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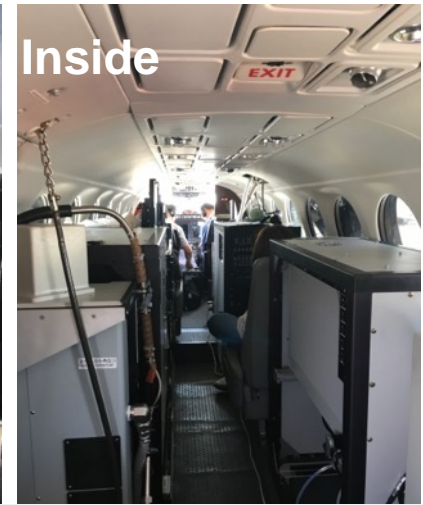
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A Airborne Measurements Platform in Korea

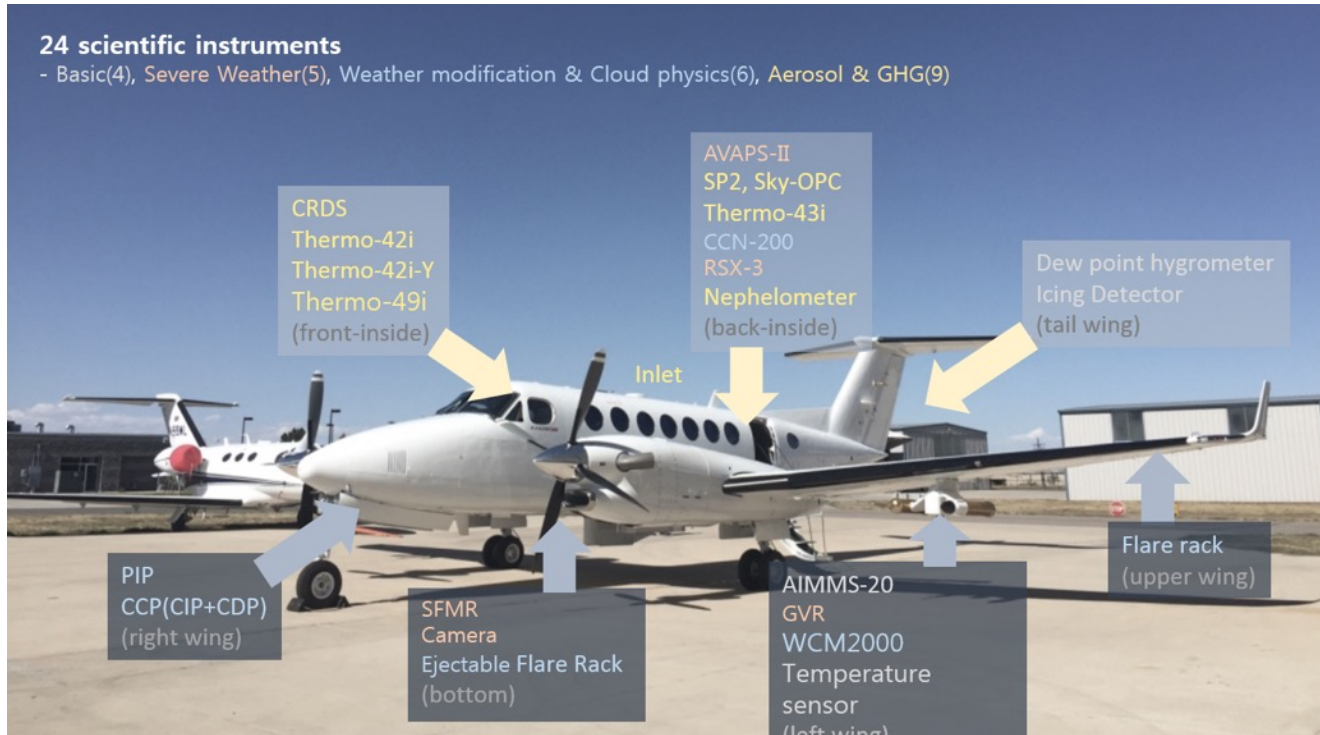
Research Aircraft in KMA: Kingair 350HW



- Started the regular airborne measurements performance since early 2018.
- Manufacturer: Beechcraft
- Engine category: Turbo-Prop
- Max altitude: 9.6 km with maximum payload
- Mission flight: 5.5 hrs with maximum payload
- Speed: 70-120 m/s
- Crews on Board: two for pilot, two for payload operator, one for scientist to manage the scientific missions
- Inlet: Mounted through an aluminum plate that replaces a circular window

A Airborne Measurements Platform in Korea

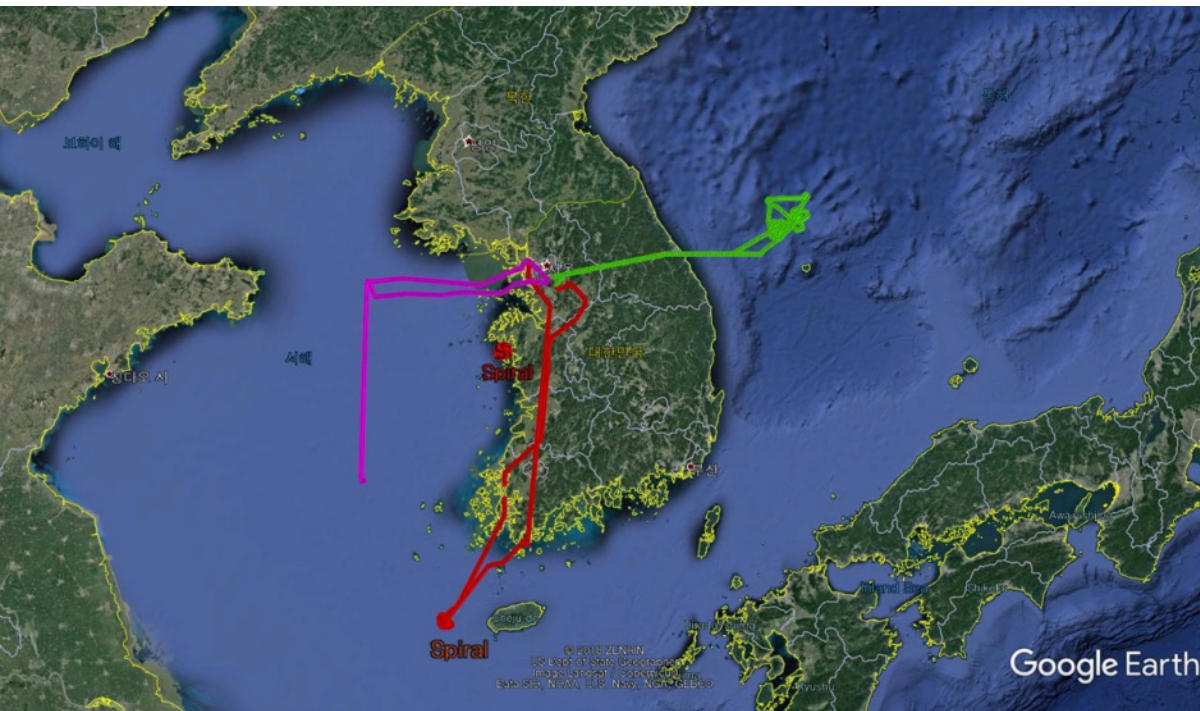
25 Instrumentations categorized four Scientific missions



1. Precedent Observations for **Severe Weather** (Heavy rain, snow, Typhoon etc.)
2. Observations of Aerosol, Reactive gases (O_3 , SO_2 , NO_y , NO_x so on.)
3. Monitoring (micro-)Physical Processes in Cloud and Precipitation system.
4. Observations of GHGs (CO_2 , CH_4 , CO , H_2O) *with CRDS -2401m, which have been optimized for airborne measurement*

Airborne Science Missions Overview

Typical flight track for KMA Science missions



- CO₂, CH₄, CO, H₂O were collected with 1 second interval through GHGs' main mission and two missions.
- About 10 times flight missions per month.

GHGs' Main missions:

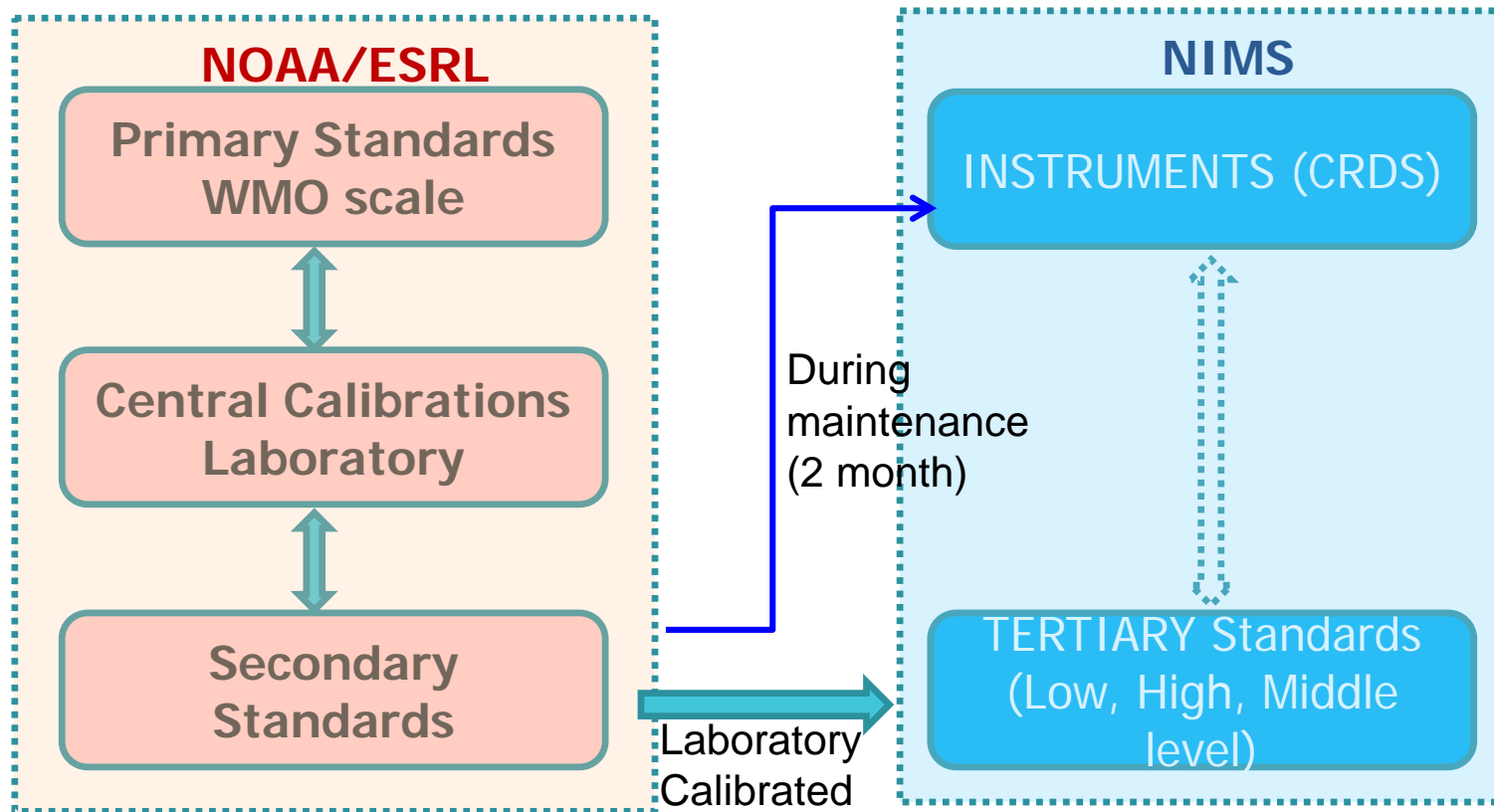
- ✓ **GHGs observation mission:**
 - **Vertical profile measurements to coincide with GOSAT overpasses:** in GAW regional stations (AMY, GSN). (0.5-9.5 km)
 - **Horizontal transections:** Low altitude survey from North to South of Korea to monitoring emission plume of GHGs

Other missions:

- ✓ **Air quality monitoring mission:**
 - Aerosol and reactive gases (e.x.SO₂,O₃,Noy etc) along Western sea route
- ✓ **Precedent Observation of Severe Weather in East sea**

A Regular Airborne GHG Observation in Korea

QA/QC: GHGs Calibration Strategy



Coordination at international level

- Placing data on **common calibration scales** with comparable precision, accuracy and measurement frequency

A Regular Airborne GHG Observation in Korea

QA/QC: Total Uncertainty Analysis

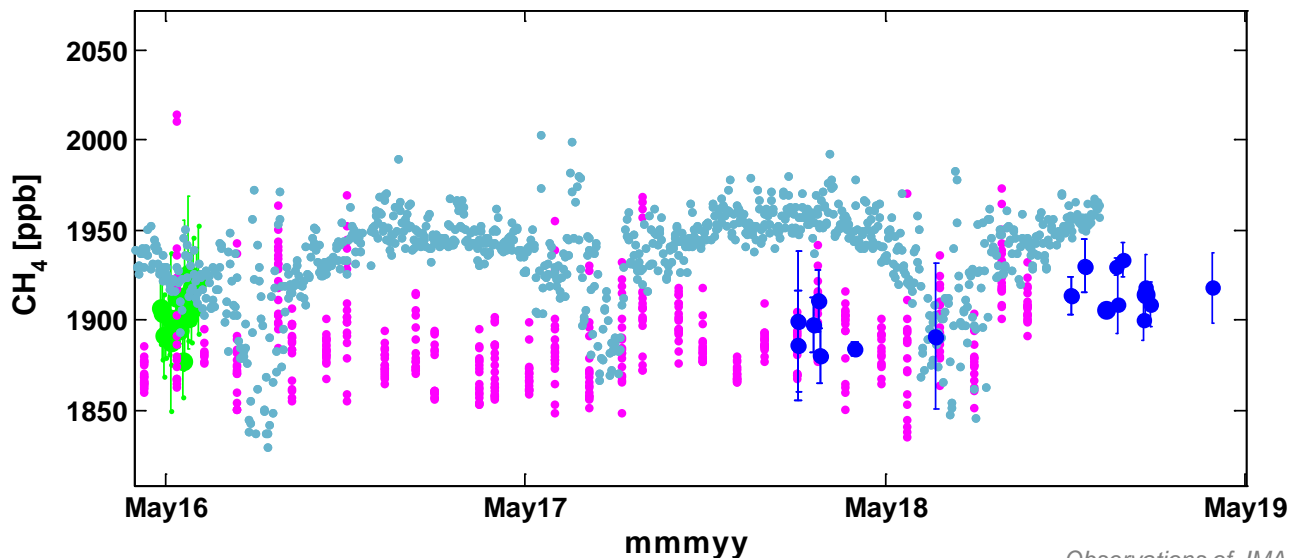
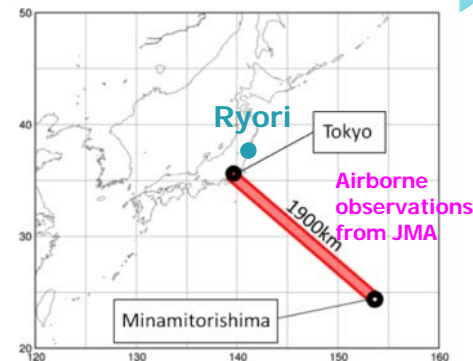
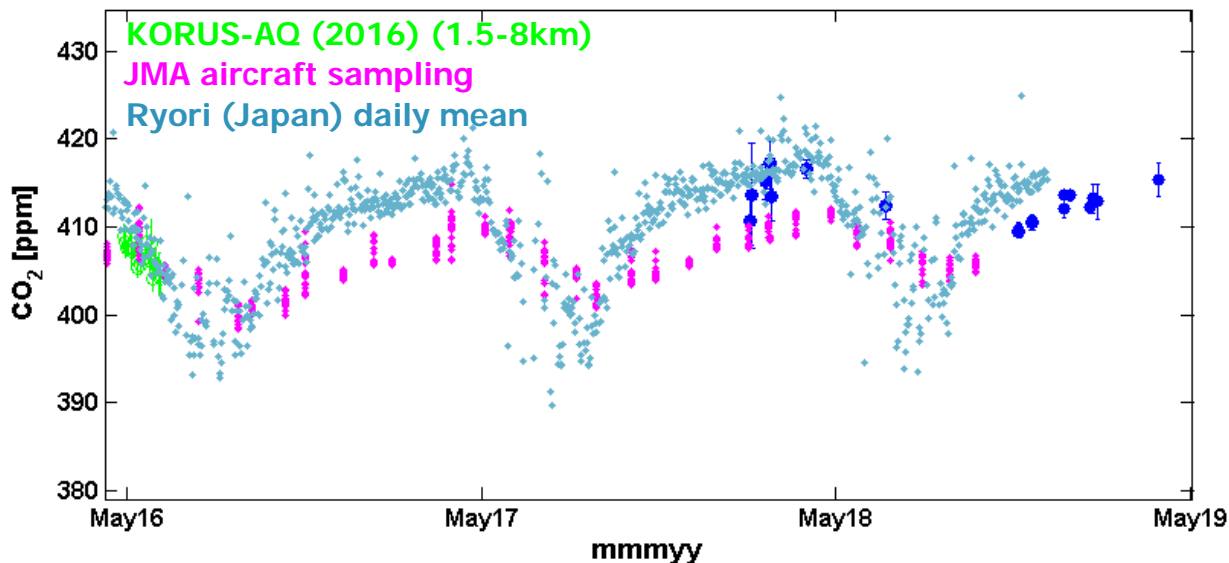
Uncertainties	CO ₂ (ppm)	CH ₄ (ppb)	CO (ppb)
Accuracy of NOAA Standard	0.21	3.6	0.9
Instrument Precision (1- σ)	0.02	0.1	2.2
£ Repeatability simulated in-flight condition	0.03	0.5	3.0
Water Correction (Rella et al., 2013)	0.05	0.01	2.0
Overall Uncertainty (1-σ) KMA airborne CRDS	0.22	3.6	4.3
§ NOAA /ESRL Uncertainty	0.15	1.4	5.0

£ The repeatability test were performed in laboratory to simulate flight conditions over the pressure range of 320-1000 hPa and calculated the average one-sigma standard deviation during 3 hour of standard gas sampling.

§ The NOAA/ESRL aircraft observation uncertainty referred to Anita et al., (2010).

Airborne GHG Observation: Time Series

KMA aircraft measurements (1.5-8km)



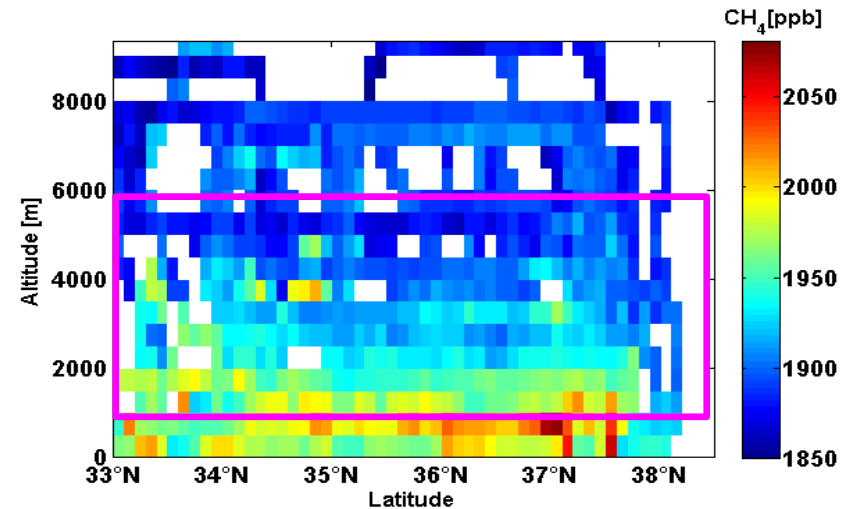
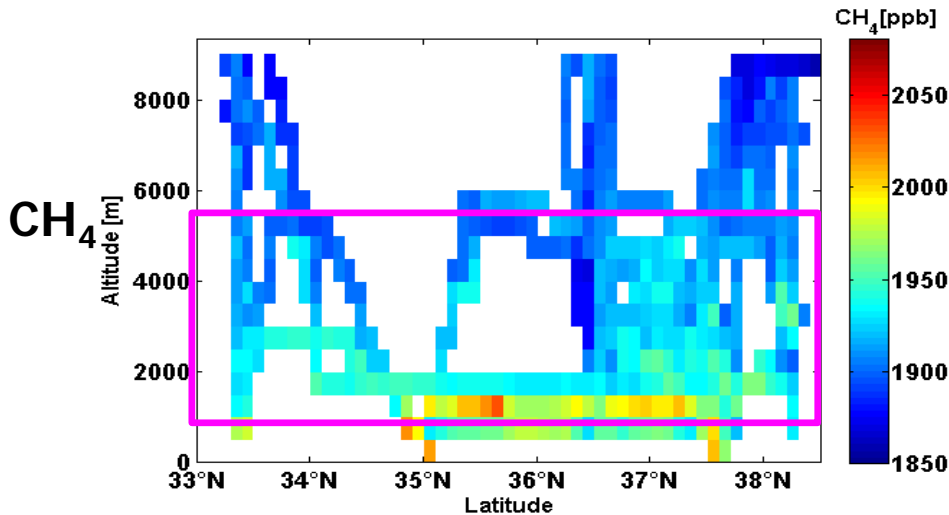
- ✓ CO₂ concentrations in Free troposphere (FT) are comparable with that observed in GAW stations.
- ✓ CH₄ concentrations show low level than those from ground GWA stations, comparable with flask airborne data observed in the north western pacific region.
- ✓ Wide range of CH₄ also shows in free troposphere from aircraft data observed not only above Korea but also above western pacific.

Airborne GHG Observation : Spatial distributions over Korea

KMA missions: Feb. 2018-Apr. 2019

vs.

KORUS-AQ campaign: May-June 2016

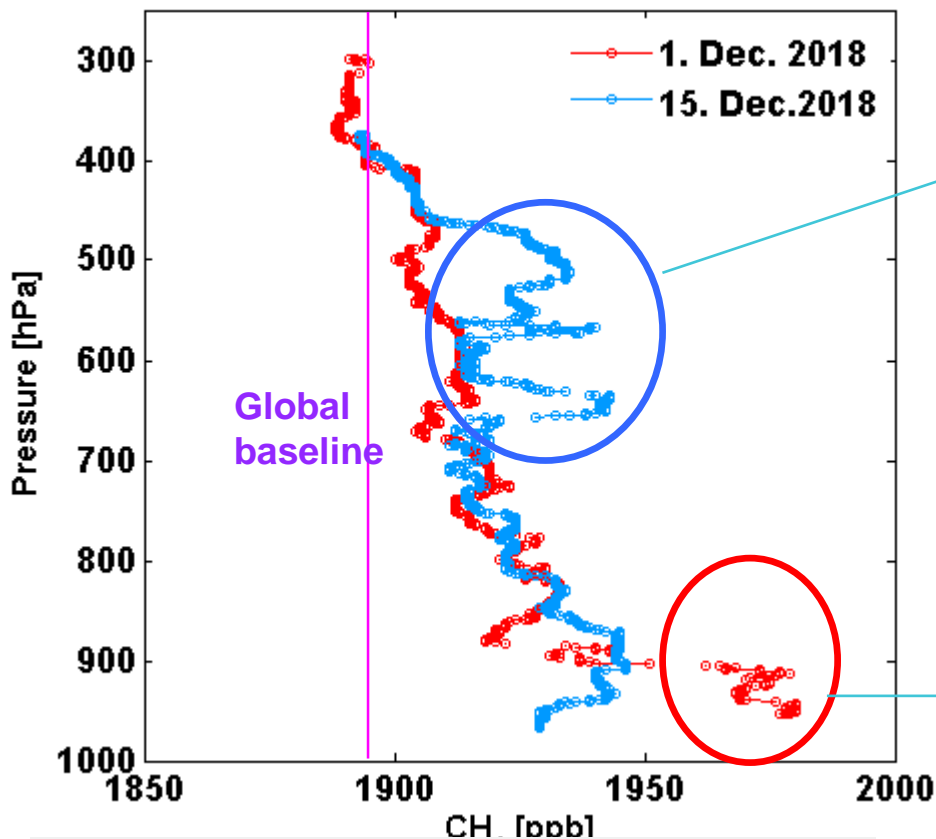


- Latitudinal gradient of CH₄ below PBL height, high concentrations in North regions where is populated with urban emissions such as Seoul megacity.
- Vertical distributions: frequent and high variable concentrations observed in free troposphere, that signature is more clear that observed during KORUS !
- It is like to be due to the transport of CH₄ in middle troposphere.

Airborne GHG Observation: Vertical profile at AMY station

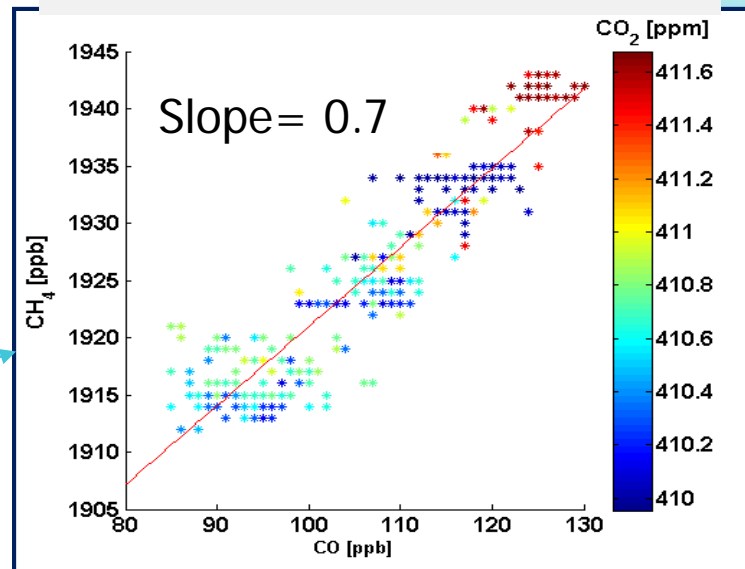
Case of Vertical distributions on 1,15 Dec. 2018

1885 ppb

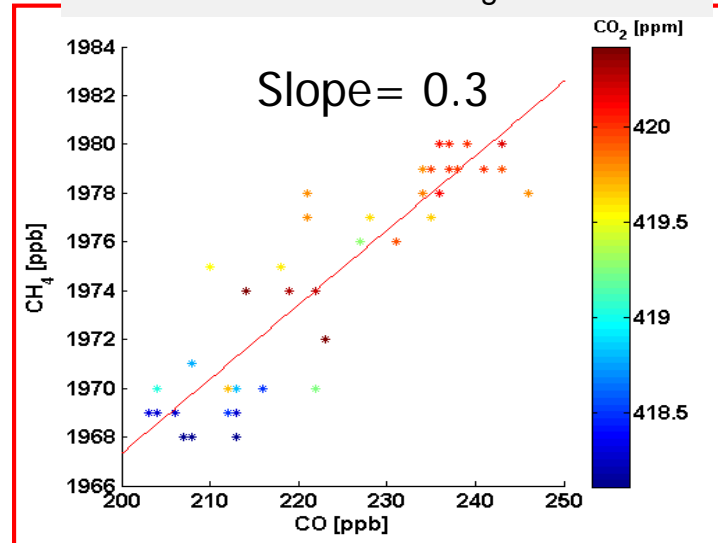


CH₄/CO ratio indicate that high CH₄ pollution plume occurred below PBL and above PBL in middle troposphere were affected different sources and/or regions

Observations above 500-700 hPa on 15. Dec.



Observations below PBL height on 1. Dec.

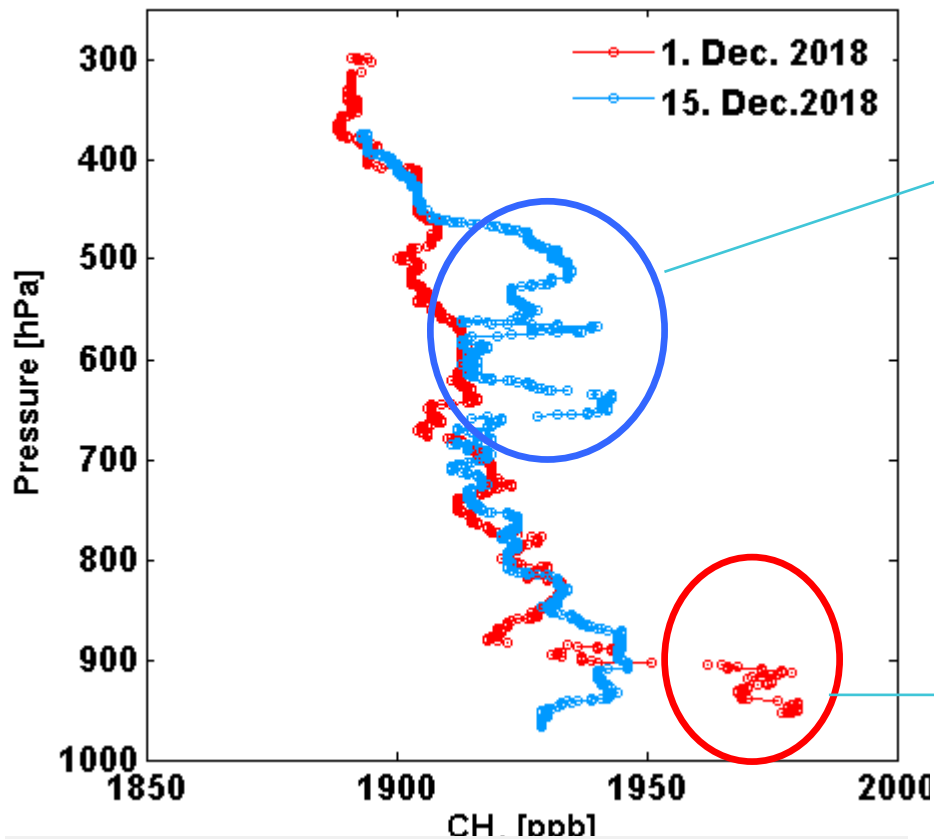


CH₄ vs. CO colored with CO₂ 9

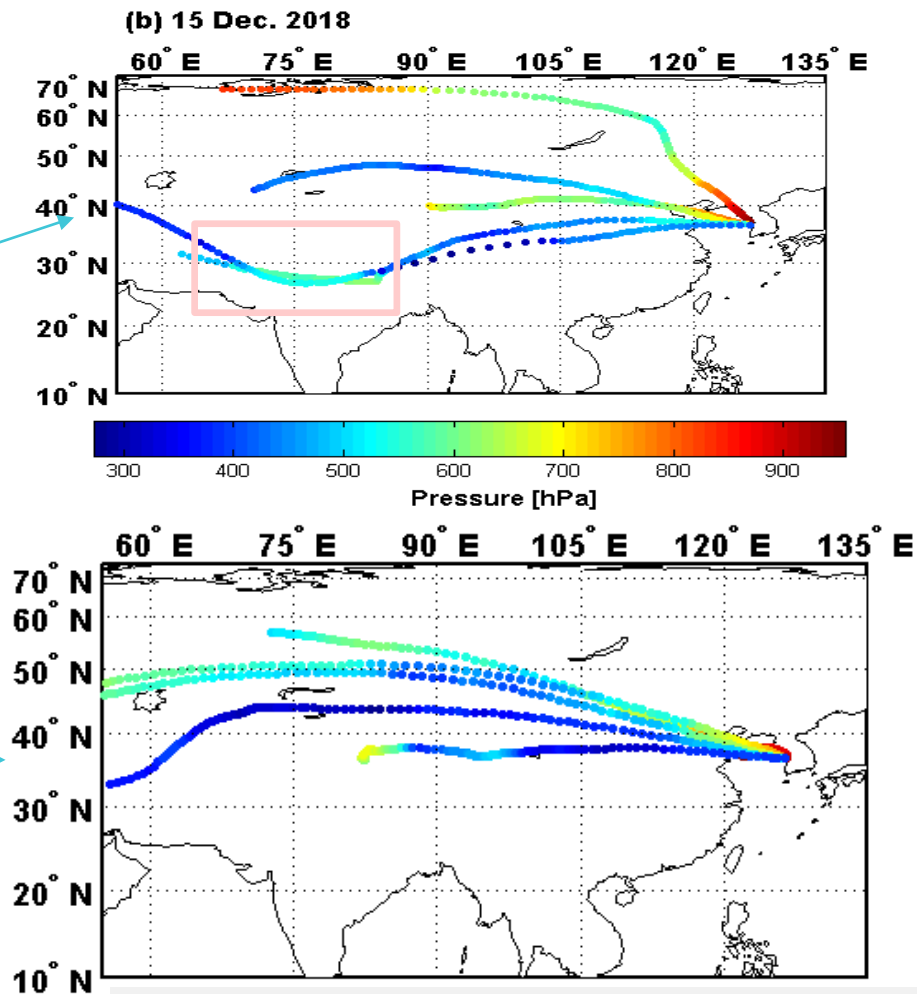
Airborne GHG Observation: Vertical profile at AMY station

Case of Vertical distributions on
1,15 Dec. 2018

Air-mass Back-trajectory



High CH₄ plume:
Below PBL: China and Local effect
Middle troposphere: Even from Indian regions via
free-tropospheric long-transport



This also why the spatial concentration in FT
are more variable, especially for CH₄

Summary

- A new **KMA Airborne platform** were established and started the regular GHGs observations in KOREA since 2018.
- Assessment of GHGs data quality by combination of laboratory test.
- Analysis of time-series and vertical distributions of GHGs over Korea.
 - ✓ The high GHGs plume in PBL height → likely affected FF sources from China (Shandong),
 - ✓ but the high plume intrusion in middle troposphere → Could be affected more broad regions such as North Indian region, densely populated with agricultural, industry emissions.
- **Future objectives are:**
 - ✓ **Validating satellite observations** in different regions after more vertical profile are collected.
 - ✓ Quantifying **CO₂, CH₄ emissions** in point and area sources through an **aircraft-based** mass balance and inversion approach.

Picture taken in Dec. 2018



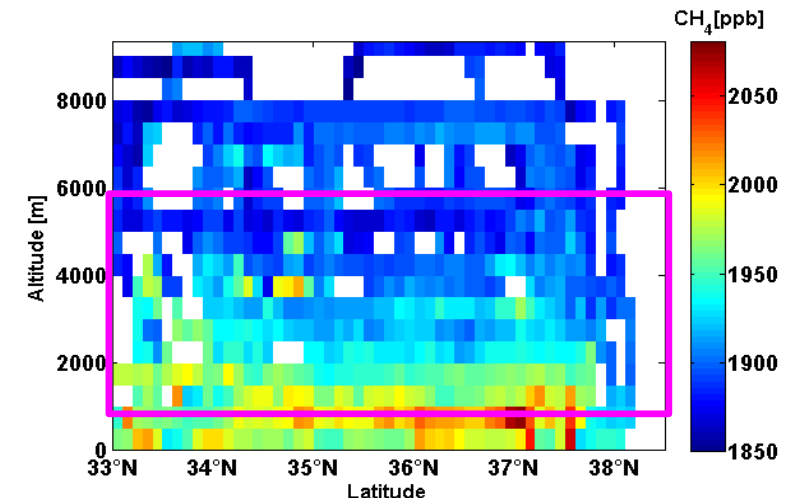
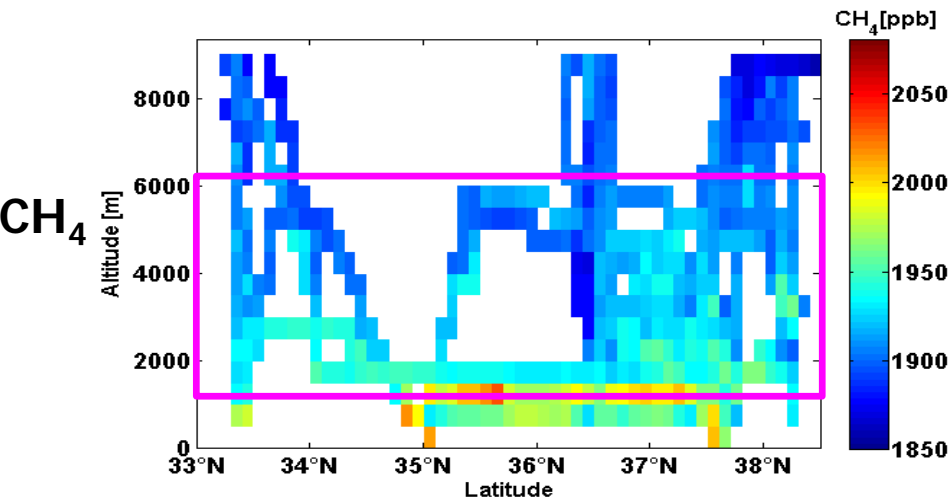
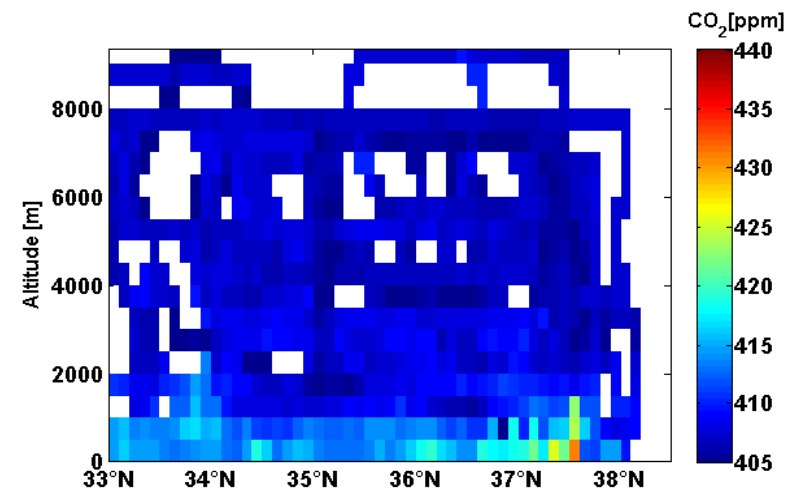
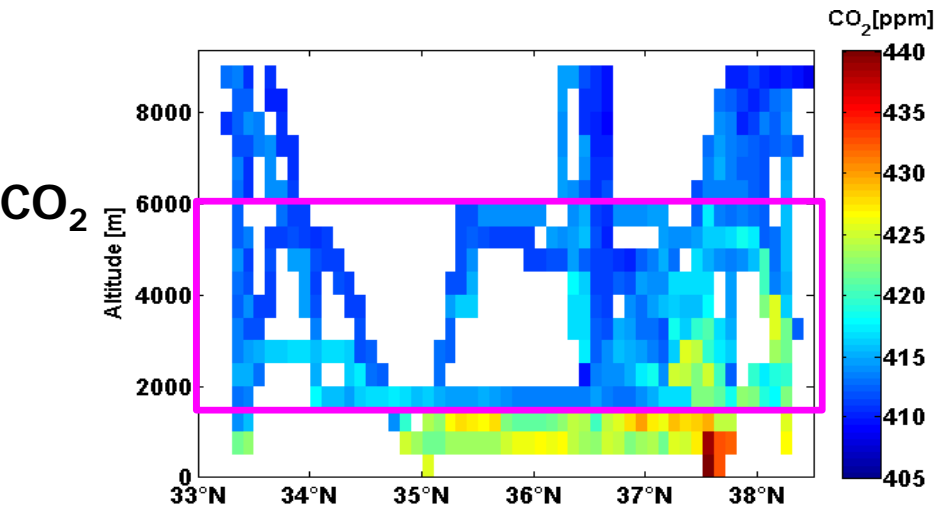
Thank you

Airborne GHG Observation : Spatial distributions over Korea

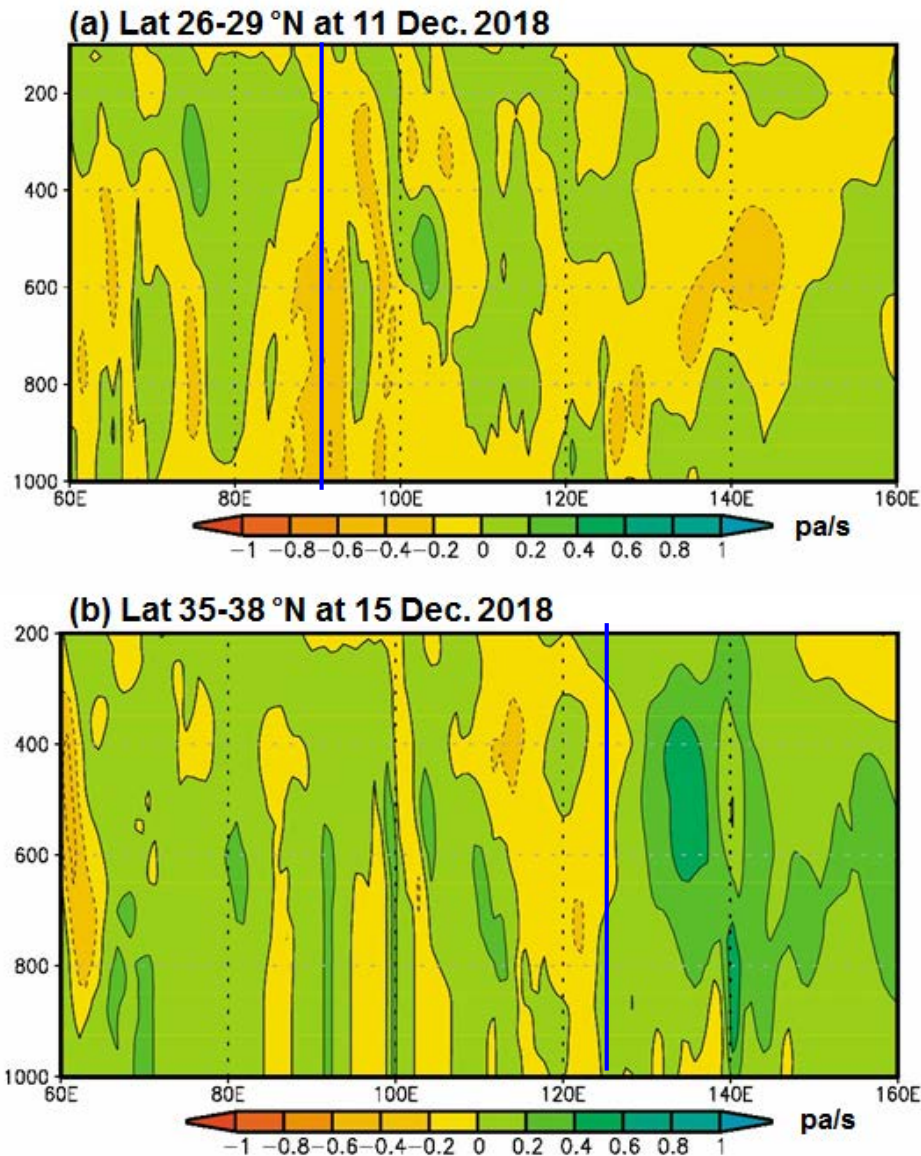
KMA missions: Feb. 2018-Apr. 2019

vs.

KORUS-AQ campaign: May-June 2016



Vertical distributions of CO₂ and CH₄: high variable concentrations in free troposphere !



ECMWF ERA-Interim derived vertical wind (pa/s) on UTC 6:00 at two latitude sector and two days (a) at 26-29°N at 11 Dec. and (b) at 35-38°N at 15 Dec. 2018, respectively.