MAX-PLANCK-INSTITUT FÜR CHEMIE

MAX-PLANCK-GESELLSCHAFT

Long-Term Observations of NMHCs from the IAGOS-CARIBIC Flying Observatory

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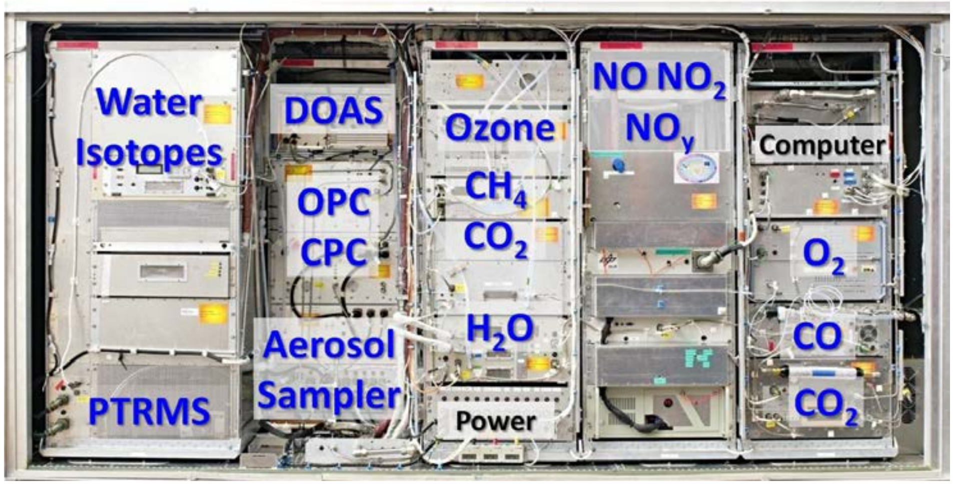
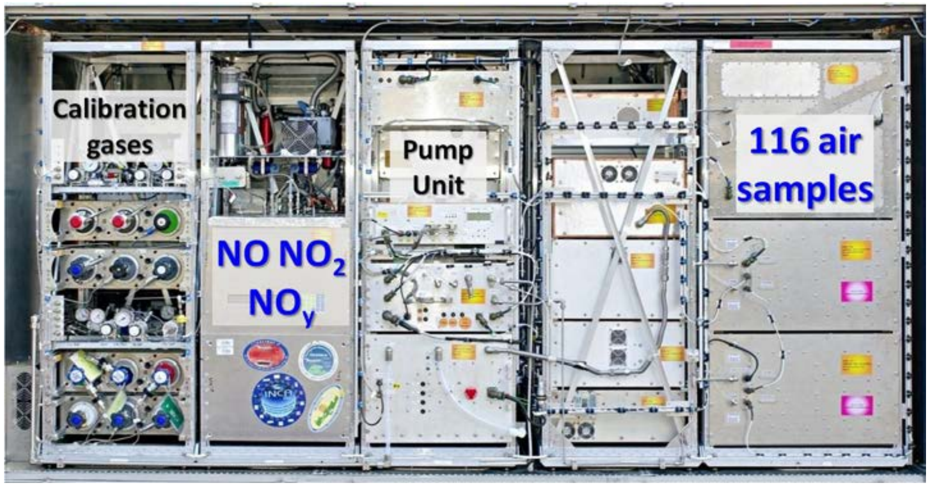
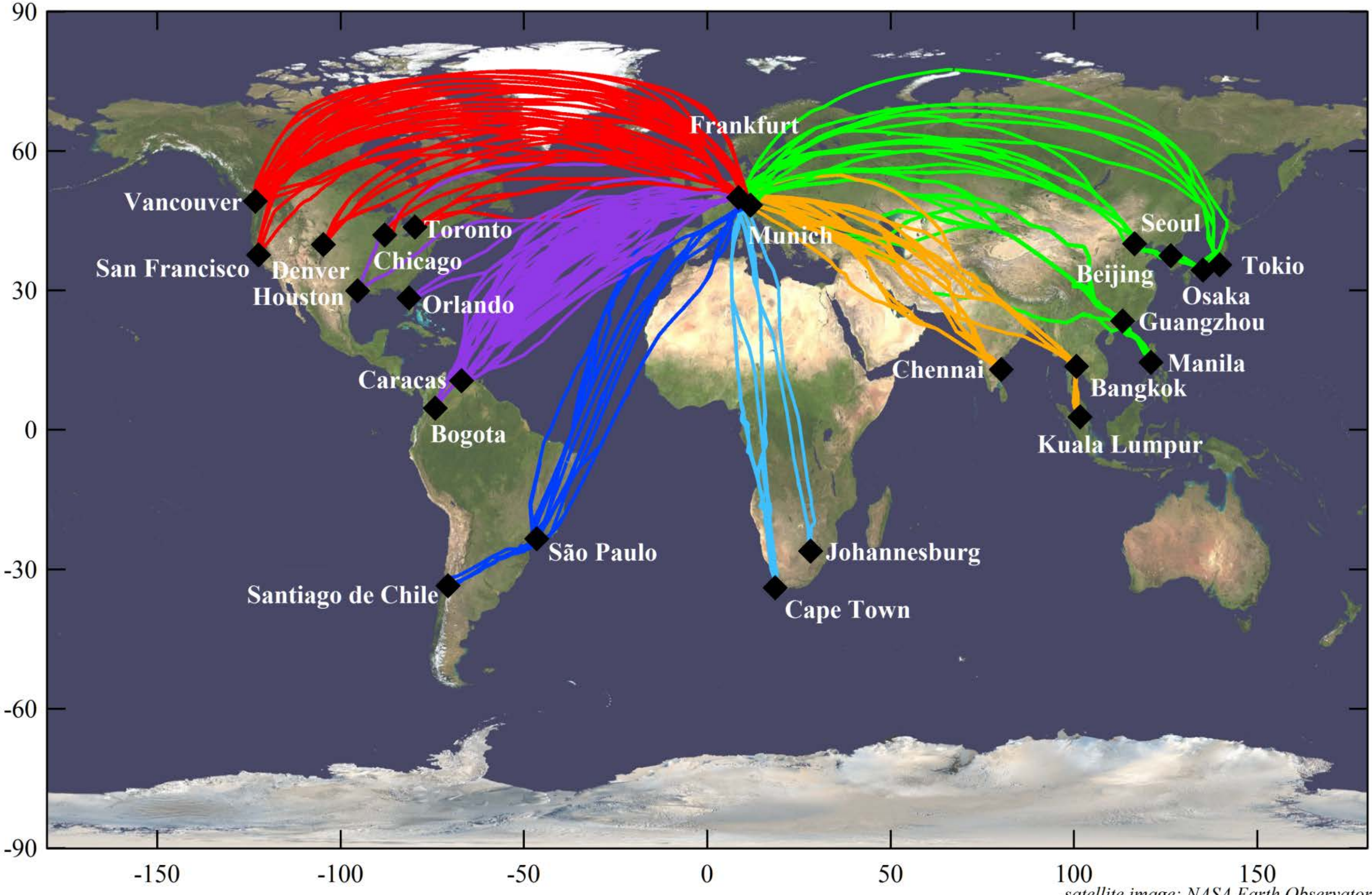
IAGOS-CARIBIC Observatory

- In service Aircraft for a Global Observation System - Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrument Container
- May 2005 – Present
- 2-6 flights per month





Where We Fly



satellite image: NASA Earth Observatory

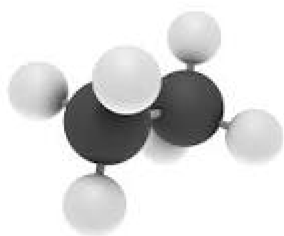
CARIBIC Whole Air Samples

- **116 WAS/month** *(Schuck et al., 2009 & Baker et al., 2010 [AMT])*
  - 28 glass, 88 stainless steel
  - GHGs, nonmethane hydrocarbons (NMHCs), halocarbons
- **Stratospheric influence:**
  - above the chemical tropopause *(Zahn et al., 2003 [JGR])*
  - N_2O >2σ below tropospheric trend *(Umezawa et al., 2014 [JGR])*
  - PV > 2 pvu, O_3 mole fraction > 150 ppb
- **3132 Tropospheric, 2944 Stratospheric Influence (May 2005 – April 2014)**

Main Players: Light NMHCs

ETHANE

C_2H_6

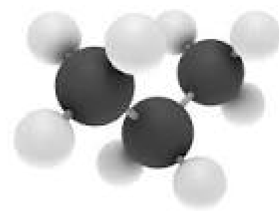


lifetime ~40 days

UT: always > LOD
LMS: always > LOD

PROPANE

C_3H_8

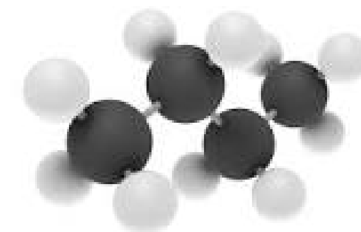


lifetime ~11 days

UT: always > LOD
LMS: 96% > LOD

BUTANE

$n\text{-}C_4H_{10}$



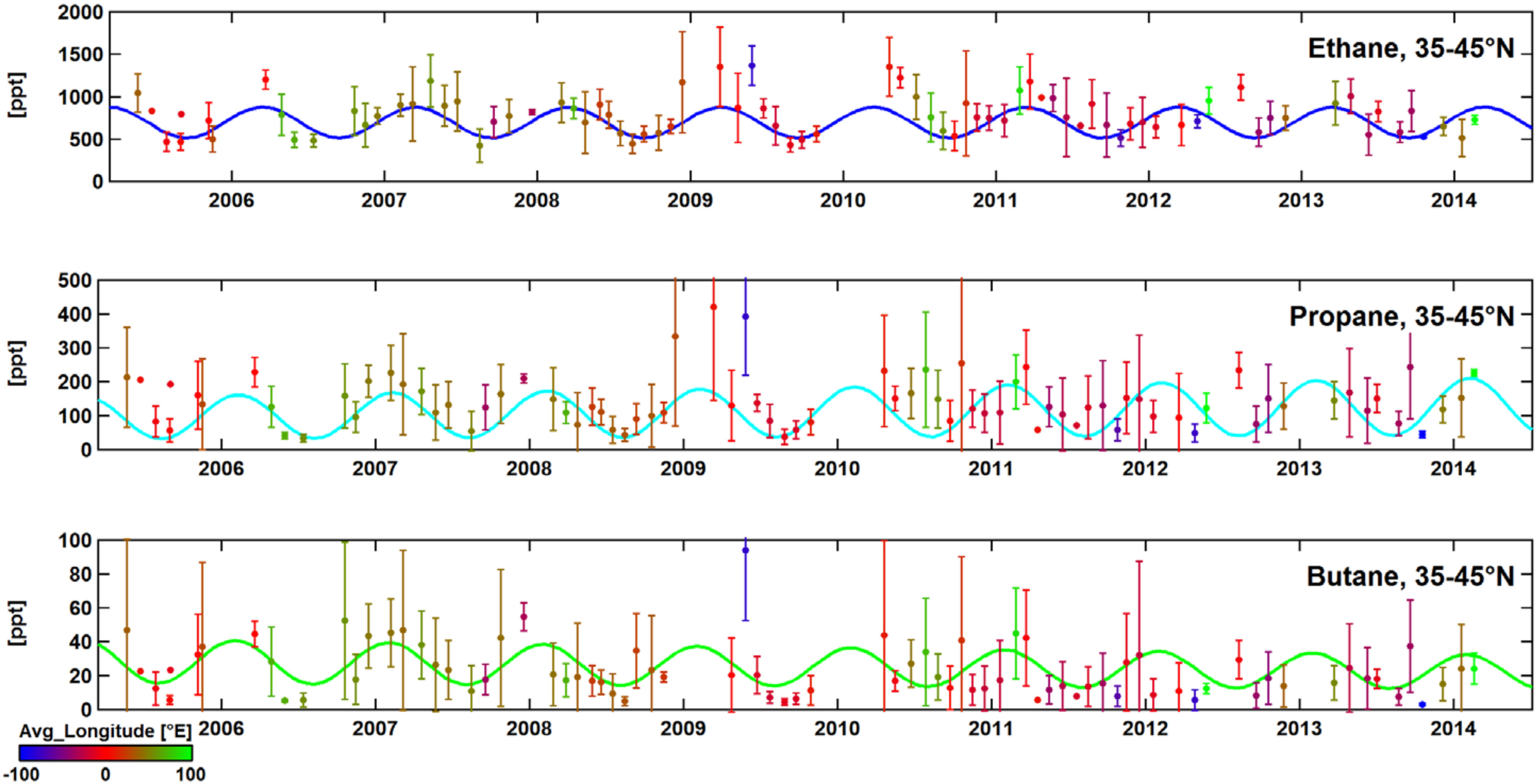
lifetime ~5 days

UT: 97% > LOD
LMS: 64% > LOD

Main sources are fossil fuel-related; small biomass burning source

Main sink is via reaction with hydroxyl radical (OH)

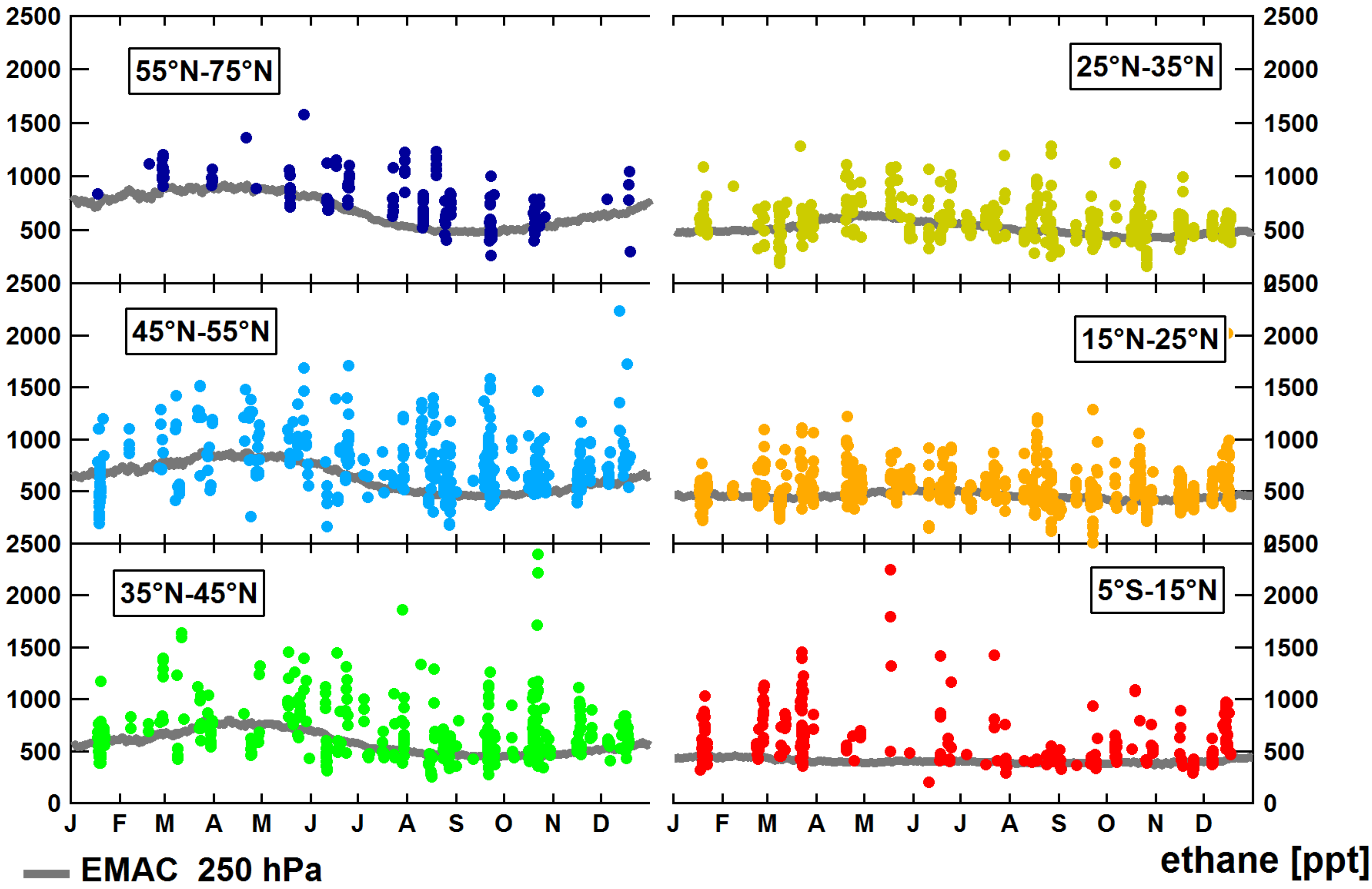
NMHCs in the UT



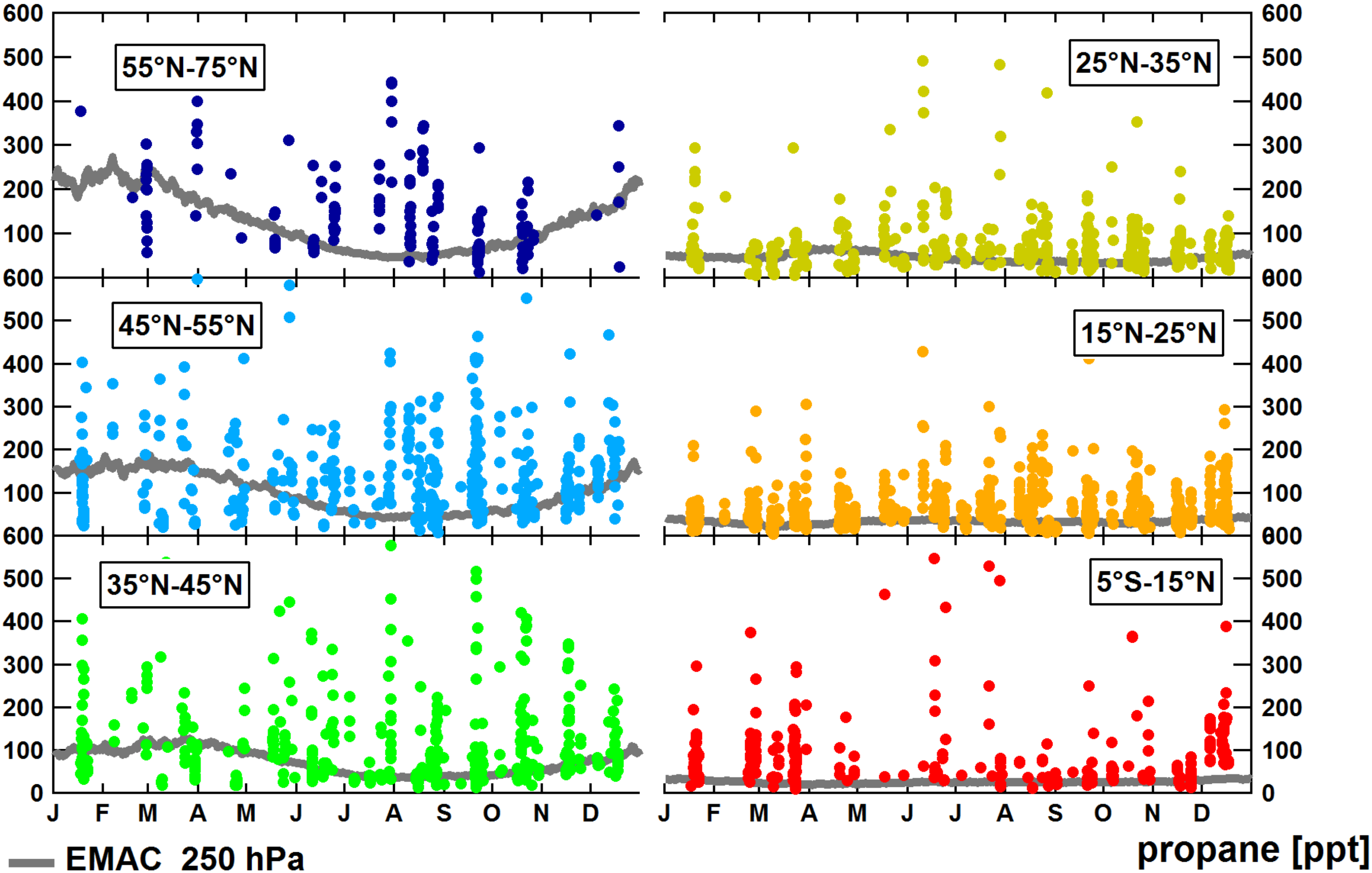
No statistically significant long-term trend

Highly variable (natural variability + varying flight route)

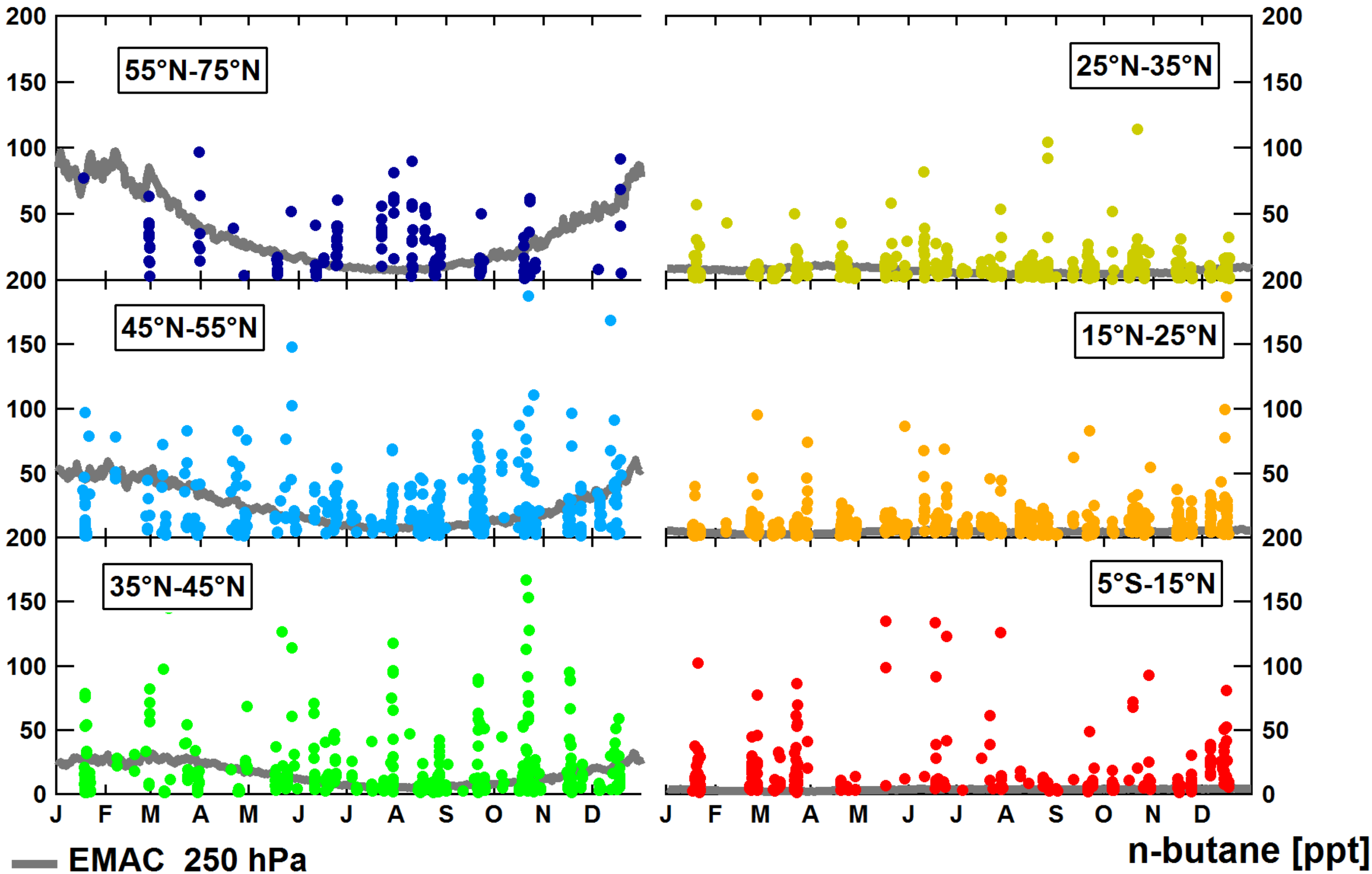
UT Distributions: Ethane



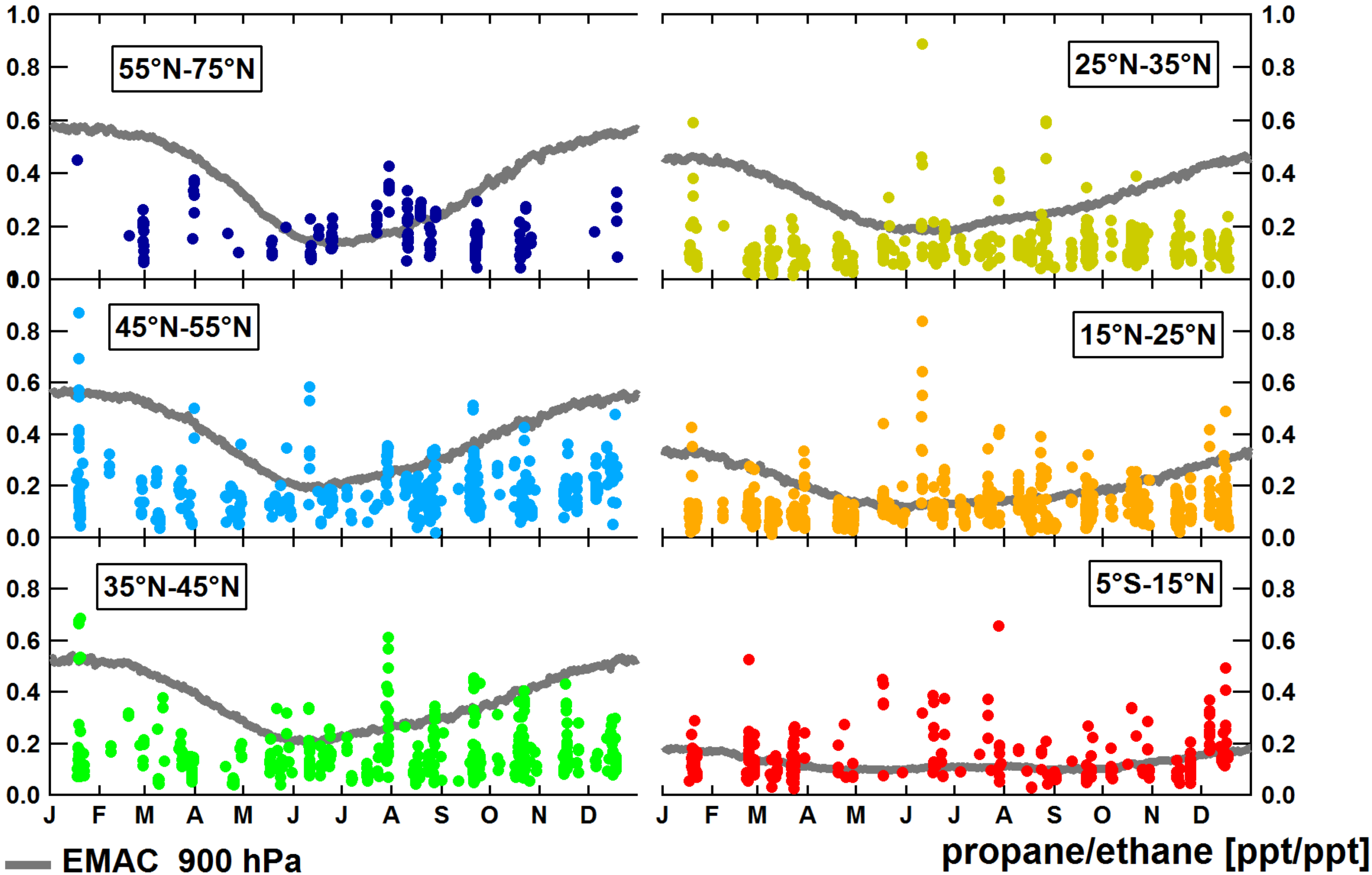
UT Distributions: Propane



UT Distributions: Butane



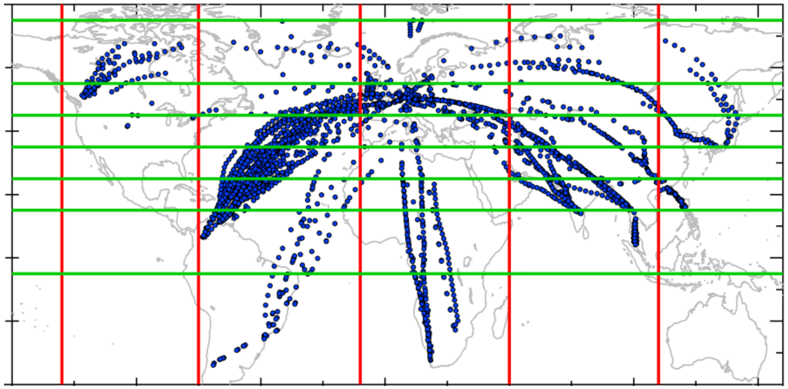
NMHC Ratios



55°N-75°N
45°N-55°N
35°N-45°N
25°N-35°N
15°N-25°N
5°S-15°N
1.0
0.8
0.6
0.4
0.2
0.0
J F M A M J J A S O N D
EMAC 900 hPa
propane/ethane [ppt/ppt]

UT "Surface Character"

- Use NMHC ratios to describe similarity of UT air to air at the surface below
  - UT ratios from CARIBIC
  - Surface ratios from EMAC simulations at 900hPa*



$$\textit{surface character} = \frac{([A]/[B])_{UT}}{([A]/[B])_{surface}}$$

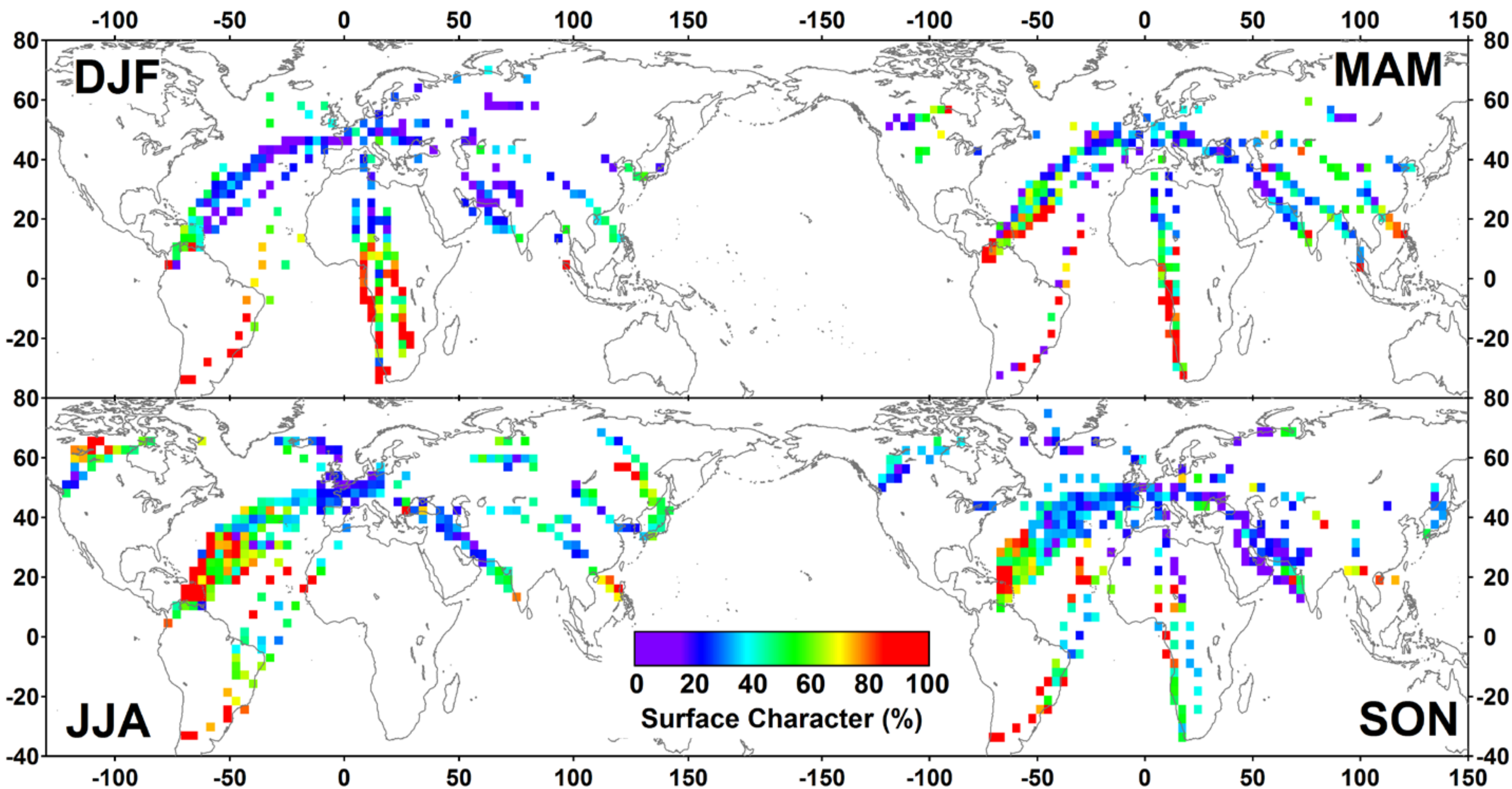
- Lower values: more processing/dilution
- Higher values: recent input of surface air

(different source ratio/ region)

*****T42L90MA, 24h DOY mean 01.2005-06.2008, VOC emissions: EDGAR 3.2FT2000 + GFED → suboptimal conditions used for "proof of concept"

(Jöckel et al., 2006 [ACP]; 2010 [GMD]; Riede et al., 2010 [GMD])

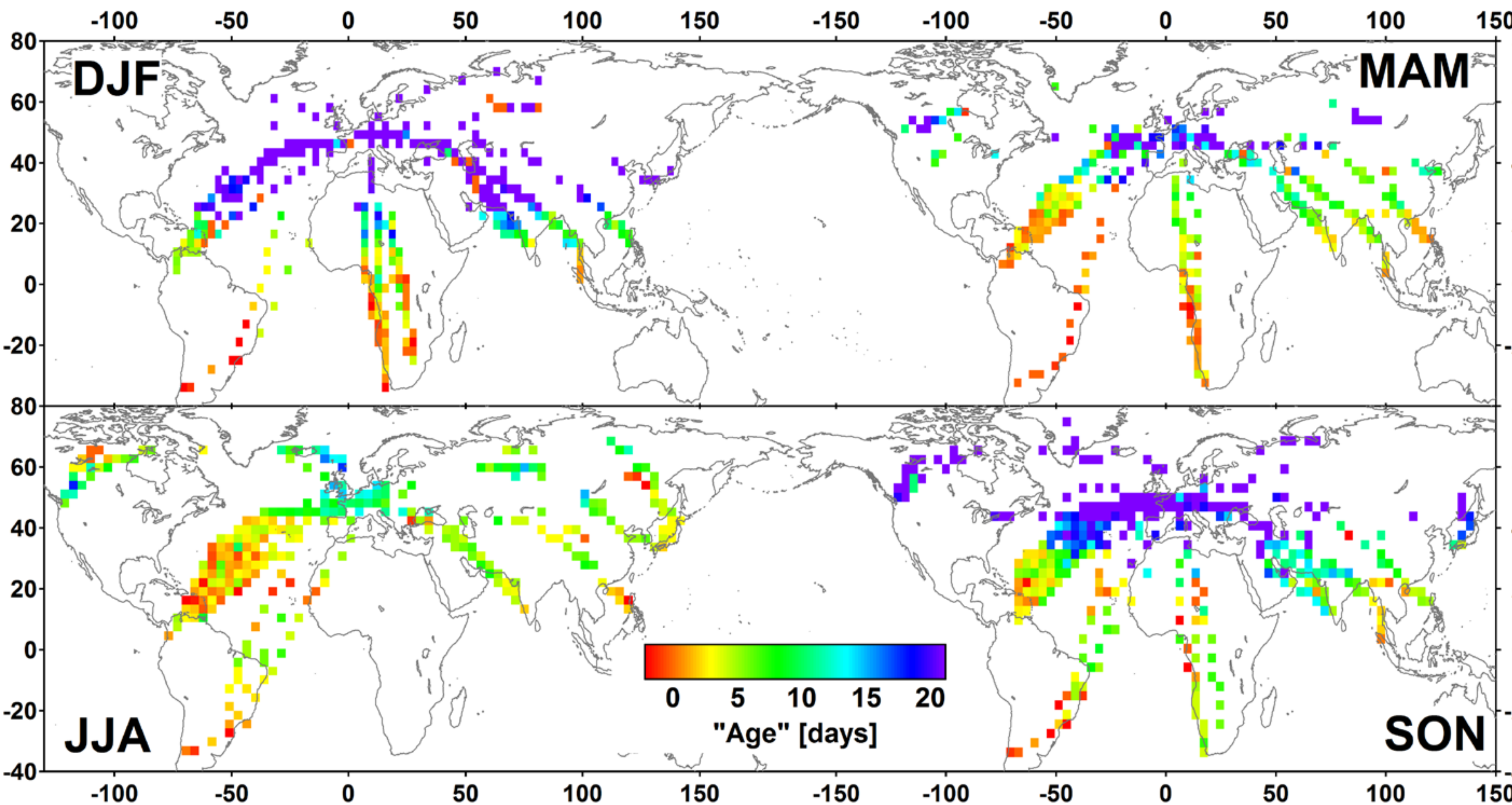
UT "Surface Character"



Air more resembles the surface moving to the equator

Greatest surface character in summer

Air Mass "Age"

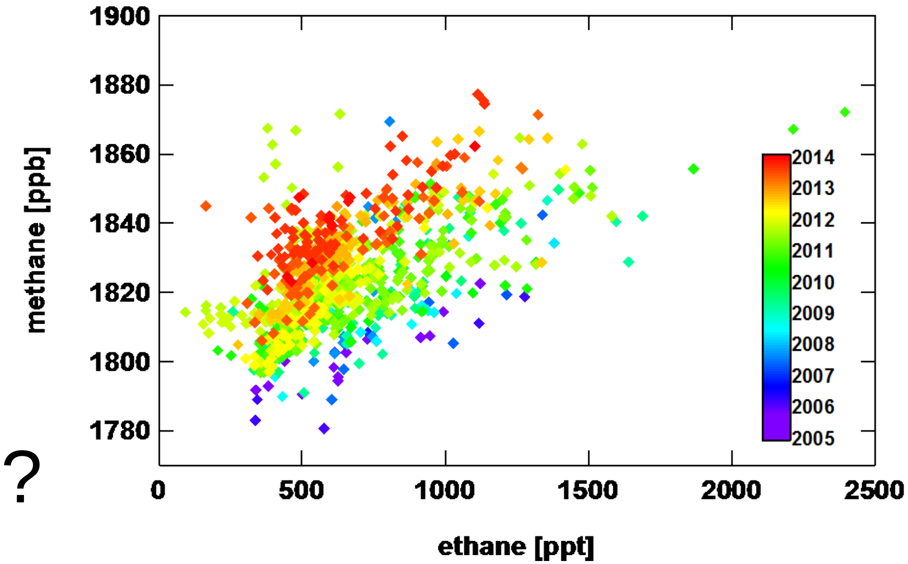


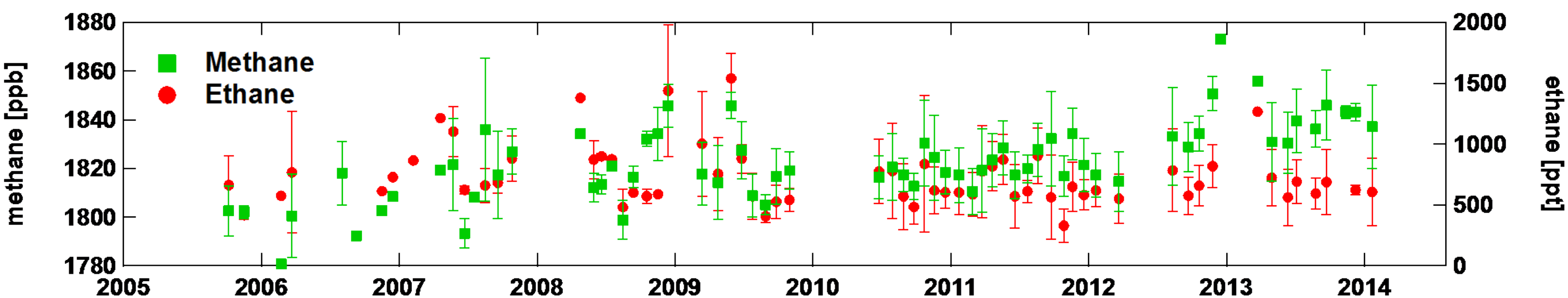
N-S gradient which is greater in NH winter and fall

Fairly "young" air in tropics; overall "younger" UT in summer

Methane and Ethane

- Co-emitted from fossil fuel related sources
  - Varying ratios depending on source type
- Relationship useful for understanding methane sources *(India, Africa)*
- Can we do the same to understand N. American sources over the Atlantic?





Summary and Outlook

- 10 years of CARIBIC NMHC data show no significant trends in the UT *(except for benzene)*
- VOC ratios highlight influence of transport from the surface on UT composition
  - Increased surface character moving to equator
  - Transport "hot spots" stand out (convection, WCBs?)
- Can we:
  - *use these hot spots to understand sources and emissions?*
  - *use CARIBIC NMHCs to understand shortcomings in EMAC convection schemes?*