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# Updated Ganymede Mosaic from Voyager and Galileo observations

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# 1. INTRODUCTION

## 1.1 Executive Summary

The JANUS instrument team at the German Aerospace Center (DLR) has created a new global mosaic of Jupiter's moon Ganymede from NASA Voyager and Galileo images with a uniform spatial resolution of 359 m/pxl.

## 1.2 Extended introduction

In preparation of the ESA JUICE mission with the primary target Ganymede a new controlled version of the global Ganymede image mosaic was generated using a combination of Voyager 1 and 2 and Galileo images. Baseline for this work was the new 3D control point network from Zubarev et al., 2016, which uses the best available images from both missions and led to new position and pointing of the images.

## 1.3 DLR_Ganymede_Voyager-Galileo_V1.0 introduction

In 1979 Voyager 1 and 2 flew by Jupiter to acquire 490 Narrow Angle Camera (NAC) and Wide Angle Camera (WAC) images of Ganymede’s surface with resolutions from 470 m/pxl down to 20 km/pxl. The Galileo spacecraft, with its Solid State Imaging (SSI) camera onboard, entered orbit around Jupiter in 1995 and took 149 images (<20 km/pxl) of Ganymede during 15 flybys. To create the new mosaic 118 Voyager and 88 Galileo images have been used including the best resolved Galileo images (<500 m/pxl) from three close encounters.

## 1.4 Abbreviations and Acronyms

DLR - German Aerospace Center

ESA - European Space Agency

JANUS - Jovis, Amorum ac Natorum Undique Scrutator

JUICE - JUpiter ICy moons Explorer

NAC - Narrow Angle Camera

NASA - National Aeronautics and Space Administration

WAC - Wide Angle Camera

## 1.5 Reference and Applicable Documents

Archinal, B.A., A’Hearn, M.F., Bowell, E., Conrad, A., Consolmagno, G.J., Courtin, R., Fukushima, T., Hestroffer, D., Hilton, J.L., Krasinsky, G.A., Neumann, G., Oberst, J., Seidelmann, P.K., Stooke, P., Tholen, D.J., Thomas, P.C., Williams, I.P., 2011. Report of the IAU Working Group on Cartographic Coordinates and Rotational Elements: 2009, Celest. Mech. Dyn. Astr., Vol. 109, pp. 101-135, DOI: 10.1007/s10569-010-9320-4.

Kersten, E., Zubarev, A. E., Roatsch, Th., and Matz, K.-D., 2021. Controlled Global Ganymede Mosaic from Voyager and Galileo Images, submitted to Planetary and Space Sciences.

Zubarev, A. E., Nadezhdina, I. E., Brusnikin, E. S., Karachevtseva, I. P., Oberst, J., 2016. A Technique for Processing of Planetary Images with Heterogeneous Characteristics for Estimating Geodetic Parameters of Celestial bodies with the

Example of Ganymede, Solar System Research, Vol. 50, No. 5, pp. 352–360, DOI: 10.1134/S0038094616050087.

# 2. SCIENTIFIC OBJECTIVES

In order to help with detailed planning of the JUICE science mission the new global mosaic of Ganymede was created. Ganymede is the largest moon in the Solar System, with a thick crust of ice on top of a global water ocean. The second half of the JUICE mission in the Jovian system in the early 2030s, called the GCO5000 orbital tour, will be in orbit around this moon for nine months to pry deeper into its secrets. The onboard JANUS camera will acquire high-resolution images of Ganymede's surface from two different altitudes (5000 and 500 km) reaching spatial resolutions from 400 to 7 m.

## 2.1 Acknowledgements

The authors thank Alexander Stark and Jürgen Oberst from DLR for their support and helpful discussions.

Users are requested to acknowledge the dataset by mentioning it in any relevant figure captions and within the reference section of their publications by citing the paper:

Kersten, E., Zubarev, A. E., Roatsch, Th., and Matz, K.-D., 2021. Controlled Global Ganymede Mosaic from Voyager and Galileo Images, submitted to Planetary and Space Sciences.

# 3. DATA PRODUCT GENERATION

The selected images were reprocessed with the new pointing and orientation data and then reprojected into the final Cylindrical Equidistant projection, where the small crater Anat defines the longitude system at 232° East (https://planetarynames.wr.usgs.gov/Feature/251).

Reviewing the single images revealed different artefacts that had to be removed manually by either cutting them off, in particular at the edges, or interpolating values from surrounding pixels. After artefact correction, images with similar observation times and resolutions i.e., from the same flyby, were set together to regional mosaics, which helps during the last step, the brightness and contrast correction. The regional mosaics can be handled like a single image due to the coherent illumination of the images that comes from the same direction. Putting it all together, the regional mosaics and the remaining single images, required major adjustments at the transition zones, where dark shadowed areas are often followed by bright illuminated ones and low contrast regions from nadir incidence angles alternate with high contrast from low solar altitudes. Following planetary mapping convention, the map resolution of the final global mosaic was set to 128 pxl/deg, as it is a power of two, and thus results in a map scale of 358.7742 m/pxl (46080 by 23040 pixels large) assuming that the radius of the reference sphere is 2631.2 km (Archinal et al., 2011). The final global mosaic was then reprojected into Polar Stereographic projection of both hemispheres (each 29335 by 29335 pixels large).

# 4. ARCHIVE FORMAT AND CONTENT

The mosaic files are archived in GeoTIFF format for all purposes requiring full resolution and georeferencing and in PNG format for preview as follows:

| Region | Projection | Center/ Dimension | Resolution | Format |
|---|---|---|---|---|
| Global | Cylindrical Equidstant | C: 0°/0°E<br>D: 90°N-90°S/180-180°E | 358.7742 m/pxl | GeoTIFF |
| Global | Cylindrical Equidstant | C: 0°/0°E<br>D: 90°N-90°S/180-180°E | 2 km/pxl | PNG |
| Global | Cylindrical Equidstant | C: 0°/180°E<br>D: 90°N-90°S/0-360°E | 358.7742 m/pxl | GeoTIFF |
| Global | Cylindrical Equidstant | C: 0°/180°E<br>D: 90°N-90°S/0-360°E | 2 km/pxl | PNG |
| North Hemisphere | Polar Stereographic | C: 90°N/0°E<br>D: 0-90°N/0-360°E | 358.7742 m/pxl | GeoTIFF |
| North Hemisphere | Polar Stereographic | C: 90°N/0°E<br>D: 0-90°N/0-360°E | 2 km/pxl | PNG |
| South Hemisphere | Polar Stereographic | C: 90°S/0°E<br>D: 0-90°S/0-360°E | 358.7742 m/pxl | GeoTIFF |
| South Hemisphere | Polar Stereographic | C: 90°S/0°E<br>D: 0-90°S/0-360°E | 2 km/pxl | PNG |

# 5. KNOWN ISSUES

There are still artefacts caused by image interpolation and brightness adjustments and one linear shift along the 180° meridian that we could not explain or eliminate from the mosaic. It looks like a vertical shift but turned out to be more than a simple offset. But, since it does not significantly influence the shape, brightness, or position of the features in that area, the user might get along with it.

# 6. SOFTWARE

The GeoTIFF files are raster images with embedded georeferencing information and can be used with geospatial software like GDAL or in a geoinformation system such as ArcGIS or the open-source version QGIS. The packages rgdal and raster provide the ability to handle such files in the R programming language. The PNG files are regular raster files that can be opened with any raster data program or viewer.