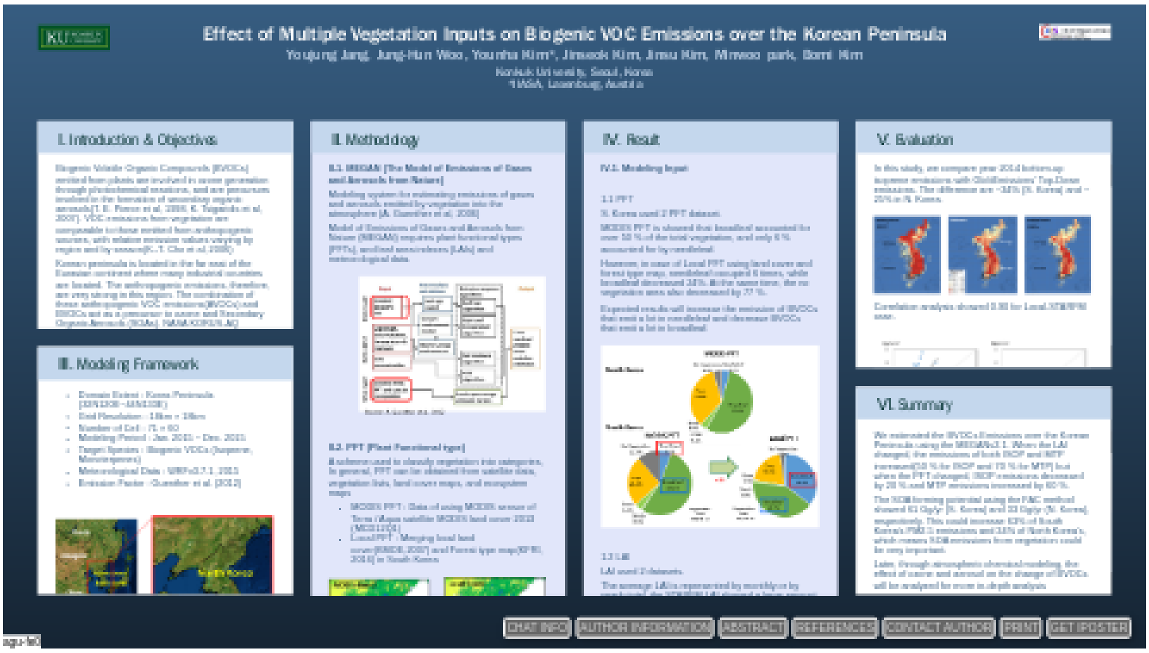
Effect of Multiple Vegetation Inputs on Biogenic VOC Emissions over the Korean Peninsula



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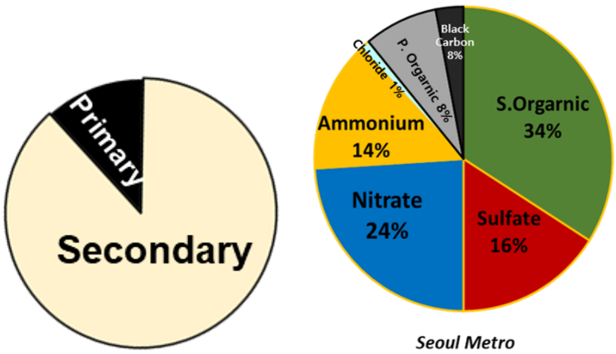
Ⅰ. INTRODUCTION & OBJECTIVES

Biogenic Volatile Organic Compounds (BVOCs) emitted from plants are involved in ozone generation through photochemical reactions, and are precursors involved in the formation of secondary organic aerosols(T. E. Pierce et al, 1998, K. Tsigaridis et al, 2007). VOC emissions from vegetation are comparable to those emitted from anthropogenic sources, with relative emission values varying by region and by season(K.-T. Cho et al, 2006)

Korean peninsula is located in the far east of the Eurasian continent where many industrial countries are located. The anthropogenic emissions, therefore, are very strong in this region. The combination of these anthropogenic VOC emissions(AVOCs) and BVOCs act as a precursor to ozone and Secondary Organic Aerosols (SOAs). NASA KORUS-AQ research shows that secondary organic aerosol (SOA) account for 34 % of fine particle concentration over the Seoul Metropolitan Area(SMA) in Korea.

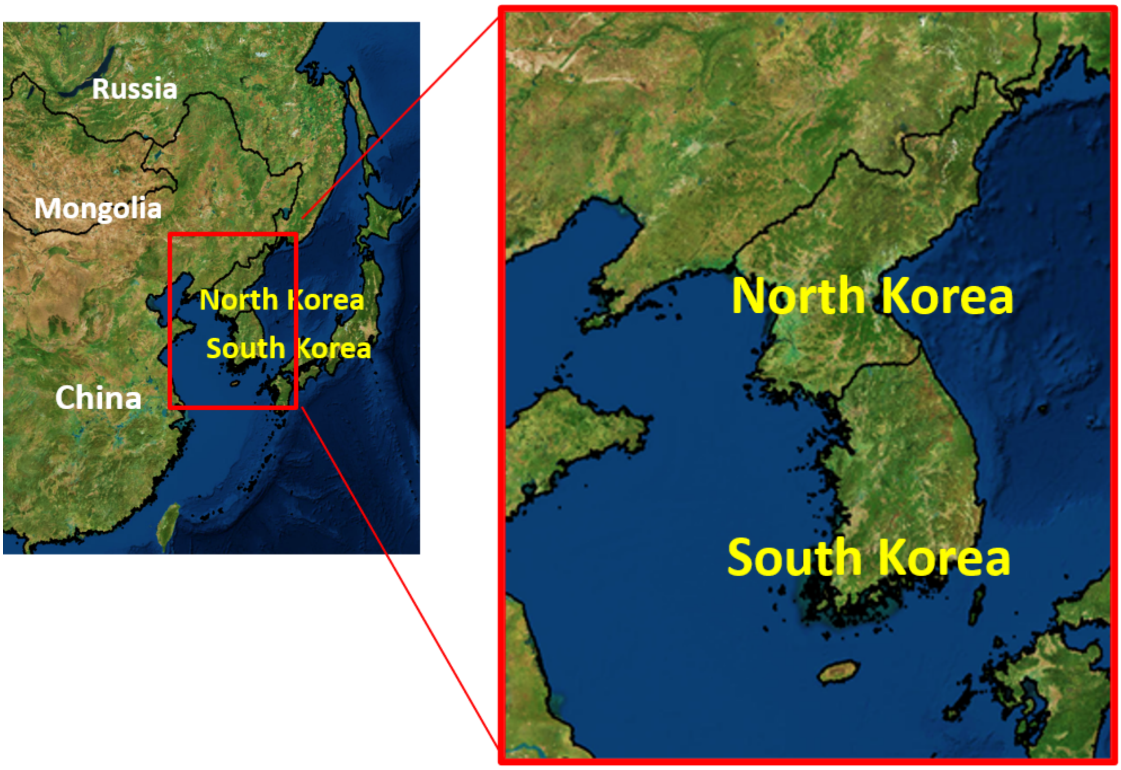
We have estimated BVOCs emission using MEGAN model with different PFT and LAI datasets to understand impact of these inputs. SOA yields from BVOCs were also estimated to understand the potential to form secondary fine particles.

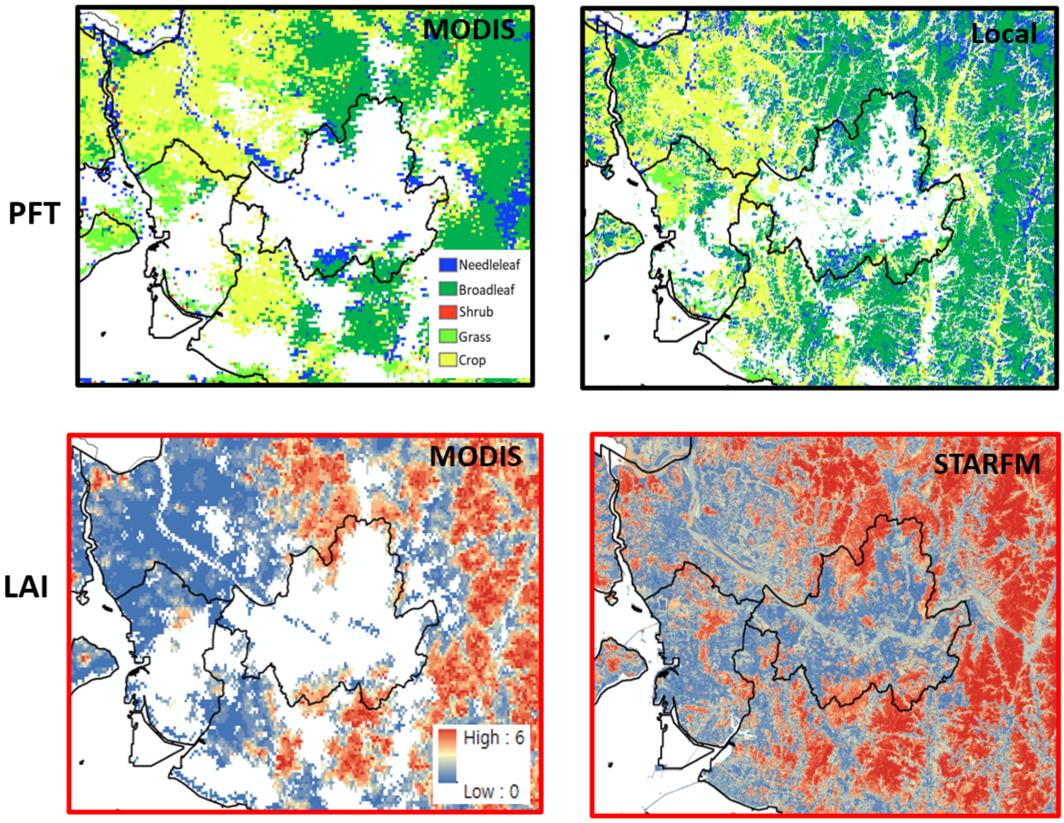


Seoul Metro
KORUS AQ, DC-8 flights
NIER/NASA, 2017

Ⅲ. MODELING FRAMEWORK

- Domain Extent : Korea Peninsula (32N120E~44N133E)
- Grid Resolution : 18km × 18km
- Number of Cell : 71 × 60
- Modeling Period : Jan. 2015 ~ Dec. 2015
- Target Species : Biogenic VOCs (Isoprene, Monoterpenes)
- Meteorological Data : WRFv3.7.1, 2015
- Emission Factor : Guenther et al. (2012)



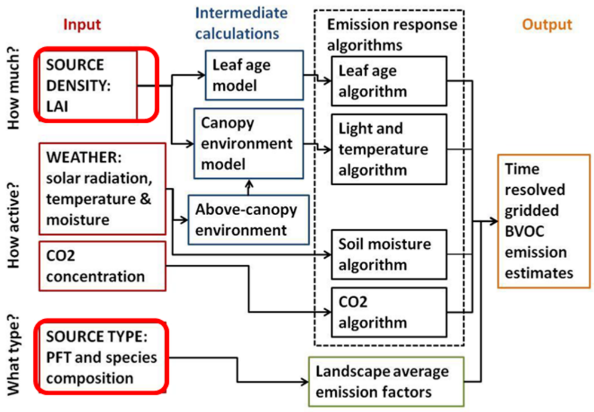

PFT
MODIS
Needleleaf
Broadleaf
Shrub
Grass
Crop
Local
LAI
MODIS
High : 6
Low : 0
STARFM

Ⅱ. METHODOLOGY

II-1. MEGAN (The Model of Emissions of Gases and Aerosols from Nature)

Modeling system for estimating emissions of gases and aerosols emitted by vegetation into the atmosphere (A. Guenther et al, 2006)

Model of Emissions of Gases and Aerosols from Nature (MEGAN) requires plant functional types (PFTs), and leaf area indexes (LAIs) and meteorological data.

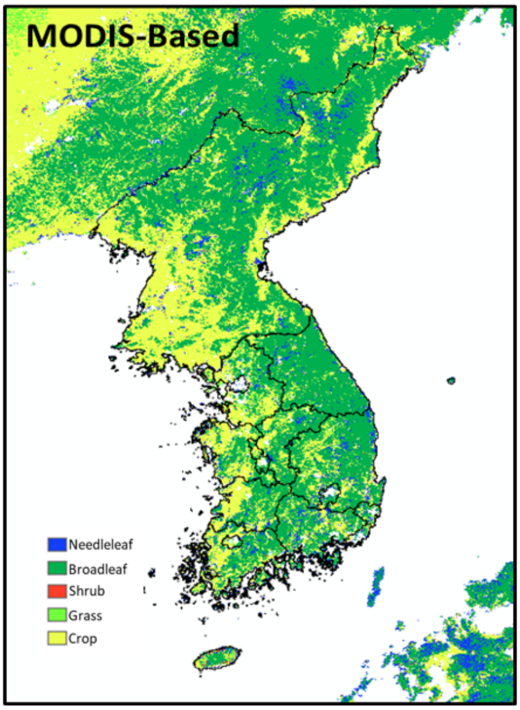


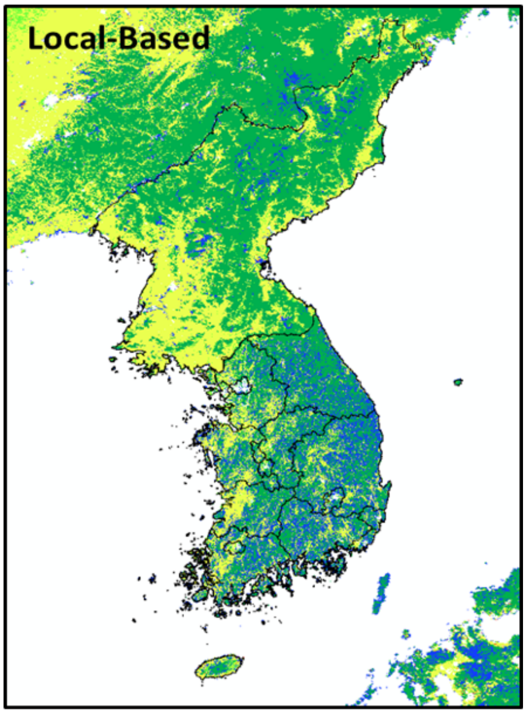
Source : A. Guenther et al., 2012

II-2. PFT (Plant Functional type)

A scheme used to classify vegetation into categories, In general, PFT can be obtained from satellite data, vegetation lists, land cover maps, and ecosystem maps

- MODIS PFT : Data of using MODIS sensor of Terra / Aqua satellite MODIS land cover 2013 (MCD12Q1)
- Local PFT : Merging local land cover(KMOE,2007) and Forest type map(KFRI, 2016) in South Korea

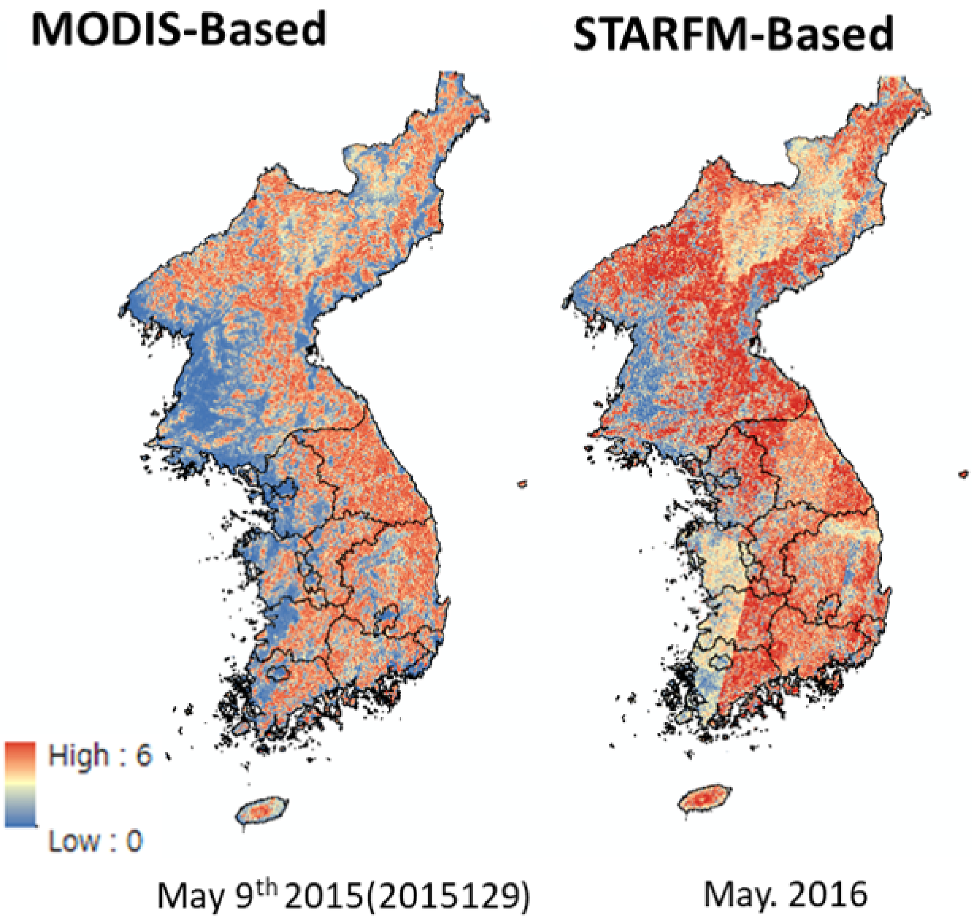




II-3. LAI (Leaf Area Index)

A parameter related to the activity of plant physiology

- MODIS LAI :Data of using MODIS sensor of Terra / Aqua satellite
  - MODIS LAI 2015 (MCD15A2H)
- STARFM LAI :Using algorithm for predicting Landsat data of desired day (Target Date) by combining Landsat data with high spatial resolution and MODIS data with high periodic resolution
  - STARFM LAI 2016



IV. RESULT

IV-1. Modeling Input

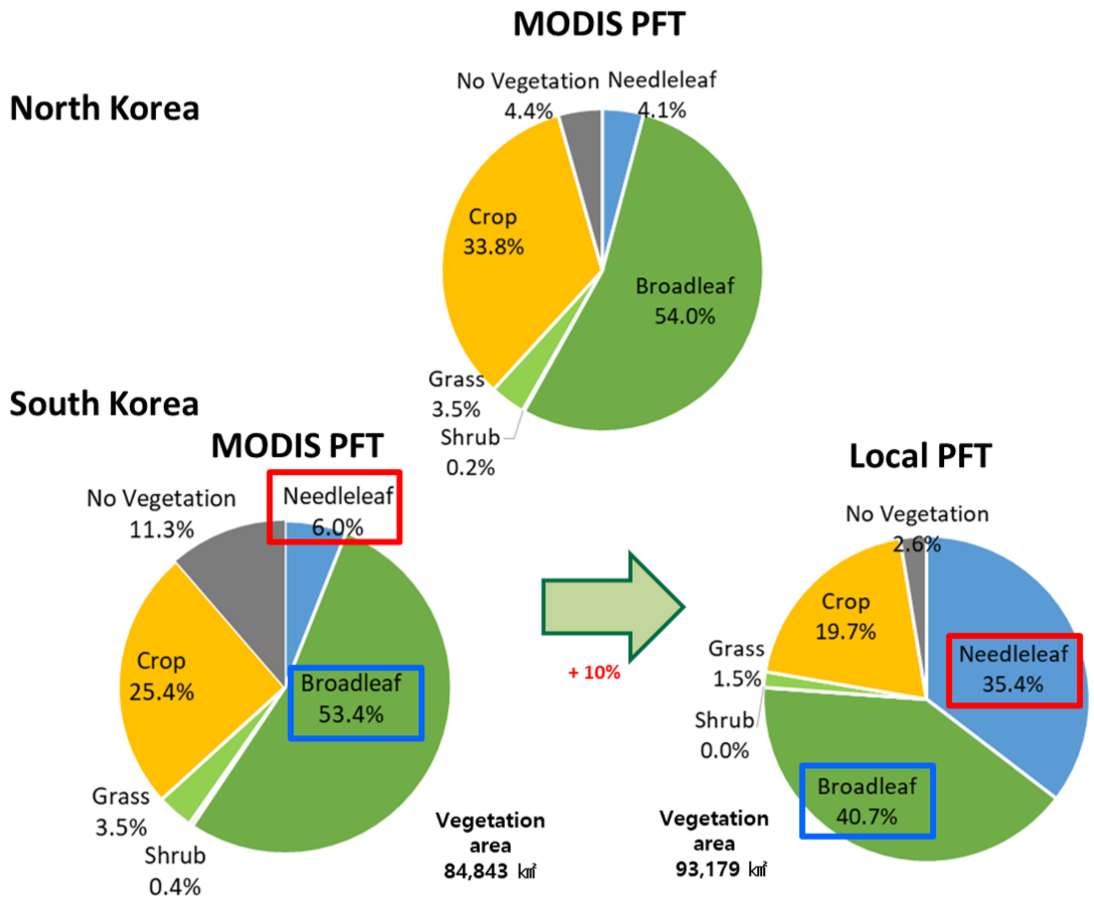
1.1 PFT

S. Korea used 2 PFT dataset.

MODIS PFT is showed that broadleaf accounted for over 50 % of the total vegetation, and only 6 % accounted for by needleleaf.

However, in case of Local PFT using land cover and forest type map, needleleaf occupied 6 times, while broadleaf decreased 24%. At the same time, the no vegetation area also decreased by 77 %.

Expected results will increase the emission of BVOCs that emit a lot in needleleaf and decrease BVOCs that emit a lot in broadleaf.

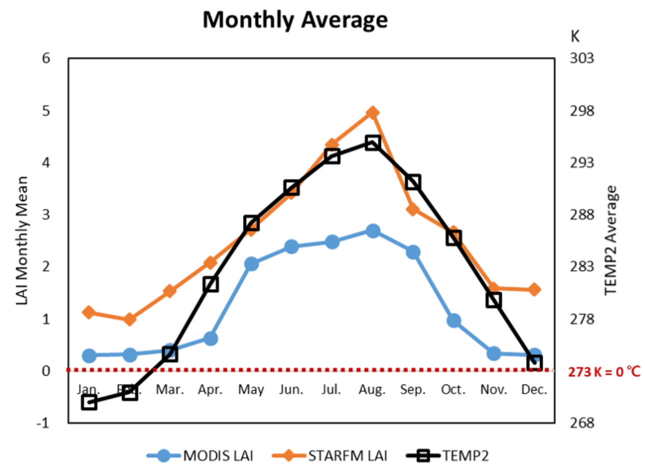


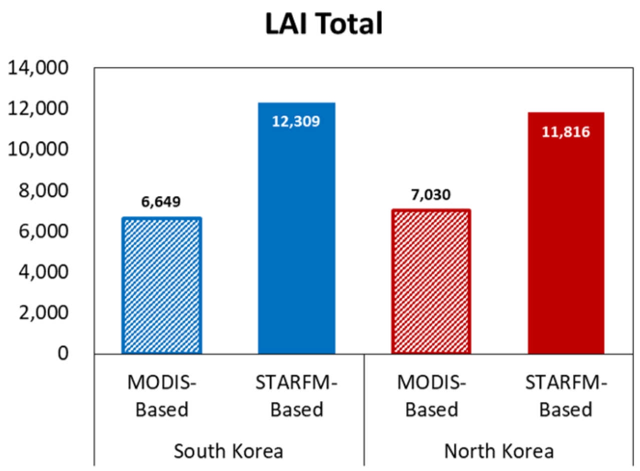
1.2 LAI

LAI used 2 datasets.

The average LAI is represented by monthly or by yearly total, the STARFM LAI showed a large amount than the MODIS LAI over 65 %.

The expected result is an increase in emissions due to changes in LAI





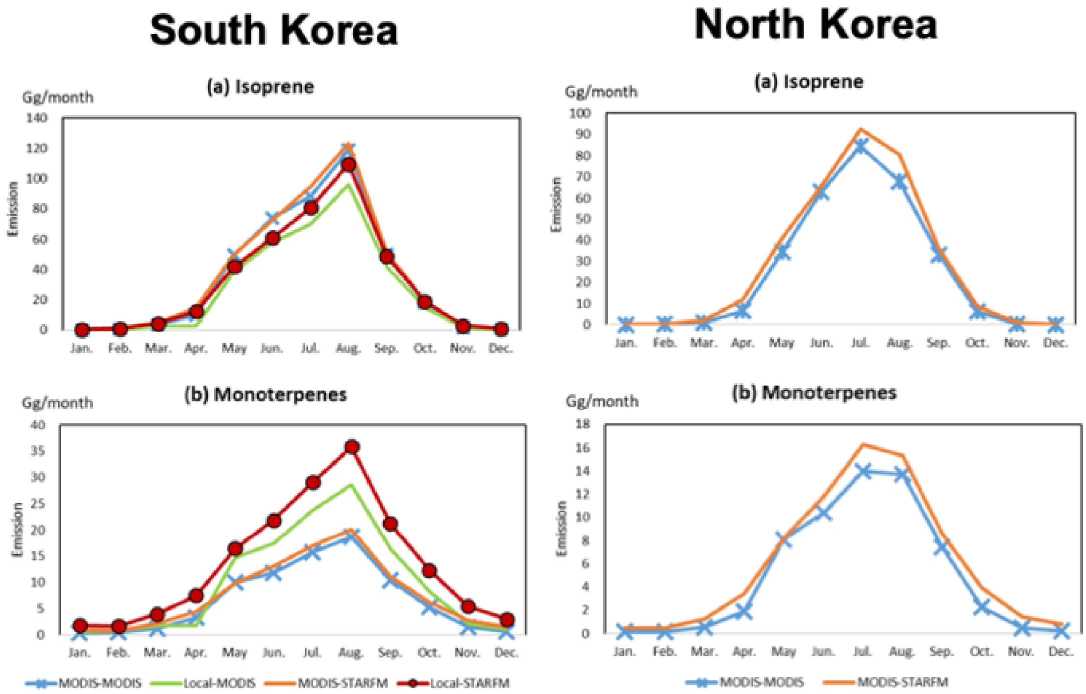
IV-2. BVOCs Emissions Estimation

The BVOCs emissions were calculated by four cases.

		LAI	
		MODIS	STARFM
PFT	MODIS	Case_1	Case_3
	Local	Case_2	Case_4

When the LAI changed from MODIS to STARFM, the emissions of both Isoprene(ISOP) and monoterpenes(MTP) increased, 50 % for ISOP and 70 % for MTP.

When the PFT changed from MODIS to Local PFT(South Korea), ISOP emissions decreased by 20 % and MTP emissions increased by 60 %.



IV-3. Secondary Organic Aerosol (SOA) Forming Potential

FAC (Fractional Aerosol Coefficient) Method

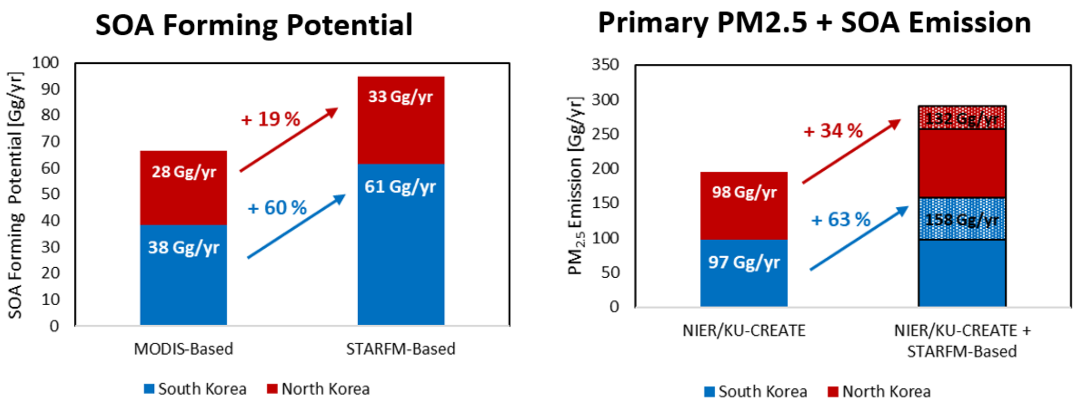
: Estimate SOA Forming Potential using VOC emission without Atmospheric Chemistry Modeling (D. Grosjean, 1992)

$$[\mathrm{SOA}] = [VOC] \times \boxed{FAC \times fraction\ of\ VOC\ reacted}$$

[SOA] : Amount of aerosol produced (Gg/yr)

[VOC] : Amount of VOC emitted (Gg/yr)

- FAC × fraction of VOC reacted
  - Isoprene : 0.03 (A. Carlton et al., 2009)
  - Monoterpenes : 0.30 (D. Grosjean, 1992)

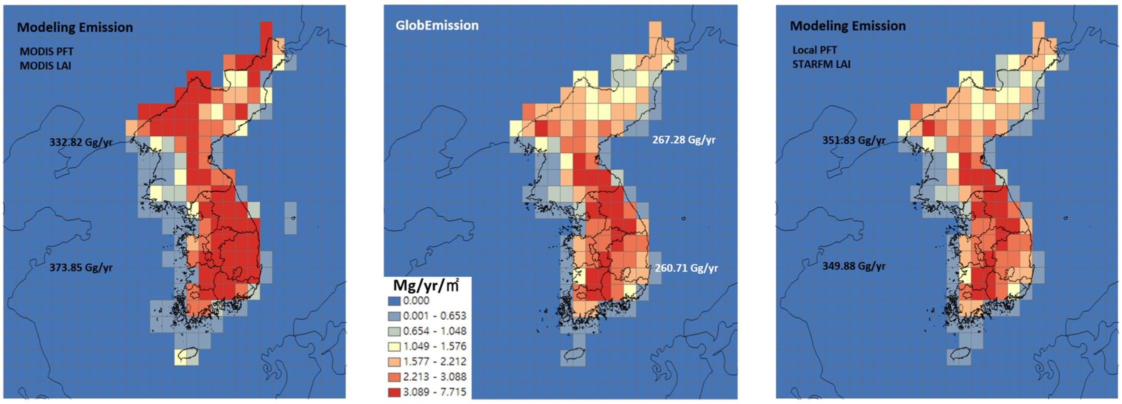


Since the coefficient of monoterpenes was 10 times larger than that of isoprene, amount of SOA forming potential are largely influenced by monoterpenes. The estimated SOA amounts using Local PFT were much higher because monoterpenes emission in the Local PFT was 1.6 times larger than that of the MODIS PFT.

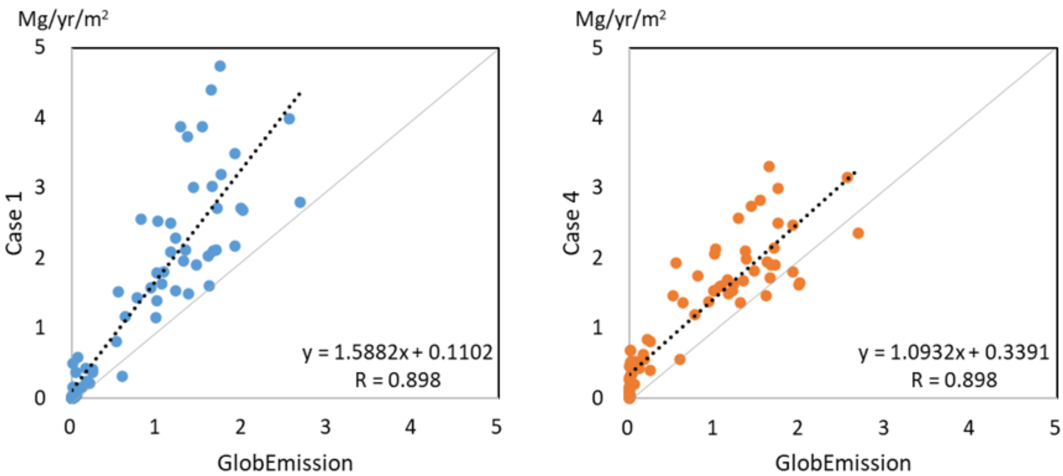
Combined with PM2.5 anthropogenic emissions, BVOC derived emissions increase by 63% in S. Korea and 34% in N. Korea.

Ⅴ. EVALUATION

In this study, we compare year 2014 bottom-up isoprene emissions with GlobEmissions' Top-Down emissions. The difference are ~34% (S. Korea) and ~ 25% in N. Korea.



Correlation analysis showed 0.90 for Local-STARFM case(Case 4). Correlation analysis indicate that our bottom-up emissions represent reasonable spatial and temporal variations using Case 4, but generally overestimated the amount of BVOCs.



VI. SUMMARY

We estimated the BVOCs Emissions over the Korean Peninsula using the MEGANv2.1. When the LAI changed, the emissions of both ISOP and MTP increased(50 % for ISOP and 70 % for MTP) but when the PFT changed, ISOP emissions decreased by 20 % and MTP emissions increased by 60 %.

The SOA forming potential using the FAC method showed 61 Gg/yr (S. Korea) and 33 Gg/yr (N. Korea), respectively. This could increase 63% of South Korea's PM2.5 emissions and 34% of North Korea's, which means SOA emissions from vegetation could be very important.

Later, through atmospheric chemical modeling, the effect of ozone and aerosol on the change of BVOCs will be analyzed for more in-depth analysis

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Jang, Y. et al., 2020.「Impact of Land Cover and Leaf Area Index on BVOC Emissions over the Korean Peninsula」, Atmosphere, 11, 806; doi:10.3390/atmos11080806

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ABSTRACT

Biogenic Volatile Organic Compounds (BVOCs) emissions from natural environments, such as forest, are a major precursor to ozone, secondary fine particles, and act as climate pollutants. In addition, estimating vegetation emissions correctly is a very important factor in air quality modeling and analysis on climate change and atmospheric environment, as more than 80% of global VOCs emissions are generated by vegetation sources. This study was conducted to understand the effect of using different PFT and LAI datasets as vegetation input data in a BVOCs emission model, when trying to quantify realistic BVOC emission estimates for the Korean Peninsula. The effect of meteorological modeling performance as an input to MEGAN v2.1 emissions model was also discussed. We had used the MEGAN (Model of Emissions of Gases and Aerosols from Nature) BVOCs emissions model to estimate BVOCs emissions. We have tested BVOCs emissions estimation over the Korean Peninsula using multiple PFTs and LAIs. Two different datasets from PFTs (MODIS vs. Local) and LAIs(MODIS vs. STARFM) combination 4 cases were used.

The emission estimate amounts change by case and by species. When the LAI changes from MODIS to Local, the fraction of vegetation area and needleleaf trees were increased. These inputs changed BVOCs emission modelling results; isoprene emissions decreased by 20 %, but monoterpenes emission is increased by 60%. When the PFT changed from MODIS to STARFM, emissions of both isoprene and monoterpenes were increased (by 50% for isoprene and 70% for monoterpenes). When compared with other BVOCs emission inventory, including inverse emissions from GlobEmission, the emissions using Local PFT and STARFM LAI turned out to be the best estimates among 4 cases. Correlation analysis and monthly inter-comparison also indicate that our bottom-up emissions represent reasonable spatial and temporal variations using Local PFT and STARFM LAI, but generally overestimated the amount of BVOCs by 30%. The main reason of this overestimation was because of solar radiation from WRF model, which constantly overestimated by 10~20%.

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LAADS(Level-1 and Atmosphere Archive & Distribution System) : https://ladsweb.modaps.eosdis.nasa.gov/

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