# NASA GSFC global mascon solution HDF5 format description: RL06 v01

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## Group: /size

This group contains variables that describe the dimensions of the variables in subsequent groups.

| Dataset | Description | Value |
|---|---|---|
| N_arcs | Number of one-day arcs of L1B data used in the full set of mascon solutions | 5487 (sample) |
| N_mascon_times | Number of solution times in data product | 189 (sample) |
| N_mascons | Number of global mascons | 41168 |

## Group: /time

This group contains the full list of GRACE L1B dates used in the solution and the beginning, middle, and end of each mascon solution time window.

| Dataset | Description | Size | Sample value |
|---|---|---|---|
| list_ref_days_solution | The full list of days of GRACE L1B data used in the full set of mascon solutions (days since Jan 0, 2002) | N_arcs x 1 | 4504 |
| n_ref_days_solution | The number of days of GRACE L1B data used in the mascon solution for this time window | N_mascon_times x 1 | 30 |
| n_ref_days_window | The number of days in the mascon solution time window (greater or equal to n_ref_days_solution) | N_mascon_times x 1 | 31 |
| ref_days_first | The first day in the mascon solution time window (days since Jan 0, 2002) | N_mascon_times x 1 | 4504 |
| ref_days_last | The last day in the mascon solution time window (days since Jan 0, 2002) | N_mascon_times x 1 | 4534 |
| ref_days_middle | The middle day of the mascon solution time (days since Jan 0, 2002) | N_mascon_times x 1 | 4519 |
| yyyy_doy_yrplot_middle | Four-digit year, day of year, and year plus fractional year for the middle of the mascon solution time window | N_mascon_times x 3 | 2014<br>136<br>2014.369863 |

## Group: /mascon

This group contains the parameters that fully describe the spatial characteristics of the global masons.

| Dataset | Description | Size | Description / Sample value |
|---|---|---|---|
| area_deg | Area of each global mascon in square degrees at the equator | N_mascons x 1 | 1.011449 |
| area_km2 | Area of each global mascon in km$^2$ | N_mascons x 1 | 12453.61 |
| lat_center | Center latitude of mascon (degrees) | N_mascons x 1 | 78 |
| lat_span | Size of mascon in latitude (degrees) | N_mascons x 1 | 1 |
| lon_center | Center longitude of mascon (degrees) | N_mascons x 1 | 289.4594595 |
| lon_span | Size of mascon in longitude (degrees) | N_mascons x 1 | 4.8648649 |
| location | Numerical identifier for each region | N_mascons x 1 | 1, 3, 4, 5, 80, 90 (see table below) |
| basin | Numerical identifier for basin within the region | N_mascons x 1 | (see table below) |
| elev_flag | Low/high elevation identifier for Greenland only | N_mascons x 1 | 1 = elevation < 2000 m<br>2 = elevation > 2000 m |

Regional information contained in **/mascon** datasets:

| Region | Indices | /location | /basin |
|---|---|---|---|
| Greenland Ice Sheet | 00001:00198 | 1 | 1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.0, 6.1, 6.2, 7.1, 7.2, 8.1, 8.2 |
| Antarctic Ice Sheet | 00199:01251 | 3 | 1–27<br>East AIS = Basins 2–17<br>West AIS = Basins 1 & 18–23<br>AIS Peninsula = Basins 24–27 |
| Gulf of Alaska | 01252:01293 | 5 | N/A |
| Ice Shelves | 01294:01425 | 4 | 0 = Small ice shelves, 1 = Ross Ice Shelf, 2 = Ronne Ice Shelf |
| Land | 01426:13028 | 80 | 1nnn = North America<br>2nnn = Mexico & Central America<br>3nnn = South America<br>4nnn = Europe<br>5nnn = Asia<br>6nnn = Middle East<br>7nnn = Africa<br>8nnn = Oceania |
| Water | 13029:41168 | 90 | 0 = Ocean<br>1 = Mediterranean Sea<br>2 = Black Sea<br>3 = Red Sea<br>4 = Caspian Sea<br>5 = Hudson Bay |

Constraint regions are: 1.) GIS elevation below 2000 m; 2.) GIS elevation above 2000 m; 3.) Antarctic ice sheet and Ronne and Ross ice shelves; 4.) Gulf of Alaska; 5.) Land including glaciers; 6.) Ocean including other ice shelves; 7-11.) Large seas.

Basin definitions for Greenland Ice Sheet and Antarctic Ice Sheet are from:
Zwally, H. et al., 2012, <http://icesat4.gsfc.nasa.gov/cryo_data/ant_grn_drainage_systems.php>

## Group: /solution

This group contains the time-variable gravity time series for each mascon in terms of cm equivalent water height. The mean over the span 2004.0–2010.0 has been removed.

| Dataset | Description | Size |
|---|---|---|
| cmwe | Solutions for each mascon location and time (cm equivalent water height) | N_mascon_times x N_mascons |

## Group: /uncertainty

This group contains the necessary information to build the mascon uncertainties for individual mascons, as well as any collection of mascons used to define a basin, region, ice sheet, etc. The details will be presented in a forthcoming manuscript. The noise component is determined from numerical estimates of the covariance, and the leakage component applies monthly resolution operators, following the procedure presented in [Loomis et al., 2019].

To summarize, the user should build the mascon uncertainties as follows (**see sample MATLAB code below**):

| | |
|---|---|
| 95% confidence uncertainty for individual mascon | $= \lvert\ell_{trend}\rvert + 2\sigma_{\ell} + 2\sigma_{noise}$ |
| 95% confidence uncertainty for mascon regions | $= \lvert\overline{\ell_{trend}}\rvert + (\overline{2\sigma_{\ell}} + \overline{2\sigma_{noise}})/\sqrt{N/Z}$ |

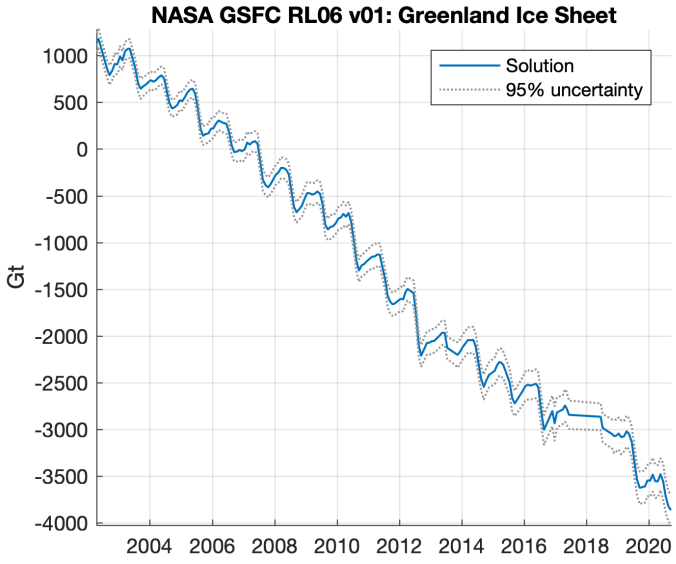
Where,

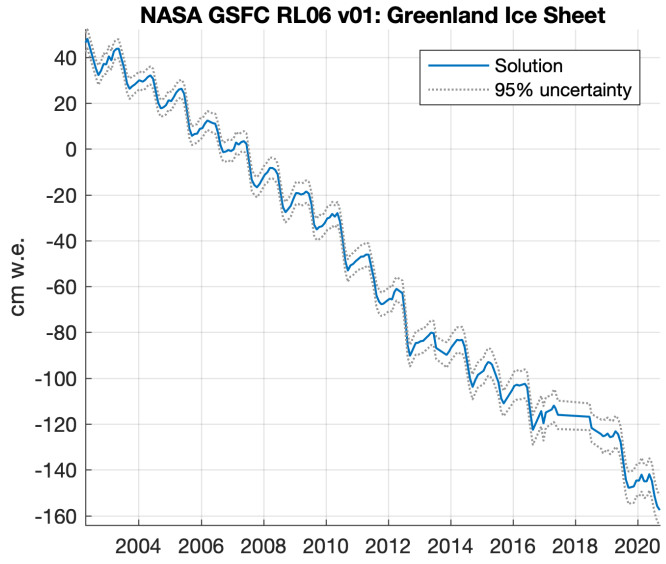
- $\ell_{trend}$, $2\sigma_{\ell}$, and $2\sigma_{noise}$ are the datasets contained in the uncertainty group (see below)
- $\overline{\ell_{trend}}$, $\overline{2\sigma_{\ell}}$, and $\overline{2\sigma_{noise}}$ are the spatial averages at each time step for the selected mascon region
- $\sqrt{N/Z}$ accounts for the fact that stochastic uncertainties are uncorrelated at a certain distance
- $N$ is the number of mascons in the region
- $Z$ is the number of mascons that defines the approximate spatial resolution:
  $Z = 22$ mascons (~300 km)
  If $N \leq Z$, then set $Z = N$, as all the uncertainties are correlated

| Dataset | Description | Size |
|---|---|---|
| leakage_trend | Leakage trend uncertainty (cm equivalent water height/year) | 1 x N_mascons |
| leakage_2sigma | 2-$\sigma$ stochastic leakage uncertainty (cm equivalent water height) | 1 x N_mascons |
| noise_2sigma | 2-$\sigma$ stochastic noise uncertainty (cm equivalent water height) | N_mascon_times x N_mascons |

## Sample MATLAB code: Read HDF5 file and plot Greenland Ice Sheet mass change & uncertainties

```
clear;

% Read information from HDF5 file
h5filename = 'GSFC.glb.200204_202009_RL06v1.0_OBP-ICE6GD.h5';
size_group.N_mascon_times = h5read(h5filename,'/size/N_mascon_times');
time_group.yyyy_doy_yrplot_middle = h5read(h5filename,'/time/yyyy_doy_yrplot_middle');
mascon_group.area_km2 = h5read(h5filename,'/mascon/area_km2');
mascon_group.location = h5read(h5filename,'/mascon/location');
mascon_group.basin    = h5read(h5filename,'/mascon/basin');
solution_group.cmwe   = h5read(h5filename,'/solution/cmwe');
uncertainty_group.leakage_trend  = h5read(h5filename,'/uncertainty/leakage_trend');
uncertainty_group.leakage_2sigma = h5read(h5filename,'/uncertainty/leakage_2sigma');
uncertainty_group.noise_2sigma   = h5read(h5filename,'/uncertainty/noise_2sigma');

% Get Greenland Ice Sheet time series in Gt
ind_region = find(mascon_group.location==1);
cmwe2GT = repmat(mascon_group.area_km2(ind_region)'*1e-5,size_group.N_mascon_times,1);
GT2cmwe = 1/(sum(mascon_group.area_km2(ind_region))*1e-5);
Gt = sum(solution_group.cmwe(:,ind_region).*cmwe2GT,2);

% Get uncertainty
N = length(ind_region);  Z = 22;
t0 = 2003.0;
dt = time_group.yyyy_doy_yrplot_middle(:,3) - t0;
leakage_trend  = abs(sum(uncertainty_group.leakage_trend(ind_region).*cmwe2GT(1,:)));
leakage_2sigma = sum(uncertainty_group.leakage_2sigma(ind_region).*cmwe2GT(1,:))/sqrt(N/Z);
noise_2sigma   = sum(uncertainty_group.noise_2sigma(:,ind_region).*cmwe2GT,2)/sqrt(N/Z);
total_uncertainty_Gt = abs(leakage_trend*dt) + leakage_2sigma + noise_2sigma;

% Make figure
figure('position',[560   651   839   297]);
subplot(121); hold on;
plot(time_group.yyyy_doy_yrplot_middle(:,3), Gt);
plot(time_group.yyyy_doy_yrplot_middle(:,3), Gt + total_uncertainty_Gt,':','color',[1 1 1]*0.6);
plot(time_group.yyyy_doy_yrplot_middle(:,3), Gt - total_uncertainty_Gt,':','color',[1 1 1]*0.6);
ylabel('Gt'); grid on; axis tight;
legend('Solution','95% uncertainty')
title('NASA GSFC RL06 v01: Greenland Ice Sheet');
subplot(122); hold on;
plot(time_group.yyyy_doy_yrplot_middle(:,3), Gt*GT2cmwe);
plot(time_group.yyyy_doy_yrplot_middle(:,3), (Gt + total_uncertainty_Gt)*GT2cmwe,':','color',[1 1 1]*0.6);
plot(time_group.yyyy_doy_yrplot_middle(:,3), (Gt - total_uncertainty_Gt)*GT2cmwe,':','color',[1 1 1]*0.6);
ylabel('cm w.e.'); grid on; axis tight;
legend('Solution','95% uncertainty')
title('NASA GSFC RL06 v01: Greenland Ice Sheet');
```



## Sample MATLAB code: Read HDF5 file and plot map of Amazon basin for a selected month

```
clear;

% Read information from HDF5 file
h5filename = 'GSFC.glb.200204_202009_RL06v1.0_OBP-ICE6GD.h5';
mascon_group.location   = h5read(h5filename,'/mascon/location');
mascon_group.basin      = h5read(h5filename,'/mascon/basin');
mascon_group.lon_center = h5read(h5filename,'/mascon/lon_center');
mascon_group.lat_center = h5read(h5filename,'/mascon/lat_center');
mascon_group.lon_span   = h5read(h5filename,'/mascon/lon_span');
mascon_group.lat_span   = h5read(h5filename,'/mascon/lat_span');
time_group.yyyy_doy_yrplot_middle = h5read(h5filename,'/time/yyyy_doy_yrplot_middle');
solution_group.cmwe = h5read(h5filename,'/solution/cmwe');

% Amazon basin mascons for May 2009
ind_region = find(mascon_group.location==80 & mascon_group.basin==3005);
gsfc_month = 83;

% Make figure
figure; hold on;
for i=1:length(ind_region)
    mcn = ind_region(i);
    x = [-1 1 1 -1]*mascon_group.lon_span(mcn)/2 + mascon_group.lon_center(mcn);
    y = [-1 -1 1 1]*mascon_group.lat_span(mcn)/2 + mascon_group.lat_center(mcn);
    fill(x, y, solution_group.cmwe(gsfc_month,mcn))
end
cc=colorbar; ylabel(cc,'cm w.e.');
title('NASA GSFC RL06 v01: Amazon basin (May 2009)')
grid on; axis tight; box on;
```