Size-resolved Characteristics of Particulate Elements in a Coastal Area: Source Identification, Influence of Wildfires, and Diurnal Variability

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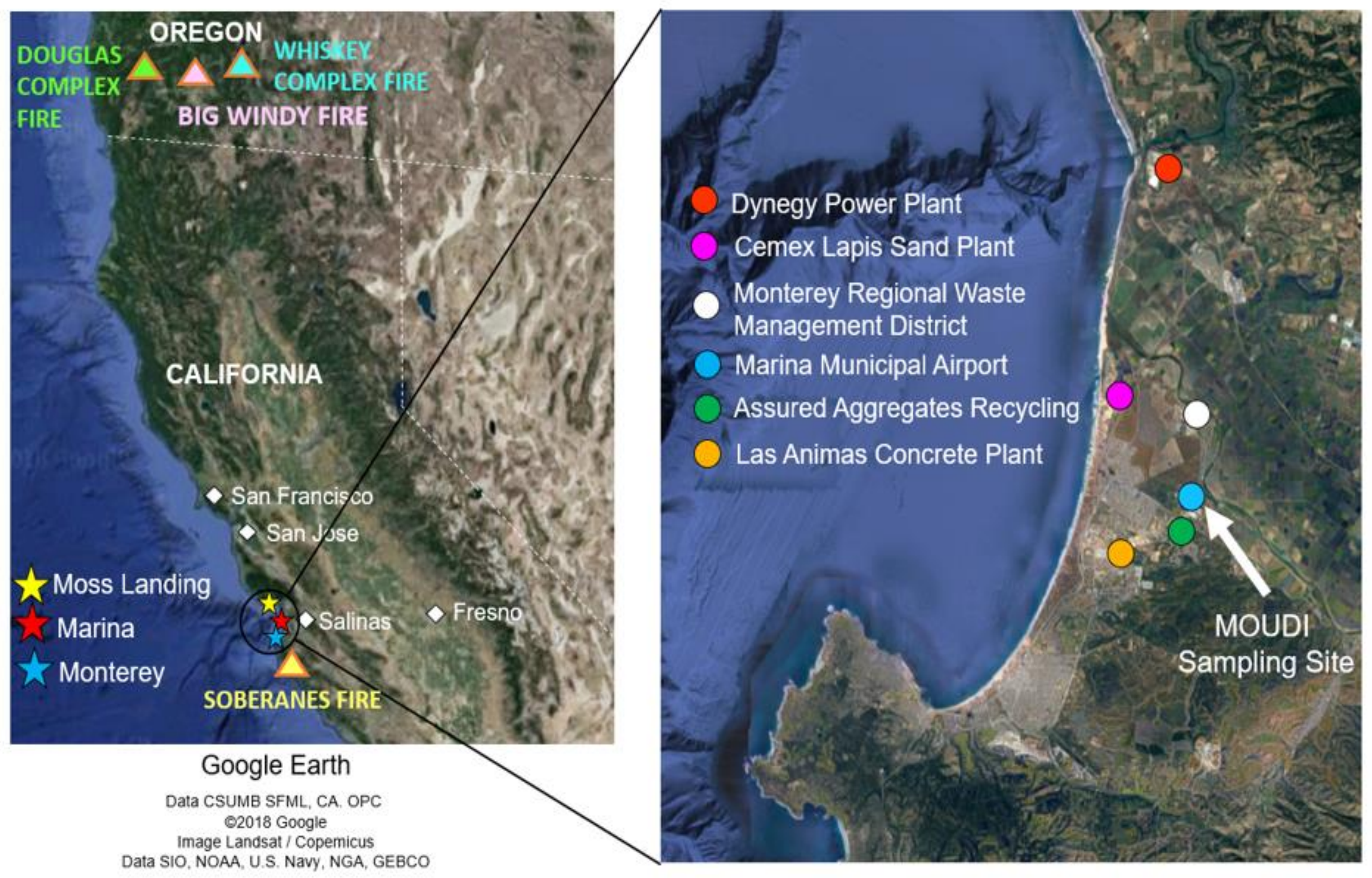
Introduction

Motivation for studying elemental composition:

- Negative impact on public health and potentially the environment
- Important agents in the biogeochemical cycling of nutrients
- Role in aqueous-phase reactions
- Tracer species to identify source of air masses



Objectives

Investigate size-resolved nature of water-soluble particulate elements in a California coastal environment

- Examine influence of two major wildfires in the Nucleation in California Experiment (NiCE) in 2013 and the Fog and Stratocumulus Evolution (FASE) campaign in 2016
- Compare night versus day periods with and without wildfire influence
- Identify sources of elements with a receptor model

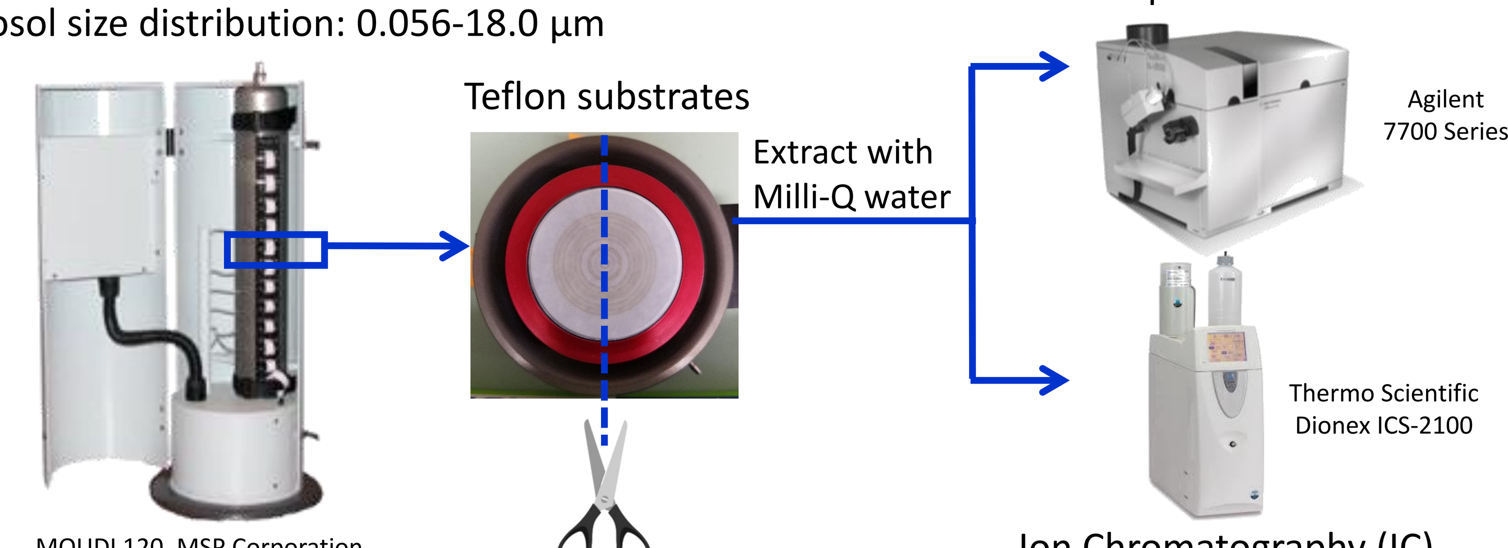
Experimental Methods

Micro-Orifice Uniform Deposit Impactor (MOUDI)

Aerosol size distribution: 0.056-18.0 µm

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Elemental composition: 29 elements



Ion Chromatography (IC)

Ionic composition: 6 ions

Positive Matrix Factorization (PMF) Model

- A receptor model (US EPA's PMF version 5) was used to identify emissions sources

PMF Model Results

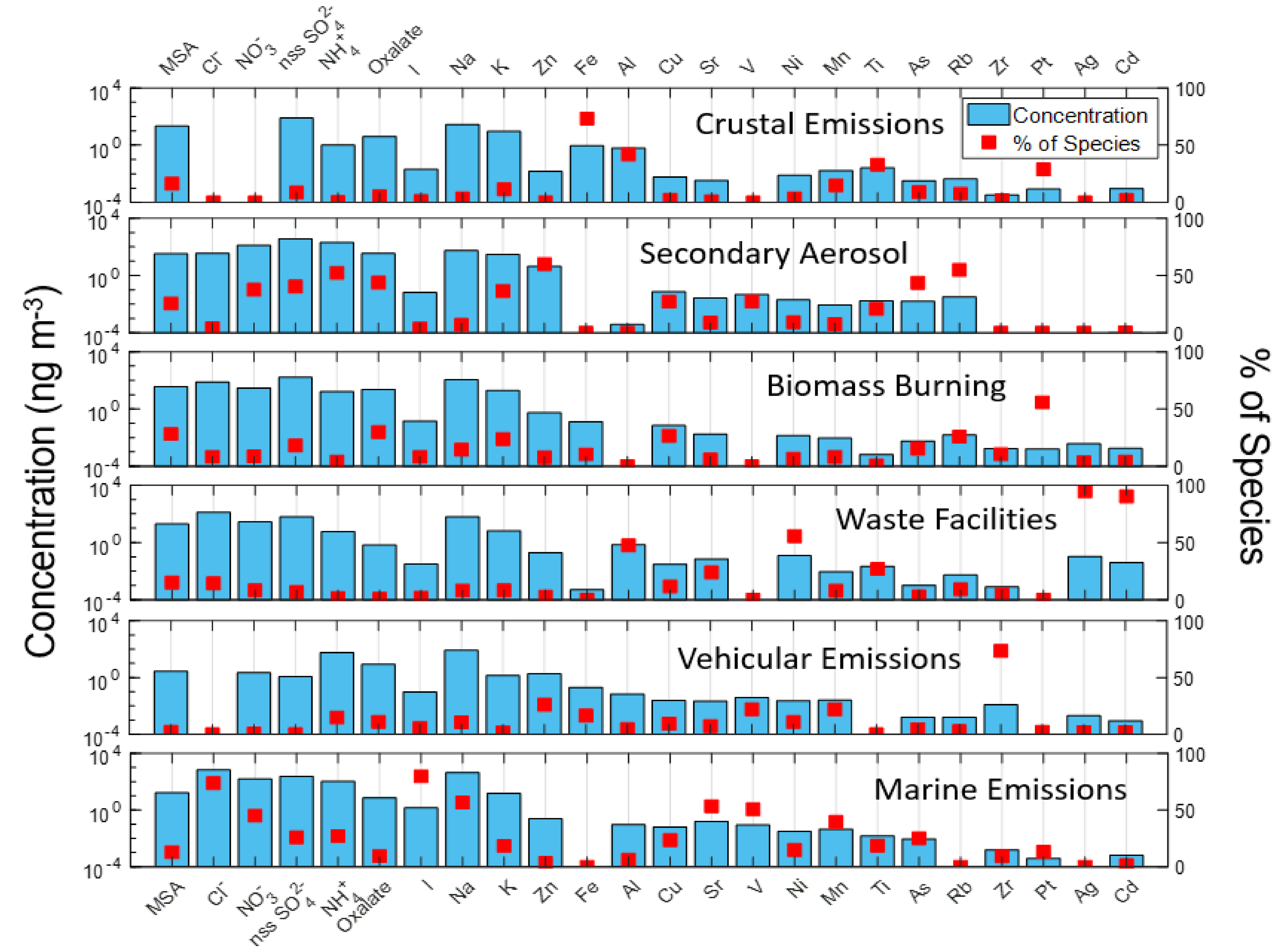


Figure 1. Summary of the six PMF source factor profiles using selected ions and elements measured during the NiCE and FASE campaigns. Blue bars represent mass concentrations and red squares represent the percentage of mass concentration contributed to constituents by each source factor.

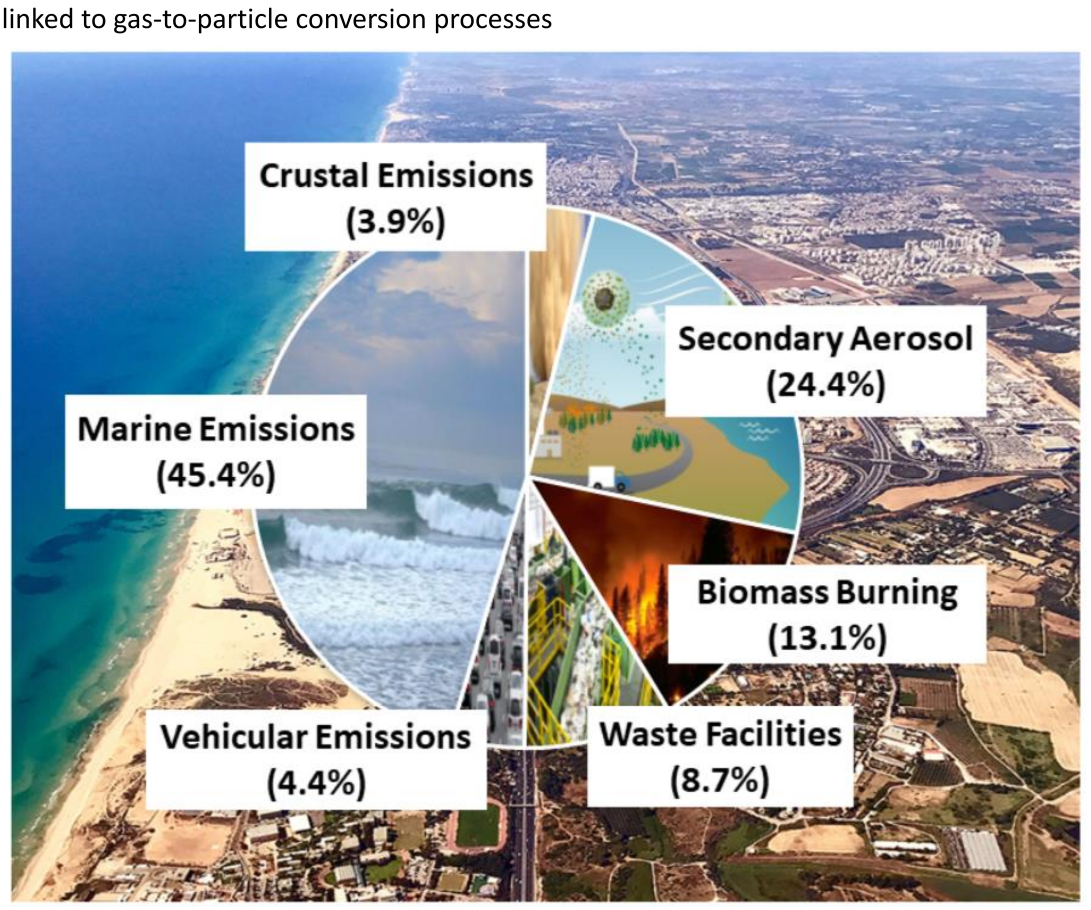
Characteristic elements from each factor:

- Crustal Emissions: Fe, Al, Ti, Pt
- Secondary Aerosol*: Zn, As, Rb, K, Cu, V
- Biomass Burning: Rb, K, Cu, Pt
- Waste Facilities: Ag, Cd, Ni, Al
- Vehicular Emissions: Zn, Zr, V, Mn
- Marine Emissions: Na, Sr, V, Mn

*= note: this is not a source; Elements enriched in Secondary Aerosol factor are likely co-emitted with NO_3^-, nss SO_4^{2-}, NH_4^+, oxalate, and MSA that are linked to gas-to-particle conversion processes

Mass concentration ratios of day versus night periods:

- Vehicular Emissions = 31.3
- Secondary Aerosol = 27.2
- Crustal Emissions = 20.0
- Marine Emissions = 1.0
- Waste Facilities = 0.7
- Biomass Burning = 0.1



Factors associated with higher particulate matter levels during the day compared to night:

- Vehicular Emissions
- Crustal Emissions
- Secondary Aerosol

- Species were enhanced during the day due to some combination of daytime anthropogenic activity, wind factors, and photochemistry

Mass Size Distributions

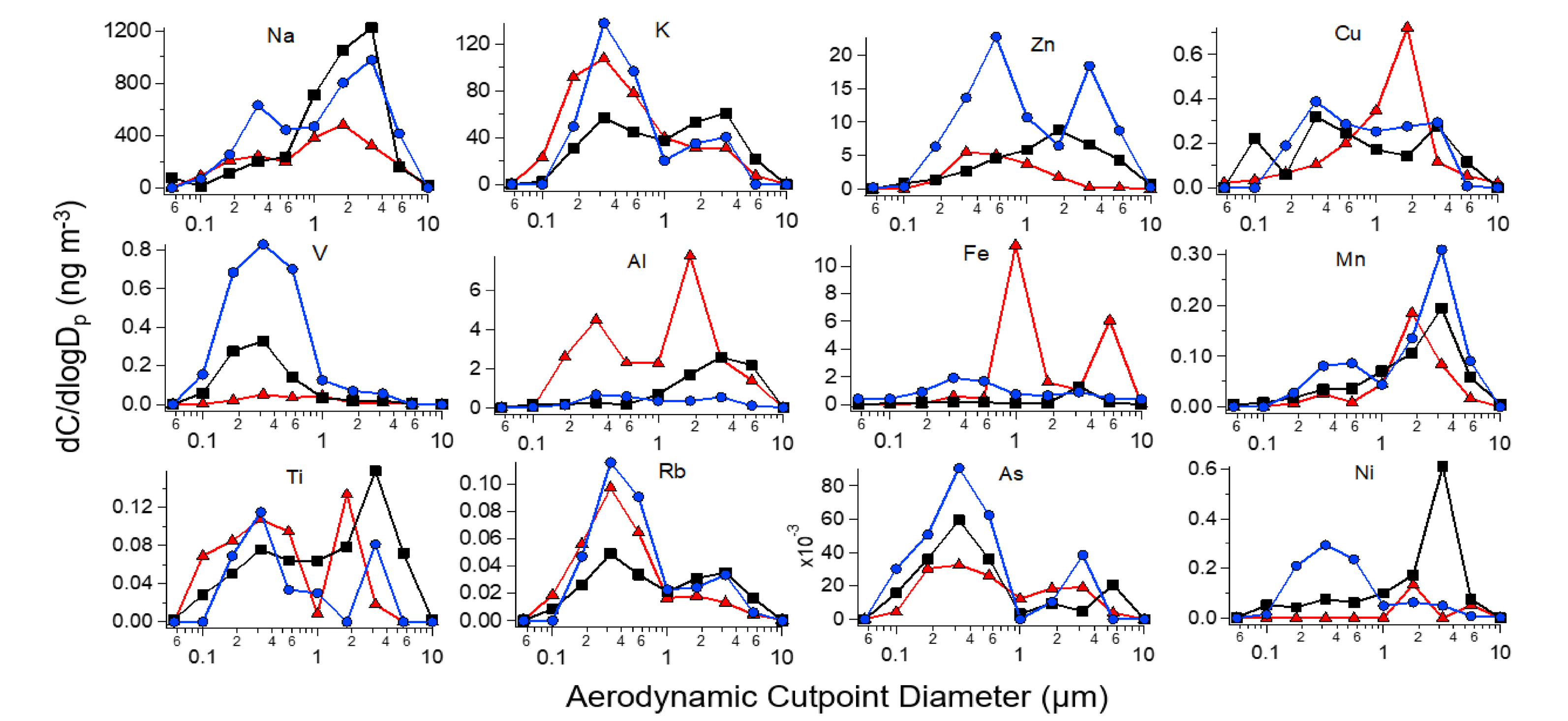


Figure 2. Mass size distributions of selected species from NiCE and FASE campaigns with and without wildfire influence. Black squares represent average non-fire conditions. Blue circles (red triangles) show measurements influenced by wildfire emissions during NiCE (FASE).

- Depending on fire, some species exhibited an enhanced concentration peak in the submicrometer mode, such as Na (0.32-0.56 µm) during NiCE and Rb (0.18-0.32 µm) during FASE
- This is presumably due to the differences in either the fire conditions (e.g., fuel type) or inclusion of other aerosol types, such as soil, with the fire plumes

Enrichment Factor

Crustal enrichment factor (EF) analysis was conducted for the elements included in the PMF analysis to determine the degree of influence from non-crustal sources to the concentrations of various elements

$$EF = \left[C_{n(PMF,crustal)}/C_{ref(PMF,crustal)}\right]/\left[C_{n(baseline)}/C_{ref(baseline)}\right]$$

- C_n represents the concentrations of element n and C_{ref} represents a reference species (Al) assumed to have minimal anthropogenic sources
- Values of EF > 10 generally indicate that there is a non-crustal source such as from various anthropogenic activities

EF > 10: Pt (23896.4) > I (9729.3) > Cd (264.7)> Na (136.3) > As (90.0) > Zn (51.1) > K (49.8) > Ni (10.9)

EF < 10: Cu (8.5) > Mn/Fe (2.5) > Rb (2.0) > Sr (1.1) > Ti (0.6) > Zr (0.2)> V/Ag (0.0)

Implication

Main area of focus for improving air quality and public health should center on mitigation of the impacts of wildfires, since crustal and marine are emitted from the natural environment of the study region

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