NOAA-GMD HIPPO data past and future: transport and chemistry in the troposphere. (HIPPO-NOAA-GMD Rack Data Set)

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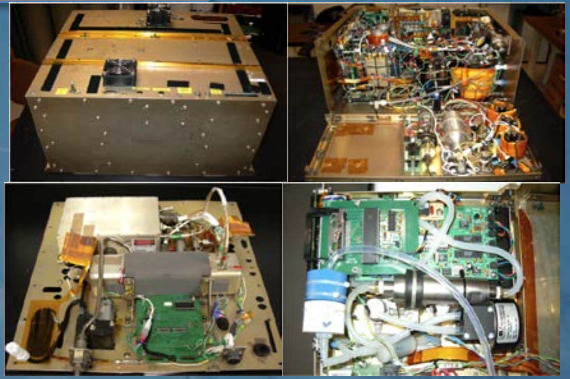
PANTHER: (PAN and other Trace Hydrohalocarbon ExpeRiment,) 200 lb., 6-channel GC (gas chromatograph).

* 3 ECD (electron capture detectors), packed columns.
* 1 ECD with a TE (thermal electric) cooled RTX-200 capillary column.
* 2-channel MSD (mass selective detector). 2 independent samples concentrated onto TE cooled Haysep traps, two temp programmed RTX-624 capillary columns.
* Tunable diode laser hygrometer (May Comm Inst.)

Measures: H2O, N2O, SF6 , CCl2F2 (CFC-12), CCl3F (CFC-11), CBrClF2 (halon-1211), H2, CH4 , CO, PAN (peroxyl acetyl nitrate), methyl halides CH3I, CH3Br, CH3Cl, the sulfur compounds COS, CS2, hydrochlorofluorocarbons CHClF2 (HCFC-22), C2H3Cl2F (HCFC-141b), C2H3ClF2 (HCFC-142b), and hydrofluorocarbon C2H2F4 (HFC-134a)

UCATS: (Unmanned aircraft systems Chromatograph for Atmospheric Trace Species), 60 lb. GC, TDL and Photometer.



* 2-Channel ECD GC, packed columns.
* Tunable diode laser hygrometer (May Comm Inst.)
* Dual-beam ozone photometer (2B Inst.)

Measures: N2O, SF6 , H2 , CH4, CO, O3 and H2O.

NWAS: (NOAA Whole Air Sampler) 20 lb. per 12 flask pkg., 2 to 4 NWAS pkg per flight, 6 in rack.

* Total > 48 flask per flight, 6 flasks per profile. [2 to 4 NWAS pkg +2 AWAS-Elliot Atlas]
* MSD (analysis by HATS/ESRL flask lab - Steve Montzka *et al*.)
* ECD, NDIR, FID and RGA (analysis by CCGG/ESRL flask lab - Pat Lang *et al*.)
* MSD (analysis by INSTARR/CU isotopes flask lab - James White *et al*.)

Measures: CO, CO2 CH4 and isotopes, H2 , SF6 , N2O, tetrachloroethylene (C2Cl4), CCl4 , CFC-11, CFC-12, CFC-13, CFC-113, CFC-114, CFC-115, HCFC-22, HCFC-124, HCFC-141b, HCFC-142b, HCFC-227ea, HFC-23, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-365mfc, halon-1211, halon-1301, halon-2402, chloroform (CHCl3), methyl chloroform (CH3CCl3), chloroethane (CH3CH2Cl), dichloromethane (CH2Cl2), methyl halides (CH3Cl CH3I CH3Br), bromoform (CHBr3), dibromomethane (CH2Br2), acetylene (C2H2), propane (C3H8), benzene (C6H6), perfluoropropane (PFC-218), iso-pentane (C5H12), n-butane (C4H10), n-pentane (C5H12), n-hexane (C6H14), carbonyl sulfide (OCS), and carbon disulfide (CS2).

Overview

Classify the HIPPO data set:

Location of tracer gradient.

- Stratosphere
- Troposphere
- Inter Hemispheric

Source of the tracer gradient.

- Growth
- Photolysis
- OH and more…

Relate this to >> how the data set is and can be used.

Stratospheric Tracers: Long lived

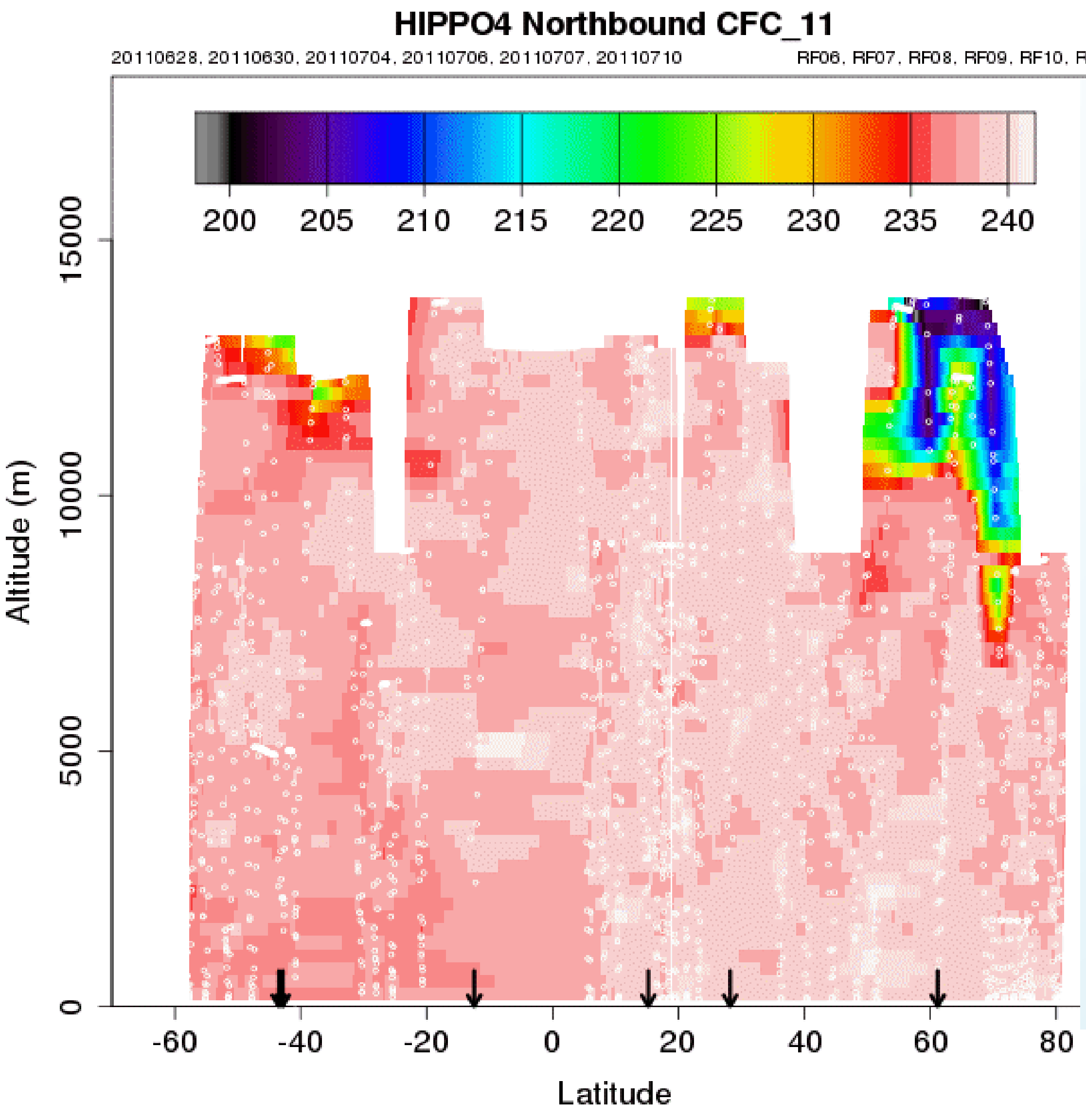
Species	~ strat lifetime (years)
CO_2	> 500
SF_6	> 500
CFC-115	> 500
CFC-13	> 500
N2O	~ 120
CFC-12	~ 100
CFC-113	~ 85
halon-1301	~ 65
CFC-11	~ 50
CCl_4	~ 35
halon-2402	~ 20
halon-1211	~ 16
O_3	(stratospheric sources)

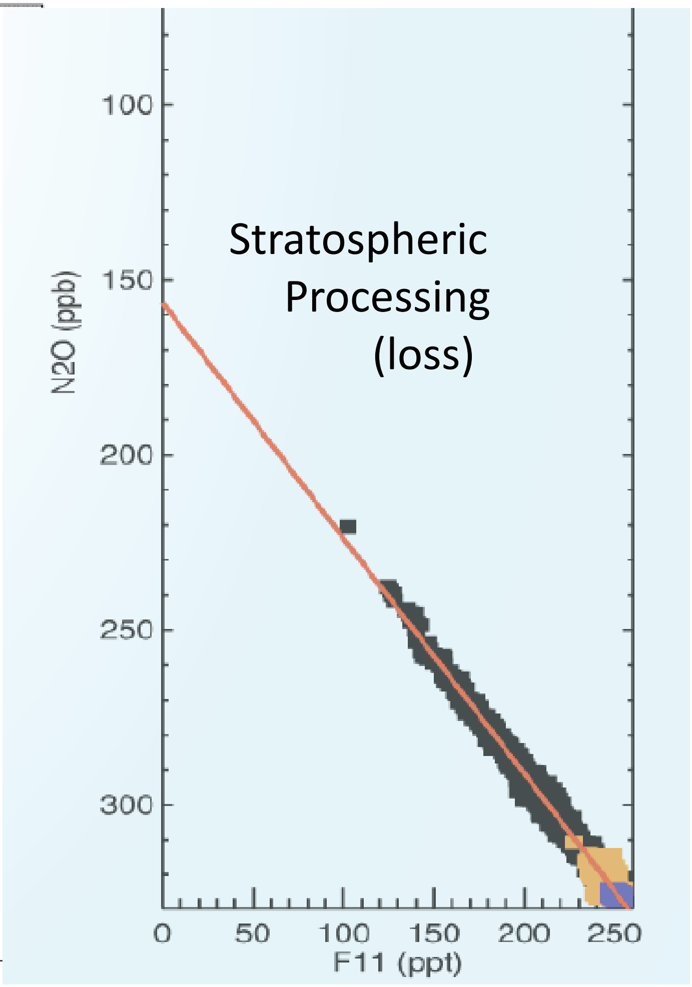
CO_2, SF_6: Growth >> age of stratospheric air and transport time scales.

CFC-115 through halon-1211: Photolytic Loss >> distributed mass flux and chemistry

CFC-11 and O_3
best signal to noise
stratospheric signature in trop

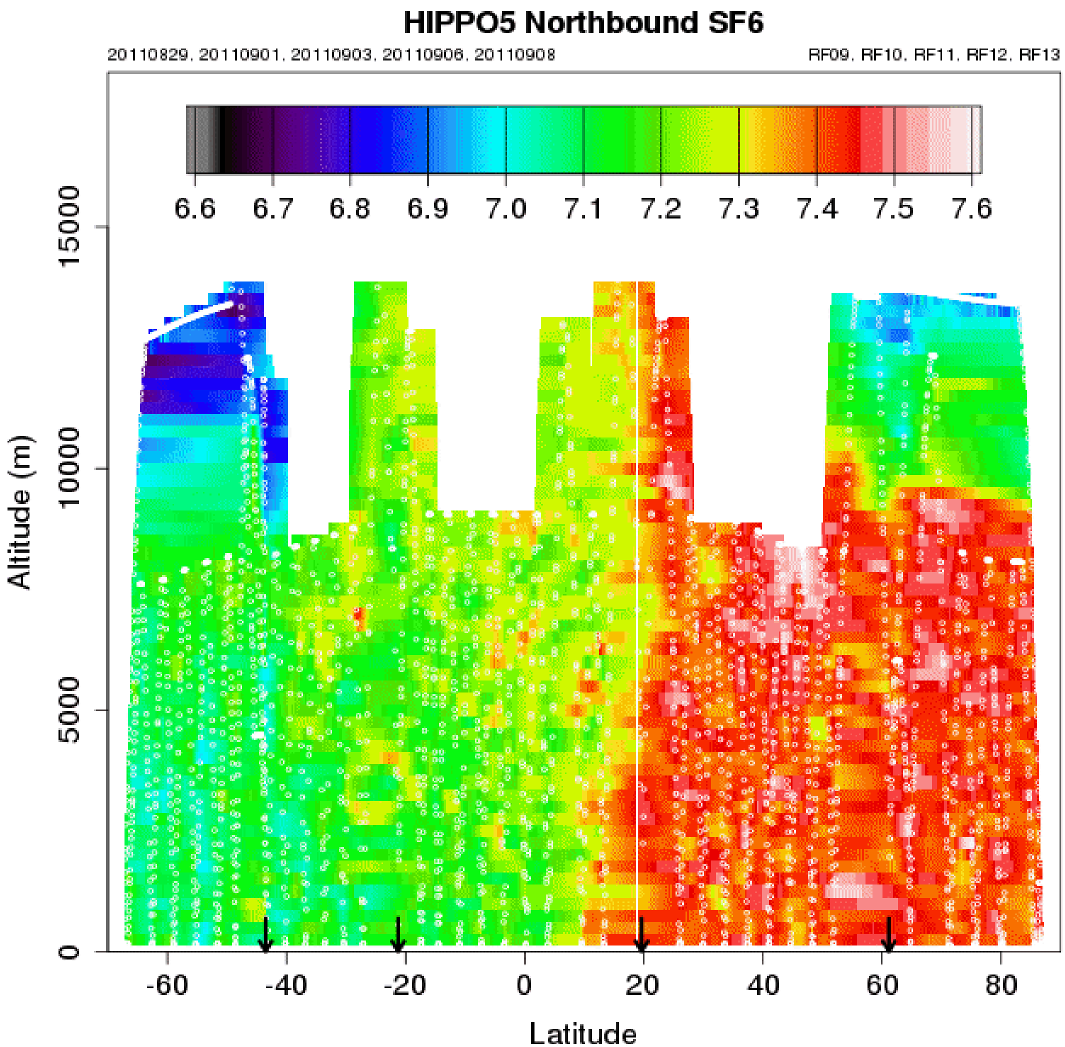
CFC-11 strat-signature in the troposphere will only mix back up to tropospheric value.
O_3 strat-signature can chemically equilibrate back to troposphere values < 20 days.


HIPPO4 Northbound CFC_11
20110628, 20110630, 20110704, 20110706, 20110707, 20110710
RF06, RF07, RF08, RF09, RF10, RF11
200 205 210 215 220 225 230 235 240
Altitude (m)
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude


Stratospheric
Processing
(loss)
N2O (ppb)
100 150 200 250 300
0 50 100 150 200 250
F11 (ppt)

Troposphere tracers: In rapid growth,
Strong and variable surface source and sinks
Short lived due to OH, photolysis, etc..

SF_6 > In rapid NH growth (surface source.)



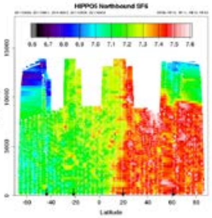
Latitudinal surface information

Dominant feature :

Inter Hemispheric Exchange

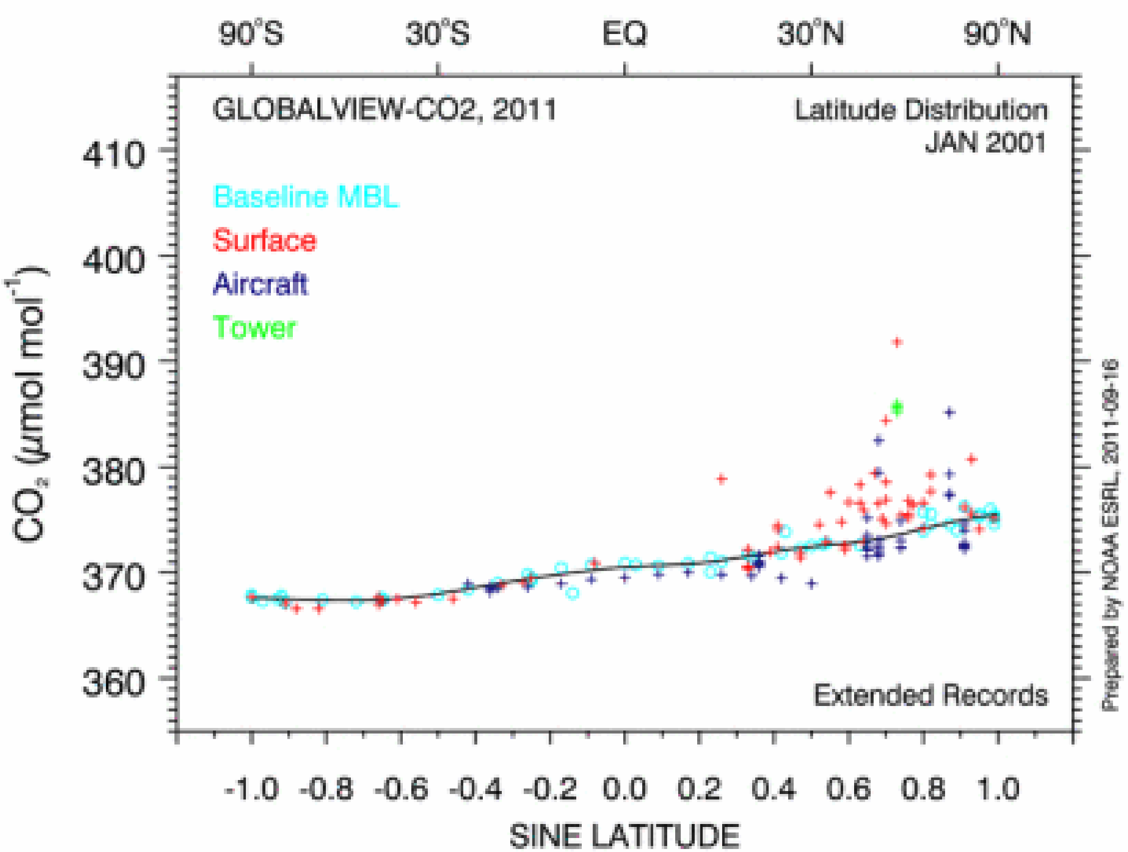
Troposphere tracers: In rapid growth,
Strong and variable surface source and sinks
Short lived due to OH, photolysis, etc..

SF_6 > In rapid NH growth (surface source.)
CO_2 > Strong and variable surface source and sink.
CH_4 > “ plus weak OH chemistry.



GLOBALVIEW

Add temporal and MBL/land surface information .



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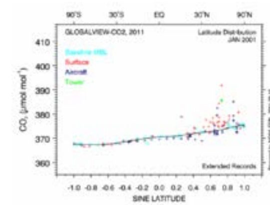
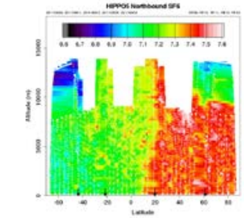
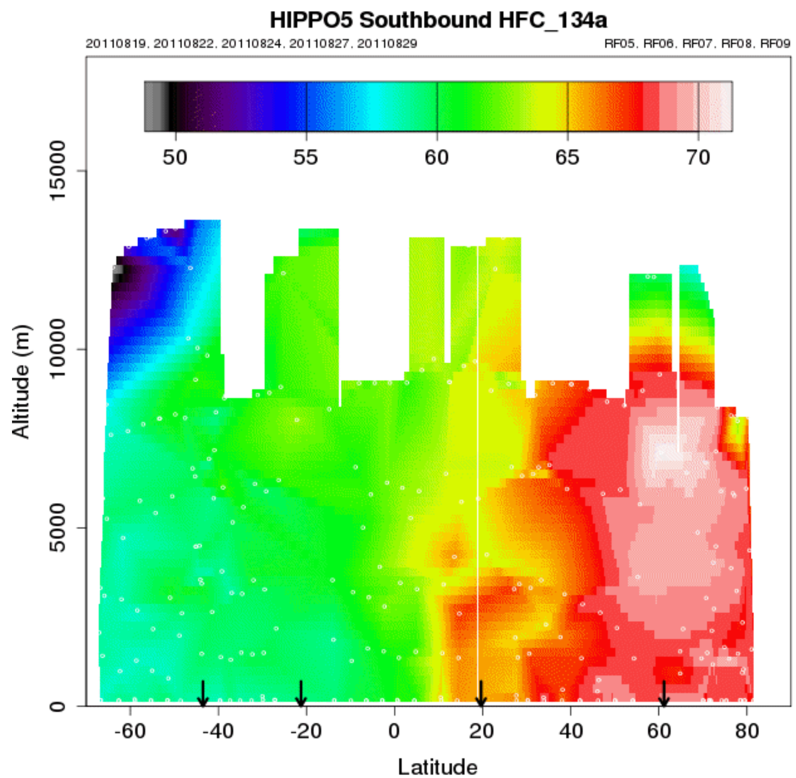




	~ total lifetime (years)
HCFC-143a	47. (OH)
HFC-125	28
HCFC-142b	17
HFC-134a	**13**
HCFC-22	12
HCFC-141b	9.2
HFC-152a	1.5

Replacement molecules: typically in rapid NH growth but ....
substantial OH loss in troposphere.
long stratospheric lifetimes > 50 years.



Gradients similar to SF_6

Troposphere tracers: In rapid growth,
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Short lived due to OH, photolysis, etc..

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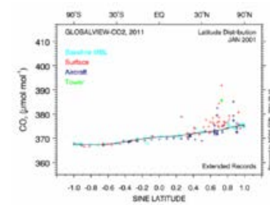

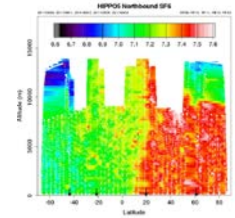

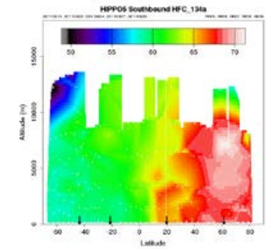

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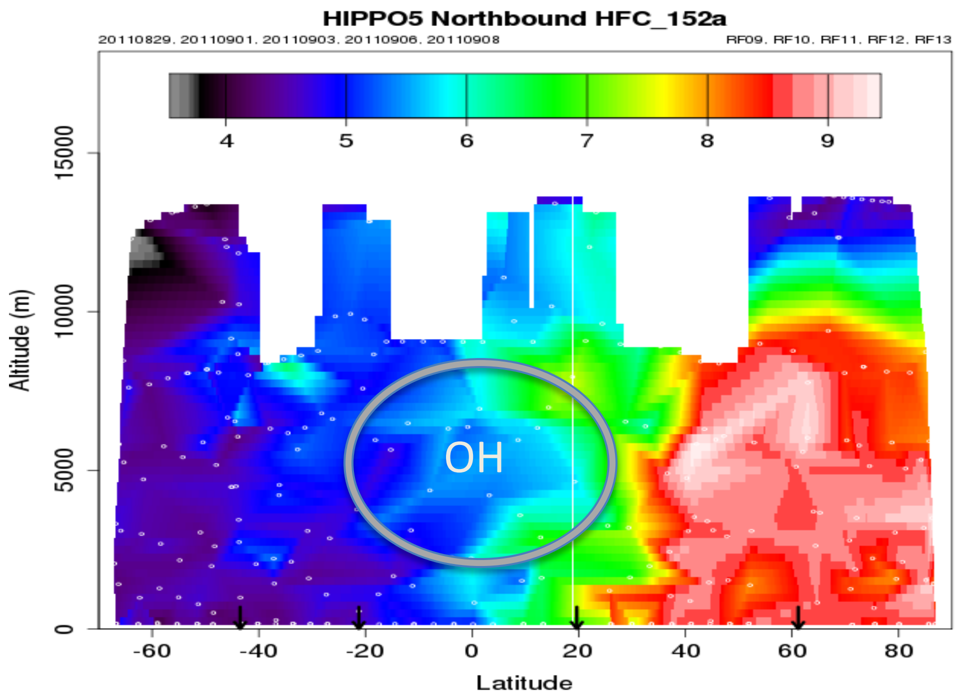
HCFC-22	12
HCFC-141b	9.2
CH_3CCl_3	5.0
HFC-152a	**1.5**
Exchange time	**1.3**
CH_3Cl	1.0
CH_3Br	0.8
$CHCl_3$	0.4
CH_2Cl2	0.4
CH2Br2	0.34
C_2Cl_4	0.25

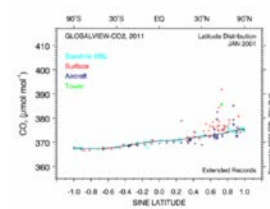


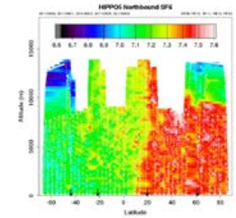
Gradients contain free trop chemistry.

Free troposphere OH, photolysis loss rates equivalent to…
large scale bulk troposphere transport time scales.

Troposphere tracers: In rapid growth,
Strong and variable surface source and sinks
Short lived due to OH, photolysis, etc..

SF_6 > In rapid NH growth (surface source.)
CO_2 > Strong and variable surface source and sink.
CH_4 >





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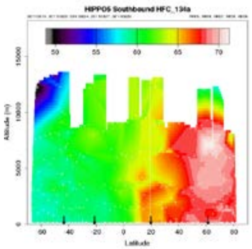

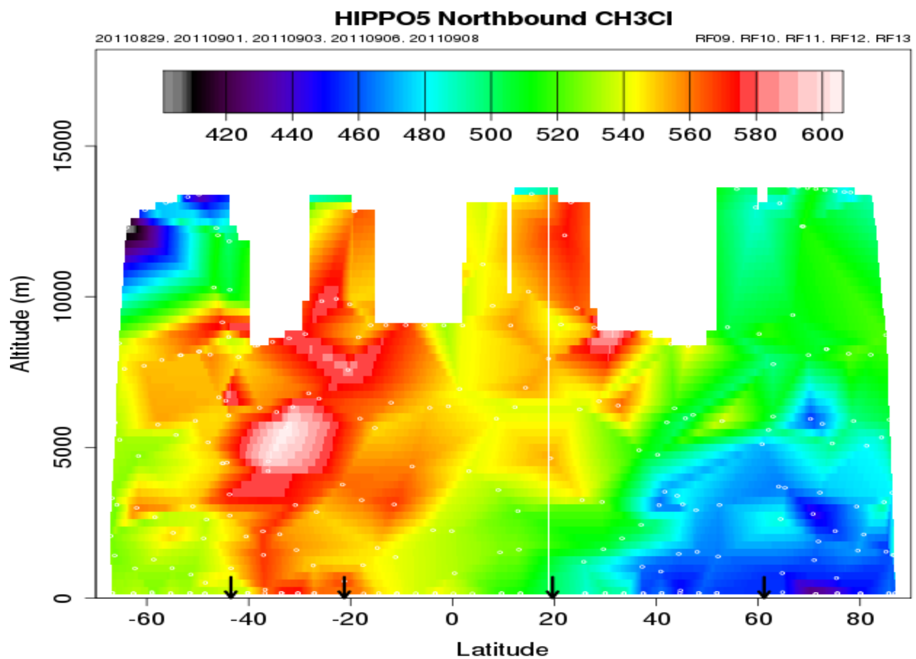

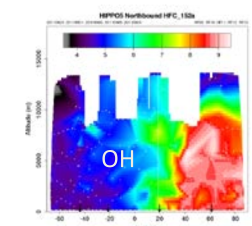

Fine source structure

Free troposphere OH, photolysis loss rates Faster than large scale bulk troposphere transport time scales.

Troposphere tracers:

In rapid growth,
Strong and variable surface source and sinks
Short lived due to OH, photolysis, etc..

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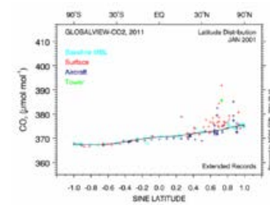

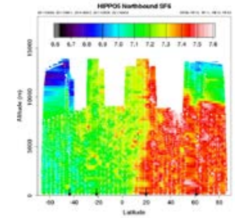

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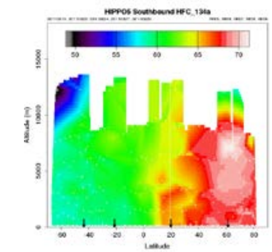
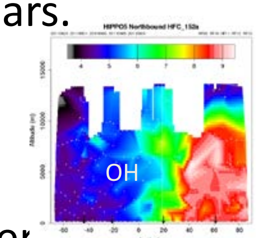
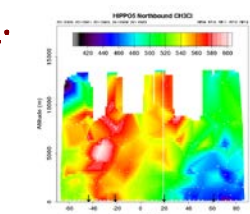


Replacement molecules: typically in rapid NH growth but ....
substantial OH loss in troposphere.
long stratospheric lifetimes > 100 years.



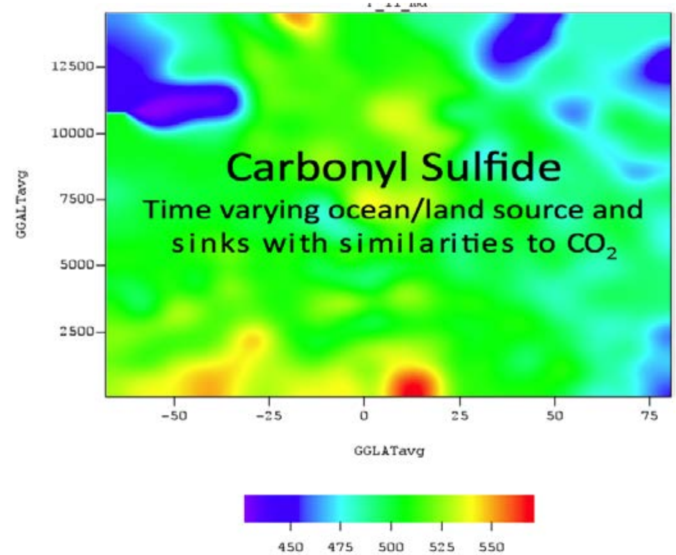
Free trop OH, photolysis loss rates equivalent or faster
large scale bulk troposphere transport time scales.



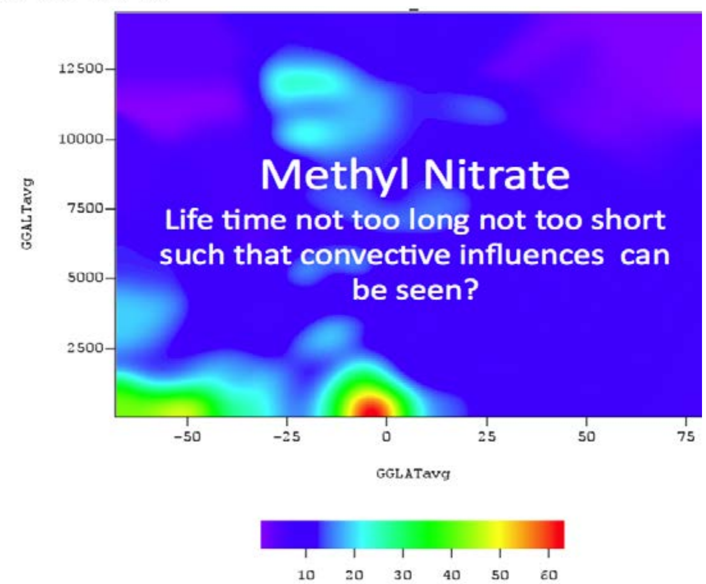
The rest of the tracers: very short lived, Atmospheric life times days to weeks
strong and variable free troposphere source and sinks.
unique surface, land., ocean source and sinks.
often used for focused and or process oriented studies.

- ethyne
- benzene
- propane
- Isopentane
- N_butane
- N_pentane
- CH_3I
- $CHCl_3$
- COS
- H_2
- CO
- O_3
- H_2O
- PAN
- O^{18}, C^{14} (CO_2)

AWAS data



Eliot Atlas's AWAS data substantially adds to this list (alternate sampling AWAS stainless steal flask and NWAS glass flasks)



Vertical and Horizontal Profiles looking for:

* Source/Sinks.

Ocean/Land/Atmospheric with dependency on Pollution/Biology/Chemistry.

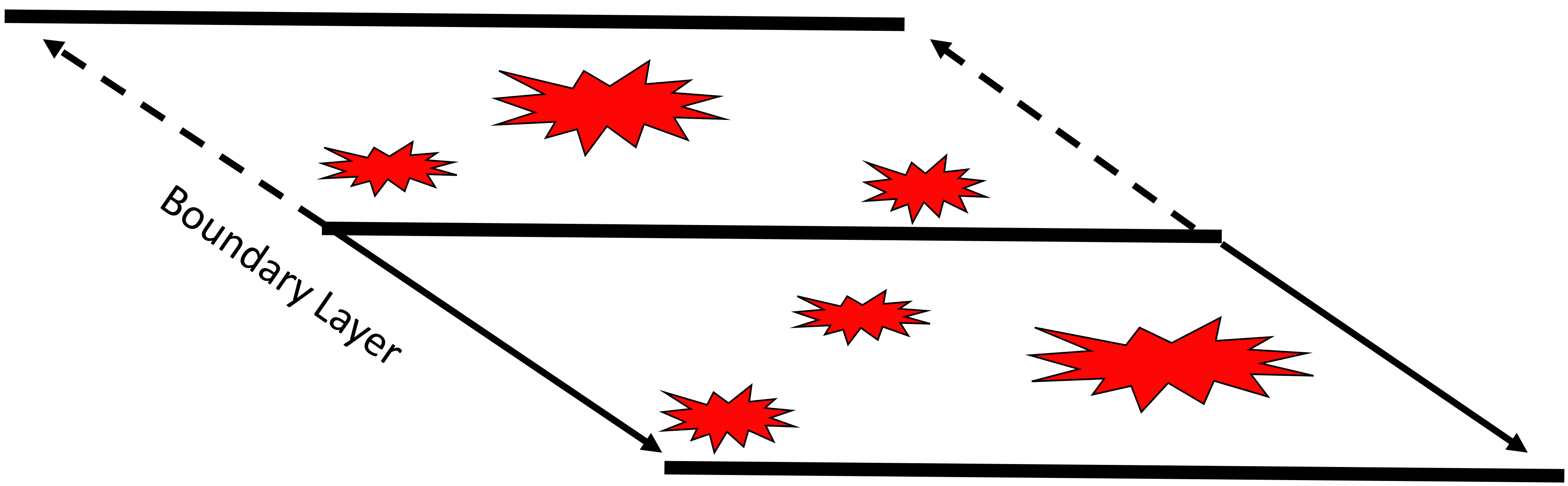
* Coupled with transport.

Upwelling and Mixing.

Inter-hemispheric Exchange.

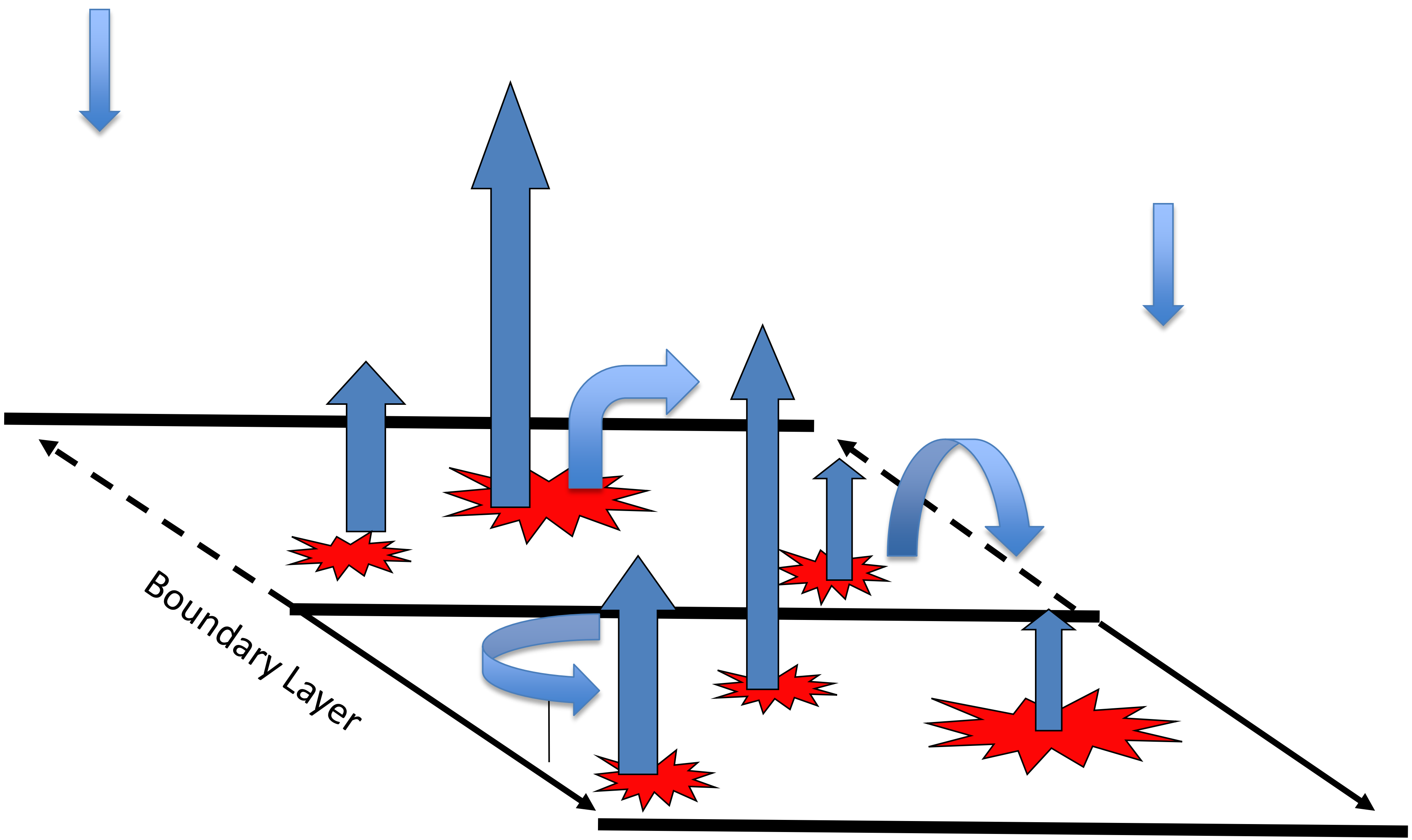
Interactions between Boundary-Layer <-> Troposphere <-> Stratosphere.

Challenge: Source region is distributed and in most cases has uncertain boundary.



Challenge: Distributed and in most cases uncertain boundary source region.

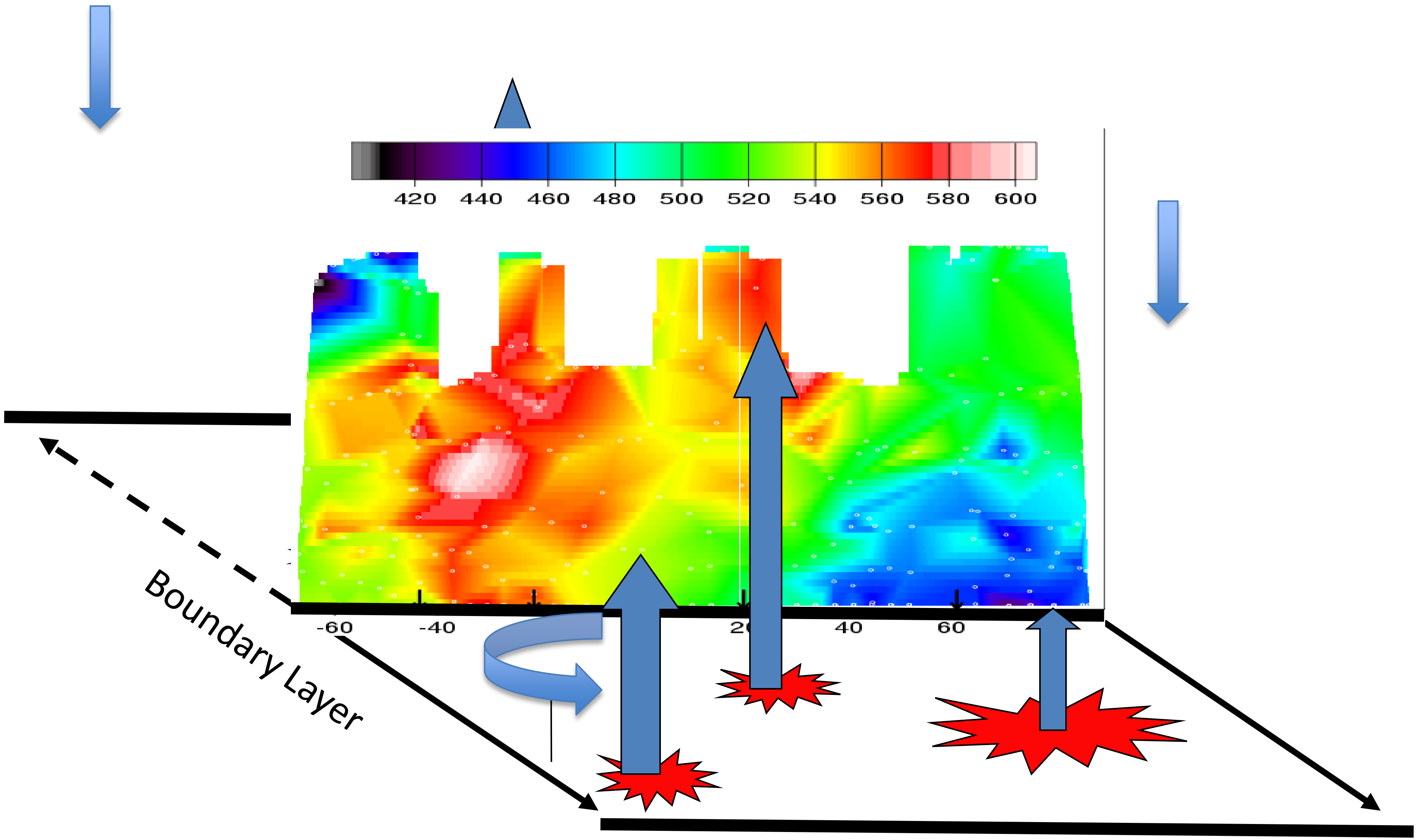
Coupled variable transport and in most cases variable chemistry.



Challenge: Distributed and in most cases uncertain boundary source region.

Coupled variable transport and in most cases variable chemistry.

Data only exist on a sheet down the pacific though with good seasonal coverage.



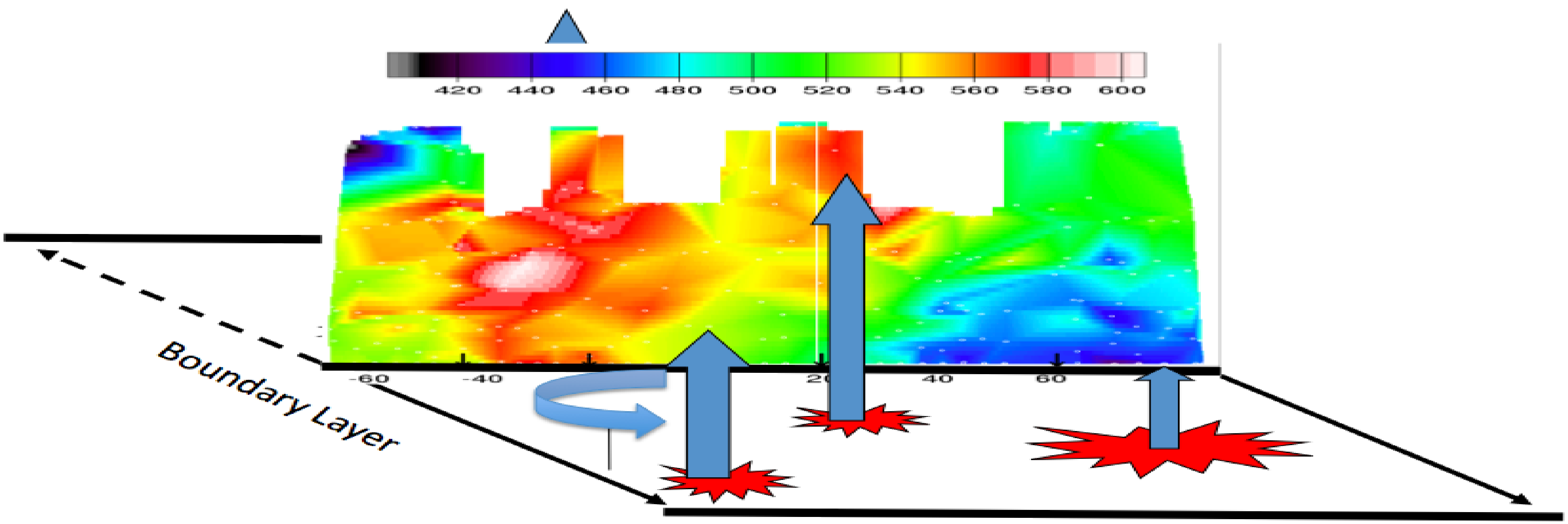
Challenge: Distributed and in most cases uncertain boundary source region.
Coupled variable transport and in most cases variable chemistry.
Data only exist on a sheet down the pacific though with good seasonal coverage.

Run 3D- model simulations:

Propagate estimates of surface sources/sinks and atmospheric chemistry onto the HIPPO data set.

Use agreement / disagreement to improve estimates of surface sources/sinks, chemistry and model transport.

Already too many HIPPO model studies to list N_2O, CH_4, Br-loading, OH, SF_6-Trop Age, PAN, H_2



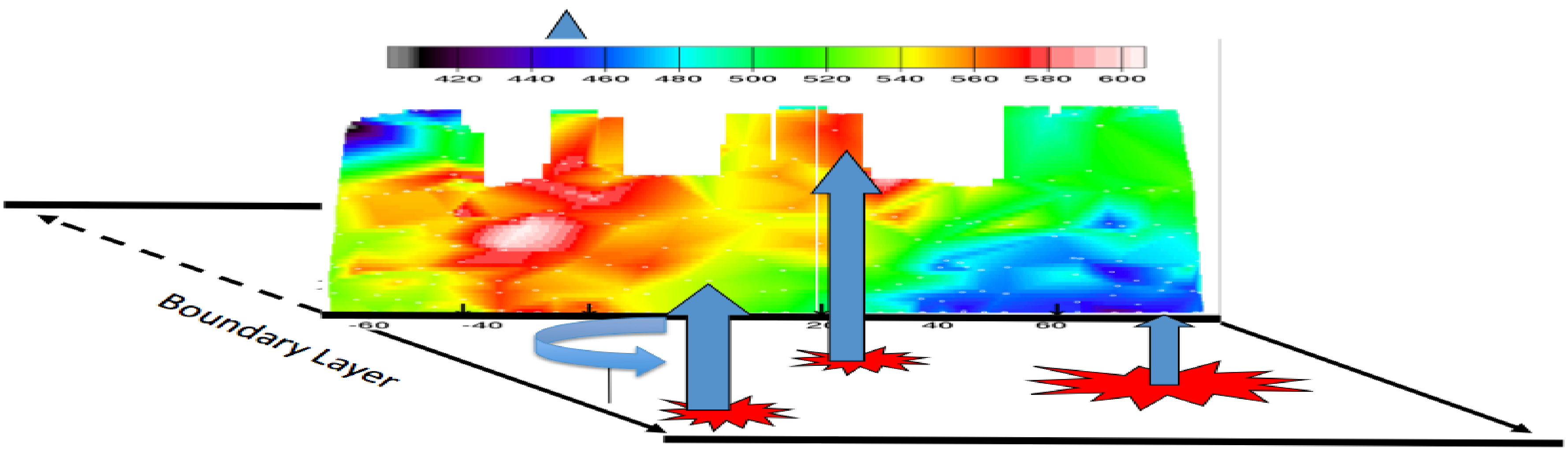
Can anything be accomplished outside the 3D-models?

correlated data set:

> many with surface source correlations .
> all species in air parcel measured by HIPPO share a common path
> all species in air parcel .... share correlated chemical fields etc.

process oriented studies... proposed example.

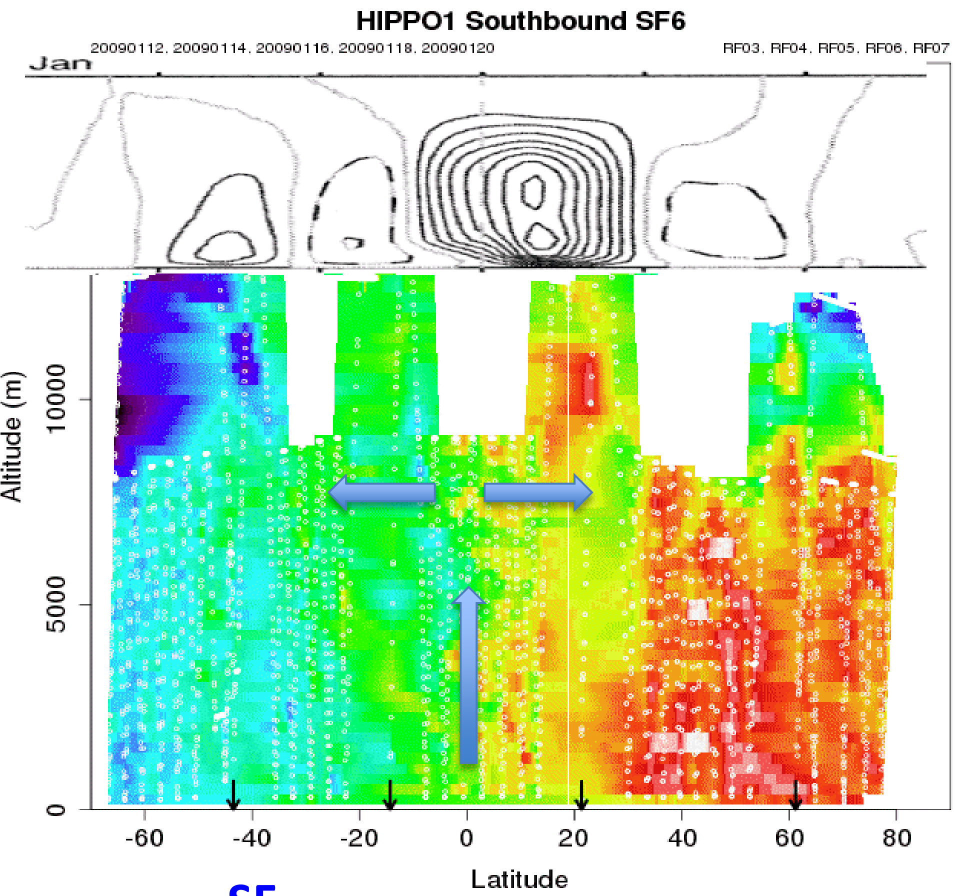
Link tropical transport to inter hemispheric exchange ?
Leverage inter hemispheric exchange to distributed OH loss ?



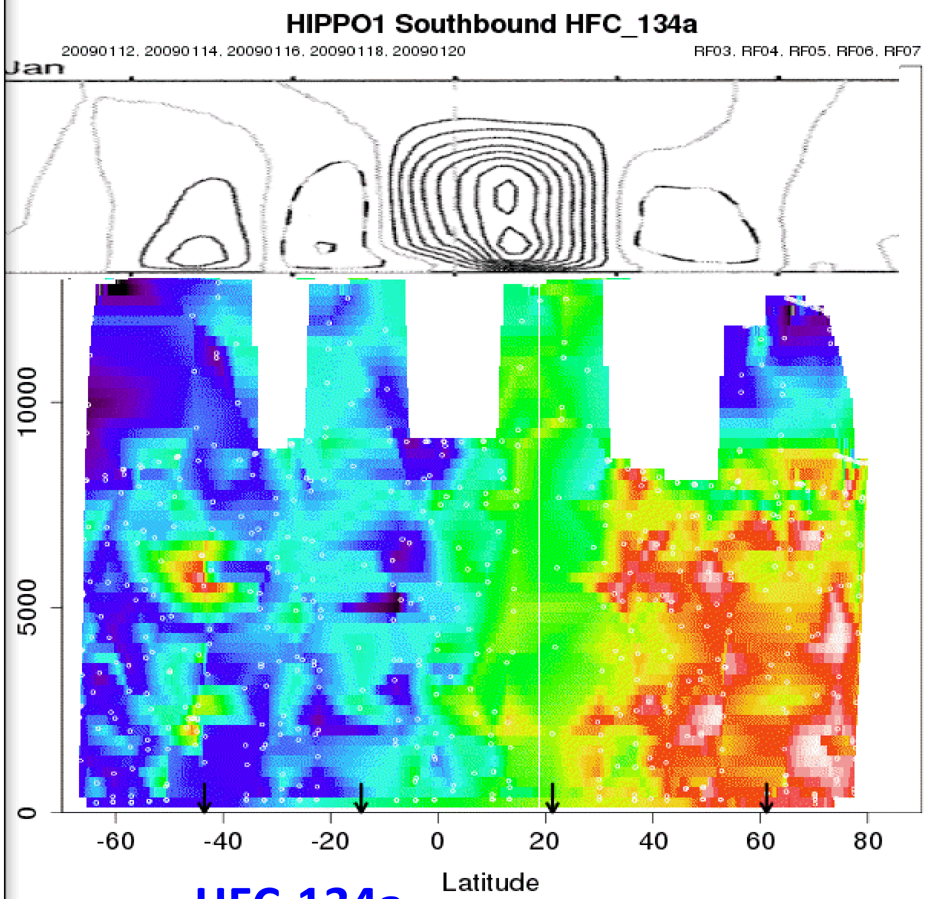
January

large tropical transport
drives inter hemispheric exchange

Mean Stream function - NCEP-NCAR reanalysis (I M Dima and JM Wallace 2002)



SF$_6$

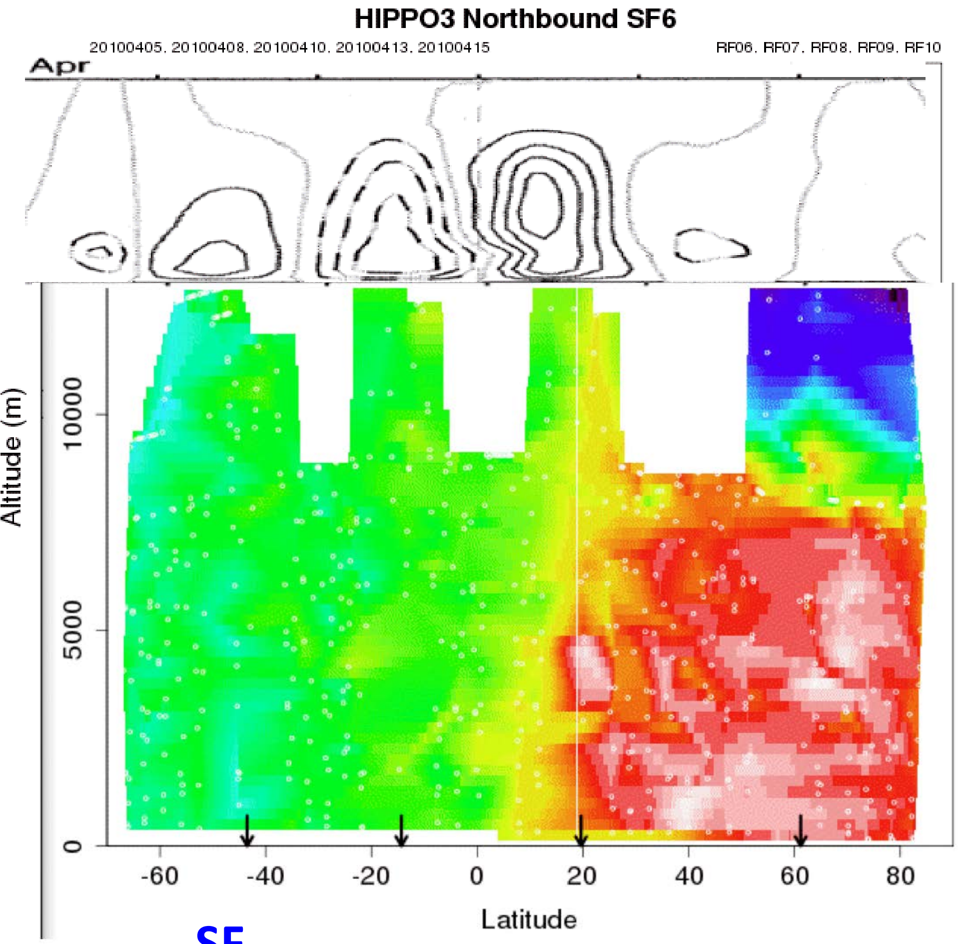


HFC-134a

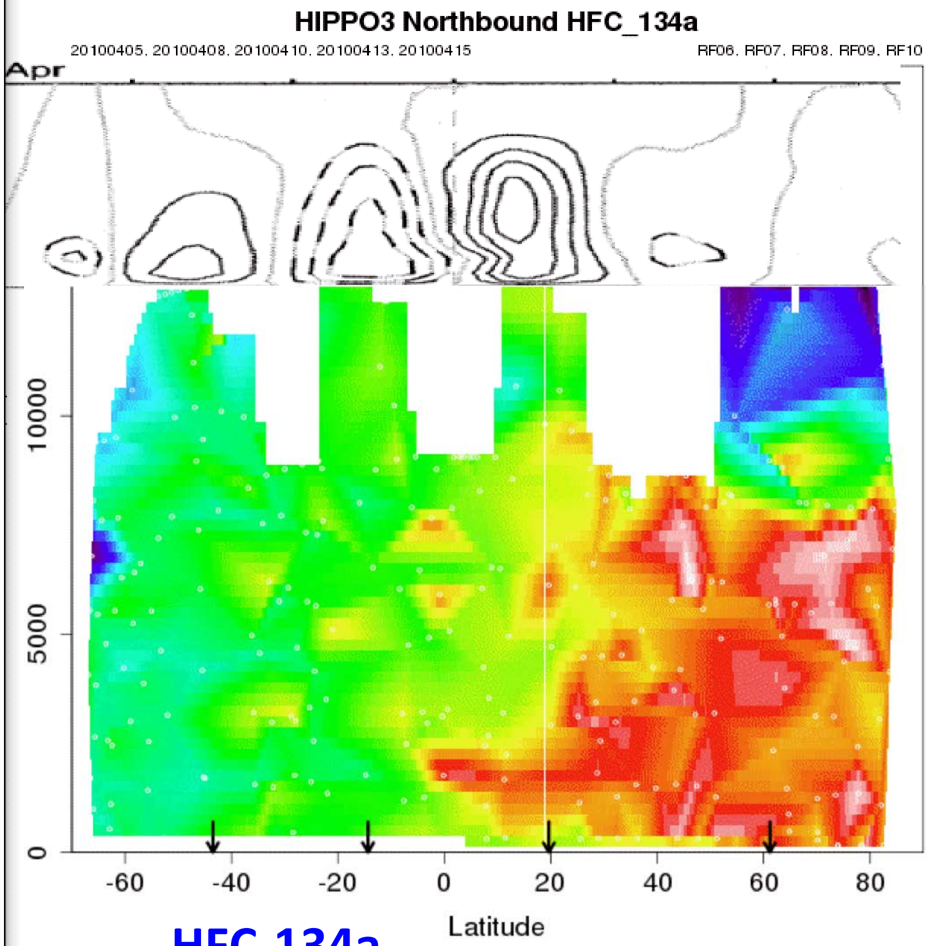
April

tropical transport slows down

hemispheres homogenize



SF_6

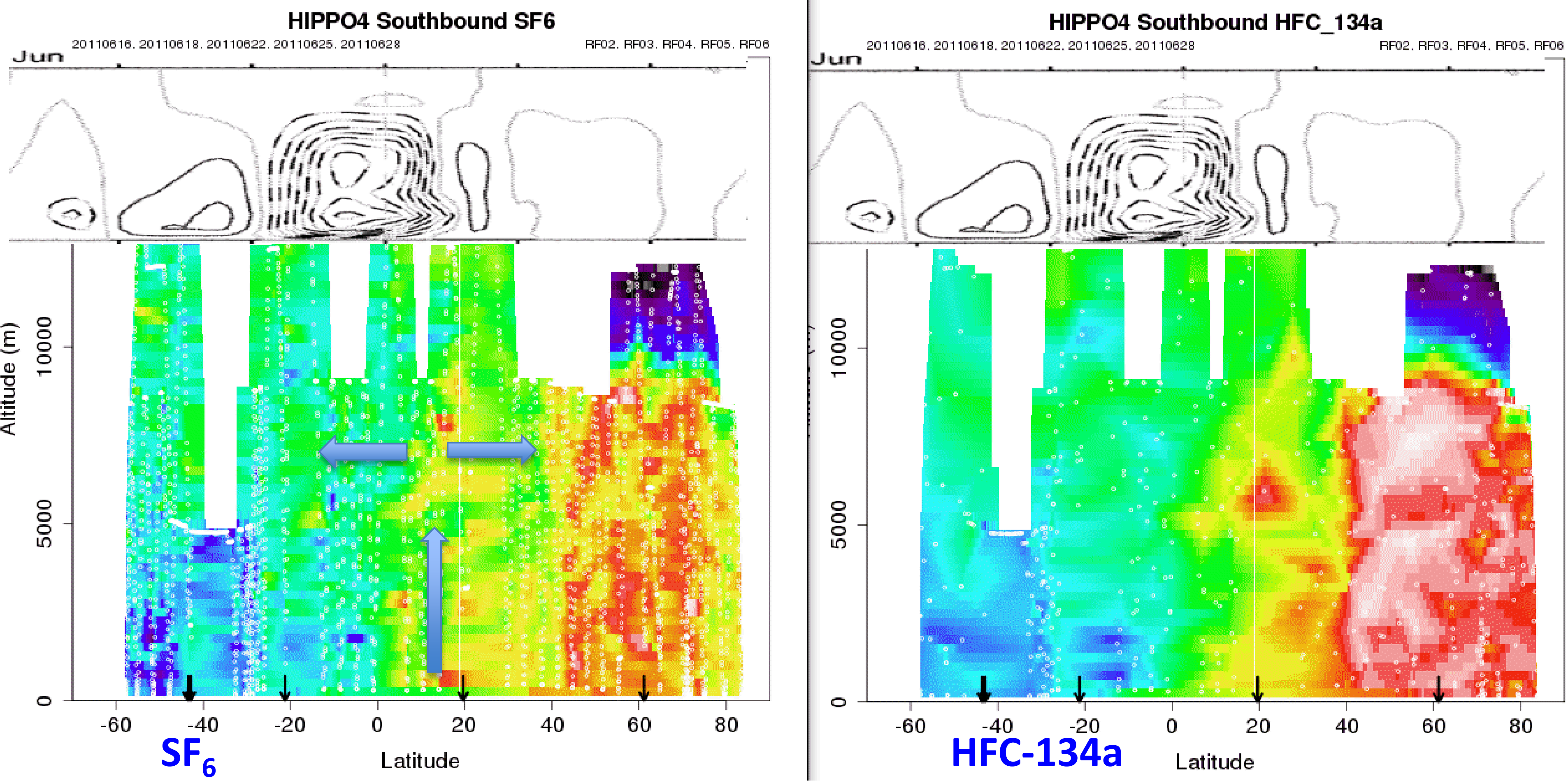


HFC-134a

June

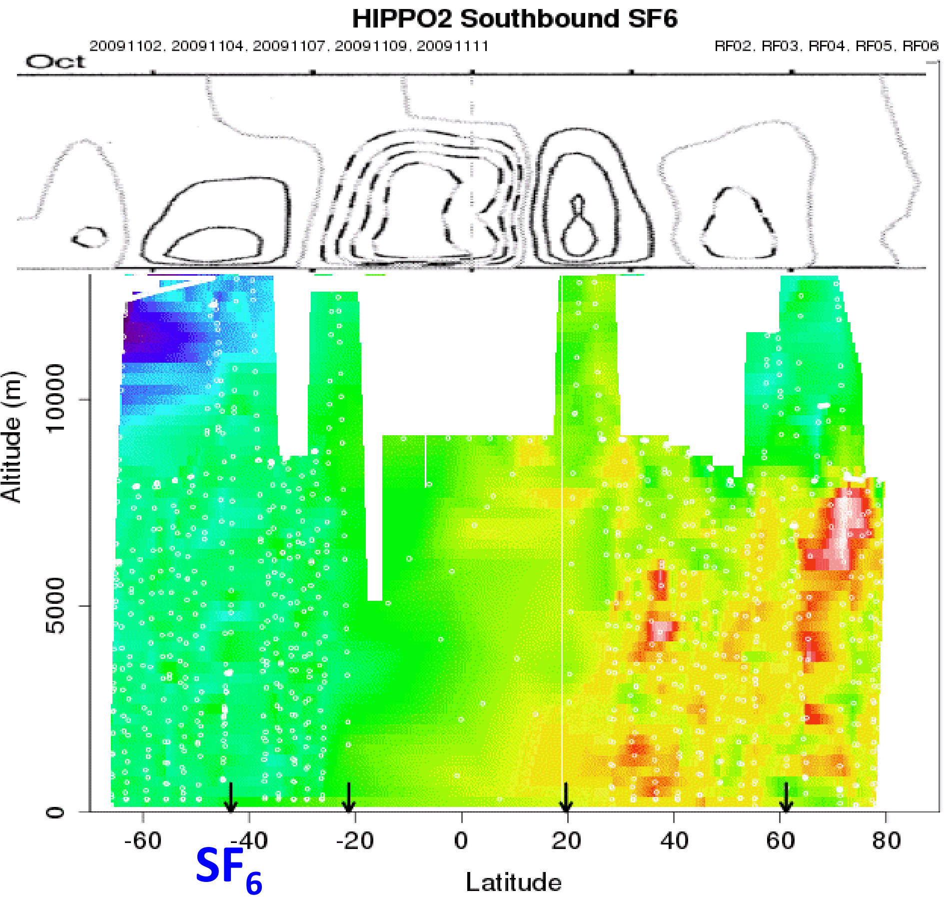
large tropical transport

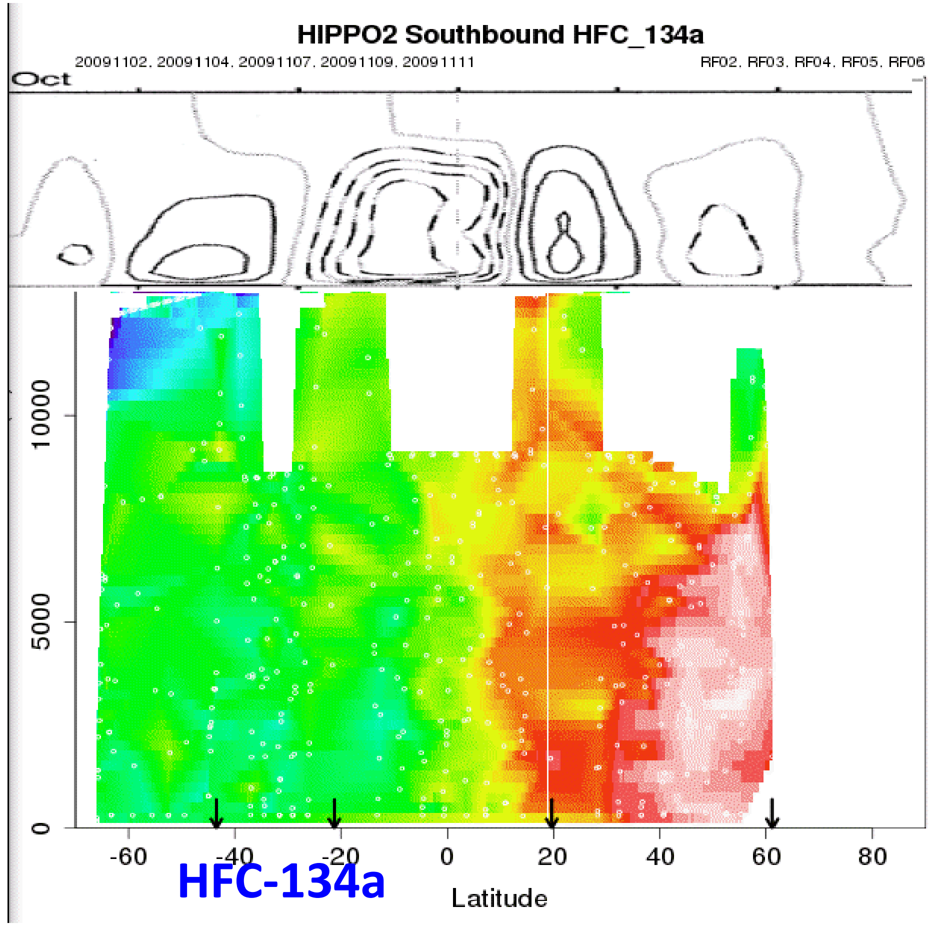
drives inter hemispheric exchange



October

tropical transport slows down
hemispheres homogenize





<u>Note:</u> that HFC-134a etc. have Northern Hemispheric <u>sources in growth</u>, similar to SF_6.

- If we normalize each tracer to there respective growth rate.
- Then (in the absence of OH loss) they would have the same inter hemispheric gradient.
- .... Differences in these normalized gradient are then a measure of loss.

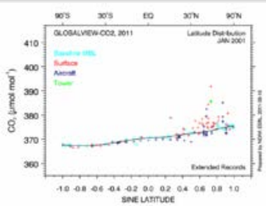
Correlated Data Set:

> all species in air parcel measured share common path
> all species in air parcel ...... share correlated chemical fields.

SF_6 > NH growth

CO_2

CH_4



NH growth

Species	~ total lifetime (years)
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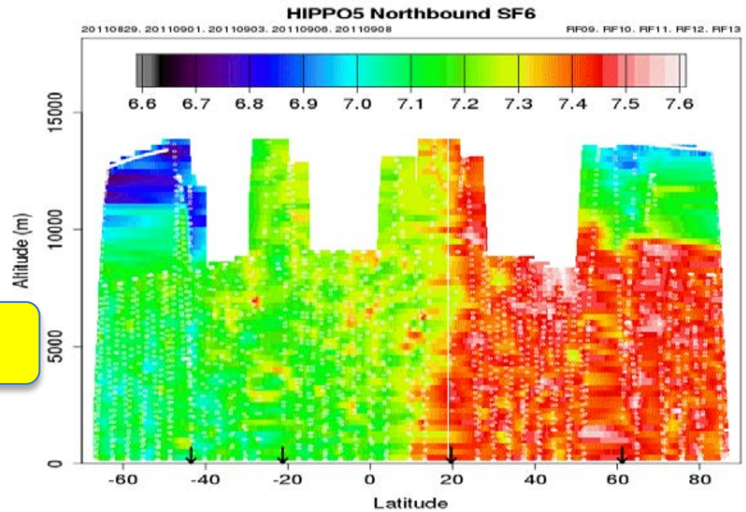
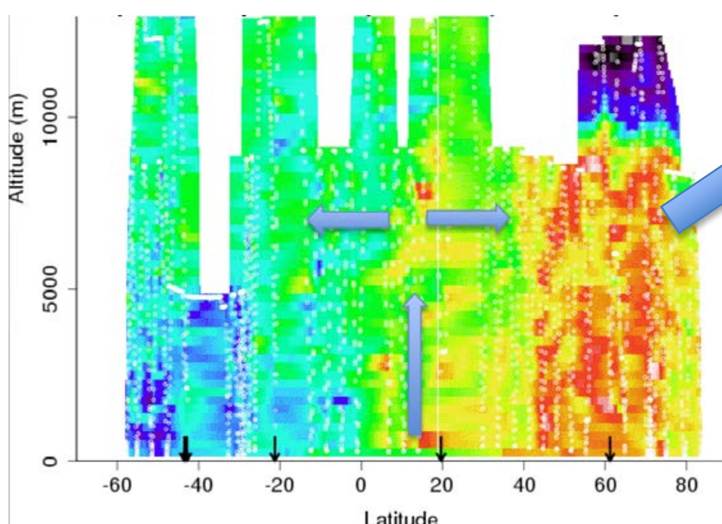
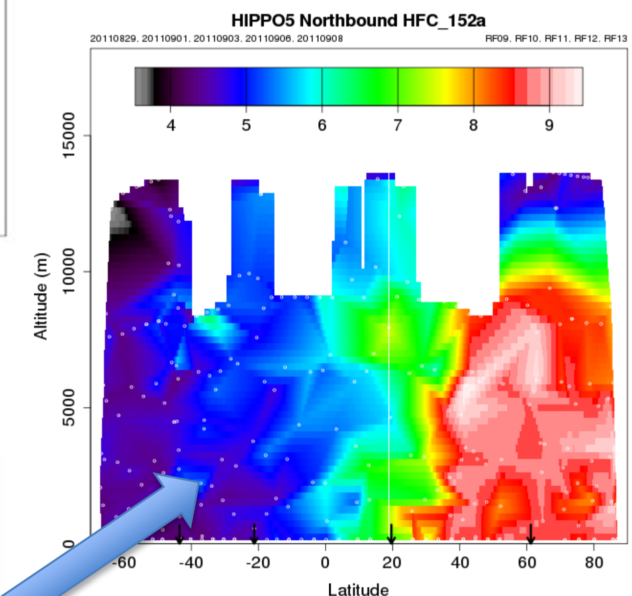


Transition time
~ 1 month



~ total lifetime (years)



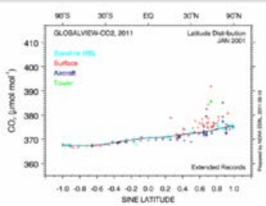
Remove gradient
due solely to transport

Correlated Data Set:

> all species in air parcel measured share common path
> all species in air parcel …… share correlated chemical fields.

SF_6 > NH growth

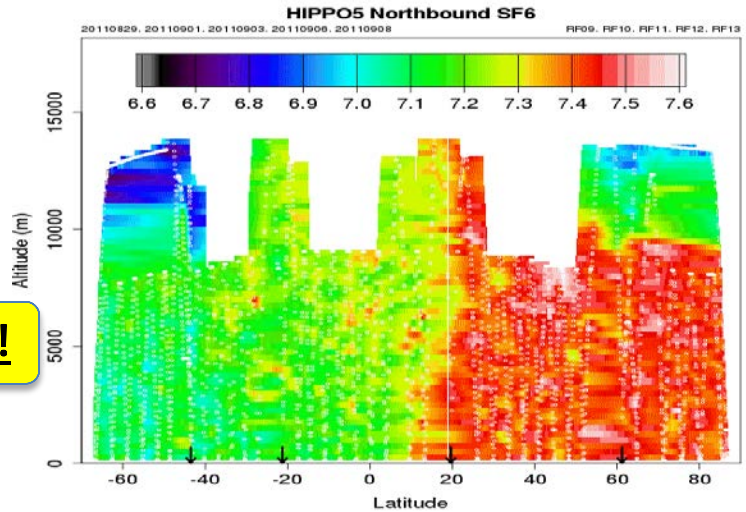
CO_2
CH_4



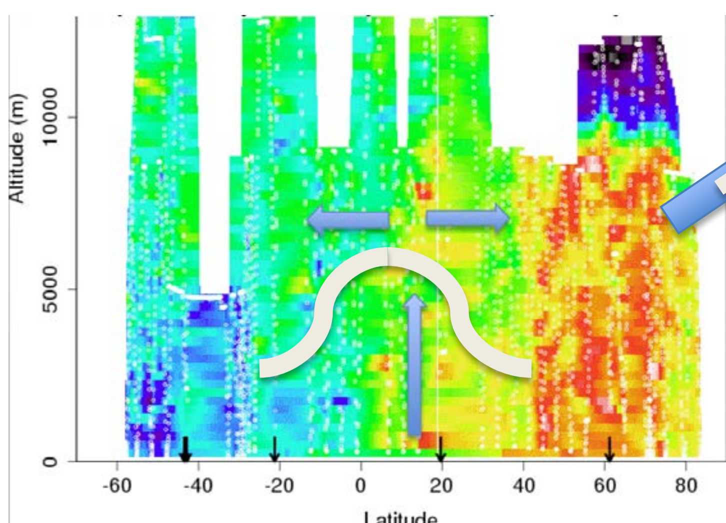
NH growth and OH loss !

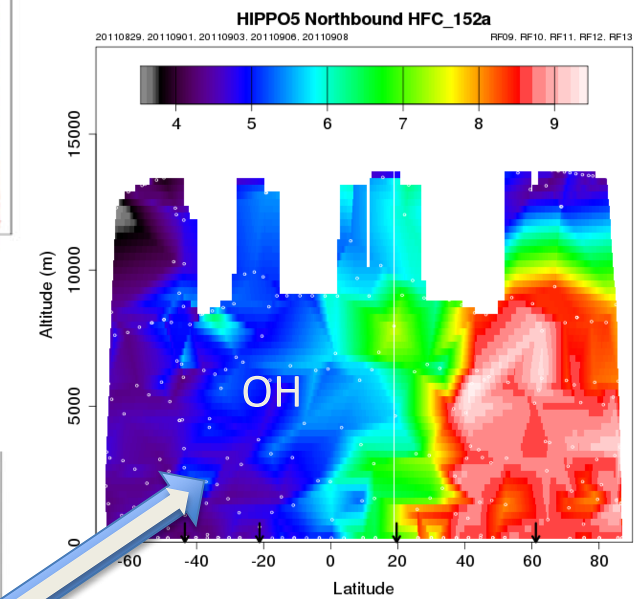
~ total lifetime (years)

HCFC-143a	47.
HFC-125	28
HCFC-142b	17
HFC-134a	13
HCFC-22	12
HCFC-141b	9.2
CH_3CCl_3	5.0
HFC-152a	**1.5**
CH_3Cl	1.0
CH_3Br	0.8
$CHCl_3$	0.4
CH_2Cl_2	0.4
CH_2Br_2	0.34
C_2Cl_4	0.25



Transition time
~ 1 month





Identify and quantify OH loss
Coupled to transport

Summary

HIPPO unique and valuable data set:

Good Seasonal and Spatial Coverage.

Large and diverse set of correlated trace gas measurements.

Producing Science:

Suited well for 3D Model studies.

Process oriented Model independent studies.

If you like and or use this data set…….

.

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.

Please support ATom proposal,

HIPPO like with added chemistry and aerosols.

Pacific and Atlantic.

NASA DC-8.

NOAA_GMD generates ***8*** separate submission **files** for each flight.

GCMS-M2_ **Mass Spec Flask Data.** *S. Montska etal.*

MAGICC_gmd_ **Carbon Cycle Group Flask Data** *C. Sweeney et. al.*
(CO_2, CO, CH_4, H_2, SF_6, N_2O)

SIL_isotopes_ **Isotope Flask Data.** (*J. White and B. Vaughn INSTARR*)
(^{18}O , ^{13}C on CO_2)

UCATSO3_ 2B Photometer (O_3) *J. Elkins et. al.*

UCATSGC_ In Situ Chromatograph-ECD *J. Elkins et. al.*
(N_2O, SF_6, CH_4, CO, H_2)

UCATSH20_ MayComm TDL (H_2O) *J. Elkins et. al.*

GC_ECD_ In Situ Chromatograph-ECD *J. Elkins et. al.*
(N_2O, SF_6, CH_4, CO, H_2, CFC-11, -12, -131, halon-1211, PAN)

GC_MSD_ In Situ Chromatograph-MSD *J. Elkins et. al.*
(CH3Cl, CH3Br, CH3I, HCFC-22, HCFC-141b, HCFC-142b, HFC-134a, OSC, CS2)

Sample Volume information:

Integrate over Fast Data sets.

PFP Flask data is altitude targeted (on dives) with ~ 10-20 seconds of sample width.
(24 to 36 flask samples per flight).
(target precision 0.05% on up depending on species)

In situ MDS data are similar to flask data except for a higher 3 min. data rate and a sample width integration of ~ 150 sec , or about an 80% sample duty cycle.
(target 1% precision)

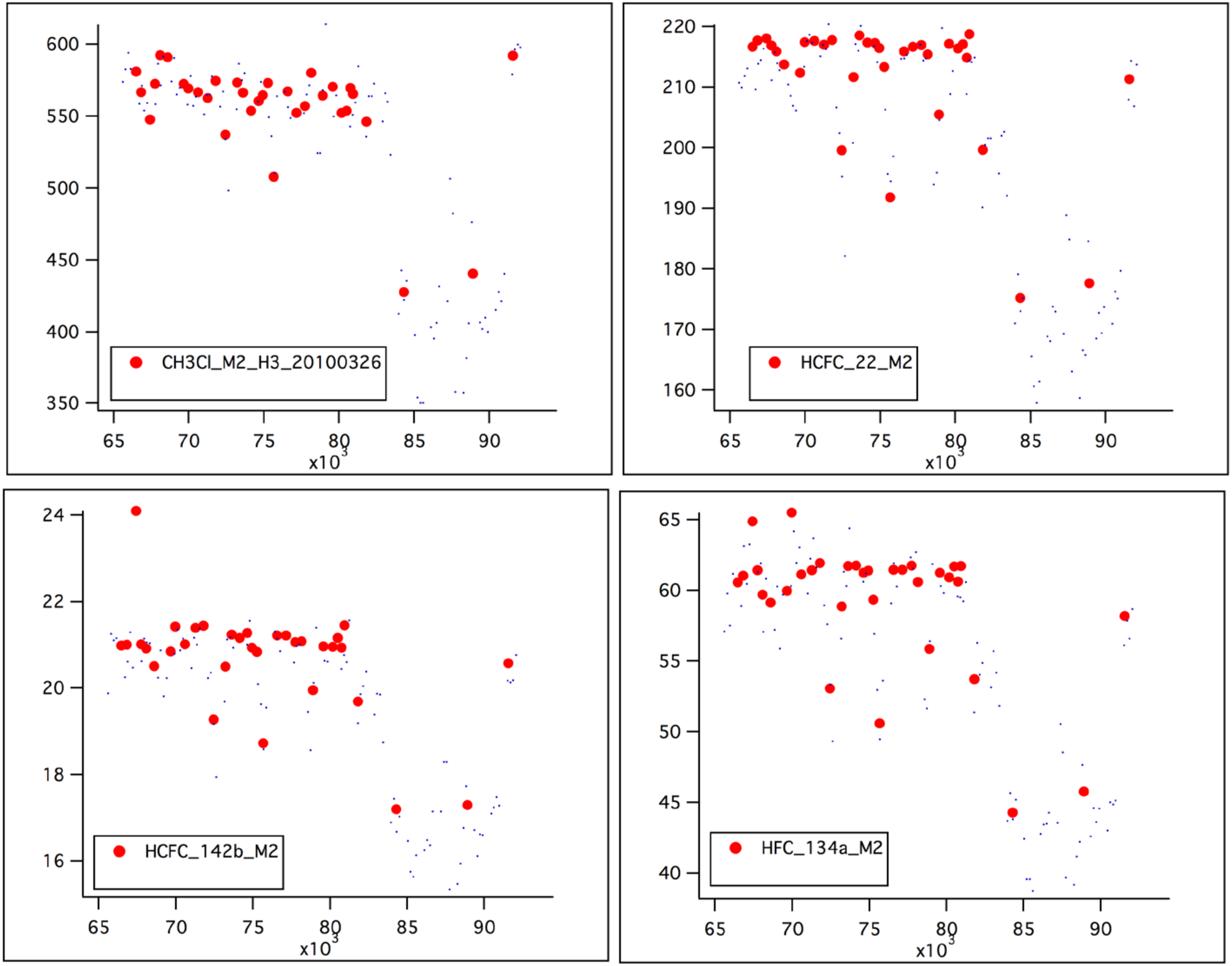
Correlate with Fast Data sets.

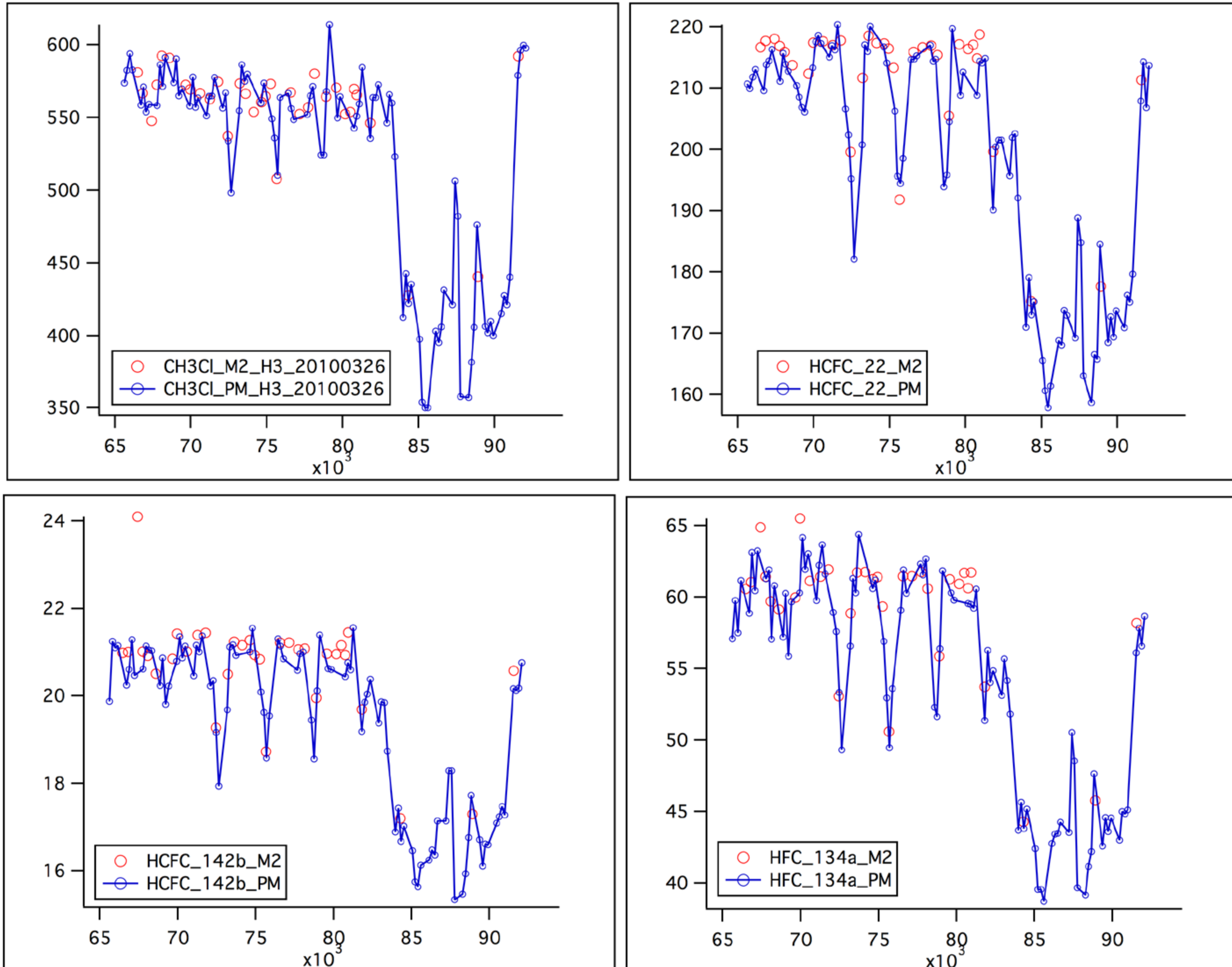
In situ ECD data have even higher data rate of 1 or 2 min (2-3 second sample width).
(target 0.5% precision)

O_3 (0.1 Hz) (target 2% +2 ppb precision)

H2O (1 Hz) (target 3% + 1 ppb precision)

Redundant data sets:


CH3Cl_M2_H3_20100326
HCFC_22_M2
HCFC_142b_M2
HFC_134a_M2
x10^3



600
550
500
450
400
350
65
70
75
80
85
90
x10^3
CH3Cl_M2_H3_20100326
CH3Cl_PM_H3_20100326
220
210
200
190
180
170
160
65
70
75
80
85
90
x10^3
HCFC_22_M2
HCFC_22_PM
24
22
20
18
16
65
70
75
80
85
90
x10^3
HCFC_142b_M2
HCFC_142b_PM
65
60
55
50
45
40
65
70
75
80
85
90
x10^3
HFC_134a_M2
HFC_134a_PM