Ocean Downscaling of Climate Projections: case study for the Arabian Gulf (using ROMS)

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1. Introduction

2. The Arabian Sea
   - Characteristics
   - Model set-up

3. Results of 20thC simulation

4. Time-slice experiments (early 21st C/ late 21st C)
Source: ETOPO1 Topographic and bathymetric dataset
We use the Regional Ocean Model System (ROMS\textsuperscript{1})

Define a domain that is stable enough to run long experiments [model setup]

Adjusting the forcing from the *Earth System Model (ESM)*

runoff

Shamal winds

Southerly winds

Inflow

Interface Physics
Strait of Hormuz
Gulf of Oman
Full depth higher saline fluxes
Upper layers lower saline fluxes

Winter cooling zone
The deep channel along the Gulf
Arabian Gulf
The Arabian Gulf circulation
Strait of Hormuz
Gulf of Oman
What we want to model
From Ocean (ESM) to Regional Climate Model (RCM)

ESM resolution

Sea Surface Temperature
MPI-ESM-MR snapshot

downscaled results

Sea Surface Temperature
RCM climag03c snapshot

From Ocean (ESM) to Regional Climate Model (RCM)
validation

temp

salt
Results

Temperature (C) 25/05/2003

Velocity (m/s) 25/05/2003

Salinity 25/05/2003

Elevation (m) 25/05/2003
Vertical profile:
Temperature and Salinity

Temperature

Salinity

TIME: 06 AUG-2003 12:00 to 11 AUG-2003 12:00
✓ We are confident Regional Model captures Arabian Gulf circulation characteristics

✓ We can now run the climate change experiments

◆ Examine 2 experiments for specific time-slices
Area averaged time series for the Arabian Gulf (low pass filter)

**Temp & Salt**

- **Temperature**
- **Salinity**

- Variability - relative units

- **MPI-ESM normalised results**
- **RCM time-slice normalised results**

- **Time-slices**
  - Early 21st Century
  - Late 21st Century
Area averaged time series for the Arabian Gulf (low pass filter)

Dynamic sea level height

SSH

Variability - relative units

MPI-ESM normalised results

RCM time-slices normalised results

Time-slices

Early 21st Century

Late 21st Century
Temperature and Salinity differences between the experiments

Early 21st: 5 years climatology

Sea surface temperature
- Cooling zone

Late 21st: 5 years climatology
- Less cooling

Difference
- ~ 3 degrees warmer on average

Sea surface salinity
- Increased freshwater area
- Slightly increase in coastal salinity
- Salinity increase along the Southwest coast

Late 21st freshening
Temperature differences (Late-Early 21st)
Salinity differences (Late-Early 21\textsuperscript{st})
Salinity differences (late-early 21st) section along and across Iran coast along and across.

increased density (saline) water in late 21st century

Salt subsidence to the channel
Salinity formation zones and its advection processes

Grey shaded areas show lower salinity levels, up to 39 psu - vector indicates flow directions.
surface currents streamlines: Early and Late time slices

23/08/2003

23/08/2096
Late 21st Century

Increased precipitation rates

Warmer "cooling zone" Minima temperature increases with global warming

Lower salinity and superficial water

Higher salinity and superficial water

Higher salinity and bottom water
By the end of the 21st C

- The Arabian Gulf is \( \sim 3^\circ C \) warmer
- Dense saline waters are advected southwards
- Stronger recirculations speeds
- Increased mixing processes