Navigation and Ancillary Information Facility

The SPICE Digital Shape Kernel (DSK) Subsystem

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3rd Planetary Data Workshop

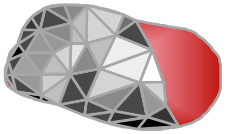
Flagstaff, AZ

June 11, 2017

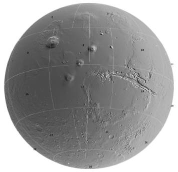
The research described in this publication was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

DSK Subsystem Overview

- The DSK subsystem of the SPICE Toolkit
  - Consists of SPICE software, DSK file format specifications, and documentation
  - Enables SPICE-based applications to conveniently make use of surface shape (topographic) data in SPICE geometry computations
    - » Thereby increasing accuracy of results, relative to those obtainable with triaxial ellipsoid shape models
  - Serves as a format for transmission and archival of surface shape data
- The DSK subsystem handles two representations of shape data
  - Tessellated plate model (supported in the N0066 SPICE Toolkit)



  - Digital elevation model (not yet supported)



N0066 DSK New Features

- **SPICE Toolkit geometry APIs now support DSK shape data, where applicable**
  - No longer necessary to access DSK data using segment-oriented APIs
- **Support for multi-segment, multi-file, and non-native DSK data sets**
  - Shape data distributed across multiple DSK files are selected automatically by SPICE geometry APIs
  - Up to 5K DSK files can be loaded simultaneously
  - Run-time data translation: big-endian DSK files can be read on little-endian platforms, and vice versa
- **DSK files and software now support “surface IDs”**
  - Enable applications to use different data sets for a target body without loading/unloading DSK files to select data
- **DSK files and software now support multiple coordinate systems**
  - Planetocentric, planetodetic, rectangular
- **DSK utility programs are included in the SPICE Toolkit**

N0066 DSK Geometry APIs

- **Computations:**
  - Ray-surface intercept: SINCPT, DSKXV, DSKXSI
  - Sub-observer point: SUBPNT
  - Sub-solar point: SUBSLR
  - Illumination angles at surface point: ILLUMF, ILLUMG, ILUMIN
  - Longitude-latitude grid: LATSRF
  - Find occultation or transit of point target behind/across DSK shape: GFOCLT
  - Occultation state at specified time: OCCULT
  - Generate limb points: LIMBPT
  - Generate terminator points: TERMPT
  - Compute outward normal vector at surface point: SRFNRM
- **DSK data access:**
  - Fetch type 2 plate/vertex data: DSKZ02, DSKP02, DSKV02

N0066 DSK Utility programs

- **Create DSK files: MKDSK**
  - Creates a DSK file containing a single type 2 segment
  - Accepts a variety of simple text (ASCII) input formats:
    - » obj (triangular plates only)
    - » Gaskell ICQ
    - » Plate-vertex
    - » Rosetta .ver
    - » Height grid in any supported coordinate system
      - Planetocentric
      - Planetodetic
      - Rectangular
- **Export DSK data to text format files: DSKEXP**
  - Writes data from type 2 DSK segments to one or more text files
  - Supported output formats are obj, plate-vertex, and .ver
- **Summarize DSK files: DSKBRIEF**
- **Merge DSK files: DLACAT**
  - Concatenates segments from multiple DSK files into a single DSK file
- **Transform binary architecture of DSK file: TOXFR, TOBIN,**
- **Read/write comment area: COMMNT**

Plate Model Surface Intercept

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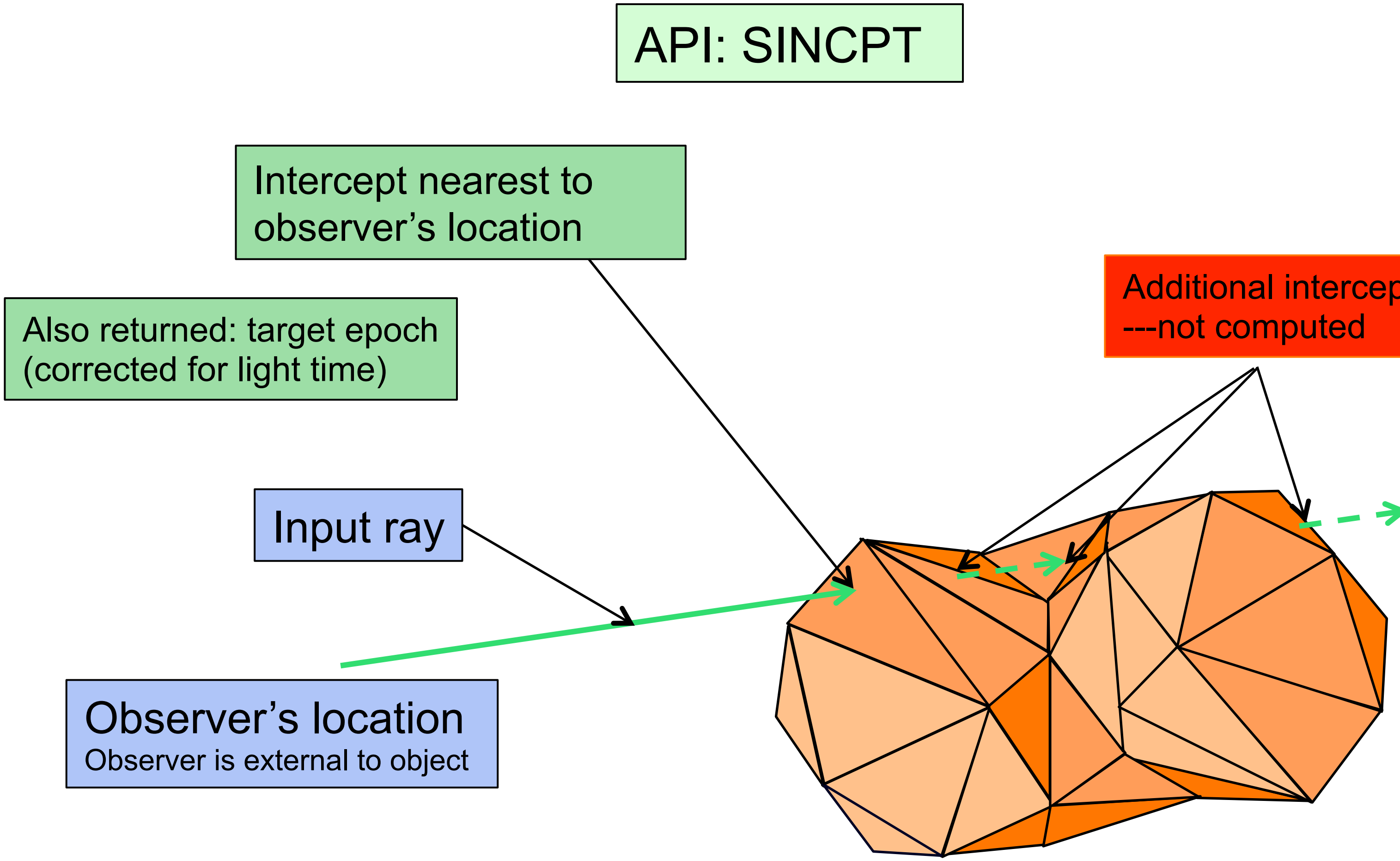

Plate Model Sub-observer Point

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API: SUBPNT

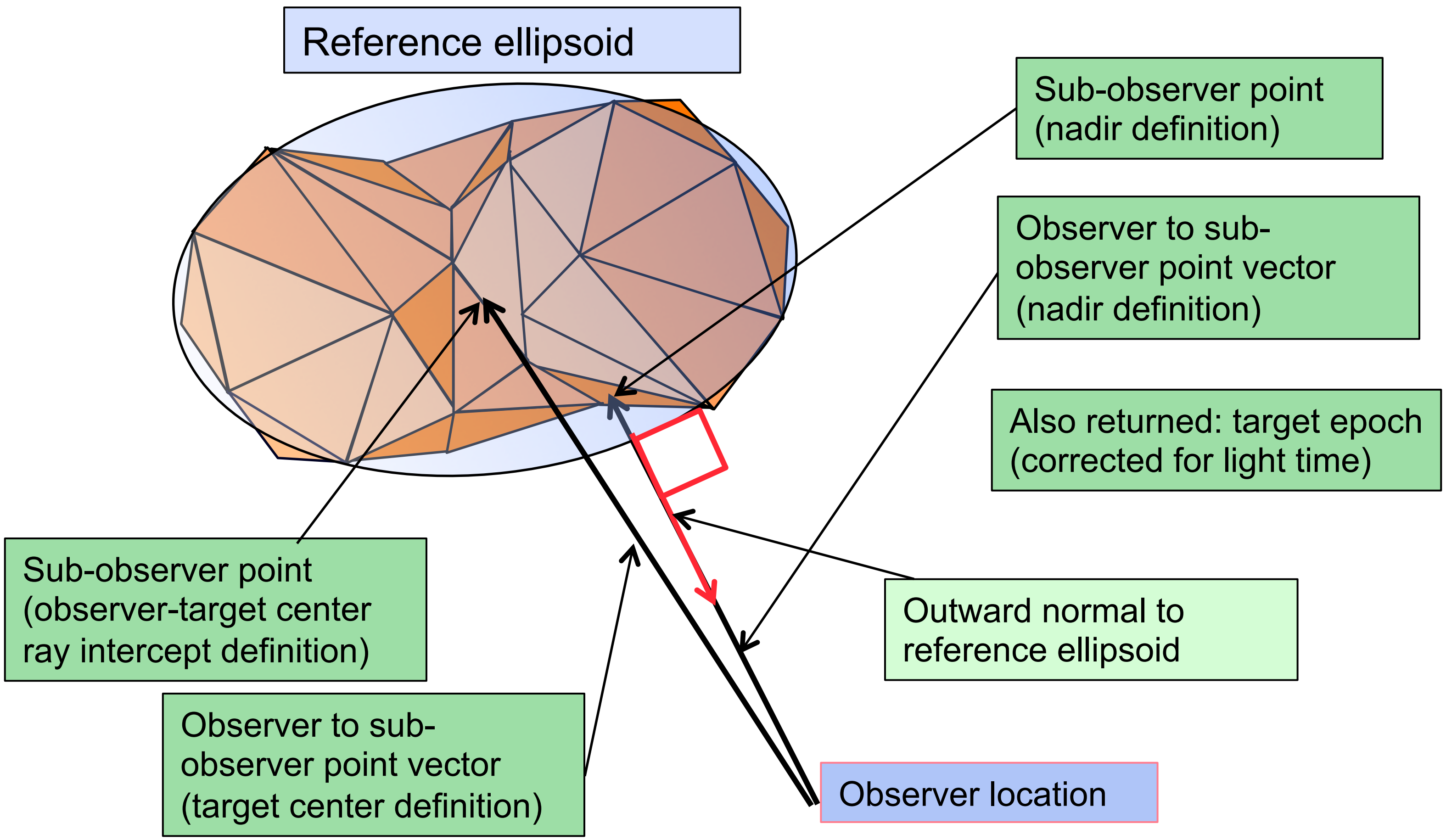


Plate model Illumination Angles

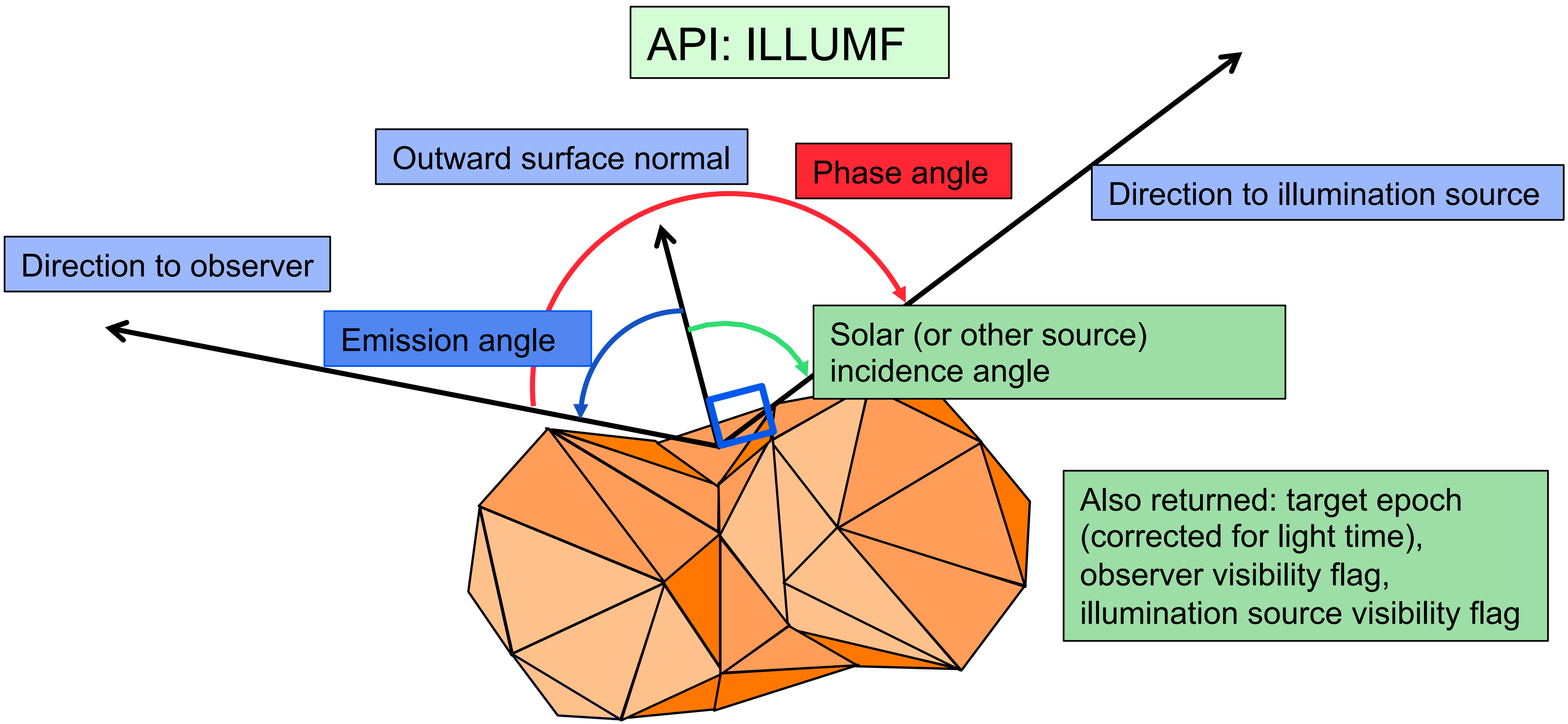


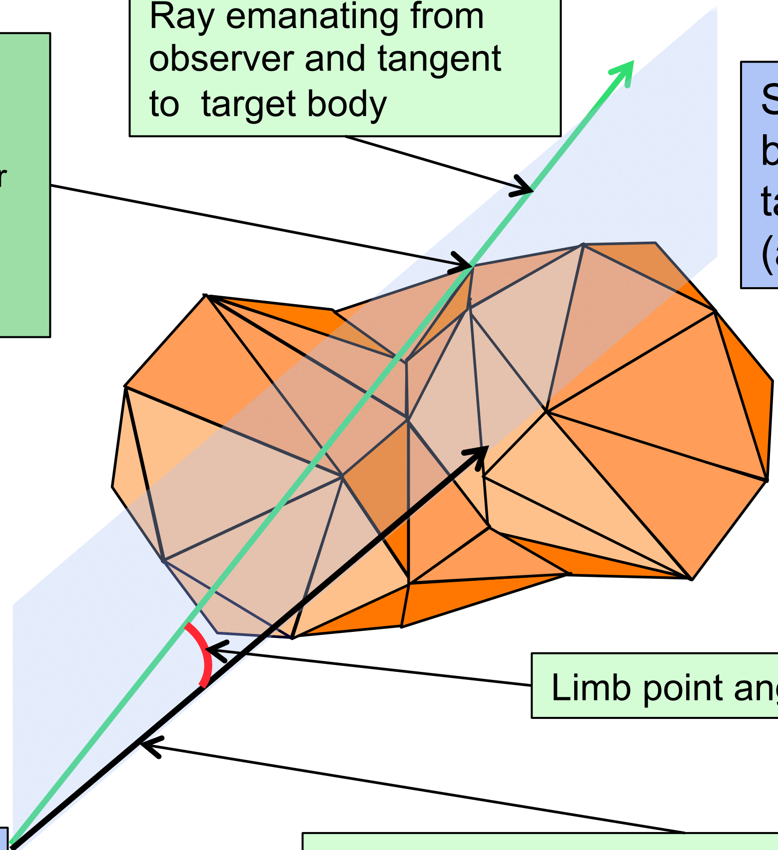
Plate Model Limb

API: LIMBPT

Limb point---on a tangent ray in the selected half-plane (for some shapes, multiple tangents will exist for a given axis and half-plane).

Ray emanating from observer and tangent to target body

Specified half-plane bounded by observer-target center line (axis): contains ray



Limb point angle relative to axis

Observer location

Axis: observer-target center vector

Plate Model Terminator-Umbral

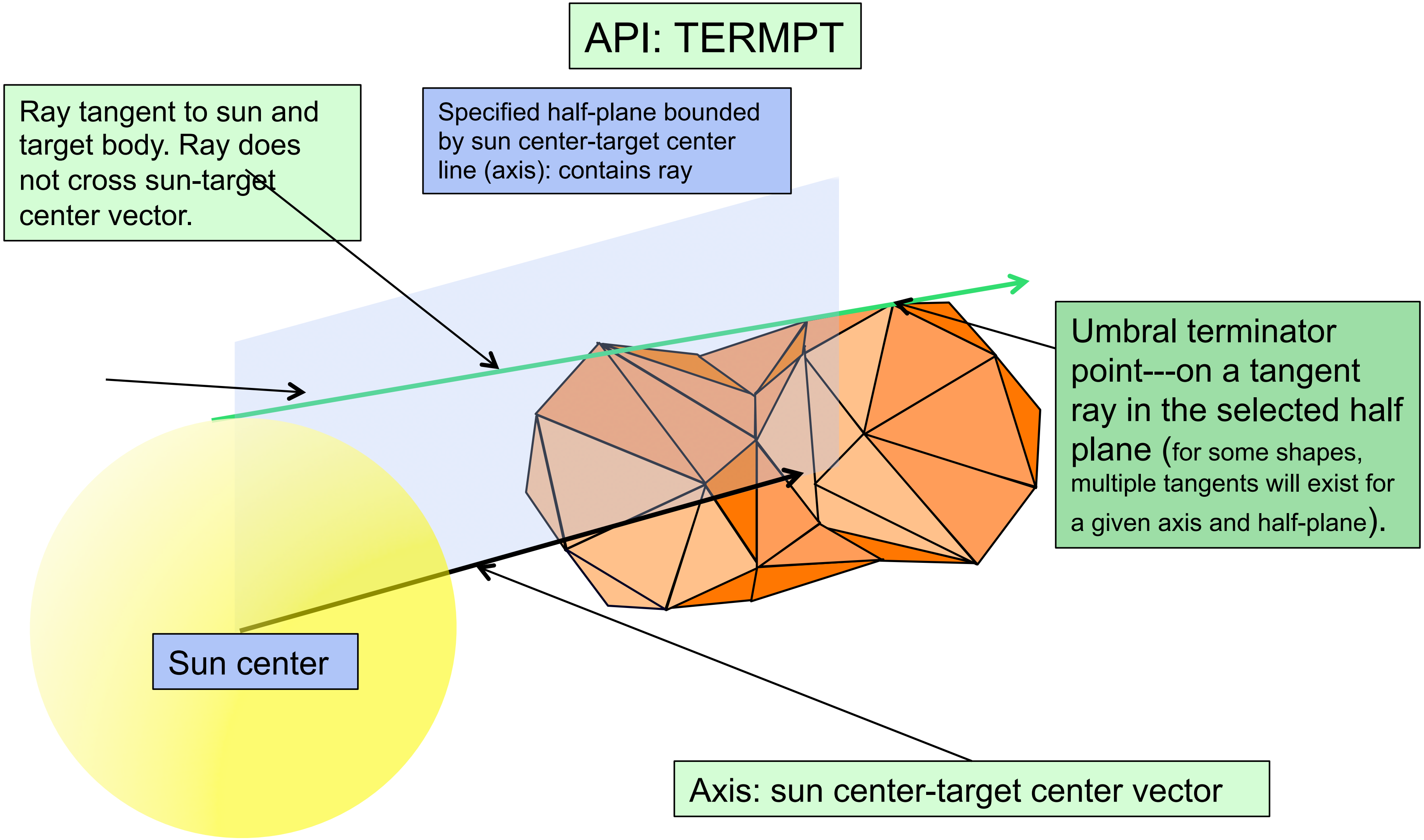


Plate Model Terminator-Penumbral

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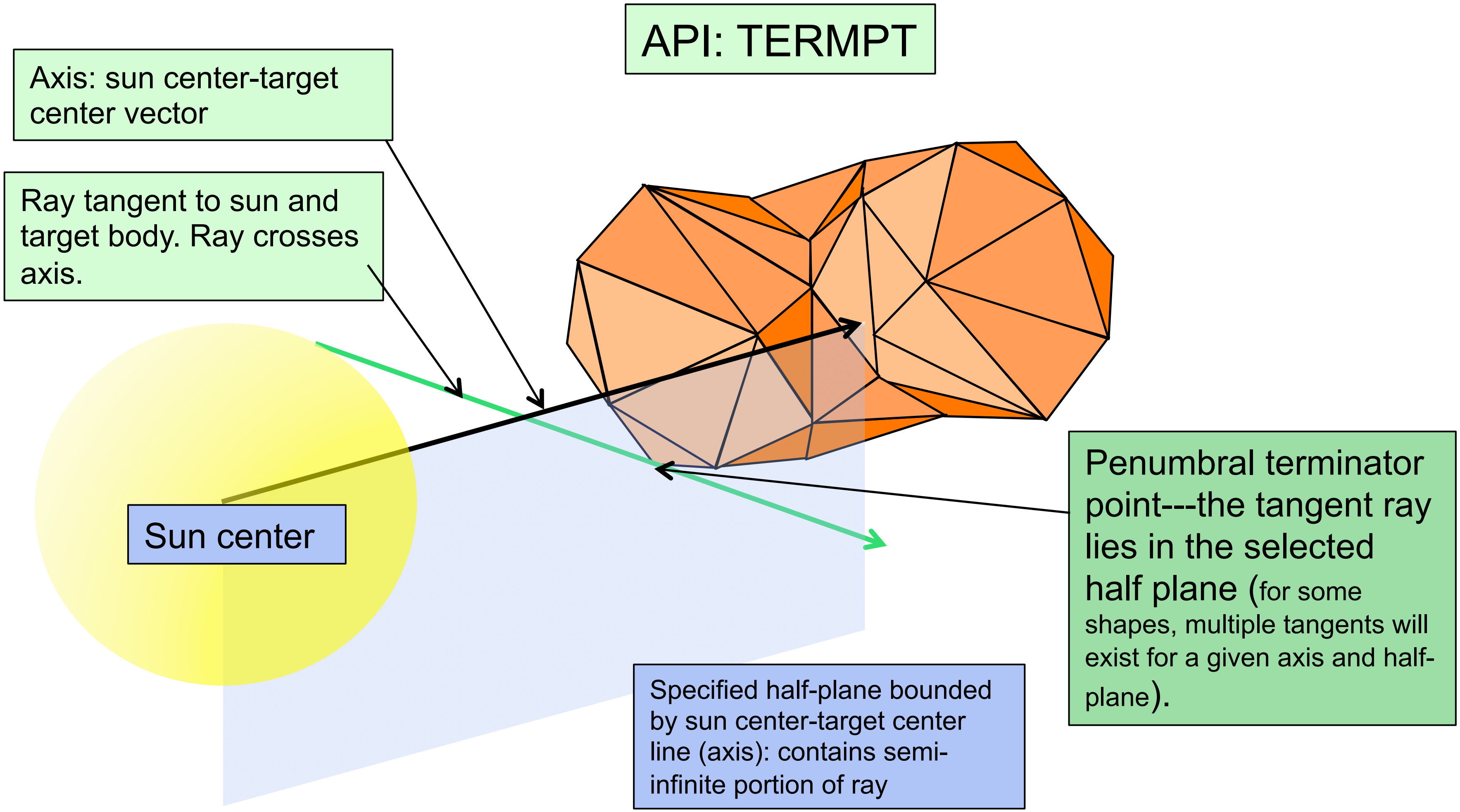
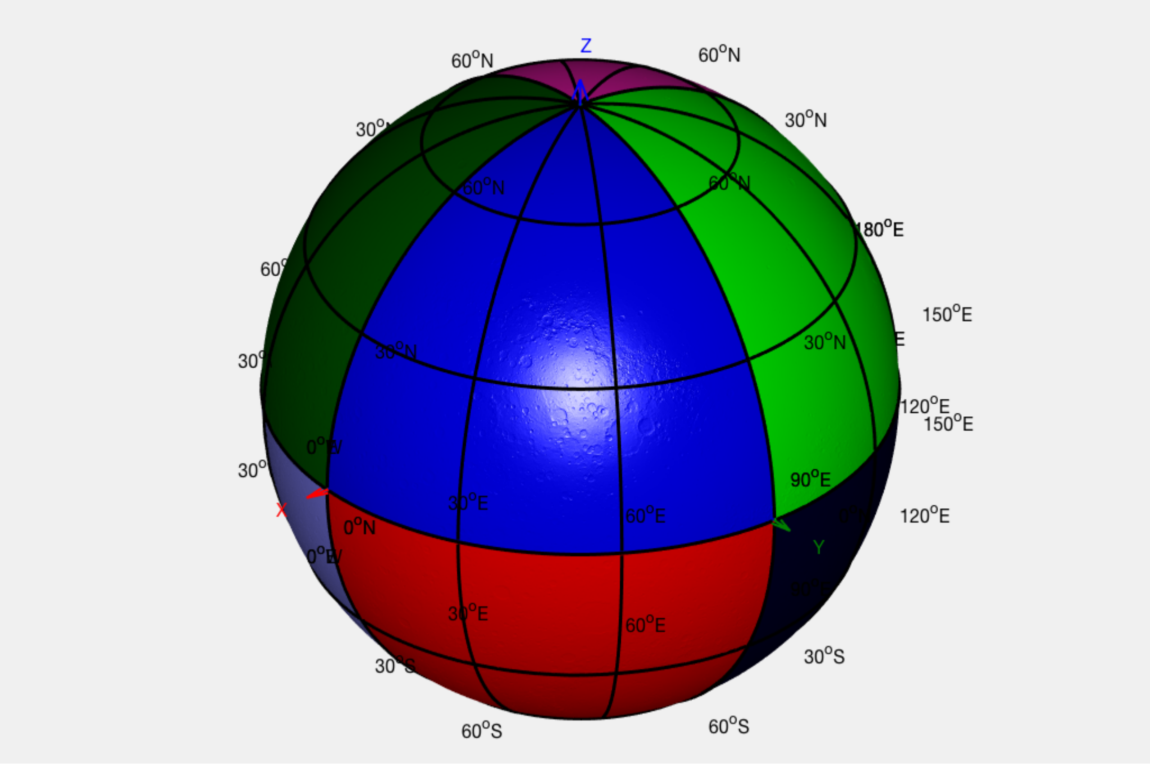


Example: Mars Image from Multi-DSK Data Set

- **Topographic data derived from MGS MOLA data, archived as megr90n000eb.img (16 pixels/deg) was converted to a tessellated plate model and partitioned into eight DSK files:**

```
KPL/MK

Meta-kernel for MRO altitude computation

\begindata

   PATH_SYMBOLS    = ( 'KERNELS' )
   PATH_VALUES     = ( '/home/nbachman/projects/N0066/dsk/build2' )

   KERNELS_TO_LOAD = (

      '$KERNELS/de430.bsp',
      '$KERNELS/mar097.bsp',
      '$KERNELS/pck00010.tpc',
      '$KERNELS/naif0012.tls',
      '$KERNELS/mro_psp4_ssd_mro95a.bsp',
      '$KERNELS/mro_v11.tf',
      '$KERNELS/mro_sclkscet_00022_65536.tsc',
      '$KERNELS/mro_sc_psp_070925_071001.bc',
      '$KERNELS/megr90n000eb_LL000E00N_UR090E90N_plate.bds'
      '$KERNELS/megr90n000eb_LL000E90S_UR090E00S_plate.bds'
      '$KERNELS/megr90n000eb_LL090E00N_UR180E90N_plate.bds'
      '$KERNELS/megr90n000eb_LL090E90S_UR180E00S_plate.bds'
      '$KERNELS/megr90n000eb_LL180E00N_UR270E90N_plate.bds'
      '$KERNELS/megr90n000eb_LL180E90S_UR270E00S_plate.bds'
      '$KERNELS/megr90n000eb_LL270E00N_UR360E90N_plate.bds'
      '$KERNELS/megr90n000eb_LL270E90S_UR360E00S_plate.bds'  )

\begintext
```

Meta-kernel providing data for MRO viewing geometry computations. DSK files have names of the form *.bds.



Example: MRO Altitude over Mars Surface

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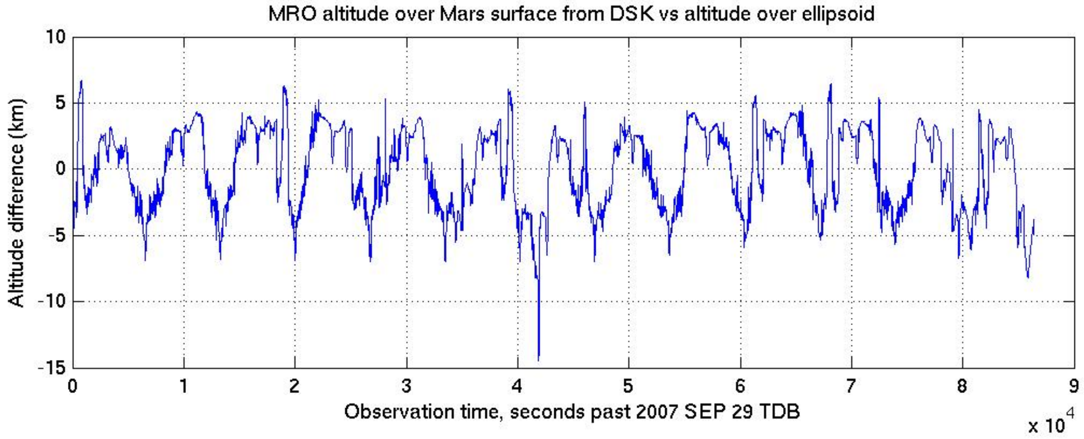

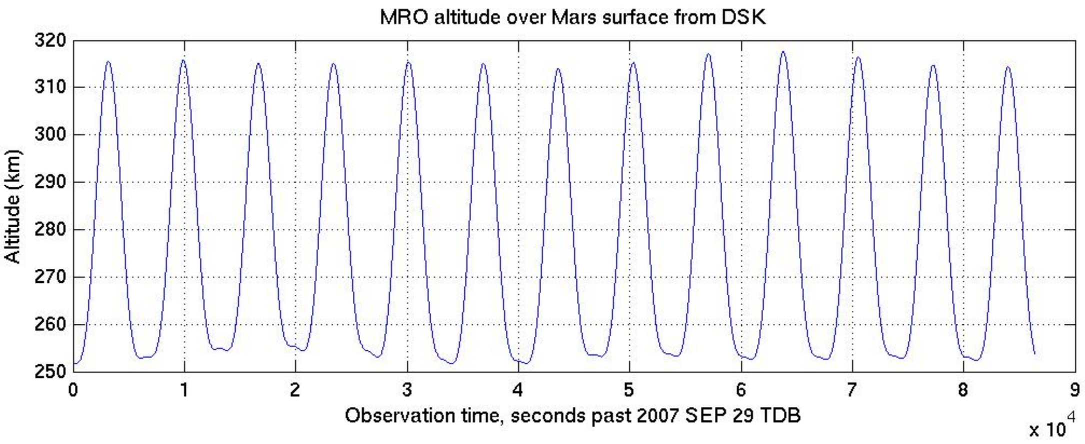

Altitudes were computed using DSKs shown in meta-kernel on previous slide. The SPICE API used was SUBPNT.

Example: Limb of Comet Churyumov-Gerasimenko

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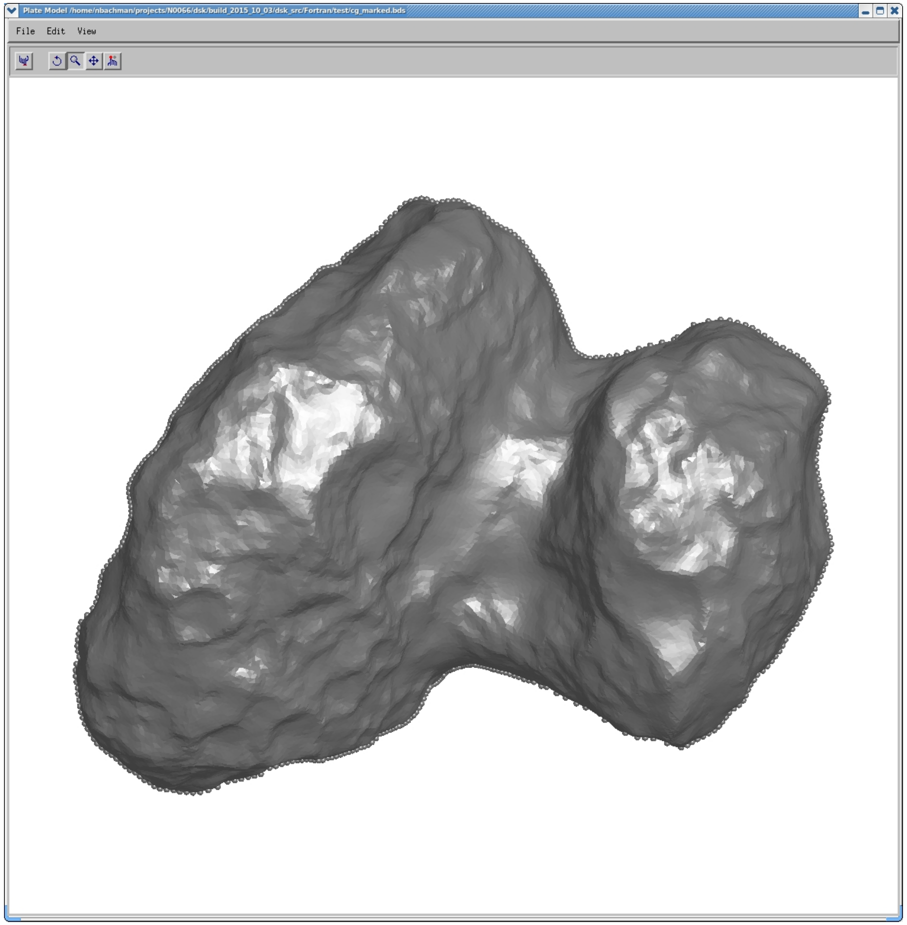

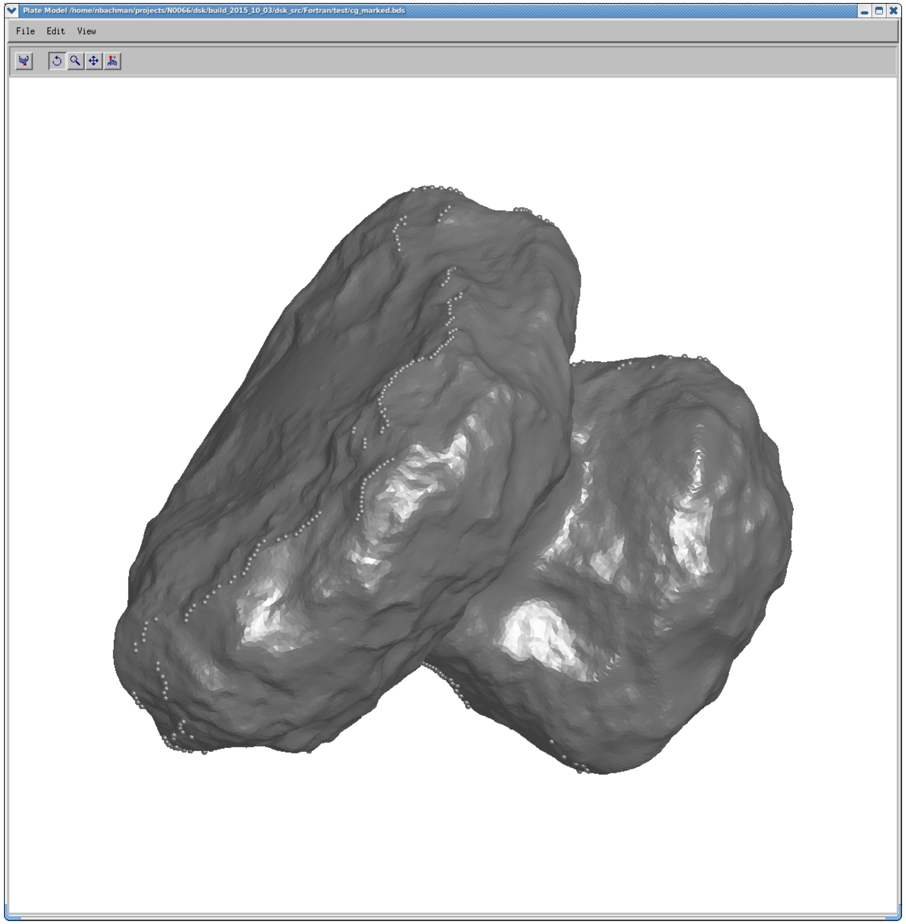

Limb points were generated using SPICE API routine LIMBPT: limb points are marked by small spheres. Viewing geometry is artificial. Image on right shows the same limb points as on the left, viewed from a different vantage point.

Example: Occultation of MRO, Seen from DSS-14

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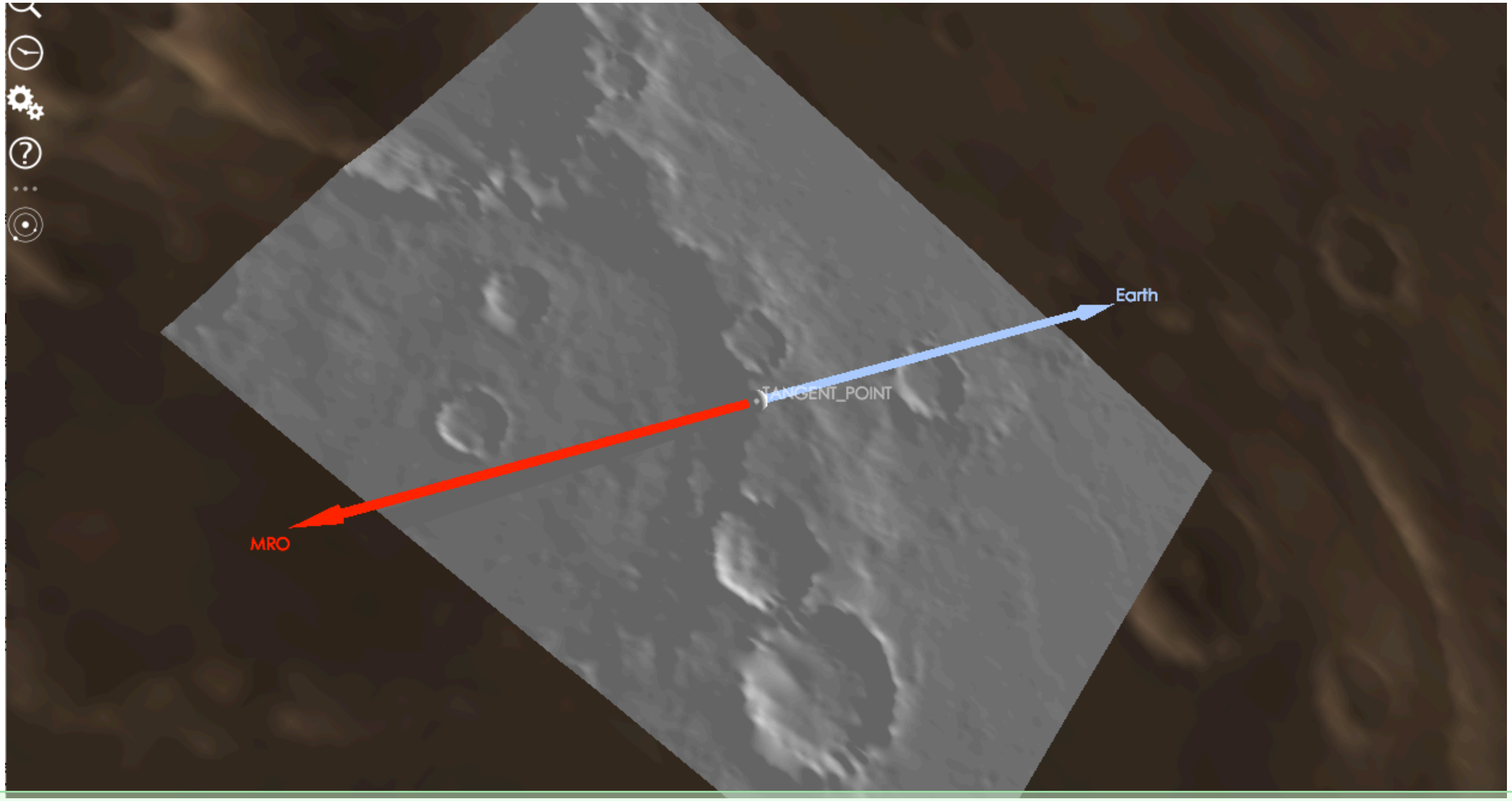
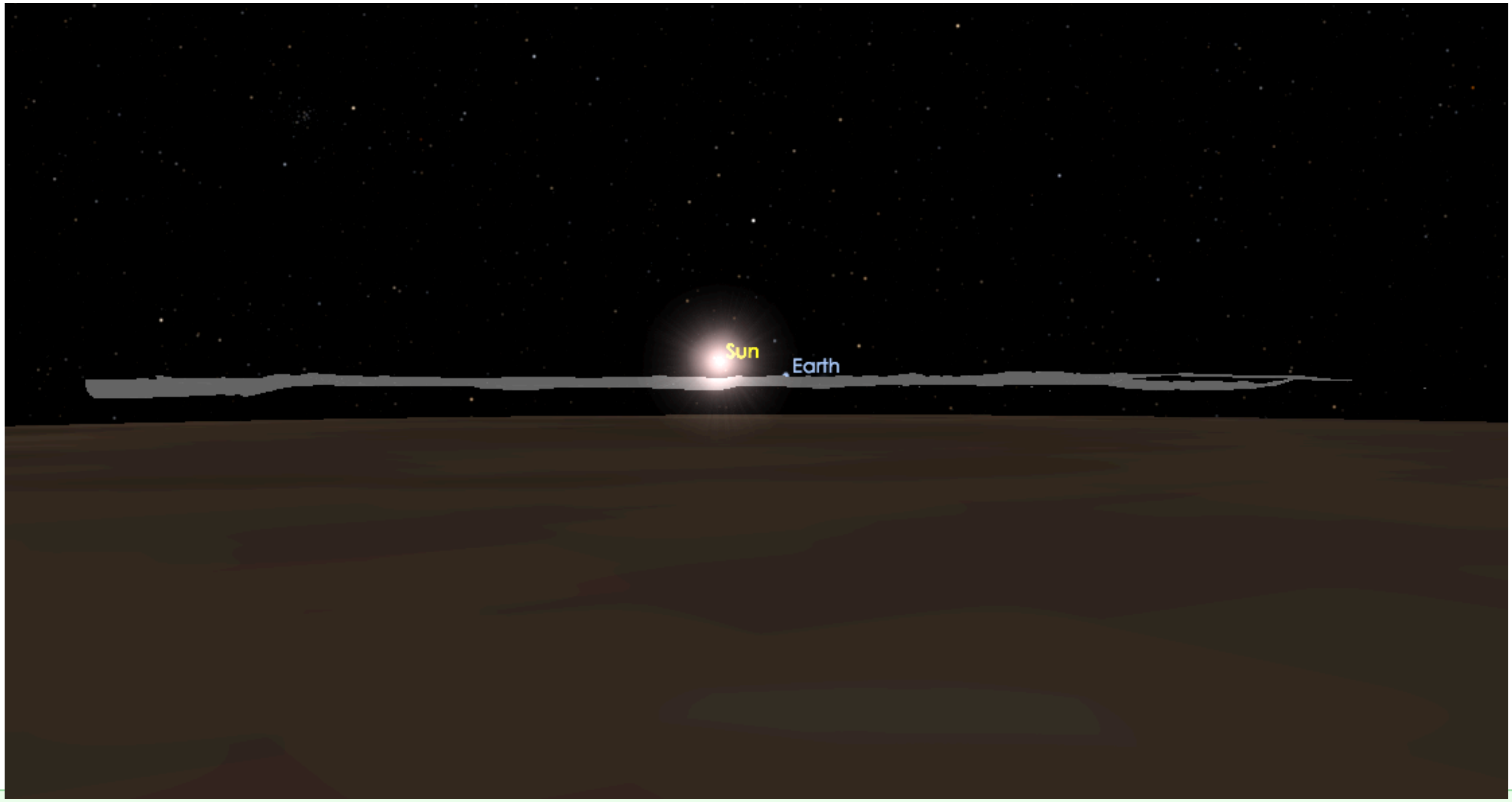


SPICE API used to find time of occultation egress: GFOCLT.

Observer: DSS-14. Target: MRO. Aberration correction: CN. Egress time: 2011 FEB 21 05:57:28.286587 UTC. DSK files were using data from MGS MOLA-based topographic data files archived as megr*hb.img. Data have resolution of 128 pixels/degree.

Example: View of Earth, Seen from MRO at Egress



Sun, Earth, Mars reference ellipsoid (brown) and Mars surface (gray) near point of occultation of line-of-sight to DSS-14 (labeled TANGENT_POINT in previous image), at the time of occultation egress.

The topography in the region of the point of occultation is ~3.7 km above the reference ellipsoid. Egress time computed using ellipsoidal Mars shape model is about 4 seconds earlier than that computed using the DSK model.