

Graphical and Analytical Software Visualization Tools for Evaluating Meteorological and Air Quality Model Performance

> Irene Lee Exponent, Inc. Natick, Massachusetts

January 8, 2013 AMS 93rd Annual Meeting Austin, Texas



A leading engineering & scientific consulting firm dedicated to helping our clients solve their technical problems.

CALApps Viewer

Features

- Freely distributed
- Plot terrain and land use
- Choose meteorological fields to overlay
- Plot concentration contours
- Plot different vertical layers
- Jump to different dates/times
- Animate
- Save animations and individual images
- Import custom base maps and custom contour levels
- Control the transparency of each layer



Air Quality Modeling Applications

160

CALPUFF

Exponent

- US EPA Approved Guideline Model
 - Long-range transport (> 50 km)
 - National Ambient Air Quality Standards (NAAQS) Analyses
 - Prevention of Significant Deterioration (PSD) Analyses
 - Air Quality Related Values in Class I Areas (National Parks and Wilderness Areas)
 - Visibility
 - Pollutant Deposition
- Strong meteorological component with links to
 - MM5/WRF
 - NAM
 - ECMWF
 - RAMS
 - Rapid Refresh Model (RAP)
 - CALMET



Complex Terrain

260

CALApps Viewer

- Plot terrain with custom contour levels
- Overlay source and surface station locations

Overview

- CALMET/CALPUFF
- Source in valley
- Observations only





Complex Terrain

280

CALApps Viewer

- Plot wind vectors at different layer heights (surface winds shown here)
- Plot concentration contours

Initial Run

 Radius of influence of surface station observations is too small





Complex Terrain

280

CALApps Viewer

- Select layers to be plotted
- Control the transparency of each layer
- Control the lengths of the wind vectors to wind speed

Final Run

 Observations are now appropriately weighted and correctly capture complex terrain features





• Designed for emergency response model evaluation

Exponent

- PMCH tracer release in Oct and Nov 1994 from northwestern France
- 12-hour release starting on Oct 23, 1994 at 16:00 UTC
- 3-hour average samples at various times over 168 samplers in 17 countries
- Most samplers over 300 km away with tracer measured to ~300 km over 2000 km from release site



European Tracer Experiment (ETEX)

CALApps Viewer

• Animate layers

E^xponent[®]

- Save animation to animated GIF file
- Insert animated GIF into PowerPoint as a Picture or Movie

EPA/ENVIRON Run

- Coarse resolution MMIF
- Errors in model setup, etc.
- Incorrect conclusion that CALPUFF performs poorly

ETEX-1 CALPUFF - EPA/ENVIRON (36 km MMIF)



European Tracer Experiment (ETEX)

CALApps Viewer

E^xponent[®]

- Jump to specific dates/times
- Step forward/backward
- Import custom base map
- Customize concentration contour levels and colors

Exponent Run

- Refined resolution
 CALMET
- Corrections to model setup, etc.
- CALPUFF performance is among the best

ETEX-1 CALPUFF – w/Corrections, 12-km CALMET

ETEX Test 4: Wind, PMCH-1HR Concentration [L01: 0 - 20 m]

[Day 296] - October 23, 1994 4:00 PM [UTC+0100]



European Tracer Experiment (ETEX)



CALApps Viewer:

E^xponent[®]

View multiple animations simultaneously in step with each other to quickly evaluate sensitivity of model performance to model settings and/or input data

CALApps TimeSeries

280

Features

- Freely distributed
- Plot multiple time series simultaneously
- Zoom and scroll
- Hover with mouse to view date/time and value of each data point
- Check and uncheck time series for viewing
- View scatter plot for two time series
- Control Y-Axes extents with one click
- Save to picture file



The Northwest Passage: Sea Ice

160

Overview

E^xponent[®]

- Coarse resolution MM5 (30 km)
- Refined resolution MM5 (10 km)



The Northwest Passage: Sea Ice

CALApps TimeSeries

- Plot the modeled and observed sea surface temperatures together
- Zoom in to winter months

Question

• Why is the coarse resolution MM5 run performing better than the fine resolution run?

Conclusion

 The 10 km run is being influenced by gridded satellite SST data which has the sea surface temperatures above freezing



CALApps Software Summary

Software Input Data Formats

- Non-proprietary, readable ASCII
- Allows software to be used with any type of data to display any type of variable, including user-generated

d2_m2d_2007_seapt.tsf - Notepad		
File Edit Format View Help		
TIMESERIES.TSF 1.3 2 comment Time series from MM5 2D.DAT fi 2D meteorological data are not 4 station	Full location/date/time documentat lines les profiled information lines	ion
WATERPT 2D.DAT: Nearest Grid Pt [(I,J) Input location: (I,J)=(37 Nearest Grid Pt: (X,Y)km=(- PS	=(37.000, 58.000)])][(x,Y)km=(.000 58.000) 120.000 90.000) in PS Project	-120.000, 90.000) in MODEL Projectio ion below
67.250000N 110.099998W 0.00000000E+00 0.00000000E+00 NW5-84 02-21-2003	50.000000N 50.000000N	
UTC-0700 GREGORIAN_YMD 2007 1 1 0 0000 2008 1 1 13 measure, units.	0 0000 3600 mol.wt., missing, 7 m, X or LON,	Y of LAT
T_GROUND K PBL_HEIGHT METERS USTAR M/S SWAVE_DOWN W/M*2	-1.000 9999.000 0.000 -1 -1.000 9999.000 0.000 -1 -1.000 9999.000 0.000 -1 -1.000 9999.000 0.000 -1	120.000 90.000 120.000 90.000 120.000 90.000 120.000 90.000
LWAVE_DOWN W/M*2 TEMP K SHUMID G/KG WSPEED M/S	-1.000 9999.000 0.000 -1 -1.000 9999.000 2.000 -1 -1.000 9999.000 2.000 -1 -1.000 9999.000 10.000 -1	120.000 90.000 120.000 90.000 120.000 90.000 120.000 90.000
WDIR DEG T_SEASFC K RAIN_TOT MM RAIN_CON MM	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	120.000 90.000 120.000 90.000 120.000 90.000 120.000 90.000 120.000 90.000
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.000 393.000 0.000 0.1 0 0000 271.435 576.095 0.1 1 0000 271.435 596.412 0.1 2 0000 271.435 533.030 0.1 3 0000 271.435 457.389 0.1 4 0000 271.435 486.440 0.1	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
$ \begin{bmatrix} 2007 & 1 & 1 & 5 & 0000 & 2007 & 1 & 1 \\ 2007 & 1 & 1 & 6 & 0000 & 2007 & 1 & 1 \\ 2007 & 1 & 1 & 7 & 0000 & 2007 & 1 & 1 \\ 2007 & 1 & 1 & 8 & 0000 & 2007 & 1 & 1 \\ 2007 & 1 & 1 & 9 & 0000 & 2007 & 1 & 1 \\ 2007 & 1 & 1 & 9 & 0000 & 2007 & 1 & 1 \\ \end{bmatrix} $	5 0000 271.435 546.892 0.1 6 0000 271.433 555.766 0.1 7 0000 271.433 552.202 0.1 8 0000 271.433 556.959 0.1 9 0000 271.433 514.860 0.1	146 0.000 208.664 263.313 1.4 145 0.000 215.670 263.492 1.4 152 0.000 240.359 263.690 1.4 163 0.000 251.688 263.819 1.5 178 0.000 251.688 263.832 1.5

Distribution

- Distributed free of charge from Exponent's website (February 2013):
 - <u>http://www.exponent.com/atmospheric_sciences/</u>
- Note that some features rely on third-party software which must be purchased separately.

CALApps Future Development

280

- GUI for the CALPUFF modeling system compatible with 64-bit OS
- Statistical software package
- Profile plotting software
- And much more

🔛 Untitled CALMET.inp - CALApps TNG			
File Tools Help			
PROJECT	CALMET GUI CALMET.INP		
INFORMATION MAIN • CALMET • CALPUFF • CALPOST GEOPHYSICAL • CTGPROC • TERREL	PROJECT NAME RUN TYPE OBS-ONLY NO-OBS HYBRID Use surface and overwater stations (no upper air observations). Use MM4/MM5/3D.DAT for upper air data.	ш	
MAKEGEO POSTPROCESSING PRTMET METEOROLOGICAL SMERGE	Check the options specified to see if they conform to regulatory values for long range transport? [MREG]		
• READ62 • BUOY	BEGIN END January 01, 2011 12:00:00 AM January 01, 2012 12:00:00 AM		
OTHER • CTGCOMP • PXTRACT	TIME ZONE		
	MAP PROJECTION		
	RUN CALMET		