Aerosol Chemistry
during TexAQS II / GoMACCS 2006

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http://saga.pmel.noaa.gov/data/

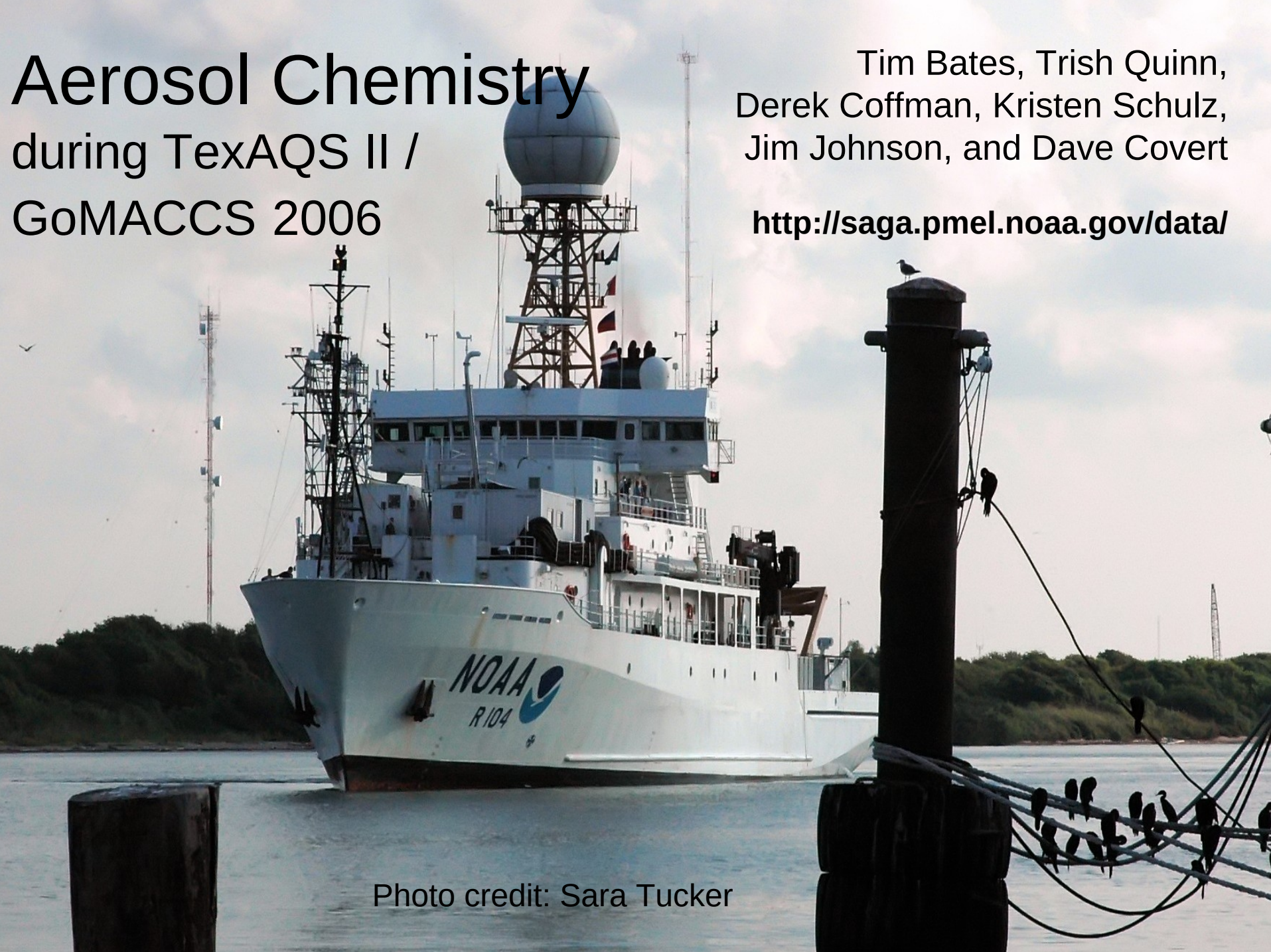
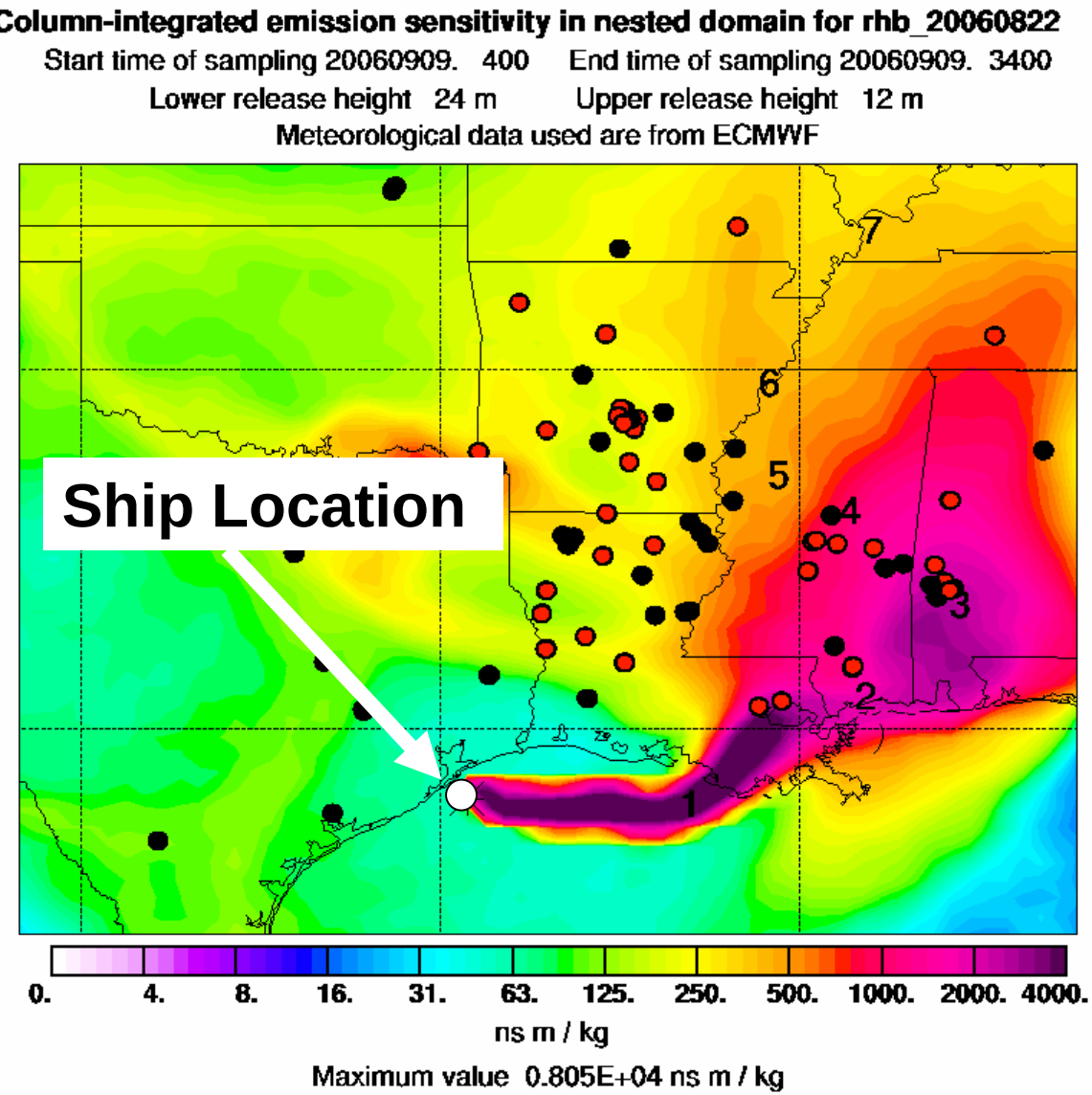


Photo credit: Sara Tucker

SIP-Relevant Science Questions

- How do emissions from local and distant sources interact to determine the air quality in Texas? How high are background concentrations of ozone and aerosol, and how do they vary spatially and temporally?
- Are there sources of ozone and aerosol precursors that are not represented in the reported emissions inventories?

Data analysis – how do we sort the data?

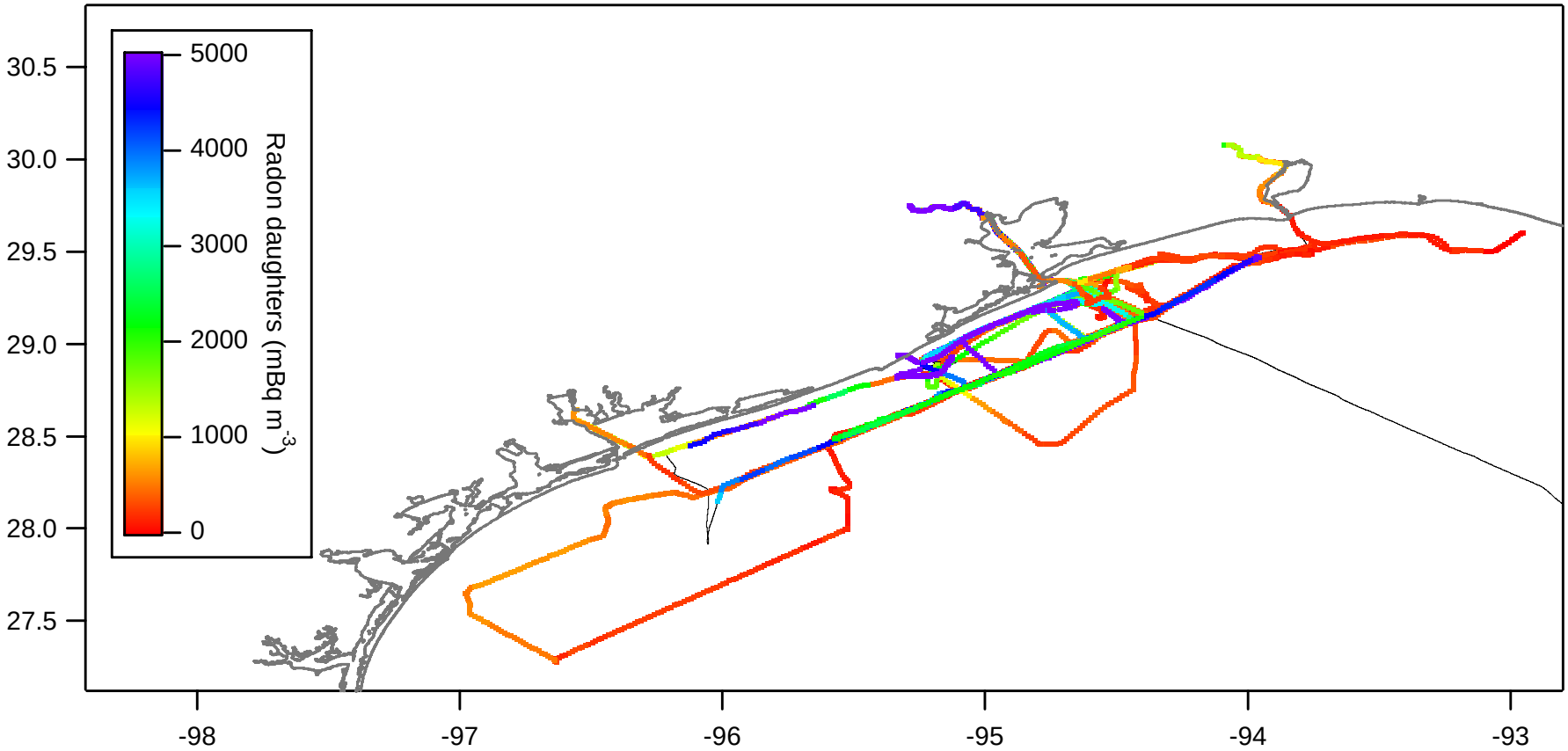


On 9 September off the coast of Houston the measured winds on the ship were from the SE.

The FLEXPART Atmospheric backward transport analysis products show that the air mass sampled at the ship had been over SE US one day earlier.

Simply sorting the data by wind direction will not clearly define source regions.

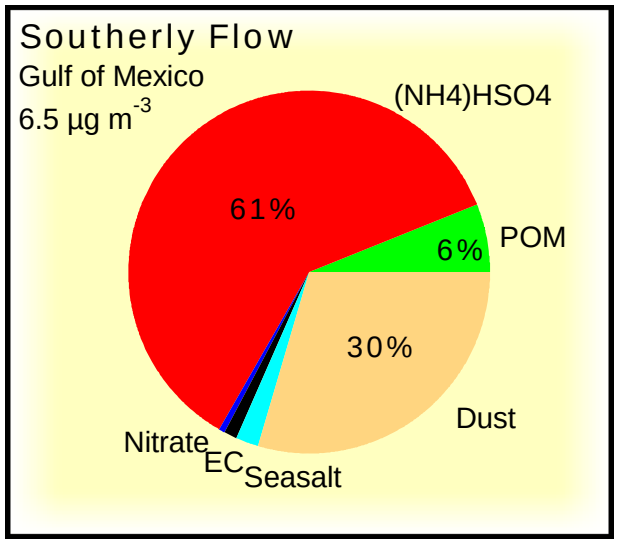
Data Sorted using Radon Concentrations

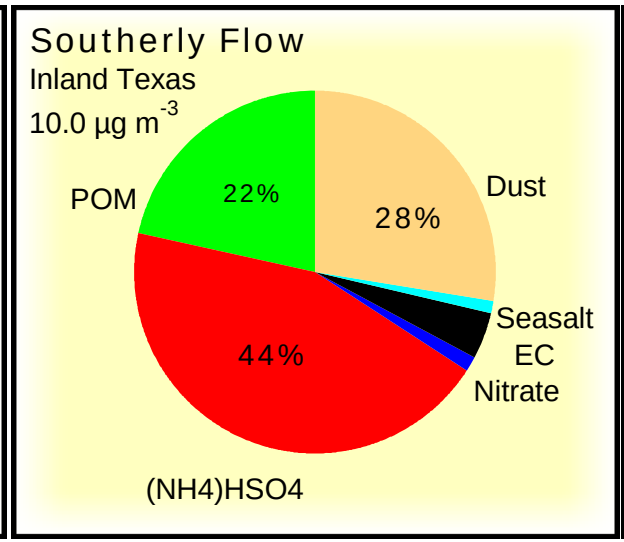


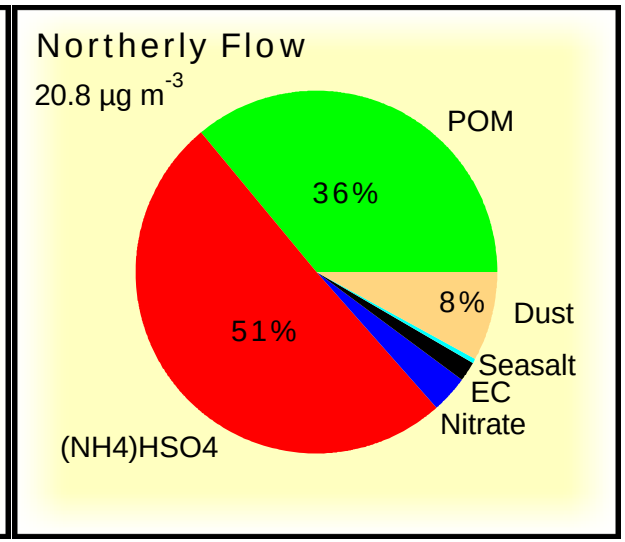
3 wind flow regimes

- Low radon offshore - southerly flow – "background" entering Texas
- Low radon inland – southerly flow – background + local aerosol sources
- High radon – northerly flow – aged aerosol over the continent > 1 day

TexAQS-GoMACCS Submicrometer Aerosol







Background aerosol (low radon) advecting into Texas:

Predominantly $(NH_4)HSO_4$ (NH_4/SO_4 MR=0.8).

Highly impacted by Saharan Dust.

Small oxidized organic fraction (OOA/POM ratio 0.87).

Local sources add organic rich aerosol (POM 66%, sulfate 20%, EC 14%).

$(NH_4)HSO_4$ less acidic (MR=1.6).

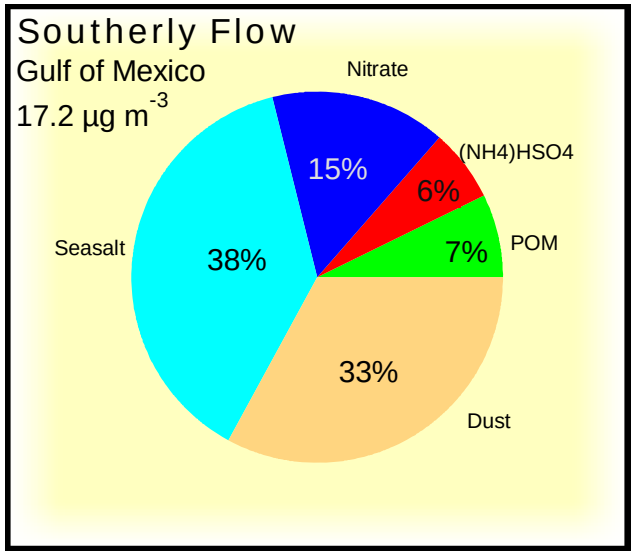
POM fraction less oxidized (OOA/POM ratio 0.60).

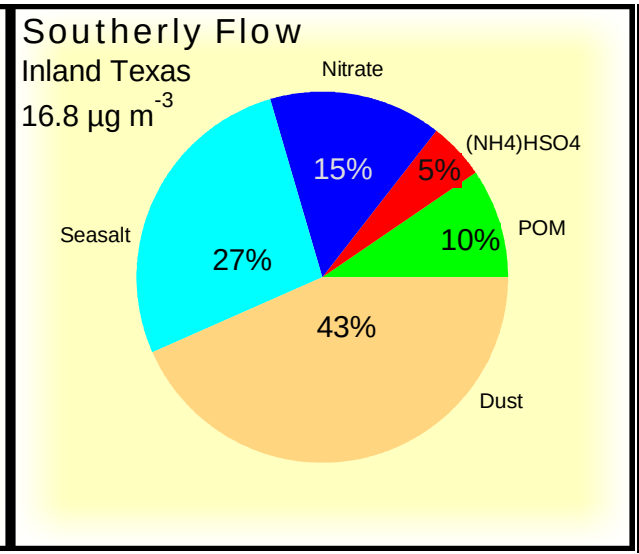
With northerly flow (high radon) both POM and sulfate concentrations increased.

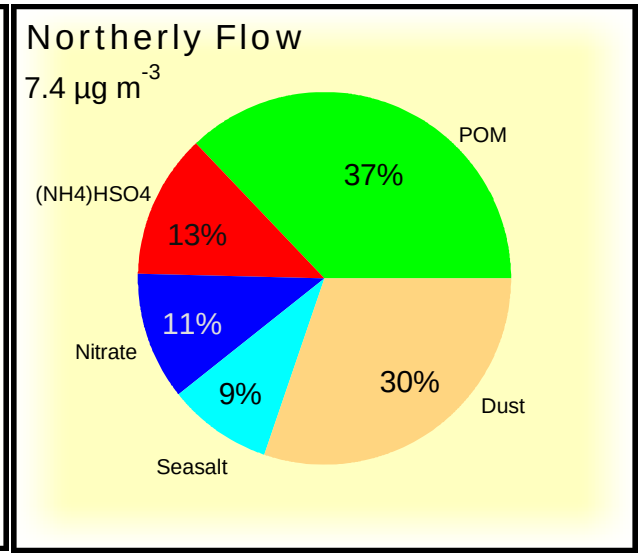
$(NH_4)HSO_4$ MR=1.6.

POM fraction more oxidized (OOA/POM ratio 0.90).

TexAQS-GoMACCS Supermicrometer Aerosol







Supermicrometer mass 3 X submicrometer mass.

Nitrate and sulfate likely associated with seasalt or dust. NH4/SO4 MR=0.16.

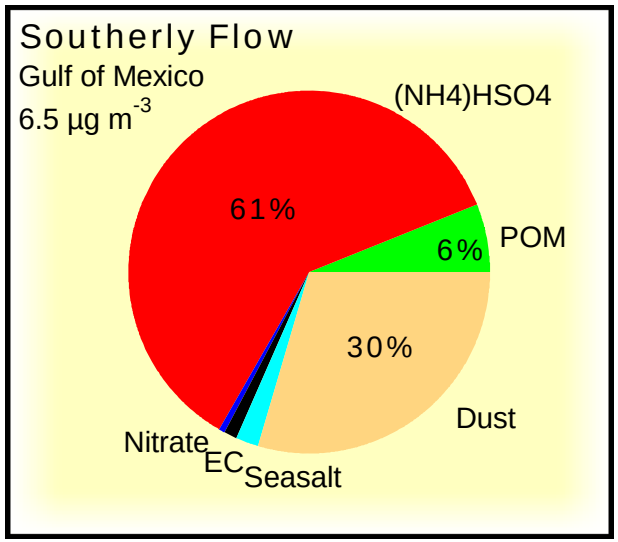
Seasalt and dust make up similar fractions.

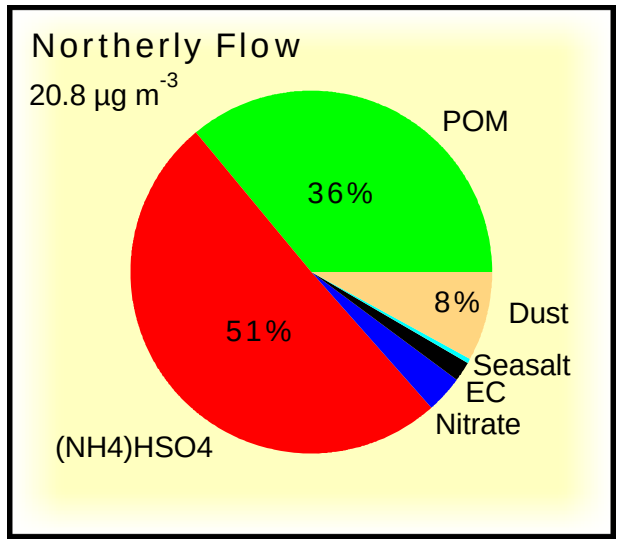
Total mass similar to that over the Gulf but less seasalt and more dust.

Supermicrometer mass 1/3 of submicrometer mass and ½ of supermicrometer mass during southerly flow.

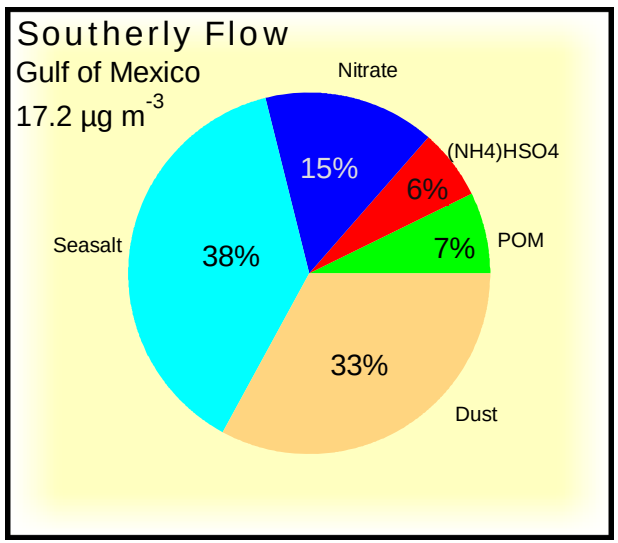
Supermicrometer POM (primary?) dominant component.

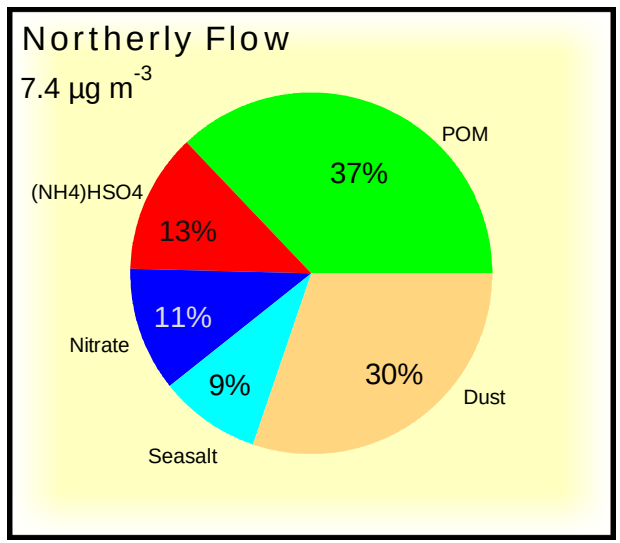
Marine Boundary Layer Aerosol Composition during GoMACCS





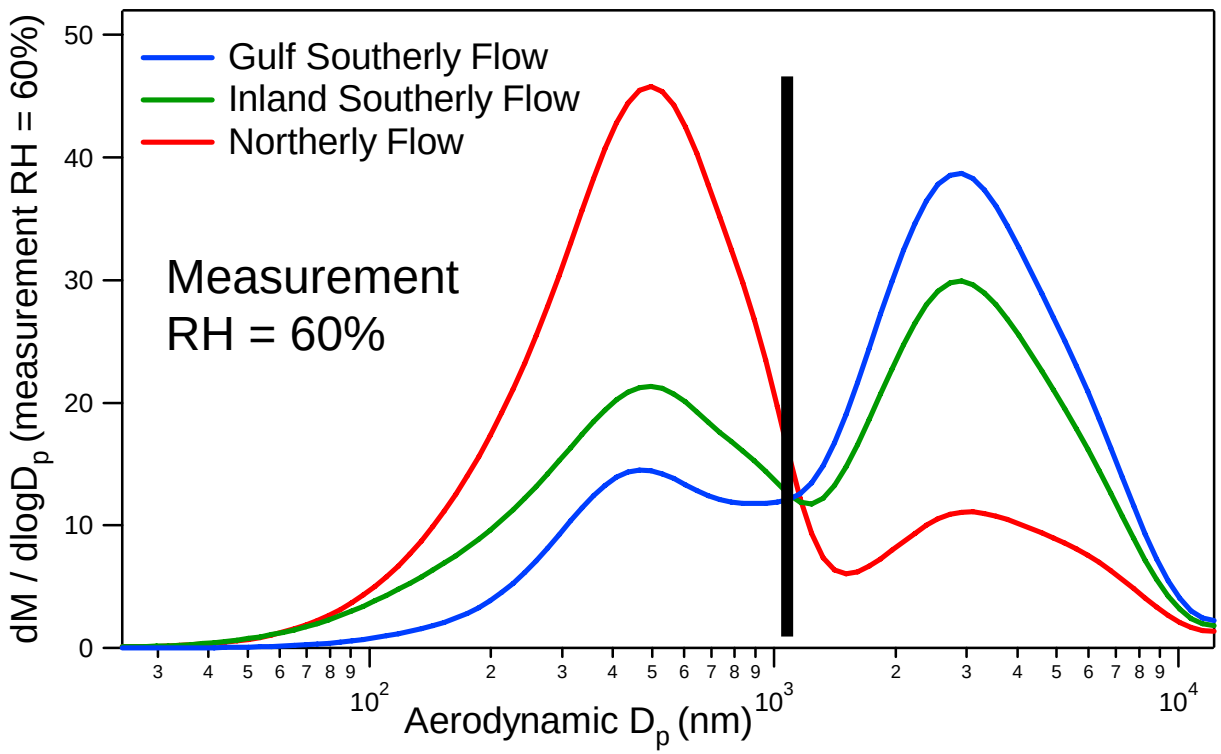
Submicrometer Aerosol





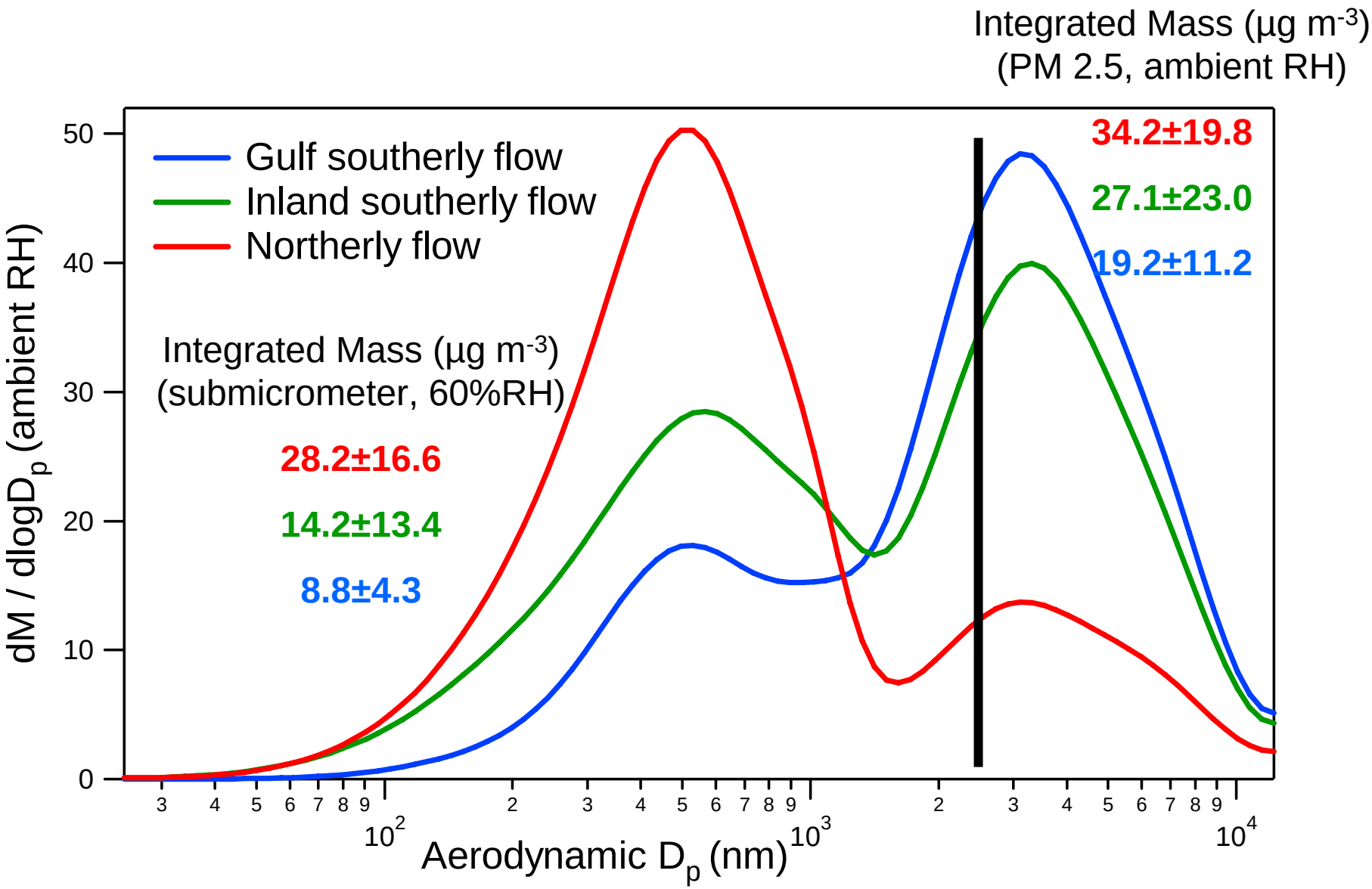
Supermicrometer Aerosol

Aerosol Mass Size Distributions

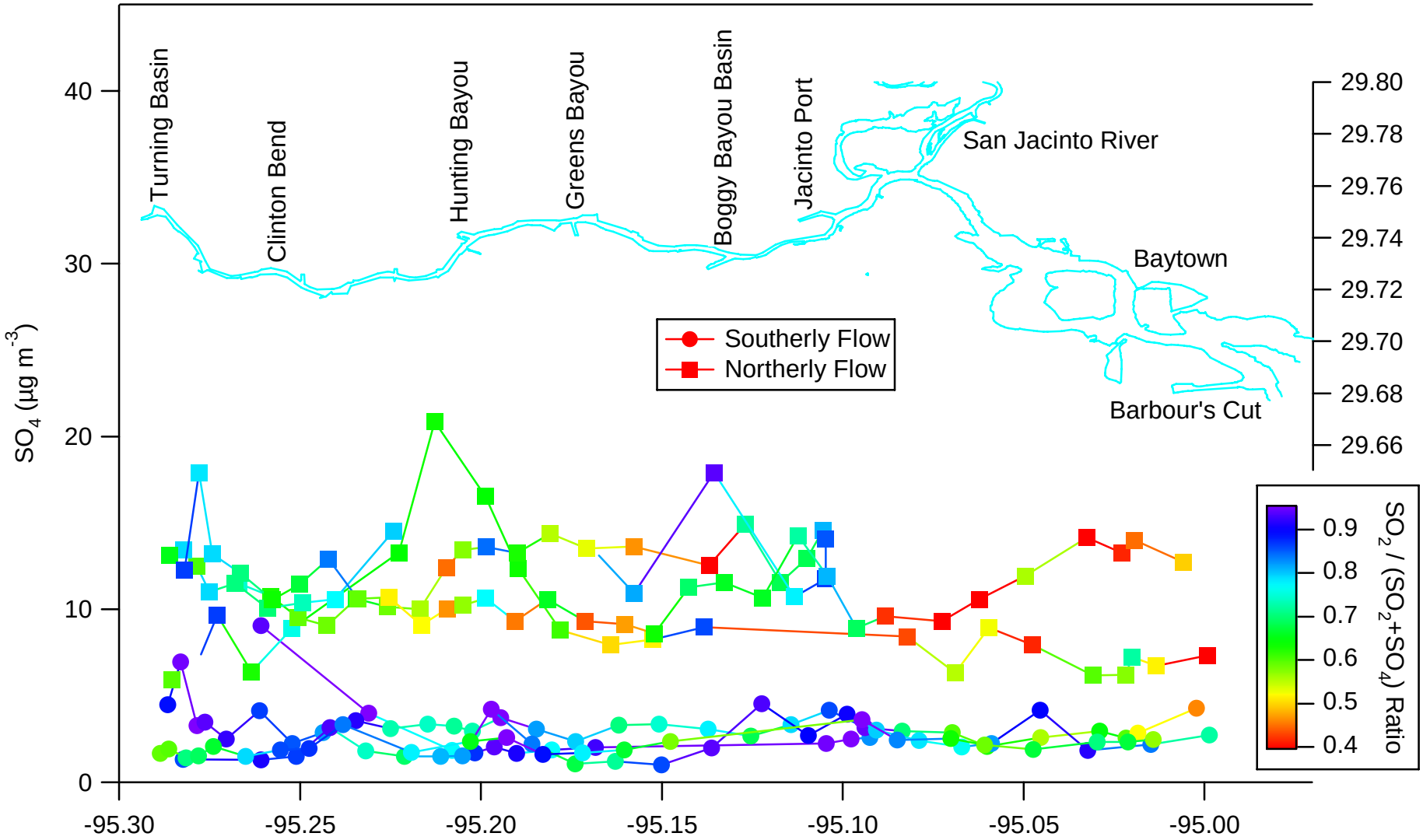


Aerosol physical properties - Coffman Poster
Aerosol optical properties – Covert Poster
Aerosol cloud – nucleating properties – Quinn Poster

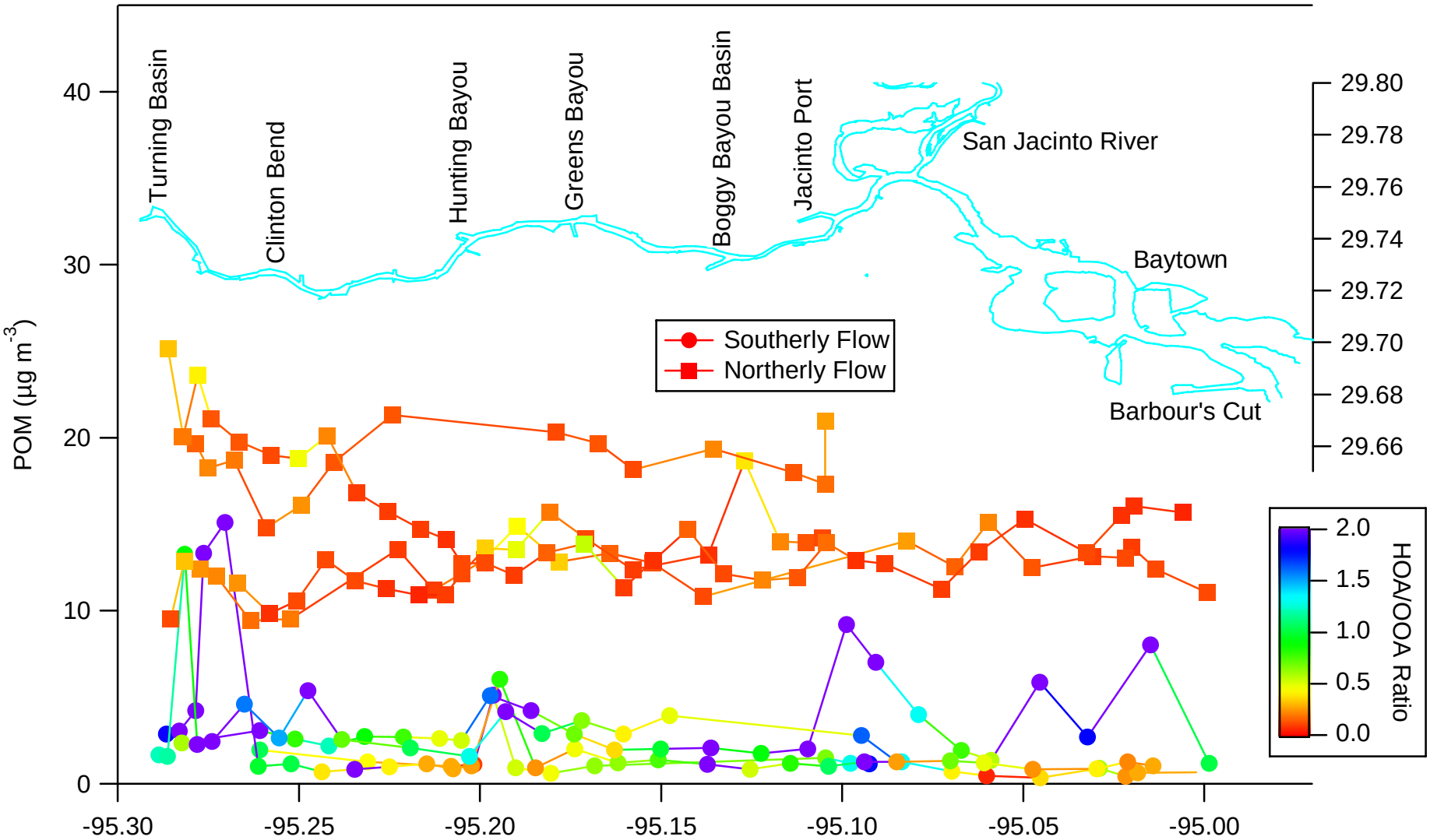
Aerosol Mass Size Distributions



Sulfate Concentrations along the Houston Ship Channel



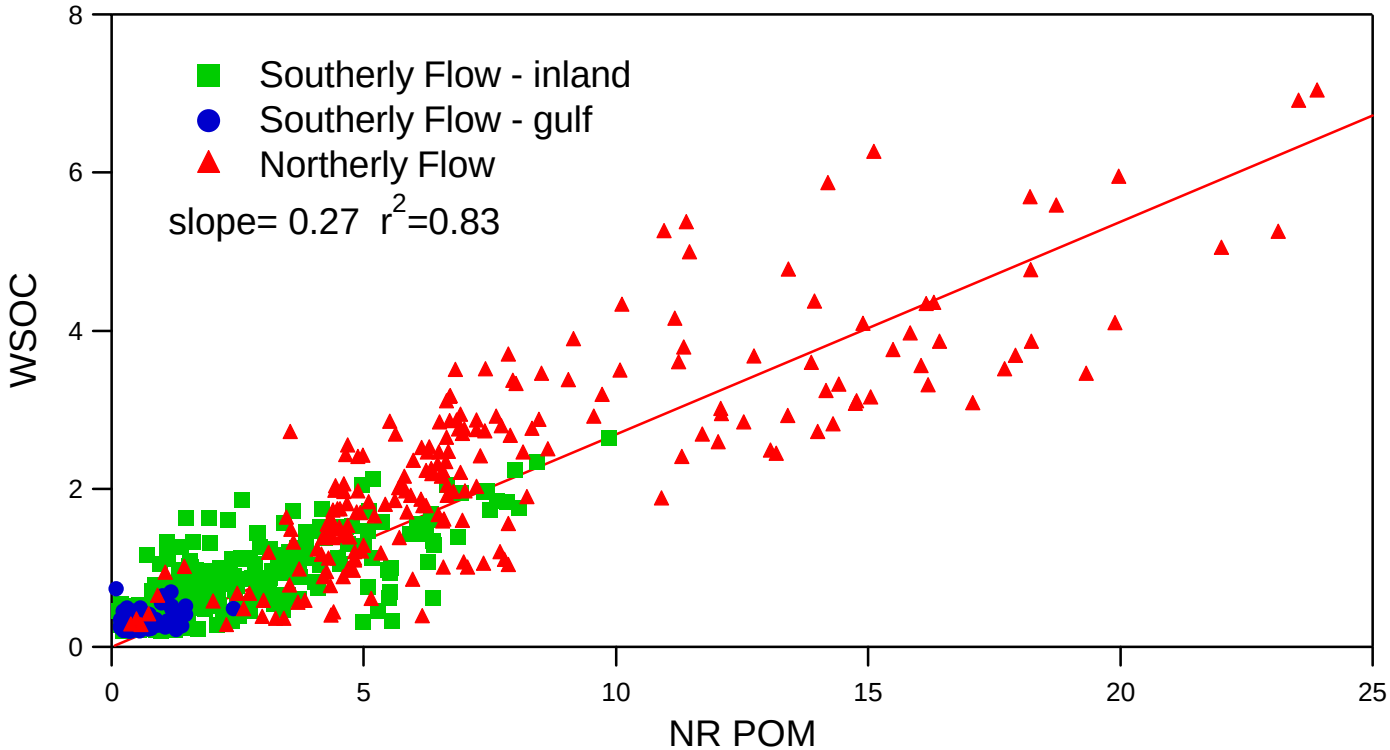
POM Concentrations along the Houston Ship Channel



Organic Aerosol

- POM concentrations over the Gulf of Mexico during periods of southerly flow were very low (<1 µg m^{-3}).

- 27% of the POM was WSOC.



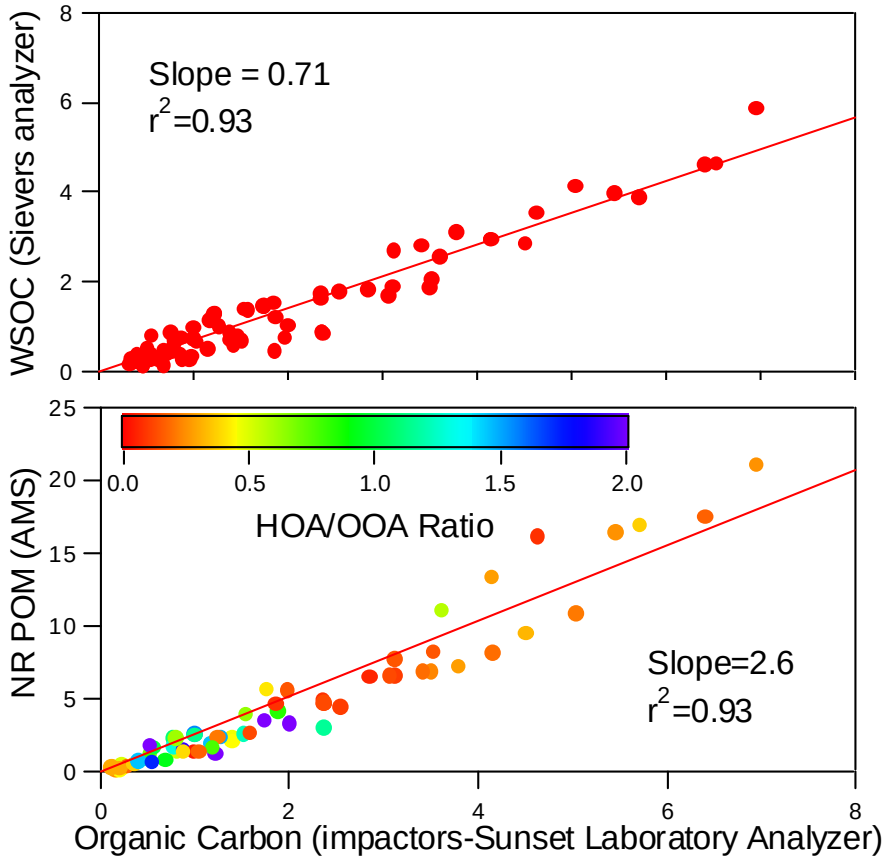
Organic Aerosol

Non-volatile organic carbon was measured with a Sunset Laboratory thermal/optical carbon analyzer.

The non-volatile OC was highly correlated with both WSOC and NR POM.

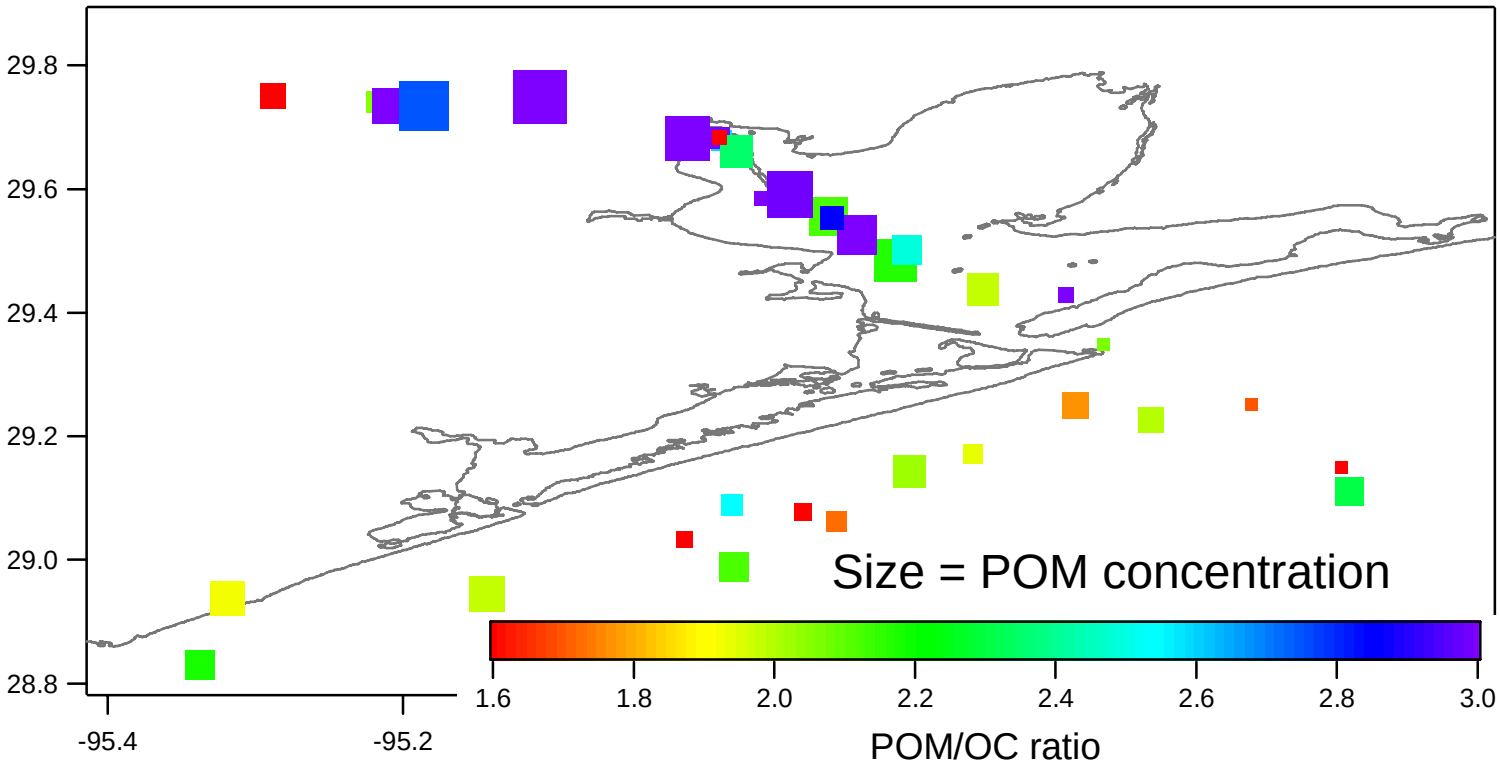
The ratio of POM/OC (2.6) was higher than typically observed in urban areas. This could result from:

- a highly oxidized aerosol or
- a loss of "volatile" OC during sampling.

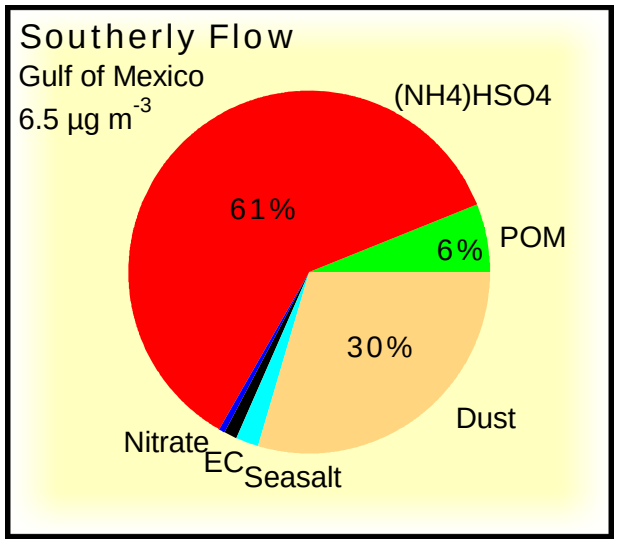


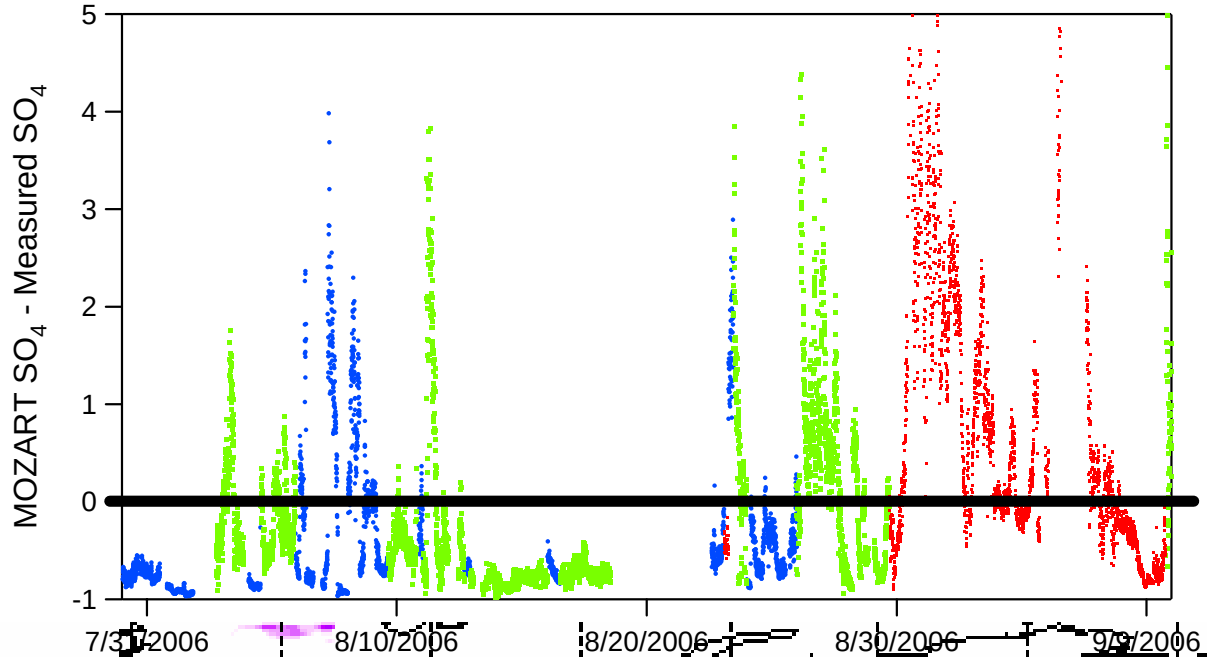
Organic Aerosol

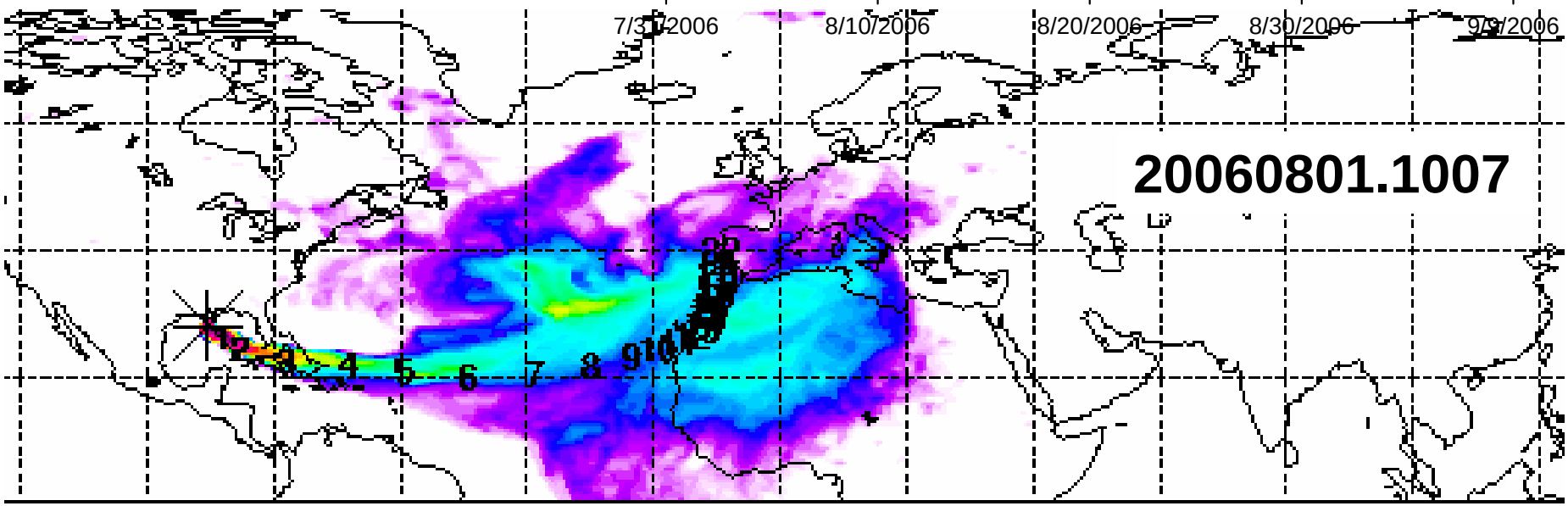
- Robinson et al., 2 March 2007 Science – Rethinking organic aerosols: semivolatile emissions and photochemical aging
  - low volatility material evaporates, oxidizes, and recondenses over time.
  - “accounting for the partitioning and photochemical processing of primary emissions creates a more regionally distributed aerosol”



TexAQS-GoMACCS Submicrometer Aerosol





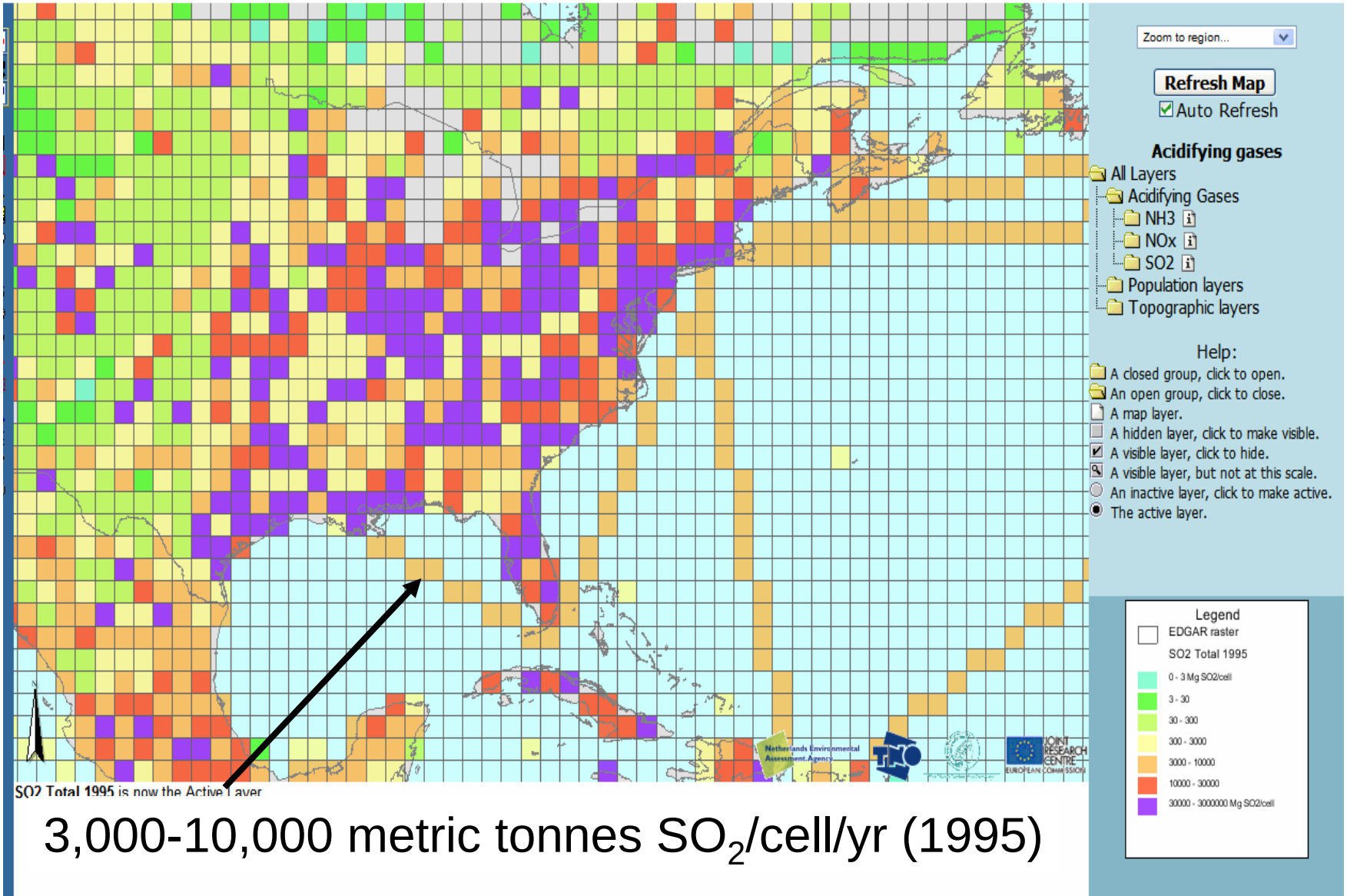


“Background” Sulfate

2006 – The Port of Houston:

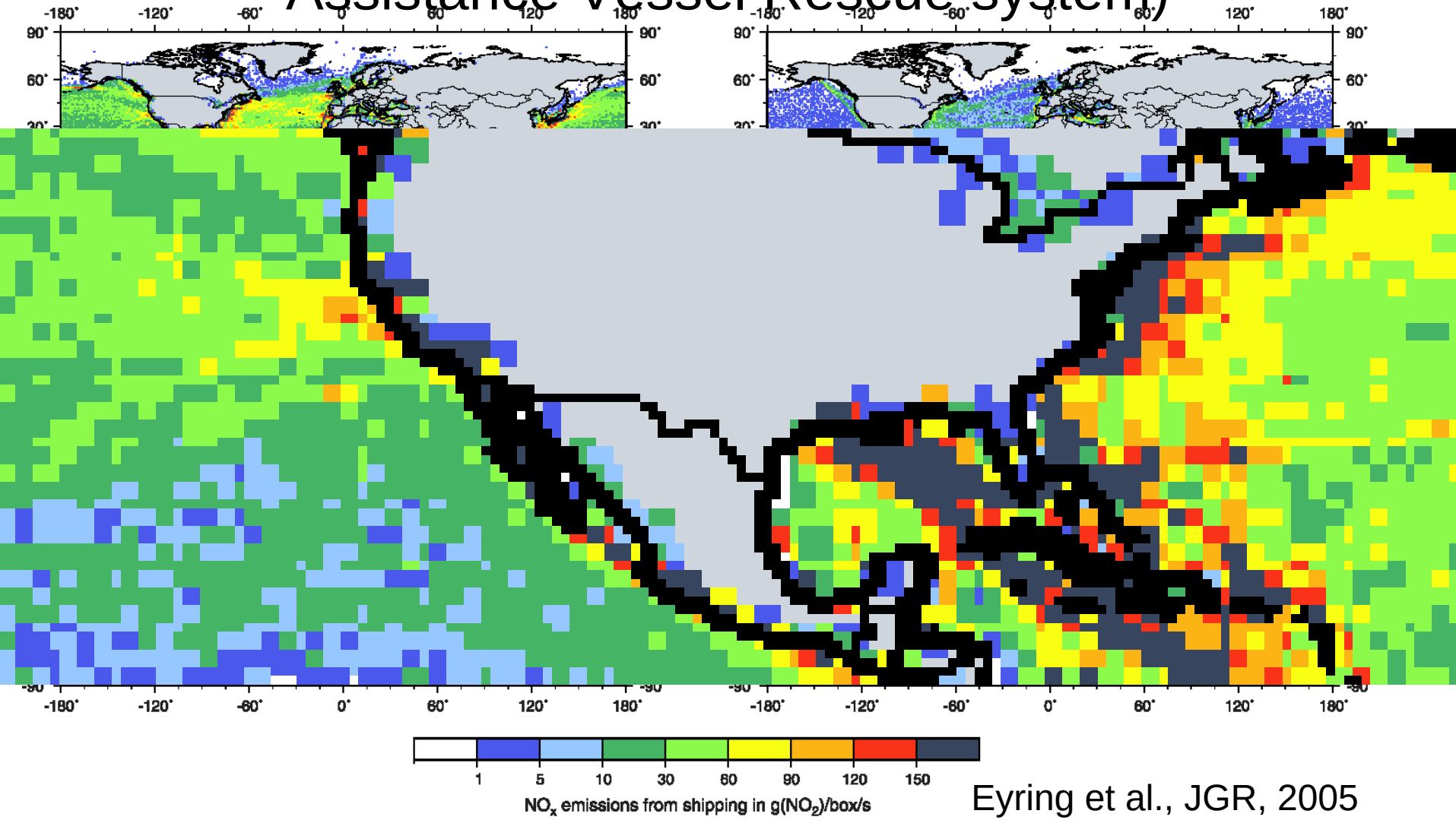
- handled more than 200 million tons of cargo
  - the 1st in US in foreign tonnage
  - the 2nd in US and 10th in the world in total tonnage
- was home to the world’s 2nd largest petrochemical complex
- received 7,550 ships and over 150,000 barges
- accommodated over 100,00 towboat movements

SO_2 Emissions (EDGAR 3.2)



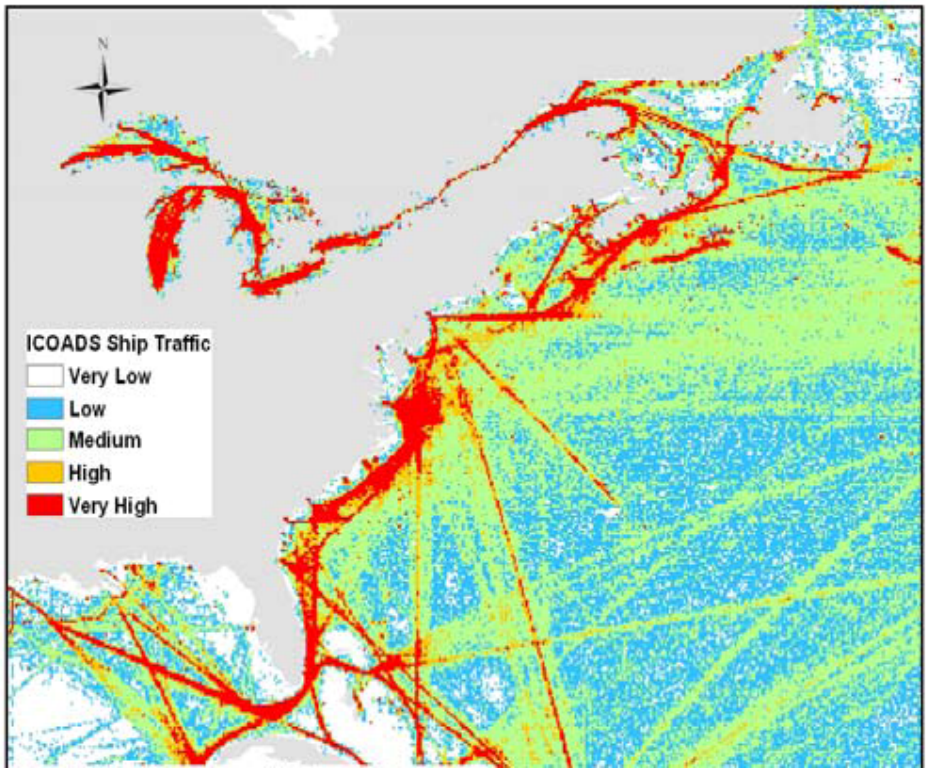
3,000-10,000 metric tonnes SO_2/cell/yr (1995)

New global ship emission data bases distributed geographically using AMVER (Automated Mutual-Assistance Vessel Rescue system)

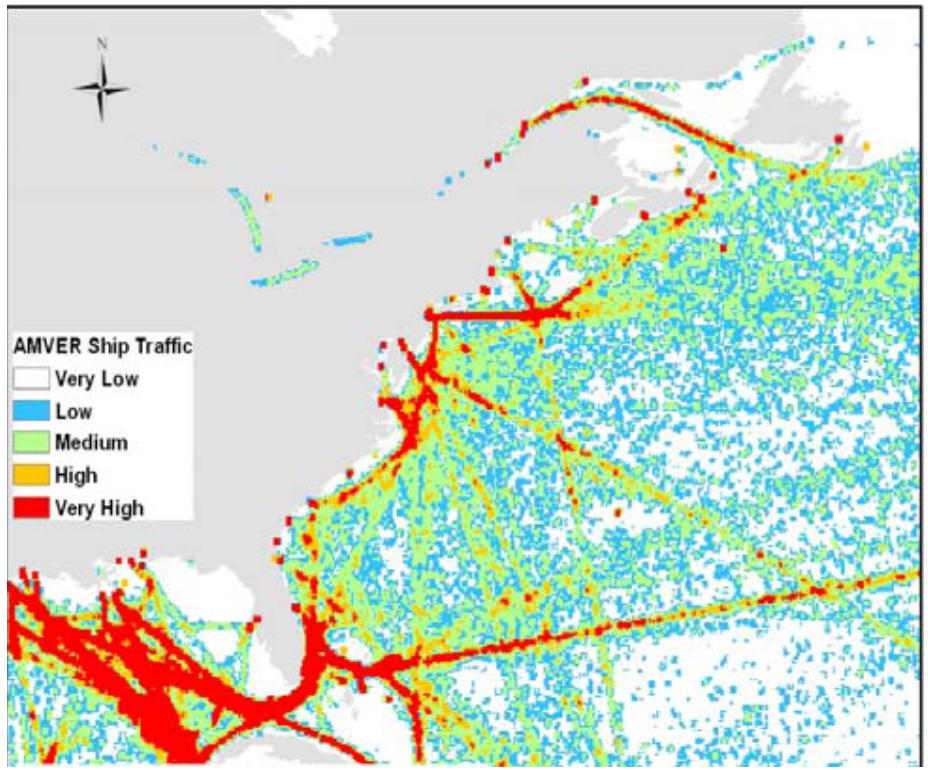


Eyring et al., JGR, 2005

ICOADS Ship Traffic



AMVER Ship Traffic



US Gulf Coast EEZ (200 nm)

SO_2 Emissions = 103,000 metric tonnes/yr (2002)

(Wang, Corbett, & Firestone, EST, 2007)

Texas SO_2 Emissions = 700,000 metric tonnes/yr (2004)

Conclusions

- The submicrometer aerosol (60% RH) entering Texas from the south during TexAQS -GoMACCS was predominantly $(NH_4)HSO_4$ and Saharan dust. This "background" averaged 6.5 µg m^{-3}. The supermicrometer aerosol was predominantly sea salt and dust (17 µg m^{-3}). The mean PM2.5 mass at ambient RH was 19.2±11.2 µg m^{-3}.
- During northerly flow submicrometer $(NH_4)_2SO_4$ and POM were the dominant aerosol components. The POM was highly oxidized. In the ship channel/bay (near sources) the POM contained a "volatile" fraction. The mean PM2.5 mass at ambient RH was 34.2±19.8 µg m^{-3}.

SIP-Relevant Science Questions

- How do emissions from local and distant sources interact to determine the air quality in Texas? How high are background concentrations of ozone and aerosol, and how do they vary spatially and temporally?
- Are there sources of ozone and aerosol precursors that are not represented in the reported emissions inventories?