Delta II Explosion Plume Analysis at Cape Canaveral, FL: Evaluation of Meteorological and Dispersion Modeling System

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Delta II Explosion Plume Analysis
Evaluation of Modeling System

• Delta II explosion background
• ERDAS meteorological and dispersion modeling system
• Delta II case study
  – Meteorological observations
  – Radar observations
  – RAMS model
  – HYPACT model
  – Observed vs. Predicted
• Ongoing RAMS evaluation in ERDAS
Delta II explosion background

- Delta II rocket exploded 12.5 sec after liftoff at Cape Canaveral AFS Launch Complex 17 at 1628 UTC, January 17, 1997
- Explosion produced two clouds which were tracked by radar and modeled with ERDAS
ERDAS meteorological and dispersion modeling system

- ERDAS (Eastern Range Dispersion Assessment System)
- RAMS (Regional Atmospheric Modeling System) provides meteorological forecast data for dispersion model(s)
- HYPACT (HYbrid Particle And Concentration Transport) model is primary dispersion model
- Other dispersion models and data available at CCAFS thru MARSS e.g. OB/DG, wind towers.
RAMS configuration (most recent)

- Version 4a
- Run with microphysics
- 4 nested grids
- Fine horizontal grid: 1.25 km. spacing (61 x 85 km domain)
- Vertical grid: ~33 levels (25 m –
- Initialization: 0000 UTC and 1200 UTC with Eta forecast grids, NWS surface, buoys and rawinsondes, local tower network, wind profiler
- Output: hourly for 24 hours
RAMS nested grids
Delta II case study: Meteorological observations
Surface weather map
17 Jan 1997
Profiles of θ, wind speed, wind direction
NWS Doppler radar

+101 min

+140 min

Plume 1  Plume 2

ground fire smoke plume

Plume 1

Plume 2
Delta II: RAMS predictions vs. obs of $\theta$, wind speed, wind direction
RAMS predictions
REEDM source term

+30 min

HYPACT predictions

+60 min
HYPACT predictions

+110 min

\( z = 187.5 \text{ m} \) \hspace{1cm} 1820 UTC

\( y = -280.43 \text{ km} \) \hspace{1cm} 1820 UTC

+180 min

\( z = 187.5 \text{ m} \) \hspace{1cm} 1930 UTC

\( y = -280.43 \text{ km} \) \hspace{1cm} 1930 UTC
HYPACT predictions

Modified source term

+30 min

$z = 187.5 \text{ m}$

+110 min

$z = 187.5 \text{ m}$

280.43 km  1700 UTC

280.43 km  1820 UTC
Observed vs. Predicted Plume 1 Center point
Subjective RAMS evaluation in ERDAS

- Computed point error statistics of
  - Root Mean Square (RMS) error
  - Bias
  - Error standard deviation
- Parameters verified included:
  - Surface wind
  - Thunderstorm days
  - Fine vs. coarse grids
  - RAMS vs. Eta model
Objective RAMS evaluation in ERDAS

- Verification of fronts
- Precipitation across Florida peninsula and local to Cape Canaveral
- Occurrence and strength of low-level inversions
- Sea breeze occurrence and timing
- Thunderstorm initiation
0000 UTC 4-grid Cycle Wind Dir (deg) for 16.5-m towers

(a) RMS Error

(b) Bias

Forecast Hour
0000 UTC 4-grid Cycle 11-h Temp (C) at XMR

(a) Observed vs. Forecast

(b) Pressure vs. RMS Error

(c) Pressure vs. Bias

(d) Pressure vs. SD
0000 UTC 4-grid Cycle 11-h Wind Dir (deg) at XMR

(a)

(b)
1200 UTC Eta/4-grid Cycle Wind Dir (deg) for TTS

(a) RMS Error

(b) Bias

Forecast Hour
Observed Winds & Sea Breeze Front
RAMS Forecast Winds & Sea Breeze Front

0000 UTC cycle, 18 Aug 2000, 15-h fcst

0000 UTC cycle, 18 Aug 2000, 17-h fcst

0000 UTC cycle, 18 Aug 2000, 16-h fcst

0000 UTC cycle, 18 Aug 2000, 18-h fcst
RAMS Evaluation: Key results

• Surface-based, daytime cool bias of 4.5°C in cool season and 3.5°C in warm season
• Wind direction RMS errors were 40° after 2 hours of run; RMS errors of 60° occurred night and early mornings with light winds
• Thunderstorms caused temperature and wind direction errors due to outflows and cold pools
• Vertical temperature profile too unstable for lowest 0.5 km
RAMS Evaluation: Key results (cont.)

- Finer grid resolution produces better temperature and moisture forecasts
- RAMS underpredicted strength of fronts (winds & temperature)
- RAMS did an excellent job of forecasting onset and movement of sea breeze. Probability of detection: 0.98
- RAMS predicted first daily thunderstorms within 3 hours of actual initiation 75% of time
Conclusions