Orographic Precipitation and Climate Change Workshop

Part of NCAR Water System Program
Funded by NSF
Snow cover over North America from MODIS

January 2002

http://www.archive.org/details/SVS-2487
Snow cover over North America from MODIS

March 2002

http://www.archive.org/details/SVS-2487
Snow cover in 2001-2002 over North America from MODIS

April 2002

http://www.archive.org/details/SVS-2487
Colorado’s Headwaters

Continental-scale river basins whose headwaters reside in Colorado

**WEST**
- Yampa River
- Upper Colorado River
- Gunnison River
- San Juan River

Supply water to the western U.S.
Flow to the Gulf of California.

**EAST**
- South Platte River
- Arkansas River
- Rio Grande River
- Republican River

Supply agricultural water to the Great Plains.
Flow to the Gulf of Mexico.

The Gunnison River in the Black Canyon, CO.
High resolution WRF simulations of current and future climate to examine changes in precipitation, snowpack, runoff, and hydrologic cycle

Verification performed using 93-112 SNOTEL sites over the Headwaters domain.
6-mo. Total Precipitation (mm) Comparison
1 Nov. 2007-1 May 2008
Why is high resolution needed?


SWE from CTRL 36km BMJ: 12/01/2007

SWE from CTRL 2km: 12/01/2007
Model Sensitivity to Various Physics Parameterizations (Liu et al. 2011)

Percent difference in DJF total precipitation from control simulation

- Microphysics
- Land Surface
- PBL
- RR

- Model values at SNOTEL sites
- Headwaters domain
- Full domain

10/8/12
“Headwaters” 8-year simulations

→ longer time period for analysis
→ avoid hydrologic spin-up issues

Uses Noah 3.2, with the “Barlage” snow scheme adjustments
# CO Headwaters Project Team

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10/8/12  RAL Program Review 2012
Similar questions regarding how to best represent orographic precipitation in climate models are being asked world-wide due to its primary role in the water cycle in these regions:

- Norway (Glaciers, Himalayas)
- Italy (Alps, Himalayas)
- Austria (Alps, Andreas Prein)
- Nepal, India. (Himalayas)
- South America (Andes)
- U.S. (Sierra Nevadas, Oregon and Washington Cascades)

Snowpack is a key water resource worldwide and if it decreases/seasonal cycle changes the livelihood of billions of people could be impacted.

Each mountain range is unique and has its own special challenges including characteristic climate and storm types (winter and summer).

Particularly challenging will be addressing embedded convection.

Survival of glaciers depends both on the temperature and also amount of precipitation.

Glaciologists don’t really have a good estimate of either one in either the present or the future.
Key questions for the workshop:

• What are the dominant processes that control orographic precipitation and how might they change in the future?

• Do current models adequately capture these processes and their likely changes?

• Can observations in current climate be used to infer possible future changes?

• Are there sufficient observations around the world in complex terrain to verify models?

• How much can be transferred from studies in one mountain range to other ranges?

• What will happen to orographic convection in a future climate?
Structure of the workshop:

• Presentations followed by extensive discussion
  ▪ Currently no breakout sessions scheduled since a fairly small group
  ▪ Discussion session will try to address some of the key questions listed about
  ▪ Encourage future collaborations and proposal writing
  ▪ BAMS paper?
Weather Research and Forecasting (WRF) Model Setup and Design

Model Setup

- NCAR WRF Model (version 3.1)
- A single domain: 1200x1000 km²; 45 levels, 4 km grid resolutions
- PBL scheme: MYJ
- Noah land-surface model
- CAM longwave & shortwave scheme
- Thompson et al. cloud microphysics scheme

Initial and Lateral Boundary Conditions

- The 3-hourly, 32-km North American Regional Reanalysis (NARR) data
- Dynamical downscaling from 32km NARR. No statistical downscaling.