Development of Long-term Climate Data Algorithm Based on GEMS Data

Ha Jeong Jeon[1], Kanghyun Baek [2], Yeonjin Jung [3], Jeong Ah Yu [4], Sang Seo Park[1*]

[1]Ulsan National Institute of Science and Technology, [2]Pusan National University, [3]Pukyong National University, [4]National Institute of Environmental Research

Introduction

- The necessity of producing long-term satellite data for climate change research
- Producing user-friendly satellite data tailored to model grid sizes
- Providing GEMS data selectable for user convenience

GEMS Level 3 Climate Data (L3C) Algorithm

### ▶ Flow Chart of the GEMS L3C Total Ozone Algorithm
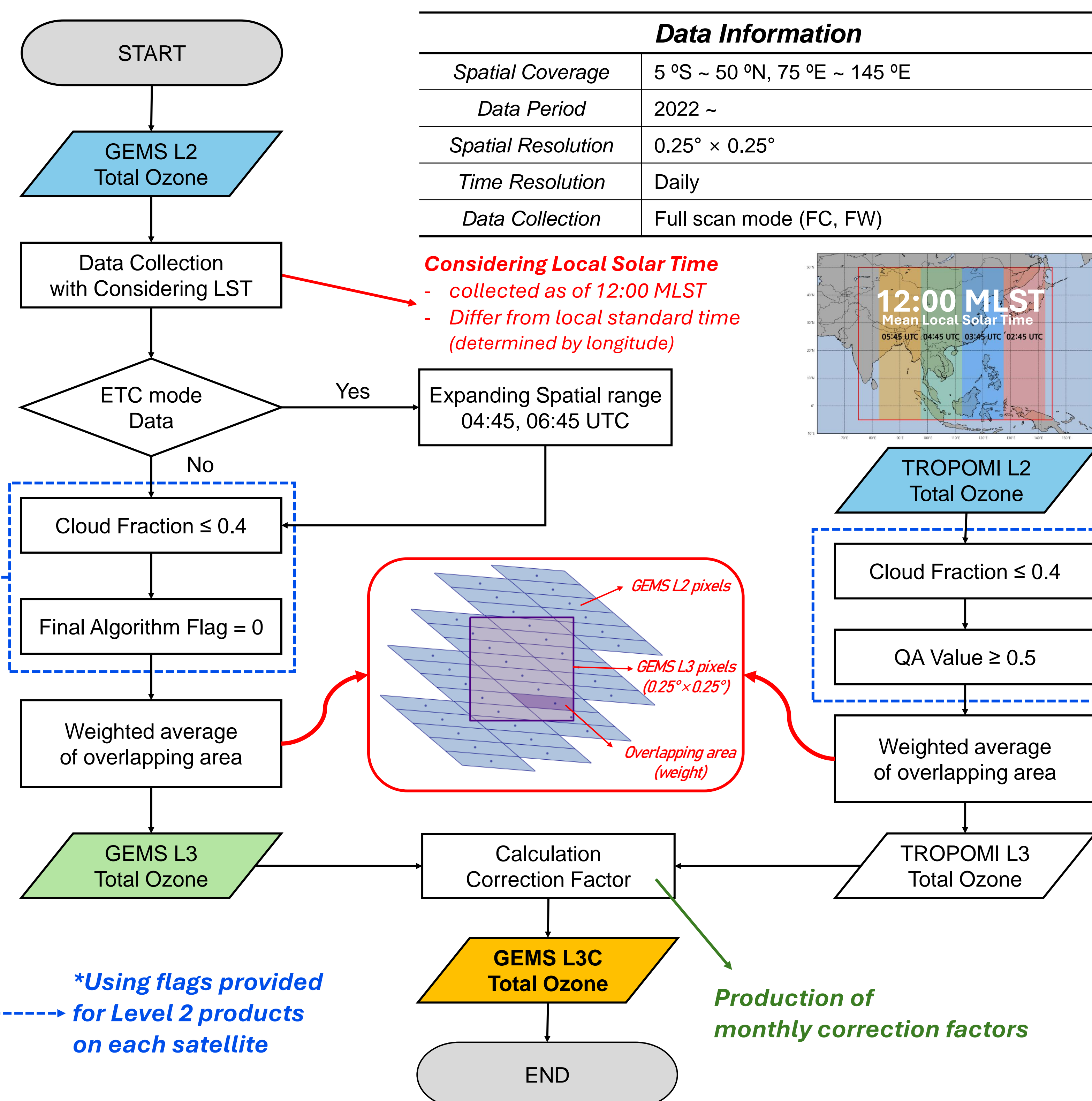
Data Information	
Spatial Coverage	5 ºS ~ 50 ºN, 75 ºE ~ 145 ºE
Data Period	2022 ~
Spatial Resolution	0.25° × 0.25°
Time Resolution	Daily
Data Collection	Full scan mode (FC, FW)

Considering Local Solar Time
- collected as of 12:00 MLST
- Differ from local standard time (determined by longitude)

*Using flags provided for Level 2 products on each satellite

Production of monthly correction factors

▶ GEMS L3C Total NO₂ Column Algorithm

Differences with Total Ozone algorithm
- ✓ Not applied: Final Algorithm Flag of GEMS data (V 2.0)
- ✓ Removing outliers of the Correction Factor (0 < CF < 4)
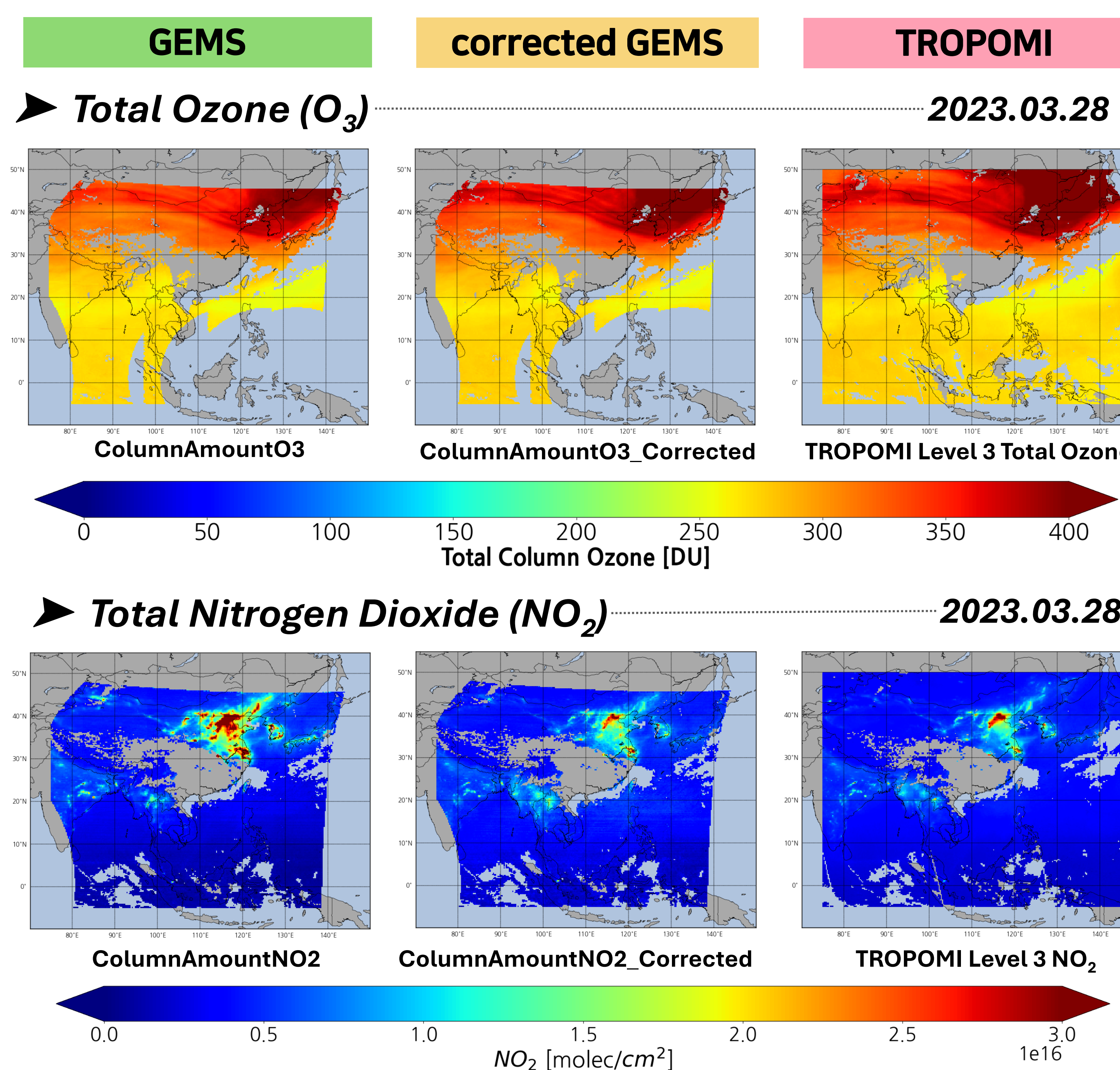

Remove Outliers
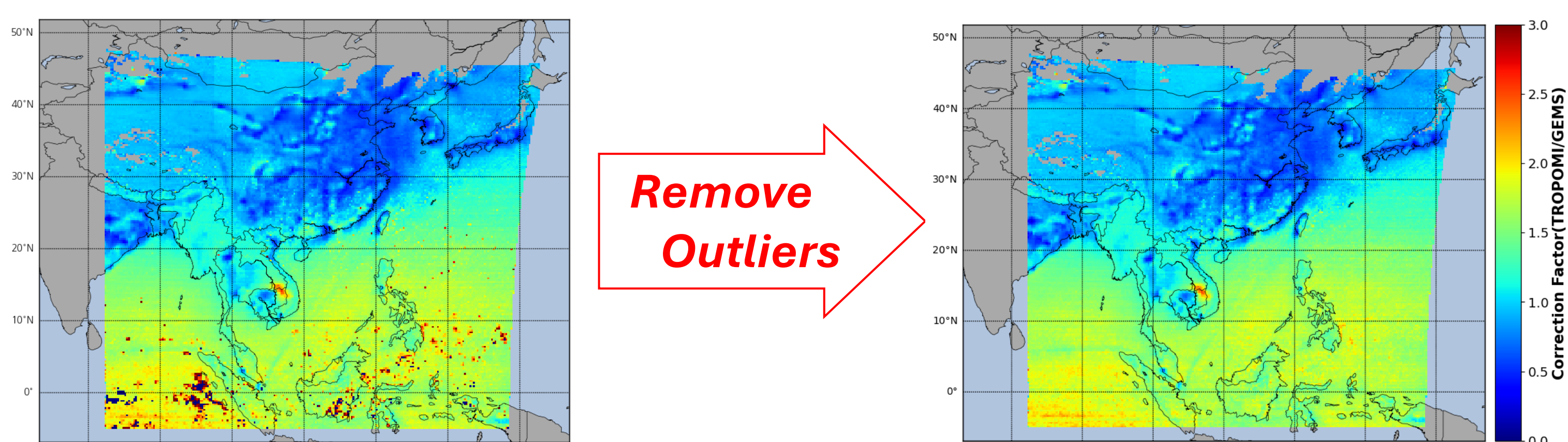
Summary & Conclusion

- Development of the GEMS Level 3C Algorithm using Level 2 data by applying Local Solar Time (LST) to account for the characteristics of polar orbit satellites.
- Producing long-term climate data by combining GEMS and TROPOMI data.
- GEMS Level 3C data closely matches TROPOMI results after applying the correction factor calculated from GEMS and TROPOMI data.

References

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Result

GEMS	corrected GEMS	TROPOMI

▶ Total Ozone (O₃)   2023.03.28

ColumnAmountO3 — ColumnAmountO3_Corrected — TROPOMI Level 3 Total Ozone

Total Column Ozone [DU] (0 – 400)

▶ Total Nitrogen Dioxide (NO₂)   2023.03.28

ColumnAmountNO2 — ColumnAmountNO2_Corrected — TROPOMI Level 3 NO₂

NO₂ [molec/cm²] (0.0 – 3.0 × 10¹⁶)

GEMS L3C Data List * : substances (e.g., O₃, NO₂)

Original Data
- ColumnAmount* *GEMS Level 3*
- ColumnAmount*_PixelCount *The number of Level 2 pixels used for Level 3 calculations*
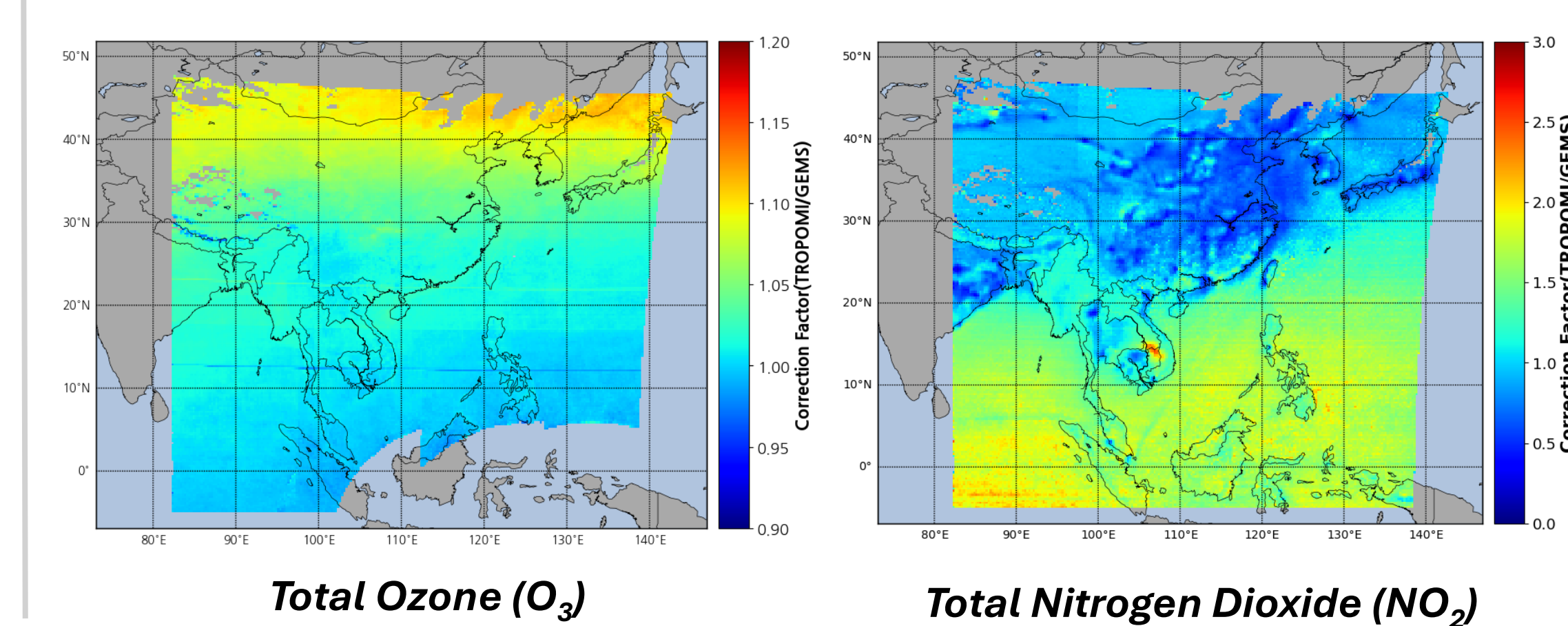
Corrected Data
- CorrectionFactor
- ColumnAmount*_Corrected *corrected GEMS Level 3*

Stastical Data
- ColumnAmount*_STD
- ColumnAmount*_Max *Level 2 data values used for Level 3 pixel calculation*
- ColumnAmount*_Min

Correction Factor
- Calculated by determining the ratio of TROPOMI to GEMS.
- Provided monthly data.
- Below is the figure for January.

Total Ozone (O₃) — *Total Nitrogen Dioxide (NO₂)*

Data Validation

▶ Total Ozone (O₃)

Monthly mean O₃ concentration — 2% average increase after applying Correction Factor

Coefficient of Determination (R²) by latitude (2023) — GEMS Level 3 / corrected GEMS Level 3

Correlation between TROPOMI and GEMS (2023)

GEMS Level 3 vs TROPOMI Level 3:
N = 9351482, R² = 0.96, Slope = 0.85, RMSE = 11.24, MAE = 8.28, MBE = 7.88

corrected GEMS Level 3 vs TROPOMI Level 3:
N = 9317943, R² = 0.99, Slope = 0.96, RMSE = 4.30, MAE = 3.00, MBE = -1.69

	GEMS Level 3 O₃			corrected GEMS Level 3 O₃		
	R²	Slope	RMSE	R²	Slope	RMSE
MAM	0.98	0.86	11.01	0.99	0.96	4.89
JJA	0.93	0.94	8.03	0.96	0.97	5.14
SON	0.94	0.80	10.01	0.98	0.98	3.37
DJF	0.98	0.79	14.29	0.99	1.00	3.74

▶ Total Nitrogen Dioxide (NO₂)

Monthly mean NO₂ concentration — 35% average increase after applying Correction Factor

Relative Difference between TROPOMI and GEMS (2023)

South Korea (Seoul, Incheon, Gyeonggi-do)

China (Beijing, Tenjin, Hebei)

Correlation between TROPOMI and GEMS (2023)

GEMS Level 3 vs TROPOMI Level 3:
N = 13287983, R² = 0.87, Slope = 1.67, RMSE = 0.20 e16, MAE = 0.11 e16, MBE = 0.02 e16

corrected GEMS Level 3 vs TROPOMI Level 3:
N = 13242322, R² = 0.87, Slope = 1.00, RMSE = 0.08 e16, MAE = 0.05 e16, MBE = 0.01 e16

	GEMS Level 3 NO₂			corrected GEMS Level 3 NO₂		
	R²	Slope	RMSE	R²	Slope	RMSE
MAM	0.84	1.62	0.17 × 10¹⁶	0.87	1.01	0.08 × 10¹⁶
JJA	0.81	1.31	0.11 × 10¹⁶	0.84	1.07	0.07 × 10¹⁶
SON	0.85	1.75	0.21 × 10¹⁶	0.87	0.99	0.08 × 10¹⁶
DJF	0.85	1.77	0.27 × 10¹⁶	0.87	0.97	0.09 × 10¹⁶