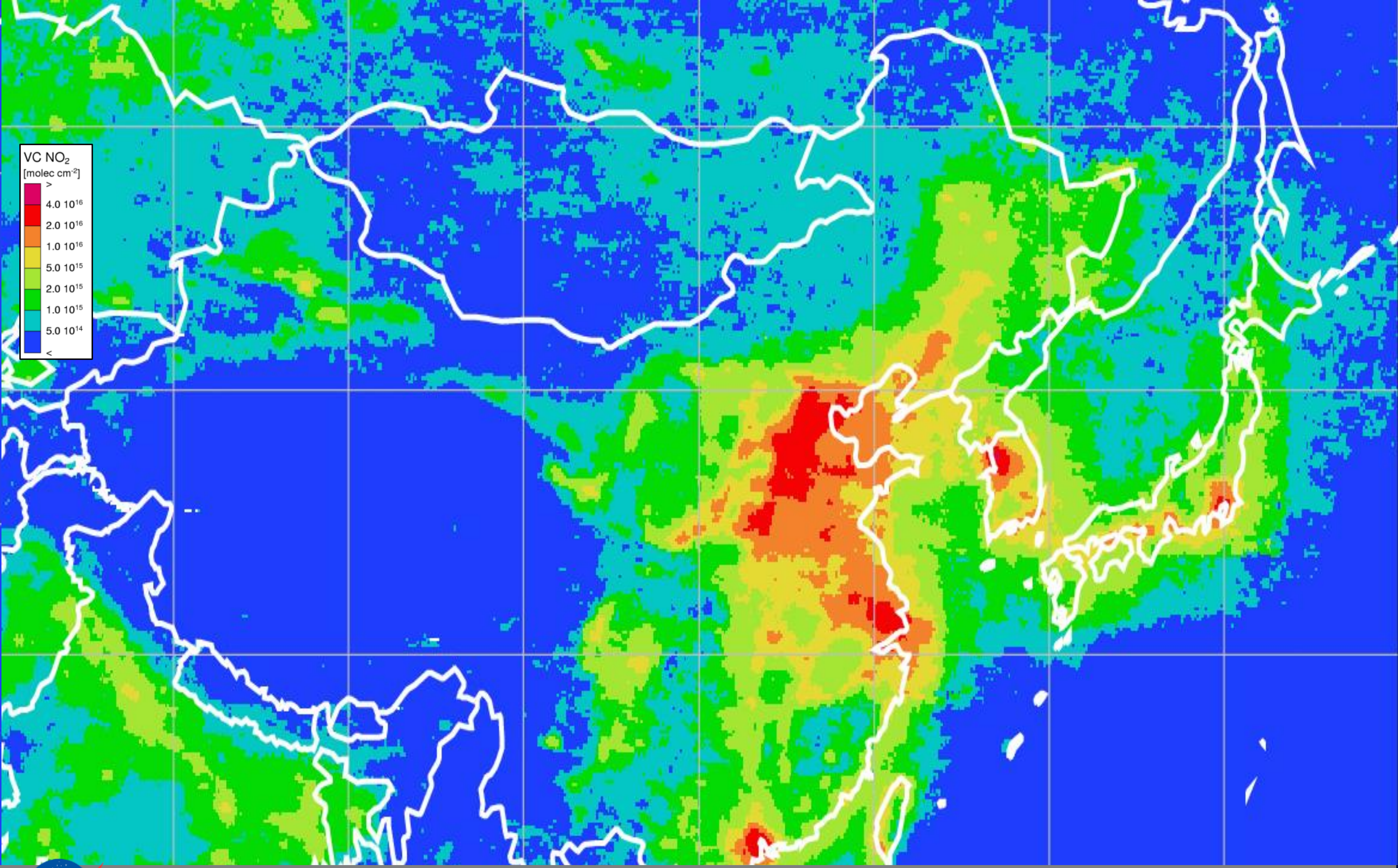
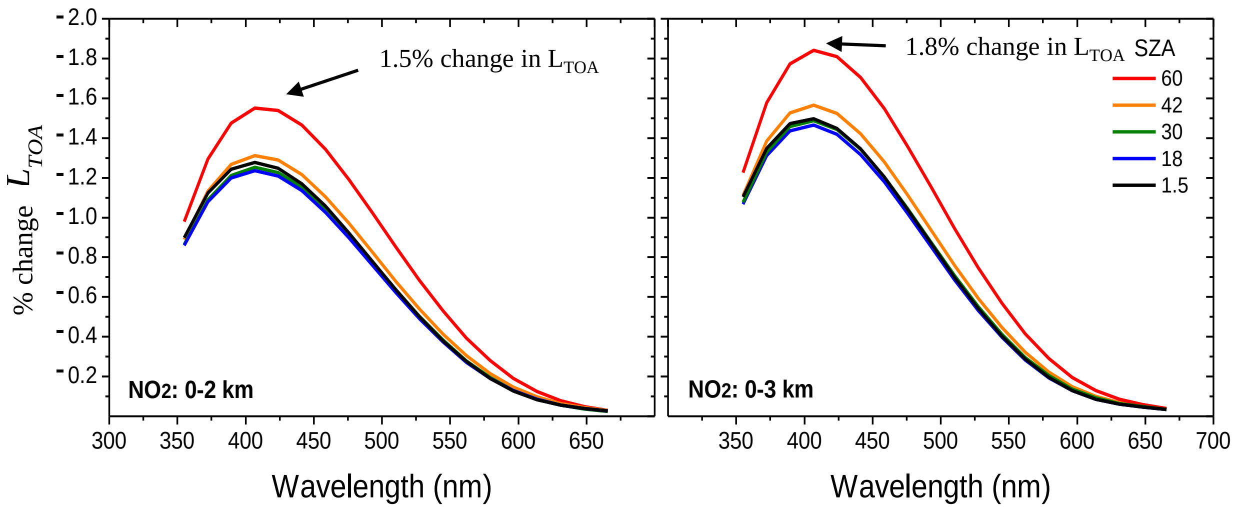


Atmospheric trace gas (NO_2 and ozone) dynamics and impacts on Ocean Color retrievals

Maria Tzortziou, Brian Lamb, Nader Abuhassan, Jay Herman , Robert Swap, Ryan Staufferr
City University of New York and Columbia University/LDEO, NASA Goddard Space Flight Center

Percent change in TOA signal, per 1 DU change in atmospheric NO_2



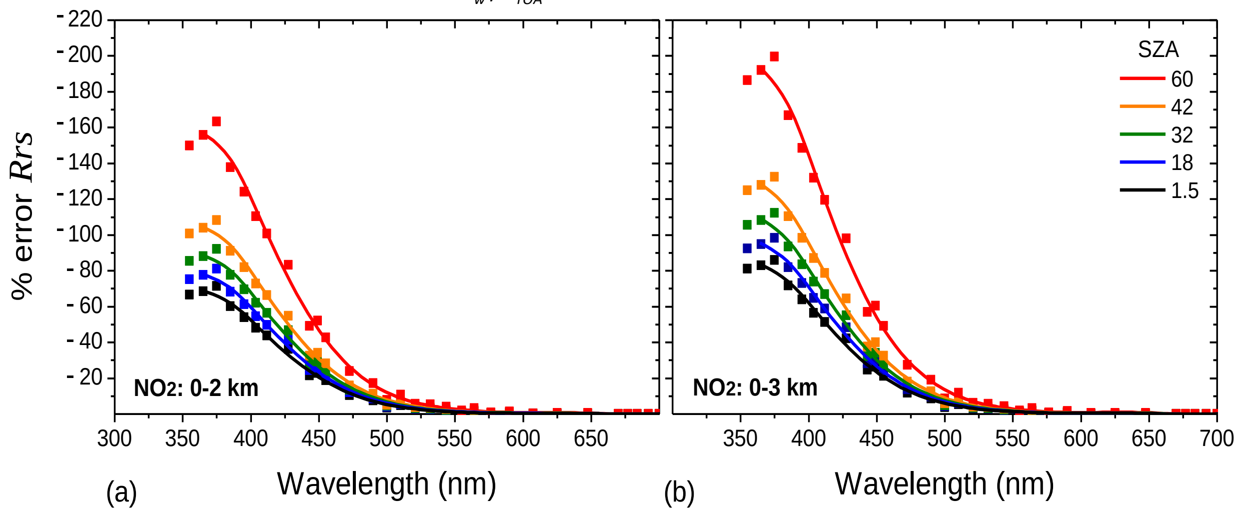
The impact on L_{TOA}

- has a strong spectral dependence: **max in 400-420 nm**, due to spectral shape in NO_2 abs. cross sections
- has a SZA dependence: because of the larger slant path with increasing SZA
- depends on NO_2 vertical distribution, and becomes larger as the NO_2 is distributed at higher altitudes

Tzortziou et al. 2014, Geophys. Res. Oceans, 119, 3834–3854, doi:10.1002/2014JC009803

Percent error in R_{rs} caused by not accounting for 1 DU of atmospheric NO_2

L_w / L_{TOA} =2.5% at 412 nm and SZA=30°



The impact on R_{rs}

- has a strong spectral dependence: **max in 350-400 nm**, due to spectral dependence of Lw/L_{TOA}
- has a SZA dependence: because of the larger slant path with increasing SZA
- depends on NO_2 vertical distribution, and becomes larger as the NO_2 is distributed at higher altitudes

Tzortziou et al. 2014, Geophys. Res. Oceans, 119, 3834–3854, doi:10.1002/2014JC009803

KORUS-AQ

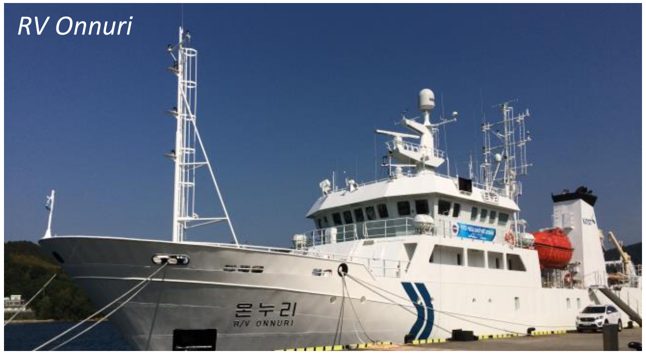
KORUS-OC

May-June 2016

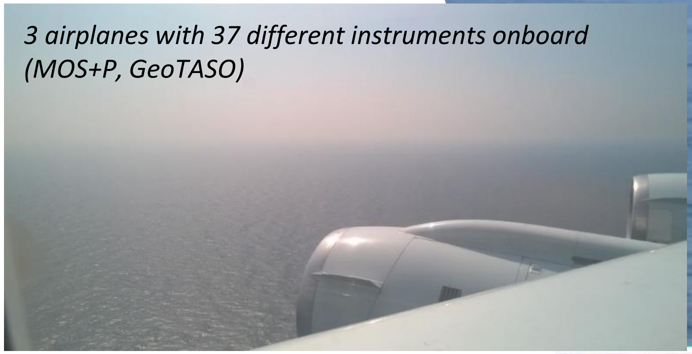
3 aircraft, 2 research vessels
> 350 scientists and other personnel in the field

Objectives:

- Capture **spatial dynamics and diurnal variability** in NO_2 and O_3 using shipboard and satellite observations
- Examine **differences in air quality across the land-ocean interface**
- **Assess source contributions** to atmospheric pollution over these coastal waters

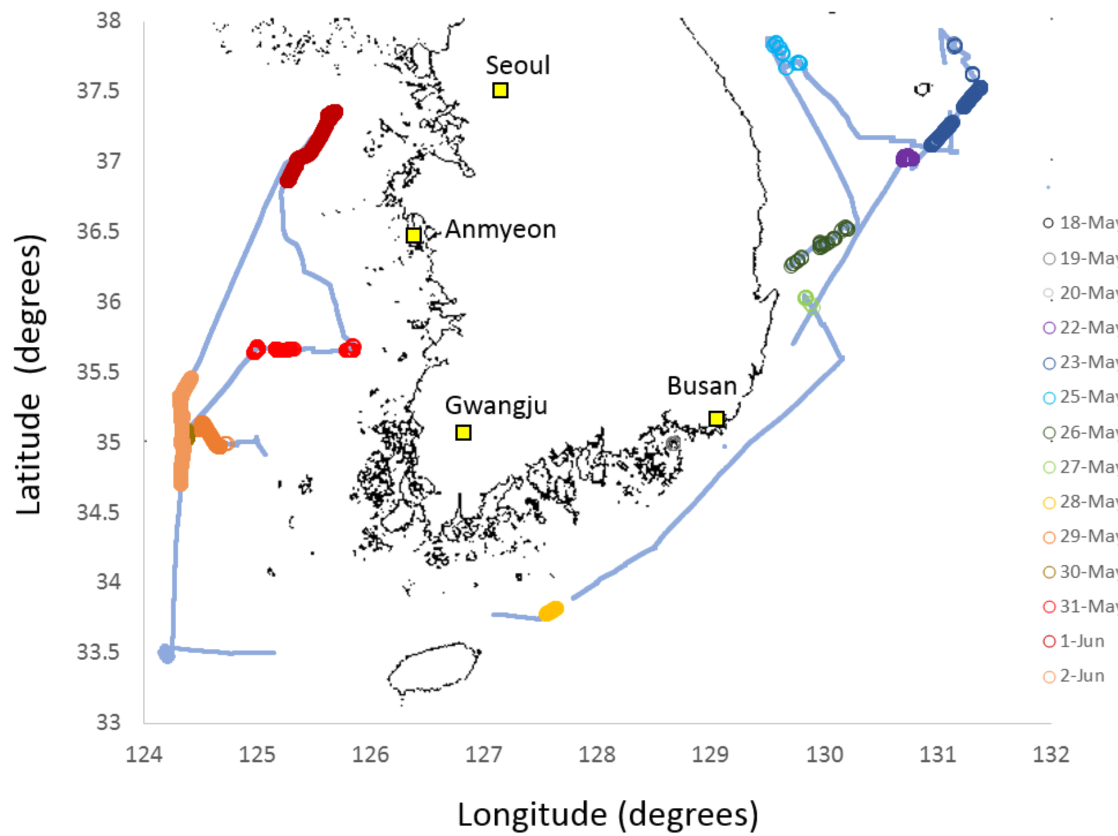

RV Onnuri


RV Jangmok

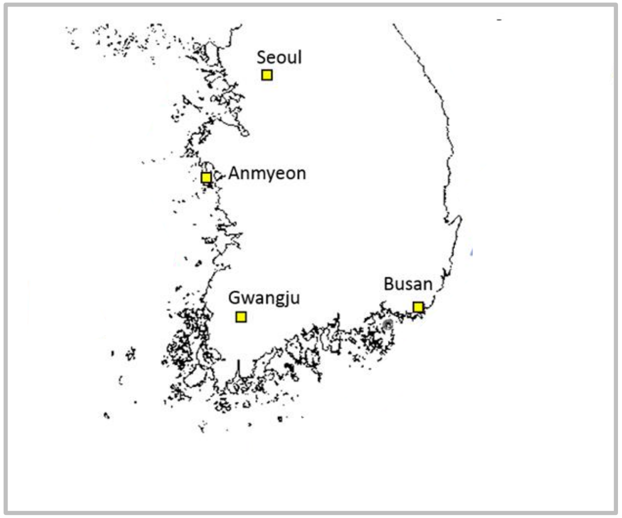

3 airplanes with 37 different instruments onboard (MOS+P, GeoTASO)

Continuous measurements of **$TCNO_2$ and TCO_3 over coastal land sites and over the coastal ocean** from the Pandora network

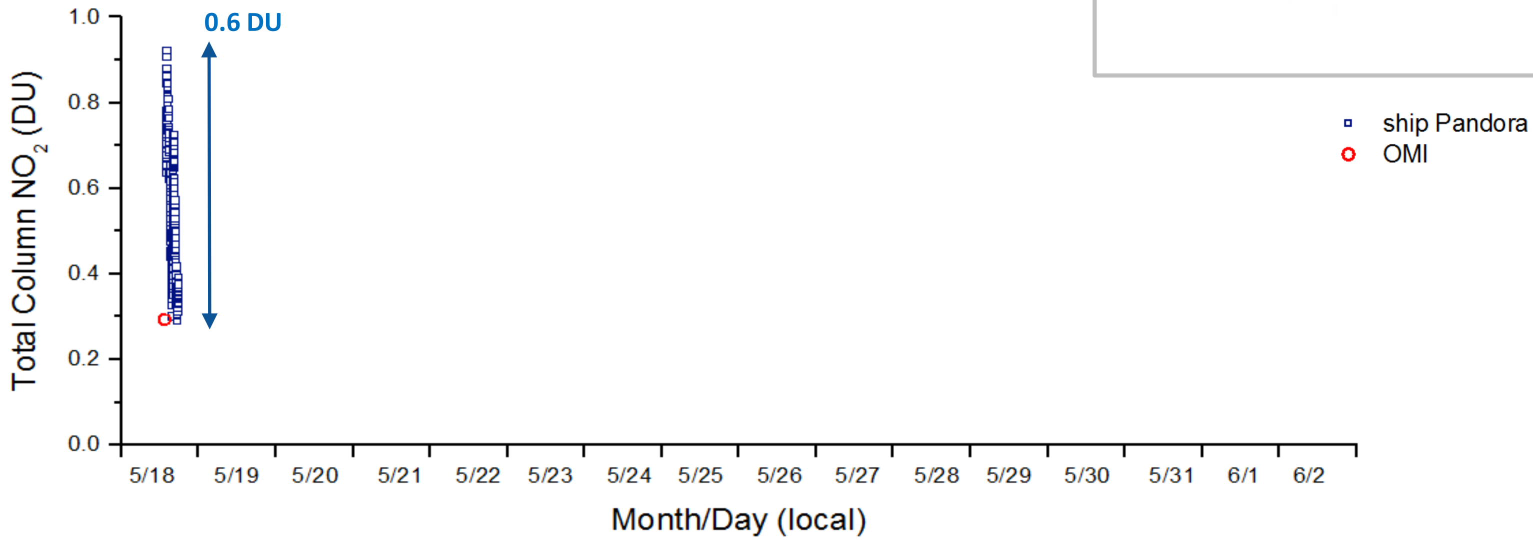
During KORUS OC, the RV *Onnuri* covered an area along the Eastern, Southern and Western South Korean coasts

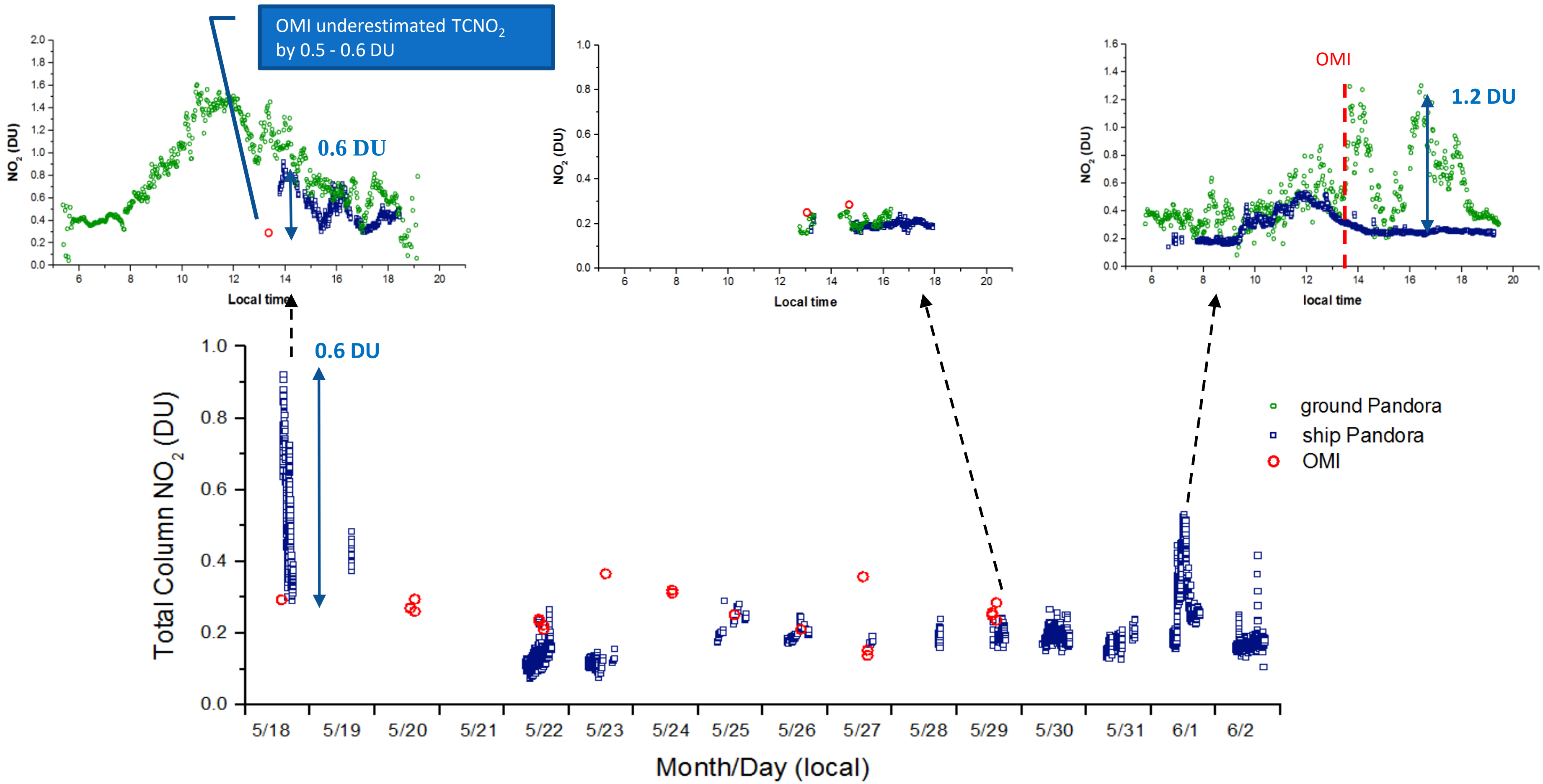


- TC NO_2 varied from 0.07 DU to 0.92 DU during KORUS OC
- OMI underestimated $TCNO_2$ in areas of high NO_2 pollution, and overestimated NO_2 over the ocean under relatively clean-air conditions
- Change as large as 0.6 DU within 3 hours



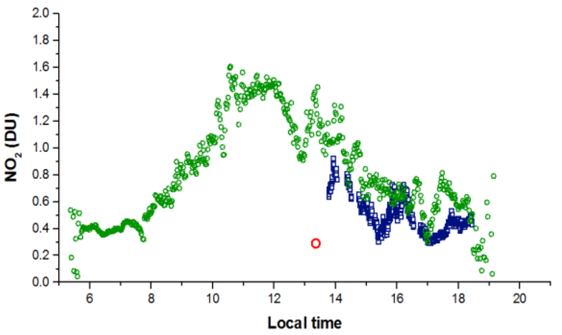
> 35 km distance from Busan

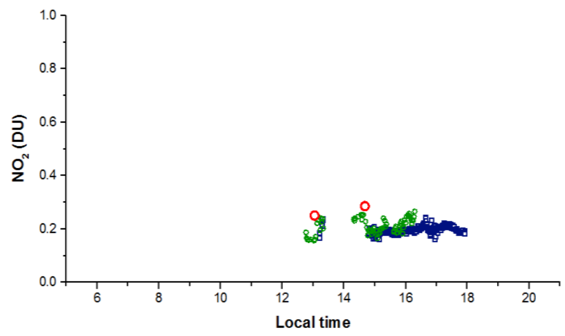


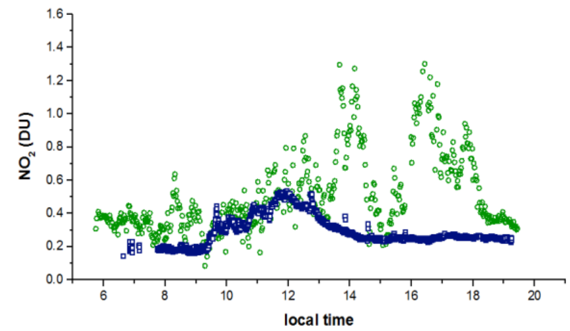

OMI underestimated TCNO2 by 0.5 - 0.6 DU
0.6 DU
NO2 (DU)
Local time
OMI
1.2 DU
local time
0.6 DU
Total Column NO2 (DU)
Month/Day (local)
5/18
5/19
5/20
5/21
5/22
5/23
5/24
5/25
5/26
5/27
5/28
5/29
5/30
5/31
6/1
6/2
ground Pandora
ship Pandora
OMI

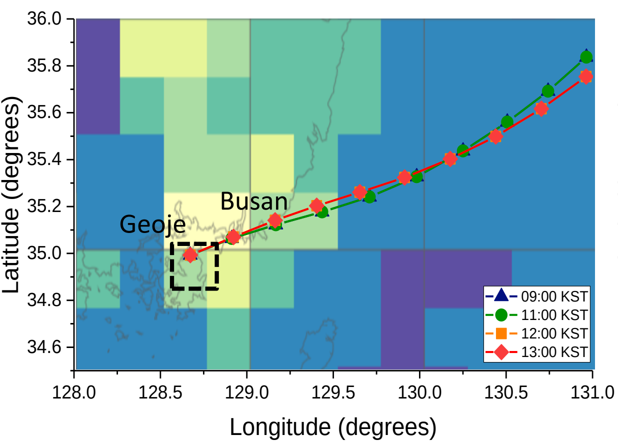
Backward air parcel trajectories simulated using HYSPLIT4 to determine the origin of air masses over *RV Onnuri*

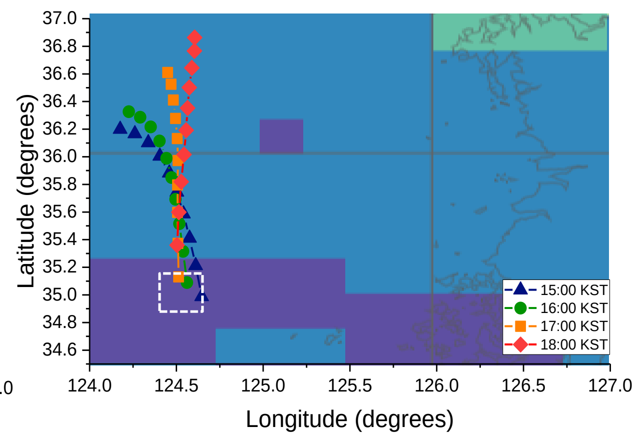
Air mass trajectories and Aura OMI NO_2 imagery

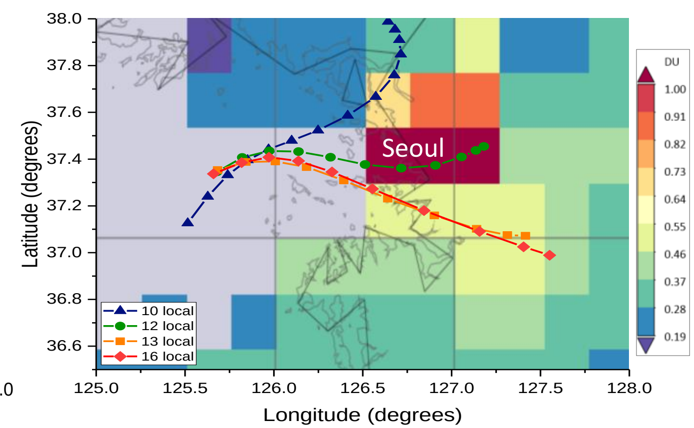










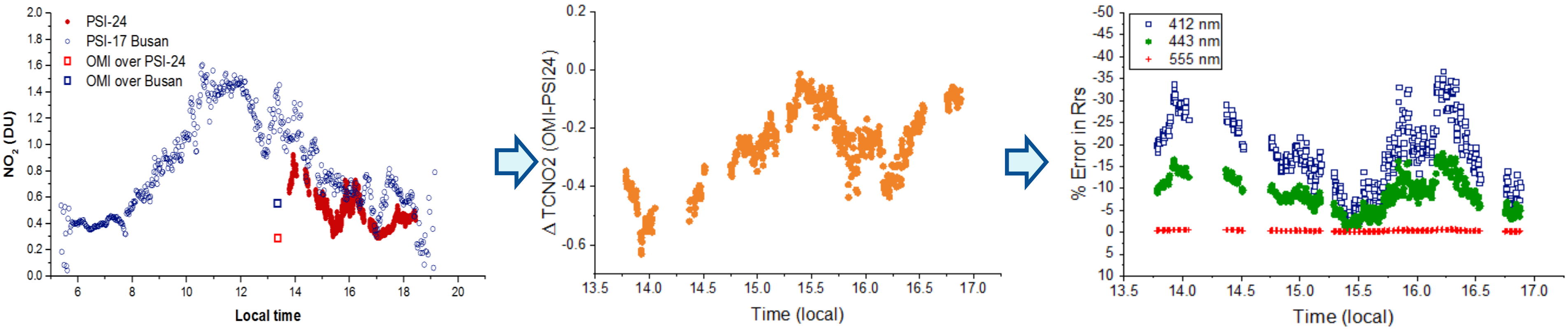


Consistent transport of pollution from Busan throughout the day

Transport of marine air masses from relatively low pollutions areas

Transport of air masses from areas characterized by different levels of NO_2 pollution drove diurnal variability over the ocean

What would be the impact of using daily ***$TCNO_2$*** *values from OMI (GOME and SCIAMACHY are much coarser resolution) in atmospheric correction algorithms for ocean color products in these coastal waters ?*

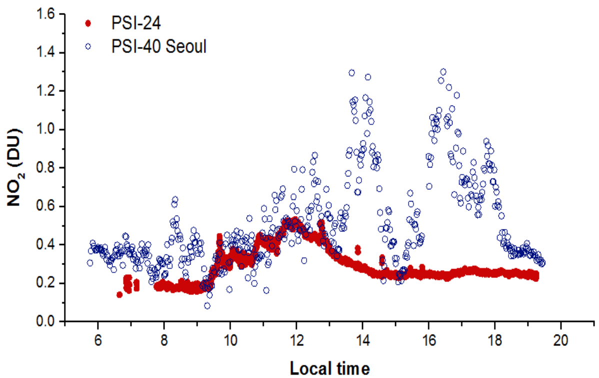


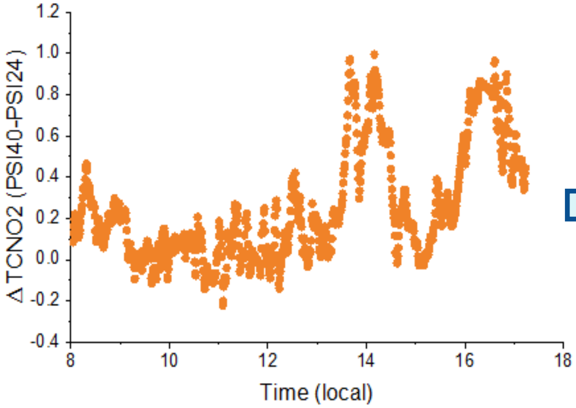
- $TCNO_2$ uncertainty of 0.6 DU during the day
- Some of the largest differences occurring at 14:00 and 16:00 local time corresponding to **25º and 50º SZA**

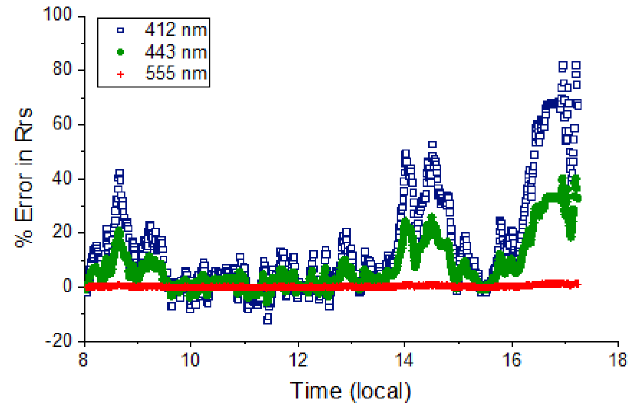
Impact:

- a false change in R_{rs}(412) by **37% during the day**
- Smaller error for 443 nm, and almost negligible error at 555 nm, introducing an **uncertainty not only in the absolute amount of R_{rs}, but also in its spectral shape**

*In the absence of information on the diurnal variability of $TCNO_2$ over the ocean (from shipboard or satellite platforms), the diurnal variability in $TCNO_2$ measured by **ground-based instruments at nearby coastal land sites** could be used as a reasonable alternative.*







- $TCNO_2$ uncertainty as large as 1 DU during the day
- Some of the largest differences occurring in the afternoon corresponding to **large SZA**s

Impact:

- a false change in R_{rs}(412) by **43% in the morning and as large as 82% in the afternoon**
- Spectral dependence on error in R_{rs} introduced an **uncertainty not only in the absolute amount of R_{rs} but also in its spectral shape**

- Small scale variability in $TCNO_2$, needs to be taken into consideration when attempting to retrieve short-term coastal ocean processes from satellite ocean color imagery.

- Need for improvements of satellite retrievals of atmospheric NO_2 over the ocean. Uncertainties in the OMI retrievals (e.g., NO_2 profile shape and surface reflectivity) contributed to the discrepancies between OMI and Pandora. Current research is focusing on reducing these uncertainties over land and over the ocean.

- Need for high-spatial resolution, high-temporal resolution observations of atmospheric NO_2 from shipboard platforms and integration of these measurements to atmospheric correction approaches

- Need for high-spatial and high-temporal resolution observations of atmospheric NO_2 from space (e.g., TEMPO, TROPOMI, GEMS, Sentinel-4, Sentinel-5)

Discussion: recommendations for AC over complex atmosphere

1. Advancement in algorithms with current sensors:

1 Is rigorous modeling of the aerosol required (IOP, PF, ALH….)?

2 How global assimilated aerosol transport models improves algorithms? Is there a need for high resolution models (~ few kilometers)?

2. Advancement in observation platforms:

3 How can UV improve the aerosol correction? What are the technological limitations in designing a high radiometric quality UV spectrometer with high spatial resolution?

4 Can hyperspectral observations:

- of the O2 bands improve layer height detection (limitations to high optical depth)?
- of the blue bands (400-450 nm) be used to correct for NO2?

5 Is there a necessity for a LIDAR/polarimeter/multiangular instrument combined with an ocean color sensor for aerosol vertical column profile detection?