Detection of Mesoscale Pressure Perturbations with Five Minute Gridded Analyses

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Weather Phenomena from Mesoscale to Synoptic Scale
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Outline

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Motivation

- Large mesoscale pressure perturbations from various phenomena (e.g., MCS, gravity waves, etc.) can produce numerous impacts:
  - Surface wind fluctuations (potentially damaging winds)
  - Precipitation generation/suppression

- Surface observations: good temporal resolution, less spatial
- Gridded datasets: good spatial resolution, less temporal

- Research demonstrates ability to effectively combine observations and gridded datasets to form a set of high temporal, high spatial analysis grids adequate for detecting prominent mesoscale pressure perturbation features

- Potential use for real-time operational detection of prominent mesoscale perturbations (e.g. strong inertial gravity waves)
USArray Transportable Array (TA)

- Temporary deployment of ~400 seismic platforms (~70 km spacing)

1 Hz Pressure Data Archive: NCAR RDA Repositories

USArray Transportable Array (TA)

• Jacques et al. (2015, MWR) identified prominent mesoscale activity over TA domain but did not assess spatial characteristics of the detected perturbation features

• TA spatial resolution (~ 70 km) too coarse to adequately describe mesoscale spatial characteristics

• Therefore, an additional resource was required to improve upon spatial resolution
Analysis Background Grids

- NOAA Real Time Mesoscale Analysis (RTMA) Surface Pressure

- 13 km RUC 1 h forecasts interpolated to 5 km across CONUS
  - Today: HRRR used instead of RUC, 2.5 km instead of 5 km
  - Conventional observations incorporated to nudge resultant analysis grids

- Grids serve as a background “first guess” surface pressure field which could be nudged using the TA observations
Analysis Creation and Feature Detection

- Grids interpolated (obs subsampled) to 5 min intervals
- Datasets converted to 5 min pressure tendency
- Background grid tendency adjusted using obs via U. of Utah Two Dimensional Variational Analysis (UU2DVAR) to create final grids
- Final analysis grids converted back to surface pressure
- Analyses band-pass filtered (10 min – 12 h) to isolate mesoscale

- Prominent mesoscale perturbations detected using analysis grids
  - Absolute perturbation magnitude ≥ 1 hPa
  - Detected lifetime ≥ 1 h
  - Areal extent ≥ 10,000 km²
Example of Analysis Grid Creation

Radar + TA Mesoscale (10 min - 12h) Perturbations (points using bottom-right color bar)

RTMA "Background"

Features to be assessed

10min - 12h Mesoscale Perturbations
Case Study I: 11-12 Aug 2011

- Radar, TA mesoscale perturbations (markers - red positive, blue negative), contoured features (solid) and tracks (dashed lines)
Case Study I: 11-12 Aug 2011

- 0900 UTC 12 Aug 2011 – Analysis Grid and Detected Features

Positive Feature #1
- Lifetime: 10.1 h
- Max Pert.: 4.9 hPa
- Med. Speed: 22.4 m s$^{-1}$

Positive Feature #2
- Lifetime: 7.6 h
- Max Pert.: 4.5 hPa
- Med. Speed: 20.8 m s$^{-1}$

Negative Feature #1
- Lifetime: 9.0 h
- Max Pert.: 5.8 hPa
- Med. Speed: 22.1 m s$^{-1}$
Case Study II: 26-27 Apr 2011

- Radar, TA mesoscale perturbations (markers - red positive, blue negative), contoured features (solid) and tracks (dashed lines)
2011 Mesoscale Feature Summaries

- Seasonal shifts in feature development region and track preference

**Spring (MAM: Figs. a-c)**
- Majority form in south/central Plains
- Primarily move in east-northeast direction

**Summer (JJA: Figs. d-f)**
- Majority form in north/central Plains
- Primarily move in east-southeast direction
2011 Mesoscale Feature Summaries

- Feature Median **Speeds** and **Directions**

- Majority of detected features (76.1%) moved within 15-35 m s\(^{-1}\) bounds previous climatologies had assessed as “typical” speeds

- Preferred propagation directions match feature track assessments
Feature movement properties were assessed every 5 minutes and are summed up regionally via these rose plots for 1 Mar – 31 Aug.

Feature movement within 15-35 m s⁻¹ is the most frequent.
2011 Mesoscale Feature Summaries

- Noticeable shift in preferred direction of movement for features from spring to summer seasons
Conclusions

• Results demonstrate ability to effectively combine observations and grids in a cohesive manner (5 km, 5 min) such that less assumptions were required to assess mesoscale features.

• Spatial review of 1+ hPa mesoscale features (1 Mar – 31 Aug 2011)
  • 72.9% lasted less than 3 h
  • 70.5% less than 40,000 km²
  • 76.1% median speed 15-35 m s⁻¹

• Seasonal reviews of feature speeds, directions, and tracks support typical climatological shift of flow patterns over central US which influence mesoscale feature development and movement.
Mesonet Obs for Operational Detection?

- Operational Perturbation/Gravity Wave Detection: can it be done?
  - Assessed before (e.g., Koch and Saleeby 2001) but issues getting better than hourly data and processing efficiently
  - Today: more resources, more sampling, better dissemination
Acknowledgments and References

Submitted Manuscripts:


Published Manuscripts:


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