CAM-chem model evaluation of the emissions and distributions of VSLS using TOGA VOC observations from *CONTRAST* and *TORERO*

(in the lower and free troposphere over the eastern and western Pacific)

TOGA and AWAS observations:

Rebecca Hornbrook, Eric Apel, Alan Hills, Dan Riemer, Nicola Blake, Stacey Hughes, Elliot Atlas, Valeria Donets, Sue Schauffler, Rich Lueb

CAM-chem modeling:

Jean-Francois Lamarque, Doug Kinnison, Simone Tilmes

CONTRAST-ATTREX-CAST Science Meeting
22-Oct-2014

Photo: ITCZ convection during RF10

TOGA: Trace Organic Gas Analyzer

VOC tracers from several sources/types:

- Biogenic VOCs and oxidation products
- Anthropogenic VOCs
- Oil and Gas Tracers
- Long-lived Halogenated VOCs
- Short-lived Halogenated VOCs
- OVOCs, including HCHO
- DMS
- Alkyl Nitrates
- Biomass burning tracers (HCN, CH_3CN)

For more information, see these posters this afternoon:

- TOGA and AWAS measurements during CONTRAST
- Inter-comparisons of TOGA and AWAS measurements during CONTRAST

TOGA Installed on the G-V

CAM-Chem with VSL Chemistry

CESM CAM-CHEM

- Global Chemistry-Climate Model
- ~1.0° horizontal resolution
- Specified Dynamics Version (GEOS5)
- 56 vertical levels (surface to ~ 2 hPa)

Lamarque et al., *Geosci. Mod. Dev.*, 2012

Tropospheric Halogen Chemistry

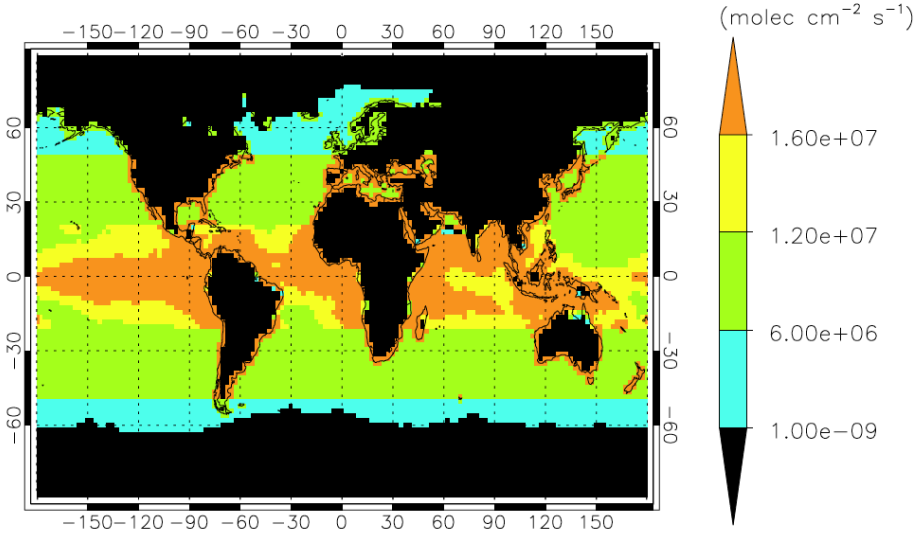
Halogenated sources from the ocean.

- Emissions following Chl-a over tropics
- Catalytic release from sea-salt
- Do NOT have polar emission processes

Chemical Processes

- Photochemistry (Cl, Br, and I)
- Dry / wet deposition
- 9 Additional vsl Organic species included.
- 160 species, 427 reactions

$CHBr_3$ Flux in CAM-Chem



Source gas	Global annual flux (Gg yr^{-1})		Lifetime (this study)
	This study	Literature	
$CHBr_3$	533	400[a], 595[b], 448[d]	17 days
CH_2Br_2	67.3	113[c], 62[d]	130 days
CH_2BrCl	10.0	6.8[c]	145 days
$CHBr_2Cl$	19.7	23[c]	56 days
$CHBrCl_2$	22.6	16[c]	46 days
CH_3Br*	climatology	131[c]	1.6 yr[g]
CH_3I**	303	304[e]	5 days
CH_2ICl	234	236[f]	8 h
CH_2IBr	87.3	87[f]	2.5 h
CH_2I_2	116	116[f]	7 min

$CHBr_3$ 17 days

CH_2Br_2 130 days

CH_2ICl 8 h

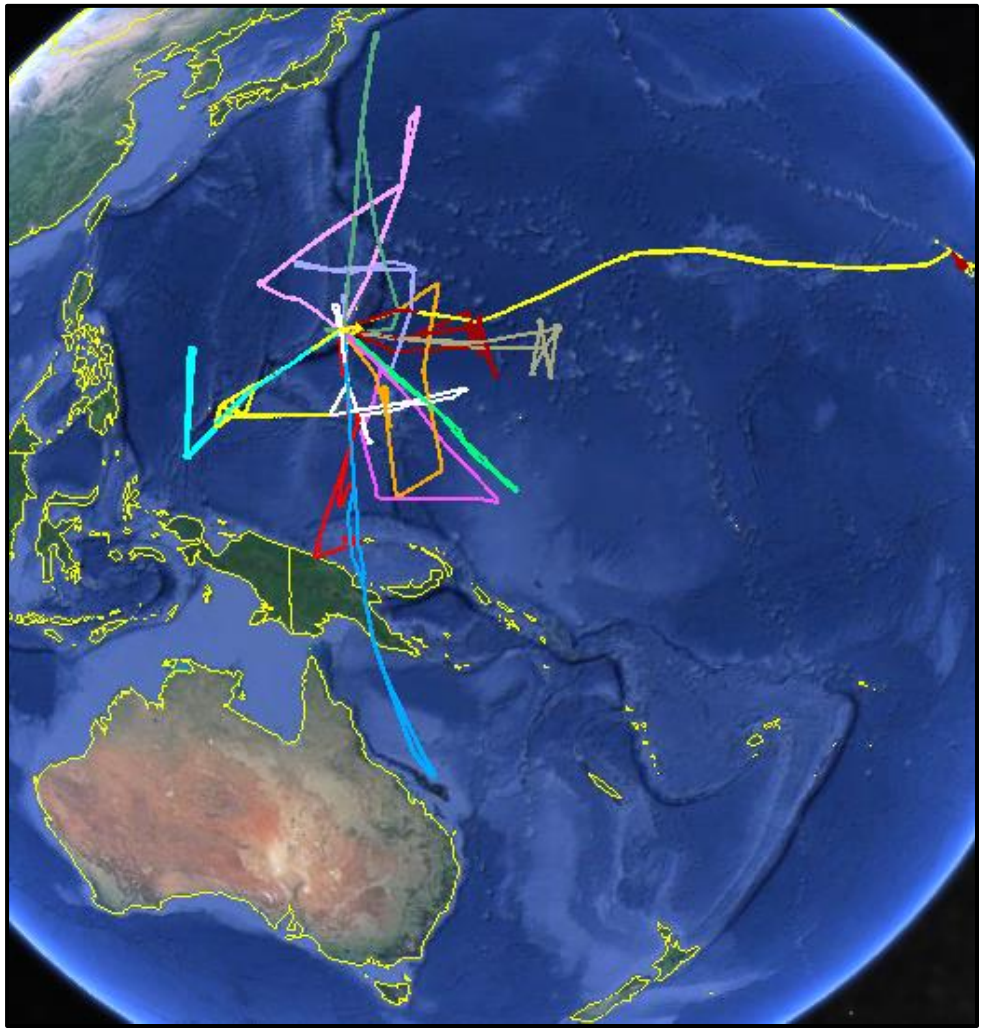
Total Bromine: 632 Gg Br yr^{-1}

Total Iodine: 600 Gg I yr^{-1}

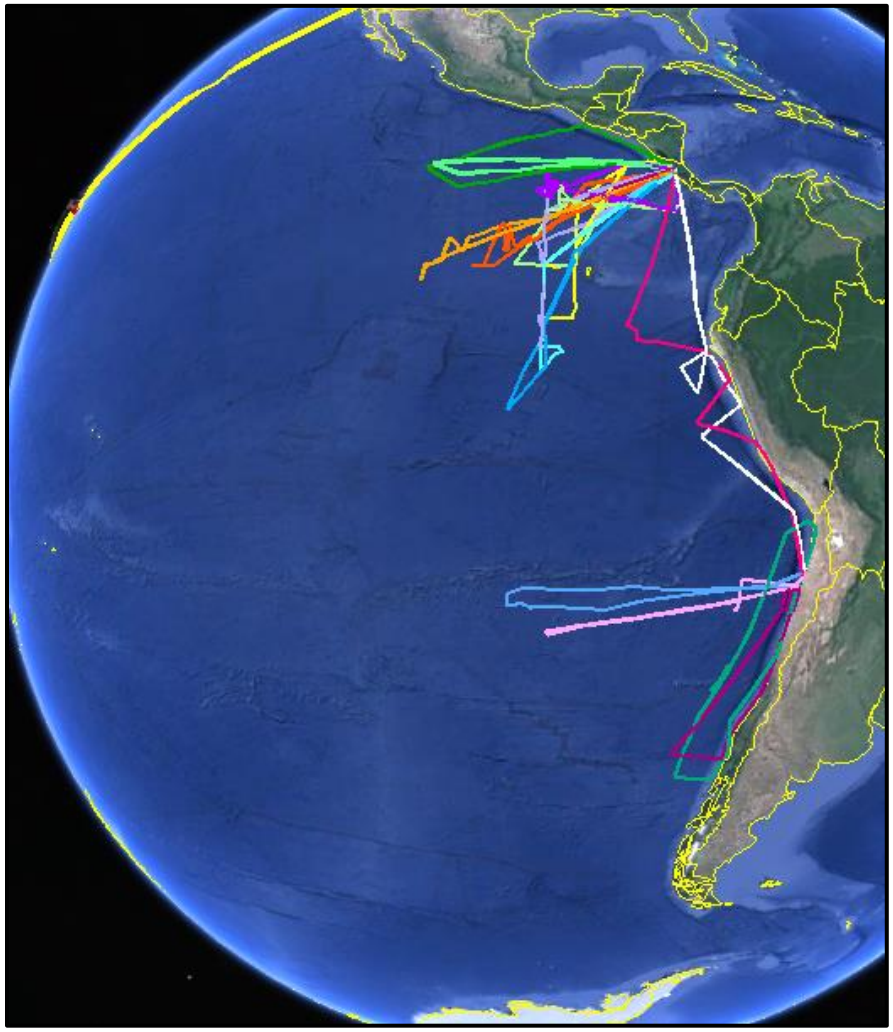
Ordoñez et al., ACP, 2012; Saiz-Lopez et al., ACP, 2012, Fernandez et al., ACP, 2014

Data Coverage: Western and Eastern Tropical Pacific

All **CONTRAST** Flights, Jan - Feb 2014

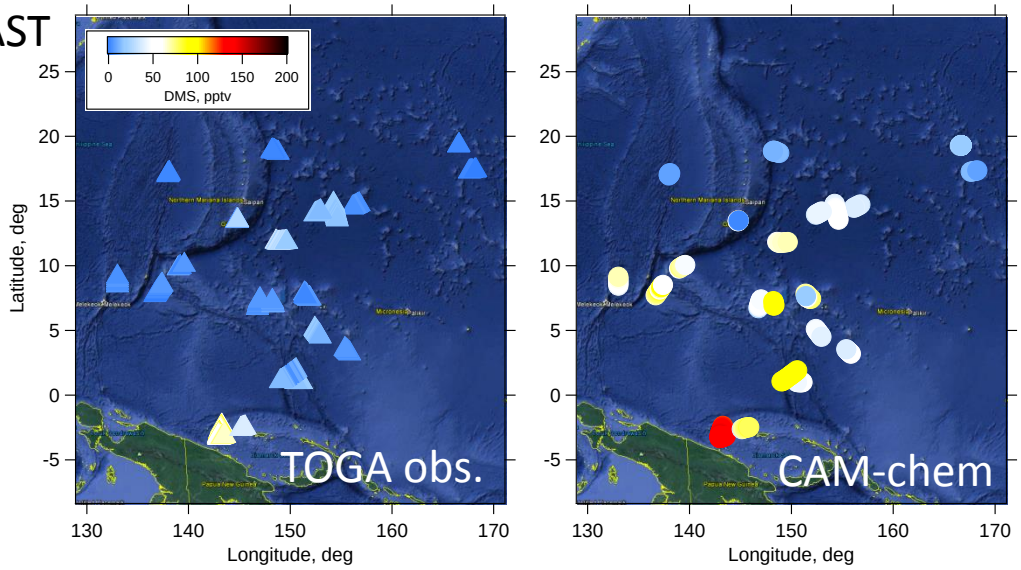


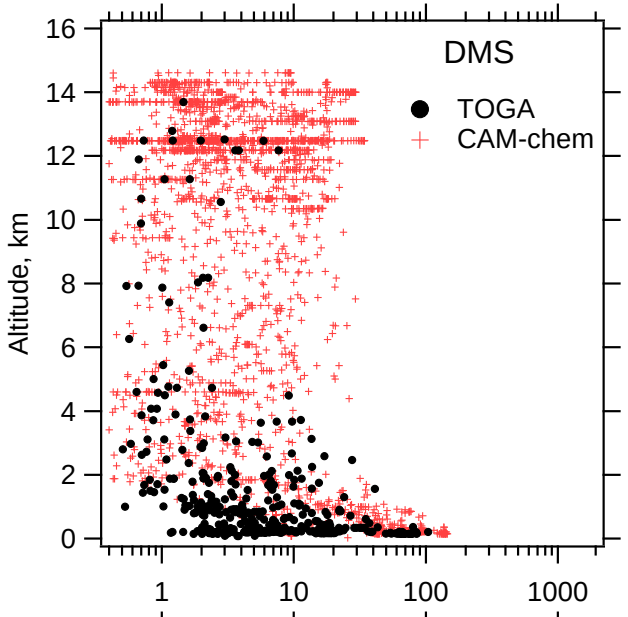
All **TORERO** Flights, Jan - Feb 2012



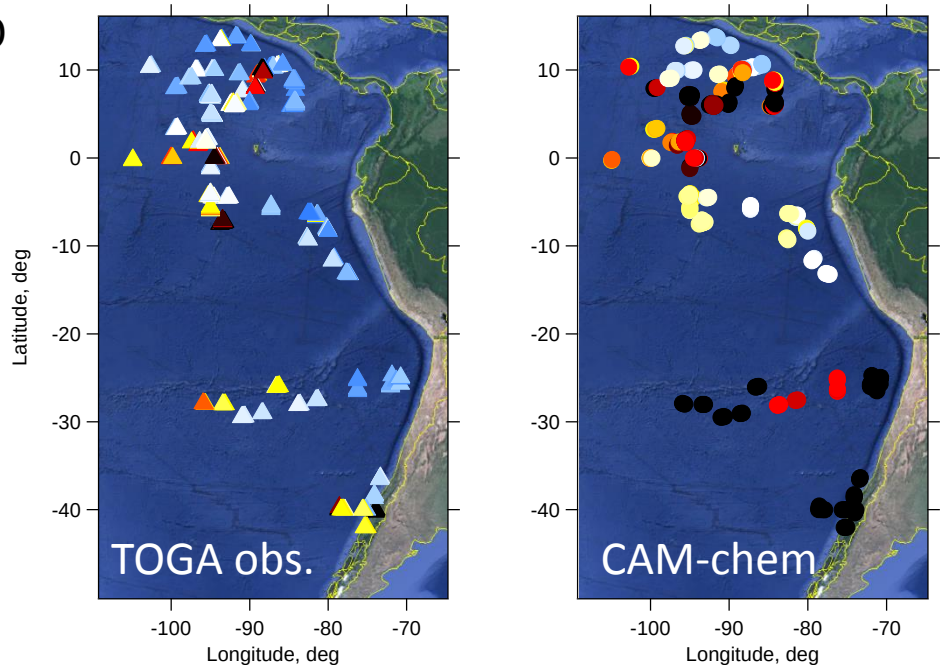
Spatial Distribution: DMS (Dimethyl sulfide, CH_3SCH_3)

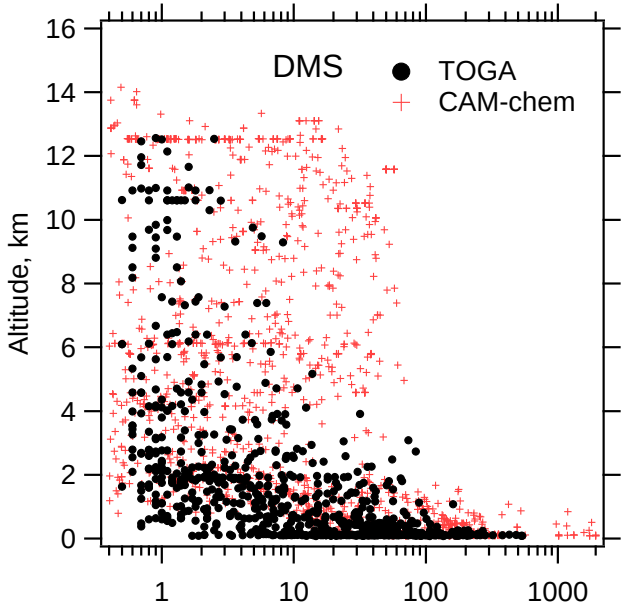
CONTRAST





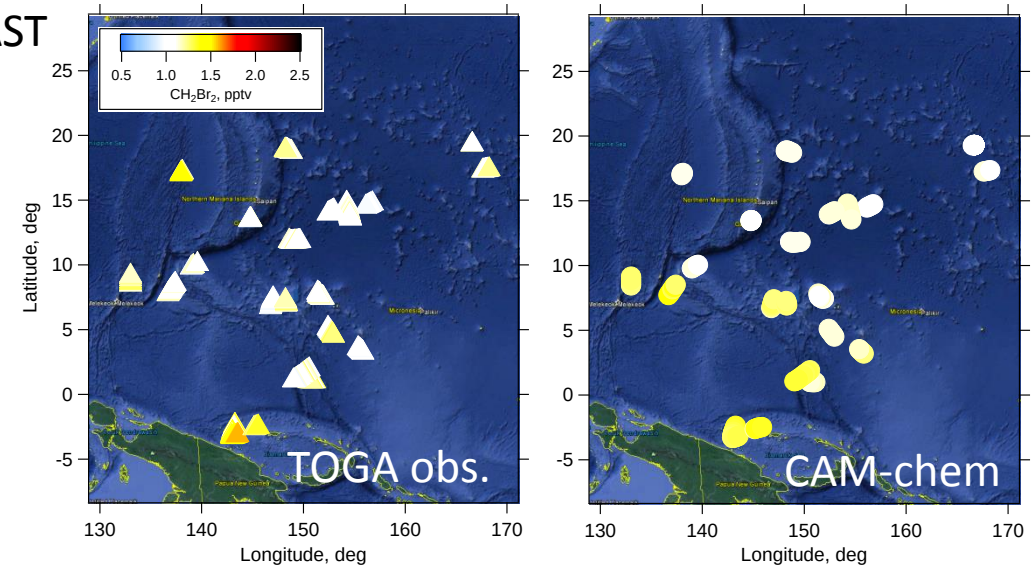
TORERO

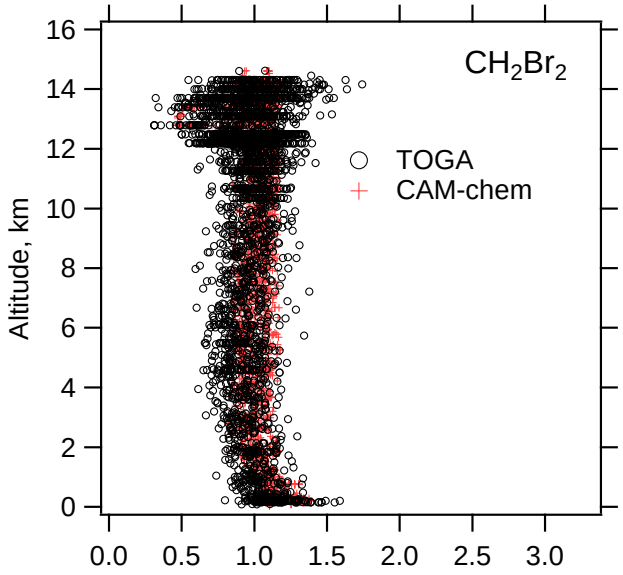




Spatial Distribution of VSLS: Dibromomethane (CH_2Br_2)

CONTRAST





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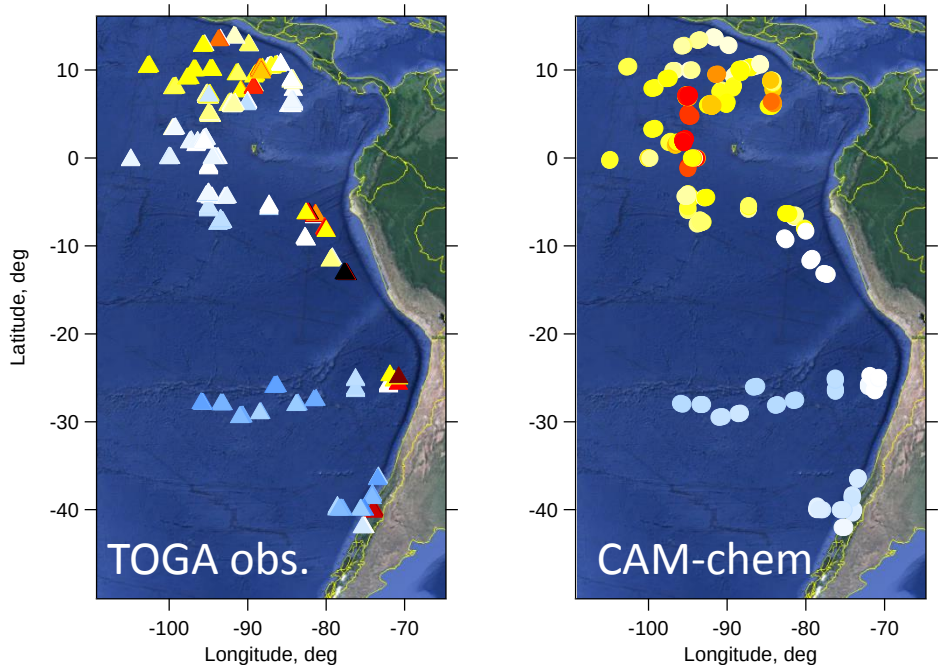
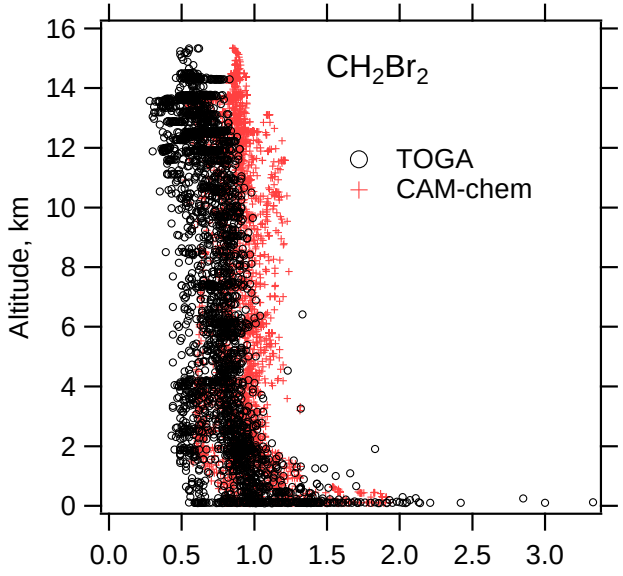
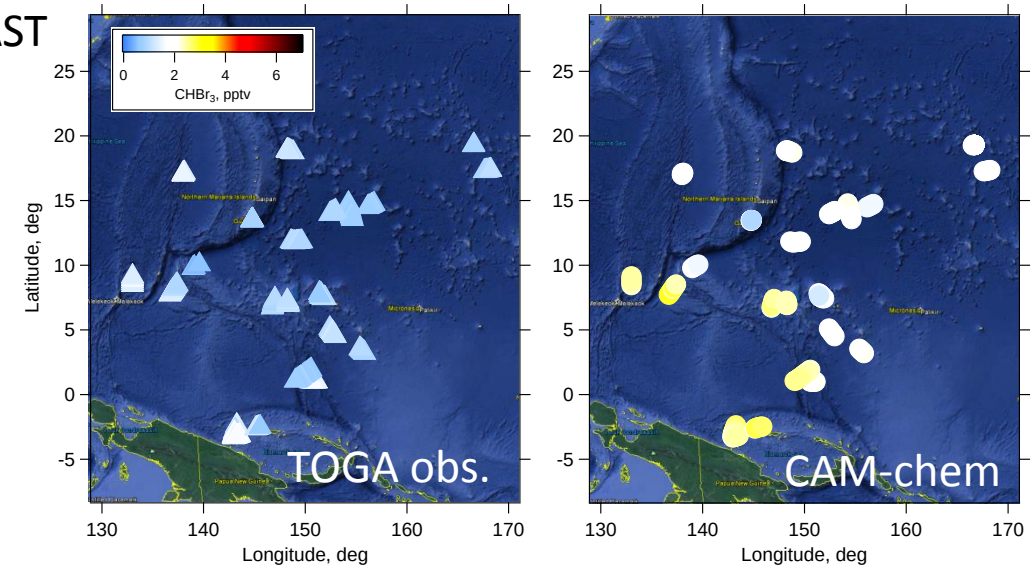
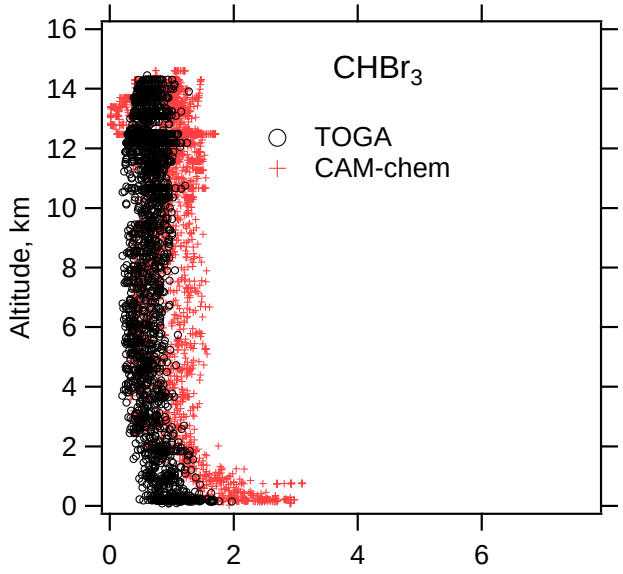




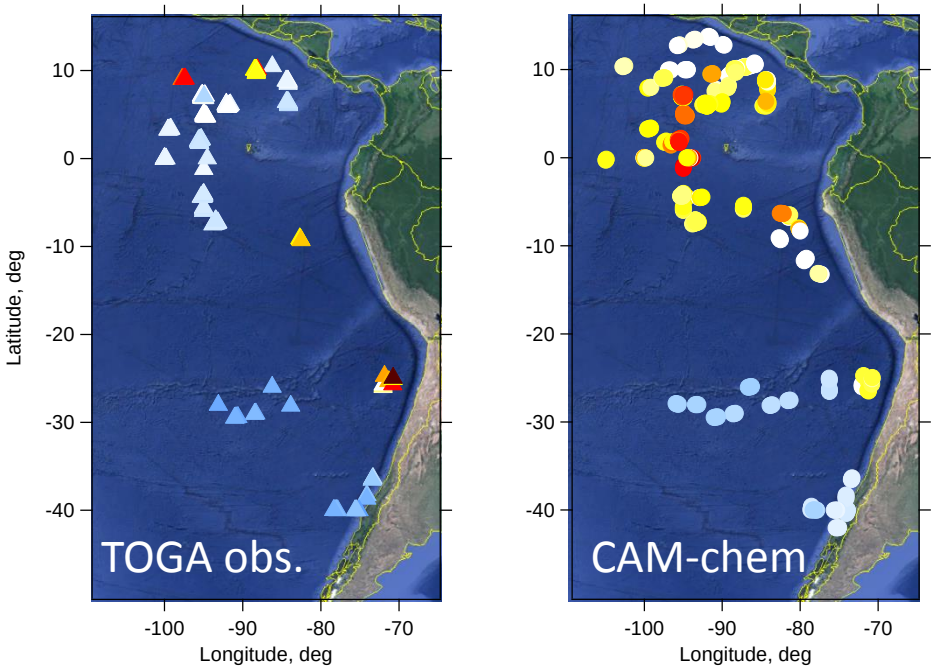
Spatial Distribution of VSLS: Bromoform ($CHBr_3$)

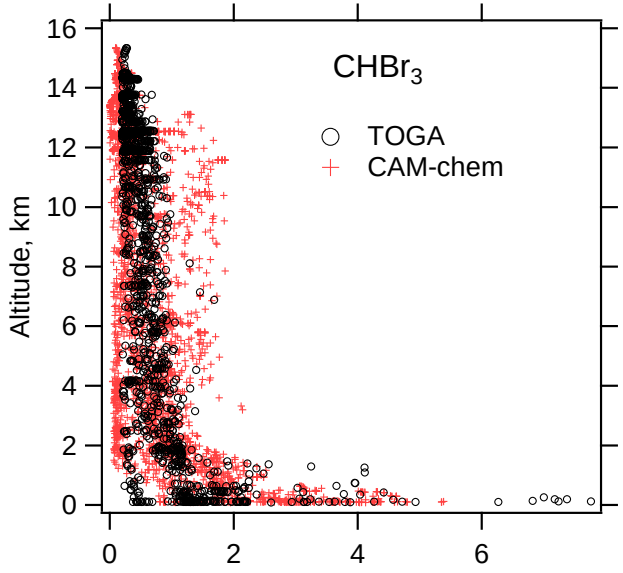
CONTRAST





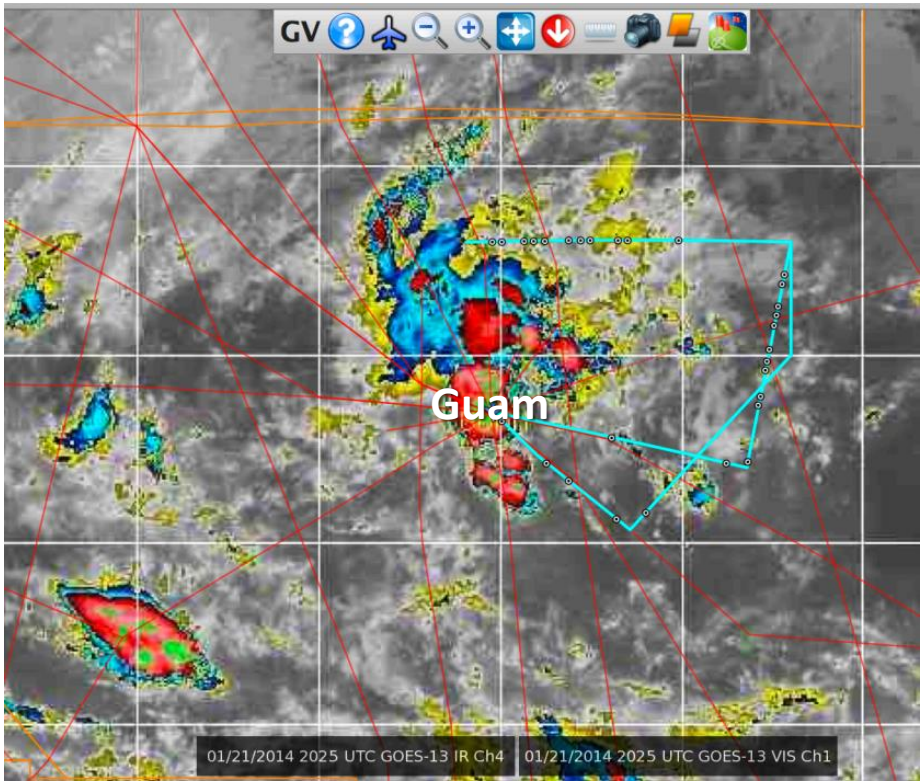
TORERO



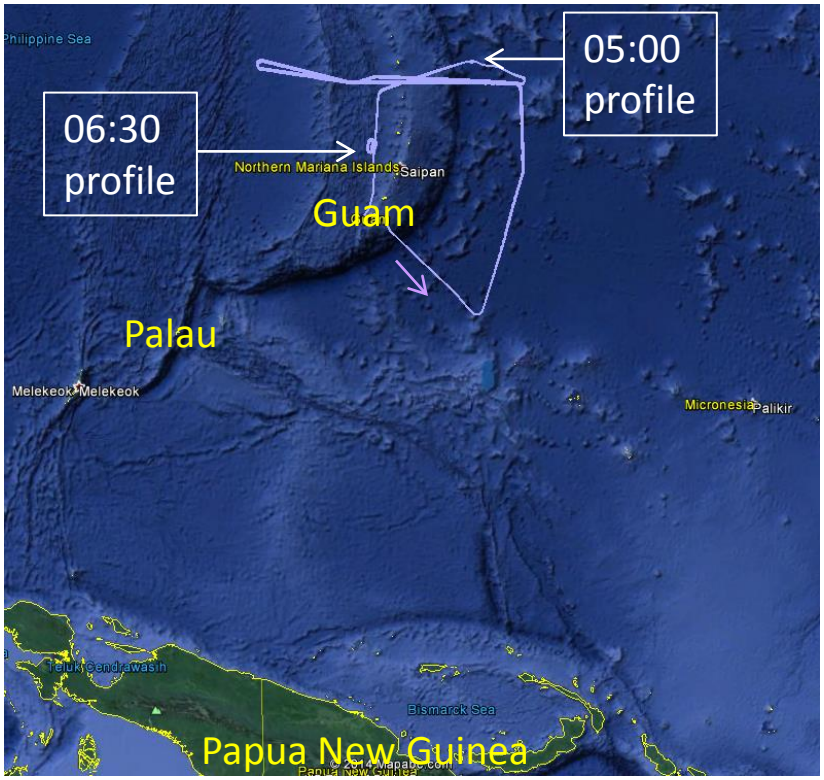


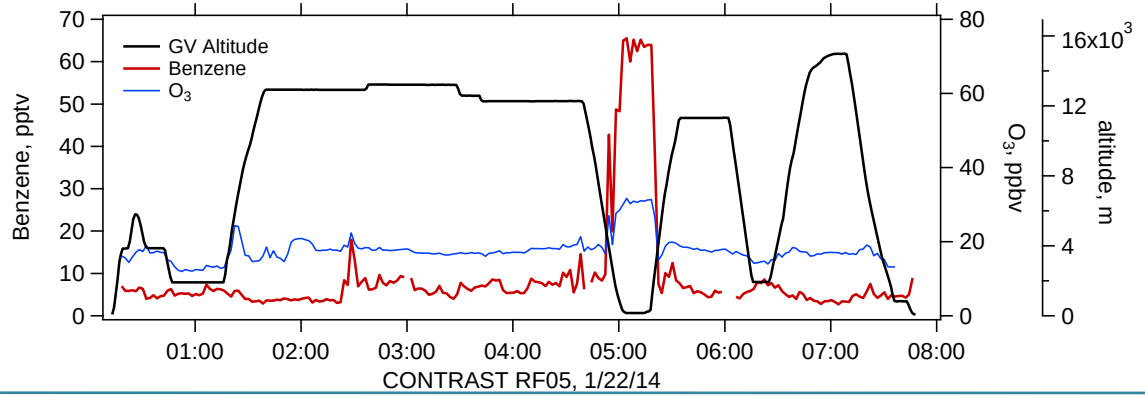
Case Study: Smaller scale convective region north of Guam – CONTRAST RF05, Jan 22

Flight plan and active convection



Actual Flight Track

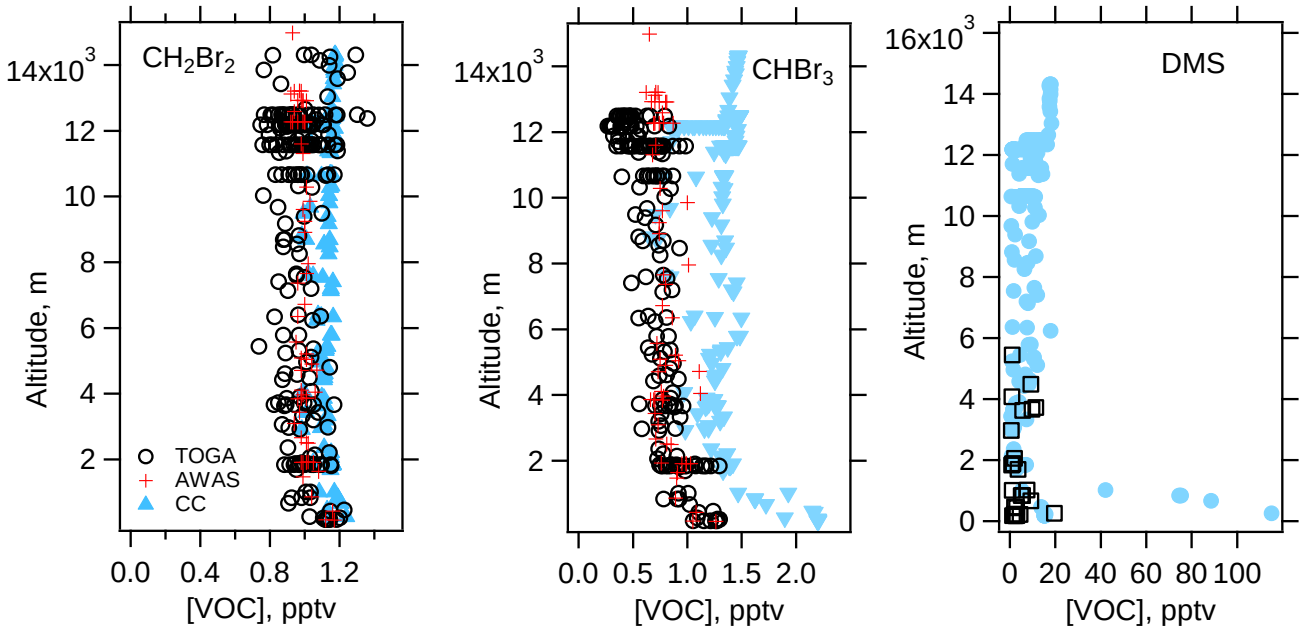


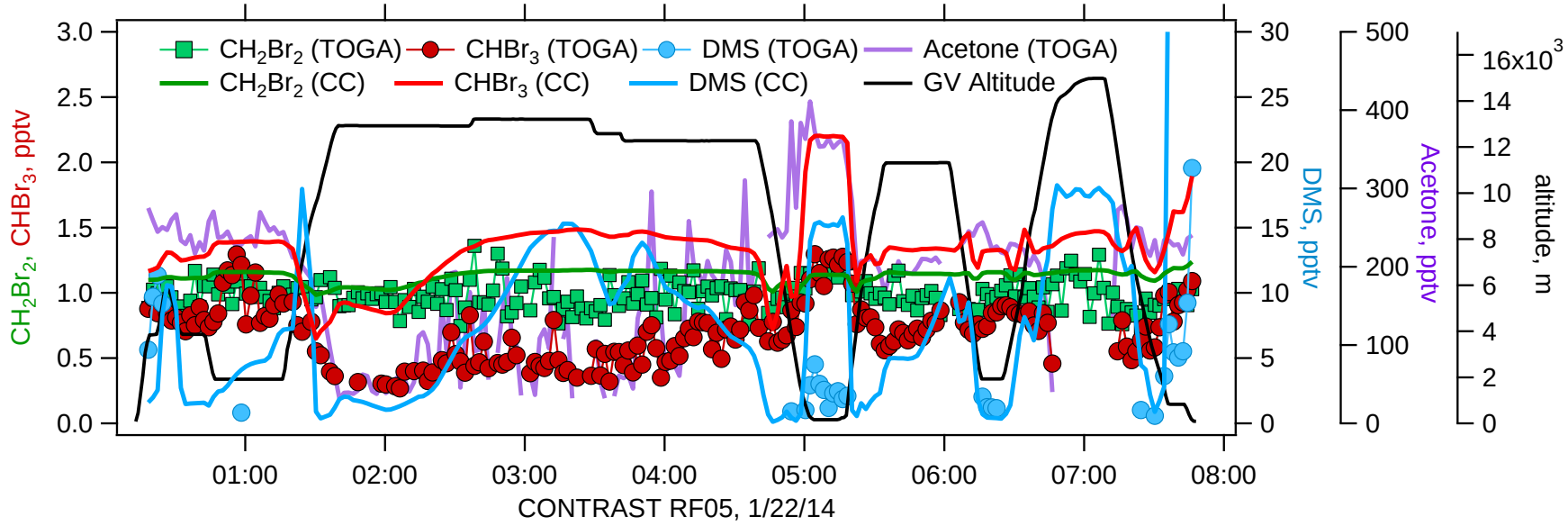


VSLS behavior during CONTRAST RF05 – Localized Convection Region

With only localized convection, $CHBr_3$ increases slightly in aged convection (see acetone). Shorter-lived species are not observed aloft, so the convection is not very recent. This region is less impacted by wide-spread convection, hence no clear C-shapes in the altitude profiles.

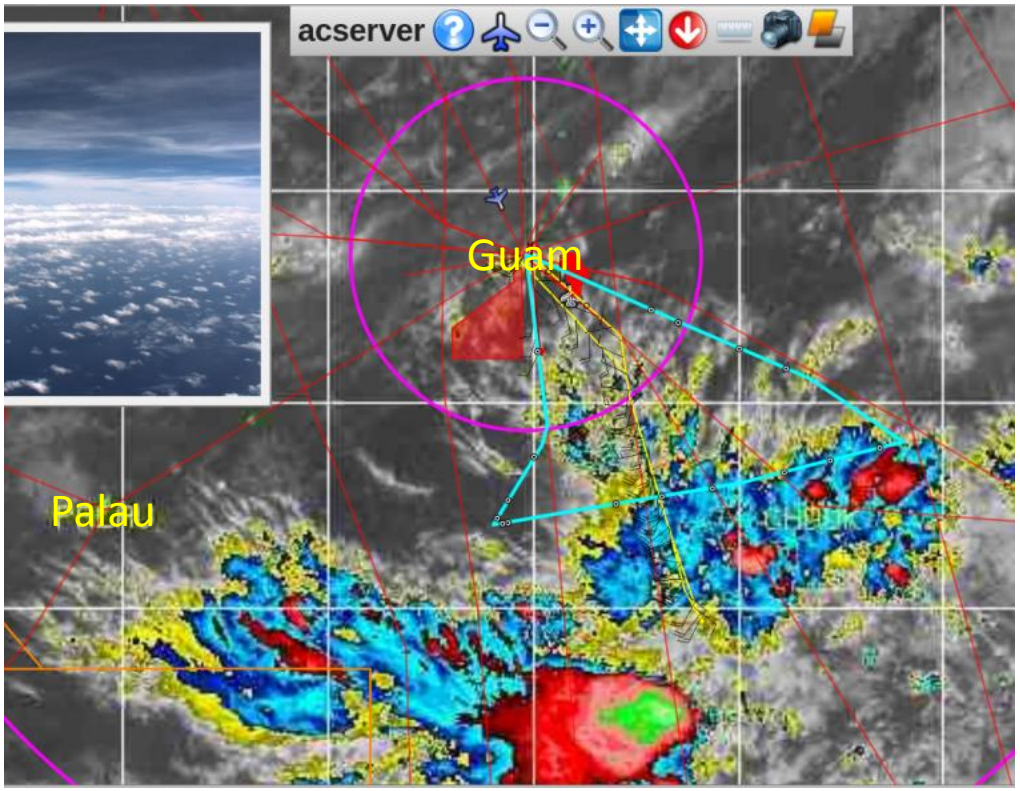
CAM-chem predicts more $CHBr_3$ and DMS than is observed aloft and in the MBL.



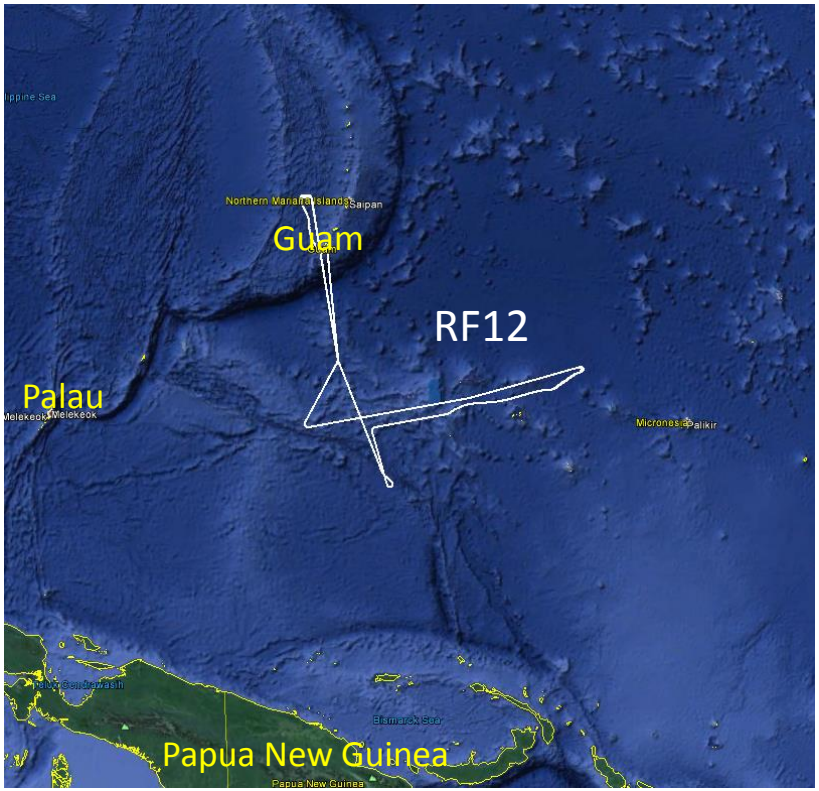


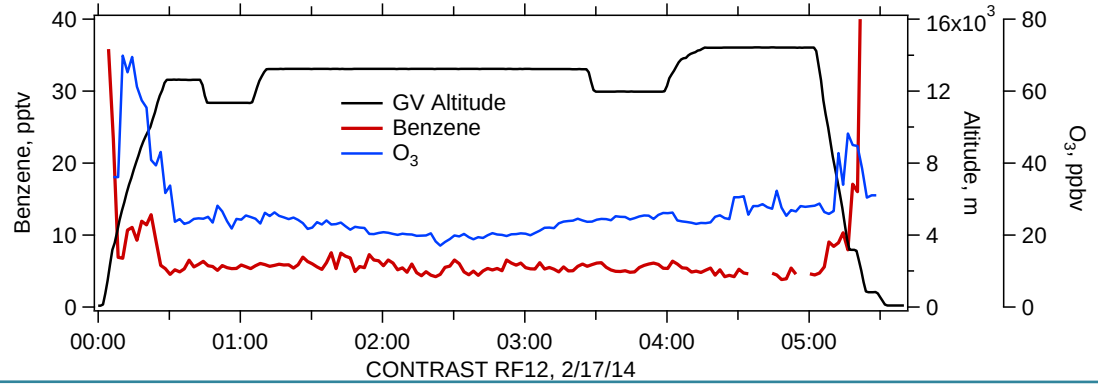
Case Study: Large scale convective region south of Guam – CONTRAST RF12, Feb 17

Flight plan and active convection



Actual Flight Track

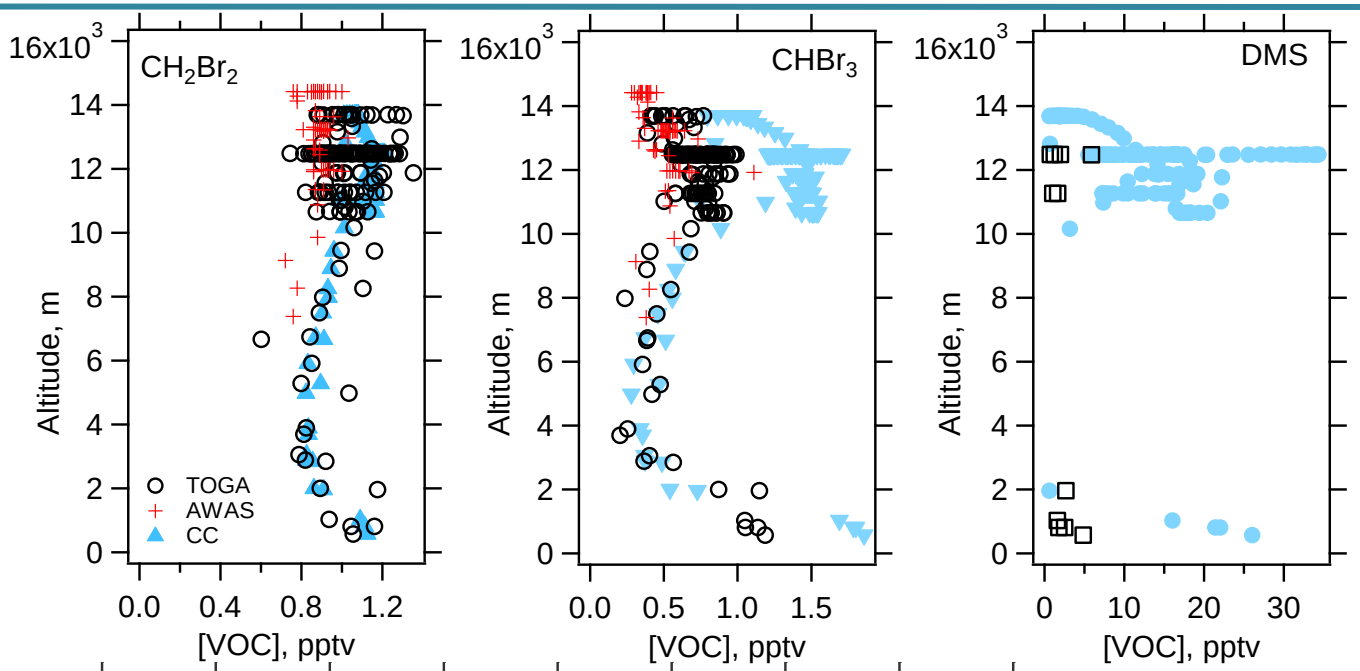


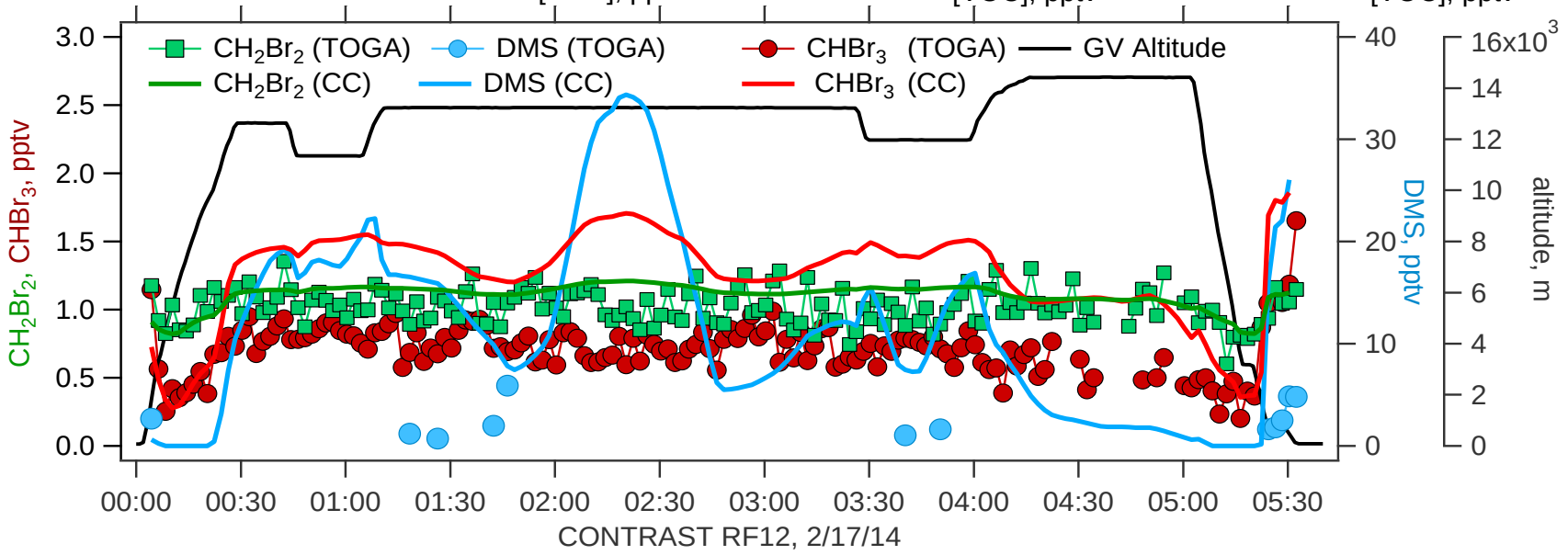


VSLS behavior during CONTRAST RF12 – Sustained Convection Region

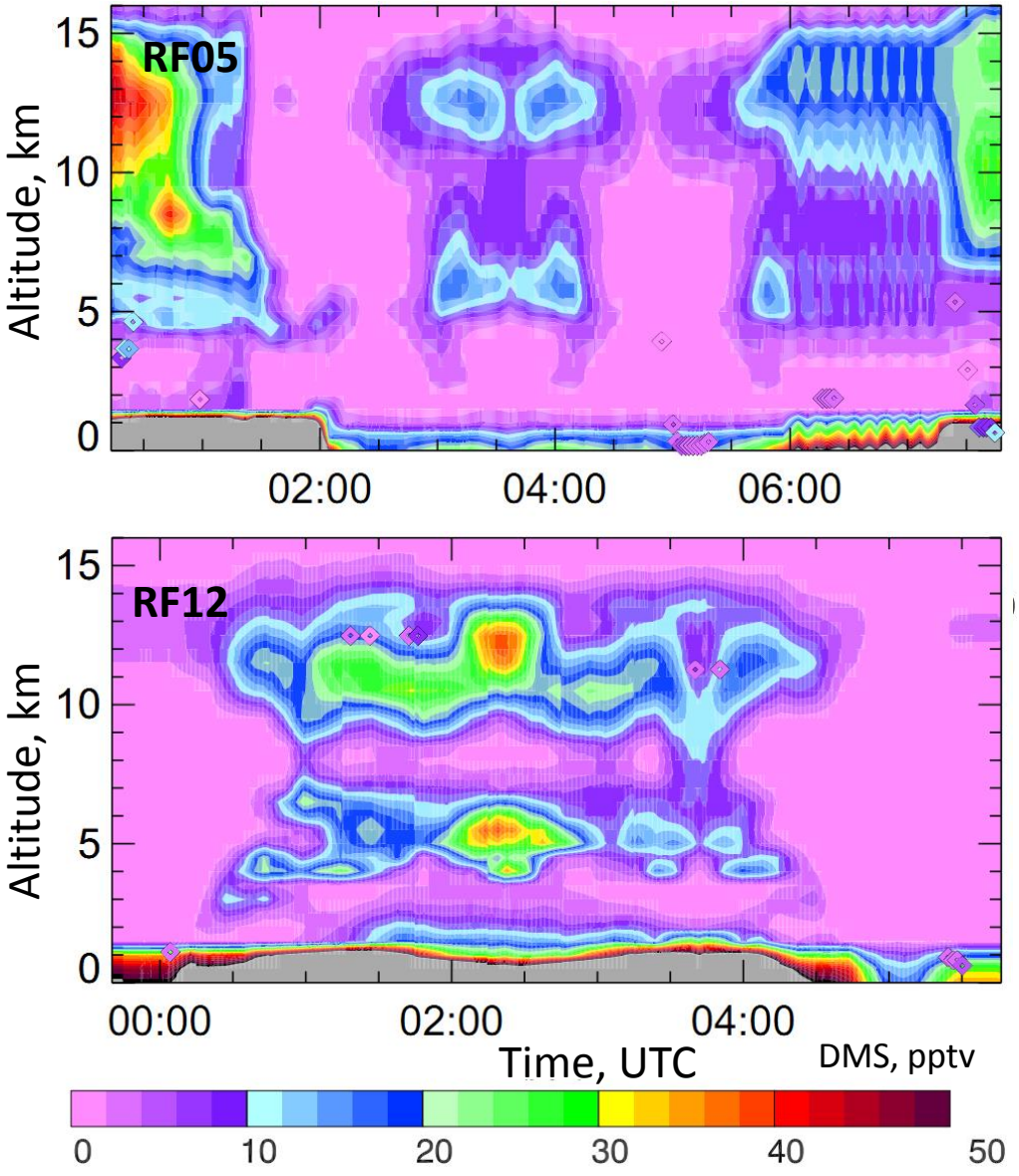
In regions with wide-spread convection, $CHBr_3$ and CH_2Br_2 are unaffected by local updrafts. However, in the entire region they are elevated compared to the profiles near Guam, hence the C-shapes in the flight altitude profiles.

CAM-chem predicts more $CHBr_3$ and DMS than is observed aloft and more DMS at the surface near Guam.





CAM-chem convection during CONTRAST RF05 and RF12 - DMS



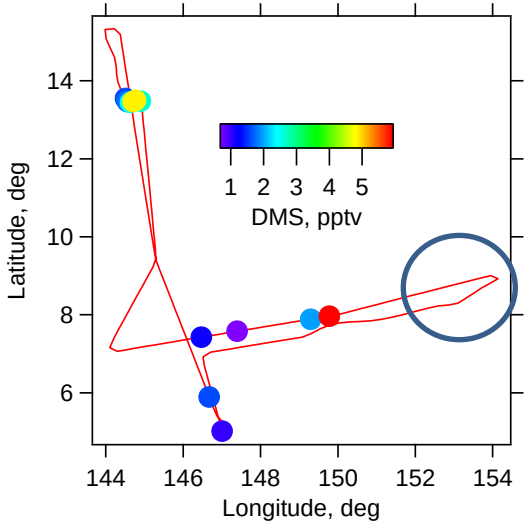
(DMS – lifetime ~ 1 day)

RF05 - no DMS obs in the UT.

- convection present in CAM-chem in region where convection was observed (in acetone, etc.)
- However MBL DMS was predicted to be relatively low.

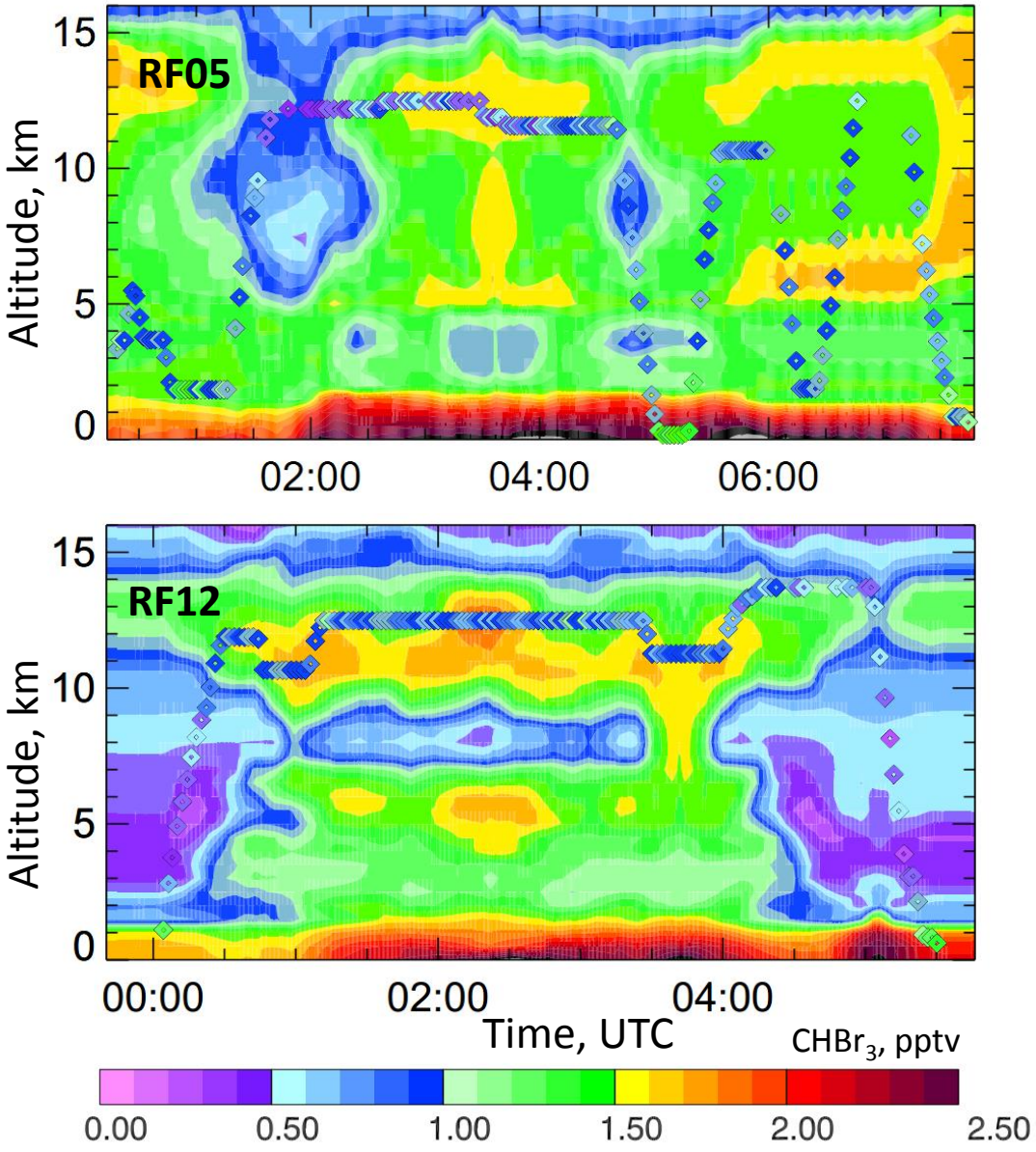
RF12 - DMS observed in the UT.

- MBL DMS predicted to be > 50 pptv
- Max convection predicted in slightly different region, DMS up to 40 pptv.



Max CAM-chem convection

CAM-chem convection during CONTRAST RF05 and RF12 – $CHBr_3$



(bromoform – lifetime ~ 17 days)

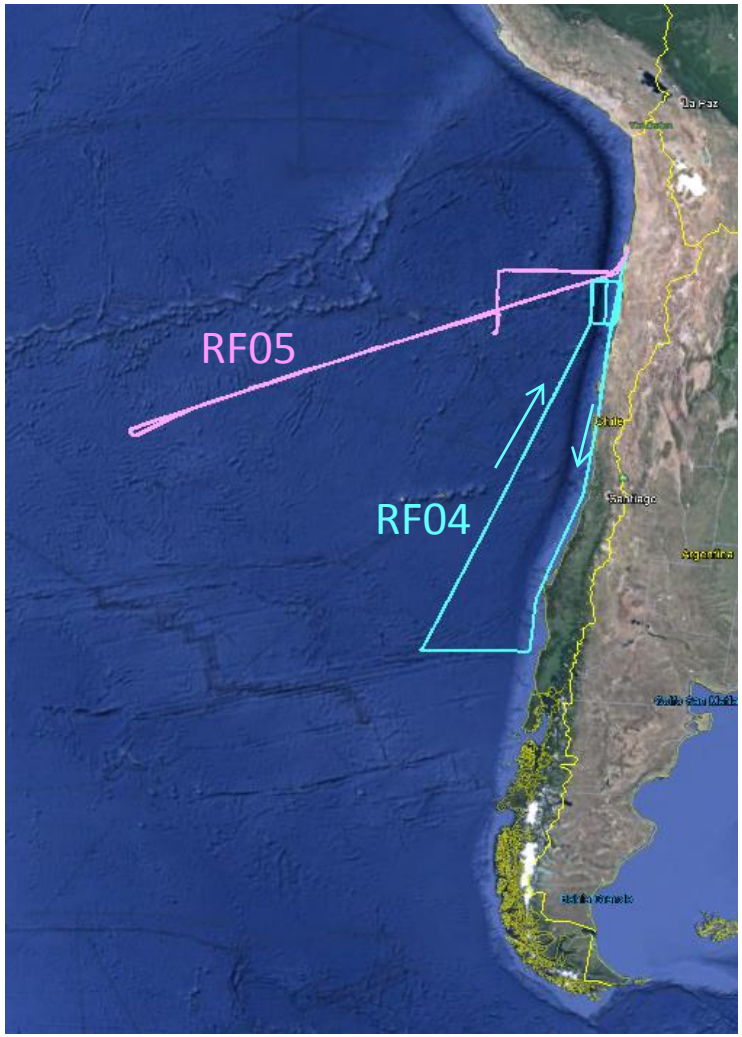
RF05

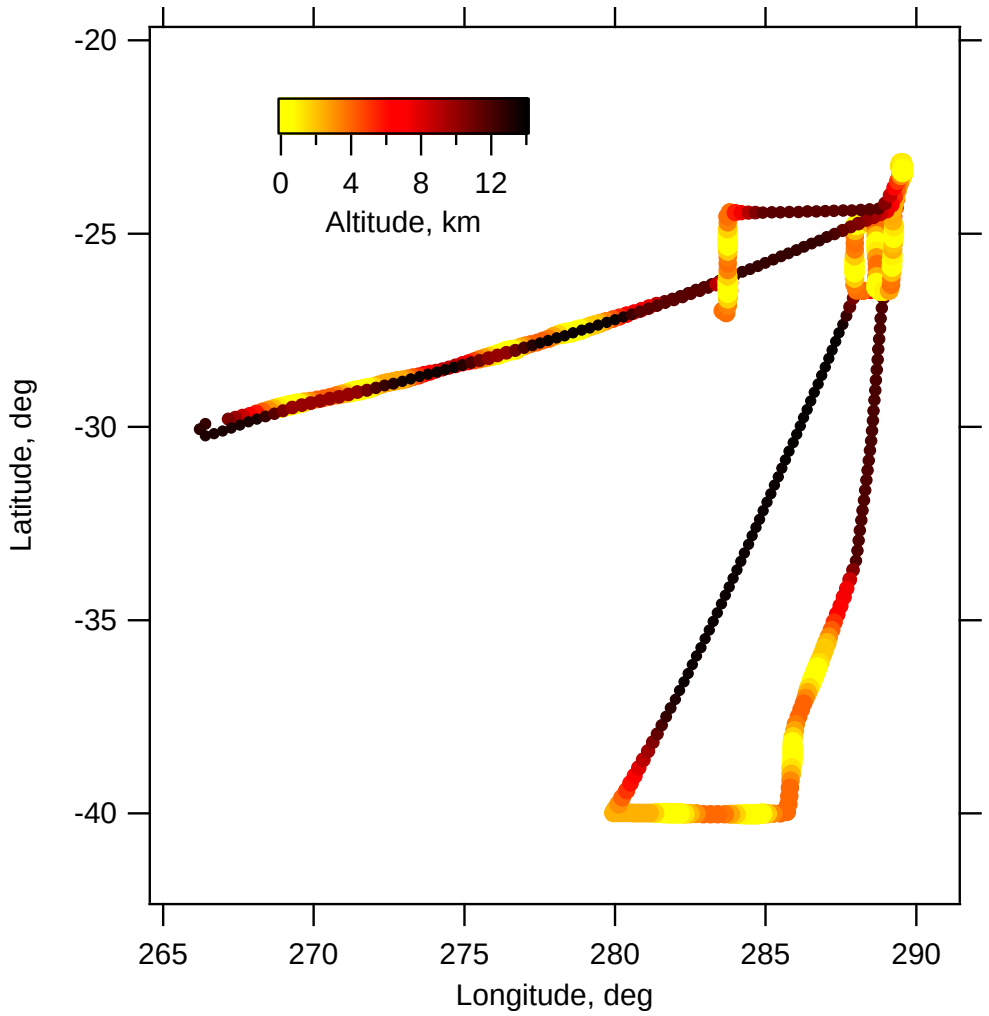
- The intrusion of low VSLS air from above was captured by the model.
- In general, BL bromoform was too high in the model, but the aged convection was seen.

RF12

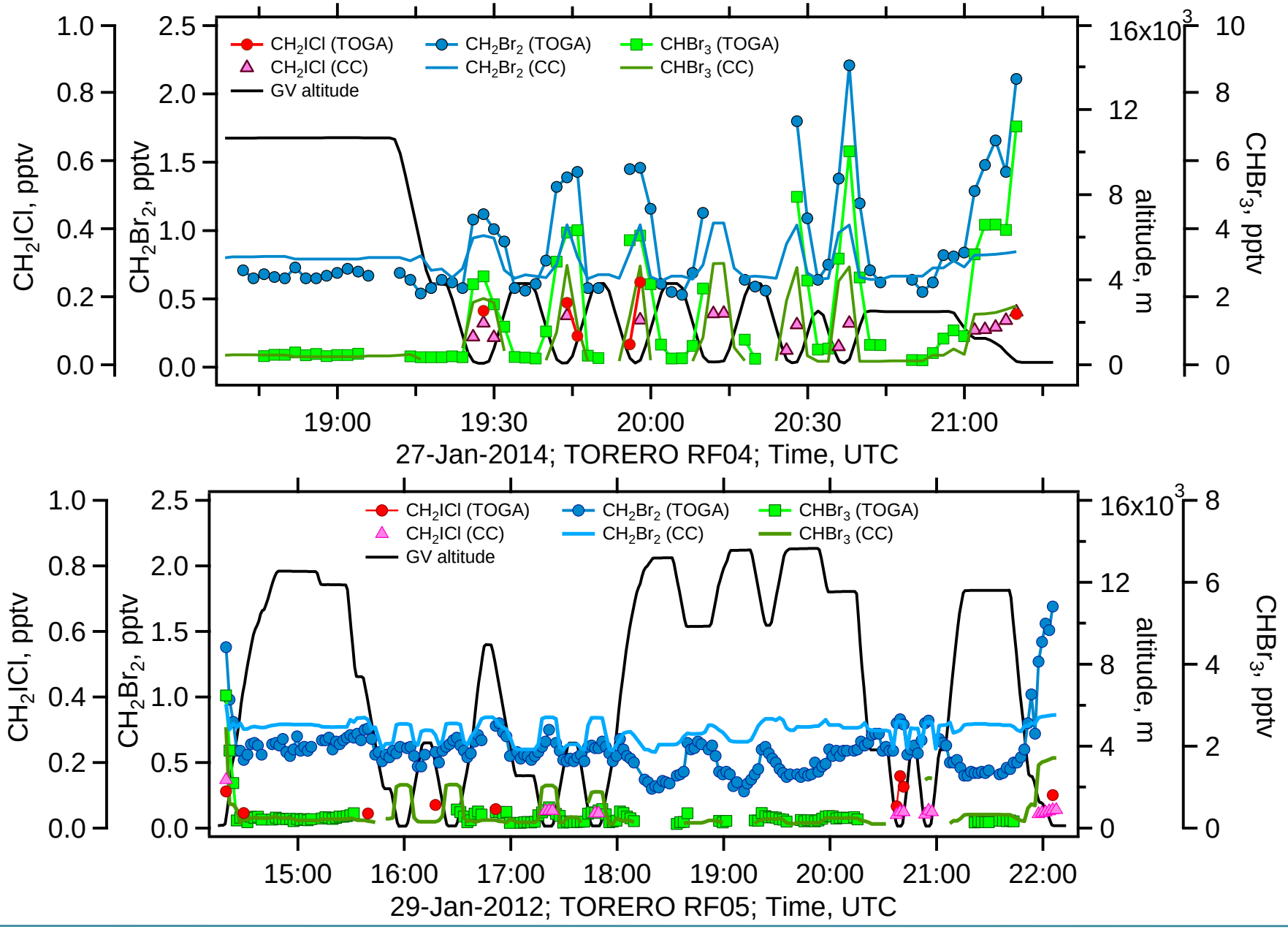
- Without sampling the boundary layer, we can't definitely state that the modeled bromoform was too high in the BL.
- The profiles near Guam were predicted really well by the model.

VSLS behavior during TORERO RF04 & RF05 – S. American Coast v. Oligotrophic Ocean

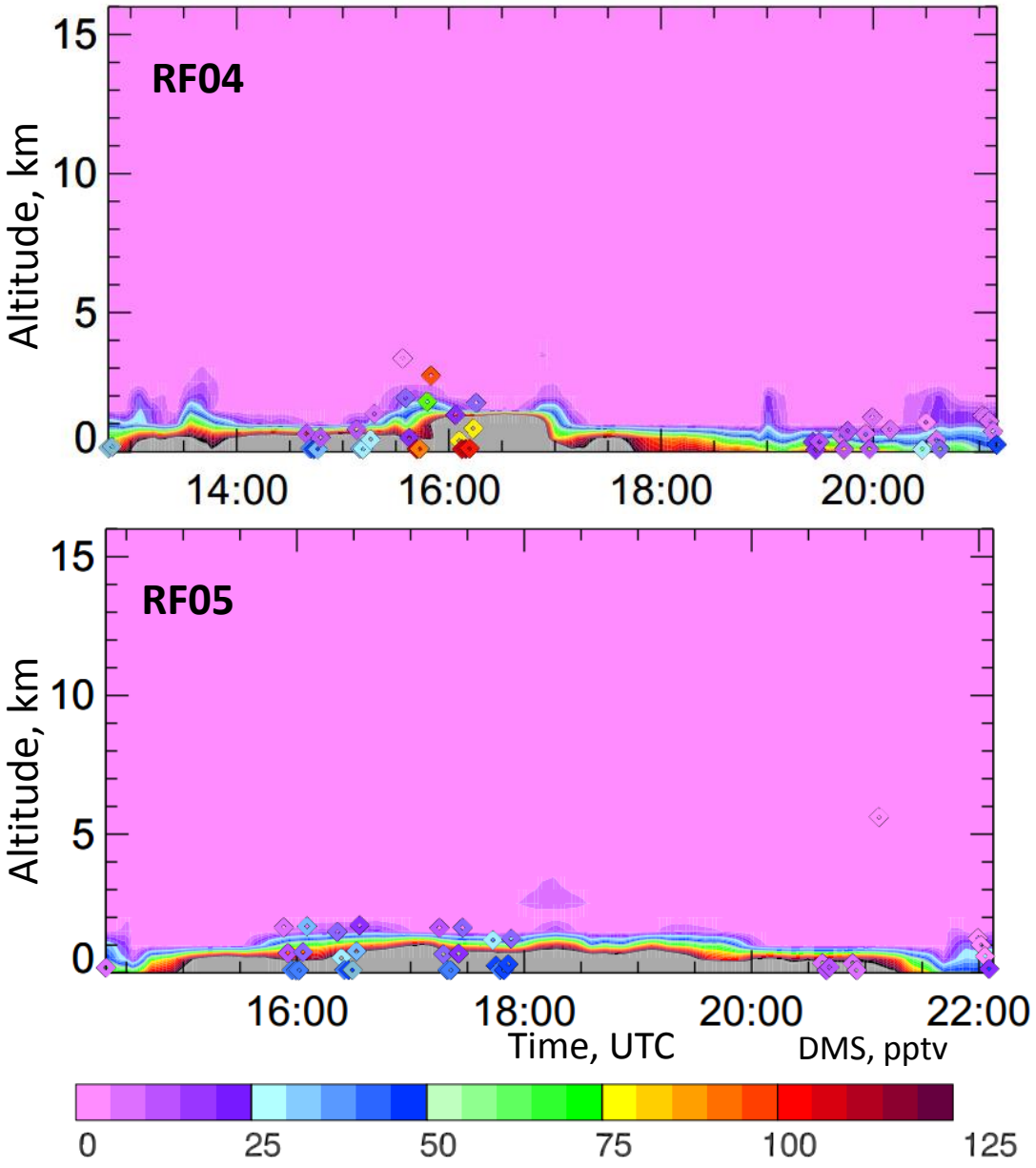


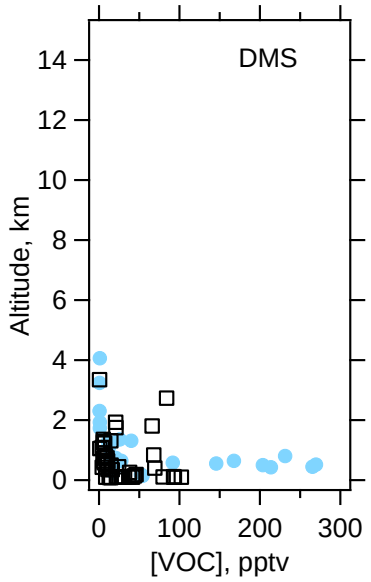


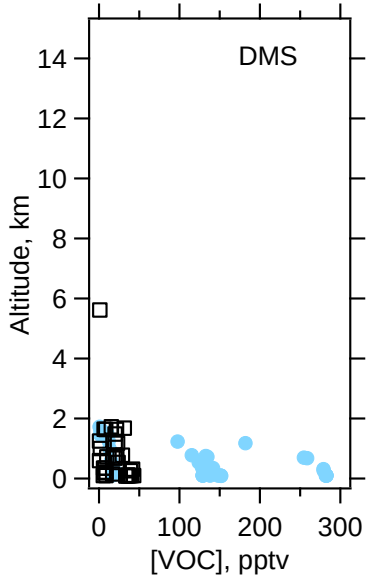
VSLS behavior during TORERO RF04 & RF05 – S. American Coast v. Oligotrophic Ocean



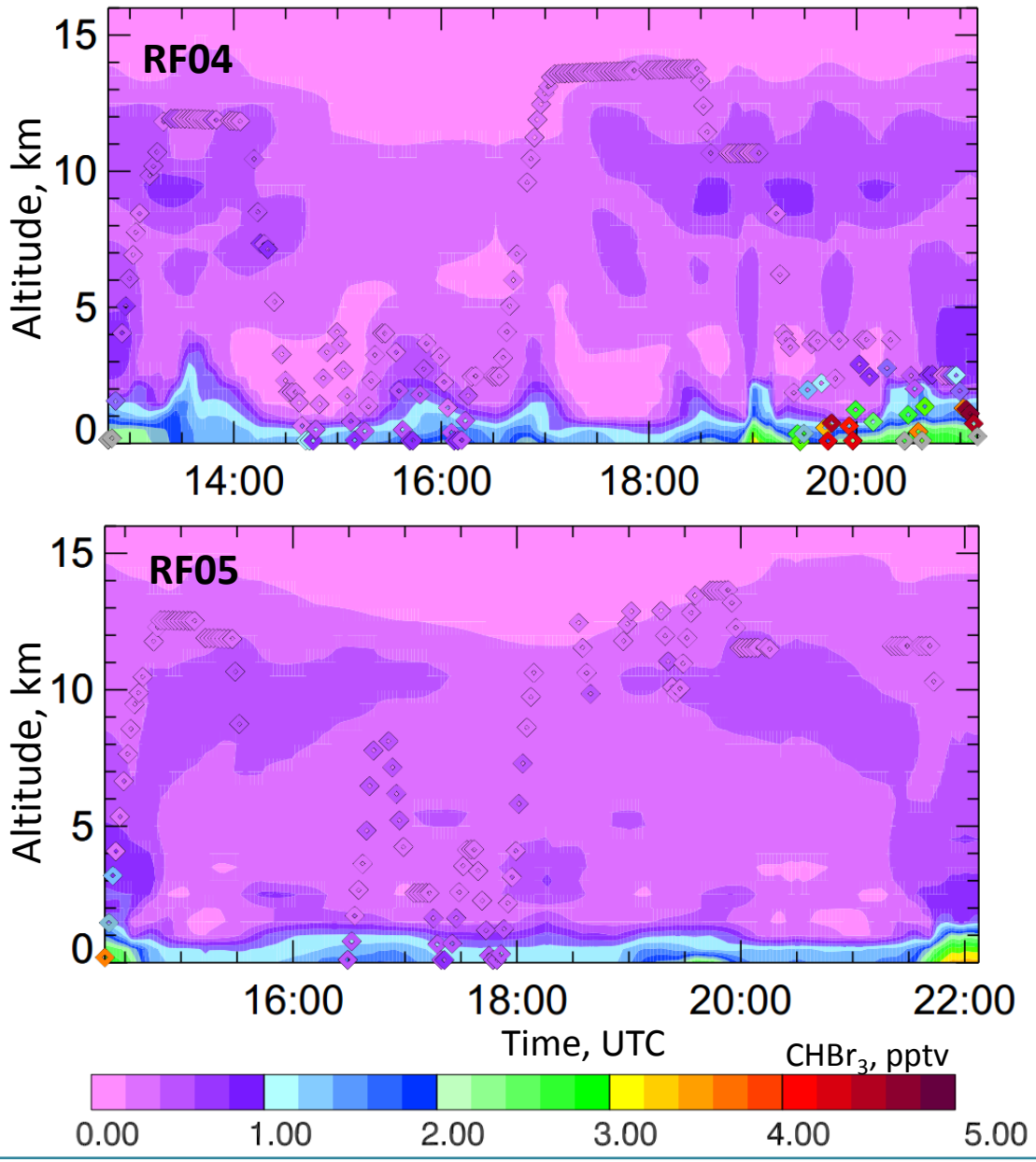
CAM-chem ~~convection~~ during TORERO RF04 and RF05 - DMS

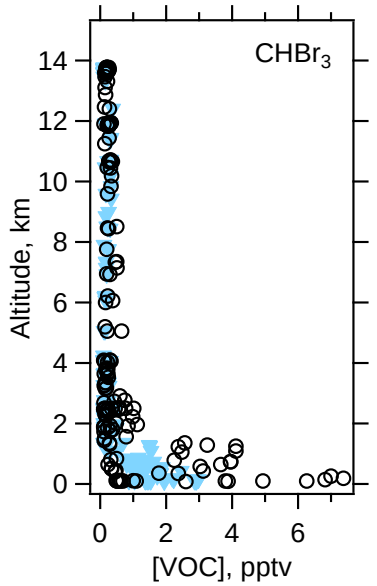


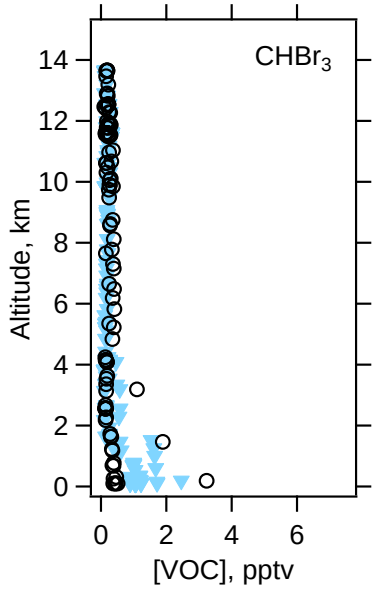




CAM-chem ~~convection~~ during TORERO RF04 and RF05 – $CHBr_3$







Summary

- Marine boundary layer VSLS concentrations in the CONTRAST study region were lower and less variable than in the eastern Pacific.
- Overall there is good agreement between the observations and CAM-chem. For many HCs and OVOCs (not shown), the agreement is excellent.
- For the VSLs, CAM-chem tends to predict higher bromoform and DMS in both the Eastern and Western Tropical Pacific, although the general spatial and vertical trends agree with the observations.

Moving forward:

- Continue to compare model and observations from the other CONTRAST and TORERO flights to better understand the horizontal and vertical distributions of VSLs throughout the Tropical Pacific.
- Use these findings to better constrain the impact of VSLS convection on the UT/LS, and contribute feedback to the model emissions.
- Compare different model resolutions on the convective scale to see what, if any, improvement we can see on the convective modeling.