Aplicación del modelo AERMOD en la dispersión de contaminantes atmosféricos producidos por plantas termoeléctricas en Quito

Revisión del uso del programa

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Itinerario de hoy

Parte 1. Introducción

Modelo, programa & lenguajes

Parte 2. AERMOD.exe

Entradas

Salidas

Modelado de la dispersión de contaminantes en el aire

$$C = \frac{Q}{2\pi\sigma_x\sigma_y} g \exp\left[-d_a^2 / \left(2\sigma_x^2\right)\right] \exp\left[-d_c^2 / \left(2\sigma_y^2\right)\right]$$

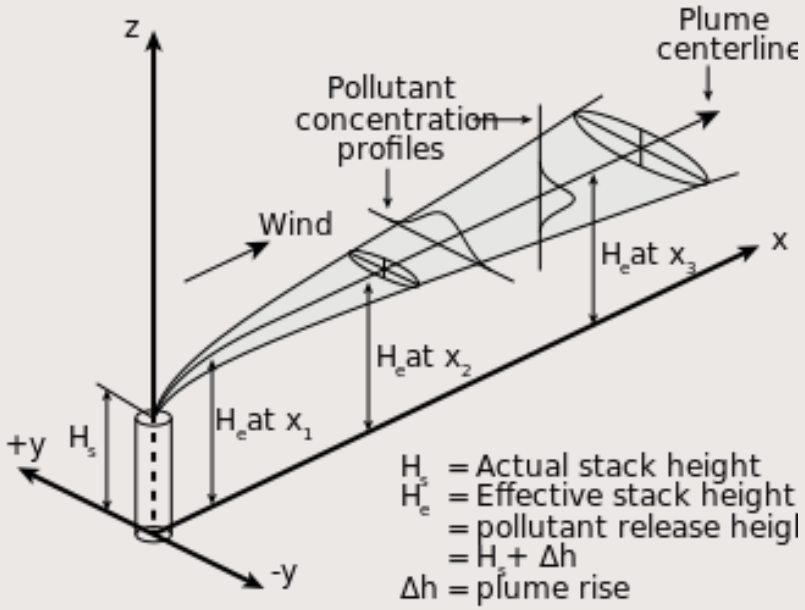
Modelo regulatorio EPA

Estacionario

Gaussiano

Capa límite planetaria

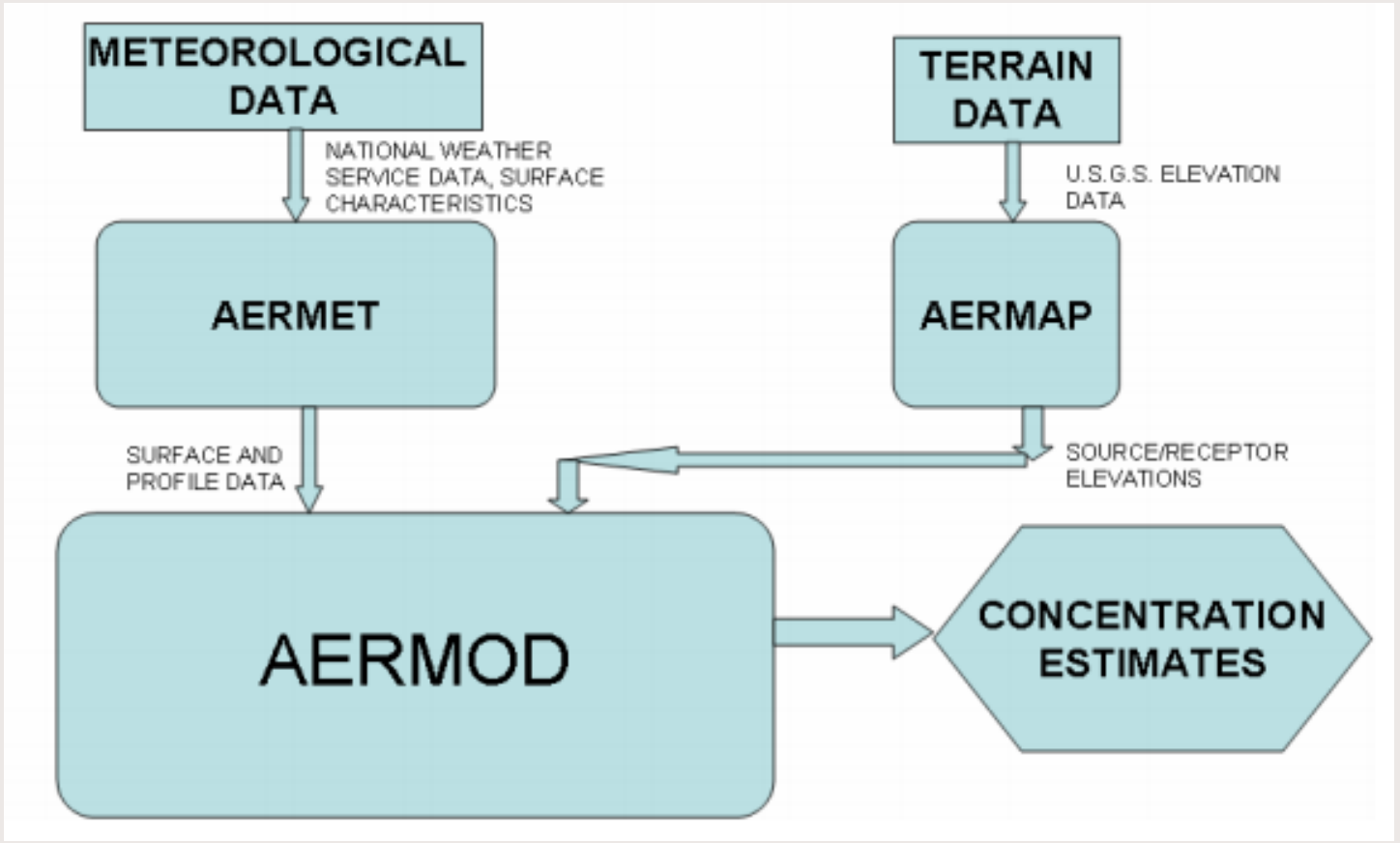
Terreno simple y complejo



aermod_mfed.pdf (epa.gov)

Air Quality Dispersion Modeling - Preferred and Recommended Models | Support Center for Regulatory Atmospheric Modeling (SCRAM) | US EPA

Programa: Sistema de modelación AERMOD

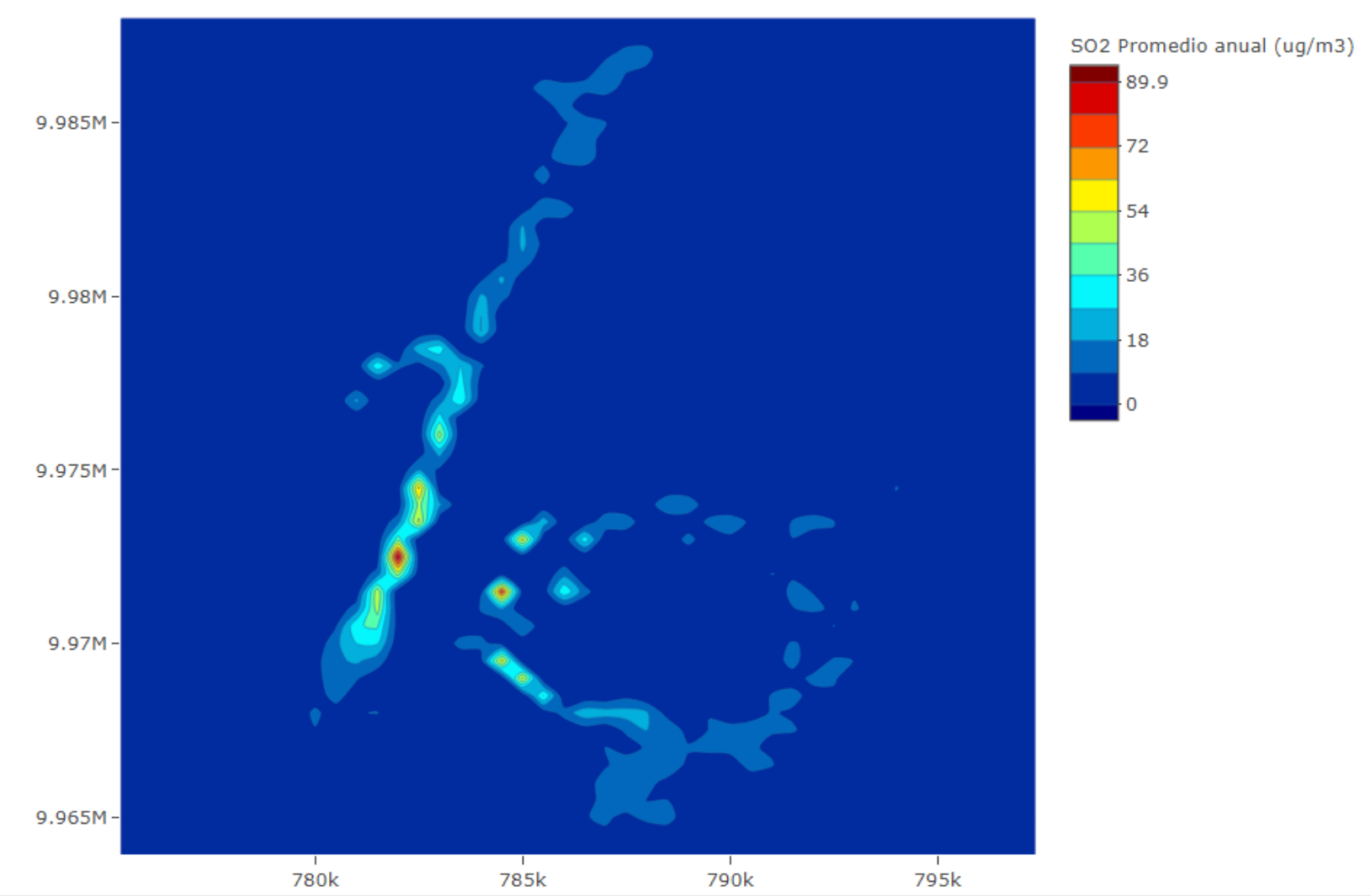


aermet.exe

aermap.exe

aermod.exe

https://www3.epa.gov/ttnecas1/regdata/RIAs/Appendix B--AERMOD Analysis.pdf

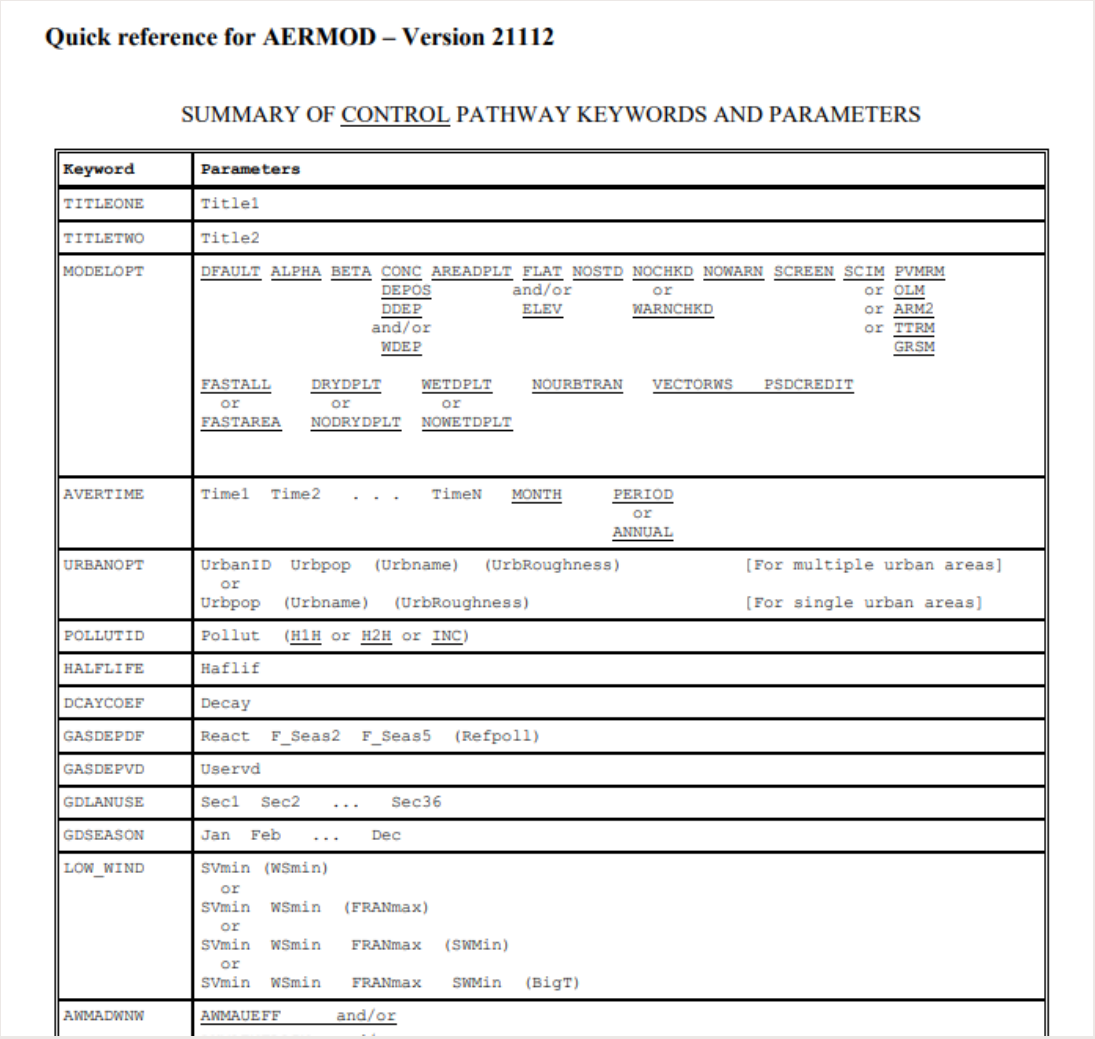

SO2 Promedio anual (ug/m3)
89.9
72
54
36
18
0
9.985M
9.98M
9.975M
9.97M
9.965M
780k
785k
790k
795k

Lenguajes de programación

Usuario:
Lenguaje interfaz

Escritura del programa:
Fortran

Compilación EPA:
Intel Visual Fortran Compiler for Windows



Quick reference for AERMOD – Version 21112

SUMMARY OF CONTROL PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters
TITLEONE	Title1
TITLETWO	Title2
MODELOPT	DFAULT ALPHA BETA CONC DEPOS DDEP and/or WDEP AREADPLT and/or ELEV FLAT NOSTD NOCHKD or WARNCHKD NOWARN SCREEN SCIM or OLM or ARM2 or TTRM GRSM FASTALL or FASTAREA DRYDPLT or NODRYDPLT WETDPLT or NOWETDPLT NOURBTRAN VECTORWS PSDCREDIT
AVERTIME	Time1 Time2 . . . TimeN MONTH PERIOD or ANNUAL
URBANOPT	UrbanID Urbpop (Urbname) (UrbRoughness) [For multiple urban areas] or Urbpop (Urbname) (UrbRoughness) [For single urban areas]
POLLUTID	Pollut (H1H or H2H or INC)
HALFLIFE	Haflif
DCAYCOEF	Decay
GASDEPDF	React F_Seas2 F_Seas5 (Refpoll)
GASDEPVD	Uservd
GDLANUSE	Sec1 Sec2 ... Sec36
GDSEASON	Jan Feb ... Dec
LOW_WIND	SVmin (WSmin) or SVmin WSmin (FRANmax) or SVmin WSmin FRANmax (SWMin) or SVmin WSmin FRANmax SWMin (BigT)
AWMADWNW	AWMAUEFF and/or

aermod_quick-reference-guide.pdf (epa.gov)

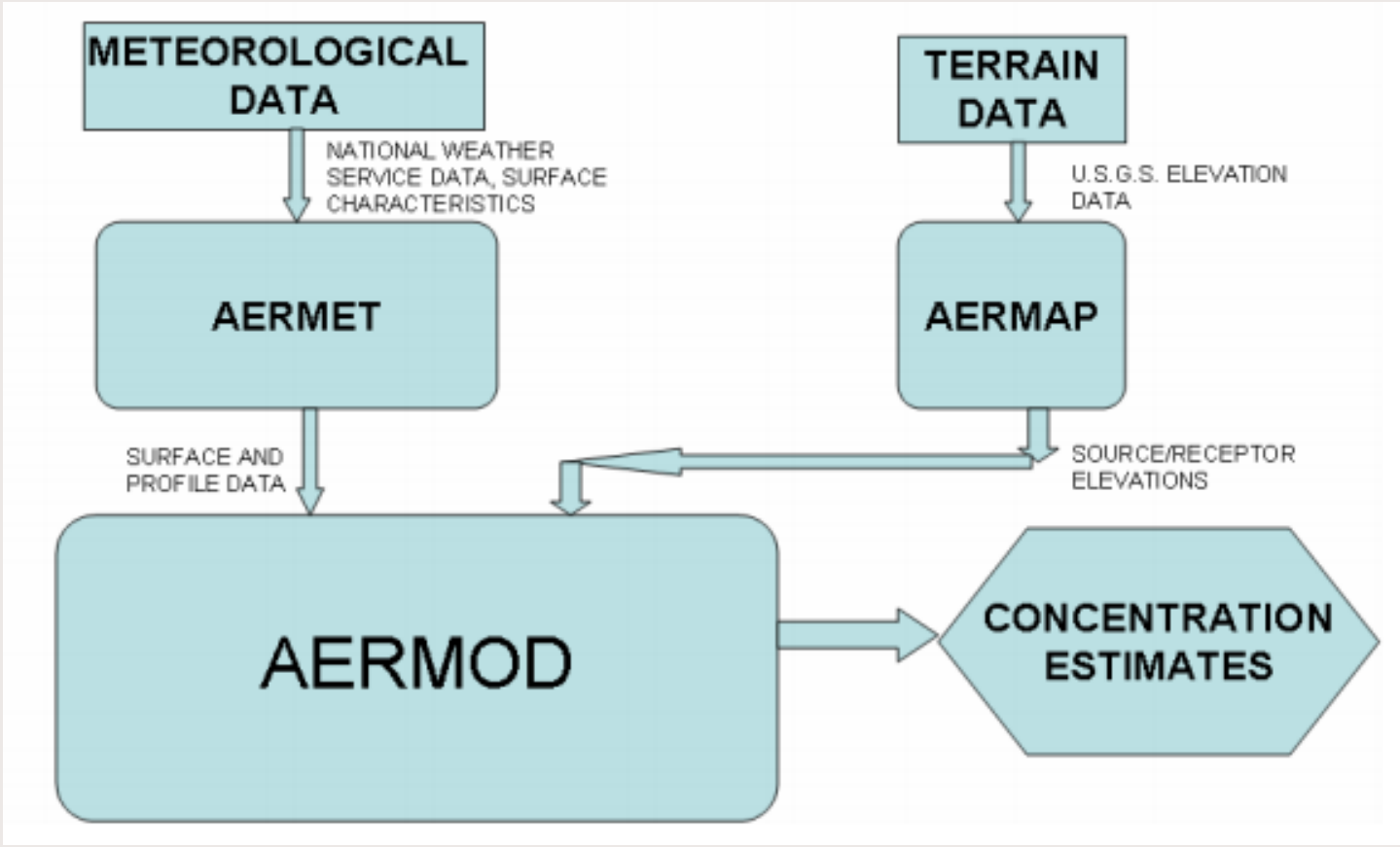
Parte 2. AERMOD.exe

Entradas

Salidas

Entradas

aermet.exe

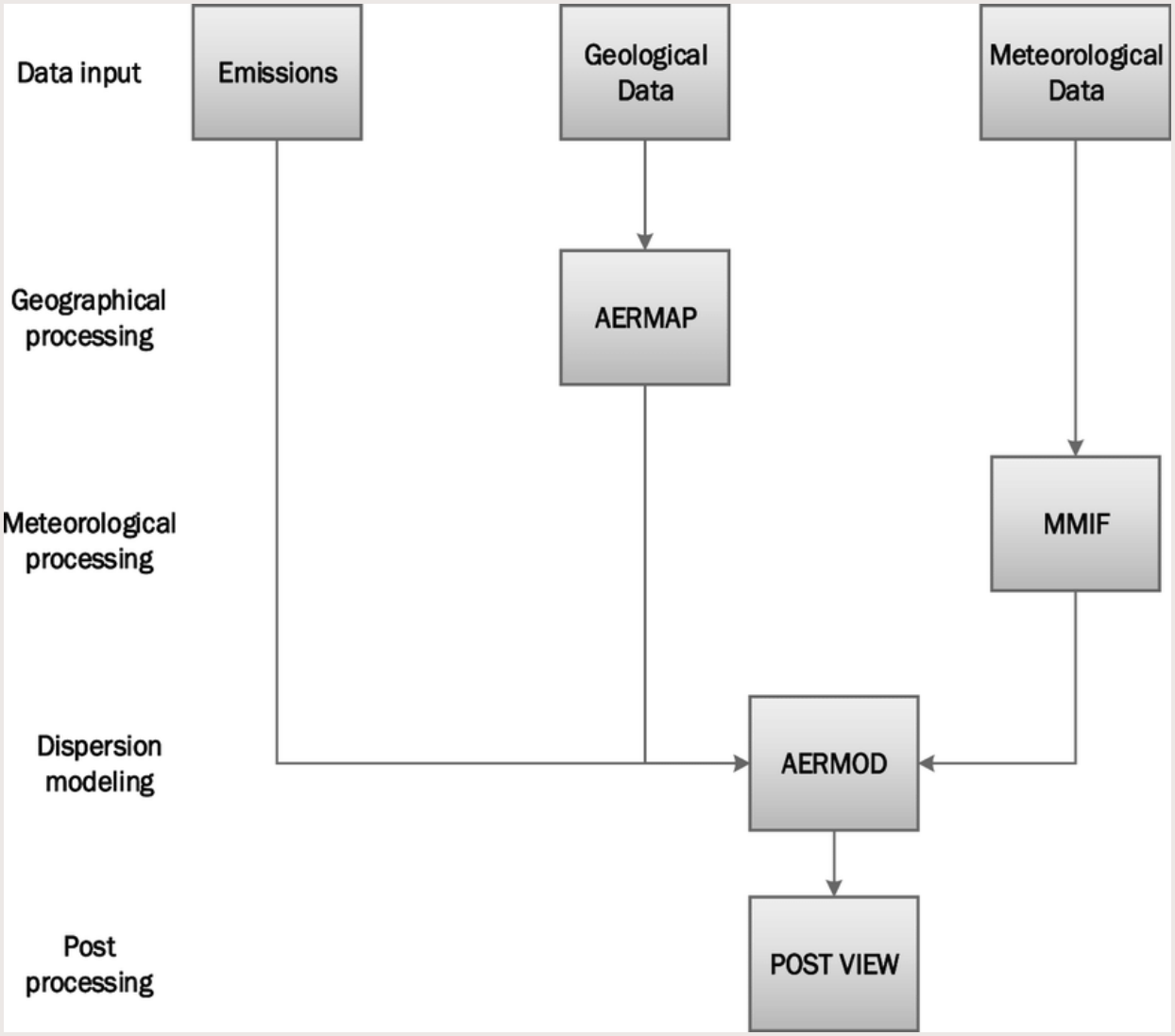


aermap.exe

aermod.exe

https://www3.epa.gov/ttnecas1/regdata/RIAs/Appendix B--AERMOD Analysis.pdf

Entradas



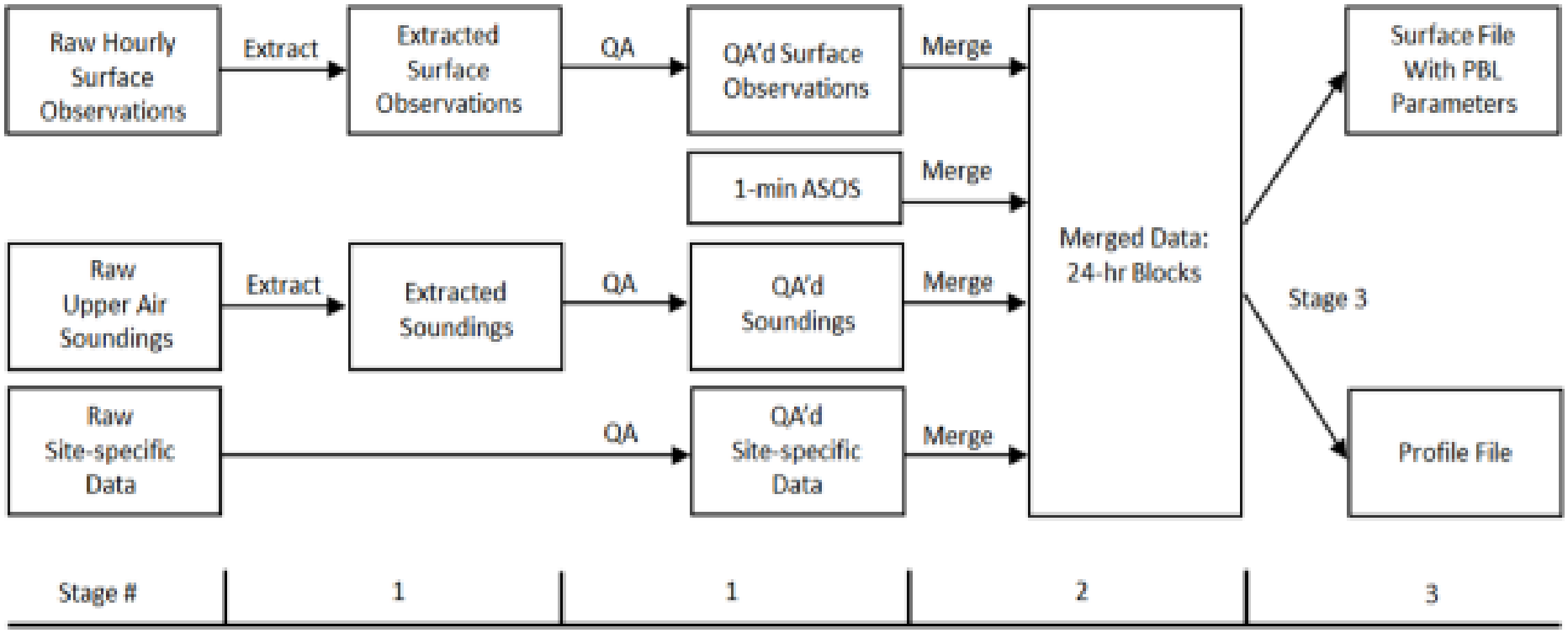
Mesoscale Model Interface Program

Flow-chart-of-AERMOD-modeling-system.png

AERMAP

```
CO STARTING
   TITLEONE  Quito Test for 1 sector
   TITLETWO  Using SRTM 3arc-minute Data

   DATATYPE  NED FILLGAPS
   DATAFILE  UIO.tif

   DOMAINXY  764000.0  9957000.0  -17  803000.0 9996000.0 -17
   ANCHORXY  765000.0  9958000.0  765000.0  9958000.0  -17  3

   RUNORNOT  RUN

   DEBUGOPT  ALL

CO FINISHED

SO STARTING
   LOCATION  STACK1 POINT  783500.0  9976500.0

SO FINISHED

RE STARTING
**          Xi     Xn    deltax  yi      yn    deltay

   GRIDCART  CART2 STA

                     XYINC 769500.0  7 3000.0 9965500.0  4 3000.0
   GRIDCART  CART2 END
RE FINISHED

OU STARTING
   RECEPTOR  Quito_REC2.OUT
   DEBUGREC  REC1DB_Quito.OUT  REC2DB_Quito.OUT  REC3DB_Quito.OUT

OU FINISHED
```

AERMET


Raw Hourly Surface Observations
Extract
Extracted Surface Observations
QA
QA'd Surface Observations
Merge
1-min ASOS
Merge
Raw Upper Air Soundings
Extract
Extracted Soundings
QA
QA'd Soundings
Merge
Raw Site-specific Data
QA
QA'd Site-specific Data
Merge
Merged Data: 24-hr Blocks
Surface File With PBL Parameters
Stage 3
Profile File
Stage #
1
1
2
3

AERMET

D:\AERMOD\AERMET4\S1 Extract SF.inp - Notepad++

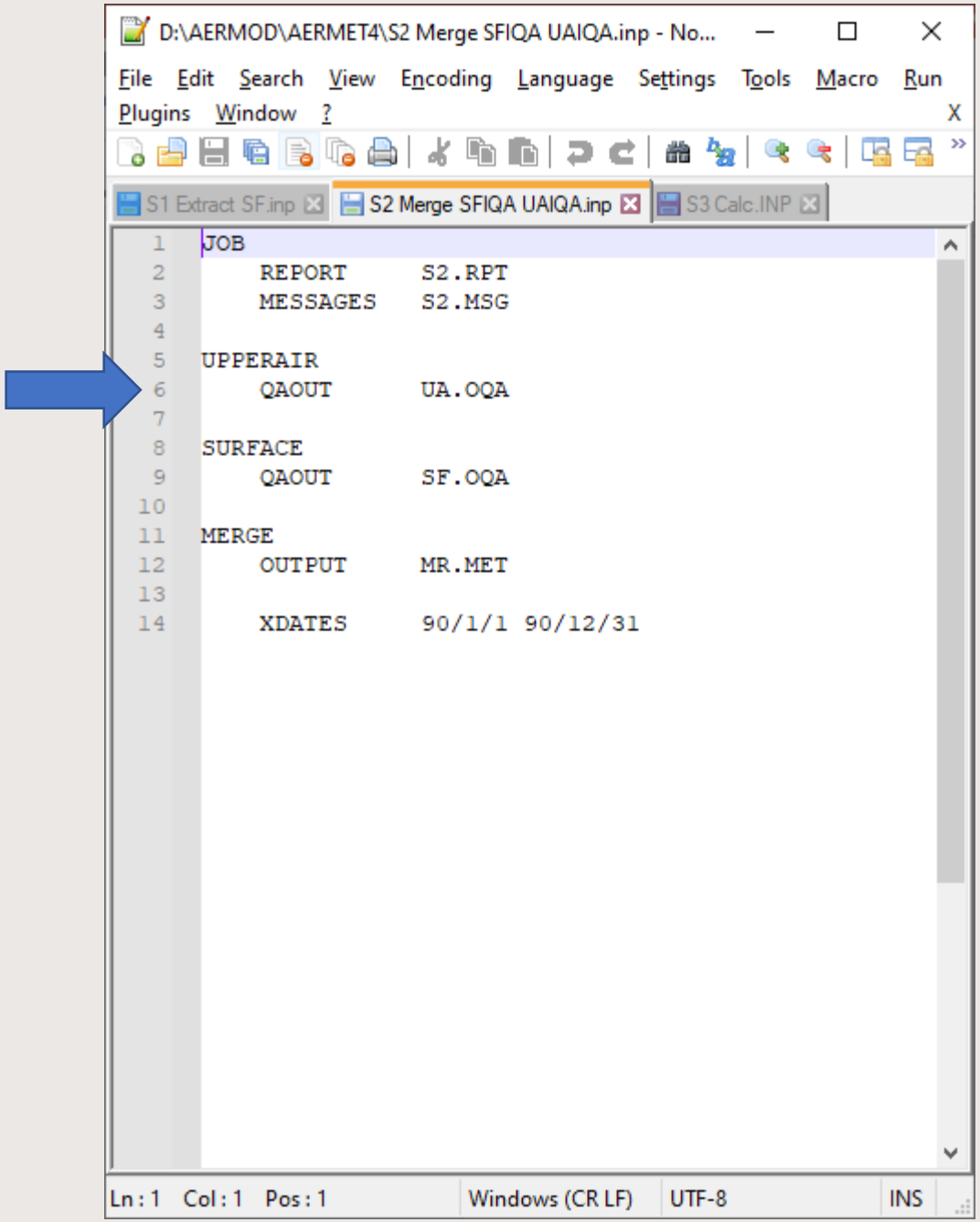
File Edit Search View Encoding Language Settings Tools Macro Run
Plugins Window ?

S1 Extract SF.inp | S2 Merge SFIQA UAIQA.inp | S3 Calc.INP

```
1   JOB
2
3       REPORT     S1.RPT
4       MESSAGES   S1.MSG
5
6   SURFACE
7
8       DATA       SF.DAT   SCRAM
9       EXTRACT    SF.IQA
10      QAOUT      SF.OQA
11
12      XDATES     90/1/1   TO   90/12/31
13
14      LOCATION   12832   0.30S   78.46W   0   2460
15
16
17
```

Ln : 1 Col : 4 Pos : 4 | Windows (CR LF) | UTF-8 | INS

AERMET


D:\AERMOD\AERMET4\S2 Merge SFIQA UAIQA.inp - No...
File Edit Search View Encoding Language Settings Tools Macro Run
Plugins Window ?
S1 Extract SF.inp
S2 Merge SFIQA UAIQA.inp
S3 Calc.INP
1 JOB
2 REPORT S2.RPT
3 MESSAGES S2.MSG
4
5 UPPERAIR
6 QAOUT UA.OQA
7
8 SURFACE
9 QAOUT SF.OQA
10
11 MERGE
12 OUTPUT MR.MET
13
14 XDATES 90/1/1 90/12/31
Ln : 1 Col : 1 Pos : 1
Windows (CR LF)
UTF-8
INS

AERMET

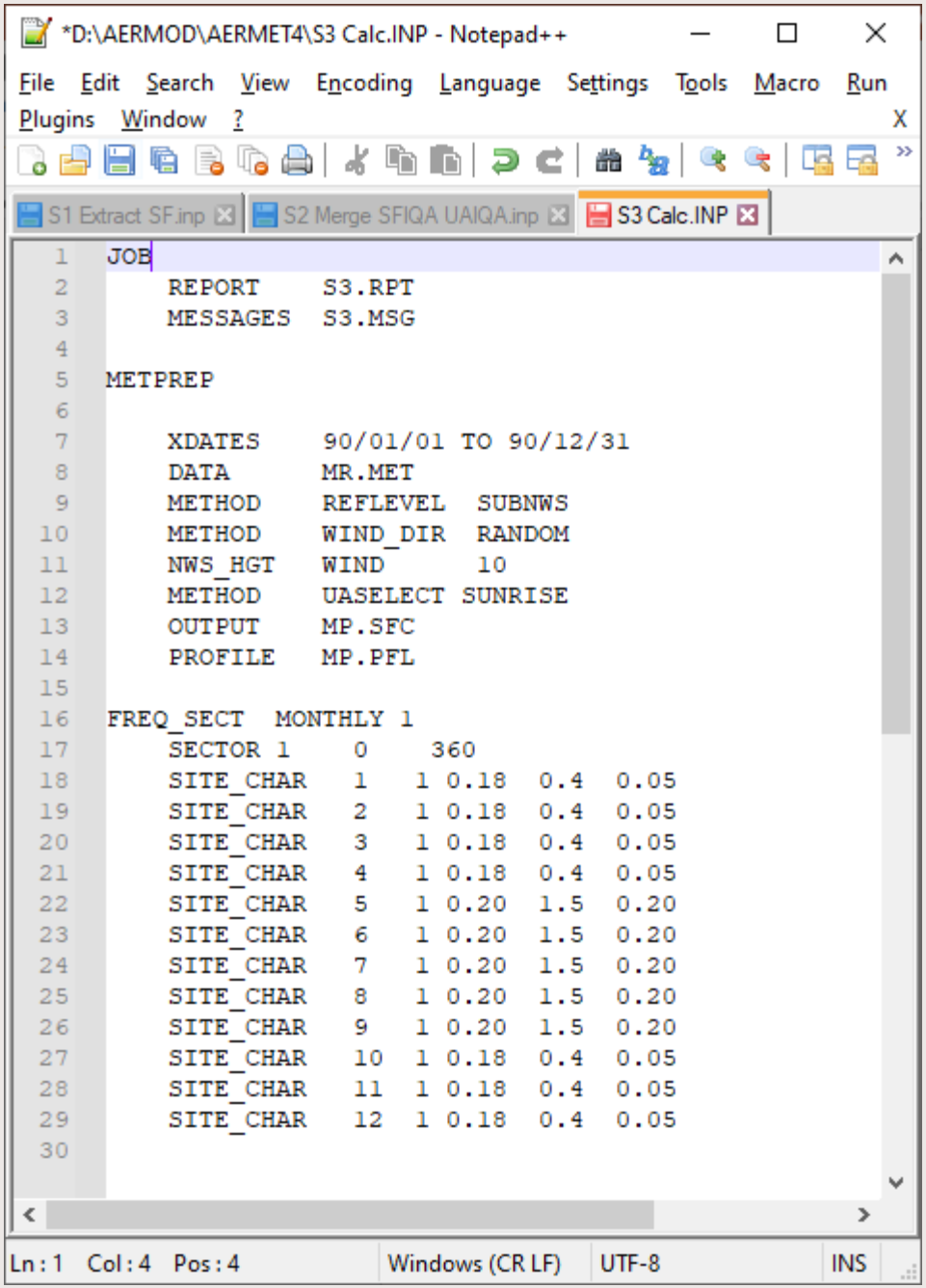

*D:\AERMOD\AERMET4\S3 Calc.INP - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run
Plugins Window ?
S1 Extract SF.inp
S2 Merge SFIQA UAIQA.inp
S3 Calc.INP
JOB
REPORT S3.RPT
MESSAGES S3.MSG
METPREP
XDATES 90/01/01 TO 90/12/31
DATA MR.MET
METHOD REFLEVEL SUBNWS
METHOD WIND_DIR RANDOM
NWS_HGT WIND 10
METHOD UASELECT SUNRISE
OUTPUT MP.SFC
PROFILE MP.PFL
FREQ_SECT MONTHLY 1
SECTOR 1 0 360
SITE_CHAR 1 1 0.18 0.4 0.05
SITE_CHAR 2 1 0.18 0.4 0.05
SITE_CHAR 3 1 0.18 0.4 0.05
SITE_CHAR 4 1 0.18 0.4 0.05
SITE_CHAR 5 1 0.20 1.5 0.20
SITE_CHAR 6 1 0.20 1.5 0.20
SITE_CHAR 7 1 0.20 1.5 0.20
SITE_CHAR 8 1 0.20 1.5 0.20
SITE_CHAR 9 1 0.20 1.5 0.20
SITE_CHAR 10 1 0.18 0.4 0.05
SITE_CHAR 11 1 0.18 0.4 0.05
SITE_CHAR 12 1 0.18 0.4 0.05
Ln : 1 Col : 4 Pos : 4
Windows (CR LF)
UTF-8
INS

Diagrama de flujo AERMOD

UIO.tif

aermap.exe

Quito_REC.OUT

aermod.inp

SECRETARÍA DE AMBIENTE

NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION NCEP

SF.DAT

UA.OQA

aermet.exe

aermod.exe

aermod.out

MP.PFL

MP.SFC

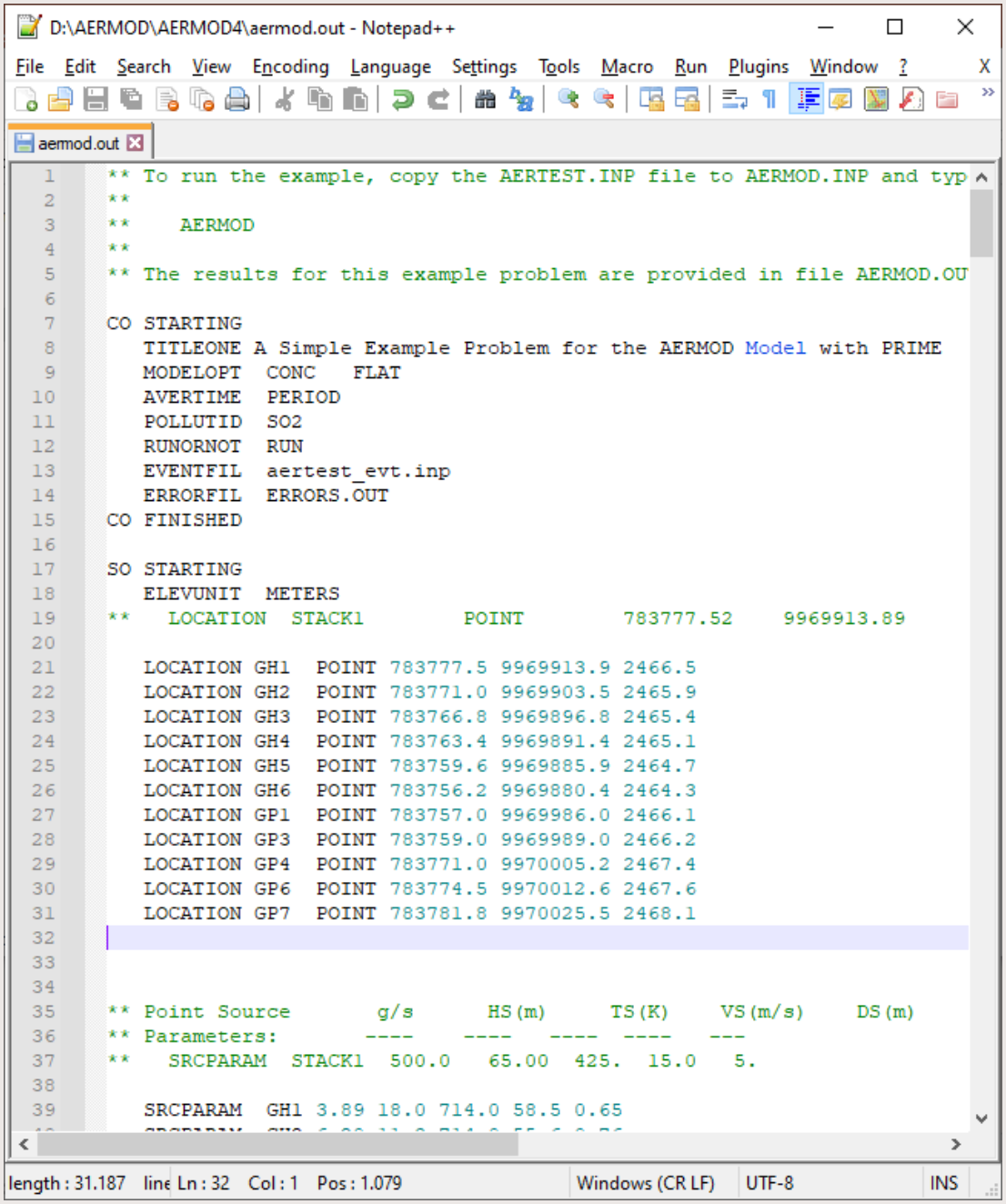
o

WRF Weather Research & Forecasting

mmif.exe

[NCEP FNL Operational Model Global Tropospheric Analyses]

Salida


D:\AERMOD\AERMOD4\aermod.out - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
aermod.out
** To run the example, copy the AERTEST.INP file to AERMOD.INP and typ
**
**   AERMOD
**
** The results for this example problem are provided in file AERMOD.OU
CO STARTING
TITLEONE A Simple Example Problem for the AERMOD Model with PRIME
MODELOPT CONC FLAT
AVERTIME PERIOD
POLLUTID SO2
RUNORNOT RUN
EVENTFIL aertest_evt.inp
ERRORFIL ERRORS.OUT
CO FINISHED
SO STARTING
ELEVUNIT METERS
**   LOCATION STACK1 POINT 783777.52 9969913.89
LOCATION GH1 POINT 783777.5 9969913.9 2466.5
LOCATION GH2 POINT 783771.0 9969903.5 2465.9
LOCATION GH3 POINT 783766.8 9969896.8 2465.4
LOCATION GH4 POINT 783763.4 9969891.4 2465.1
LOCATION GH5 POINT 783759.6 9969885.9 2464.7
LOCATION GH6 POINT 783756.2 9969880.4 2464.3
LOCATION GP1 POINT 783757.0 9969986.0 2466.1
LOCATION GP3 POINT 783759.0 9969989.0 2466.2
LOCATION GP4 POINT 783771.0 9970005.2 2467.4
LOCATION GP6 POINT 783774.5 9970012.6 2467.6
LOCATION GP7 POINT 783781.8 9970025.5 2468.1
** Point Source g/s HS(m) TS(K) VS(m/s) DS(m)
** Parameters: ---- ---- ---- ---- ---
**   SRCPARAM STACK1 500.0 65.00 425. 15.0 5.
SRCPARAM GH1 3.89 18.0 714.0 58.5 0.65
length : 31.187 line Ln : 32 Col : 1 Pos : 1.079
Windows (CR LF) UTF-8 INS

Salida

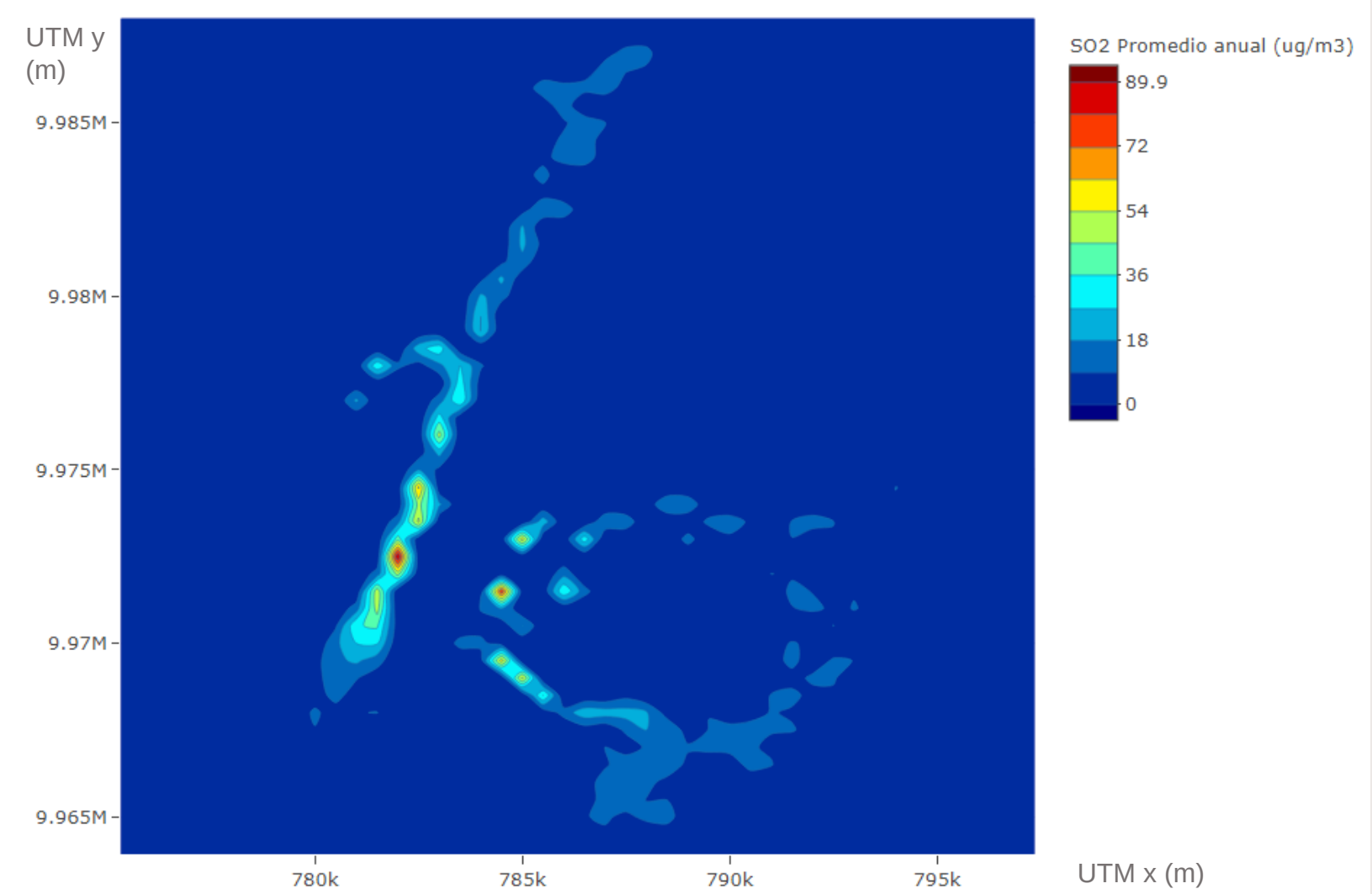
D:\AERMOD\AERMOD4\aermod.out - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

aermod.out

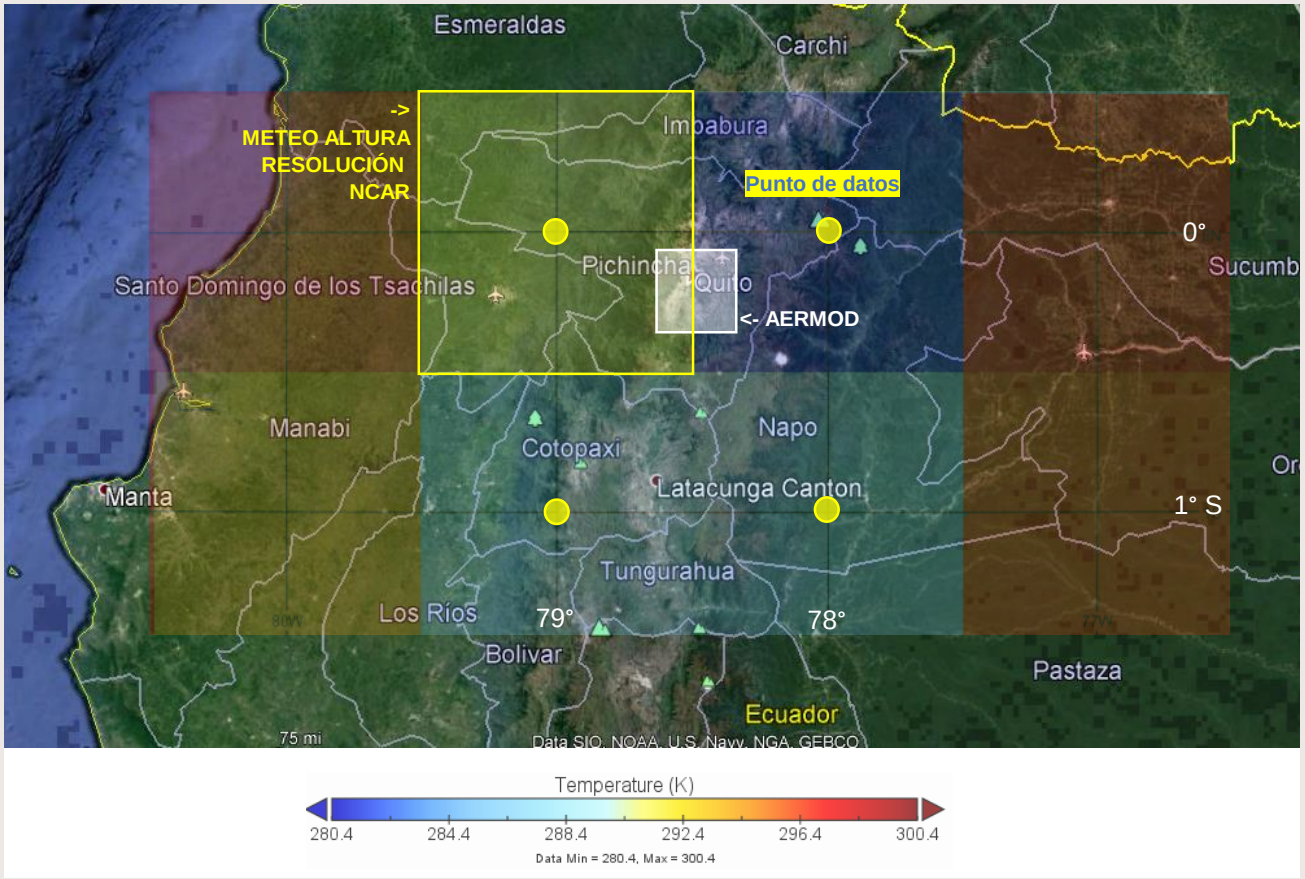
```
*** AERMOD - VERSION  15181 ***   *** A Simple Example Problem for the AERMOD Model with PRIME            ***        06/26/20
*** AERMET - VERSION  19191 ***   ***                                                                   ***       10:12:32
                                                                                                                 PAGE    8

**MODELOPTs:   NonDFAULT CONC       FLAT      RURAL

                          *** THE PERIOD (  8760 HRS) AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP: ALL      ***
                              INCLUDING SOURCE(S):     GH1         , GH2         , GH3         , GH4         , GH5         ,
               GH6         , GP1         , GP3         , GP4         , GP6         , GP7         ,

                              *** NETWORK ID: CART1    ;  NETWORK TYPE: GRIDCART ***

                                  ** CONC OF SO2      IN MICROGRAMS/M**3                        **

   Y-COORD  |                                            X-COORD (METERS)
   (METERS) |     765000.00    768000.00    771000.00    774000.00    777000.00    780000.00    783000.00    786000.00    789000.00
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 9985000.00 |       0.20011      0.22087      0.24197      0.27695      0.29263      0.27474      0.28825      0.25522      0.22591
 9982000.00 |       0.21330      0.22638      0.25750      0.29176      0.34994      0.33067      0.34357      0.29459      0.25752
 9979000.00 |       0.26102      0.26343      0.27088      0.32030      0.39215      0.43699      0.43639      0.36387      0.31828
 9976000.00 |       0.26290      0.29215      0.35215      0.37465      0.45190      0.60575      0.62604      0.48601      0.38794
 9973000.00 |       0.25195      0.28147      0.34032      0.45368      0.60428      0.81890      1.17575      0.76625      0.46257
 9970000.00 |       0.21579      0.24741      0.29396      0.36977      0.51643      0.90509      5.73154      1.20551      0.54717
 9967000.00 |       0.17617      0.20263      0.24280      0.29733      0.40049      0.54688      0.69970      0.76555      0.57393
 9964000.00 |       0.16790      0.18844      0.21168      0.24736      0.26843      0.32715      0.35762      0.48892      0.47965
 9961000.00 |       0.15063      0.16280      0.17646      0.18381      0.21748      0.25913      0.23988      0.36397      0.31952
 9958000.00 |       0.13675      0.13660      0.14269      0.15960      0.18403      0.19933      0.18213      0.31642      0.34677
*** AERMOD - VERSION  15181 ***   *** A Simple Example Problem for the AERMOD Model with PRIME            ***        06/26/20
*** AERMET - VERSION  19191 ***   ***                                                                   ***       10:12:32
                                                                                                                 PAGE    9

**MODELOPTs:   NonDFAULT CONC       FLAT      RURAL

                          *** THE PERIOD (  8760 HRS) AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP: ALL      ***
                              INCLUDING SOURCE(S):     GH1         , GH2         , GH3         , GH4         , GH5         ,
               GH6         , GP1         , GP3         , GP4         , GP6         , GP7         ,

                              *** NETWORK ID: CART1    ;  NETWORK TYPE: GRIDCART ***

                                  ** CONC OF SO2      IN MICROGRAMS/M**3                        **

   Y-COORD  |                                            X-COORD (METERS)
   (METERS) |     792000.00
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 9985000.00 |       0.20284
 9982000.00 |       0.25492
```

spice file | length : 31.187 lines : 490 | Ln : 32 Col : 1 Pos : 1.079 | Windows (CR LF) | UTF-8 | INS



Promedio anual de SO2 simulado con AERMOD. Año 2009

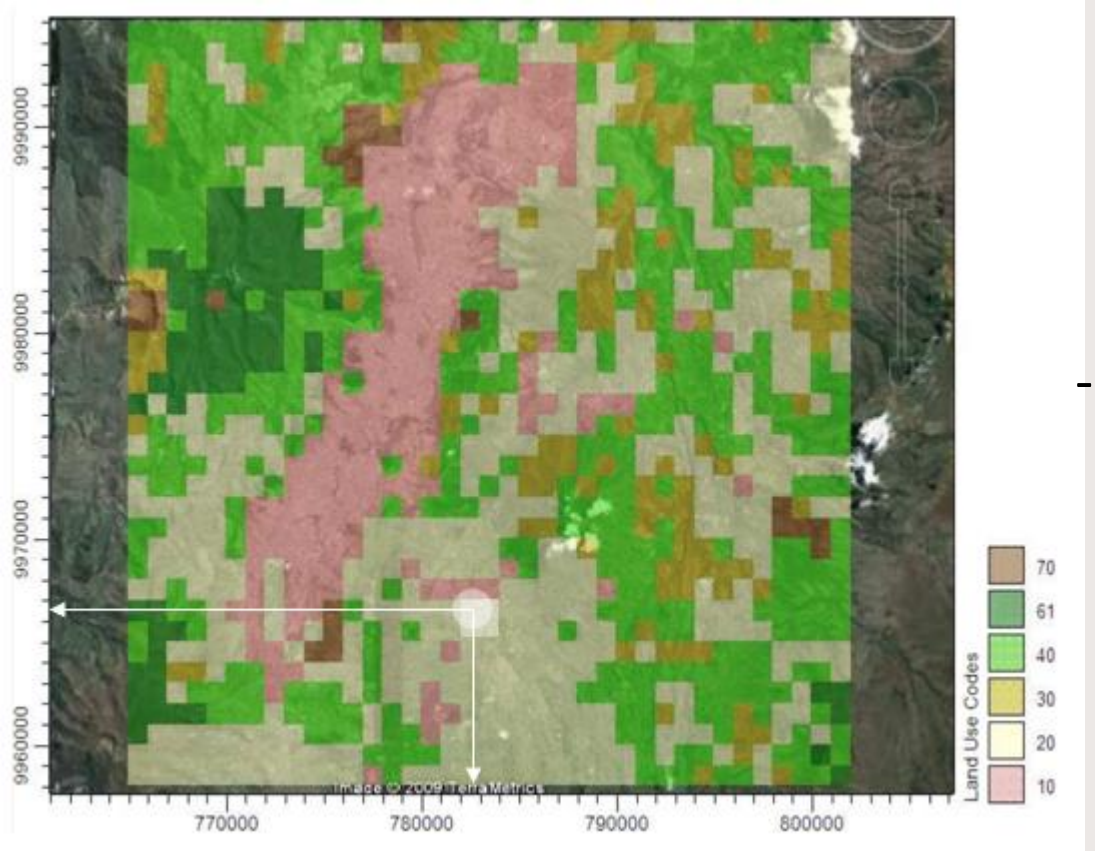
UPPER AIR Data




```
#recupera datos para cada variable
lat = ncvar_get(f,"lat_3")
lon = ncvar_get(f,"lon_3")
lev = ncvar_get(f,"lv_ISBL4")
hgt = ncvar_get(f,"HGT_3_ISBL")
tmp = ncvar_get(f,"TMP_3_ISBL")
r_h = ncvar_get(f,"R_H_3_ISBL")
u_w = ncvar_get(f,"U_GRD_3_ISBL")
v_w = ncvar_get(f,"V_GRD_3_ISBL")

#variable attributes
#r_h2 = ncatt_get(f,"R_H_3_ISBL")

#missing values
#ncvar_change_missval(f, "R_H_3_ISBL", 99990)

#extrae vectores y toma alturas
lonlat <- expand.grid(lon, lat)
lev.vec <- as.vector(lev)[-(1:13)]
hgt.vec <- as.vector(hgt)[-(1:13)]
tmp.vec <- as.vector(tmp)[-(1:13)]
```

NetCDF4 -> .UA

Land Use



->

```
FREQ_SECT  MONTHLY 1
    SECTOR 1    0    360
    SITE_CHAR   1   1 0.18  0.4  0.05
    SITE_CHAR   2   1 0.18  0.4  0.05
    SITE_CHAR   3   1 0.18  0.4  0.05
    SITE_CHAR   4   1 0.18  0.4  0.05
    SITE_CHAR   5   1 0.20  1.5  0.20
    SITE_CHAR   6   1 0.20  1.5  0.20
    SITE_CHAR   7   1 0.20  1.5  0.20
    SITE_CHAR   8   1 0.20  1.5  0.20
    SITE_CHAR   9   1 0.20  1.5  0.20
    SITE_CHAR   10  1 0.18  0.4  0.05
    SITE_CHAR   11  1 0.18  0.4  0.05
    SITE_CHAR   12  1 0.18  0.4  0.05
```

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