Convective-Stratiform-Anvil Transition (CStAT)

• Science questions
  – What are relative roles of LS conditions, aerosol, wind shear, small scale variability in determining structure morphological and microphysical properties?
  – What are most relevant properties models should reproduce to predict the convective lifecycle structure-wise? To what degree of accuracy?
  – How do errors in model microphysics, radiative and latent heating affect prediction of LS circulation?

• Objectives
  – Develop important observational targets for CRM, GCM, SCM
  – Identify (i) key differences in structural, microphysical properties of structures across models and observations, (ii) processes responsible for differences
  – Identify key measurements, retrievals, techniques (e.g., model simulators) needed to make progress
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• Schumacher—Profiler observations of vertical velocity in convective, stratiform and anvil cloud over Darwin (demonstrate an elevated peak in convective vertical velocity at circa 8 km)

• Varble—The challenge of adequately representing deep convective dynamics, bulk microphysics, and their interaction in CRM and LAM simulations (includes simply identifying adequate spatial resolution)

• Rowe—Analysis of X-SAPR and C-SAPR data from MC3E

• Scott Collis—Forecast for MC3E and AMIE radar products
Vertical Velocity

- From dual-Doppler synthesis
  - XSAPRs – SW and SE
- Example from 20 May 2011 shows reasonable vertical velocities for both convective and trailing stratiform regions

Source: Angela Rowe
Hydrometeor Identification

  - Modified to include hail, wet snow, and big drops
- Will use CSAPR data to create a dual-wavelength product
  - Greater sensitivity to phase shift at X-band (ice crystals, winter systems)

Source: Angela Rowe
State of precipitation radar VAPs related to CStAT

**Map to grid:**
- X-NW
- X-SW
- X-SE
- C

**Const. Cor:**
- X-NW
- X-SW
- X-SE
- C

**Map to grid:**
- XNW MMCG
- XSW MMCG
- XSE MMCG
- C MMCG

**Var 3D winds:**
- Vertical Velocity
- QPE
- Lig.DSD N0, D0
- Con/Str, Echo Top

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

**Pol DSD retrvl:**
- Texture Map: Stiefer based convective stratiform classification, echo top detection

**Operational:**
- Easy, Algorithm essentially done
- Moderate development work required
- Significant development work required, or further science needed.

**DeaHs:**
- U Washington 4DD velocity unfolding
- Atten. Cor: PhiDP based attenuation and differentiation attenuation correction.
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• Tianle Yuan—Combining ASR obs and modeling: what can be done for CStAT?
• Christopher Williams—Developing an ARM simulator
• Alain Protat—What the BOM can contribute
Suggested approaches

1. Develop obs-based metrics for cloud life cycle and cloud macrophysical properties
2. Build statistics of these metrics and characterize meteorological regimes
3. Model-based simulator output and the same set of metric and environmental conditions
4. In-depth analysis of cases based on ground (esp. newly available radars) obs
5. Evaluate and identify critical processes and regimes from analyses of obs and model

Source: Tianle Yuan
CStAT: Develop a Single Column Model-to-Radar “Translator”

**Method**

**Phase I – Generate a Library of Single Particle Electromagnetic (EM) Scattering Tables**
- EM scattering table describes how EM wave interacts with a single particle
- Scattering depends on many factors:
  - Mie vs. T-Matrix code, operating freq., habit (liquid, mixed, solid), a/b ratio, view angle, etc.
- One EM scattering table is constructed for each combination of factors
  - 1. T-Matrix, liquid drops, Thurai & Bringi (2005) a/b ratio, 90° view angle, 5° canting, 20°C
  - 3. ...
- Each row of the EM scattering table corresponds to an equivalent melted diameter
- Each column of the EM scattering corresponds to an output:
  - Radar backscattering cross section, $\sigma_b$ (mm$^2$)
  - Scattering cross section, $\sigma_s$ (mm$^2$)
  - Extinction cross section, $\sigma_e$ (mm$^2$)
  - Asymmetry factor, g (dimensionless)
- CStAT does not generate EM scattering tables
  - Find experts already making these complicated calculations
- CStAT creates a library of EM scattering look-up tables
  - Anyone can contribute to this library

**Phase II – Develop Modules that Translate Simulated Hydrometeor Distributions into an Integrated Radar Observables**
- Uses individual particle EM scattering table to generate integrated radar observations

Source: Christopher Williams
Inputs from CAWCR

From scanning weather radars (CPOL, CSAPR)
- Convective / Stratiform separation, area, fraction, rainfall
- Large-scale atmospheric regime (for Darwin) to further bin the data
- Hydrometeor classification in convective and stratiform
- DSD properties (Nw, Do) and composite analysis of their variability
- Convective cell volume, speed, lifetime, occurrence (for Darwin) in LS regimes
- 3D dynamics and mean advection speed of convective systems
- (soon) 3D water content
- Diurnal cycle of the above properties

From scanning and vertically-pointing cloud radars (SACR, KAZR, MMCR) and lidars
- Ice cloud macrophysical (cloud fraction in model grid, frequency of cloud occurrence)
- Ice cloud microphysical properties (IWC, extinction, fall speed, optical depth, concentration)
- In-cloud vertical air motions

Can relate variability of ice cloud properties to properties of parent convection within the coverage of CPOL (not fully exploited yet, but “cirrus age” methodology developed)

Geostationary satellite could play an important role in this? (eg Mace et al. 2006 JAS)
Intercomparison mode

Source: Ann Fridlind
State of the CStAT

• Ambitious problems
• Big ideas for collaboration
• Strong interest, contributions, attendance, discussion from observationalists and modelers (cloud-scale, global-scale)
• Strong interest in cross-campaign work (TWP-ICE, MC3E, AMIE)
• Way forward is not clear
• Keep meeting, communicating
• E-mail Sally.McFarlane@pnnl.gov or Ann.Fridlind@nasa.gov to be added to our e-mail discussion list