IMPACTS: Investigation of Microphysics and Precipitation in Atlantic Coast-Threatening Snowstorms:

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Andy Heymsfield NCAR
Instrument PIs and others: NASA Goddard, NASA Langley, NASA
Marshall
IMPACTS is investigating snowbands in East Coast Snowstorms

Science Goals

- **Characterize** spatial and temporal scales and structures of snowbands
- **Understand** the dynamical, thermodynamical and microphysical processes that control snowbands
- **Apply** this understanding to remote sensing and modeling of snowfall
**ER-2**: Satellite-simulating, high altitude with passive and active remote sensing instruments

**P-3**: In situ microphysical instrumentation, flight level environmental measurements and dropsondes

**Ground**: Radiosonde launches, NY mesonet observations, mobile ground radars and a fixed site with radars and other instruments
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<th>Instrument</th>
<th>PI/Organization</th>
<th>Characteristics</th>
<th>Derived Data Products</th>
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<td>Advanced Microwave Precipitation Radiometer</td>
<td>T. Lang/MSFC</td>
<td>Cross-track scanning microwave radiometer at 10, 19, 37, 85 GHz</td>
<td>Precipitation characteristics, path integrated LWC and IWC</td>
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<tr>
<td>Cloud Physics Lidar</td>
<td>M. McGill/GSFC</td>
<td>Attenuated backscatter at 355, 532, 1064 nm; depolarization ratio at 1064 nm</td>
<td>Cloud/aerosol layer boundaries, cloud/aerosol optical depth, extinction, depolarization; detection of cloud phase at cloud top</td>
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<td>Cloud Radar System</td>
<td>M. McLinden/GSFC</td>
<td>W-band nadir-pointing Doppler radar with minimum detectable threshold of –30 dBZ @ 10 km altitude; Linear Depolarization</td>
<td>Vertical velocity, precipitation rates, phase, hydrometeor size, various vertical profile characteristics</td>
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<tr>
<td>Conical Scanning Millimeter-wave Imaging Radiometer</td>
<td>R. Kroodsma/GSFC</td>
<td>Conical and/or Cross-track scanning passive microwave radiometer at ~50, 89, 165.5, &amp; 183 GHz</td>
<td>Precipitation characteristics, path integrated LWC and IWC</td>
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<tr>
<td>ER-2 X-Band Doppler Radar</td>
<td>G. Heymsfield/GSFC</td>
<td>X-band nadir &amp; conical scanning Doppler radar with minimum detectable threshold of –12 dBZ /-3 dBZ (nadir/scanning) @ 10 km range</td>
<td>Vertical velocity, precipitation rates, phase, hydrometeor size, various vertical profile characteristics, horizontal winds</td>
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<td>High-altitude Imaging Wind and Rain Airborne Profiler</td>
<td>L. Li/GSFC</td>
<td>Ku- and Ka-band nadir-pointing Doppler radars with minimum detectable threshold of –10 dBZ (Ku) and –12 dBZ (Ka) @ 10 km altitude; Linear Depolarization</td>
<td>Vertical velocity, precipitation rates, phase, hydrometeor size, various vertical profile characteristics</td>
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<tr>
<td>Lightning Instrument Package</td>
<td>C. Schultz/MSFC</td>
<td>Electric Field</td>
<td>Vector electric field and changes due to lightning occurrence</td>
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</table>

**Radiometers:**
- AMPR
- CoSMIR

**Radars:**
- CRS (W-band)
- HIWRAP (Ka- Ku-band)
- EXRAD (X-band, conical scanning)

**Lidar:**
- CPL

**Lightning detector:**
- LIP
## IMPACTS: P-3 Aircraft Instrumentation for 2022

<table>
<thead>
<tr>
<th>Instrument -PI/Organization</th>
<th>Instrument Characteristics</th>
<th>Derived Data Products</th>
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<tr>
<td>Turbulent Air Motion Measurement System (TAMMS) - K. Thornhill/LaRC</td>
<td>In-situ measurement systems designed to acquire high-frequency state parameters</td>
<td>Flight level 3D-wind vector, temperature, humidity</td>
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<tr>
<td>Advanced Vertical Atmospheric Profiling System (AVAPS) - K. Thornhill/LaRC</td>
<td>Expendable GPS-tracked device dropped from aircraft to measure in-situ profiles</td>
<td>Vertical profiles of pressure, temperature, relative humidity, and winds</td>
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<tr>
<td>Cloud-Droplet Probe (CDP) - M. Poellot/UND</td>
<td>Particle samples in 2-50 μm size range</td>
<td>Concentration and size distribution of cloud droplets</td>
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<tr>
<td>Particle Habit Imaging and Polar Scattering (PHIPS) - M. Schnaiter/KIT</td>
<td>High resolution particle information up to ~700 μm size range</td>
<td>2D particle images, Single particle phase discrimination and particle size distribution up to ~700 μm size range</td>
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<tr>
<td>2D-Stereo Probe (2DS) - M. Poellot/UND</td>
<td>Particle samples in 10 μm to 3 mm size range</td>
<td>Droplet, Ice Particle Size Distributions, 3D particle images</td>
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<tr>
<td>High-Volume Precipitation Spectrometer-3 (HVPS-3) - M. Poellot/UND</td>
<td>Particle samples in 150 μm to 10 cm size range</td>
<td>Droplet, Ice Particle Size Distributions, 2D projections of 3D particle images</td>
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<tr>
<td>WCM-2000</td>
<td>Cloud liquid and total condensate up to 2 g m⁻³</td>
<td>Liquid &amp; Ice Water Content</td>
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<tr>
<td>King Probe - M. Poellot/UND</td>
<td>Liquid water probe, up to 2 g m⁻³, for cloud droplet sizes of 2-30 μm</td>
<td>Liquid Water Content</td>
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<tr>
<td>Hawkeye Probe - M. Poellot/UND</td>
<td>Multi-probe sensor (FastCDP, 2DS, CPI)</td>
<td>Droplet, Ice Particle Size Distributions, 3D particle images</td>
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<tr>
<td>Rosemont Icing Detector (RICE) - M. Poellot/UND</td>
<td>Supercooled liquid water measurements in excess of 0.01 g m⁻³</td>
<td>Presence and approximate amount of supercooled liquid water</td>
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<tr>
<td>Water Isotope System for Precipitation and Entrainment Research (WISPER) - D. Toohey/U. Colo</td>
<td>Total Ice measurements up to 2 g m⁻³</td>
<td>Cloud particle concentration, condensate mass, water vapor, ice water content</td>
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<tr>
<td>Vapor In-cloud Profiling Radar (VIPR)</td>
<td>In cloud water vapor content</td>
<td>Profiles of water vapor mixing ratio and profiles of aerosol/cloud optical properties</td>
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<tr>
<td>High Altitude Lidar Observatory (HALO)</td>
<td>Water vapor 0.001 – 25 g/kg of water vapor</td>
<td>Profiles of water vapor mixing ratio and profiles of aerosol/cloud optical properties</td>
</tr>
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</table>

### Probes:
- CDP
- PHIPS
- 2DS
- HVPS
- WCM-2000
- King
- Hawkeye (Fast CDP, 2DS, CPI)
- RICE
- WISPER

### Environment:
- TAMMS
- AVAPS

### Extra:
- VIPR
- HALO
## IMPACTS: Ground Operations for 2022

<table>
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<th>Instrument - PI/Organization</th>
<th>Location</th>
<th>Measurement Details</th>
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<tr>
<td>Mobile rawinsondes - Lead by UIUC, SBU and Millersville</td>
<td>Various locations in NY, New England, NJ, Pennsylvania, Illinois</td>
<td>UIUC out of Binghamton, SBU out of Stony Brook, also fixed</td>
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<tr>
<td>Fixed NOAA rawinsondes J. Walstreicher (lead)/NWS</td>
<td>Fixed NWS sounding locations</td>
<td></td>
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<tr>
<td>Pluvio2 P. Kollias/SBU</td>
<td>SBU</td>
<td>Weighing gauge 1 min frequency</td>
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<tr>
<td>KASPR P. Kollias/SBU</td>
<td>SBU</td>
<td>VPT, PPI, and RHI measurements by Ka-band scanning polarimetric radar at high temporal and spatial resolutions</td>
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<tr>
<td>ROGER P. Kollias/SBU</td>
<td>SBU</td>
<td>W-band profiling radar, 4 s and 30 m resolutions</td>
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<tr>
<td>MWR P. Kollias/SBU</td>
<td>SBU</td>
<td>Microwave radiometer measuring liquid water path</td>
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<tr>
<td>Parsivel P. Kollias/SBU</td>
<td>SBU/Mobile truck</td>
<td>Optical disdrometer PSD</td>
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<tr>
<td>MRR P. Kollias/SBU</td>
<td>SBU/Mobile truck</td>
<td>Vertically pointing K-band profiling radar (4 s, 60 m resolutions)</td>
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<tr>
<td>Ceilometers P. Kollias/SBU</td>
<td>SBU/Mobile truck</td>
<td>Profiling lidar backscatter 15 s, 10-60 m resolution</td>
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<tr>
<td>SKYLER P. Kollias/SBU</td>
<td>SBU/Mobile truck</td>
<td>X-band phased array radar</td>
</tr>
<tr>
<td>RaXPOL H. Bluestein/OU</td>
<td>OU/Mobile truck based out of SUNY Albany</td>
<td>X-band phased array radar</td>
</tr>
<tr>
<td>WFF PIP, MRR, Pluvio, Parsivel, Wolff/WFF</td>
<td>Storrs, CN Uconn and at Wallops</td>
<td>Precipitation amount, PSD, K-band vertically pointing radar</td>
</tr>
<tr>
<td>NYS Mesonet J. Brotzge/ SUNY Albany</td>
<td>NY State various locations</td>
<td>Surface observations 1 min frequency. Profiling stations</td>
</tr>
</tbody>
</table>

### Rawinsondes:
- 3 mobile teams (UIUC out of Binghamton, SBU and Millersville)
- SBU (fixed)
- NWS

### Ground Radars
- **SBU site**
  - Mobile: SKYLER (SBU)
  - Mobile: RaXPOL (SUNY Albany, from OU)

### Surface Networks:
- **NY Mesonet**
- **Ground Site at UConn** provided by D. Wolff (GPM GV)
- **Ground Site at Wallops** (GPM GV)
IMPACTS: First Deployment January – February 2020

We go where the storms are

P-3 Flights: 10 Missions

ER-2 Flights: 9 Missions

Coordinated Flights: 5

Multiple storm events were sampled in the NE (mainly over NY and New England) and 2 over the Midwest near Illinois.
Operations Timeflow

• 2022 operations: January 10 – February 28, 2022.
• Daily weather briefings 9am (afternoon updates on as needed basis)
• Flight plans submitted to ATC ~48 hr prior to planned flight, sounding and mobile radar operations also communicated same time
• Go/No Go decision at TO-3hr
• Adjustments made up to Take Off time, flight legs can be somewhat adjusted in real time – often request flight elevations in realtime. In constant communication with aircraft who then communicates to ATC about next flight leg location/elevation
• Have 2 people in ops center who communicate with the pilots and ATC to facilitate the coordination between aircraft
• Flights monitored with MTS2 software and Chat function used to communicate with Pilots (also sat phone)
Example from our dry run of operations if coordinating with WINTRE-MIX – 27 Feb 2021

- Forecast of ‘wintry-mix’ to approach WINTRE-MIX operations area over Champlain and then St. Lawrence Seaway
- Take off time: ~1400 UTC 27 Feb ER-2
- Overview: perform ER-2 P-3 and Convair stack legs either N-S along Champlain and/or over St. Lawrence (Coordinate with WINTRE-MIX)
  - Leg length ~150 km ER-2 (shorter P-3)
  - P-3 altitudes: start high near generating cell level, then descend to -15°C at 5°C intervals
  - Try to get 4 legs in ~<= 2 hours
  - Then repeat (either same location or to St. Lawrence).
- Soundings: Move UIUC team to north of Albany and south of WINTRE-MIX. NWS extra KALB soundings.
Example Operations if coordinating with WINTRE-MIX – Example from our Dry Run

- P-3 Dropsonde just south of Long Island
- P-3 passes over SBU heading north
- P-3 arrives just below cloud top and starts first stack over Champlain Valley or continue to St. Lawrence depending on how storm develops
- Stack legs over Champlain (~150 km in length for ER-2)
Example Operations if coordinating with WINTRE-MIX – Example from our Dry Run

- 2\textsuperscript{nd} Stack of legs over St. Lawrence by ~1800 UTC 27 Feb 2021
- ER-2 returns home after the stack (4?)
- Spiral over St. Lawrence for P-3?
IMPACTS Overview

- IMPACTS is investigating snowband structures in East Coast snowstorms
- Flying 2 aircraft in coordinated flight legs: ER-2 (remote sensing instruments) and P-3 (in situ microphysics)
- Aircraft operations can be anywhere from the Midwest to offshore Atlantic
- Have ground assets at SUNY Stony Brook, UConn
- Have 2 mobile X-band phase array radars (RaXPOL only during February 2022)
- Have 3 mobile sounding teams, one based out of Binghamton NY, one out of SBU and the 3rd at Millersville
Daily briefings 9am and updates in afternoon as needed
Flight plans submitted ~48 hours in advance, adjustments up to during flight
Have Field Catalog: http://catalog.eol.ucar.edu/impacts_2022/ and ESPO website for IMPACTS: https://espo.nasa.gov/impacts/
Data available on the GHRC NASA DAAC: http://ghrc.nsstc.nasa.gov/ and doi: http://dx.doi.org/10.5067/IMPACTS/DATA101