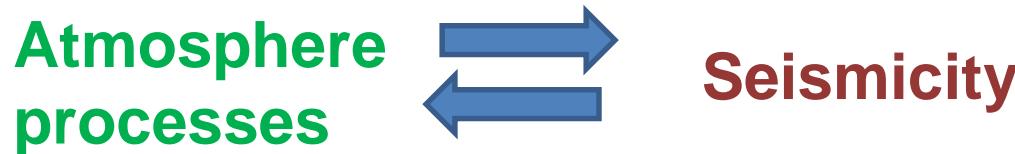


IKI, November 2008

Climate- Seismicity Coupling

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1. Introduction: EL Nino and global warming
2. Data for analysis
3. Seasonal variations in seismicity
4. EL Nino variations in seismicity
5. Correlation in trend
6. Possible mechanism



A) Tidal, daily, seasonal variation → Seismicity

$\Delta\sigma$ (tides) $\approx 0.01 \Delta\sigma$ (EQ), Local Tides
al., Chebrov et al., Schekotov et al.) →
Seasonal, 11yr variation (Sitinsky, Bokov et al.) – local influence

**B) Seismicity → Atmosphere perturbations
(small and local)**

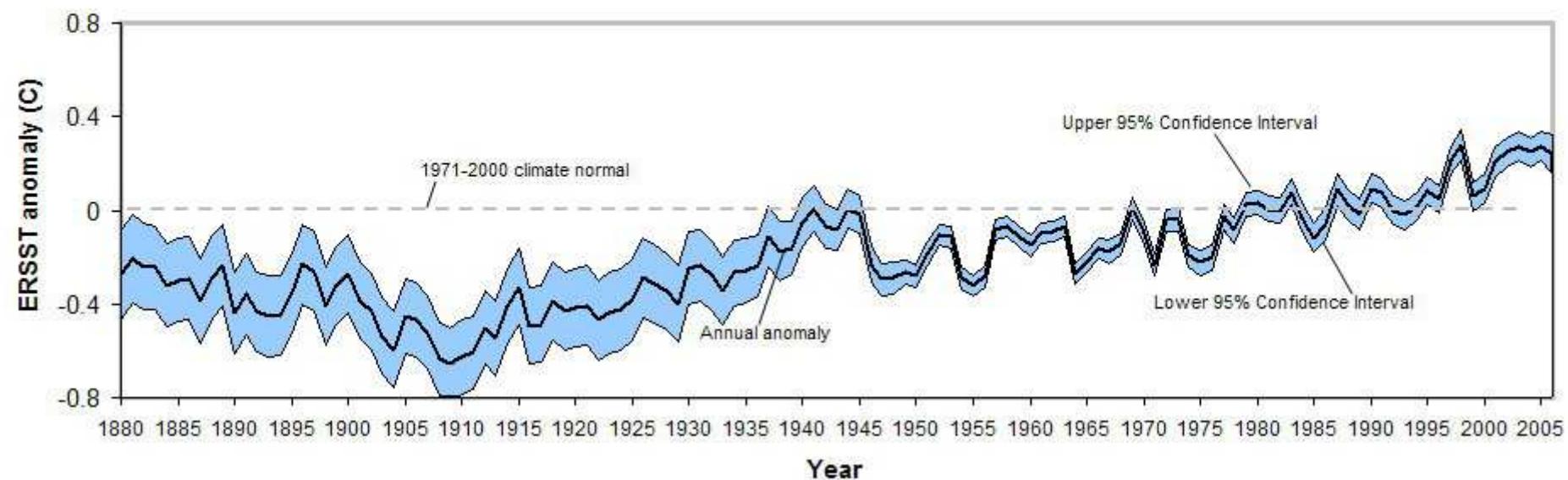
$\Delta T \sim 1-2$ gr.C and humidity for large EQ from RS observations (Russia, Italy, India)

Gas/water release from hydrology/geochemistry observations
(Wakita, King, Tomas)

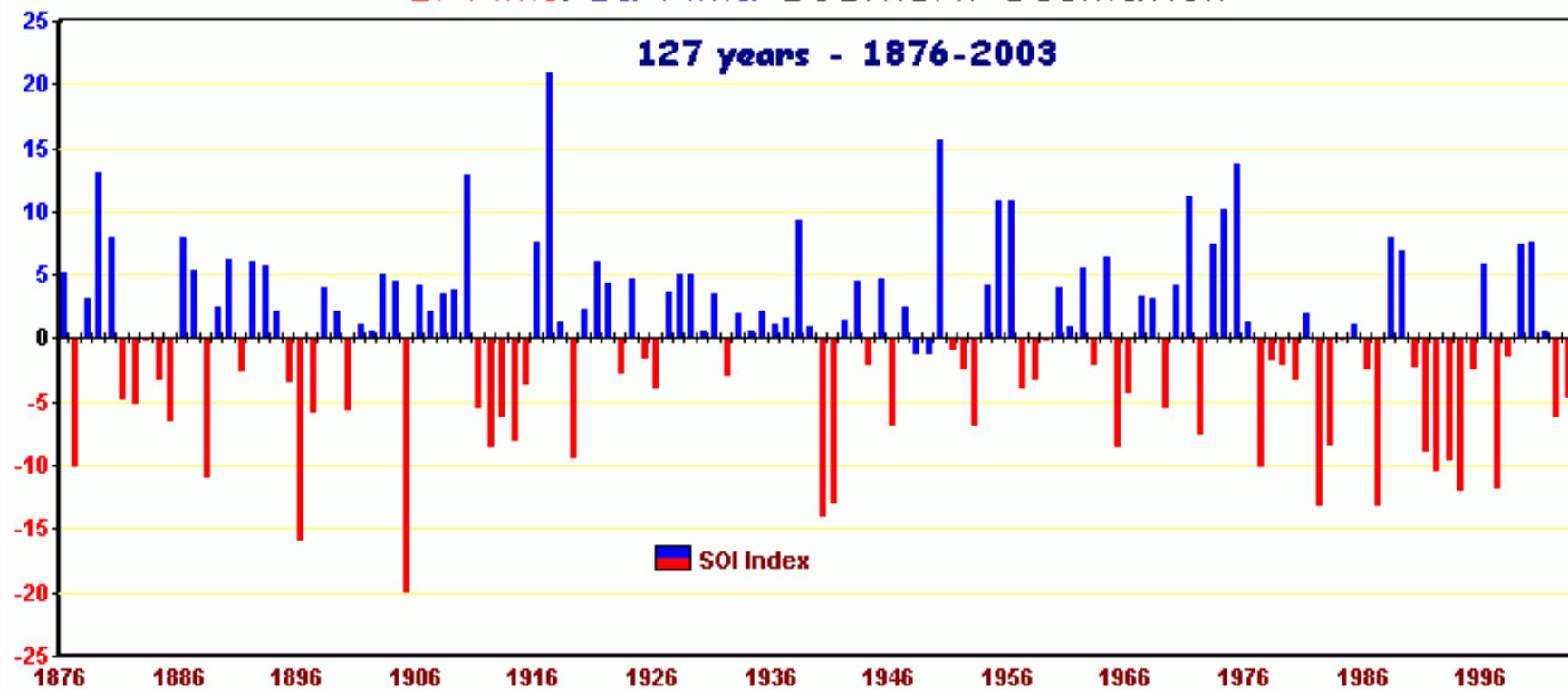
Electromagnetic variations (Molchanov and Hayakawa, 2008)

Our goal : Correlation of slow and large-scale atmosphere processes with seismic energy release in statistics

60S-60N ERSST annual anomaly(1880-2006)



El Niño/La Niña Southern Oscillation



Earth Heat Budget

Name	Flux W/m ²	%	Variation	Periodicity
Solar radiation	340	99.98	No,?	?
Atm.Abs: Evaporation	78	23	Yes	Seasonal
Rising air	24	7		Seasonal
Clouds	10	3		Seasonal
Geothermal Energy	0.045	0.013	No	
Tidal Energy	0.006	0.002	Yes,	Daily
Fossil fuel	0.025	0.007	No	
Anthropo genic	2.4	0.6	Yes	Weekly Seasonal
Earthquakes	0.01	<0.003	?	?

2. Data for analysis

EL Nino/La Nino Methods

1)Winds

200 MB Zonal Winds Equator (165W-110W) , Base period (BP): **1979**-1995

850 MB Trade Wind Index(5N-5S ,135E-180W) West Pacific, BP: 1979-1995

850 MB Trade Wind Index(5N-5S ,175W-140W) Central Pacific , BP:1979-1995

850 MB Trade Wind Index(5N-5S, 135W-120W) East Pacific , BP:1979-1995

2)Sea Level Pressure: Southern Oscillation Index (SOI)

Darwin Sea - Tahiti Sea , BP: **1951**-1980

3)Sea Surface Temperature : SSTOI

Nino 1+2 (0-10S, 90W-80W) , Nino 3 (5N-5S,150W-90W)

Nino 3.4 (5N-5S,170-120W) , Nino 4 (5N-5S,160E-150W)

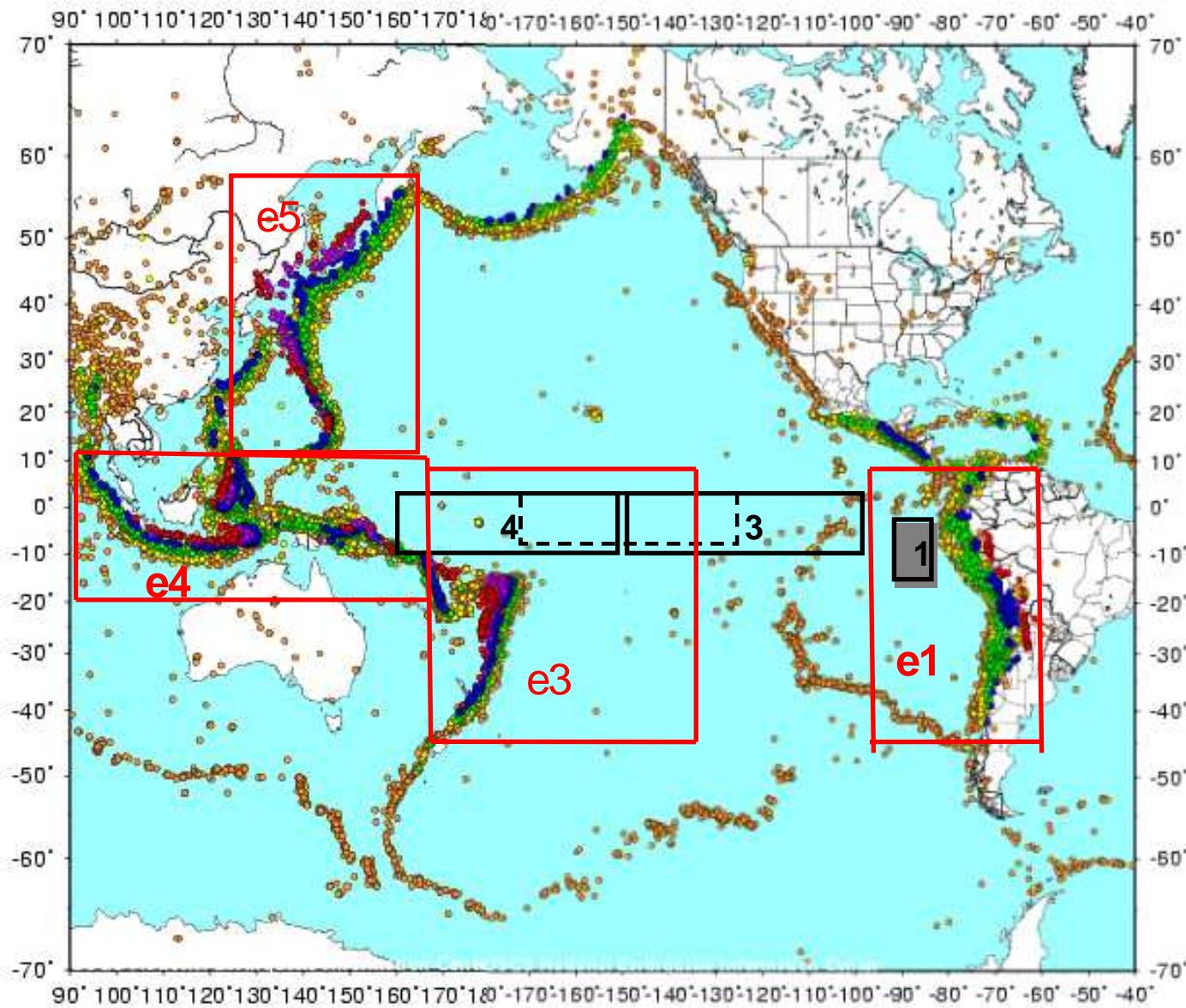
BP: **1950**-1979(ext.to 2001)

4)Warm Water Volume: WWV

5°N to 5°S, 120°E to 80°W, BP: **1980**-2002

5) Outgoing Long Wave Radiation

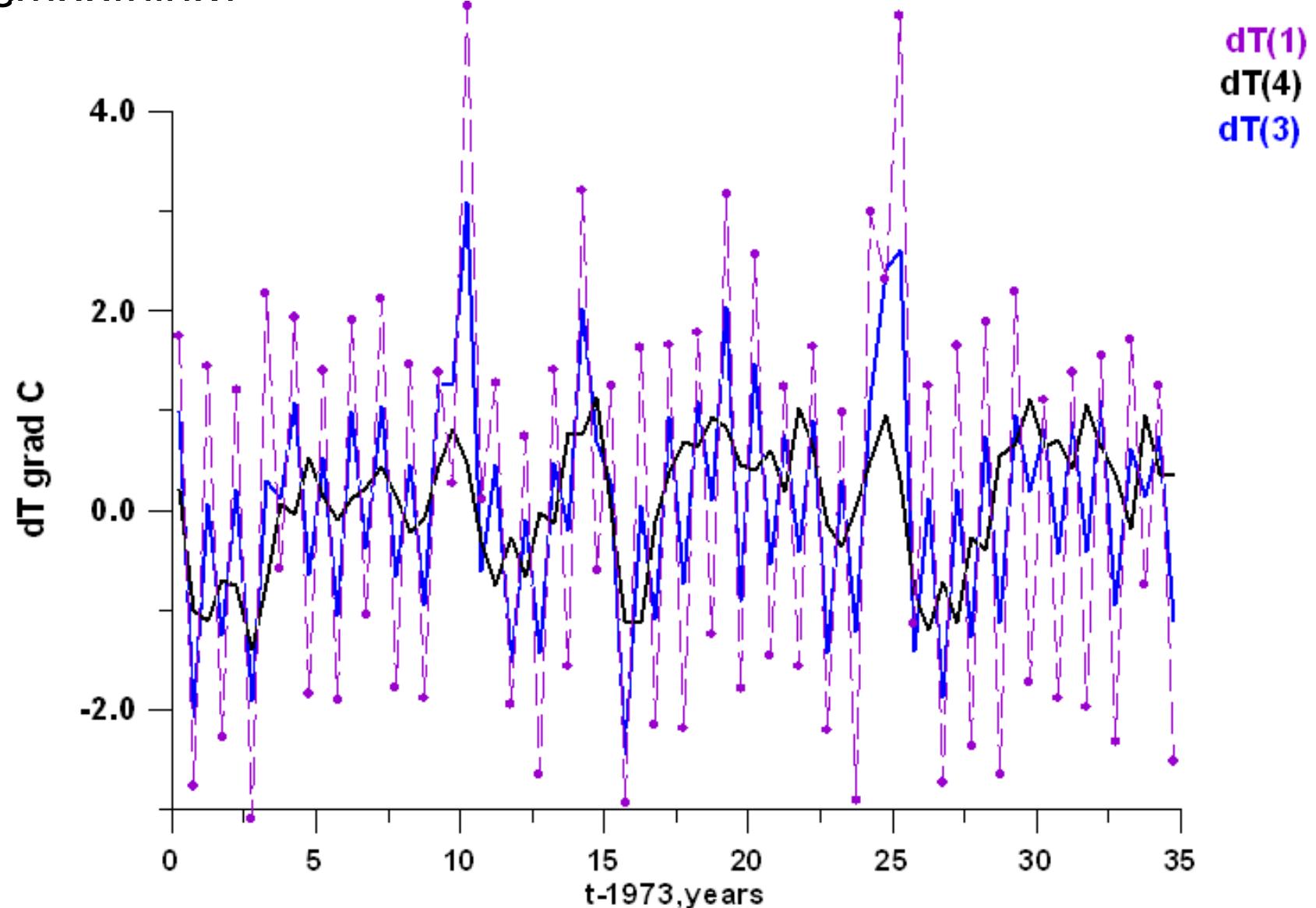
Equator (160E-160W) , BP: **1979**-1995

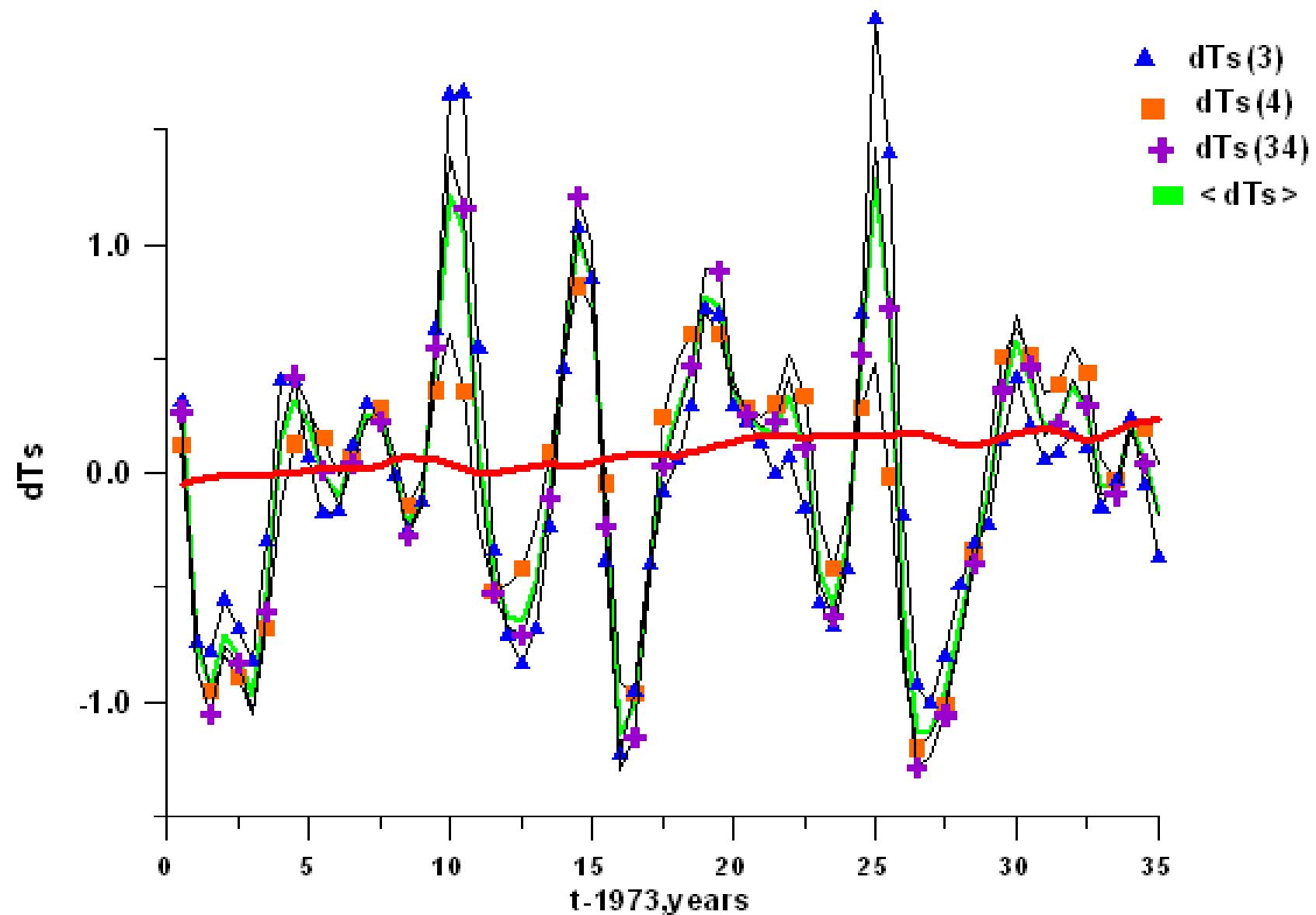


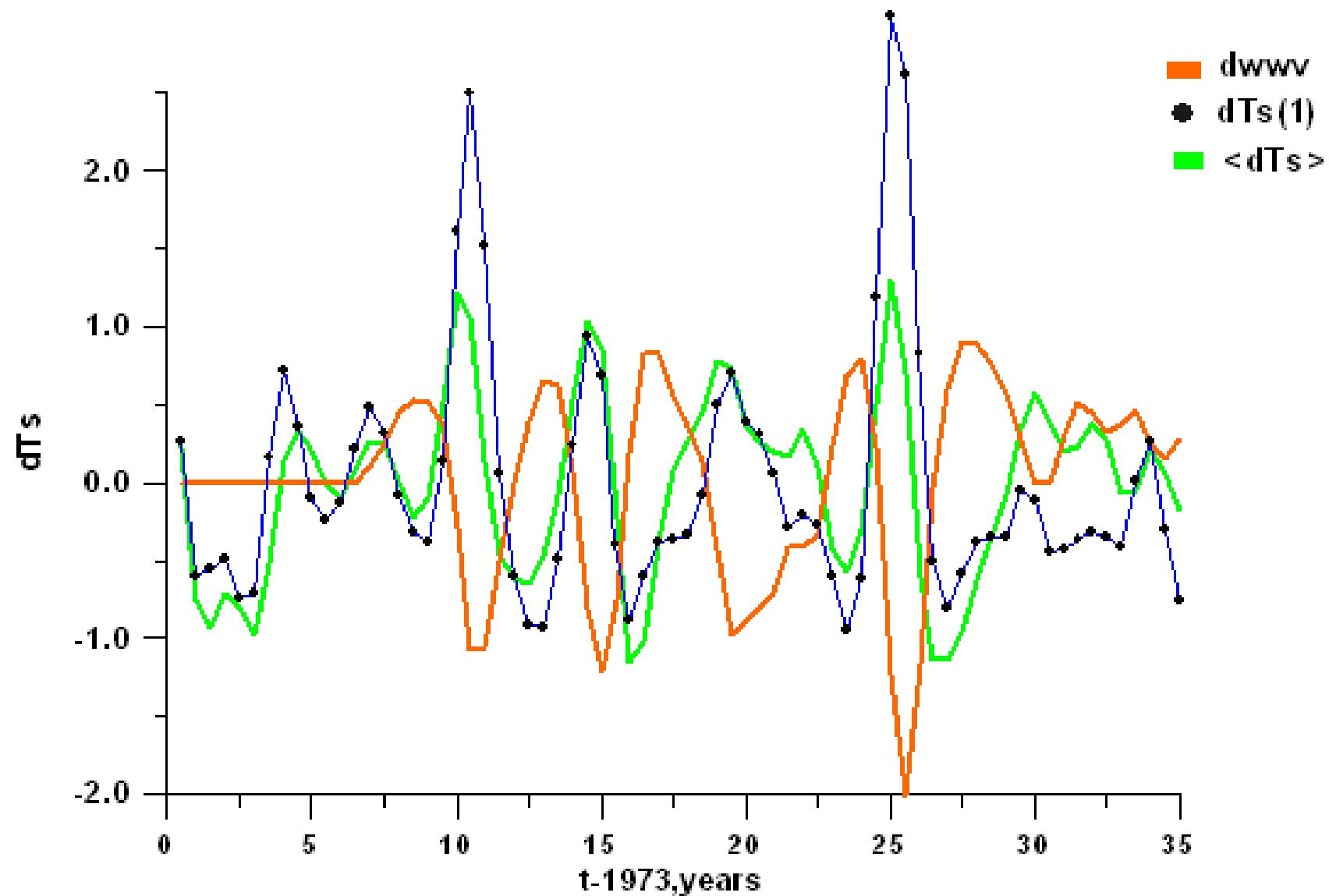
sstoi.indices

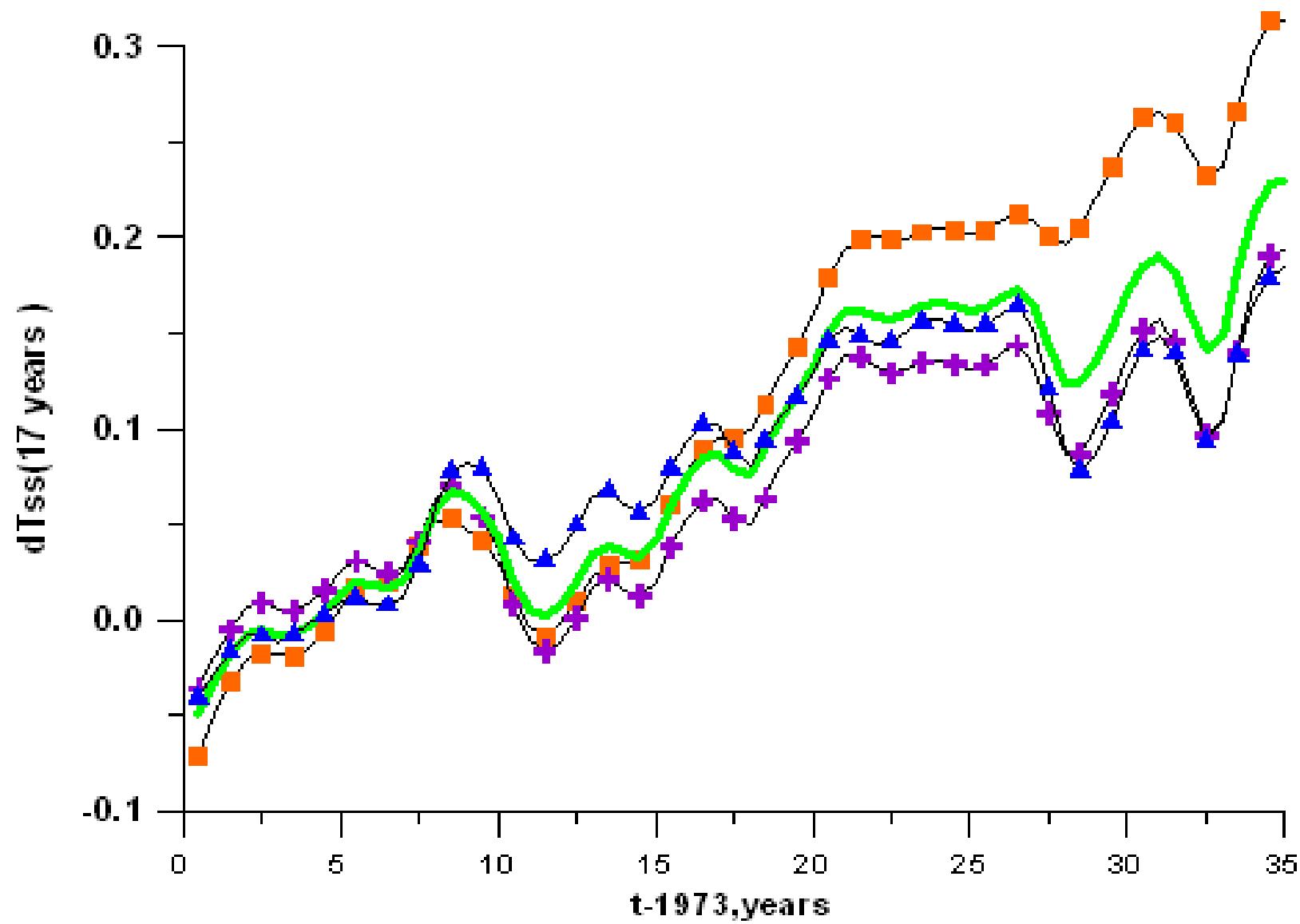
Nino 1+2 (0-10S)(90W-80W) Nino 3 (5N-5S)(150W-90W)
Nino3.4(5N-5S)(170-120W) Nino 4 (5N-5S)(160E-150W)

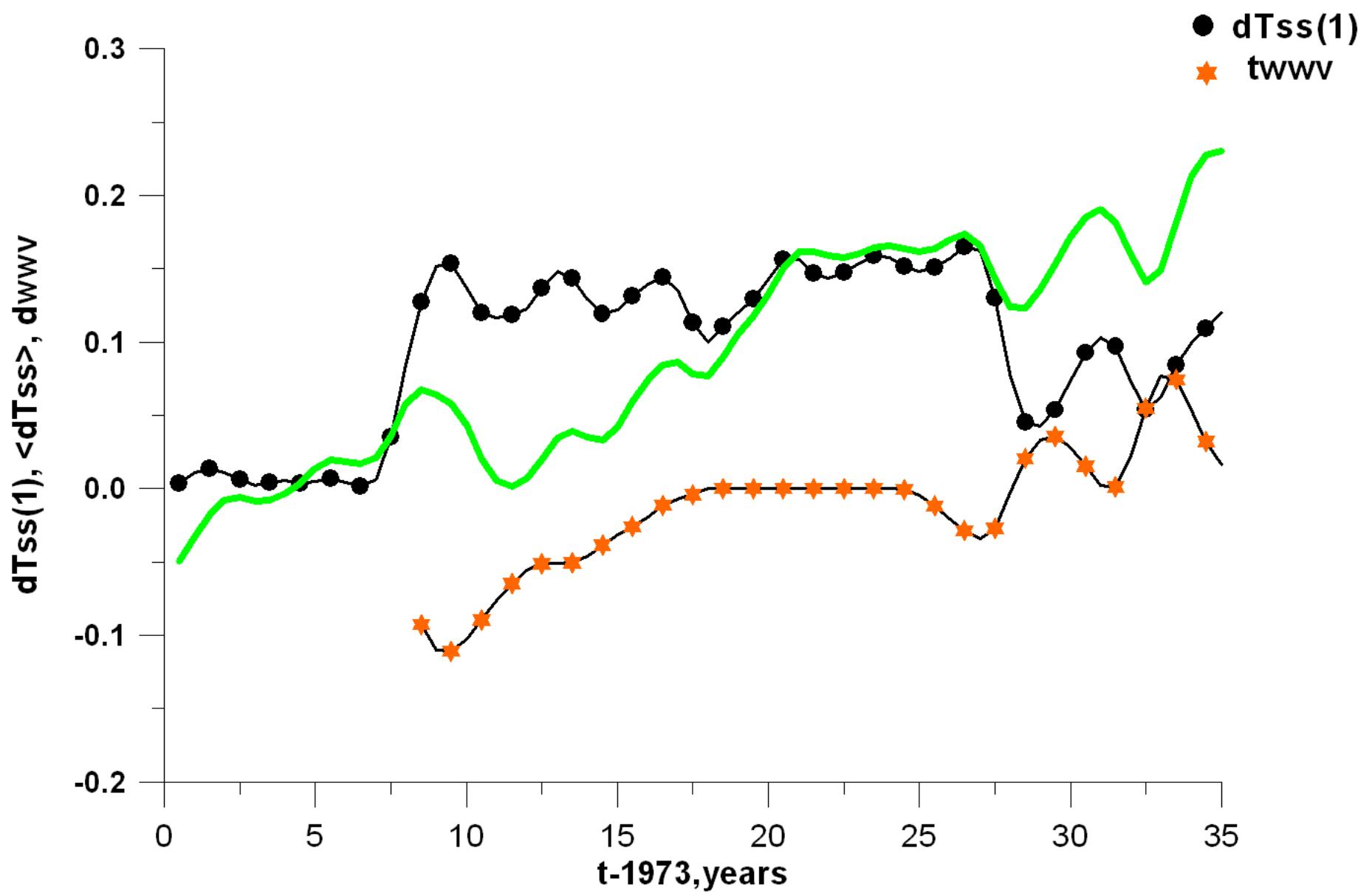
$dT = T - \langle T \rangle$, $dTs = dT(1\text{yr smoothing})$, $dTss = dT(17\text{ yr smoothing})$











$$de = e - \langle e \rangle \quad e = \log(a + Es/\langle Es \rangle)$$

$$\frac{Es}{\langle Es \rangle} = F(T/\langle T \rangle) \quad \text{or} \quad T/\langle T \rangle = \Phi(Es/\langle Es \rangle)$$

$$\Phi(Es/\langle Es \rangle) = [C(a + Es/\langle Es \rangle)]^\gamma$$

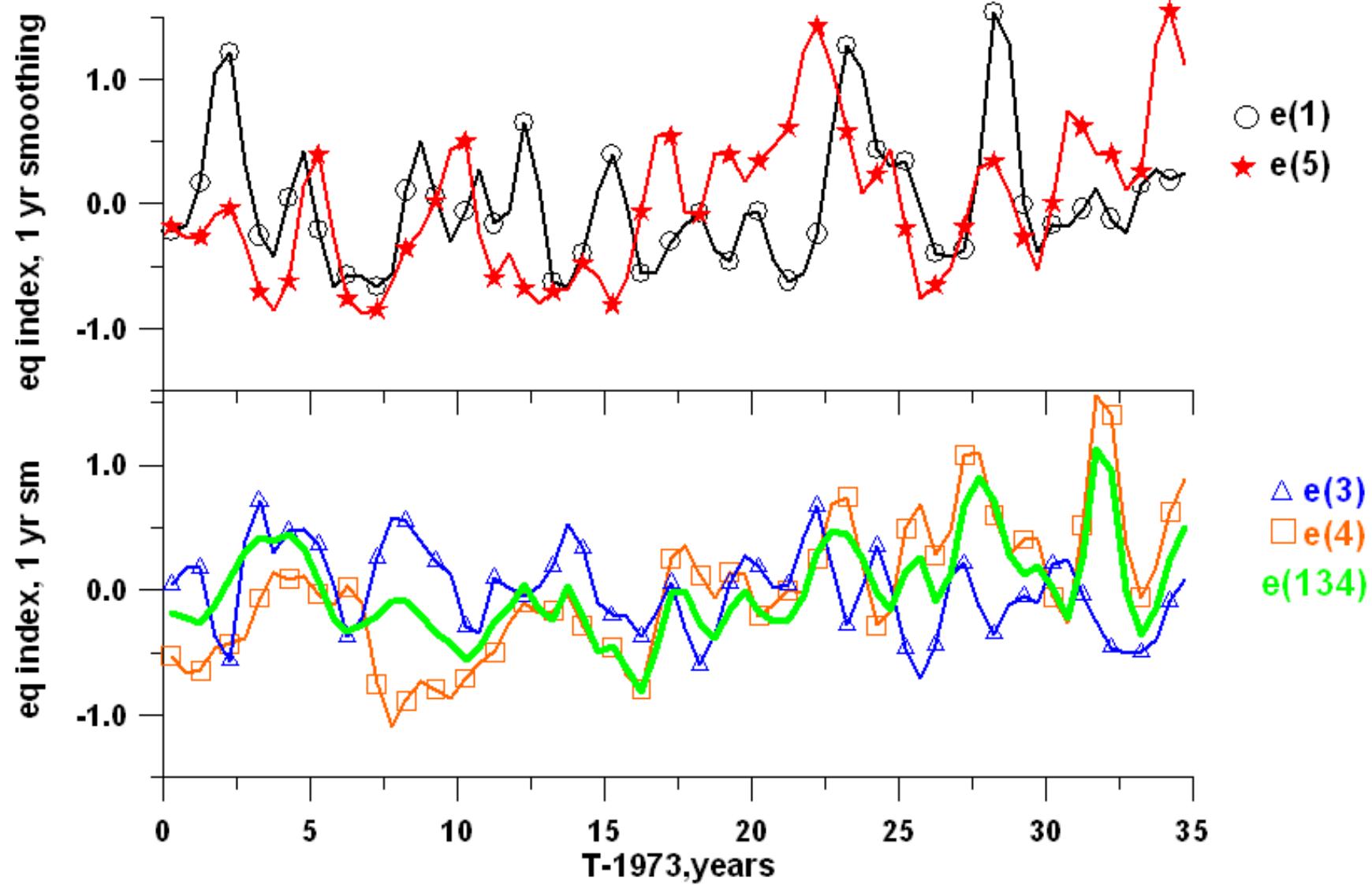
$$\log(T/\langle T \rangle) = \log(1 + dT/\langle T \rangle) = \gamma[\log(a + (a + Es/\langle Es \rangle) + \log C)]$$

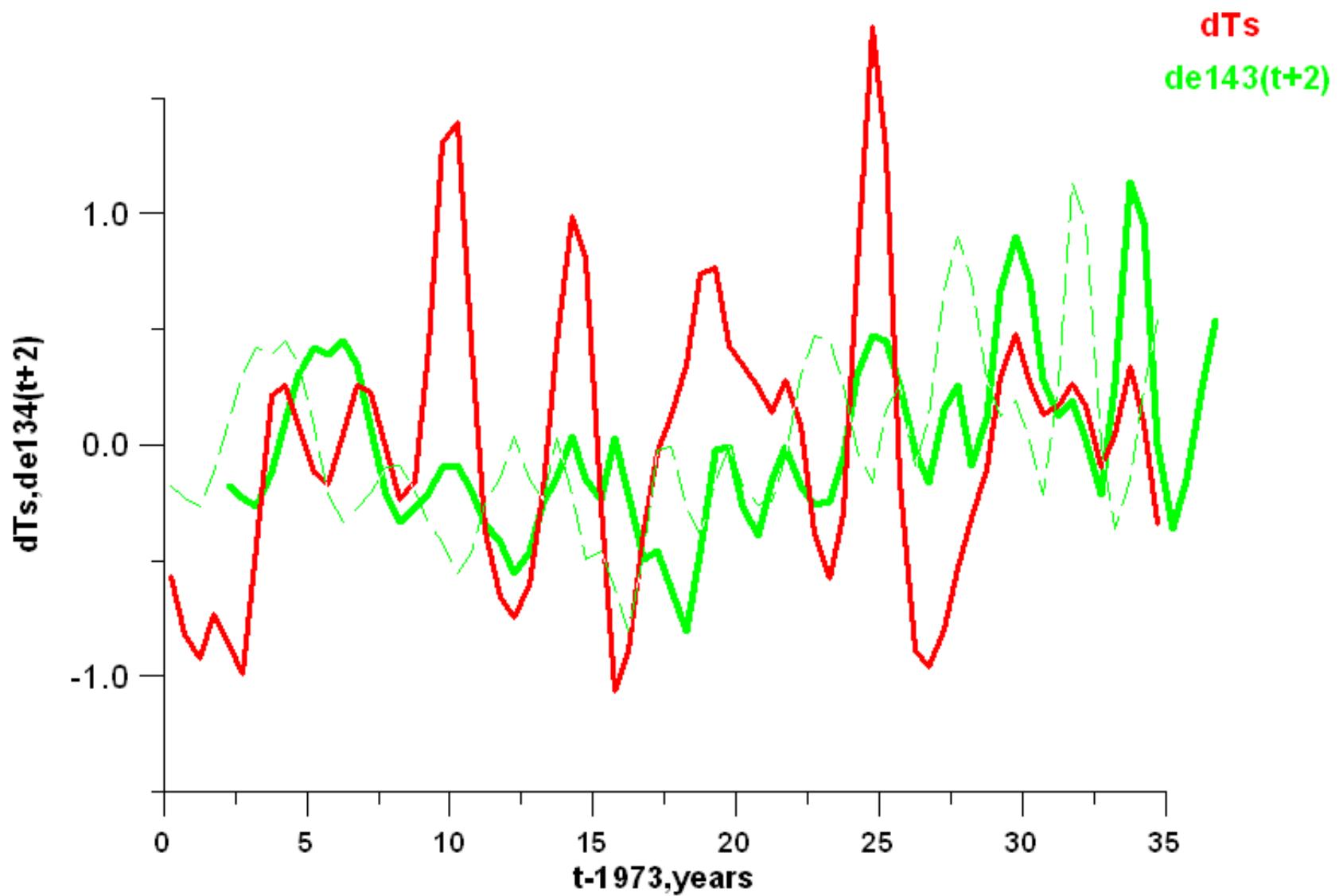
For $(dT/\langle T \rangle) \ll 1$ and $\langle dT \rangle = 0$ hence $\log C = -\langle e \rangle$ and

$$dT \sim de$$

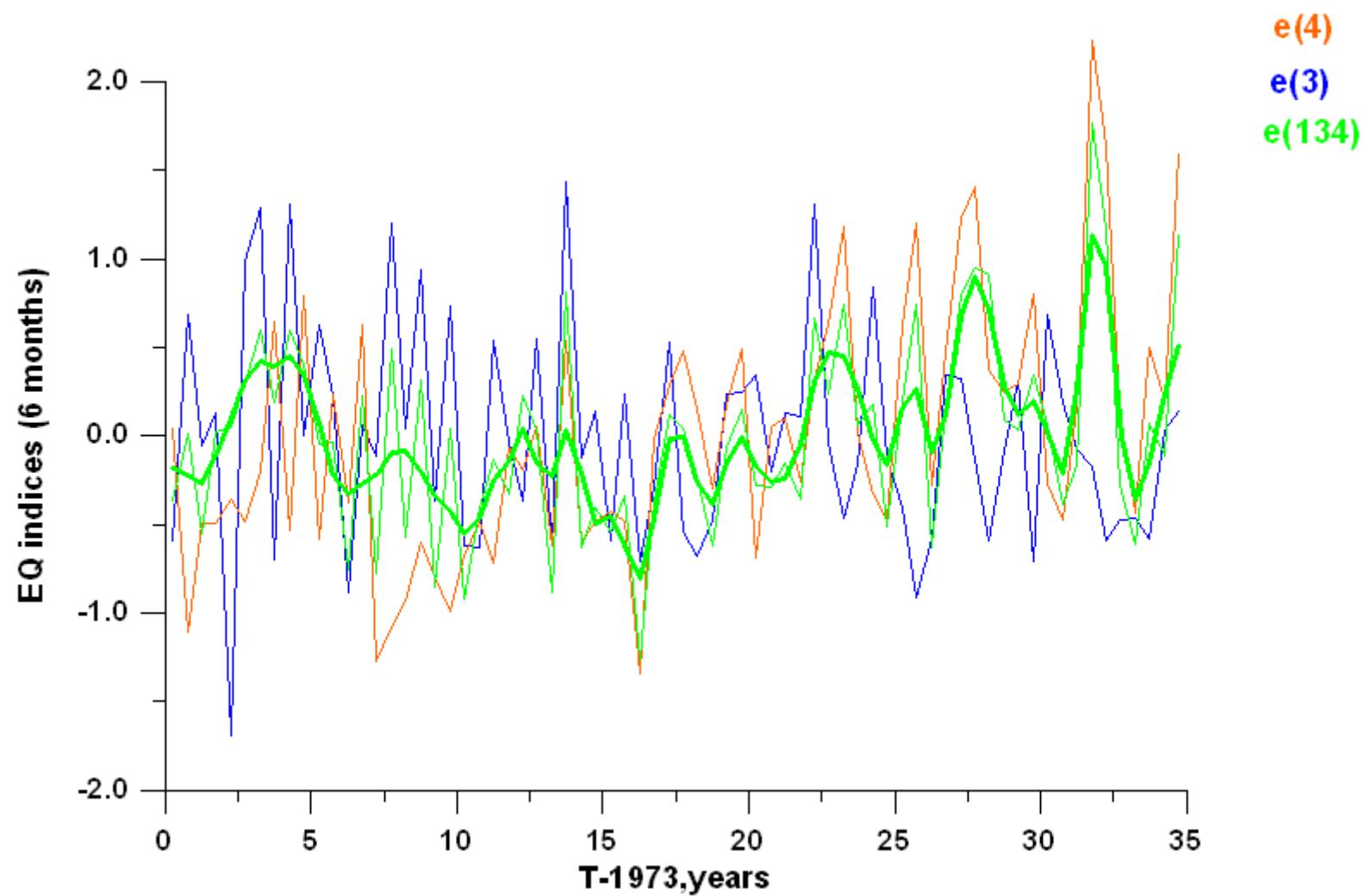
Energy/Zones	e1	e3	e4	e5	e(eqt)
<Es> 10^{14} J/6months in crust (0- 38 km)	105	308	108 8	237	1489
<ES> crust percentage	55%	73%	92%	69%	83%
<Es> 10^{14} J/6months in depth >500 km	34	27	15	2	75
<Es> depth >500 km percentage	18%	6%	1%	0.5%	4%

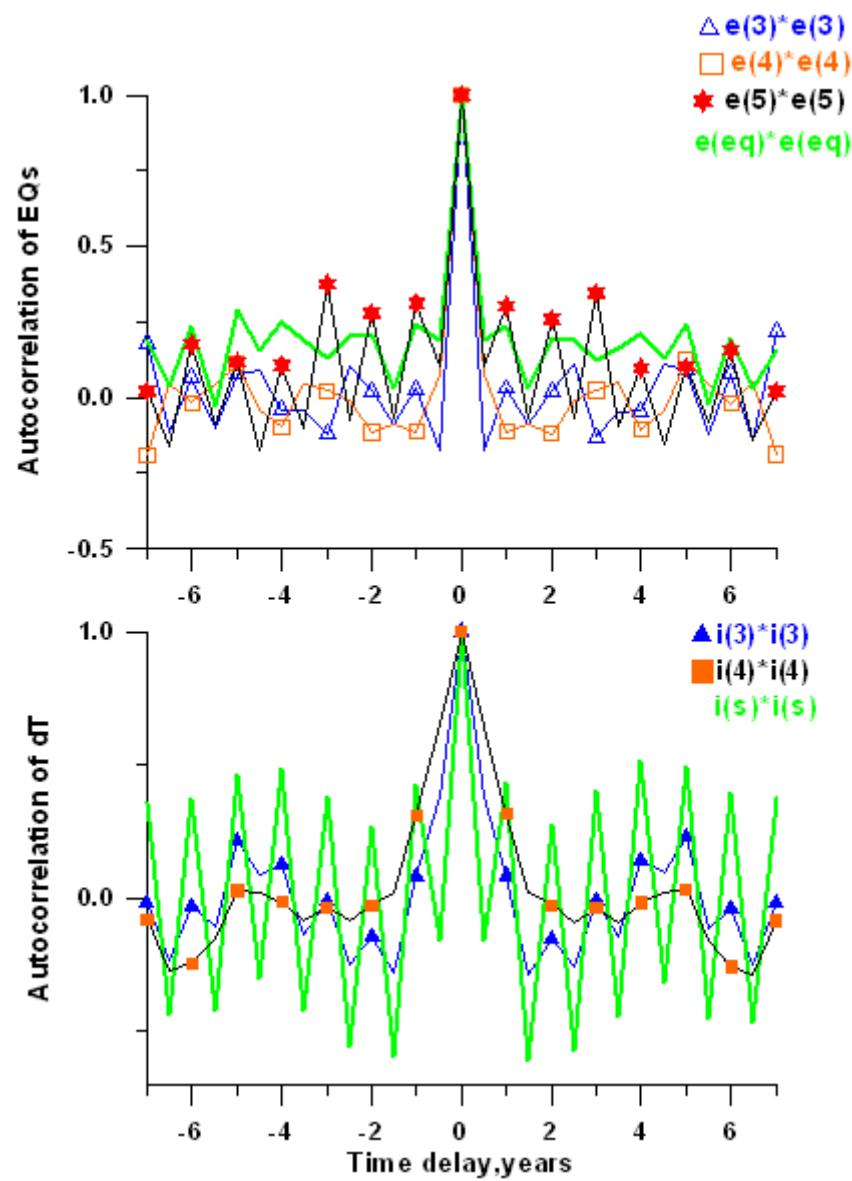
$$W \approx \sigma / \Delta \sigma \quad Es \approx 100 \quad Es, \quad 10^{14} \text{ J} \approx 2 \text{ HAB}$$



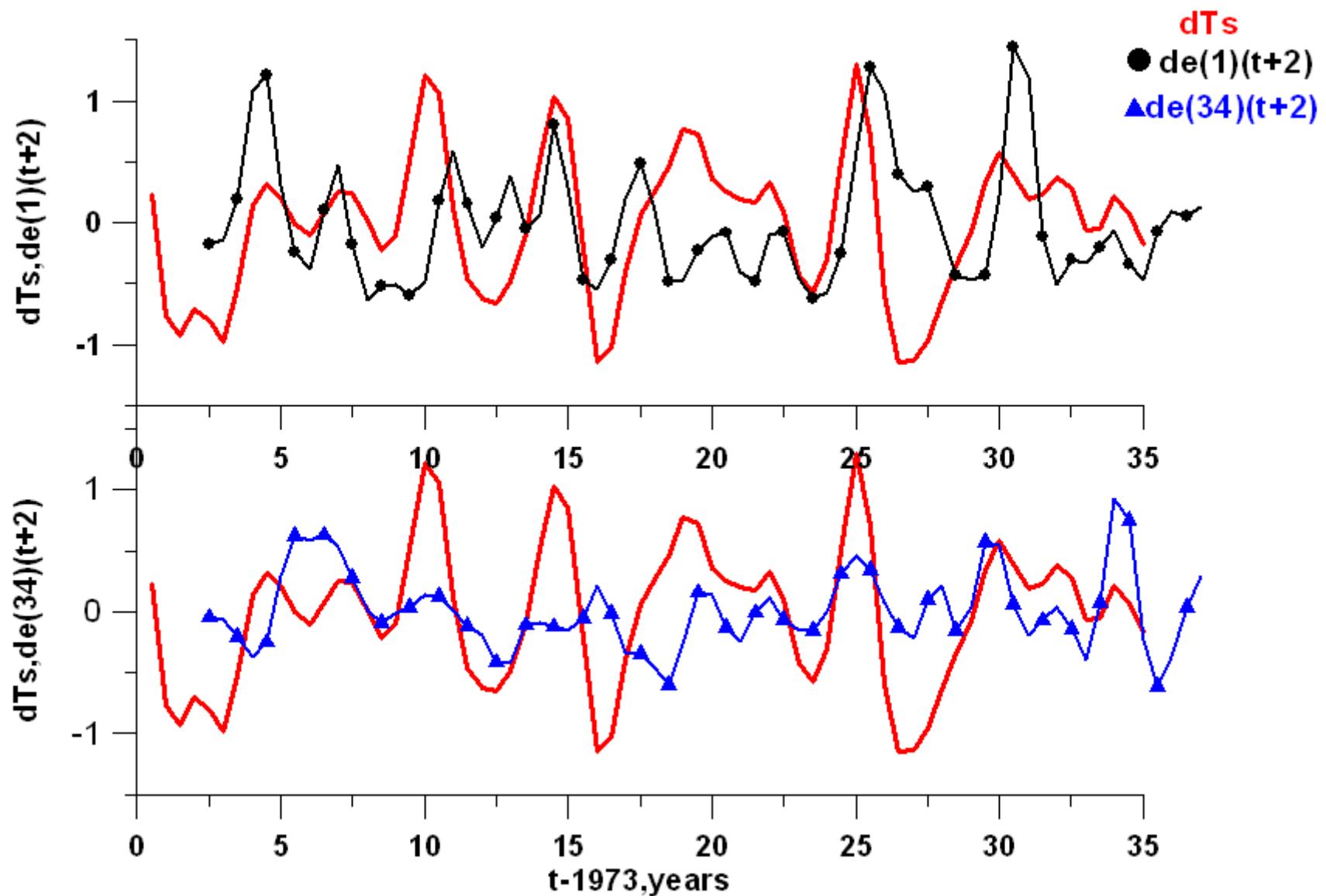


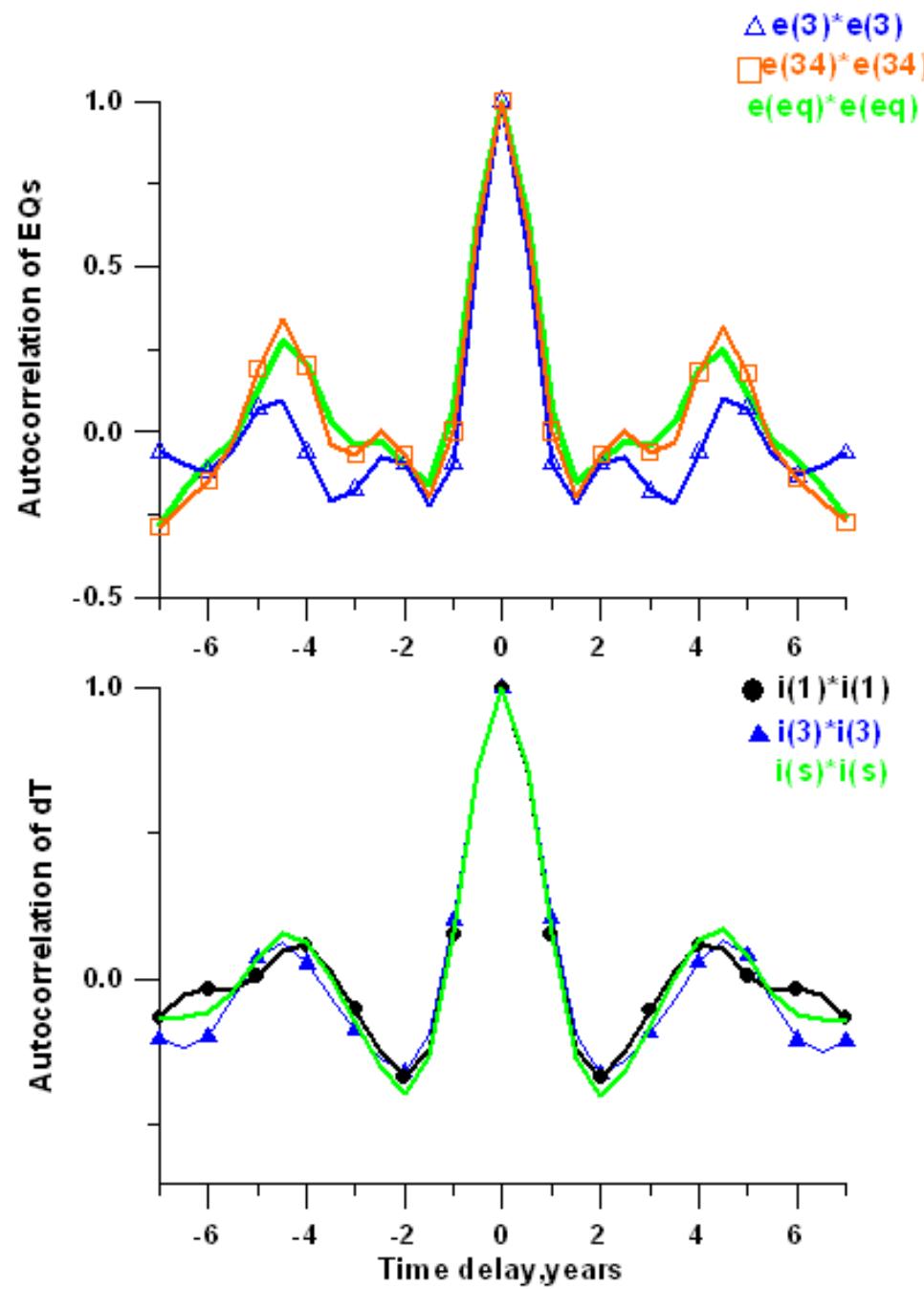
3. Seasonal variation in seismicity

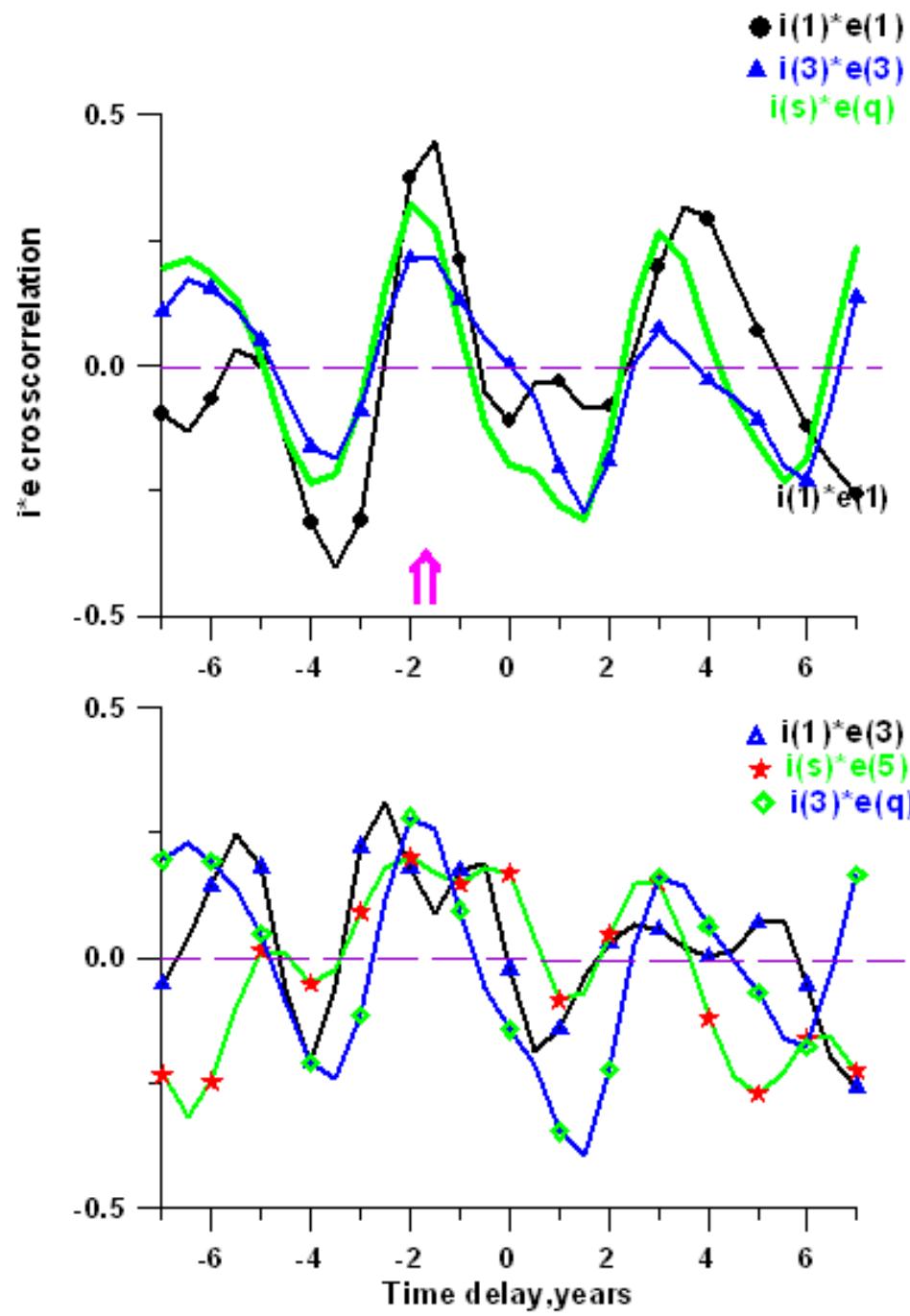


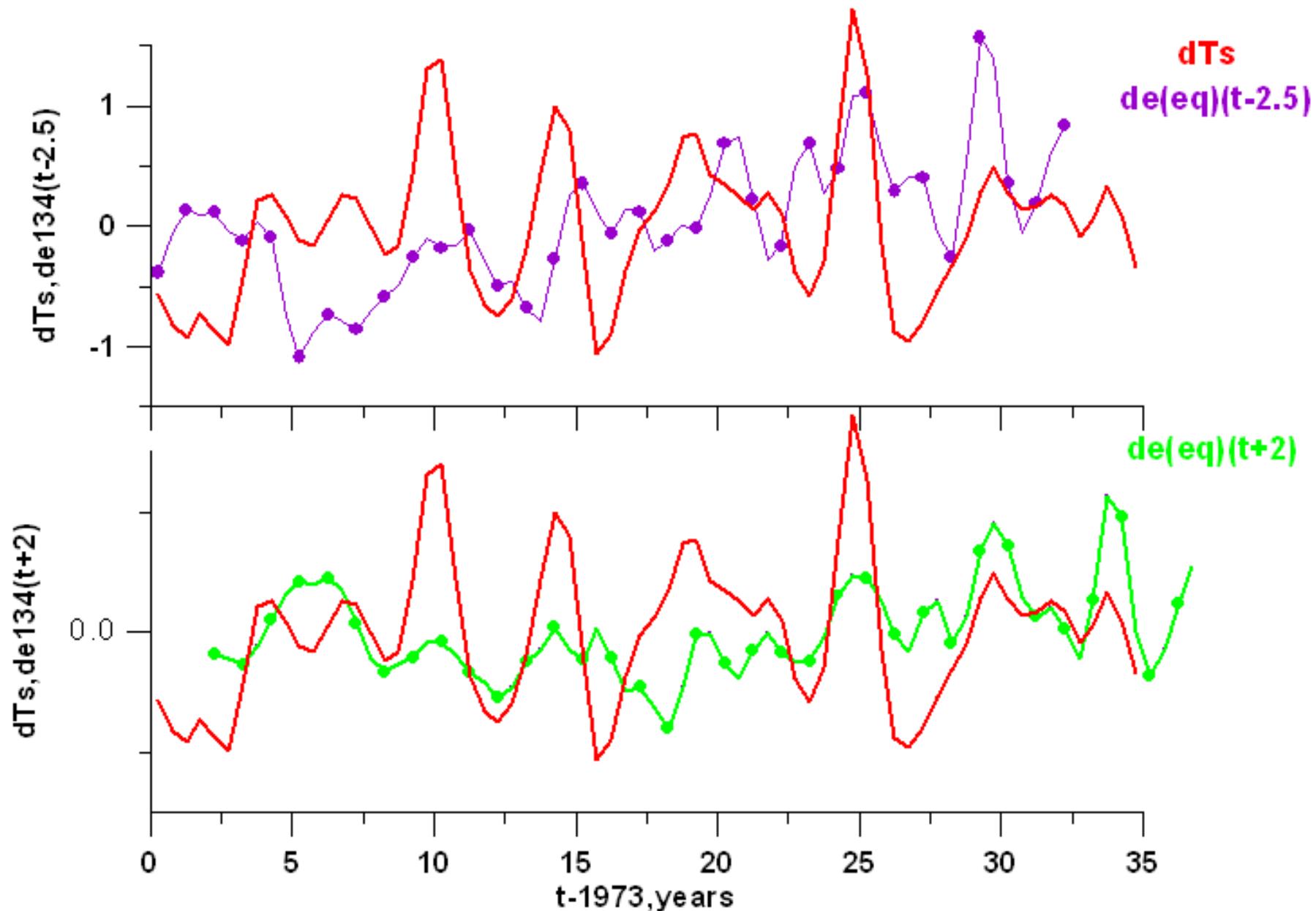


4. EL Nino variation

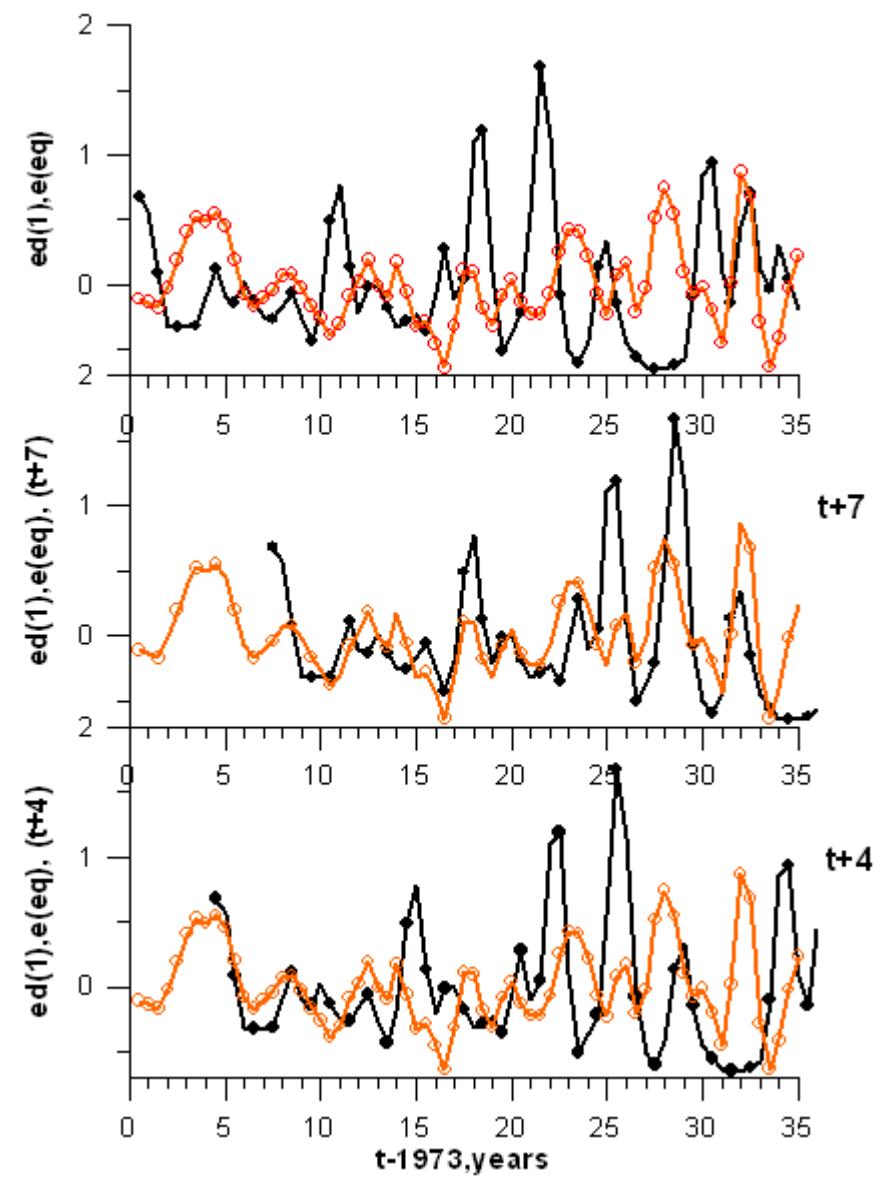
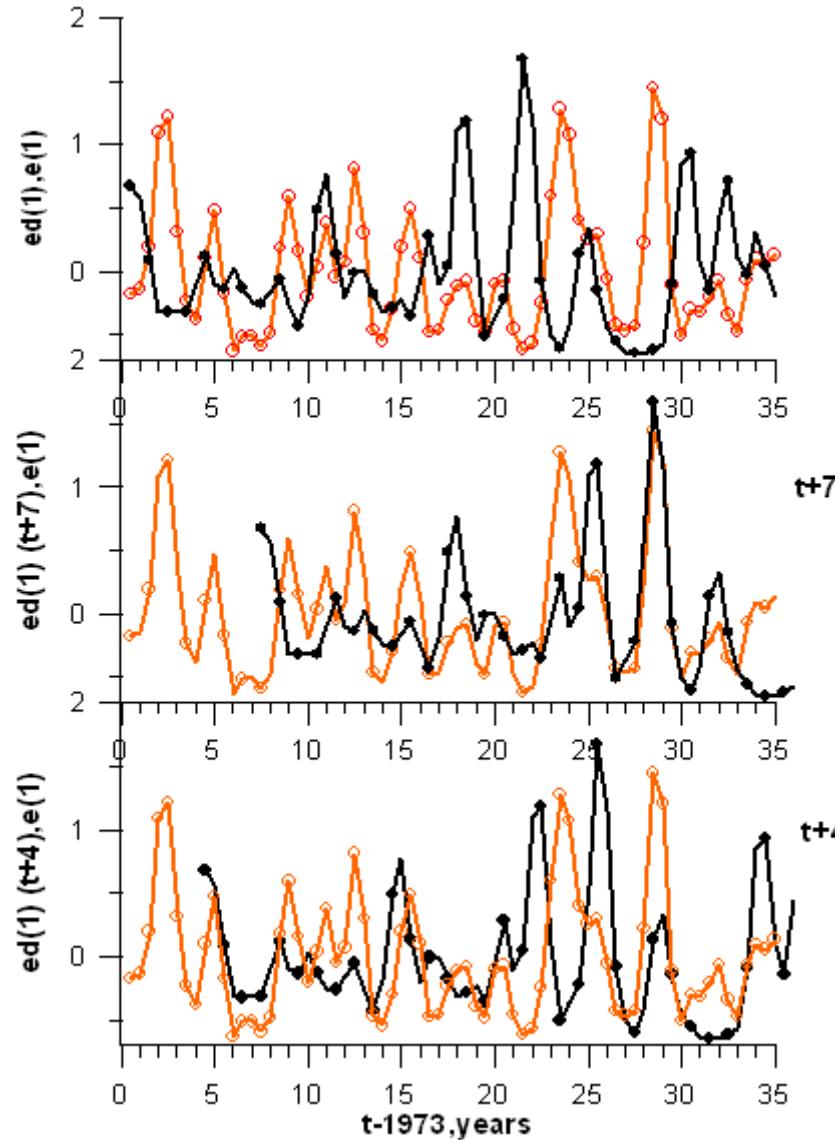


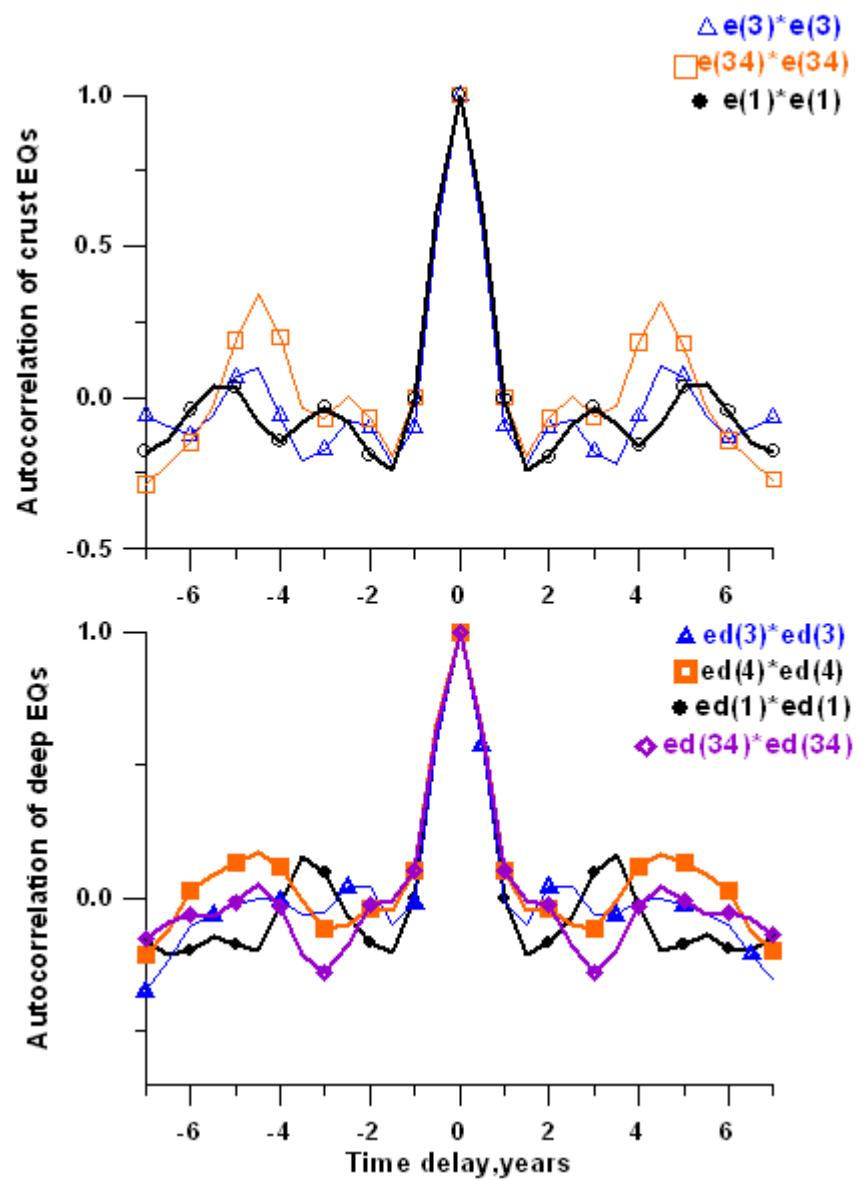


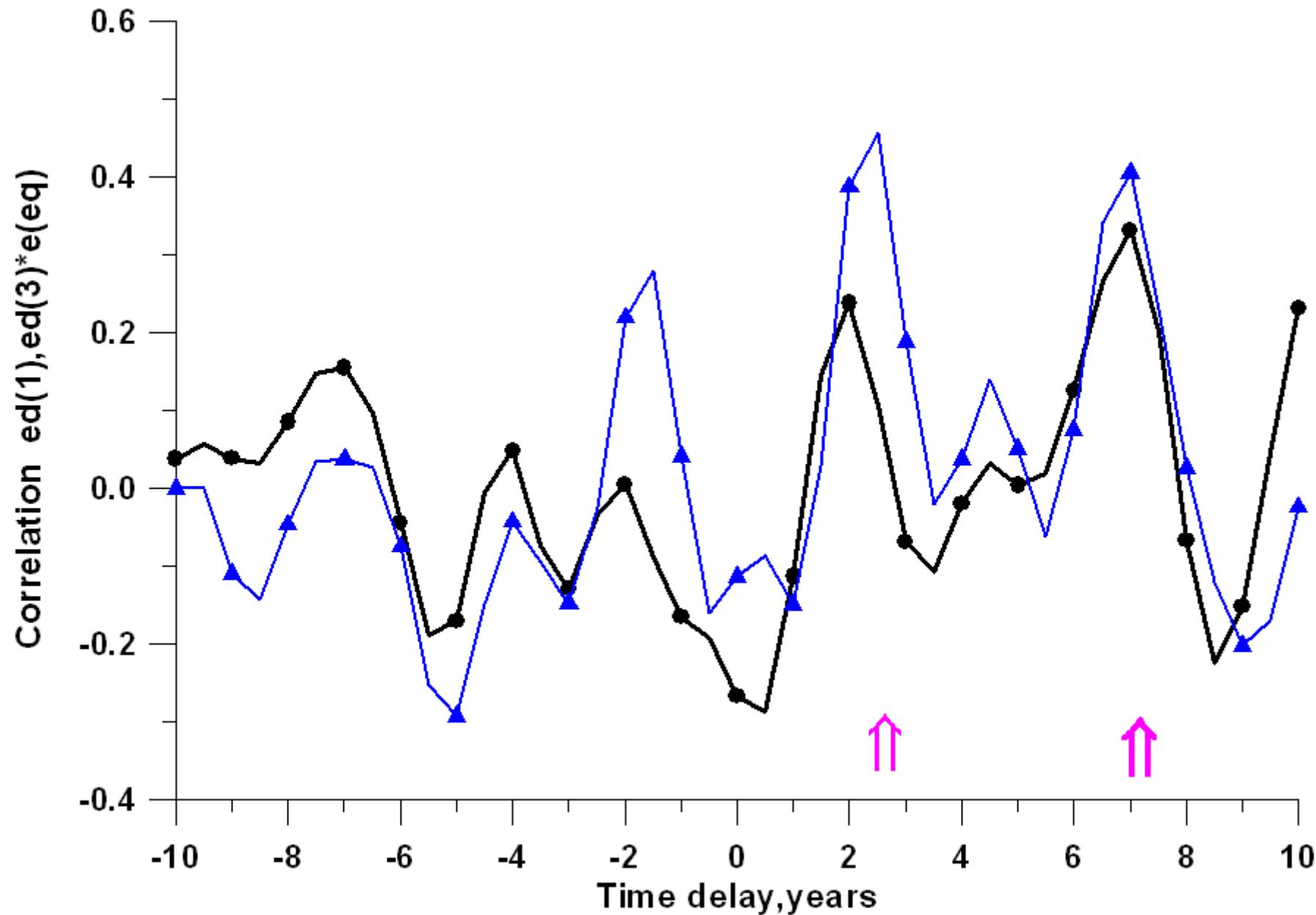




5. Causative relation (Mother-daughter problem)







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Upward migration of earthquake hypocenters in Japan, Kurile-Kamchatka and Java Wadati-Benioff zones

O. Molchanov⁽¹⁾, and S. Uyeda⁽²⁾

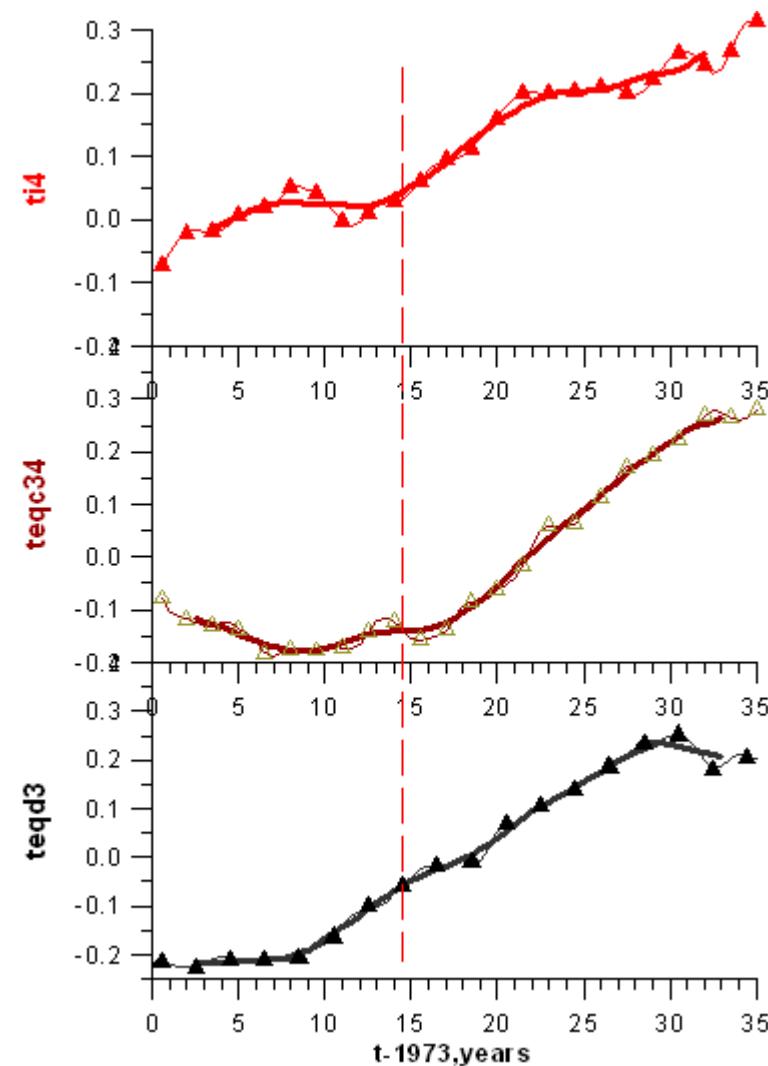
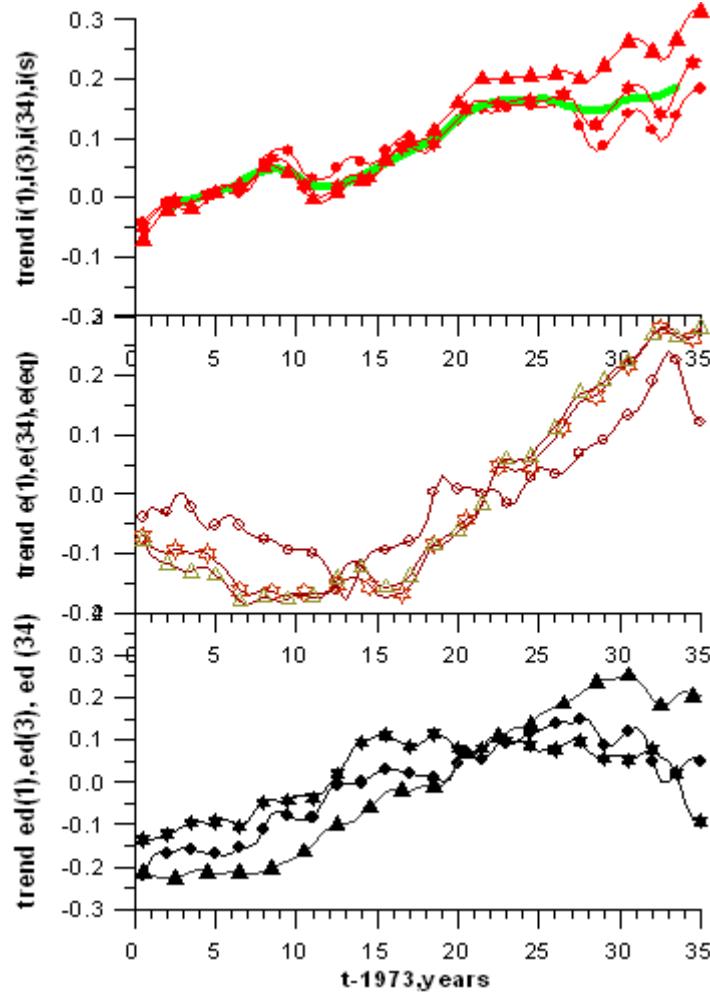
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Abstract

It is shown by a special data processing that there is definite upward migration of earthquake hypocenters in Japan, Kurile-Kamchatka and Java Wadati-Benioff zones. Total time of the migration appears to range from 3-4 years to 10-12 years. Probably it corresponds to upward movement of forcing agent like stress or deformation wave from depths of the upper mantle (600-700 km) to the level of the lithosphere with subsequent initiation of fluid migration inside the crust. These findings may be helpful for explanation of earthquake triggering and analysis of seismic precursors.

6. Trend



Conclusions

- Climate-seismicity coupling definitely exists
 - Seasonal variation in seismicity is induced by climate forcing
 - In opposite , EL Nino variations and background (natural) trend in climate are probably induced by seismicity
 - Such a coupling can be explained by critical state of both climate and seismic systems