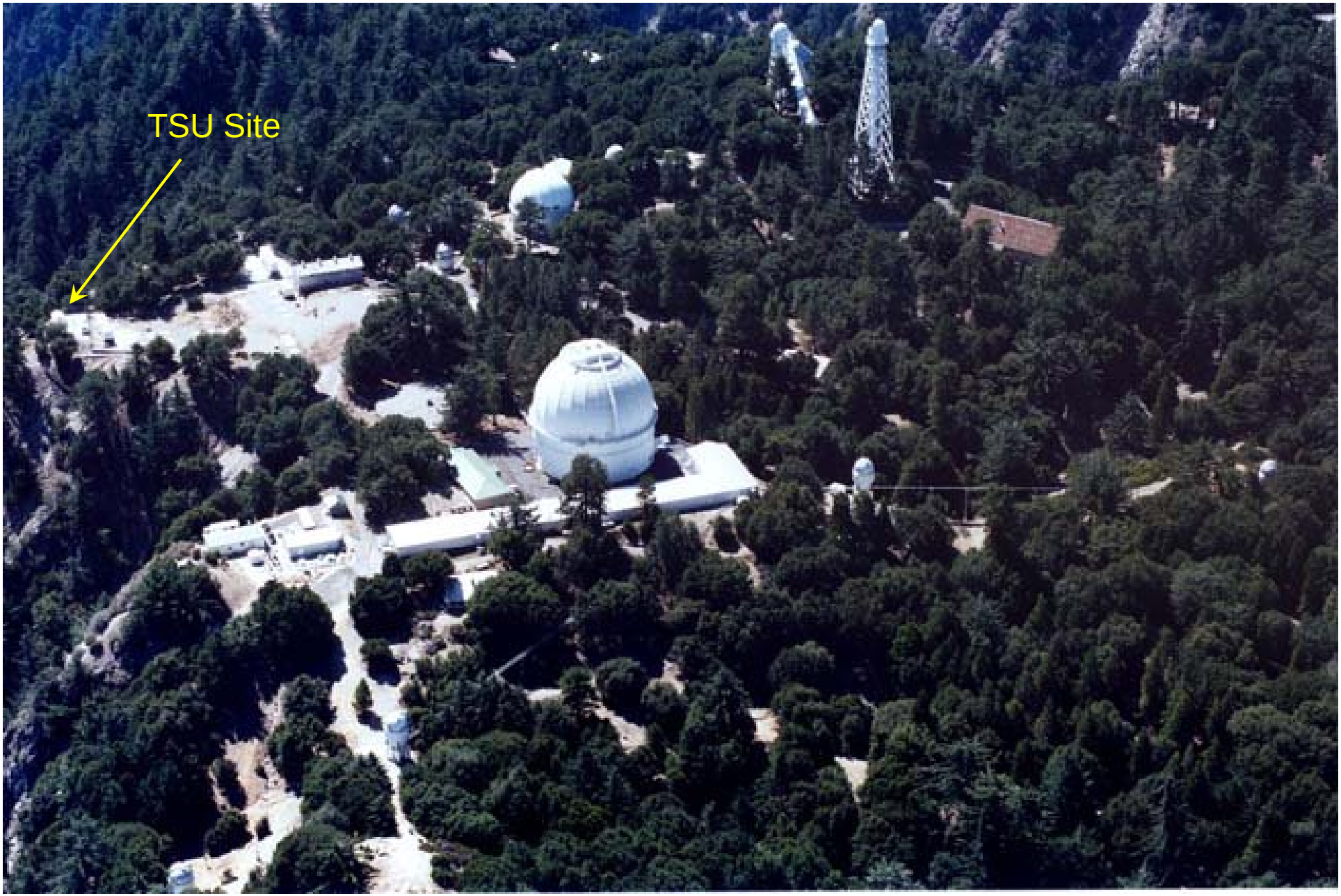
# Mount Wilson GHG Monitoring "Proof of Concept" Pilot Study, 2007


- Donald R. Blake
- Department of Chemistry
- University of California
- Irvine, CA


- September 11, 2007

# Mt Wilson from Pasadena

# MWO Grounds



# Mt. Wilson Spring 2007 Study

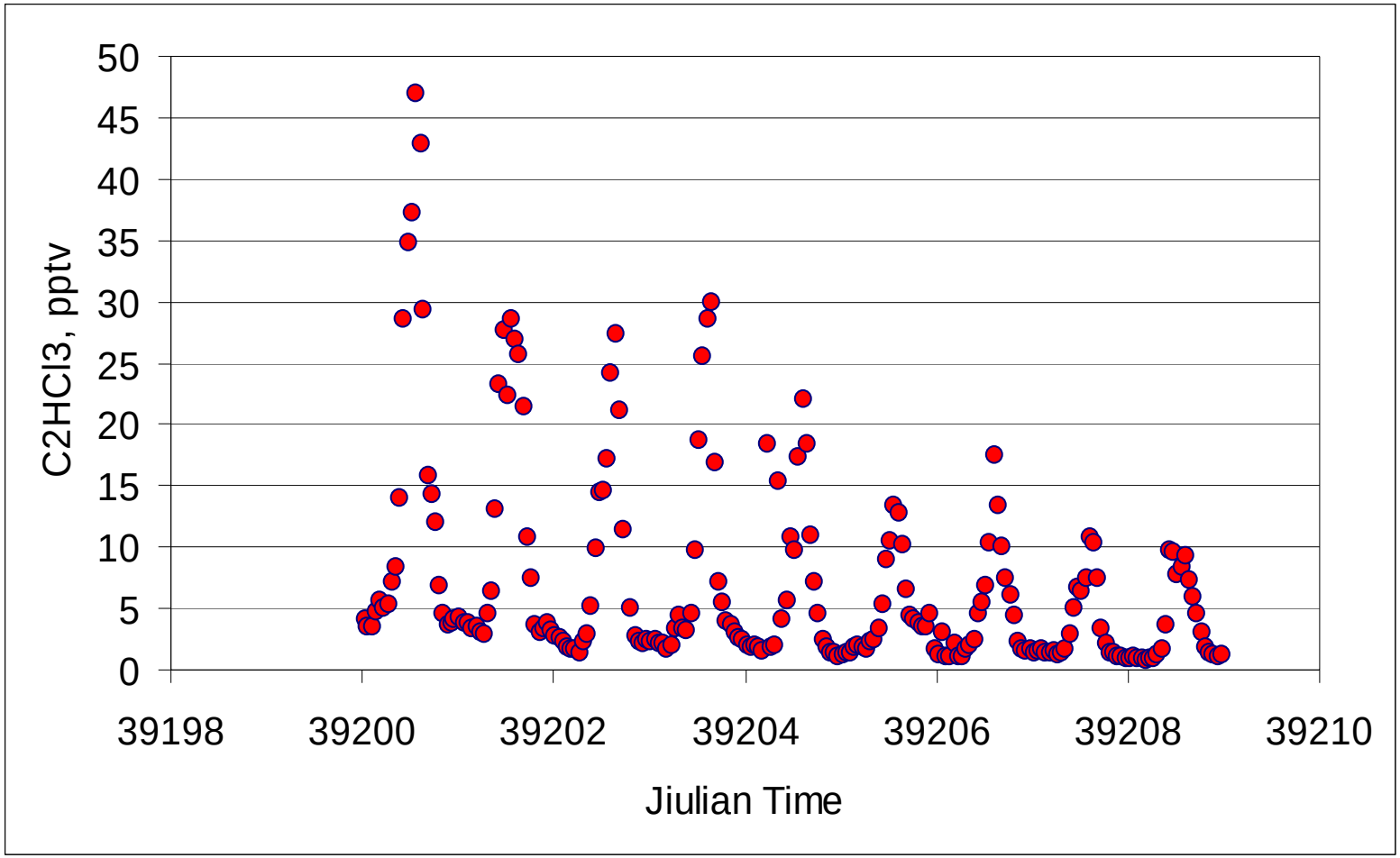
- April 28-May 6
- Hourly integrated samples in 2-liter canisters (frequency okay or too high?)
- Canisters pressurized to 25 psig
- Started Friday night at midnight
- Ended Sunday Night at midnight 9 days later
- Gas chromatographic analysis of 50 VOCs
- Summer study currently underway-began midnight Friday and will end this Sunday

PUMA

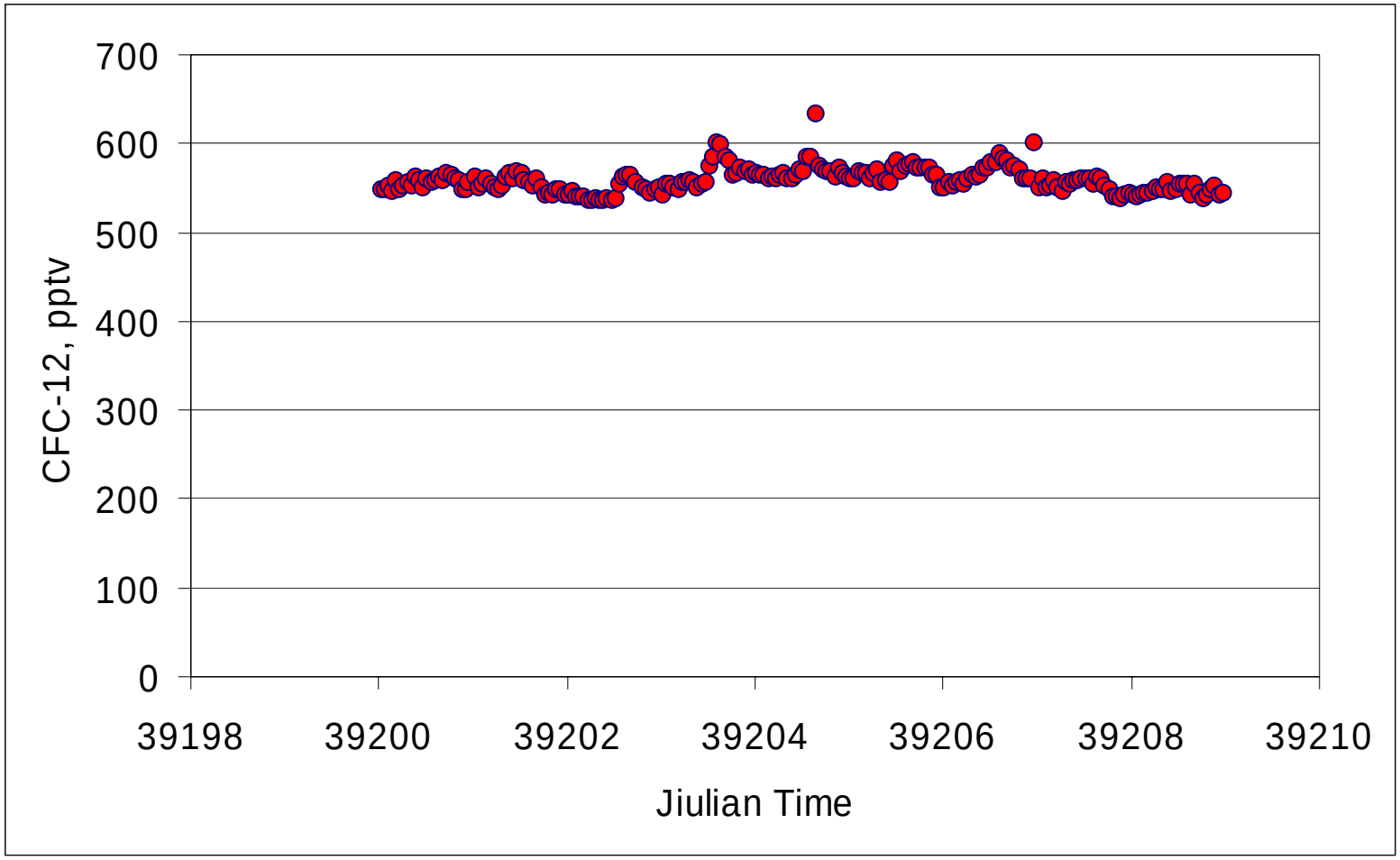
We work with NASA, NOAA, NCAR and other groups around the world studying processes important to global climate

SELF INFLATING MAT
1355

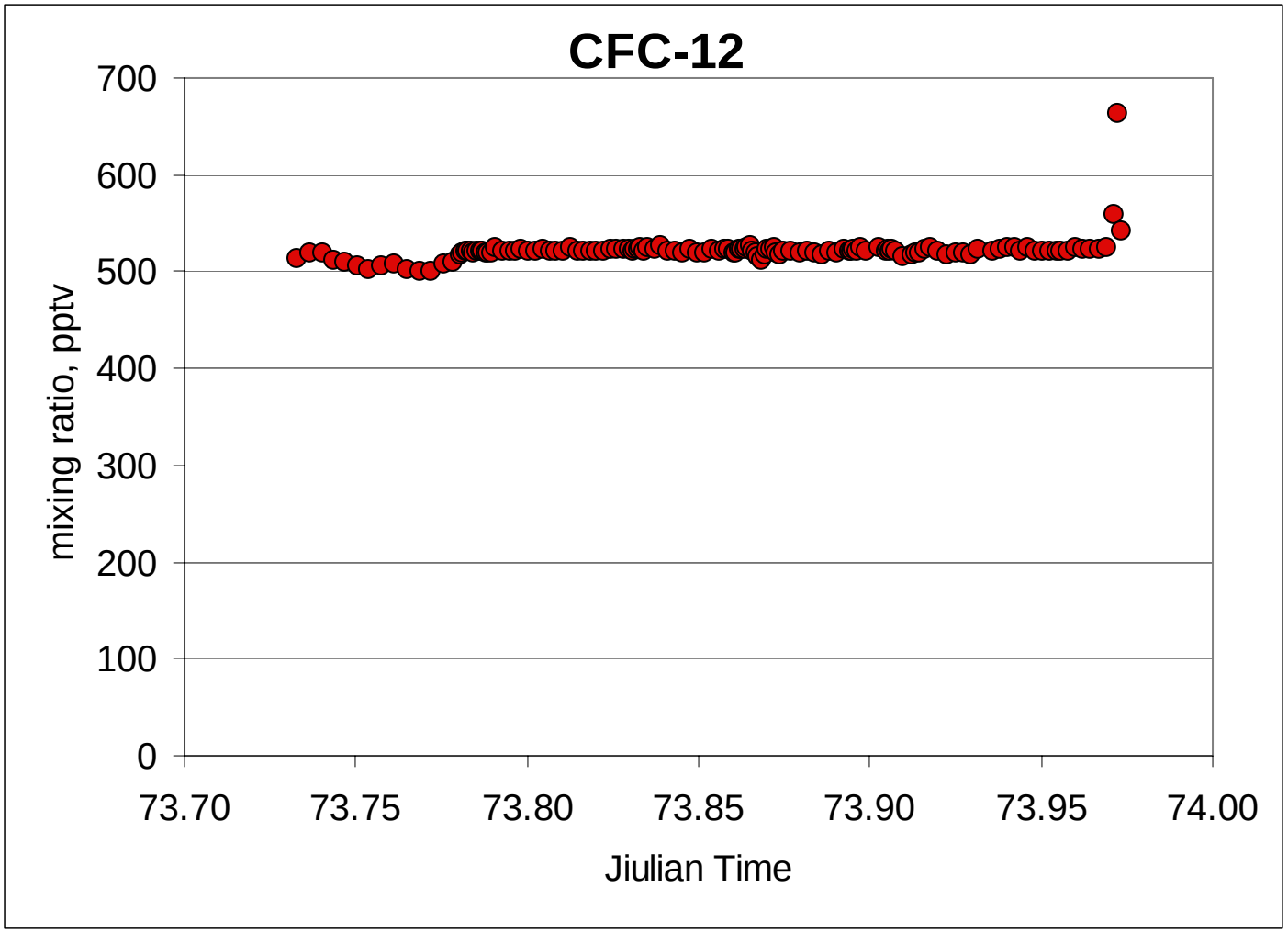
# Mount Wilson, April 28-May 6, 2007



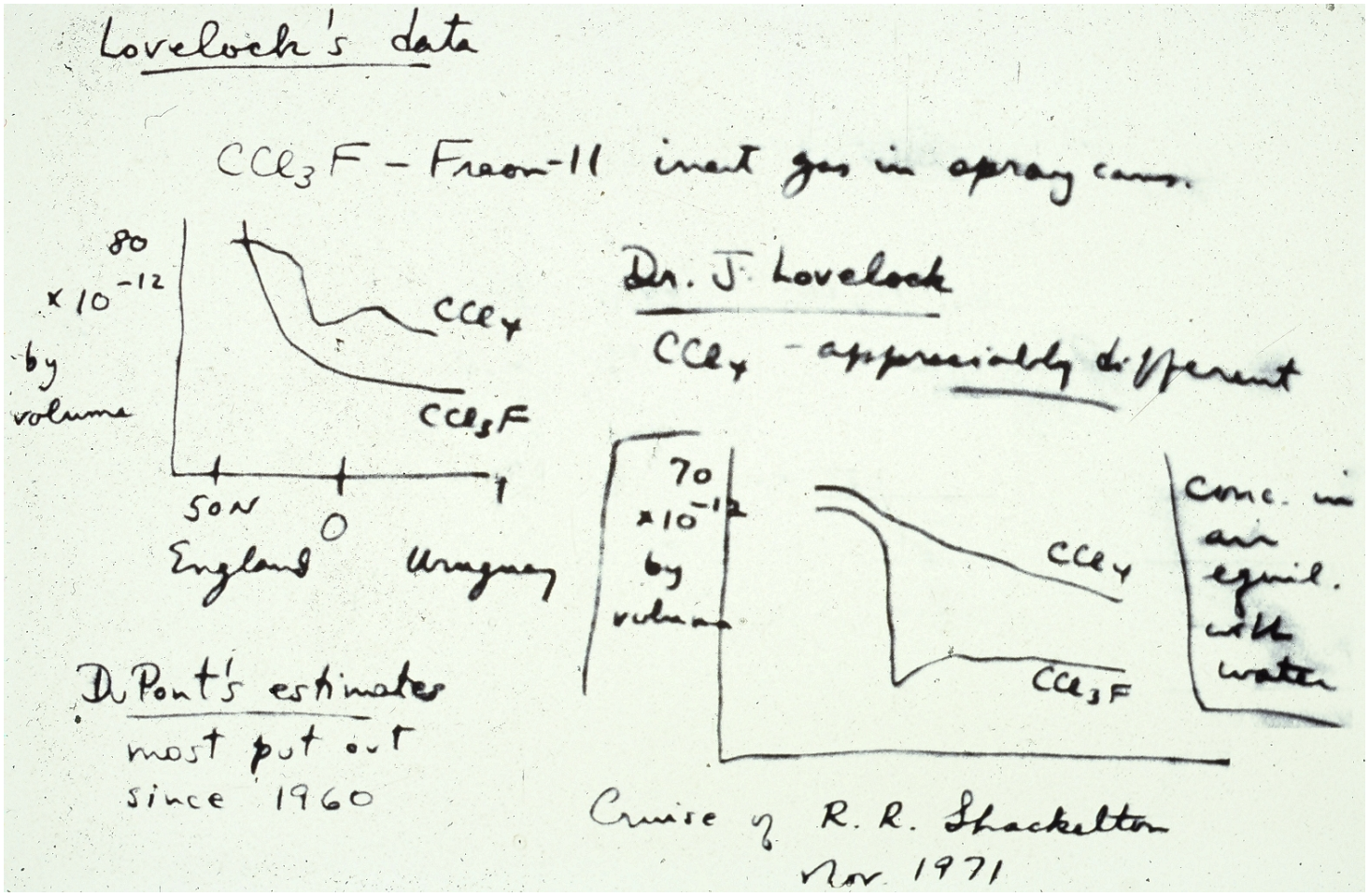
# Mount Wilson CFC-12 vs time



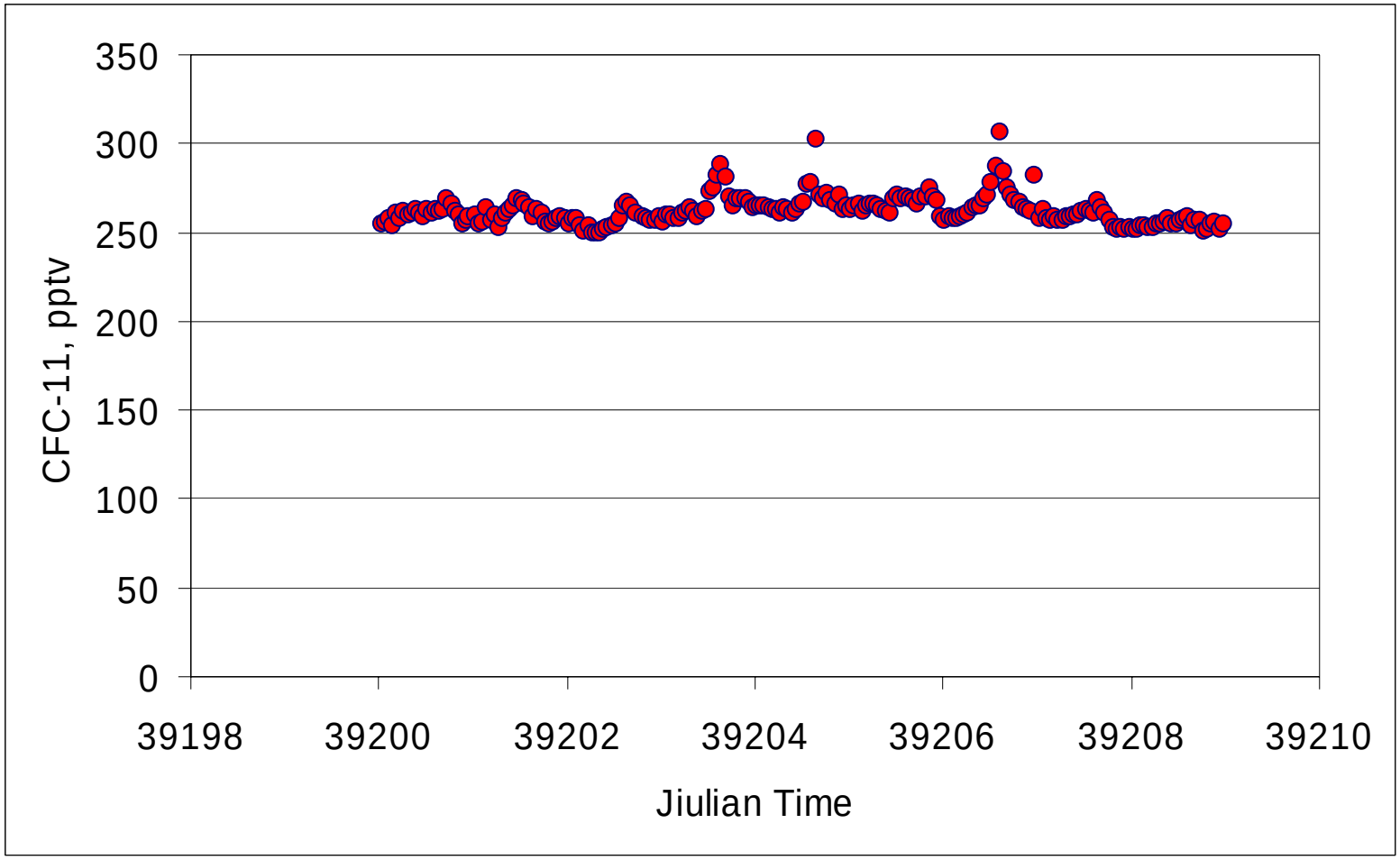
# PEM-West B 1994 flight into San Jose



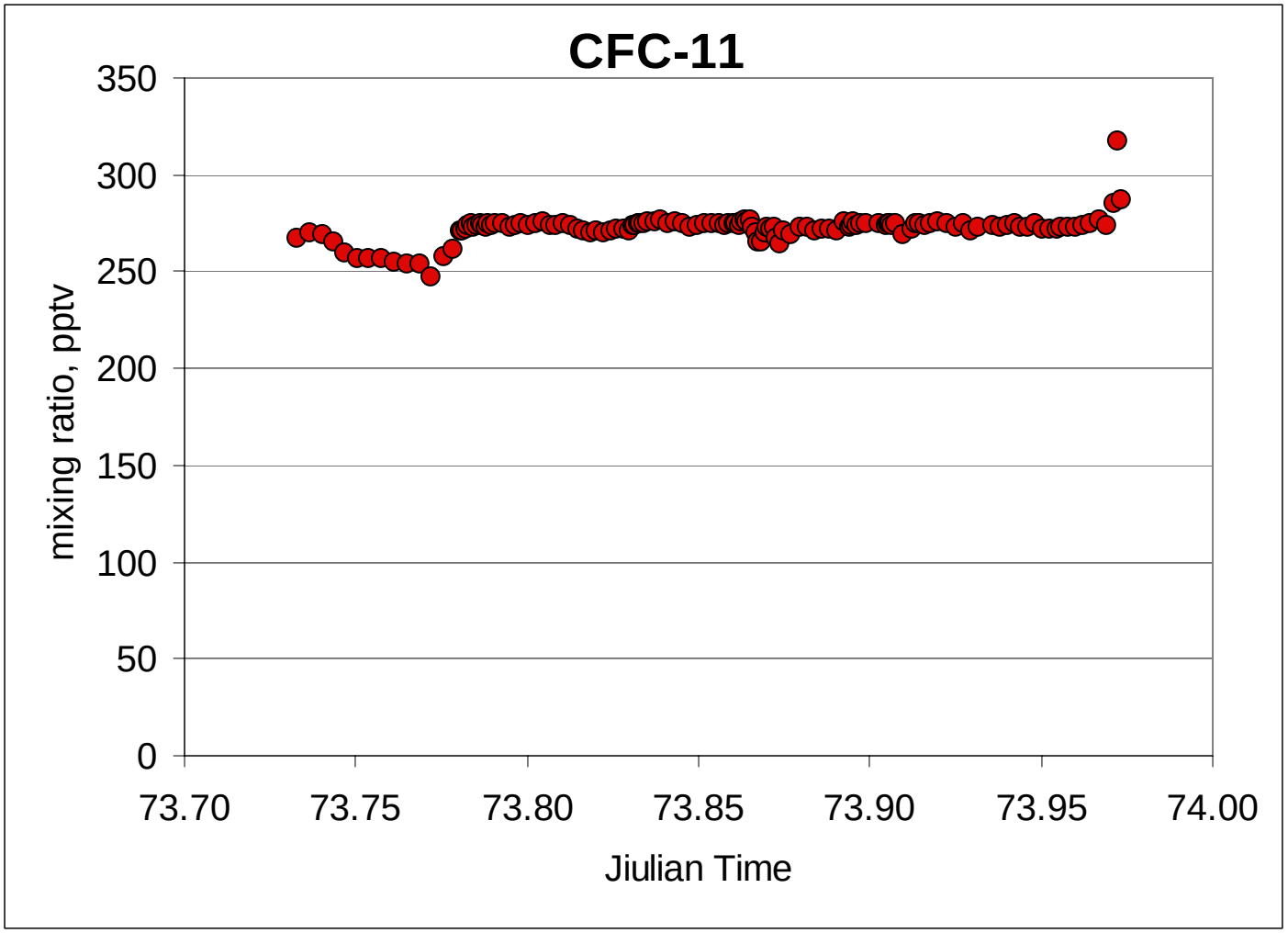
# Sherry Rowland's notes from 1972



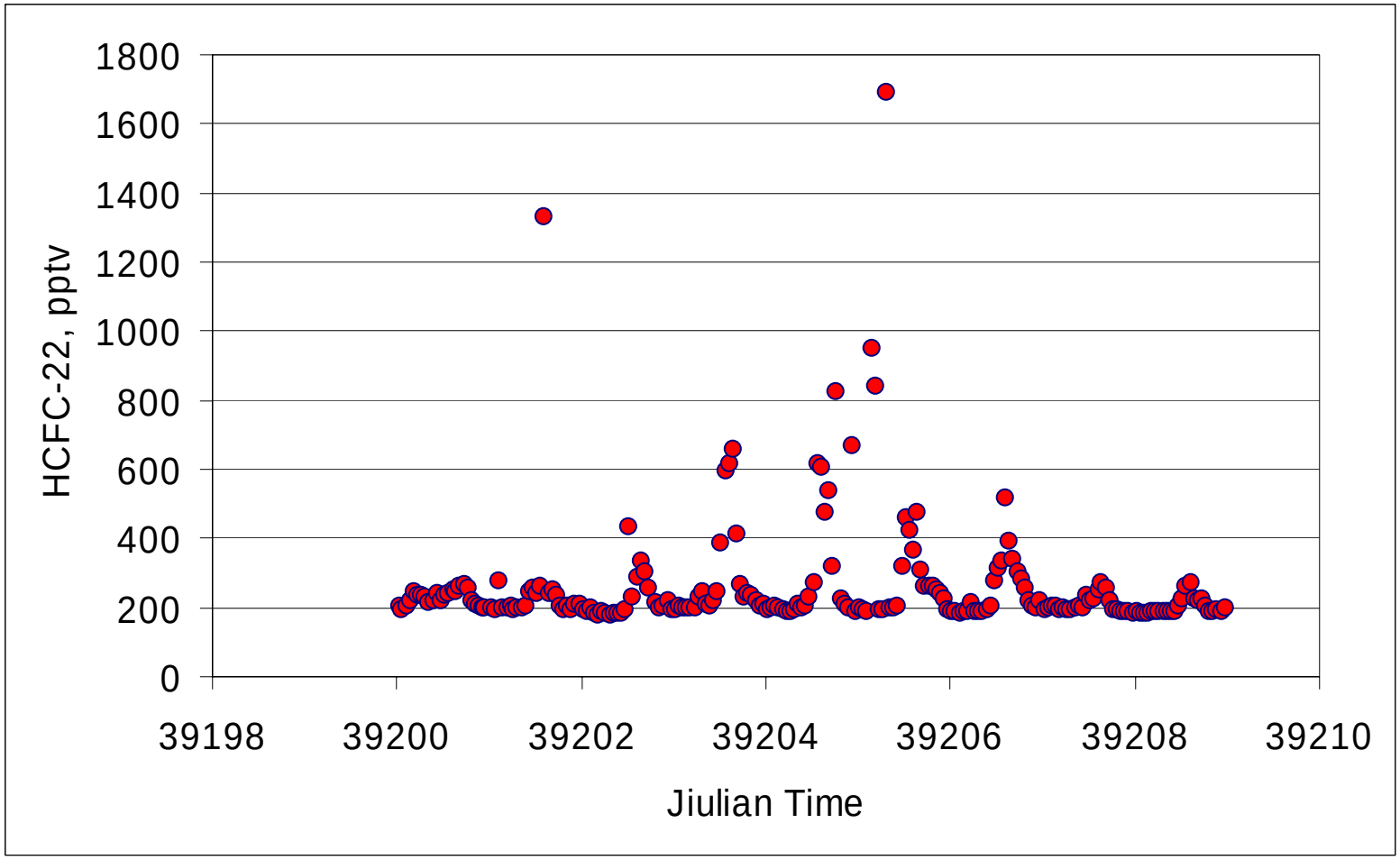
# Mount Wilson CFC-11 vs time



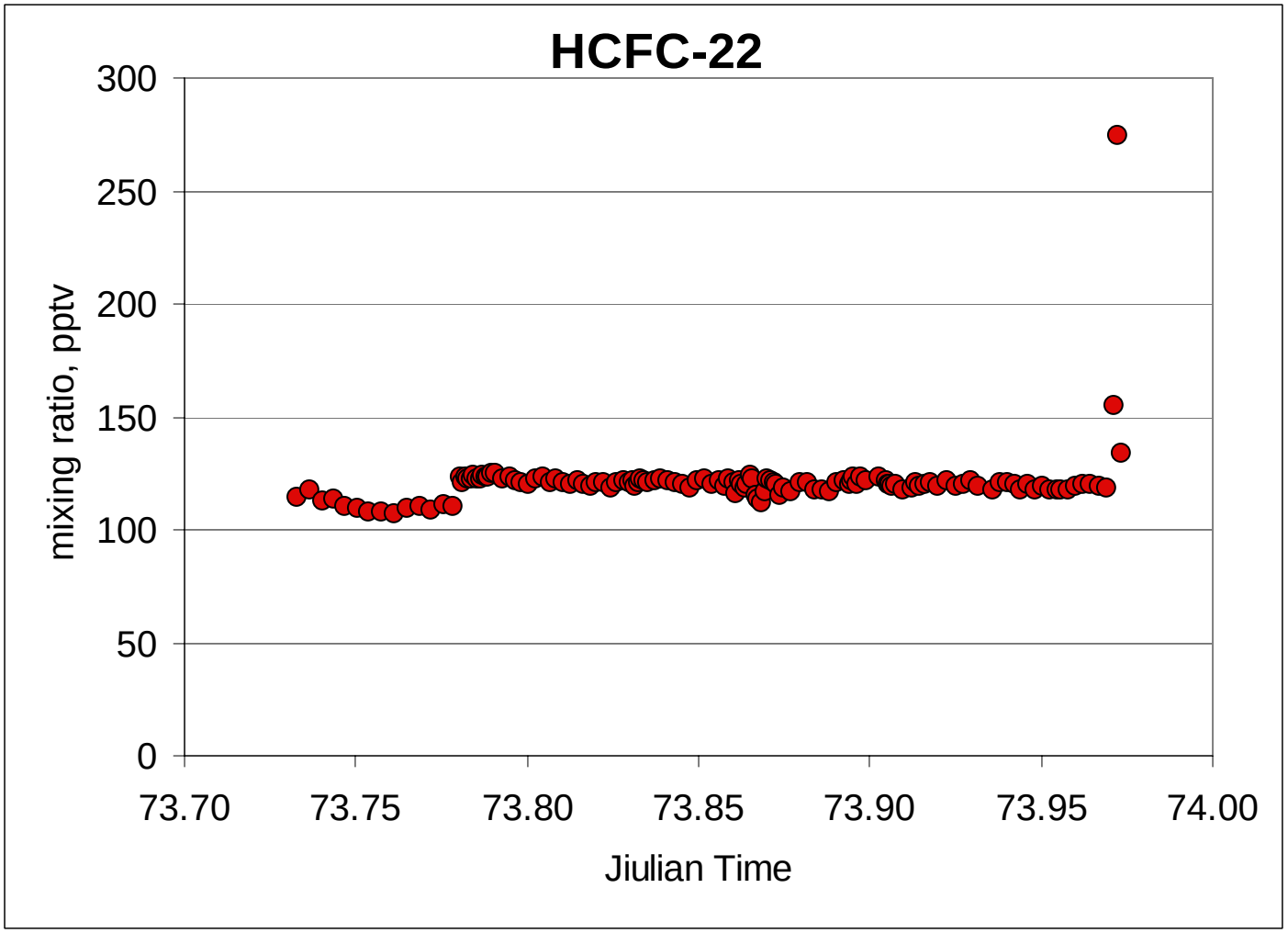
# PEM-West B 1994 flight from Japan to San Jose



# Mount Wilson HCFC-22 vs time

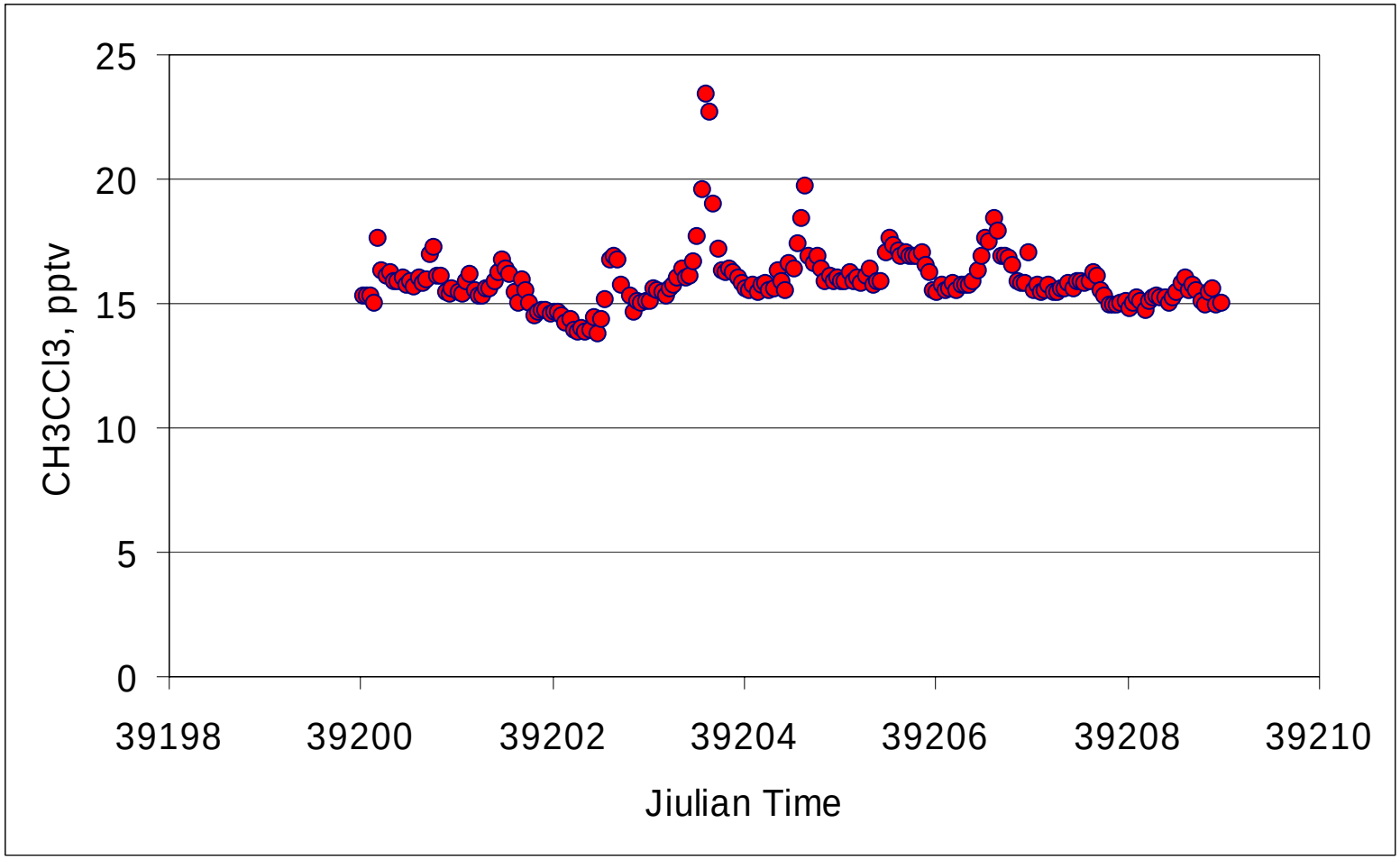


# PEM-West B 1994 flight from Japan to San Jose

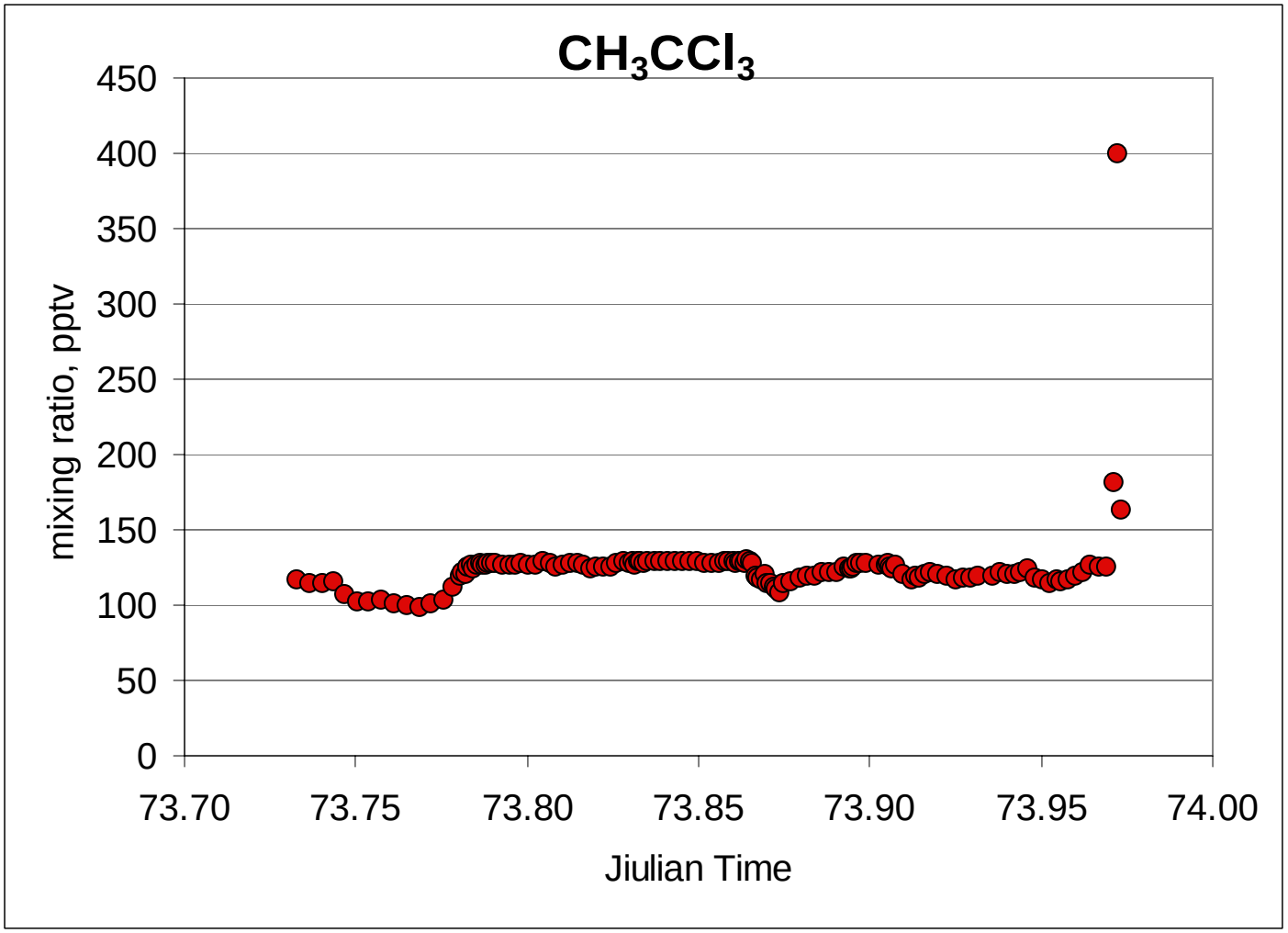


# Do it yourself Auto AC

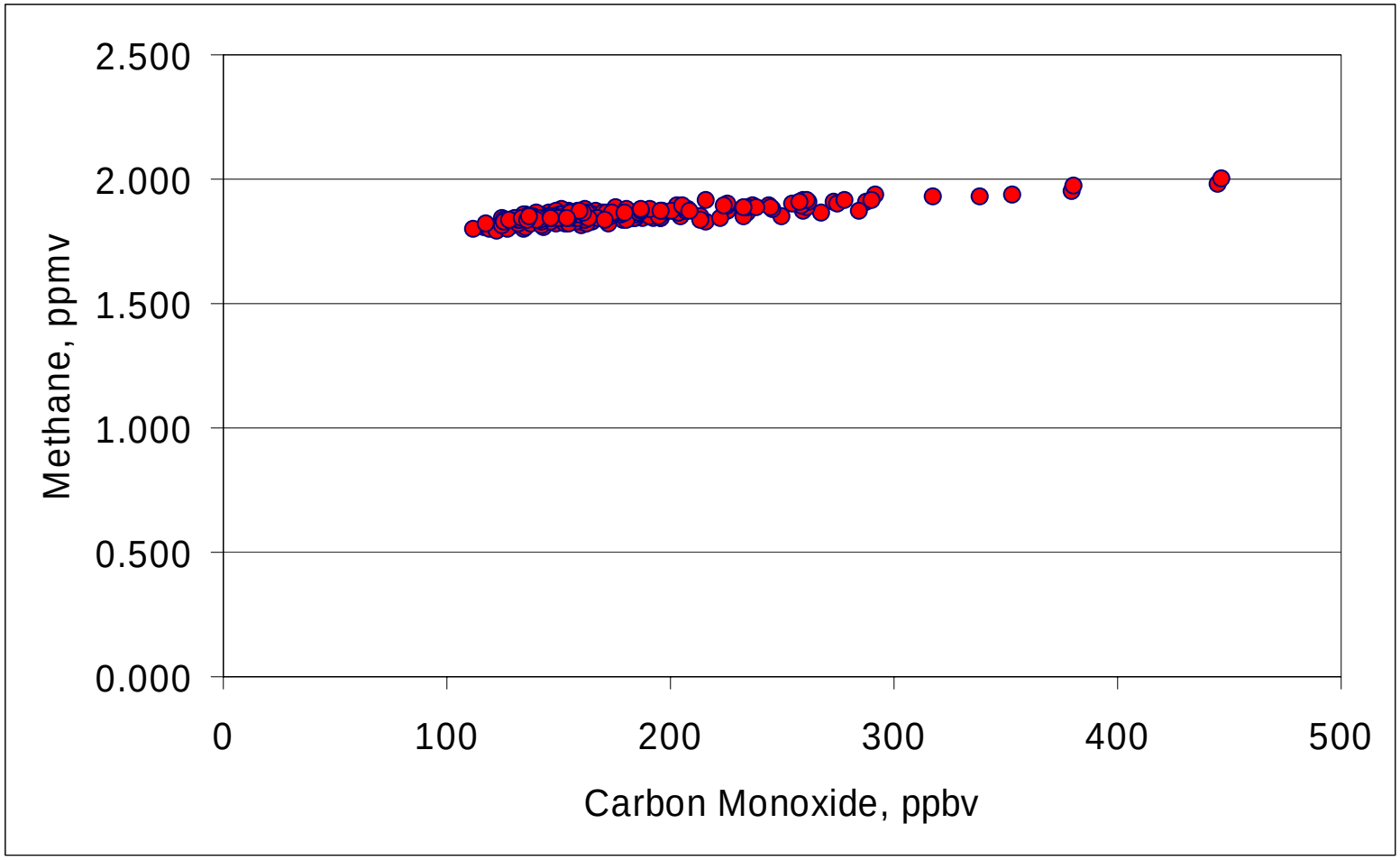
# Mount Wilson $CH_3CCl_3$ vs time



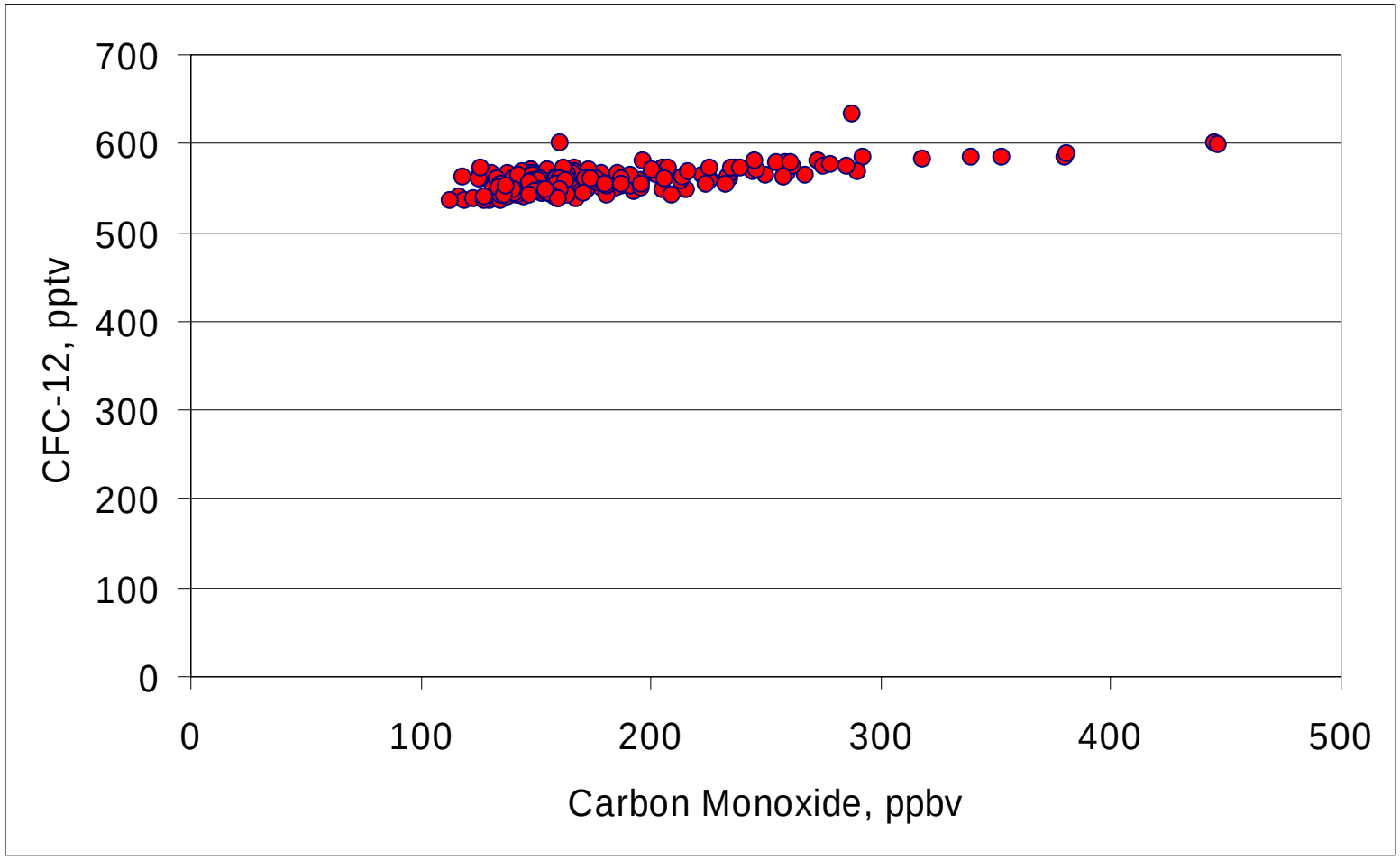
# PEM-West B 1994 flight from Japan to San Jose



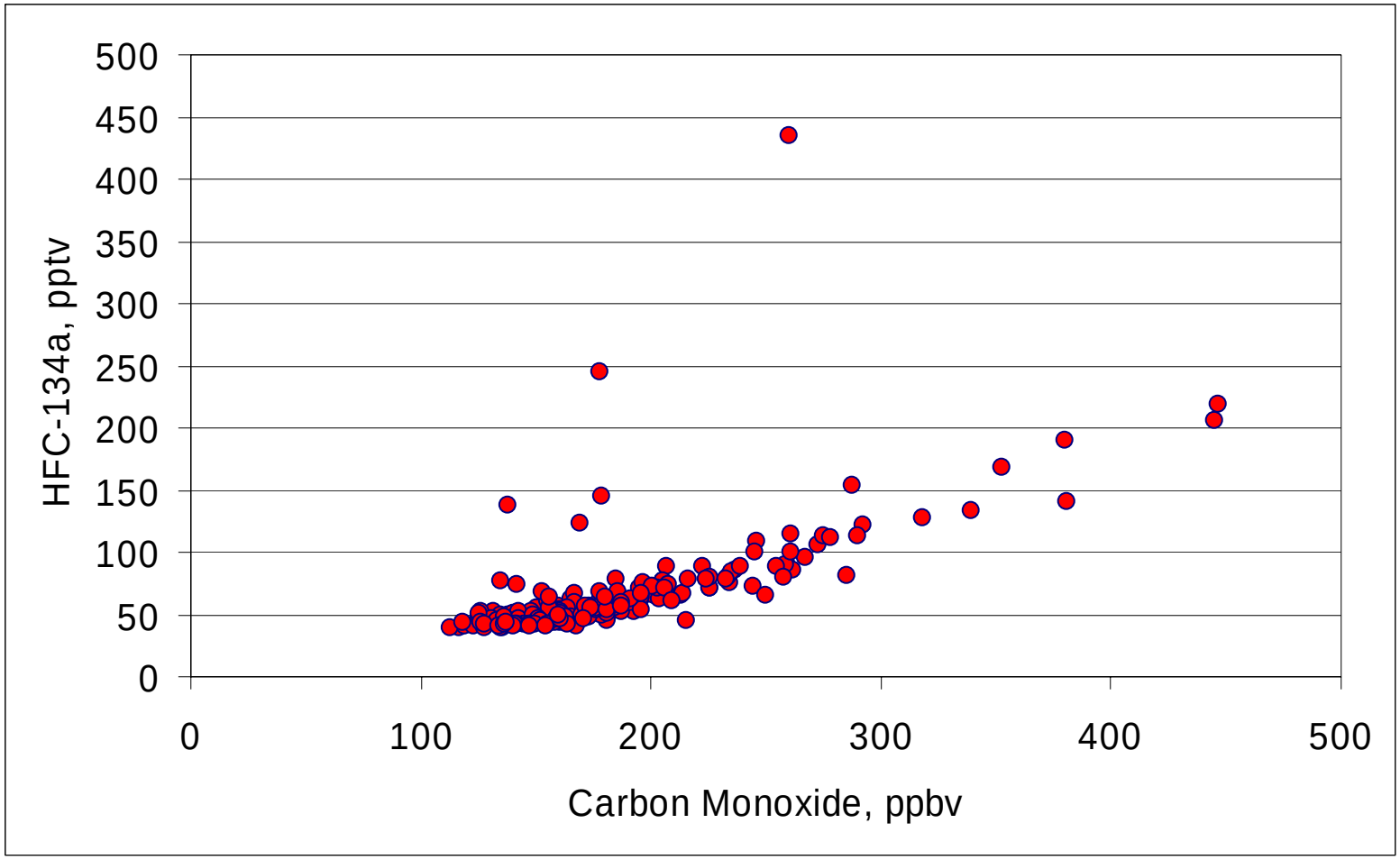
# Mount Wilson Methane vs CO



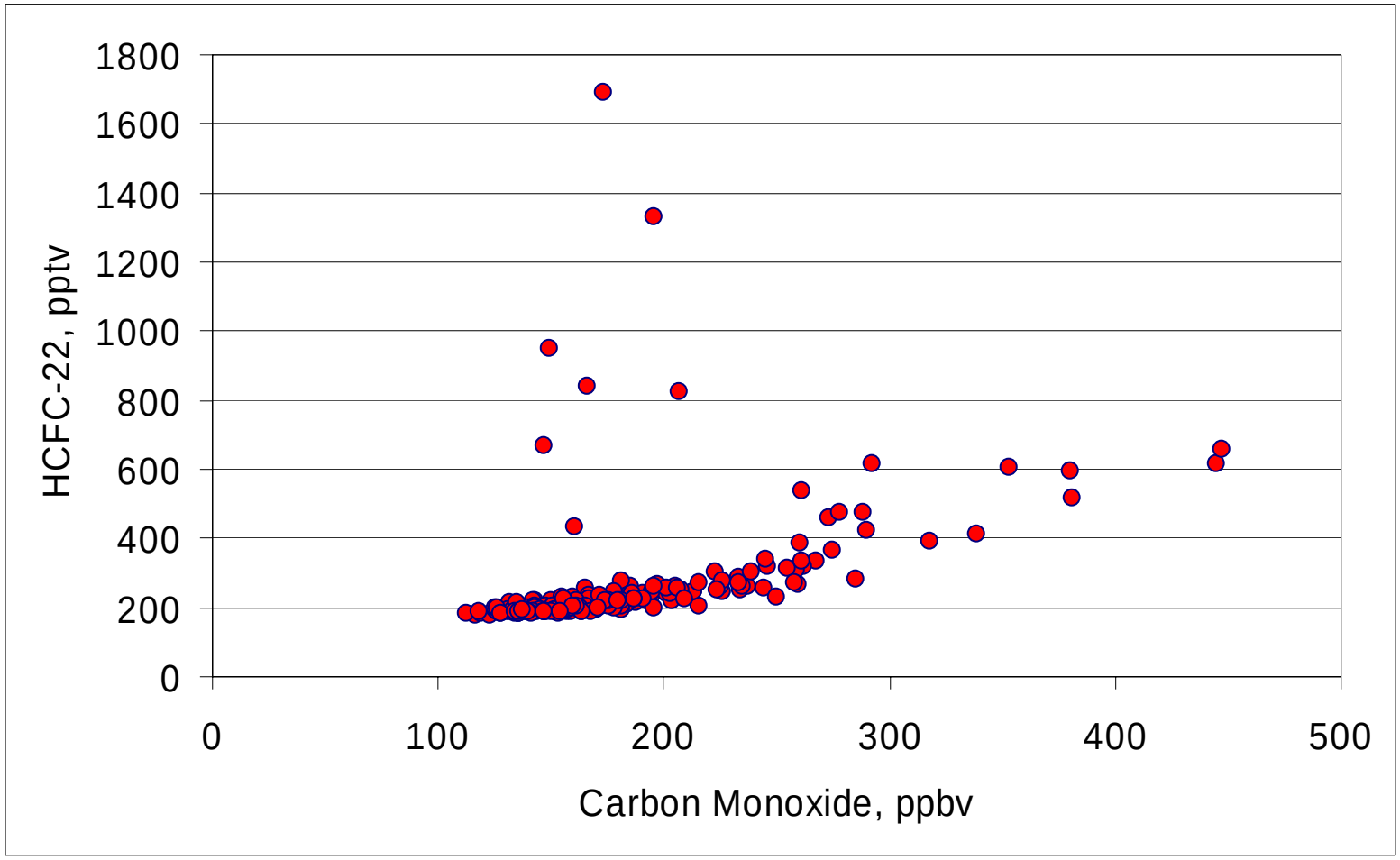
# Mount Wilson CFC-12 vs CO



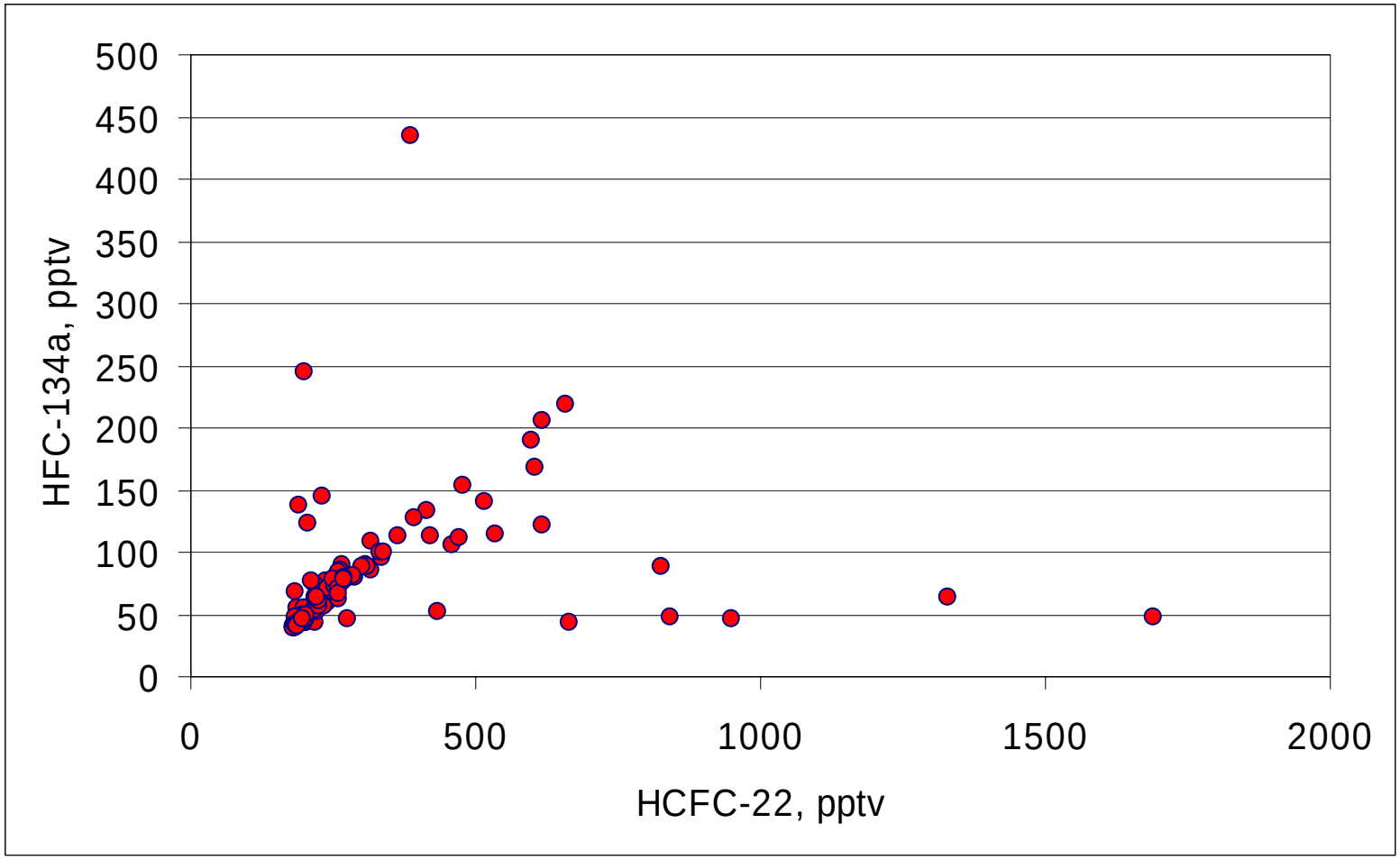
# Mount Wilson HFC-134a vs CO



# Mount Wilson HCFC-22 vs CO



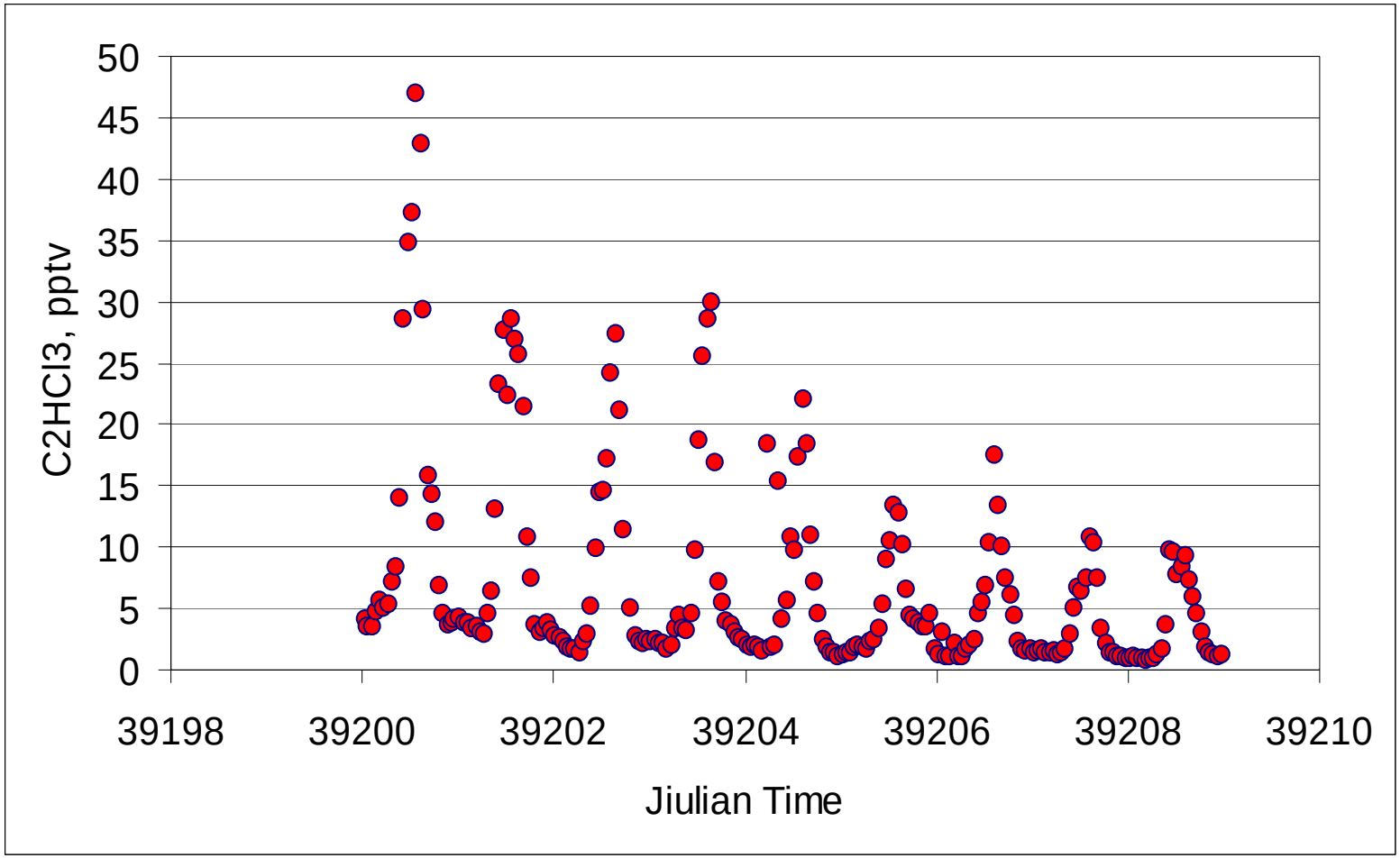
# HFC-134a vs HCFC-22



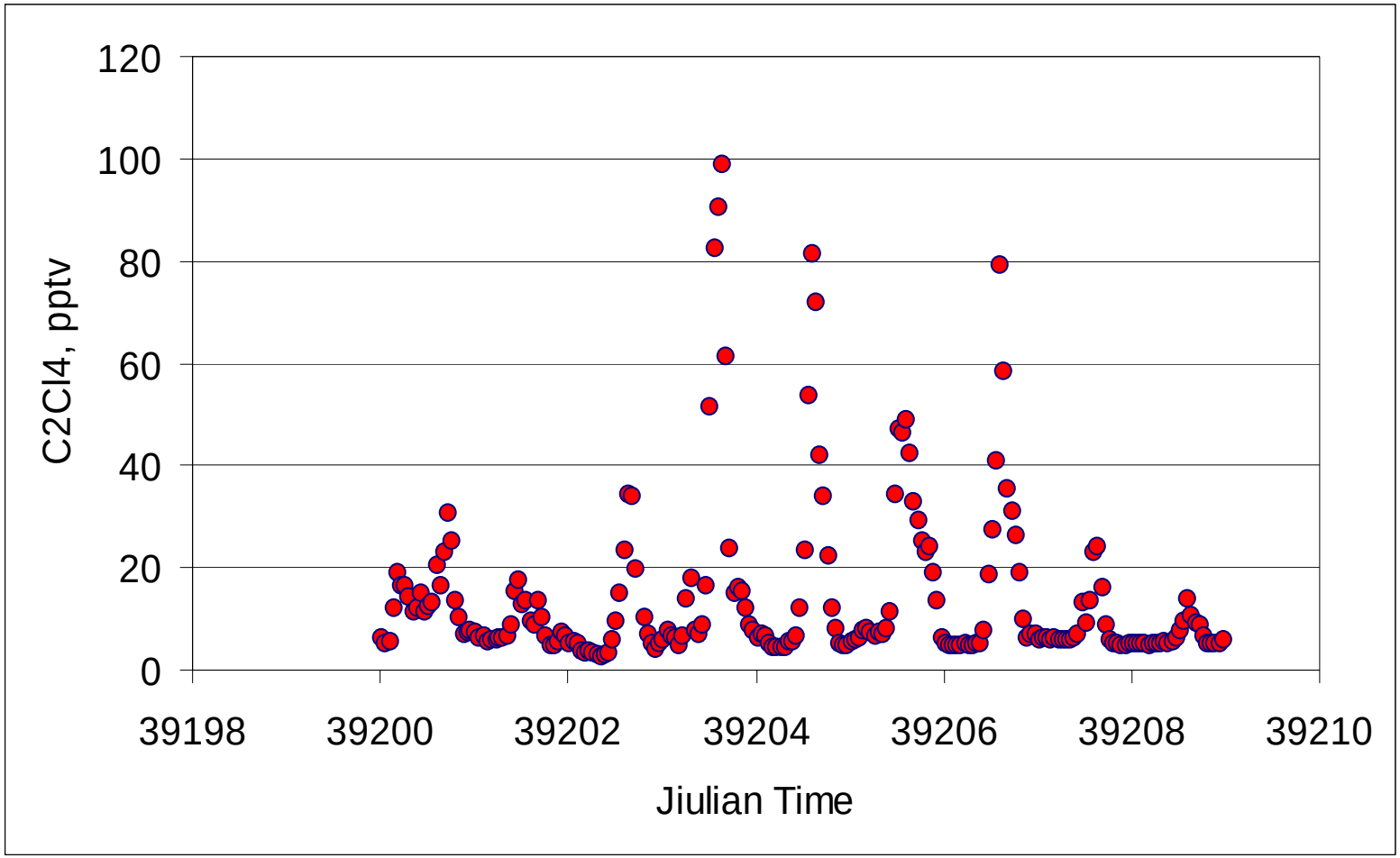
# Is there a “weekend” effect?

- If so it tells us something about usage.
- If not it tells us something about usage.

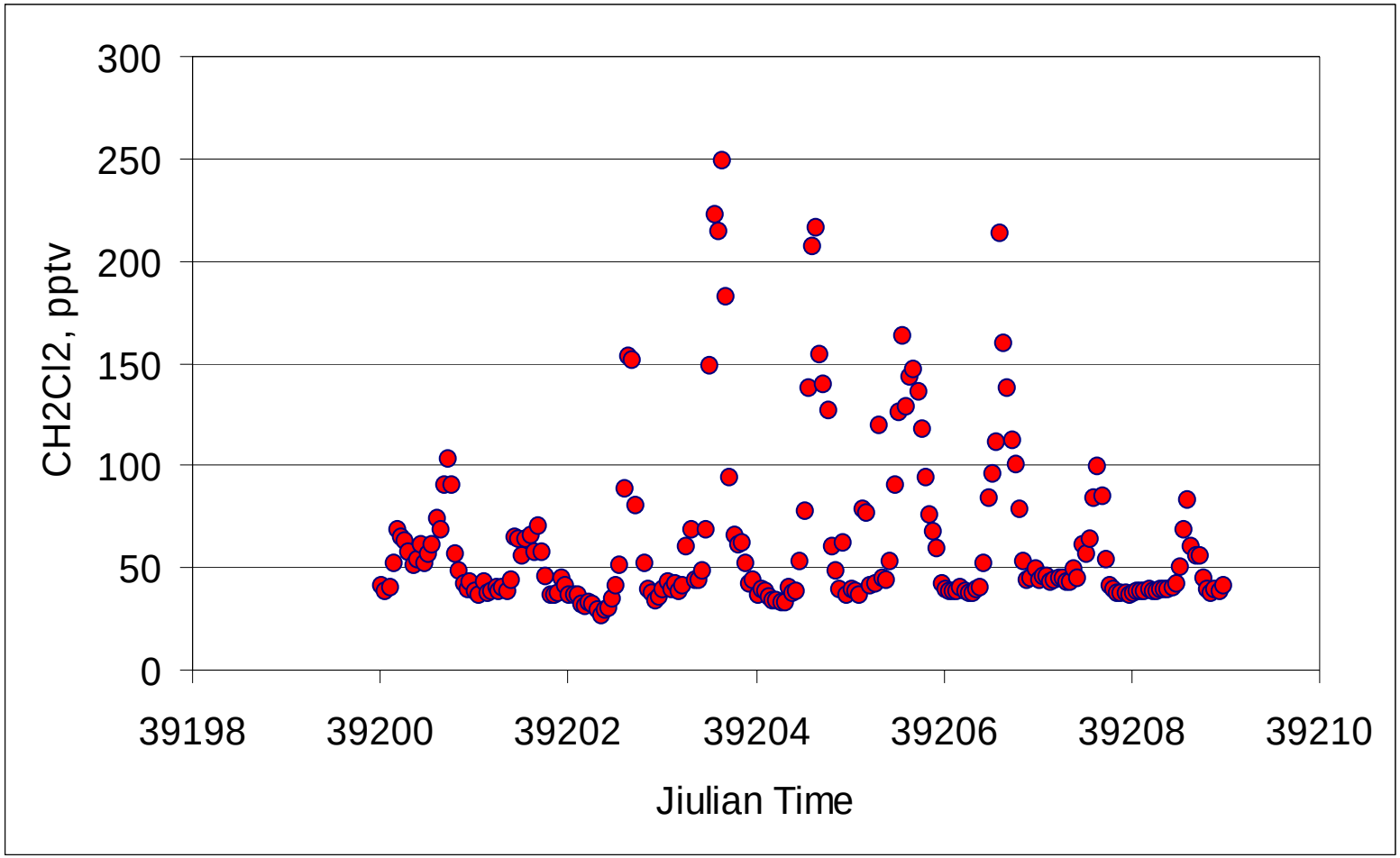
# Mount Wilson



# Mount Wilson



# Mount Wilson



| | | | |
|---|---|---|---|
| Methane ($CH_4$) | Cyclohexane ($C_6H_{12}$) | 1,2,4-Trimethylbenzene ($C_9H_{12}$) | CFC-12 ($CCl_2F_2$) |
| Carbon Monoxide (CO) | 2,2-Dimethylbutane ($C_6H_{14}$) | 1,3,5-Trimethylbenzene ($C_9H_{12}$) | CFC-11 ($CCl_3F$) |
| Carbon Dioxide ($CO_2$) | 2,3-Dimethylbutane ($C_6H_{14}$) | *m*-Ethyltoluene ($C_9H_{12}$) | CFC-113 ($C_2Cl_3F_3$) |
| Ethane ($C_2H_6$) | 2-Methylpentane ($C_6H_{14}$) | *p*-Ethyltoluene ($C_9H_{12}$) | Chloromethane ($CH_3Cl$) |
| Ethene ($C_2H_4$) | 3-Methylpentane ($C_6H_{14}$) | *n*-Decane ($C_{10}H_{22}$) | Bromomethane ($CH_3Br$) |
| Ethyne ($C_2H_2$) | Methylcyclopentane ($C_6H_{12}$) | *α*-Pinene ($C_{10}H_{16}$) | Iodomethane ($CH_3I$) |
| Propene ($C_3H_6$) | *n*-Heptane ($C_7H_{16}$) | *β*-Pinene ($C_{10}H_{16}$) | Trichloromethane ($CHCl_3$) |
| Propane ($C_3H_8$) | Methylcylohexane ($C_7H_14$) | *d*-Limonene ($C_{10}H_{16}$) | Tribromomethane ($CHBr_3$) |
| *i*-Butane ($C_4H_{10}$) | 2-Methylhexane ($C_7H_{16}$) | 1,3-Diethylbenzene ($C_{10}H_{14}$) | Carbon Tertachloride ($CCl_4$) |
| *n*-Butane ($C_4H_{10}$) | 3-Methylhexane ($C_7H_{14}$) | 1,4- Diethylbenzene ($C_{10}H_{14}$) | Tetrachloroethylene ($C_2Cl_4$) |
| 1-Butene ($C_4H_8$) | 2,3-Dimethylpentane ($C_7H_{16}$) | 1,2-Diethylbenzene ($C_10H_{14}$) | 1,2-Dichloroethene ($C_2H_2Cl_2$) |
| *i*-Butene ($C_4H_8$) | 2,4-Dimethylpentane ($C_7H_{16}$) | *n*-Undecane ($C_{11}H_{24}$) | Methyl Chloroform ($CH_3CCl_3$) |
| *trans*-2-Butene ($C_4H_8$) | Toluene ($C_7H_8$) | Acetaldehyde ($CH_3CHO$) | Ethyl Chloride ($C_2H_5Cl$) |
| *cis*-2-Butene ($C_4H_8$) | *n*-Octane ($C_8H_{18}$) | Methanol ($CH_3OH$) | Trichloroethylene ($C_2HCl_3$) |
| 1,3-Butadiene ($C_4H_6$) | Ethylbenzene ($C_8H_{10}$) | Ethanol ($CH_3CH_2OH$) | Dichlorobromomethane ($CHBrCl_2$) |
| *i*-Pentane ($C_5H_{12}$) | *m*-Xylene ($C_8H_{10}$) | Acetone ($CH_3COCH_3$) | Dichloromethane ($CH_2Cl_2$) |
| *n*-Pentane ($C_5H_{12}$) | *p*-Xylene ($C_8H_{10}$) | Isopropanol ($C_3H_8O$) | Dibromomethane ($CH_2Br_2$) |
| 1-Pentene ($C_5H_{10}$) | *o*-Xylene ($C_8H_{10}$) | Propan-1-ol ($C_3H_8O$) | Methyl Nitrate ($CH_3ONO_2$) |
| Isoprene ($C_5H_8$) | 2-Methylheptane ($C_8H_{18}$) | Butanone ($C_4H_8O$) | Ethylnitrate ($C_2H_5ONO_2$) |
| *cis*-2-Pentene ($C_5H_{10}$) | 3-Methylheptane ($C_8H_{18}$) | 2-Pentanone ($C_5H_{10}O$) | *i*-Propylnitrate ($C_3H_7ONO_2$) |
| *trans*-2-Pentene ($C_5H_{10}$) | 2,2,4-Trimethylpentane ($C_8H_{18}$) | 3-Pentanone ($C_5H_{10}O$) | *n*-Propylnitrate ($C_3H_7ONO_2$) |
| 2-Methyl-2-Butene ($C_5H_{10}$) | 2,3,4-Trimethylpentane ($C_8H_{18}$) | Methyl Isobutyl Ketone ($C_6H_{12}O$) | 2-Butylnitrate ($C_4H_9ONO_2$) |
| Cyclopentane ($C_5H_{10}$) | *n*-Nonane ($C_9H_{20}$) | Carbonyl Sulfide (OCS) | 2-Pentylnitrate ($C_5H_{11}ONO_2$) |
| *n*-Hexane ($C_6H_{14}$) | *i*-Propylbenzene ($C_9H_{12}$) | Carbon Disulfide ($CS_2$) | 3-Pentylnitrate ($C_5H_{11}ONO_2$) |
| *cis*-3-Hexene ($C_6H_{12}$) | *n*-Propylbenzene ($C_9H_{12}$) | Dimethyl Disulfide ($C_2H_6S_2$) | |
| Benzene ($C_6H_6$) | 1,2,3-Trimethylbenzene ($C_9H_{12}$) | Dimethyl selenium ($C_2H_6Se$) | |

# What makes a gas a greenhouse gas?

**Able to absorb infrared light**

- **Must have molecular vibration(s)**
  - **Excludes monoatomic gases like Argon**
- **The molecular vibrations must be non-symmetric, i.e. infrared active**
  - **Homonuclear diatomic molecules only have symmetric vibrations. That's why $N_2$, $O_2$ are not greenhouse gases.**

**$CO_2$ $CH_4$ $N_2O$**

**$O_3$ CFCs $SF_6$ $H_2O$**

# Genealogy

Joseph Louis Gay-Lussac
Laws about combining gases
(1778-1850)

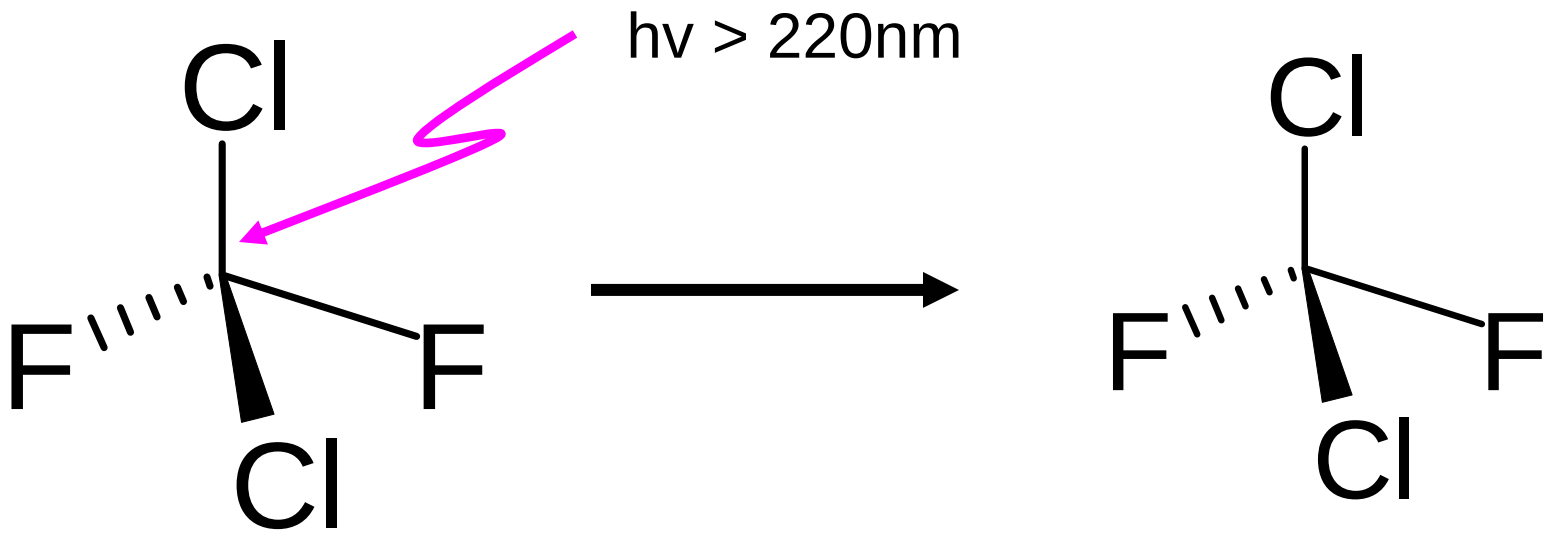
Willard Frank Libby
Nobel Prize 1960: $^{14}C$ Dating
(1908-1980)

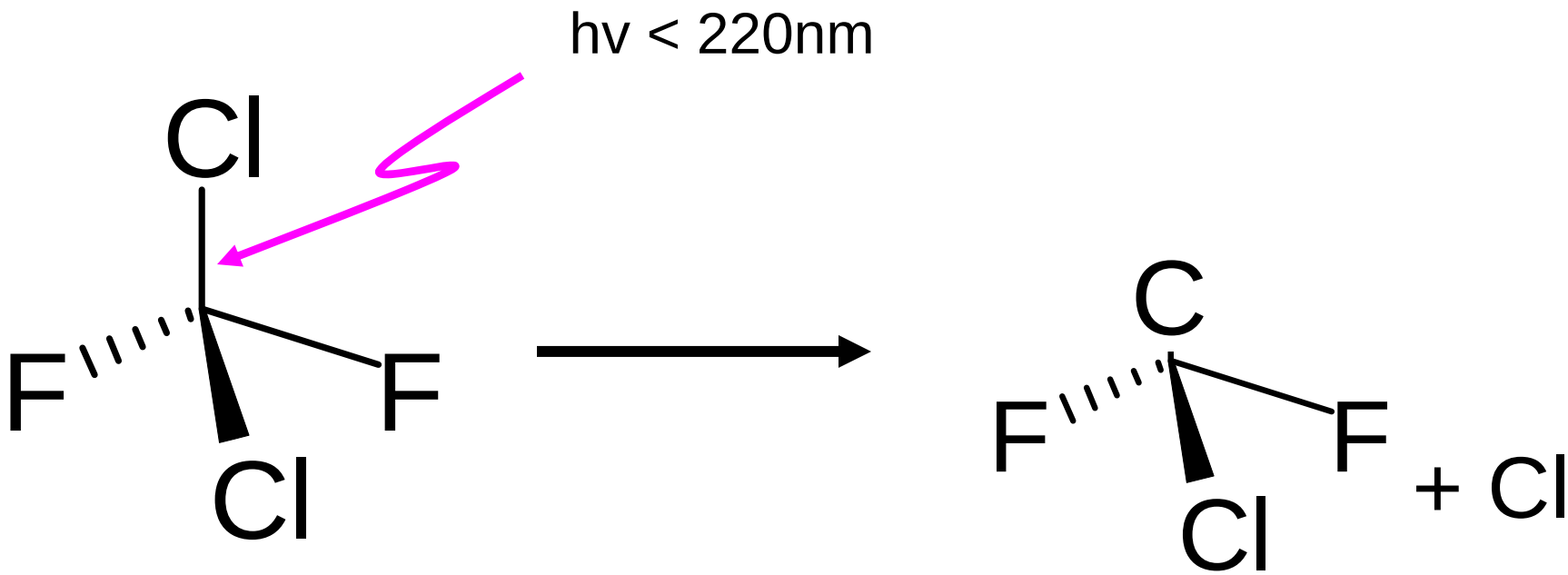
F. Sherwood Rowland
Nobel Prize 1995:
Stratospheric ozone

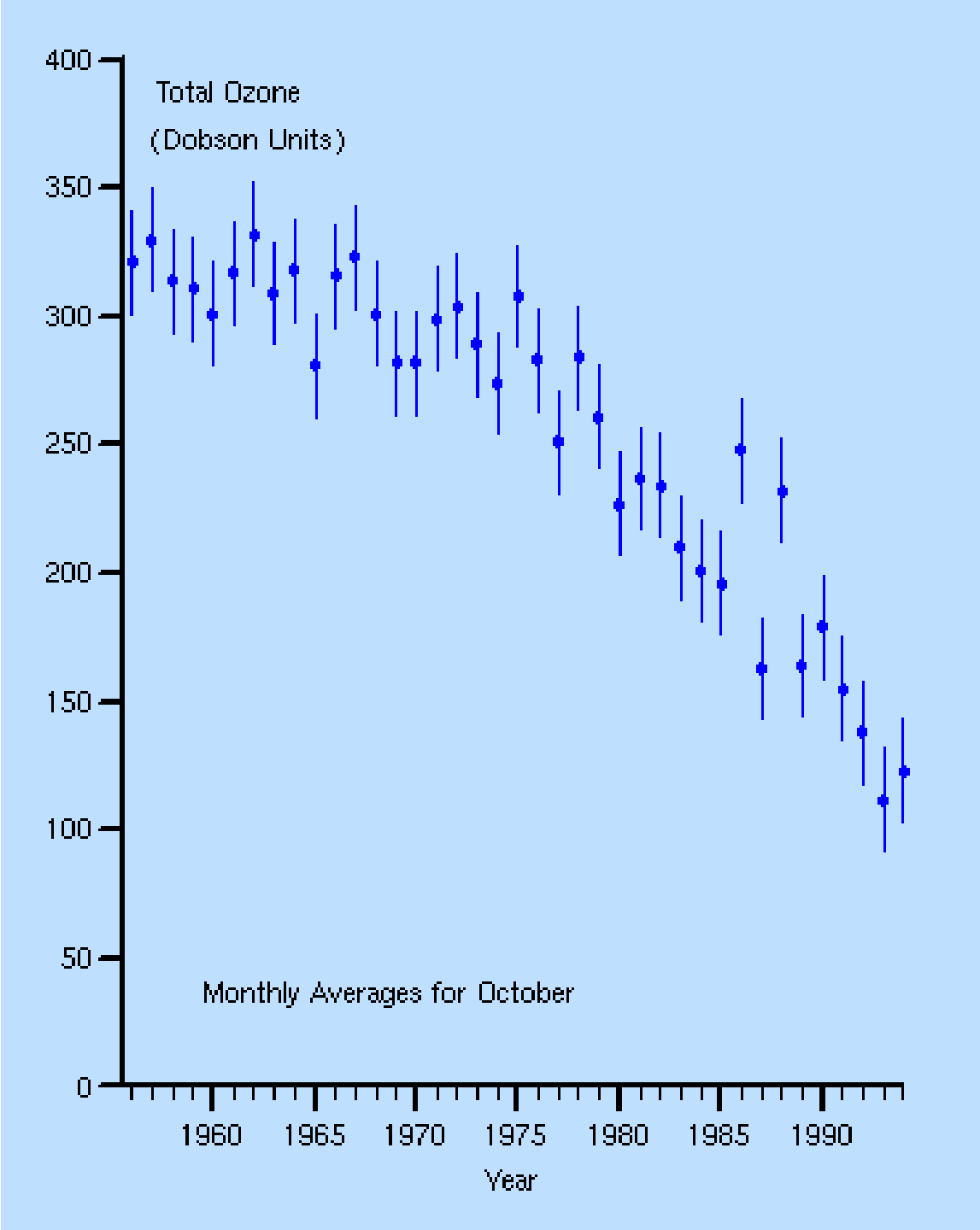
Donald R. Blake
Hasn’t done much

Nobel Prize Ceremony 1995
– 21 years after first ozone publication

Post Ceremony Dinner With 1320 Guests

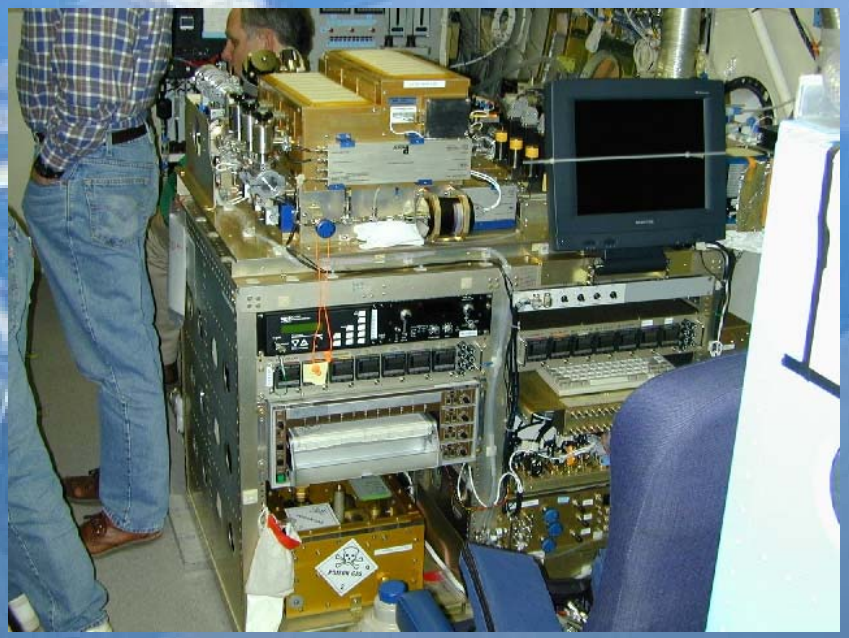

hv > 220nm
Cl
F
F
Cl
Cl
F
F
Cl


hv < 220nm
Cl
F
F
Cl
C
F
F
Cl
+ Cl

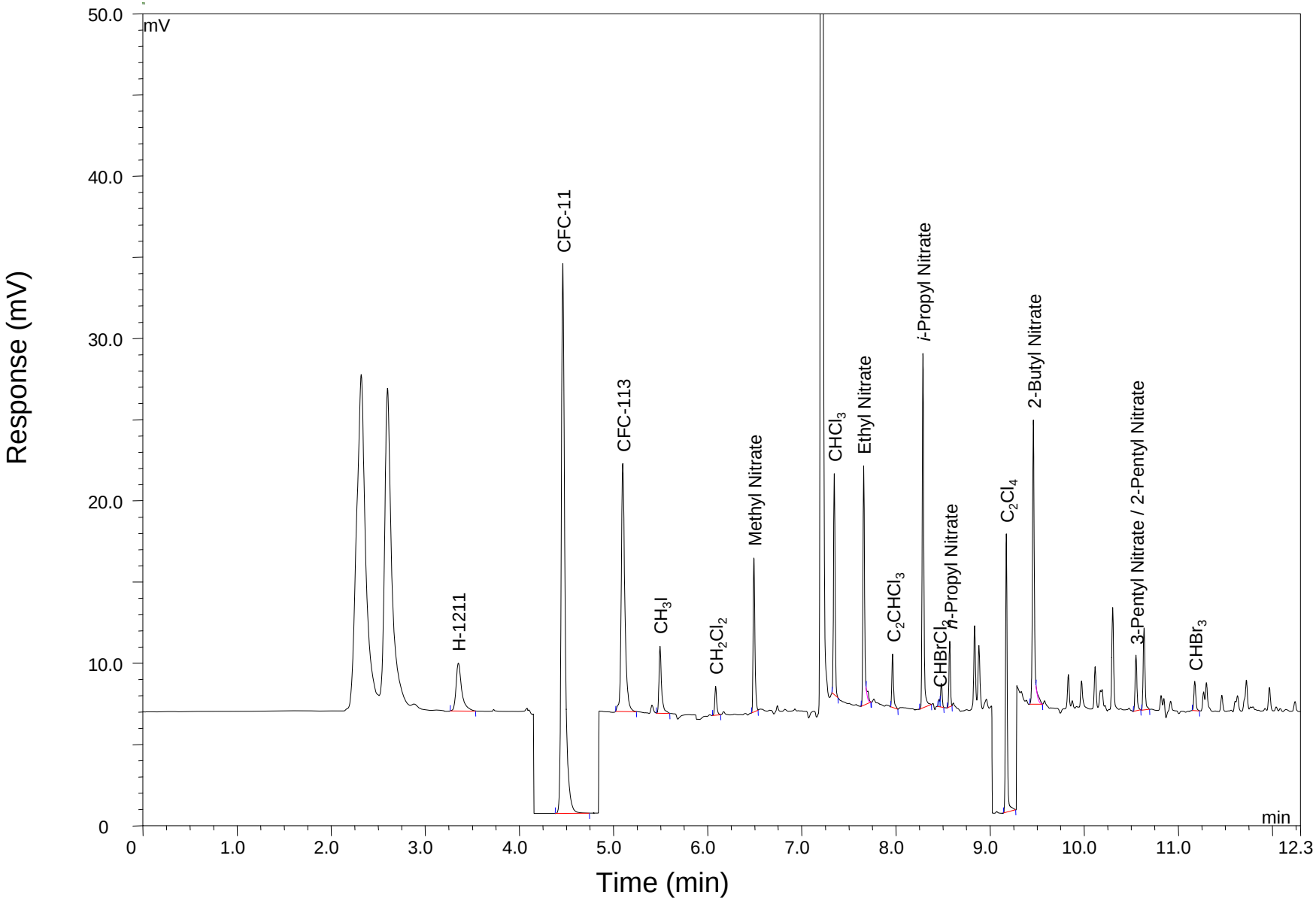

Total Ozone
(Dobson Units)
400
350
300
250
200
150
100
50
0
Monthly Averages for October
1960
1965
1970
1975
1980
1985
1990
Year

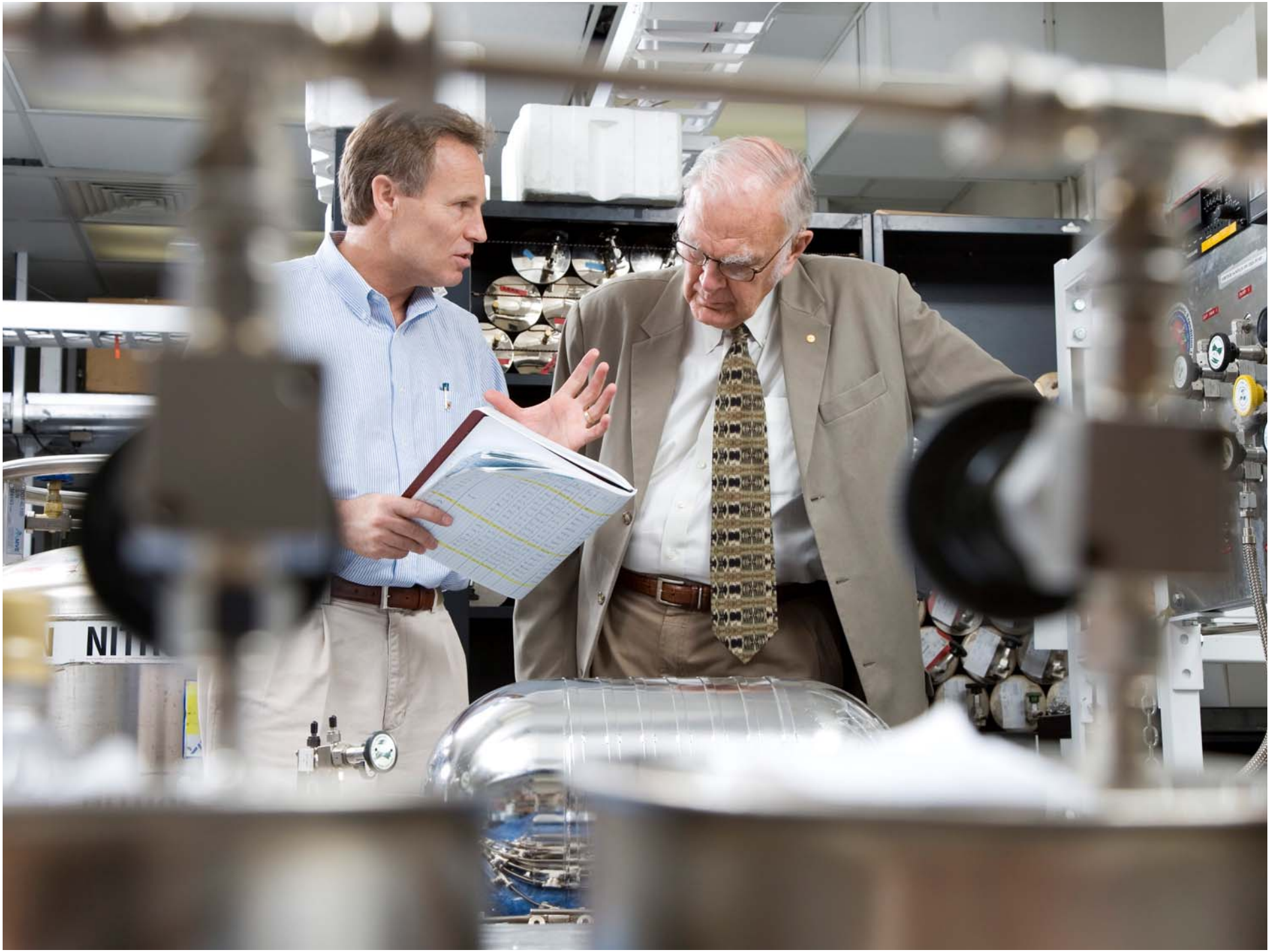
**Blake rack**

**Ridley rack**



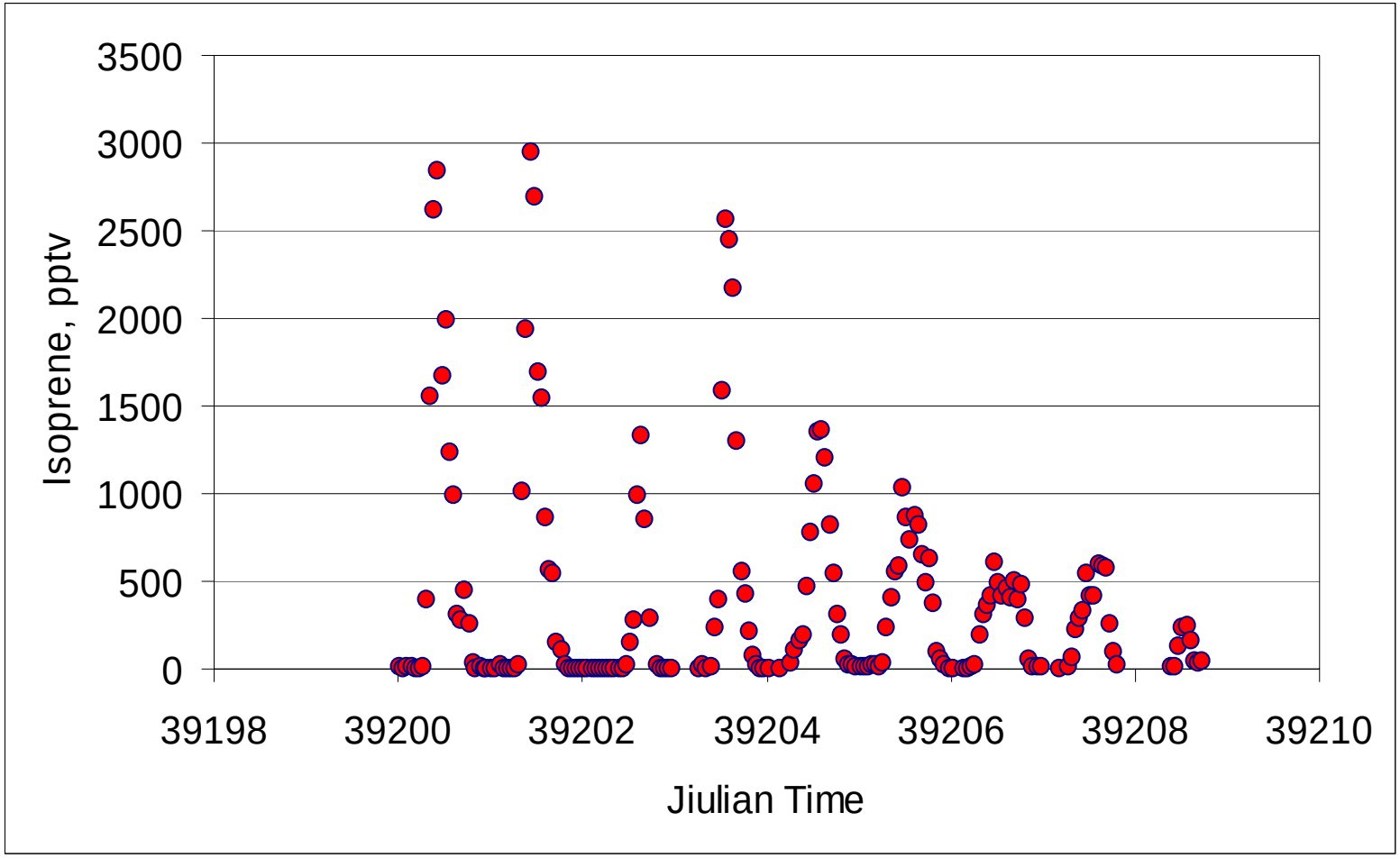
# Sample Chromatogram



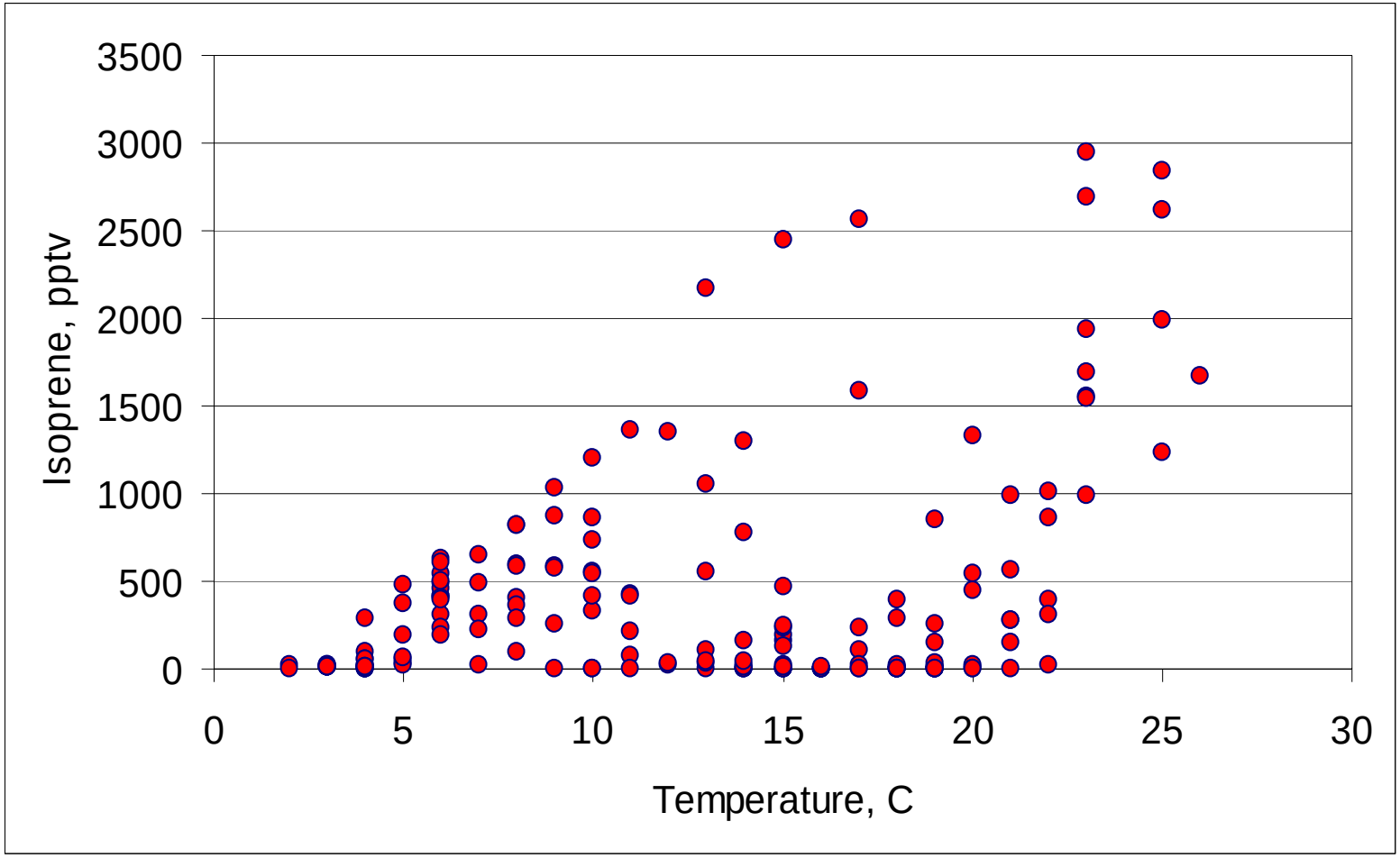


# University of California, Irvine 6-Column System

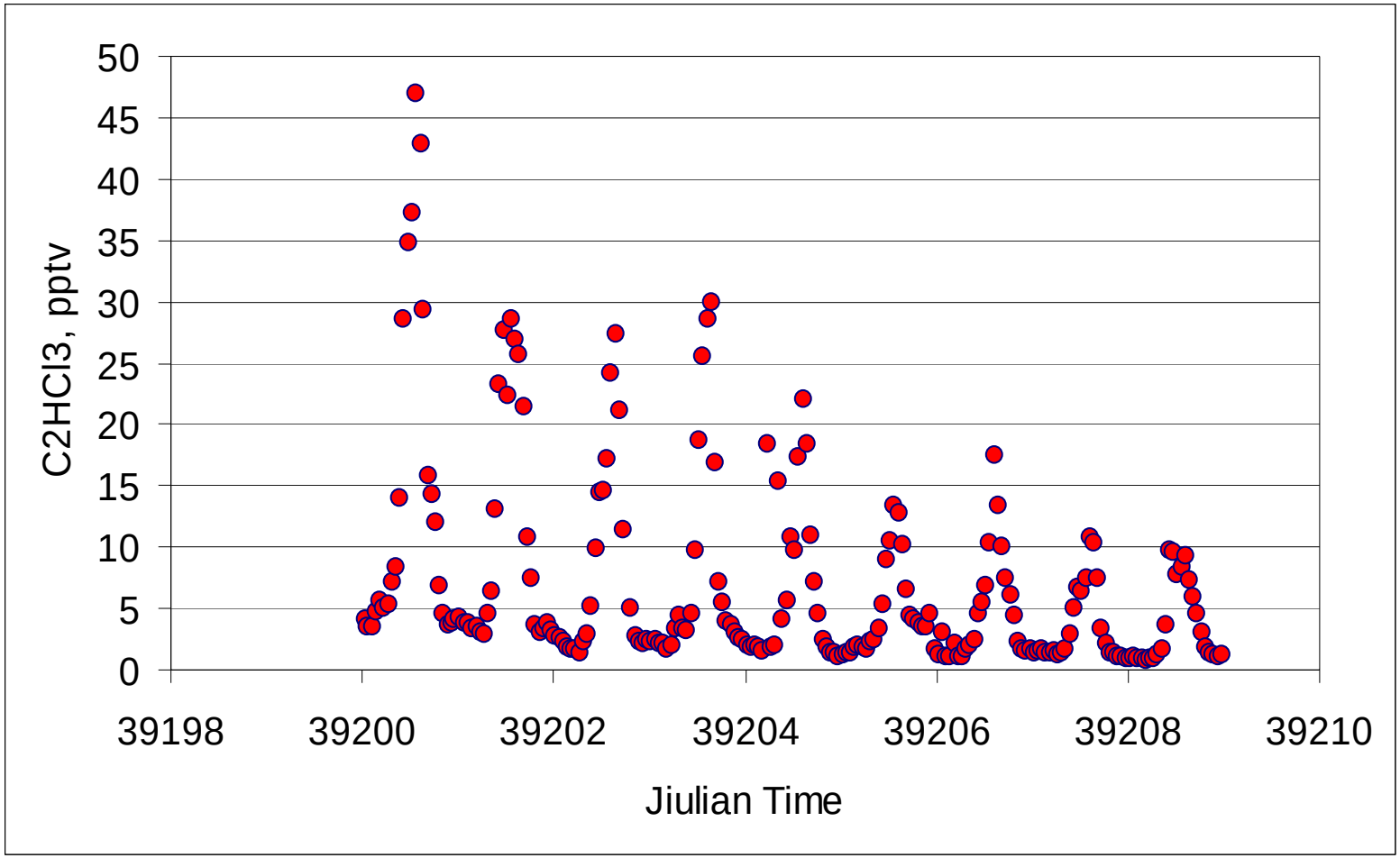
# Mount Wilson



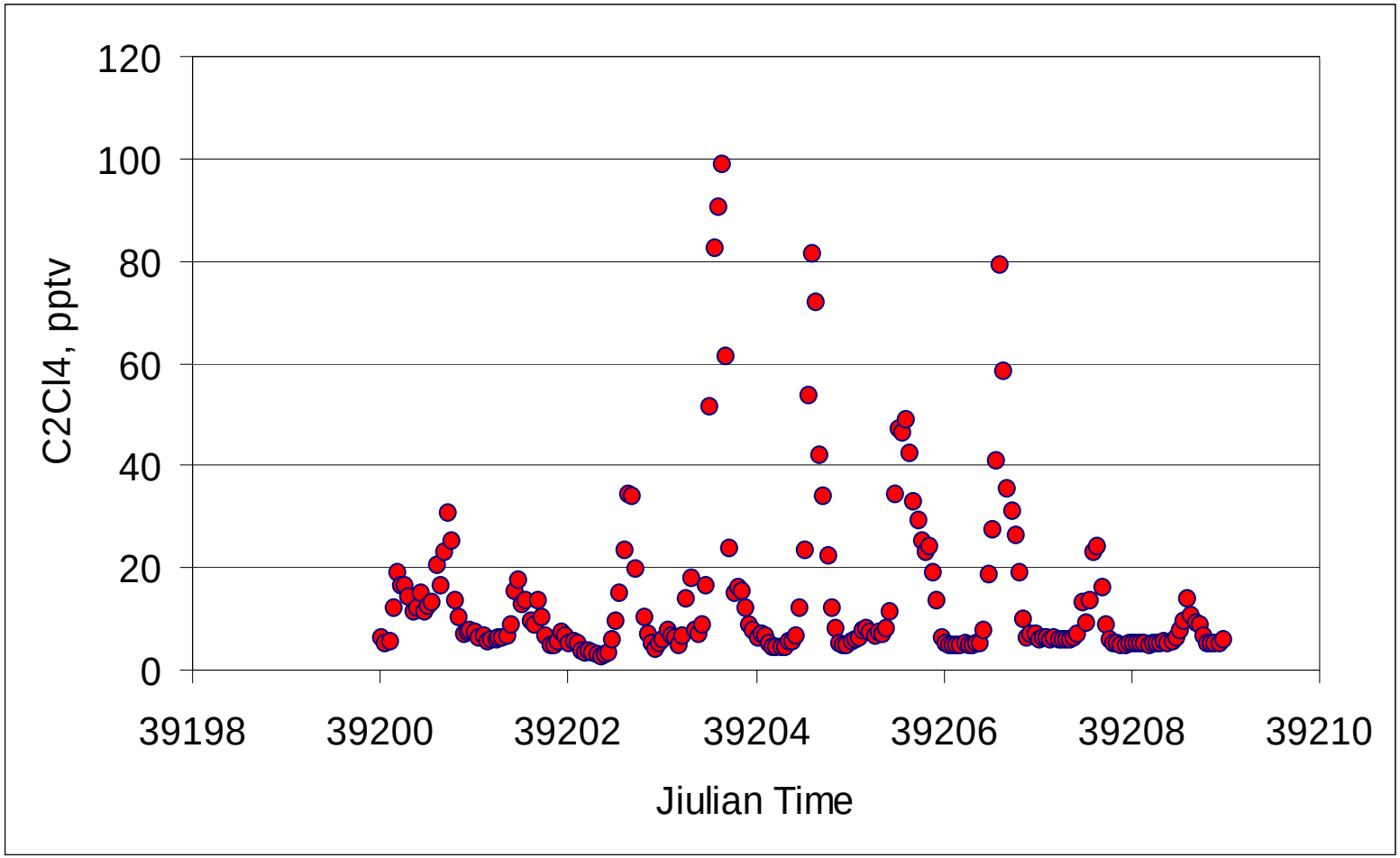
# Mount Wilson



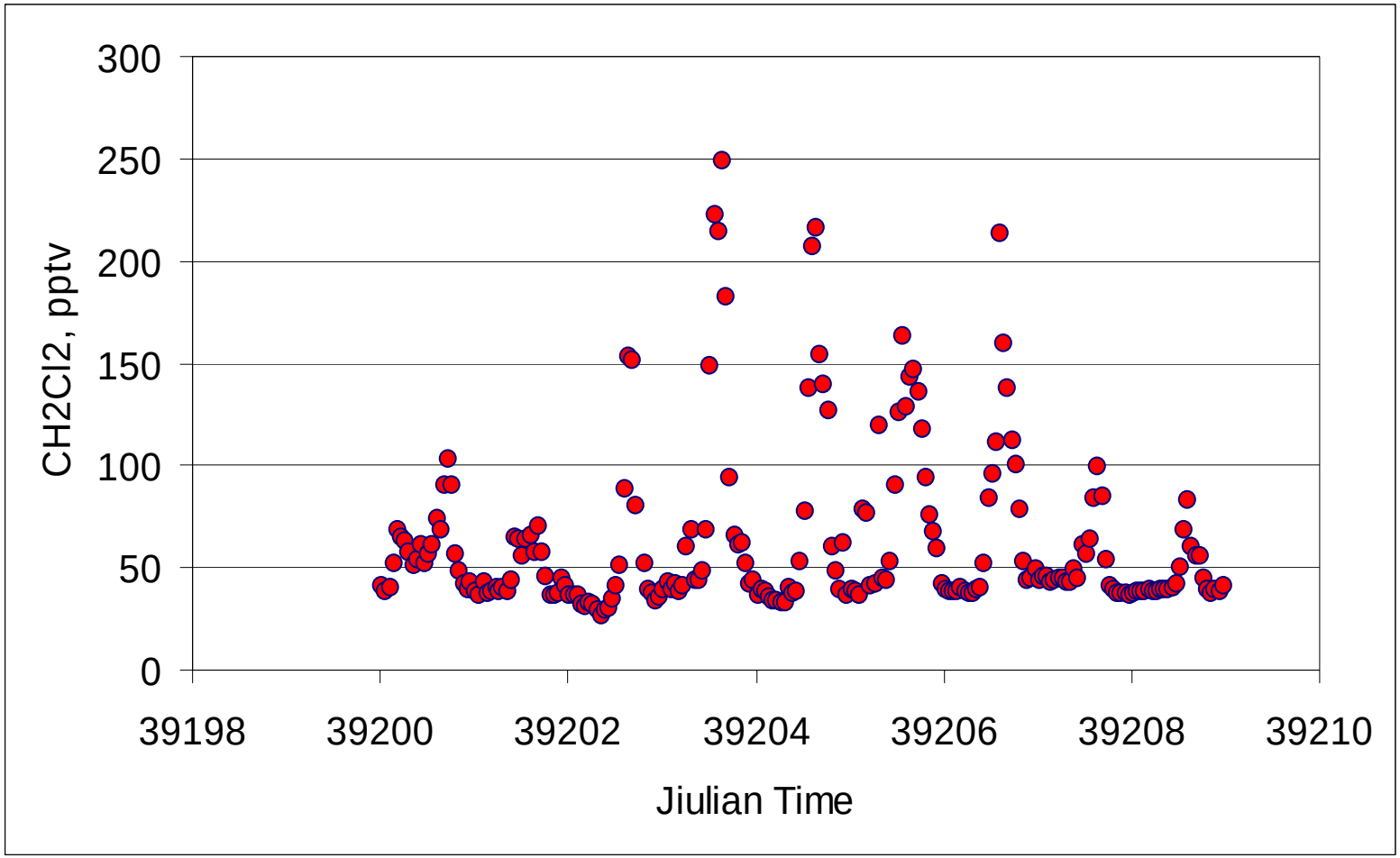
# Mount Wilson



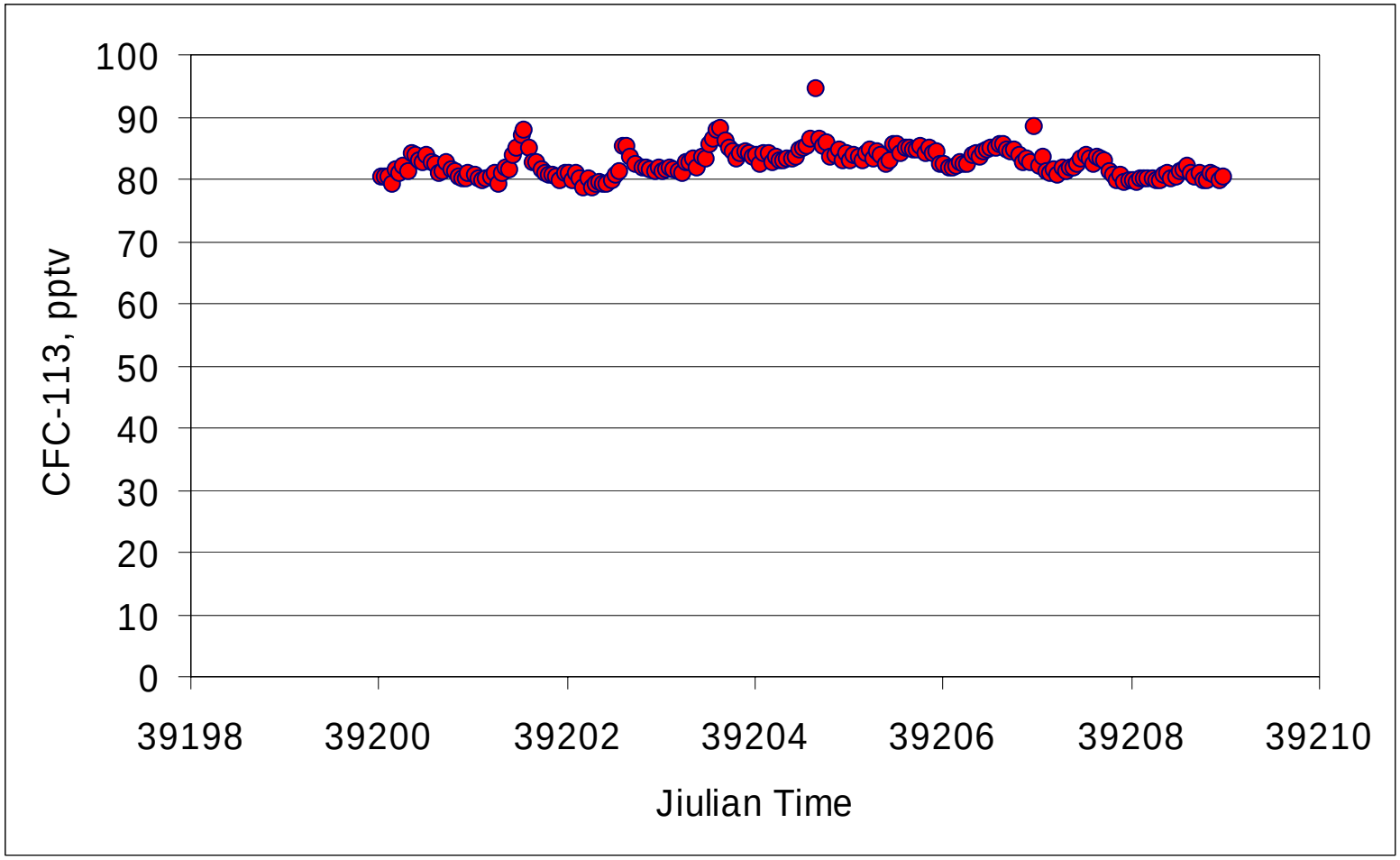
# Mount Wilson



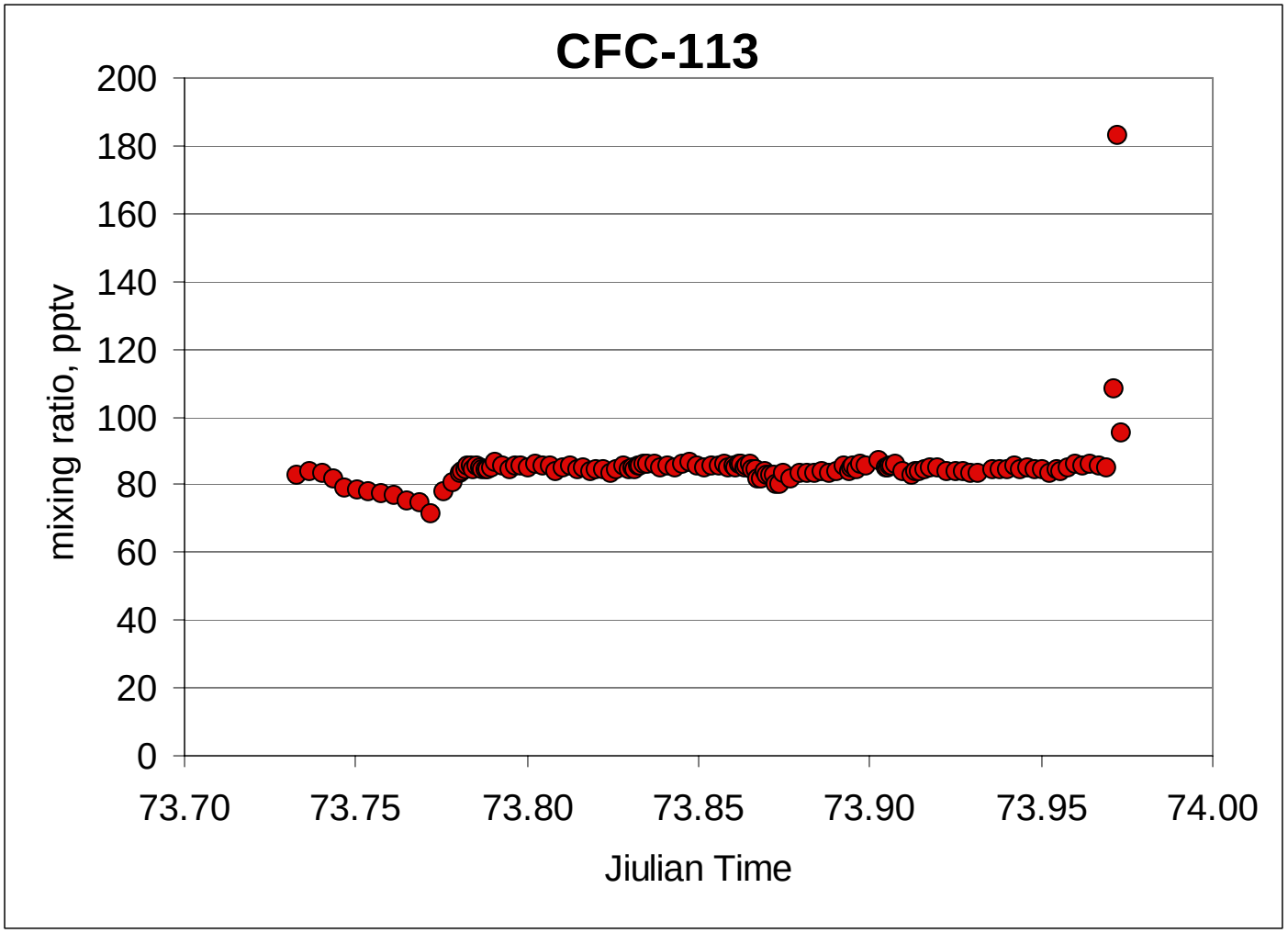
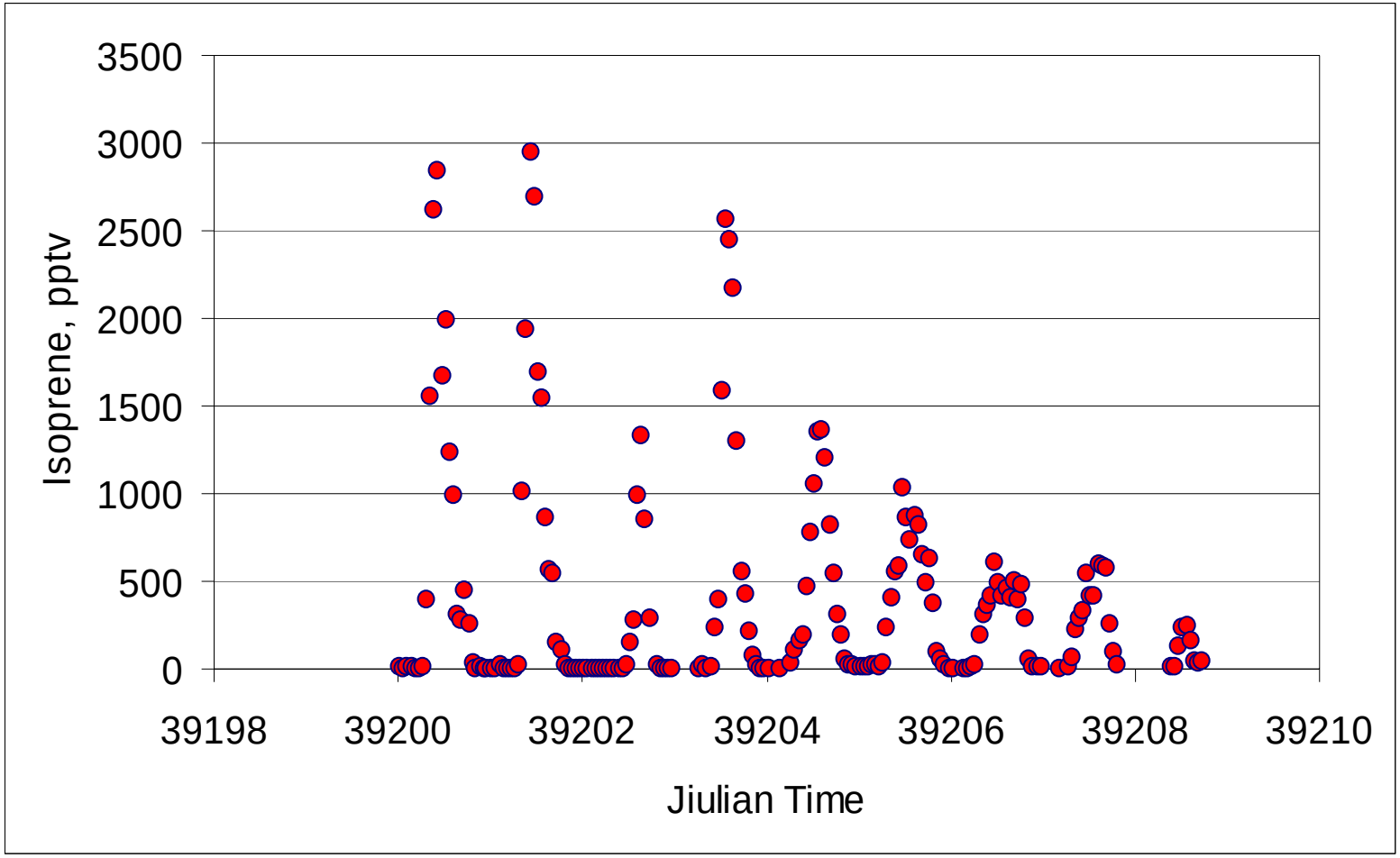
# Mount Wilson



# Mount Wilson CFC-113 vs time



# PEM-West B 1994 flight from Japan to San Jose



# Mount Wilson, April 28-May 6, 2007