Polar Stratospheric Clouds Detectability Version Description

UPOS-BH3-03

25 February 2004

Version 1.0

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1. INTRODUCTION

1.1 Document Overview

Section 1 describes the scope of the Polar Stratospheric Clouds Detectability software system.

Section 2 lists Referenced Documents.

Section 3 provides a detailed description of the contents of Version 1.0 of the Polar Stratospheric Clouds Detectability software system.

1.2 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. *Hanson and Mauersberger* [1988] provided a detailed description of the phase diagram of the HNO_3/H_2O system. 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.

Comparisons with solar occultation measurements made by the Polar Ozone and Aerosol Measurement (POAM) III satellite instrument during the Southern Hemisphere 2003 winter have shown that the model does an excellent job predicting when and where PSCs will occur.

1.3 System Overview

The system architecture is based on software currently used for similar purposes at JHU/APL. Figure 1 shows a diagram of the architecture and data flow.

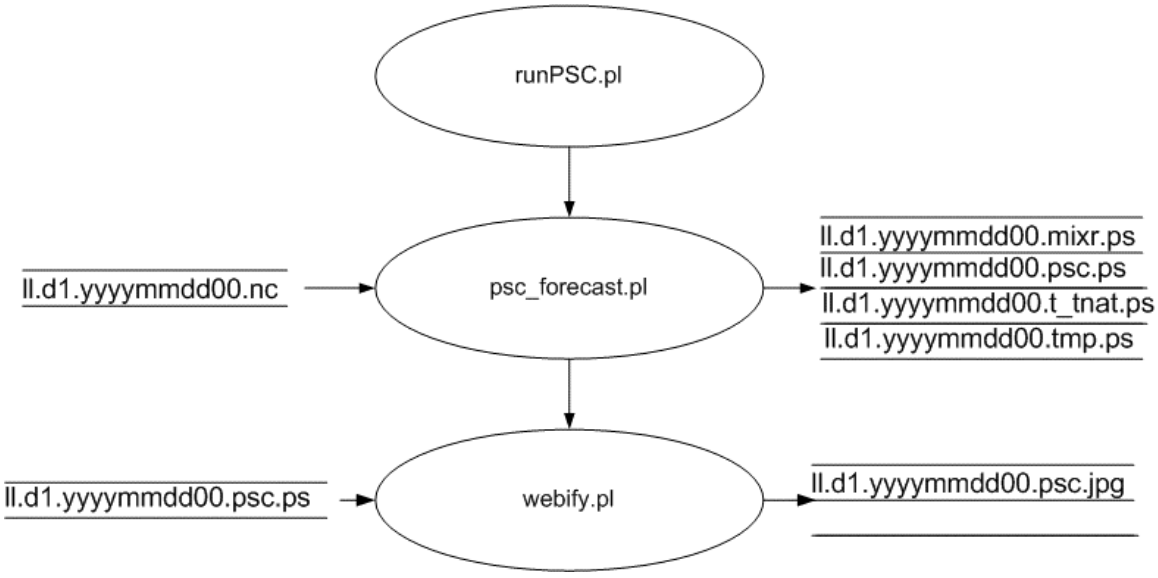

Figure 1.

An executive script coordinates the execution of the PCS Detectability process. The output images can be displayed using most image viewers such as xv or any web browser.

The PSC Detectability application requires AFWA MM5 gridded binary format data (grib). The MM5 weather data variables used by the PSC model are extracted and saved in a NetCDF format by an IDL subprocess. The MM5 NetCDF file is designated by a letter prefix “d” (i.e. *d02012203*, 2002-Jan-22 at 3 GMT). The PSC Detectability application reads in the appropriate NetCDF data

files for each model time step and calculates PSC probability. The model outputs temperature (temperature and temperature relative to T_{NAT}), water vapor, and PSC probability calculations on 24 pressure levels from 1001 to 10 mb (temperature relative to T_{NAT} and PSC probability only on the top 6 levels, from 150 to 10 mb). The output files are in Postscript format. The PSC Detectability output data is converted by a perl script that reads in the PSC Detectability output and produces .jpeg images showing the probabilities of PSC occurrence on each level.

2. Referenced Documents

Hanson, D. and K. Mauersberger, Laboratory studies of the nitric acid trihydrate: Implications for the south polar strato sphere, *Geophys. Res. Lett.,* **15**, 855-858, 1988.

3. Version Description

3.1 Inventory of Materials Released

The Polar Stratospheric Clouds Detectabiltiy software system is being released via a tar file labeled PCS_Detectabiltiy_Software_Ver_1_0.

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

- Polar Stratospheric Clouds Detectability Functional Requirements Document, UPOS-BH3-01, Version 1.0, Linda. M. Burke, Michael A. Kelly, Steve A. Lloyd, William H. Swartz, Bruce A. Toth, 31 July 2003

- Polar Stratospheric Clouds Detectability Support Plan, UPOS-BH3-02, Version 1.0, Linda. M. Burke, Michael A. Kelly, Steve A. Lloyd, William H. Swartz, Bruce A. Toth, 31 July 2003

- Polar Stratospheric Clouds Detectability Software Version Description, UPOS-BH3-03, Version 1.0, Linda. M. Burke, Michael A. Kelly, Steve A. Lloyd, William H. Swartz, Bruce A. Toth, 31 July 2003

- Polar Stratospheric Clouds Detectability User's Guide, UPOS-BH3-04, Version 1.0, Linda. M. Burke, Michael A. Kelly, Steve A. Lloyd, William H. Swartz, Bruce A. Toth, 31 July 2003

- Polar Stratospheric Clouds Detectability Design Document, UPOS-BH3-05, Version 1.0, Linda. M. Burke, Michael A. Kelly, Steve A. Lloyd, William H. Swartz, Bruce A. Toth, 31 July 2003

- Polar Stratospheric Clouds Detectability Test Plan, UPOS-BH3-06, Version 1.0, Linda. M. Burke, Michael A. Kelly, Steve A. Lloyd, William H. Swartz, Bruce A. Toth, 31 July 2003

3.2 Inventory of Software Components

Appendix B contains the complete list of directories and files being delivered as Version 2.0 of the Polar Stratospheric Clouds Detectability software system.

3.3 Changes Installed

This is the initial delivery of the software system.

3.4 Related Documents

All documents pertinent to Version 1.0 of the Polar Stratospheric Clouds Detectability software system are included in the release.

3.5 Install Instructions

A UNIX system administrator will need to perform the installation and the acceptance testing for the UNIX version of the Polar Stratospheric Clouds Detectability software system. The Polar Stratospheric Clouds Detectability software was backed up using tar (tape file archiver).

A. Acronyms and Abbreviations

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

B. Inventory of Software Contents of Version 1.0

UNIX SOFTWARE

Directory /project/upos/PSC			
PSC_software uninstall.pl	511	output	2048
data	512	psc	512
forecasts	512	scripts	512
Total of 6 files, 4607 bytes.			
Directory /project/upos/PSC/psc			
climatology	512	psc_forecast.pl	2503
idl	1536	sav	512
ps	512	webify.pl	1639
Total of 6 files, 7214 bytes.			
Directory /project/upos/dust/PSC/psc/climatology			
CLAES_HNO3	512	poam	512
HALOE+MLS_H2O	512		
Total of 3 files 1536 bytes.			
Directory /project/upos/dust/PSC/psc/climatology			
CLAES_HNO3	512	poam	512
HALOE+MLS_H2O	512		
Total of 3 files 1536 bytes.			
Directory /project/upos/PSC/psc/climatology/CLAES_HNO3			
README.txt	399	claes_hno3.txt	97317
claes_hno3.sav	33408		
Total of 3 files, 131124bytes.			
Directory /project/upos/PSC/psc/climatology/ HALOE+MLS_H2O			
SPARC	512		
Total of 1 file, 512 bytes.			
Directory /project/upos/PSC/psc/climatology/HALOE+MLS_H2O/SPARC			
README.txt	399	haloe+mls_h2o.sav	97320
haloe+mls_h2o.sav	33412		
Total of 3 files, 131131 bytes.			
Directory /project/upos/PSC/psc/climatology/poam			
poam_h2o_clim.txt	1378		
Total 1 file, 1378 bytes.			
Directory /project/upos/PSC/psc/idl			
Standard_solve.prf	11089	interpol_2d_single.pro	4216
altitude.pro	1865	load_colors.pro	462
append_struct.pro	1952	load_netcdf.pro	5989
autopos.pro	7770	mask.sav	264376
bang_p_default.sav	3248	num2str.pro	2260
bang_x_default.sav	4316	parse_fn.pro	2805
bang_y_default.sav	4316	parse_netcdf_times.pro	1759
bang_z_default.sav	4316	plot_netcdf_image.pro	5043
calc_nat.pro	3541	ps_fullpage.pro	1137
calc_netcdf_psc.pro	5172	ps_off.pro	1487
calc_psc.pro	2854	ps_on.pro	2205
calc_psc_prob.pro	2850	ps_reset.pro	1130
climatology.pro	10794	read_netcdf.pro	2115

closest_index.pro	3388	read_prf.pro	3526
color_map.pro	20568	reset.pro	1656
colors.sav	2164	smart_interpol.pro	4744
defined.pro	1203	smart_interpol_loglin.pro	2131
do_psc_calculations.pro	3681	stamp.pro	2042
has_file.pro	1218	str_match.pro	2793
has_tag.pro	2334	type.pro	1139
idl_settings.pro	82	where_common.pro	1889
idl_startup.pro	248		
Total of 43 files, 416874 bytes.			
Directory /project/upos/PSC/scripts			
runPSC.py	1957		
Total of 1 file, 1957 bytes.			
Grand total of 5directories, 58files, ~700 MB.			