7 SouthEast Asian Studies (7-SEAS) - Briefing and updates

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7-SEAS team of TH/TW/VN
Primary collaborators:

- Chung-Te Lee – aerosol chemistry
- Charlie Wang – gas-phase chemistry
- Guey-Rong Sheu – Hg chemistry
- Carlo Wang – radiation
- Kai-Hsien Chi - Dioxins
- Ta-Chih Hsiao – aerosol physics
- Lin-Chi Wang – PAHs and metals
- Roger Chuang – air quality modeling
- Ming-Cheng Yen - climatology
- Tang-Huang Lin – satellite
- Ou-Yang Chang-Feng – GHGs
- Taiwan EPA, MOST
- Researchers from USA, Thailand, Vietnam and others
Biomass Burning (BB) in SE Asia

7 SouthEast Asia Studies (7-SEAS)

Examples of spring campaigns results

Future plan
Biomass-burning haze in SEA

Clear day: $PM_{2.5} \approx 10 \mu g m^{-3}$

Hazy day: $PM_{2.5} \approx 150 \mu g m^{-3}$

Agricultural residue burning

Forest floor burning

Stoke and waste fire
SE Asia has two fire seasons.

Northern spring peak is often more intense than southern August-October peak.

Both peaks have large interannual variability.

Chicken and Egg: How does meteorology impact emissions which impact meteorology?

Courtesy: Edward Hyer
A Frequent Mileage: the pathway

SeaWiFS True Color

Smoke interact with stratiform clouds

Event on 21 March 1999

(Provided by Christina Hsu, NASA)
Investigate the impacts of aerosol particles on weather and the total SE Asian environment.

In order to do this, we need input from seven science areas:

- 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 activities since 2007

- 10 workshops and training courses
- 2007 VBBE (Virtual BB Experiment)
- 2012 Cruise mission in southern SE Asia

In-situ Experiments in northern SE Asia:
- 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
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 Spring field campaigns

Terra/MODIS true color image with AOD (2013/3/23)
7-SEAS 2010-2015 *in-situ* instrumentation

**Chemistry**
- High-Volume
- PS1
- Hg
- Mini-Volume
- Denuder

- Toxin Chemistry
  - mass concentration
  - Dioxin
  - Metal
  - PAHs

- Mercury Chemistry
  - mass concentration
  - gaseous mercury
  - particulate mercury

- Aerosol Chemistry
  - mass concentration
  - water soluble ions
  - carbon composition
  - levoglucosan

**Physics**
- CCN
- Lidar

- Cimel
- AOD - Radiation

**NASA COMMIT - Dongsha, Son La**
- Air quality mobile - Hengchun

**NASA ACHIEVE Yen Bai**
- NCU mobile 1 - Doi Ang Khang

**NCU mobile 2 – Hengchun**

**NCU Mt. Lulin Dongsha supersites**
At the Yen Bai supersite, ACHIEVE instrument setup for (a) AERONET/Cimel sunphotometer with polarization for cloud-mode operations, (b) the ACHIEVE mobile laboratory in action, and (c) a 18.4m high corner-cube (6.4-inch inner dimension) calibration tower, located at the west bank of the Red River, Vietnam, and 370m to the ACHIEVE radars.

6:35 UTC

CloudSat W-band reflectivity

ACHIEVE W-band reflectivity
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.
Aerosol and Air Quality Research

2nd 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

Published in Nov. 2016

27 papers
Example spring campaigns results

- Meteorology and transport
- Physical measurements
- Chemical measurements
Annual variation of Fire count for both 312K and 308K threshold plot against precipitation histogram (Yen et al., 2013, AE)
Weakening anticyclone over northeast China couples with westward extent of the western Pacific subtropical high

(Yen et al., 2013, AE)
2010

Hengchun site (receptor)

Yen et al. (2013, AE)
Transport of PM$_{2.5}$ – WRF/CMAQ simulation

MT Chuang

Dongsha Experiment

Cross-sectional transport
Schematic diagram for illustrating how an intensified India-Burma Trough modulates the occurrence of biomass burning in northern Indochina and its downwind impact on Taiwan (Huang et al., 2016, JGR).
(Lin et al., 2013; Yen et al., 2013)
Doi Ang Khang supersite (DAK)
1,534 m MSL
northern Thailand

Air quality and aerosol in-situ
Chemistry sampling

Radiation
2014 Doi Ang Khang field experiment

Chemical platform

Lidar
Doi Ang Khang Met station
19.93° N, 99.05° E; 1536 m

Myanmar fort
Thai small village

National border
Myanmar
Thailand

Myanmar fort

Thailand-Myanmar border
Doi Ang Khang, Thailand
(a middle-size village nearby our station)
Identified emissions around Doi Ang Khang

Agricultural Residue Burning

Sideway open burning

Waste (garbage) burning

Wood & branch smoke

stoke fire
AERONET sites over the region during the 7-SEAS Experiments

New concept of AERONET deployments for resolving:
1. Aerosol distributions in an unprecedented region of Indochina peninsula
2. Aerosol dynamics interacts with complex topography
3. Aerosol vertical distribution and characteristics
Regional biomass-burning smoke haze
3/1-4/15, 2014
Aerosol extinction profiles at Doi Ang Khang (DAK) in spring 2014

(a) mean profile

Mean aerosol extinction profile at Doi Ang Khang

Number of profile = 50400

(b) 3-hourly mean profile

3-hourly aerosol extinction profile at Doi Ang Khang

PBL development plays a vital role on the distribution
Aerosol micro-physical measurements at Doi Ang Khang

- **Aerosol Inlet (d_{p,a} < 2.5\mu m)**
  - **Aerosol Inlet (d_{p,a} < 2.5\mu m)**

**NASA Trailer NCU instruments**

- **APS (TSI 3321, 5.0 lpm, course PSD)**
- **TEOM (RP 1400, 16.7 lpm, PM2.5 mass conc.)**
- **CCNC (DMT 100, 0.5 lpm, CCN conc.)**
- **CPC (TSI, 3010, 1.0 lpm, CN conc.)**
- **Aerotrak (TSI 9000, 2.5 lpm, Alv. S.A. conc.)**
- **SMPS (TSI 3936, 0.3 lpm, fine PSD)**
- **PSAP (Radiance Research, BC)**

S.S.: 0.15%, 0.3%, 0.45%, 0.6%, 0.75%

\[
\frac{N_{CCN}}{N_{CN}} \times 100\%
\]

(Hsiao et al., 2016, AAQR)

The fire counts recorded by two satellite, Terra and Aqua. The recorded domain was 15°N~22°N and 90°E~101°E.

(Hsiao et al., 2016, AAQR)
2013-2015 7-SEAS/BASELINEnE

Aerosol-cloud interactions

Son La and Yen Bai sites in VN
Vertical distribution of Aerosol and Cloud in transition zone

(a) Aqua/MODIS true color image on 2013/3/15

(b) Aqua/MODIS AOD on 2013/3/15

Day/Night detected counts of aerosol and cloud according to CALIPSO (2007-2016) and CloudSat (2007-2011) datasets.
Impact of BB aerosols on regional climate
Why it’s important of decoupling aerosol layer on radiative effects and atmospheric heating?

April 11, 2010 at Dongsha Island

(BB plume)

\[
\begin{aligned}
AOD_{500} &= 0.52 \\
SSA_{500} &= 0.91 \\
DARE_{SFC} &= -41 \text{ W m}^{-2}
\end{aligned}
\]

(Mixed aerosols)

\[
\begin{aligned}
AOD_{500} &= 0.22 \\
SSA_{500} &= 0.95 \\
DARE_{SFC} &= -10 \text{ W m}^{-2}
\end{aligned}
\]

The direct aerosol radiative effect (DARE, W m\(^{-2}\)) was defined as:

\[
DARE(p) = F_{wa}(p) - F_{na}(p)
\]

where \(F_{wa}(p)\) and \(F_{na}(p)\) represent the net downward flux in the presence and absence of aerosols, respectively, at pressure level \(p\).

\[
\frac{\partial T}{\partial t} = \frac{g}{c_p} \frac{F(p)}{\Delta p}
\]

where \(g\) is the gravitational acceleration, \(c_p\) is the specific heat at constant pressure.

(Pani et al., 2016, JGR)
## 7-SEAS/BASELInE Data Products

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

- 2016-2018
- Data analysis and modeling
- Regional networking
- 2018 spring campaign
- 2018 fall campaign in collaboration with NASA flight missions of SW monsoon studies in SE Asia
- The 3rd special issue on JGR
7-SEAS 2018 spring campaign

- March - mid-April 2018
- Plume transport observation: TH-VN-CN/HK-TW
- Vertical profiling
- Aerosol-cloud interaction in N. VN
- Sources from southern China?
- Impact studies
7-SEAS 2018 Spring field campaign

Terra/MODIS true color image with AOD (2013/3/23)
Drone Measurements: Atmospheric (& Aerosol) Profiling

Fixed wing UAV

Specifications

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<table>
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<tr>
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<tr>
<td>Max. Payload</td>
<td>4 kg</td>
</tr>
<tr>
<td>Max. altitude</td>
<td>1200 m</td>
</tr>
<tr>
<td>Measured parameters</td>
<td>Pressure, Temperature, RH, Radiation flux, PM conc.</td>
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Aerosol Counting Composition Extinction and Sizing System
ACCESS (BRECHTEL 9400)

ACCESS includes:
• Mixing-based Condensation Particle Counter
• 3-wavelength absorption photometer
• 8-channel automated filter sampler
• Optical Particle Counter
• Total power at 12 VDC: 60 watts
• System size: 10(L) x 8(W) x 6(H) inches
• System weight: 9.5 lbs (without battery)
Cloud-Aerosol-Monsoon Philippines Experiment (CAMPEx) - August and September 2018
Summary

• BB aerosol chemical, microphysical and radiative properties over Indochina region have been characterized.
• Transport pattern of BB plumes from Indochina region was described and verified by in-situ measurements.
• BB types in our sites nearby source region were identified.
• More to be studied...
Our group members
Welcome you to join 7-SEAS!
Bring your instruments here!

Contact:
nhlin@cc.ncu.edu.tw
Website:
http://aerosol.atm.ncu.edu.tw

THANK YOU!