



GED I: Forest biomass & carbon fluxes

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Introduction

GED I (Global Ecosystem Dynamics Investigation) is a full-waveform LiDAR instrument that makes detailed measurements of the 3D structure of the Earth's surface. Launched in 2018 and installed on the ISS, it makes precise measurements of forest canopy height and structure as well as ground surface elevation.

System Overview

- 3 Nd:YAG (neodymium-doped yttrium aluminum garnet) lasers, emitting 1064 nm light
 - Nd:YAG is a crystal that is used as a lasing medium for solid-state lasers
- Two full-power lasers and one is split into two beams giving in total four beams
- Beam Dithering Units (BDUs) rapidly change the deflection of the outgoing laser beams by 1.5 mrad, giving in total 8 ground tracks
- Pulse 242 times per second with a power of 10 mJ, resulting in footprints averaging 25 m in diameter
- Waveform refers to the distribution of energy that returns to the sensor. GED I is a full waveform instrument, meaning it tracks the full energy profile that is returned by the laser pulses.
- Horizontal accuracy within +/- 9 m of waveform position on Earth's surface. For application in European temperate forest canopy measurements vertical accuracy was found to be within 50 cm [3]. Depending on the application the resolution may vary, while staying in the order of magnitude as above.
- Distance of 600 m between each of the 8 tracks (across track direction) and 60 m between each sample of 8 tracks (along track direction)

Real Life Examples

Canopy characteristics vs severity of fires

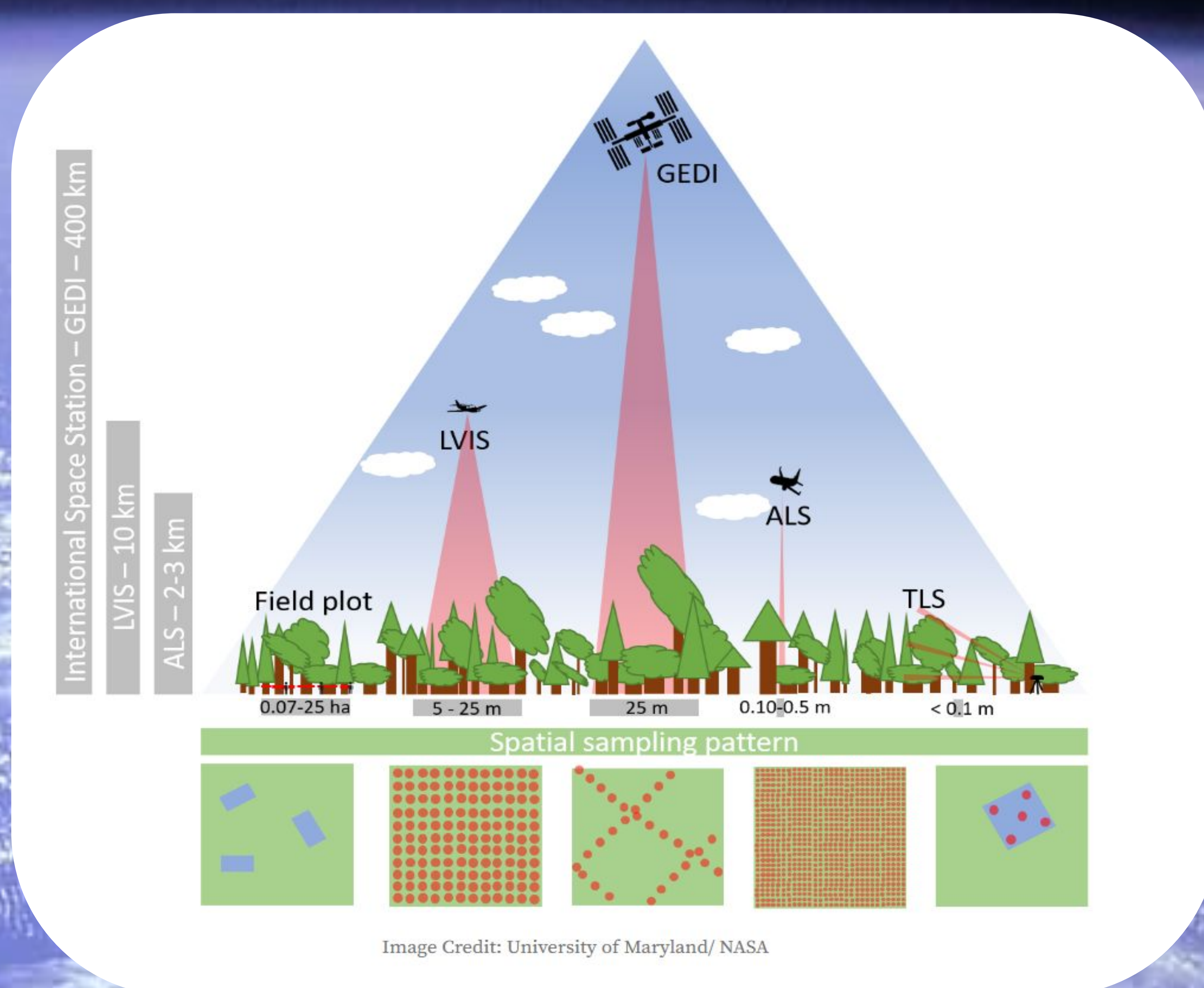
- Study used GED I to assess how pre-fire forest fuel structure affected wildfire severity across 42 California wildfires between 2019–2021. The study found:
 - Fires increase in severity with greater fuel loads until a decline in severity in the tallest and most voluminous forest canopies.
 - In extreme topographic and weather conditions, though, fuel volumes became decoupled from severity patterns and vertical continuity metrics like layering and ladder fuels more consistently predicted the severity.

Forest regrowth after fire

- Study used GED I to measure the vertical distribution of canopy in a forest site where a severe fire had taken place in 2019.
 - The GED I measurement revealed a significant reduction in overstorey (uppermost) vegetation density and an increase in understorey (layer below the overstorey) vegetation density.
 - This contributed to reduced carbon uptake, compared to pre-fire, due to the lower efficiency of light use of lower canopy species, which was verified with in-situ gas exchange measurements.

Applications

Application	Explanation	What makes the sensor fit the application?
Carbon flux modelling	GED I allows collection of information on forest canopy characteristics which, coupled with supplementary information (e.g. plant sampling, in-situ gas measurements), can be used to understand the carbon uptake of a forest.	10%-30% of LiDAR pulses can penetrate forest canopy. Therefore information can be collected on the different layers of the forest. Vertical accuracy of ~50 cm is suitable for providing detailed enough measures of the structure.
Forest fires modelling	Canopy characteristics measured by GED I, especially the vertical distribution, impact behaviour and severity of potential fires.	
Biodiversity modelling	Vertical distribution of vegetation provided by GED I is a strong indicator of habitat suitability for many animals. Interpreted with wildlife observations, this can inform scientists on animal behaviours and populations.	



Sampling Scheme

- Unique scheme due to positioning and BDU deflections
- Grid structure of samples
- BDUs are equipped to deflect outgoing lasers to produce a staggered sampling scheme
- Full-power beams provide higher quality waveform data while the coverage beams provide larger spatial coverage

Challenges

- **Inclination:** Due to the fact that GED I is on the ISS, it is limited in its coverage of Earth. It cannot measure any data outside the range ± 51.6 degrees latitude
- **Integration with other data:** Often the data with GED I needs to be fused with other sensor data or physical observations to be useful

Sources:

1. <https://www.nature.com/articles/s43247-024-01893-8>
2. <https://gedi.umd.edu/>
3. <https://www.mdpi.com/2072-4292/12/23/3948#B14-remotesensing-g-12-03948>
4. <https://www.sciencedirect.com/science/article/pii/S003442572400556X>