



Horizontal transport of ASM air into the NH LS

The Phileas campaign in 2023

6 June 2024 | Rolf Müller | IEK-7

Probing High Latitude Export of air from the Asian Summer Monsoon (PHILEAS)

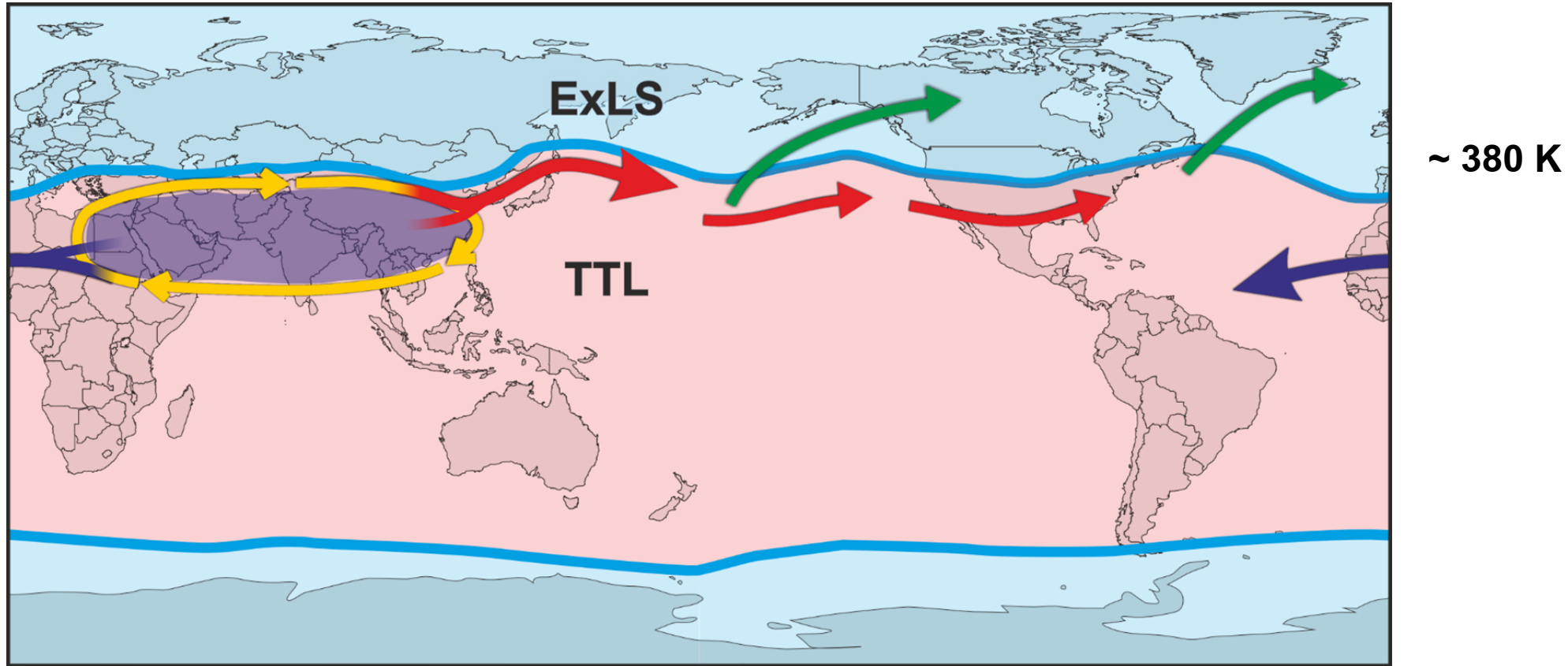


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Content

- **The Phileas aircraft campaign and its objectives**
- **Selected early results**
- **Summary**

Probing westward and eastward outflow of ASM air



Adapted from Vogel et al., 2016

Research questions



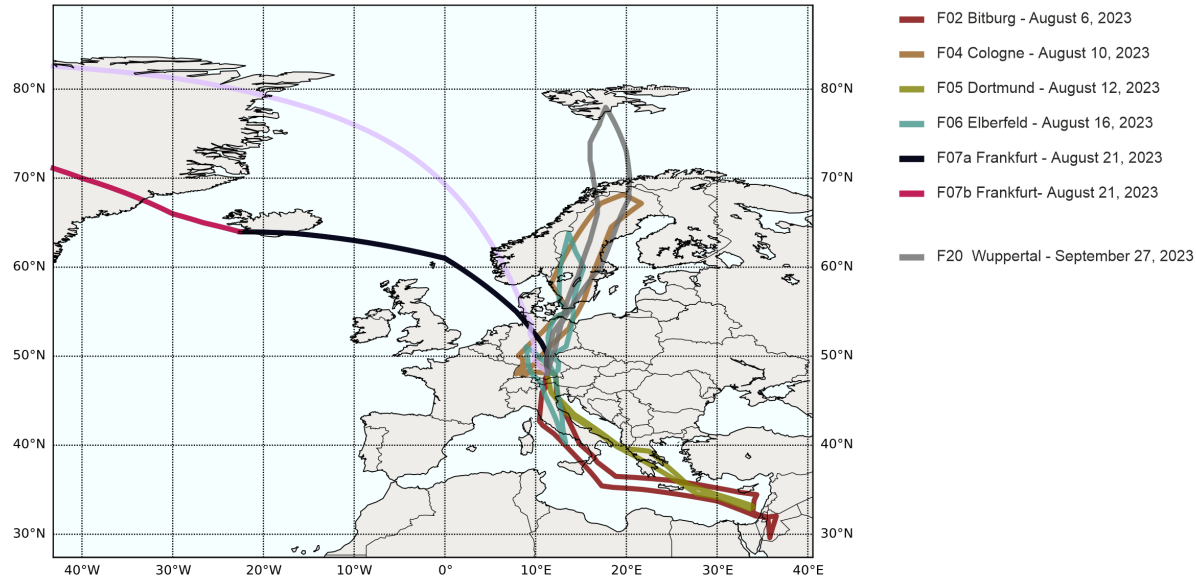
1. What are the **pathways, time scales and dynamical processes** of air mass transport from the ASM into the extratropical UTLS and LMS?
2. How do **gas-phase and particulate constituents** evolve in large-scale eddies which are shed from the monsoon anticyclone?
3. How does eddy shedding from the monsoon **impact on extratropical LMS composition** in particular the water vapor and radiatively active species?
4. What is the **impact of forest fires** in Canada on UTLS composition?

PHILEAS campaign phases and flight tracks

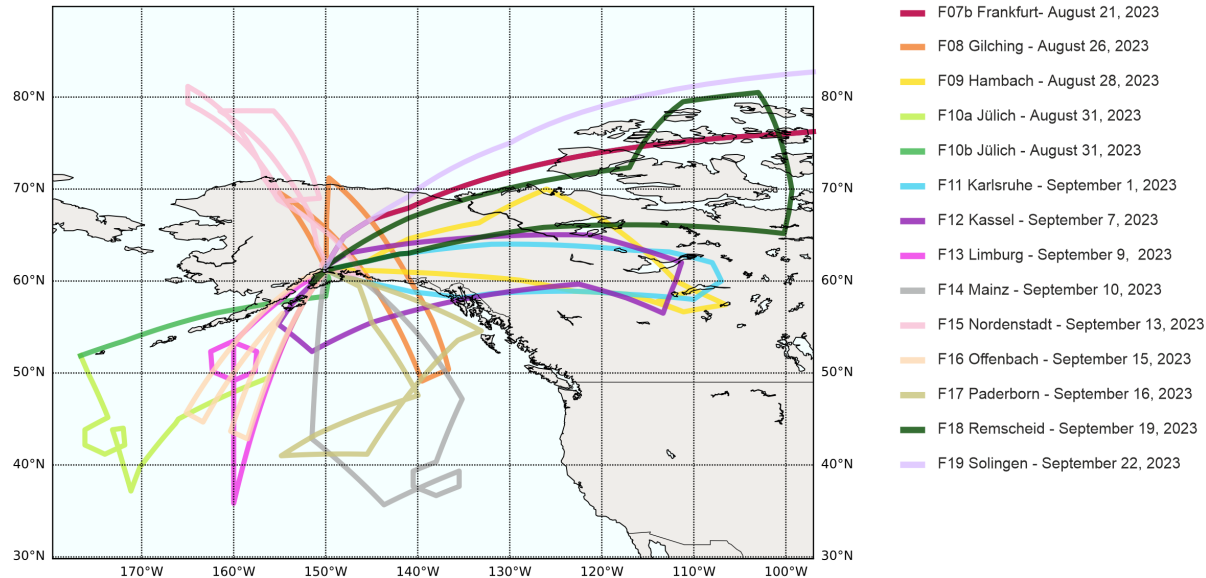


Phase I:
6 August -
21 August

Phase III:
27 September

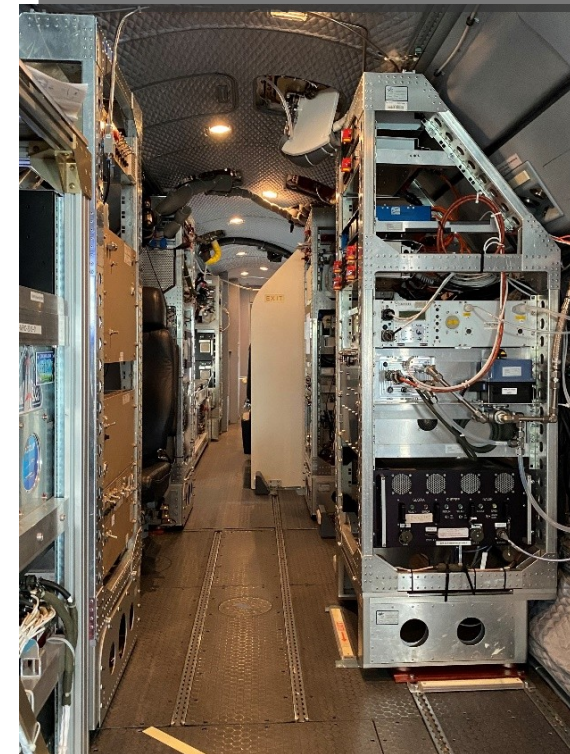
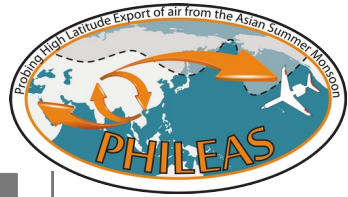


Phase II:
21 August –
22 September



Instrument	Target Parameter	Technique	Institution	Reference
GLORIA	Ammonium nitrate, NH ₃ , O ₃ , H ₂ O, HNO ₃ , PAN, C ₂ H ₆ , C ₂ H ₂ , HCOOH ...	Imaging IR limb sounder	FZ Jülich; KIT	Riese et al., 2014 Friedl-Vallon et al., 2014
AENEAS	NO, NO _y	Chemilumin.	DLR-IPA	Ziereis et al., 2000.; Stratmann et al., 2016
AMICA	COS, CO, CO ₂	OA-ICOS	FZ Jülich	Kloss et al., 2021
AIMS	HCl, HNO ₃ , ClONO ₂ , SO ₂	Mass spectrometer		Jurkat et al., 2016, 2017 Voigt et al., 2014
BCPD	Cloud droplet size distribution	Back scatter with polarization detection		Jurkat-Witschas / Voigt DLR
BAHAMAS	Meteorological and avionic data	Basic Measurement and sensor system	DLR-FX	Krautschunk and Gietz, 2012
ERICA	Aerosol composition and size distribution	Mass spectrometry	MPI Mainz	Hünig et al. 2021 AMT, Appel et al. 2021 ACP
FAIRO	O ₃	UV / Chemilumin.	KIT	Zahn et al., 2012
FASD	Aerosol number and size distr.		TROPOS	Pöhlker, TROPOS
FISH	Total and gas-phase H ₂ O	Lyman-alpha hygrometer	FZ Jülich	Zöger et al., 1999 Meyer et al., 2015
GhOST-MS	SF ₆ , CFCs, CH ₃ Br, CHBr ₃ , CHCl ₃ , ...	GC-MS	University of Frankfurt	Jesswein et al., 2021
HAGAR-V	CO ₂ , SF ₆ , CFCs, CI-VSLS	NDIR GC-ECD GC-MS	University of Wuppertal	Lauther et al. 2022
UMAQS	CO, N ₂ O, CH ₄ , C ₂ H ₆	QCL absorption spectrometer	University of Mainz	Kunkel et al., 2018

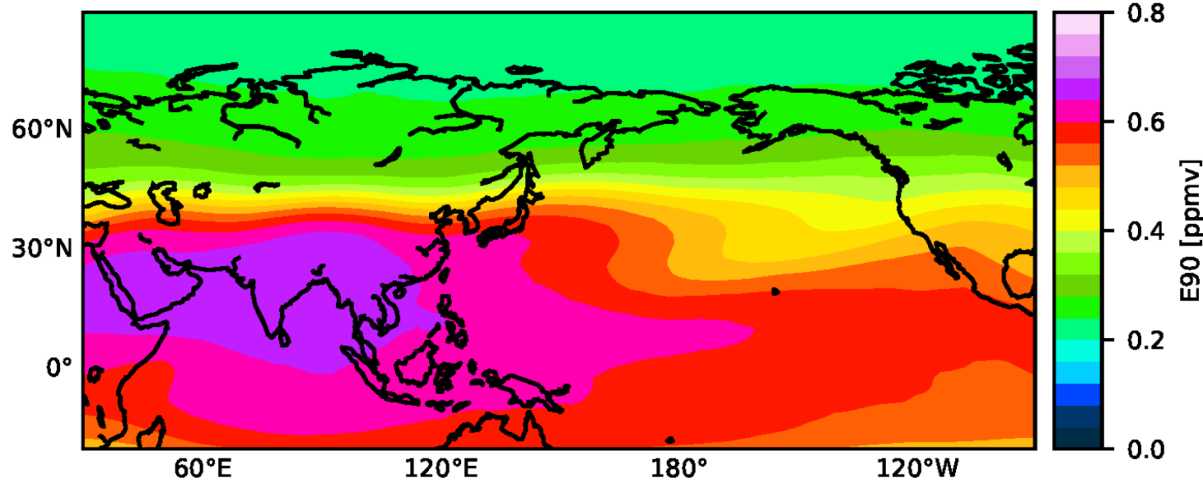
Instrumentation



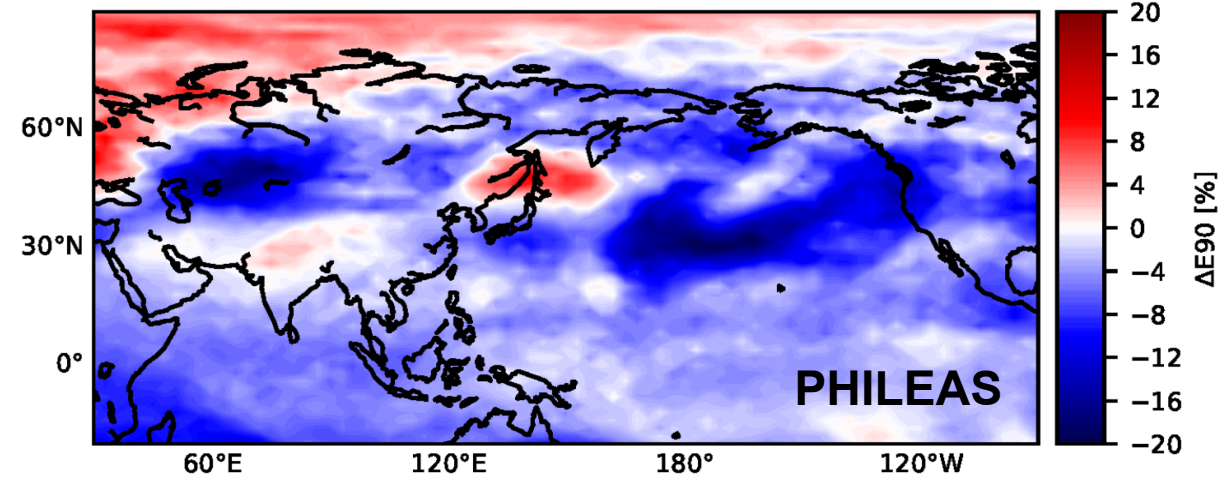
PHILEAS – climatological context / E90 tracer @146hPa

Courtesy of Felix Plöger

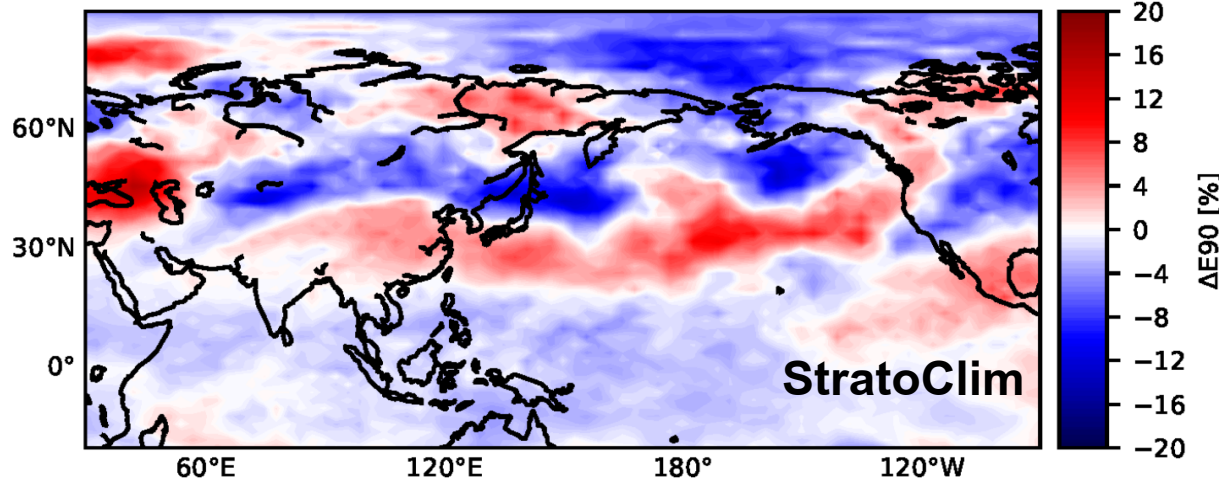
climatology/Aug-Sep (146hPa)



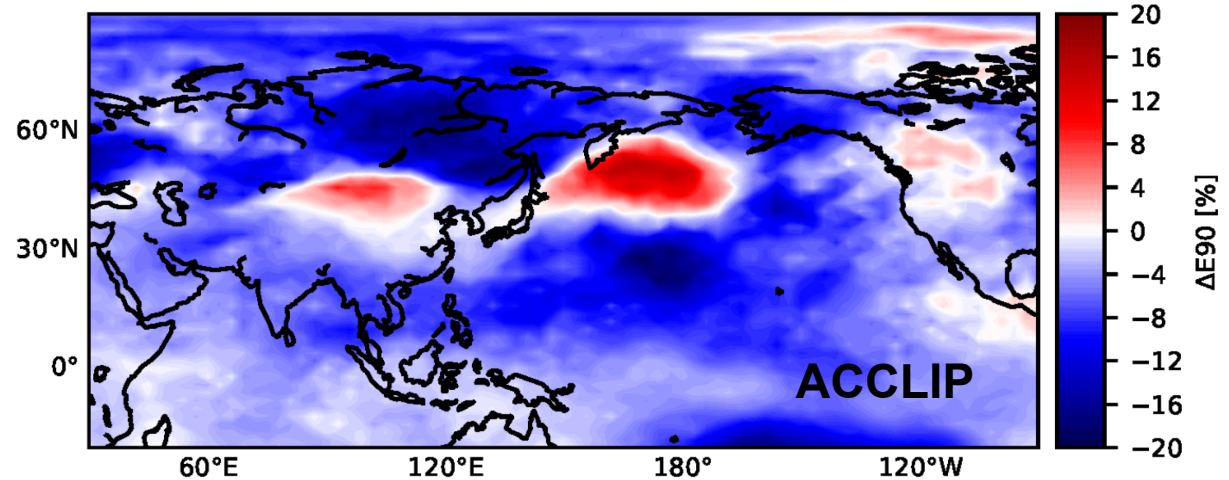
2023 minus climatology/Aug-Sep (146hPa)



2017 minus climatology/Aug-Sep (146hPa)

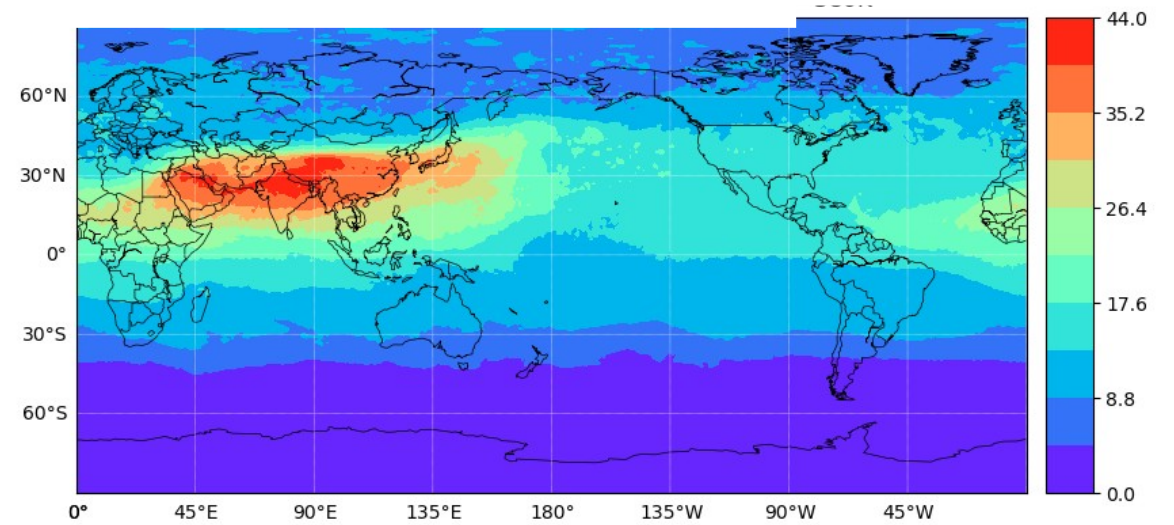
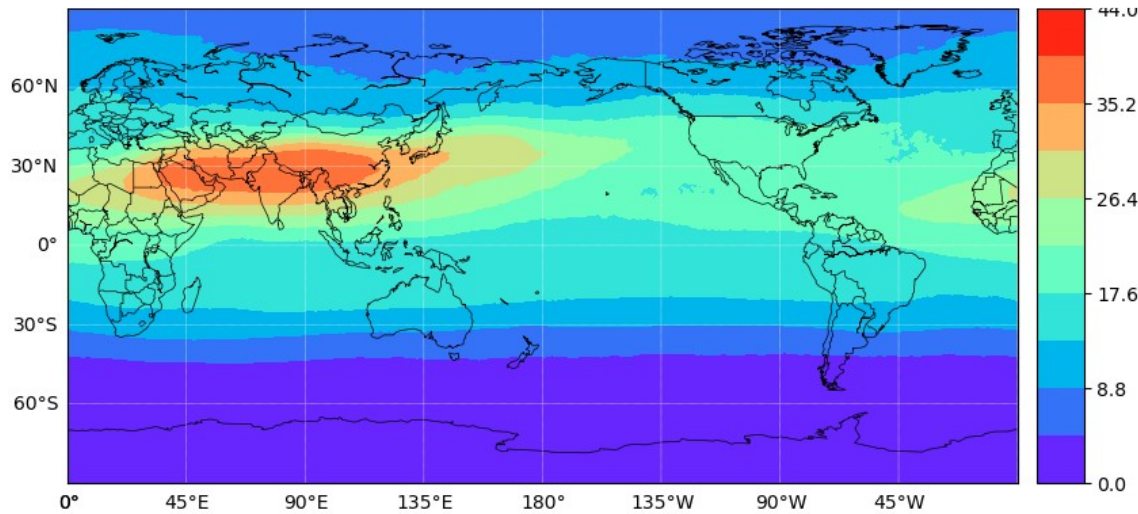


2022 minus climatology/Aug-Sep (146hPa)

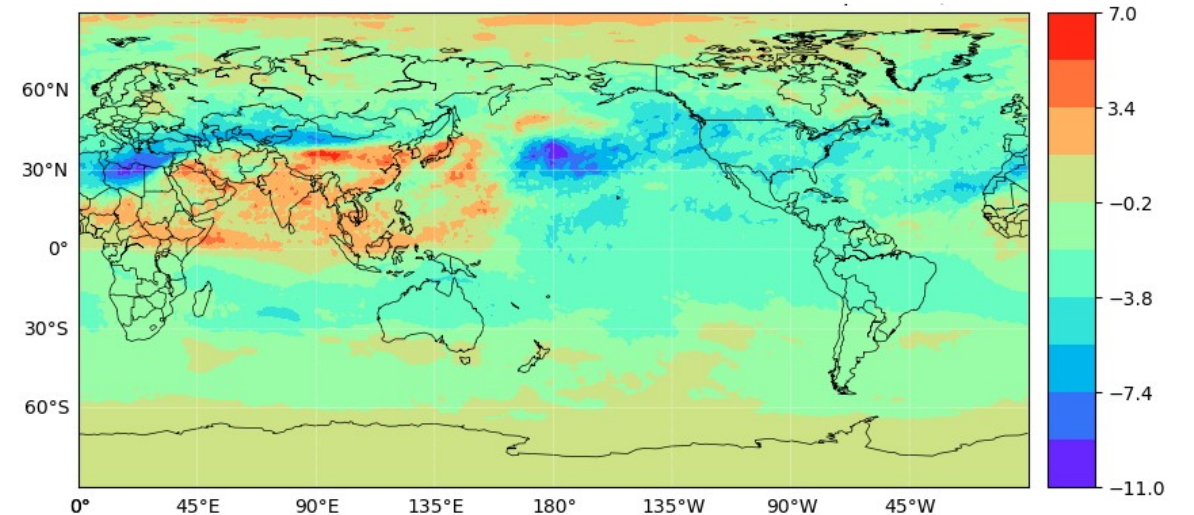


- Somewhat stronger than average flushing of the LMS in 2023 (PHILEAS) ?
- Somewhat stronger than average EASM influence in 2022 (ACCLIP) ?

PHILEAS – climatological context / South Asia tracer @380K



September 2023 anomaly, 380K



Courtesy of Bärbel Vogel, FZJ

Slight northward shift of the pathway into the LMS

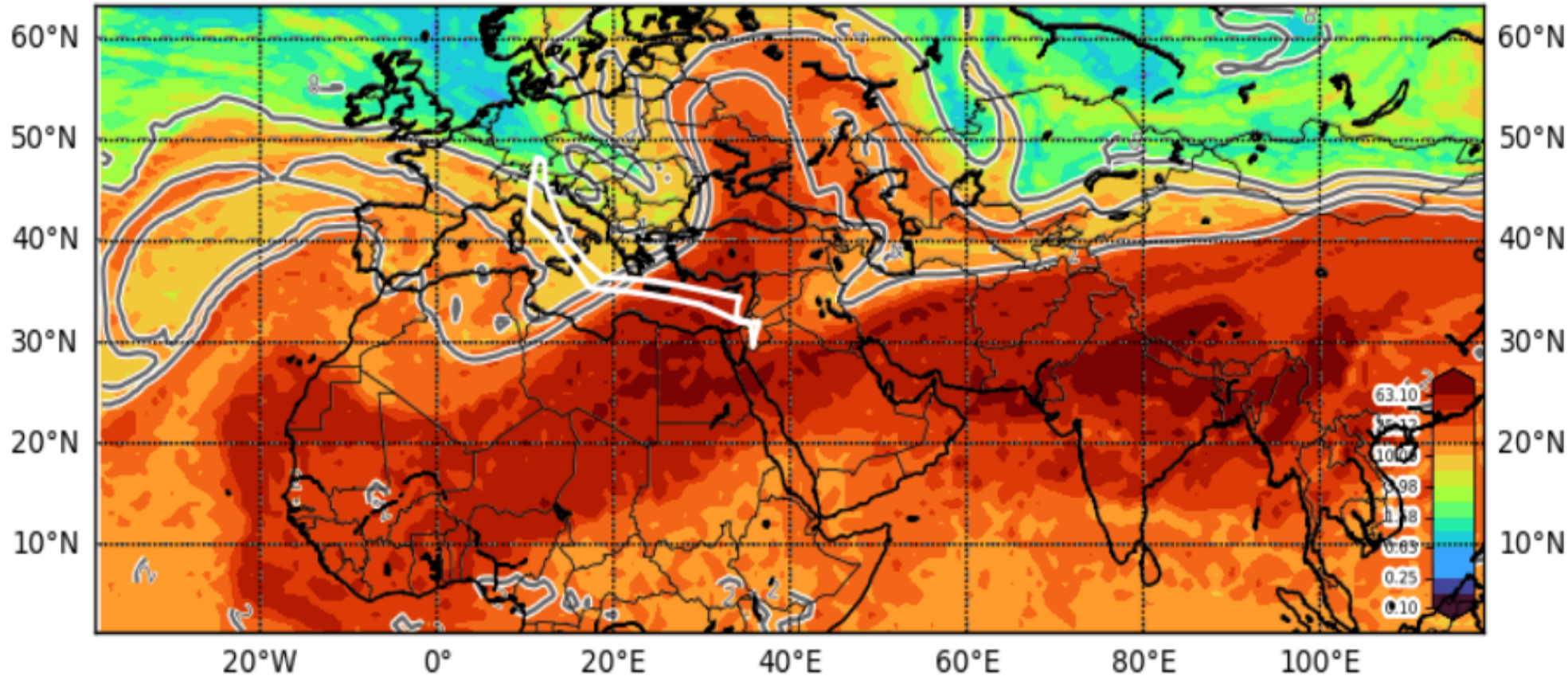
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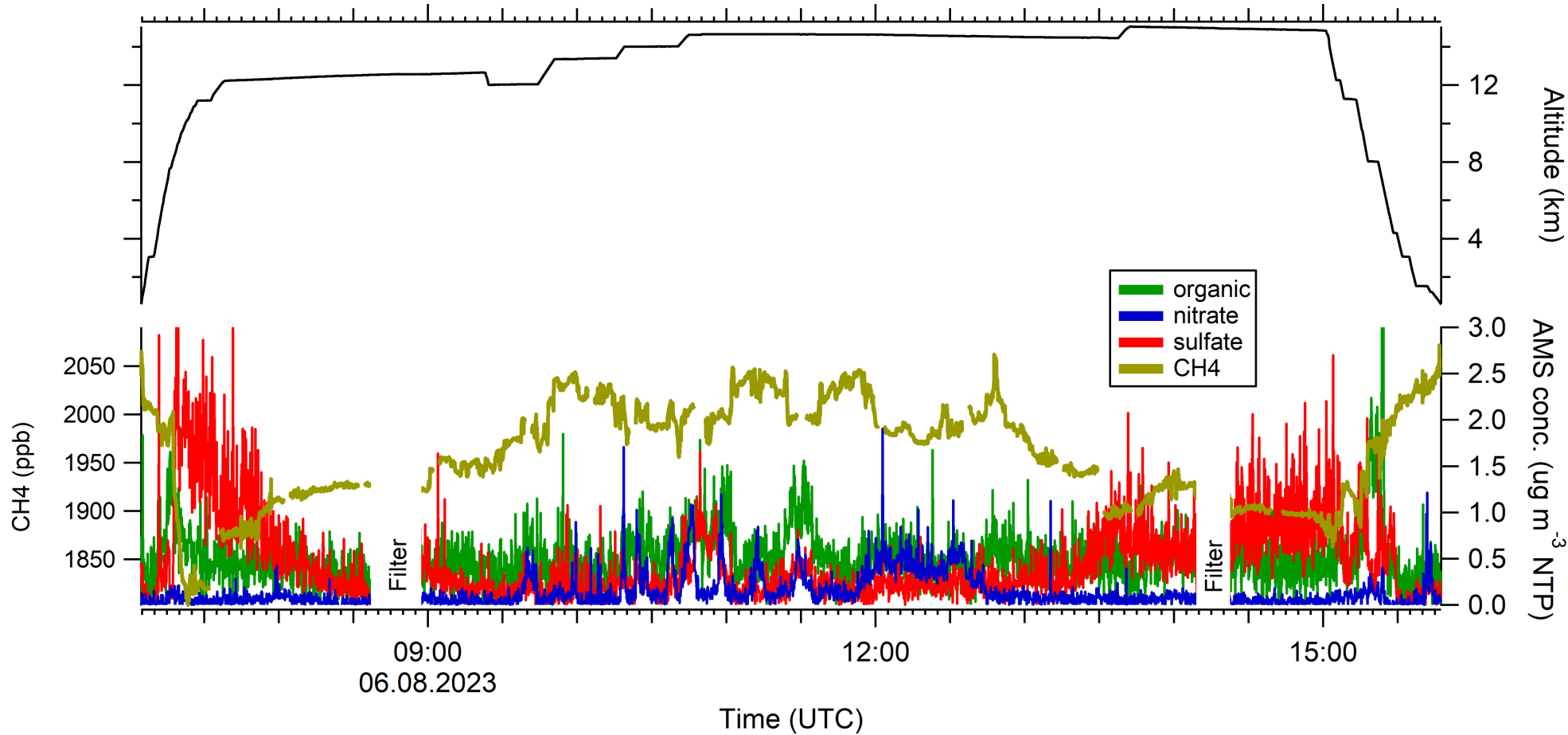
Probing the westward displacement/elongation of AMA

F02 Bitburg, August 6, 2023, Analysis South Asia AM Tracer @360K

CLaMS-SFC south asia (percent) (autolog) at 360 (K)
Valid: 2023-08-06T12:00:00Z



Probing the westward displacement/elongation of AMA

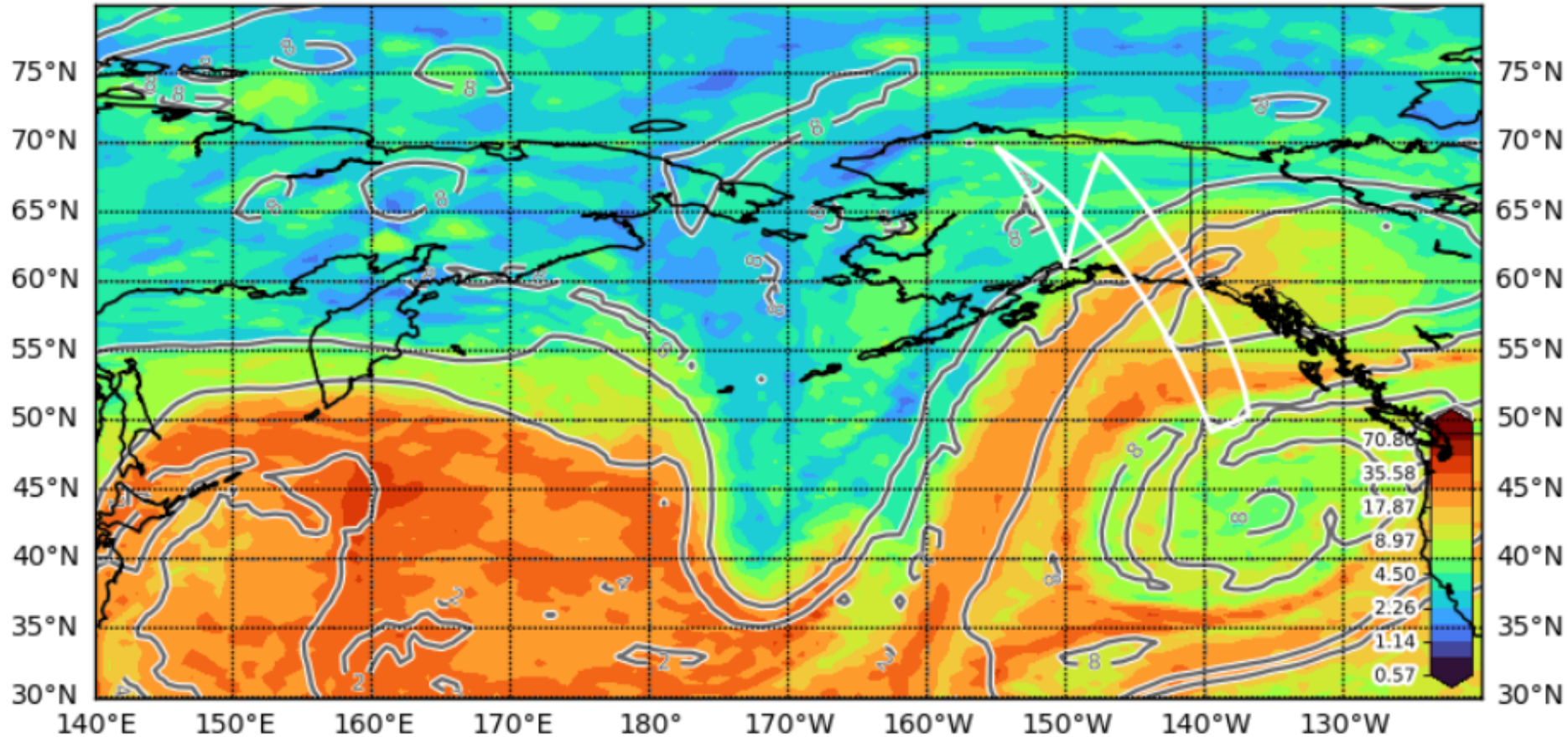


- **Enhanced concentrations of nitrate and organics in UT associated with higher CH₄**
Courtesy F.Köllner, O.Eppers, F. Ekinci, J. Schneider, S. Borrmann, MPI-C/JGU Mainz

Probing eastward outflow of ASM air

F08 Gilching, August 26, 2023, Analysis CLaMS South Asia AM Tracer @360K

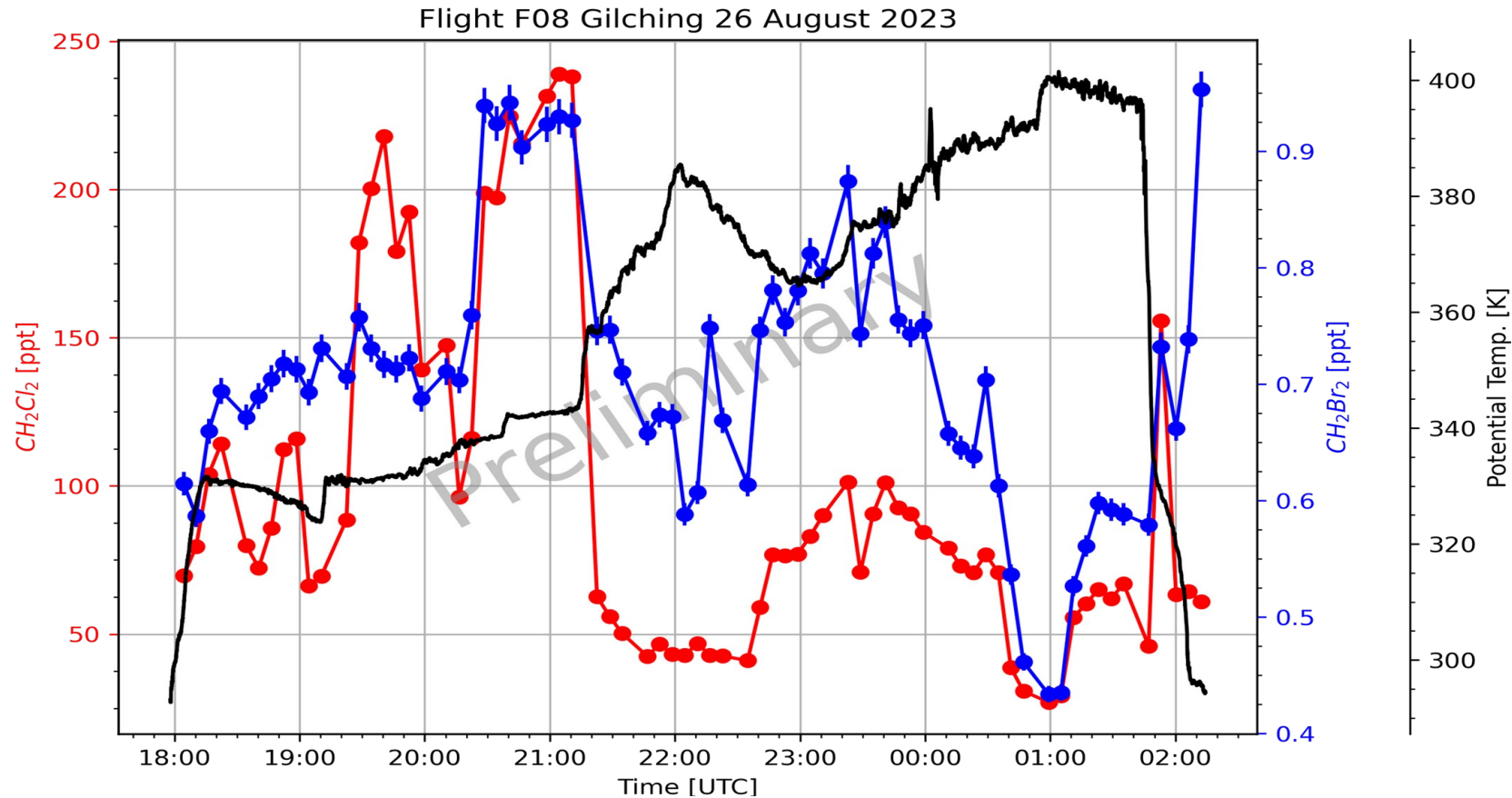
CLaMS-SFC south asia (percent) (autolog) at 360 (K)
Valid: 2023-08-27T00:00:00Z



Probing eastward outflow of ASM air

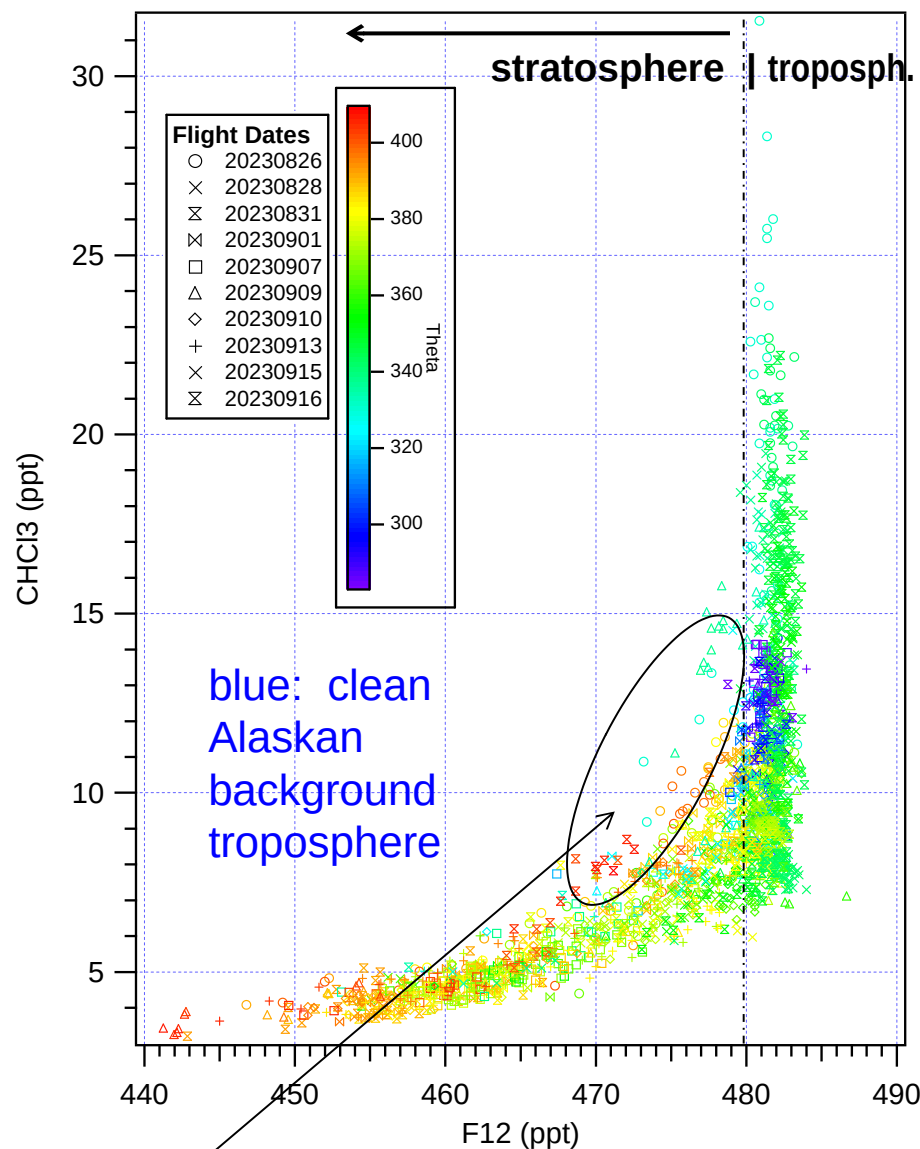
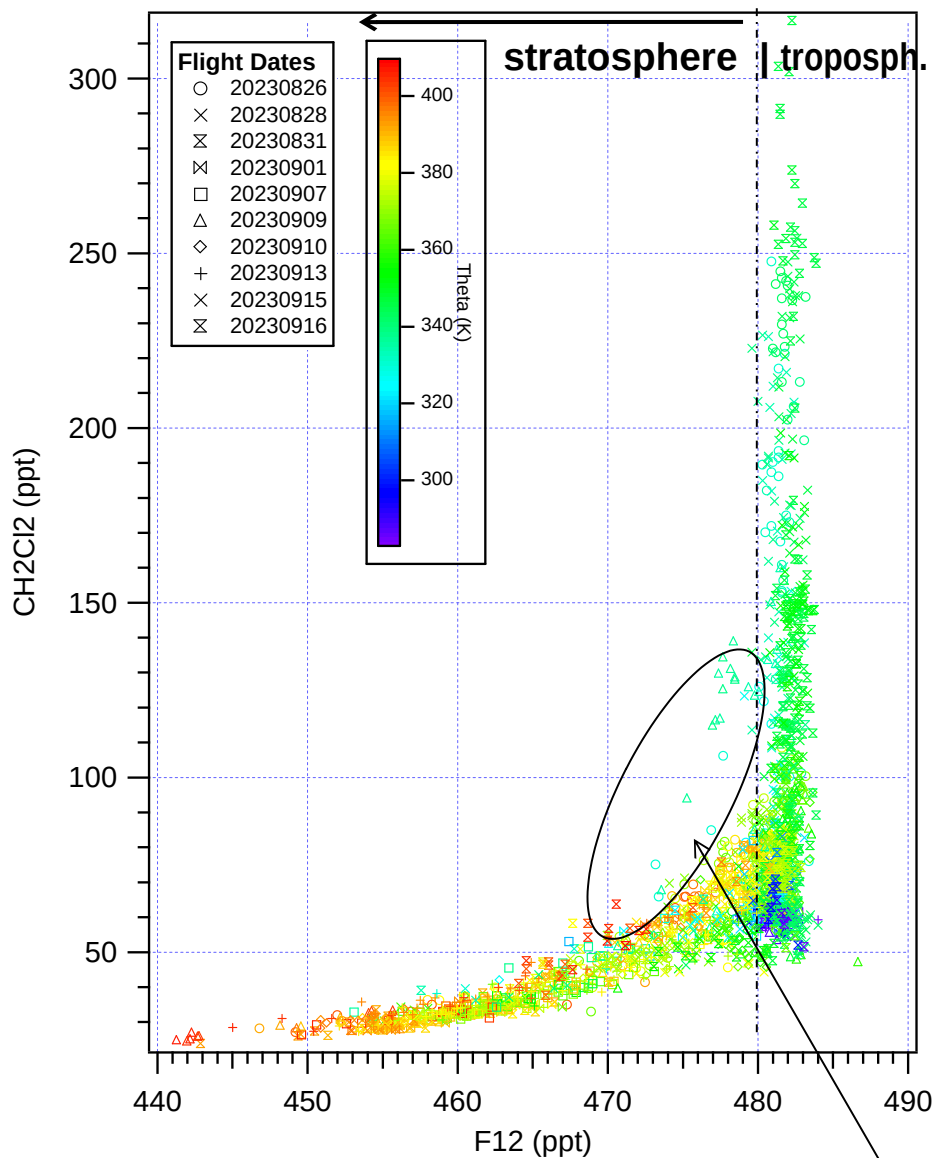
F08, August 26, 2023, Ghost CHCl_2 , CHBr_2

Courtesy of Markus Jesswein,
U Frankfurt



- Strong enhancement of Cl-VSLs, e.g. dichloromethane (CH_2Cl_2)
- Larger values of CH_2Cl_2 in UT than during StratoClim 2017 in AMA (Adcock et al., 2019)

Mixing into the lower stratosphere ?



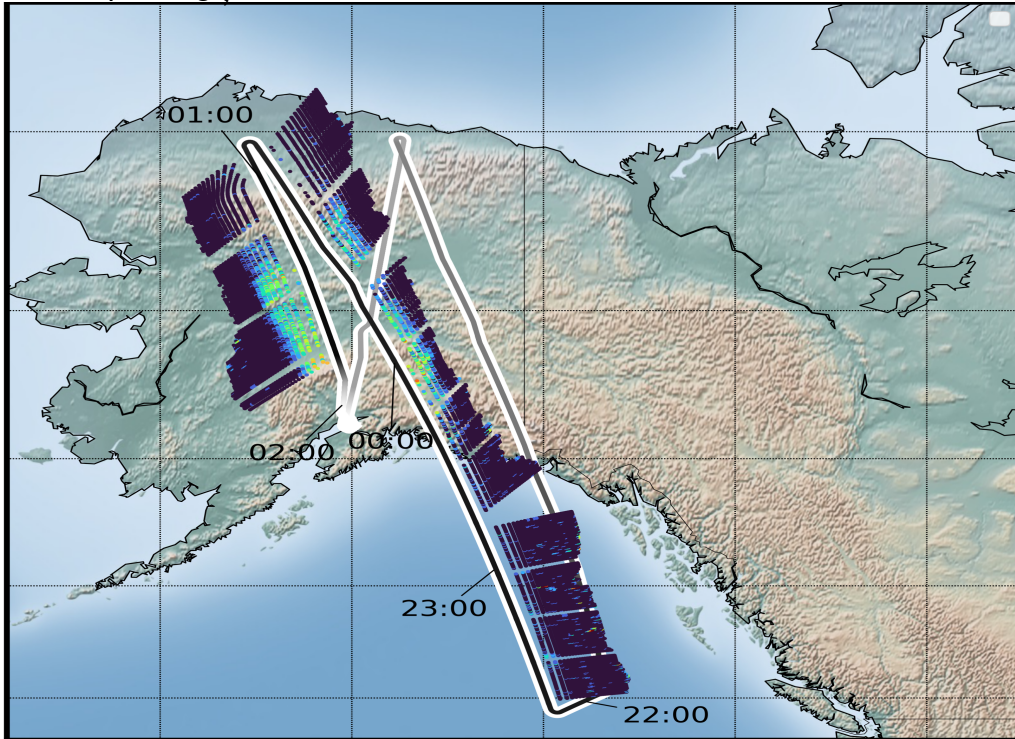
HAGAR-V tracer correlations:
 CH_2Cl_2 and CHCl_3
vs F12

Courtesy of Michael Volk,
U Wuppertal

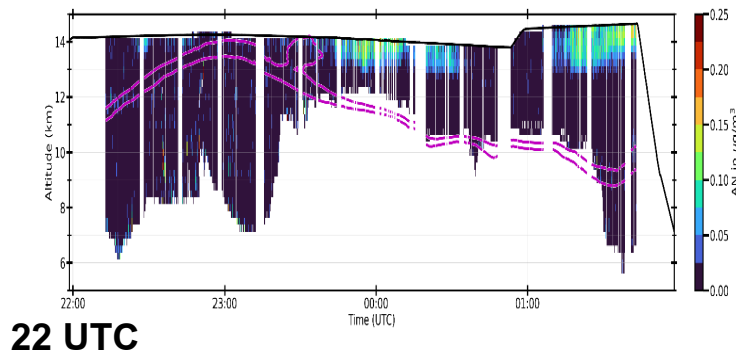
Polluted ASM filaments gradually mix into lower stratosphere

Probing eastward outflow of ASM air

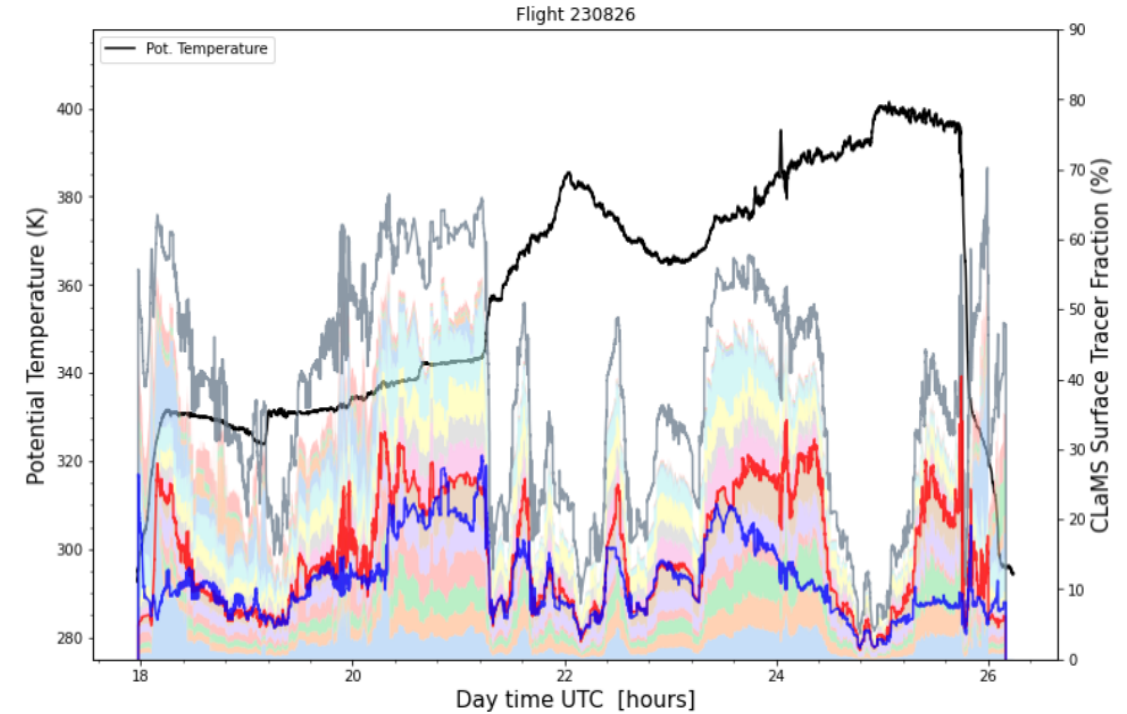
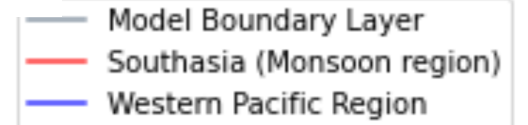
NH_4NO_3 , August 26, 2023



Courtesy of
Sören Johansson



CLaMS Origin Tracer



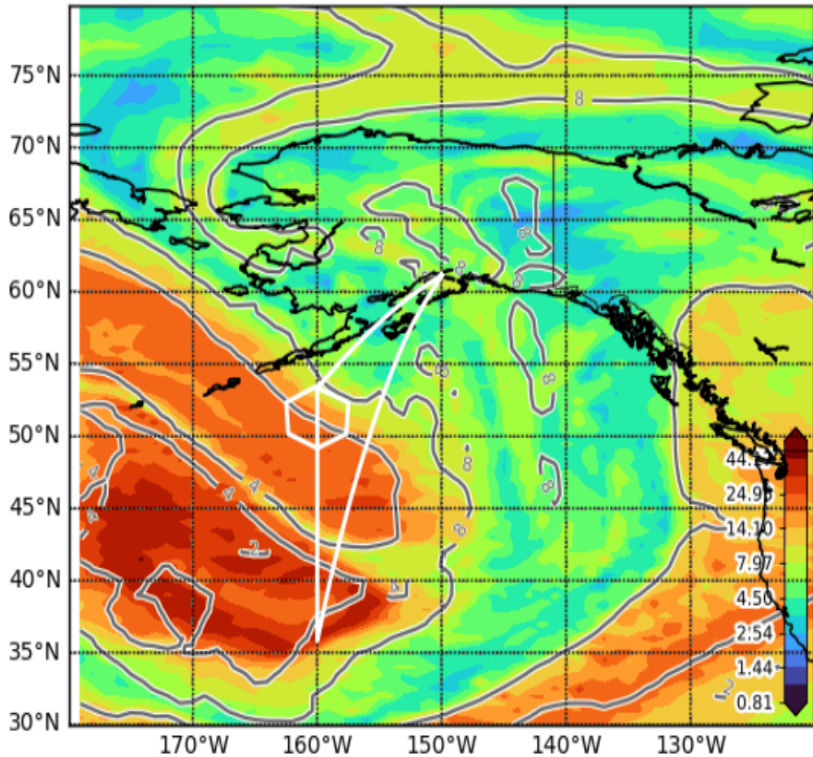
- Strong layer of solid ammonium nitrate (NH_4NO_3) AN from above Alaska
- Indication of in-mixing into LMS ?

Probing eastward outflow of ASM air

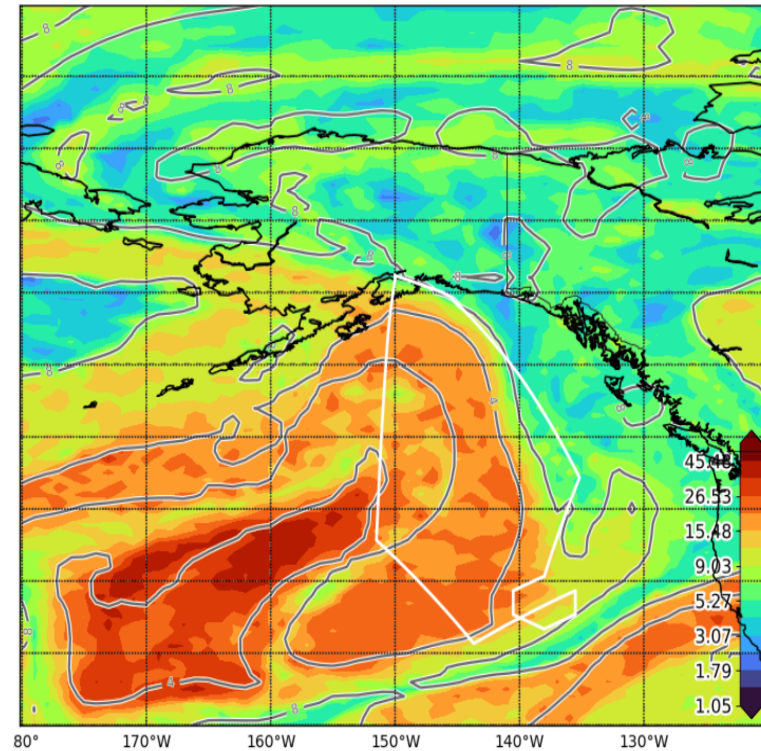


Use Lagrangian triple flight to study mixing processes

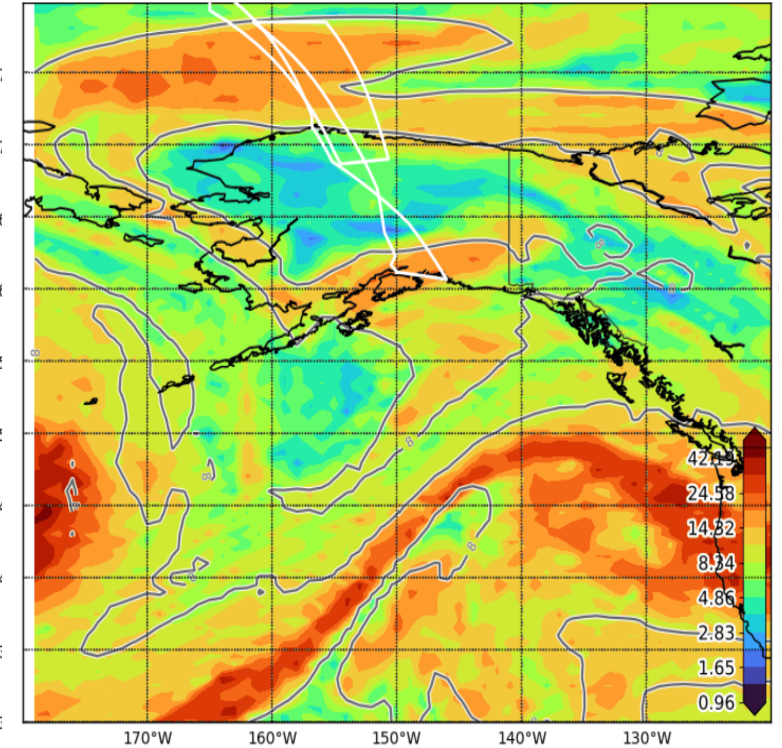
September 9, SA tracer @ 370K



September 10, SA tracer @ 370K

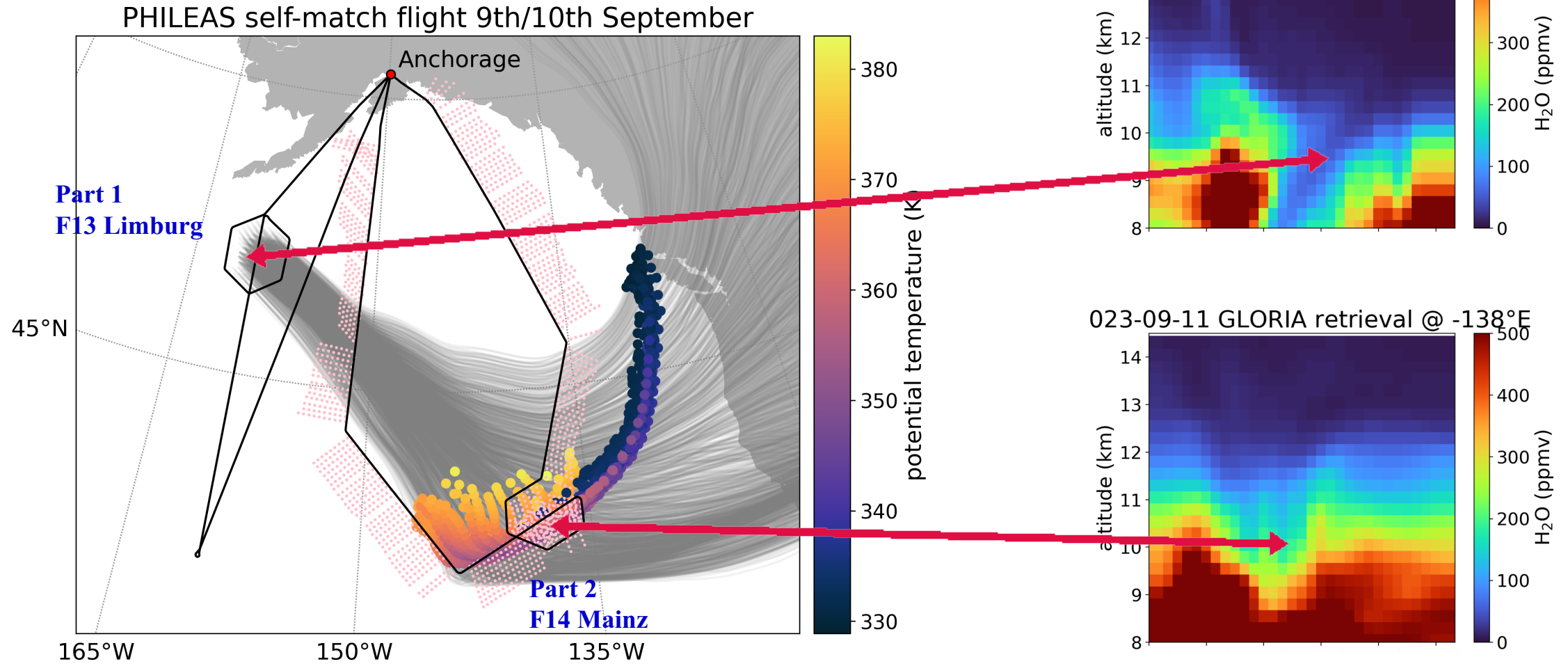


September 14, SA tracer @ 380K



Probing eastward outflow of ASM air

3D tomographie



Courtesy Jörn Ungermann, Jan Kaumanns

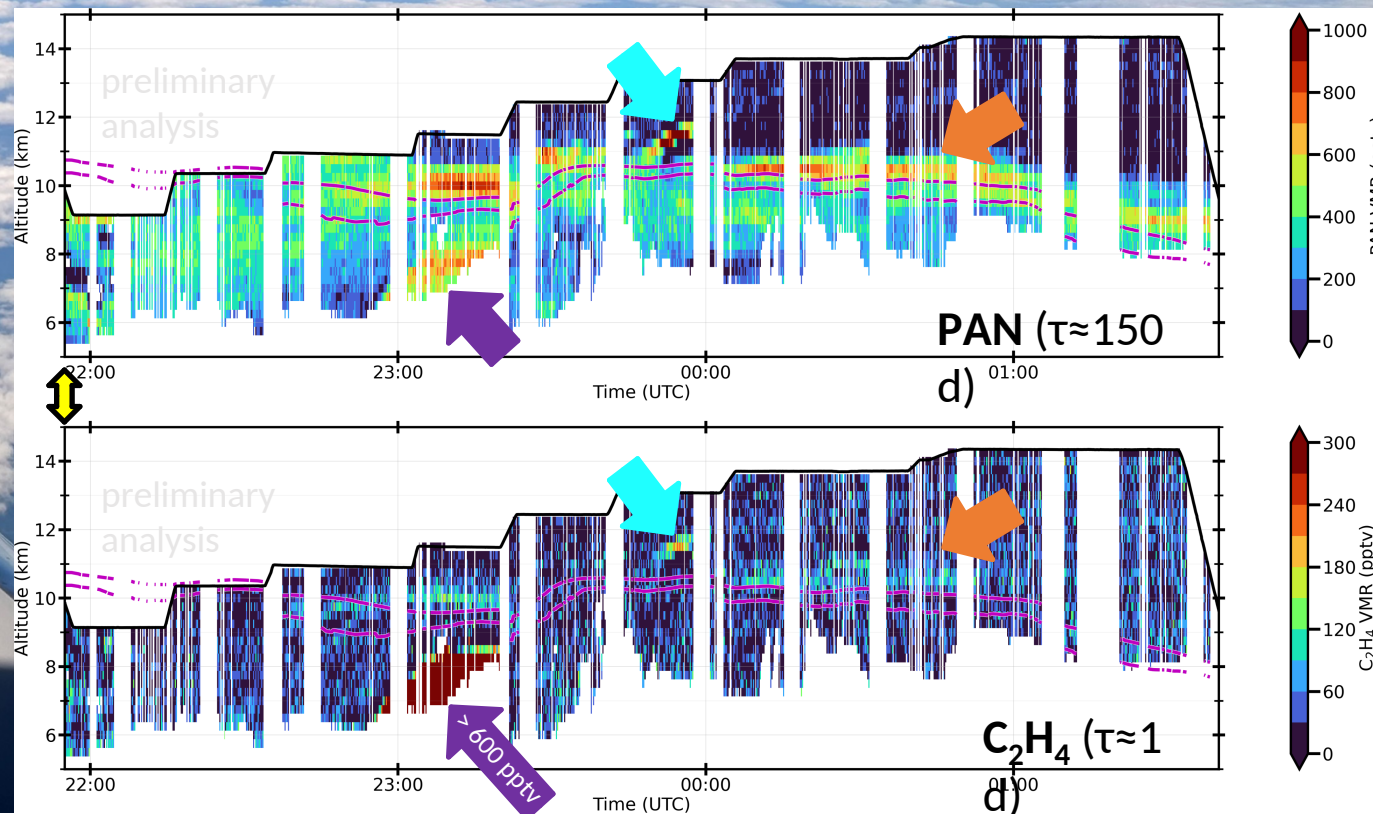
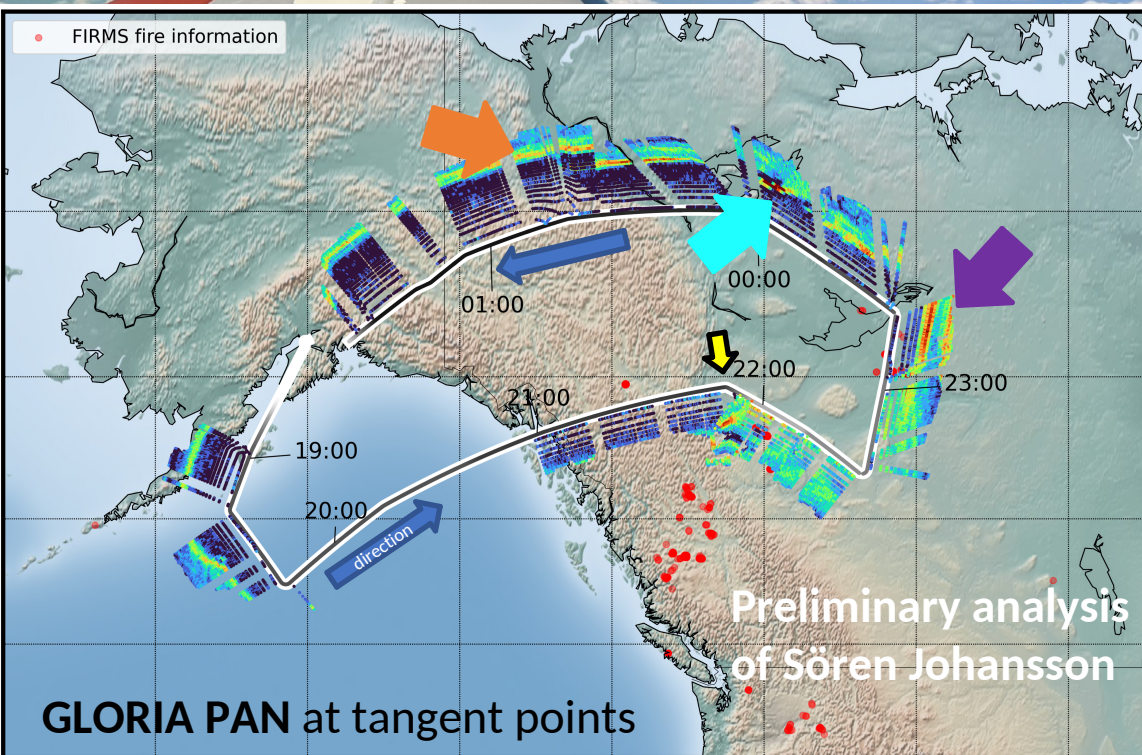
Probing plumes of the Canadian wildfires

September 7, 2023

Picture: E. Kretschmer



Picture: L.



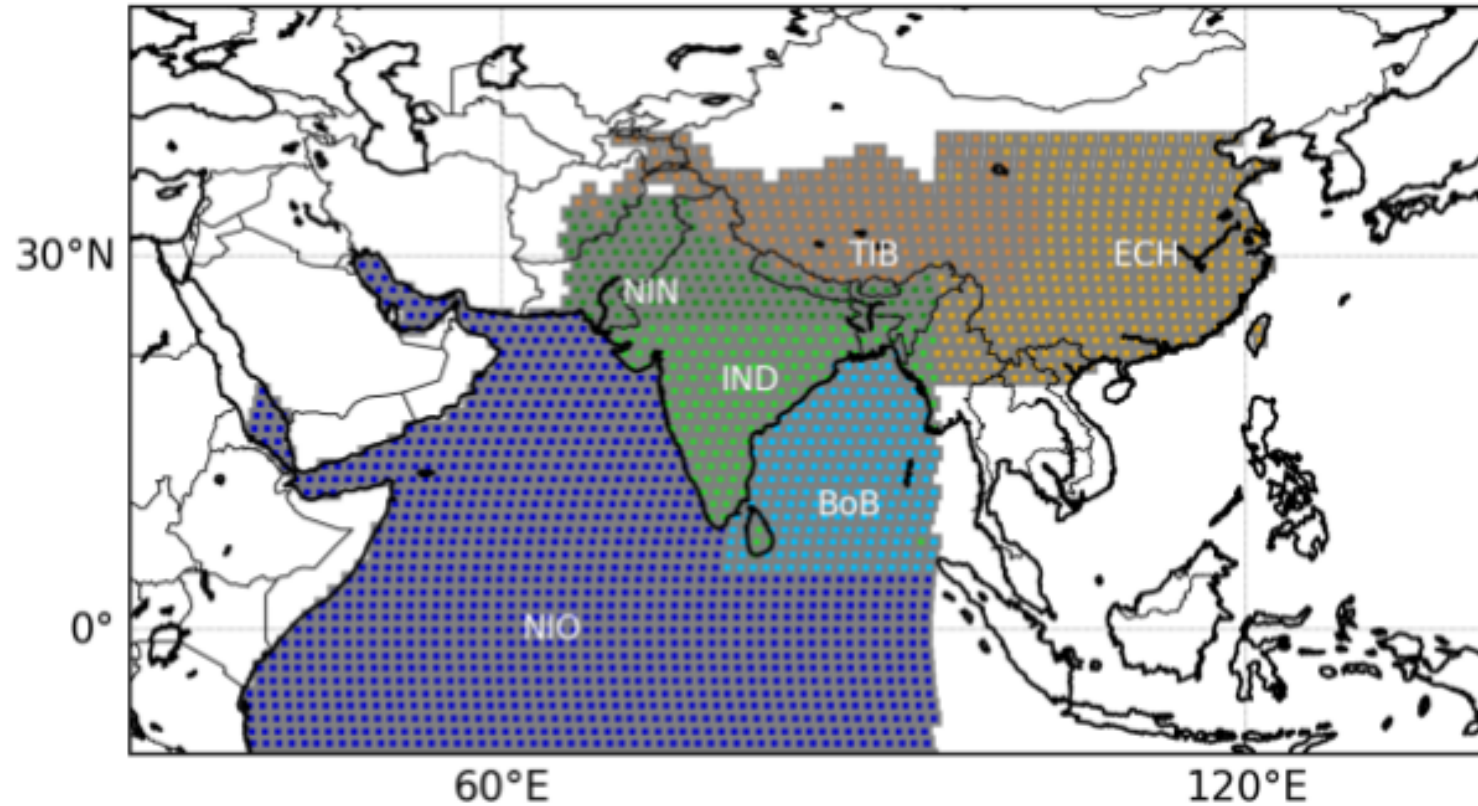
Summary



- The Asian summer monsoon provides a strong link between the near-surface pollution and the global atmosphere.
- Currently, there is a lack of observations in the northern hemisphere transition area at middle and high latitudes where mixing of shed eddies into the lower stratosphere takes place.
- The recent HALO campaign PHILEAS aimed to fill this important gap by dedicated aircraft observations from Anchorage/Alaska and Oberpfaffenhofen/Germany in summer and autumn 2023.
- From Anchorage pronounced filaments of ASM air could be observed.
- Several consecutive flights were made to study mixing of greenhouse gases (e.g. methane), ozone depleting substances and aerosols originating from the ASM region into the extratropical LMS.
- During a flight over the Eastern mediterranean sea and Jordan, we probably probed the bottom of the displaced AMA.

Many thanks to the whole PHILEAS team
for a great campaign !!!





Southasia (= marker for Asian monsoon air):

$$\Sigma \text{ IND} + \text{NIN} + \text{TIB} + \text{ECH} + \text{BoB} + \text{NIO}$$

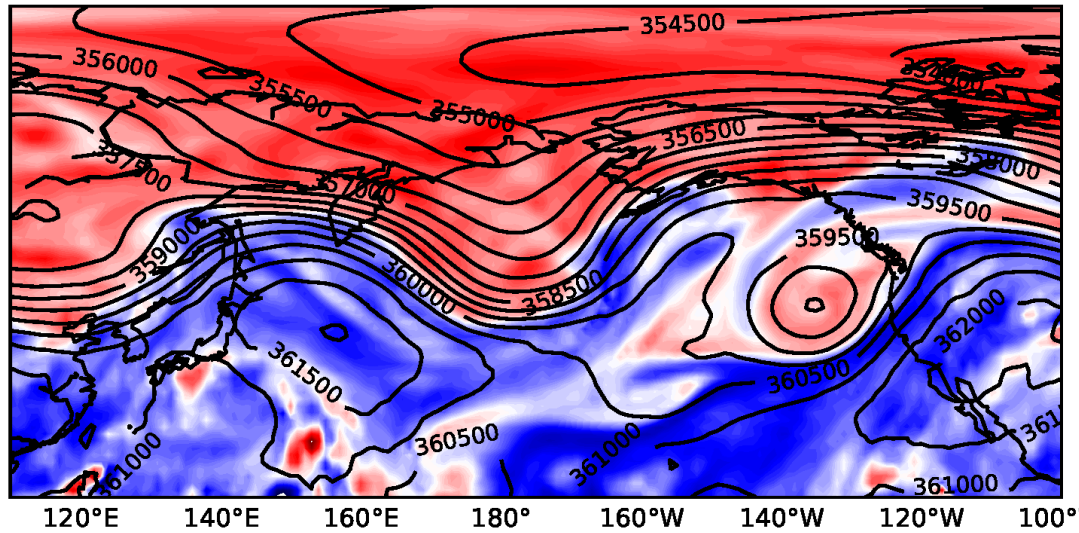
BoB	Bay of Bengal
ECH	Eastern China
IND	Indian Subcontinent
NIN	Northern India/Pakistan/Himalayan foothills
NIO	Northern Indian Ocean
TIB	Tibetan Plateau

Contact: b.vogel@fz-juelich.de

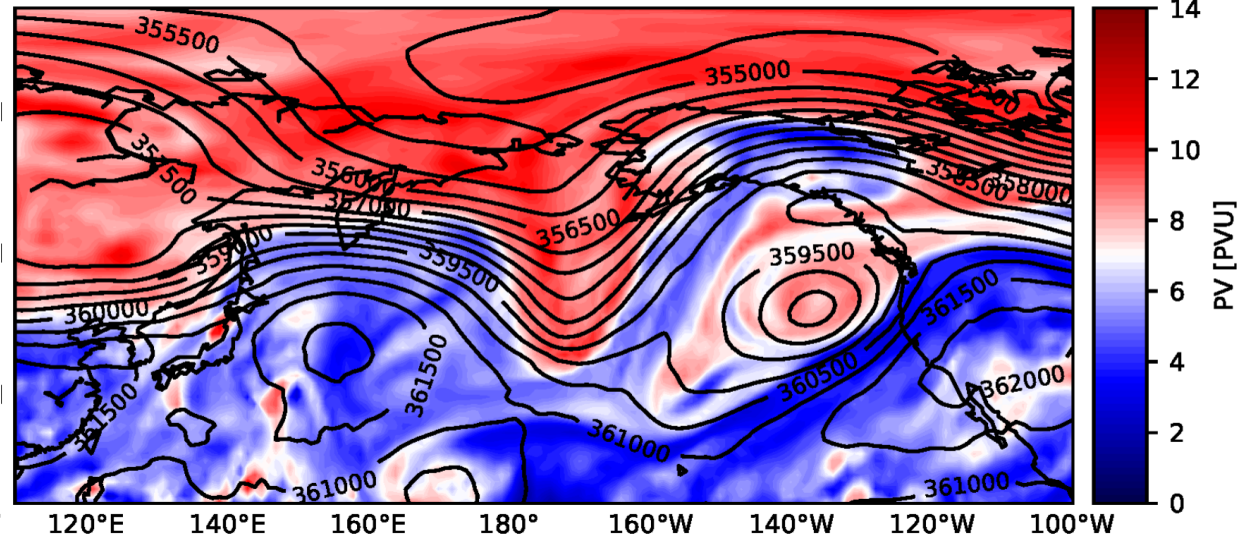
Eastward export of ASM air



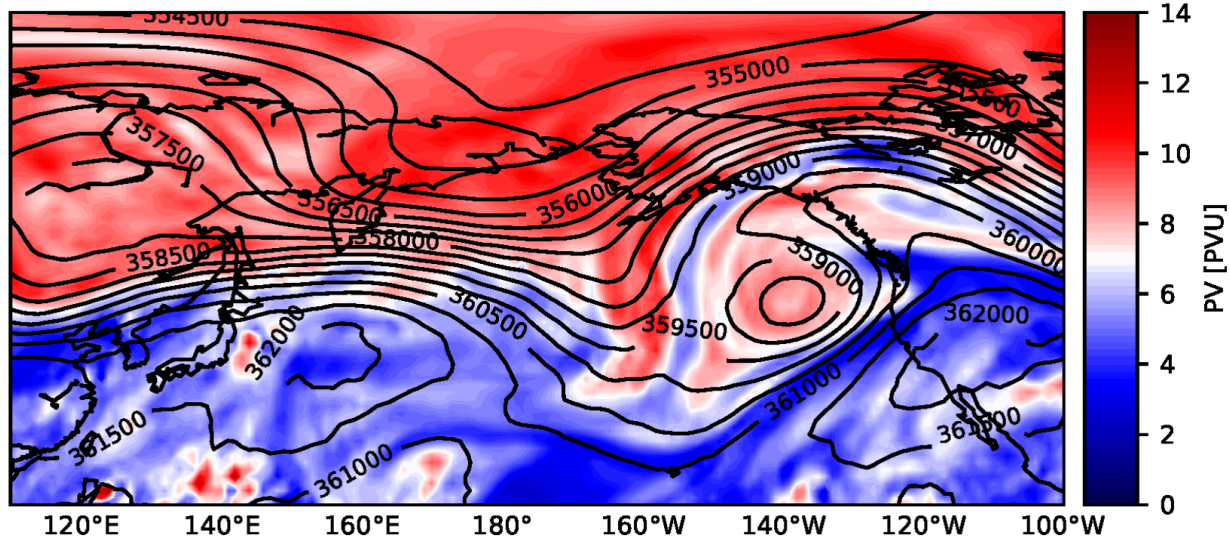
2023-08-26 00UTC (380K)



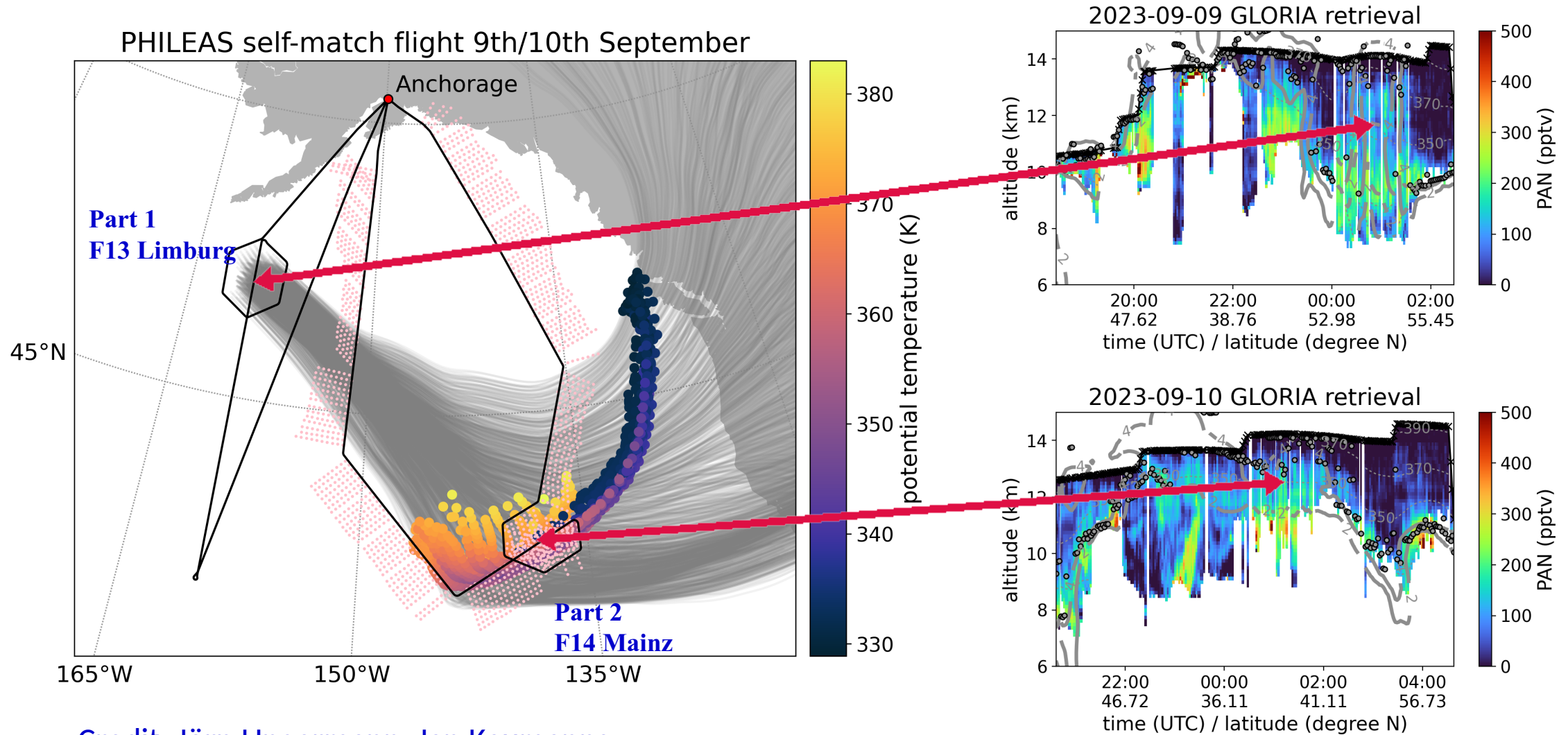
2023-08-27 00UTC (380K)



2023-08-28 00UTC (380K)



Probing eastward outflow of ASM air



Credit: Jörn Ungermann, Jan Kaumanns