Simulating Beaufort Sea Coastal Wind Events Using MM5 and WRF

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Motivation

Beaufort Sea Mesoscale Meteorology Model Study  ------ funded by MMS, DOI

• Surface wind simulation
• Impacts of terrain and land-ocean-ice

• MM5, WRF?
• Their capability?
Objectives

- Test the two models, MM5 and WRF, on their capability and performance in simulating wind events along the Beaufort Sea coastal region.
  - High resolution: 10-km
  - Different driving data sources: NARR (North America Regional Reanalysis), ERA-40 reanalysis
  - Nesting: (e.g., ERA-40 is 1.125 degree resolution)
  - FDDA (Four dimensional data assimilation): Nudging
Domain & Resolution

- 75 terrain-following sigma levels
Two Extreme Wind Events

- **August 09-13, 2000**
  - Max daily average wind speed: 25 m/s at Deadhorse
  - Low pressure system

- **October 07-11, 2006**
  - Max daily average wind speed: 20 m/s at Deadhorse
  - High pressure system
Modeling Configuration

**MM5 v3.7**
- LW Radiation: RRTM
- (SW Radiation: Dudhia)
- Cumulus: Kain-Fritsch2
- Microphysics: Reisner1
- NOAH land surface model
- PBL: MRF

**WRF v2.2**
- LW Radiation: RRTM
- SW Radiation: Dudhia
- Cumulus: Kain-Fritsch (new)
- Microphysics: NCEP 5-class
- NOAH land surface model
- PBL: MRF

**Experiments**
- NARR driven, 10-km
- NARR driven, 10-km, nudging
- ERA40 driven, nested 10-km
- ERA40 driven, nested 10-km, nudging

(NCEP/NCAR reanalysis is not as good as ERA-40, at least for Arctic, proved from our one-year Arctic reanalysis experiments)
Results & Problems

August 2000

MM5 (ref)

WRF

Cold surface at night time.
Problems

- Problems with the new release WRF v2.2 pre-processing system (WPS)

- Three major problems found:
  
  (Jeremy Krieger has reported to NCAR 2 days ago)

  - Bugs in sea ice processing
  - Bugs in soil T and M processing – missing value
  - Humidity initialization (when using NARR data)
Sea-Ice Problem

August 2000

MM5

WRF

Fixed

Concentration

Flag

October 2006

Concentration

Flag

Fixed
Humidity Initialization Problems
with NARR

MM5

August 2000

WRF

Fixed
New WRF output

August 2000

MM5 (ref) vs WRF

Dataset: NARR, RIP: SLP T/Lc 20008
Forecast: 0000 UTC Wed 09 Aug 00
Valid: 1200 UTC Wed 09 Aug 00 (0400 LDT Wed 09 Aug 00)
Surface air temperature
Horizontal wind vectors
Sea-level pressure

Dataset: NARR, RIP: SLP T/Lc 20008
Forecast: 0000 UTC Wed 09 Aug 00
Valid: 1200 UTC Wed 09 Aug 00 (0400 LDT Wed 09 Aug 00)
Surface air temperature
Horizontal wind vectors
Sea-level pressure

Observed vs MM5-narr vs WRF-narr
48-hr Sfc Wind Fcst:

**MM5** vs. **WRF**

**August 2000**

**Dataset:** NARR R/B: Wind spd barb sfc
**Init:** 0000 UTC Wed 09 Aug 00
**Fcast:** 48.00 h

Horizontal wind speed

- **Valid:** 0000 UTC Fri 11 Aug 00 (1600 LDT Thu 10 Aug 00)
- **Horizontal wind vectors**
  - at k-index = 74

**October 2006**

**Dataset:** NARR R/B: Wind spd barb sfc
**Init:** 0000 UTC Wed 09 Aug 00
**Fcast:** 48.00 h

Horizontal wind speed

- **Valid:** 0000 UTC Fri 11 Aug 00 (1600 LDT Thu 10 Aug 00)
- **Horizontal wind vectors**
  - at k-index = 74

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**August 2006**

**Dataset:** NARR R/B: Wind spd barb sfc
**Init:** 0000 UTC Sat 07 Oct 06
**Fcast:** 48.00 h

Horizontal wind speed

- **Valid:** 0000 UTC Mon 09 Oct 06 (1600 LDT Sun 08 Oct 06)
- **Horizontal wind vectors**
  - at k-index = 74

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**October 2006**

**Dataset:** NARR R/B: Wind spd barb sfc
**Init:** 0000 UTC Sat 07 Oct 06
**Fcast:** 48.00 h

Horizontal wind speed

- **Valid:** 0000 UTC Mon 09 Oct 06 (1600 LDT Sun 08 Oct 06)
- **Horizontal wind vectors**
  - at k-index = 74
Station Verification
August 2000

Sea Level Pressure

Wainwright

Nuiqsut

Barrow

Deadhorse
August 2000

2-m Temperature
August 2000

10-m Wind Speed

Wainwright

10-m wind speed

Barrow

10-m wind speed

Nuiqsut

10-m wind speed

Deadhorse

10-m wind speed
August 2000

Temperature Profile – Barrow

24 hr 00Z 08/10/2000

Dataset: NARR; RIP: mw diff 1
Fest: 24.00 h
Valid: 0000 UTC Thu 10 Aug 00 (1600 LDT Wed 09 Aug 00)
Temperature \( x,y=111.00, 69.43 \) lat,lon= 71.25, -156.78 stn=PABR.70026
Temperature \( x,y=111.00, 69.43 \) lat,lon= 71.25, -156.78 stn=PABR.70026

Rawinsonde

70026 PABR Barrow

MM5 T ———— WRF T

Td ———— Td

00Z 10 Aug 2000

University of Wyoming
August 2000

Temperature Profile – Barrow

36 hr 12Z 08/10/2000

Rawinsonde

70026 PABR Barrow

12Z 10 Aug 2000

University of Wyoming
Summary

- WRF new release problem fixes, works well with NARR and ERA-40 reanalyses;
- Humidity initialization affects the simulation badly, esp. obvious on surface temperature;
- High-resolution modeling produces more short-range variations, while
- Nudging (to a coarse-resolution field) is helpful for simulating SLP and synoptic variations of other variables;
- Extreme wind speed is not well captured by mesoscale models, but is seen in ERA40 driven run for the synoptic scale pattern;
- WRF simulation results are encouraging for surface and upper-air variables, compared to MM5.
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