Canadian Centre for Climate Modelling and Analysis

CCCma AGCM4

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CCCma AGCM4: Basic Features

- **Spectral model (current resolution is T47)**
- **35 vertical levels**
- **Hybrid moisture and chemical tracer variables for advection and horizontal diffusion**
- **Prognostic cloud microphysics (Lohmann and Roeckner 1996)**
- **Deep convection (Zhang and McFarlane 1995)**
- **Shallow convection (von Salzen and McFarlane 2002)**

CCCma AGCM4: Basic Features (cont'd)

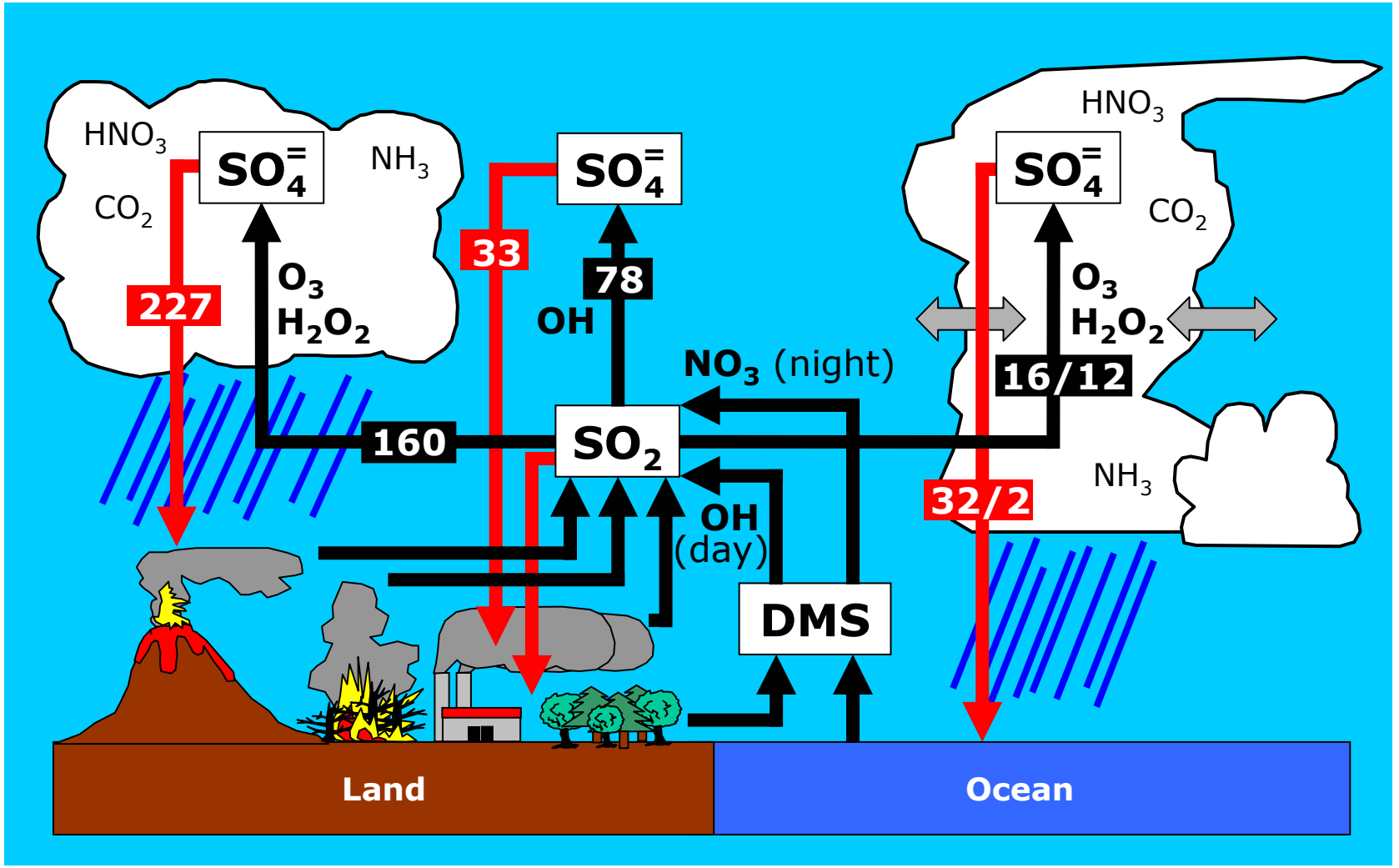
- **Fully coupled cycles of sulphur, mineral dust, and sea salt (black and organic carbon aerosol to come soon)**
- **Nine aerosol log-normal modes**
- **Correlated k-distribution method for gaseous transmission (Li and Barker 2002)**
- **Aerosol and cloud optical depth for 9 IR and 4 solar bands**
- **Subgrid-scale variability of cloud optical properties (Barker 1996)**
- **CLASS land surface scheme (Verseghy et al. 1992)**

Aerosol and Precursors in GCM4: Emissions

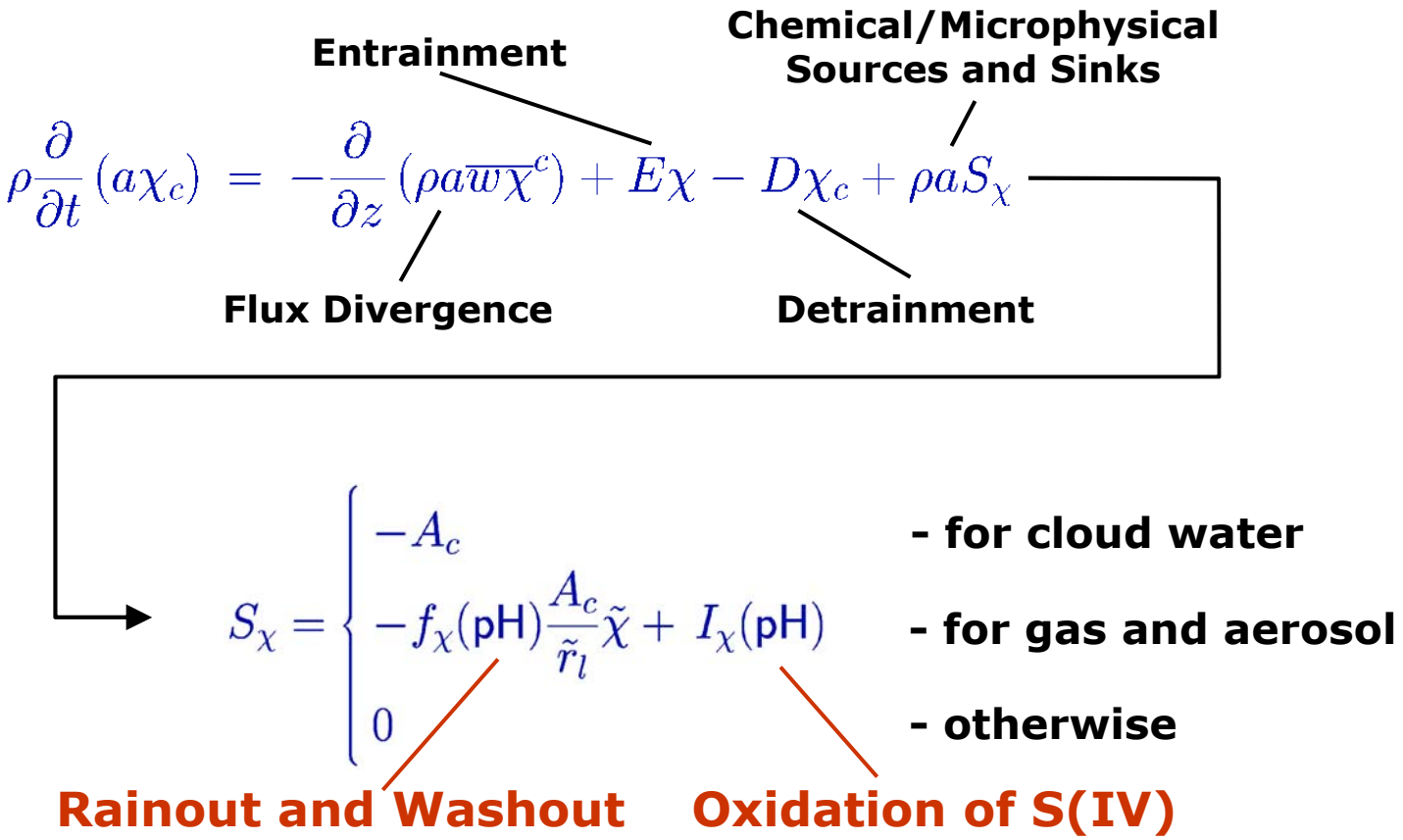
Species	Surface Source	Strength (Tg/Year)	Reference
DMS (gas)	marine biosphere	17.3	Kettle et al. (1996)
	terrestrial biosphere	0.9	Spiro et al. (1992)
SO_2 (gas)	non-eruptive volcanoes	8.0	Spiro et al. (1992), Graf et al. (1997)
	biomass burning	2.5	Hao et al. (1990)
	fossil fuel use	66.8	Benkovitz et al. (1994)
$SO_4^=$	-	-	von Salzen et al.
Black Carbon[1]	anthropogenic	6.1	Liousse et al. (1996)
	biomass burning	5.6	Liousse et al. (1996)
Organic Carbon[1]	natural	16.2	Guenther et al. (1995)
	anthropogenic	29.6	Liousse et al. (1996)
	biomass burning	59.3	Liousse et al. (1996)
Sea Salt[2]	natural	-	von Salzen et al.
Mineral Dust[2]	natural	-	Reader et al.

[1]hydrophobic and hydrophilic components
[2]accumulation and coarse modes

Sulphur Cycle in CCCma AGCM4 (JJA – ugS/m^2/day)



Parameterization of Convection: Basic Equations



Parameterization of Microphysical Processes in Stratiform Clouds

Lohmann and Roeckner (1996):

$$\frac{dq_l}{dt} = R(q_l) + Q_{\text{cnd}} + Q_{\text{melt}} - Q_{\text{auto}} - Q_{\text{acr}} - Q_{\text{freez}} - Q_{\text{evap}}$$

$$\frac{dq_i}{dt} = R(q_i) + Q_{\text{dep}} - Q_{\text{melt}} - Q_{\text{agg}} - Q_{\text{acr}} + Q_{\text{freez}} - Q_{\text{sub}}$$

$$Q_{\text{auto}} = 1350\, q_c^{2.47}\, N_l^{-1.79}$$

$$R_{\text{eff}} = k \left(\frac{3\,\rho\, q_l}{4\pi\, b\, \rho_l\, N_l} \right)^{\frac{1}{3}}$$

cloud droplet number concentration

$$N_l = 10^6 \cdot 10^{2.41 + 0.50 \log([\text{SO}_4^{=}]) + 0.05 \log([\text{Na}^{+}])}$$

Status of AEROCOM Runs

- Latest model run completed on May 17, 2003 with AEROCOM output variables
- Diagnostics currently being done
- AEROCOM output fields ready for download by end of June, 2003
- Climate mode only (no nudging)

Name	Dim.	Meaning	Units
PS	2D	Surface pressure	

Basic results on pressure levels

Name	Dim.	Meaning	Units
T	3D	Temperature	K
U	3D	Zonal wind	M/S
V	3D	Meridional wind	M/S

Basic results on hybrid levels

Name	Dim.	Meaning	Units
GST	3D	Temperature	K
GSU	3D	Zonal wind	M/S
GSV	3D	Meridional wind	M/S
RHC	3D	Relative humidity	%

Mixing ratios on pressure levels

Name	Dim.	Meaning	Units
BCO	3D	Black carbon (hydrophobic) mixing ratio	
BCY	3D	Black carbon (hydrophilic) mixing ratio	
DMS	3D	DMS mixing ratio	kg-S/kg
DUA	3D	Min. dust acc. mode mixing ratio	kg/kg
DUC	3D	Min. dust coarse mode mixing ratio	kg/kg
OCO	3D	Organic carbon (hydrophobic) mixing ratio	
OCY	3D	Organic carbon (hydrophilic) mixing ratio	
SSA	3D	Sea salt acc. mode mixing ratio	kg-NaCl/kg
SSC	3D	Sea salt coarse mode mixing ratio	kg-NaCl/kg
SO2	3D	Sulphur dioxide mixing ratio	kg-S/kg
SO4	3D	Sulphate mixing ratio	kg-S/kg

Mixing ratios on hybrid levels

Name	Dim.	Meaning	Units
GBCO	3D	Black carbon (hydrophobic) mixing ratio	
GBCY	3D	Black carbon (hydrophylic) mixing ratio	
GDMS	3D	DMS mixing ratio	kg-S/kg
GDUA	3D	Min. dust acc. mode mixing ratio	kg/kg
GDUC	3D	Min. dust coarse mode mixing ratio	kg/kg
GOCO	3D	Organic carbon (hydrophobic) mixing ratio	
GOCY	3D	Organic carbon (hydrophylic) mixing ratio	
GSSA	3D	Sea salt acc. mode mixing ratio	kg-NaCl/kg
GSSC	3D	Sea salt coarse mode mixing ratio	kg-NaCl/kg
GSO2	3D	Sulphur dioxide mixing ratio	kg-S/kg
GSO4	3D	Sulphate mixing ratio	kg-S/kg

Vertical integrals

Name	Dim.	Meaning	Units
VI01	2D	Cloud liquid water path	kg/m**2
VI02	2D	Cloud ice water path	kg/m**2
VI05	2D	Black carbon (hydrophobic) burden	
VI06	2D	Black carbon (hydrophylic) burden	
VI07	2D	Organic carbon (hydrophobic) burden	
VI08	2D	Organic carbon (hydrophylic) burden	
VI09	2D	Sea salt acc. mode burden	kg-NaCl/m**2
VI10	2D	Sea salt coarse mode burden	kg-NaCl/m**2
VI11	2D	Min. dust acc. mode burden	
VI12	2D	Min. dust coarse mode burden	
VI13	2D	DMS burden	kg-S/m**2
VI14	2D	Sulphur dioxide burden	kg-S/m**2
VI15	2D	Sulphate burden	kg-S/m**2
VI16	2D	Hydrogen peroxide burden	kg-S/m**2
VI17	2D	Total water path	kg/m**2

Name	Dim.	Meaning	Units
AB11	2D	Aerosol absorption for sulphate aerosol in band 1	
AB21	2D	Aerosol absorption for sulphate aerosol in band 2	
AB31	2D	Aerosol absorption for sulphate aerosol in band 3	
AB41	2D	Aerosol absorption for sulphate aerosol in band 4	
AB12	2D	Aerosol absorption for sea salt aerosol in band 1	
AB22	2D	Aerosol absorption for sea salt aerosol in band 2	
AB32	2D	Aerosol absorption for sea salt aerosol in band 3	
AB42	2D	Aerosol absorption for sea salt aerosol in band 4	
AB13	2D	Aerosol absorption for mineral dust in band 1	
AB23	2D	Aerosol absorption for mineral dust in band 2	
AB33	2D	Aerosol absorption for mineral dust in band 3	
AB43	2D	Aerosol absorption for mineral dust in band 4	
AB1T	2D	Aerosol absorption for total aerosol in band 1	
AB2T	2D	Aerosol absorption for total aerosol in band 2	
AB3T	2D	Aerosol absorption for total aerosol in band 3	
AB4T	2D	Aerosol absorption for total aerosol in band 4	
AO11	2D	Aerosol optical depth for sulphate aerosol in band 1	
AO21	2D	Aerosol optical depth for sulphate aerosol in band 2	
AO31	2D	Aerosol optical depth for sulphate aerosol in band 3	
AO41	2D	Aerosol optical depth for sulphate aerosol in band 4	
AO12	2D	Aerosol optical depth for sea salt aerosol in band 1	
AO22	2D	Aerosol optical depth for sea salt aerosol in band 2	
AO32	2D	Aerosol optical depth for sea salt aerosol in band 3	
AO42	2D	Aerosol optical depth for sea salt aerosol in band 4	
AO13	2D	Aerosol optical depth for mineral dust in band 1	
AO23	2D	Aerosol optical depth for mineral dust in band 2	
AO33	2D	Aerosol optical depth for mineral dust in band 3	
AO43	2D	Aerosol optical depth for mineral dust in band 4	
AO1T	2D	Aerosol optical depth for total aerosol in band 1	
AO2T	2D	Aerosol optical depth for total aerosol in band 2	
AO3T	2D	Aerosol optical depth for total aerosol in band 3	
AO4T	2D	Aerosol optical depth for total aerosol in band 4	
W1A	2D	Aerosol water sulphate	
W2A	2D	Aerosol water sea salt acc. mode	
W2C	2D	Aerosol water sea salt coarse mode	
WACT	2D	Aerosol water sulphate + sea salt	

Emissions

Name	Dim.	Meaning	Units
BCOE	2D	Black carbon (hydrophobic) emissions	
BCYE	2D	Black carbon (hydrophylic) emissions	
DAFX	2D	Min. dust acc. mode emissions	
DCFX	2D	Min. dust acc. mode emissions	
OCOE	2D	Organic carbon (hydrophobic) emissions	
OCYE	2D	Organic carbon (hydrophylic) emissions	

Dry deposition

Name	Dim.	Meaning	Units
DDBC	2D	Black carbon (hydrophobic) dry deposition	
DDBY	2D	Black carbon (hydrophylic) dry deposition	
DDDA	2D	Min. dust acc. mode dry deposition	
DDDC	2D	Min. dust coarse mode dry deposition	
DDNA	2D	Sea salt acc. mode dry deposition	kg-Nacl/m**2/sec
DDNC	2D	Sea salt coarse mode dry deposition	kg-Nacl/m**2/sec
DDOC	2D	Organic carbon (hydrophobic) dry deposition	
DDOY	2D	Organic carbon (hydrophylic) dry deposition	
DD6	2D	Sulphate dry deposition	kg-S/m**2/sec

Wet deposition

Name	Dim.	Meaning	Units
WDBC	2D	Black carbon wet deposition	
WDMA	2D	Min. dust acc. mode wet deposition (total)	
WDMC	2D	Min. dust coarse mode wet deposition (total)	
WDNA	2D	Sea salt acc. mode wet deposition	kg-Nacl/m**2/sec
WDNC	2D	Sea salt coarse mode wet deposition	kg-Nacl/m**2/sec
WDOC	2D	Organic carbon wet deposition	
WDD6	2D	Sulphate wet deposition due to deep convection	kg-S/m**2/sec
WDL6	2D	Sulphate wet deposition due to stratiform clouds	kg-S/m**2/sec
WDS6	2D	Sulphate wet deposition due to shallow convection	kg-S/m**2/sec

Chemical sources and sinks

Name	Dim.	Meaning	Units
DOX4	2D	Suphate production in gas-phase	kg-S/m**2/sec
SDHP	2D	Sulphate production in deep convection due to hydrogen peroxide	kg-S/m**2/sec
SDO3	2D	Sulphate production in deep convection due to ozone	kg-S/m**2/sec
SLHP	2D	Sulphate production in stratiform clouds due to hydrogen peroxide	kg-S/m**2/sec
SLO3	2D	Sulphate production in stratiform clouds due to ozone	kg-S/m**2/sec
SSHP	2D	Sulphate production in shallow convection due to hydrogen peroxide	kg-S/m**2/sec
SSO3	2D	Sulphate production in shallow convection due to ozone	kg-S/m**2/sec

Extra

Name	Dim.	Meaning	Units
RHOA	3D	Air density on hybrid levels	kg/m**3