ANALYSIS OF DROUGHT PHENOMENA USING MODIS NORMALIZED DIFFERENCE VEGETATION INDEX AND LAND SURFACE TEMPERATURE PRODUCTS

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ABSTRACT:

As global warming proceeds, South Eastern Asia is undergoing drought, and the harshness of drought in the middle area of Korea is increasing. Especially, there has been the worst spring drought in 2001 since the first meteorological observation, and the damages caused by that drought are being analysed in various ways. In this study, spectral indices derived from satellites are used to examine 2001 spring drought, and the application of MODIS Data products as the quantitative tool to analyse drought in the future is examined.

Key Word: Spring-Drought, MODIS, NDVI, EVI, LST

1. INTRODUCTION

Drought is the unusual meteorological phenomenon which lasts so song without rain causing problems with growth of plants or water supply. Drought is the complex natural disaster creating environmental, social, financial losses around the world. As it develops slowly widely without clear beginning or end, it is difficult to predict drought (Wilhite and Glantz, 1985).

Korea has droughts with 5~8-year cycle. For recent 10 years, there were summer droughts between 1994 and 1995, and spring droughts between 2000 and 2001. Especially, 2001 spring drought was exasperated to cause a big social problem with short of agricultural water and drinkable water. Though there are differences in intensity of spring drought, since the southern part of Korea, Chungchung and Gyunggi north have chronic spring drought, we need to develop effective measures for this problem.

Nowadays satellite images are used to observe and map drought, and there have been many studies to analyze drought with vegetation indices(VIs) and Land surface temperature(LST).

There have been studies with VIs from satellite images: analysis of drought area(Yang et al, 1998), examination of relationship between accumulated rainfall and VIs(McVicar & Bierwirth, 2001) and study of drought indices which evaluate drought intensity (Ji & Peters, 2003). Also in Korea, there are many studies with NDVI(Normalized Difference Vegetation Index) from artificial satellite, NOAA AVHRR (Kim, 2003; Shin, 2005; Park et al, 2005; Kwon et al, 2005).

In this study, MODIS VIs and LST with superior space resolution and sensibility to AVHRR-NDVI are used to 2001 spring drought by a unit zone.

2. MODIS DATA PRODUCT

MODIS(Moderate Resolution Imaging Spectroradiometer) sensor of Terra, the artificial satellite launched in 2000 as a part of EOS program, has been used to monitor changes in biological status of the earth, providing image products on vegetation, clothing, atmosphere and ocean. MODIS Vegetaton Index Products are used to analyse biological structures and changes in bio-climate factors and biophysical factors. Two vegetation indices of MODIS are NDVI and Enhanced Vegetation Index(EVI) which provide 1-Km, 500-m, and 250-m resolution products over the whole earth every 16 days. NDVI is used for diverse vegetation monitoring such as NPP prediction of various types of vegetation, monitoring of vegetations according to their breeding period, prediction of certain plant' s growing period and dry period; and prediction of LAI and FPAR.

EVI has been developed to use plant signals in high biological value areas by improved sensibility. Also, EVI enables us to separate soil reflection value which affects plant reflection values by using atmosphere effect correction constant, soil effect correction constant and effective indices to remove aerosol, and monitor vegetation more thoroughly by reducing atmosphere effects.

Compared to AVHRR-NDVI , MODIS-NDVI has more improved space resolution and reflects more reliable vegetation status by using narrow bandwidth ultra violet and near infrared (Huete 2002).

LST(Land Surface Temperature) is the physical factor that controls the energy and vapor exchange between surface and atmosphere, as it has a faster reaction for drought than vegetation indices, it is widely used to monitor drought and evaluate surface water content.

3. STUDY AREA

In this study, drought analysis is done according to irrigation zone and weather data is used. Ansung River basin of Chungchungnamdo and southern Gyunggi and upper Namhan river basin of Eastern Gangwon are selected for this study, and downfall is recorded according to observation points and year. The typical plain river is Ansung basin composed of 50% agricultural field with average altitude 60m. In 2001 it was categorized as the severe drought area based on observation in Ichun, Chunan and Suwon from May to June 16th 2001. At that time it had 16~15% of average rainfall and was recorded the lowest rainfall since the first observation.

Upper Namhan river basin located at average altitude 741m is ranked 10th place of rainfall among 95 irrigation areas from March to May. In 2001 it was categorized as less severe drought area compared to other areas. Five observation centers in upper Namhan river showed 33~52% rainfall and three of them showed the lowest record.

Average rainfall of this two basin has been calculated by using IDW(inverse distance weighted interpolation) with observation data. Table 2 show landcover types and area about two study area.

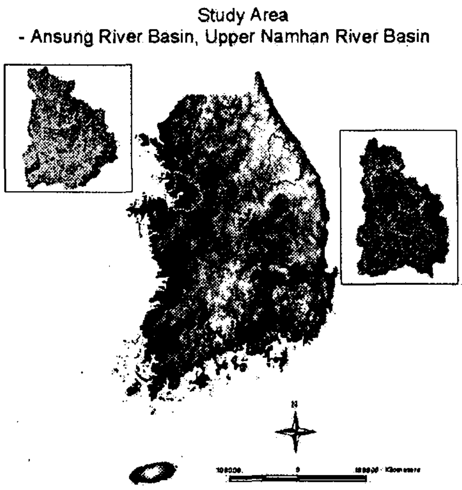


Figure 1. Study Area

Table 1. Soil structure of study areas

	Ansung River Basin		Upper Namhan River Basin	
	Area(㎢)	%	Area(㎢)	%
Water	39.90	2.05	6.56	0.27
Urban	184.65	11.17	11.57	0.47
Bare	2.82	0.17	0	0.00
Wet land	56.39	3.41	31.65	1.30
Grass	108.35	6.56	71.27	2.92
Forest	601.77	36.41	2056.74	84.25
Farmland	664.78	40.22	270.06	11.06

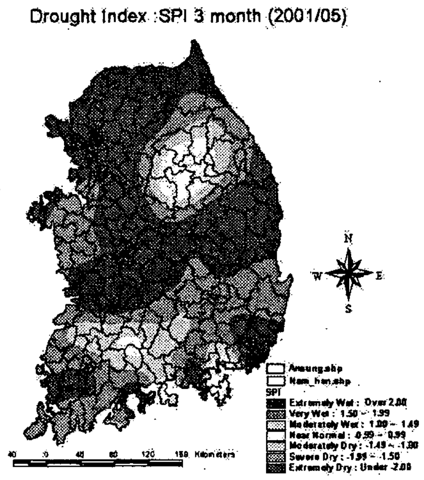
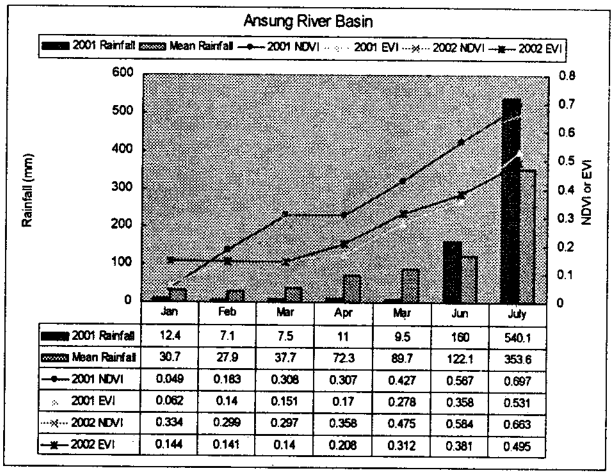


Figure 2. 2001 drought depth

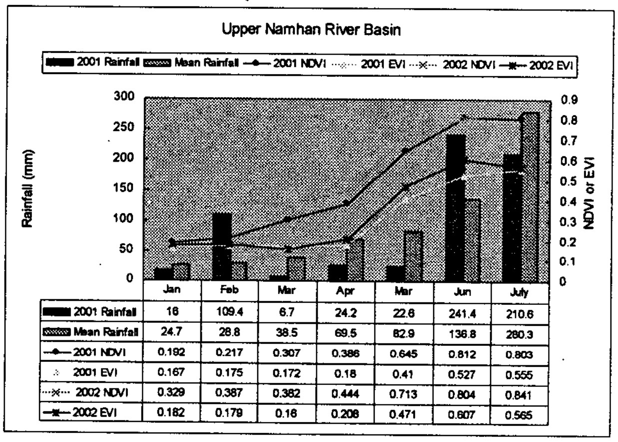
4. DROUGHT ANALYSIS WITH MODIS NDVI AND LST

Since MODIS Data Products began to be provided from February 2000, it is difficult to find out meteorological change factors through long-term observation. Therefore, for rainfall with direct impacts on drought, the closest rainfall to average rainfall was used to compare. As we examined rainfall from 2002 to 2005, we selected 2002 rainfall for average year, and compared this to 2001 rainfall and vegetation indices.

Fig. 3 shows average rainfall/vegetation indices and 2001 rainfall/vegetation indices of Ansung river basin and upper Namhan river basin.



	Jan	Feb	Mar	Apr	Mar	Jun	July
2001 Rainfall	12.4	7.1	7.5	11	9.5	160	540.1
Mean Rainfall	30.7	27.9	37.7	72.3	89.7	122.1	353.6
2001 NDVI	0.049	0.183	0.308	0.307	0.427	0.567	0.697
2001 EVI	0.062	0.14	0.151	0.17	0.278	0.358	0.531
2002 NDVI	0.334	0.299	0.297	0.358	0.475	0.584	0.663
2002 EVI	0.144	0.141	0.14	0.208	0.312	0.381	0.495



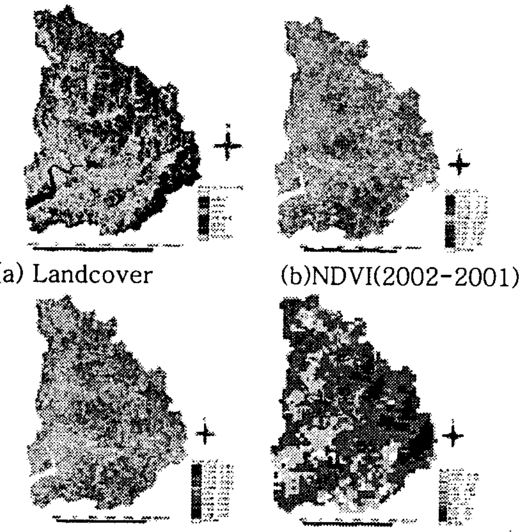
	Jan	Feb	Mar	Apr	Mar	Jun	July
2001 Rainfall	16	109.4	6.7	24.2	22.6	241.4	210.6
Mean Rainfall	24.7	28.8	38.5	69.5	82.9	136.8	280.3
2001 NDVI	0.192	0.217	0.307	0.386	0.645	0.812	0.803
2001 EVI	0.167	0.175	0.172	0.18	0.41	0.527	0.555
2002 NDVI	0.329	0.387	0.382	0.444	0.713	0.804	0.841
2002 EVI	0.182	0.179	0.16	0.208	0.471	0.607	0.565

Figure 3. Changes in monthly rainfall and vegetation indices

As the chart shows, upper Namhan river basin with a wider forest has high vegetation indices on the whole compared to Ansung river basin. As we compared 2002 VIs and 2001 VIs during drought (March ~ May), May, which had the severest drought depth, showed more than 10% under prediction of VIs. Also, spring change patterns of rainfall and vegetation shows there is a relationship between rainfall and vegetation with around one month lag time.

When it comes to LST, it was higher in drought season than in non-drought season. Ansung river basin has 0.325℃ difference, and upper Namhan basin has 0.391℃ difference. With short of rainfall, high surface temperature is also considered to worsen drought because high surface temperature leads high evaporation values.

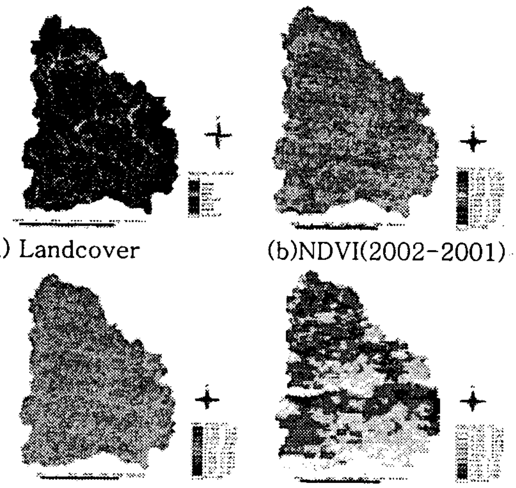
Based on these results, Fig 5 and 6 show special difference of vegetation indices and LST between average year and drought year.



(a) Landcover (b)NDVI(2002-2001)

(c)EVI(2002-2001) (d)LST(2002-2001)

Figure 5. Ansung river basin in average year and drought year



(a) Landcover (b)NDVI(2002-2001)

(c)EVI(2002-2001) (d)LST(2002-2001)

Figure 6. Upper Namhan river basin in average year and drought year

From Fig. 5, areas in Ansung river with over 0.048 NDVI difference between the average year and the drought year can be found. Only forest areas have higher NDVI changes than average, and agricultural areas, which take up 40% of basin, have little difference between the average year and the drought year. As documents say the latest possible rice transplanting period is June 5 for Gyunggi and Gangwon, June 20 for southern Gangwon, Gyunggi where Ansung river belongs had 90% transplanting and Gangwon where Upper Namhan river runs had 79% transplanting compared to the same period of the average year. Therefore, most agricultural fields show no NDVI difference since transplanting is over by that time.

It is clear that changes of EVI and LST in forest areas are prominent. While there was a huge difference in NVDI in Ansung river basin, there was not constant NVDI in upper Namhan river basin or forest areas though it has over 80% forest areas. The reasons behind this phenomenon are presumed that over 90% upper Namhan river basin is covered with conifer and mixed forest while 60% Ansung river basin is covered with broad-leaf trees. And there should be further study on this issue.

5. CONCLUSION AND FUTURE WORK

In this study, VIs and LST of the drought year and the average year were compared, and conclusions are as follows.

First, NDVI EVI, and LST can be used to analyze drought. NDVI, EVI and LST have an inverse relationship.

Second, As agricultural usage in spring is different, there is a small difference in VI in agricultural field compared to forest.

Third, the area(Ansung river basin) decided as severe drought area by accumulated rainfall has less difference in Vis and LST than the area with high accumulated rainfall(upper Namhan river basin). Through this result, we found out that VIs and LST can be greatly affected by the landcover of basin.

In the future, based on quantitative comparison results, we will verify relationships between VIs and LST on periodical surface status, and find out relationships between rainfall and vegetation indices according to species of trees

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