PUFF – Volcanic Ash Dispersion Modeling
PUFF-AFWA Version 3.00
Version Description Document

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Table of Contents

Section **Page**

List of Figures and Tables

Name **Page**

1 Introduction

1.1 Purpose

This document is the version description document for the PUFF volcanic ash dispersion modeling programs, which predict the geographical distribution of volcanic ash from an eruption versus time. It provides a detailed description of the contents of Version 3.00 of the PUFF application system.

1.2 Background

PUFF is a volcanic ash dispersion prediction tool. PUFF was developed at the Geophysical Institute, University of Alaska Fairbanks and used by the Alaska Volcano Observatory (AVO) for volcano monitoring. Initially, PUFF was a research tool conceived by Dr. Hiroshi Tanaka for predicting the movement of eruption clouds. Dr. Craig Searcy conceived and developed the present version of PUFF as part of his PhD program. This version is used by the National Weather Service (NWS) and AVO to track volcanic eruption clouds.

Refinements in the Graphical User Interface (GUI) and data conversions were implemented by The Johns Hopkins University Applied Physics Laboratory (JHU/APL) in a joint project with the University of Alaska. JHU/APL is responsible for modifying the program and/or developing supporting utilities to facilitate its deployment at the Air Force Weather Agency (AFWA) site at Offutt AFB, NE. An additional responsibility is to develop a basic documentation set including this document. The system is currently in operation at the Air Force Weather Agency (AFWA).

1.3 Overview

The PUFF program models the dispersion of volcanic ash from an eruption and provides predictions of ash particle locations (latitude/longitude/altitude) versus time given eruption characteristics and wind field forecasts produced by another model. The PUFF application suite comprises five executable programs (puff, afwa2puff, puffgui, puffview, and ashdump) that provide the modeling capability; input data preprocessing; a graphical user interface (GUI) for model run specification; a GUI for viewing results; and utilities for viewing summaries of binary file contents. The application is written in C++, while the associated GUI functions are largely handled via the Tool Command Language (Tcl) scripts employing Toolkit (Tk) Motif widgets. The application suite can be hosted on Unix systems.

The PUFF model predicts the movement of ash particles ejected from a volcano versus time. The operator may select from a number of different initial conditions for the ash distribution and particle size. Particle locations are computed for each integration step (typically 5 minutes), with a snapshot of all particle locations at a given summation time (typically one or more hours) being written to an ash file.

For input, PUFF requires the name of a volcano, eruption characteristics, and forecasts of wind speeds for the time period of interest. The wind speed data must be available in gridded binary (GRIB) files. At AFWA, these required wind GRIB files are produced by a variety of models. PUFF's afwa2puff program converts the GRIB file outputs of the various wind models to U and V wind velocity versus geopotential height files. The U and V files serve as inputs for PUFF's volcanic ash tracking model. PUFF's puffview program displays a map of the area surrounding the volcano of interest overlaid with a graphical depiction of the ash distribution and overlaid with location identifier labels (pushpins). The PUFF volcanic ash tracking model outputs a series of ash files in Network Common Data (netCDF) format, describing the ash distribution over time.

The processes used in the model and an analysis of model results versus observations are given in "PUFF: A high-resolution volcanic ash tracking model," (see reference 1).

1.4 Components

Table 1-1 identifies and provides a brief description of the roles of the PUFF application suite components.

Table 1-1 PUFF Suite Executables

Executable	Role
puff	Contains the volcanic ash dispersion model and is executed for each model run.
puffgui	GUI invoked by the operator and used to specify model parameters and select source wind data for use by the model; automatically invokes afwa2puff (wind data conversion), puff (model), and puffview (view results) as necessary.
puffview	GUI normally invoked automatically by puffgui following a model run. This displays a map of an area surrounding the volcano of interest overlaid with a graphical depiction of the ash distribution and overlaid with location identifier labels (pushpins).
ashdump	Utility normally invoked by puffview to extract data from the ash files produced during the model run. It can also be invoked from the command line by a knowledgeable operator to inspect ash data.
afwa2puff	Utility normally invoked by puffgui to convert wind speed data contained in gridded binary (GRIB) files into a form usable by the puff executable. Can also be invoked from the command line to automate source wind file creation.

1.5 Document Organization

Section 1 describes the scope of the PUFF application system.

Section 2 lists applicable references.

Section 3 provides a detailed description of the contents of Version 3.00 of the PUFF application system.

Section 4 provides a list of acronyms and abbreviations.

Appendix A provides an index of software.

2 References

"PUFF: A high-resolution volcanic ash tracking model," Journal of Volcanology and Geothermal Research 80 (1998) pp1-16, Craig Searcy, Ken Dean, and William Stringer

"NetCDF User's Guide for C – An Access Interface for Self-Describing, Portable Data", Version 3, Russ Rew, Glenn Davis, Steve Emmerson, and Harvey Davies, Unidata Program Center, June 1997 - http://www.unidata.ucar.edu/packages/netcdf/index.html

"The WMO Format for the Storage of Weather Product Information and the Exchange of Weather Product Messages in Gridded Binary Form as used by NCEP Central Operations," Clifford H. Dey, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, National Centers for Environmental Prediction Office Note 388, GRIB (Edition 1), 10 March 1998

3 Version Description

3.1 Inventory of Materials Released

Version 3.00 of the PUFF software system is being released on a single CD labeled PUFF-AFWA Software Version 3.00.

The documentation that supports this version is listed below and has been delivered prior to installation of the system.

PUFF-AFWA Functional Requirements Document, UPOS-B33-01, D. S. Tillman and R. Crane, 30 November 2001, L. Nguyen 25 September 2003.

PUFF-AFWA User's Guide, UPOS-B33-02, D. S. Tillman, J. J. Harrison, and R. Crane, 30 November 2001, L. Nguyen 25 September 2003.

PUFF-AFWA Detailed Design Document, UPOS-B33-03, D. S. Tillman and R. Crane, 30 November 2001

PUFF-AFWA Test Plan, UPOS-B33-04, R. Crane, 30 November 2001, L. Nguyen 25 September 2003.

PUFF-AFWA Test Report, UPOS-B33-05, R. Crane, 30 November 2001, L. Nguyen 25 September 2003.

PUFF-AFWA Support Plan, UPOS-B33-06, R. Crane, 30 November 2001, L. Nguyen 25 September 2003.

PUFF-AFWA Version Description Document, UPOS-B33-07, R. Crane, 30 November 2001, L. Nguyen 25 September 2003.

3.2 Inventory of Software Components

Appendix A contains the complete list of directories and files being delivered as Version 3.00 of the PUFF software system.

3.3 Changes Installed

Version 3.00 of PUFF-AFWA is based on Version 2.00 of PUFF-AFWA with the inclusion of the features described below, which were developed at the Geophysical Institute (GI) at the University of Alaska, Fairbanks (UAF) and are included in their version 2.0 of PUFF. The GI UAF PUFF is an independent development branch of PUFF-AFWA and its version numbering is independent of the PUFF-AFWA version numbering.

3.3.1 Version 3.00 of the PUFF software system contains the following changes:

- Ability to run multiple eruptions from either the same or different volcanos.
- Ability to simulate the movement of an existing ash cloud.
- Ability to run a new eruption with an existing ash cloud.
- The GUI now includes a cloud editor to allow the user to graphically generate the specifications of an existing ash cloud.
- New ash color schemes have been added as an option to the puffview map.

3.3.2 Version 2.00 of the PUFF software system contains the following changes:

- Modified to handle the new format for NOGAPS wind data where 'anl' records are gleaned from multiple source wind files.
- Location identifiers (pushpins) have been added to the map in the form of labels with icons. New pushpins can easily be added by editting the pushpin.txt file.
- These pushpins can be controlled by type by using the new pushpin type list on the puffview window. They can also be selected individually by use of the new pushpin selection button and window.
- New parameters have been added to the args list (viewMapCoastline, viewMapSize, pinPath, and pushpinCfg).
- Puffgui command line parameters will now be transferred from puffgui to puffview when puffview is started.
- The 'loop' speed slider in the puffview window now works in a more natural manner.
- Changing the volcano start date and time can now be done more feasibly and faster with the mouse button.
- The viewable area for the map has been increased.
- Comments are now allowed in the volcano.txt file as well as the pushpin.txt file and the pushpin.cfg file by use of the # sign. Entries can be 'commented' out rather than deleted.

3.3.3 Version 1.02 of the PUFF software system contains the following changes:

- *GRIB Processing*

    1. To address the need to handle forecast cycle file collections arriving over a period of time, the original "convert hours" parameter has been replaced by "minimum convert hours" and "desired convert hours." The algorithm followed is:

Find the latest forecast **cycle** (looking at the base file in the cycle) whose internal time is equal to, or earlier than, the eruption time.
Access each subsequent forecast **file** whose name is based on that forecast cycle in turn, inspecting the internal date/time to ensure the file was generated in the same run as the base file. Stop when either 1) the next file in sequence doesn't exist, 2) the next file in sequence has a different internal date/time, or 3) sufficient files have been examined to meet the "desired convert hours" level.
If at least "minimum convert hours" worth of files exist, process the files from this forecast cycle. If not, look for the next earlier forecast cycle and repeat the procedure. If no previous cycles exist, display an error message to the operator.

- *Lat/Lon Presentation*

    Puffgui

Reordered the volcano latitude and longitude widgets so latitude comes first.
Changed the specification range for latitude to –180 < lon <= 180 East.

    Puffview

Reordered the location presentation from longitude/latitude to latitude/longitude in the volcano summary and in the cursor position display in the bottom right corner. Latitude/longitude information is displayed in positive WESN terms (e.g., 70 W instead of –70 E) for those two displays.

    Printout

Reordered the volcano latitude and longitude presentation so latitude comes first.

1. Latitude/longitude information is displayed in positive WESN terms (e.g., 70 W instead of –70 E).

Added "kft" (kilofeet) to the printed legend.

- *Height Presentation*

1. Volcano elevation, plume top, and plume base values now use “feet” for the primary display. The “meters” equivalent is given in the label.

- *Ash File Manipulation*

Upon entry and re-entry into puffview, ash files are automatically loaded and displayed.
Multiple selection of ash files in the ash list is now possible via click-and-drag (range), shift-click (range), ctrl-click (non-contiguous group) mouse actions.
Any change to the ash legend (color redefinition, number of colors, min or max altitudes) results in the ash display being cleared. This reflects the fact that the previously displayed information no longer correlates with the ash legend.
Added a button to the main puffview window under the ash legend that can be used to reload all ash files in a single action.

- *General Issues*

Modified program to query the user’s display for color depth, resolution, and screen width and height. The program now will select 24 bit color only if available; otherwise it uses the system’s default. This eliminates the dramatic color shifts resulting from palette switching on PCs with 8 bit color.
Corrected the map width option in the Map Options dialog box so that the requested width is honored regardless of the screen resolution. For example, a 12 inch-wide map should be 12 inches wide on a 90 dpi Sun display as well as on a 72 dpi PC display.
The puffview window automatically resizes after the map loads to fit in <= 95% of the screen space and scrollbars appear if needed when running under Sun Openwindows.
The loop speed slider in puffview has been modified so that moving the slider to the right increases the animation speed and moving it to the left decreases animation speed. This is the reverse of what it was previously.

- *Bug Fixes*

1. It’s now possible to print when the legend is set to a single color.

A problem with the display of maps where the user has selected a very tall, narrow region in the Map Options dialog box has been corrected.
A problem with meeting the user’s requested coverage on mapping using the South Polar Stereo projection has been corrected.
A problem with the puffview display of volcano names beginning with a non-alphabetical character (e.g., ‘) has been corrected.

- *Investigations*

1. Keypad entry of numbers into “Tix Control” mega-widgets (e.g., SAVE HOURS on the puffgui display) does not work correctly on Sun computers. This was traced to an apparent bug in Sun’s X-server implementation. Unlike other X-servers, the Sun X-server reports UP, DOWN, LEFT, and RIGHT keysyms associated with the keypad 8, 2, 4, and 6 keys respectively regardless

of whether NUMLOCKS is set to on. Other X-servers report KP_8, KP_2, KP_4, and KP_6 keysyms respectively when NUMLOCKS is on and UP, DOWN, LEFT, and RIGHT when NUMLOCKS is off.

Since the Tix Control mega-widget registers for the UP and DOWN events for incrementing and decrementing the displayed value, and the LEFT and RIGHT events for moving the insertion point left and right, it ends up responding to two conflicting events when the NUMLOCKS is set to on. For example, pressing the keypad 8 key results in an "UP" keysym with an "8" value. So the widget increments the displayed value and inserts an additional number "8" in the entry box wherever the insertion point was placed.

Work-around – Numeric entry using the number keys on the main keyboard works correctly. It is recommended that these keys be used for direct numeric entry, and that the non-keypad arrow keys or the mouse be used for incrementing and decrementing displayed numbers.

3.4 Related Documents

All documents pertinent to Version 3.00 of the PUFF software system are included in the release.

3.5 Install Instructions

A UNIX system administrator will need to be available to monitor the installation and the acceptance testing for the 3.00 version of the PUFF software system. The details for installing the system can be found in the PUFF installation Procedures document.

3.6 Possible Problems and Known Errors

There are no known problems.

4 APPENDIXES

APPENDIX A - Inventory of Software Contents of Puff Version 3.00

Directory /opt/production/upos/puff/puff-afwa-v300/src	
Makefile	7220
et2c	365876
Directory /opt/production/upos/puff/puff-afwa-v300/src/bin	
afwa2puff	6507948
ashdump	6579416
puff	6951856
puffgui	7477024
puffview	7097884
Directory /opt/production/upos/puff/puff-afwa-v300/src/dstsrc	
afwa2puff.C	103039
grib_utils.C	5415
grib_utils.h	2021
Directory /opt/production/upos/puff/puff-afwa-v300/src/gui	
afwaopt.tcl	19371
afwarun.tcl	5651
cloud_editor.tcl	45442
gui.tcl	27122
guiopt.tcl	8006
help.tcl	5831
inclusion_test.C	4234
inclusion_test.h	398
puffgui.C	4601
puffgui_utils.C	9592
resource.tcl	6945
run.tcl	25080
splash.tcl	2997
tcl_utils.C	2593
windfile_summary.tcl	6103
xpm.tcl	7495
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc	
Makefile	3688
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/dynstream	
dynstream.C	24732
tokstream.C	2572

Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/et	
et2c.c	40136
et80.c	35824
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/fltGrid4.5	
display.C	15617
fg_copy.C	14880
fg_io.C	25273
fg_rebin.C	13153
fg_resize.C	11939
fltGrid.C	18630
hdf_io.C	8287
netcdf_io.C	19263
patch.C	8538
vspline.C	34396
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/include	
dynstream.h	5480
fltGrid.h	10273
nmcGrid.h	5327
projectionGrid.h	12254
tokstream.h	578
uniGrid.h	1574
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/lib	
libdynstream.a	41164
libet.a	186608
libfltGrid4.5.a	185290
libnmcGrid4.5.a	32352
libprojectionGrid1.0.a	54208
libuniGrid4.5.a	35818
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/nmcGrid4.5	
nmcGrid.C	26418
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/projectionGrid1.0	
projectionGrid.C	58825
Directory /opt/production/upos/puff/puff-afwa-v300/src/libsrc/uniGrid4.5	
cdfread.C	19189
uniGrid.C	14658
utils.C	7143
Directory /opt/production/upos/puff/puff-afwa-v300/src/puffsrc	
args.C	26916

args.h	3252
ash.C	22894
ash.h	2054
ashdump.C	21573
ashdump.args	1487
cloud.C	14921
cloud.h	1978
point.C	2389
point.h	423
puff.C	39691
puff.args	4637
puff.h	989
puff_utils.C	8501
ran_utils.C	5868
ran_utils.h	549
status_constants.h	250
uni2puff.C	23120
uni2puff.args	1439
volc_utils.C	3384
volc_utils.h	465
volcanos.txt	113335

Directory /opt/production/upos/puff/puff-afwa-v300/src/viewgmt	
cities.dat	94899
dialog.tcl	5036
dialog_prompt.tcl	1796
gmt_ashlegend.tcl	18450
gmt_ashlist.tcl	4864
gmt_ashloop.tcl	4012
gmt_ashprint.tcl	20722
gmt_ashsave.tcl	38193
gmt_ashtools.tcl	18711
gmt_basemap.tcl	12105
gmt_help.tcl	2917
gmt_initps.tcl	8473
gmt_mapopts.tcl	15231
gmt_mk4x4.tcl	25746
gmt_pushpin_cfg.tcl	8139
gmt_pushpin_list.tcl	4605
gmt_pushpins.tcl	8811
gmt_resources.tcl	3361
gmt_startview.tcl	20529
gmt_utils.tcl	5661
gmt_xpm.tcl	103039
puffview.C	6695
puffview.args	1110
pushpins.C	8624
pushpins.cfg	848
pushpins.h	802
pushpins.txt	13276

APPENDIX B – Acronyms and Abbreviations

AACGM	Attitude Adjusted Corrected Geomagnetic
ACE	Advanced Composition Explorer
AFCCC	Air Force Combat Climatology Center
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AFSCN	Air Force Satellite Control Network
AFSPACECOM	Air Force Space Command
AFSWC	Air Force Space Weather Center
AFWA	Air Force Weather Agency
AFWIN	Air Force Weather Information Network
AF/XOW	Air Force Director of Weather
APL	Applied Physics Laboratory of Johns Hopkins University
ASCII	American Standard Code for Information Interchange
ASPAM	Atmospheric Slant Path Analysis Model
AVHRR	Advanced Very High Resolution Radiometer
AVN	Aviation Model
AVO	Alaska Volcano Observatory
BATS	Biosphere-Atmosphere Transfer Scheme
CLASS	Canadian Land Surface Scheme
CME	Coronal Mass Ejections
COE	Common Operating Environment
DII	Defense Information Infrastructure
DMSP	Defense Meteorological Satellite Program
Dst	Disturbance, storm
ECMWF	European Center for Medium-Range Weather Forecasts
EIT	Extreme Ultraviolet Imaging Telescope
EVA	Extravehicular Activities
FAC	Field Aligned Currents
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FSL	Forecast Systems Laboratory
FTP	File Transfer Protocol
GDS	Grid Description Section
GI	Geophysical Institute
GIC	Ground Induced Currents
GIF	Graphic Interchange Format
GIT	Georgia Institute of Technology
GMT	Generic Mapping Tools
GOLD	Geophysical On-Line Data
GOES	Geostationary Operational Environment Satellite

GRIB	Gridded Binary
GSE	Geocentric Solar-Ecliptic
GSFC	Goddard Space Flight Center
GUI	Graphical User Interface
HLBL	High Latitude Boundary Layer
IDL	Interactive Data Language
IMF	Interplanetary Magnetic Field
ISS	International Space Station
JHU	Johns Hopkins University
JHU/APL	Johns Hopkins University/Applied Physics Laboratory
Kp	Planetary Index of Geomagnetic Activity
LAN	Local Area Network
LAPS	Local Analysis and Prediction System
LASCO	Large Angle Spectroscope Coronagraph
LEO	Low-attitude Earth Orbit
LSM	Land Surface Model
MATCH	Model of Atmospheric Transport and Chemistry
MeV	Million Electron Volts
MM5	Fifth Generation Mesoscale Model
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
netCDF	Network Common Data Form
NGDC	National Geophysical Data Center
NGM	Nested Grid Forecast Model
NOAA	National Oceanic and Atmospheric Administration
NOGAPS	Navy Operational Global Atmospheric Prediction System
NRL	Naval Research Laboratory
NWP	Numerical Weather Prediction
NWS	National Weather Service
OWS	Operational Weather Squadron
PACE	Polar Anglo-American Conjugate Experiment
PBL	Planetary Boundary Layer
PCA	Polar Cap Absorption
PDS	Product Definition Section
PFRR	Poker Flat Research Range
PNG	Portable Network Graphics
PUFF	From Puff the Magic (ash spewing) Dragon

RBE	Radiation Belt Environment
SAA	South Atlantic Anomaly
SABER	Sounding of the Atmosphere using Broadband Emission Radiometry
SD	Space Department of the Applied Physics Laboratory
SDP	Software Development Plan
SEC	Space Environment Center
SEE	Solar EUV Experiment
SEON	Solar Electro-optical Observing Network
SEP	Solar Energetic Particles
SFOC	Space flight Operations Center
SOHO	Solar and Heliospheric Observatory
SPE	Solar Particle Event
STP	Solar Terrestrial Physics
SWOC	Space Weather Operations Center (Offutt)
SWXS	Space Weather Squadron
SXI	Soft X-ray Imager
Tcl	Tool Command Language
Tk	Toolkit
Tix	Tk Interface Extension
UAF	University of Alaska, Fairbanks
UCAR	University Corporation for Atmospheric Research
UCB	University of Colorado, Boulder
UPOS	University Partnering for Operational Support
UTC	Coordinated Universal Time
WDC	World Data Center
WF	Weather Flight
WMO	World Meteorological Organization
XDR	External Data Representation