# Optical Properties of Mixed Organic / Inorganic Aerosols at High Relative Humidities

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## Background

- Aerosol water content and size are a function of ambient relative humidity (RH) and aerosol chemical composition
- Water content alters the optical properties of an aerosol in terms of light scattering and light absorption
- Light absorption of organic and mixed organic / inorganic aerosols have rarely been examined at variable and high RH values (>85%)

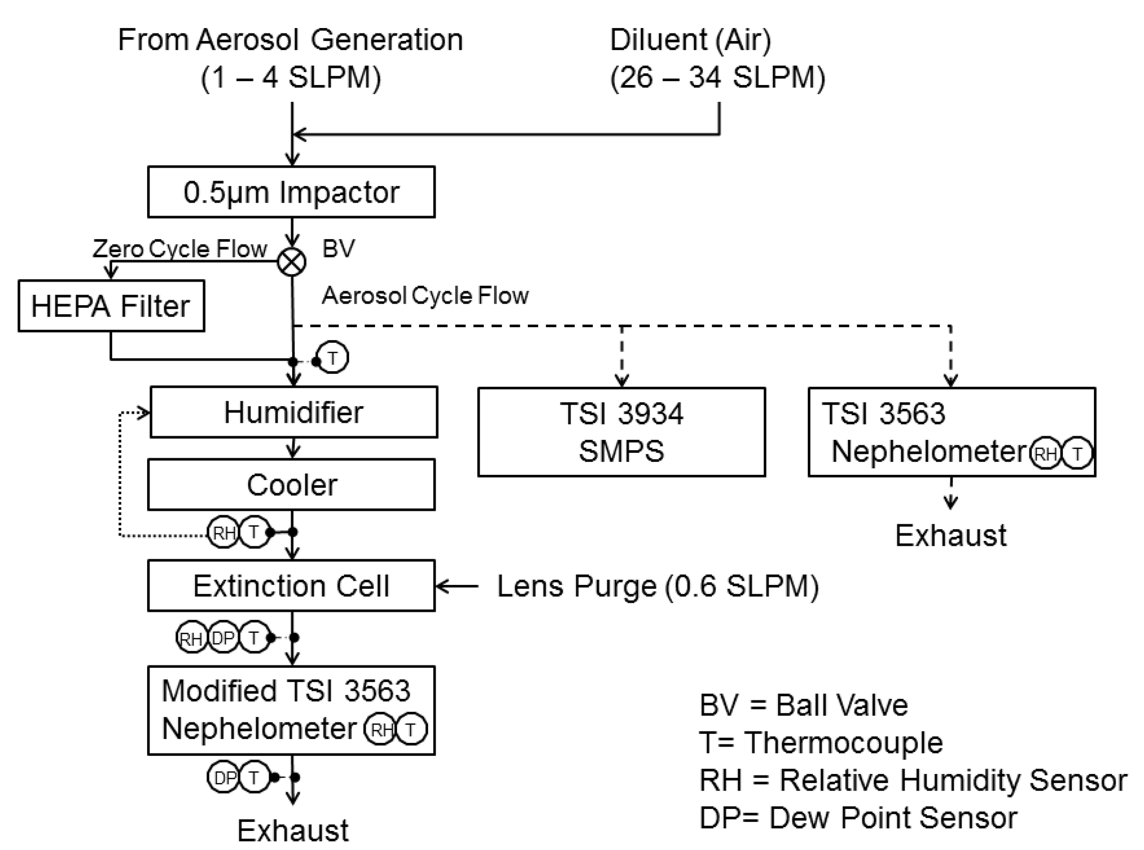
## Objectives

- Determine light scattering and absorption of organic and mixed inorganic aerosols as a function of RH in a laboratory setting and evaluate closure with models
- This work: Determine light absorption as a function of RH for organic wood pyrolysis aerosols and verify methodology with benchmarks (ammonium sulfate, water soluble nigrosin)
- Future work: Measure light absorption of organic wood pyrolysis aerosols mixed with ammonium sulfate and ammonium nitrate; provide parameterization of results

## Methodology

### Instrumentation

- Light absorption ($\sigma_{ap}$) → difference method: light extinction ($\sigma_{ep}$) minus light scattering ($\sigma_{sp}$)
- Light extinction ($\sigma_{ep}$) → measured with a custom-made extinction cell at 467, 530 and 660 nm wavelength
- Light scattering ($\sigma_{sp}$) → nephelometer (TSI 3563) Instrument modifications: optical band-pass filters changed to 470, 530 and 660 nm, electronics separated (heating reduced from 4.5 to 0.6 ˚C)
- RH control and characterization → membrane humidifier, 2 RH sensors (Vaisala, HMP-233) and 2 dew point meters (General Eastern, Hygro M1)



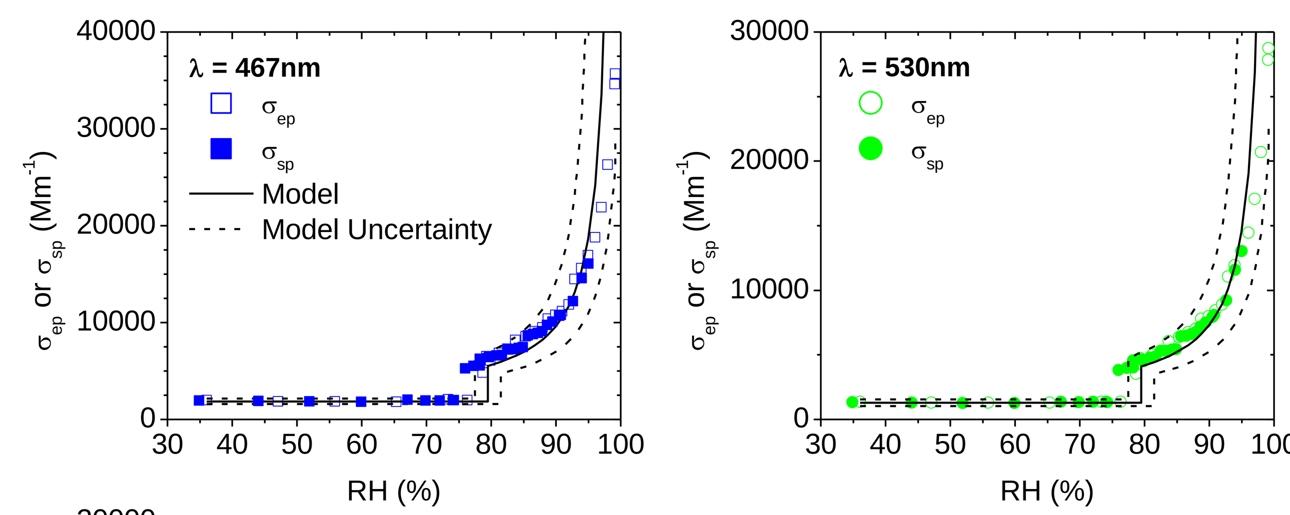

## Modeling

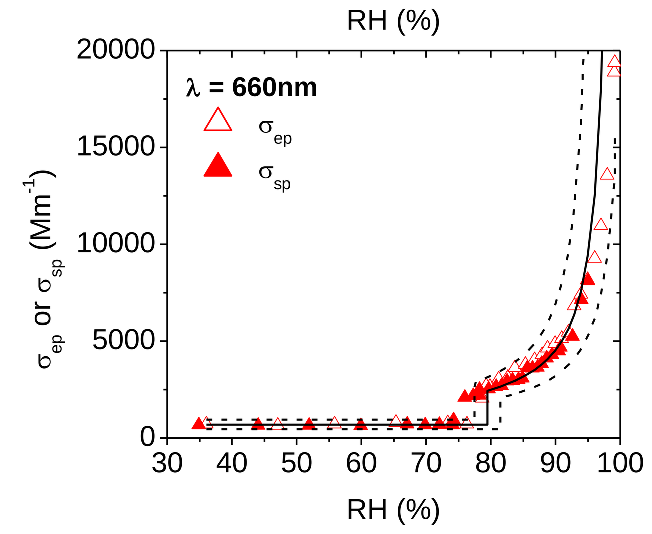
- Thermodynamic model or size growth factor used to model change in particle size with RH
- Mie model used to evaluate closure between measured and modeled optical properties

## System Benchmarking Results

### Humidified Ammonium Sulfate

- **Good sampling system performance under non-absorbing conditions for RHs between 32 and 95%**




Mean Absolute Error (MAE) between measured and modeled:

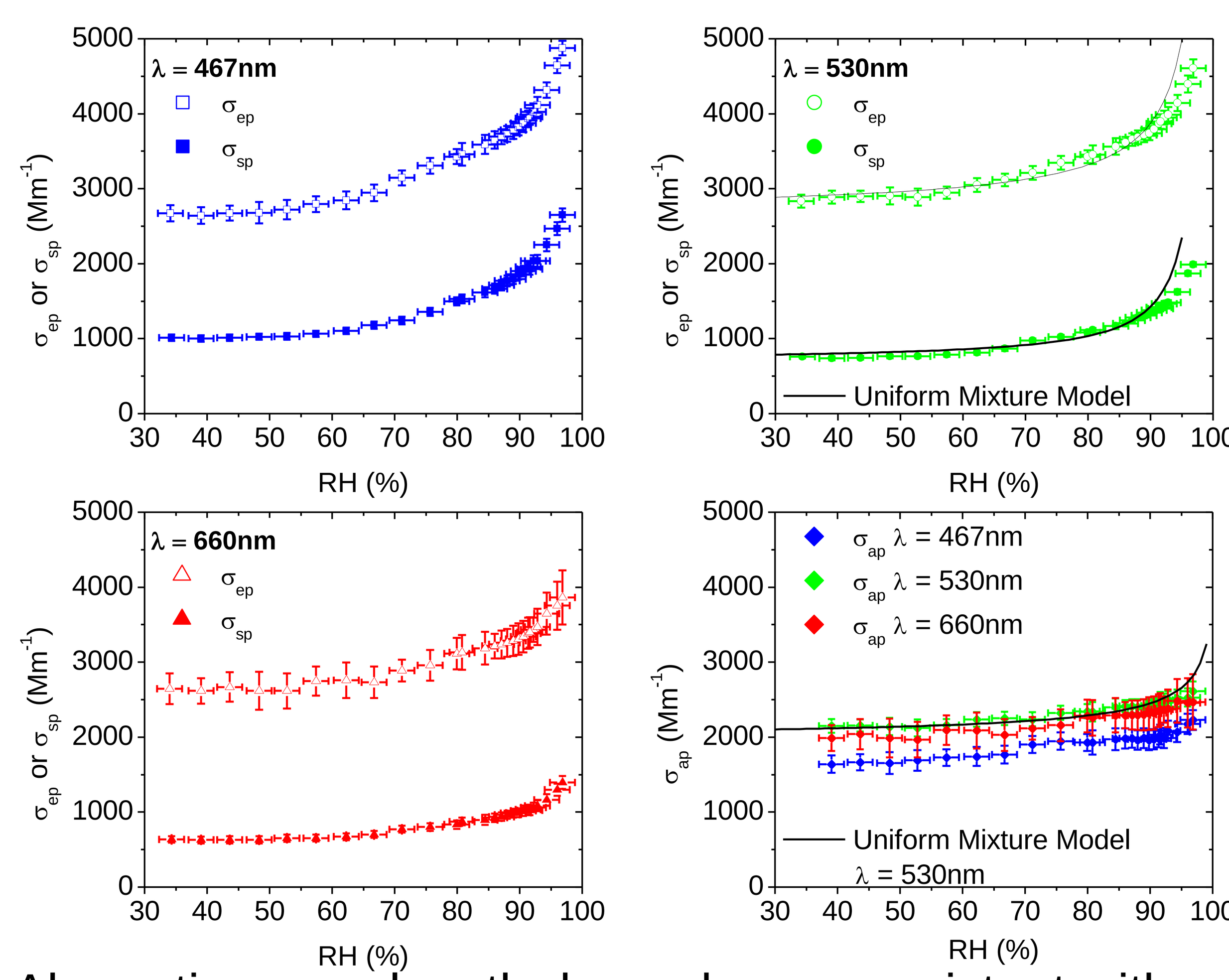
| λ | $\sigma_{sp}$ MAE [%] [1] | $\sigma_{ext}$ MAE [%] [2] |
|---|---|---|
| 467 nm | 5.3 | 6.0 |
| 530 nm | 6.1 | 7.3 |
| 660 nm | 4.2 | 8.2 |

[1] Measurements between 75 and 80% RH excluded
[2] Values > 95% RH excluded

- Shift in $\sigma_{sp}$ deliquescence due to nephelometer heating
- Particle losses at RH > 95% cause measurement/ model mismatch

### Humidified Nigrosin

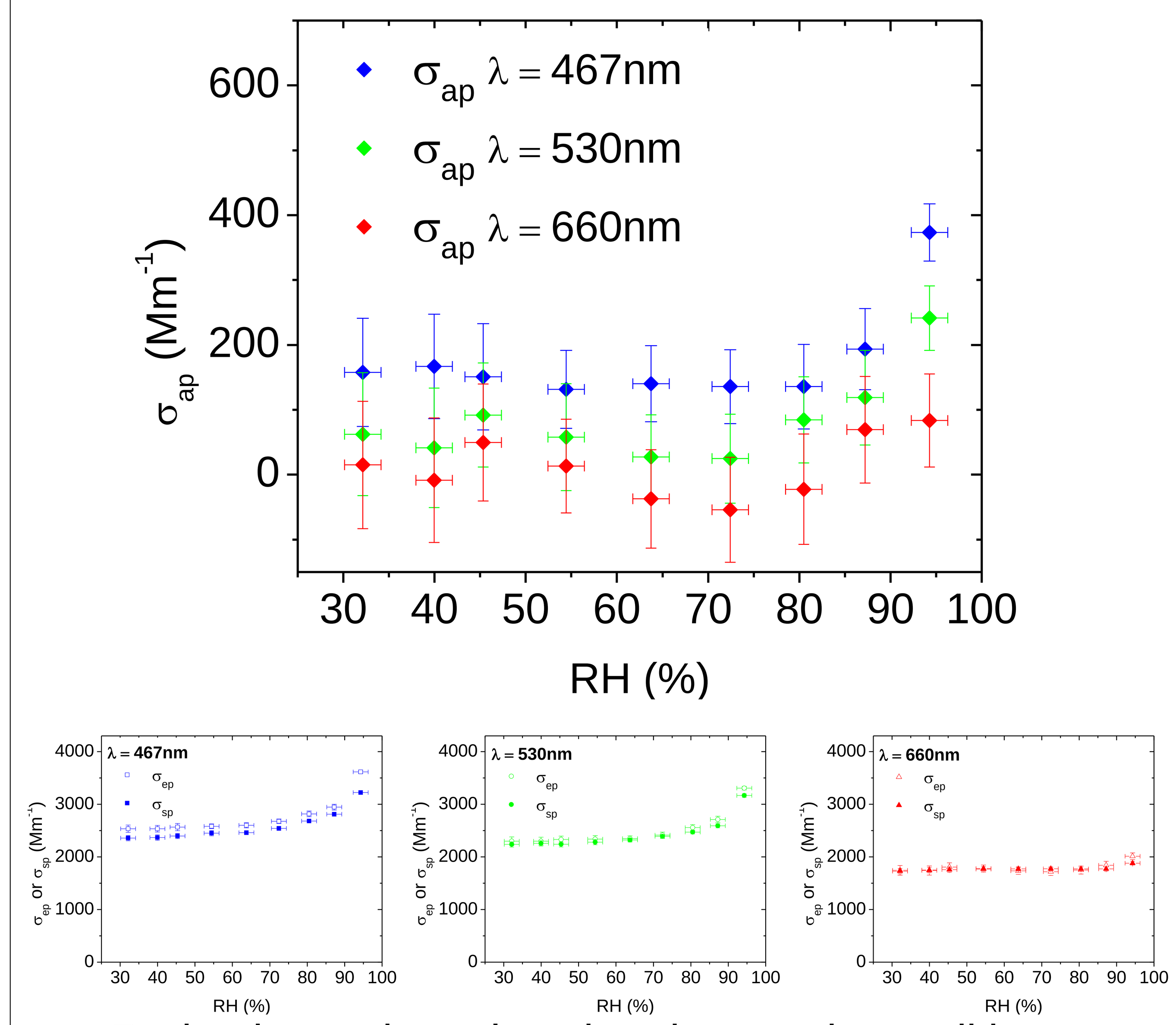
- **Absorption enhanced by a factor of 1.3 +/- 0.07 between 38 and 95% RH**




- Absorption wavelength dependence consistent with spectrophotometric bulk liquid measurements
- Optical model agrees for RH < 90%. At RH > 90% mis-match likely caused by growth factor and particle losses

## Humidified OC Aerosol Results

- **Absorption enhanced by factor of 2 +/- 0.2 between 32 and 95% RH at the 467 and 530nm wavelength**




- Red oak wood pyrolyzed under anoxic conditions at 425ºC to produce absorbing OC aerosols
- Absorption wavelength dependence similar to field data of smoldering biomass OC aerosols
- Enhancement could be caused by strongly absorbing water insoluble OC
- No significant absorption detected at the 660nm wavelength

## Implications

- OC from biomass or biofuel burning can be up to 90% of primary organic aerosols
- Increase in OC absorption with increasing RH needs to be implemented in radiative transfer models

## Conclusions and Outlook

- Instrumentation is capable of measuring aerosol optical properties including absorption as a function of RH between 32 and 95%
- Absorption of both the benchmark nigrosin and the pyrolyzed OC aerosols was enhanced with higher RH
- Current work focuses on closure evaluation of results with modeling and additional measurements, as well as on mixing the generated OC with inorganic salts

## Acknowledgement

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