GFDL and the IPCC Special Report on The Ocean and Cryosphere in a Changing Climate (IPCC/SROCC)

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Geophysical Fluid Dynamics Laboratory Review
October 29-31, 2019
GFDL Contributions to IPCC

GFDL contributes to IPCC assessments via:

• Coupled Models & Earth System Models
• Model output (e.g., CMIP)
• Published studies of the climate system
• Authors in all 6 IPCC Assessment Reports
• 5 GFDL IPCC authors / editors in AR6:
  • Land Report – SRCCL (E. Shevliakova)
  • Ocean Report – SROCC (R. Hallberg)
  • Physical Climate – AR6 WG-I (J. Dunne, V. Naik, V. Ramaswamy)
• Numerous scientific reviewers and contributing authors

GFDL scientists provide a comprehensive perspective on the climate system derived from our experience with climate model development.
Overview of Key SROCC Findings

- The cryosphere is shrinking; the oceans are warming, acidifying, expanding, stratifying, losing oxygen and exhibiting shifting biological ranges.
- Many changes in the oceans and cryosphere have been observed to be accelerating, consistent with CMIP5 coupled model historical simulations.
- 21st Century changes are committed, but can be limited by restricting CO2 emissions.
- Coastal blue-carbon storage is intensive, but at most a small fraction (<2%) of emissions.
- GFDL is a key contributor to underlying science, projections and detection/attribution.

SROCC SPM Figure 1

Past and future changes in the ocean and cryosphere

<table>
<thead>
<tr>
<th>Historical changes (observed and modelled) and projections under RCP2.6 and RCP8.5 for key indicators</th>
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<tbody>
<tr>
<td>Historical (observed)</td>
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- Global mean surface air temperature
- Global mean sea surface temperature
- Surface ocean pH
- Ocean oxygen
- Sea surface temp.
- Arctic sea-ice
- Marine heatwaves
- Ocean heat content
- Greenland ice loss
- Antarctic ice loss
- Glacier ice loss
- Permafrost area
- June snow cover
- Global mean sea level rise

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Projected Changes in the Ocean

SROCC details a series of robust physical changes

Globally the ocean is warming and acidifying
- Surface intensified changes increase density stratification
  ▶ Reducing subsurface dissolved oxygen
  ▶ Reducing supply of nutrients to the ocean surface
  ▶ Reducing net primary productivity (varies regionally)

For RCP8.5, novel conditions in all 5 variables occur in 60% of ocean area prior to 2100; 30% of area for RCP2.6.

Regional Changes
- Expanded hypoxia
- Reduced overturning
- Regional variations in sea level rise
- Tidal amplitudes

RCP8.5 Zonal Mean Projected Trends, (1986-2005) to (2081-2100)
Physical Changes Lead to Ecosystem Impacts

Global Net Primary Production is projected to very likely decrease by 4% to 11% by 2100 under RCP8.5.

Total animal biomass in the ocean is projected to very likely decrease by 15±5.9% by 2100 under RCP8.5.

GFDL Contributed 2 of the 10 Earth System Models that were used here.

Globally integrated maximum fisheries catch potential is projected to decrease by 20.5% to 24.1% by 2100 under RCP8.5.
Ecosystems at Risk from Climate Change

Ongoing or planned areas of research at GFDL

(d) Impacts and risks to ocean ecosystems from climate change

Level of added impacts/risks

Very high

High

Moderate

Undetectable

Purple: Very high probability of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.

Red: Significant and widespread impacts/risks.

Yellow: Impacts/risks are detectable and attributable to climate change with at least medium confidence.

White: Impacts/risks are undetectable.

Confidence level for transition

**** = Very high
*** = High
** = Medium
* = Low
| = Transition range

** see figure caption for definition
Summary & Future Challenges

• Climate is changing the state of the oceans and cryosphere, with profound consequences for ocean ecosystems and people.

• GFDL’s ocean science and scientists address key questions highlighted by IPCC, all in direct alignment with NOAA’s mission.

• The IPCC is a strong venue for communicating the consequences of GFDL’s policy-relevant science with the world

Emerging challenges:

• Expanding demands for GFDL models and data, especially via numerous Model Intercomparison Projects (MIPs)

• Recruiting and retaining a diverse team of scientists at GFDL and cultivating collaborations to address the expanding range of scientific questions about the implications of climate change.