Extending the capabilities of the Humidified Tandem Differential Mobility Analyzer (HT-DMA)

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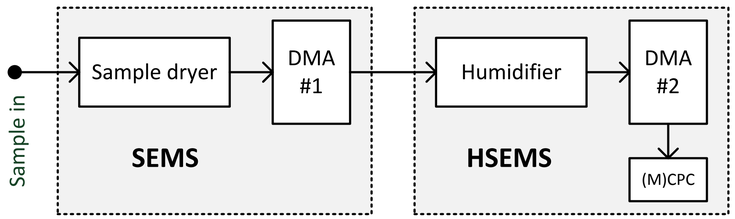
Humidified Tandem Differential Mobility Analyzer

The ARM Humidified Tandem Differential Mobility Analyzer (model 3002, Brechtel Manufacturing Inc.) measures the change in ambient aerosol particle size (growth factor, GF) due to water uptake, thus providing information about the chemical composition of the aerosol particles. HT-DMA is part of the ARM Aerosol Observing System (AOS) core measurements and has been successfully deployed for several years in various environments during ARM field campaigns. ARM currently has 5 HT-DMA units.

HT-DMA installed in AMF 3

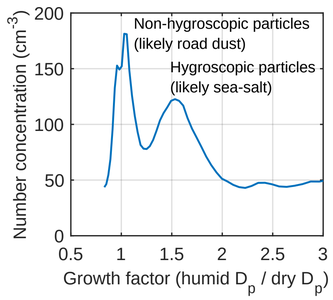
The HT-DMA consists of two major parts:

- **Scanning Electrical Mobility Sizer**. SEMS dries the aerosol sample and size-selects a narrow range to be humidified in the HSEMS.
- **Humidified Scanning Electrical Mobility Sizer**. HSEMS humidifies the dry size-selected aerosol sample at a fixed RH and measures the resulting size distribution from which the particle GF is derived.



Schematic diagram of the HT-DMA

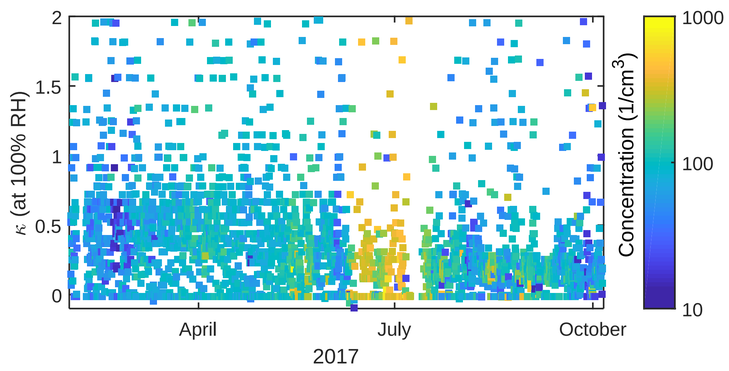
HT-DMA periodically scans through 5 dry sizes between 50 and 250 nm and measures the humidified particle size distribution at each step. This allows the GF of aerosol particles with different dry sizes (and possibly different origins) to be measured. The entire cycle, covering all 5 dry sizes, takes about an hour to complete.



A typical GF measurement from Oliktok (AMF 3)

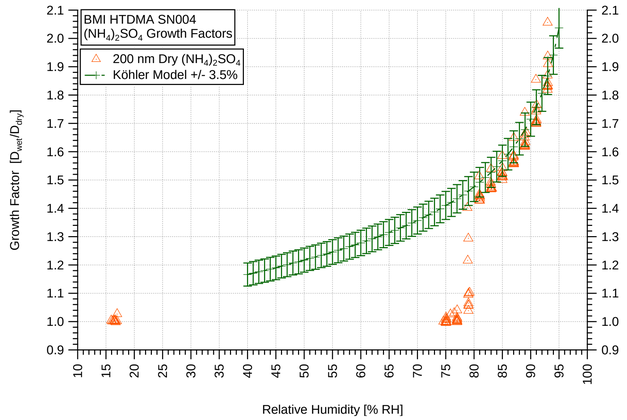
Extending hygroscopicity measurements

It is possible to derive the hygroscopicity parameter κ from the existing HT-DMA GF measurements at a single fixed RH (around 80–90%) without change to the instrument configuration by extrapolating the measurements at a lower RH up tp 100% RH (Tang *et al.* (1977). *J. Aer. Sci.*, 8.):



Hygroscopicity parameter κ for 150 nm dry particles calculated from HT-DMA measurements during LASIC

However, the HT-DMA is also capable of scanning through multiple RH set points. This would provide confidence in extrapolating the GFs measured at a lower RH up to 100% RH and also allow deliquescence curves of ambient aerosol to be obtained.



Deliquescence curve of ammonium sulfate measured by the HT-DMA Graph by Brechtel

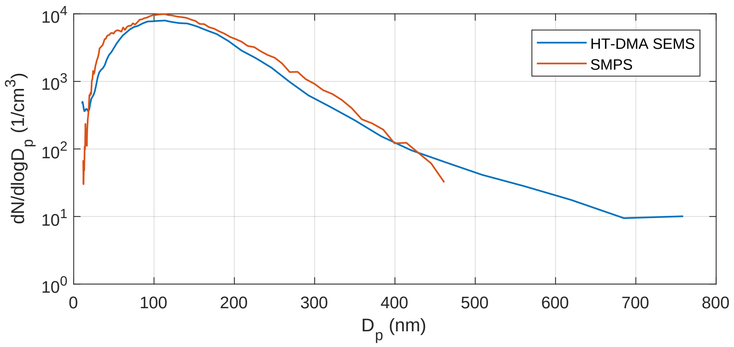
HT-DMA RH scans would complement the existing CCN and f(RH) measurements:

- Measurements at multiple RH values, CCN is limited to 100–101%.
- HT-DMA measurements are size-selected, CCN/f(RH) are usually not.
- HT-DMA κ would provide some closure to the CCN measurements.

Measuring ambient aerosol size

The design of the HT-DMA allows the first "dry" DMA to be used as a standalone particle sizer if an additional external (M)CPC is added to the system. This would allow scans of the ambient aerosol size distribution to be made, similar to an SMPS, interspersed with regular HT-DMA GF measurements.

The benefit of using the HT-DMA for ambient particle size scans over the regular SMPS would be the higher size range (up to 1000 nm) as compared to the already deployed TSI SMPS (limited to below 500 nm):



Ambient aerosol size distribution from SGP measured by the SMPS and the HT-DMA

Trade-offs

While the above options would extend the HT-DMA capability, they would also limit the existing GF measurements:

- **Deliquescence scans**. Would provide deliquescence curves of ambient aerosol, but would significantly lower the time resolution of GF measurements as the system scans through multiple RH set points.
- **Hygroscopicity parameter κ**. Can be obtained without any change to current configuration if only a single RH set point is used. Using multiple RH set points would lower the time resolution of GF measurements.
- **Ambient size scans**. Minimal impact on the usual GF measurement cycle – slight increase in the overall scan time. Would need an external (M)CPC to be added to the system.

Decision to implement any of the above would have to be made on a per-deployment basis, considering what kind of measurements are more important in each case.

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