

Atmospheric Dispersion Simulation using HYSPLIT with Real-time Weather Forecasts

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Singapore Nuclear Research & Safety Initiative

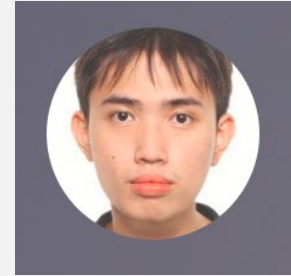
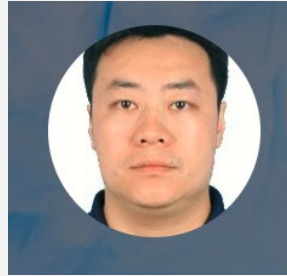


NUS
National University
of Singapore

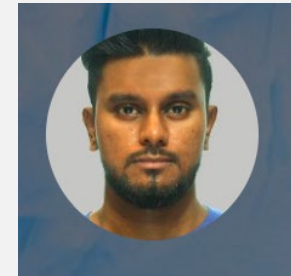
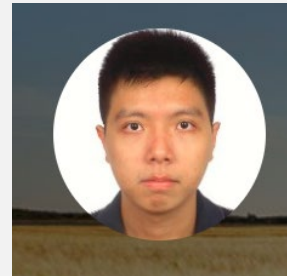
National University of Singapore

Team

- ▶ Full time on atmospheric dispersion



- ▶ Part time on risk analysis and MACCS





HYbrid

Single-**P**article

Lagrangian

Integrated

Trajectory model

- ▶ <https://www.ready.noaa.gov/documents/Tutorial/html/index.html>
- ▶ Windows/Linux/Mac OS/Web

HYSPLIT Implementation Requirement

▶ Software

▶ Windows (v5.2.2)

- ▶ Tcl/Tk
- ▶ Ghostscript
- ▶ Ghostview
- ▶ ImageMagick

▶ Linux (v5.2.3)

- ▶ Fortran 90 compiler (serial and/or parallel)
- ▶ C compiler
- ▶ eccodes library
- ▶ NetCDF library

▶ Hardware

- ▶ Multiple-core 64-bit architecture
- ▶ Large memory (8G/CPU)

Before running HYSPLIT

- ▶ Prepare meteorological data
 - ▶ Single station data (wind, stability, etc.)
 - ▶ GFS gridded data
- ▶ Setup HYSPLIT
 - ▶ Source term (release rate, duration...)
 - ▶ Grid (domain, grid spacing, vertical levels...)
 - ▶ Species (half-life, form, deposition parms...)
 - ▶ Simulations (run mode/length, # particles...)

GFS Data

▶ Global Forecast System (GFS)

- ▶ National Centers for Environmental Prediction
- ▶ Operational 4 times a day, 16-day forecasts
- ▶ Global domain (0.25°/0.5°)
- ▶ GRIB2 format

```
461:343224539:d=2022101800:HGT:850 mb:48 hour fcst:  
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475:354090630:d=2022101800:GRLE:850 mb:48 hour fcst:  
476:354185646:d=2022101800:O3MR:850 mb:48 hour fcst:  
477:355408835:d=2022101800:HGT:900 mb:48 hour fcst:
```

Format conversion GRIB2 → ARL

▶ <ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/v16.2/gfs.20220806/00/atmos/gfs.t00z.pgrb2.0p50.f024>

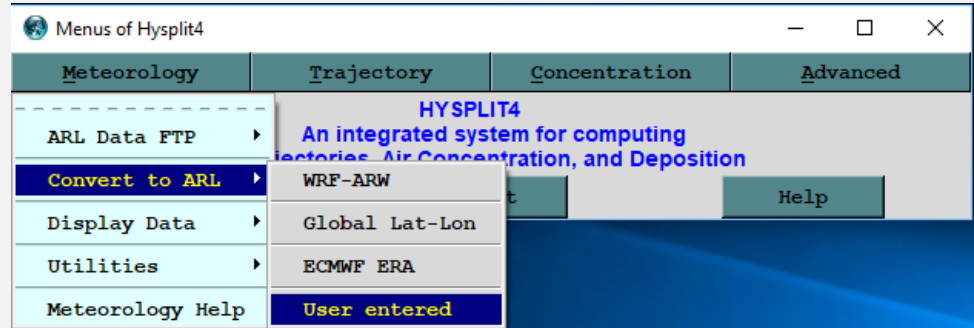
```
api2arl_v1 -i gfs.t00z.pgrb2.0p50.f000 -of000
```

```
api2arl_v1 -i gfs.t00z.pgrb2.0p50.f003 -of003
```

...

```
api2arl_v1 -i gfs.t00z.pgrb2.0p50.f024 -of024
```

```
cat f* > hysplit.t00z.gfs0p25f024
```



▶ <https://nomads.ncep.noaa.gov/pub/data/nccf/com/hysplit/prod/hysplit.20221001/hysplit.t00z.gfs0p25f072>

Setup HYSPLIT

▶ Menu Concentration → Setup Run

Concentration Setup

Starting time (YY MM DD HH): 00 00 00 00

Number of starting locations: 1 =====> Setup starting locations

Total run time (hrs)	Direction	Top of model (m agl)
384	<input checked="" type="radio"/> Fwr <input type="radio"/> Back	12000

Vertical Motion Method: 0 = input model data Select

Add Meteorology Files Clear Selected Files: 1

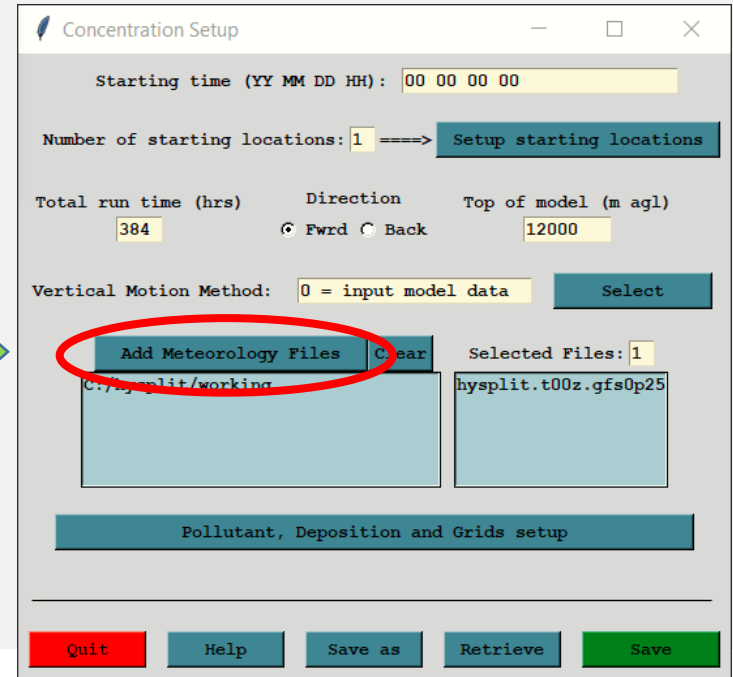
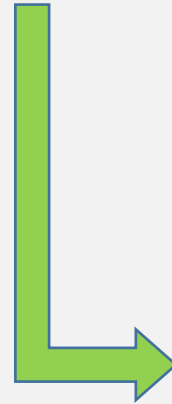
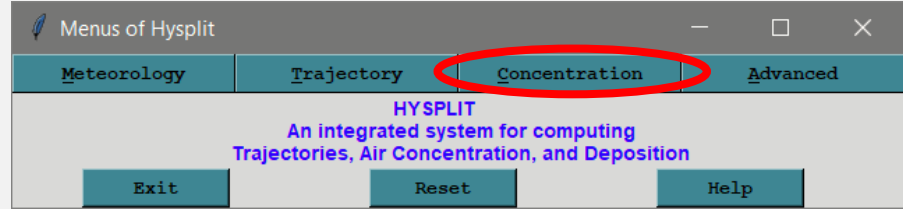
C:/hysplit/working hysplit.t00z.gfs0p25

Pollutant, Deposition and Grids setup

Quit Help Save as Retrieve Save

Setup HYSPLIT (continued)

- ▶ Menu → Concentration [or Trajectory] → Setup Run



Setup HYSPLIT (continued)

Concentration Setup

Starting time (YY MM DD HH): 00 00 00 00

Number of starting locations: 1 =====> Setup starting locations

Total run time (hrs) 384 Direction Fwrd Back Top of model (m agl) 12000

Vertical Motion Method: 0 = input model data Select

Add Meteorology Files Clear Selected Files: 1

C:/hysplit/working hysplit.t00z.gfsOp25

Pollutant, Deposition and Grids setup

Quit Help Save as Retrieve Save

- ▶ Menu → Concentration → Setup Run → Pollutant, Deposition and Grids setup

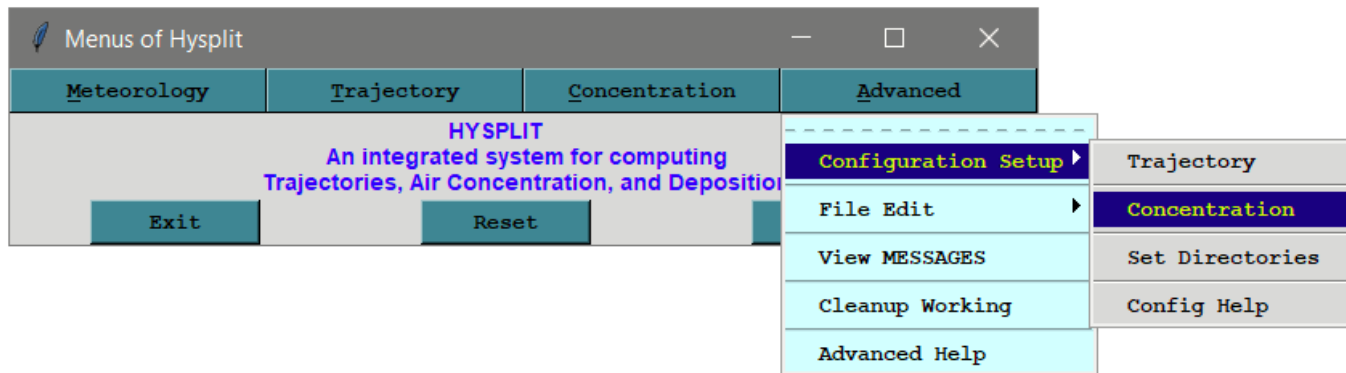
Pollutant, Concentration Grid, and ...

Pollutant:	Grids:	Deposition:
Num= 1	Num= 1	Num= 1
<input checked="" type="radio"/> Specie 1	<input checked="" type="radio"/> Grid 1	<input checked="" type="radio"/> Specie 1
<input type="radio"/> Specie 2	<input type="radio"/> Grid 2	<input type="radio"/> Specie 2
<input type="radio"/> Specie 3	<input type="radio"/> Grid 3	<input type="radio"/> Specie 3
<input type="radio"/> Specie 4	<input type="radio"/> Grid 4	<input type="radio"/> Specie 4
<input type="radio"/> Specie 5	<input type="radio"/> Grid 5	<input type="radio"/> Specie 5
<input type="radio"/> Specie 6	<input type="radio"/> Grid 6	<input type="radio"/> Specie 6
<input type="radio"/> Specie 7	<input type="radio"/> Grid 7	<input type="radio"/> Specie 7

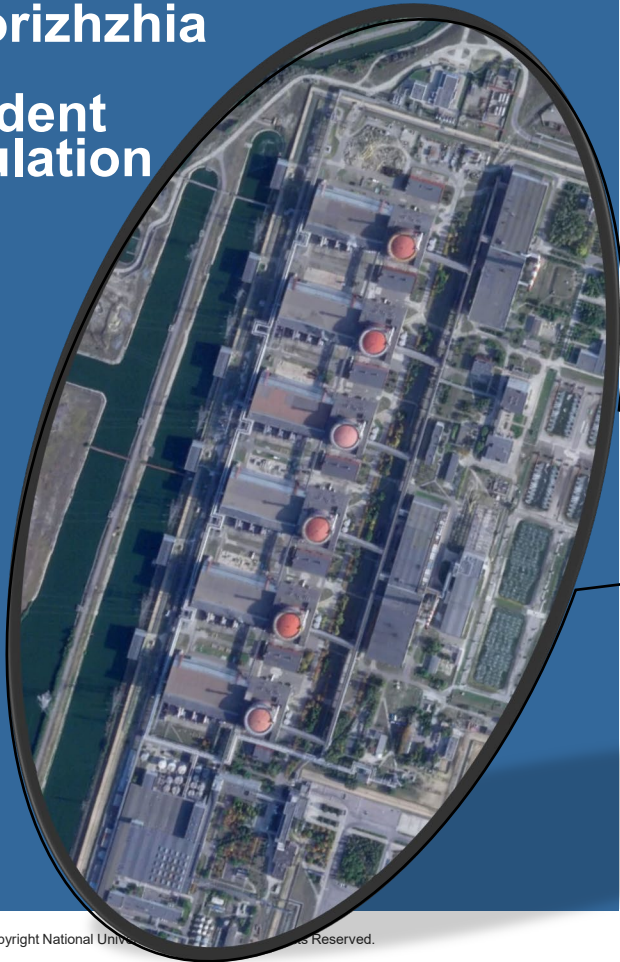
Quit Help Save

Setup HYSPLIT (advanced)

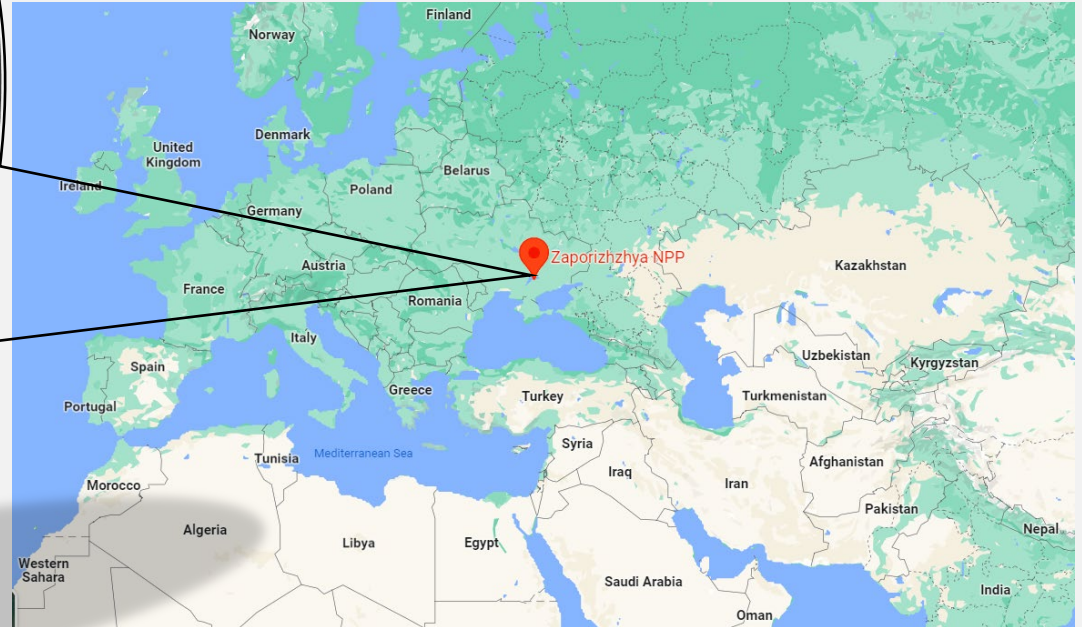
- ▶ Menu → Advanced → Configuration Setup → Concentration
 - ▶ Time step
 - ▶ Number of particles
 - ▶ Puff or particles running mode
 - ▶ Advanced emission scenario
 - ▶ Ensemble simulations



Hypothetical Zaporizhzhia NPP Accident Simulation



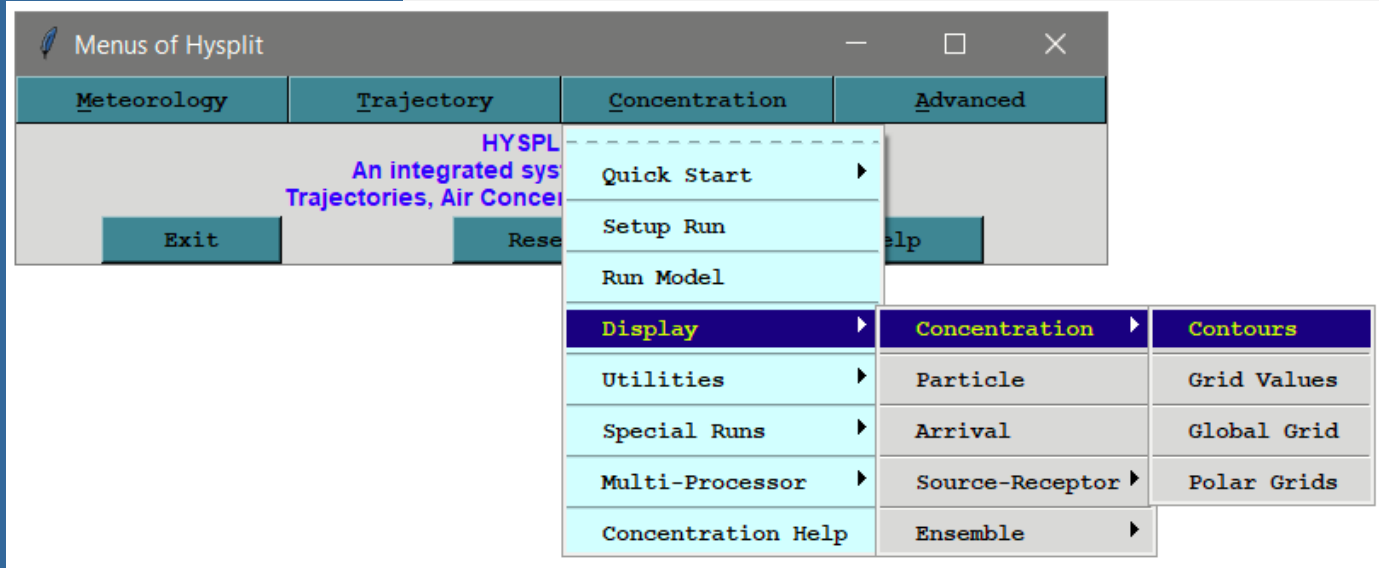
- ▶ GFS 0.5° 3-hourly 16-day forecasts
- ▶ Cs-137 released for 7 days at 1×10^{13} Bq/h
- ▶ Grid spacing 0.5°
- ▶ Dry deposition only



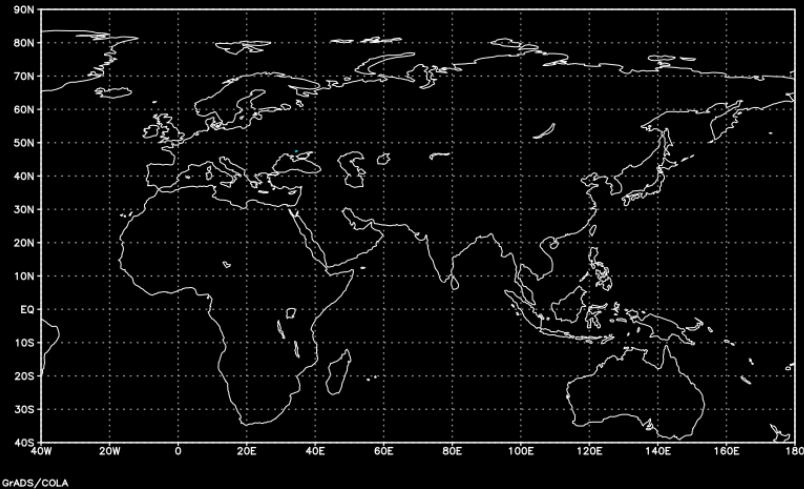
Postprocessing

► cdump

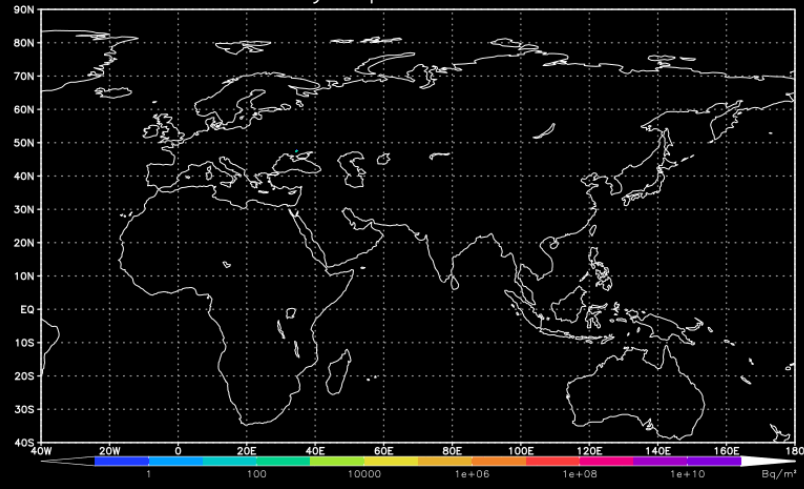
- con2asc.exe -icdump -ocdump.txt
- con2grad.exe cdump
- con2grib.exe -icdump -ocdump.grib (Linux)
- integrated visualisation functions



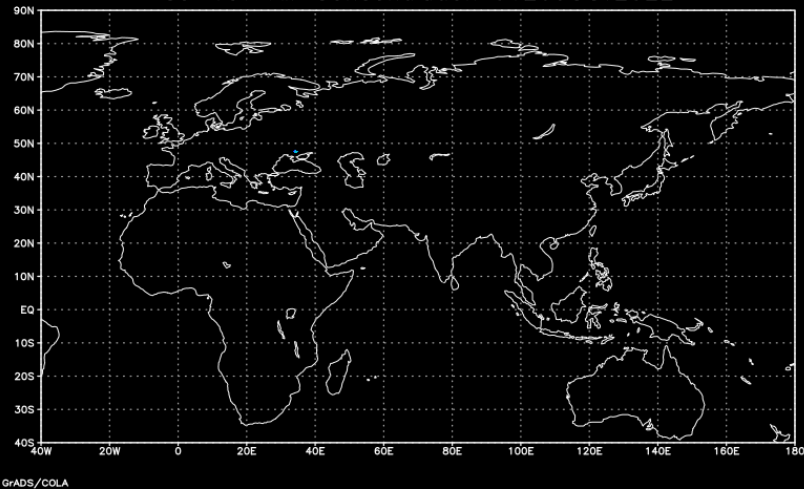
Cs-137 Air Concentration 01Z09OCT2022



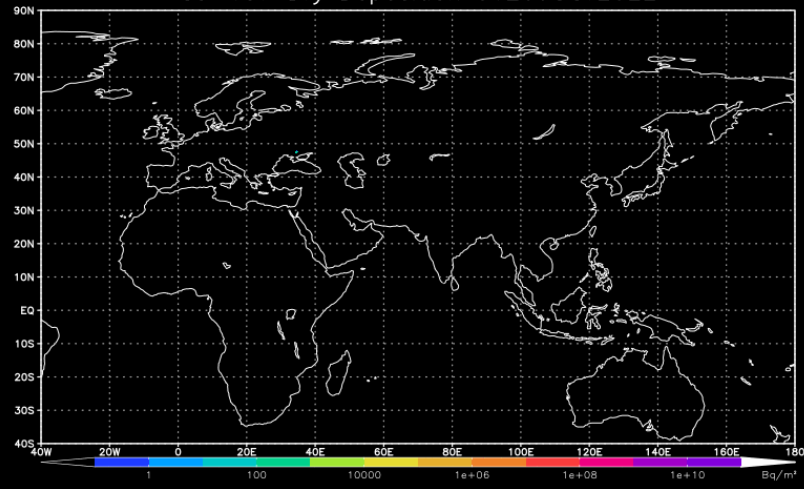
Cs-137 Dry Deposition 01Z09OCT2022



Cs-137 Air Concentration 01Z09OCT2022



Cs-137 Dry Deposition 01Z09OCT2022



0.5° GFS

0.25° GFS

THANK YOU
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