



# Working Group on Nowcasting Mesoscale Research

## WGNE Meeting

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20150324

# Outline

- Background
- Nowcasting-Mesoscale Merger
- Projects of Interest
  - Aviation RDP
  - Lake Victoria
  - Korea 2018
  - Pan Am Legacy – GURME
- Other Projects
- WGNE Collaborations

# What do we do?

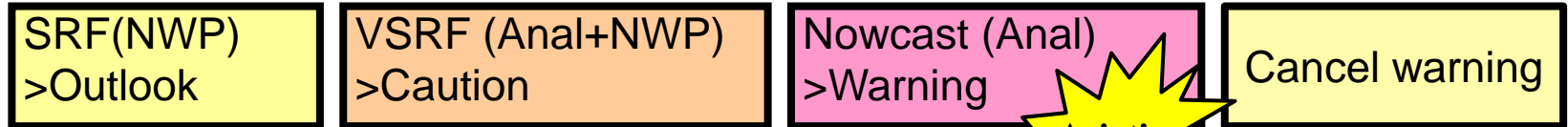
- Advance the science
- Promote the science
- Capacity Build



# Nowcasts leads to a “call to action”

## High Impact – Forecast System

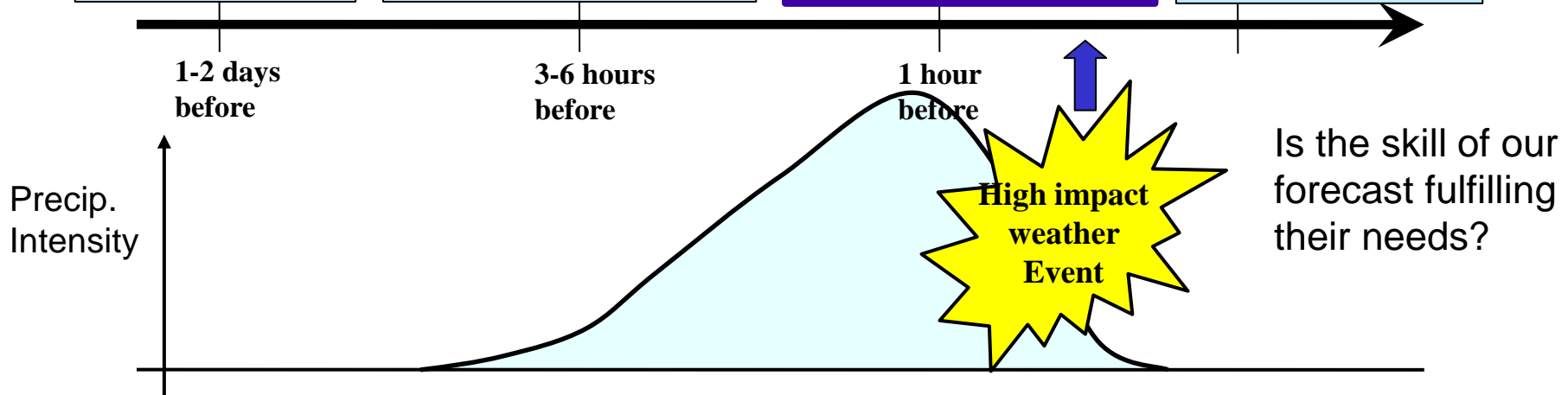
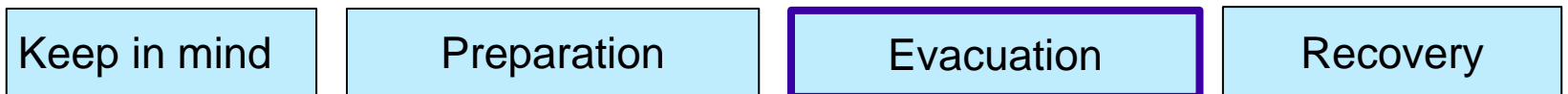
### Met. Information



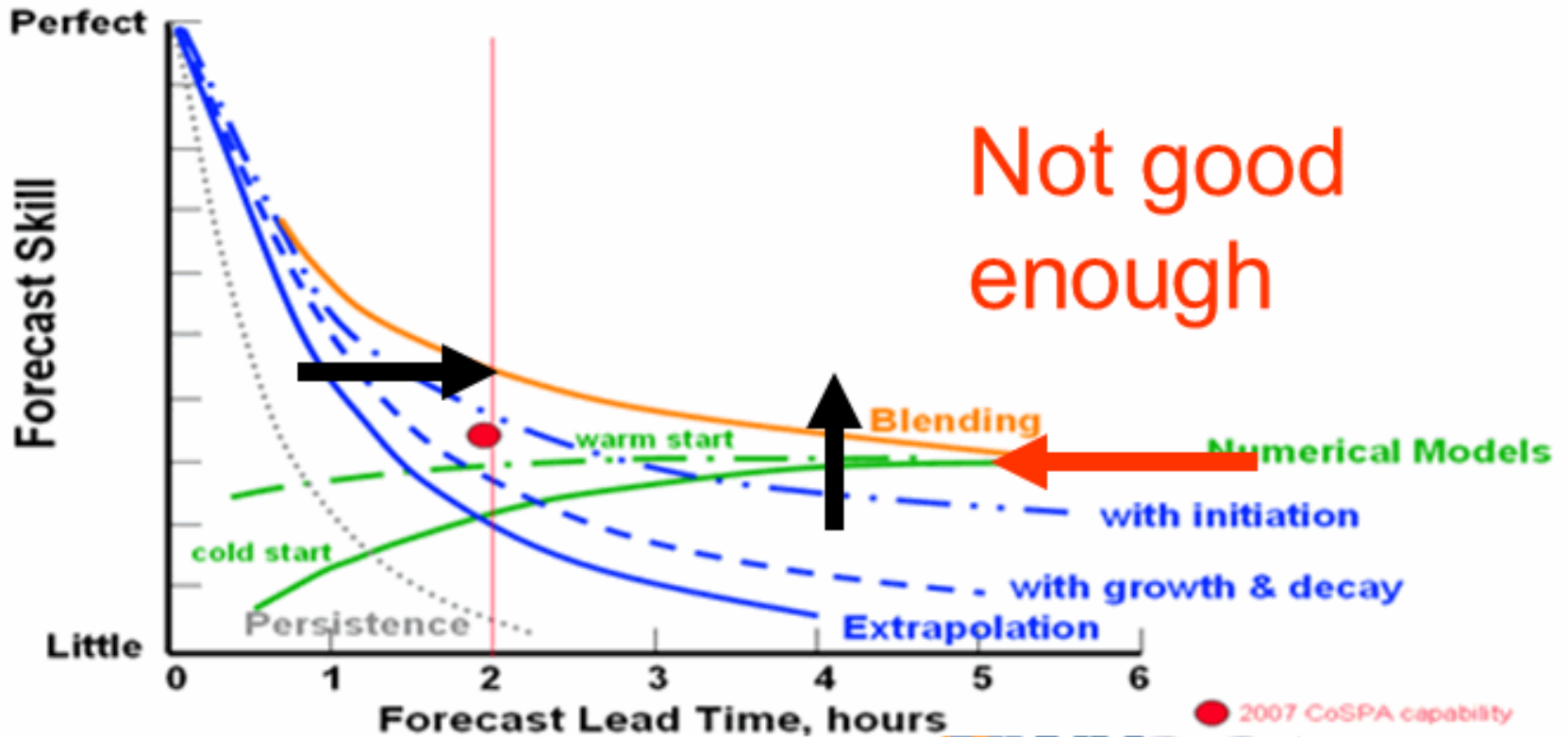
### Local Government / Industry



### Citizen



# Early Notification, Watches and Warnings and Decision-making



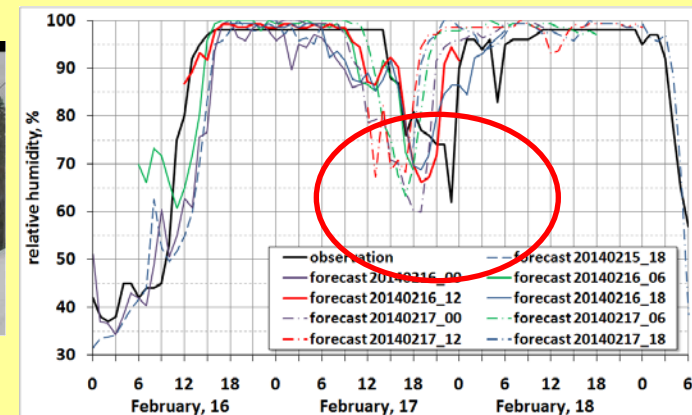




17.02.2014 . Camera shots from Gornaya Carousel-1500

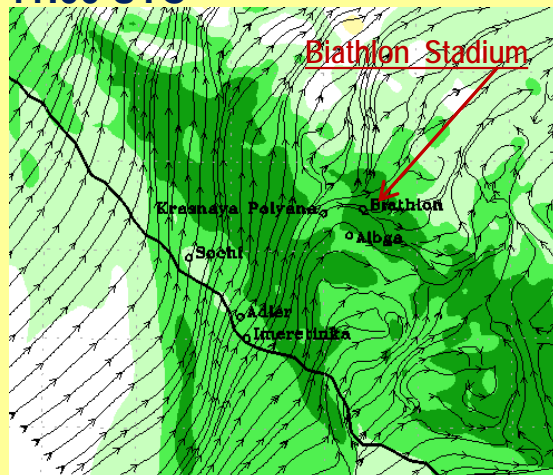


RH at 2m: Forecast and observations

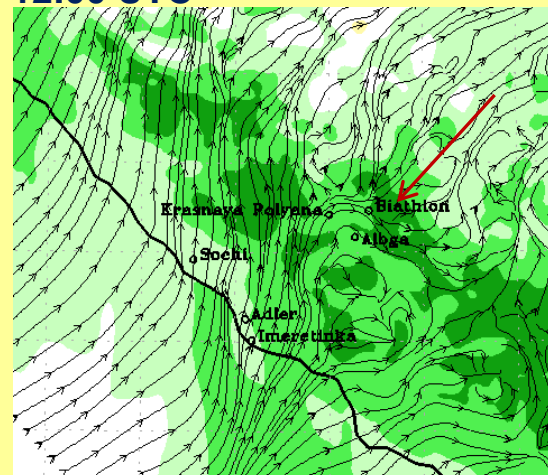


Wind and RH at 850 hPa. Forecast from 12 UTC 16.02.2014

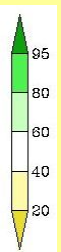
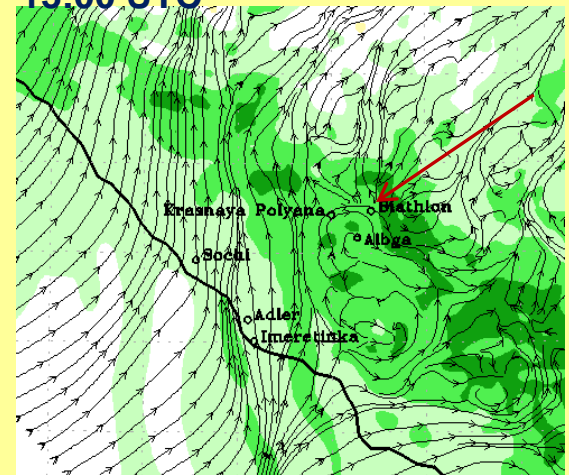
11:00 UTC



12:00 UTC



13:00 UTC



# Merger Rationale: Key Issues

## Vision:

- High Impact, Seamless, Multi-scale, Multi-Hazard Semi-Automated Forecast System

## Specific challenge:

- 1-6 h nowcasts sufficient to issue warnings!!!

# Science Challenges

- High Resolution
- Observations
- Boundary Layer – vertical resolution
- Boundary Layer and Surface Physics
- Microphysics
- Spin Up Time reduction



# **AVIATION RESEARCH DEVELOPMENT PROJECT**

# Weather Information and Air Traffic Management (ATM)



Air traffic growth expands two-fold once every 15 years. The Challenge is how to achieve both safety and operational improvements

- Globally harmonized
- Environmentally responsible
- Cost-effective
- 2028 implement

- Complex ATM decision-making -> needs more precise weather information and forecast, in both time and space
- Increasing air traffic -> aerodrome and terminal area capacity prediction
- Weather-related delays generate extra fuel consumption -> increase cost to airlines and environmental impact
- Aviation users (airlines) start to experiment probabilistic weather forecasts for decision-making -> “level of confidence”
- Better weather information for supporting Trajectory-Based Operation

# ICAO CAEM CONJOINT MEETING

## 7-18 JULY 2014, MONTREAL

### Recommendation 2/10 —Development of meteorological service for the terminal area

That ICAO, in close coordination with WMO, be tasked to:

- a) include meteorological service for the terminal area and other relevant operational requirements in Block 1 and subsequent blocks of the aviation system block upgrade methodology to highlight potential related impacts on air traffic flow in consideration of air traffic control and air traffic management (ATM);
- b) develop ATM-tailored meteorological service for the terminal area to meet future ATM requirements identified by the *Global Air Navigation Plan* (Doc 9750) and reflect the appropriate functional and performance requirements in the relevant provisions, noting outcomes from ICAO expert groups on meteorology, ATM and flight operations.;
- c) develop guidance on verification methodology toward the continuous improvement of meteorological information to ATM; and
- d) integrate the information concerning meteorological service for the terminal area into the future system-wide information management environment underpinning the future globally interoperable ATM system.

ICAO Meetings / Meteorology (MET) / Divisional Meeting 2014



French - Français

Spanish - Español

Russian - Русский

Arabic - العربية

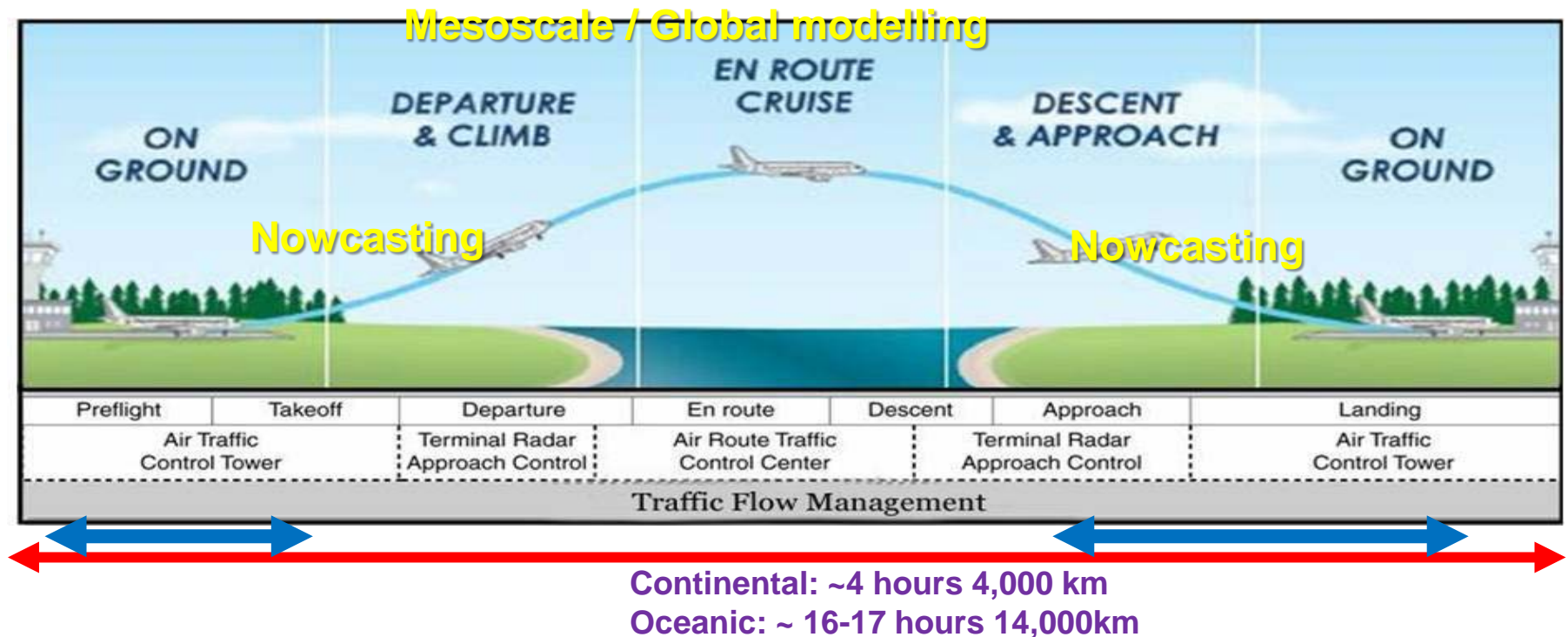
### ICAO Meteorology Divisional Meeting

(in part conjointly with the Fifteenth Session of the World Meteorological Organization  
Commission for Aeronautical Meteorology (CAeM) including Technical Conference)

MET/14-WP/64  
CAeM-15/Doc.64  
Report on B1-AMET

# Trajectory-Based Operation (TBO)

- Transition from nowcasting scale -> mesoscale -> global scale -> mesoscale -> nowcasting scale



Nowcasting scale: meters to kilometers, seconds to minutes

Mesoscale: kilometers to 10's of kilometers, 10's minutes to hours

Planes move ~500+ km/h enroute, slow down to 200km/h near touch down

Our space-time concepts/scales are extended/compressed

# MET information needs

## Enroute

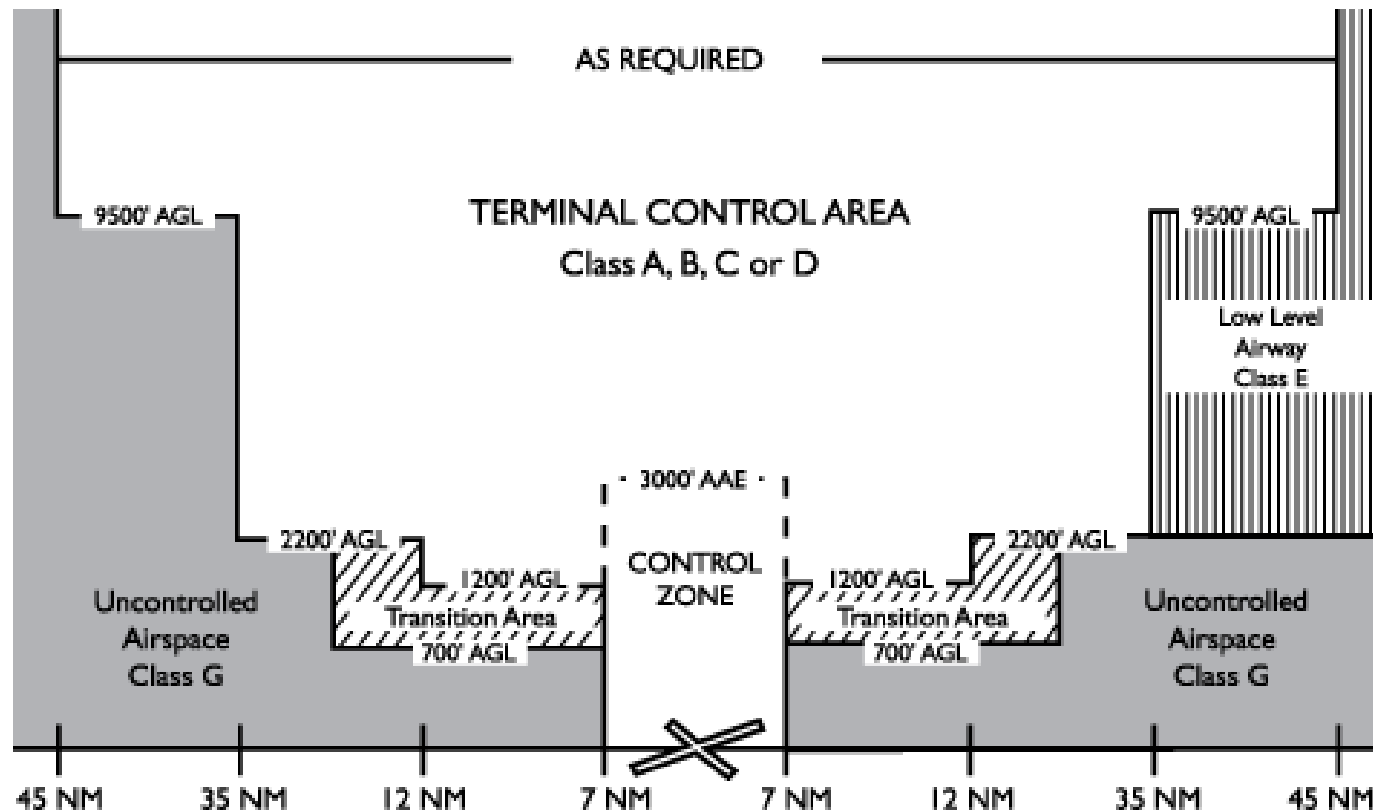
- Aviation Global Models
- WAFC – London
- WAFC – Washington
- (multimodel AGM to come)
- Harmonized WAFS products
  - winds, temp, icing, turbulence, Cb, etc.
  - Horizontal resolution 1.25deg
  - Temporal resolution 6hr (to increase to 3hr)
  - T+0 – T+36hr

## Terminal Control Area

- Meteorological Service information for the Terminal Area (MSTA)
- ICAO in close collaboration with WMO will develop MSTA to meet future ATM requirement under GANP
  - Establish the functional and performance requirements
  - Develop guidance on verification for continuous improvements
  - Integrate the MSTA into SWIM

# Impact = End User Decision-making

## Complex Terminal Area



- ~100-200km
- ~30-60min+ flight to/from airport
- area mostly needs nowcast and mesoscale modelling

Domain	Resolution	Validity Range	Refresh Rate
GLOBAL	15 km	[0 - 20 min]	20 min
REGIONAL	1.5 km	[0 - 20 min]	20 min
LOCAL	0.3 km	[0 - 3 min]	3 min

Domain	Resolution	Validity Range	Refresh Rate
GLOBAL	3 km	[0 - 2 h]	20 min
REGIONAL	2.5 km	[0 - 2 h]	20 min
LOCAL	1.5 km	[1-3 h]	20 min

Domain	Resolution	Validity Range	Refresh Rate
GLOBAL	15 km	[6 - 240 h]	6 h
REGIONAL	2.5 km	[2 - 21 h]	1 h
LOCAL	0.5 km	[1-3 h]	20 min

**OBSERVATION**

**NOWCASTING**

**FORECAST**

T0-years

T0-6  
months

T0-days

T0-hours

T0-  
minutes

TO



BDT

SBT

SBT

SBT

SBT

SBT

RBT

**Business  
Development  
Trajectory**

**Shared  
Business  
Trajectory**

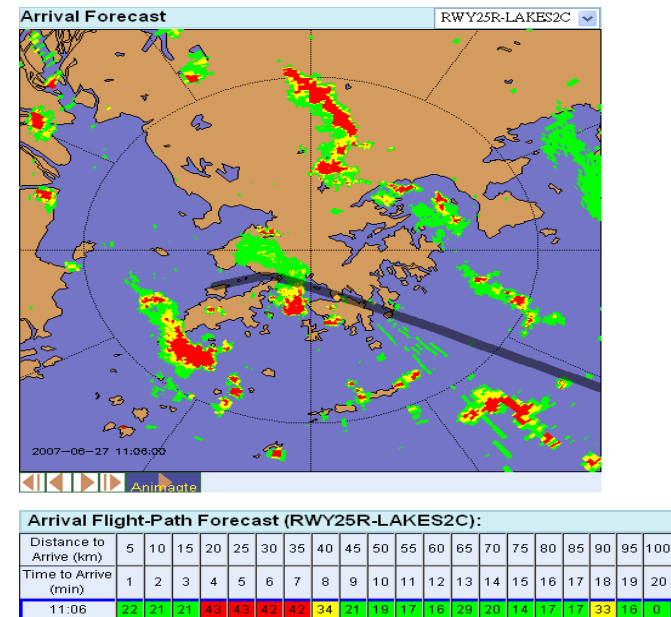
**Reference  
Business  
Trajectory**



# The AvRDP goals are

1. Demonstrate the current state-of-art of the nowcasting and mesoscale modeling techniques for the Trajectory Based Operations concept;
2. Determine the suitable aviation nowcasting and modeling, verification methods (deterministic and probabilistic) and verification, to meet the ASBU requirements
3. Work with end-users to translate the MET nowcast/forecast products and uncertainty information into ATM impact products?
4. Capacity Building and Technology Exchange/Transfer to WMO/CAeM Members

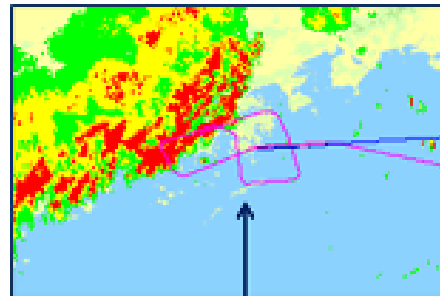
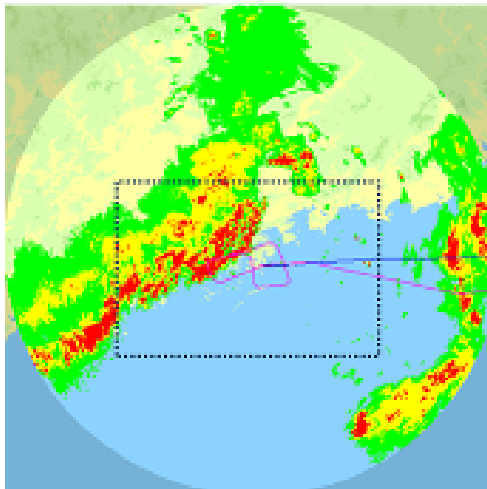
*Conceptual Trajectory Based Convection Nowcast*



*Flight specific weather forecast*

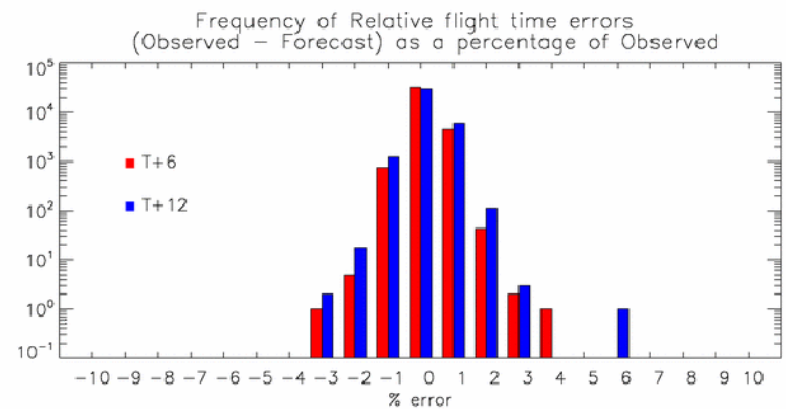
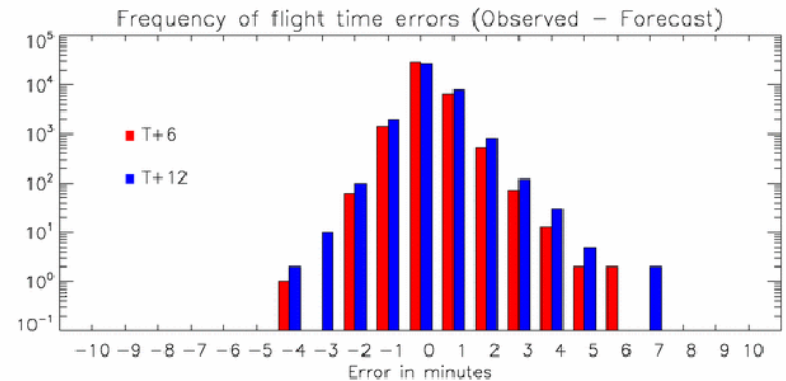
# Impact Based Verification

## Predicted Runway Capacity



**Missed Approach**

## Flight Time Accuracy



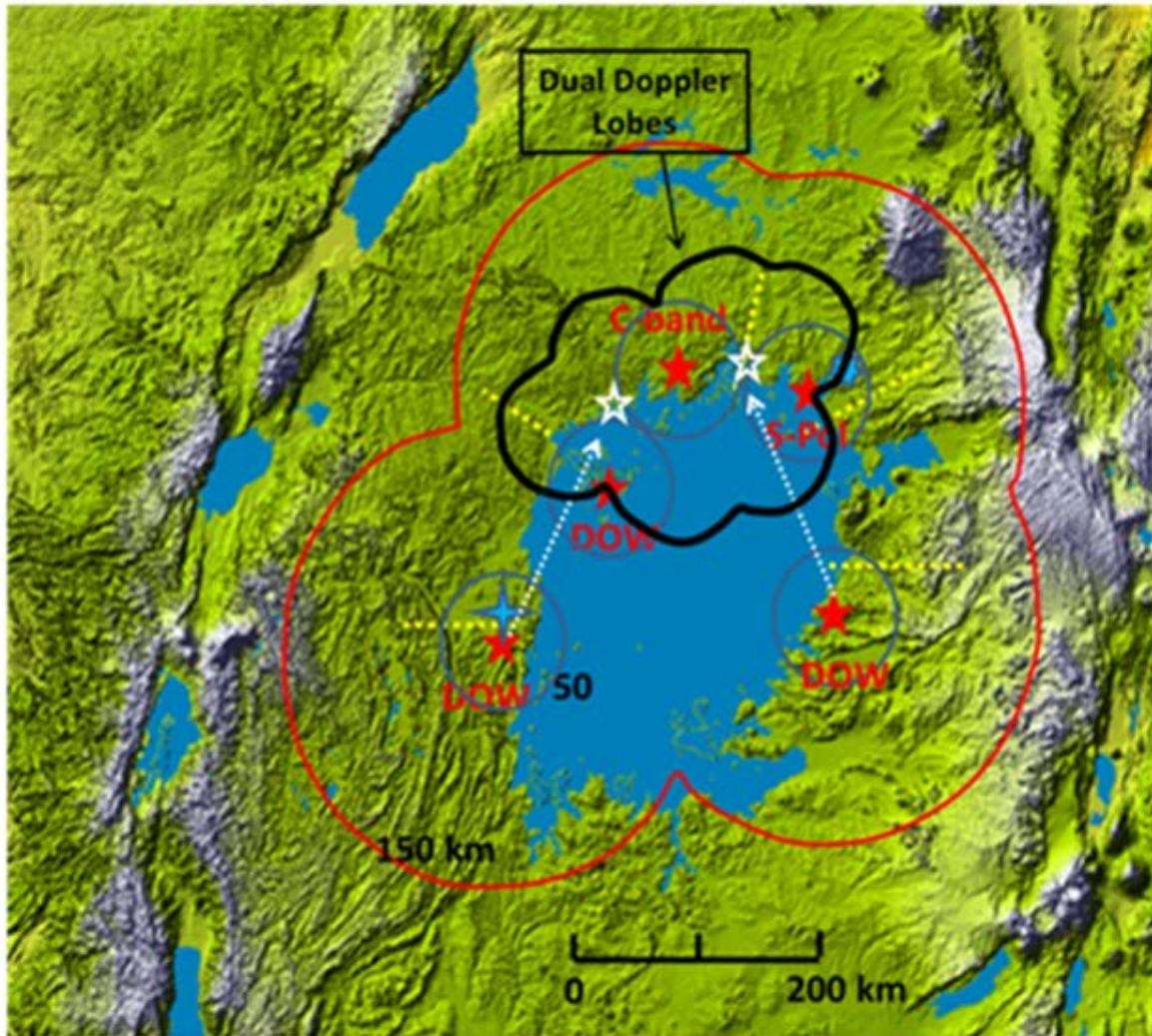
**LAKE VICTORIA BASIN  
HYDROCLIMATE TO  
NOWCASTING EARLY WARNING  
SYSTEM**

# LVB-HyNEWS

Lake Victoria Basin – Hydroclimate to Nowcasting Early Warning System

Mar 3 2015

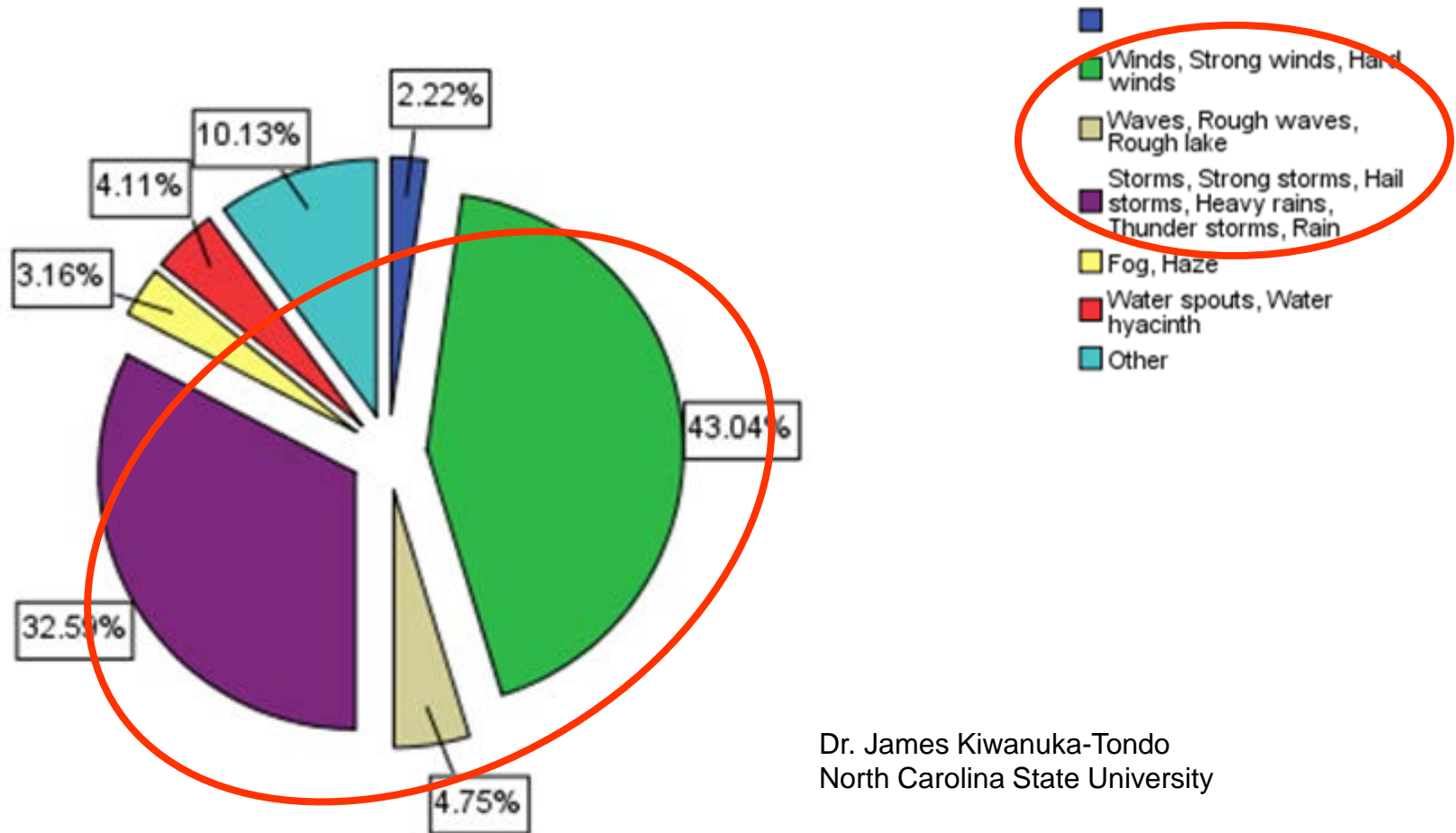
Survivors count their losses after freak storm kills over 40





# Over Lake Victoria

## Wind and waves are the problem!



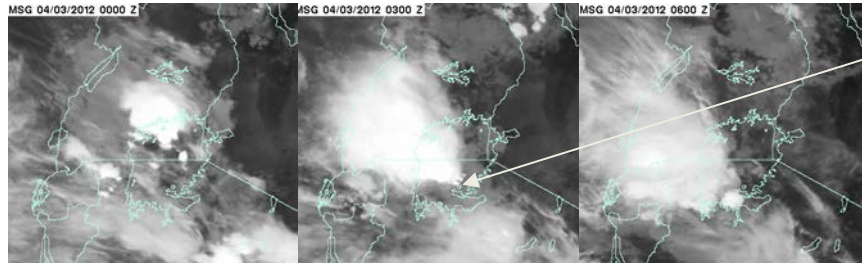
Dr. James Kiwanuka-Tondo  
North Carolina State University

# Lake Victoria

Validation of model: Case study 4<sup>th</sup> March 2012

Caroline Bain

Using the 4 km NWP for direct detection of high winds, heavy rains not just the environmental conditions!  
Need more study!

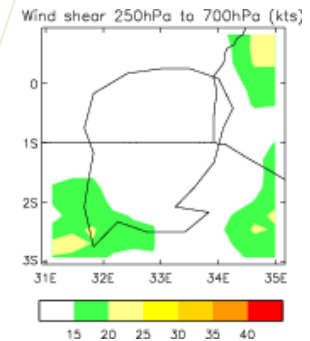
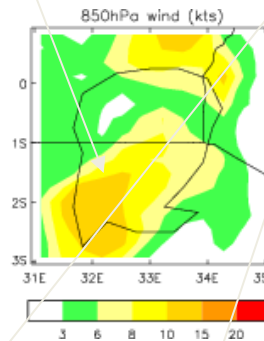
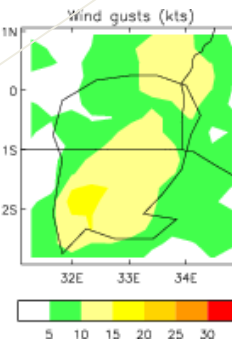
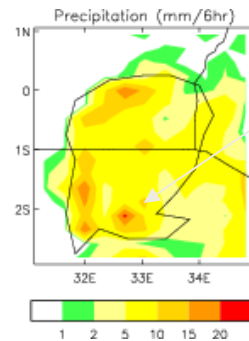
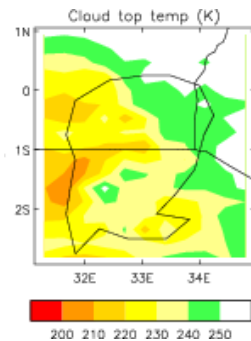


4<sup>th</sup> March 2012: Storm over Lake Victoria caused the deaths of 2 fishermen when a boat capsized

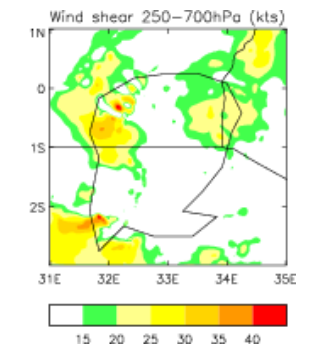
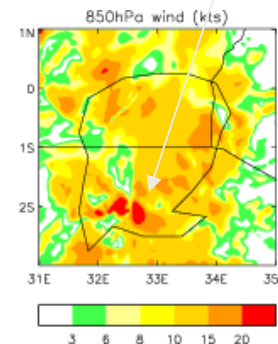
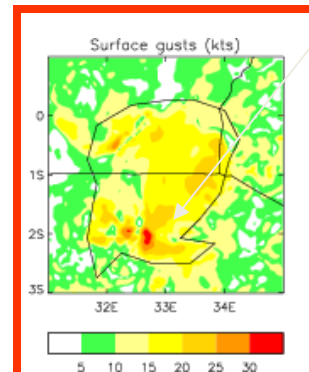
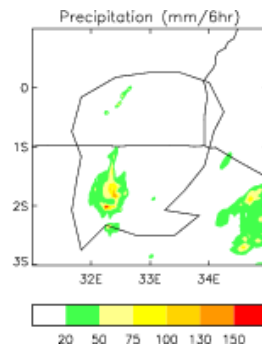
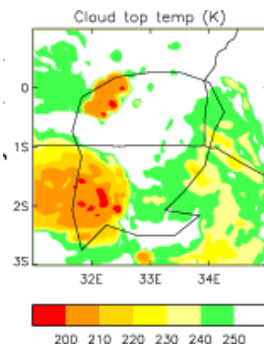
The Global UM showed some indication of the event in T+6 forecast

The 4km UM showed increased indication of the storm in T+6 forecast

Global UM



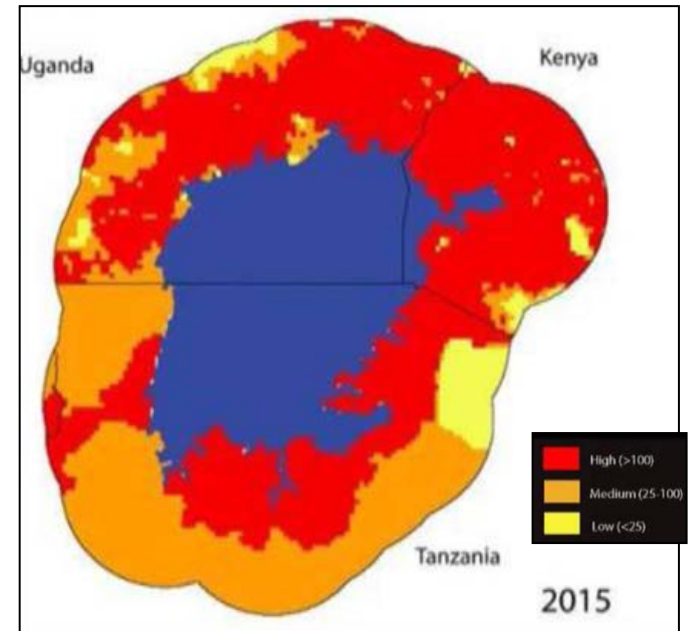
4km UM



# Background: EAC EWS Recommendation

“Enhancing safety of navigation and efficient exploitation of natural resources over Lake Victoria and its basin by strengthening meteorological services on the lake”

- Enhancement and upgrading of the meteorological and marine observation systems
- Development of a Navigation Early Warning System
- Hotspots Atlas
- Establish a Centre of Meteorological Services for LV



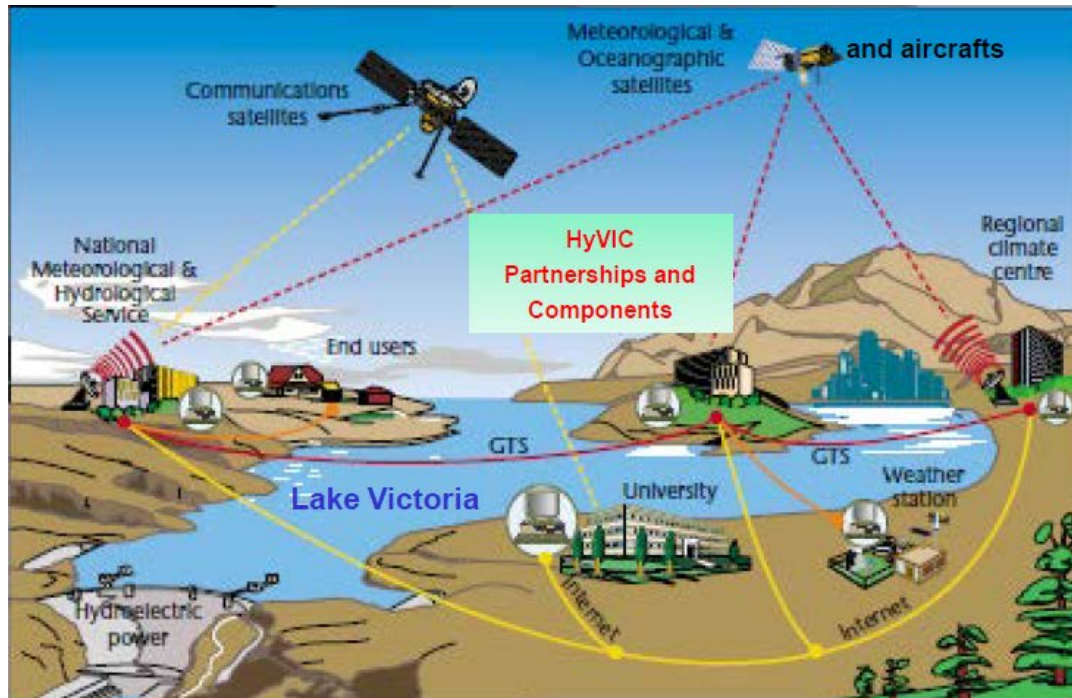
“WMO Executive Council (EC) recommended that a World Weather Research Programme (WWRP) project be considered for the Lake Victoria Watershed that would include a test-bed for field campaigns to collect data for research to understand the dynamics over the lake in order to reduce disaster from water spouts, waves, and wind gusts that affect both lake transport and fishermen who rely on the lake for their livelihoods. The EC further noted the potential linkages with the SWFDP for Eastern Africa.”

*Source: WMO EC report, 2010*



# WCRP: HyVIC Science Plan

## A GEWEX Project



### Primary Authors Team

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Authors and Contributors (TBC<sup>2</sup>): Fredrick Semazzi (Lead), Sam Benedict (GEWEX ICPO, TBC), Peter J. van Elven (GEWEX ICPO, TBC), Paul Joe (Environment Canada), Norman Müller (Earth Sciences Division, Berkeley National Laboratory and the Department of Geography, University of California at Berkeley), Richard Anya (University of Connecticut), Blank General (Texas A&M University, TBC), Alton Gallo (University of Nairobi and ICPC, Kenya), Joseph Mute (University of Nairobi and ICPC, Kenya), Henry Tale (Department of Civil Engineering, Makerere University, Uganda), Joseph Decapolis (North Carolina State University), Shun Borah (University of Minnesota), Steffen Lies (University of Minnesota, TBC), James Kiwanuka-Tondo (North Carolina State University), Lian Xue (North Carolina State University), Roy He (North Carolina State University), George Xue (North Carolina State University), Andrew Githeko (Kenya Medical Research Institute, TBC), Evelyn Kobusangwe (TBC, agriculture and food, TBD (lead for DFB project), Andrew Seruma (TBC, Ministry of Water, Uganda), Kara Smith (North Carolina State University), Pascal Wamala (Tanzania Meteorological Agency, North Carolina State University), Richard Graham (UKMO, TBC), Gerson Fumbuka (EAC-LVBC, TBC), James Mungai (East African Community, TBC), John Morrison (University of Wilmington, TBC), Pius Yanda (University of Dar-es-Salaam), Francis Kuridde (Uganda, UMEME), Tate et al (UK, TBC), Yik-Lang Lin (North Carolina A&T University), Solomon Billig (North Carolina A&T University), Andrew Monaghan (UCAR-RAI, TBC), Mary Hayden (UCAR-RAI, TBC), Vase-Lange Kigeme (TBC), Fredrick Muma (University of Nairobi, Lake Victoria Hydrology, TBC), Ben Zaitchik (Hopkins University, TBC), Andrew Nyblade (Penn State University, TBC), Sandra Yuter (North Carolina State University, TBC), Bin Liu (North Carolina State University), Lynn Rose (Atmospheric Technology Services Company, Norman, OK, TBC), Ruben Barakiza (Institut Géographique du Burundi), Peter Ambenje (Kenya, Meteorology Department), Anthony Twahirwa (Rwanda Meteorological Service), Hamza Kabeila (Tanzania Meteorological Agency), Ronald Wesonga (Uganda Meteorological Department), Karsten Steinhauser (University of Minnesota, TBC), Hans-Peter Plag (University of Nevada, TBC), Matt Rodell, NASA/GSFC GRACE, TBC), Raj Pandya (UCAR/NCAR, TBC), Elaine Laug (UCAR/NCAR, TBC), Margery Overton (North Carolina State University, TBC), Sankar Arunagann (North Carolina State University, TBC), Patrick Manguha (Research and Education Network for Uganda, RENUNet, TBC), Isaac Kasana (RENUNet, TBC), Julianne Santa-Olivia (RENUNet, Makerere University, TBC), Margaret Ngunira (UgandaNet Alliance, TBC), Chris Funk (USGS EROS/USCB Geography, FEWSNet), Hassan Virji (START, TBC), African Association of Universities (AAU, TBC), TARNet (TBC), Tiwonge Mtshira Banda (UgandaNet-CHAIN, TBC), Simon Muna Karume (UgandaNet-CHAIN, TBC), Gonzalo Míguez-Machó (Universidade de Santiago de Compostela, Galicia, Spain, TBC), Helena Mitrova (North Carolina State University, USA, TBC), Peter Ojumbo (North Carolina State University, USA), Kerry Cook (University of Texas at Austin, TBC), Wamala Thaw (NOAA Climate Prediction Center, National Centers for Environmental Prediction, TBC), Michael Nkhalubo (Department of Meteorology, Uganda, TBC), Gideo Galu (FEWSNet, Kenya, TBC), Sharon Nicholson (Florida State University, TBC, TBC), T. N. Krishnamurti (Florida State University, TBC), Wilfrid Motif Ouma-Okin (UKMO, TBC), Patrick Lugunda (Farmers Media Link Center, AMELI, Uganda), Joshua Zake (Environmental Alert - Uganda), Elmhil Elshar (MIT), Filipo Georgi (ICTP), Chris Thorncroft (State University of New York, University at Albany, TBC), Richard Washington (University of Oxford, TBC), Felix Muma (Kenya University, Kenya, TBC), Jim Wilson (NCAR, TBC), Rim Roberts (NCAR, TBC), Alice Soares (WMO, INT, TBC), Peter Lamb (University of Oklahoma, TBC), Yong Wang (Central Institute for Meteorology and Geodynamics, Hobe Warte, Vienna, Austria, TBC), Belay Demze (Howard University, TBC), Lawrence Carey (University of Alabama, Huntsville, TBC), Belay Demze (Howard University, TBC), Brian Golding (UK Met Office, TBC), Steven Goodman (NOAA, TBC), Yang Hong (University of Oklahoma, TBC), Kevin Knapp (University of Alabama, Huntsville, TBC), Karen Kosiba (Center for Severe Weather Research, TBC), William McCall (USA, TBC), David Parsons (University of Oklahoma, TBC), Ralph Petersen (U. of Wisconsin, TBC), James Panto (NCAR, TBC), Yvette Richardson (Pennsylvania State University, TBC), Tammy M. Weckwerth (NCAR, TBC), Eadie Williams (Massachusetts Institute of Technology, TBC), Josh Wurman (Center for Severe Weather Research, TBC), Sakeena Bharmani (metADAPT, United Kingdom, TBC), Ronald Comber (University of Reading, UK), GHP (Bahex, HyMex), Kamazima Luiza (Stoney Brook University), Joseph Awange (Curtin University Australia)

- 1: Translational Research to Interface with Applications,
- 2: Severe weather and water currents,
- 3: Lake Victoria basin water and energy budgets,
- 4: Modeling of LVB hydroclimatological system,
- 5: Monitoring of LVB hydroclimatological system.

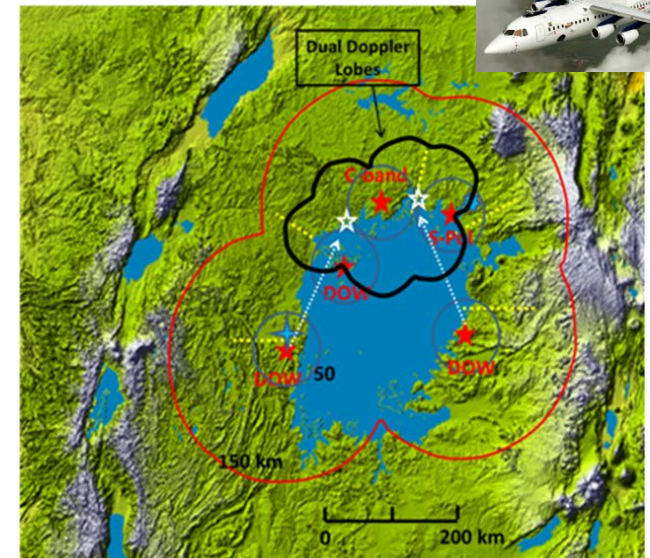
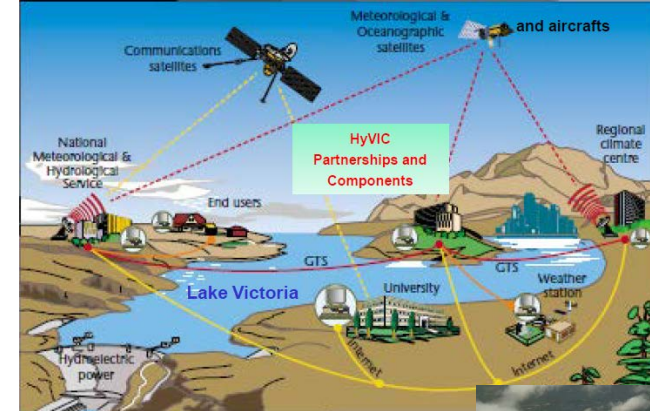
# LVB-HyNEWS

## Consortium of Projects

1. Develop a Sev Wx Nowcasting Demonstration Project (**SWNDP**) using global and regional data for all of LVB and multi-purposes (severe wx, aviation, agriculture, public health, disaster risk reduction)
2. Conduct a **Field Project** for Understanding and Verification and Validation of the SWNDP, HyVic and Thorpex HIW
3. Conduct Underpinning science to understand **climate variability/change**, improve climate predictability and to improve the projections, support decision making
4. Enhance the **monitoring network** for climate, weather and nowcaster including over the lake and its **sustainability**



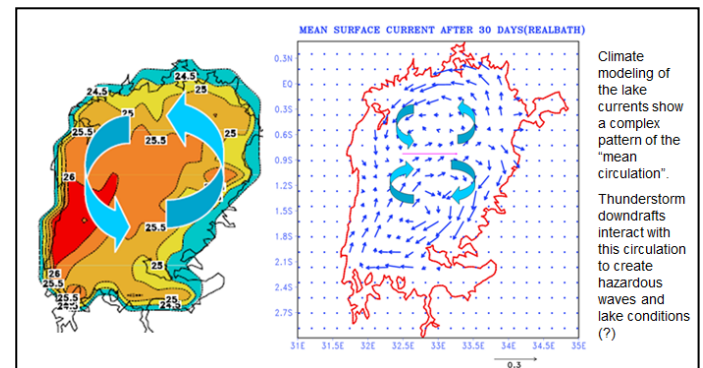
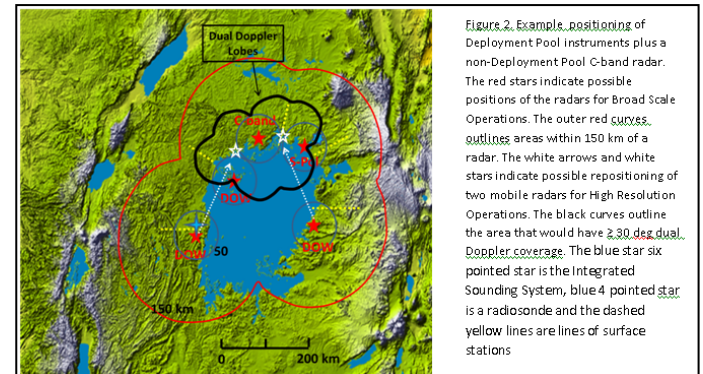
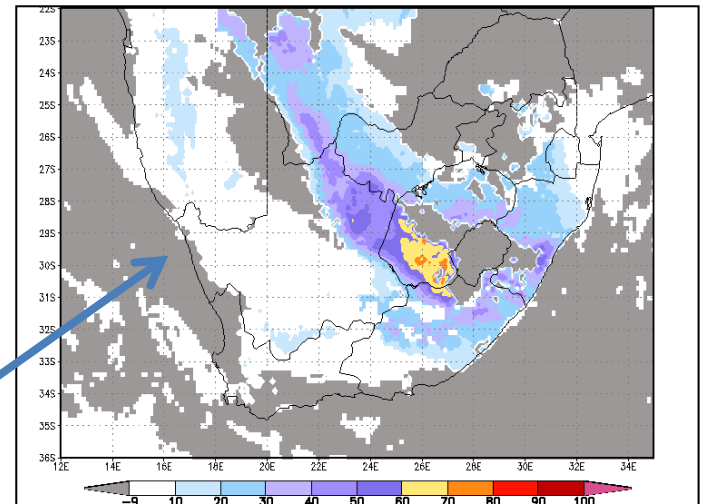
EAST AFRICA COMMUNITY MEETING OF HEADS OF METEOROLOGICAL SERVICES & JOINT ECA/AMC/AMW WORKSHOP FOR THE PROPOSED LAKE VICTORIA





# Next Steps

- May 4-8 2015
- Focal Points identified and authorized to help prepare research proposal/donor bids
- Need to increase knowledge of nowcasting (capacity building)
- Need to refine concept of the Nowcast System/Feasibility
- Develop a Nowcasting System within SWFDP framework
- Project coordinaton
- Field project preparation
- Funding/Budget planning
- Need to prepare donor requests
- Need to engage HIWeather, Lake Model, RCM ...



## Dry Season Thunderstorm – Mar 3 2015

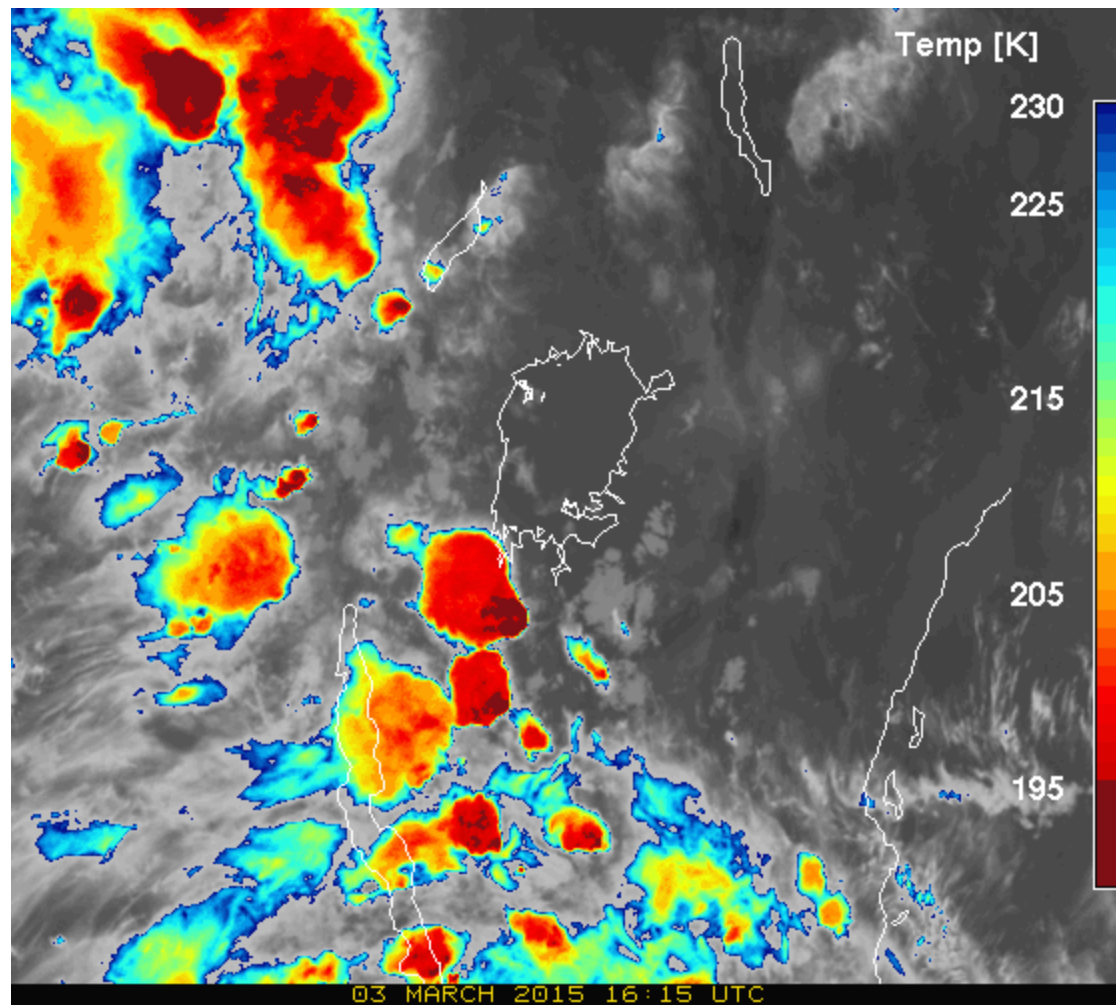
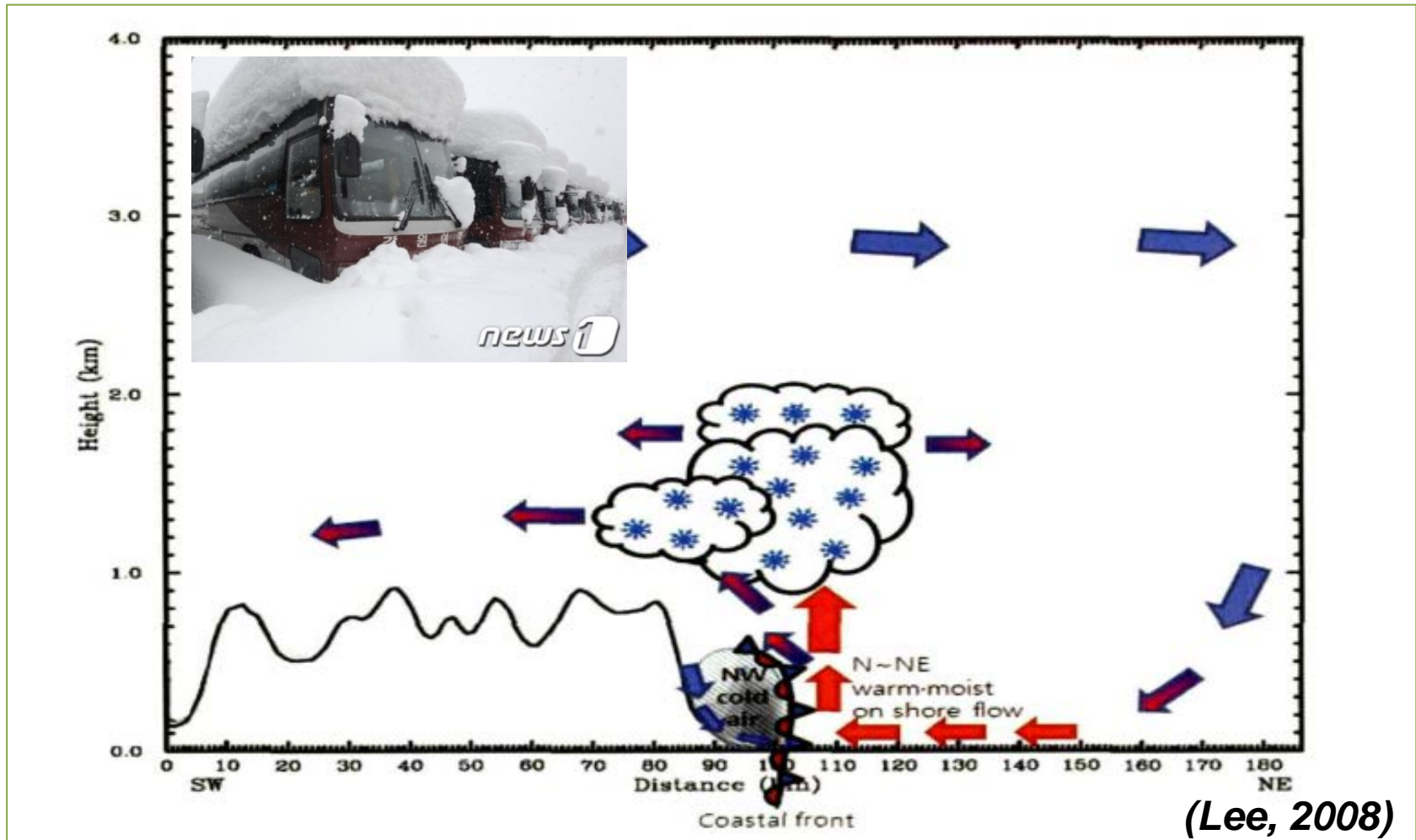


Figure courtesy of Marianne Koenig, EUMETSAT

Cold Season Microphysics Research Development Project

**KOREA 2018**

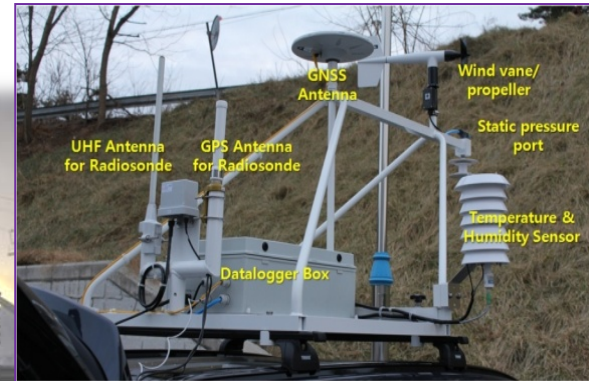
# Korea 2018 Research Development Project



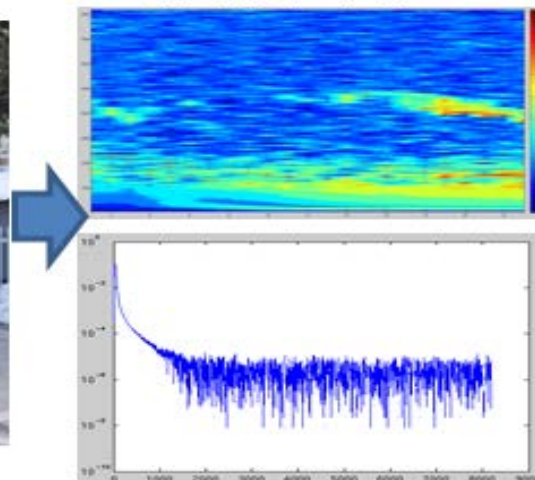


# Intensive obs campaign in 2016 – 2017

## Mobile obs vehicle to attend the campaign



Mobile Scanning Lidar





# Airborne Instruments to be constructed by 2015



## MW Radiometer



- ❖ LWC, Precipitable water, Rain rate, etc.
- G-band, W-band

## Hawkeye

- ❖ Clouds, aerosols, and precipitation

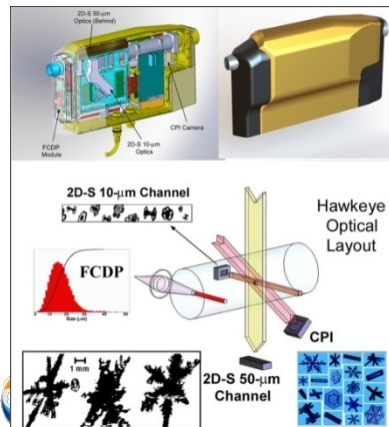
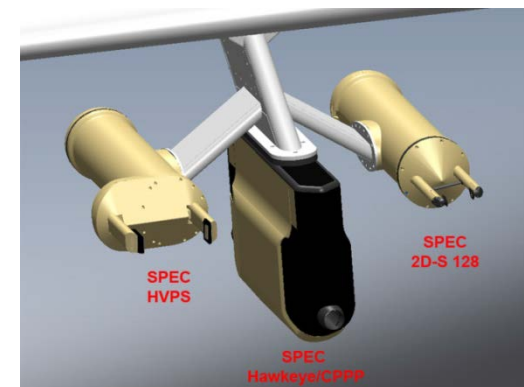
### - Hawkeye (SPEC)

- FCDP: 0.5~70  $\mu\text{m}$  (resol. 1  $\mu\text{m}$ )
- 2D-S (ch.1): 10~1280  $\mu\text{m}$  (10  $\mu\text{m}$ )
- 2D-S (Ch.2): 50~6400  $\mu\text{m}$  (50  $\mu\text{m}$ )
- CPIP: 50~6400  $\mu\text{m}$  (2.3  $\mu\text{m}$ )

### - HVPS (SPEC): 150~19200 $\mu\text{m}$

### - 2D-S128 (SPEC): 20~2560 $\mu\text{m}$

### - CCNC-200 (DMT): 0.75~10 $\mu\text{m}$ (20 bins)



High Density Measurements

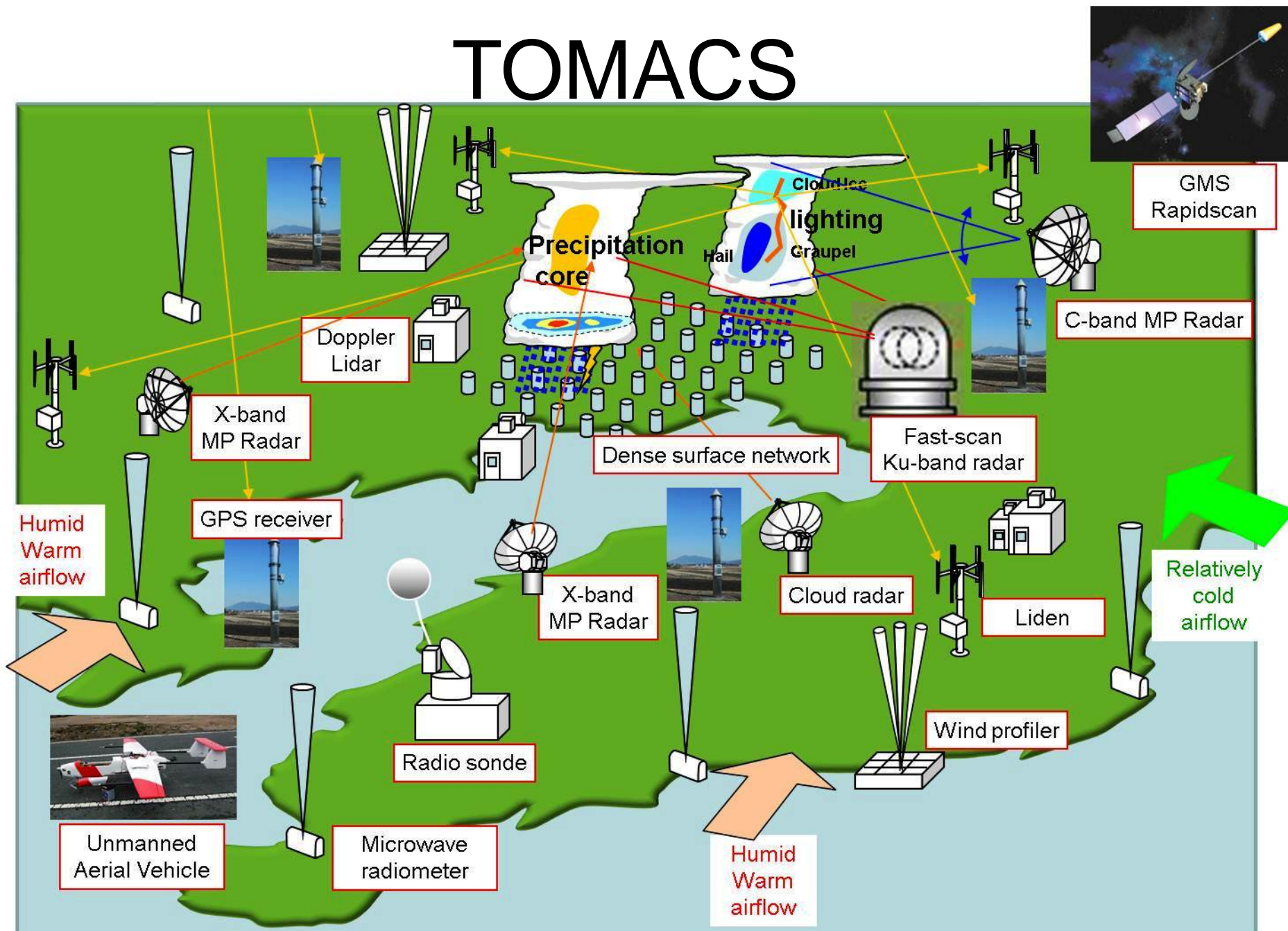
Nowcasting – Very Short Range Forecasting

Social Experiment

Urban

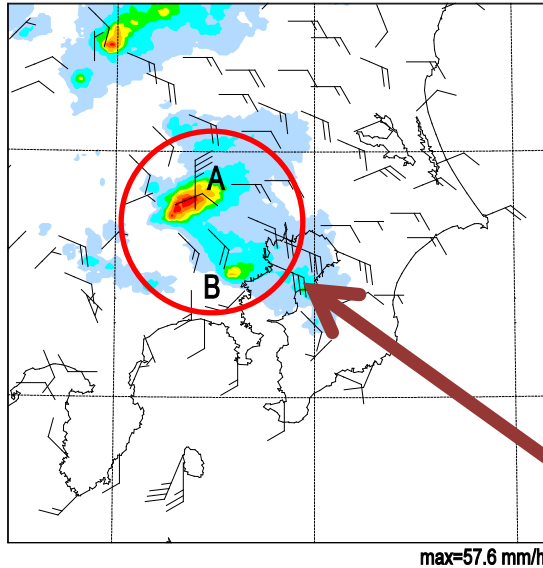
# **TOMACS**

# TOMACS



# 4DVAR assimilation of Radar, GPS and Lidar data: Local heavy rainfall event on 2010.7.5

Observation



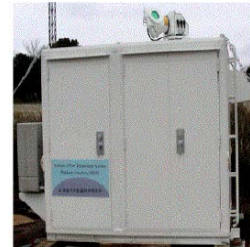
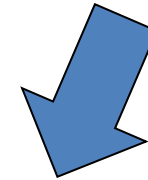
Data for data assimilation

Doppler Radar  
(Doppler velocity, Reflectivity)

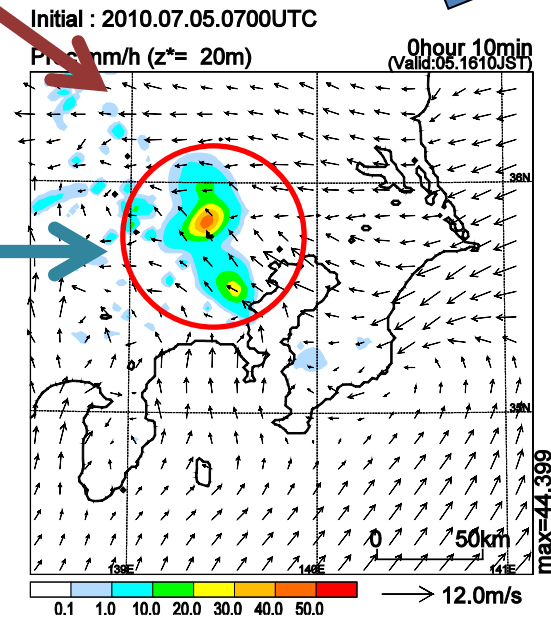
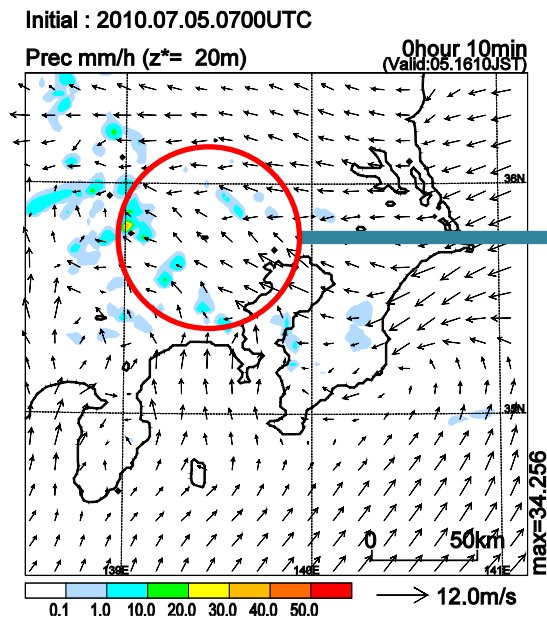
GPS Precipitable Water Vapor

Doppler Lidar Data (NICT)

Heavy rainfall  
was reproduced



First guess  
(without data  
assimilation)



Assimilated  
Results

Kawabata  
et al. (2014;  
Mon. Wea.  
Rev., cond.  
accepted)

GURME RDP Proposal – Veronique Bouchet

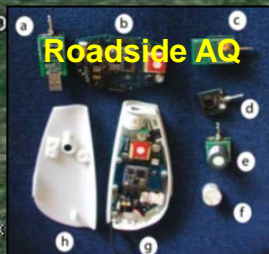
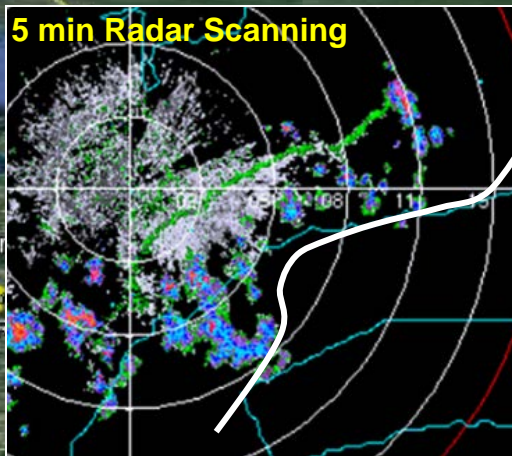
# **PAN AM GAMES 2015 TORONTO**



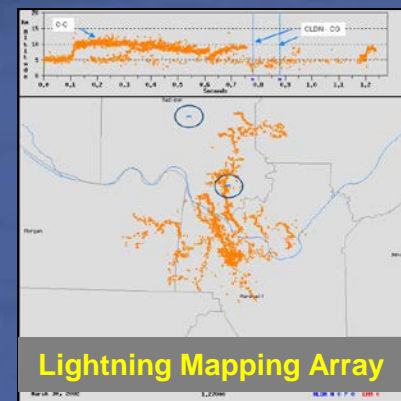
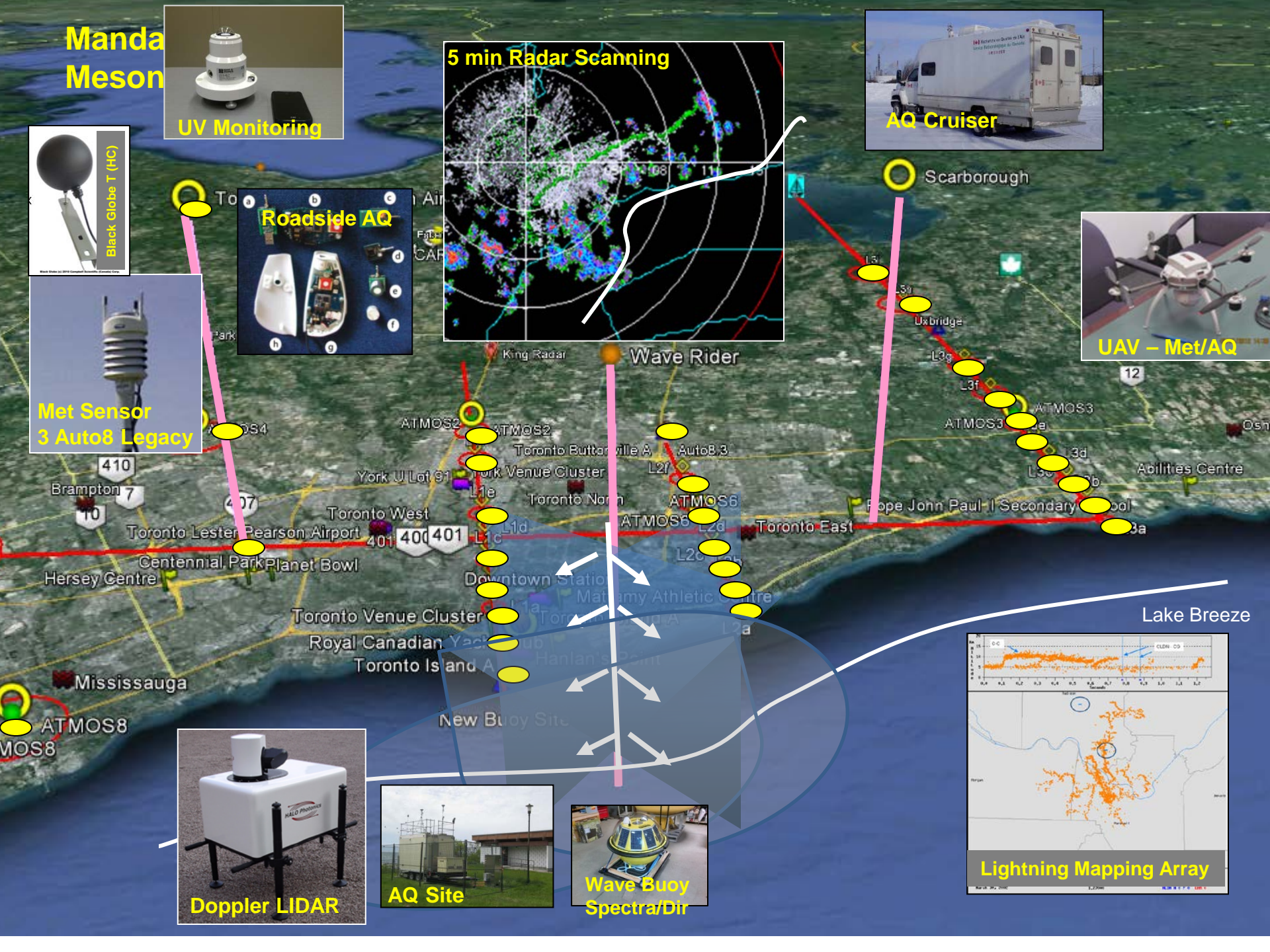
**Manda  
Meson**



**5 min Radar Scanning**



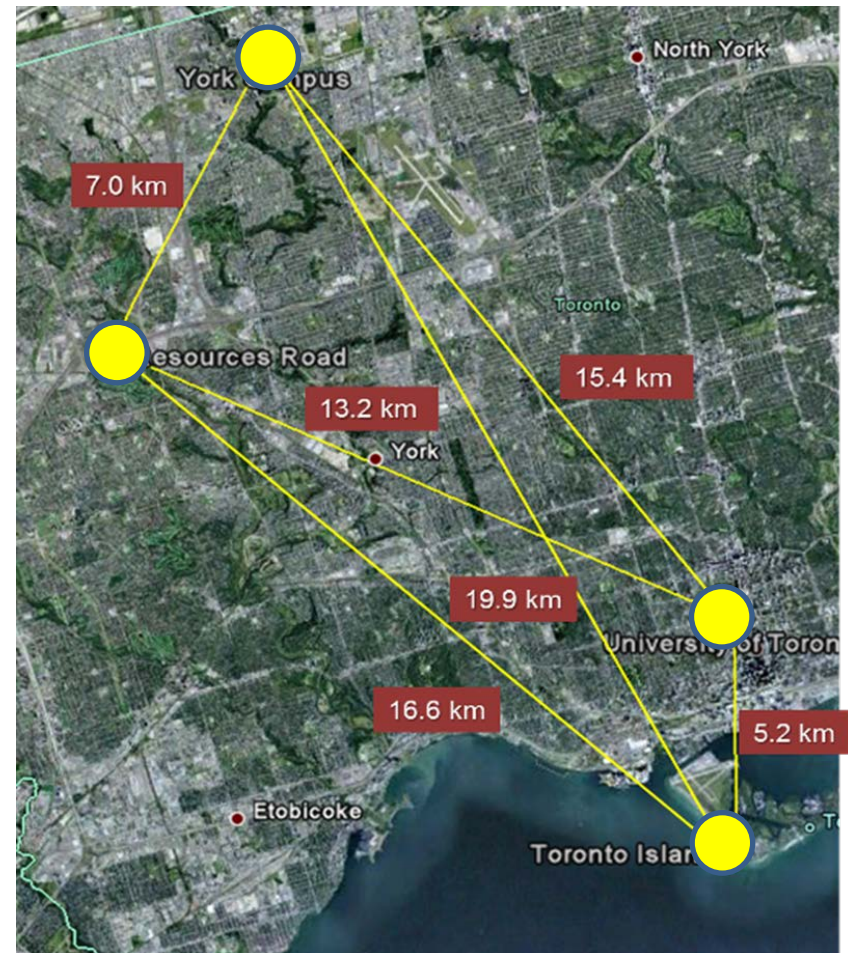
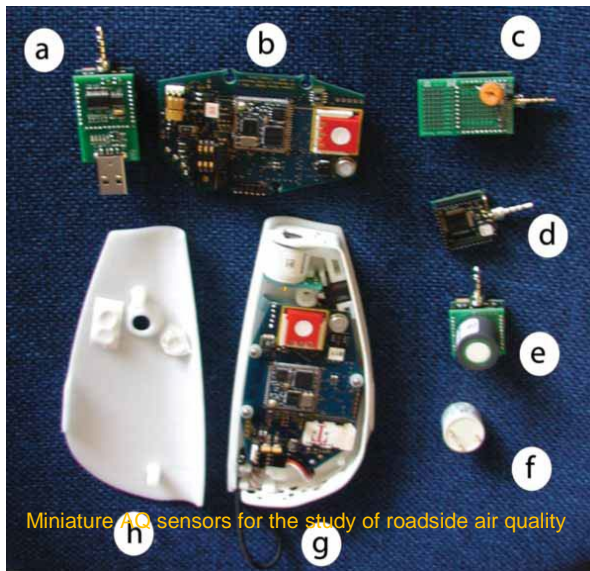
Scarborough





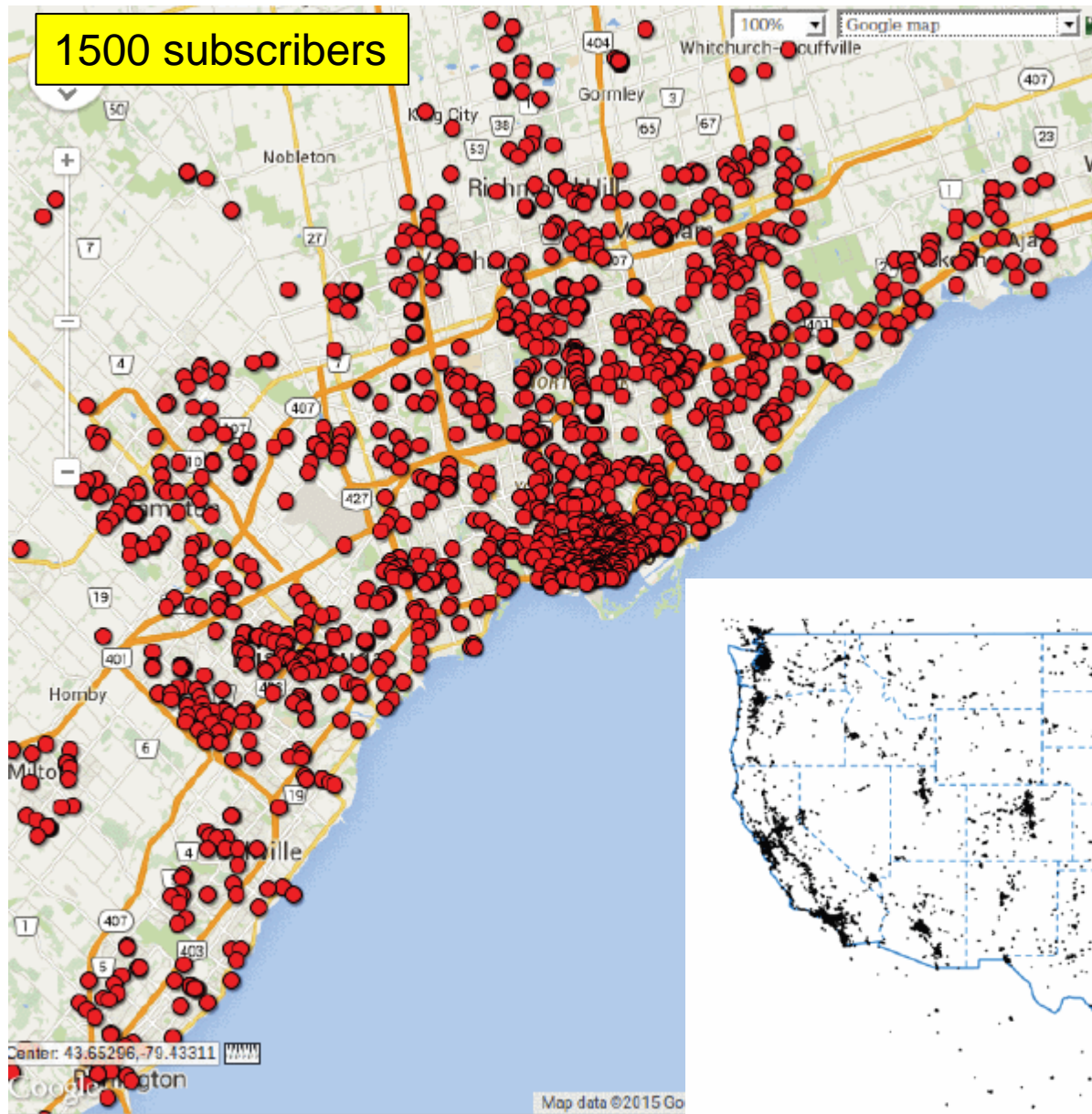
# AQ monitoring

- **Elements observed (hourly):**
  - PM2.5; PM10; Ozone; NO2; some UV
  - 2 additional AQ monitoring stations (at U of T Downtown & at York U)
- **Two additional AQ monitoring stations**
  - (U of T Downtown & York U)



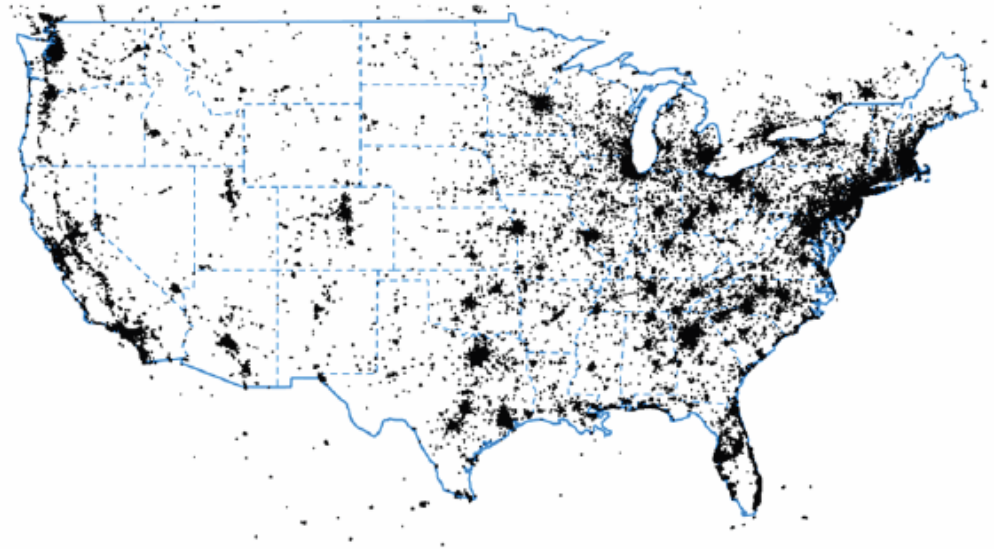


1500 subscribers



## SMART PHONE

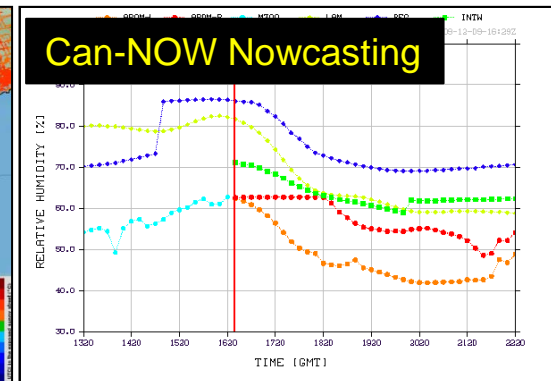
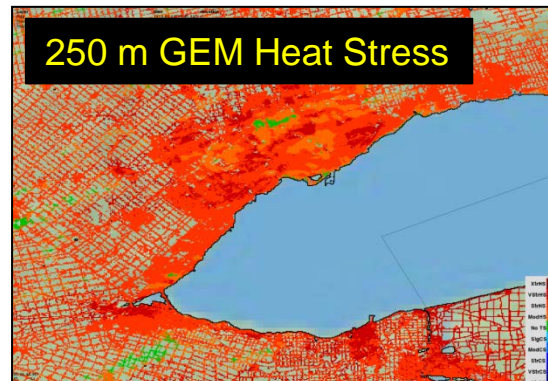
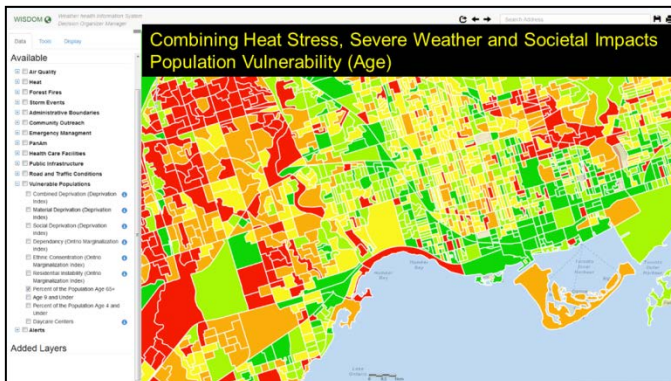
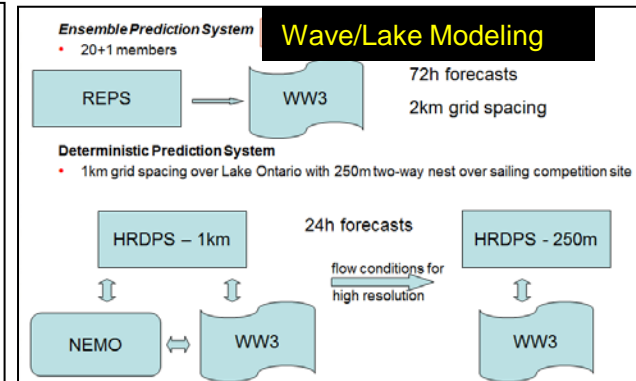
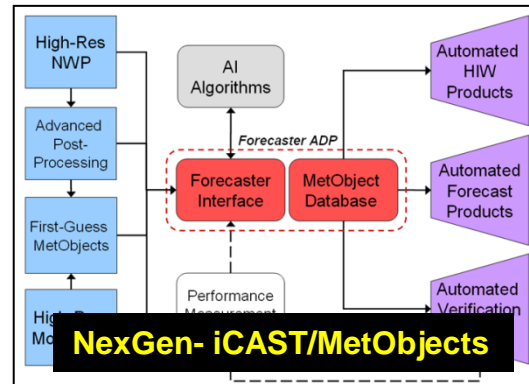
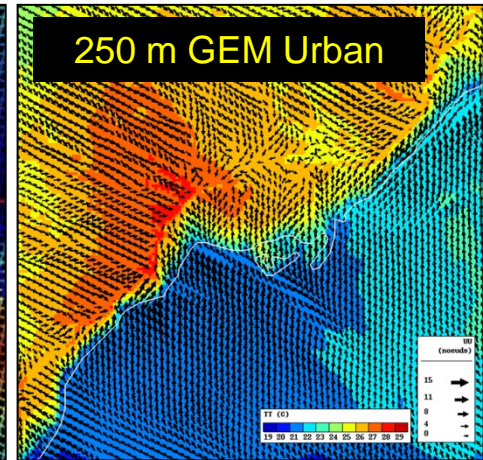
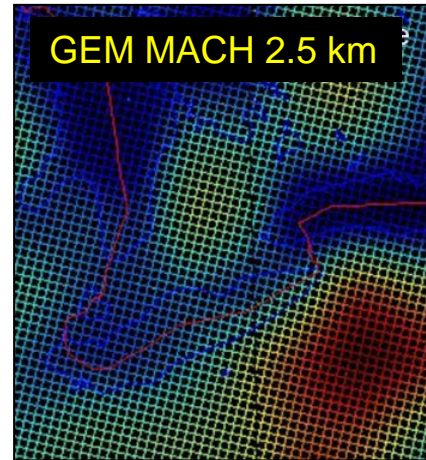
- Pressure
- *Temperature*
- *Relative Humidity*
- *Signal strength*
- *UV*



200,000 North America Sensors

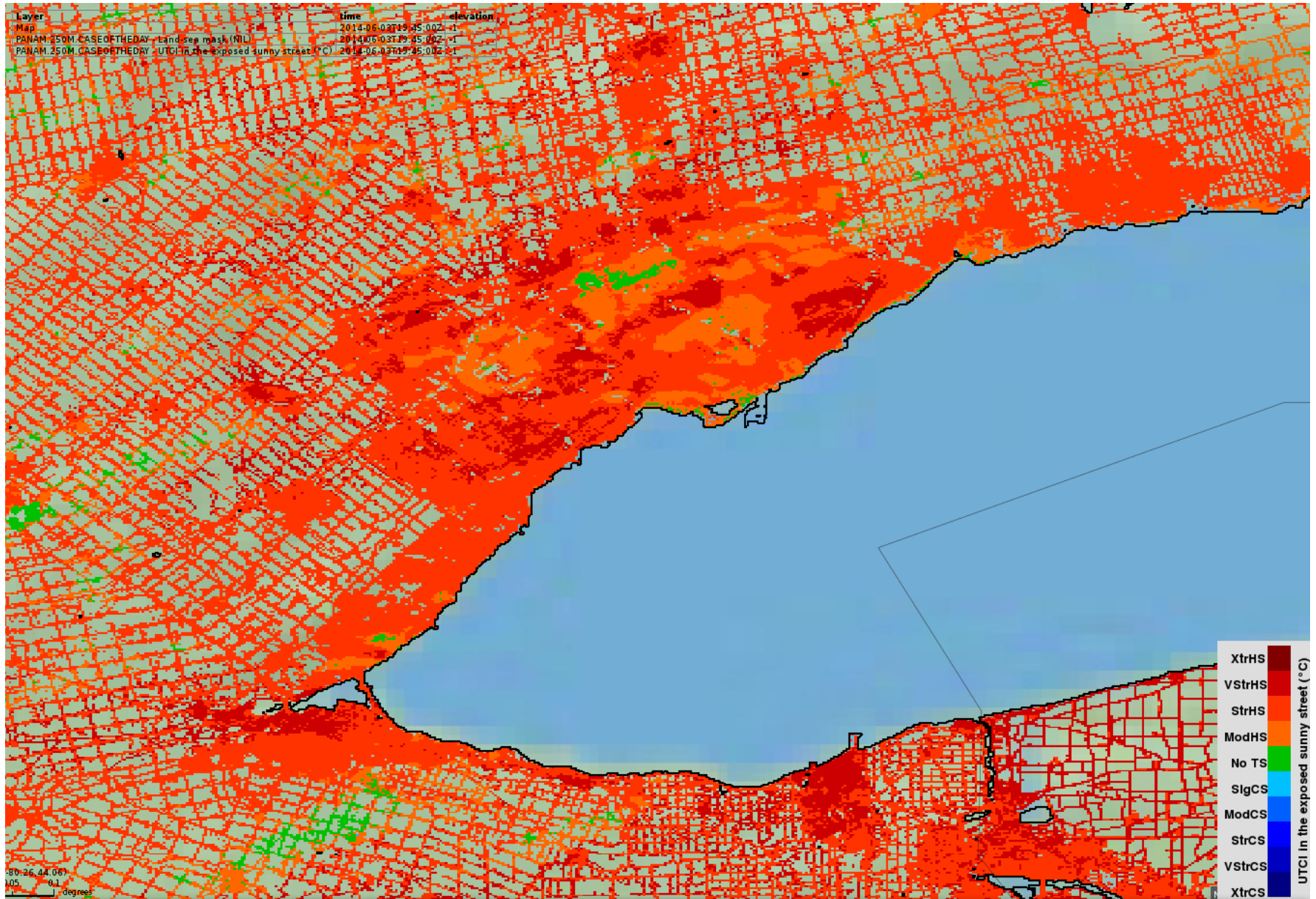
# Forecast/Nowcast System

- 2.5 km GEM MACH AQ (HPC)
- 250 m GEM Urban Model (HPC)
- Wave/Lake Model (MetAreas)
- NextGEN (MetObjects)
- Point Nowcasting
- Health Services
- Societal User Impacts





# Comfort Indices (here UTCI) over Greater Toronto Area



8 July 2013

# Collaboration Proposition

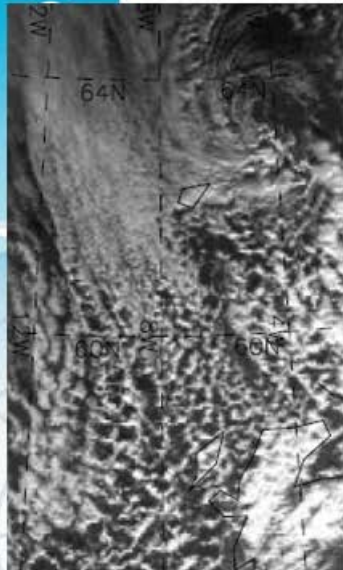
- Pan Am 15 proposed to be a “legacy dataset” under WWRP
  - Joint GURME + NMR
  - Aug 2015, Toronto, Kickoff
- Urban Workshop???
  - TOMACS, SREP, Pam Am15, others
  - GURME

Project	Main Science Focus
FROST14	Winter Nowcasting; complex terrain
TOMACS	Role of high density observations; urban
Grey Zone	Microphysics vs convection scheme
SCMREX	Precipitation physics of Monsoons
Polar Prediction Project	High Impact Polar Weather
UPDRAFT	Precipitation Physics of Land Fall Hurricanes
Lake Victoria	Nowcasting for DC; coupled models
Aviation RDP	Seamless
La Plata Basin/Relampago	Predictability
Korea 2018	Microphysics
HIWeather	TBD
GEOWOW	Ensembles
MesoVICT	Mesoscale Verification
SRNWP	Nowcasting, EPS and new observation types
Observation	New observation technologies

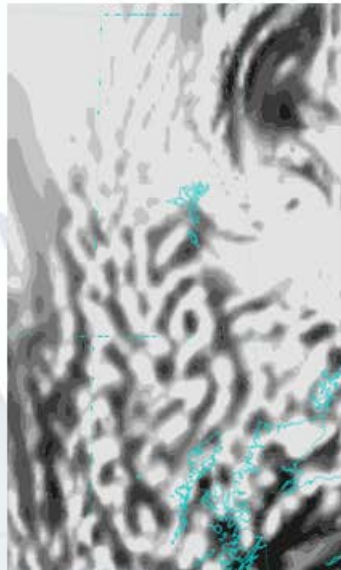


*Example of a multi-scale convection scheme (ALARO); 24h total cloud cover*

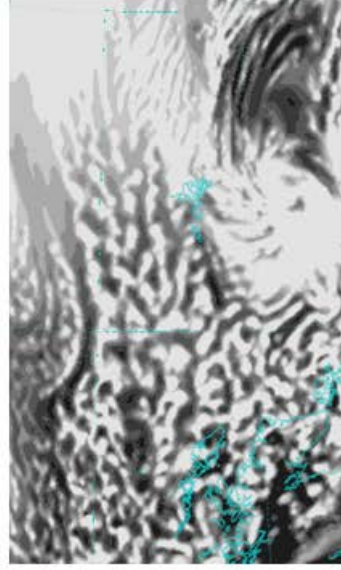
MODIS ch 4



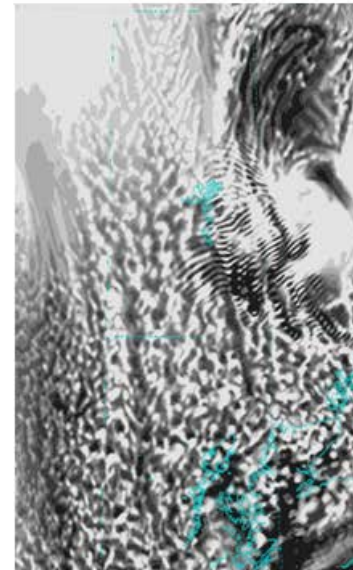
$\delta x=8\text{km}$



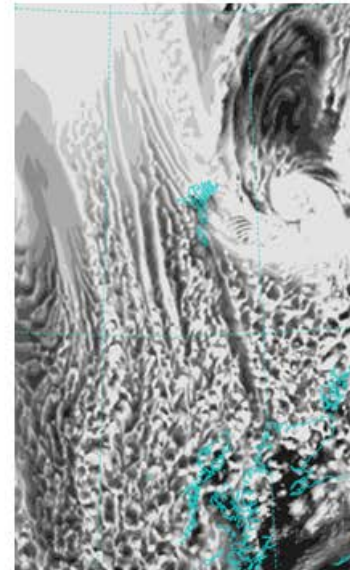
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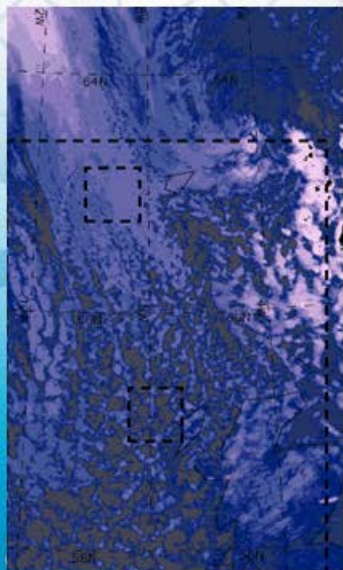
$\delta x=2\text{km}$



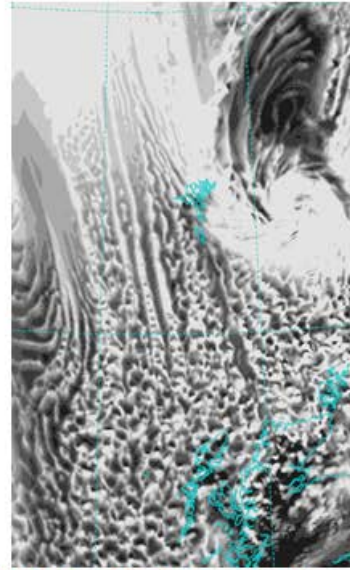
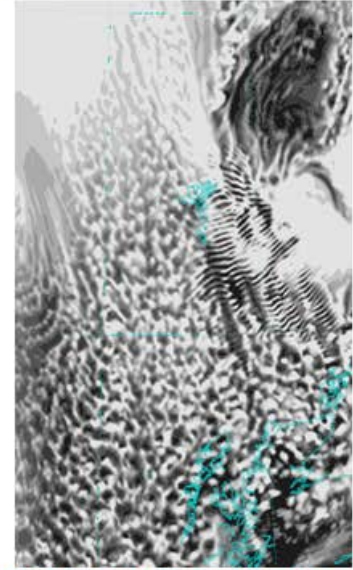
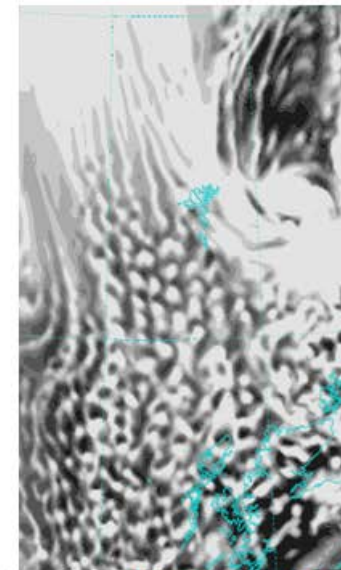
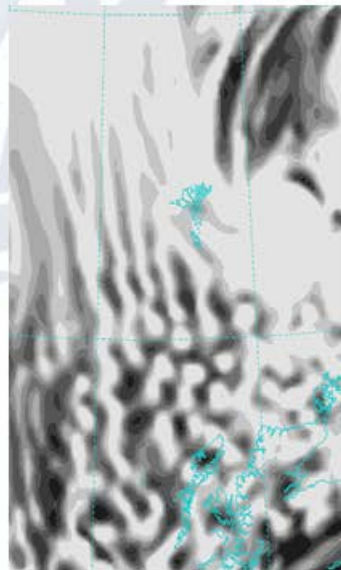
$\delta x=1\text{km}$



MODIS ch 31



ALARO-0 physics (multiscale convective scheme '3MT' activated)



ALARO-0 physics (multiscale convective scheme '3MT' disabled)

# WGNE Collaborations

- Aviation RDP – enRoute requirements need collaboration
- Lake Vic – high res NWP RDP?
- GURME – urban, Tokyo 2020?
- Grey Zone - ongoing



Questions?

**THANK YOU**

**BACKUP**

# Heuristics for Nowcasting Workshop

## Munich Aug 2014

Introduction by Alan Seed

**Keynote review talks on nowcasting research**

*Coffee break*

**Progress in understanding precipitation processes relevant to nowcasting**

*Lunch*

**Nowcasting thunderstorm initiation, growth and decay I**

*Coffee break*

**Nowcasting thunderstorm initiation, growth and decay II**

**Free discussion**

**Methods for ensemble/stochastic/probabilistic nowcasting**

*Coffee break*

**Blending techniques and NWP post-processing**

*Lunch*

**Verification of nowcasts**

*Coffee break*

**Hydrological applications, operational and end-user needs**

**Planning of future joint efforts**

# FROST-14



*Slides provided by Dmitri Kiktev*

# SUMMARY - 3 NOWCASTS 60 MIN (18.02.2014 – 19.03.2014)

## Biathlon Stadium

CARDS (Env.Canada)	INTW, ABOM (Env.Canada)	INCA (ZAMG, Austria)	MeteoExpert (IRAM, Russia)	Joint (Multi-system forecast integration)
<ul style="list-style-type: none"> <li>• 10 min/1,5 hour</li> <li>• Only precipitation (rate and accumulated)</li> </ul>	<ul style="list-style-type: none"> <li>• 10 min/6 hours</li> <li>• Temperature</li> <li>• Humidity</li> <li>• Wind direction, and speed</li> <li>• Precipitation</li> </ul>	<ul style="list-style-type: none"> <li>• Hourly/ up to 48 hours</li> <li>• Temperature</li> <li>• Humidity</li> <li>• Wind direction, speed and gusts</li> <li>• Precipitation</li> </ul>	<ul style="list-style-type: none"> <li>• 10 min/4 hours</li> <li>• Temperature</li> <li>• Humidity</li> <li>• Wind direction, and speed</li> <li>• Precipitation</li> <li>• Visibility</li> <li>• Ceiling</li> </ul>	<ul style="list-style-type: none"> <li>• Hourly/up to 48 hours</li> <li>• Temperature,</li> <li>• Humidity</li> <li>• Wind speed, direction and gusts</li> <li>• PMSL</li> </ul>

Techniques:

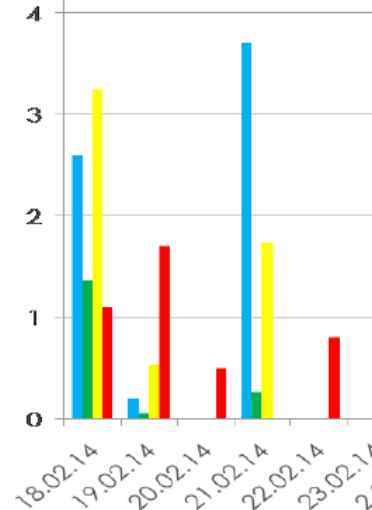
Radar - CARDS

Point + NWP - INTW

Analysis + extrapolation - INCA

## SUMMARY

1. In general, all nowcasting methods demonstrate good skills.
2. They were very useful for forecasters for the Olympic period.
3. The scatterplots show underestimation for some sites.
4. There are poor forecasts of some intensive precipitation (missed).
5. EDI shows that extreme precipitation was better predicted for Ski Jump and Biathlon Stadium, not good for Imeretinka and Rosa.
6. CARDS shows the best overall scores.
7. INTW has the worst scores.
8. In severe weather cases there is a need to have 10-15 minutes time lead forecasts.





# Role of spatial resolution for ensemble forecasts – continued

## COSMO-S14-EPS (7km grid spacing) vs COSMO-RU2-EPS (2km grid spacing)

### Verifications for ensemble mean

**Verification Period: 15.1.2014-15.3.2014**

Station	BIAS (for 6/12/18hr lead time)		Mean Absolute Error (for 6/12/18hr lead time)	
	COSMO-S14-EPS	COSMO-RU2-EPS	COSMO-S14-EPS	COSMO-RU2-EPS
<b>Sledge (~700m)</b>	-1.3 / -2.0 / -1.4	0.2 / -1.9 / -0.1	1.6 / 2.2 / 1.6	1.4 / 3.5 / 1.7
<b>Freestyle (~1000m)</b>	-2.0 / -1.8 / -1.9	0.3 / -0.7 / 0.0	2.1 / 2.0 / 2.1	1.6 / 2.4 / 1.7
<b>Biathlon Stadium (~1500m)</b>	-1.4 / -1.3 / -1.4	0.9 / 0.0 / 0.5	2.0 / 1.8 / 2.1	2.1 / 2.6 / 2.3
<b>Mountain Skiing(start) (~2000m)</b>	1.6 / 2.2 / 1.6	0.6 / 0.2 / 0.1	2.8 / 3.1 / 2.8	2.1 / 2.2 / 2.6

- **T2m:** Some positive effect of downscaling from 7 to 2 km resolution.
- **Wind Speed:** No positive effect of dynamical downscaling was found.

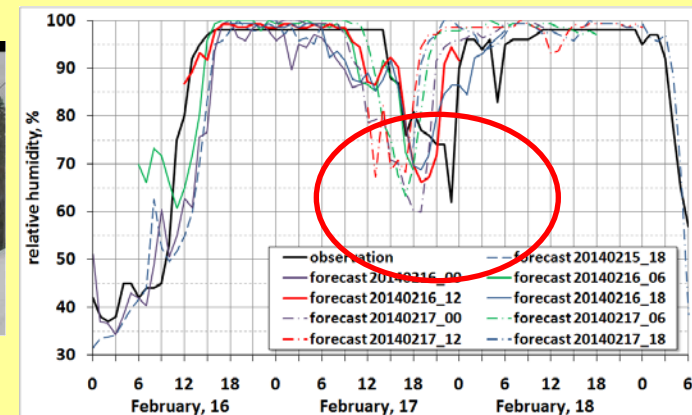
# FROST14



17.02.2014 . Camera shots from Gornaya Carousel-1500

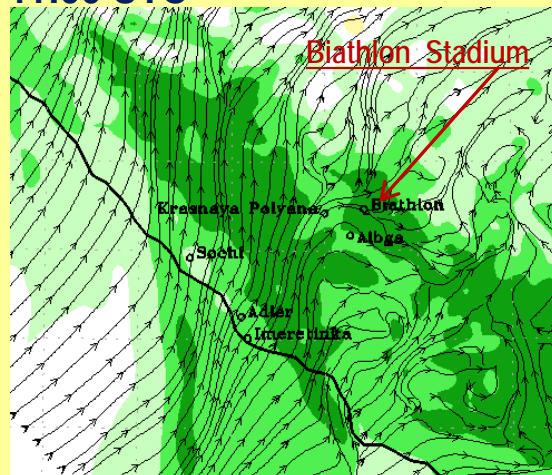


RH at 2m: Forecast and observations

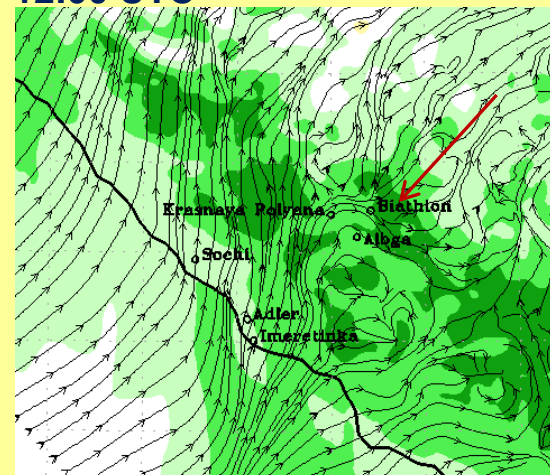


Wind and RH at 850 hPa. Forecast from 12 UTC 16.02.2014

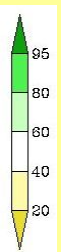
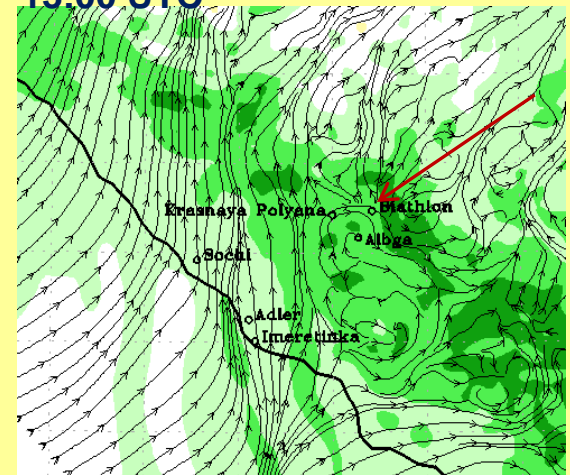
11:00 UTC



12:00 UTC

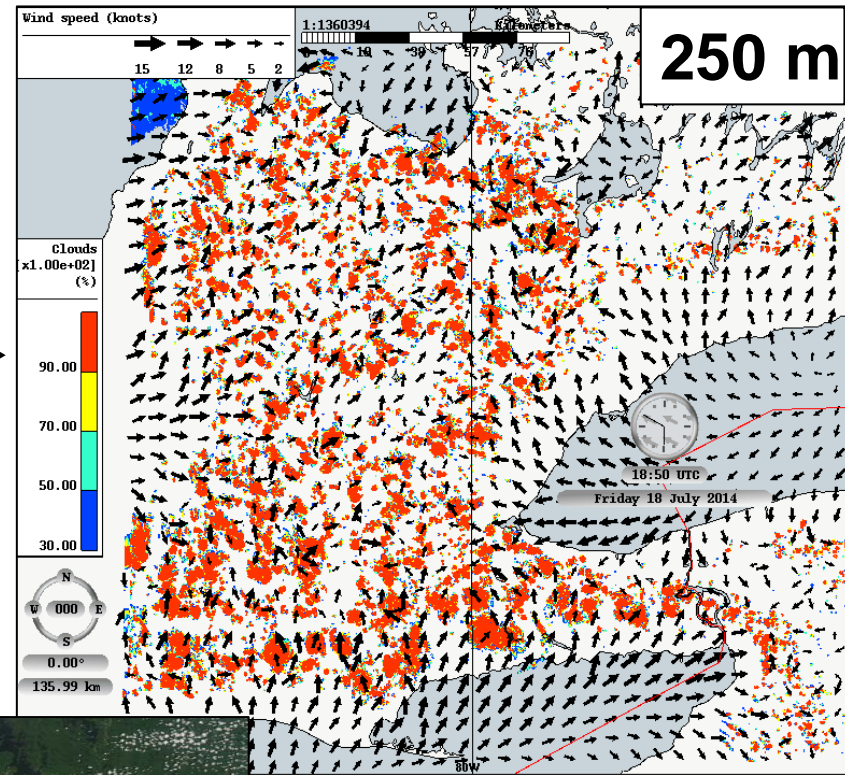
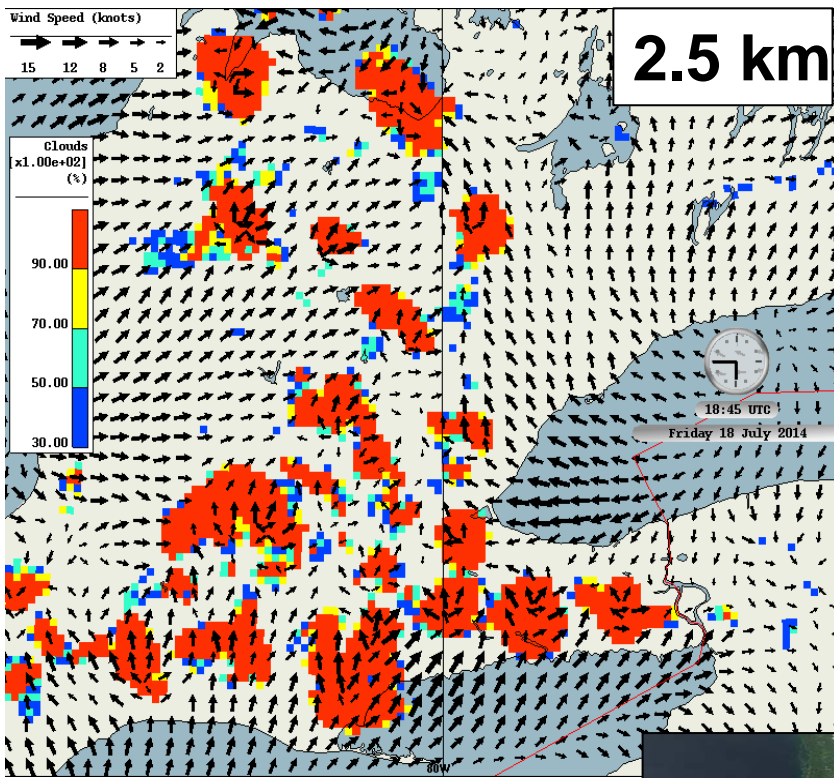


13:00 UTC





# Going from 2.5-km Grid Spacing (Operational) to 250-m (P



**Cloud coverage  
and near-  
surface winds  
Valid at 1850  
UTC  
18 July 2014**



**MODIS  
(Aqua satellite)**

# Use of Time Averaged Imagery

