Argonne NATIONAL LABORATORY

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Value adding Science

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U.S. DEPARTMENT OF ENERGY

Outline

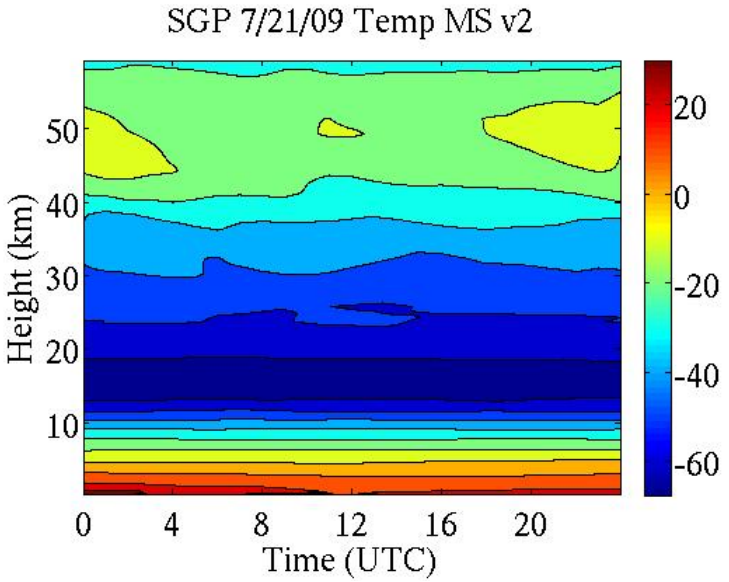
- Sounding Value Added Products (Jensen)
- The ARM radar network (Collis)
- Cloud Radar Value Added products (Jensen)
- Precipitation Radar Value Added Products (Collis)

Merged Sounding (MS)

Developer: David Troyan

• Uses a combination of radiosonde profiles, MWR integrated water vapor, surface meteorology, and ECMWF model output to provide a thermodynamic profile of the atmosphere at one minute intervals

• Version 2 (available as an Evaluation Product)
  - Uses ARM radiosondes corrected for using Miloshevich method
  - 315 Altitude Levels to 60 km AGL



Interpolated Sonde

• Intermediate step in MS processing
• Immediate users – radar VAPs

Sonde Adjust

• Corrects the dry-bias found in Vaisala (RS-80 , RS-90, RS-92)radiosondes
• Employs the correction algorithms described in
  - Miloshevich et. al. (2001, 2004, 2006)
  - Turner et. al. (2003)
  - Wang et. al. (2002)
  - Vomel et. al. (2007)

Data Availability for Sounding VAPs

Datastream/Site	mergesonde1mace	sondeadjust	mergesonde2mace	Interpolatedsonde
Location	Data Archive	Evaluation Area	Evaluation Area	Beta Version*
SGP	1996-2011	1996-2009	2002-2009	2011
NSA	2002-2011	2002-2009		
TWP C1	2000-2011	2000-2008	2008	2011
TWP C2	2002-2011	1999, 2001-2008		
TWP C3	2002-2011	2002-2008	2008	
PYE	**X**	**X**	**X**	
NIM	**X**	**X**	**X**	
FKB	**X**	**X**	**X**	
HFE	**X**	**X**	**X**	
GRW	**X**	**X**	**X**	

Radar Types

- Scanning ARM Precipitation sensitive Radar, SAPR.
- Two variants.
- C-Band or 5cm wavelength radar.
- X-Band or 3cm wavelength radar.
- Main product is a nested constant elevation scans suitable for mapping to a model like grid.

- Scanning ARM Cloud sensitive Radar: SACR.
- Two variants.
- Dual frequency Ka/W band.
- Dual frequency Ka/X band.
- Scanning is prioritizes the detection of cloud layers, rotating through several modes.

- And of course the workhorse of the program, the Ka Band Zenith Radar, KaZR.

Radar Types

Tropical Western Pacific

Darwin

- Ka/X band SACR, No data at archive yet.
- KAZR.
- BoM operated CPOL radar at Gunn Point (non-ARRA).
- LONG record of CPOL data, shorter record of distrometer measurements.
- Maritime continent, Highly seasonal (buildup, active/suppressed monsoon, break, dry).

Manus

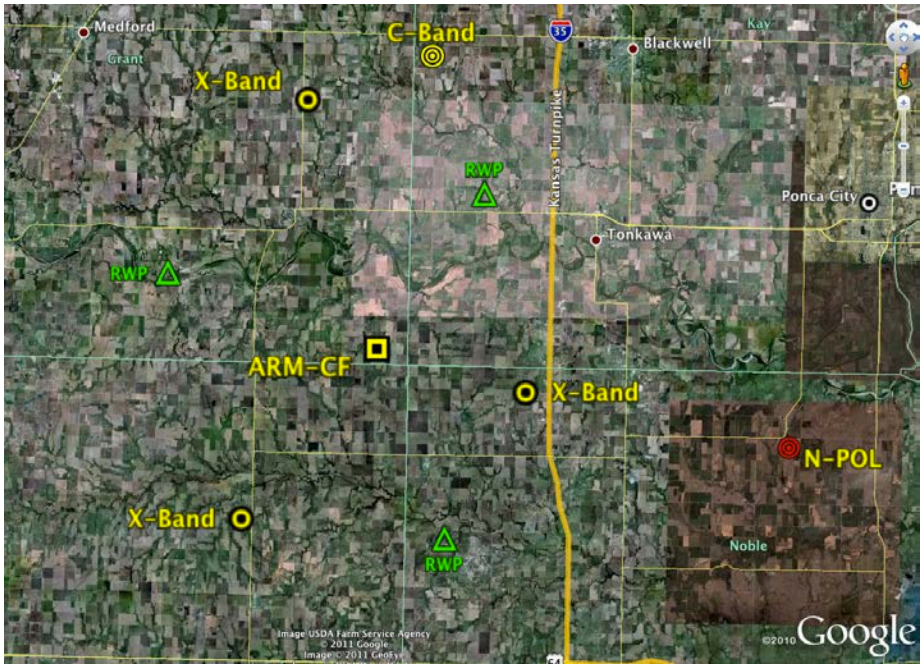
- Ka/X SACR, no data at archive yet.
- KAZR.
- CSAPR ~7km West of CF.
- Unique location, MJO influenced, very different morphology and temporal evolution to Darwin.
- Very brief data set, only a few months of distrometer and radar data.

North Slope of Alaska

- Ka/W SACR, some data available at archive.
- KAZR.
- X-SAPR, some downtime.
- Very low tilt added to track sea ice.
- Northernmost weather radar installation in the world.
- VERY challenging environment for “classical” precipitation radar retrievals.

Southern Great Plains

- Think of it the Southern Great Plains multi-frequency multi-scale radar facility.
- Ka/W band SACR, long but spotty data in Archive, some data from the end of MC3E.
- KAZR.
- Three synchronized X-SAPR systems monitoring the dynamical environment. Complimented by three UHF ARM Zenith Radars UAZR.
- C-SAPR providing larger scale monitoring of the microphysical environment.

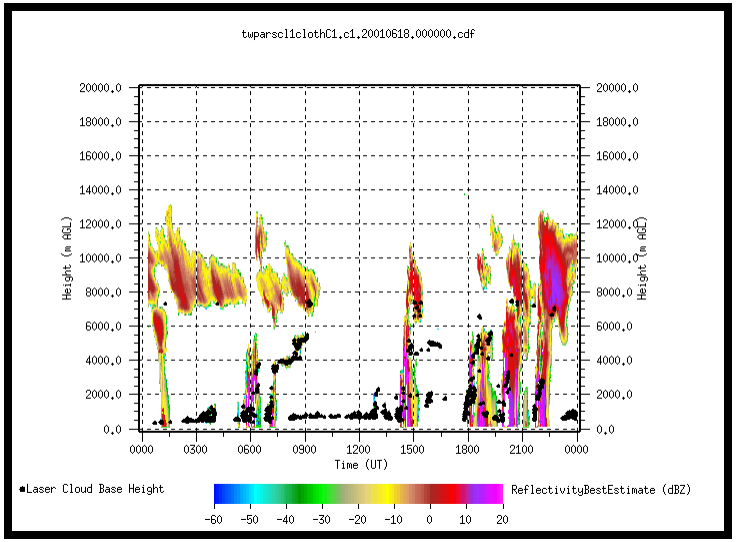


Mobile Facilities.

- Both have a KAZR.
- AMF 1 has a Ka/W SACR, no data available from GVAX.
- AMF 2 has a Ka/X SACR, limited data available from Gan Island.
- Ka/X will not be going to MAGIC, but the W band radar will be modified to become a Marine W band ARM Cloud Radar or WACR.

Active Remote Sensing of CLouds (ARSCL)

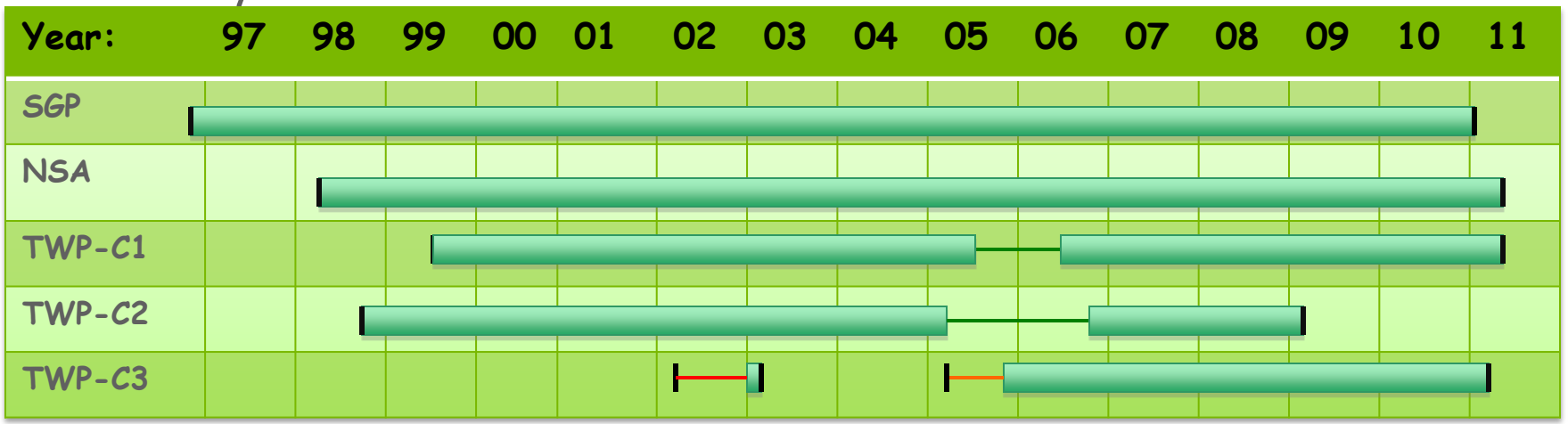
Developers: Karen Johnson, David Troyan



Provides:

- Cloud boundaries,
- Hydrometeor height distributions and radar reflectivity estimates
- Vertical velocities
- Doppler spectral widths

Availability at ARM Archive:



WACR – ARSCL Evaluation Product:

NIM, FKB, HFE, GRW, SGP available

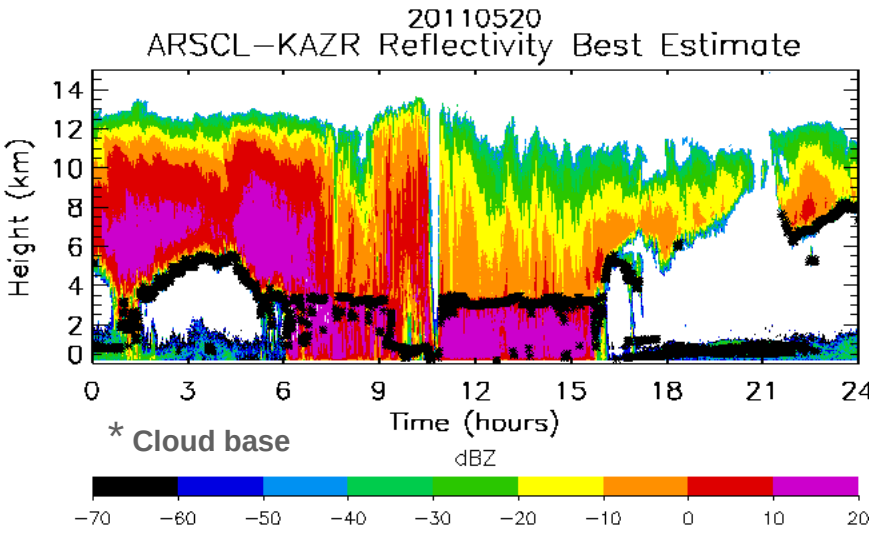
KAZR vs. MMCR
What's the difference?

KAZR is a major upgrade. Like MMCR, it's a vertically-pointing 35 GHz cloud radar, but KAZR has…

- –Greater sensitivity with fewer signal artifacts due to signal control made possible by the new digital transceiver
- –Higher resolution measurements in time (4 s), height (30 m)
- –Higher unambiguous velocities
- –Doppler Spectra that are 'cleaner' (e.g., no 'image' spectrum)
- –Improved polarization measurements due to better cross-polar isolation
- –Better calibration potential due to additional sensors and environmental controls

KAZR-ARSCL VAP

cloud radar, micropulse lidar, ceilometer
+ interpolated sonde
+ rain gauge
+ microwave radiometer



Why a *new* VAP?

- New radar operating modes → Simpler mode merging
- Improved polarization modes → LDR used in insect detection
- Insect detection algorithm expanded (LWP, temperature,…)
- Reflectivities corrected for water vapor attenuation
- Improved velocity dealiasing algorithm
- New KAZR-ARSCL software easier to maintain, update
- More timely processing

KAZR-ARSCL
Proposed Data Products
… feedback welcome*

Full output file: arsclkazr 1kollias

Cloud boundaries only: arsclkazr bnd 1kollias

* Corrected individual radar mode products?
  - e.g., kazrgecor, kazrblcor, …
  - Significant detection mask
  - Data artifacts flagged

* Data Flags of interest?

  insects, artifacts, precip, bad data, ?

* Level 2 product using MicroARSCL as an input?
  - Improve moment estimation using spectra
  - Higher-order moments: kurtosis, skewness
  - Insect identification more precise
  - Level 2 product, e.g., arsclkazr1kolliasCx.**c2**

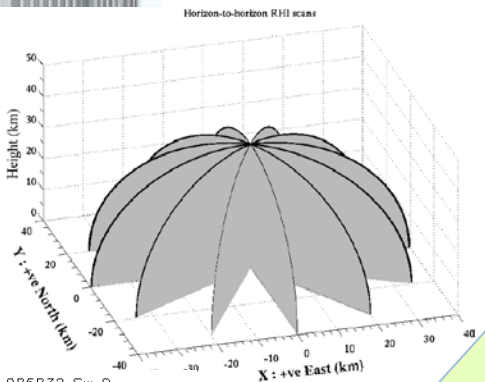
Ideas for Historic MMCR Calibration

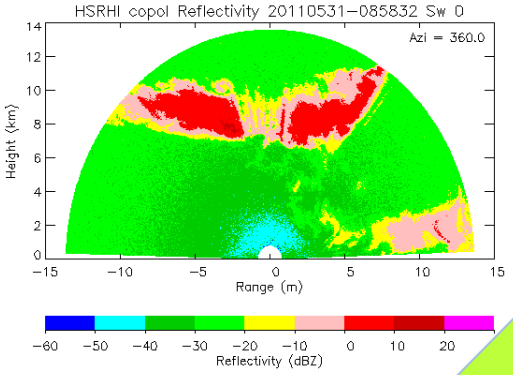
Years of data: SGP 15, NSA 13, Manus 11+, Nauru 10+, Darwin 5+

- Noise power trends
- Cirrus minimum observed reflectivity
- Polarimetric CDR drift
- Insect average power
- Lowest height maximum reflectivity
- Comparisons to WACR, guest radars

Scanning Cloud Radar Products

Ka, W, and X-bands

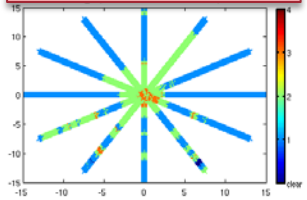




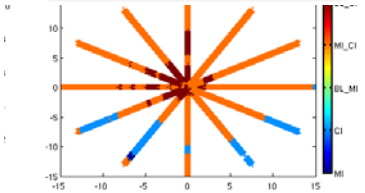
Product Development in 3 stages

Cloud Tops

Cloud Layers



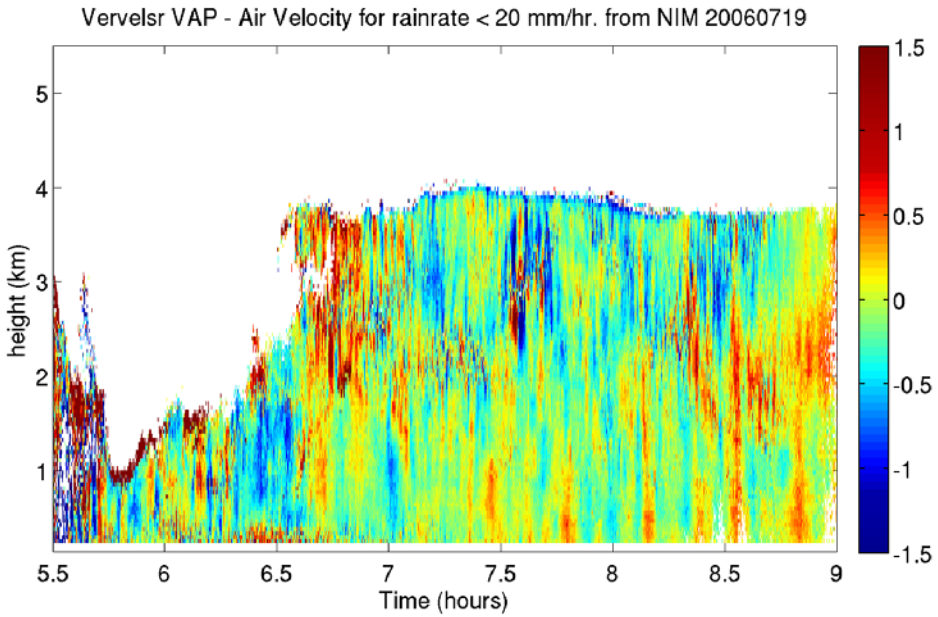
Cloud Type



Vertical Velocity VAPs

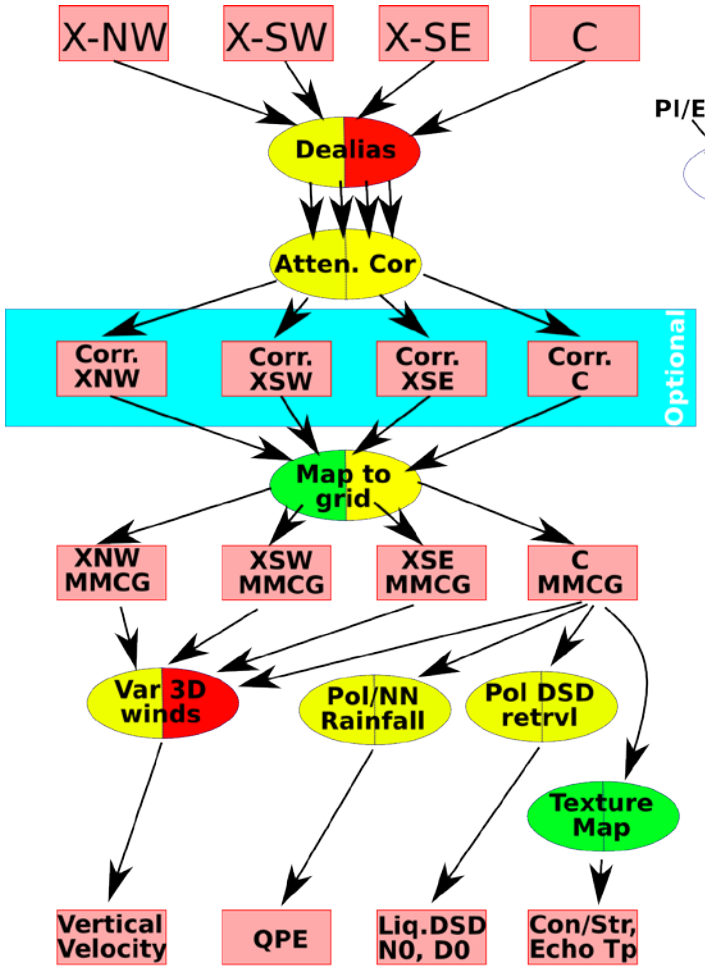
Deep Convective Clouds	**Large-scale Precip (Liquid)**	Warm Rain	**Ice clouds**	Drizzling clouds	**Non-precip. clouds**	Clear Air

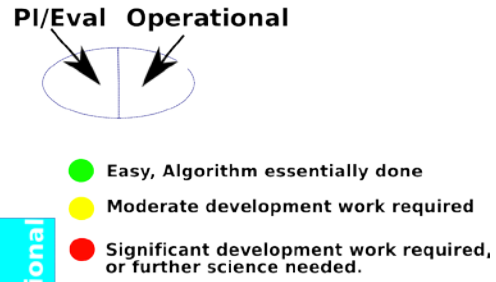
Giangrande et al. 2010
Developer: M. Dunn
ECO-00804



- **Vertical Velocity in stratiform rain**
- **94 GHz Doppler spectra as input**
- **First step towards a continuous VV product**

Scanning ARM Precipitation Radar Value Added Products.





Var 3D winds: Variational 3D wind retrievals

Pol DSD retrvl: Polarimetric Drop size retrieval in warm rain

Pol/NN Rainfall: Polarimetric or Neural Network based rainfall retrieval

Texture Map: Stiener based convective stratiform classification, echo top detection

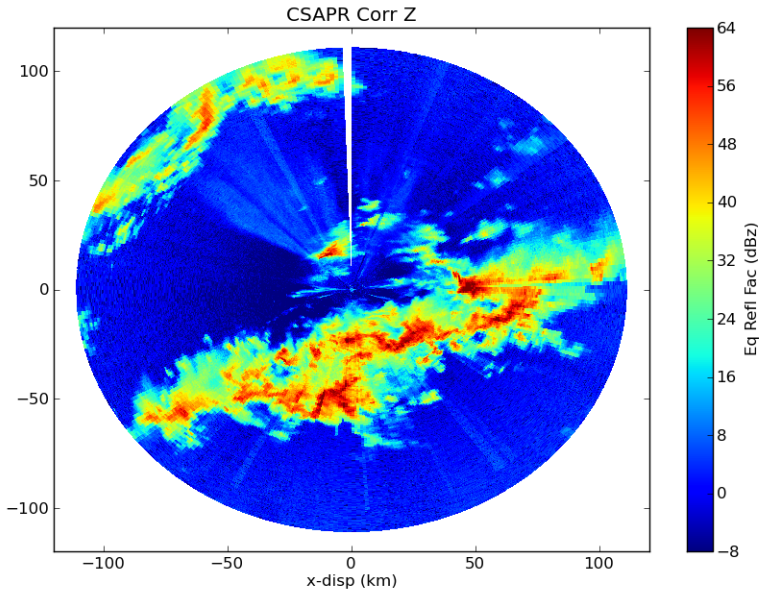
Map to grid: Balltree based Barnes filter

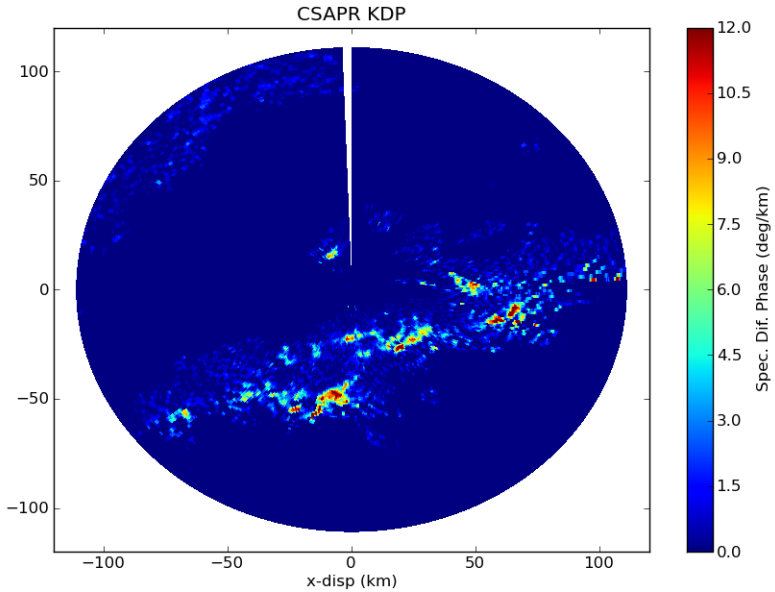
Dealias: U Washington 4DD velocity unfolding

Atten. Cor: PhiDP based attenuation and differential attenuation correction.

Corrected Moments in Antenna Coordinates

- Data in antenna coordinates is corrected for aliasing and phase folding.
- KDP is recalculated using a filter approach and a ZPHI (Bringi et al 2001 and Gu et al 2011) like attenuation correction algorithm is applied.
- Version 0.1Evaluation available for MC3E C-SAPR, soon to be available for X-SAPR.
- Active work on V1.0E which will include advanced phase processing.
- Format will be similar to SACR data as CF-Radial.

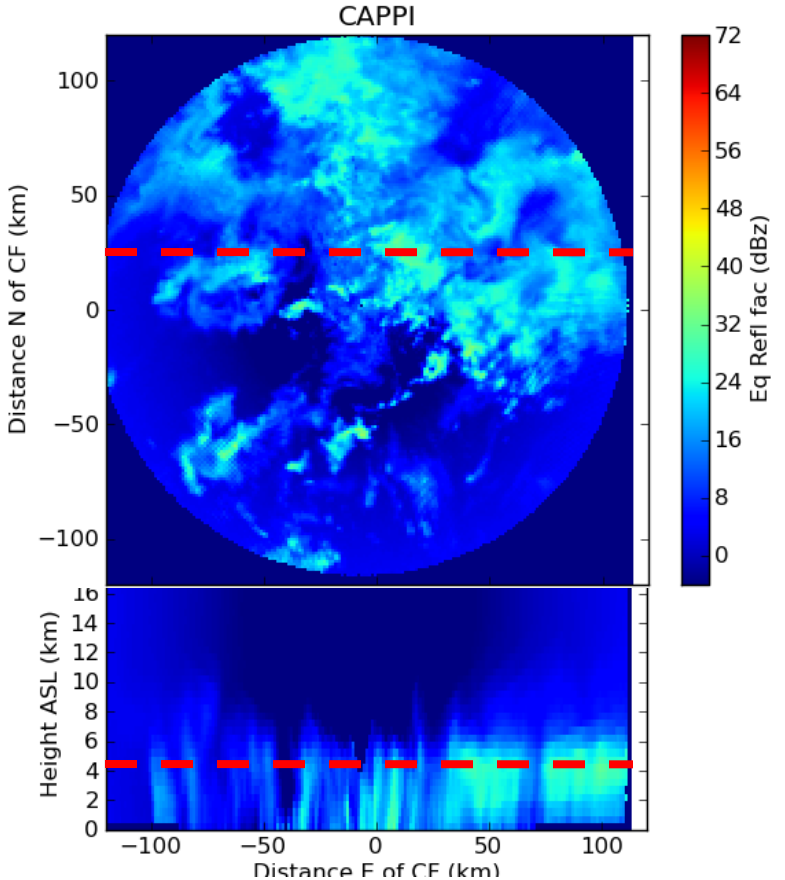


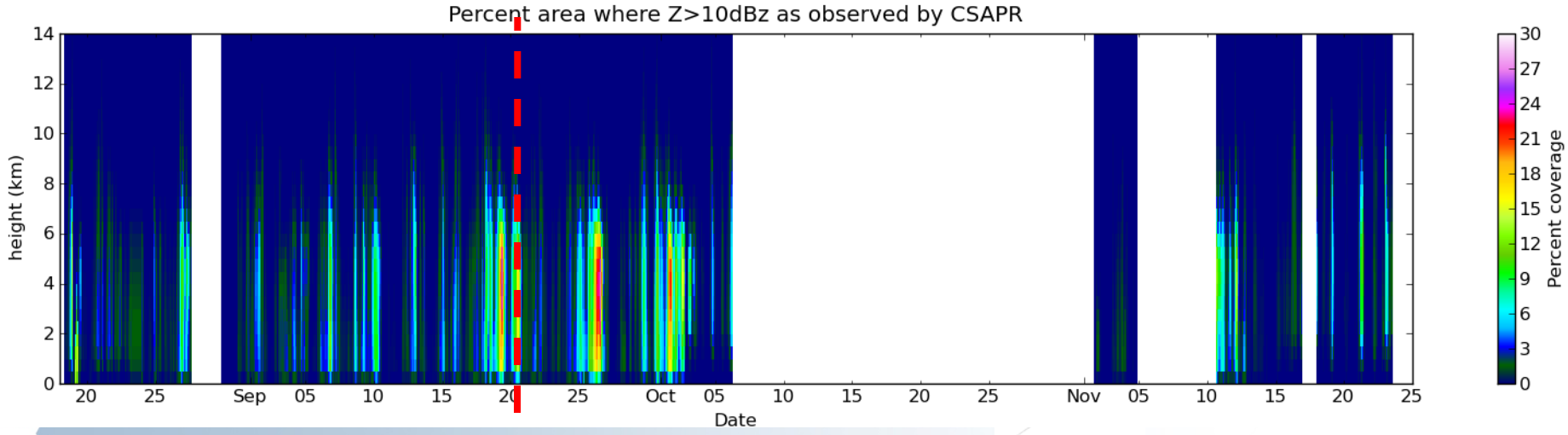


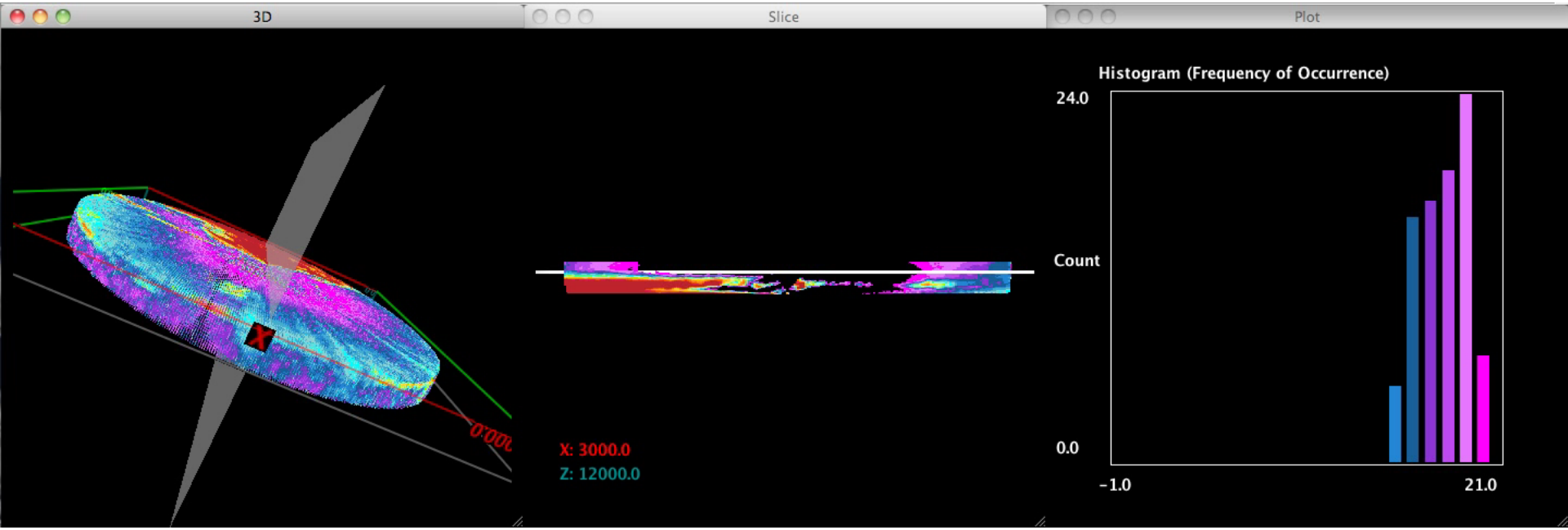
Mapped Moments to a Cartesian Grid (MMCG)

- First VAP from the ARM radars.
- CSAPR data from MC3E is in the development section (V0.1E) of the Archive AMIE Manus data soon to follow as well as X-SAPR data.

Site	Radar	Domain, resolution
SGP	CSAPR	240x240x17km, 1x1x0.5km
	CSAPR	100x100x17km, 0.5x0.5x0.5km
	XSAPR (x3)	100x100x17km, 0.5x0.5x0.5km
TWP Manus	CSAPR	240x240x18km, 1x1x0.5km
NSA Barrow		120x120x10km, 0.5x0.5x0.5km

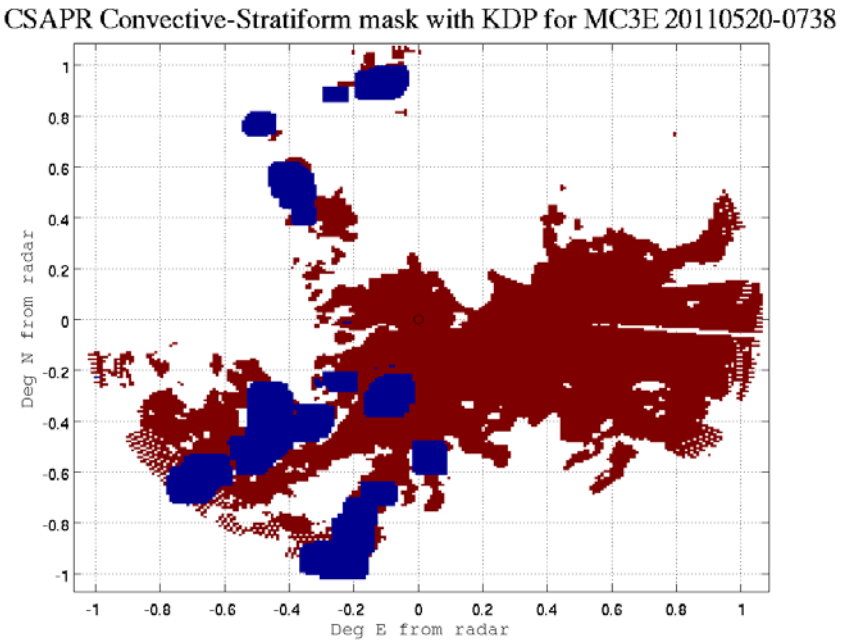


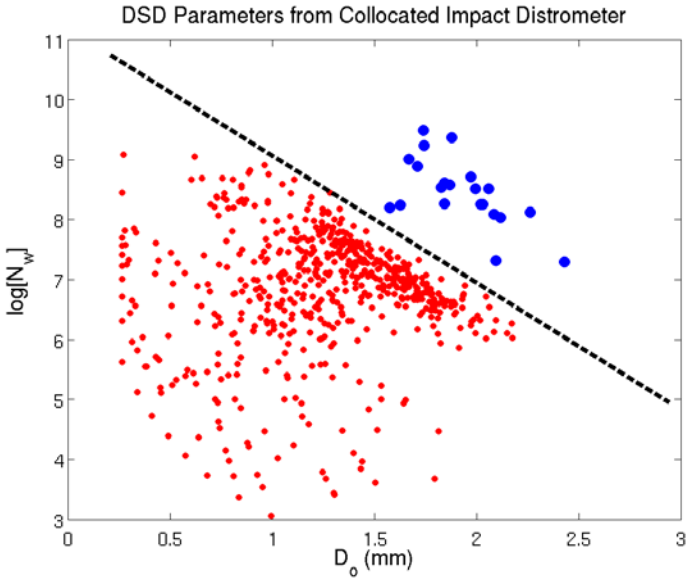



3D
Slice
Plot
Histogram (Frequency of Occurrence)
24.0
Count
0.0
-1.0
21.0
X: 3000.0
Z: 12000.0

Geophysical Retrievals

- Much work has been focused on the correction and conditioning of the radar moments.
- We are starting to move in to retrieving model like properties from the scanning radar data.
- Rainfall will be available for MC3E (Dual pol) and AMIE Manus (Z-R).
- PI work and good progress on vertical velocity and storm dynamics for MC3E.
- Work at BNL on convective stratiform partitioning including DSD verification/tuning.
- First stop for volumetric microphysics likely to be LWC retrievals.

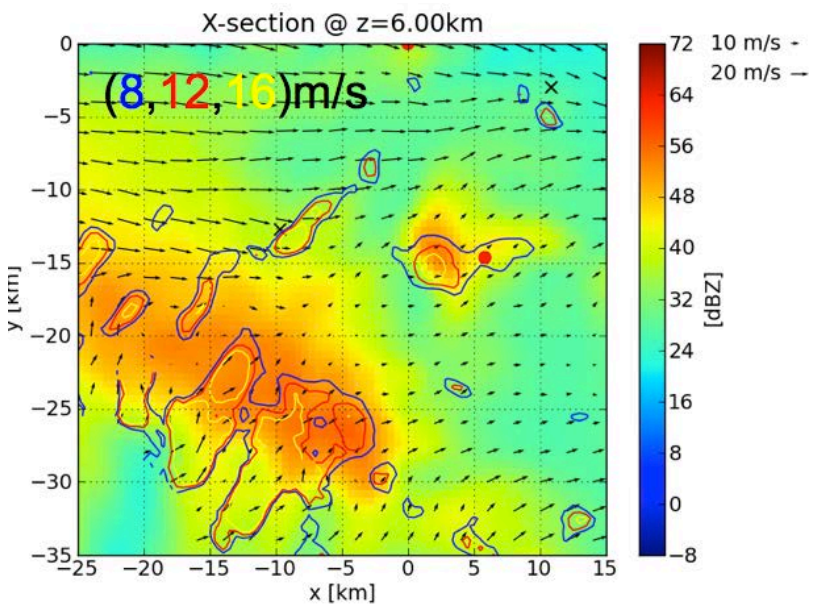


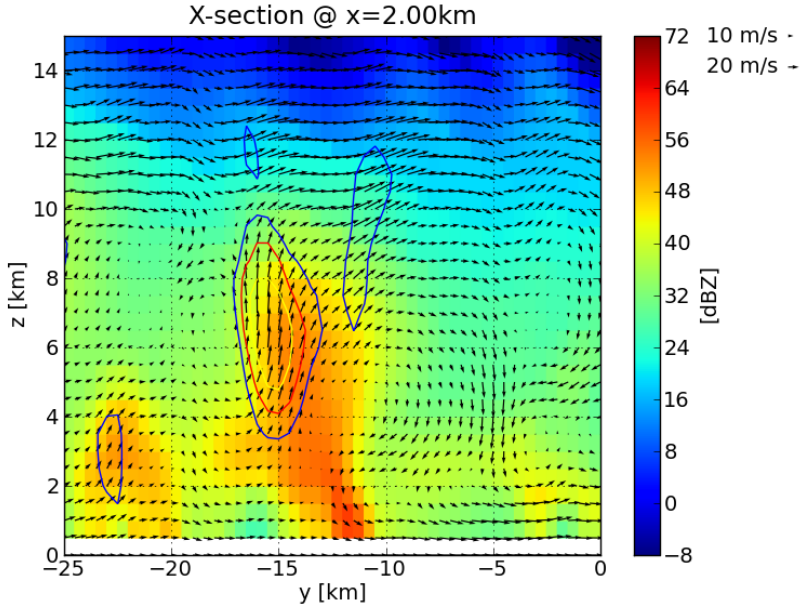


Vertical Velocity VAPs

Deep Convective Clouds	**Large-scale Precip (Liquid)**	Warm Rain	**Ice clouds**	Drizzling clouds	**Non-precip. clouds**	Clear Air

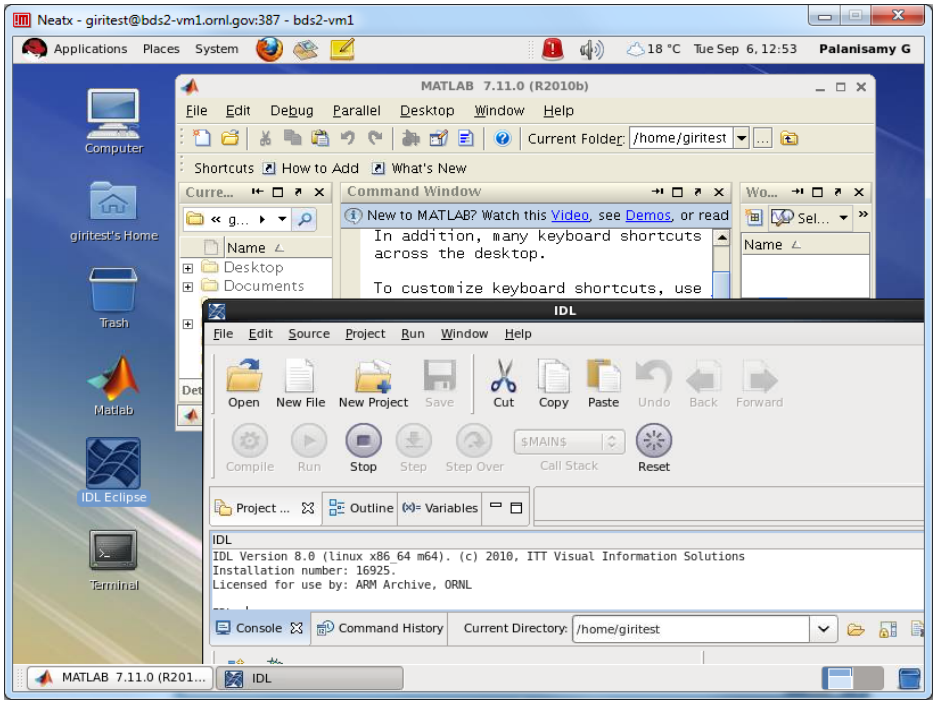
Ray et al. 1980, Collis et al. 2010
PI Product from McGill
EWO-13977





ARM Data Cluster, the (high performance) place to play…

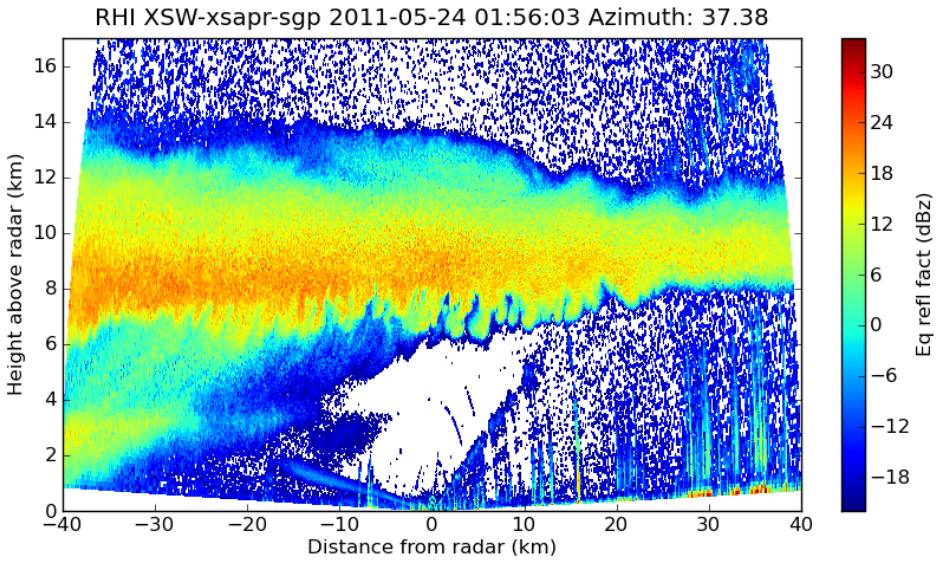
- Corrections, retrievals and mappings performed on the ARM Data Cluster at ORNL.
- Very open, easy to use environment with plenty of grunt.
- Currently we have 5TB of radar data staged there, 1TB of VAP data.
- If you are doing long term studies or retrieval work usage of this system is strongly encouraged.



Interested in using the ARM Viz cluster? http://www.archive.arm.gov/cluster.pdf

Currently identified capability gaps.

- Arctic rainfall, even warm season.
- Any kind of scanning radar retrievals in ice anvils.
- Uncertainty studies. (Role for QUICR?)
- High performance programming (bringing prototyped code to production speeds).
- Building useful products from HSRHI scanning modes.
- Feature tracking.
- Multi-wavelength, multi-instrument whole of system retrievals.



VAP Menu (Bon Appetite)

- Scanning Precipitation radars
  - MMCG – Mapped Moments to Cartesian Grid (Available now as Evaluation Product)
  - CMAC – Corrected Moments in Antenna Coordinates (Probably mostly for work with retrievals)
  - QPE – Quantitative Precipitation Estimation (in development)
  - Drop Size Distributions
  - Vertical Velocity for Deep Convective Clouds
- Interpolated Sounding (Mostly for near real-time input to new radar VAPs)
- VARANAL Continuous Forcing Dataset
- Large-scale forcing for AMIE (and future field programs)
- Cloud Radar VAPs
  - KAZR-ARSCL – New ARSCL product for new generation cloud radar
  - Scanning Cloud Radar – Significant detection mask, 3-D ARSCL Vertical Velocity
  - VV (Stratiform Rain) - Using W-band Doppler spectra (in development)
  - VV (Clear Air, Non-precip. Clouds, drizzling clouds, warm rain)Integrated VV product Atmospheric State
- Improved Merged Sounding (Evaluation Product)
- Humidity Corrected Soundings (Evaluation Product)
- CMBE Enhanced CMBE for all sites
- Averaged RIPBE

Cloud Life Cycle Working Group Translators

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