HIPPO and the distribution of long and short-lived gases

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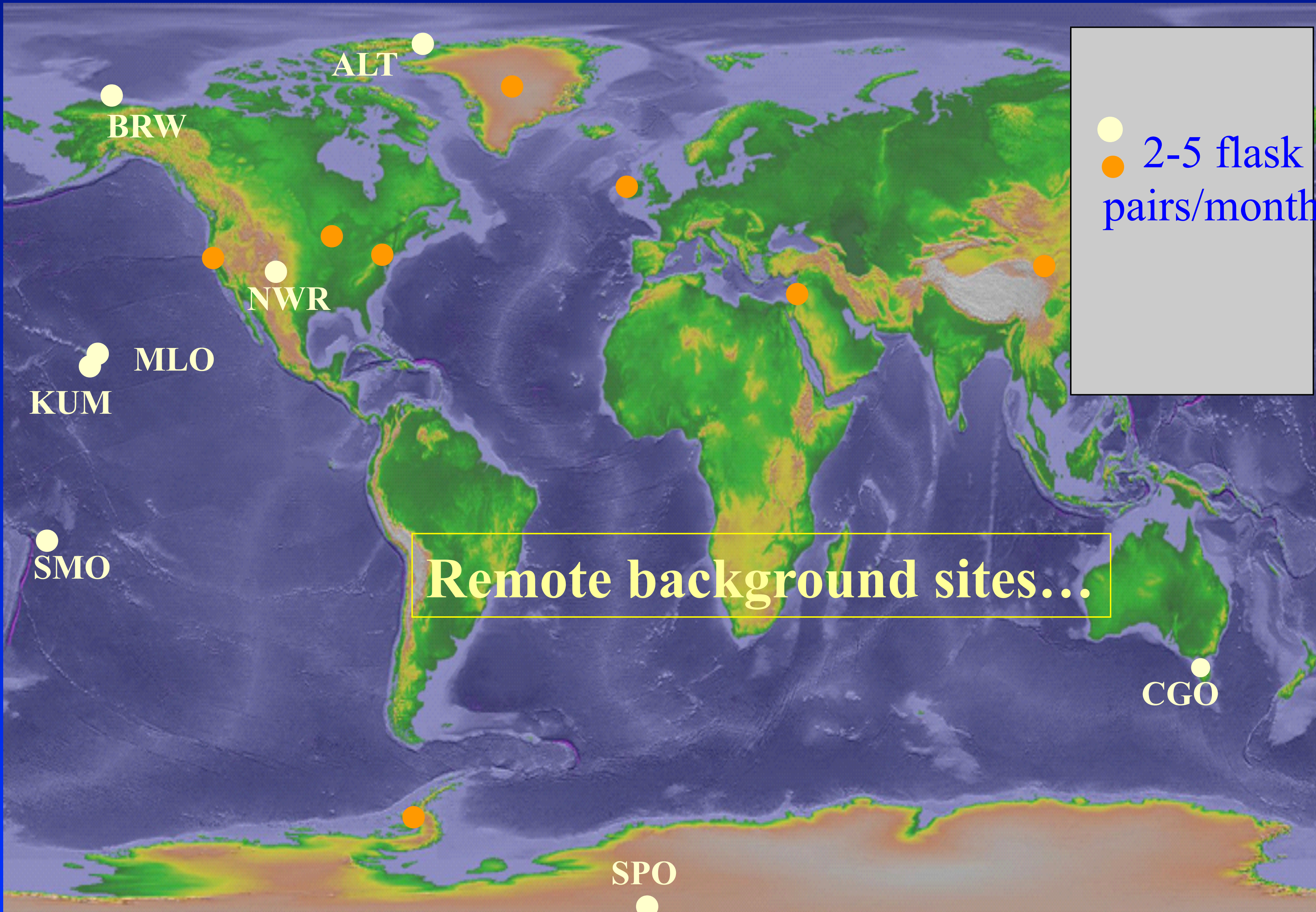
1) **Long-lived chemicals**:

How well do we capture the tropospheric background concentration of a long-lived trace gas from remote surface observations (NOAA background sites)?

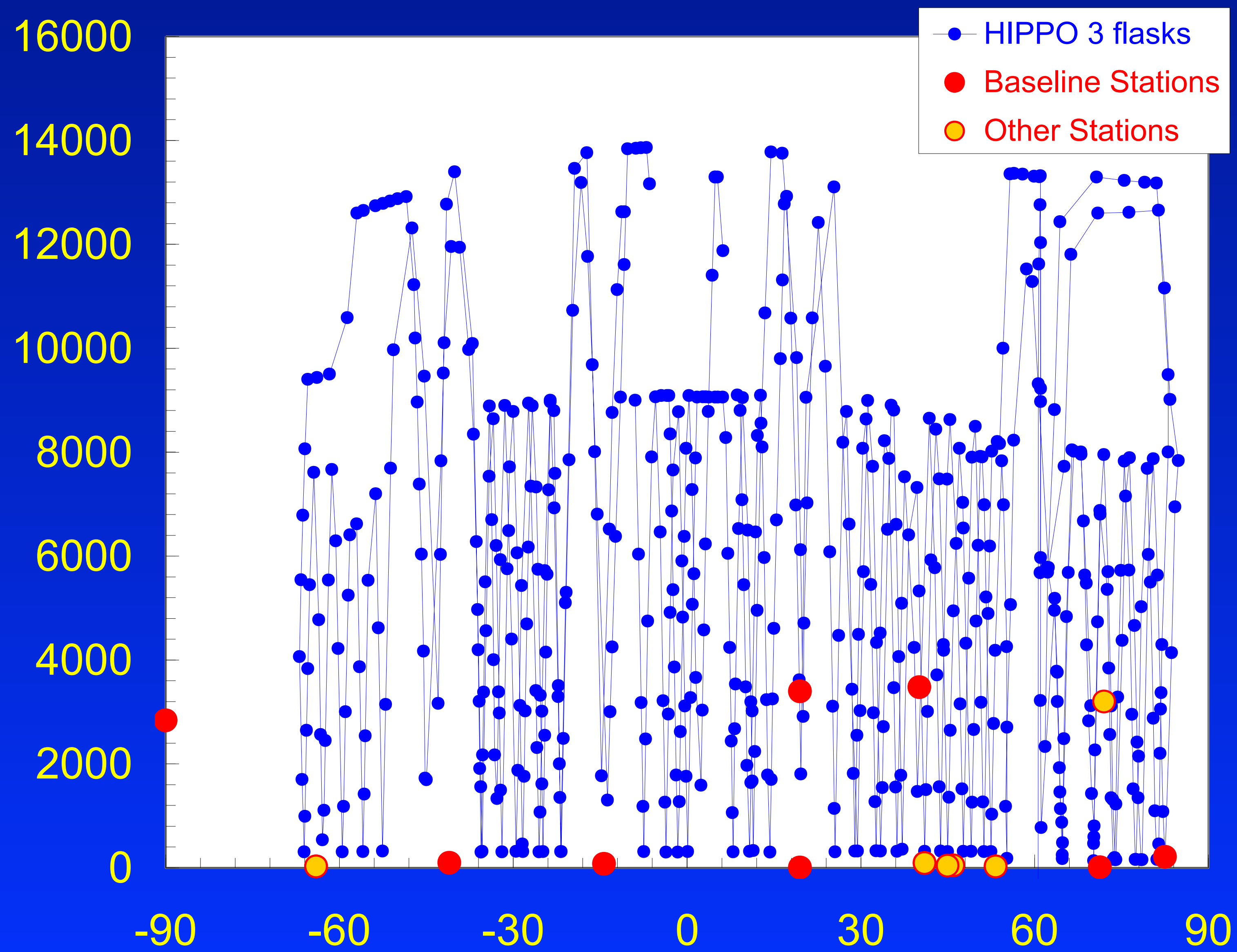
→ HIPPO results provide a test
→ look at rapidly increasing gases (HFC, HCFC)

Compare global tropospheric monthly means:
HIPPO / NOAA surface sites
→ samples collected below 10 km
→ weighting by latitude, pressure

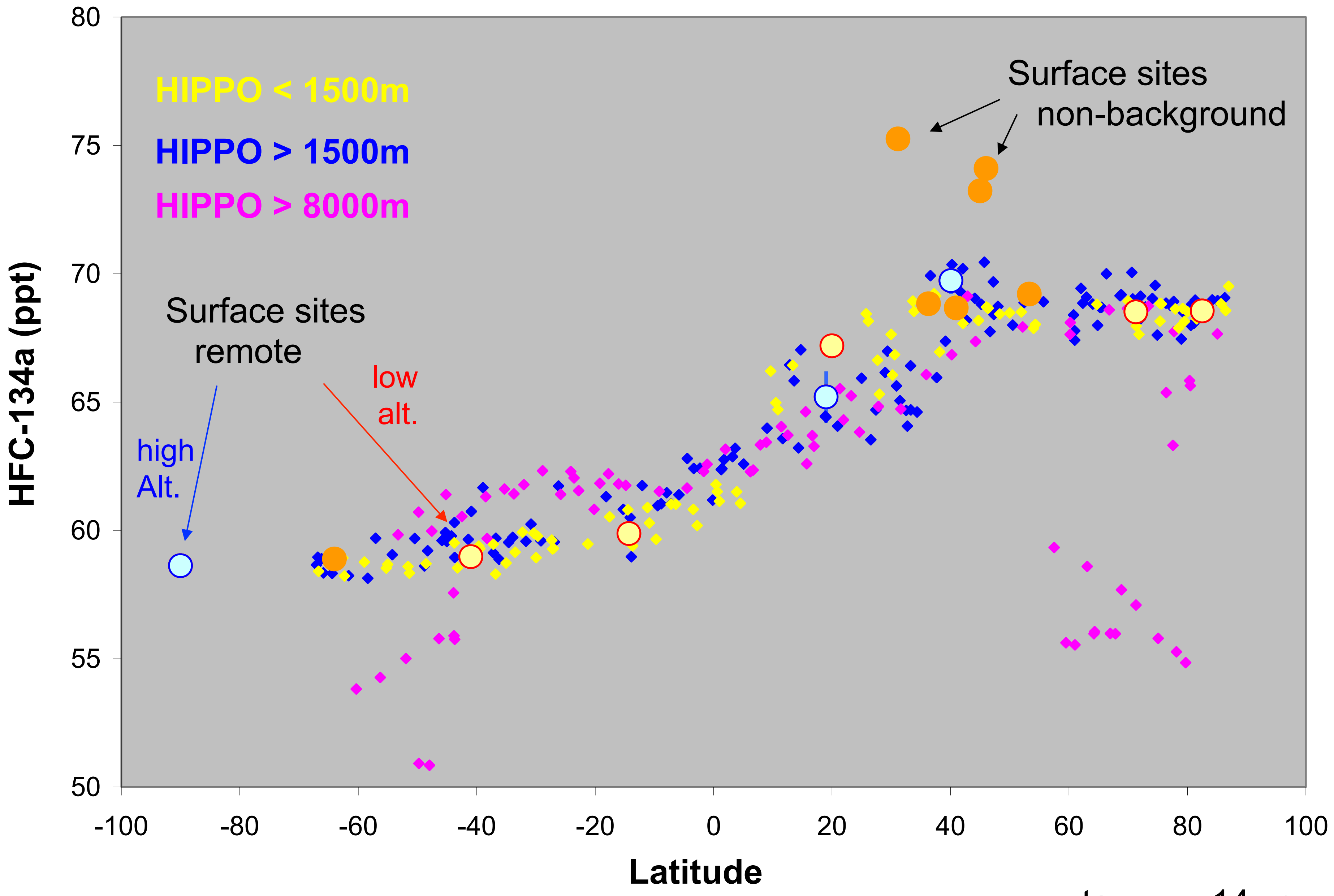
Tropospheric Halocarbon Sampling Network



NOAA surface sampling site distribution relative to HIPPO 3 samples



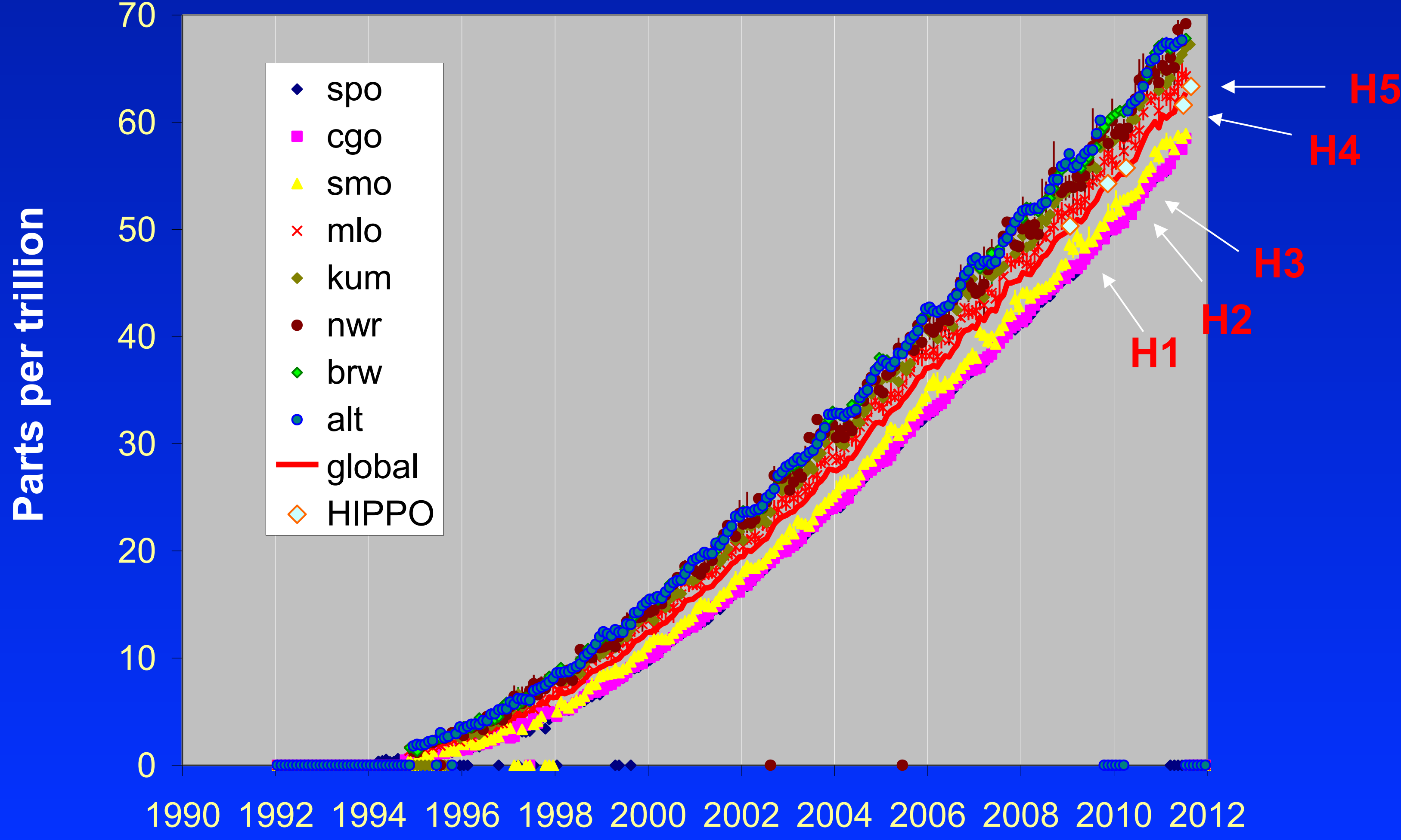
HFC-134a: HIPPO 5 *vs.* August 2011 sample site means



tau_{134a} ~14 yr

HIPPO tropospheric mean / NOAA surface monthly means:

		flasks		Panther
HFC-134a	HIP 1	1.000	NWAS & AWAS	1.003
	HIP 2	1.002	NWAS & AWAS	1.006
	HIP 3	1.004	NWAS & AWAS	1.001
	HIP 4	0.989	NWAS	
	HIP 5	0.997	NWAS	



HIPPO tropospheric mean / NOAA surface mean:

HCFC-22

	flasks	
HIP 1	0.998	NWAS & AWAS
HIP 2	1.000	NWAS & AWAS
HIP 3	1.003	NWAS & AWAS
HIP 4	0.989	NWAS
HIP 5	0.996	NWAS

HCFC-142b

	flasks	
HIP 1	1.001	NWAS & AWAS
HIP 2	1.004	NWAS & AWAS
HIP 3	1.001	NWAS & AWAS
HIP 4	0.984	NWAS
HIP 5	0.993	NWAS

Despite mixing ratio biases at the surface in both hemispheres, tropospheric means derived from surface data are fairly representative of tropospheric means defined by HIPPO samples. . .

Now to look at some short-lived gases:

Why?
they may contribute significant halogen to the stratosphere
we know less about their sources and sinks
we know less about their tropospheric distributions

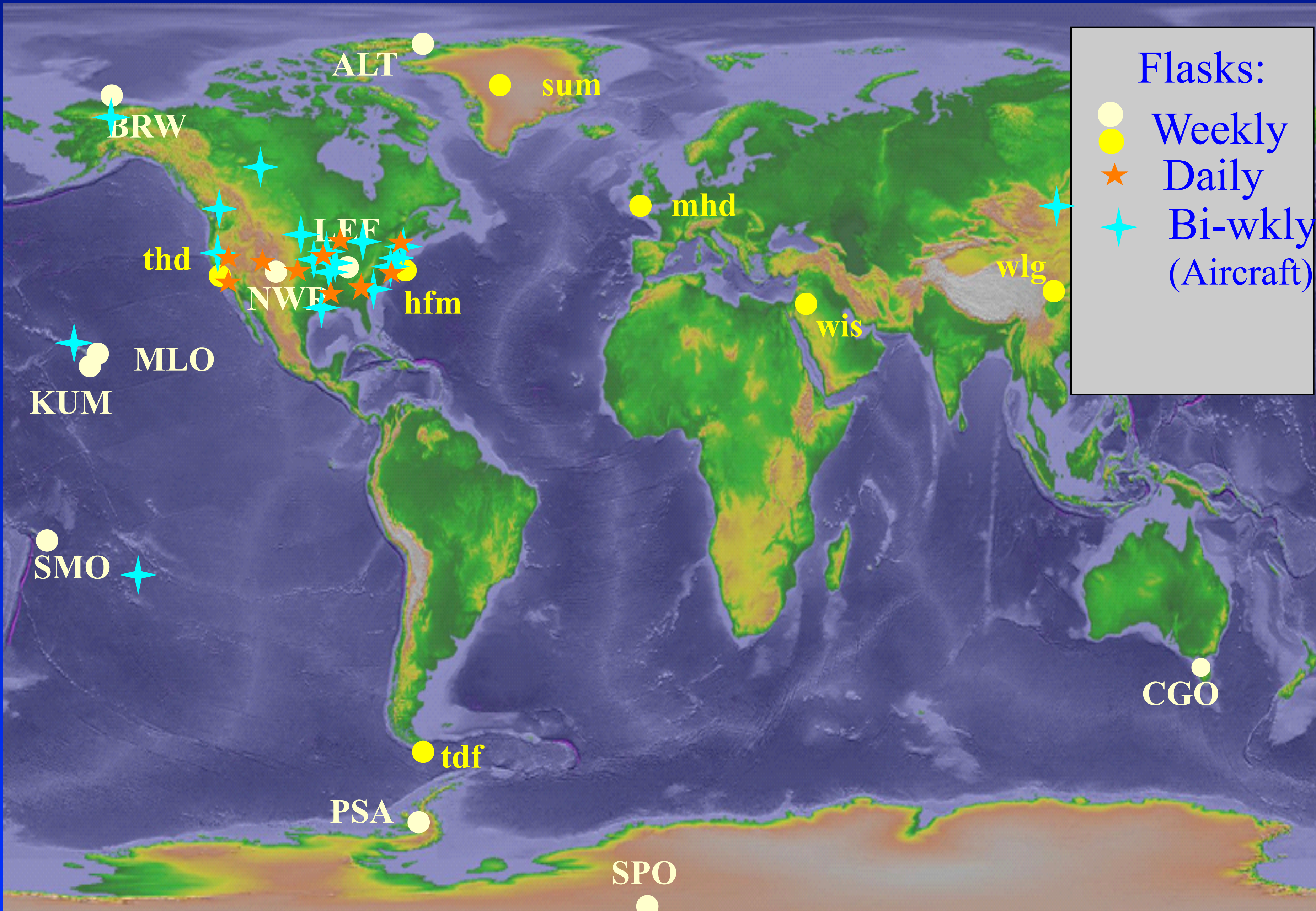
	Reference lifetimes**	
CH_2Br_2	123 d	(OH predominantly)
$CHBr_3$	24 d	(mostly photolysis)
CH_3I	7 (4-12) d	(photolysis predominantly)

To explore: Compare results over ocean (HIPPO west of -135°W) to results over land (NOAA):

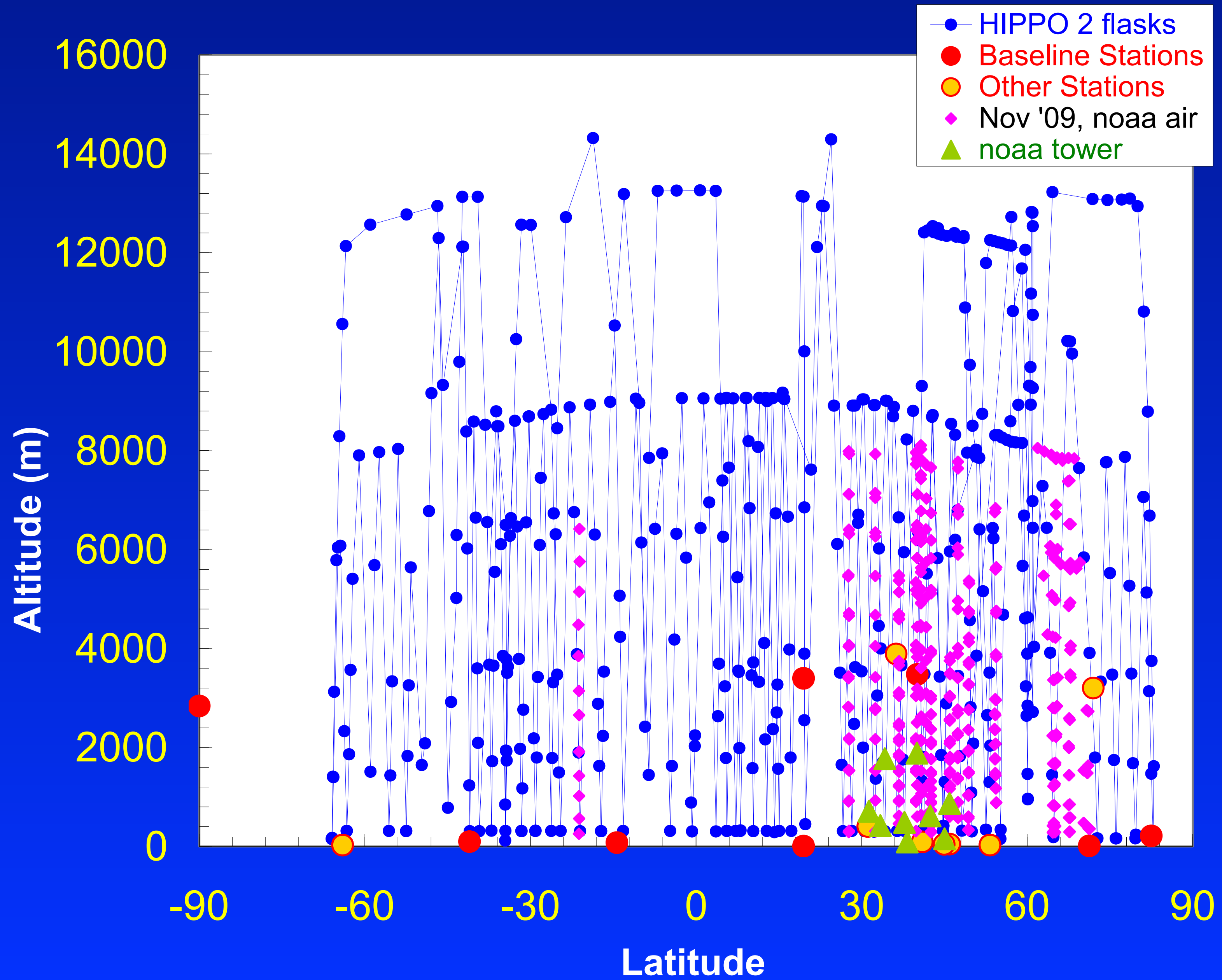
1) How do HIPPO results compare to ongoing NOAA programs?
→ Oceanic (Pacific basin) *vs.* above North America
2) Is there a 'background' mixing ratio for short-lived gases?
→ and does the picture change seasonally?
3) What do these results imply about distribution and seasonality of sources and sinks?

** Lifetimes calculated here with OH = 1e6 rad cm-3, photolysis at 5 km; from WMO(2003 and 2011)

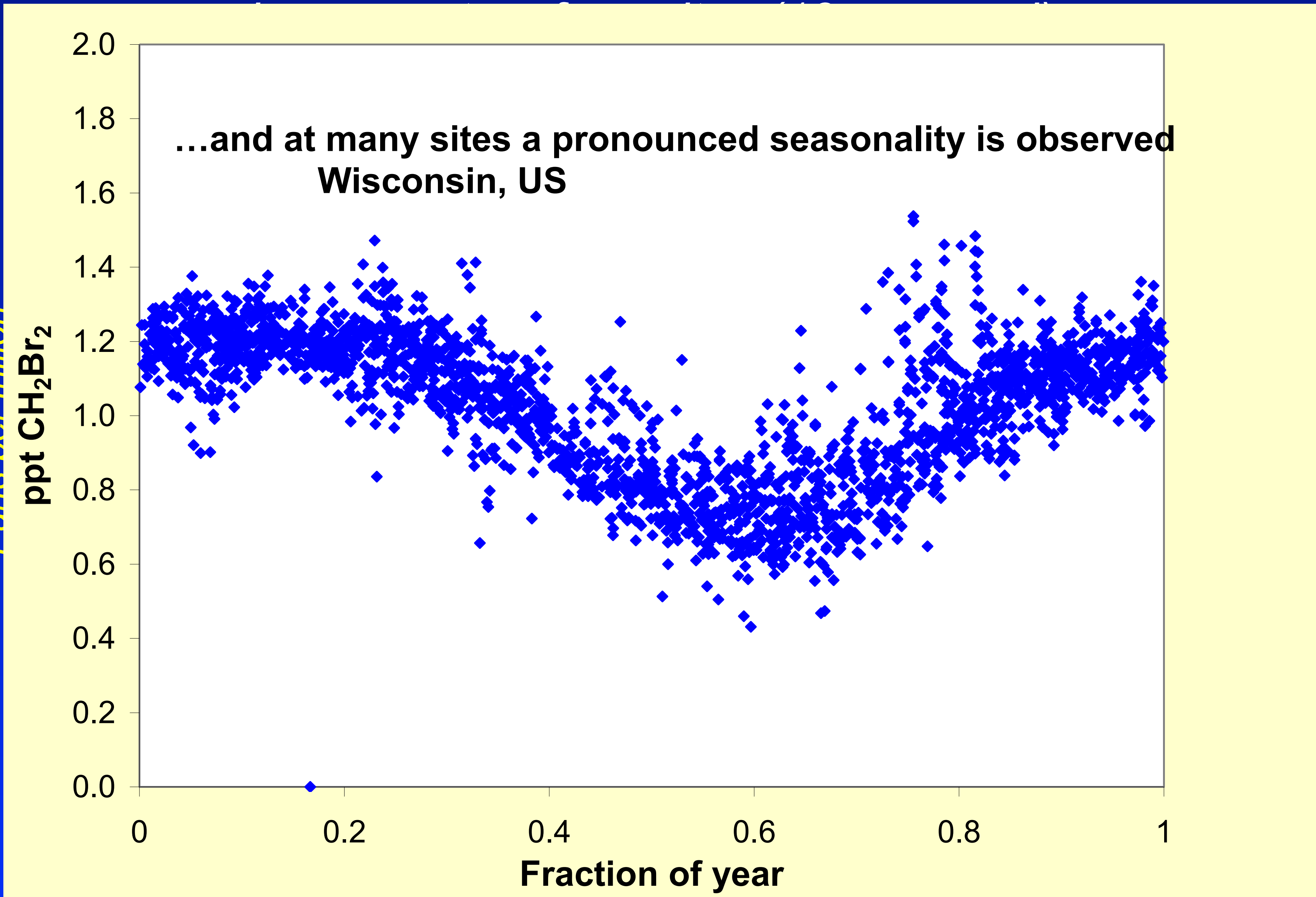
Tropospheric Halocarbon Sampling Network



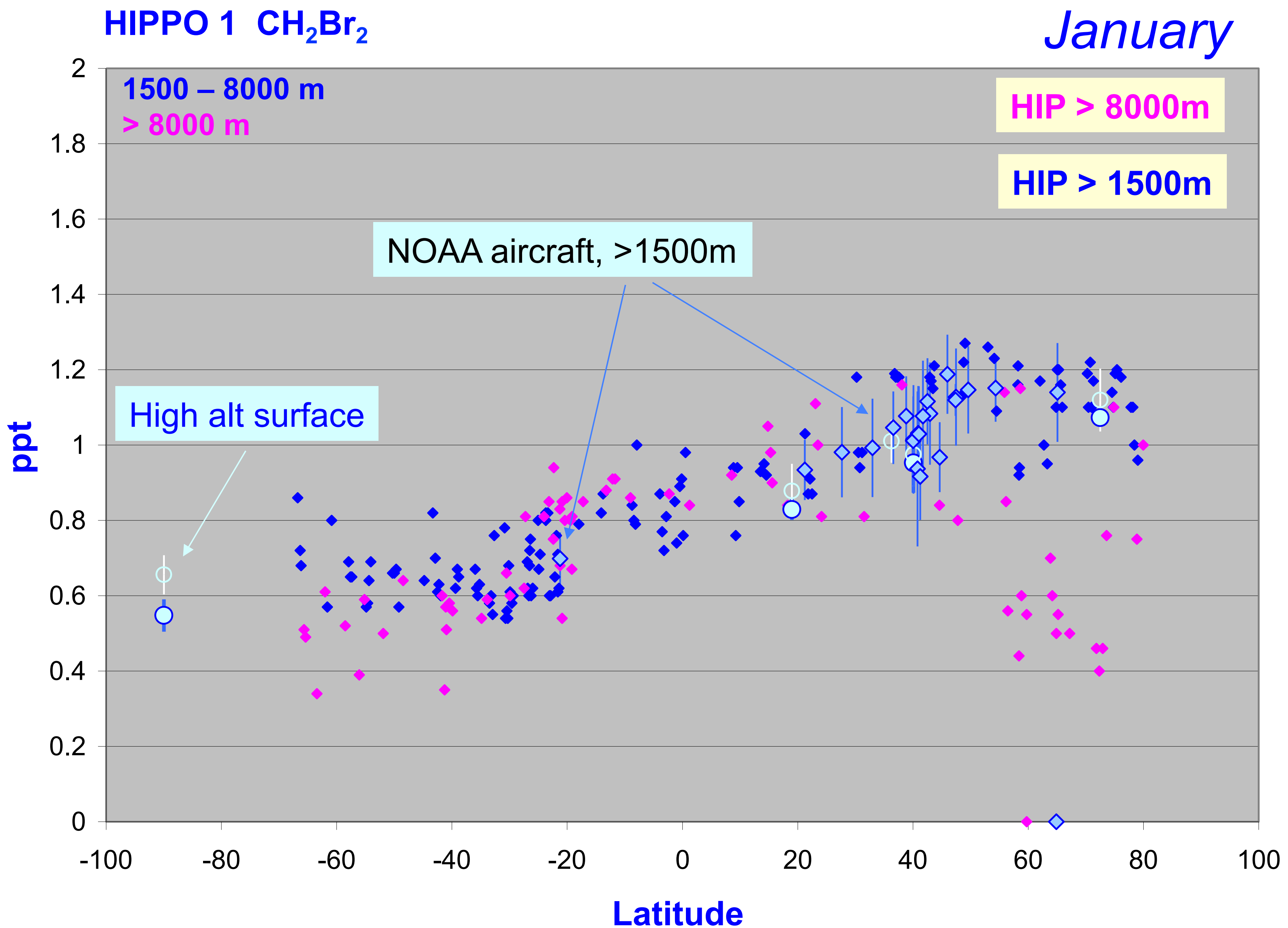
Many samples: November 2009…

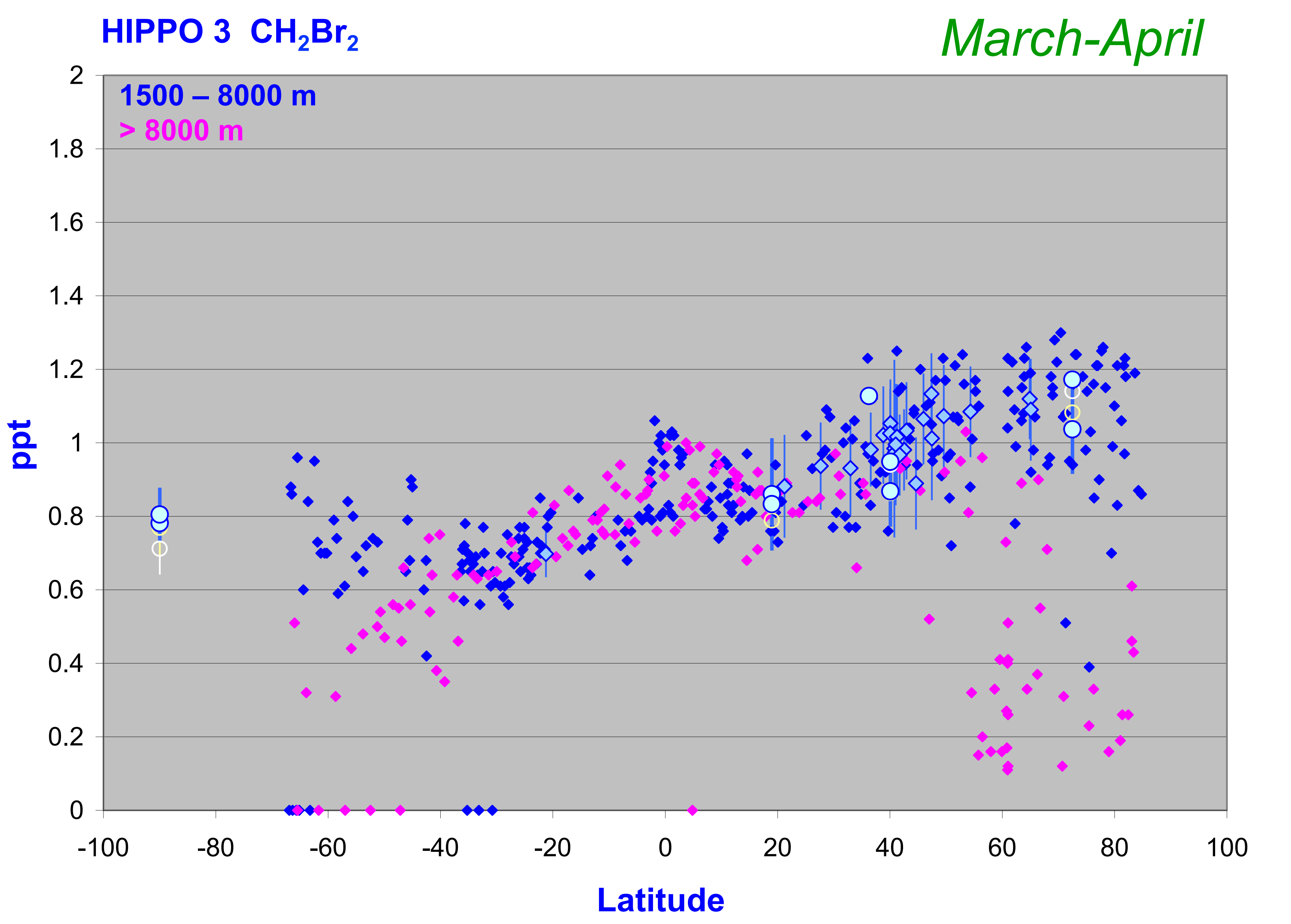


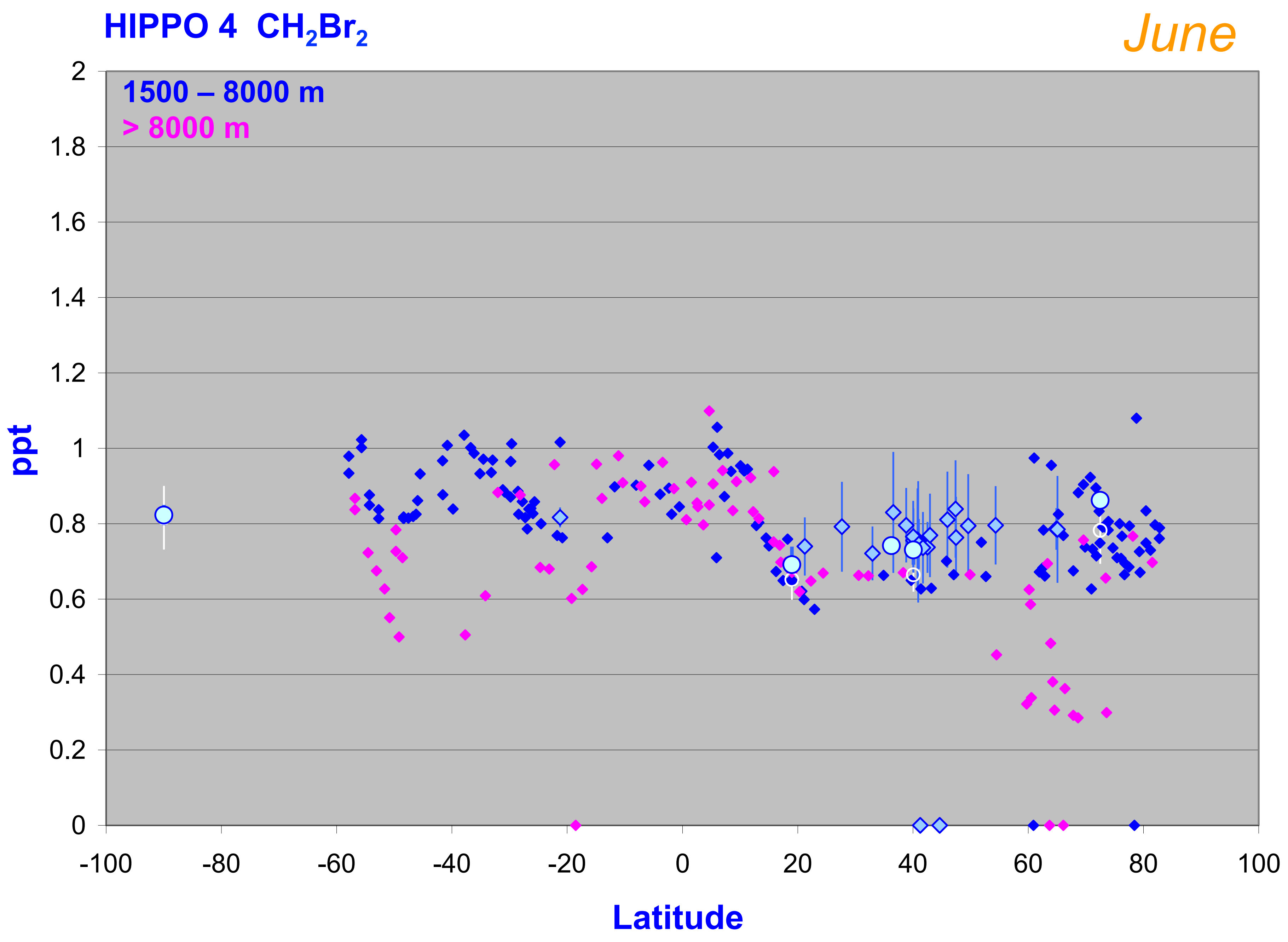
Dibromomethane (CH_2Br_2)



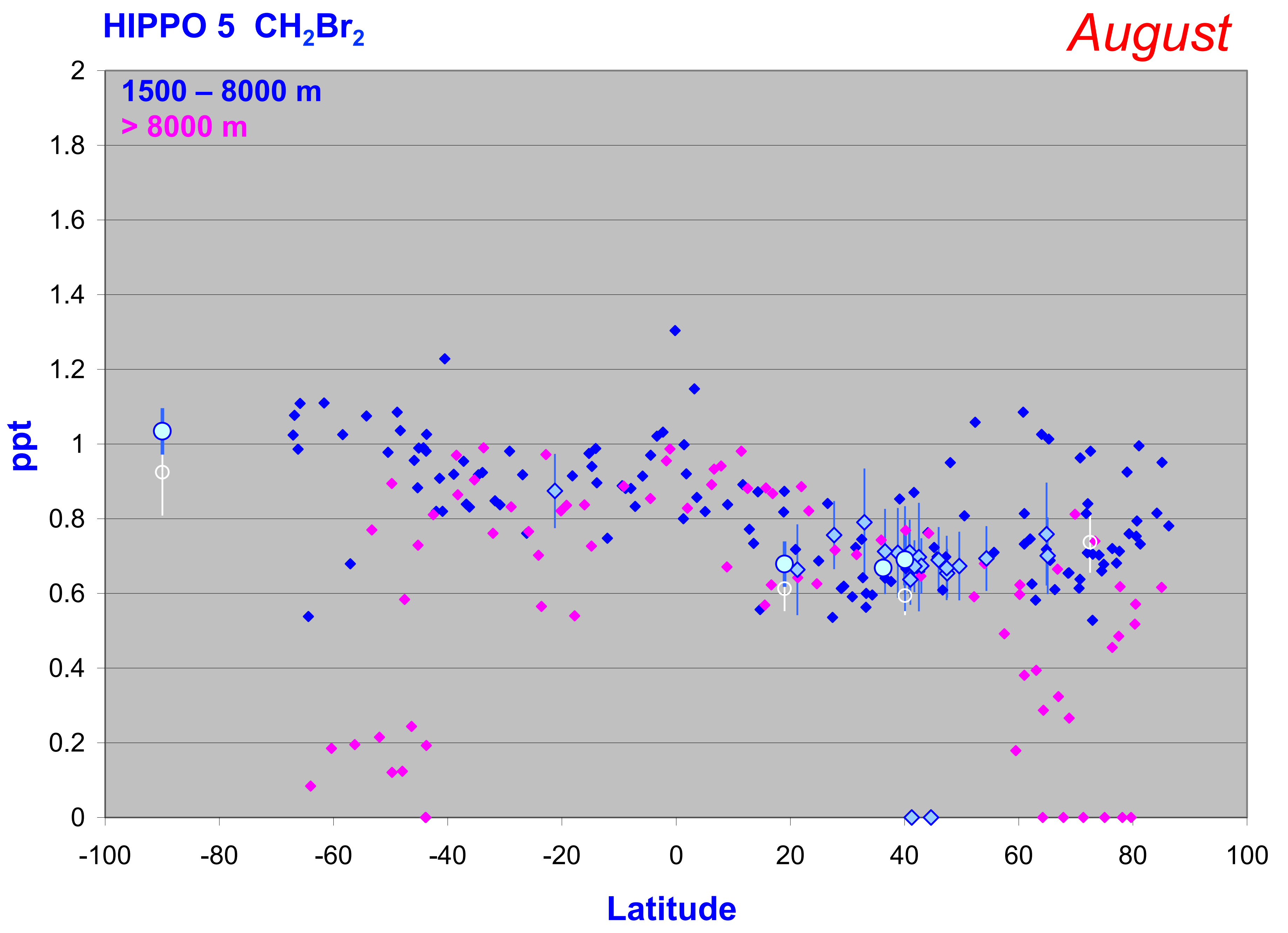
NOAA flask data


HIPPO 1 CH2Br2
January
1500 – 8000 m
> 8000 m
HIP > 8000m
HIP > 1500m
NOAA aircraft, >1500m
High alt surface
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


HIPPO 3 CH_2Br_2
March-April
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

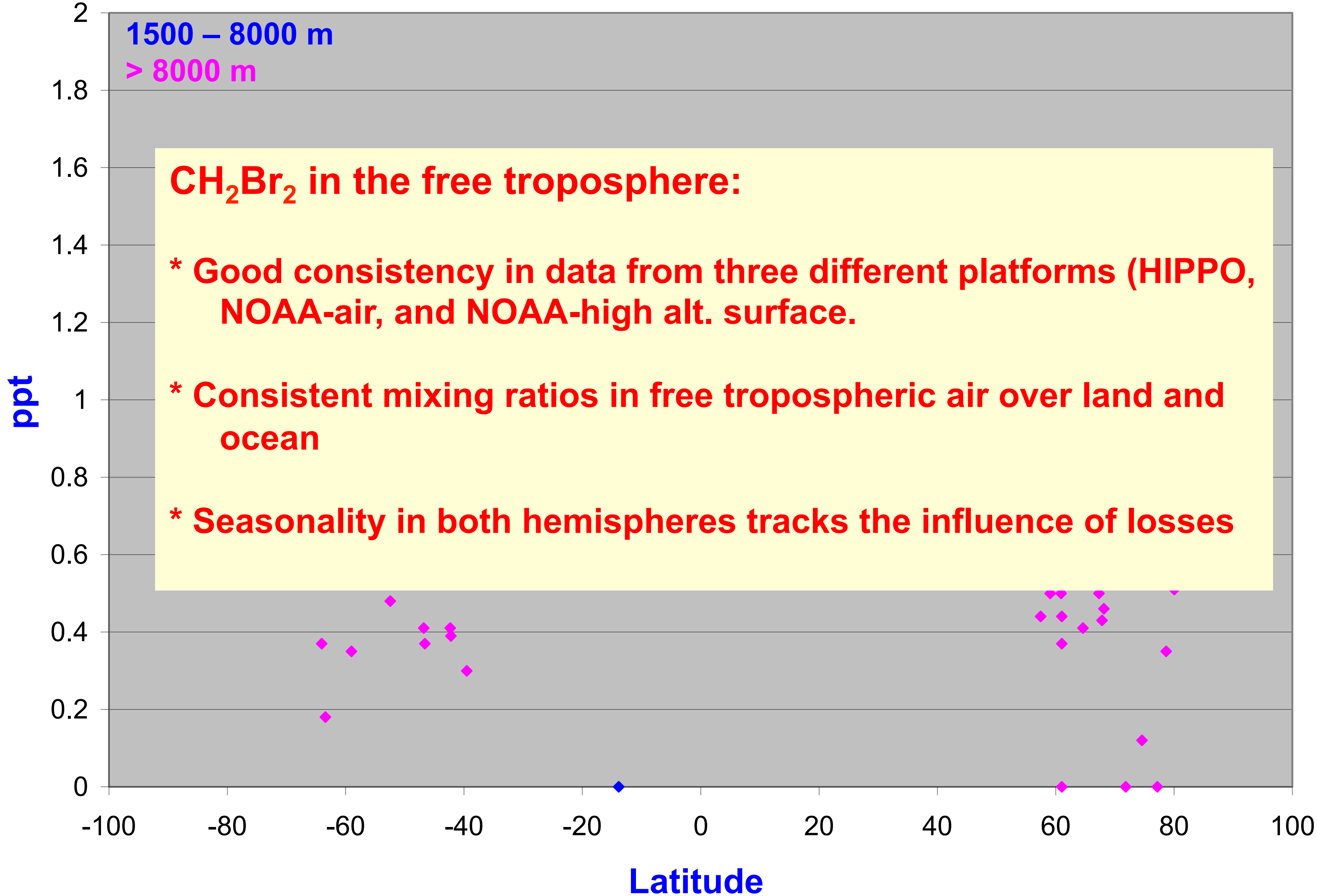


HIPPO 4 CH_2Br_2
June
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


HIPPO 5 CH_2Br_2
August
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

HIPPO 2 CH_2Br_2

November

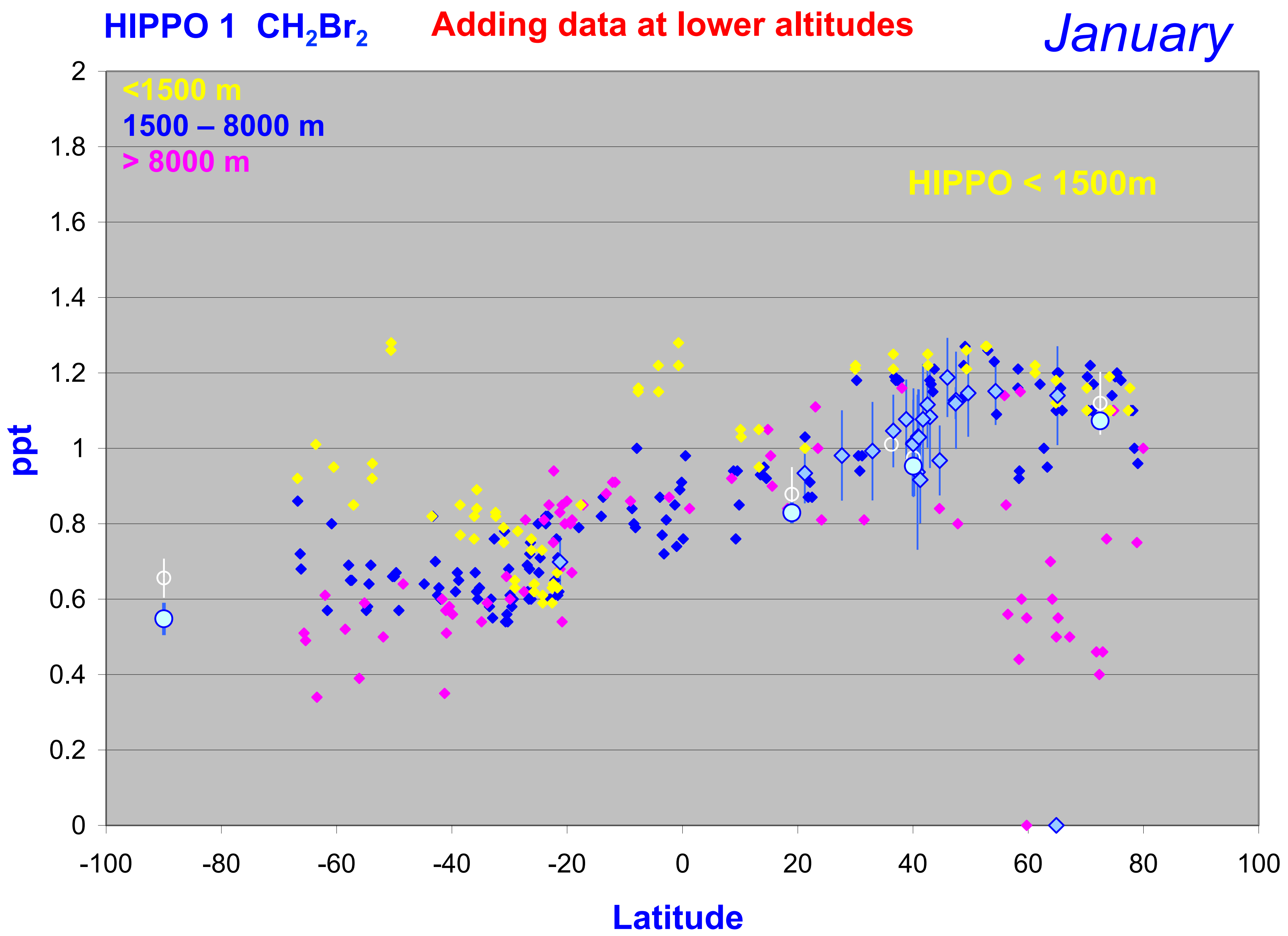


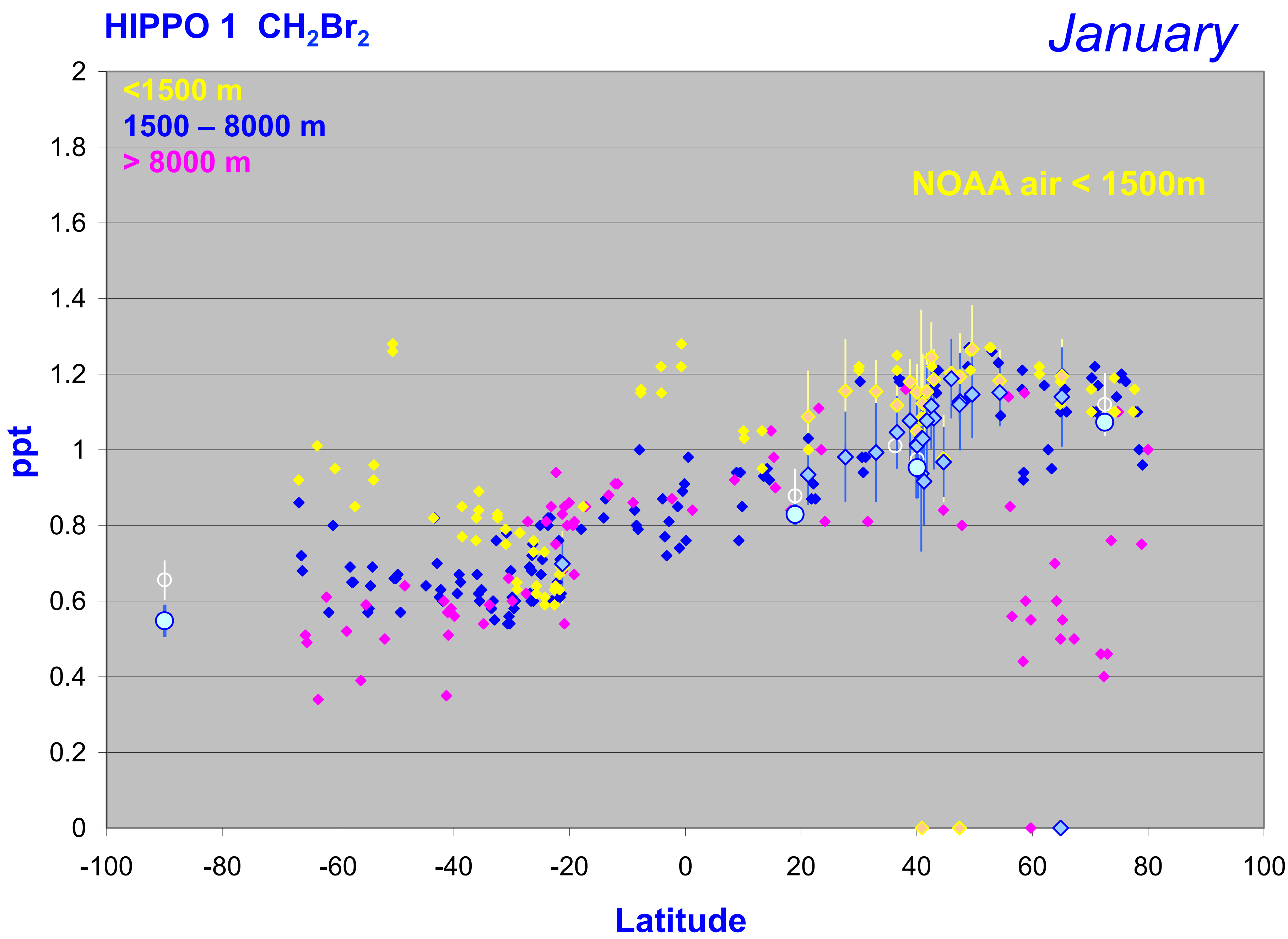
CH_2Br_2 in the free troposphere:

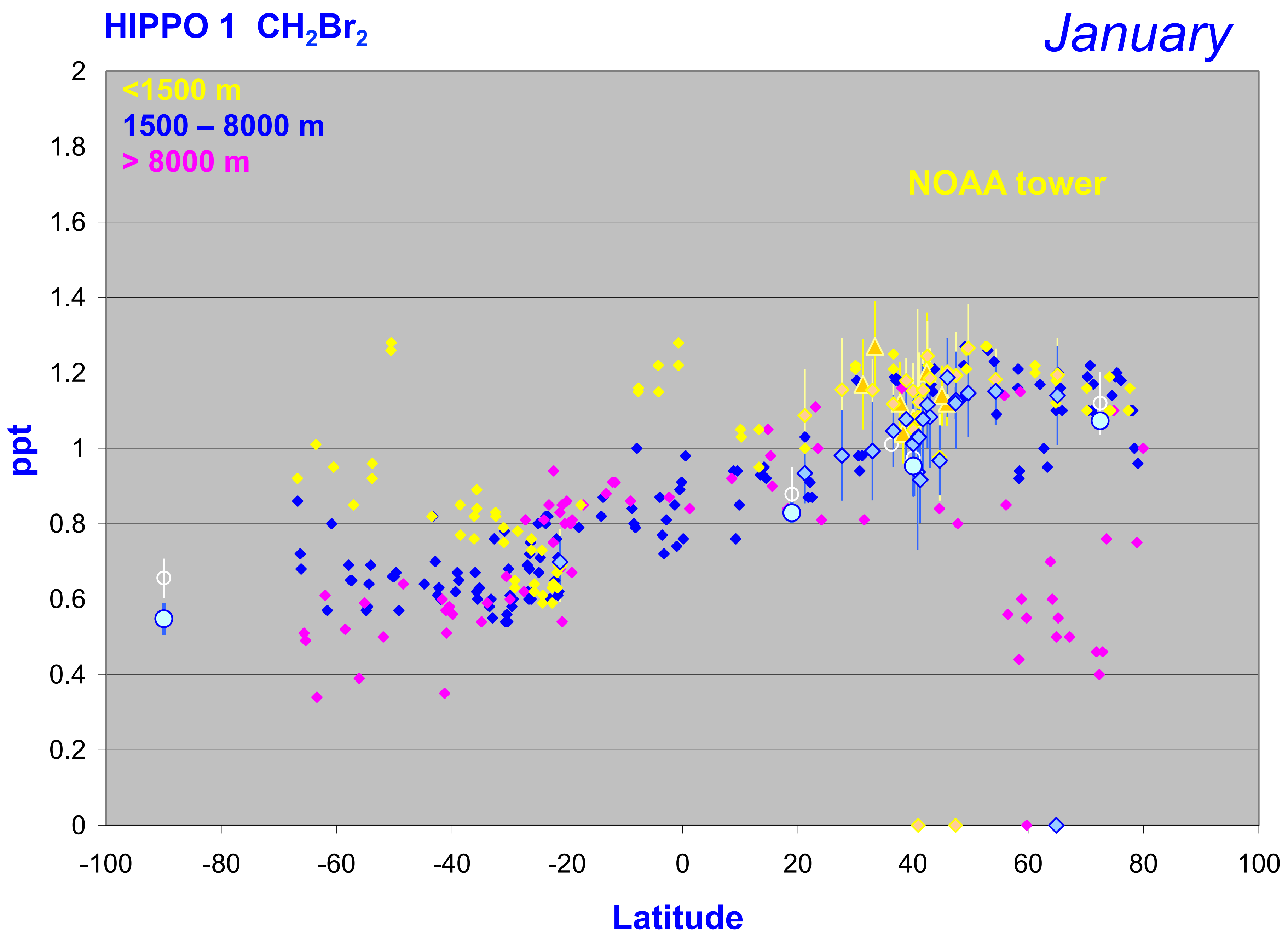
* **Good consistency in data from three different platforms (HIPPO, NOAA-air, and NOAA-high alt. surface.**

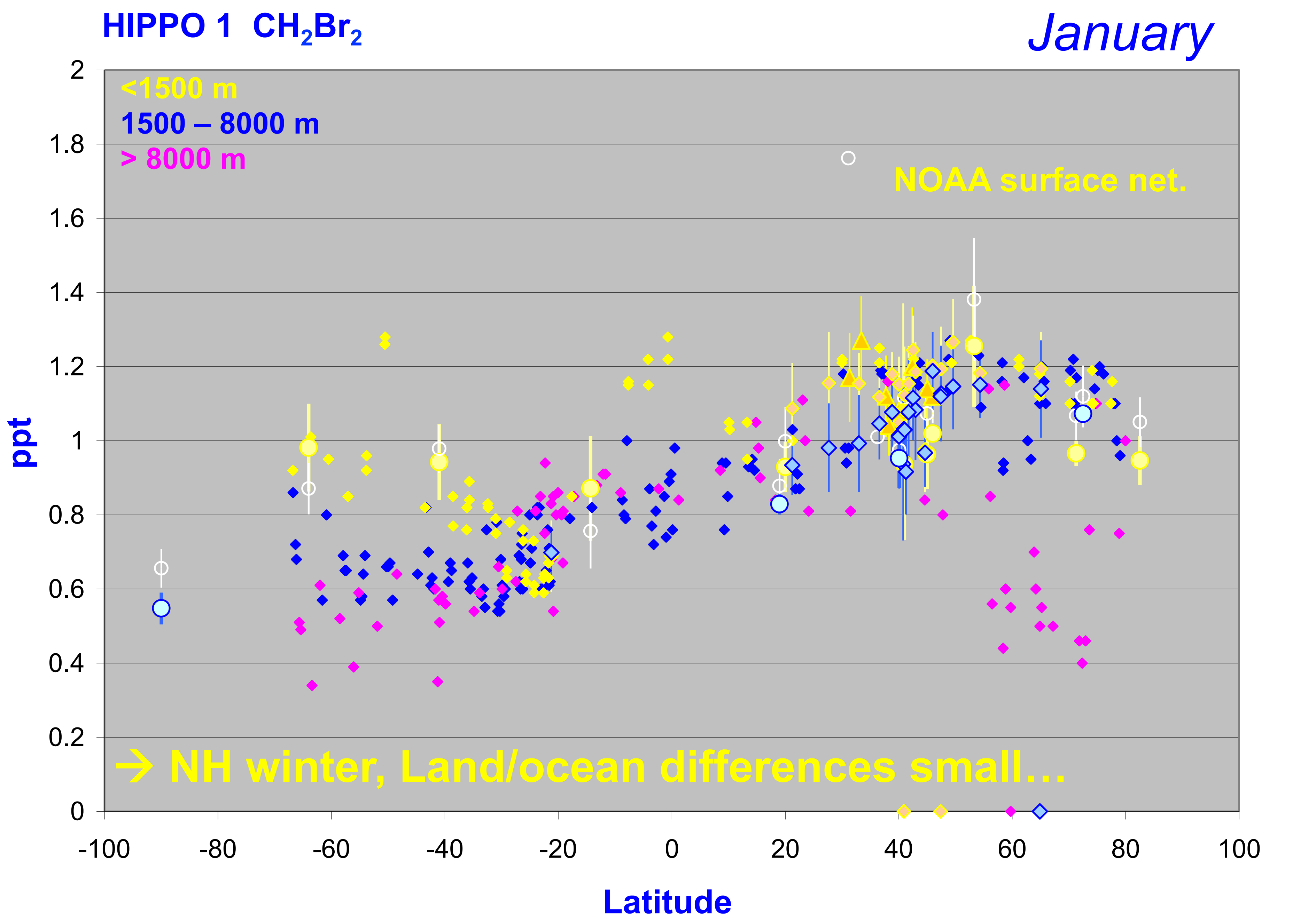
* **Consistent mixing ratios in free tropospheric air over land and ocean**

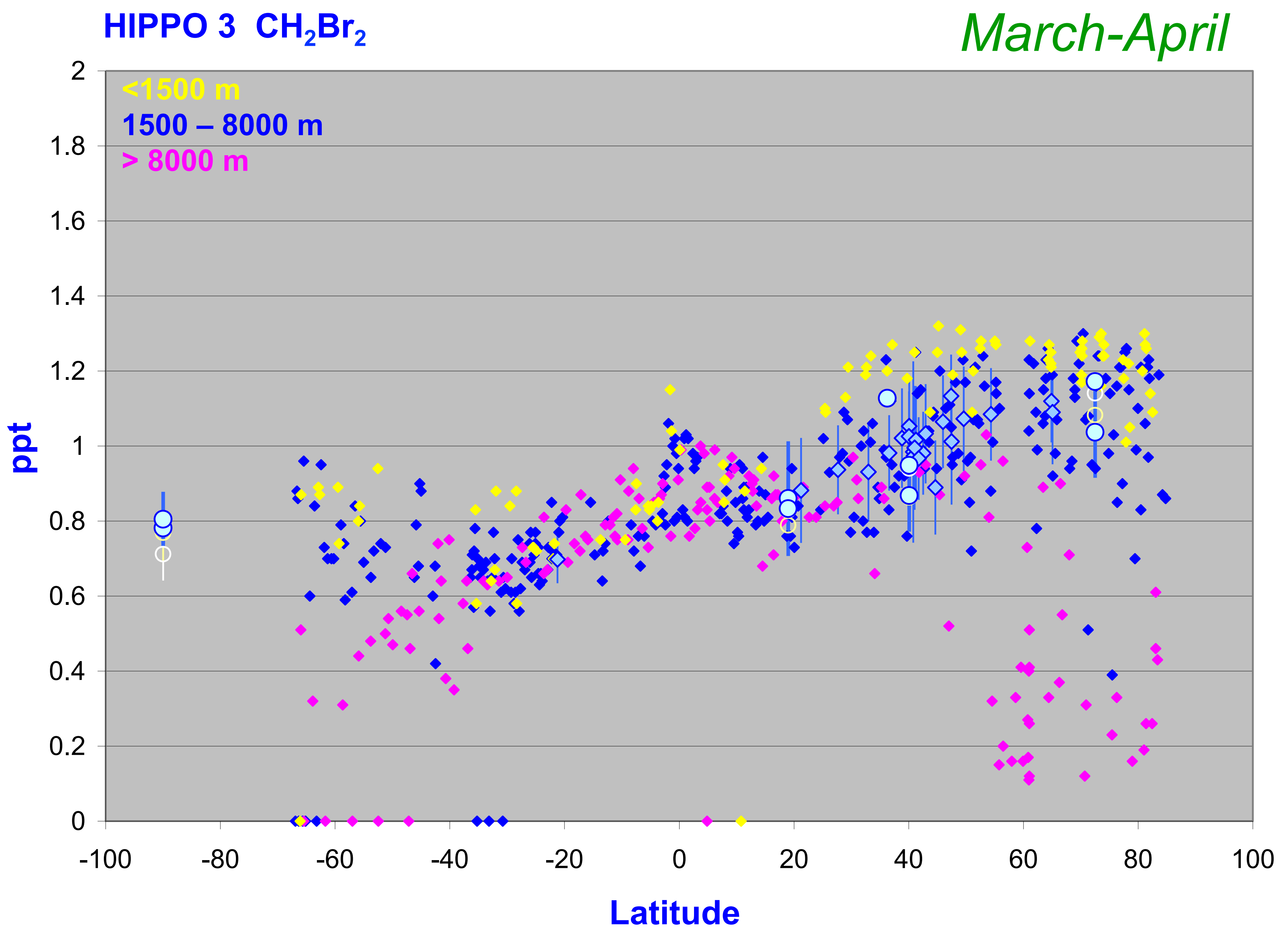
* **Seasonality in both hemispheres tracks the influence of losses**

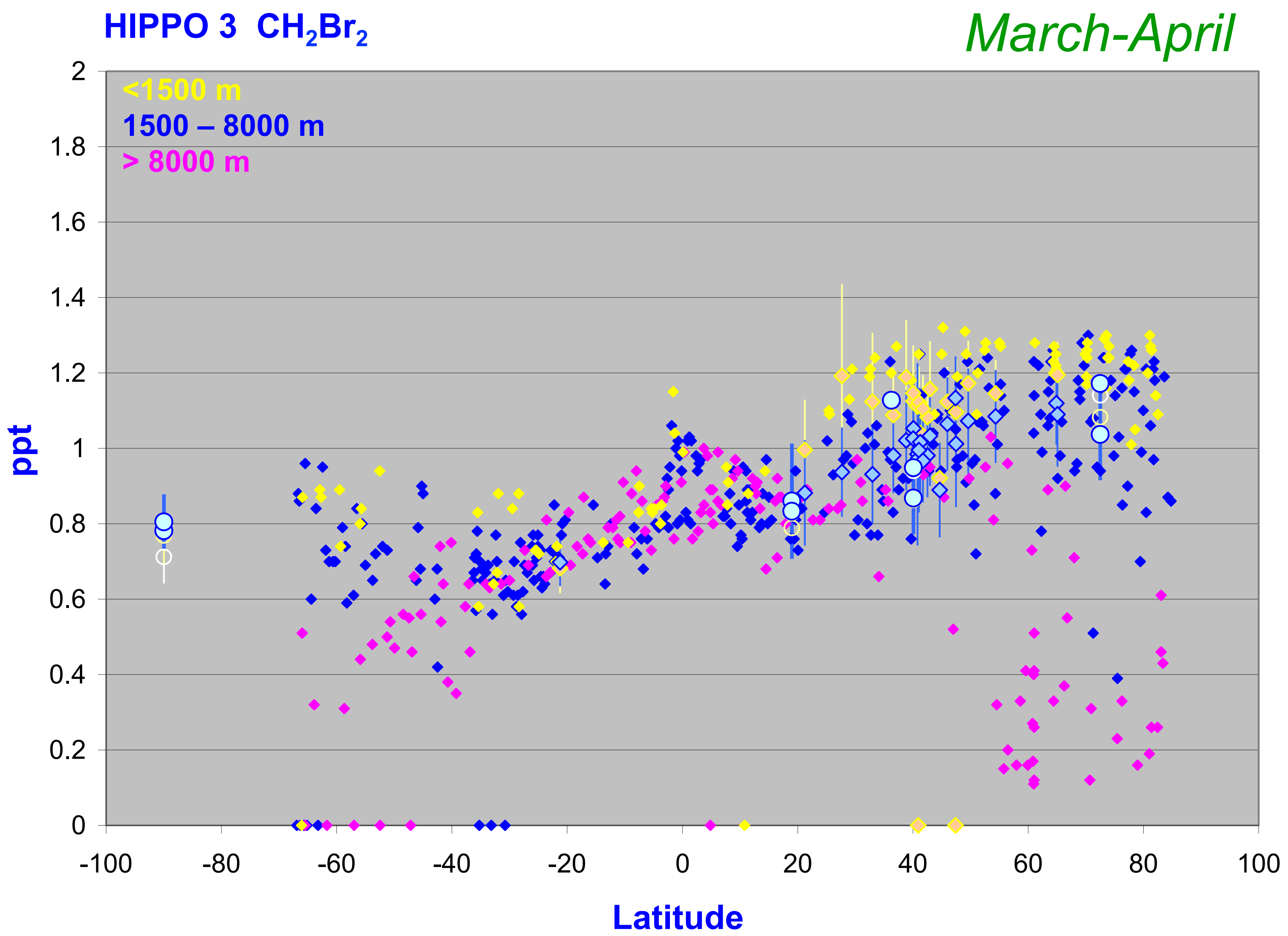

HIPPO 1 CH_2Br_2
Adding data at lower altitudes
January
<1500 m
1500 – 8000 m
> 8000 m
HIPPO < 1500m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

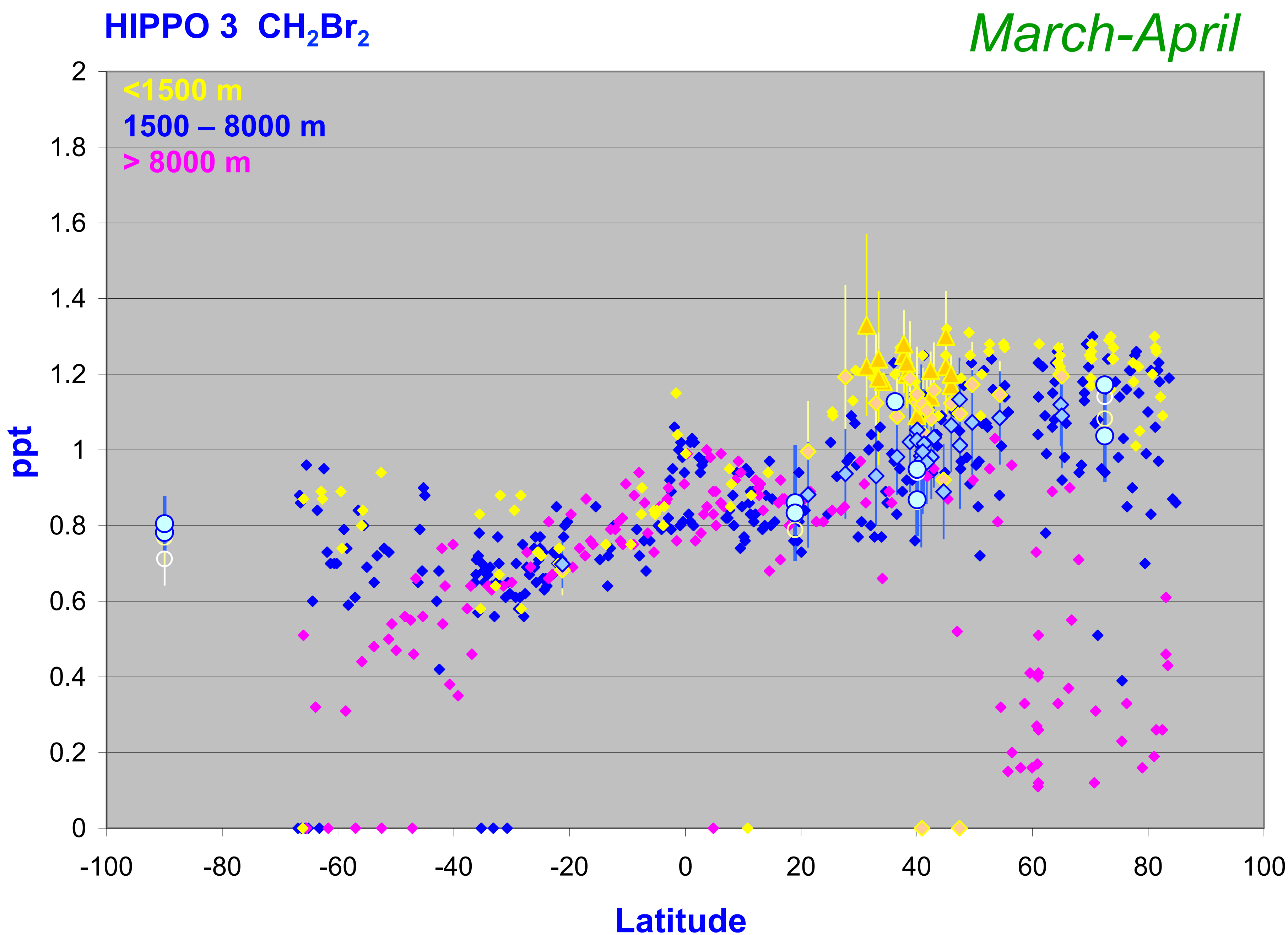

HIPPO 1 CH2Br2
January
<1500 m
1500 – 8000 m
> 8000 m
NOAA air < 1500m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


HIPPO 1 CH2Br2
January
<1500 m
1500 – 8000 m
> 8000 m
NOAA tower
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

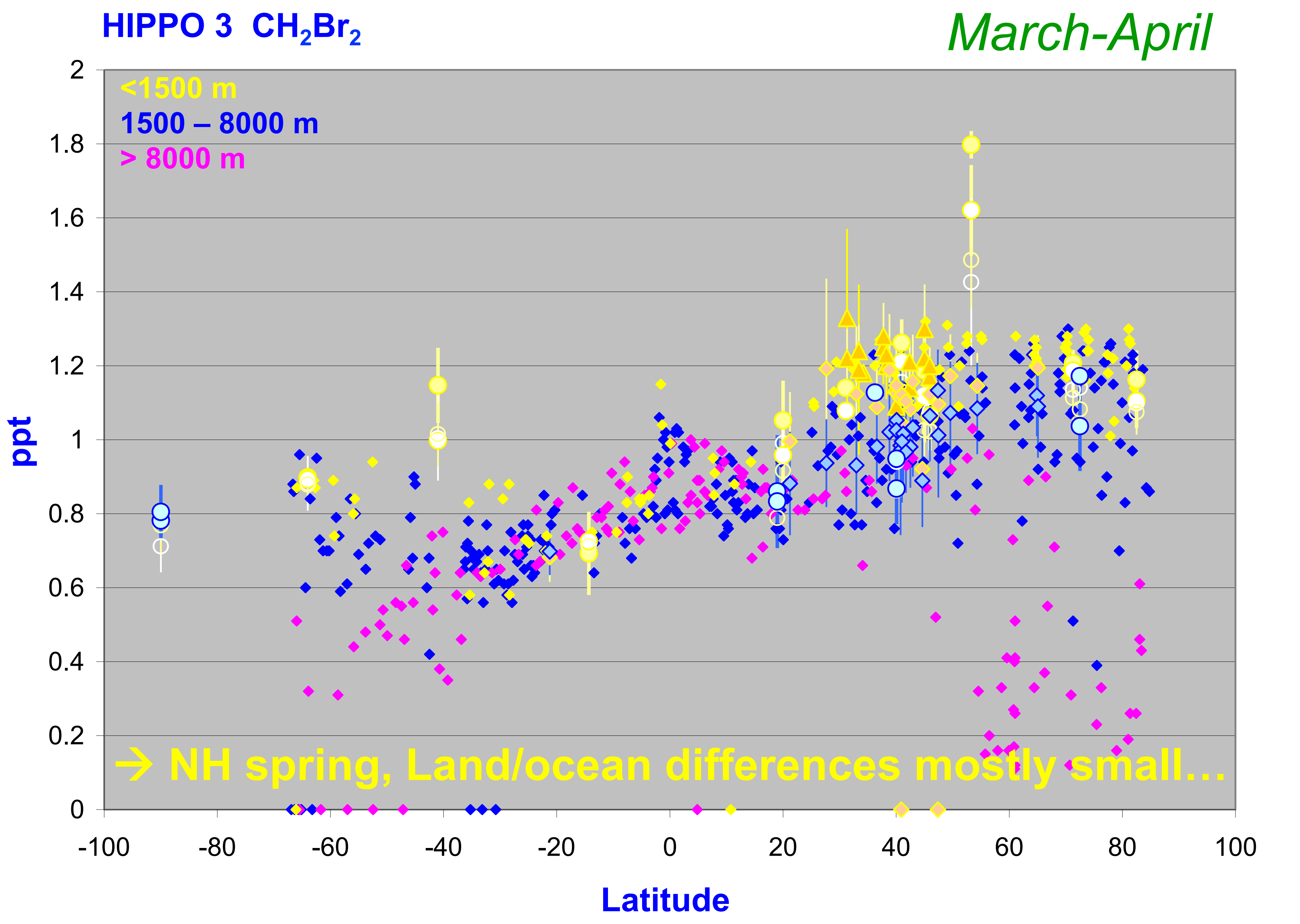

HIPPO 1 CH2Br2
January
<1500 m
1500 – 8000 m
> 8000 m
NOAA surface net.
→ NH winter, Land/ocean differences small…
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

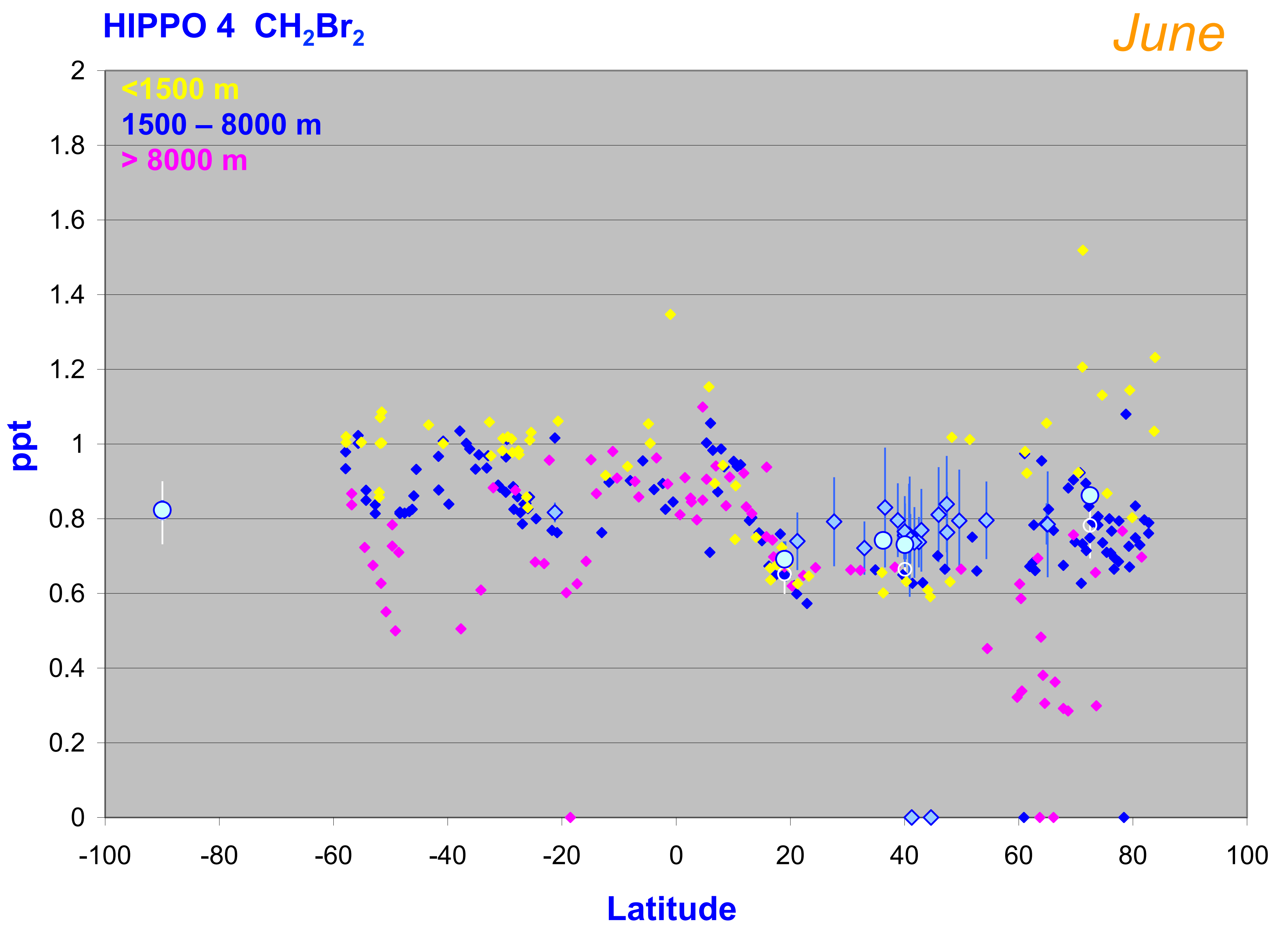

HIPPO 3 CH_2Br_2
March-April
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


HIPPO 3 CH_2Br_2
March-April
<1500 m
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

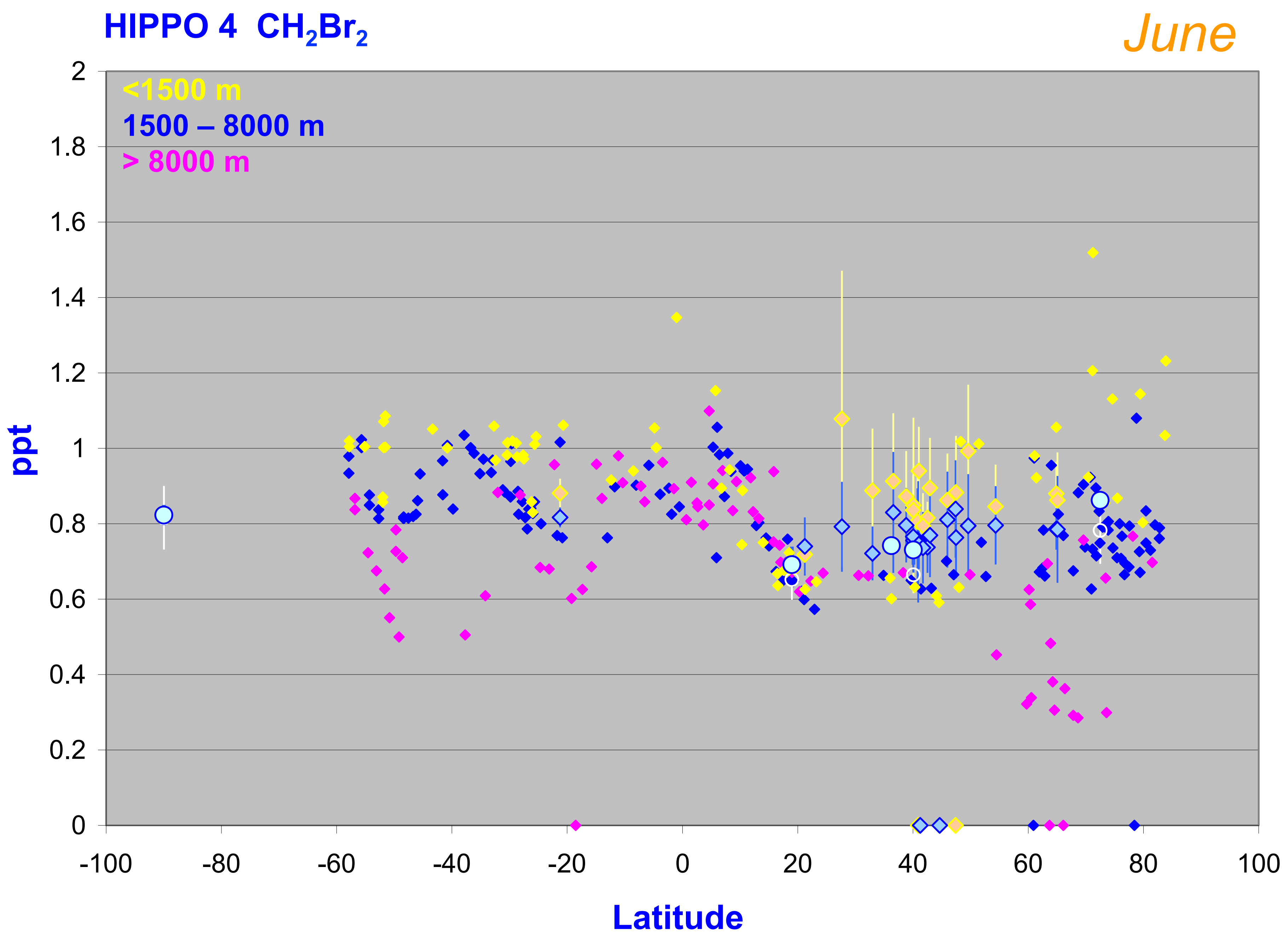


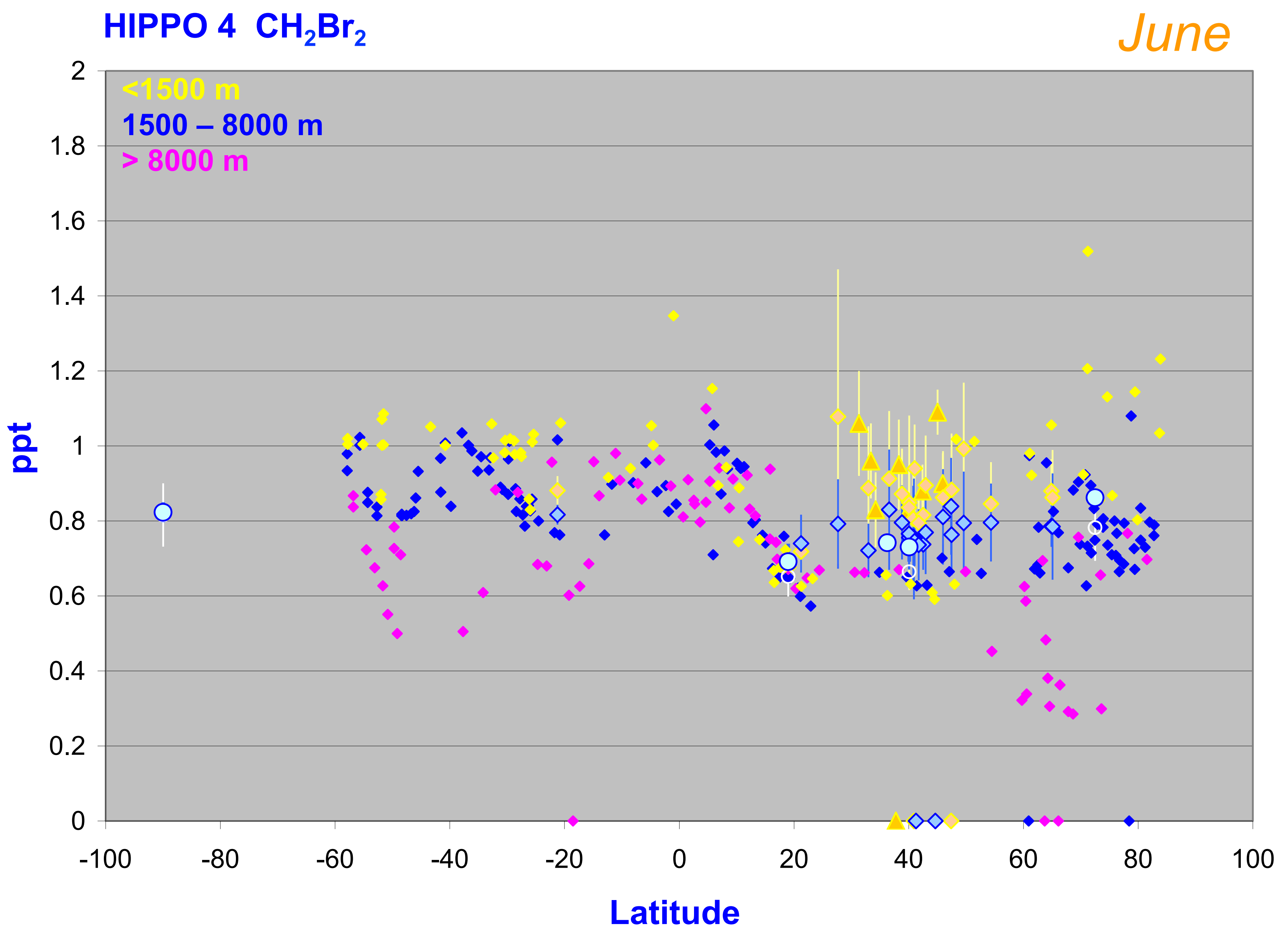
HIPPO 3 CH_2Br_2
March-April
<1500 m
1500 – 8000 m
> 8000 m
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
ppt
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude


HIPPO 3 CH_2Br_2
March-April
<1500 m
1500 – 8000 m
> 8000 m
→ NH spring, Land/ocean differences mostly small…
ppt
Latitude
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
-100
-80
-60
-40
-20
0
20
40
60
80
100

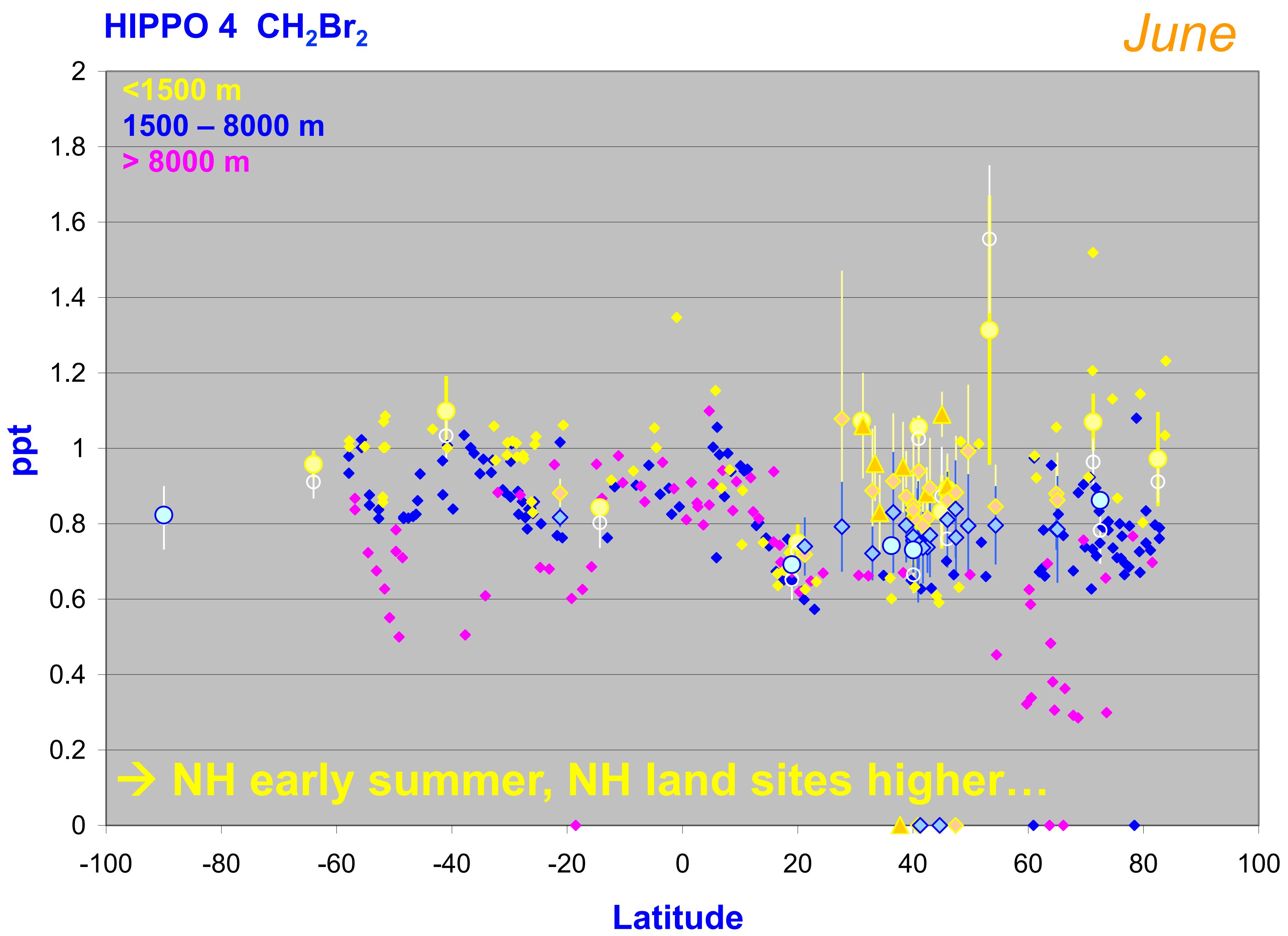


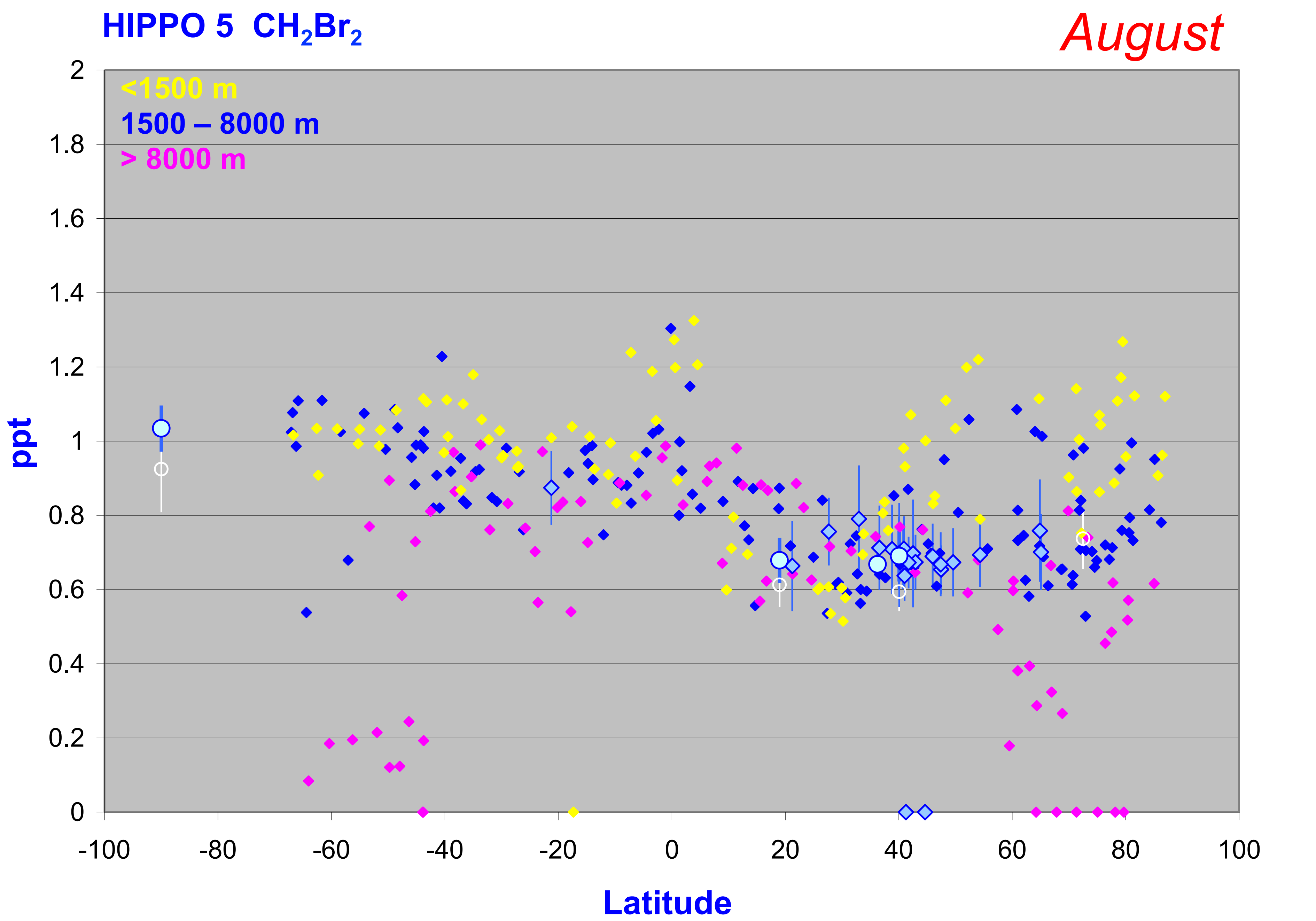
HIPPO 4 CH2Br2
June
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


HIPPO 4 CH_2Br_2
June
<1500 m
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

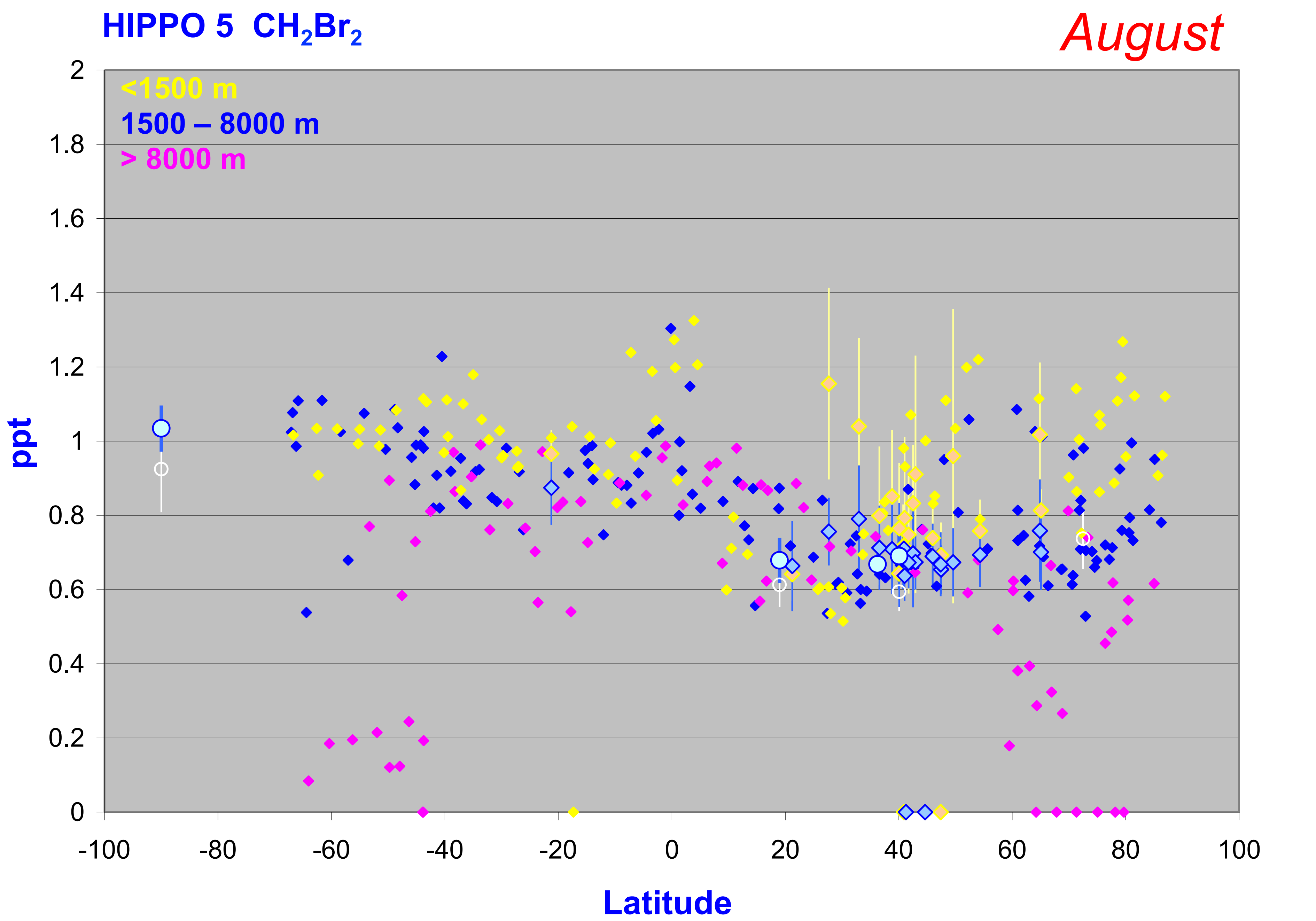


HIPPO 4 CH2Br2
June
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

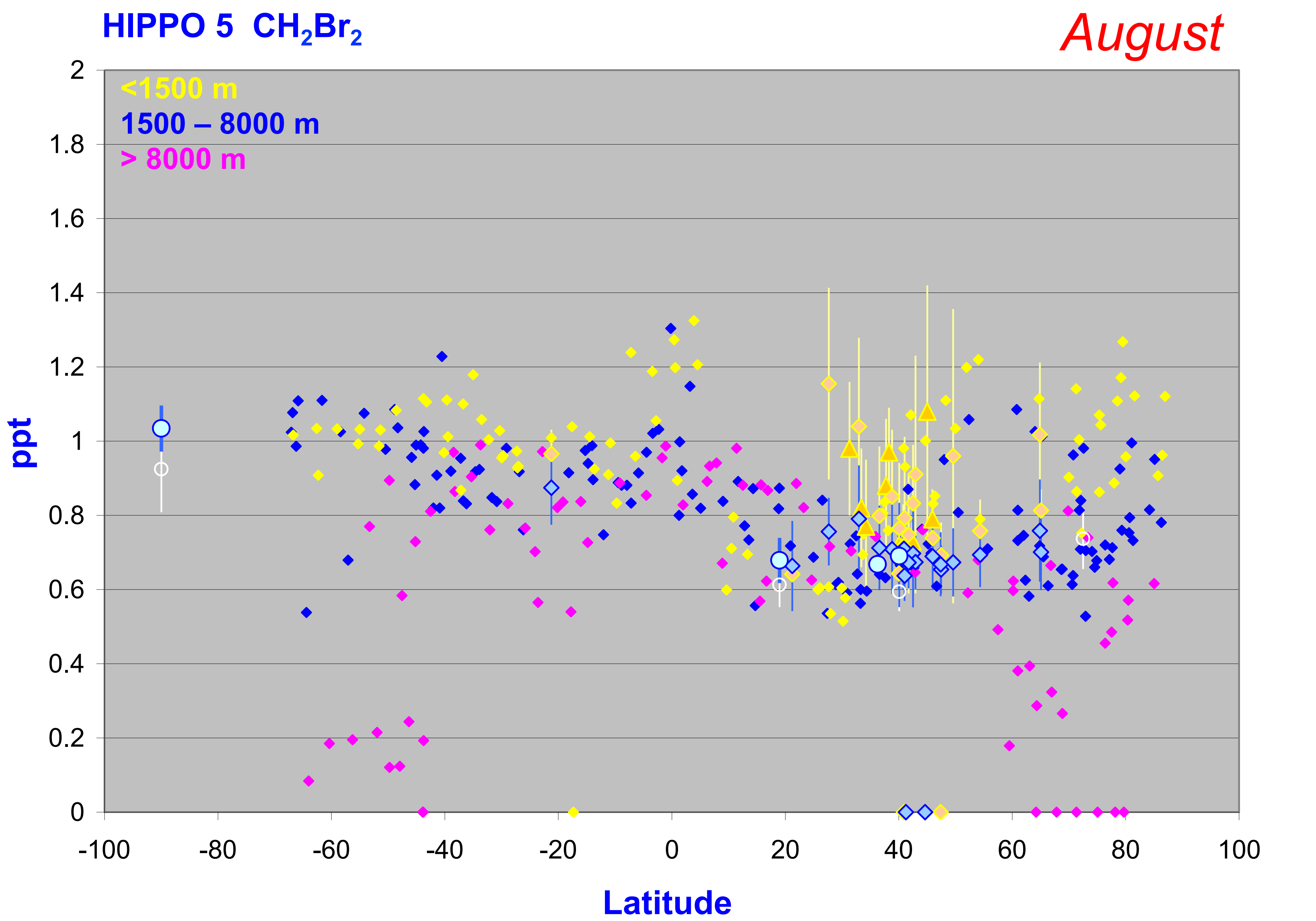

HIPPO 4 CH_2Br_2
June
<1500 m
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude
→ NH early summer, NH land sites higher…



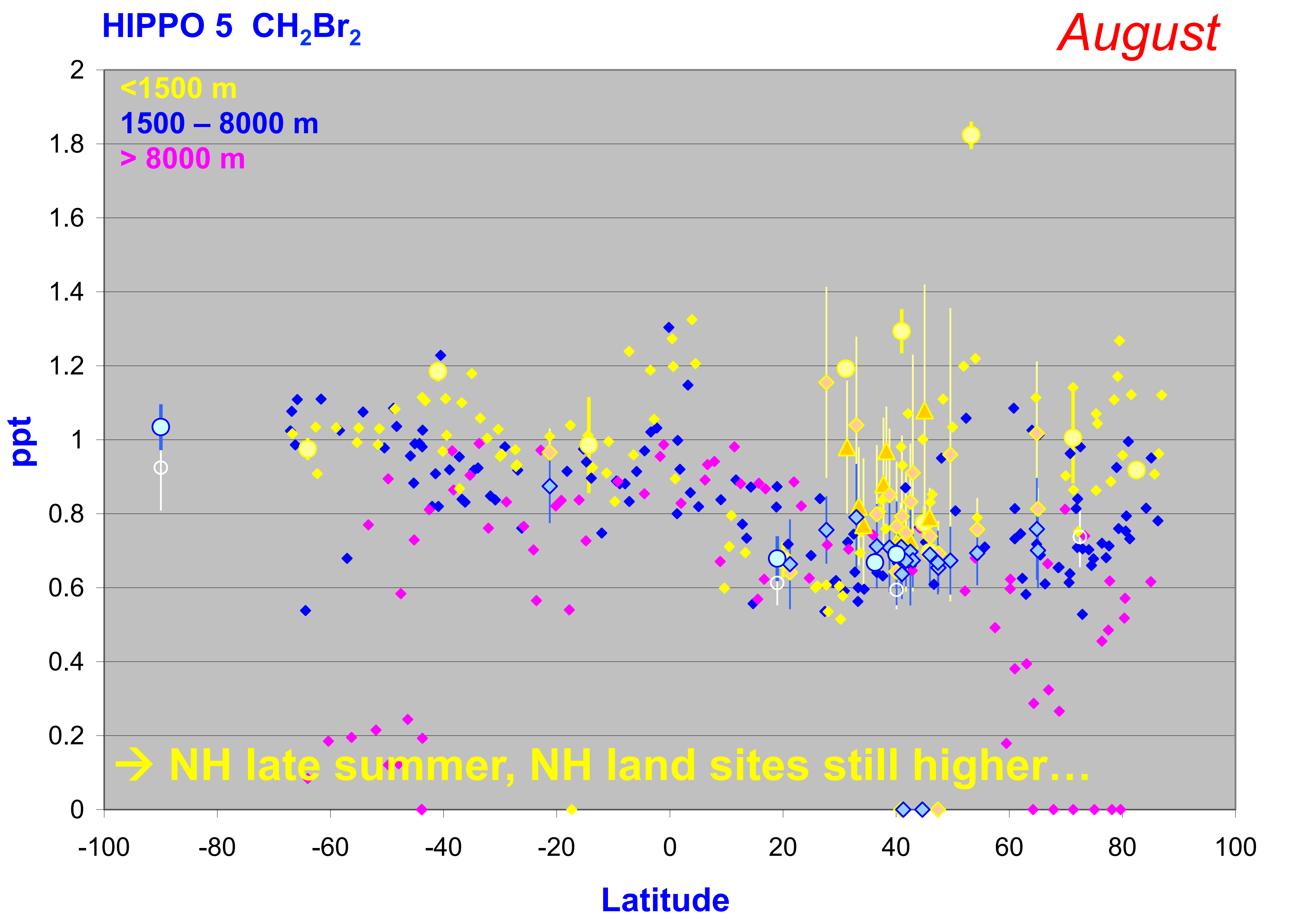
HIPPO 5 CH_2Br_2
August
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100



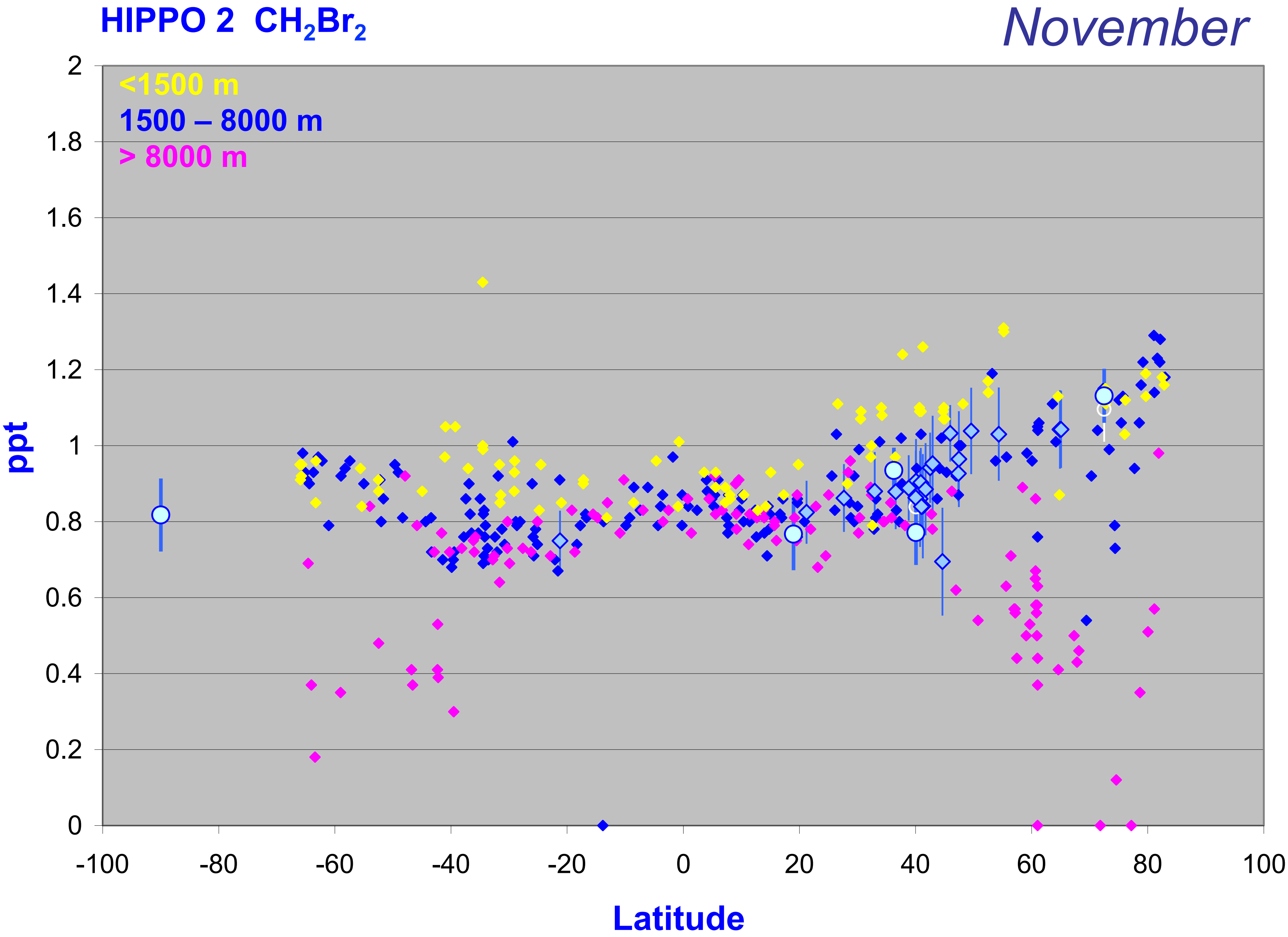
HIPPO 5 CH_2Br_2
August
<1500 m
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

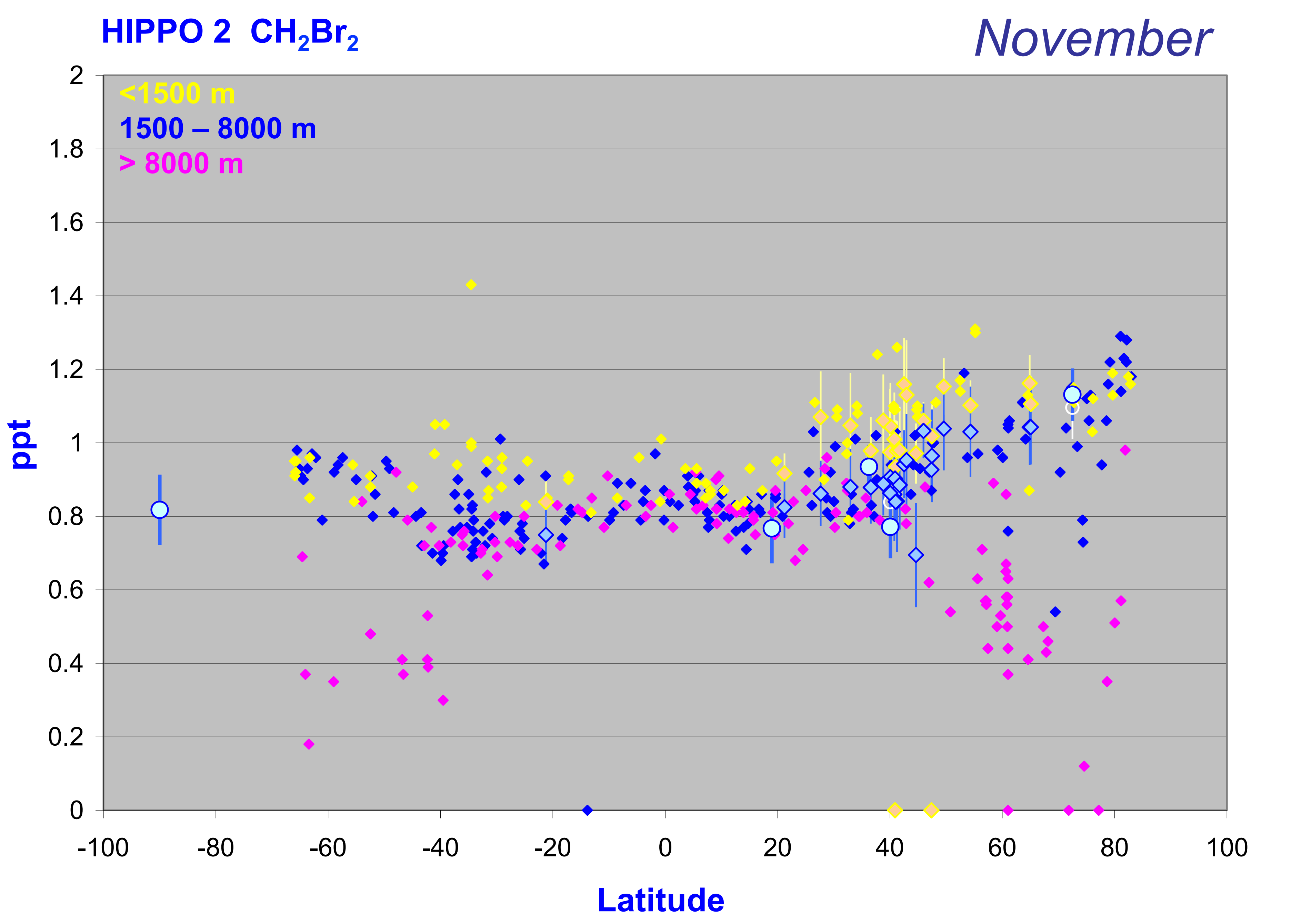


HIPPO 5 CH_2Br_2
August
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

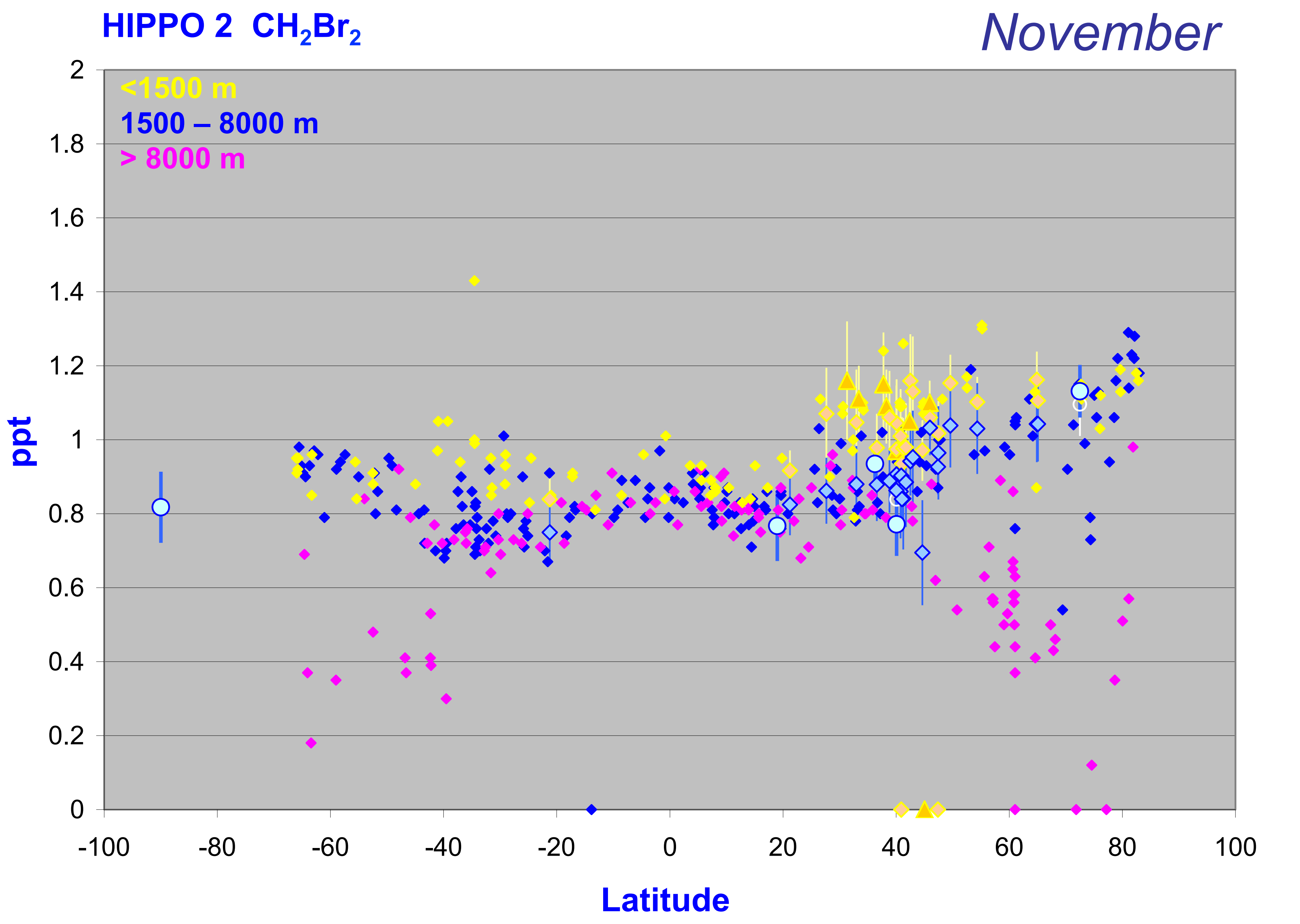


HIPPO 5 CH_2Br_2
August
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
-100
-80
-60
-40
-20
0
20
40
60
80
100
→ NH late summer, NH land sites still higher…

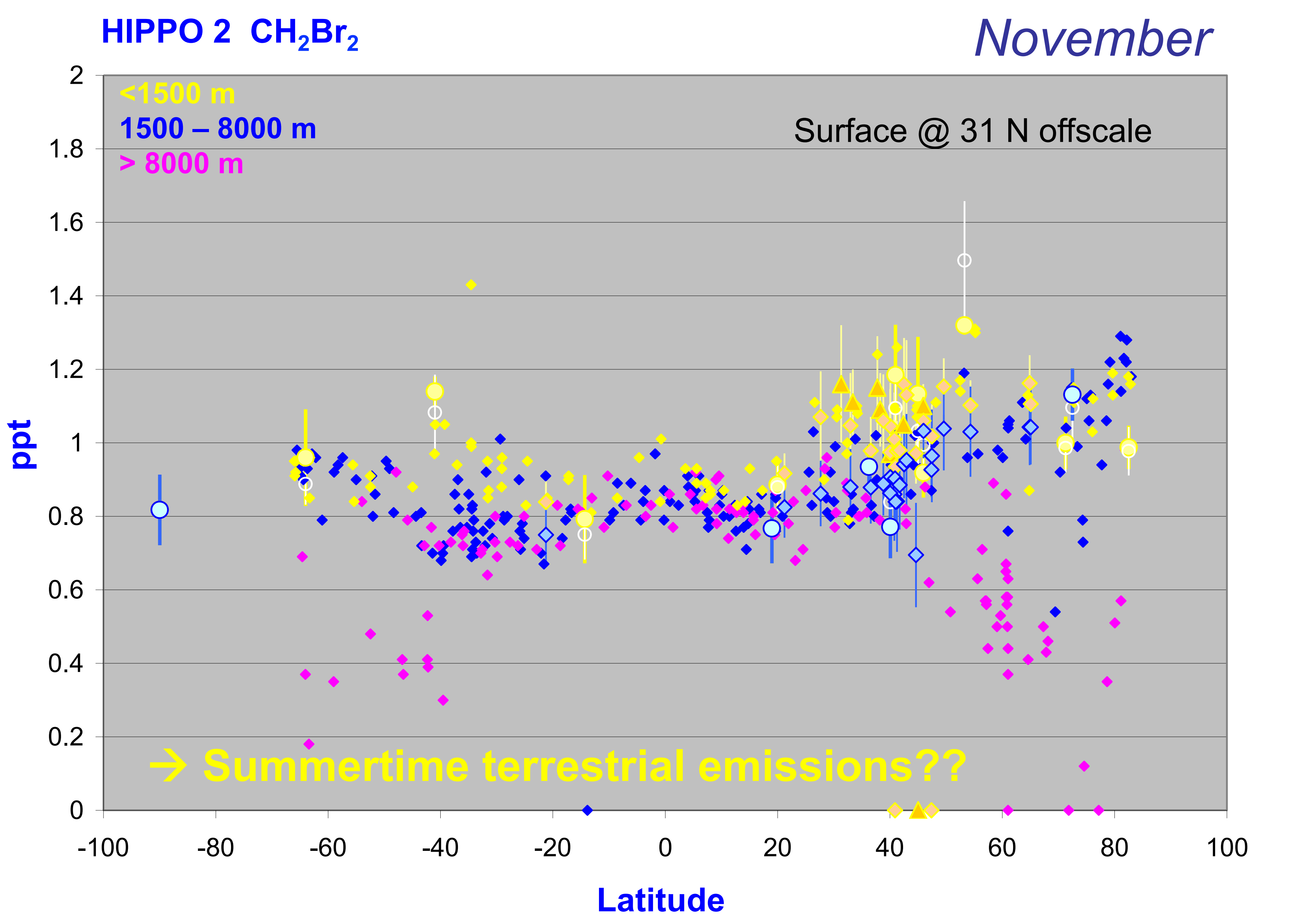

HIPPO 2 CH2Br2
November
<1500 m
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude



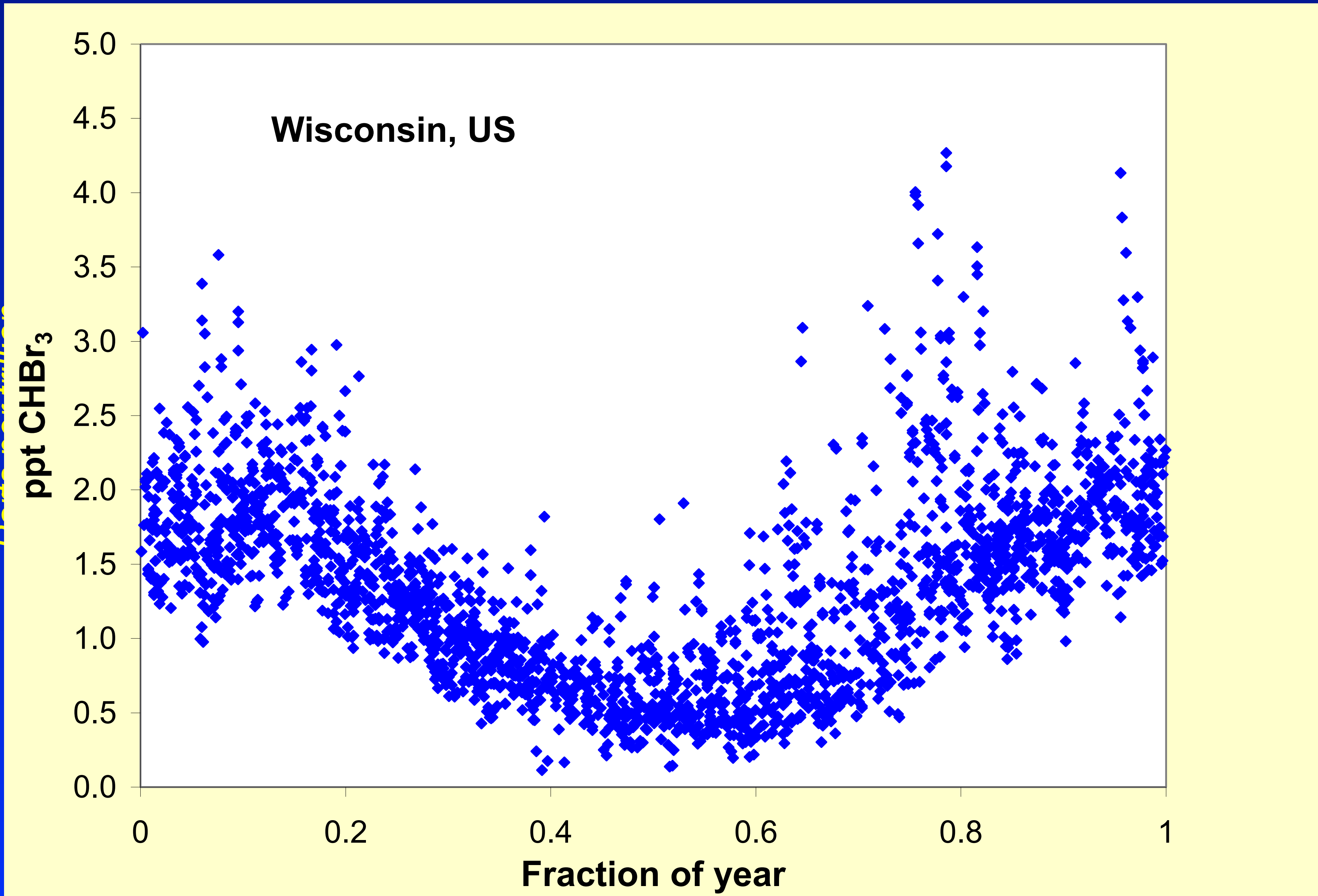
HIPPO 2 CH_2Br_2
November
<1500 m
1500 – 8000 m
> 8000 m
ppt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude



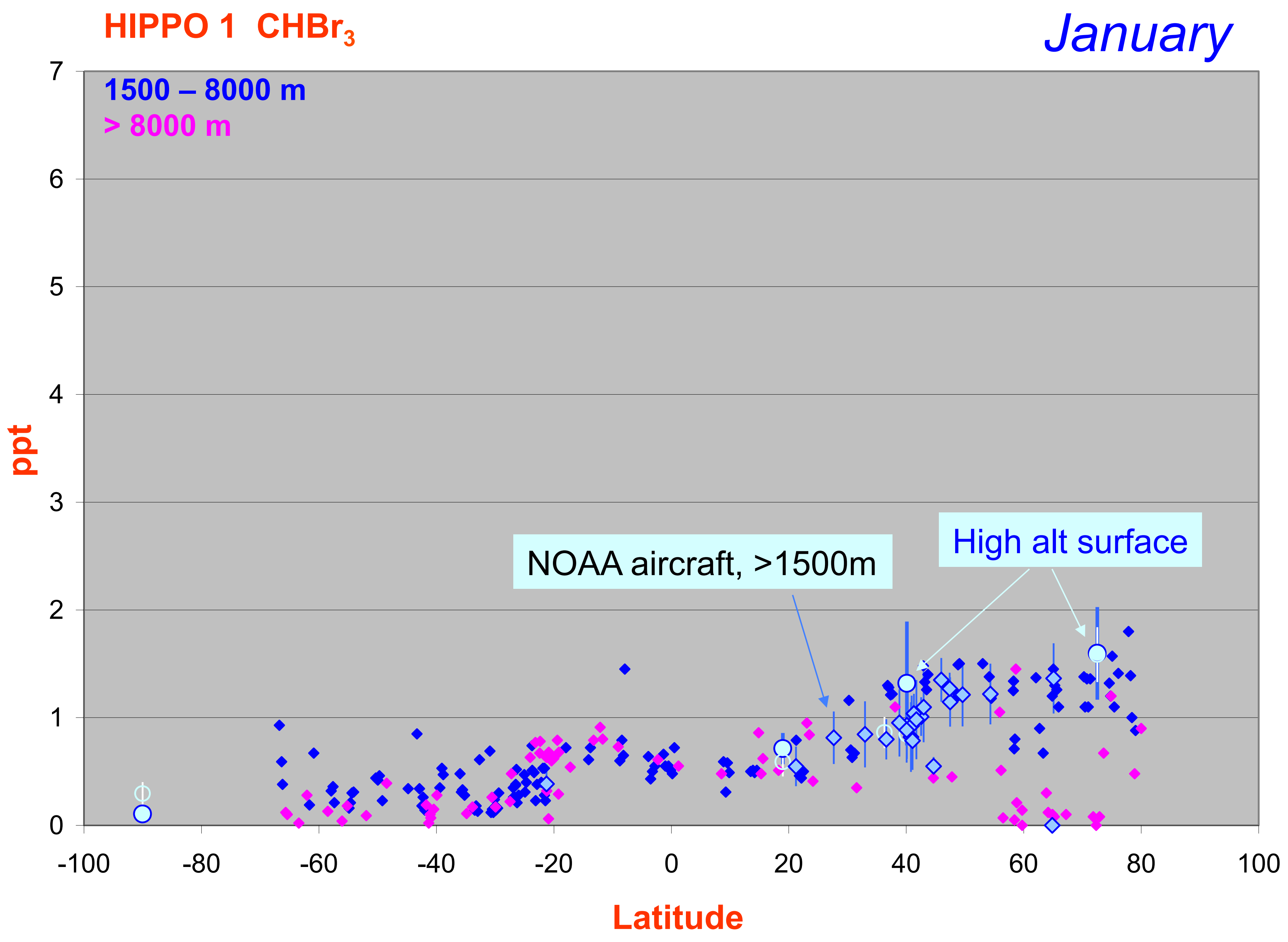
HIPPO 2 CH_2Br_2
November
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

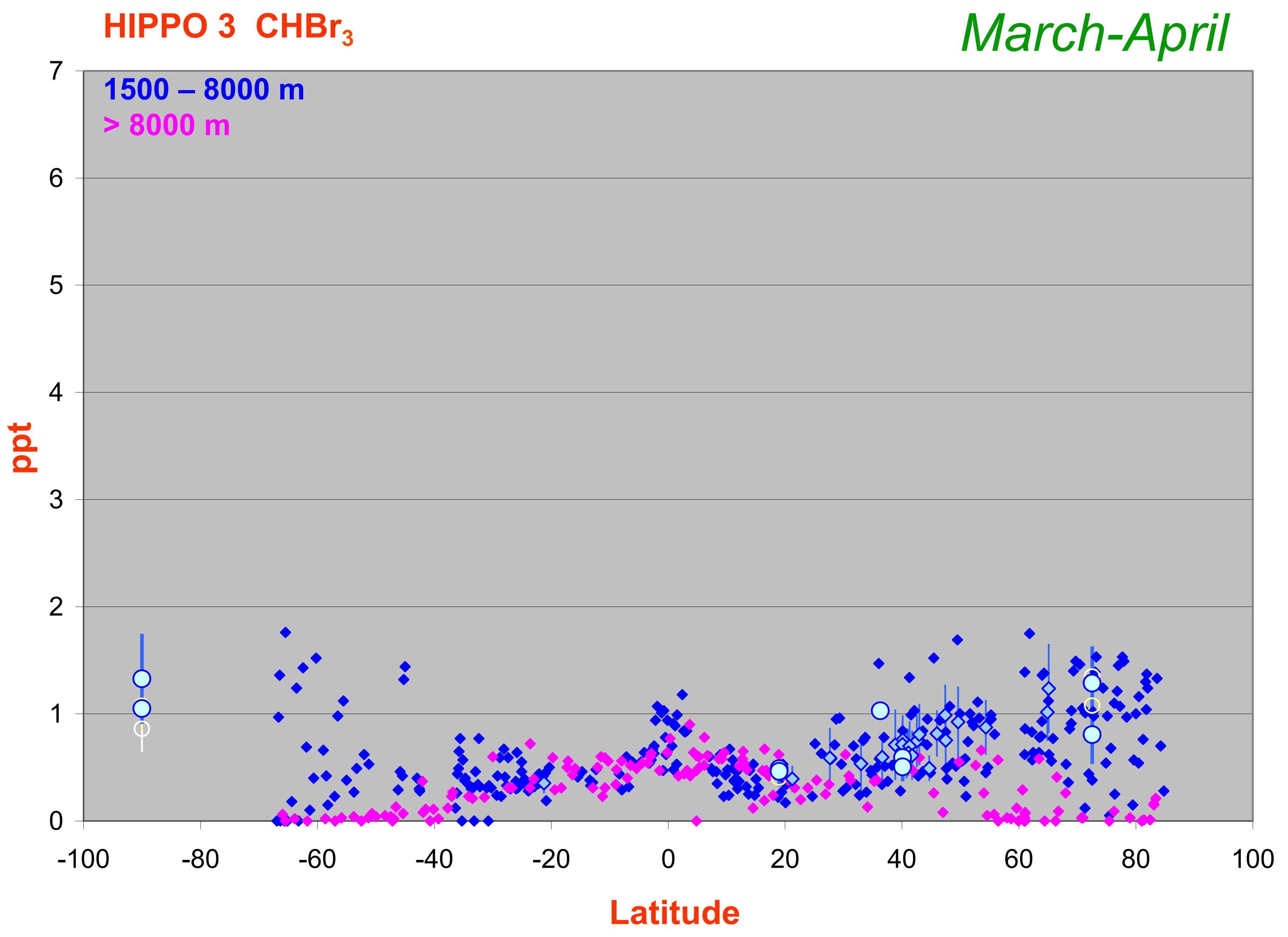

HIPPO 2 CH_2Br_2
November
<1500 m
1500 – 8000 m
> 8000 m
Surface @ 31 N offscale
→ Summertime terrestrial emissions??
ppt
Latitude
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

Bromoform ($CHBr_3$)

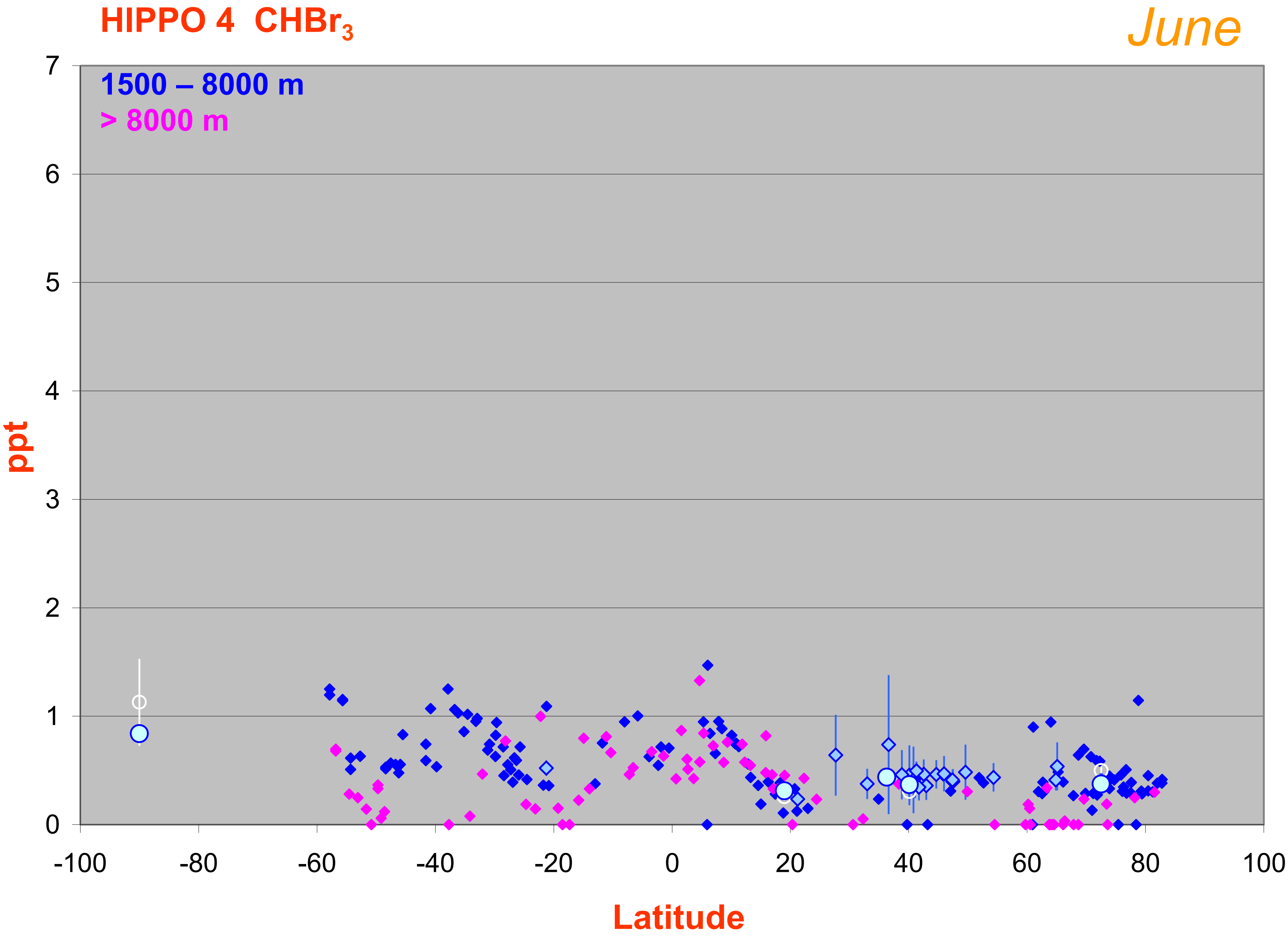


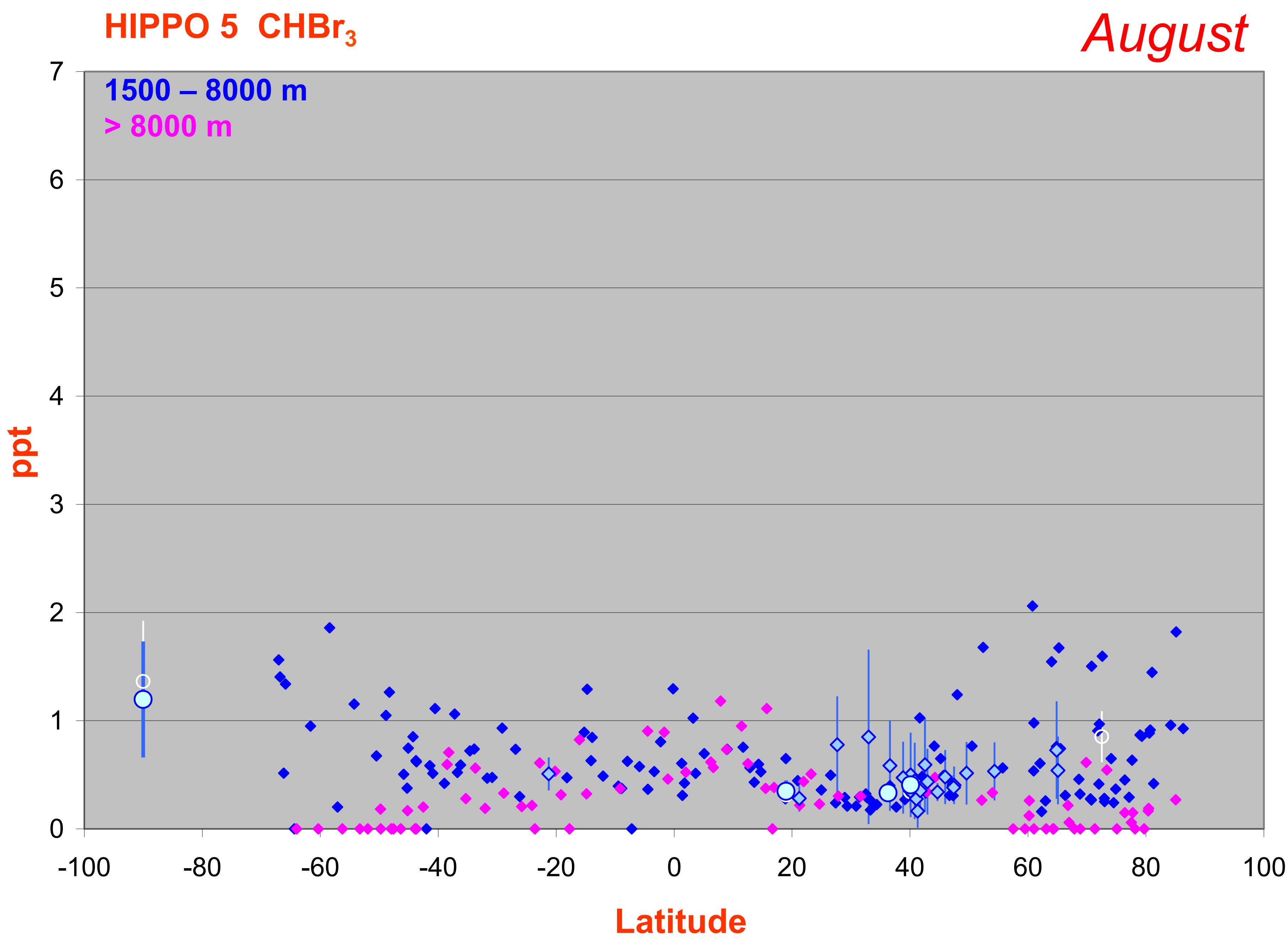
NOAA flask data


HIPPO 1 CHBr3
January
1500 – 8000 m
> 8000 m
NOAA aircraft, >1500m
High alt surface
ppt
Latitude
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100

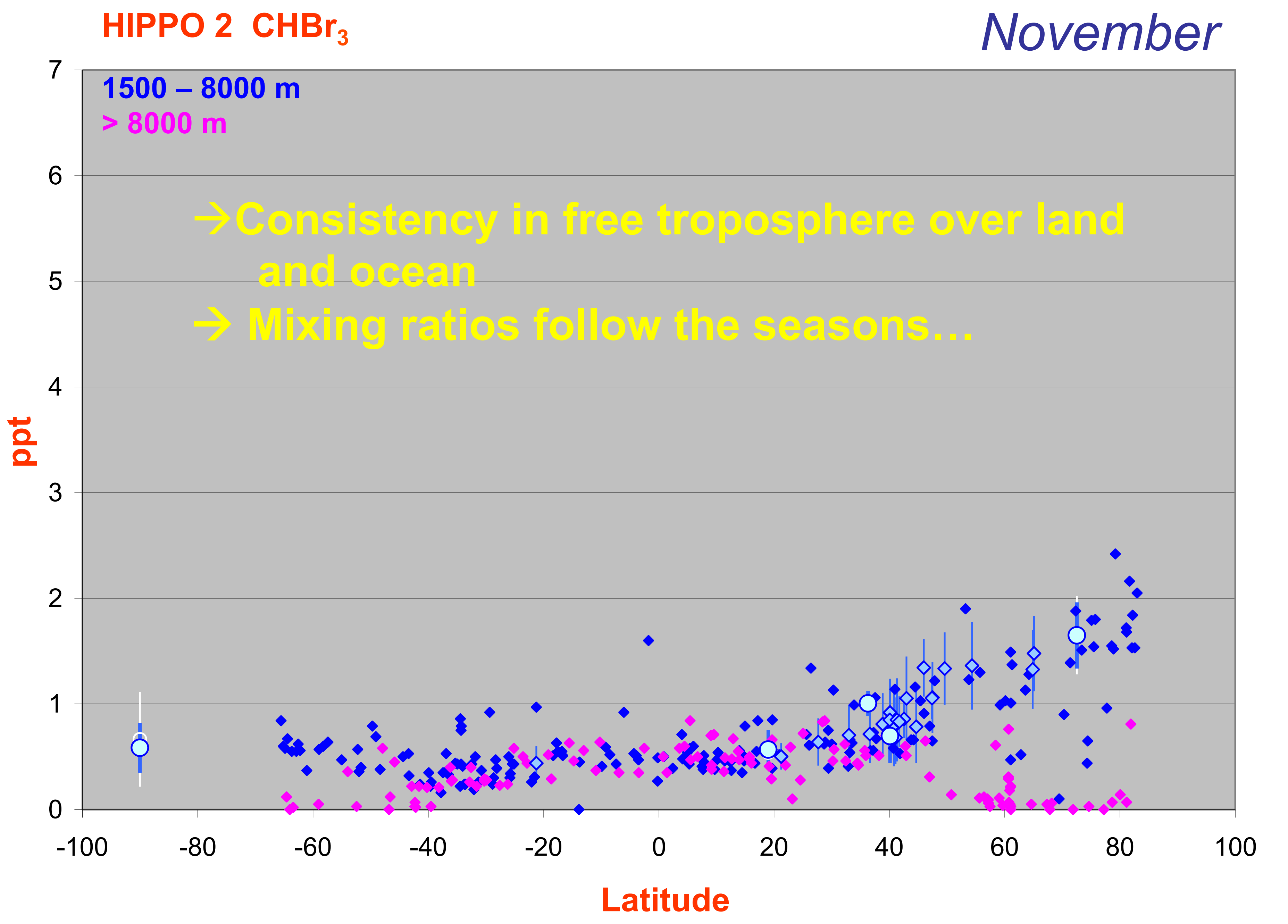


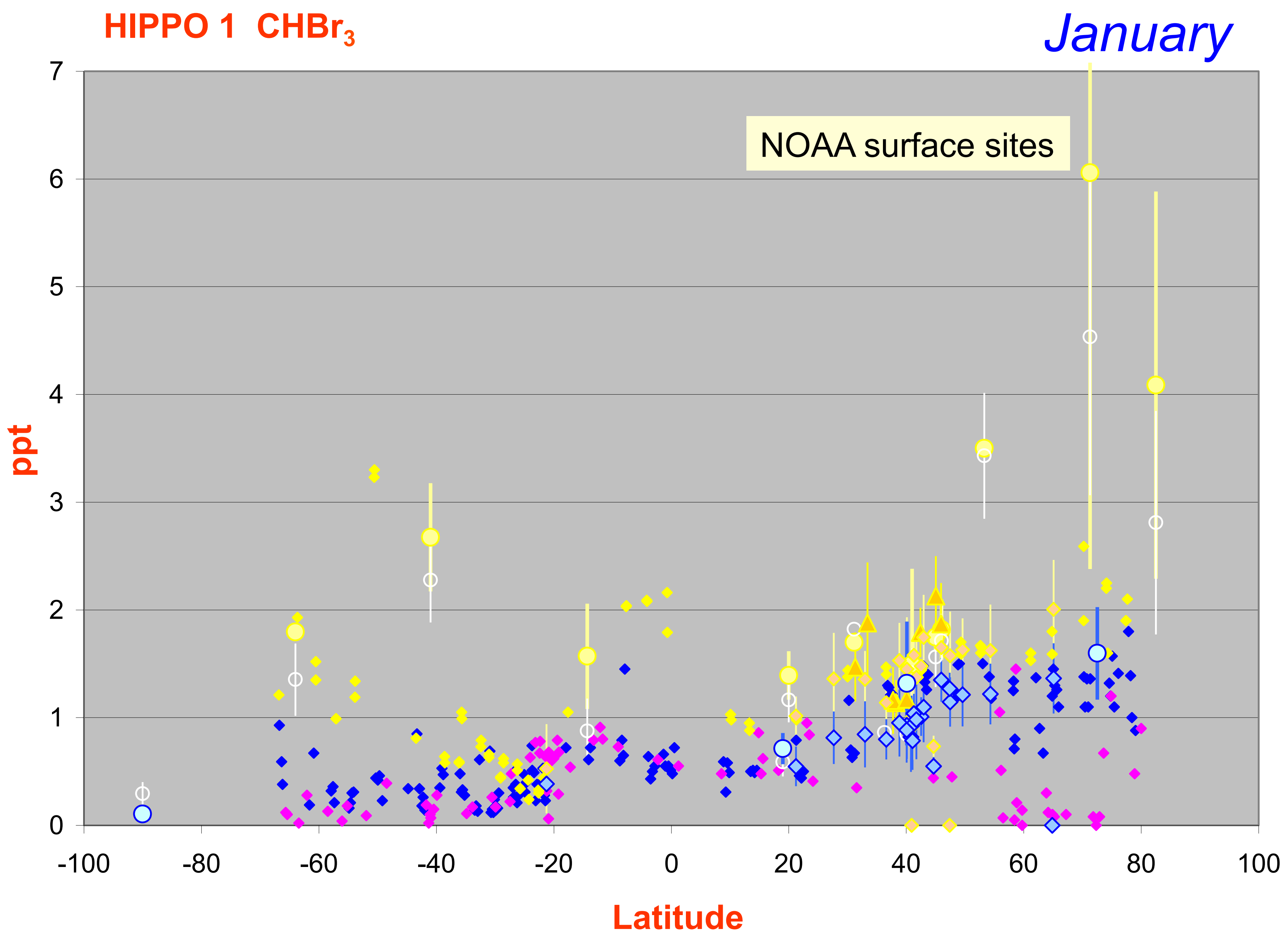
HIPPO 3 $CHBr_3$
March-April
1500 – 8000 m
> 8000 m
ppt
Latitude
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100

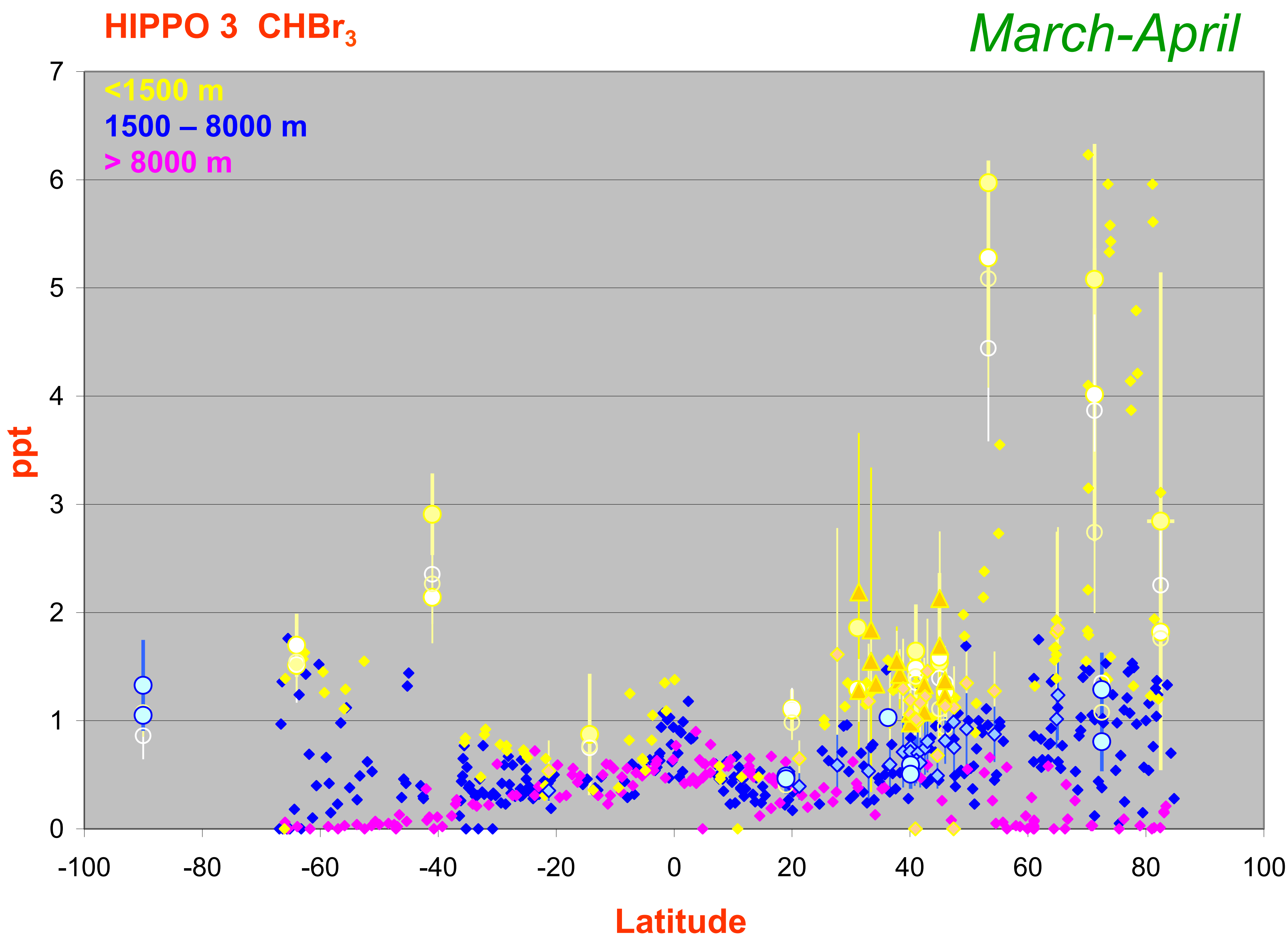

HIPPO 4 $CHBr_3$
June
1500 – 8000 m
> 8000 m
ppt
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

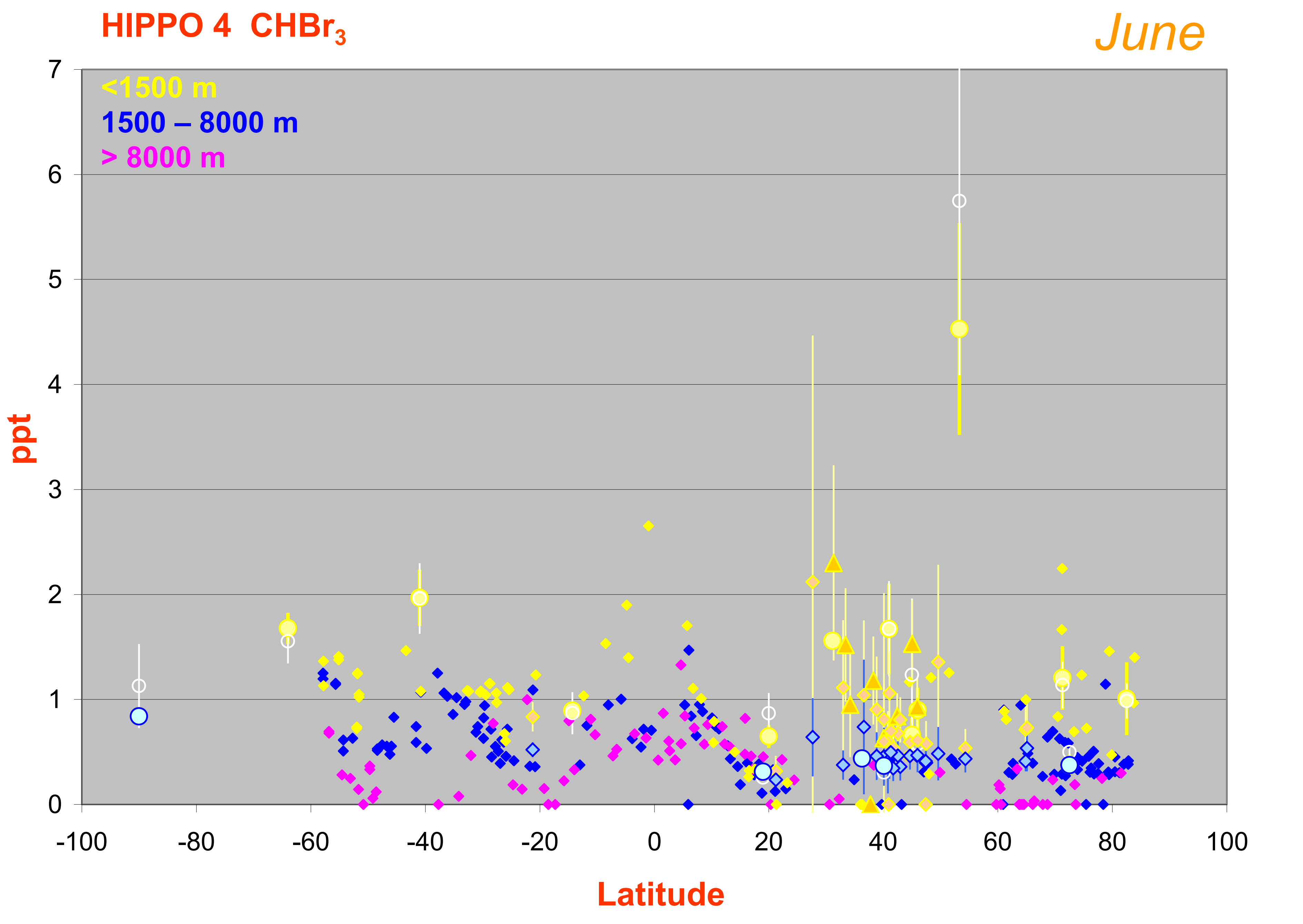


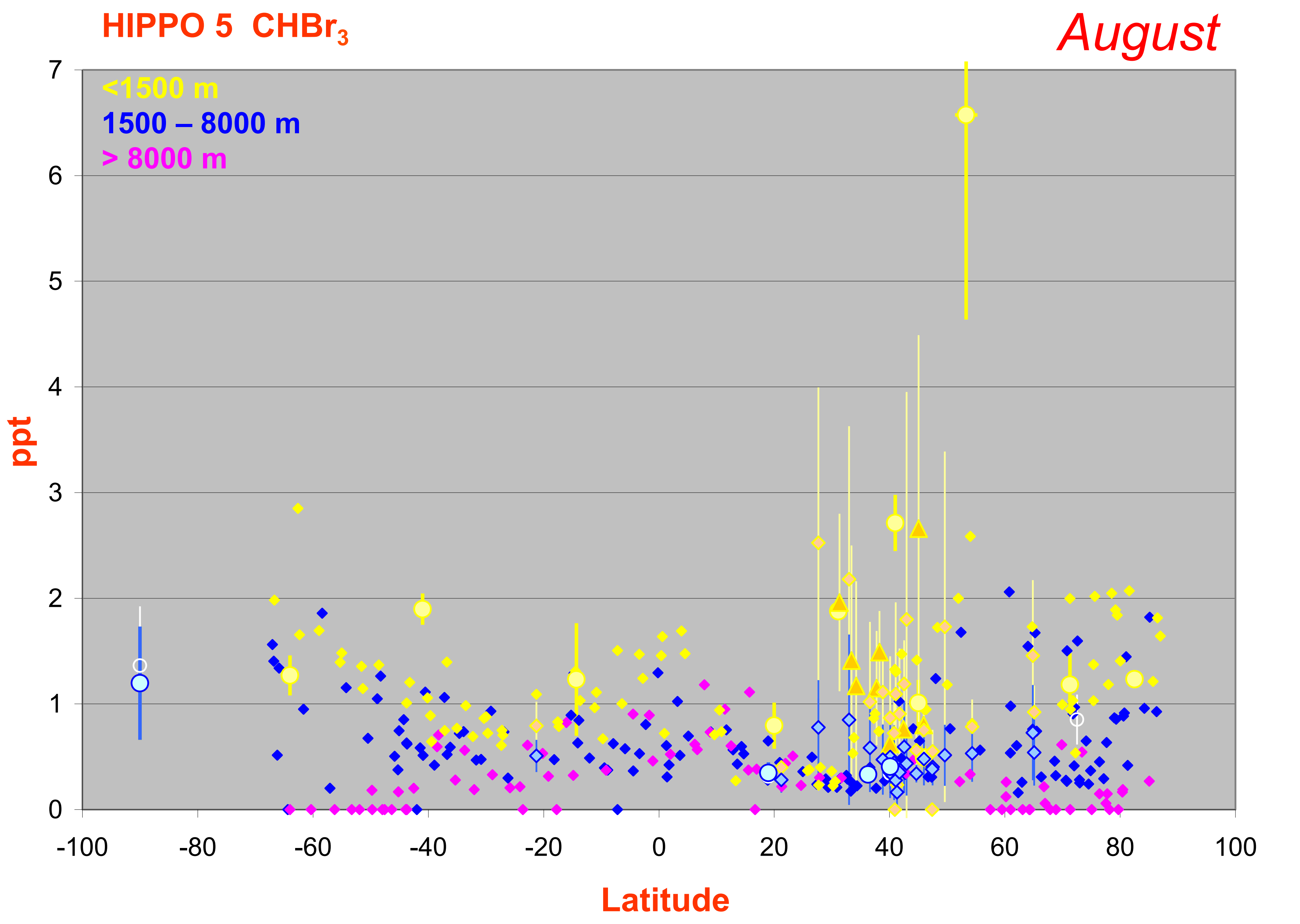
HIPPO 5 CHBr3
August
1500 – 8000 m
> 8000 m
ppt
Latitude
7
6
5
4
3
2
1
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


HIPPO 2 CHBr3
November
1500 – 8000 m
> 8000 m
→Consistency in free troposphere over land and ocean
→ Mixing ratios follow the seasons…
ppt
7
6
5
4
3
2
1
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

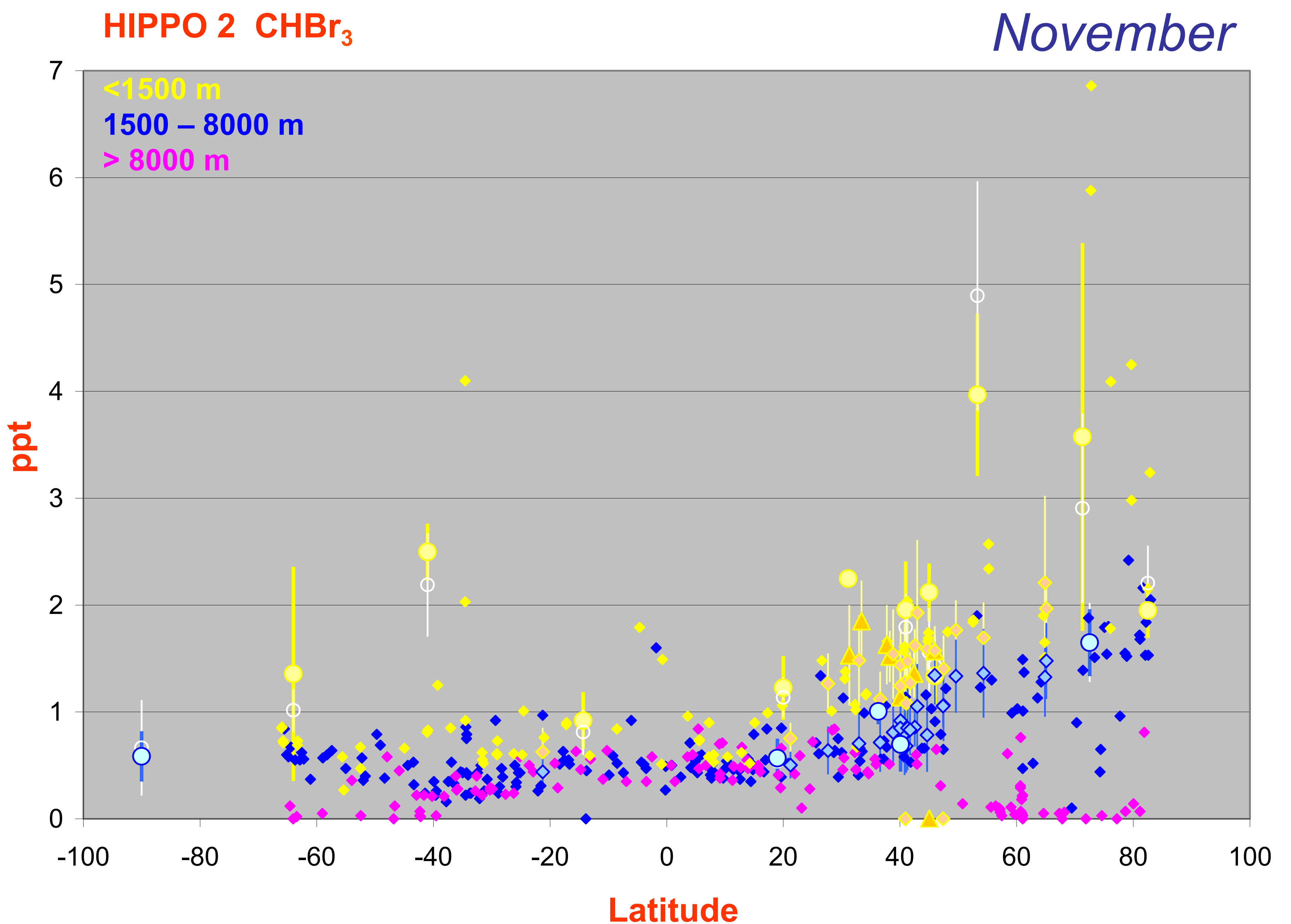

HIPPO 1 CHBr3
January
NOAA surface sites
ppt
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude


HIPPO 3 CHBr3
March-April
<1500 m
1500 – 8000 m
> 8000 m
ppt
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude


HIPPO 4 CHBr3
June
<1500 m
1500 – 8000 m
> 8000 m
ppt
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

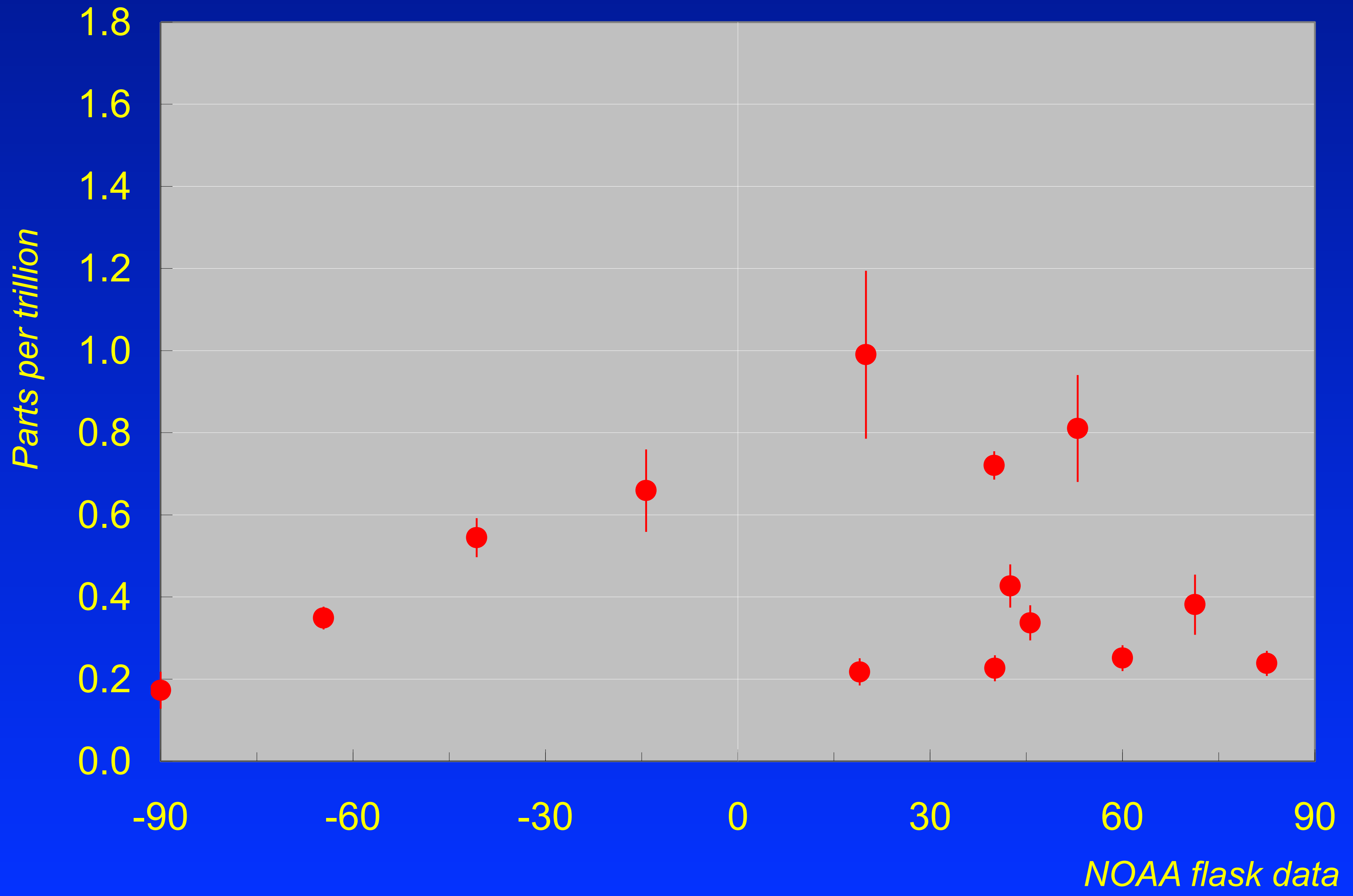


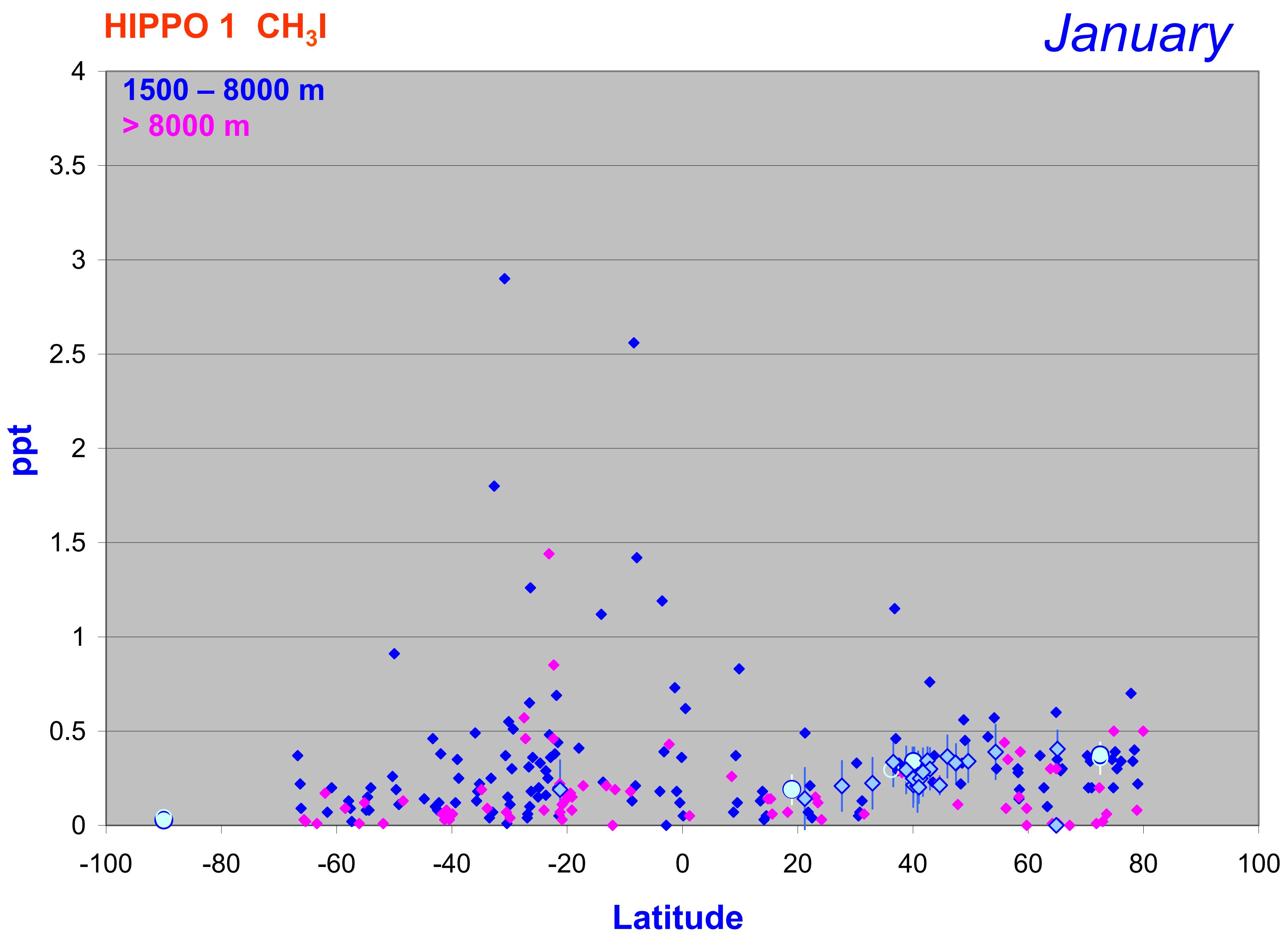
HIPPO 5 CHBr3
August
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
7
6
5
4
3
2
1
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

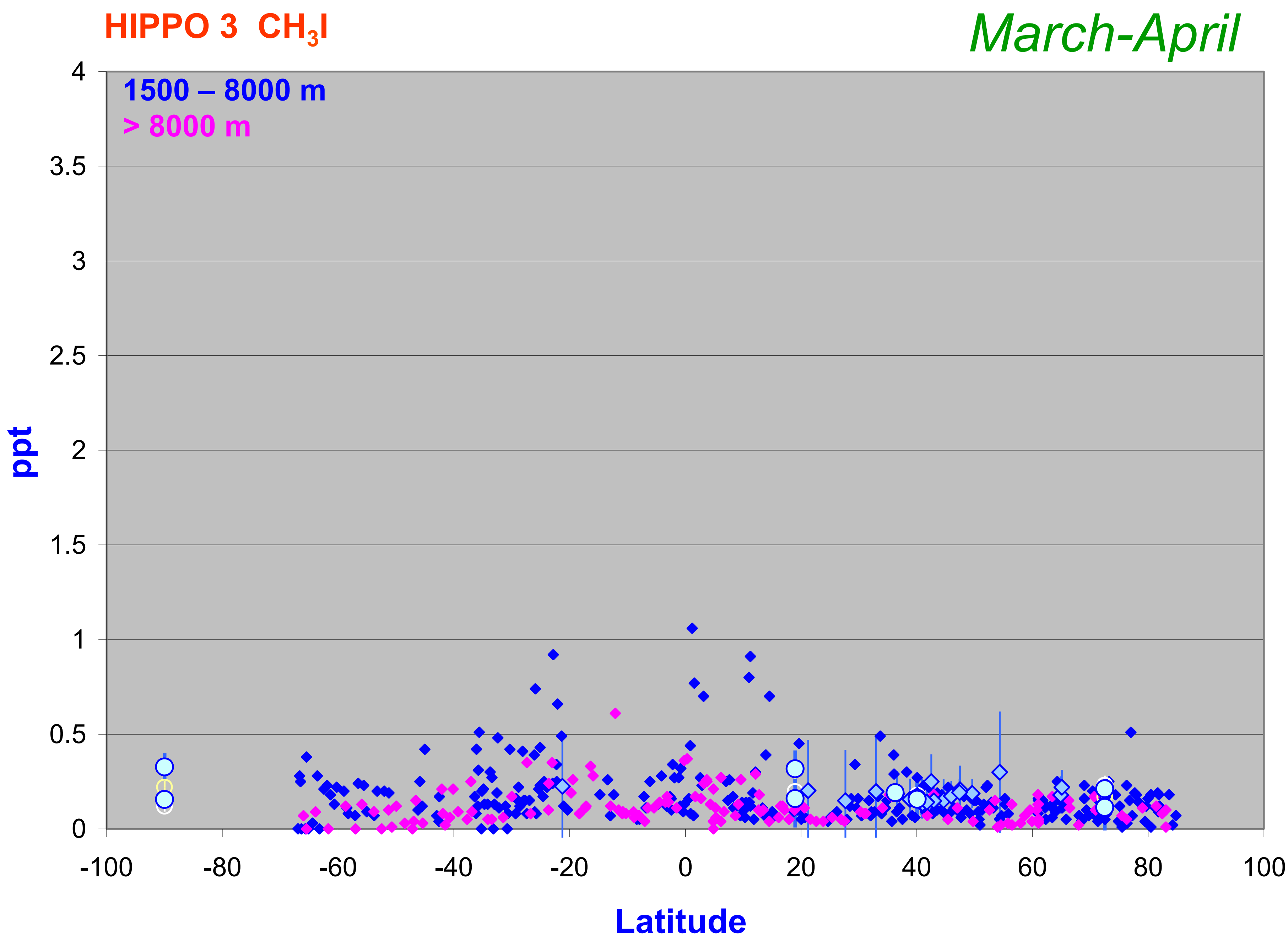

HIPPO 2 CHBr3
November
<1500 m
1500 – 8000 m
> 8000 m
ppt
0
1
2
3
4
5
6
7
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

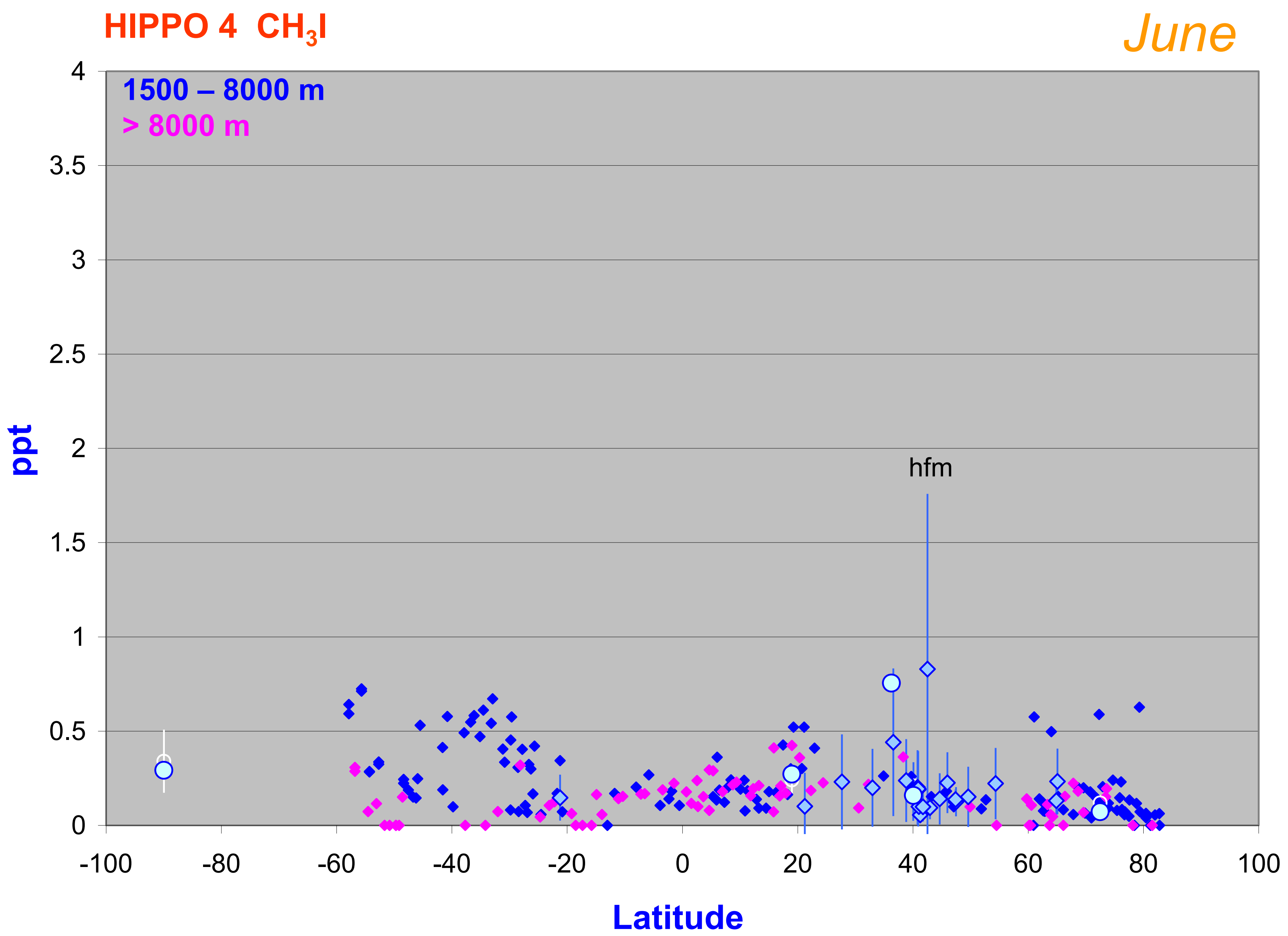
Methyl Iodide (CH_3I)

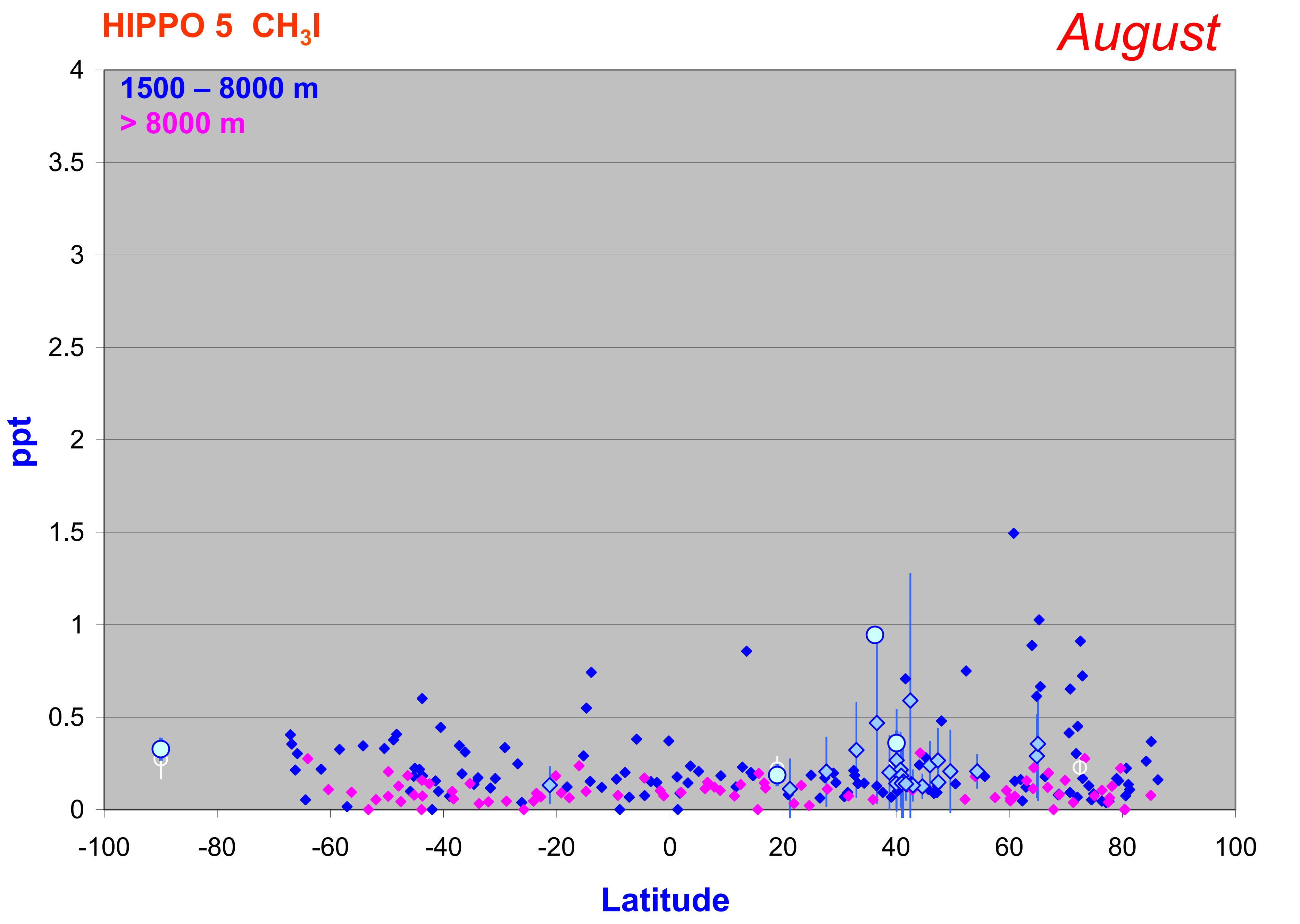
annual means at surface sites (13 yr record)



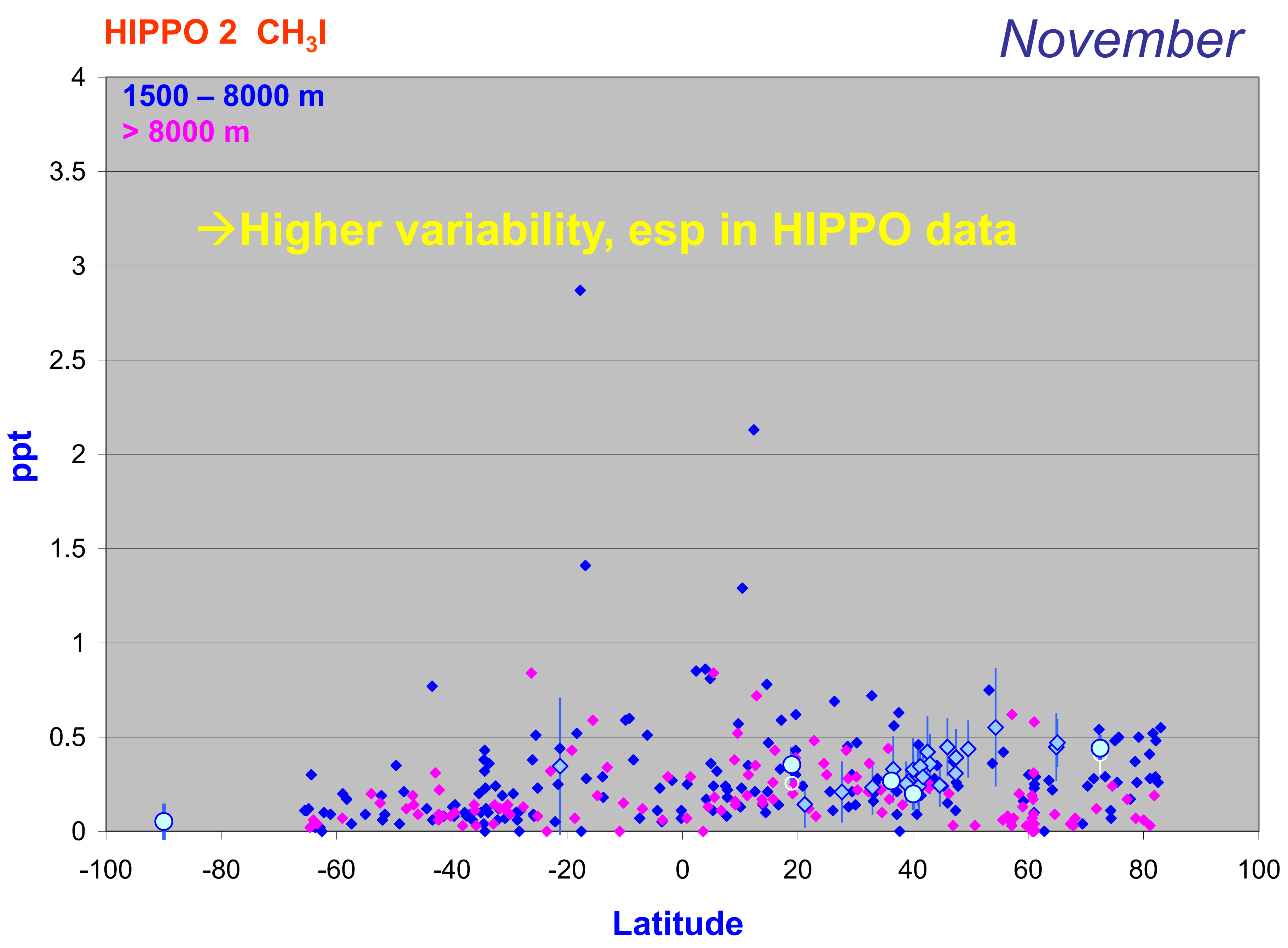

HIPPO 1 CH3I
January
1500 – 8000 m
> 8000 m
ppt
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude


HIPPO 3 CH3I
March-April
1500 – 8000 m
> 8000 m
ppt
Latitude
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

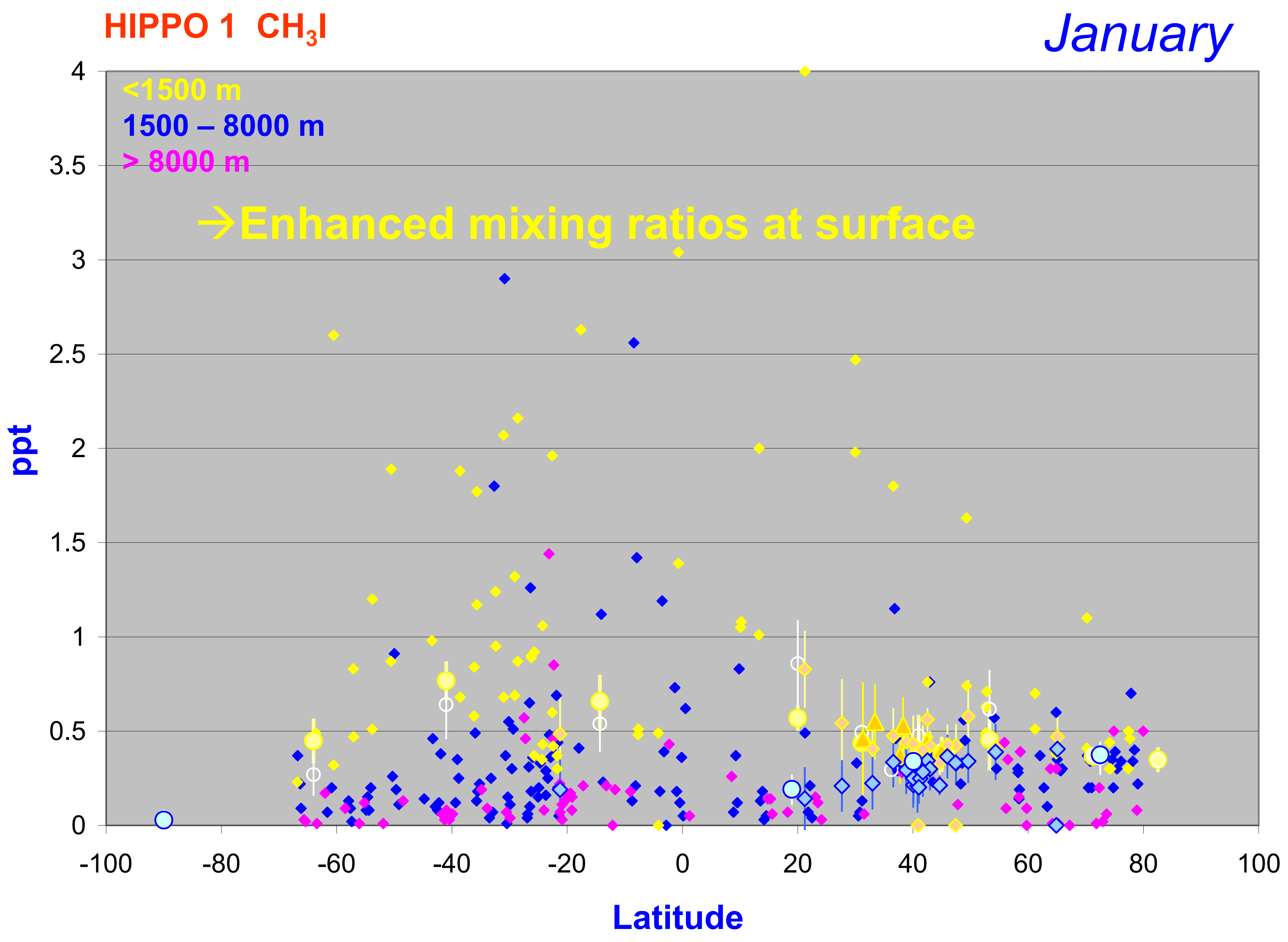

HIPPO 4 CH3I
June
1500 – 8000 m
> 8000 m
hfm
ppt
Latitude
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

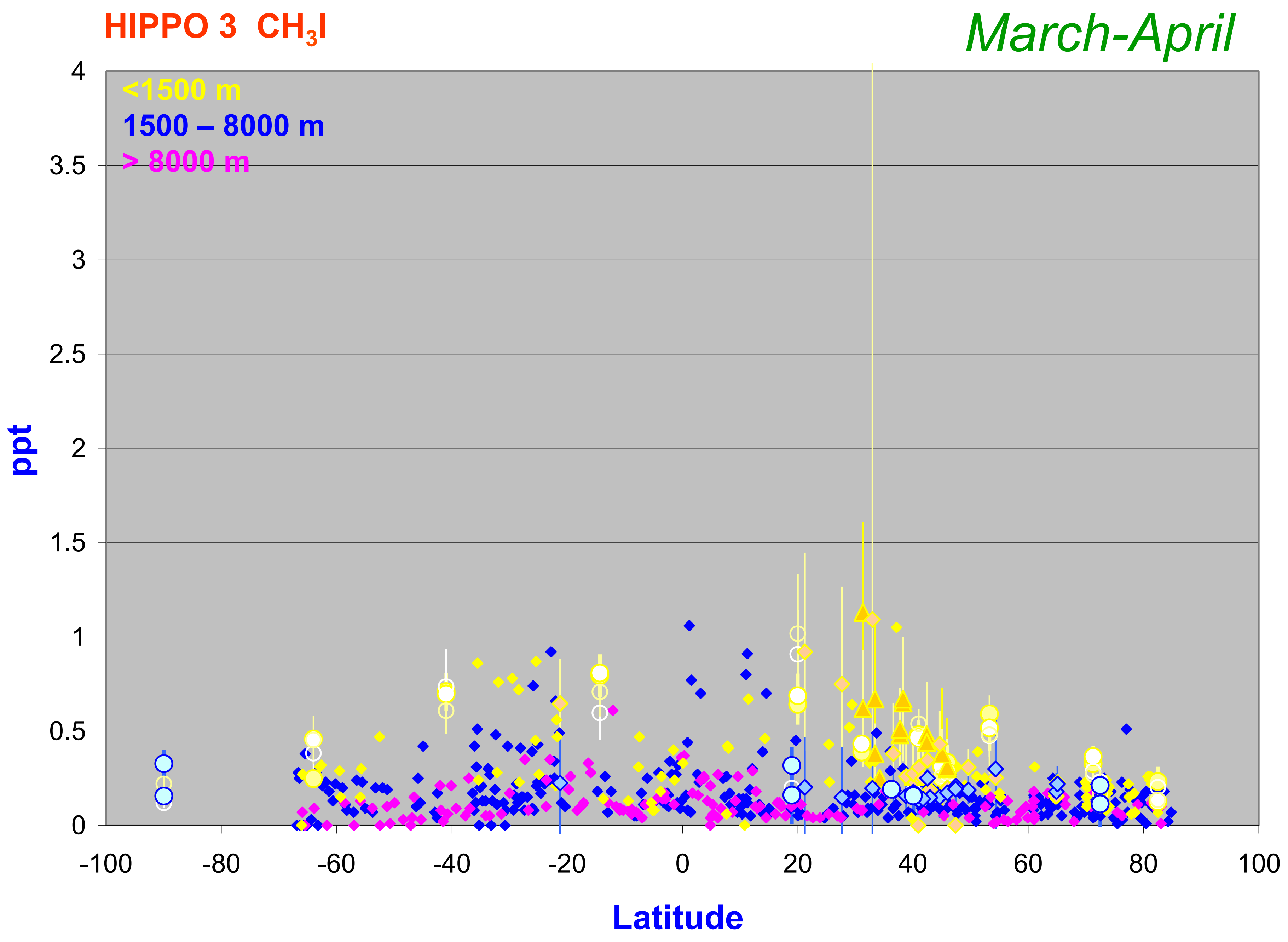


HIPPO 5 CH_3I
August
1500 – 8000 m
> 8000 m
ppt
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

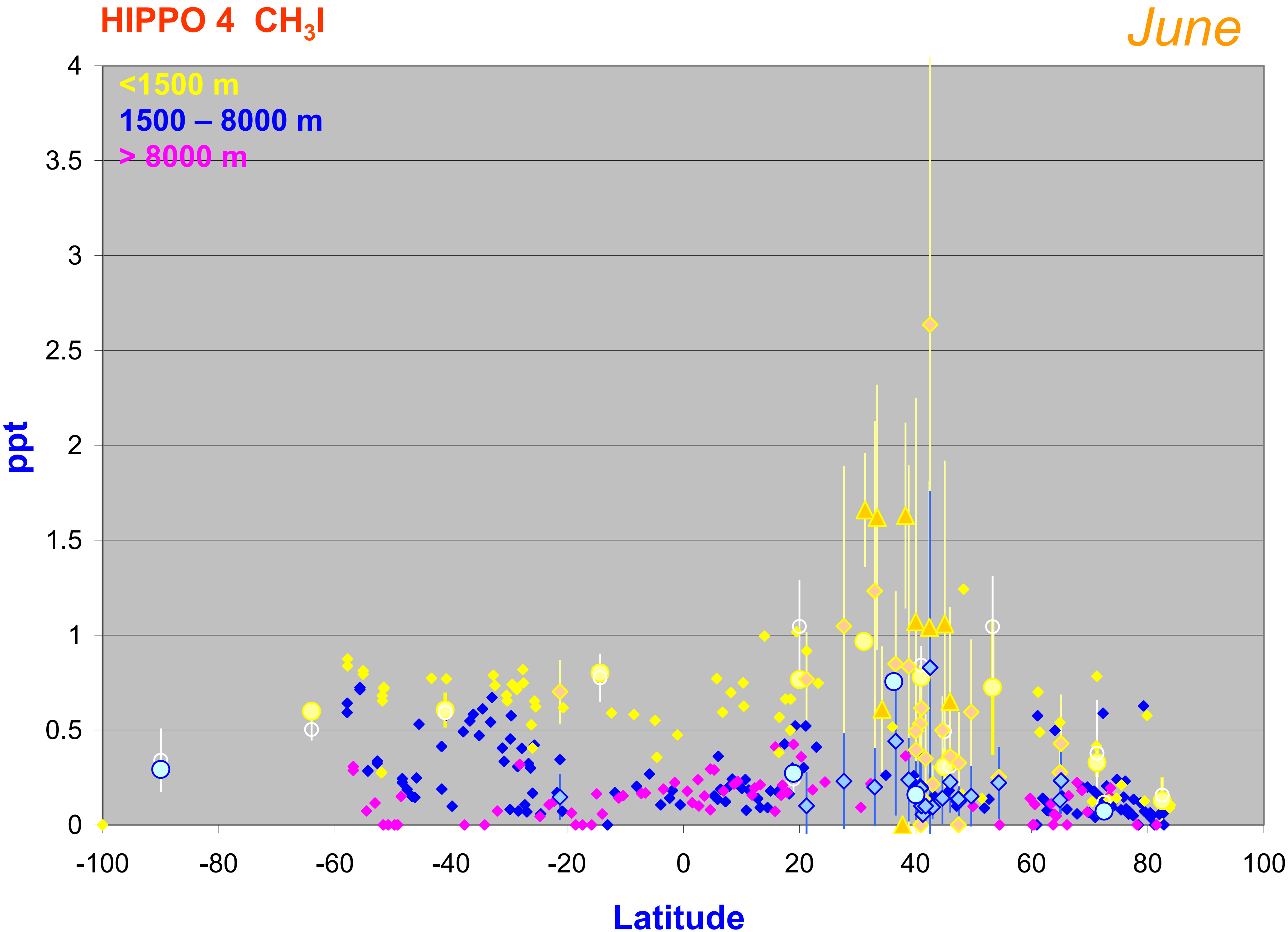


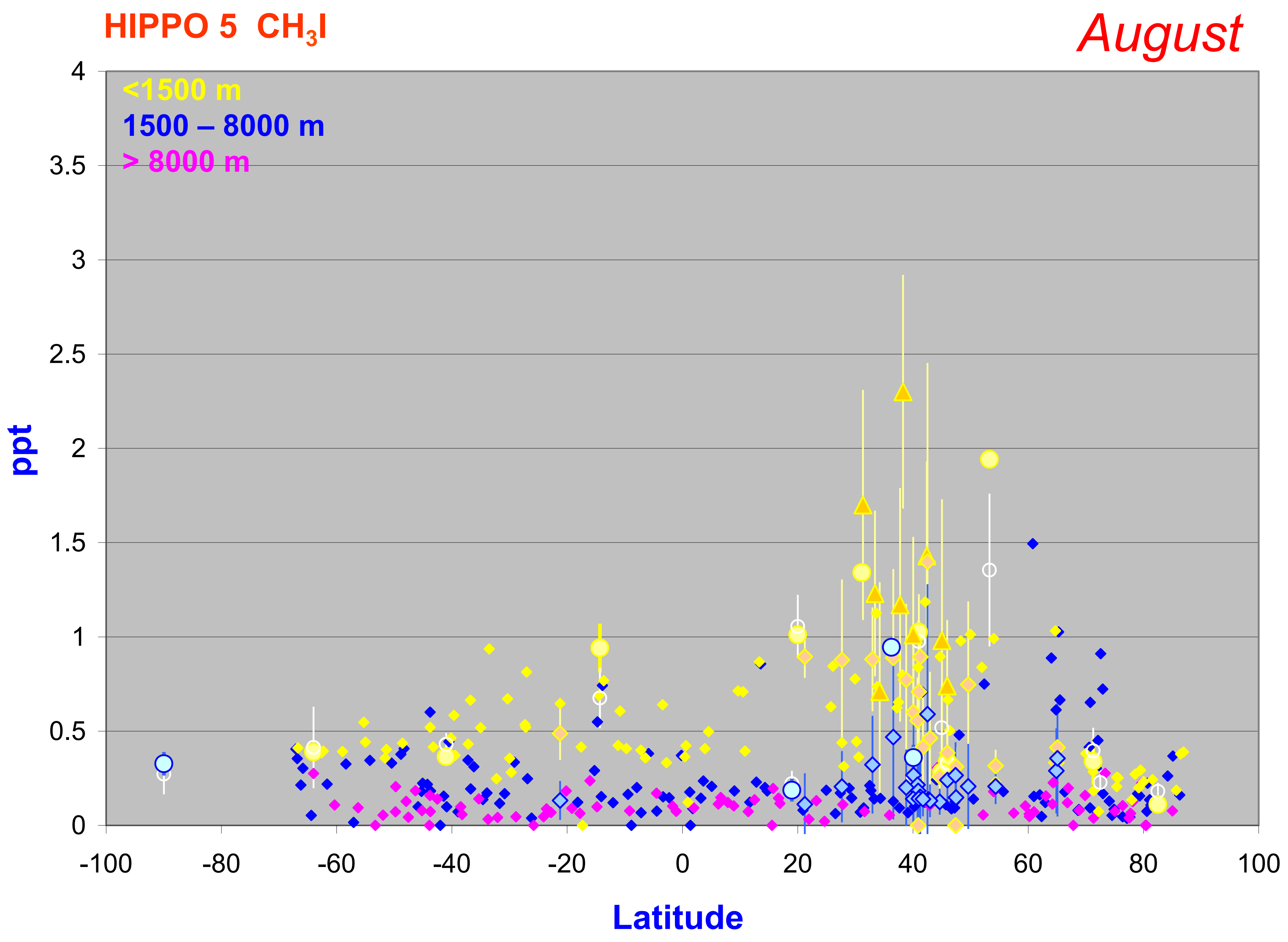
HIPPO 2 CH3I
November
1500 – 8000 m
> 8000 m
→Higher variability, esp in HIPPO data
ppt
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

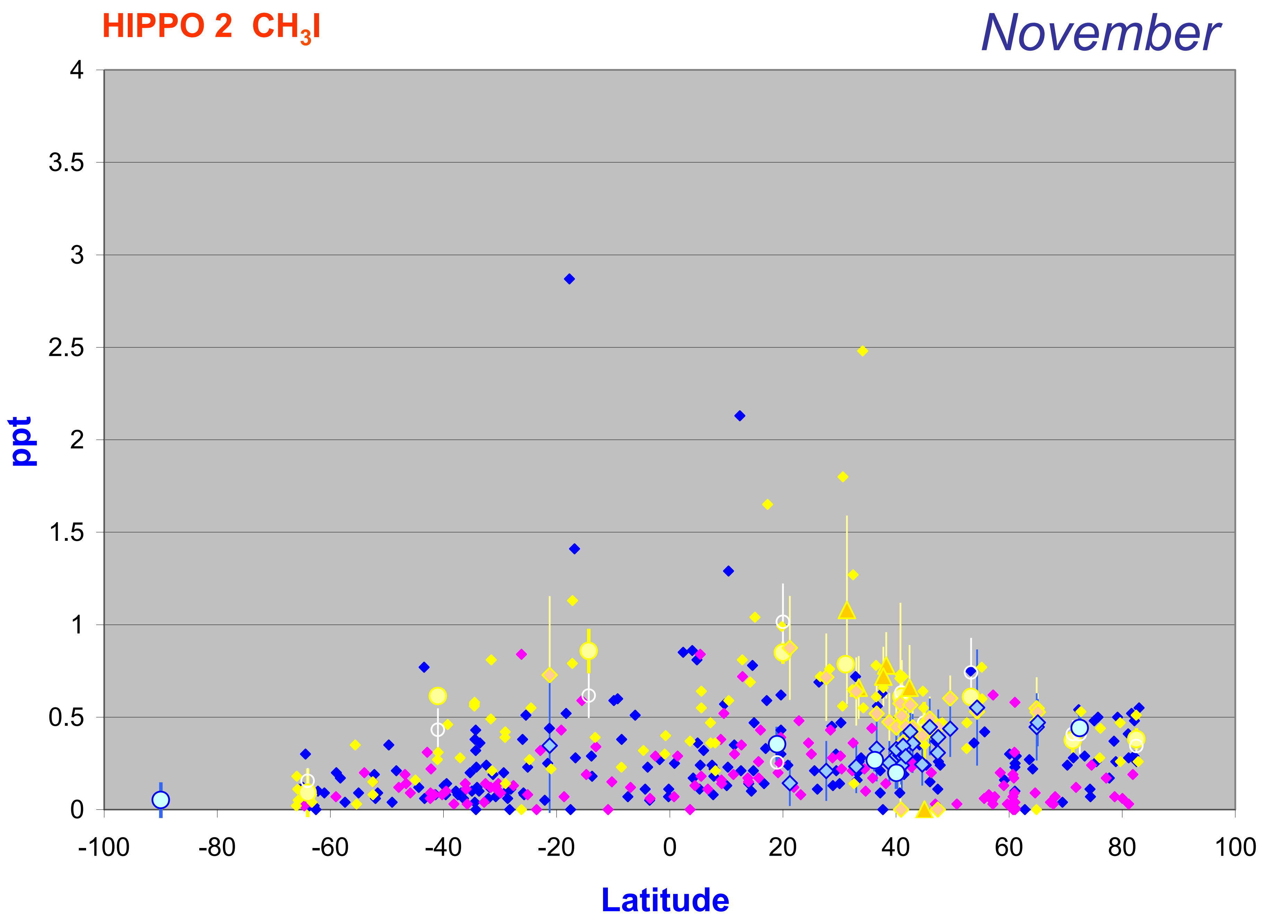

HIPPO 1 CH$_3$I
January
<1500 m
1500 – 8000 m
> 8000 m
→Enhanced mixing ratios at surface
ppt
Latitude
0
0.5
1
1.5
2
2.5
3
3.5
4
-100
-80
-60
-40
-20
0
20
40
60
80
100



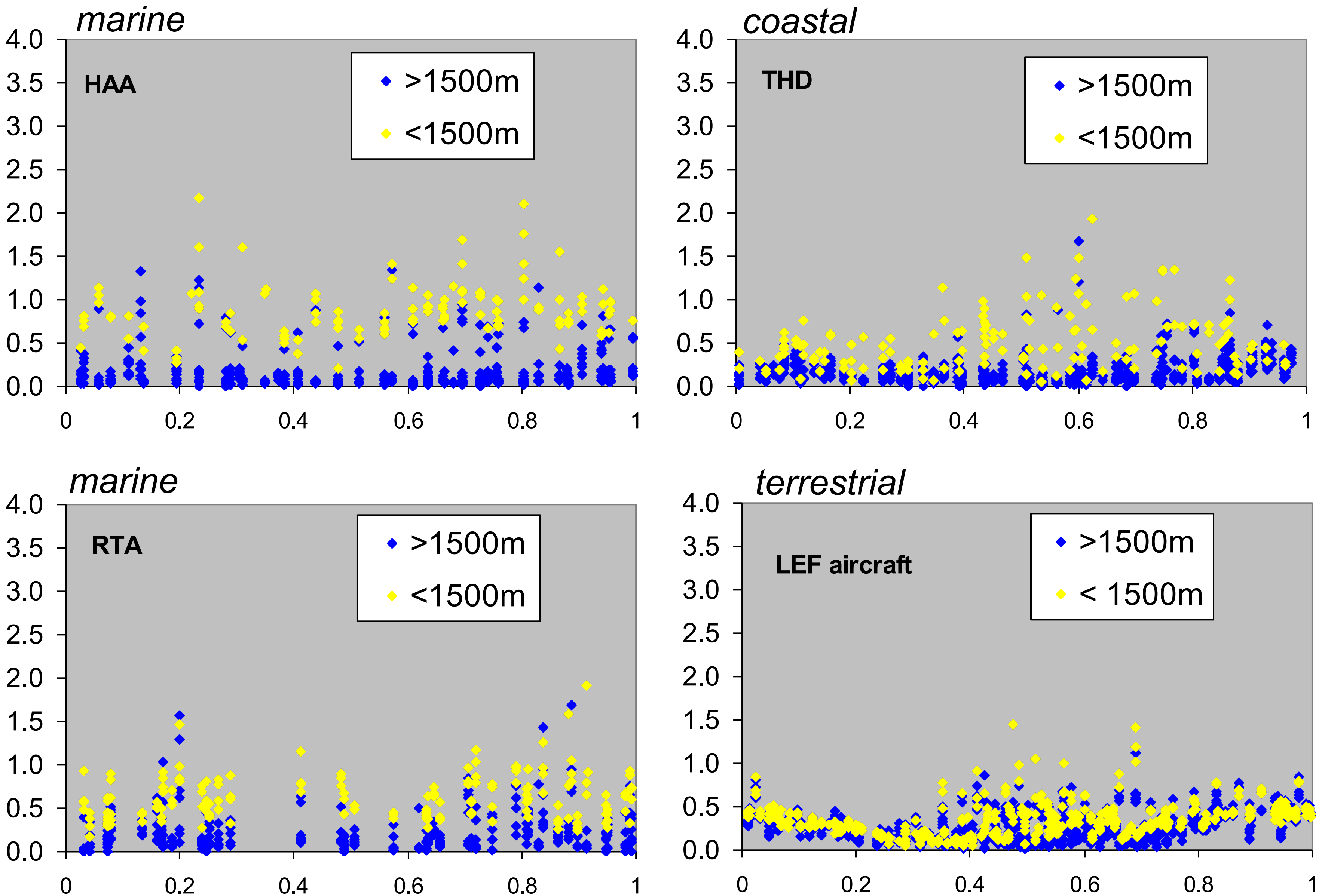
HIPPO 3 CH3I
March-April
<1500 m
1500 – 8000 m
> 8000 m
ppt
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude


HIPPO 4 CH_3I
June
<1500 m
1500 – 8000 m
> 8000 m
ppt
Latitude
0
0.5
1
1.5
2
2.5
3
3.5
4
-100
-80
-60
-40
-20
0
20
40
60
80
100

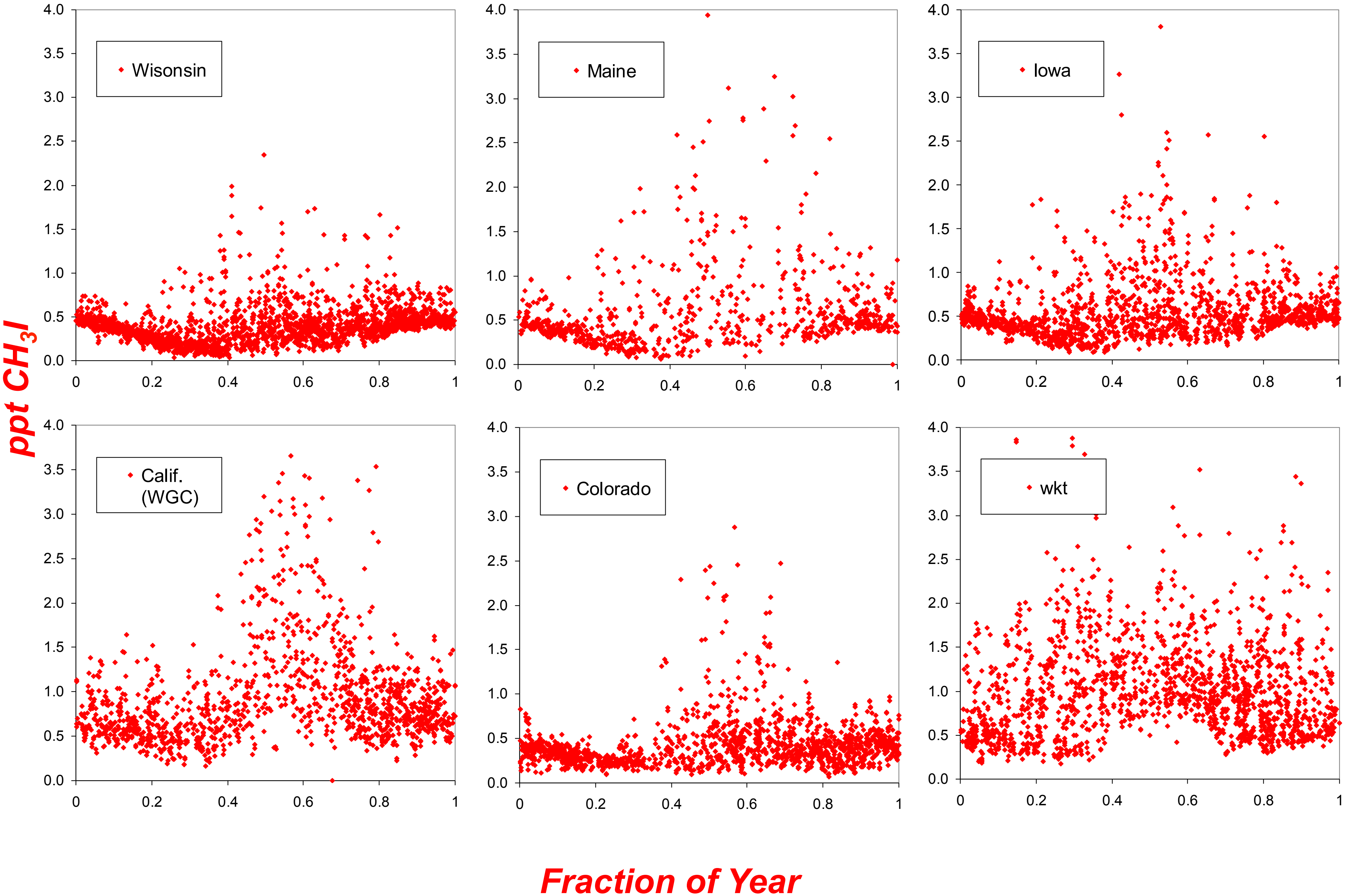

HIPPO 5 CH3I
August
<1500 m
1500 – 8000 m
> 8000 m
ppt
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude


HIPPO 2 CH_3I
November
ppt
4
3.5
3
2.5
2
1.5
1
0.5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Latitude

CH_3I from selected AIRCRAFT sites in the NOAA network



CH_3I from selected TERRESTRIAL sites in the NOAA tower network



Summary, short-lived gases:

At all surface sites:

→ consistent annual means are measured from year-to-year

→ but large site-to-site differences are observed

In HIPPO and NOAA-air data:

→ Boundary layer mixing ratios are enhanced above land and sea

→ magnitude of enhancements varies seasonally

(less so for CH_2Br_2, more so for $CHBr_3$ and CH_3I)

For CH_2Br_2 and $CHBr_3$

→Though persistent site-to-site differences are observed *at the surface*, more consistent mixing ratios are found *in the free troposphere, over land or sea… with seasonal variations driven primarily by losses.*

For CH_3I

→ shorter lifetime, more variability.

→ strong evidence for a substantial terrestrial summertime source

The **NE**ext best thing to an **O**ngoing HIPPO continues at NOAA (NEO-HIPPO)…