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

Lynn McMurdie, PI
University of Washington

Science Team:

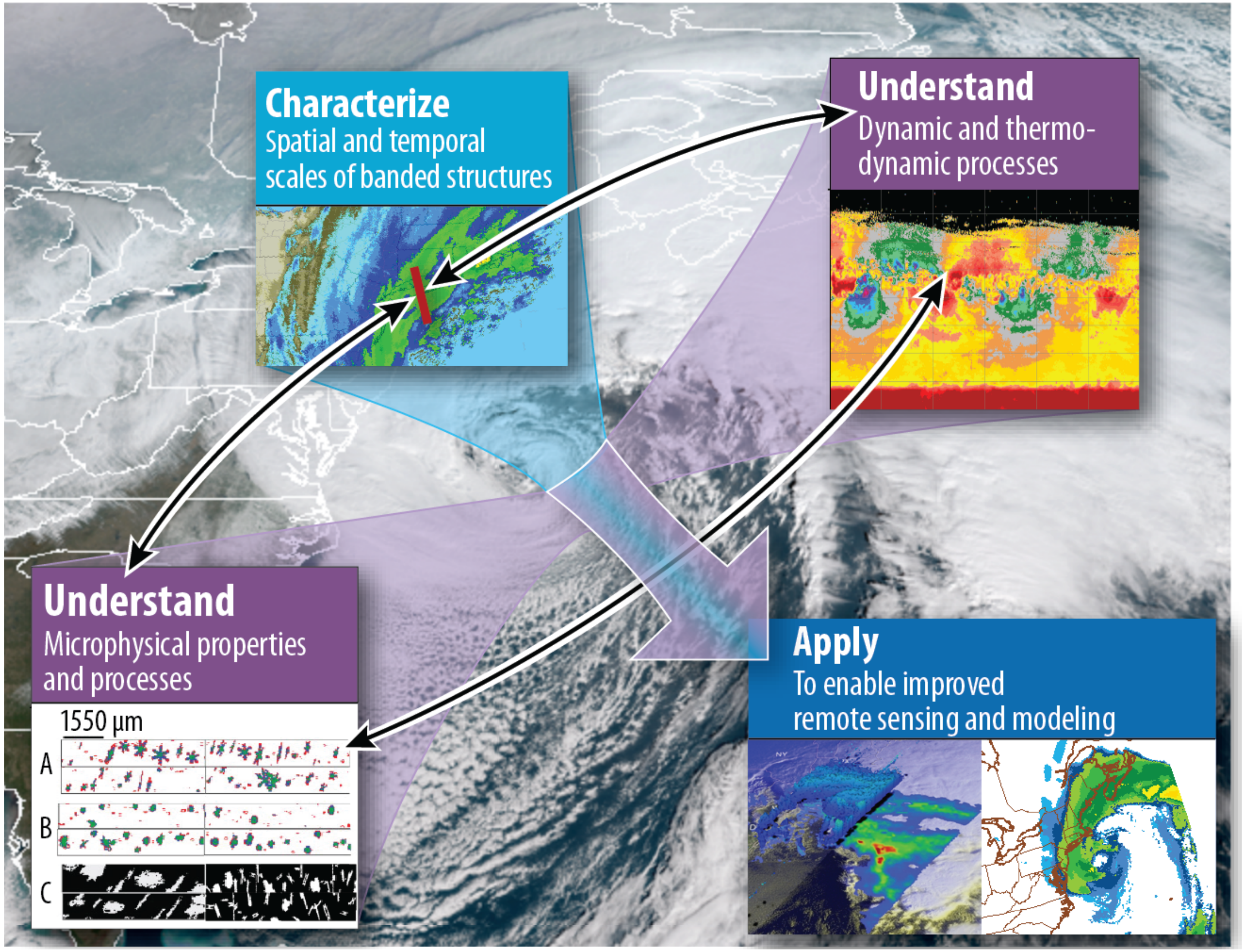
Deputy PIs: Gerald Heymsfield and John Yorks, NASA Goddard

Co-Is: Bob Rauber UIUC, Brian Colle SBU, Sandra Yuter NCSU, Matt Kumjian PSU, Dave Delene UND, Greg McFarquhar OU, Andy Heymsfield NCAR

Instrument PIs and others: NASA Goddard, NASA Langley, NASA Marshall

lynnm@uw.edu

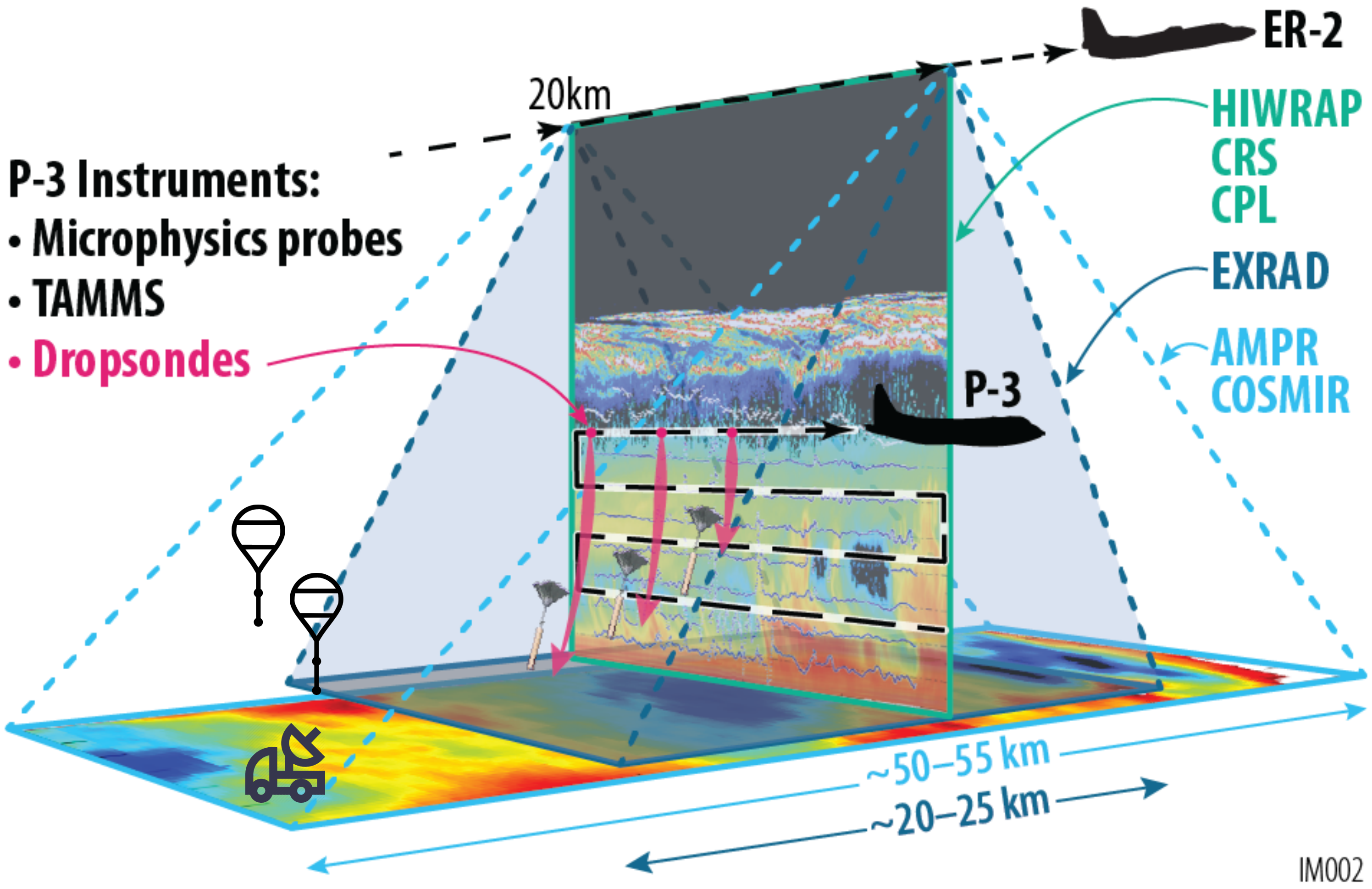
IMPACTS is investigating snowbands in East Coast Snowstorms



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

IMPACTS Observational Strategy: Aircraft coordination



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

IMPACTS: ER-2 Aircraft Instrumentation for 2020 and 2022

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

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

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

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

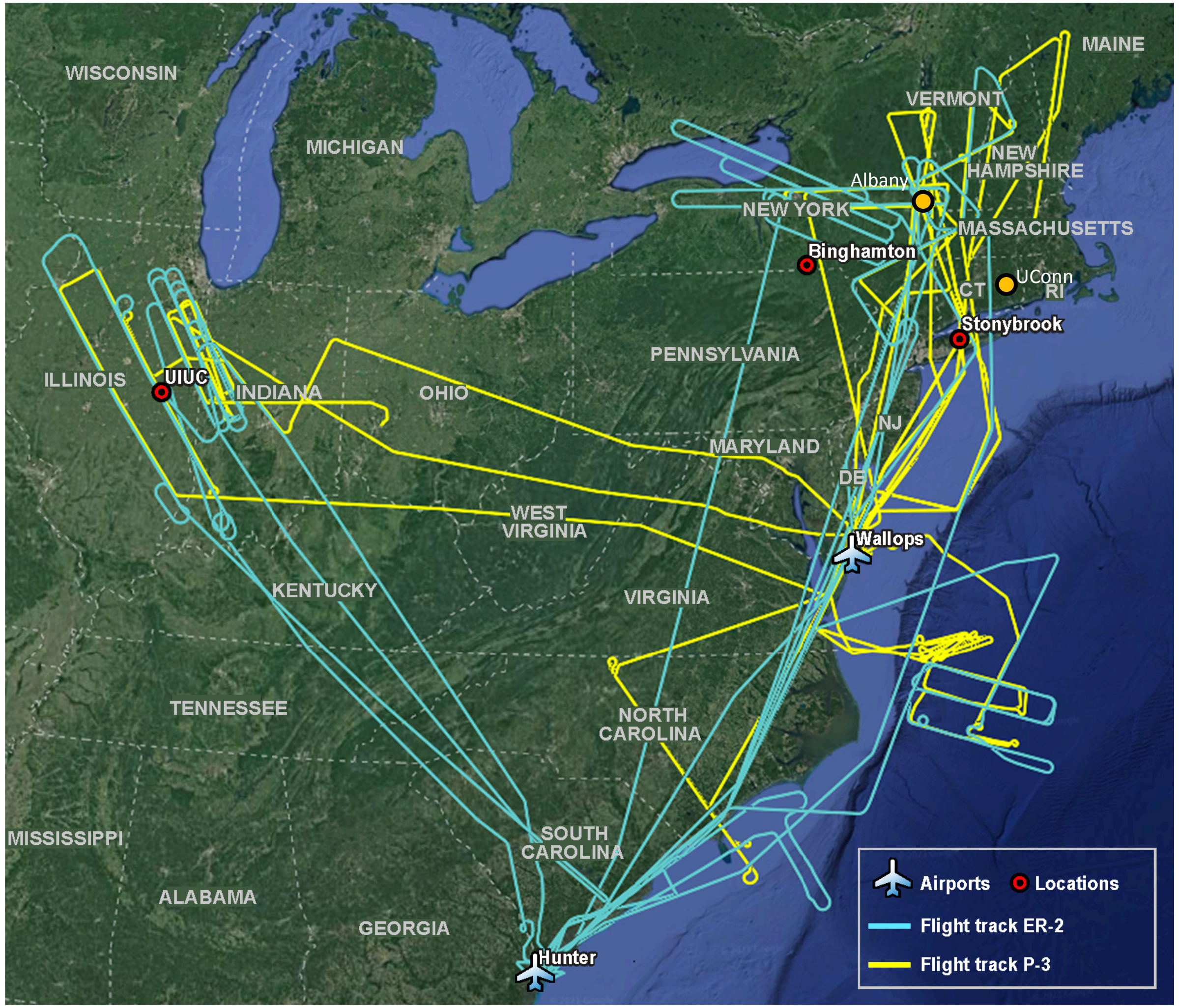
Instrument - PI/Organization	Location	Measurement Details
Mobile rawinsondes - Lead by UIUC, SBU and Millersville	Various locations in NY, New England, NJ, Pennsylvania, Illinois	UIUC out of Binghamton, SBU out of Stony Brook, also fixed
Fixed NOAA rawinsondes J. Walstreicher (lead)/NWS	Fixed NWS sounding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

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



Maps data: Google Landsat / Copernicus Data SIO, NOAA, U.S. Navy, NGA, GEBCO INEGI Data LDEO-Columbia, NSF, NOAA

We go where the storms are

P-3 Flights: 10 Missions

ER-2 Flights: 9 Missions

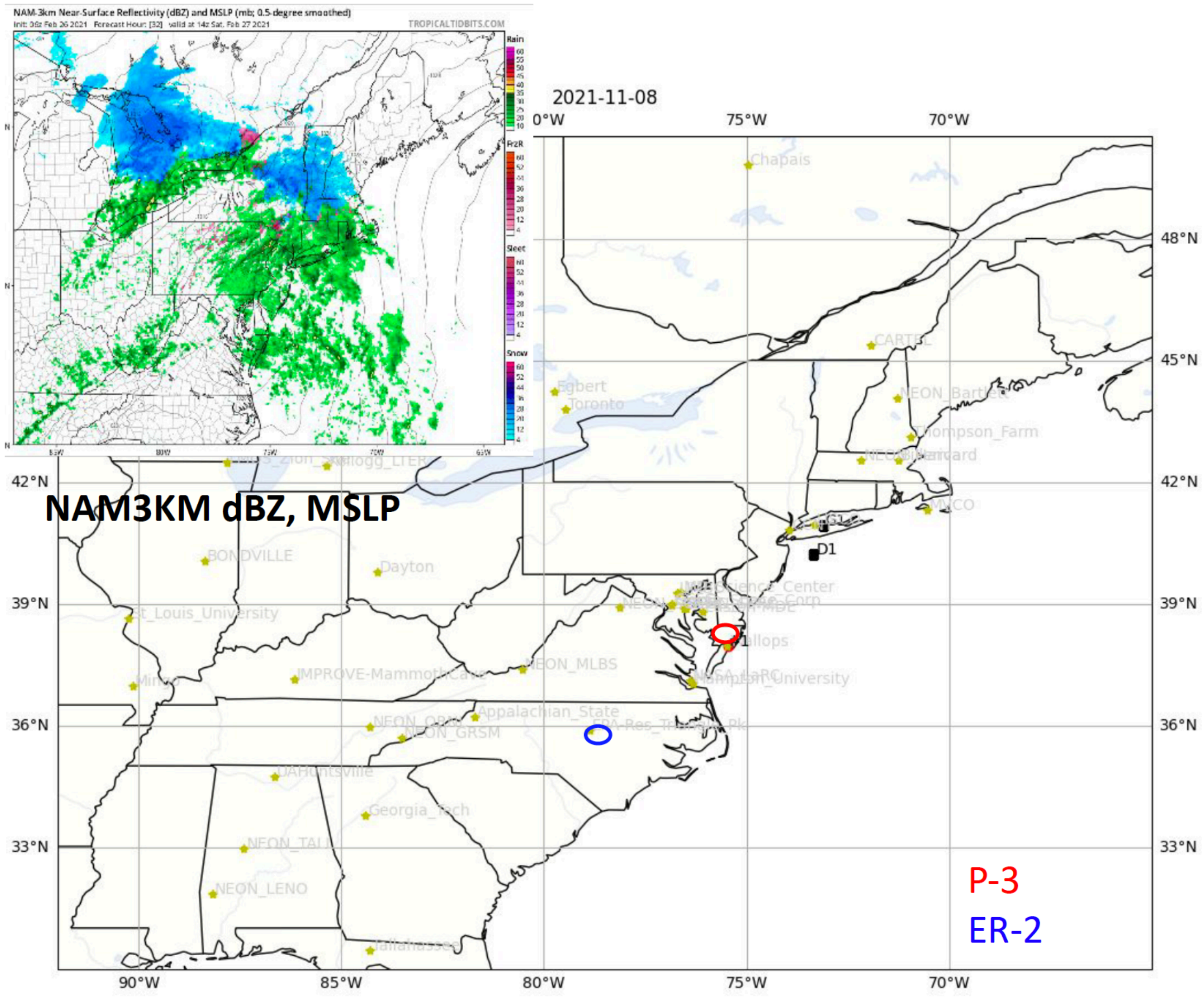
Coordinated Flights: 5

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

Operations Timeflow

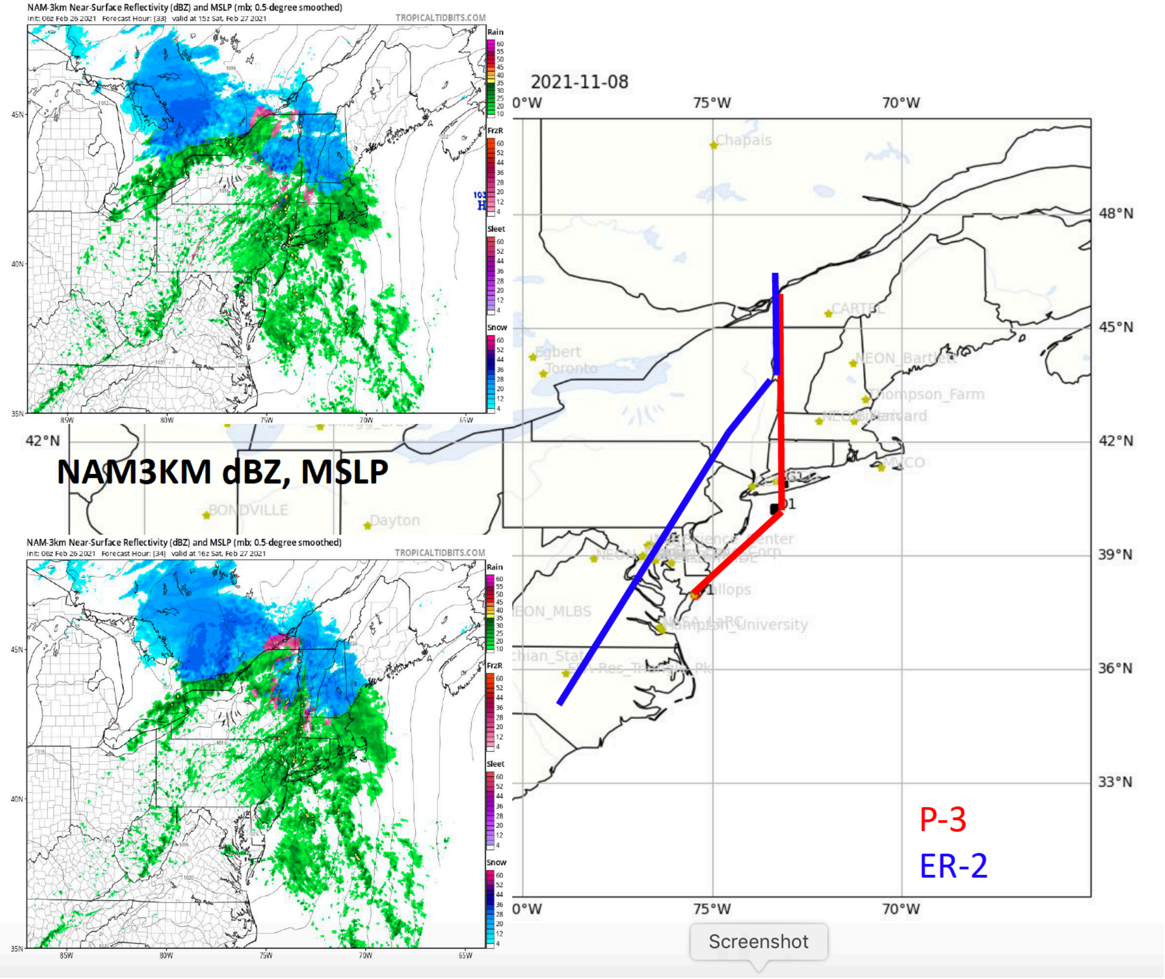
- 2022 operations: January 10 – February 28, 2022.
- Daily weather briefings 9am (afternoon updates on as needed basis)
- Flight plans submitted to ATC ~48 hr prior to planned flight, sounding and mobile radar operations also communicated same time
- Go/No Go decision at TO-3hr
- Adjustments made up 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



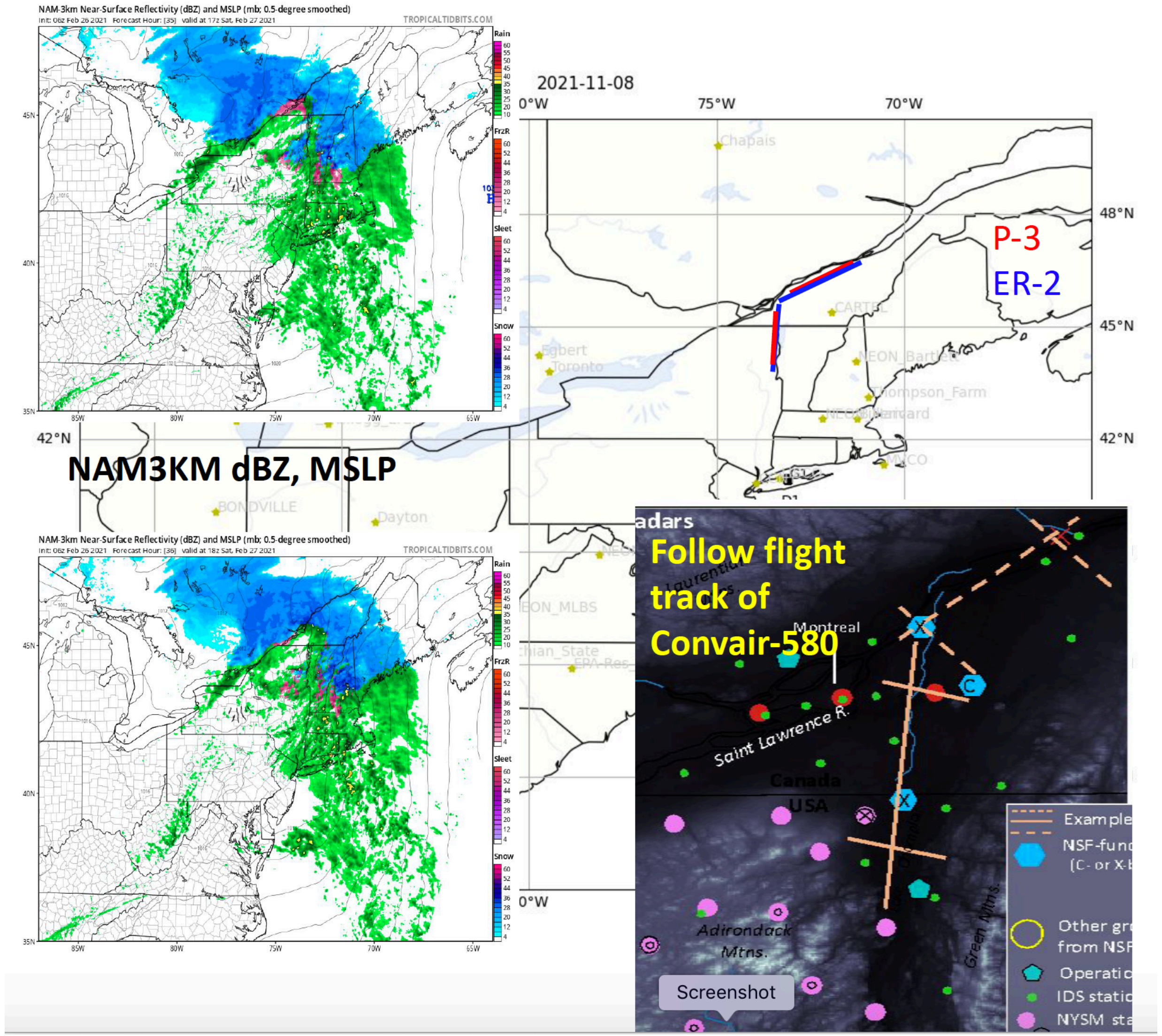
- Forecast of ‘wintry-mix’ to approach WINTRE-MIX operations area over Champlain and then St. Lawrence Seaway
- Take off time: ~1400 UTC 27 Feb ER-2
- Overview: perform ER-2 P-3 and Convair stack legs either N-S along Champlain and/or over St. Lawrence (Coordinate with WINTRE-MIX)
- Leg length ~150 km 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

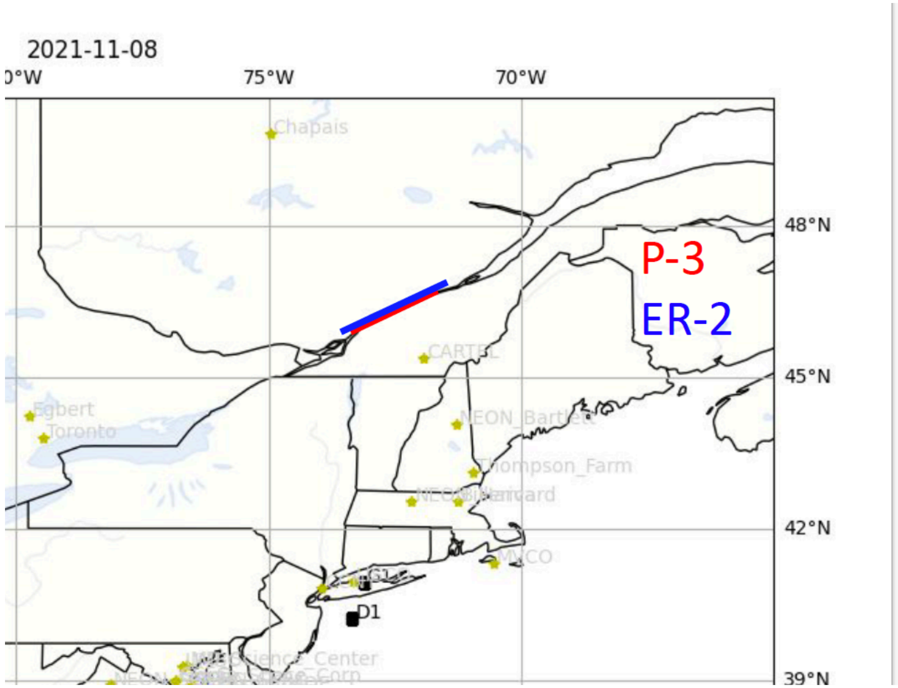


- P-3 Dropsonde just south of Long Island
- P-3 passes over SBU heading north
- P-3 arrives just below cloud top and starts first stack over Champlain Valley or continue to St. Lawrence depending on how storm develops
- Stack legs over Champlain (~150 km in length for ER-2

Example Operations if coordinating with WINTRE-MIX – Example from our Dry Run



- 2nd 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

IMPACTS Overview continued

- 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