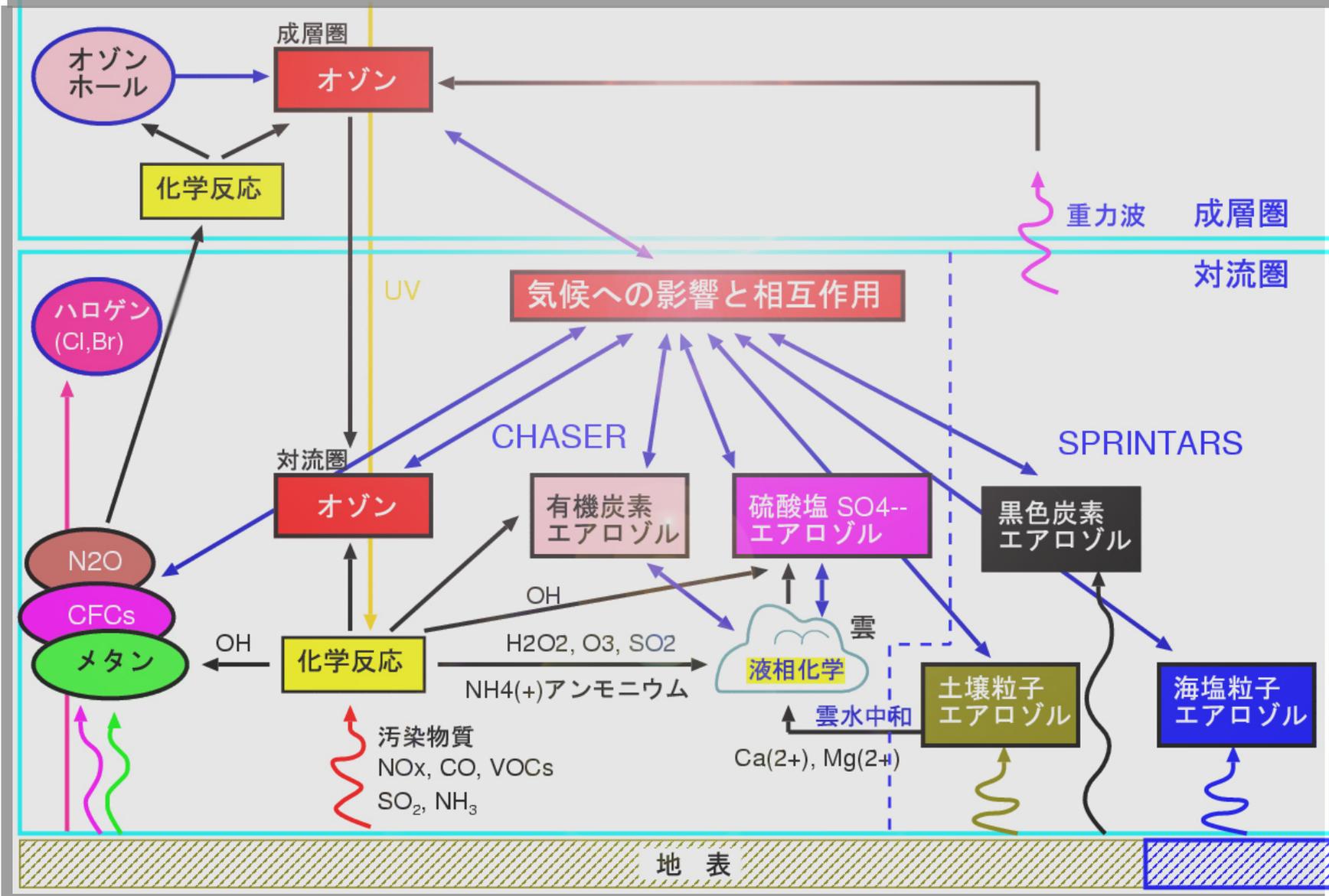


CHASER-SPRINTARSによるエアロゾル・大気化学シミュレーション



● 化学・気候結合モデル CHASER [Sudo et al., 2002]

基本モデル	CCSR/NIES/FRCGC GCM (5.7b) : 気候モデル
空間解像度	水平:T42(2.8°x2.8°), 鉛直: 32 layers(地表~40km)
輸送過程	グリッドスケール(flux-form semi-Lagrangian)+積雲対流, 鉛直拡散
化学過程	<p>56 化学種, 142 化学反応(気相,液相,不均一*)</p> <p>(1)O₃-HO_x-NO_x-CO-CH₄, (2)非メタン炭化水素(NMHCs)酸化, (3)SO₂, DMS 酸化(硫酸塩エアロゾルシミュレーション)</p> <p>*不均一反応は N₂O₅, HO₂, RO₂ラジカルについて雲粒子、硫酸エアロゾル、および海塩粒子表面上で考慮 (高度 20km 以上の O₃, NO_y については衛星データなどで prescribe)</p>
光解離定数	<p>GCM放射スキーム中の紫外光を用いオンラインで計算</p> <p><u>※放射スキーム中では化学過程で計算されたオゾン、メタン、硫酸エアロゾルの分布を使用。</u></p>
Emission (人為・自然)	<p>産業・交通, 森林火災, 植生/土壌/海洋, 雷からの NO_x</p> <p>(NO_x, CO, CH₄, C₂H₆, C₂H₄, C₃H₈, C₃H₆, アセトン, イソプレン, テルペン, メタノール, SO₂, DMS)</p>
Dry deposition (乾性沈着)	地表面の植生タイプ、気温、太陽光入射、積雪などの関数 [Wesely, 1989]
Wet // (湿性沈着)	<p>Rain-out (in-cloud), wash-out (below-cloud), ice-sedimentation</p> <p>Reevaporation & reemission processes considered.</p>

Aerosol simulation in CHASER-SPRINTARS

Sulfate (SO_4^{2-})	Chemical production by OH, O_3 , and H_2O_2 is calculated in the chemistry component of CHASER. (!) cloud pH is calculated as a function of <u>ammonium (NH_4^+)</u> , <u>dust(Ca^{2+}, etc)</u> , <u>nitrates</u> , and <u>sulfate concentrations</u>
Nitrates (NO_3^-)	<u>Aerosol thermoequilibrium model</u> implemented in CHASER calculates sulfate-nitrate-ammonium (SO_4^{2-} - NO_3^- - NH_4^+) system in aerosol-phase.
Carbonaceous (EC/OC)	Basically based on SPRINTARS [Takemura et al., 2000] , but for SOA production which is calculated in CHASER. (e.g., Terpenes + $\text{O}_3 \rightarrow \text{SOA}$)
Mineral dust	Based on SPRINTARS [Takemura et al., 2002]
Sea-Salt	Based on SPRINTARS [Takemura et al., 2002]

(!) calculated aerosols concentrations are reflected on the radiation (incl. J-values), cloud/precipitation, and heterogeneous reactions in the model.

Annual total (/yr) based on the EDGAR

	NO _x TgN	CO TgCO	C ₂ H ₆ TgC	C ₃ H ₈ TgC	C ₂ H ₄ TgC	C ₃ H ₆ TgC	Acetone TgC	ONMV TgC	Isoprene TgC	Terpenes TgC
産業/交通	23.10	337.40	3.15	5.76	2.00	0.85	1.02	29.20	0.00	0.00
森林火災	9.65	889.40	4.50	2.62	14.10	6.39	7.17	8.55	0.00	0.00
植物	0.00	0.00	1.20	1.60	4.30	1.20	11.20	20.00	400.00	102.00
海洋	0.00	0.00	0.10	0.11	8.28	10.10	0.00	2.00	0.00	0.00
土壌	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
雷	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
航空機	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
合計	43.80	1226.8	8.95	10.09	28.68	18.54	19.39	59.75	400.00	102.00

(Sulfate simulation)

- ✓ SO₂ : 71.83 TgS(産業), 2.64 TgS(森林火災), 0.085 TgS (航空機), 4.80 TgS(火山)
- ✓ DMS: 14.8 TgS (海洋)

The seasonal timing of biomass burning emissions is simulated by using satellite derived hot-spot data.

IPCC-AR4実験用Emissions: (S1)

NOx: TgN/yr, CO:TgCO/yr, NMHCs:TgC/yr, SO2: TgS/yr

	Industr	B.B.	Vegit.	Ocean	Soil	LNOx	Aircrft	Total
NOx	27.8	10.2	0	0	5.5	5.03(S1G) 5.22(S5G)	0.55- 1.5	~49.10
CO	471	507.5	0	0	0	0	0	978.00
C2H6	4.35	1.75	1.20	0.10	0	0	0	6.20
C3H8	5.21	0.51	1.60	0.11	0	0	0	7.43
C2H4	5.16	3.91	4.30	2.76	0	0	0	16.13
C3H6	2.38	1.88	1.20	3.36	0	0	0	8.82
Acetone	1.37	0.16	11.2	12.00	0	0	0	24.73
CH3OH	1.39	0.95	25.2	10.0	0	0	0	37.54
ONMV	71.11	15.15	20.0	2.0	0	0	0	108.11
Isoprene	0	0	400.	0	0	0	0	400.00
Terpene	0	0	100.	0	0	0	0	100.00
SO2	54.2	1.4		0	0	0	0.09	55.70
DMS	0	0		15.2	0	0	0	15.20

(!) CO: chemical production (Tg/yr) = [1605 \(S1\)](#), [1747 \(S2\)](#), [1557 \(S3\)](#), [1845 \(S4\)](#)

(!) SO2: volcanic emission = 4.80 TgS/yr

各種エアロゾルのエミッションおよび排出源データベース

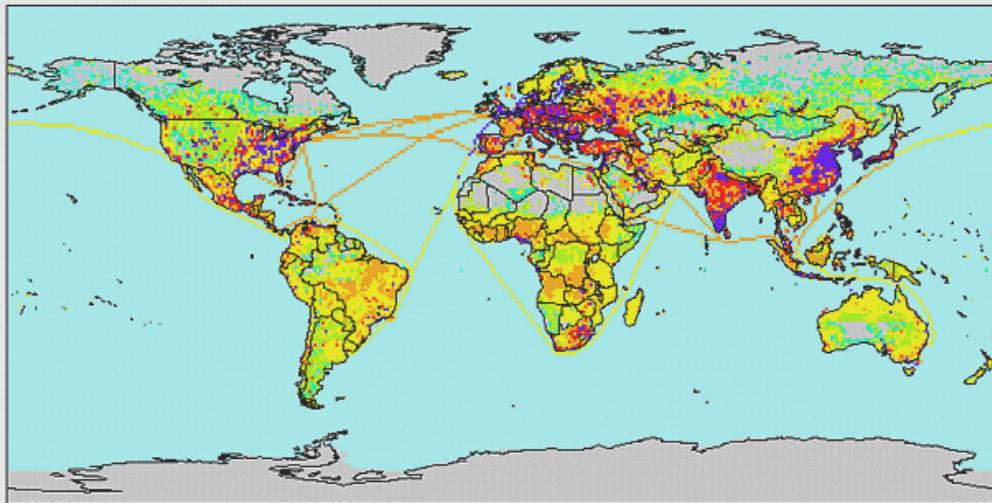
SPRINTARS emissions

SO ₂ 、無機・有機炭素 (BC/OC)	GEIA/EDGAR などのインベントリデータを使用
土壌ダスト、海塩	GCM中でオンライン計算

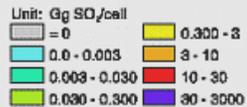
SO₂: EDGAR-HYDE

SO₂ from anthropogenic sources in 2000
Sources: EDGAR 32FT2000

SO₂: EDGAR-V32



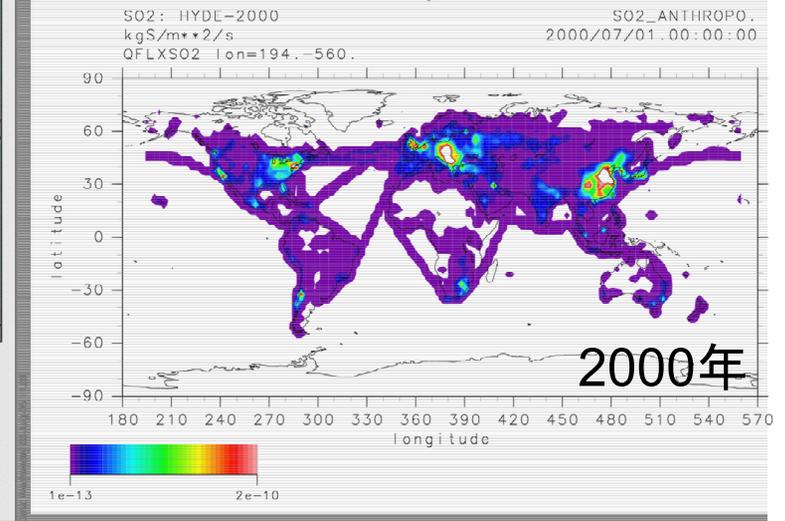
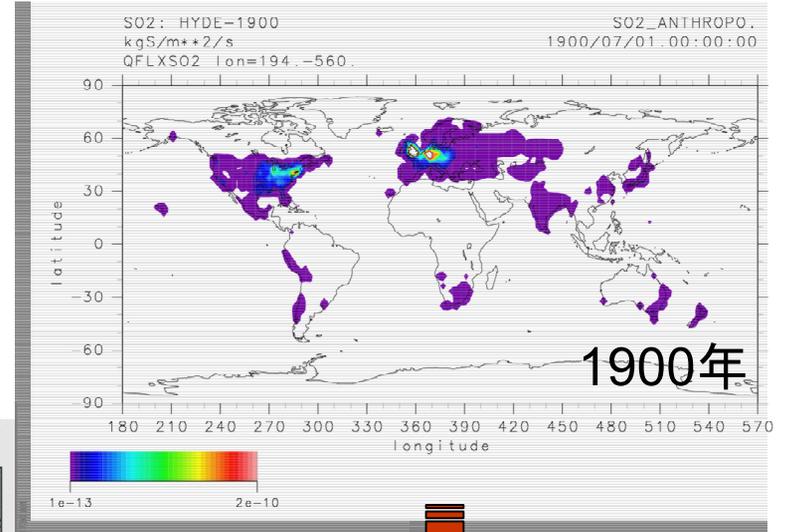
Global total: 1.4e+011 kg (min. = 8.5, max. = 1.5e+008)



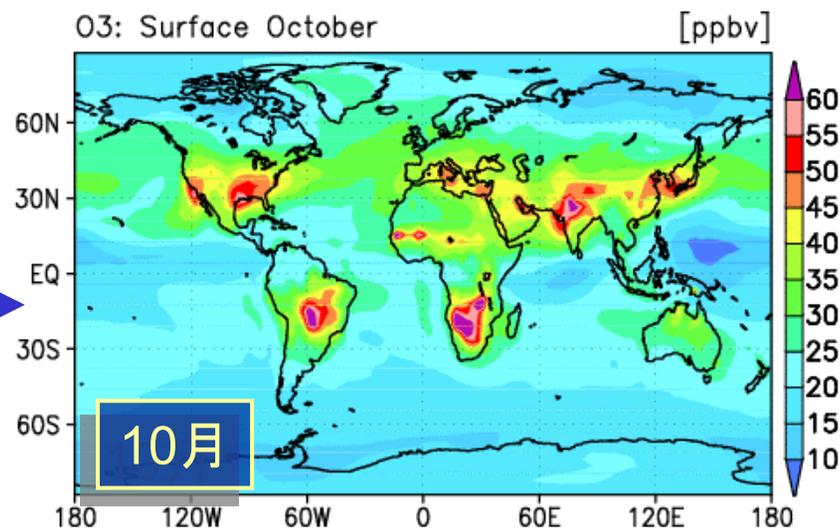
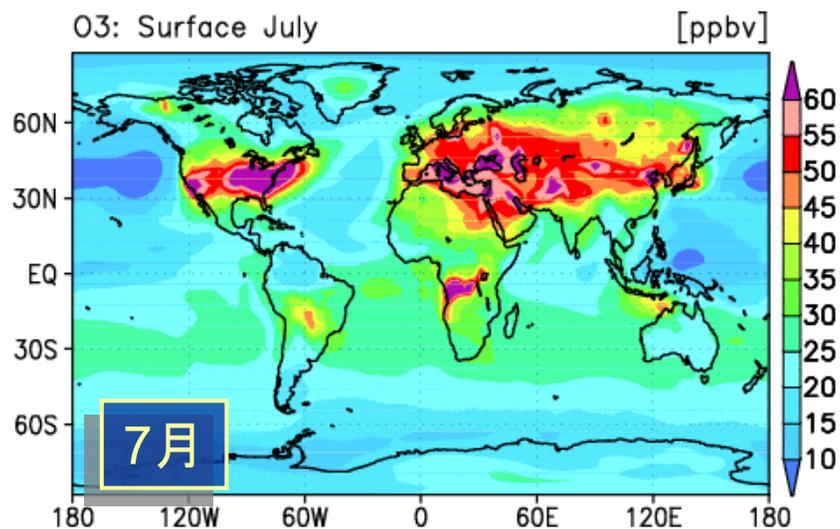
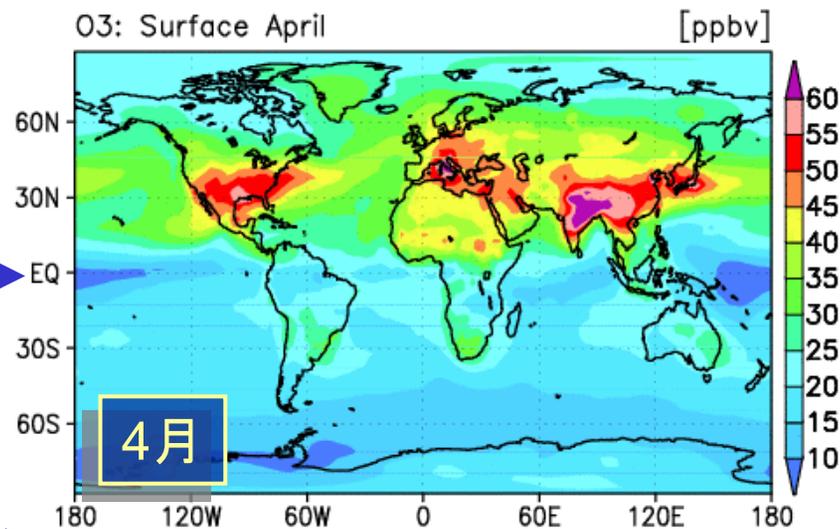
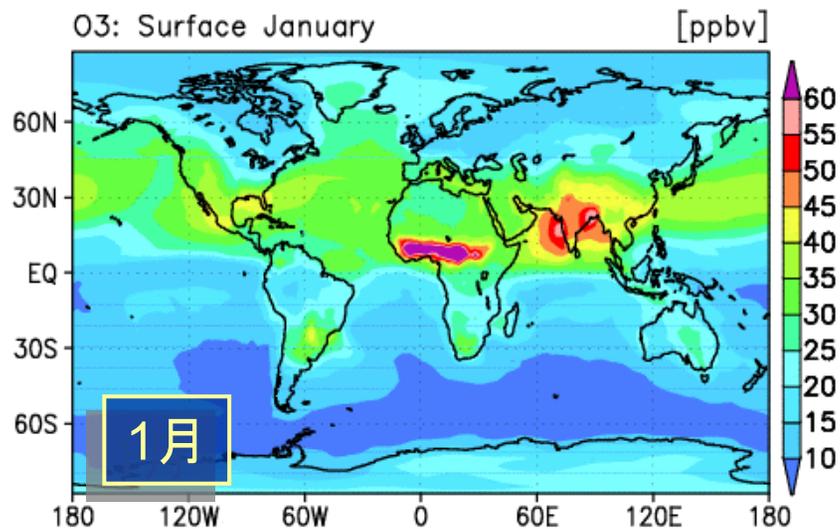
Tangent cylinder projection

LTO Emissions included
Biomass burning
Average 1997 - 2002 EF EDGAR 32
L47 Mid and High lat. grassland fire n.i.

Sources: EDGAR - JRC-IES/MNP/MPIC-AC/TNO 2006



地表におけるオゾン分布(ppbv)



対流圏カラムオゾン量 衛星観測とモデル

Annual mean

April

[直接観測
(地表・航空機・ゾンデ)
との比較では良い一致]

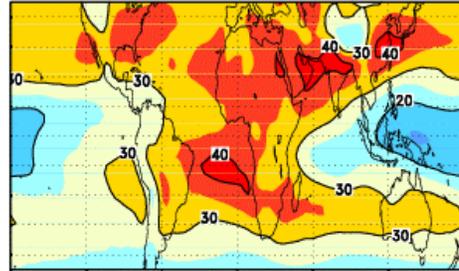
July

CHASER Met:
moderately relaxed
to ECMWF 1996.

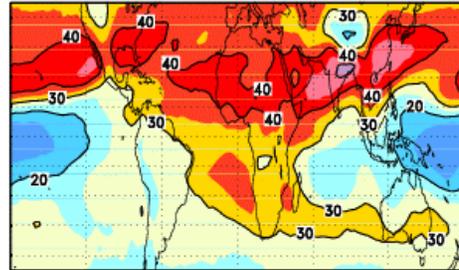
October

CHASERモデル

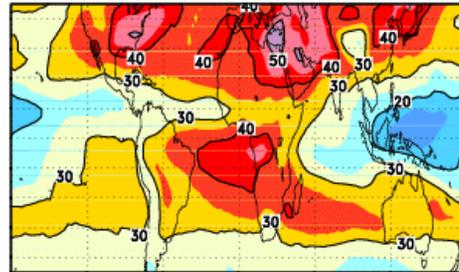
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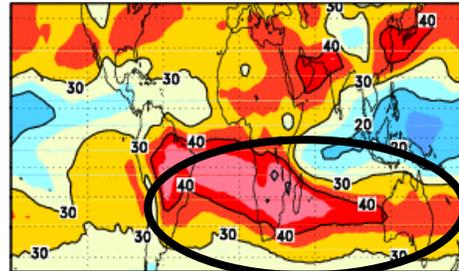
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CHASER <MM=07>



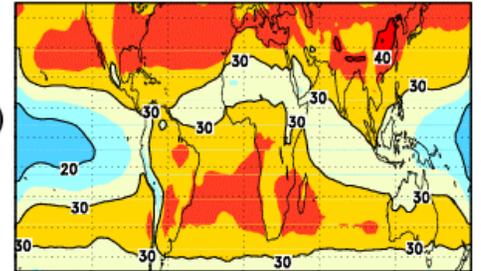
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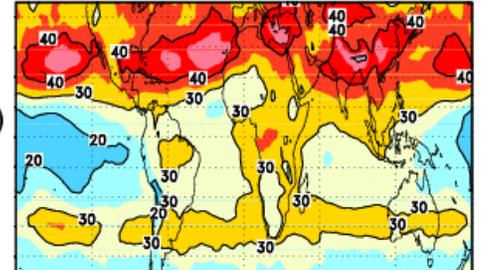
TOR (1998-2001)

Fishman et al., 2003

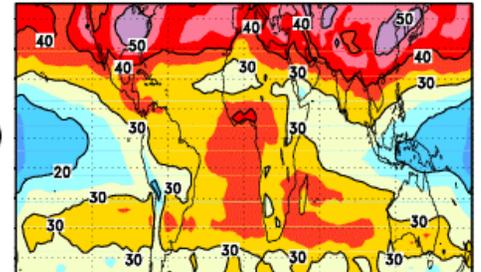
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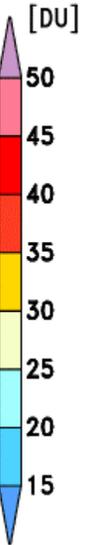
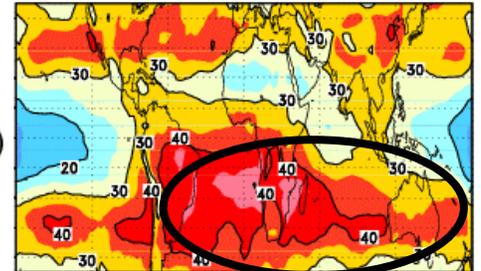
TOR <MM=04>



TOR <MM=07>



TOR <MM=10>



● 全球 OH ラジカル濃度場

i.e. 大気の酸化能力

- Simulated global OH concentrations (below 200 hPa)

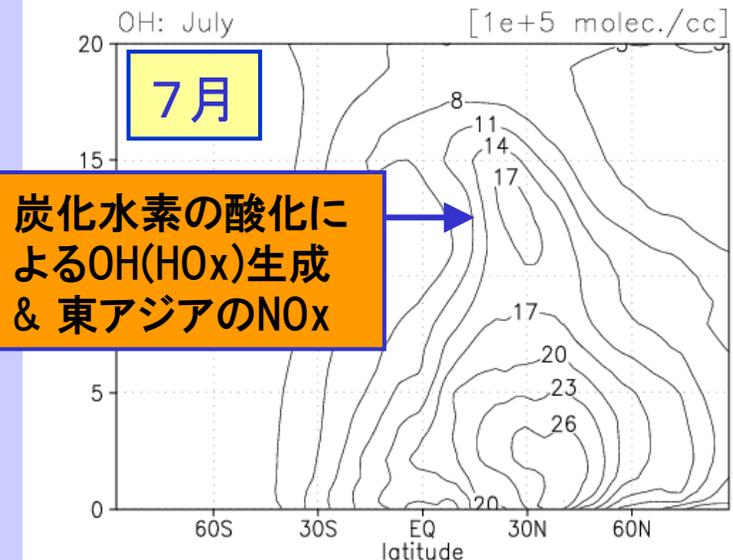
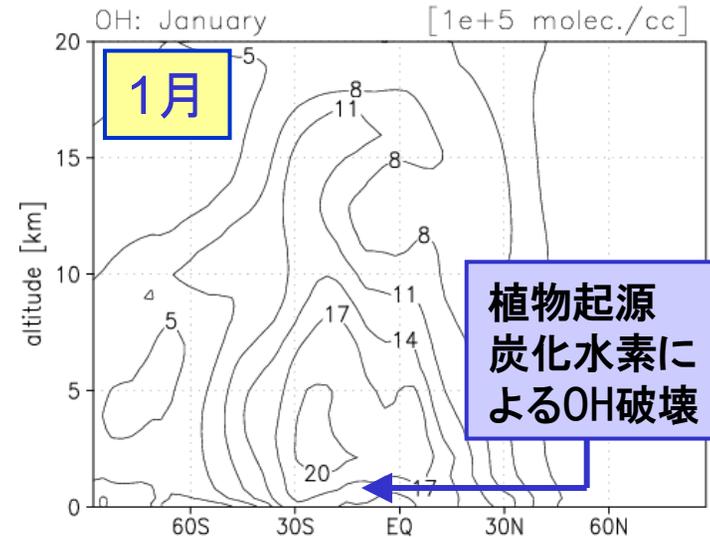


- Global CH_3CCl_3 lifetime of 5.0 years
 - 4.9 ± 0.3 years (観測からの推定値, Prinn et al. [1995])

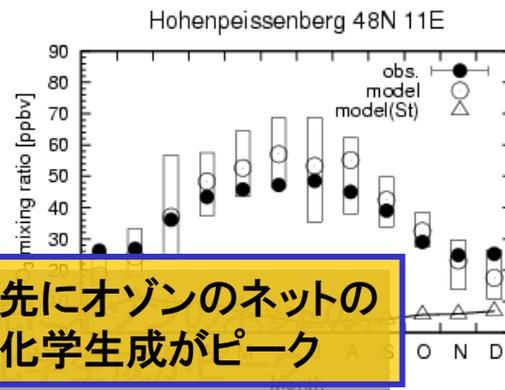
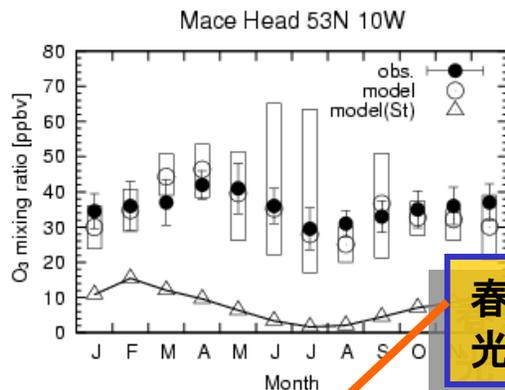
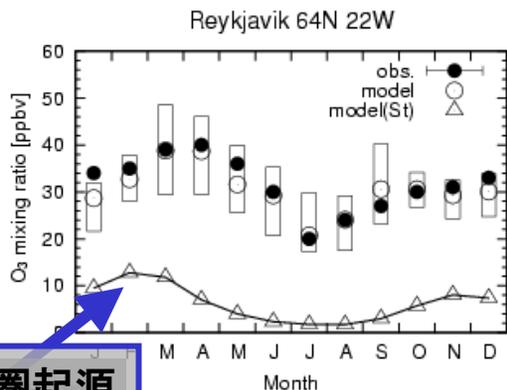
Methane lifetime defined as
(global CH_4 burden) / (loss in the troposphere)

- Global CH_4 lifetime = 9.4-9.8 years (cf. The IPCC estimate = 9.6 years)

東西平均 OH 濃度場

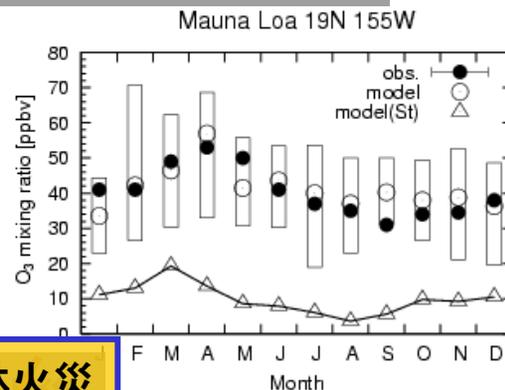
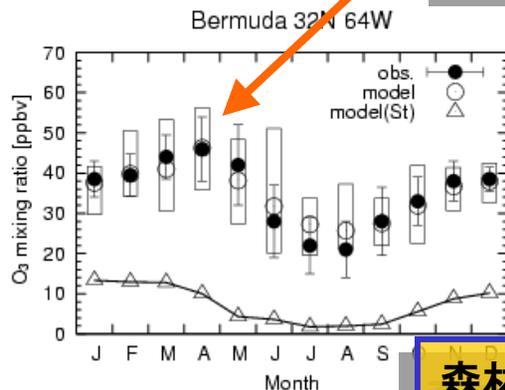
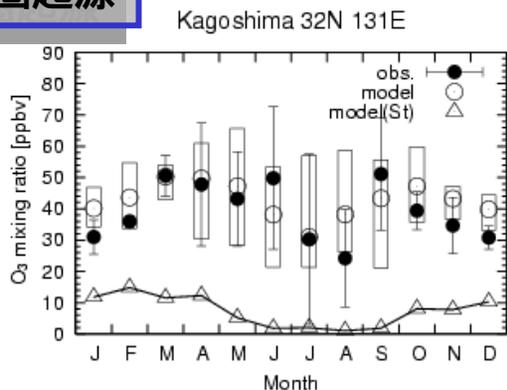


地表付近オゾン季節性の観測との比較 Observed (●) & calculated (○)

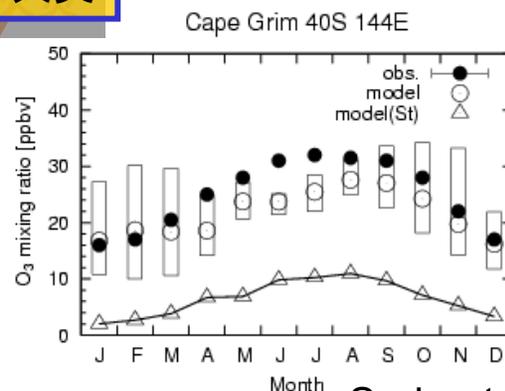
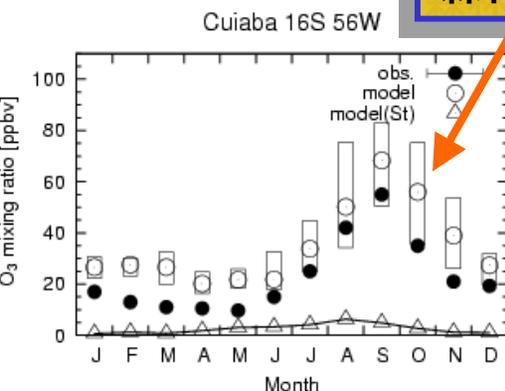
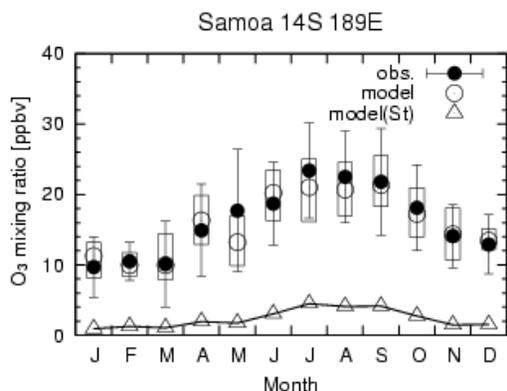


成層圏起源

春先にオゾンのネットの光化学生成がピーク



森林火災



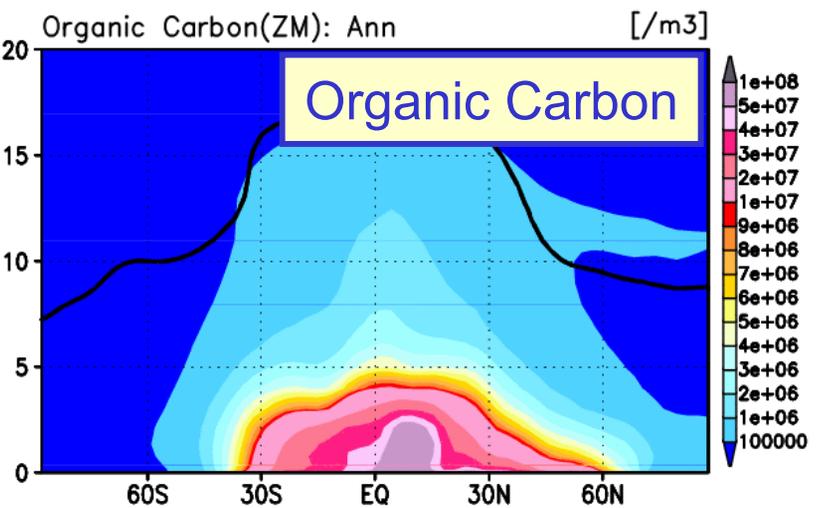
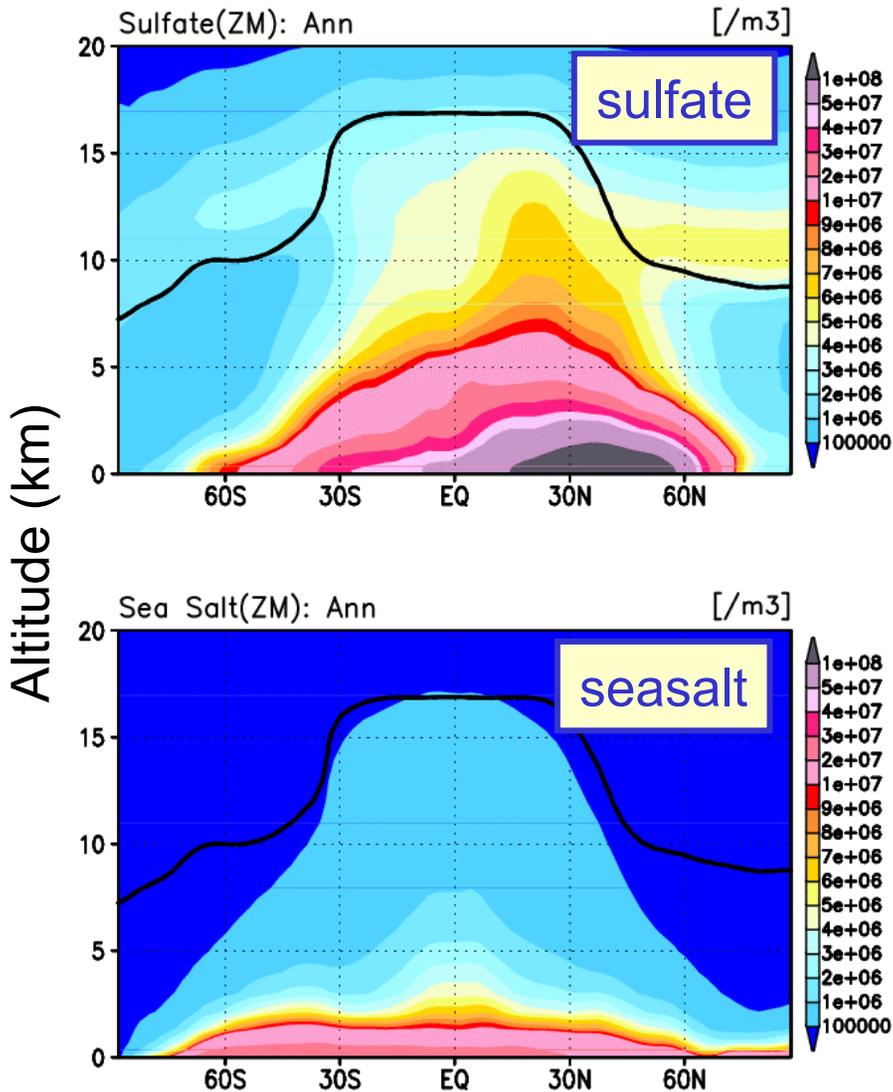
対流圏オゾンの全球収支(Tg/yr)

	Global	NH	SH
ソース	5312	ExplicitのSTE流入量は ~1000 Tg/yr	
成層圏オゾン流入	485		
化学生成(※1)	4827	2961	1866
シンク	-5312	-3176	-2136
化学破壊(※2)	-4420	-2596	-1824
乾性沈着	-892	-580	-312
ネット化学生成	407	365	42
Oy光化学寿命(日)	25	24	27
対流圏総量(Tg)	340	185	155

※1 $\text{NO} + \text{HO}_2 \rightarrow$: 64%、 $\text{NO} + \text{CH}_3\text{O}_2 \rightarrow$: 22%、 $\text{NO} + \text{RO}_2 \rightarrow$: 14%

※2 $\text{O}(1\text{D}) + \text{H}_2\text{O} \rightarrow$: 57%、 $\text{O}_3 + \text{HO}_2 \rightarrow$: 28%、 $\text{O}_3 + \text{OH} \rightarrow$: 13%、その他: 2%

Aerosols (CCN) number density calculated by the K2 ES model



→ Reflected on radiation/ cloud processes in the ES model.