Planet and Moon Verification Report

The script verify_planet_moon_astronomy.R is currently configured to read the first Excel file, Planet and Moon Chart.xlsx, sheet Planet & Moon Verification. This file contains 15 cases and includes more variables per case than the newer Excel file.

SCRIPT SUMMARY

The script reads the following main data from the Excel file: case number, group, location, latitude, longitude, UTC date, UTC time, local time as text, astronomical body, Engine Az°, Engine Alt°, Illuminated %, Phase Angle°, App. Mag., PyEphem values, result, and notes.

It then recalculates each case with astronomyengine. For each planet or the Moon, it obtains calculated azimuth, calculated altitude, visibility, illuminated percentage, phase angle, apparent magnitude, RA, Dec, and distance. These calculated values are saved in planet_moon_calculated.dat.

The script then compares the calculated values against the Excel values and writes planet_moon_verification_results.dat. That output contains the Excel data, the script-calculated data, the differences, and the final PASS or FAIL status.

The main functions are: normalize_time_text(), which normalizes times such as 02:00 to 02:00:00; derive_phase_angle_deg(), which calculates phase angle from illuminated fraction; read_planet_moon_workbook(), which reads the Excel file; clean_planet_moon_cases(), which cleans and converts the data; validate_planet_moon_cases(), which checks dates, coordinates, and duplicates; calculate_single_planet_moon_position(), which performs the astronomical calculation; calculate_planet_moon_positions(), which applies the calculation to all cases; compare_with_references(), which calculates errors and assigns PASS/FAIL; and write_planet_moon_outputs(), which writes the two final output files.

DIFFERENCE CALCULATION

For azimuth, the script uses a circular formula because azimuth wraps from 0° to 360°: abs(((calc_az_deg - engine_az_deg + 180) %% 360) - 180). For the other variables, it uses a simple absolute difference: abs(calc_alt_deg - engine_alt_deg), abs(calc_illuminated_pct - reference_illuminated_pct), abs(calc_phase_angle_deg - reference_phase_angle_deg), and abs(calc_app_mag - reference_app_mag).

The current PASS criterion requires all of the following tolerances to be met: azimuth <= 0.5°, altitude <= 0.5°, illumination <= 1%, phase angle <= 1°, and apparent magnitude <= 0.1. Under this criterion, the script currently returns 6 PASS and 9 FAIL. The FAIL cases are caused by apparent magnitude; position, illumination, and phase are within tolerance in all of those cases.

MANUAL RESULTS WITH HORIZONS

The manual comparison with NASA JPL Horizons allows three sources to be compared: the Excel values, the script-calculated values, and an independent external astronomical reference. This review was performed on the 15 cases from the first planet and Moon Excel file, which is the file with the most detailed numerical data because it includes azimuth, altitude, illuminated percentage, phase angle, and apparent magnitude.

In general terms, Horizons confirms that the script is highly consistent in the main astronomical variables: azimuth, altitude, illuminated percentage, and phase angle. In most cases, the differences between the script and Horizons are very small, especially in altitude, illumination, and phase. This indicates that the geometric calculation of position and phase is working correctly.

The automatic comparison between the script and the Excel file gives 6 PASS and 9 FAIL when all five available variables are evaluated. However, when the errors are reviewed by variable, the failed cases do not show a general problem with astronomical position. Almost all of them comfortably pass the tolerances for azimuth, altitude, illuminated percentage, and phase angle. The main reason for the FAIL results is the difference in apparent magnitude.

Cases 3, 4, 5, 6, 8, 10, 11, 14, and 15 fail mainly because of App. Mag. In those same cases, the manual comparison with Horizons shows that the script is often as close as, or closer than, the Excel file in position, illumination, and phase. Some examples are especially clear: in case 6, Mercury, the Excel altitude differs from Horizons by approximately 0.419°, while the script differs by only 0.00019°; in case 14, Jupiter, the Excel magnitude differs from Horizons by approximately 0.154, while the script differs by only 0.0049; and in case 15, the script is very close to Horizons in all main variables.

INTERPRETATION OF THE DIFFERENCES

The differences in apparent magnitude should be interpreted carefully. Unlike azimuth or altitude, apparent magnitude is not a direct geometric coordinate, but a photometric estimate. It depends on the model used for each planet, the Sun-planet-observer distances, the phase angle, body-specific corrections, and library-specific conventions. Saturn can be especially sensitive because of how the rings are handled; Mercury and Venus can also show variation because of their strong dependence on phase angle.

The Excel positions are acceptable for a printed star chart. In the reviewed cases, the Excel agrees well with Horizons in azimuth, altitude, illumination, and phase angle, within reasonable tolerances for an artistic printed product. The most visible differences are in apparent magnitude, especially for some planets. These differences do not affect the placement of the object in the chart, but they could affect relative size or brightness if the rendering uses apparent magnitude directly to draw the planets.