Surface Ozone Problem in Two Polluted Regions in China and VOGA-NCP 2013 Summer Campaign

Liang Ran
Key Laboratory of Middle Atmosphere and Global Environment Observation (LAGEO)
Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS)
Email: shirleyrl@mail.iap.ac.cn
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Personal Infos

2002.09-2006.07 **B. S.**
Department of Astronomy, School of Physics, Peking University (PKU)
Major in : Astrophysics
Specialty: Star Formation

2006.09-2012.7 **Ph. D.**
Department of Atmospheric and Oceanic Sciences, School of Physics, PKU
Major in: Atmospheric Physics & Atmospheric Environment
Specialty: Atmospheric Chemistry

2012.7- **Assistant Research Scientist**
Key Laboratory of Middle Atmosphere and Global Environment Observation (LAGEO)
Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS)

Outline

- Introduction
- Surface Ozone Problem in China
  - Background
  - Spatial and Temporal Characteristics of Ozone and Its Precursors
  - Ozone Precursor Sensitivity
- VOGA-NCP 2013 Summer Campaign
  - Motivation
  - Preparation

Introduction

- IAP, CAS (1928-)

  Physical and Chemical Processes
  Interactions

- LAGEO

1. Process of Middle Atmosphere
   Its Synoptic and Climatic Effects
2. Remote Sensing of Atmospheric Radiation
   and Atmospheric Environment
3. Lightning Physics
4. Advanced Observational Techniques

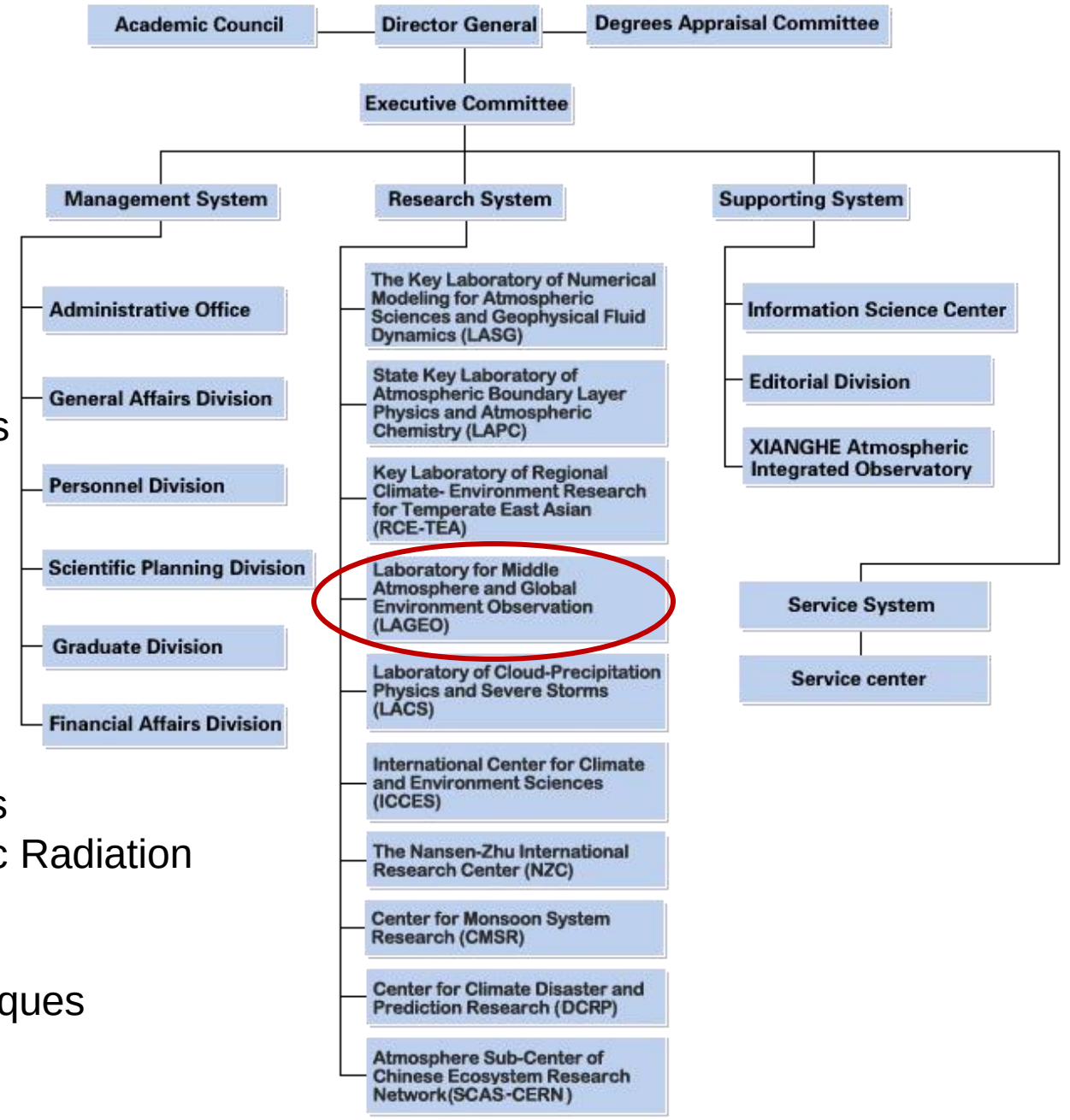


Figure Source : http://english.iap.cas.cn/.

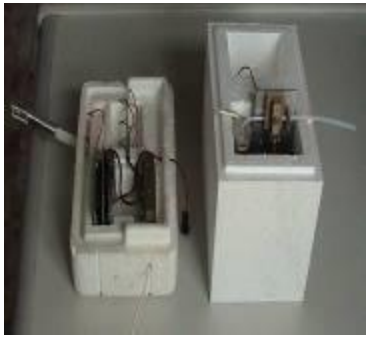
Introduction

- Observational System

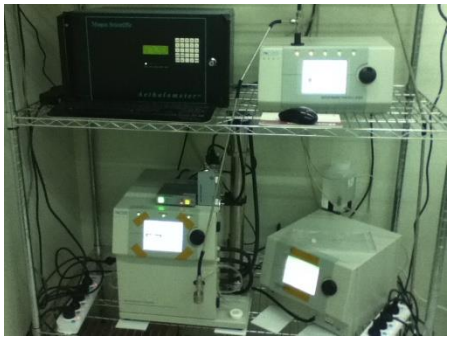


Tethered Balloon System; Unmanned Aircraft; Aerosol-Cloud-Radiation Observation Platform.

- Instrumentation





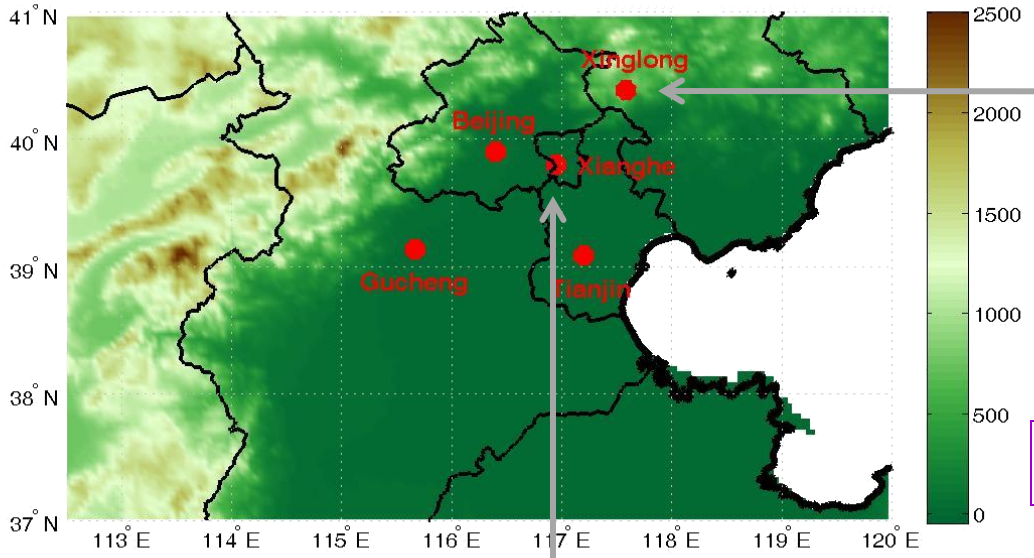


Ozone Sonde; LIDAR (355 nm); Instruments for Surface Gases and Aerosols Measurements.

Figure Source : http://lageo.iap.ac.cn/index.php/index.

Introduction

- Monitoring Sites



➢ Xinglong

(40°23′N,117°35′E, 960m a.s.l.)

Background Site

ARONET(AErosol RObotic NETwork)

➢ Xianghe (39°47′N,116°57′E, 95m a.s.l.) Supersite

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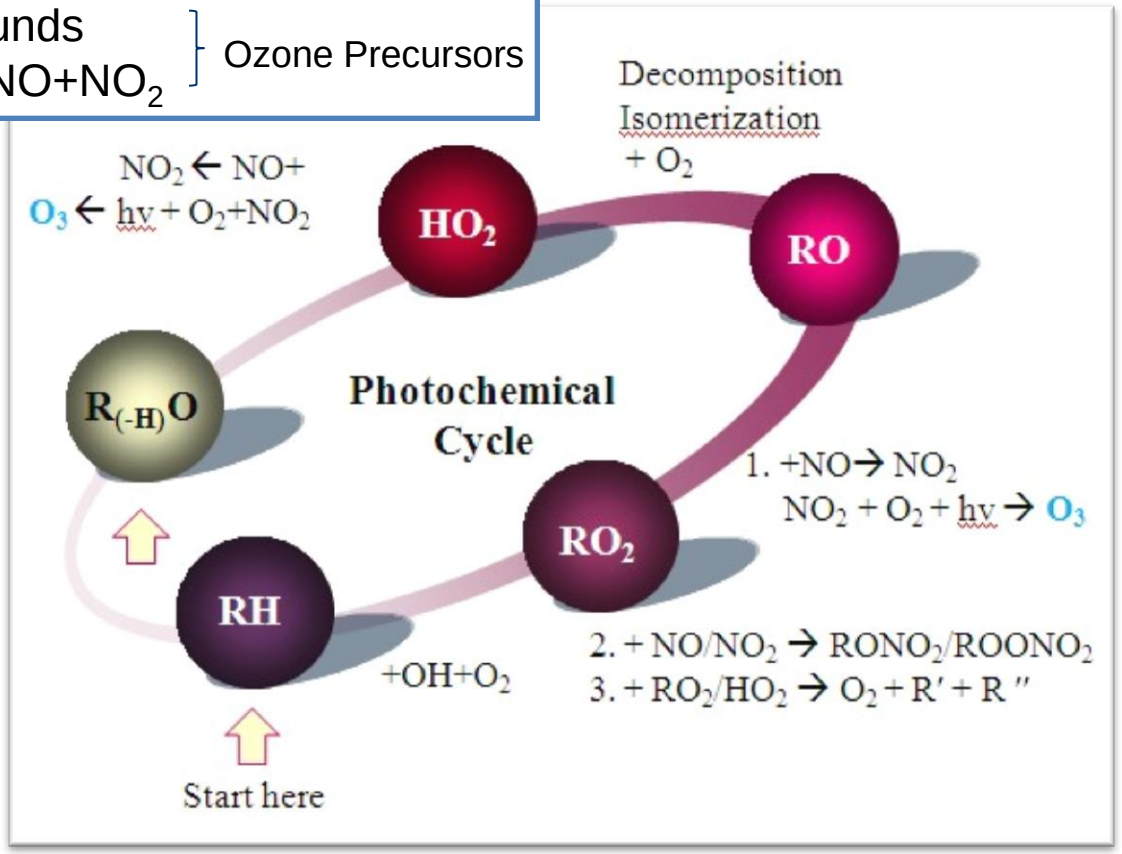
Background

Ozone Photochemical Production

NOx + ***VOCs/CO*** + ***hv*** → O_3

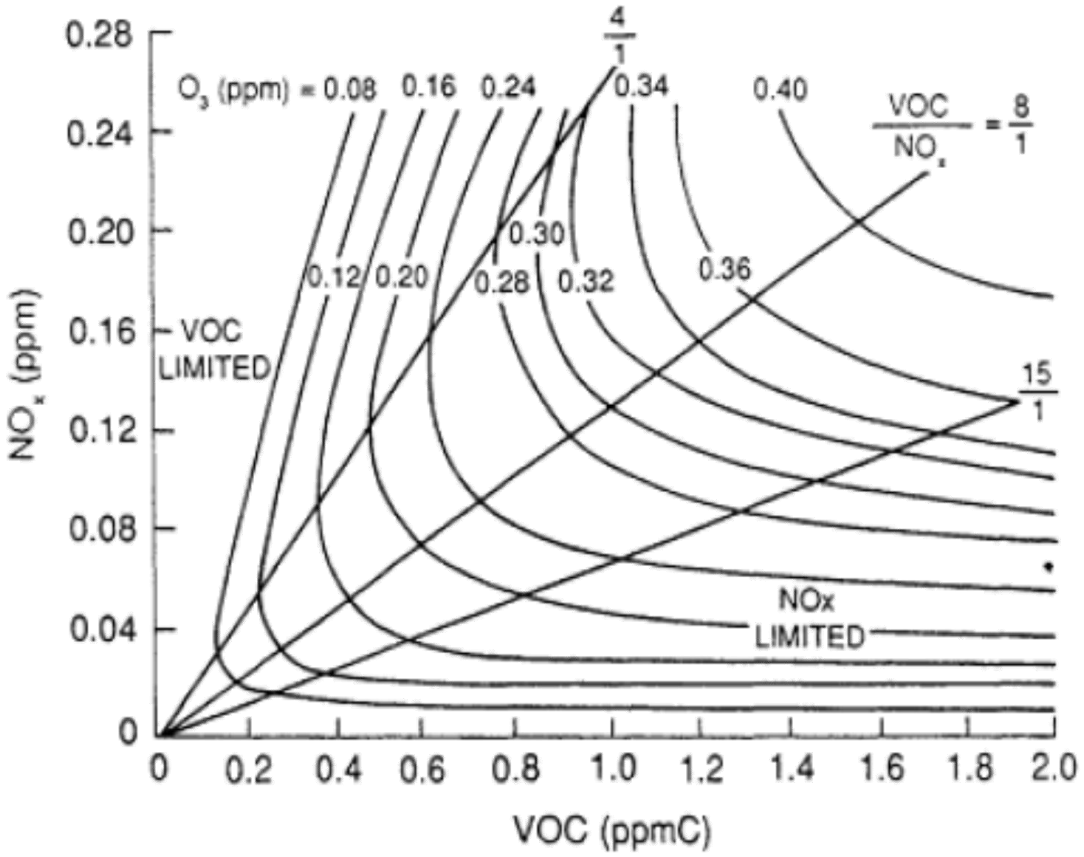
VOCs: Volatile Organic Compounds
NOx: Nitrogen Oxides, NOx=NO+NO_2

} Ozone Precursors



A sketch of ozone photochemical cycle.

Background

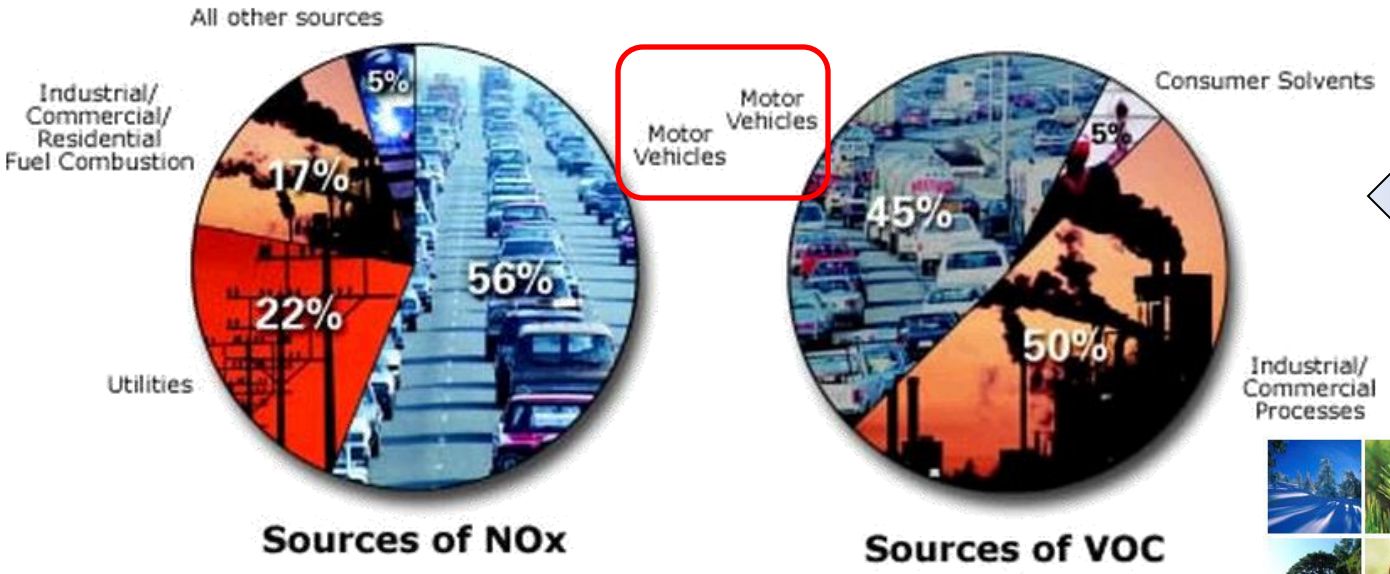


Typical ozone isopleths. Source: Rethinking the ozone problem in urban and regional air pollution, 1991.

- **Ozone precursor relationship**
  - Highly nonlinear
  - Crucial for ozone control strategies

Background

- **Sources of ozone precursors**



AVOC
（Anthropogenic VOC）

(Biogenic VOC)
BVOC

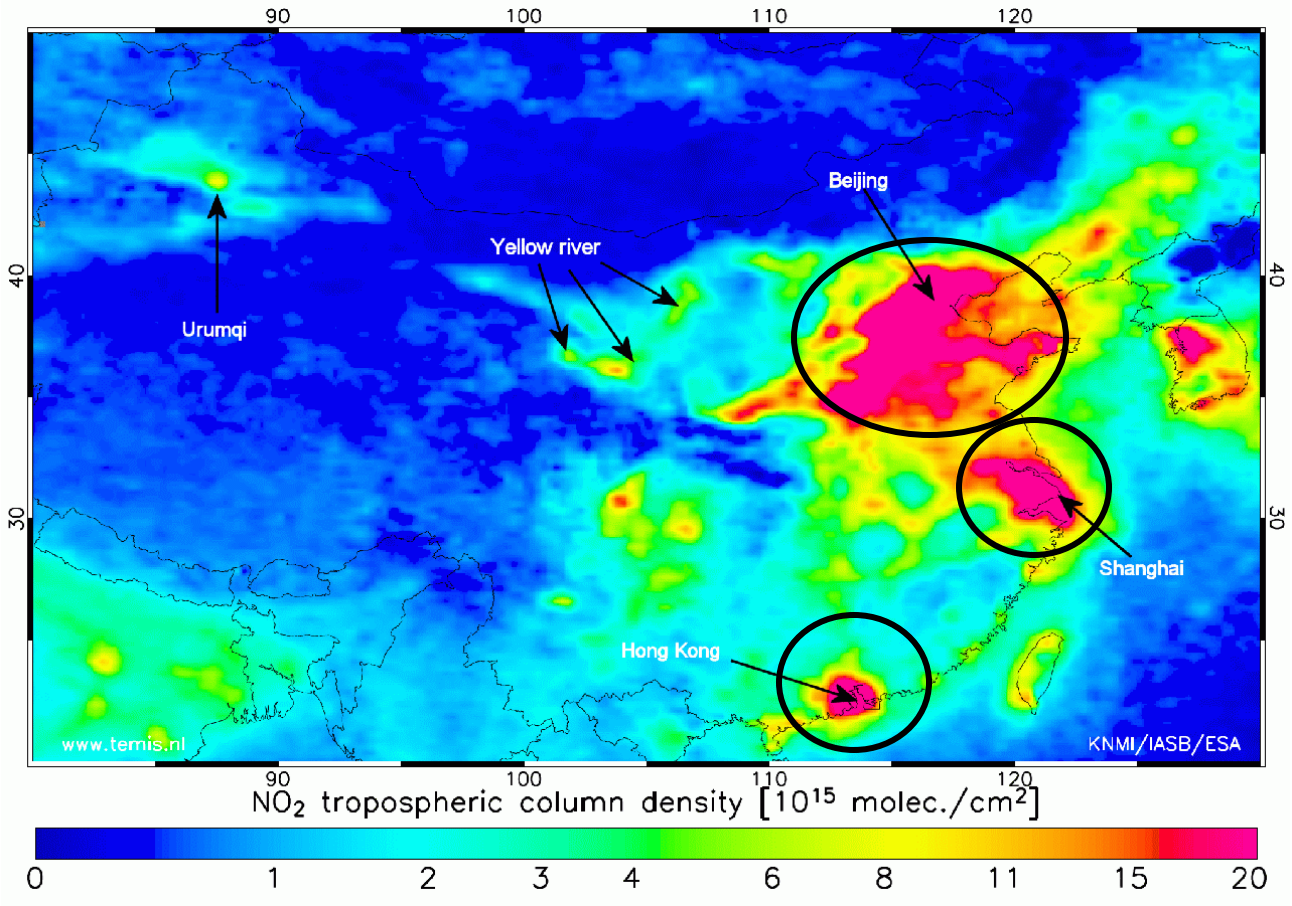
(Upper) Anthropogenic sources of NOx and VOCs. Source: http://www.epa.gov/oaqps001/gooduphigh/bad.html.
(Right) Some biogenic sources of VOCs.

SCIAMACHY NO_2 for 2004 in China.
Figure source: http://www.temis.nl/products/no2.html.

Background

- **Environmental issues in China**

Rapid Urbanization & Industrialization
Significant increase in precursor emissions



Background

- **The North China Plain (NCP)**
  The Yangtze River Delta (YRD)

- **HaChi (Haze in China) Project**

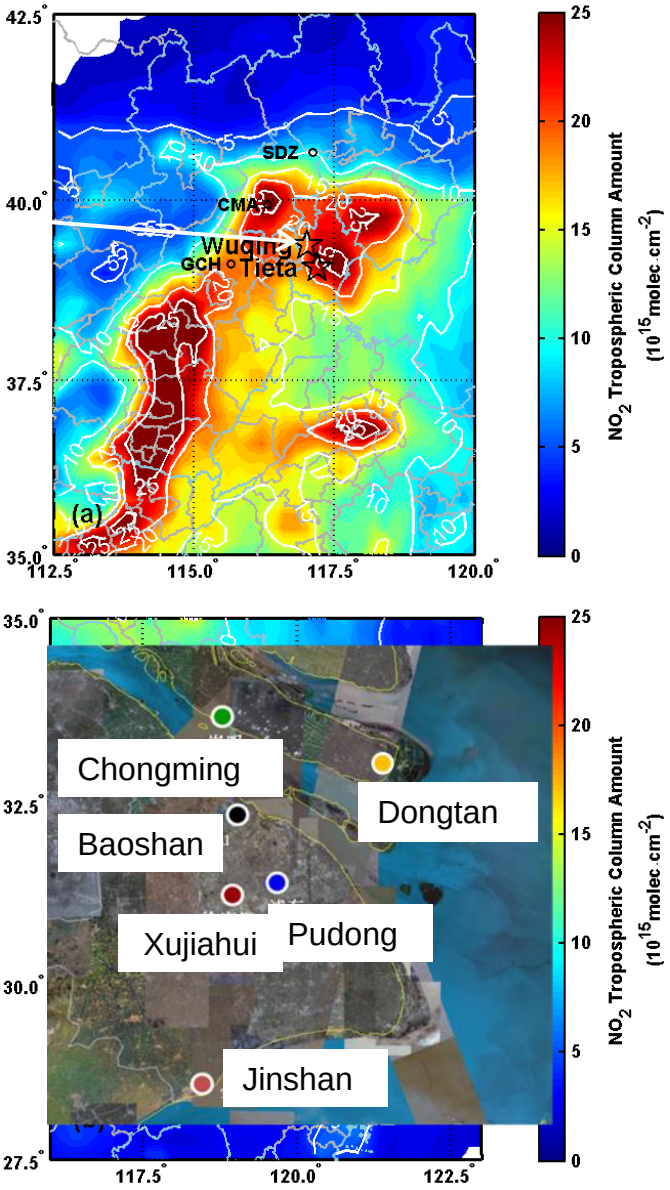
  Wuqing District of Tianjin(39º23′N, 117º01′E)
  Winter and Summer, 2009

  ACP-Special Issue
  Haze in China (HaChi2009-2010)
  Editors: V.-M. Kerminen, D. Covert, and E. Swietlicki

Mirage-Shanghai Project

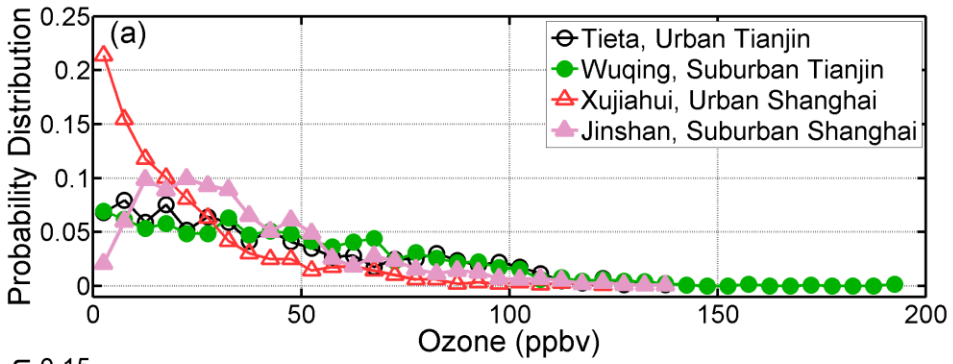
Fall, 2009

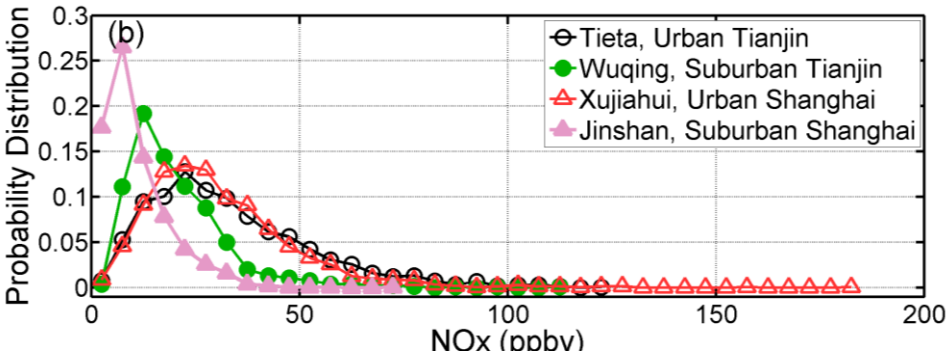
ACP-Special Issue
Atmospheric impacts of Eastern Asia megacities
Editors: A. B. Guenther, C. H. Song, X. Tie, T. Wang, and K. Schaefer

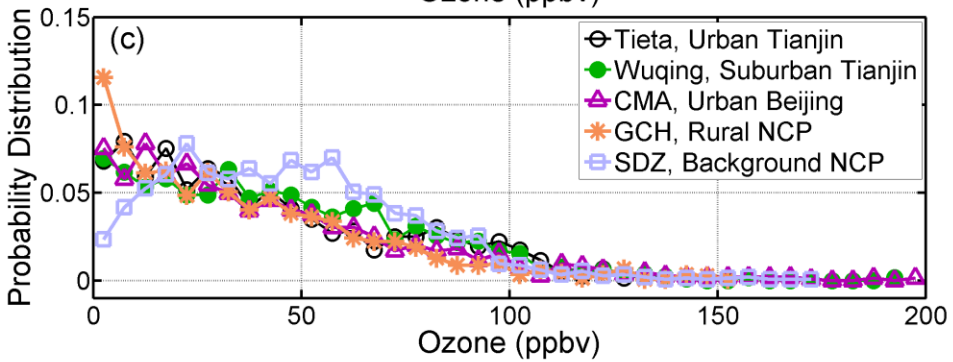


Average distribution of NO_2 tropospheric column amount (OMI, Resolution: 0.25° ×0.25 °) in the NCP and YRD.
Source: Xu et al., *Atmos. Chem. Phys.,* 11, 4353-4369, 2011.

Ozone and its precursors in NCP and YRD

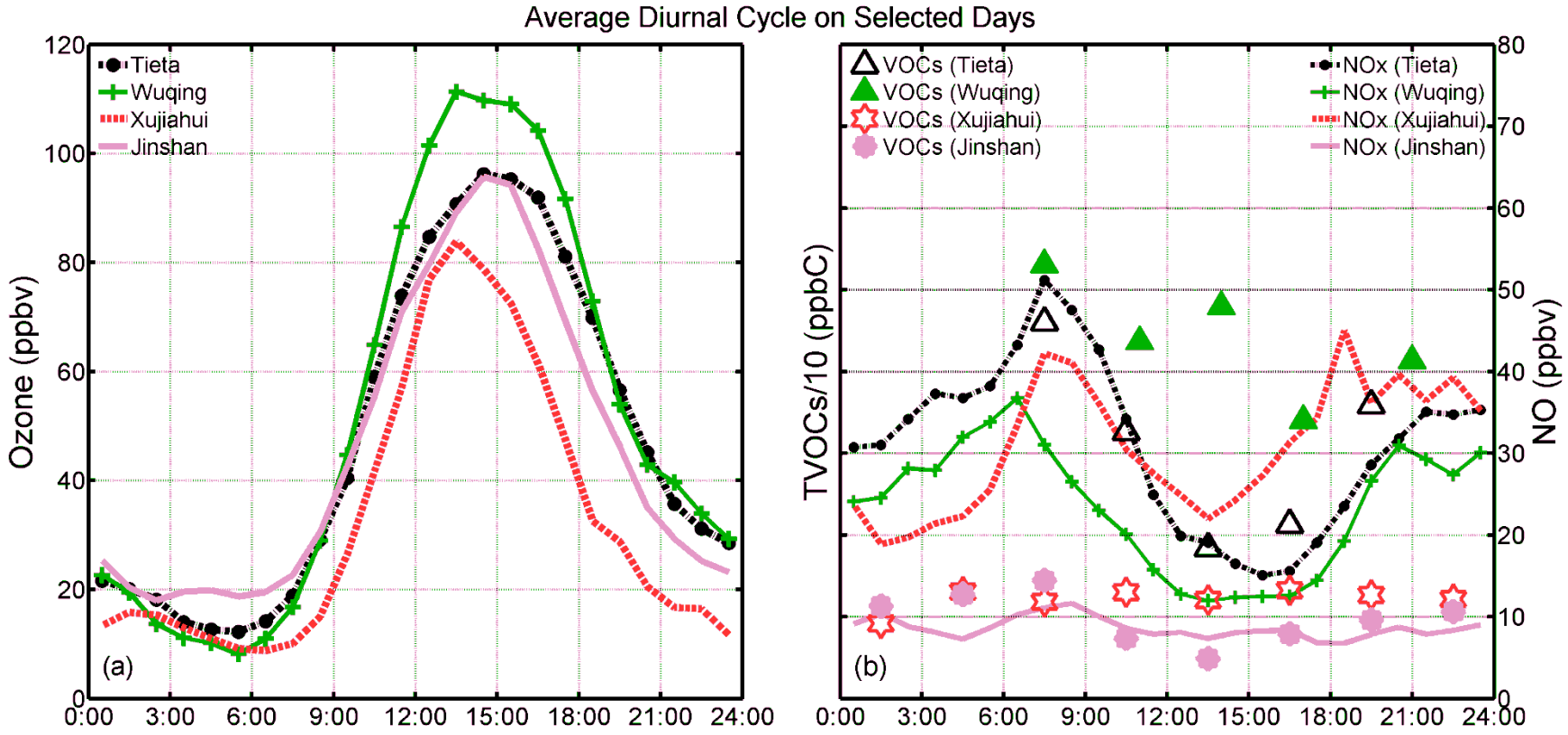




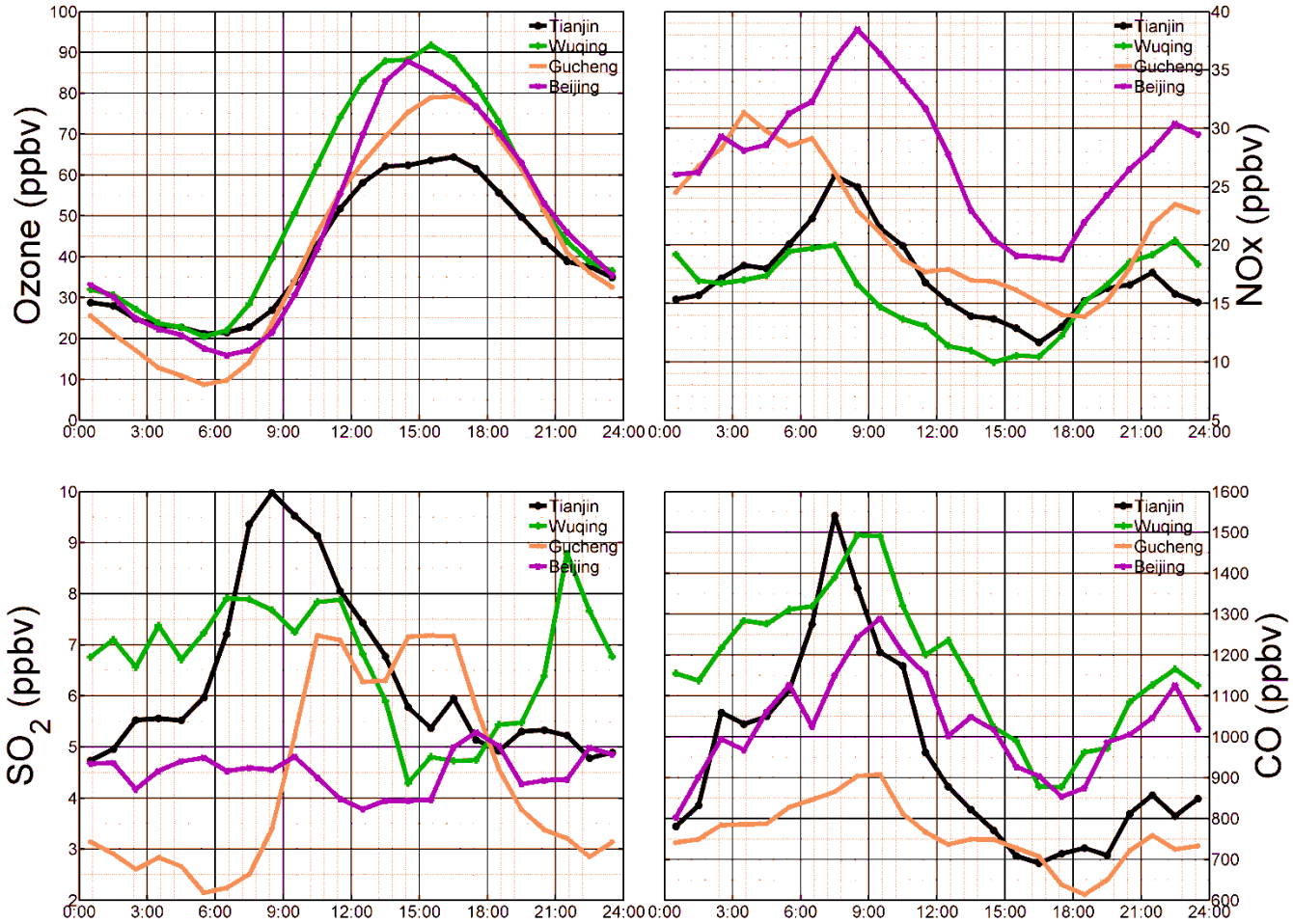


Probability distributions (5 ppbv per bin) of (a)(c) ozone and (b) NOx in July-August 2009 (Tianjin: 2010).

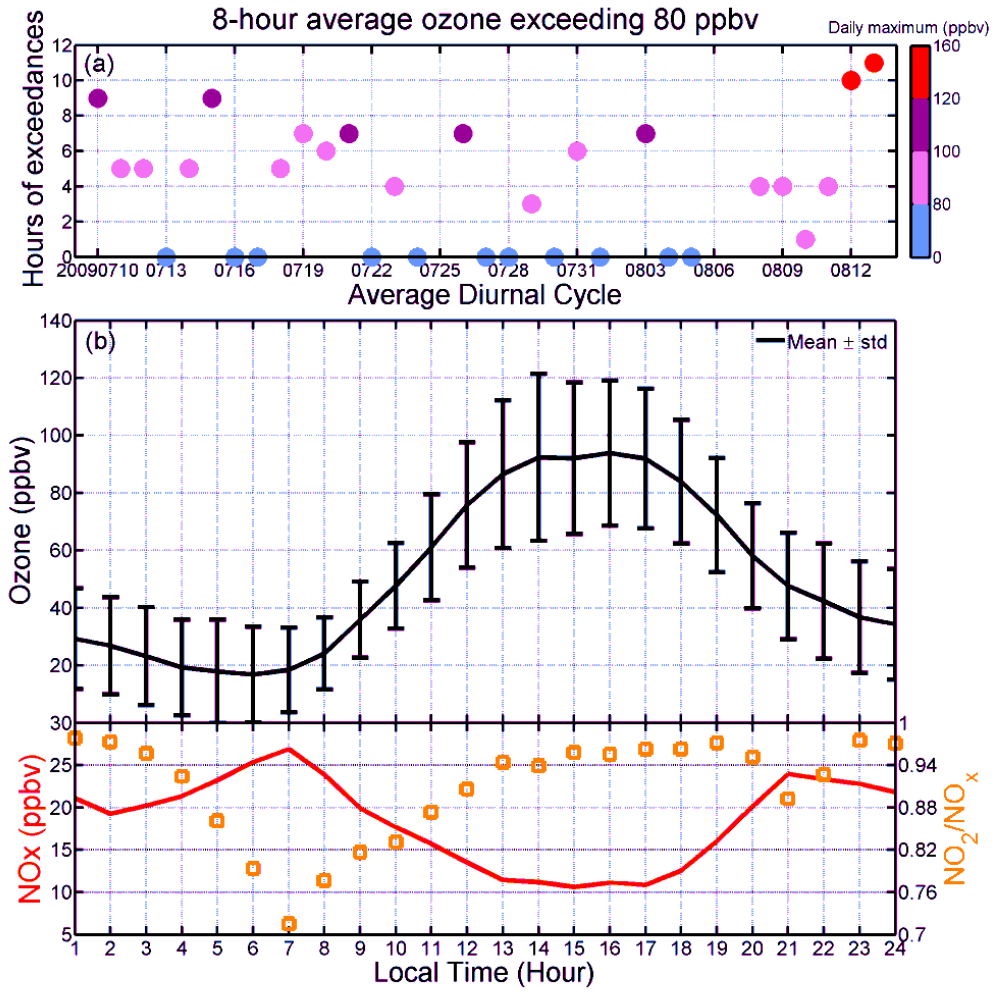
Ozone and its precursors in NCP and YRD



Gas pollutants in NCP – July 2009



Characteristics of ozone and its precursors

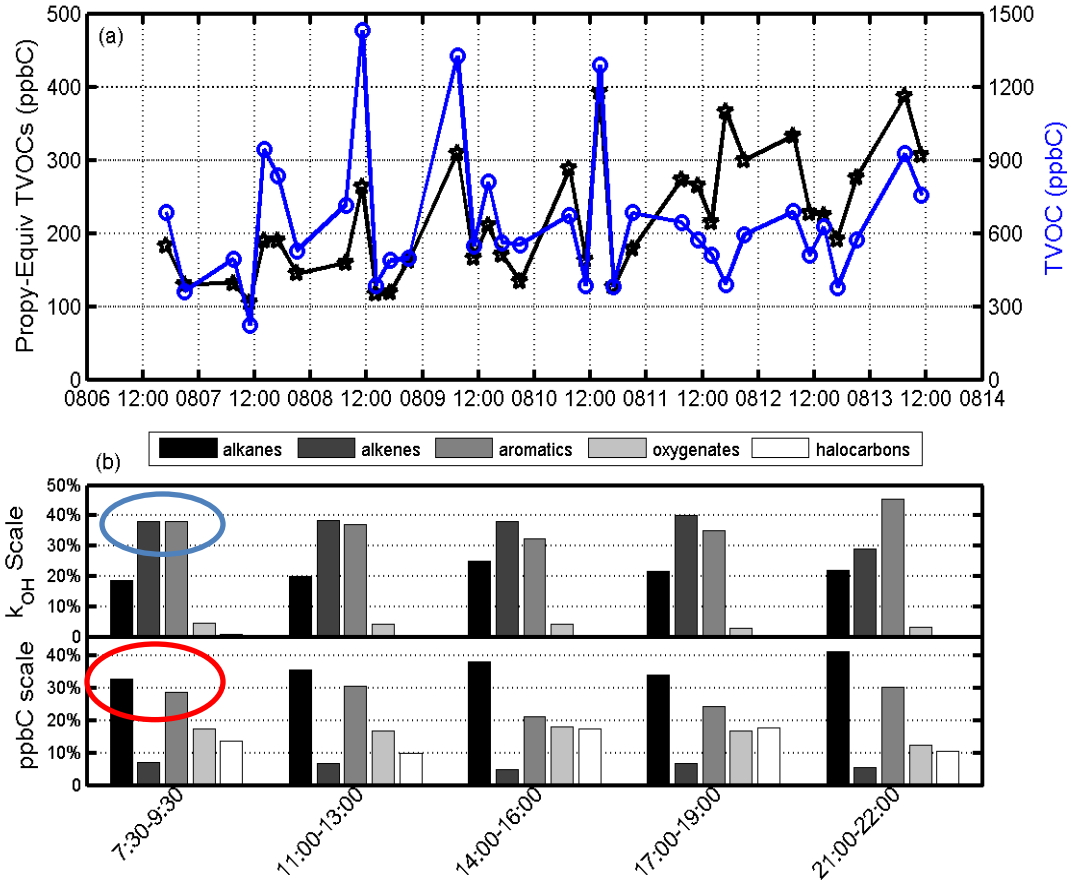


(a) Durations of ozone 8-hour exceedances over 80 ppbv on each day.
(b) Average diurnal cycle of ozone and NOx during the HaChi summer campaign.

- Ozone episodes frequently encountered during the campaign
- Occurrences of running 8-hour averages in excess of 80 ppbv lasted for more than 4 hrs on about 2/3 of the campaign days
- Persisting high ozone exposure risks for vegetation and outdoor human activities
- Averagely, NOx exhibited a double-peak diurnal pattern
  Conversion of NO to NO_2 quite efficient in the daytime

Characteristics of ozone and its precursors

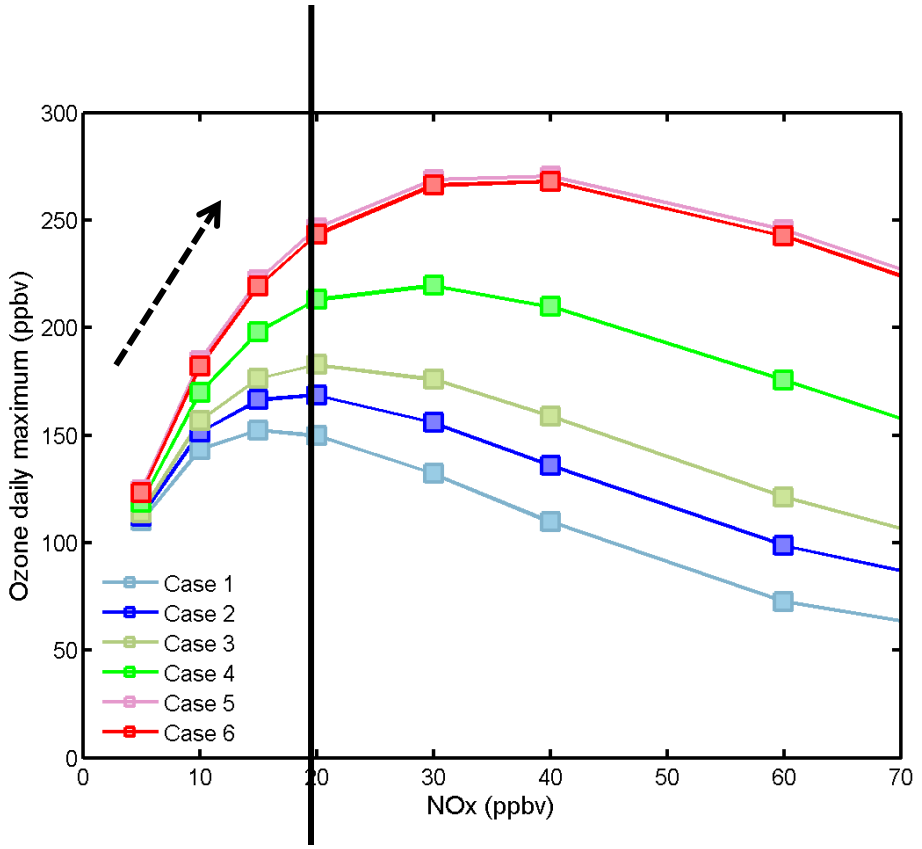
- Averages of total VOCs were170 ppbv, 650 ppbC and 220 Propy-Equiv ppbC
- No apparent differences in composition at different periods of time
- On the ppbC scale, major components were alkanes & aromatics
  While alkenes & aromatics dominated in the contribution to total reactivity
- Key species (~70%)
  2-butenes, isoprene, trimethylbenzenes xylenes, 3-methylhexane, n-hexane, toluene



(a) Time series of total VOCs in Wuqing, in ppbC and Propy-Equiv ppbC units.
(b) VOC composition based on ppbC and k_{OH} scale.

Ozone precursor sensitivity

- Examination of measured VOCs/NOx ratios ~10 → NOx-limited
- Model simulations
  Box model (NCAR Master Mechanism) coupled with a TUV model
- NOx-limitation confirmed
- A sensitivity to the changes in VOC reactivity was also found



NCAR-MM model simulation results. Six cases are based on measurements of VOCs on each day of August 7-12, with all other parameters set to be the same. The square markers are selected cases for NOx = 5, 10, 15, 20, 30, 40 and 60 ppbv.

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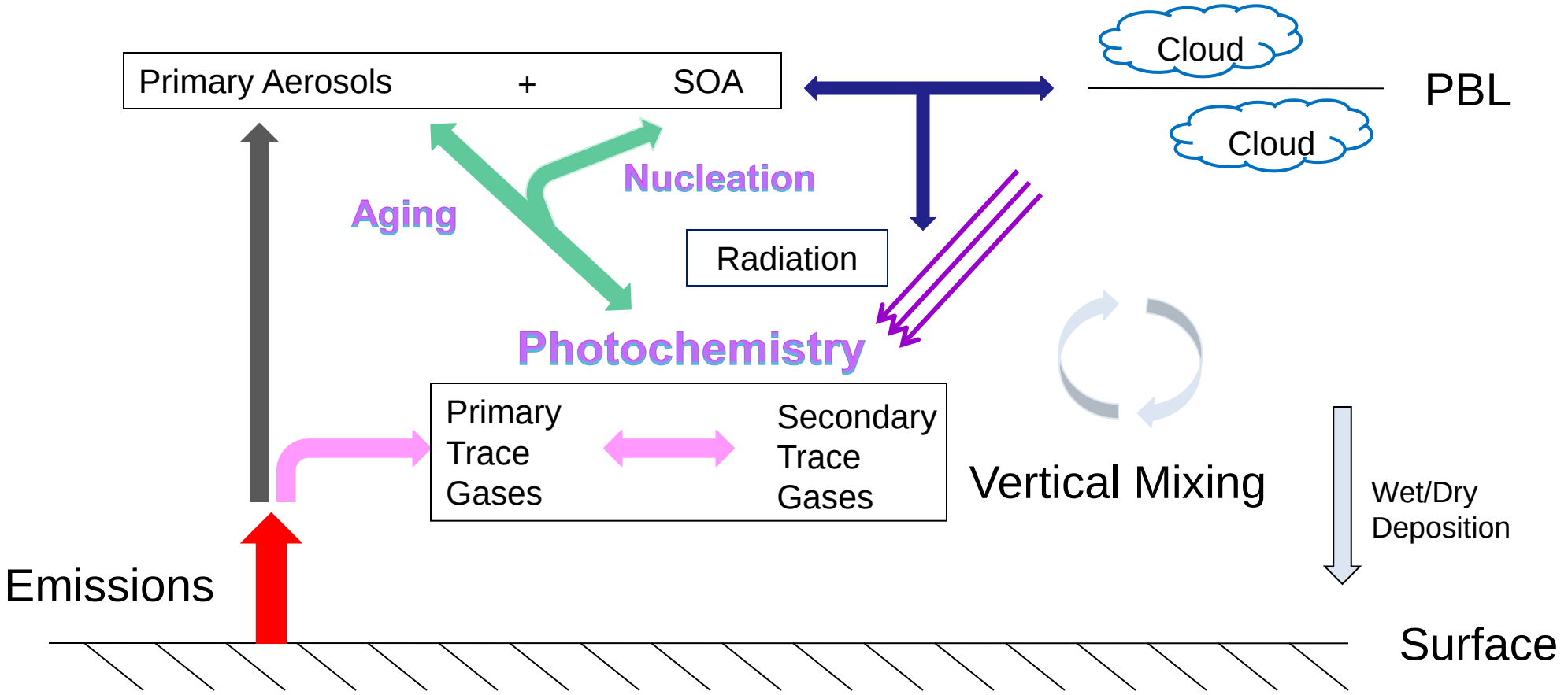
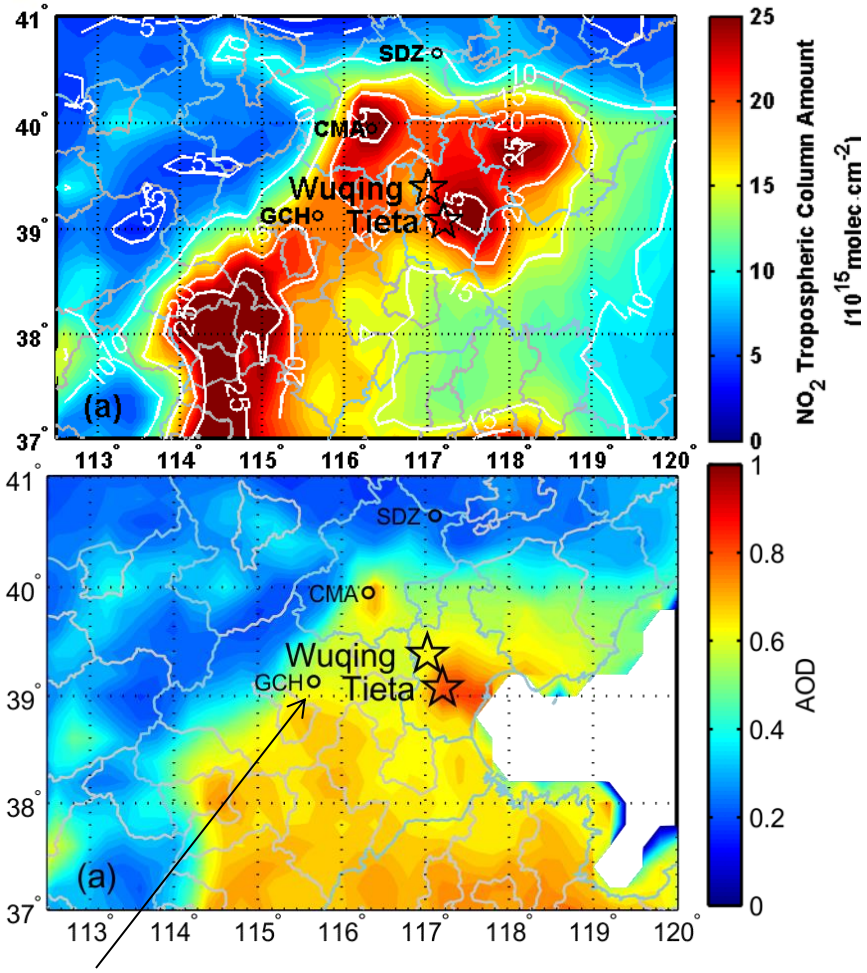
Motivation

- **VOGA-NCP**
  Vertical Observation of Gas pollutants and Aerosols in the North China Plain



Site and Measurements



Gucheng (GCH), a rural site

Weili Lin, et al, Characteristics of gaseous pollutants at Gucheng, a rural site southwest of Beijing, *J. Geophy. Res.,* 2009.

- Surface measurements
  1. Trace gases (O_3, NOx, CO, SO_2, VOCs)
  2. Aerosols (PNSD, Optical Properties, Activation Properties)
  3. Radiation (Visible, UVB)

- Vertical Measurements-Tethered Balloon
  1. in-situ Aerosol measurement: OPC, BC
  2. Bag Sampler: sub-miron aerosol PNSD, Activation Properties
  2. Ozone sonde
  3. NO_2 sonde

Observations at Xianghe Site

- Surface Trace gases
  O_3, NOx, CO, SO_2: May-Oct. (long term if possible)
  VOCs: depends

- Surface Aerosols
  PNSD, Optical Properties, Activation Properties: long term

- Vertical Profiles of Aerosols
  LIDAR: long term

- Radiation
  Visible, UVB: long term