Supplementary Material

Real-Time Air Quality Forecasting, Part I: History, Techniques, and Current Status

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Table A1. The U.S. EPA Air Quality Index for O_3 and PM (http://www.airnow.gov; U.S. EPA, 2000; 2009)

AQI Values	AQI Category	Color Code	Meanings (Health Effect)	O_3 (ppb) Maximum 8-h Average	O_3 (ppb) Maximum 1-h Average	$PM_{2.5}$ 24-h Average (µg m^{-3})	PM_{10} 24-h Average (µg m^{-3})
0-50	**Good**	**Green**	Satisfactory air quality (Air pollution poses little or no risk.)	**0-59**	**-**	**0.0-15.4**	**0-54**
51-100	**Moderate**	**Yellow**	Acceptable air quality. Unusually sensitive people should consider reducing prolonged or heavy outdoor exertion.(Unusually sensitive individuals may experience respiratory symptoms.)	**60-75**	**-**	**15.5-35.4**	**55-154**
101-150	**Unhealthy for Sensitive Groups**	**Orange**	Sensitive groups should reduce prolonged or heavy outdoor exertion (Sensitive groups may experience health effects.)	**76-95**	**125-164**	**35.5-65.4**	**155-254**
151-200	**Unhealthy**	**Red**	Sensitive groups should avoid prolonged or heavy outdoor exertion; everyone else should limit prolonged or heavy outdoor exertion (Everyone may begin to experience health effects.)	**96-115**	**165-204**	**55.5-150.4**	**255-354**
201-300	**Very Unhealthy**	**Purple**	Sensitivity groups should avoid all outdoor exertion, everyone else should limit outdoor exertion (Health warnings of emergency conditions; the entire population is likely to be affected.)	**116-374**	**205-404**	**150.5-250.4**	**355-424**
301-500	**Hazardous**	**Maroon**	Everyone should avoid all physical outdoor activities (Health alert; everyone may experience more serious health effects.)	**-**	**405-604**	**250.4-500.4**	**425-604**

Table A2. Inputs of Major RT-AQF Model Systems

Model System	Emissions	Chemical Initial/ Boundary Conditions
Global Models		
GOCART	Anthropogenic emissions based on EDGAR and Cooke et al., 1999. Dust, sea-salt, and DMS emissions based on an empirical formula. BVOCs emissions based on Guenther et al.,1995.continuous volcanic emissions are taken from a database of Andres and Kasgnoc (1 998)	Default chemical ICs
GEM-AQ	Anthropogenic emissions based on EDGAR 2.0 and GEIA. biogenic, ocean and soil emission for CO, NO, and 7 VOC species. Regional application uses regional emissions	The CMAM model for the first time model run. Use a spinup of 6-month; Global BCs: climatologies for O_3, NO, NO_2, HNO_3, HNO_4, and N_2O_5 for upper boundary; Reginal BCs: Global GEM-AQ
LMDzt -INCA	Anthropogenic emissions based on EDGAR v2.0 and v3.2 and various sources such as Liousse et al. 1996. NO_x emissions from oceangoing ships and aircraft emissions. Soil emissions of NO and BVOC are based on the ORCHIDEE dynamical vegetation model [Krinner et al., 2005]. Online dust and sea-salt emissions, emissions of N_2O and CH_4	Chemical ICs based on MOZART: BCs: O_3 profiles based on sounding and satellite data in the stratosphere
MOCAGE	Offline anthropogenic emissions based on GEIA, EDGAR, or GEMS-TNO inventories; static biogenic emissions based on Gunther (1997)	Default ICs for day 1 and the previous day's forecast afterwards; BCs: N/A for global runs; climatologies computed with another version of MOCAGE for regional runs
MATCH-NCAR	Anthropogenic emissions based on 1990 EDGAR inventory; soil emissions; lightning NO_x emissions, aircraft emissions	Default ICs based on previous model runs for day 1 and the previous day's forecast afterwards; BCs: prescribed CH_4 at surface and top of the domain, and O_3 and NO_y in the stratosphere based on observations
ECHAM5	Anthropogenic emissions of SO_2, CO, BC, POM based on AEROCOM; prescribed Terrestrial biogenic DMS emissions, online oceanic DMS, sea-salt and dust emissions	Prescribed CO_2;OH, H_2O_2, NO_2, and O_3 based on MOZART; BCs: N/A
FLEXPART	EDGAR industrial CO emissions inventory. Biogenic and NMHC emissions are not included	ICs: Zero; BC: N/A
ECMWF-IFS-CTM	Anthropogenic emissions are based RETRO, GFEDv2, SPEW, EDGAR, in all three models; online sea-salt and dust emissions	ICs are from previous run for day 1 and previous day's forecast afterwards; BCs: N/A
GR-AQF	anthropogenic emissions based on JCAP and EAgrid 2000 over Japan, REAS over China and Korea, and EDGAR over Russia; Biogenic emissions are based on Guenther et al. (1993)	ICs: None for global, CHASER for regional; BCs: N/A for global runs; BC for WRF/Chem is derived from CHASER
Regional Models		
AAQFS	offline forecasted anthropogenic emissions; online biogenic, sea-salt and dust emissions	ICs: a generic set of continental/oceanic concentration profiles for day 1 and the previous day's forecast afterwards; BCs: clean background trace species concentrations
MAQSIP-RT & CMAQ	projected anthropogenic emissions using online SMOKE; online biogenic emissions by BEIS 3.9	Default ICs; BCs: fixed boundary conditions of $PM_{2.5}$ and its composition
AIRPACT3	offline projected anthropogenic emissions; forecasted fire emissions using USDA-FSB BlueSky; biogenic emissions by BEIS; Meteorologically dependent NH_3 emissions	Default ICs for day 1 and the previous day's forecast afterwards; BCs: average of 1990-1999 results of the MOZART-2
AQFMS	Offline anthropogenic emissions based on U.S. NEI-99 processed with SMOKE; biogenic emissions by BEIS2	ICs: A 2-day spin-up run from nominal ICs (35 ppb for O_3 and 180 ppb for CO) for day 1 and the previous day's forecast afterwards; BCs: Prescribed time-invariant O_3 and CO concentration of 35 ppb and 100 ppb at all heights
STEM-2K3	Offline anthropogenic emissions based on U.S. NEI-99 (v. 3) and 2000 Canadian inventory; Biogenic emissions from the 1990 IGAC-GEIA archive or BEIS2	Default ICs for day 1 and the previous day's forecast afterwards; BC: time-varying lateral and top BCs based on the MOZART or RAQMS global model forecast
NAQFC	Offline projected anthropogenic emissions based on 2001 NEI processed with SMOKE; Biogenic emissions by BEIS v. 3.13 ,	Default ICs for day 1 and the previous day's forecast afterwards; BCs: all species with static lateral BCs based on continental clean condition profiles; in some cases, climatology and NCEP GFS forecast for low and upper tropospheric O_3, respectively
WRF/Chem	Offline anthropogenic emissions based on U.S. NET-99 v. 3; online biogenic emissions based on Guenther et al. (1994, 1995) and Simpson et al. (1995), Online sea-salt and dust emissions	Default ICs for day 1 and the previous day's forecast afterwards; BCs: prescribed BCs based on average of mid latitude aircraft profiles over the eastern Pacific. fixed BCs of $PM_{2.5}$ and its composition
WRF/Chem-MADRID	Offline projected anthropogenic emissions based on VISTAS2002; Online biogenic emissions based on Guenther et al. (1994, 1995) and Simpson et al. (1995). Online sea-salt and dust emissions	ICs based on VISTAS 2009 CMAQ simulations for day 1 and the previous day's forecast afterwards; BCs: time-varying BCs based on VISTAS 2009 CMAQ simulations
GEM-AURAMS	Offline projected anthropogenic emissions based on the 1990 Canadian and U.S. national criteria air contaminant inventories processed with CEPS; Online biogenic emissions by BEIS2; online sea-salt emissions	A horizontally homogeneous, uniform initial O_3 profile of 48.2 ppb; in some cases, ICs for all species except O_3 are set to BCs profiles that decreased exponentially with height; static BCs for all species
GEM-CHRONOS	Offline projected anthropogenic emissions based on the 1990 Canadian and U.S. national criteria air contaminant inventories processed with CEPS; Online biogenic emissions by BEIS2	A horizontally homogeneous, uniform initial O_3 profile of 36.1 ppb. Fixed chem. ICs for day 1, and the previous day's forecast afterwards; static BCs for all species, zero gradient inflow, open boundary out-flow
GEM-MACH15	CAN 2005 emissions and US emissions processed with SMOKE2.3. BVOC and NO from BEIS v3.0.9	Default Chemical ICs for initial run and the previous day's forecast afterwards; BC: climatological profiles for O_3, CO and $PM_{2.5}$ based on satellite observations, other gases based on old ADOM-II clean atmosphere conditions

Table A2. Inputs and Outputs of Major RT-AQF Model Systems (continued)

Model System	Emissions	Chemical Initial/ Boundary Conditions
	Regional Models	
AIRPARIF [1]	Regional emission inventory developed by air quality agencies of the Paris region and adjacent regions.	ICs: previous day's forecast; BCs: from the national CHIMERE simulation.
CHIMERE	Offline projected anthropogenic emissions based on the EMEP yearly totals, with monthly, daily, and hourly factors or based on other inventories such as GEMS-TNO; parameterized biogenic emissions based on Guenther (1997).	Default ICs for day 1 and previous day's forecast for remaining days. Default ICs are based on LMDzINCA climatological monthly means for gases from the LMDzINCA model and the GOCART climatological monthly means for aerosols; in some cases, ICs are based on MACC-GRG; BCs: monthly means climatological data simulated by the LMDz-INCA global CTM for gaseous species; monthly mean PM predictions from GOCART
POLYPHEMUS	Offline projected emissions based on the EMEP yearly totals, with monthly, daily and hourly factors; biogenic emissions based on Simpson et al. [1999]	Default ICs for day 1 and the previous day's forecast afterwards; BCs: derived from a "typical year" simulation of MOZART for gases and from a simulation of GOCART for PM species.
-ATMI THOR	Anthropogenic emissions are based on EMEP and the Danish emission inventories; Biogenic emissions calculated from land use data.	Default ICs for day 1 and the previous day's forecast afterwards; BCs: seasonal mean for O_3
DACFOS	Anthropogenic and biogenic emissions are based on EMEP and TNO/MEGAPOLI emissions and land-use; Pollen emissions calculated online.	A 2-day spin-up run from climatic IC data; BCs: time-varying BCs based on the MOZART global model forecast for regional scale and GEMS/MACC BC for inner domain
FUMAPEX UAQIFS	Anthropogenic emissions are based on multiple emission inventories processed with EMMA	Derived from measurements or a coarser grid model such as global ECMWF model or CHIMERE or PREV'AIR; BCs: derived from a coarser model such as global ECMWF model or CHIMERE or measurements
EURAD	Anthropogenic emissions based on 2000 GEMS-TNO inventory; biogenic emissions based on NKUA monthly emission potentials; online sea-salt and dust emissions	3d-var analysis for the day before; BCs: based on the MOZART IFS forecast for the day before
EMEP-Unified	Anthropogenic emissions based on EMEP 2003 emissions; online biogenic emissions	Default ICs based on climatologies for day 1 and the previous day's forecast afterwards; BCs: climatologies for all gases except for O_3, which is set to be a constant of 40 ppb
MATCH	Anthropogenic emissions based on 2000 GEMS-TNO inventory	Default ICs for day 1 and the previous day's forecast afterwards; BCs: static BCs based on climatology or MOZART IFS forecast for the day before. In some cases, dynamic BCs are used
LOTOS-EUROS	Anthropogenic emissions are based on 2000 GEMS-TNO (2000) inventory; biogenic emissions based on Guenther et al., 1993; online sea-salt emissions	Default ICs for day 1 and the previous day's forecast afterwards; BCs: based on GRG MOZART/IFS global model forecast for the day before. Either 0 or a constant for PM species
SILAM v.4.5.4	Anthropogenic emissions based on GEMS-TNO and EMEP inventory; online biogenic emissions based on Guenther et al., 1993; online sea-salt emissions	Default ICs for day 1 and the previous day's forecast afterwards; BCs: based on the MOZART model values for all species
WRF/CMAQ	Anthropogenic emissions based on UK NAEI and EMEP inventories; biogenic emissions calculated using a biogenic potential inventory	Default ICs for day 1 and the previous day's forecast afterwards; BCs: based on the global STOCHEM model
NAME-III	All emissions are represented by PM emissions	Monthly average 3-D background fields from STOCHEM; BCs: BCs derived from mean monthly levels observed at Mace Head
OPANA v4.0 & Predecessors	Global and European emission inventories processed with the EMIMO emission model; biogenic and anthropogenic emissions	ICs for MM5-CMAQ-EMIMO are from a global model; ICs for CFD are from MM5-CMAQ-EMIMO; BCs for MM5-CMAQ-EMIMO are from a global model; BCs for CFD are from MM5-CMAQ-EMIMO
CALIOPE	The EMEP expert emission inventory, the HERMES emission model, and the Dream dust model	Day 1: Default ICs based on climate profiles in CMAQ; monthly climatology from LMDz-INCA for CHIMERE. The previous day's forecast afterwards; BCs: derived from the LMDz-INCA2 global climate-chemistry model
SKIRON/TAPM	Anthropogenic emissions based on combination of TNO European emissions, EMEP shipping emissions and GEIA global emissions database	Default ICs for day 1 and the previous day's forecast afterwards; default BCs in CAMx
ForeChem	Anthropogenic emissions based on EMEP expert emissions at continental scale and from CTN-ACE in Italy. Biogenic emissions are from MEGAN	Default ICs for day 1 and the previous day's forecast afterwards; default hourly dynamic BCs in CHIMERE
EMS-Beijing	Anthropogenic emissions based on Trace_P, INTEX-B, and emissions from local EPA agencies; BVOCs are based on GEIA, processed with SMOKE	Default ICs for day 1 and the previous day's forecast afterwards; BC for O_3 is fixed at 20 ppb and change exponentially to 30 ppb
CFORS	The anthropogenic emission inventories of Streets et al. (2003). Online dust emission module, sea salt emissions.	ICs of chemical tracers are set to zero; zero-gradient BCs
POLYPHEMUS	the Comisión Nacional del Medio Ambiente (CONAMA) anthropogenic emission inventory of Departamento de Investigaciones Cientificas y técnicas de la Universidad Catolica (DICTUC) for the Santiago region	Default ICs for day 1 and the previous day's forecast for remaining days; BCs: derived from a "typical year" simulation of the MOZART 2 model

[1] There are several air quality systems used by regional air quality agencies (e.g., Association agréées de surveillance de la qualité de l'air (AASQAs)) and only the one for the Paris region is given here as an example.

Table A3. Chemistry and Aerosol Treatments in Major RT-AQF Model Systems[1]

Organization/Model System	Gas-phase chemistry	Aerosol Size and Composition	Aerosol Microphysical Processes	Cloud Chemistry
Global Models				
GOCART	SO_2 and DMS oxidation by prescribed OH and NO_3	Sectional (4-bin for sea-salt over 0.1-10 μm, 7-bin for dust over 0.1-6 μm) SO_4^{2-}, EC, primary OC, Na^+, Cl^-, H_2O, dust	None	SO_2 oxidation by dissolved prescribed H_2O_2
.GEM-AQ	Modified ADOM-II	Sectional (12-bin over 0.005 – 10.24 μm) SO_4^{2-}, EC, primary OC, Na^+, Cl^-, soil dust	Detailed microphysical processes (except for SOA) as treated in CAM of Gong et al., 2003)	A simplified aqueous phase reaction module for oxidation of SO_2 to SO_4^{2-}
LMDzt -INCA	Detailed CH_4-NOx-CO-O_3 –NMHC chemistry	Modal (accumulation mode) Prescribed SO_4^{2-} field	None	None
MOCAGE	RACM for tropospheric chemistry and REPROBUS for stratospheric chemistry	Sectional; dust, EC, sulfate, sea salts, primary $PM_{2.5}$ and PM_{10}	None	None
MATCH-NCAR	O_3-HO_x-NO_y-CH_4-CO-organic chemistry using MATCH-MPIC	None	None	Equilibrium partitioning of 19 species into H_2O/ice crystals using Henry's law constants
ECHAM5	CH_4-N_2O-CFC-SO_2-DMS-sulfate chemistry with prescribed OH, H_2O_2, NO_2, and O_3	Modal (7-mode) SO_4^{2-}, EC, primary OC, Na^+, Cl^-, dust	Detailed microphysical processes as in M7 module of Vignati et al. (2004)	SO_2 oxidation by O_3 and H_2O_2
FLEXPART	No explicit chemistry, CO is simulated by assuming an e-folding lifetime of 36 days	None	None	None
ECMWF-IFS-CTM	JPL-03 and JPL-06 and SO_x/NH_3/NH_4 mechanism from MOZART4 in MOZART-3,CBM-IV in TM5, REPROBUS in MOCAGE	Sectional (3-bin) for sea-salt and dust; and bulk for other aerosols SO_4^{2-}, EC, primary OC, Na^+, Cl^-, dust	None	None
GR-AQF	O_3–HO_x–NO_x–CH_4–CO-NMHC chemistry in CHASER RADM2 for WRF/Chem	None	None	None
Regional Models				
AAQFS	GRS and CB-IV	Sectional (8 bins);SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, wind-blown dust	None	None
MAQSIP-RT & CMAQ	Modified CB –IV for MAQSIP, CB05 for CMAQ	No PM treatments in MAQSIP; modal (3-mode); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O for CMAQ	None for MAQSIP; Detailed microphysical processes as treated AERO5 in CMAQ v4.5.1 with modified SOA	None for MAQSIP RADM for CMAQ
AIRPACT3 & Predecessors	SAPRC99	Modal (3-mode); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O	Same as US NOAA/EPA's NAQFC with AERO4 in CMAQ v4.6	Same as US NOAA/EPA's NAQFC
AQFMS	Modified CB –IV, CB05	Modal in both CAMx and CMAQ; SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O	Detailed microphysical processes as treated in CF in CAMx 5.2 and AERO5 in CMAQ v4.7.1	RADM in CAMx and CMAQ
STEM-2K3	SAPRC99	Sectional (4-bin); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, K^+, CA^{2+}, Mg^{2+}, CO_3^{2-}, H_2O, mineral dust	Detailed microphysical processes	equilibrium partitioning of SO_2, H_2O_2 and O_3 into cloud using Henry's Law
NAQFC	CB-IV	Modal (3-mode); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O	Detailed microphysical processes as treated in AERO4 in CMAQv4.6	equilibrium partitioning of SO_2, H_2O_2 and O_3 into cloud using Henry's Law; RADM2 aqueous-phase chemistry including 5 kinetic reactions for aqueous-phase oxidation of SO_2
WRF/Chem	RADM2	Modal (3-mode); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, dust	Detailed microphysical processes as treated in MADE/SOAGAM	None
WRF/Chem-MADRID	CB05	Sectional (8-bin); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, dust	Detailed microphysical processes as treated in MADRID	CMU aqueous-phase chemistry
GEM-AURAMS	ADOM-II	Sectional (12-bin over 0.01 to 40.96 μm); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, crustal materials	Detailed microphysical processes as treated in the CAM aerosol model	ADOM aqueous-phase chemistry with mass transfer of SO_2, O_3, H_2O_2, ROOH, HNO_3, NH_3, and CO and oxidation of S(IV) by dissolved O_3, H_2O_2, ROOR', and O_2 (catalyzed by Fe^{3+} and Mg^{2+})
GEM-CHRONOS	ADOM-II	Moment or sectional (2-bin: 0-2.5 and 2.5-10 μm); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O	equilibrium gas-particle mass transfer Thermodynamics based on vectorized ISORROPIA, SOA formation based on fixed aerosol yield approach	None
GEM-MACH15	Modified ADOM-II + N_2O_5 + H2O heterogeneous Reaction to form NO_3^-	Sectional (2-12 bins) SO_4^{2-}, NO_3^-, NH_4^+, EC, POC, SOA, CM, Na^+, Cl^-, H_2O	Detailed microphysical processes as treated in CAM (Gong et al., 2003)), SOA based on instantaneous aerosol yield	ADOM mechanism (Young and Lurmann, 1984) with 20 reactions involving 7 gaseous and 13 aqueous species

Table A3. Chemistry and Aerosol Treatments in Major RT-AQF Model Systems[1] (continued)

Organization Model System	Gas-phase chemistry	Aerosol Size and Composition	Aerosol Microphysical Processes	Cloud Chemistry
AIRPARIF[2]	MELCHIOR	Sectional (6-bin from 0.010 to 40 µm); SO_4^{2-}, NO_3^-, NH_4^+, SOA, POA, EC, H_2O, dust	Detailed microphysical processes	7 aqueous reactions are included. Several aqueous-phase reactions considered.
CHIMERE	MELCHIOR1 and MELCHIOR2	Sectional (6-bin from 0.010 to 40 µm); SO_4^{2-}, NO_3^-, NH_4^+, SOA, POA, EC, H_2O, dust	Detailed microphysical processes	7 aqueous reactions are included. Several aqueous-phase reactions considered.
POLYPHEMUS	RACM	Sectional (10-bin, from 0.010 to 10 µm); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC (several group), Na^+, Cl^-, H_2O, dust	Detailed microphysical processes as treated in SIREAM	aqueous chemistry scheme derived from the one proposed in VSRM (Fahey and Pandis, 2001).
THOR	CB-IV	Bulk, primary $PM_{2.5}$, PM_{10}, and TSP, sea salt	None	None
DACFOS	CB-IV	Bulk, modal (CAC) or sectional (CAMx), primary $PM_{2.5}$, PM_{10}, TSP and pollen; SO_4^{2-}, NO_3^-, NH_4^+, SOA, POA, EC, H_2O	Detailed microphysical processes as treated in CAMx 5.2	RADM approach
UAQIFS[3]	1. PSSA for NO_2 2. Basic reactions for NO_x and O_3 3. CBM-IV 4. SAPRC-90, 5. MELCHIOR 6. None	1. Bulk, $PM_{2.5}$ and PM_{10} 2. Bulk, $PM_{2.5}$ 3. none 4. modal (aero3), SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O or bulk (aero0), inorganic aerosols 5. Sectional (same as the CHIMERE PM module) 6. None	1. None 2. None 3. None 4. CMAQ aero3 and a simplified bulk module 5. Same detailed as treated in CHIMERE 6. None	1. None 2. None 3. None 4. None 5. None 6. None
EURAD	RADM2; RACM-MIM	Modal with fixed standard deviations (two fine and one coarse modes); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, dust	Detailed microphysical processes	10 gas/aqueous-phase equilibria,5 irreversible S(IV) oxidation by H_2O_2, O_3, CH_3OOH, O_2 catalyzed by Fe^{3+} and Mg^{2+}, and CH_3CO_3H
EMEP-Unified	The EMEP gas-phase chemistry	Sectional (2-bin, $PM_{2.5}$ and $PM_{10-2.5}$);SO_4^{2-}, NO_3^-, NH_4^+, Na^+, Cl^-, H_2O, anthropogenic primary PM	Inorganic aerosol thermodynamic equilibrium is based on the EQSAM model	SO_2 oxidation by O_3 and H_2O_2
MATCH	Revised EMEP chemistry scheme with isoprene production	Sectional (4-bin from 0.02- 10 m) SO_4^{2-}, NO_3^-, NH_4^+, EC, primary OC, Na^+, Cl^-, H_2O, dust	$(NH_4)_2SO_4$ and NH_4NO_3 formation via 5 aerosol equilibrium reactions following Hov et al. (2004)	SO_2 oxidation by O_3 and H_2O_2, equilibrium partitioning of SO_2, CO_2, H_2O_2 and O_3 into cloud using Henry's Law (Berge, 1993)
LOTOS-EUROS	TNO Modified CBM- IV, CB99	Bulk; SO_4^{2-}, NO_3^-, NH_4^+, EC, primary OC, biogenic SOA, Na^+, Cl^-, H_2O	ISORROPIA inorganic thermodynamics, MARS or EQSAM; Biogenic SOA formation SORGAM. No anthropogenic SOA formation	One first-order reaction to account for aqueous phase and heterogeneous formation of SO_4^{2-}
SILAM v.4.5.4	Two main options 1. Basic acid and O_3 chemistry 2. CB-IV	Bulk or Sectional (ADB); SO_4^{2-}, NO_3^-, NH_4^+, Na^+, Cl^-, biogenic primary PM such as natural birch pollen	Bulk treatments for inert PM; ADB scheme includes detailed l microphysics. Its tracer module also treats radioactive decay of up to ~500 nuclides and natural birch pollen.	None
WRF/CMAQ	CB05	Modal (3-mode); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O	Detailed microphysical processes as treated in AERO5 in CMAQ v4.7.1	RADM Aqueous-phase chemistry
NAME-III	the STOCHEM mechanism used in STOCHEM global chemistry	Bulk; SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, dust	None	None
OPANA v4.0	CB05, RADM, SAPRC99	Modal (3-mode); SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, dust	Detailed microphysical processes	RADM aqueous-phase chemistry
CALIOPE	CBM-IV in CMAQ and MELCHIOR in CHIMERE	Same as CMAQ and CHIMERE, plus dust	Detailed microphysical processes as treated in CMAQ and CHIMERE	Same as CMAQ and CHIMERE
SKIRON/TAPM	CBM-IV (mechanism 4 in CAMx)	Modal; SO_4^{2-}, NO_3^-, NH_4^+, EC, OC, Na^+, Cl^-, H_2O, dust.	Detailed microphysical processes as treated in CF in CAMx 4.31	RADM aqueous-phase chemistry
ForeChem	MELCHIOR 1 and MELCHIOR2	Sectional (8-bin from 0.010 to 40 µm); SO_4^{2-}, NO_3^-, NH_4^+, Na^+, Cl^-, OC, EC, H_2O, dust	Detailed microphysical processes as treated in CHIMERE	Same as CHIMERE
EMS-Beijing	CBMZ in NAQPMS, and CB-IV in CMAQ and CAMx	Sectional (9 bins) in NAQPMS Modal (3-mode in CMAQ and 2-mode in CAMx)	Detailed microphysical processes as treated in CF in NAQPMS, CAMx, AERO4 in CMAQ	RADM aqueous-phase chemistry
CFORS	Linear conversion of SO_2 to SO_4^{2-}	Sectional (12 bins); SO_4^{2-}, EC, POC, Na^+, Cl^-, H_2O, dust	None	None
POLYPHEMUS	RACM	None	None	None

[1] The list of acronyms is provided in Appendix.
[2] There are several air quality systems used by regional air quality agencies (Association agr éées de surveillance de la qualité de l'air (AASQAs)) and only the one for the Paris region is given here as an example.
[3] FUMAPEX includes six UAQIFS model systems implemented in six cities in five countries. The labels 1-6 correspond to the six model systems listed in Table 5.

Table A4. Discrete and categorical evaluation of RT-AQF results for O_3 and $PM_{2.5}$ predictions.

pollutants	Area	Period	MB	RMSE	NMB (%)	NME (%)	Threshold	A (%)	CSI (%)	POD (%)	B	FAR (%)	model	reference
maximum 1-h average O_3	W EU	5/1-9/30,1998	1.5	11.0	—	—	—	—	—	—	—	—	ECMWRF/CHIMERE	SC01
	Melbourne	March 7-9, 2001	-6 to -1		-12 to -14	17-24							AAQFS	MA01b
	/Sydney,	1/1-5/31, 2001					60			30-70		14-63	AAQFS	CO04
	Australia	Summer,					60			33-89			AAQFS	CH05[a]
		2001-2003					80			37-53			AAQFS	CH05[a]
	NE US	8/5-29,2002	1.4	14.6	2.2	18.0	125	99.2	9.7	14.0	0.6	76	MAQSIP-RT	KA05
	NE US	8/5-29,2002	9.5	21.3	15.0	25.8	125	97.0	9.8	29.8	2.3	87.2	MM5/Chem	KA05
	NE US	8/5-29,2002	3.2	19.1	5.1	23.4	125	99.0	8.3	18.2	1.4	86.7	Hysplit/CheM	KA05
	NIP	8/13-16,2000	—	—	—	—	60	89.7-92.2	6.7-15.0	6.9-22.1	0.1-0.7	33.3-69.6	MM5/CMAQ	JI06
	E US.	7/1-8/15,2004	8.5	16.9	16.4	25.3	—	—	—	—	—	—	Eta/CMAQ[a]	YU07
	E US.	7/1-8/15,2004	4.3	14.8	7.0	18.2	—	—	—	—	—	—	Eta/CMAQ[b]	YU07
	EU	Spring/summer, 2004-2006	0-5.6 μg m^{-3}	0.83-20.1 μg m^{-3}			180 μg m^{-3}	15-41				0.3-0.9	PREV'AIR	HO08
	EU	7/1-8/31,2005	-0.7	—	—	—	—	—	—	—	—	—	CHIMERE	SZ09
	S US	5/1-9/30,2009	4.5	16.8	9.5	26.7	80	94.0	5.2	31.3	5.3	94.1	WRF/Chem-MADRID	MT11/12
							60	75.3	21.7	46.1	1.6	71.1		
maximum 8-hr average O_3	NE US	8/1-10,2001					85	80.0	34.0	49.0	1.1	13.0	MM5/MAQSIP_RT	MC04
	NE US.	8/5-29,2002	8.3	18.2	15.1	25.4	85	85.8	18.1	26.7	0.7	64.0	MAQSIP-RT	KA05
	NE US	8/5-29,2002	2.8	13.0	5.0	18.6	85	76.2	17.6	36.4	1.4	74.6	MM5/Chem	KA05
	NE US	8/5-29,2002	-1.2	15.8	-2.1	22.5	85	89.5	5.8	7.1	0.3	76.3	Hysplit/Chem	KA05
	NE US	6/1-9/30,2004	10.2	15.7	22.8	28.1	85	98.9	14.2	41.0	2.3	82.1	Eta/CMAQ	ED06
	E US	7/1-8/15,2004	10.4	16.6	22.6	28.8	—	—	—	—	—	—	Eta/CMAQ	YU07
	E US	7/1-8/15,2004	6.5	13.9	11.9	19.7	—	—	—	—	—	—	Eta/CMAQ[c]	YU07
	NY	7/1-9/30,2004	6.5	12.8	—	—	—	—	—	—	—	—	Eta/CMAQ	HO07
	NY	1/1-3/31,2005	1.4	8.7	—	—	—	—	—	—	—	—	Eta/CMAQ	HO07
	NY	6/1-9/30,2005	4.7	13.0	—	—	—	—	—	—	—	—	Eta/CMAQ	HO07
	NY	7/1-9/30,2004	—	—	—	—	65	84.0-95.2	31.4-53.2	46.5-84.8	—	32.9-55.2	Eta/CMAQ	HO07
		1/1-3/31, 6/1-9/30,2005	—	—	—	—	85	96.1-99.8	0.0-29.0	0.0-58.3	—	N/A[d], 36.7-82.5	Eta/CMAQ	HO07
	NE US	7/14-8/17,2004	14.3	20.9	—	—	—	—	—	—	—	—	WRF/chem-1	MK07
	and		3.4	11.6	—	—	—	—	—	—	—	—	WRF/chem.-2[a]	MK07
	SE CA		11.9	16.6	—	—	—	—	—	—	—	—	WRF/chem.-2[b]	MK07
			17.0	23.2	—	—	—	—	—	—	—	—	CHRONOS	MK07
			5.9	16.2	—	—	—	—	—	—	—	—	AURAMS	MK07
			26.4	31.0	—	—	—	—	—	—	—	—	STEM-2K3	MK07
			13.4	17.9	—	—	—	—	—	—	—	—	ET/CMAQ	MK07
	PN	8/1-9/30,2004	2.7	—	6	17	—	—	—	—	—	—	MM5/CMAQ	CH08
	NE US	8/12,2005	—	—	—	—	85	91.6	23.4	31.3	0.7	51.6	Eta/CMAQ	LE08
	E US	8/12,2005	—	—	—	—	85	90.4	24.3	37.5	0.9	59.1	Eta/CMAQ	LE08
	CONUS	8/12,2005	—	—	—	—	85	87.4	26.0	54.2	1.6	66.7	Eta/CMAQ	LE08
	E US	6/1-9/30,2005	10.9	16.3	22.4	27.1	—	—	—	—	—	—	WRF-NMM/CMAQ	ED09
	E US	6/1-9/30,2006	10.5	15.6	25.2	30.4	—	—	—	—	—	—	WRF-NMM/CMAQ	ED09
	E US	6/1-9/30,2007	7.9	14.5	16.5	24.1	—	—	—	—	—	—	WRF-NMM/CMAQ	ED09
	CONUS	6/1-8/31,2007	4.3	13.0	8.7	20.4	75	92.4	23.2	42.5	1.2	66.3	WRF-NMM/CMAQ	ED09
	CONUS	6/1-8/31,2007	—	—	—	—	85	96.9	15.4	32.2	1.4	77.3	WRF-NMM/CMAQ	ED09
	Eastern	8/31-10/12,2006	6.0	13.1			75		18.0	32.0		59.0	7-model ensemble [e]	DJ10
	Texas						85		6.0	10.0		70.0		

Table A4. Discrete and categorical evaluation of RT-AQF results for O_3 and $PM_{2.5}$ predictions (continued)

pollutants	Area	Period	MB	RMSE	NMB (%)	NME (%)	Threshold	A (%)	CSI (%)	POD (%)	B	FAR (%)	model	Author
maximum 8-h average O_3	S US	5/1-9/30, 2009	3.5	13.6	8.3	25.0	65	91.5	9.2	28.4	2.4	88.0	WRF/Chem-MADRID	MT11/12
							75	97.2	3.9	25.5	5.8	95.6		
							85	99.0	0.9	15.6	17.0	99.1		
hourly O_3	NE US	8/1-10,2001	-18.0 – 12.5	14.0 – 25.9	—	—	—	—	—	—	—	—	MM5/MAQSIP_RT [f]	MC04
	W EU	1999 – 2002	3.2–4.4	—	9.8–10.8	—	—	—	—	—	—	—	CHIMERE	BV04
	LP-S	6/21-23,2001	-13.2	—	—	—	—	—	—	—	—	—	UAM-V	OR04
	SP-B	8/2-5,11-14,1999	3.8–5.8	14.7–20.3	—	—	—	—	—	—	—	—	RAMS	DE05
	NIP	8/13-16,2000	0.52	6.7	1.7	30.8	—	—	—	—	—	—	MM5/CMAQ	JI06
	E US	7/1-8/15,2004	11.5	19.4	40.9	54.8	—	—	—	—	—	—	Eta/CMAQ [b]	YU07
	E US	7/1-8/15,2004	3.2	14.9	6.1	21.5	—	—	—	—	—	—	Eta/CMAQ [a, c]	YU07
	EU	Spring/summer, 2004-2006	12.3 µg m^{-3}	28.2 µg m^{-3}									PREV'AIR	HO08
	NA	6/8-7/13,/2007	-6.2	17.3									GEM-CHRONOS	MO08
	NA	2/2-3/8, 2008	-18.4	22.1									GEM-CHRONOS	MO08
	NA	6/8-7/13,/2007	-6.1	16.2									GEM-MACH15	MO08
	NA	2/2-3/8, 2008	-7.1	13.5									GEM-MACH15	MO08
	EU	7/1-8/31,2005	-4.7	—	—	—	—	—	—	—	—	—	CHIMERE	SZ09
	IP	2004	-8.3 – -9.7	13.5 – 14.5	-6.8 – -8.3	—	—	—	—	—	—	—	CHIMERE	VI09
	S US	5/1-9/30,2009	4.5	14.9	15.4	39.9	80	99.2	2.5	18.8	6.8	97.2	WRF/Chem-MADRID	MT11/12
24-h average $PM_{2.5}$	NY	7/1-9/30,2004	5.4	13.2	—	—	—	—	—	—	—	—	Eta/CMAQ	HO07
	NY	1/1-3/31,2005	6.2	14.5	—	—	—	—	—	—	—	—	Eta/CMAQ	HO07
	NY	6/1-7/31,2005	4.4	13.6	—	—	—	—	—	—	—	—	Eta/CMAQ	HO07
	NY	7/1-9/30,2004		—	—	—	15.5	60.8-89.7	22.5-53.7	24.3-90.9	—	25.0-55.0	Eta/CMAQ	HO07
		1/1-3/31, 6/1-7/31,2005		—	—	—	45.5	91.4-99.7	0-3.6	0-44.7	—	N/A[d], 96.2-100	Eta/CMAQ	HO07
	EUS	7/14-8/17, 2004		1.96									WRF/chem-1[c]	MK07
	EUS	7/14-8/17, 2004		1.86									WRF/chem.-2[g]	MK07
	EUS	7/14-8/17, 2004		2.03									WRF/chem.-2[h]	MK07
	EUS	7/14-8/17, 2004		1.96									CHRONOS	MK07
	EUS	7/14-8/17, 2004		1.92									AURAMS	MK07
	EUS	7/14-8/17, 2004		1.77									STEM-2K3	MK07
	EUS	7/14-8/17, 2004		1.79									Eta/CMAQ	MK07
	EUS	7/14-8/17, 2004		1.68									6-model ensemble [i]	MK07
	EUS	7/14-8/17, 2004		1.69									6-model ensemble [i]	MK07
	PN	8/1-11/30,2004	2.1-2.2	—	17-32	70-81	—	—	—	—	—	—	MM5/CMAQ	CH08
	E US	7/14-8/18,2004	-3.2	8.8	-21.0	41.2	—	—	—	—	—	—	Eta/CMAQ	YU08
	eastern	8/31-10/12,2006	-1.3	5.5			31.5		0.0	0.0		100	7-model ensemble [e]	DJ10
	Texas						16.5		8.0	14		80		
	NA	Summer 2008	-2.08	12.8									GEM-CHRONOS	MA09
	NA	Winter 2008	0.86	14.1									GEM-CHRONOS	MA09
	NA	Summer 2009	-0.70	12.9									GEM-CHRONOS	MA09
	NA	Summer 2008	0.69	13.5									GEM-MACH15	MA09
	NA	Winter 2008	-0.18	15.9									GEM-MACH15	MA09
	NA	Summer 2009	2.08	13.6									GEM-MACH15	MA09
	S US	5/1-9/30,2009	-0.6	5.9	-5.6	37.0	15.5	78.0	20.6	29.1	0.7	58.8	WRF/Chem-MADRID	MT11/12
							45.5	99.5	0.0	0.0	1.9	100.0		

Table A4. Discrete and categorical evaluation of RT-AQF results for O_3 and $PM_{2.5}$ predictions (continued)

Hourly $PM_{2.5}$	E US	7/14-8/18,2004	-3.3	11.3	-21.1	51.4	—	—	—	—	—	—	Eta/CMAQ	YU08
	S US	5/1-9/30,2009	-0.6	8.3	-5.2	49.8	15.0	72.1	20.5	29.2	0.7	59.1	WRF/Chem-MADRID	MT11/12
24-h average PM_{10}	ME	March, June, July, 2001								31-65		78-98	AAQFS	MA01b
	OS	11/01,1999 – 04/30, 2000	-20.9 to 13.8 [j]	37.9-47.2	-36.5 to 24 [j]								MM5- AirQUIS	BE02
	EU	Summer, 2004-2006	-3.5 to -1.3	8.3-8.9									PREV'AIR	HO08
		Winter, 2004-2006	-5.7 to -1.5	12.5-14.3										
	IP	6/19-7/12, 2006	-29				30.0	29.2-54.2	15.0-54.2	15.0-54.2	0.5-0.9	0	MM5/CMAQ	JI08
							50.0	16.7-79.2	9.1-16.7	9.1-16.7	0.8-0.9	0		
			-7				30.0	95.8-100	95.2-100	100.0	0.9	0-4.8	MM5/CMAQ/DREAM	
							50.0	70.8-95.8	68.2-83.3	68.2-83.3	0.9	0		
	NE	2005		15.4									LOTOS-EUROS	MAN09
	NE	2004-2006	-13.2	16.3					8.3					
	NE	2004-2006	-0.03 to -1.3	9.1-9.6					44.5-49.2				LOTOS-EUROS With bias correction	

1. MB: Mean Bias; RMSE: Root Mean Square Error; NMB: Normalized Mean Bias; NME: Normalized Mean Error; A: Accuracy; CSI: Critical Success index; POD: Probability Of Detection; B: Bias; FAR: False Alarm Ratio.
2. The unit for MB, RSME, and threshold are ppb for O_3 (except those indicated) and $\mu g\ m^{-3}$ for $PM_{2.5}$.
3. Superscripts a:all data pairs are included without cutoff threshold value; b: cutoff threshold value for O_3 concentrations is 40 ppb; c: based on the EPA NET-96 emissions inventory for the United States, and a 1985 base year inventory for Canada at a horizontal resolution of 27-km; d: An FAR of N/A indicates that no exceedances were predicted by the AQF model; e: the seven models include: WRF/chem-2 (27-km), WRF/chem-2 (12-km), CHRONOS, AURAMS, STEM-2K3, BAMS (15-km), and NMM/CMAQ; f: cutoff threshold value for O_3 concentrations is 60 ppb; g: based on the EPA NEI-99 inventory for the United States and a 2000 base year inventory for Canada at a horizontal resolution of 27 km; h: the same as g but at a horizontal resolution of 12 km; i: the six models include: WRF/chem (36-km), WRF/chem. (12-km), CHRONOS, AURAMS, STEM-2K3, and Eta/CMAQ; j: calculated based on data reported in this paper.
4. S US: Southeastern U.S.; E US: Eastern U.S., NE US: Northeastern U.S.; PN: Pacific Northwest; NY: New York State; EU: Europe; W EU: Western Europe; SE CA: southeastern Canada; LP-S: La Plana, Spain; SP-B: São Paulo, Brazil; NIP: Northeastern Iberian Peninsula; IP: Iberian Peninsula; NA: North America; ME: Melbourne, Australia; OS: Oslo, Norway; NE: the Netherlands.
5. See a list of acronym in the Appendix for all model names
6. MT11/12: Chuang et al. (2011)/Chuang et al. (2012); MA01a: Manins (2001a); MA01b: Manins (2001b); SC01: Schmidt et al. (2001); BV04: Blond and Vautard (2004); CO04: Cope et al. (2004); MC04: McHenry et al. (2004); OR04: Ortega et al. (2004); DE05: de Freitas et al. (2005); CH05: Cope and Hess (2005); KA05: Kang et al. (2005); ED06: Eder et al. (2006); HO07: Hogrefe et al. (2007); JI06: Jiménez et al. (2006); MK07; McKeen et al. (2007); YU07: Yu et al. (2007); CH08: Chen et al. (2008); MO08: Moran and Crevier, 2008; MA09: Makar et al., 2009; ED09: Eder et al. (2009); LE08: Lee et al. (2008); YU08: Yu et al. (2008); HO08: Honoré et al., 2008; SZ09: Szopa et al. (2009); VI09: Vivanco et al. (2009); BE02: Berge et al., 2002; JI08: Jiménez et al. (2008); MAN09: Manders et al. (2009); DJ10: Djalalova et al. (2010).

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Appendix: List of Acronyms and Symbols

Acronyms and Symbols	Definitions
3-D	Three-dimensional
3D-Var	Three-dimensional variational method
4D-Var	Four-dimensional variational method
A	Accuracy
AAQFS	The Australian Air Quality Forecasting System
AASQAs	The Association agréées de surveillance de la qualité de l'air
ACCENT+	Atmospheric Composition Change: a European Network- Plus
ACE Asia	The Asian Aerosol Characterization Experiment
ADB	Aerosol Dynamics Basic research mode only
ADMS-Urban	The Atmospheric Diffusion Modeling System for Urban planning
ADOM	The Acid Deposition and Oxidants Model
AEC	The AER/EPRI/Caltech SOA model
AEROCOM	Aerosol Comparisons between Observations and Models
aFAR	Area false-alarm ratio
AFR	Air Force Regulation
aH	Area hit
AIRNow	The Aerometric Information Retrieval Now network
AIRPACT	The Air Indicator Report for Public Access and Community Tracking
AirQUIS	Air QUality Information System
NILU	The Norsk Institutt for LUftforskning (Norwegian Institute of Ai Research)
ALADIN	The Aire Limitée Adaptation Dynamique Développement InterNational
ANNs	Artificial neural networks
AOD	Aerosol optical depth
API	Air pollution index
APP	Air pollution potential
AQF	Air quality forecasting
AQFMS	Air Quality Forecast Modeling System
AQI	Air quality index
AQMs	Air quality models
ASHOE	The Airborne Southern Hemisphere Ozone Experiment
AURAMS	A Unified Regional Air-quality Modelling System
ARGOS/DEMA	The Accident Reporting and Guidance Operational System of The Danish Emergency Management Agency
ARIMA	Auto-Regressive Integrated Moving Average model
ARPEGE	Action de Recherche Petite Échelle Grande Échelle (Action Research from large to small scale, a global numerical weather prediction system developed by Météo France)
ARW	The Advance Research Weather Research and Forecast
B	Bias
BAMS	The Baron Advanced Meteorological System, Inc.
BASTER	Base de données en temps reel (real-time database)
BCONs	Boundary conditions
BEIS	Biogenic Emissions Inventory System

Acronyms and Symbols	Definitions
BL	Boundary layer
BLUE	The Best Linear Unbiased Estimator
$BrONO_2$	Bromine nitrate
BS	Brier score
BSC-CNS	Barcelona Supercomputing Center – Centro Nacional de Supercomputación
BVOCs	Biogenic volatile organic compounds
C_6H_6	Benzene
CAA	The Clean Air Act
CAC	Chemistry Aerosol Cloud (CAC) model
CALMET	The California Meteorological model
CALGRID	The California Grid model
CALIOPE	An air quality forecasting system for Spain developed under The CALIOPE project funded by The Spanish Ministry of The Environment
Caltech	The California Institute of Technology
CAM	Canadian Aerosol Module
CAMx	Comprehensive Air quality Model with extensions (CAMx)
CAMO	The cellular automata traffic model
CAQI	The Common Air Quality Index
CAR-FMI	Contaminants in The Air from a Road of The Finnish Meteorological Institute
CART	Classification And Regression Trees
CASTNET	Clean Air Status and Trends Network
CB05	The 2005 version of carbon bond gas-phase mechanism
CB05Cl	The CB05 mechanism with chlorine extensions for The troposphere
CB05-TU	The CB05 with a new toluene mechanism
CB6	The carbon bond gas-phase mechanism version 6
CBM-Z	The carbon bond mechanism – version Z
CCN	Cloud condensation nuclei
CCSR/NIES/FRCGC	The Center for Climate System Research/National Institute for Environmental Study/Frontier Research Center for Global Change, Japan
CDA	Chemical data assimilation
CETEMPS	The Center of Excellence for The integration of remote sensing Techniques and numerical Modelling for The Prediction of Severe weather
CF	Coarse and Fine
CFD	Computational Fluid Dynamical models
CFORS	The Chemical Weather Forecast System
CFreq	The climatological frequency
CHASER	CHemical Atmospheric general circulation model for Study of atmospheric Environment and Radiative forcing
CFCs	Chlorofluorocarbons
CH_4	Methane
CHRONOS	The Canadian Hemispheric and Regional Ozone and NO_x System
CIT	The Carnegie Mellon/California Institute of Technology photochemical airshed model
CITEPA	Centre Interprofessionnel Technique d'Études de la Pollution Atmosphérique
Cl	Chlorine radical
Cl_2	Molecular chlorine

Acronyms and Symbols	Definitions
$ClONO_2$	Chlorine nitrate
CMAQ	The Community Multiscale Air Quality Modeling System
CMU	The Carnegie-Mellon University
CO	Carbon monoxide
CONAMA	The Comisión Nacional del Medio Ambiente of Chili
COST	The European Cooperation in Science and Technology
CSI	Critical success index or threat score
CSIRO	The Commonwealth Scientific and Industrial Research Organization of Australia Atmospheric Research
CTM	Chemical Transport Module (Model)
CTN-ACE	Italian National Focal Point on Atmospheric Emissions
DACFOS	The Danish Atmospheric Chemistry FOrecasting System
DAQM	The Denver Air Quality Model
DERMA	The Danish Emergency Response Model of The Atmosphere
DICTUC	Departamento de Investigaciones Cientificas y técnicas de la Universidad Catolica
DMI	Danish Meteorological Institute
DMS	Dimethyl sulfide
DMU - ATMI	Danmarks Miljøundersøgelser (DMU), Department of Atmospheric Environment, Afdelingen for ATmosfærisk MIljø (ATMI, The Department of Atmospheric Environment)
DREAM	The Danish Rimpuff and Eulerian Accidental release Model
DREAM	The Dust REgional Atmospheric Model
EAgrid 2000	East Asian Air Pollutant Emissions Grid Inventory
EBI	The Euler backwards iterative solver
EC	Elemental carbon
EC FP7	The European Commission Seventh Framework Programme
ECHAM5	A Global Climate Model developed based on ECMWF global forecast model by Max Planck Institute for Meteorology, HAMburg, version 5
ECMWF	The European Center for Medium-Range Weather Forecast
ECMWF-IFS-CTMs	ECMWF Integrated Forecast System with CTMs
EDGAR	The Emission Database for Global Atmospheric Research
EEA	European Environment Agency
EFA	The Ensemble Forecast of Analyses
EIM	An emissions inventory module used in AAQFS
EKF	The extended Kalman filter
EMEP	The European Monitoring and Evaluation Programme Model
EMEP-unified	The EMEP unified model that unifies previous versions of EMEP for acidification and oxidant modeling developed by The Norwegian Meteorological Institute
EMMA	The Emission Model for Mobile Machines
EMIMO	EMIssion Model
EMS-Beijing	The ensemble air quality multi-model forecast system for Beijing
EnKF	Ensemble Kalman filtering
Enviro-HIRLAM	Online coupled CTM-NWP model 'Environment - HIgh Resolution Limited Area', developed by The Danish Meteorological Institute

Acronyms and Symbols	Definitions
EOS	Earth Observing System
EPA	The U.S. Environmental Protection Agency
ESMERALDA	ÉtudeS Multi RégionALes De l'Atmosphère (Multi Regional Studies of The Atmosphere)
ESSA	The Environmental Science Services Administration
ETEX I and II	European Tracer EXperiment I and II
ETKF	Ensemble Transform Kalman Filter
EXPAND	The EXposure model designed especially for Particulate matter And Nitrogen oxiDes
EU	European Union
EURAD	The EURopean Air pollution Dispersion model
EV	economic value
FAR	false alarm ratio
FARate	false alarm rate
FARM	The Flexible Air quality Regional Model
FB	fractional bias
FDDA	The four-dimensional data assimilation
FGE	fractional gross error
FL	Fuzzy logic
FMI	Finnish Meteorological Institute
ForeChem	The Italian air quality Forecasting model
FRCGC	The Frontier Research Center for Global Change
FUMAPEX	Integrated Systems for Forecasting Urban Meteorology, Air Pollution and Population Exposure
GAMs	generalized additive models
GATOR-GCMOM	The gas, aerosol, transport, radiation, general circulation, mesoscale, and ocean model
GCM	General Circulation Model
GCTM	a global Chemical Transport Model
GEIA	Global Emissions Inventory Activity
GEM	Global Environmental Multiscale Model
GEM-AQ	The Global Environmental Multiscale weather prediction model with Air Quality processes
GEM-MACH15	a limited-area 15-km version of Global Environmental Multiscale model-Modelling Air quality and CHemistry
GEMS	Global and regional Earth-system (Atmosphere) Monitoring using Satellite and in-situ data
GEOS DAS	The Goddard Earth Observing System Data Assimilation System
GFDL	Geophysical Fluid Dynamics Laboratory
GFED	Global Fire Emission Database
GMES	The Global Monitoring for Environment and Security Programme
GOCART	The Georgia Tech/Goddard Global Ozone Chemistry Aerosol Radiation and Transport model
GOME	Global Ozone Monitoring Experiment
GOMOS	Global Ozone Monitoring by Occultation of Stars

Acronyms and Symbols	Definitions
GRANTOUR	Global Aerosol Transport and Removal model
GR-AQF	The global-regional air-quality forecasting model system
GRG MOZART	Global Reactive Gases The Model for OZone and Related chemical Tracers
GRS	The Generic Reaction SET Model for Ozone
HCHO	formaldehyde
HCl	hydrochloric acid
HERMES	The High-Elective Resolution Modelling Emission System
Hg	Mercury
HIRLAM	HIgh Resolution Limited Area Model
HKD	Hansen and Kuipers discriminant
HNO_3	Nitric acid
HNO_4	Peroxynitrous acid
HO_2	Hydroperoxy radical
HO_x	Hydrogen oxide radicals, =OH+HO_2
H^2O	The hydrophobic/hydrophilic organic molecular approach
H_2O_2	Hydrogen peroxide
HONO	Nitrous acid
HRate	Hit rate
HSS	Heidke skill score
H_2SO_4	Sulfuric acid
HYSPLIT	HYbrid Single-Particle Lagrangian Integrated Trajectory
HYSPLIT –CheM	HYSPLIT-Chemistry Model
ICARTT	The International Consortium for Atmospheric Research on Transport and Transformation
ICONs	Initial conditions
IDEA	Infusing satellite data into environmental applications
IFS	Integrated forecasting system
IMPACT	The Integrated. Massively Parallel Atmospheric Chemical Transport
INDOEX	The Indian Ocean Experiment
INERIS	The French National Institute for Industrial Environment and Risks
INTERREG IIIC	The European Union INTERREGional co-operation (strand C) programme
INTEX-B	The Intercontinental Chemical Transport Experiment-Phase B
IOA	Index of agreement
IPCC	Intergovernmental Panel on Climate Change
IPSL	The Institut Pierre-Simon Laplace
IVOCs	Intermediate volatility organic compounds
JCAP	Japan Clean Air Program
JPL-06 chemistry	The Jet Propulsion Laboratory 2006 mechanism
KF	The Kalman filter method
LACAPCD	Los Angeles County Air Pollution Control District
LAMI	The Limited Area Model Italy
LAPS	Limited Area Prediction System of Bureau of Meteorology, Australia
LES	Large Eddy Simulation
LETKF	Local Ensemble Transform KF
LMDzt-INCA	The Laboratoire de Météorologie Dynamique (Dynamic Meteorology Laboratory) – Zoom Tracers GCM with INteraction of Chemistry and Aerosol

Acronyms and Symbols	Definitions
LOTOS-EUROS	LOng Term Ozone Simulation - EURopean Operational Smog model
LRA	Linear Regression Analysis
MACC	Monitoring atmospheric composition & climate
MADE/SORGAM	The Modal Aerosol Dynamics Model for Europe/The Secondary Organic Aerosol Model
MADRID	The Model of Aerosol Dynamics, Reaction, Ionization, and Dissolution
MAGE	Mean absolute gross error
MAQSIP-RT	The Multiscale Air Quality Simulation Platform—Real Time
MATCH	Multiple-Scale Atmospheric Transport and Chemistry Modeling System (Sweden)
MATCH-MPIC	The Model of Atmospheric Transport and Chemistry- MPIC version
MATCH-NCAR	The Model of Atmospheric Transport and Chemistry developed at The U.S. National Center for Atmospheric Research
MB	Mean bias
Météo France	The French Meteorological Office
MDC	The Model Diagnostic and Correction approach
MEGAN	The Model of Emissions of Gases and Aerosols from Nature
MEGAPOLI	Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation
MELCHIOR1 and 2	The Mode lE Lagrangien de la CHImie de l'Ozone a l'échelle Régionale versions 1 and 2
MFB	Mean fractional bias
MFE	Mean fractional error
MICROSYS	Micro-scale air quality modeling system
MIRAGE 1 & 2	The Model for Integrated Research on Atmospheric Global Exchanges, versions 1 & 2
MM5	Mesoscale Model version 5
MM5/Chem	MM5 with Chemistry
MNB	Mean normalized bias
MNGE	Mean normalized gross error
MNFB	The mean normalized factor bias
MNGFE	The mean normalized gross factor error
MOCAGE	The Modèle de Chimie Atmosphérique à Grande Echelle
MODIS	MODerate-resolution Imaging Spectroradiometer
MOPPIT	Measurements Of Pollution In The Troposphere
MOS	The model output statistics
MOSAIC	The Model for Simulating Aerosol Interactions and Chemistry
MOST	The Monin-Obukhov similarity theory
MOZART-3 & 4	The Model for Ozone and Related chemical Tracers, versions 3 & 4
MPIC	Max-Planck-Institute for Chemistry
MSC	The Meteorological Service of Canada
MYJ	The Mellor-Yamada-Janjic scheme
Na^+	Sodium
NAAQSs	National Ambient Air Quality Standards
NaCl	Sodium chloride

Acronyms and Symbols	Definitions
U.K. NAEI	UK National Atmospheric Emissions Inventory
NAME III	The Numerical Atmospheric dispersion Modeling Environment model
$NaNO_3$	Sodium nitrate
NAQFC	The National Air Quality Forecast Capability
NAQPMS	The IAP/CAS nested air quality prediction modeling system
NCAR	The U.S. National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NEAQS	2004 New England Air Quality Study field experiment
NEI	National Emissions Inventory
NERI	National Environmental Research Institute, Denmark
NH_3	Ammonia
NINFA	North Italian Network to Forecast Aerosol pollution
NLR	Nonlinear regression
NMB	Normalized mean bias
NMBF	The normalized mean bias factor
NMC	The USWB National Meteorological Center
NMEF	The normalized mean error factor
NMGE	Normalized mean gross error
NMM	Nonhydrostatic mesoscale model
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_3	Nitrate radical
NO_x	Nitrogen oxides – The sum of NO and NO_2
NO_y	Reactive odd nitrogen species – includes NO_x and secondary nitrogen species, excludes N_2O
N_2O	nitrous oxide
N_2O_5	Dinitrogen pentoxide
NOAA	The U.S. National Oceanic and Atmospheric Administration
NRC	The U.S. National Research Council
NSW	New South Wales, Australia
NUDAPT	The National Urban Database and Access Portal Tool
NWP	Numerical Weather Prediction system
NWS/NCEP	The U.S. National Weather Service
O_3	Ozone
OA	Organic aerosol
OAD	Ozone Action Days
OH	Hydroxyl radical
OC	Organic carbon
OI	Optimal interpolation
OM	Organic matter
OOA	Oxygenated organic aerosol
OPANA	OPerational version of The Atmospheric Numerical pollution model for urban and regional Areas
OPPIO	Ozone and PM_{10} Polynomial Inference based on Observations
ORCHIDEE	Organizing Carbon and Hydrology in Dynamic Ecosystems dynamical vegetation model

Acronyms and Symbols	Definitions
OSPM	The Operational Street Pollution Model
PAN	Peroxyacytyl nitrate
Pb	Lead
PBL	Planetary boundary layer
PCA	Principal Components Analysis
PEACE-C	The Pacific Exploration of Asian Continental Emission phase C
PM_1	Airborne particulate matter with an aerodynamic diameter of 1 μm or less
PM_{10}	Airborne particulate matter with an aerodynamic diameter of 10 μm or less
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of 2.5 μm or less
POA	Primary organic aerosol
POD	Probability of Detection
POLINAT 2	The Pollution from Aircraft Emissions in The North Atlantic Flight Corridor
PPA	pair peak accuracy
Prev'air	Prévision de l'air (Air forecast)
PSI	The Pollutant Standard Index
PSS	Pierce skill score
PSSA	Peudo steady state approximation
r	Correlation coefficient
RACM	The Regional Atmospheric Chemistry Model
RADM	The U.S. EPA Regional Acid Deposition Model
RAMS	The Regional Atmospheric Modeling System
RANS	The Reynolds Average Navier Stokes model
REAS	Regional Emission Inventory in Asia
REMSAD	Regional Modeling System for Aerosols and Deposition
REPROBUS	The REactive Processes Ruling The Ozone BUdget in The Stratosphere (REPROBUS) model
RMSE	The root mean square error
Rn	Radon
ROM	The regional oxidant model
RPM	The Regional Particulate Model
RT-AQF	Real-time air quality forecasting
RTD	Research and Technological Development
SAPRC-90	The 1990 Statewide Air Pollution Research Center gas-phase mechanism
SAPRC-99	The 1999 Statewide Air Pollution Research Center gas-phase mechanism
SAPRC-07	The 2007 Statewide Air Pollution Research Center gas-phase mechanism
SCAPE II	Simulating Composition of Atmospheric Particles in Equilibrium, version 2
SCIAMACHY	SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY
SEEK	Singular Evolutive Extended KF
SEIK	Singular Evolutive Interpolated KF
SESAME	The Second European Stratospheric Arctic and Middle-Latitude Experiment
SILAM	System for Integrated modeLling of Atmospheric coMposition
SIREAM	The SIze REsolved Aerosol Model
SKIRON/TAPM	The SKIRON forecasting model/The Air Pollution Model
SMHI	Swedish Meteorological and Hydrological Institute
SMOKE	The Sparse Matrix Operator Kernel Emissions
SMVGEAR	The sparse-matrix vectorized GEAR code

Acronyms and Symbols	Definitions
SO_2	Sulfur dioxide
SO_x	Sulfur oxides
SOA	Secondary organic aerosol
SPEW	Speciated Particulate Emission Wizard
SPPA	Spatially-paired peak accuracy
SS	Skill score
STEM-I	Sulfur Transport Eulerian Model version I
STEM-2K3	The Sulfur Transport and Emissions Model 2003
STOCHEM	The Global 3-D Lagrangian chemistry-transport model
SVOCs	Semi-volatile organic compounds
TexAQS II/GoMACCS	The 2006 Second Texas Air Quality Study/Gulf of Mexico Atmospheric Composition and Climate Study
Denmark/DMU-ATMI THOR	Denmark/Danmarks Miljøundersøgelser (DMU)-_Afdelingen for Atmosfærisk Miljø (The National Environmental Research Institute (NERI)-Department of Atmospheric Environment) an Integrated Air Pollution Forecasting and Scenario Management System
TM5 (KNMI-cy3-GEMS)	Tracer Model version 5 (Koninklijk Nederlands Meteorologisch Instituut (KNMI), Royal Netherlands Meteorological Institute –cy3 - Global and regional Earth-system (Atmosphere) Monitoring using Satellite and in-situ data)
TNO	Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (The Netherlands Organisation for Applied Scientific Research Emissions Assessment Model (TEAM))
TOMS	The Total Ozone Mapping Spectrometer
TPPA	Temporally-paired peak accuracy
TRACE-P	The Transport and Chemical Evolution over The Pacific
TS	Threat score
TSS	True skill score
UAQIFS	Urban air quality information and forecasting system
UAM	Urban airshed model (The first three-dimensional air quality model for photochemical pollution
UAM- IV & V	Urban airshed model version IV & V
UAM-AERO/LT	The Long Term UAM with aerosols
UC	Urban canopy
UCMs	Urban canopy models
UN	United Nations
UNFPA	The United Nations Population Fund
UPA	Unpaired peak accuracy
URM1ATM	Urban to Regional Multiscale – one Atmosphere
USAF AWS	The U.S. Air Force Air Weather Service
USDA-FS	U.S. Department of Agriculture - Forest Service
USWB	The U.S. Weather Bureau
USWRP	The U.S. Weather Research Program
VBS	Volatility basis-set
VOCs	Volatile Organic Compounds (typically excluding methane)
VSRM	Variable size resolution model

Acronyms and Symbols	Definitions
WHO	The World Health Organization
WRF	The Weather Research and Forecast model
WS10	Wind speed at 10-m
WSI	The weighted success index
YSU	The Yonsei University scheme