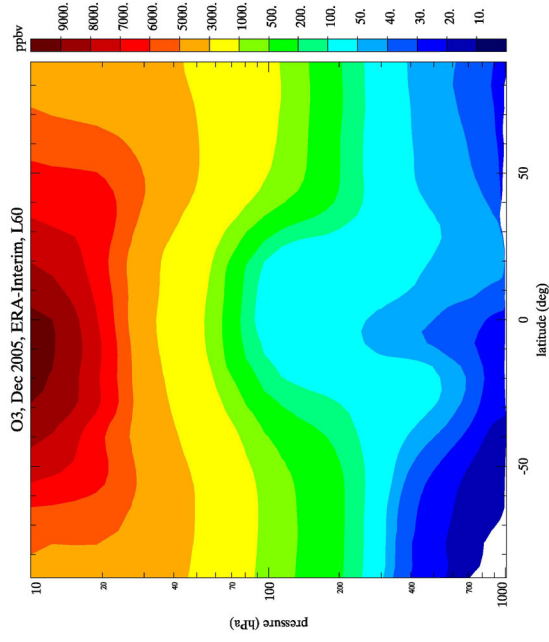
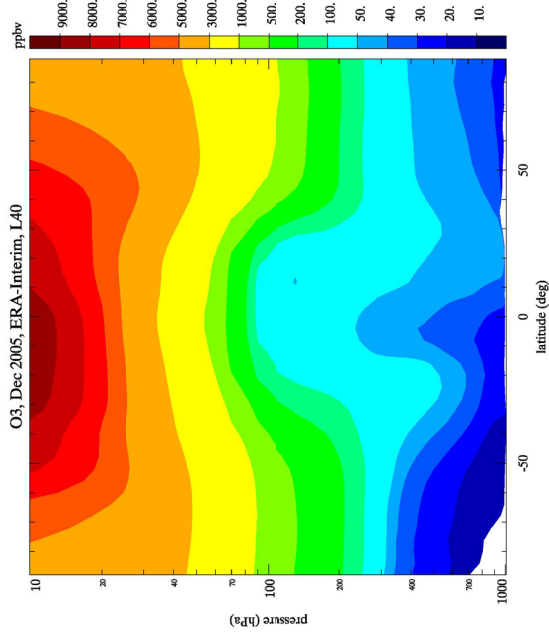
Status of the coupling with TM5



TM5 at EC-Earth resolution L40 vs. L60 (driven by ERA-Interim)



Stratospheric ozone (above 50/100 hPa)
constrained based on observations



TM5 at EC-Earth resolution L40 vs. L60 (offline meteorology)

Tropospheric ozone budget

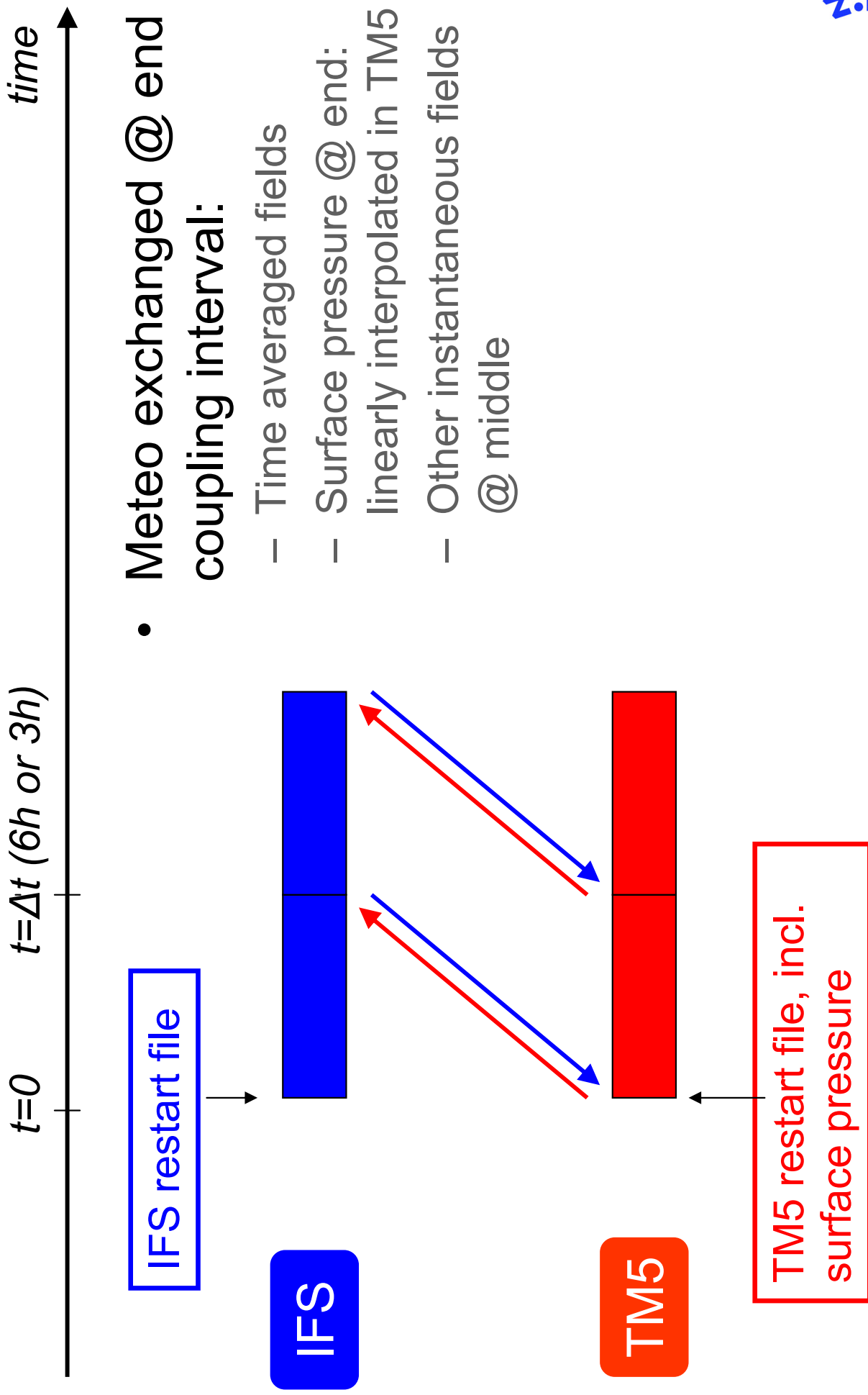
	OD L60	ERA-Interim L60	ERA-Interim L40	Stevenson et al. (2006)
Tropospheric burden (Tg)	301	295	296	
Tropospheric production (Tg/yr)	4311	4473	4417	
Tropospheric loss (Tg/yr)	4168	4192	4131	
Deposition (Tg/yr)	760	760	764	953 ± 154
Stratosphere-troposphere exchange (Tg/yr)	618	478	480	
Tropospheric O ₃ lifetime (days)	22.3	21.8	22.0	22.2 ± 2.2

Methane budget

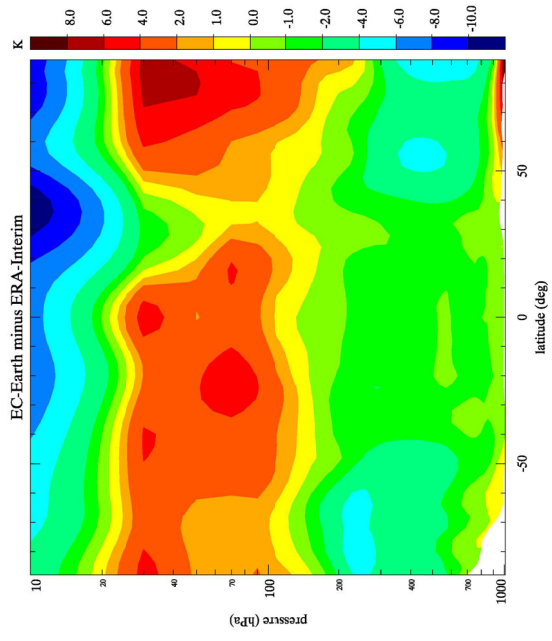
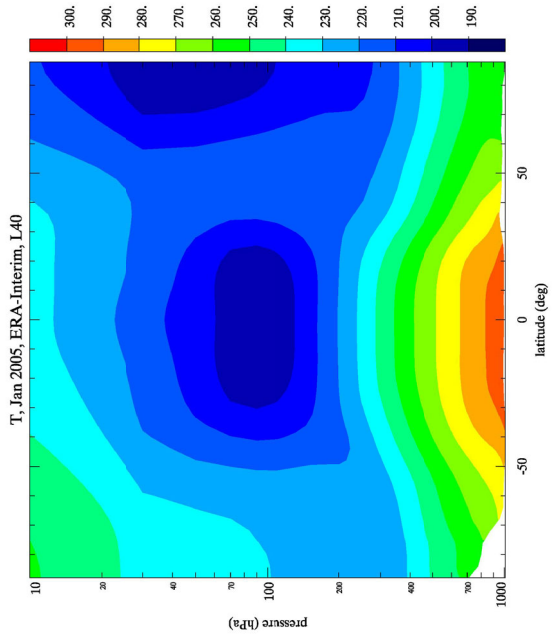
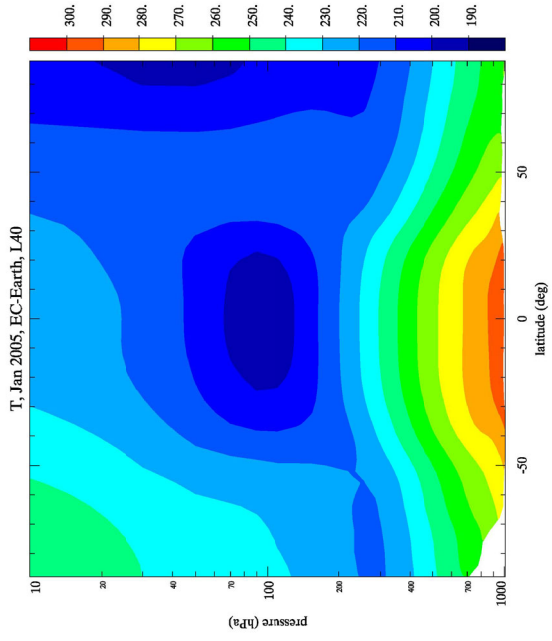
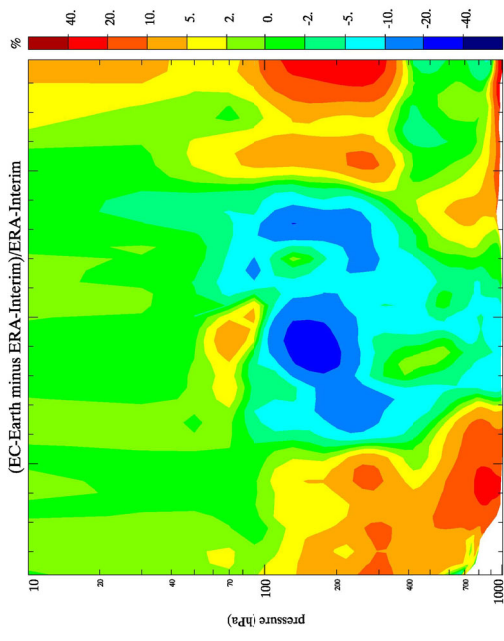
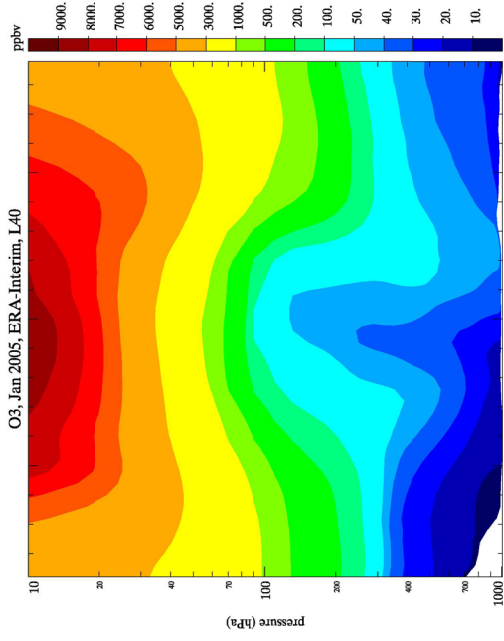
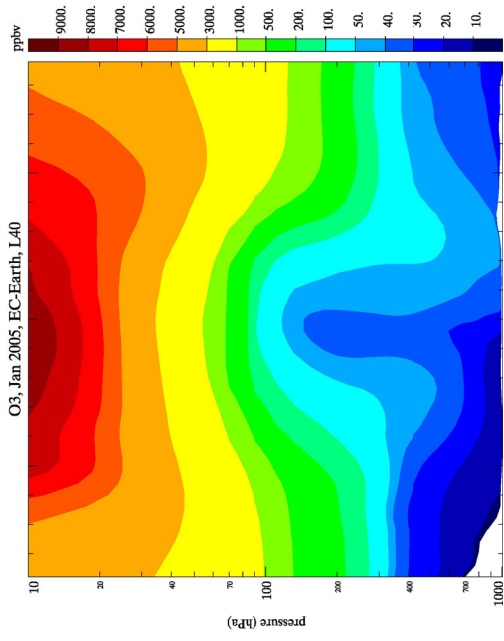
	OD L60	ERA-Interim L60	ERA-Interim L40	Stevenson et al. (2006)
Atmospheric burden (Tg)	4823	4823	(4933)	
Tropospheric burden (Tg)	3890	3890	3893	
Tropospheric loss due to OH (Tg/yr)	489	496	486	
Lifetime (yr)	8.45	8.52	(8.86)	8.45 ± 0.38

Here tropopause is at 215 hPa.

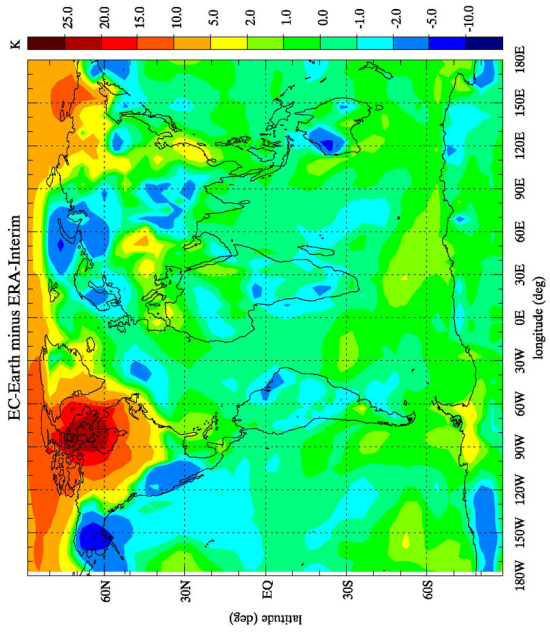
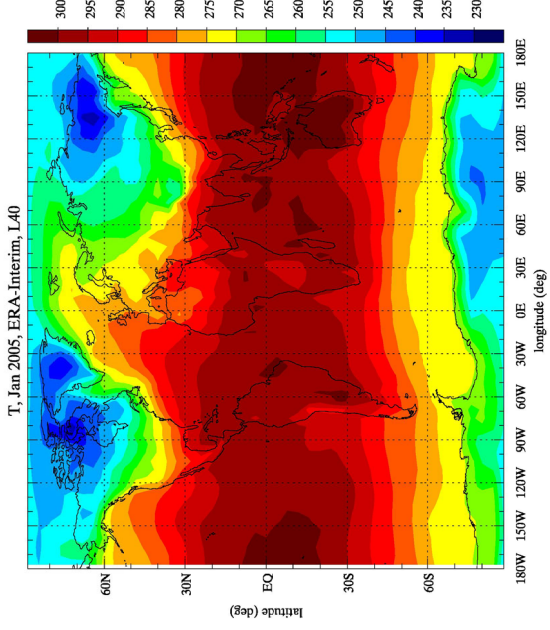
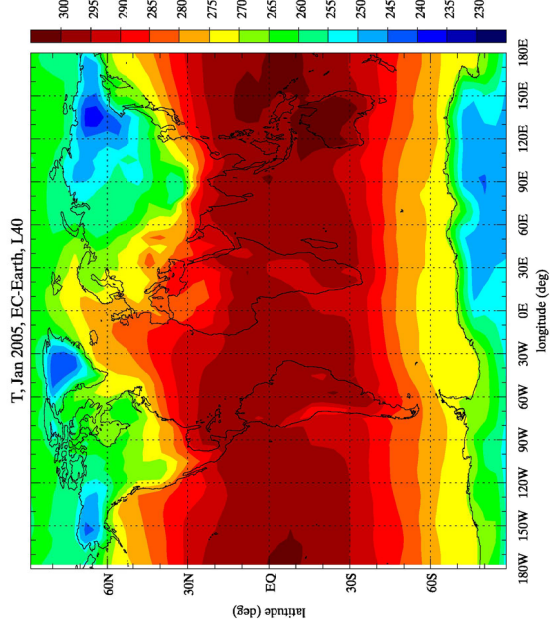
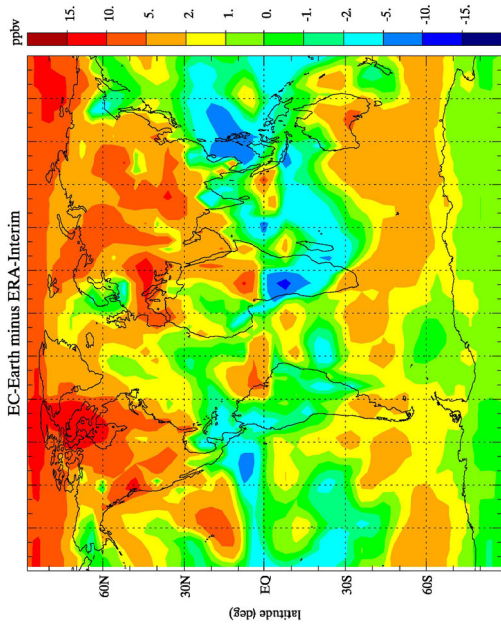
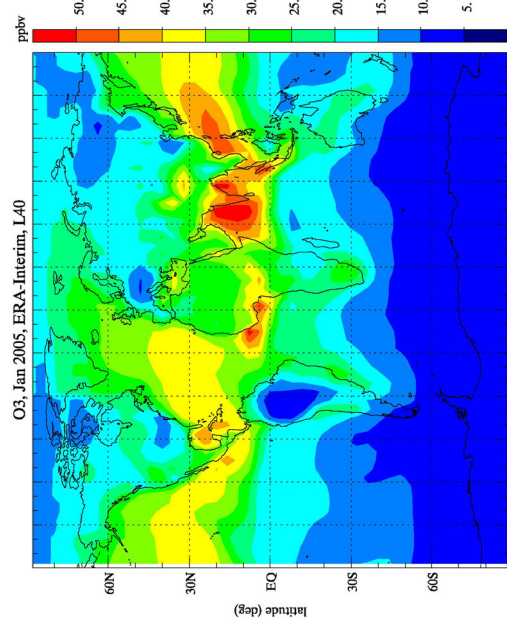
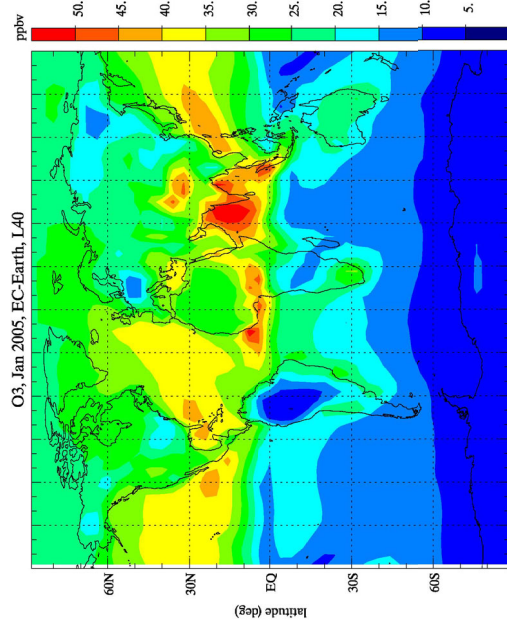
Online coupling



EC-Earth vs. ERA-Interim: ozone

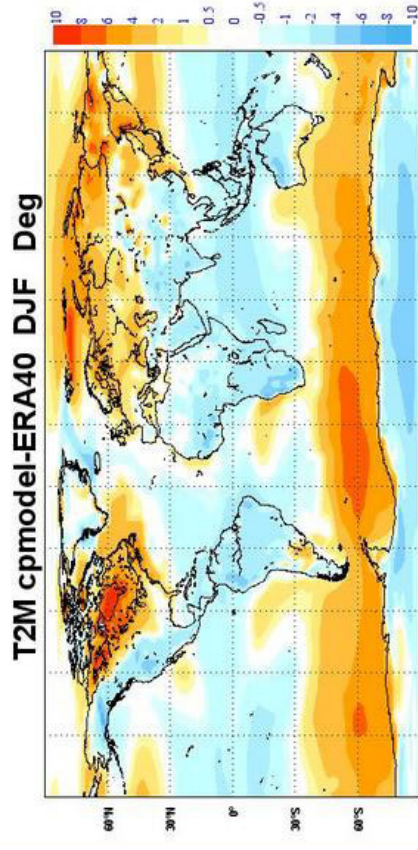


EC-Earth vs. ERA-Interim: surface ozone

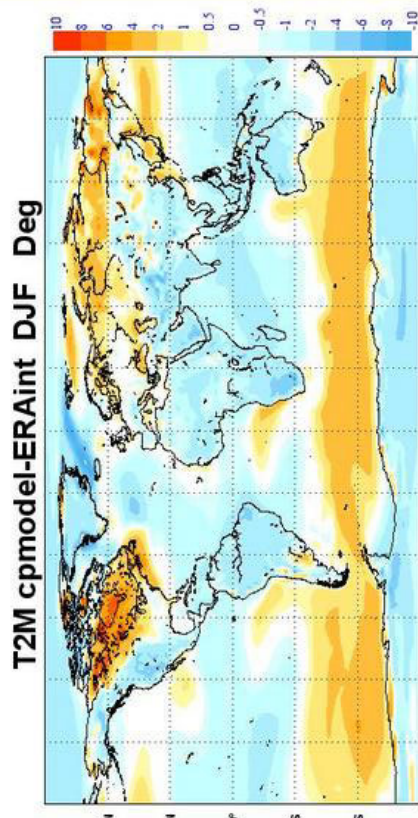


Temperature bias in subsequent EC-Earth versions

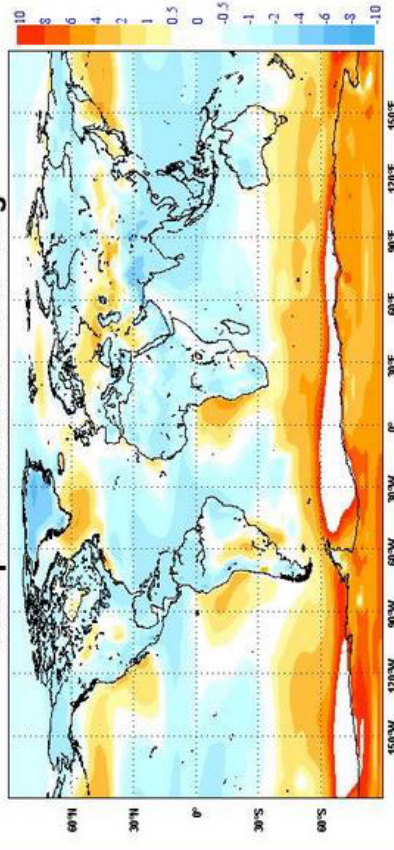
Version 1



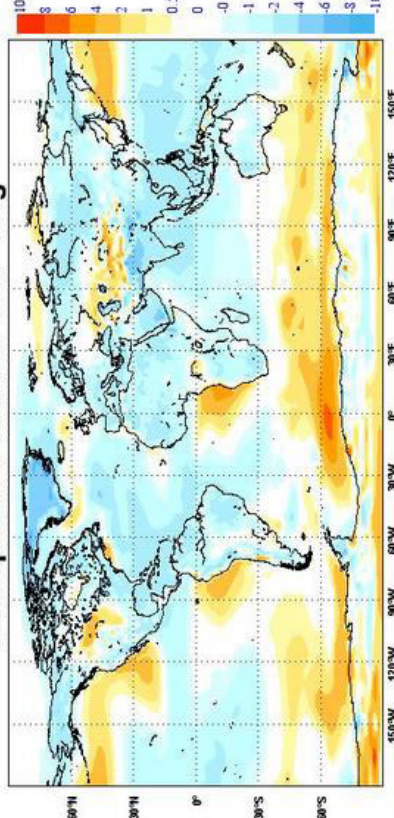
Version 2 (CMIP5)



T2M cpmodel-ERA40 JJA Deg



T2M cpmodel-ERAInt JJA Deg



EC-Earth vs. ERA-Interim

Tropospheric ozone budget
(January)

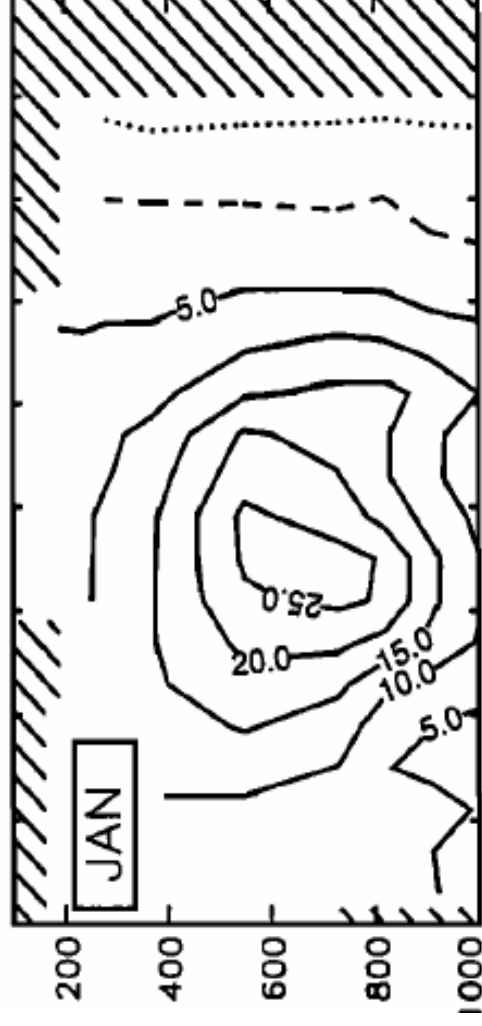
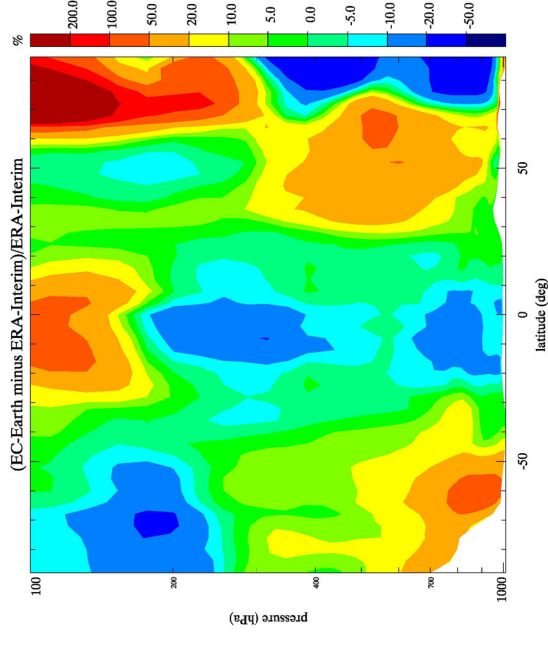
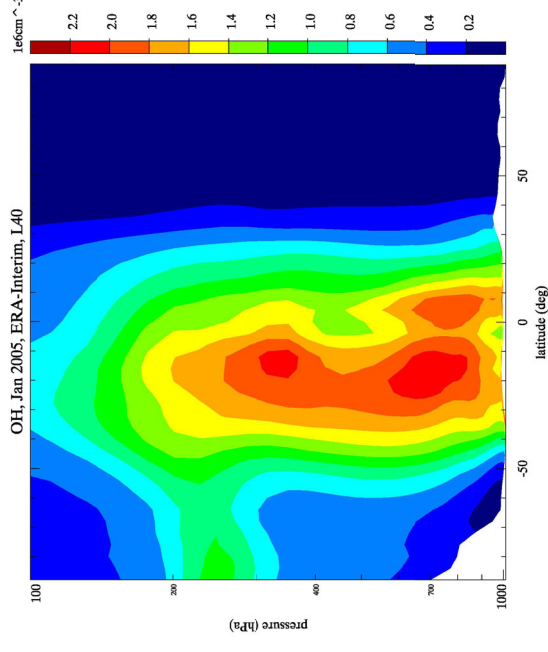
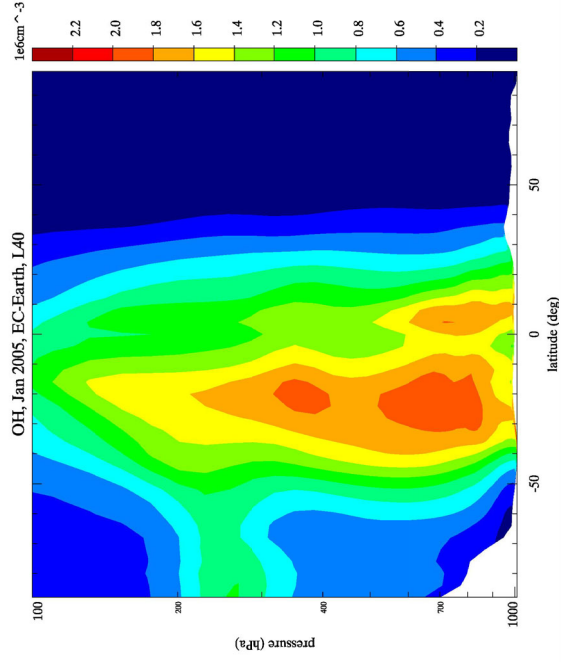
	EC-Earth	ERA-Interim
Tropospheric burden (Tg)	282	282
Tropospheric production (Tg/month)	297	317
Tropospheric loss (Tg/month)	271	287
Deposition (Tg/month)	50.2	47.8
Stratosphere-troposphere exchange (Tg/month)	57.6	49.8
Tropospheric burden change (Tg)	32.3	31.9
Tropospheric O ₃ lifetime (days)	27.2	26.1

Methane budget
(January)

	EC-Earth	ERA-Interim
Atmospheric burden (Tg)	4914	4910
Tropospheric loss due to OH (Tg/month)	36.1	38.4

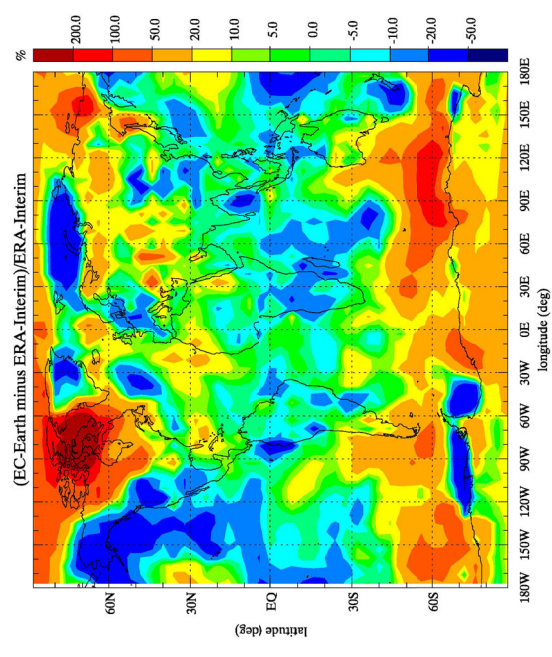
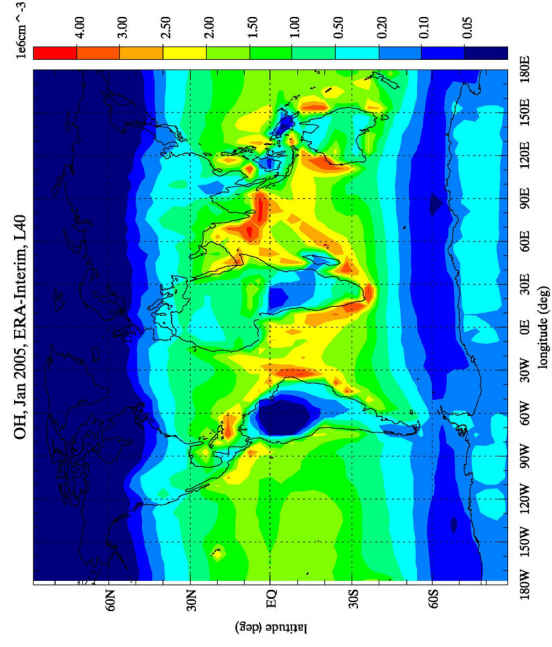
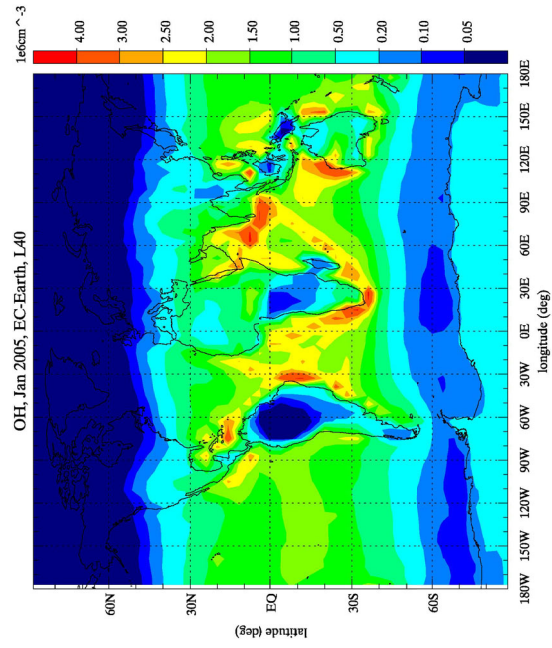
Here tropopause is at 215 hPa.

EC-Earth vs. ERA-Interim: OH

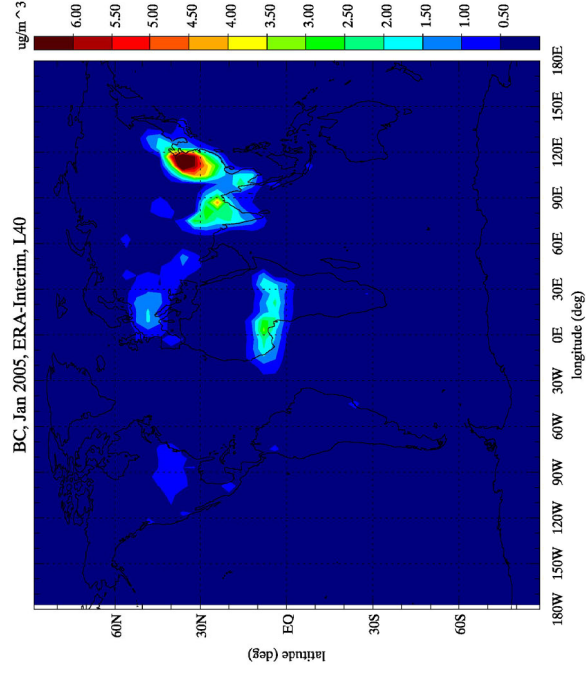
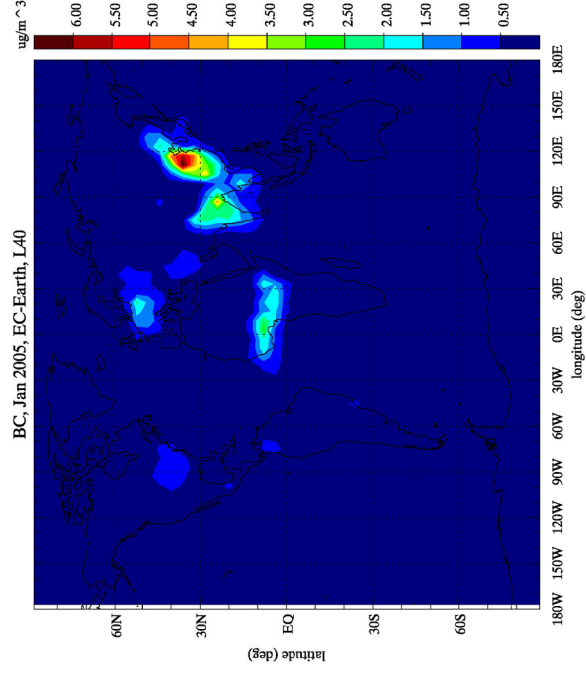
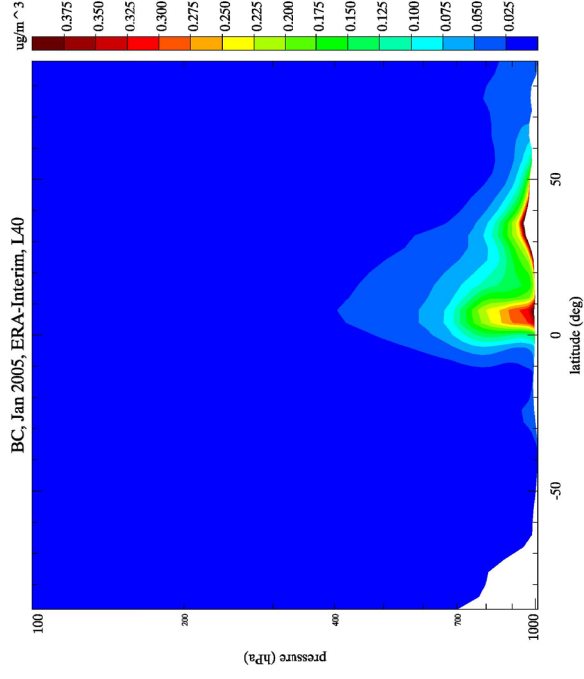
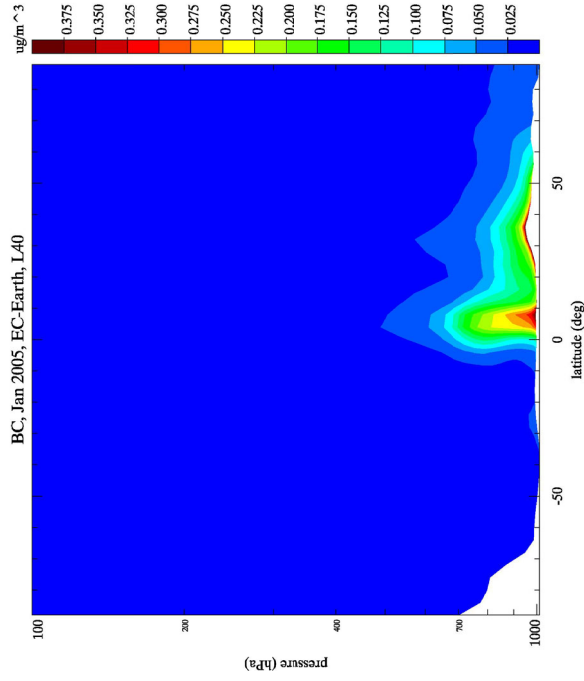


Spivakovsky et al. (2000)

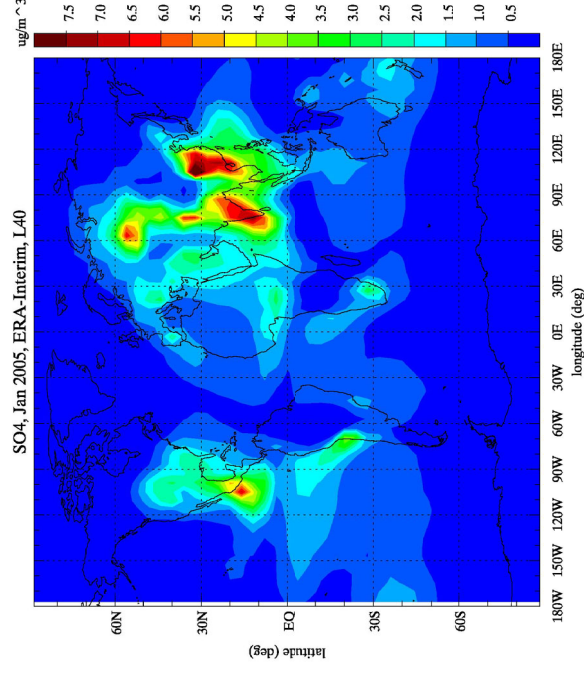
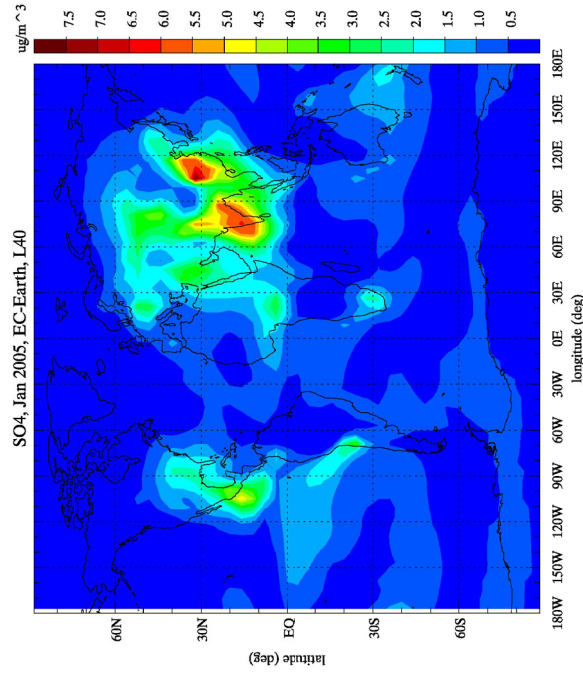
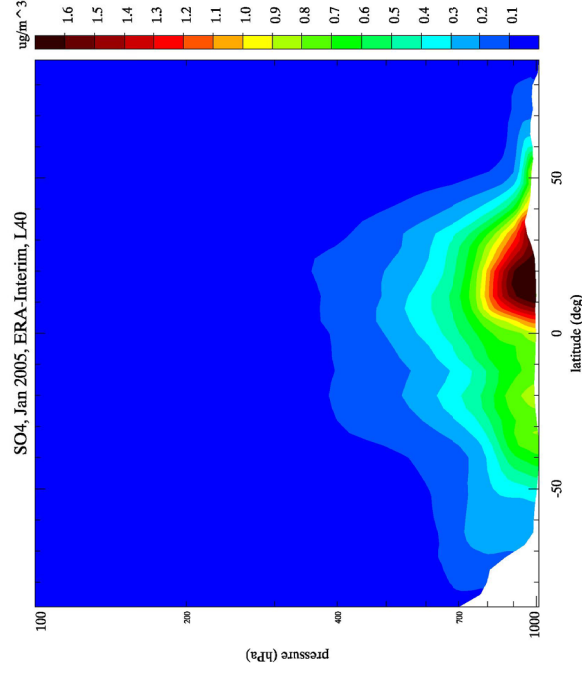
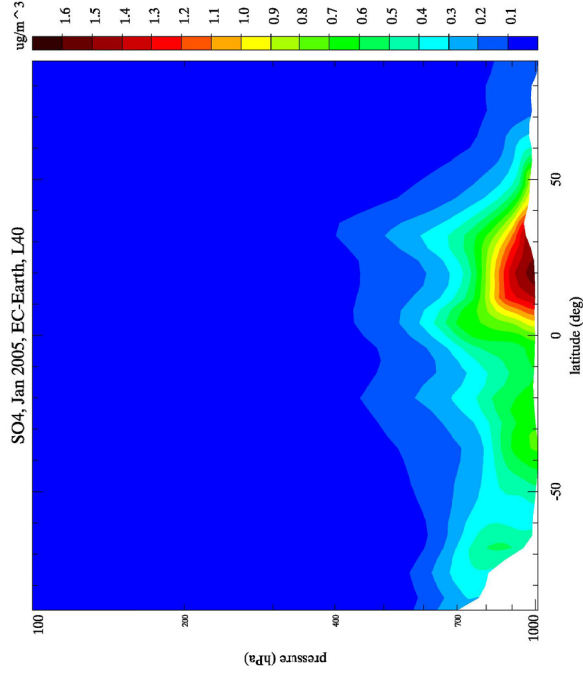
EC-Earth vs. ERA-Interim: OH at surface



EC-Earth vs. ERA-Interim: black carbon



EC-Earth vs. ERA-Interim: sulphate



Performance

	EC-Earth	TM5/EC-Earth	TM5 (offline)
Number of MPI tasks	6 (4 for IFS)	14	8
Total CPU time (hours per month)	2.9	19.9 (6.8 x more)	10.4
Elapsed time (minutes per month)	41.5	129.15 (3.1 x longer)	145.35

Resolution: T95L40 (IFS), ORCA2 (NEMO), 6x4xL40 (TM5)

Conclusions

- TM5 has been integrated into EC-Earth
- Working version with one-way coupling exist
- Ozone, methane and aerosol (mass and number concentrations and aerosol radiative fields (at different wavelengths) are given back to IFS
- **Next steps:**
 - Upgrade to latest EC-Earth version
 - Evaluation of longer integrations
 - Coupling to IFS radiation and cloud scheme