

Korea's Integrated GHG Observing Network and its role in WMO G3W

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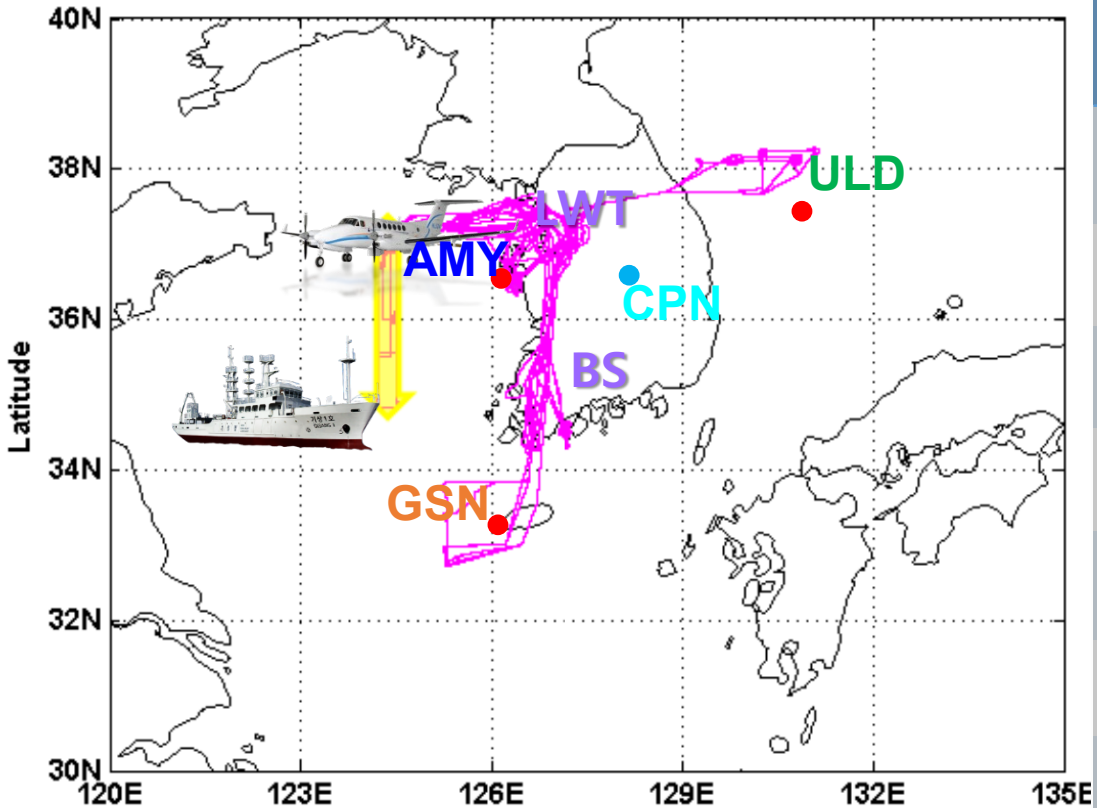
Background

WMO G3W aims to produce global-scale top-down gridded flux estimates, where accurate satellite retrievals — underpinned by high-quality in situ observations — are essential.

Context

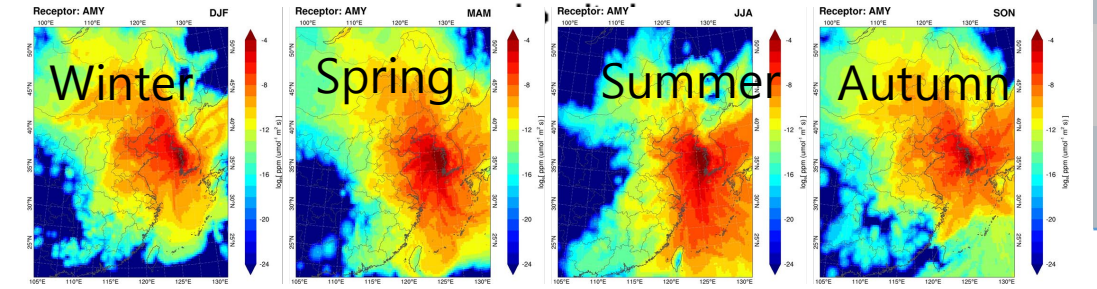
1. GHGs observing network of KMA
2. Top-down approach using measurement data
3. Plan of linkage to G3W

Korea's Multi-Platform GHG Observing Network



Platform	CO ₂	CH ₄	N ₂ O	SF ₆	CFCs	δ ¹³ CO ₂	δ ¹³ CH ₄
AMY (in situ)	★ (1999)	★ (1999)	★ (1999)	★ (2007)	★ (1999)	● (Flask, 2014) ★ (2024)	● (Flask, 2014) ★ (2025)
AMY (TCCON, total column)	★ (2014)	★ (2014)	★ (2014)				
GSN (in situ)	★ (2012)	★ (2014)	★ (2012)	★ (2017)			
ULD (in situ)	★ (2014)	★ (2018)	★ (2019)	★ (2017)			
LWT (tall-tower)	★ (2023)	★ (2023)					
BS (tall-tower)	★ (2024)	★ (2024)					
NARA (Aircraft)	● (2018)	● (2018)				● (δ ¹³ C)**	● (δ ¹³ C)**
Gisang (Vessel)	◎ (2021)	◎ (2021)					
							<i>From 2026, to cover all seas around Korea</i>
CPN (in situ)	★ (2024)	★ (2024)					

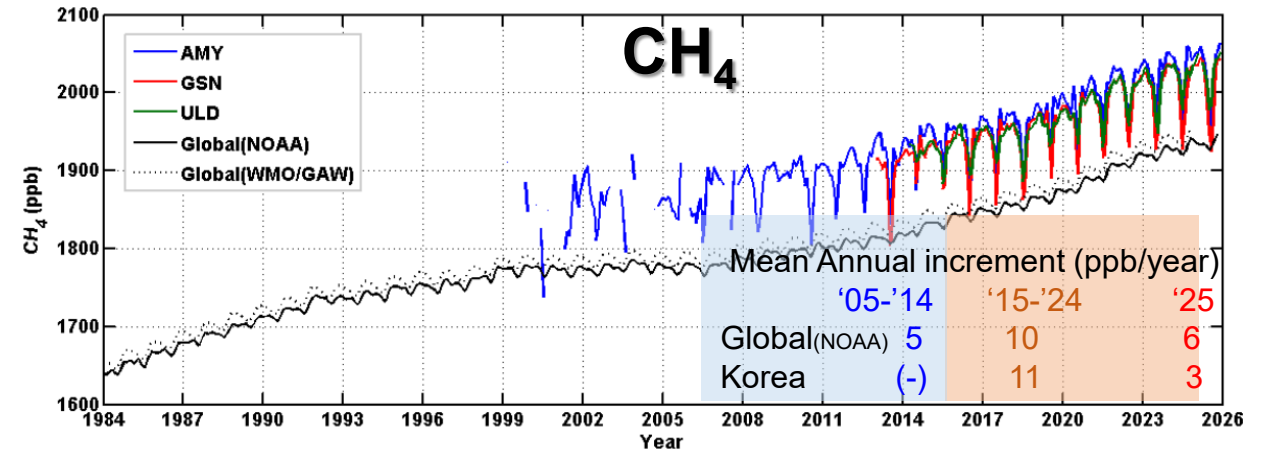
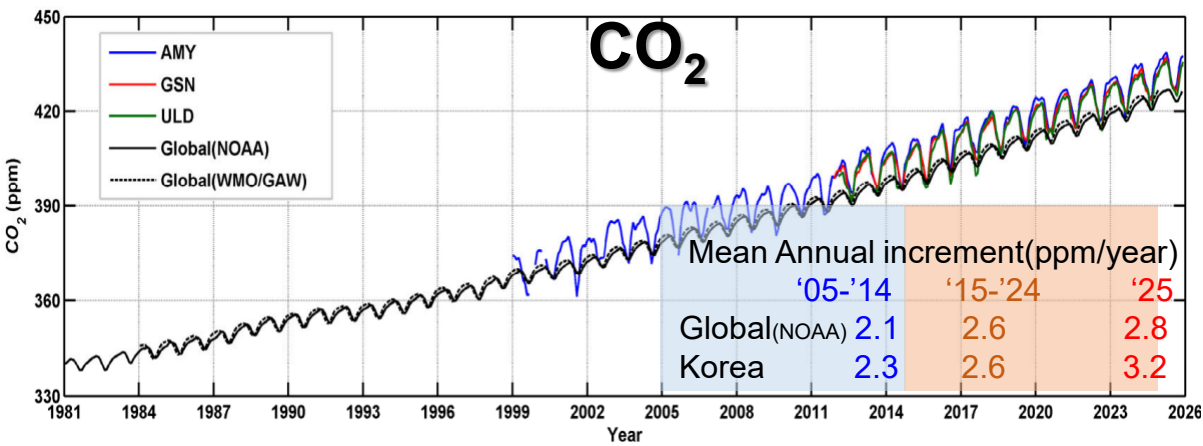
★ Continuous (in real-time)
 ● biweekly
 ◎ 20 days (March to May)



<AMY seasonal footprint from ERA5-STILT>

** NARA flask sampled for isotopes of greenhouse gases (δ¹³CO₂, δ¹³CH₄)

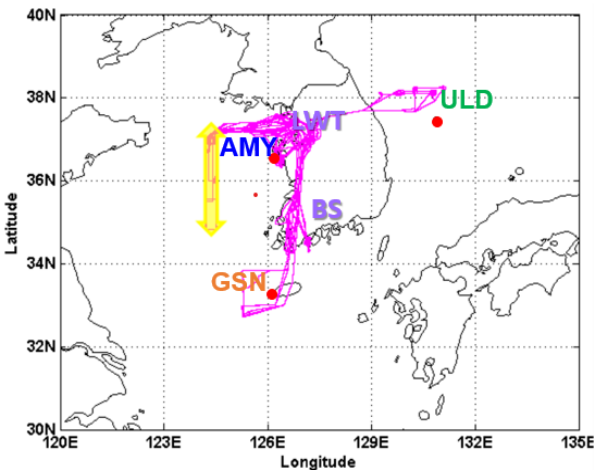
Korea's GHG Levels Consistently Exceed the Global Mean



GHGs data from 3 regional GAW stations are included in WMO Global annual mean.

The background concentration was calculated from hourly L2 data. The level of 3 stations are **higher than global mean**.

However the mean **annual absolute increase** of CO₂ and CH₄ over the latest 10years **is similar**.



Satellite and FTS Observations: Bridging Surface and Space

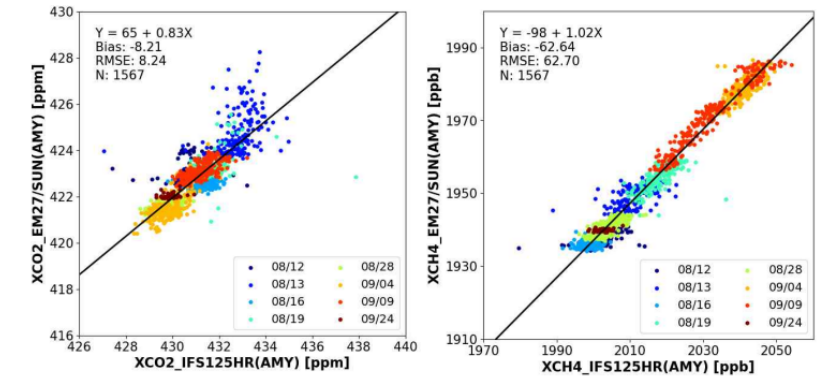
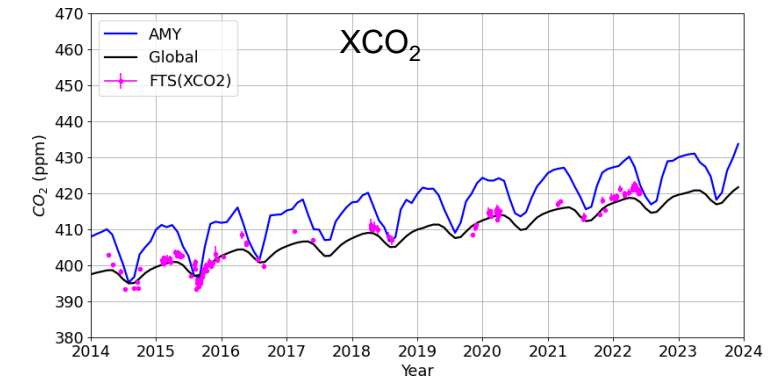
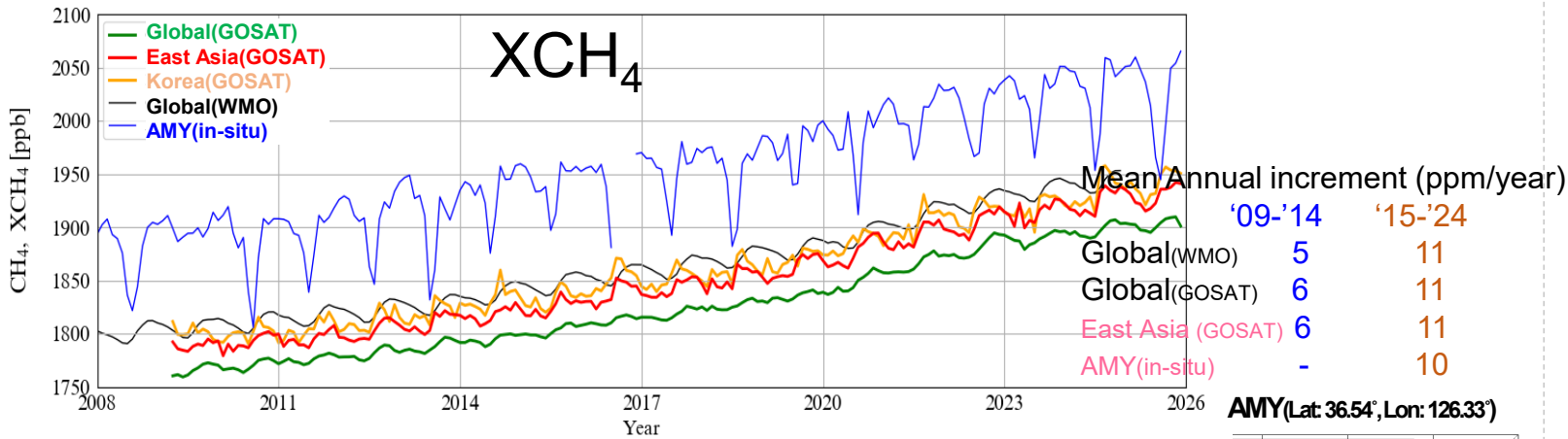
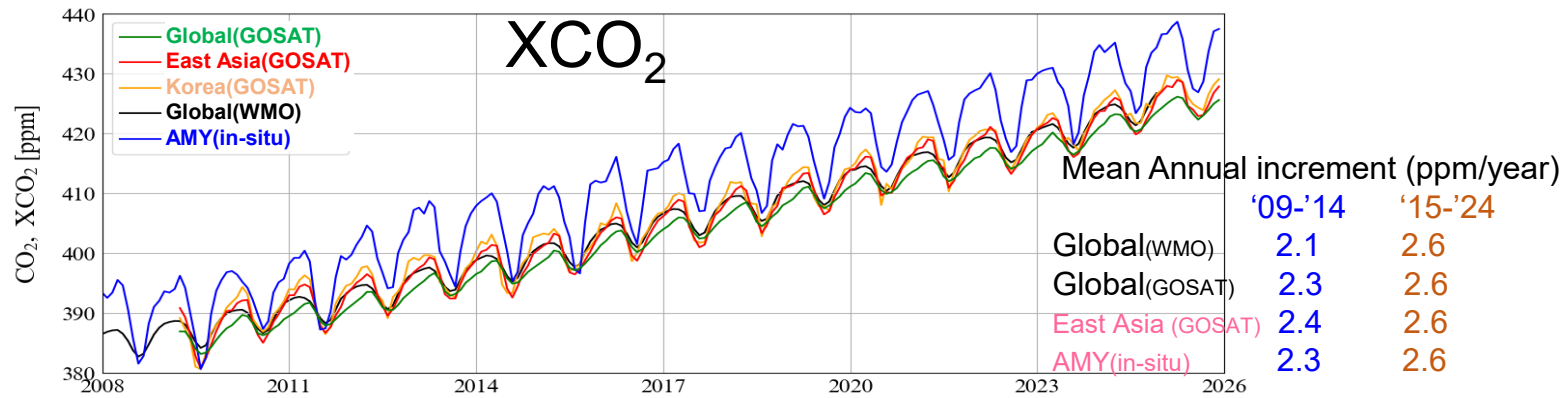


Figure 3. Comparison of the same Xgas between the EM27/SUN and IFS125HR at AMY. (left: XCO₂, right: XCH₄)

GOSAT running by Japan

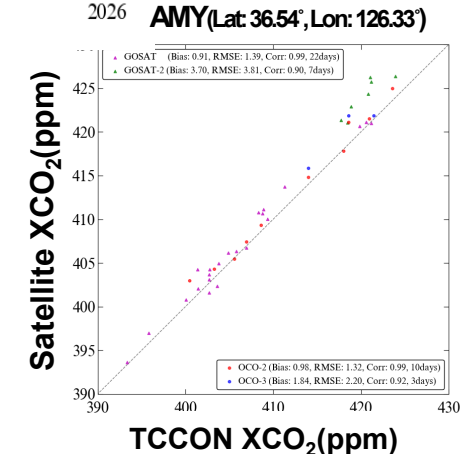
- ✓ The world first polar-orbiting GHG SAT
- ✓ KMA/NMSC use of L2 data
- ✓ Observations over Korea 125 day per year(3-day cycle)

Global

East Asia
(15~50°N, 100~150°E)

Korea
(32~43°N, 121~132°E)

30 days coverage ~25%



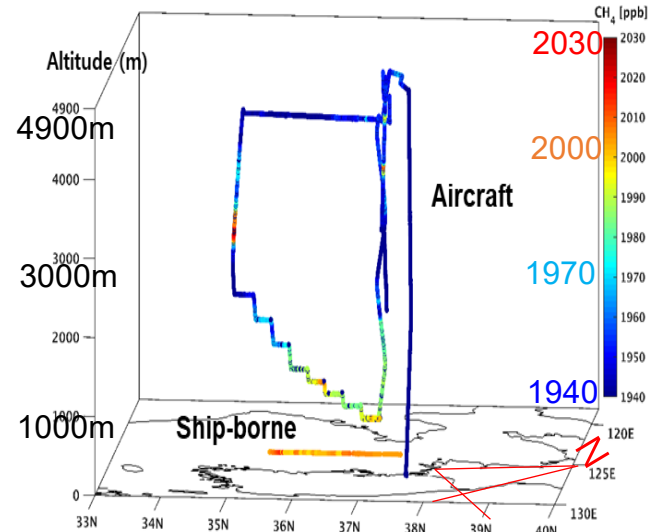
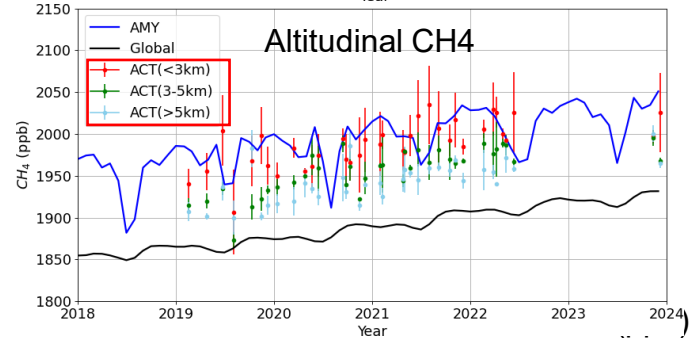
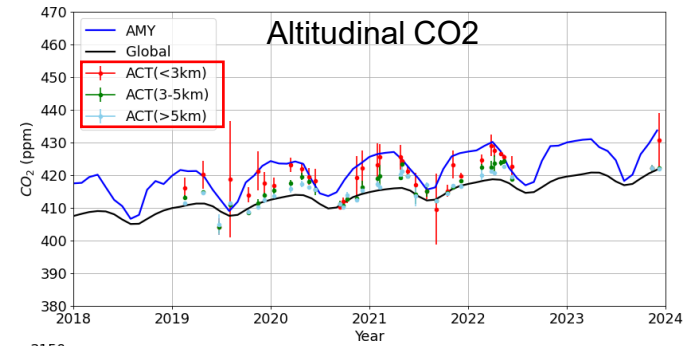
Aircraft Observations: Validating Satellite Retrievals Over Korea



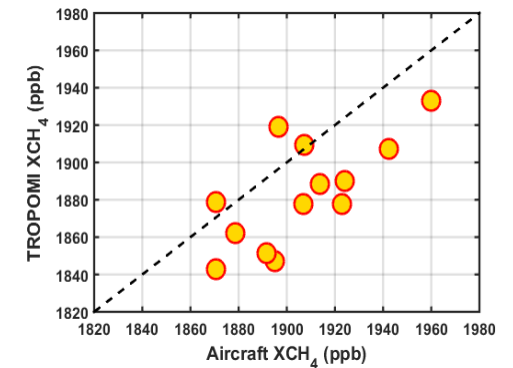
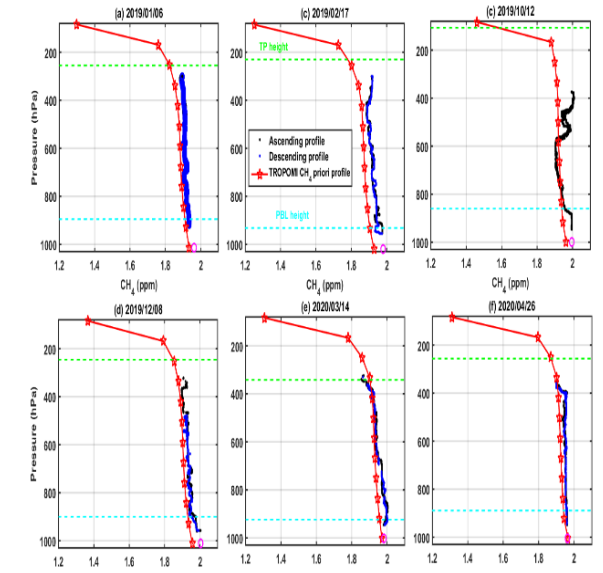
Photo by NASA DC-08 Team (ASIA-AQ in 2024)

Matching flight with NASA during ACCLIP(2023), ASIA-AQ(2024)

Cross checking the aircraft measurement data



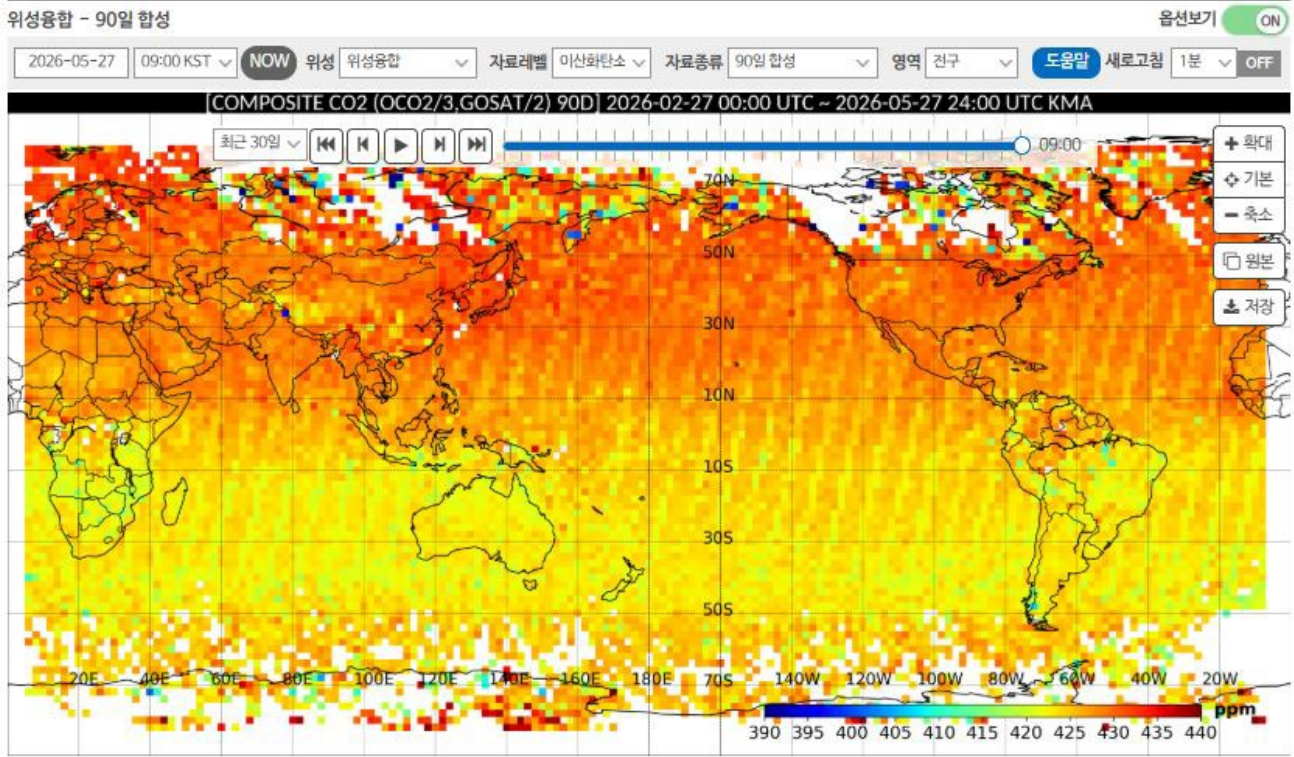
• Aircraft data + TROPOMI a priori profile



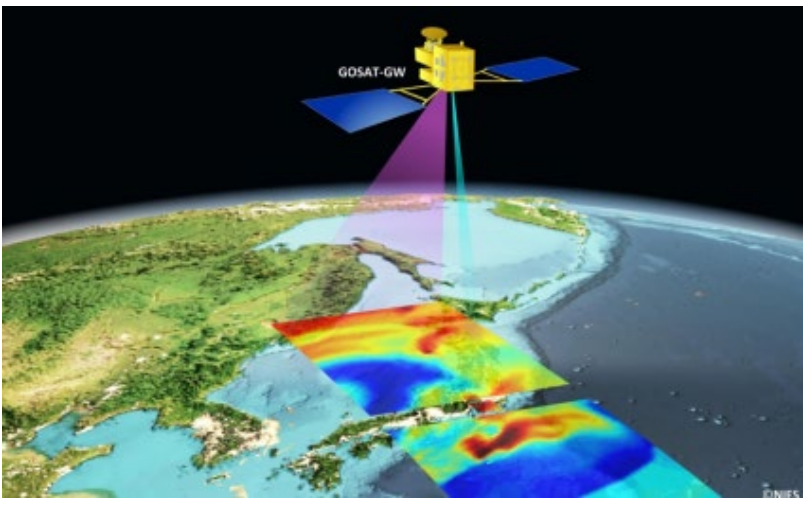
Most of TROPOMI Satellite retrievals fell just below the one to one line. The underestimation of XCH₄ seems to be attributed to low surface albedo in satellite retrievals.

Multi-Satellite Image Compositing Service for GHG Monitoring

NMSC_Homepage(<https://nmsc.kma.go.kr/homepage/html/satellite/viewer/selectNewSatViewer.do?dataType=greenHouseGas>)



TOKYO-FIELD CAMPAIGN (TOKYO-FC)



Matching flight on 22 March 2026 over Korea

GOSAT-GW validation will leverage KMA's integrated observing network including in situ, aircraft, and FTS data.

- Supported by Sang-Woo Kim (Seoul Univ.) et al

Image Service with low-orbit satellites

⇒ (Temporal/Spatial Coverage) 1, 10, 30, 60, 90 days mean compositing / Global, East Asia, Korea region

- **XCO₂**: OCO-2, OCO-3, GOSAT/TANSO-FTS, GOSAT-2/TANSO-FTS2
- **XCH₄**: GOSAT/TANSO-FTS, GOSAT-2/TANSO-FTS2
- **XO₃**: Sentinel-5p/TROPOMI, MetOp/IASI, MetOp/GOME-2, SNPP/OMPS

⇒ Anticipating the release of GOSAT-GW data, we plan to develop a Low Earth Orbit(LEO) satellite-based greenhouse gas compositing technology by integrating satellite observations, reanalysis, and modelling data.

INVERSE-KOREA: A Top-Down System for High-Resolution GHG Flux Estimation

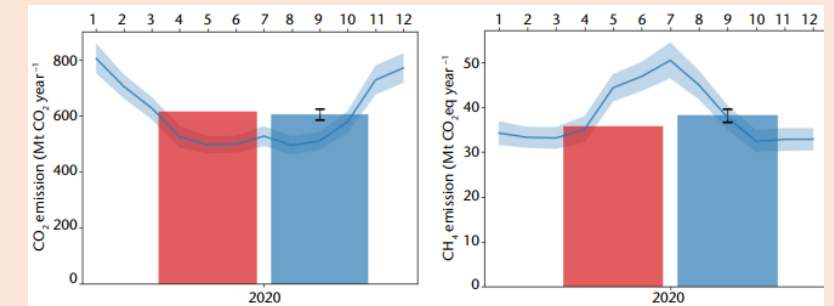
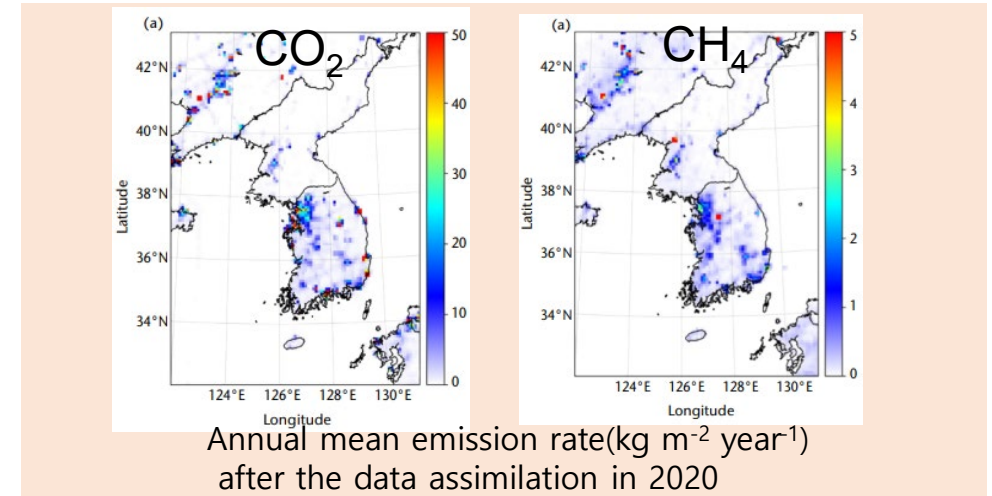
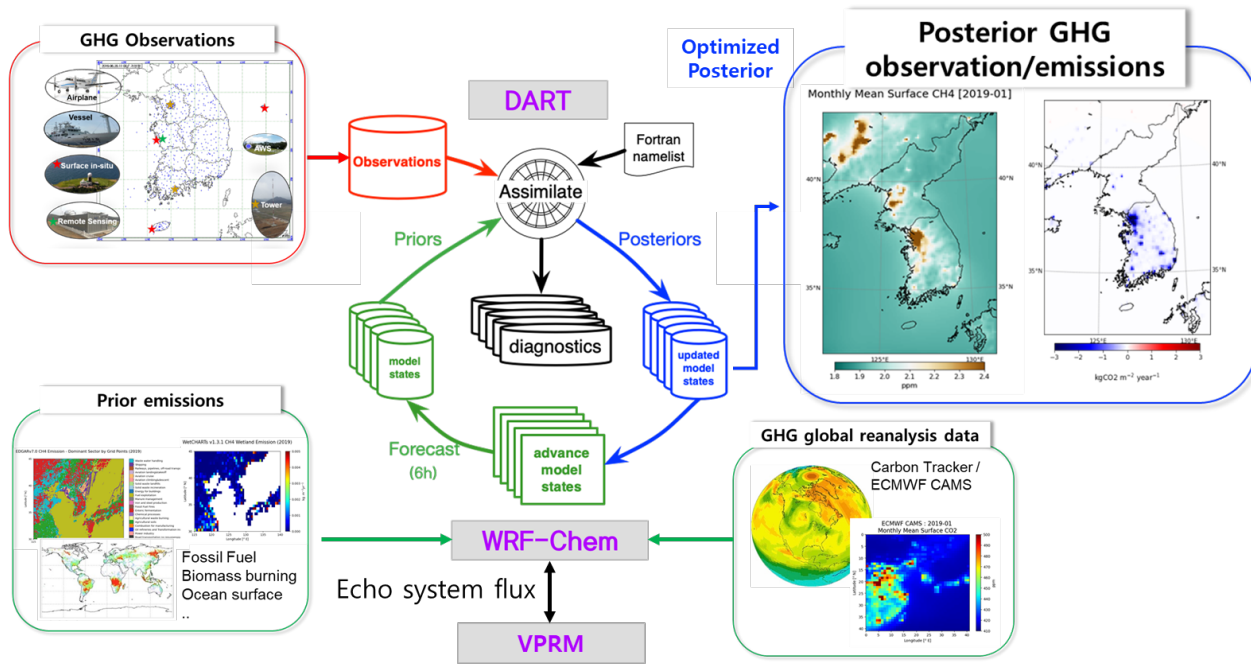


Figure 55. CO₂ emission (left panel) and CH₄ emission (right panel) and their monthly variations in 2020. The bars represent the inventory emission data from the Republic of Korean Government (red) and their posterior estimates from the WRF-Chem/DART system (blue). The vertical solid black error bars denote the uncertainty in the annual posterior estimates. The solid blue line represents the monthly variability of posterior CO₂ and CH₄ emissions, with the 2-standard deviation uncertainty range expressed by the shaded area.

Initiate WMO endorsed project **INVERSE-KOREA**
(INverse modeling for Validating and Evaluating the Reduction of Sectoral GHG Emissions in KOREA)

Developed by Prof. Hong Jinkyu (Yonsei Univ.)
who is IG3IS steering committee member

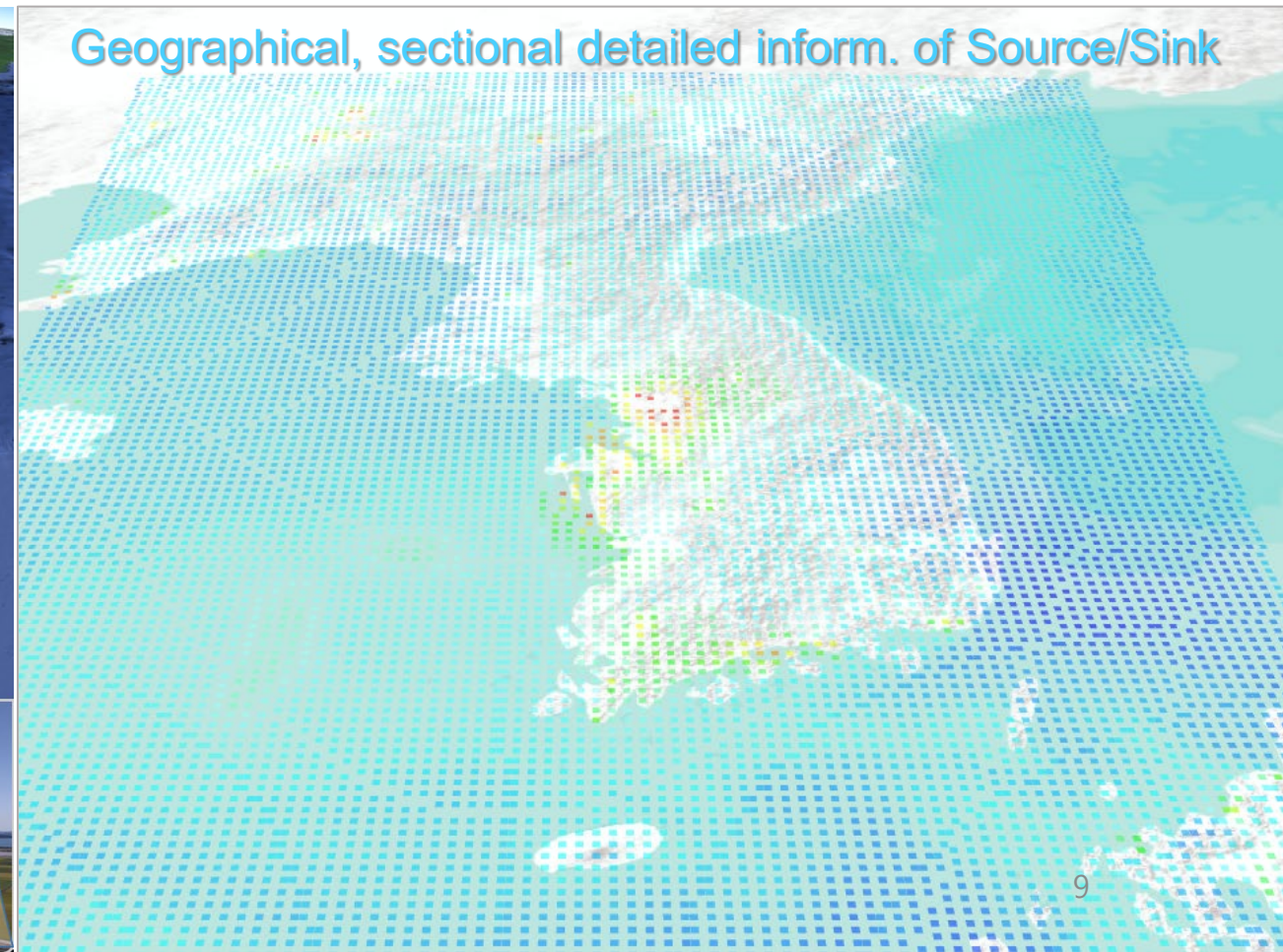
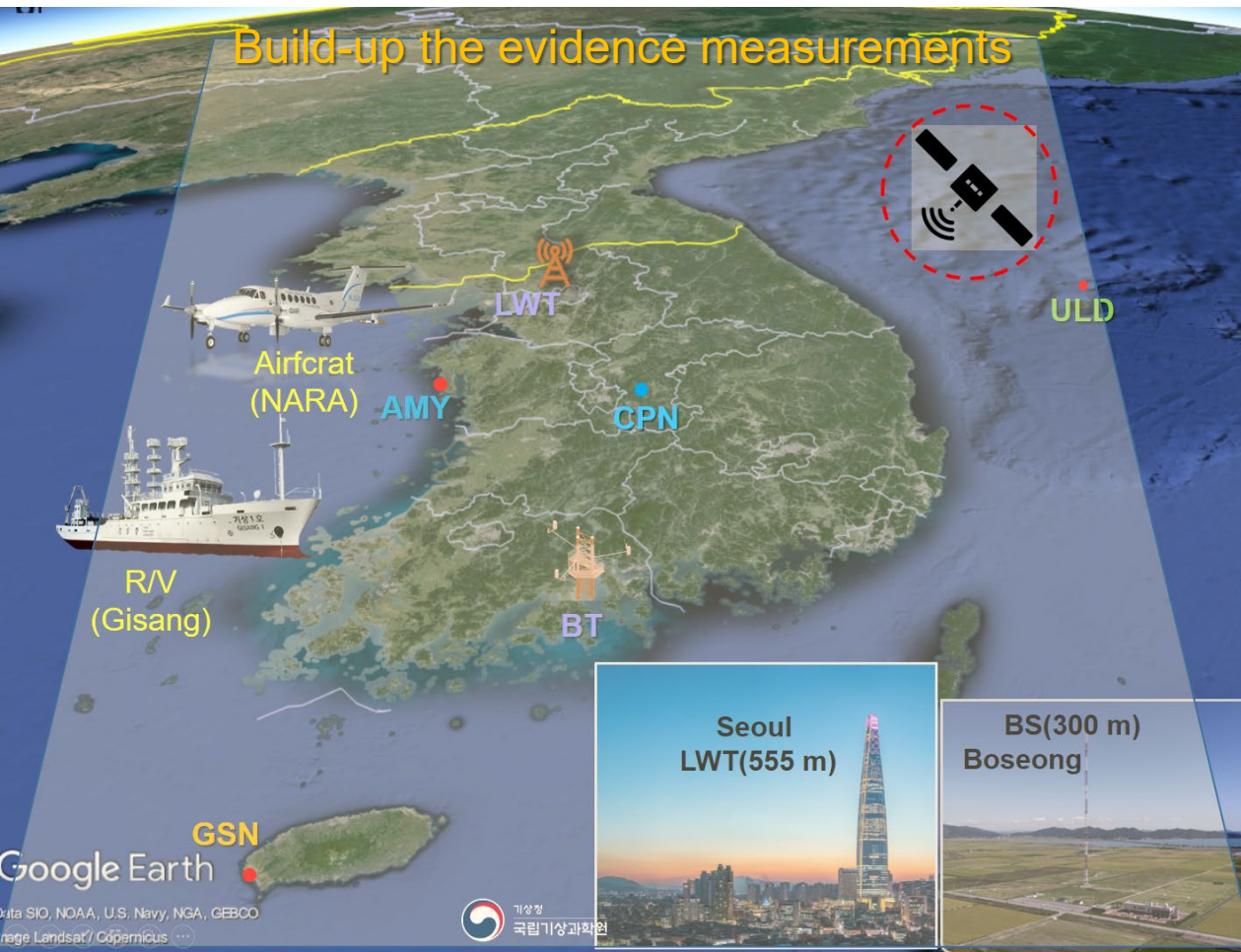
1. INVERSE-KOREA works like a weather forecast system, based on **Eulerian** framework.
2. **Boundary layer** parameterization accounts for Korea's complex mountainous terrain
3. Assimilates: GHGs concentrations, meteorology (Wind, T, P, humidity)

→ 9 km x 9 km concentration fields with 51 vertical layers, and surface flux field
→ Quantifying sectorial attributions for increasing GHG (2019 revision of 2006 IPCC report, Tier3)

WMO report No.318(2025)
IG3IS good practice guidance for National scale

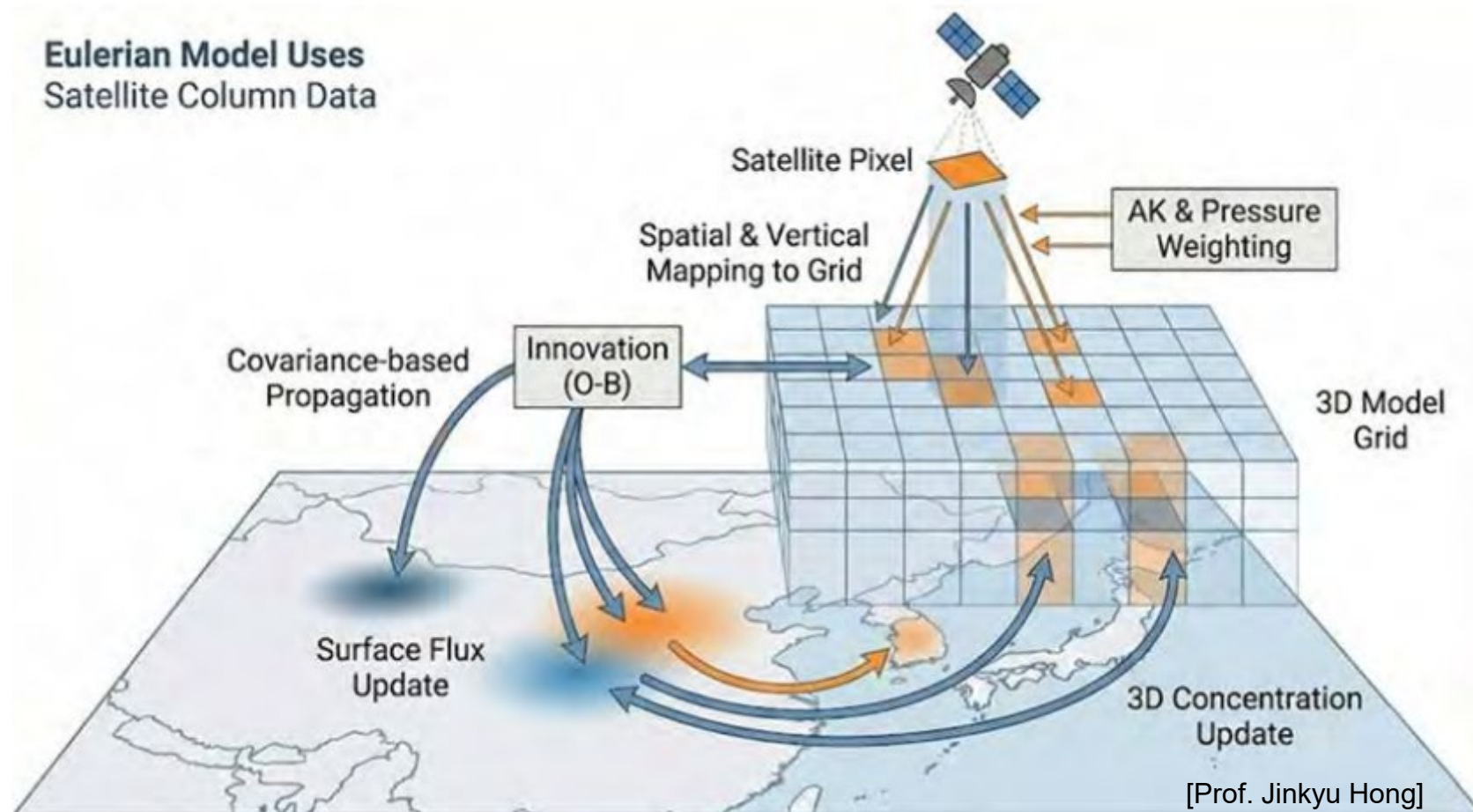
Producing Reliable GHG Source and Sink Information Across Korea

- ✓ Producing reliable GHG source and sink information through the integrated observing network and INVERSE-KOREA
 - 2014~2020 using 3 GAW stations, 2024~ adding 3 sites(LWT, BT, CPN)
 - collaborate on GHG surface measurements with other Korean research institutes



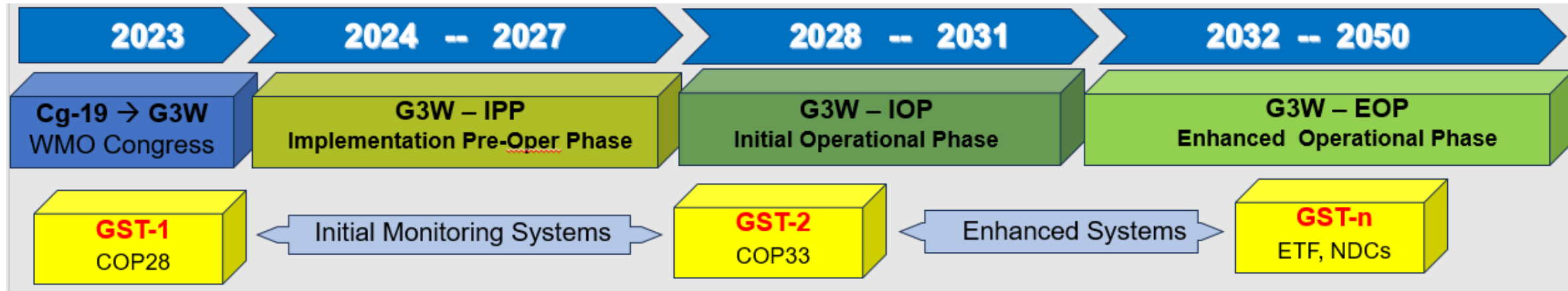
Next Step: Expanding INVERSE-KOREA to East Asia with Multi-Satellite Data

- ✓ We plan to expand the domain to East Asia with the integration of multi-satellite data



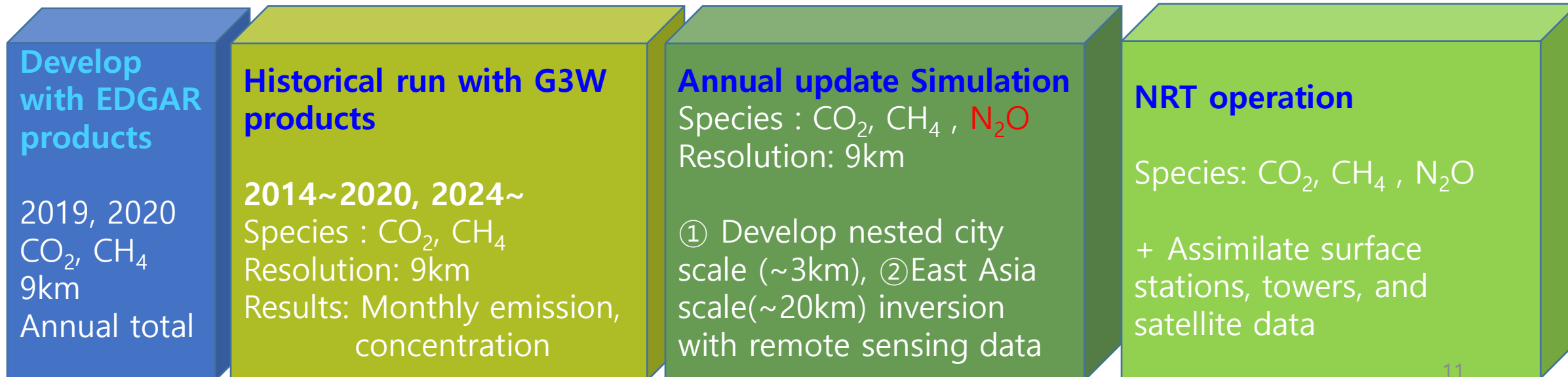
Stepwise Integration of INVERSE-KOREA with G3W IP

G3W



Through its alignment with the G3W output, INVERSE-KOREA can provide detailed GHG information with confidence and support national and local government climate change policies in Korea.

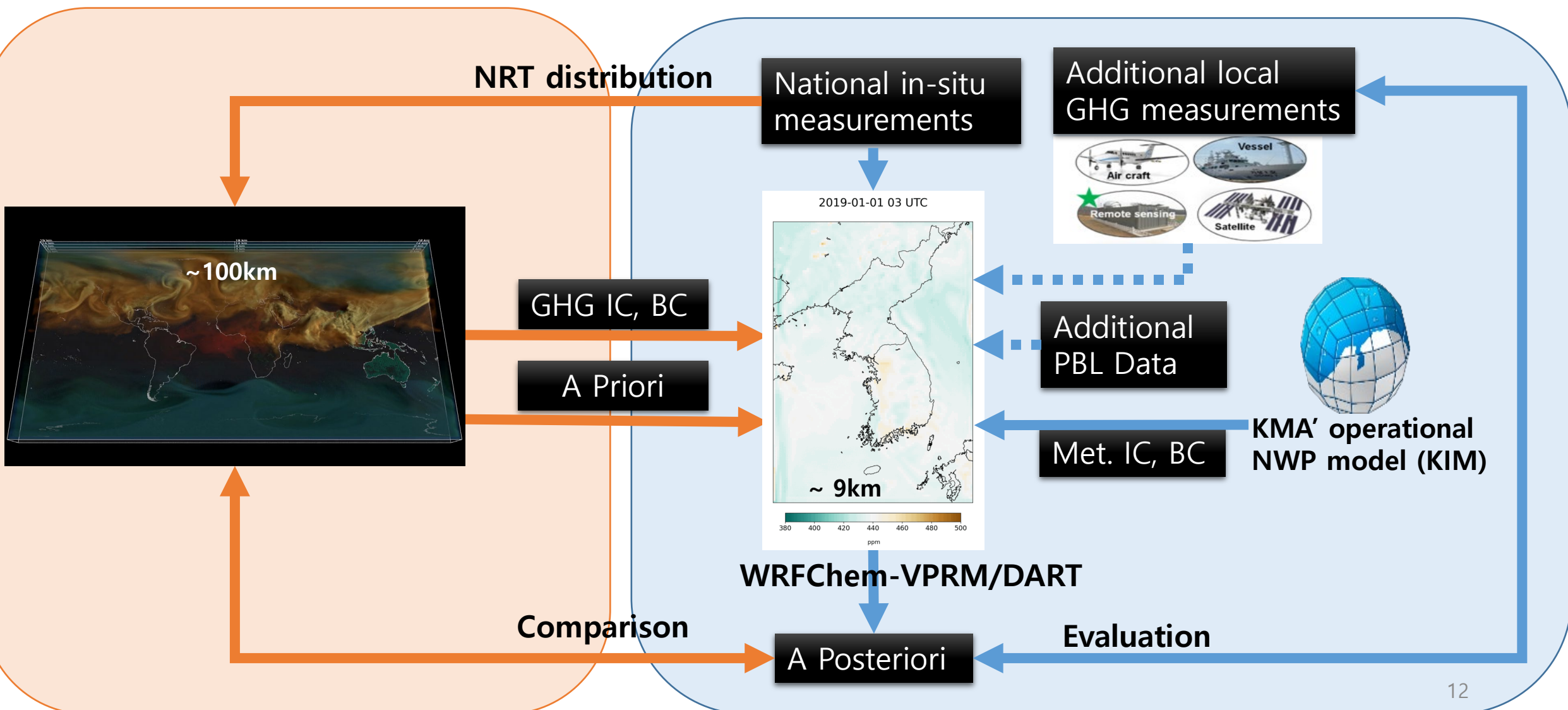
INVERSE-KOREA



Data Flow Between G3W and INVERSE-KOREA

G3W

INVERSE-KOREA



Summary and Commitments

1. G3W aims to provide timely, and dynamic information on GHGs.
 - monthly data on a global grid scale of $1^\circ \times 1^\circ$ for CO_2 , CH_4 , (N_2O) since 2028
2. KMA collaborates with G3W.
 - to provide GHG observing data to G3W
 - to use G3W data for INVERSE-KOREA
3. We will continue to produce high-quality data and monitor the changes.
In long-term background air, the Earth reflects our choices on silence.



Supporting Korea's carbon neutrality policies
through a transparent and traceable information flow framework