NO_2 vertical profiles over South Korea and their relation to oxidant chemistry: Implications for geostationary satellite retrievals

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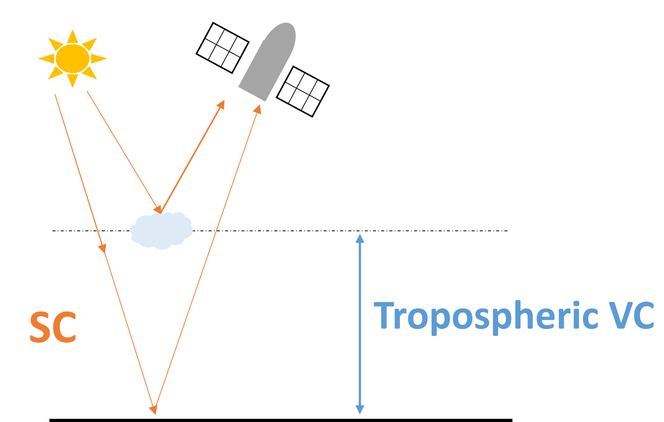
INTRODUCTION / BACKGROUND

- The recent launch of the GEMS geostationary instrument over East Asia enables first-time direct measurements of diurnal variation of NO_2 from space
- A chemical transport model like GEOS-Chem needs to provide the NO_2 vertical profiles required for NO_2 solar backscatter retrieval

Solar backscatter retrieval requires 3 steps

1. Convert radiance to slant column (SC)
2. Remove stratospheric portion from SC
3. Convert tropospheric SC to vertical column (VC)



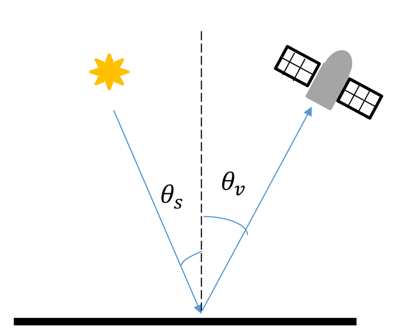
$$VC = \frac{SC}{AMF}$$

AMF depends on 3 different variables

$$AMF = AMF_G \int_0^{z_T} w(z)S(z)dz$$

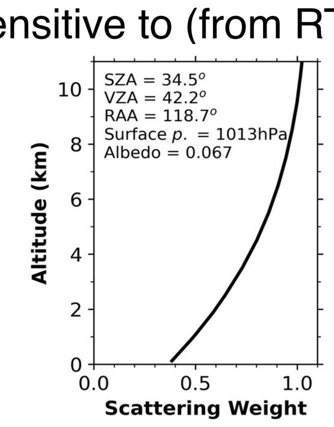
Viewing Geometry

Solar zenith angle (SZA; θ_s)
Satellite viewing angle (VZA; θ_v)



Scattering Weight

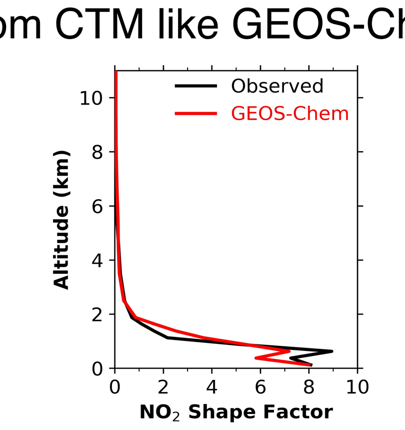
Captures where the satellite is sensitive to (from RTM)



Scattering weight vs. altitude

Shape Factor

Vertical distribution of NO_2 (from CTM like GEOS-Chem)



NO_2 shape factor vs. altitude

OBJECTIVES

1. Test the capability of the GEOS-Chem model in providing AMF in support of the GEMS retrieval
2. Quantify what drives the diurnal variation in AMF and its magnitude

METHODS

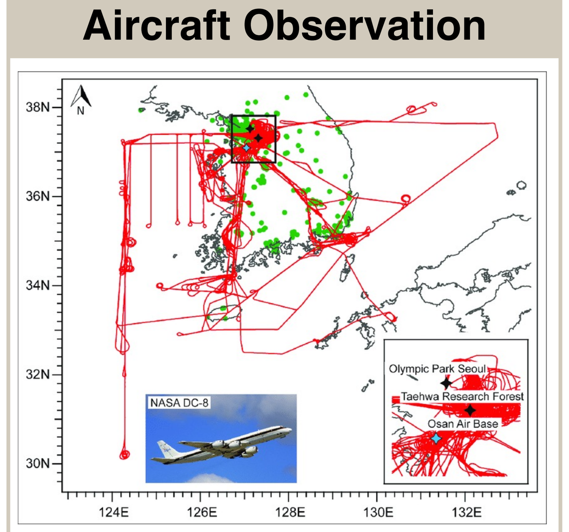
GEOS-Chem Standard Model
v13.3.4
0.25° × 0.3215°

No nitrate photolysis
No HNO_3 uptake by PMC
No VCP emission
$\gamma_{HO_2} = 0.2$

GEOS-Chem Modified Model
GEOS-Chem
0.25° × 0.3215°

With nitrate photolysis
With HNO_3 uptake by PMC
With VCP emission
CO boundary condition ×1.5
$\gamma_{HO_2} = 0.1$

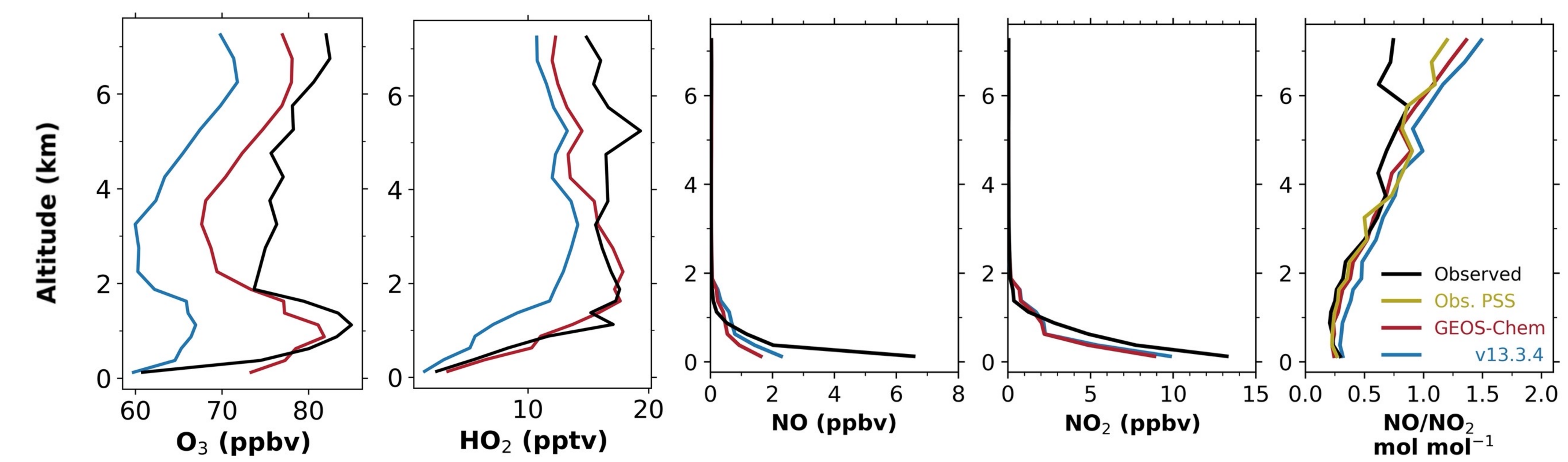
KORUS-AQ
May – June 2016
Aircraft Observation



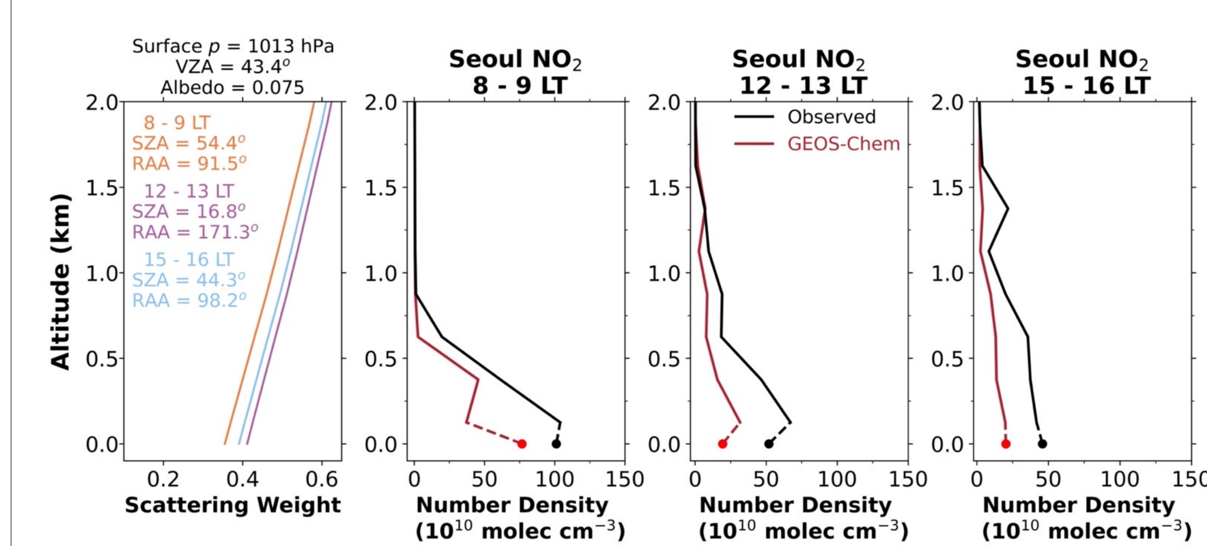
Source: Peterson et al. 2019
[Crawford et al. 2021]

RESULTS

GEOS-Chem is successful in simulating key species that drive NO_2 formation & oxidant chemistry as compared to aircraft observation



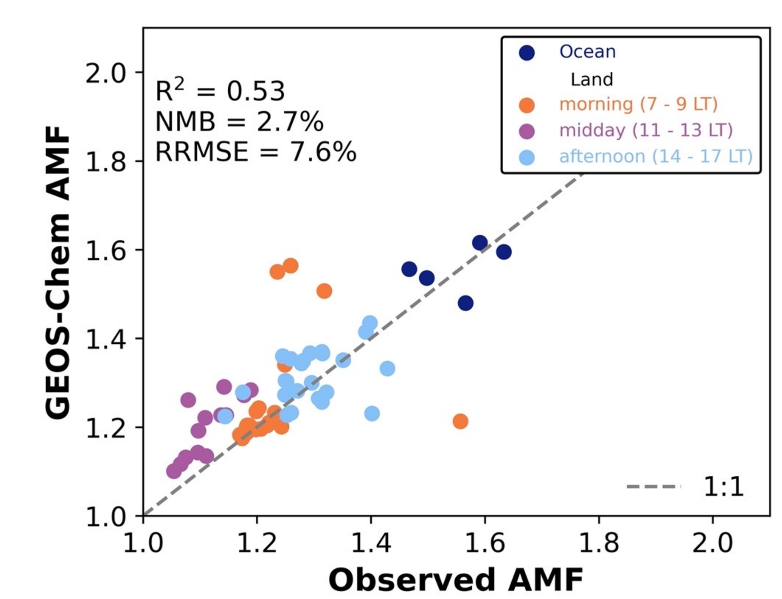
Solar zenith effect (24%) offsets the scattering correction factor (18%)



Time of day	AMF_G	$\int_0^{z_T} w(z)S(z)dz$	AMF
8-9 AM	3.09	0.38 (0.39)	1.19 (1.20)
12-1 PM	2.42	0.46 (0.47)	1.11 (1.14)
3-4 PM	2.77	0.46 (0.46)	1.26 (1.27)

Diurnal variation in scattering correction factor driven by mixed layer growth
Column's diurnal variation (22%) is much smaller than that of the surface (87%)
Diurnal variation in AMF (14%) is comparable to that of column (~22%)

GEOS-Chem can capture the variability of observed AMF



Ocean vs. land, and the time-of-day drive observed variability

Timing of the mixed layer growth in the morning is the largest contributor to the model error

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Contact Information & Link

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