VTRC
Virginia Transportation Research Council

We bring innovation to transportation.

Monitoring of I-77 Slopes Using Satellite Remote Sensing

17th Forum – Geohazards Impacting Transportation in the Appalachian Region
August 15-17, 2017 – Blacksburg, Virginia

Edward Hoppe

Acknowledgements

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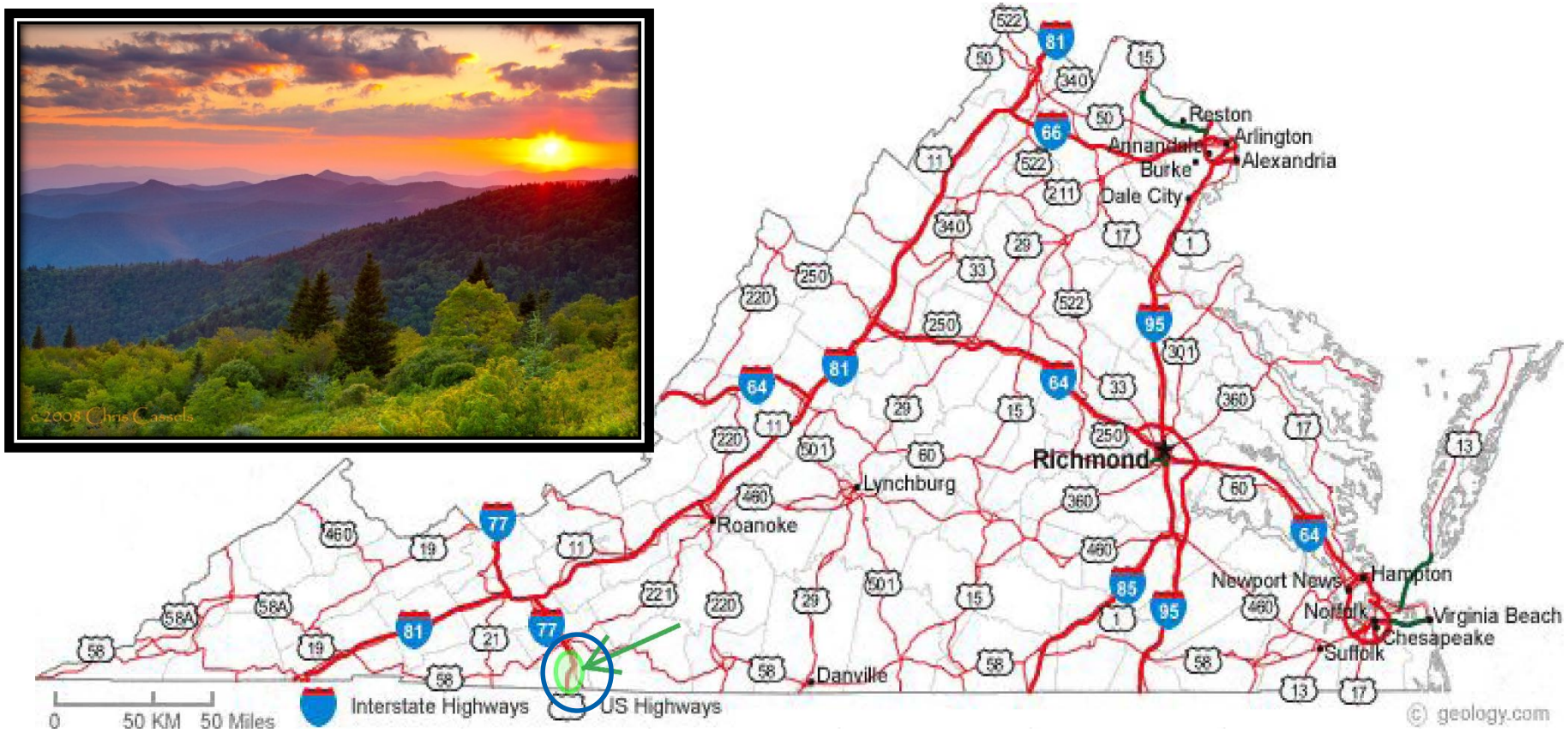
I-77 Site Location



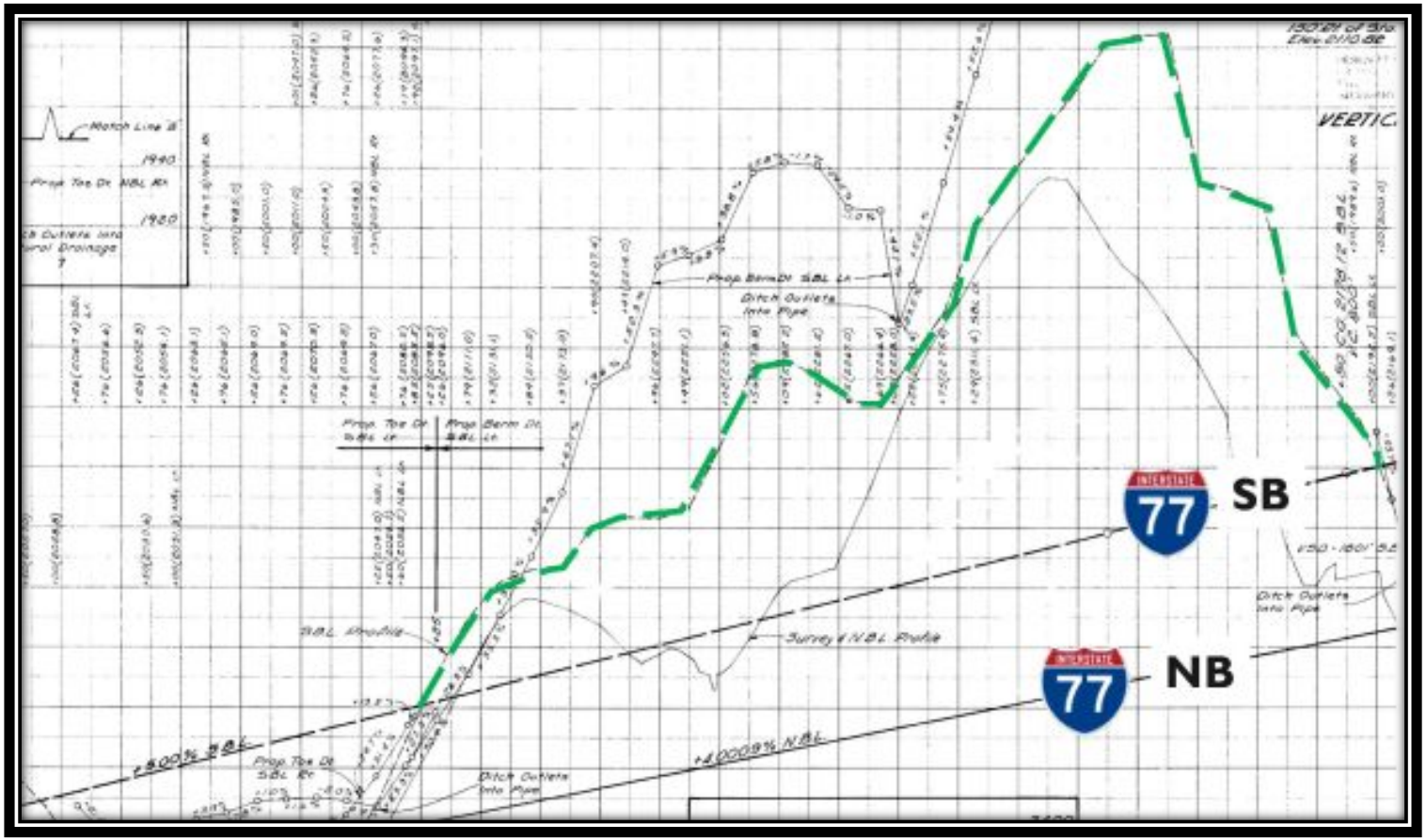
Carroll County

I-77 Corridor Challenges - Traffic

ADT
18,000 NB
18,000 SB

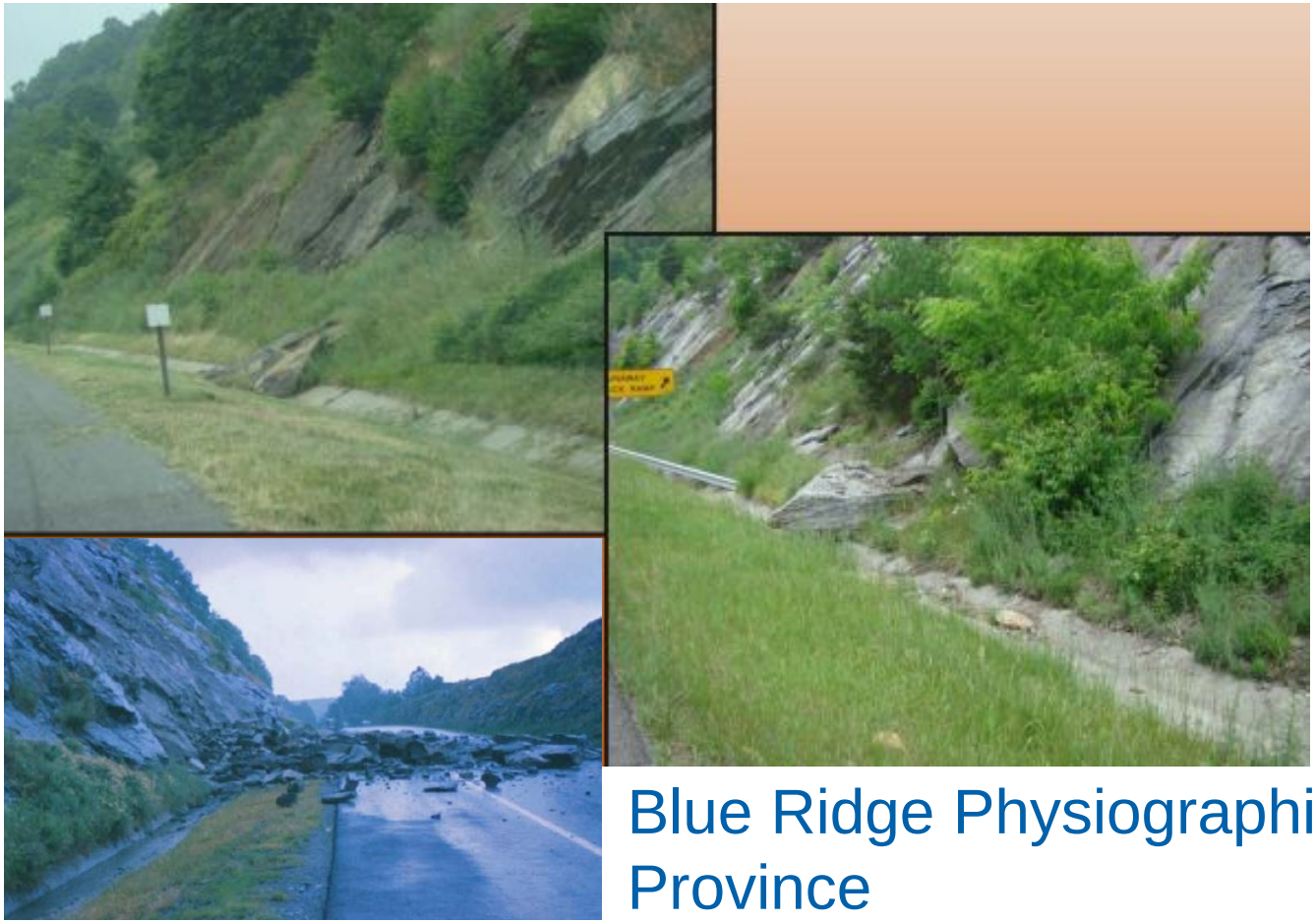
% Trucks
21% NB
27% SB

I-77 Corridor Challenges – Steep Grades



I-77 Corridor Challenges – Fog

I-77 Corridor Challenges – Rockfalls

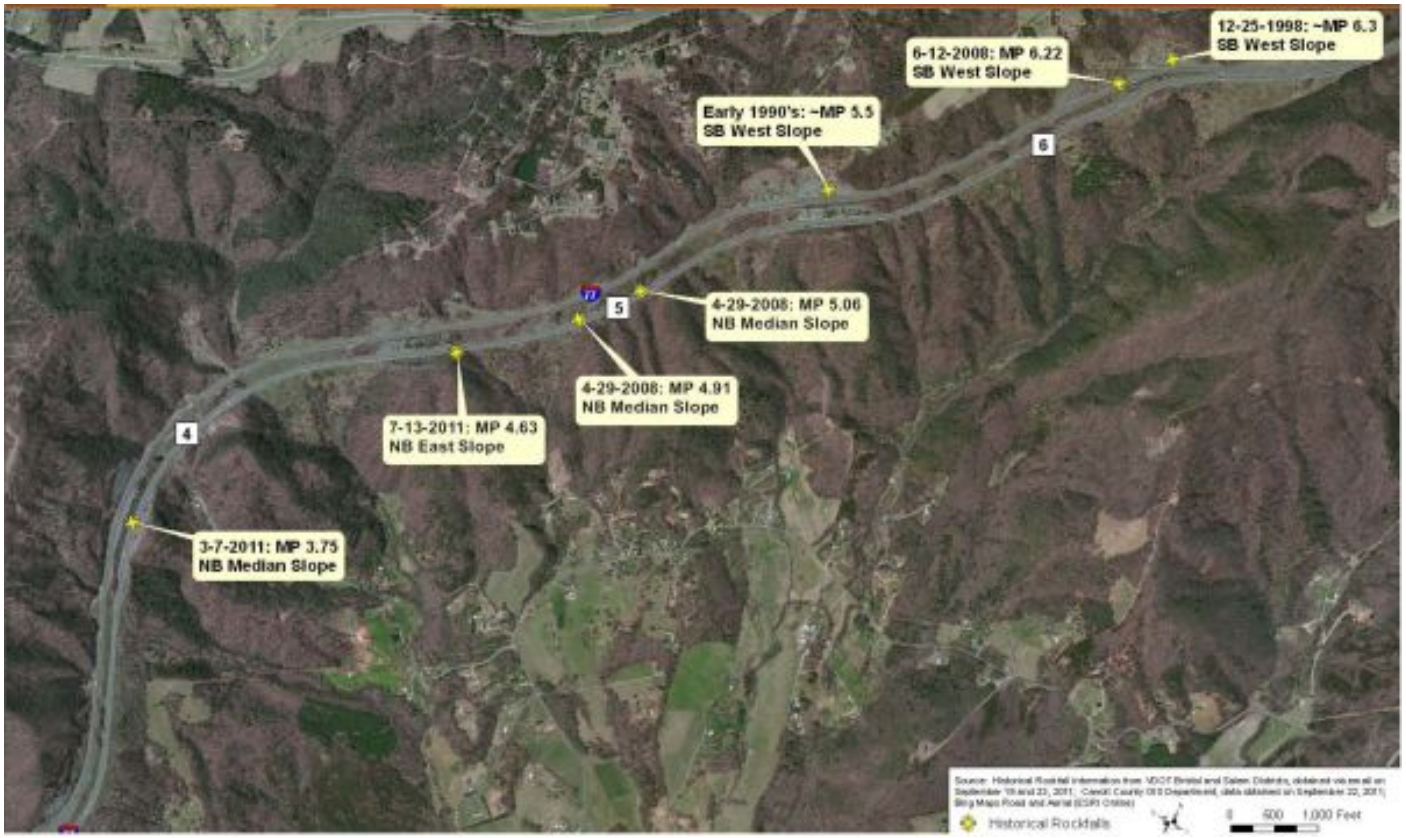


Blue Ridge Physiographic Province

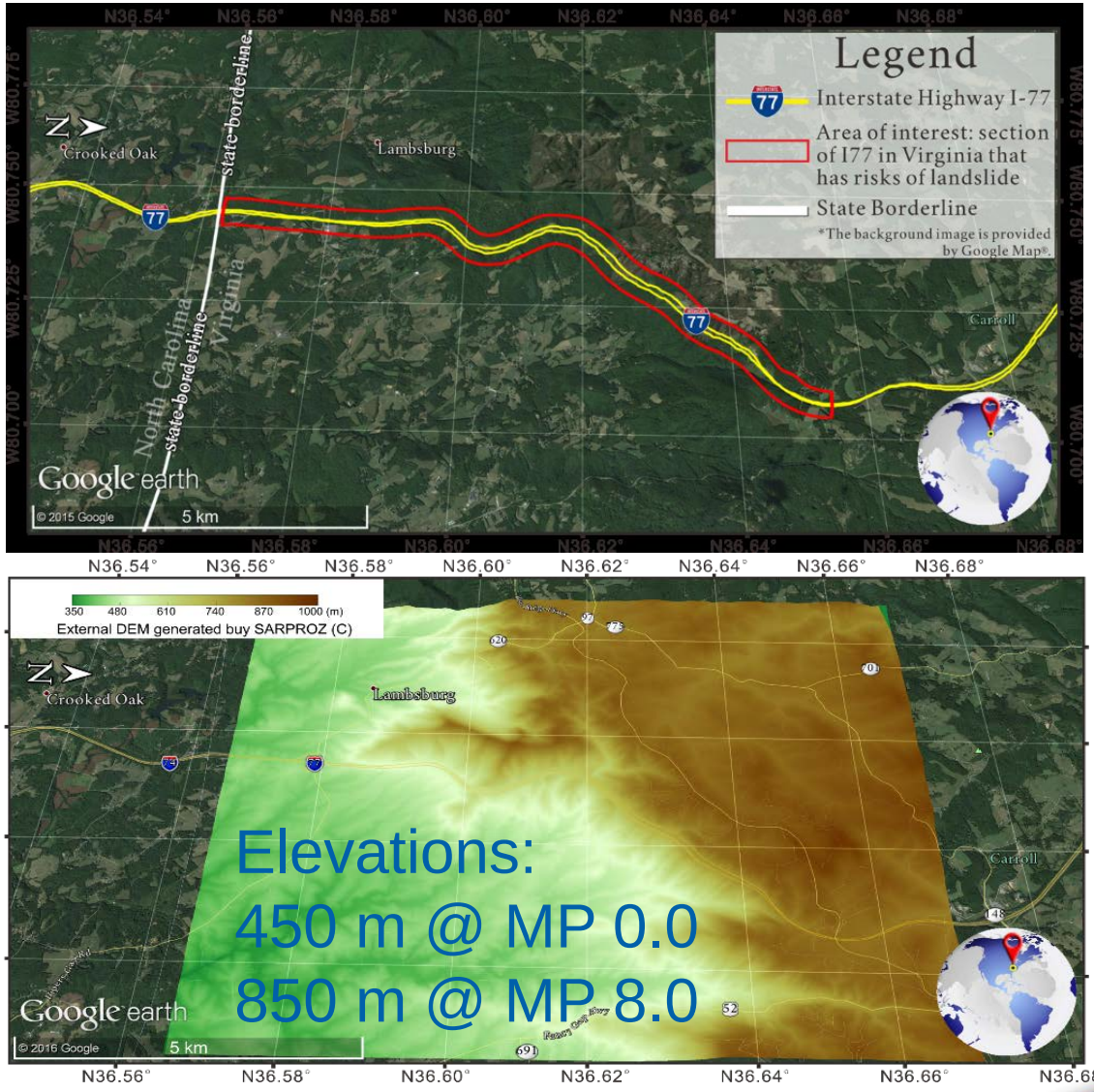
Slope angles: 0.25:1 to 1:1

Principal rock type: metagraywacke

I-77 Rockfall History

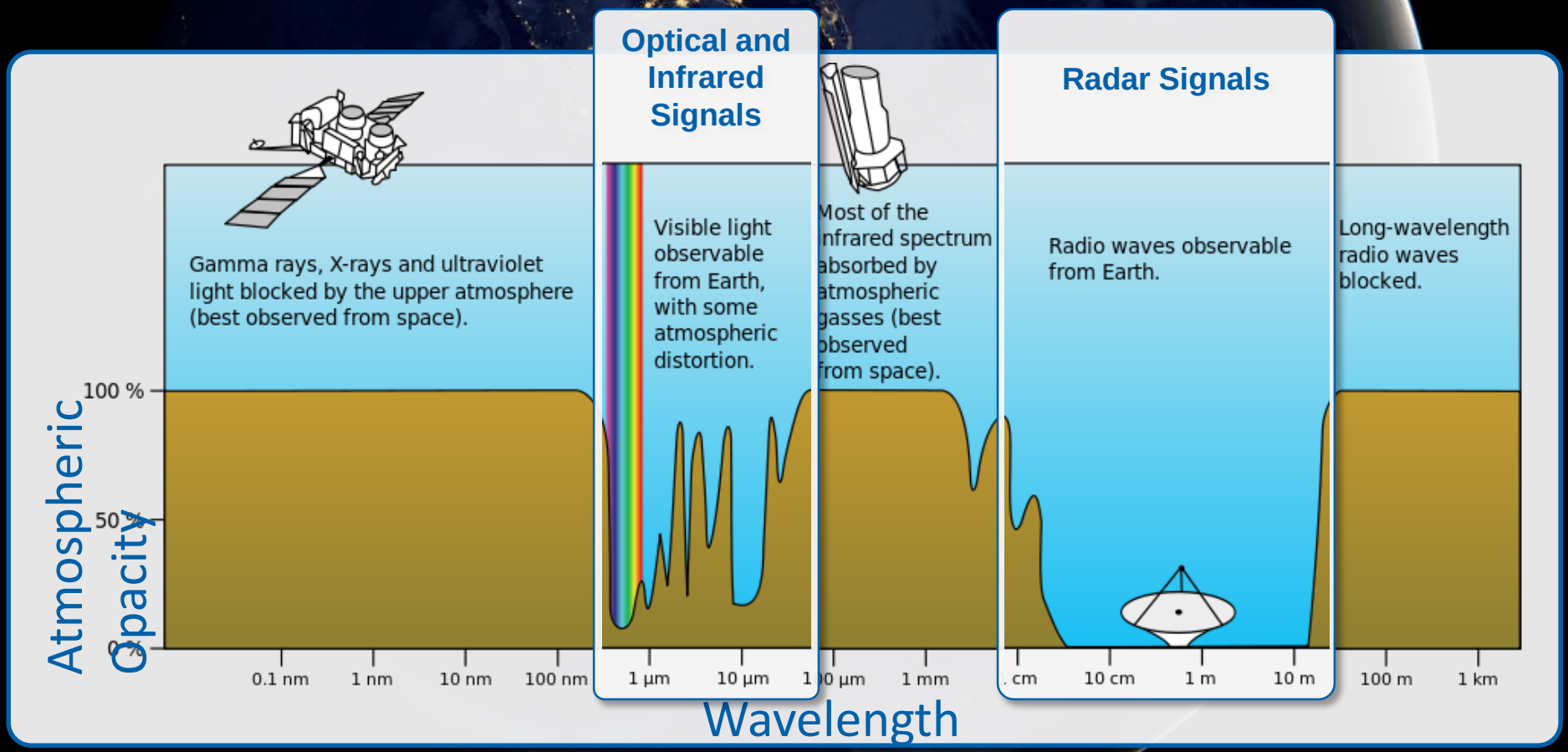


Area of Interest



The Benefits of Radar Sensors For Change Detection

- **Radar has excellent capabilities for routine global change monitoring**
  - **24/7 imaging capabilities:** due to weather and illumination independence
  - **Advanced change detection performance**: due to stable image geometry and own signal source
  - **Complementary to optical sensors**: provides independent information about surface

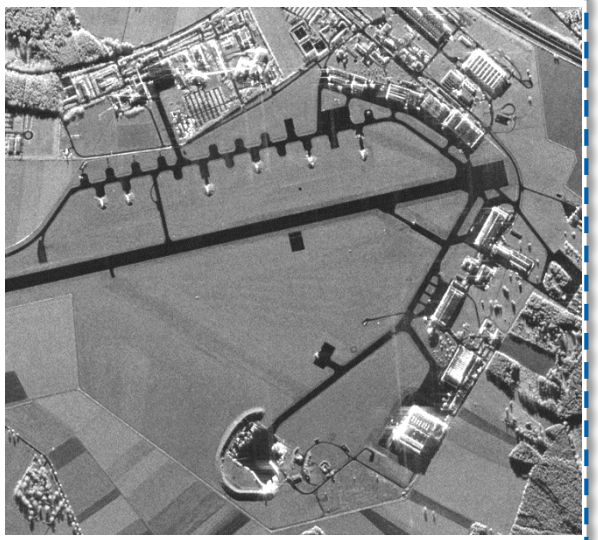


NASA Earth Observatory images by Robert Simmon, using Suomi NPP VIIRS data from Chris Elvidge (NOAA National Geophysical Data Center)

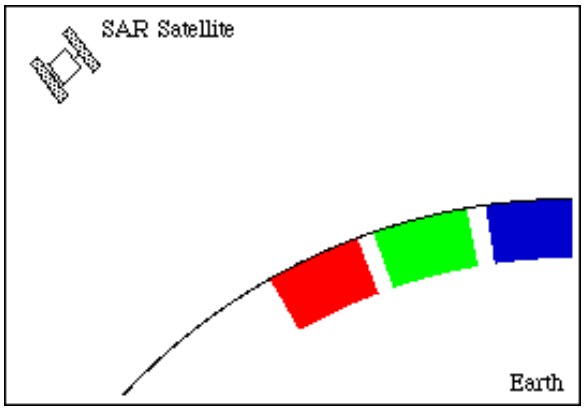
Radar – Amplitude and Phase

With every radar acquisition, we record both Amplitude and Phase of the reflected polarized microwave signals

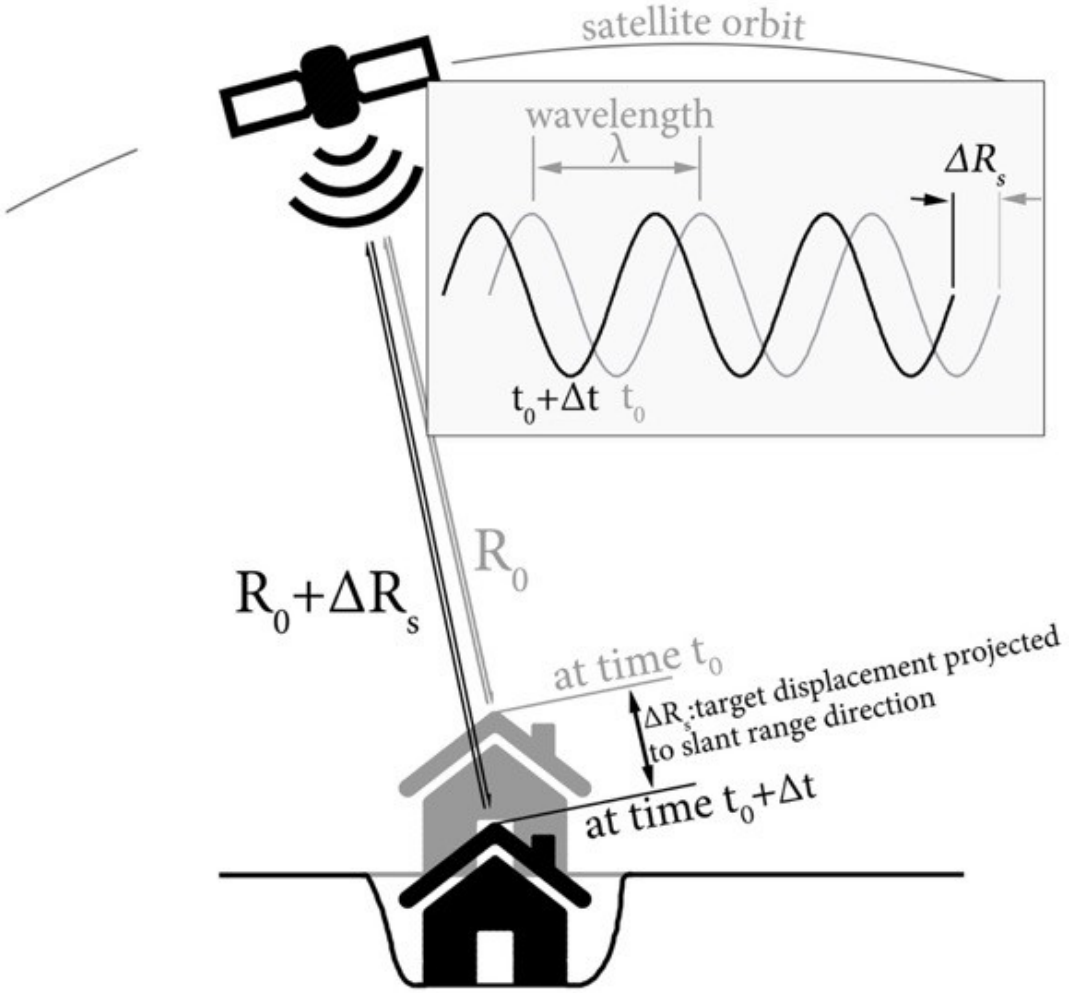
Amplitude forms SAR Image



Phase measures the range to objects on ground

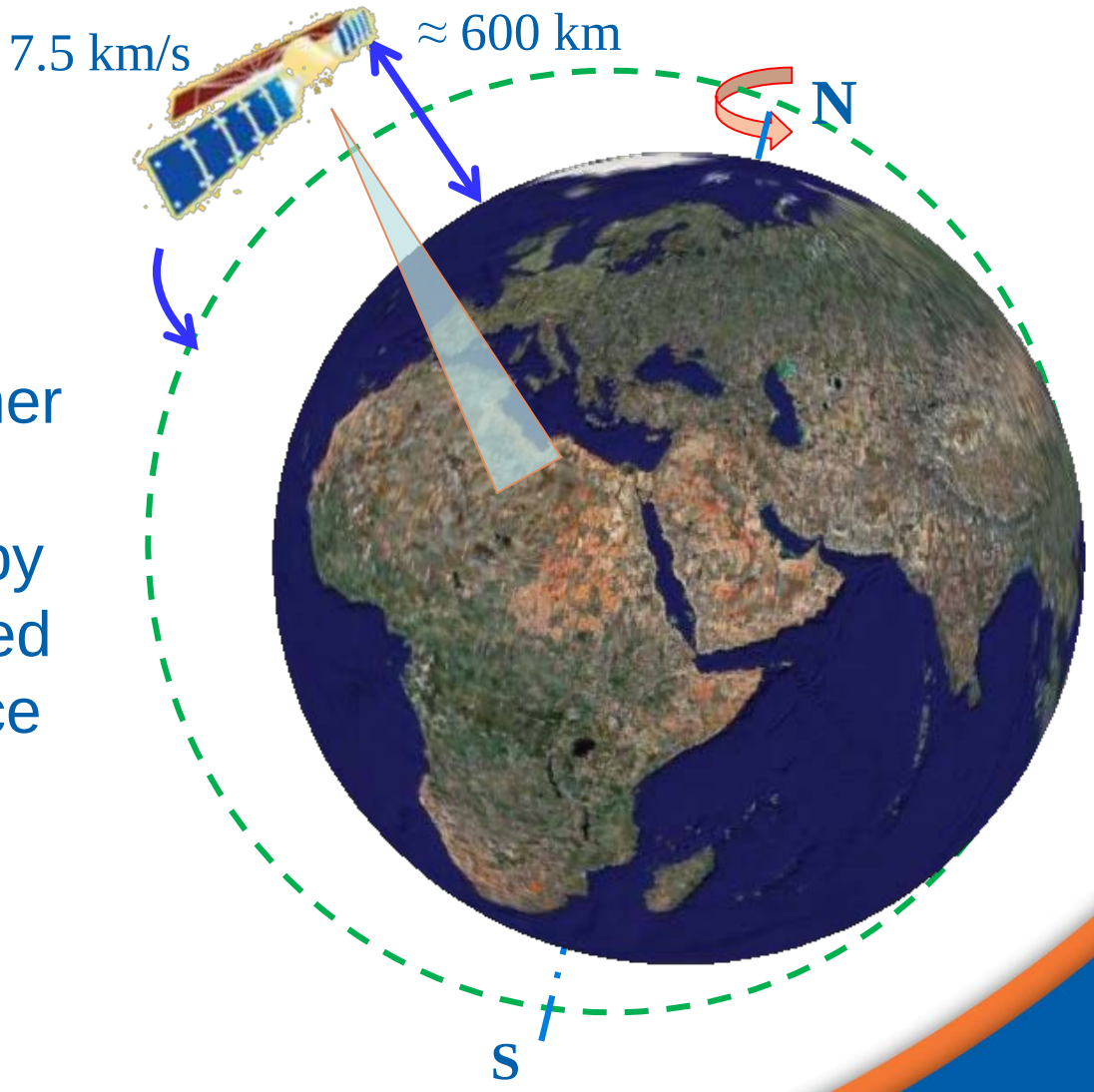


Satellite Radar Remote Sensing



Remote Sensing with Radar Satellite

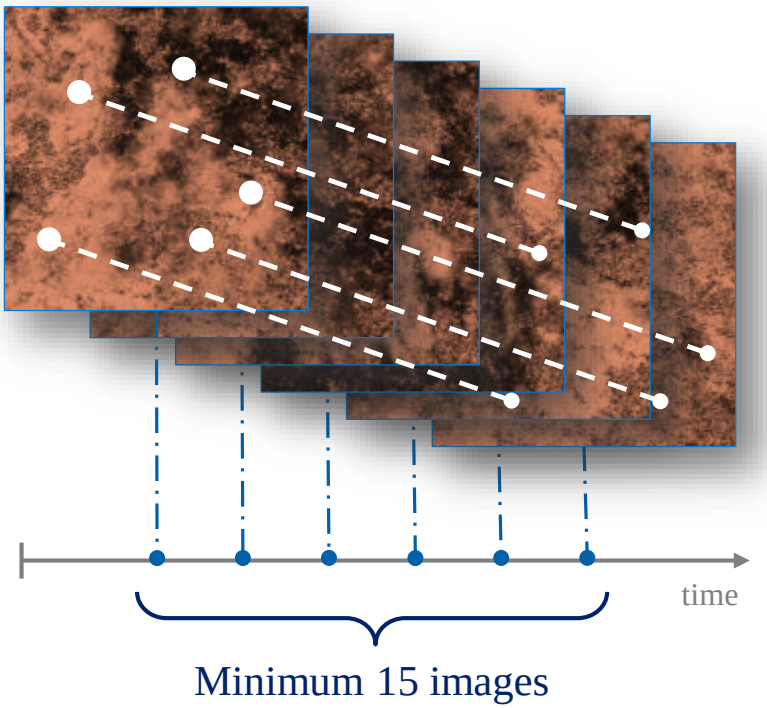
- Active system, not affected by solar illumination or weather
- Images are formed by radar signals reflected off the Earth's surface
- Millimeter accuracy



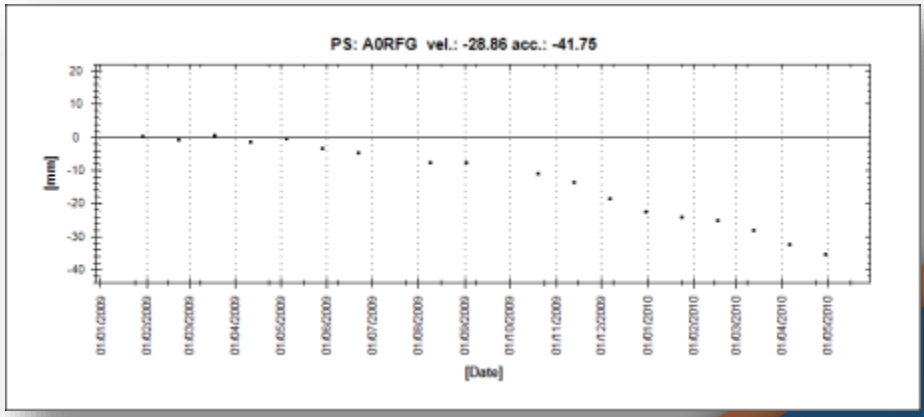
Scanning the Earth

InSAR – Interferometric Synthetic Aperture Radar
Multi-Interferogram Techniques

Principle: Image Stacking



- Identifies coherent points in every image
- Measurements have mm accuracy
- Produce time series of deformation



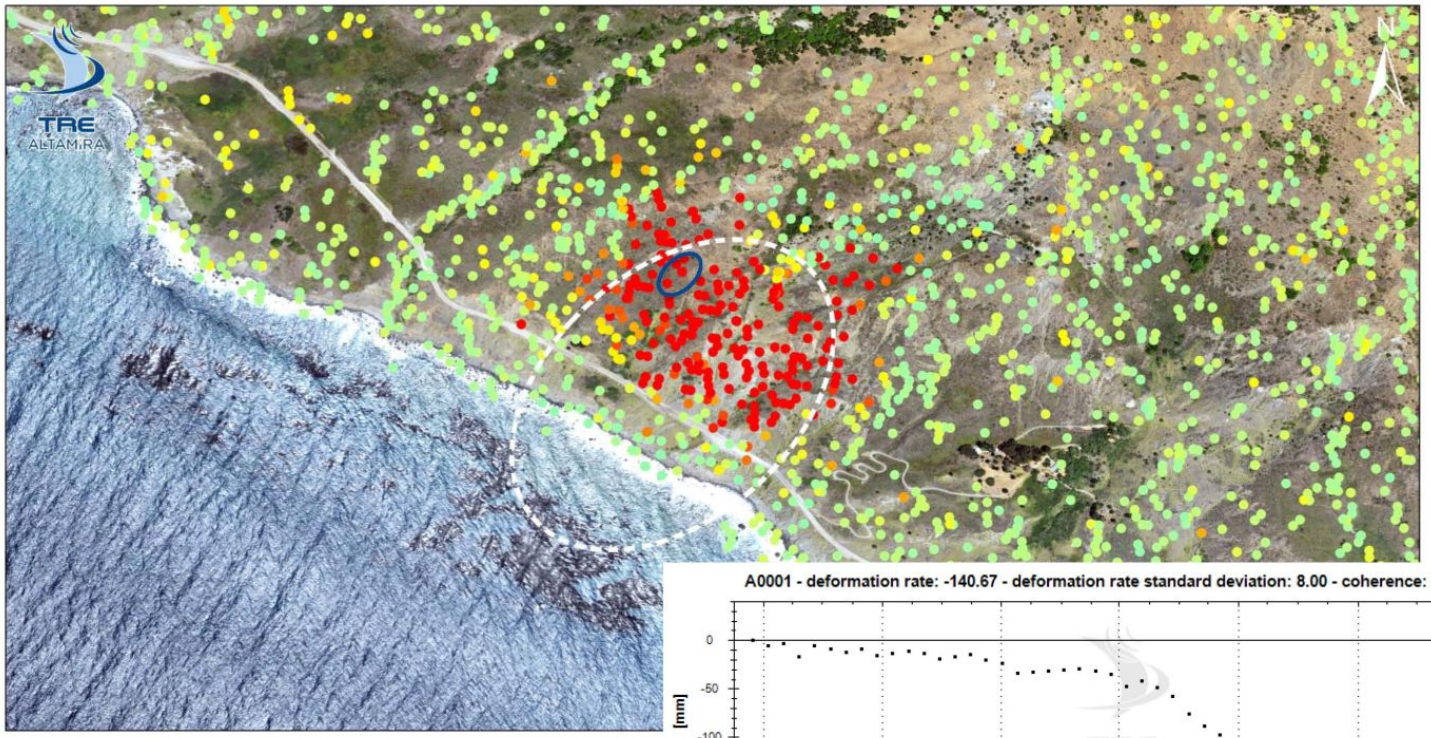
SAR vs LiDAR

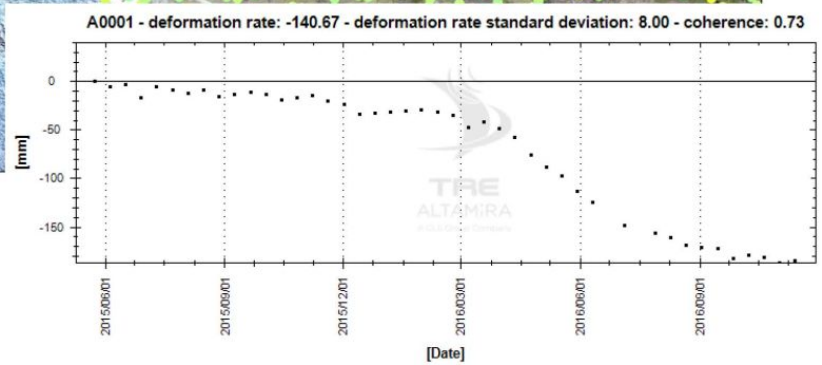
- Millimeter vs centimeter precision in displacement monitoring
- Regular acquisition schedule, typically every 8-14 days
- No field work required
- Works in all weather conditions
- Access to historical data – look back in time
- Point density much higher for LiDAR

Big Sur Landslide – Highway 1 at Mud Creek, Monterey County, California

More than 5 million cubic yards of soil and rock.
1,000 feet of highway affected.
(Civil Engineering, July/August 2017)

Big Sur Landslide – Highway 1, California





SqueeSAR™ Analysis

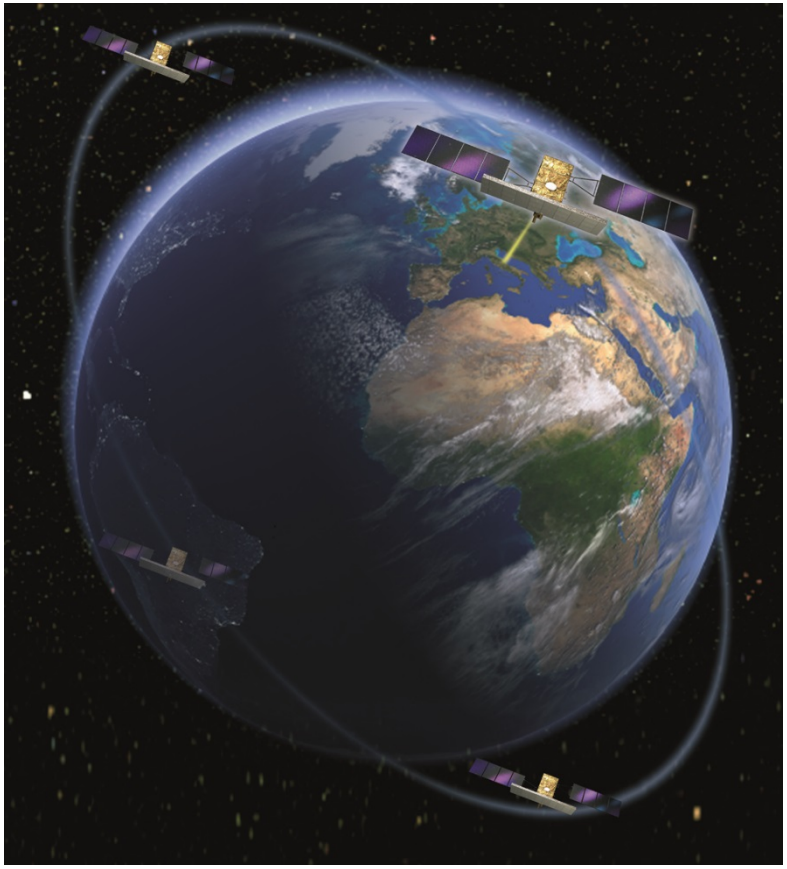
Big Sur (Mud Creek Slide)
California, USA
Displacement Rate

Satellite	Sentinel
Geometry	Descending
Track	T42
N. of Images	44
Date Range	24 May 2015 - 14 Nov 2016

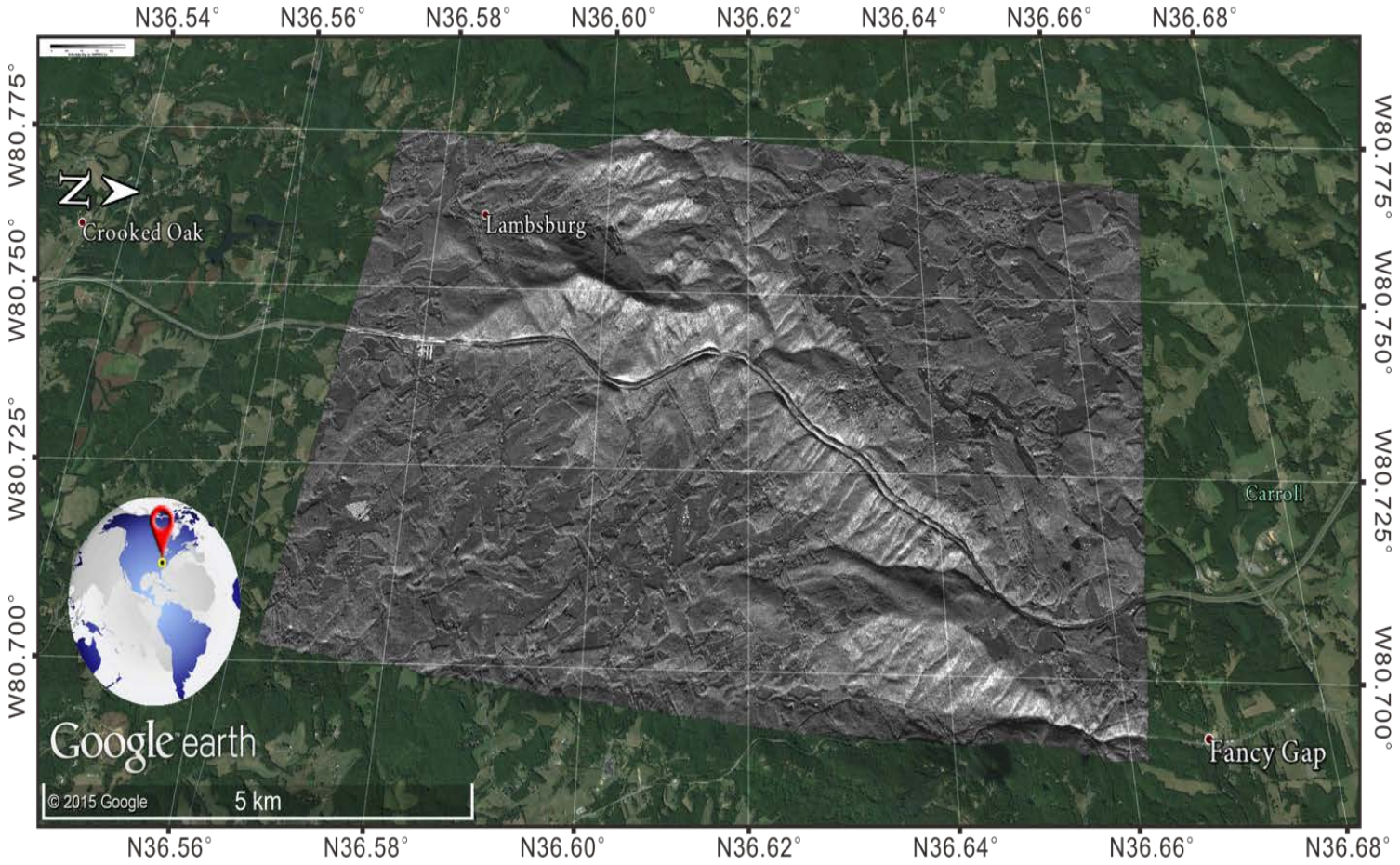
Sentinel radar data
processed by TRE Altamira

Remote Sensing of I-77 Using COSMO-SkyMed

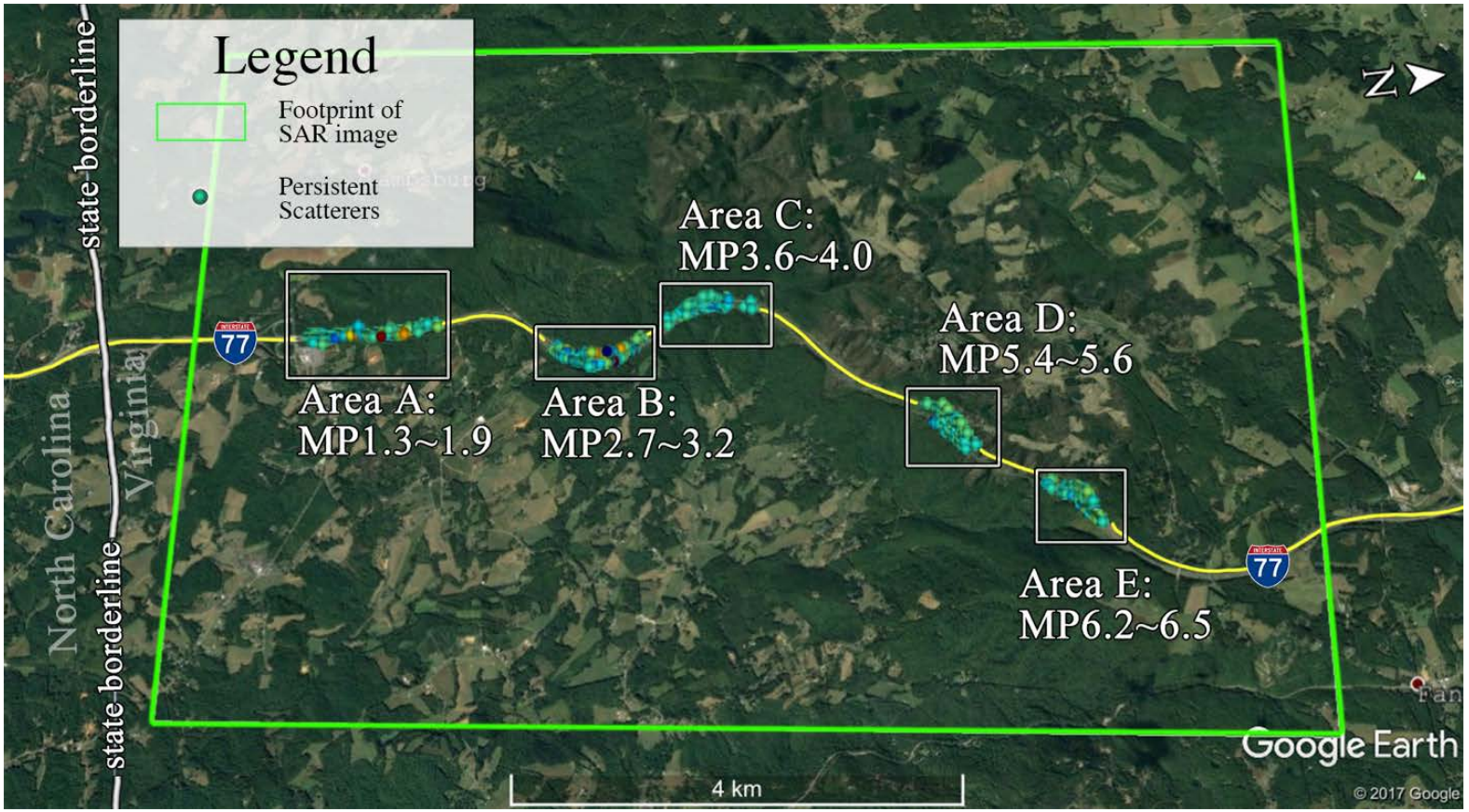
Band	Wavelength	Resolution	Orbit Pass	Incidence Angle
X	31mm	2m*2m	Descending	56.2°
Image No.	Start Date	End Date	Revisit Days	Time of Acquisition
52	11/04/2015	03/14/2017	8	17:59EST



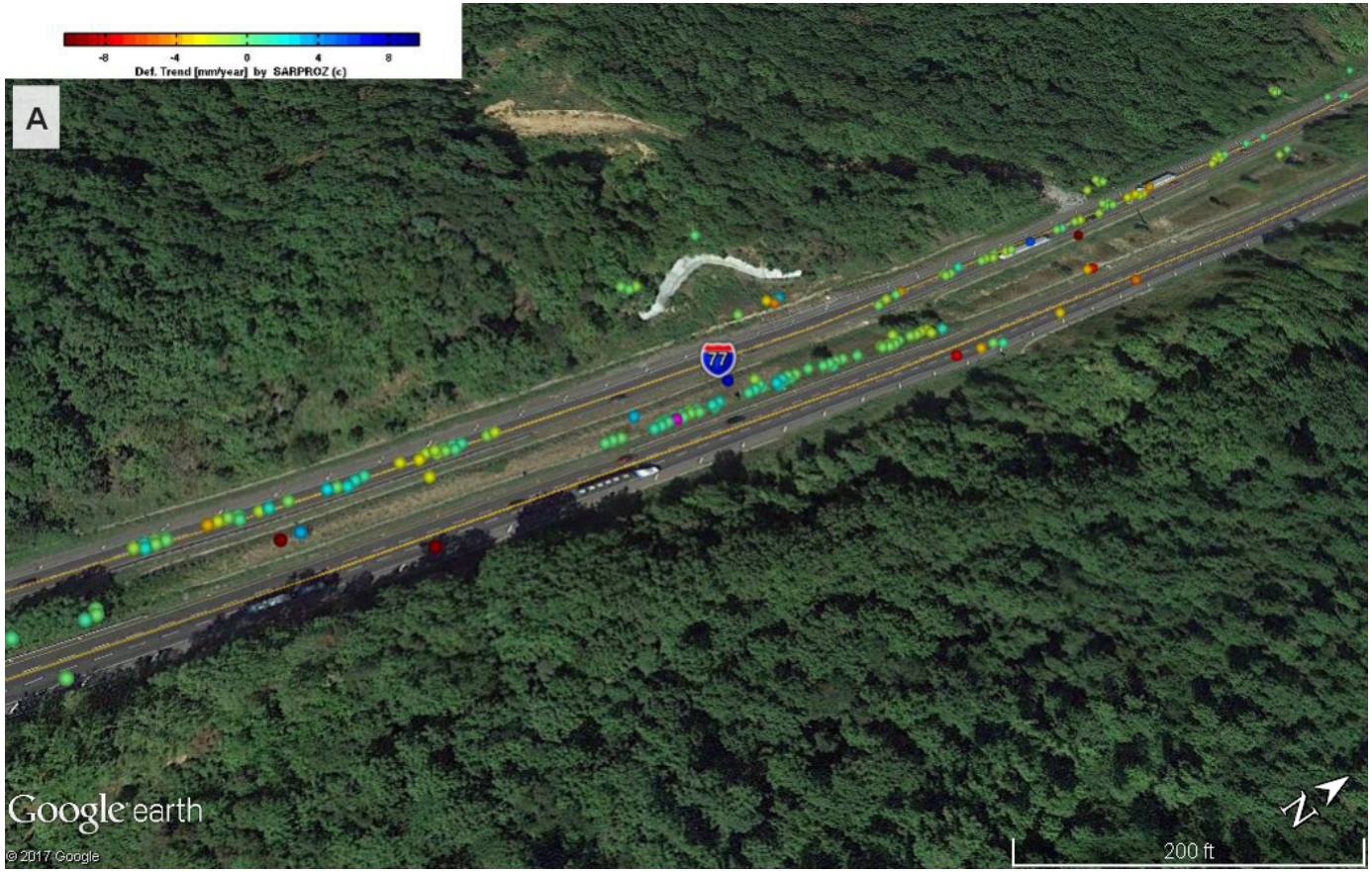
Reflectivity Map



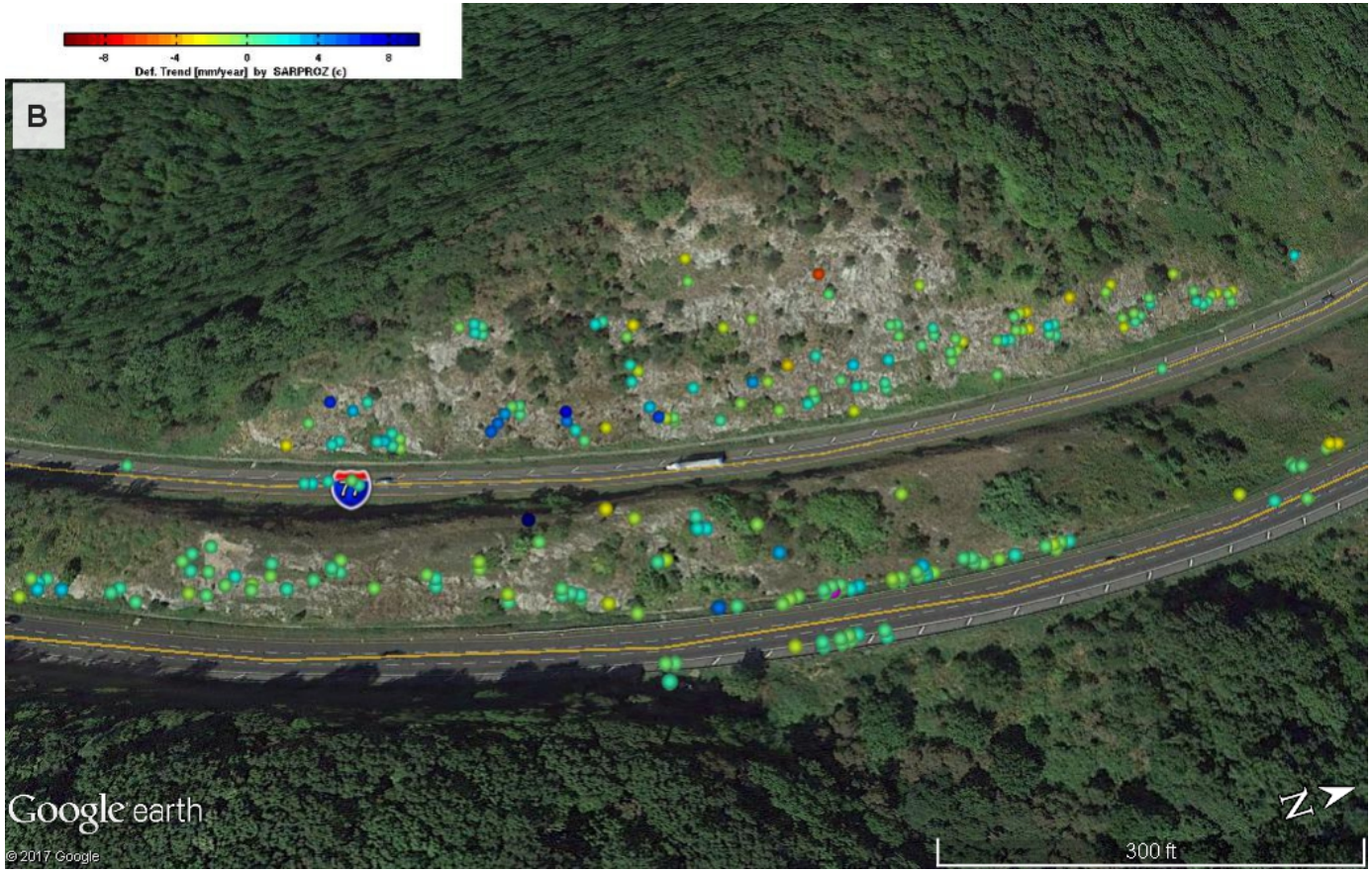
I-77 Study Area



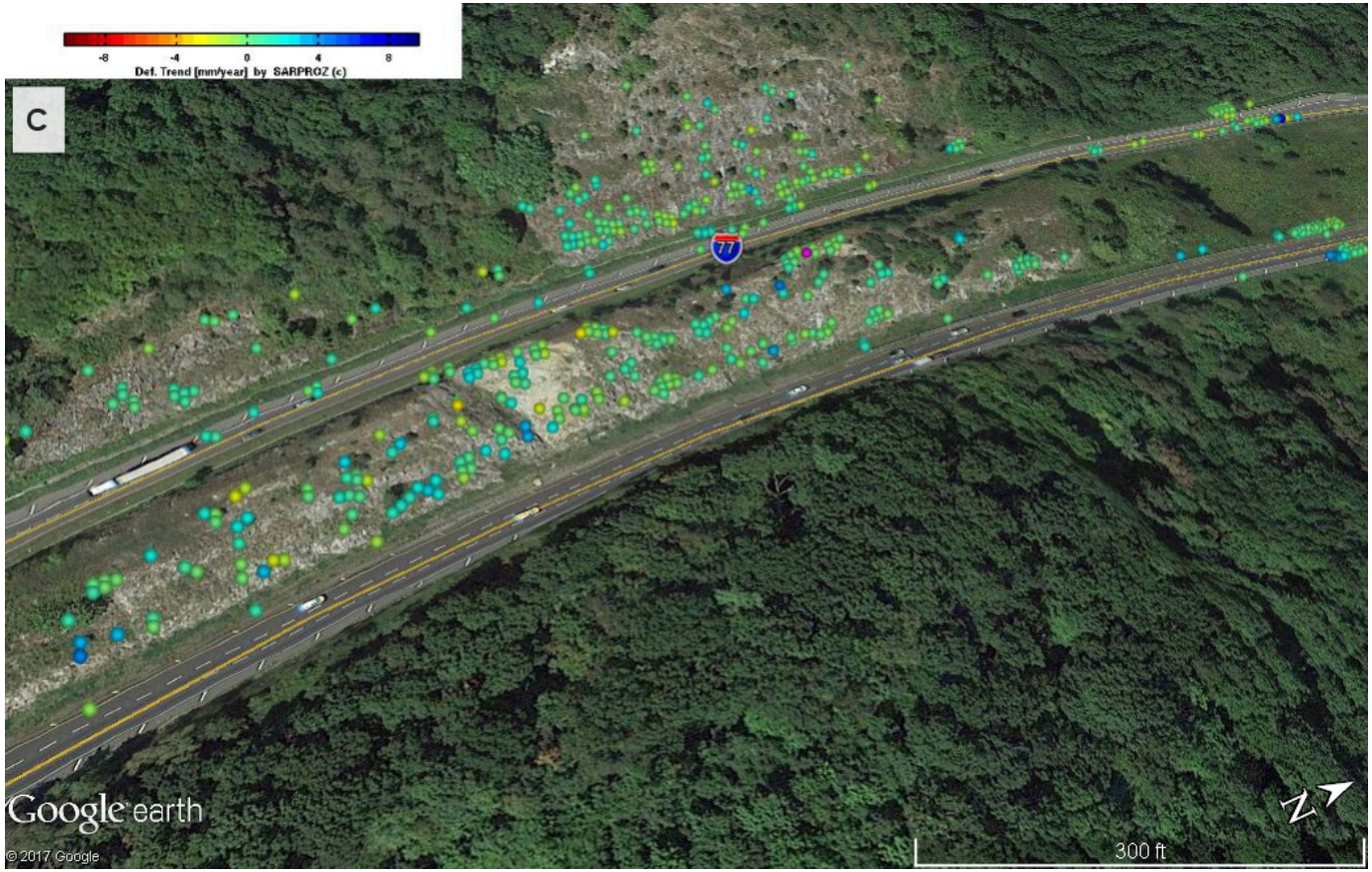
I-77 Area A


-8
-4
0
4
8
Def. Trend [mm/year] by SARPROZ (c)
A
77
Google earth
© 2017 Google
200 ft
N

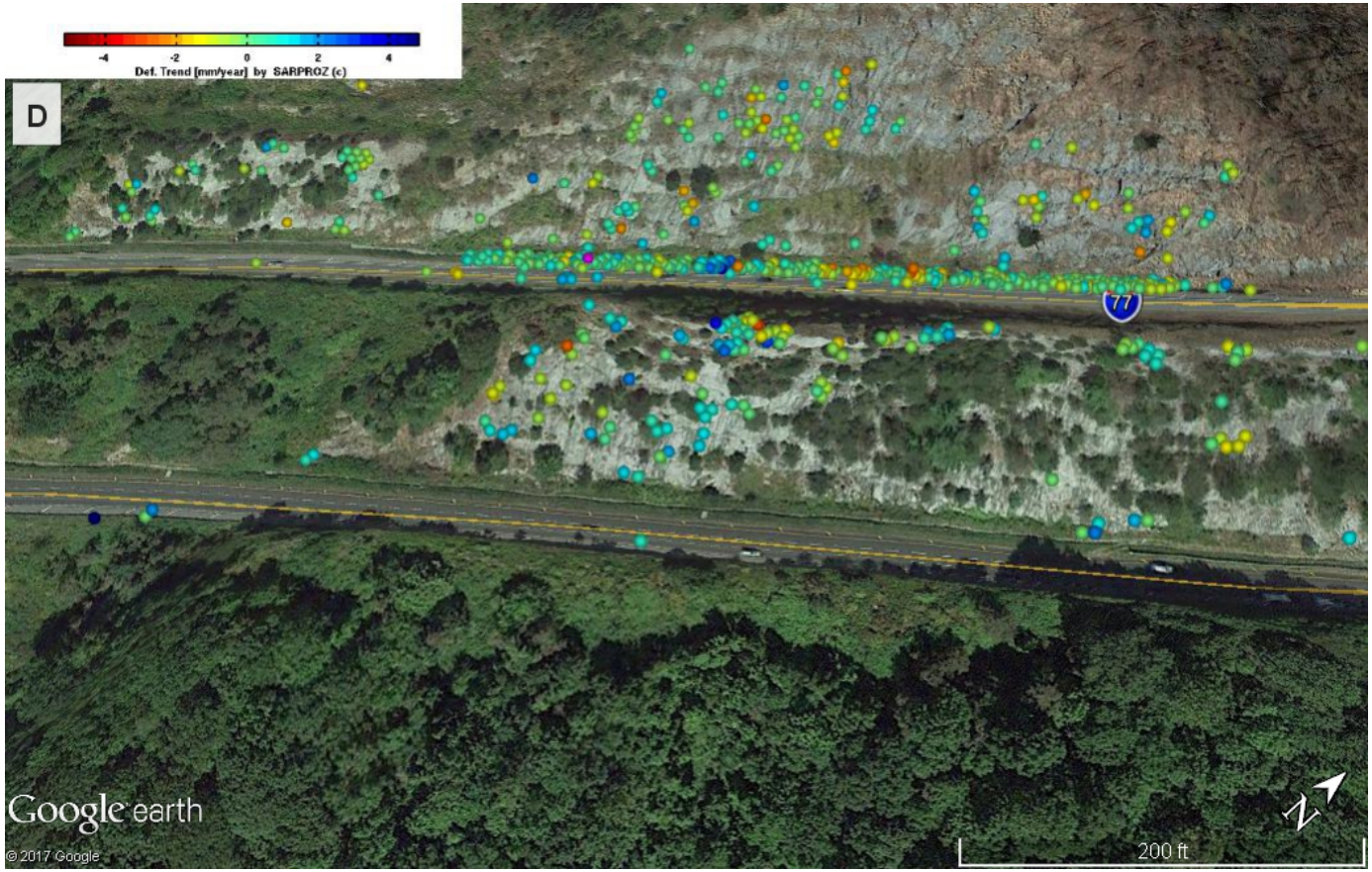
I-77 Area B


-8
-4
0
4
8
Def. Trend [mm/year] by SARPROZ (c)
B
Google earth
© 2017 Google
300 ft
N

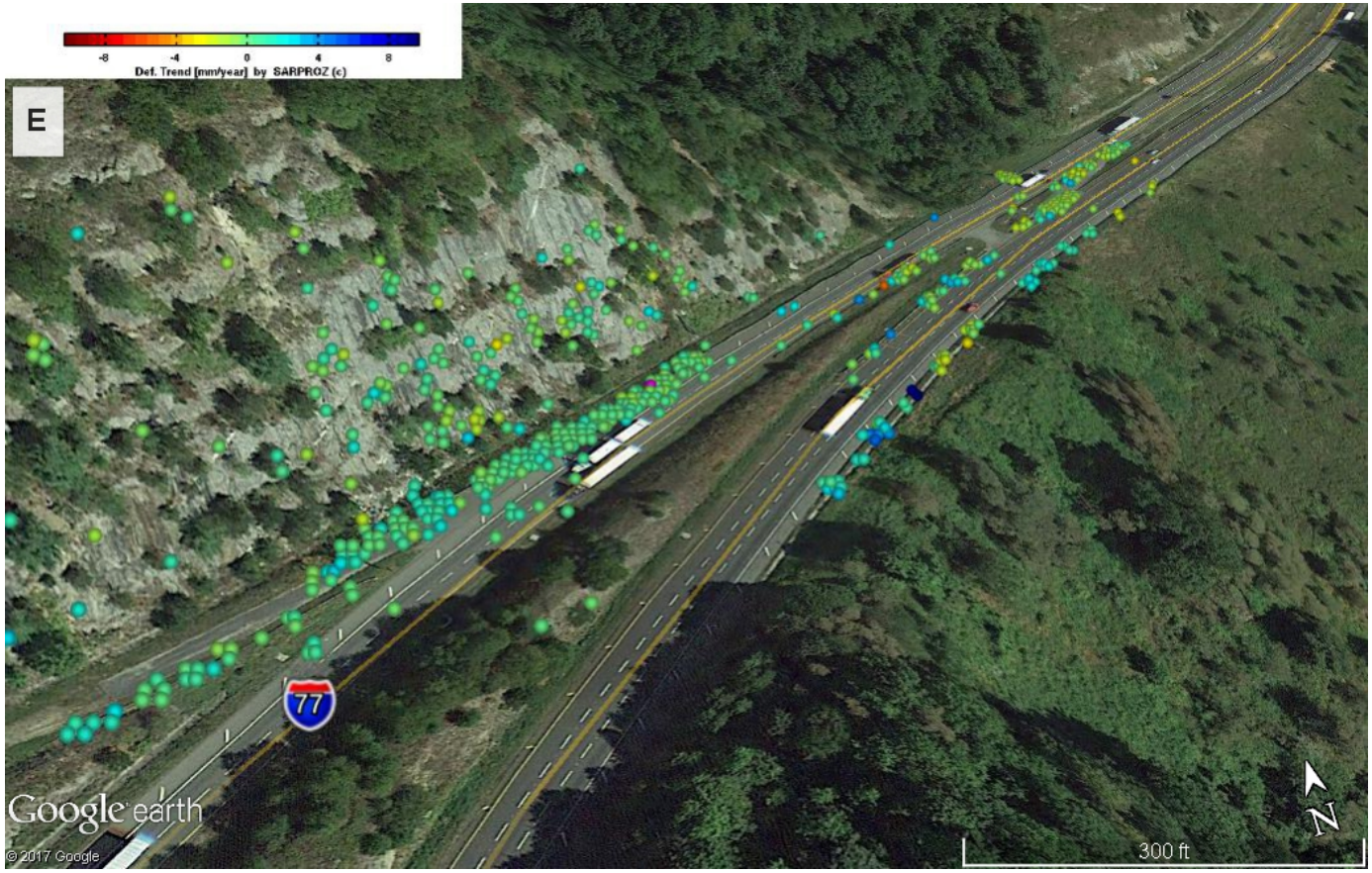
I-77 Area C


-8
-4
0
4
8
Def. Trend [mm/year] by SARPROZ (c)
C
77
Google earth
© 2017 Google
300 ft
N

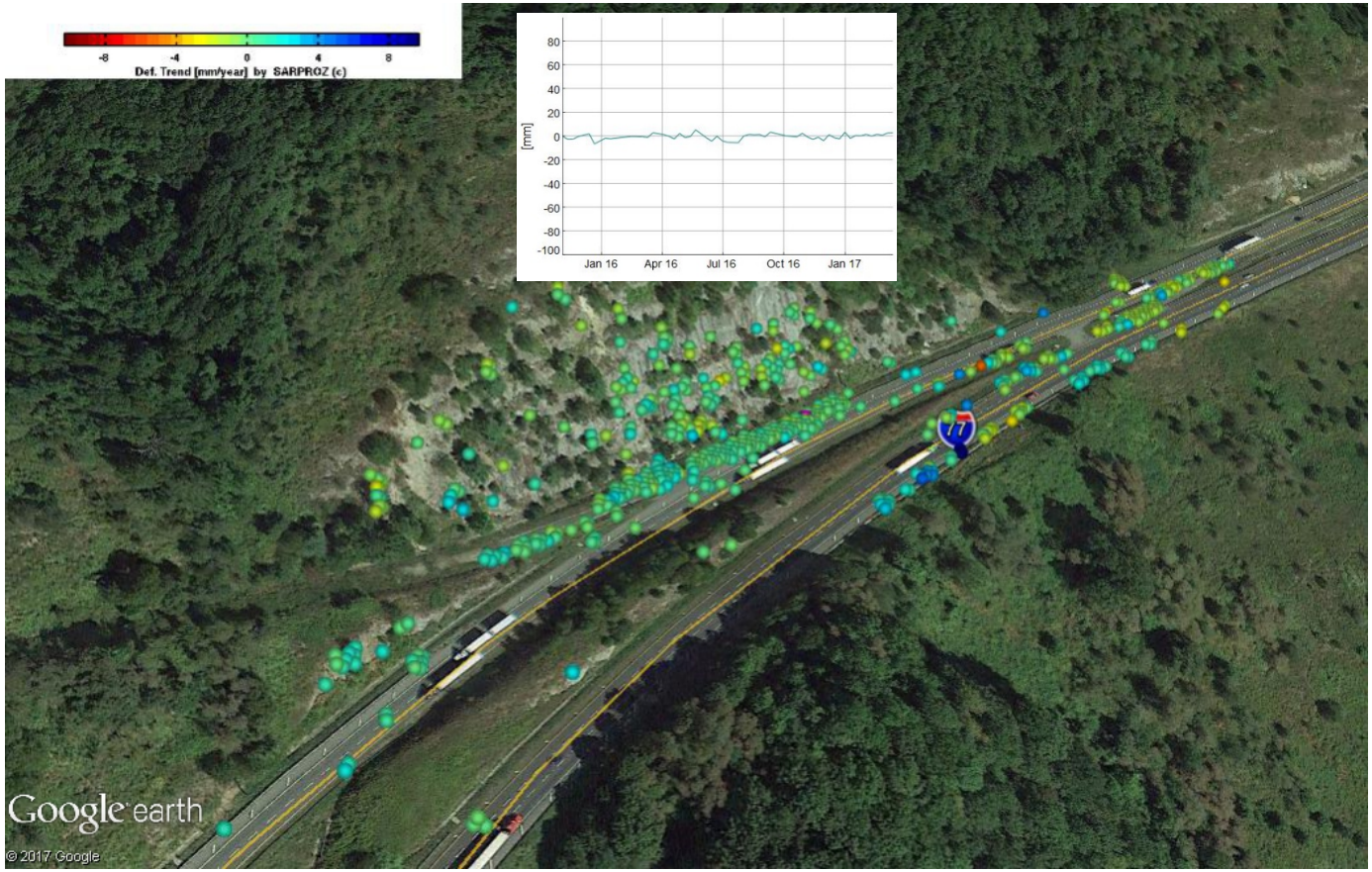
I-77 Area D


-4
-2
0
2
4
Def. Trend [mm/year] by SARPROZ (c)
D
77
Google earth
© 2017 Google
200 ft
N

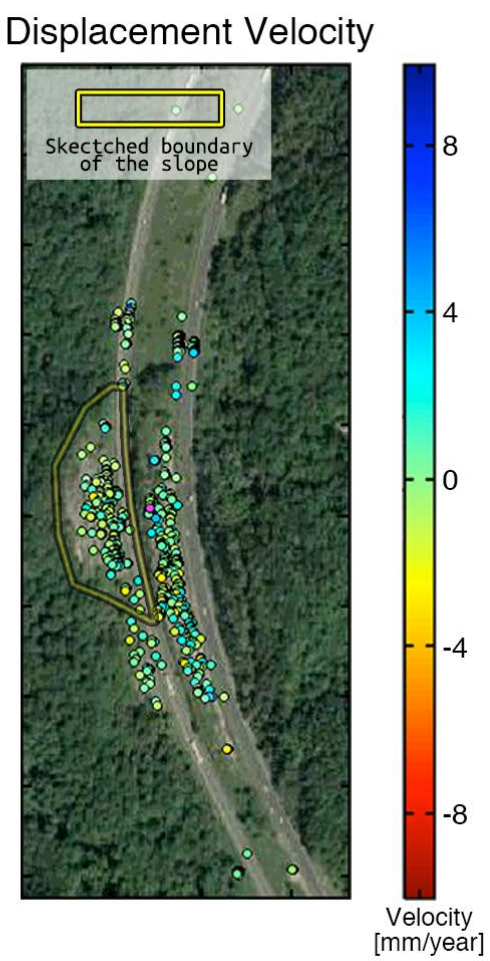
I-77 Area E

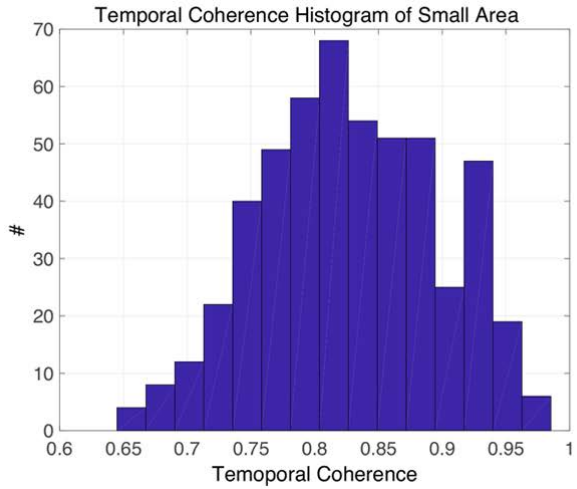

-8
-4
0
4
8
Def. Trend [mm/year] by SARPROZ (c)
E
77
Google earth
© 2017 Google
300 ft
N

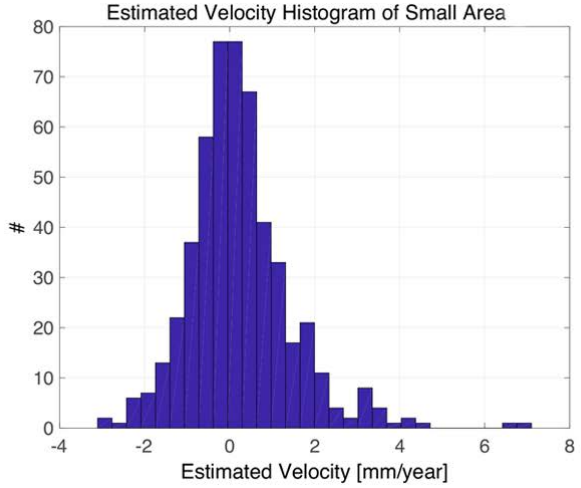
I-77 Area E


-8
-4
0
4
8
Def. Trend [mm/year] by SARPROZ (c)
80
60
40
20
0
-20
-40
-60
-80
-100
[mm]
Jan 16
Apr 16
Jul 16
Oct 16
Jan 17
77
Google earth
© 2017 Google

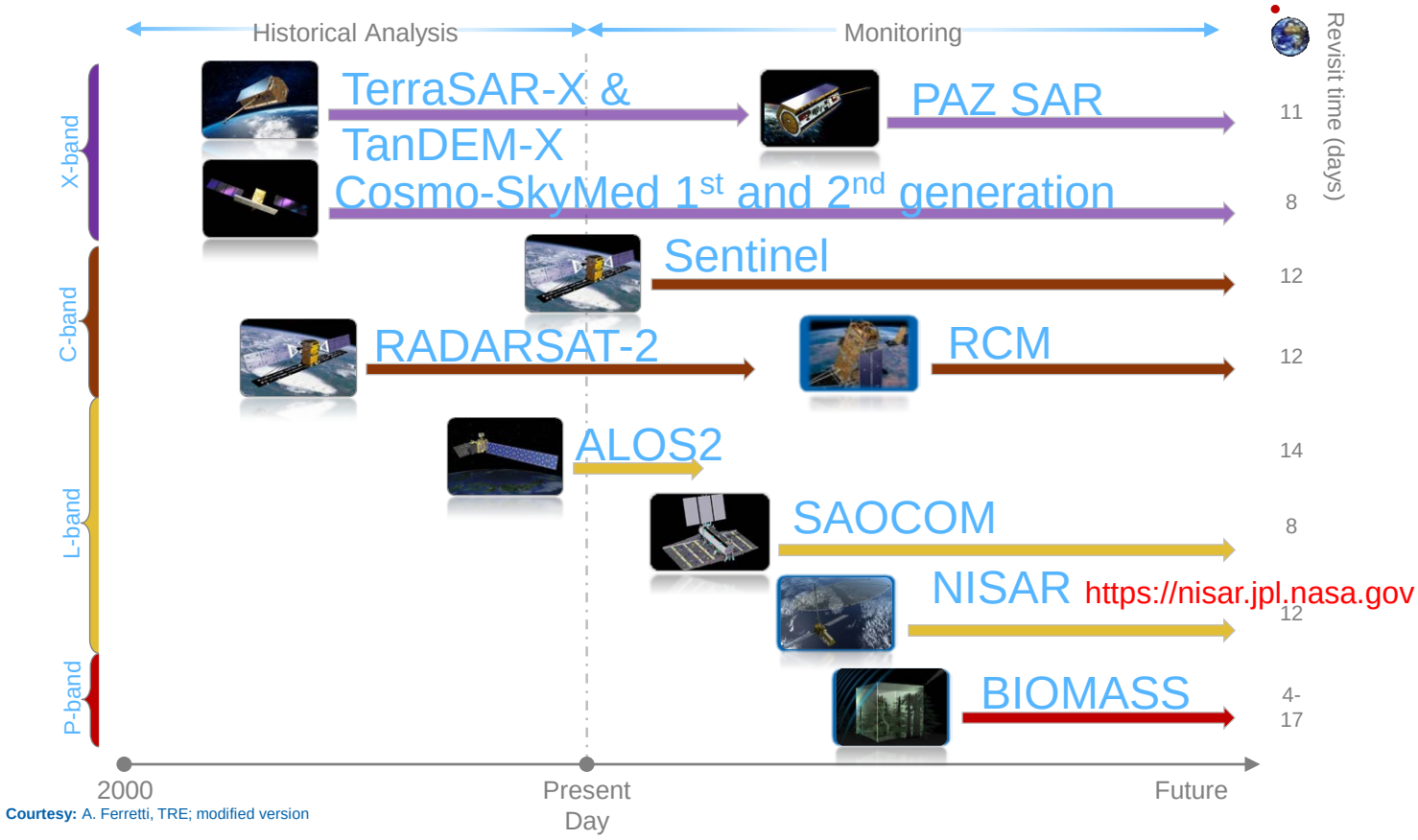
I-77 Area C – MP 3.6~MP 4.0







Current and Future SAR Satellites

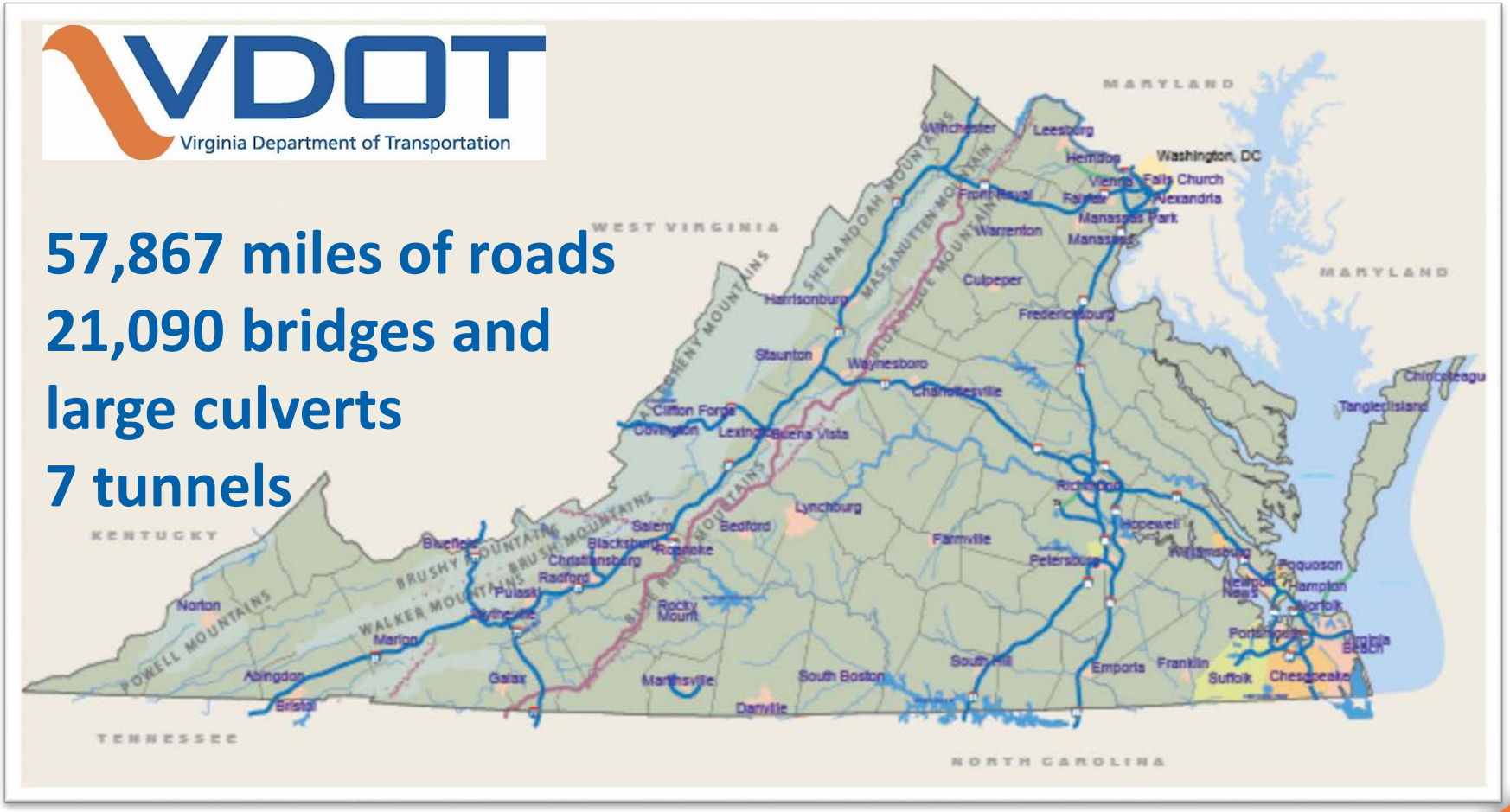


Courtesy: A. Ferretti, TRE; modified version

Transportation Applications of InSAR Technology

- Roads
- Bridges
- Railways
- Tunnels
- Rapid transit
- Airports
- Marine facilities
- Landslides

VDOT Network



How can we monitor transportation assets?

More Information

http://viva-lab.ece.virginia.edu/foswiki/InSAR/WebHome