IDENTIFICATION OF DISTRIBUTED TARGET SITES IN INDIA FOR EXTERNAL CALIBRATION OF SAR DATA

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9. Abstract	Distributed target sites such as Amazon and Congo rainforests are widely used for external calibration of various SAR sensors. As India is having wide variety of tropical and sub-tropical rainforests so an attempt has been made to identify suitable site for distributed target within India. Suitability of distributed target is a function of flatness and uniform radiometric stability. Radiometric stability of RISAT-1 data over Indian rainforests is assessed by studying the uniformity and consistency of backscattering coefficient (Gamma-Nought) with wide range of incidence angle. Out of the three sites, Parmbikulan National Park was found to be suitable as a distributed target, however, more data is required to study the temporal variability of gamma0.
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1. Introduction

SAR data used for quantitative temporal and/or spatial analysis requires calibration to ensure that observed pixel values of amplitude and phase can be related to the geophysical parameters of interest. To achieve calibration accuracies required for most scientific analysis, a complex process utilizing Internal (built-in device) measurements and External (ground deployed device) measurements is needed. The advantage of external calibration over internal calibration is that the end-to-end system performance can be directly measured. Therefore, system parameters, which are difficult to measure, such as antenna pattern, the bore sight gain and angle and also signal propagation effects, can be determined from the external calibration. The external calibration technique generally involves two type of targets, Point target (Corner reflector, ARC) and Distributed target (Forests and deserts).

Distributed targets are an extension of point targets; due to terrain irregularities, most natural targets do not have well-defined reflection geometry, but rather they tend to have many scattered reflection points. Distributed targets are comprised of many elementary point scatterers, where each scatterer has random reflection amplitude, but the superposition of these random amplitudes will result in the total RCS for that distributed target.

Followings assumptions are taken in to consideration while selecting distributed target

- A flat terrain is considered, i.e. there is no slope.
- Any change in incidence angle across a distributed target is neglected, i.e. a distributed target corresponds to one average value of the incidence angle.
- The pixel value in the image is proportional to square root of intensity,
- The intensity value is proportional to the radar brightness $\square^{o}$

Amazon Rainforest is an established distributed target for SAR data calibration as announced by SAR subgroup of Working Group on Calibration and Validation (WGCV) of Committee on Earth Observation Satellite (CEOS). Canadian Boreal forest is also being used by researchers as distributed target for SAR calibration. As India is having wide variety of tropical and sub-tropical rainforests so an attempt has been made to identify suitable site for distributed target among Indian rainforests. Suitability of distributed target is function of flatness and Isotropy (uniform backscatter stability). Isotropy of RISAT-1 data over Indian rainforests is assessed by studying the uniformity and consistency of backscattering coefficient (Gamma-Nought) with wide range of incidence angle. This study attempts to carry out feasibility analysis for identification of suitable distributed target sites in India.

2. Objective

To study the spatial and temporal variability of the sites by studying the variation of gamma naught.

3. Study area

Potential sites were searched using optical satellite images and topographical data.

Three potential areas were identified, which are as following:

- Parmbikulan National Park,
- Periyar National Park and
- Berambadi National Park

3.1 Parmbikulan National Park

Parambikulam forest is located at central latitude and longitude longitude 10.444 N & 76.759 E and widespread in 391 square kilometres area in Chittur taluk in Palakkad district of Kerala state, South India. The sanctuary has a variety of trees mainly teak, neem, sandalwood and rosewood. The Altitude ranges between 300 m and 1438 m.

Figure 1 Location of Parmbikulan Nat. Park on google earth [Courtesy: Google Erath]

3.2 Periyar National Park

Periyar National Park, is an example of nature's bounty with great scenic charm and rich bio diversity. It is sprawled over an area of 925 Sq. .km. Periyar National Park and Wildlife Sanctuary (PNP) is located at 9.354 N 77.244 E in the districts of Idukki, Kottayam and Pathanamthitta in Kerala. It is located high in the Cardamom Hills and Pandalam Hills of the south Western Ghats along the border with Tamil Nadu. It is 4 km (2.5 mi) from Kumily,

approximately 100 km (62 mi) east of Kottayam, 110 km (68 mi) west of Madurai and 120 km (75 mi) southeast of Kochi. The forests contain deciduous and semi evergreen trees like teak, rosewoods, terminalias, sandalwoods, jacarandas, mangoes, jamun, tamarind, banyans, sacred fig, plumerias, royal poinciana, kino tree, bamboos, and the only South Indian conifer, Nageia wallichiana. Periyar National Park lies in the middle of a mountainous area of the Cardamom Hills. In the north and the east it is bounded by mountain ridges of over 1,700 m altitude and toward the west it expands into a 1,200 m high plateau. From this level the altitude drops steeply to the deepest point of the reserve, the 100 metre valley of the Pamba River. The highest peak is the 2,019 m high Kottamalai. The Periyar and Pamba Rivers originate in the forests of the reserve.

Figure 2 Location of Periyar National Park on google earth [Courtesy: Google Erath]

3.3 Berambadi National Park

Berambadi State Forest is located in the Gundlupet taluka of Chamarajanagar district, in the state of Karnataka in India. Berambadi State Forest is located at central latitude and longitude 11.73 N and 76.325 N where the Deccan Plateau meets the Western Ghats and the altitude of the park ranges from 680 meters to 1,454 meters. As a result, the park has a variety of biomes including dry deciduous forests, moist deciduous forests and shrublands. Berambadi State Forest comprised of wide range of timber trees including: teak (Tectona grandis), rosewood (Dalbergia latifolia), sandalwood (Santalum album V), Indian-laurel (Terminalia tomentosa), Indian kino tree (Pterocarpus marsupium), giant clumping bamboo (Dendrocalamus strictus), clumping bamboo (Bambusa arundinacea) and Grewia tiliaefolia.

Figure 3 Location of Berambadi Nat. Park on google earth [Courtesy: Google Erath]

4. Data used

In this study, satellite data of three potential distributed target sites as Parmbikulan National Park, Periyar National Park and Berambadi National Park. Duel pol SLC data of these sites was acquired from NRSC, Hyderabad. Total 12 (Twelve) Single Look Complex (SLC) images of RISAT-1 data in Medium Resolution ScanSAR mode were used in (CEOS) format. The details of the data sets used in this study are as follows:

Table 1 Data Used in this Study

Sr. No.	Location	Date of Pass	Center Lat.	Center Long.	Incidence Angle (Deg.)	Mode	Polri-zation	Beam No.	Node	Orien-tation
1	Parmbikulan National Park	15/05/13	10.64	76.84	53.33	MRS	HH/HV	56	ASCENDING	RIGHT
2		16/05/13	10.13	76.95	53.35	MRS	HH/HV	56		RIGHT
3		17/05/13	10.39	76.9	53.36	MRS	HH/HV	56		RIGHT
7	Periyar National Park	31/01/13	9.95	77.13	21.05	FRS	RH/RV	73		LEFT
8		15/05/13	9.61	77.06	53.35	FRS	HH/HV	56		RIGHT
9	Berambadi National Park	31/01/13	11.57	76.72	20.98	FRS	RH/RV	73		LEFT
10		31/01/13	11.83	76.66	20.96	FRS	RH/RV	73		LEFT
11		15/05/13	11.67	76.61	53.36	FRS	HH/HV	56		RIGHT
12		15/05/13	11.93	76.55	53.34	FRS	HH/HV	56		RIGHT

RISAT-1 data is used to assess the radiometric uniformity over potential sites and in addition to that we are using 10 m resolution Carto-DEM data to assess the flatness.

5. Methodology

Radiometric calibration involves characterizing the SAR processing system's ability to generate image pixel intensities that are directly expressed in terms of the mean surface backscatter coefficient, $\sigma 0$:

$$\sigma 0 = 10 \log 10(DN)2$$

DN is the digital number.

For a suitable distribute target site, it is assumed that gamma naught should be constant over an incidence angle. The gamma0 measurements over the Parmbikulan National Park, Periyar National Park and Berambadi National Park can also be used to investigate the stability of these potential distributed target.

$$\gamma o = \text{constant} = \sigma o / \cos\theta$$

In this study, variation of gamma naught with incidence angle is assessed to evaluate backscatter stability. SARC-View tool is used to estimate backscattering σo and γo. The nominal value of gamma0 value of amazon rainforest for linear co-polarization (HH) is -6.5 dB, nominal gamma0 for linear cross-polarization (HV) is -12.5 dB and nominal gamma0 for circular co-cross polarization (RH/RV) is -5.6 dB (Schwerdt et al. 2016; Hawkins et al. 2000. As amazon rainforest is widely acceptable distributed target and been continuously used as distributed target for Calibration in various SAR mission worldwide.

6. Results and Discussion

The data set which was analyzed in this work consists of 12 images of portions of a region of the three potential distributed target sites. These images were collected in the period from January 2013 to May 2015, on both ascending and descending passes of the satellite in MRS mode. The independence of backscatter gamma0 to incidence angle has been indicated by previous studies. The results of this study show that there is no gross variatio n of gamma0 over the incidence angle range covered by the RISAT-1 beams. All three selected potential sites are having large geographic area covered with a dense leaf canopy of tropical rain forest vegetation. The criteria of selecting suitable site is dependent on availability of large homogenous area, isotropy (radiometric uniformity) and flatness. For radiometric calibration, minimum 1000 pixels are required so for selecting suitable site, scene area is selected accordingly for analysing both isotropy and flatness.

The backscatter from areas of rain-forest has been extensively studied using the RISAT-1 has been found to be relatively stable. In addition to isotropy, an attempt has been made to validate RISAT-1 data by taking RISAT-1 backscatter measurements from this rain-forest region, calculating γ0, and comparing it to the expected value. The detailed results are shown in **table 2.** In addition to the isotropy, flatness of potential sites was assessed by utilizing CartoDEM data of 10 m resolution. The results shown in figure 1, 2 and 3 clearly depicts that selected site is having almost flat terrine.

Table 2 Results of Backscatter (Gamma0) over potential distributed targets

Parmbikulan National Park										
Sr.No.	**Date**	**Latitude**	**Longitude**	**Pixel Number**	**Incidence angle in degree**	**Estimated Gamma 0 (in dB)**		**Average Gamma 0 (in dB)**		**Polarization**
1	15-May-13	10.7396	76.714	11708	53.92085	-12.3258	-7.35363	**-11.9**	**-7.2**	**HV/HH**
2		10.5169	76.7779	10803	53.82356	-11.8572	-7.10444			
3		10.4891	76.7623	11918	53.94337	-11.9994	-7.48289			
4		10.51	76.78	10344	53.77404	-11.5757	-6.70966			
1	15-May-13	9.9763	76.8735	12064	53.95726	-12.018	-7.14514	**-11.8**	**-6.8**	
2		10.0458	76.857	12070	53.9579	-11.7674	-6.81688			
3		10.1645	76.8366	11864	53.93583	-11.6356	-6.67477			
4		10.2214	76.8188	12054	53.95619	-11.6673	-6.72945			
1	15-May-13	10.4724	76.7694	11778	53.73285	-11.3401	-6.48882	**-11.8**	**-7.0**	
2		10.3221	76.8001	11793	53.71805	-11.9277	-7.16785			
3		10.4143	76.7979	10990	53.84291	-11.9606	-6.95503			
4		10.4993	76.7619	11717	53.92104	-11.8705	-7.26451			
Periyar National Park										
1	31-Jan-13	9.4482	77.2056	3484	21.39709	-7.49024	-8.72994	**-7.2**	**-8.3**	**RH/RV**
2		9.4946	77.1632	2909	21.10993	-6.97691	-8.18981			
3		9.3831	77.0579	582	19.88922	-7.56991	-8.10491			
4		9.3786	77.1914	2981	21.14589	-6.96646	-8.18206			
1	15-May-13	9.6142	76.9717	11044	53.84599	-12.3703	-7.68761	**-12.0**	**-7.0**	**HV/HH**
2		9.4608	76.9998	11598	53.90551	-11.6288	-6.32843			
3		9.7238	76.9369	11638	53.90979	-11.9823	-7.11531			
4		9.6826	76.9463	11609	53.90669	-11.9823	-7.11531			
Berambadi National Park										
1	31-Jan-13	11.6137	76.6442	1274	20.26893	-7.83258	-8.41548	**-7.7**	**-8.7**	**RH/RV**
2		11.6196	76.7315	3126	21.06157	-6.86302	-7.98752			
3		11.5925	76.8105	4689	21.83804	-7.9864	-9.2135			
4		11.6249	76.7378	3209	21.30084	-8.2457	-9.4327			
1	31-Jan-13	11.7035	76.6045	658	19.77477	-8.25393	-8.86673	**-8.2**	**-8.8**	
2		11.8887	76.5722	775	19.53894	-8.16658	-8.65318			
3		11.862	76.5659	518	19.69799	-8.27892	-8.78432			
4		11.6989	76.6789	2179	20.58756	-8.16129	-9.06129			
1	15-May-13	11.6503	76.5491	9444	53.67909	-12.0424	-6.72497	**-11.6**	**-6.3**	**HV/HH**
2		11.7225	76.5037	10839	53.82993	-11.4179	-6.23057			
3		11.6613	76.5051	11434	53.89392	-11.4235	-6.15753			
4		11.609	76.5323	10692	53.81408	-11.4966	-6.26862			
1	15-May-13	11.8583	76.4827	10396	53.78265	-12.0208	-6.71427	**-11.8**	**-7.0**	
2		11.7225	76.5037	10839	53.83042	-12.2496	-7.63552			
3		11.783	76.4882	10941	53.8414	-11.5983	-6.81259			
4		11.8231	76.4753	11105	53.85908	-11.5669	-6.86615			

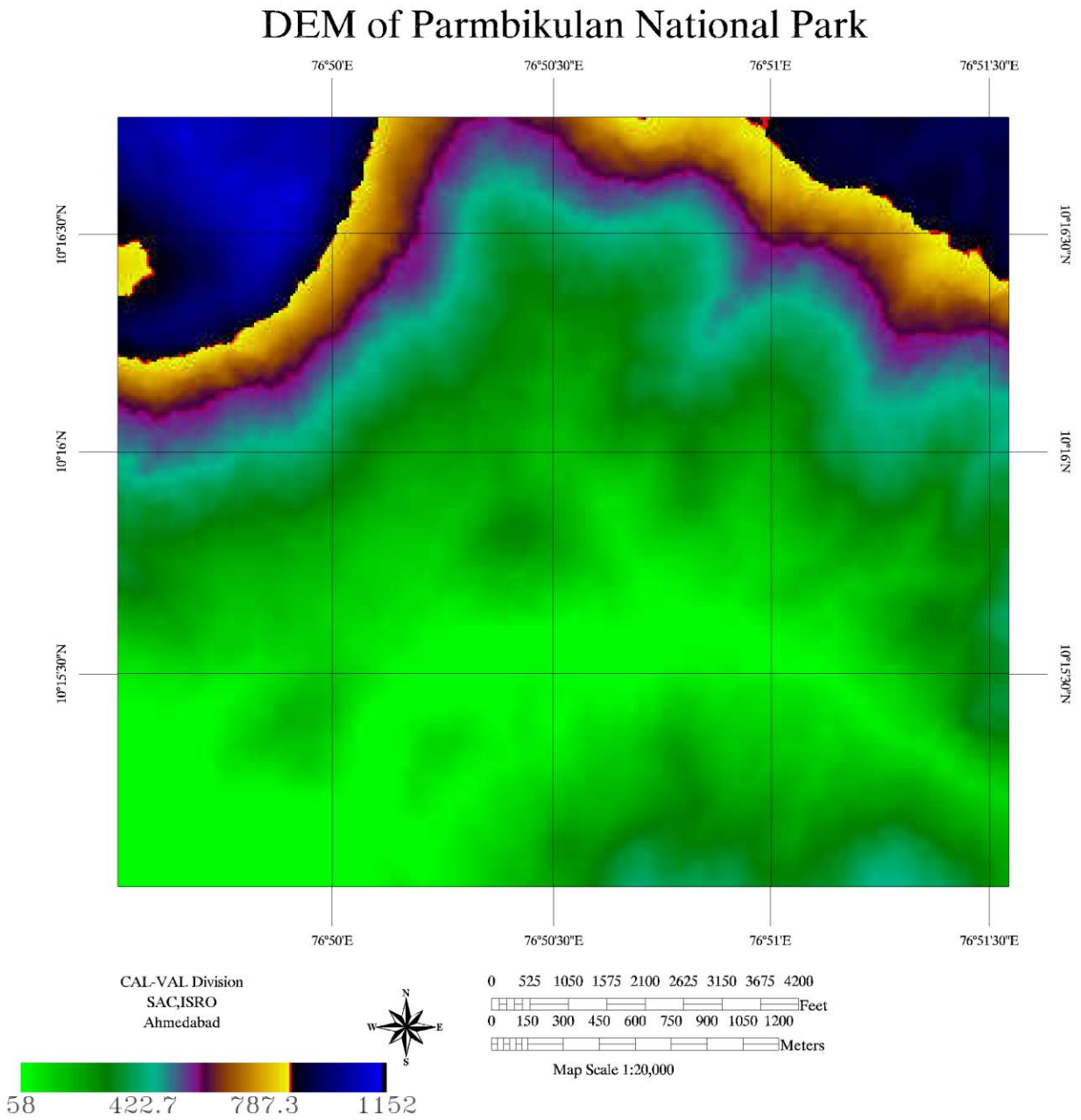

Figure 4 DEM of Parambikulan National Forest

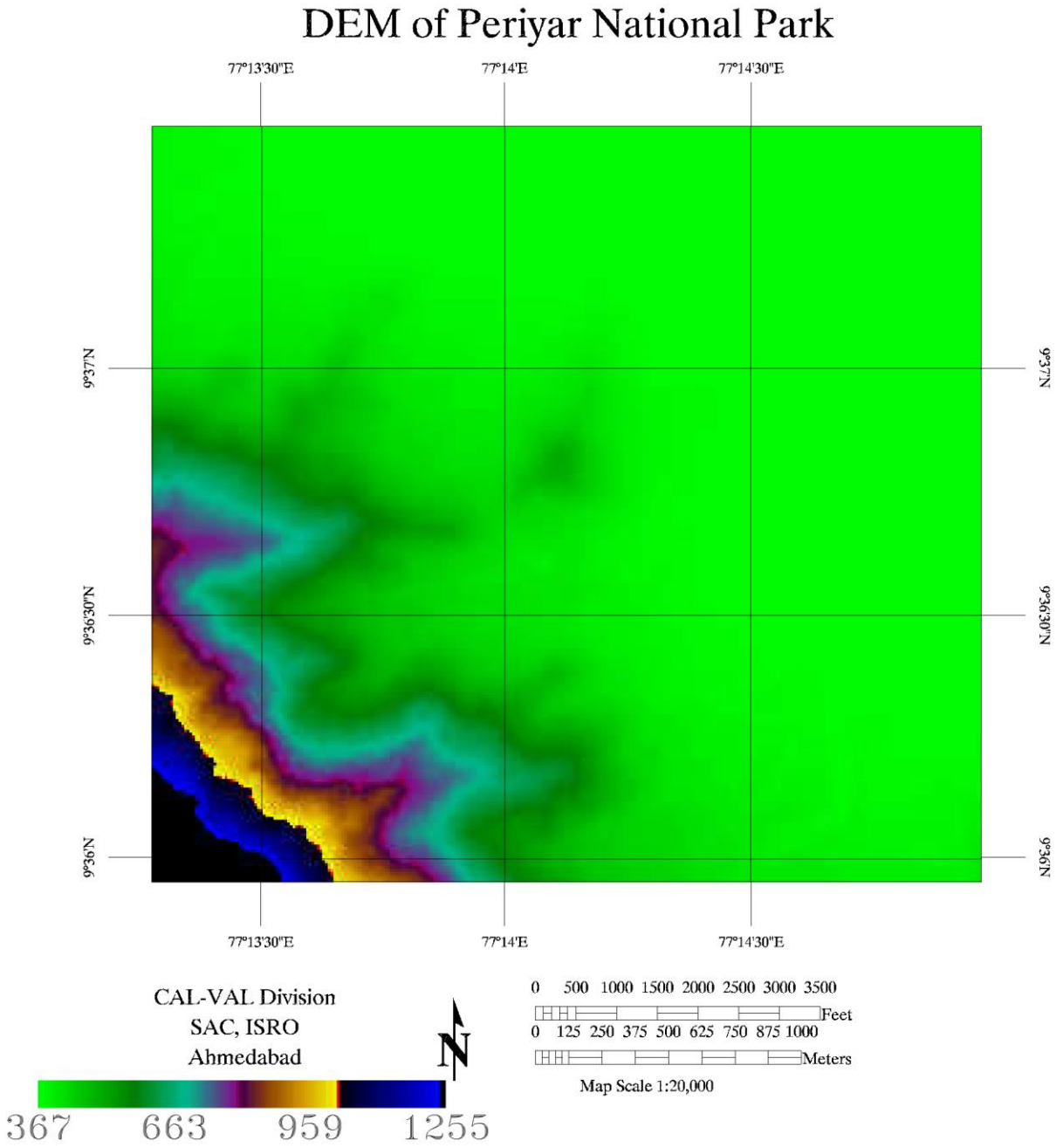

Figure 5 DEM of Periyar National Forest

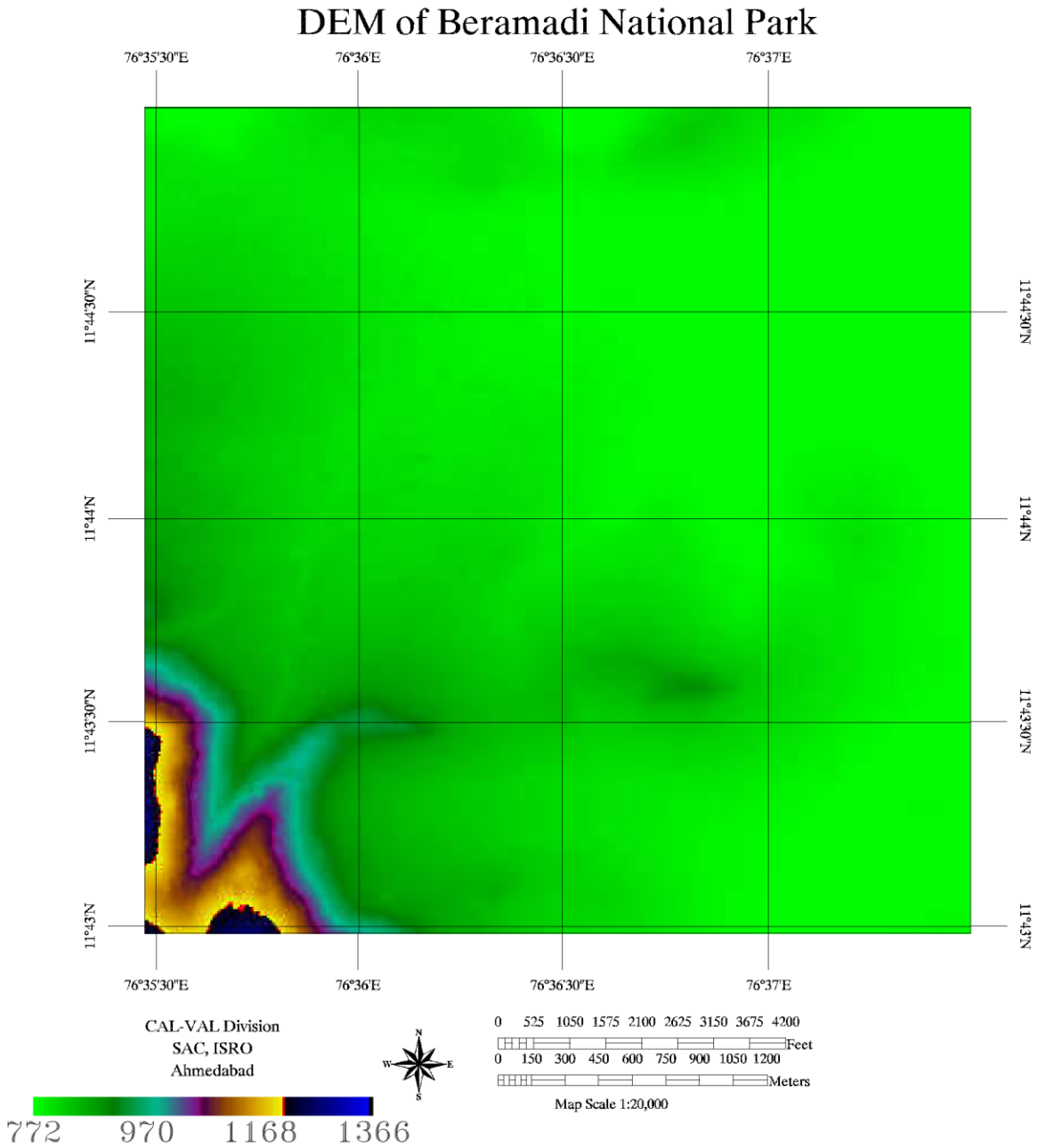

Figure 6 DEM of Beramadi national forest

7. Conclusion

Suitability of distributed target is function of flatness and Isotropy (uniform backscatter stability). Isotropy of RISAT-1 data over Indian rainforests is assessed by studying the uniformity and consistency of backscattering coefficient (Gamma-Nought) with wide range of incidence angle. This study attempts to carry out feasibility analysis for identification of suitable distributed target sites in India. Results of Gamma-naught on study area shows that selected area is suitable for distributed target as there is very less variation in gamma-naught values with incidence angle and also obtained gamma-naught values are relatively near to expected value for respective polarization. Flatness of potential distributed target sites were measured by Carto-DEM data of 10 m resolution, which also proves that selected sites are having relatively flat terrain. Out of the three sites, Parmbikulan National Park was found to be suitable as a distributed target, however, more data is required to study the temporal variability of gamma0.

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