Future changes in water balance components across irrigated lands of Central Asia as projected by a high-resolution modeling system

Igor Shkolnik, Anastasia Pikaleva, Ekaterina Nadyozhina, Aleksandra Sternzat

Voeikov Main Geophysical Observatory, 7, Karbyshev street, 194021, St.-Petersburg, Russia

ICRC-2019, 14-18 October, Beijing
High resolution probabilistic climate projections for the Arctic, Russia and Central Asia (grid step 25 km)

Pan-Arctic RCM (CORDEX)

RCM for Russia
50 ensemble members

A drier climate is projected in southwestern Russia and Central Asia

RCM for Central Asia
30 ensemble members

Shkolnik et al 1998-2019
There projected the drop in yield of wheat
Irrigation in Central Asia is critical to sustain productivity of major crops

Area of irrigated lands in Central Asia

Development of irrigated areas in five countries of Central Asia during 1930-2010

Map of Irrigation Areas

Major plants
- cotton
- wheat

Large number of small plots of land are not resolved explicitly at 25 km resolution

Nurbekov 2017
Siebert et al 2013
Experiments

97×181 grid points in the horizontal and 25 unequally spaced levels in the vertical

30 simulations spanning 10yr slices in the past (1990-1999) and future (2050-2059) with perturbed initial conditions in the atmosphere and land surface, driven by MGO AGCM T42L25

prescribed SST/SIC evolution derived from the three CMIP5 models:
ACCESS1-0
CESM1-CAM5
MPI-ESM-MR

300 yrs of simulated climate variability (3 bc × 10 simulations × 10 yrs) for each temporal window

IPCC RCP8.5 scenario

Downscaling RCM projection using an atmospheric boundary layer model in order to describe future changes in water demand across irrigated lands during crop season (May-September)
Atmosphere Boundary Layer Model (ABLM) driven by RCM

- High resolution vertical structure (151 levels)
- Two-equation turbulence model (k-ξ) is used as a closure for the Navier–Stokes equations
- Subgrid surface heterogeneity is considered
- Detailed description of the temperature and moisture distributions on scales not resolved explicitly by the RCM grid

Nadyozhina and Shklyarevich, 1994
Projected changes in surface temperature and precipitation by 2050-59 relative to 1990-1999, MJJAS

T, degC, standalone RCM

T, degC, RCM+ABLM for irrigated area

P, %, standalone RCM
Projected changes in evapotranspiration ET and water deficit D (mm/season) by 2050-59 relative to 1990-1999, MJJAS

**RCM**

**RCM+ABLM for irrigated area**
Projected changes in irrigation rate (m³/ha) as simulated by individual ensemble members, MJJAS
Projected changes in irrigation rate (m$^3$/ha) averaged for different SST/SIC projections (10 members each), MJJAS.

ACCESS-1.0

CESM1-CAM5

MPI-ESM-MR

30-member ensemble mean
Intraensemble standard deviation of the projected changes in irrigation rate for different SST/SIC projections, m³/ha

ACCESS-1.0

CESM1-CAM5

MPI-ESM-MR

Intraensemble standard deviation due to differences in the three SST/SIC projections, m³/ha
Averaged over irrigated lands intraensemble standard deviation of the projected changes in irrigation rate, m$^3$/ha, MJJAS
Summary

Development of modeling chains from global and regional models to sub-models and impact models is an important step in developing effective mechanisms for providing climate information to end users;

Here, downscaling the RCM projection allows one to approach a quantitative assessment of future water demand for irrigated cropping regions, where it turns out to be critical to justifying regional development strategies; in this study, the projected increase in future irrigation water consumption by the mid 21st century falls in the range 5-10% relative to its current estimate;

In the Central Asia, there is a pressing need to apply multiscale downscaling methodologies, including very high resolution systems, to describe the effects of climate change on agriculture in the regions with complex topography;

Further assessments should include building larger ensembles accounting for a wider range of forcings and models – a good opportunity for CORDEX-CA community.

Acknowledgement: The study is supported by the Russian Science Foundation (Grant 16-17-00063)