ANALYSES OF CLOUD COVER AND EFFECTS ON THERMAL POTENTIAL VARIATION

Ahmet TOKGÖZLÜ

Süleyman Demirel University, Faculty of Science, ISPARTA, TÜRKİYE,

tokgozlu@fef.sdu.edu.tr

Zafer ASLAN

Beykoz Logistic School of Higher Education, Kavacık, ISTANBUL, Türkiye,

zaferaslan@beykoz.edu.tr

AIM

- to analyze the climatologic variation effects on cloud cover,
- to analyze cloud cover role on thermal potential in selected areas in Turkey,
- to compare North Atlantic Oscillation (NAO) anomalies with cloud cover and precipitation values,
- to define the role of large scale effects like El Nino, La Nina and NAO on soaring conditions,
- to apply Wavelet Tools (1D Wavelet packets and continuous wavelets) on historical cloud cover values in North western and central parts of Turkey.

OUTLINES

- **INTRODUCTION**
- **MATERIAL AND METHODS**
- **WAVELET TECHNİQUES**
- **ANALYSIS**
- **MONTHY AND ANNUAL VARİATİON OF CLOUD COVER**
- **ANALYSİS OF NORTH ATLANTİC OSCİLLATİON EFFECTS**
- **RESULTS AND CONCLUSION**

INTRODUCTION

Olofsson and his group describe a technique to define the thermal height and the lowest value of the top of dry thermals and cu-base, (Olofsson and Olsson, 2006).

Evaluating weather predictions using glider flights have been analyzed by determining convective boundary layer (CBL) depth, glider climb rates, wind velocity at 1000m amgl and onset of convective clouds, (Hindman, 2007).

For thermal forecasting, sensible heat flux, terrain characteristics, temperature advection, wind veloctiy and cloud cover are listed as important variables.

INTRODUCTION (cont.)

Ionosphere

The purpose of wavelet analysis is to find out the cluster pattern of smooth versions of variables. Wavelet techniques which have been commonly used in the engineering problems in recent years are an alternative method to FFT algorithm.

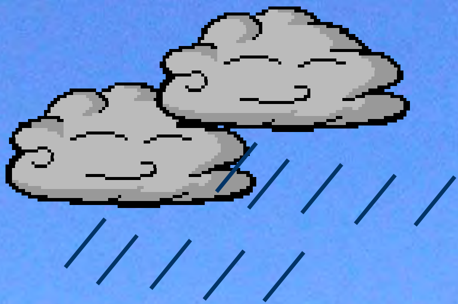
Functions can be approximated to any prescribed accuracy with a finite sum of wavelet transforms. The wavelet transform decompose a signal into a set of special basis functions that are wavelet functions.

INTRODUCTION (cont.)

The wavelet expansion gives a time – frequency localization of the signal. This specification means that the most of the energy of the signal is well represented by a few set of wavelet basis functions. This can help in signal identification.

After several introductions to apply wavelet in monthly and annual variations of cloud cover data in Central Anatolia and Marmara Region, small, meso and large scale effects on fluctuations are being demonstrated. Wavelet analyses helps to explain cross interactions between variables. Results of this paper can be used to determine changes in climate, thermal potential and roles of El Nino and NAO.

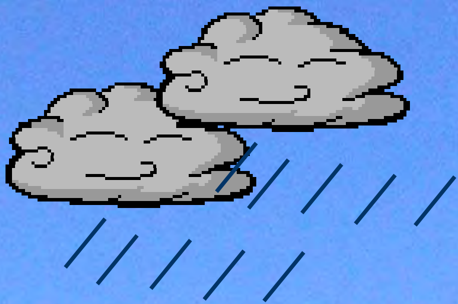
MATERIAL AND METHODS



Study Area

Study area covers cloud cover observations of climatological stations at the Marmara Region and Central Anatolia.

MATERIAL AND METHODS



Data

Monthy and annual average values of cloud cover observations between 1970 and 2007 at Kandilli (Istanbul; 40°55' N, 29°05' E, h=.114m above msl), Eskişehir (39° 30' N, 30° 31' E, h=800m above msl) and Isparta (37°46' N, 30°33' E, h=997m above msl) have been analysed.

Methods

This study is mainly based on wavelet techniques and it’s applications on cloud cover data.

Wavelet Techniques

In this section we shall give some basic definitions about wavelet transform. Wavelet is families of small waves generated from a single functions f(t) which is called mother wavelet. A sufficient condition for a function f(t) to qualify as a mother wavelet is given as below; (Meyer, 2000 and Can et al., 2004).

$$\int_{-\infty}^{\infty} |f(t)|^2 \, dt < \infty$$

(1a)

The Fourier transform F of f(t) is defined as

$$F(w) = \int_{-\infty}^{\infty} f(t) e^{iwt} \, dt$$

(1b)

Wavelet Techniques (Cont.)

A function ψ(t) satisfying the following condition is called a continuous wavelet:

$$\int_{-\infty}^{\infty} \left|\psi(t)\right|^2 dt = 1$$

(2a)

and

$$\int_{-\infty}^{\infty} \left|\psi(t)\right| dt = 0$$

(2b)

Higher order moments may be zero, that is,

$$\int_{-\infty}^{\infty} t^k \psi(t) dt = 0$$

for k=0,….,N-1

Wavelet Techniques (Cont.)

The wavelet transform of f(t) denoted by W_f (a,b) is defined as:

$$W_f(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} \psi((u-b)/a) f(u) du = \int_{-\infty}^{\infty} f(u) \psi_{a,b}^{(u)} du$$

(3)

$$\psi_{a,b}^{(u)} = \frac{1}{\sqrt{a}} \psi((u-b)/a)$$

Where

(4)

Here “a” is a scaling parameter, b is a location parameter and

$\psi_{a,b}^{(u)}$ is often called continuous wavelet (or daughter wavelet)

Wavelet Techniques (Cont.)

If $\psi_{j,k}^{(u)} = 2^{j}\psi\left(2^{j}u - k\right)$ is an orthonormal system, that is;

$$\int_{-\infty}^{\infty} \psi_{j,k}^{(u)} \psi_{m,n}^{(u)} du = \delta_{j,m}\delta_{k,n}$$

(5)

Then ψ is a wavelet and the admissibility condition

$$C_{\psi} = 2\pi \int_{-\infty}^{\infty} \left|\psi(w)\right|^{2} / w\, dw < \infty$$

(6)

is satisfied.

$$\int_{-\infty}^{\infty} \left|W_f(a,b)\right|^{2} db = W(a)$$

$\left|W_f(a,b)\right|^{2}$ is called the scalogram of the function *f* and it can also be interpreted as energy density, (Can et al., 2005),

Wavelet Techniques (Cont.)

Which is called the wavelet variance or wavelet spectrum. It may be observed that the scalogram can be represented either as three-dimensional plot or as a 2-dimensional grey scale image, (Siddiqi et al. 2002). Here parameters a and b represent respectively the scaling factor and the location in time, (Siddiqi et al., 2005). In the following sections f(t) will be considered as monthly or annual average values of cloud cover over selected areas in Turkey.

Table 1 presents climate variability and related time scale values as months or years. In this paper by applying wavelet techniques climate variability of cloud cover and its time scale will also been defined.

Climate Variability

Climate Variability	Time Scale
Inter-monthly fluctuations	2,0-3,1 months
Semi-annual cycle	4,7-7,4 months
Residual annual cycle	1,3-16,0 months
Inter-annual variations	2,2-3,5 years
Sub-decadal variations	5,3-8,3 years
Decadal to centennial changes	10,6-110,7 years

ANALYSIS

This part is related with analysis of clould cover data and wavelet technique applications.

Monthy and Annual Variation of Cloud Cover

Figure 1 (a) and (b) show temporal variation of cloud cover in Eskişehir. In recent year cloud cover values have a decreasing trend. Standard deviations of cloud cover data and mean deviations are smaller in the midle part of the study period.

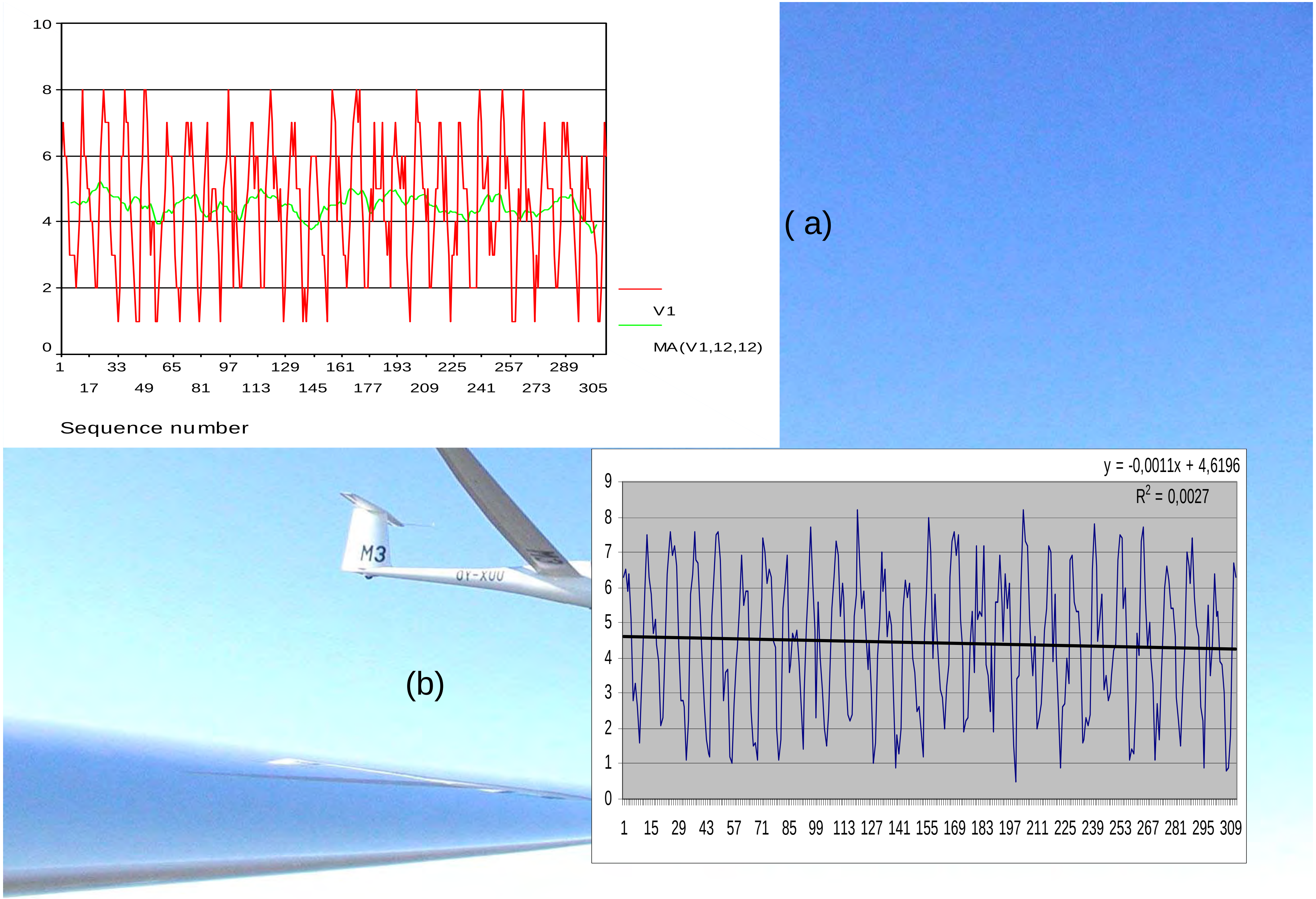
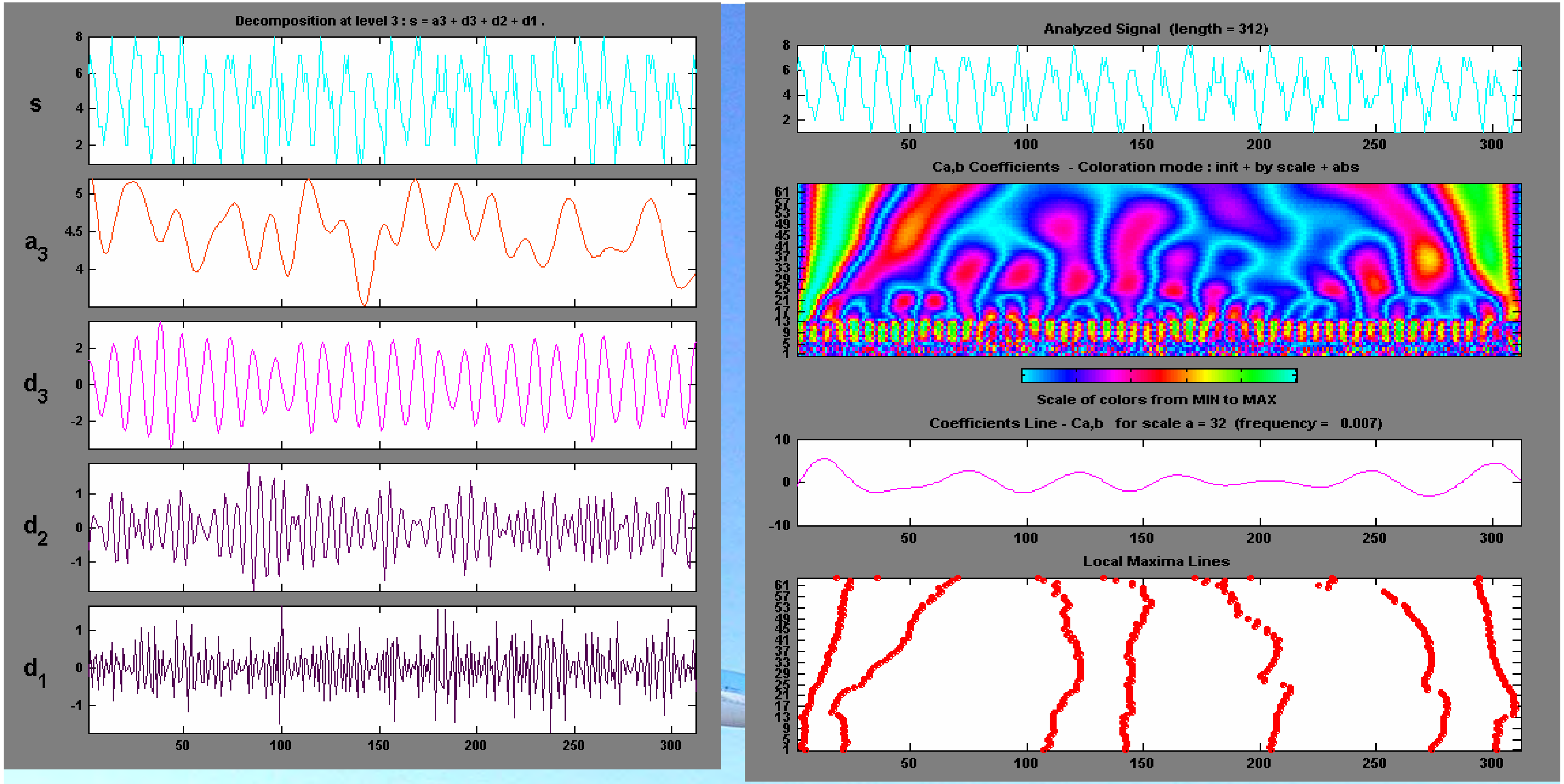


Figure 1 (a, b)- Temporal variation of cloud cover in Eskişehir between (1982-2007), (a) moving averages for lag=12, (b) linear trend



(C)

(d)

Figure 1 (c,d) - Wavelet analysis of cloud cover values in Eskişehir between 1982 and 2007, (c) 1D wavelet analysis, dMeyer, Level 3; (d) 1D Continuous Wavelet Analysis, dMeyer, Sampling Period 3.

Monthy and Annual Variation of Cloud Cover

Figure 1 (c) and (d) present 1D wavelet and Continuous wavelet analyses of cloud cover values observed in Eskişehir between 1982 and 2007. Annual cycle (1,3-16 month) of cloud cover values and large scale effects on this variation are being observed. But in 1990, 1998 and 2007 in general small and meso scale fluctuatinos play an important role on cloud cover values.

Monthy and Annual Variation of Cloud Cover

Figure 2 presents annual variations of cloud cover data between 1975 and 2006. In genereral untill 1990's the more decreasing trend was observed than the last part of study period. Statistical analysis shows that there is a sufficient evidence to support of the linear correlation with α = 0

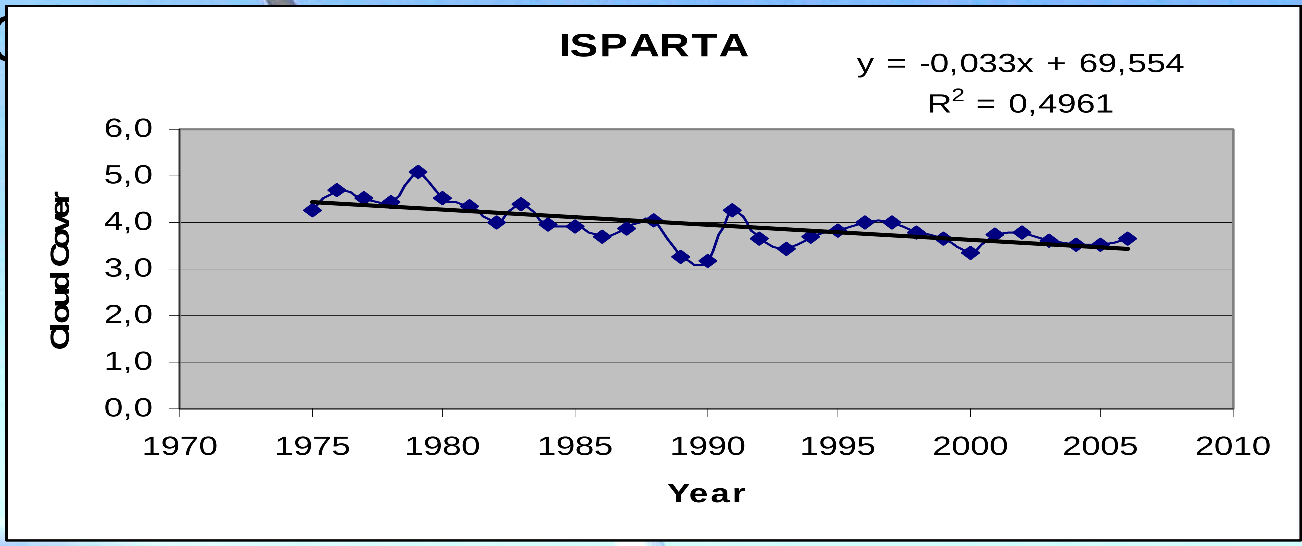


Figure 2(a)- Monthly variation of cloud cover values in Isparta (1975-2006)

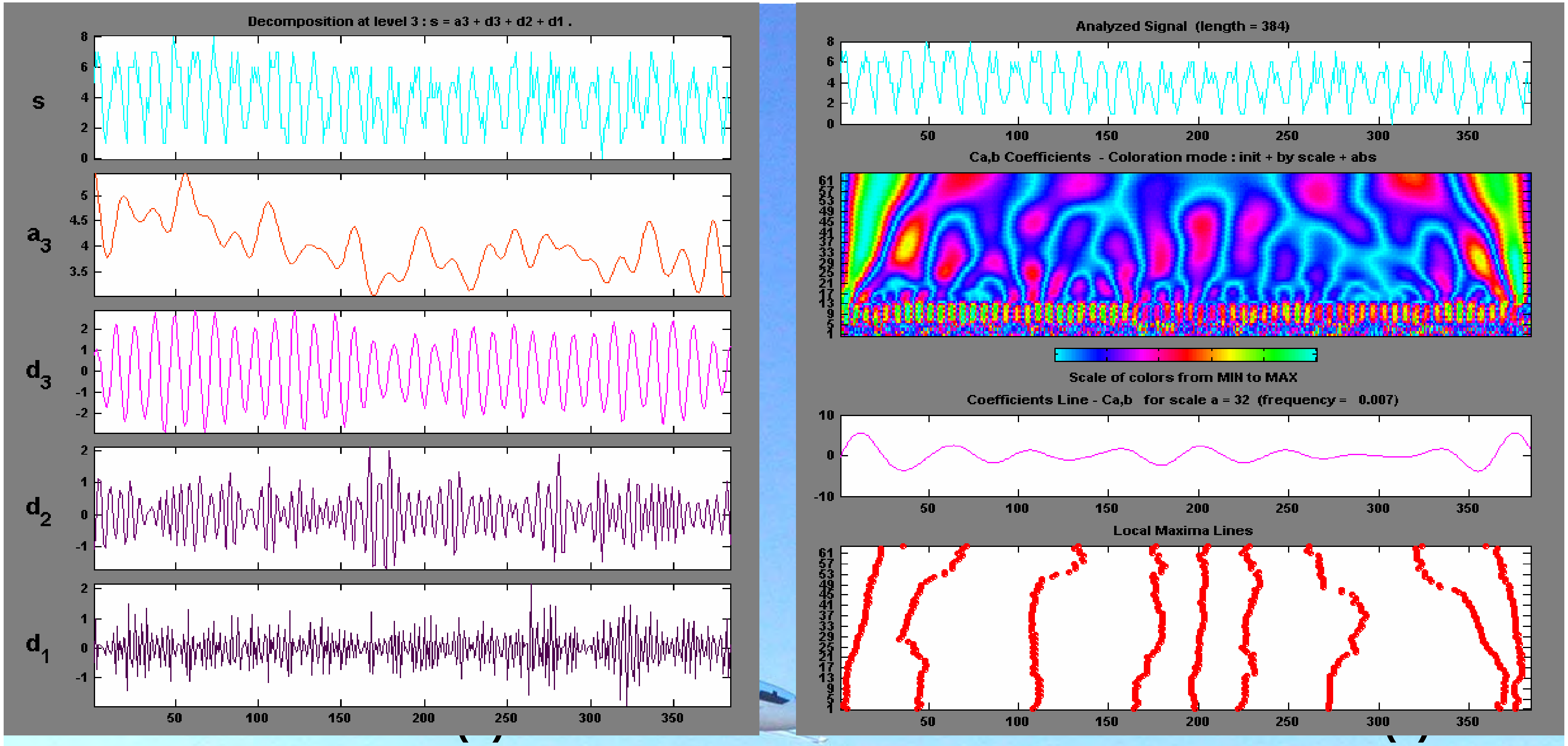
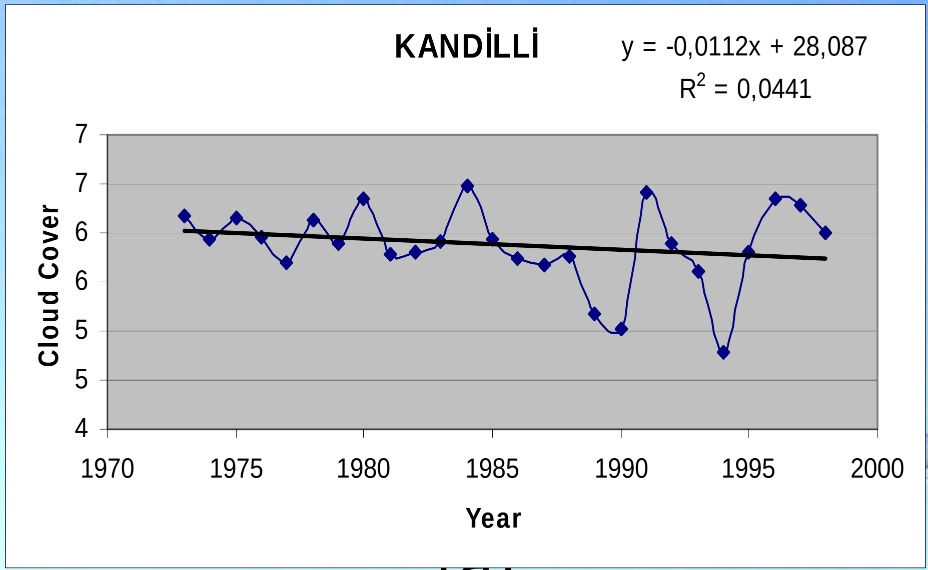


Figure 2 (b,c)- (b) 1D wavelet analysis of cloud cover values in Isparta, dMeyer, Level 3, (c)- Monthly variation of 1D continuous wavelet (dMeyer, Sampling period: 3) of cloud cover values in Isparta (1975-2006)

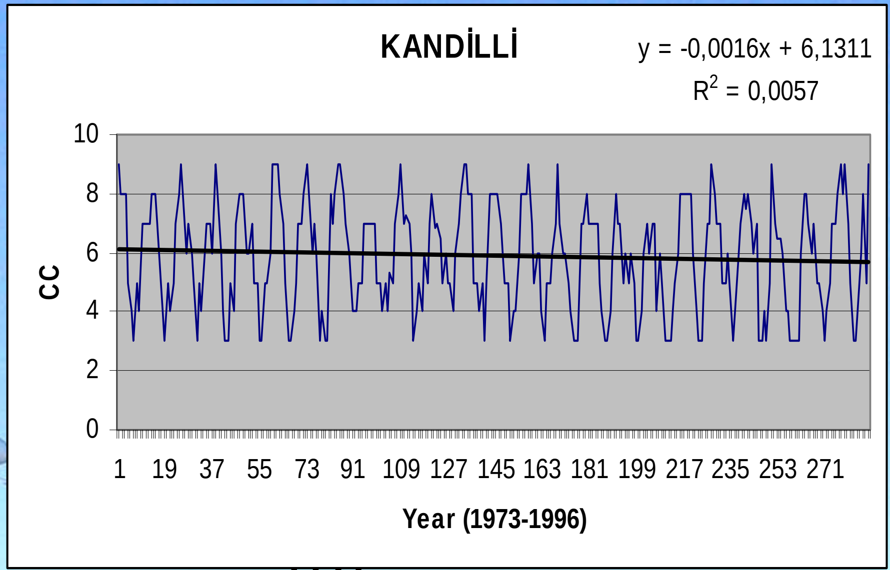
Figure 2b and 2c represent wavelet analyses of cloud cover data in Isparta. In the first part of study period, standard deviation values are larger than the values observed in the second part. In all periods, large and meso scale fluctuations play an important role on data. But, meso scale fluctuations role on cloud cover values are more effective between 1990 – 1992 and 1996-1998. These periods are accompanied by El – Nino

Monthy and Annual Variation of Cloud Cover

Figure 3 shows temporal variation of cloud cover values in İstanbul (Kandilli). It has a similar trend of cloud cover values as observed in Eskişehir and Isparta.



(a)



(b)

Figure 3 (a,b)- (a) Anunal average values and (b) - Monthly average values of cloud cover variations, (Kandilli; 1973-1996)

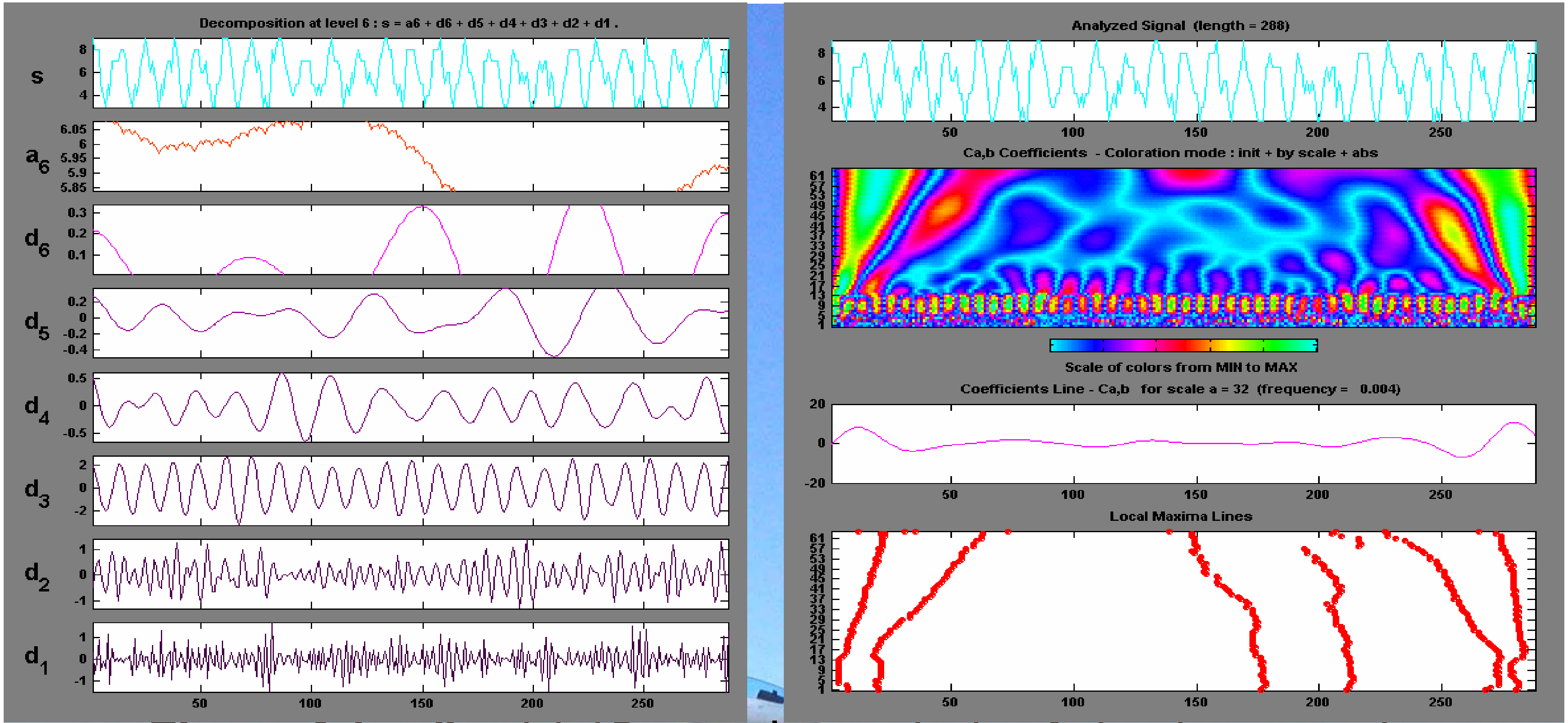


Figure 3 (c, d) – (c) 1D wavelet analysis of cloud cover values in Kandilli, dMeyer, level 3, (d)- Monthly variation of 1D continuous wavelet (dMeyer, Sample period: 3) of cloud cover values, (Kandilli; 1973-1996)

Similar decreasing trend and small, meso and large scale effects on cloud cover have been observed in and near vicinity of Kandilli.

Analysis of North Atlantic Oscillation Effects

Analysis of North Atlantic Oscillation temporal variations between 1950 and 2006 has been presented in Figures 4 (a-d).

Between 1992-2006, cloud cover valules in Isparta are smaller than the other part of the study period, (Figure 2a). NAO fluctuations show more positive anomalies beginning from 1990’s and this period corresponds lower cloud observations in study area. As a result, positive NAO anomalies cause decreasing value of precipitations in Eastern Anatolia.

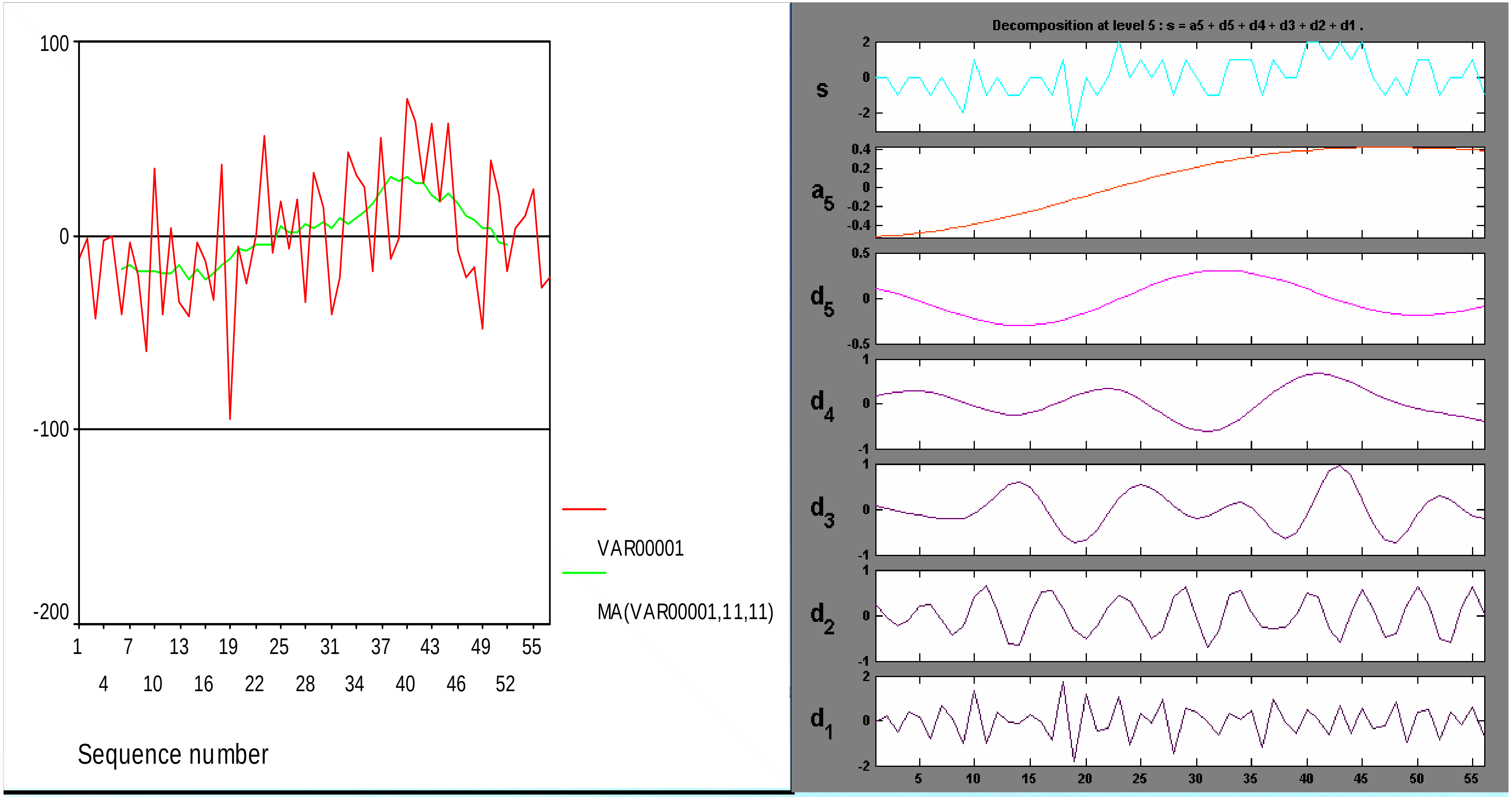


Figure 4 (a,b) - (a) – Temporal variation and moving averages of NAO

z-scores between 1950 and 2006. (b)- z-score, NAO, 1D

Wavelet, dMeyer, Level 5.

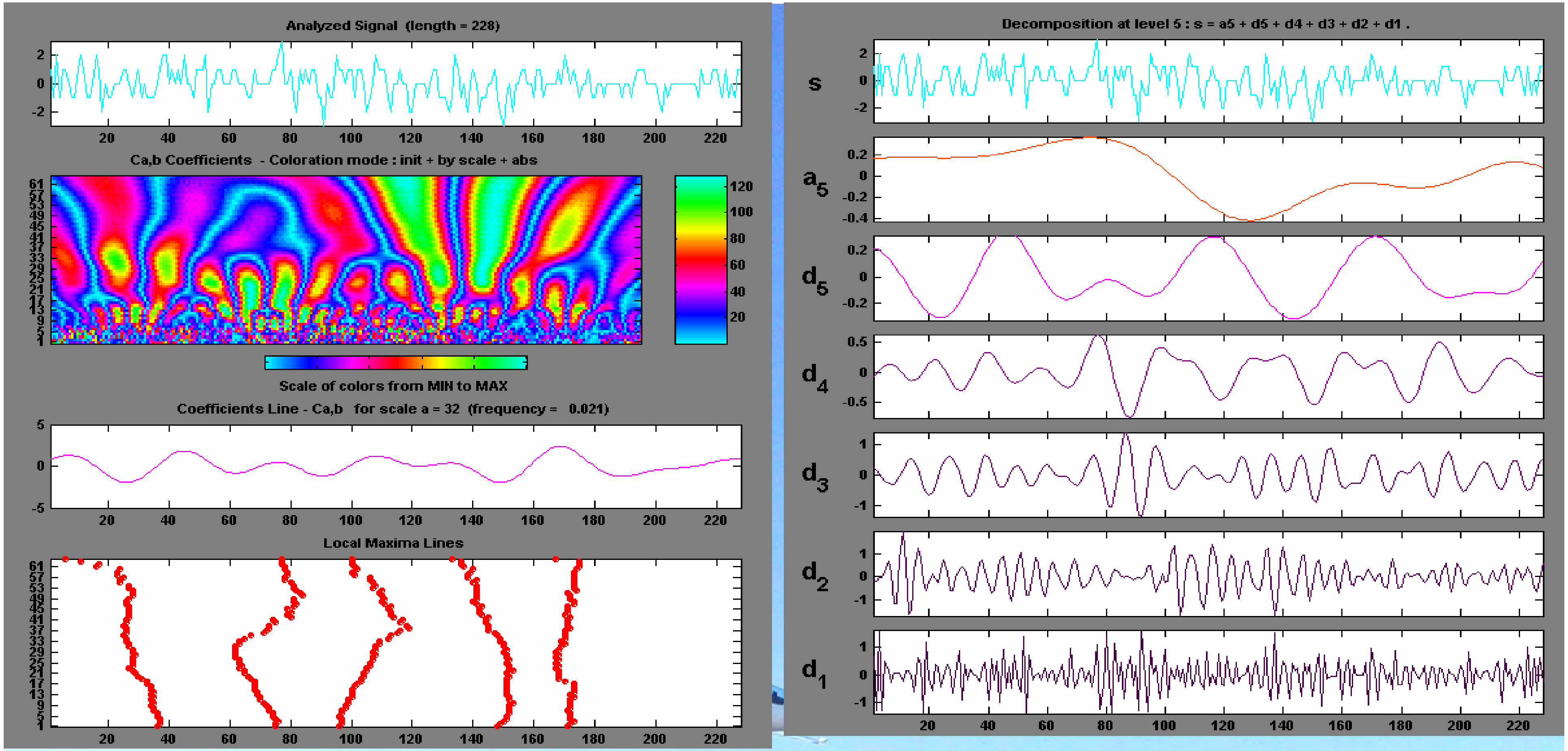


Figure 4 (c,d) – c) Continuous wavelet NAO Z-scores, 1986-2004 (dMeyer, Sampling period: 1), d) 1D Wavelet (dMeyer, level 5).

Meso scale effects have been observed between 1996 and 1998.

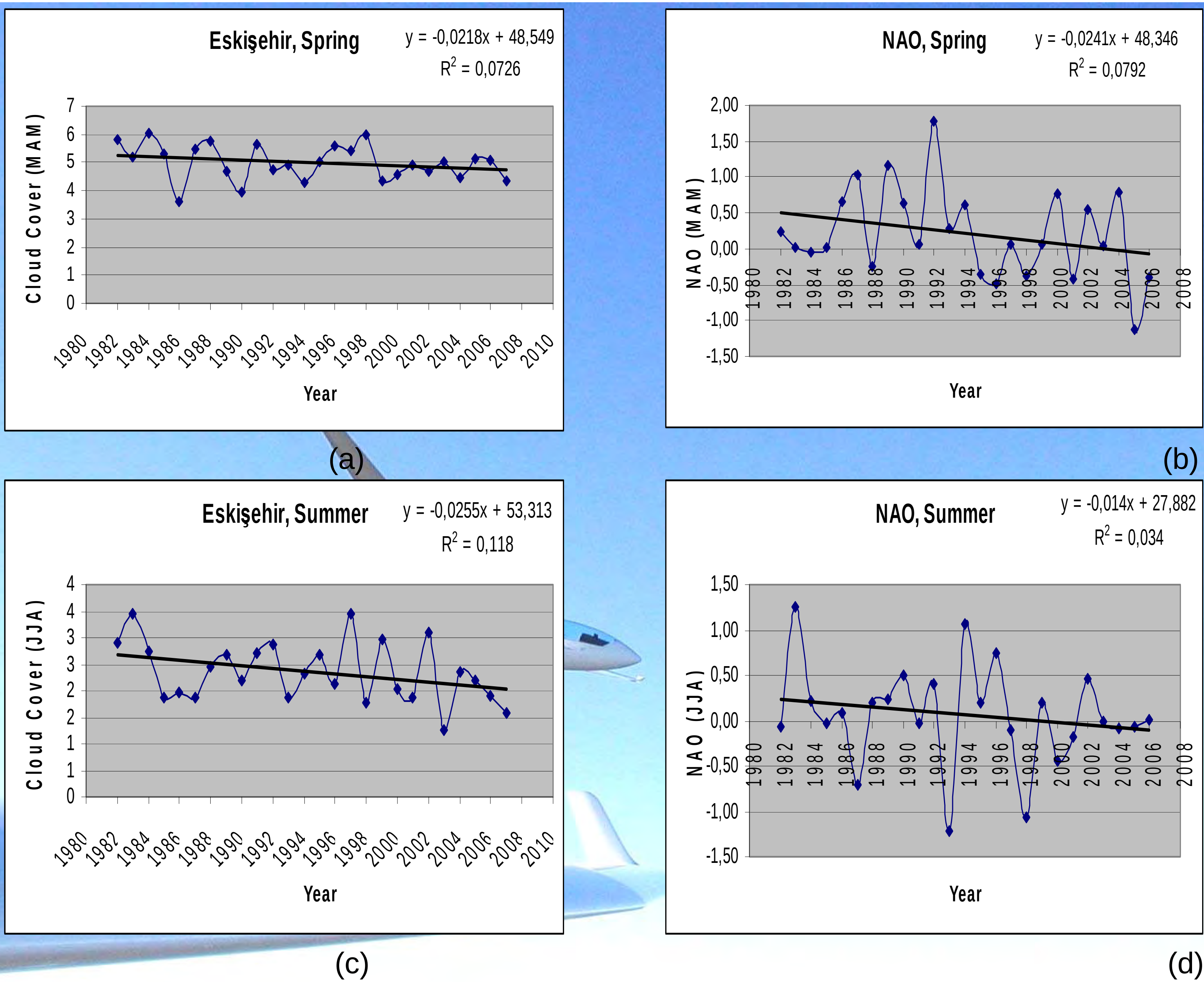


Figure 5- Seasonal Variations of Cloud Cover in Eskişehir between 1982 - 2006 and annual averages of NAO in spring(a and b), in summer (c and d).

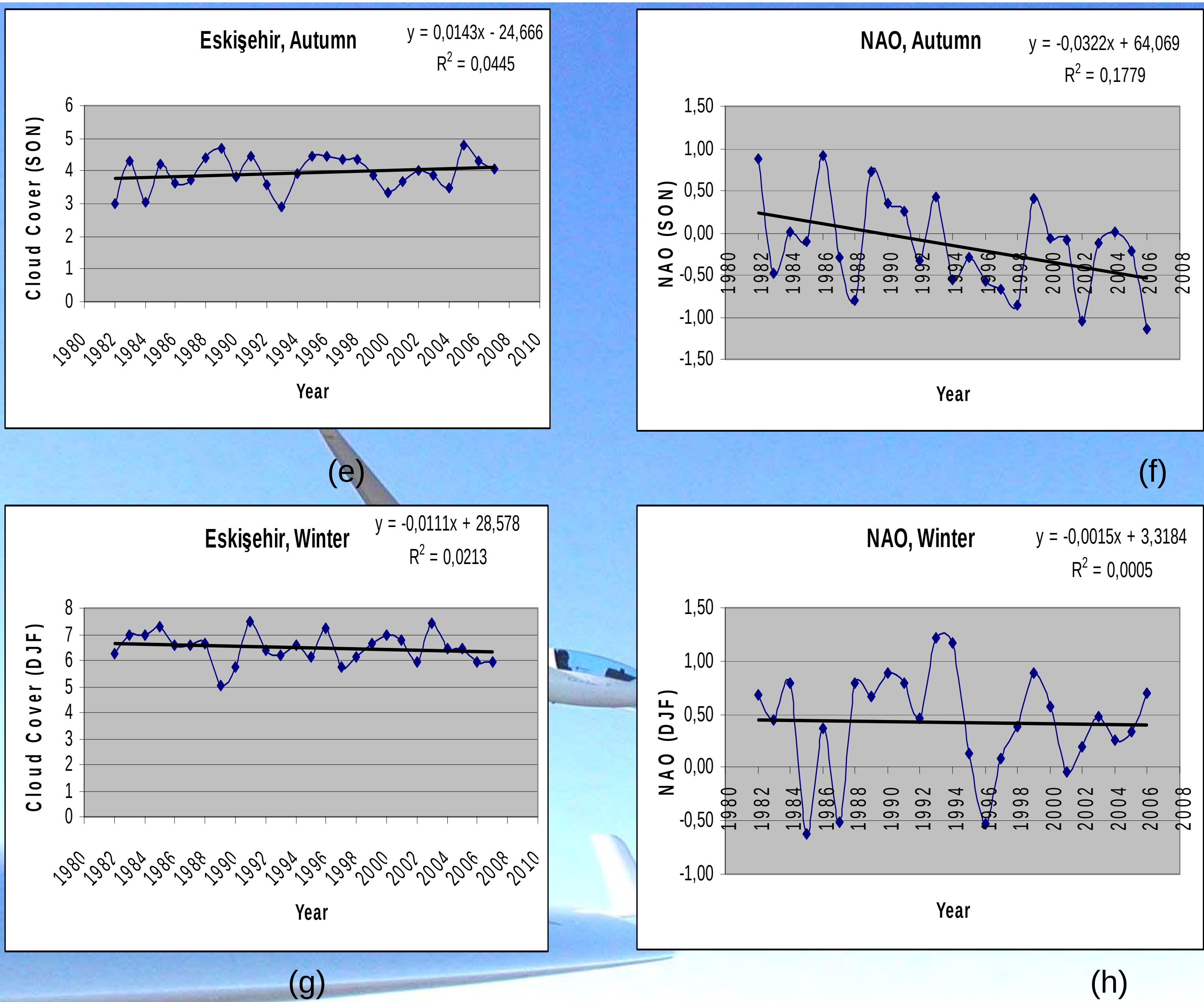


Figure 5- (continued), Seasonal Variations of Cloud Cover in Eskişehir between 1982 - 2006 and annual variations of NAO values, in autumn (e and f) and in winter (g and h)

Analysis of North Atlantic Oscillation Effects

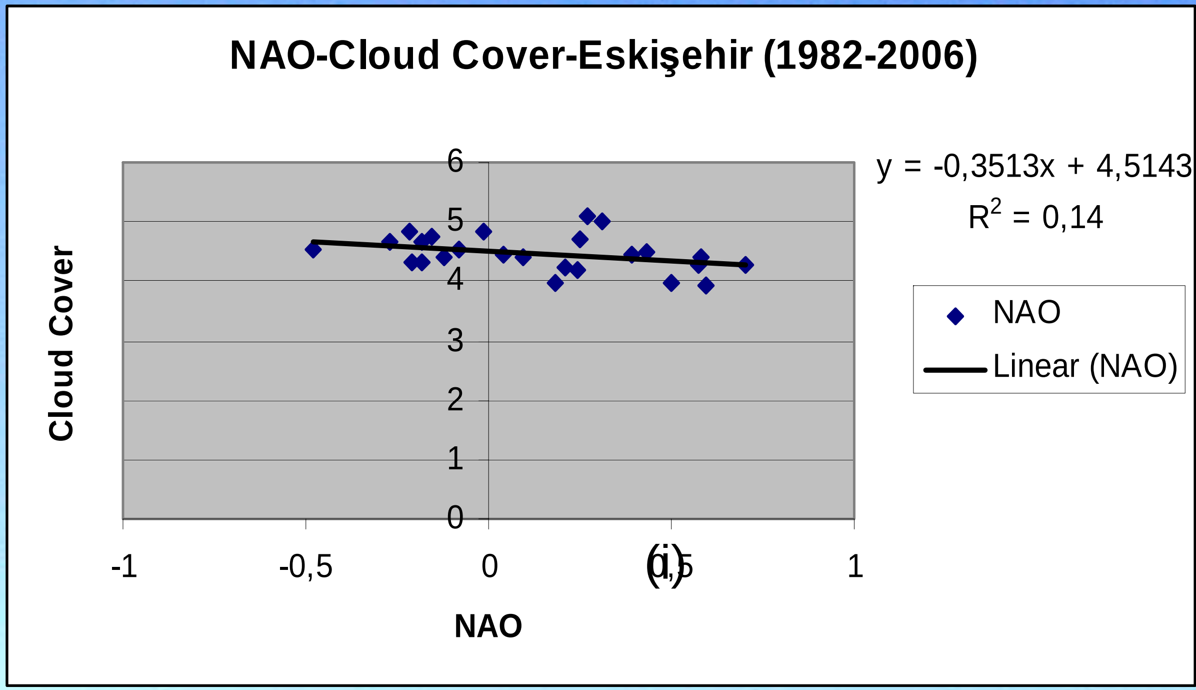


Figure 5- (continued), j) linear relation between NAO and Cloud Cover Values in Eskişehir, (1982-2006)

Analysis of North Atlantic Oscillation Effects (Cont.)

Some details on seasonal variations of cloud cover in Eskişehir and NAO values have been analysed in Figure 5:

- Similar decreasing trend has been observed in cloud cover and NAO values in spring, summer and winter.
- In autumn trends are different from each other. Cloud cover values show slightly increasing trend in autumn.
- There is a sufficient evidence of a negative linear relation (α = 0,10) between cloud cover and NAO.

Analysis of North Atlantic Oscillation Effects (Cont.)

- These results will effect on soaring conditions at the study area, (http://www.germany, 2008).

- Over the study area it is concluded that in spring and summer more dry thermics would be observed but more wet thermics would be organised in Autumn in following years.

- More wet thermics and favourable conditions would be available at higher latitudes in study area.

RESULTS AND CONCLUSION

- The wavelet toolbox contains graphical tools and it is available to appl to examine and explore properties of individual wavelets and wavelet packets It examines statistics of signals and signal components and, a continuou wavelet transform of a one-dimensional signal performs discrete analysis an synthesis of one- and two-dimensional.

- The main purpose of this study is to detect the large scale effects like E Nino and North Atlantic Oscillations (NAO) on cloud cover variations i Norhern and Central part of Turkey. For this purpose monthly and annua cloud cover values have been analyzed.

- Long term data (1950-2006) shows positive and negative relation between cloud cover values and NAO variations in different seasons. Th results show that there is a negative relation between positive NAO an mothly average cloud cover values in study area.

- Cloud cover values show slightly increasing trend in autumn. Thes results will effects on soaring conditions over the study area. It would b concluded that in spring and summer more dry thermics wolud be observe but, more wet thermics would probably be organised in Autumn in followin years.

SUMMARY

The main aim of this paper is to analyze the climatologic variation effects on cloud cover and its role on thermal potential in selected areas in Turkey. It is reported that positive anomalies of North Atlantic Oscillations (NAO) resulted in decreasing trends of cloud cover and precipitation values in Eastern Mediterranean Area. Negative NAO anomalies are accompanied by increasing precipitation values in and near vicinity of Turkey. This study covers 1D Wavelet packets and continuous wavelets on historical cloud cover values in North western and central parts of Turkey. Outputs of wavelet applications explain tele -connections between El Nino, NAO and cloud cover variations. The results of this study will explain the role of cloud cover variations on thermal structure and soaring potential of study area in last 35 years.

Keywords: Thermal potential, cloud cover, El Nino, NAO, wavelet analysis

REFERENCES

- Hindman, [illegible] 07): Evaluating Weather Predictions using Glider Flights, Fall 2006 and Sp[illegible]07 Pennsiylvania, USA", Workshop of Meteorological Panel, 24-30 Sept. [illegible] St. Auban, France.
- Meyer, Y., (2000[illegible] role of oscillation in some nonlinear problems, School on Mathematica[illegible]ems in Image Processing, ICTP, SMR 1237/4, p. 4-22, Italy.
- Olofsson, B. And E. [illegible]n, (2006): "Automatic Thermal Forecast from the Swedish HIRLAM", Technica[illegible]ing an International Journal, Vol. 30, No: 4, p. 101-104.
- Siddiqi, A. H., Z. Aslan an[illegible]kgozlu, (2002): " Wavelet based computer simulation of some meteorolog[illegible]meters: Case Study in Turkey", Trends in Industrial and Applied Mathema[illegible] A. H. Siddiqi and M. Kocvara, p. 95-105, Kluwer Academic Publishers, [illegible]
- Siddiqi, A. H., S. Alsan, M. Ras[illegible] Oğuz and Z. Aslan: (2005): International Workshop on Applicatio[illegible]velets to Real World Problems: IWW2005, July 17-18, ITICU, Istanbu[illegible]
- Can, Z., Z. Aslan and O. Oguz, (2[illegible]e-Dimensional Wavelet and Reanalysis of Gravity Waves", The Arabi[illegible]al for Science ad Engineering, Vol. 29, No. 2C, p. 33-42.
- Can, Z., Z. Aslan, O. Oguz and A. H. Si[illegible], (2005): "Wavelet transforms of meteorological parameters and gravity waves", Annales Geophysicae, Vol. 23, p. 650-663.
- http://www.germany\Soaring Society of America, the source for Gliding in the USA.mht ; "Thermal Forecast Methodology", July 21, 2008.