Polar Stratospheric Clouds Detectability Support Plan

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Version 1.0

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1 OVERVIEW

1.1 System Overview

Polar stratospheric clouds (PSCs), which are often present at high latitudes during winter, pose a number of threats to operations. They form in the stratosphere from near the tropopause to altitudes of roughly 30 km. When optically thick, especially when viewed at long slant look angles, they have the potential to inhibit operations that require optical transmission in the atmosphere, including missile detection and kill, satellite-based intelligence, and satellite-based atmospheric temperature profiling.

PSCs are common at high southern latitudes and occur intermittently in the Northern Hemisphere, persistently reducing optical transmission over large areas. The principal component of PSCs is nitric acid (HNO_3) trihydrate (NAT), and PSCs form when the *in situ* temperature drops below the NAT saturation temperature (T_{NAT}), which is a function of the HNO_3 and H_2O vapor pressures. PSCs are also composed of a ternary mixture of HNO_3, sulfuric acid (H_2SO_4), and water and also water ice at colder temperatures. Moreover, the documented stratospheric trends of decreasing temperature and increasing HNO_3 and H_2O suggest that PSCs will occur more frequently and with greater optical depth in the future.

We have developed a forecast model, based on standard Air Force Weather Agency (AFWA) MM5 model runs, that computes the probability of PSC existence by comparing forecast *in situ* temperatures with T_{NAT} derived from either satellite climatologies of HNO_3 and H_2O or assuming constant mixing ratios, which are typically very uniform in the polar lower stratosphere. Several climatologies have been considered. A zonally averaged monthly HNO_3 climatology has been taken from CLAES measurements at 16 levels throughout the stratosphere and lower mesosphere. For H_2O, we have used two climatologies. The first is from the POAM satellite at 16 stratospheric levels, from November through March. The other is from HALOE/MLS, analogous to the CLAES HNO_3 climatology. We have also experimented with using fixed mixing ratios (e.g., 10 ppbv HNO_3 and 5 ppmv H_2O).

MM5 temperatures are generated on six pressure levels, from 150 to 10 mb. Temperature and trace gas fields are uniform in the polar lower stratosphere, so this relatively course altitude resolution is sufficient to capture the vertical structure.

1.2 Document Overview

The purpose of this document is to outline the resources necessary to install, run, and evaluate the PSC Detectability software system.

2 Product Support Resources

2.1 *Facilities*

The PSC Detectability software has been adapted for the AFWA facilities. No resources other than those listed in the following subsections will be required from these facilities.

2.2 Hardware

The software was developed for use on a SUN platform (see section 2.3 below for operating system requirements). For installation and operation of the software, access to a Sun platform with a color display, approximately 700 MB of disk space for software.

2.3 *Software*

The software was developed under Solaris 2.7 and Solaris 2.8. IDL, Python, and Perl libraries should be present on the target system.

There are possible incompatibilities that need to be worked arising from version differences in the operating system and the required software. We do not expect problems arising from operating system minor version differences, as very few operating system services are used.

2.4 Data

The software was tested with MM5 forecast files in the netcdf format with the naming convention *ll.d1.yyyymmddhh.nc*, where yyyy = year, mm = month, dd = day of month, and hh is forecast hour.

The file contains fields, which have been interpolated from a polar stereographic grid to a uniform $1^\circ \times 1^\circ$ latitude/longitude grid. The fields and units of the file are as follows: latitude in degrees, longitude in degrees, pressure levels in pascals, temperature in Kelvin and water vapor mixing ratio in kg/kg.

2.5 Personnel

2.5.1 Personnel required for installation

The installation process is expected to take less than 1 business day. We request that the UNIX system administrator be responsible for the installation process. During this time, access to the individual(s) that will be evaluating the software will be required. The APL Transition Team will be available during this period, via email or telephone, to answer questions or troubleshoot.

2.5.2 Personnel required for evaluation

We recommend that one person be assigned to the evaluation at a level of effort conducive to the desired level of intensity of the evaluation. This person should be competent to evaluate the output of the software.

2.6 Error handling

Currently, the error reporting mechanisms in the software are written to the screen as well as an error log.

3 Recommended Procedures for Operation

The software as delivered is designed to run without human intervention.

4 Training

Person(s) at AFWA conducting the installation and evaluation will be able to contact the UPOS Transition Team by telephone or email to ask questions.

5 Anticipated Areas of Change

Additional software changes can be made through the UPOS Transition Team corrective action process via the UPOS web page. A general purpose email account has been setup to accept project-related feedback. This email link is available under the feedback section of the UPOS web page. The URL for the UPOS web page is: http://sd-www.jhuapl.edu/UPOS/index.html

6 Evaluation and Transition

The software is being delivered to AFWA for the purpose of evaluation. We will make resources available to support the evaluations conducted at AFWA. Additional requirements, documentation and training may be negotiated as a result of the evaluation.

APPENDIX A: ACROYNMS AND ABBREVIATIONS

Acronym	Definition
AFWA	Air Force Weather Agency
APL	Applied Physics Laboratory of Johns Hopkins University
ASCII	American Standard Code for Information Interchange
CLAES	Cryogenic Limb Array Etalon Spectrometer
COE	Common Operating Environment
FTP	File Transfer Protocol
GRIB	Gridded Binary
GSFC	Goddard Space Flight Center
HALOE	Halogen Occultation Experiment
IDL	Interactive Data Language
JHU	Johns Hopkins University
LAN	Local Area Network
MLS	Microwave Limb Sounder
MM5	Fifth Generation Mesoscale Model
NAT	Nitric Acid Trihydrate
netCDF	Network Common Data Form
NWP	Numerical Weather Prediction
PNG	Portable Network Graphics
POAM	Polar Ozone and Aerosol Measurement
ppbv	Parts per billion by volume
ppmv	Parts per million by volume
PSC	Polar Stratospheric Cloud
SD	Space Department of the Applied Physics Laboratory
SDP	Software Development Plan
Tcl	Tool Command Language
Tk	Toolkit
UPOS	University Partnering for Operational Support
UTC	Coordinated Universal Time
XDR	External Data Representation