Validation of ACE by non-coincident MkIV Balloon Profiles

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MkIV Validation Heritage

MkIV interferometer is a solar occ FTS designed and built at JPL

It has made 21 balloon flights since 1989, including 4 from Ft Sumner

New Mexico, since ACE was launched in Aug 2003.

It will likely make another flight this Fall from Ft. Sumner, NM

MkIV has a long validation history that includes:

- UARS 1990's (HALOE, CLAES, MLS, ISAMS),
- ILAS-1 & ILAS-2 (1997; 2003)
- In-Situ sensors aboard the NASA ER-2 aircraft (Alaska 1997)
- Ground-based O_3 inter-comparisons
- POAM3 2002
- MLS (Aura) 2004-present

The MkIV is the perfect validation instrument for ACE: it uses the same technique (solar occ) and covers the same spectral region.

But…

MkIV balloon launches occur during the “turn-around” period when stratospheric float winds are light.

This happens in late-September in Ft Sumner

This falls in a “hole” in the ACE coverage

ACE Occultation Latitudes

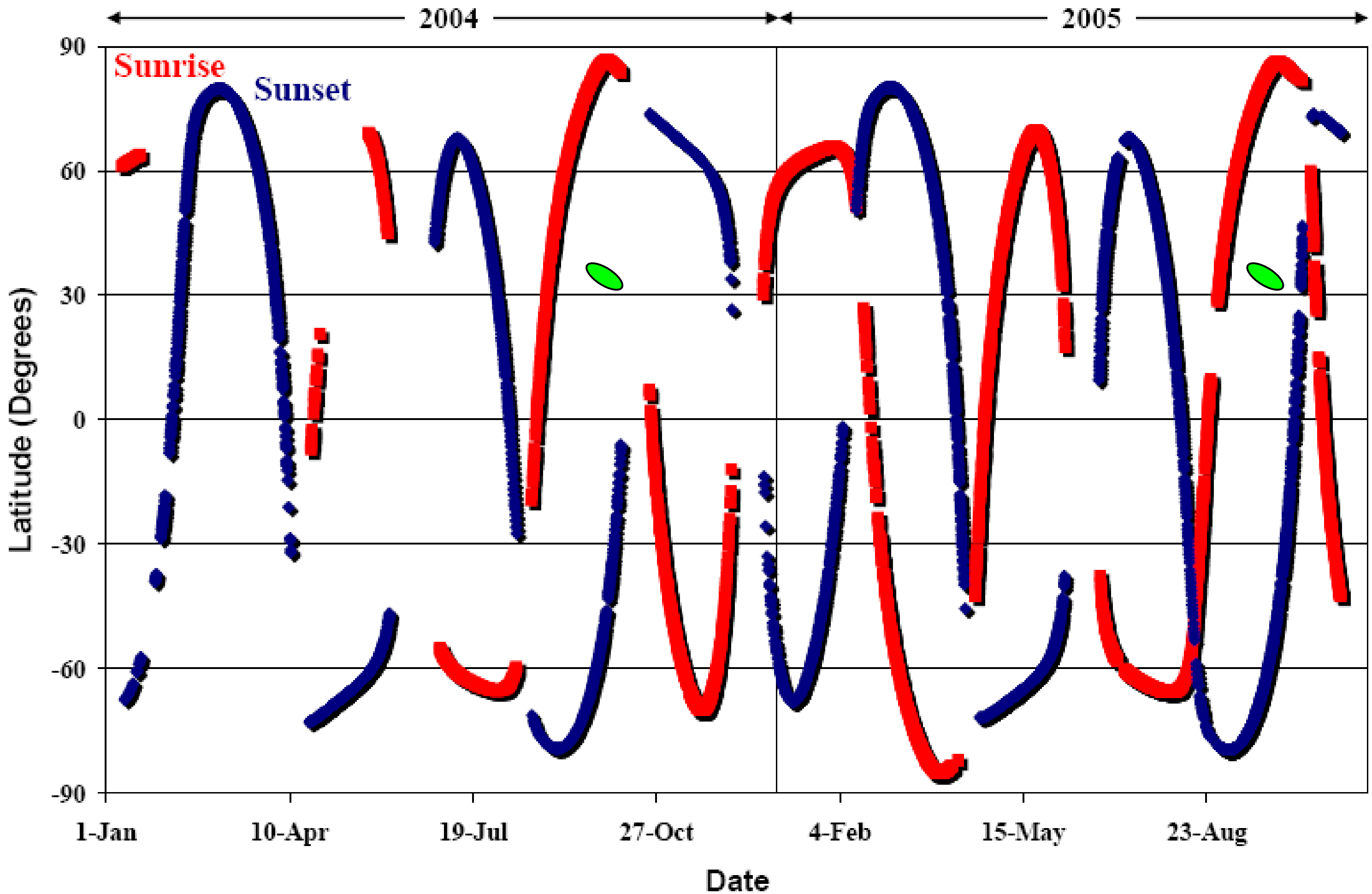


Figure 1: ACE occultation latitudes in 2004/5: ***sunrise/sunset.***
Green *ovals represent the Fall turn-arounds at Ft. Sumner (35N).*

Co-incidence Criteria

The ACE observations that are closest in **TIME** to the MkIV balloon profiles at 34N are at 80N or 50S

The ACE observations that are closest in **LATITUDE** to the MkIV balloon profiles are 3-4 weeks earlier or 2-3 weeks later

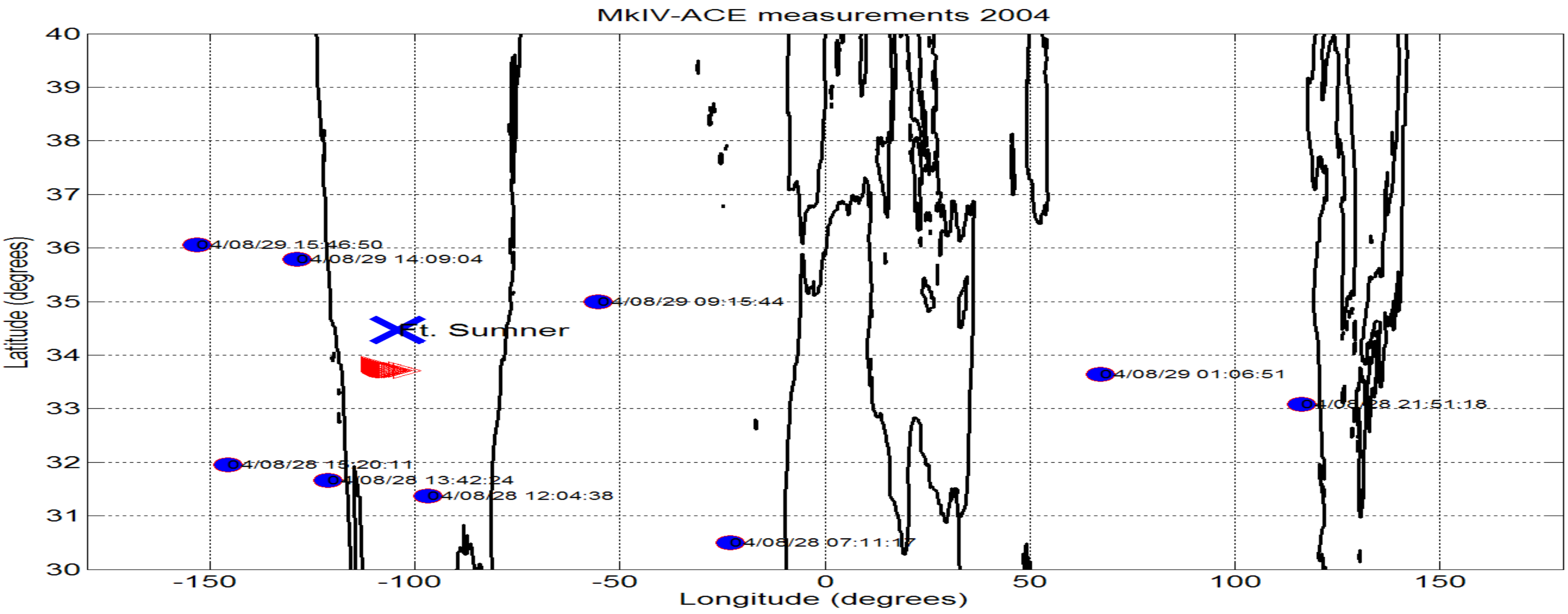
So the MkIV Ft Sumner balloon data fail any sort of spatial or temporal co-incidence criterion applied to the comparisons (e.g. De Maziere used ±24 hours & ±500 km)

Consequently, MkIV balloon data have so far not been used much for ACE validation, only for gases (e.g. CH_3Cl, HCOOH) for which there is no other choice.

Looked at Gloria Manney's DMP to see if these could help

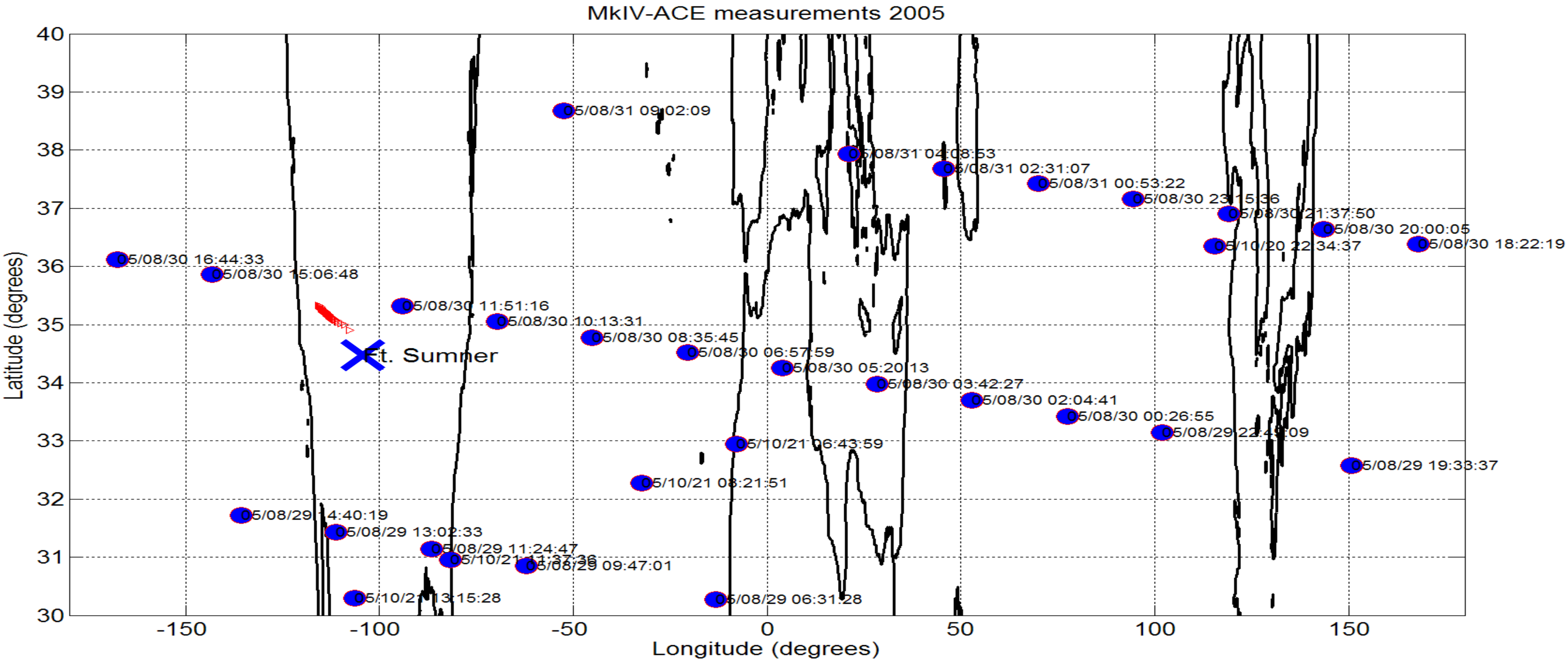
Selected ACE Occultations 2004

30<Latitude < 39 ; -180<Longitude<180 ; mid-August to Late October; 10-40 km

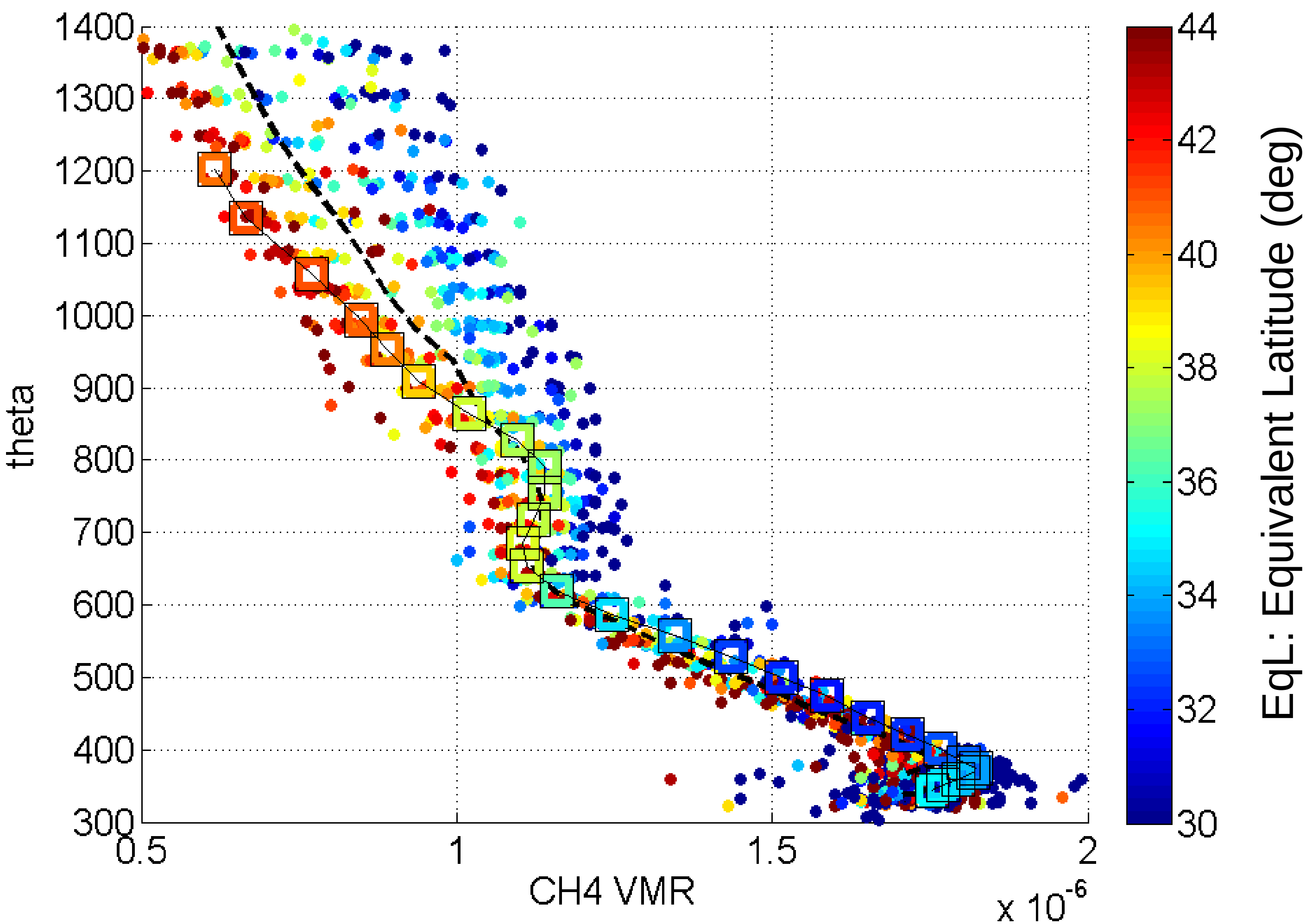


Selected ACE Occultations 2005

30<Latitude < 39 ; -180<Longitude<180 ; mid-August to Late October; 10-40 km



MkIV / ACE CH_4 comparison



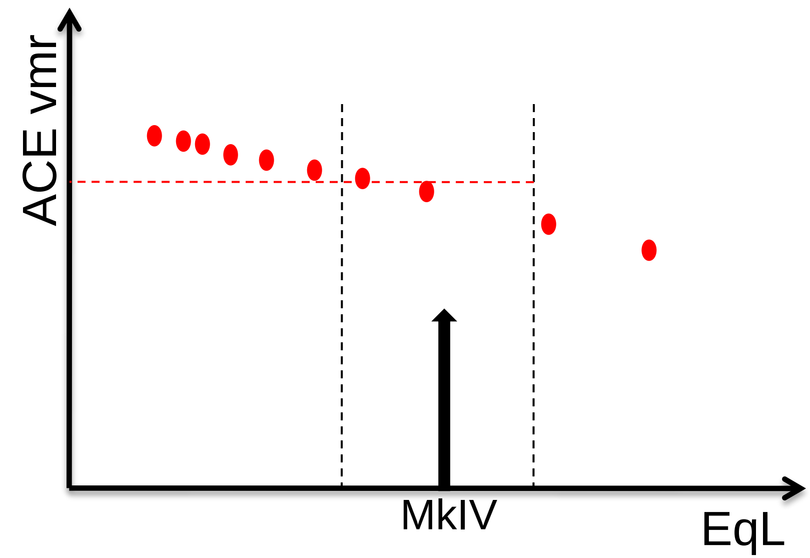
MkIV measurements (squares) agree well with ACE measurement of same EqL (color), but not with ACE ensemble-mean (black dashed line).

How to make best use of the EqL - ϴ information in the DMP

Clearly the EqL of the MkIV and ACE observations must somehow be taken into account in the intercomparison. But how best to do this?

Simplest approach would be to bin the ACE measurements according to the EQL of the MkIV measurement . Then average the ACE data in the bin.

But how wide should each bin be?
•If the bins are narrow, they won't capture much ACE data (sparse)
•If the bins are wide, their mean EqL value won't necessarily match MkIV's

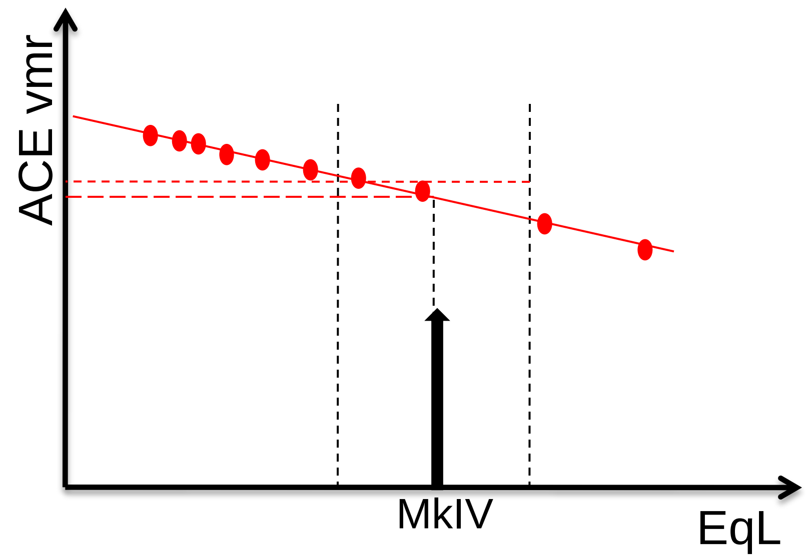


Even in the absence of measurement noise, any asymmetry of the ACE data as a function of EqL will result in biased estimate of the ACE vmr at the MkIV EqL

How to make best use of the EqL/Ө information in the DMP

A better approach is to fit a function to the ACE vmrs. An ACE vmr value can then be evaluated at the exact (EqL,Ө) co-ordinate of the MkIV observation, without risk of bias due to asymmetry of the distribution of ACE observations in EqL space.

This also has the advantage that the inferred ACE vmr is insensitive to the chosen bin limits.



Fit a 2-D function to the ACE VMRs

ACE vmrs are represented by the first-order Taylor expansion

$$Y(\theta_i, EqL_i) = Y_O + \alpha.(\theta_i-\theta_m) + \beta.(EqL_i-EqL_m)$$

in the immediate vicinity of a MkIV observation at $(\theta_m$, $EqL_m)$.

Three unknowns, Y_0, α, and β were then obtained by minimizing :

$$\sum w_i\, [(Y_i(\theta_i, EqL_i) - Y_O - \alpha.(\theta_i-\theta_m) - \beta.(EqL_i-EqL_m) / \varepsilon_i]^2 / \sum w_i$$

where Y_i=VMR for the i'th ACE observation
ε_i=uncertainty in Y_i (the ACE-supplied error bar)
Y_0=interpolated ACE CH_4 VMR at the MkIV observation (θ_m , φ_m)
α, β = coefficients to be determined
w_i= weights given for each ACE observation

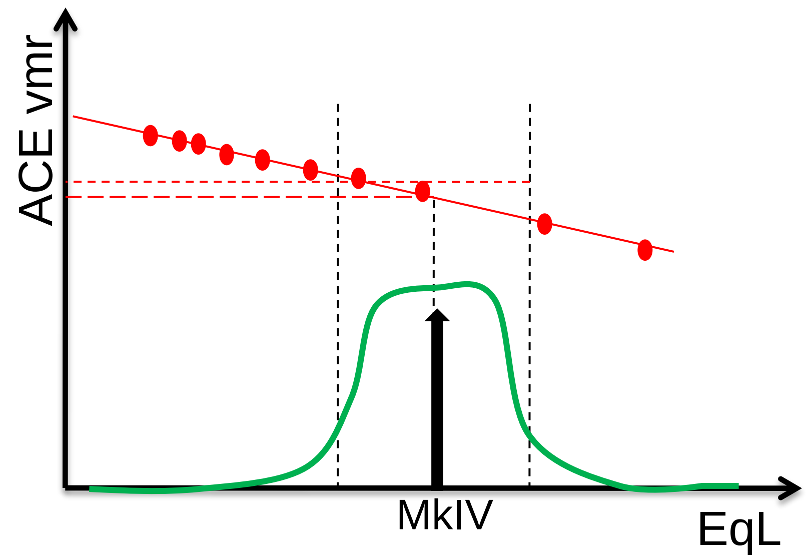
Weights

The weights depend on the proximity (in EqL/Θ-space) of a particular ACE measurement to the MkIV observation. The closer, the higher the weight,

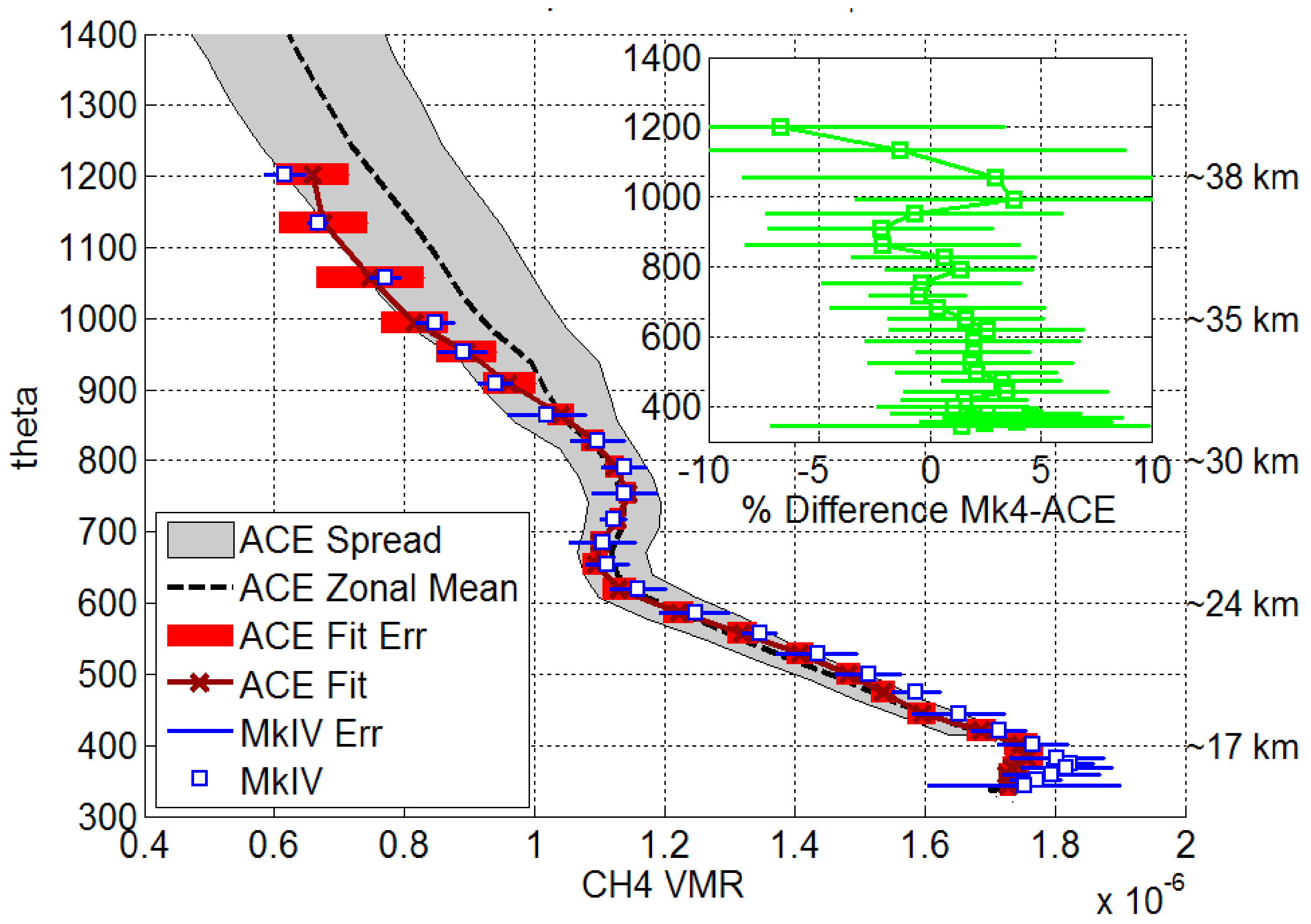
Binning essentially gives ACE points a weight of 0 or 1.

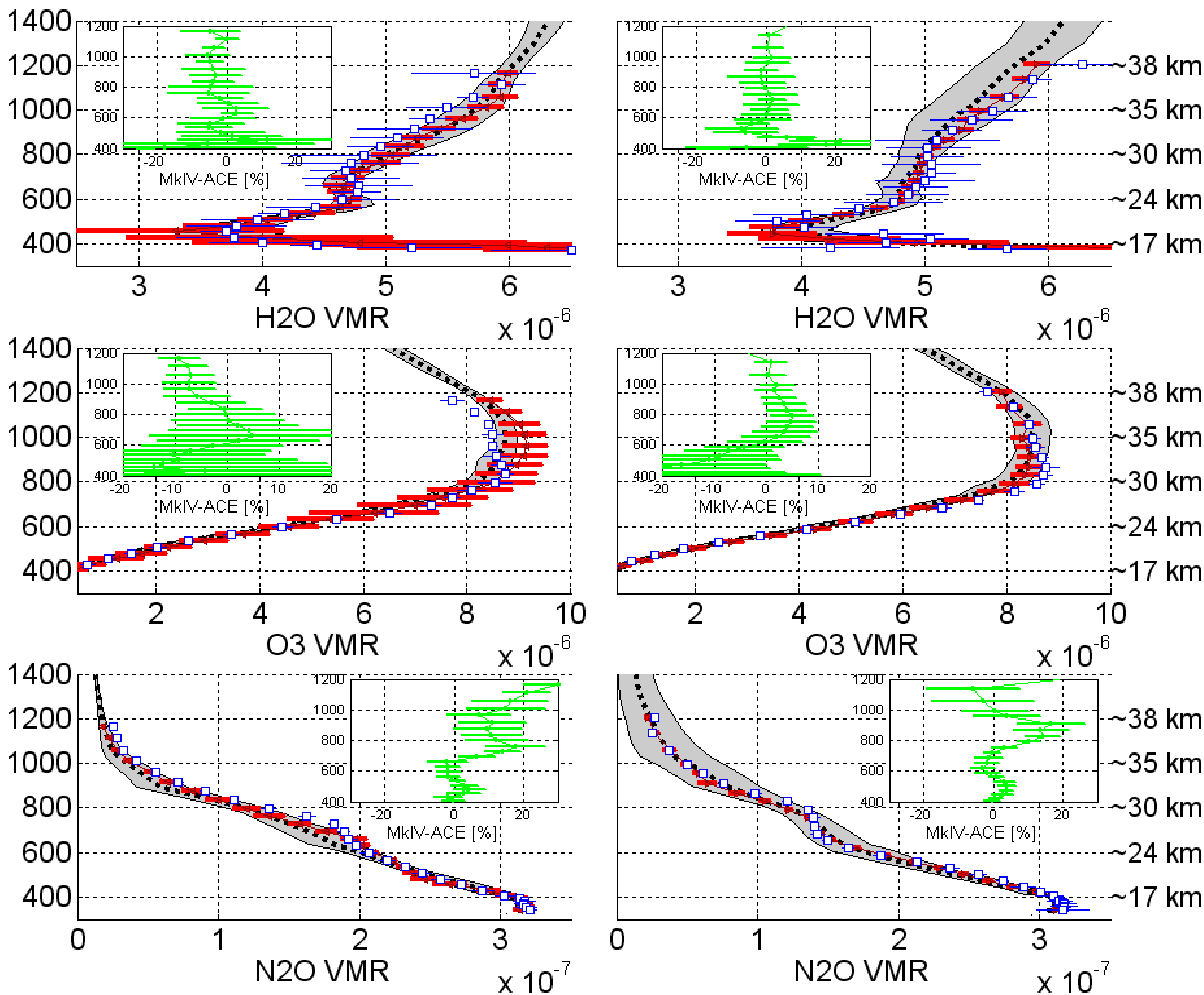
Our approach uses a continuous weighting function

$$w_i = 1 / [\ 1 + \ (EqL_i - EqL_M)/\Delta EqL)^4 + ((\Theta_i - \Theta_M)/\Delta\Theta)^4\ ]$$

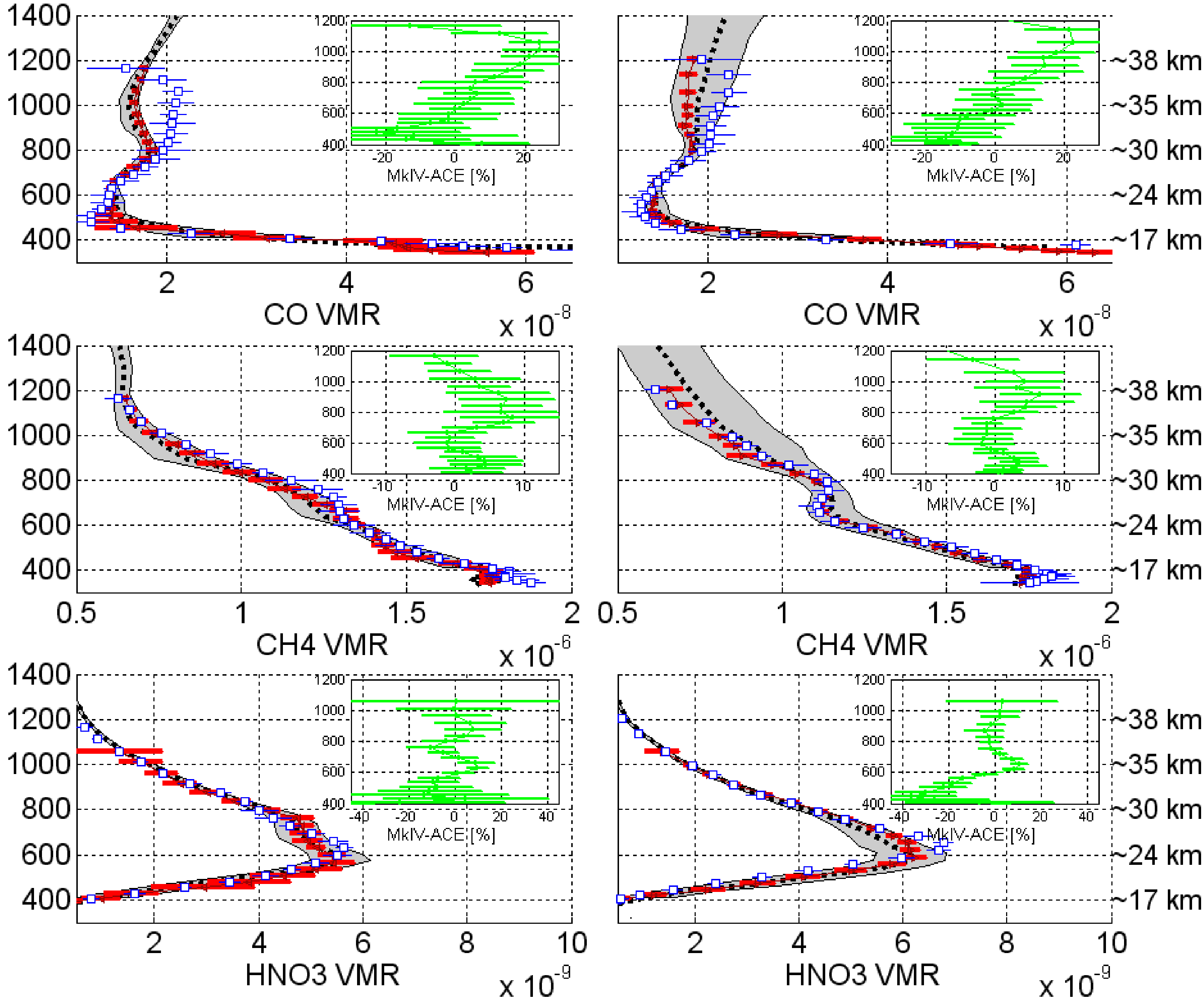


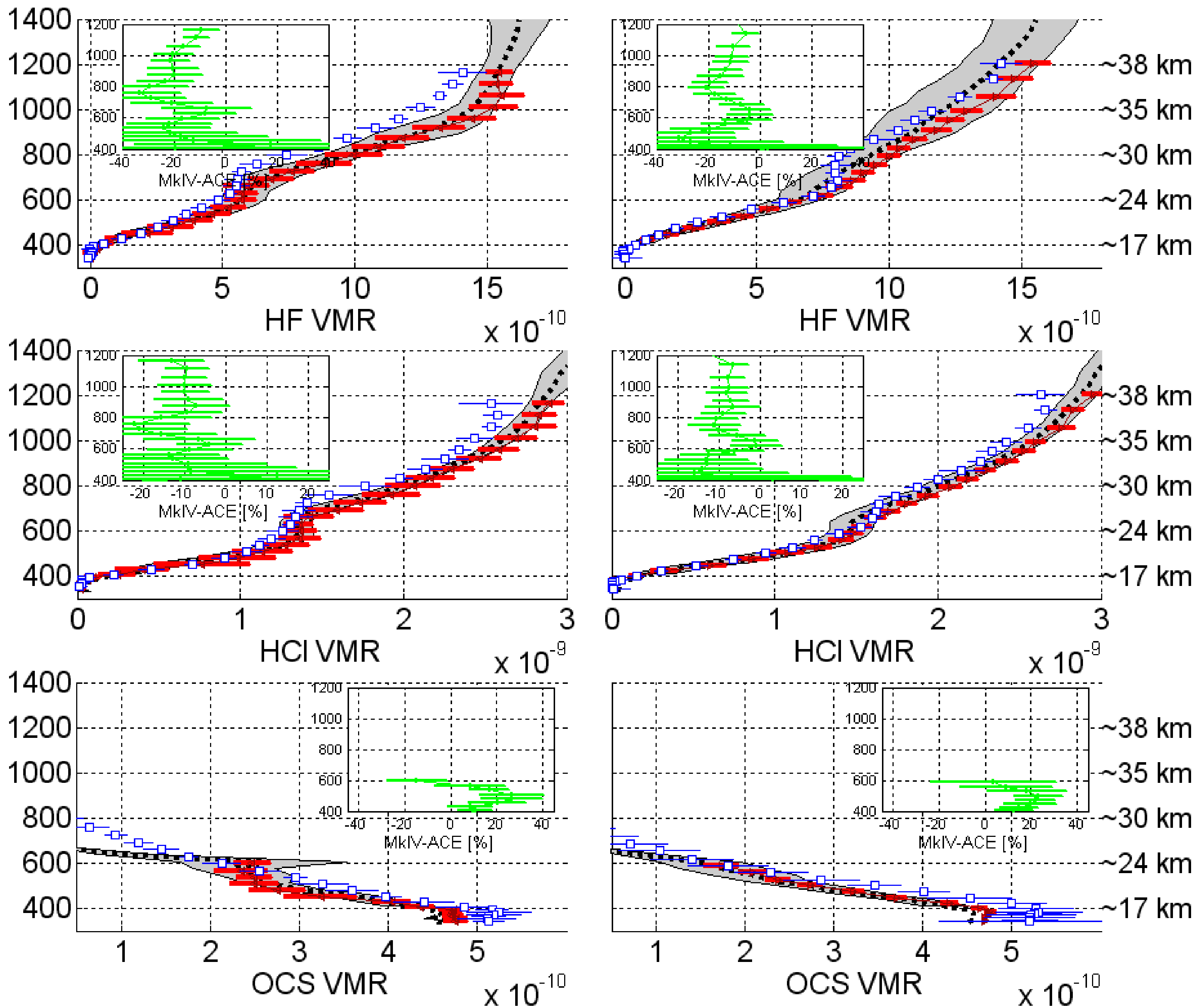
MkIV Comparison with 2-D interpolated ACE data





1400
1200
1000
800
600
400
3
4
5
6
H2O VMR
x 10^-6
MkIV-ACE [%]
~38 km
~35 km
~30 km
~24 km
~17 km
2
4
6
8
10
O3 VMR
N2O VMR
x 10^-7
0
1
2
3


1400
1200
1000
800
600
400
1200
1000
800
600
400
-20
0
20
MkIV-ACE [%]
2
4
6
CO VMR
x 10^-8
~38 km
~35 km
~30 km
~24 km
~17 km
0.5
1
1.5
2
CH4 VMR
x 10^-6
-10
0
10
MkIV-ACE [%]
HNO3 VMR
x 10^-9
-40
-20
0
20
40
MkIV-ACE [%]
2
4
6
8
10



HF VMR
x 10^-10
HCl VMR
x 10^-9
OCS VMR
x 10^-10
MkIV-ACE [%]
~38 km
~35 km
~30 km
~24 km
~17 km

MkIV-ACE Validation Summary

Using DMP, it is possible to make meaningful MkIV-ACE comparisons, despite the large separation (~3 weeks and up to180^{O} in longitude) of the measurements.

ACE and MkIV represent two sparse datasets (esp. MkIV) – binning using DMP won't work very well (few samples per bin)

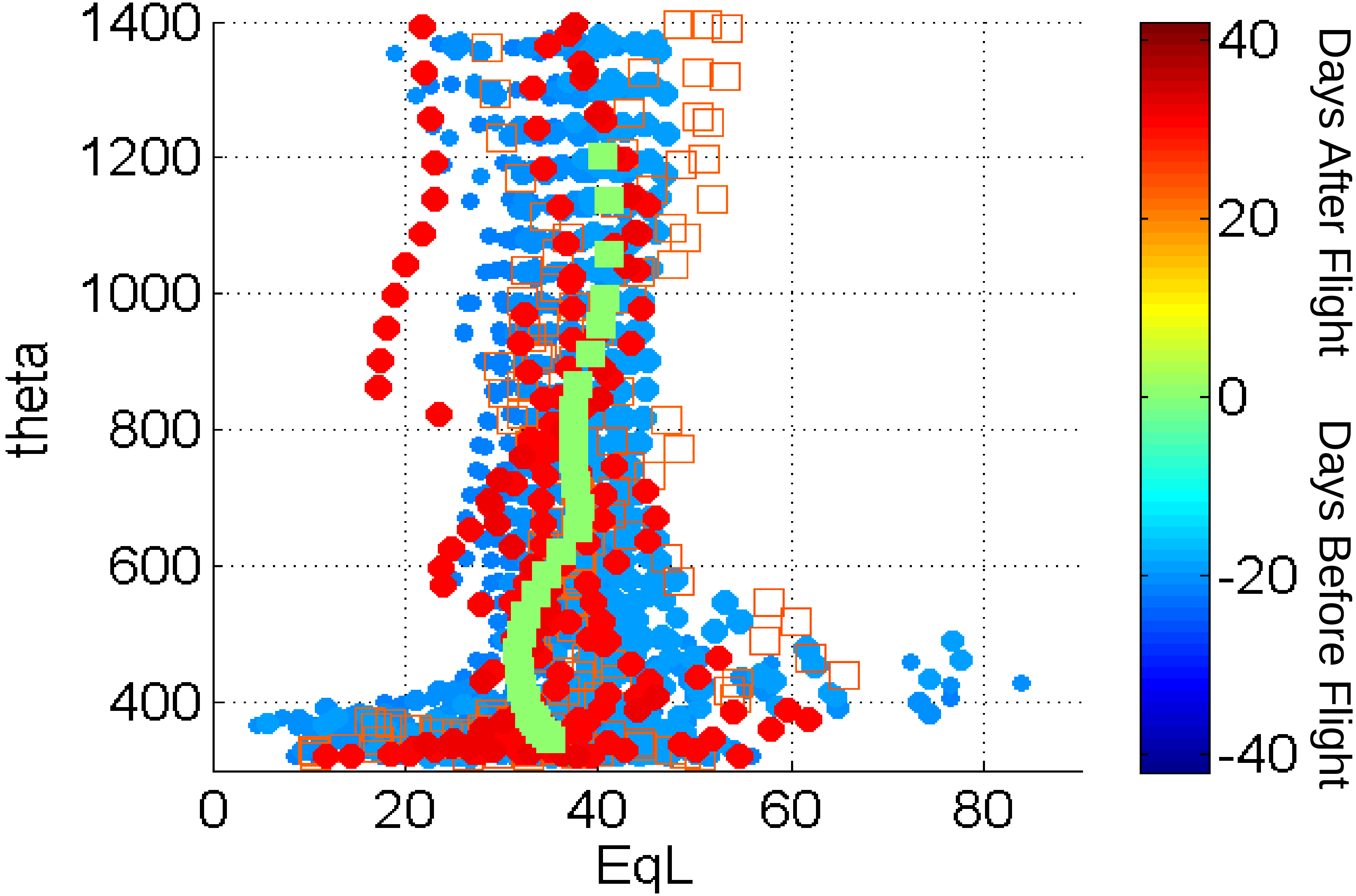
Therefore fitted 2-D surface to ACE data as a function of EqL-Ө

This approach seems to work best for long-lived gases (e.g., CH_4, N_2O).

The main problem seems to be an altitude mis-registration between MkIV and ACE

Shifting down the MkIV profiles (or shifting up ACE's) by ~1 km would improve agreement. This is currently not understood.

MkIV /ACE obs in EqL/Θ space



Although MkIV observations were physically 34-35 N, their EqL varies from 30-42N