VEGETATION TYPES MAPPING USING ALOS/AVNIR-2 AND PRISM DATA USING UNIVERSAL PATTERN DECOMPOSITION METHOD

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ABSTRACT:

Vegetation species maps are useful for forestry managements and environmental ecological study. From the forestry management, broad and conifer leaf forest should be mapped. In addition to them, land-cover mapping data with high resolution is needed as validation data sets for low resolution's land-cover mapping results. SGLI sensor on board GCOM-C satellite, which will be launched in 2014, has 250m spatial resolution and it's data will be used for making global land-cover data set. ALOS satellite was launched in 2006. It has AVNIR-2 sensor and PRISM sensor. AVNIR-2 sensor has four spectral bands 460, 560, 650 and 830nm with 10-m spatial resolution. PRISM sensor has panchromatic band from 520nm to 770 nm with 2.5m spatial resolution. If use the both of image, pseudo high spatial multi-spectal image can be processed. Because of the spatial resolution and multi-spectral information, these sensor data are expected to useful for making high resolution land-cover data set. We have developed Universal Pattern Decomposition Method (UPDM)(Zhang, L.F. et.al, 2006 (Zhang et al., 2006)) and Modified Vegetation Index based on UPDM (MVIUPD)(Zhang, L.F. et. al, 2007 (Zhang et al., 2007) and Xiong, Y., 2005 (**?**)) for satellite sensor data analysis for land cover mapping and vegetation monitoring. In the UPDM method, three coefficients of water, vegetation and soil is calculated using three standard patterns of water, vegetation and soil. One of this method's characteristics is the UPDM coefficients from different sensors for the same object being same as each other. The capability of vegetation species mapping was studied with ALOS/AVNIR-2 data and UPDM method. Japanese cedar, Japanese cypress, deciduous forest, bamboo forest, orchard and grass land can be classified using AVNIR-2 summer and winter data. In this study, AVNIR-2 and PRISM data are used for vegetation types mapping using universal pattern decomposition method. Firstly, the pan-sharpen image was processed using AVNIR-2 and PRISM data. Each band's Digital Number (DN) value of AVNIR-2's band is calculated using DN of PRISM and AVNIR-2. The reflectance of AVNIR-2 is calculated from calculated DN values. UPDM method is applied to the set of re-calculated reflectance. Using the coefficients of UPDM and vegetation index, evergreen forest and deciduous forest were classified using two seasonal data. These results are compared with forest resource information. The tendency was agree with each other, although detailed validation is needed. From these results, the UPDM method can be applied to pan-sharpen image and the pan-sharpen image can be used for vegetation type classification. In the near future, calculation methods with retaining the original reflectance should be improved.

1 INTRODUCTION

Vegetation species maps are useful for forestry managements and environmental ecological study. From the forestry management, broad and conifer leaf forest should be mapped. In addition to them, land-cover mapping data with high resolution is needed as validation data sets for low resolution's land-cover mapping results. SGLI sensor on board GCOM-C satellite, which will be launched in 2014, has 250m spatial resolution and it's data will be used for making global land-cover data set. ALOS satellite was launched in 2006. It has AVNIR-2 sensor and PRISM sensor. AVNIR-2 sensor has four spectral bands 460, 560, 650 and 830nm with 10-m spatial resolution. PRISM sensor has panchromatic band from 520nm to 770 nm with 2.5m spatial resolution. If use the both of image, pseudo high spatial multi-spectral image can be processed. Because of the spatial resolution and multi-spectral information, these sensor data are expected to useful for making high resolution land-cover data set. We have developed Universal Pattern Decomposition Method (UPDM)(Zhang, L.F.

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pattern decomposition method.

2 STUDY SITE AND USED DATA

2.1 Study site

Study site is the basin of tributary of Miyagawa River in Mie, Japan. The map of forest management is shown in Figure 1. The area A and B are the study site as shown in Figure 1. Pink line shows the rivers and blue line the ridge. From the forest management record in 2003, the cover ratio of artificial forest of evergreen such as Japanese cedar and Japanese cypress is 58.2 % for the area A, and 97.8 % for the area B.
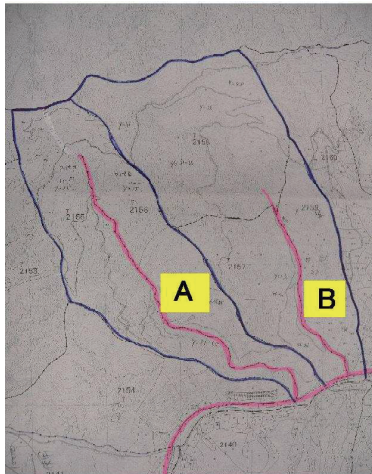
Figure 1: The map of the forest management. Study area are shown in site "A" and "B".

2.2 Used data in this study

In this study, ALOS/AVNIR-2 and PRISM data are used. AVNIR-2 sensor has four spectral bands from visible to near-infrared, such as 0.42~0.50, 0.52~0.60, 0.61~0.69, and 0.76~0.89 μm with 10~15 m spatial resolution. PRISM sensor has one band from visible to near-infrared such as 0.52~0.77 μm with 2.5 m spatial resolution, and has three different angle observation modes. In this study, the nadir observation mode data was used. In order to make clear pan-sharpen image, the both of AVNIR-2 and PRISM data observed on the same day or in the same season are needed. Fathermore in order to make classification of evergreen and deciduous forest, winter and summer data sets are needed. Because of the observing condition limit and the weather condition, there were not good both sensor's data observed on the same day. As for the winter data, AVNIR-2 data observed on Jan. 29, 2009 and PRISM data observed on Oct. 24, 2006 were used. As for the summer data, AVNIR-2 data observed on Sep. 16, 2009 and PRISM data observed on July 27, 2007 were used. The images of study area are shown in Figure 2. Figure 2 (a) is the false color image of AVNIR-2 and (b) is the panchromatic image of PRISM for the summer and (c) of AVNIR-2 and (d) of PRISM for the winter data sets.

3 METHOD

3.1 Pan-sharpen processing

Two images of AVNIR-2 and PRISM of the same season was registered using control points with affine transfer mapping equations. Brightness values of pan-sharpen image is calculated as
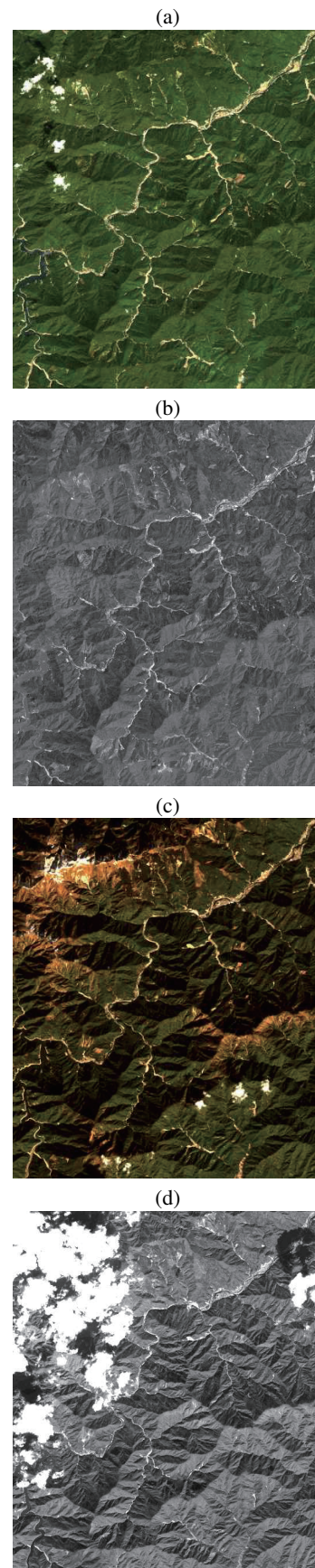
(a)

(b)

(c)

(d)

Figure 2: The images for using data. (a) AVNIR-2 observed on Sep. 16, 2009, (b) PRISM observed on July 27, 2007, (c) AVNIR-2 observed on Jan. 29, 2009 and (d) PRISM observed on Oct. 24, 2006.

follows.

$$B' = 4 \times P \times \frac{B}{B+G+R+N} \qquad (1)$$

$$G' = 4 \times P \times \frac{G}{B+G+R+N} \qquad (2)$$

$$R' = 4 \times P \times \frac{R}{B+G+R+N} \qquad (3)$$

$$N' = 4 \times P \times \frac{N}{B+G+R+N}, \qquad (4)$$

where P, B, G, R, N are DN values of PRISM, AVNIR-2 band 1, band 2, band 3 and band 4, respectively. New DN values are used for calculating brightness and the reflectance for each bands. The cross section of Rayleigh scattering (Hill and Stum, 1991, (Hill et al., 1991)) was calculated for each bands with the condition of the solar zenith angle and Earth-Sun distance for each image data and subtracted.

3.2 Universal Pattern Decomposition Method

Using the spectral reflectance data, the Universal Pattern Decomposition Method (UPDM) coefficients are calculated. The method is based on the pattern decomposition method (PDM)(Fujiwara 1996, (Fujiwara et al., 1996) Muramatsu 2000 (Muramatsu et al., 2000), Daigo 2004 (**?**)). In the PDM framework, the normalization of standard patterns depends on how many bands and which wavelengths the sensor observes. As the results the obtained patten decomposition coefficients may differ for each sensor such as TM or GLI, even when the same sample is observed. Since the same normalized spectral patterns for any sensor is used in UPDM. In the UPDM, the same value of the coefficients can obtained for results measured by different sensor such as TM or GLI. The method is briefly explained in this section.

The set of spectral reflectance values $(R_1, R_2, \ldots, R_n)$ of n bands for a pixel is transformed into four coefficients such as water (C_w), vegetation (C_v), soil (C_s) with three standard spectral shape patterns. In the three standard spectral shape patterns, three are correspond to typical ground objects, namely water (P_{iw}), vegetation (P_{iv}) and soil (P_{is}). The general equation of universal PDM was as follows:

$$R_i \rightarrow C_w P_{iw} + C_v P_{iv} + C_s P_{is} \ . \qquad (5)$$

In UPDM, the standard pattern was defined using the continuous spectral function from 350nm to 2500nm, as follows:

$$\int |P_k(\lambda)d\lambda| = \int d\lambda \ (k = w, v, s) \ . \qquad (6)$$

Here $\int d\lambda$ refers to integration of the total wavelength range, and $P_k(\lambda)$ is defined as

$$P_k(\lambda) = \frac{\int d\lambda}{\int |R_k(\lambda)|d\lambda} R_k(\lambda) \ (k = w, v, s) \ . \qquad (7)$$

For each sensor band, the standard patters are defined by

$$P_{ik} = \frac{\int_{\lambda_{si}}^{\lambda_{ei}} P_k(\lambda)d\lambda}{\int_{\lambda_{si}}^{\lambda_{ei}} d\lambda} \ (k = w, v, s) \ , \qquad (8)$$

where λ_{si} and λ_{ei} are the start and end wavelength for band i, respectively, and $\int_{\lambda_{si}}^{\lambda_{ei}} d\lambda$ is the wavelength with of band i. The decomposition coefficients were obtained for each sensor by the
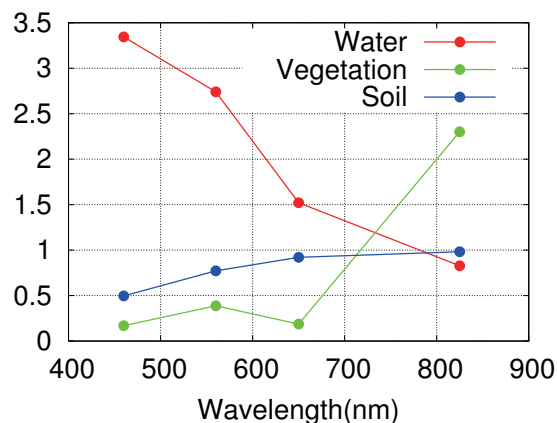

Figure 3: The three standard patterns of UPDM for ALOS/AVNIR-2 sensor.

least squares method using the equation 5. The standard patterns for ALOS/AVNIR-2 sensor are shown in Figure 3.

The modified vegetation index based on UPDM was determined as follows:

$$MVIUPD = \frac{(C_v - 0.2C_s - C_4 - C_w)}{C_w + C_v + C_s}. \qquad (9)$$

It is determined to have linear relationship with vegetation cover and with the quantity of photosynthesis (XIONG Yan 2005, L.F.Zhang et al., 2004).

4 RESULTS AND DISCUSSION

4.1 Characteristics of reflectance and UPDM coefficients of land cover objects for pan-sharpen image

The characteristics of reflectance for typical land cover objects are studied for pan-sharpen image and original AVNIR-2 image. The reflectance of water, soil, and evergreen forest are shown in Figure 4 (a), (b) and (c), respectively. Red line shows the pan-sharpen of summer image, and blue that of winter image. Green line shows the original AVNIR-2 of summer image, and pink that of winter image. The reflectance of pan-sharpen processing is higher than that of original AVNIR-2. Since the pan-sharpen processing was calculated using DN values, the original reflectance value was not constant. For using the reflectance values of pan-sharpen image, the improvement is needed for the pan-sharpen processing. Although the reflectance was not constant after the processing, reflectance pattern was not changed. Since the these data sets are used to calculate UPDM coefficients.

The results of UPDM coefficients calculation using the same samples of Figure 4 is shown in Figure 5. The three coefficients of water, soil, evergreen forest are shown in Figure 5 (a), (b) and (c), respectively. Line colors meaning is the same as in the case of Figure 4. For the water samples, three coefficients values are lower than 0.04. For soil samples, soil coefficients are highest among three coefficients. For vegetation samples, vegetation coefficients are highest among three coefficients.

4.2 Classification threshold determination

In order to determine the classification threshold, relationships among coefficients and vegetation index MVIUPD are studied. The relationship between MVIUPD and the sum of three coefficients, MVIUPD and soil coefficients, and soil coefficient and the
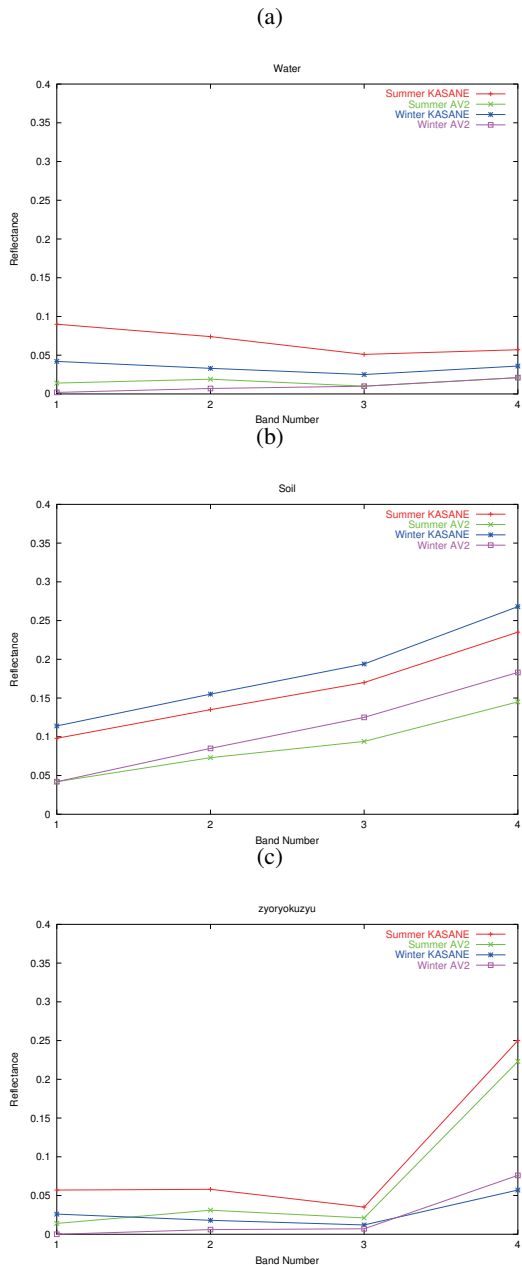
(a)

Water

(b)

Soil

(c)

zyoryokuzyu

Figure 4: Reflectance for water samples (a), soil (b) and forest (c).

(a)
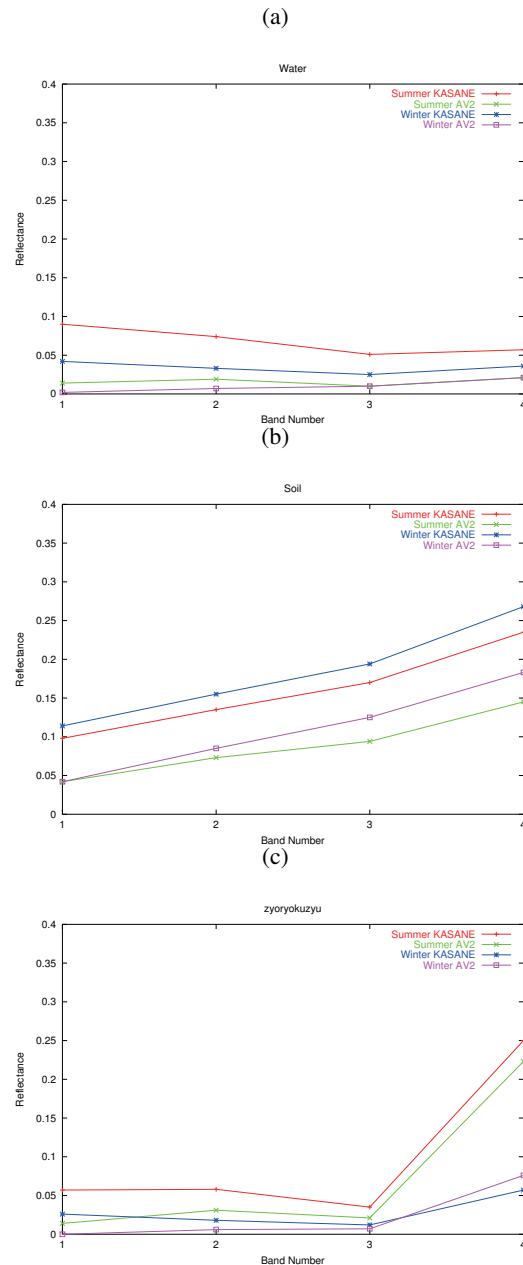
Water

(b)

Soil

(c)

zyoryokuzyu

Figure 5: UPDM coefficients for water samples (a), soil (b) and forest (c).

sum of three coefficients are shown in Figure 6 (a), (b) and (c), respectively. As shown in Figure 6 (a), water samples (dark blue for summer and light blue for winter) are clustered MVIUPD lower than 0. and the sum of three coefficients are lower than 0.05. As shown in Figure 6 (b), soil samples (red for summer) are clustered vegetation coefficients lower than 0.15 and MVI-UPD lower than 0.6 and higher than -0.2. As shown in Figure 6 (c), evergreen samples are clustered soil coefficients lower than 0.01. Yellow plots are samples of deciduous in winter. They are divided from soil samples using the function of the soil coefficients.

Using these characteristics, the classification threshold were determined as follows. Firstly, water area is classified with the condition of MVIUPD < 0 and MVIUPD > -0.6 and the sum of three coefficients are higher between from 0 to 0.05 for summer or winter image. Secondly, soil area is classified with the condition of MVIUPD < 0.6 and MVIUPD > -0.2, and $C_v < 0.6$

and MVIUPD > -0.2 for summer or winter image. Thirdly, deciduous forest area is classified with the condition of $C_s^{winter} \geq$ 0.01 and the sum of coefficients are higher than $1.84 \times C_s$ -0.02. Finally, evergreen area is classified with the condition of -0.05 > $C_v < 0.01$.

4.3 Classification results and validation

The mapping result is shown in Figure 7. In the figure, green area shows evergreen forest, pink deciduous forest, black soil, blue water white cloud. Dark blue line shows the ridge. The tributaries of Miyagawa River were not detected, because of the tributaries being too thin. Although there are cloud noise, deciduous area of A are larger than that of B. This result is roughly consistent with the forest management information in 2003. Although quantitative validation is needed, we can consider pan-sharpen image of reflectance is useful for mapping with high spatial resolution.
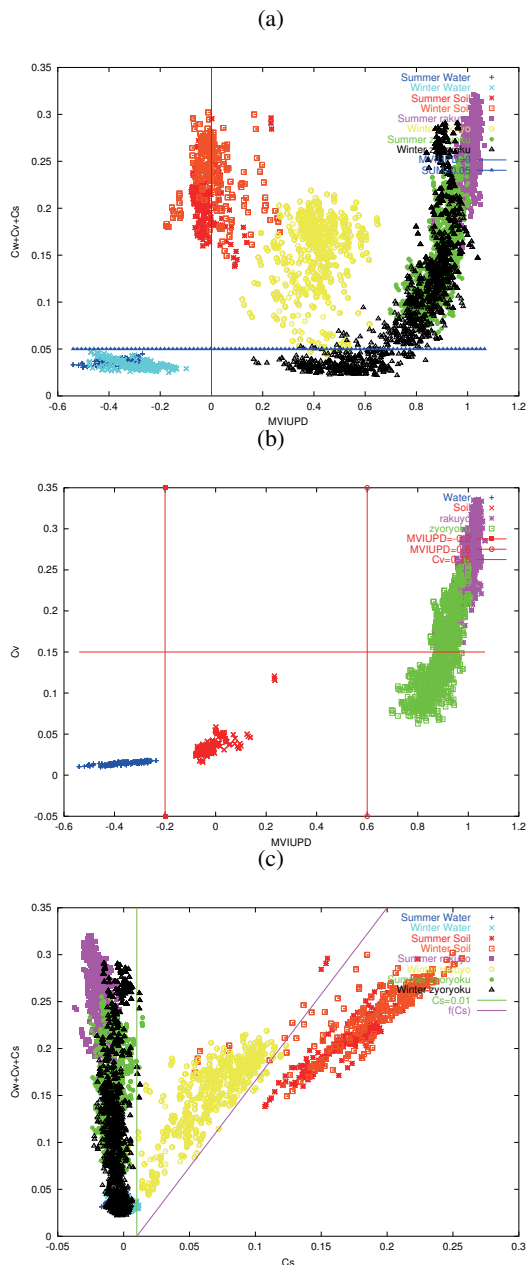
(a)

(b)

(c)

Figure 6: The relationship between (a) MVIUPD vs. the sum of three coefficients, (b) MVIUPD vs. soil coefficients, and (c) soil coefficient vs. the sum of three coefficients.

5   CONCLUSIONS AND FUTURE WORK

Firstly, the pan-sharpen image was processed using AVNIR-2 and PRISM data. Each band's Digital Number (DN) value of AVNIR-2's band is calculated using DN of PRISM and AVNIR-2. The reflectance of pan-sharpen image is calculated from DN values. UPDM method is applied to the set of re-calculated reflectance. Using the coefficients of UPDM and vegetation index, evergreen forest and deciduous forest were classified using two seasonal data. These results are compared with forest resource information. The tendency was agree with each other, although detailed validation is needed. From these results, the UPDM method can be applied to pan-sharpen image and the pan-sharpen image can be used for vegetation type classification. In the near future, calculation methods with retaining the original reflectance should be improved.
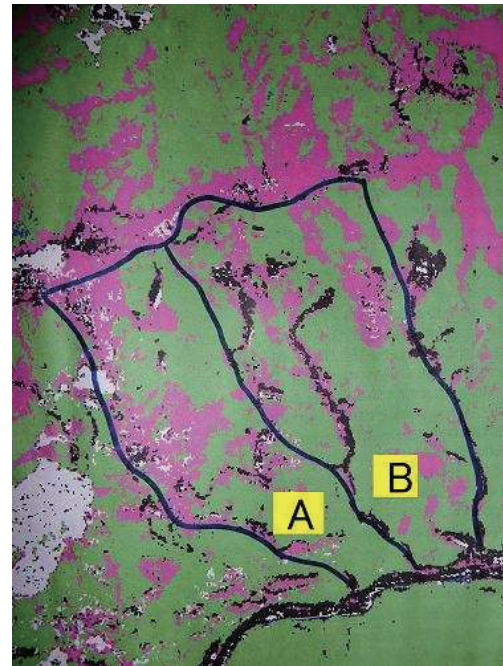

Figure 7: The mapping result for study site. green area shows evergreen forest, pink deciduous forest, black soil, blue water white cloud. Dark blue line shows the ridge.

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