



Exceptional service in the national interest

SANDIA'S ROLES IN THE ARCTIC

DOE Related Projects in Alaska and the Arctic

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Alaska Regional Decarbonization Workshop

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OUTLINE

- Sandia's Arctic Roles
- Representative Projects
- Arctic Facilities and Capabilities
 - North Slope
 - Oliktok
 - Atqasuk
 - Field Campaigns
- Arctic Energy Office
- Methane Monitoring
- Emerging Research Topic
 - Geologic Hydrogen For Energy in Alaska
 - A Systems Perspective on H₂
- Questions



Credit: Benjamin Jones, USGS

SANDIA'S ARCTIC ROLE



Accelerate clean energy transitions

- Renewable technologies for critical infrastructure in remote and harsh environments
- Emphasis in sustainability, capacity building and EEEJ aspects as part of technology research and pilots
- Representative projects
 - PV research for Arctic applications
 - Cordova Energy Storage and RADIANCE
 - St Mary's / Mountain Village Grid Bridging System
 - Port of Alaska / JBER
 - 4 communities under ETIPP

Advance security and science

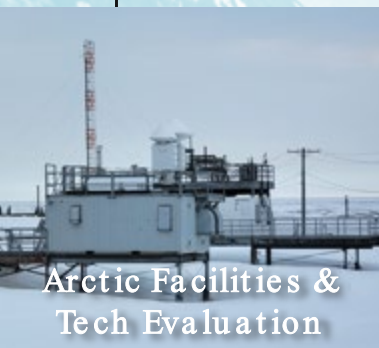
- Oliktok observational and experimental research center
- Climate measurements, modeling, and impact analysis
- Greenhouse gas monitoring
- Domain awareness and resilient military systems



MEASUREMENT & MODELING

CLEAN ENERGY & PROCESSES

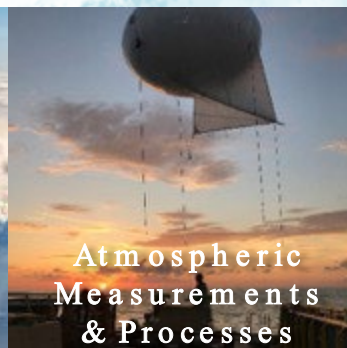
RESILIENT INFRASTRUCTURE



Arctic Facilities & Tech Evaluation



High-Resolution Cloud Modeling



Atmospheric Measurements & Processes



Permafrost & Coastal Erosion



Bifacial PV



PROJECTS



REPRESENTATIVE PROJECTS

- Port of Alaska MOU
 - Evaluate potential for renewable energy in Upper Cook Inlet
- Port of Alaska Energy Resilience Planning (OE)
- Clean Energy Demonstration – Hilcorp (FECM, WETO connection)
- Arctic Road Rally
 - Decarbonizing transportation (VTO)
- North Slope Clean Energy Evaluation and Demonstration
 - Oliktok bifacial PV/Aeromine
- Boost (OTT)
 - Lab Tech commercialization for community energy challenges



FACILITIES/ CAPABILITIES

SANDIA-MANAGED DOE/ARM NORTH SLOPE OF ALASKA (NSA) FACILITIES



ARM–NSA and Adjacent Arctic Ocean Research Facilities:

- **Utqiagvik/Barrow:** Measures ocean-land-atmosphere interface conditions
- **Atqasuk: (Inactive)** Measured land–atmosphere interface for comparison with Barrow measurements for differences between land and shore conditions (inland)
- **Oliktok and ARM Mobile Facility 3:** Measured ocean–land–atmosphere interface; use of controlled airspaces for aerial atmospheric measurements



Utqiagvik
1997–Present



Atqasuk
1999–2010



Oliktok (AMF-3)
2013–2021





NORTH SLOPE ALASKA: UTQIAGVIK

Capabilities: User Facilities

- **Site Instrumentation**

- Over 50 instruments are supported at the NSA site
- Measurements include
 - Cloud Condensation Nuclei
 - Aerosol properties
 - Radar and lidar capabilities
 - Soot photometers
 - Eddy covariance flux tower
 - Meteorological parameters
 - Snow and precipitation measurements
 - Radiosonde soundings
 - Sky imaging
 - Near-shore sea ice scans with ARM XSAPR

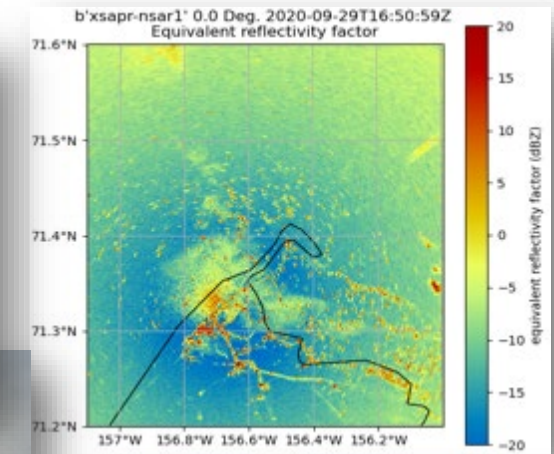
- **Guest Instrumentation**

- ARM and Sandia support the deployment of guest instrumentation as part of stand-alone field deployments
- Larger ARM directed campaigns also occur

ARM hosts data from any field campaign at the site for users

<https://www.arm.gov/capabilities/observatories/nsa>

<https://www.arm.gov/publications/fact-sheets/docs/doe-sc-arm-14-004.pdf>





ARCTIC ENERGY OFFICE - OLIKTOK POINT/AIRSPACE

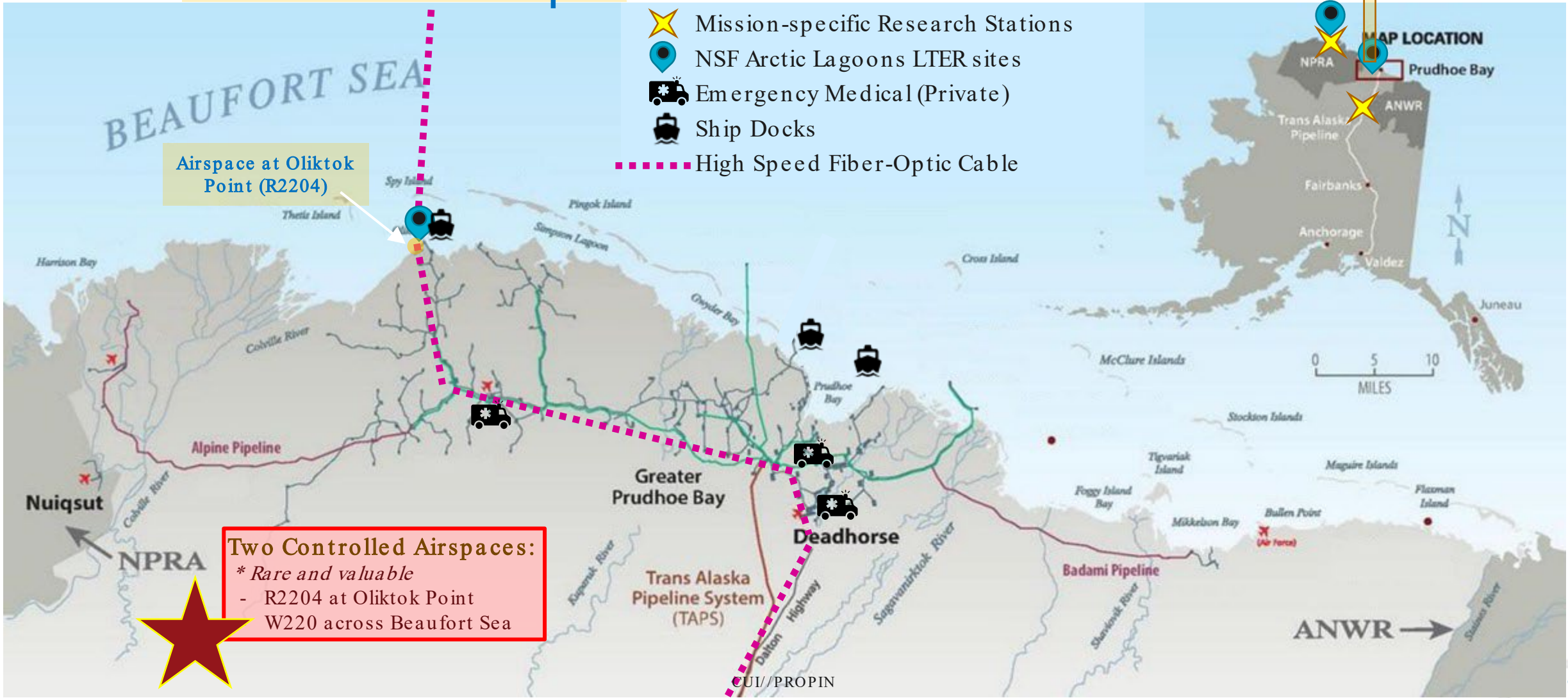
★ Controlled airspace
46 x 775 miles north (W220) ↑

★ Airspace toward North Pole (W220) →

- ★ Mission-specific Research Stations
- 📍 NSF Arctic Lagoons LTER sites
- 🚑 Emergency Medical (Private)
- 🚢 Ship Docks
- High Speed Fiber-Optic Cable

Airspace at Oliktok Point (R2204)

Two Controlled Airspaces:
* Rare and valuable
- R2204 at Oliktok Point
W220 across Beaufort Sea





OLIKTOK POINT HISTORY – ARM TO SANDIA



2013–2021

- ARM Mobile Facility (AMF3)
- Over 50 instruments onsite
- 13 shelters and sprung
- Tethered (TBS) and free release balloons
- Controlled airspace



2021–2023

- ARM removed the site
- Internal LDRD and ALD investments
- Distributed acoustic sensing (DAS)
- Guest national security PIs



2024–Future

- New Shelter install – awaiting NEPA approval
- Identifying support instruments for future use
- Arctic Renewable Energy Test Bed
- Continued partnerships with DOD, OGA, Nat. Security and science partners
- Small scale demonstration site

METHANE

ARCTIC METHANE

Humans have released about **500 billion tons** of carbon into the atmosphere since the Industrial Revolution.

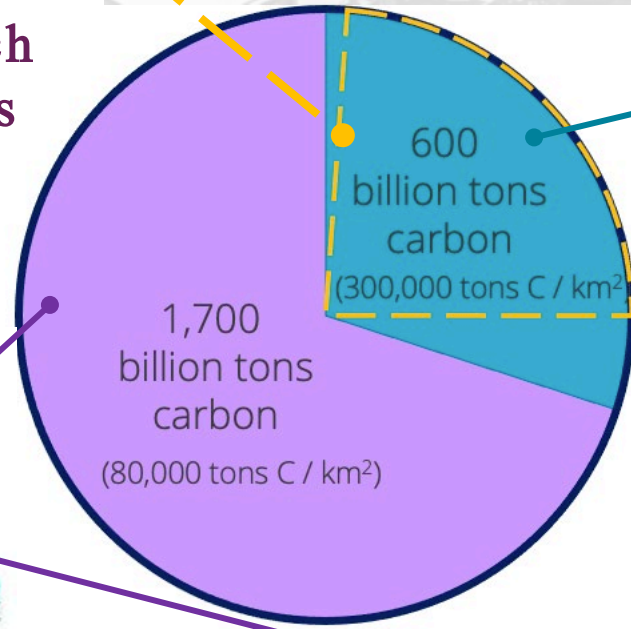
Sayed et al. (2020), Subsea permafrost carbon stocks and climate change sensitivity estimated by expert assessment, Environmental Research Letters.

Submarine permafrost

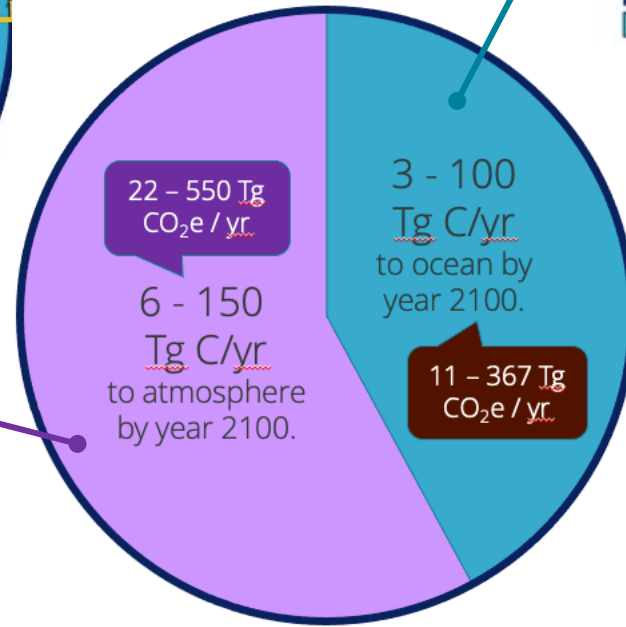


■ LGM permafrost extent on continental shelves
■ Current subsea permafrost extent

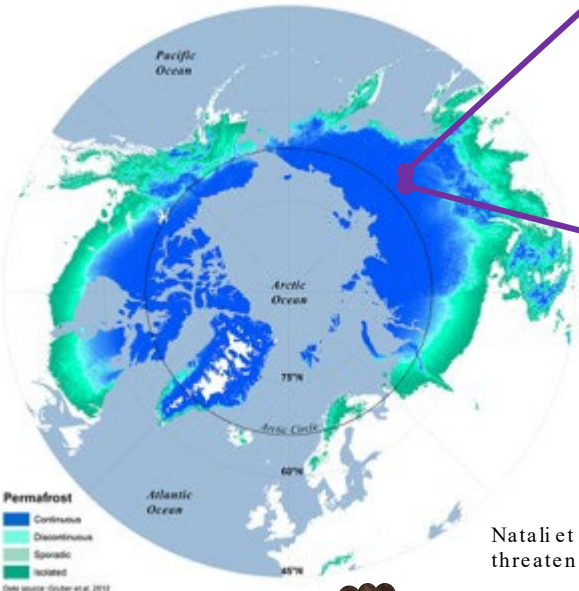
How much carbon is stored?



How much carbon is emitted?



Terrestrial permafrost

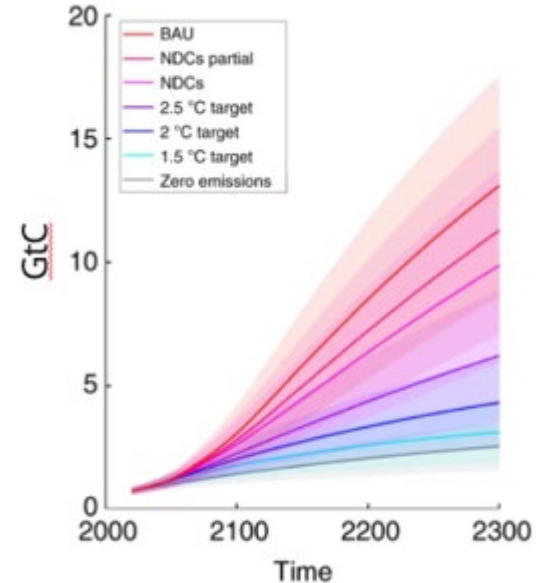


Permafrost
■ Continuous
■ Discontinuous
■ Sporadic
■ Isolated
Data source: Ginder et al. 2012

Natali et al. (2021), Permafrost carbon feedbacks threaten global climate goals, PNAS.



organic matter

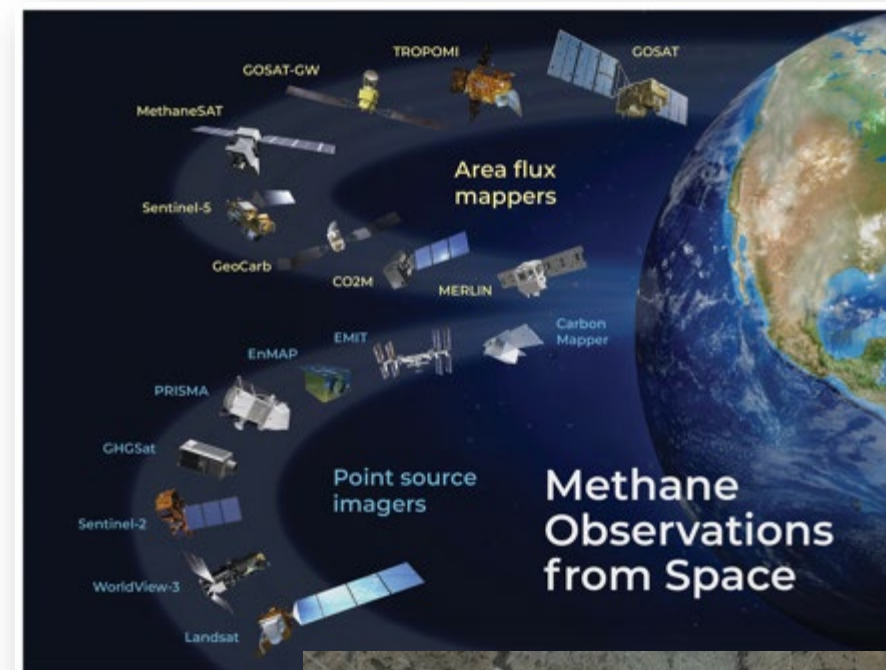


Simulated methane emissions from thawing permafrost.



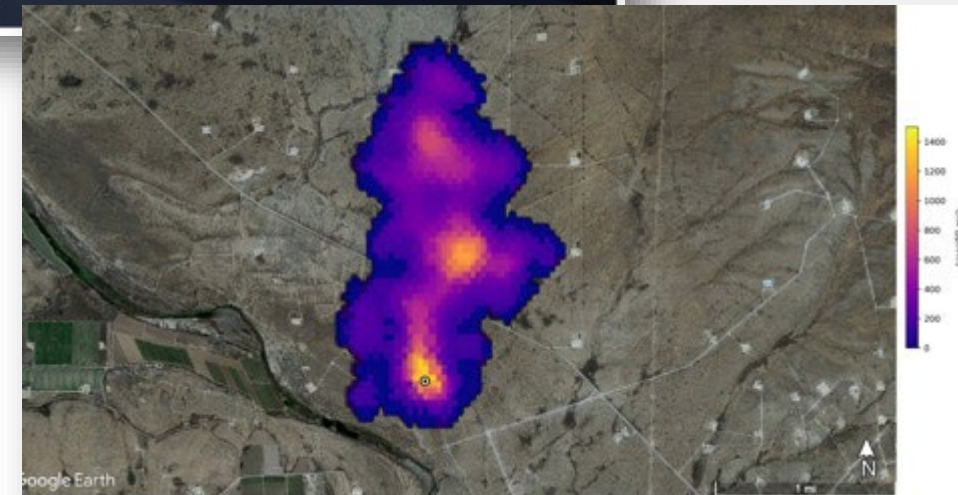
MONITORING METHANE EMISSIONS IN THE ARCTIC IS A CHALLENGE

- Difficult to obtain accurate measurements in remote areas
- Methane sources are widely distributed spatially
- Carbon decomposition effects, vegetation and hydrology combine to create a complex system
- Highly variable measurement conditions, temperatures, polar night, marine vs ice vs tundra



Jacob et al., 2022

Sandia has been actively performing research to improve methane monitoring, with special focus in the Arctic.





CURRENT WORK IN METHANE MONITORING

Natural emissions

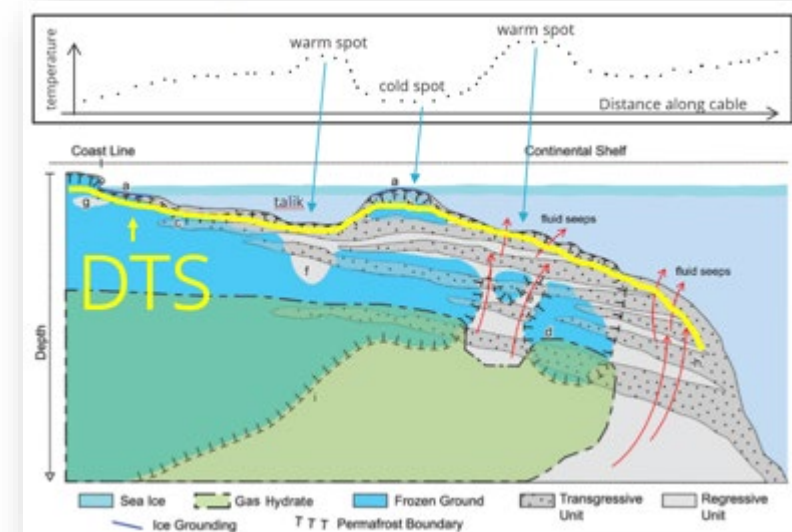
- Quantifying marine and terrestrial permafrost emissions
 - DAS and temperature sensing
- Understanding the role of biology on permafrost degradation and subsequent GHG release to increase biological fidelity of climate models
- Developing next generation scaling and forecasting capability for land-atmosphere fluxes

Integrated Methane Monitoring System

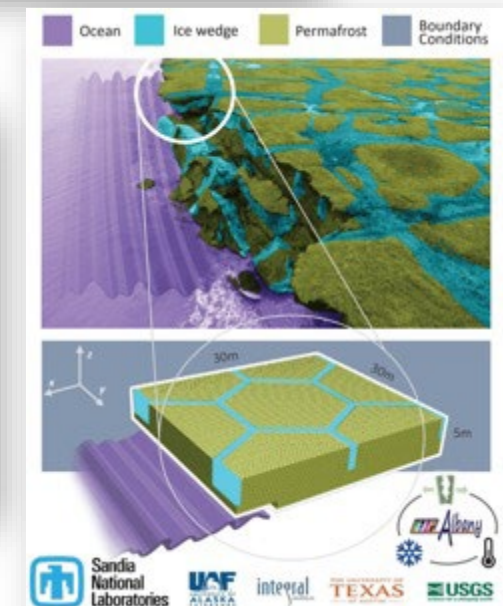
- Anthropogenic focus

“Rosetta Stone” concept

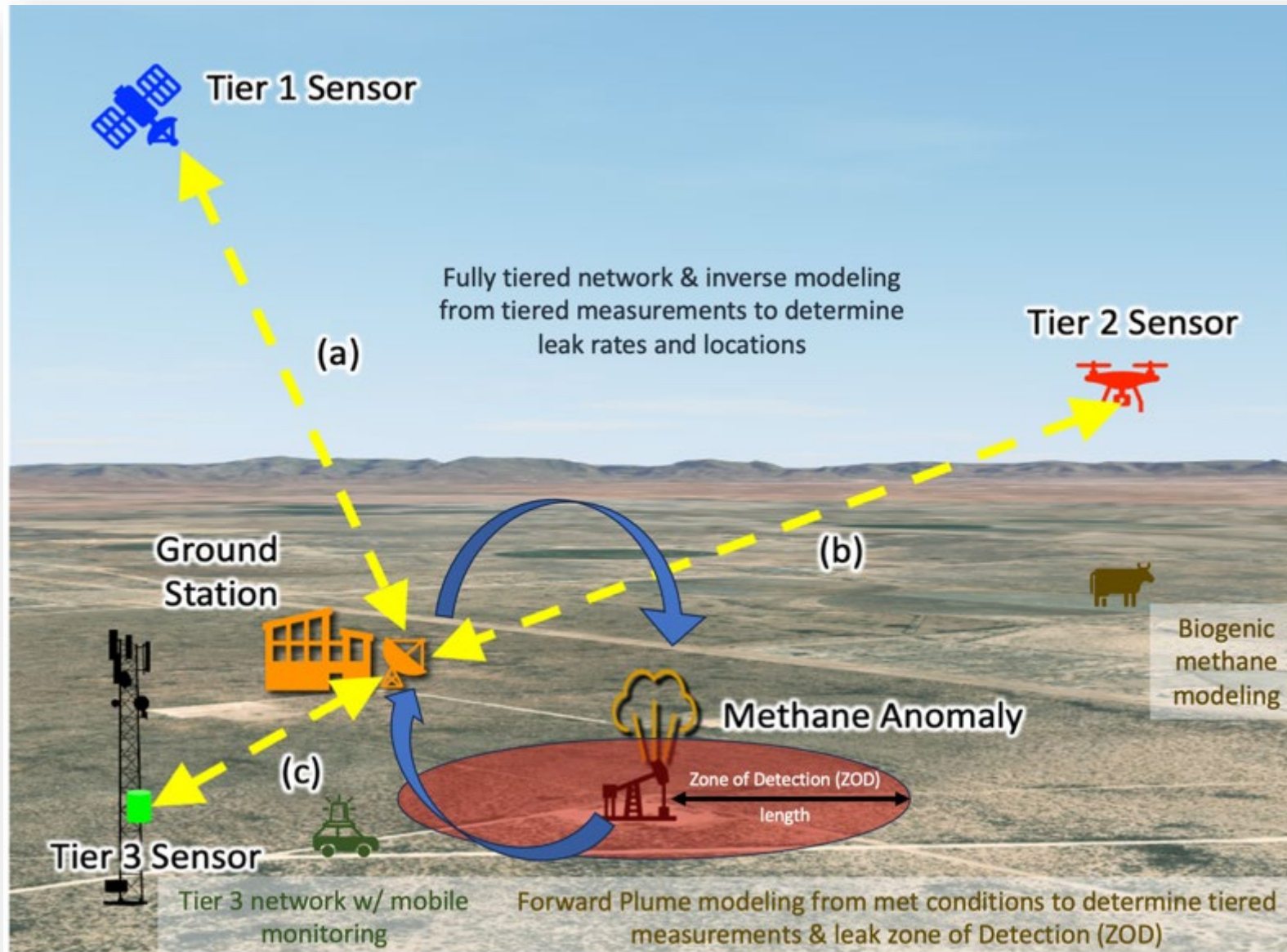
- Active sensors to fill monitoring gaps



42-km long sensor comprising over 20,000 seafloor measurement points

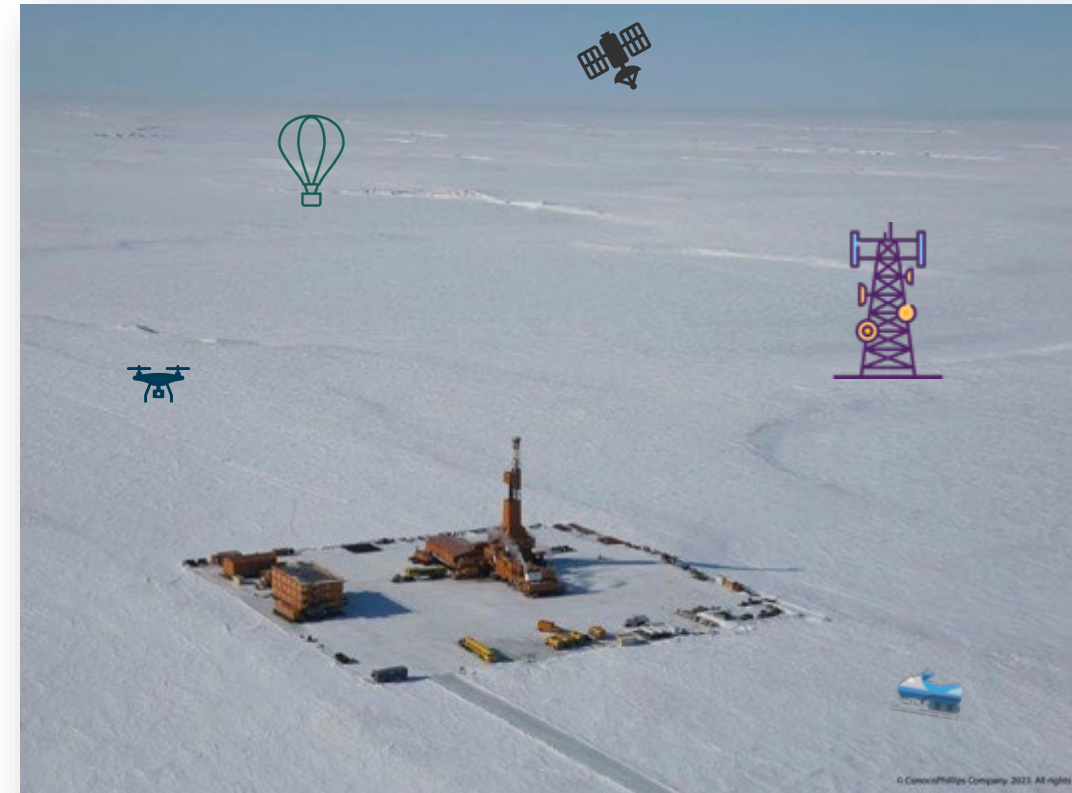
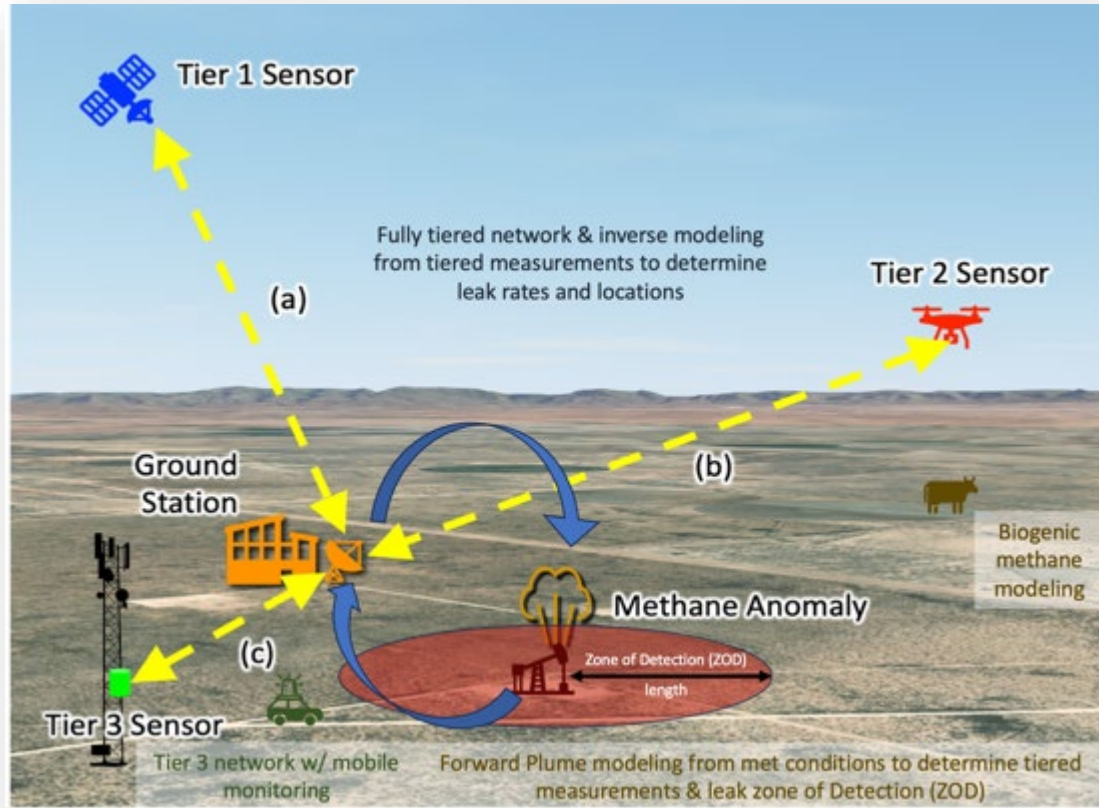


TIERED METHANE MONITORING SYSTEM DESIGN





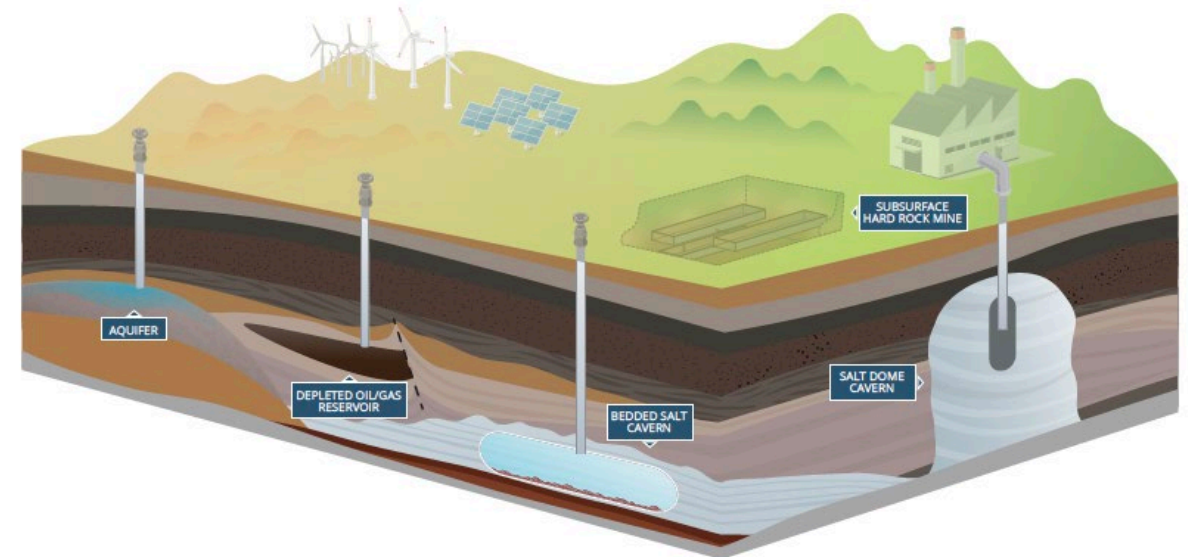
BASIN -> ARCTIC FRAMEWORK COMPARISON





GEOLOGIC HYDROGEN IN ALASKA

- We are in discussions with research partners in Alaska about the potential to use geologic hydrogen to accelerate decarbonization.
- Practical issues like leasing, permitting, standards are not developed.
- Many technical issues need to be addressed and better understood to develop H₂ resources
- Leveraging established capabilities at Sandia including:
 - Subsurface storage, detection, downhole monitoring
 - Grid integration
 - Hydrogen Fuel Cells
 - Materials issues
 - Systems perspectives and analysis

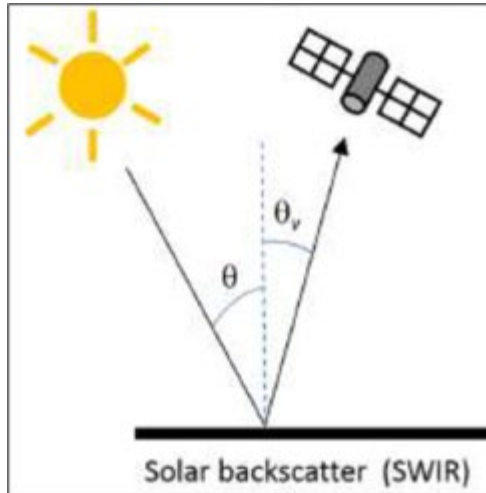


EXTRA SLIDES

ACTIVE SENSORS WOULD FILL IMPORTANT SENSING & CALIBRATION GAPS

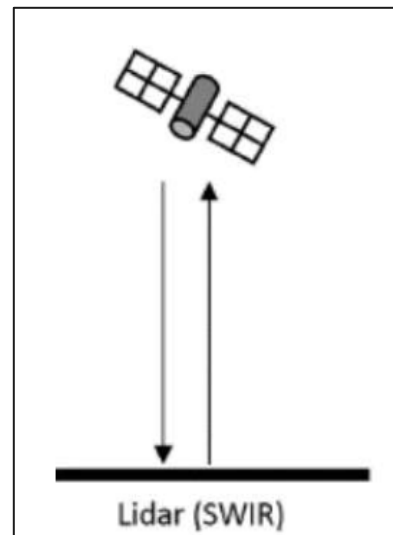


Space-based LiDAR for Arctic methane measurements

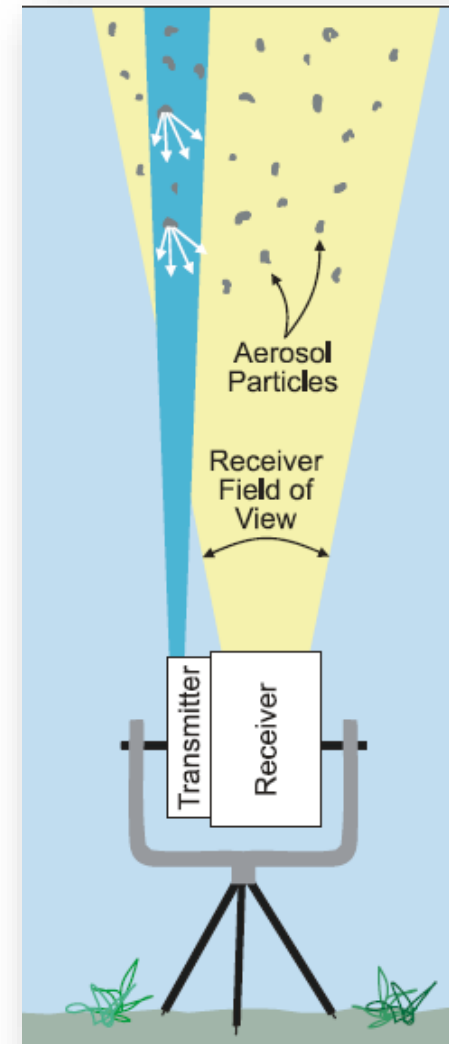


Passive sensing using solar reflectance spectroscopy requires sunlight and often doesn't work over water

LiDAR deployed on a satellite in a highly inclined, highly elliptical orbit could provide year-round methane measurements

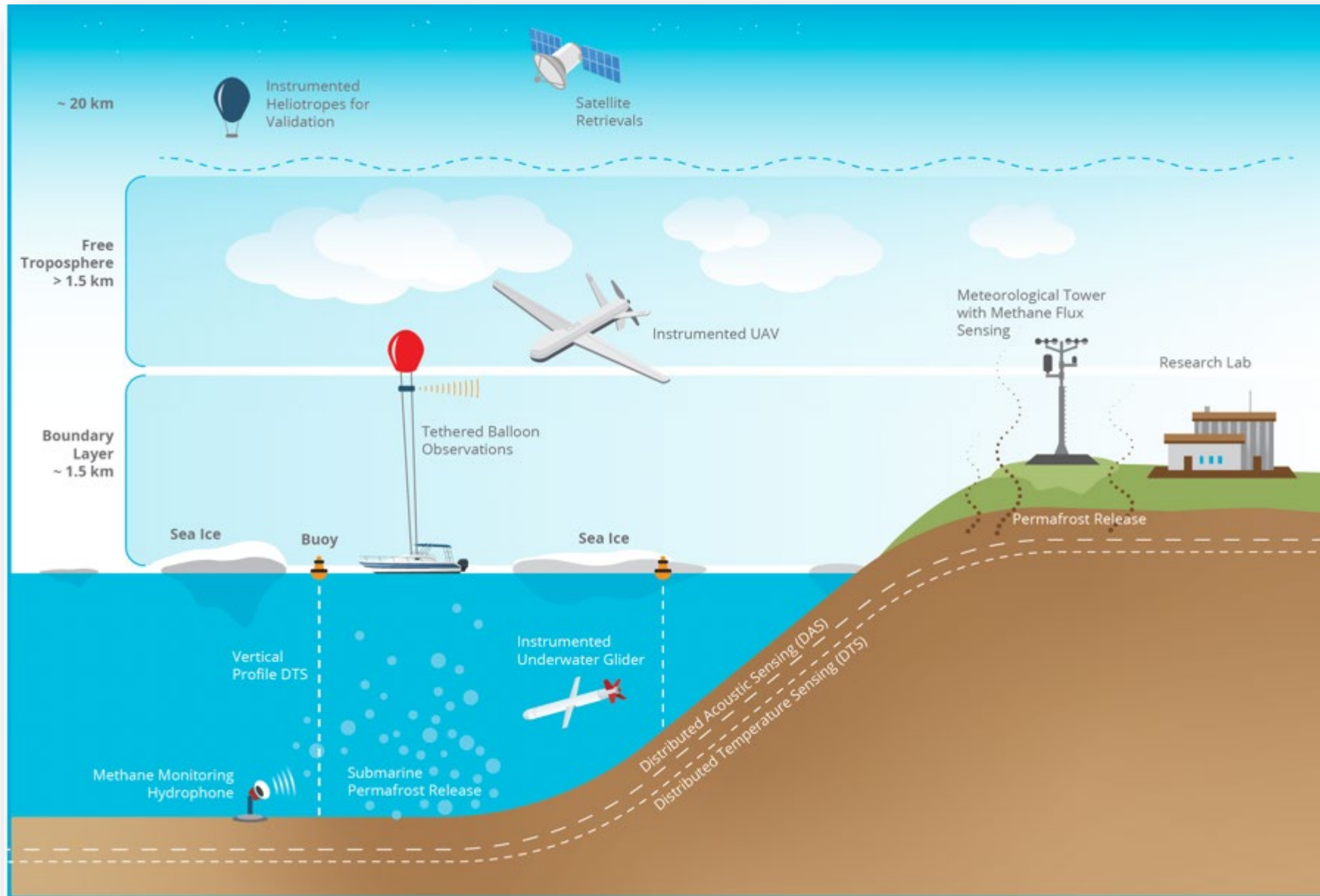


A "Rosetta Stone": Ground-based LiDAR system for sensor calibration



UNM's LiDAR system

VISION FOR INTEGRATED METHANE MONITORING SYSTEM



QUESTIONS?



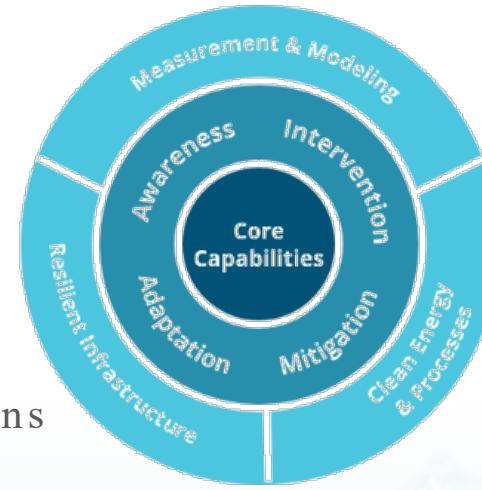
SANDIA'S ARCTIC STRATEGY

Advance science and security

- Climate measurements, modeling, and impact analysis
- Greenhouse gas monitoring
- Domain awareness and resilient military systems

Accelerate clean energy transitions

- Renewables for harsh environments and polar applications
- Justice40 technology demonstrations and deployments



Arctic expertise for broad climate & national security applications



MEASUREMENT & MODELING

CLEAN ENERGY & PROCESSES

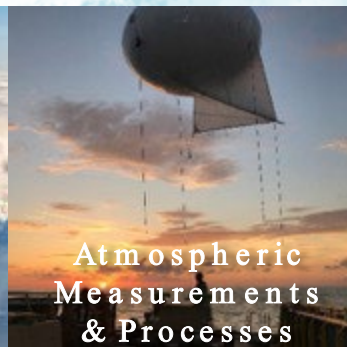
RESILIENT INFRASTRUCTURE



Arctic Facilities & Tech Evaluation



High-Resolution Cloud Modeling



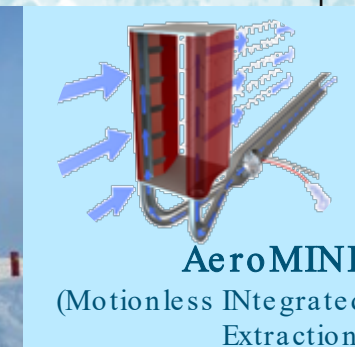
Atmospheric Measurements & Processes



Permafrost & Coastal Erosion



Bifacial PV



AeroMINE (Motionless INtegrated Extraction)



Levelock Microgrid Project

ADVANCE ARCTIC SCIENCE & SECURITY

- 26 Years of climate measurement on Arctic Coast
- Greenhouse gas and thawing permafrost assessments
- Computer modeling of ice sheets and coastal erosion
- Distributed acoustic sensing in Arctic Ocean
- Energy transitions for Alaska native villages
- Search and rescue drills with the US Coast Guard
- Down South — Airborne SAR to detect crevasses in landing area in Antarctica



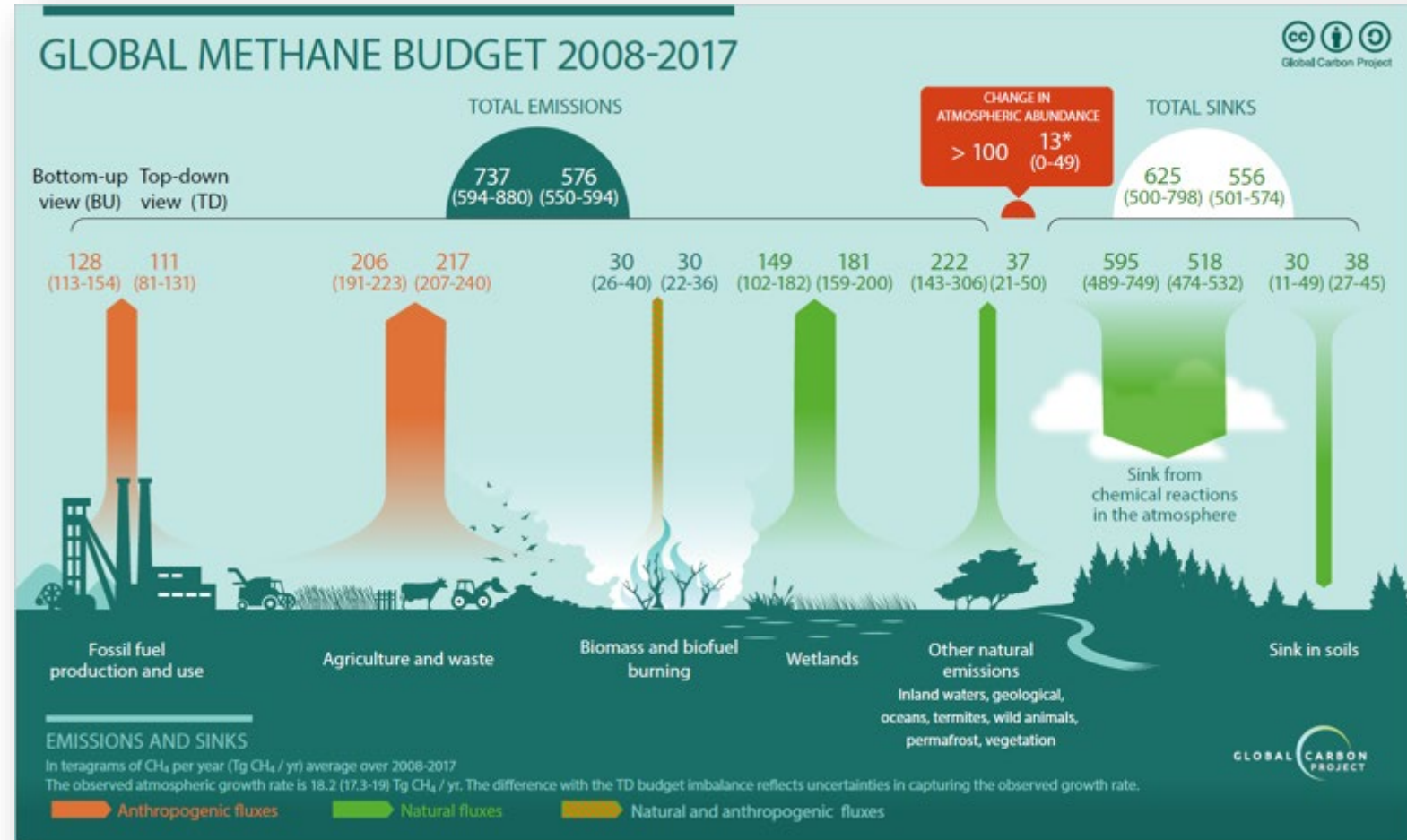


METHANE EMISSIONS

Global Methane Budget

- **60% anthropogenic sources:** largest emitters energy sector and waste management
- **40% natural sources:** fresh waters, geologic seepage, wild animals, termites, wild fires, permafrost and vegetation
- **Regional Variation:** Anthropogenic and natural variation complicates the assessment

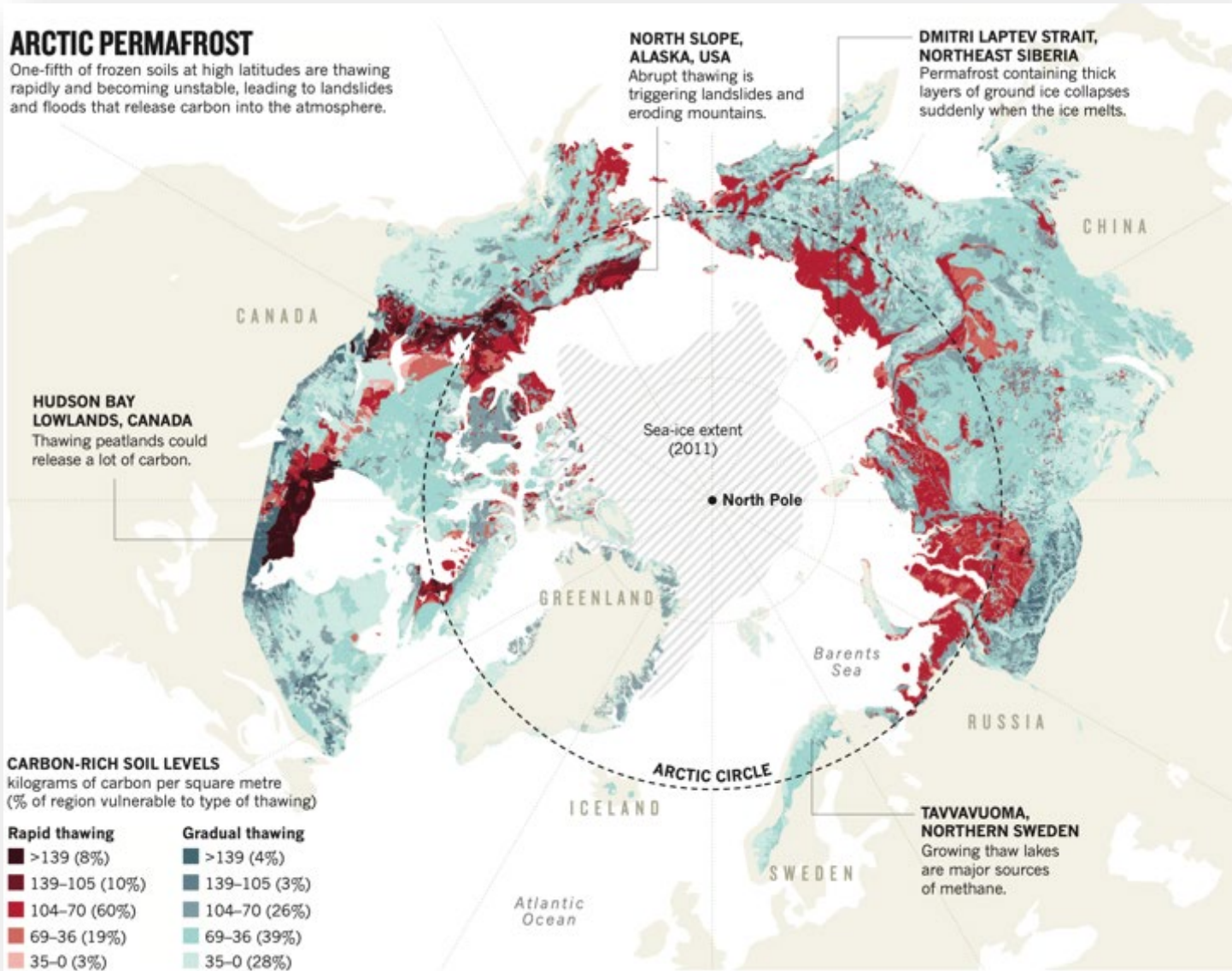
Top Down \neq Bottom Up



Source: [Global Carbon Project](https://www.globalcarbonproject.org/)

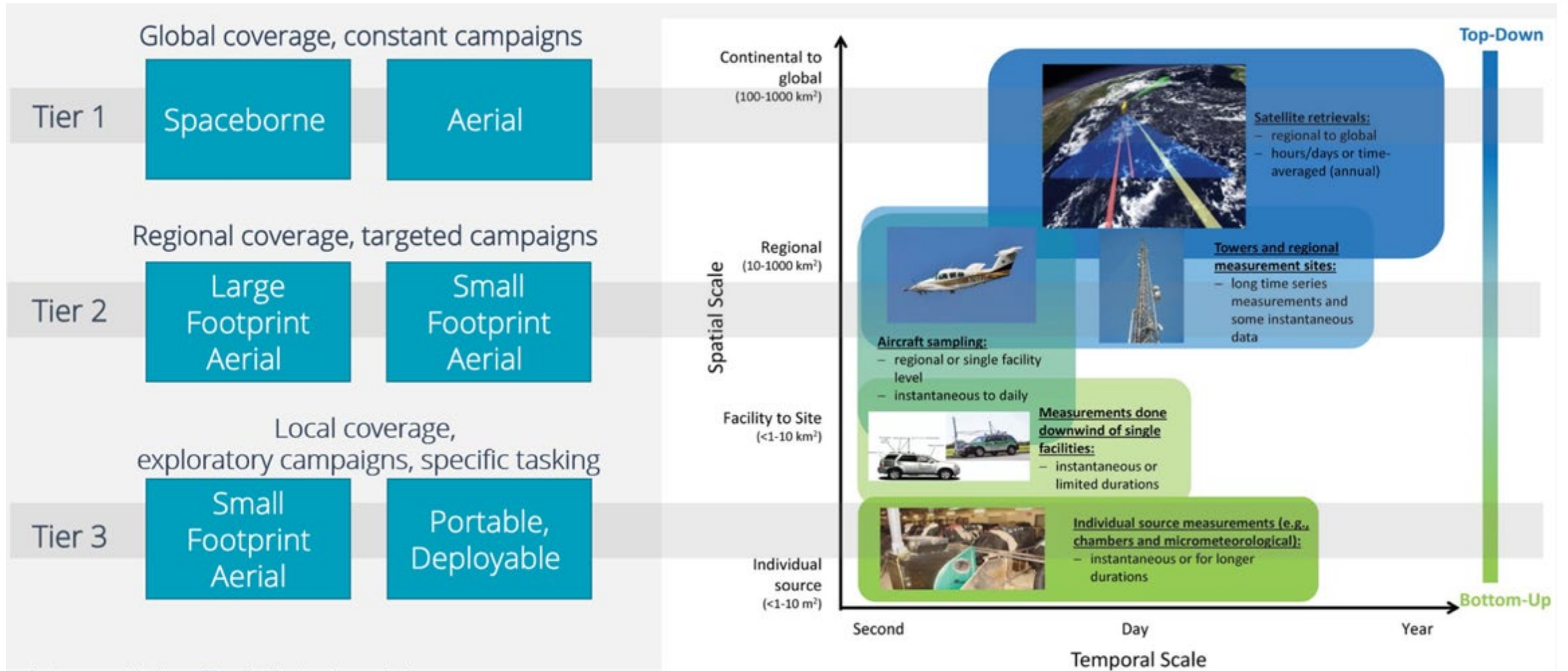


PERMAFROST THAW IS A MAJOR CLIMATE RISK





CURRENT METHANE DETECTION TECHNOLOGY FALLS SHORT



U.S. National Academies of Sciences, Engineering, and Medicine, 2018