Overview and Presentation of New Low Cost Technologies for Monitoring and Forecasting

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Workshop "Multi Country Support Programme to Strengthen Climate Information Systems in Africa" under

the Least Developed Countries Fund (LDCF)

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UN Conference Center, Addis Ababa, Ethiopia

First of three related talks

- ***"Guinea Met Case Study."*** Mamadou Lamine Bah, National Director, Direction Nationale de la Meteorologie-Guinea
- ***"Overview of Private Sector Engagement in Climate Information in Developing Countries."*** Alan Miller, Consultant on Climate Risk and Finance

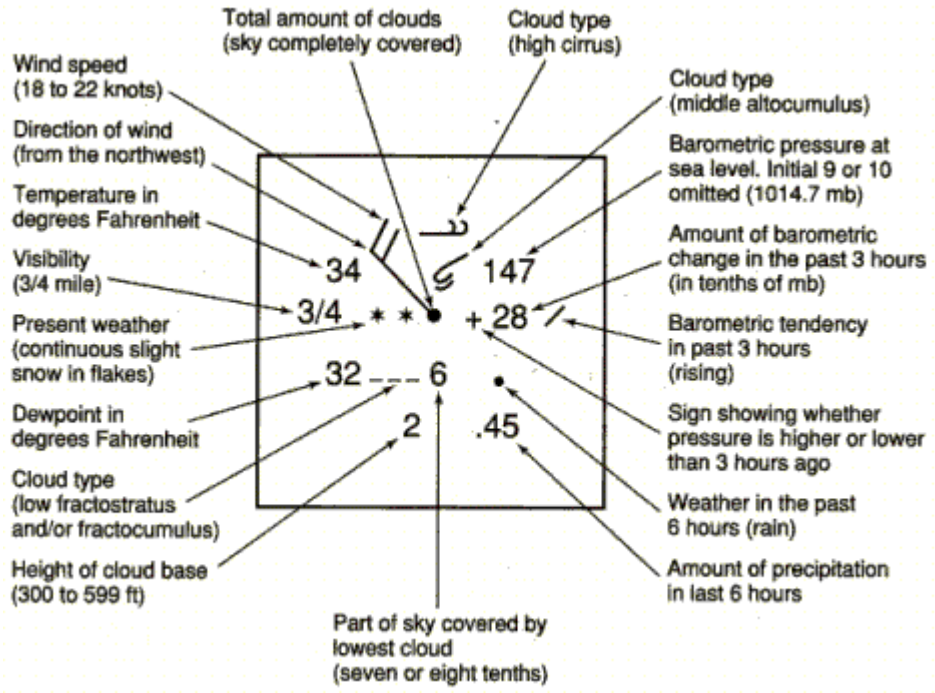
Not an endorsement or a sales pitch

The hardware shown in these slides and the software mentioned during the presentation are provided solely as exemplars.

There is no endorsement intended or implied of particular hardware or software.

Observations and Measurements = Fundamental for Meteorology and Climatology

- **Weather observations** – surface and upper air – are the ***fundamental data*** necessary for providing meteorological and climatological services
- Goal of observations: <u>quantitatively</u> monitor the temporal evolution of the 3-D distribution of meteorological variables (temperature, pressure, moisture, winds, etc…) to support services



Theme of the presentation: Non-traditional approaches have potential to support the development and sustainment of weather observing networks

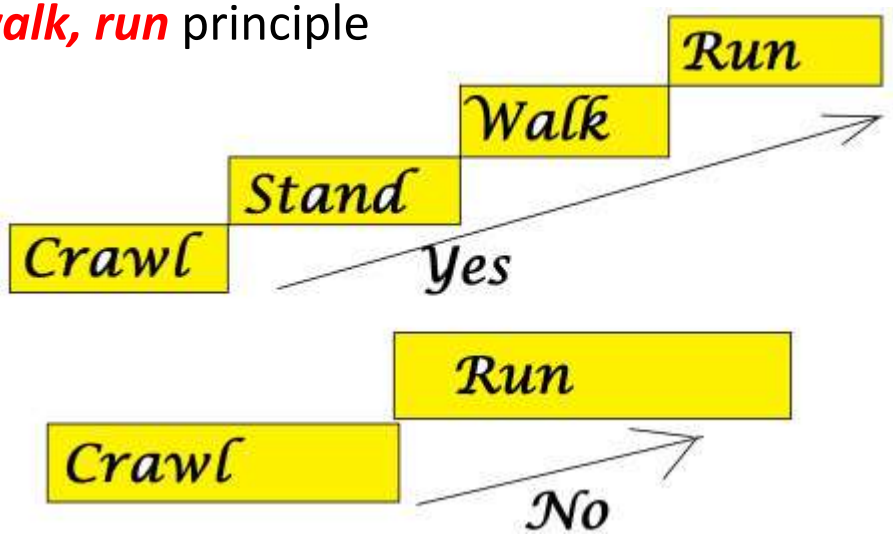
Emphasis is on ***meteorological systems engineering*** and ***leapfrog technologies*** to establish the above sequence of actions. Here we focus on the first step.

Improving Observing Networks and Enhancing NHMS Capacity → a widely accepted goal whose attainment has proved to be elusive, leading to frustration in both the NHMS and the supporting international aid community

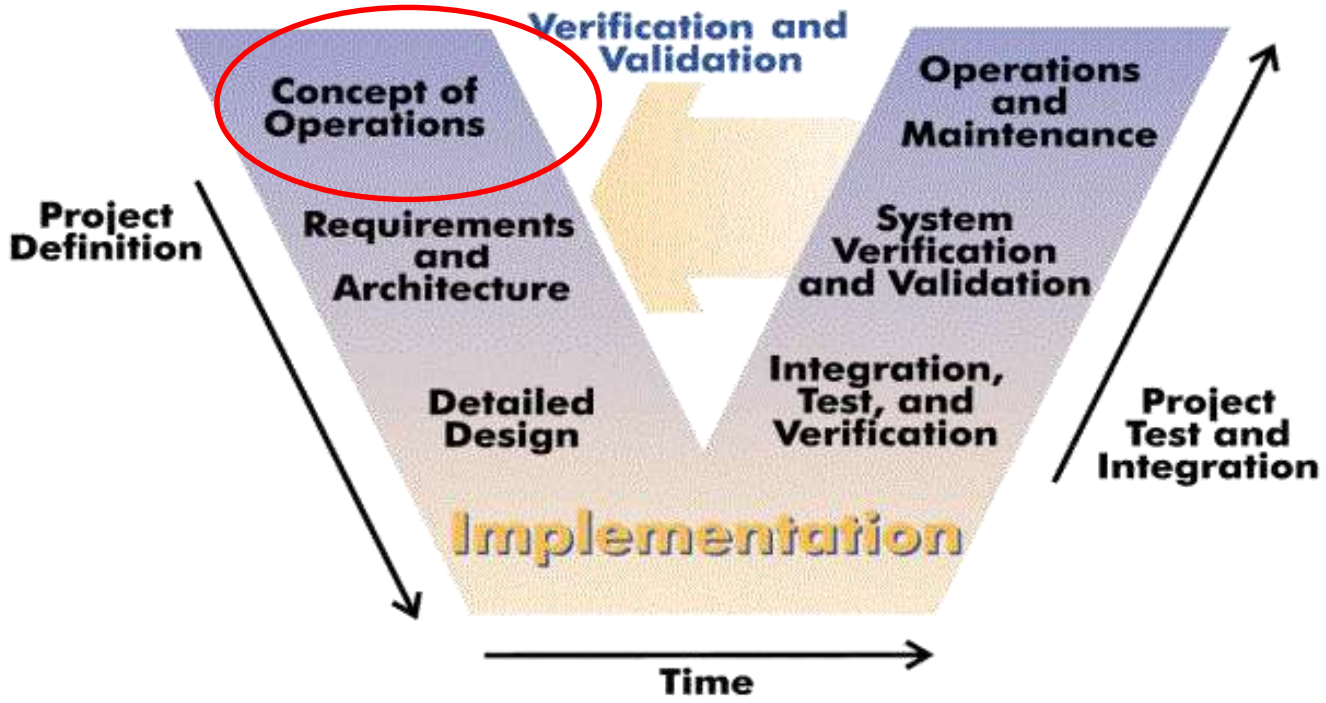
The challenges are well known:

- Lack of supporting technical infrastructure within the NHMS and the nation
- Limited choices w/r/t number of sites, equipment; too often budget limited
- The chosen technology can be too big of step for the NHMS
- Lack of a long-term sustainability plan for the network

→ The above suggest focusing on improving the capabilities of NHMSs in small steps, e.g., apply the ***crawl, stand, walk, run*** principle



Meteorological Systems Engineering 101



Developing the **"concept of operations"** is the first and most essential step in the design of an observing network. Requires one to specify exactly what data are required to provide the desired outcome, expressed in terms of meteorological and climatological products and services delivered to customers.

Leapfrog Technologies 101

"Leapfrogging" is the notion that areas which have under-developed technology or economic bases can move forward rapidly through the adoption of modern systems *without going through intermediary steps*. Examples: cell phones, solar power (Pakistan); free broadband and Linux machines (Brazil)

Lessons learned to date:

Technologies and ideas which seem somewhat powerful when implemented in the West may be utterly transformative in locations not laden down with legacies of past development

To successfully leapfrog an organization requires a shared vision, leadership at all levels, ‘inclusive growth‘, a staff suited to cope with rapid growth and changes, growth diagnostics of the organization's bottlenecks and focused reforms

Leapfrog Technologies 101, continued

Most of the time, to go high-tech, one must go medium-tech first → capacity to absorb and benefit from new technology depends on staff capabilities and the availability of more basic forms of infrastructure

Leveraging the investments of other rapidly growing technology organizations is often a successful strategy → mutually beneficial partnerships.

Leapfrogging doesn't always work. There may be government policies or mandates requiring the adoption of certain technologies which made sense a decade or two ago, but are less useful now. There may be resistance for reasons of tradition or marketing. And chosen leapfrog technologies may simply not work well

The future belongs to those best able to change along with it; sometimes, starting from nothing can be an engine for just that sort of change.

Example 1: A Way Forward – Leverage Cell Towers as Observing Sites

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Utilization of the cell phone systems – towers, communications, electrical power, etc… – as the backbone for national/regional weather observing networks

- **Cell phone networks** are spreading rapidly across the globe, in developing as well as developed countries → **a "leapfrog" technology**
- Cell tower sites provide communications, power, security, trained technical support staff, profit-driven incentive to stay up, and potential revenue stream

Weather Observations on Cell Towers: Good enough? *Yes!*

"Cell phone tower mounted meteostation and standard meteostation data four seasons inter comparisons."

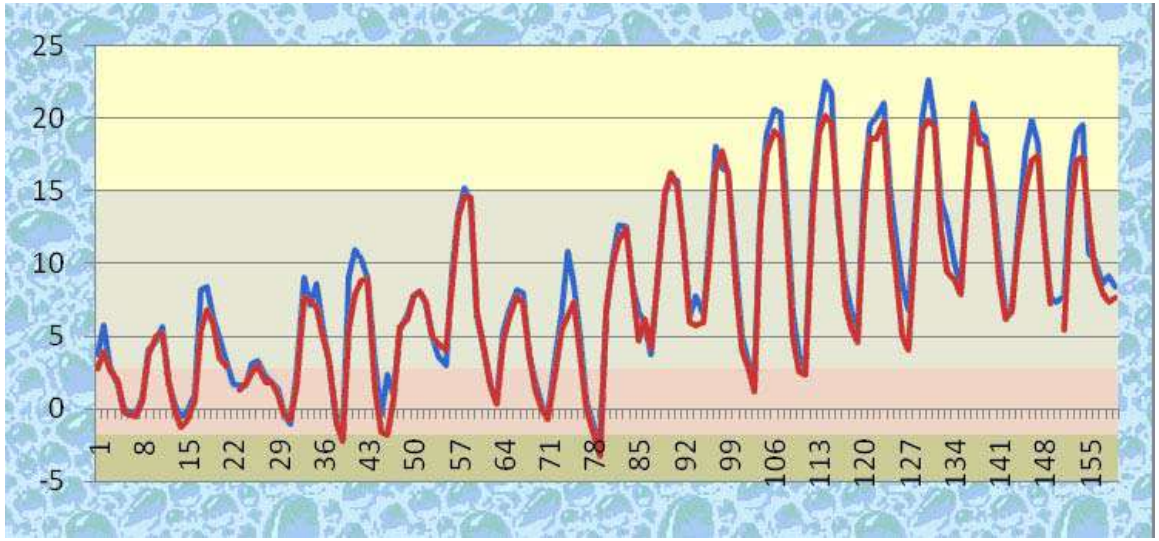
By Roman Bakhtin, Arkadiy Koldaev, Yuri Lanin, Sergey Sarychev RPA "Typhoon", Roshydromet, Russia

http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-109_TECO-2012/Session1/P1_14_Koldaev_Cell_phone_tower_meteostation.pdf

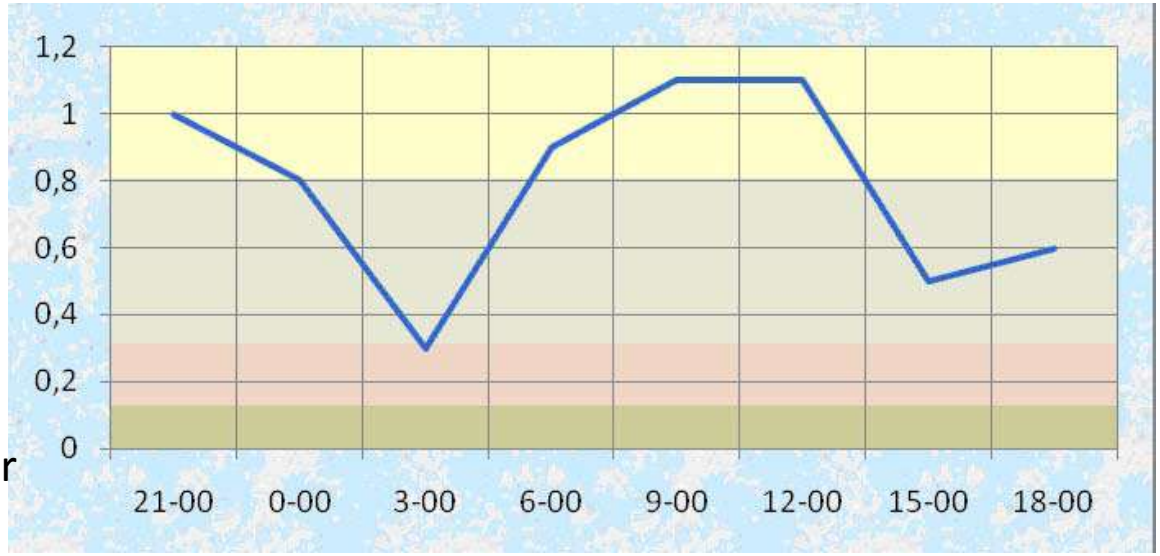
Extensive testing for traditional surface observations (p, T, T_d, wind, etc…) on open lattice towers

Findings of Bakhtin et al. (2012): Temperature

Upper plot shows time series of the observed atmospheric temperature at a cell-tower site (blue) and a nearby standard site (red) for a period of 20 days in March 2011. Values are at three-hourly intervals, for eight points per day; lower axis is labeled with the index number of the observation, starting from 1 at the left.

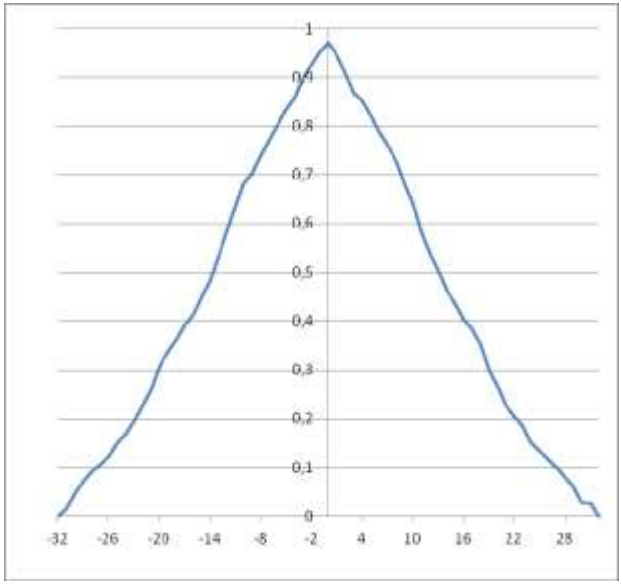


Lower plot shows average differences in temperature between the observing sites (with 20 observations at each three-hour observing time) versus observing time: **temperature differences never exceeded more than 1.1C°**.

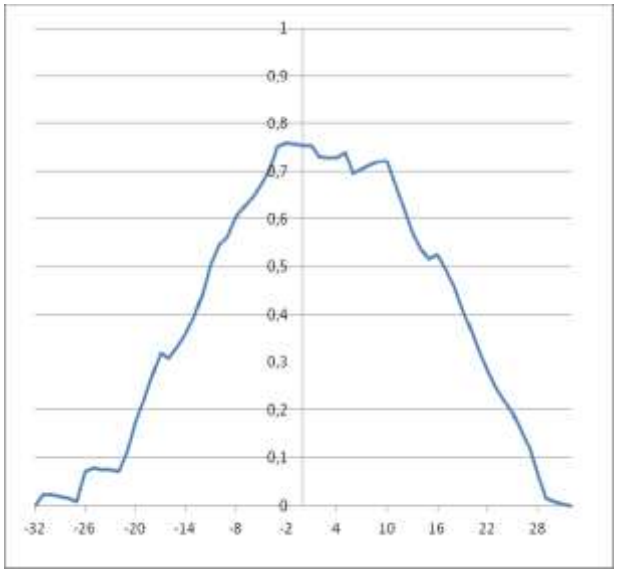


Findings of Bakhtin et al. (2012):
Wind Direction

Two plots showing the results of a correlation analysis of wind direction between cell-tower observations and those at a nearby standard observing site. The data were first sorted by average wind direction.



Upper plot: So long as the wind does not blow through the lattice tower before reaching the wind vane, the correlation is quite high, 0.95



Lower plot: If the wind blows through the tower before reaching the wind vane, then a significant fraction of the correlation is lost due to local effects, e.g., eddies from the tower structure

N.B.: Post-processing can restore some of the loss of correlation once details of local site are documented

The Next Wave: *Facebook* for Every Phone

Social media companies are beginning to deploy technologies that provide smart-phone capabilities on the low-price, simple feature phones most commonly found in developing countries → **market-driven**

Cellular companies offering a feature phone Facebook service as of July 2013

Aircel (India)	Reliance (India)
Airtel (India)	Smart (Philippines)
Banglalink (Bangladesh)	Smartfren (Indonesia)
Beeline (Russia)	elkomsel (Indonesia)
Etisalat (Egypt, Nigeria)	Three (Indonesia, United Kingdom)
Globe (Philippines)	TIM (Brazil)
Idea (India)	TMN (Portugal)
O2 Telefonica (Germany)	Ufone (Pakistan)

Bottom line: Many cellular telephone towers are suitable sites for making weather observations that are sufficiently accurate to support local forecasting and climate studies

Partnership with cell company offers a viable path forward for development of national/regional surface network and delivery of services to a growing population

Effective coordination, collaboration to ensure buy-in, significant involvement of all partners: the NHMSs, telecom/utility co, instrument makers, data wholesalers, …

Example 2: A Way Forward – Deploy observing technologies that are sustainable (affordable, maintainable)

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Consider the new generation of sensing systems that apply novel technological approaches to meteorological observations that satisfy many applications, e.g., ag met

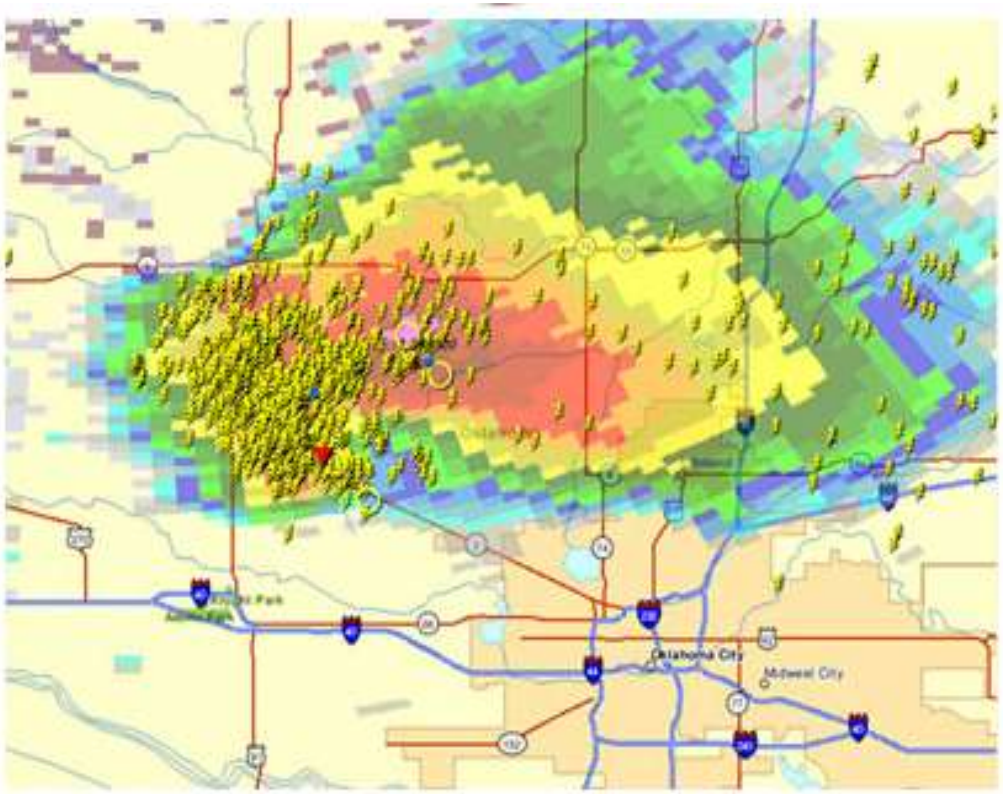
Thoughts on Selecting, Utilizing Instrumentation

- Ensure suitability for the intended operating environment → operational experience, field testing ***only way*** to ensure suitability
- QA/QC system to track each instrument's performance, identify need for service
- Minimize moving parts, expendables
- Minimize in-field maintenance – sufficient stock to swap out instrumentation for repair
- Major repair, calibration done by a service company
- Could field service be done by telephone company or other partner's staff?
- To ensure sustainability, need a revenue stream

Lightning Detection of Deep Convection

Overlaying lightning locations with radar observations allows determination of correlations between lightning and storm features. As shown in figure, strikes are often concentrated in the updraft region, the most active region of the storm.

Can serve as a complement or substitute for weather surveillance radar and/or satellite observations



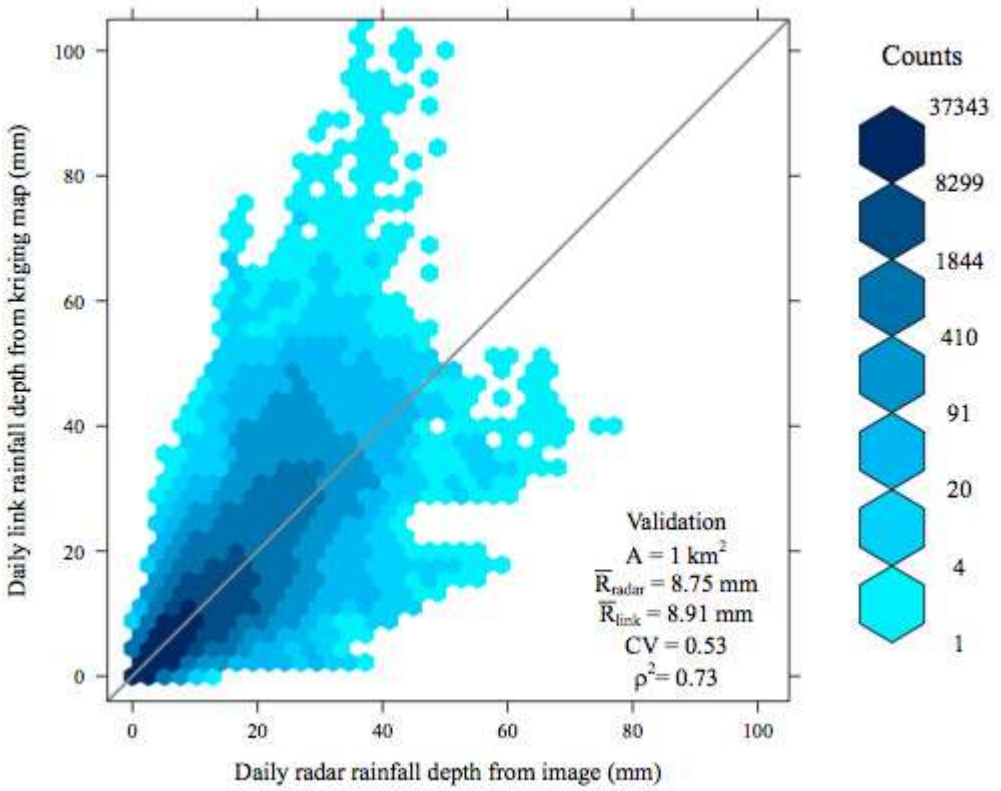
A near-real time meteorological product marketed by Weather Decision Technologies. This product is derived from lightning data produced by the United States Precision Lightning Network, Inc. (USPLN). The USPLN was developed and is now operated by a partnership of WSI Corporation and TOA Systems, Inc.

Other Novel Observing Options

- **Rain-fade in Cell Phones: An Emerging Complement to Lightning-based Systems**
- **Aircraft-based systems** - a complement to radiosonde data, providing upper-air data between the standard radiosonde releases at 00Z and 12Z
- **Emerging crowd-sourced cell phone observations**
- **Self-contained X-Band dual-polarized, Doppler weather surveillance radars**, particularly when utilized in self-controlling networks
- **Cloud computing**

Rain-fade in Cell Phones: An Emerging Complement to Lightning-based Systems

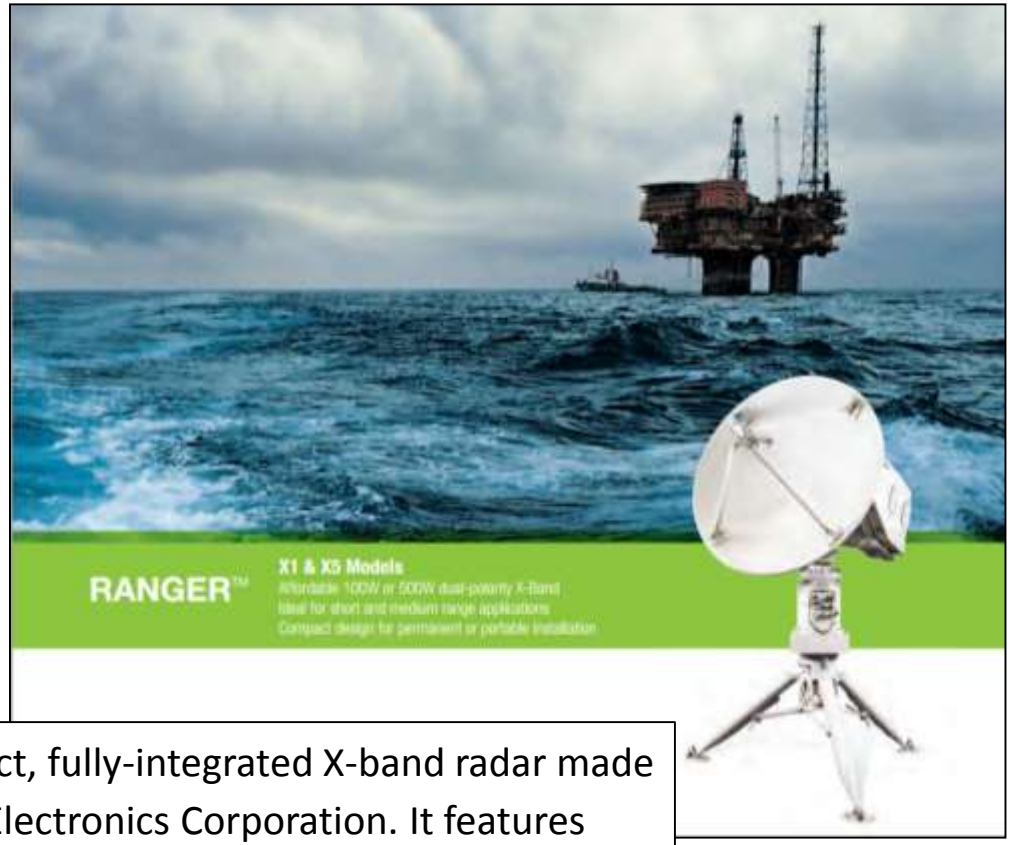
- By definition, lightning-based systems require lightning → adequate for deep convective rainfall
- For shallow convection (showers) and stratiform rain, use a different approach → rain fade in cell phone signals. Data already available at cell tower sites
- Needs data brought to a central site for processing
- Best where there are many cell towers – in and near urban areas; along major roadways



Validation of cell link rainfall estimates against corresponding radar rainfall estimates -- daily rainfall depths for each radar pixel of 1 km^2. Only those rainfall depths have been used where link and/or radar have measured >0.1 mm. Gray line is y= x line; R = average rainfall depth at the radar pixel, CV = coefficient of variation, and ρ^2 = correlation coefficient. Overeem et al. (2013).

Small, Networked X-band Radars

- Provides a radar capability where deemed essential.
- **Extraordinary value comes when a number of such radars are networked and operated using a central, highly autonomous weather-adaptive control system**
- Maintenance handled by swapping out an entire unit or by major assembly replacement

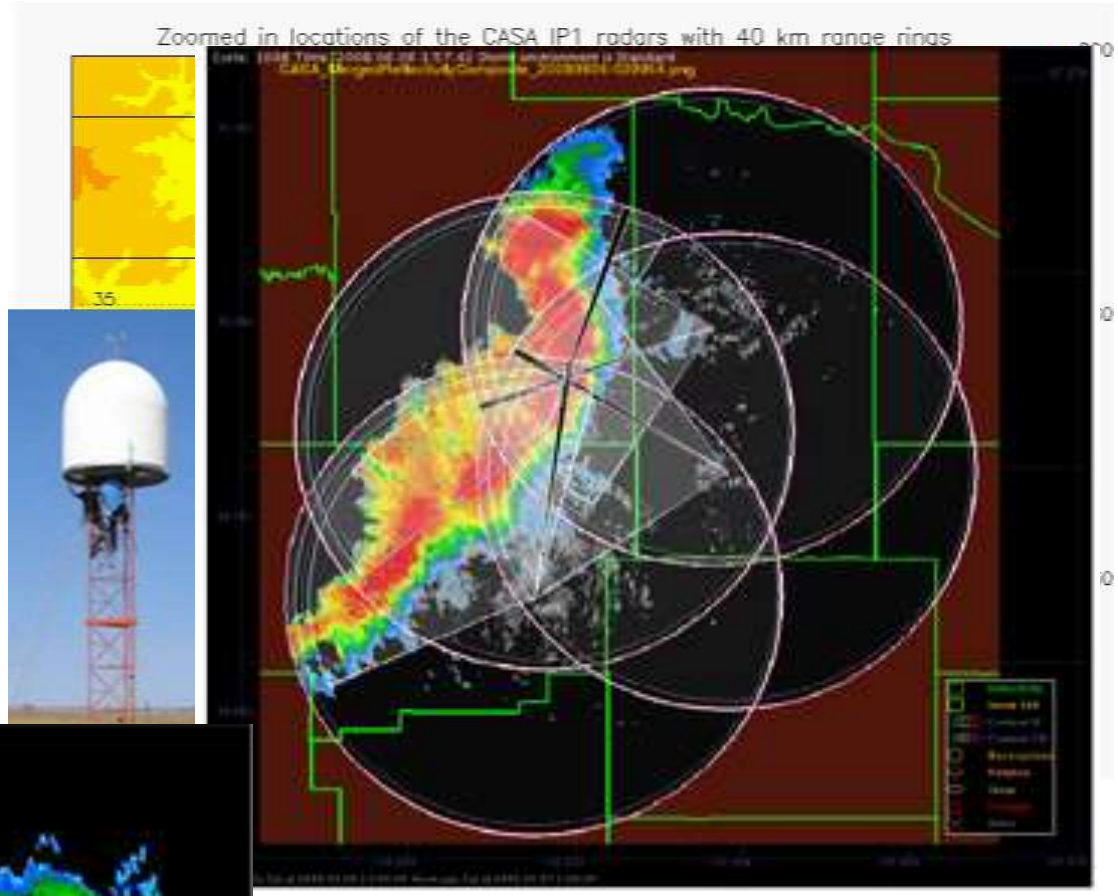


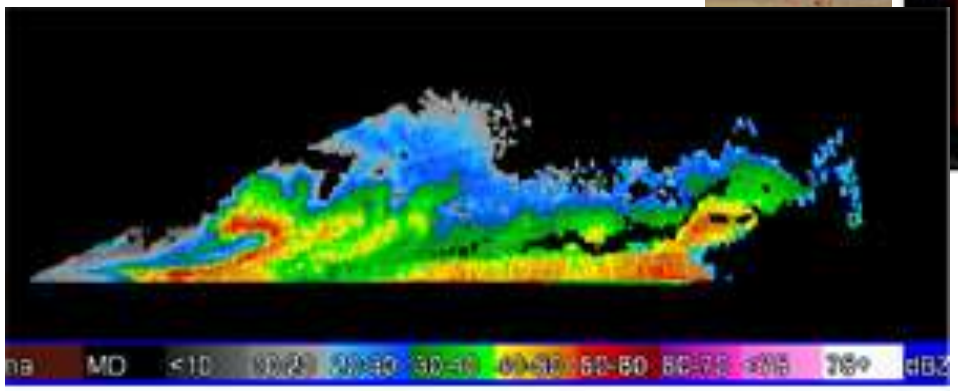
Example: A compact, fully-integrated X-band radar made by the Enterprise Electronics Corporation. It features Doppler and dual-polarization capability, choice of 100- or 500-Watt solid-state transmitters, and very low power consumption, all in a unit weighing less than 400 lbs/180kg.

A Four-Radar X-band Network

Map shows the CASA IP1 four-radar network in southwestern Oklahoma; black circles are 40-km range rings for the indicated radars.

- Inset picture shows one of the CASA X-band systems; for size, note the technician about to work on the radar.





An Emerging Success Story: WeatherPhilippines Foundation

Home › Metro Manila ›

1,000 weather instruments rolled out WFP

ABS-CBNnews.com
Posted at 02/17/2014 3:15 PM | Updated as of 02/17/2014 3:16 PM

MANILA -- Weather Philippines Foundation (WPF) said it will be completi 1,000 weather instruments to various cities and provincial capitals nationv provide accurate and localized weather forecasts, as well as to mitigate ri natural calamities.

The instruments, composed mostly of automated weather stations (AWS) determining temperature, pressure, humidity, wind speed and direction, s locally. These local data will then be processed to provide localized weath

In 2013, WPF completed 402 AWS, and conducted training on the use of other related software found in its **website**.

The website and the AWS proved useful during the onslaught of super typ was used by provinces, cities, various media companies and private indiv information on the weather.

"This is in line with the foundation's thrust to contribute in disaster risk red change adaptation. Tools in the website, for instance, assist and provide information to LGUs in planning and decision-making during severe weath WPF General Manager Celso C. Caballero III.

The foundation also trained about 358 city and provincial risk reduction pe information officers and administrators nationwide to maximize use of tool

WPF reported installation of 205 AWS in all cities and provincial capitals of the Philippines and League of Provinces of the Philippines last year.

The roll-out of another 197 AWS were made possible with help from priva site partners.

weather philippines
My Philippines. My Weather.

WeatherPhilippines Foundation, Inc. (WPF) aims to deliver critical and accurate weather information to aid local governments, communities, and individuals in disaster preparedness and timely response to variable weather conditions. By bringing together the Aboitiz Group's resources and network, and Swiss company mminternational's (formerly Meteomedia) technical expertise, WPF is poised to be the country's premiere private weather information/content provider.

WPF has deployed more than 400 Automated Weather Stations (AWS) across the country, and intends to install 600 more with the help of private sponsors and site partners who would like to participate in this cause.

SPONSORSHIP

Platinum Donor:
- Donation of Php25M, equally divided over a 10-year period
- Recognition as a Platinum Sponsor in WPF's website
- Recognition as a Platinum sponsor in various media coverage where WPF representation is made

Gold Donor:
- Donation of US$2,500 in exchange for assignment of one (1) AWS in donor's nominated site
- Recognition as a Gold Donor in WPF's website
- Gold Donor will be given preferred rates by technology partner, mminternational, in the access of the "Weather Cockpit" – a web-based tool that uses customizable weather widgets with higher 10-minute resolutions compared to the standard WPF website

These donations will allow WPF to purchase more AWS that can be used as a tool for disaster risk reduction. The Foundation provides localized weather forecasts to the Filipino public through its website: www.weather.com.ph

For more information, please contact:

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Final Comment: Training and professional development, and then retention of NHMS staff is key to successful deployment, operation, and sustainment

- Success hinges on the enthusiastic involvement of the NHMS administrative staff responsible for the project, the forecasters who will be using the data, and the supporting technical staff.
- To obtain the desired sense of ownership for the system by these individuals, **training and professional development in advance of and/or parallel with the deployment of new technologies are essential**
- Retention of staff through rewards and incentives such as pay increases and performance bonuses needs to be a priority with the NHMS senior management

Thank you very much

Questions?