Springtime Aerosol Observations at Dongsha Atoll, Taiwan

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Acknowledgments

• NRL Base Research Program
• Colorado State University Center for Geosciences / Atmospheric Research (CG/AR)
• Naval Research Enterprise Internship program (NREIP: S. Atwood)
• Dongsha Experiment deployment:
  – Taiwanese Environmental Protection Agency
  – National Science Foundation
  – staff and students of the National Central University of Taiwan
• Aerosol and Radiation Section, including James Campbell, Cynthia Curtis, Walter Sessions, and Peng Xian-Lynch
• Advanced Light Source program, including Kevin Perry
Background

• Role of anthropogenic aerosols in SE Asia visibility and climate (including aerosol-cloud interactions)
  – Steep gradients, seasonal variations in aerosol loading of interest
  – Interactions with “background” aerosol?
• The (Multi-Partner) Seven SouthEast Asian Studies (7 SEAS) Mission: A Program to Study Pollution-Meteorology Feedbacks in Southeast Asia
• Spring 2010 intensive: international field mission to study the transport of smoke and pollution from Indochina to Taiwan, led by National Central Univ of Taiwan
  – Dongsha Island SuperSite in S. China Sea

Dongsha (aka Pratas) Island

AERONET Sun Photometer
DRUM 8-Stage Cascade Impactor
TEOM (PM\textsubscript{10} + PM\textsubscript{2.5})

Dongsha Island is at edge of transport regimes in springtime

- NOGAPS model output, averaged over the March 31-May 8 study period
- South China Sea in a transitional region between the northern synoptic storm track and dry Southeast Asian boreal winter monsoon
- Strong vertical shear:
  - Boundary layer winds light E / NE
  - Free troposphere W
  ➔ Aerosol sources different in BL and aloft
Regional Aerosol

(a) Total

(b) Dust

(c) Smoke

(d) Sulfate

NAAPS AOD (550 nm)
Surface observations

DRUM images courtesy Prof. Cathy Cahill

XRF analysis, Advanced Light Source

(c) Stage 2 Soil Elements (2.5-5 μm)

Time series of 27 elements in ultrafine, accumulation, and coarse modes

Principal Component Analysis
Six factors extracted
(HYSPLIT 5 day backtrajs, GDAS 1° × 1°)

- **DUST**: Crustal elements in coarse + accum modes
- **INDUSTRIAL**: S, Mg, K in ultrafine mode (shipping? BB?)
- **MARINE**: Cl, Mg in coarse + accum modes
- **METALS**: Heavy metals in accum mode (Pearl River Delta?)
- **INDUSTRIAL**: Metals (no S) in ultrafine mode
- **SULFUR (?)**: S, P, Mg in accum mode + ultrafine K
Factor timelines
(factor scores > 1)
Factor timelines
(factor scores > 1)

Pearl River Delta event
Factor timelines
(factor scores > 1)

Pearl River Delta event

DUST
Factor timelines
(factor scores > 1)

Pearl River Delta event

DUST

Industrial
Factor timelines
(factor scores > 1)

- Pearl River Delta event
- Ultrafine S, Mg, K
- DUST
- Industrial
Factor timelines
(factor scores > 1)

Pearl River Delta event

Ultrafine S, Mg, K

accum mode S

DUST

accum mode S

Industrial
Factor timelines
(factor scores > 1)

Pearl River Delta event

Ultrafine S, Mg, K

accum mode S

DUST

marine

accum mode S

Industrial
Factor timelines
(factor scores > 1)

Pearl River Delta event

Ultrafine S, Mg, K

accum mode S

DUST

marine

accum mode S

Industrial

Mixture of aerosol types at start
Sometimes (short events)
fine mode S is dominant
Factor timelines
(factor scores > 1)

Pearl River Delta event

Ultrafine S, Mg, K

accum mode S

DUST

marine

Relatively clean period
15 – 24 April
marine aerosol dominant
Factor timelines
(factor scores > 1)

Pollution events mixed with dust during last 2 weeks
Clear dust-dominated period
PM\textsubscript{2.5} and PM\textsubscript{10} closely track coarse mass concentration $\approx$ fine mass concentration

- sea salt (and dust) always present
- dust present in particles smaller than 2.5 $\mu$m, and dominates variations in PM\textsubscript{2.5} mass concentrations
Size distribution of elements
Size distribution of elements

mostly coarse mode (sea salt)
Size distribution of elements

mostly FINE mode ("pollution")

mostly coarse mode (sea salt)
Size distribution of elements

mostly FINE mode ("pollution")

“DUST” elements over 50% of mass in PM$_{2.5}$

mostly coarse mode (sea salt)
Aerosol vertical distributions

(b) NAAPS Dust

(c) NAAPS Smoke

(d) NAAPS Sulfate

(e) AODs
Aerosol vertical distributions

Dust at surface later in the study arrives with high sulfate
Aerosol vertical distributions

Dust at surface later in the study arrives with high sulfate.

Smoke aloft at study start linked to largest AODs, attribution primarily to fine mode; does not often mix to surface.
Aerosol vertical distributions

Dust at surface later in the study arrives with high sulfate

Smoke aloft at study start linked to largest AODs, attribution primarily to fine mode; does not often mix to surface

AOD captured well in NAAPS (assimilated)
Factor analysis appears to be consistent with modeling, other obs
Summary

• Strong evidence in MBL aerosol data of persistent marine + dust aerosol, with stronger dust and pollution transport events superimposed

• Smoke was mostly transported aloft, where it contributed strongly to high AODs, but was likely only sporadically mixed to surface

• Need additional tracers (organic aerosol, levoglucosan) to clearly identify smoke in MBL

• Vertical wind shear separated aerosol types and transport; important to characterize vertical structure of winds and aerosols in this region