# Implementation of Canopy Height Values from Space-borne Lidar in the WRF-Chem Model for Air Quality Predictions in Northeast Asia

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## Introduction/Motivation

❖ The air quality over Northeast Asia have deteriorated in the recent years due to rapid industrialization
❖ PM 2.5: particulate matter measuring less than 2.5 micrometers in diameter
❖ O3: ground level ozone that forms when pollutants chemically react in sunlight
❖ Exposure to ozone and particulate matter are associated with the respiratory and circulatory diseases [Pope 2002]

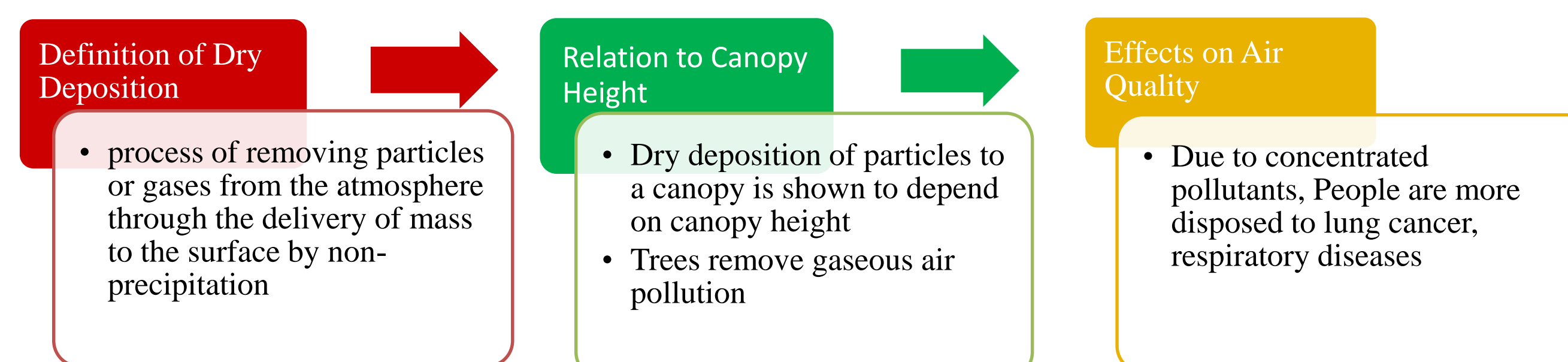| Korea | PM2.5 concentration level in Seoul two times higher than the WHO's guidelines of other major cities in developed countries. |
| China | Alarming smog outbreaks during the 2010-13 period prompted the government to introduce reforms to control air pollution |
| Japan | Almost 80% of the Japanese residents were exposed to an annual concentration of PM2.5 above the WHO guideline |

[Botta and Yamasaki 2020; Yang 2020; Trnka 2020]

❖ The Organization for Economic Co-operation and Development projects that outdoor air pollution could cause
  ❖ 6 – 9 million premature deaths a year by 2060
  ❖ 1 percent of Global GDP

## Background Information

**Canopy Height**

❖ There have been many studies to research what affects air quality including the property of canopy heights
❖ Canopy height can affect air quality through dry deposition [Mariraj 2016]

| Definition of Dry Deposition | Relation to Canopy Height | Effects on Air Quality |
| • process of removing particles or gases from the atmosphere through the delivery of mass to the surface by non-precipitation | • Dry deposition of particles to a canopy is shown to depend on canopy height • Trees remove gaseous air pollution | • Due to concentrated pollutants, People are more disposed to lung cancer, respiratory diseases |

**WRF-Chem**

❖ WRF-Chem, the Weather Research and Forecasting model coupled with Chemistry, is used for investigation of regional-scale air quality.

❖ Canopy Height is always set as a static value in the model despite that canopy height varies greatly by geographical region[Lee and Hong 2016]

❖ With the proper lidar instruments, realistic canopy height can be obtained, yielding more accurate results for input data.

## Proposal

❖ In our research, we would use data from space-borne lidar as part of NASA's Earth Observing System to change to dynamic values of canopy height in the WRF-Chem model.

❖ We predict that there will be a large difference with retrieved data having more accurate canopy height represented in the model.

## Previous Studies

Implementation of spaceborne lidar-retrieved canopy height in the WRF model [Lee and Hong 2016]

Tested the difference between using default canopy height and realistic canopy height specific to the region retrieved from a more accurate source of spaceborne lidar.

❖ In their study, the responses of the model were investigated for the Amazon Basin

❖ Results revealed that the lidar-derived canopy height led to improved precipitation simulation in terms of magnitude and spatial variations of rainfall

❖ This emphasizes the necessity of more realistic representation of canopy height in atmospheric models for better simulations
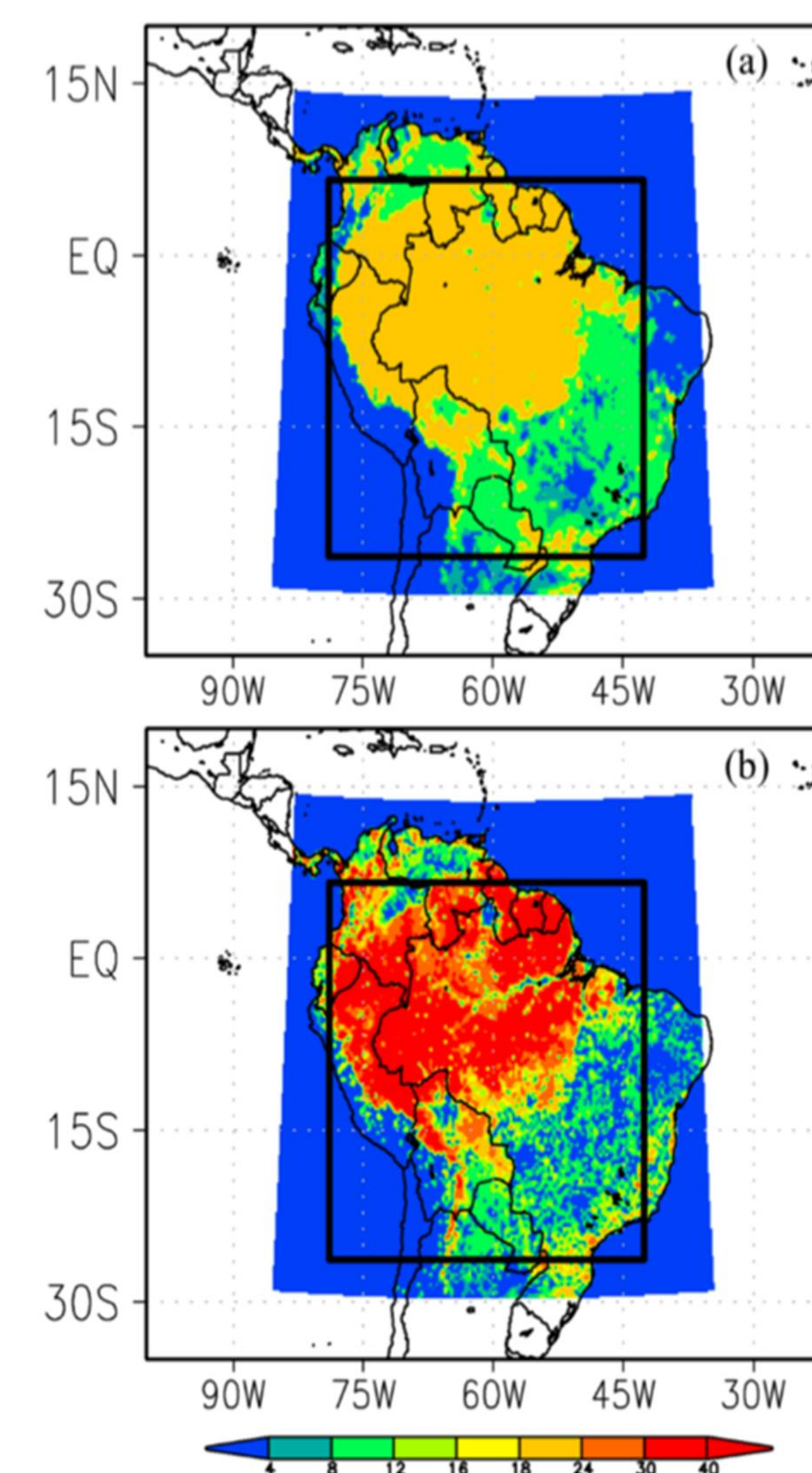


**Figure 1.** Map of canopy height (m) of the (a) original model data and the (b) revised canopy height data retrieved from the ICESat data over the Amazon Basin (the box indicates the domain 2 area).

## Methods

**Obtaining Canopy Height Data**
❖ Measurements of canopy height were made possible through the Ice, Cloud and Land Elevation Satellite (ICESat) mission with Geoscience Laser Altimeter System (GLAS) [Zwally et al., 2002; Simard et al., 2011]

  Data was obtained globally from spaceborne light detection and ranging (lidar)

  GLAS/ICESat operated from 2003 to around 2009

  Average forest canopy height data during the period is used in substitution of static canopy height values

**Compiling WRF-Chem**
❖ Currently, our lab is going through an online training to compile WRF-Chem for our research with instructions from a previous lab manual.
❖ We have successfully compiled WRF-Chem 3.5
❖ We are in the progress of debugging files in WRF-Chem 3.7.1

## Future Directions

Moving forward, we will run two simulations: one with default and the other revised canopy height in the WRF-Chem model. We will then compare air pollutant concentrations in Seoul and South Korea, focusing on PM2.5 and O3. Eventually, utilizing the more accurate dataset we will look into air quality predictions in the Northeast Asian region.

## Citations

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