UNIVERSITY OF CAMBRIDGE

NATURAL ENVIRONMENT RESEARCH COUNCIL

COORDINATED AIRBORNE STUDIES IN THE TROPICS

NAME modelling activities for ATTREX VSLS measurements

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SPARC CT3LS Meeting, Boulder, 20-23/07/2015

Overview

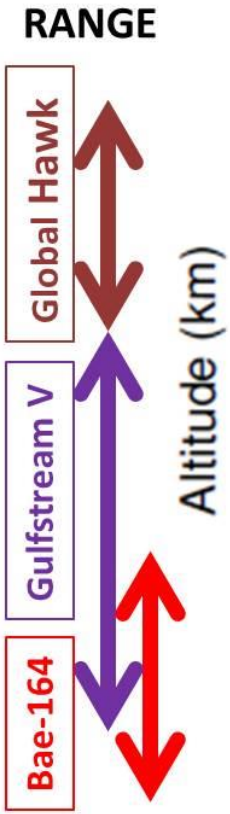
Transport from low troposphere in ATTREX 2013 and 2014

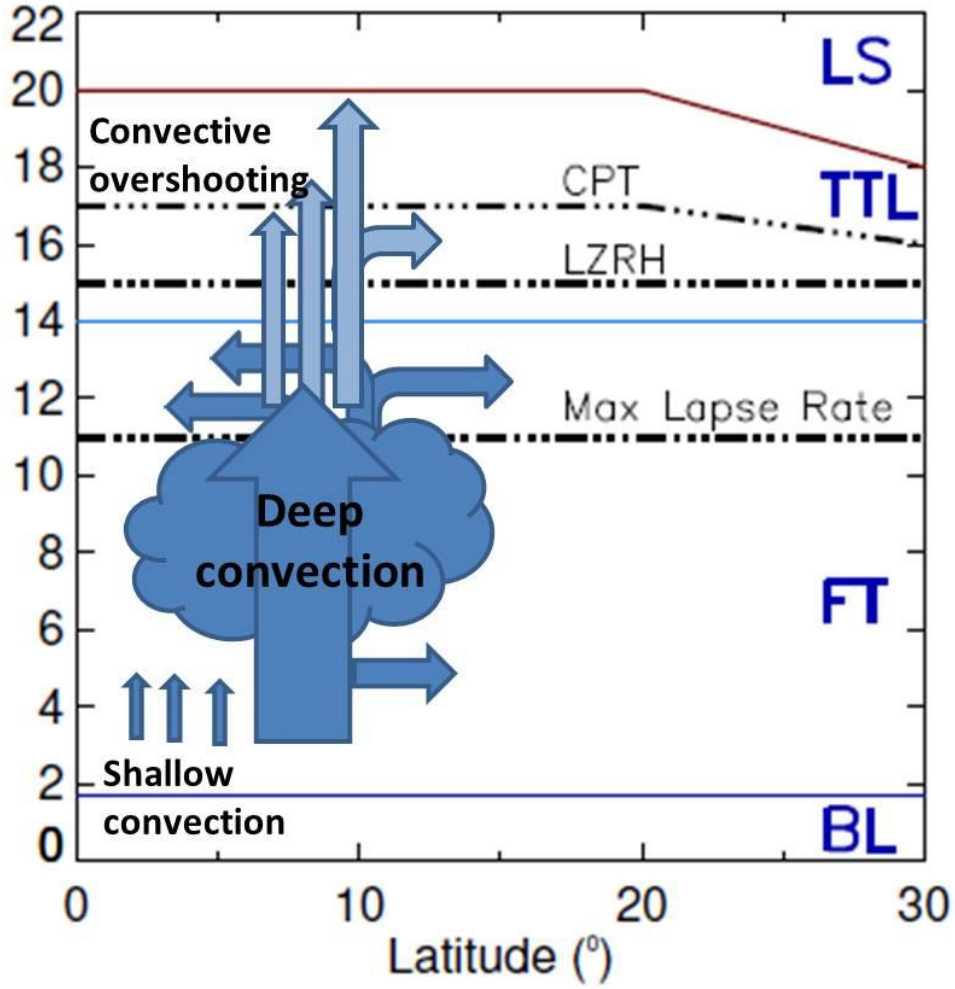
- Regional assessment: East Pacific 2013 and West Pacific 2014
- Research flight variability
- Summary and further work

I would like to thank NERC for my PhD studentship

Background

- Joint campaign in West Pacific, 2014
- Characterise chemistry, composition and transport to/through TTL
- Halogenated VSLS

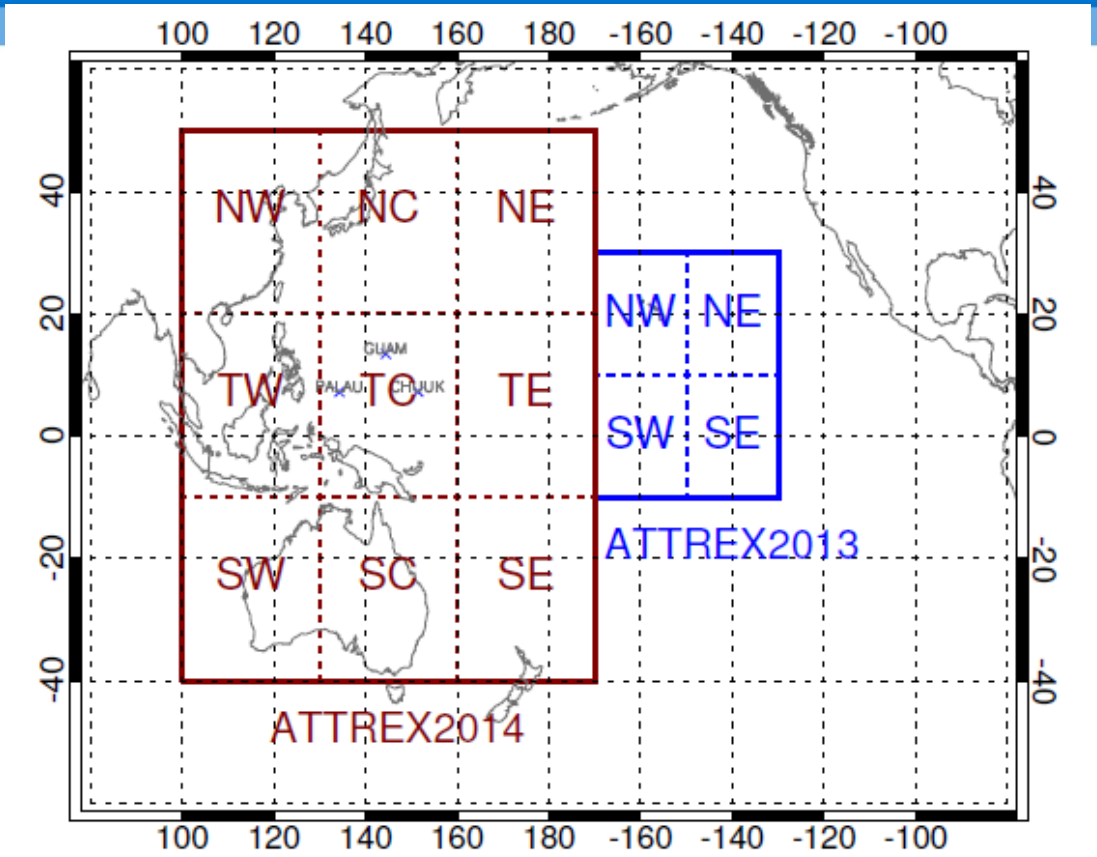




NAME model

- NAME is a Lagrangian Dispersion Model for representing atmospheric transport
- Uses 3D UM global wind fields with horizontal resolution of *25km (6v3 MO2014)
- No parameterised convection scheme
- Particles released backward to identify airmass origin/transport timescales
- First use of NAME for such analysis:
  - ASHFOLD, M. J., et al., 2012, Transport of short-lived species into the Tropical Tropopause Layer ACP., 12(14), 6309-6322

NAME Assessment of ATTREX regions



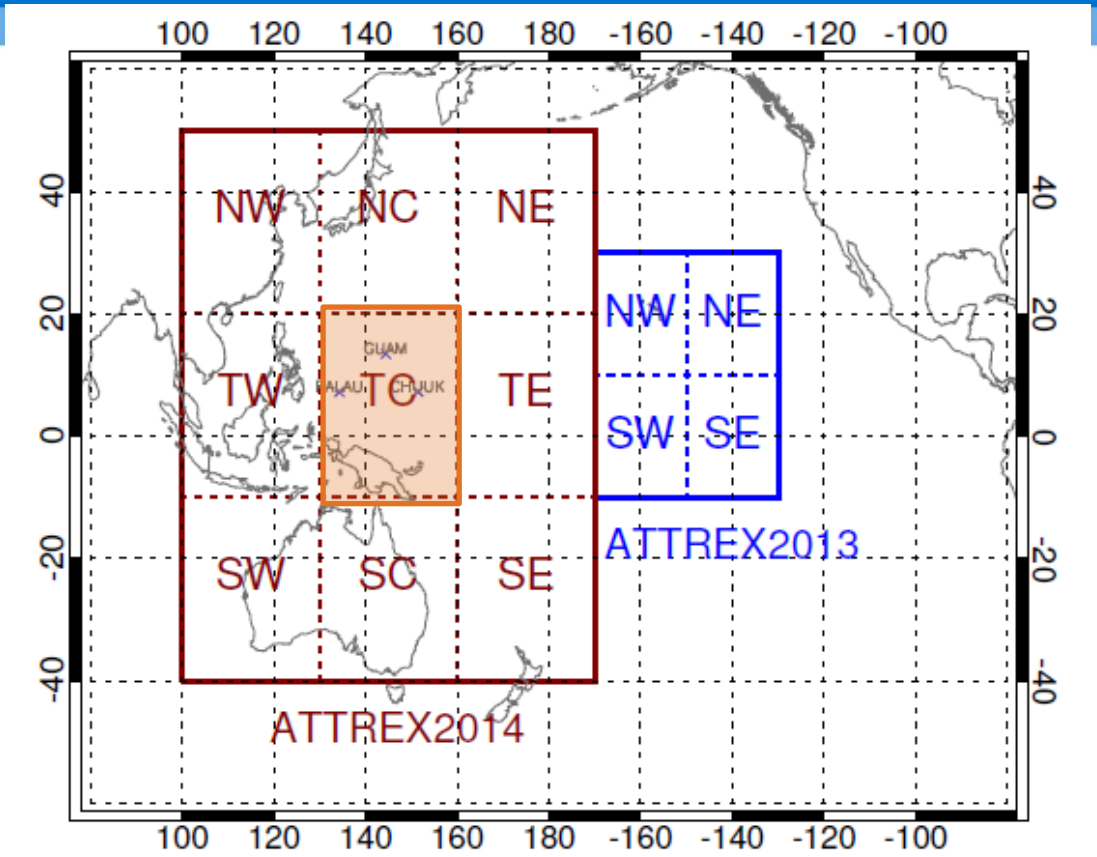
ATTREX 2014

- 45,000 particles released
- 18 boxes: 30 x 30 x 2 deg^2 km
- 100 E-170 W, 40 S-50 N, 14-16 /16-18km
- 12 days back

ATTREX 2013

- 20,000 particles released
- 8 boxes: 20 x 20 x 2 deg^2 km
- 130-170 W, 10 S-30 N, 14-16 / 16-18km
- 12 days back

NAME Assessment of ATTREX regions



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ATTREX 2013

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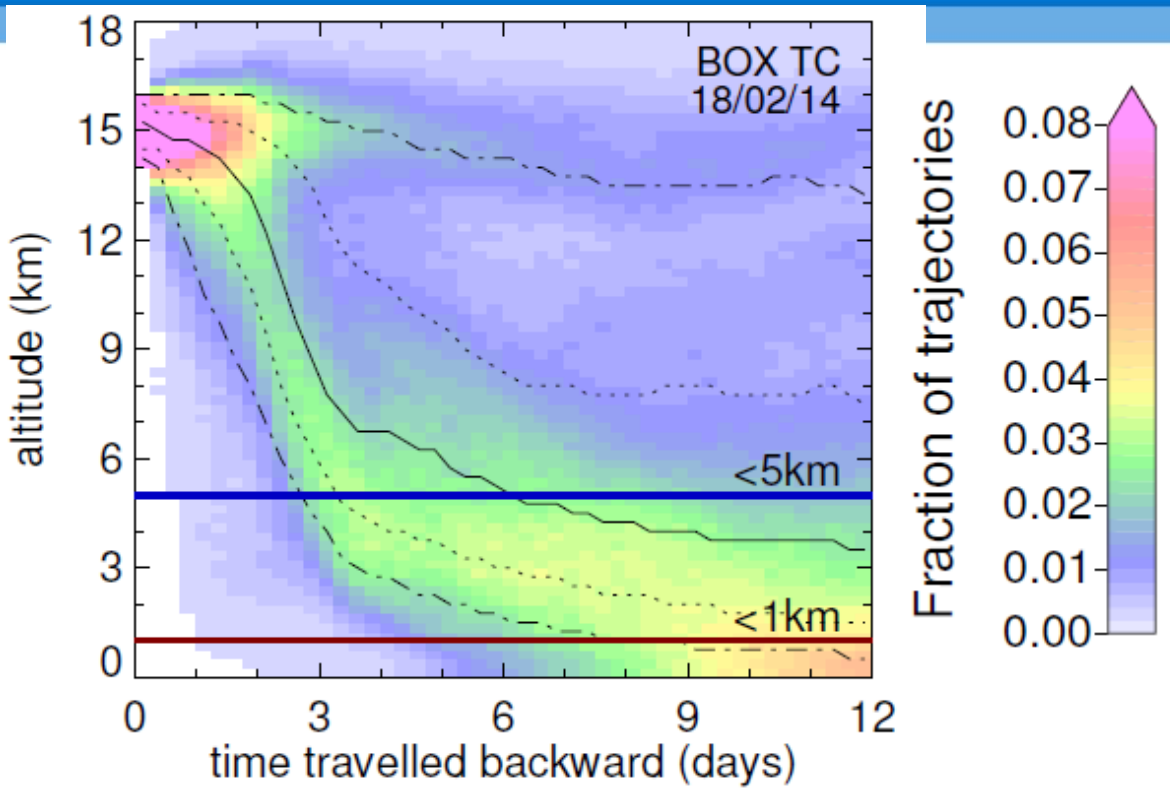
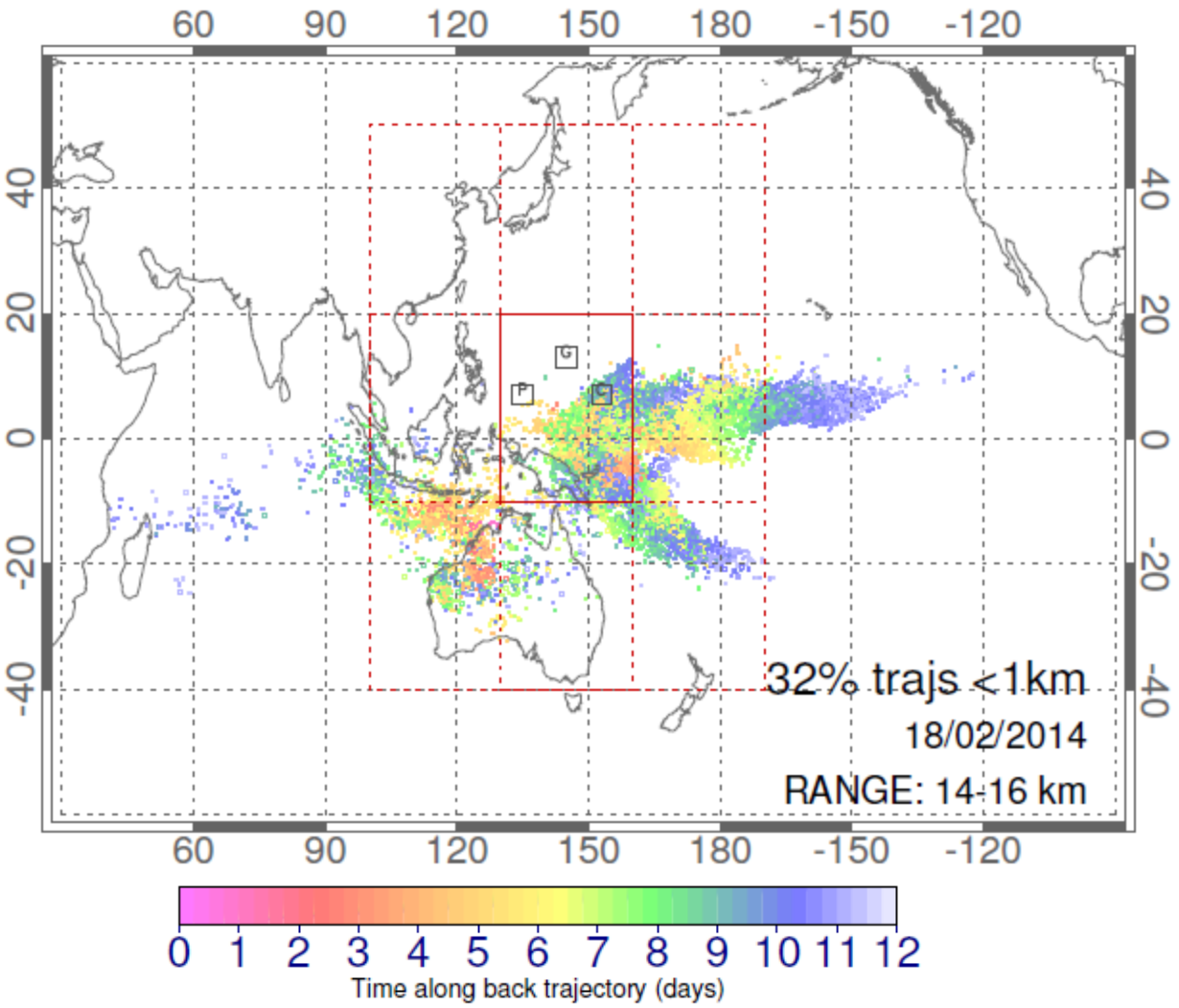
NAME for ATTREX – Product: Z vs T plot



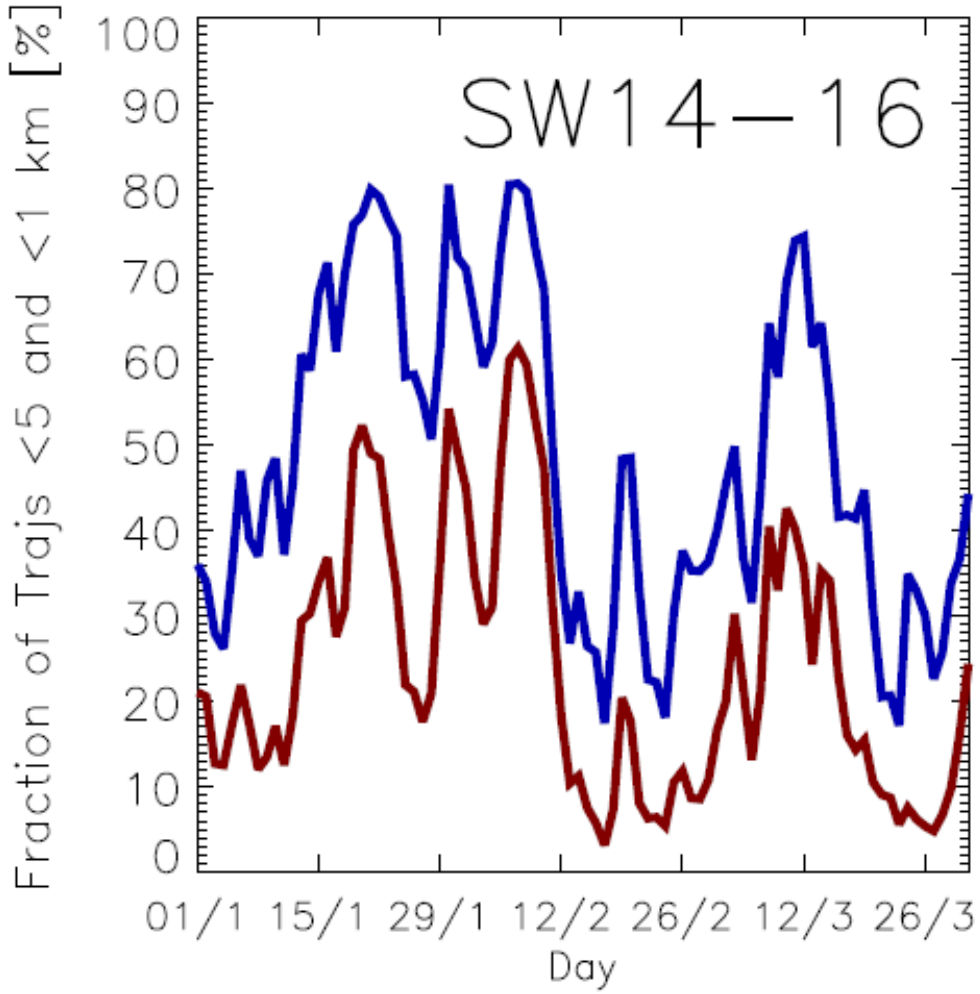
- Low-level airmass contribution to TTL
- Particle density vertical distribution
- How many crossed below 1/5 km

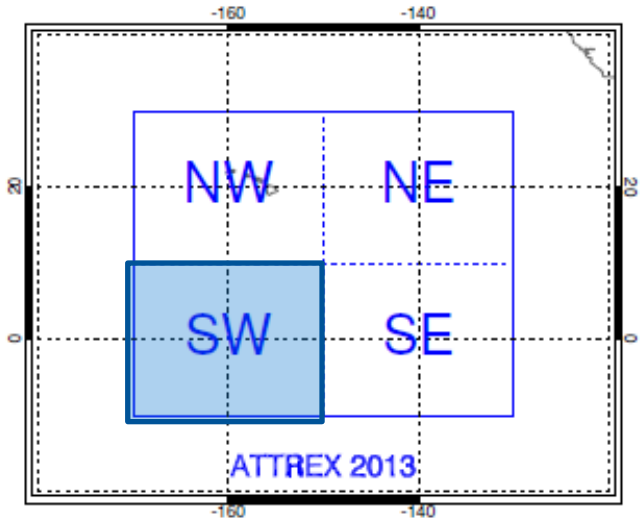
NAME for ATTREX – Product: Crossing Location Map



- Low-level airmass contribution to TTL
- Crossing locations of particles which went below 1 km
- Time when and how many of the released particles crossed <1 km
- *Also done for <5 km*

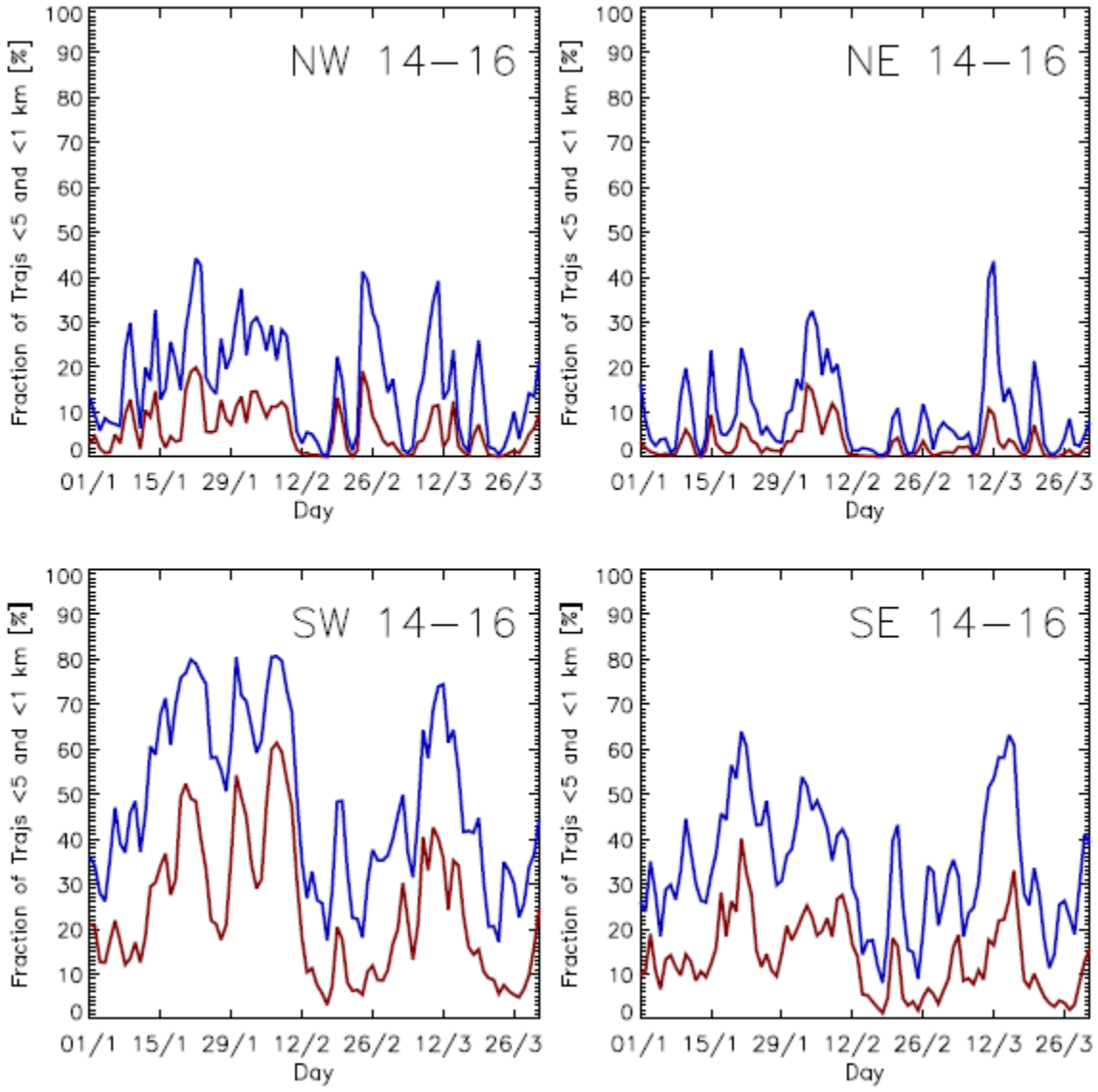
NAME assessment of variability: East Pacific 2013





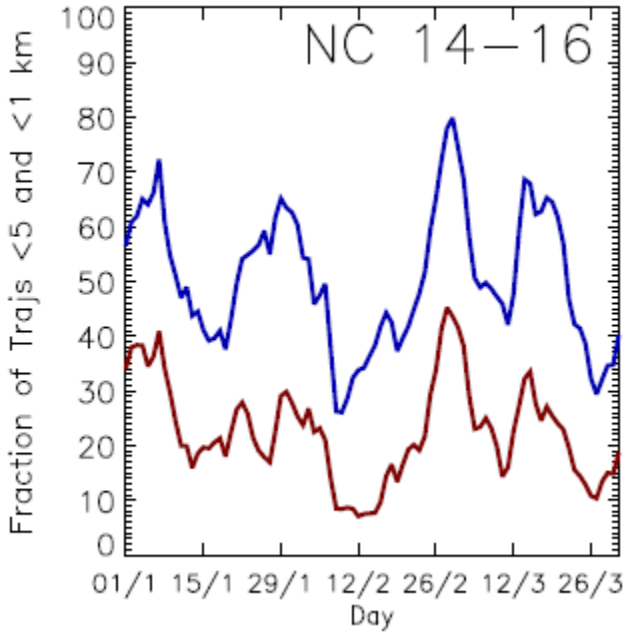
- high week-to-week variability in low level airmass contribution
- <1km contribution consistent with <5km contribution
- is the pattern consistent for the rest of boxes?

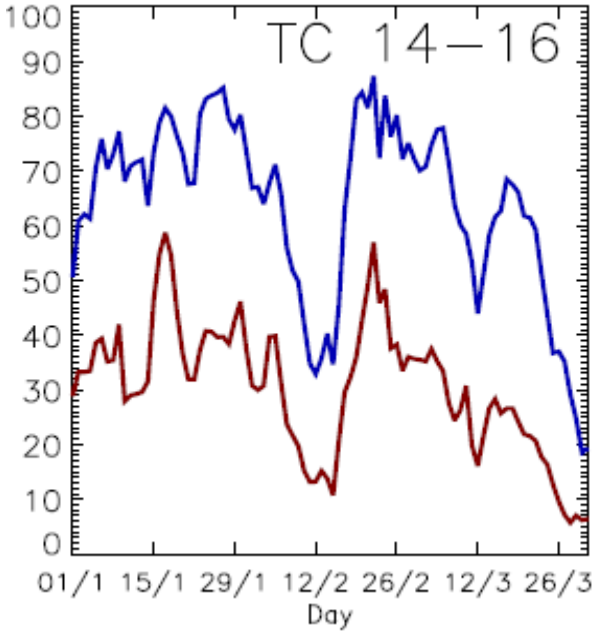
NAME assessment of variability: East Pacific 2013

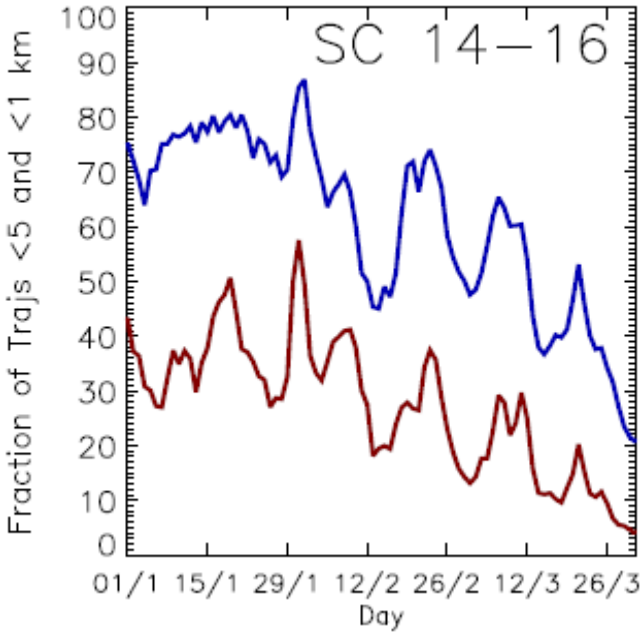


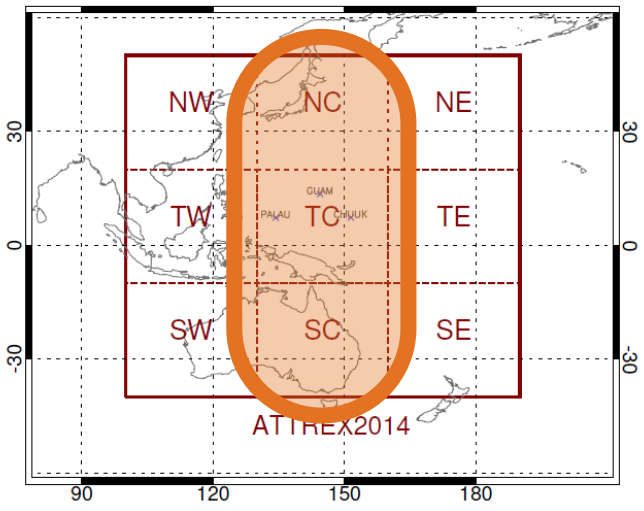
- Week-to-week variability in all four boxes
- Two main periods of enhanced low level air mass contribution
- Lower values for N boxes
- Peaks and lows more discrete
- Primary sources: W. Pacific, SPCZ
- 16-18km:
  - highest variability for SW box
  - v low influence for the rest

NAME assessment of variability: West Pacific 2014





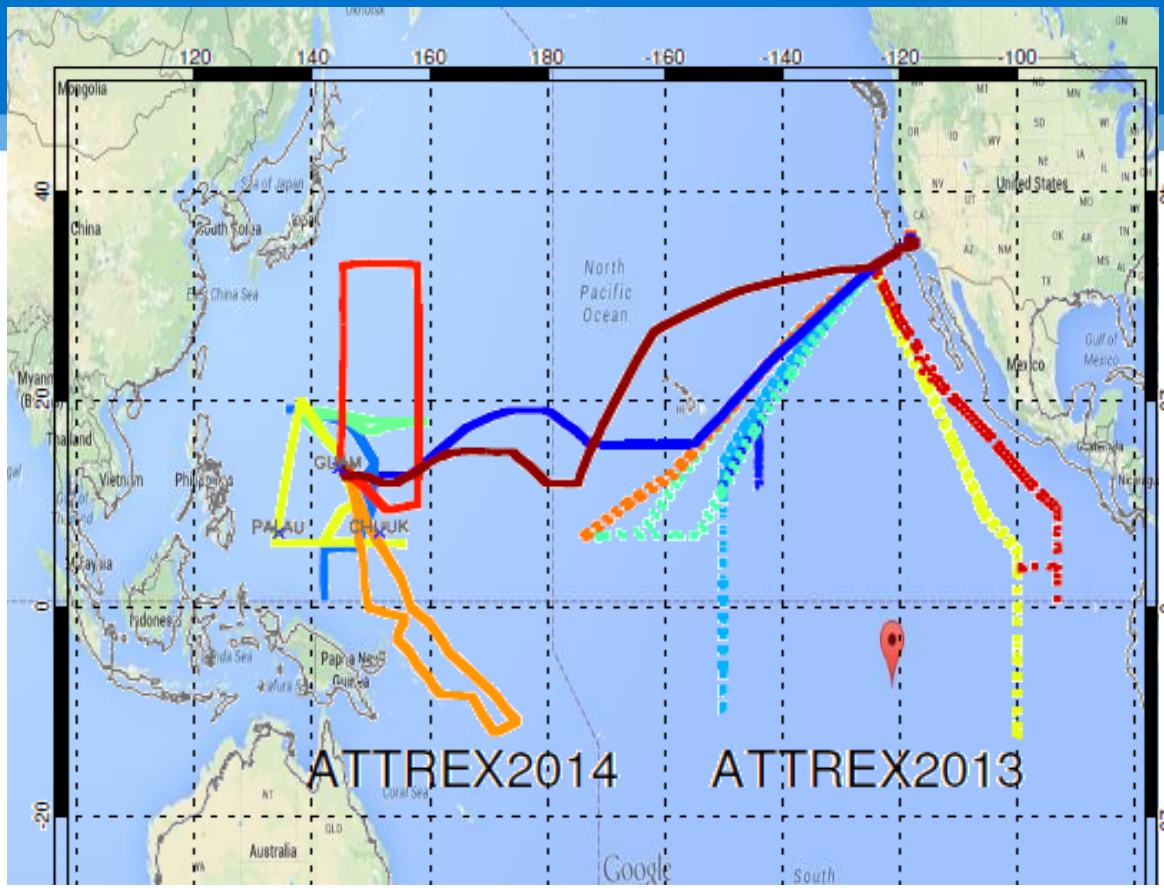




- Week-to-week variability
- Higher <1 km and <5 km values than 2013
- More recent air encountered
- Primary source: West Pacific Warm Pool
- Local influence more evident

ATTREX campaigns

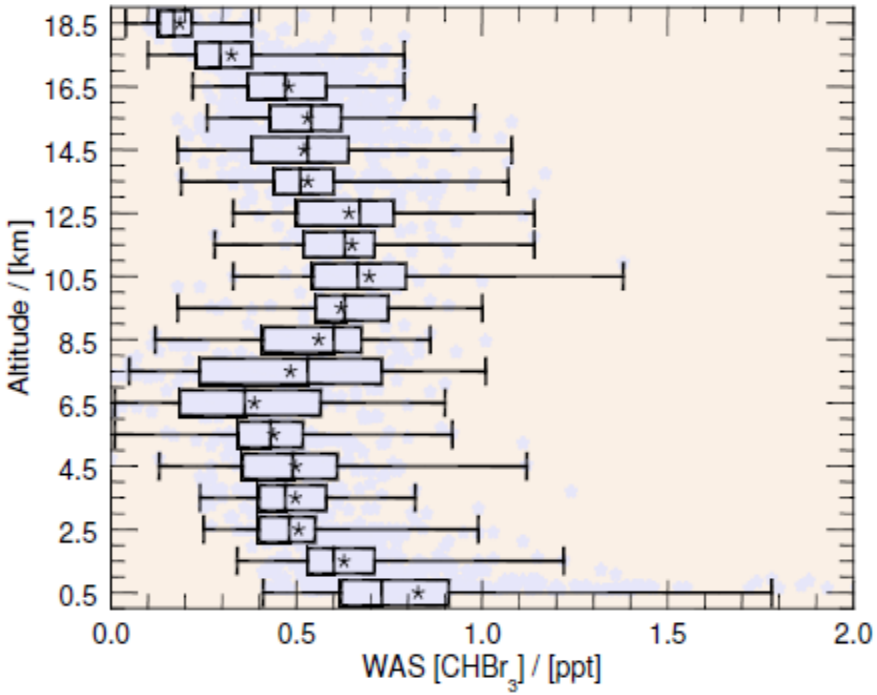
- Characterise chemistry and transport within TTL
- Vertical profiles for [$CHBr_3$] and [CH_3I] for TROP and TTL

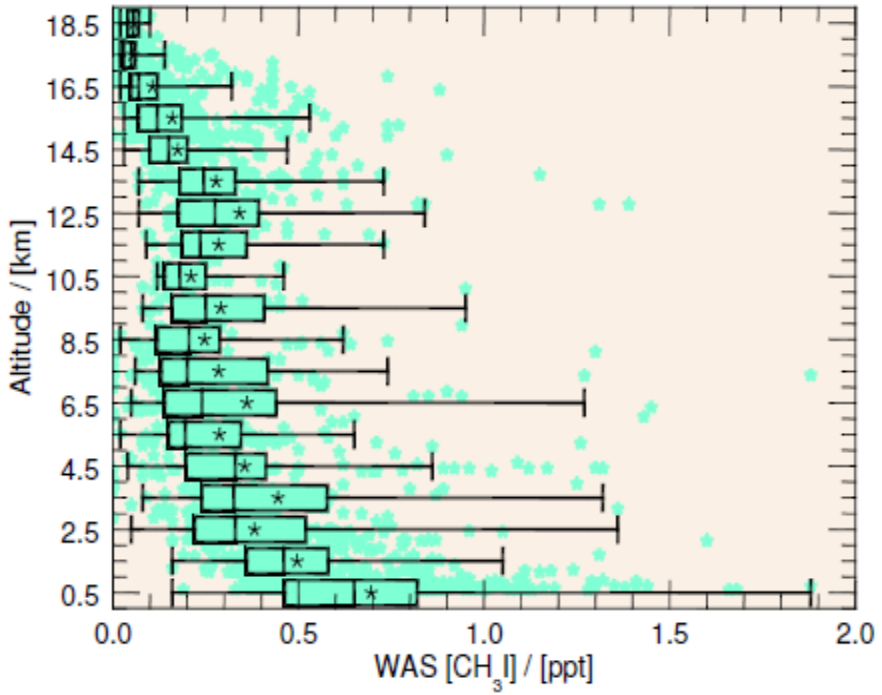


ATTREX-2	2013	East Pacific	146 hrs	6 RFs (*5 RFs WAS)	388 WAS
ATTREX-3	2014	West Pacific	139 hrs	8 RFs	669 WAS

VSLS WAS measurements

CAST-CONTRAST-ATTREX 2014 **LAT<20N**



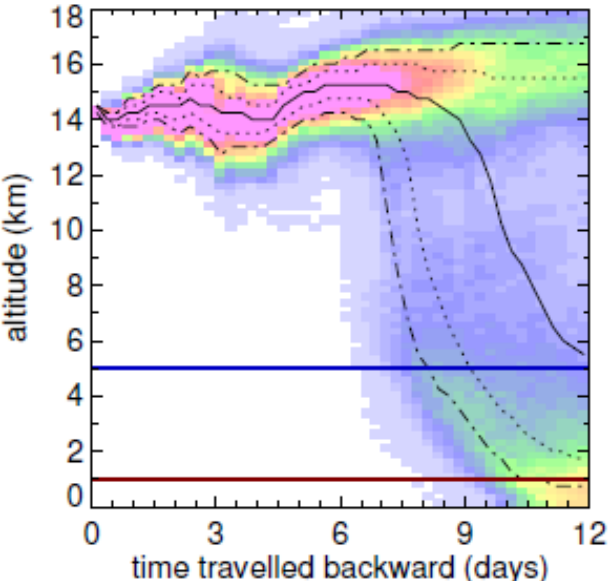


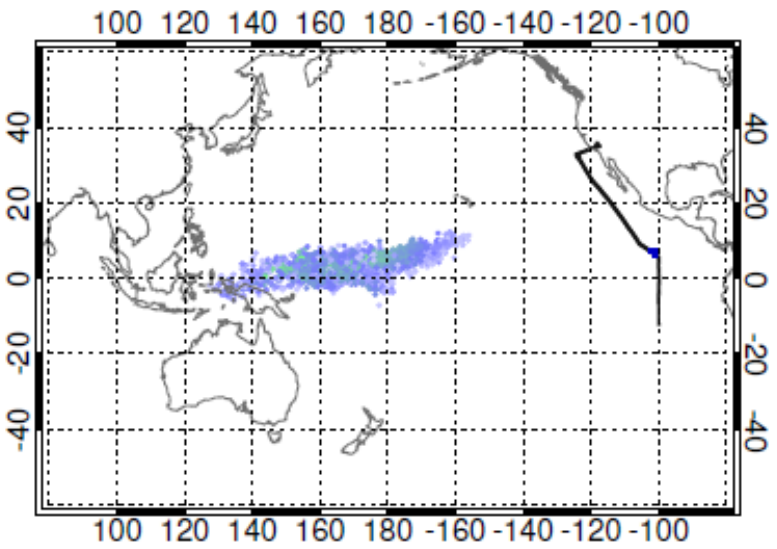
- Vertical profiles for [$CHBr_3$] and [CH_3I] for TROP and TTL
- Characteristic double maxima, drop off at 2km (MBL) and 16-17km (TTL)
- Vertical transport (deep convection) – how significant ?

NAME for ATTREX – Methodology and Products

- Low-level airmass contribution to TTL
- 15000 particles,12-day back
- Release box of 0.1 x 0.1 x 0.3 deg^2 km (WAS sample origin)
- Particle density vertical distribution over time plots
- Cross location maps <5 / <1 km
  - Timescales / how many of the released particles crossed <5 and <1 km, and location

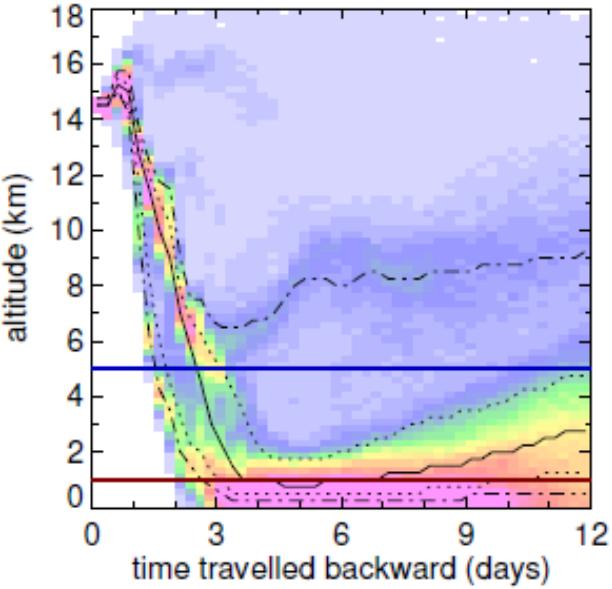
NAME products for ATTREX

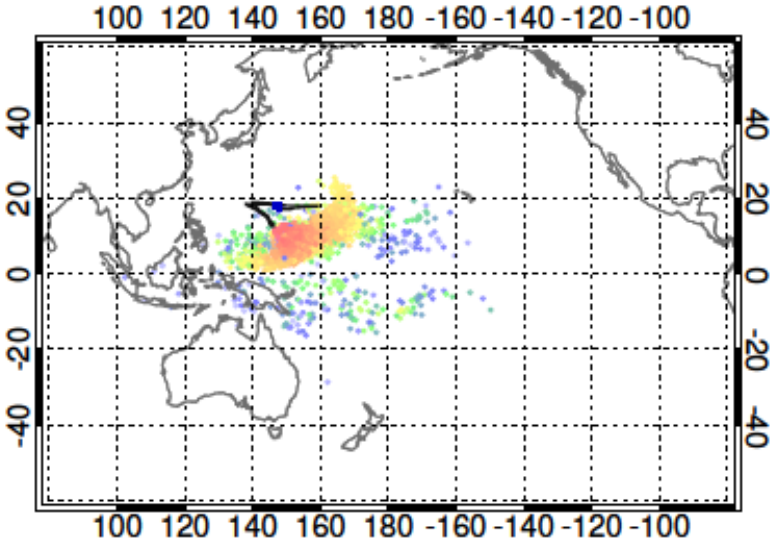




ATTREX2013
RF04
DAY: 21/02/13 22:58
ZREL: 14.34km

22% (1km)
50% (5km)

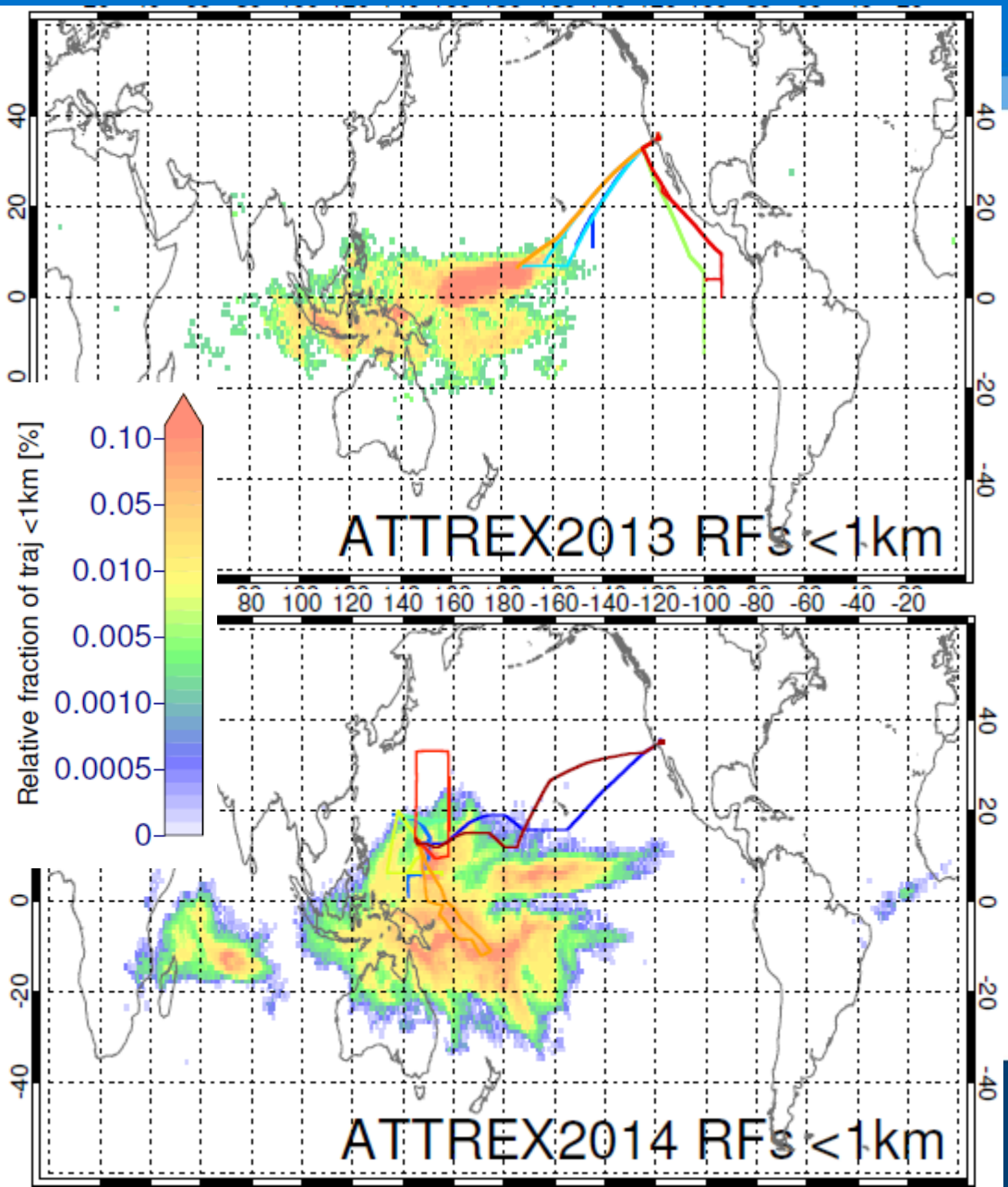




ATTREX2014
RF04
DAY: 04/03/14 21:25
ZREL: 14.43km

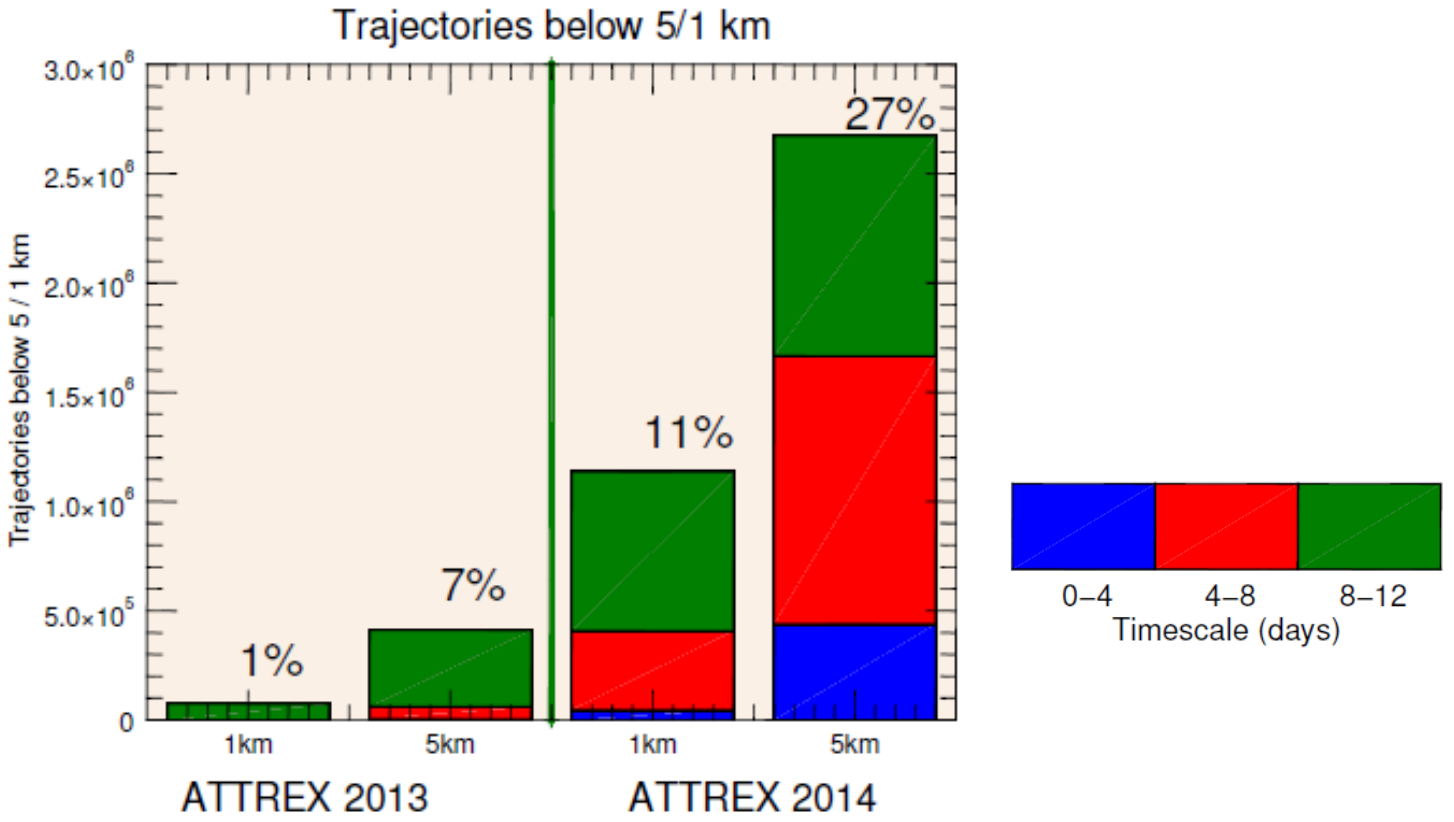
81% (1km)
90% (5km)

NAME for ATTREX – Spatial variability



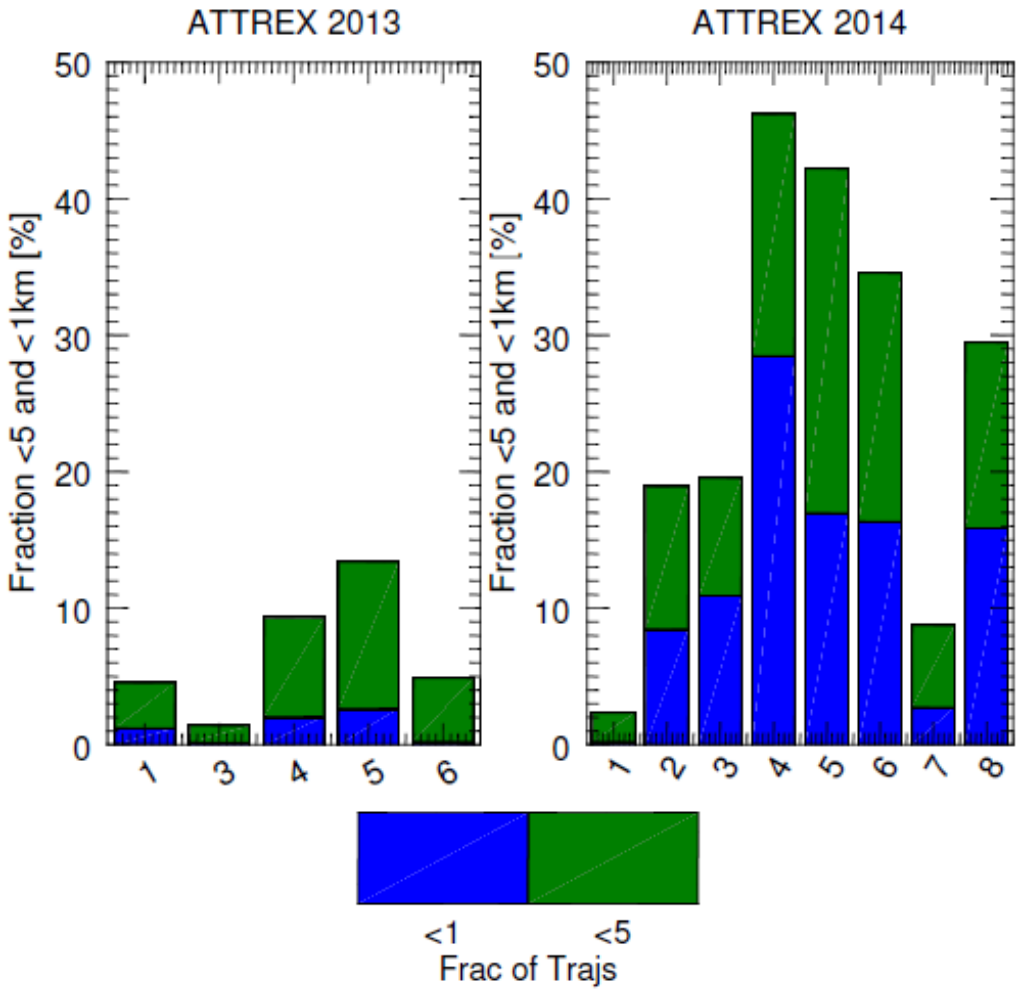
- Primary source: West/Central Pacific
- Consistent with horizontal transport more important for ATTREX 2013
- Flights over West Pacific encountered more recent air
- Signals of enhanced low level airmass contribution to TTL by rapid vertical transport

NAME for ATTREX – Timescales variability



- More recent air encountered for ATTREX 2014
- Vertical transport played more significant role

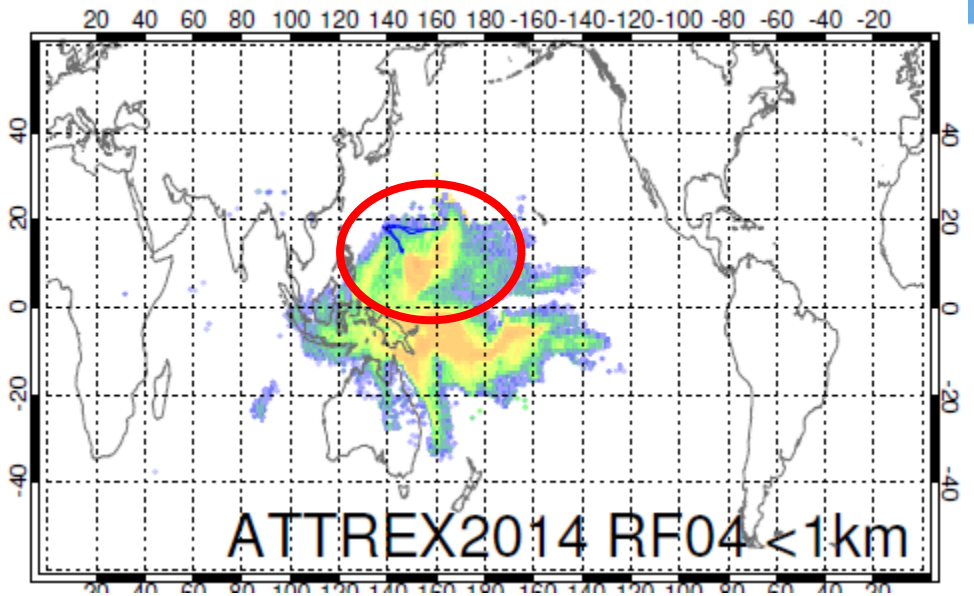
NAME for ATTREX – Flight-to-flight variability

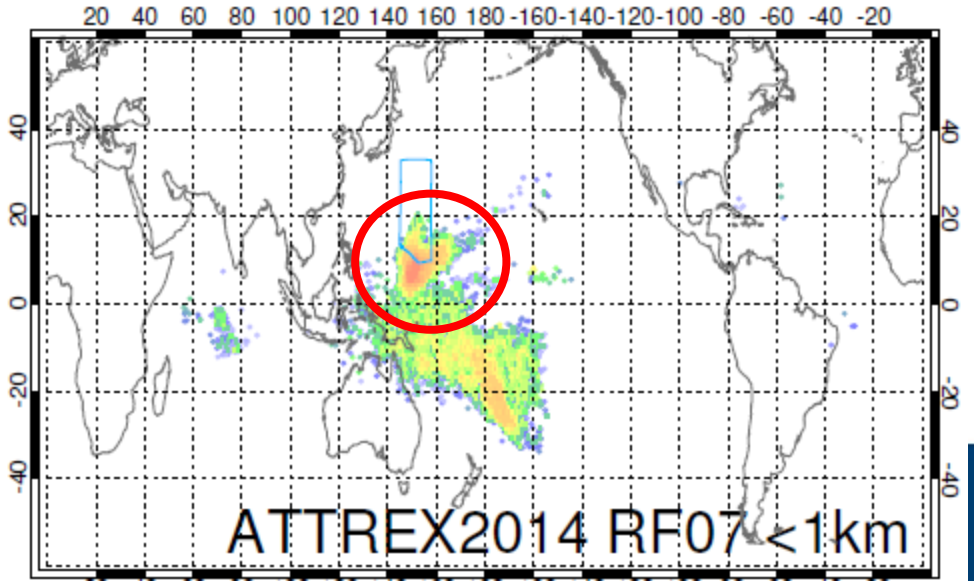


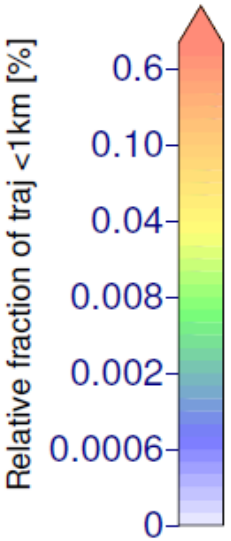
- Large inter-flight variability for both campaigns
- More uplift in ATTREX 2014
- Higher variability in ATTREX 2014
  - flights closer to main convective region
  - <1km fractions larger constituents of all <0-5km trajs

Total fraction of trajs [%]	2013 All RFs	2014 All RFs
< 5 km	7	27
< 1 km	1	11

NAME for ATTREX 2014 – Flight-to-flight variability

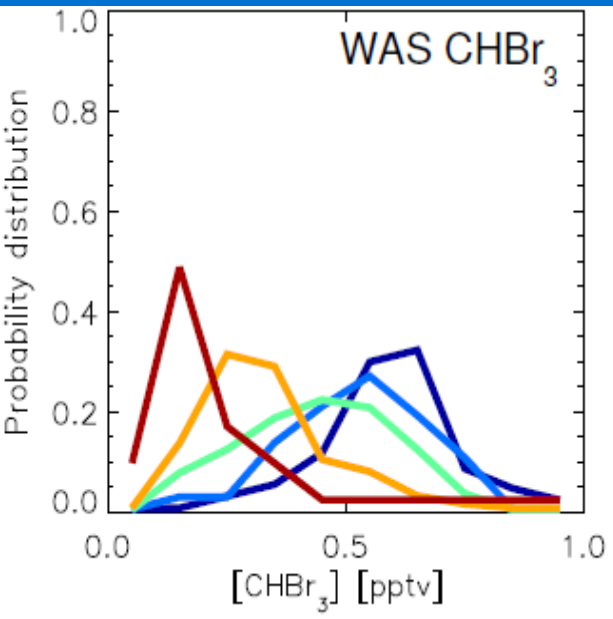


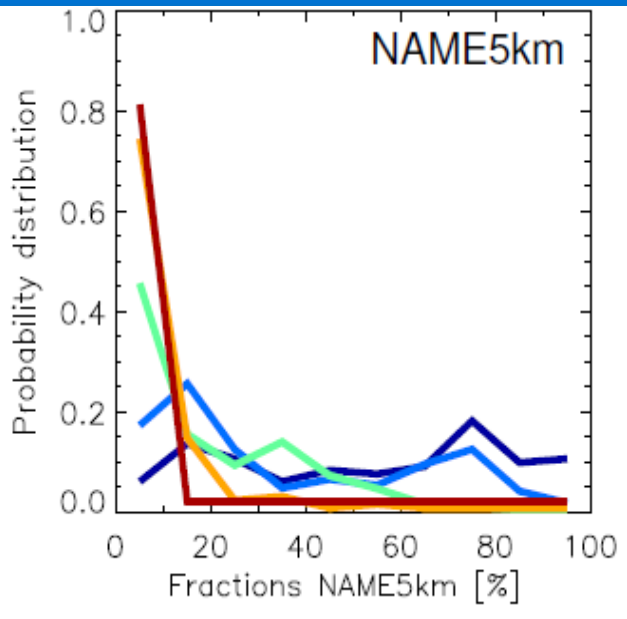


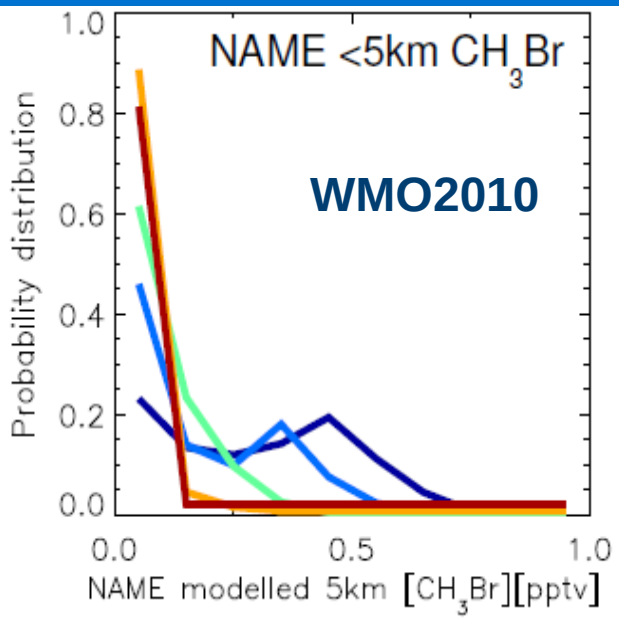


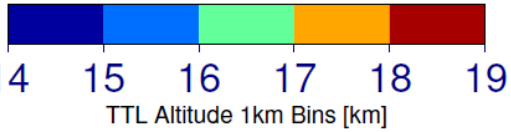
- Signals of enhanced low level airmass contribution to TTL by rapid vertical transport (ATTREX 2014: RF03,RF04)
- RF04: following on Faxai tropical typhoon
- RF07: going North to survey ExtraTropics

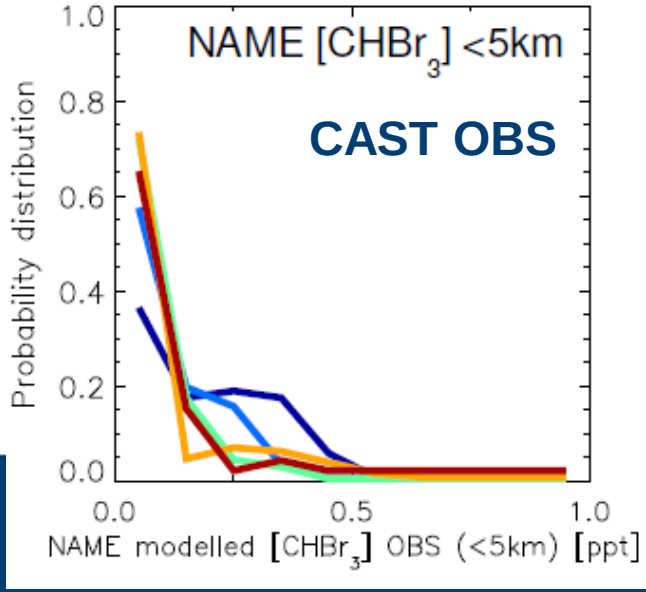
NAME for ATTREX – TTL variability PDF plots









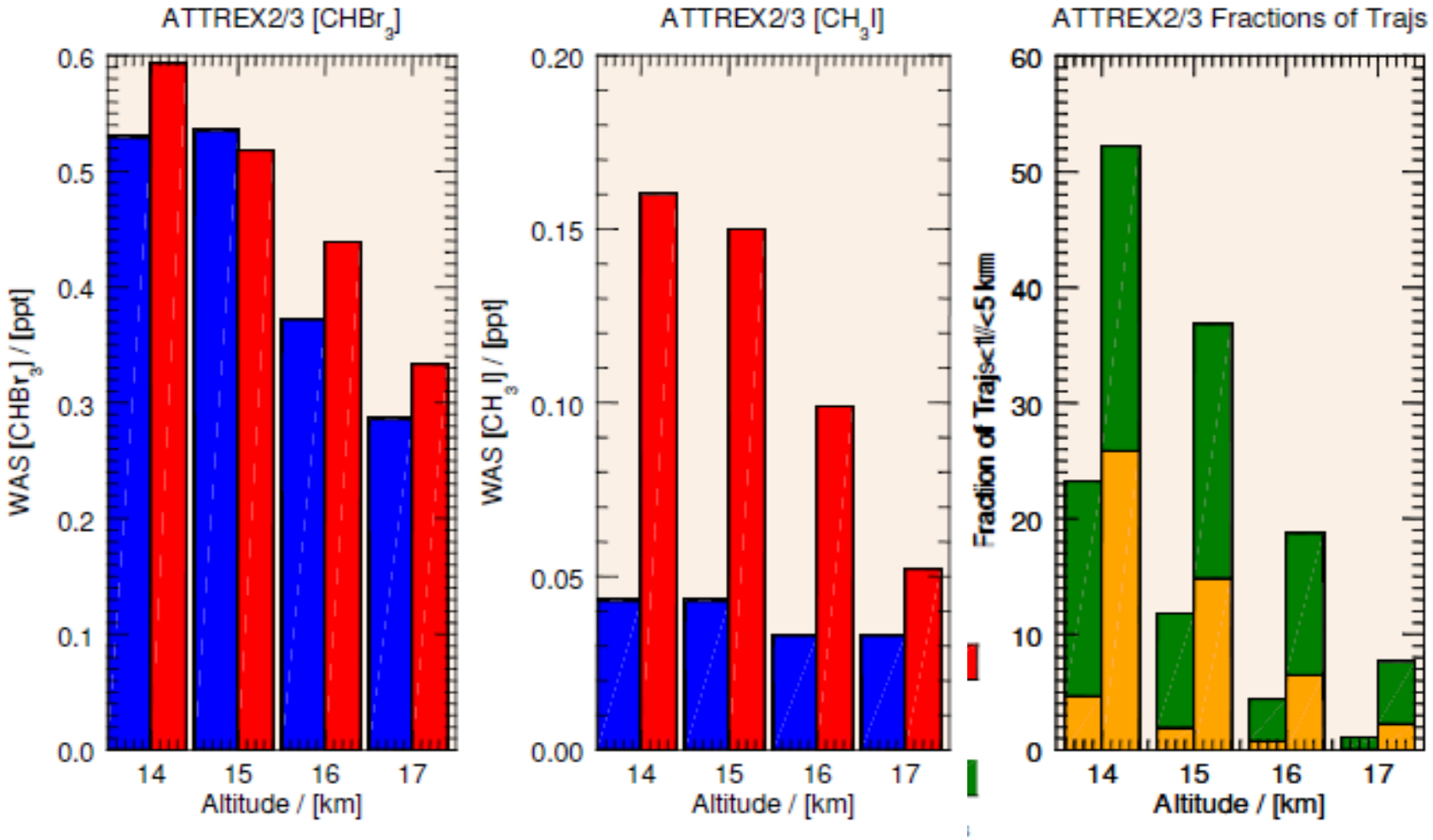


- 2 regimes and transition evident for $CHBr_3$
- NAME underestimates convective events (with convection scheme off), thus the flux of VSLS to TTL

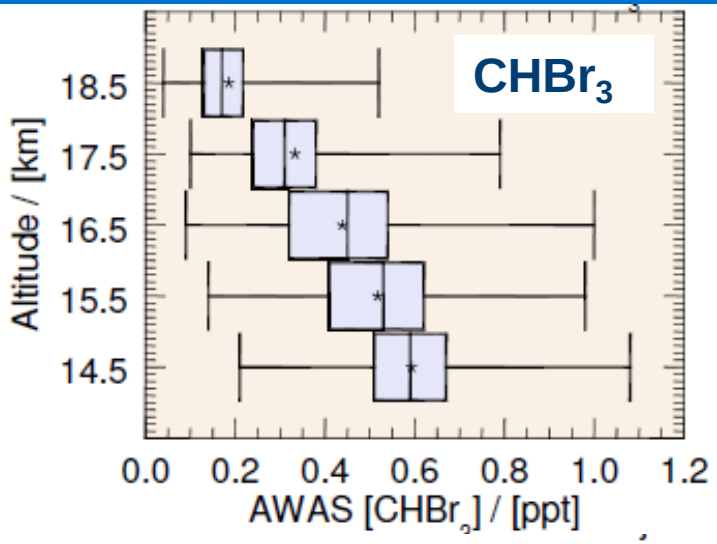
Conclusions / Further work

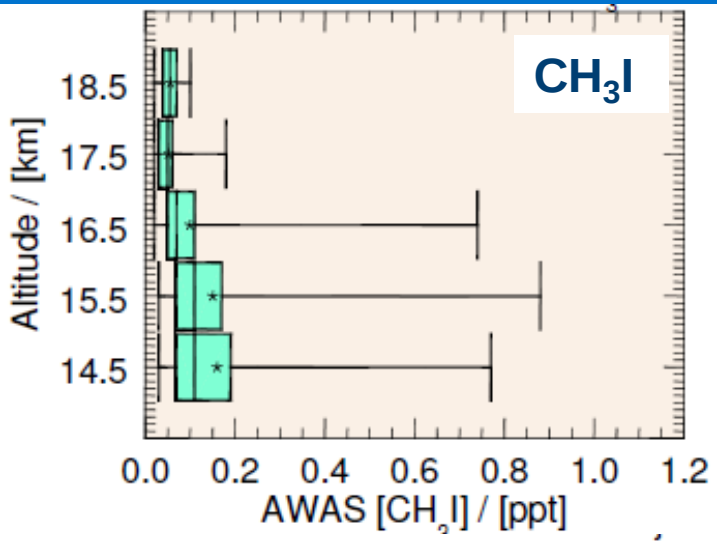
- ATTREX 2013 - Horizontal transport as predominant VSLS pathway into TTL
- ATTREX 2014 - Flights over West Pacific encountered more recent air
  - Signals of enhanced low level air mass contribution to TTL
  - Variety of source regions contribute to VSLS budget in TTL
- Poor quantitative comparison of NAME modelled VSLS with GWAS observations
- **Further Work:**
  - Repeating analysis with improved parameterisation of deep convection within NAME
  - How representative the regional assessment is compared to research flights analysis
  - Investigate the MJO influence on low-level air mass transport and contribution to TTL

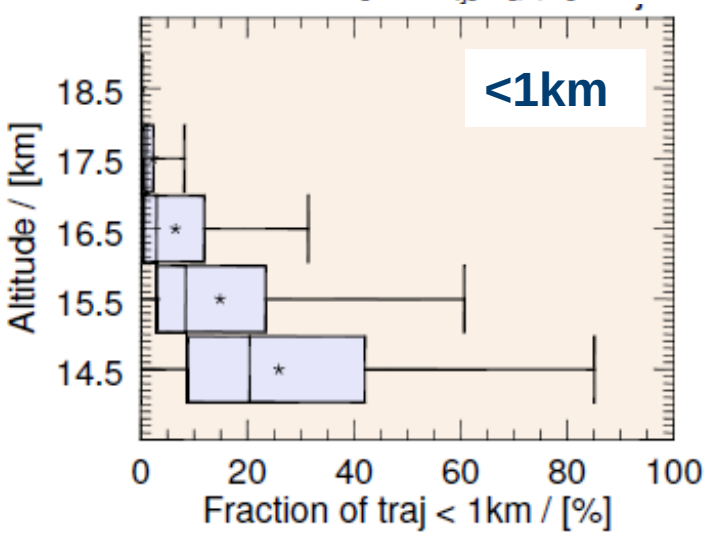
ATTREX2014 TTL Alts vs AWAS concentrations

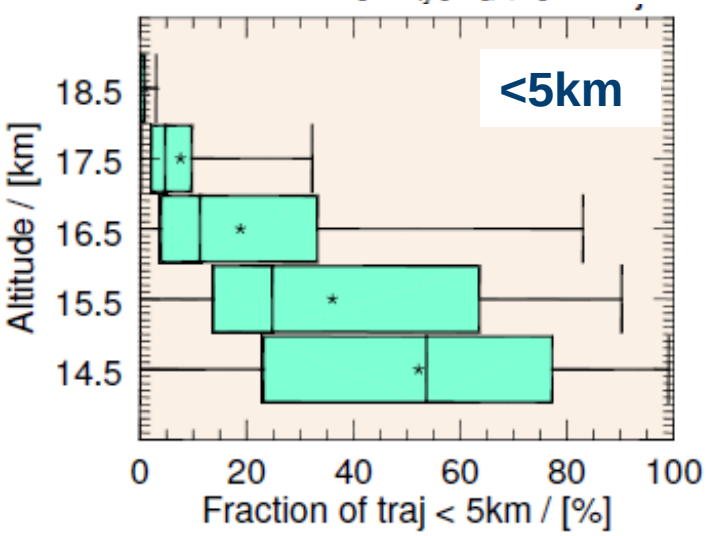


NAME for ATTREX





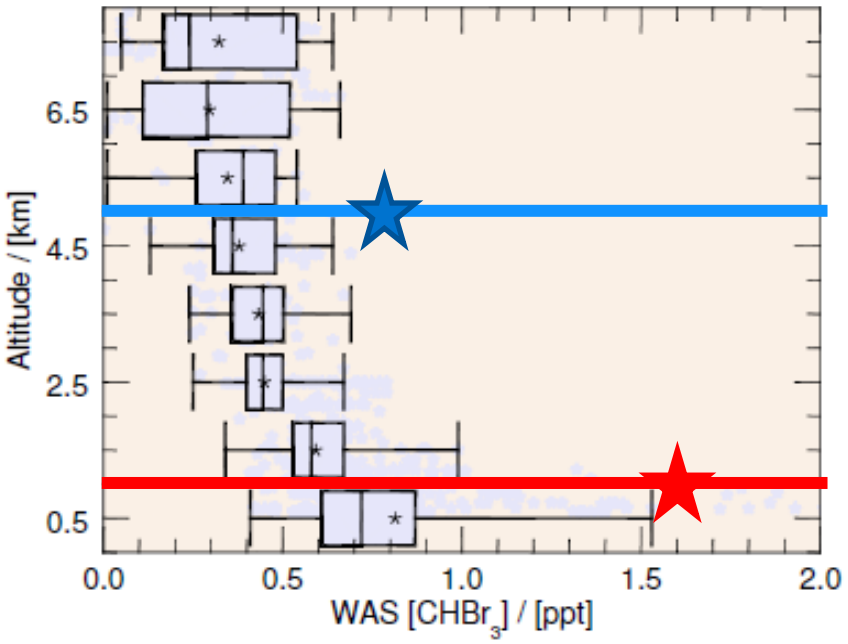


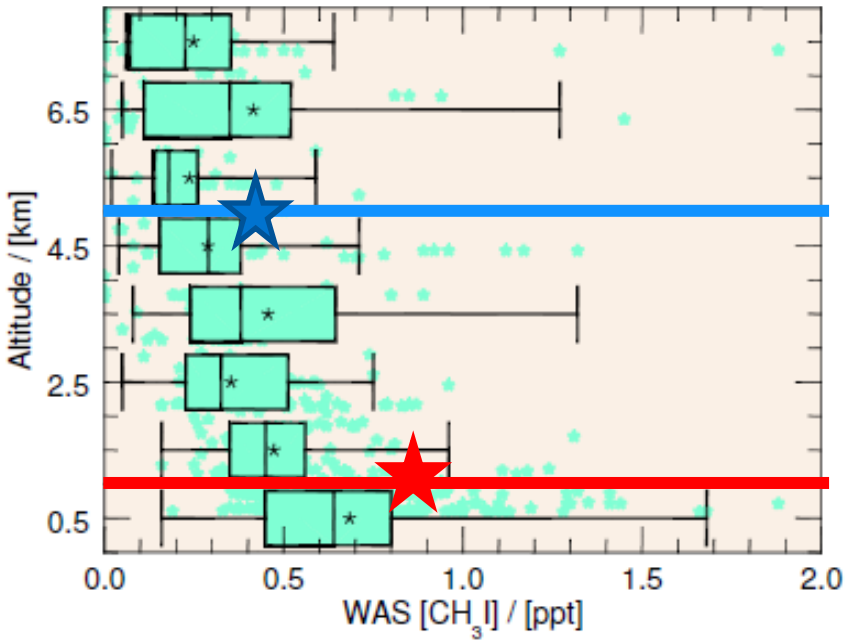


- $CHBr_3$, CH_3I and calculated % of air from below 5/1 km all decrease with altitude above 14 km
- A drop-off in tracer concentration and variability at 16-17 km, corresponding with 5/1 km fractions
- How much do the low level airmass contribute?

NAME for ATTREX – use of CAST data

CAST-CONTRAST 2014 [$CHBr_3$] and [CH_3I]



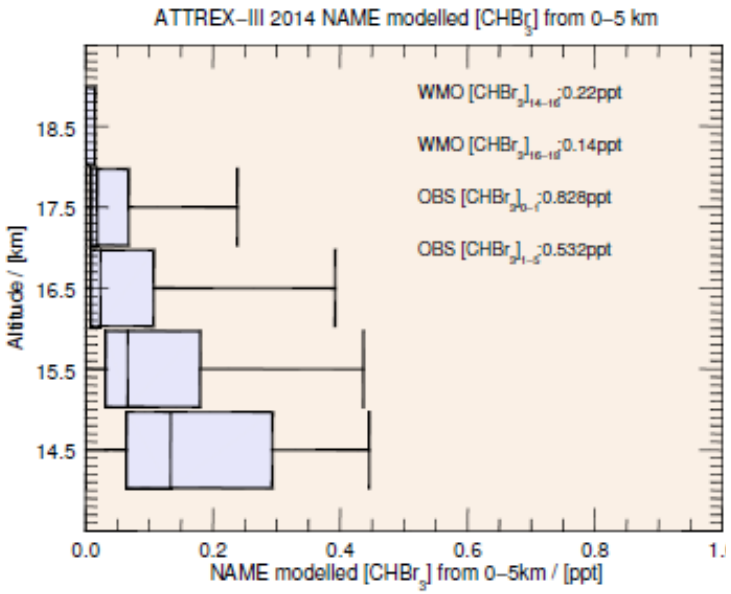


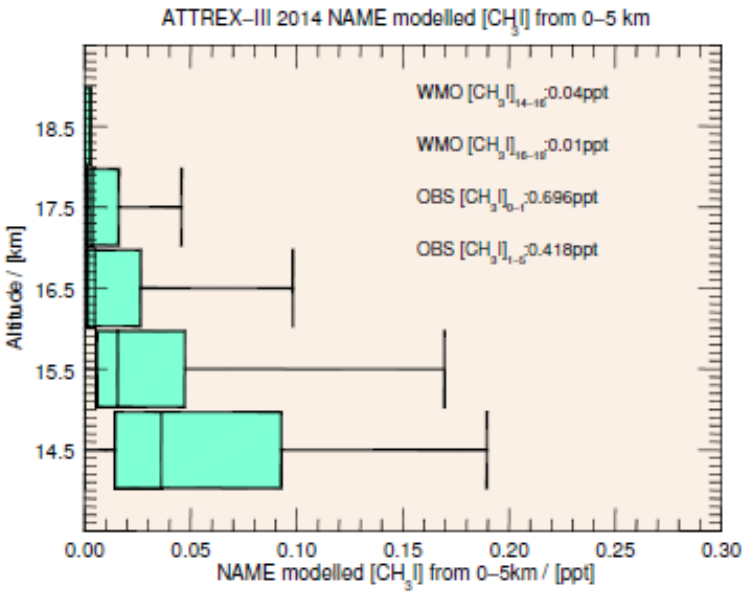
- Assigning initial tracer concentrations to trajs <1/<5km – WMO2010 and CAST obs
- Equations : $[X]_{TTL\ from\ 0\text{-}1km} = [X]_{WMO2010/CAST\_0\text{-}1km} * TRAJ_{0\text{-}1}/ALL * exp^{(-t/tau)}$

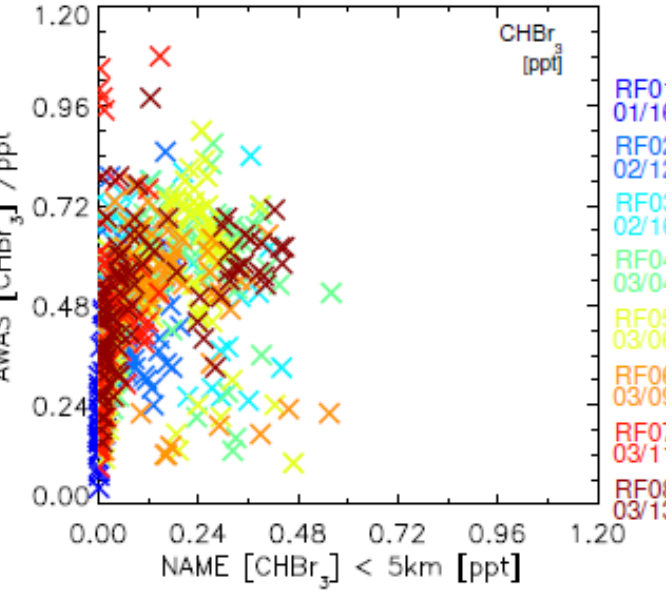
$$[X]_{TTL\ from\ 0\text{-}5km} = [X]_{WMO2010/CAST\_0\text{-}1km} * TRAJ_{0\text{-}1}/ALL * exp^{(-t/tau)} +$$

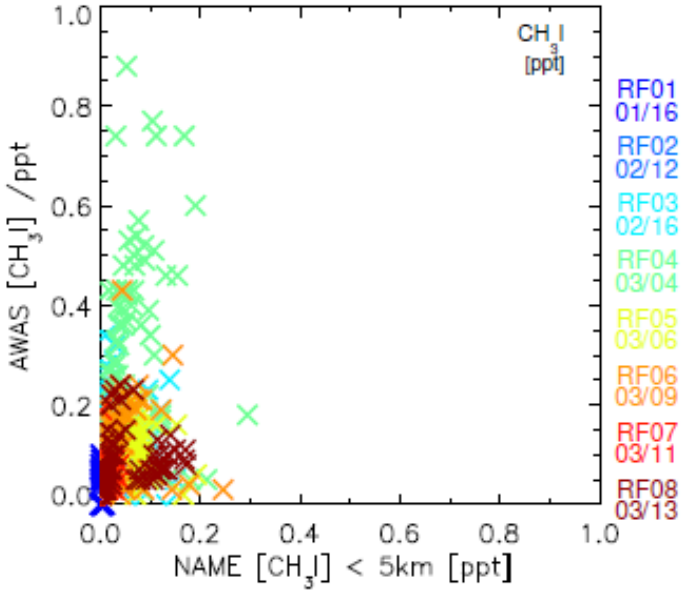
$$[X]_{WMO2010/CAST\_1\text{-}5km} * TRAJ_{1\text{-}5}/ALL * exp^{(-t/tau)}$$

NAME for ATTREX – use of CAST data



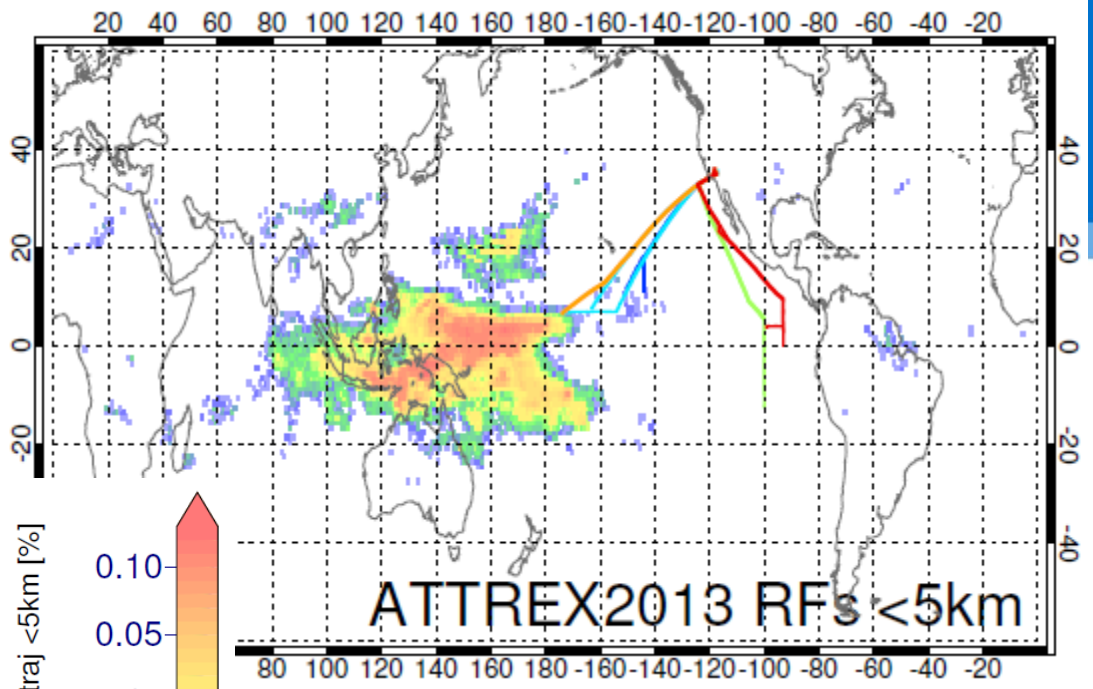


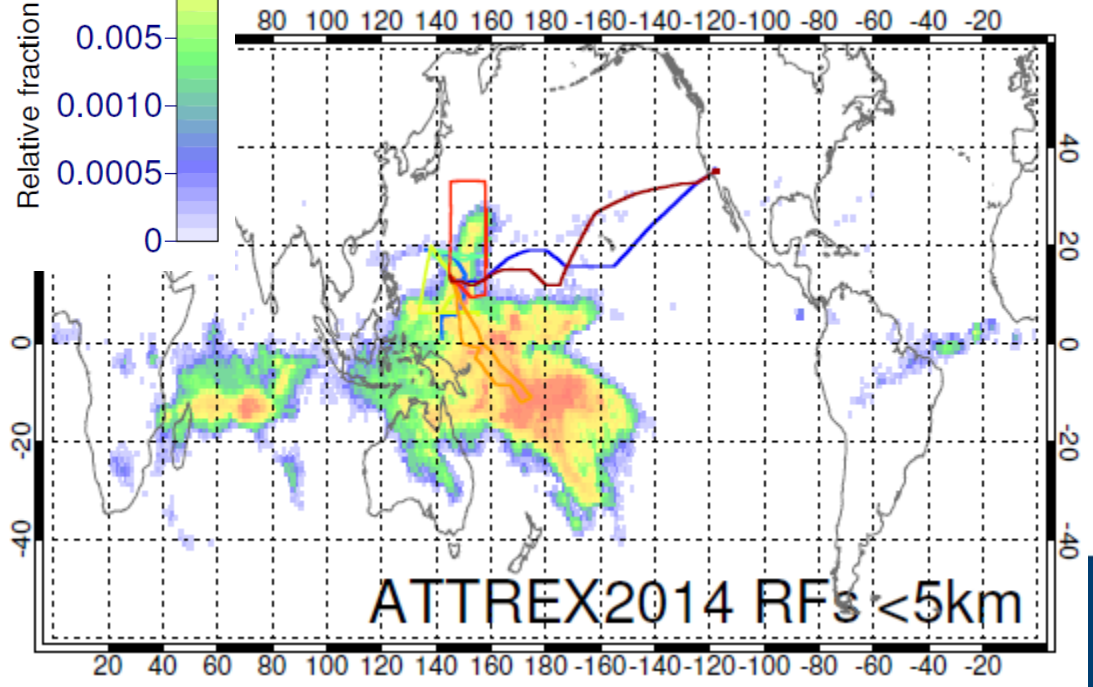


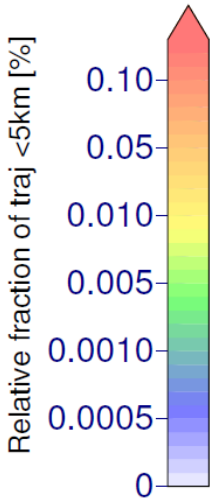


- Positive relation between observed and NAME modelled $CHBr_3$ from below 5 km
- Less clear relation for CH_3I with increased a flight-to-flight variability in observed CH_3I

Spatial Variability <5km







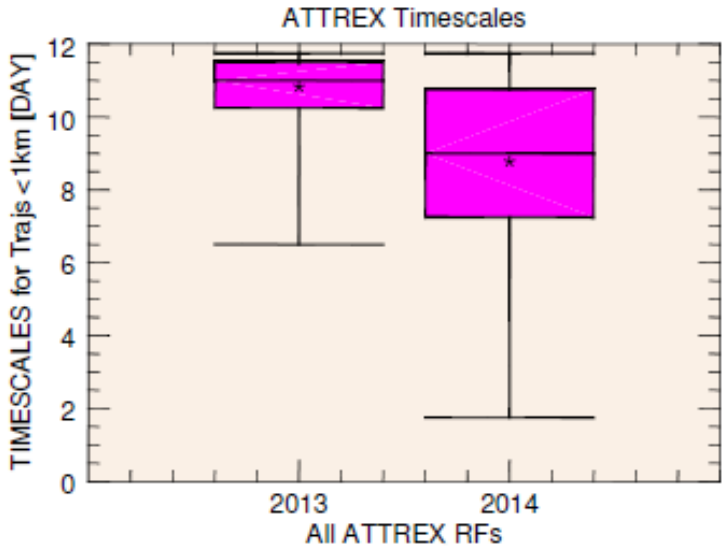
ATTREX 2013

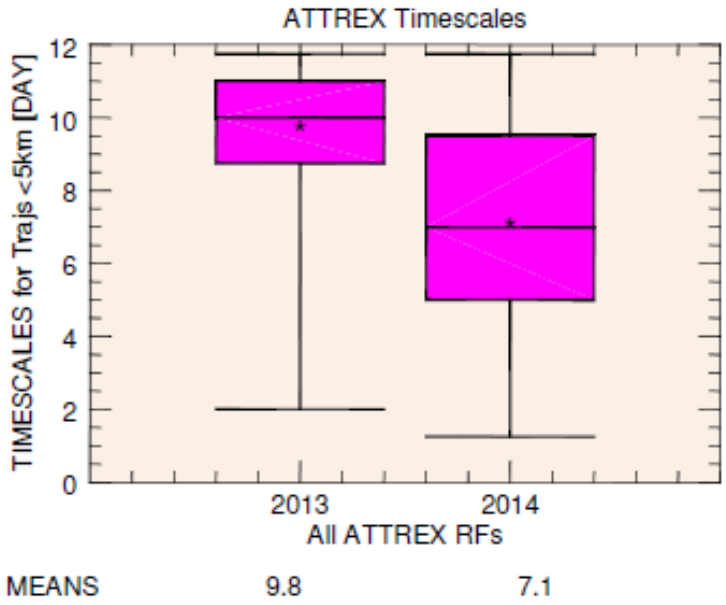
- Predominant West/Central Pacific
- Vertical Uplift followed by horizontal transport within TTL

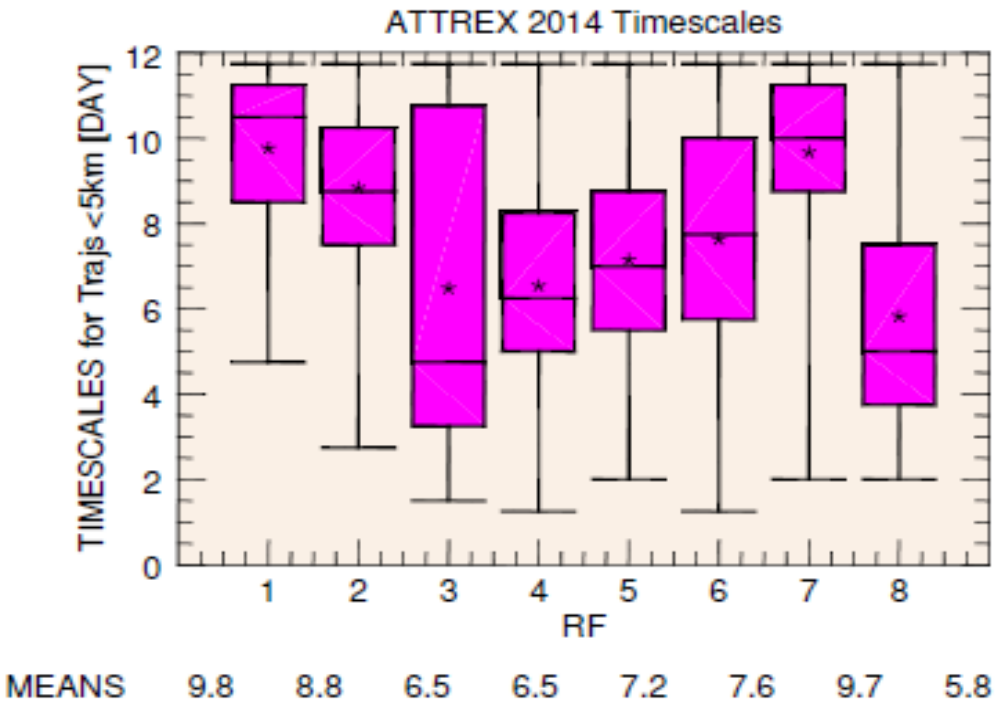
ATTREX 2014

- Main sources: West Pacific / SPCZ / Indian Ocean
- Sources more disperse
- More local influence
- Convective events playing more significant role

NAME for ATTREX: Transport Timescales







- Shorter timescales for ATTREX 2014 – rapid vertical uplift signals
- Higher flight-to-flight variability - ATTREX 2014