# MY34/30 C storm reference manual

## Dataset summary

This dataset contains reanalyses of the global atmospheric state of Mars over the specified time period through a synthesis of the Mars Global Circulation Model (GCM) used at the Open University and observational data taken by multiple instruments in orbit around Mars. This reanalysis product is useful as a reference global Martian atmosphere that has been constrained by observations, and for several different studies related to the Martian atmospheric structure. Modelled hydrogen escape rates from coupling the global lower atmosphere to an upper atmosphere 1-D photochemical model are also included in the dataset.

For any queries on the dataset, please contact: james.holmes@open.ac.uk

## Accessing the reanalysis dataset

The reanalysis 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 reanalysis data files

This section details the structure of the files from the reanalysis which are made publicly available to interested users.

### Dataset description

The reanalysis produced for this dataset covers the C storm time period in MY34 and MY30, with any particular data file covering 30 sols. Data files are provided in netCDF4 format which are easily accessible by Python. The filename convention is as follows:

myMM_Cstorm_lsL_lsL.nc

where MM (34 or 30) indicate the Mars Year (MY) and L (0 to 359) the start/end value of solar longitude (to the nearest integer) for the period covered by the data file.

### Dimensions

The dimensions of the reanalysis data files are listed in Table 1. The surface and atmospheric reanalysis output in the data files depend on three (longitude, latitude, time) and four dimensions (longitude, latitude, level, time) respectively, with one exception being the visible column dust optical depth which depends on only three (longitude, latitude, time) dimensions. The horizontal grid spacing is 5° in both longitude and latitude, with four-dimensional atmospheric variables defined on model sigma levels $\sigma$ (where $\sigma = p/p_s$, $p$ is atmospheric pressure and $p_s$ is surface pressure) that are non-dimensional terrain-following levels. There are 70 vertical levels in this reanalysis data product extending to an altitude of around 90 km.

**Table 1 - Dimensions used for variables in the reanalysis data files.**

| Dimension | Number of values | Description |
|---|---|---|
| lon | 72 | Longitude |
| lat | 36 | Latitude |
| lev | 70 | Vertical level |
| time | 720 | 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. The surface and atmospheric variables are output every 1 Martian hour starting at 1 a.m. on sol 7261 (sol 571 of MY34) for the MY34 reanalysis and sol 4591 (sol 577 of MY30) for the MY30 reanalysis, with sol 0 corresponding to $L_S = 0°$ MY 24.

**Table 2 - One-dimensional variables in each reanalysis data file.**

| 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 |

## Surface variables

The surface variables included in each reanalysis data file are listed in Table 3. Although only the surface pressure is included in the reanalysis data files, the atmospheric pressure can be calculated for each vertical level of the atmosphere by multiplying the surface pressure variable ps by the corresponding sigma value of each vertical level in lev.

Although none of the surface variables are directly assimilated in the reanalysis product, each one is altered indirectly as a result of the assimilation of temperature profiles and column dust optical depth.

**Table 3 - Surface variables in each reanalysis data file.**

| Variable | Dimension | Description | Units |
|---|---|---|---|
| ps | lon, lat, time | Surface pressure | Pa |
| tsurf | lon, lat, time | Surface temperature | K |

## Atmospheric variables

The atmospheric variables included in each reanalysis data file are listed in Table 4. As previously mentioned, as the variable dustcol is a column value it only has three dimensions whereas the other atmospheric variables are all four-dimensional. The zonal wind u and meridional wind v are positive in the eastward and northward direction respectively. Although not directly assimilated, u and v are both indirectly altered as a result of the assimilation procedure.

**Table 4 - Atmospheric variables in each reanalysis data file.**

| Variable | Dimension | Description | Units |
|----------|-----------|-------------|-------|
| dustcol | lon, lat, time | Visible column dust optical depth | NU |
| temp | lon, lat, lev, time | Atmospheric temperature | K |
| u | lon, lat, lev, time | Zonal wind (Eastward) | $ms^{-1}$ |
| v | lon, lat, lev, time | Meridional wind (Northward) | $ms^{-1}$ |
| vmr_co2 | lon, lat, lev, time | $CO_2$ volume mixing ratio | mol/mol |
| vmr_h | lon, lat, lev, time | H volume mixing ratio | mol/mol |
| vmr_o | lon, lat, lev, time | O volume mixing ratio | mol/mol |
| vmr_h2 | lon, lat, lev, time | $H_2$ volume mixing ratio | mol/mol |
| vmr_h2o | lon, lat, lev, time | $H_2O$ volume mixing ratio | mol/mol |
| vmr_co | lon, lat, lev, time | CO volume mixing ratio | mol/mol |
| vmr_o1d | lon, lat, lev, time | $O^1D$ volume mixing ratio | mol/mol |
| vmr_o2 | lon, lat, lev, time | $O_2$ volume mixing ratio | mol/mol |
| vmr_o3 | lon, lat, lev, time | $O_3$ volume mixing ratio | mol/mol |
| vmr_oh | lon, lat, lev, time | OH volume mixing ratio | mol/mol |
| vmr_ho2 | lon, lat, lev, time | $HO_2$ volume mixing ratio | mol/mol |
| vmr_h2o2 | lon, lat, lev, time | $H_2O_2$ volume mixing ratio | mol/mol |
| vmr_n2 | lon, lat, lev, time | $N_2$ volume mixing ratio | mol/mol |
| vmr_ar | lon, lat, lev, time | Ar volume mixing ratio | mol/mol |

## Overview of the components used to create the reanalysis dataset

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

While the actual data in this dataset is at different vertical resolution and covers later years than those covered by the above manual, the details of the MGCM, observational data, and assimilation technique (including quality control) are the same. Note however that for this reanalysis dataset 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 assimilated only for the MY34 C storm reanalysis were temperature profiles and water vapour profiles from the NIR instrument on ACS and water vapour retrievals from the NOMAD instrument. See Fedorova et al. (2020) for further details on the ACS temperature and water vapour profiles and Aoki et al. (2019) for further details on the NOMAD water vapour profiles respectively.

For any further queries not covered in the reference manual, please contact james.holmes@open.ac.uk

## Structure of the hydrogen escape data files

The files contained in the H_flux_my30.zip and H_flux_my34.zip folders are a collection of one-column text files which include the daily hydrogen escape flux calculated for the specified model grid points from $L_S$ = 321°-344°. The filename convention is as follows:

H_flux_myMM_LAT_LON.txt

where MM (34 or 30) indicate the Mars Year, LAT indicates the latitude and LON indicates the longitude for the model grid point. For both Mars year there is also a H_flux_myMM_globavg.txt file which is contains the globally averaged hydrogen escape flux. The output hydrogen escape rates are modelled by passing the chemical densities at 80 km of each chemical species in the reanalysis files as the lower boundary of a 1-D photochemical model that can be found on Zenodo (Cangi et al., 2020).

## Acknowledgments

## References

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