The **R**adar **Q**uality Control and **Q**uantitative Precipitation Estimation **I**ntercomparison Project

RQQI
(pronounced Rickey)

Paul Joe and Alan Seed

Environment Canada
Centre for Australian Weather and Climate Research

Outline

- Applications and Science Trends
- Processing Radar Data for QPE
- Inter-comparison Concept
  - Metrics
  - Data
- Summary

Progress in the Use of Weather Radar

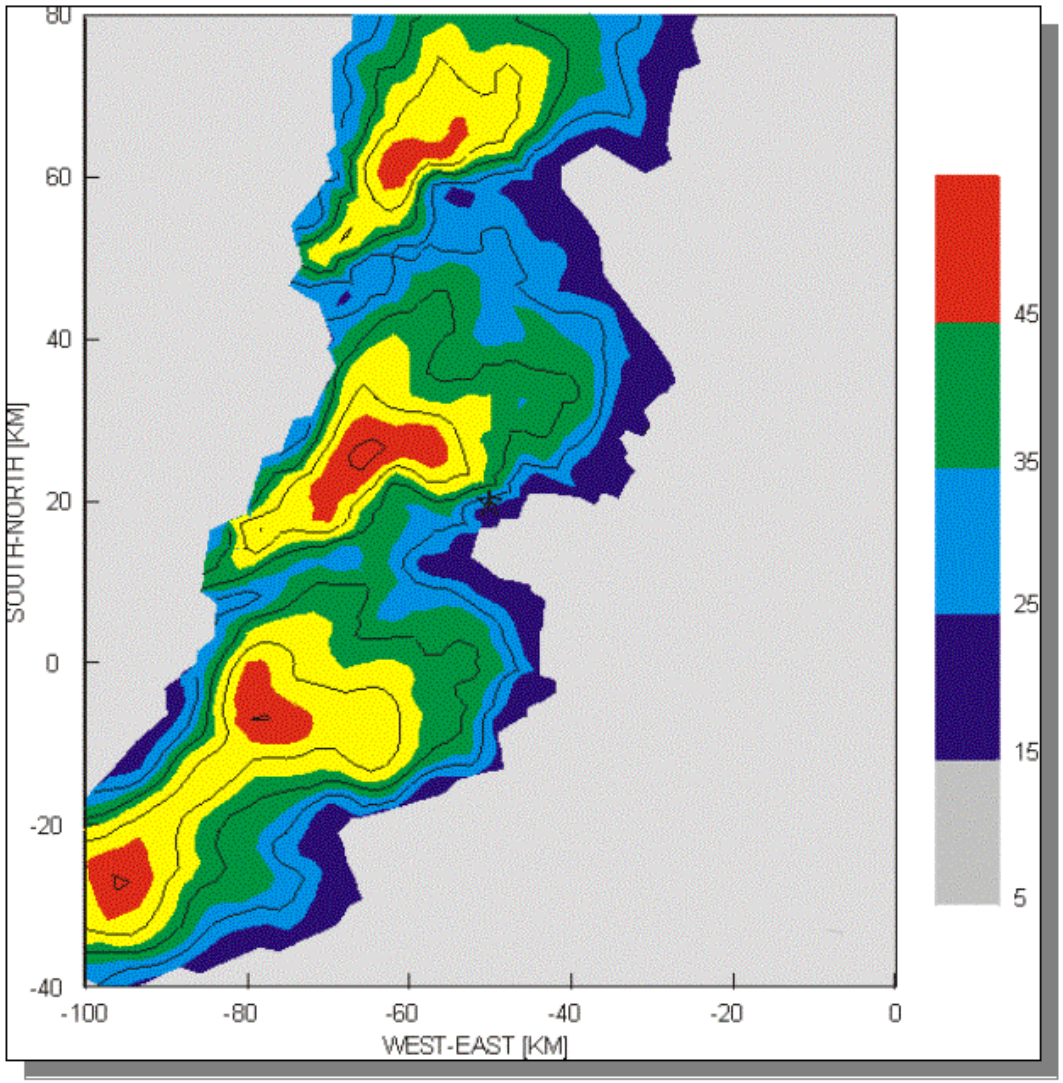
- Qualitative – understanding, severe weather, patterns
- Local applications
- Instrument level quality control

Before

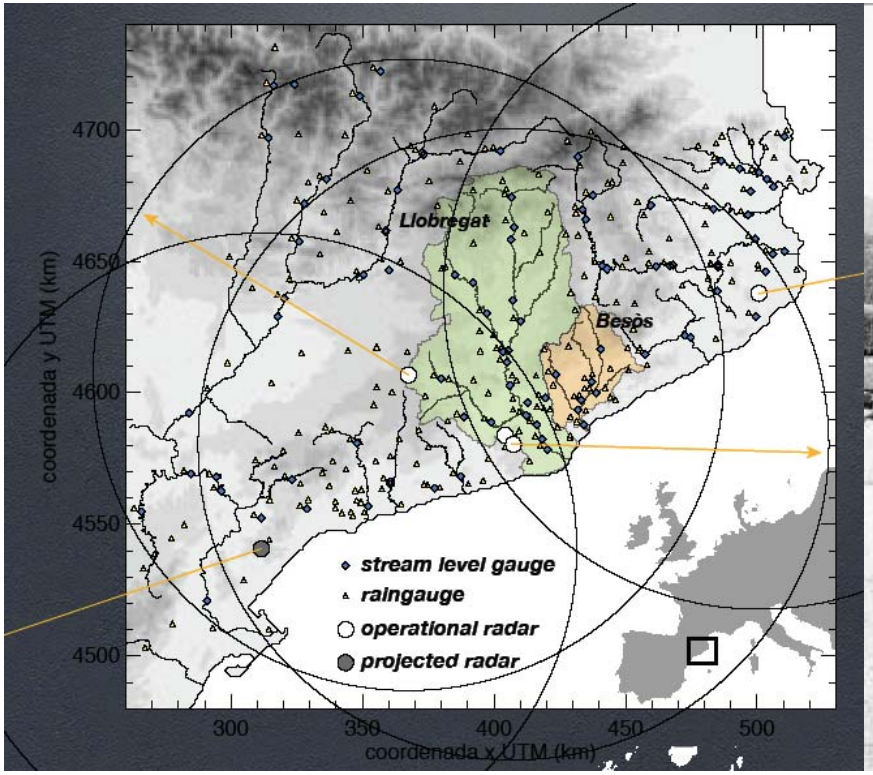
- Quantitative
  - hydrology
  - NWP
  - Data Assimilation
  - Climate
- Exchange composites
- Global quality control

Emerging

Local Applications: Severe Weather

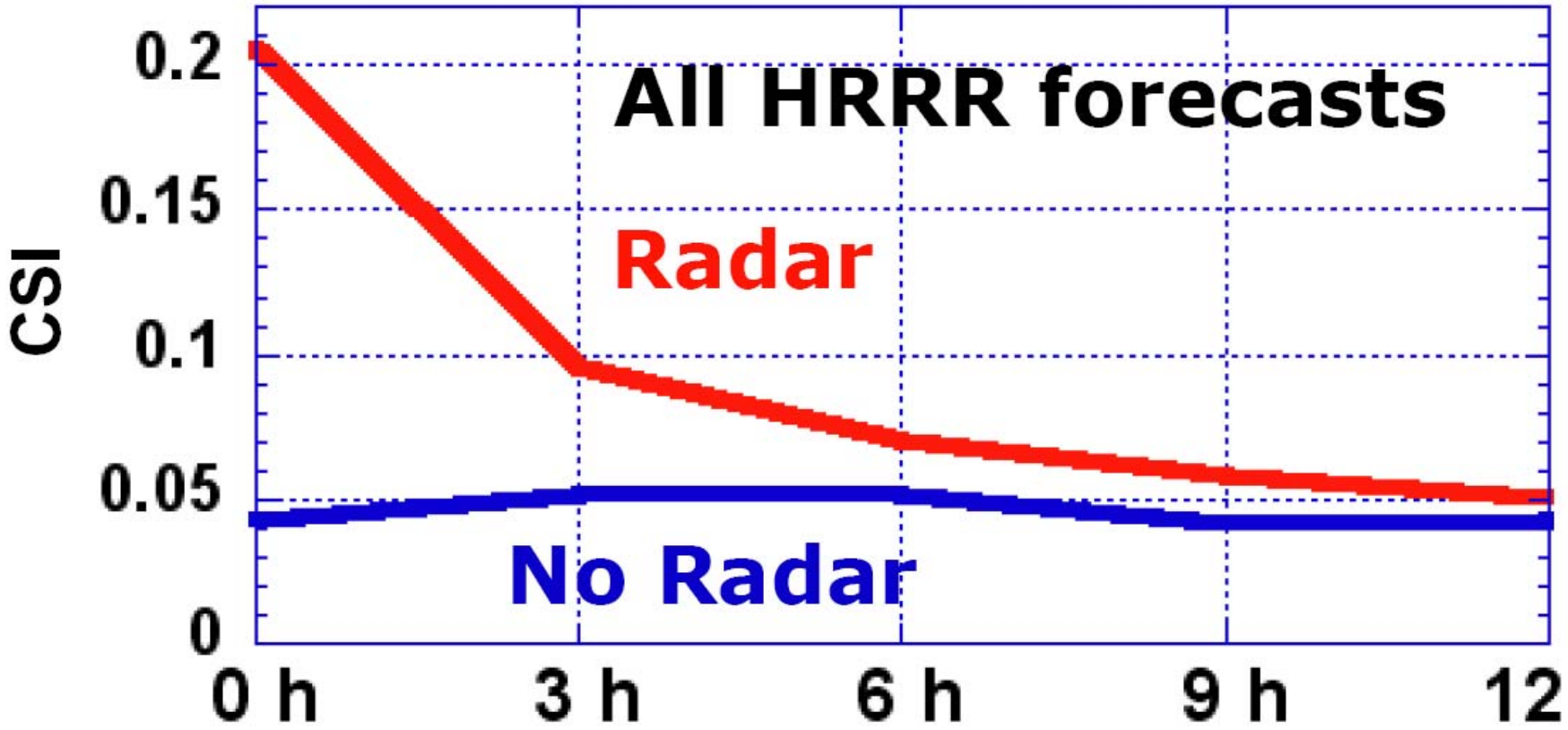


Local Application: Flash Flooding



Sempere-Torres

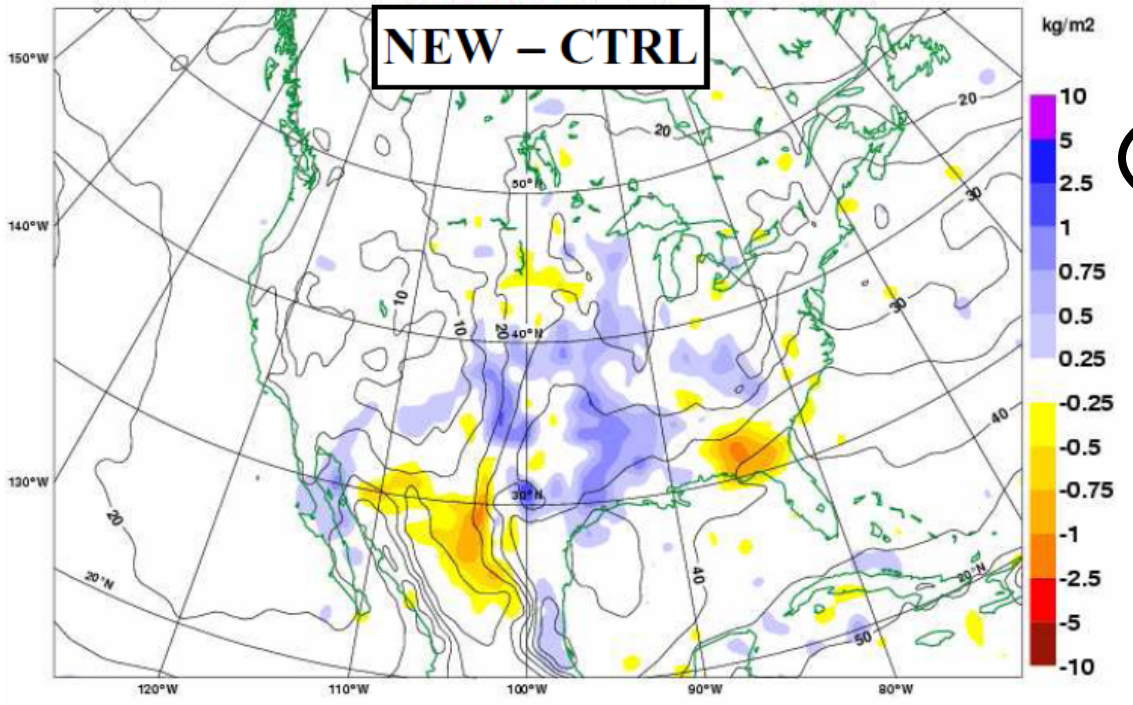
Regional:
Radar Assimilation and NWP

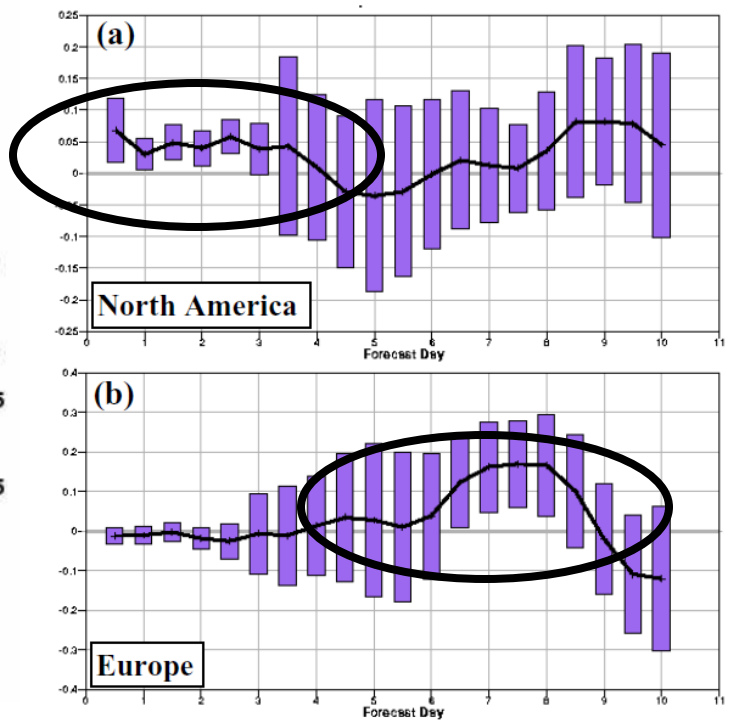


Reflectivity Assimilation

Weygandt et al, 2009

Global: Precipitation Assimilation and NWP





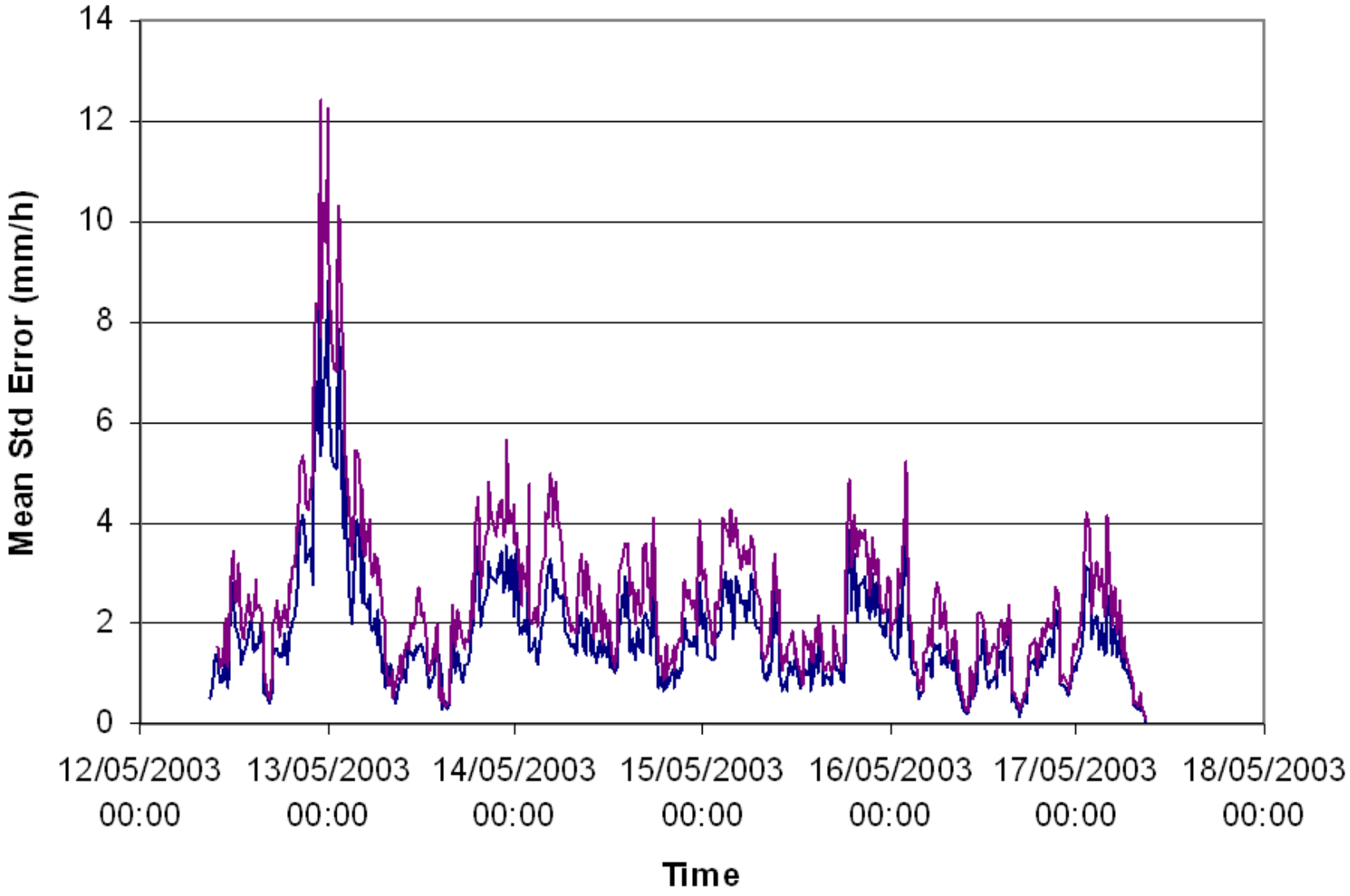
Lopez and Bauer, 2008

Climate Applications

- The GEWEX Radiation Panel is organizing an international Working Group to foster systematic and collective use of comprehensive precipitation radar products, especially from extensive networks that provide large-area coverage for long time periods with very high space-time resolutions, to allow for the study of the coupling of small-scale and large-scale variability and the examination of the statistics of extreme events.

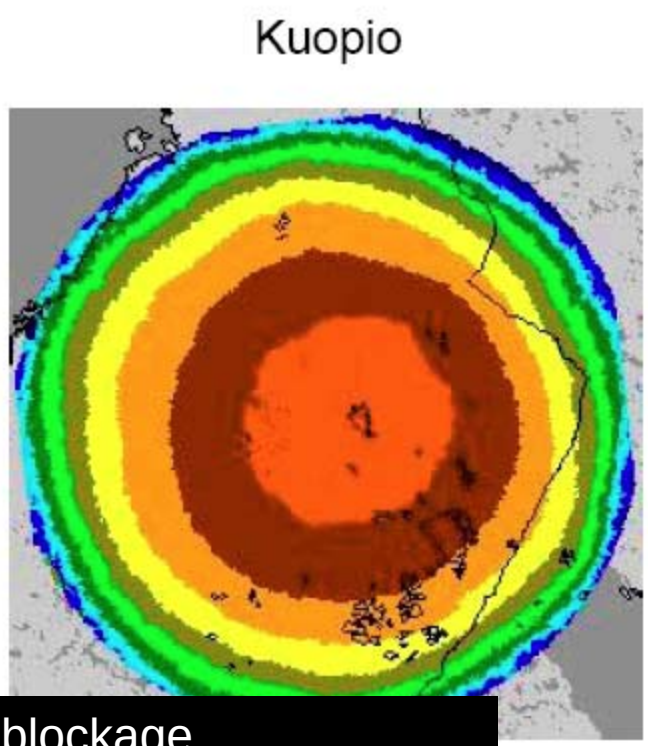
- Such studies are needed to advance understanding of the precipitation process.

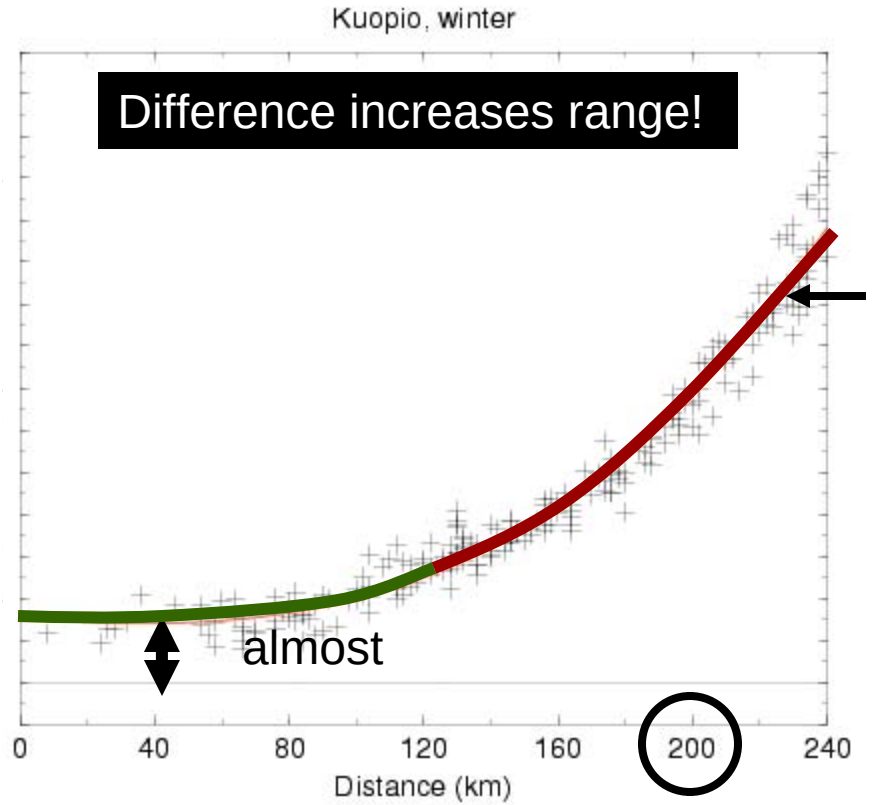
The Potential: Radar-Raingauge Trace



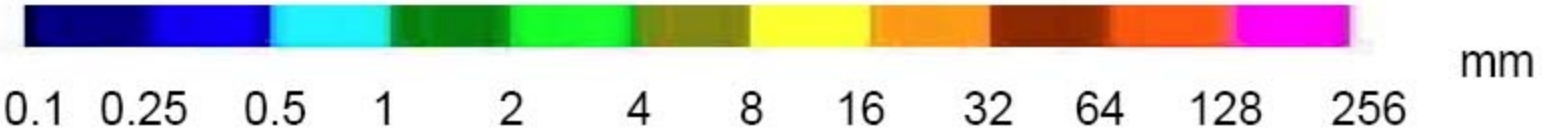
Almost A Perfect Radar!

Accumulation – a winter season log (Raingauge-Radar Difference)



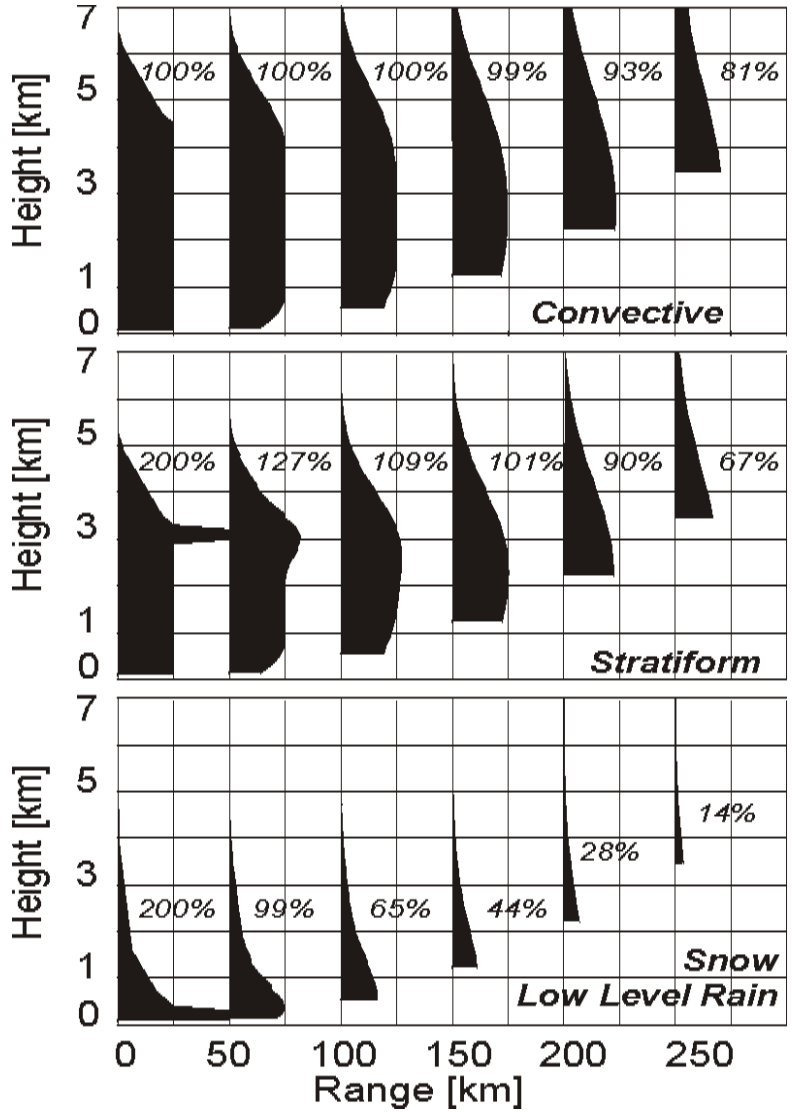


No blockage
Rings of decreasing value



Michelson, SMHI

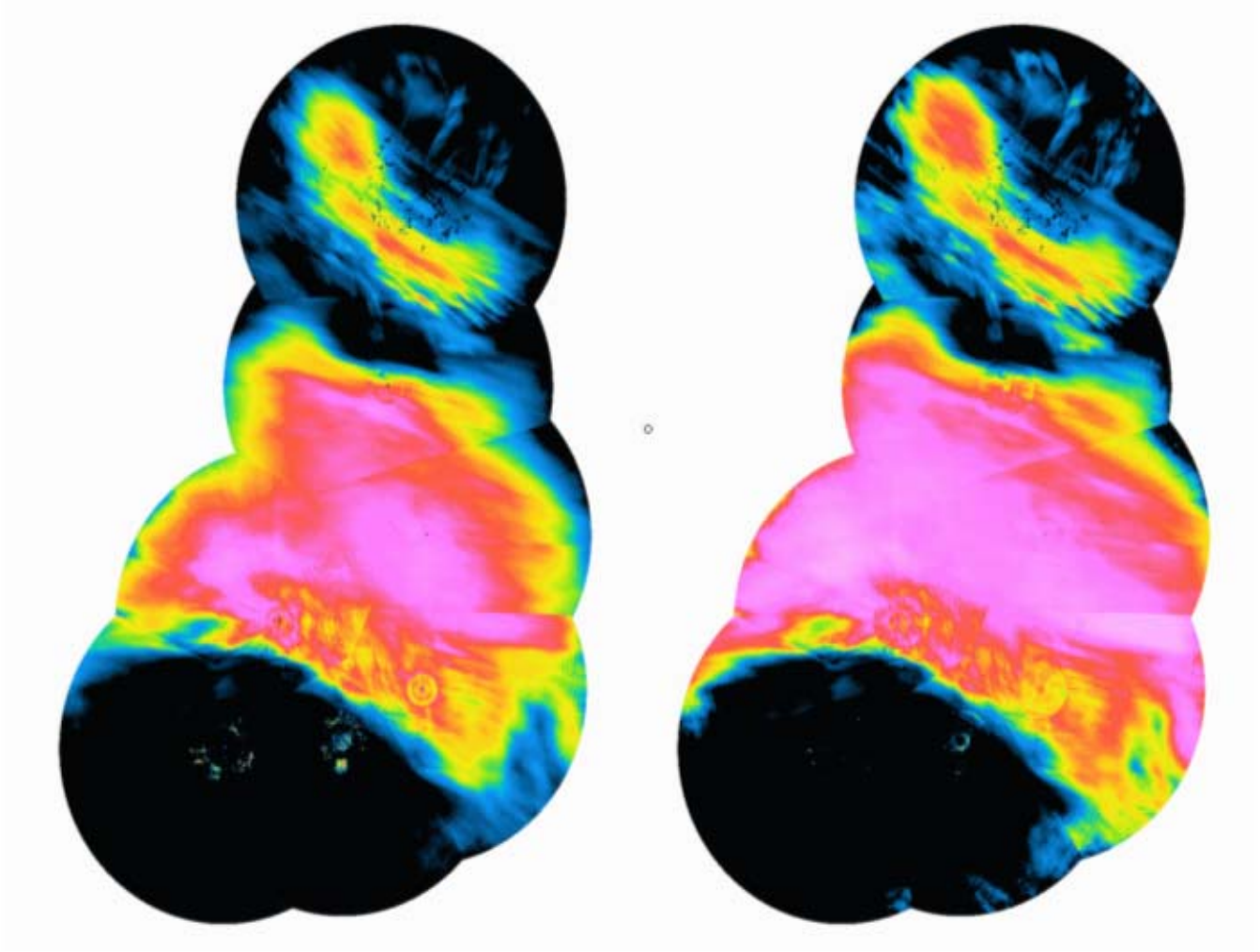
Vertical Profiles of Reflectivity



1. Beam smooths the data AND
2. Overshoots the weather

Explains increasing radar-raingauge difference with range

Joss-Waldvogel

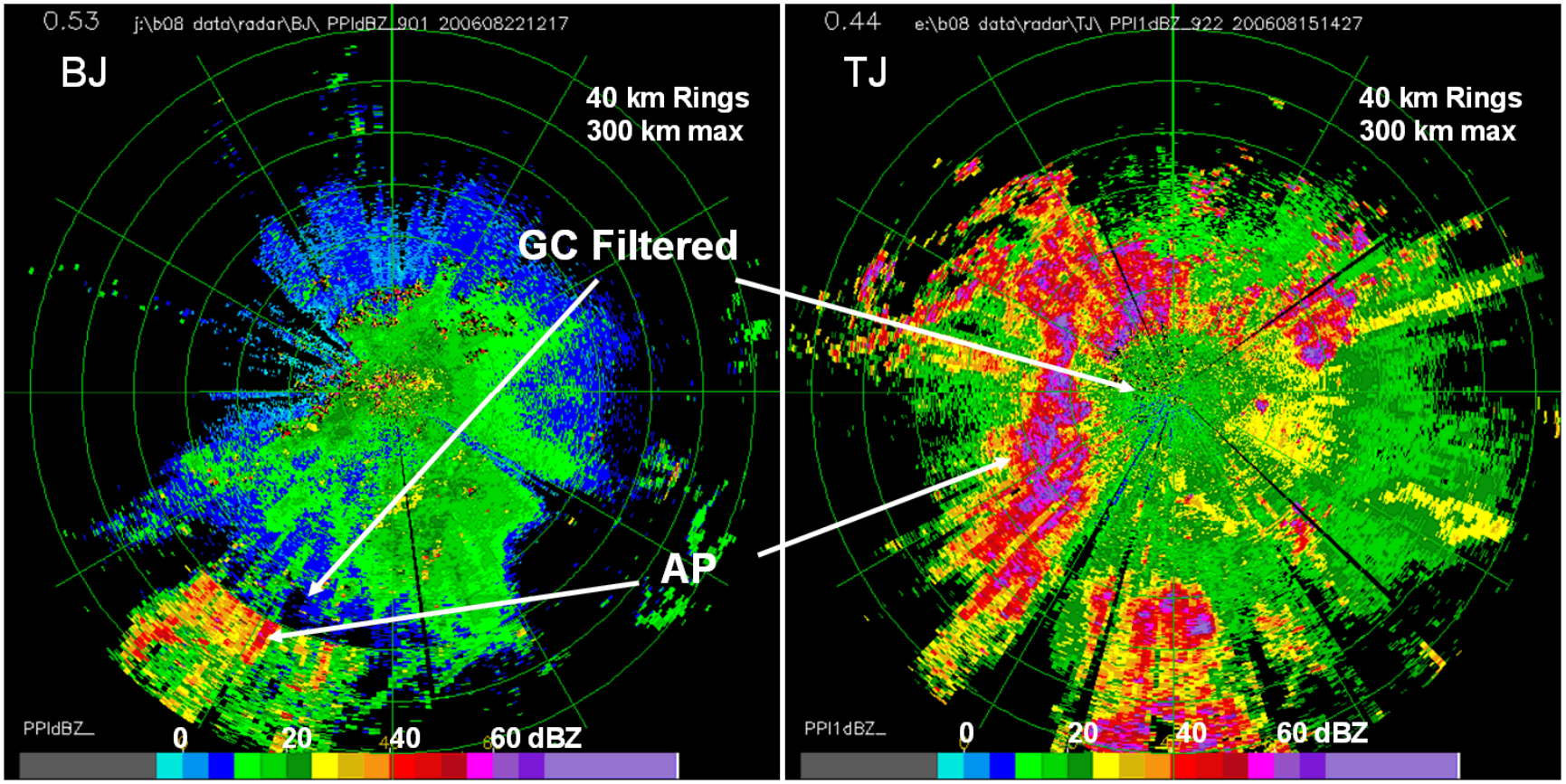


No correction

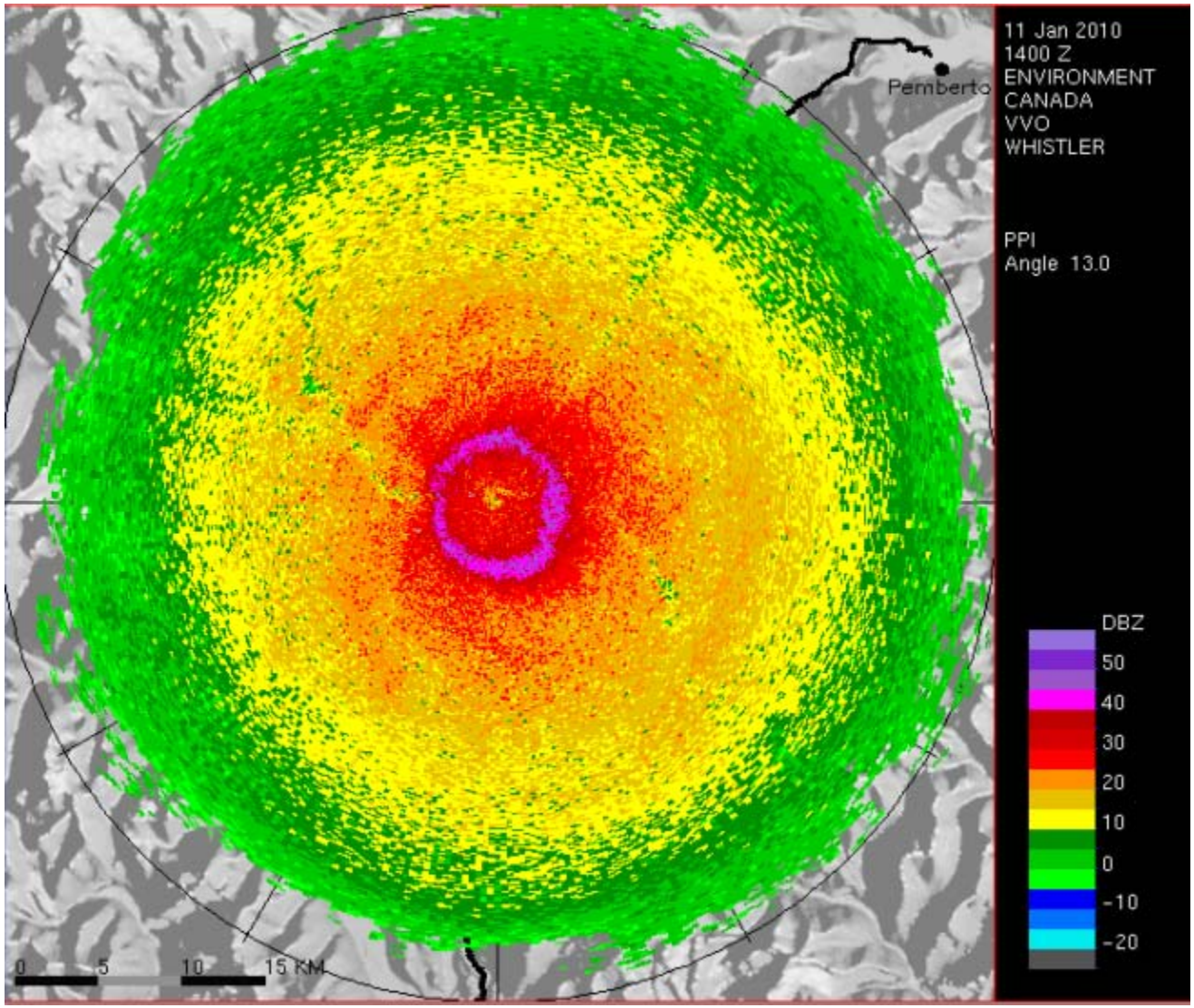
VPR correction

FMI, Koistinen

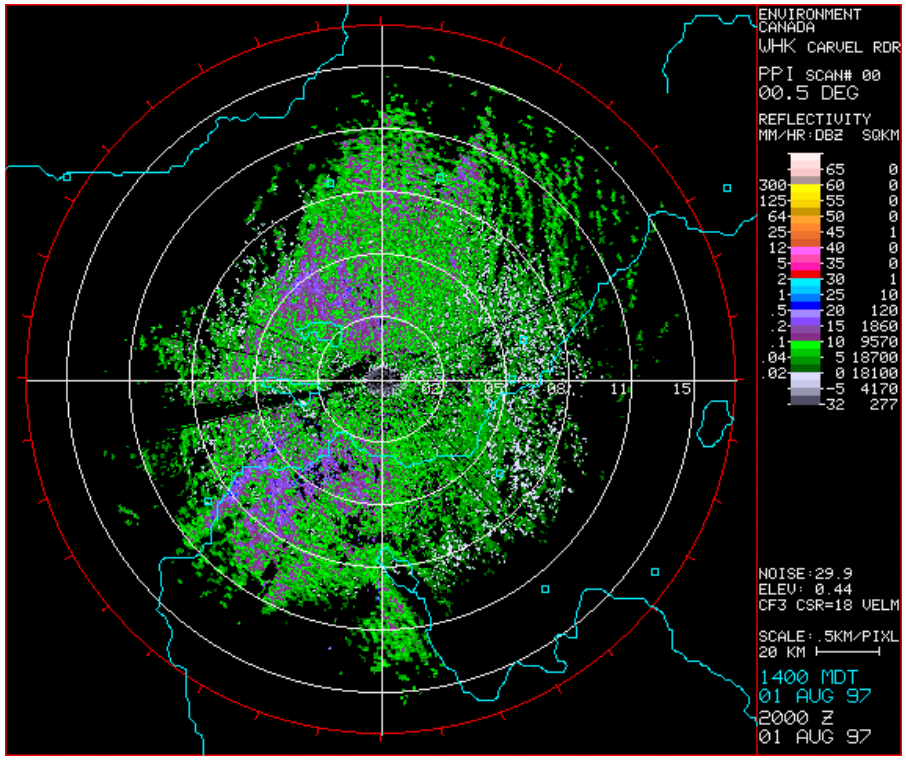
Anomalous Propagation Echo
Beijing and Tianjin Radars

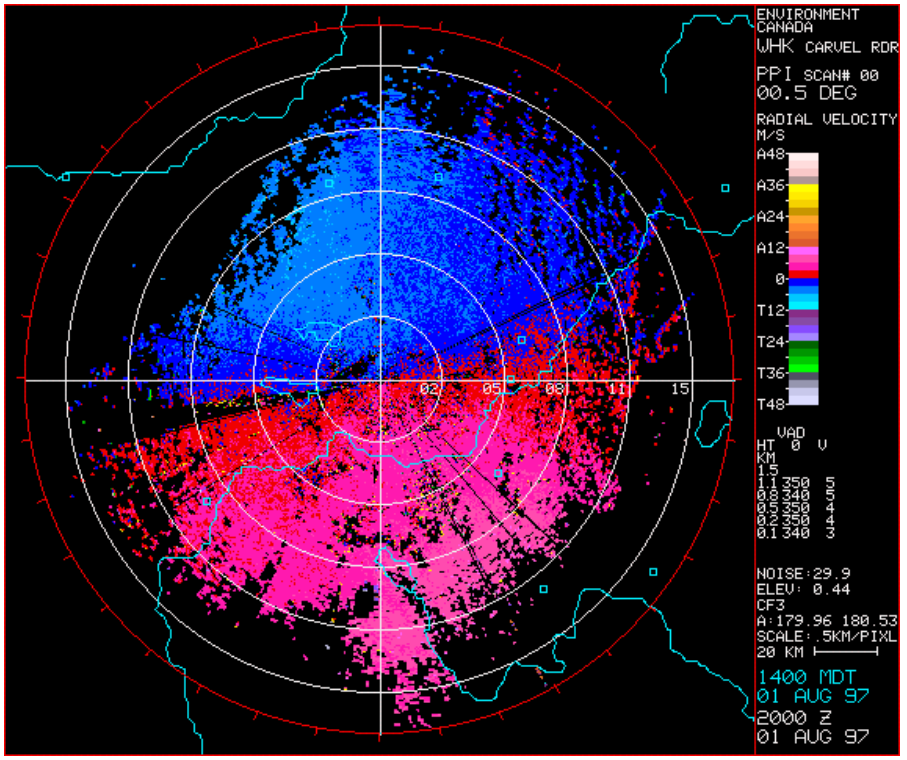


Bright Band

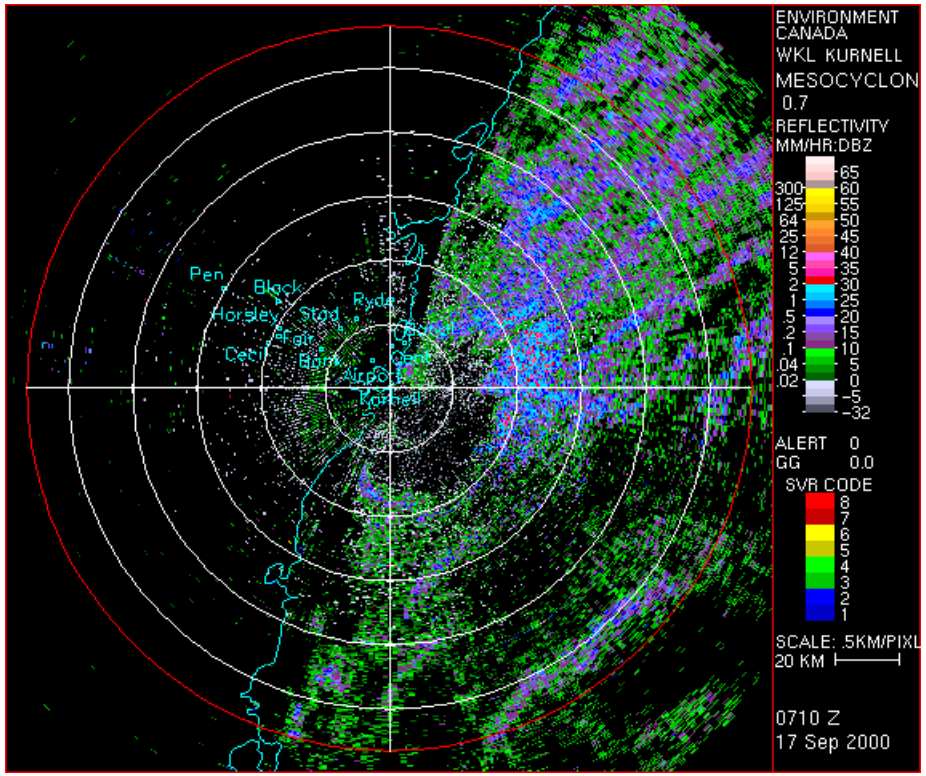

Pemberton
11 Jan 2010
1400 Z
ENVIRONMENT
CANADA
VVO
WHISTLER
PPI
Angle 13.0
DBZ
50
40
30
20
10
0
-10
-20
0
5
10
15 KM

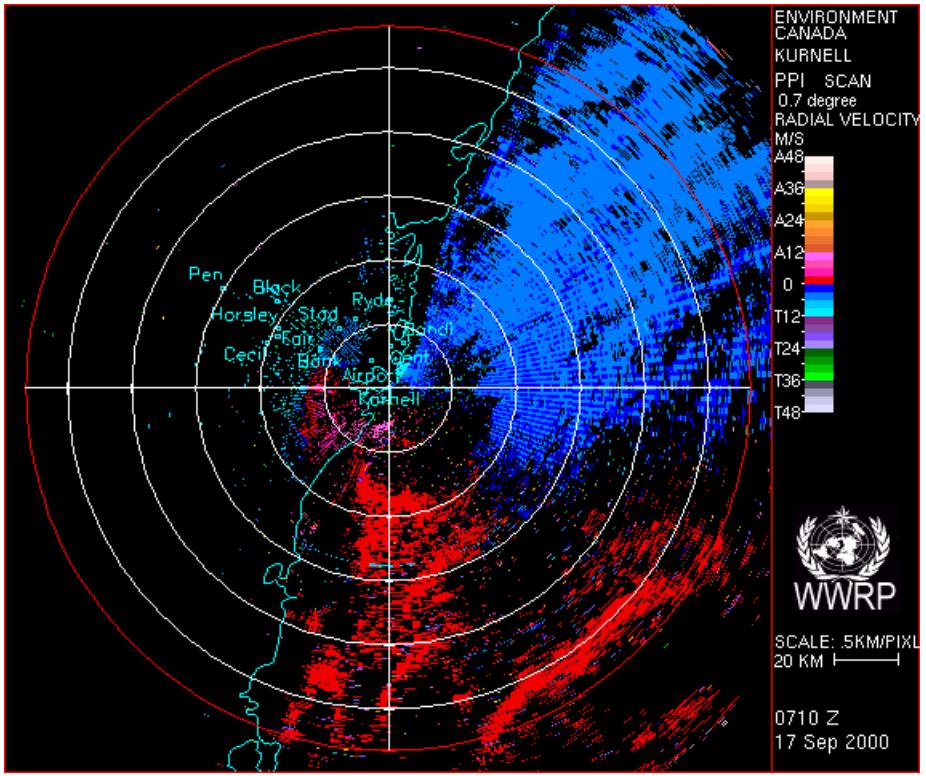
Insects and Bugs
Clear Air Echoes





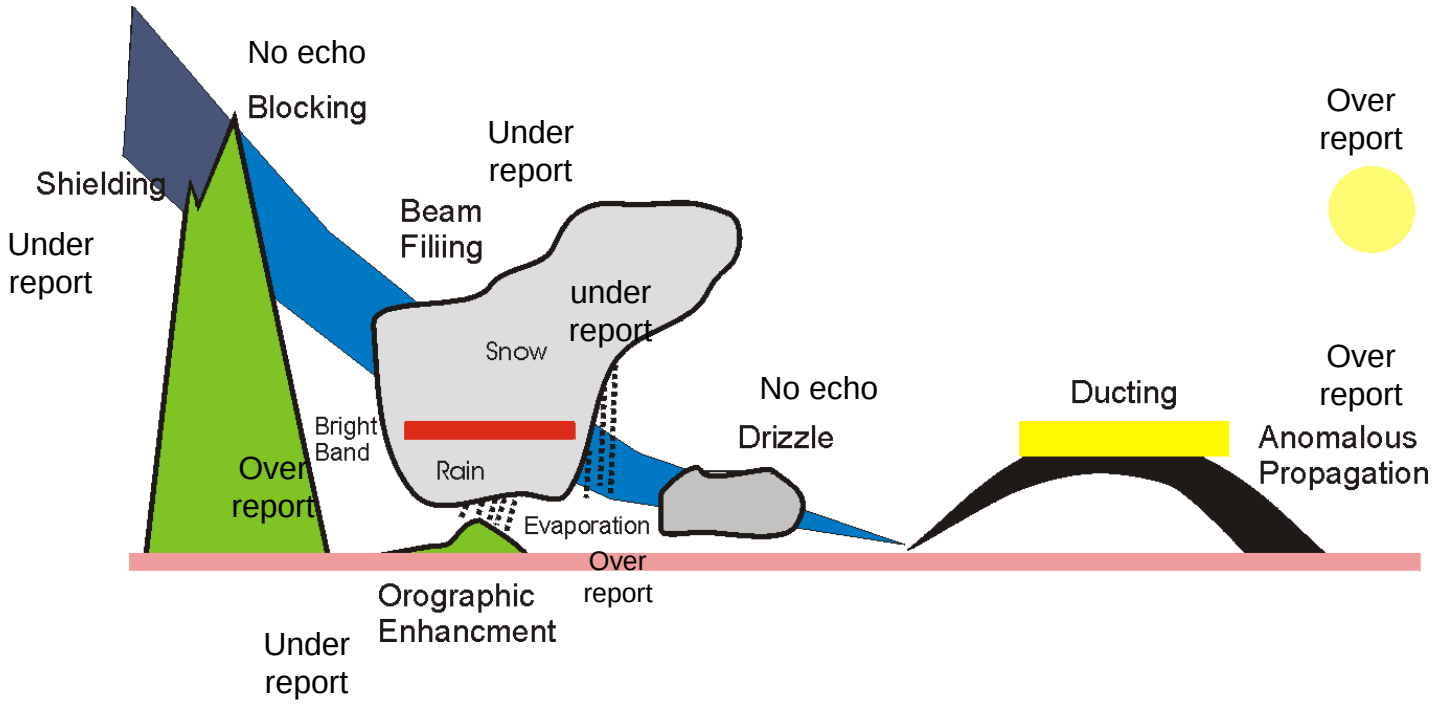
Sea Clutter Obvious



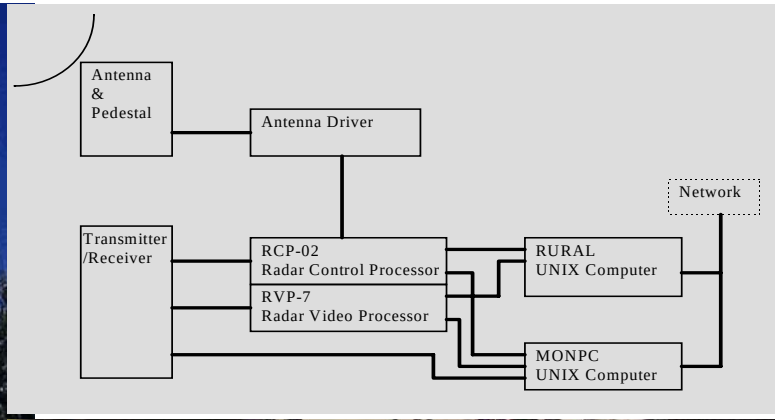


Radar is near the sea on a high tower.

Problem: The Environment



Weather Radar



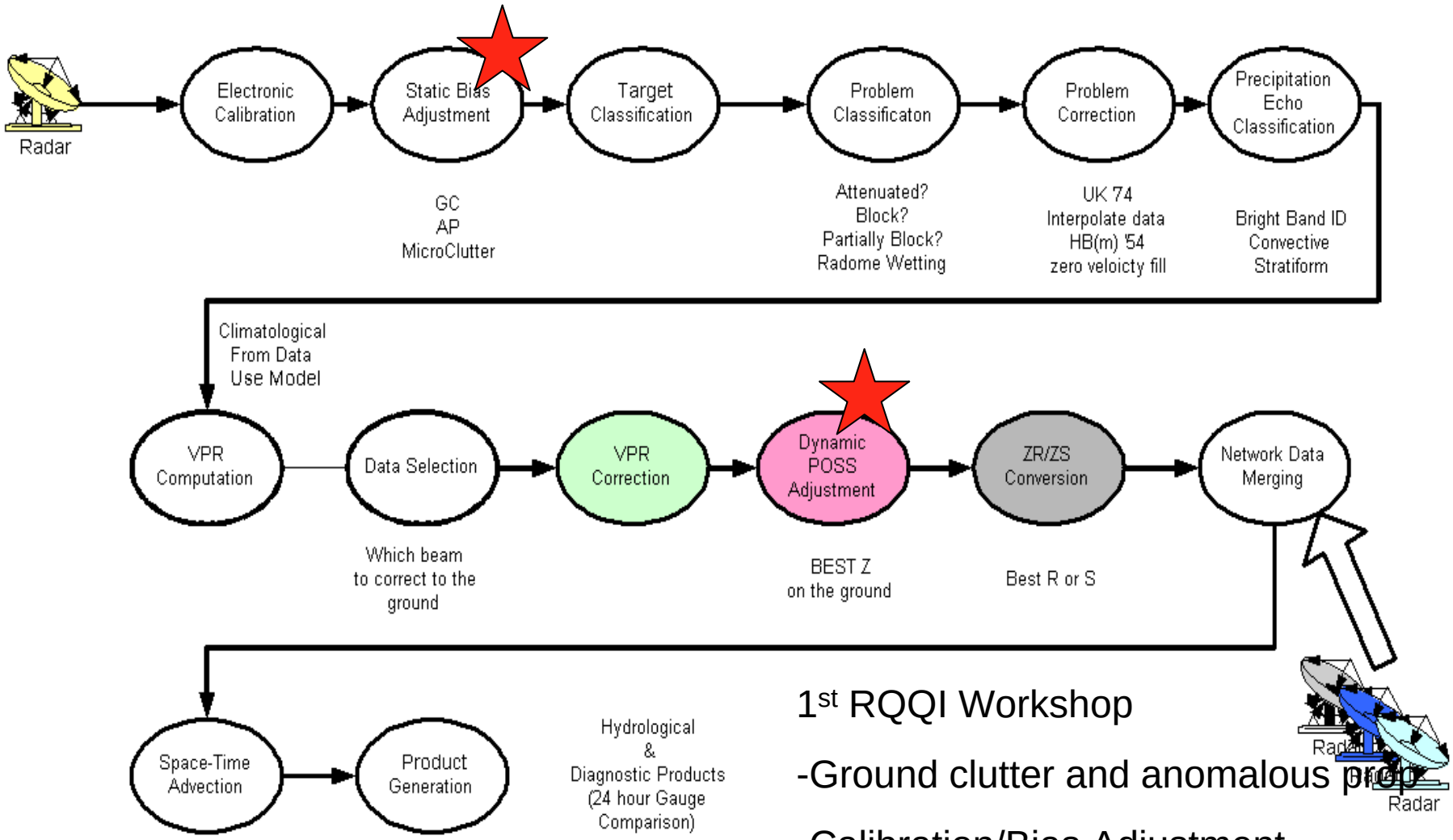
Whistler Radar

WMO Turkey Training Course

A complex instrument but if maintained is stable to about 1-2 dB cf ~100 dB.

Note TRMM spaceborne radar is stable to 0.5 dB

Processing: Conceptual QPE Radar Software Chain



1st RQQI Workshop

-Ground clutter and anomalous prop

-Calibration/Bias Adjustment

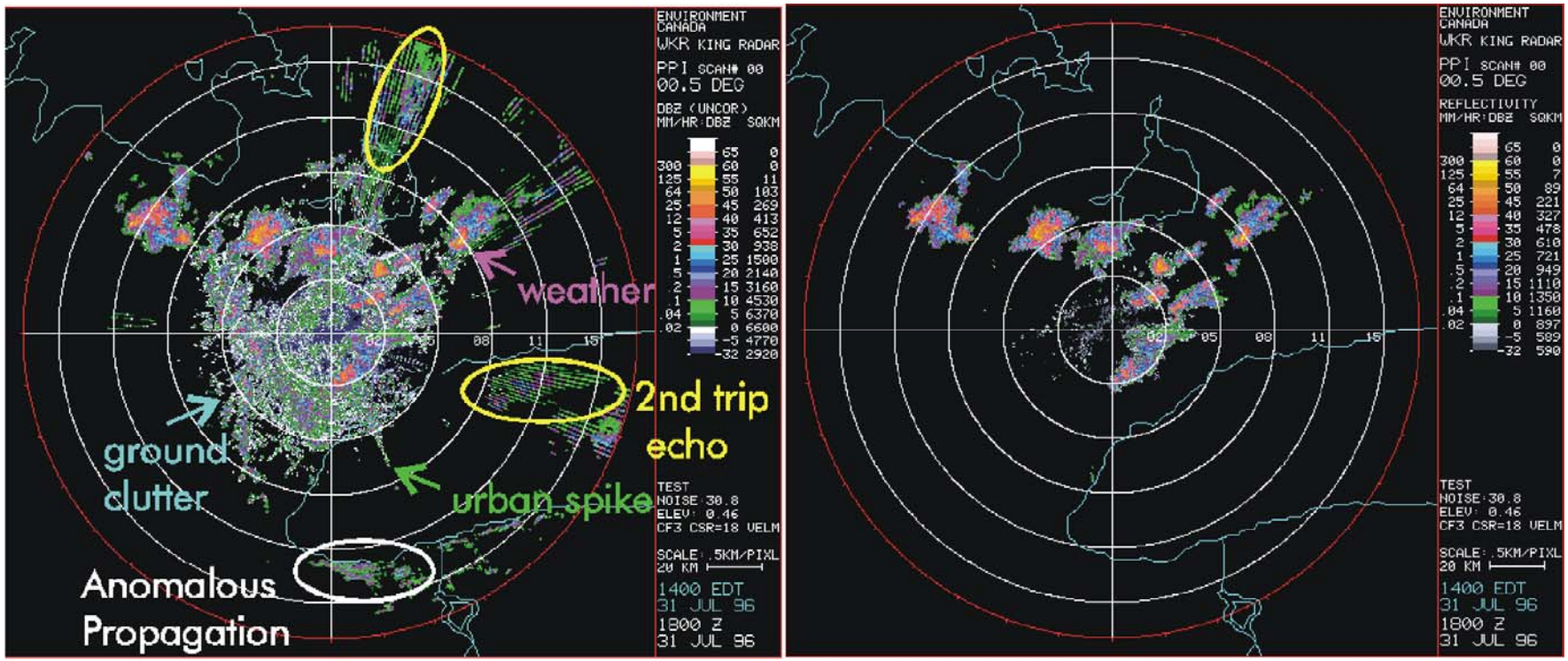
RQQI

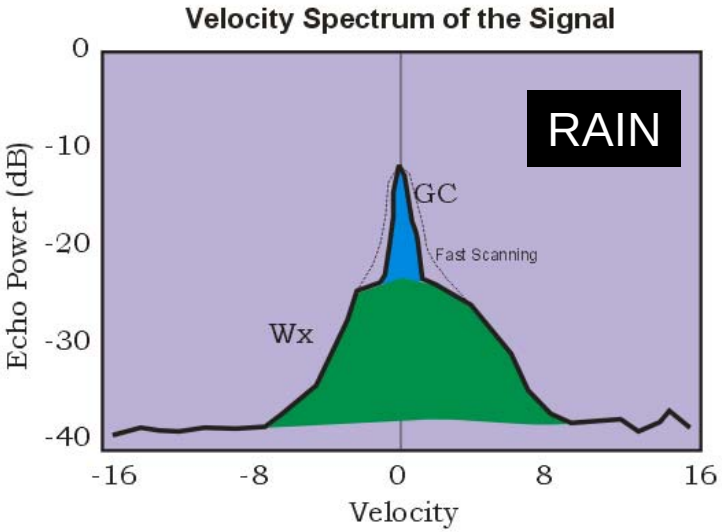
- A variety of adjustments are needed to convert radar measurements to precipitation estimates
- Various methods are available for each adjustment and dependent on the radar features
- A *series* of inter-comparison workshops to *quantify* the quality of these *methods* for quantitative precipitation estimation *globally*
- *The first workshop will focus on clutter removal and "calibration"*

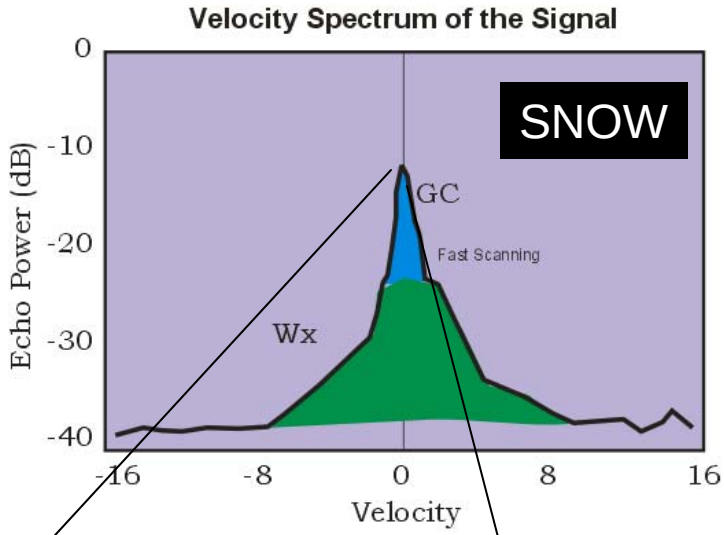
Ground Echo Removal Algorithms

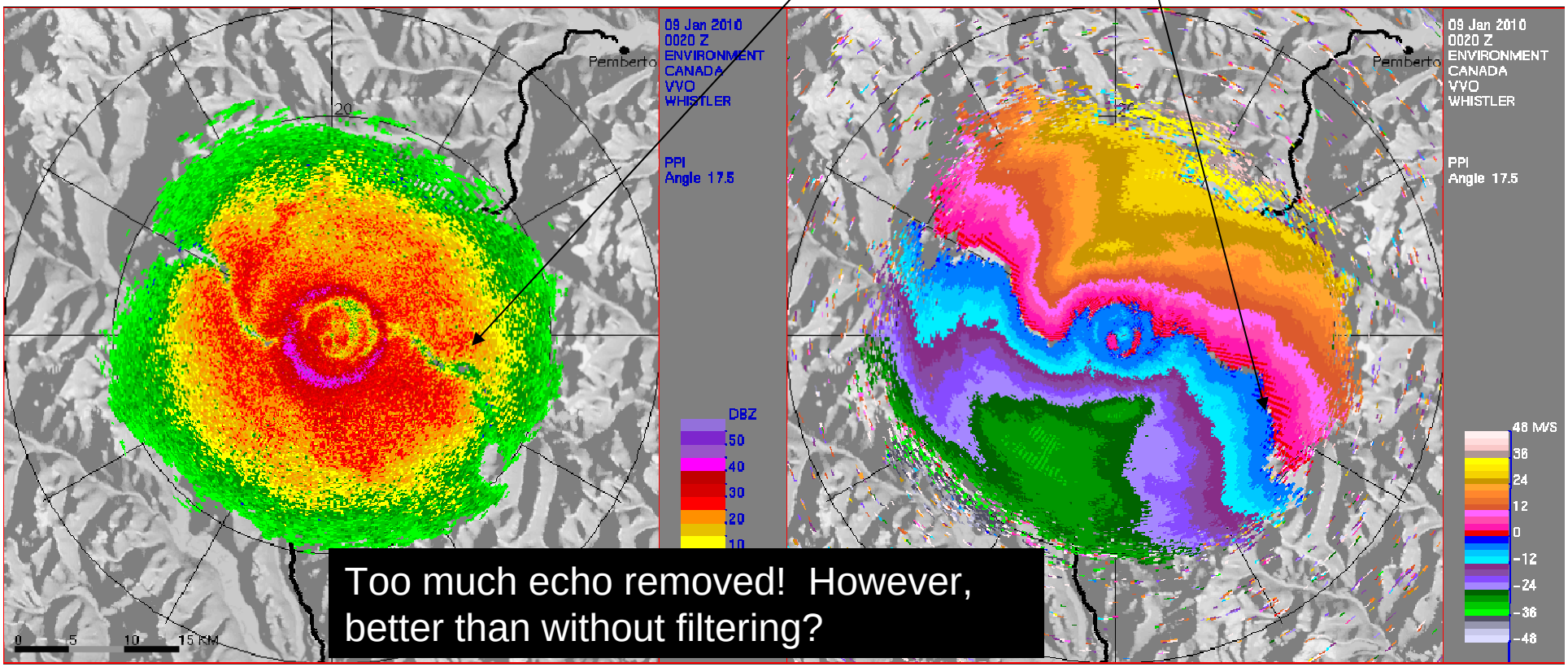
- Signal Processing
  - Time domain/pulse pair processing (Doppler)
  - Frequency domain/FFT processing (Doppler)
  - Reflectivity statistics (non-Doppler)
  - Polarization signature (dual-polarization, Doppler)
  - Averaging, range resolution, radar stability, coordinate system
- Data Processing
  - Ground echo masks
  - Radar Echo Classification and GE mitigation

Signal Processing or Doppler Filtering



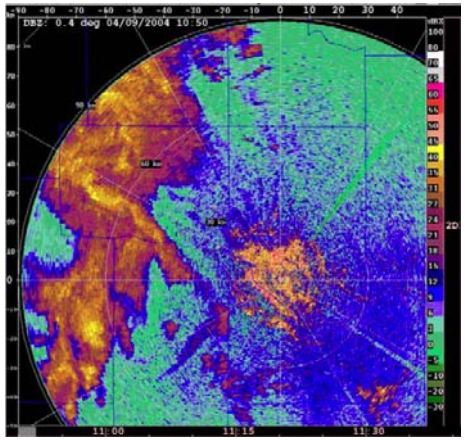


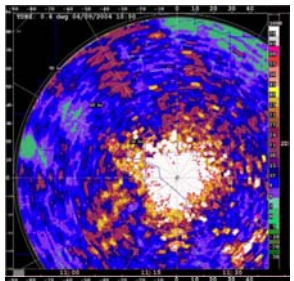


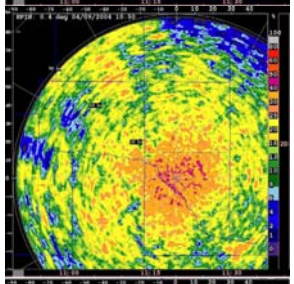


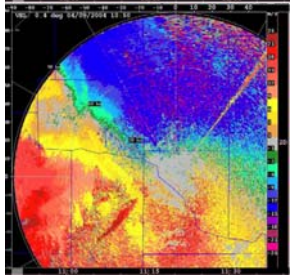
Too much echo removed! However, better than without filtering?

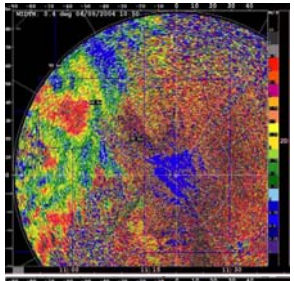
Data Processing plus Signal Processing

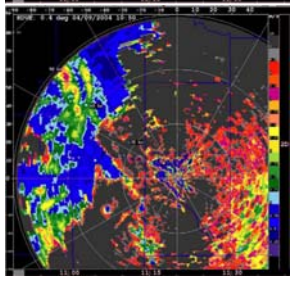


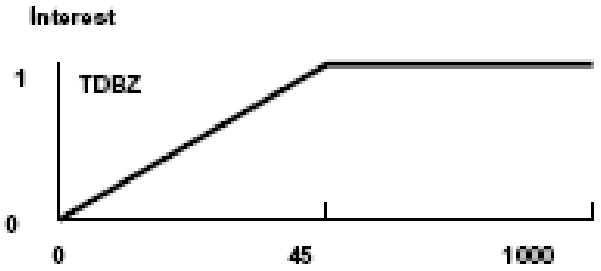


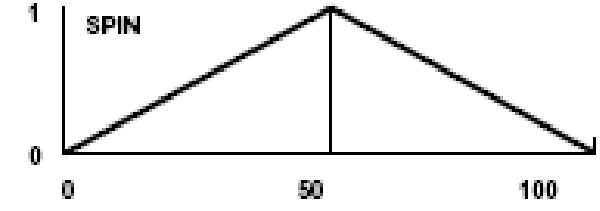


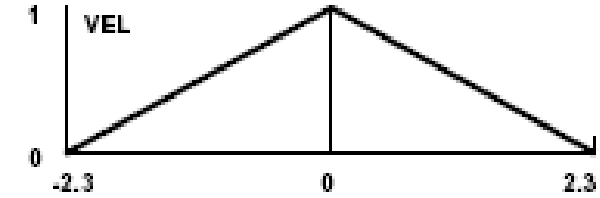


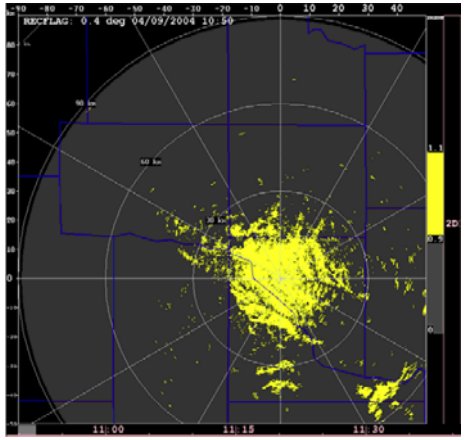


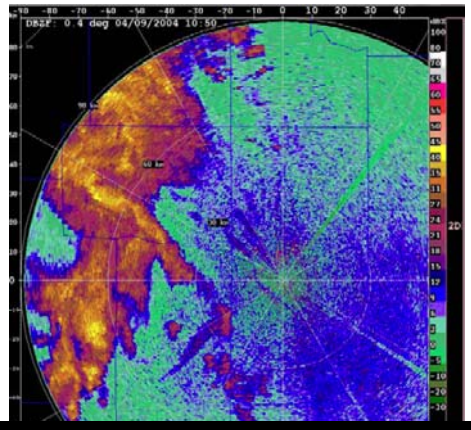










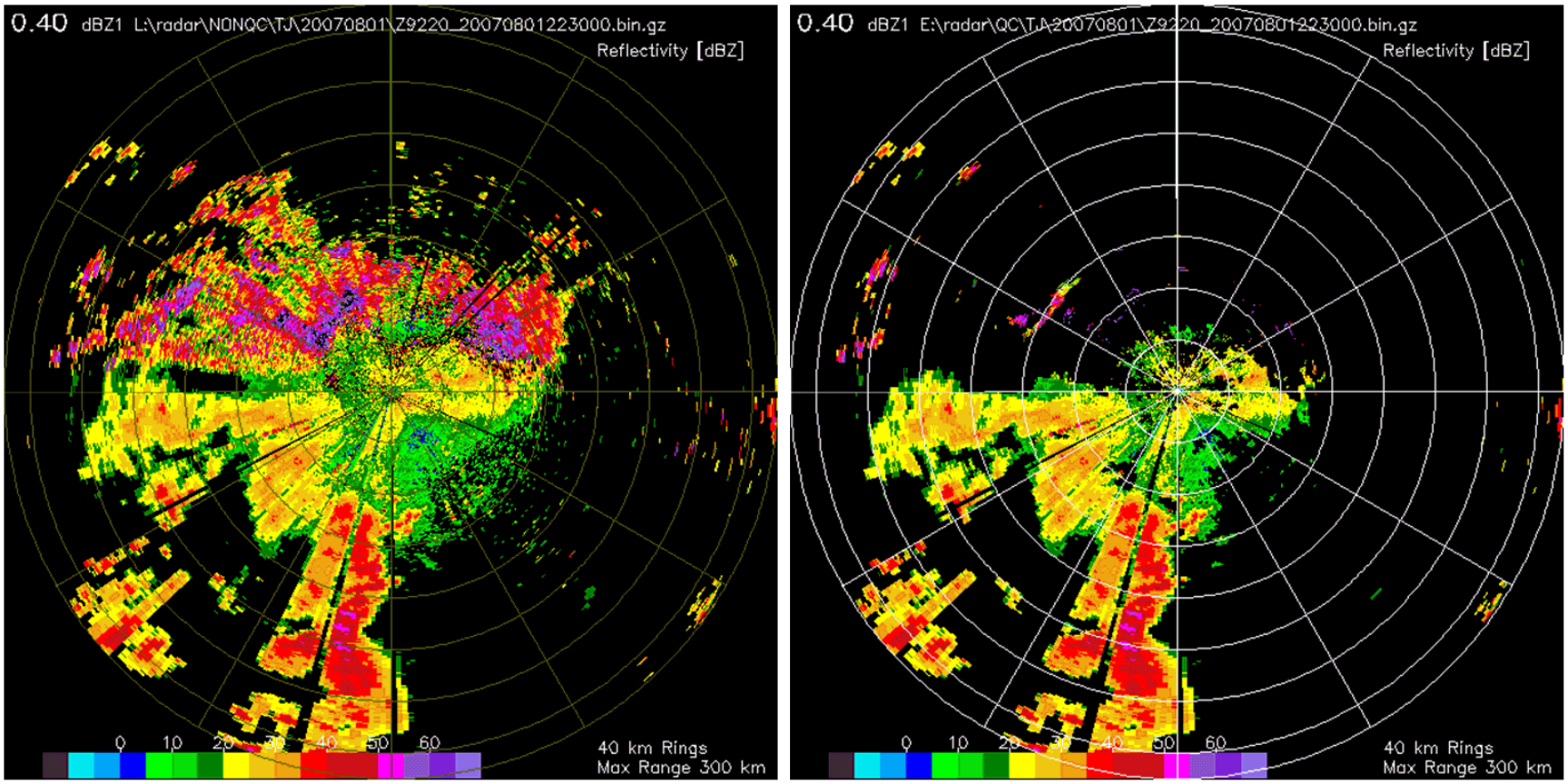


Dixon, Kessinger, Hubbert

Data Processing plus Signal Processing

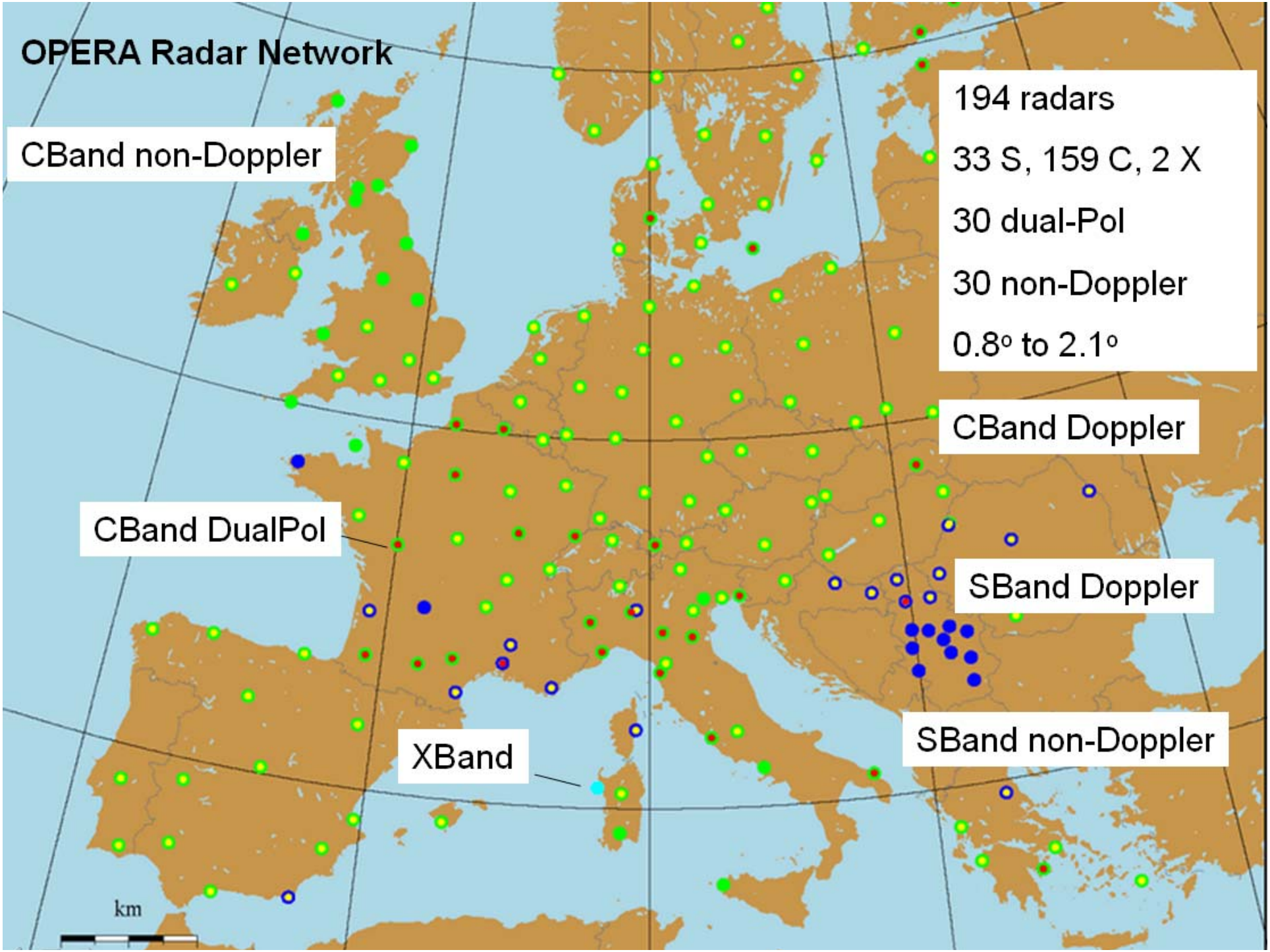
Texture + Fuzzy Logic + Spectral

Example of AP and Removal



NONQC **QC**

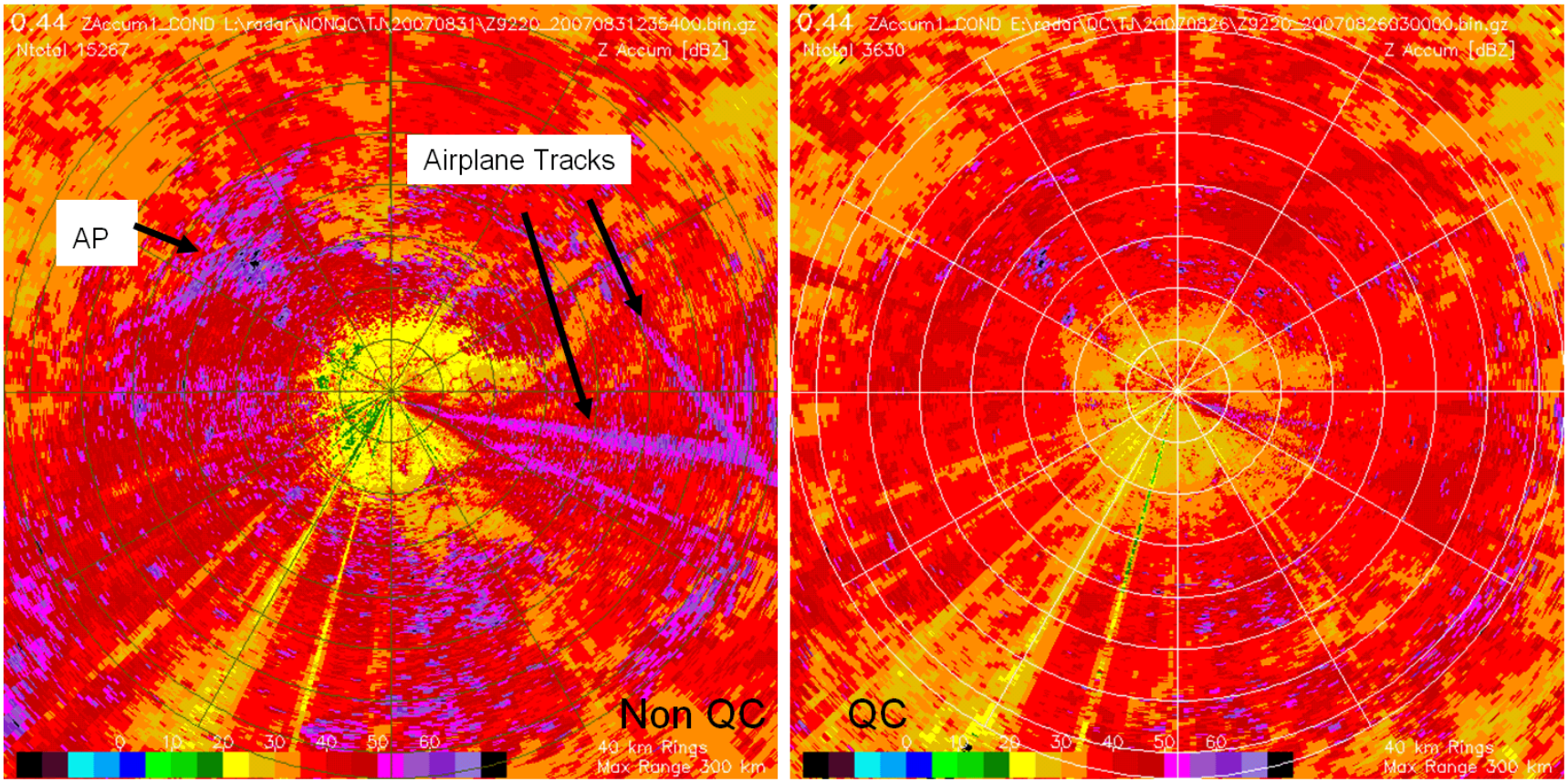
Liping Liu


OPERA Radar Network
194 radars
33 S, 159 C, 2 X
30 dual-Pol
30 non-Doppler
0.8º to 2.1º
CBand non-Doppler
CBand Doppler
CBand DualPol
SBand Doppler
SBand non-Doppler
XBand
km

Relative Metrics

- ***Metrics***
  - "truth" is hard to define or non-existent.
  - result of corrections will cause the spatial and temporal statistical properties of the echoes in the clutter affected areas to be the same as those from the areas that are not affected by clutter
  - UNIFORMITY, CONTINUITY AND SMOOTHNESS.
- **Temporal and spatial correlation of reflectivity**
  - higher correlations between the clutter corrected and adjacent clutter free areas
  - improvement may be offset by added noise coming from detection and infilling
- **Probability Distribution Function of reflectivity**
  - The single point statistics for the in-filled data in a clutter affected area should be the same as that for a neighbouring non-clutter area.

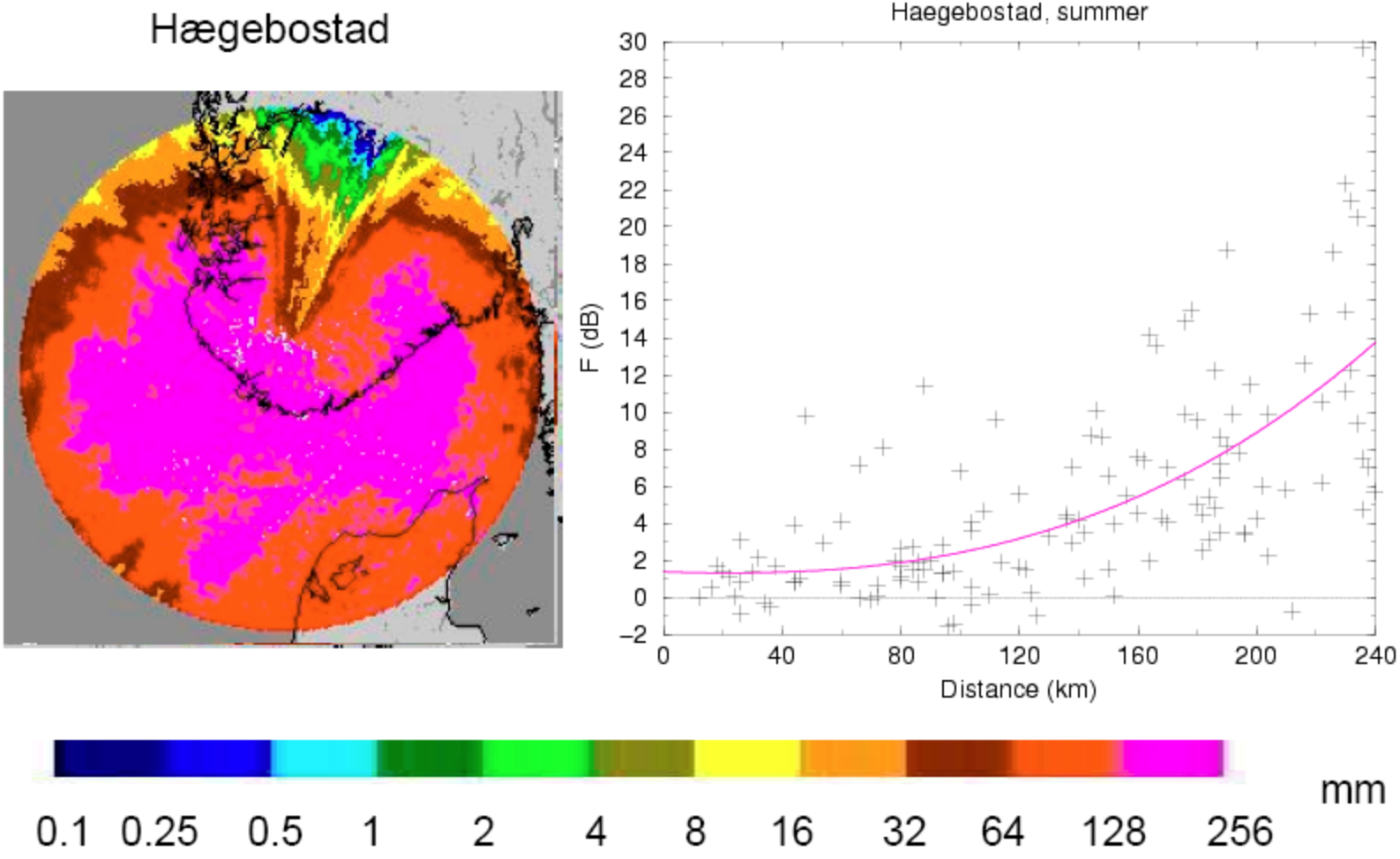
Reflectivity Accumulation – 4 months



Highly Variable

More uniform, smoother, more continuous

Impact of Partial Blockage



Similar to before except area of partial blockage contributes to lots of scatter
Algorithms that are able to infill data should reduce the variance in the scatter!

Michelson

“Absolute” Metrics

- **“No absolute” but dispersion quality concept - bias**
  - Convert Z to R using $Z=aR^b$ with a fixed b
  - With focus on QPE and raingauges, comparing with rain gauges to compute an “unbiased” estimate of “*a*”. This would be done over a few stratiform cases.
  - The RMS error (the spread) of the log (RG/RR) would provide a metric of the quality of the precipitation field. Secondary “success”
- **Probability Distribution Function of log(gauge/radar)**
  - The bias and reliability of the surface reflectivity estimates can be represented by the PDF location and width respectively. (Will require a substantial network of rain gauges under the radars).

Inter-comparison Modality

- Short data sets in a variety of situations
  - Some synthetic data sets considered
- Run algorithms and accumulate data
- Independent analysis of results
- Workshop to present algorithms, results

Inter-comparison Data Sets

Must be chosen judiciously

- No Weather
  - urban clutter (hard),
  - rural clutter (silos, soft forests),
  - mountain top- microclutter
  - valley radar-hard clutter
  - intense AP
  - mild anomalous propagation
  - intense sea clutter [Saudi Arabia]
  - mild sea clutter [Australia]
- Weather
  - convective weather
  - low-topped thunderstorms
  - wide spread weather
  - convective, low topped and wide spread cases with overlapping radars

Deliverables

- A better and documented understanding of the relative performance of an algorithm for a particular radar and situation
- A better and documented understanding of the balance and relative merits of identifying and mitigating the effects of clutter during the signal processing or data processing components of the QPE system.
- A better and documented understanding of the optimal volume scanning strategy to mitigate the effects of clutter in a QPE system.
- A legacy of well documented algorithms and possibly code.

Inter-comparison Review Panel

International Committee of Experts

- Kimata, JMA, Japan
- Liping Liu, CAMS/CMA, China
- Alan Seed, CAWCR, Australia
- Daniel Sempere-Torres, GRAHI, Spain
- OPERA
- NOAA
- NCAR

Summary

- RQQI's goal is to inter-compare different algorithms for radar quality control with a focus on QPE applications
- Many steps in processing, first workshop to address the most basic issues (TBD, ICE)
- Ultimately, the goal is to develop a method to assess the overall quality of precipitation products from radars globally