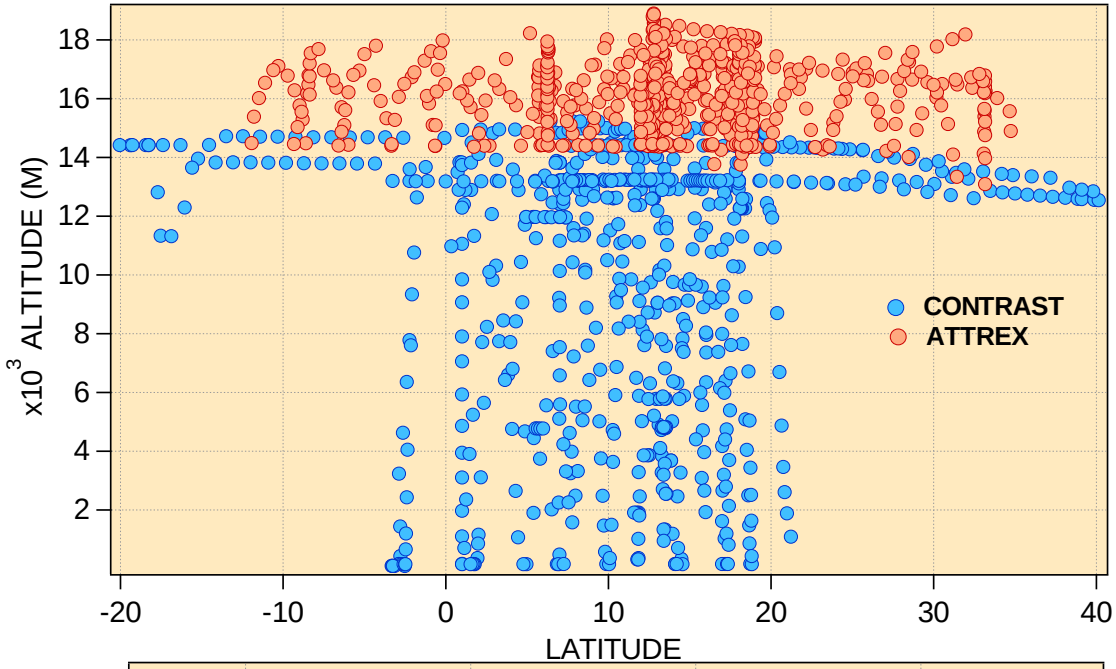
Organic Halogen and Related Trace Gases in the Tropical Atmosphere: Results from Recent Airborne Campaigns over the Pacific

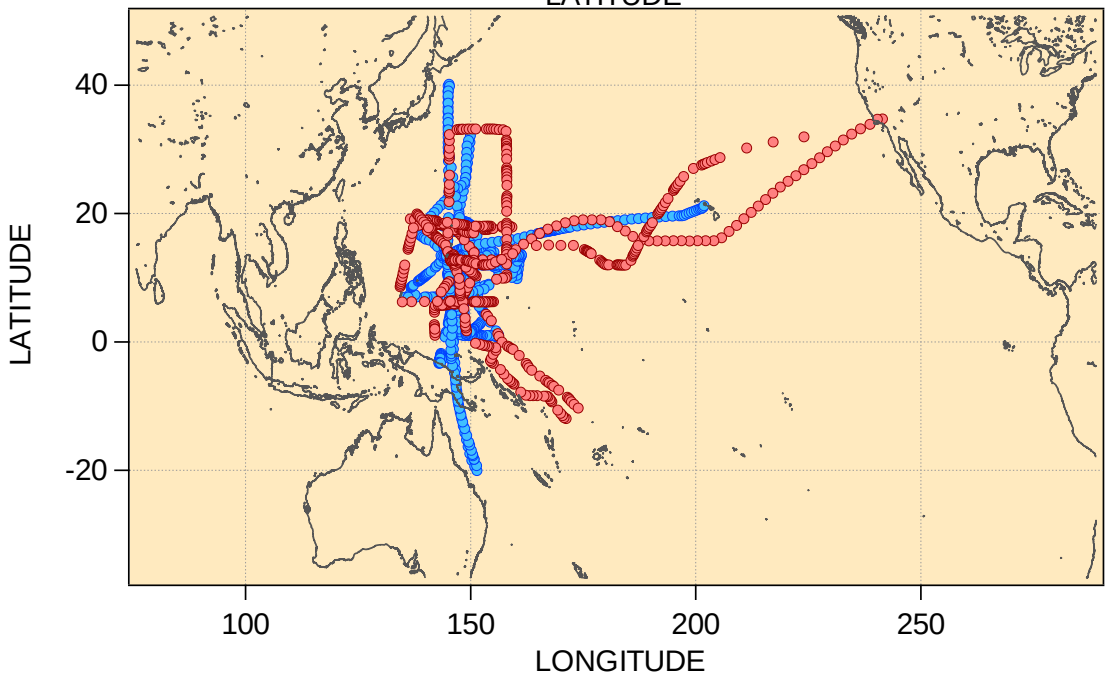
Elliot Atlas[1], Maria Navarro[1], Valeria Donets[1], Sue Schauffler[2], Rich Lueb[1], Roger Hendershot[2], Steve Gabbard[2], Rebecca Hornbrook[2], Eric Apel[2], Dan Riemer[1], Laura Pan[2], Ross Salawitch[3], Julie Nicely[3], Steve Montzka[4], Ben Miller[4,5], Fred Moore[4,5], James W. Elkins[4], Eric Hintsa[4,5],Teresa Campos[2], Birgit Quack[6], Xiaorong Zhu[1], Leslie Pope[1] + SHIVA, ATTREX and CONTRAST teams

[1] RSMAS, University of Miami, Miami, FL
[2] Atmospheric Chemistry Division, NCAR, Boulder, CO
[3] University of Maryland, College Park, MD
[4] ESRL, NOAA, Boulder, CO
[5] CIRES, NOAA, Boulder, CO
[6] GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany

Motivation

- How does tropical convection in the West Pacific influence the composition of air entering the stratosphere?
  - CONTRAST: define vertical distributions, variations, sources; transport to/into the base of the TTL
  - ATTREX: evaluate variation and transport through TTL and into lower stratosphere.





AWAS Sample Locations

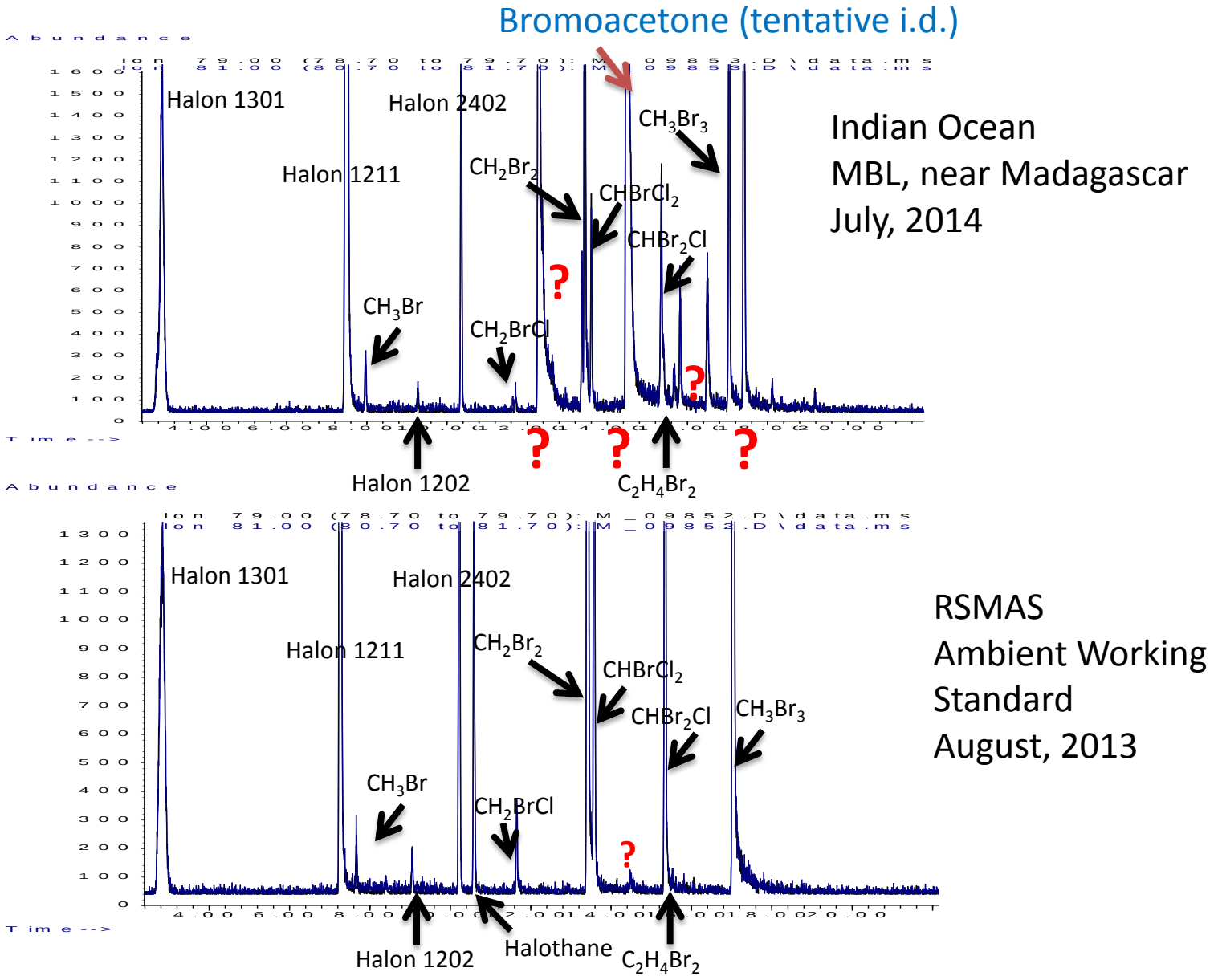
Focus on AWAS tracers

- Organic Halogen Distribution/Budget
  - Distribution/Composition
  - Comparisons to recent studies
    - HIPPO (H1: January, 2009), SHIVA (S. China Sea, Nov, 2011 – Sala et al., ACP, 2014), TC4 (August,2007)
- Tracer/Tracer correlations
  - relationships from lower troposphere to UT/LS
- Example TTL tracer profiles
  - relation to clouds/convective outflow

Tracer Selection

- Organic Halogen (VSLS)
  - →Br: $CHBr_3$, CH_2Br_2, $CHBrCl_2$, $CHBr_2Cl$, CH_2BrCl, + ?
  - →I: CH_3I
  - →Cl: $CHCl_3$, C_2Cl_4
- Organic Nitrates
  - →Methyl nitrate (CH_3ONO_2)
- Hydrocarbons
  - →C2: Ethane (C_2H_6), Ethyne (C_2H_2)

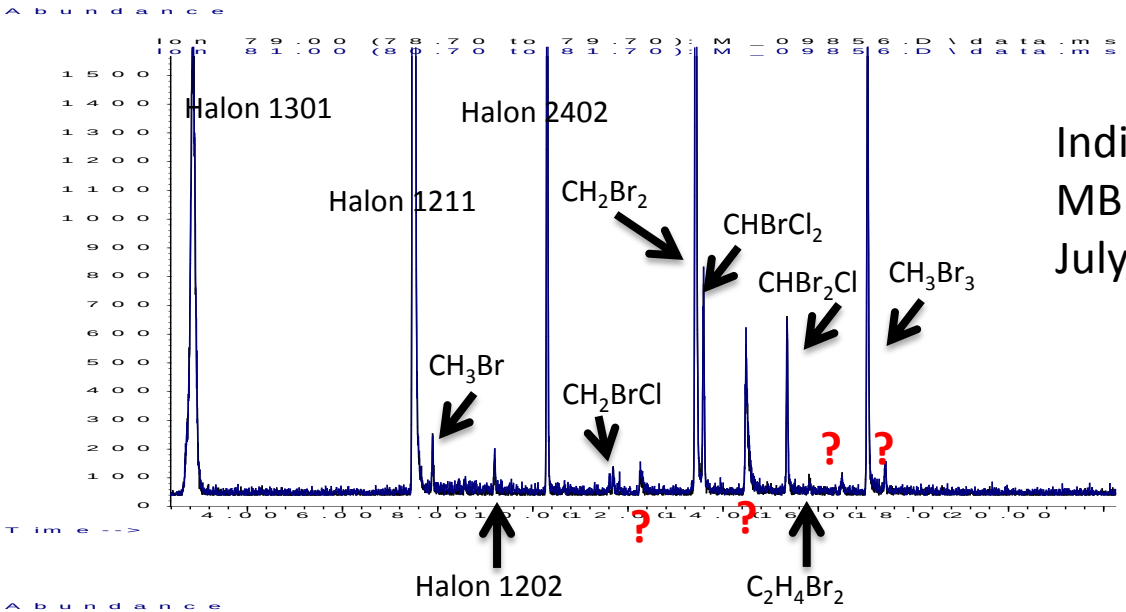
Bromine signal (79,81) NICI GC/MS



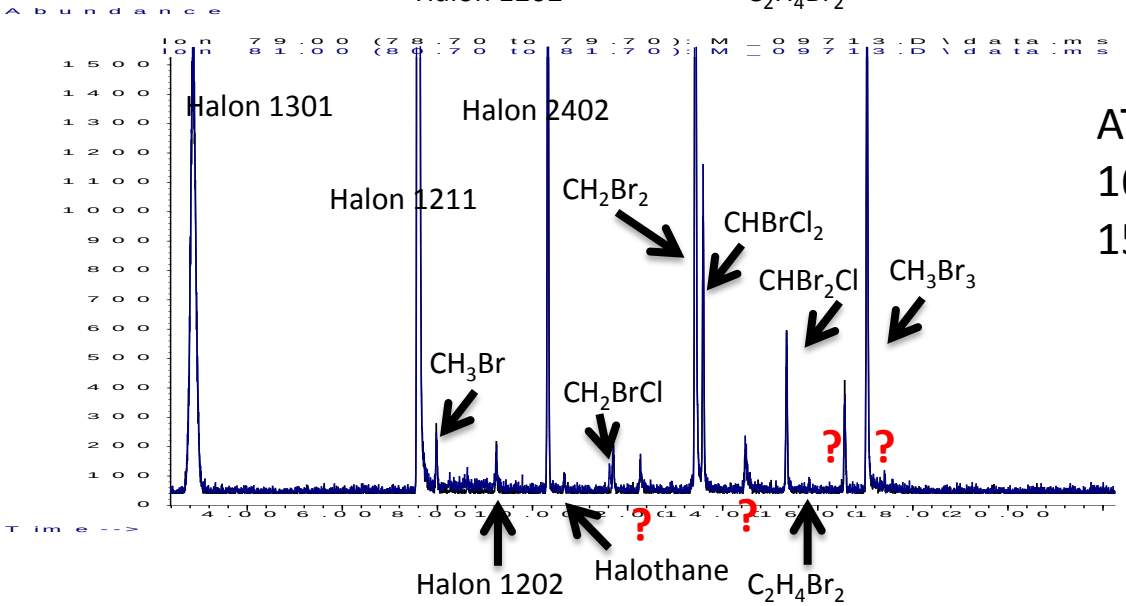
Indian Ocean
MBL, near Madagascar
July, 2014

RSMAS
Ambient Working
Standard
August, 2013

Bromine signal (79,81) NICI GC/MS

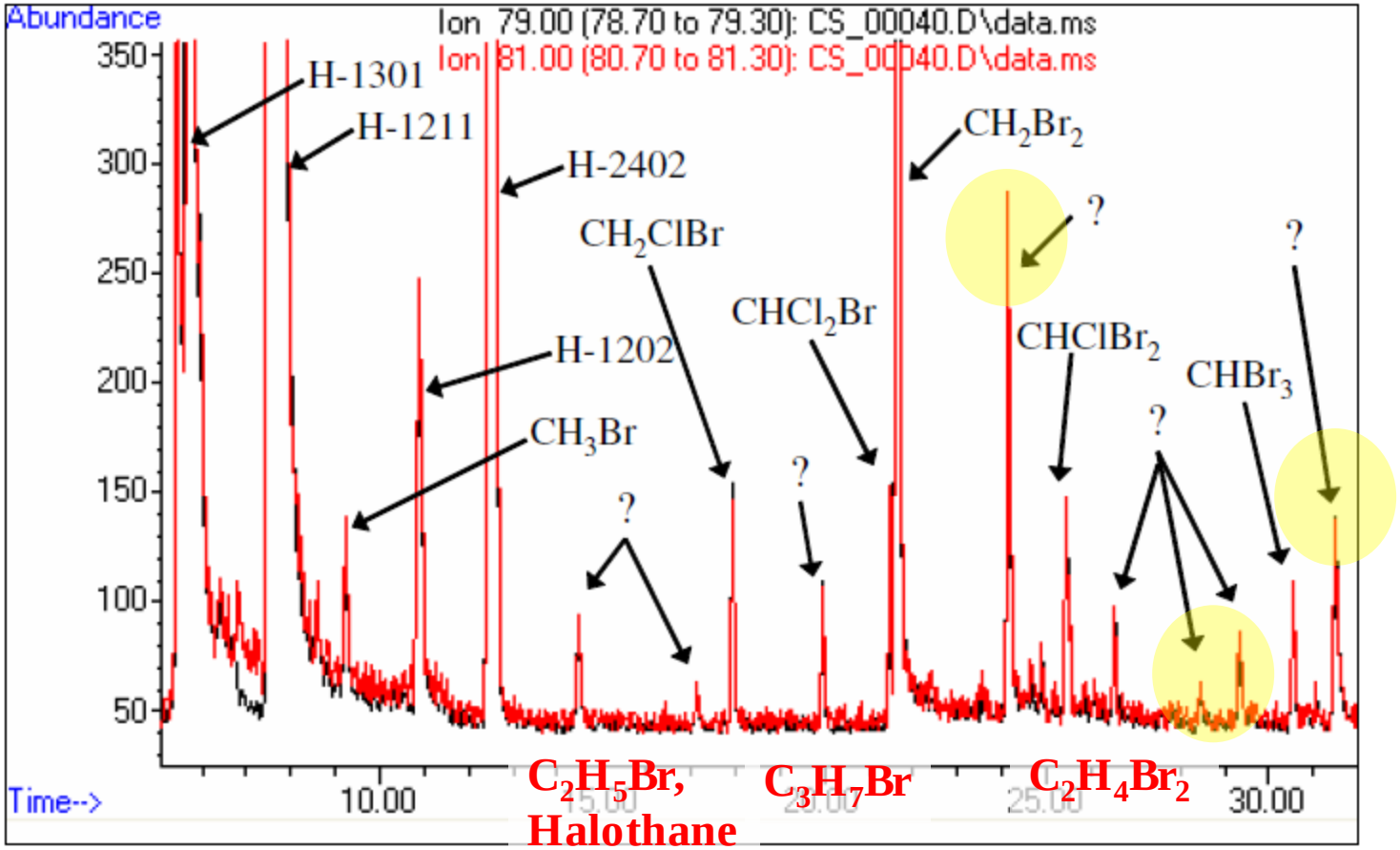


Indian Ocean
MBL
July, 2014



ATTREX RF07
16.6N
15.8 km

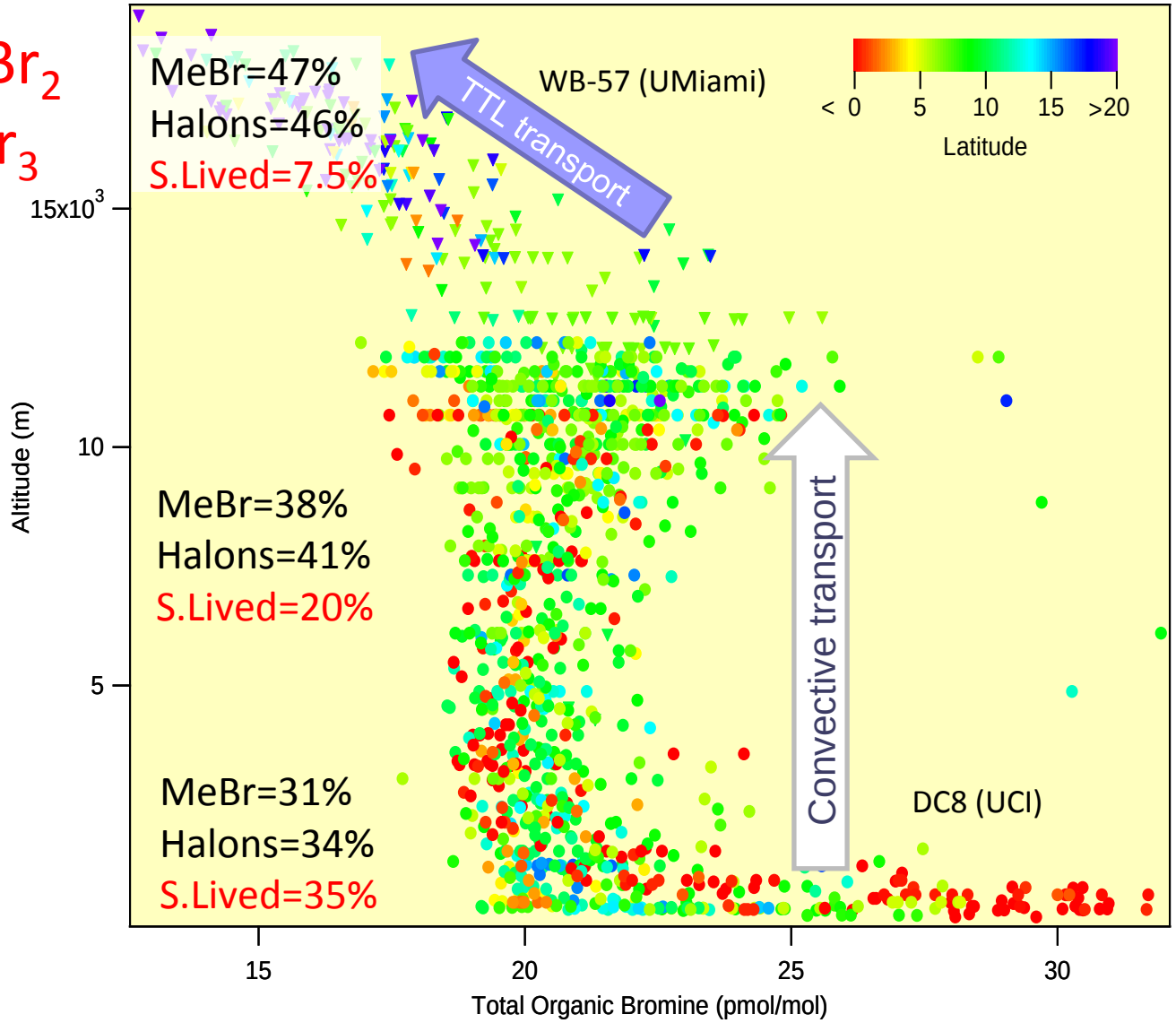
Bromine signal (79,81) NICI GC/MS (from Laube et al., ACP, 2008)



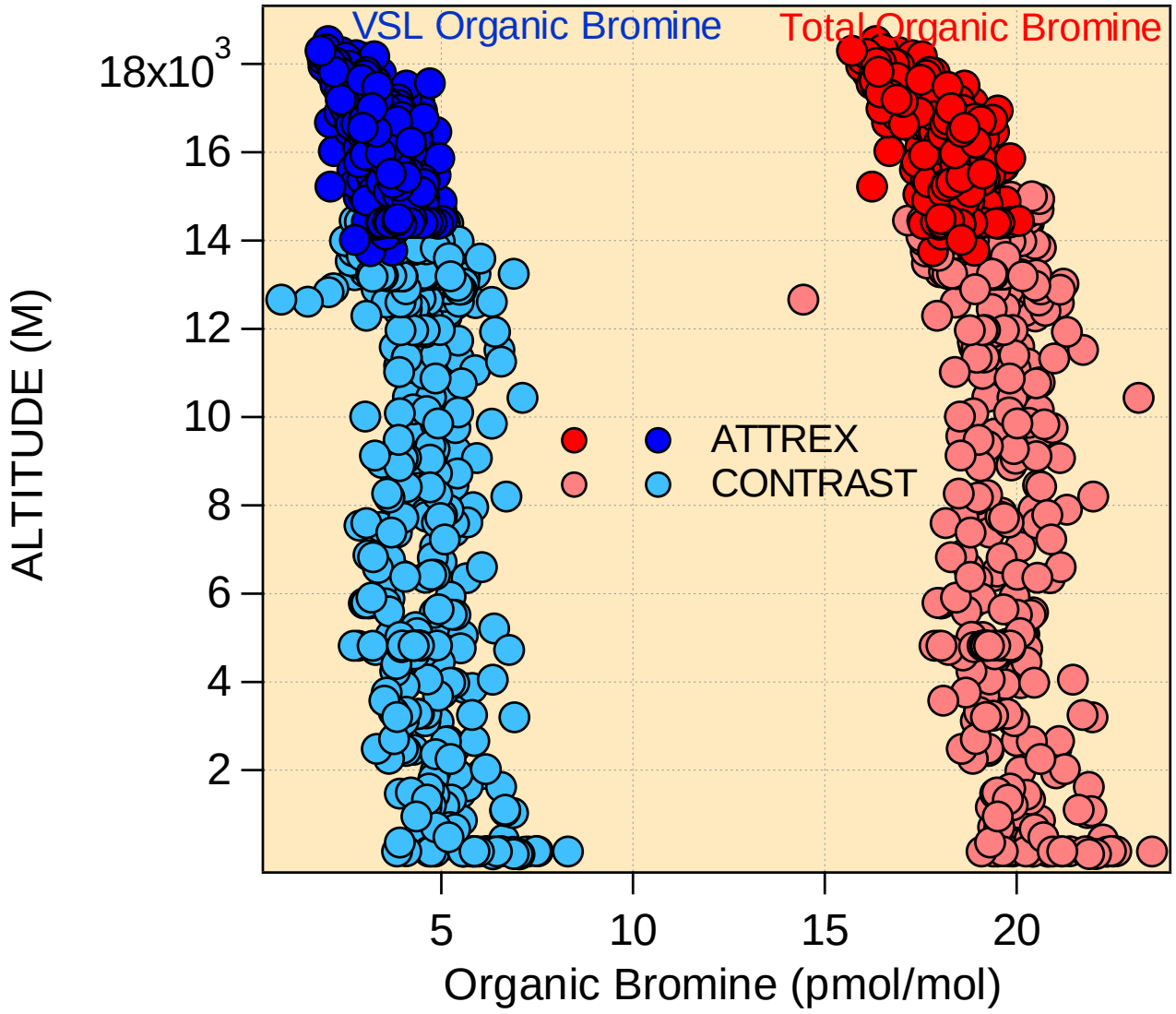
Cryogenic air sample, 15.2 km, Teresina, Brazil (5.4° S), 8 June 2005

Organic Bromine over the Eastern Pacific (TC4)

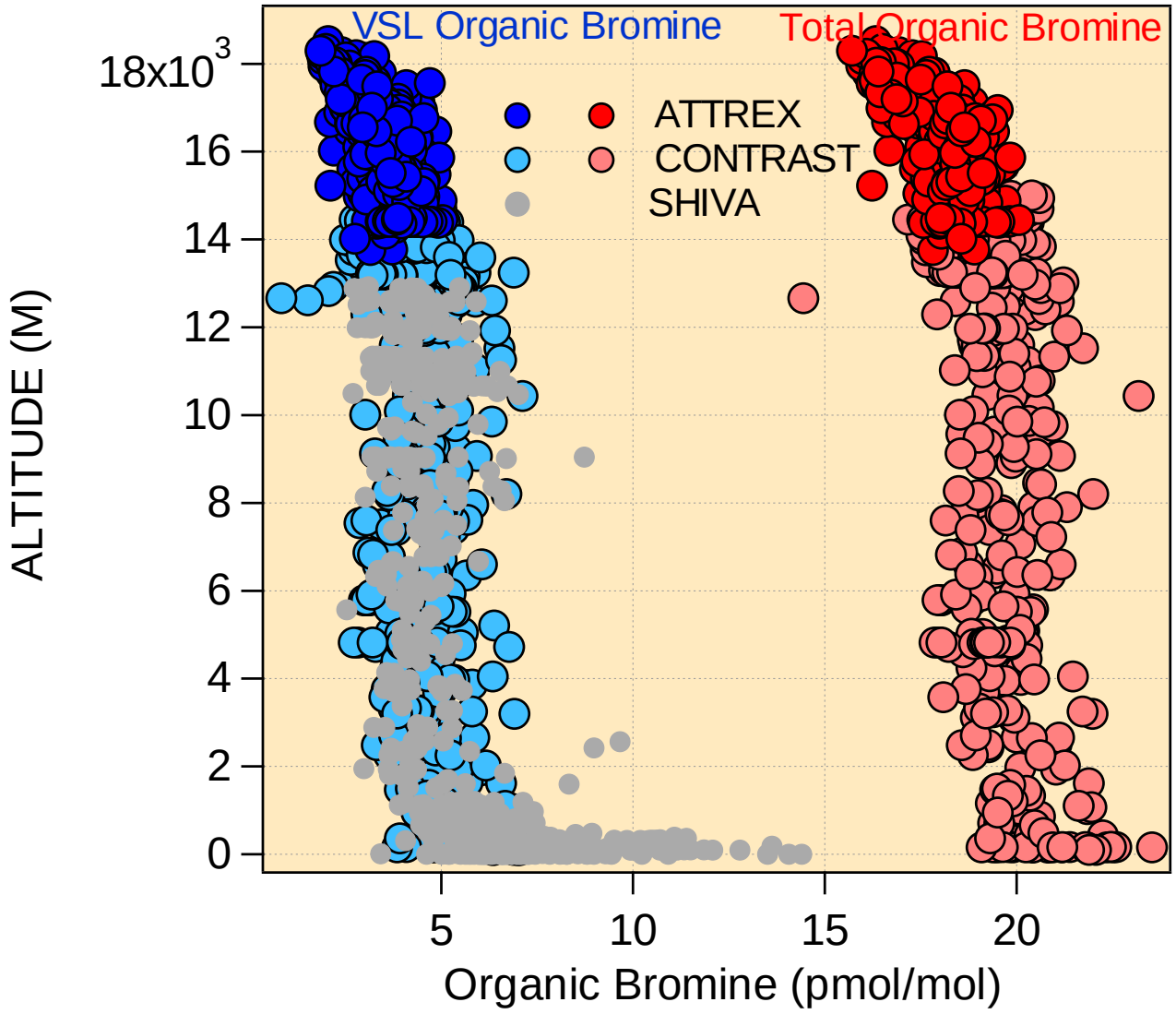
65% CH_2Br_2
20% $CHBr_3$



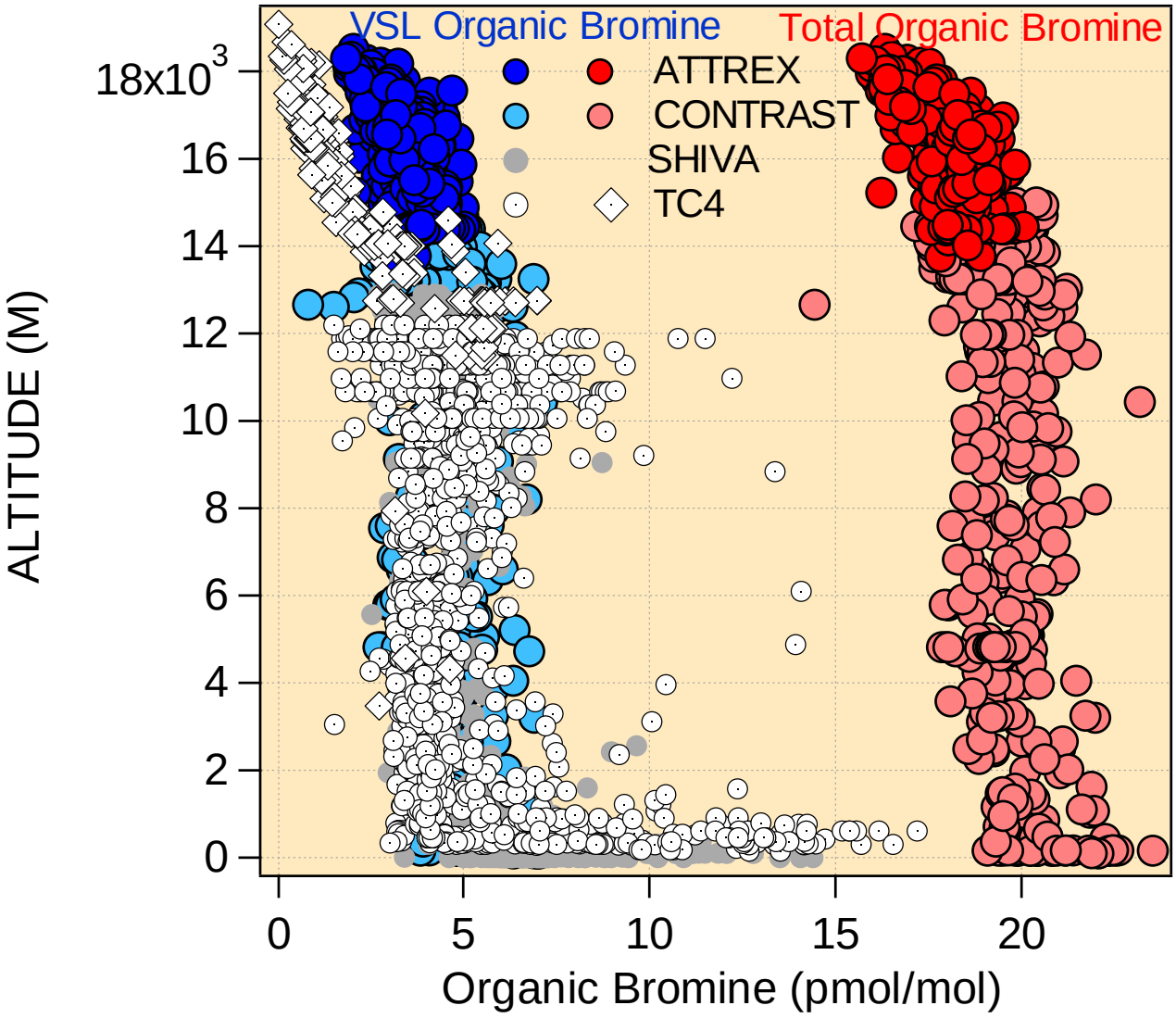
Organic Bromine – CONTRAST/ATTREX



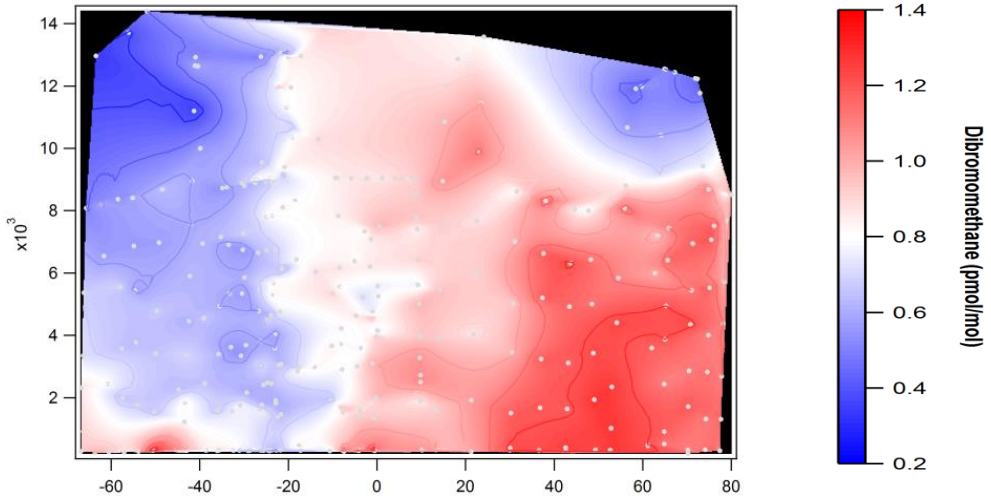
Organic Bromine + SHIVA

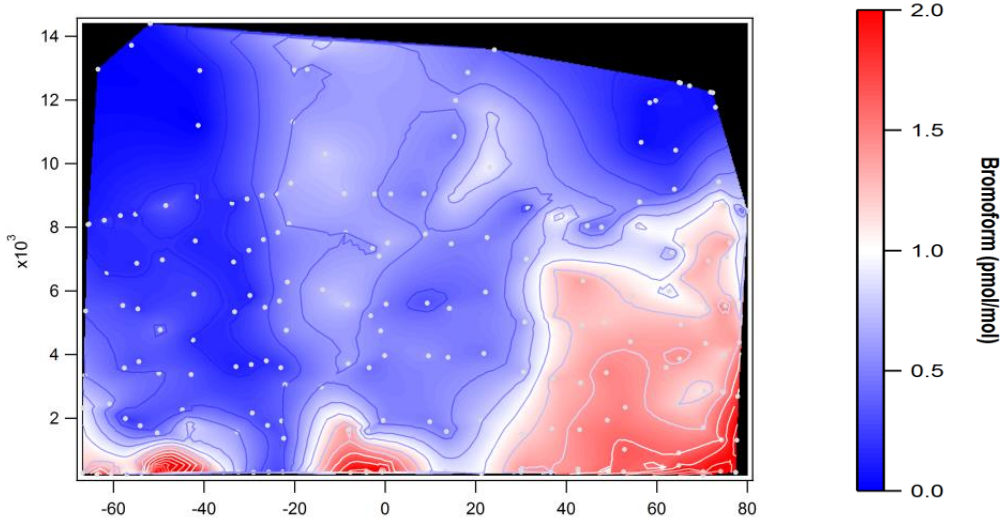


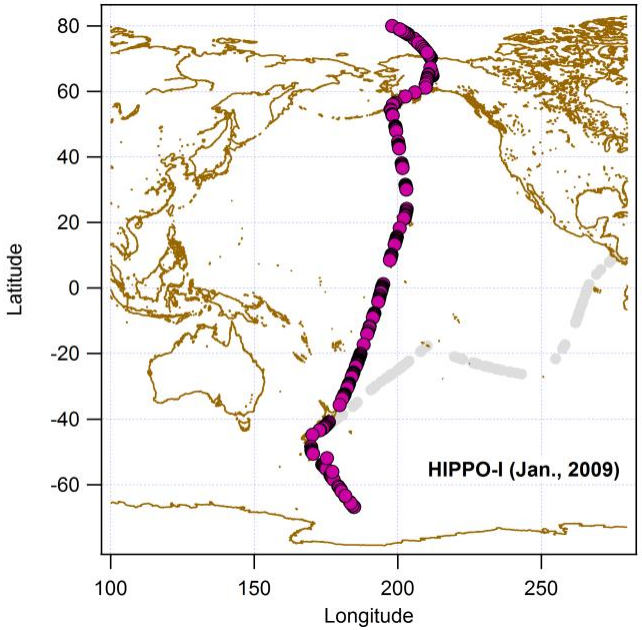
Organic Bromine + SHIVA +TC4



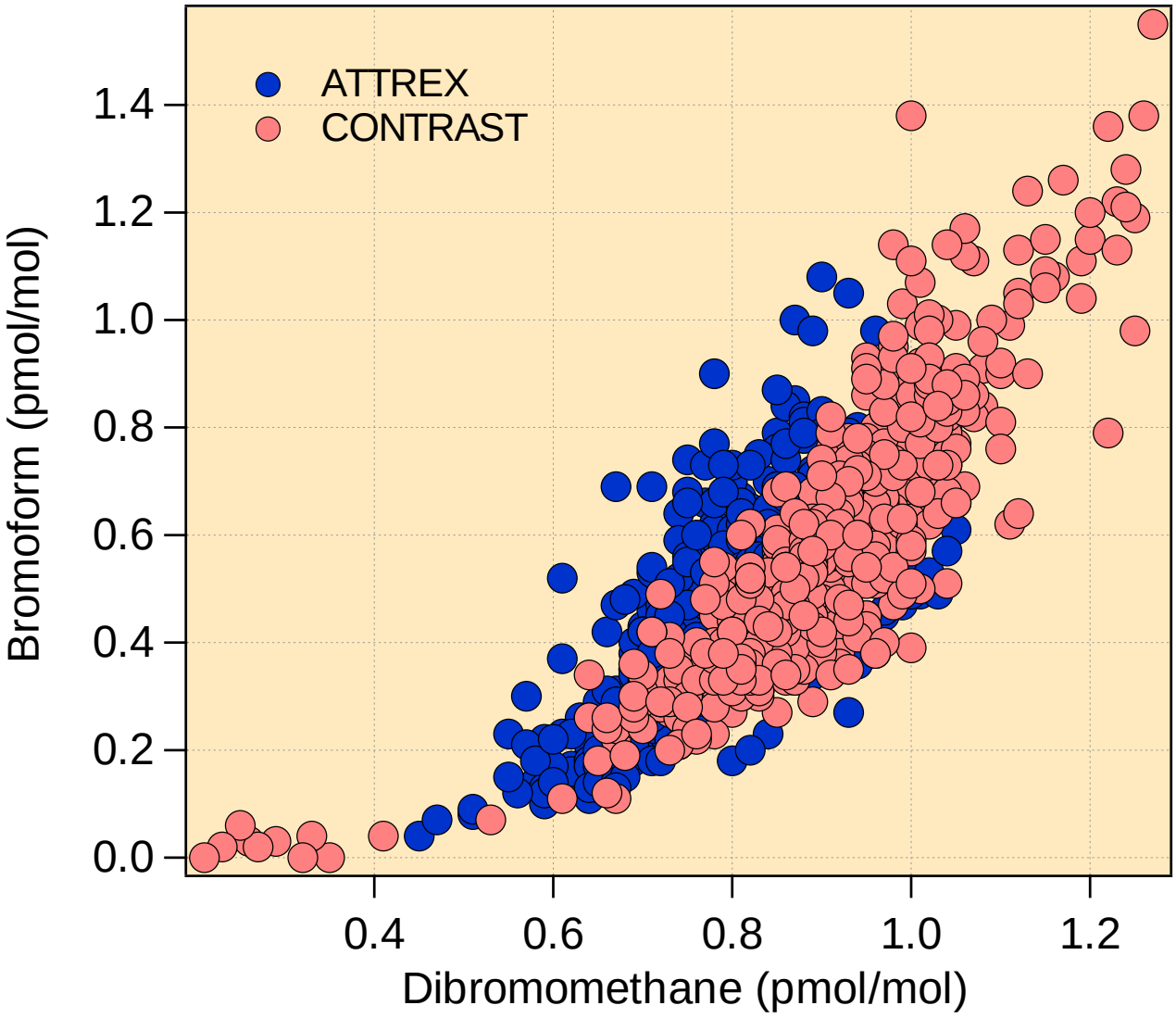
HIPPO-1 (Jan)


x10^3
Dibromomethane (pmol/mol)
1.4
1.2
1.0
0.8
0.6
0.4
0.2

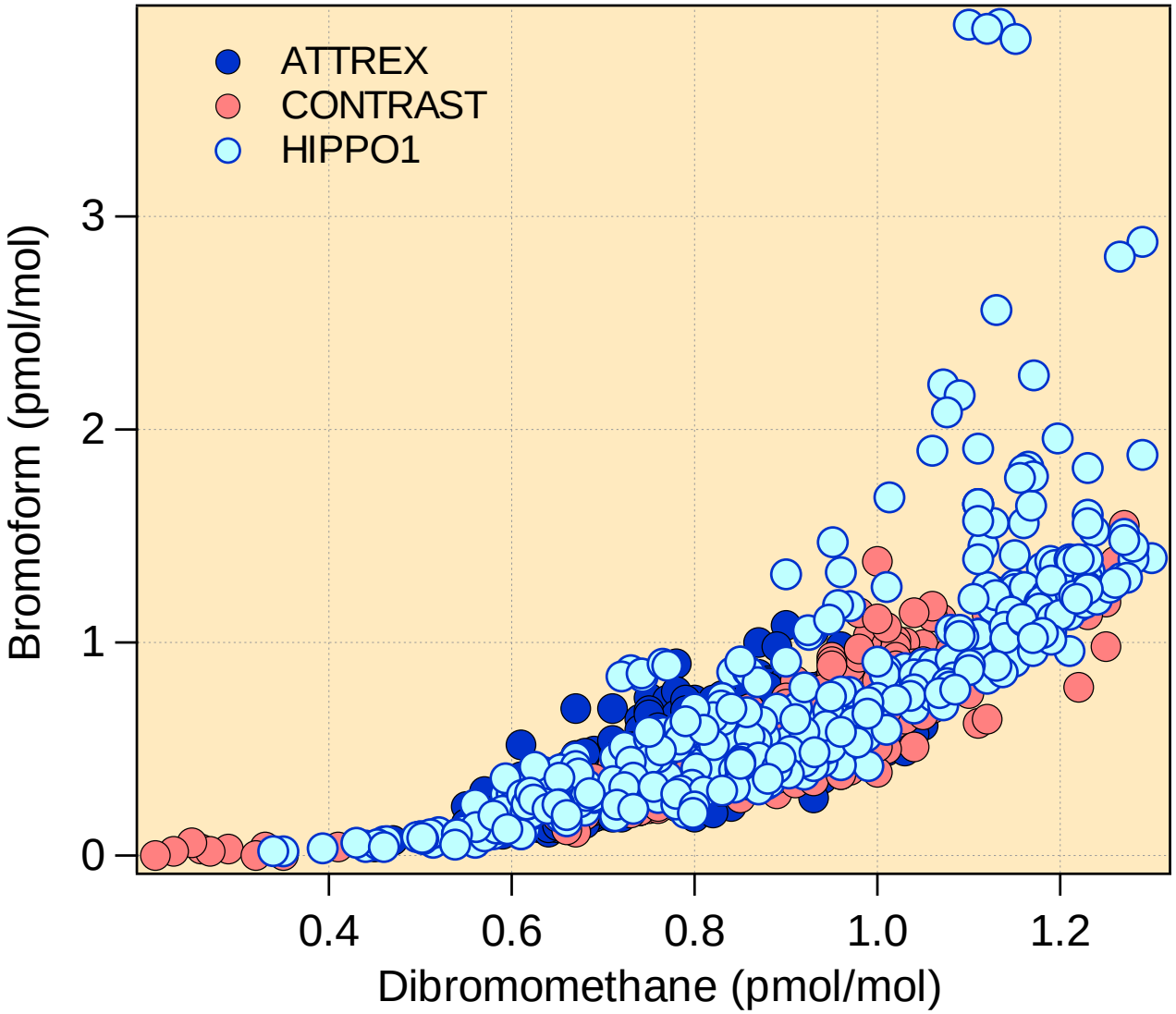

x10^3
Bromoform (pmol/mol)
2.0
1.5
1.0
0.5
0.0


Latitude
Longitude
HIPPO-I (Jan., 2009)

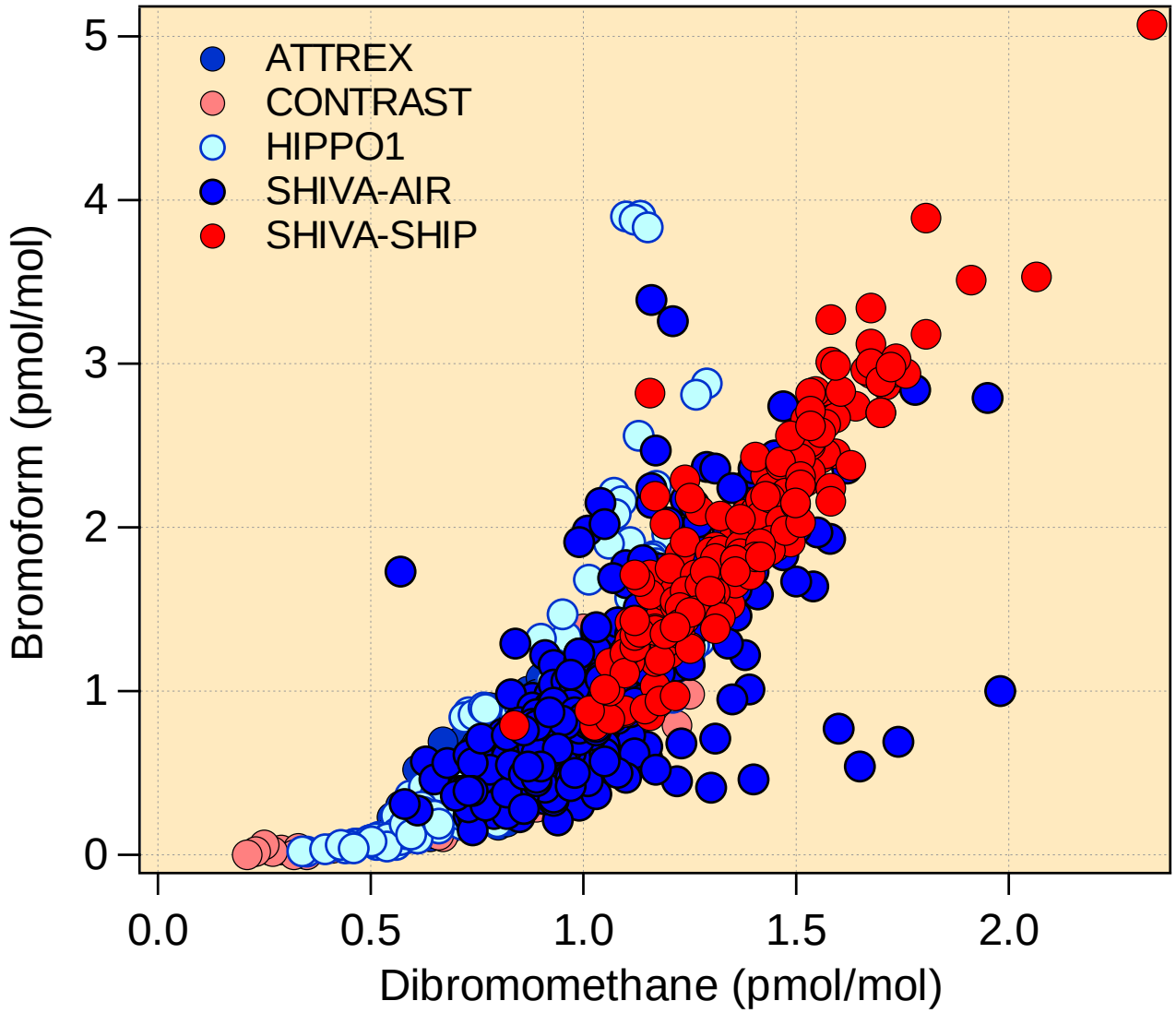
$CHBr_3$:CH_2Br_2 Correlation



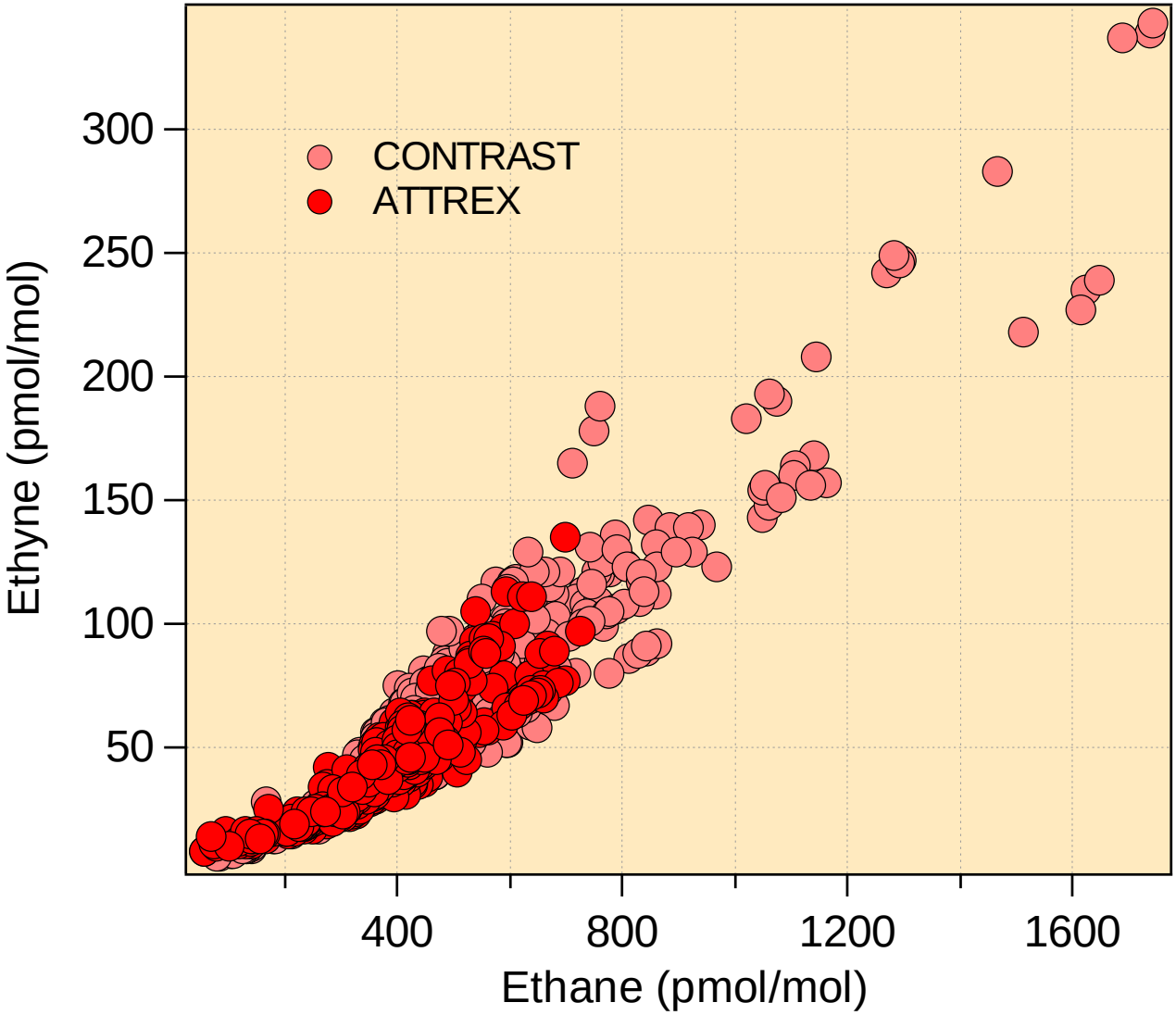
$CHBr_3$:CH_2Br_2 Correlation + HIPPO



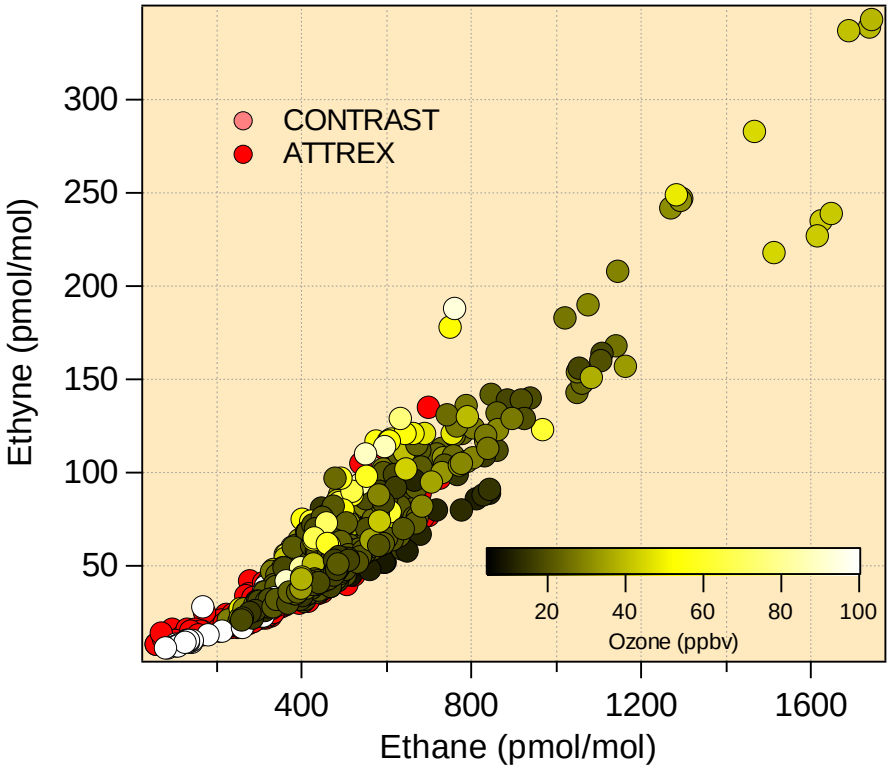
$CHBr_3$:CH_2Br_2 Correlation + SHIVA

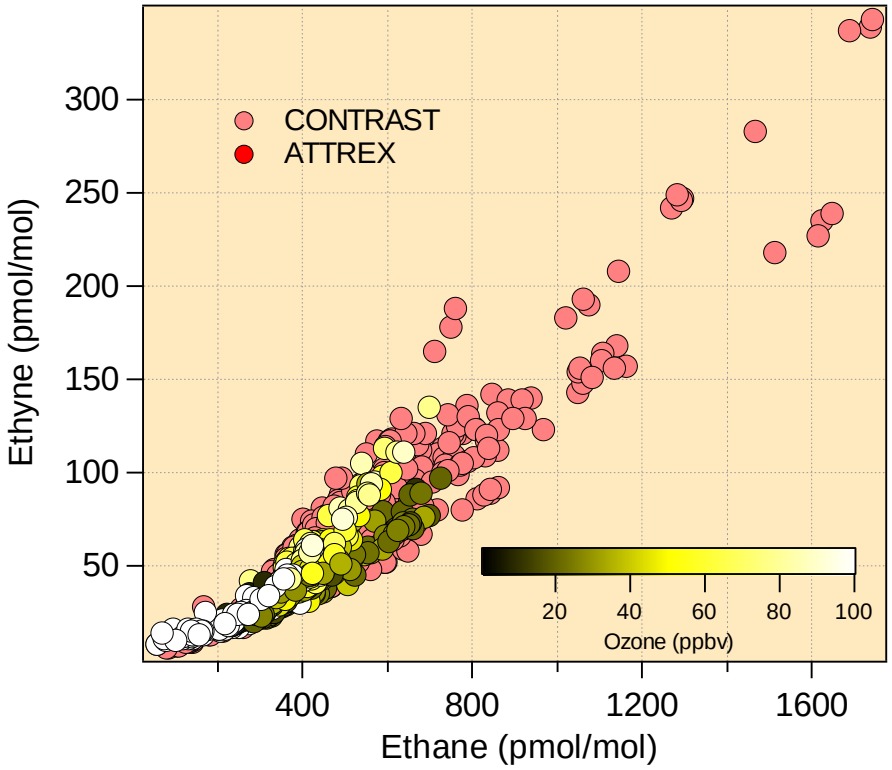


Ethane: Ethyne Correlation

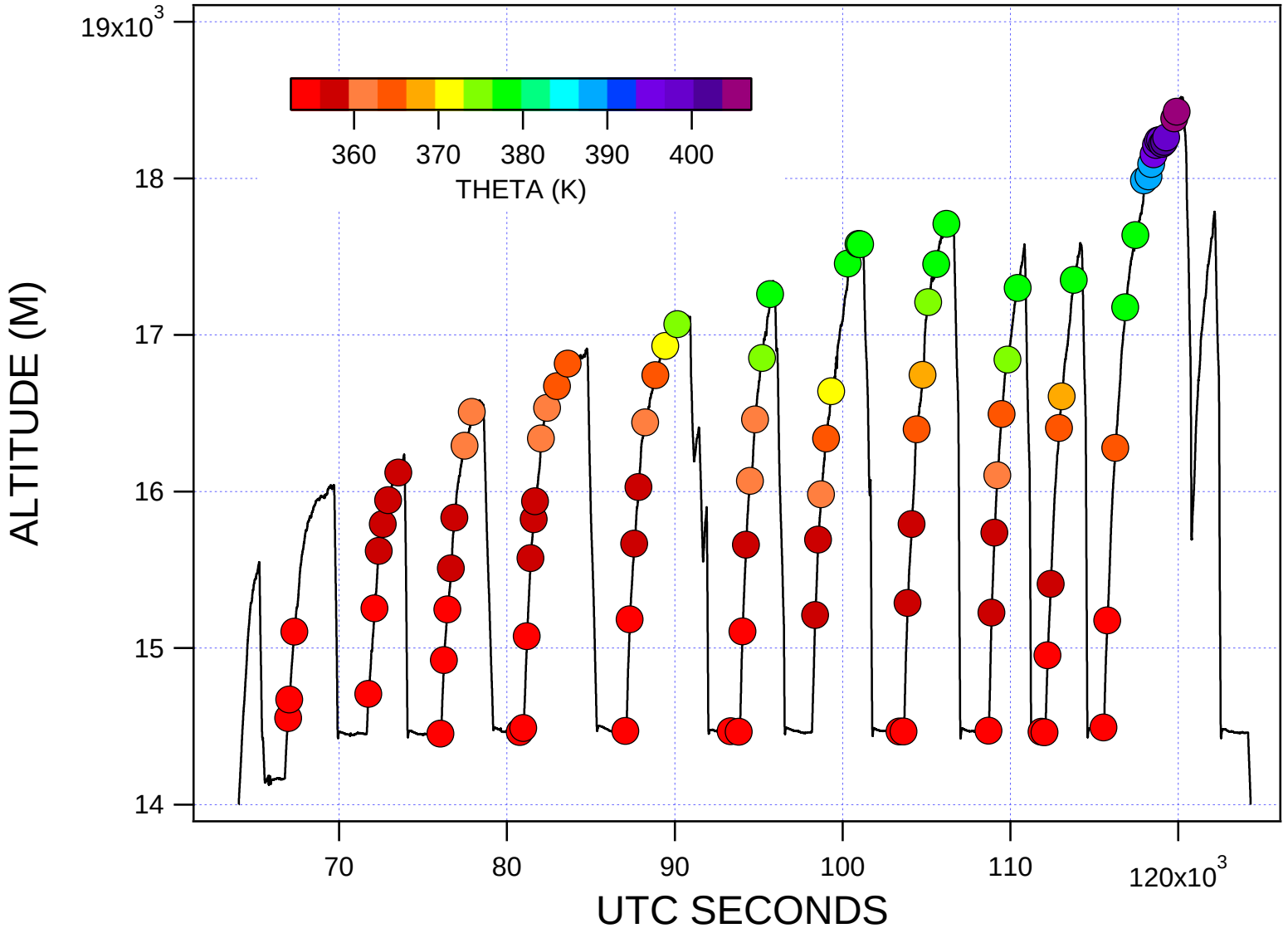


Ethane: Ethyne Correlation

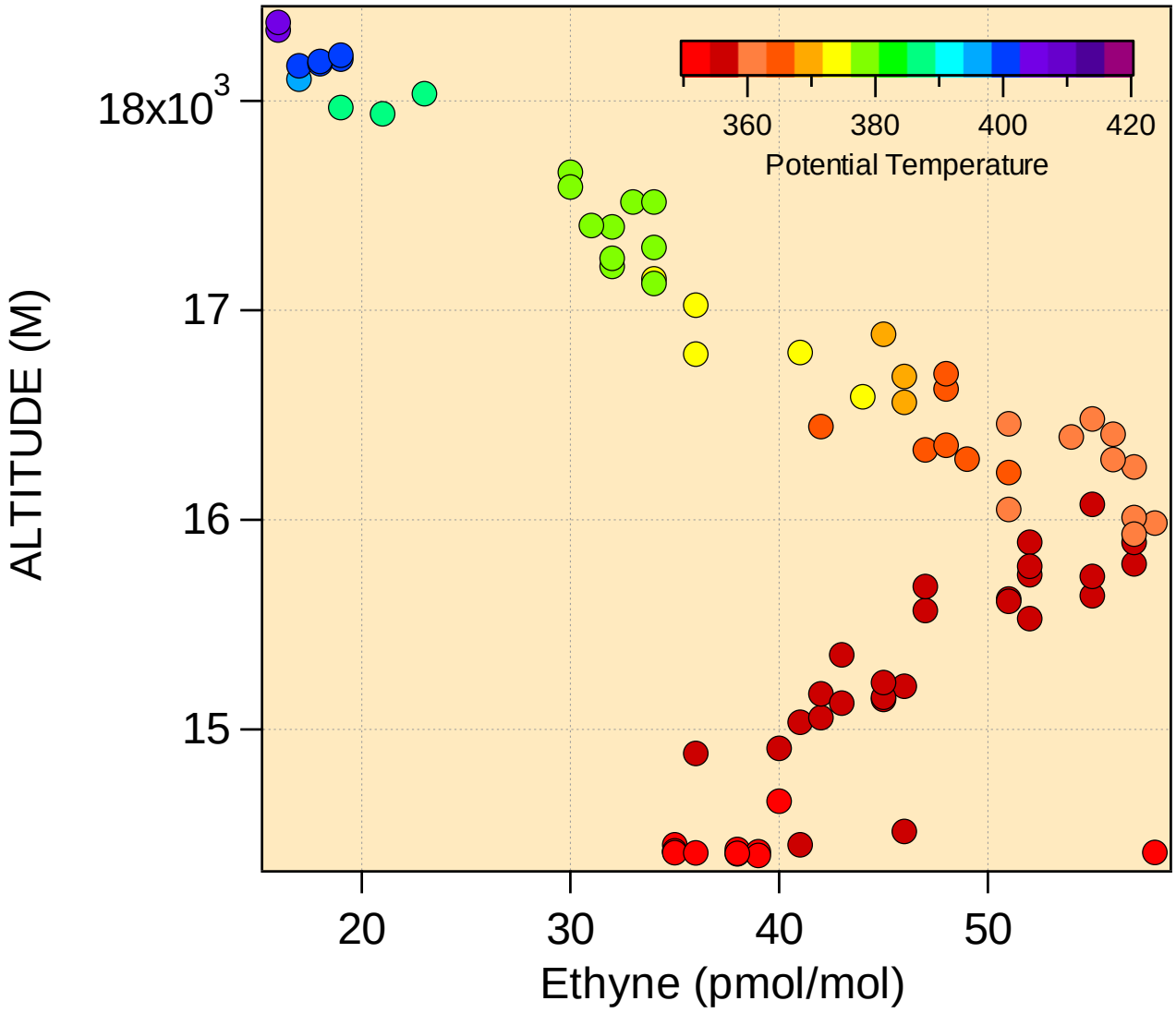




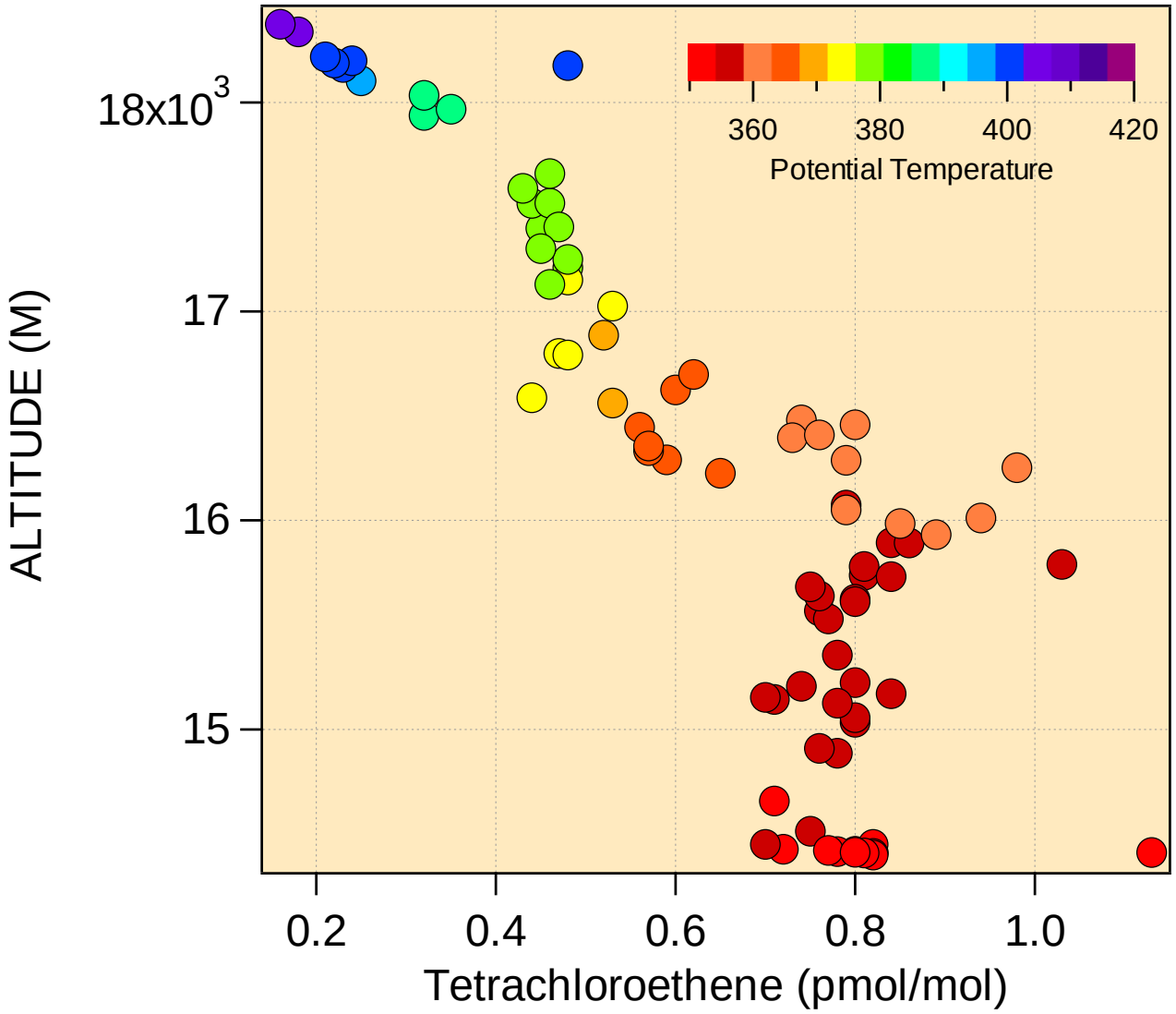
GWAS SAMPLES RF_02 (Circle Flight)



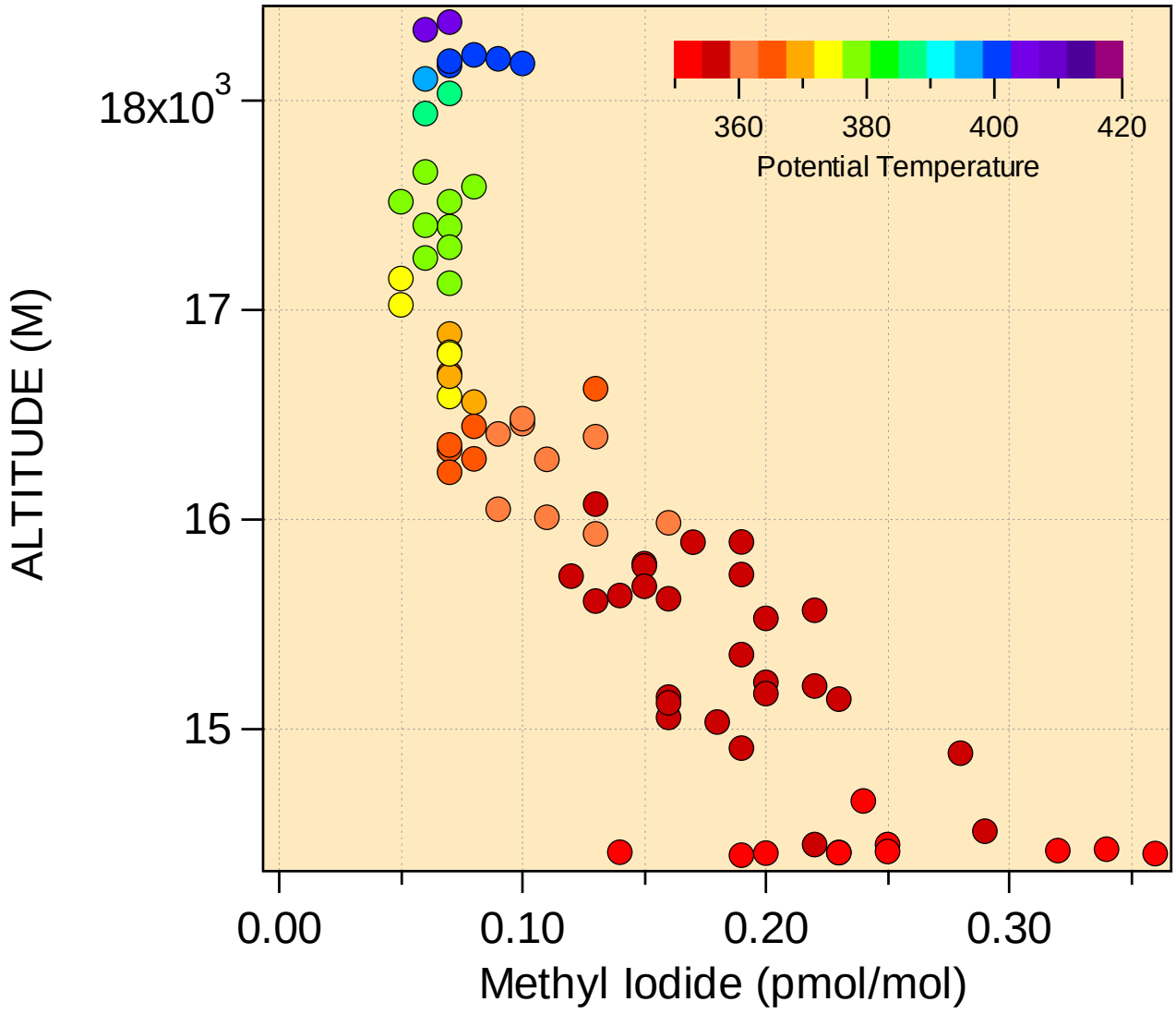
Ethyne C_2H_2(RF02)



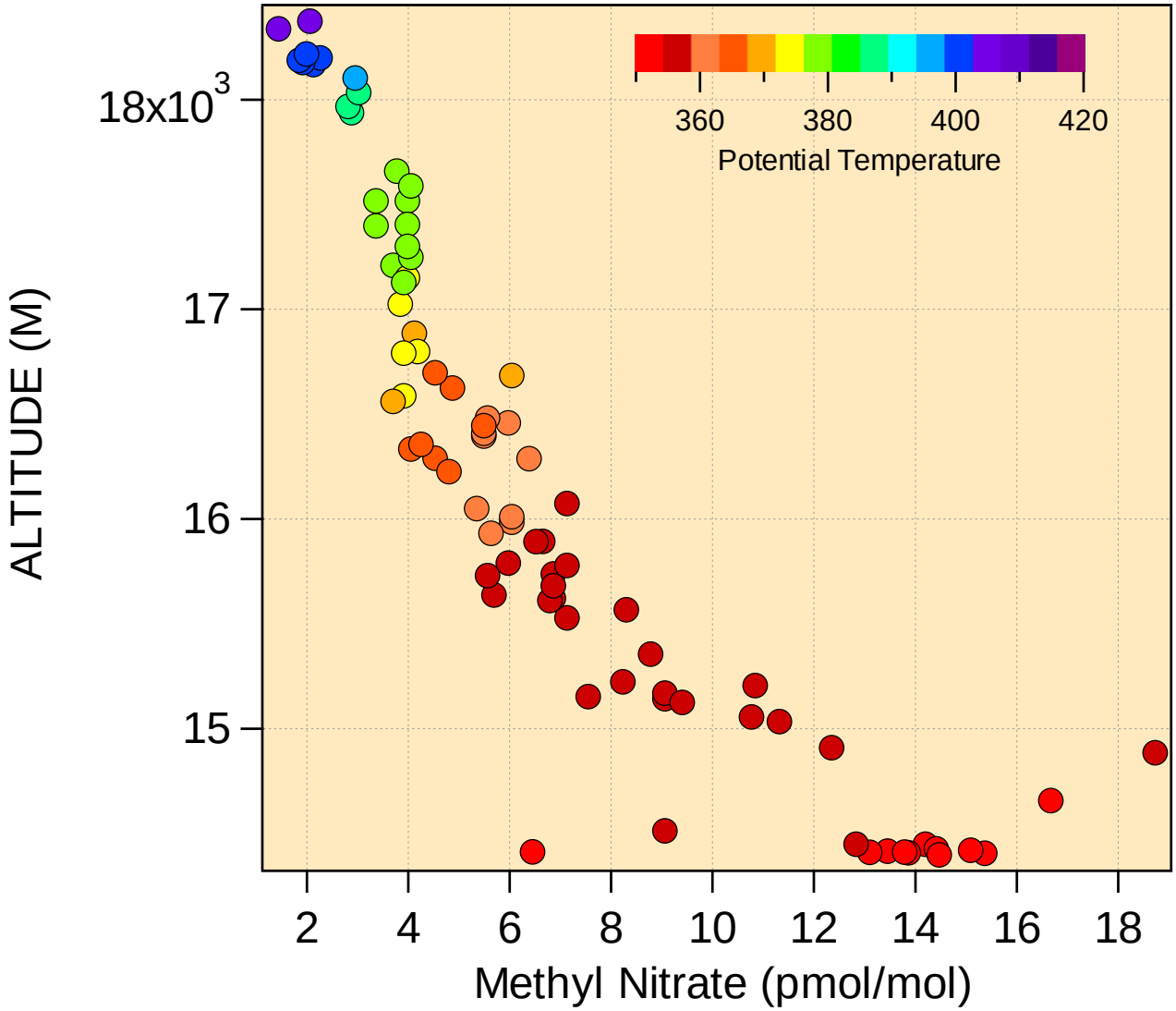
Tetrachloroethene C_2Cl_4 (RF02)



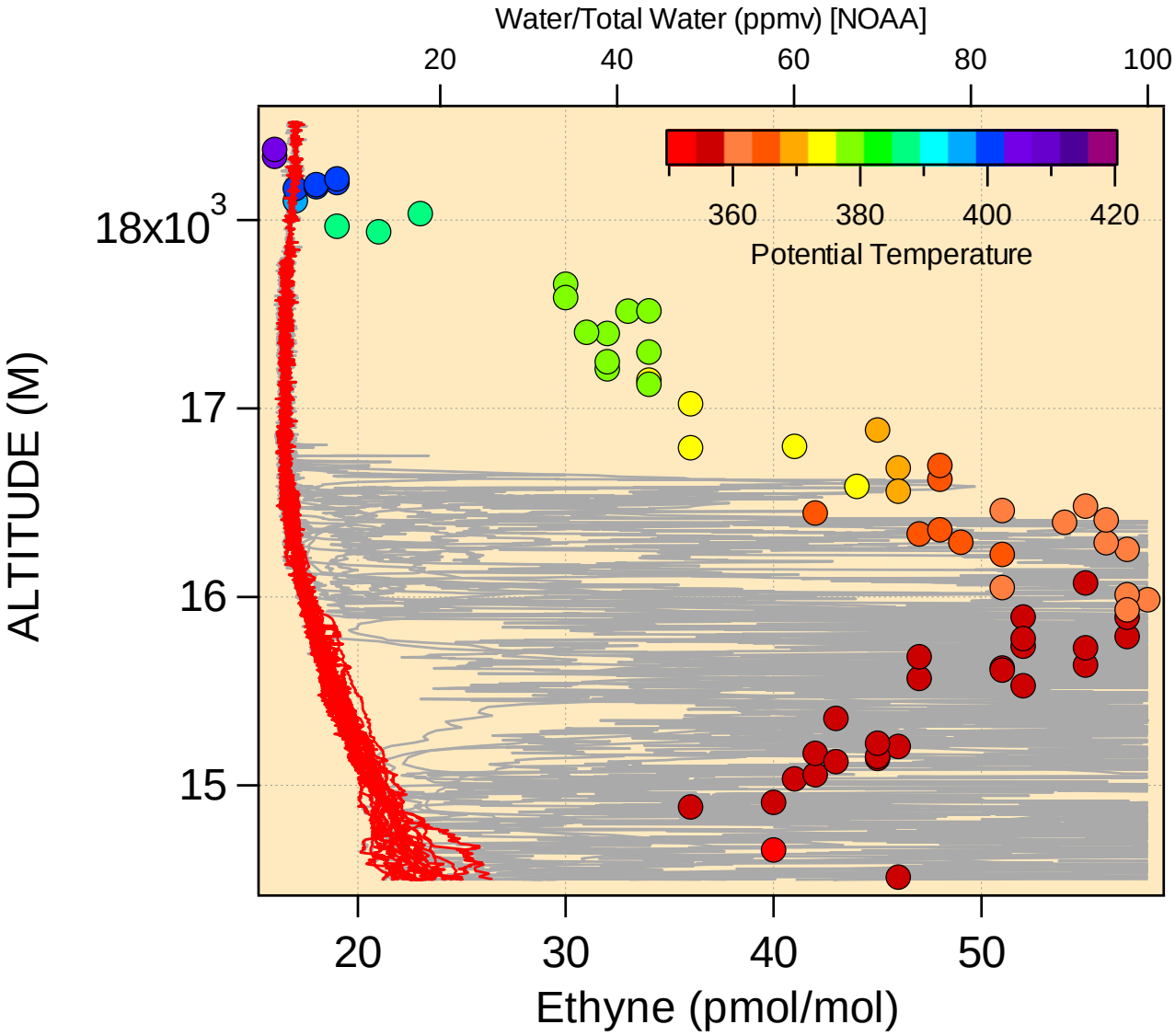
Methyl Iodide CH_3I (RF02)



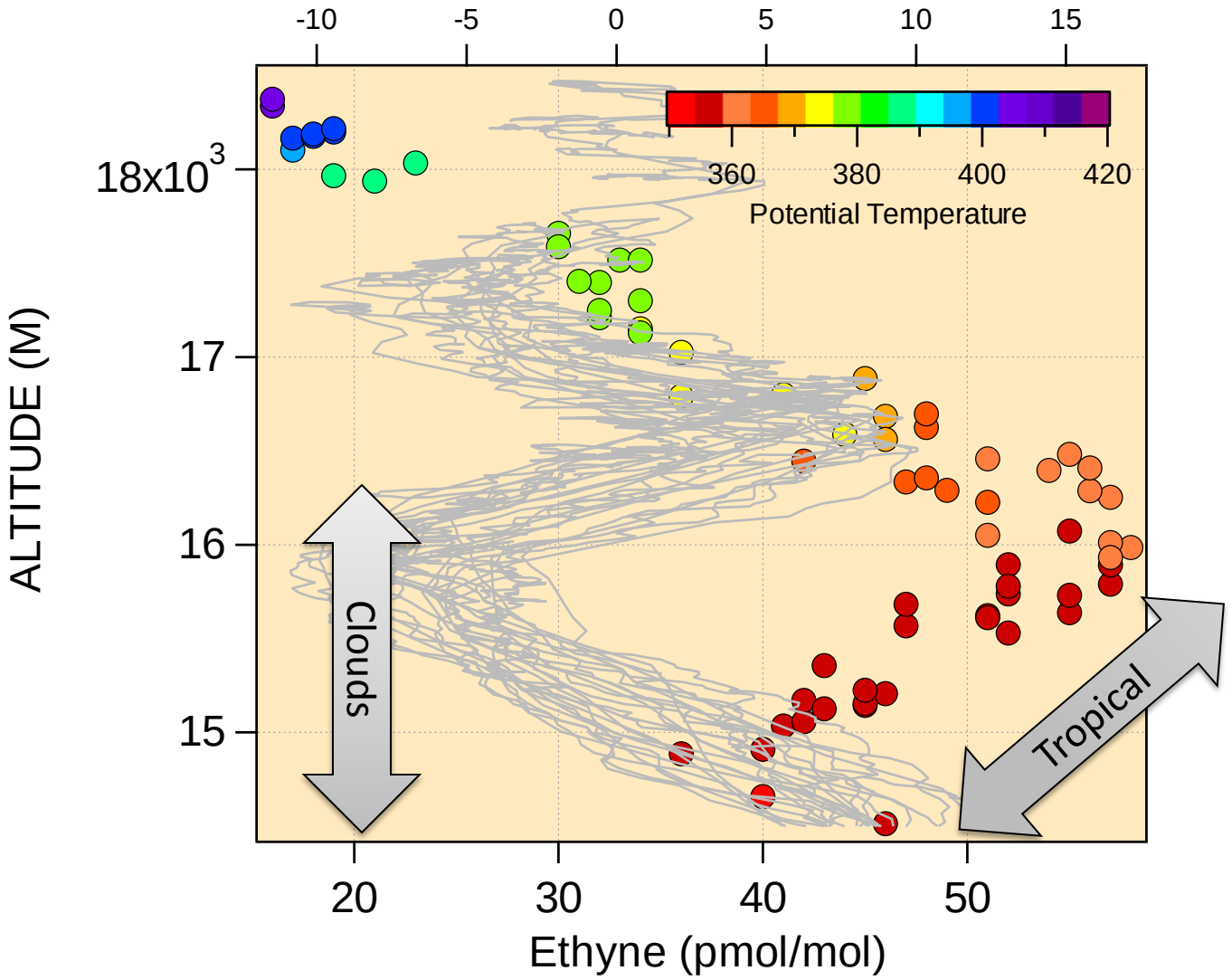
Methyl Nitrate CH_3ONO_2 (RF02)



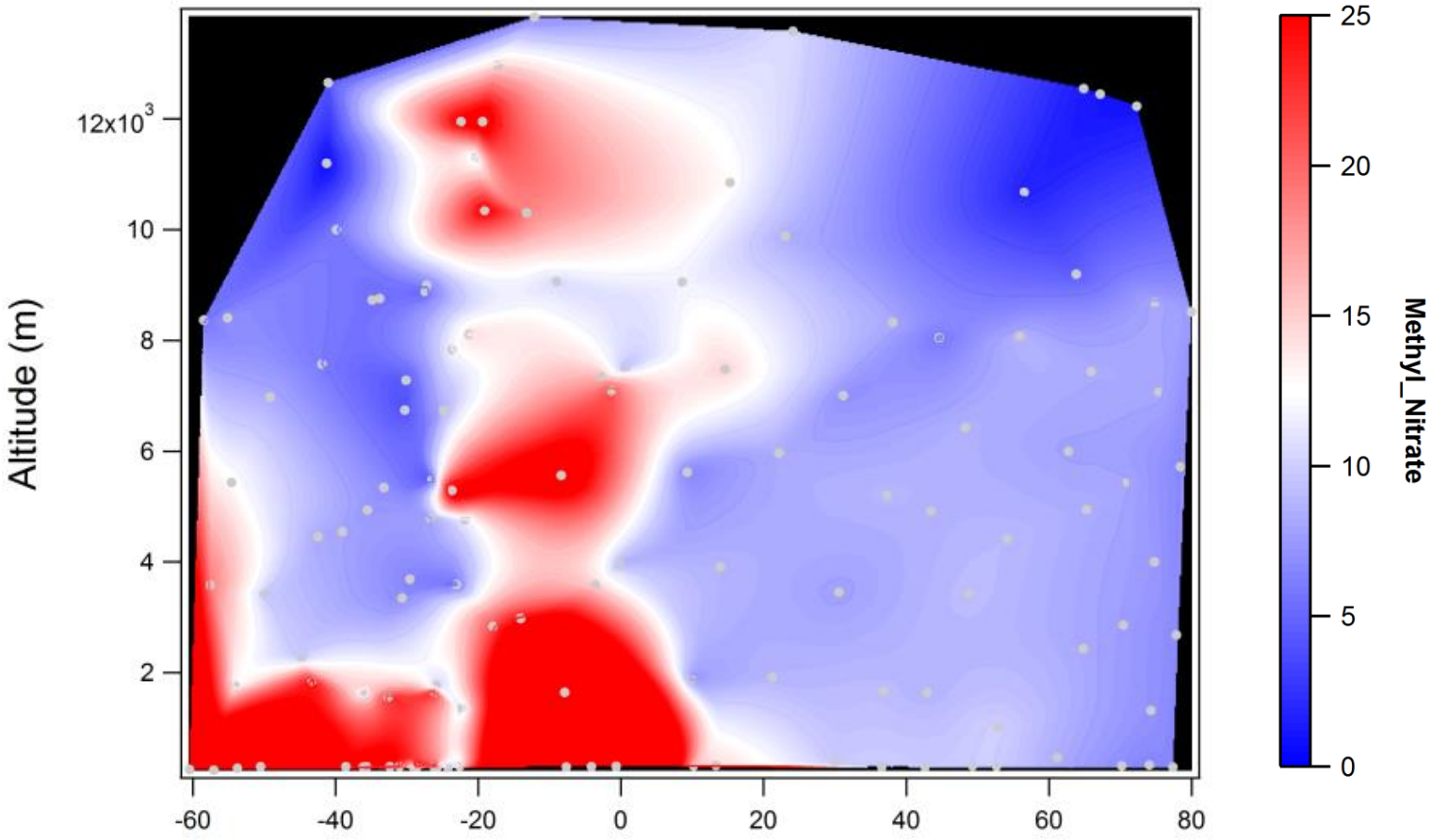
Ethyne C_2H_2(RF02)



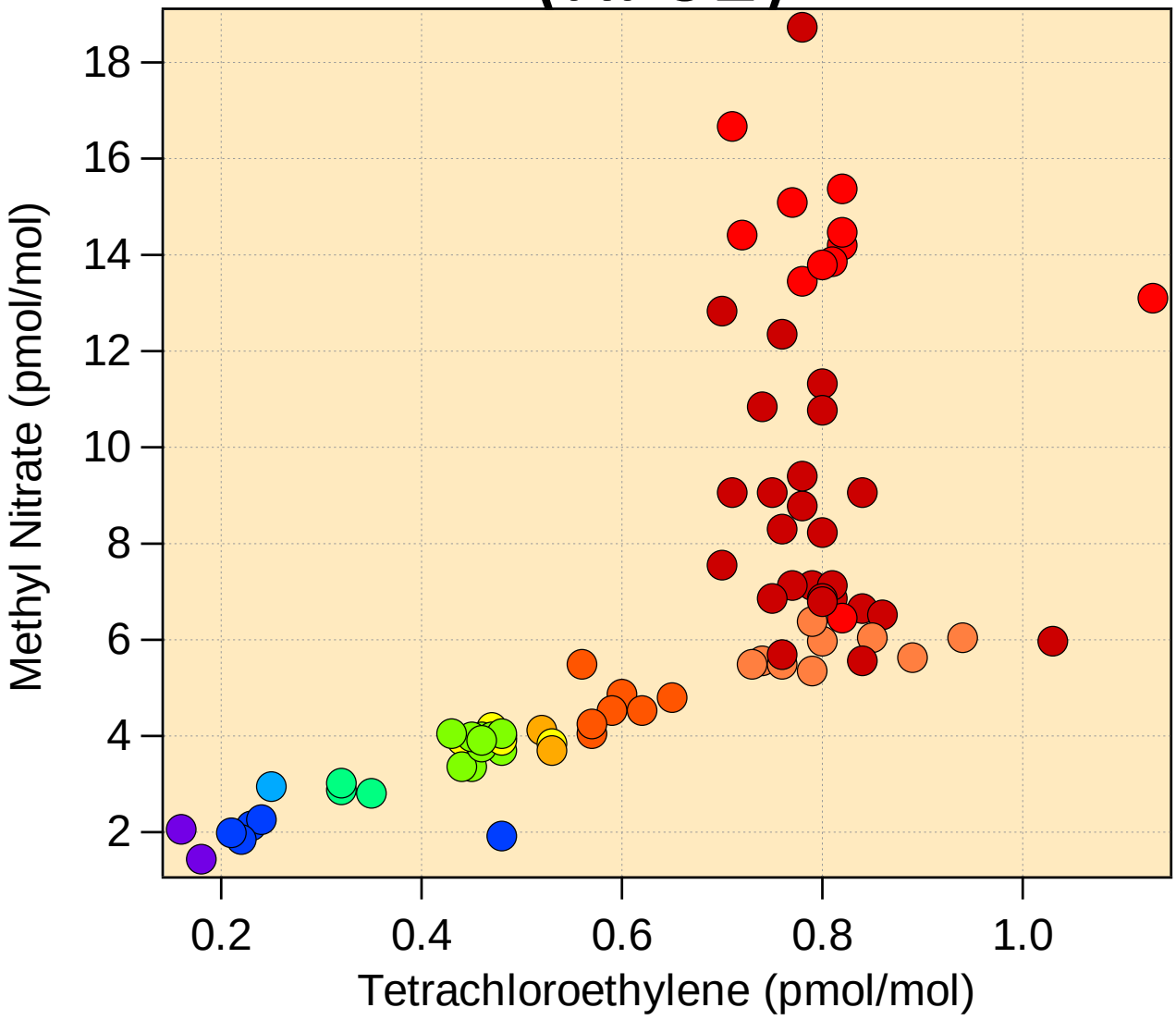
Vertical Distribution + v



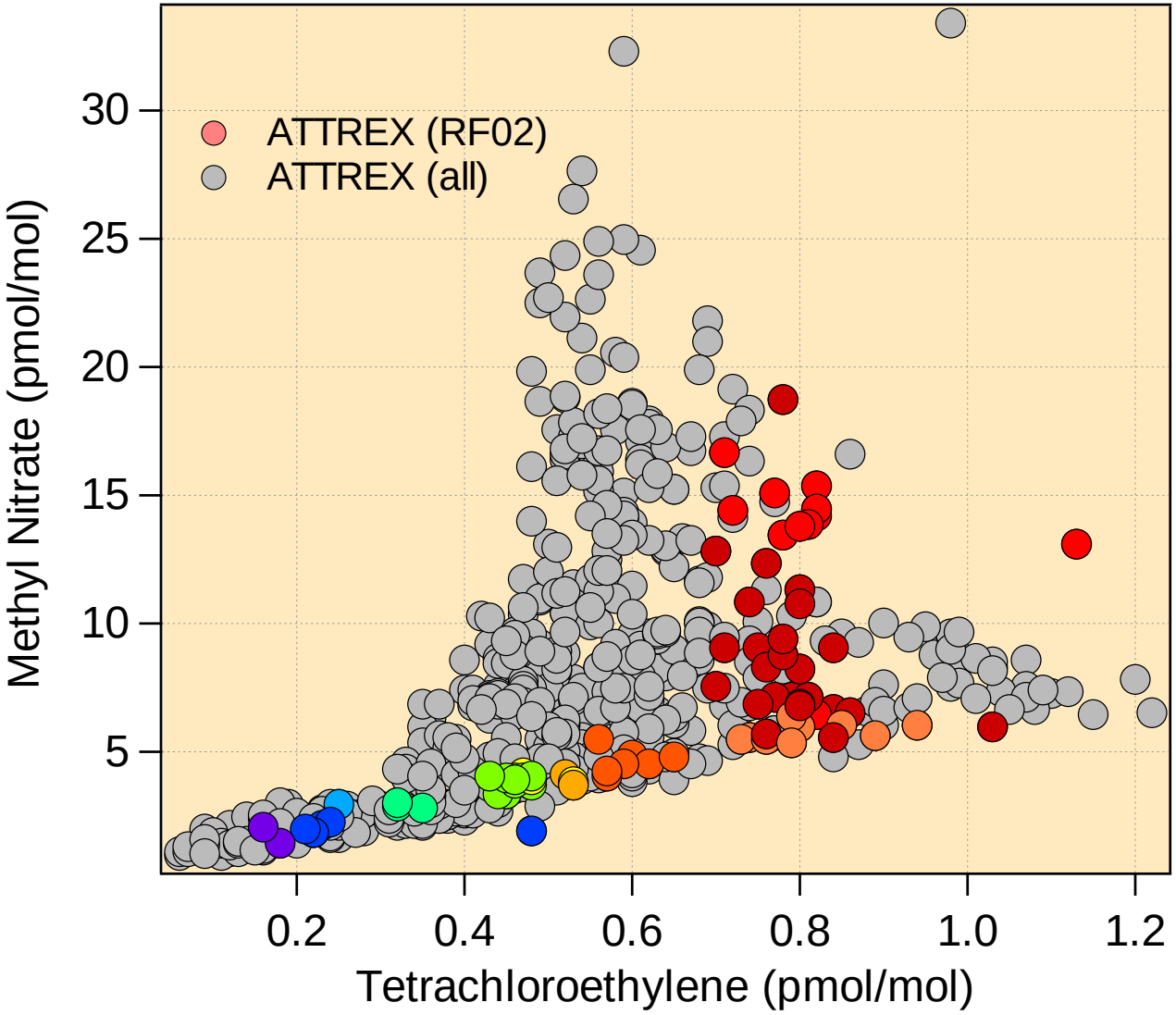
HIPPO1 Methyl Nitrate



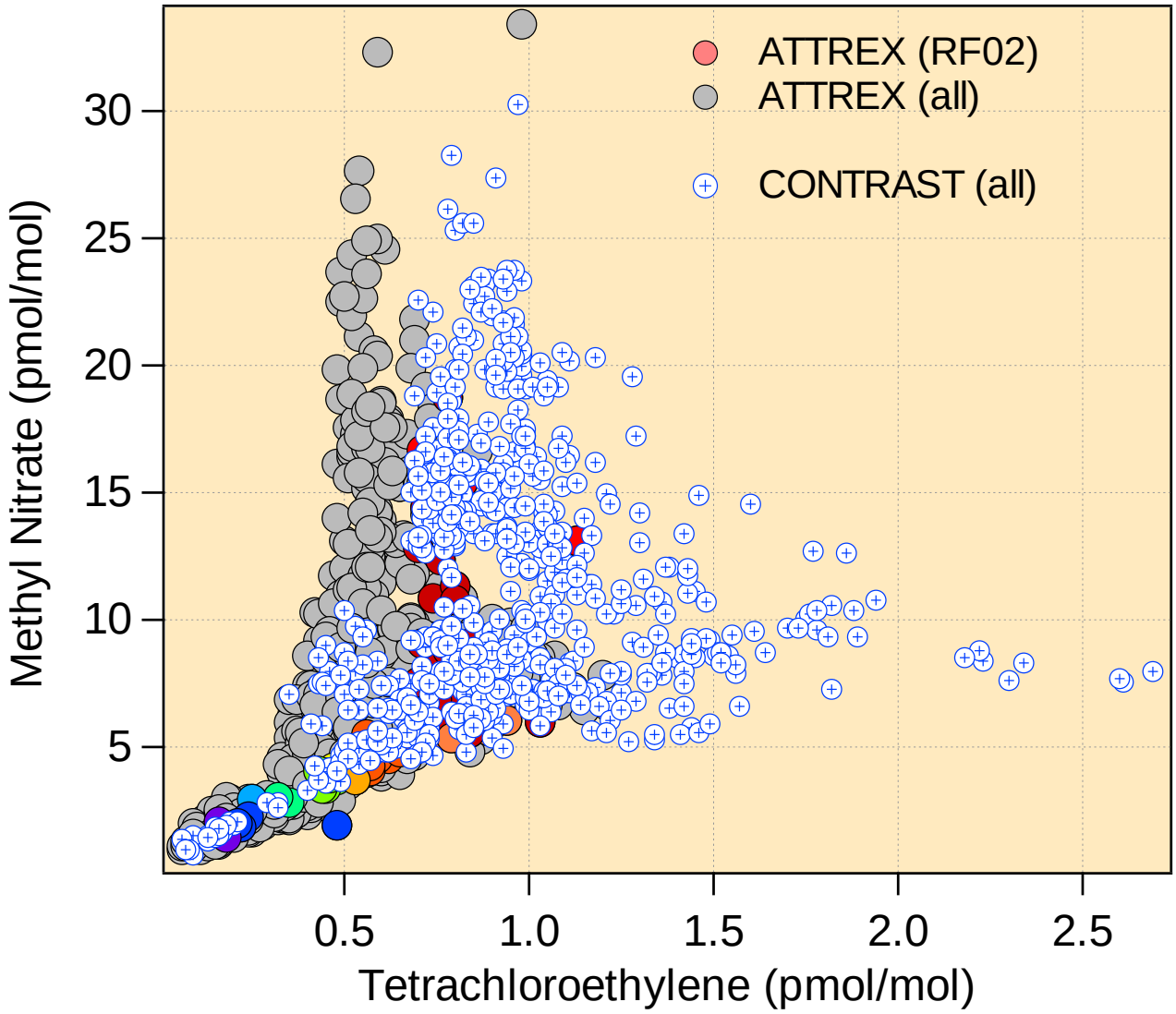
Methyl Nitrate: C_2Cl_4 Correlation (RF02)



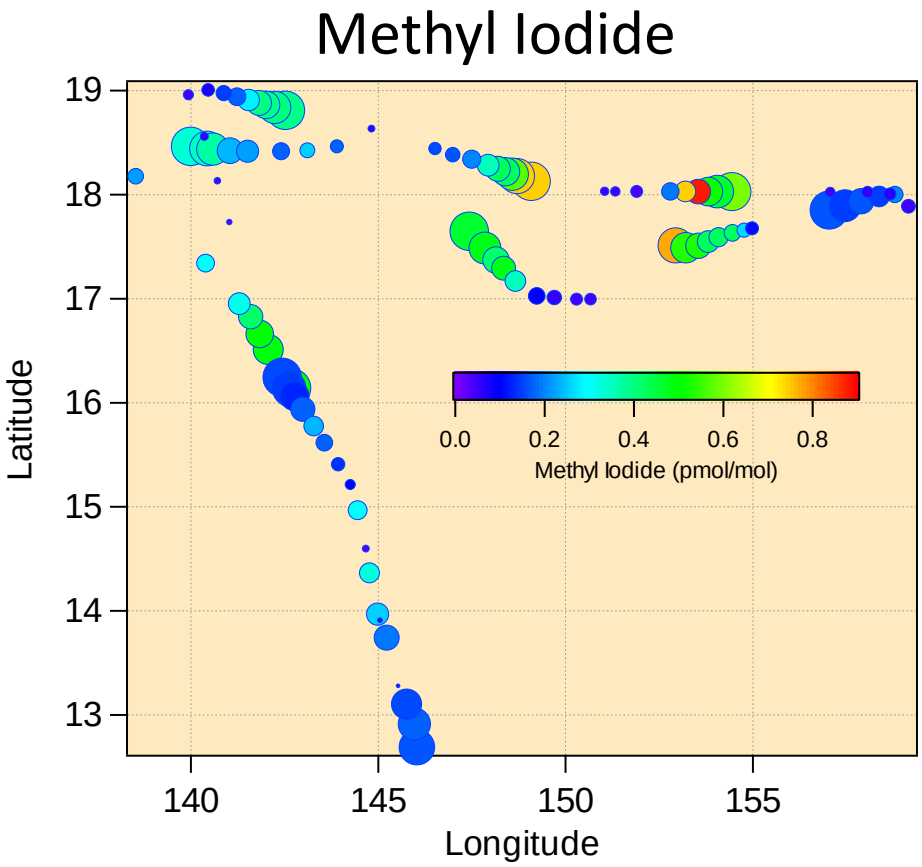
Methyl Nitrate: C_2Cl_4 Correlation
ATTREX (all)

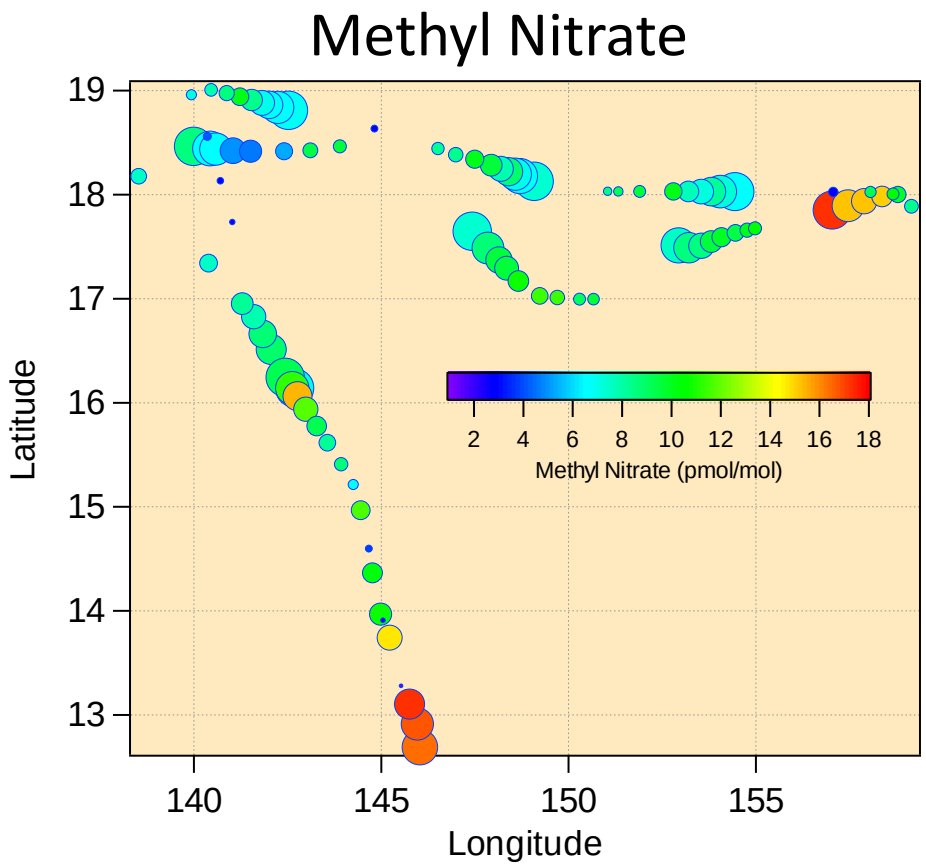


Methyl Nitrate: C_2Cl_4 Correlation
ATTREX + CONTRAST

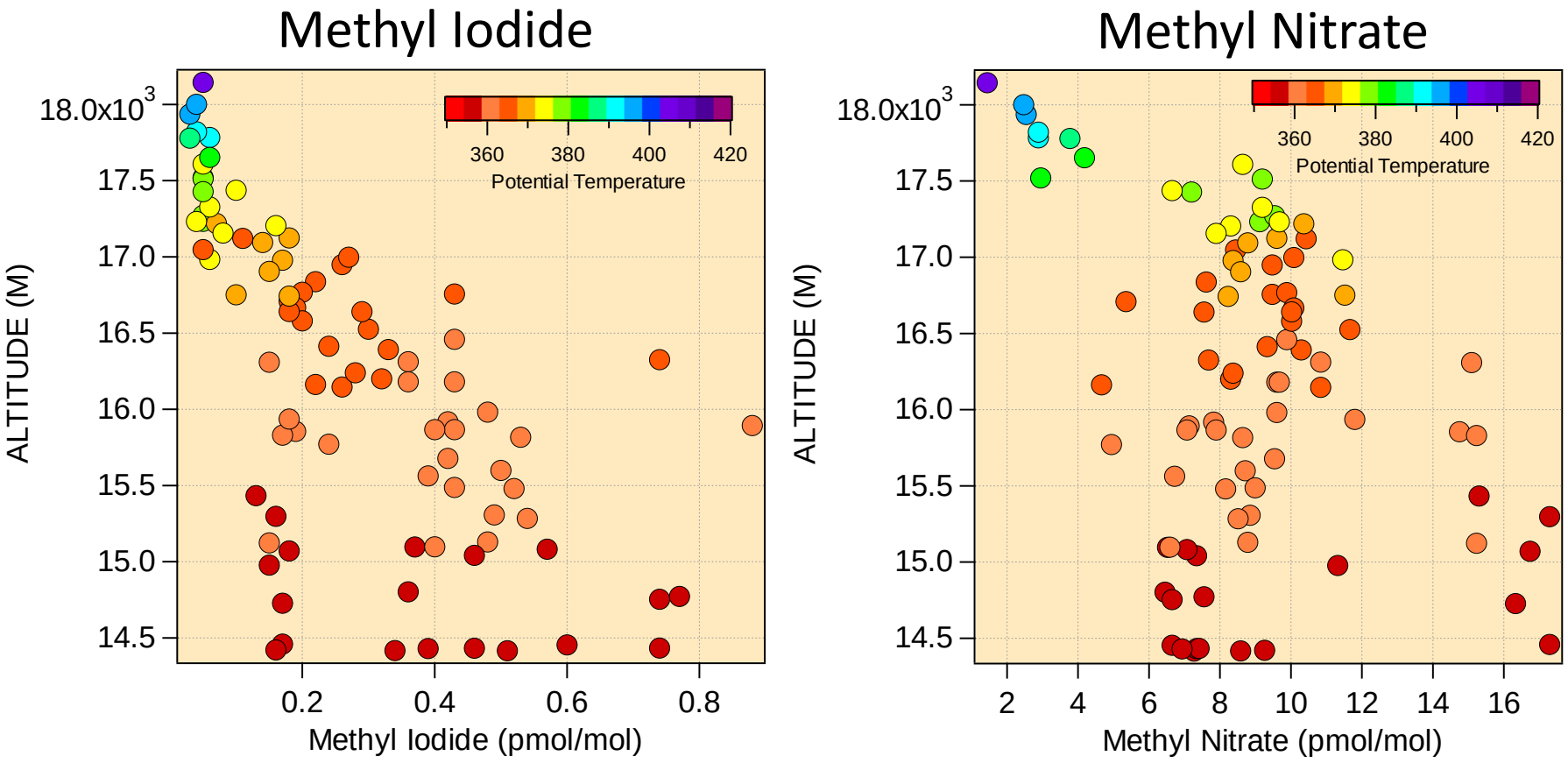


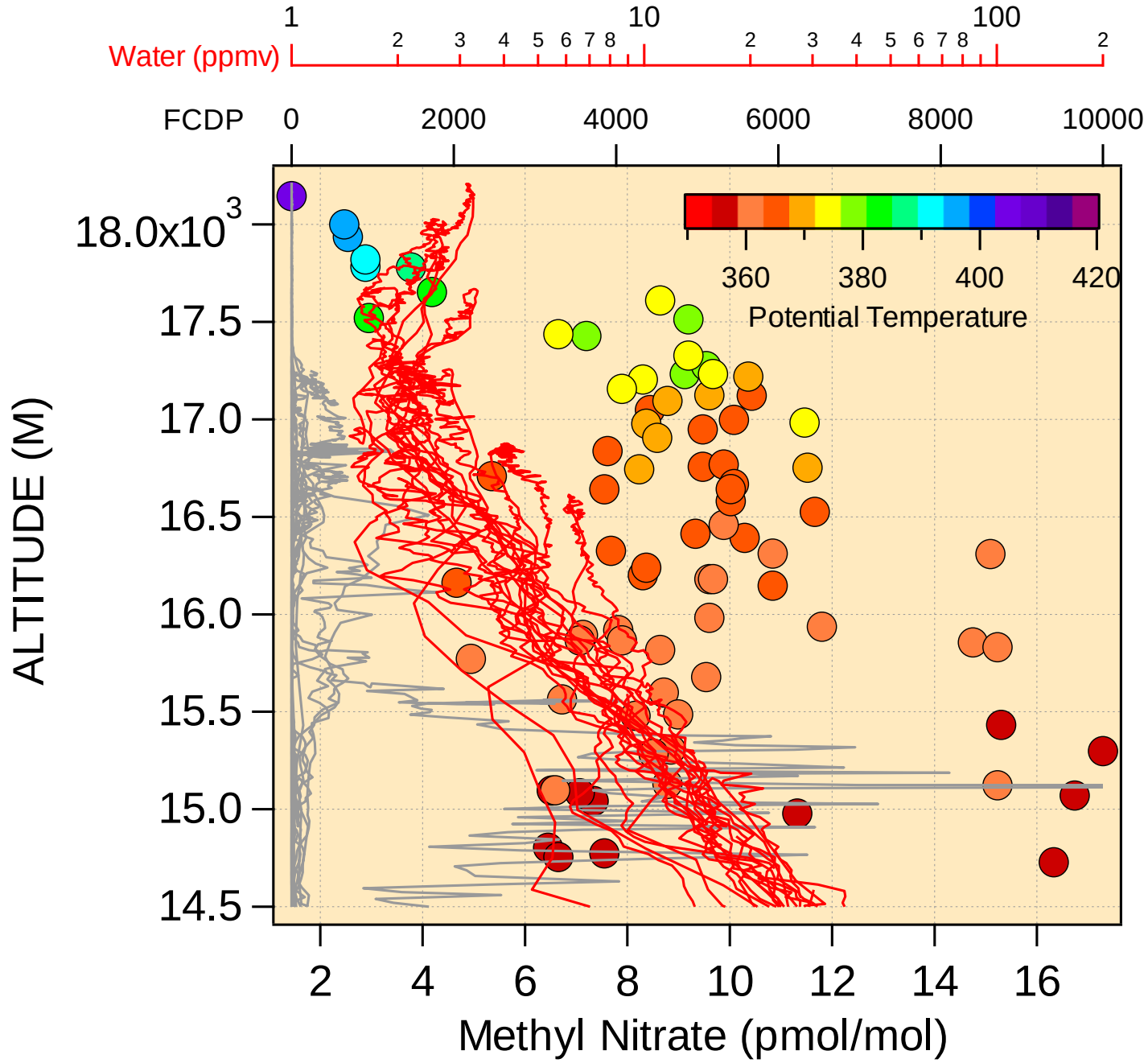
ATTREX RF03 (Faxai)





ATTREX RF03 (Faxai)




Water (ppmv)
1
10
100
2
3
4
5
6
7
8
FCDP
0
2000
4000
6000
8000
10000
360
380
400
420
Potential Temperature
18.0x10^3
17.5
17.0
16.5
16.0
15.5
15.0
14.5
ALTITUDE (M)
2
4
6
8
10
12
14
16
Methyl Nitrate (pmol/mol)

SUMMARY

- Organic bromine budget well constrained in TTL; consistent with larger scale distributions
- Tracer-tracer correlations identify links between CONTRAST/ATTREX measurement
- Gradients in TTL often complex in this region; impact of clouds/variable sources/layers.