A Field Instrument for Measuring Rain Conductivity in Real-time

Alfred M. Moyle and Dennis Lamb
Meteorology Department, 503 Walker Building
The Pennsylvania State University
University Park, PA 16802

What?

- Develop an economical, real-time, single parameter monitor of precipitation quality as a supplement to NADP network operations.
- Ultimately, to build a network of instruments; some co-located at existing AIRMoN or NTN sites (validation) & some located between existing network sites (interpolation).

Why?

To provide data with high spatial & temporal resolution to -

- Guide the development of deposition models.
- Improve our understanding of source-receptor relationships.

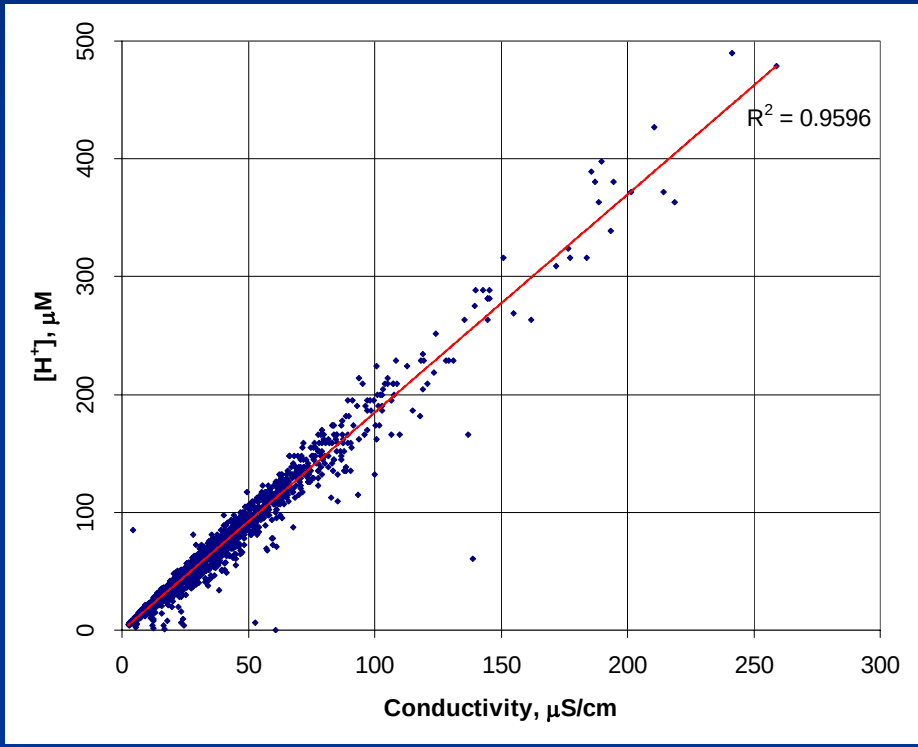
How?

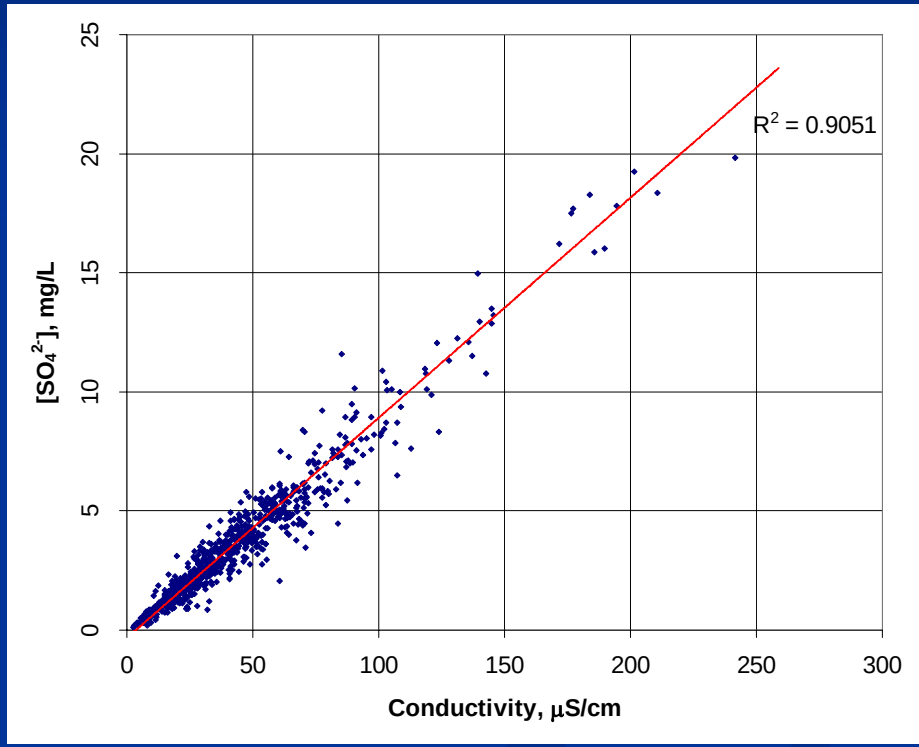
Take advantage of -

- Strong statistical links between the concentration of sulfate, pH, & the electrical conductivity of rainwater in the northeastern United States.
- The fact that electrical conductivity, unlike pH, is relatively easy to measure & conductivity electrodes are inexpensive & robust.

PA15 AIRMoN Data – 1992 Thru 2007

Strong correlation between electrical conductivity & [H^+] or [SO_4^{2-}] ...

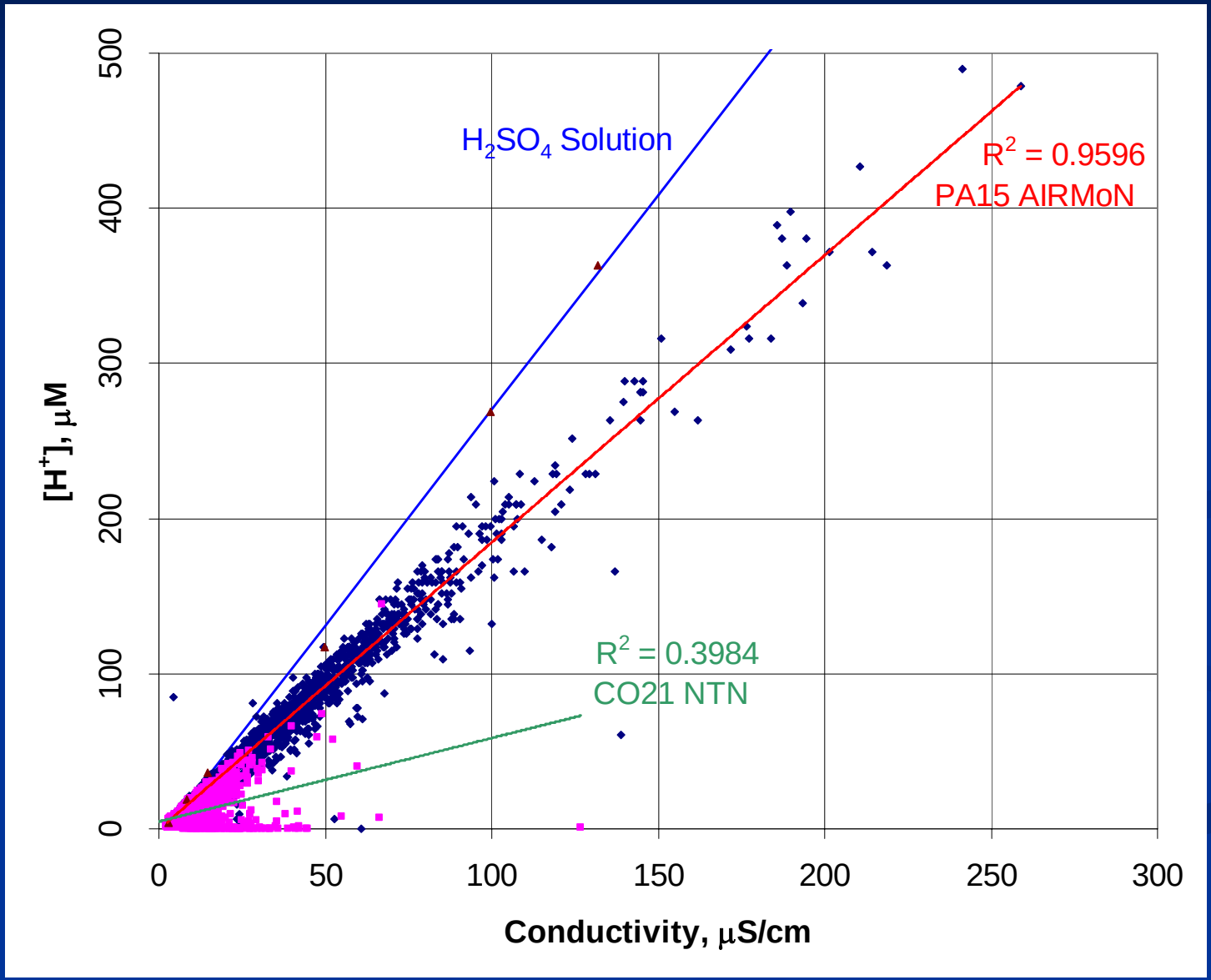




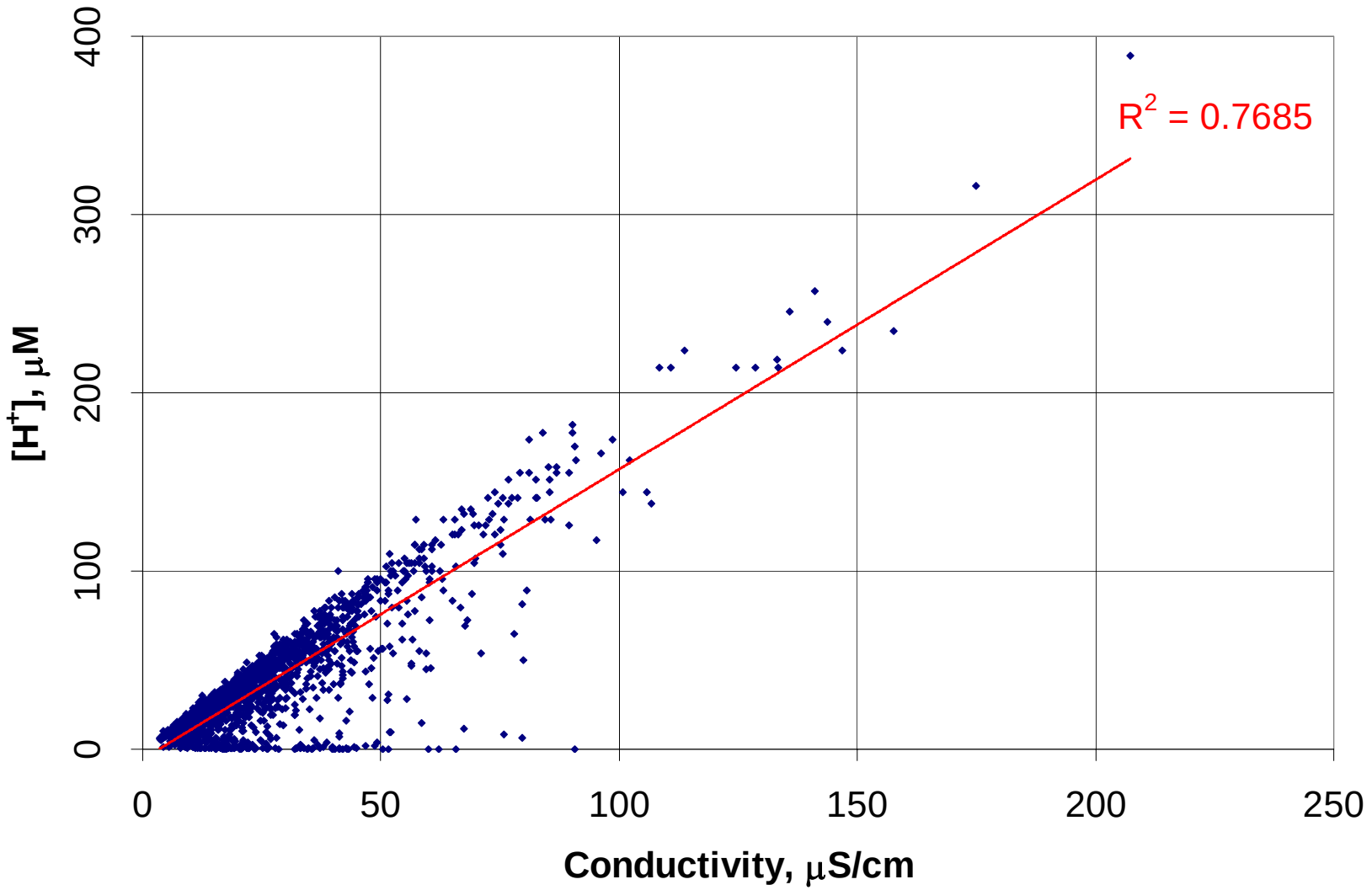
This is the basis for the Penn State conductivity instrument.

Contrast – CO21 vs. PA15

CO21 NTN data (1978-2007) exhibit distinctly different behavior ...



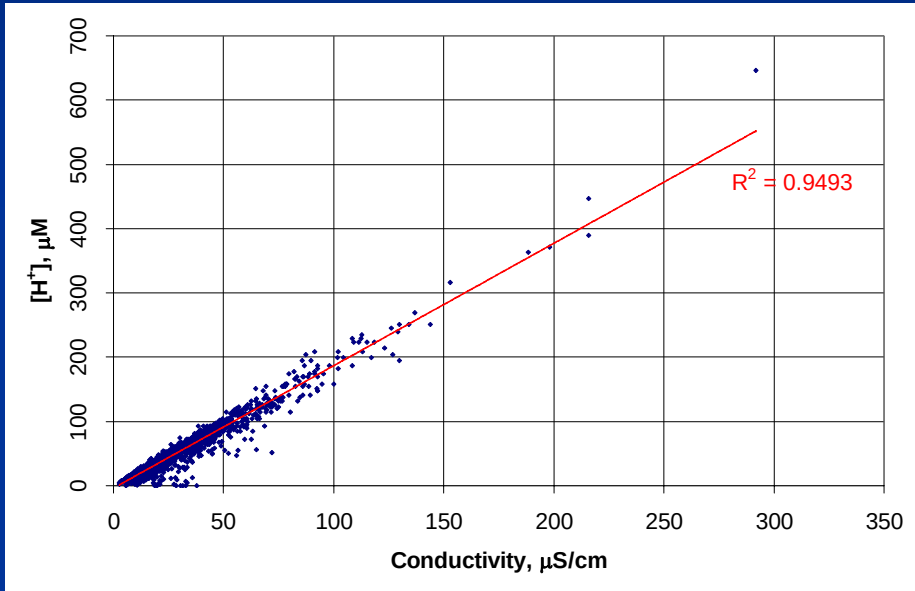
IL11 AIRMoN – Intermediate Behavior



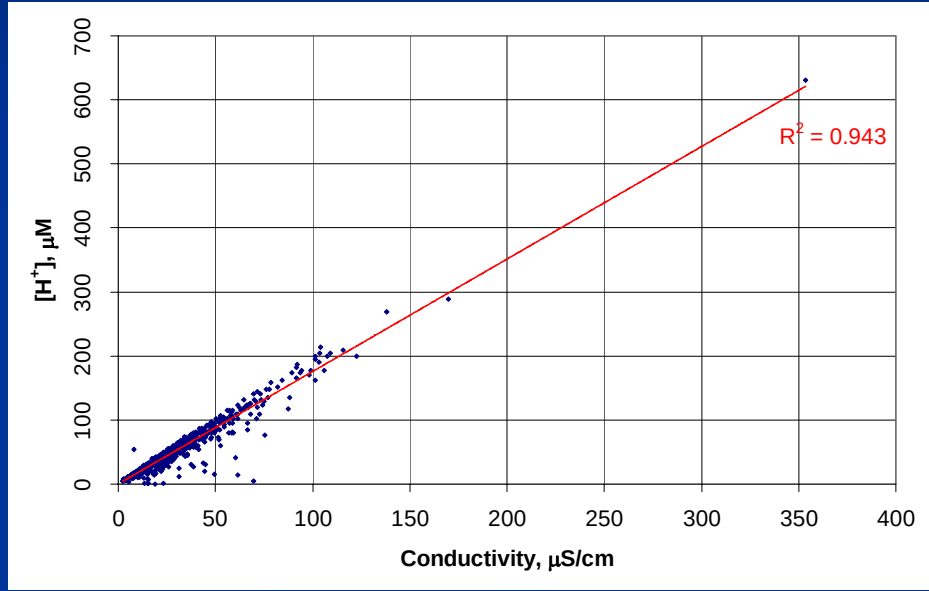
Has characteristics of both northeastern & western sites ...

Northeastern AIRMoN Sites

NY67 ...

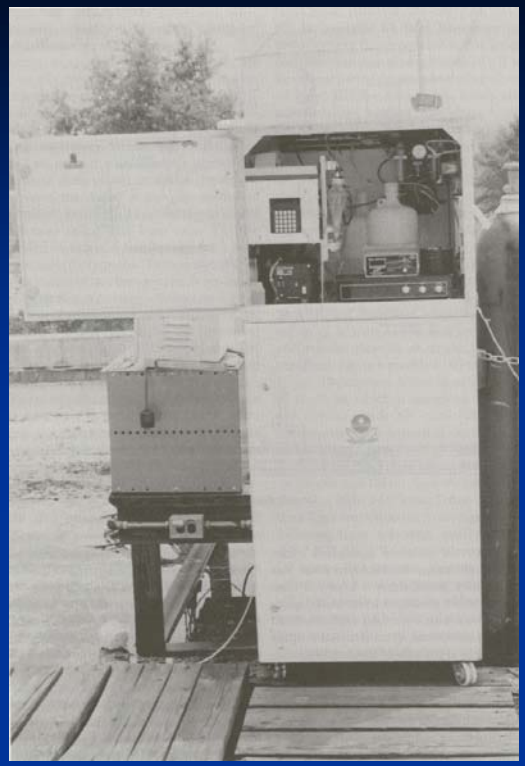


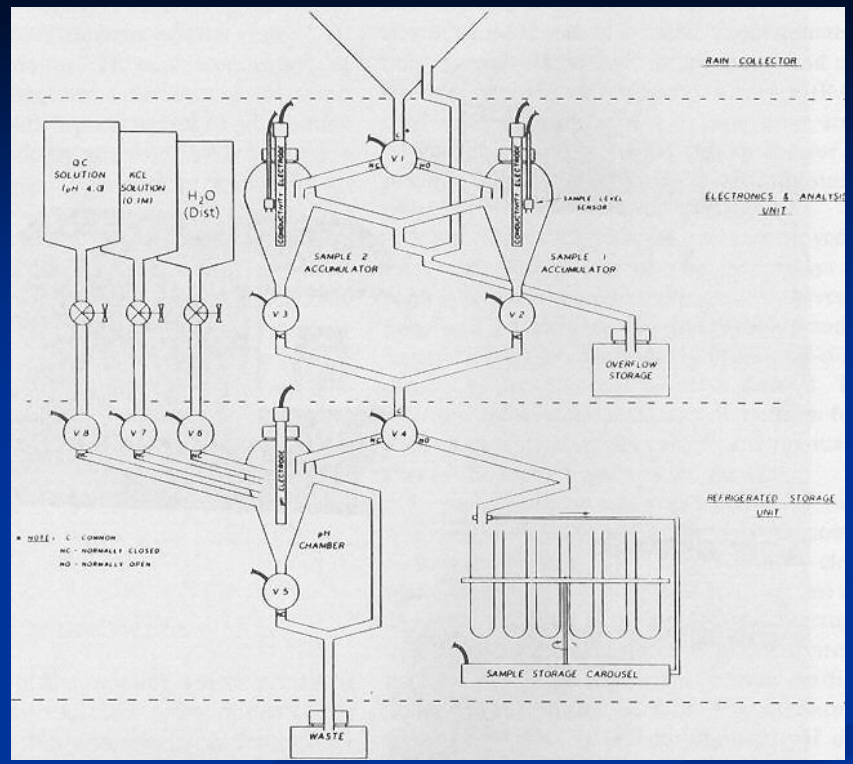
WV99 ...



Strong correlation between conductivity and pH ... Similar to PA15.

An Earlier Real-time Instrument





Kronmiller, et al (1990) Atmospheric Environment **24A**, 525-536 -

- Direct measurement of pH under full computer control ... Requires frequent calibration of the pH meter & careful storage of the pH electrode when in standby mode.
- Provides real-time measurements of pH & conductivity & fractional event sampling with refrigerated storage of samples for lab analysis.
- Instrument was large, relatively complex, & relatively expensive - thus limiting the number which could be deployed.
- Up side – direct measurement of pH applicable anywhere.

The Penn State Conductivity Instrument

- Lid mechanism consists of an MIC 300C wet sampler, on loan from CAPMoN.
- Polypropylene funnel collects falling precipitation and channels it into the instrument.

The Penn State Conductivity Instrument

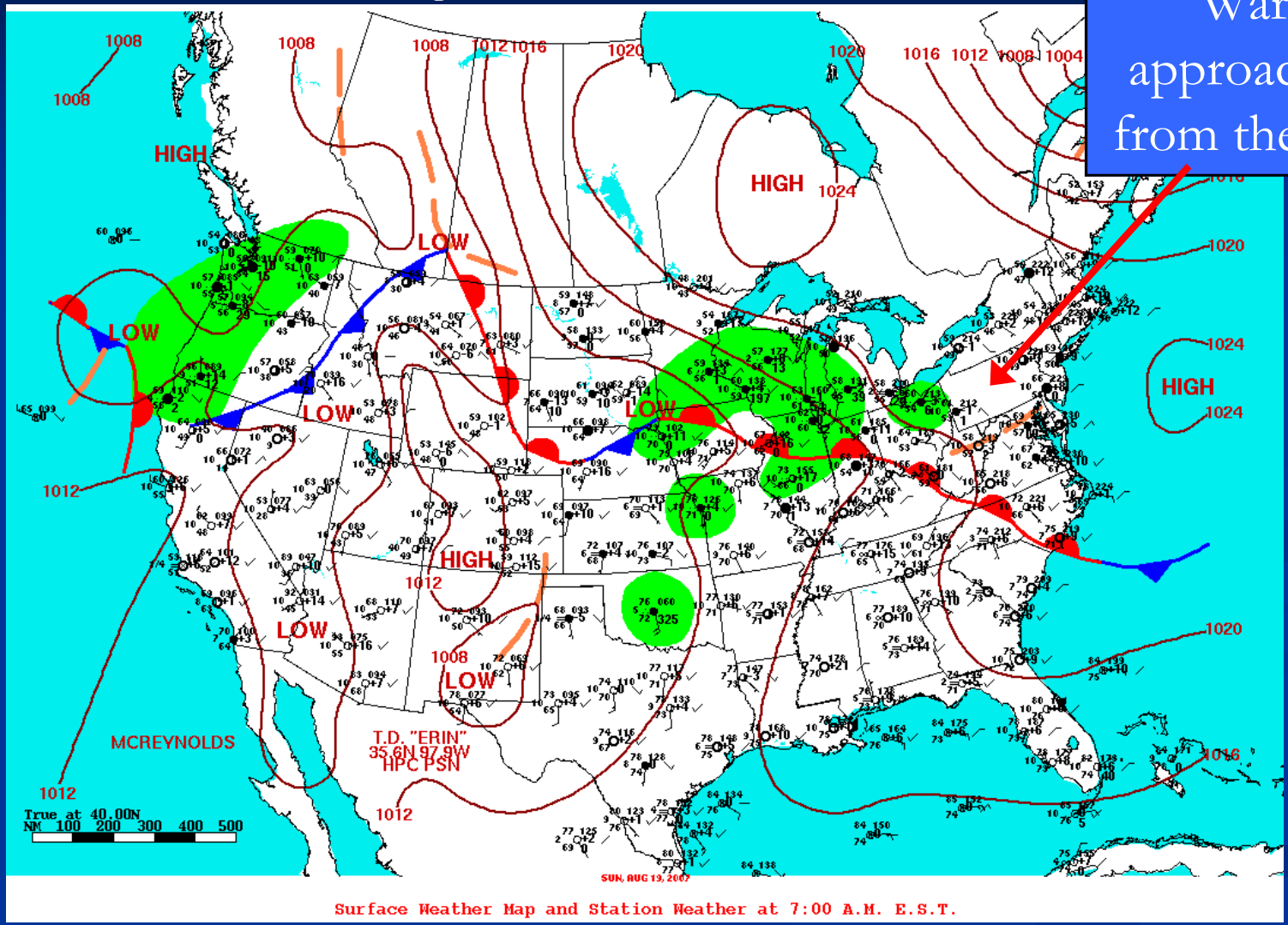
- Conductivity electrode mounted in a cast acrylic, flow-through cell.
- Trap on downstream side of cell insures that the electrode remains wet and free of air bubbles.
- Tipping bucket rain gauge (0.0045" of precipitation per tip) provides rain rate information.

The Penn State Conductivity Instrument

- Utilizes off-the-shelf, NIST-traceable digital conductivity meter, modified to provide for computer data logging.
- Meter calibrated using commercially available standards.
- Data logging system uses SD memory cards to record conductivity, cell temperature, tipping bucket signal, and MIC 300C signals (lid open/closed, sensor wet/dry, and error conditions).

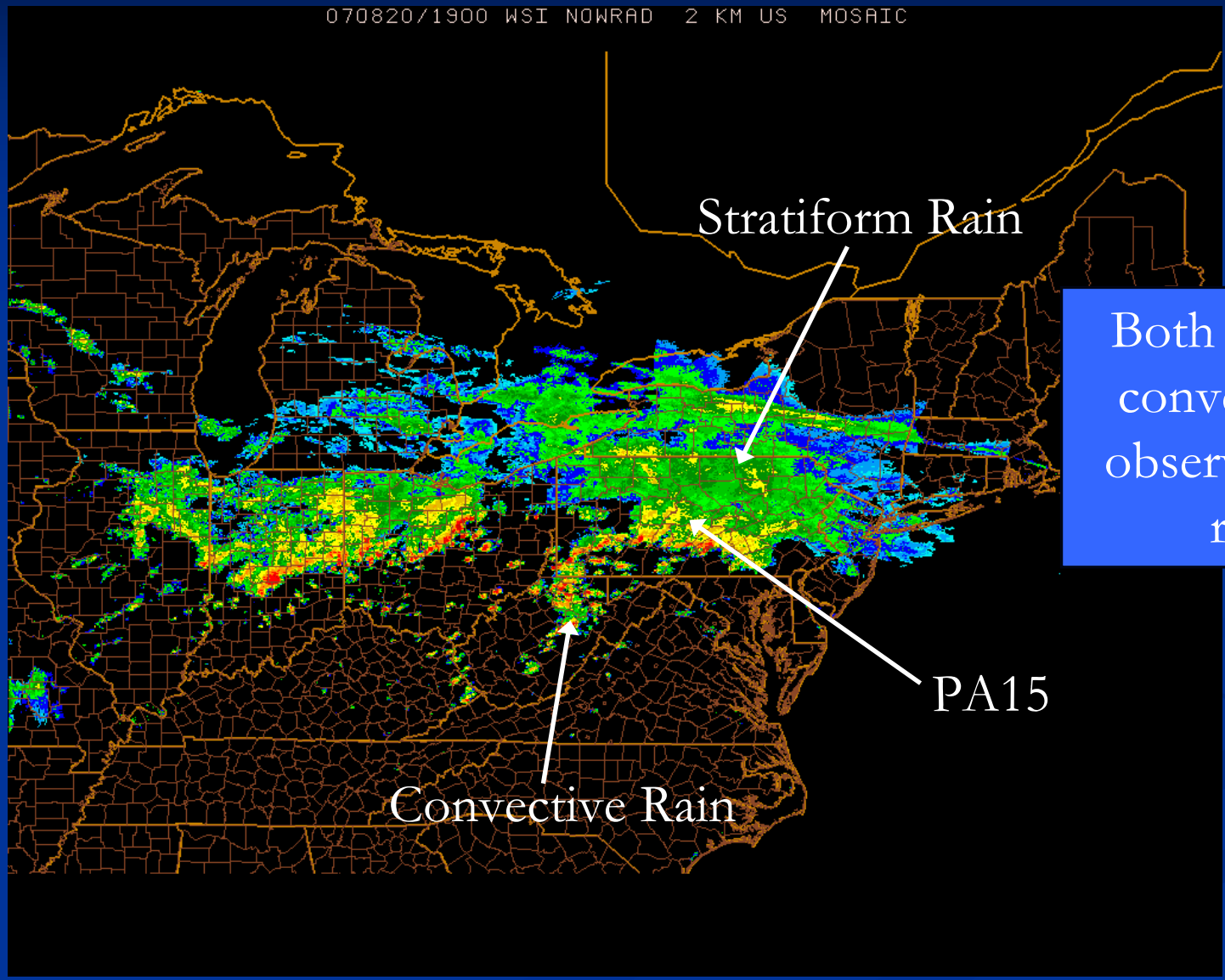
Case Study: 19 – 21 August 2007

August 19, 2007 – 7:00 AM EST



Warm front approaching PA15 from the southwest.

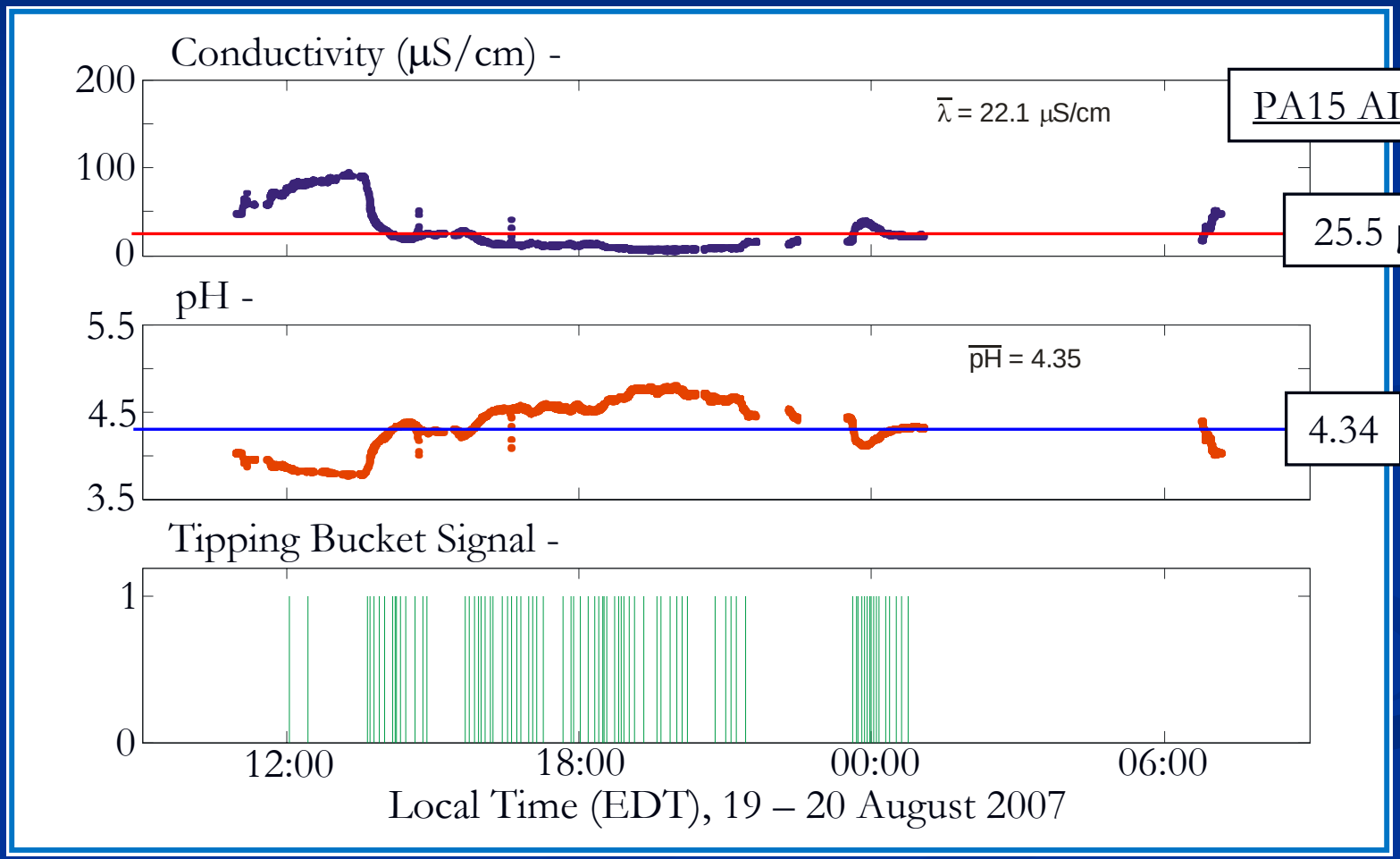
Case Study: 19 – 21 August 2007



Both stratiform and convective features observed during this rain event.

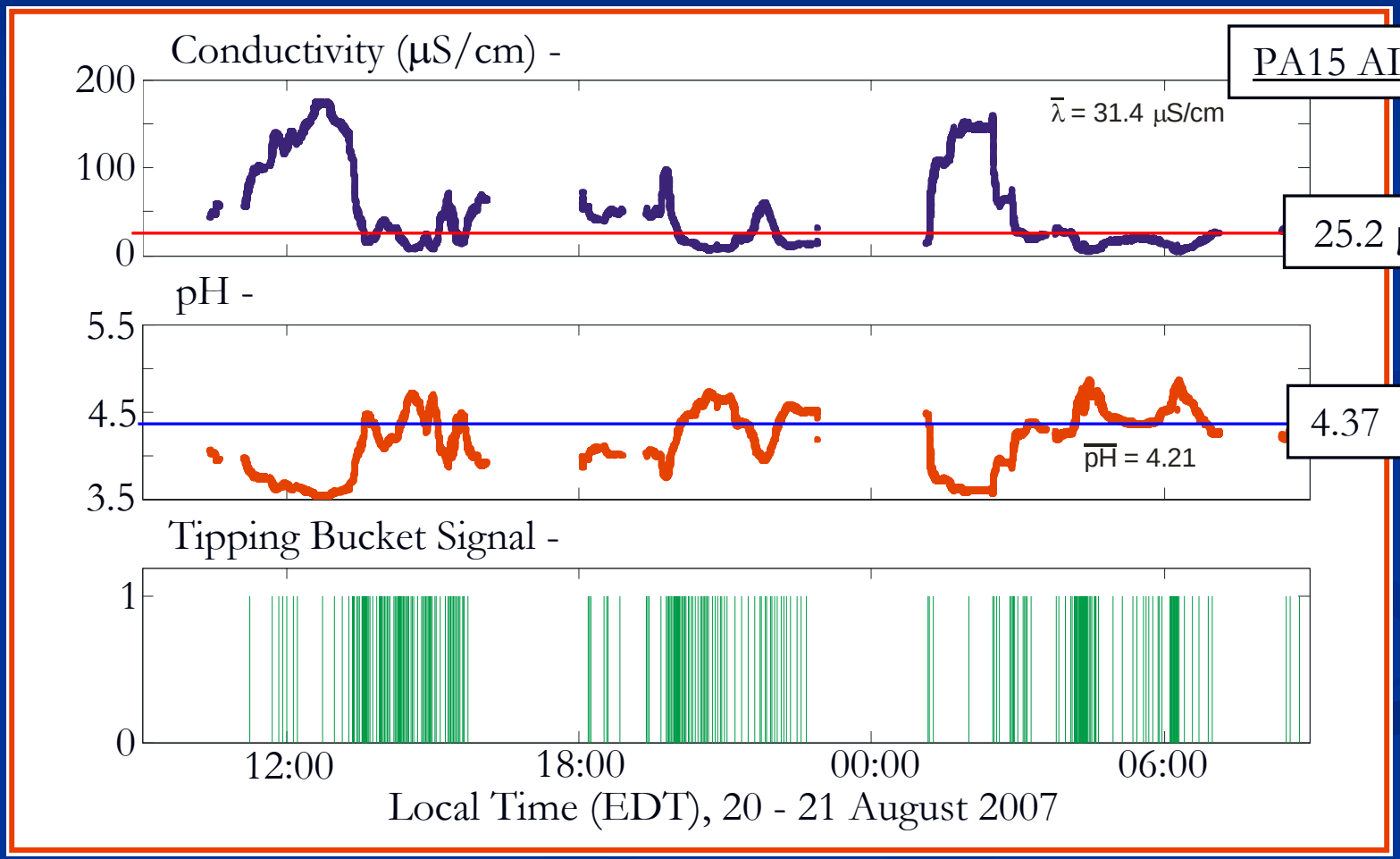
Case Study: 19 – 21 August 2007

Chemical signature of stratiform rain -



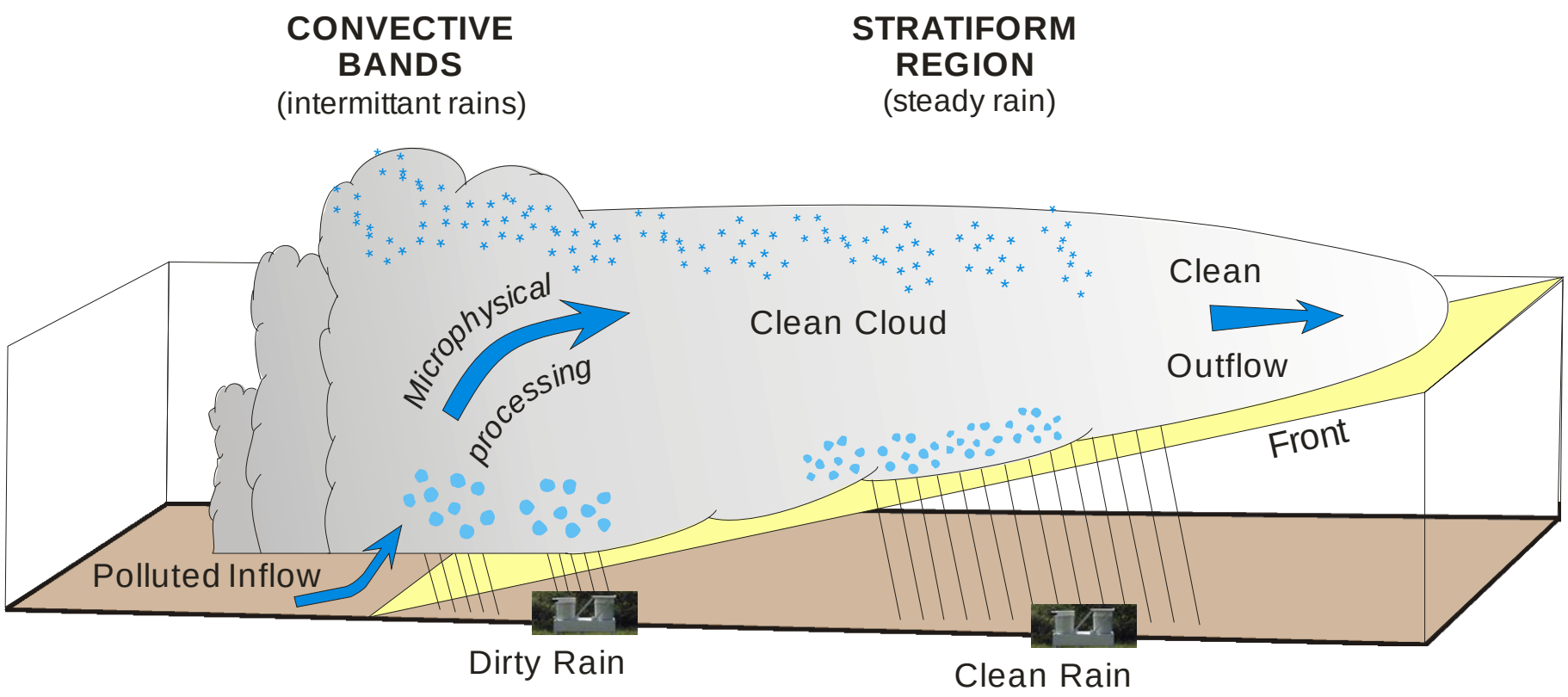
Case Study: 19 – 21 August 2007

Chemical signature of convective rain -



Case Study: 19 – 21 August 2007

Chemical Quality of Rains from a Warm Front



Adapted from Ahrens (1994)

Conclusions

- The electrical conductivity of rain can be measured automatically and in real time.
- Using conductivity as a surrogate for rain pH is appropriate for decisively acidic precipitation that we see in the northeast.
- This technique provides high temporal resolution results which allow us to see the details "inside" AIRMoN data.
- Initial results suggest a strong relationship between the conductivity of rain and any "processing" which the precipitation has experienced.

Future Steps

- Develop a more compact version of the instrument and deploy multiple units at AIRMoN or NTN sites in the northeastern United States.
- Eventually expand operations up to the mesonet scale for the purpose of testing chemical deposition models.

Acknowledgements

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- We thank Bob Vet and Dave MacTavish of the Canadian Air and Precipitation Monitoring Network for lending the MIC 300C collector used in this project.