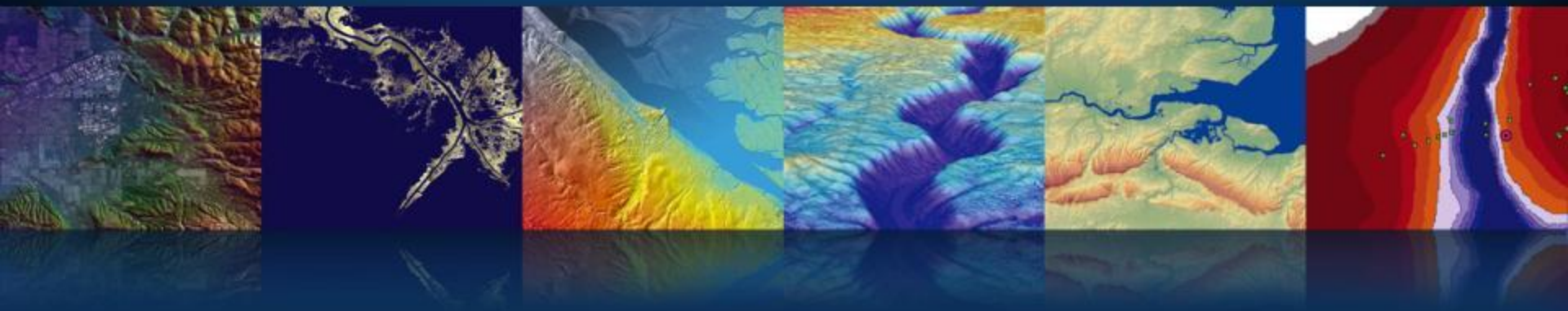

COMPARISON OF X-BAND AIRBORNE AND SPACEBORNE IMAGERY

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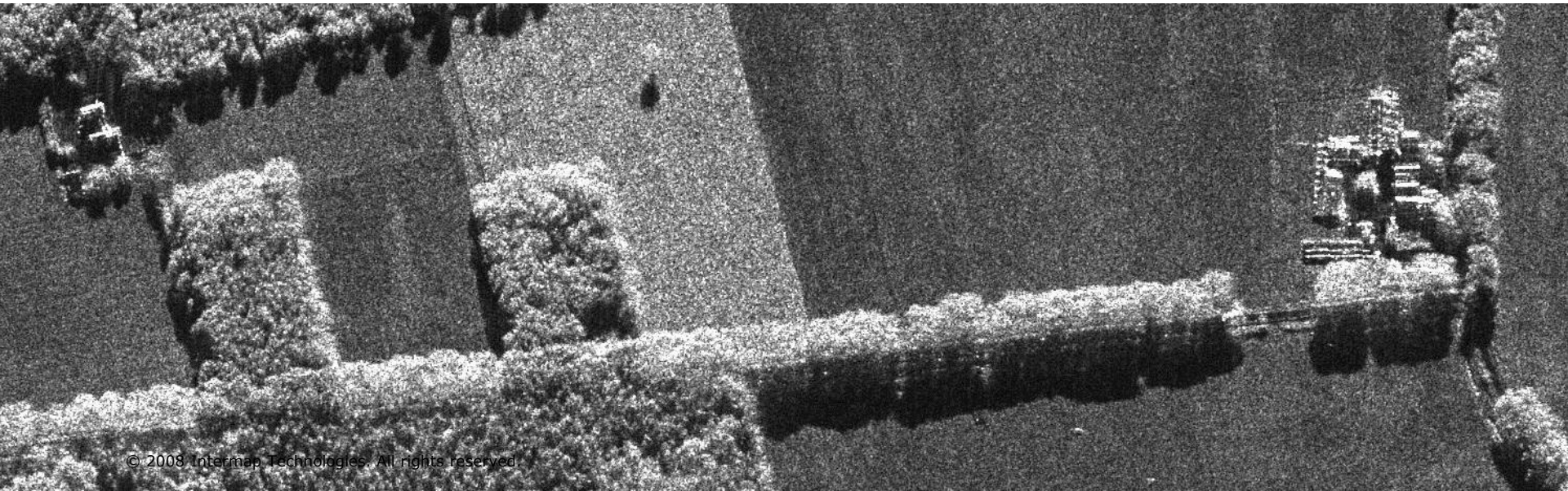
Agenda

- SAR Overview
- Benefits of SAR Data (cloud belt of the world)
- InSAR Platforms and Imagery Evaluated
- Study Sites
- SAR Imagery Absolute and Relative Horizontal Accuracy
- SAR Imagery Visual Assessment
  - SAR Spatial Content of X-band Imagery
- Conclusions

SAR Data

- **SAR** is an acronym that stands for **S**ynthetic **A**perture **R**adar, which is a spacecraft/airborne radar that looks out to the side to collect a radar image.
- Advantages of SAR:
  - Fast data collection;
  - Day & Night Collection;
  - Cloud penetration;
  - Provides own source of illumination;
  - Corresponding DSM and ORI

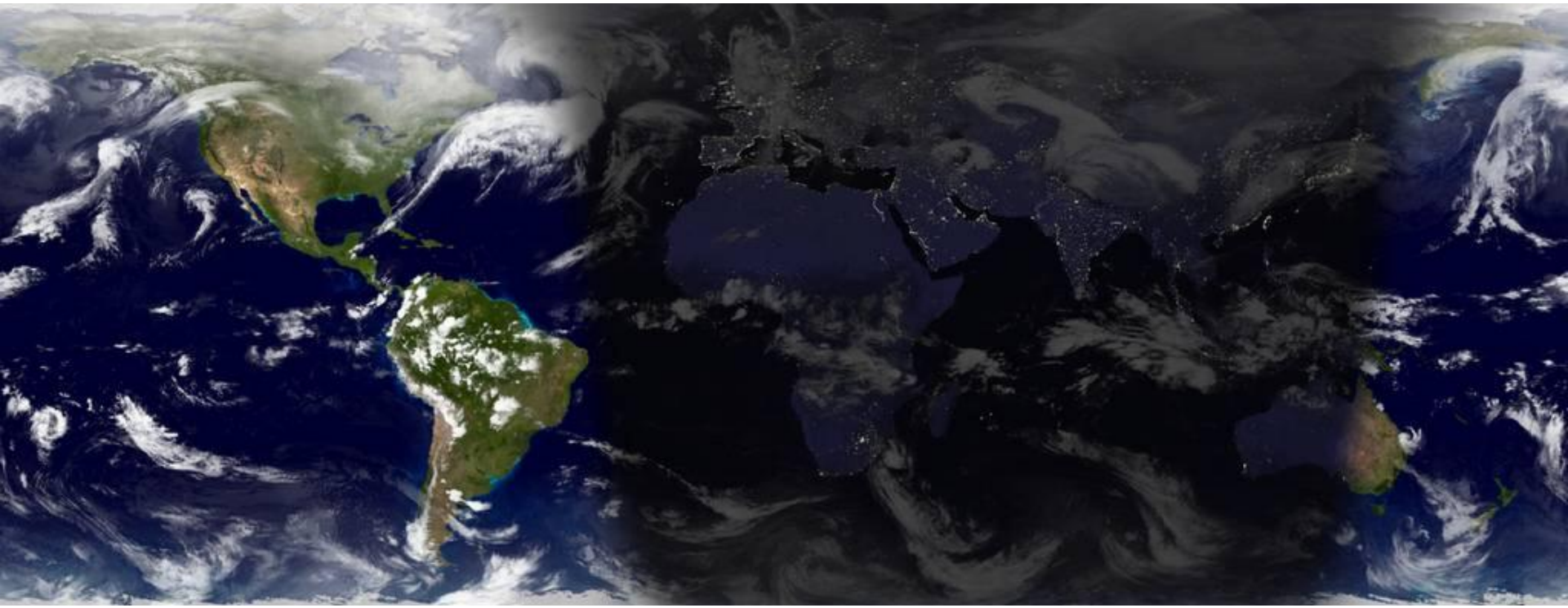


Cloud Belt Region

INTERMAP

SAR Data key differentiators are:

1) See through clouds
2) >95% acquisition, day or night
3) Orthorectified Imagery



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InSAR Sensors & Imagery Evaluated

INTERMAP

- There are a number of SAR air- and space-borne platforms currently in operation that can generate SAR imagery and elevation data using InSAR techniques. The three sensors and their specifications evaluated in this study.

	Airborne	Spaceborne	
Sensor	**NEXTMap**	**Tandem-X**	**COSMO-SkyMed**
Country	Canada	Germany	Italy
Wavelength	X	X	X
Polarization	HH	Quad	Quad
Image Resolution	0.63 & 1.25	3-10	3-10
Horizontal Accuracy - rmse	2 m CE	5 m CE	5 m CE
DEM	DSM/DTM	DSM	DSM
DEM GSD	5 m	5 m	5 - 30 m
Vertical Accuracy - rmse	0.50 - 3 m	10m	10m
InSAR Pass	Single	Repeat	Repeat

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Study Sites

- Three study sites were used in this research:

  1) Bolzano, Italy Alps

  2) French Alps, France site

  3) Napa Valley, California, US

Study Sites

- Three study sites were used in this research:

1) Bolzano, Italy Alps: high relief terrain (mountainous) with sharp ridges and steep slopes, an average slope is 22^{o} (40% grade) covering an area of 264 km^{2} over elevation changes by 1650 meters across this scene.

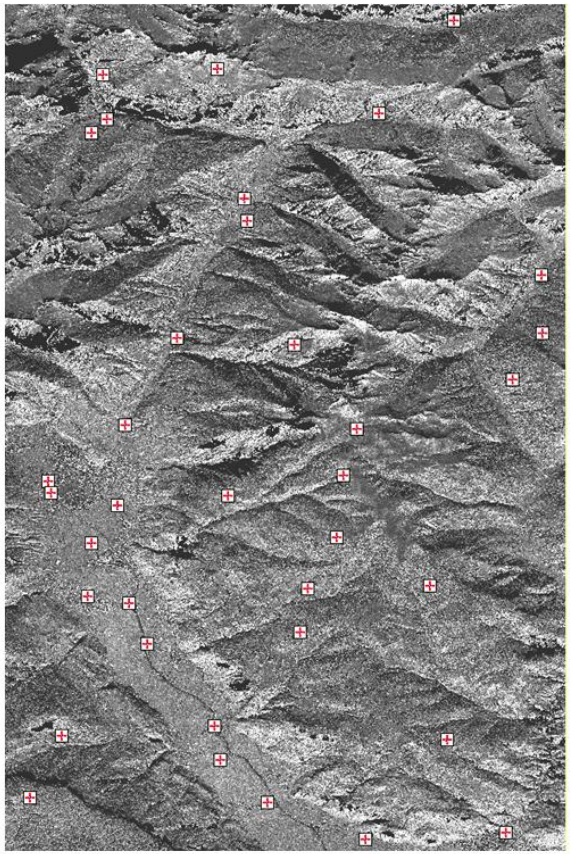
2) French Alps, France site: has rugged terrain, with sharp ridges and steep slopes, an average slope is 21^{o} (38% grade) covering an area of 255 km^{2} over elevation changes by 2017 meters across the site.

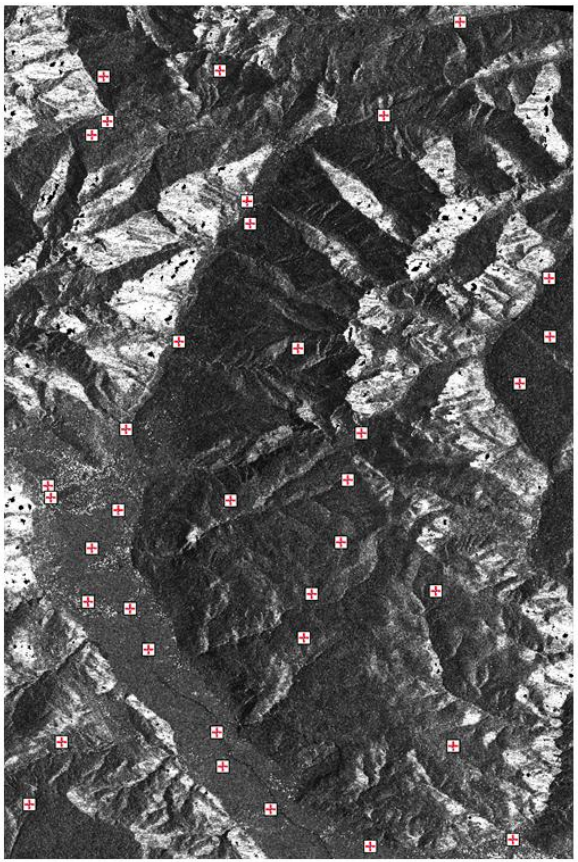
3) Napa Valley, California, US: has moderate relief, an average slope of 20^{o} (36% grade) covering 52 km^{2} over elevation changes of 700 meters across this scene.

Methods: Horizontal Accuracy CE90%

INTERMAP

- Horizontal accuracy of the spaceborne SAR imagery were calculated using the airborne SAR imagery as reference.
- The root mean square difference (RMSD; since the airborne data is not true reference) were calculated.
- In addition, feature content was assessed visual for all three X-band SAR image types over the Napa Valley Site. Visual comparisons are presented.





Match Points Overlaid on NEXTMAP ORI (Left) and CSM ORI (Right)

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Results: Statistics

Table 2: Absolute Horizontal Accuracy of Cosmos-SkyMed

Bolzano, Italy Alps	X Direction (m)	Y Direction (m)	Combined Error (m)
Min	0	0	1.31
Max	16.87	10.99	16.76
Mean	4.88	3.89	7.12
Standard Deviation	4.28	3.24	4.04
RMSD	6.49	5.063	8.19

Results: Statistics

Table 3: Absolute Horizontal Accuracy of Cosmos-SkyMed

French Alps, France	X Direction (m)	Y Direction (m)	Combined Error (m)
Min	0.27	0.00	0.63
Max	10.38	10.07	12.72
Mean	3.80	2.78	5.29
Standard Deviation	2.62	2.73	2.89
RMSD	4.61	3.90	6.03

Table 4: Absolute Horizontal Accuracy of TerraSAR-X

French Alps, France	X Direction (m)	Y Direction (m)	Combined Error (m)
Min	0.71	0.02	0.92
Max	9.20	16.12	17.34
Mean	3.44	4.05	5.84
Standard Deviation	2.54	3.82	3.86
RMSD	4.76	5.59	7.00

Results: Visual - NEXTMap

INTERMAP

NEXTMap 5m resolution ORI imagery (X-band) over the Napa Valley Site

Results: Visual – TerraSAR-X

TerraSAR-X band 20m imagery resampled to 5m resolution (X-band) over the Napa Valley Site.

Results: Visual – COSMO-SkyMed

INTERMAP

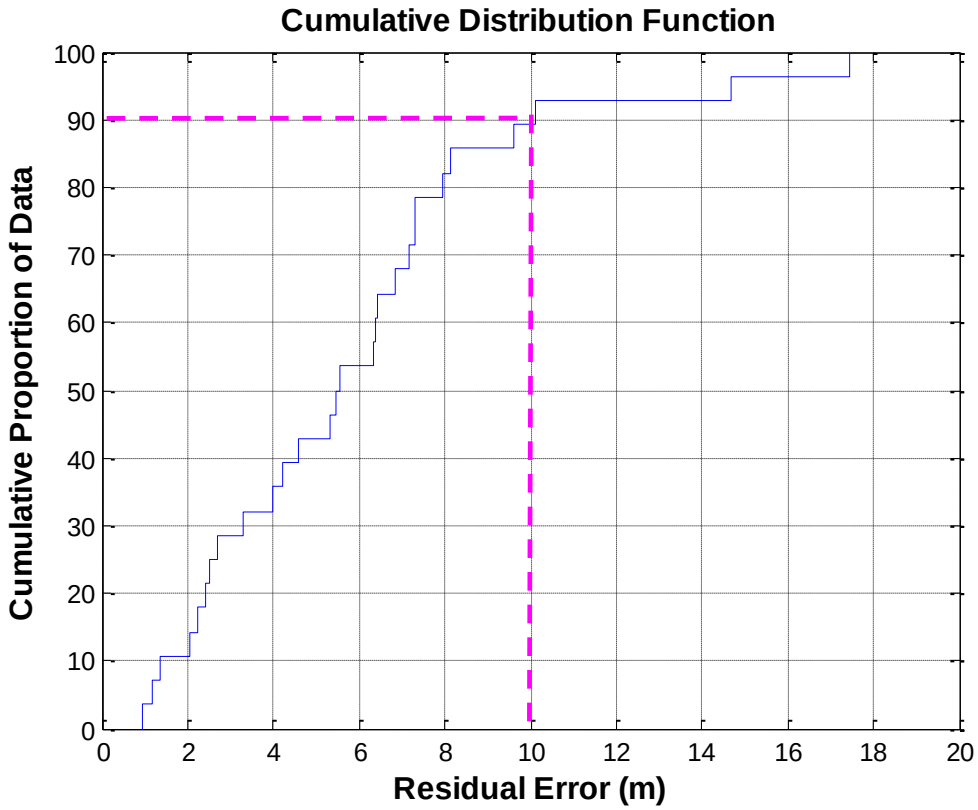
COSMO SkyMed X band 20 m imagery resampled to 5 m resolution (X-band) over the Napa Valley Site.

Summary

- This study has presented the horizontal imagery accuracy of COSMO-SkyMed and TerraSAR-X SAR imagery in comparison to the NEXTMap high resolution 5 m data.
- The results indicate that the overall X-Y horizontal accuracy expressed in RMSD was better for the COSMO-SkyMed SAR imagery than the TerraSAR-X SAR imagery
- Horizontal accuracy expressed as CE90% was less than 5m for the Italian and CA sites, and less than 6 m for the French Alps.
- Image content was greater and crisper in the TerraSAR-X imagery compared to the COSMO-SkyMed Data.
- All three sites represented rugged terrain.

Additional

- Calculation of combined horizontal error:



Cumulative Distribution Function of the Combined Horizontal Error