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On Measurements and Spatial Distribution of Light Absorbing Aerosols in the Arctic

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International Arctic Systems for Observing the Atmosphere
IASOA

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How to measure eBC in the Arctic and from where does it come?

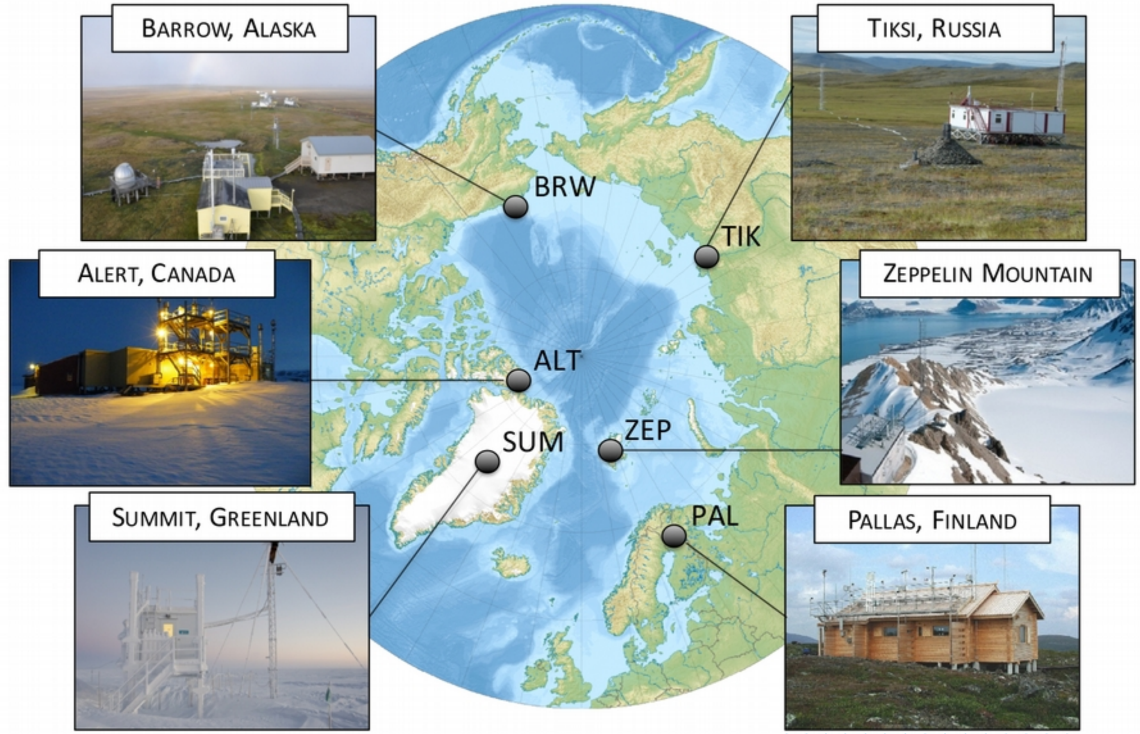
Six stations were included in the analysis

Instrumentations measuring aerosol optical properties

Similar instrumentations

Barrow (USA), Alert (Canada), Summit (Greenland), Zeppelin (Svalbard), Pallas (Finland), Tiksi (Russia)

Light absorption measurements in AMT, seasonal cycles in ACPD, and spatial distribution presented here



Schmeisser, L., Backman, J., Ogren, J. A., Andrews, E., Asmi, E., Starkweather, S., Uttal, T., Fiebig, M., Sharma, S., Eleftheriadis, K., Vratolis, S., Bergin, M., Tunved, P., and Jefferson, A.: Seasonality of aerosol optical properties in the Arctic, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-1117, in review, 2018.

Method to lower the detection limit of Aethalometers (AE31)

Ran into the problem:

– At times, Aethalometers can seemingly be just reporting noise (below DL); more noisy than PSAP/CLAP/MAAP

Solution:

– This can be overcome by data post processing

– Idea from Hagler et al., 2011 and Springston&Sedlacek 2007

– Start from the Aethalometer equation:

$$\sigma_0 = \frac{A}{Q\,\Delta t}\,\frac{\Delta \mathrm{ATN}}{100}$$

– Instead of using ΔATN to invoke boxcar averaging, ΔATN was used as criterion (ΔATN>x) → results in constant relative uncertainty of σ_0 and concentration adapted temporal resolution

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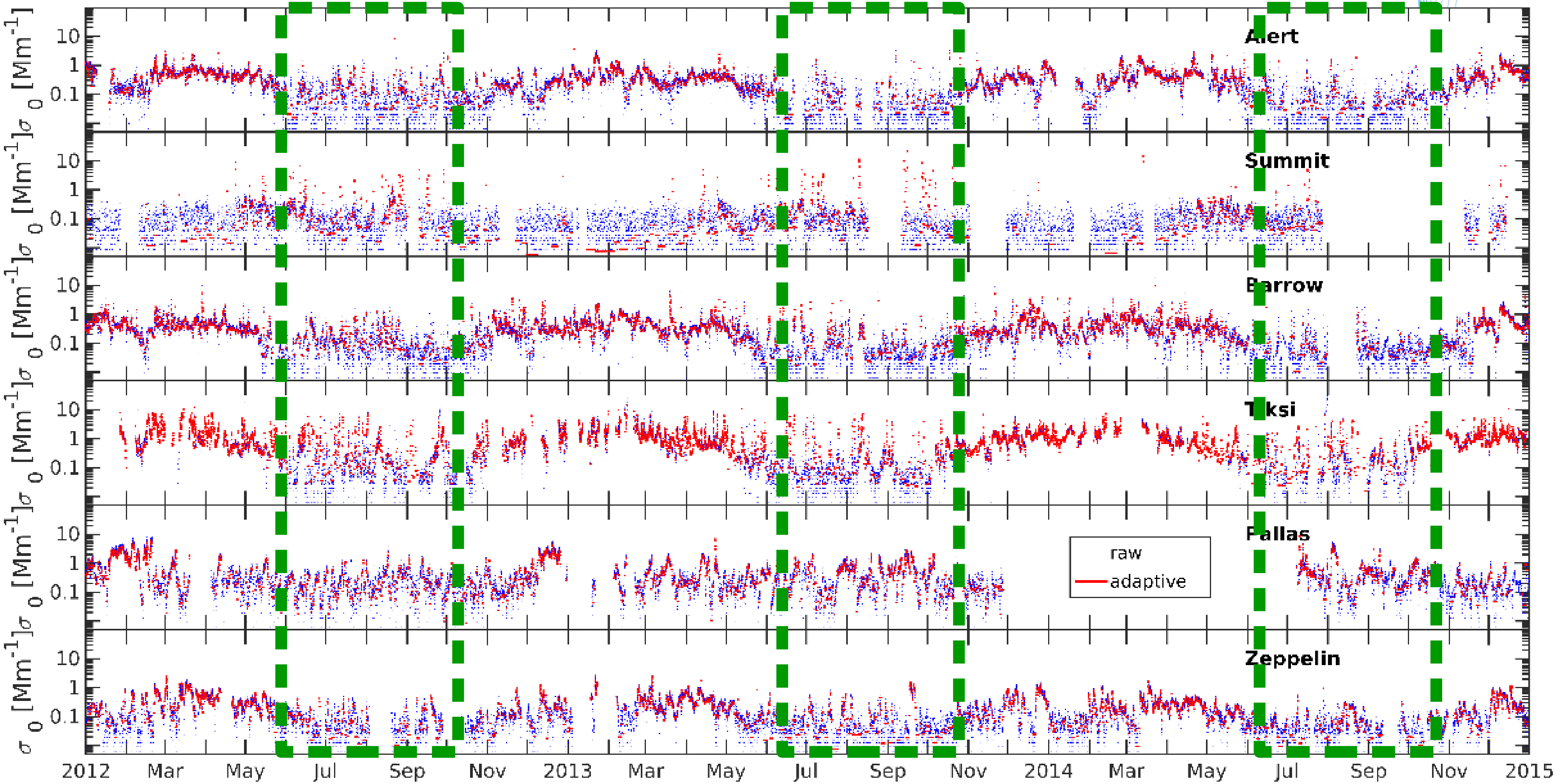
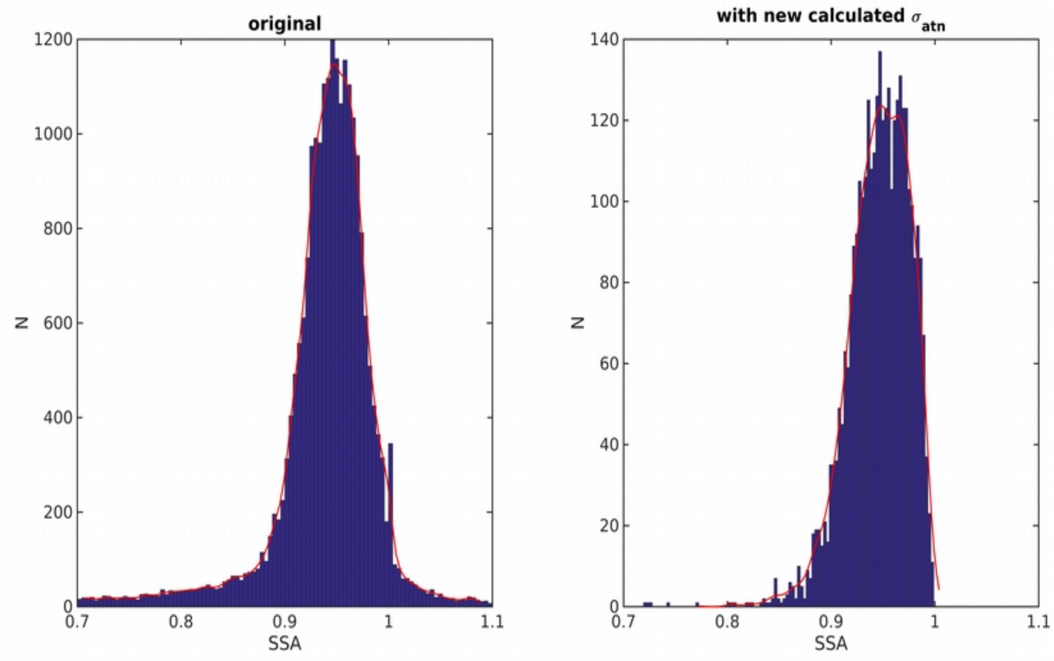
The ΔATN criterion will result in a concentration adapted time series



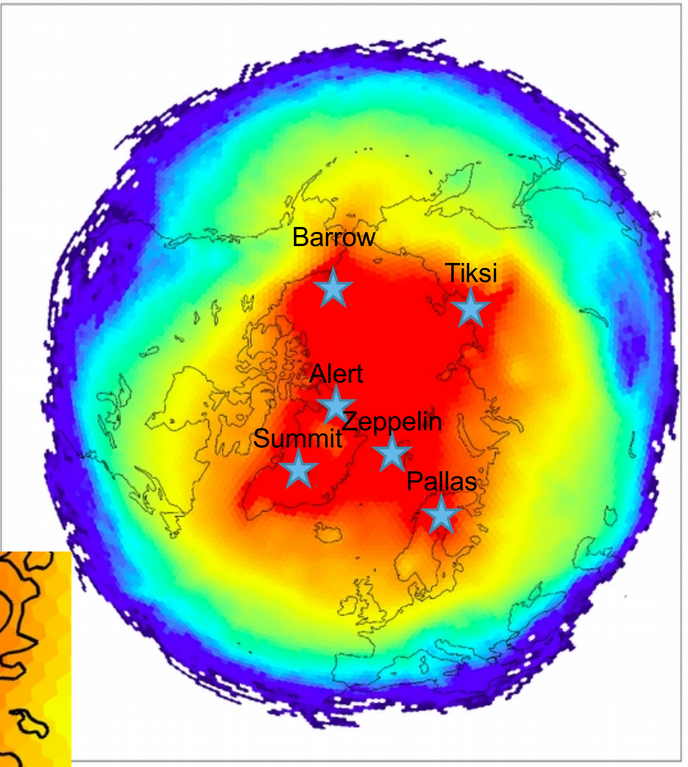
The method will result in a time series with no negative values

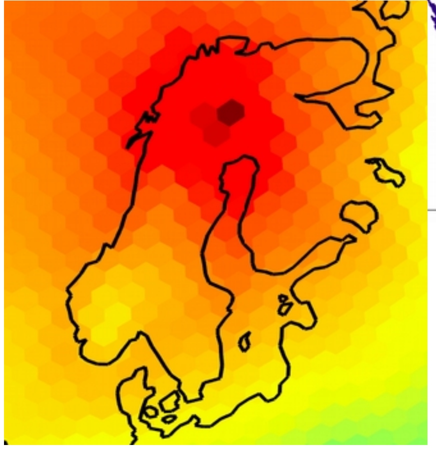
- When concentrations are low, e.g. SSA calculations tend to get noisy.
- $SSA=\sigma_{sp}/(\sigma_{sp}+\sigma_{ap})$
- Concentration adapted makes the data analysis more neat



The source area of all stations combined covers the Arctic well

- HYSPLIT 4.9
  - ensemble run (27 trjs)
- GDAS 1^{o} gridded met data
  - 3 h resolution
- Geodesic grid
- 7 days back

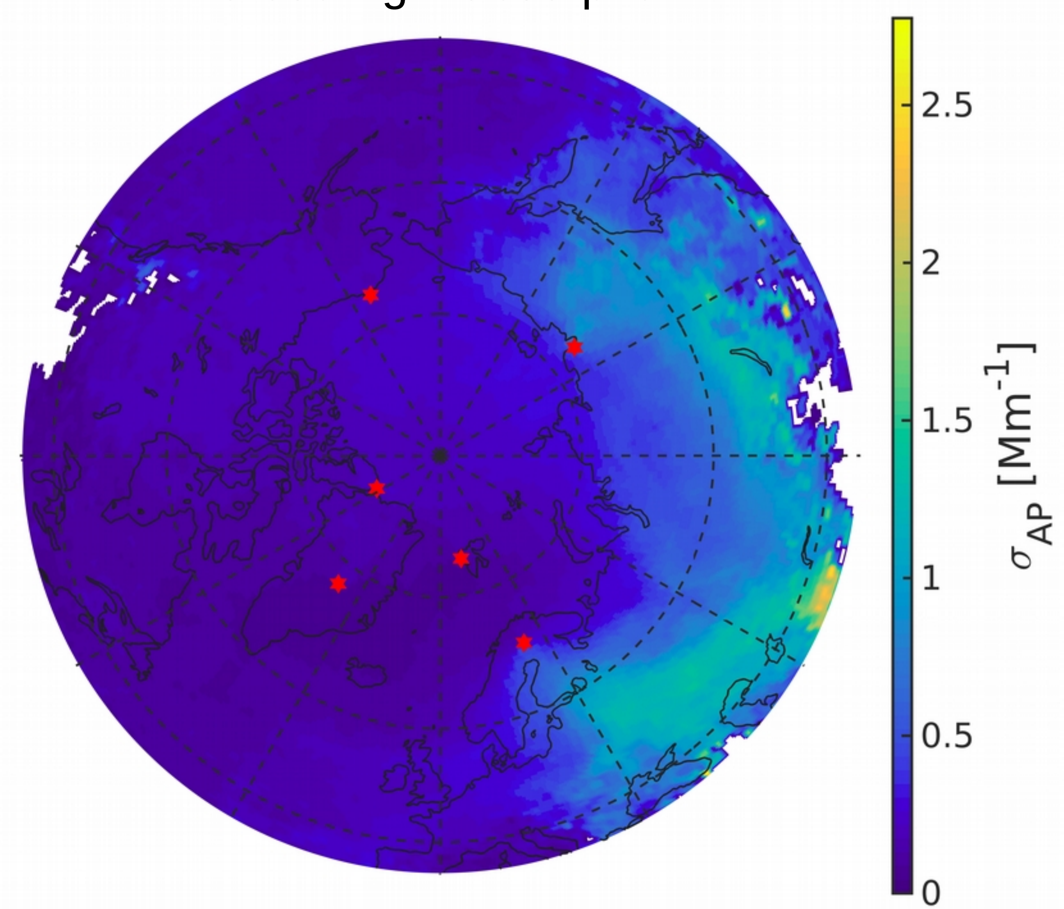




Trajectory analysis

- Match trajectories with measurements
  - Each trajectory was matched with measured σ_{ap}
  - All grid cells traversed were assigned the measured σ_{ap}
- Repeated for all stations for the whole time series
- Stitching everything together, weighing was done according to distance from receptor point
  - closer=more weight
- Closest station is probably the most accurate
  - No transformation on the way

Aerosol light absorption



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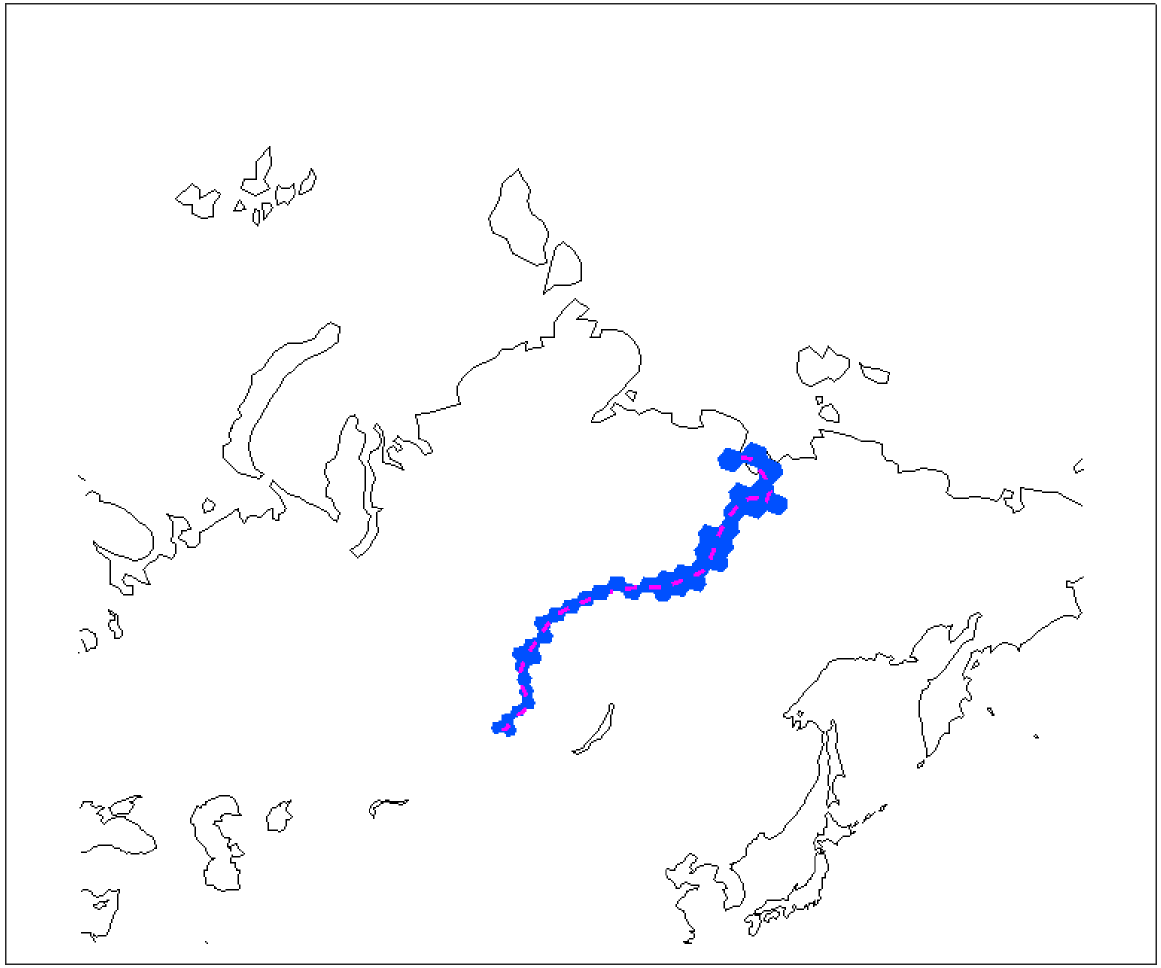

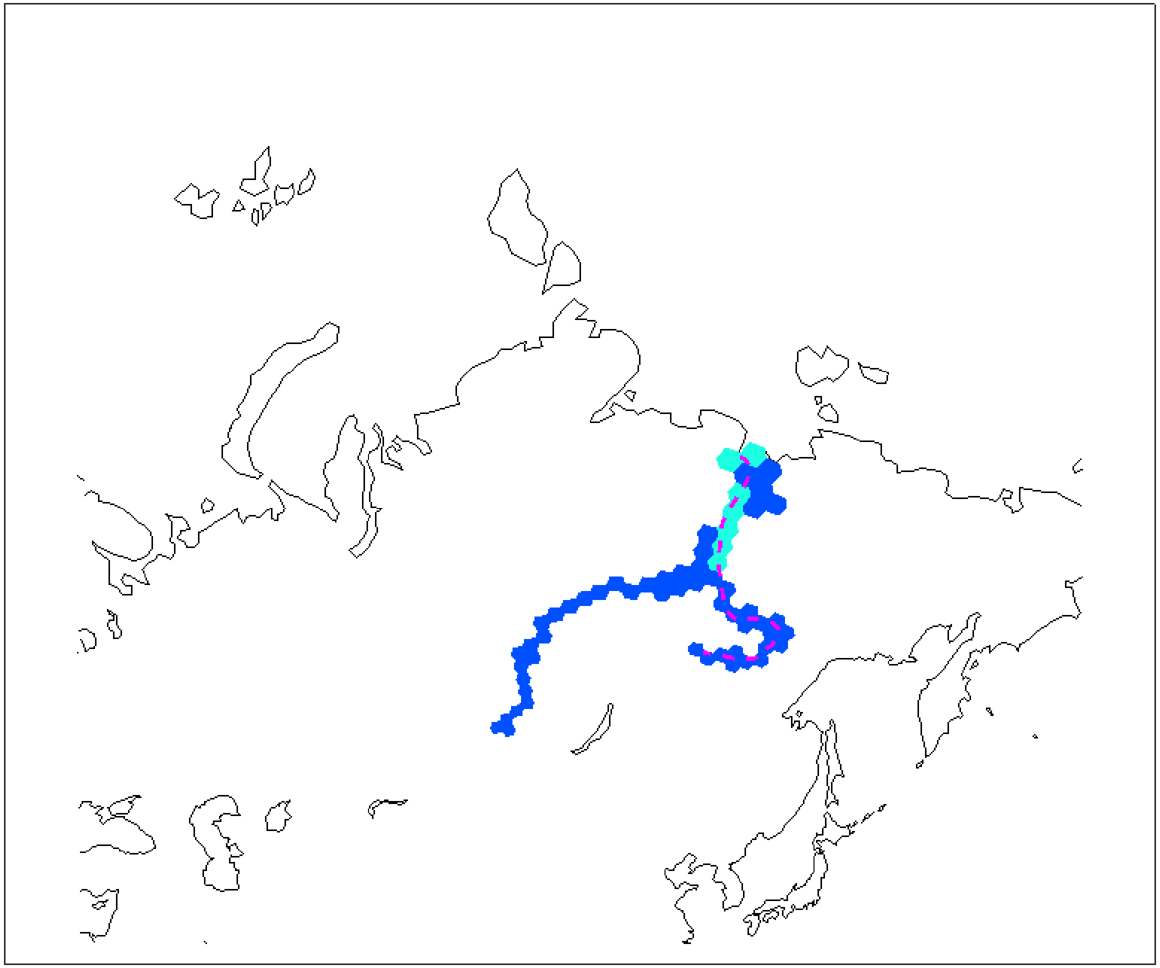

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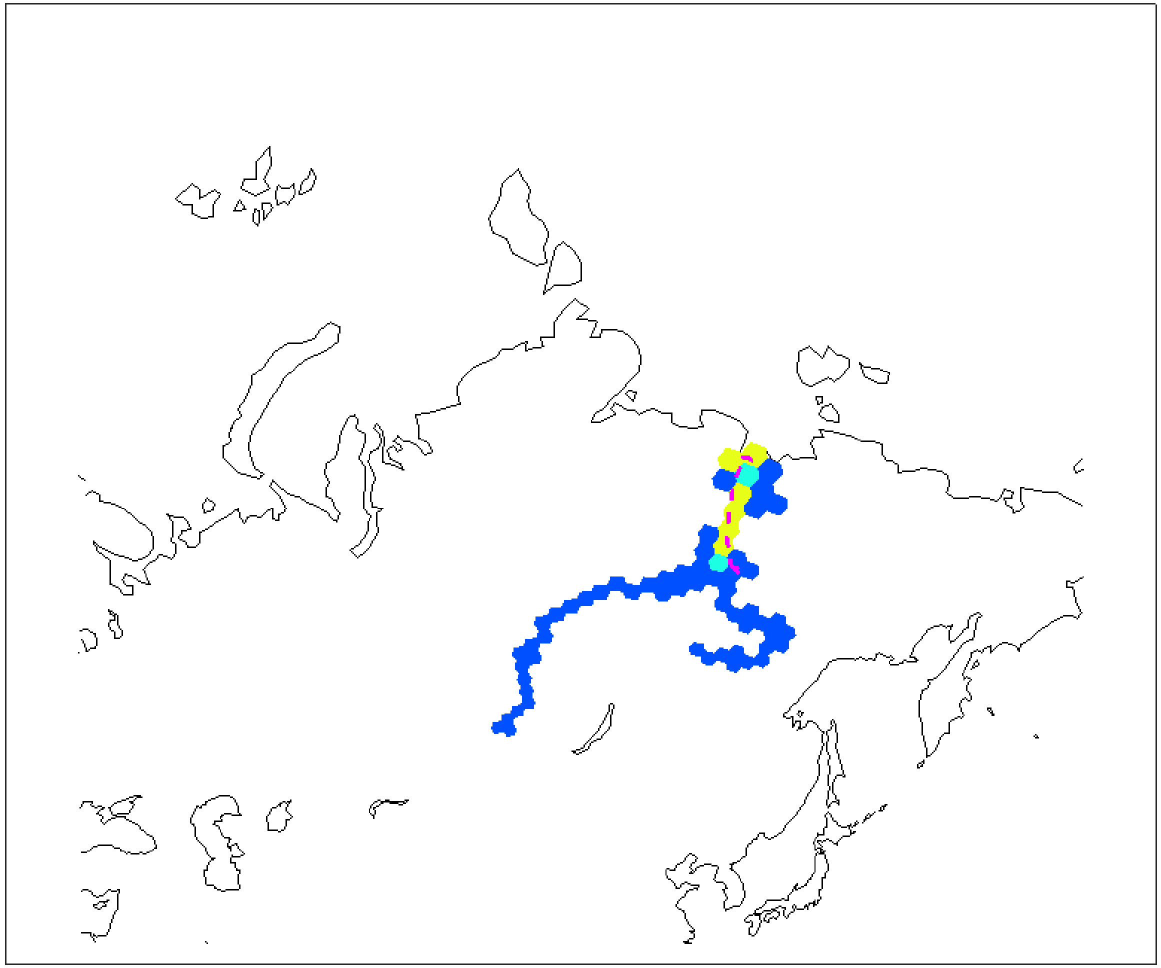

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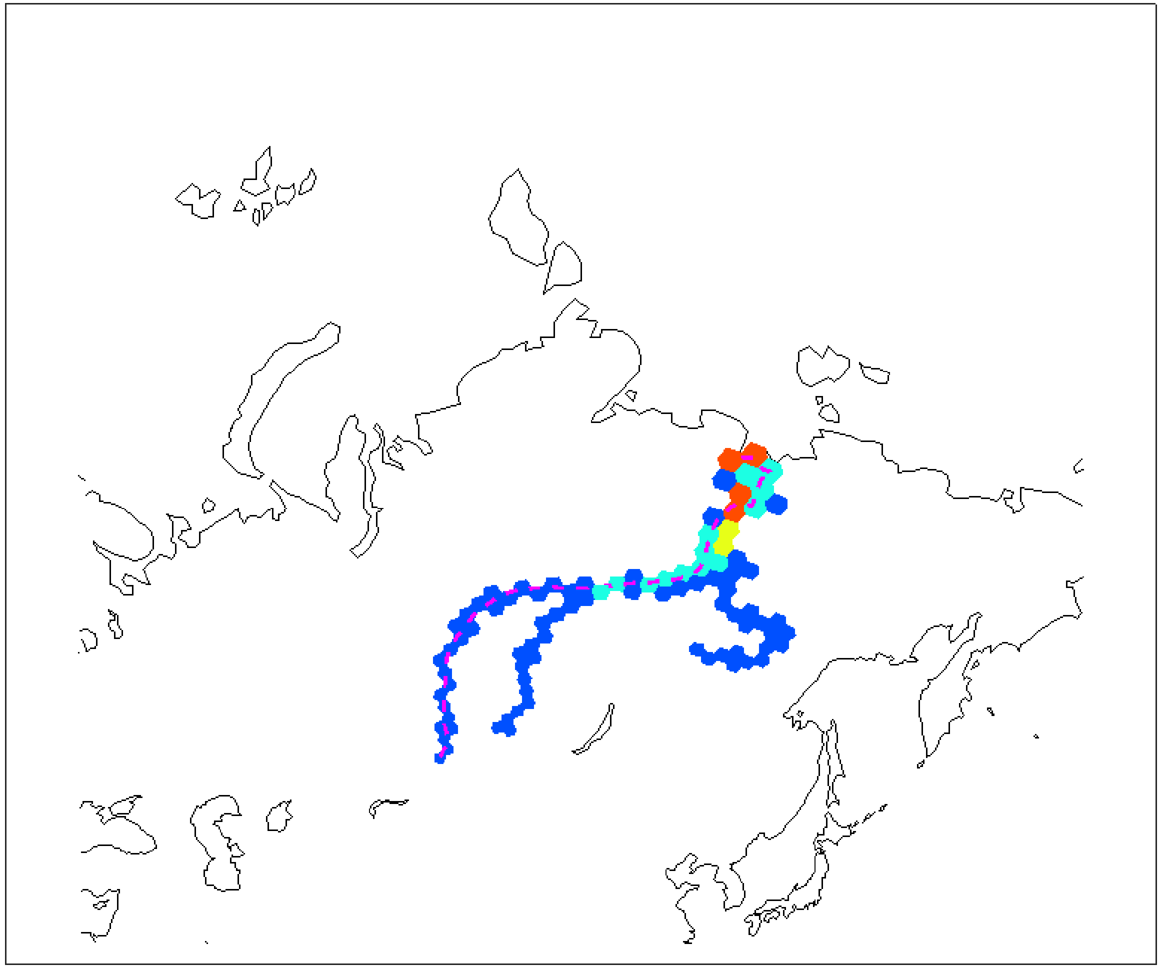

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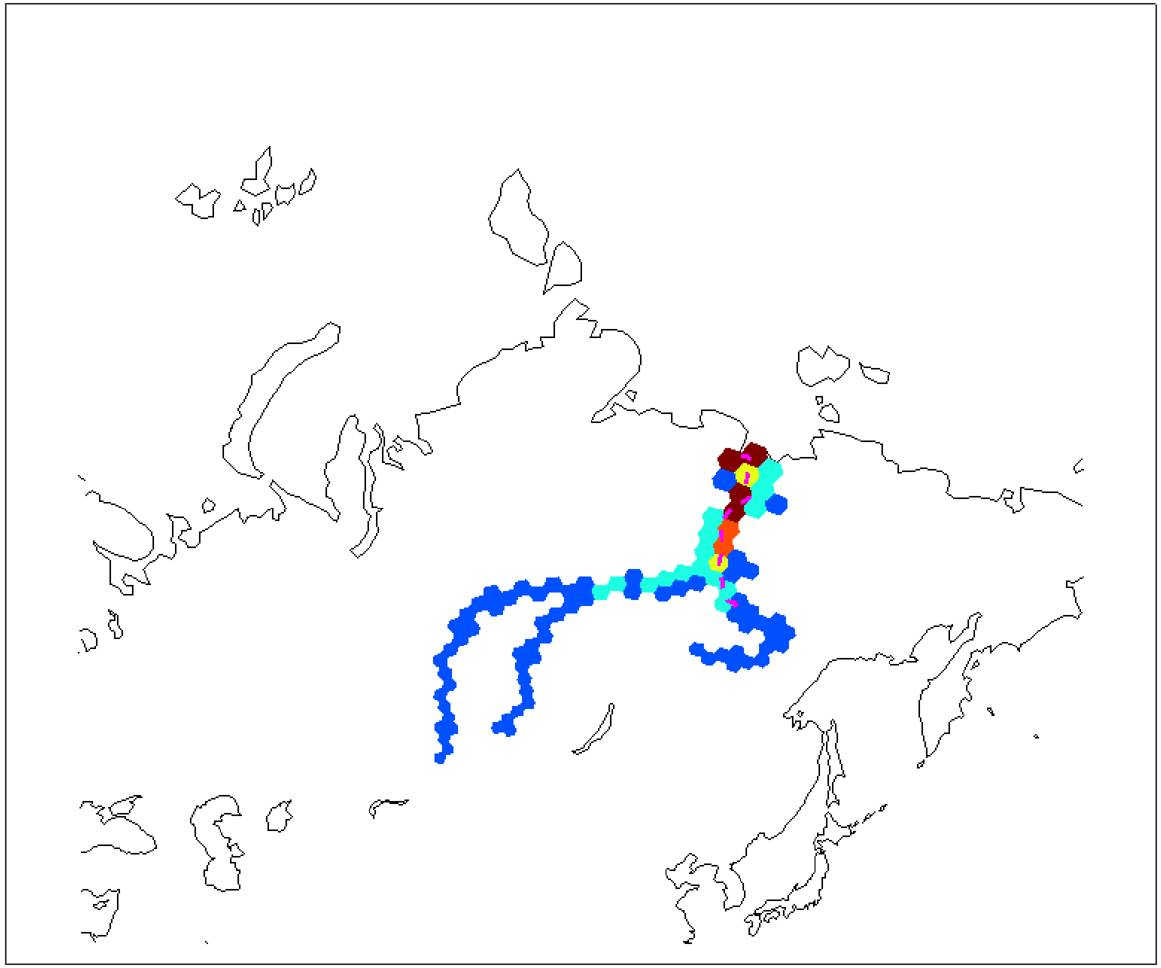

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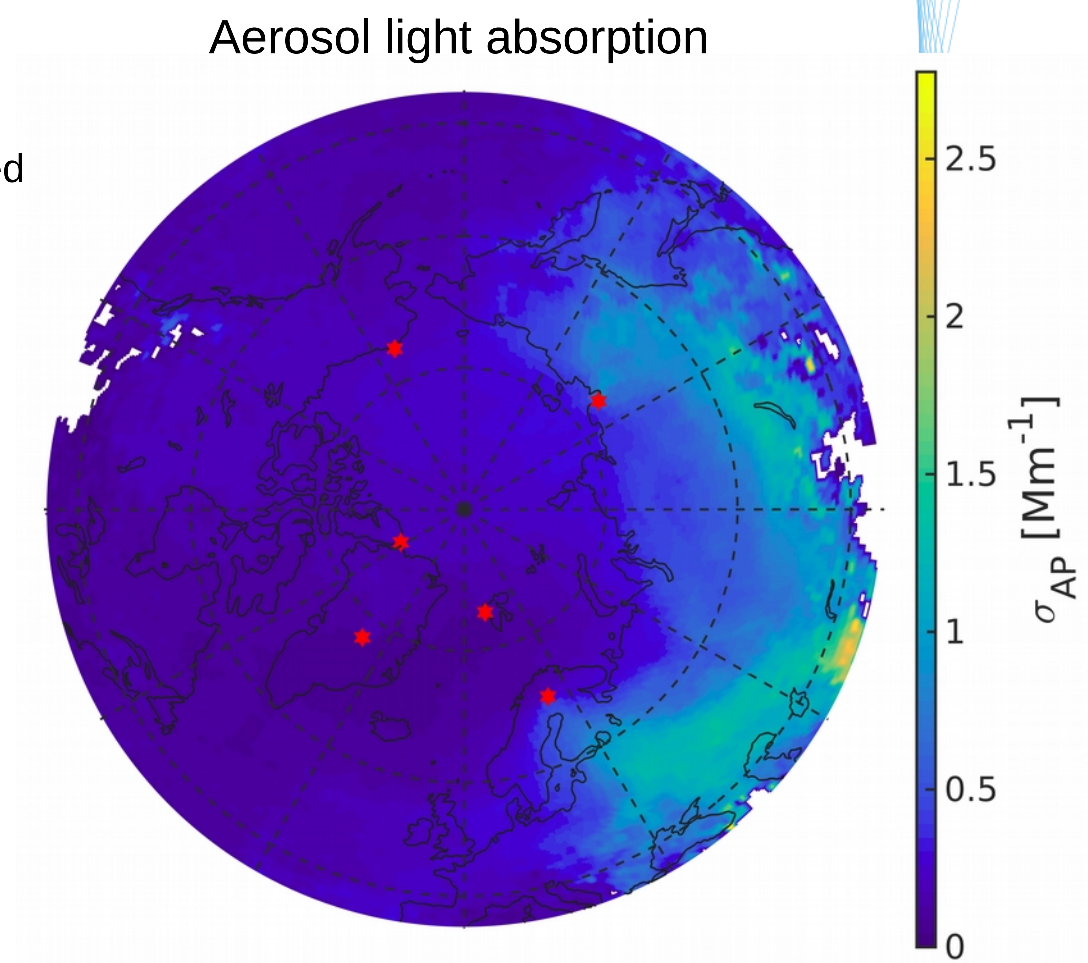
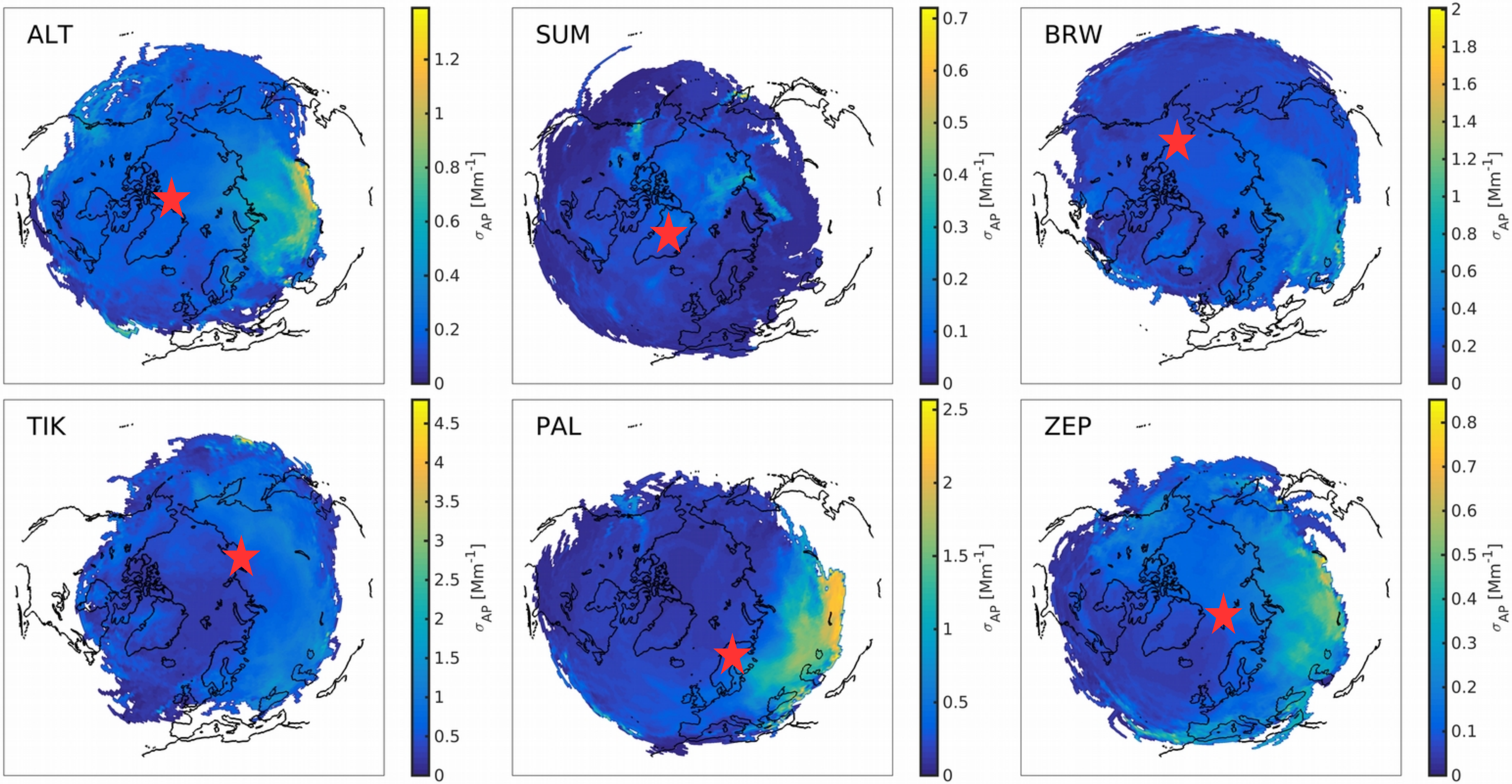


Light absorption coefficients as "seen" by different stations



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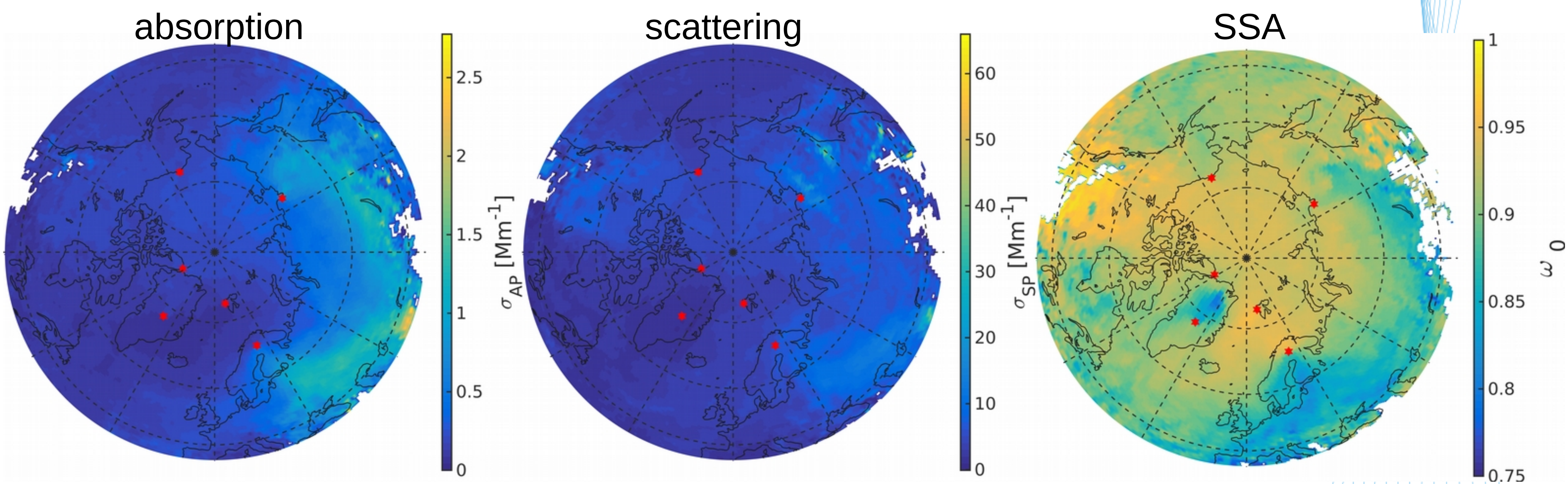
Thank you!



Further reading:

Schmeisser, L., Backman, J., Ogren, J. A., Andrews, E., Asmi, E., Starkweather, S., Uttal, T., Fiebig, M., Sharma, S., Eleftheriadis, K., Vratolis, S., Bergin, M., Tunved, P., and Jefferson, A.: **Seasonality of aerosol optical properties in the Arctic**, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-1117, in review, 2018.

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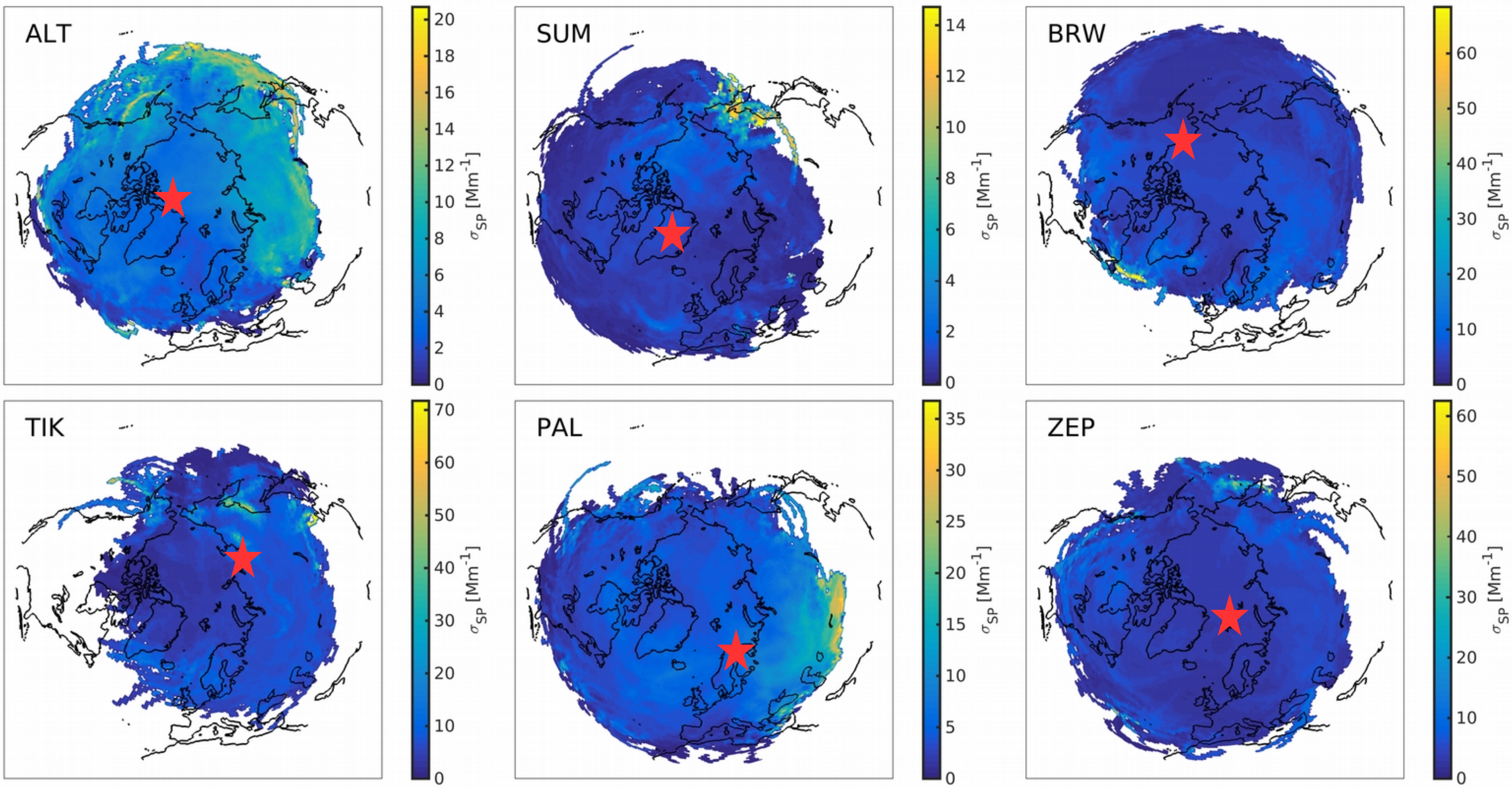
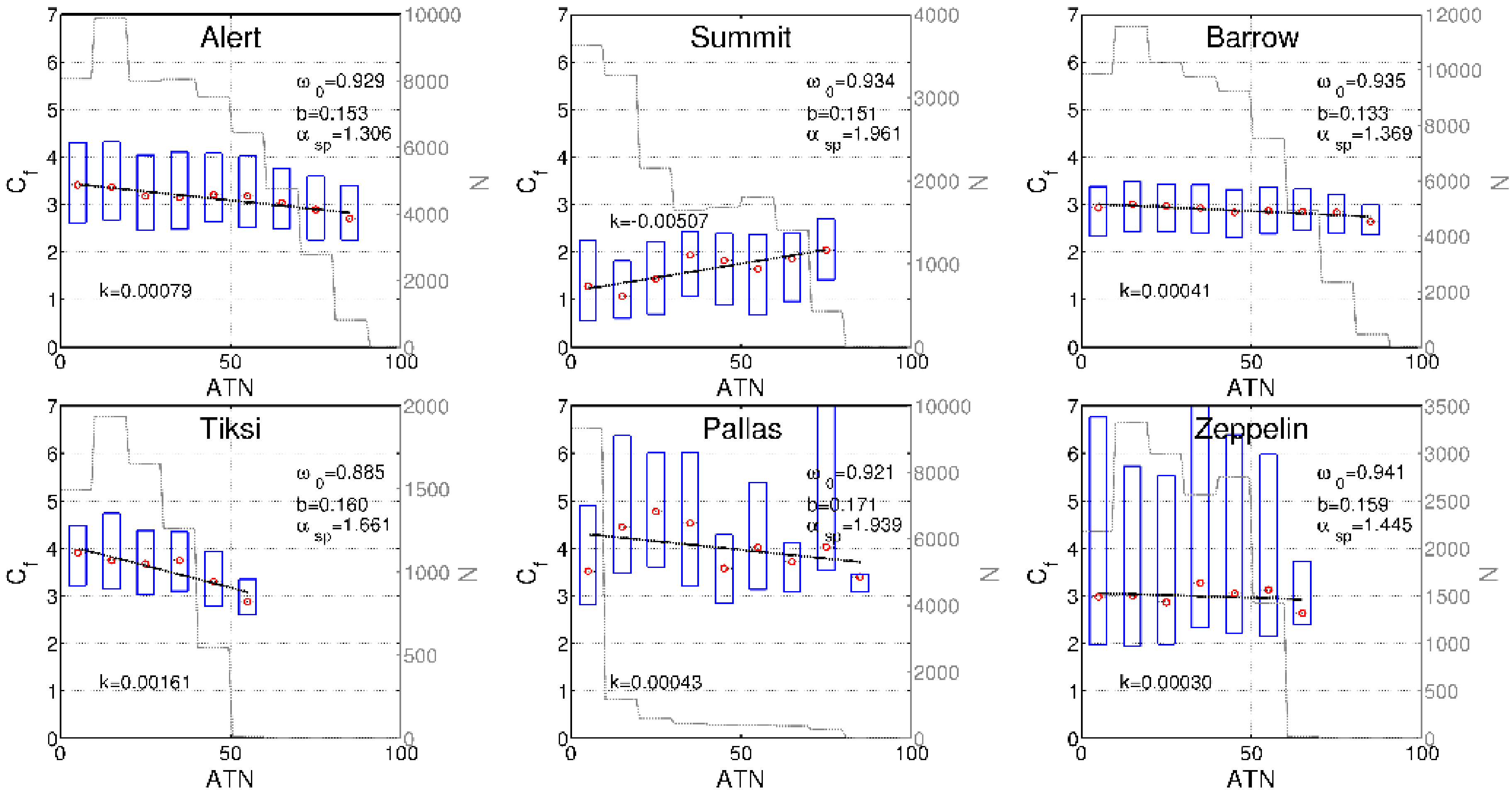
Light scattering coefficients



Correction factor to harmonize light absorption measurements in the Arctic

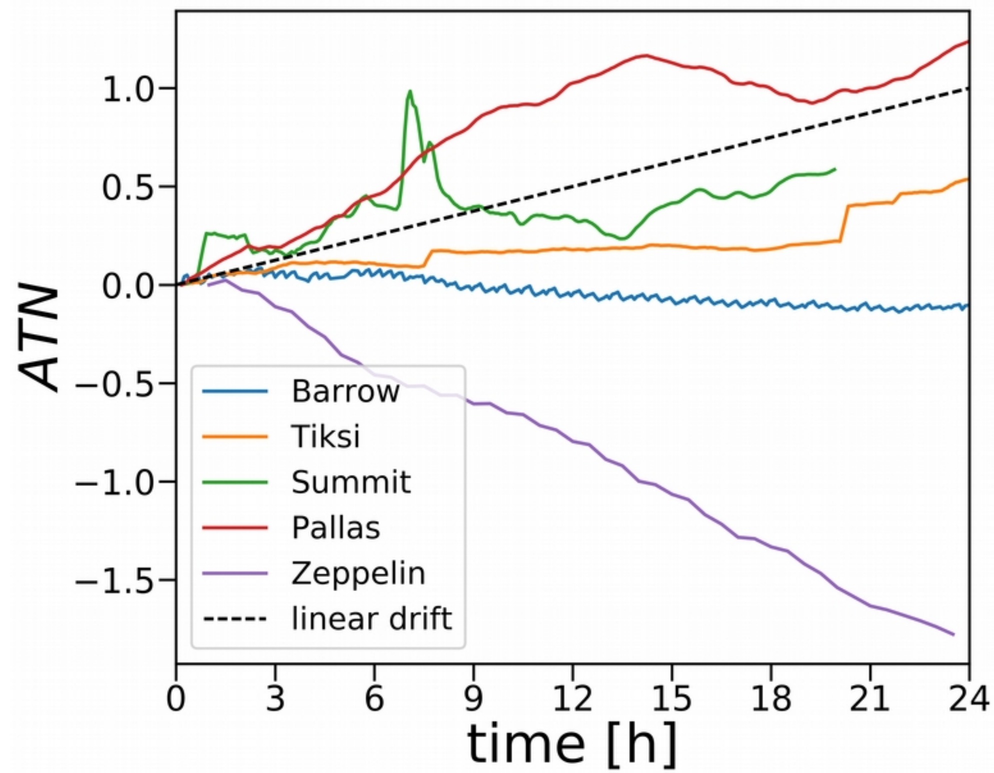


Drift in Aethalometers were observed at all stations

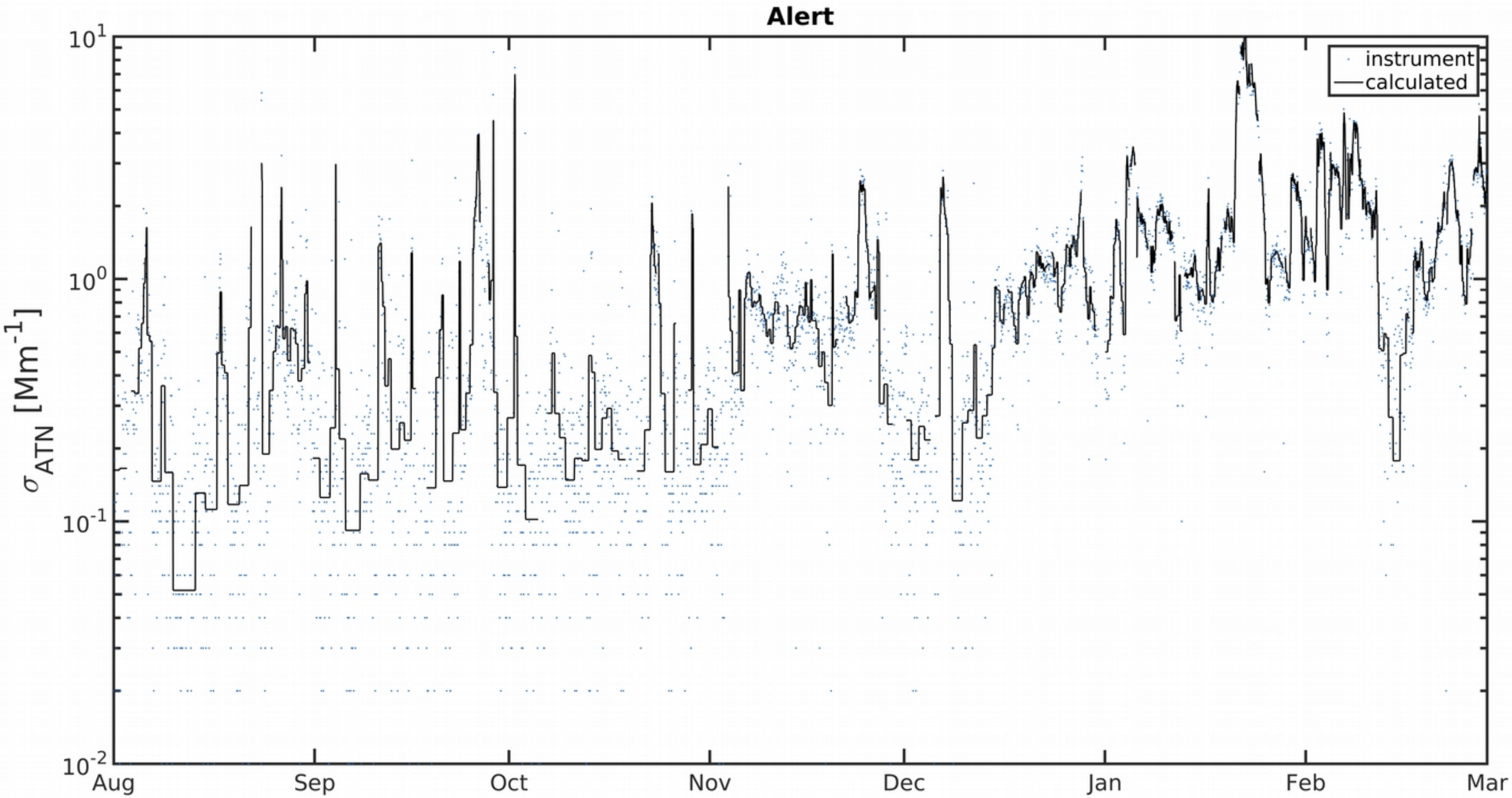
– Works best when instrument drift is minimal
  * How to minimise drift is tricky
  * Is it humidity, leak, electronic, etc.

– Absolute filter at the inlet can reveal how much the drift is

– Zero measurements should be conducted for at least 24 hours



Zoom in for Alert station



Best benefit of the method when ATN drift is minimized

- Boxcar averaging, noise is reduced as $\Delta t^{-0.5}$
- With no drift, noise is reduced as Δt^{-1}
- From error propagation

$$\delta\sigma_0 = \sqrt{\sigma_0^2\left(f_a^2 + f_q^2\right) + \left(\frac{\delta\sigma_{0,\mathrm{air}}\Delta t_{\mathrm{air}}}{\boxed{\Delta t}}\right)^2}$$

- Drift can be an issue