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Characterization of black carbon-containing particles from AMS measurements on the *R/V* Atlantis during CalNex 2010

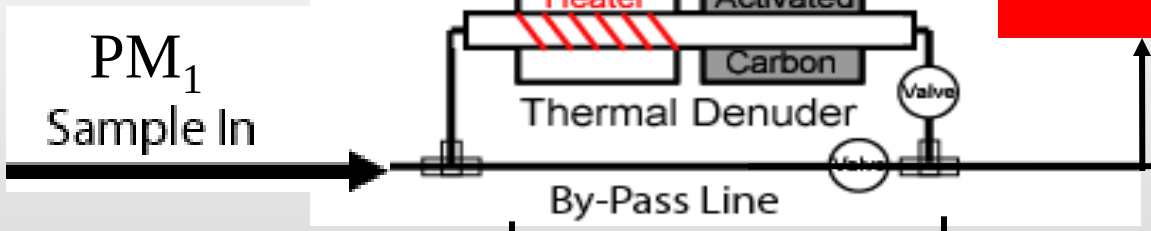
Paola Massoli [1], K. Hayden[2], I. Nuamaan [2,3], D. Sueper[4], S.M. Li[2], C. Cappa[5], J. Hakala[6], D. Worsnop[1], and Timothy Onasch[1]

[1]Aerodyne Research, Billerica, MA [2]Environment Canada, Toronto

[3]York University, Toronto [4]CU Boulder [5]UC Davis [6]University of Helsinki

R/V Atlantis on the Sacramento River
(photo taken from the DoE G1 plane)

Guest Van Layout CalNex 2010



SP-AMS (ARI)

SMPS (Env. CA)

SP2 (Env. CA)

VH-TDMA (U. Helsinki)

HR-AMS (Env.CA)

PAS/CRD (UC Davis)

Guest Van Measurement Objectives

a) Soot particle mass loading, chemical composition, size distributions (*SP-AMS*, *HR-AMS*, *SMPS*, *SP2*)

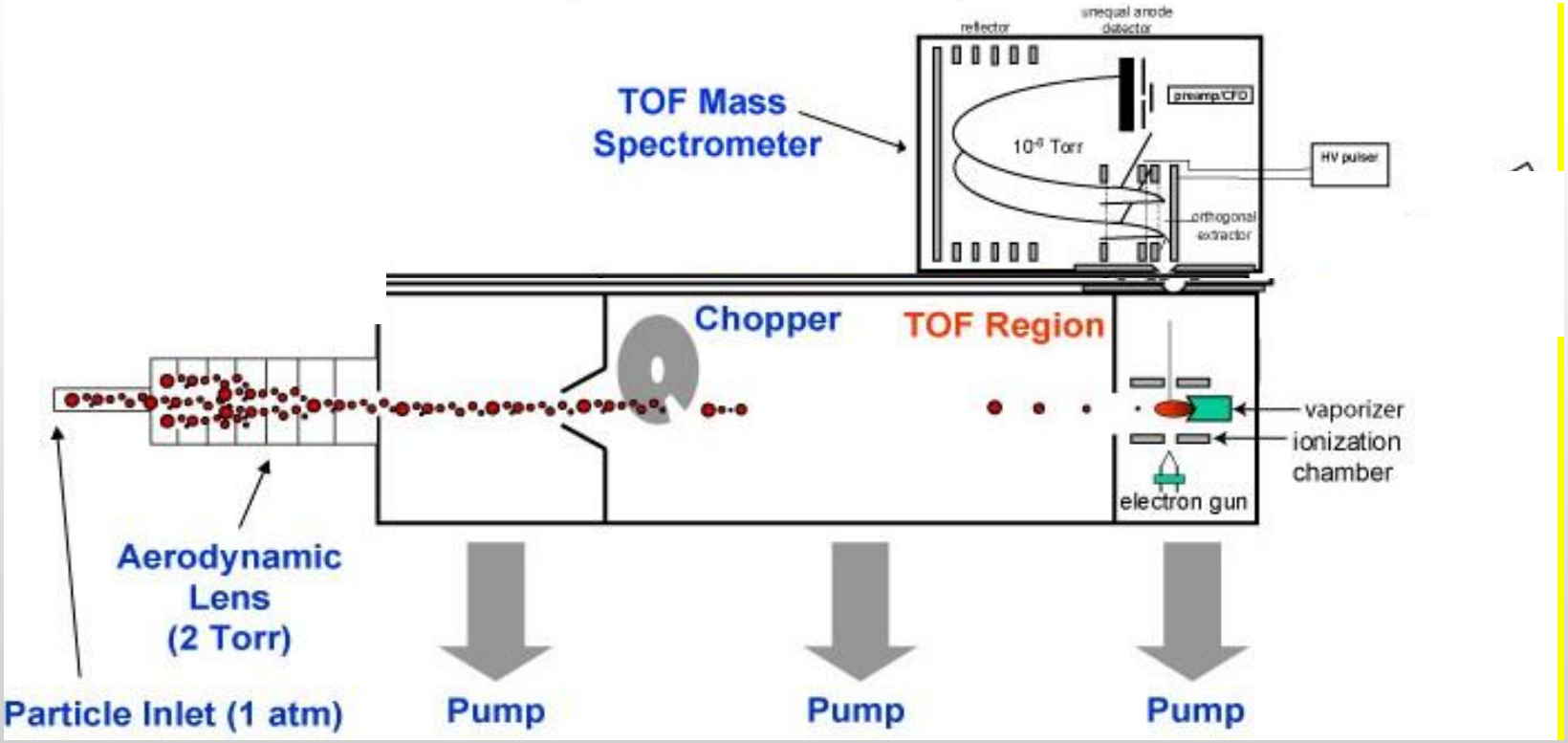
b) PM chemical composition and optical properties as a function of T (*TD-SP-AMS; TD-HR-AMS; TD-PAS*)

c) Hygroscopic growth factors (GF) as a function of particle size, volatility, and RH (*VH-TDMA*)

d) Particle optical properties: absorption, extinction, fRH (*PAS, CRD*)

- Combine chemical, microphysical, optical properties
- Source emission characterizations (e.g., shipping)

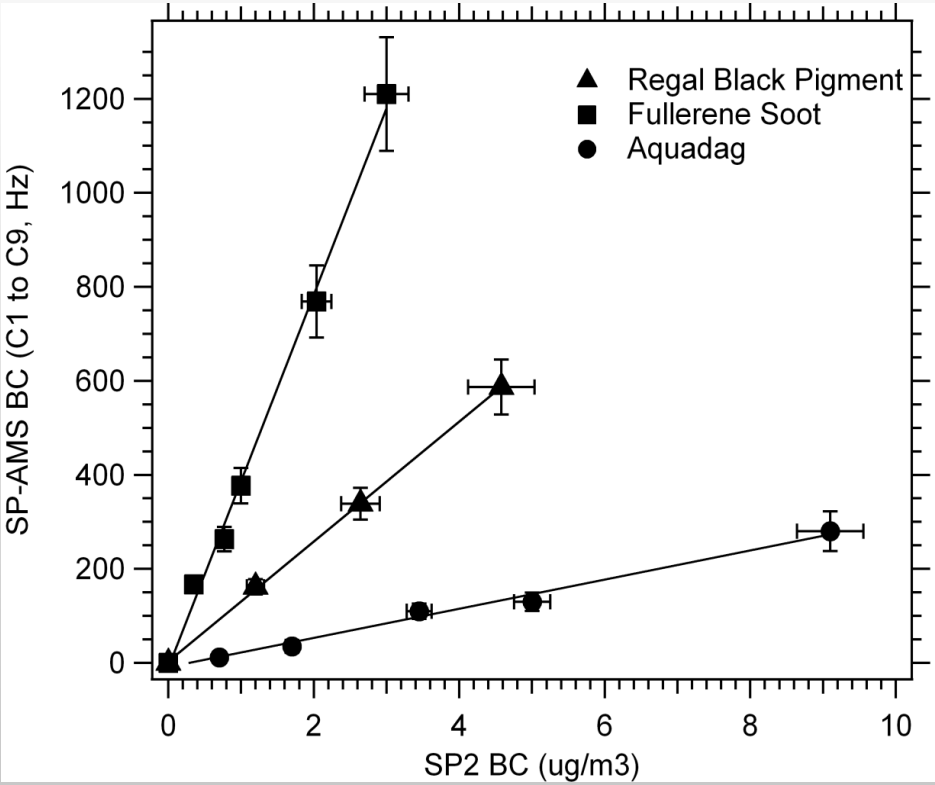
Soot Particle Aerosol Mass Spectrometer (SP-AMS)



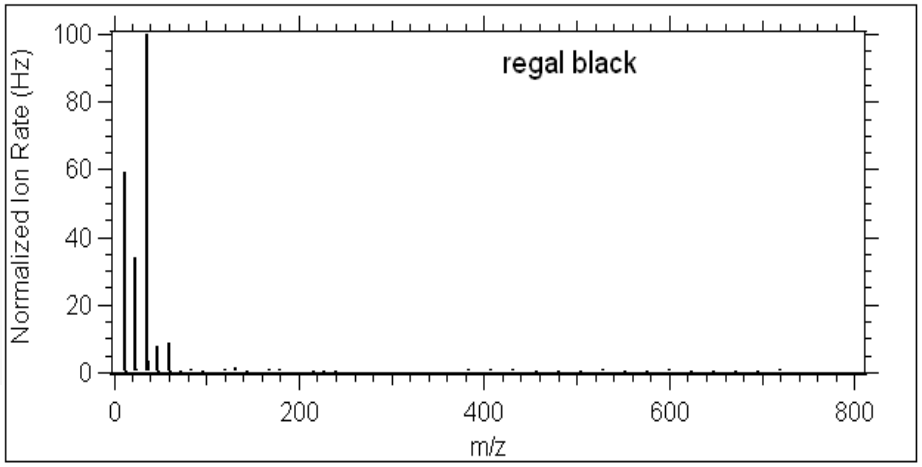
- Detect submicron refractory material (black carbon) under SP2-like incandescence conditions
- Measure the chemical composition of the non-refractory coating material (e.g. organics, sulfate, nitrate)

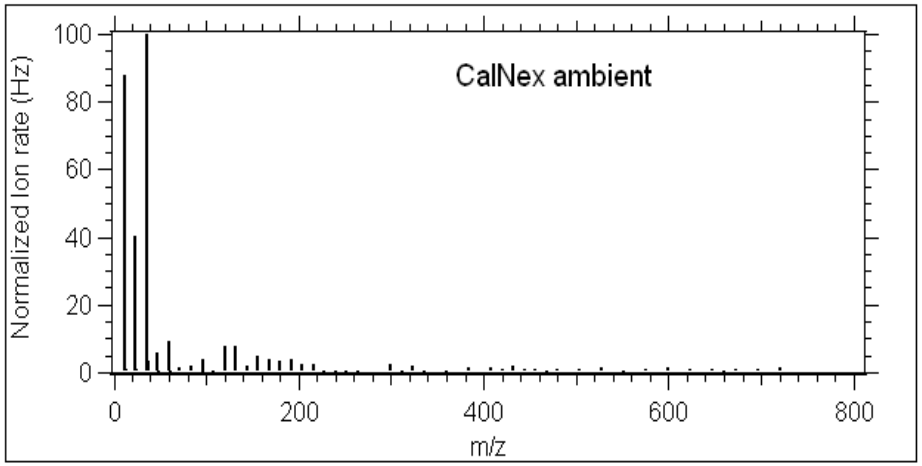
BC Quantification

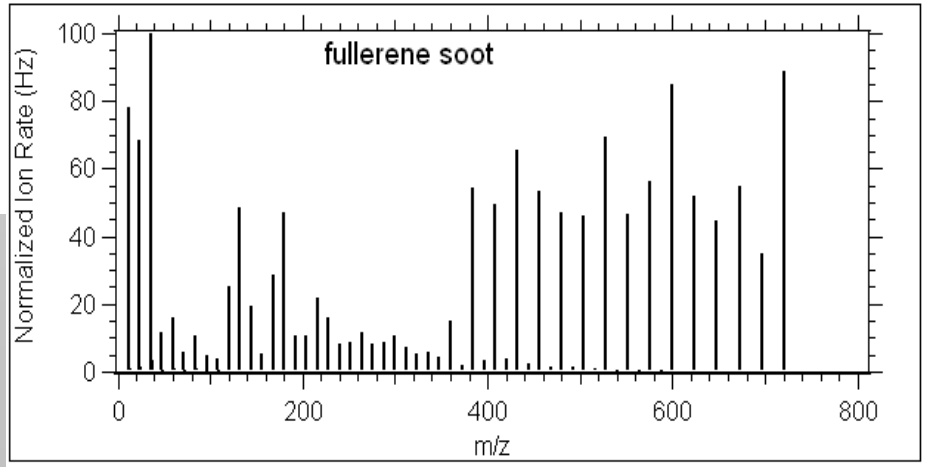
SP-AMS vs SP2 for different BC standards

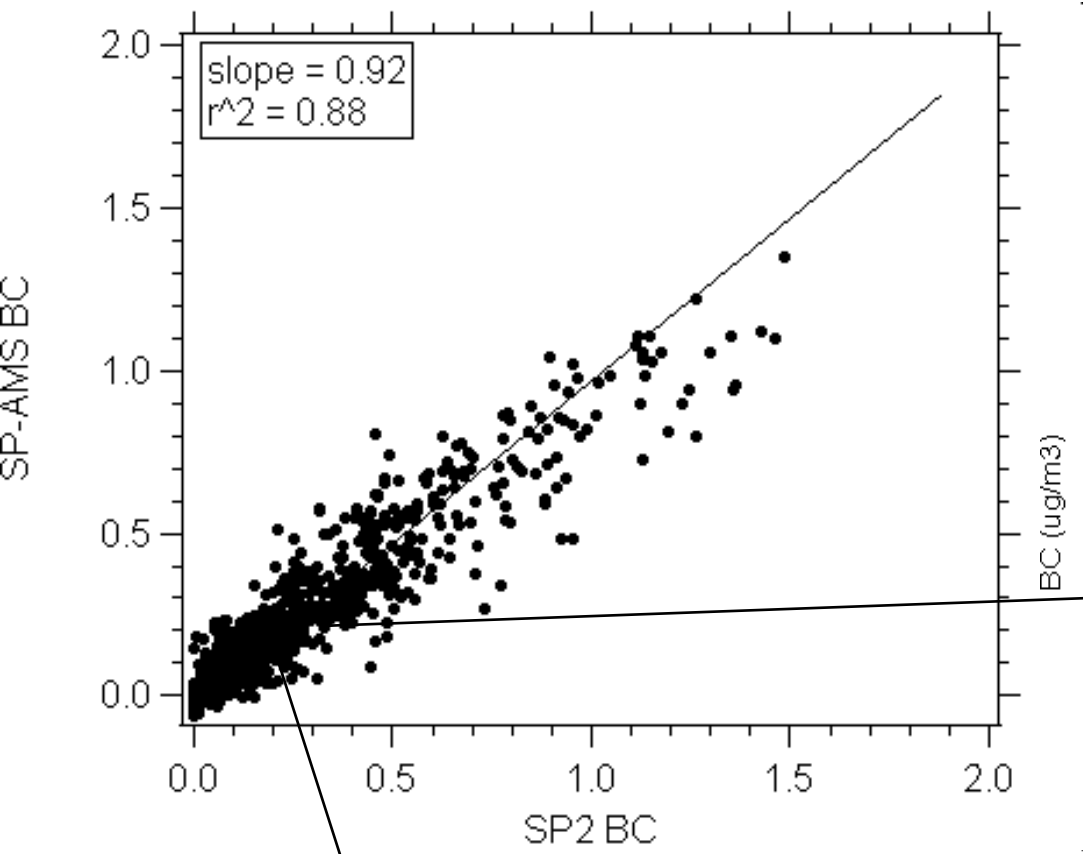


Regal Black represents well ambient BC during CalNex 2010

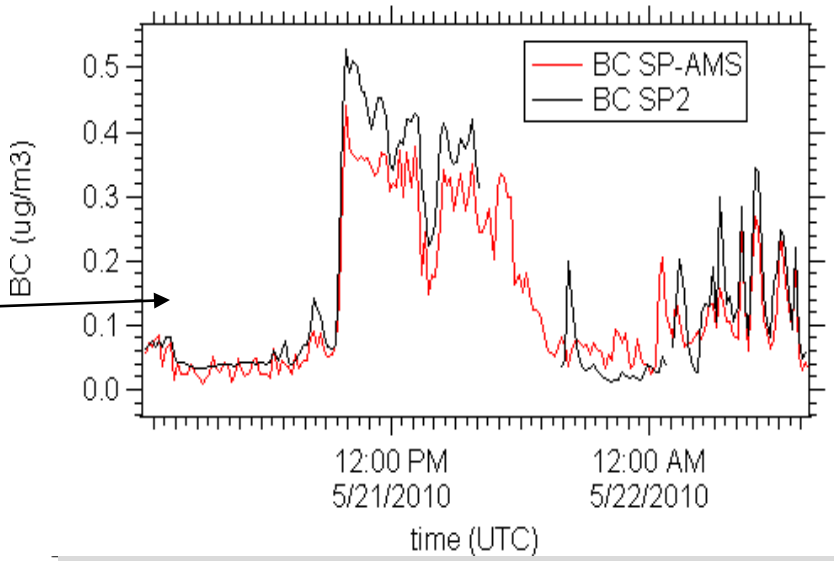


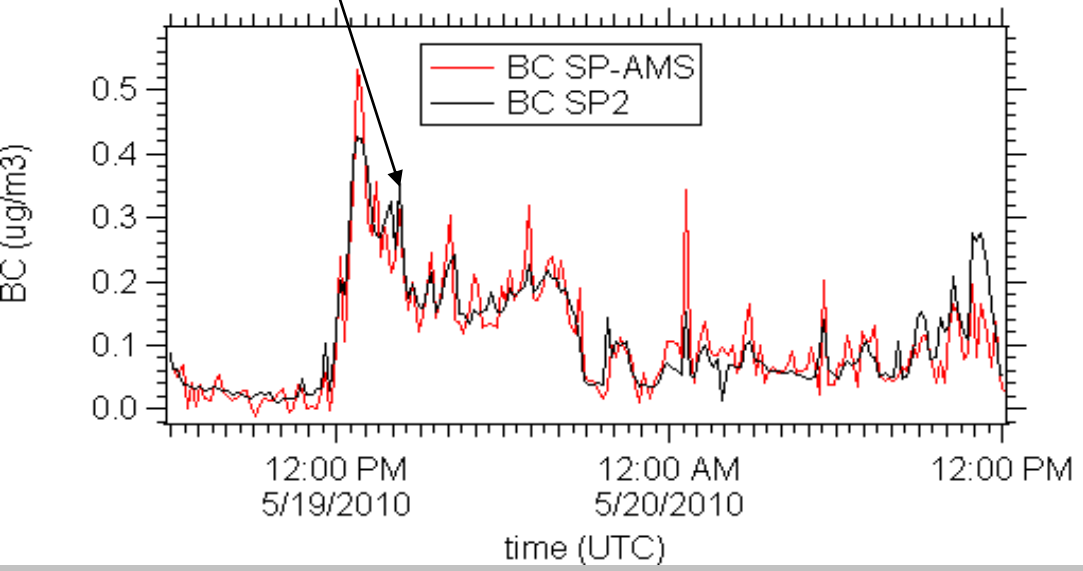






10 min average
ship plumes removed

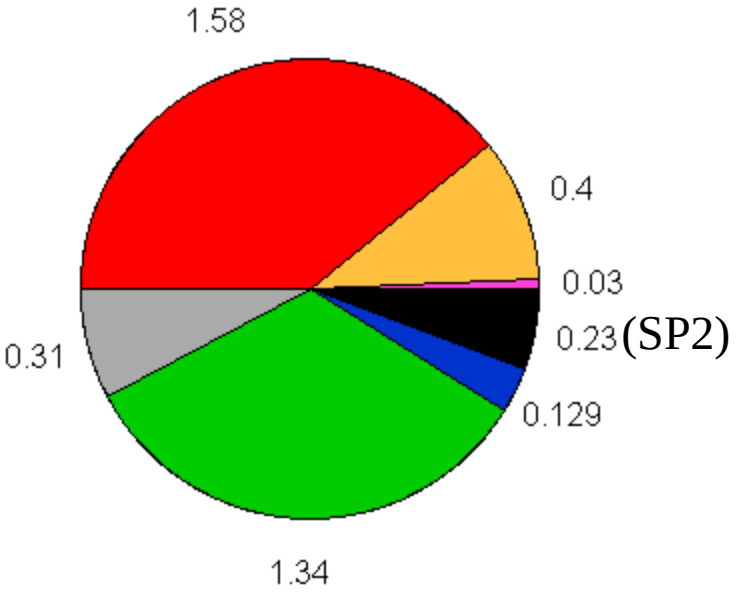




Disagreement most
likely related to BC shape
(need to look at coating & size
information from SP2)

CalNex 2010 Campaign Overview

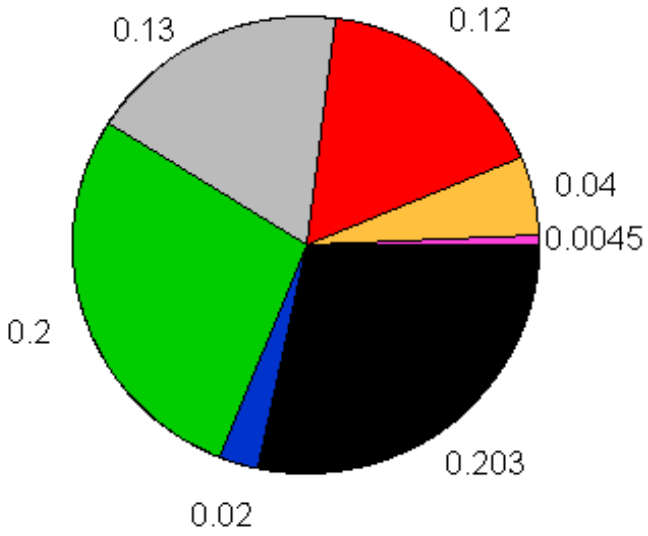
HR-AMS (4 ± 2 ug/m3)



BC
SO4
NO3
NH4
Chl

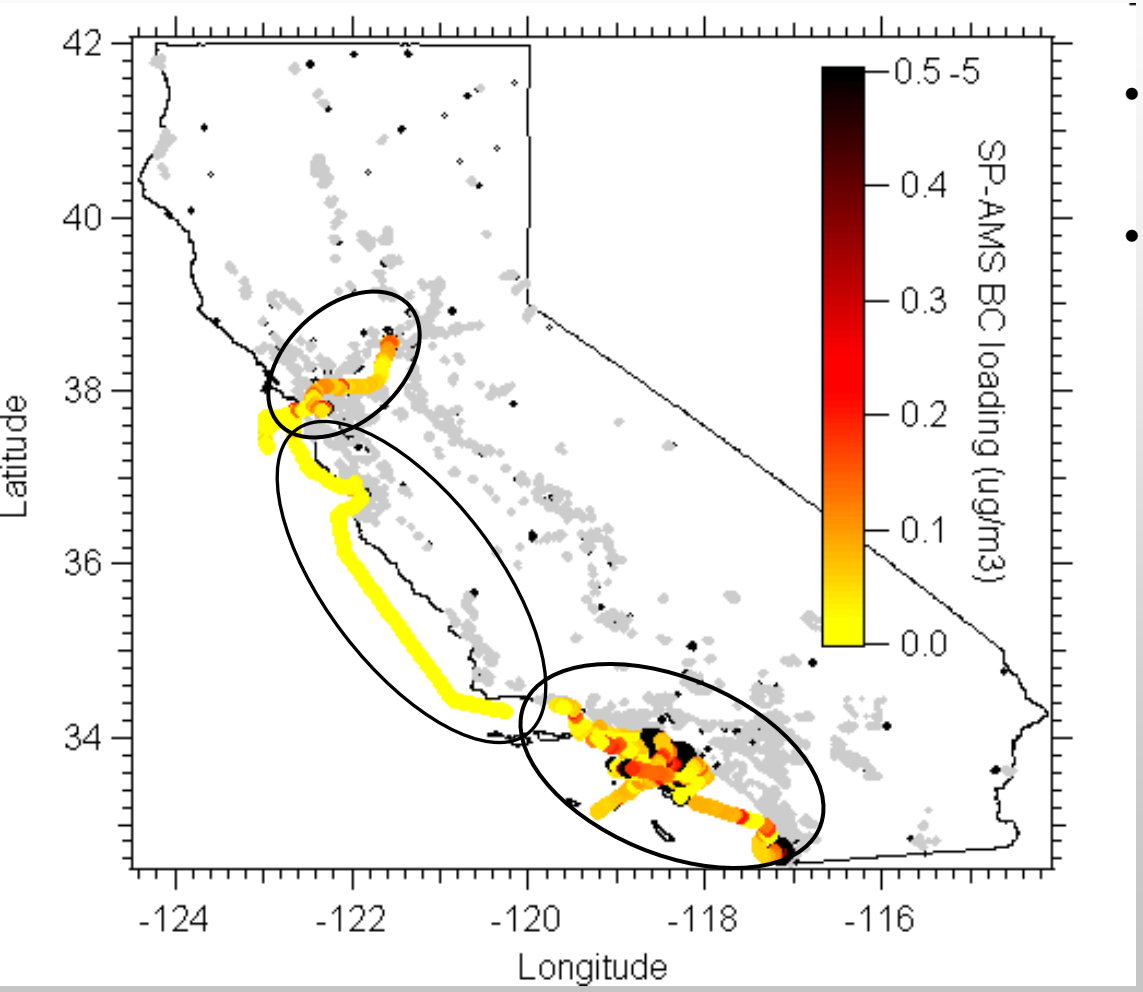
HOA
OOA

SP-AMS (0.8 ± 0.5 ug/m3)



-NR PM1 associated with BC particles is ~ 20 %
(lower limit – more calibrations on the way)
-The fraction of SO4 associated with BC is significantly lower than the fraction of organics associated with BC

Air Mass Classification based on BC loading & location



LA Basin

- Up to 4 ug/m3 BC near shore (LA Port, Long Beach)
- Up to 1 ug/m3 BC off-shore air (Santa Monica bight)

Marine

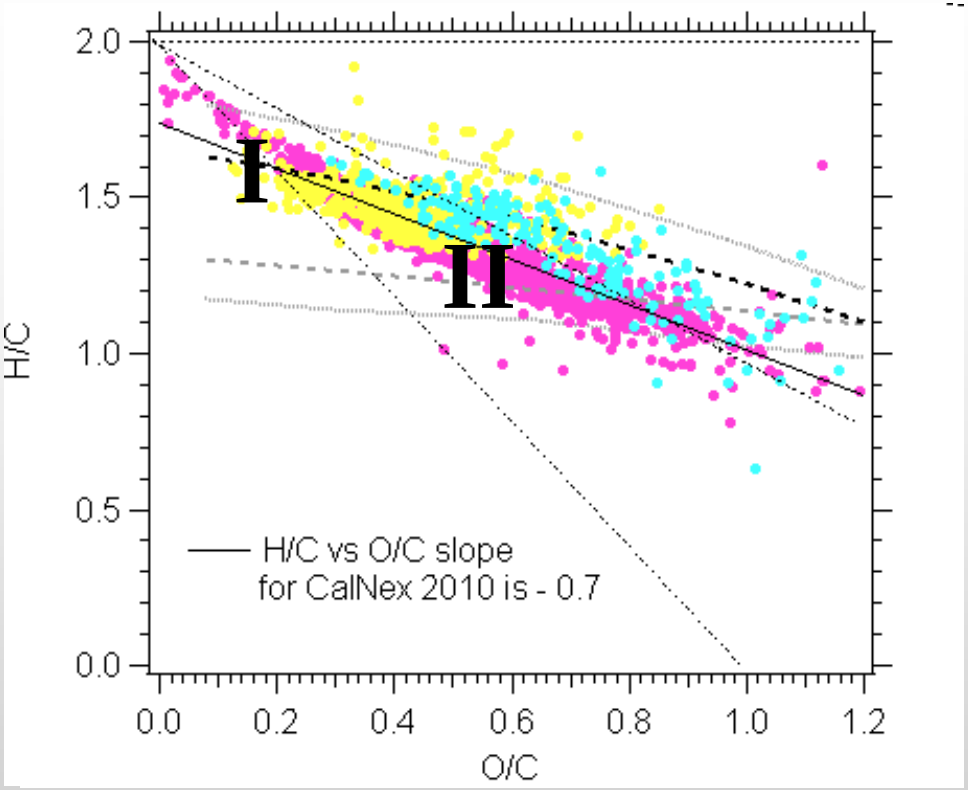
< 0.1 ug/m3 BC
(clean marine and/or very old polluted air)

Northern California

- 0.1- 0.25 ug/m3 BC

(SF Bay, San Pablo Bay, & Sacramento river)

Aerosol Aging Frameworks (HR-AMS)



Aging moves the aerosol towards lower H/C & higher O/C values
[Ng et al., ACPD, 2011]

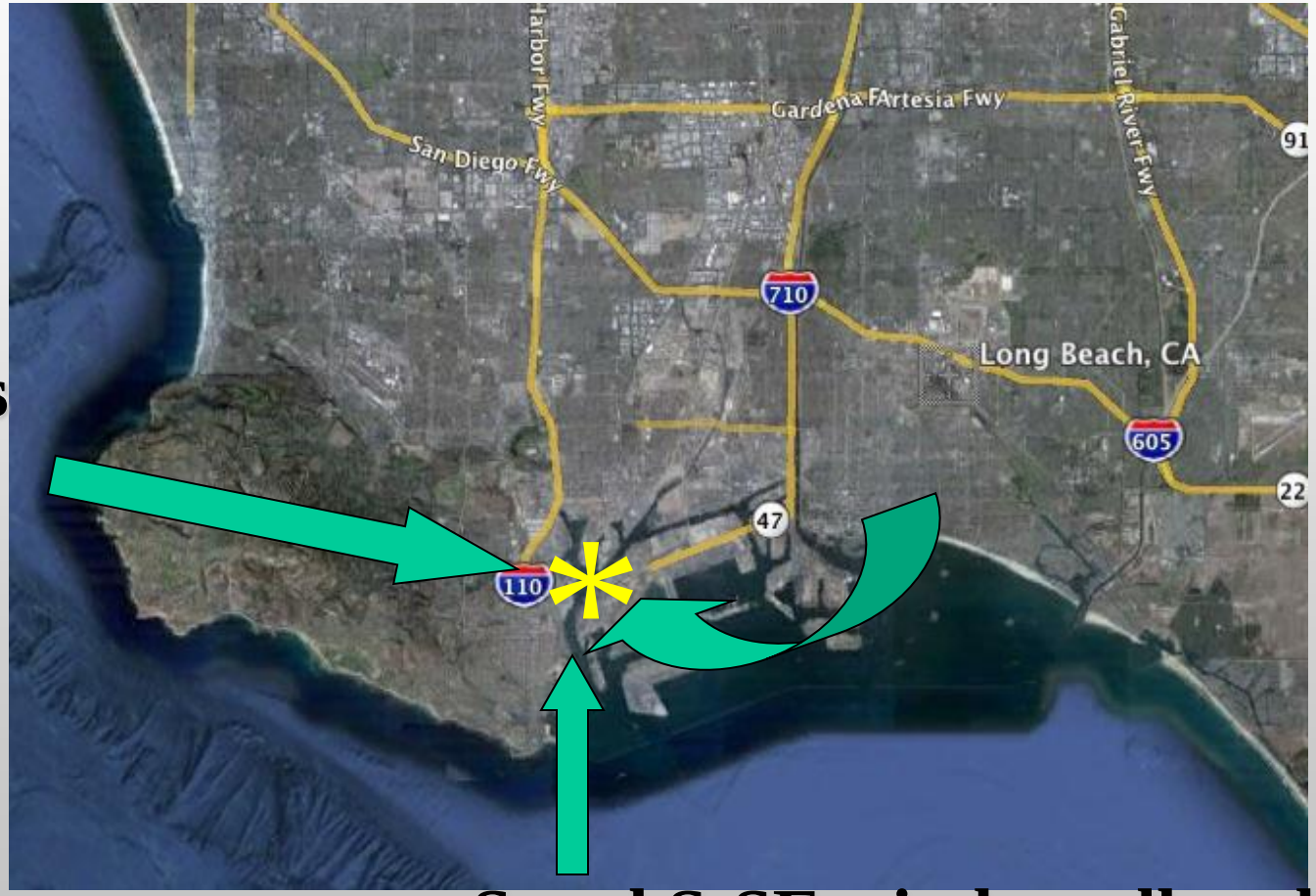
LA Basin = aerosol ranging from fresh to aged
Clean Marine = moderately to aged aerosol
Northern California = moderately aged aerosol

PM_1 composition and size distribution, LA basin

I) LA Port emissions / Long Beach outflow

(May 26, 0500 UTC to May 27, 1900 UTC)

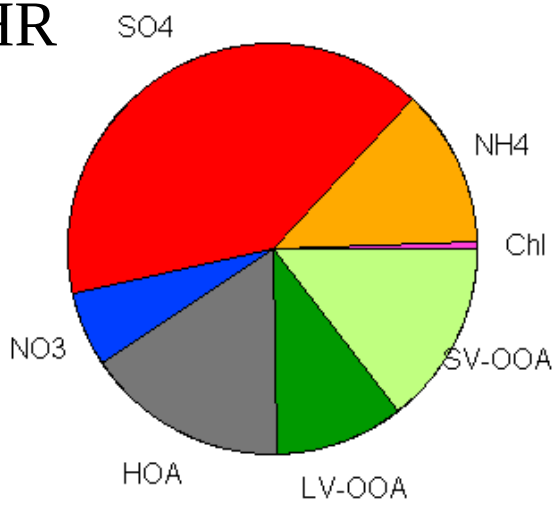
NW winds clean air



S and S-SE winds, polluted air (port and port/urban)

I) May 27 0700–1030 UTC, LA Port + Long Beach (SE)
(O/C = 0.2; H/C = 1.6)

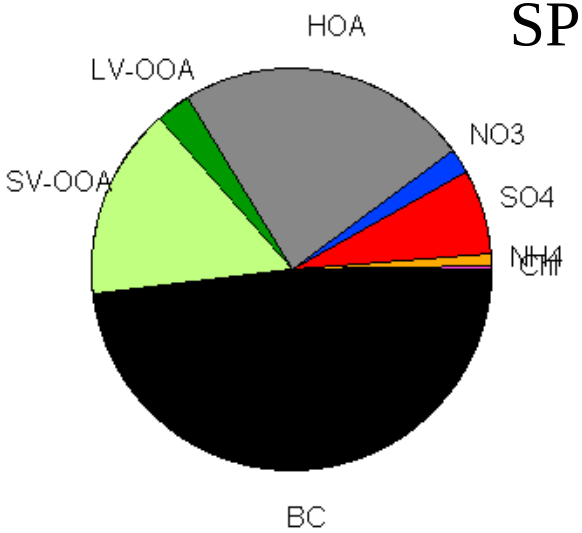
HR

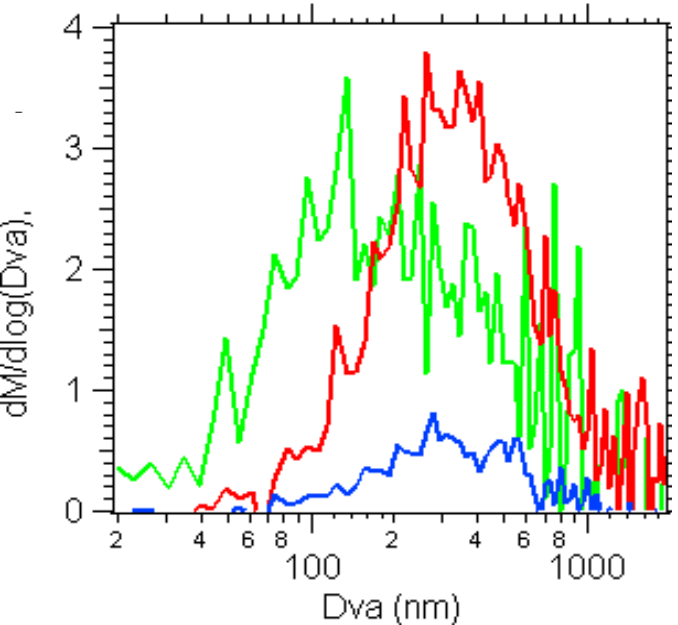


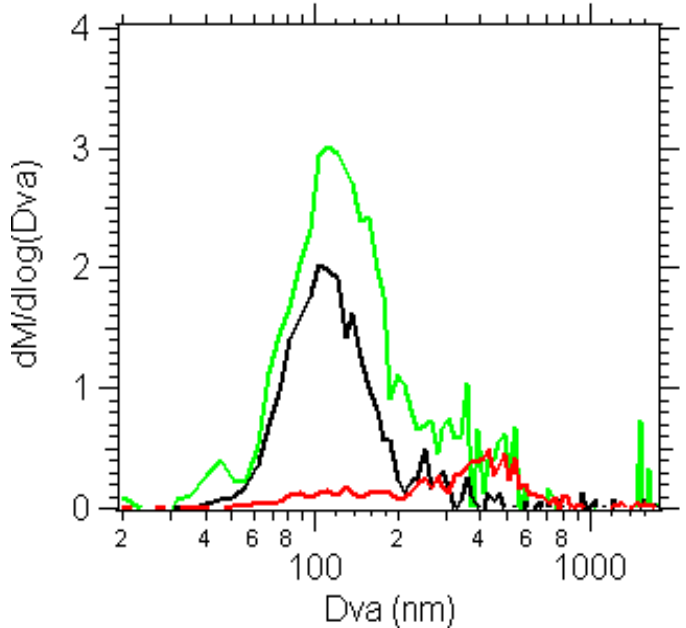
26 % of ORG
4 % of SO4
associated w/ BC

HOA and SV-OOA
dominate ORG

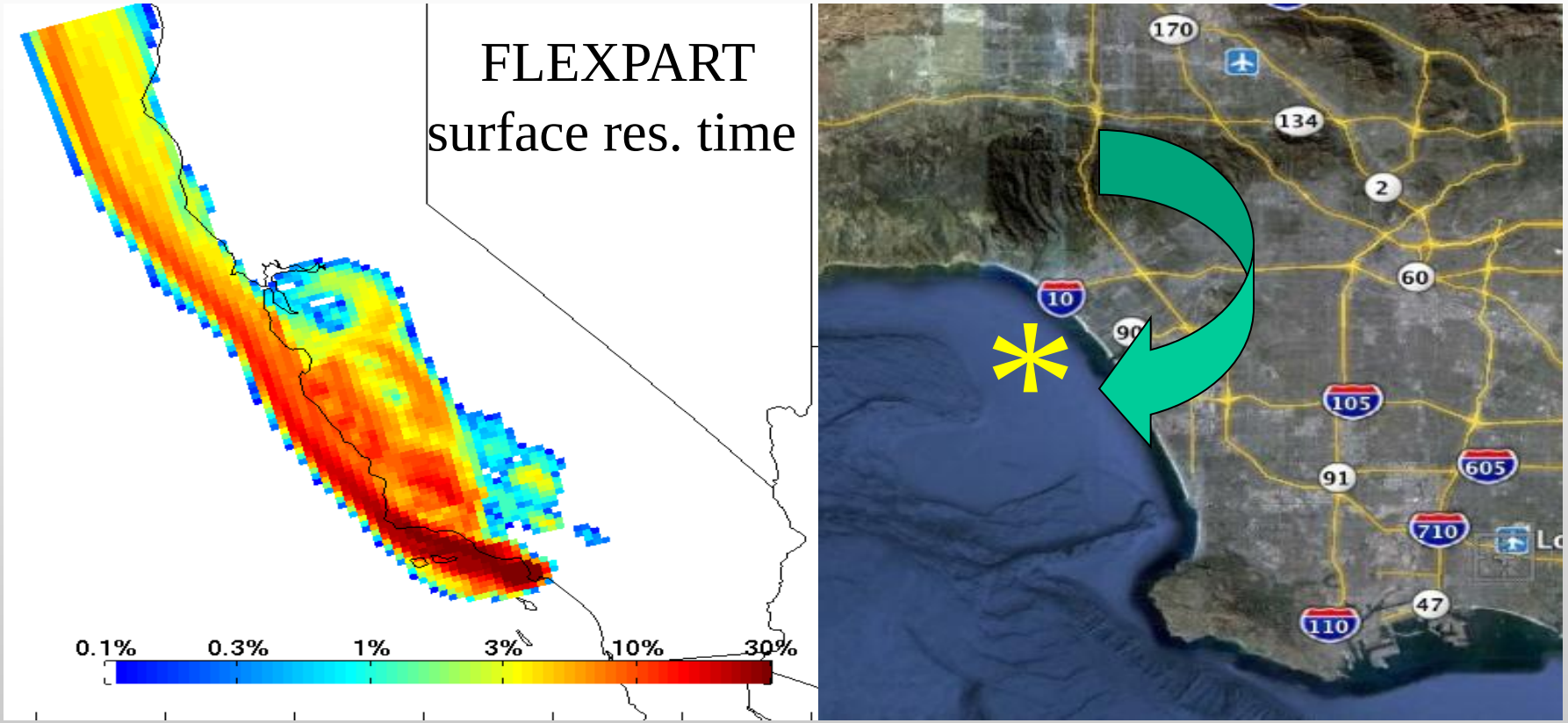
SP







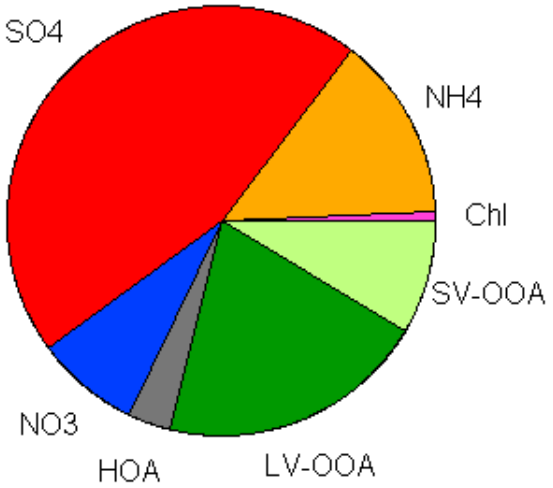
II) Santa Monica Bay May 16, 0900 -1400 UTC (variable winds, mainly NE)



Coastal outflow event driven by land breeze to Santa Monica bay and Los Angeles bight (one of many events)

II) Santa Monica Bay (O/C = 0.55; H/C = 1.28)

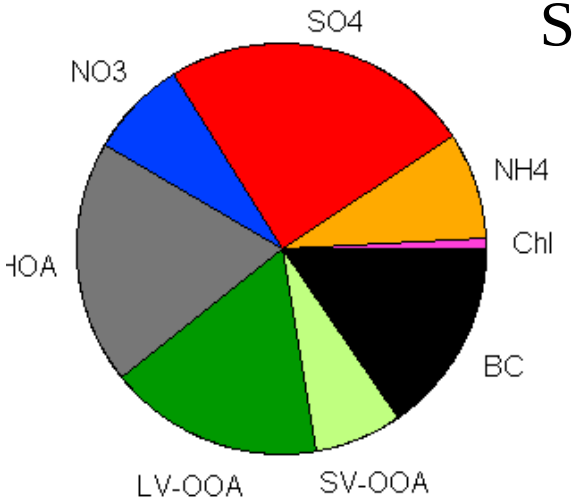
HR

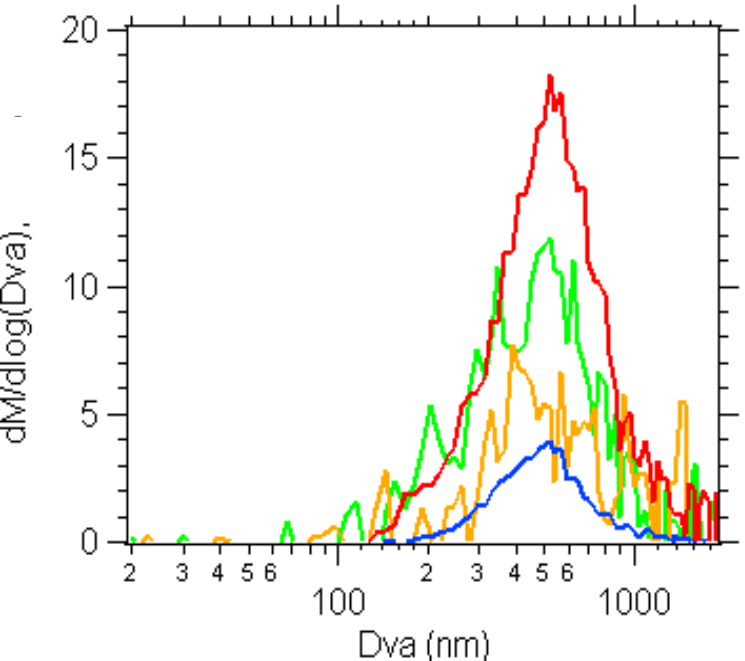


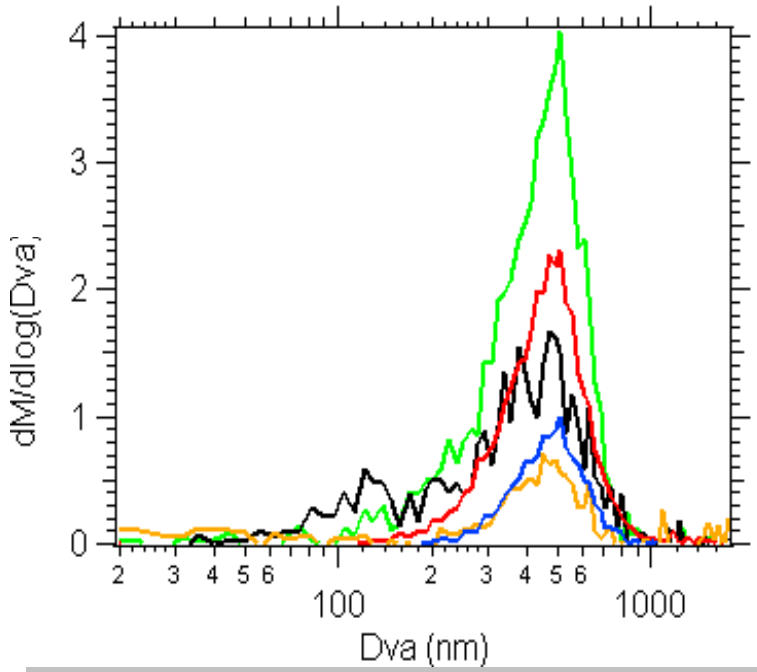
12 % of ORG
9 % of SO4
25 % of NO3
associated w/ BC

LVOOA > SV-OOA

SP

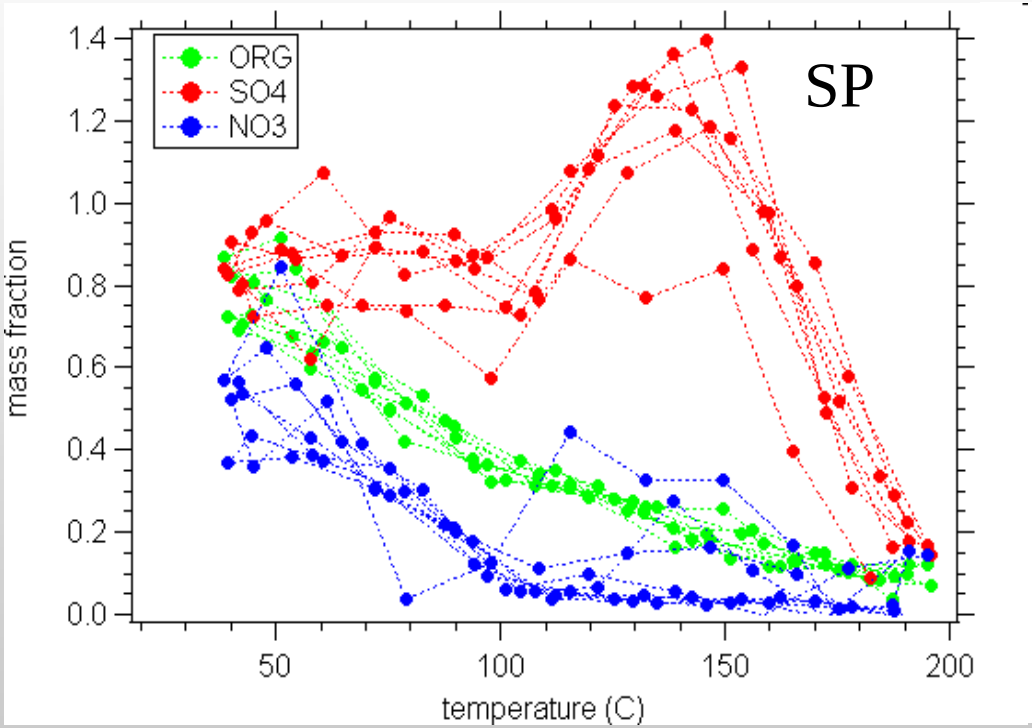


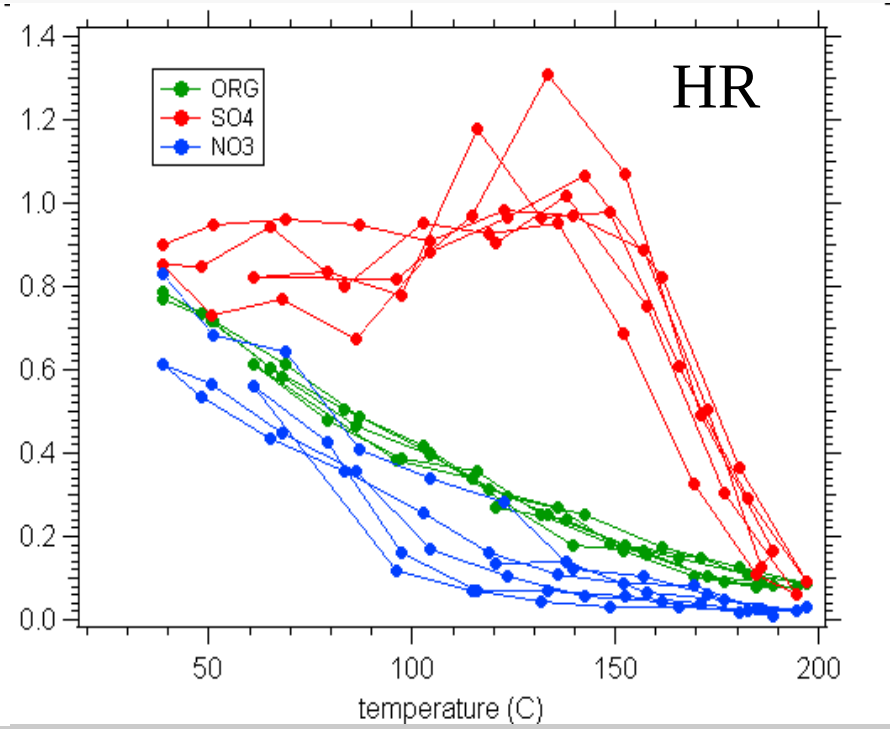




Particle Volatility

Quantify coating material removed as function of temperature
(volatile PM comes off first)

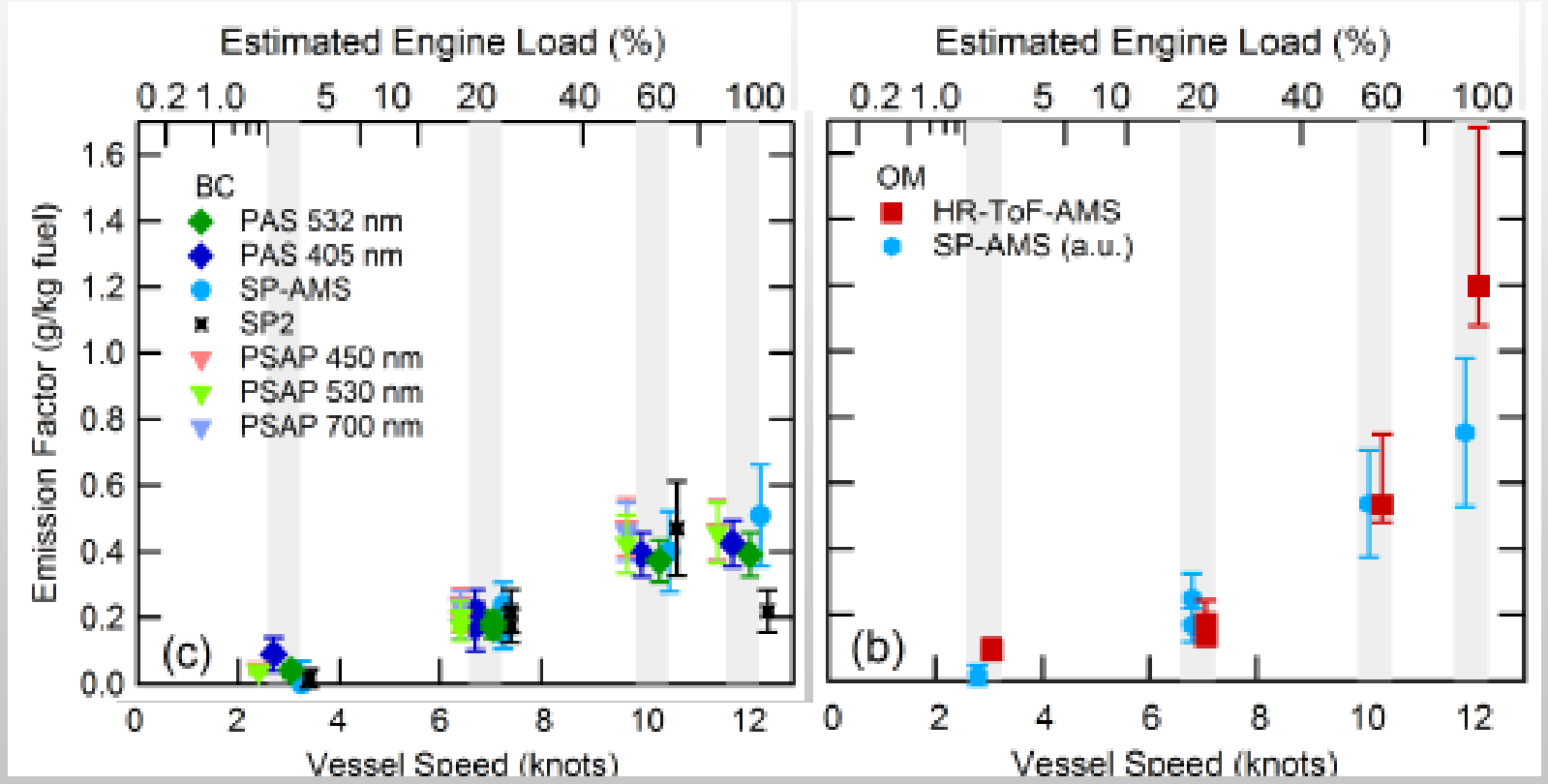




-ORG, NO3 are volatile; SO4 becomes volatile at T > 150 C
- Thermal denuded information useful for optical properties
(optical absorption enhancement)

R/V Miller Freeman "experiment"

"The influence of operating speed on gas and particle-phase shipping emissions: results from the R/V Miller Freeman"
C. D. Cappa et al., ES&T, submitted, 2011



EF from SP-AMS are in good agreement with other EF estimates

Conclusions and future work

- We characterized a variety of air masses downwind port sources and urban areas along coastal California.

- The combination of SP2, HR-AMS and SP-AMS offered a unique opportunity to characterize refractory and non refractory PM during

- Our preliminary result indicate that ~20% of the PM1 measured by ToF AMS (15% organics, 5% inorganics) was associated with BC during CalNex 2010. Numbers highly variable upon source type & location

- More exciting work left to do as we fully explore and combine the Guest Van instruments (credit to Tim Onasch)

Acknowledgements

- Edward Fortner (ARI) - laboratory SP-AMS calibrations
  Manjula Canagaratna (ARI) - PMF analysis
  John Jayne (ARI) - thermal denuder

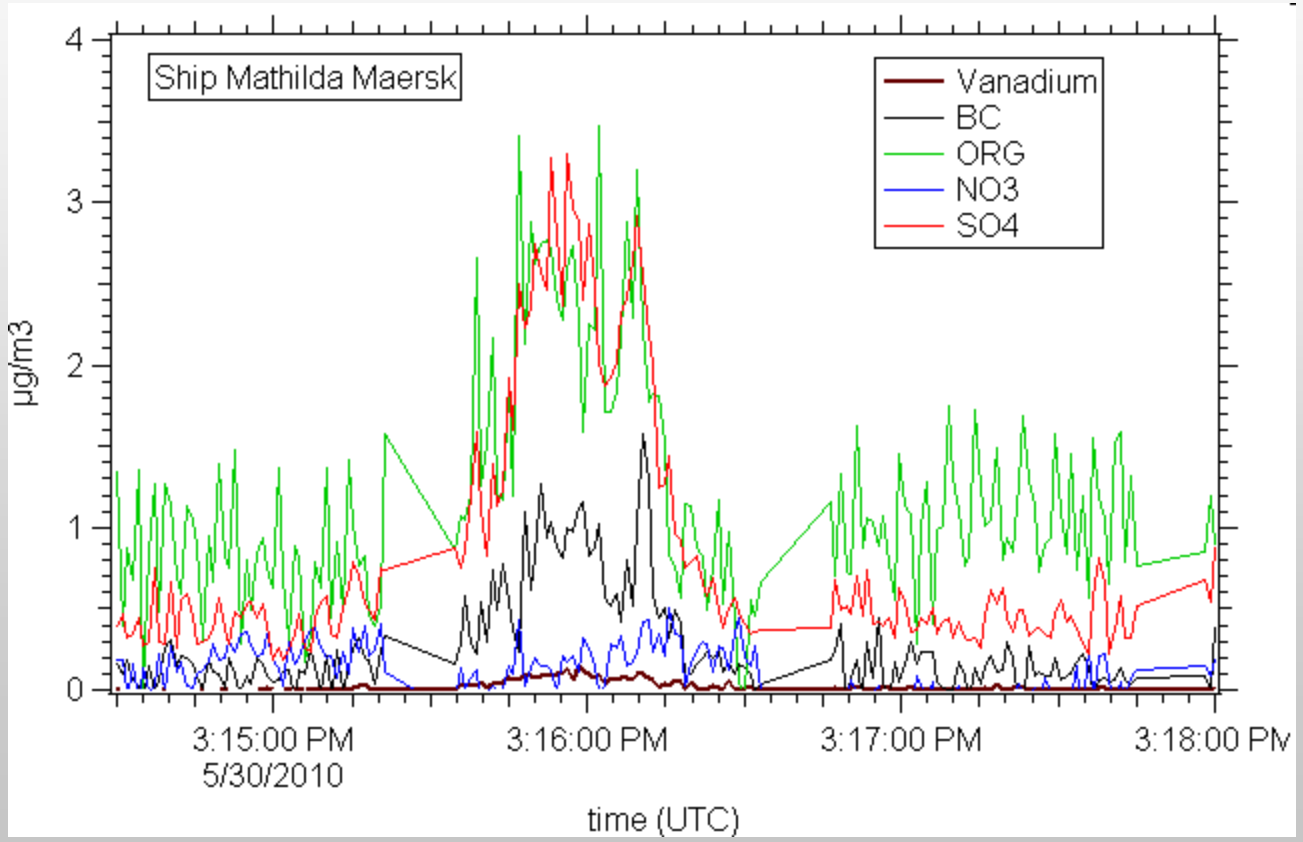
- NOAA PMEL (Tim Bates, Trish Quinn, Derek Coffman, Jim Johnson and Drew Hamilton)

- WHOI *R/V* Atlantis crew

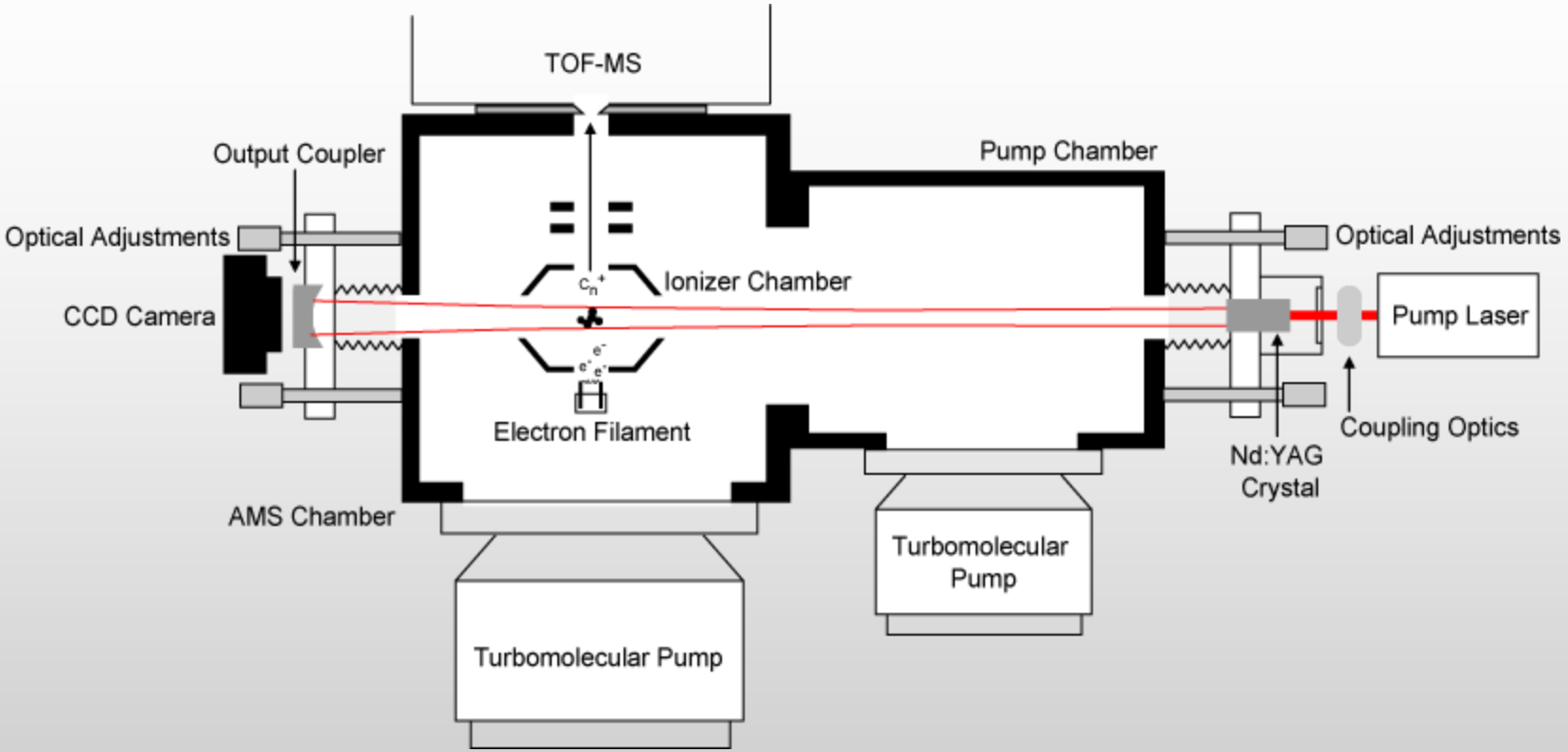
- NOAA Global Climate Change Program ($$$$$)
  contract # NA09AR4310125

Extra Slides

Heavy Metals in Shipping Emissions



Schematic of the SP module



- ✓ Vaporization via intra-cavity pump laser (λ = 1064 nm, 5-20 μsec)
  Coatings evaporate first (<600 C). Core evaporates last (>1000 C)
- ✓ Ionization of vapour (core + coatings) by electron impact (EI)
- ✓ Detection (core + coatings) with Time-of-Flight mass spectrometry