Asymmetric impacts on Mars' polar vortices from an equinoctial Global Dust Storm

Open-access dataset

Dataset summary

This dataset contains reanalyses of the global atmospheric state of Mars over the specified time period, through an assimilation into the Mars Global Circulation Model (MGCM) used at the Open University of observational data from the Mars Climate Sounder (MCS) instrument aboard the Mars Reconnaissance Orbiter (for MY 33 and 34) and from the Atmospheric Chemistry Suite (ACS) aboard the ExoMars Trace Gas Orbiter (for MY 34 only). These reanalyses are provided for the approximate period L_S = 200°-230° of Mars Years (MY) 33 and 34, though the exact L_S (areocentric solar longitude) values for each differ slightly due to the structure of the simulations. The MY 34 reanalyses contain the peak of the 2018 Global Dust Storm (GDS).

Contained for each period are two kinds of files: files containing MGCM diagnostics, and files containing specifically potential vorticity (PV) as calculated from the MGCM using a modified version of the BGFLUX2 diagnostic program from the University of Reading.

For any queries regarding the dataset, please contact paul.streeter@open.ac.uk

Accessing the data

The data is provided in the widely-used netCDF4 format; for sample Python scripts, see the **OpenMars standard database** (MY 24-27: https://doi.org/10.21954/ou.rd.7352270.v1; MY 28-32: https://doi.org/10.21954/ou.rd.7352579.v1).

Structure of the data files

The filename convention for the general MGCM diagnostics from the reanalyses is as follows:

NAME_myMM_lsL_myMM_lsL.nc

where NAME indicates the variables contained in the file (NAME can be "diag", "htrt", "wind" ("MGCM diagnostics"), or "pv" ("PV diagnostics")), MM (33 or 34) indicates the MY, and L (0 to 359) the start/end value of solar longitude (to the nearest integer) for the period covered.

Dimensions

The dimensions of all the data files are listed in Tables 1a and 1b. The MGCM was run at spectral resolution T42, which corresponds to approximately 3.75° grid spacing in both latitude and longitude on the physics grid ("diag", "htrt", and "wind"), and approximately 2.8° grid spacing on the finer dynamics grid, which PV is calculated from ("pv"). The vertical is defined in terms of model sigma levels σ (where $\sigma = p/p_s$, p is atmospheric pressure, and p_s is surface pressure) which are non-dimensional and terrain-following. There are 55 vertical levels in these data files, extending to an altitude of approximately 105 km. The PV diagnostics are shown only for one isentropic surface, at 300 K.

Table 1a: Dimensions for MGCM diagnostics (diag_*.nc, htrt_*.nc, wind_*.nc)

Dimension	Number of values	Description
lon	96	Longitude
lat	48	Latitude
lev	55	Vertical level
time	360	Time

Table 1b: Dimensions for PV diagnostics (pv_*.nc)

Dimension	Number of values	Description
lon	128	Longitude
lat	64	Latitude
time	300	Time

The primary time variable used for each data file is the martian Sol (see Table 2 for all time variables). For ease of conversion and since the majority of the Mars science community use solar longitude and Mars Year, these values are also included. Variables are output 12 times every martian Sol for the MGCM diagnostic data, and 10 times every Sol for the PV diagnostic data; a Sol is a day-night cycle on Mars, which lasts 24 hours, 39 minutes, and 35.244 seconds, or 88775.244 seconds. Mars Years are defined according to the calendar introduced by R. Todd Clancy, where Mars Year 1 (L_S = 0°) begins on April 11th, 1955 (Clancy et al., 2000).

Table 2: Dimension variables

Variable	Dimension	Description	Units
lon	lon	Longitude	Degrees east
lat	lat	Latitude	Degrees north
lev	lev	Model sigma level	NU
time	time	Martian Sol	Sols since 0.0
Ls	time	Solar longitude	Degrees
MY	time	Mars Year	NU

3D variables

The 3D variables included in each data file are listed in Tables 3a and 3b. Although only the surface pressure is included in the MGCM diagnostic files, the atmospheric pressure can be calculated for each vertical level of the atmosphere by multiplying the surface pressure variable p_s by the corresponding sigma value of each vertical level in lev.

Table 3a: 3D variables for MGCM diagnostics (diag_*.nc)

Variable	Dimension	Description	Units
ps	lon, lat, time	Surface pressure	Pa
tau	lon, lat, time	Column dust optical depth at 600 nm	NU

Table 3b: 3D variables for PV diagnostics (pv_*.nc)

Variable	Dimension	Description	Units
pv	lon, lat, time	Ertel potential vorticity on the 300 K isentropic surface	PVU

Potential vorticity units (PVU) are standardly used for terrestrial PV studies as a shorthand. 1 PVU = 1.0×10^{-6} m^2 s^{-1} K kg^{-1}.

4D variables

The 4D variables included in each data file are listed in Tables 4a, 4b, and 4c.

Table 4a: 4D variables for MGCM diagnostics (diag_*.nc)

Variable	Dimension	Description	Units
temp	lon, lat, lev, time	Atmospheric temperature	K
dust_opac	lon, lat, lev, time	Dust opacity at 600 nm	NU

Table 4b: 4D variables for MGCM diagnostics (htrt_*.nc)

Variable	Dimension	Description	Units
sw_htrt	lon, lat, lev, time	Shortwave (SW) radiative heating rate	K/s
lw_htrt	lon, lat, lev, time	Longwave (LW) radiative heating rate	K/s

Table 4c: 4D variables for MGCM diagnostics (wind_*.nc)

Variable	Dimension	Description	Units
u	lon, lat, lev, time	Zonal wind speed (positive=westerly)	m/s
v	lon, lat, lev, time	Meridional wind speed (positive=southerly)	m/s

Details of model, MCS and ACS data, and assimilation scheme used

For details of the MGCM, the MCS temperature profiles and dust columns used for the reanalyses, and the analysis correction (AC) data assimilation scheme, please see the **OpenMARS MY28-32 reference manual (Holmes et al., 2019)**, available at the following link: https://doi.org/10.21954/ou.rd.7352579.v1

Note however that for the period of the 2018 GDS, the MCS data used in the assimilation is the v5.3.2 dataset, available at: https://mcs-ws1.jpl.nasa.gov/level_2_2d_v532/

Also note that for the period of the 2018 GDS, the usual filtering of equatorial dayside dust columns from MCS described in the **OpenMARS MY28-32 reference manual** was not performed.

Also assimilated only for MY 34 were temperature profiles from the NIR instrument on ACS. See (Korablev et al., 2018) and (Fedorova et al., 2020) for further details on ACS and ACS temperature profiles respectively.

While the actual data in this dataset is at different spatial/vertical resolution and covers later years than those covered by the manual, the details of the MGCM, observational data, and assimilation technique (including quality control) are the same. For any further queries not covered in the reference manual, please contact paul.streeter@open.ac.uk

References

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