CONTRAST:
Convective Transport of Active Species in the Tropics

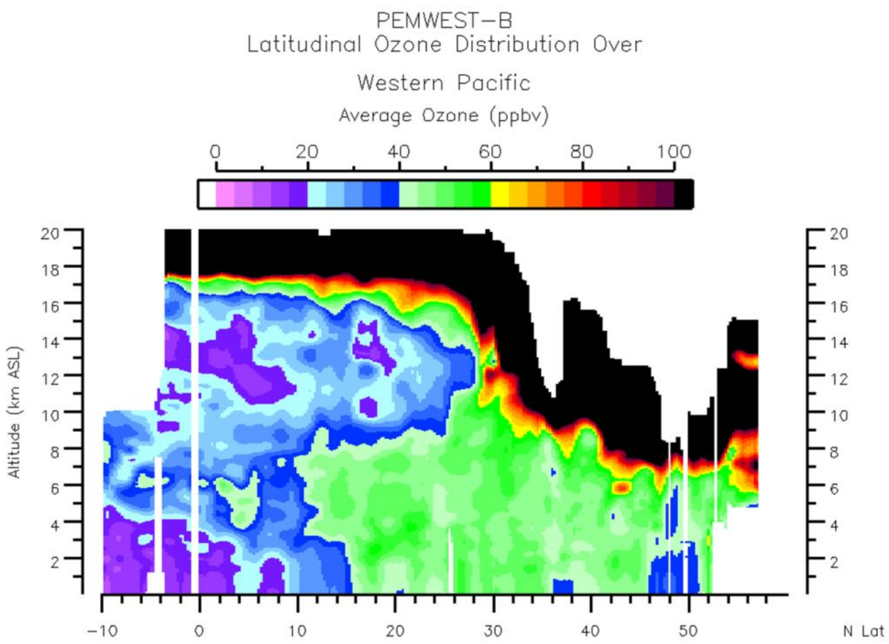
Co-PIs: Elliot Atlas (U.Miami); Ross Salawitch (U.Md.); Laura Pan (NCAR)

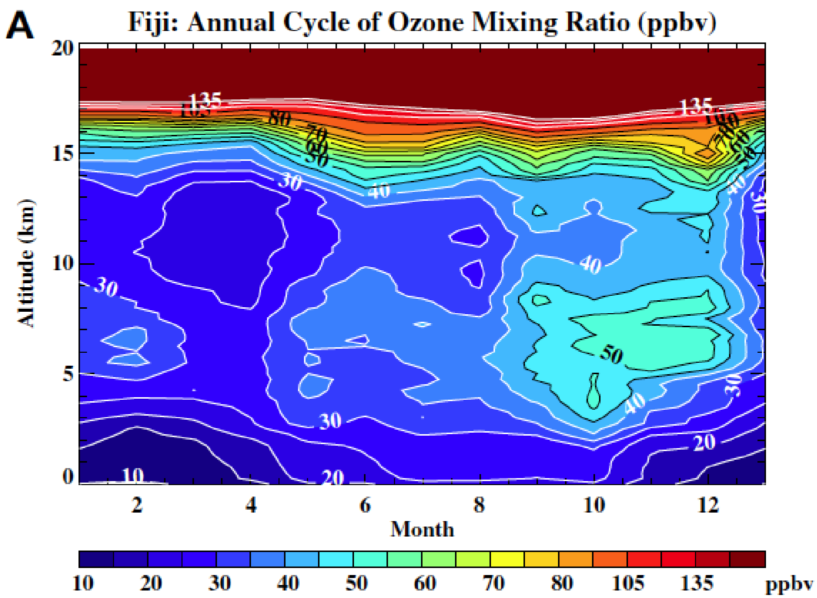
Location: Guam

Dates: January - February 2014

Partners: NASA ATTREX & UK CAST

Low ozone conditions observed by airborne LIDAR and ozonesondes





Lidar O_3 observations from PEM WEST-B

Feb 1994, along ~ 140 E

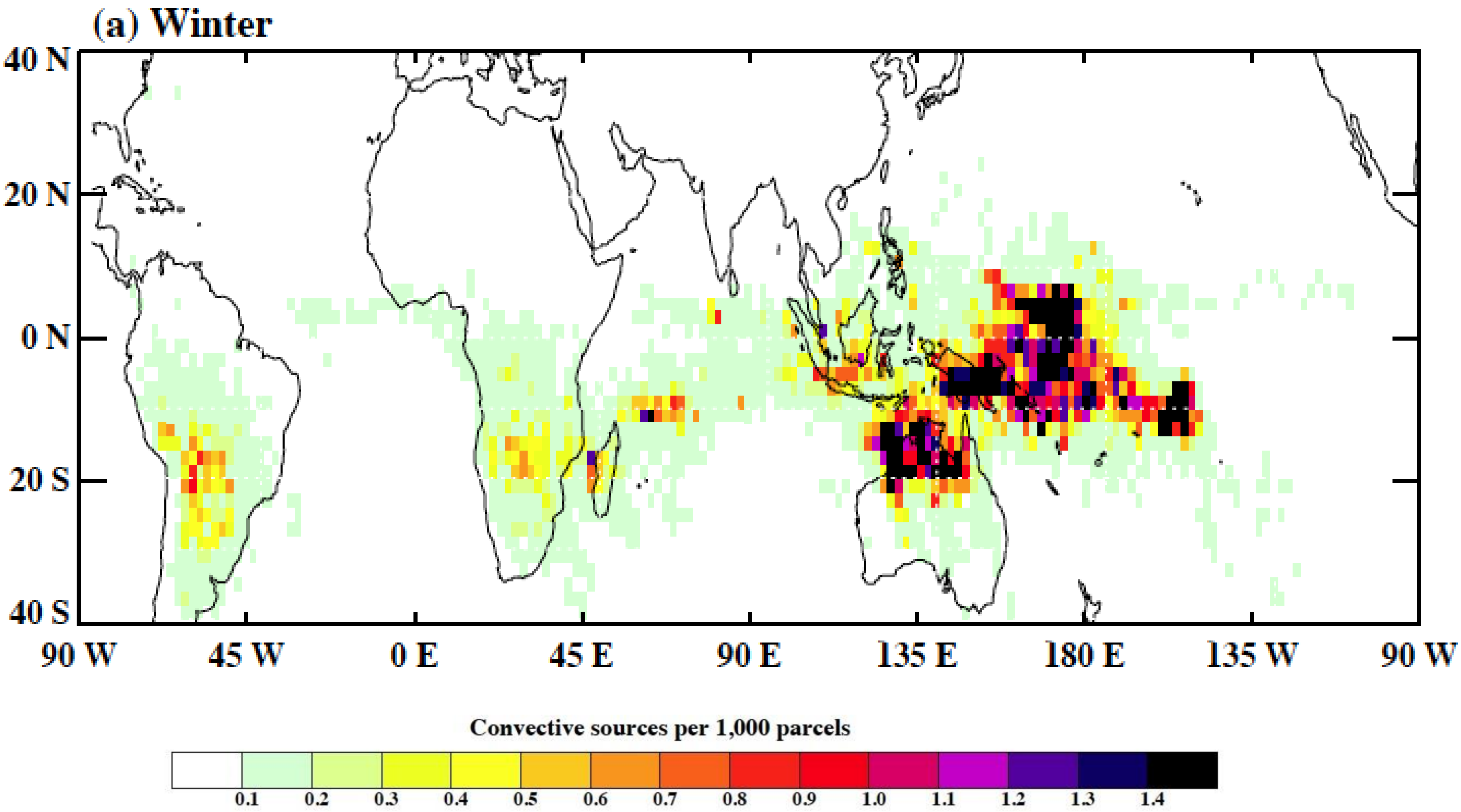
Crawford et al., 1997, Newell et al., 1997

O_3 seasonal cycle 1998-2008 SHADOZ/Fiji

Thompson et al., 2011

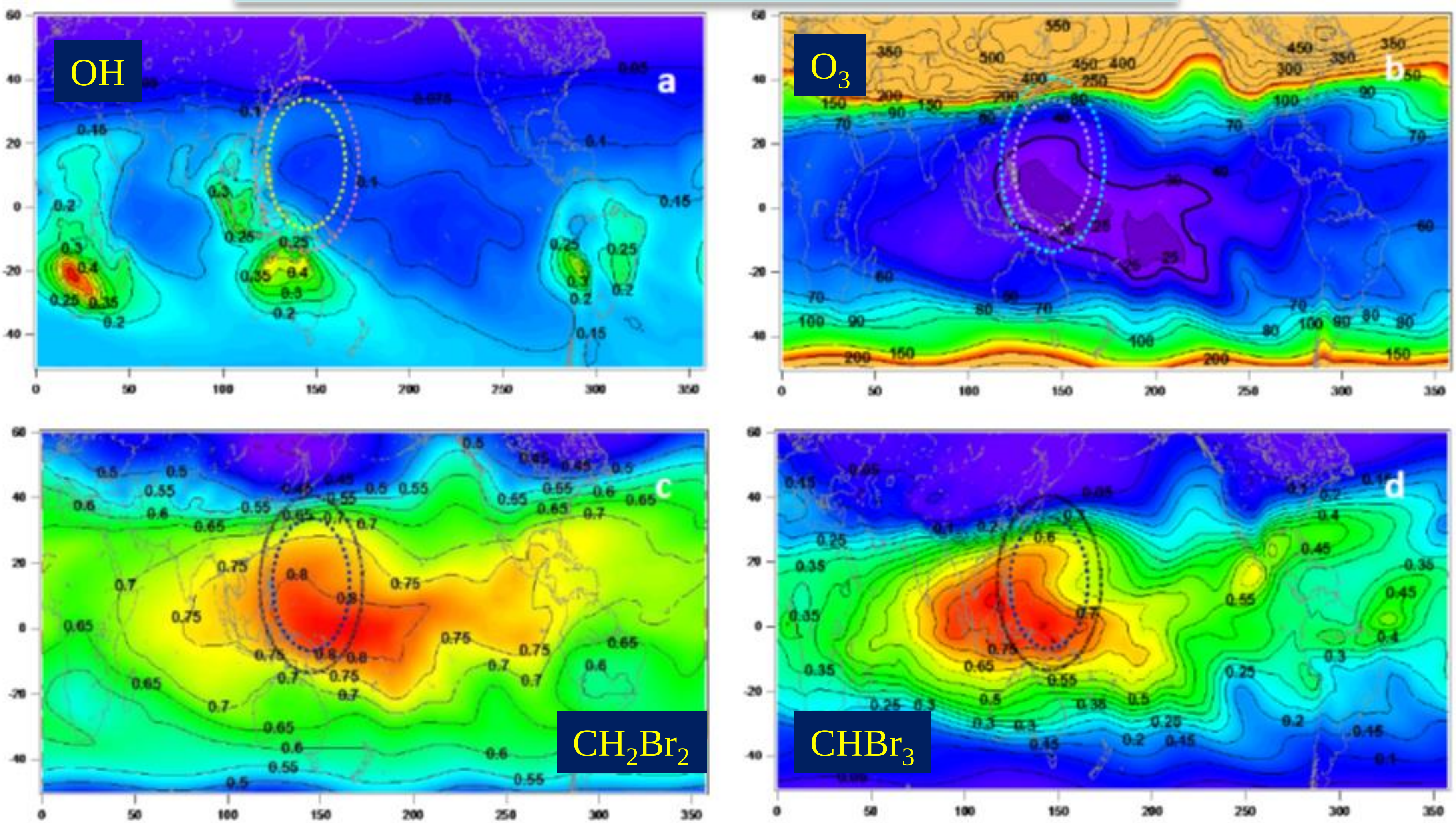
Bergman et al., 2011

Convective detrainment for air reaching 380 K

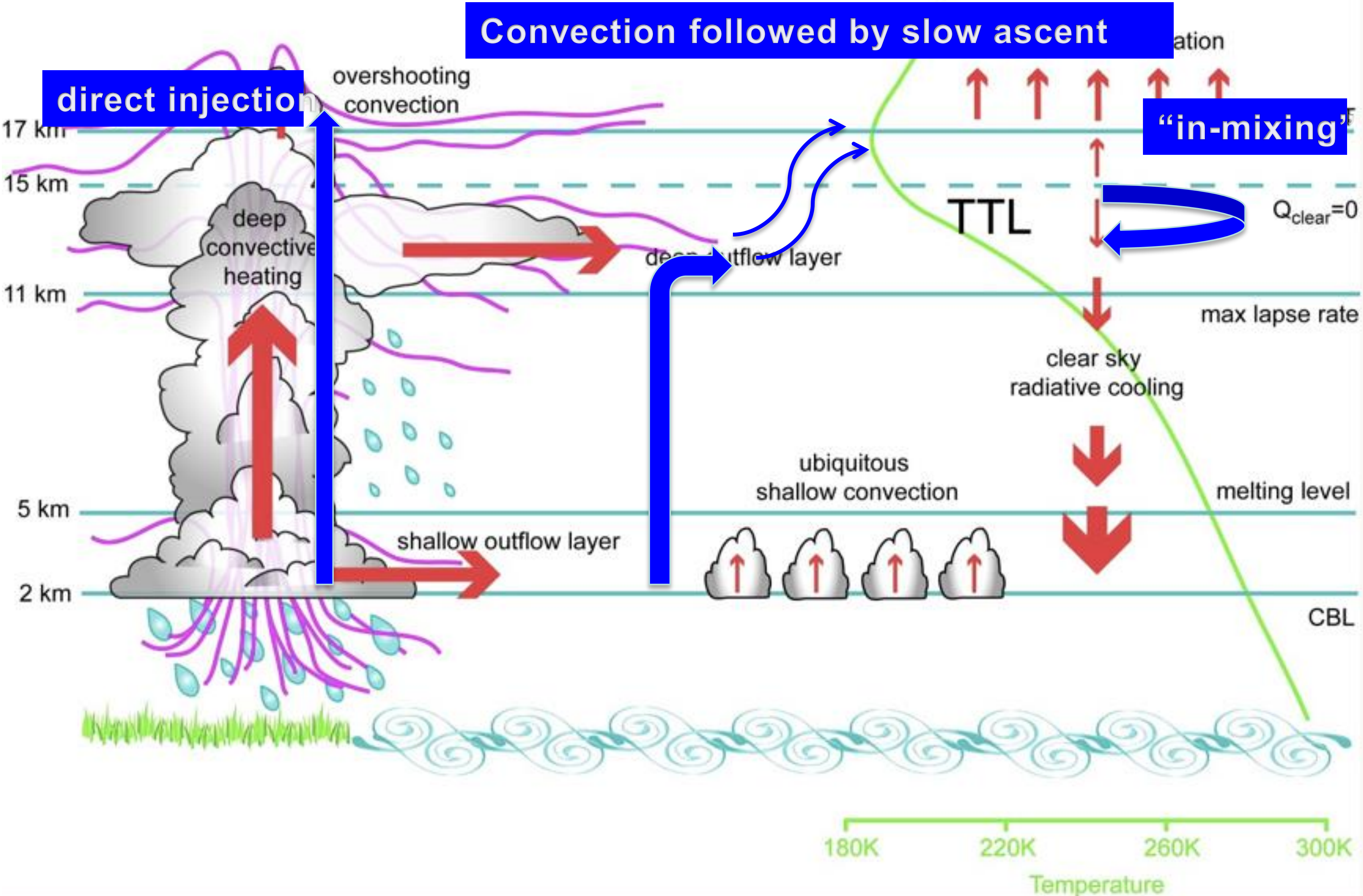


Models predict high levels of reactive halogens, low ozone and OH, with significant loss of O_3 due to halogen cycles. CONTRAST will test these model predictions.

Model predictions from CAM-CHEM



Tropical Tropopause Layer and Deep Convection



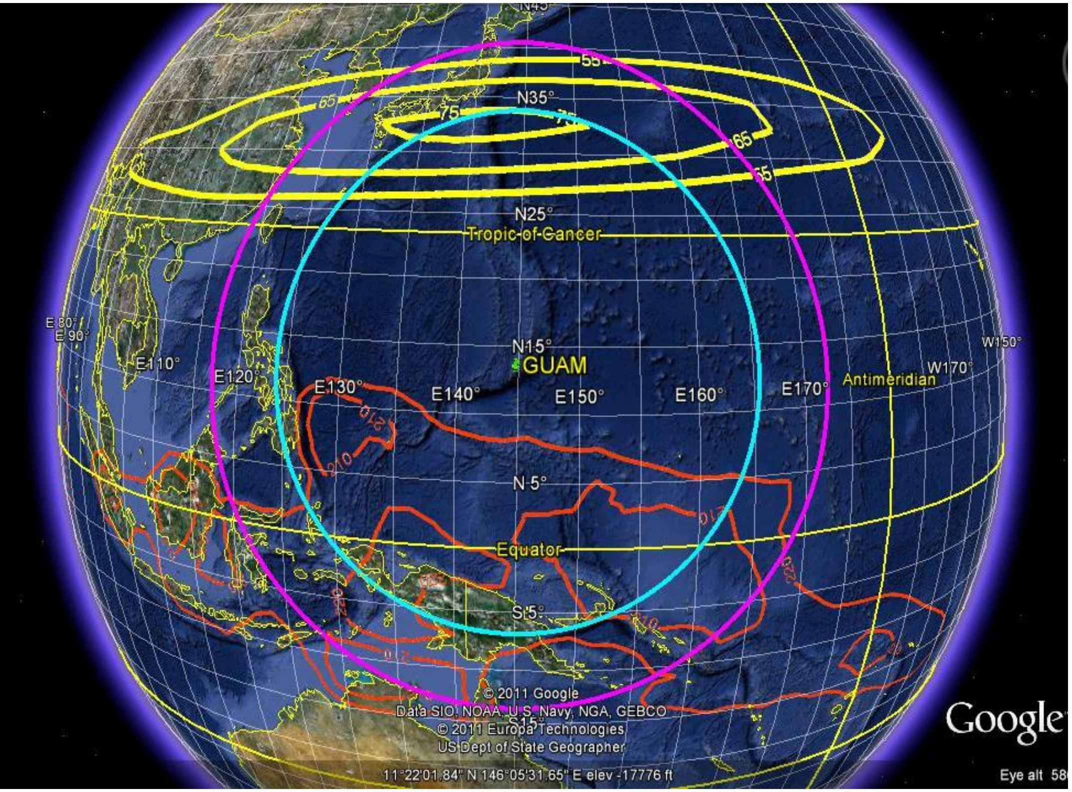
CONTRAST: Scientific Objectives

- Characterize the chemical composition and ozone photochemical budget at the level of convective outflow over the Western Pacific during the deep convective season
- Evaluate the budget of organic and inorganic bromine and iodine in the TTL
- Investigate transport pathways from the oceanic surface to the tropopause using the GV coordinated flights with BAe-146 and Global Hawk

CONTRAST – Hypotheses and Goals

- **The photochemical budget of O_3 in the tropical TTL is determined by the strength of inputs of chemical precursors from convection and lightning.**
- **The low O_3 environment of air undergoing recent, deep convection will increase the atmospheric lifetime of halocarbons lost by reaction with OH.**
- **CH_2Br_2, $CHBr_3$, and other VSL bromocarbons will be elevated in air parcels that have undergone recent deep convection will remain elevated in the TTL**
- **When CBr_y and CCl_y species decompose, the resulting inorganic species remain as labile, gas phase species.**
- **Coordinated aircraft measurements can quantify the relative importance of convective detrainment, deep convective injection, and lateral mixing for trace gas transport from the surface to the stratosphere, based on observations in the tropical TTL.**

CONTRAST Operations



Mission Dates:

15 Jan – 28 Feb, 2014

Location:

Guam

Science Research Flights:

96 hrs + transit flight

CONTRAST Payload (1)

Chemistry		Investigator	GH	BAe-146
NO_x	NO, NO_2	Weinheimer/NCAR ACD	NO	YES
Fast Ozone	O_3	Weinheimer/NCAR ACD	YES	YES
VUV Carbon Monoxide	CO	Campos/NCAR ACD	YES	YES
Picarro	CO_2, CH_4	Flocke/NCAR ACD	YES	YES
TOGA	NMHCs, OVOCs	Apel/NCAR ACD & Riemer / U Miami	NO	YES
GT-CIMS	BrO, BrCl, HOBr, ClO	Huey/GIT	NO	YES
AMAX	BrO, IO, H_2CO (remote)	Volkamer/CU	YES	NO
HAIS Advanced Whole Air Sampler (AWAS)	Trace gases	Atlas/U.Miami	YES	YES
In Situ Airborne Formaldehyde (ISAF)	H_2CO	Hanisco/ NASA GSFC	NO	NO
Inorganic Br	Br* (Σ BrO + Br)	Atlas/U.Miami & Flocke/ACD	NO	NO
Radiation				
HARP	Spectral Actinic Flux	Hall /NCAR ACD	YES	YES

CONTRAST Payload (2)

State parameters		
State Parameters	Lat/Lon, P, T, 3D wind	Jensen/NCAR RAF
RAF Digital Video	Fwd view	Jensen/NCAR RAF
Microphysics		
CDP Cloud Probe	2 - 50 um, water droplets, ice crystals	Jensen/NCAR RAF
2D-C Precipitation Probe	25-1600 um, ice, water	Jensen/NCAR RAF
UHSAS Aerosol Probe	0.075 - 1 um, aerosols	Jensen/NCAR RAF
WCN CN Counter	0.01 - 3 um, aerosols	Jensen/NCAR RAF
VCSEL Laser Hygrometer	water vapor	Jensen/NCAR RAF

CONTRAST – Forecast and Modeling

Theory and Modeling:		Affiliation
J.-F. Lamarque	NCAR CAM CHEM	NCAR/ACD
Doug Kinnison	NCAR CAM CHEM	NCAR/ACD
Alfonso Saiz-Lopez	NCAR CAM CHEM	CSIC
Tim Canty		U. Maryland
Julie Nicely		U. Maryland
Bill Randel		NCAR/ACD
John Orlando		NCAR/ACD
John Bergman	Trajectory Model	NCAR/ACD
Qing Liang		NASA/GSFC
Darryn Waugh		Johns Hopkins Univ.

Meteorology and Operations:		
Jim Bresch	Lead Meteorologist	NCAR/MMM
Shawn Honomichl		NCAR/ACD
Cameron Homeyer	Trajectory Model	NCAR/ASP/ACD
Jiali Luo		NCAR/ACD
Thomas Robinson	Meteorologist	University of Hawaii
Owen Shieh	Meteorologist	University of Hawaii

Part II:
Short-lived organic compounds in the tropical atmosphere

with contributions from:

K. Smith, M. Navarro, X. Zhu, L. Pope, R. Lueb, R. Hendershot, F. L. Moore, B. R. Miller, S. A. Montzka, J. W. Elkins, L. Pan, S. C. Wofsy, D. R. Blake, S. Meinardi , B. Quack, K. Krüger, S. Tegtmeier, R. Salawitch, +…

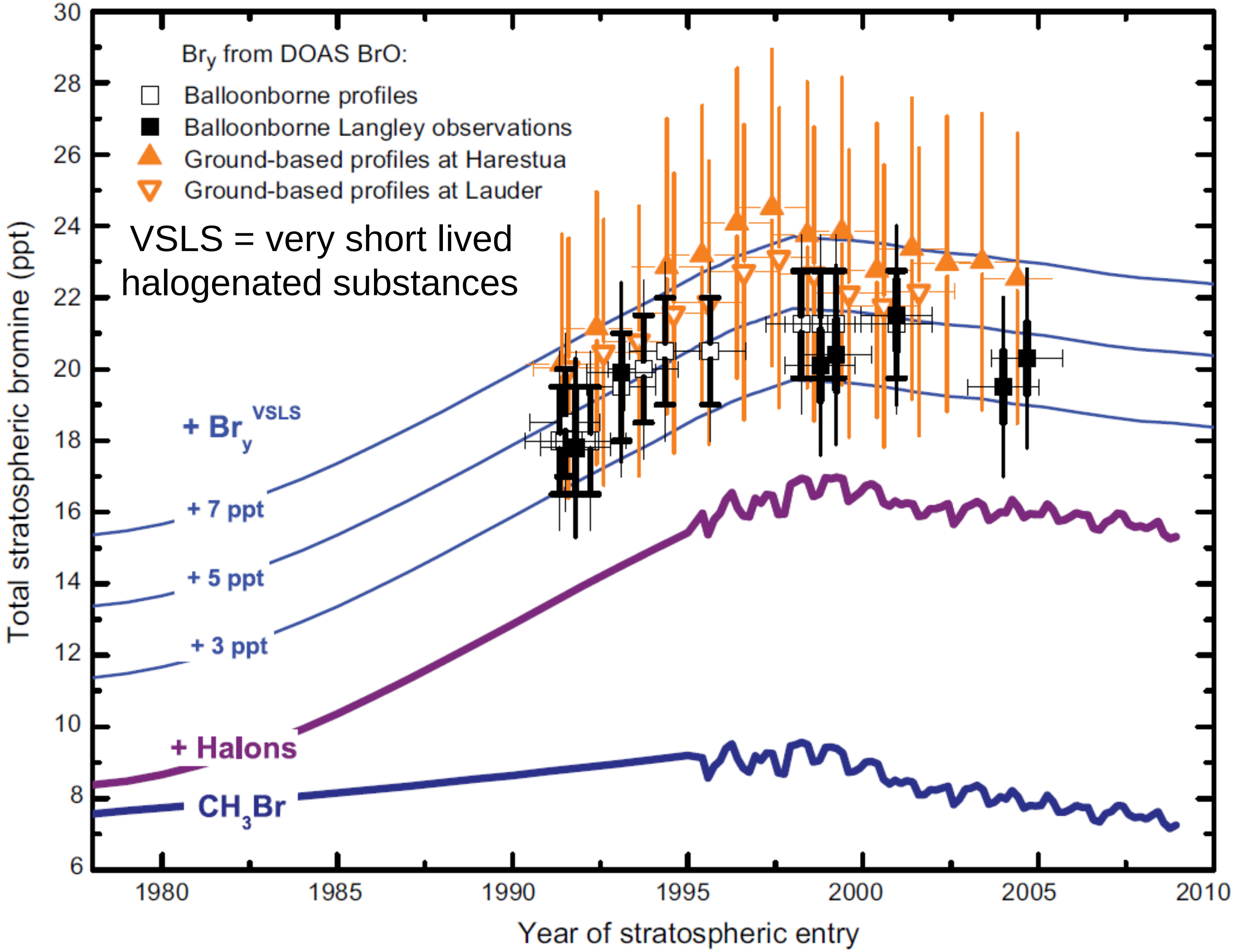
Short-lived organics and CONTRAST:

1. Examine budget and partitioning of organic halogens in the TTL

2. Identify chemical signatures of air mass sources and photochemical processing

3. Evaluate transport pathways and variability of short-lived organics into and through the TTL.

Stratospheric Bromine Budget: WMO 2010



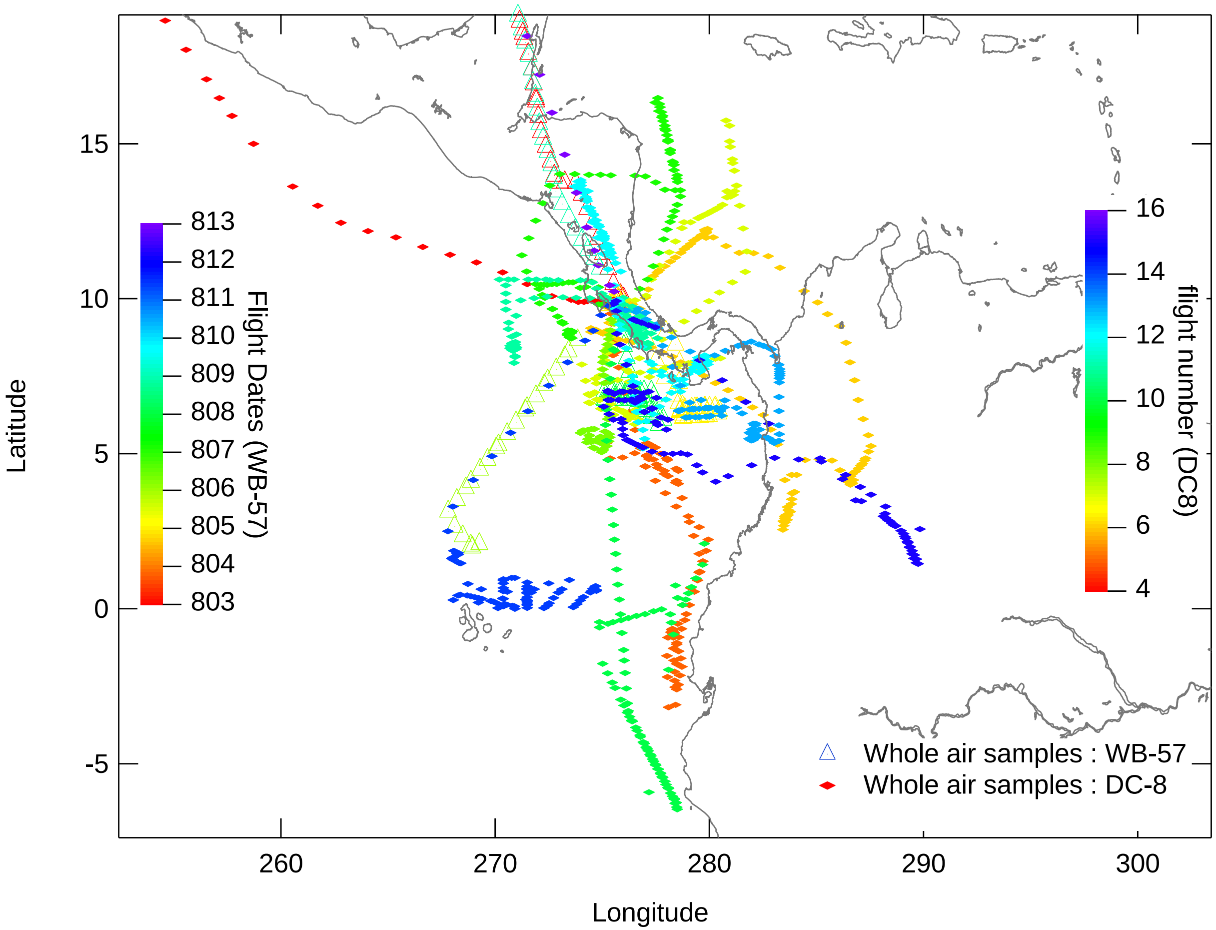
+ CH_2Br_2
+ $CHBr_3$
+....

Scientific Assessment of Ozone Depletion: 2010

Figure 1-21

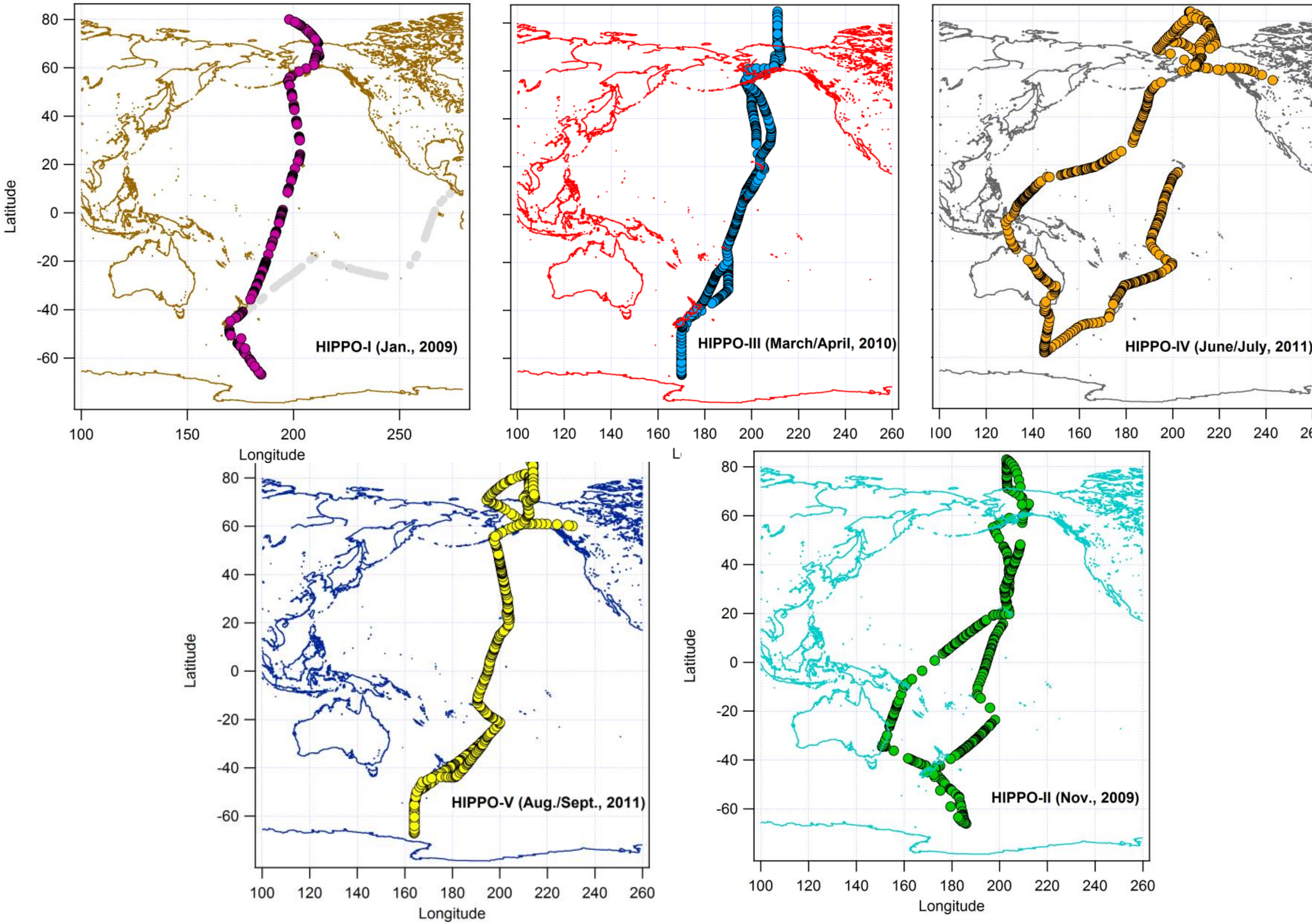
Recent field studies:

- TC4 mission: Costa Rica: 2006 (+ other AVE)

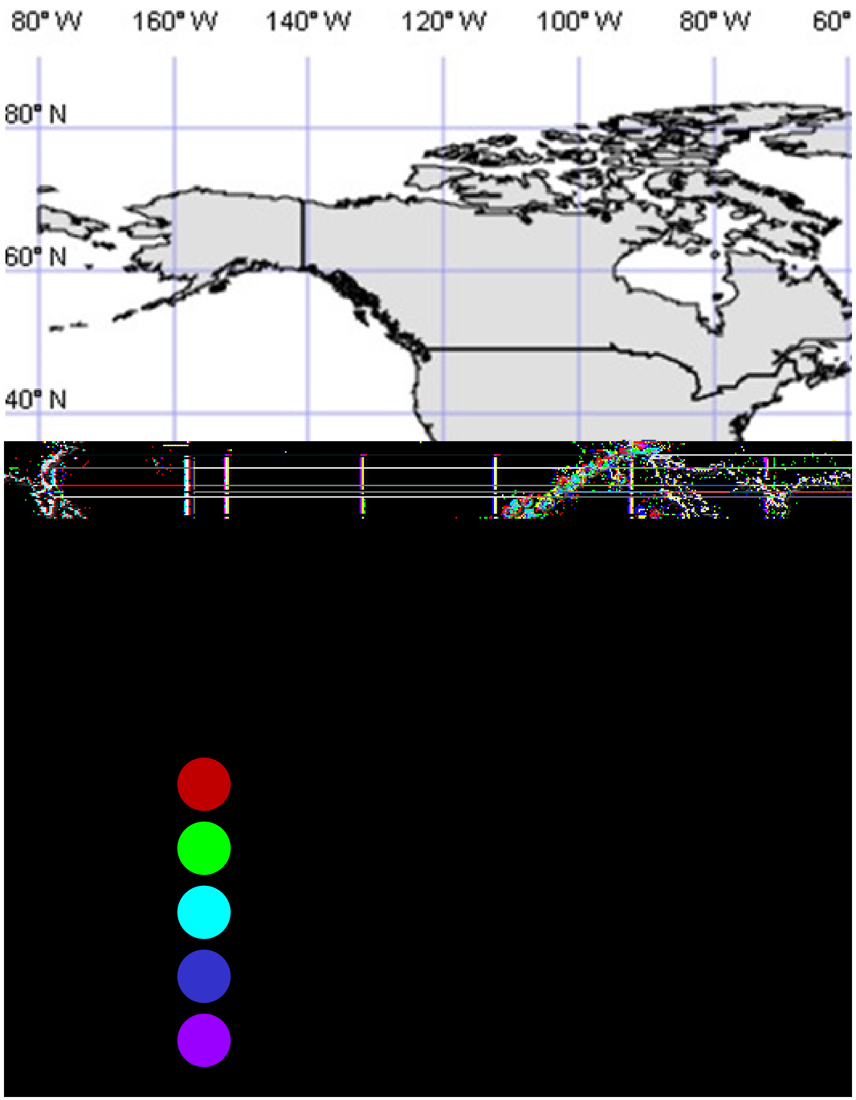


Recent field studies:

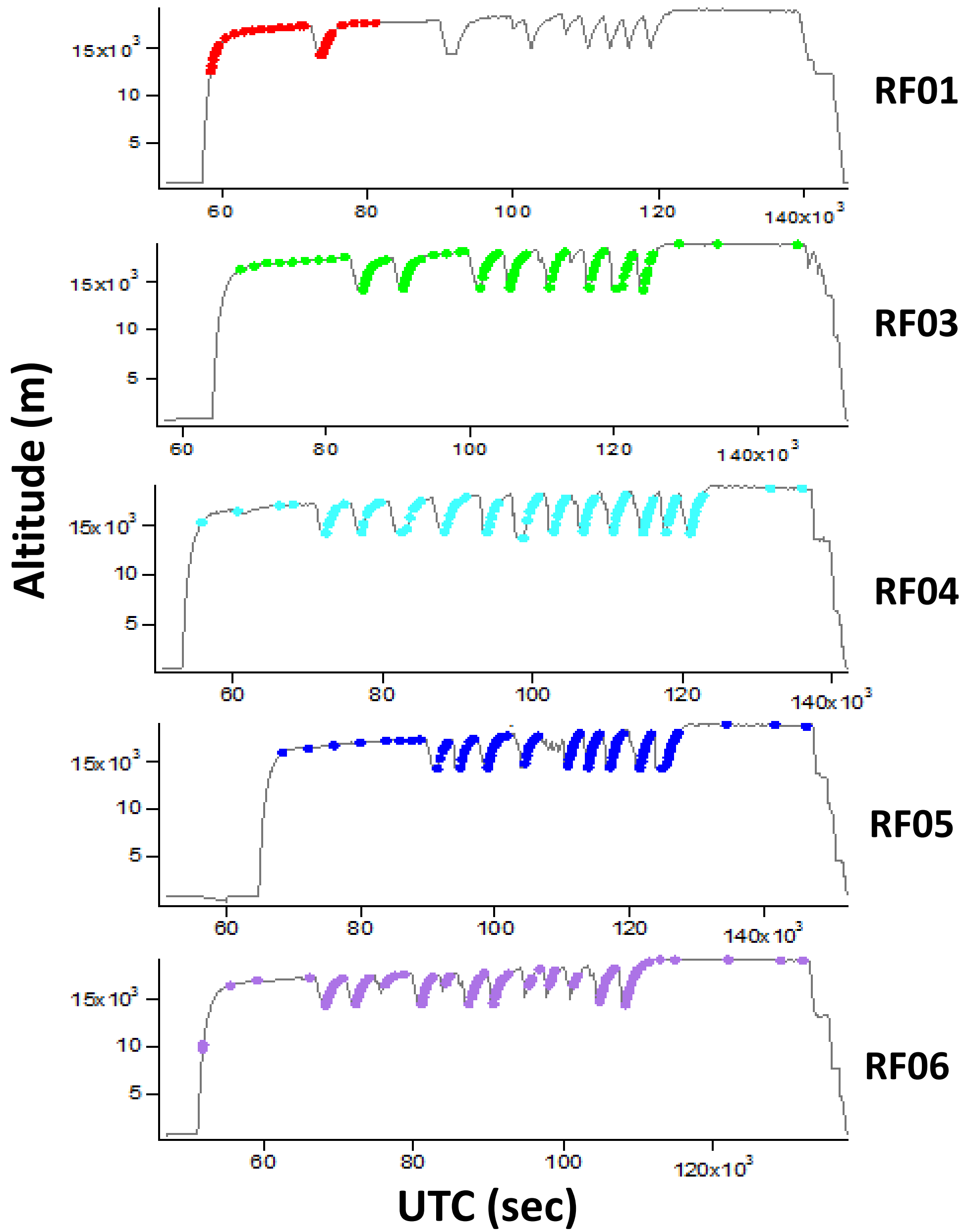
- HIPPO Missions (2009-11)[Jan., Mar., June, Aug, Nov]



ATTREX 2013

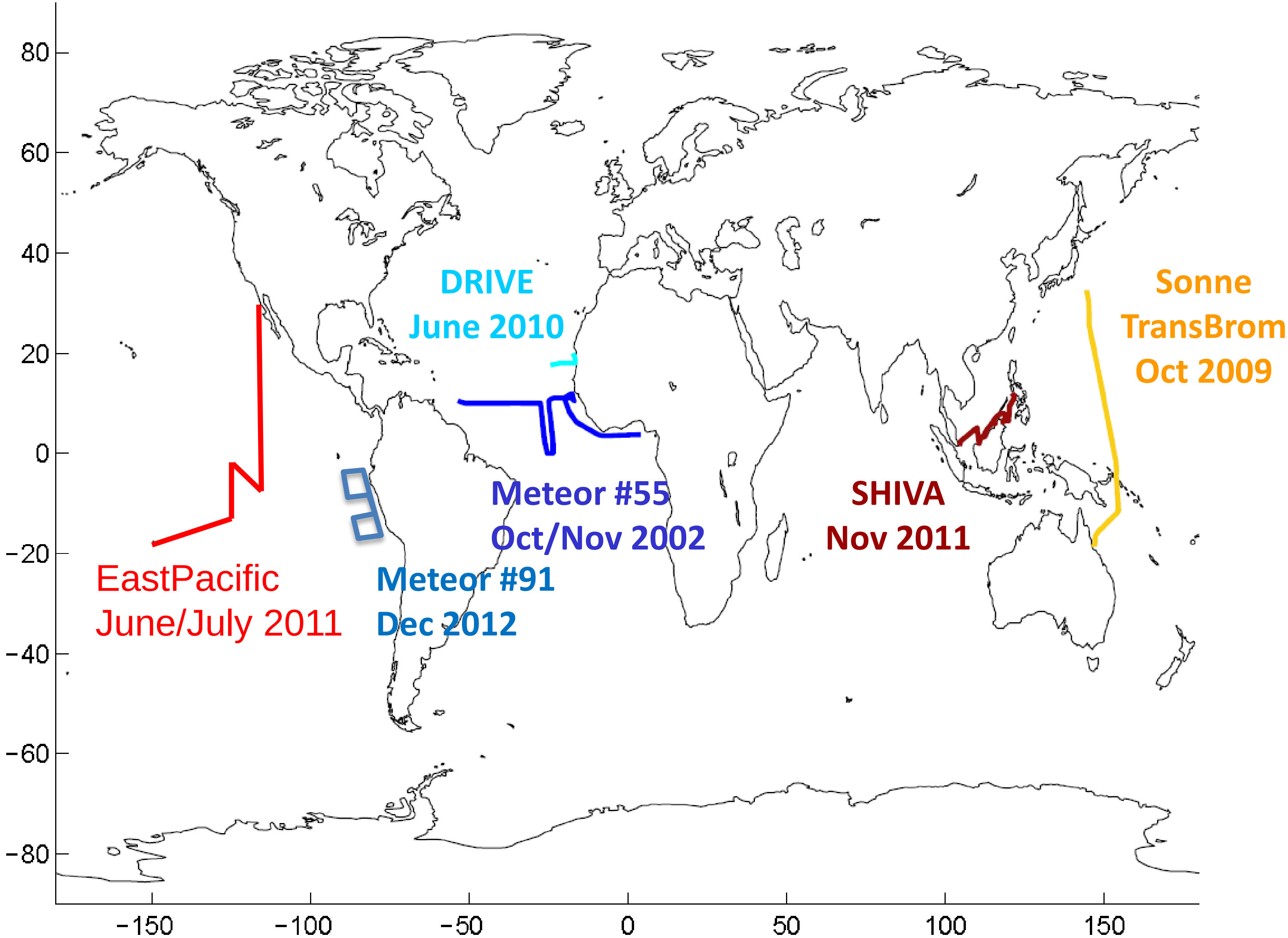


80° W
160° W
140° W
120° W
100° W
80° W
60°
80° N
60° N
40° N



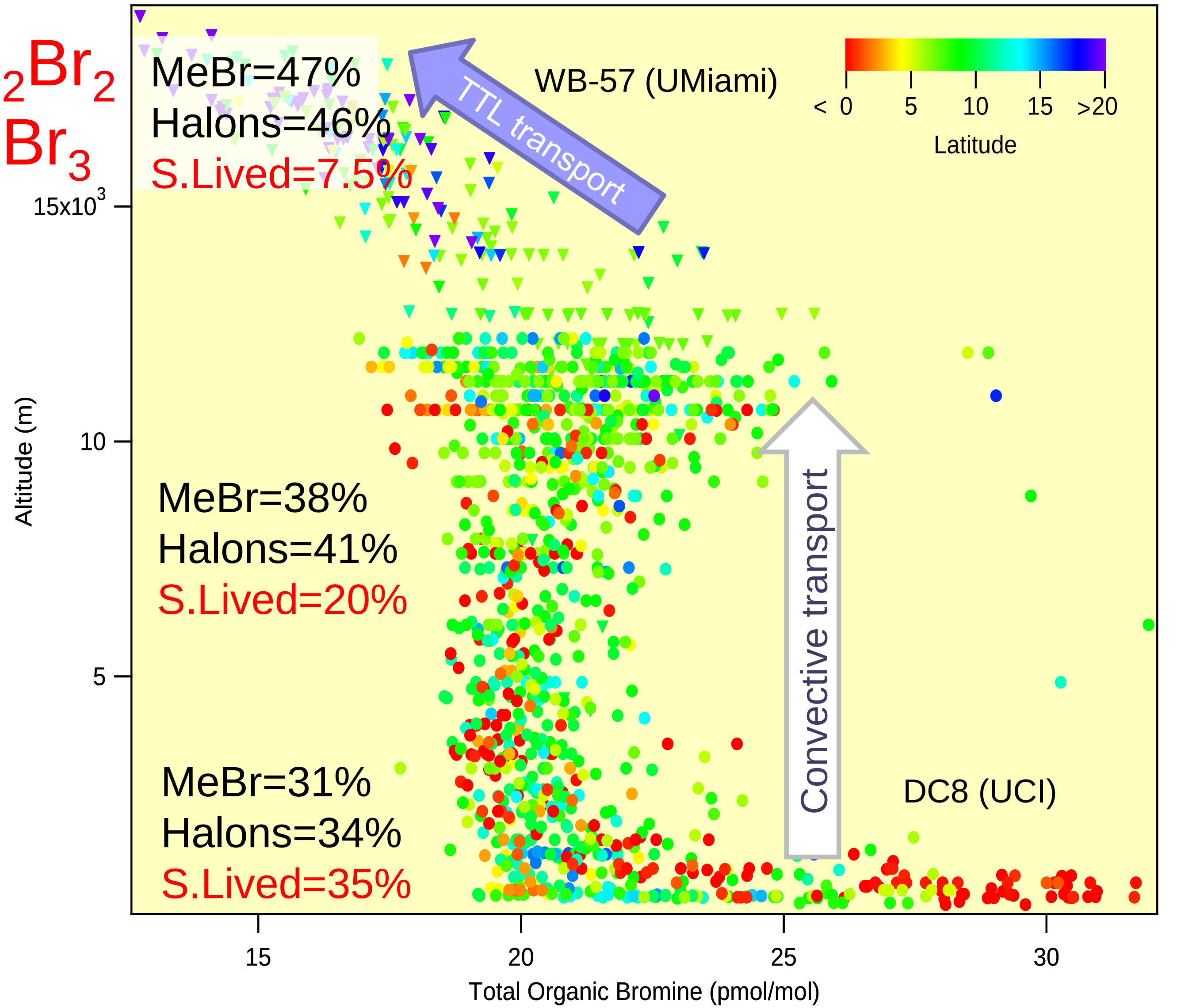
RF01
RF03
RF04
RF05
RF06
Altitude (m)
UTC (sec)

Ship-based Measurements

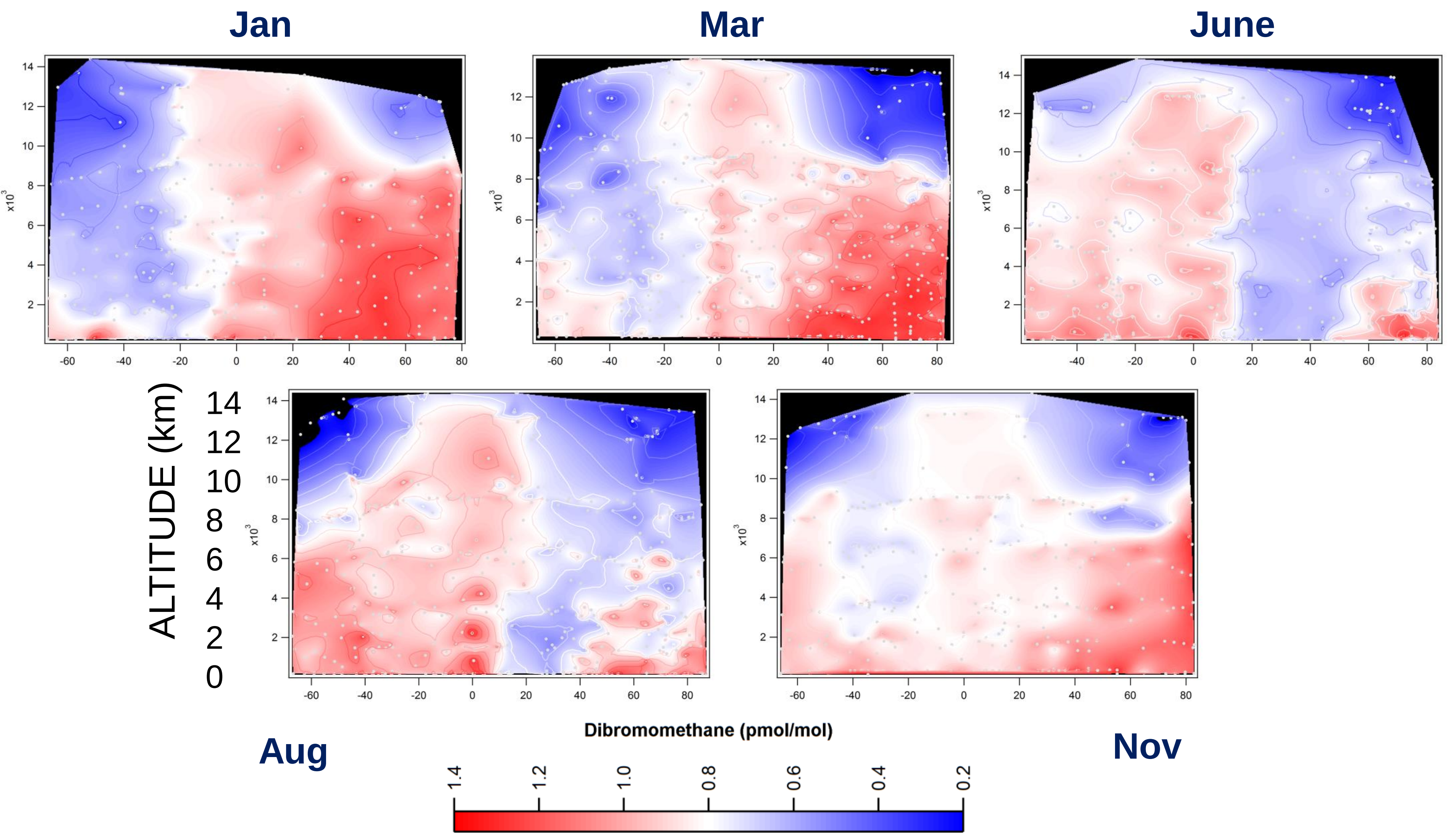


Organic Bromine over the Eastern Pacific (TC4)

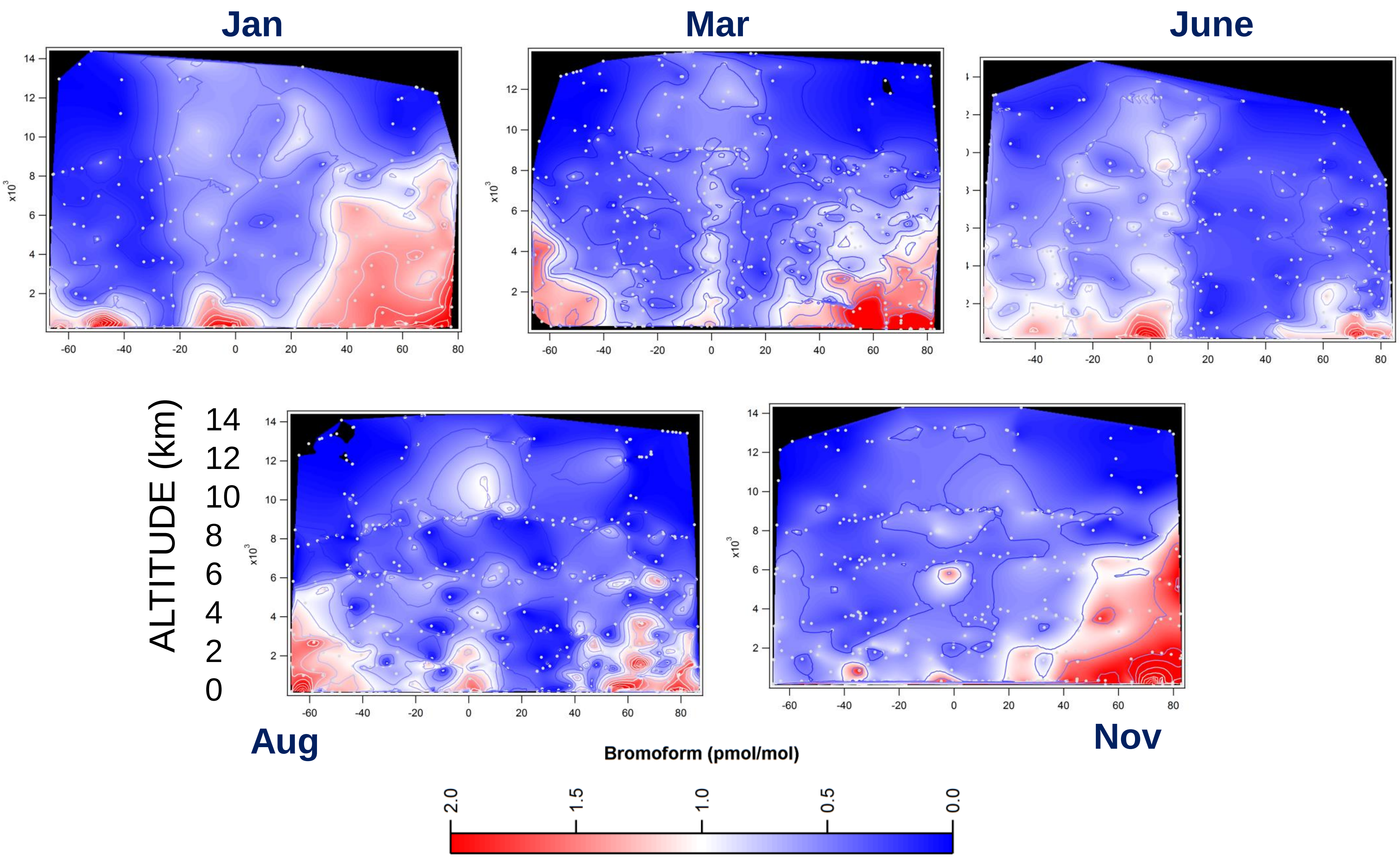
65% CH_2Br_2
20% $CHBr_3$



Dibromomethane (CH_2Br_2)



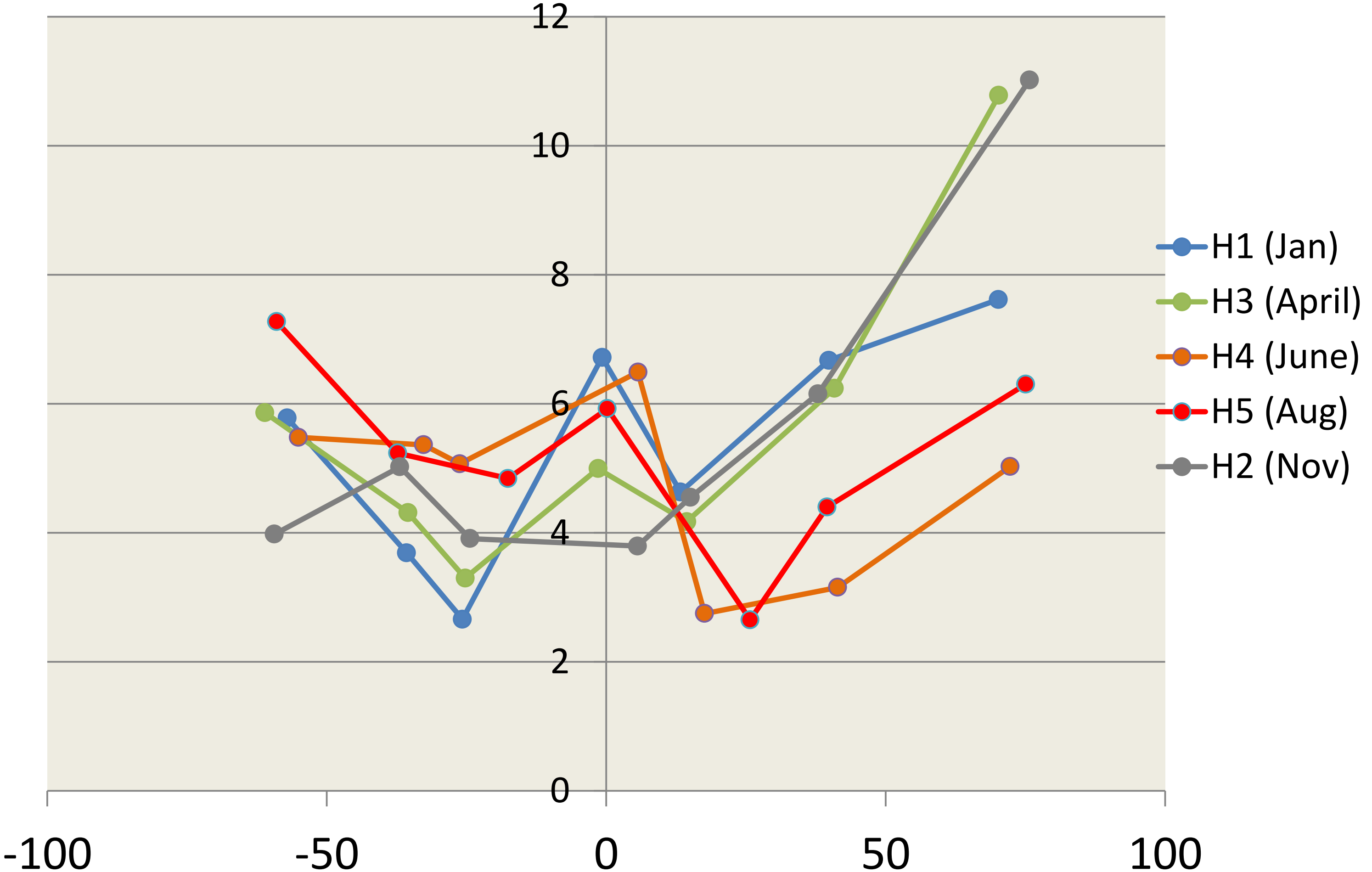
Bromoform ($CHBr_3$)



Short-lived Organic Br

$(CHBr_3+2*(CH_2Br_2+CHBr_2Cl))$

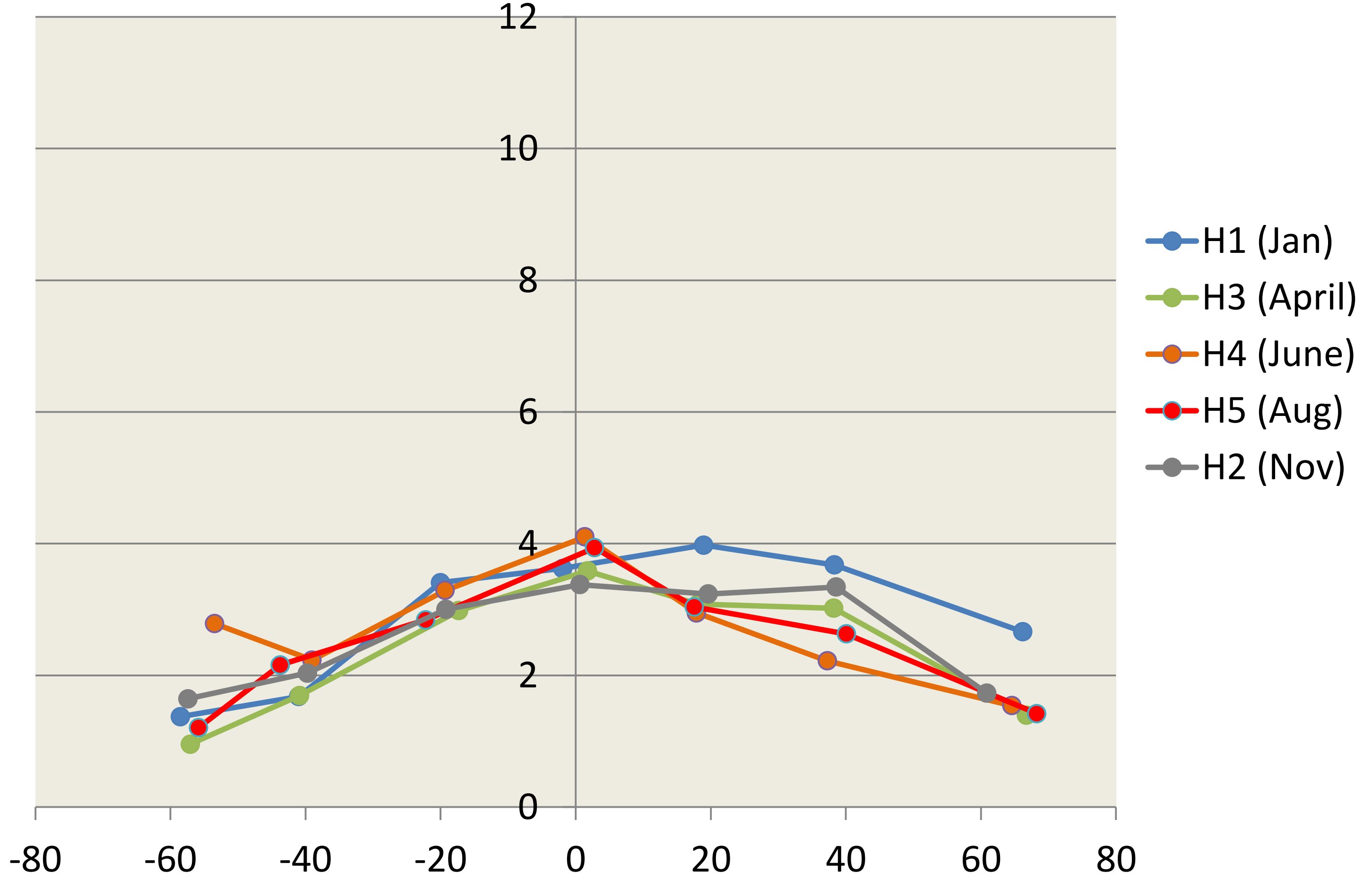
0-2km



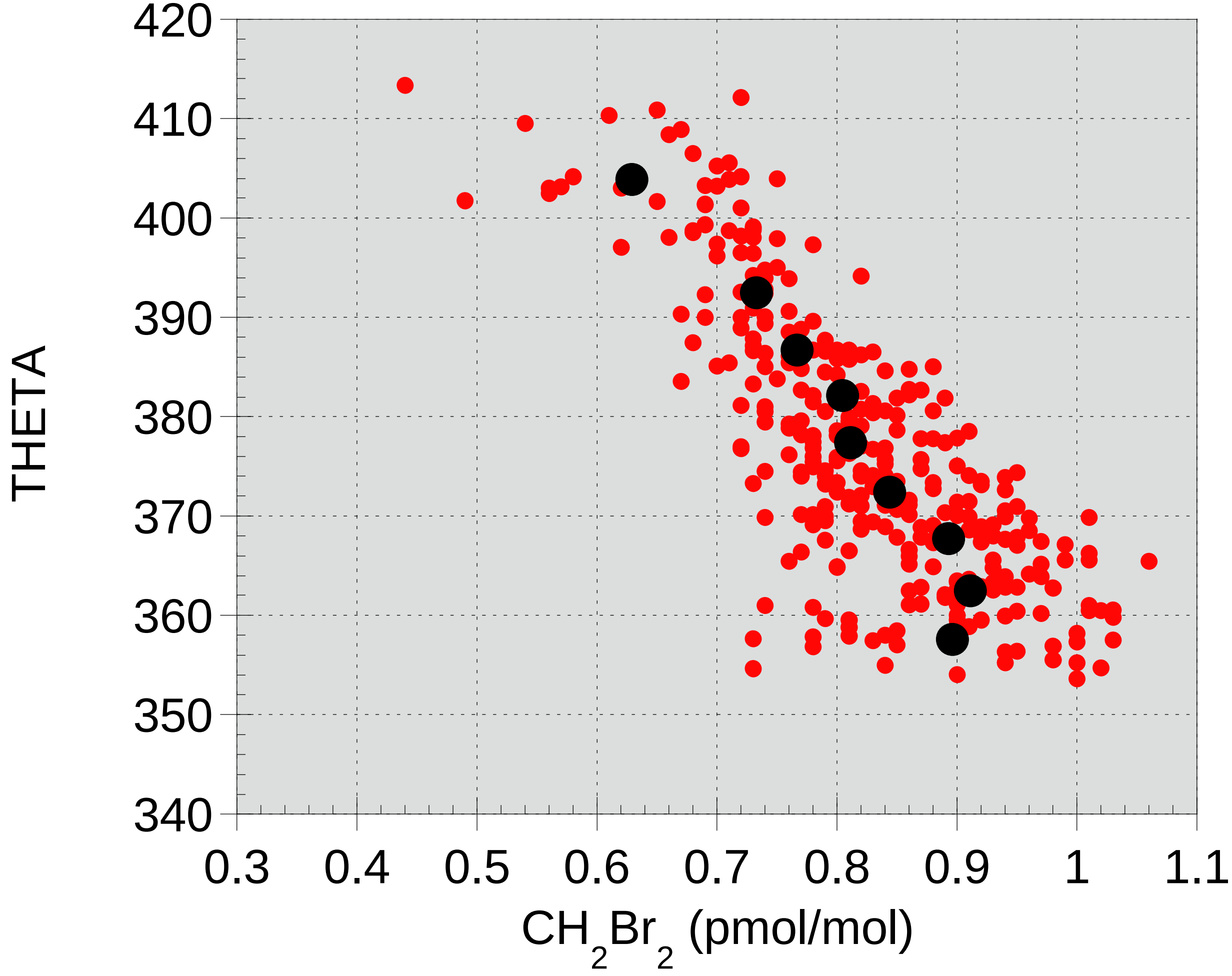
Short-lived Organic Br

$(CHBr_3+2*(CH_2Br_2+CHBr_2Cl))$

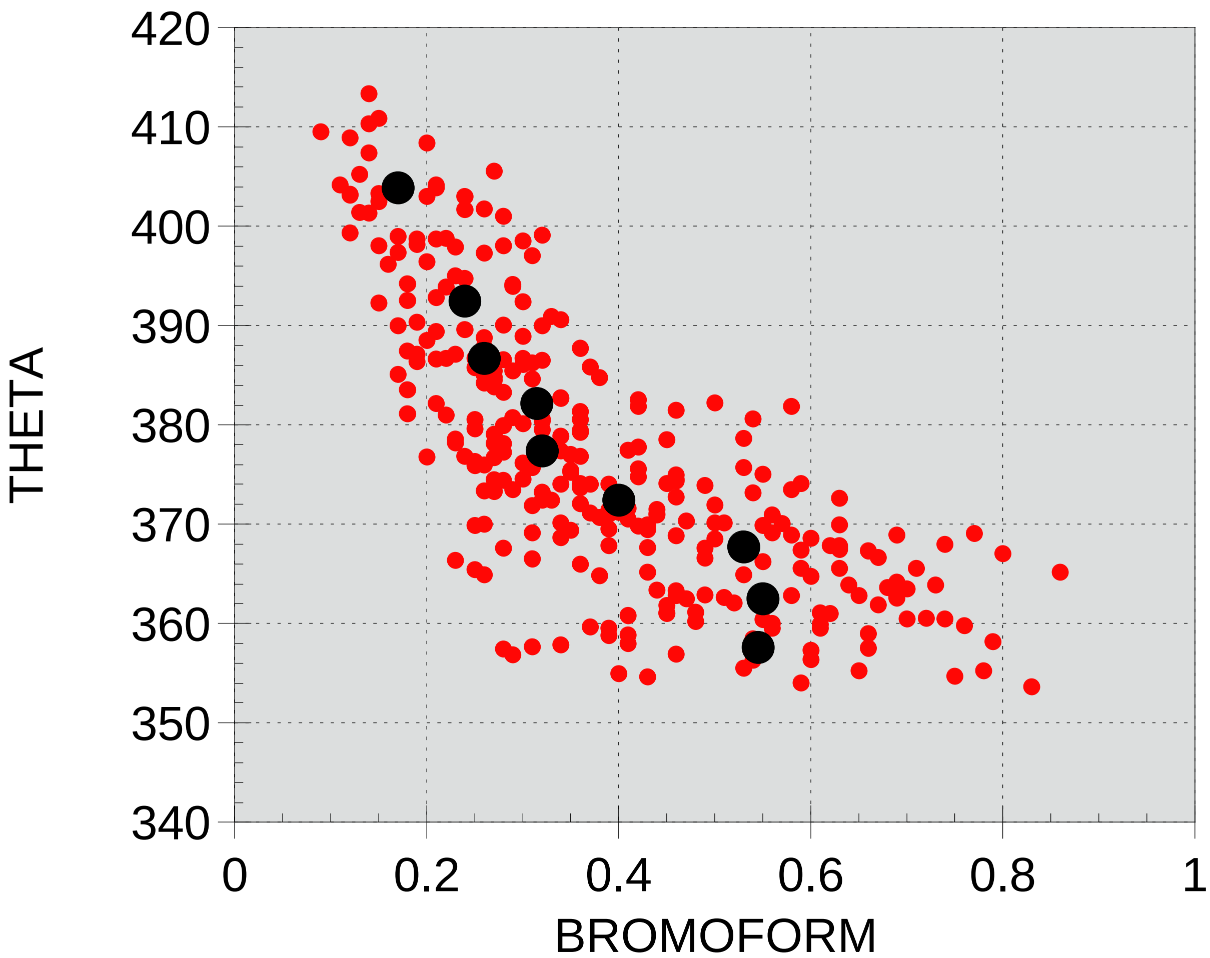
>8km



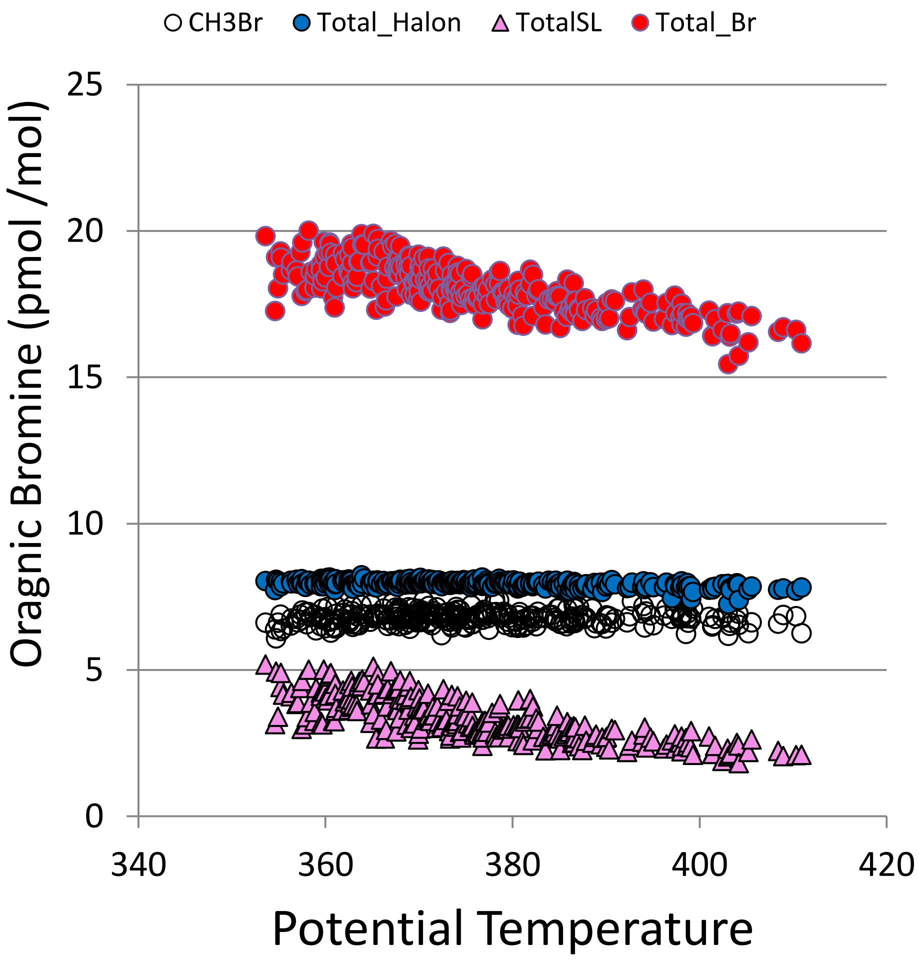
Vertical structure of organic bromine in the TTL (ATTREX 2013)

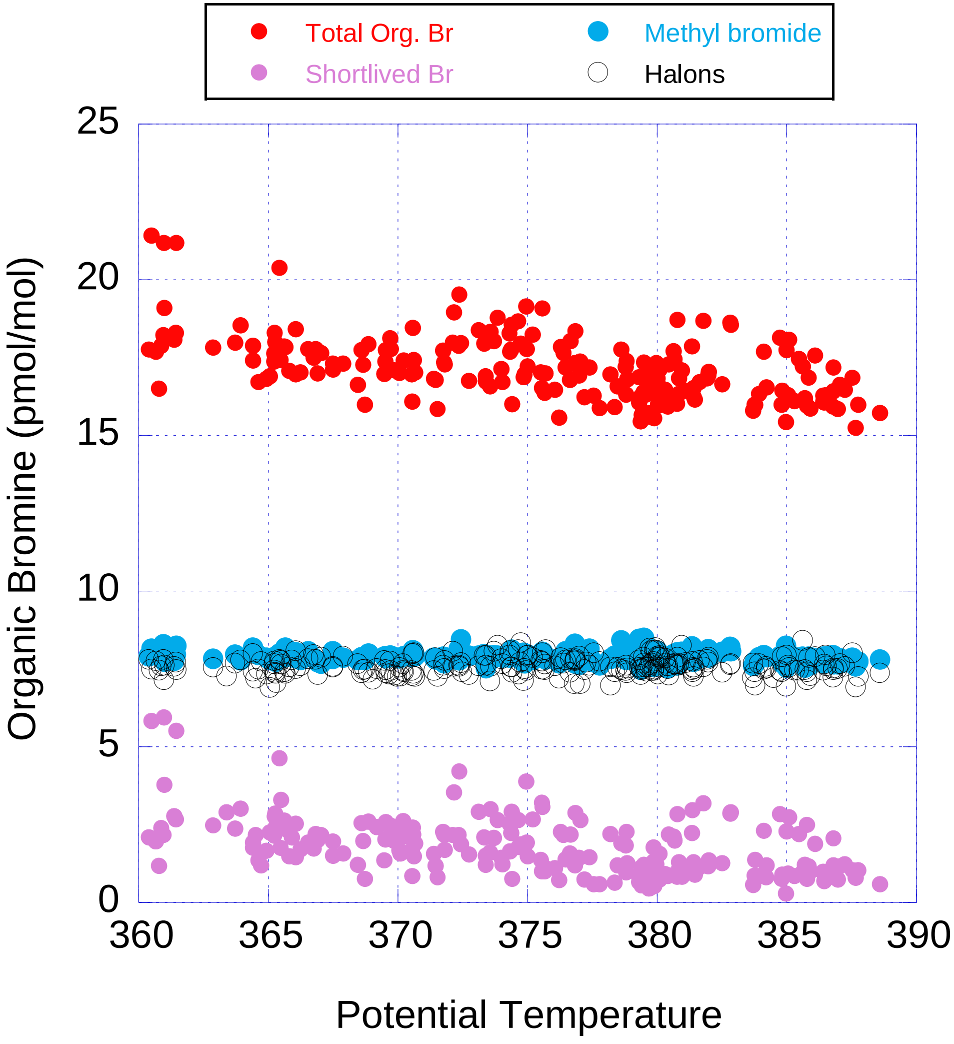


Vertical structure of organic bromine in the TTL (ATTREX 2013)

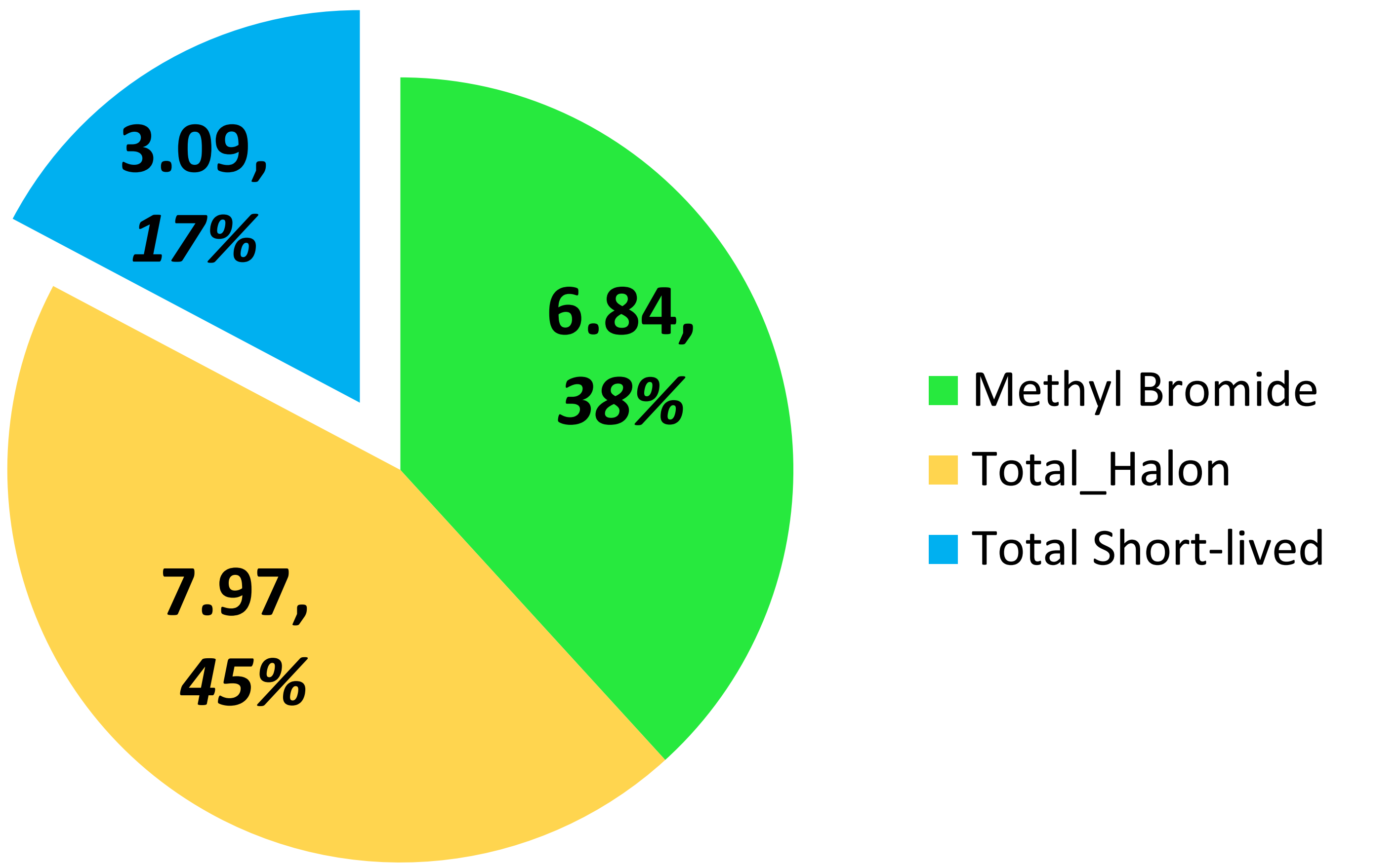


Organic Br partitioning across TTL ATTREX (2013) and CR-AVE (2006)

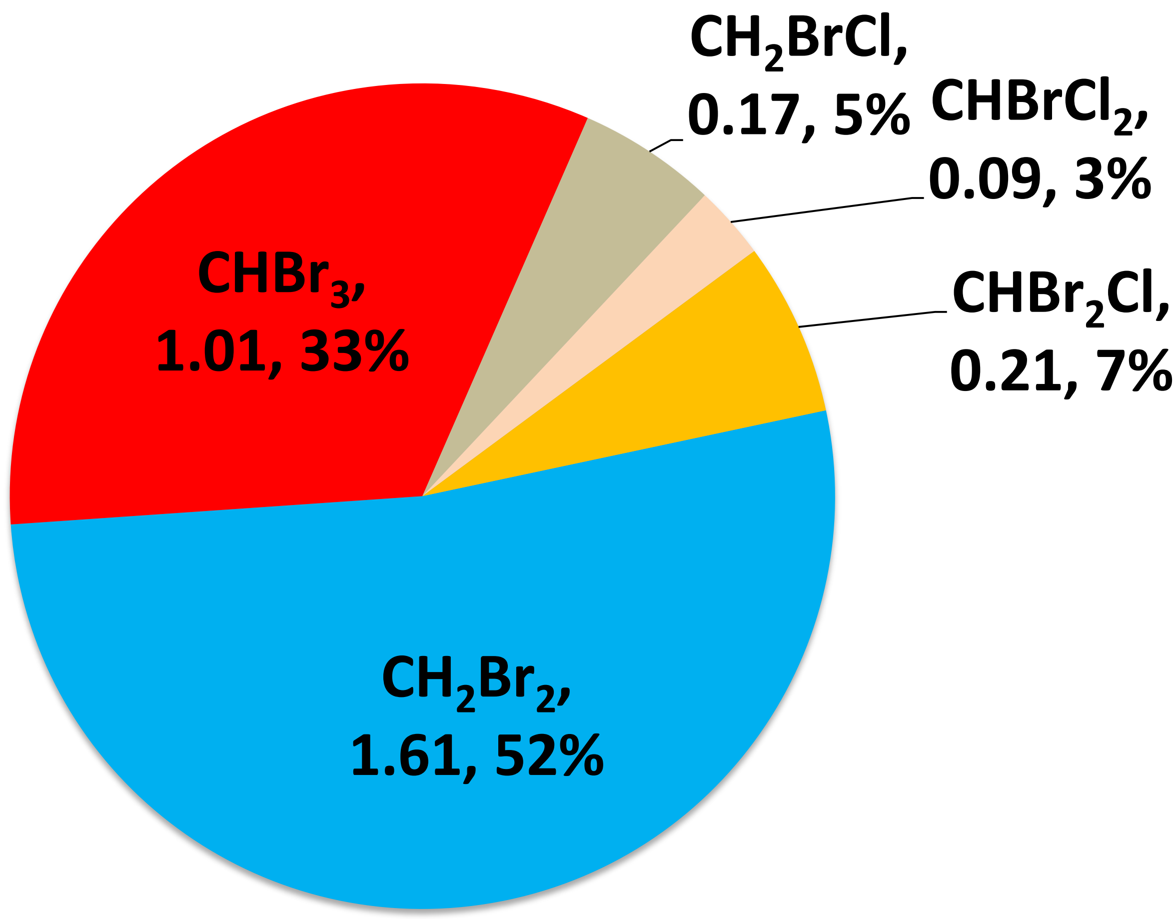




Organic Br partitioning near tropopause (375-380K avg)

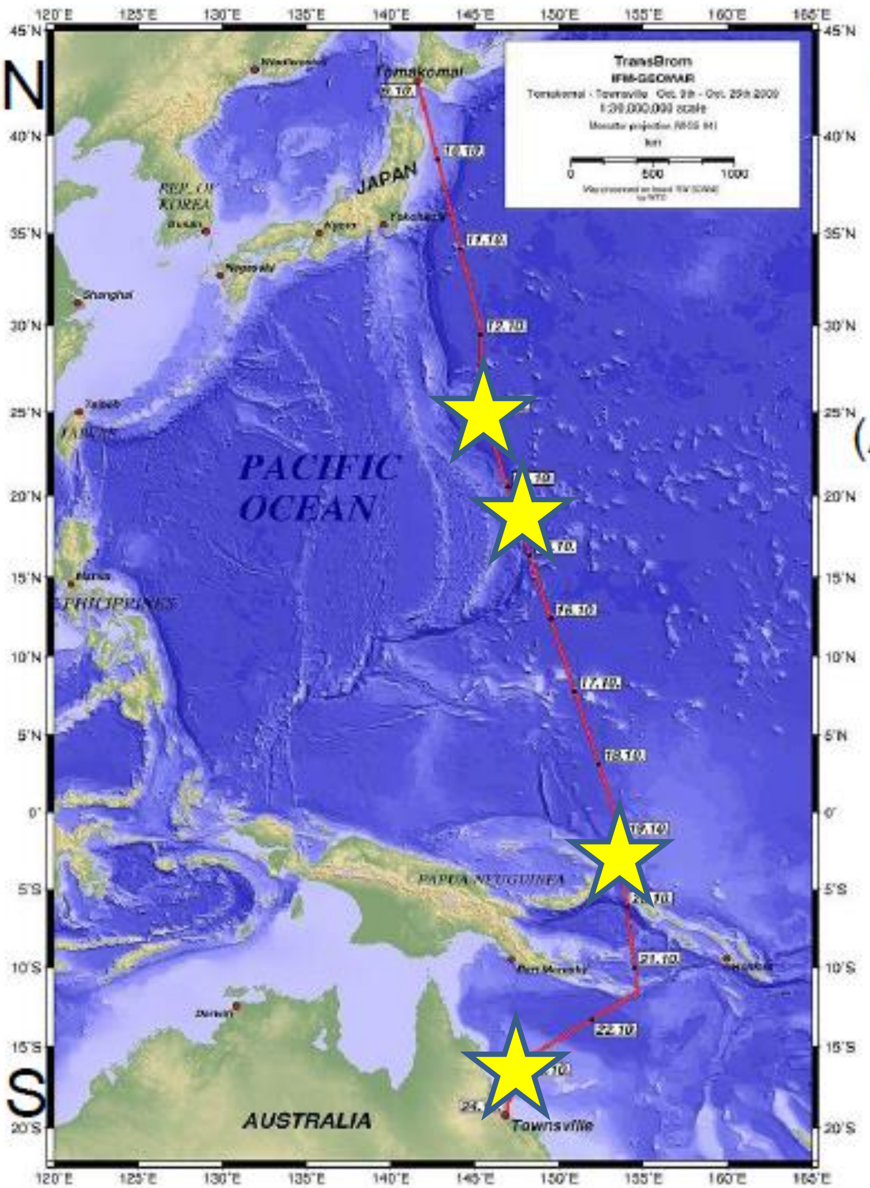


Short-lived Br composition near tropopause (375-380K avg)



145 E

42 N



19 S

Tomakomai
(Japan, 42 35.4‘N/ 141 37.5‘E)

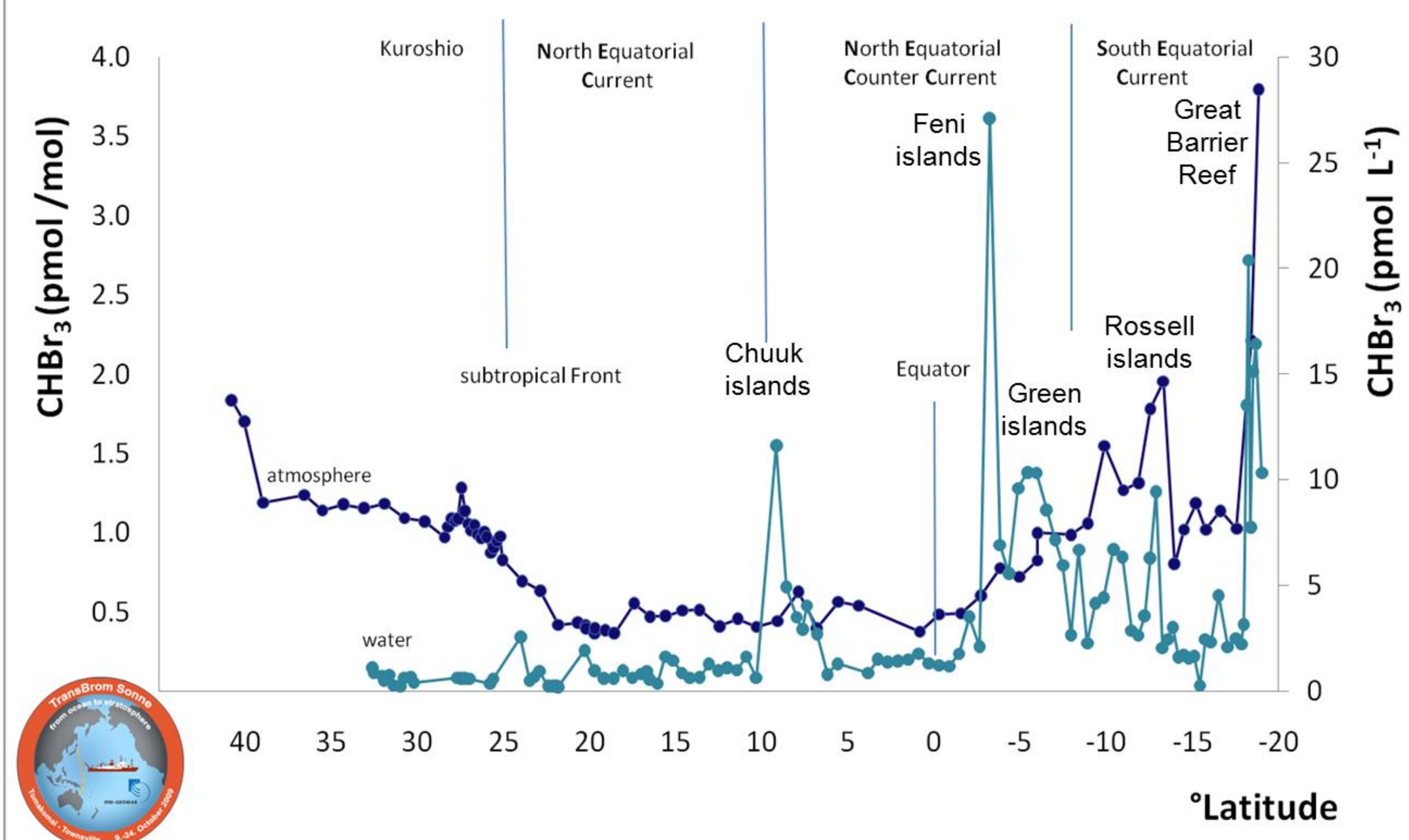
60 lat (7,500 km)

Townsville
(Australia, 19 06.6’S/ 146 50.5‘E).

TransBrom Sonne
from ocean to stratosphere
Tomakomai - Townsville 9.-24. October 2009
IFM-GEOMAR

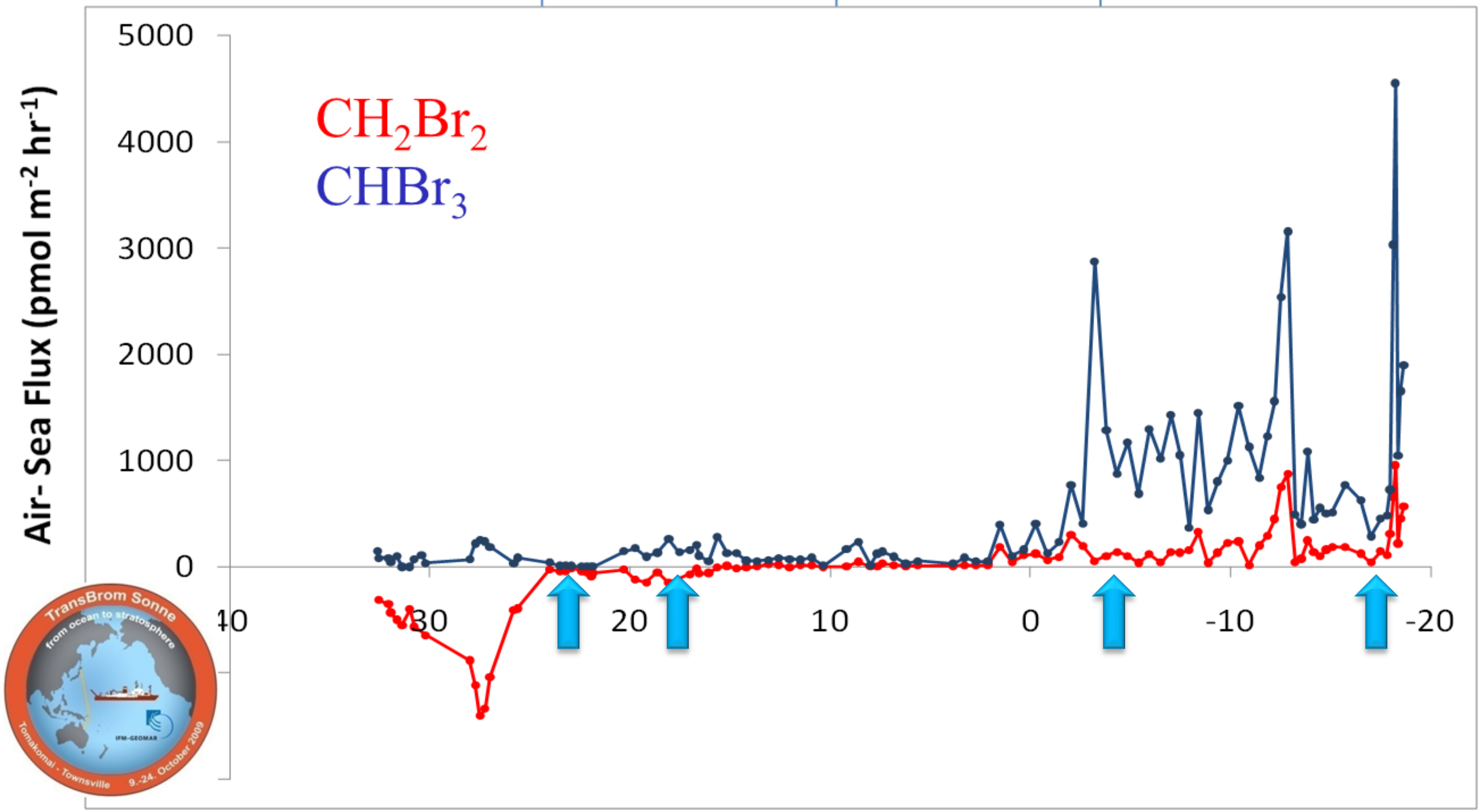
Birgit Quack, Chief Scientist

$CHBr_3$ in and over the western Pacific in October 2009



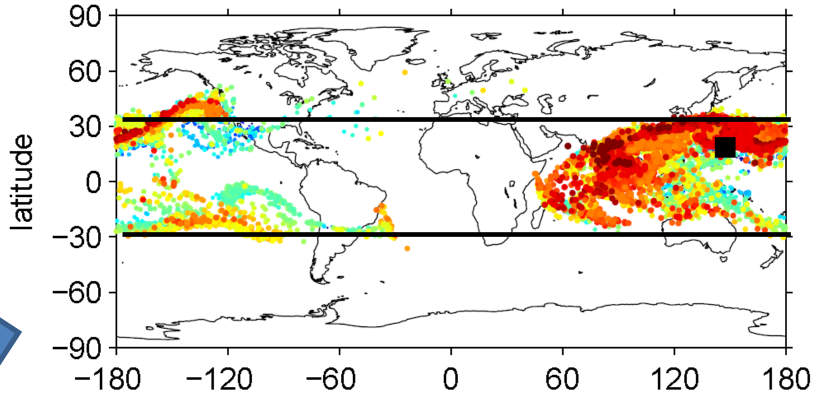
$CHBr_3$ in seawater data courtesy of Birgit Quack

$CHBr_3$ and CH_2Br_2 emissions in the western Pacific in October 2009



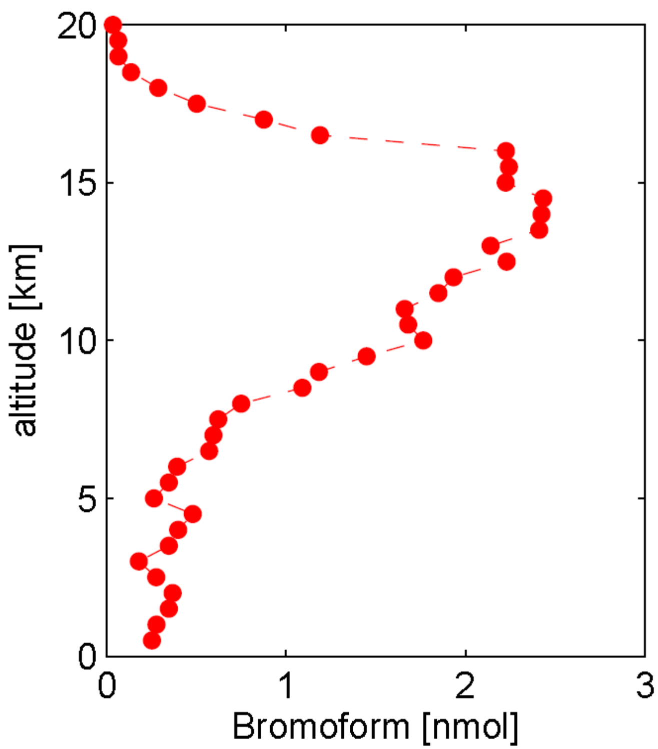
Method - illustrated by one case study

average over tropics

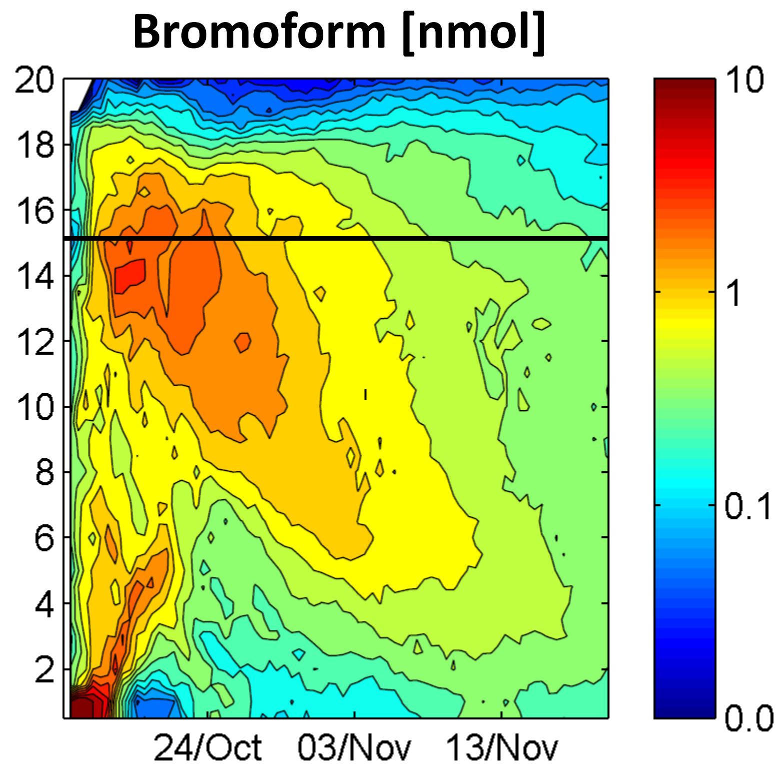


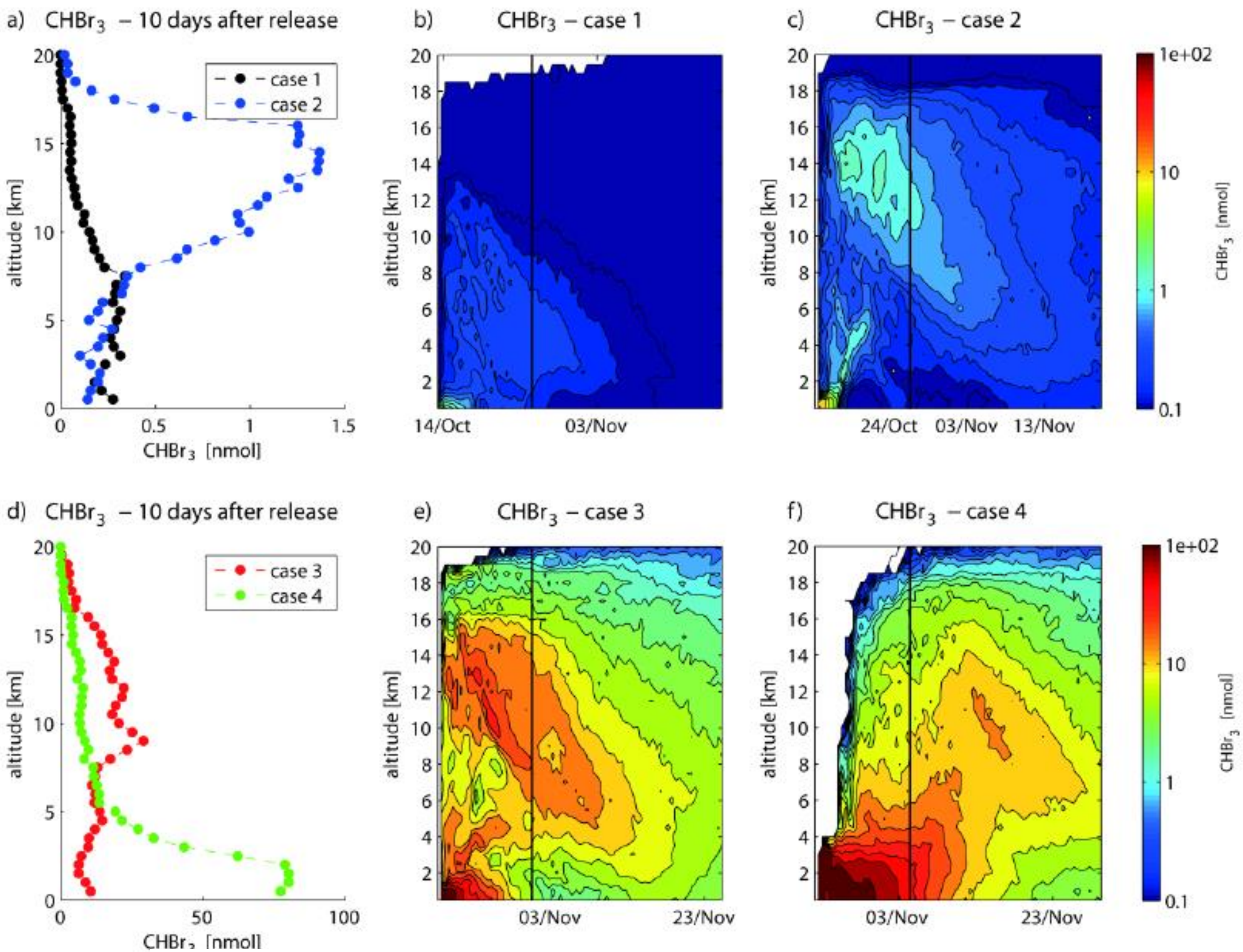
23.3 nmol Bromoform entrained above 15 km

Analyze air parcels crossing 15 km

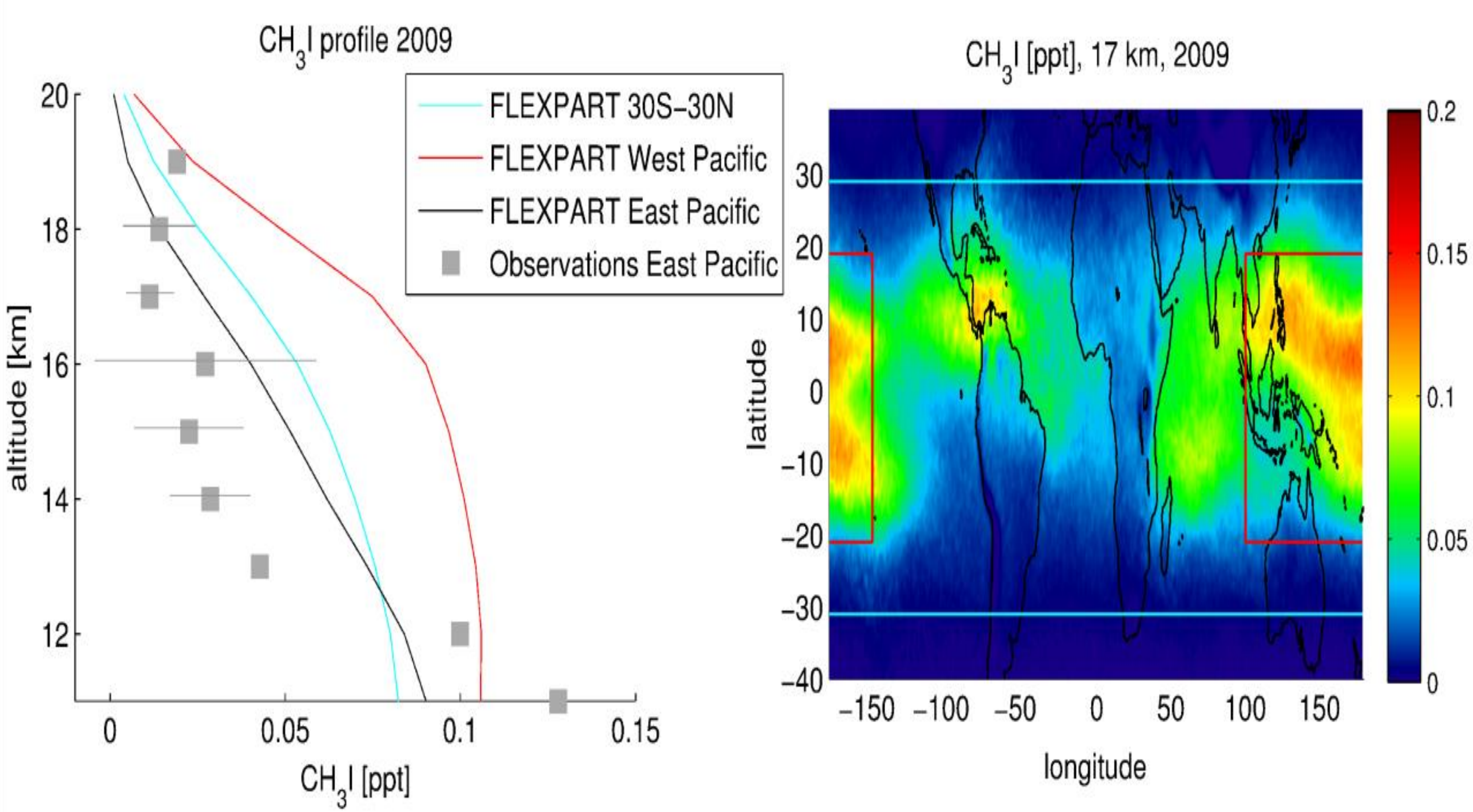


displayed for all time steps





a) CHBr3 – 10 days after release
case 1
case 2
altitude [km]
CHBr3 [nmol]
b) CHBr3 – case 1
14/Oct
03/Nov
c) CHBr3 – case 2
24/Oct
03/Nov
13/Nov
1e+02
10
1
0.1
CHBr3 [nmol]
d) CHBr3 – 10 days after release
case 3
case 4
e) CHBr3 – case 3
03/Nov
23/Nov
f) CHBr3 – case 4



from Tegtmeier et al., The contribution of oceanic methyl iodide to stratospheric iodine, ACPD, 2013.

Short-lived organics and CONTRAST:

1. Examine budget and partitioning of organic halogens in the TTL
   - *Measurements of reactive organic halogens*
   - *Measurement of inorganic halogens*

2. Identify chemical signatures of air mass sources and photochemical processing
   - *Measurement of many species with unique source emissions and locations*

3. Evaluate transport pathways and variability of short-lived organics into and through the TTL.
   - *Coordinated measurements from GH, GV, BAe evaluated for specific transport conditions*