Assessing the variability and relative accuracy of digital terrain models of Europa

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This work is supported by NASA's PDART Program

Topographic information is critical for science



Topographic information is critical for exploration



The outer solar system presents unique challenges for DTM generation...

Absolute elevation is poorly constrained

- No altimeter data (except Titan)
 - No global reference
- Elevations are always relative
- Difficult to assess DTM accuracy

Data challenges

- Low and inconsistent resolution data
- Inconsistent lighting and viewing geometry
- Incomplete data return
- Poor stereo strength
- Poor initial SPICE





245 m/pixel i = 80° e = 44°

Base to Height: 1.83(0.4 - 0.6 recommended) EP = 21 - 30 m 126 m/pixel i = 58° e = 48°

Pwyll Crater: uncontrolled mosaic



Objective: Assess the variability of DTMs created for the outer solar system

- Variation in DTMs created using different software (SOCET SET, ASP)
- Variation in DTMs created using different methodologies / assumptions
- Variation in DTMs created by users of different experience levels
- Assess time/cost trades

Goals:

- Determine what the "real" uncertainty is in a DTM (not the formal uncertainty)
 - Example:
 - How well do I actually know the depth of that crater?
 - What if I had used SOCET SET instead of ASP?
 - What if an "expert" had made this for me?
- Provide "best practices" for the outer planets community
 - Methodologies that work and potential pitfalls

What we are *NOT* doing:

- Determining who's "right" and who's "wrong"
 - We can't know this without ground truth!
- Evaluating which method is "better"
 - This depends on what you're using the DTM for!
- Creating DTMs for every stereo pair on Europa

Methodology

Create Individual DTMs using SOCET SET and Ames Stereo Pipeline

- Three study sites (Cilix crater, Pwyll crater, Agenor Linea)
- Multiple DTMs per study site (i.e., using same image set)

Evaluate individual DTM quality as a function of parameters used

- Contours on orthoimages
- Compare hillshade
- Assess texture
- Small feature detection

Compare pairs of DTMS (SOCET-SOCET, ASP-ASP, SOCET-ASP):

- Relative alignment of DTMs using ASP pc_align
- Create...
 - Difference maps
 - Individual profiles
 - Slope maps

Calculate...

- Mean/median of elevation
- RMS heights
- RMS slopes
- Slopes over various baselines
- Hurst exponent

SOCET vs. SOCET: Europa's Pwyll crater











Summary to Date

ASP Advantages:

- Fast!
 - Explore the parameter space
- Free and well-documented
- DTMs capture broad-scale features well

ASP Challenges:

- Must control images before use (e.g., using ISIS jigsaw)
- Difficulty using multiple images (work ongoing)
- Smoother DTMs
- Greater number of "blunders"

SOCET SET Advantages:

- Manual editing
- Results in finer detail in DTM
 - Better resolved ridges, crater central peaks
- Fewer blunders
- Better at handling "uncooperative" data (at least in some cases)

SOCET SET Challenges:

- Time consuming (~40 hours per DTM) = \$\$\$
- Requires specialized (\$\$\$) software, workstation, training



Outer Solar System DTMs Lessons Learned (to date)

SOCET SET

- For a "simple" image pair, dependent solution = independent solution, but with a subtle horizontal shift
- Independent solution critical for multi-image DTMs
- Manual editing is critical (ASP out performs SOCET unedited DTM)
- Generally resolves small-scale features better than ASP
- SOCET SET's flexibility is helpful for challenging datasets
- Lower resolution ≠ less time (challenging data)

Ames Stereo Pipeline

- Subpixel refinement is the critical parameter to consider
- User should test multiple parameter settings
- Images *MUST* be controlled (e.g., using ISIS *jigsaw*) before DTM creation
- Greatest success with map-projected images, without bundle adjustment
- DTMs generally smoother, but resolve large-scale structure
- Challenges with multi-image DTMs

More good stuff behind this slide

SOCET vs. SOCET: Europa's Pwyll crater

<u>Dependent Solution</u>: Nadir most image held fixed.

Independent Solution: All images adjusted independently. Add height control.



Europa's Cilix Crater *D* = 15 km







*Adirectional slope over 1 post spacing

Slope



SOCET vs. ASP: Pwyll crater



Agenor Linea



SOCET SET: Agenor Linea



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SOCET SET: Dependent Solution Range: 12,540 – 9707 m SOCET SET: Independent Solution Range: 1399 – -1289 m





Effect of subpixel refinement

true_1.5_21_15_258-hs_warp_stretch