



**Atmospheric Science**

# Using Satellite Data for Improving PM10 Model Outputs

*A Test Case Over Chiang Mai City*

by

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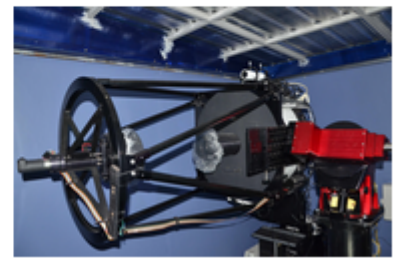
TNO (Thai National Observatory)

(Chalermprakhat Astronomical Observatory Commemorating King Bhumibhol's 7th Birthday Anniversary)



Regional Observatories for the Public

In addition to the main National Observatory at Doi Inthanon, NARIT has been committed to establish 5 more regional observatories scattered through the five geographical zones of the country.



TST (Thai Southern Hemisphere Telescope)

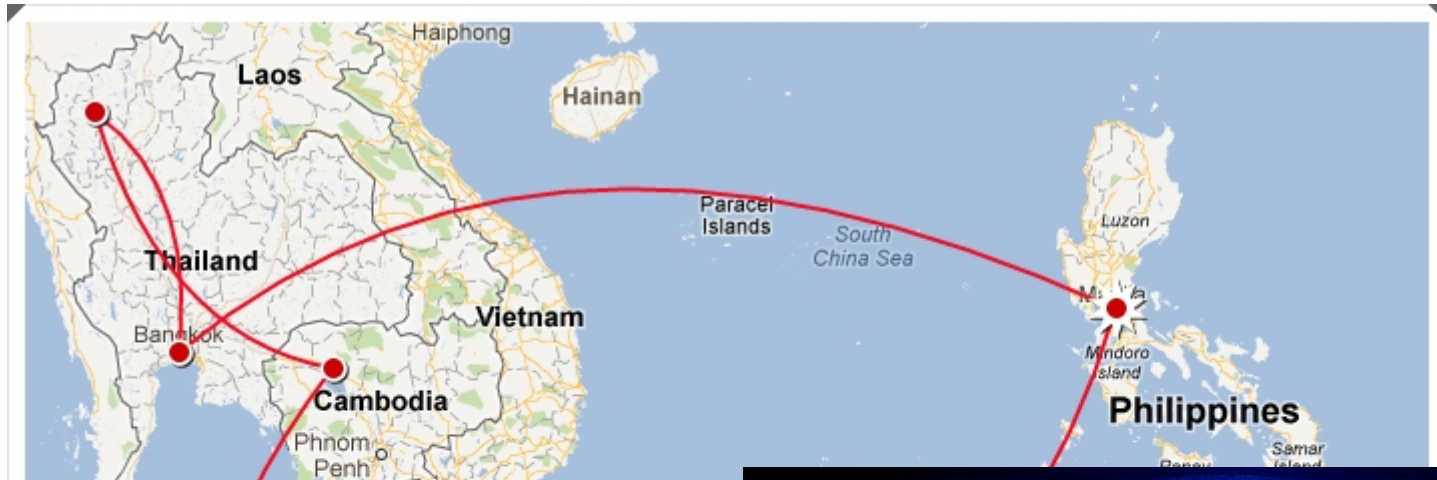
In collaboration with the University of North Carolina at Chapel Hill



**NARIT Establishment of a National Research Center for Atmospheric Science (Oct 2016) – mini-Micropulse LiDARs (aerosol profiles up to 10 km: Jan. 2017)**



# Motivation



# Causes



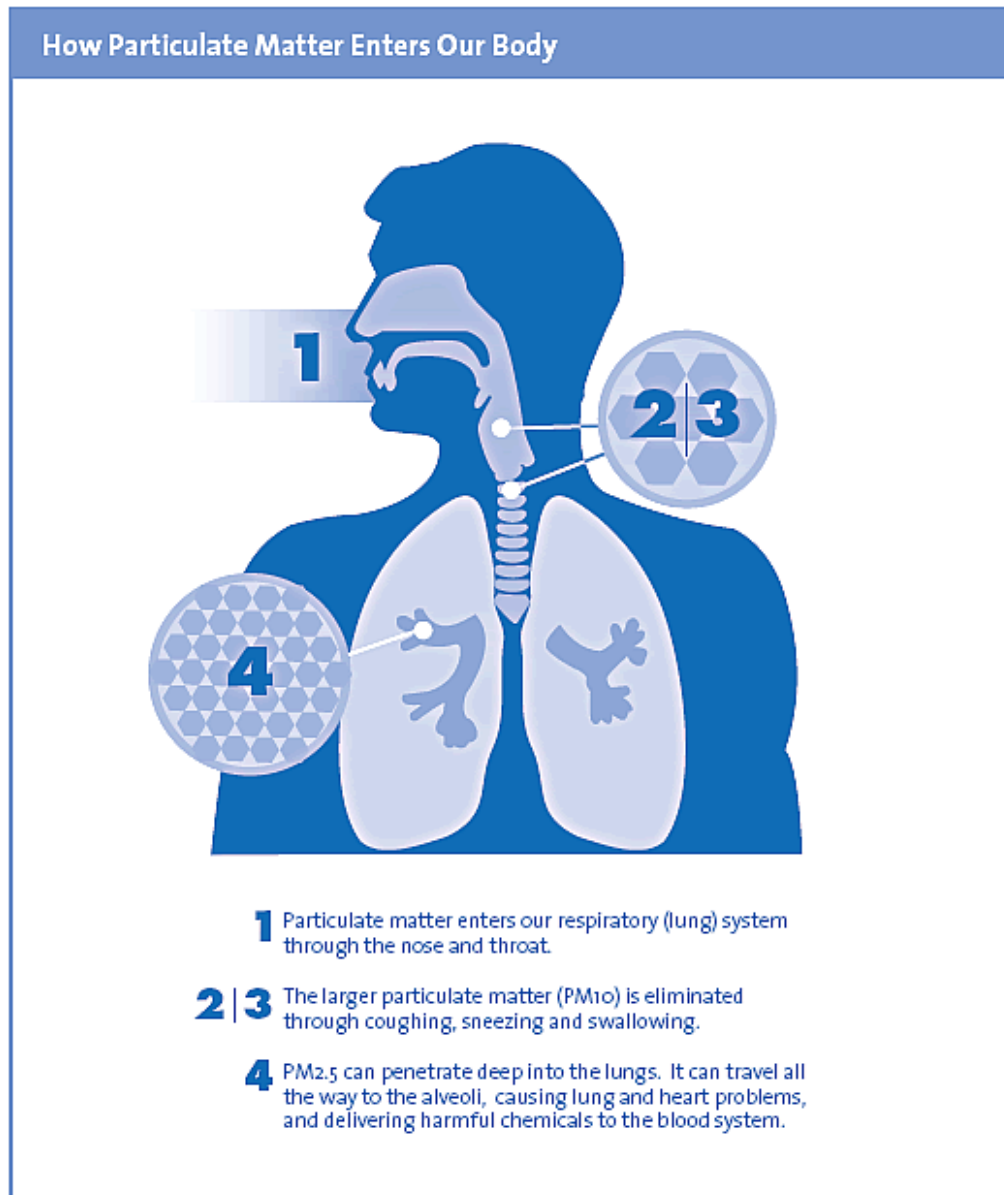
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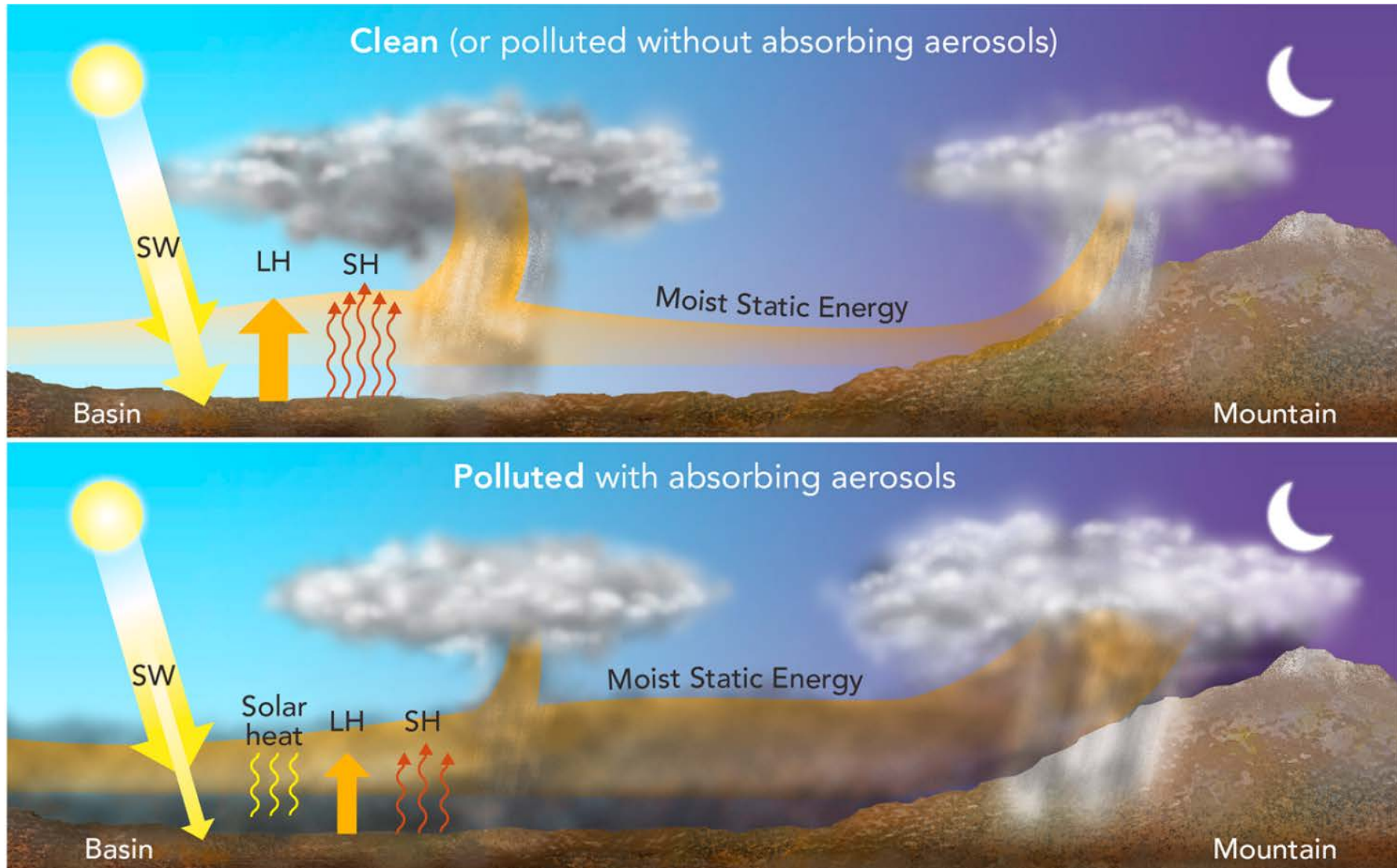
www.alamy.com - CFKWN2



# Effects on Health



# Effects on Climate



# From what we have...

## Weather Model

- High Resolution
- Fast
- Highly Accurate
- Fairly Simple

## Chemistry-Coupled Model

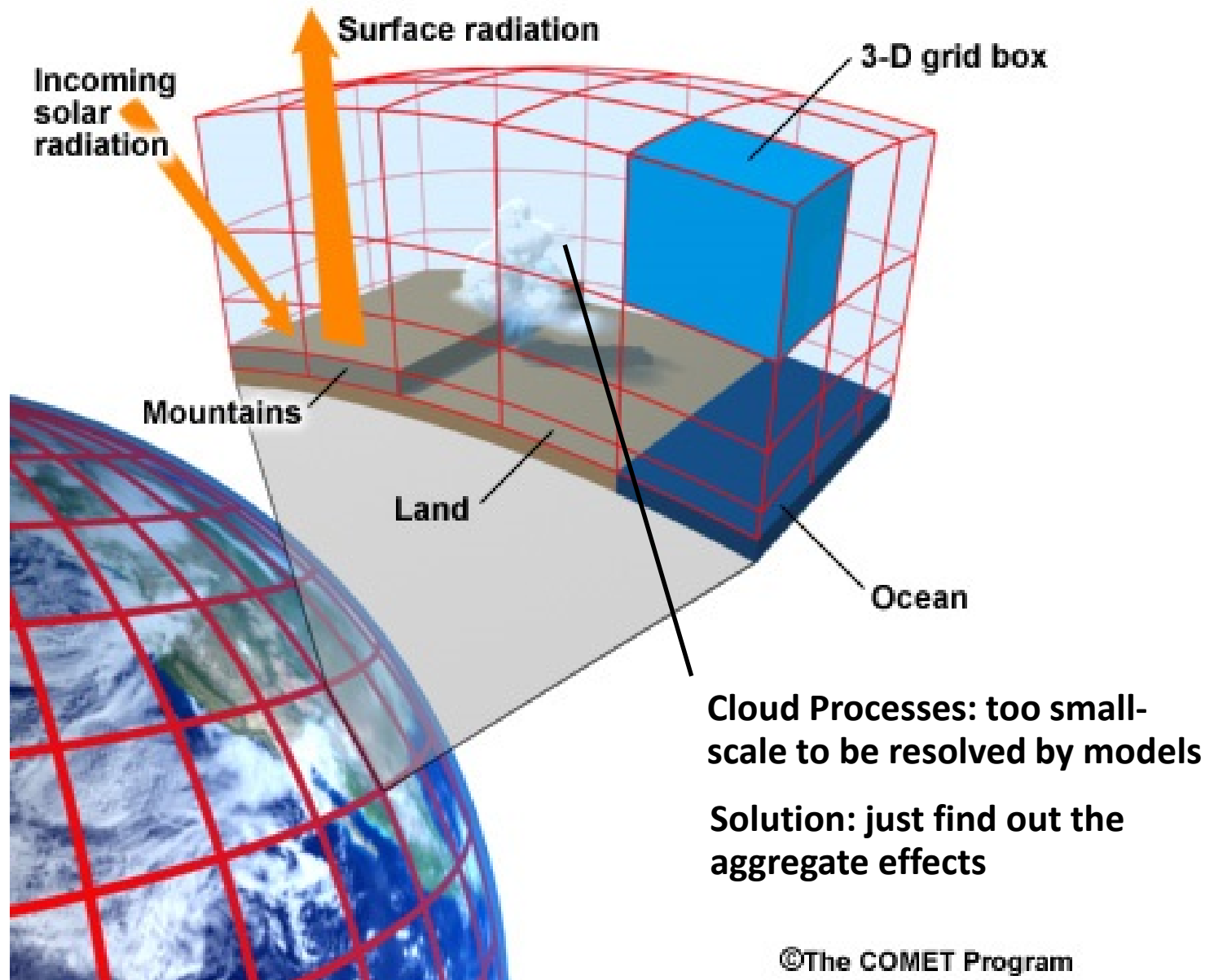
- High Resolution
- Slow
- Moderate Accuracy
- Complicated

# to what we want...

High Resolution, Relatively Fast, Moderate Accuracy, Fairly Simple PM10 Model (implications to PM10 forecasting)

Can we simulate PM10 without chemistry coupling so we can have PM10 forecasts as fast as weather forecasts?

# Parameterization in Atmospheric Models

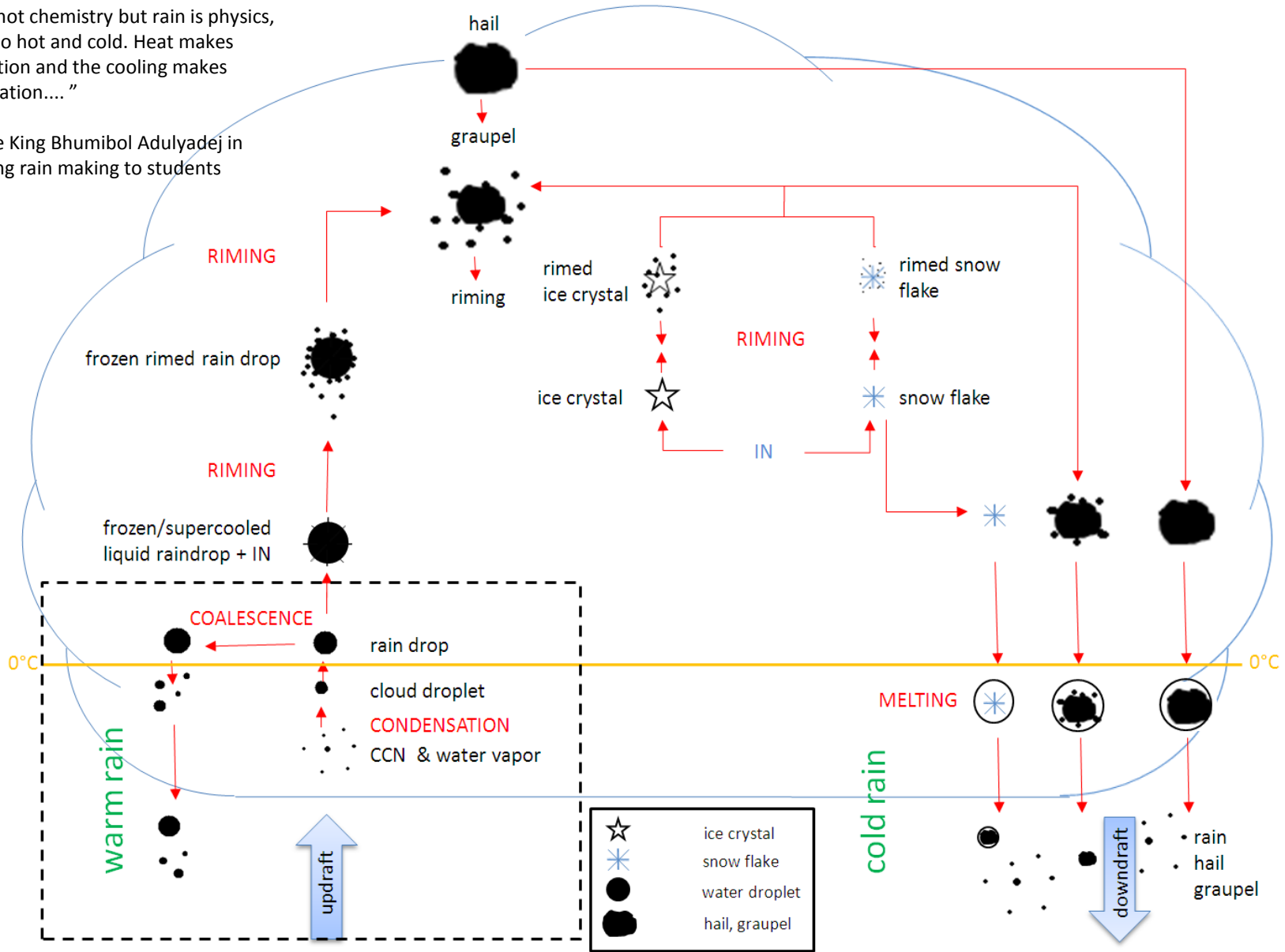




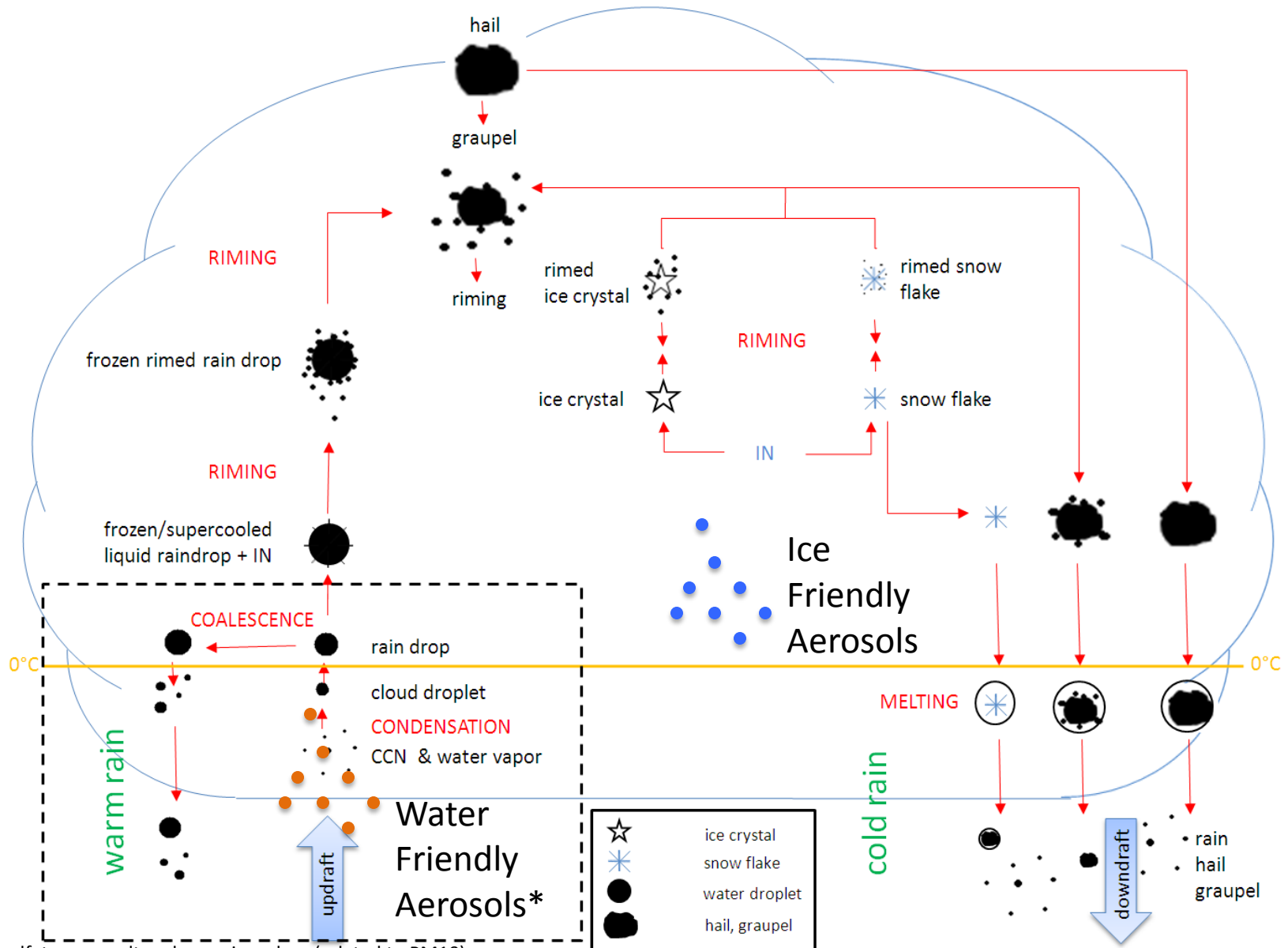
# Microphysics Processes

"Rain is not chemistry but rain is physics, related to hot and cold. Heat makes evaporation and the cooling makes condensation...."

- the late King Bhumibol Adulyadej in explaining rain making to students

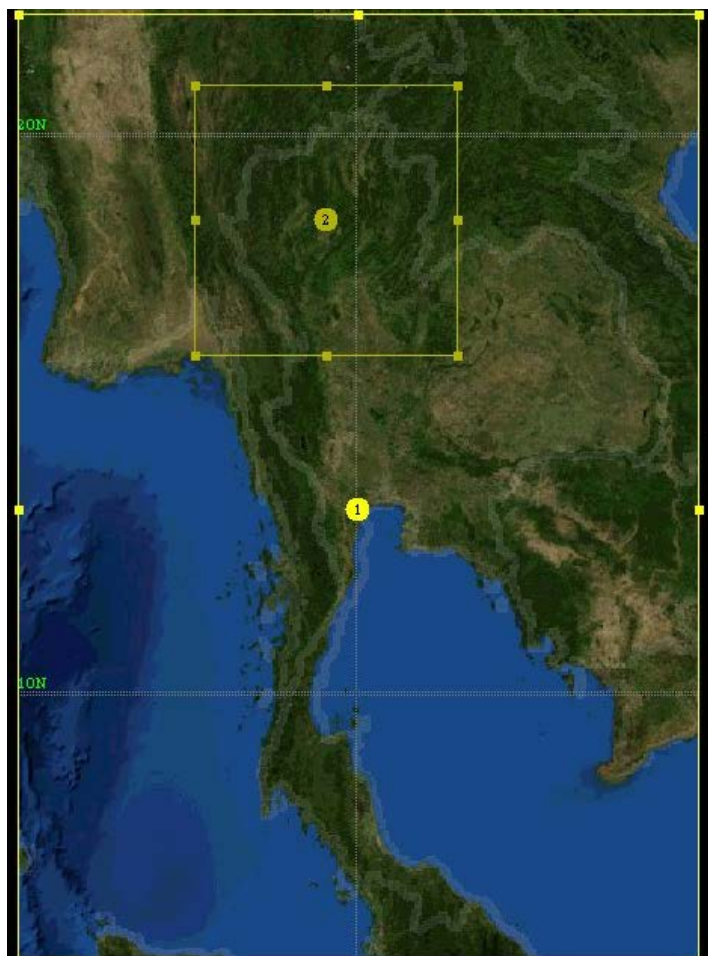


# Aerosol-Aware (Thompson) Microphysics Parameterization Scheme



\*sum of sulfates, sea salt and organic carbon (related to PM10)

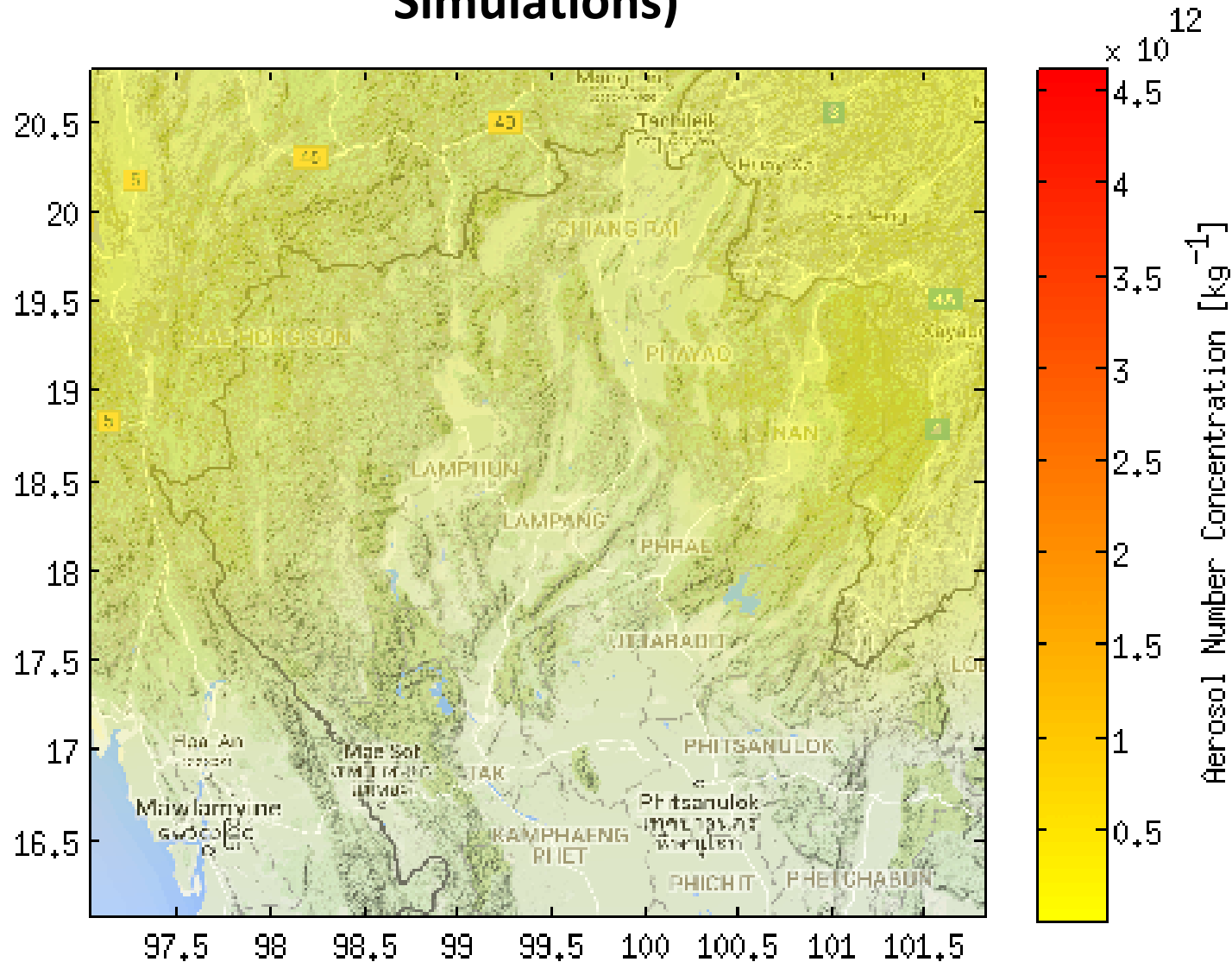
# Domain and Model Setup



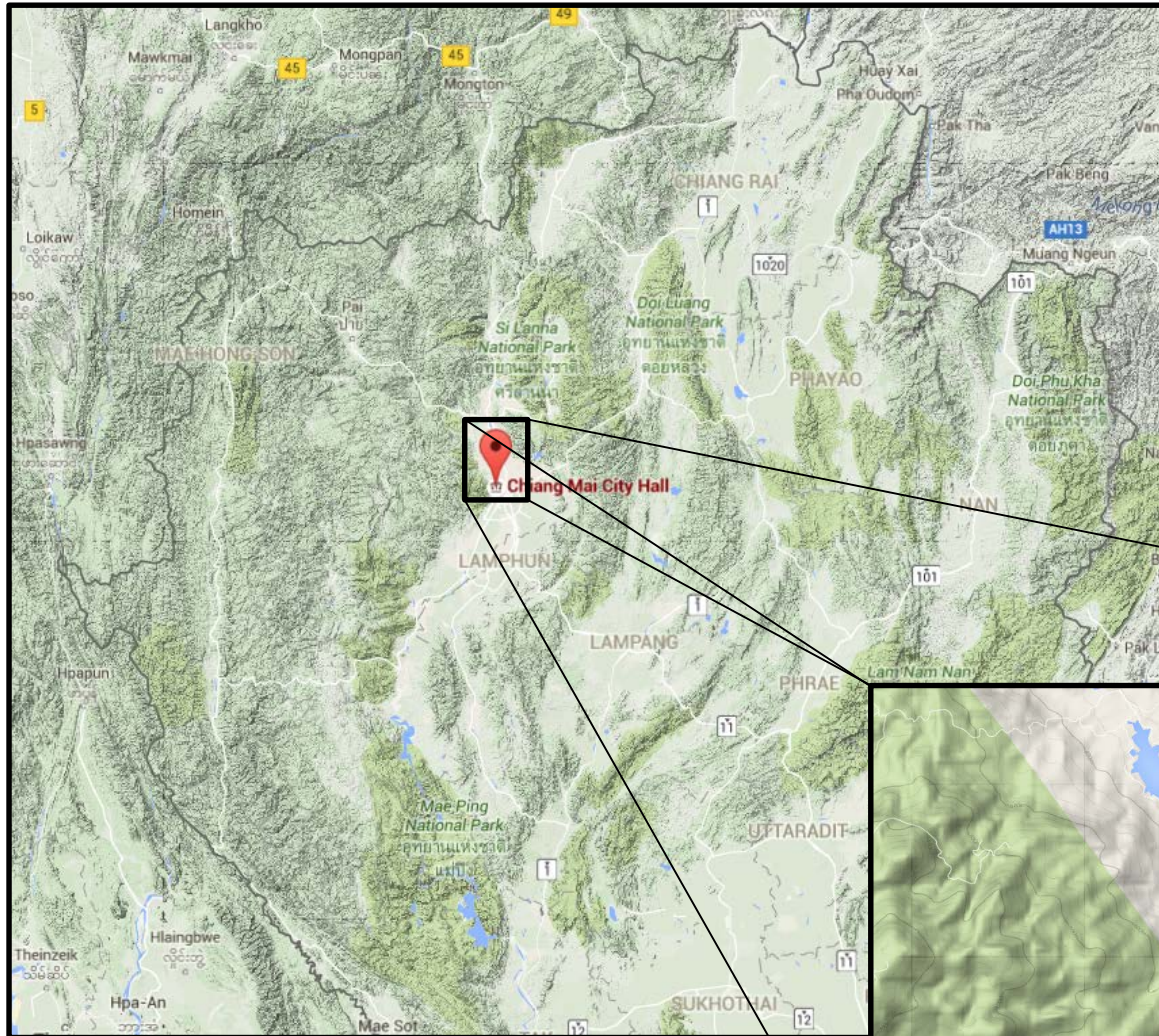
- Weather Research and Forecasting (WRF) model v3.7
- 0.25 deg NCEP GDAS/FNL lateral boundary conditions
- Nested Domains (10 and 3 km)
- MODIS Land Use Dataset (default USGS)
- 3-Category Urban Canopy Model (roof, wall, road)
- No chemistry coupling
- Thompson Aerosol Aware Microphysics (with aerosol climatology)

# Aerosol Number Concentration Initialization

## Monthly Aerosol Climatology (2001-2007 GOCART Simulations)

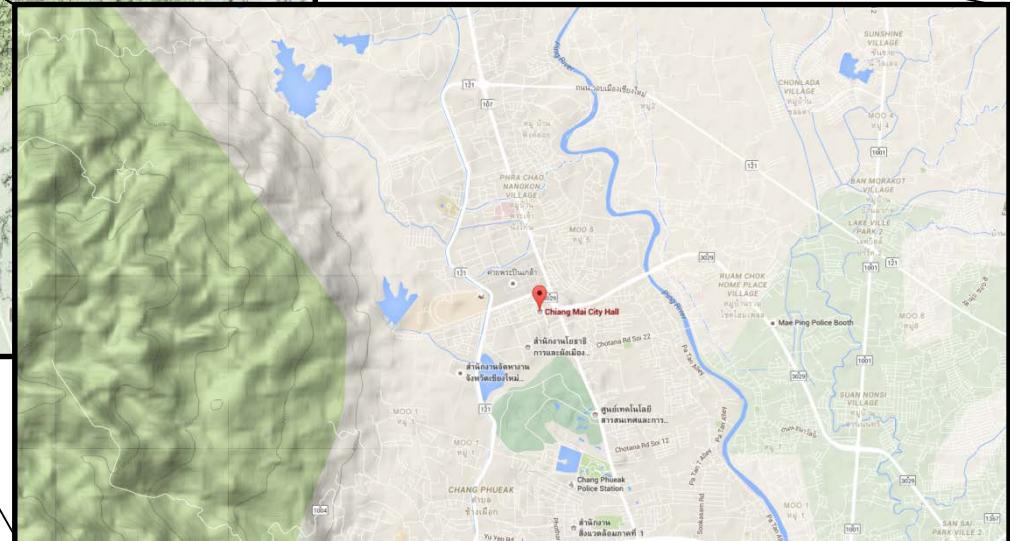


# Comparison Site (Chiang Mai City Hall - April 10-20, 2016)



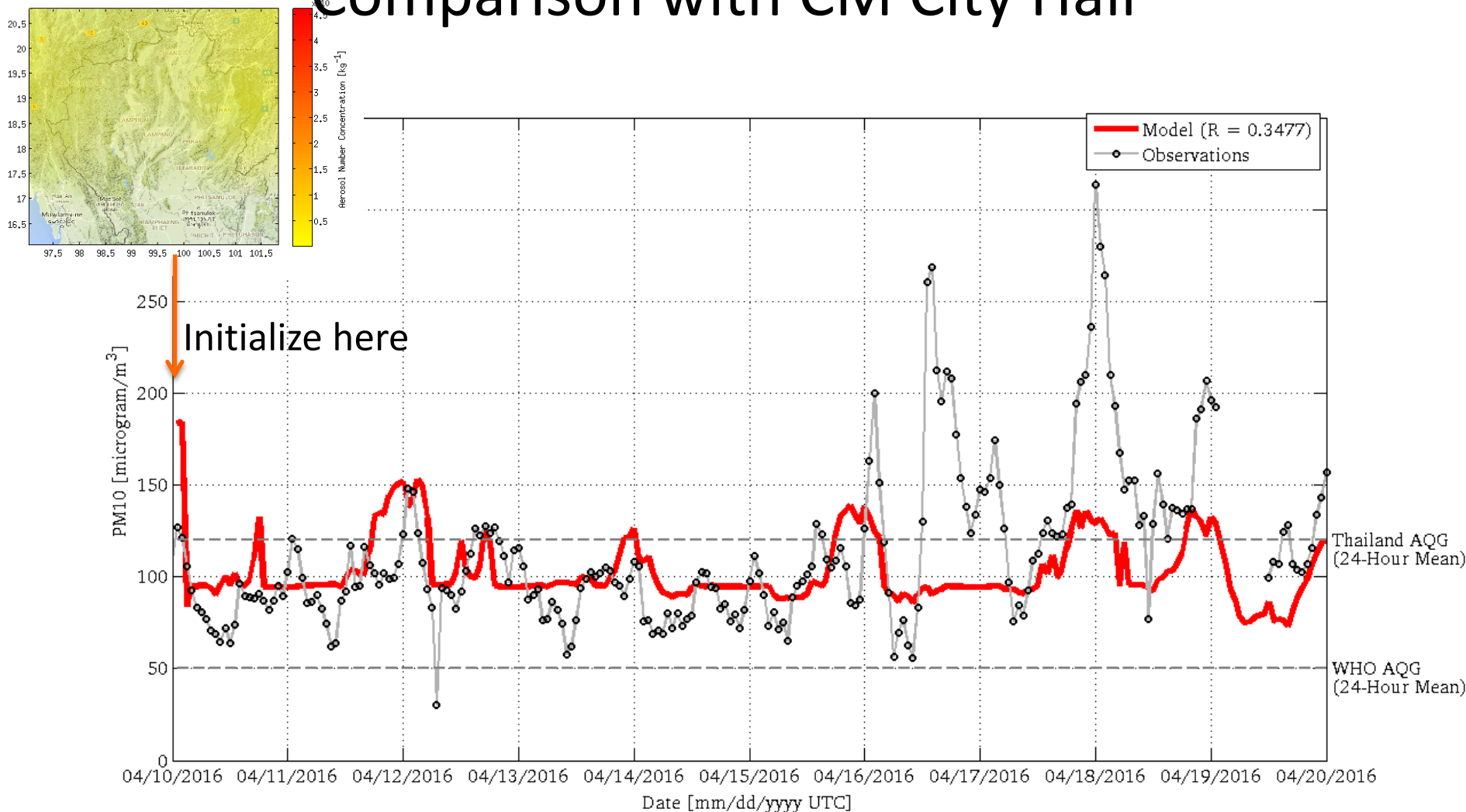
Pollution Control Department (PCD) Air Quality Monitoring site:

Latitude: 98.97 degrees N  
Longitude: 18.84 degrees E  
Altitude: 324.92 mASL



Haze Prone: Rapid Development, Topography, Land Use Changes (Corn)

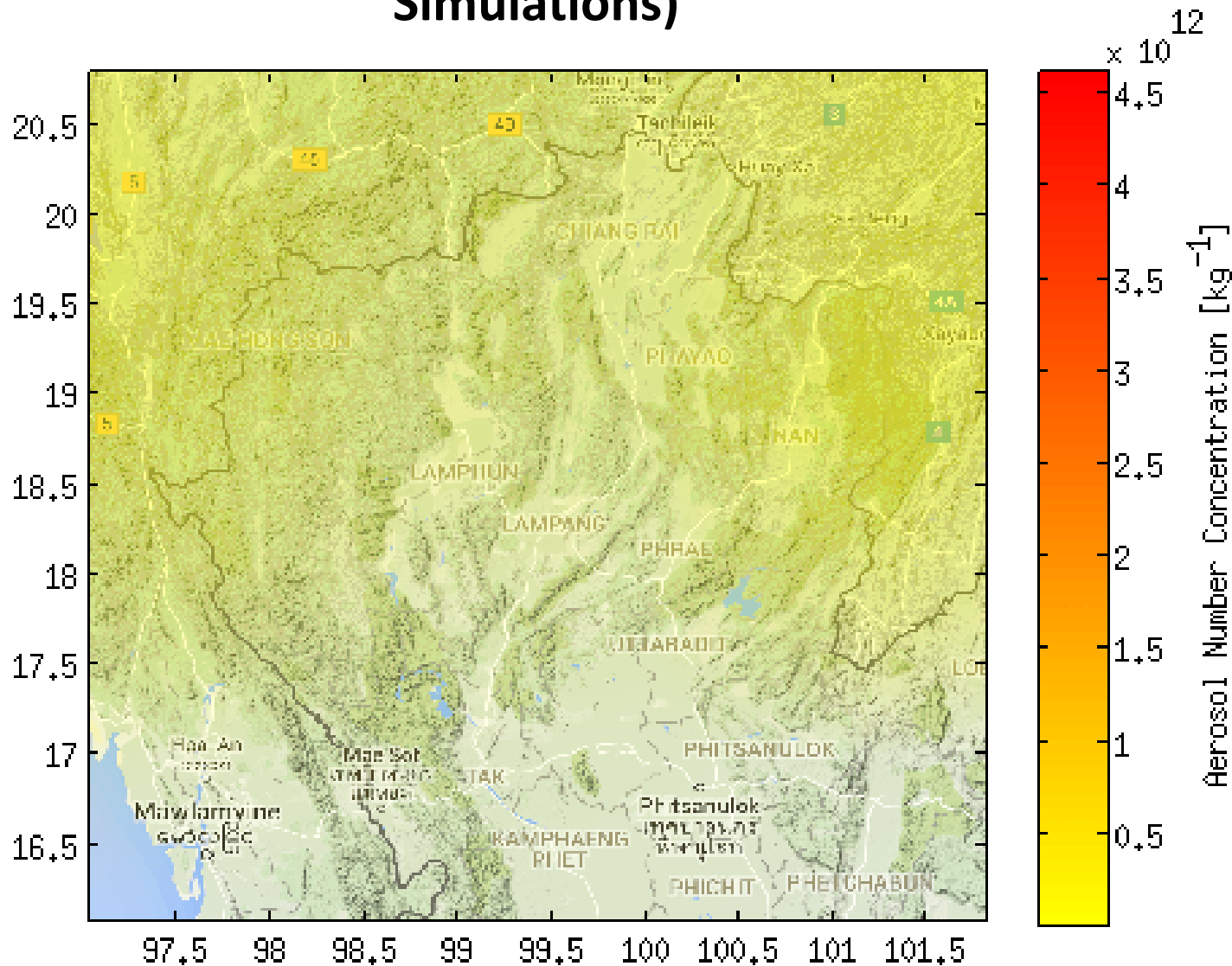
# Control Model Run (Aerosol Climatology) and Comparison with CM City Hall



Aerosol number concentration converted to PM10 using an empirical relationship (Mönkkönen et al., 2004)

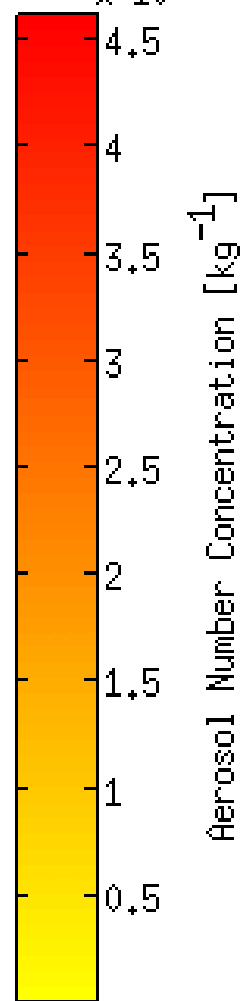
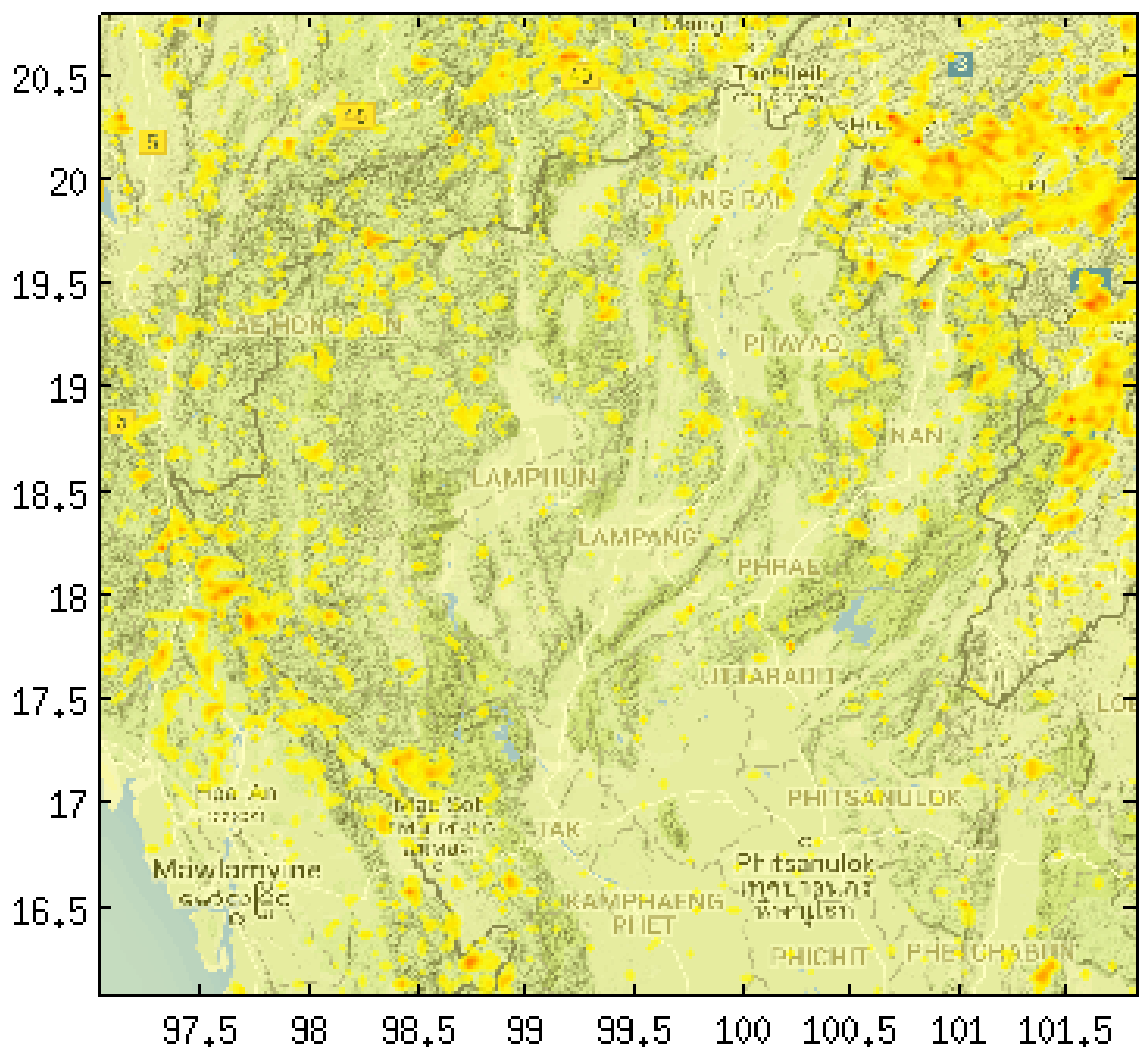
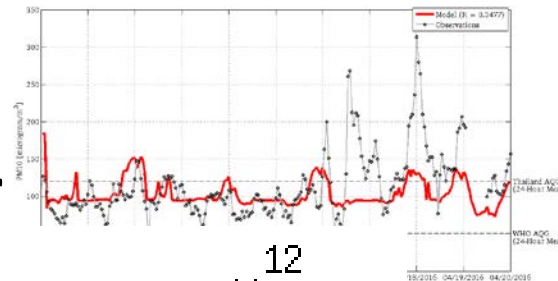
# Aerosol Number Concentration Initialization

## Monthly Aerosol Climatology (2001-2007 GOCART Simulations)





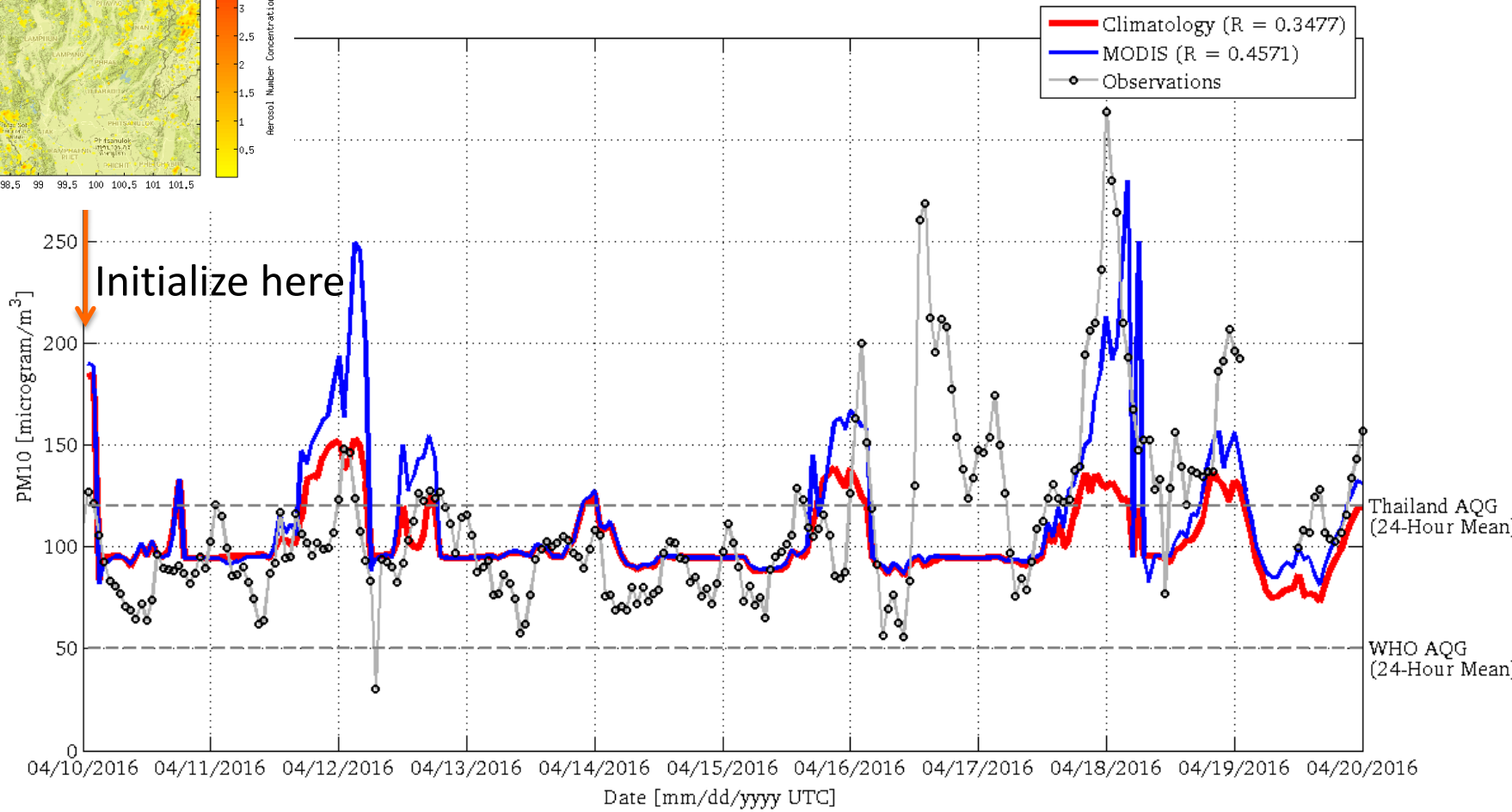
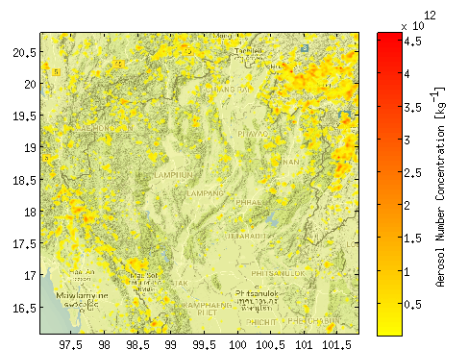
# Monthly Aerosol Climatology + 10-Day Average Prior to Model Start Time MODIS Brightness Temperature Data Converted to Aerosol Number Concentration Using an Empirical Relationship







# Improved Model Run and Comparison with CM City Hall

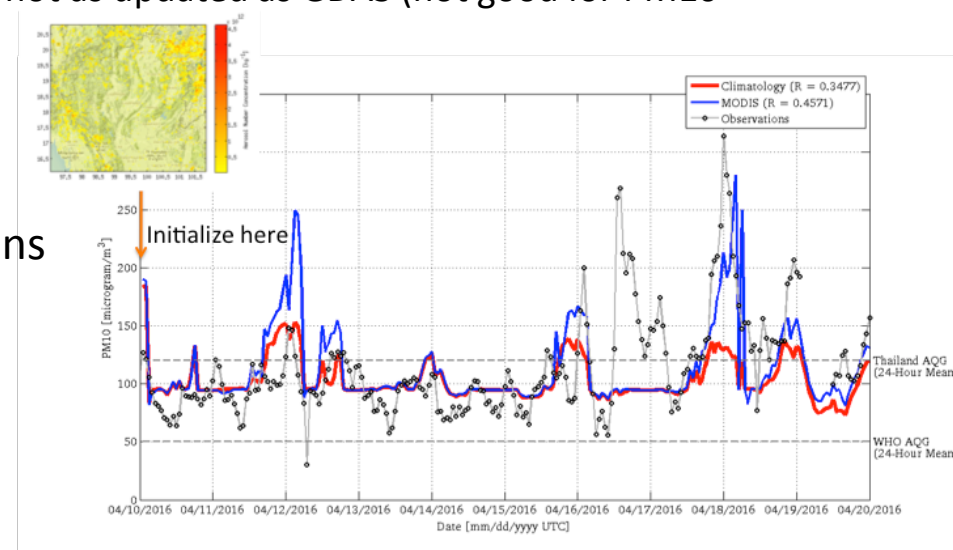


model underestimated the concentrations by  $53.4 \mu\text{g}/\text{m}^3$   
(added to model outputs)

# The Answer and Next Steps

- Can we simulate PM10 without chemistry coupling so we can have PM10 forecasts as fast as weather forecasts?
  - 3-day PM10 forecasts takes less than 12 hours to simulate using the domains presented using 8 cores on the HPC (normal weather forecasts usually updates every 6 hours)
- Use the ECMWF interim re-analysis, or ERA-Interim 0.7 deg the lateral boundary conditions
  - R improves from approx. 0.45 to 0.6
  - Takes longer due to additional nesting and not as updated as GDAS (not good for PM10 forecasting)

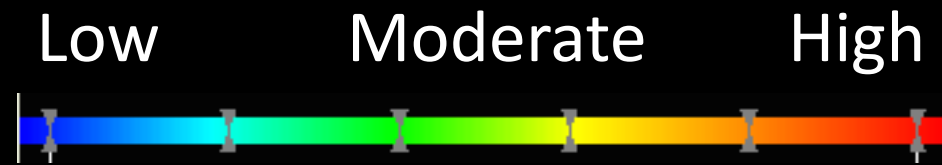
- Daily updated initialization times
- Add the offset to the boundary conditions
- Sensitivity to rainfall feedback (try other time periods and locations)
- Compare with WRF-Chem
- Try to apply to PM 2.5



model underestimated the concentrations by  $53.4 \mu\text{g}/\text{m}^3$   
(added to model outputs)



@ the NARIT  
HPC



# PM10 Concentrations

Thanks to

Utane Sawangwit  
Saijai Cumwan  
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Suparek Aukkaravittayapun

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Soonthornthum

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Kanlaya Thapiang

Bhenjamin Jordan Ona

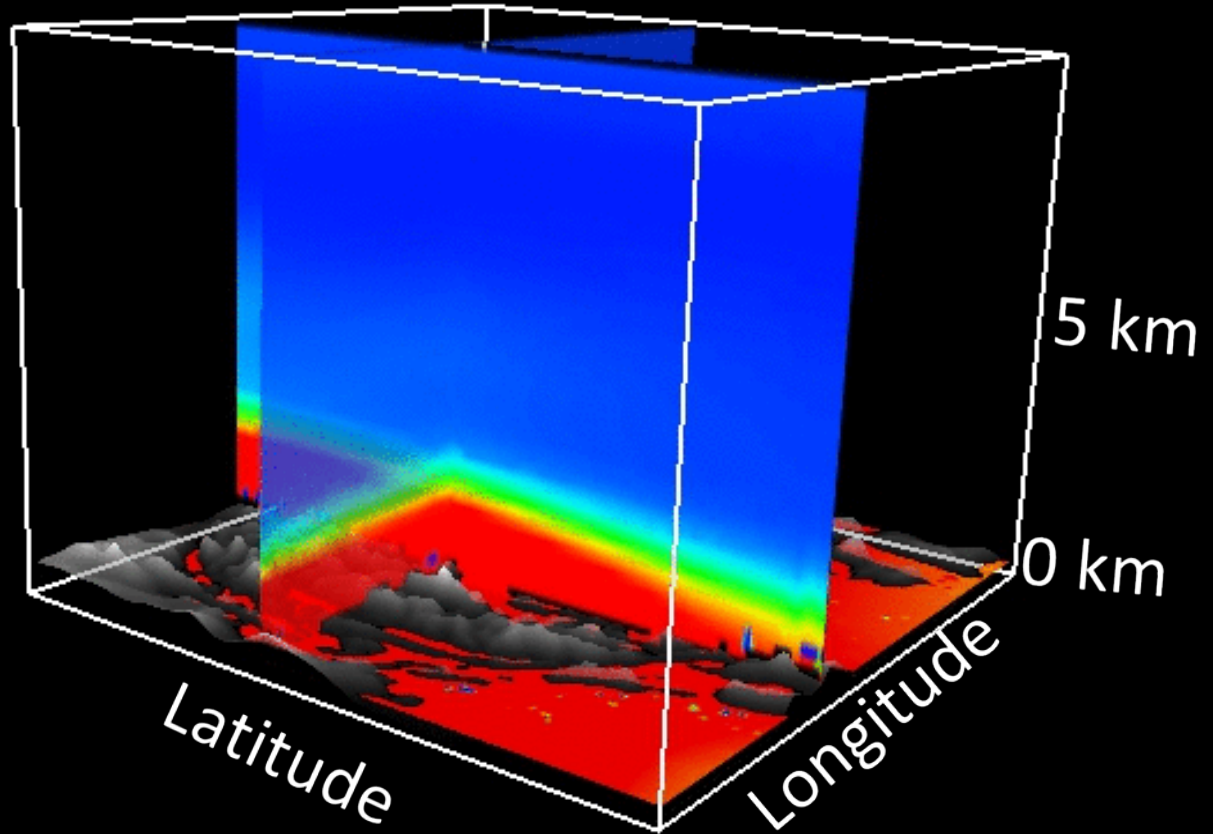
Natapit Thongsavai

Thirasak Panyaphirawat

Anut Sangka

Thai Meteorological  
Department

Pollution Control  
Department



Date/Time: 2016-04-10\_00:00:00

# Announcement: Job Positions (ronald@narit.or.th)

- Post-doc
  - 2-years with possibility of extension
  - Roles:
    - Aside from model validation, extract more science out of atmospheric LiDAR observations (feasibility study, proposal, publication)
    - Assist in the establishment of the National Research Center for Atmospheric Science
  - <http://www.narit.or.th/en/index.php/job-opportunities/508-postdoc-atmospheric-science>
- Research Assistant
  - 2-years with possibility of extension
  - Roles:
    - Instrument / data management
    - Statistical analysis / Modelling
  - <http://www.narit.or.th/en/index.php/job-opportunities/509-research-assistant-atmospheric-science>
- Facebook Page: <https://www.facebook.com/AtmosphericScience/>

# Training: Atmospheric Modelling Concepts and Applications (Oct. 22, 2016 9 AM)

- NASA GISS: Panoply 4 netCDF, HDF and GRIB Data Viewer 2-years with possibility of extension
  - <http://www.giss.nasa.gov/tools/panoply/>
- HYSPLIT (WRF driven)
  - WRF-to-ARL Conversion
    - Not covered
  - ARL input file (2 GB)
    - See me
  - for Windows - Public (unregistered) Version Download
    - [https://www.arl.noaa.gov/HYSPLIT\\_hytrial.php](https://www.arl.noaa.gov/HYSPLIT_hytrial.php)
    - Graphical Utilities ([http://ready.arl.noaa.gov/HYSPLIT\\_util.php#TCLK](http://ready.arl.noaa.gov/HYSPLIT_util.php#TCLK))
      - Tcl/Tk Graphical User Interface
      - Ghostscript/Ghostview Postscript
  - for Apple Mac - Registered Needed
    - [https://www.arl.noaa.gov/hyreg/HYSPLIT\\_applehysp.php](https://www.arl.noaa.gov/hyreg/HYSPLIT_applehysp.php)
    - See me for disk image file
  - for Linux
    - See me
  - Background
    - <http://ready.arl.noaa.gov/documents/Tutorial/html/index.html>