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

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Surface drag parameterization

New topo\_wind options to improve topographic effects on surface winds in YSU PBL scheme:

– \texttt{topo\_wind}=1 (v3.4, Jimenez and Dudhia 2012)

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

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

– \texttt{topo\_wind}=2 (v3.4.1+, Mass and Ovens 2010; 2011; 2012)

- \textit{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

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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

00f12

Median Surface Wind Speed Bias

twind0

twind1

twind2

m s⁻¹

Median Surface Wind Speed Bias

twind0

twind1

twind2

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Breakdown by region: $\text{twind0}$, $\text{twind1}$, $\text{twind2}$

- **$\text{twind0}$**: high wind bias for all forecast lead times, maximum bias overnight and minimum during the day

- **$\text{twind1}$, $\text{twind2}$**: bias reduced over night, over-corrected during the day
Breakdown by region: twind0, twind1, twind2
Breakdown by season: \texttt{twind0} - \texttt{twind1}

\texttt{00f12h}

- Very complex pattern for any given day
- \textbf{Blue:} \texttt{twind1} stronger – generally over Mountain West
- \textbf{Orange:} \texttt{twind1} weaker – generally over East Plains
Breakdown by season/region: `twind0`, `twind1`

Wind (m/s) Bias

**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

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

Visit P68 by Lorente-Plazas et al for improvement
Breakdown by season: twind0 - twind2

- Orange: 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_winds=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_winds=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?