Committee meeting 4

10/7/2024

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Meeting outline and objectives

Outline slide to prep the audience for what is coming

Outline

1. Research objectives and contributions refresher
2. Visibility metric
   a) Case study on glacier extent mapping and translation to satellite operations
3. Observation scheduling
   a) Task list creation
   b) Optimization setup
   c) Scheduling results
4. Next steps and PhD timeline
   a) Visibility-optimal orbit design

Objectives

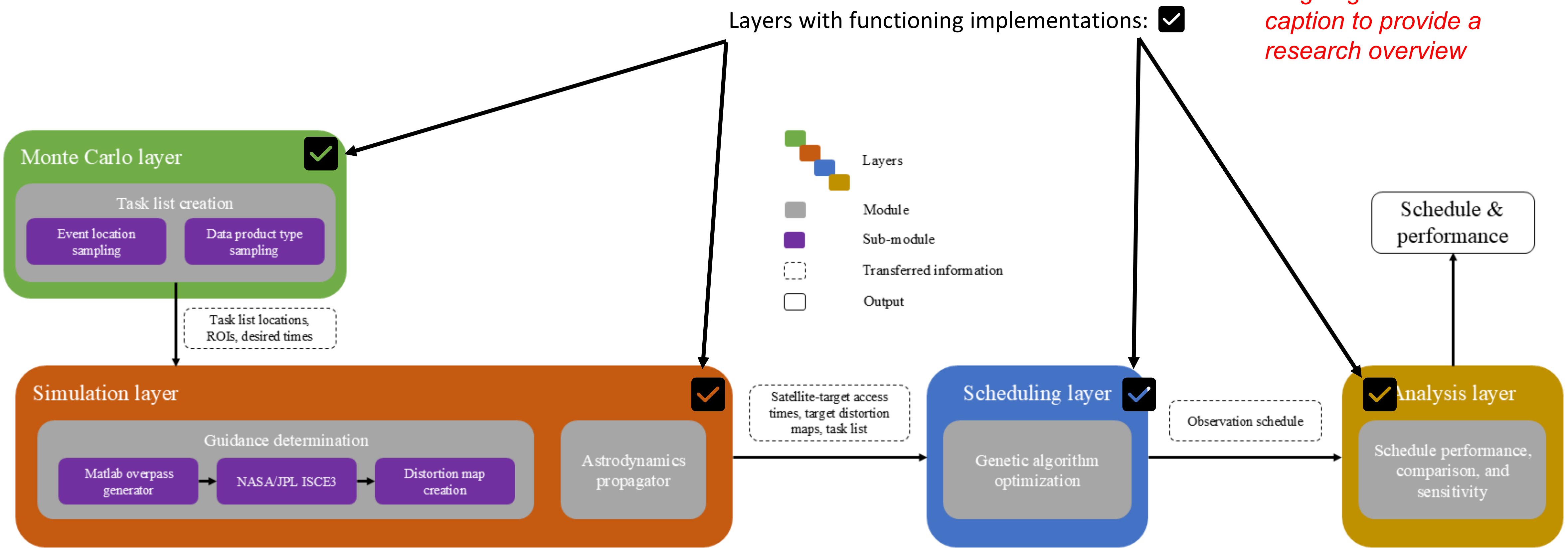
1. Receive feedback on scheduling results
   a) Any other objective functions or constraints to consider?
2. Receive feedback on importance of accounting for squinted geometries in VM
   a) Sufficient to perform scheduling analysis for near-broadside geometries only?
3. Does the committee find the presented results sufficient for completing contributions 1 & 2?

Directed questions for audience to think about during the presentation

Presentation outline at top of each slide for reference

Research diagram

Large figure with a clear caption to provide a research overview



Block diagram of software architecture enabling distortion map creation, satellite observation scheduling, and data product accuracy and utility analysis.

Large font size for caption

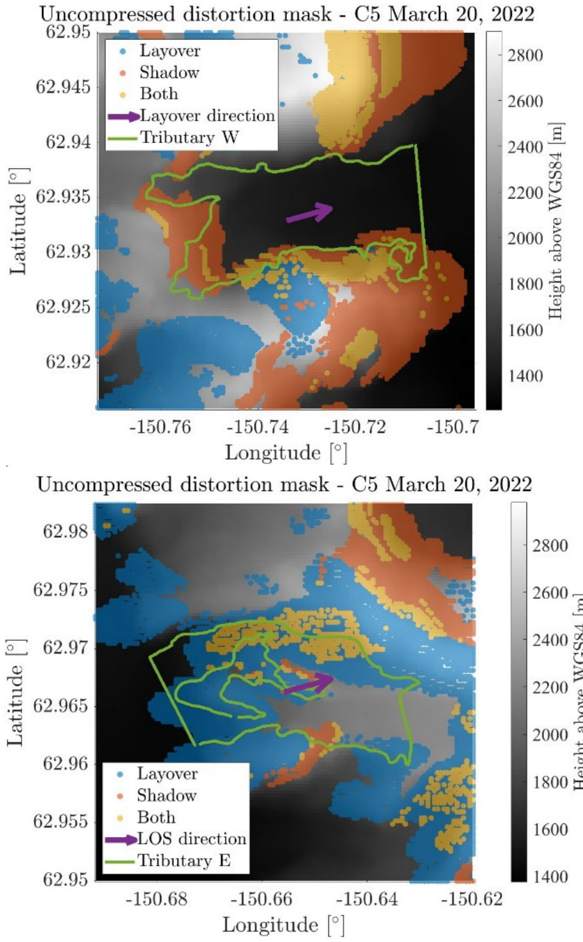
Visibility metric – glacier extent mapping

Visibility metric for planning SAR observations in challenging terrain to be published in IEEE TGRS!

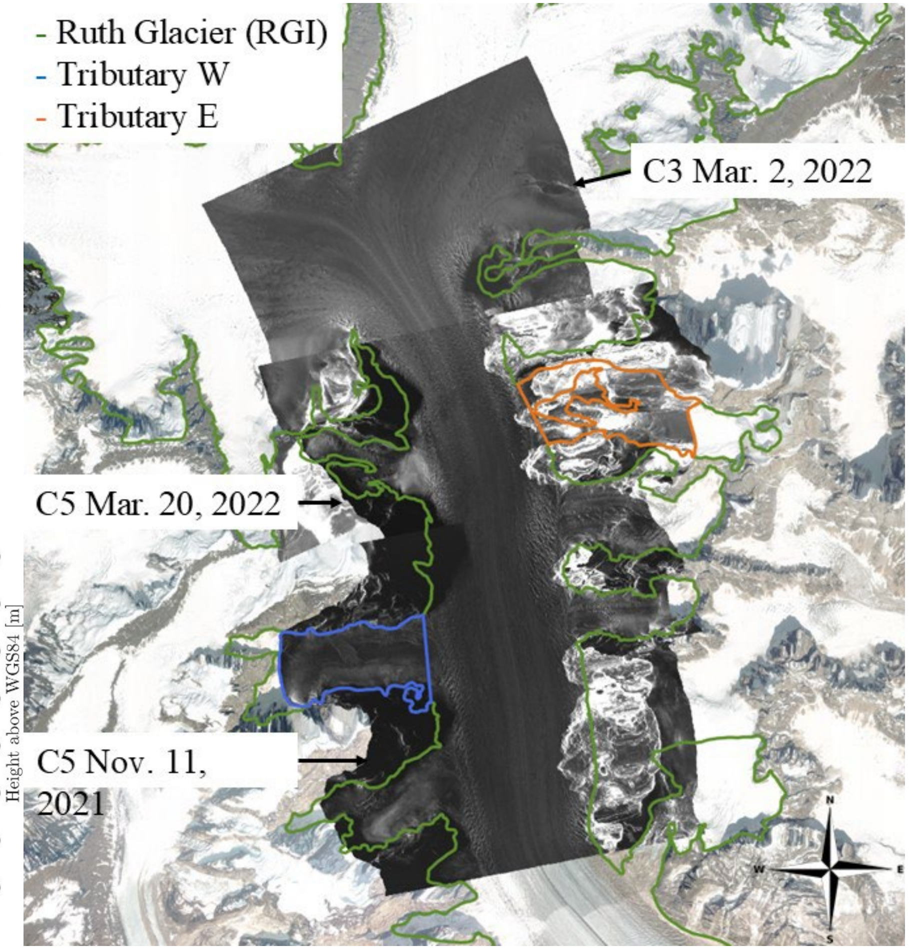
1. Established mathematical foundation for deterministic and stochastic visibility metrics.

2. Demonstrated implementation in ideal and real-world scenarios.
   a. Ruth Glacier extent mapping scenario considered
   b. Maximally-visible SAR images of two tributaries are sought

Figure snippets to highlight key results from published paper



Distortion masks for Ruth Glacier tributary W and E.



Capella SAR acquisitions of Ruth Glacier with tributary extents outlined.

Translating visibility to operations

Similar layout as previous slide to highlight more key results

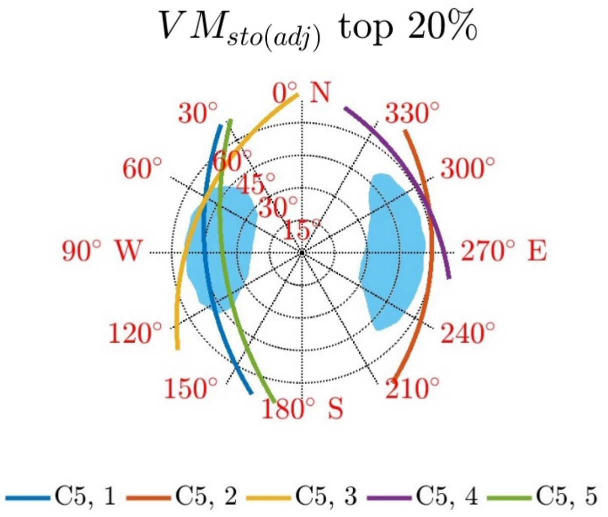
Visibility metric for planning SAR observations in challenging terrain to be published in IEEE TGRS!

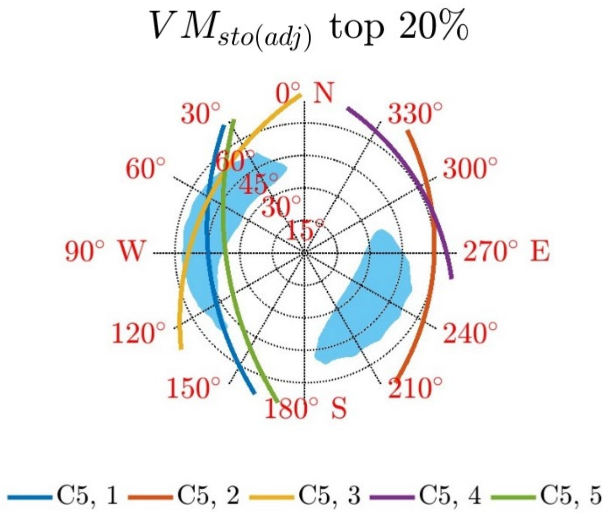
3. Demonstrated how visibility metrics can be manually incorporated into satellite operations.

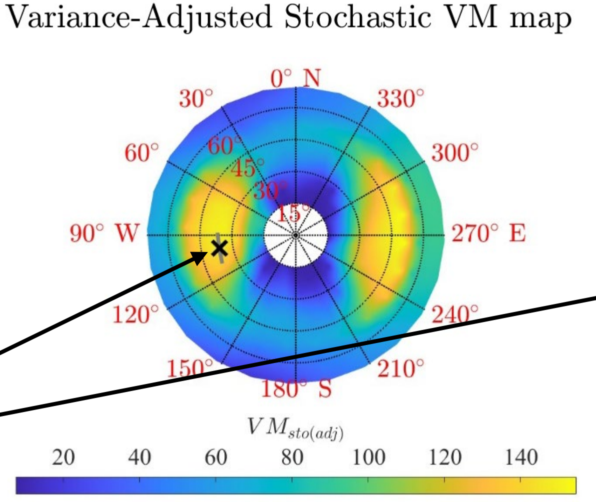
4. Alignment between Capella SAR imagery and visibility maps shown - tributary W is visible while tributary E is not.

Note: Visibility maps are valid for planning broadside imaging acquisitions. New maps need to be created for squinted geometries.

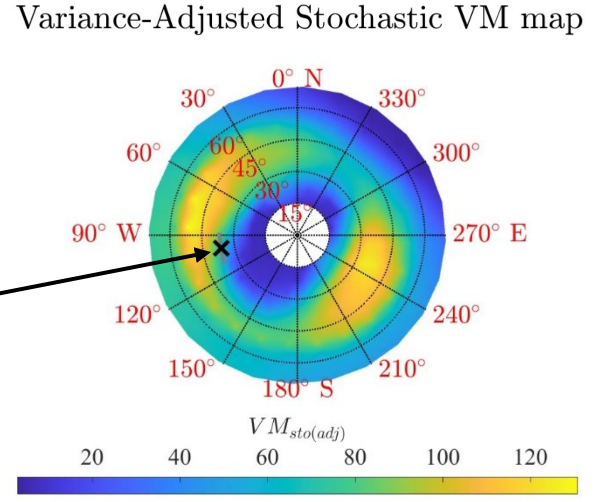
Capella image geometry







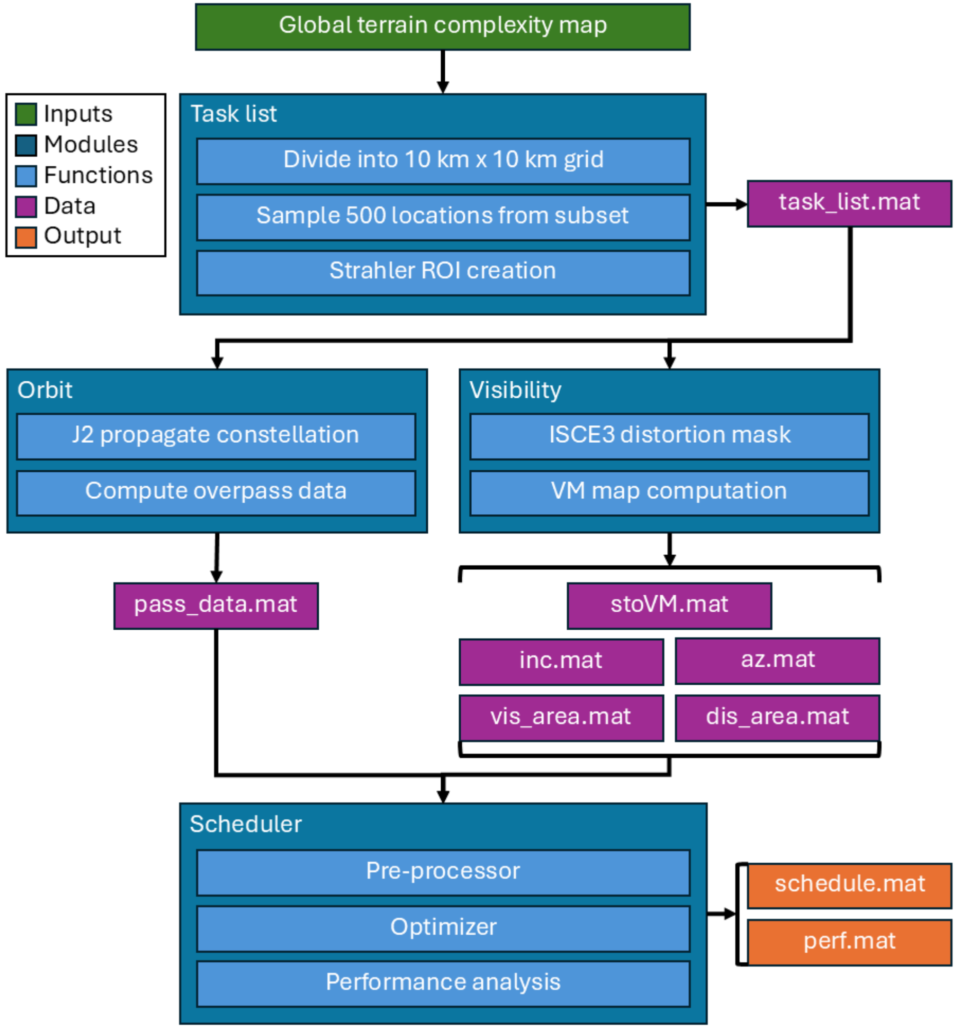
Visibility maps and overpass geometries for tributary W



Visibility maps and overpass geometries for tributary E

Scheduler objectives and framework

Main message identified in slide title



Optimization diagram

Scheduler development seeks to establish the following:

1. Ability to incorporate ROI visibility into a SAR constellation observation schedule
2. Improvement in ROI visibility using visibility-informed schedule versus other traditional schedules
3. Affects of incorporating visibility into scheduling on traditional constellation scheduling objectives

Large block diagram with readable text

Task list creation

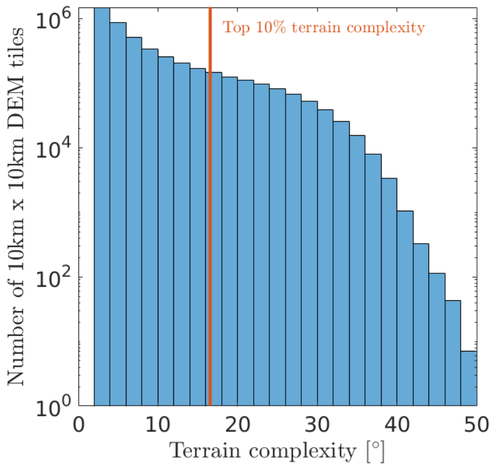
1. Divided global Copernicus 30m DEM into 10km x 10km tiles

2. Computed mean slope ($\bar{s}$) and slope standard deviation (σ_s) for each tile

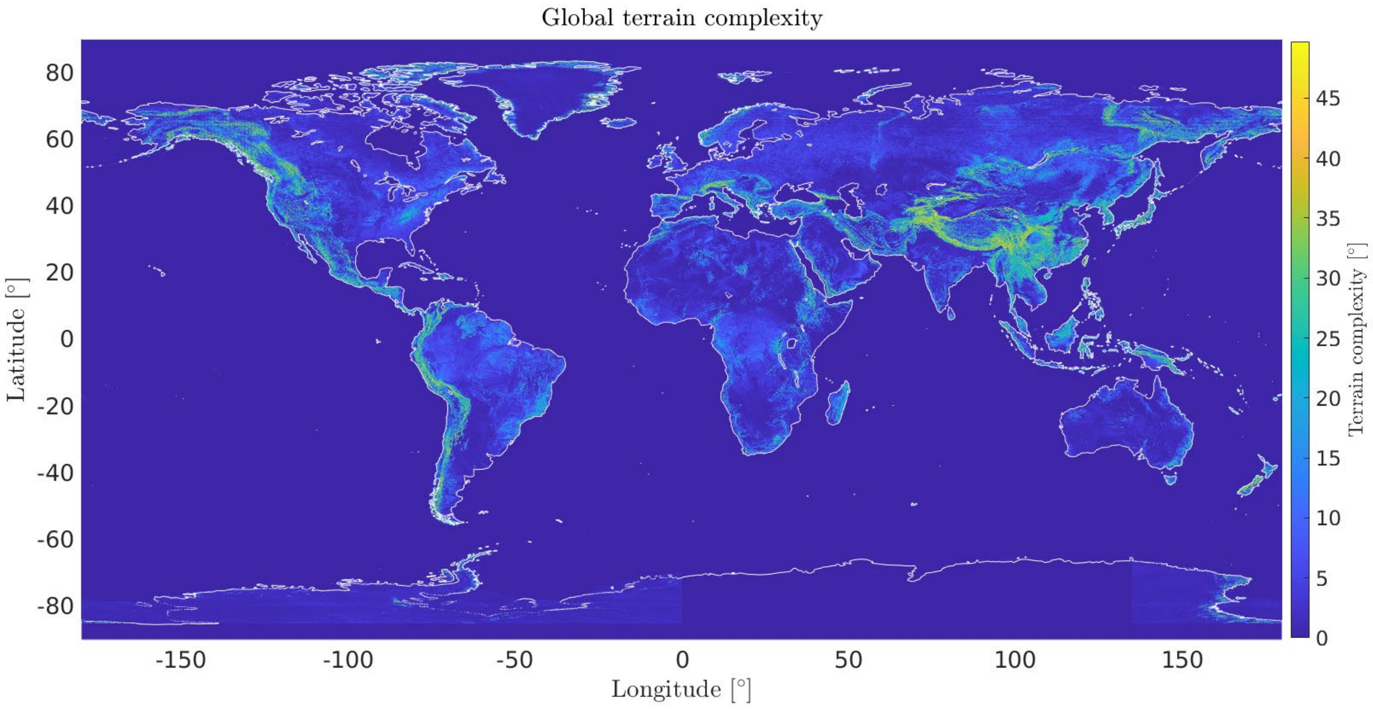
3. Defined terrain complexity metric as sum of slope mean and standard deviation: $\xi = \bar{s} + \sigma_s$

4. Consider tiles with top 10% terrain complexity to be "visibility stressing." Others are "visibility relaxing."

Histogram of 10km x 10km global terrain complexity scores.



Large figures and font sizes for captions



Global terrain complexity map from Copernicus 30m global DEM.

Task list creation

Good color contrast used in figures

1. Strahler stream network computed for local area around each target coordinate in task list.
2. Highest-order streams selected and ranked according to orientation, surrounding features, and size.
3. Closed polygons are formed for the highest-ranking streams.

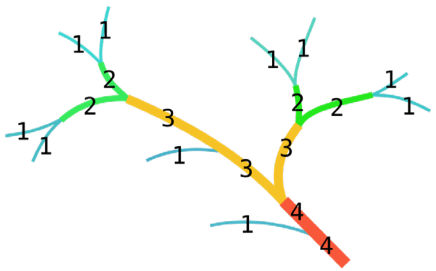
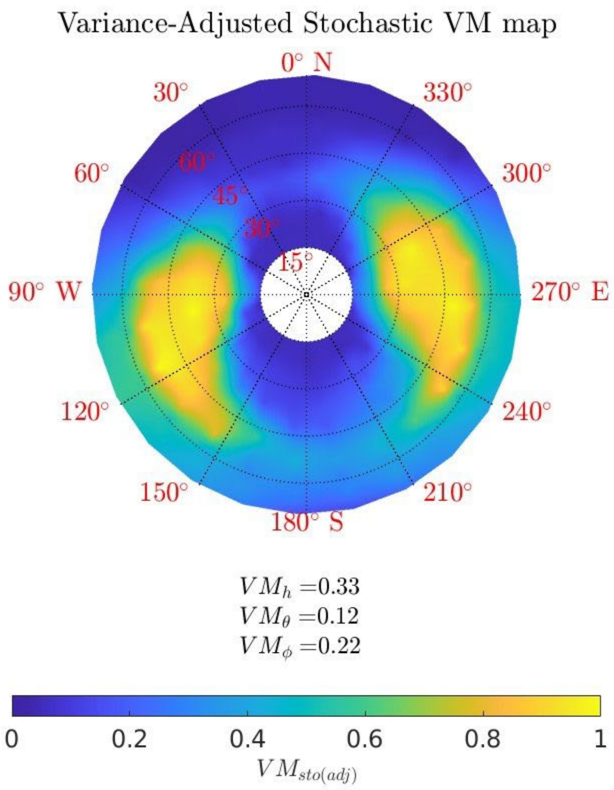
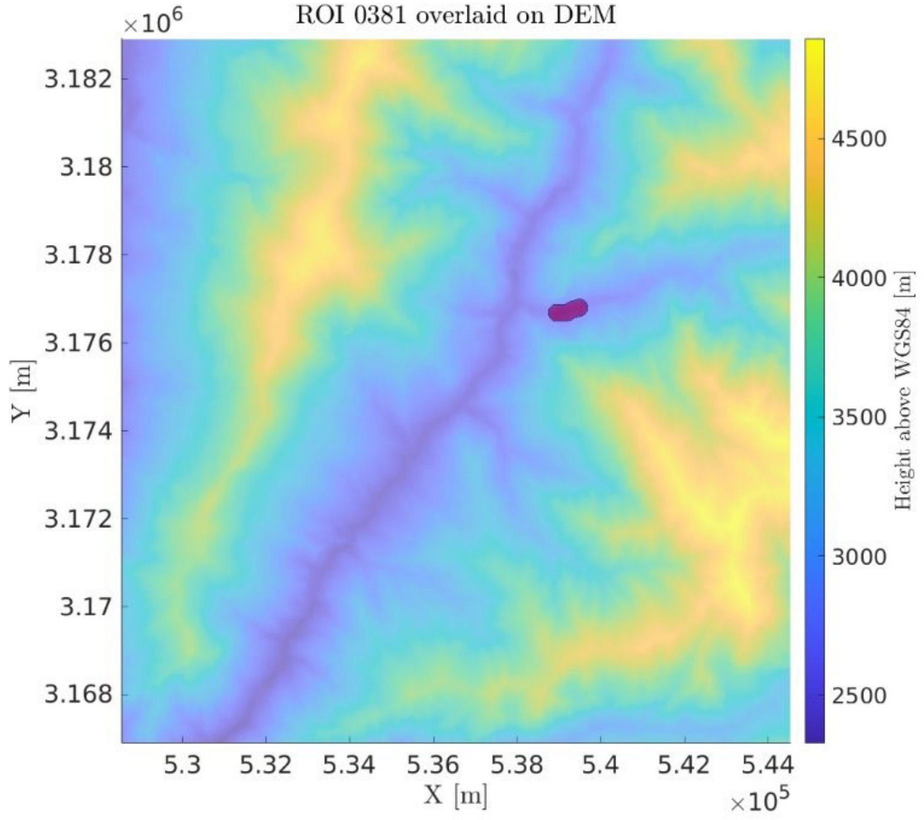


Diagram of Strahler stream network



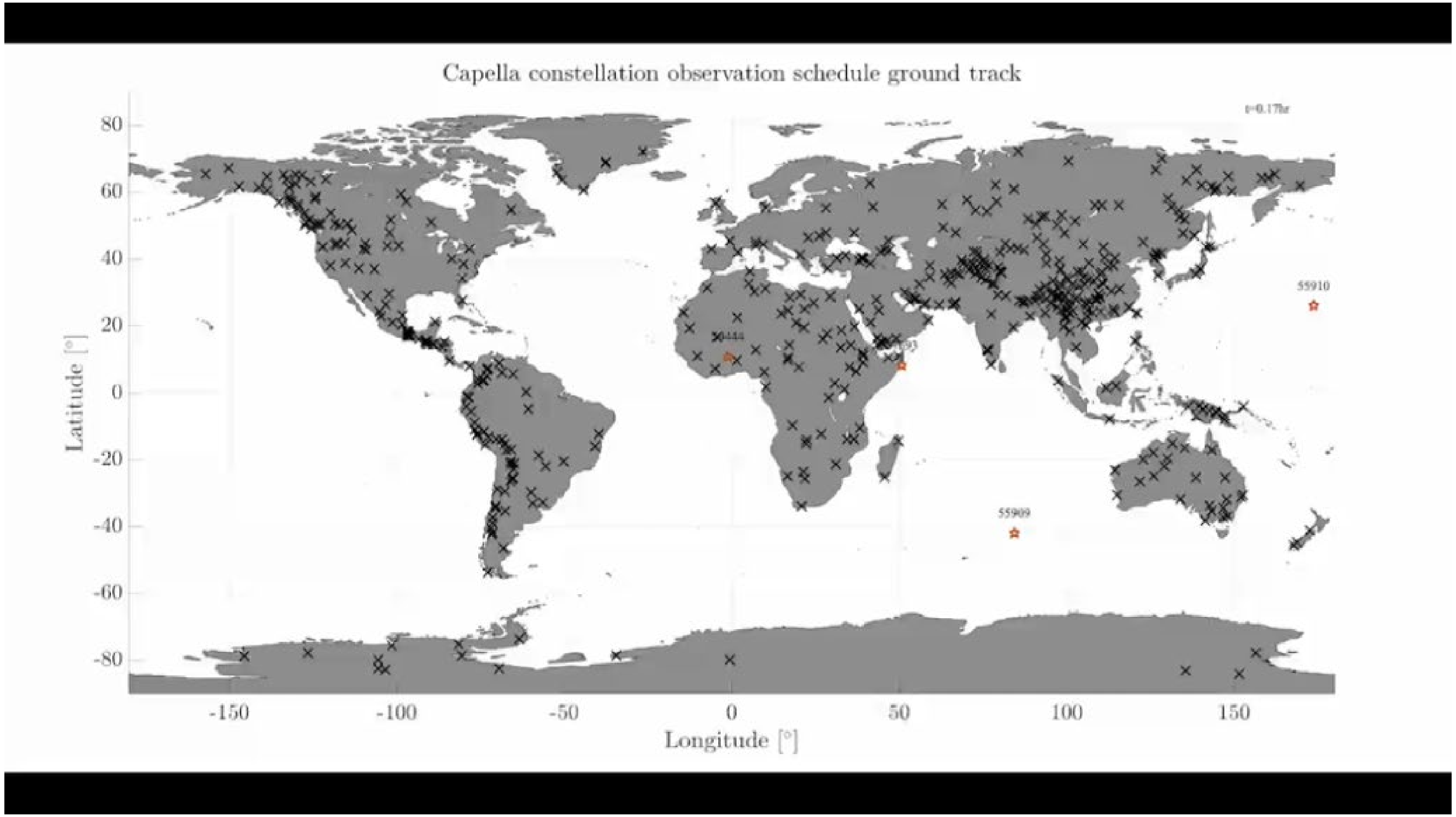
Stochastic visibility map for ROI 381 in task list.



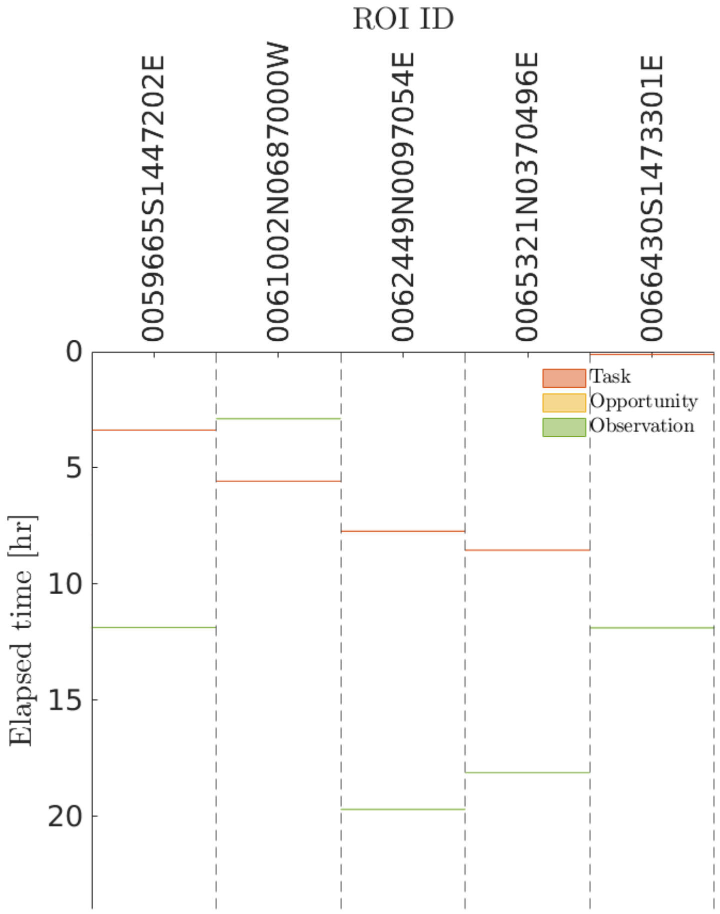
Strahler ROI overlaid on DEM for task 381.

Schedule animation

Large video with labeled components



Animation of observation schedule. Orange stars = sat not available, blue stars = sat available. Gold x = visibility stressing target, purple x = relaxing target.

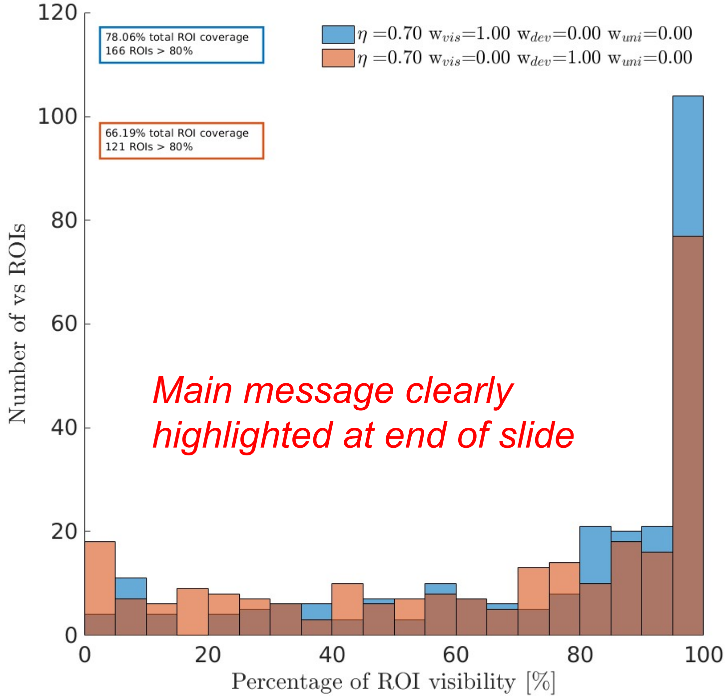


Observation timeline for 5 tasks.

Schedule performance

Figures organized based on objective

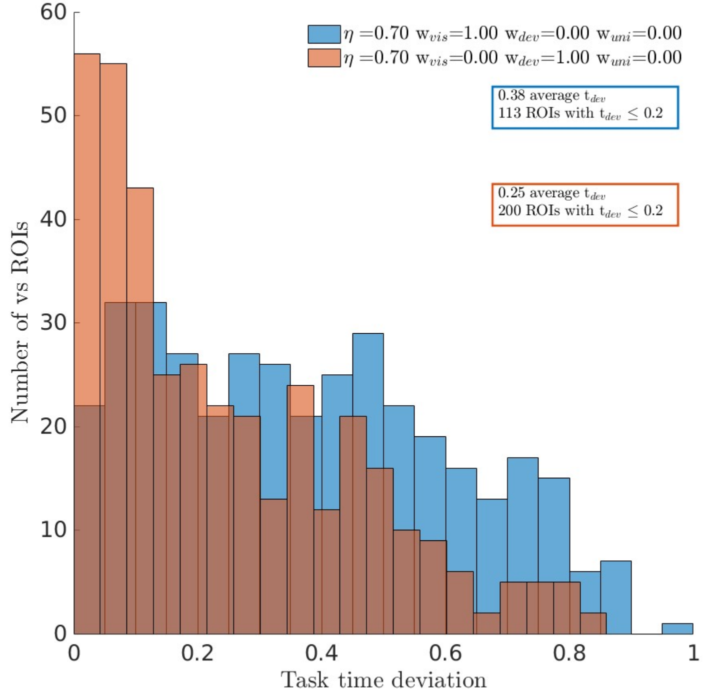
Obj 1. Total visibility



Main message clearly highlighted at end of slide

Visibility-informed scheduler shows 12% greater total ROI coverage compared to traditional schedulers.

Obj 2. Total time deviation



Traditional schedulers minimize time deviation more effectively compared to visibility-informed scheduler.

Obj 3. Number unique images

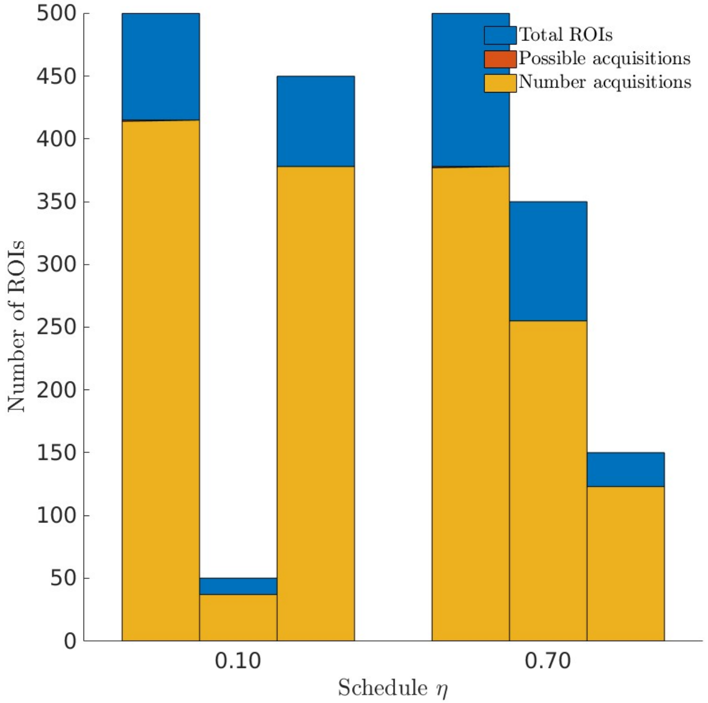


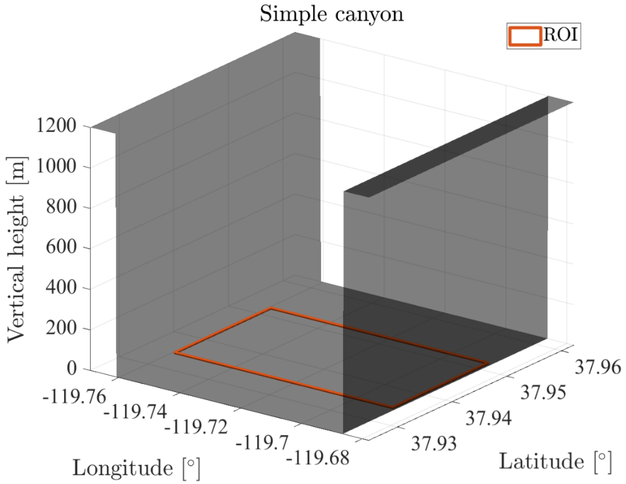
Image count is limited by los access. Visibility-informed and traditional schedulers perform similarly.

Takeaway: Visibility can be incorporated into observation scheduling and results in increased target visibility compared to traditional schedulers. A combined visibility and traditional scheduler may produce the best balance in tradeoffs.

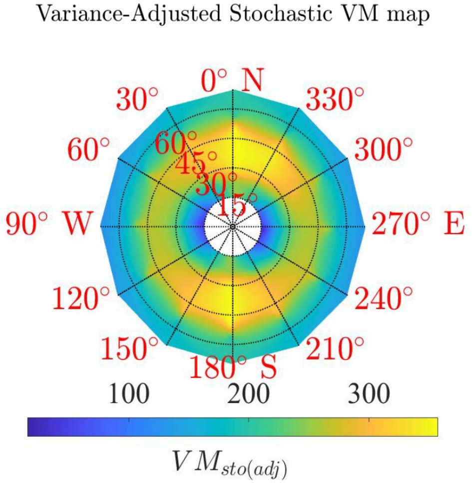
*C3 – Orbit design

Visibility-optimal orbit design

Already performed initial work characterizing VM map characteristics:



Manually-created 1D North-South canyon



Stochastic visibility map for 1D North-South canyon

Focused questions:

Important questions enclosed in boxes

Are ROIs with heterogeneous visibility maps better suited for observations from satellites in particular orbits?

What are the ideal orbital parameters for families of ROIs with characteristic visibility maps?

Can a case study be performed to demonstrate how orbital parameters for a future SAR satellite can be determined for regional visibility-optimal observations?