WHAT IS CMAQ
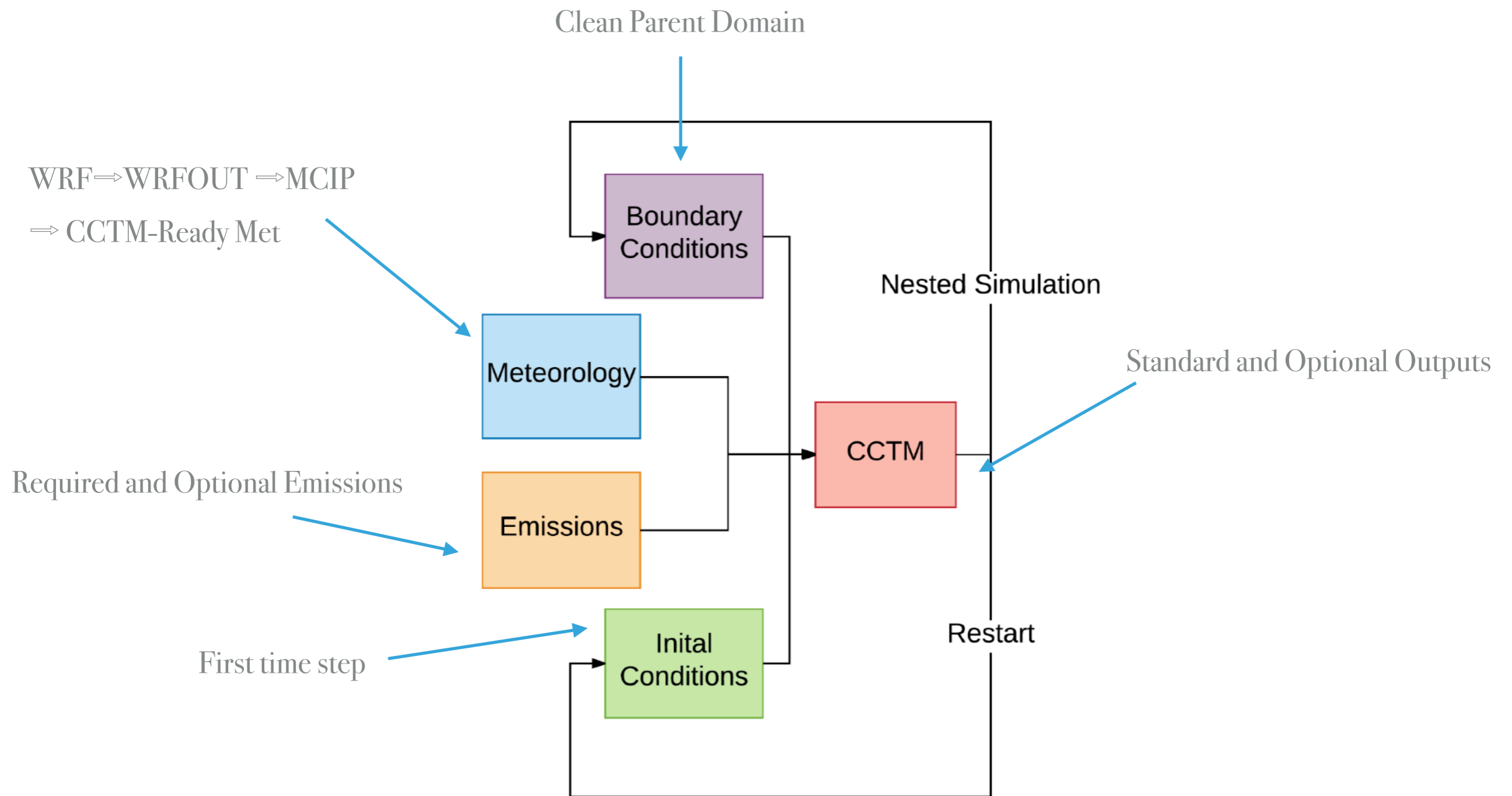
▸ Community Multi-scale Air Quality Modelling System, first version was released in 1998

▸ "an active open-source development project of the U.S. EPA that consists of a suite of programs for conducting air quality model simulations." (EPA)

▸ ".. combines current knowledge in atmospheric science and air quality modelling, multi-processor computing techniques, and an open-source framework to deliver fast, technically sound estimates of ozone, particulates, toxics and acid deposition." (EPA)

BASIC STRUCTURE

Clean Parent Domain

WRF⇒WRFOUT ⇒MCIP
⇒ CCTM-Ready Met

Boundary
Conditions

Nested Simulation

Meteorology

Standard and Optional Outputs

Required and Optional Emissions

Emissions

CCTM

First time step

Inital
Conditions

Restart

INSTALLING CMAQ

▸ Four main CMAQ programs are: the initial conditions processor (ICON), the boundary conditions processor (BCON), the meteorology-chemistry interface processor (MCIP), the CMAQ chemistry-transport model (CCTM)

▸ There are lots of steps in the installation process. It ended up being much too complicate for me to install on my own.

▸ Installation Instructions (https://github.com/USEPA/CMAQ/blob/5.2/DOCS/ User_Manual/CMAQ_OGD_ch05_sys_req.md)

▸ Github (https://github.com/USEPA/CMAQ)

FOUR MAIN CMAQ PROGRAMS

▸ Initial conditions processor: generates initial conditions for individual model species.

▸ Boundary conditions processor: generates boundary conditions for individual model species.

▸ Meteorology-chemistry interface processor: acts as post-processor to meteorological model and pre-processor to CMAQ modelling system. Takes meteorological data as input and outputs meteorological fields in a form required by CMAQ.

▸ Chemistry-transport model: uses input data that was produced by other CMAQ programs/meteorological models to produce output files that include information such as average hourly concentration files, visibility estimates etc.

WHO USES IT?

▸ Centers for Disease Control and Prevention (CDC)

▸ EPA's Office of Air Quality Planning and Standards

▸ National Weather Service's Air Quality Forecast

▸ University research

▸ Graduate theses

▸ Many more Government, Local, Private, and Academic institutions

CMAQ Downloads by Country Since September, 2005 (All versions)

CMAQ Downloads

- <= 50
- 51 - 150
- 151 - 500
- 501 - 1000
- 1001 - 2000
- 2001 - 10000
- 10001 - 12500

Labels on map:
1744, 12058, 224, 8, 211, 10, 18, 95, 13, 619, 288, 68, 4, 19, 12, 29, 27, 1, 5, 61, 22, 21, 11, 2, 35, 628, 1085, 113, 137, 251, 75, 183, 348, 223, 52, 70, 28, 38, 55, 8, 7, 3, 204, 91, 15, 14, 26, 16, 488, 10013, 1166, 20, 723, 1284, 472, 100, 142, 169, 2489, 161, 32

Scale: 0 1,875,000 3,750,000 7,500,000 Meters

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WILDLAND FIRES

▸ Fires emit smoke that can affect the air quality in the surrounding area. CMAQ can model how emissions from the fire are transported downwind and how the smoke will react with the atmosphere.

▸ CMAQ takes as input daily wild fire emissions and outputs ambient composition and deposition estimates for a lot of different pollutants (Ozone, particulate matter, air toxics etc.)

▸ Fire emissions are based on the amount of vegetation in the area around the fire as well as factors that are specific to the vegetation type. This information can be found on the Bluesky framework.
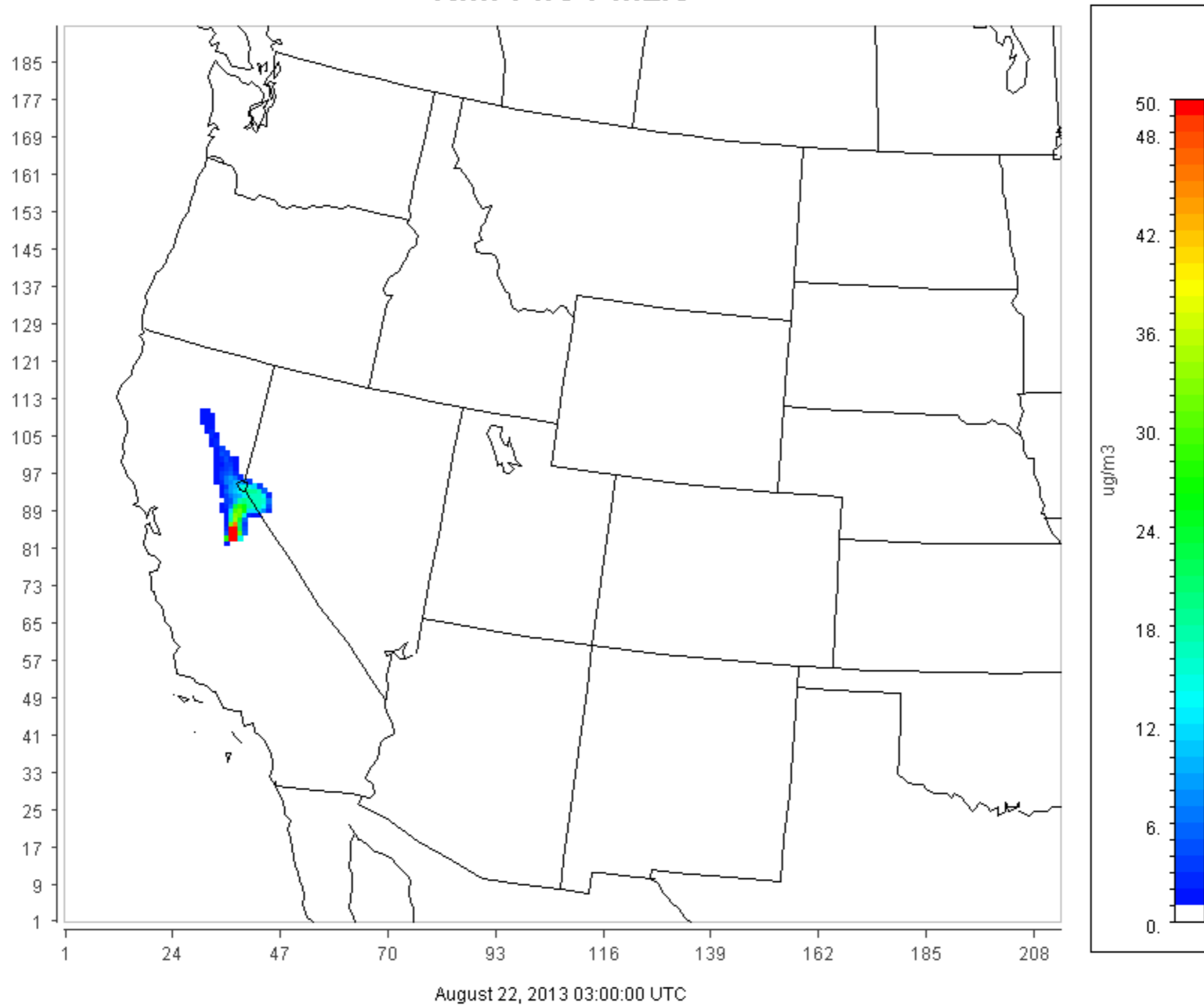
Time-lapse of CMAQ predicted PM$_{2.5}$ concentrations from a wildland fire in California

OVERVIEW OF SCIENCE PROCESSES

▸ https://www.epa.gov/cmaq/overview-science-processes-cmaq

ASSUMPTIONS MADE

▸ [Science documentation - page 3](https://www.cmascenter.org/cmaq/science_documentation/pdf/ch06.pdf) (https://www.cmascenter.org/cmaq/science_documentation/pdf/ch06.pdf)

OUTPUT

▸ Once the model is run, a ton of output files are created, each containing different information from CMAQ.

▸ They are all netCDF files and must be downloaded from the server to a local computer and then opened in a program that is equipped to deal with netCDF files (i.e. panoply)

Name	^	Date Modified	Size	Kind
CCTM_ACONC_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	174.4 MB	netCDF Dataset
CCTM_AOD_DIAG_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	779 KB	netCDF Dataset
CCTM_APMDIAG_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	1.05 GB	netCDF Dataset
CCTM_APMVIS_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	3.1 MB	netCDF Dataset
CCTM_B3GTS_S_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	16.1 MB	netCDF Dataset
CCTM_CGRID_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	255.4 MB	netCDF Dataset
CCTM_CONC_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	5.96 GB	netCDF Dataset
CCTM_DEPV_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	41.5 MB	netCDF Dataset
CCTM_DRYDEP_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	107.6 MB	netCDF Dataset
CCTM_DUSTEMIS_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	43.8 MB	netCDF Dataset
CCTM_LTNGCOL_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	779 KB	netCDF Dataset
CCTM_LTNGHRLY_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	26.9 MB	netCDF Dataset
CCTM_MEDIA_CONC_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	3.1 MB	netCDF Dataset
CCTM_PHOTDIAG1_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	45.3 MB	netCDF Dataset
CCTM_PHOTDIAG2_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	1.21 GB	netCDF Dataset
CCTM_PMDIAG_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	1.05 GB	netCDF Dataset
CCTM_PMVIS_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	3.1 MB	netCDF Dataset
CCTM_SOILOUT_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	882 KB	netCDF Dataset
CCTM_SSEMIS_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	11.5 MB	netCDF Dataset
CCTM_VDIFF_DIAG_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:35 AM	6.2 MB	netCDF Dataset
CCTM_VSED_DIAG_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	161.3 MB	netCDF Dataset
CCTM_WETDEP1_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	103 MB	netCDF Dataset
CCTM_WETDEP2_v52_gcc_SE52BENCH_20110701.nc		Yesterday, 11:37 AM	111.4 MB	netCDF Dataset
LOGS		Yesterday, 11:37 AM	--	Folder

INPUT

▸ "The input files for CMAQ consist of a domain definition file for all programs; two sets of file options for both ICON and BCON; two types of input files (WRF/MM5 and terrain) for MCIP; five mandatory and one optional input file for JPROC; and for CCTM, emissions, initial conditions, and boundary conditions files, six files that define the meteorological conditions to be simulated, and a photolysis rates file. For most CCTM input, a separate data set is required for each horizontal domain that is modelled. When CMAQ is configured for in-line emissions and deposition, there are additional emissions input files that are required." (CMAQ Github)

▸ Input Files (https://github.com/USEPA/CMAQ/blob/5.2/DOCS/User_Manual/CMAQ_OGD_ch08_input_files.md)

CHEMISTRY

▸ [Version 6 of the Carbon Bond Mechanism](https://www.tceq.texas.gov/assets/public/implementation/air/am/committees/pmt_set/20101014/20101014-GregYarwood-CB6.pdf) (https://www.tceq.texas.gov/assets/ public/implementation/air/am/committees/pmt_set/20101014/20101014- GregYarwood-CB6.pdf)

▸ There are a ton of elements, even though many listed are not regulated, some can turn into ones that are regulated so all are listed and kept track of. (ex. page 13 of link above)

ADDING CHEMICALLY INERT TRACER SPECIES

‣ https://github.com/USEPA/CMAQ/blob/5.2.1/DOCS/Tutorials/CMAQ_Tracers.md