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Organic, inorganic and total bromine observations around the extratropical tropopause and lowermost stratosphere

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Contents

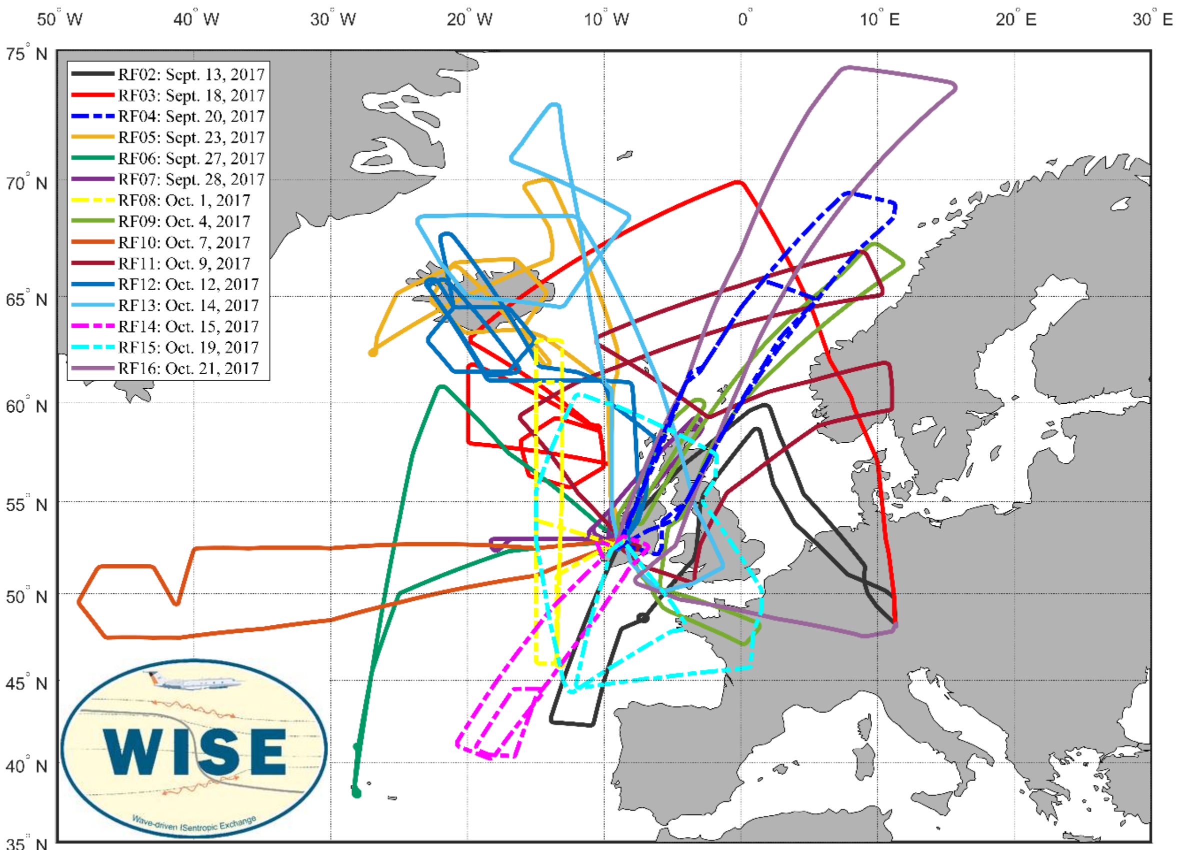
- **Airborne WISE & SouthTRAC Campaign Measurements**
- **Br^{org}, Br_y^{inorg}, and Br^{tot} Budget in the UTLS**
- **Summary and Outlook**

Airborne Measurements from HALO Aircraft

- HALO: High Altitude and LOng range research aircraft
- Flight altitudes up to ~15km: mainly along the upper troposphere and lower stratosphere (UTLS)
- Campaigns: WISE → Sept. & Oct. 2017 (Northern Hemisphere) and SouthTRAC → Sept. – Nov. 2019 (Southern Hemisphere)

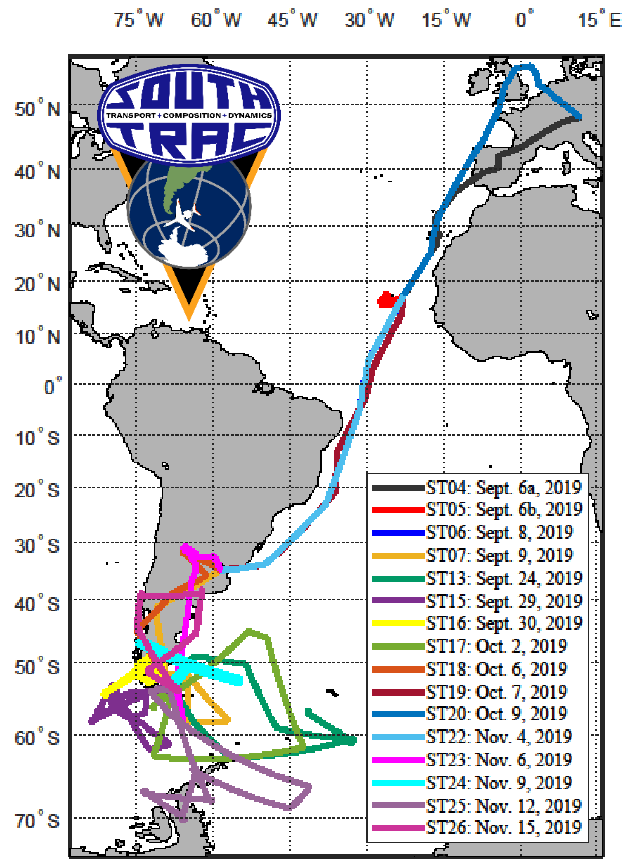
[Adopted from: http://www.gulfstream.com/special-missions/recent-programs]

Wave-driven ISentropic Exchange (WISE) 2017



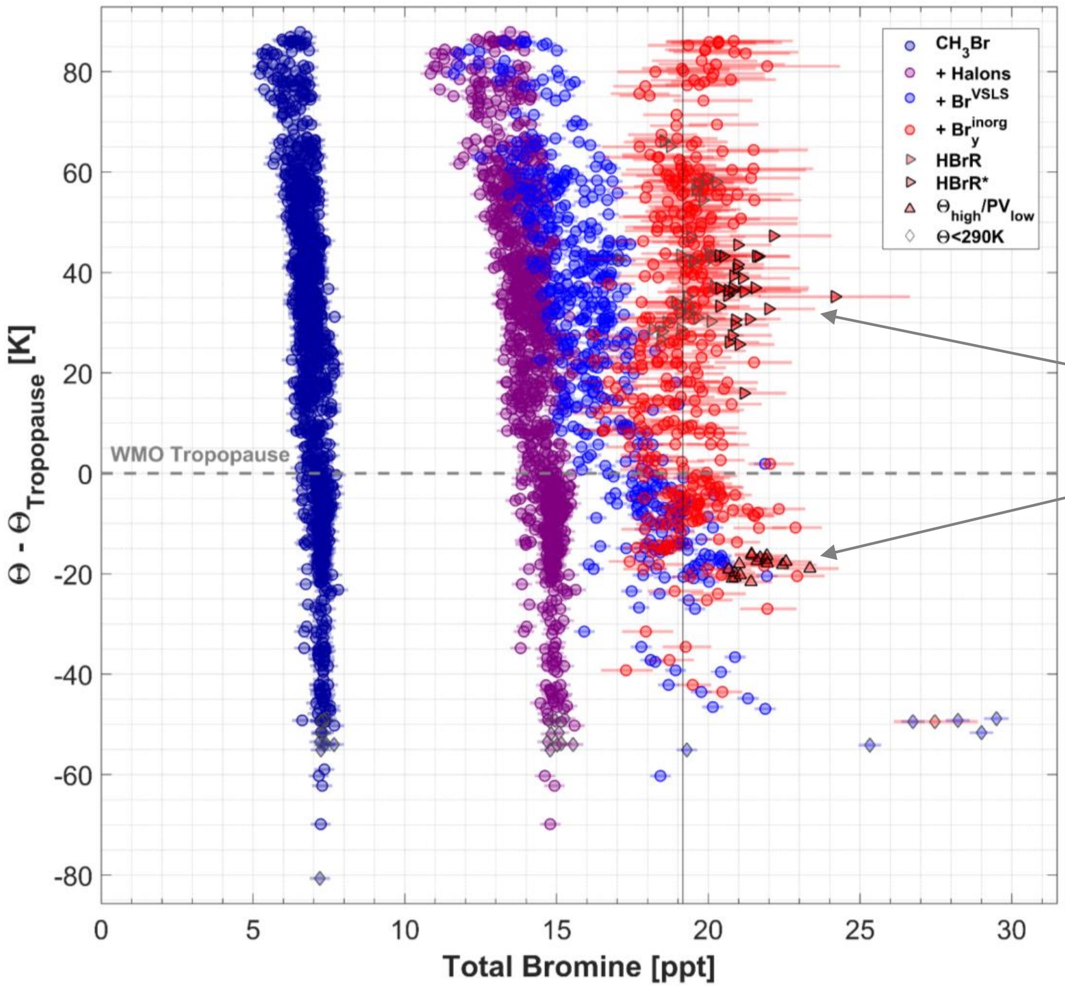
[Rotermund et al. (2021), https://doi.org/10.5194/acp-21-15375-2021]

Transport and Composition in the Southern Hemisphere UTLS (SouthTRAC) 2019



Br^{tot} vs Potential Temperature Distance from the Tropopause: Northern Hemisphere WISE Campaign in Fall 2017

CH_3Br + Halons + Br^{VSLS} + Br_y^{inorg} = Br^{tot}

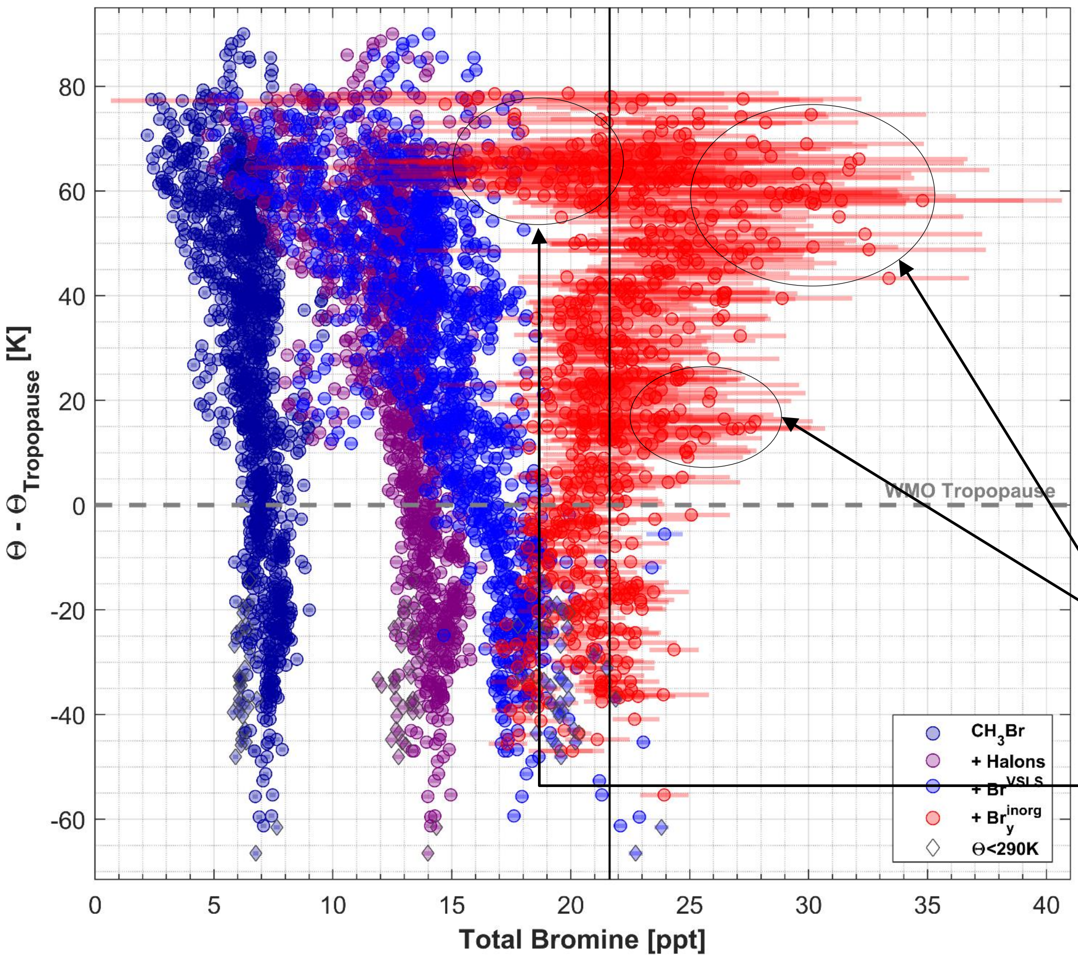


- Approx. constant Br^{tot} in UTLS
- LS ($\Delta\theta$>0 K) campaign average (black solid line): [Br^{tot}] = 19.2 ± 1.2 ppt
- Elevated bromine regions:
  - High bromine region (HBrR) in LS between 55-80°N
  - High potential temp. and low potential vorticity region (Θ_{high}/PV_{low}) → tropical UT
- Bromine rich air mass transport pathways:
  - Isentropic transport from SE Asia via monsoon anticyclone (and Central America via hurricanes)
  - Secondary stratosphere-troposphere exchange (STE) in mid-latitudes

[Rotermund et al. (2021), https://doi.org/10.5194/acp-21-15375-2021]

Br^{tot} vs Potential Temperature Distance from the Tropopause: Southern Hemisphere SouthTRAC Campaign in Fall 2019

CH_3Br + Halons + Br^{VSLS} + Br_y^{inorg} = Br^{tot}



- Br^{tot} fluctuations in UTLS due to different air masses observed (northern/tropical/southern latitudes)
- LS campaign average (black line): [Br^{tot}] = 21.6 ± 1.8 ppt
- Individual regions of elevated bromine VMRs identified through air mass transport from bromine rich sources
  - High Br^{tot} observed over the Antarctic Peninsula ~ΔΘ = 60K (and ~ ΔΘ = 20K) during flight ST25: Nov. 12th
  - Low Br^{tot} approaching Antarctic Peninsula ΔΘ = 60-70K (ST17 Oct. 2nd) at high SZA~84°

EGU General Assembly 27.04.2023

Rotermund et al. https://doi.org/10.5194/egusphere-egu23-9161

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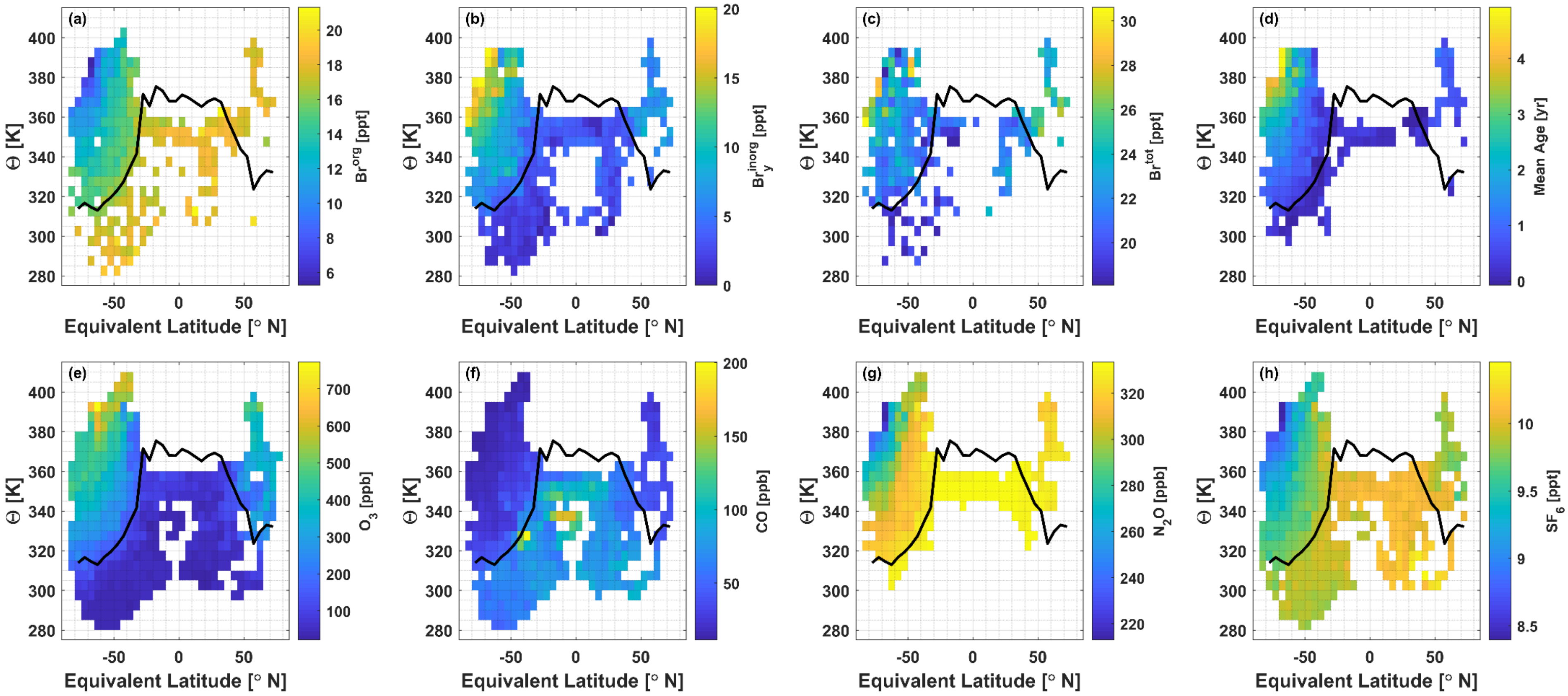
University of Heidelberg

Latitudinal Distribution of Br^{org}, Br_y^{inorg}, Br^{tot} and Air Mass Transport Tracers during SouthTRAC in Fall 2019



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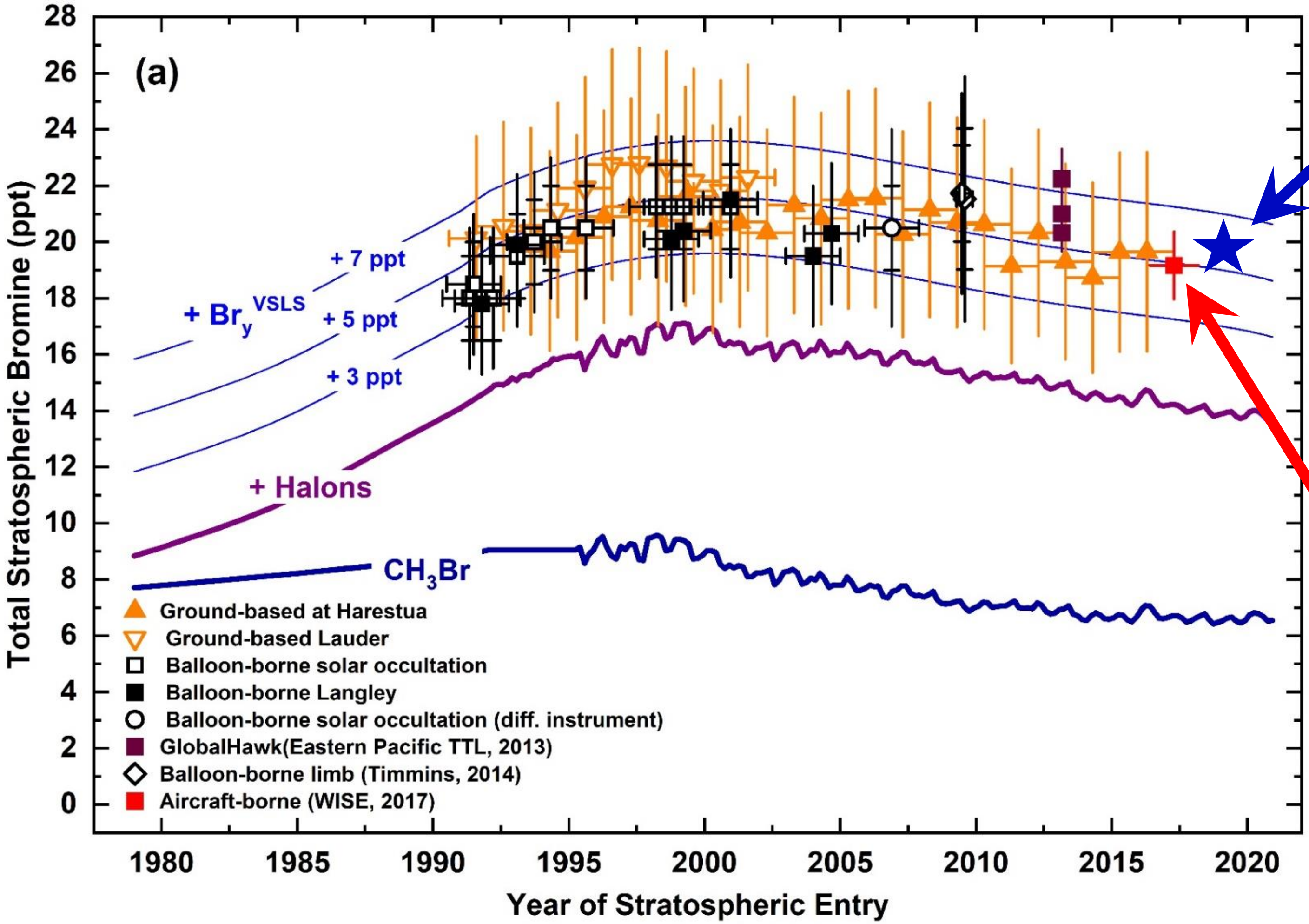
Updated Trend in Stratospheric Bromine (included in 2022 WMO Ozone Assessment Report)



The SouthTRAC campaign lower stratospheric mean: [Br^{tot}] = 21.6 ± 1.8 ppt

WISE campaign LS mean: [Br^{tot}] = 19.2 ± 1.2 ppt

Summary & Outlook

Completed:

Northern Hemisphere WISE 2017 campaign analysis for Br^{org}, Br_y^{inorg}, Br^{tot}, bromine transport pathways, source regions, and consequences on UTLS ozone

- **Published in ACP: Rotermund et al., (2021) https://doi.org/10.5194/acp-21-15375-2021**
- **Included in 2022 WMO Ozone Assessment Report**
  Laube J.C. and S. Tegtmeier (Lead Authors), R.P. Fernandez, J. Harrison, L. Hu, P. Krummel, E. Mahieu, S. Park, L. Western, Update on Ozone-Depleting Substances (ODSs) and Other Gases of Interest to the Montreal Protocol, Chapter 1 in *Scientific Assessment of Ozone Depletion: 2022*, GAW Report No. 278, 509 pp., WMO, Geneva, 2022.

Southern Hemisphere SouthTRAC 2019 campaign retrievals of Br_y^{inorg}, Br^{org} and Br^{tot}

- **Ongoing: transport pathway analysis of bromine rich air masses**
- **Collaborations with Rafael Fernandez with CAM-Chem model**
- **Manuscript for ACP in preparation: Rotermund et al. (2023)**

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