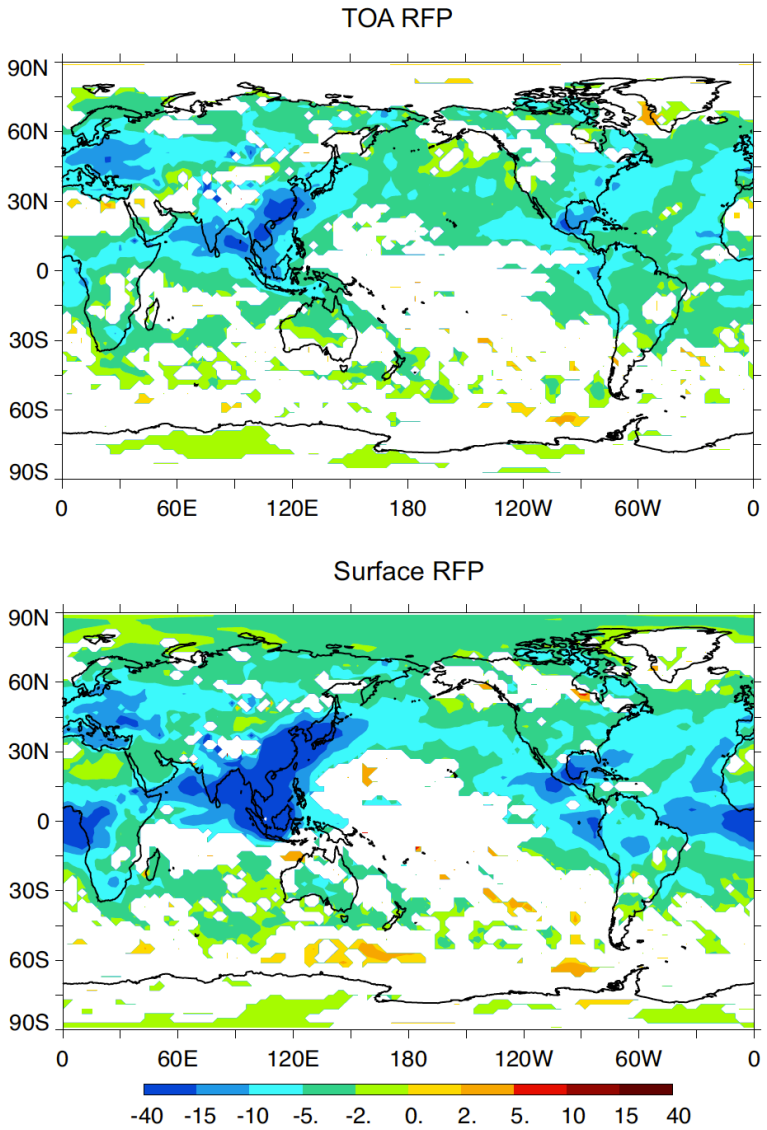
Springtime Aerosol Observations at Dongsha Atoll, Taiwan

Sonia Kreidenweis, Colorado State University
Samuel Atwood (*CSU*), Jeffrey Reid (*NRL*),
Steven Cliff (*UC Davis*), Yongjing Zhao (*UC Davis*),
Neng-Huei (George) Lin (*NCU Taiwan*), and
Douglas Westphal (*NRL*)

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



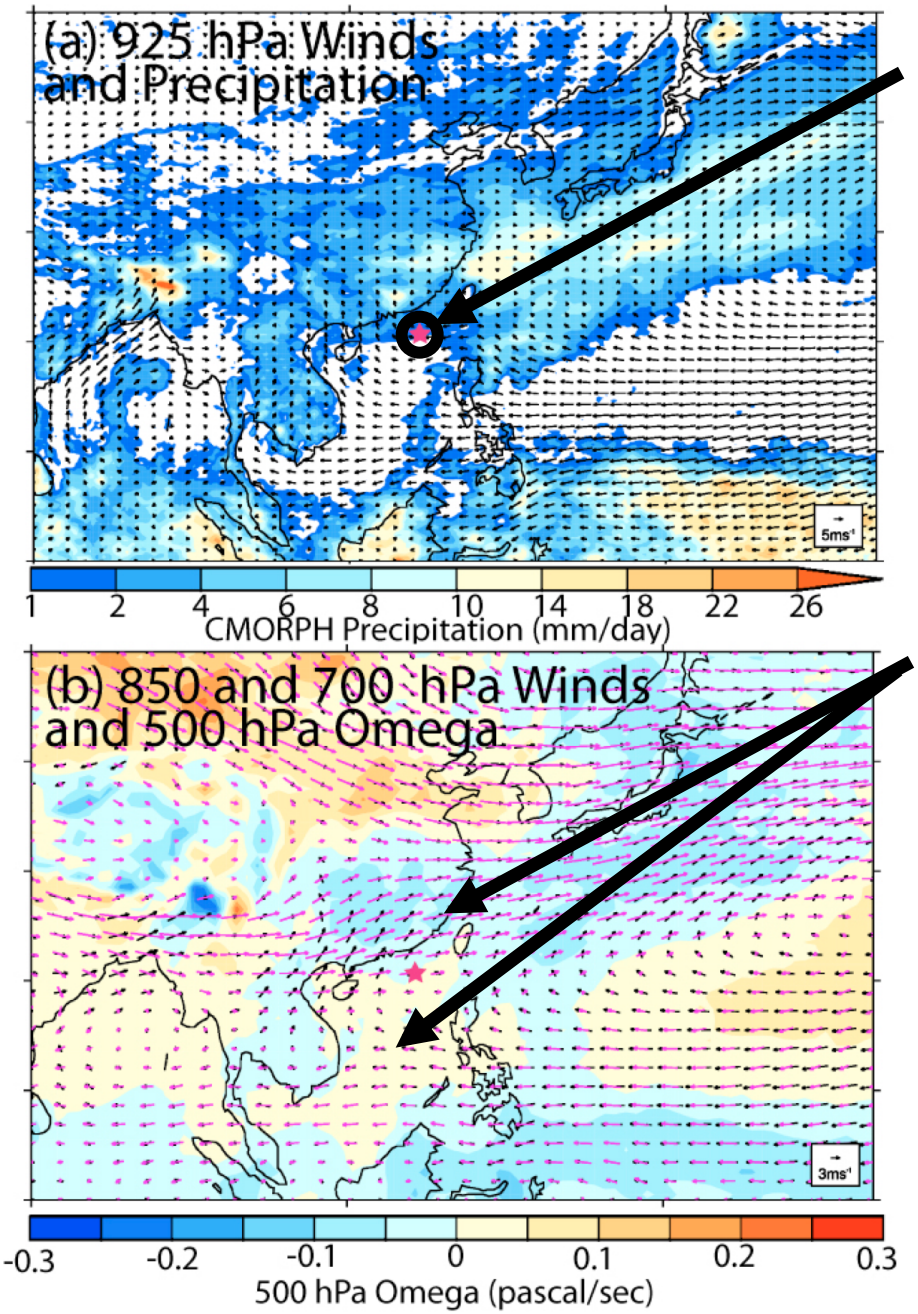
- Role of anthropogenic aerosols in SE Asia visibility and climate (including aerosol-cloud interactions)
  - Steep gradients, seasonal variations in aerosol loading of interest
  - Interactions with "background" aerosol?
- The (Multi-Partner) Seven SouthEast Asian Studies (7 SEAS) Mission: A Program 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

Bollasina, *et al., Science,* 2011: Anthropogenic Aerosols and the Weakening of the South Asian Summer Monsoon

Dongsha (aka Pratas) Island

AERONET Sun Photometer
DRUM 8-Stage Cascade Impactor
TEOM (PM_{10} + $PM_{2.5}$)

http://www.taiwantoday.tw/ct.asp?xItem=30627&CtNode=427

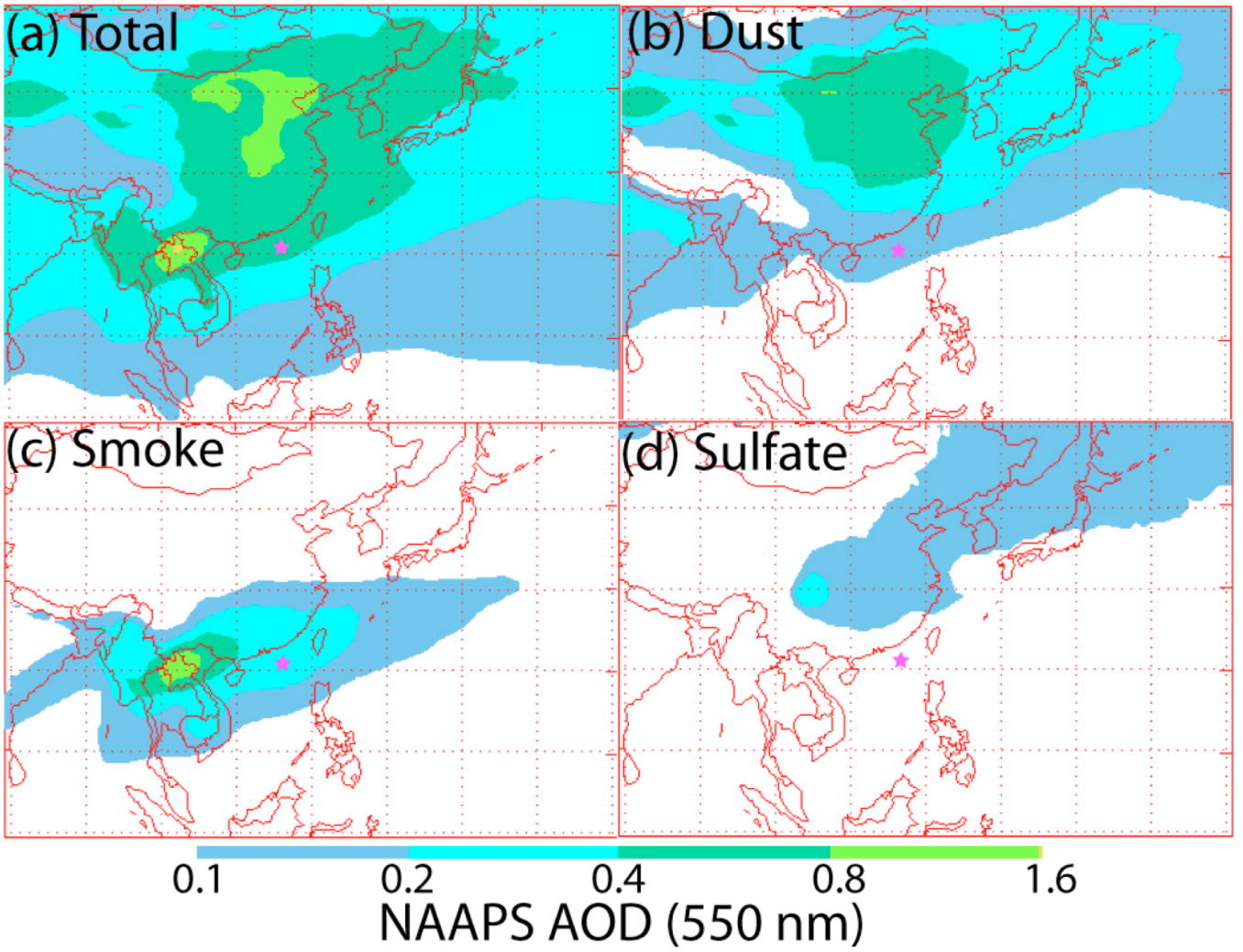


Dongsha Island is at edge of transport regimes in springtime

- 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

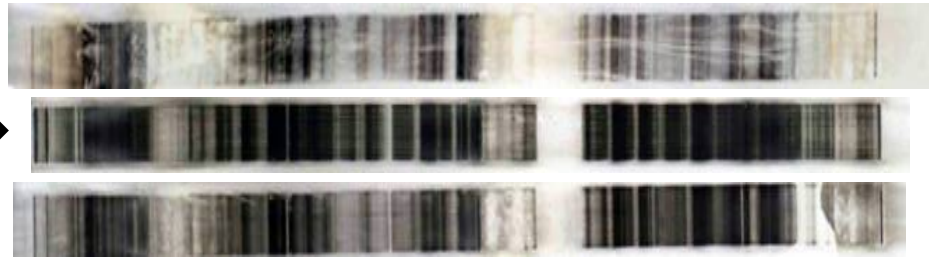
➡ Aerosol sources different in BL and aloft

Regional Aerosol

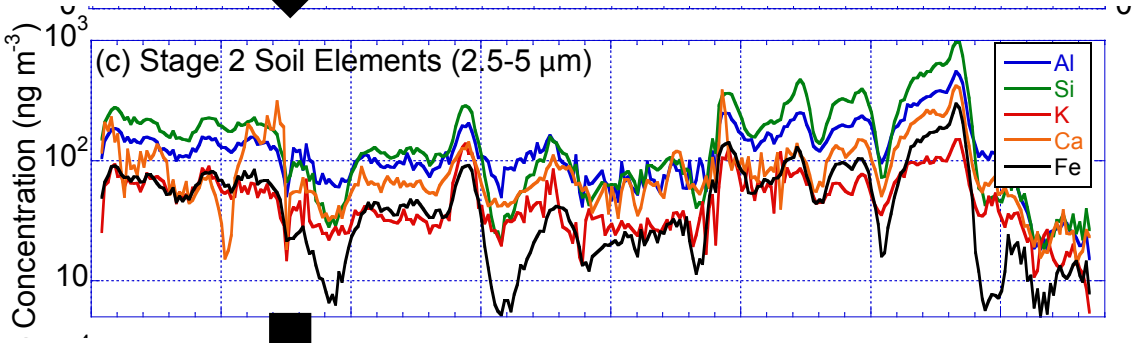


Surface observations

DRUM images courtesy
Prof. Cathy Cahill



XRF analysis, Advanced Light Source



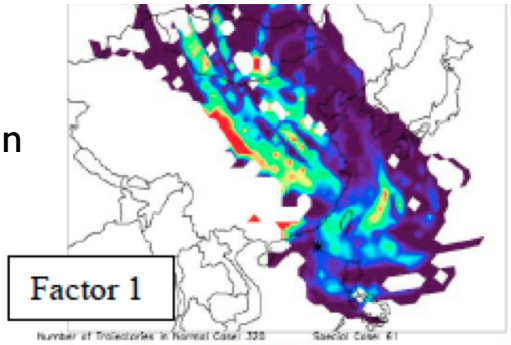
Time series of 27 elements in
ultrafine, accumulation, and coarse modes

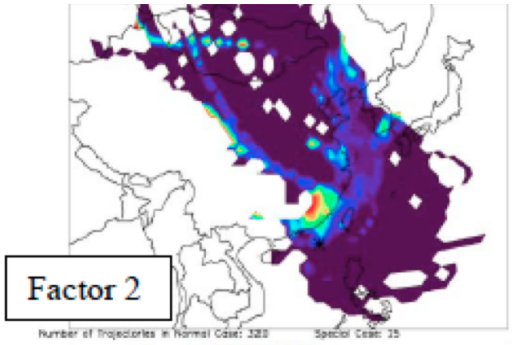
Principal Component Analysis

Six factors extracted

(HYSPLIT 5 day backtrajs, GDAS 1°×1°)

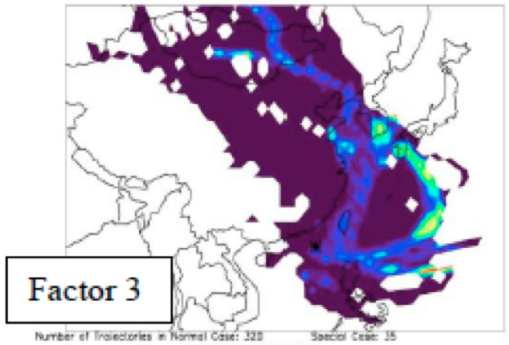
DUST
Crustal elements in coarse + accum modes

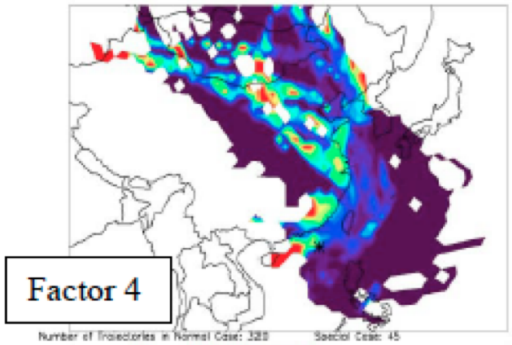




METALS
Heavy metals in accum mode (Pearl River Delta?)

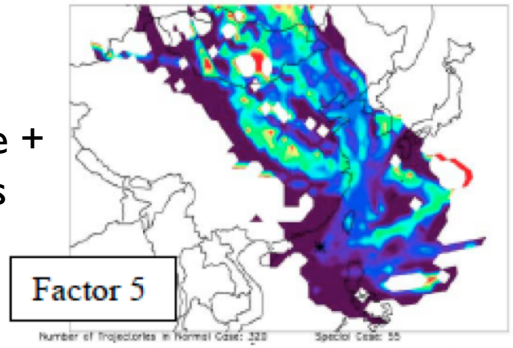
INDUSTRIAL
S, Mg, K in ultrafine mode (shipping? BB?)

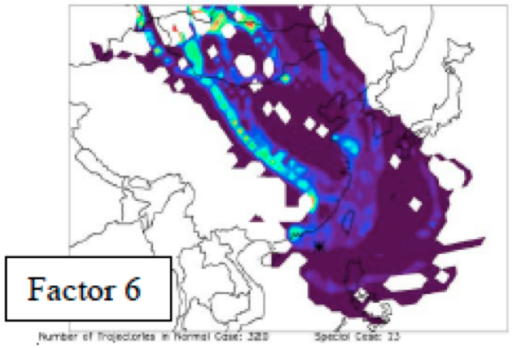




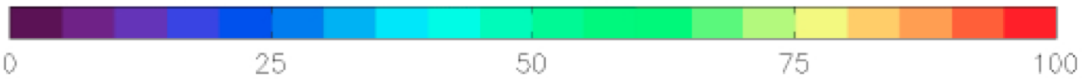
INDUSTRIAL
Metals (no S) in ultrafine mode

MARINE
Cl, Mg in coarse + accum modes

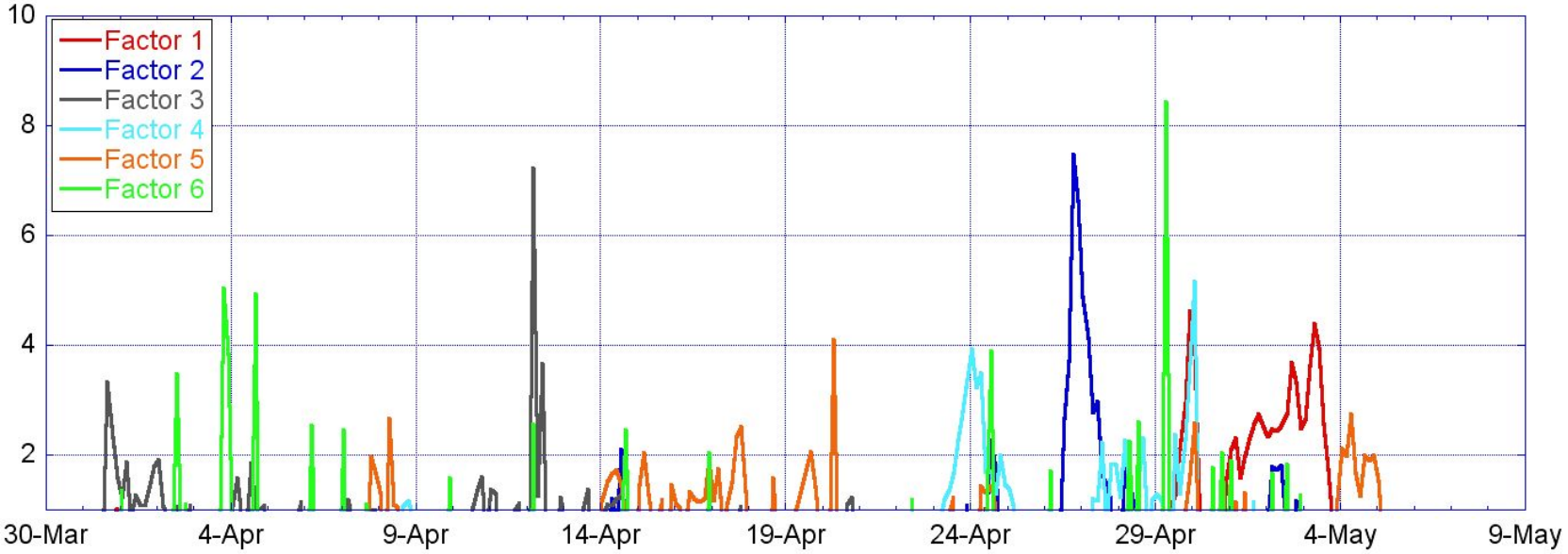




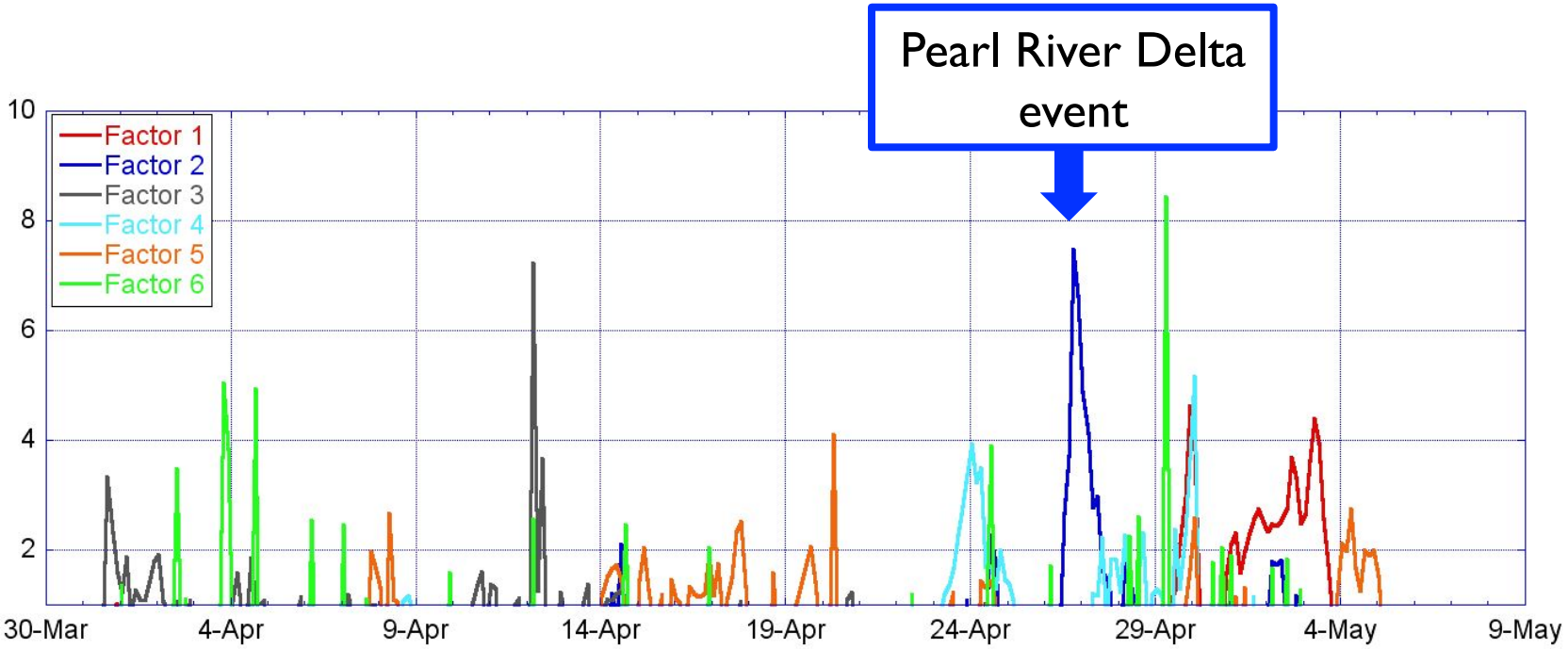
SULFUR (?)
S, P, Mg in accum mode + ultrafine K



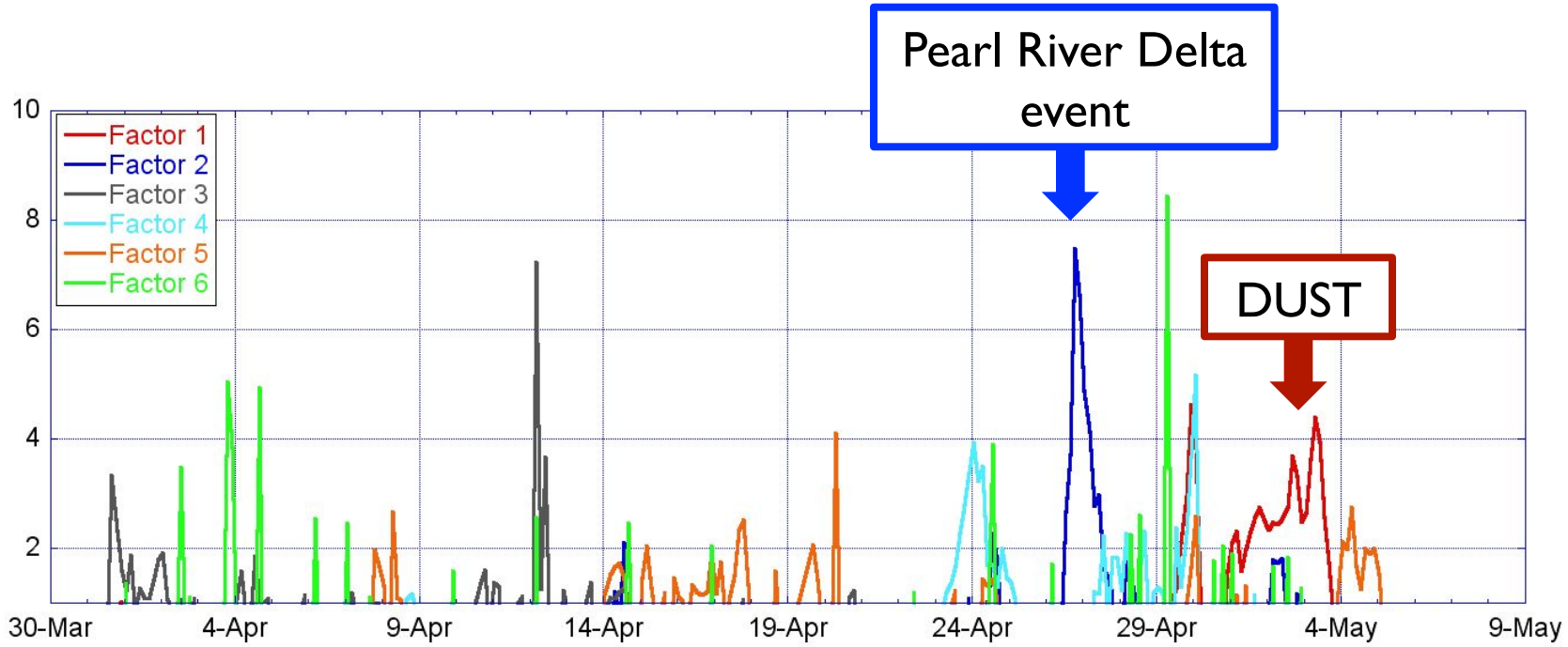
Factor timelines
(factor scores > 1)



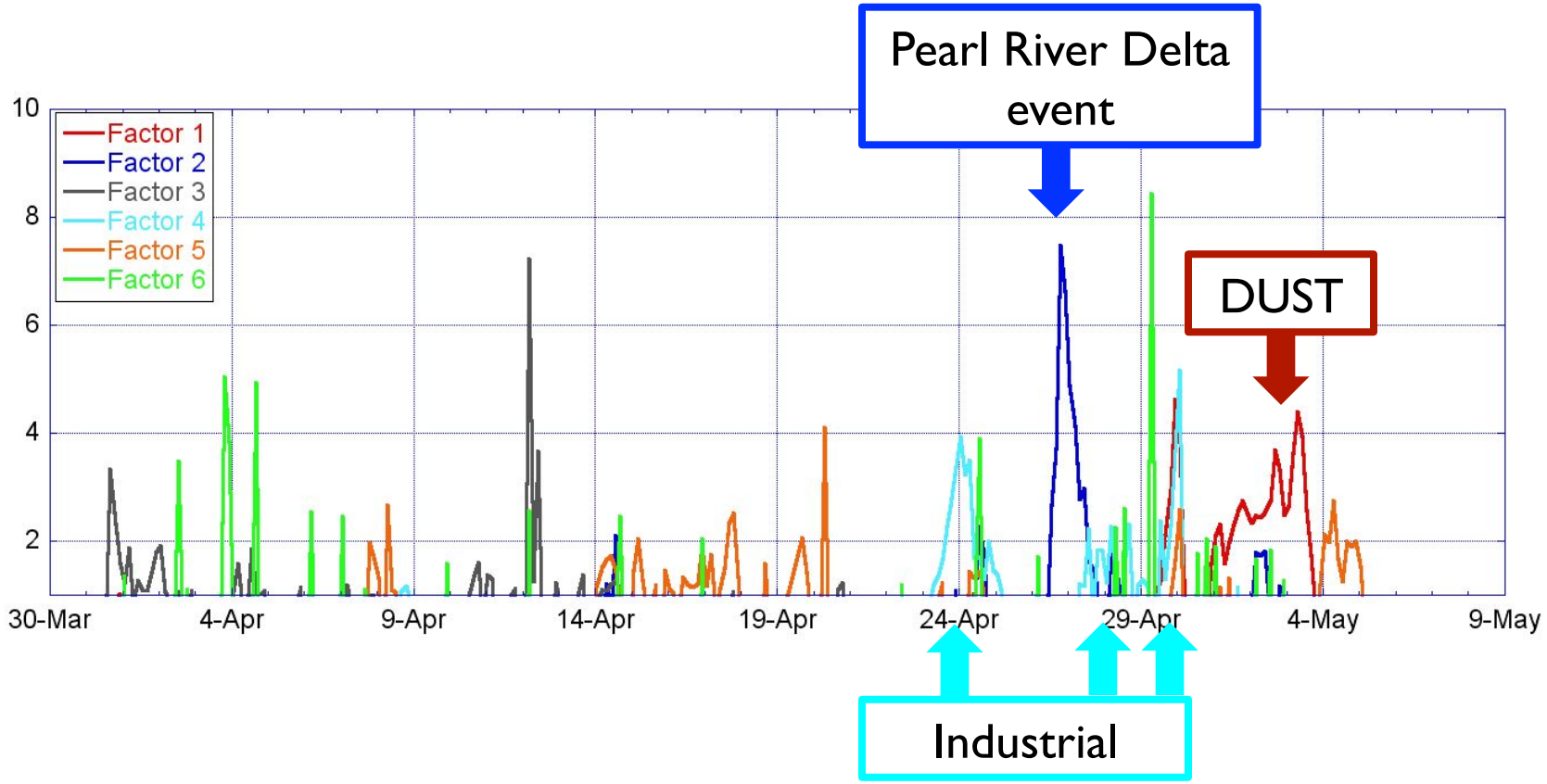
Factor timelines
(factor scores > 1)



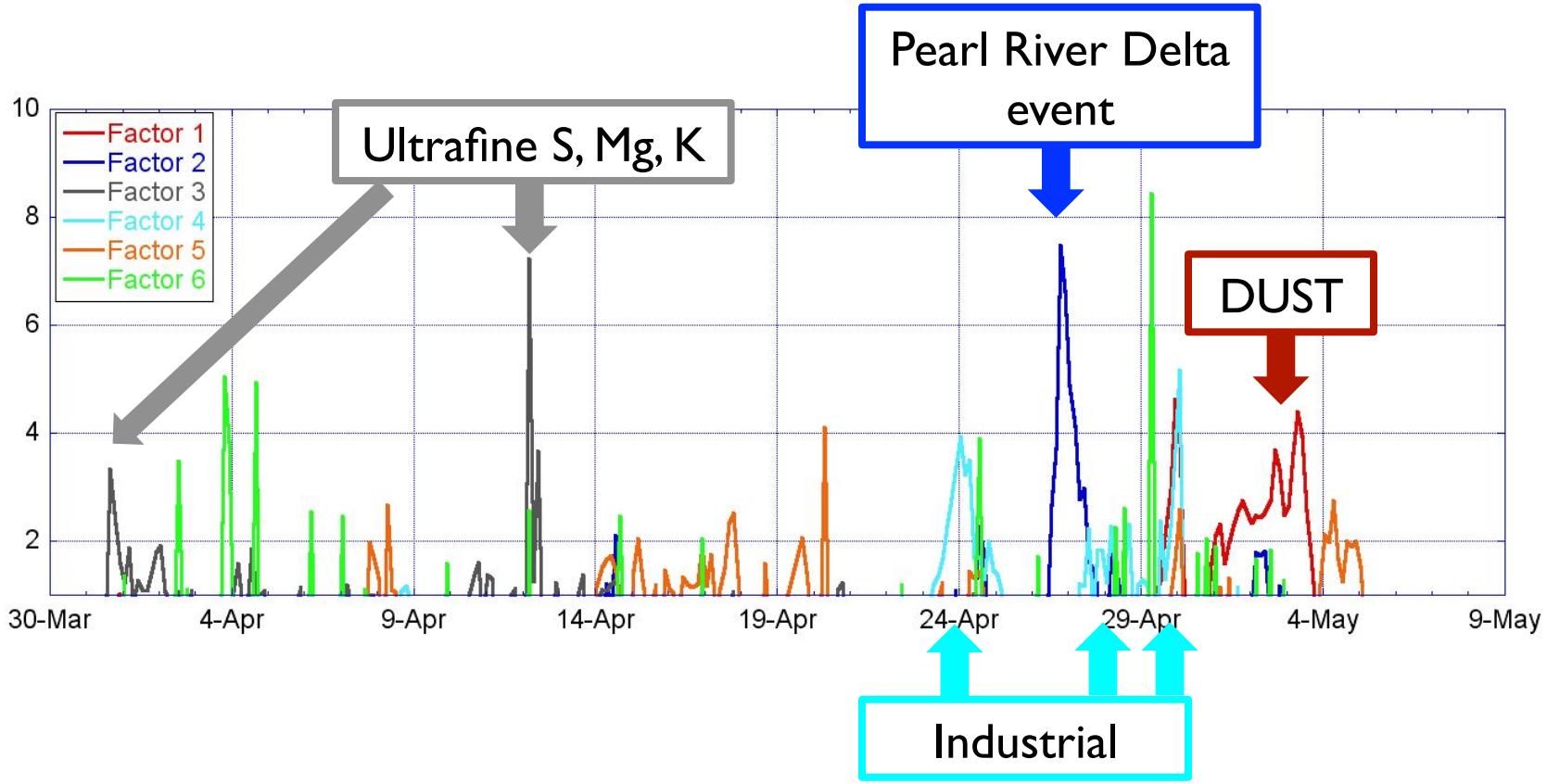
Factor timelines
(factor scores > 1)



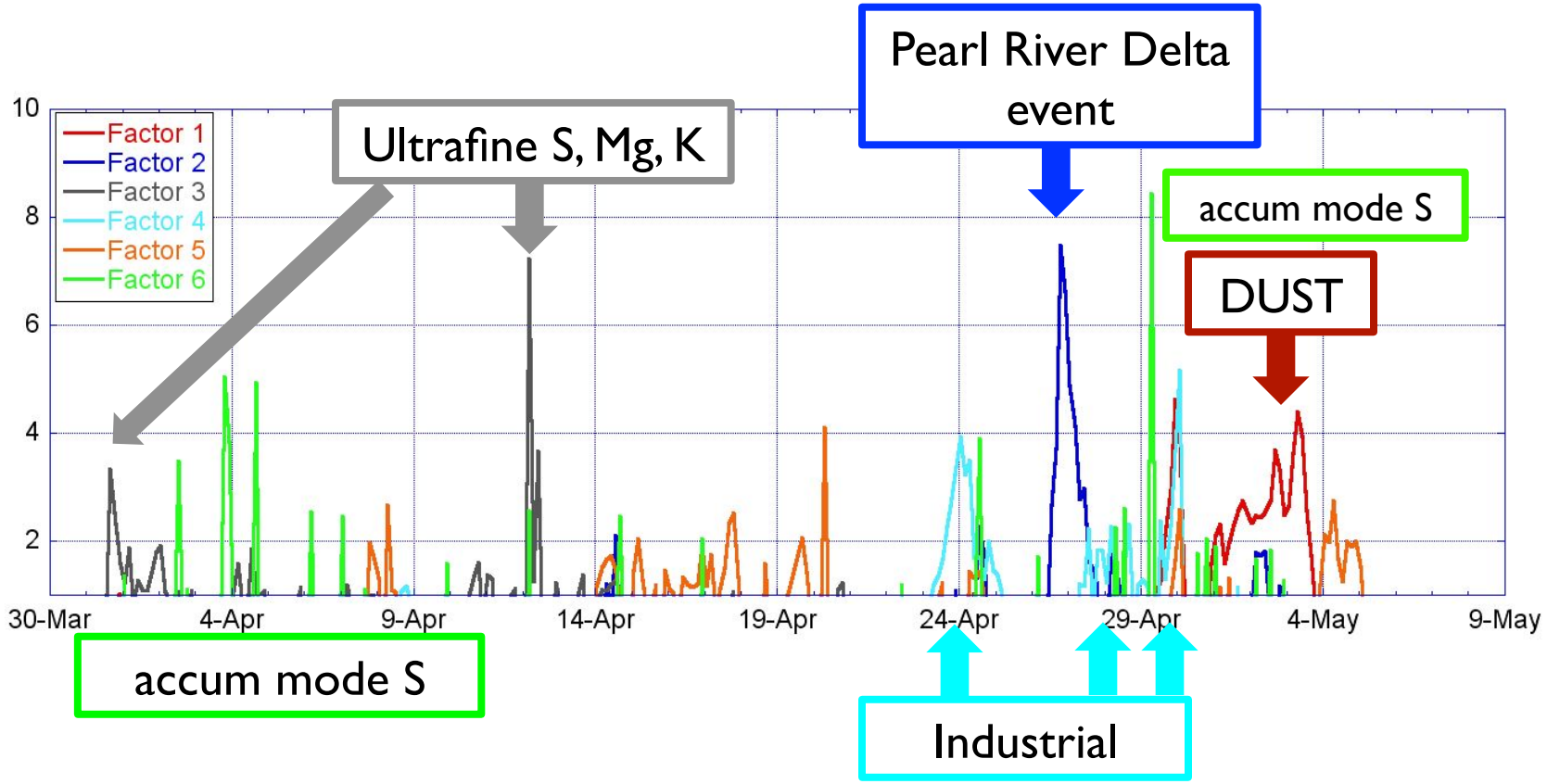
Factor timelines
(factor scores > 1)



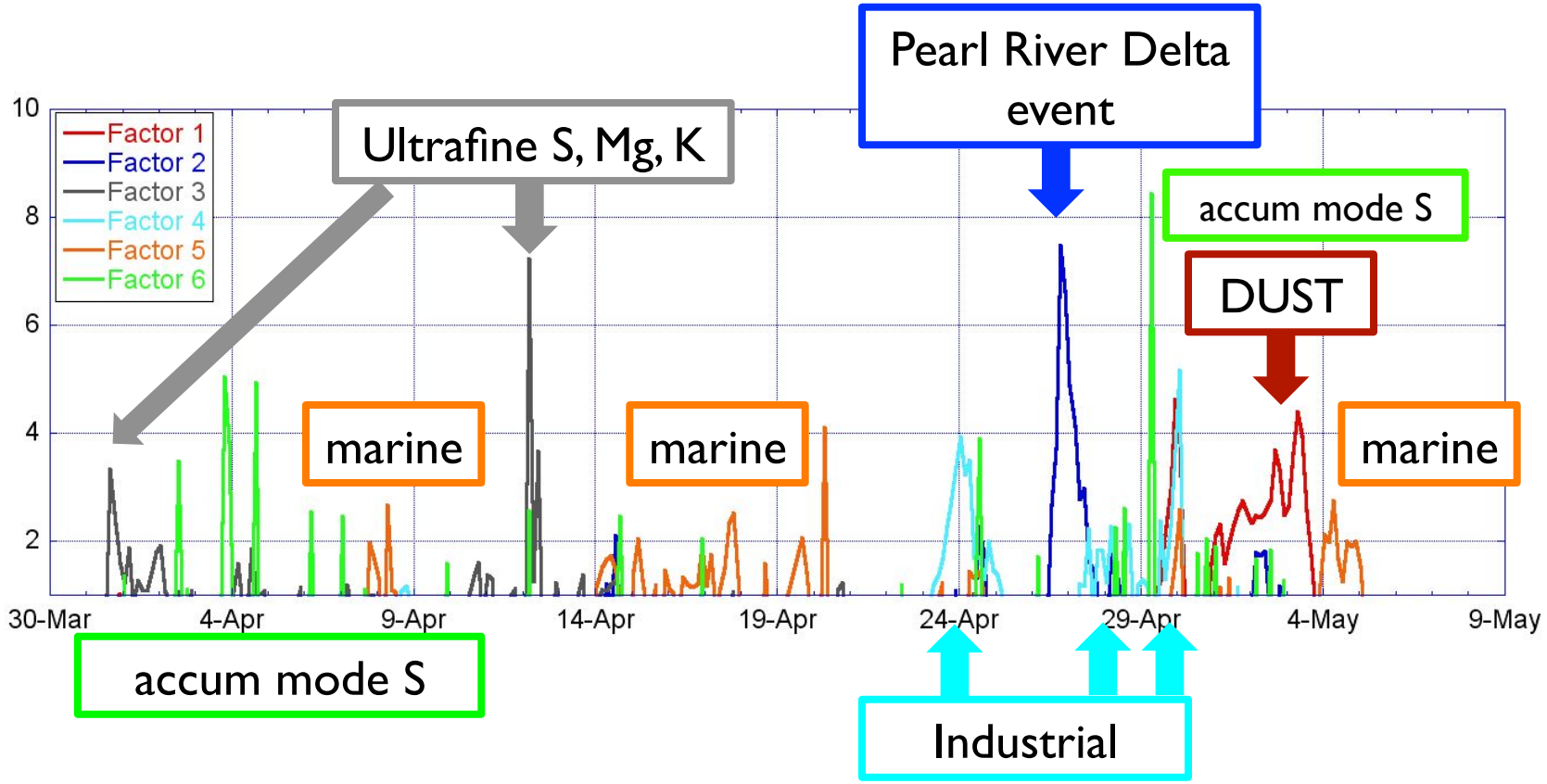
Factor timelines
(factor scores > 1)



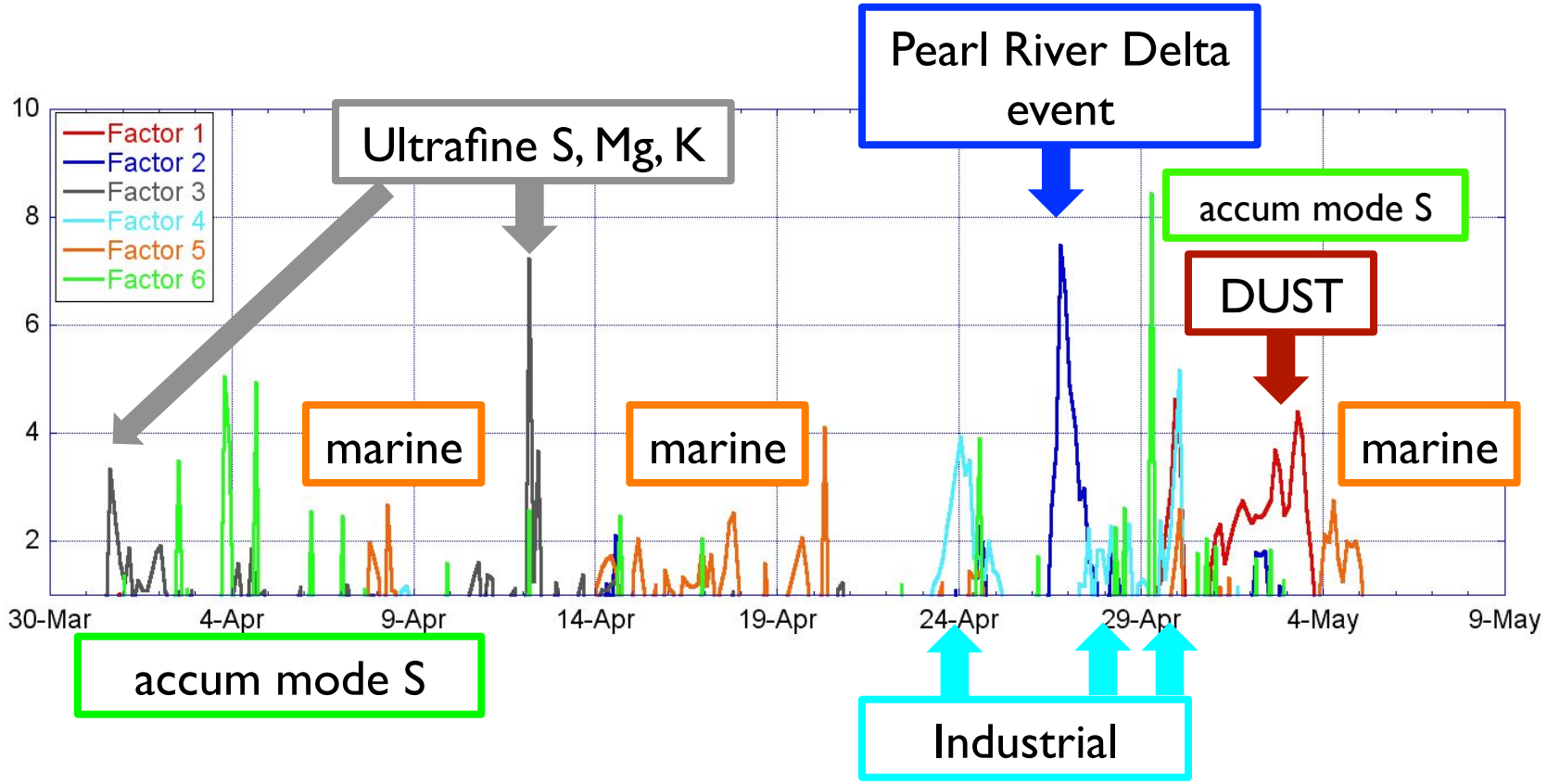
Factor timelines
(factor scores > 1)



Factor timelines
(factor scores > 1)

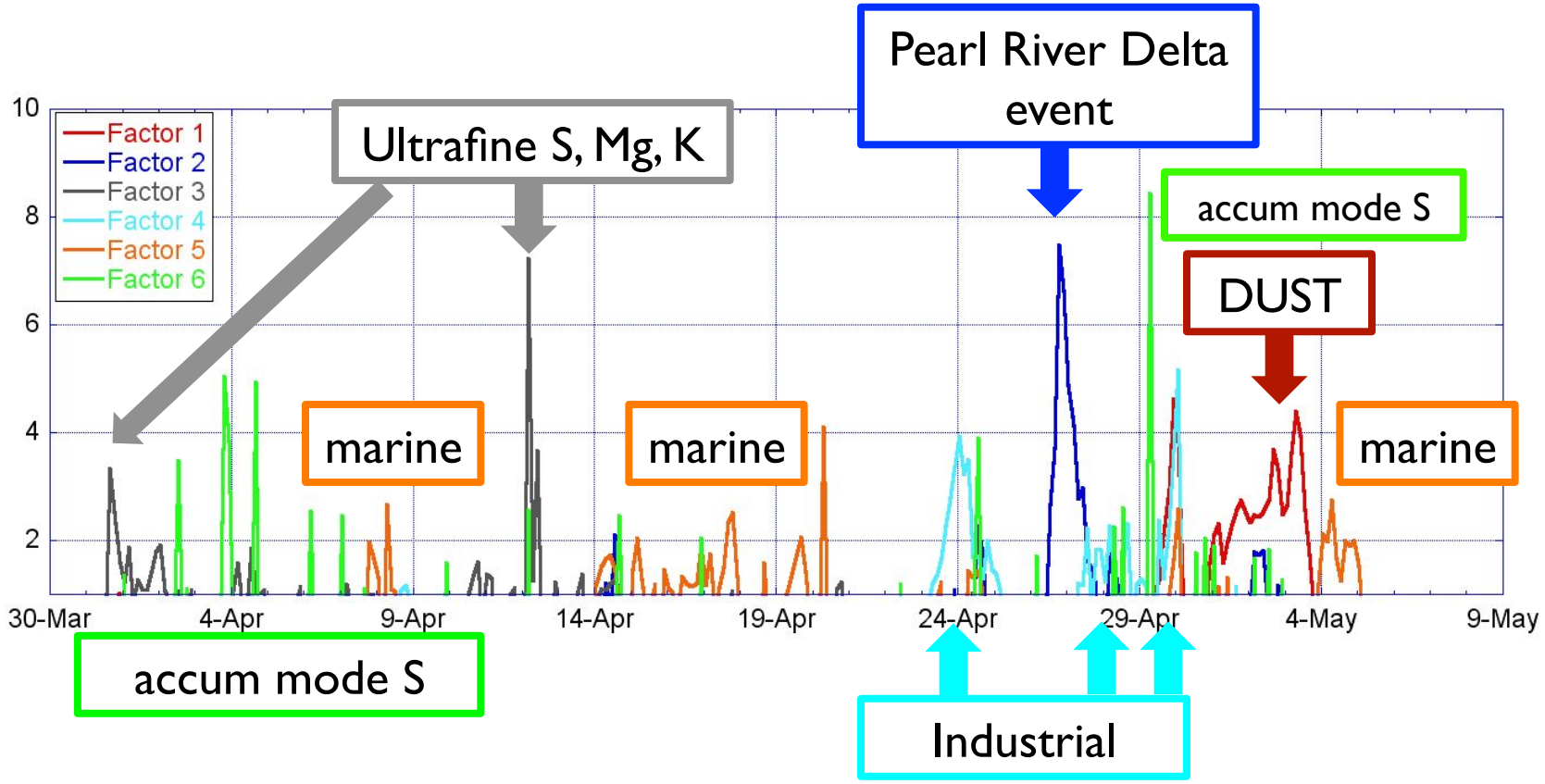


Factor timelines
(factor scores > 1)



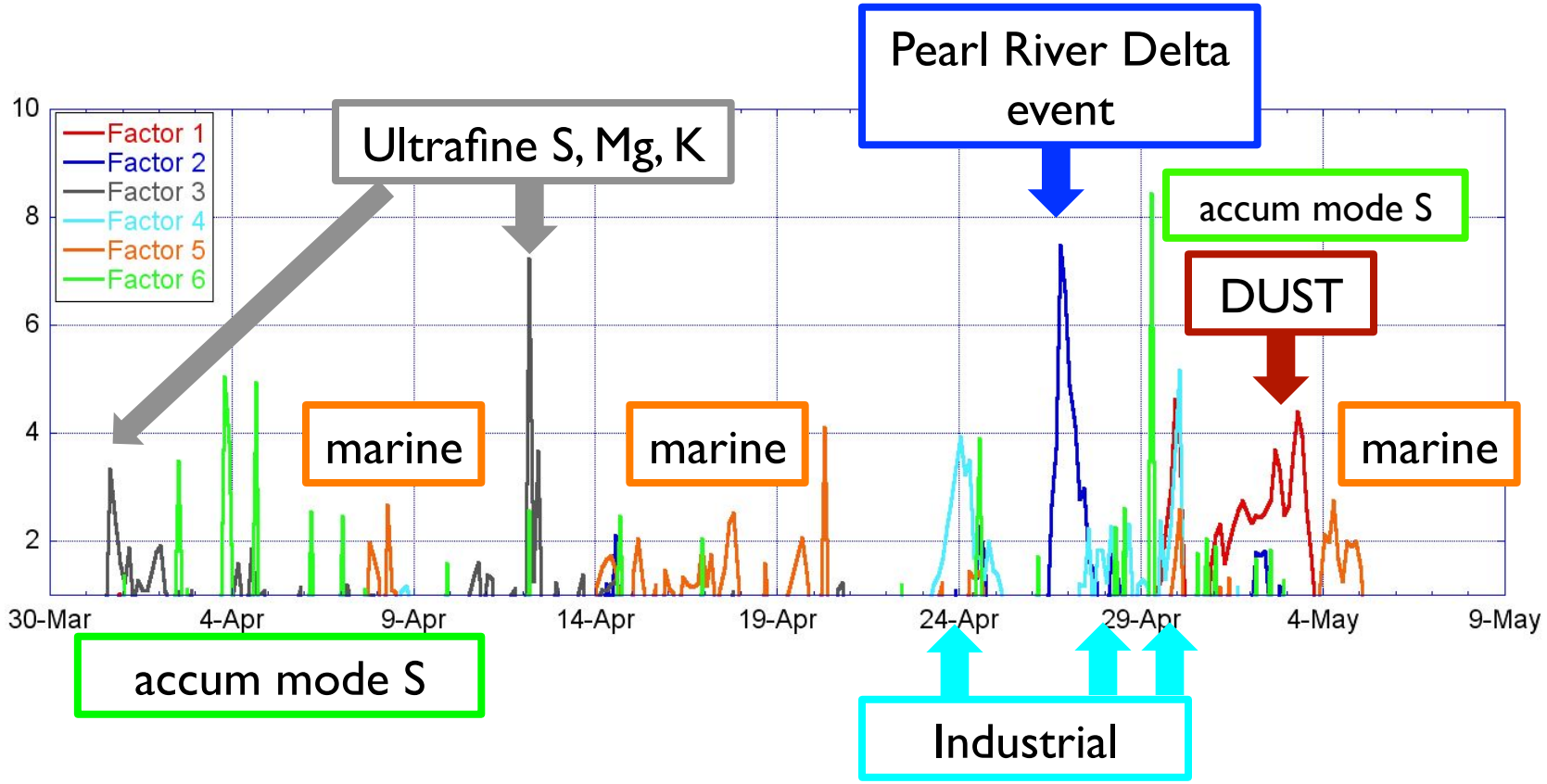
Mixture of aerosol types at start
Sometimes (short events)
fine mode S is dominant

Factor timelines
(factor scores > 1)



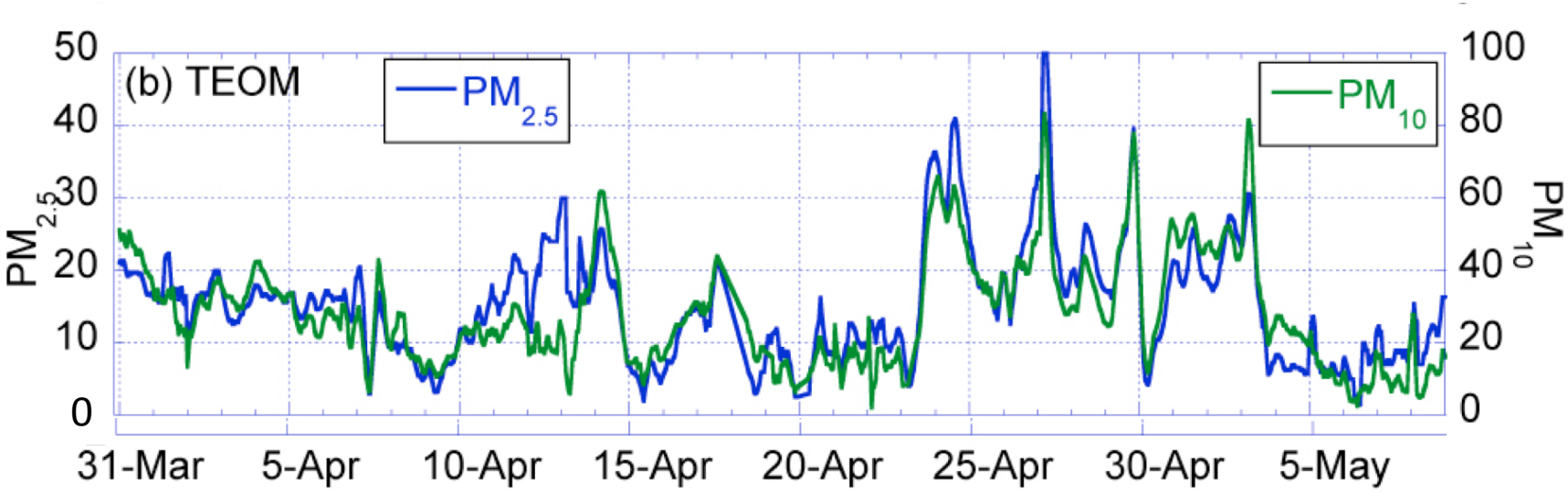
Relatively clean period
15 – 24 April
marine aerosol dominant

Factor timelines
(factor scores > 1)



Pollution events mixed with dust during last 2 weeks
Clear dust-dominated period

$PM_{2.5}$ and PM_{10} closely track

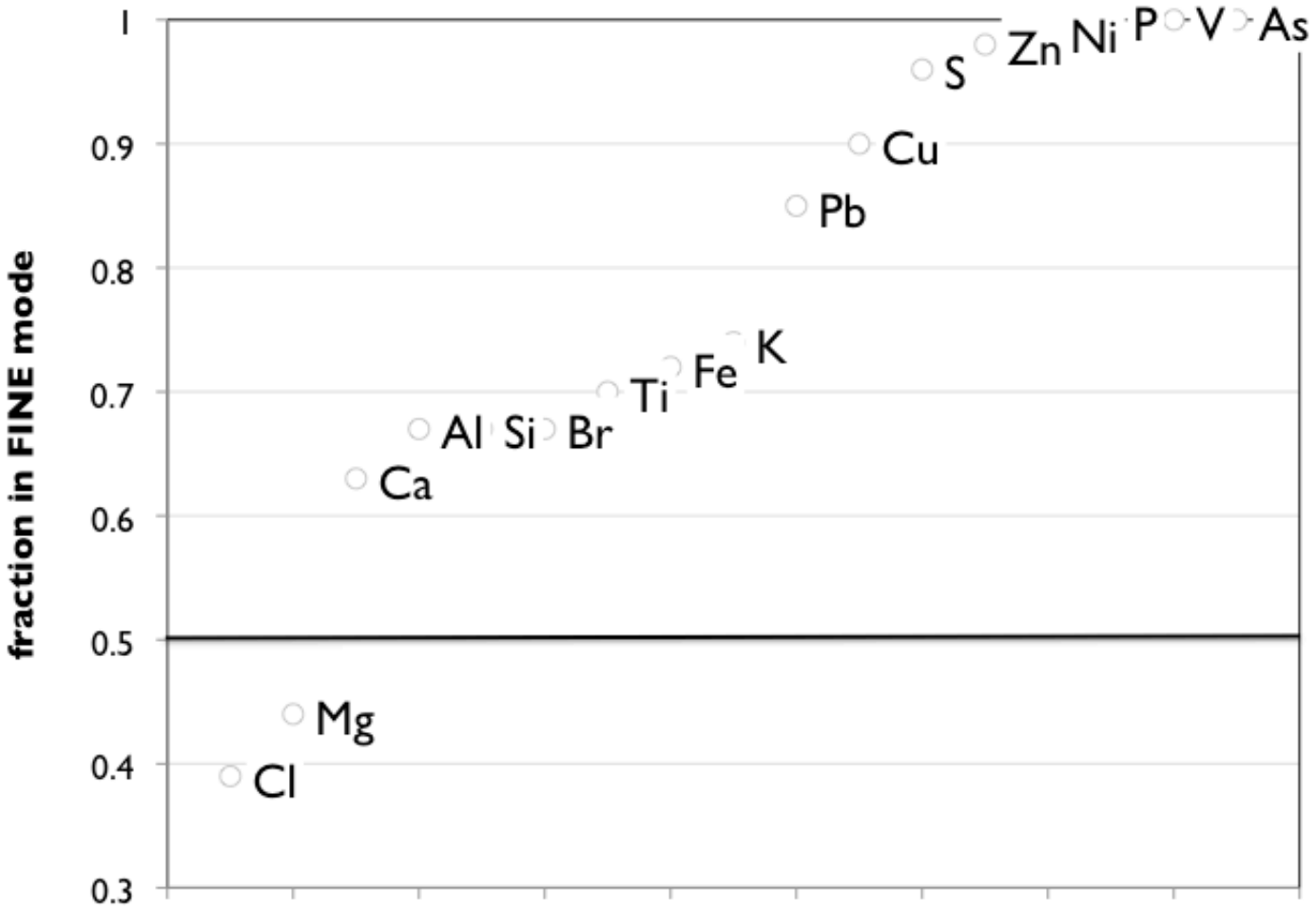


coarse mass concentration ≈ fine mass concentration

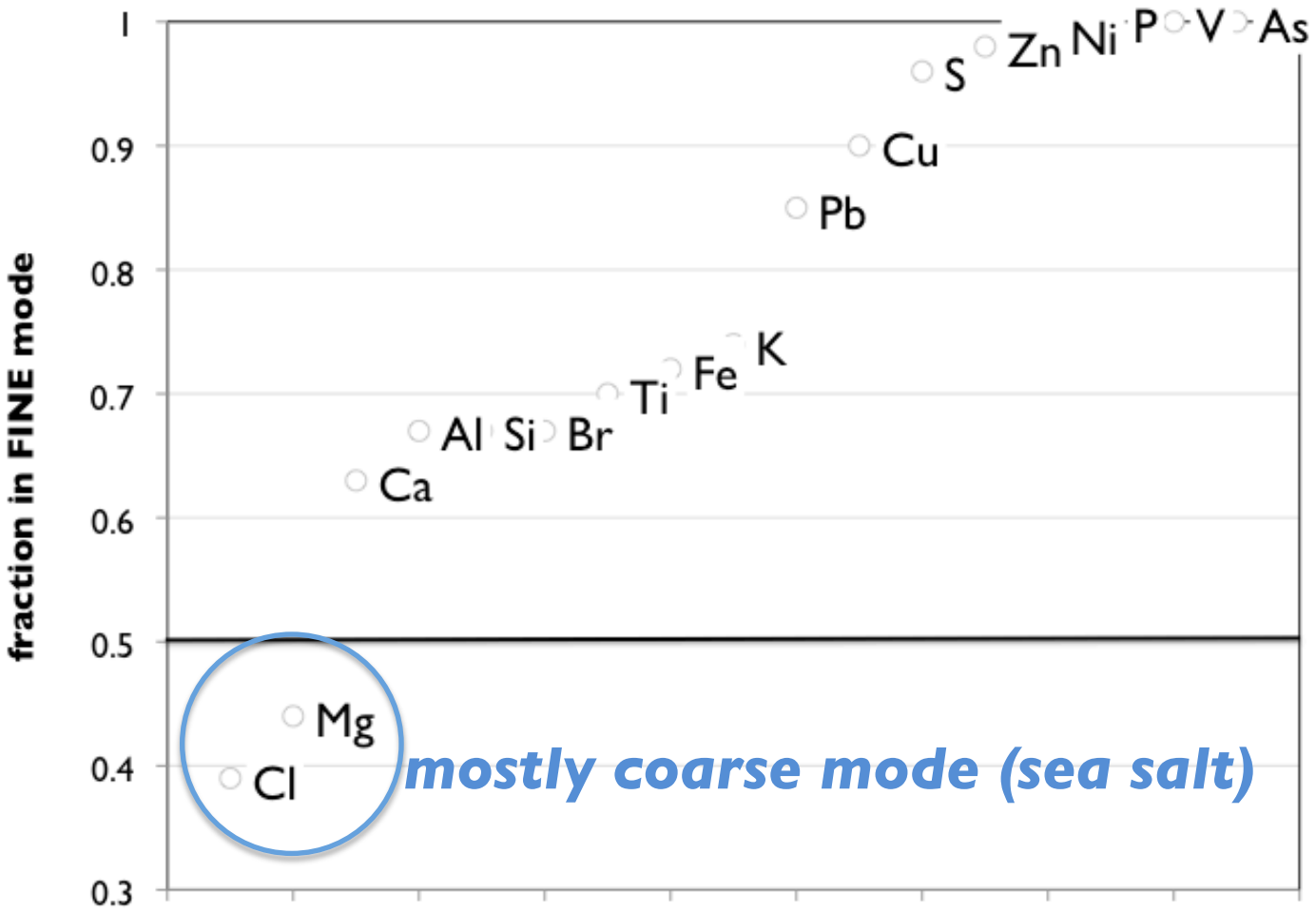
➔ sea salt (and dust) always present

➔ dust present in particles smaller than 2.5 μm, and <u>dominates variations</u> in $PM_{2.5}$ mass concentrations

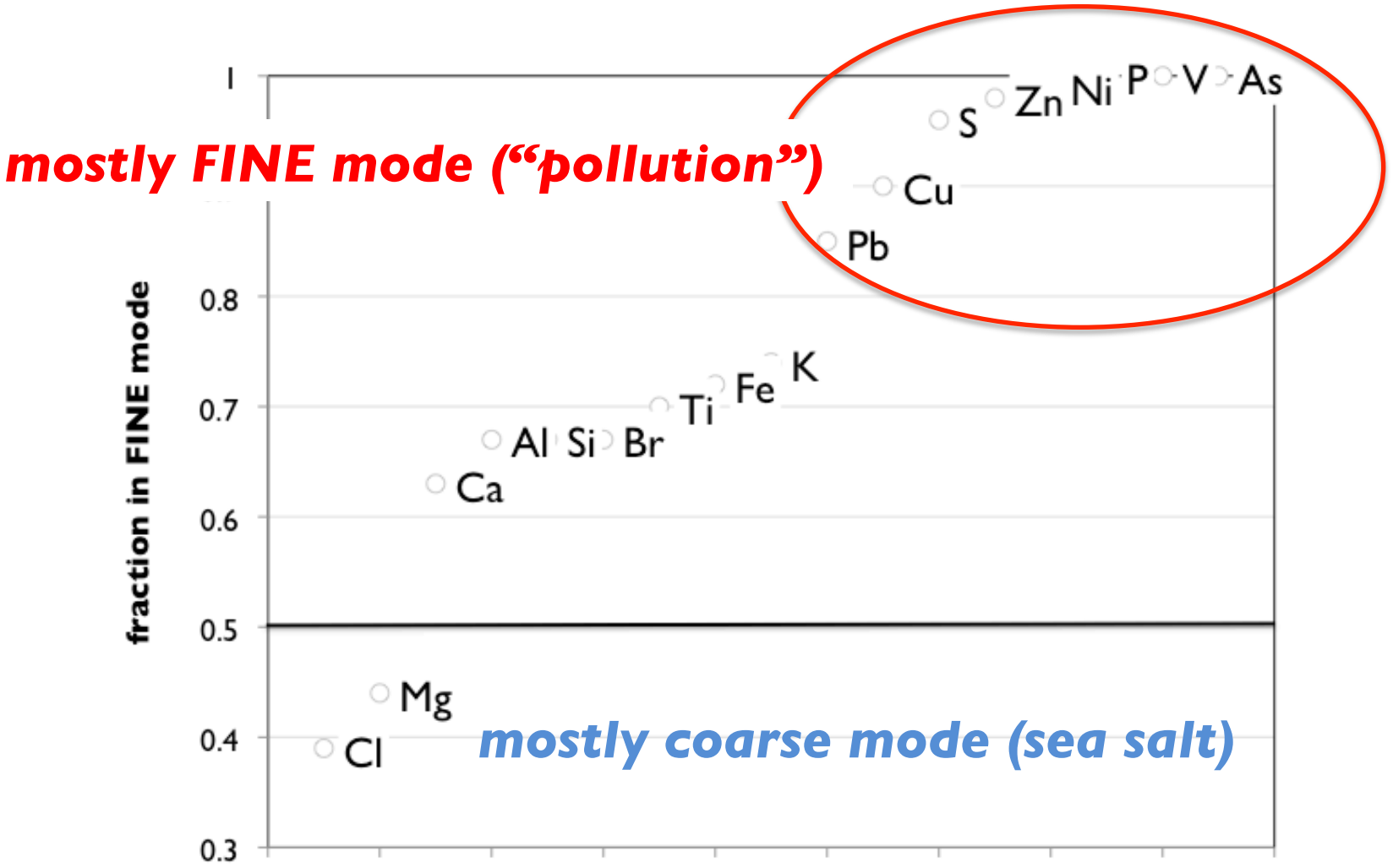
Size distribution of elements



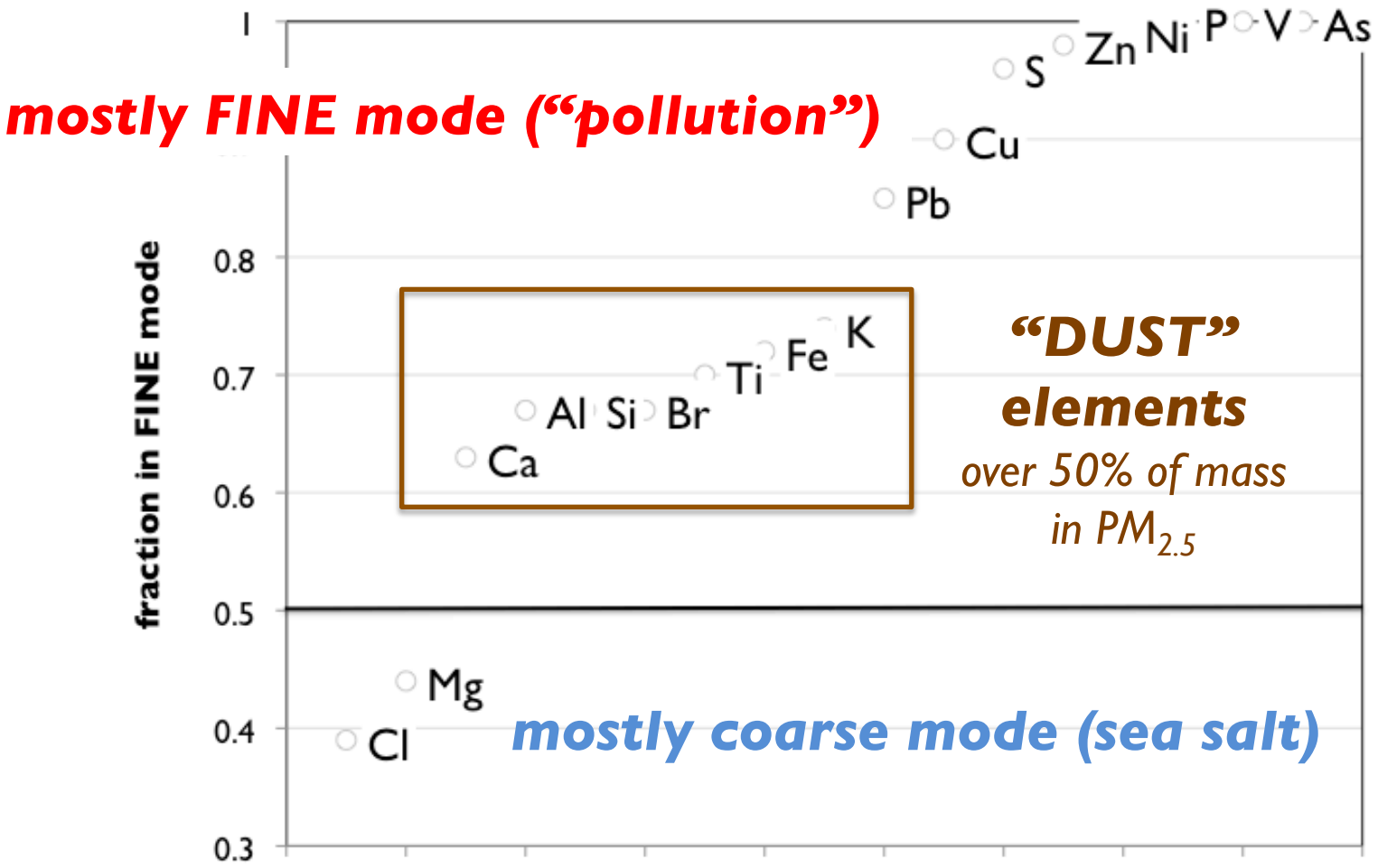
Size distribution of elements



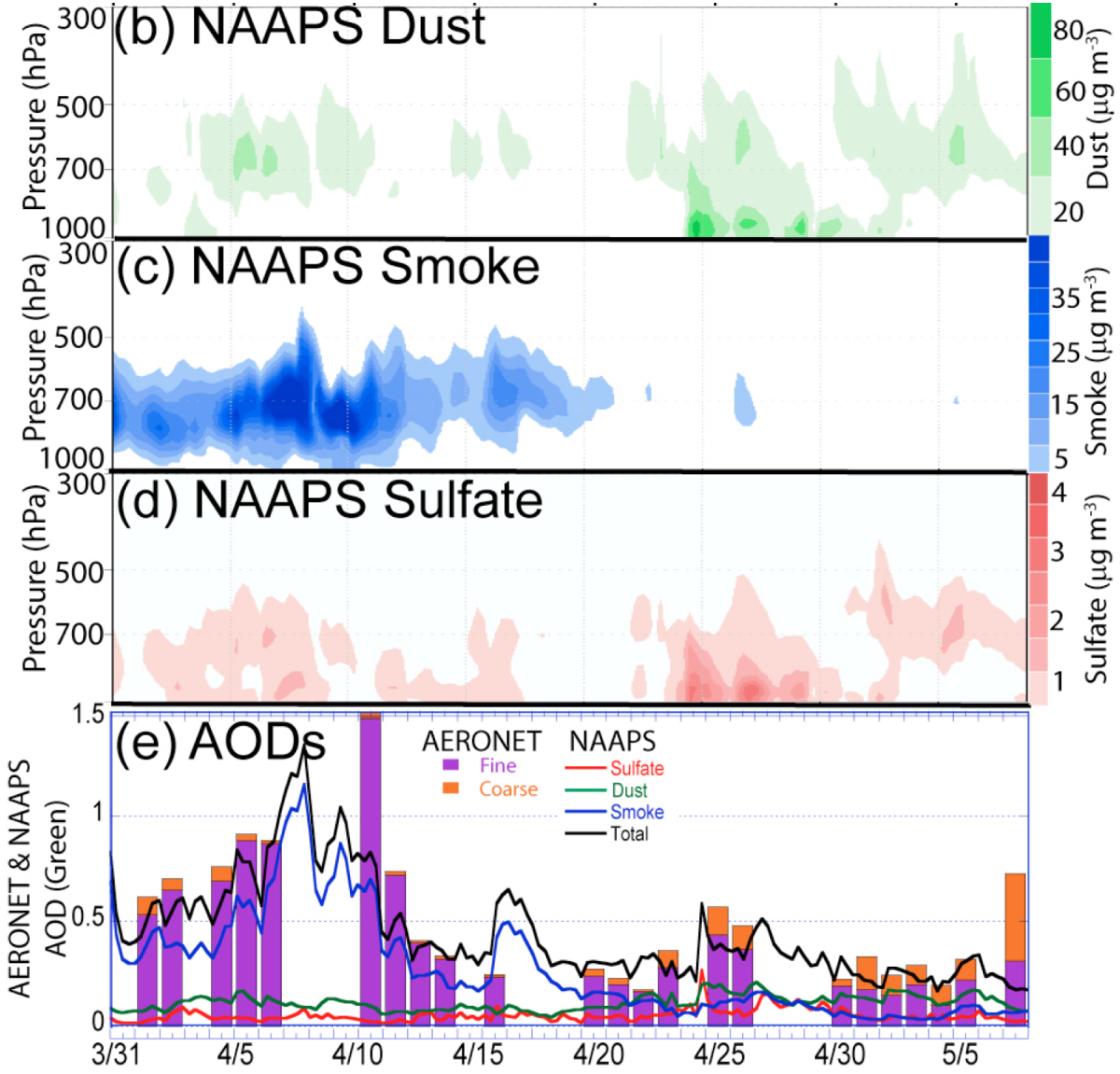
Size distribution of elements



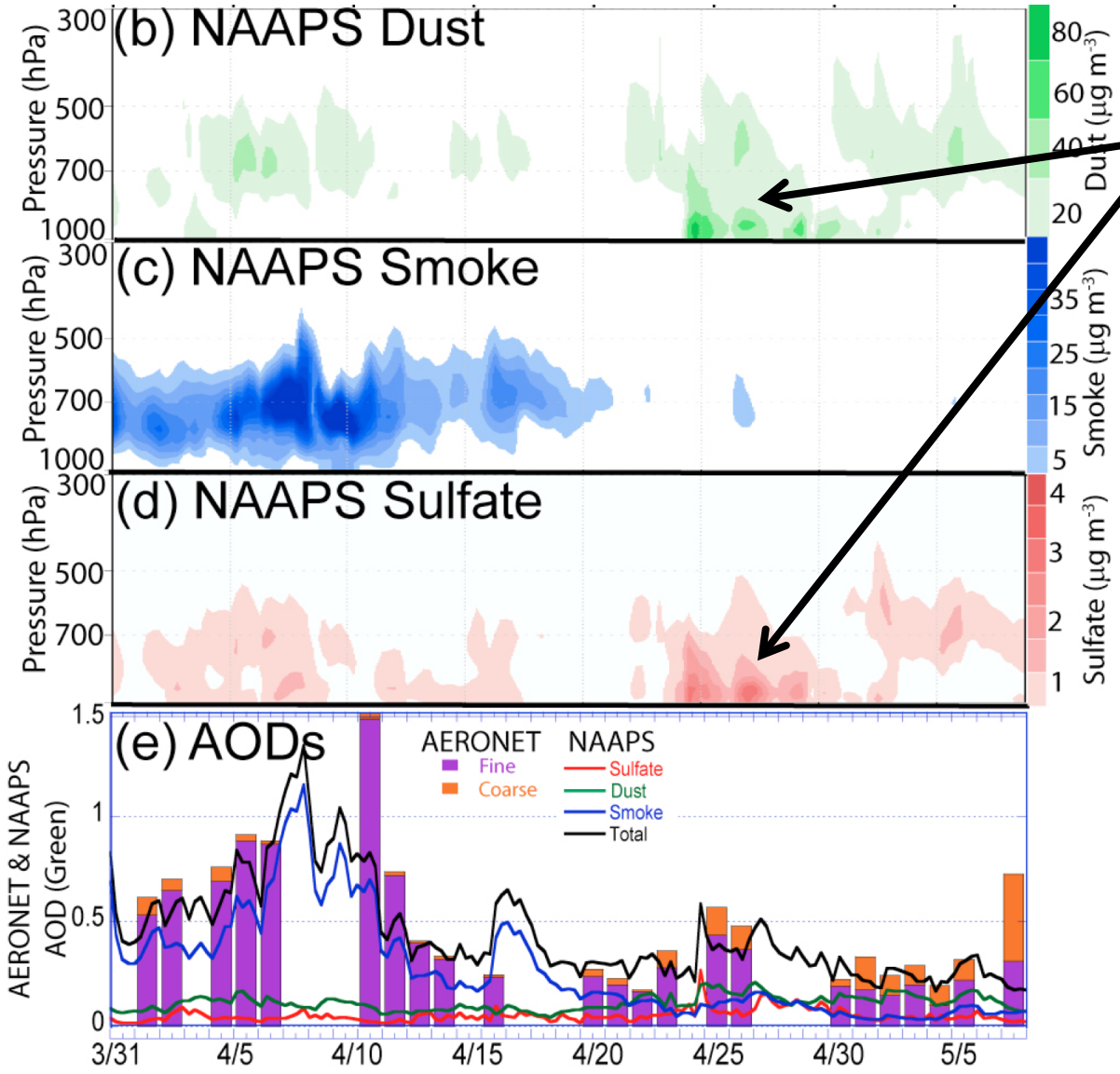
Size distribution of elements



Aerosol vertical distributions

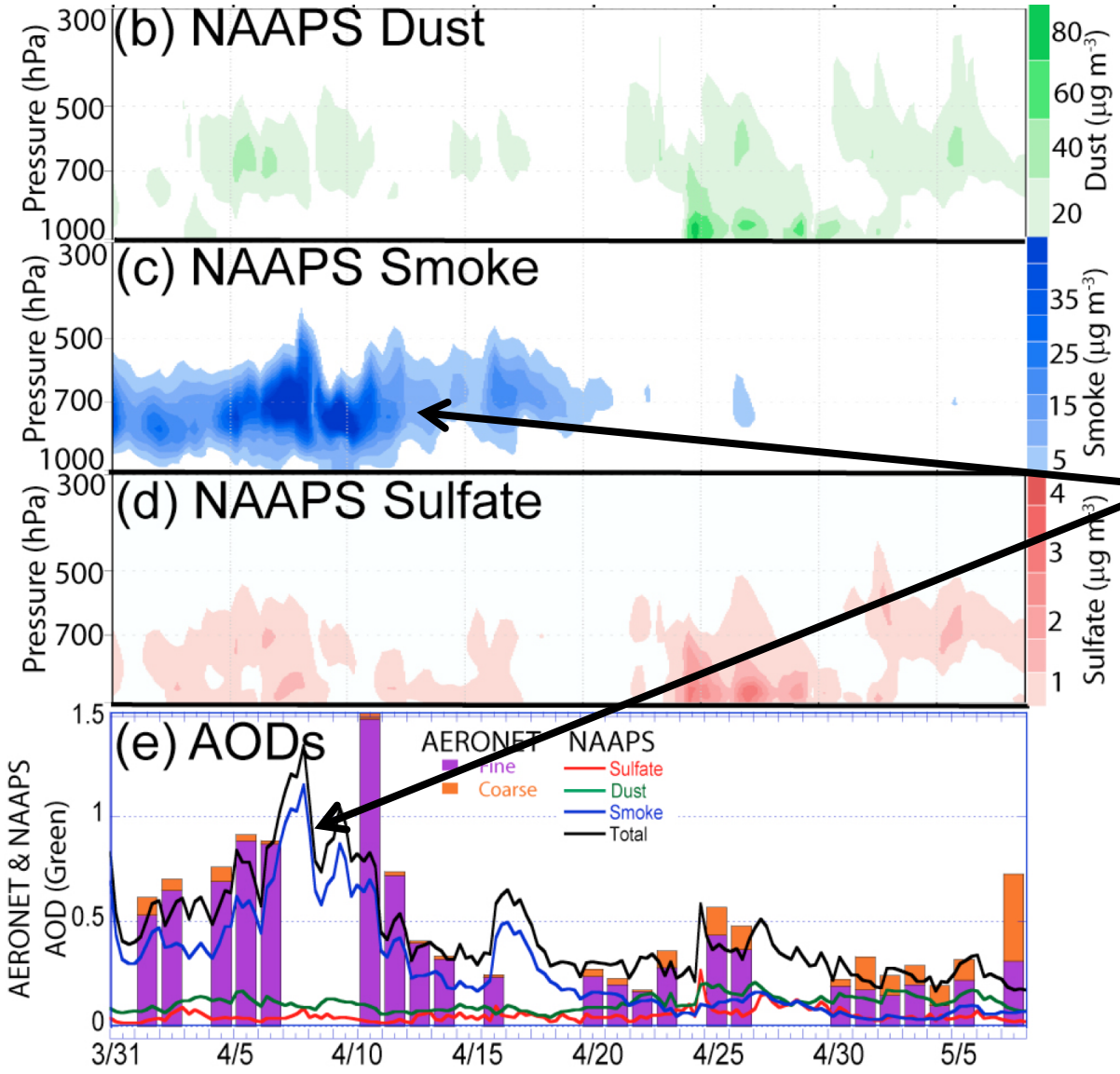


Aerosol vertical distributions



Dust at surface later in the study arrives with high sulfate

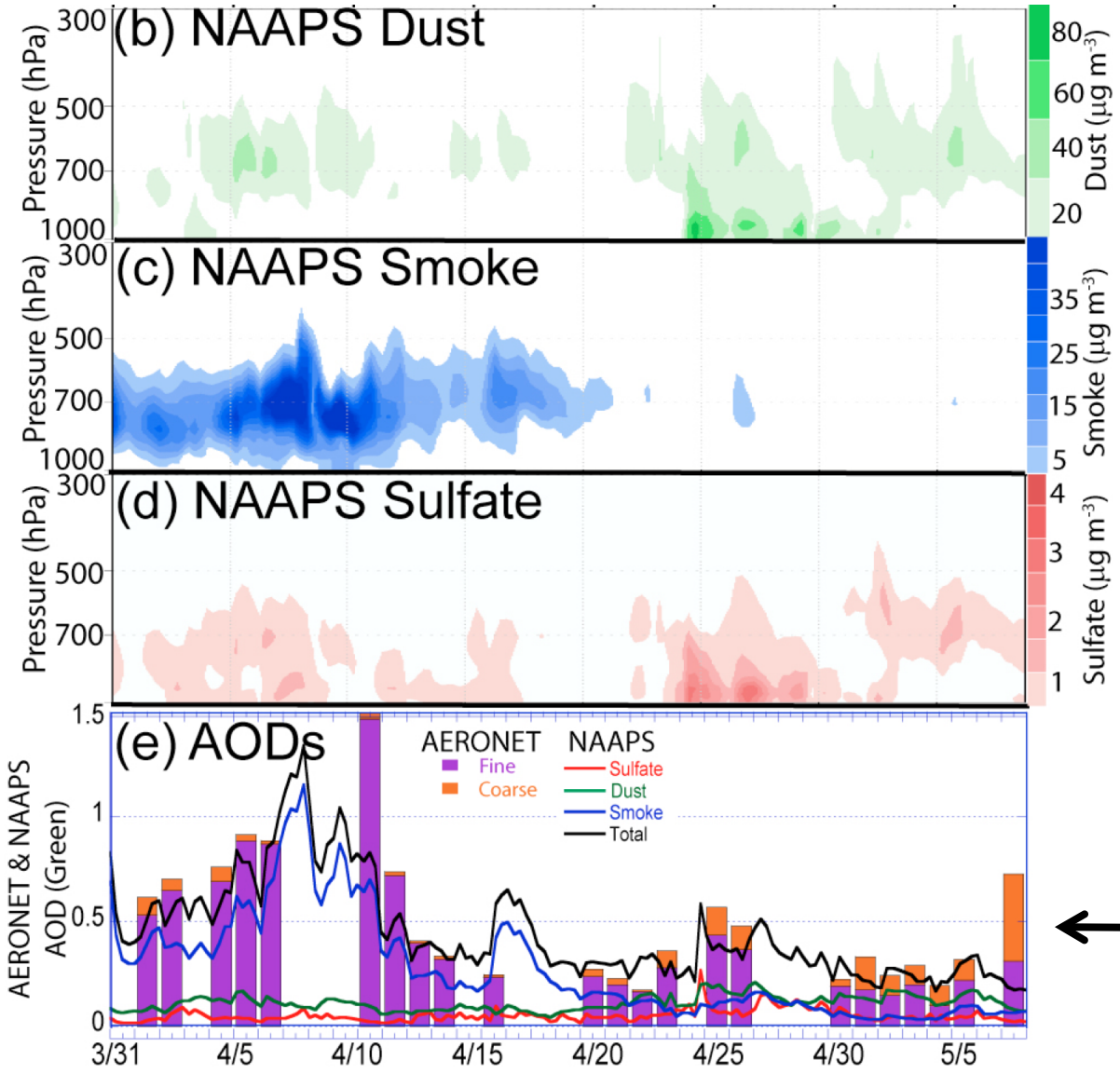
Aerosol vertical distributions



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

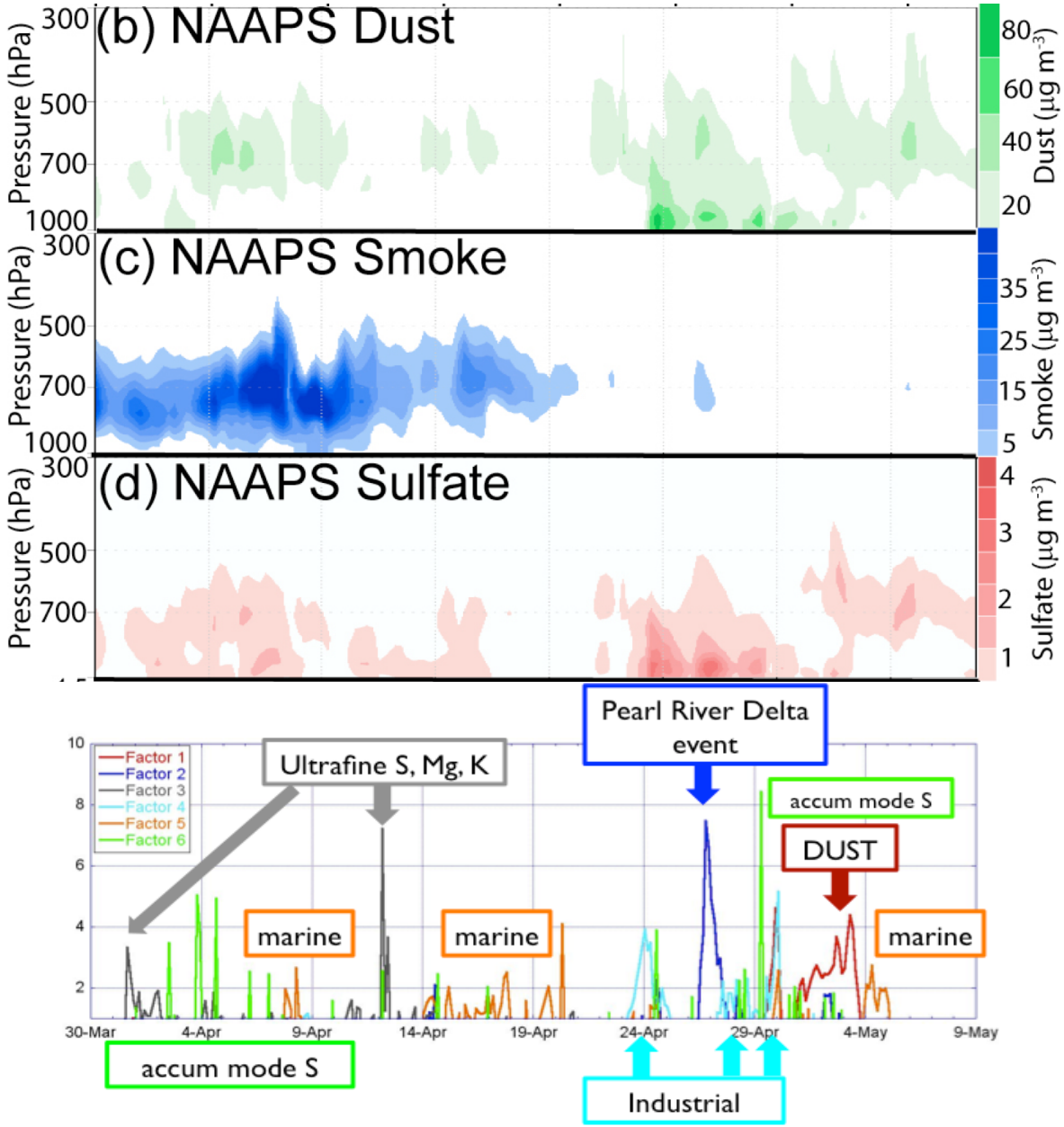
Aerosol vertical distributions



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