

ON THE VARIABILITY OF SLAB THICKNESS

S. S. Kouris ⁽¹⁾, Lj. R. Cander ⁽²⁾ and K. V. Polimeris ⁽¹⁾

(1) Aristotle University of Thessaloniki, Faculty of Engineering, Electrical and Computer Eng. Dept., GR-54124, Thessaloniki, Greece.

(2) Rutherford Appleton Lab., Radio Communication Research Unit, Chilton, Didcot, Oxon, OX11 0QX, U. K.

Introduction

The slab thickness τ , is defined as the ratio of the vertical electron content divided by the peak electron density:

$$\tau = \frac{TEC}{N_{\max}} = \frac{10^6}{1.24} \frac{TEC}{(foF2)^2}$$

TEC is measured in TEC units (10^{16} electrons/m²), foF2 in MHz and τ in meters.

It has been found (Leitinger et al., 2004; Kouris et al., 2005) that the slab thickness has a diurnal variation in winter from about 200 to 450 km on average whereas in equinoxes and summer from about 300 to 450 km depending on the time of the day, that is in winter and equinoxes the night-time values of τ are much higher than the day-time ones whereas in summer the opposite occurs. Moreover, the predawn peak has a large amplitude in winter and equinoxes, around 500 to 700 km and a smaller in summer, i.e. 400 to 450 km on average.

In this work the latitude dependence of the slab thickness τ is investigated either from hourly daily TEC and $(foF2)^2$ values measured at a given day/month/year/location or from hourly monthly median.

The TEC data used are from GPS measurements made mainly at Hailsham (50.9°N , 0.3°E) and Matera (40°N , 16°E) during 1998 to 2004, as well as from those measured at Brussels (50.8°N , 4.3°E) and Nicosia (35.1°N , 33.2°E) during 2002 and 2004. The corresponding foF2 data used are those measured at the nearby stations of Chilton/Slough (51.5°N , 359.4°E), Rome (41.8°N , 12.5°E) and Athens (38.0°N , 23.6°E). Furthermore, we investigate the variability of τ from day-to-day and from hour-to-hour in each location and calculate corresponding deciles.

Results and discussion

In Tables 1 and 2 there are reported average values of the slab thickness counted from monthly median values of TEC and foF2 measured at Hailsham and Matera in 1999 and 2002 during day-time ($\cos\chi \geq 0.10$) and night ($\cos\chi < 0.10$), as well as at Brussels and Nicosia during 2002. In the same Tables are also listed extreme values (max/min) recorded in each month/location during 1999 and 2002, respectively. It can be seen that the monthly average values of slab thickness all over Europe are practically the same within a range of less than 15 km, apart the night values during winter. Big differences exist in the extreme (maximum) values during the night. Matera seems to reach high maximum values during the night-time, especially in winter. On the contrary, the minimum values are pretty well similar in all locations. Thus, it can be accepted that the slab thickness is virtually independent of latitude. To further assess this statement the differences between average values of τ at the different locations, as well as of the extreme values have been compared. As an example Fig. 1 illustrates

differences in the monthly median values of slab thickness at different European locations. These differences vary around zero within a narrow range during day-time; big variations exist around dawn in winter and may be attributed at local disturbed conditions (Kouris et al., 1999; Fuller-Rowell et al., 2000; Mikhailov, 2000). Similar results to those found above are obtained when hourly daily values are considered.

To investigate the variability from day-to-day and hour-to-hour decile factors are calculated for each hour of each month/year/location, as well as of each day in each month/year/location, respectively. As an example Figs. 2 and 3 illustrate deciles of the variability of slab thickness from day-to-day and from hour-to-hour, respectively at Matera and Hailsham for 1999. The levels of variability at the two locations are similar during the summer months except at the equinoxes and winter, since disturbed conditions are different in the two locations (Fotiadis et al., 2004). This statement is justified in the results reported in Fig. 3. The variability from one day to the next could be very different, especially in winter.

Fig. 4 shows deciles of variability from day-to-day at different European locations. It is evident that the levels of variability are similar everywhere but strongly depending on local disturbed conditions.

Conclusions

The present study shows that the slab thickness over Europe is rather independent of latitude but strongly dependent on season and regional disturbed conditions.

References:

1. Fuller-Rowell, Codrescu, Wilkinson, 2000, *Ann. Geophysicae*, vol. **18**, pp. 766-781.
2. Fotiadis D.N., S.S. Kouris, V. Romano and B. Zolesi, 2004, Climatology of ionospheric F-region disturbances, *Annals of Geophysics*, vol. **47**, pp. 1311-1323.
3. Kouris S. S., D. N. Fotiadis and B. Zolesi, 1999, Specifications of the F-region variations for quiet and disturbed conditions, *Phys. Chem. Earth (C)*, vol. **24**(4), pp. 321-327.
4. Kouris, S.S., K. V. Polimeris, Lj. R. Cander, 2005, Specifications of TEC variability, *Adv. Space Res.*, (in press).
5. Leitinger L., L. Ciraolo, L. Kersley, S. S. Kouris and P. Spala, 2004, Relations between electron content and peak density: regular and extreme behaviour, *Annals of Geophysics*, Sup. Vol. **47**, pp. 1093-1107.
6. Mikhailov A. V., 2000, *Fisica de la Tierra*, vol. **12**, pp. 223-262.

1999 Hailsham

	J	F	M	A	M	J	J	A	S	O	N	D	
Day	max.	227	250	350	394	417	405	430	431	401	309	234	222
	mean	213	241	305	356	385	390	406	403	346	271	225	208
	min.	193	230	273	321	347	350	368	371	322	252	216	193

1999 Matera

	J	F	M	A	M	J	J	A	S	O	N	D	
Day	max	279	287	432	437	443	427	468	470	423	440	335	282
	mean	227	252	305	350	371	375	405	397	337	288	248	231
	min	169	204	217	252	323	329	355	339	280	205	178	203

2002 Hailsham

	J	F	M	A	M	J	J	A	S	O	N	D	
Day	max.	242	278	373	438	428	428	454	448	355	317	240	224
	mean	227	265	307	386	399	399	403	392	329	281	215	204
	min.	207	250	286	347	347	345	362	358	314	253	199	193

2002 Brussels

	J	F	M	A	M	J	J	A	S	O	N	D	
Day	max.	248	295	412	456	473	457	475	459	431	477	310	241
	mean	238	271	314	399	414	400	407	398	348	316	238	208
	min.	225	262	277	351	352	341	354	347	320	245	207	195

2002 Matera

	J	F	M	A	M	J	J	A	S	O	N	D	
Day	max.	266	303	331	370	392	344	359	396	330	311	272	237
	mean	248	285	298	319	341	323	323	349	288	285	245	221
	min.	215	264	267	283	299	280	283	307	251	262	214	197

2002 Nicosia

	J	F	M	A	M	J	J	A	S	O	N	D	
Day	max.	312	327	353		456	412	429	413	324	343	292	246
	mean	281	301	331		378	371	382	364	299	282	247	228
	min.	250	267	307		339	321	346	325	263	266	207	192

Table 1 Average values of slab thickness and extreme (max./min.), using monthly median values of TEC and foF2, during day ($\cos\chi \geq 0.10$) at different locations and years.

1999 Hailsham

	J	F	M	A	M	J	J	A	S	O	N	D	
Night	max.	513	503	474	449	382	381	403	453	539	566	533	527
	mean	401	371	347	334	311	316	320	348	382	375	372	410
	min.	213	257	264	284	277	278	274	307	294	262	223	204

1999 Matera

	J	F	M	A	M	J	J	A	S	O	N	D	
Night	max	796	785	651	539	536	471	519	602	584	943	1059	878
	mean	435	410	351	341	320	318	320	334	366	413	465	481
	min	178	226	185	218	266	267	269	251	236	189	185	164

2002 Hailsham

	J	F	M	A	M	J	J	A	S	O	N	D	
Night	max.	510	463	425	451	376	413	406	515	420	675	531	512
	mean	367	339	317	345	322	320	324	363	320	421	391	396
	min.	239	262	277	305	291	274	284	298	280	262	237	209

2002 Brussels

	J	F	M	A	M	J	J	A	S	O	N	D	
Night	max.	616	477	520	488	412	448	447	563	497	697	664	654
	mean	375	331	319	350	318	322	326	359	321	442	423	412
	min.	213	247	273	305	287	271	289	289	269	255	225	217

2002 Matera

	J	F	M	A	M	J	J	A	S	O	N	D	
Night	max.	472	332	378	357	406	346	369	425	310	491	453	378
	mean	367	303	301	288	295	253	268	331	285	394	364	311
	min.	223	254	266	264	269	229	239	277	245	276	233	193

2002 Nicosia

	J	F	M	A	M	J	J	A	S	O	N	D	
Night	max.	449	441	426		403	359	382	385	401	484	528	486
	mean	360	357	359		346	283	306	351	343	343	353	385
	min.	276	296	303		300	260	271	303	251	229	232	224

Table 2 Average values of slab thickness and extreme (max./min.), using monthly median values of TEC and foF2, during night ($\cos\chi < 0.10$) at different locations and years.

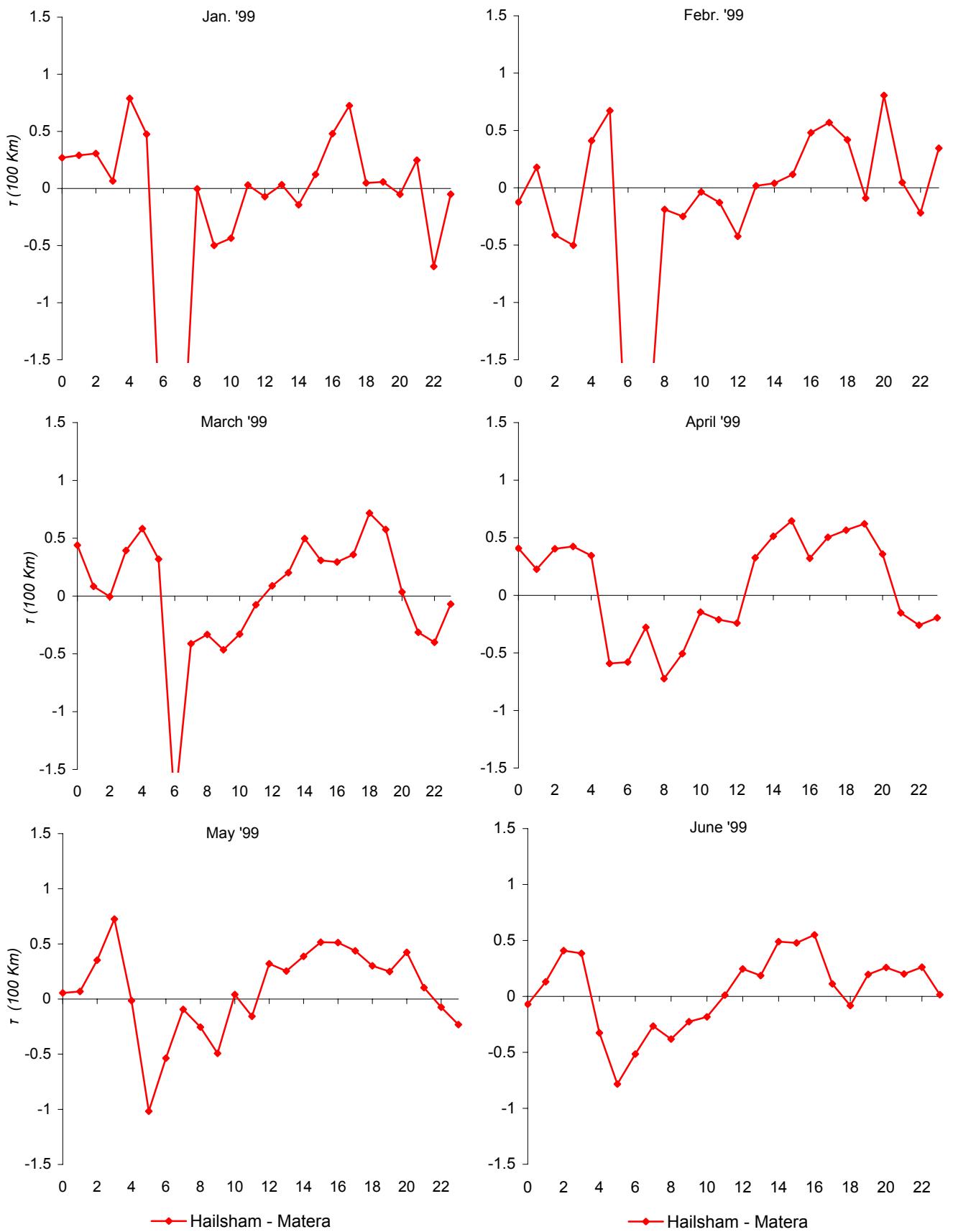


Fig. 1a Differences of estimated Slab Thickness at different locations

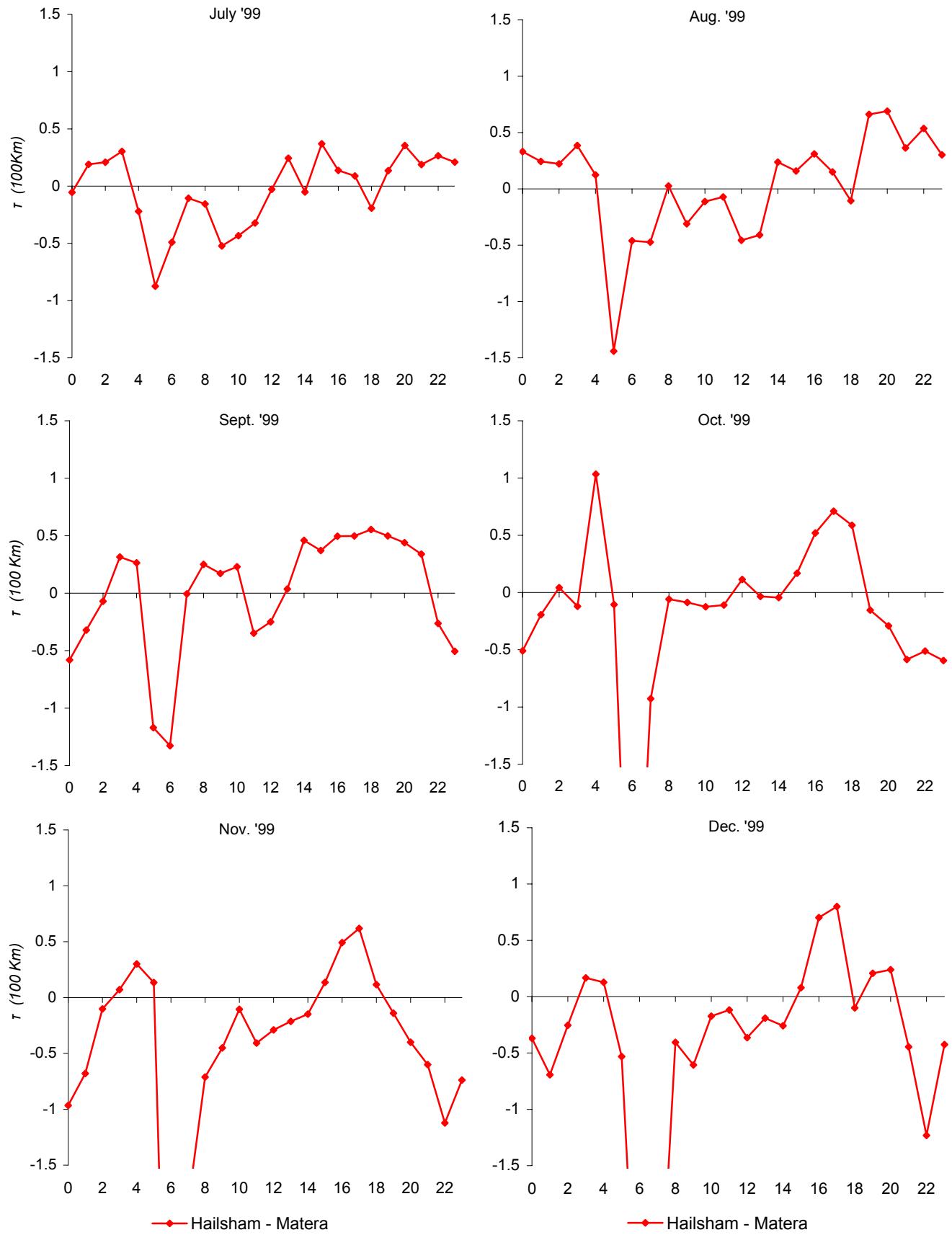


Fig. 1a Differences of estimated Slab Thickness at different locations

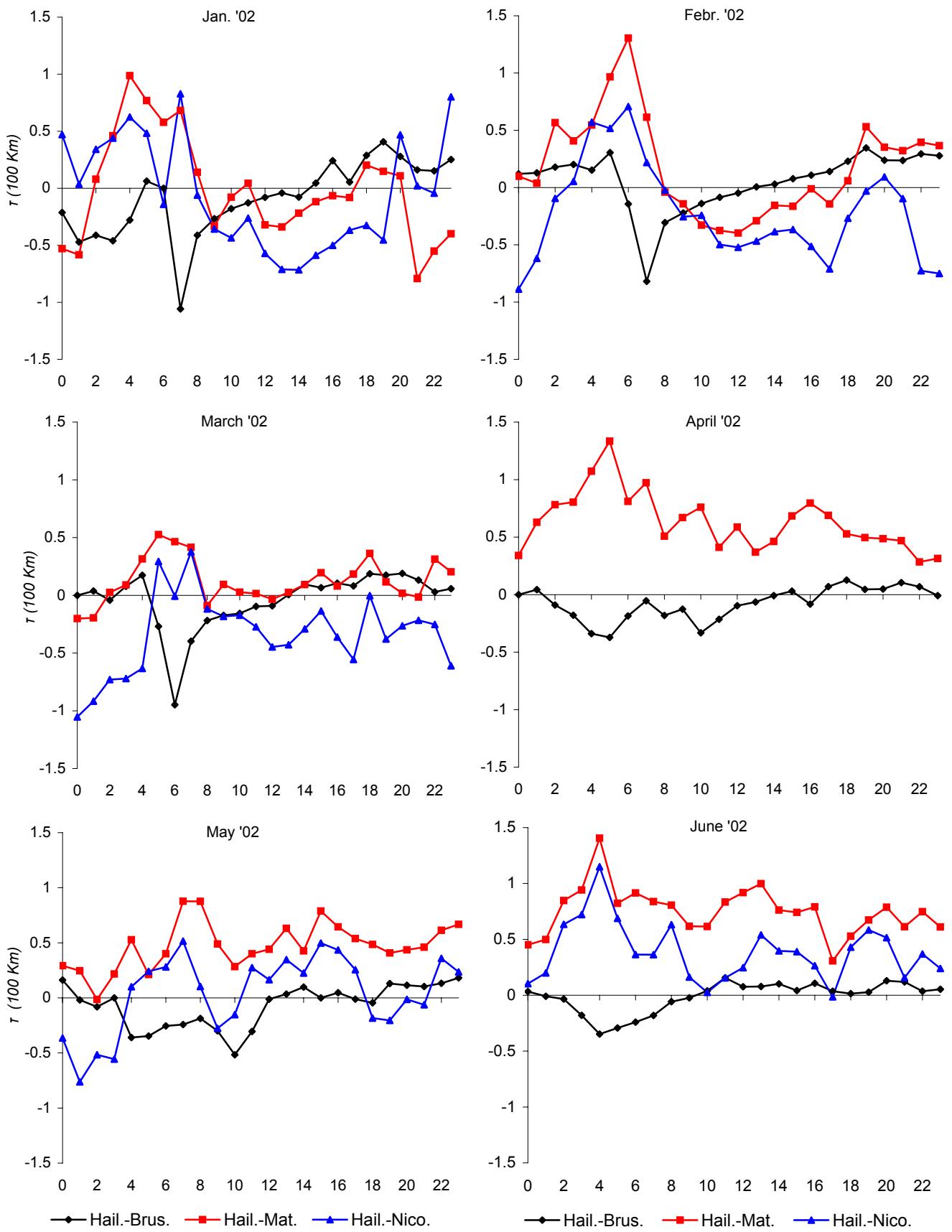


Fig. 1b Differences of estimated Slab Thickness at different locations

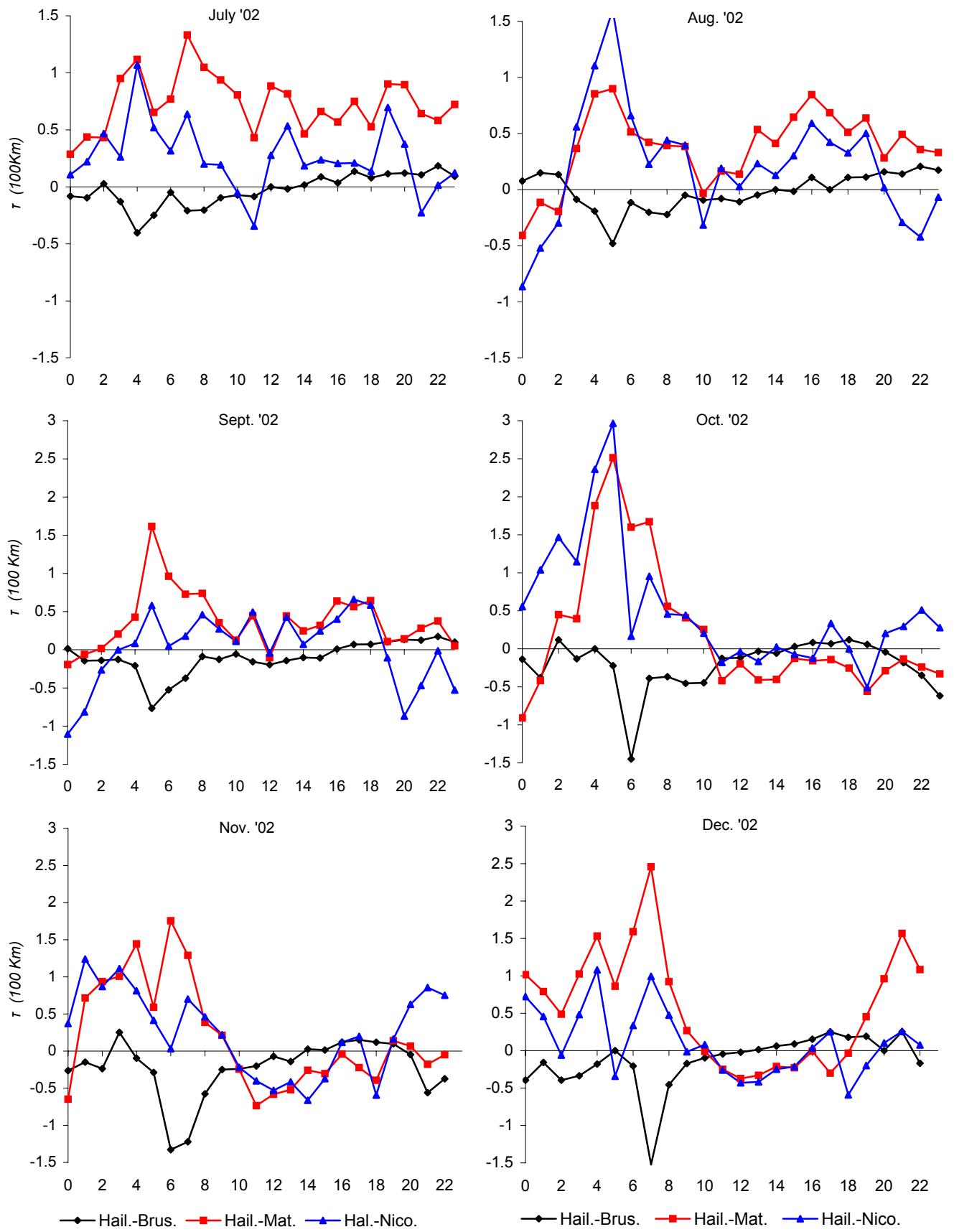


Fig. 1b Differences of estimated Slab Thickness at different locations

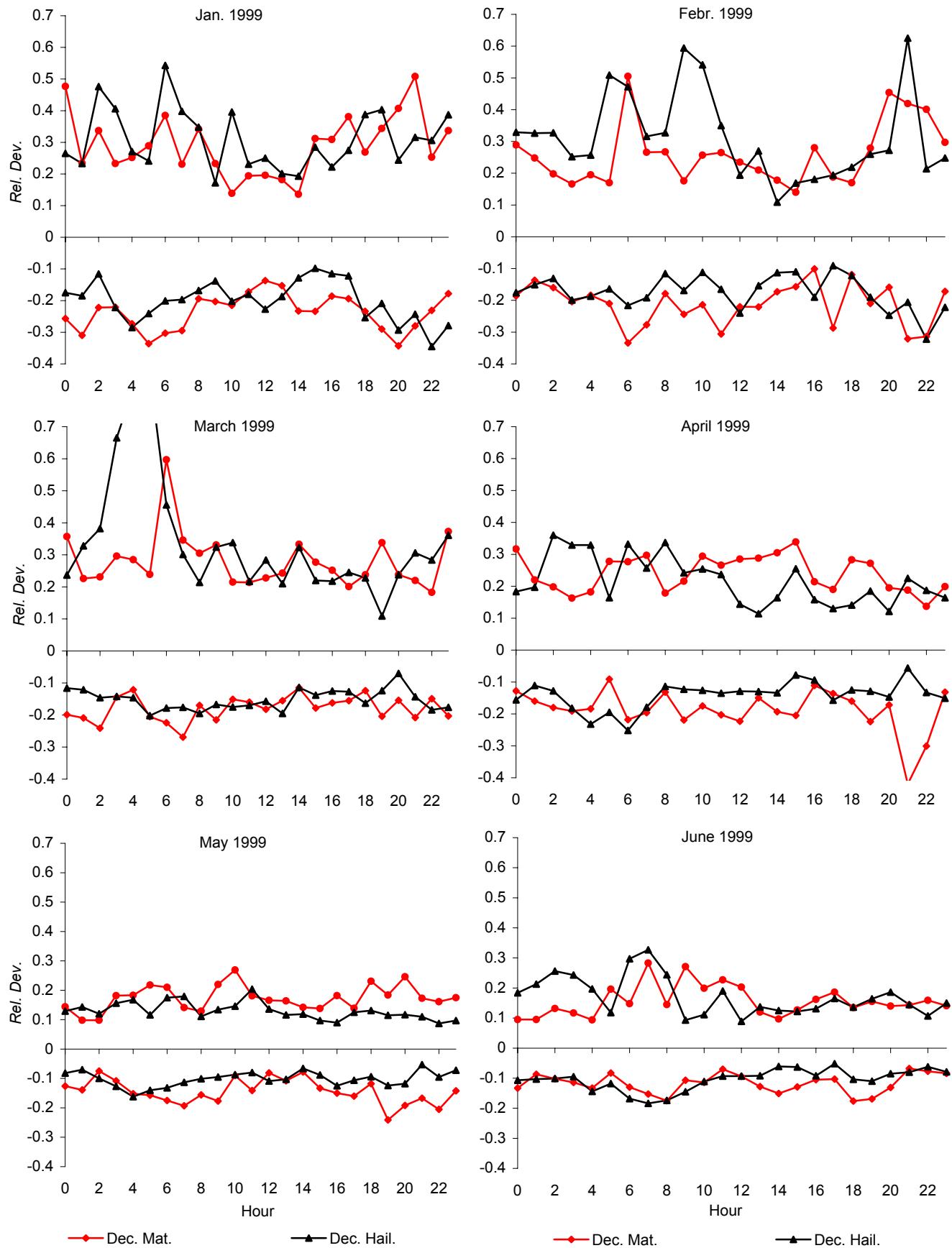


Fig. 2a Deciles of variability of τ from day-to-day. Data from Matera and Hailsham measured in 1999.

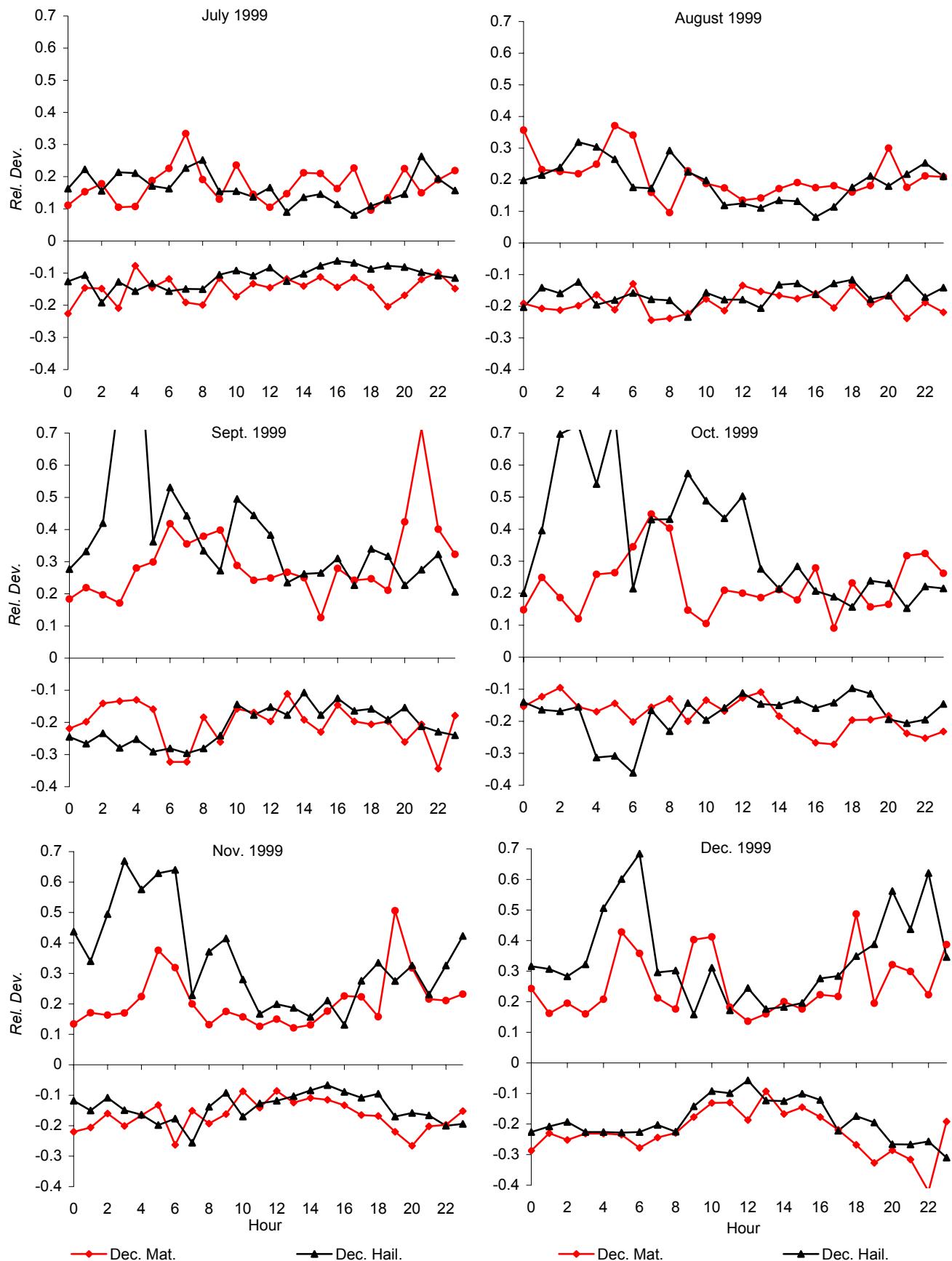


Fig. 2b Deciles of variability of τ from day-to-day. Data from Matera and Hailsham measured in 1999.

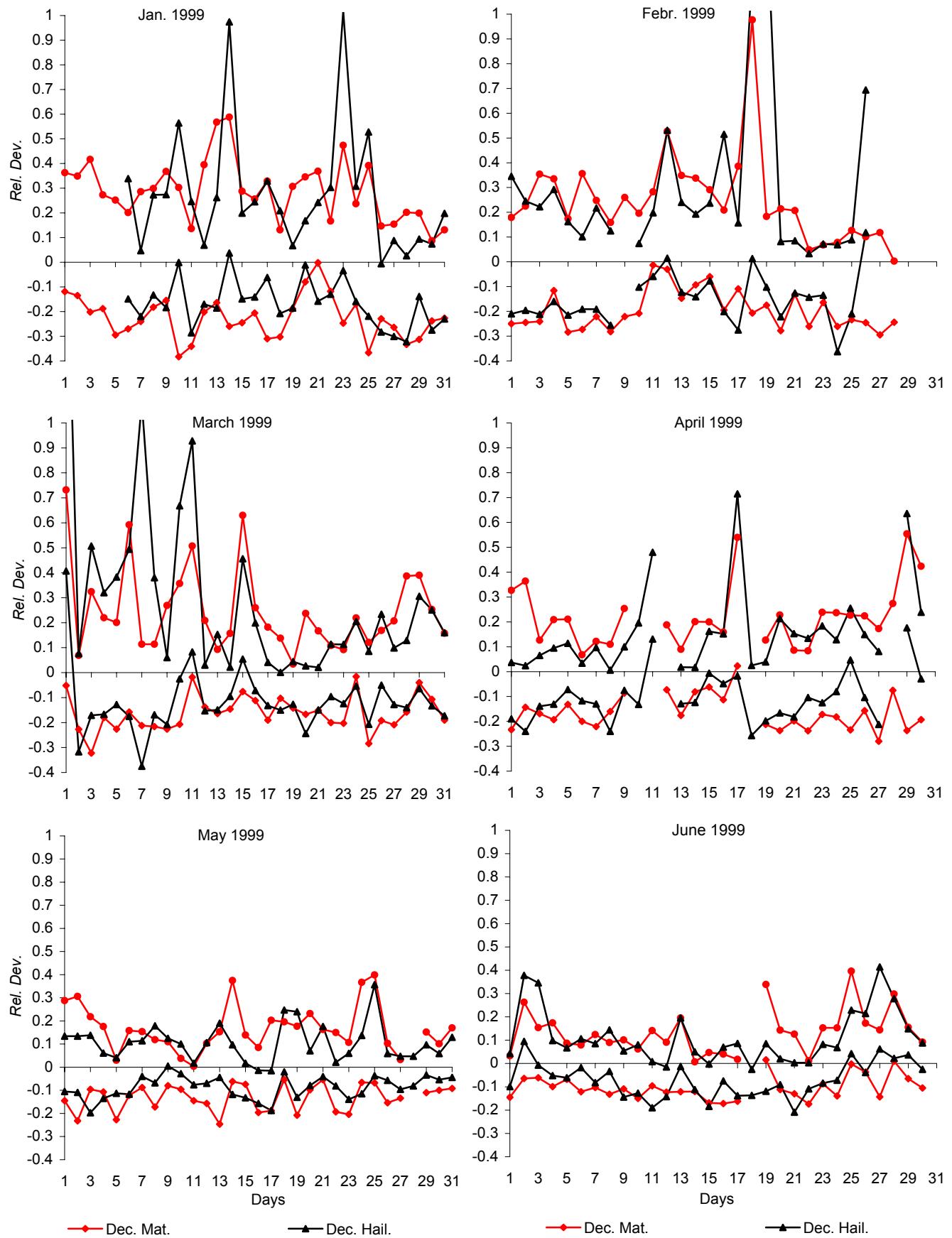


Fig. 3a Deciles of variability of τ from hour-to-hour. Data from Matera and Hailsham measured in 1999.

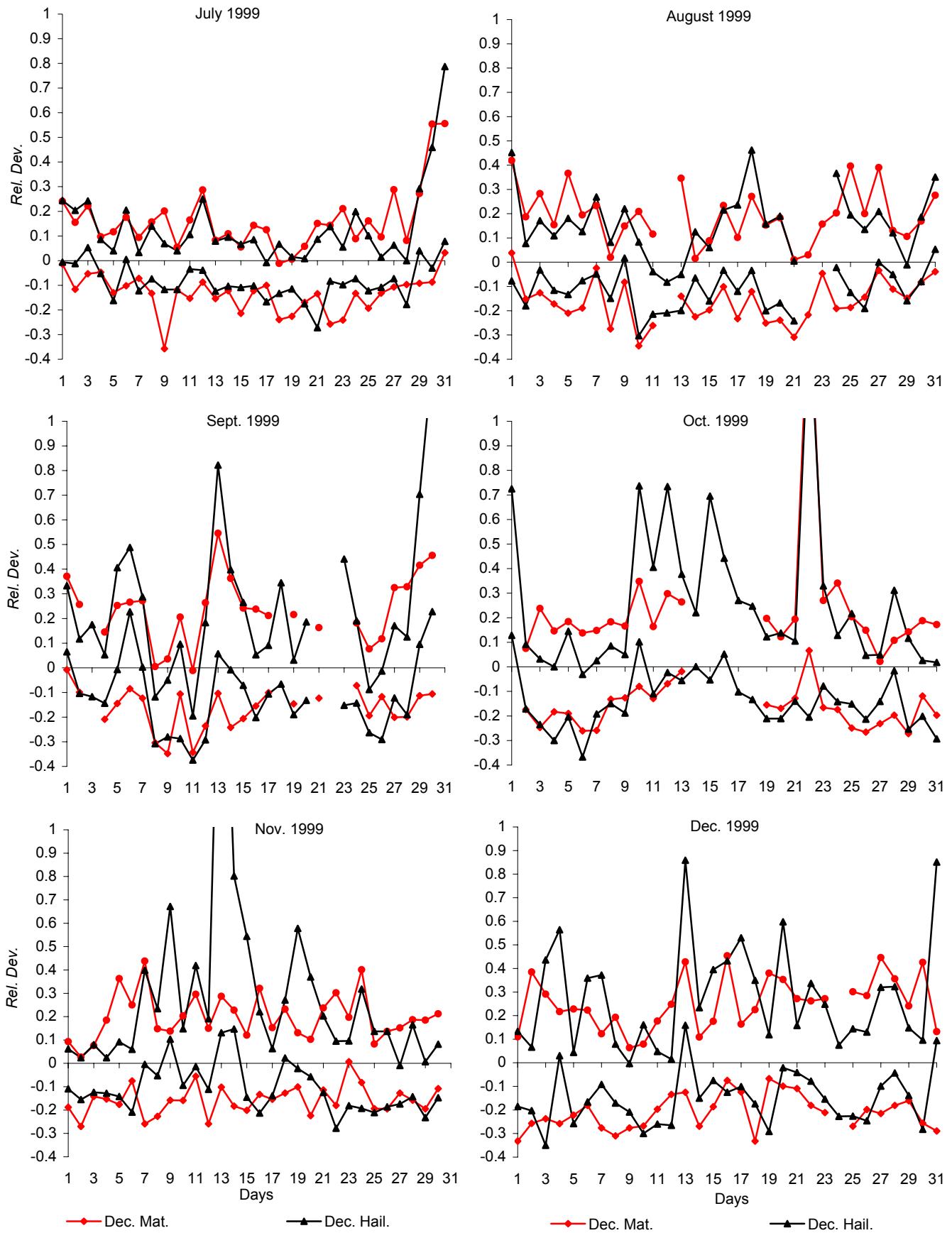


Fig. 3b Deciles of variability of τ from hour-to-hour. Data from Matera and Hailsham measured in 1999.

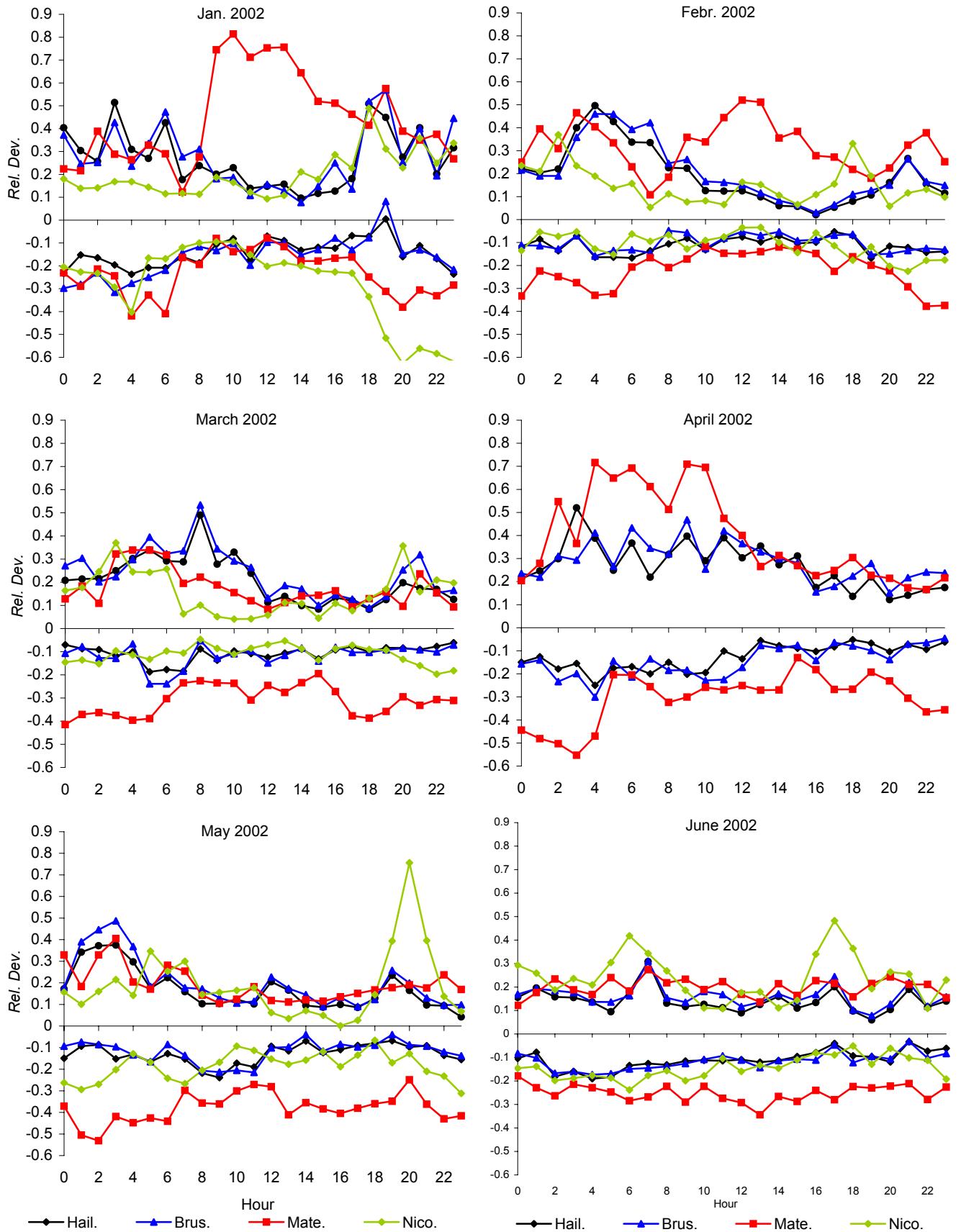


Fig. 4a Deciles (day-to-day) at different locations

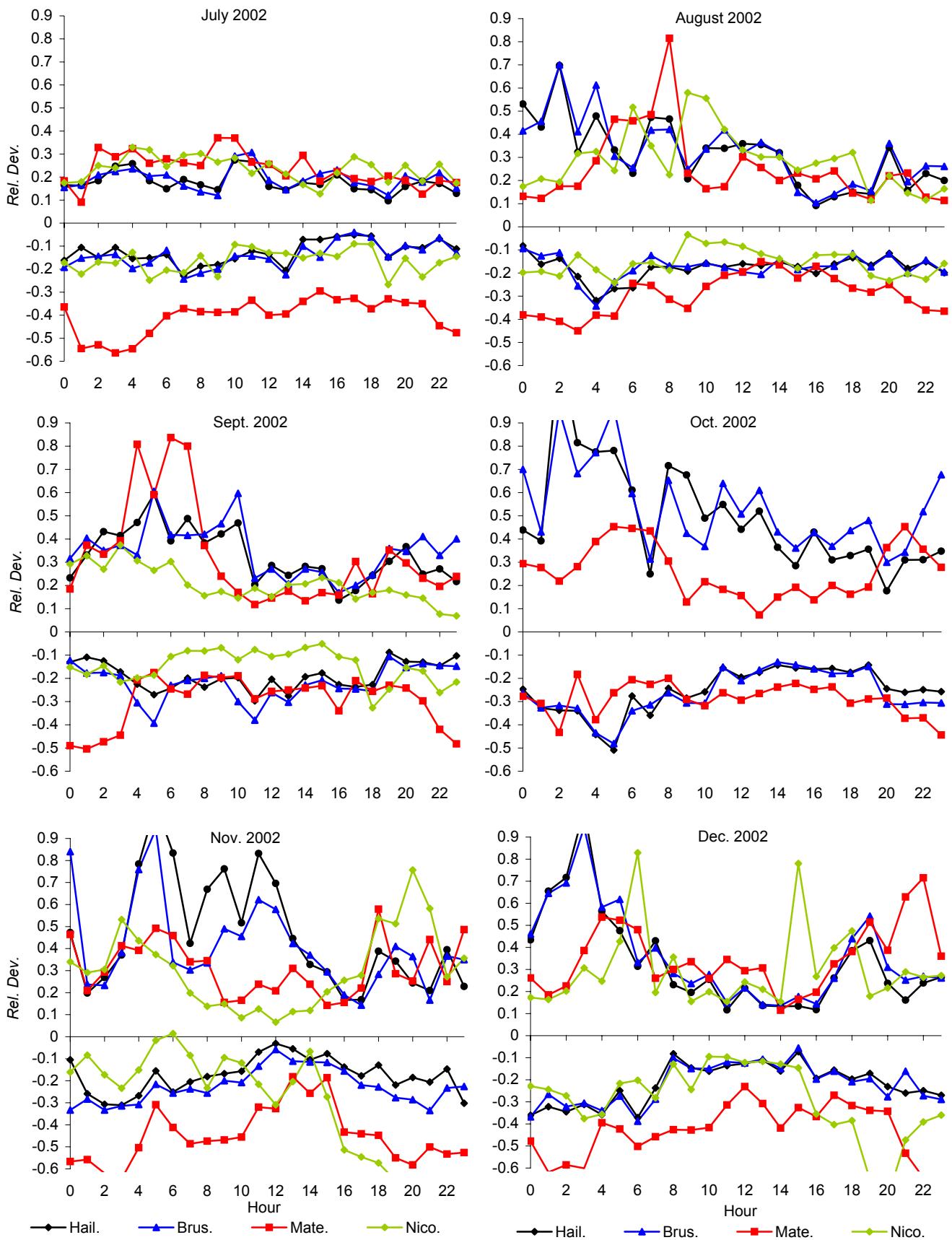


Fig. 4b Deciles (day-to-day) at different locations