7 South East Asian Studies

- Overview of 2010-2015 spring campaigns and future plan

George Lin, National Central U.,
Si-Chee Tsay, Brent Holben,
Christina Hsu, NASA/GSFC
Jeff Reid, Naval Research Lab,
7-SEAS team of TH/TW/VN
(Tang-Huang Lin)
Biomass Burning (BB) in SE Asia

7 South East Asia Studies (7-SEAS)

7-SEAS spring campaigns

Future plan
Biomass-burning haze in SEA

Clear day

\[ PM_{2.5} \sim 10 \mu g m^{-3} \]

Hazy day

\[ PM_{2.5} \sim 150 \mu g m^{-3} \]

Agricultural residue burning

Forest floor burning

Stoke and waste fire
Patterns of Total Smoke Flux

- SE Asia has two fire seasons.
- Northern spring peak is often more intense than southern August-October peak.
- Both peaks have large interannual variability.

Courtesy: Edward Hyer
Quick View: MISR 2001-2009
Aerosol Optical Depth
(Courtesy of Jianglong Zhang, UND)

- Chinese pollution and dust
- Indian Pollution
- Pan SE Asian Smoke
- Hanoi Superplume
- Thai and Myan. Pollution and Smoke
- Thai Pollution and Smoke
- Cambodia Smoke And Ho Chi Min
- Central Sumatra Burning
- Southern Kalimantan Burning
- Jakarta Superplume
7 South East Asian Studies

(7-SEAS)
In order to investigate the impacts of aerosol particles on *weather and the total SE Asian environment*, seven inputs are needed:

- Aerosol lifecycle and air quality
- Tropical meteorology
- Radiation and heat balance
- Clouds and precipitation
- Land processes and fire
- Oceanography (phys. and bio.)
- Verification, analysis and prediction
7-SEAS utilized regional sites
South China Sea region renown for complicated vertical distribution of cloud and aerosol layers

- Lidar measurements are necessary to constrain vertical scattering and extinction profile and assess efficacy of concurrent passive observations
- Integration of NASA CALIOP satellite-borne polarization lidar observations (ESA/JAXA EarthCARE?)
- Partners: Japan, Singapore, Taiwan, Philippines, and Vietnam.

Unprecedented coverage for active-profiling on lands surrounding the South China Sea, with support from NASA MPLNET/AERONET and Asian SKYNET.
What are the scientific issues of biomass-burning aerosol and related pollutants in SE Asia we concern about, particularly for Springs?

- Source/receptor BB characterization
- Environment and climate impact
- Health effects
7-SEAS activities since 2007

- 8 workshops and training courses
- 2007 VBBE (Virtual BB Experiment)

3 phases proposed for scientific issues:

Phase I (2010-2012)
- 2010 Dongsha Experiment
- 2011 Son La Campaign I
- 2012 Son-La Campaign II

Phase II (2013-2015)
- 2013 BASELInE I
- 2014 BASELInE II
- 2015 BASELInE III

Phase III (2016-2018): Data and network
7-SEAS Spring field campaigns

Terra/MODIS true color image with AOD (2013/3/23)
Surface measurements at sites: chemistry

- Air quality: continuous PM, O₃, CO, SO₂, etc.
- Aerosol chemistry – PM$_{2.5}$/PM$_{10}$ for mass, ions, metals and OC/BC, organic acids
- Segmented aerosol chemistry
- Hg, Dioxins and PAHs
- VOCs
Surface measurements at sites: physical

- Meteorological data
- AOD
- Radiation
- Lidar
- CCN, aerosol size spectrum
- Continuous BC mass concentrations
- Aerosol absorption and scattering
2010 Dongsha Experiment

A pre-study of 7-SEAS
Capacity building
To characterize aerosol chemistry and physics over BB source/receptor sites in northern SE Asia: TH-VN-TW
Transport of PM$_{2.5}$ – WRF/CMAQ simulation

3 km, horizontal

3/9-3/10 2010 Dongsha Experiment

Cross-sectional transport
Atmospheric Environment

2013 Nov (78) special issue on:

“Observation, Modeling and Impact Studies of Biomass Burning and Pollution in the SE Asian Environment – From BASE-ASIA and Dongsha Experiment to 7-SEAS”

Guest Editors:
George Lin, NCU (nhlin@cc.ncu.edu.tw)
Hal Maring, NASA
Jeff Reid, NRL

28 papers – overview, aerosols/gases/toxics, remote sensing, modeling and impact studies.
7-SEAS/ Son La Experiments in northern Vietnam

**2011 3/18-4/6:** A pilot study of aerosol chemistry near biomass-burning source regions in northern Vietnam

**2012 3/13-4/9:** Comprehensive *in-situ* and vertical profiling measurements
A Frequent Mileage: the pathway

SeaWiFS True Color

SeaWiFS True Color

TOMS Aerosol Index

Laos

Vietnam

Thailand

Vietnam

Southern China

Taiwan

Son La

Burned

Vietnam

Laos

Philippines

Laos

Thailand

Cambodia

Vietnam

03/21/99

0.5

Index

5.5

Event on 21 March 1999

(Provided by Christina Hsu, NASA)
Son La, Vietnam

Samplers
Lidar

NASA/COMMIT
Son La, Vietnam (2012)

AOD$_{500\text{nm}} = 2.7$

MOD$_{500\text{nm}} = ?$

PM1&PM2.5 data during 2012 SonLa Experiment

PM conc. [µg m$^{-3}$]
Phase II: 2013-2015 7-SEAS/BASELInE

Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles and Interactions

- Lifecycle of biomass-burning aerosols from source to receptor regions in springtime northern SE Asia
- Aerosol-cloud interaction
7-SEAS/BASELInE spring campaigns

NSPO/FORMOSAT II (2 m resolution)
2013/3/23 images
Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles & Interactions Experiment BASELINhE: Overview and Follow-on

NASA: S.-C. Tsay, N. C. Hsu, B. N. Holben, E. J. Welton
Taiwan: led by N.-H. George Lin
Thailand: led by Serm Janjai and by Somporn Chantara
Vietnam: led by Anh X. Nguyen

Normalized Relative Backscatter

\[ \lambda = 532 \text{nm} \]

18 March 2013

background molecules + ice crystals

Background molecules + aerosols

Doi Angkhang site

± 1σ

Mean

Normalized Relative Backscatter

(Counts km\(^2\) μJ\(^{-1}\) μs\(^{-1}\))

Height (km)

0.0 0.5 1.0 1.5 2.5

15 10 5 0

Counts km\(^2\) μJ\(^{-1}\) μs\(^{-1}\)

Normalized Relative Backscatter

Aqua/MODIS: 9 April 2013

e-DB Aerosol Optical Thickness \( \leq 0.55 \mu \mum \)

Cloud Feature

Aerosol Feature

CALIOP Samples \( \times 10^9 \)
**A Synergistic & Derivatives-based Approach**

**FORWARD MODEL**

- **General Settings**
  - Geolocation
  - Resolution
  - Geometry

- **Modules**
  - Microphysics
  - Chemistry
  - Optics
  - Thermo-dynamics
  - Radiation
  - [I, Q, U, V]

**INPUTS**

**MULTI-SENSOR OBSERVATION**

**GROUND-BASED**

**SUB-ORBITAL**

**ANALYSIS & SYNTHESIS**

- L1 observations
- L2: \( \rho(t, s, \Theta) \)

**OUTPUTS**

**GEOPHYSICAL PARAMETERS**

- L1/L2 parameters
- Instrument Simulators for Synthetic Signals
  - Radiance
  - Reflectivity
  - Backscatter
- Retrieval Algorithms
  - Atmospheric State
  - Aerosol Properties
  - Cloud Properties
- Aerosol-Cloud Interaction
- Sensitivity Matrices & Vectors

\[
\frac{dY_{\lambda,t}}{d\rho} = \left[ M \right]_{\lambda,t} C(\rho)_t + \left. \frac{\partial Y_{\lambda,t}}{\partial \rho} \right|_C
\]

*Tsay et al., 2014, in preparation*
Aerosol and Air Quality Research

2015 special issue on:

“Aerosol Impact on Physical, Chemical and Biological Processes in Southeast Asia and the Maritime Continent”

Guest Editors:
James Campbell, NRL
Guey-Rong Sheu, NCU
Somporn Chantara, CMU

Deadline: 15 July 2015

45 submissions
<table>
<thead>
<tr>
<th>SMARTLabs/AERONET/MPLNET</th>
<th>Regional Instrumentation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trace Gas – Column</strong>: O₃, NO₂, SO₂, HCHO, CO,</td>
<td><strong>Organic Carbon</strong> (OC): OC₁ (120°C), OC₂ (280°C),</td>
</tr>
<tr>
<td>H₂O; <strong>Surface</strong>: CO, CO₂, O₃, SO₂, NO, NOₓ/NOᵧ;</td>
<td>OC₃ (480°C), OC₄ (580°C), OP (pyrolyzed organic carbon, e.g.,</td>
</tr>
<tr>
<td><strong>Profile</strong>: NO₂, (O₃ in progress)</td>
<td>anhydrosugars, dicarboxylic acids)</td>
</tr>
<tr>
<td><strong>Aerosol Optical Thickness</strong>: multi-spectral from</td>
<td><strong>Elemental Carbon</strong> (EC): EC₁ (580°C – OP), EC₂</td>
</tr>
<tr>
<td>shortwave-IR, dust at longwave-IR, and extinction</td>
<td>(740°C), EC₃ (840°C)</td>
</tr>
<tr>
<td>profile</td>
<td></td>
</tr>
<tr>
<td><strong>Aerosol Microphysics/Chemistry</strong>: size, mass,</td>
<td><strong>Water soluble ions</strong>: Na⁺, NH₄⁺, K⁺, Mg²⁺, Ca²⁺, Cl⁻,</td>
</tr>
<tr>
<td>type, CCN, hygroscopicity, scattering/absorption/</td>
<td>NO₃⁻, SO₄²⁻, nss-SO₄²⁻, NO²⁻, F⁻</td>
</tr>
<tr>
<td>extinction</td>
<td></td>
</tr>
<tr>
<td><strong>Cloud Optical Thickness</strong>: multi-spectral from</td>
<td><strong>Toxic</strong>: Mercury, PCDD/Fs (dioxin)</td>
</tr>
<tr>
<td>visible to longwave-IR</td>
<td></td>
</tr>
<tr>
<td><strong>Cloud Microphysics</strong>: size, liquid-/ice-water</td>
<td><strong>Metal</strong>: Ti, Mn, Co, Ni, Cu, Zn, Mo, Ag, Cd, Sn, Sb,</td>
</tr>
<tr>
<td>content, cloud-base/top/height, thermodynamic</td>
<td>Tl, Pb, V, Cr, As, Y, Se, Zr, Nb, Ge, Rb, Cs, Ga, La, Ce, Pr,</td>
</tr>
<tr>
<td>phase, Doppler fall-velocity, depolarization and</td>
<td>Nd, Sm, Eu, Gd</td>
</tr>
<tr>
<td>reflectivity profiles</td>
<td></td>
</tr>
<tr>
<td><strong>Radiation Flux</strong>: surface solar and terrestrial</td>
<td><strong>UV radiation</strong>: spectral UV (erythemal) irradiance</td>
</tr>
<tr>
<td>irradiance</td>
<td></td>
</tr>
<tr>
<td><strong>Meteorology</strong>: P, T, RH, wind, mixed-layer</td>
<td><strong>Supplementary data</strong>: sounding profile, sky image,</td>
</tr>
<tr>
<td>height, precipitation, visibility</td>
<td>particle spectroscopy/morphology, rainfall amount</td>
</tr>
</tbody>
</table>
Where to get…

- Images can always be found on the NRL aerosol webpage: http://www.nrlmry.navy.mil/aerosol/
- The big data repository for NRL and Navy is GODAE and the product will appear there as soon. http://www.usgodae.org/
- We are trying to push it to LANCE.
7-SEAS Phase III

- 2016-2018
- Data analysis and modeling
- Regional network for long-term studies
- Incorporation with 2018 NASA flight missions of SW monsoon studies in SE Asia
Cloud-Aerosol-Monsoon Philippines Experiment (CAMPEx)

The purpose of this mission is to investigate the role of anthropogenic and natural aerosol emissions in modulating the frequency and amount of precipitation in the Philippines during the southwest monsoon.
Joint US-Philippine airborne mission to study aerosol impacts on monsoonal precipitation during August and September 2018
Contact:
George Lin
nhlin@cc.ncu.edu.tw
http://aerosol.atm.ncu.edu.tw