

Preliminary Results from GMD's Halocarbons and other Trace Gases Measurements on Atmospheric Tomography Mission (ATom)

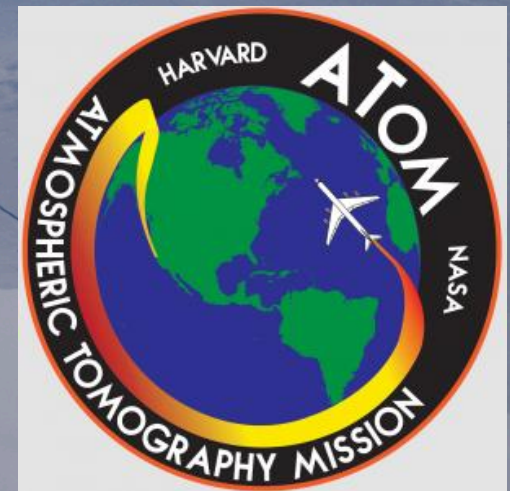
Tomography is imaging by sections or sectioning.

Primary science goal: Measure the chemical reactivity of the troposphere and how it is modified by human pollution and the effect of air quality on climate using the NASA DC-8 aircraft.

J.W. Elkins¹, F.L. Moore^{2,1}, E.J. Hints^{2,1}, E. Ray^{2,3}, G.S. Dutton^{2,1},
J.D. Nance^{2,1}, B.D. Hall¹, S.A. Montzka¹, C. Sweeney¹,
B.R. Miller^{2,1}, E.J. Dlugokencky¹, P.A. Newman⁴ and S.C. Wofsy⁵

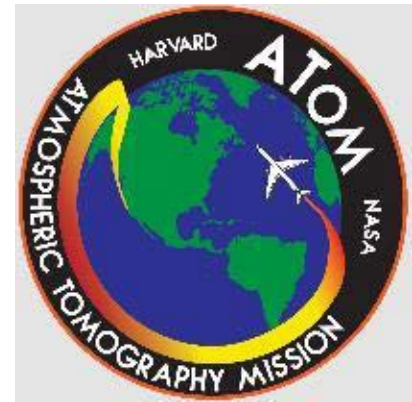
¹NOAA/GMD, ²CIRES, ³NOAA/CSD, ⁴NASA GSFC, & ⁵Harvard

NOAA GMAC, Wednesday, May 23, 2018



Sea ice meets land over Antarctica, photo by Jim Elkins

ATom Management



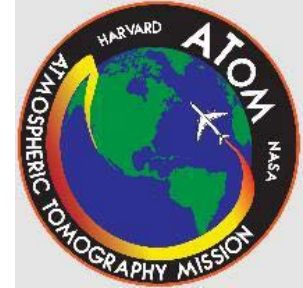
- Funded by NASA Earth Venture Suborbital 2 (EVS-2), 5 yr.; **Barry Lefer**, NASA, New Headquarters Lead
- **Steve Wofsy**, Harvard, Principal Investigator
- **Michael Prather**, UCI, Deputy PI
- **Tom Ryerson**, NOAA CSD, Science Team Lead and DC-8 Instrument Coordinator
- Dave Jordan, NASA, Project Manager
- Paul Wennberg, CIT, Paul Newman & Tom Hanisco (GSFC), ATom-3 Mission Scientists



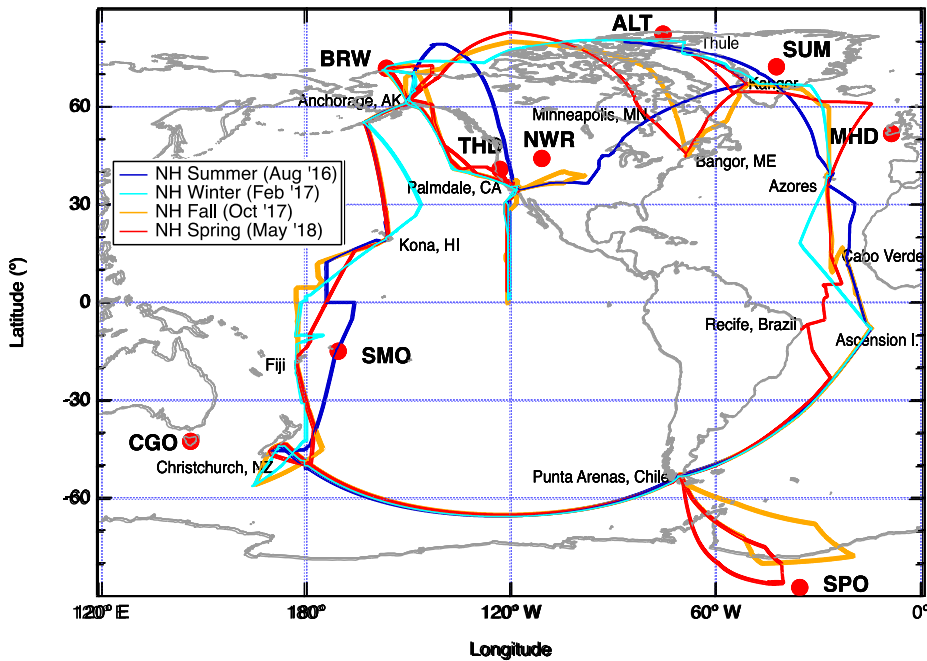
NASA DC-8 aircraft: Built in 1957

Instruments on NH Spring (ATom-4)

- AMP (Brock) Aerosol size
 - AO2 (Stephens) O₂
 - ATHOS (Brune) OH,HO₂
 - CAFS (Hall) Actinic flux
 - CANOE% (Hanisco) NO₂
 - CAPS (Weinzierl*) Aerosol size & cloud H₂O
 - CIT-CIMS (Wennberg) HNO₃,H₂O₂
 - DLH (Diskin) H₂O
 - GT-CIMS (Huey) PAN
 - HR-AMS (Jimenez) Cl,NH₄,NO₃
 - HTS/QCLS (Daube) CO,CO₂,CH₄,N₂O
 - ISAF (Hanisco) CH₂O
 - Medusa (Keeling) O₂,CO₂,N₂,Ar
 - MMS (Bui) Met data
 - NOAA CIMS# (Ryerson) Cl₂, BrCl, N₂O₅
 - NOAA Picarro (McKain) CO₂,CH₄,CO
 - NOyO3 (Ryerson) NO,NO₂,NO_y,O₃
 - PALMS (Murphy) Particle Composition
 - PANTHER (Elkins) PAN, halocarbons
 - PFP (Montzka) hydro- & halo-carbons
 - SAGA (Dibb) Aerosols
 - SP2 (Schwarz) Black Carbon
 - SO2% (Rollins) SO₂
 - SOAP% (Wagner) Aerosol absorption & extinction
 - TOGA (Apel) VOCs
 - UCATS (Elkins) O₃,H₂O,SF₆,N₂O,H₂,CO,CH₄
 - WAS (Blake) hydro-,halo-carbons
 - Ozonesondes (Johnson) O₃, RH%, T, P
 - 28 instruments in total
 - 7 from Universities
 - In red, 12 instruments from NOAA/ESRL, plus weather guidance (Ray/Rosenlof)
 - In blue, 4 NCAR instruments + QCLS
 - In purple, 4 NASA center instruments, plus weather, flight tracks, and forecasting from GFSC (Newman)
 - Many modeling teams from University NOAA and NASA.
 - Over 330 atmospheric parameters measured
-
- *University of Vienna (Wien), Austria
 - #Added for NH Fall (ATom-3)
 - %Added for NH Spring (ATom-4)



Flight Tracks of ATom



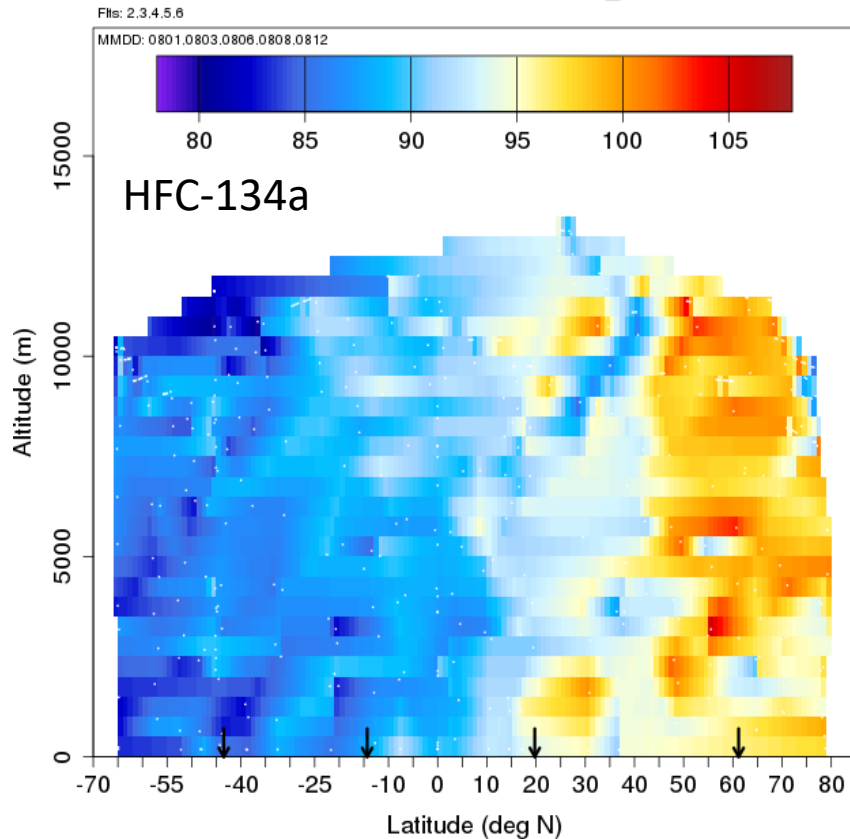
- “Round the World” circuit: ~12 research flights
- Mission: 4 circuits, one for each season over 3 years.
- Vertical profiles: **500’** (150 m) to **42,000’** (13 km)
- 4 to 9 vertical profiles/flight
- NASA Frequent Flyer Miles: 1 circuit = **40,540 miles** (57,500 km). Total (4 circuits)=**161,750 miles** (258,800 km)

● Circles HATS stations; Names of Stops

NH Summer Long-lived Halocarbons (ATom-1)

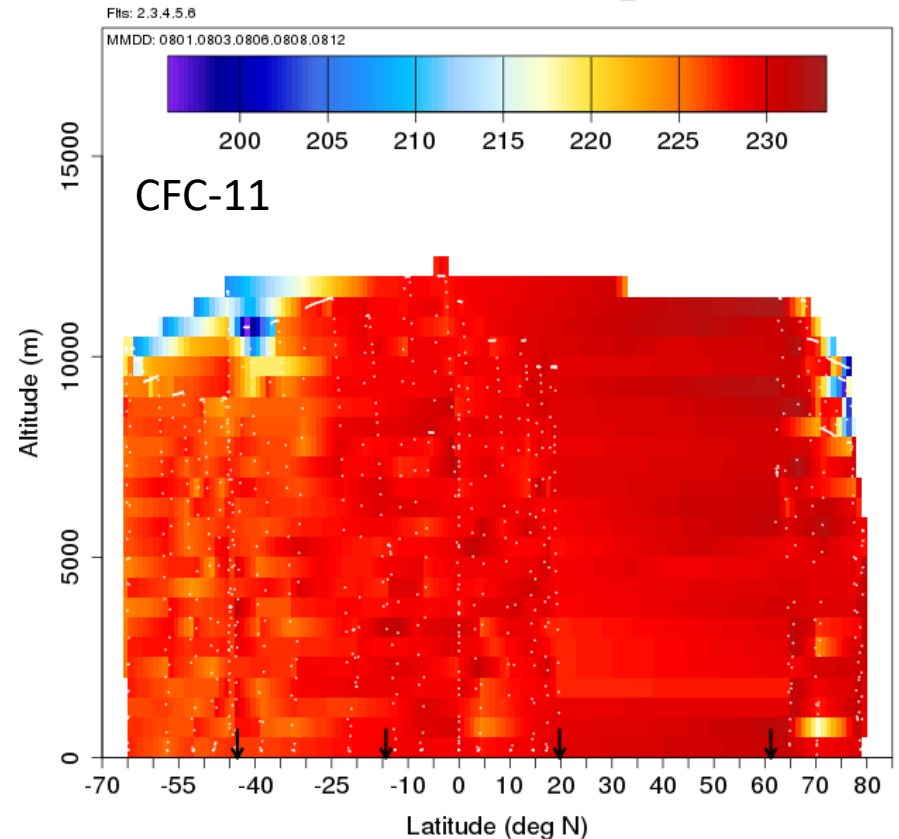
CFC Replacement

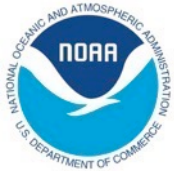
ATOM1 Southbound HFC134a_PMSD



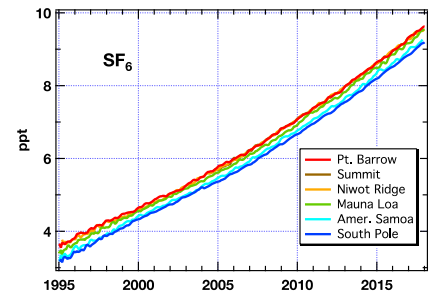
Regulated gas by Montreal Protocol

ATOM1 Southbound CFC11_PECD

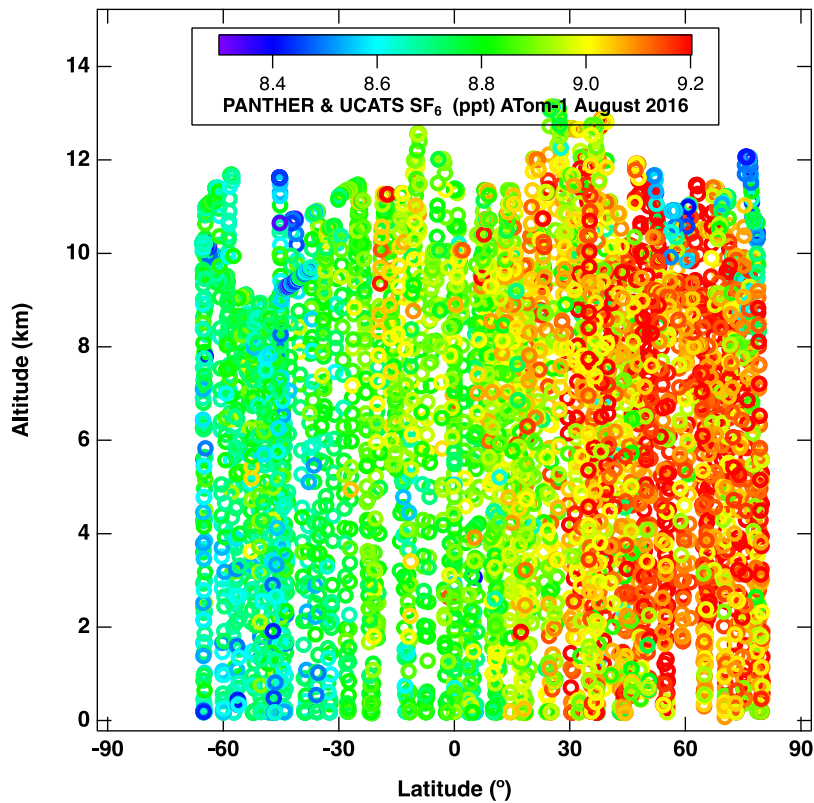




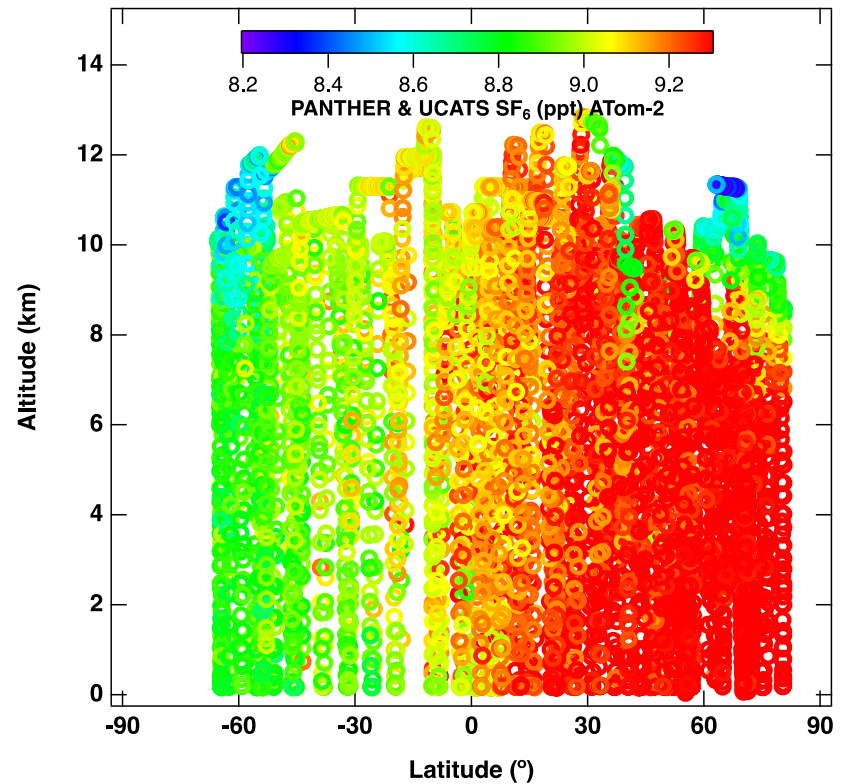
NH Summer & Winter SF₆



NH Summer
More mixing across ITCZ



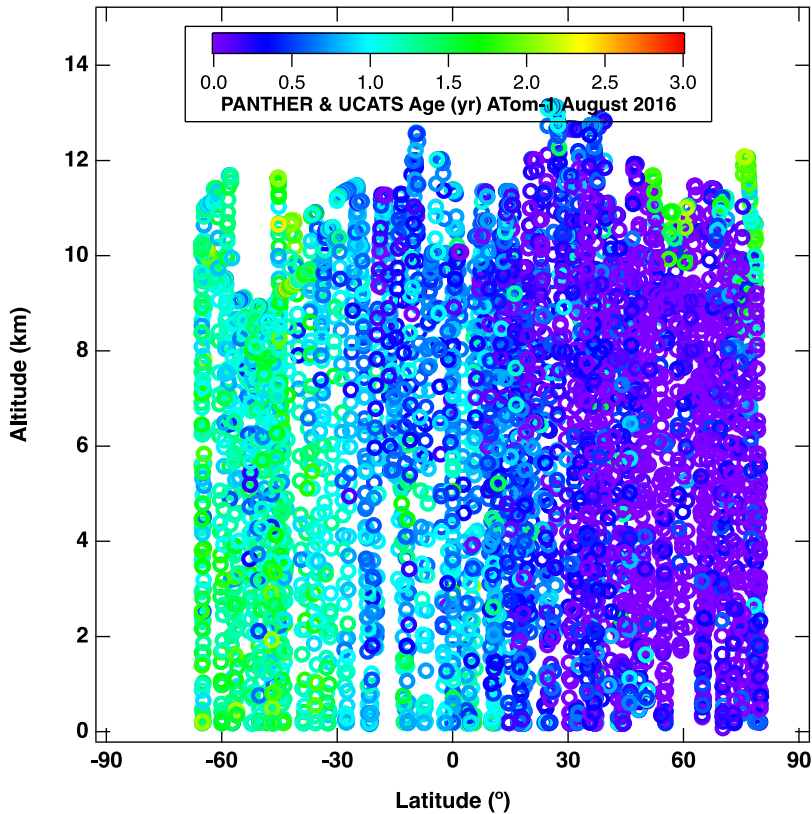
NH Winter
Less mixing across ITCZ



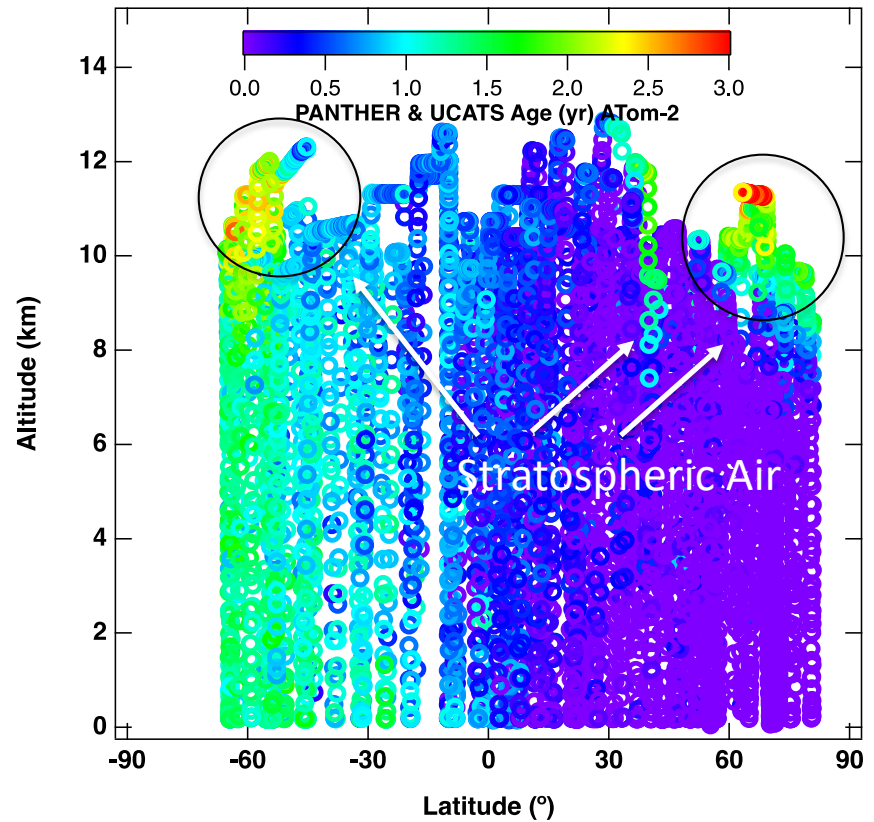


Age from NH Mid-Latitude Pollution (Waugh et al., 2013)

NH Summer
 $\text{Age}(\text{yr.}) = (9.1 - \text{SF}_6) / 0.32$

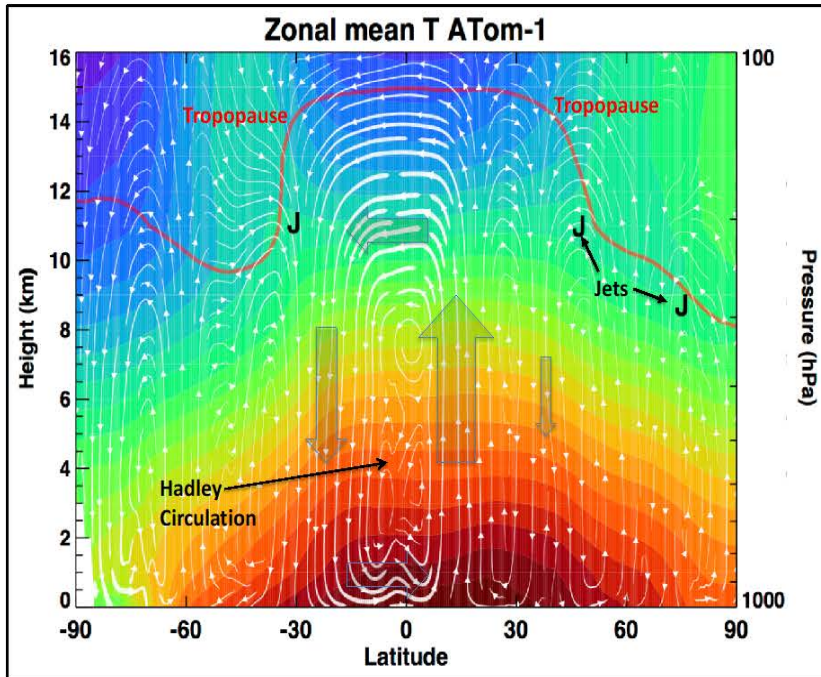


NH Winter
 $\text{Age}(\text{yr.}) = (9.25 - \text{SF}_6) / 0.32$

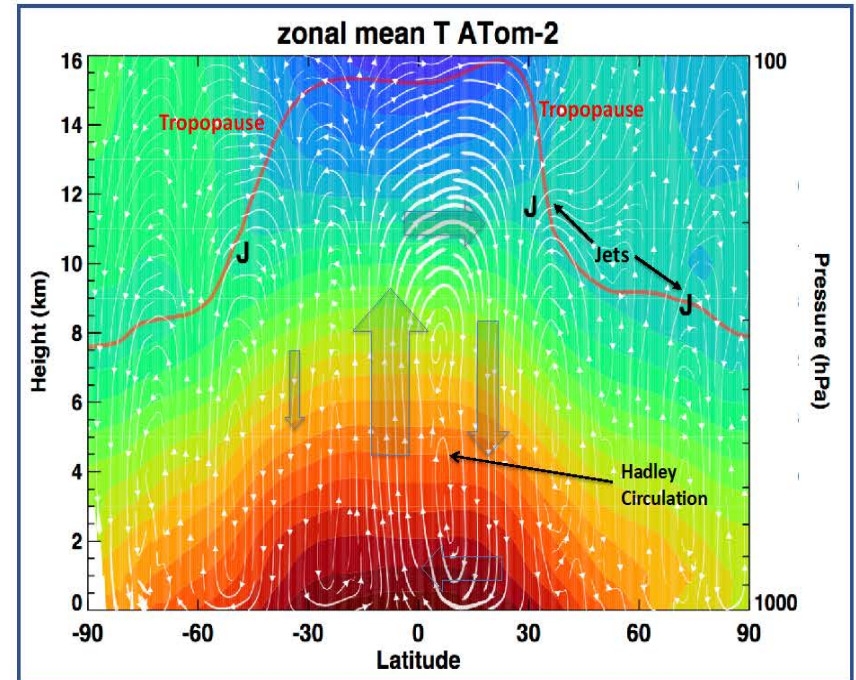


ATom Meteorology

NH Summer

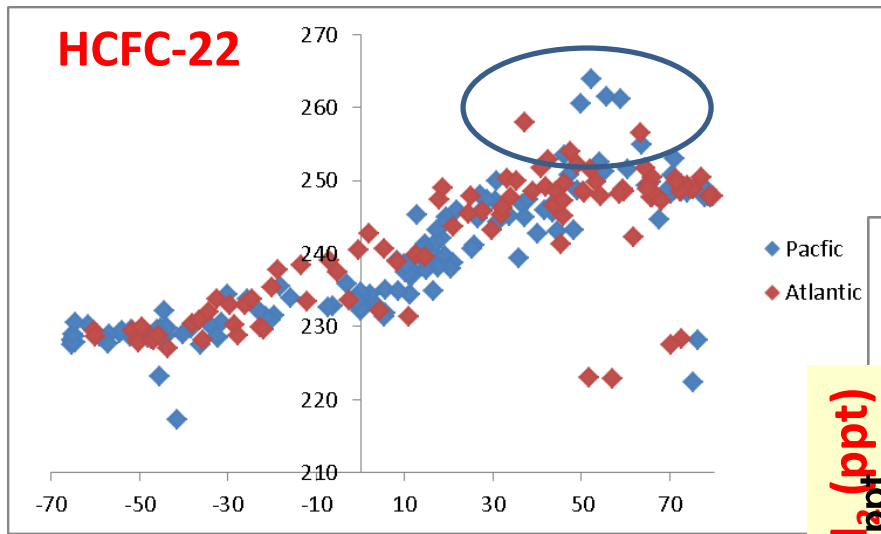


NH Winter

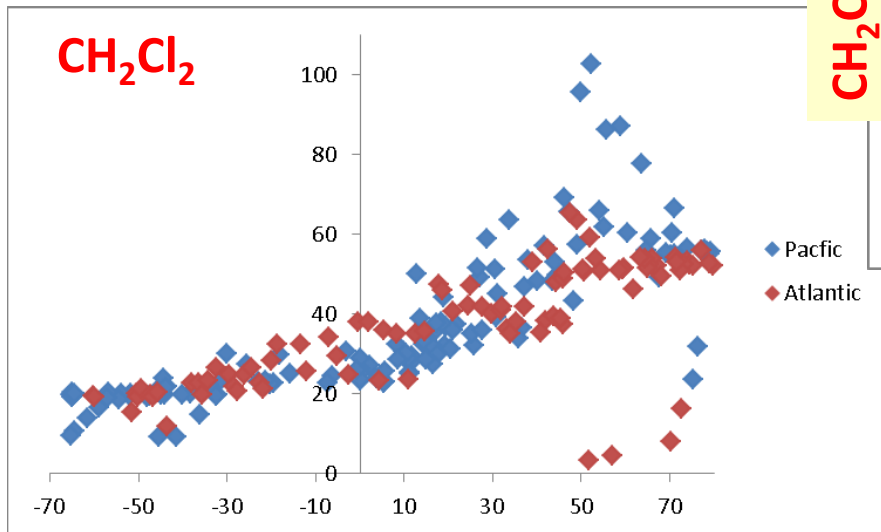


Temperature (K)

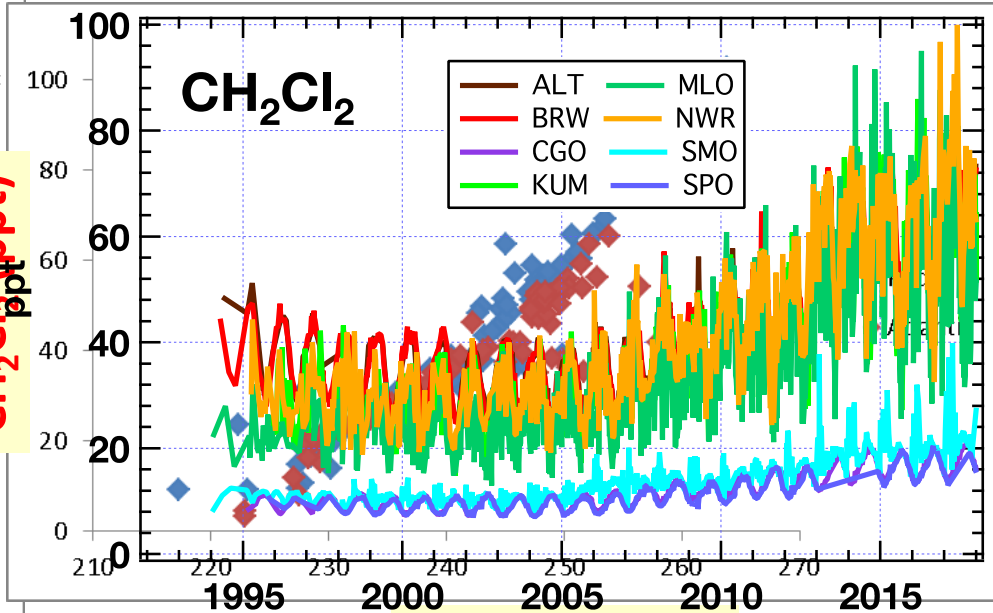
Long-range transport of industrial solvents: ATom-1



Elevated mole fractions observed
In many gases, more prominently in the
Pacific than the Atlantic



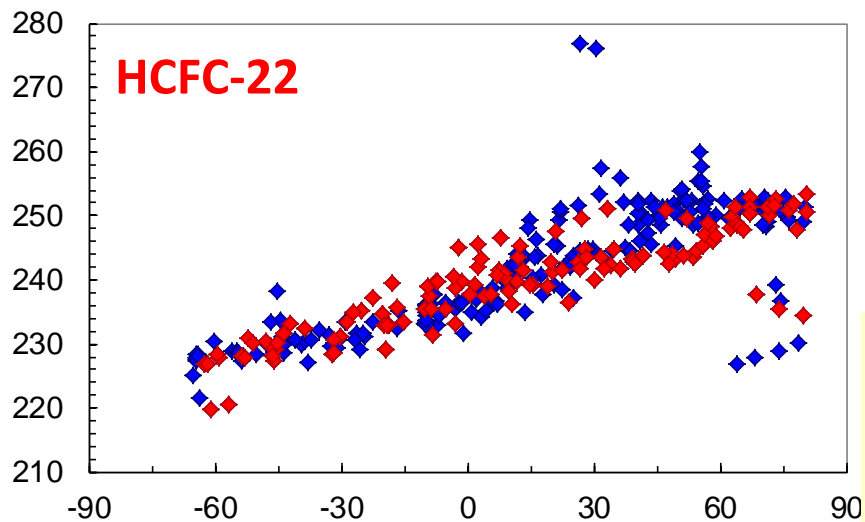
CH₂Cl₂ (ppt)



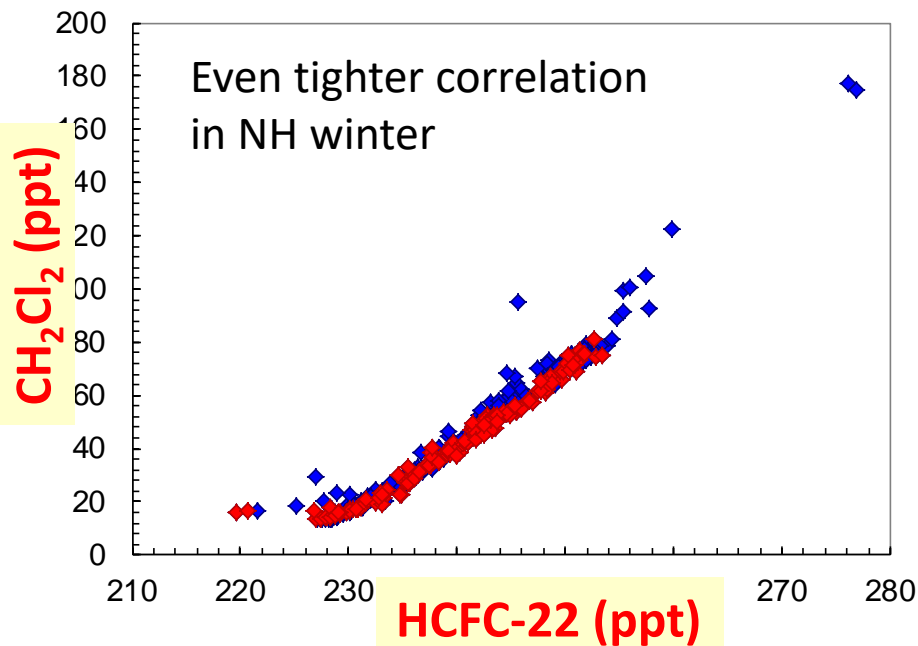
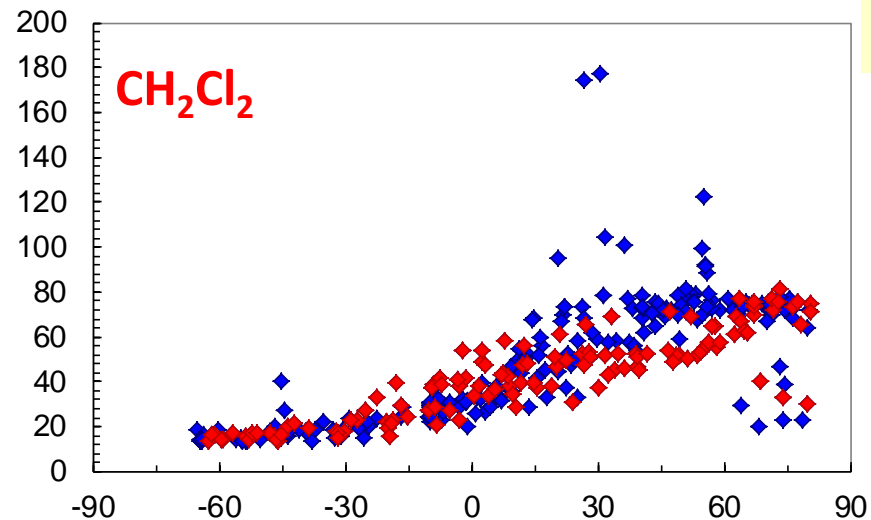
HCFC-22 (ppt)

Co-variations for elevated HCFC-22 and
CH₂Cl₂ points to a common source for
these elevations, likely East Asia (high
HCFC-22 production remains only there)

Long-range transport of industrial solvents: ATom-2



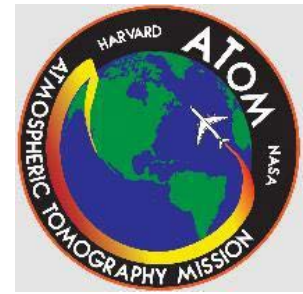
Elevated mole fractions observed
In many gases, more prominently in the
Pacific than the Atlantic



Note much different scale for CH₂Cl₂
during ATom2

→ NH winter

Latitude



Summary of ATom



- All four ATom seasonal circuits are almost completed, ATom-4 going on now. ATom-1 and ATom-2 data are publicly available for flights before 03/01/2017.
- ATom-3 data release date is 07/31/2018.
- SF₆ and halocarbons make useful tracers of air mass motion & sources.
- On personal note, we are seeing striking impacts in biomass burning and desert dust over the middle of the oceans, lack of sea ice near Barrow, Alaska and off Greenland in NH winter.

NH Summer (ATom-1) & NH Summer (ATom-2) data are available publicly at <https://espoarchive.nasa.gov/archive/browse/atom>

Questions?

Sahara dust and smoke in lower troposphere between equator and Azores over 1000s km east from Africa.

Thanks to the crew of the NASA DC-8

Photo: J. Elkins