Real-time Rain Conductivity as a Surrogate for pH: Development of a Field-deployable Instrument

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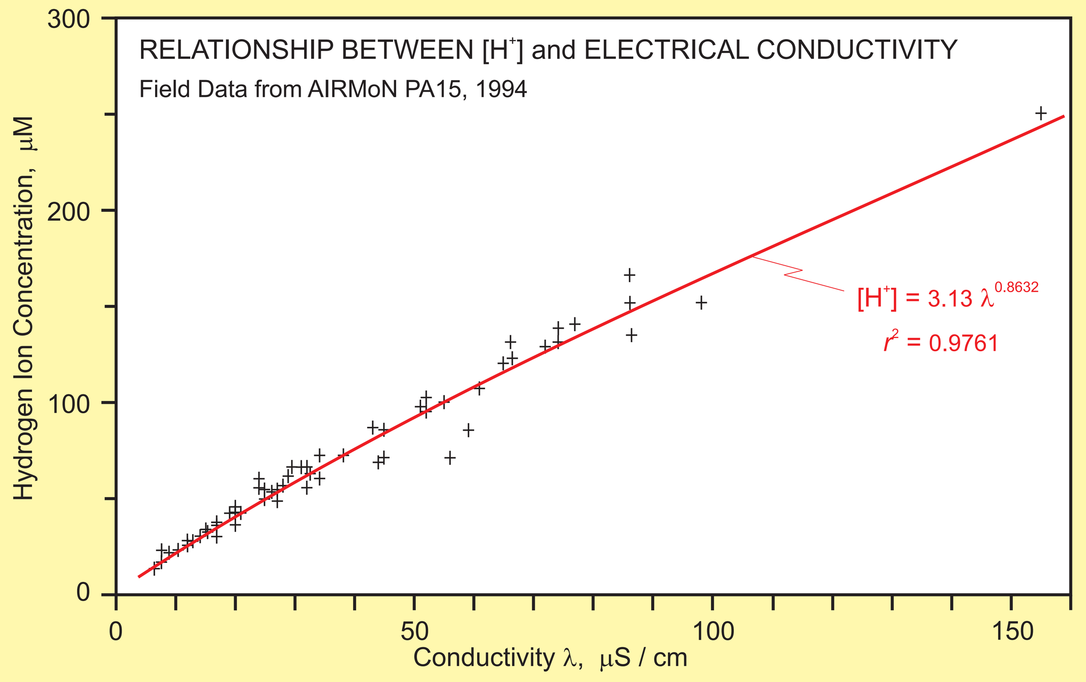
INTRODUCTION

The "daily" protocol of AIRMoN, compared with the "weekly" sampling of NTN, represents a significant improvement in the temporal resolution of wet-deposition data. Still, the single measurement of pH that AIRMoN currently provides on a given day represents only the broadest average of rain acidity; all the natural variability of the weather system is masked by the collection of a single rain sample. The fine temporal signature of individual storms at a given location, which might well reveal mechanistic information about cloud processes, is not available with the current monitoring strategy. In order to address the need for higher-resolution data, we have developed an economical, real-time, single-parameter monitor of precipitation quality.

Electrical conductivity (λ), unlike pH, is relatively easy to measure, and its variations can be monitored continuously in time to give data representative of rain pH throughout a storm. In a presentation at the Fall 2006 NADP Technical Meeting, we described a manually-operated prototype instrument designed to measure the conductivity of precipitation in real-time and presented measurements made during a convective precipitation event in State College, PA on 28 September 2006. The prototype system has now been converted to an automatic, field-deployable form and is undergoing testing on the roof of Walker Building at Penn State, prior to deployment at our Scotia (PA15) field site. Initial results reveal that convective storms yield rain with highly variable conductivity (hence pH) and that the chemical signatures of convective and stratiform events are significantly different. It is hoped that routine measurements of conductivity may help unravel the temporal signature of rain pH and yield a wealth of new data about the chemical evolution of acidic storms.



THE CONDUCTIVITY INSTRUMENT

•Utilizes an off-the-shelf, NIST-traceable digital conductivity meter (VWR International, Cat. No. 23226-501) which was modified to provide for computer logging of the conductivity signal. The meter is calibrated on a weekly basis, using commercially available conductivity standards or standards provided by the NADP/NTN Central Analytical Laboratory.

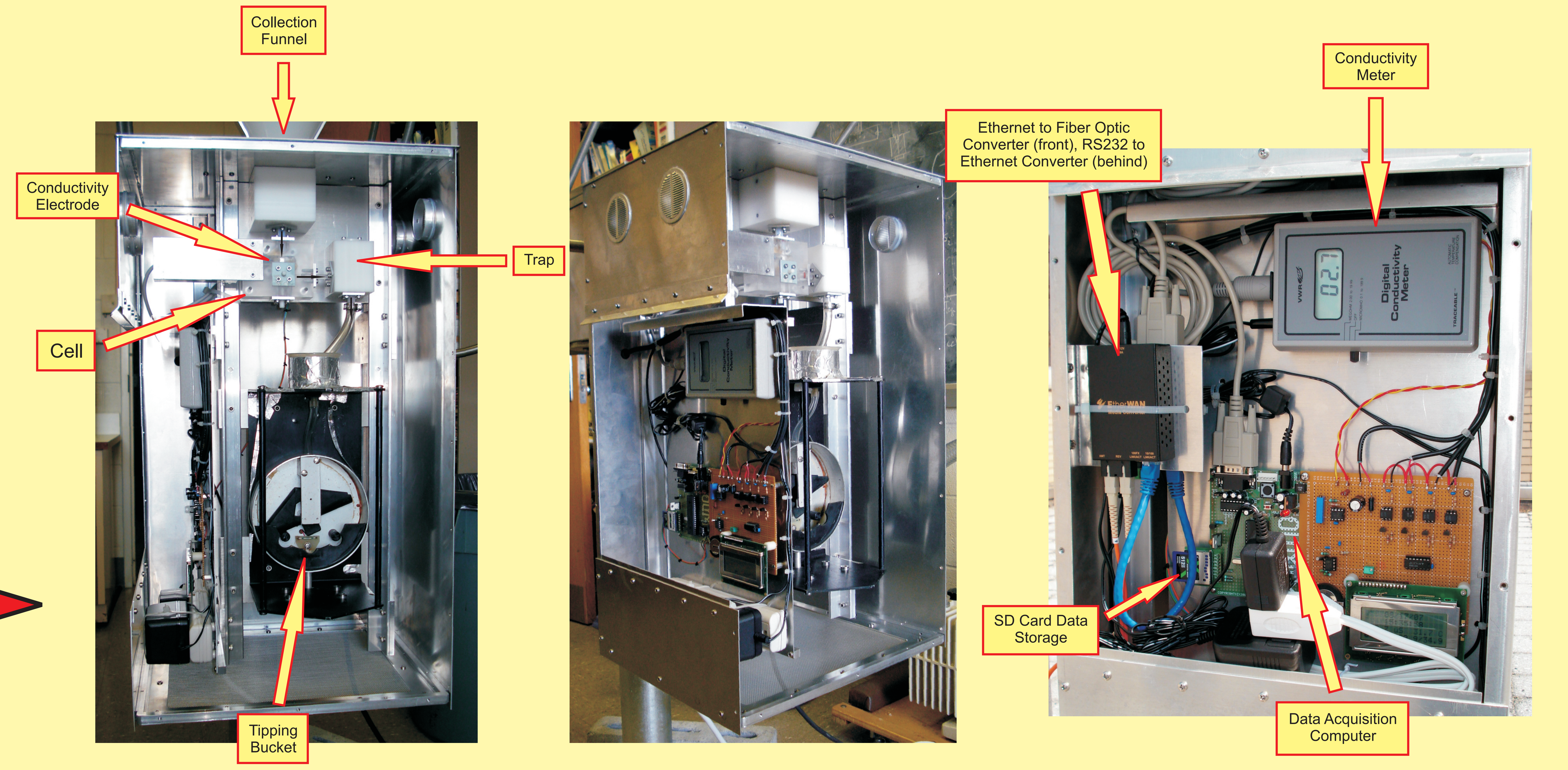
•The lid mechanism consists of an MIC 300C wet sampler, on loan from the Canadian Air and Precipitation Monitoring Network.

•The conductivity electrode is mounted in a custom designed, cast acrylic, flow through cell.

•A large polypropylene funnel collects the falling precipitation and channels it into the cell, where it encounters the conductivity electrode. A trap on the downstream side of the cell insures that the electrode remains wet and free of air bubbles.

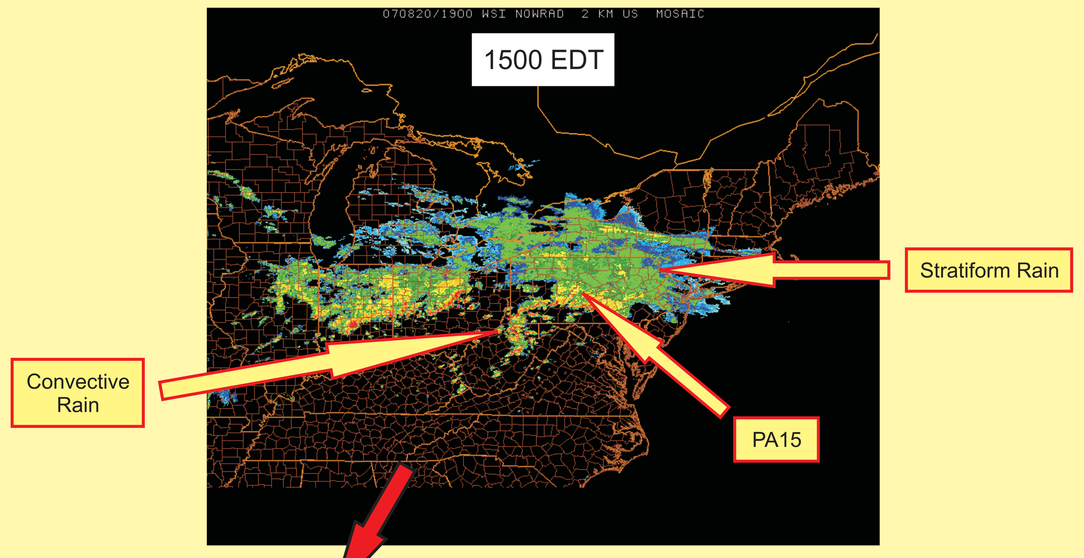
•A tipping bucket rain gauge (MRI, Inc., 0.0045" of precipitation per tip) provides rain rate information.

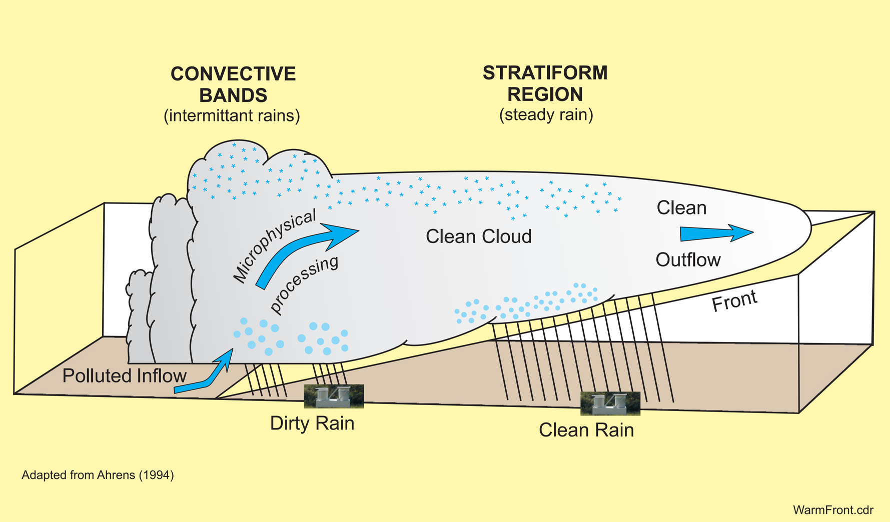
•Real-time conductivity/pH information is available on the Internet - http://mie.met.psu.edu.

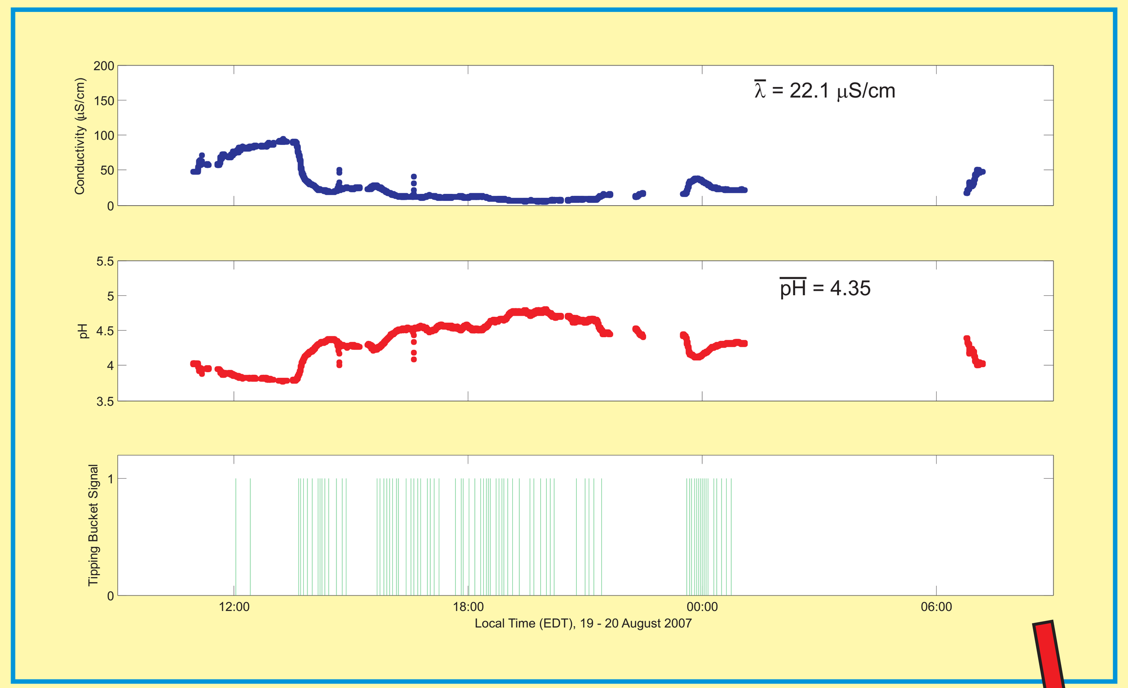


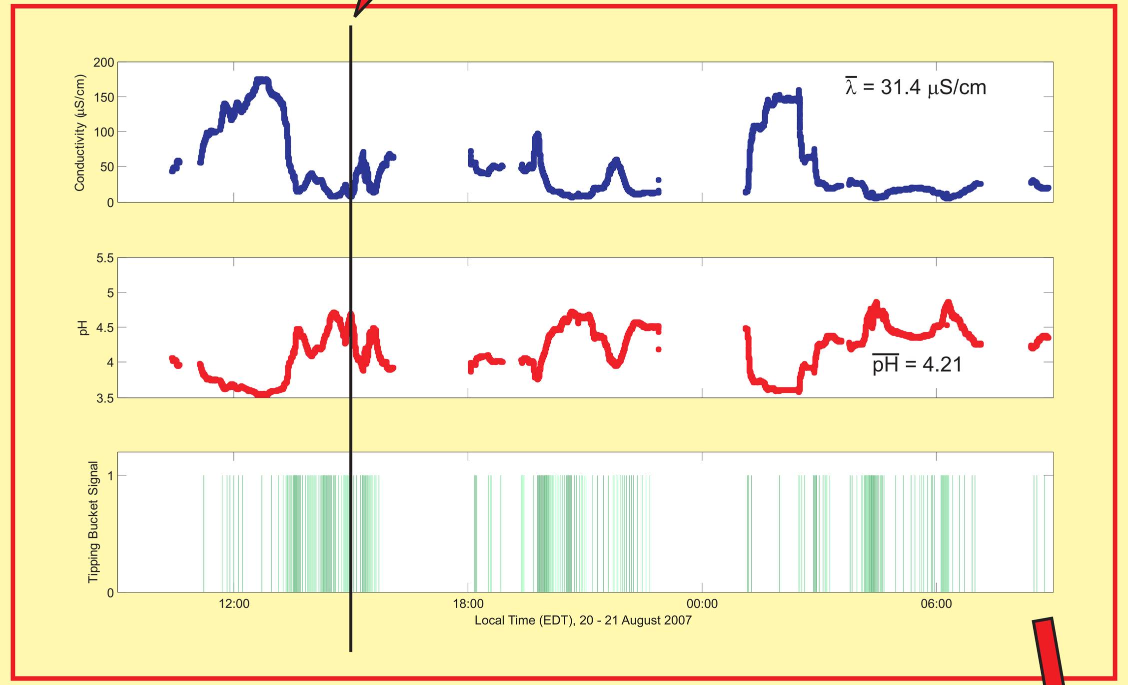
CASE STUDY: 19 - 22 AUGUST 2007

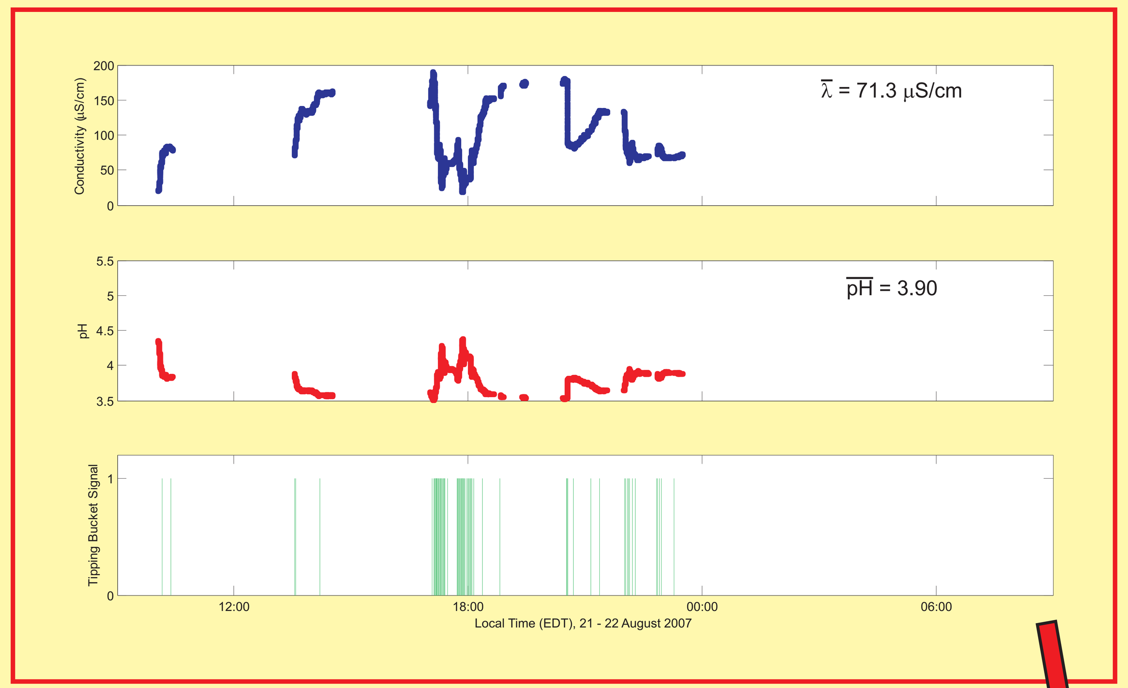
- Contrasting the chemical signatures of stratiform and convective rain events.

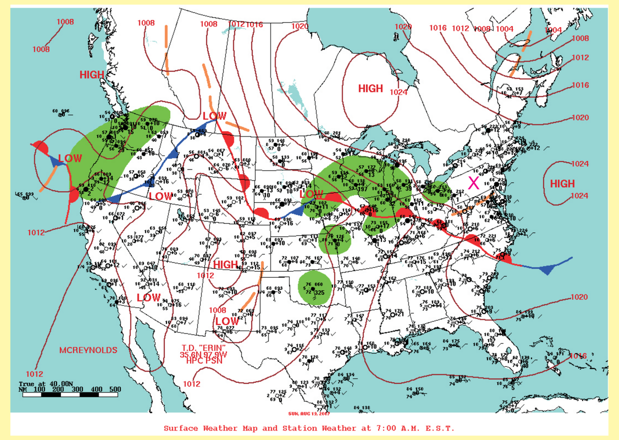


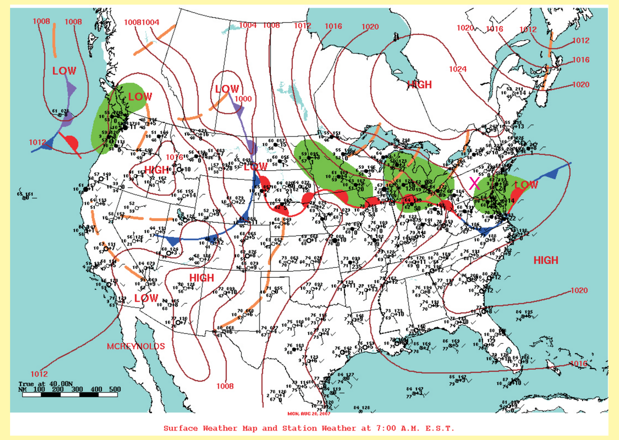


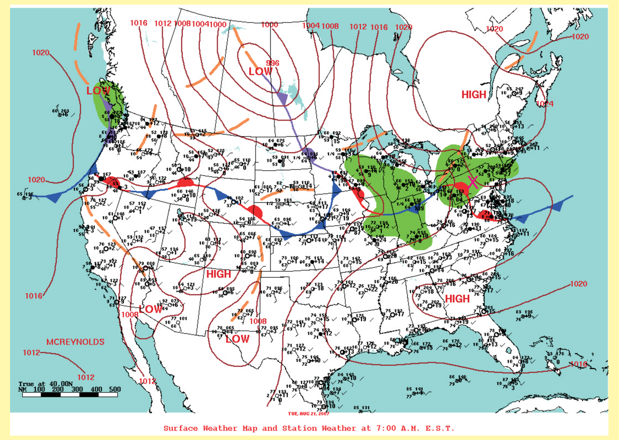












CONCLUSIONS

•The electrical conductivity of rain can be measured automatically **and** in real time.

•Using conductivity as a surrogate for rain pH is appropriate for precipitation that is decisively acidic.

•This technique provides high temporal resolution results which allow us to see "inside" AIRMoN data.

•Initial results suggest a strong relationship between the conductivity of rain and any "processing" which the precipitation has experienced. We found that the conductivity of highly-processed stratiform rain in advance of a warm front is lower and less variable than the conductivity observed during convective portions of the same event.

FUTURE STEPS

• Continue operation of the instrument on the roof of Walker Building throughout the Fall of 2007.

• Operate the existing unit at a remote site (PA15), co-located with our other precipitation sampling programs.

•Develop a more compact version of the instrument and deploy multiple units at AIRMoN sites in the Northeastern United States.

• Eventually expand operations up to the mesonet scale for the purpose of testing chemical deposition models.

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