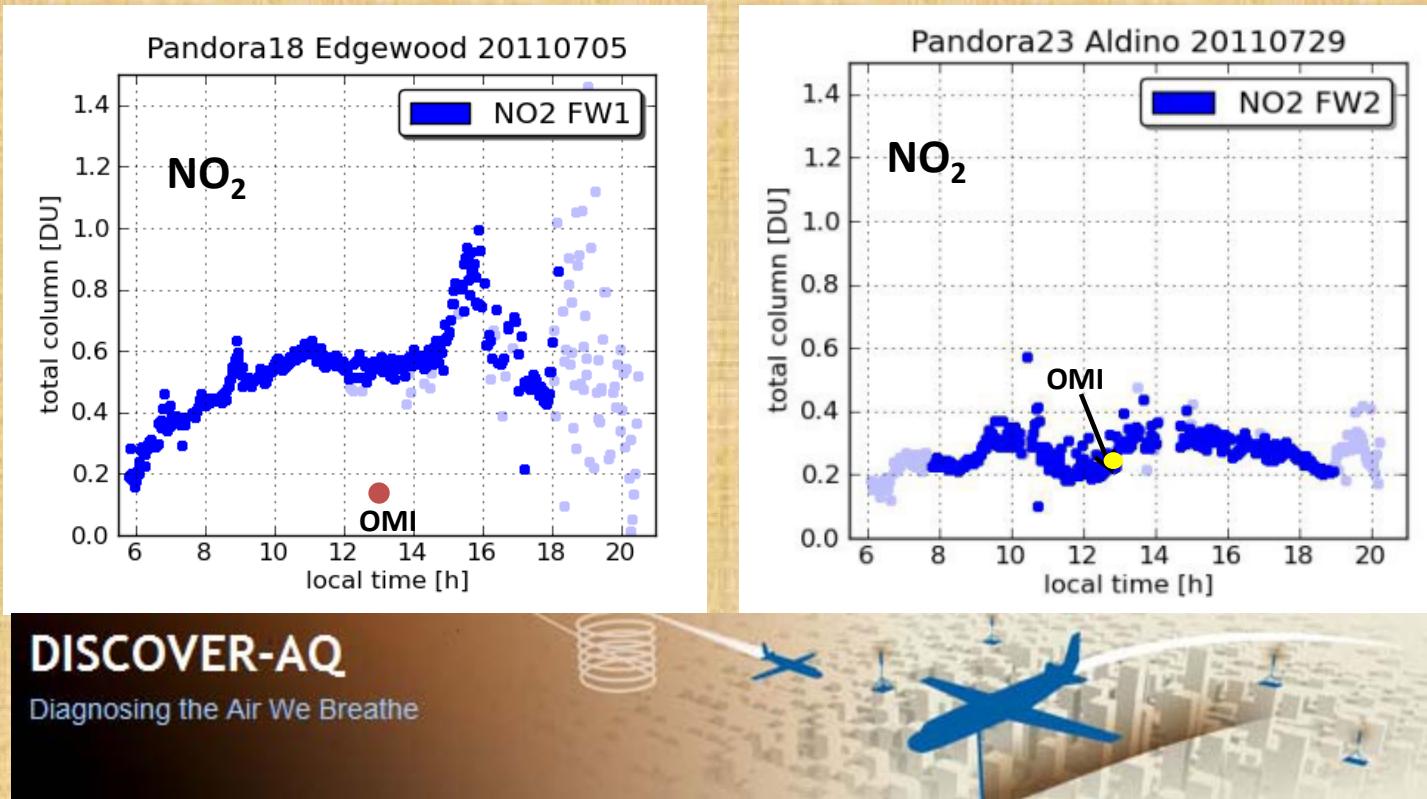


DISCOVER-AQ

Measuring NO₂ and O₃ from a Grid of Small PANDORA Spectrometer Systems



Jay Herman Alexander Cede Maria Tzortziou

Nader Abuhassan Christian Retscher

What is PANDORA?

Pandora is a small spectrometer system, which we have been developing since 2006. It consists of ...

a “miniature” spectrometer



and a head sensor on a sun tracker



Measures sun and sky radiance from 270 to 530 nm in 0.5 nm steps with a 1.6° field of view.

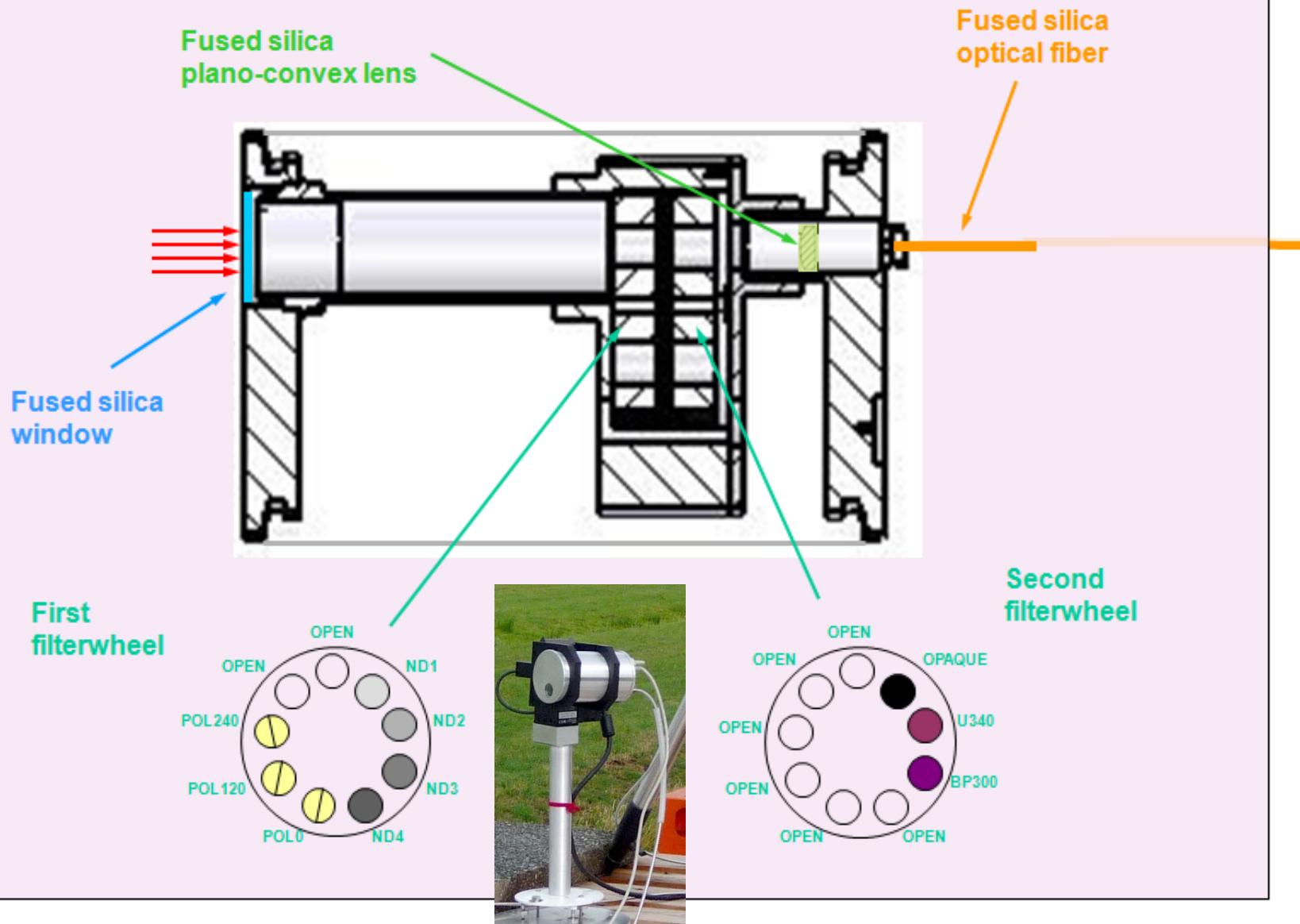
Products: NO₂, H₂O, O₃, SO₂, HCHO, and aerosol properties.

O₃: 3 DU accuracy and 1 DU precision

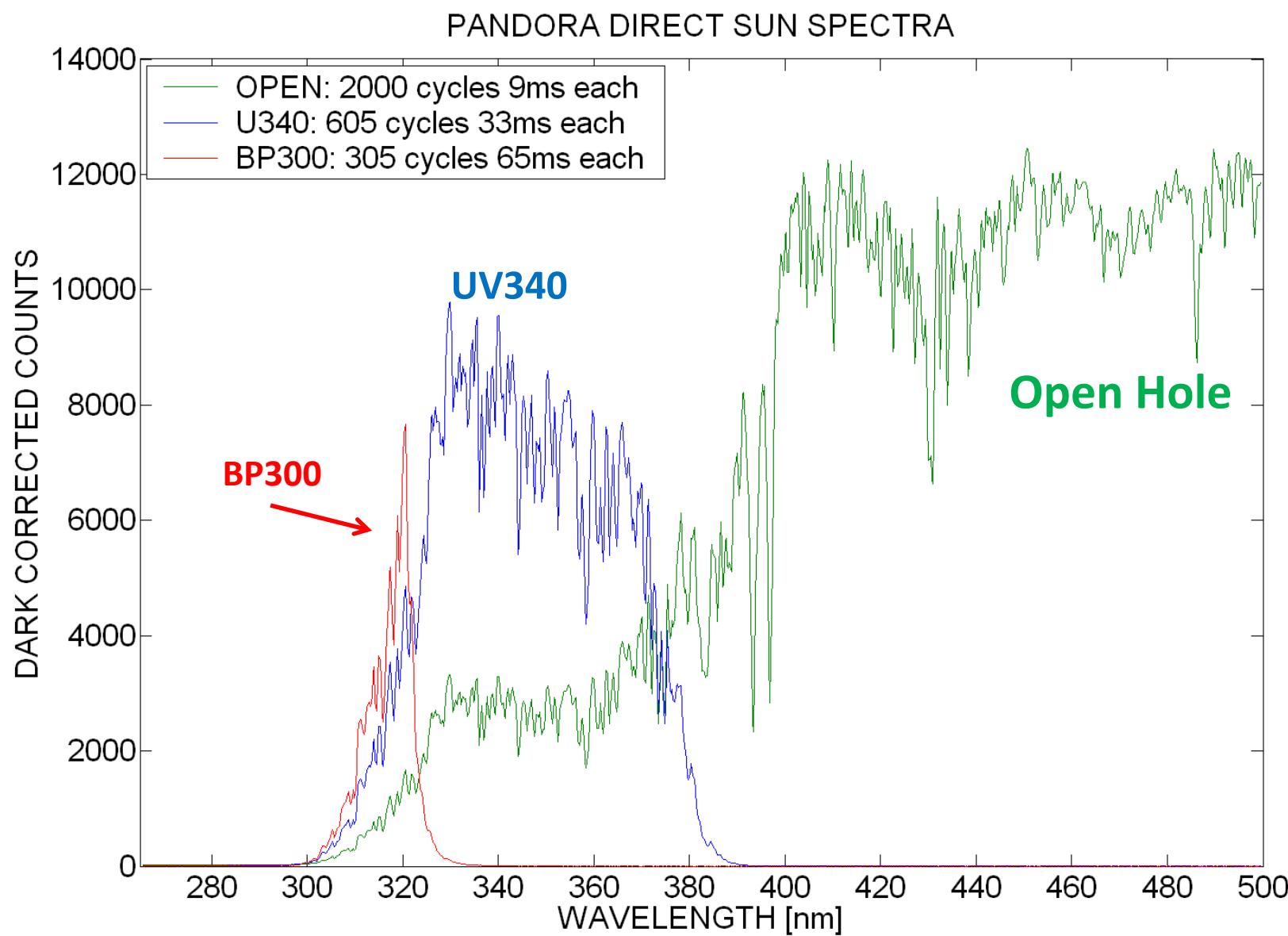
NO₂: 0.1 DU accuracy and 0.01 DU precision



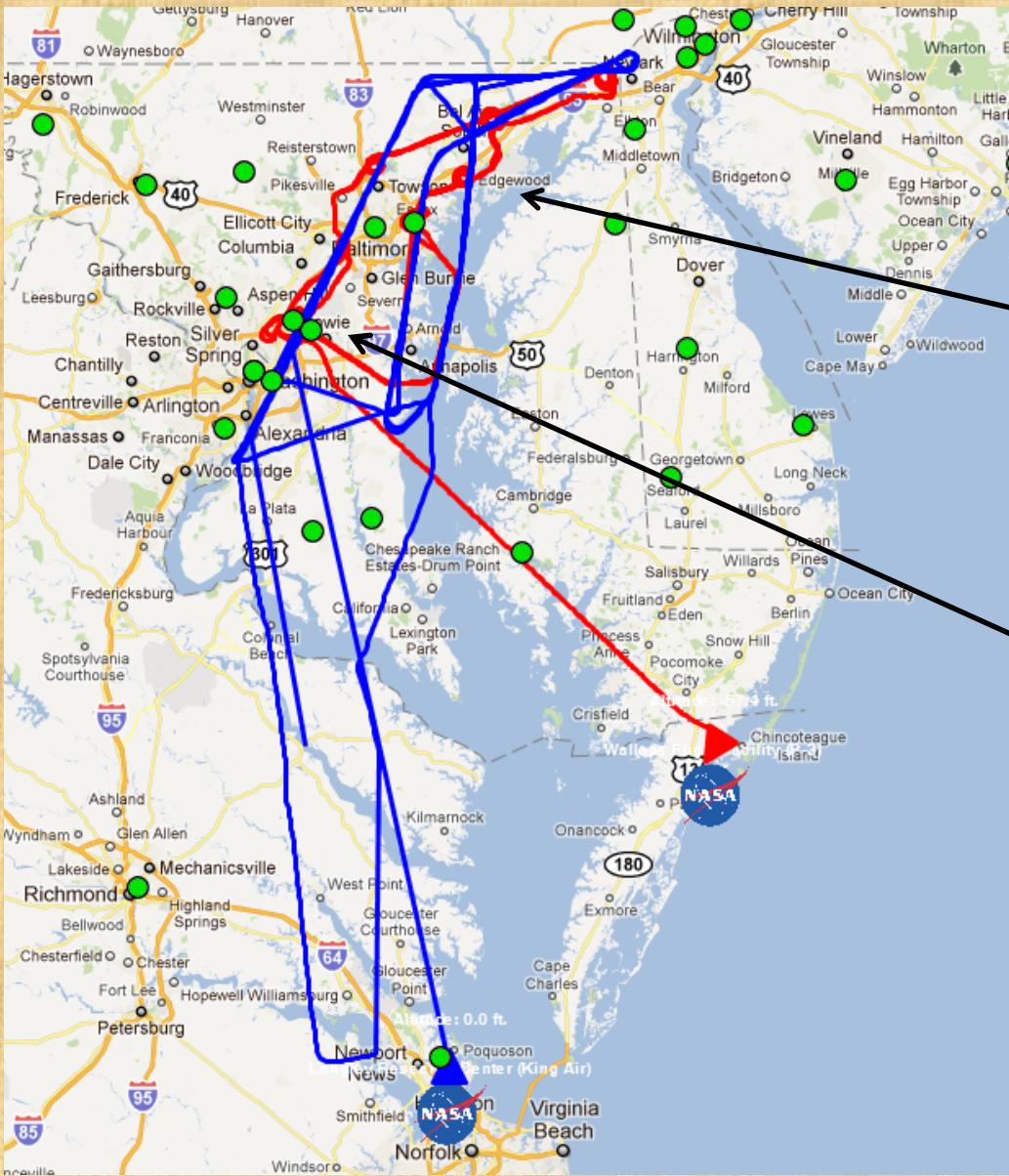
Pandora Head Sensor



What Does Pandora Measure



DISCOVER-AQ Sites and Aircraft Flight Tracks



PANDORA SITES

Oldtowne
Edgewood
Fairhill
Padonia
Essex
Aldino

UMCP
GSFC
UMBC
SERC
USNA
Beltsville

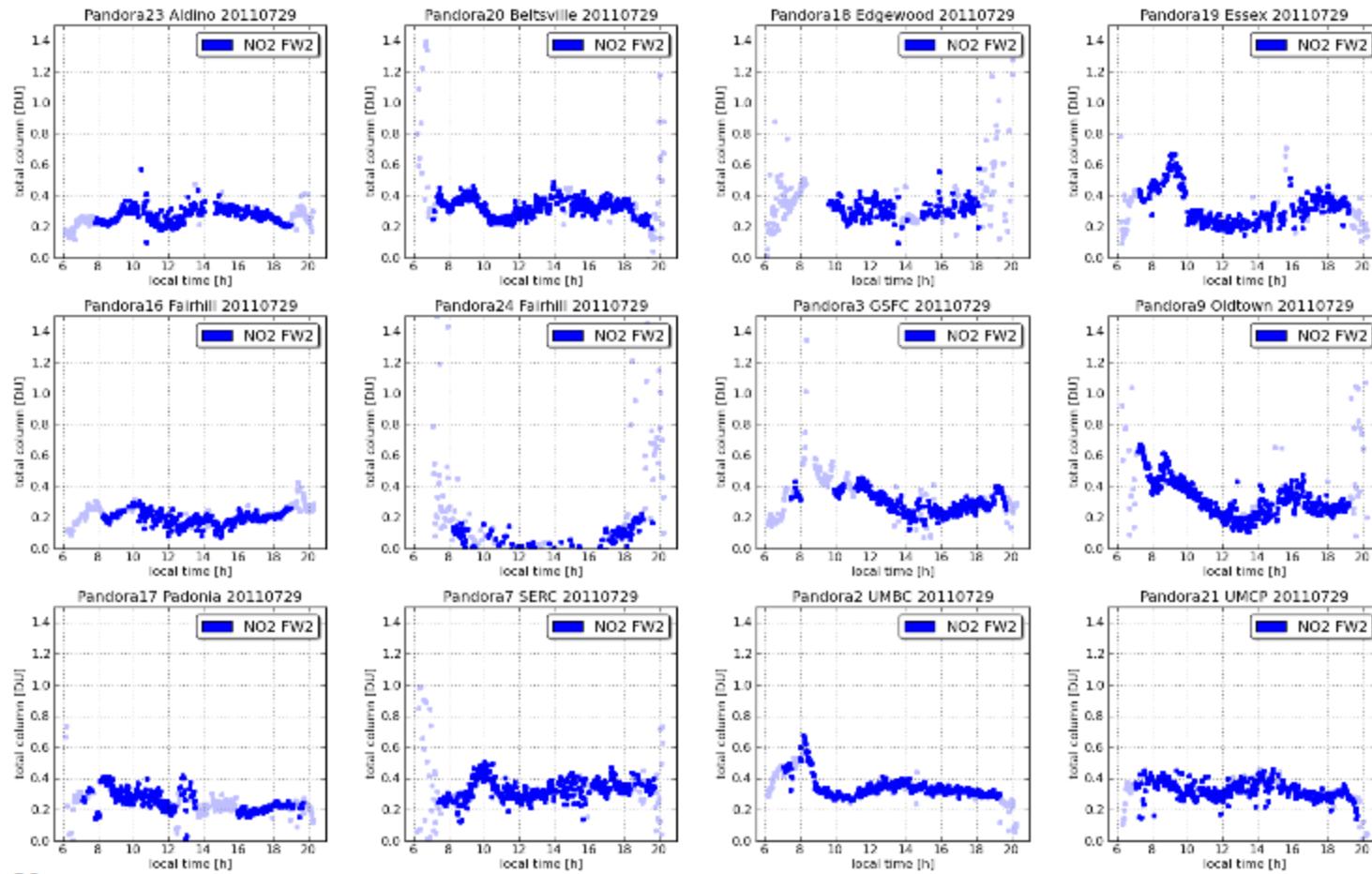
Chesapeake Bay

Diurnal Variation at 12 Pandora Sites - Friday 29 July 2011

NO₂

20110729

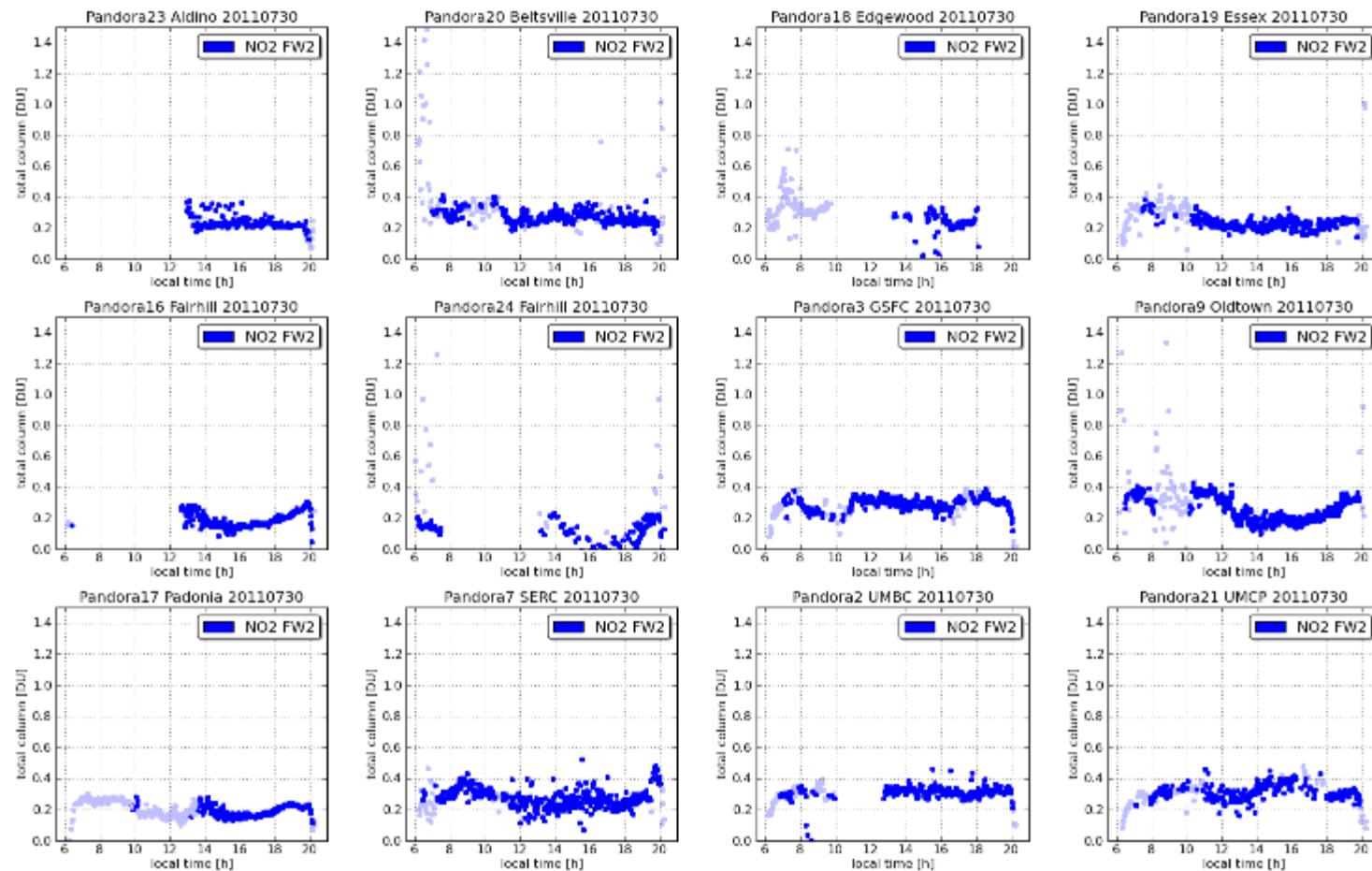
NO₂



Diurnal Variation at 12 Pandora Sites - Saturday 30 July 2011 NO_2

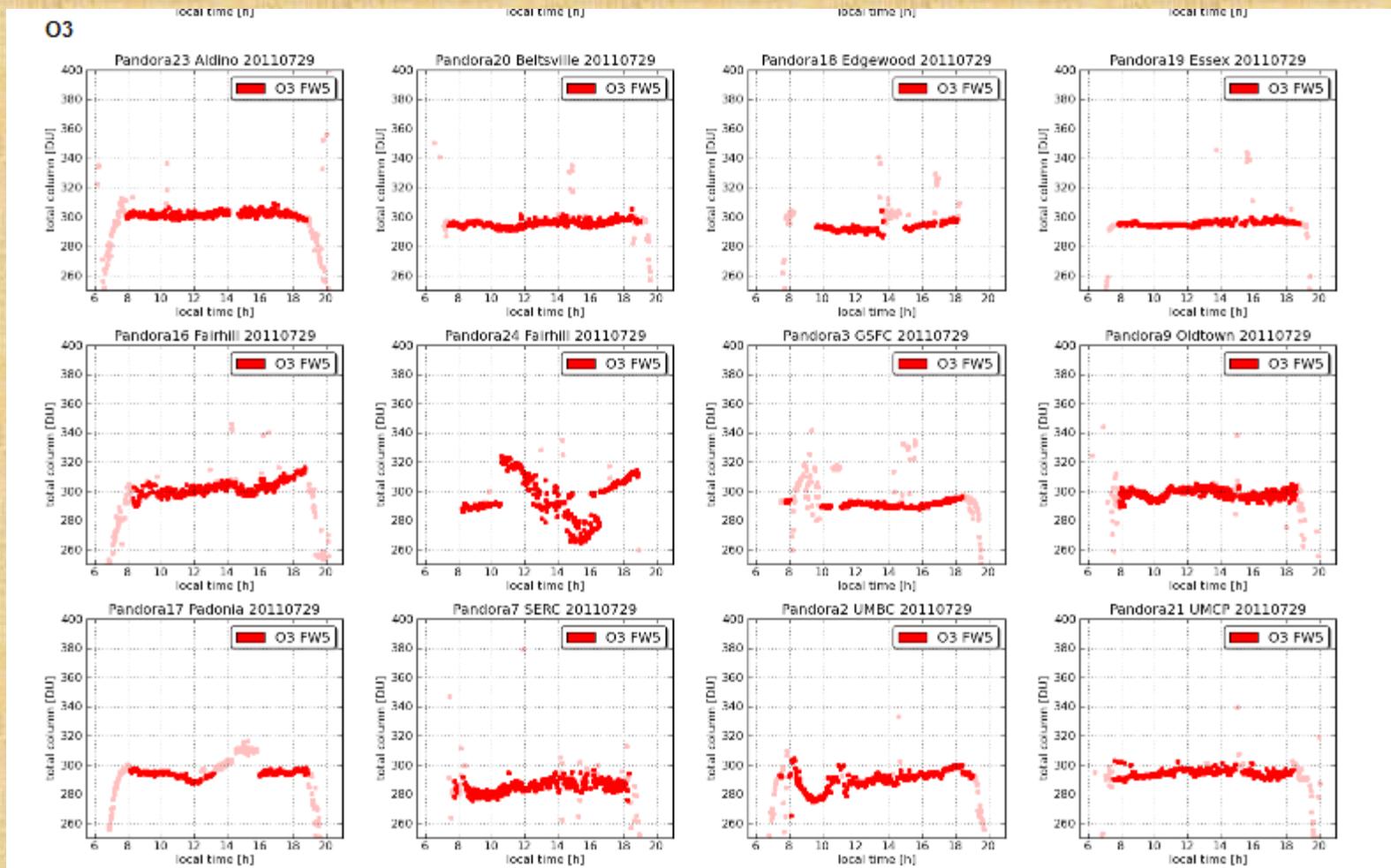
20110730

NO2



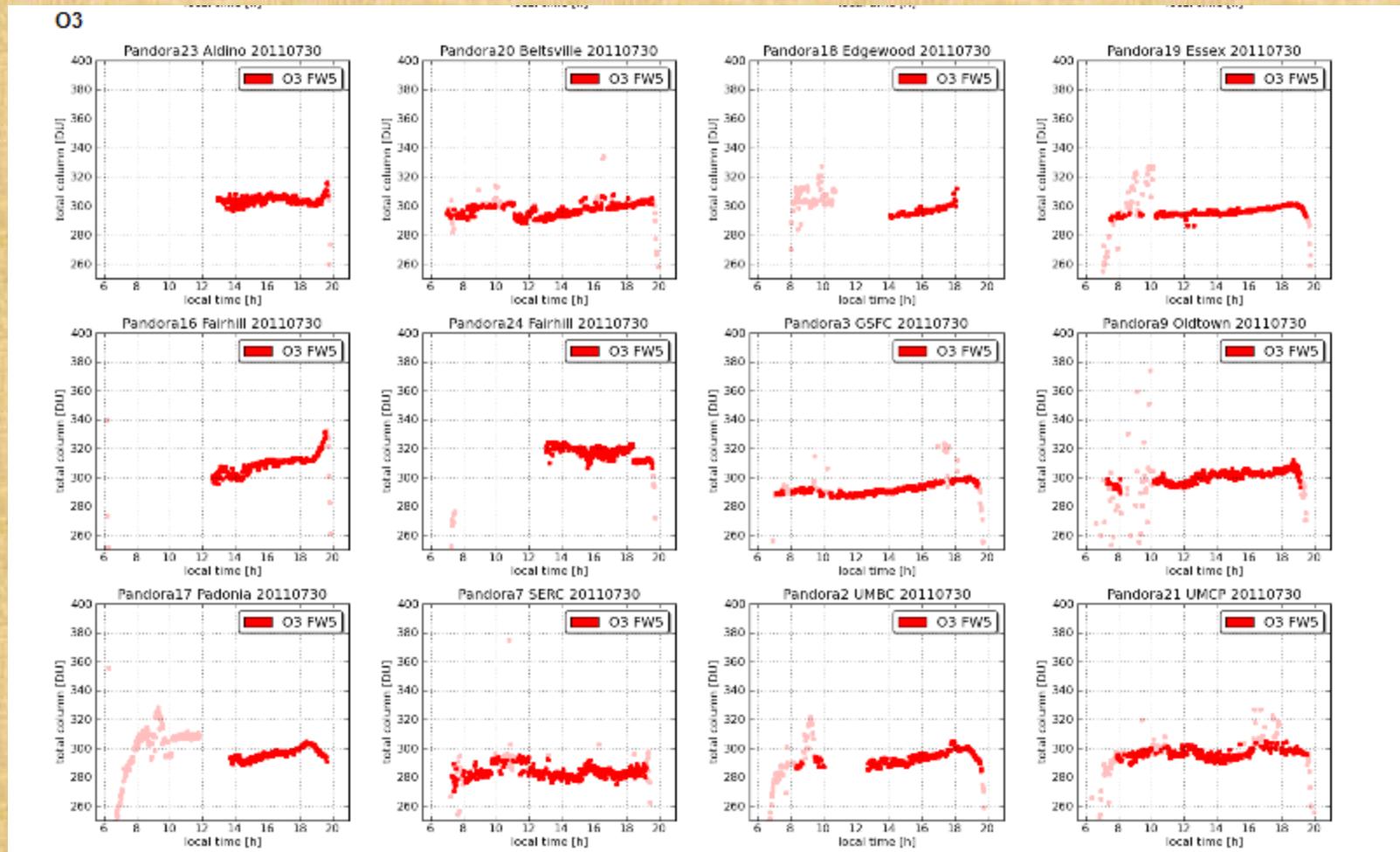
Diurnal Variation at 12 Pandora Sites - Friday 29 July 2011

O_3

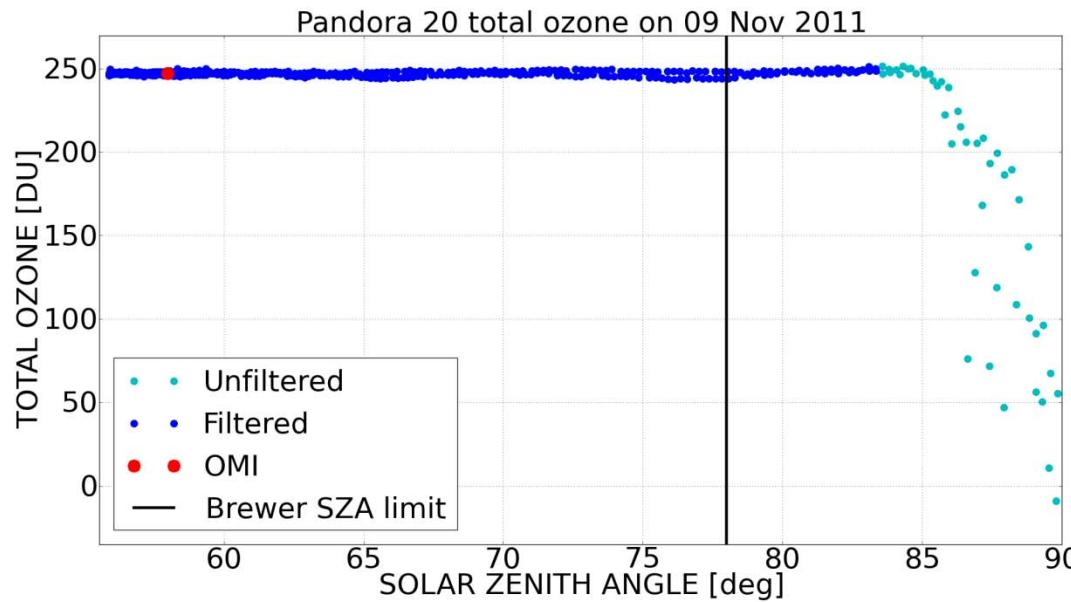
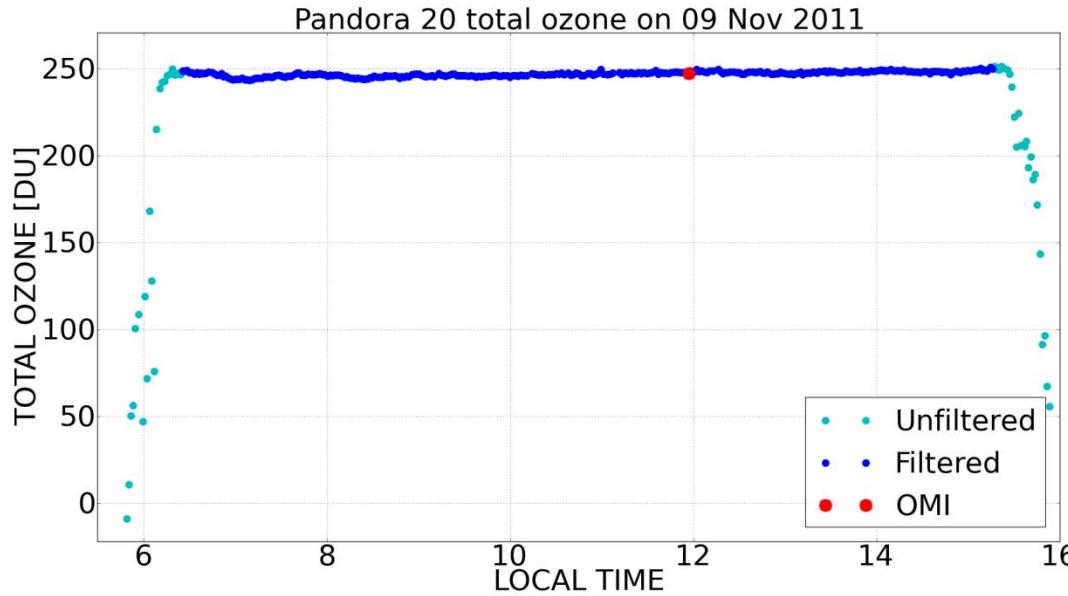


Diurnal Variation at 12 Pandora Sites - Saturday 30 July 2011

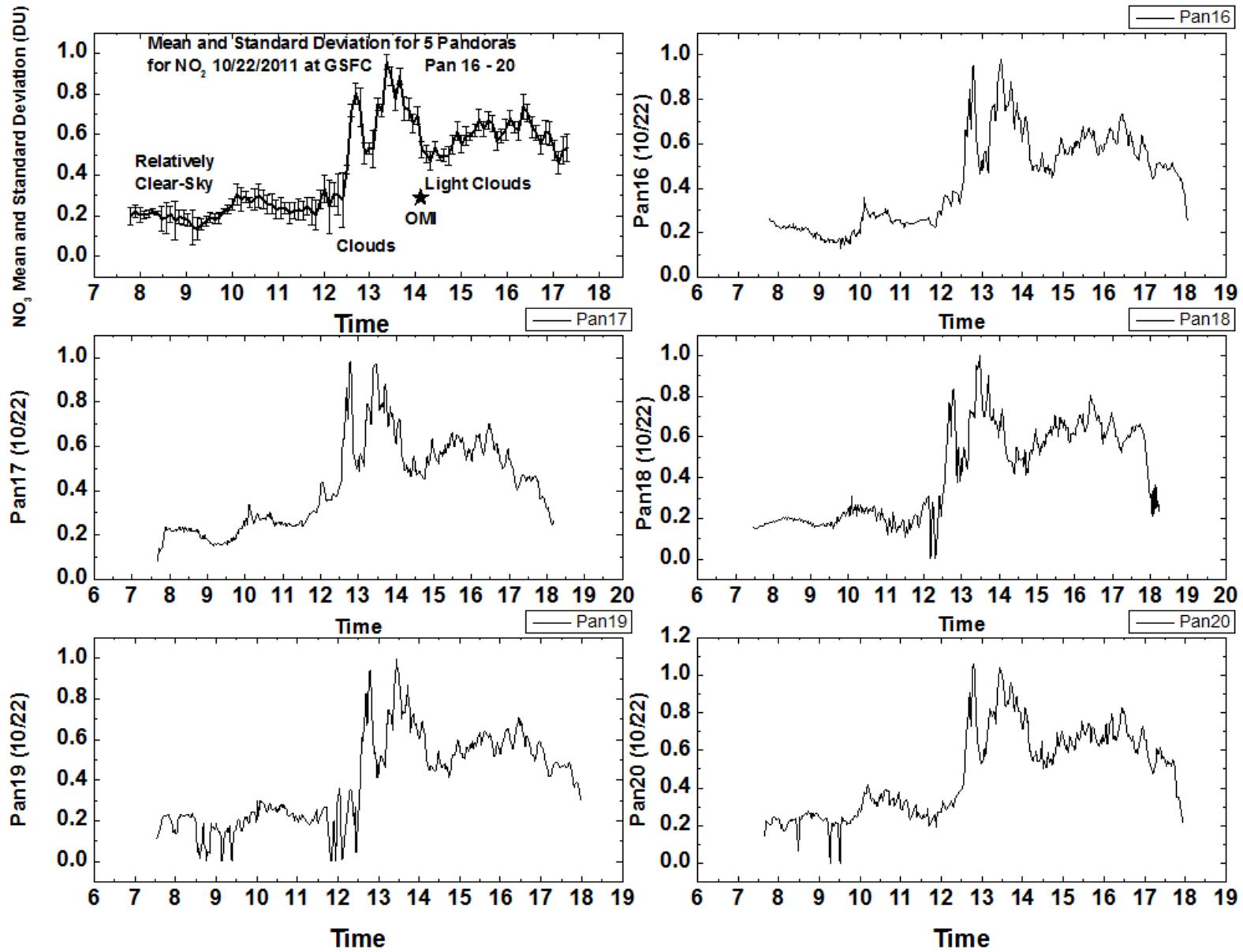
O₃



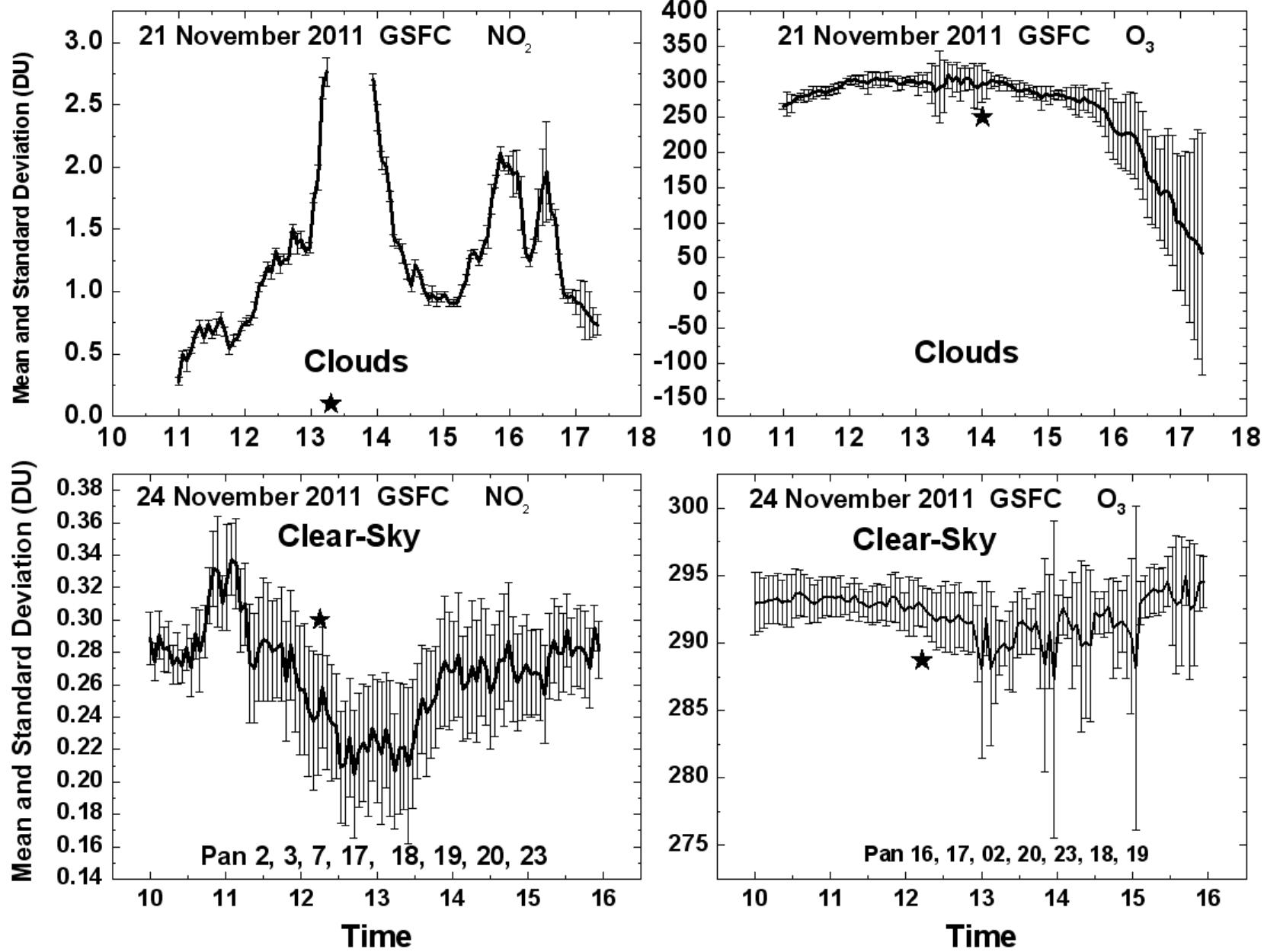
).



Comparison Between 5 Pandoras at GSFC (Lab and Independent Field Calibration)



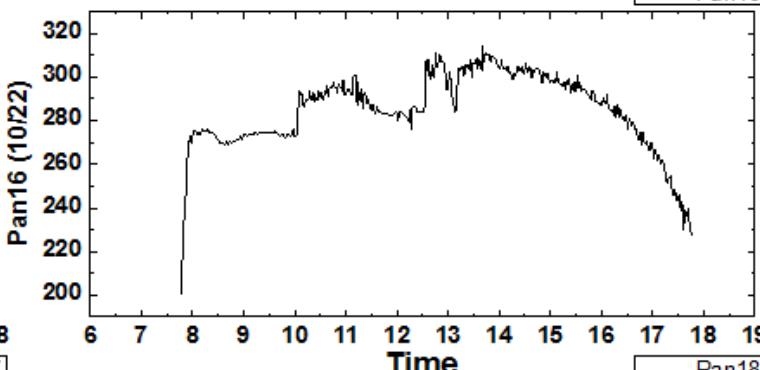
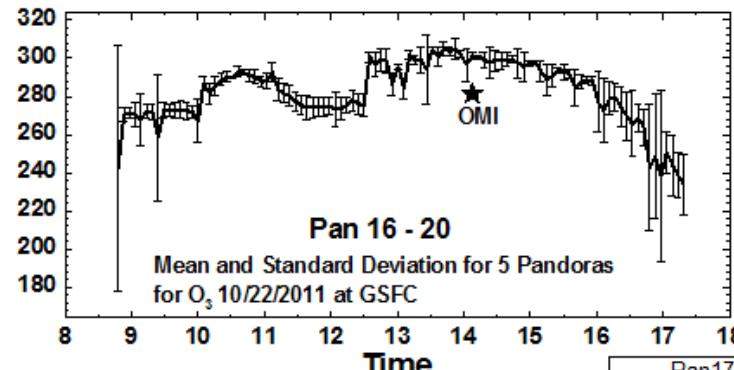
Mean and Standard Deviation (DU)
for 7 Pandoras at GSFC on Cloudy and Clear Days



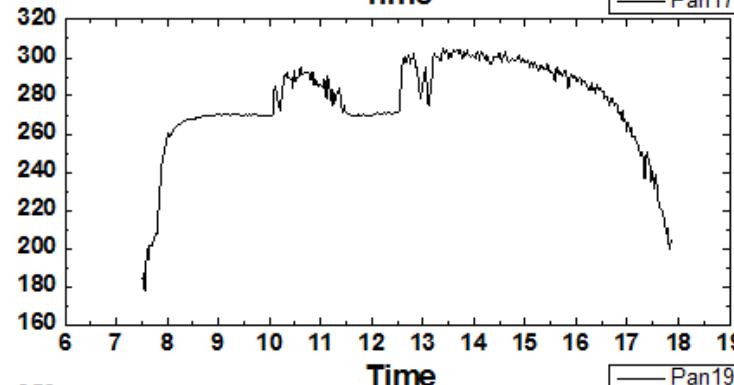
Comparison Between 5 Pandoras at GSFC (Lab Calibration)

O₃

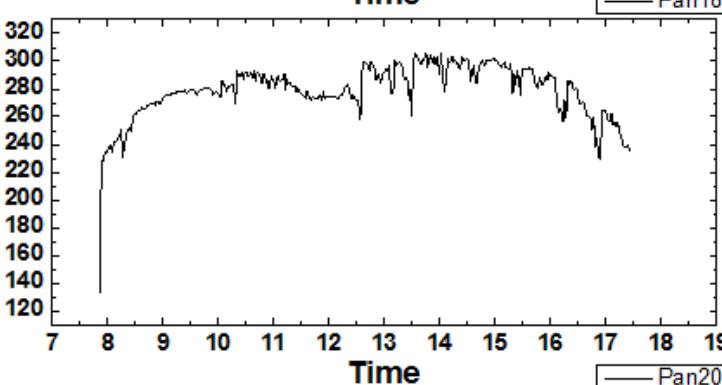
O₃ Mean and Standard Deviation (DU)



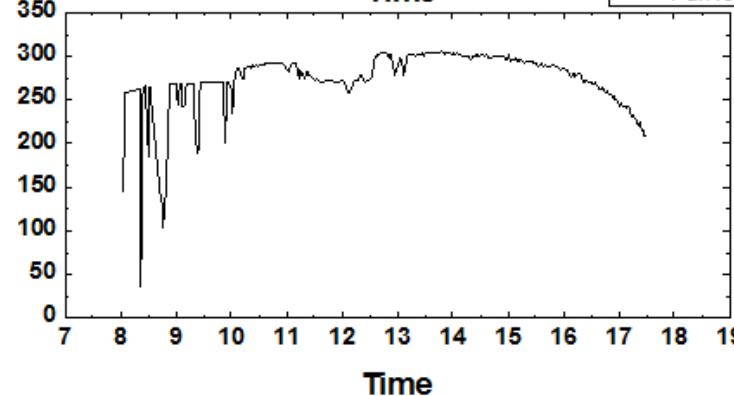
Pan17 (10/22)



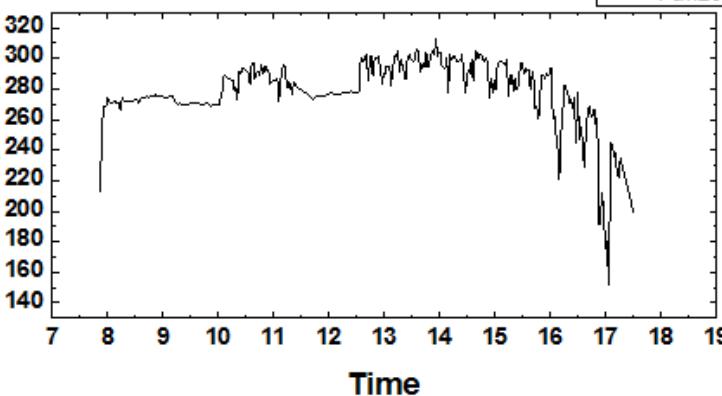
Pan18 (10/22)



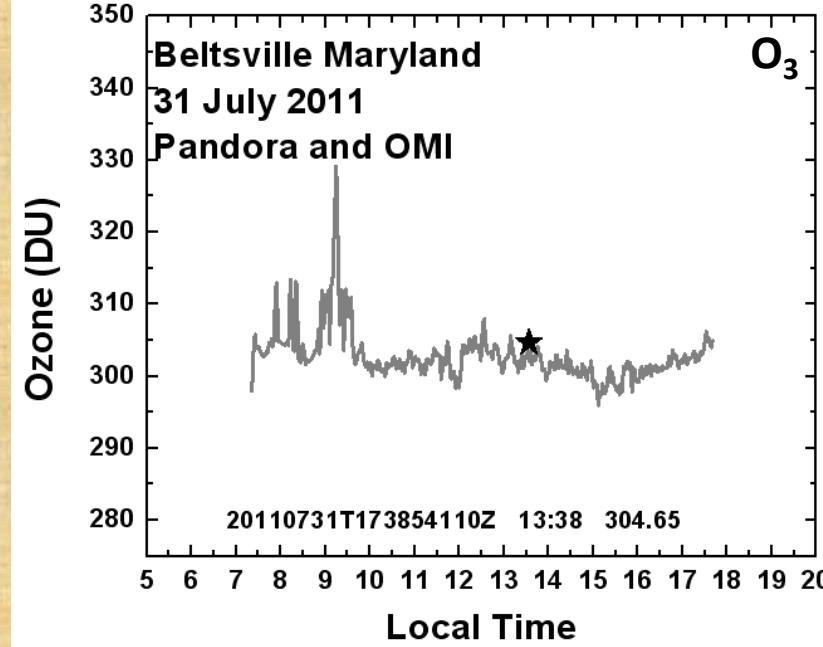
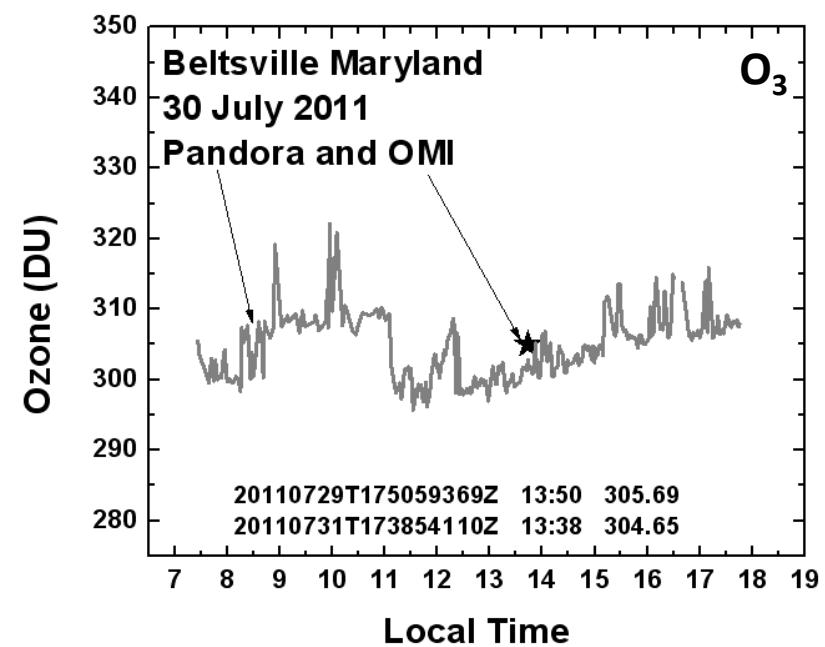
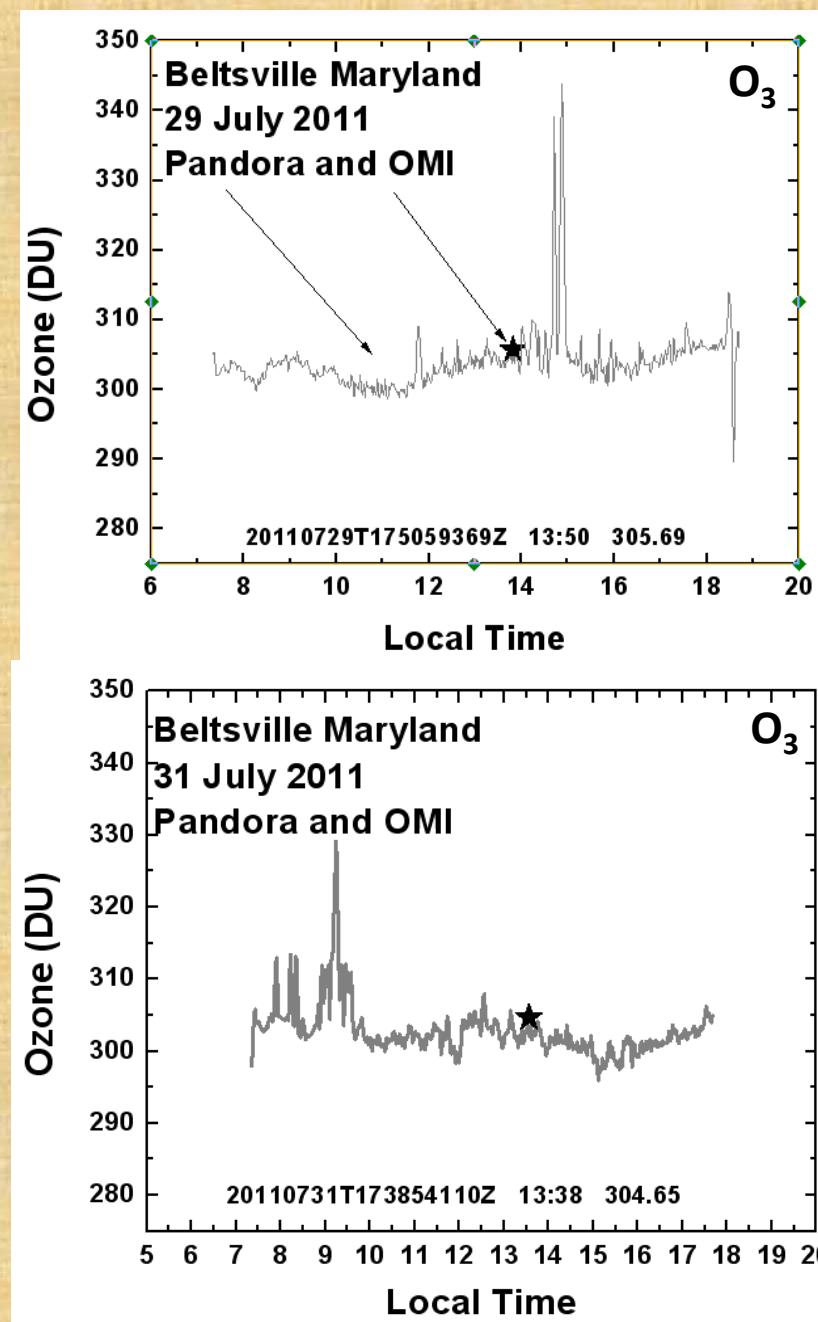
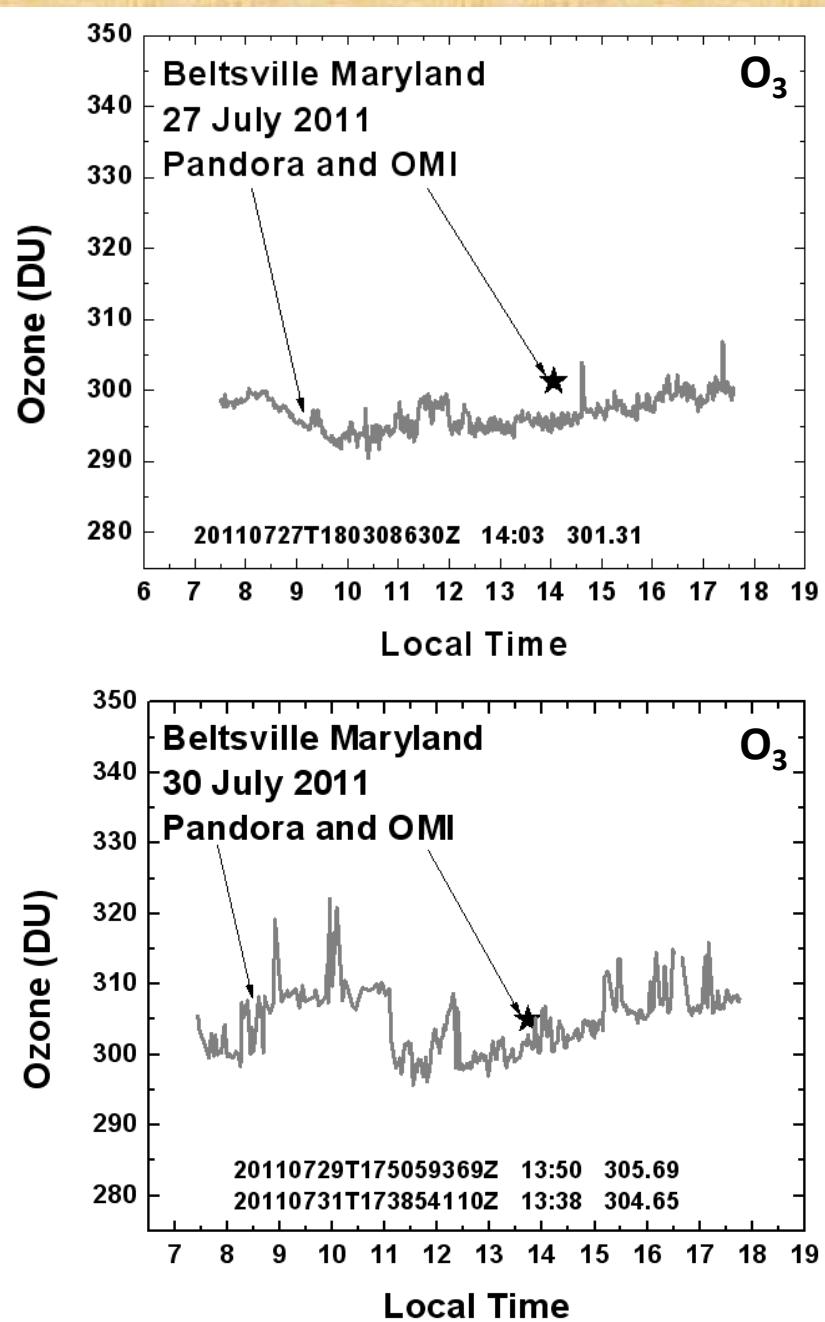
Pan19 (10/22)



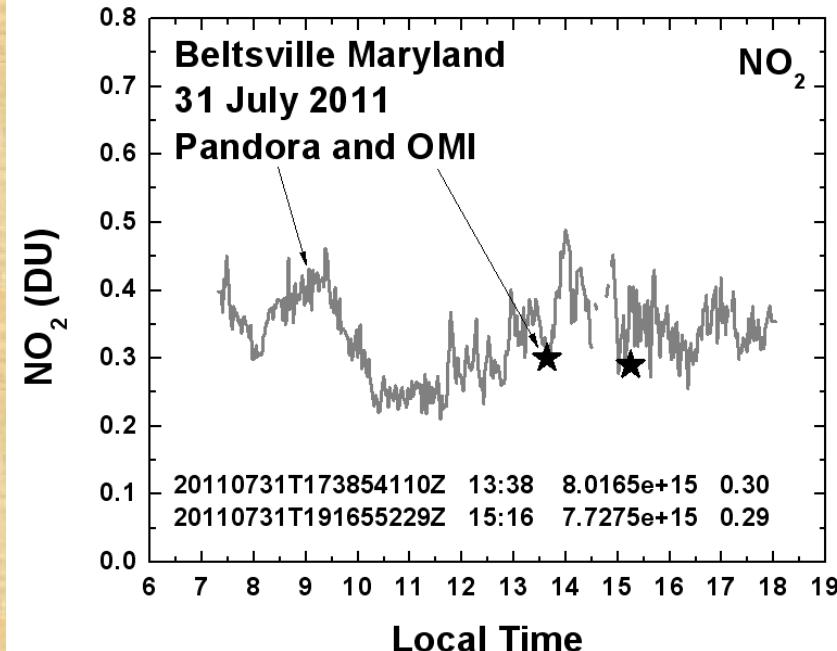
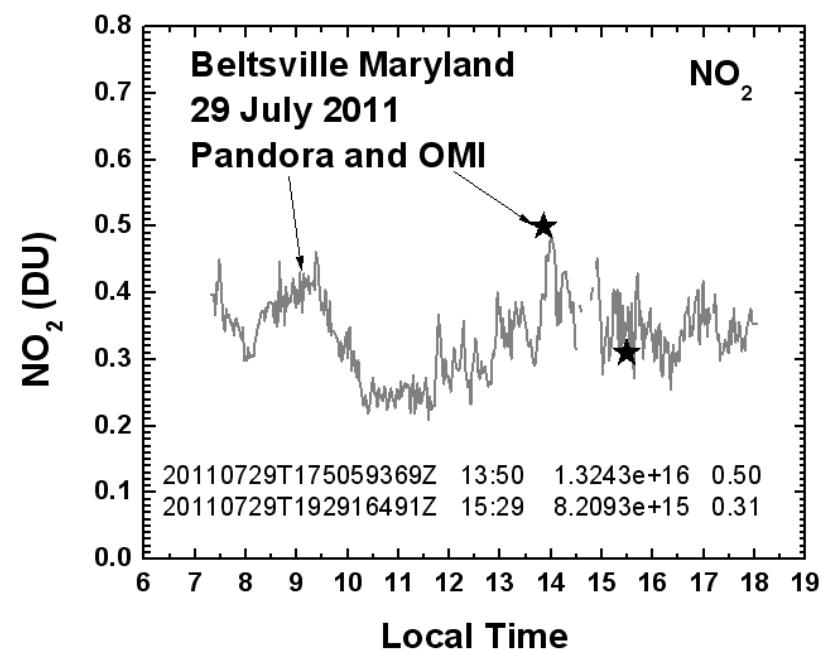
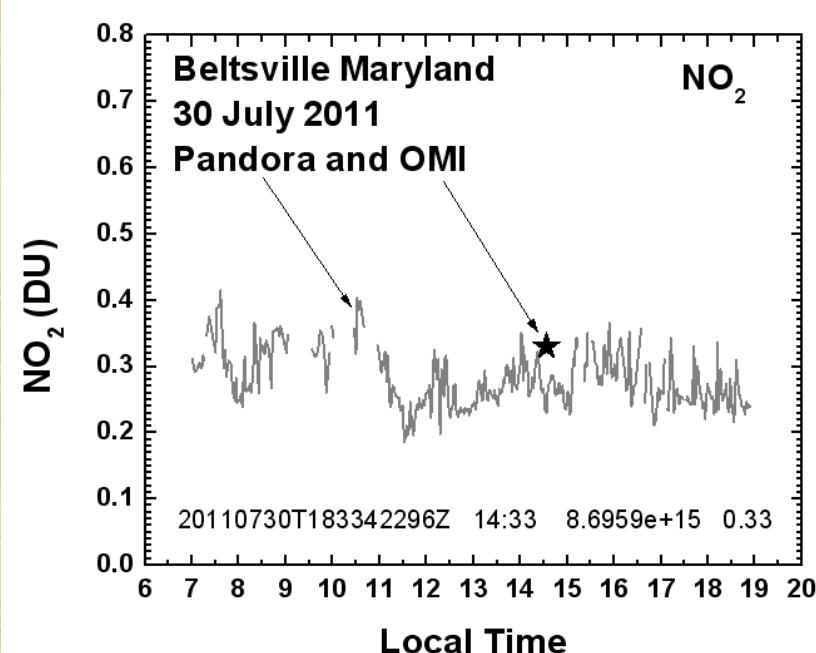
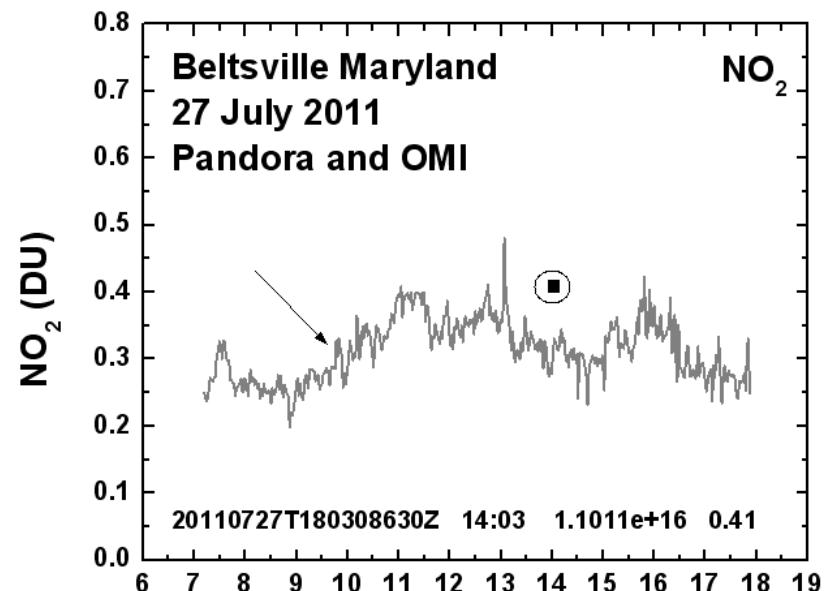
Pan20 (10/22)



O_3 Comparison between Pandora and OMI

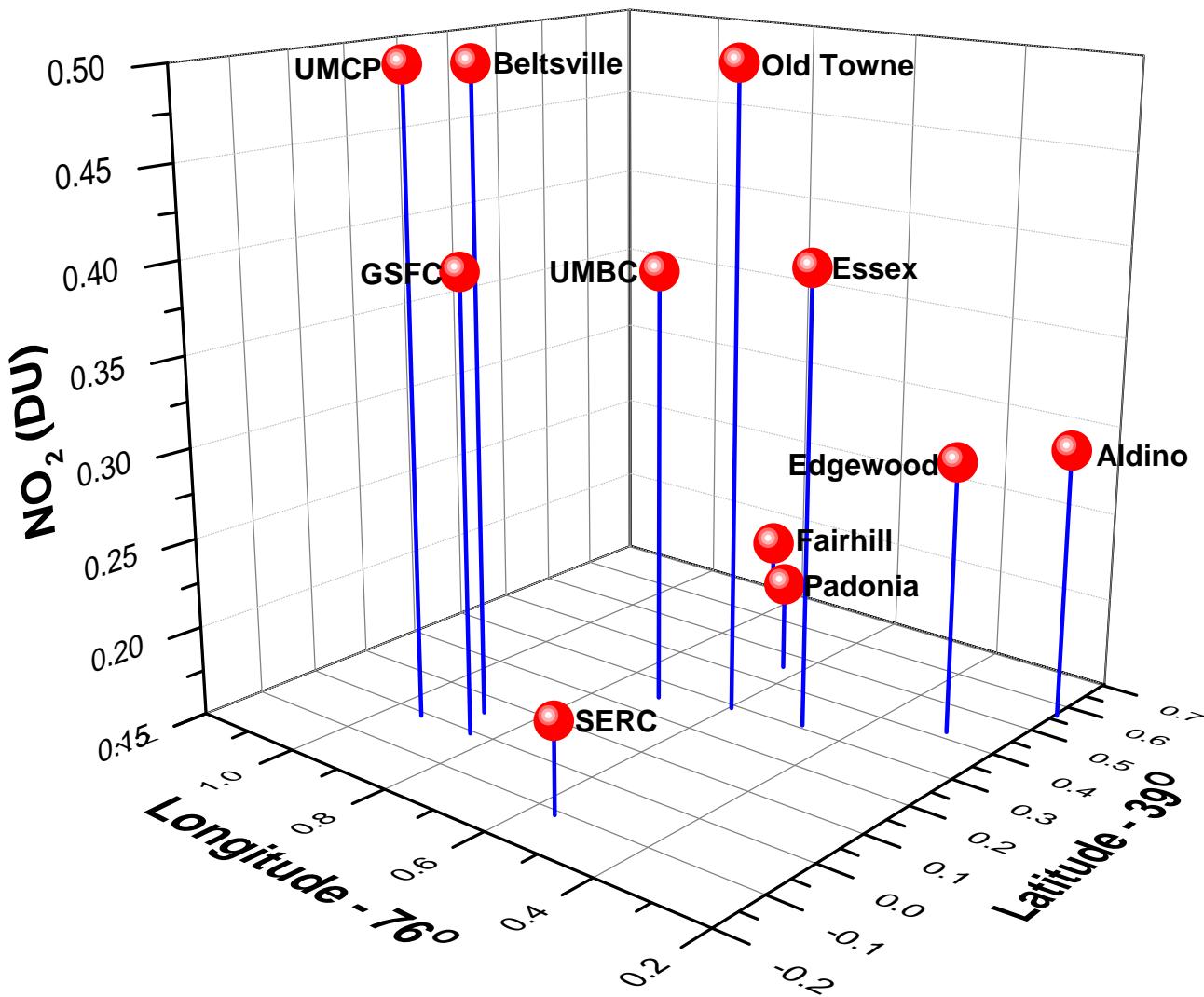


NO_2 Comparison between Pandora and OMI

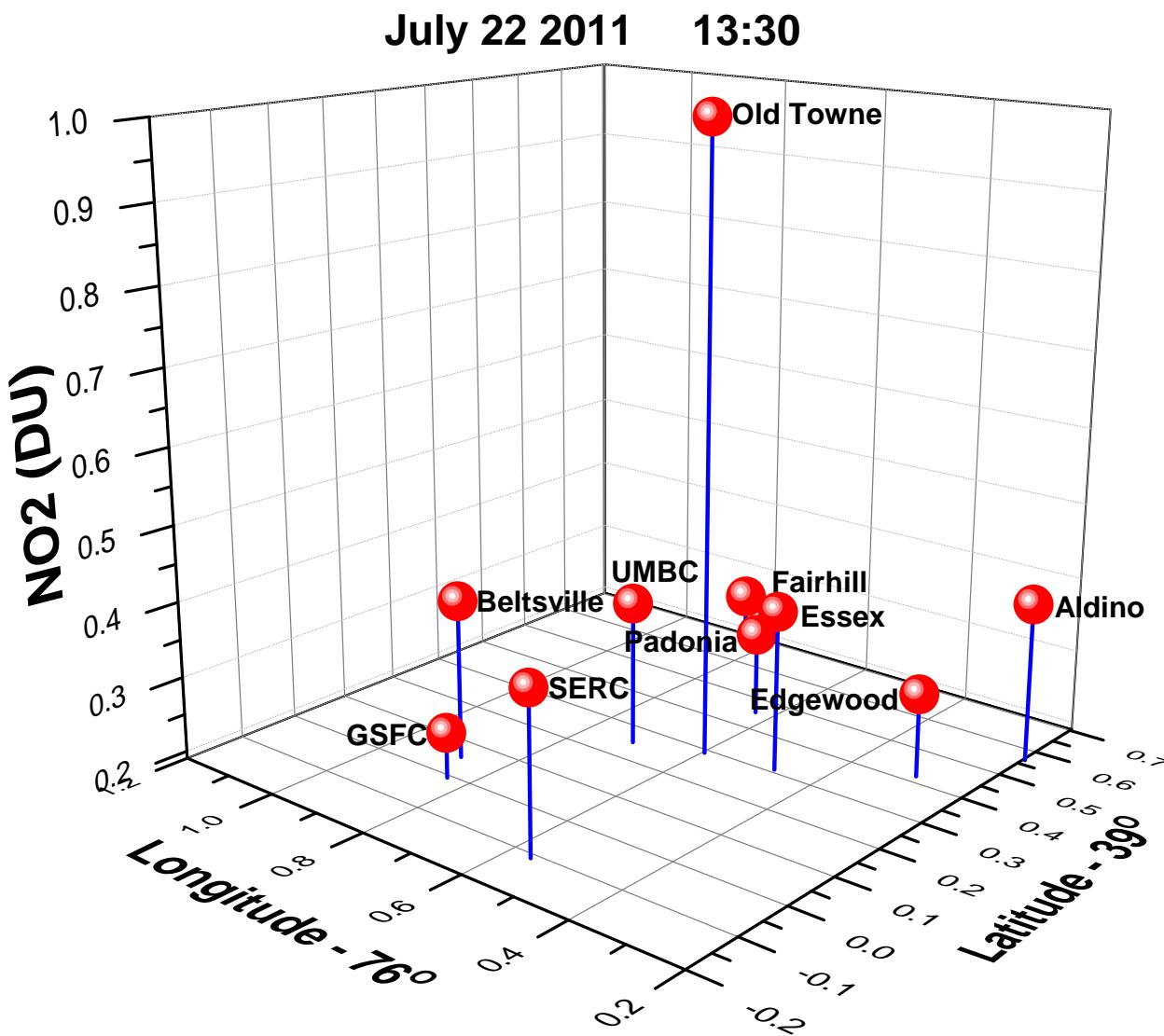


Pandora NO₂ 21 July 2011

July 21 2011 13:30

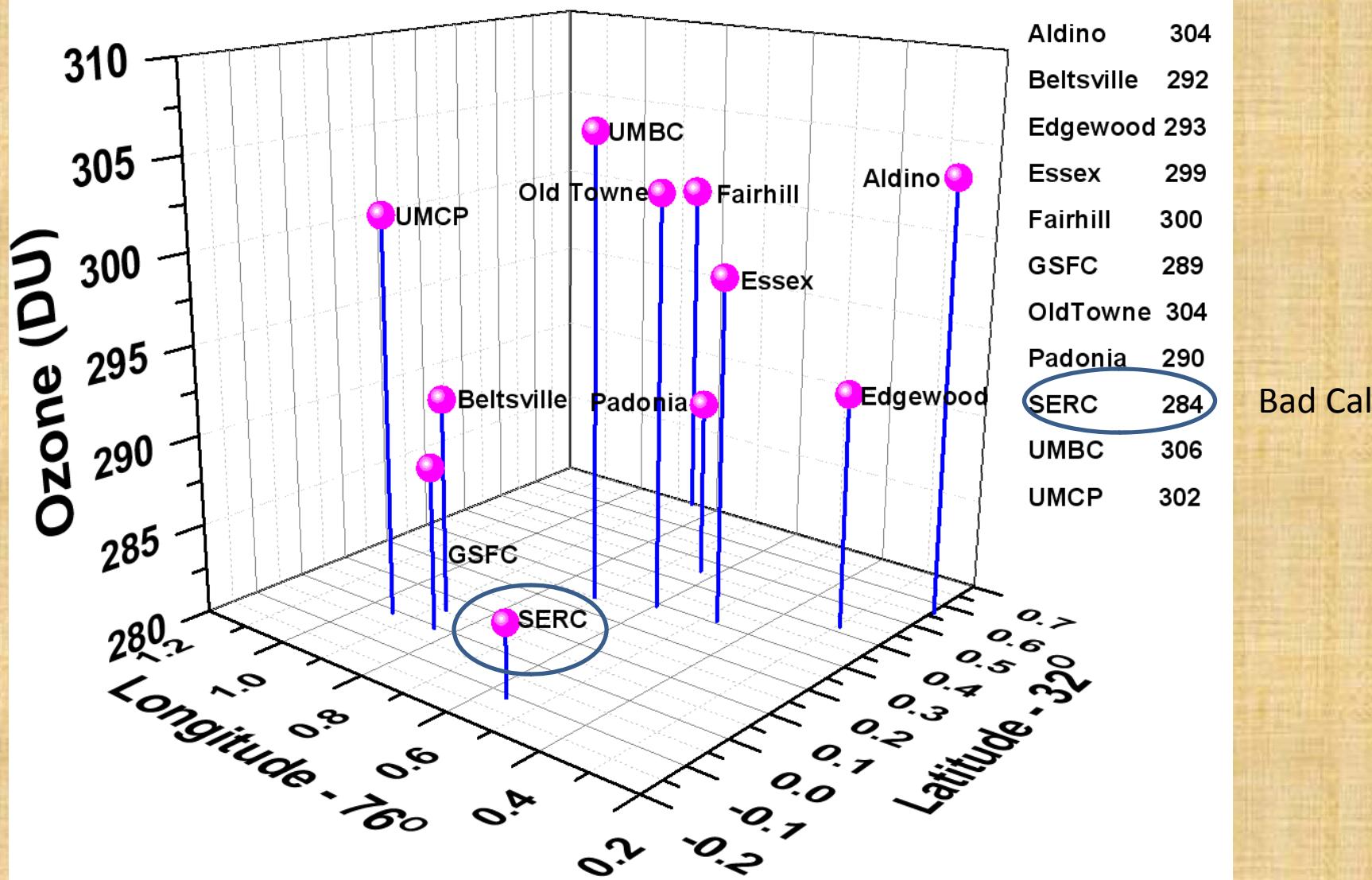


Pandora NO₂ 22 July 2011



Pandora O₃ 21 July 2011

July 21 2011 13:30



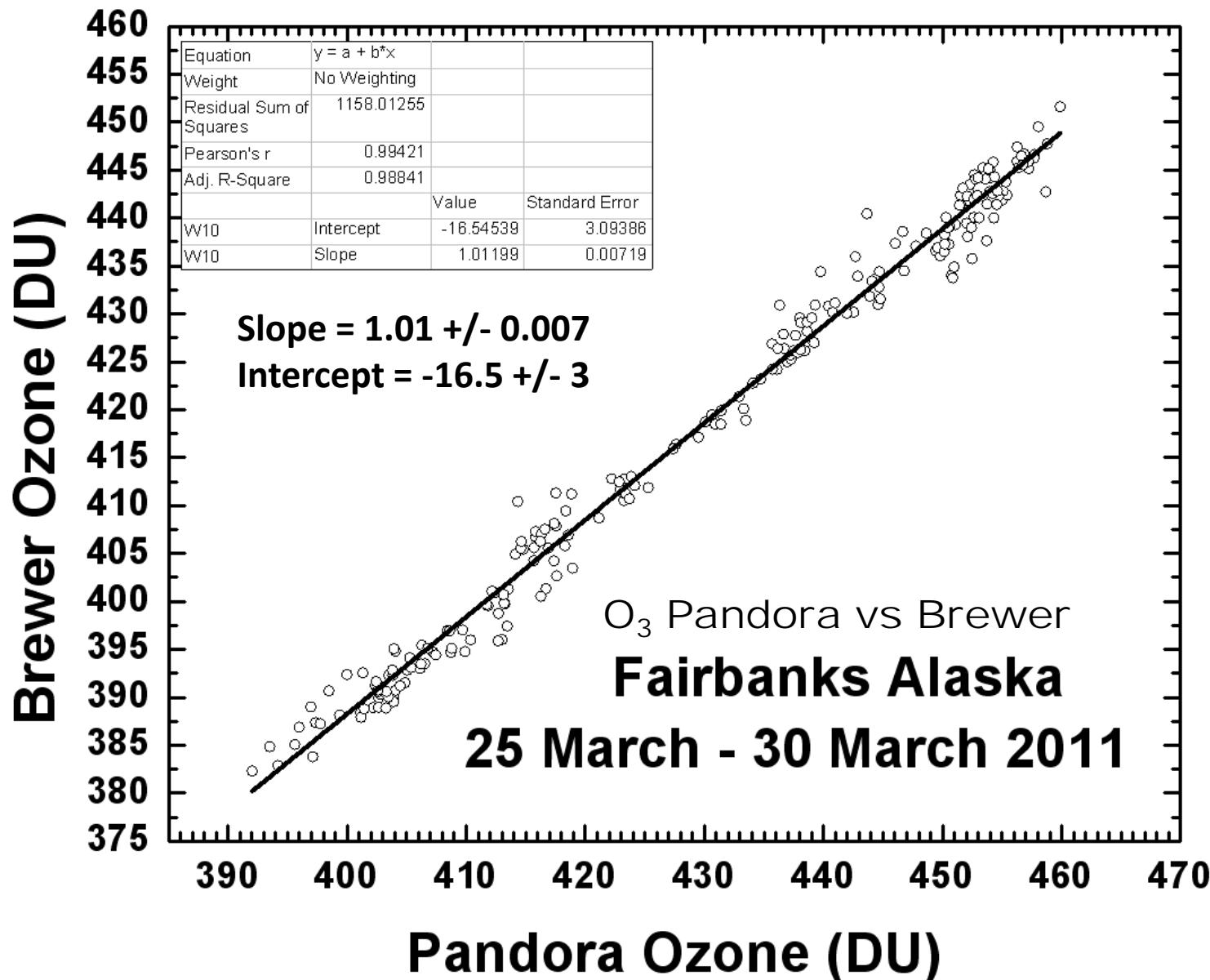
Given the significant amount of observed NO₂ and O₃ variation,

How much is due to instrumental differences?

How much is real variation?

- In contrast, OMI shows some spatial variation in NO₂ and little variation in O₃ over the area covered by Discover-AQ
- Pandora shows that there is significant day-to-day variation in both NO₂ and O₃, especially in the morning.
- The agreement with OMI is good at 1:30 pm

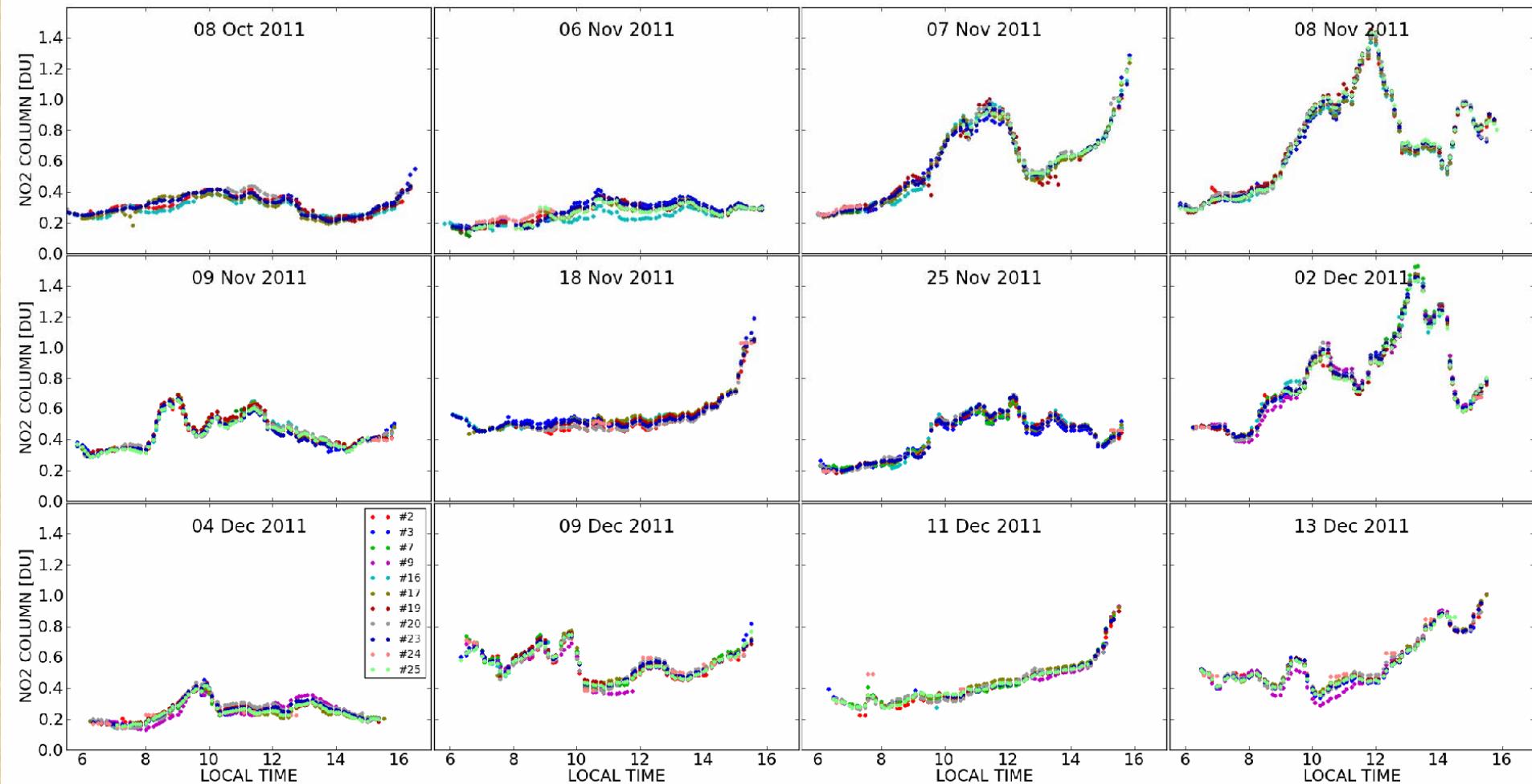
Compare Pandora with the Brewer #171 Double Monochromator



Pandoras at GSFC/2011



Comparison of 11 Pandoras at GSFC

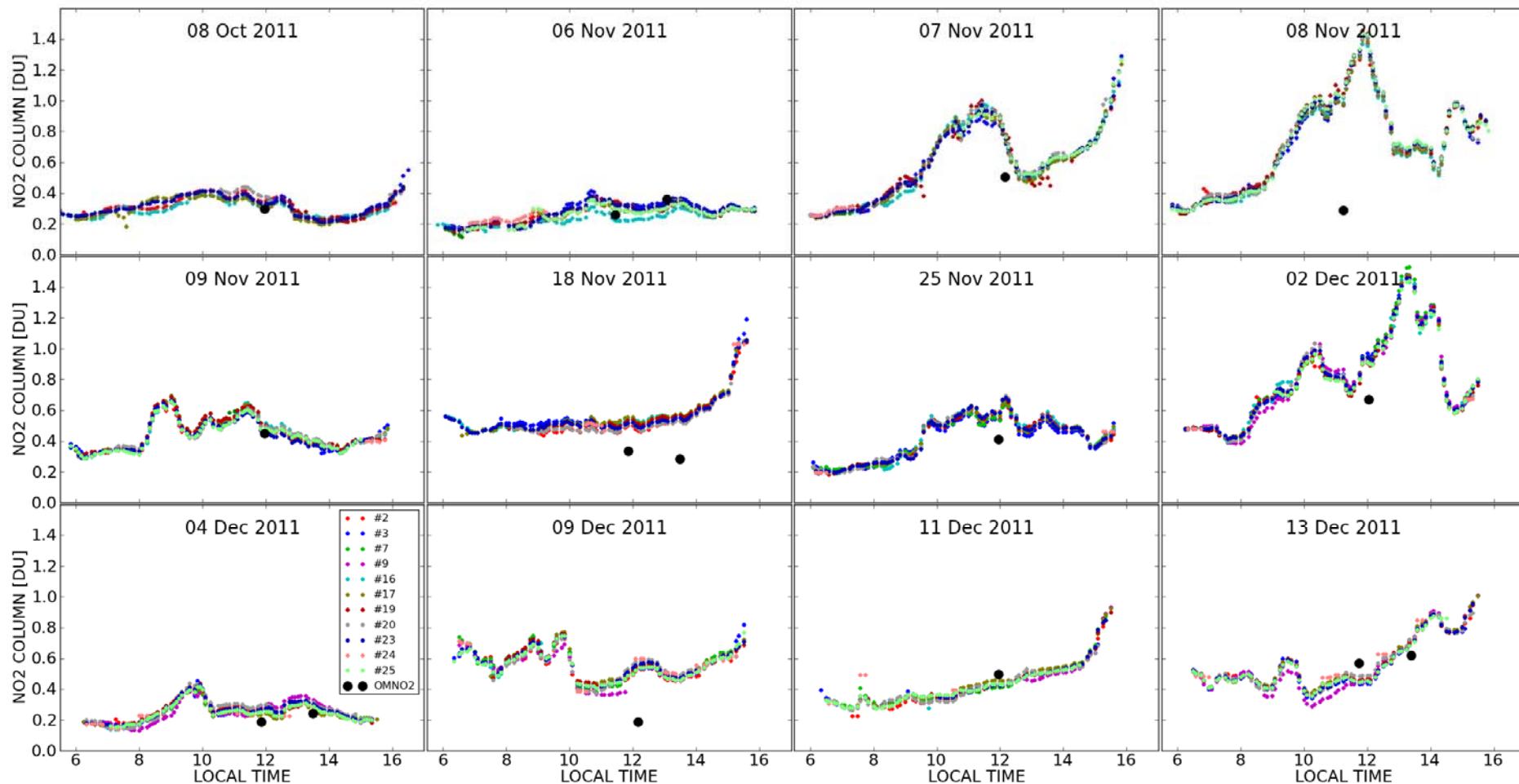


All Pandoras are in agreement for NO₂

Small differences (e.g. 6 Nov, 13 Dec) are caused by sun pointing errors

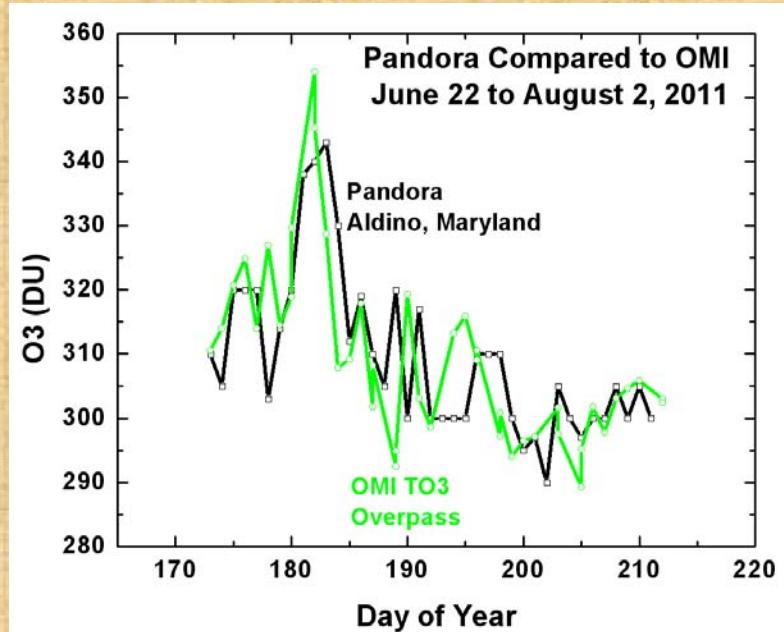
These differences interfere with Formaldehyde retrieval

We are working on this problem

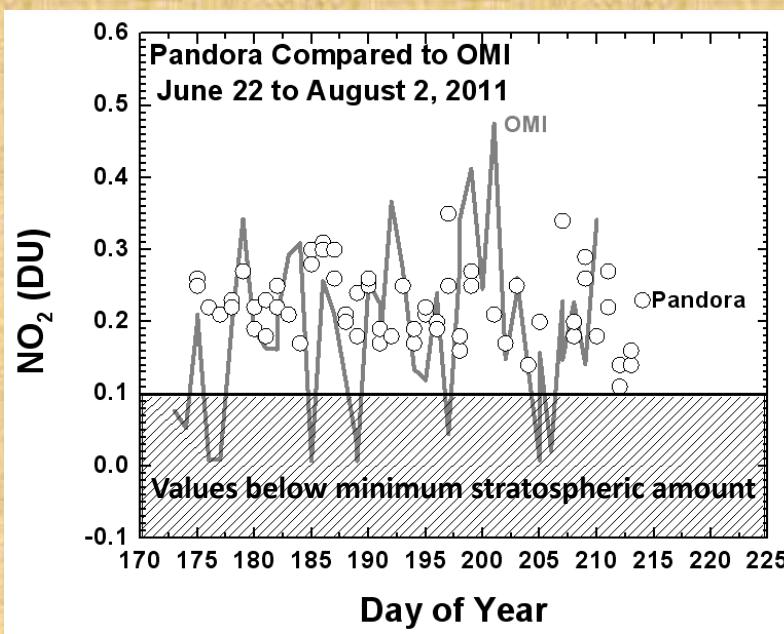


Pandora Compared to OMI- TO_3 & NO_2 Overpass

O_3



NO_2



- 1) OMI “Overpass” pixel is sometimes more than 50 km distant.
- 2) All days were included, both clear and cloudy days.
- 3) OMI values of $\text{NO}_2 < 0.1$ DU are not possible.
- 4) There is good agreement for the entire time series.



Summary: Pandora and OMI O_3 & NO_2

1. The Pandora spectrometer system is able to make high precision measurements that agree closely between 12 independent Pandoras, with the O_3 reference Brewer, and with the OMI satellite spectrometer.
2. Large spatial variation was observed for NO_2 , which was expected between sites that varied between city (high automobile traffic) and country (low automobile traffic) sites.
3. Significant spatial variation was observed for O_3 for sites that are separated by a maximum of 80 km. Based on the small observed OMI 12x25 km O_3 spatial variation, a significant portion of the Pandora observed variation must be in the troposphere.

Pandora head sensor and spectrometer in temperature controlled box

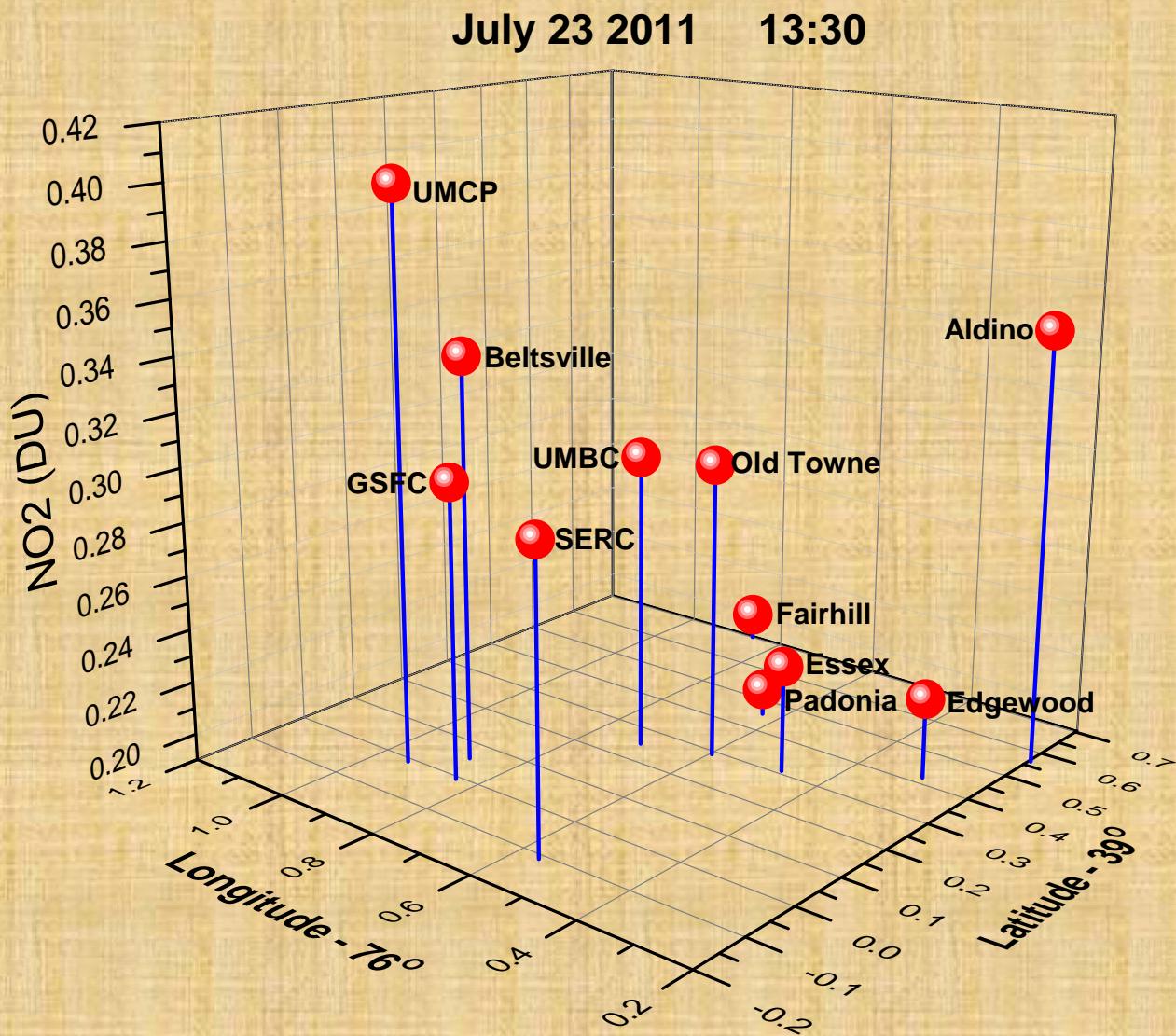


PANDORA Specifications

- Sun spectrometer, 75mm focal length symmetrical Czerny-Turner
- Uses Hamamatsu image sensor (CCD 2048x16 array)
- Wavelength range: 270nm to 530nm, resolution ~0.5nm
- Field of view ~1.8 full angle
- Two filterwheels with opaque for dark count, short-pass filters to reduce stray light.
- S/N: ~400:1 for single shot at 400nm
→ >10,000 for 20sec average
- Regular measurement mode:
Every minute 20 seconds averaged measurement
with each filter + dark counts
- Open, UV-340, ND-1, ND-2, ND-3, Opaque



Pandora NO₂ 23 July 2011



Pandora NO₂ 24 July 2011

