Investigating the impact of surface drag parameterization schemes available in WRF on surface winds

Hongli Jiang\textsuperscript{1,3}, Michelle Harrold\textsuperscript{2,3} and Jamie Wolff\textsuperscript{2,3}

\textsuperscript{1}: NOAA/ESRL/CIRA, Colorado State University
\textsuperscript{2}: NCAR/Research Applications Laboratory
\textsuperscript{3}: Developmental Testbed Center

Acknowledgements: Pedro Jimenez and Cliff Mass
Surface drag parameterization

New topo_wind options to improve topographic effects on surface winds in YSU PBL scheme:

– **topo_wind=1** (v3.4, Jimenez and Dudhia 2012)

\[
\frac{\partial u}{\partial t} = \cdots - C_t \frac{u_*^2 u}{\Delta z V}, \quad C_t = fn(\Delta^2 h, \sigma_{sso})
\]

- **h**: topographic height
- **\( \sigma_{sso} \)**: Standard deviation of subgrid-scale orography

– **topo_wind=2** (v3.4.1+, Mass and Ovens 2010; 2011; 2012)

- **Enhancing**: \( u_* \) (~subgrid terrain variance)
Testing the New `topo_wind` Option

- Year-long simulations: 1 July 2011 – 30 June 2012
- Initialized every 36 h, 48-h forecasts
- Domain: 15-km/5-km nest
- Focus on winds

- Three configurations:
  - `topo_wind`=0 (twind0)
  - `topo_wind`=1 (twind1)
  - `topo_wind`=2 (twind2)

- Comparisons: (5-km domain only)
  - twind0 - twind1
  - twind0 - twind2
  - twind0, twind1, twind2
  - twind1 - twind2

Visit P67 by Harrold et al. for information regarding additional variables for twind0
Surface wind speed bias ($twind0$), 00 UTC INIT

- High wind bias
- Diurnal variation
- Regional variation (East vs. West)
- Yellow: 0.5 to 1.5 m/s
- Green: -0.5 to -1.5 m/s
Comparison among three configurations

Median Surface Wind Speed Bias

**twind0**

**twind1**

**twind2**
Breakdown by region: **twind0, twind1, twind2**

- **twind0**: high wind bias for all forecast lead times, maximum bias overnight and minimum during the day
- **twind1, twind2**: bias reduced over night, over-corrected during the day
Breakdown by region: twind0, twind1, twind2
Breakdown by season: `twind0 - twind1`

- **Very complex pattern for any given day**

- **Blue: `twind1` stronger** – generally over Mountain West

- **Orange: `twind1` weaker** – generally over East Plains
Breakdown by season/region: \textit{twind0, twind1}

Wind (m/s) Bias

**Summer**

- West region:
  - twind1 reduces bias to near zero 12h, 36h
  - Over corrected during the day

- East region:
  - twind1 shifts bias downward
  - bias still high overnight

**Fall**

- General offset of ~0.5 m/s between the two configurations

Visit P68 by Lorente-Plazas et al for improvement
Breakdown by season: $\text{twind0} - \text{twind2}$

- 20110725 - Summer
- 20120115 - Winter
- 20111017 - Fall
- 20120423 - Spring

- Orange: $\text{twind2}$ weaker
Breakdown by season/region: twind0, twind2

**West region:**
- twind2 reduces bias to below zero 12h, 36h
- over corrected during the day

**East region:**
- bias reduced
- higher than the West

General offset of ~0.5 m/s between the two configurations
Summary

topo_wind=0:
  • High surface wind bias (known issue)
    – maximum at 12 h and 36 h
    – minimum at 24 h
  • Higher bias over East, Lower over West (for all seasons)
    – unresolved subgrid topography
    – smoother or flatter topography used in the model
    – absence of topographic drag

topo_wind=1, 2:
  • Overall high bias reduced in both options
    – at night: improvement
    – during the day: over-corrected
  • Other factors
    – fewer stations over West/Mountains, Hills
    – representativeness error over West
    – is subgrid topography correctly resolved? at what resolution?