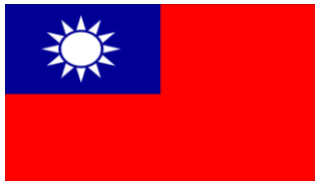
US-Taiwan Partnerships for International Research and Education (PIRE) Project

NSF – MOST PIRE: Building Extreme Weather Resiliency Through Improved Weather and Climate Prediction and Emergency Response Strategies



February 2016

Outline

- ASRC Research Highlights
- Collaborative Projects
  - NYS Mesonet
  - US-Taiwan PIRE

Atmospheric Sciences Research Center

UNIVERSITY AT ALBANY
State University of New York

Mission

- Performs world-class research to study the physical and chemical nature of the atmosphere and its implications to the environment
- Enhances the scientific capacity and infrastructure of New York State, through technology transfer and collaboration with state, federal and industrial partners
- Advance the quality of life and economic well being of of New Yorker

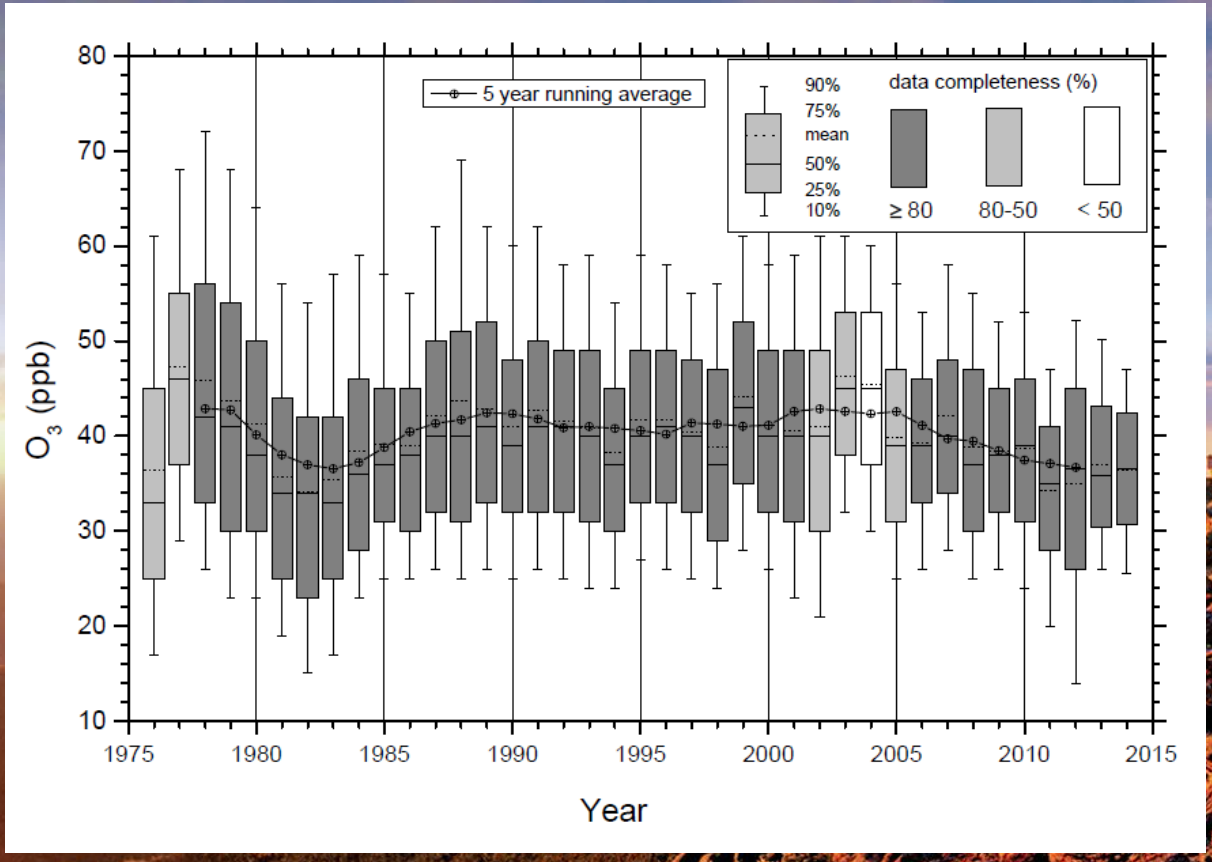
People

ASRC Structure and Size

- 16 Research Groups
  - PI/Research Faculty
  - Graduate Students
  - Research Scientists and Post Docs
- 6 Research areas: Climate, AQ, Weather, Remote Sensing, Renewable Energy, Ecosystems
- Support staff (Admin and Technical)
- Adjunct faculty
- Active Emeriti

Research Facilities Statewide

Long term research stations in the Adirondacks (Whiteface Mountain) and SW New York State (Pinnacle State Park)



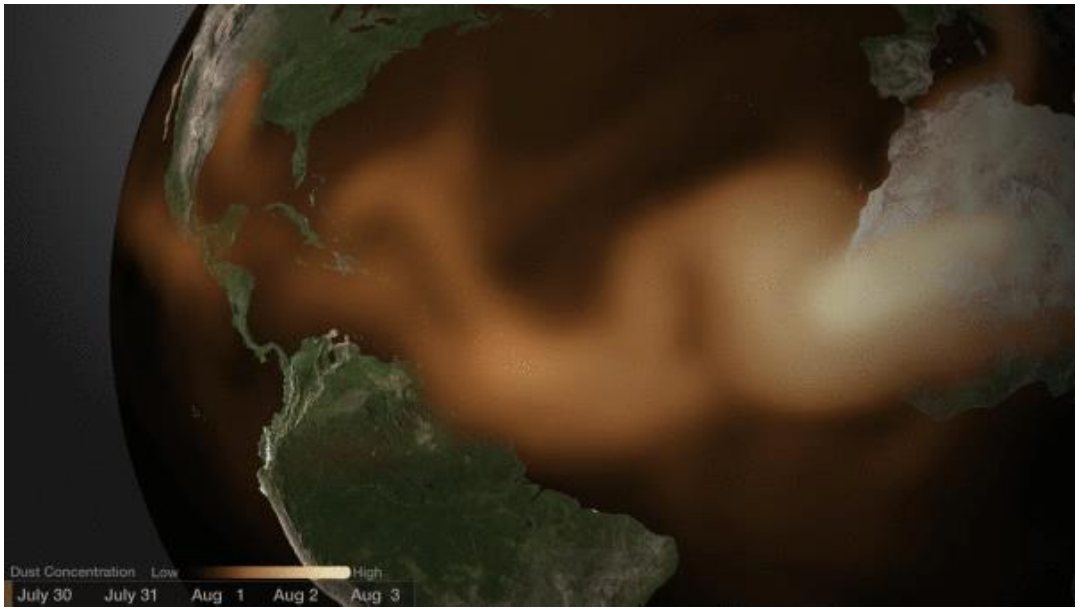
Research Areas

- Renewable Energy (Wind and Solar)
  - Resource assessment, forecasting, technology development and transfer
- Climate Studies
  - Climate diagnostics, cloud and aerosol processes, sensor development, Carbon cycle
- Air Quality and Atmospheric Chemistry
  - Monitoring strategies, inventories, processes, and modeling, driving dynamics and thermodynamics
- Weather
  - Improved understanding and representation of physical processes in models, sensor development (surface and space), early warning network
- Ecosystems
  - Monitoring strategies

Air Quality

Developing NOAA's global aerosol forecasting and assimilation system

- Quantifying the distributions and properties of tropospheric aerosols, its impact on weather forecasts and climate predictions, and improving aerosol forecasts through the assimilation of satellite and in situ aerosol observations
- Providing quality atmospheric constituent products serving wide-range stakeholders, such as health professionals, aviation authorities, policy makers, and solar energy plant managers.



Nightly News | July 31, 2013
Massive dust storm sweeps over Atlantic

Building Pollution Measurement Systems to Improve Adirondack Air Quality and Reduce Incidence of Asthma

- Characterize wood smoke pollution in a Rural Community in NYS
- Develop low cost portable monitors for use by the NYDEC in addressing wood smoke and other air quality related complaints.

A Mobile Laboratory for On-Road and Near-Roadway Measurements of Fine Particulate Matter and Pollutant Gases

James Schwab[1], Min-Suk Bae[1], G. Garland Lala[1], Kenneth L. Demerjian[1] Wei-Nai Chen [1,2], Yu-Chi Lin[1,2], Yele Sun[1,3], and Qi Zhang[1,3]

[1]Atmospheric Sciences Research Center, University at Albany, State University of New York, Albany, NY, USA [2]Research Center for Environmental Changes, Academia Sinica, Taiwan

[3] Department of Environmental Toxicology, University of California, Davis, CA , USA

INTRODUCTION

We have developed a state-of-the-art mobile laboratory capable of fast and highly specialized measurements of fine PM and pollutant gases during on-road and near-roadway deployments. The vehicle is a 2007 diesel powered Dodge 2500 Sprinter Van equipped with catalytic diesel filter trap emission control. On-road power can be supplied through 1) heavy duty engine alternator; 2) a 4kW gasoline generator; and/or 3) a bank of rechargeable Li ion batteries. For stationary deployments there is also the option of using shore power . While some measurement systems have their own data collection and storage systems, we also have two rack mounted DC-powered computers – one running Windows, and the other running Linux. Instrumentation is described in the next section.

The maiden mission of the mobile laboratory occurred during a three week field study in Queens, New York City during the summer of 2009. The study was part of a NYSERDA funded program to measure aerosols and trace gases in the vicinity of the Queens College measurement site. Selected measurements from this deployment are shown below.

INSTRUMENT DESCRIPTIONS

Aerosol Inlet
- 1" (2.5 cm) OD SS tube over driver's seat
- Inline cyclone to remove particles > 2.5 µm diam.
- 3 SS isokinetic draw off ports
  - 5 li/min to AMS (& AMS bypass)
  - 1 li/min to PASS
  - 10.6 li/min to FMPS and WCPC

Gas Inlet
- ¾" (1.9 cm) OD PFA tube inside 1" OD SS tube
- Inside vehicle draw off tees for
  - QCL (dedicated line)
  - Rack instruments (CO_2, NO/NO_2, O_3, BTEX)
  - Vacuum pump

Aerodyne High Resolution AMS
- Composition and size distributions of sub-micron (~30-1500nm) non-refractory particle components
- Up to 100 Hz operation (longer averaging for most applications)
- 1 minute DLs of ~6-80 ng/m^3
- Mass Resolution (m/Δm) of ~2000 in "V" mode and 5000-6000 in "W" mode

Aerodyne Quantum Cascade Laser Spectrometer
- Dual laser system (NO_2 and HCHO in this study)
- Fast (1 Hz), sensitive detection (DL's ~0.1 ppbv for NO_2 and HCHO – 100 s averages)
- 76 meter multipass absorption cell

Photoacoustic Soot Spectrometer (DMT PASS)
- Measures B_{asb} (781 nm)of black carbon at 1 Hz
- Absorbed light is converted to heat pulses which are detected by sensitive microphone
- DL ~ 0.5 Mm^{-1} (equiv. to ~ 0.05 ug/m^3 BC)

Fast Mobility Particle Sizer (TSI 3091)
- Measures particle size distribution from 5.6 to 600 nm with 1 sec resolution
- Detection using 22 electrometer rings

Other Instruments
- WCPC – TSI 3781 – measure n_p (total > ~8 nm)
- LICOR – measure [CO_2] and [H_2O] at up to 10 Hz
- 2B O_3 – measure ozone with up to 10 s resolution
- 2B NO/NOx – measure NO and NOx at up to 10 s
- BTEX – 6 min GC measurement of BTEX cmpds

Sprinter Van at Queens

Parked ~ 30 m south of Long Island Expressway

Gas and aerosol inlets above driver's side front roof.

Aerodyne HR-ToF-AMS in mobile laboratory

QCL system in van.

Instrument rack in van (PASS, gas analyzers).

FMPS and WCPC.

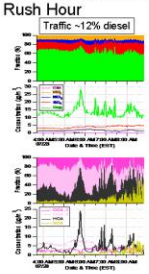
LIE at night.

Data Obtained from Near-Roadway Deployment in Queens, NYC – roughly 30 m south of LIE

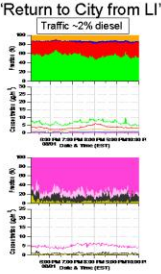
Location of deployment adjacent to LIE.

HR-ToF-AMS Data

7/28: Weekday AM Rush Hour

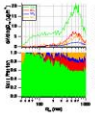


8/1: Weekend PM "Return to City from LI"

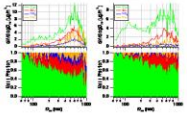


Size Distributions

7/28:Tue

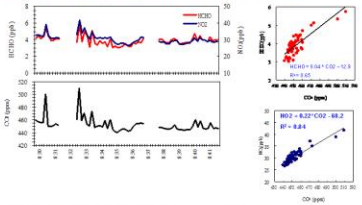


7/30:Thu



QCL Data – July 28 AM

July 28 (traffic flow is 10440 vehicles/h; diesel trucks ~ 12 %)



Assessment of emission ratios

The emission ratios (ER) for HCHO and NO_2 for mixed vehicles were calculated as (Kolb et al., 2004):

$$ER = \Delta Signal / \Delta CO_2$$

Selection criteria for emission ratio determination from these plume events:

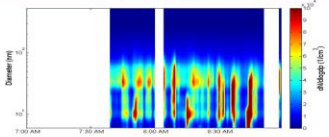
(a) Peaks for HCHO, NO_2 and CO_2 occur simultaneously.

(b) The increase of CO_2 (ΔCO_2) was at least 40 ppm above baseline for 10-s data.

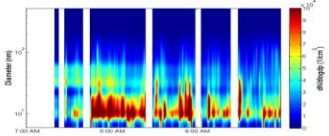
(c) The enhancement of HCHO and NO_2 was at least 50 % for 10-s data.

From roughly 100 cases that fit these criteria, the average emission ratios for HCHO and NO_2 were 0.05 and 0.19 ppb/ppm CO_2, respectively.

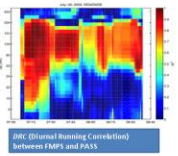
Data from FMPS and PASS



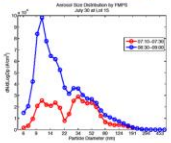
7/28 Weekday AM rush hour – relatively stable mode at ~40 nm (NMD), "bursts" of particles with NMD ~10 nm



7/30 Weekday AM rush hour – very small particles dominate

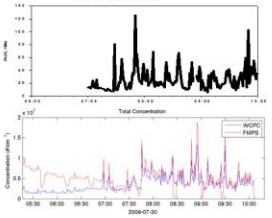


FMPS Size Distributions



PASS Absorption

Highest observed BC absorption was on 7/30 – less PM mass, but small particles dominated – note FMPS size distributions above.



Summary

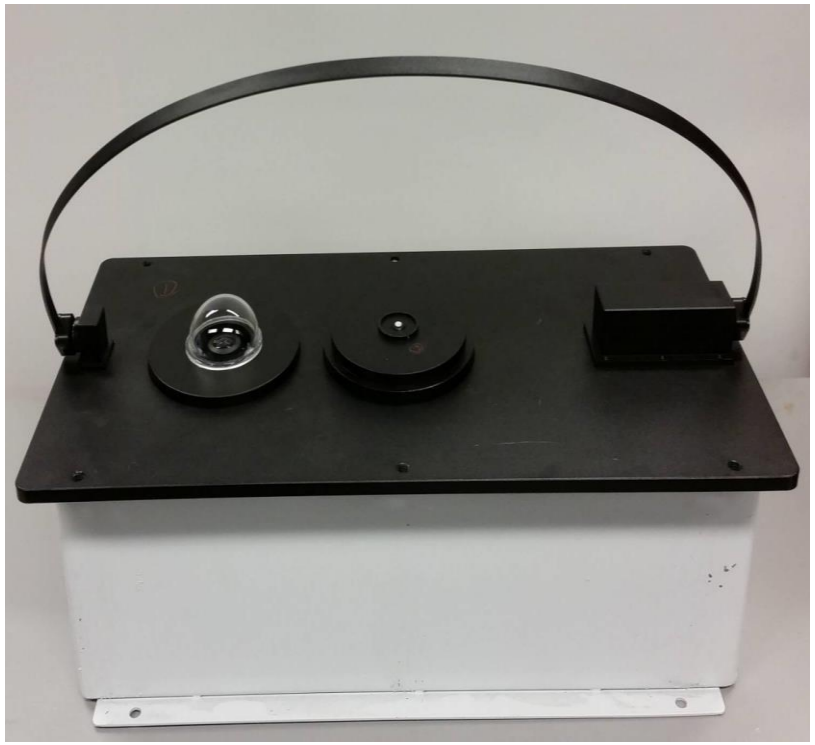
- We have outfitted, deployed, and field tested a mobile laboratory suitable for on-road and near-roadside measurements.
- The installed instrumentation has very fast time response (down to 1 Hz or better), and high sensitivity (at least in some cases).
- The field test consisted of a three week deployment that included 4 near-roadway measurement periods.
- The measurements were done in conjunction with on-road measurements by the Aerodyne mobile laboratory (presented in session 5A).
- The AMS observes very dynamic patterns of HOA and OOA at the roadside.
- The QCL measurements were able to determine roadside emission ratios for NO_2 and HCHO.
- PASS and FMPS measurements emphasize the importance of wind direction, mixing and ventilation.

This field study was supported by NYSERDA contract 10602. Purchase and outfitting of the Mobile Laboratory was made possible by support from NYSTAR, the New York State Office of Science, Technology and Academic Research. We also thank Queens College for hosting the field study and acknowledge our Aerodyne Research, Inc. partners.

Advance Environmental Sensor

Drop-Sonde Development
Observing the Dynamics of Tropical Storms

MMR (Multi-scan Multi-channel Radiometer)



- Weather/climate application
- Air quality application
- Solar energy application

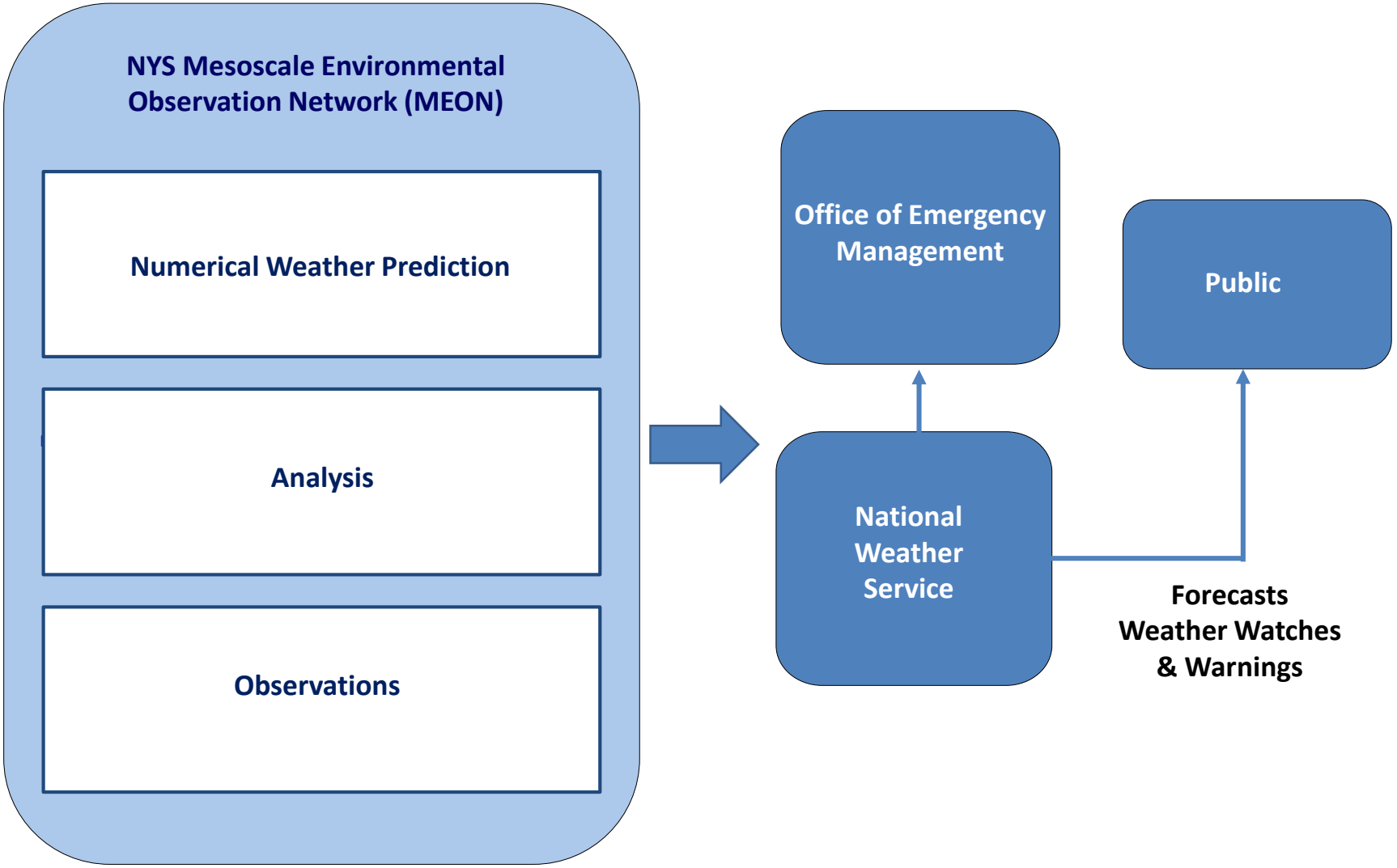
Carbon Dioxide Fluxes from an Adirondack Lake

- Quantify the efflux of carbon dioxide from a well-studied lake ecosystem.

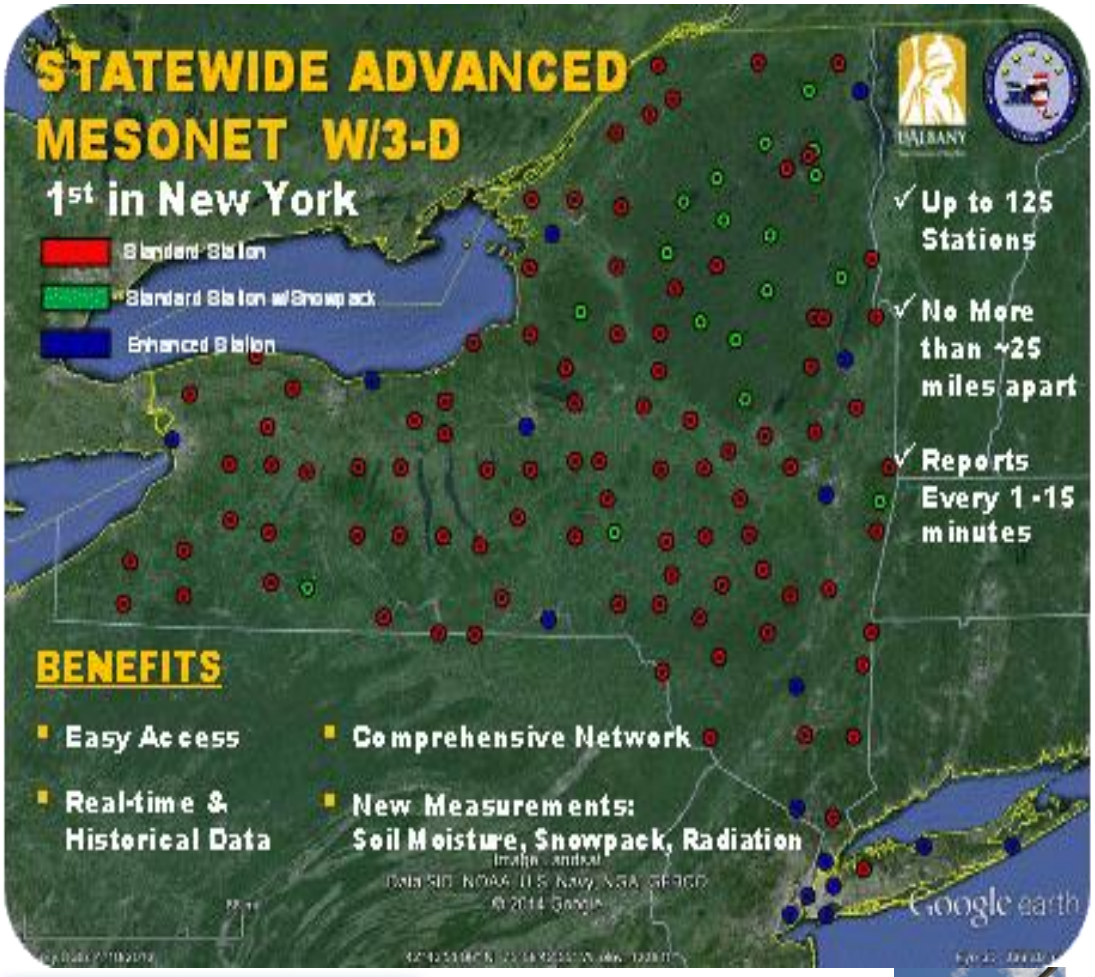
- A 2-week intensive field campaign at Cranberry Lake in summer 2014 to measure lake-atmosphere interaction, in-lake chemistry, and wind profiles through the atmospheric boundary layer using remote sensing profilers (sodar and lidar).

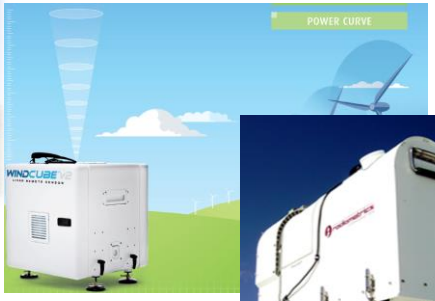
Collaborative Projects

Improved Monitoring and Short-Term Predictability



Mitigation: more precise forecasts, more effective warning tools, and more effective decision support for decision makers and emergency responders





125 standard sites

- **Standard Observations**
  Rainfall
  Temperature
  Wind Speed
  Wind Direction
  Surface Pressure
  Humidity
- **Additional Observations**
  Soil Moisture (3 levels)
  Soil Temperature
  Radiation

17 Enhanced Sites

- Profiling Mircrowave Radiometer (T, and RH)
- 3D Scanning Wind Doppler Lidars (Winds, PBL, aerosols and cloud base height)
- MMR radiation
- Flux tower

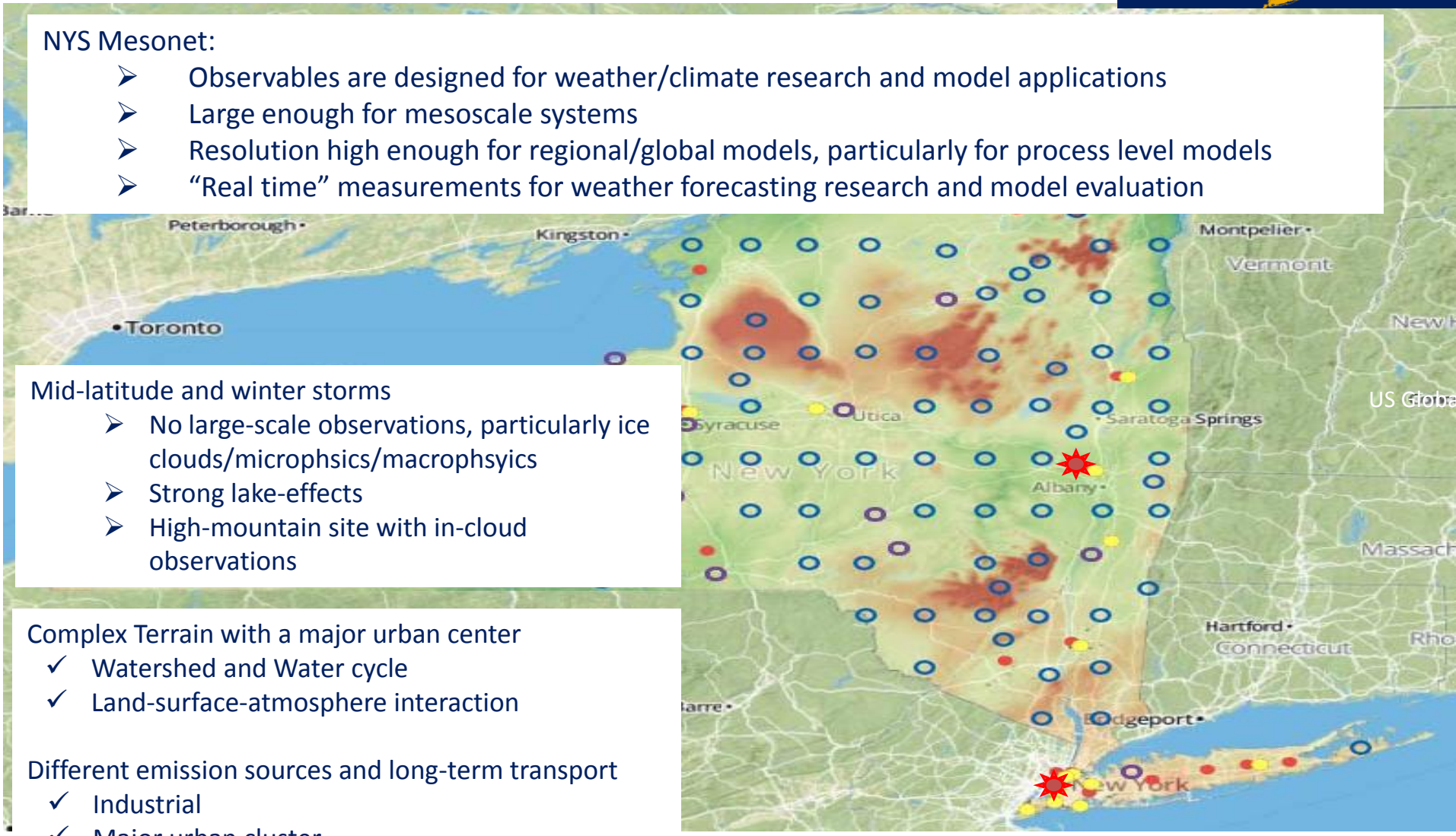
20 Snowpack sites

- **Instrument:**
  Snow Water Equivalent (SWE)
- **Expand state network:**
  NYCDEP network in Catskills

Uniqueness of NYS and NYS Mesonet

NYS Mesonet:

- Observables are designed for weather/climate research and model applications
- Large enough for mesoscale systems
- Resolution high enough for regional/global models, particularly for process level models
- "Real time" measurements for weather forecasting research and model evaluation



Mid-latitude and winter storms

- No large-scale observations, particularly ice clouds/microphsics/macrophsyics
- Strong lake-effects
- High-mountain site with in-cloud observations

Complex Terrain with a major urban center

- ✓ Watershed and Water cycle
- ✓ Land-surface-atmosphere interaction

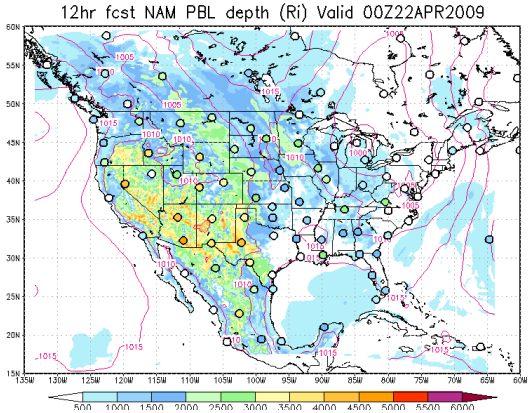
Different emission sources and long-term transport

- ✓ Industrial
- ✓ Major urban cluster
- ✓ Northern clean
- ✓ Oceanic

ASRC-NCEP collaborations toward enhancing NOAA model/analysis capabilities: PBL analysis

Real-time PBL analysis system using multi-platform profile observations

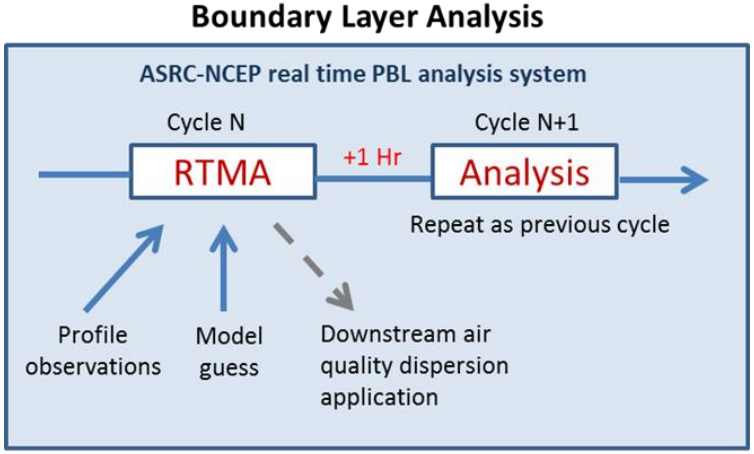
SUNYA: Sarah Lu, Qilong Min, Jeongran Yun*, and NYS mesonet team
NCEP/EMC : Geoff DiMego, Jeff McQueen, Jeff Whiting, Perry Shafran, Manuel Pondeca, Yanqiu Zhu



From NCEP/EMC website

Joint development of near-real-time planetary boundary layer (PBL) analysis system with NOAA/NWS/NCEP

- PBL is a critical parameter for dispersion decision support tools
- Project deliverable: A unified PBL analysis system used by ASRC for NYS applications and by NCEP for National applications
- Project approach: Developing near-real-time PBL products by blending model estimates and multi-platform profiles observations (radiosonde, aircrafts, and profilers from surface and satellites, including Mesonet profilers)



Profile observation data:

Baseline: radiosondes, aircraft profiles
Enhancement: NYS Mesonet (17 enhanced network sites)
Optional data: NWS ceilometer, MPLNET, and CALIPSO

Unified framework fostering R2O and O2R:

Code development is based on NCEP's RTMA and obs-processing systems under operational-like environment (JCSDA's S4 cluster)

US-Taiwan Partnerships for International Research and Education (PIRE) Project

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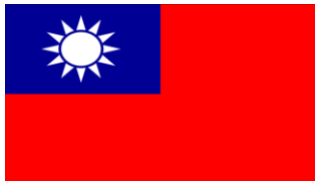

Scientific Challenge:

- Globally, extreme weather is on the rise
  - Flooding impacts alone are impact 96 million people a year at an average cost of $13.7 billion

- <u>YET a number of challenges remains</u>:
  1. Accurate prediction of intense rainfall continues to be a critical scientific challenge, and
  2. There continues to be a substantial need to better understanding of decision-making risk and response during extreme events

Research Goals:

1. **Better quantify trends in weather extremes on a regional scale in East Asia & NE US using climate diagnostics and improved models** to complete in-depth studies of the synoptic control of the extreme events & relationship w/regional environmental conditions

2. **Examine more robust ensemble techniques** for providing probabilistic numerical weather guidance

3. **Investigate the efficacy of decision-making and the response of emergency managers** with probabilistic weather and impacts information of extreme weather events

Research Program:

GOAL:

Building Extreme Weather Resiliency and Global Community Resiliency Through Improved Weather and Climate Prediction and Public Response Strategies

OBJECTIVES:

- Advance Quantification and Characterization of Past and Future Climate Influences on Regional Weather Extremes
- Advance NWP Research in Probabilistic Prediction of Weather Extremes
- Advance Research on Decision Support and Response in Emergency Management of Weather Extremes

RESEARCH THRUSTS:

- Climate Diagnostic & Analysis Research
- NWP Research
- Decision & Response Research

WORKGROUPS:

- Climate Diagnostic & Analysis
  - Land-Atmosphere & Weather Systems & Extreme Participation
- Regional Climate Model Improvement
- Ensemble
- Microphysics Parameterization
  - -Ice Nucleation & Growth
  - -PDFs for Ensemble
  - -W, LWP, LH
- Mesonet & Radar Observations
  - -Evaluation for Microphysics Parameterization
  - -Evaluation of NWP
- Development of Decision Support Tools for Rendering Forecast Probabilities to EMs
- Research on Improving Probabilistic Based Decision-Making

Education Focus:

Graduate

Dual Degree
- ✓ *NCU-UAlbany / NTU-UAlbany****
- ✓ *NCU-Howard / NTU-Howard*

****Already in place*

Graduate Certificate
- ✓ *NCU-UAlbany / NTU-UAlbany*
- ✓ *NCU-Howard / NTU-Howard*

Dual Degree
- ✓ *NCU-UAlbany / NTU-UAlbany*
- ✓ *NCU-Howard / NTU-Howard*

Undergraduate

Major
- ✓ *NCU-UAlbany / NTU-UAlbany*
- ✓ *NCU-Howard / NTU-Howard*

Minor
- ✓ *NCU-UAlbany / NTU-UAlbany*
- ✓ *NCU-Howard / NTU-Howard*

Undergraduate Certificate
- ✓ *NCU-UAlbany / NTU-UAlbany*
- ✓ *NCU-Howard / NTU-Howard*

Major
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Minor
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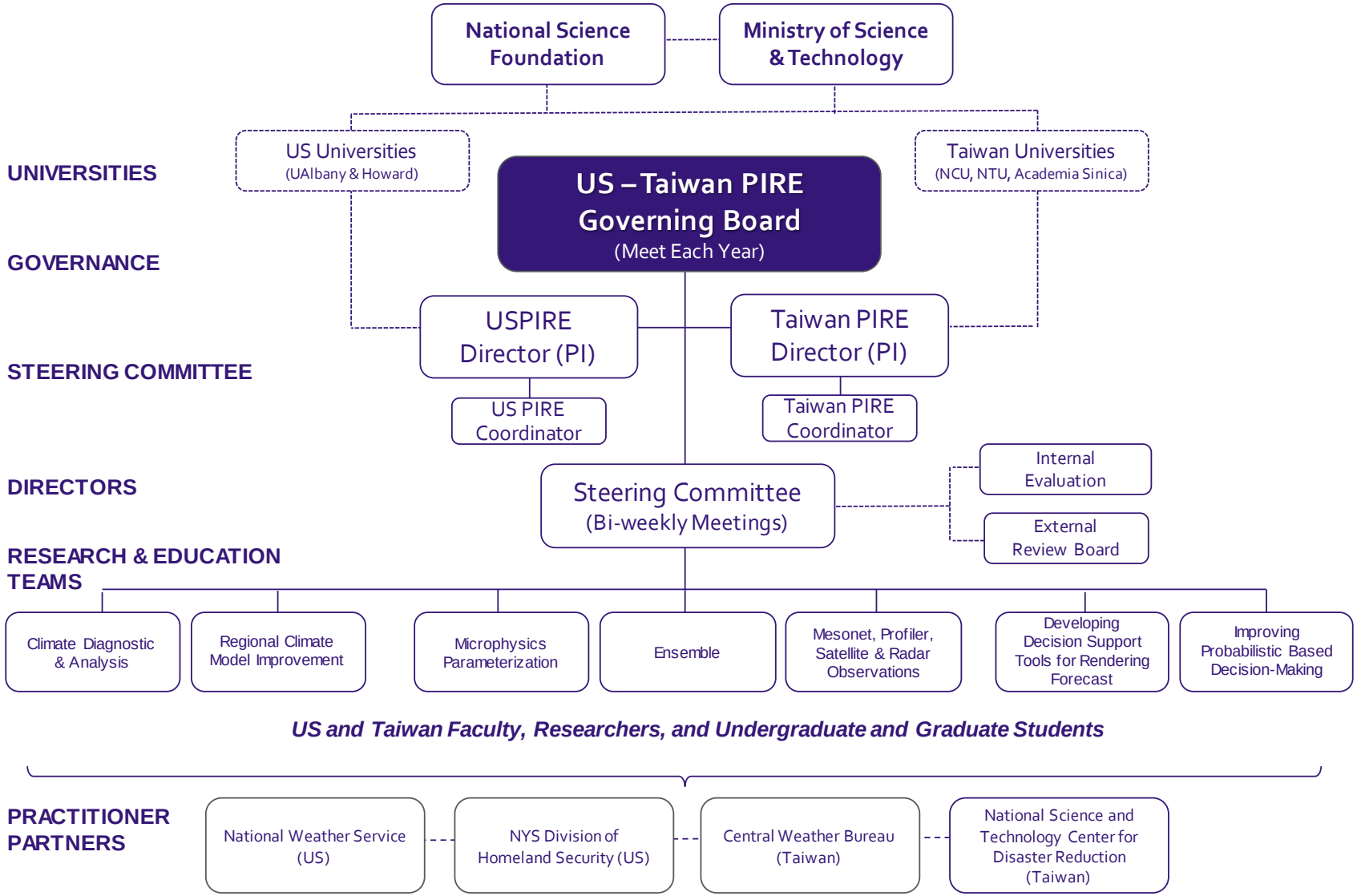
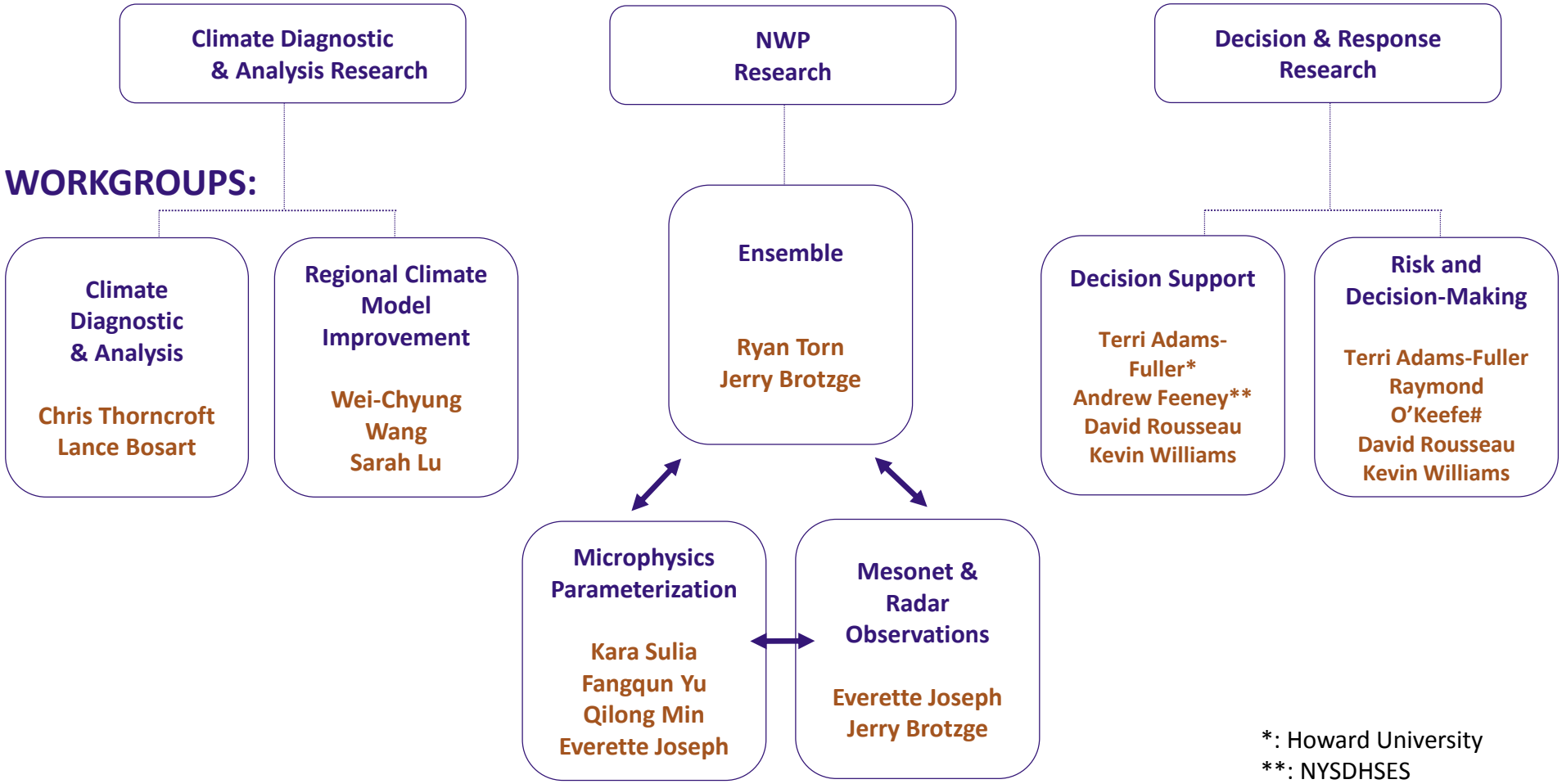
Management Structure:



US Team:

US PI: Everette Joseph
US PIRE Coordinator: Danielle Leonard

RESEARCH THRUSTS:

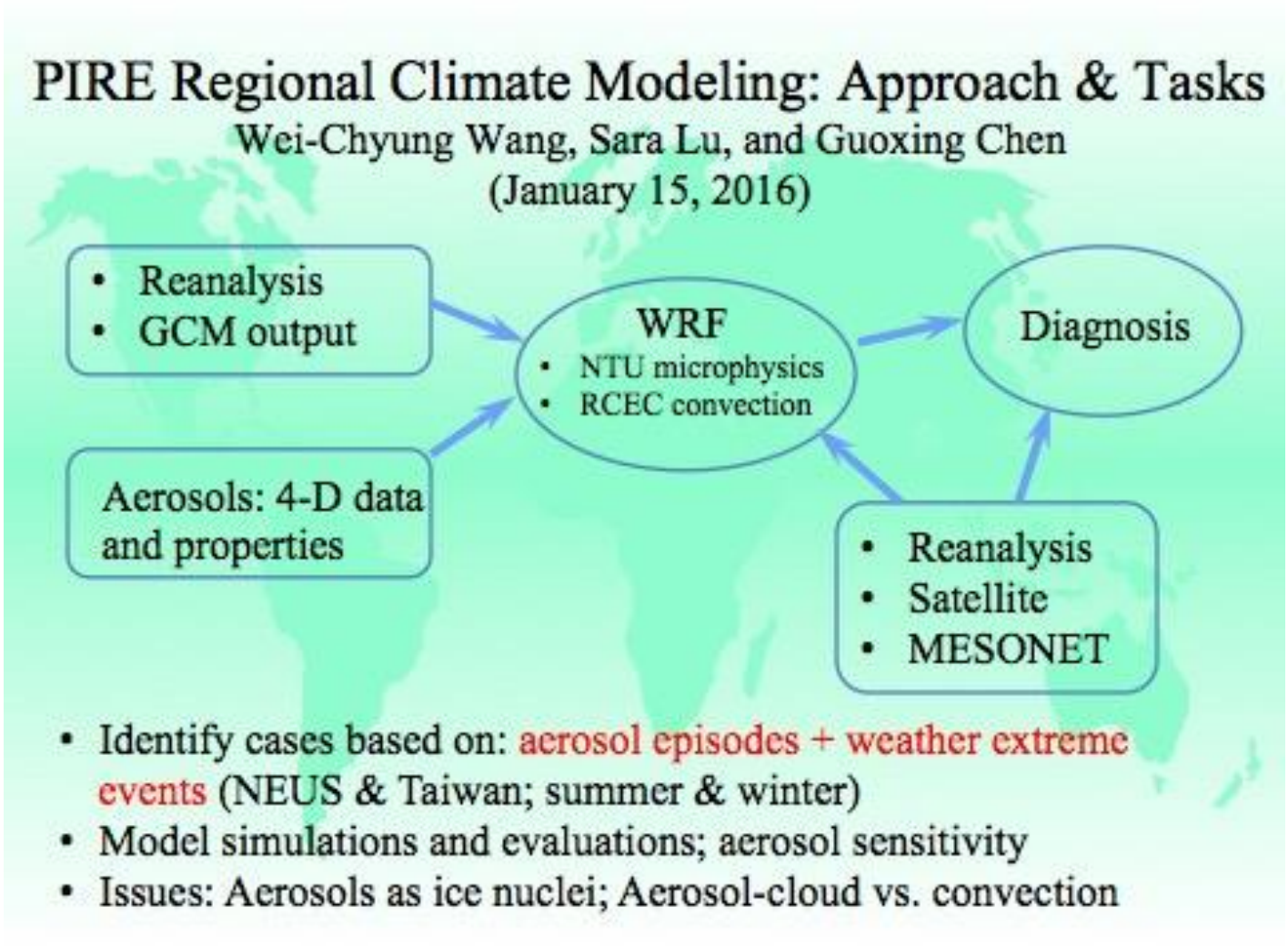


*: Howard University
**: NYSDHSES
#: NWS

Proposed Research – climate diagnostics:

1. Investigate the atmospheric processes that results in rainfall extremes with the focus on the types of the underlying weather systems, how they are established, and how they may change in the future
2. Subtasks:
    1. Case studies
    2. Composite analysis
    3. Analysis of CMIP5 model outputs

Regional Climate Modeling:



Proposed Research - Ensemble:

1. Investigate how to generate probabilistic quantitative precipitation forecast (QPF) derived from high-resol ensemble forecasts
2. Develop novel methods of communicating forecast uncertainty to emergency managers and decision makers
3. Subtasks:
    1. Initial condition uncertainty
    2. Stochastic microphysics
    3. Forecast rendering
    4. Convective-scale data assimilation for extreme rainfall prediction

Project Status:

1. Selected and funded by NSF since Sept 2015
2. US evaluation team led by Dr. Kinser visited Taiwan/NCU on Dec 2015
3. US-Taiwan evaluation team met at Albany on Jan 2016
4. US PIRE Coordinator came on board on Jan 2016
5. On-going activities
    1. Research group meetings
    2. Graduate recruiting
    3. Summer program in planning
    4. US-Taiwan project meeting (tentatively Oct at Albany)

Summary:

1. Extreme weather events are increasing globally likely associated with climate change: 20 year events predicted to become 10-5 year events
2. Increases the risk of weather impact/disaster on communities.
3. Increasing the resiliency of communities (NY) by decreasing vulnerability and exposure through better disaster management and adaptation
4. Deploying the NY Mesonet to improved real-time monitoring of events and short-term prediction
5. Establish US-Taiwan partnership to
    1. Improve understanding of climate impact on extreme events in NE and E. Asia
    2. Improve probabilistic forecasting of these events
    3. Improve decision-making based on probabilistic information
    4. Train experts in these areas

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