Obs-nudging RTFDDA and Its Extension for Ensemble, Climate and LES Modeling

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Overview

1. Obs-nudging Updates in WRF v3.1
2. Review of WRF-RTFDDA
3. Advanced RTFDDA Capabilities
   → Ensemble-RTFDDA
   → Climate-FDDA
   → RTFDDA-LES
4. Summary
Obs-nudging New Features in WRF V3.1

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- Assimilation of height-based observations
e.g. Wind profilers, Met-towers, Sodars, Radars (VAD) …

- “OBSGRID” preprocessor
e.g. Produce QC-ed obs-nudging data files

- Enhanced obs-nudging diagnostics
name list: obs_prt_max, obs_prt_freq (for serious users)

- Assimilate “raw” meteorological winds
U, V: assign QC flags to 129.

- On-line similarity-theory for surface winds and T observations for all surface-layer schemes
Single-Sounding Test: U Analysis Increments
(at 40 minute into data assimilation, 00h40 Nov 12, 2007)

Input Height-based Sounding
Input Pressure-based Sounding
PBL height (m), 3h Runs (Valid at 15Z, Dec. 12, 2008)

WRFV3.0 + PBL Fix  WRFV3.1  WRFV3.1 + PBL Fix

DX=3.3km
T2 (C) & Winds, 3h Runs (Valid at 15Z, Dec. 12, 2008)

WRFV3.0 + PBL Fix  WRFV3.1  WRFV3.1 + PBL Fix

DX=3.3km
RTFDDA: Continuous Cycling 4DDA and Forecasting

Obs-nudging FDDA:
\[ \frac{dx}{dt} = ... + GW(x_{\text{obs}} - x_{\text{model}}) \]
where \( x = T, U, V, Q, P1, P2 ... \)

\( W \) is weight function
Advanced Modeling With RTFDDA

- Ensemble-RTFDDA
- Climate-FDDA
- RTFDDA-LES

Probabilistic Analysis & forecasting
Climate Downscaling
Nested down

WRF/MM5-RTFDDA
An Example of Need for Broad Weather Info

→ Wind Energy

Regional wind resources

Wind plant siting

Wind turbine siting

Production Load & Trade

“Needs”

Highly accurate
→ 0 – 200m Winds
→ Multi-scale weather
→ Local topography, land uses, and soil properties
→ Model physics for PBL, clouds, LSM, radiation, and
→ Uncertainties
→ Micro-climatography

Wind Energy

Regional wind resources

Wind plant siting

Wind turbine siting

Production Load & Trade
Initial Operational RTFDDA Wind Forecasting in the Mid-western States

3 hourly analysis-forecast cycles with 24h forecasts for all domains and 72h forecasts for Domain 1 and 2.

Cheng et al. P3B.34 SENSITIVITY OF A SIMULATED WINTER STORM TO WRF MODEL PHYSICS OVER COMPLEX TERRAIN.

Roux et al. 5B.5 VERIFICATION OF HIGH-RESOLUTION WRF-RTFDDA SURFACE FORECASTS OVER MOUNTAINS AND PLAINS
1. Ensemble-RTFDDA

Member 1
Perturbations
observations

Member 2
Perturbations
observations

Member 3
Perturbations
observations

...  

Member N
Perturbations
observations

N forecasting nodes | x spare nodes | M pre/post- proc nodes

36-48h fcsts

Post processing

Input to decision support tools

Archiving and verification
An Operational E-RTFDDA System

Surface and X-sections – Mean, Spread, Exceedance Probability, Spaghetti, …

Pin-point Surface and Profiles – Mean, Spread, Exceedance probability, spaghetti, Wind roses, Histograms …

Operated at US Army DPG since Sep. 2007
Rain Fcsts at Boulder. June 23, 00Z Cycle

https://147.241.62.30/images/e4dwx/GE3DPG/

1h Rain, 00Z, June 24, 2009
2. Climate-FDDA

- Goal: high-resolution grid regional and local scale wind resource and climatography
- Methodology: dynamical climatology downscaling—~200 km global to 1 – 5 km grids for 20 – 30 yrs.

Essentially, run RTFDDA for the past history
A Climate-FDDA Wind Analysis Example

July 1998 - 2007
60-m AGL winds of C-FDDA (5km grid), ECMWF (40km grid) and observations
Microscale Precipitation Climatology

2008-2009 Winter Seasonal Rain

D4: DX=1.5km

Rostkier-Edelstein et al. 3A.5 HIGH RESOLUTION WRF-FDDA SEASONAL PRECIPITATION OVER COMPLEX TERRAIN.
3. RTFDDA-LES Modeling

Cedar Creek Wind Farm
Nested-domain WRF-RTFDDA-LES

Liu et al. 2B.7 SIMULATING INTRA-FARM WIND VARIATIONS WITH THE WRF-RTFDDA-LES MODELING SYSTEM.
Summary

- New features of “Obs-nudging” has been added to WRF 3.1

- The “Obs-nudging” based RTFDDA has been enhanced for E-RTFDDA, C-FDDA, and RTFDDA-LES modeling.

- An “obs-nudging”-EnKF based hybrid 4D-EnKF data assimilation is currently under development and the new enhancements will be incrementally added to WRF community releases.

Thank you!