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| **WORLD METEOROLOGICAL ORGANIZATION**  **COMMISSION FOR BASIC SYSTEMS OPAG on DPFS**  **EXPERT TEAM ON EMERGENCY RESPONSE ACTIVITIES (ET-ERA)**  VIENNA, AUSTRIA, 1-5 OCTOBER 2018 |  | CBS-DPFS/ET-ERA/Doc. 4.5(1)  (7.IX.2018)  \_\_\_\_\_\_\_  Agenda item : 4.5  ENGLISH ONLY |

**Update on the RSMC TCM Website Development**

*(Submitted by RSMC Washington)*

**Summary and purpose of document**

This document provides background information on the development of a prototype web site to display results of the RSMC TCM modeling approach to dispersion modeling.

**Action Proposed**

The meeting is invited to note and discuss the information presented in this paper and consider requesting the RSMCs to begin testing the sending of their Atmospheric Transport Model (ATM) products to the developmental prototype RSMC TCM web site developed by RSMC Washington.

**Reference:** -

<http://www.wmo.int/pages/prog/www/CBS-Reports/documents/Final-ReportET-ERABuenosAires2015.pdf>

<http://www.wmo.int/pages/prog/www/DPFSERA/Meetings/ET-ERA_BuenosAires2015/documents/Doc-4-5-2-Washington.doc>

<http://www.wmo.int/pages/prog/www/CBS-Reports/documents/Final-Report-ET-ERA-CollegePark2013.pdf>

<http://www.wmo.int/pages/prog/www/DPFSERA/Meetings/ET-ERA_College-Park2013/documents/Doc-4-5-1_RSMCWashington.doc>

<http://www.wmo.int/pages/prog/www/DPFSERA/Meetings/ET-ERA_College-Park2013/documents/Doc-4-5-2_RSMCWashington.doc>

**1.** I**NTRODUCTION**

**1.1 Proposed RSMC Use of Transfer Coefficient Matrix (TCM)**

In 2013 the ET-ERA was introduced to the Transfer Coefficient Matrix (TCM) at the CBS/ET-ERA meeting in College Park, MD, USA. The TCM was developed after Fukushima by RSMC Washington to allow the end user the flexibility to modify the source term and output products without having to rerun the lengthy ATM simulation again. In addition, information on applying the TCM approach in a proposed RSMC/IAEA exercise was described in 2013 and again in 2015 at the ET-ERA meeting in Buenos Aires, Argentina.

In the TCM approach, the dispersion model is run independently for a time series of segments using a unit source emission rate (1 unit/emission period) and 4 surrogate species that are dry and wet deposited as they are transported. Since the transport, dispersion, and deposition of any given species is completely independent of the actual source’s emission of that species, the dispersion model needs to be run only once. The concentration or deposition at any grid cell in the domain will be the sum of the contribution from each ATM emission segment after multiplying the resulting unit concentrations by the actual emission rate for each segment. Radioactive decay can also be applied during this post-processing step.

A TCM web interface (<http://www.ready.noaa.gov/ready_fdnppwmo.php>) was developed as a result of the work of the WMO Task Team on Meteorological Analyses for the Fukushima-Daiichi Nuclear Power Plant Accident (<http://www.wmo.int/pages/prog/www/DPFSERA/Meetings/ET-ERA_College-Park2013/documents/Doc-4-10-1.doc>).

This interface allowed the user to select not only the radiological species, but also one of several estimated source terms and dispersion model simulations (CMC, JMA, NOAA, UKMET, ZAMG) used by the Task Team or an ensemble mean of several combinations of simulations. In addition, measurements taken at several locations in Japan were overlaid on the model results and statistics provided to the user.

This document updates the ET-ERA on the progress of developing a TCM web site for the RSMC/IAEA program and documents how other RSMCs can contribute their model products to the site.

**2. Brief description of the TCM simulation at RSMC Washington**

The TCM approach is designed to simulate a long-lived continuous release by successive, independent, 6-h unit releases of radionuclides. At RSMC Washington, the HYSPLIT ATM is used to create the TCM files. Six hours into every forecast, the HYSPLIT model computational particles are saved so that they can be used to initialize the next run’s continuation of the transport and dispersion of those particles. The output particle positions are considered pseudo-analyses because they result from use of model analyses and short term forecasts (up to 6 hours). Every six hours new forecast meteorology becomes available and is called a 6-hour “cycle”. When the TCM is started for the first time, there exists one dispersion model run associated with an emission and one set of output files (particles and concentration) 6 hours into the forecast. With the next cycle there are two runs of the dispersion model. One is a new emission simulation; the second is called a “zero”, because there is zero (no) emission, but it is initialized with the particles that were output from the 1st cycle’s run. The zero can be thought of as bringing the previous emission up to the present time. With the 3rd cycle, there are 3 runs of the dispersion model. One is a new emission simulation; the other two are zeros – one from the 1st cycle’s emission, the other from the 2nd cycle’s emission. And so on. In other words, every 6-hours, when the new meteorological forecast becomes available, the TCM is run with a 6-h emission beginning at the start of the meteorological forecast and the set of zeros are run to bring all the previous emissions up to the present time.

Because particles do not need to be tracked forever, at some point, with every cycle, the oldest zero is dropped, meaning those particles are no longer tracked. This results in a constant number of dispersion run executions every cycle. However, when notified of a new incident/exercise (the release location presumably being different) the TCM run must start from “scratch” with a single emission.

Lastly, with any cycle, all the dispersion runs’ results can be combined, the source term and decay applied, and currently required RSMC graphics or other products created. If a revised source term becomes available, then revised products can be created using post-processing programs, without rerunning the dispersion model. This is a key feature of the system – dispersion is run once, post-processing can be easily run again as a new source terms become available.

**3. Experience of running the TCM in an operational setting at RSMC Washington**

The National Oceanic and Atmospheric Administration’s (NOAA) Air Resources Laboratory (ARL), the research part of RSMC Washington, is running the TCM unit-source dispersion job four times per day (00, 06, 12, 18 UTC) in a development account on the NOAA National Centers for Environmental Prediction (NCEP) supercomputer, sending the output dispersion files to an ARL web server for subsequent post-processing. The operational plan is to replace the current RSMC run at NCEP with this run, tentatively in 2019. The emission duration is currently set to 6-hourly, and concentrations/depositions[[1]](#footnote-1) are 6-h averages/accumulations. Current required RSMC output products for a typical RSMC/IAEA exercise scenario are also created with each TCM run because it is assumed they will still be required when the TCM is initially implemented into operations.

For this initial WMO demonstration, ARL recommends 6-h emissions and 6-h average concentrations because of the complexity of the run, potentially high resource requirements, and the need to keep the file sizes reasonable for transmission between centres. Later, based on analysis of the exercise results and ET-ERA recommendations, a subsequent version could be made with a higher resolution (the averaging time need not be the same as the emissions duration).

With each meteorological cycle, the TCM dispersion run is composed of successive forecast segments called “f000” and “f006”. Note, the f000 segment covers the pseudo-analysis time (first 6-h of the forecast) and the f006 covers the forecast period. f000 is a 6-hour simulation from the meteorological forecast initialization time (+0[[2]](#footnote-2)) to 6 hours after the forecast initialization (+6). f006 is a 78-hour simulation from +6 to the end of the forecast period (+84). For each of these two segments, there is one 6-h emission beginning at the start of the segment (+0 for f000, and +6 for f006). For example, say notification for an exercise is given at 1300 UTC, when the 06z is the current cycle. Typical release periods may be from 06-12 UTC or 12-18 UTC, which correspond to the f000 and f006 segments, respectively.

For releases other than the fixed 6-h periods of the TCM run, the release time is shifted to the nearest fixed periods. For example, with the 06z cycle of the typical exercise, if the requested release is from 13-19 UTC, in the TCM run the release will be from 12-18 UTC due to the fixed, available, release times. Clearly 1-h or 3-h emission cycles would help resolve shorter emissions, but then computer resource needs increase substantially.

For NMSs with new meteorological forecasts every 12 hours, as opposed to every 6 hours, the f006 segment described above will need to be split into a 6-hour duration f006 segment, again with f006.PARINIT output at the end as was done for f000.PARINIT, and a f012 segment with f012.PARINIT output 6-h into this period. The f012 segment will be initialized with the f006.PARINT particle positions. This is done so that releases into the near future will be able to be immediately run, rather than waiting until the next cycle. For example, with notification about 1400 UTC for a release from 12 – 18 UTC, for centres with a 06z cycle, the f006 can be used (valid from 12z through the end of the run) and for centres with a 00z cycle, the f012 segment can be used (valid from 12z through the end of the run).

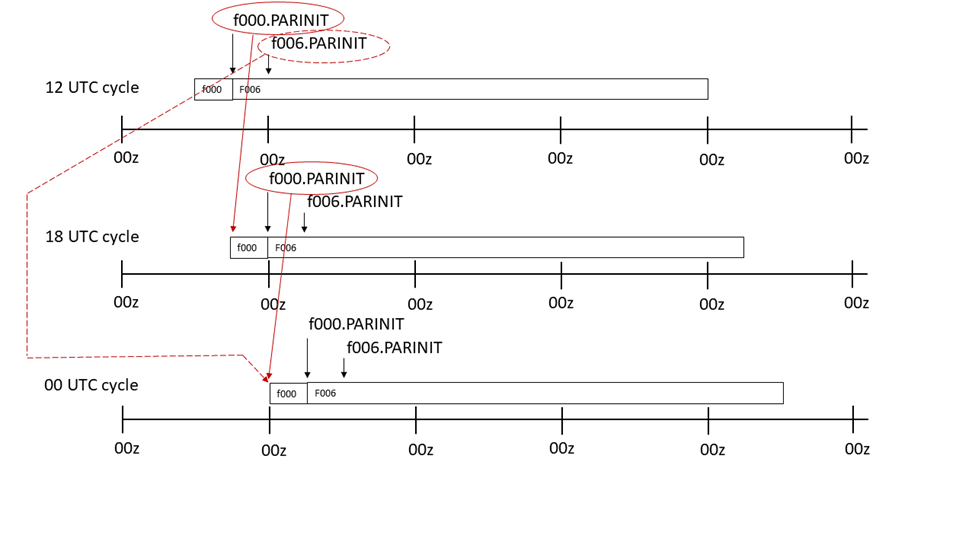


Fig. 1. Timeline showing successive 12, 18, and 00 UTC cycles. For all, at the end of the f000 segment particle positions are output and 6-hours into the f006 segment particle positions are output (depicted by black arrows). The f000 particle positions file for one cycle is used to initialize the f006 segment in the same cycle (no arrow shown) and the f000 segment of the next cycle (depicted by the red arrow and solid line). As an example of skipping the 18 UTC cycle, the f006 particle position file of the 12 UTC cycle can be used to initialize the f000 segment of the 00z cycle (red arrow and dashed line).

Output files saved on the supercomputer for a given cycle are called:

f000.PARINIT.YYYYMMDDHH

f000.cum\_arch.YYYYMMDDHH

f000.zerolist.txt

f006.PARINIT.YYYYMMDDHH

f006.cum\_arch.YYYYMMDDHH

f006z.zerolist.txt

f006.TG.YYYYMMDDHH

The “cum\_arch” files are the cumulative archive from the start of the release through the pseudo-analysis time (f000 for 6-h cycles, f006 for 12-h cycles). The “cum\_arch” files are used to create the “TG” TCM files. The “zerolist.txt” files give the dates/times of the zeroes for that cycle. Details are given in **Appendix II**.

Because input from the previous cycle is used to initialize the current cycle’s run, it is **very** important that cycles not be missed. Given how NMS numerical centres operate, it would be a rare occurrence to miss a cycle, however being able to operate through such an occurrence is prudent. One cycle can be skipped simply by starting from the model particle positions that were output from the f006 TCM segment instead of from the f000 particle position file. When multiple cycles are missed (extremely rare operational occurrence, however somewhat common for ARL’s development account because of computer maintenance), ARL runs a “catchup” script that is initialized from the last successful run, then each subsequent cycle is run to get up to the present. Further, as a development contingency, ARL downloads another set of output files, called ‘continuity’, every cycle to have a successful run that could be manually uploaded to the supercomputer, and the job re-started. These are most useful for ARL when NCEP swaps the operational (production) and backup (development) machines.

**4. ATM setup and required output files**

The ATM should be setup to run with four generic species (computational particles) as surrogates for the radionuclides and output in the following order (see table 1):

1. a relatively heavy (**Hpar**) particle with a large dry deposition velocity,
2. a relatively light (**Lpar**) particle with a small dry deposition velocity,
3. a depositing gas (**Dgas**) with a relatively large dry deposition velocity and wet removal, and
4. a non-depositing gas (**Ngas**) with no dry or wet removal.

The scavenging coefficients and removal rates should be the same as normally used by each RSMC in their ATM simulations, however, some suggestions for a dry deposition removal rate are provided in Table 1.

Table 1. Surrogate computational particles.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | Wet Removal | Dry Deposition | Possible surrogate for |
| Particle, heavy | Hpar | Yes | Yes (0.01 m/s) |  |
| Particle, light | Lpar | Yes | Yes (0.001 m/s) | Cs-137; I-131 |
| Gas, depositing | Dgas | Yes | Yes (0.01 m/s) | I-131 |
| Gas, non-depositing | Ngas | No | No | Noble gases |

The output concentration/deposition grid should be a regular-spaced, latitude-longitude grid. Although multiple output levels are possible, to limit the size of the output files, it is proposed that only the data from two levels are provided: a level at height “**0**” m AGL to define the deposition, and a level at “**500**” m AGL to represent the average concentration from the ground to 500 m AGL (current RSMC protocol). The gridded output should be on a global latitude-longitude grid with 0.5 degree latitude/longitude grid spacing and each cell is centered about the latitude-longitude point. The resulting concentration grid will be 721x361 grid points centered over the prime meridian (the lower-left corner point is located at 90 degrees South, 180 degrees West). Since the file size for such a large grid can be significant, and to allow currently developed post-processing programs to be easily able to read the output files, we propose using the output format described below (an example Fortran routine to write these files will be provided to the RSMCs). File sizes will vary by ATM and the number of non-zero grid points. Output files should be named according to the start of the release time:

***TG\_YYYYMMDDHH***, where ***YYYY*** is the 4-digit year, ***MM*** is the 2-digit month, ***DD*** is the 2 digit day and ***HH*** is the 2-digit hour (UTC) of the start of the 6 hour release period.

The concentration file format is the same used by RSMC Washington for the HYSPLIT ATM and the resulting files are compatible with the current RSMC TCM web site post-processing routines as well as numerous graphics and other output file manipulation programs. Concentration files may be written in either packed or unpacked format. Concentration file packing does not write the same information in fewer bytes, but rather writes the same information using twice as many bytes. The packed files are generally smaller because only concentration values at the non-zero grid points are written to the output file. However, this requires the grid point location to be written with the concentration data, hence the additional bytes. If most of the grid is expected to have non-zero concentrations, then the unpacked format will save space. However, for this global grid implementation, at least initially most of the grid will have zero values, and therefore the packed method is recommended. The output files should be as unformatted, big-Endian binary according to the specification in **Appendix I**.

**5. Uploading of RSMC TCM files to RSMC Washington**

It is recommended that the TCM files be updated by each RSMC at least every 12 hours and sent to the RSMC Washington (ARL) FTP server (ftp://arlftp.arlhq.noaa.gov/) for processing within approximately 6-12 hours after the model initialization times. The file should be placed in the same directory as the current RSMC uploads. Since each ***TG\_YYYYMMDDHH*** file is modified each time the ATM is run, all (from the beginning of the simulation) of the TG files should be tarred and compressed with GNU [gzip](https://www.gnu.org/software/gzip/) into a file with the following filename:

***TCM.tar.gz.partial,*** where “***partial***” refers to a partially uploaded file

To avoid the server processing the ensemble mean with a partially uploaded file, the file should be renamed to ***TCM.tar.gz*** once the file is finished uploading to the server (delete any previously uploaded file first). If the server does not find this filename, any previous TCM files will be deleted (clean-up process) and the file will not be processed by the server, and therefore also not be available to the end user.

The server will periodically check for newer TCM files on the FTP server, process them, and recalculate the ensemble mean of the unit-source runs. Therefore, if an RSMC no longer wishes their results be included in the ensemble calculation, or posted to the TCM web site, they need to delete the ***TCM.tar.gz*** file from the FTP upload directory.

**6. Prototype RSMC TCM web site**

Similar to the web site that was setup following Fukushima, as mentioned in the introduction, an initial implementation of the RSMC TCM web-based system (<https://www.ready.noaa.gov/rsmctcm/index.php>) was recently developed by ARL using a series of web pages that allows the end user to select up to four radionuclides, their emission rates, their particle type, and their radioactive half-life. After entering this information the user selects a location (latitude/longitude, city name, or WMO ID) where the program will then extract the model results and produce time-series graphs and maps of concentration and deposition at that location, thereby tailoring the results to locations of interest to the user (for example where ground measurements are available or at population centres). In addition, the server routinely calculates the ensemble mean concentration/deposition of all available RSMC TCM files and produces statistical graphics based on a unit-source emission and the light particle specie. (At this time, if RSMC Washington TCM files are available, it will only use a listing of available RSMC Washington file names to calculate the ensemble of other RSMC TCM files if the same files names are available in their directories.) The ensemble mean concentration/deposition TCM files, which may be better than any one set of RSMC TCM files, are also made available to the web user to allow the same post-processing of the results with a user-entered source term and location of time series.

The time to post-process the TCM files will depend on the number and size of the TCM files and possibly the number of users on the system, hence longer duration events will take longer to process.

**7. Possible limitations/considerations of the current system**

Until all the RSMCs have had a chance to upload their TCM files to the new prototype web site it is difficult to predict where some bottlenecks may occur and fixes may need to be made. However, based on the testing done so far with RSMC Washington products, the following items may present a challenge in the future that may need to be addressed:

1. Uploading of large TCM files may take too long to be useful especially for slow FTP connections and long duration events.
2. Given (1) above, hosting the web server may need to be done by only one organization instead of residing at each RSMC. Or as an alternative, the Lead RSMC, as chosen by IAEA (one location will need to be defined per region), could be the host server for a particular event and all other RSMCs send their products to only that server.
3. Should this RSMC TCM web site be hosted by IAEA or WMO, and if so, who will maintain the site? RSMC Washington does not have the resources to host the operational RSMC TCM web site.
4. Timing of background ensemble calculation versus receipt of RSMC products may allow simulations with varying end times
5. How far back in time should the TCM be able to start? For example is it possible to be notified of an event that started yesterday? 5 days ago? This has implications for the TCM “catchup” operational script.

**8. Summary of recommended TCM specifications/information**

1. 6-hour emissions (duration) cycle (unit emission per emission cycle)
2. Source uniformly distributed from the ground to 500 m above ground
3. 6-hour average concentrations and total deposition
4. Forecast duration is 84-h from the meteorological model initialization time (the cycle time)
5. Particles are tracked for at most 18 days, 15 days’ back plus 3 days’ forecast
6. Gridded output is on a global grid with 0.5 degree latitude/longitude grid spacing with 721x361 grid points centered over the prime meridian (90 degrees South, 180 degrees West is the lower-left corner point)
7. Emission start date/time is the key identifier in the filenames (*TG\_YYYYMMDDHH*)
8. Incident/exercise emission beginning at the midpoint of the 6-h TCM emission are moved back to the beginning of the 6-h TCM emission (incident emission start 09z corresponds to TCM emission starting 06z).
9. Files should be tarred and compressed and uploaded to RSMC Washington’s FTP server with a unique filename (***TCM.tar.gz.partial***) and renamed to ***TCM.tar.gz*** upon completion.

**9. Recommendations**

Given the successful post-facto application of the TCM approach for the Fukushima incident,

* RSMC Washington will give an overview of the current developmental prototype RSMC TCM web site at the next ET-ERA meeting in Vienna.
* Other RSMCs are encouraged to create TCM files in the appropriate format and naming convention and practice uploading them to the RSMC Washington FTP site and viewing the results through the prototype RSMC TCM web site.
* Upload TCM products for an IAEA exercise during 2019 to test the process.
* Consider at least one other site (RSMC, IAEA, WMO) to host a backup prototype RSMC TCM web page during 2019 in regard to the limitations/considerations described in Section 7, and because of anticipated staffing changes at ARL. A permanent location for an operational version of the web site also needs to be defined as RSMC Washington does not have the resources to host the operational TCM web server.
* Request IAEA assign radionuclides to the Hpar, Lpar, Dgas, Ngas surrogates and provide them to RSMC Washington for inclusion in the web scripts.

**10. RSMC Washington Future Work**

RSMC Washington plans to complete the simulated operational development of this approach and transfer the creation of the TCM files to operations at NCEP in 2019.

RSMC Washington plans to make any needed modifications to the prototype TCM web site for any unanticipated issues that may develop once other RSMC centres have had a chance to post their products to the site and/or propose suggestions for possible alternatives.

**APPENDIX I: Concentration/deposition output format**

Record #1

* CHAR\*4 Meteorological *MODEL* Identification
* INT\*4 Meteorological file starting time (*YEAR, MONTH, DAY, HOUR, FORECAST-HOUR*)
* INT\*4 *NUMBER* of starting locations
* INT\*4 Concentration packing flag (0=no 1=yes)

Record #2 Loop to record: Number of starting locations

* INT\*4 Release starting time (*YEAR, MONTH, DAY, HOUR*)
* REAL\*4 Starting location and height (*LATITUDE, LONGITUDE, METERS*)
* INT\*4 Release starting time (*MINUTES*)

Record #3

* INT\*4 Number of (*LATITUDE-POINTS, LONGITUDE-POINTS*)
* REAL\*4 Grid spacing (*DELTA-LATITUDE,DELTA-LONGITUDE*)
* REAL\*4 Grid lower left corner (*LATITUDE, LONGITUDE*)

Record #4

* INT\*4 *NUMBER* of vertical levels in concentration grid
* INT\*4 *HEIGHT* of each level (meters above ground)

Record #5

* INT\*4 *NUMBER* of different pollutants in grid
* CHAR\*4 Identification *STRING* for each pollutant

Record #6 Loop to record: Number of output times

* INT\*4 Sample start (*YEAR MONTH DAY HOUR MINUTE FORECAST*)

Record #7 Loop to record: Number of output times

* INT\*4 Sample stop (*YEAR MONTH DAY HOUR MINUTE FORECAST*)

Record #8 Loop to record: Number levels, Number of pollutant types

* CHAR\*4 Pollutant type identification *STRING*
* INT\*4 Output *LEVEL* (meters) of this record

No Packing (all elements)

* REAL\*4 Concentration output *ARRAY*

Packing (only non-zero elements)

INT\*4 Loop non-zero elements

* INT\*2 First (I) index value
* INT\*2 - Second (J) index value
* REAL\*4 - Concentration at (I,J)
* … repeat the above three values; times the number of non-zero elements

**Appendix II. Additional information on TCM dispersion runs**

This appendix contains the following information:

* Workflow – key points and detailed example of two successive cycles
* Information on how long particles are tracked and ‘dropping’ the oldest runs
* Example HYSPLIT input files for those RSMCs that run HYSPLIT – CONTROL and SETUP.CFG

I. Workflow.

Key points on runs:

1. Emission duration is 6-hours, meteorology cycle is either 6- or 12-hours.
2. Segments for a given cycle –
   1. f000 segment is a 6-h run for both 6- and 12-h meteorological cycles (pseudo-analysis; short-term meteorology forecast)
   2. f006 segment is a 6-h run when the meteorological cycle is 12-h (pseudo-analysis), but covers the period from 6-h to 84-h into the forecast with a 6-h meteorology cycle. In both cases, the run is initialized with the particles from the end of the f000 segment
   3. f012 segment is only run with 12-h meteorological cycle, and covers the period from 12-h to 84-h into the forecast. It is initialized with particles from the end of the f006 segment.
   4. TG files are created in the last segment in a cycle, and sent to the TCM web server
3. For the f000 segment, the emission starts at the meteorological forecast initialization time.
4. For non-starting-from-scratch cycles, the f000 segment is initialized with particles from the previous cycle. For 6-h meteorological cycles, the initialization is from the end of the f000 segment; for 12-h cycles, the initialization is from the end of the f006 segment.
5. Concentration/Deposition files –
   1. **CG\_first** has the 6-h average starting at the beginning of each segment
   2. **CG\_rest** has 6-h averagesfor the period AFTER the file **CG\_first**
6. Particle positions are output at the end time of the **CG\_first** file and named **PARINIT** because they can be used to initialize a subsequent run
7. TG files contain output starting at the beginning of the emission through the end of the forecast. For periods prior to the forecast, output is from short-term forecast meteorology (pseudo-analysis).
8. **cum\_arch** (cumulative archive) files are pseudo-analysis files from the beginning of the emission through 6 or 12-h into the forecast, for 6-h or 12-h meteorological cycles, respectively. This is used to create the TG files.
9. For every emission (not the zeros) the start date/time of the emission is written to text file **zerolist.txt**. This is used in subsequent segments/runs to know what zeroes to run.
10. Saved filenames include the segment identifier (e.g. f000) and emissions start time (YYYYMMDDHH).
11. Each dispersion model run is done in a unique working directory to allow for parallel processing. The name of the working directory is identified by the segment and emission start time. It is assumed cycle time and date are in the directory name and/or filename to uniquely identify files.

Here is an example for a 00 UTC cycle on 20180821, starting from scratch, assuming 12-h cycles, and a working directory named “working”, with the filenames and directory structure ARL is using.

1. The f000 segment is run first (duration 6 hours) –

A. 6-h emission starting at 2018082100

* 1. Subdirectory is working/000/2018082100/
  2. 6-h average concentrations written 6-h into run (e.g. at end) to file named **CG\_first**
  3. Particle positions written 6-h into run to file named **PARINIT**
  4. **CG\_first** is copied to **cum\_arch** (pseudo-analysis file)
  5. The start time of the emission (2018082100) is written to file **zerolist.txt**. When the f006 is run a zero will be run for the date in the file **zerolist.txt**.
     1. Save files for next segment.

**f000.PARINIT.2018082100**

**f000.cum\_arch.2018082100**

**f000.zerolist.txt**

1. The f006 segment is run next (duration 6 hours) (A and B can be run in parallel) –

A. 6-h emission starting at 2018082106

1. Subdirectory working/006/2018082106
2. 6-h average concentrations written 6-h into run to file named **CG\_first**
3. Particle positions written 6-h into run to file named **PARINIT**
4. **CG\_first** is copied to **cum\_arch**
5. Copy **zerolist.txt** (f000, Sec. 1.A.e) to here. Append the start time of the emission (2018082106) to file **zerolist.txt**. When the f012 is run zeroes will be run for the dates in the file zerolist.txt.

B. zero from emission starting at 2018082100

1. Subdirectory working/006/2018082100
2. Initialize with **f000.PARINIT.2018082100** (current cycle f000)
3. 6-h average concentrations written 6-h into run to file named **CG\_first**
4. Particle positions written 6-h into run to file named **PARINIT**
5. **CG\_first** is appended[[3]](#footnote-3) to **f000.cum\_arch.2018082100** (current cycle f000) and named **cum\_arch**
6. Save files for next segment.

**f006.PARINIT.2018082100** (Sec. B.d)

**f006.PARINIT.2018082106** (Sec. A.c)

**f006.cum\_arch.2018082100** (Sec. B.e)

**f006.cum\_arch.2018082106** (Sec. A.d)

**f006.zerolist.txt** (Sec. A.e)

**3.** The f012 segment is run last (duration 72 hours) (A, B, and C can be run in parallel) -

A. 6-h emission starting at 2018082112

* 1. Subdirectory working/012/2018082112
  2. 6-h average concentrations written 6-h into run to file name **CG\_first**
  3. 6-h average concentrations written every 6 hours for the rest of the run to file named **CG\_rest**
  4. Particle positions written 6-h into run to file named **PARINIT**
  5. **CG\_first** is copied to **cum\_arch**
  6. Copy **zerolist.txt** (from f006, this cycle, 2.A.e) to here. Append the start time of the emission (2018082112) to file **zerolist.txt**
  7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018080212**

B. zero from emission starting at 2018082106

1. Subdirectory working/012/2018082106
2. Initialize with **f006.PARINIT.2018082106** (current cycle f006, 2.C above)
3. 6-h average concentrations written 6-h into run to file named **CG\_first**
4. 6-h average concentrations written every 6 hours for the rest of the run to file named **CG\_rest**
5. Particle positions written 6-h into run to file named **PARINIT**
6. **CG\_first** is appended to **f006.cum\_arch.2018082106** (current cycle f006) and named **cum\_arch**
7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082106**

C. zero from emission starting at 2018082100

1. Subdirectory working/012/2018082100
2. Initialize with **f006.PARINIT.2018082100**
3. 6-h average concentrations written 6-h into run to file named **CG\_first**
4. 6-h average concentrations written every 6 hours for the rest of the run to file named CG\_rest
5. Particle positions written 6-h into run to file named **PARINIT**
6. **CG\_first** is appended to **f006.cum\_arch.2018082100** and named **cum\_arch**
7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082100**
8. Save files

**f012.PARINIT.2018082100**

**f012.PARINIT.2018082106**

**f012.PARINIT.2018082112**

**f012.cum\_arch.2018082100**

**f012.cum\_arch.2018082106**

**f012.cum\_arch.2018082112**

**f012.zerolist.txt**

**TG\_2018082100**

**TG\_2018082106**

**TG\_2018082112**

Continuing the example for the next cycle, 12 UTC on 20180821. The working directory is “working2”.

1. The f000 segment is run first (duration 6 hours) (A, B, and C can be run in parallel) –

A. 6-h emission starting at 2018082112

* 1. Subdirectory is working2/000/2018082112/
  2. 6-h average concentrations written 6-h into run to file named **CG\_first**
  3. Particle positions written 6-h into run to file named **PARINIT**
  4. **CG\_first** is copied to **cum\_arch**
  5. Copy previous cycle **f006.zerolist.txt** to working directory **zerolist.txt** (This has 2018210800 and 2018210806, the pseudo-archive.) Append the start time of the emission (2018082112) to file **zerolist.txt**.

B. zero from emission starting at 2018082106

a. Subdirectory working2/000/2018082106

1. Initialize with **f006.PARINIT.2018082106** (previous cycle)
2. 6-h average concentrations written 6-h into run to file named **CG\_first**
3. Particle positions written 6-h into run to file named **PARINIT**
4. **CG\_first** is appended to **f006.cum\_arch.2018082106** (previous cycle) and named **cum\_arch**

C. zero from emission starting at 2018082100

* 1. Subdirectory working2/000/2018082100
  2. Initialize with **f006.PARINIT.2018082100** (previous cycle)
  3. 6-h average concentrations written 6-h into run to file named **CG\_first**
  4. Particle positions written 6-h into run to file named **PARINIT**
  5. **CG\_first** is appended to **f006.cum\_arch.2018082100** and named **cum\_arch**

1. Save files

**f000.PARINIT.2018082100**

**f000.PARINIT.2018082106**

**f000.PARINIT.2018082112**

**f000.cum\_arch.2018082100**

**f000.cum\_arch.2018082106**

**f000.cum\_arch.2018082112**

**f000.zerolist.txt**

1. The f006 segment is run next (duration 6 hours) -

A. 6-h emission starting at 2018082118

a. Subdirectory working2/006/2018082118

1. 6-h average concentrations written 6-h into run to file named **CG\_first**
2. Particle positions written 6-h into run to file named **PARINIT**
3. **CG\_first** is copied to **cum\_arch**
4. Copy **zerolist.txt** (f000 this cycle, Sec. 1.A.e) to here. Append the start time of the emission (2018082118) to file **zerolist.txt**

B. zero from emission starting at 2018082112

a. Subdirectory working2/006/2018082112

1. Initialize with **f000.PARINIT.2018082112** (current cycle f000)
2. 6-h average concentrations written 6-h into run to file named **CG\_first**
3. Particle positions written 6-h into run to file named **PARINIT**
4. **CG\_first** is appended to **f000.cum\_arch.2018082112** (current cycle f000) and named **cum\_arch**

C. zero from emission starting at 2018082106

a. Subdirectory working2/006/2018082106

1. Initialize with **f000.PARINIT.2018082106** (current cycle f000)
2. 6-h average concentrations written 6-h into run to file named **CG\_first**
3. Particle positions written 6-h into run to file named **PARINIT**
4. **CG\_first** is appended to **f000.cum\_arch.2018082106** (current cycle f000) and named **cum\_arch**

D. zero from emission starting at 2018082100

a. Subdirectory working2/006/2018082100

1. Initialize with **f000.PARINIT.2018082100** (current cycle f000)
2. 6-h average concentrations written 6-h into run to file named **CG\_first**
3. Particle positions written 6-h into run to file named **PARINIT**
4. **CG\_first** is appended to **f000.cum\_arch.2018082100** (current cycle f000) and named **cum\_arch**
5. Save files for next segment.

**f006.PARINIT.2018082100**

**f006.PARINIT.2018082106**

**f006.PARINIT.2018082112**

**f006.PARINIT.2018082118**

**f006.cum\_arch.2018082100**

**f006.cum\_arch.2018082106**

**f006.cum\_arch.2018082112**

**f006.cum\_arch.2018082118**

**f006.zerolist.txt**

**3.** The f012 segment is run last (duration 72 hours) -

A. 6-h emission starting at 2018082200

* 1. Subdirectory working2/012/2018082200
  2. 6-h average concentrations written 6-h into run to file name **CG\_first**
  3. 6-h average concentrations written every 6 hours for the rest of the run to file named **CG\_rest**
  4. Particle positions written 6-h into run to file named **PARINIT**
  5. **CG\_first** is copied to **cum\_arch**
  6. Copy **zerolist.txt** (from f006, this cycle, 2.A.e) to here. Append the start time of the emission (2018082200) to file **zerolist.txt**
  7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082200**

B. zero from emission starting at 2018082118

* 1. Subdirectory working2/012/2018082118
  2. Initialize with **f006.PARINIT.2018082118** (current cycle f006)
  3. 6-h average concentrations written 6-h into run to file named **CG\_first**
  4. 6-h average concentrations written every 6 hours for the rest of the run to file named **CG\_rest**
  5. Particle positions written 6-h into run to file named **PARINIT**
  6. **CG\_first** is appended to **f006.cum\_arch.2018082118** (current cycle f006) and named **cum\_arch**
  7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082118**

C. zero from emission starting at 2018082112

a. Subdirectory working2/012/2018082112

1. Initialize with **f006.PARINIT.2018082112** (current cycle f006)
2. 6-h average concentrations written 6-h into run to file named **CG\_first**
3. 6-h average concentrations written every 6 hours for the rest of the run to file named **CG\_rest**
4. Particle positions written 6-h into run to file named **PARINIT**
5. **CG\_first** is appended to **f006.cum\_arch.2018082112** (current cycle f006) and named **cum\_arch**
6. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082112**

D. zero from emission starting at 2018082106

1. Subdirectory working2/012/2018082106
2. Initialize with **f006.PARINIT.2018082106** (current cycle f006)
3. 6-h average concentrations written 6-h into run to file named **CG\_first**
4. 6-h average concentrations written every 6 hours for the rest of the run to file named **CG\_rest**
5. Particle positions written 6-h into run to file named PARINIT
6. **CG\_first** is appended to **f006.cum\_arch.2018082106** (current cycle f006) and named **cum\_arch**
7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082106**

E. zero from emission starting at 2018082100

1. Subdirectory working2/012/2018082100
2. Initialize with **f006.PARINIT.2018082100**
3. 6-h average concentrations written 6-h into run to file named **CG\_first**
4. 6-h average concentrations written every 6 hours for the rest of the run to file named CG\_rest
5. Particle positions written 6-h into run to file named **PARINIT**
6. **CG\_first** is appended to **f006.cum\_arch.2018082100** and named **cum\_arch**
7. **CG\_rest** is appended to **cum\_arch** and named **TG\_2018082100**
8. Save files

**f012.PARINIT.2018082100**

**f012.PARINIT.2018082106**

**f012.PARINIT.2018082112**

**f012.PARINIT.2018082118**

**f012.PARINIT.2018082200**

**f012.cum\_arch.2018082100**

**f012.cum\_arch.2018082106**

**f012.cum\_arch.2018082112**

**f012.cum\_arch.2018082118**

**f012.cum\_arch.2018082200**

**f012.zerolist.txt**

**TG\_2018082100**

**TG\_2018082106**

**TG\_2018082112**

**TG\_2018082118**

**TG\_2018082200**

II. Particles are tracked for a given number of days (ARL defines variable num\_days\_back=11). In the f000 segment only, it is determined if any zeroes need to be dropped. If so, they are removed from **zerolist.txt** before the f000 is run.

III. Example HYSPLIT input file named CONTROL for an emission. The duration is 78-hours implying this is for an f006 segment, 6-h meteorological cycles.

18 08 24 12

2

35.74 135.99 0

35.74 135.99 500

78

0

14000.

1

/com2/hysplit/prod/hysplit.20180824/

hysplit.t06z.gfs0p5f

4

Hpar

1.0

006

00 00 00 00 00

Lpar

1.0

006

00 00 00 00 00

Dgas

1.0

006

00 00 00 00 00

Ngas

1.0

006

00 00 00 00 00

2

0.0 0.0

0.5 0.5

0.0 0.0

/working/loc1/006/2018082412/

CG\_first

2

0 500

00 00 00 00 00

00 00 00 006 00

00 6 00

0.0 0.0

0.5 0.5

0.0 0.0

/working/loc1/006/2018082412/

CG\_rest

2

0 500

00 00 00 006 00

00 00 00 00 00

00 6 00

4

1.0 1.0 1.0

0.01 0.0 0.0 0.0 0.0

0.0 8.0E-05 8.0E-05

0.0

0.0

1.0 1.0 1.0

0.001 0.0 0.0 0.0 0.0

0.0 8.0E-05 8.0E-05

0.0

0.0

0.0 0.0 0.0

0.01 0.0 0.0 0.0 0.0

0.08 0.0 0.0

0.0

0.0

0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0

0.0

0.0

IV. Example HYSPLIT input file named SETUP.CFG corresponding to the CONTROL file above.

&SETUP

delt = 20.0,

initd = 0,

khmax = 440,

mgmin = 200,

numpar = -1.000000e+04,

maxpar = 2.424000e+05,

maxdim = 1,

ninit = 1,

ndump = 006,

ncycl = 0,

pinpf = 'PARINIT',

poutf = 'PARINIT',

cpack = 1,

/

1. Further mention of “concentration” implies also deposition. [↑](#footnote-ref-1)
2. Times given with a plus sign are with respect to the meteorological model initialization (cycle) time, unless otherwise stated. [↑](#footnote-ref-2)
3. The HYSPLIT utility program ‘conappend’ can append one concentration file to another. [↑](#footnote-ref-3)