IAV Science Questions that Require Coupling and/or Inputs from IAM/ESM

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Workshop on
Climate Change Impacts and integrated Assessment
Snowmass Colorado
July 25, 2016
Outline

“Together We Are More”

• Trends IAV Research – As Snowmass Perspective
• Evidence from IPCC, NCA, etc.
• Needs from IAM/ESM communities
Trends in IAV Analyses

• More geographical resolution
• More ground truthing with observations
• More focus on extremes than means
• More attention to income distribution
• Better understanding of interactions
  – Between climate and society
  – Between sectors (inc. GE and Growth)
  – Between mitigation and adaptation
  – Between regions
• More Sectors - ocean acid., conflict, migration
• Better understanding of catastrophies/hazards
IPCC AR5 Working Group II Overview

Katharine Mach

Carnegie Science
Vulnerability
Exposure
RISK
Hazards

IMPACTS

CLIMATE
- Natural Variability
- Anthropogenic Climate Change

SOCIOECONOMIC PROCESSES
- Socioeconomic Pathways
- Adaptation and Mitigation Actions
- Governance

EMISSIONS and Land-use Change

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
A focus on **risk** emphasizes...

**Interactions** among climate & society

The link between **present & future** experience

The importance of **extremes**

The full **range** of possible outcomes

Available **tools** for managing risks across contexts
Human influence on the climate system is clear.

Worldwide Effects

- atmosphere, land, ocean
- extreme events
- water cycle
- sea ice, glaciers, ice sheets
- global mean sea level
Observed impacts of climate change are widespread and consequential.
Widespread impacts attributed to climate change based on the available scientific literature since the AR4

Confidence in attribution to climate change

- very low
- low
- med
- high
- very high

Indicates confidence range

Physical systems
- Glaciers, snow, ice and/or permafrost
- Rivers, lakes, floods and/or drought
- Coastal erosion and/or sea level effects

Observed impacts attributed to climate change for

Biological systems
- Terrestrial ecosystems
- Wildfire
- Marine ecosystems

Human and managed systems
- Food production
- Livelihoods, health and/or economics

* Impacts identified based on availability of studies across a region

Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change
PEOPLE, SOCIETIES, AND ECOSYSTEMS AROUND THE WORLD VULNERABLE AND EXPOSED IN DIFFERENT WAYS
The likelihood of increasing magnitudes of warming increases the likelihood of severe and pervasive impacts.
Risks of impacts

- Extreme Events
- Food, Water, & Human Security
- Health & Productivity
- Biodiversity & Heritage
- Tipping Points & Vicious-cycle Feedbacks
A global perspective on risks

Based on WGII Box SPM 1 Figure 1
Stabilizing temperature (eventually) requires zero net emissions – regardless of the warming limit chosen.
Vulnerability & Exposure
- Vulnerability & exposure reduction
- Low-regrets strategies & actions
- Addressing multidimensional inequalities

Adaptation & Interactions with Mitigation
- Incremental & transformational adaptation
- Co-benefits, synergies, & trade-offs
- Context-specific adaptation
- Complementary actions

Risk
- Risk assessment
- Iterative risk management
- Risk perception

Governance
- Decision-making under uncertainty
- Learning, monitoring, & flexibility
- Coordination across scales

CLIMATE
- Natural Variability
- Anthropogenic Climate Change

Socioeconomic Pathways
- Diverse values & objectives
- Climate resilient pathways
- Transformation

Adaptation & Mitigation Actions
- Incremental & transformational adaptation
- Co-benefits, synergies, & trade-offs
- Context-specific adaptation
- Complementary actions

Exposure
- Mitigation

Vulnerability
- Vulnerability

Risk
- Risk

Impact
- Impact

Governance
- Governance

Emmissions
- Emmissions

Anthropogenic Climate Change
- Anthropogenic Climate Change

Co-benefits, synergies, & trade-offs
- Co-benefits, synergies, & trade-offs

Low-regrets strategies & actions
- Low-regrets strategies & actions

Addressing multidimensional inequalities
- Addressing multidimensional inequalities
IAV Needs from IAM and ESM

• From ESMs
  – Hi resolution (both space and time) climate information
  – More on extremes

• From IAMs
  – Higher resolution information
  – Socio-economic drivers – SSP scenario “user guides”
  – More information on “key/emerging” interactions
    • Between people and physical systems
    • Between sectors (including GE and growth)
    • Between regions
  – Better understanding of catastrophies with cascading failures
A Few Examples of Multi-Sector Multi-Stressor Risks

- Drought in one region/sector on other regions/sectors
- Warming leading to more electricity demand and more cooling water but with less water available
- Large BioEnergy deployment causing increased competition for land, water, energy.
- Impacts of vegetation die back on other sectors
The End
Comments/Questions?
GHG EMISSIONS GROWTH HAS ACCELERATED DESPITE REDUCTION EFFORTS
EFFECTIVE CLIMATE CHANGE RESPONSES
A MORE VIBRANT WORLD
Investment needs = Investment opportunities

Average Changes in Annual Investment Flows from 2010 to 2029 (430–530 ppm CO$_2$eq Scenarios)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Max</th>
<th>Median</th>
<th>Min</th>
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<tr>
<td>Extraction of Fossil Fuels</td>
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<td>Energy Efficiency Across Sectors</td>
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<td>Total Electricity Generation</td>
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<td>Renewables</td>
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<td>Nuclear</td>
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<td>Power Plants with CCS</td>
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<tr>
<td>Fossil Fuel Power Plants without CCS</td>
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</table>
Stabilizing temperature (eventually) requires zero net emissions – regardless of the warming limit chosen.
Four pillars for Paris

- Universal, binding agreement
- INDC from every country
- Finance and Technology
- Role for non-State Actors
INDCs: A first step or a last step?
Climate change is a challenge in managing risks
Adaptation is building momentum
Mitigation is building momentum

Many opportunities for win-win solutions that help build robust economies and vibrant communities
THE PROBLEM SPACE
VULNERABILITY AND EXPOSURE AROUND THE WORLD
INDCs: Budget mostly used by 2030

Cumulative emissions (GT CO₂ since 1870)

- Historical through 2011 = 1890
- INDCs through 2025
  - 12 years at 2010 rates
- INDCs through 2030
  - 7 years at 2010 rates
CLIMATE CHANGE
UNDERSTANDING, MANAGING, & REDUCING RISKS
Annex B versus non-Annex B countries

There is not a clear distinction between Annex B and non-Annex B countries based on economic activity per capita or emissions per capita.

Data: CDIAC/UNstats/GCP

GDP is measured here in Market Exchange Rates

Source: United Nations; CDIAC; Le Quéré et al 2015; Global Carbon Budget 2015
The largest producers of CO2 emissions worldwide in 2015, based on their share of global CO2 emissions

- China: 28.03%
- U.S.: 15.9%
- India: 5.81%
- Russian Federation: 4.79%
- Japan: 3.84%
- Germany: 2.23%
- Korea: 1.78%
- Canada: 1.67%
- Iran: 1.63%
- Brazil: 1.41%
- Indonesia: 1.32%

Source: Germanwatch
© Statista 2015

Additional information: Worldwide
Per Capita Emissions for Top 10 Emitters

Total GHG Emissions Per Capita (tCO₂-e per capita, 2011)

- Canada
- United States
- Russian Federation
- Japan
- European Union (28)
- Indonesia
- China
- Brazil
- World Average
- Mexico
- India

http://bit.ly/11SMpjA
Figure 2. Per-capita energy-related carbon dioxide emissions by state, 2013
metric tons carbon dioxide per person

Source: U.S. Energy Information Administration.
Forest canopy water content in August 2015

Gregory P. Asner et al. PNAS 2016;113:E249-E255
Level of additional risk due to climate change

Based on WGII
Box SPM 1 Figure 1
Projected effect of temperature changes on regional economies

California, Average Temperature, January-December

Avg: 56.5°F
Emissions from fossil fuel use and industry

Estimates for 2012, 2013, 2014, and 2015 are preliminary
Source: CDIAC; Le Quéré et al 2015; Global Carbon Budget 2015
States of the Antarctic Ice Sheet after 10,000 years

A. No further emissions
B. 500 GtC
C. 1000 GtC
D. 2500 GtC
E. 5000 GtC
F. 10,000 GtC

Ice thickness (m)

Ricarda Winkelmann et al. Sci Adv 2015;1:e1500589