159 “special” nights of airglow data from El Leoncito

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IAFE, Buenos Aires

Journal of Atmospheric and Solar-Terrestrial Physics 186 (2019) 20–27

Contents lists available at ScienceDirect

Journal of Atmospheric and Solar-Terrestrial Physics

journal homepage: www.elsevier.com/locate/jastp

The semidiurnal tide for individual nights derived consistently from O_2 and OH intensities and temperatures

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We use airglow data from El Leoncito (32°S, 69°W) obtained between 1998 and 2014.
Those are band intensities and rotational temperatures of the OH(6-2) and O2*b*(0-1) bands.

1. Among those 4034 data nights, we find 2879 nights with more than 250 data.

2. By spectral analysis, we determine the main spectral component, and we select...

3. 159 cases where periods of intensity and temperature for both airglow emissions agree closely.

Table 1
Numbers of nights per month used in the analysis, of special (self-consistent) cases, fraction of cases normalized by number of nights and cases with very long vertical wavelength.

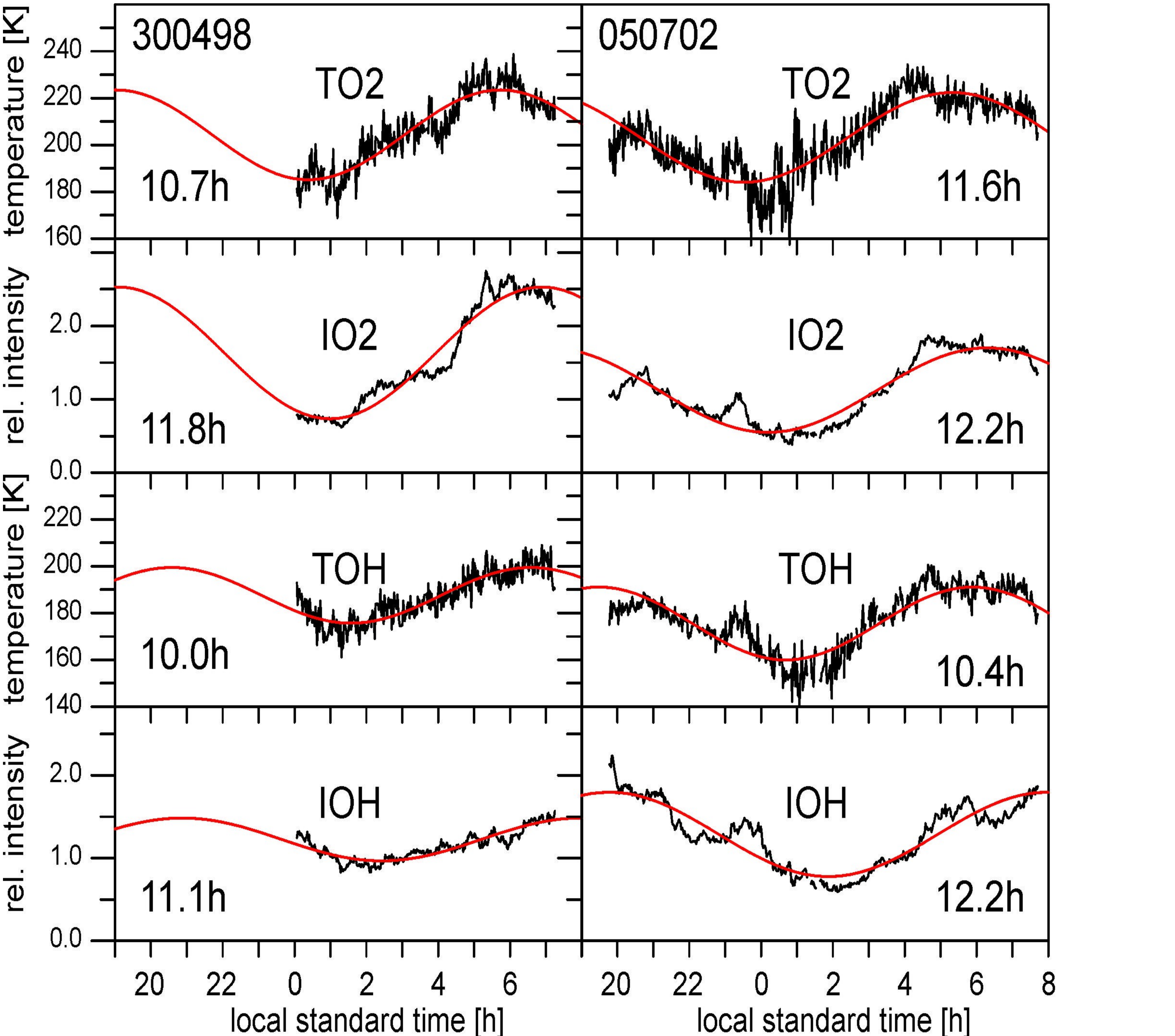
month	# nights	# special	%	#long λ_z
1	155	0	0	0
2	180	6	3.3	0
3	221	10	4.5	0
4	283	25	8.8	0
5	265	23	8.7	4
6	263	22	8.4	5
7	240	22	9.2	2
8	263	23	8.7	1
9	236	11	4.7	1
10	309	14	4.5	0
11	264	3	1.1	1
12	200	0	0	0
total	**2879**	**159**	**5.5**	**14**

Two examples of measured parameters and spectral fits:

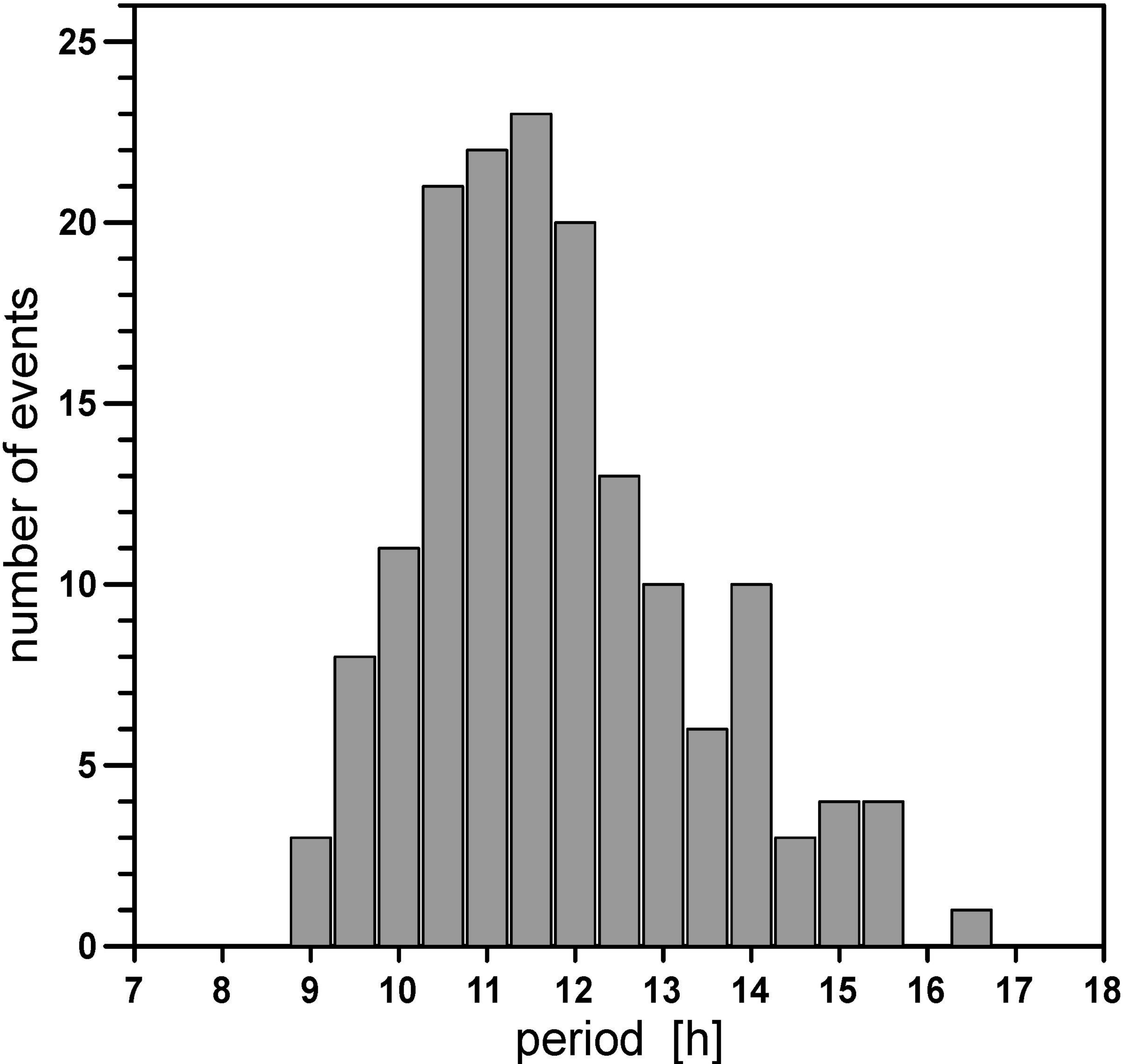
April 30, 1998 with data spanning 7.2 hours (the shortest case),

and

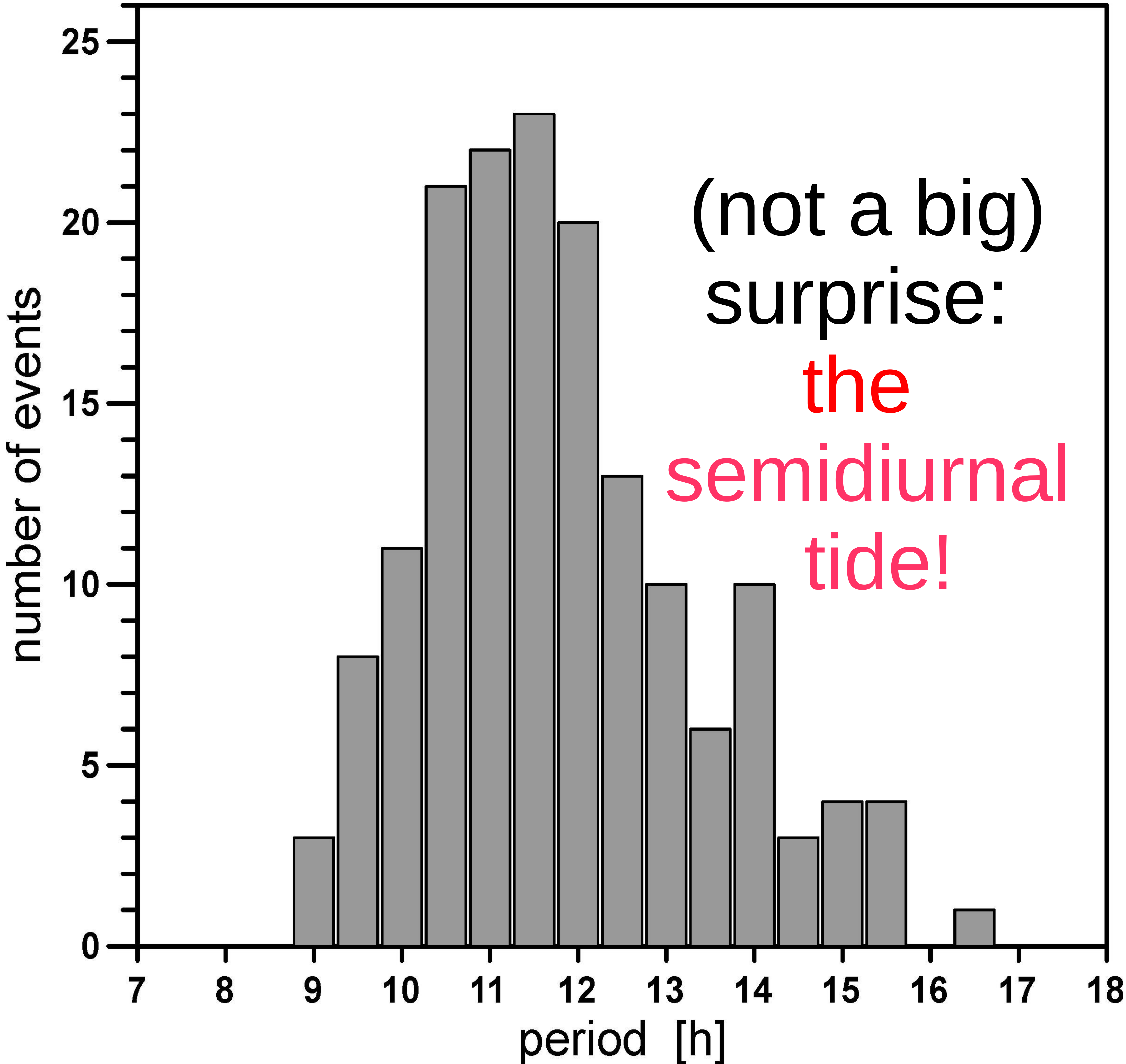
July 5, 2002 with data spanning 11.9 hours (the longest case).



300498
050702
TO2
10.7h
11.6h
IO2
11.8h
12.2h
TOH
10.0h
10.4h
IOH
11.1h
12.2h
temperature [K]
rel. intensity
temperature [K]
rel. intensity
local standard time [h]
local standard time [h]

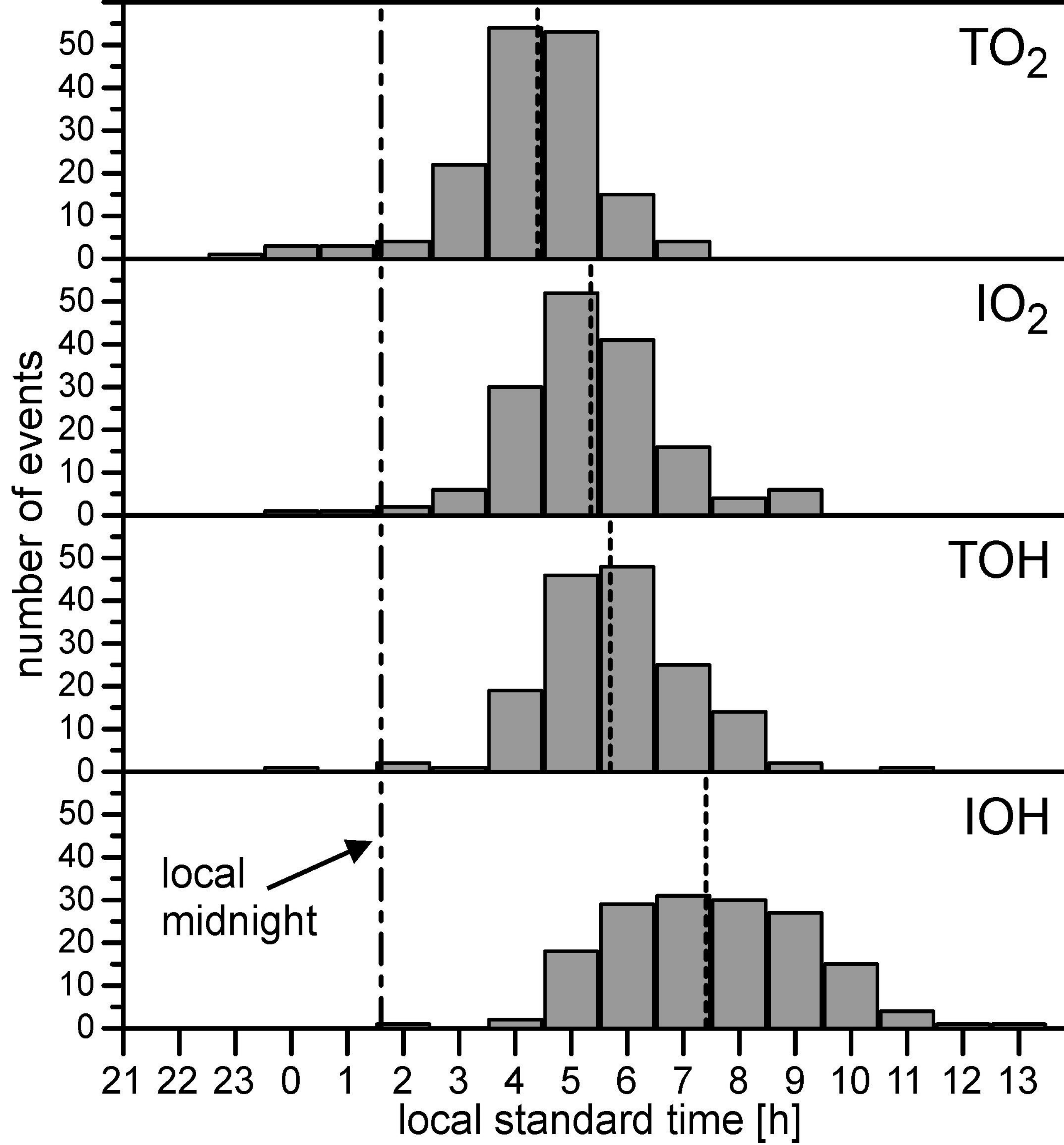


0
5
10
15
20
25
number of events
7
8
9
10
11
12
13
14
15
16
17
18
period [h]



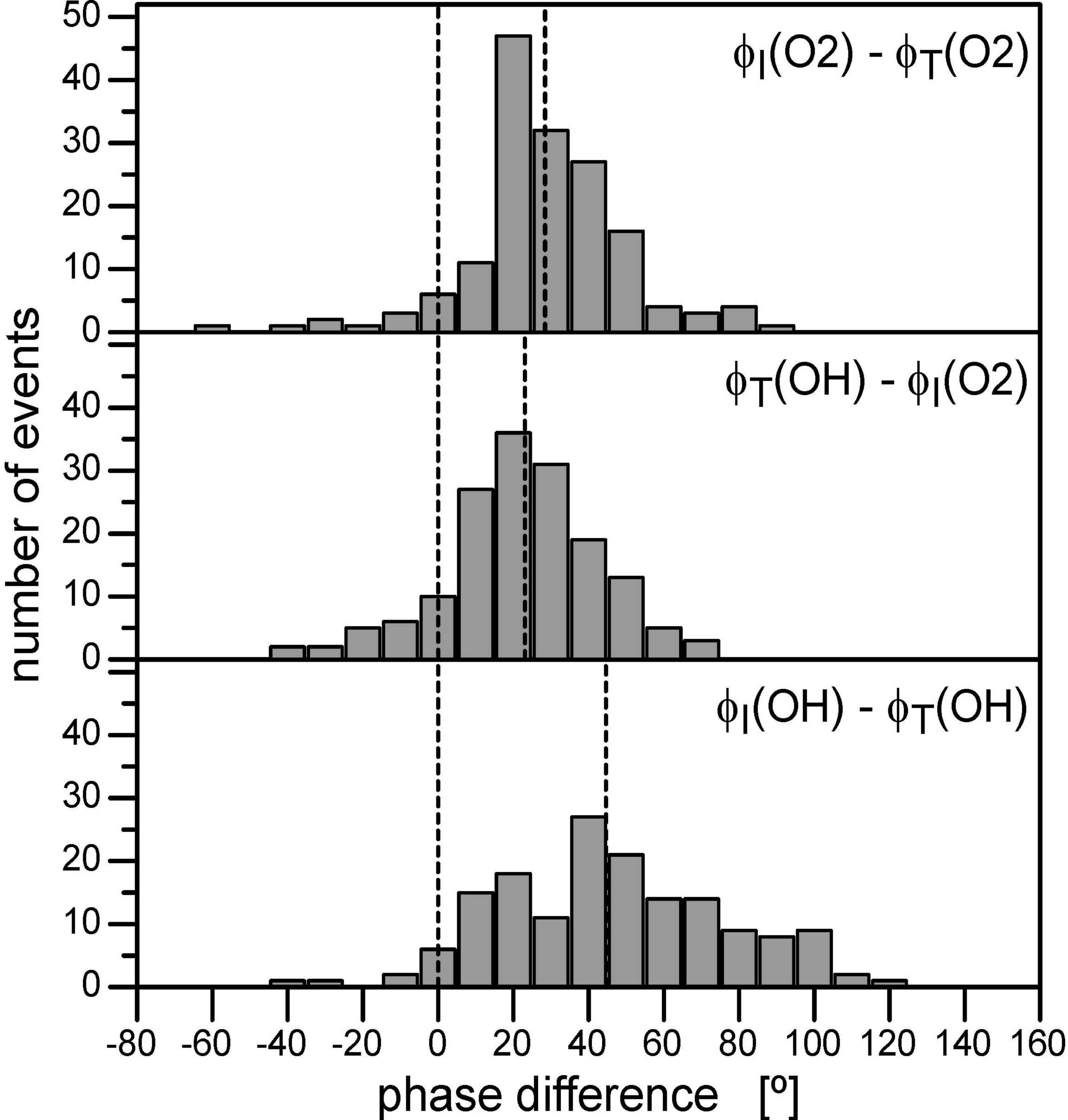
(not a big)
surprise:
the
semidiurnal
tide!
number of events
period [h]
0
5
10
15
20
25
7
8
9
10
11
12
13
14
15
16
17
18

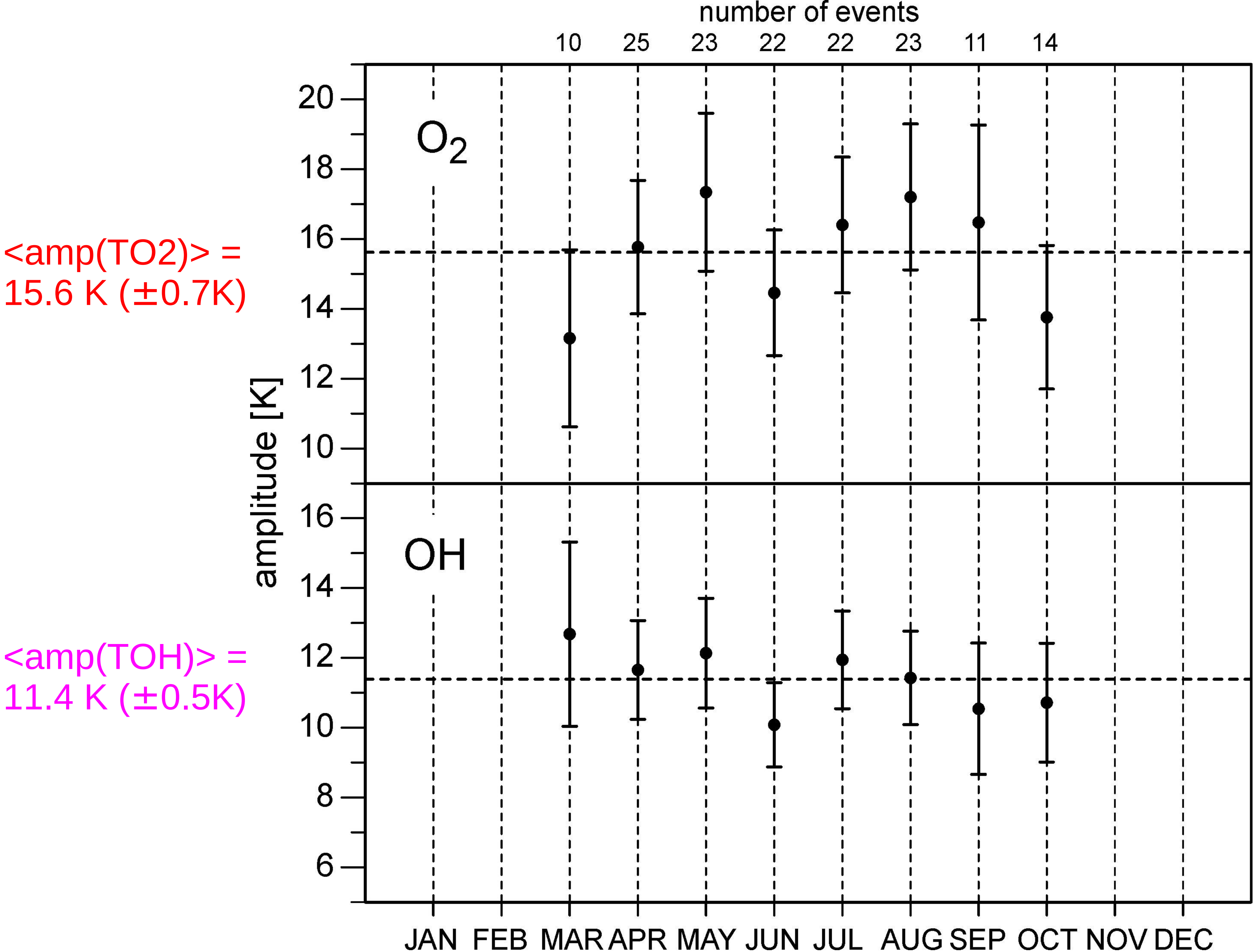
These histograms, although treated as if they were independent, already suggest downward phase propagation from the highest level (TO2) to the lowest one (IOH).



Phase (time of maximum)

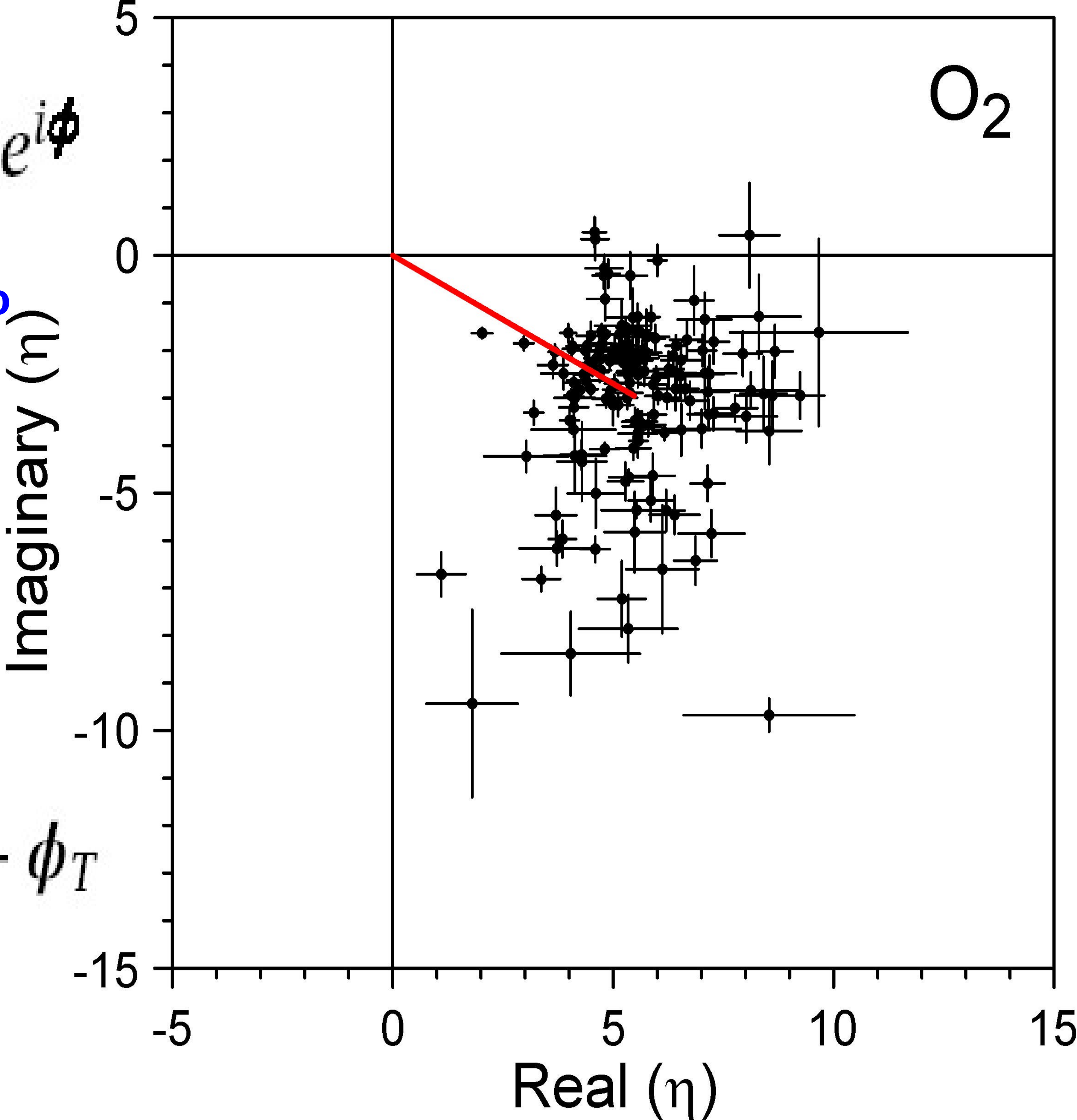
phase change of parameters at neighboring effective heights




number of events
10 25 23 22 22 23 11 14
O2
OH
amplitude [K]
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
<amp(TO2)> =
15.6 K (±0.7K)
<amp(TOH)> =
11.4 K (±0.5K)

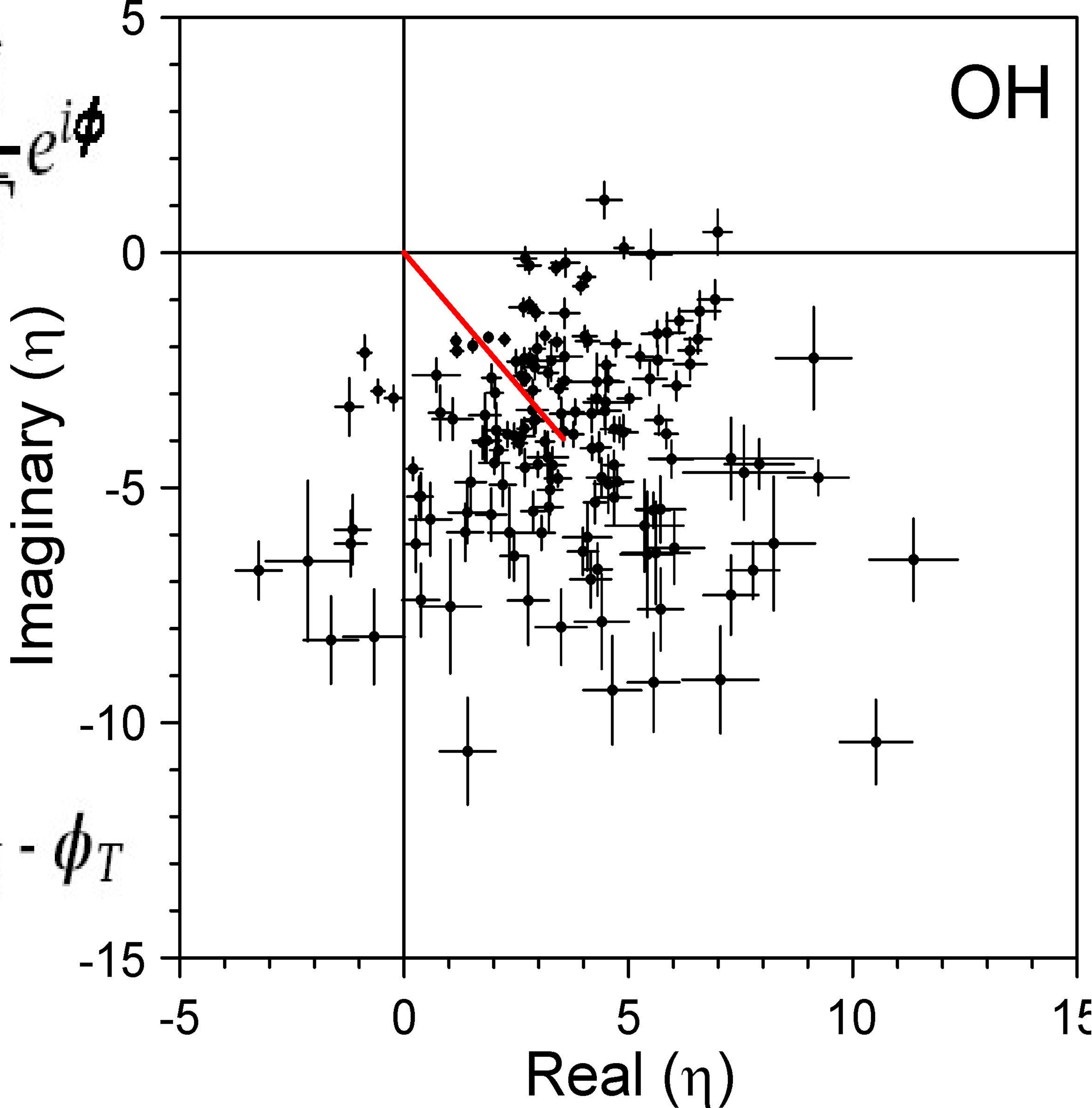
$$\eta = \frac{A_I / \bar{I}}{A_T / \bar{T}} e^{i\phi}$$

Krassovsky's ratio



$$\text{phase } \phi = \phi_I - \phi_T$$

$$\eta = \frac{A_I / \bar{I}}{A_T / \bar{T}} e^{i\phi}$$

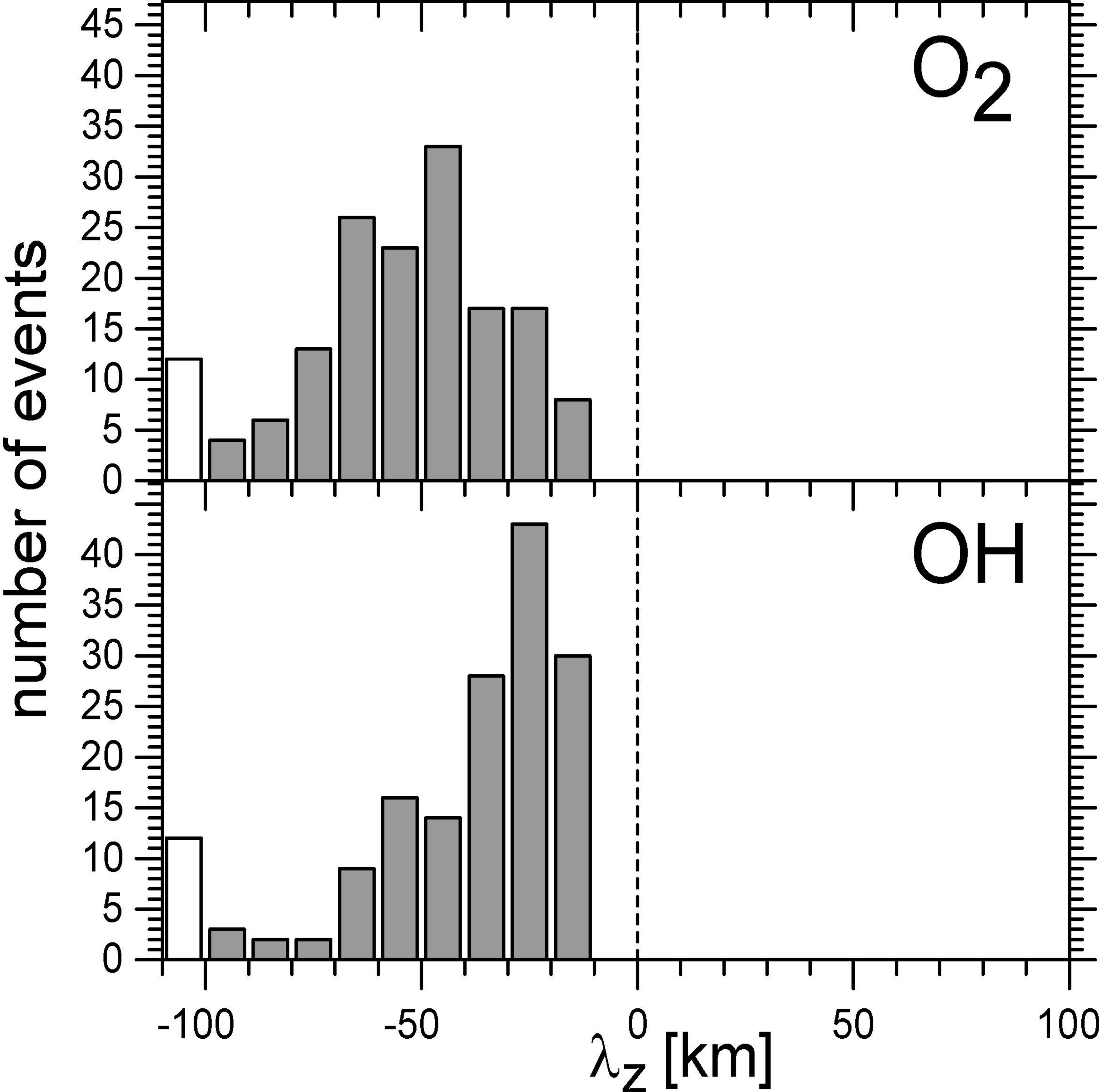


phase $\phi = \phi_I - \phi_T$

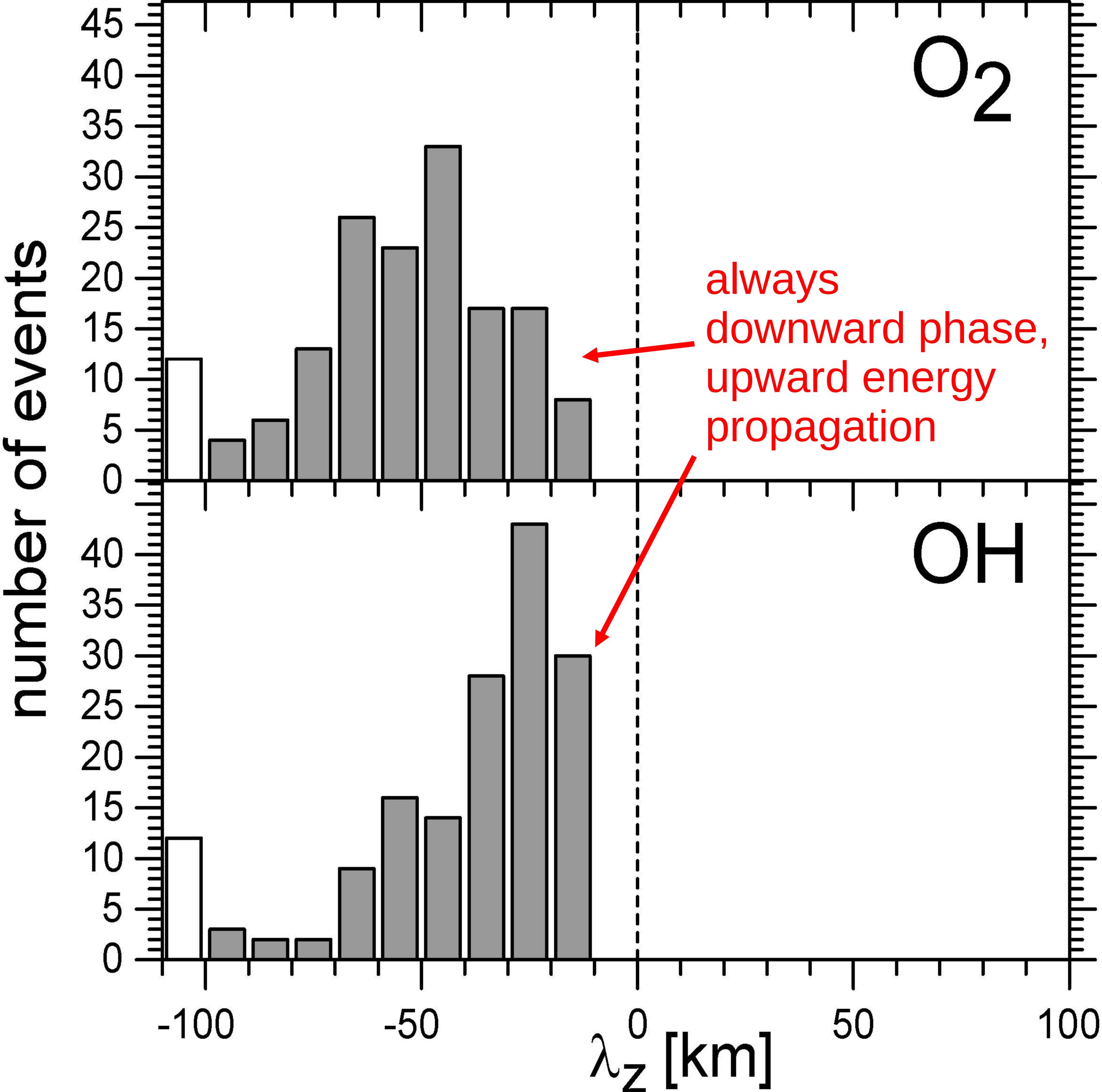
Hines and Tarasick theory (1987)

says that for zenith observation, vertical wavelength depends on the imaginary part of Krassovsky's ratio:

$$\lambda_z \approx \frac{2\pi\gamma H}{(\gamma - 1)|\eta|\sin\phi}$$



O2
OH
number of events
λz [km]
0
5
10
15
20
25
30
35
40
45
-100
-50
0
50
100

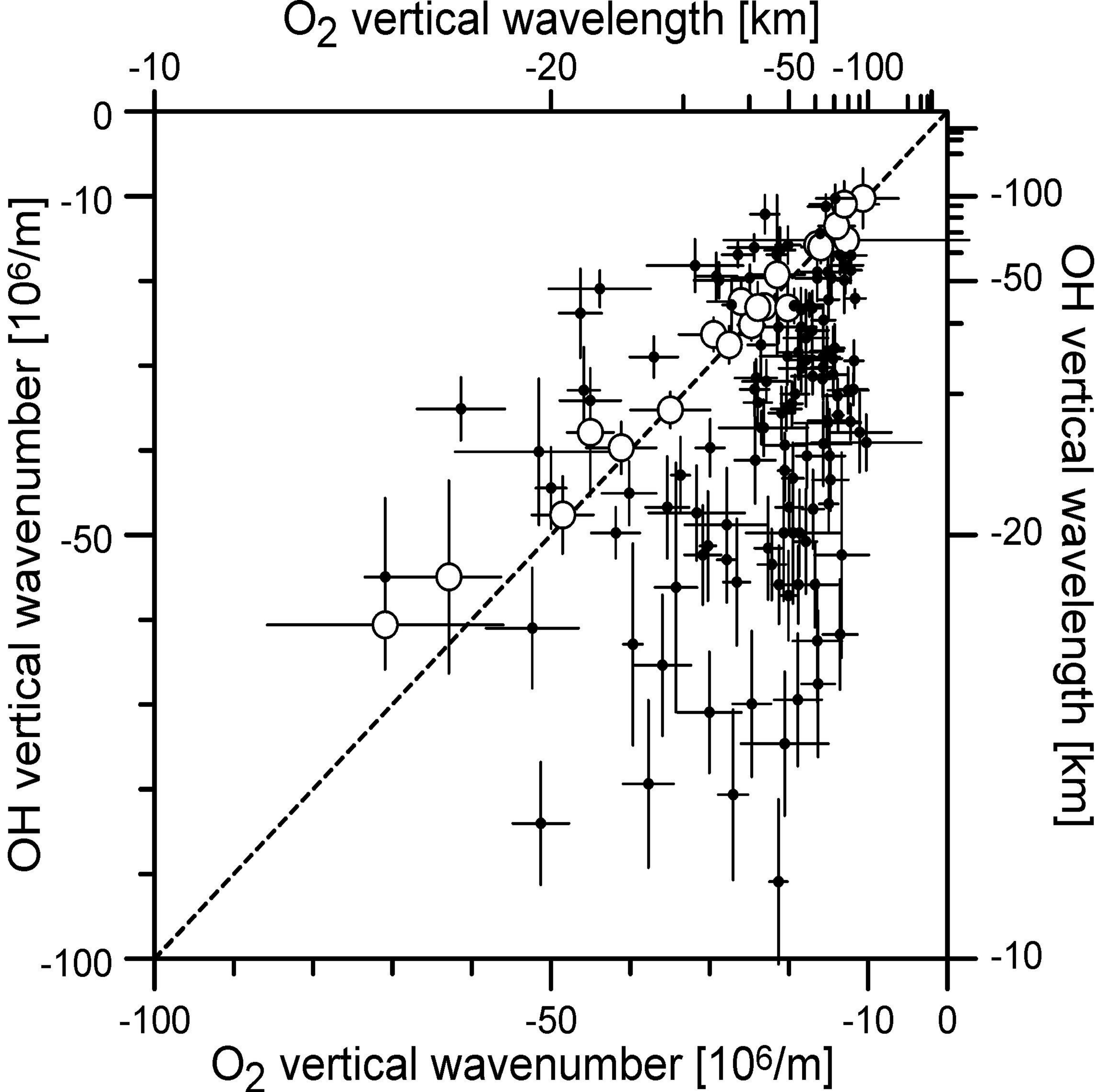


O2
OH
always
downward phase,
upward energy
propagation
number of events
λz [km]
-100
-50
0
50
100
0
5
10
15
20
25
30
35
40
45

Vertical wavelengths tend to be shorter, at the height of the OH emission (nominally at 87 km), than that of the O2 emission (nominally at 95 km):

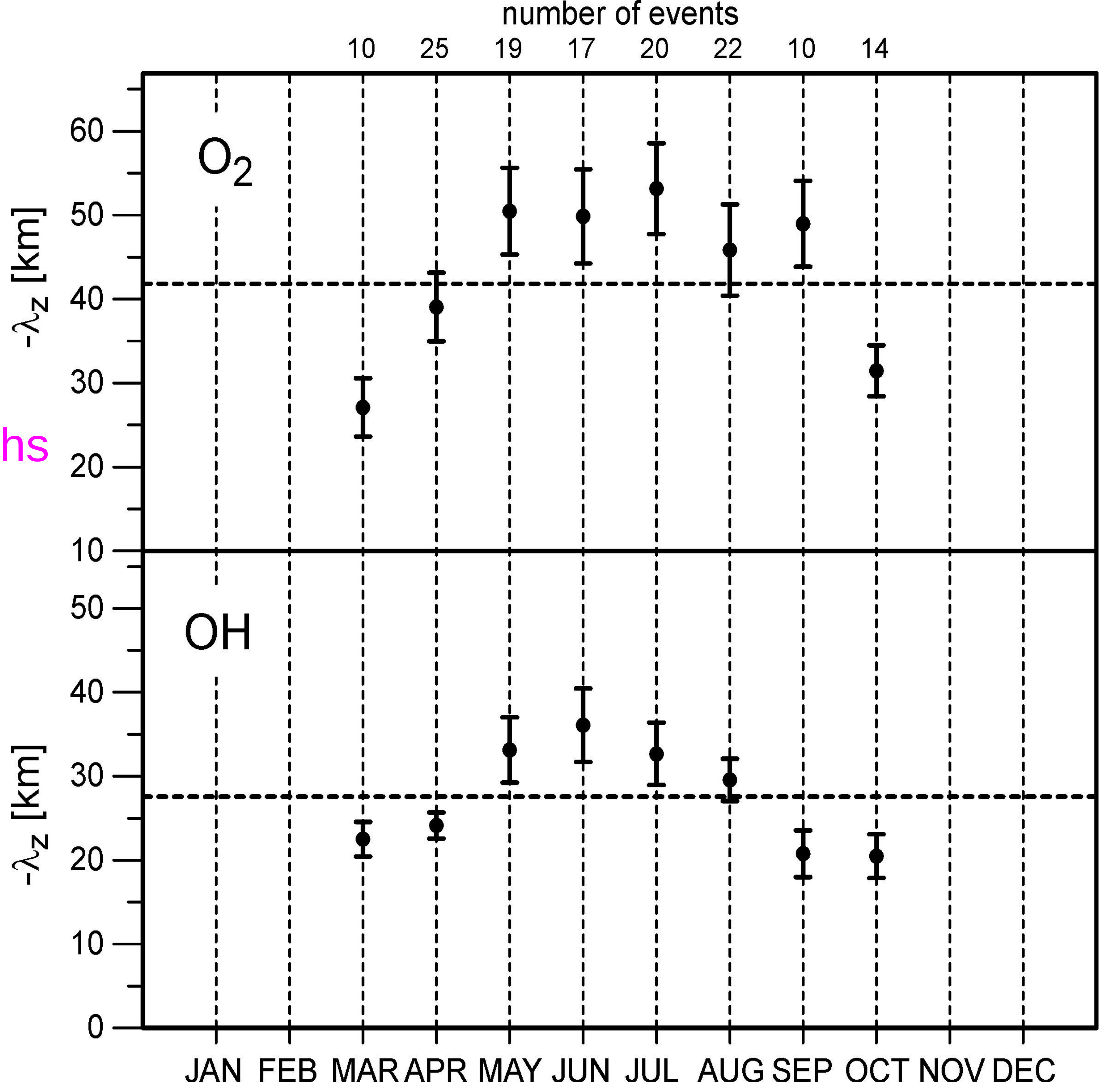
Mean value for OH -27.6 km (±1.1 km),
for O2 -41.8 km (±1.8 km)

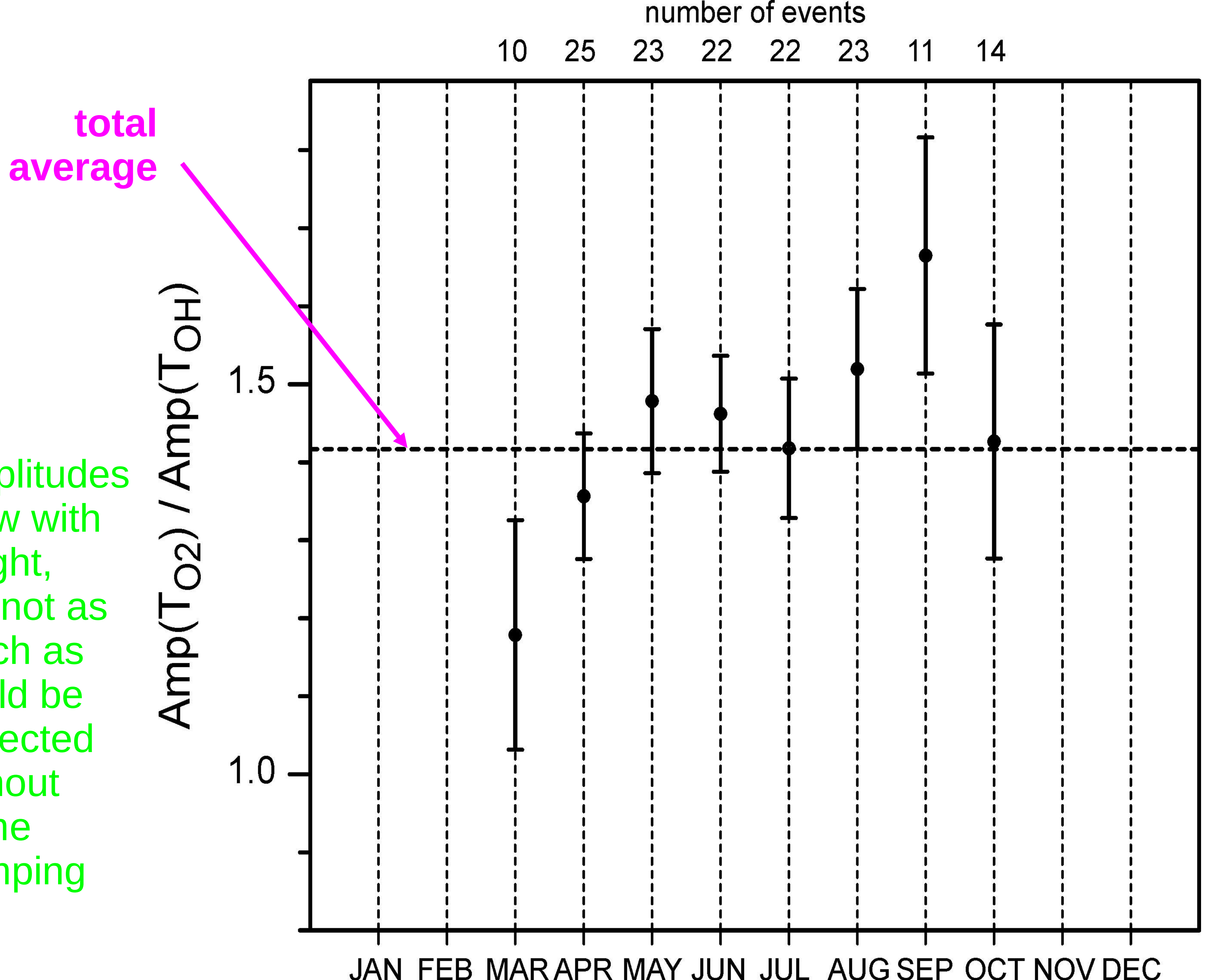
We see this not only in the histograms, but also when we compare individual results, like this....



O2 vertical wavelength [km]
-10
-20
-50
-100
0
-10
-50
-100
OH vertical wavenumber [10^6/m]
-100
-50
-20
-10
OH vertical wavelength [km]
-100
-50
-10
0
O2 vertical wavenumber [10^6/m]

Do wavelengths really drop slightly, near the equinoxes?





Amplitudes grow with height, but not as much as could be expected without some damping

Conclusions

In southern winter, 9% of the nocturnal data have consistent tidal signatures in intensities and temperatures of both measured airglow emissions, but none, or few, from November to February.

Identification as tide is based on observed periods, phases, and the downward phase progression.

Monthly mean amplitudes from March to October are close to annual means.

As expected from the Hines & Tarasick model, values of Krassovsky's eta are concentrated in the fourth quadrant of the complex plane.

Mean vertical wavelengths are about 42 km for O_2 and 28 km for OH.

We also confirm our earlier findings about the effective layer separation which differs when based on intensities (resulting in 7.1 km) or on temperatures (resulting in 4.8 km).

The mean amplitude growth factor for the temperature oscillations is 1.42, compatible with moderate attenuation.

Many thanks
for
your attention!

Some references:

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Monthly and yearly distribution of special events, total data per year, and yearly yields

mon	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	all	
jan	-	-	-	-	-	-	n	a	n	-	-	-	-	-	-	-	-	0	
feb	-	1	-	1	-	n	o	t	1	1	-	-	1	-	-	-	1	6	
mar	n	1	3	-	-	o		a	2	1	1	-	2	-	-	-	-	10	
apr	2	3	-	-	-		d		1	3	4	2	3	1	4	2	n	25	
may	1	-	3	1	1	d	a	n	3	1	1	1	3	5	2	1	o	23	
jun	-	3	2	1	2	a	t	o	1	1	2	-	2	2	2	4		22	
jul	1	1	1	n	3	t	a		-	4	3	1	3	2	-	3	-	22	
aug	-	-	3	3	2	a		d	-	1	2	2	3	1	1	1	4	23	
sep	1	-	-	-	2		n	a	-	1	1	1	4	-	1	-	-	11	
oct	1	2	-	1	1	n	o	t	2	2	1	-	3	-	-	1	-	14	
nov	-	-	-	-	-	o		a	1	1	-	-	-	1	-	-	-	3	
dec	-	-	-	-	-	-	d		-	-	-	-	-	-	-	-	-	0	
allm	6	11	12	7	11				11	16	15	7	24	12	10	12	5	159	
t	1	1	1	1	2	1	0	0	2	2	2	2	2	2	3	2	1		
o	7	7	7	7	2	2			7	7	7	9	9	8	0	8	6		<- w/o jan, dec
t	0	6	4	5	9				2	1	5	0	3	6	1	5	8		
%	3.5		6.9		4.8				4.0		5.5		8.2		3.3		3.0		
		6.3		4.0		0				5.9		2.4		4.2		4.2			