Demonstration of radar-data assimilation and prediction for Front Range convection

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1 HR Max UH

Storm Reports

Spatial smoother 24 HR UH density

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Project Overview

Ensemble-based data assimilation and prediction

- Test drive for Data Assimilation Research Testbed (DART) system
- Mesoscale DA on CONUS domain
- Storm-scale DA on Front Range → High Plains domain 4-17 June 2009
  - Overlaps the most interesting time/region of VORTEX2 domain in 2009
  - Complex terrain a focus of STEP program (our funding source)
- Probabilistic analyses and 6 hr forecasts from 50-member ensembles

15 km mesoscale, 3 km storm-scale
Chugwater and Denver Tornado Alleys

Cumulative Storm Reports 15-06Z daily 04-18 June

Topography height

Significant spatial relationship between storm report locations and terrain features:

Cheyenne Ridge
Palmer Divide
Raton Mesa
Preparations

DART enhancements (~v.4320):
• Improved observation processing (especially MADIS stream)
• Additive noise for radar obs, low reflectivity observations, utilizing model state defined fall velocity in radial velocity forward operator
• Enhanced radar operators for ingesting fall velocity and reflectivity from the microphysics

WRF model (v3.1.1) enhancements:
• Thompson microphysics (v3.2) with reflectivity and fall velocity diagnostics
• Inline NSSL severe weather diagnostics (e.g. every time step max updraft helicity, reflectivity, surface winds, updraft, downdraft)
• Cavallo RRTM patch (corrects lw radiation problems at model top)
• HRRR-like model configuration

Datasets:
• Standard “mesoscale” observations: radiosonde, surface, aircraft, satellite track cloud winds, buoy
• WSR-88D velocity and reflectivity:  KFTG, KCYS, KPUX, KDDC, KGLD, KLNX
• MADIS, NCEP reanalysis, HDSS

Radar processing:
• Using objective analysis tools built by David Dowell
• Accommodating super-res, simple clutter filter, improved mapping for meshing observations from multiple radars
System Configuration

- **DART**
  - 50 members, EAKF, adaptive prior inflation & localization (AL)
  - localization $\sim 320/4$ [km] H/V halfwidth, AL - 1600 obs
  - Continuous cycling (3-hourly) on mesoscale
  - Configuration adapted from Ryan Torn’s RTA system

- **WRF**
  - ESRL’s HRRR-like configuration
  - Physics: KF, Thompson, Noah, Dudhia, RRTM, MYJ
  - Grids 369x297 / 301x301 x51

Initialized 12Z 31 May

4 ensemble forecasts spawned daily 4-17 June, continuous cycling
Ground Clutter: Mountains

Reflectivity

Velocity

5.1 deg

1.3 deg
Ground Clutter: Highways

Reflectivity

Velocity
Ground-Clutter Removal: Two Approaches

- Steiner and Smith (2002)

- Clutter mask identified from multi-day radar-data statistics
  - Statistics for each elevation angle
  - Highways
    - high $Z_{dB}$ ob availability
    - low std. dev. of $Z_{dB}$
    - high std. dev. of $V_r$
  - Other ground clutter
    - high $Z_{dB}$ ob availability
    - low std. dev. of $Z_{dB}$
    - low std. dev. of $V_r$
    - $V_r$ near 0
Ground-Clutter Removal: Reflectivity
Ground-Clutter Removal: Reflectivity
Ground-Clutter Removal: Velocity
Ground-Clutter Removal: Velocity
Preliminary test case event 20090605 – radar evolution
Preliminary results from ‘control’ storm-scale ensemble forecast

Max. Updraft Helicity 090605_20-03Z

Updraft helicity swath $\sim=$ rotating storm tracks
HRRR and NSSL WRF forecast verification

Composite Radar

6/5 21Z

HRRR Sim. Radar

3 hr
Very preliminary impressions

- Continuously cycled mesoscale background is providing an adequate convective scale IC/BC
- Good range of convective environments encapsulating the observed event in 0-4 hrs
- Excess convection (anticipated from HRRR real time performance)
- Slow spinup in control (expect improvement with radar data assimilation)
Objectives moving forward

• Demonstrate consistent short-range forecast guidance exceeding that from HRRR (best deterministic guidance, different IC)
• Smooth transition from analysis to ensemble forecast (probabilistic nowcast to convective forecast)
  – Clean spin up/down
  – e.g. fit to radial velocity observations 0-30 minutes
• Develop novel probabilistic guidance (potential application to severe weather watches)
  – November workshop
  – Focused collaboration with NOAA ESRL and NSSL