VERIFICATION OF HIGH RESOLUTION WRF-RTFDDA SURFACE FORECASTS OVER MOUNTAINS AND PLAINS

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Motivations

- Needs of high-resolution weather analysis and forecasts for wind energy production and management
- RTFDDA implemented for Xcel energy, to support wind power forecasting
- Previous studies show WRF overestimating the 10-m wind speed and underestimating the 2-m daytime temperature

Outline

1) WRF-RTFDDA Modeling System
2) Characteristics of surface bias
3) Kalman Filter Bias Correction
4) Summary
RTFDDA - 4D Continuous DA and Forecasting

8 cycles a day
- 3-hour FDDA analysis
- 24 hour forecast (D3)
- 72 hour forecast (D1/2)

RTFDDA
Regional-scale model, based on WRF

Mesoscale DA

Weather observations

Cold start

Forecast

WRF

Etc.

Mesonet

ACARS

GOES

Radars

Wind Prof

All WMO/GTS

Met-Towers

Etc.
Xcel WRF-RTFDDA Demonstration Runs

Model physics:
- Lin et al. microphysics
- YSU for PBL
- Monin-Oboukov for surface layer
- Kain-Fritsch CUP (Domain 1 / 2)
- Noah Land Surface Model

D1: 30 km  128x114
D2: 10 km  253x232
D3: 3.3 km  541x571
37 vertical levels with 12 levels in the lowest 1-km
Bias Verification

• WRF-RTFDDA against MADIS surface stations

• 3550 stations over Domain 3 (at least 50%)

• From May 2 to June 7 2009

• We focus on 2-m temperature and 10-m wind-speed bias

• Model data interpolated to station locations

MADIS surface observations
Model Surface Temperature Bias

Temperature Average bias:
- $-0.33^\circ C \pm 2.21^\circ C$
Model Surface Wind Speed Bias

Wind Speed Average bias:
- 0.46 m/s ± 2.17 m/s
### Diurnal Evolutions

**Temperature**
- Cold bias increases during the day
- Maximum before sunset

**Wind speed**
- Higher bias during night time
- High variations at sunset/sunrise
Dependency of Bias on Terrain Height

**Temperature**
- Highest errors for day time mountain stations
- Highest errors for night time near sea-level stations

**Wind Speed**
- Highest errors for high altitude/near sea-level stations

**Temperature**:
- Highest errors for:
  - Day time mountain stations
  - Night time near sea-level stations
Bias Variation with Weather Regimes

Wind speed

Temperature

Driving processes?
Kalman Filter Bias Correction

Post-processing predictor bias correction method:
- linear, adaptive, recursive, and optimal
- recent past forecasts and observations used to revise the estimate of the current raw forecast.
- predicts the future bias as equal to the old bias plus uncertainty, but corrected by a linear function of the difference between the previous prediction and the verifying bias.

\[
\hat{x}_{t+\Delta t|t} = \hat{x}_{t|t-\Delta t} + \beta_{t|t-\Delta t} \left( y_t - \hat{x}_{t|t-\Delta t} \right)
\]

Kalman Filter Bias Correction Results

Average bias:

- $-0.33 \, ^\circ C \rightarrow -0.01 \, ^\circ C$ for temperature
- $0.46 \, m/s \rightarrow 0.14 \, m/s$ for wind-speed

22Z cycle bias average (May 2009) for 20hr fcst

![Map and chart showing bias corrections for temperature and wind-speed over a region with topography heights and forecast hours.](image)
Kalman Filter Bias Correction Results

Average bias:

- $-0.33 \degree C \rightarrow -0.01 \degree C$ for temperature
- $0.46 \text{ m/s} \rightarrow 0.14 \text{ m/s}$ for wind-speed

→ bias, RMSE decrease
→ correlation/ spread increase
Summary

- Underpredicts 2-m temperature by -0.33°C
- Overpredicts 10-m wind speed by +0.46 m/s
- Errors highly depend on diurnal cycles, station locations, forecasts ranges and weather regimes.
  - Highest errors found for high altitude stations and near sea-level stations (up to 1 m/s and -1°C)
  - Highest errors before sunset for T and during night for SPD
  - High influence of weather regimes (up to 5 m/s / -4°C)
- Need to understand model physics scheme deficiencies
  - land surface, PBL, radiation transfer, etc.
- Application of a KF based bias correction can improve the forecasts
QUESTION?