Working towards spaceborne lidar with wall-to-wall coverage for bare-Earth topography and vegetation change mapping: Small-sats and novel laser sources

Global Lidar Altimetry MISsion: GLAMIS

University of Edinburgh: Steven Hancock, Matthew Purslow, Robbie Ramsey, Johannes Hansen, Ian Davenport, Euan Mitchell, Iain Woodhouse, Kristina Tamane

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Space Flow Ltd.: Callum Norrie

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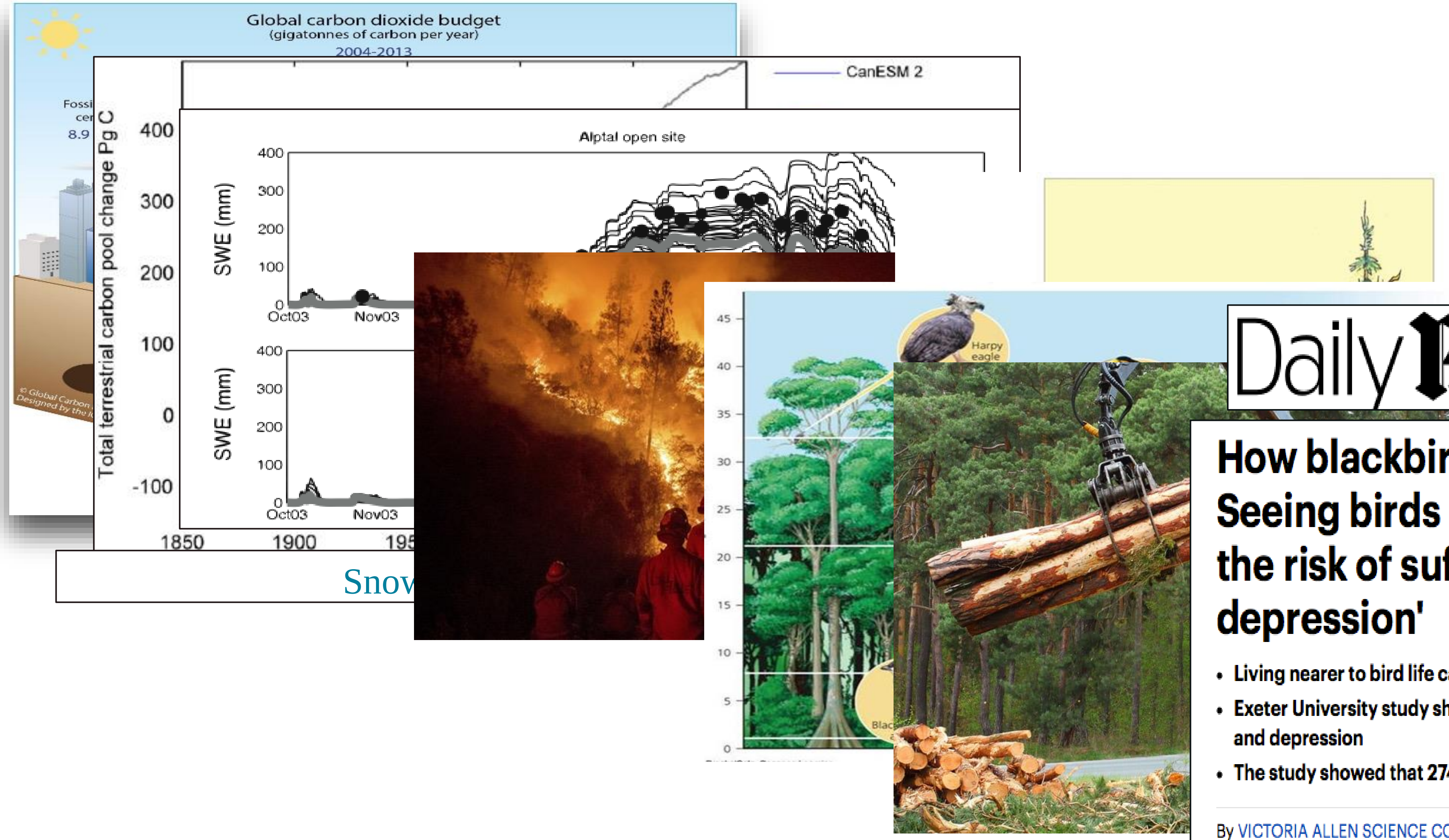
Need for vegetation structure data



DailyMail.com

How blackbirds help us beat the blues: Seeing birds in your garden 'can cut the risk of suffering stress and depression'

- Living nearer to bird life can improve mental health new research suggests
- Exeter University study shows those living close to birds reduce the risk of stress and depression
- The study showed that 274 people exposed to bird song saw a fall in stress levels

By VICTORIA ALLEN SCIENCE CORRESPONDENT FOR THE DAILY MAIL

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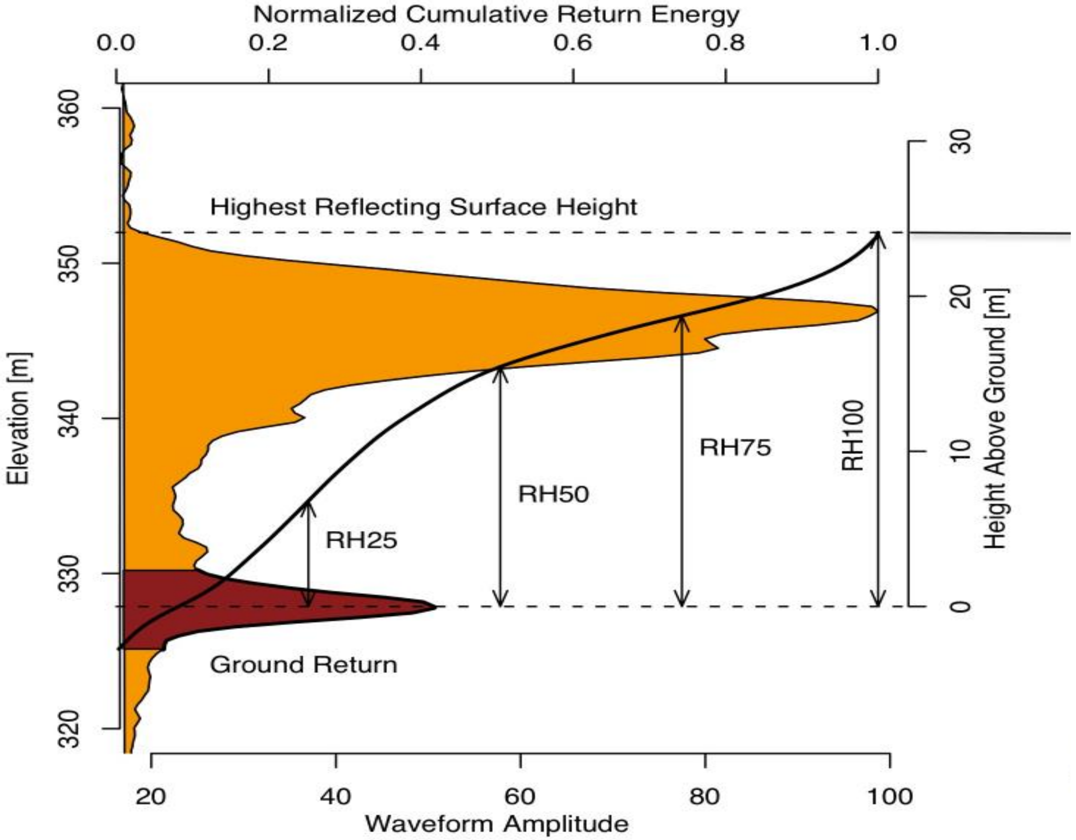
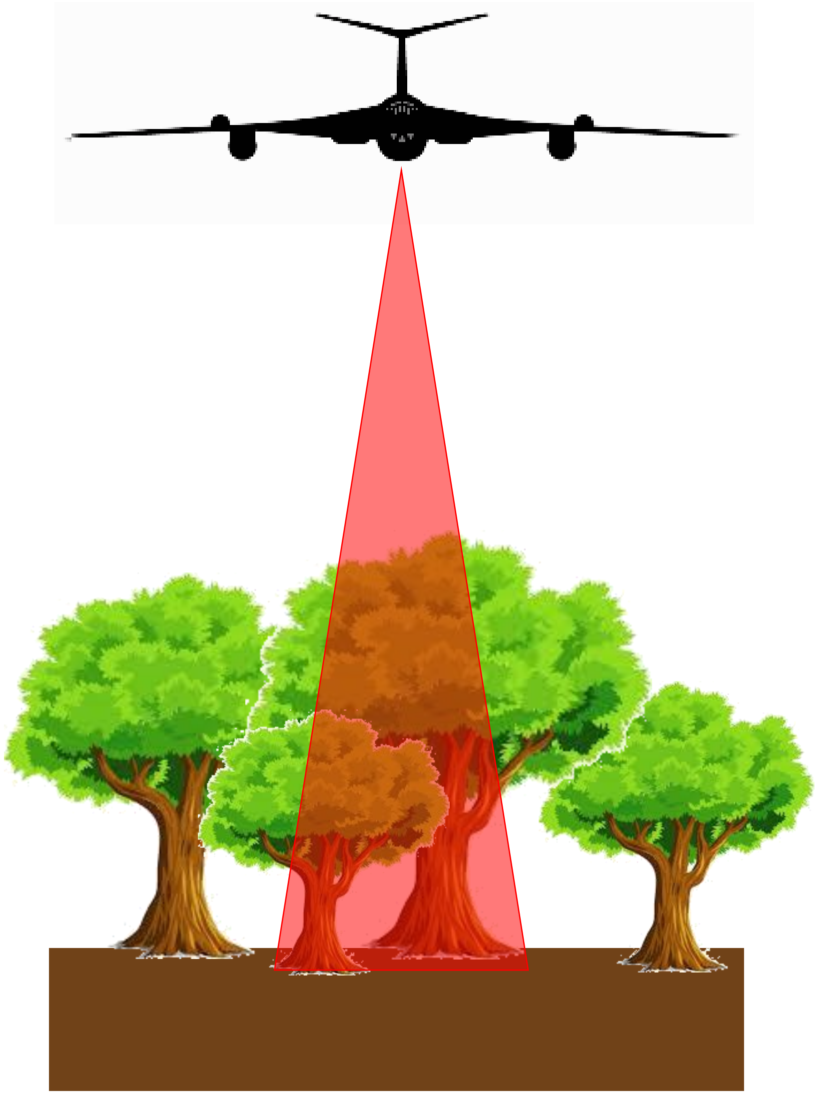
Lidar measurement





Spaceborne lidar missions

NASA LITE: 1994

- Technology demonstrator

NASA ICESat/GLAS: 2003-2009

- Ice elevation and volume

NASA Calipso/CALIOP: 2006-2023

- Cloud profiles

NASA CATS: 2015-2017

- Cloud profiles

ESA Aeolus/ALADIN: 2018-2023

- 3D wind speed

NASA ICESat-2/ATLAS: 2018-

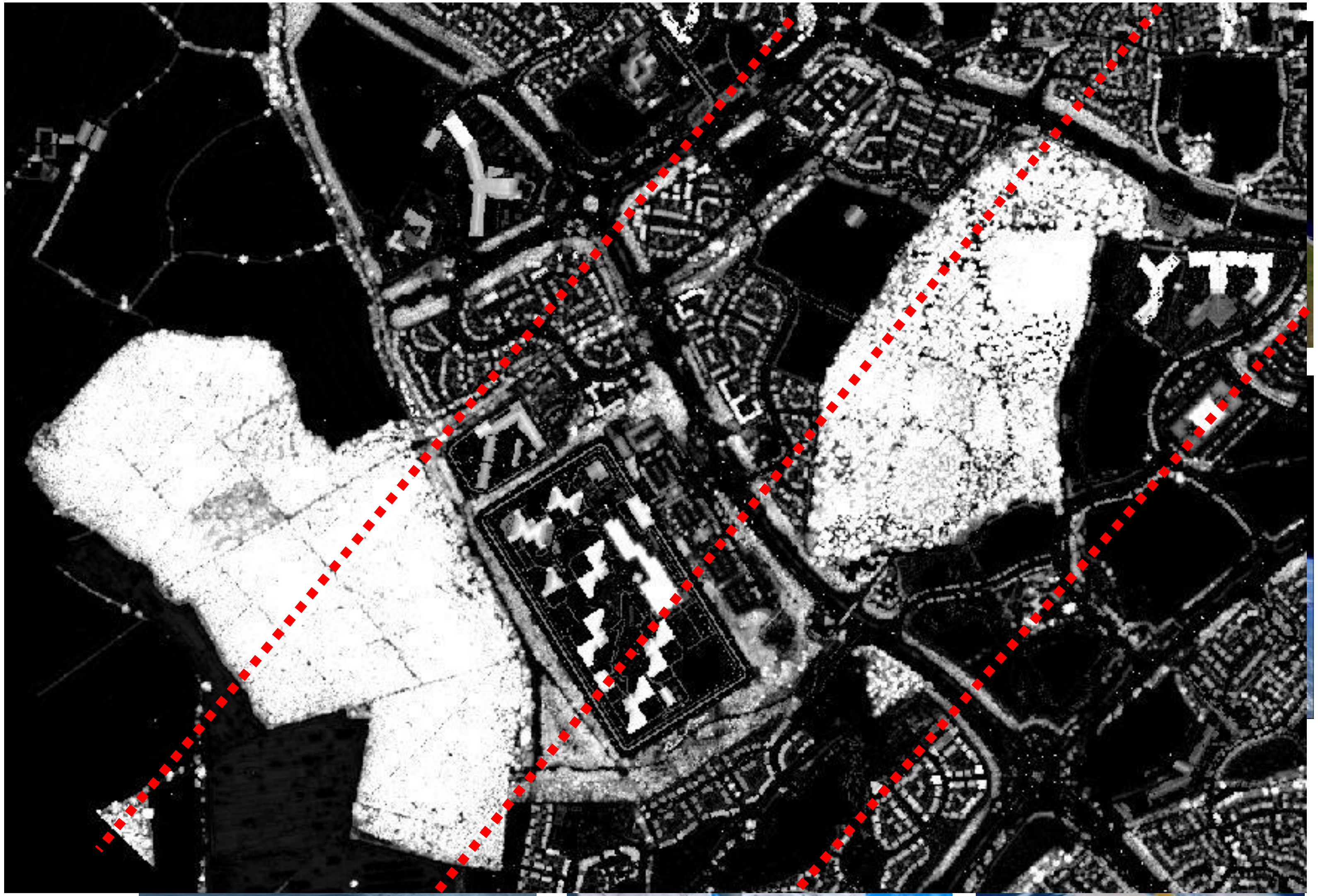
- Ice elevation and volume

NASA GEDI: 2018-2023

- Forest biomass and structure

CNSA TECIS: 2022- (?)

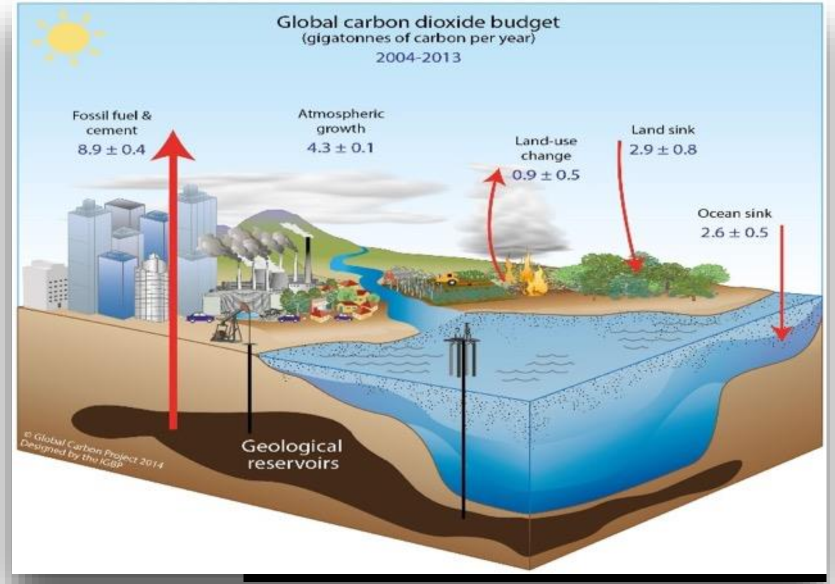
- Dual wavelength



Lidar data

Lidar is the only way to directly measure

- Bare-Earth topography
- Tree height and cover

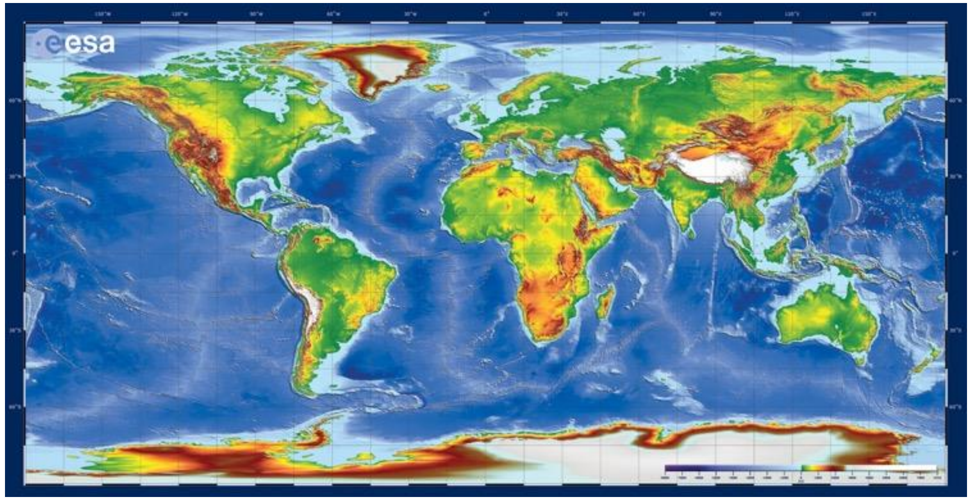


This enables (amongst others)

- Flood modelling
- Biomass mapping (underpins many other efforts)

Many remote sensing techniques are collected operationally

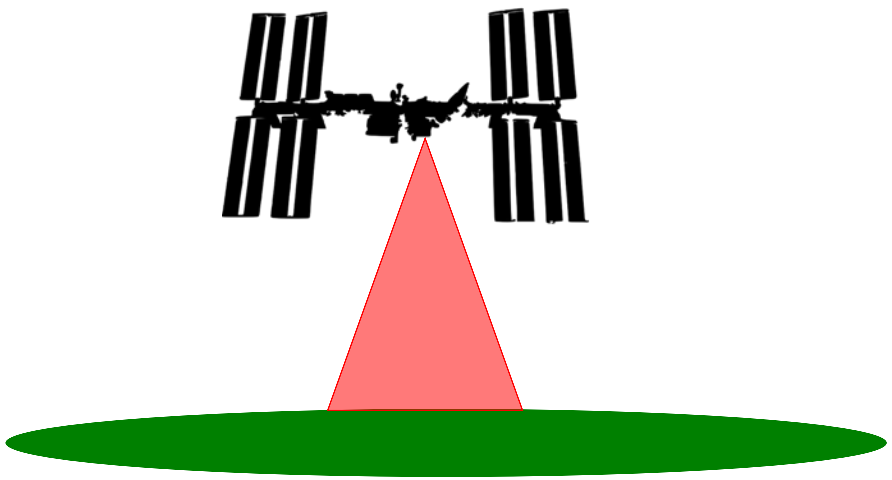
- There are no globally continuous lidar datasets
- There is no long-term (decadal) lidar dataset

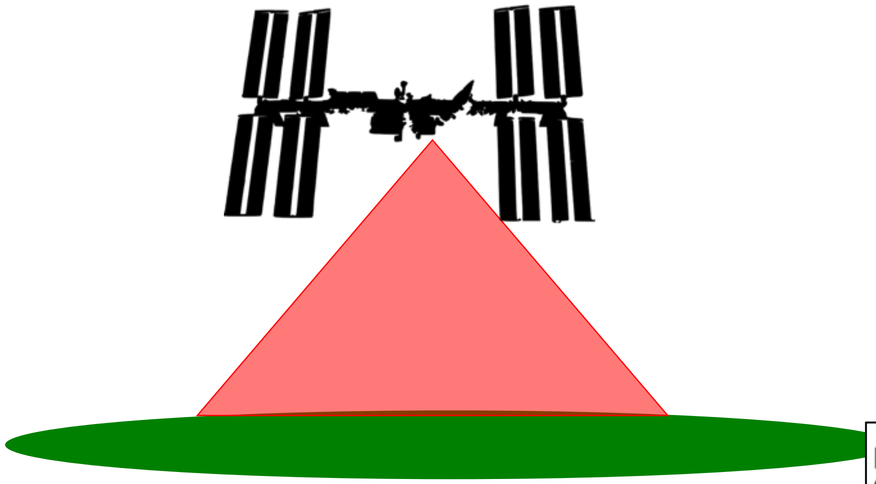


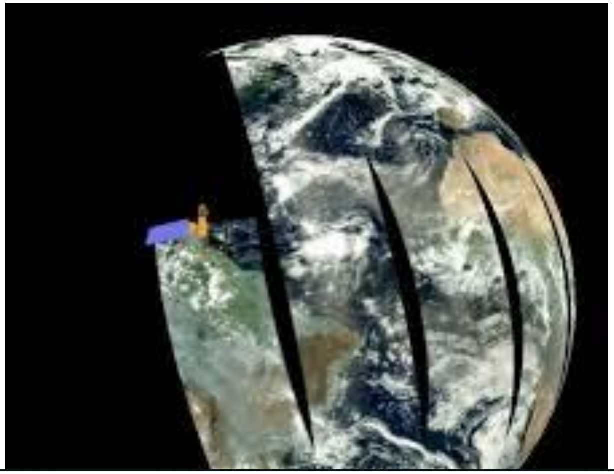
Increasing lidar coverage

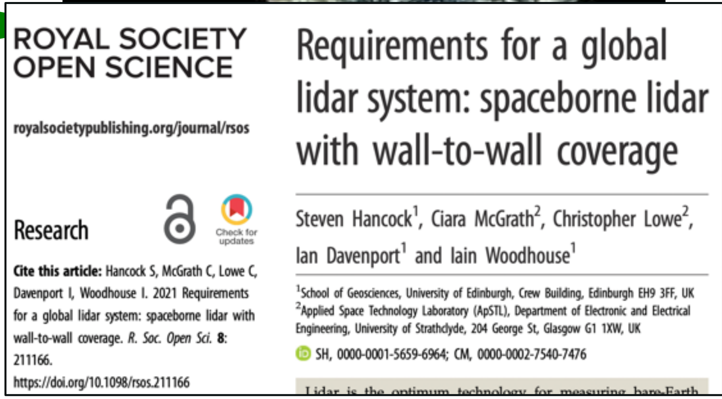
Which parts could we adjust to maximise coverage per unit cost?

- **Instrument:** Laser and detector efficiencies improved with new photonics
- **Platform:** Maximise payload power and telescope area per unit cost
- **Processing:** Reduce energy requirements with signal processing









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Research

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Requirements for a global lidar system: spaceborne lidar with wall-to-wall coverage

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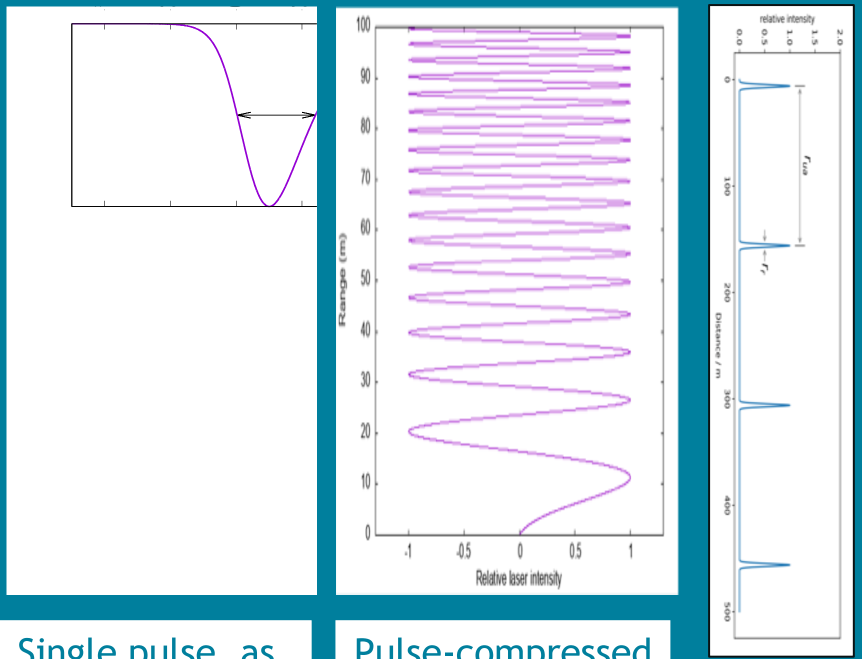
GLAMIS: Diode lasers

Compared to solid-state, diode lasers offer

- Higher efficiencies
- Lower size, mass, complexity and cost
- Lower peak power

Requires a different modality

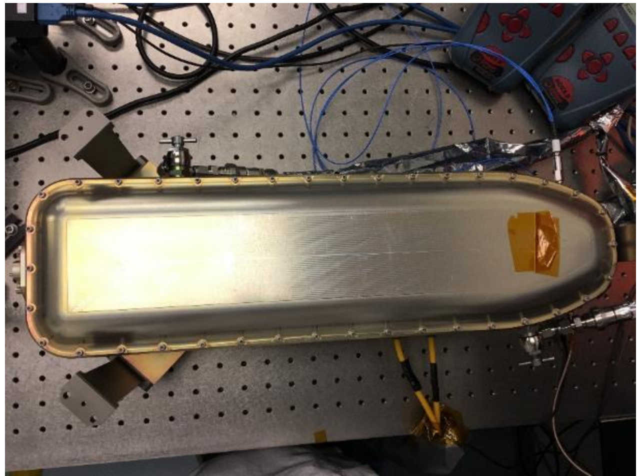
- Pulse-compressed lidar
- Pulse-train

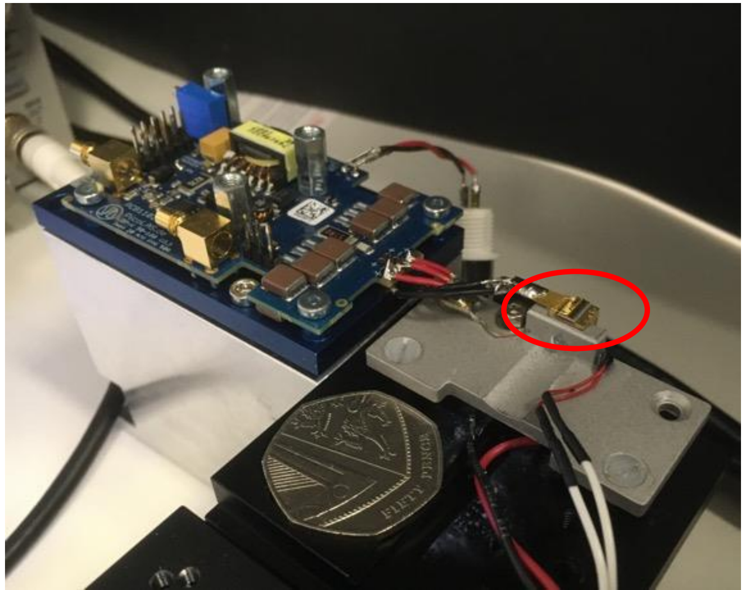


Single pulse, as used by solid-state lasers

Pulse-compressed lidar, PCL

Pulse-train





remote sensing — MDPI

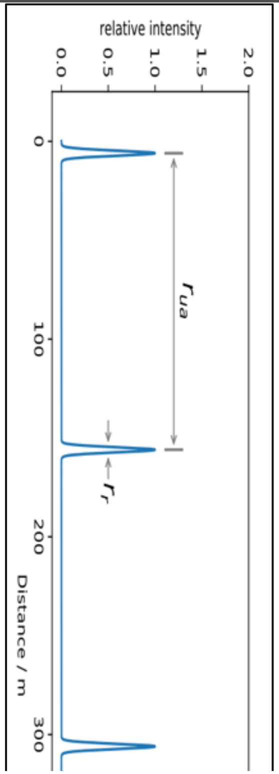
Article

Assessing Novel Lidar Modalities for Maximizing Coverage of a Spaceborne System Through the Use of Diode Lasers

Johannes N. Hansen [1,*], Steven Hancock [1], Ludwig Prade [2], Gerald M. Bonner [2], Haochang Chen [2], Ian Davenport [1], Brynmor E. Jones [2] and Matthew Purslow [1]

GLAMIS constellation

Characteristic	Value
Altitude	500 km
Beam footprint	30 m
Peak power	>= 4W
Pulse length	<= 33 ns
Average power	0.13 W
Laser	diode laser, ~ 850 nm
Laser efficiency	>= 10%
Detector efficiency	58%
Payload power	120 W
Telescope diameter	58 cm
Number of lasers	30
Swath width	900 m (4.5 km if 20% sampling)



Spatial coverage	Number of satellites	
	5 year repeat	Annual repeat
100%	1	6
20%	1	2

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Research Paper

Spacecraft and optics design considerations for a spaceborne lidar mission with spatially continuous global coverage

Christopher John Lowe [a], Ciara Norah McGrath [b], Steven Hancock [c], Ian Davenport [c,g], Stephen Todd [d], Johannes Hansen [c,f], Iain Woodhouse [c], Callum Norrie [e], Malcolm Macdonald [a,*]

Next steps needed

Essential

- Diode + driver efficiency raised
- TRL raised to 6
- Power requirements finalised (noise)
- 20% or 100% sampling decided (or configurable?)
- Instrument design
- Satellite platform selected
- Funding to launch identified (1 demonstrator then constellation)

Desirable

- More efficient detector
- Spatial algorithms made robust
- Deployable optics
- Analysis Ready Data product plans?

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