Extensions to parameterized orographic drag in CAM

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Overview

- Motivation
- Anisotropic/blocking scheme description
- Results
  - AMIP results
  - CAPT
- Future work
1980-81 DJF mean $\omega$ fields
ne30~100km

**CAM-SE is noisy**
2 approaches to mitigate this
• smoother topo
• increased divergence damping

Smooth topo (smoothing scale~800km)

“Rough” topo (smoothing scale~400km)
Energy spectra

increased divergence damping impacts spectra
Smooth topo (smoothing scale~800km)

“Rough” topo (smoothing scale~400km)

Climate somewhat better overall with rougher topography
Smooth topo

“Rough” topo

1980-90 DJF mean Precipitation
Annual mean surface stress 1980-1990

Smooth topo

Surface stress
mean = 0.07
N/m²

“Rough” topo

Surface stress
mean = 0.07
N/m²

ERS

Surface stress
mean = 0.06
N/m²

sgoro_ne30_ne30_CTL - ERS

Surface stress
mean = 0.01
N/m²

sgoro_ne30_ne30_RCTL - ERS
New orographic drag scheme

- Anisotropy
- Low-level processes (blocking)
- Lee-wave trapping
- Multiple ridges and scales
Blocking, low-level turning
(follows Scinocca & McFarlane 2000)

i – vertically propagating waves $\partial_z \tau$ via saturation

ii - downslope wind layer $\partial_z \tau \sim U^3$

iii – low-level flow turning $\partial_z \tau \sim U^2$
Anisotropy

CTL

wave

"Aniso"

wind

wave

wind
Ridge finding

• Smooth (Bandpass) topography (scale ~ $L_s$)
• Calculate variances of mean cross-sectional profiles at 16 different orientations on $L_a \times L_a$ domains
• Maximum 1D vs 2D variance determines “ridge” angle

• Outputs
  • Orientation
  • Ridge height (different from std. dev. of topo)
  • “quality” ratio of 1D/2D variance
  • Width
Ridge finding

L_s ~ 80 km

Boulder
Further innovations/complications

Multiple ridges possible in any AGCM gridbox depending on remapping from topo grid

2 families of ridges:
• Meso $\beta$ 800km-80km
• Meso $\gamma$ 80km-3km

Trapped lee wave parameterization. Uses width estimate to calculate

$$m^2 = \frac{N^2}{U^2} - k^2$$
AMIP runs 1/1979-1/1990

- ne30
- 3 runs
  - **RCTL** - "rough" control. Rougher topo (L<400km) w/ old isotropic OGW scheme
  - **CTL** - control. Smoother topo (L<800km) w/ isotropic
  - **Aniso** – new anisotropic scheme w/ blocking, lee-waves etc..
- All still use TMS
- All use *low* value for divergence damping
DJF Zonal mean temperatures

MERRA

RCTL-MERRA

CTL-MERRA

Aniso-MERRA
JJA Zonal mean temperatures

- **MERRA**
- **RCTL-MERRA**
- **CTL-MERRA**
- **Aniso-MERRA**
Annual mean wind stress

**RCTL-MERRA**

Surface stress
mean = 0.07
N/m²

**Aniso-MERRA**

Surface stress
mean = 0.07
N/m²
1980-90 DJF mean Precipitation
DJF mean sea-level pressure

RCTL
sgoro_ne30_ne30_RCTL (yrs 1980-1989)

Sea-level pressure  millibars

MEAN = 1012.60  Min = 993.06  Max = 1034.95

991 997 1003 1009 1015 1021 1027 1033

sgoro_ne30_ne30_RCTL - MERRA

Sea-level pressure  millibars

MIN = -3.89  MAX = 8.03

12 10 8 6 4 2 1 0 -1 -2 -4 -6 -8 -10 -12

Aniso
sgoro_ne30_ne30_B004 (yrs 1980-1989)

Sea-level pressure  millibars

MEAN = 1014.54  Min = 997.33  Max = 1035.37

991 997 1003 1009 1015 1021 1027 1033

sgoro_ne30_ne30_B004 - MERRA

Sea-level pressure  millibars

MIN = -2.28  MAX = 11.27

12 10 8 6 4 2 1 0 -1 -2 -4 -6 -8 -10 -12
CAPT forecasts 1/2003

- Forecasts initialized from ERA-I reanalyses
- Once per day 00Z (1/1-1/31) run for 20 days
Forecasts of U at 700 hPa 1/2003

Correlation with ERA-I (CTL)

Correlation with ERA-I (Aniso)

Forecast lead (days)
Forecast start day (Jan)

Correlation

Forecast lead (days)
Mean errors in 0.7-0.95 σ–lev $U$ at Day 3

- **CTL**: Global Mean = 3.45 ms\(^{-1}\)
- **Aniso**: Global Mean = 3.30 ms\(^{-1}\)
- **CTL-Aniso**: Global Mean = 0.14 ms\(^{-1}\)

Aniso better

CTL better
Future work

• Tease out relative impacts of
  • Low-level flow parameterization
  • Lee-waves
  • Meso $\beta$ vs meso $\gamma$

• High-resolution – ne120
• Anisotropic TMS