POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Modeling the impacts of climate change on fisheries and marine ecosystems

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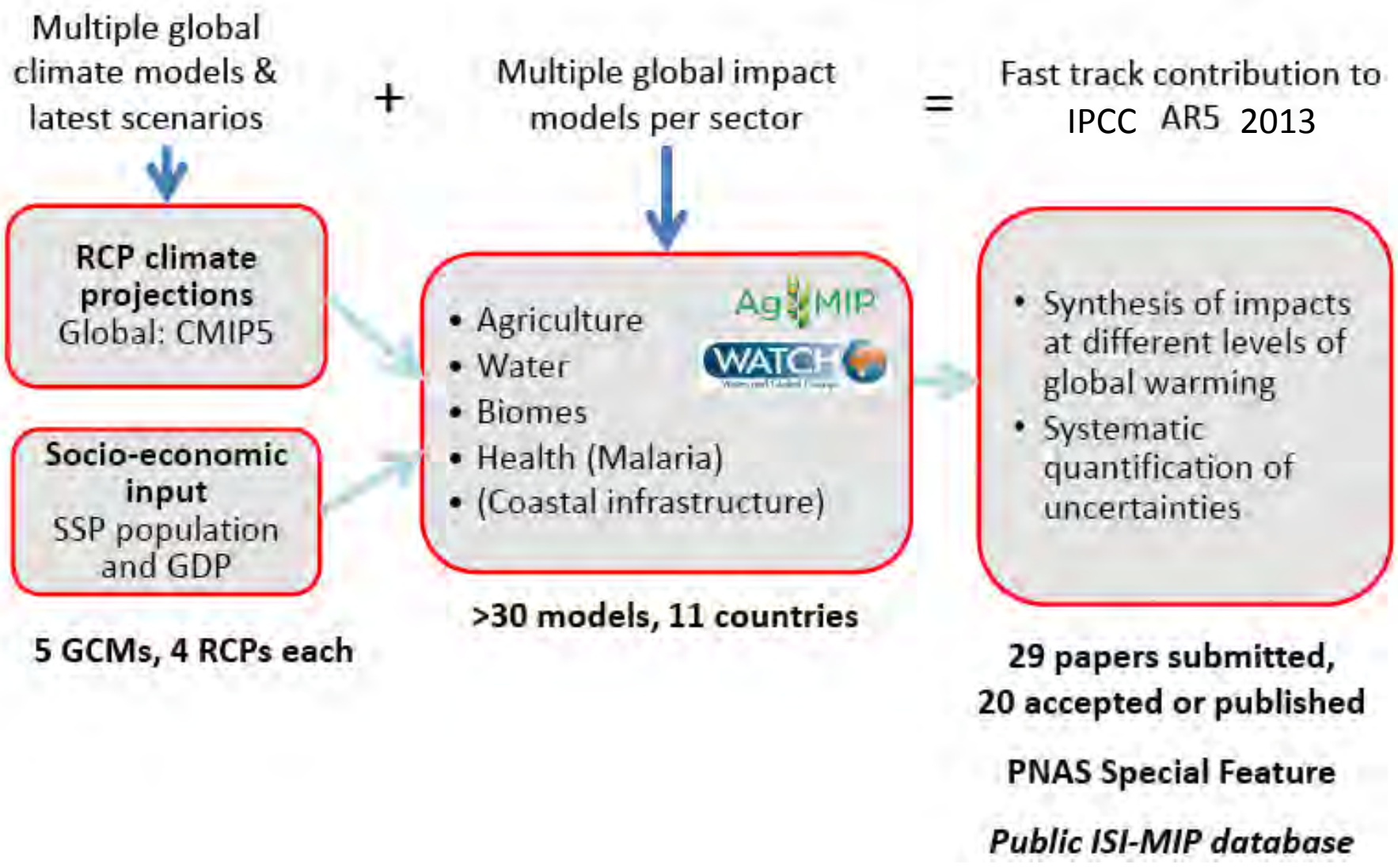
ISI-MIP Phase 1 (2012-2013)



ISI-MIP 2.1A
Historical runs & model validation

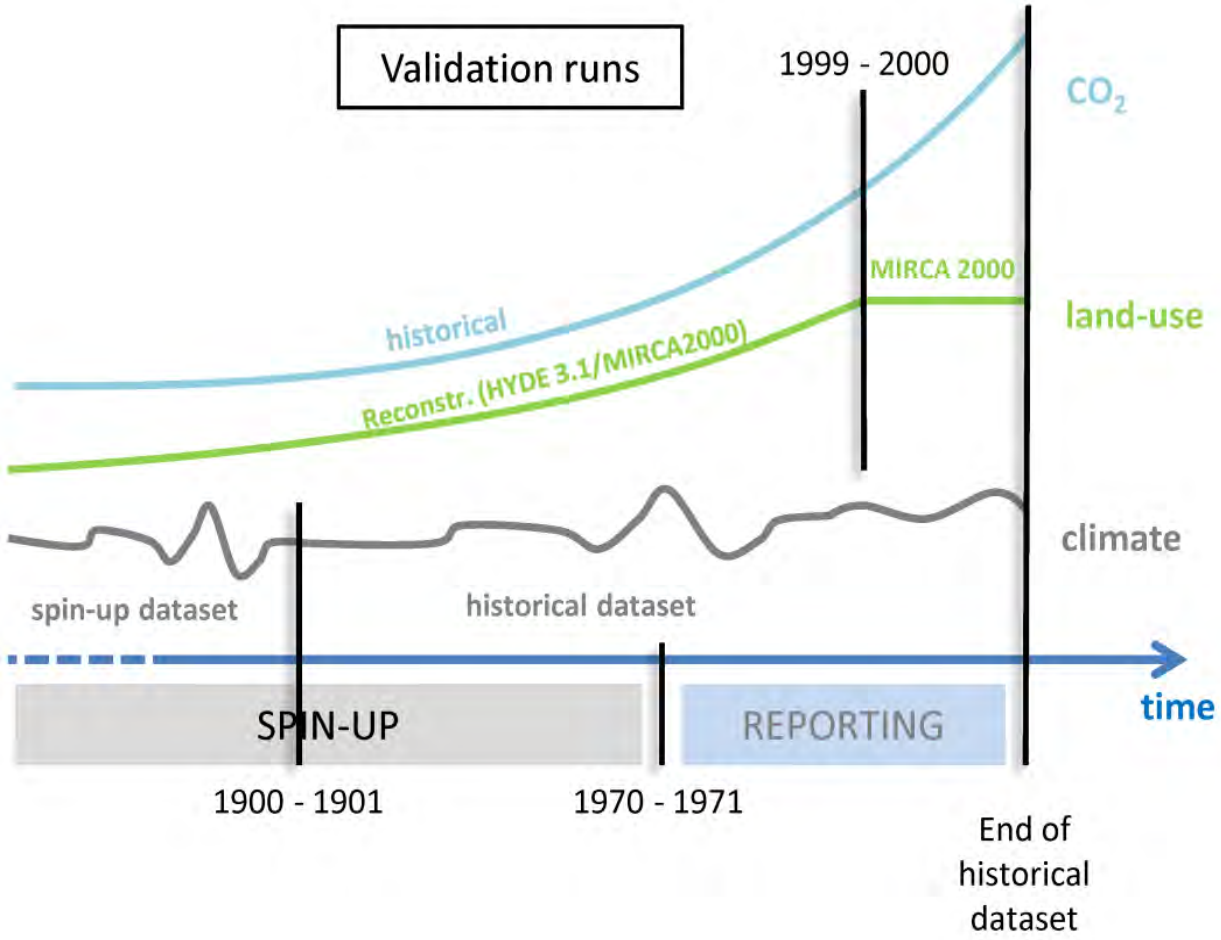
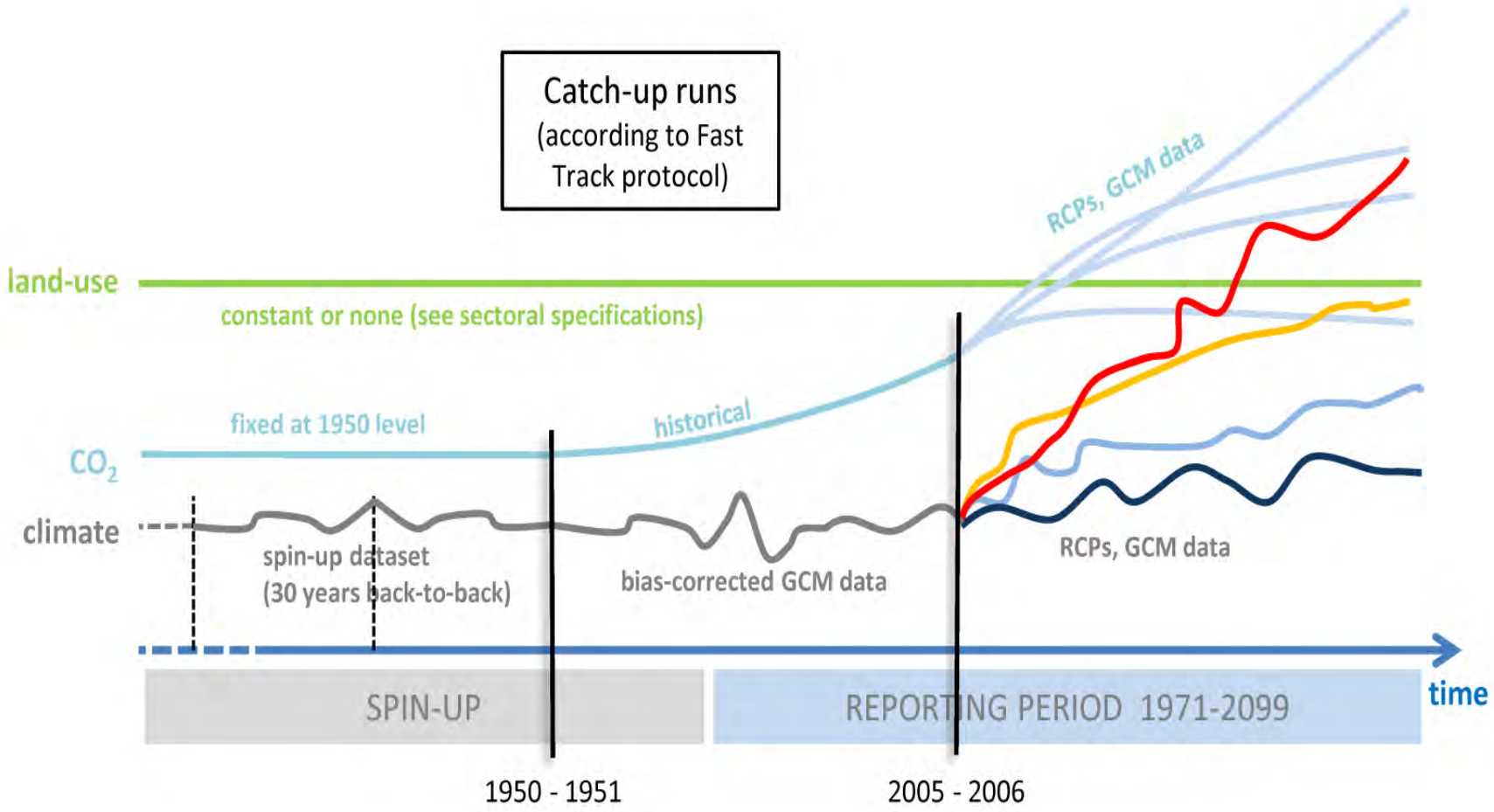


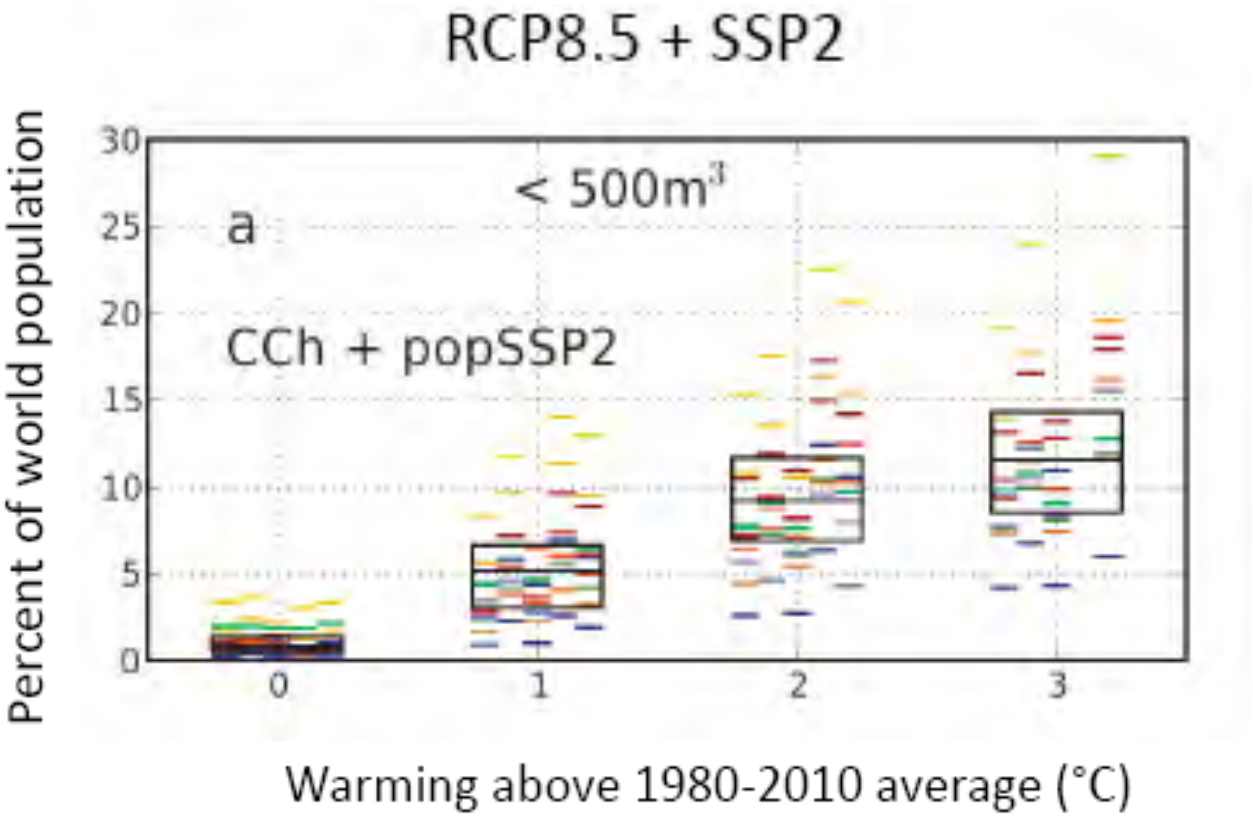
Figure 3: *Input data scheme for historical validation runs. Information shown here holds for all sectors, but further details may vary across sectors – see Chapter* ***6****.*

ISI-MIP 2.1B
Future projections



11 global hydrological models

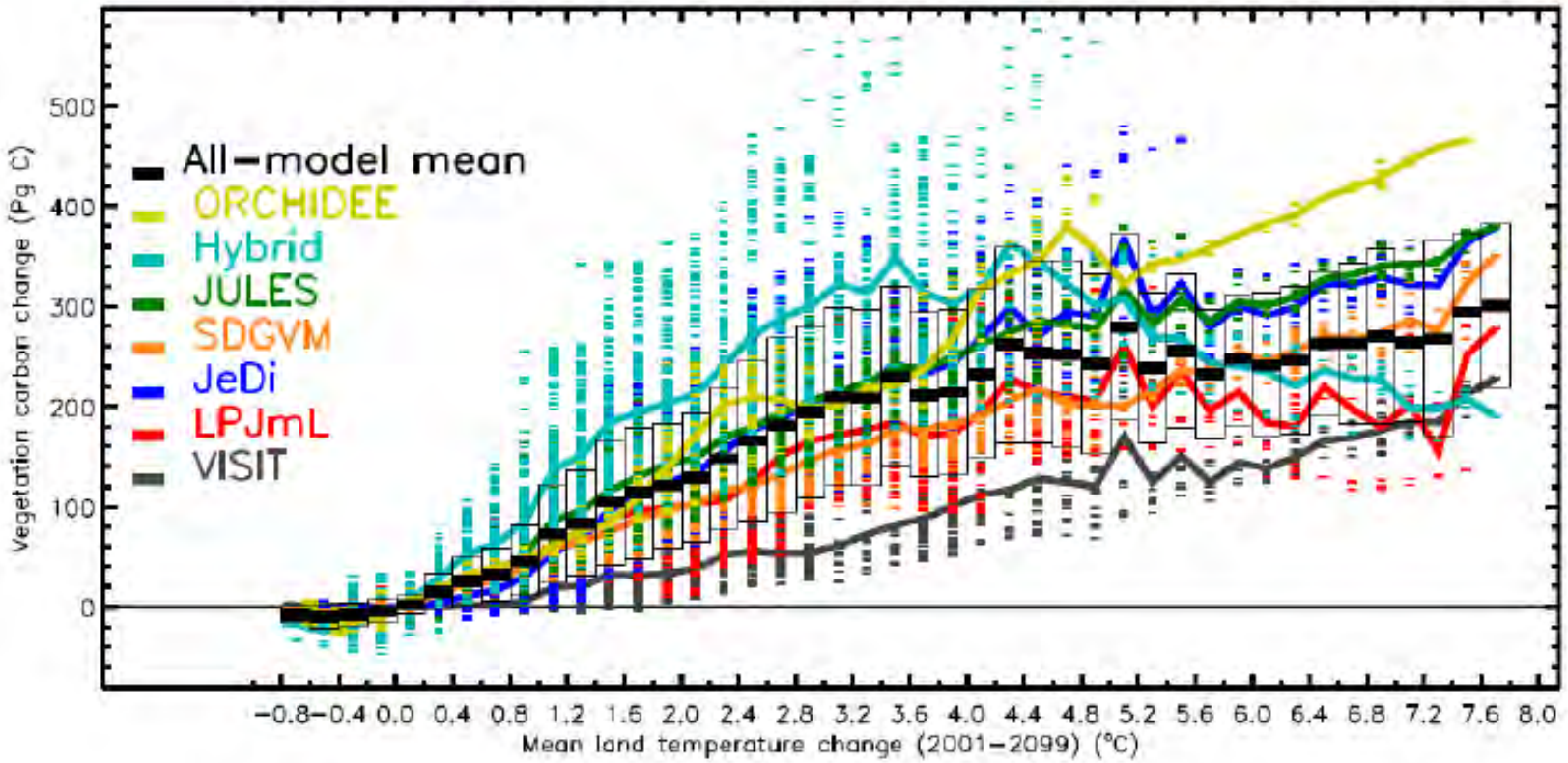
Water Scarcity



Schewe et al., PNAS 2013

7 global dynamic vegetation models

Uncertainty in Changes in Vegetation Carbon

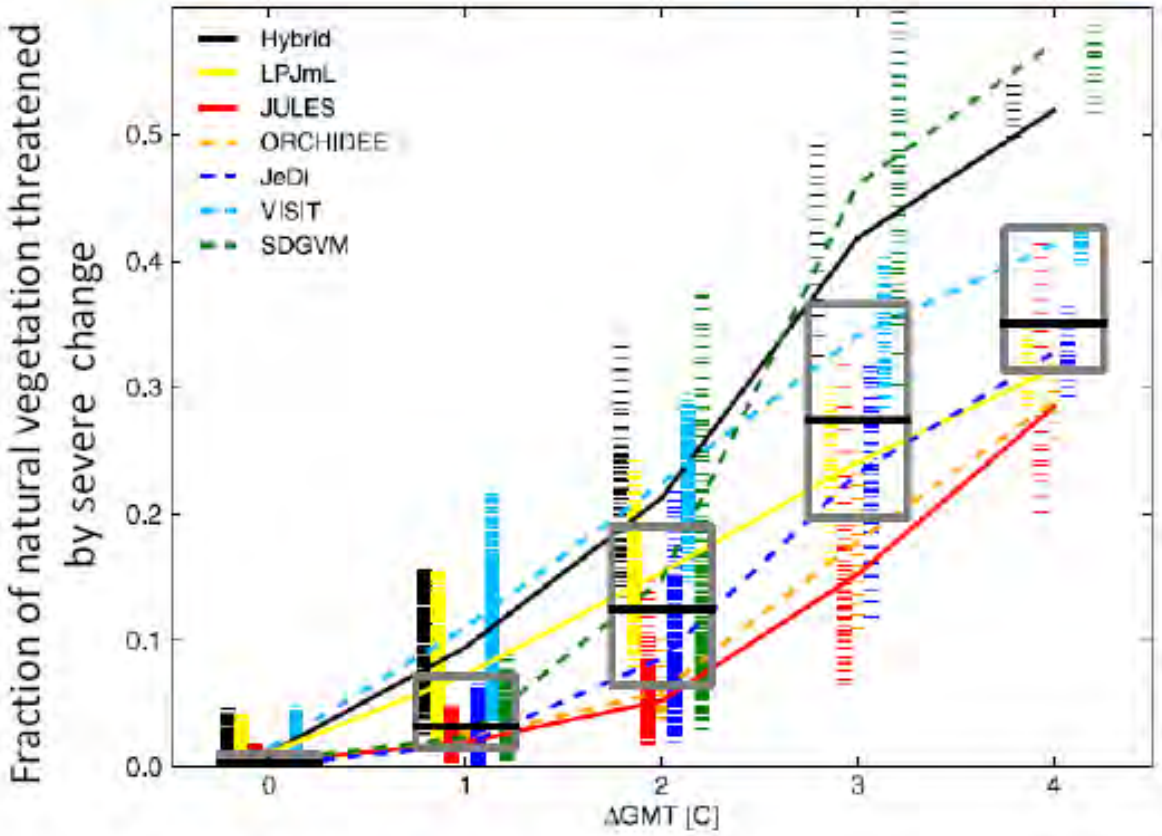


At 4 °C of global land surface warming vegetation carbon increases by 52–477 Pg C, mainly due to CO_2 fertilization of photosynthesis.

PIK

Friend et al., PNAS, 2013

Risk of Severe Ecosystem Changes

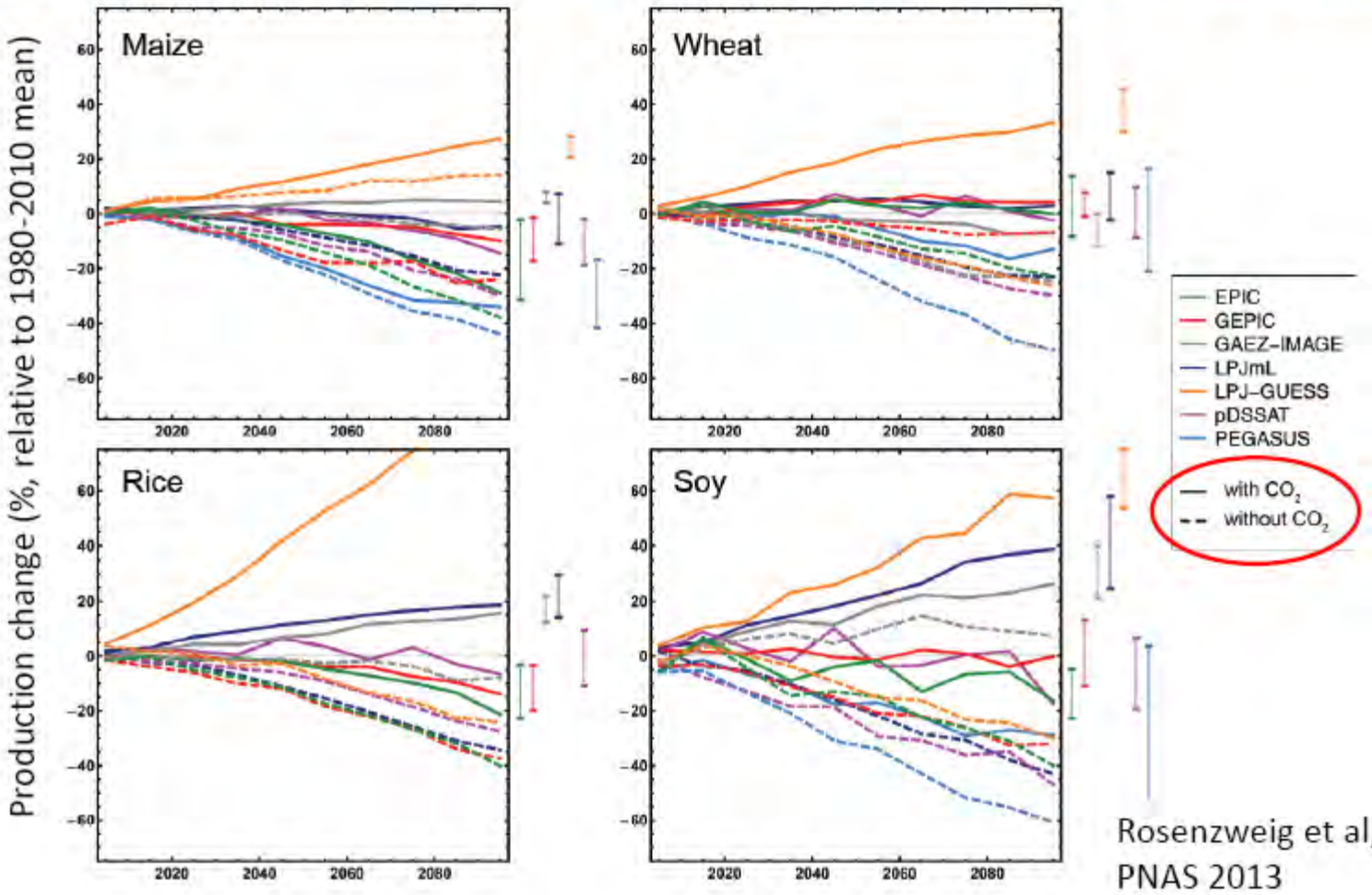


The extent of regions at risk of severe ecosystem change is projected to rise with global warming; median value of 36% at 4°C, ~ doubling between 2°C and 3°C.

Warszawski et al., ERL, 2013

Agriculture
(7 global gridded crop models)

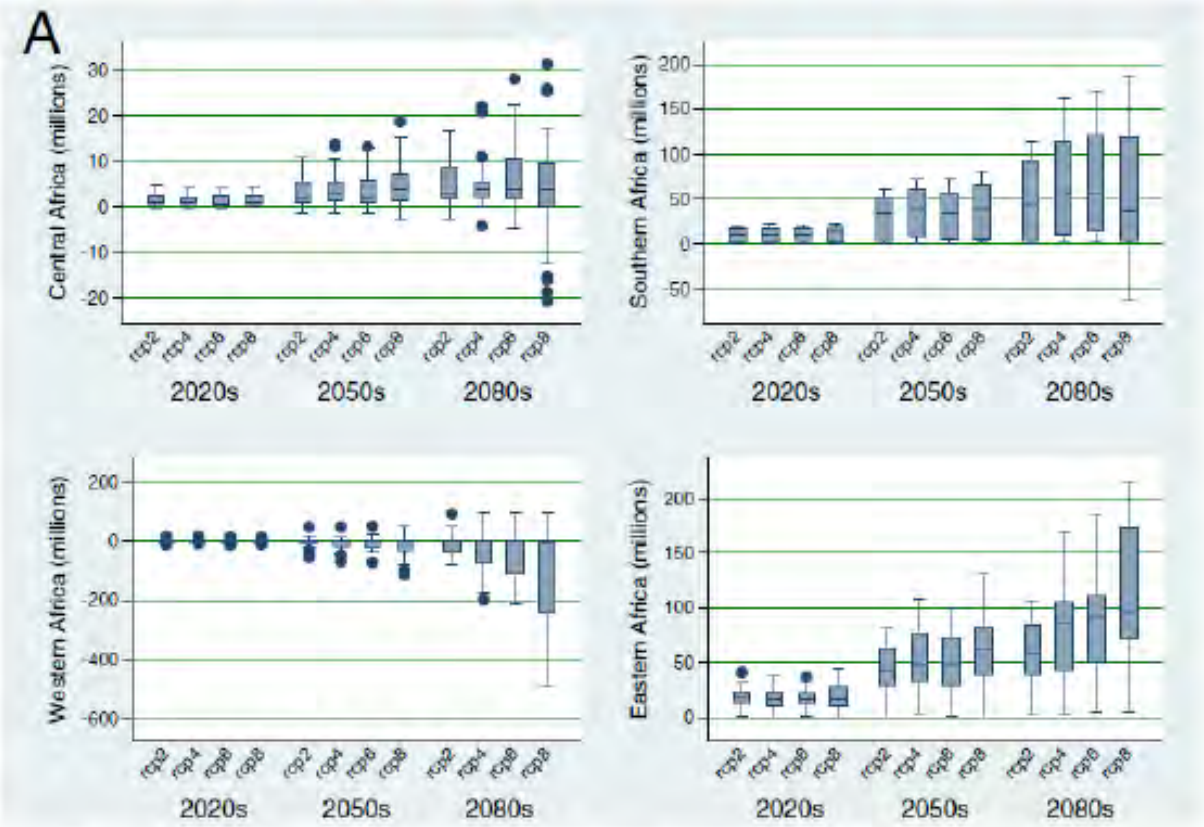
Projected Changes in Crop Production (for RCP 8.5)



Rosenzweig et al, PNAS 2013

Human Health 5 global malaria models

Additional People at Risk from Malaria in Africa

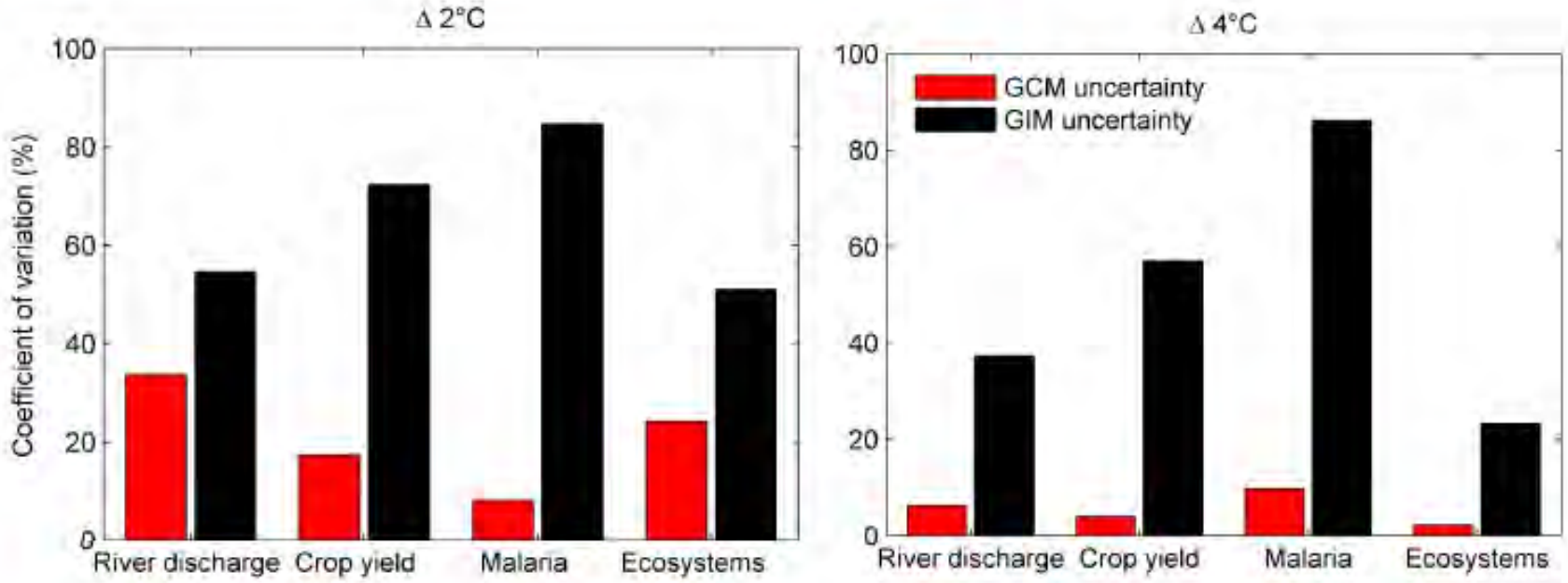


... but defined by *climate suitability* only; models do not include socio-economic factors, such as vector and disease control, and urbanization

PIK

Caminade et al. 2014 PNAS

Mind the Impact Model Uncertainties!



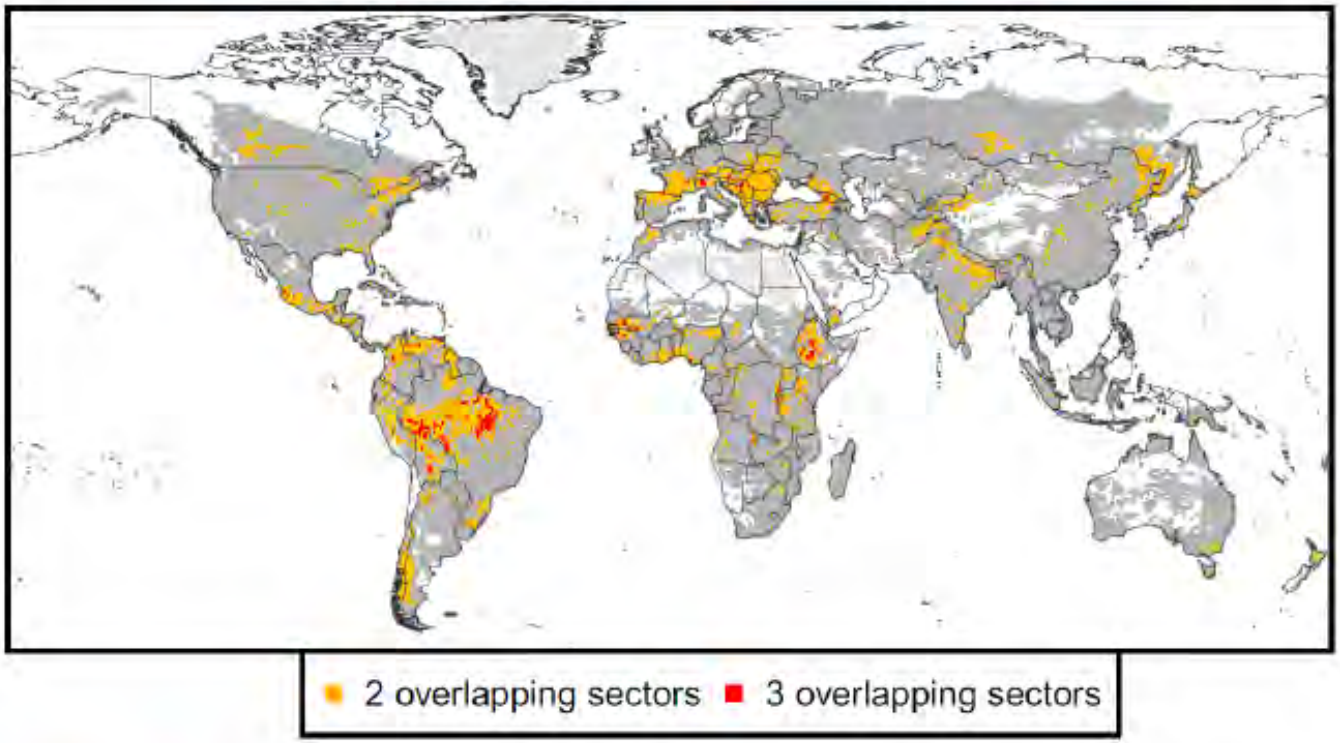
" [...] uncertainty stemming from *global impact models (GIMs)* is generally of similar magnitude or even larger than the uncertainty stemming from *global climate models (GCMs)*."

Huber et al. *in prep* (data from Piontek et al. 2014 PNAS)

Cross-Sectoral Integration

11 water + 7 crop + 7 biomes + 4 malaria models

Multi-Sectoral Impact Hotspots



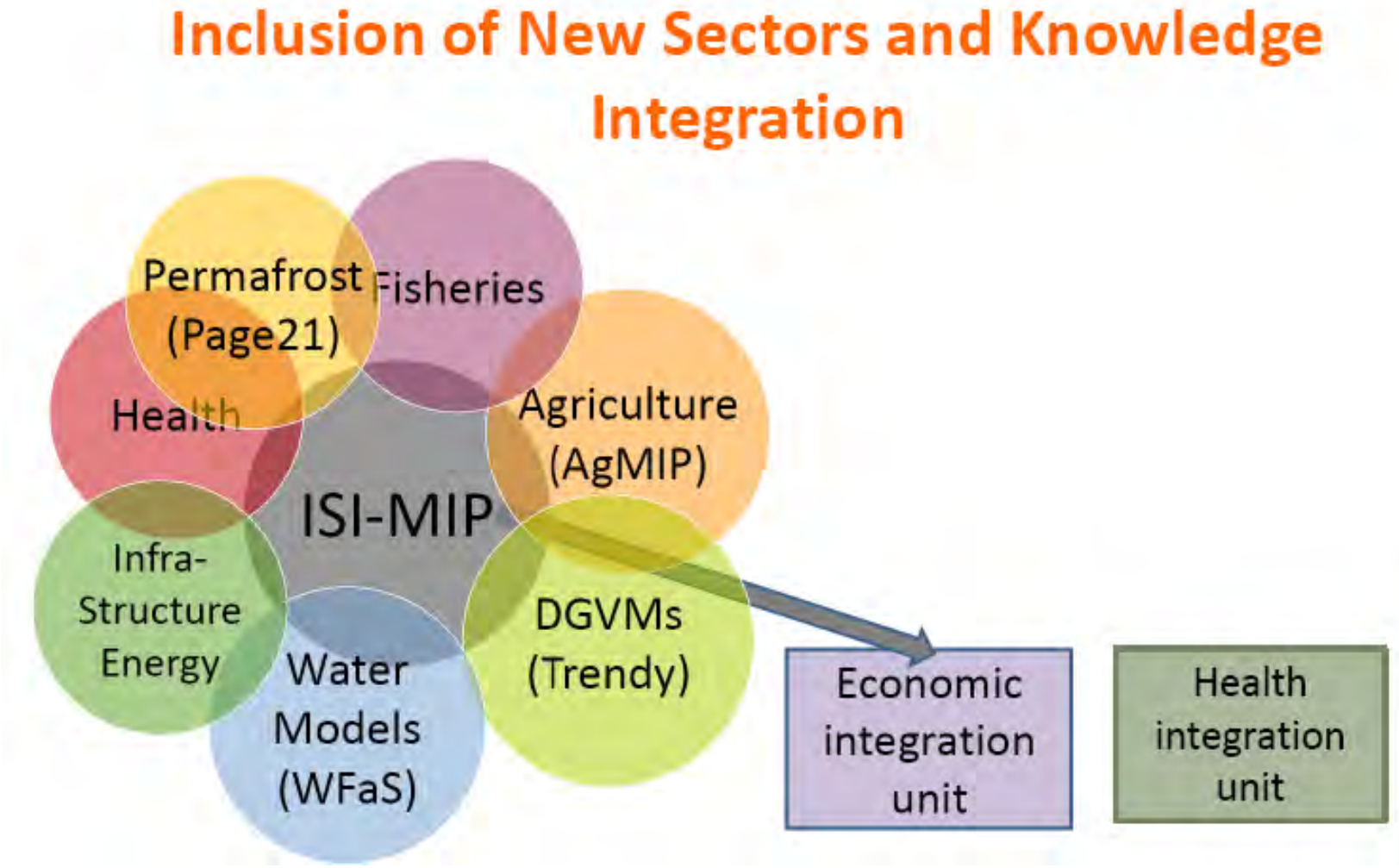
Orange/**red**: strict assessment with 50% of models agreeing on threshold crossing

Grey: worst-case assessments with 10% of models agreeing in at least 2 sectors

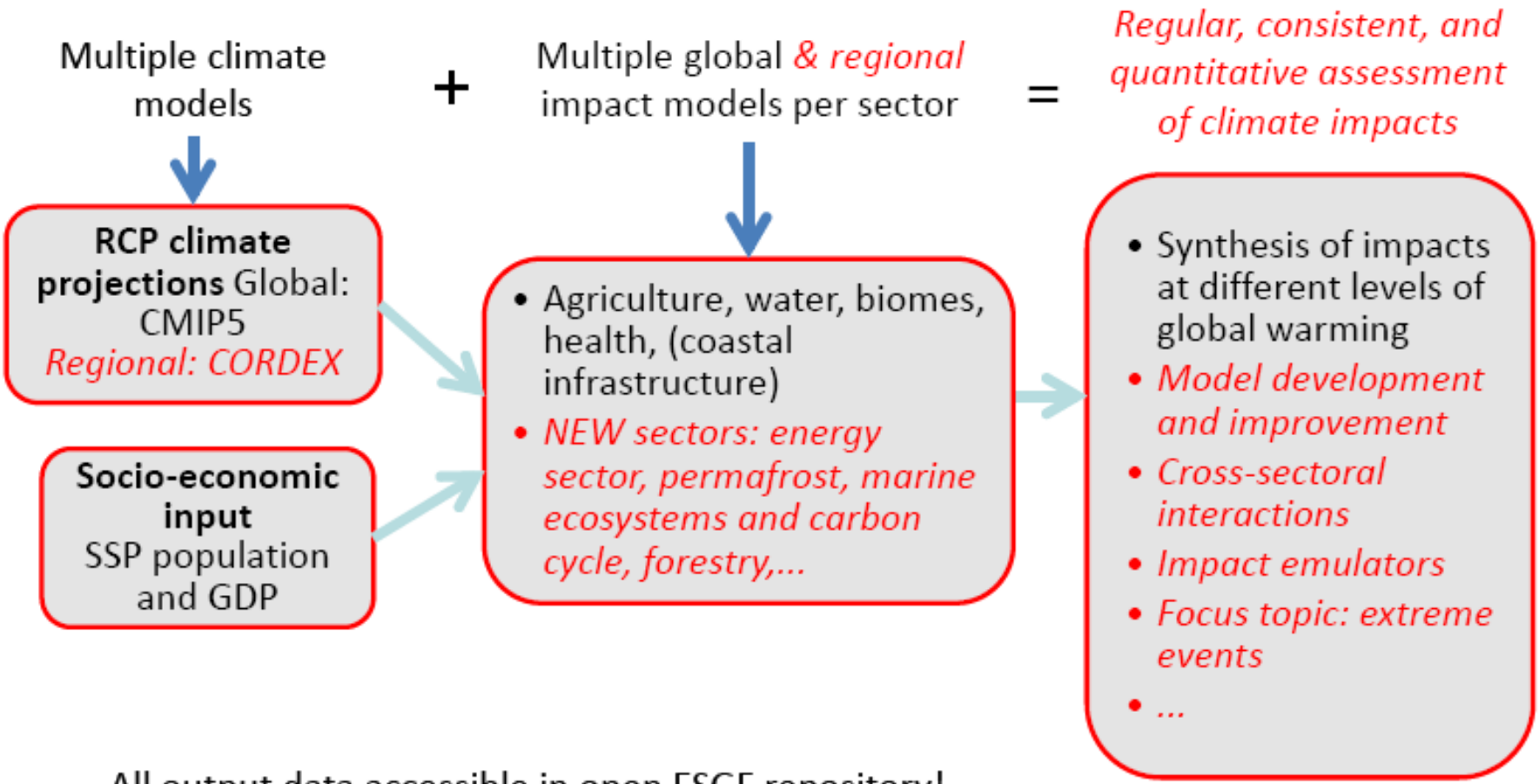
PIK

Piontek et al., PNAS, 2013

ISI-MIP Phase 2 (2014-2017)

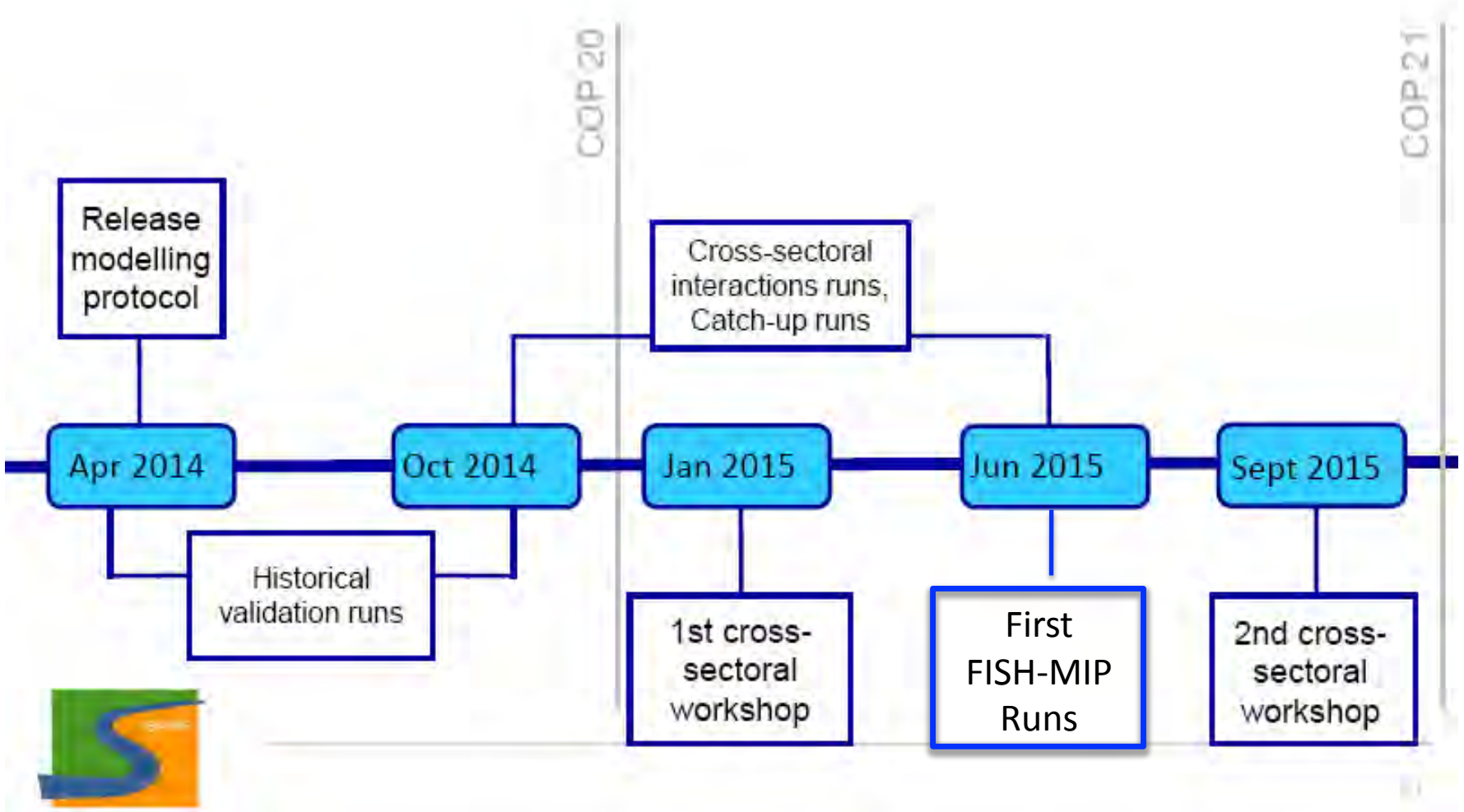


ISI-MIP Phase 2 (2014-2017)



All output data accessible in open ESGF repository!
Enable systematic impact research by entire community.

ISI-MIP2.1 timeline



Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP)

RCP climate projections
global: CMIP5
regional: CORDEX

Socio-economic input
SSP populationa & GDP

Impact models global & regional

agriculture
natural ecosystems
coastal infrastructure
energy
water
permafrost
health
fisheries

- Synthesis of impacts at different levels of global warming
- Quantification of uncertainties
- Representation of extreme events
- Model improvement
- Cross-scale intercomparison

Global Circulation Models (GCMs)
- Climate data from 1950 - 2100

Ocean Social Pathways (OSPs)
- Socio-economic scenarios

Marine Ecosystem & Fisheries Models

ISI-MIP

FISH MIP

Idea$_{2010/2013}$ => Network$_{2015}$

GLOBAL models

1. POEM
2. BOATS
3. EcoOcean
4. DBEM
5. Madingley
6. Macroecological model
7. DBPM
8. SS-DBEM
9. APECOSM
10. SEAPODYM

REGIONAL models

1. EwE (Ecopath with Ecosim)
2. Atlantis
3. OSMOSE
4. Size-structured
5. End-to-End

$\Rightarrow$ 20 models

$\Rightarrow$ 13 regions

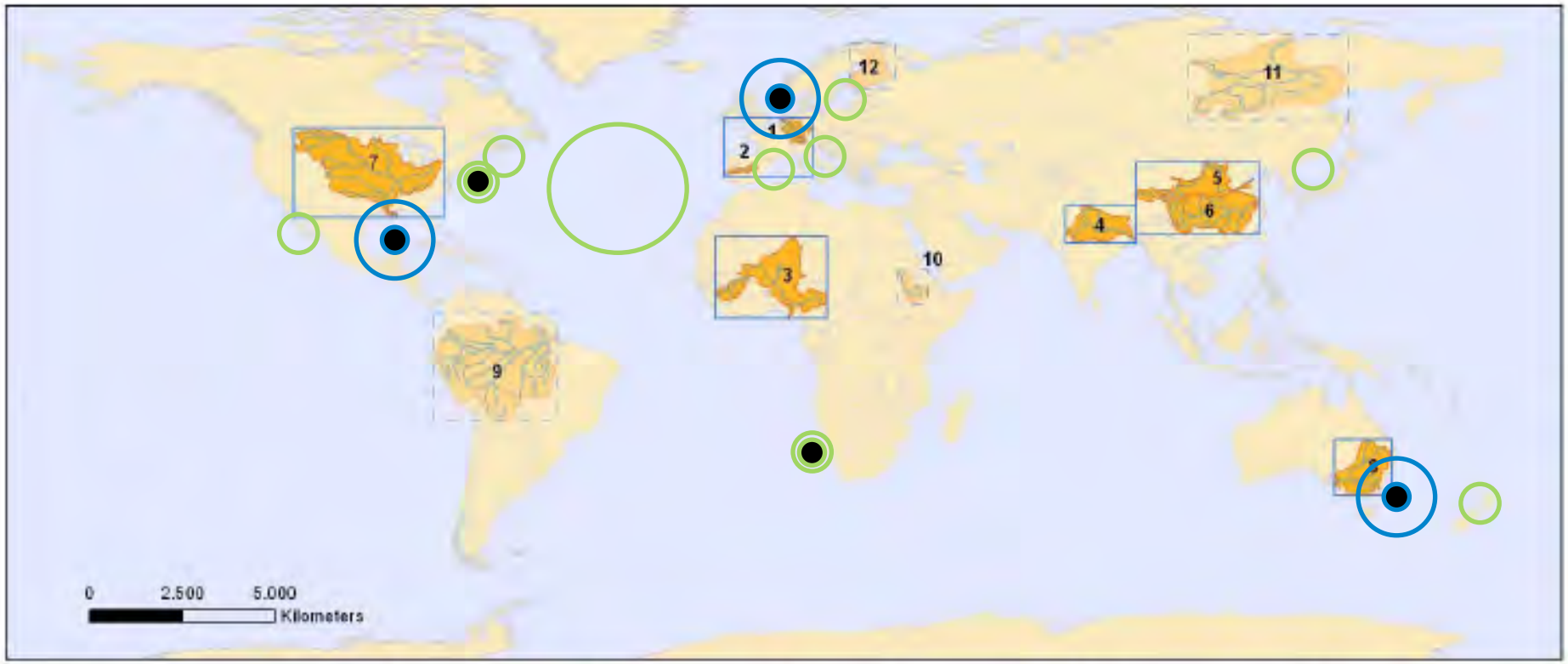
$\Rightarrow$ 5 regions with model overlap

Focus regions FISH-MIP

Other regions FISH-MIP

Focus Regions of ISI-MIP2

- Model overlap in 5 regions



Europe	Africa	Asia	N.America	Australia	S.America
1. Rhine	3. Niger	4. Ganges	7. Mississippi	8. Murray Darling	9. Amazon
2. Tagus	10. Blue Nile	5. Yellow			
12. Finland		6. Yangtze			
		11. Lena			

Goal

⇒ use same future climate scenarios as other ISI-MIP sectors

- 5 GCMs, 4 RCPs
- adapt to oceanic climate change scenarios

⇒ use same shared socioeconomic pathways (SSPs)

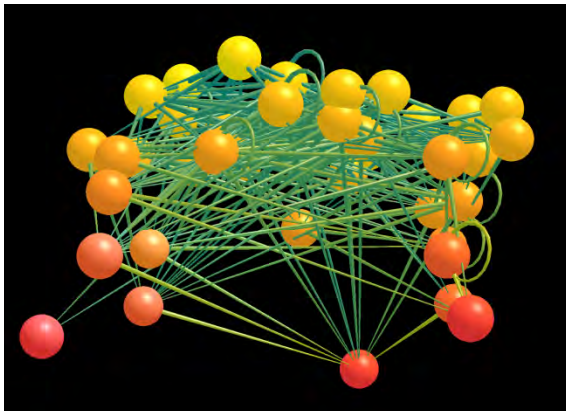
- human population growth and GDP
- adapt to future fishing scenarios

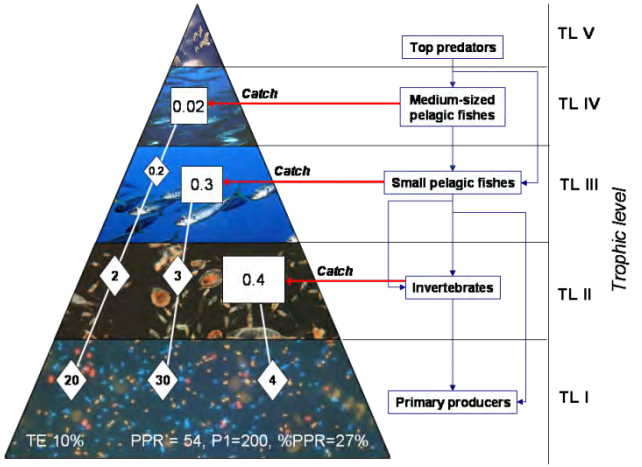
Problems:

- very varied marine ecosystem model structure
- different input & output data
- limited data on depth-resolved physical & biogeochemical variables
- limited observational data for historical runs and model validation
- limited data on spatially resolved fishing effort

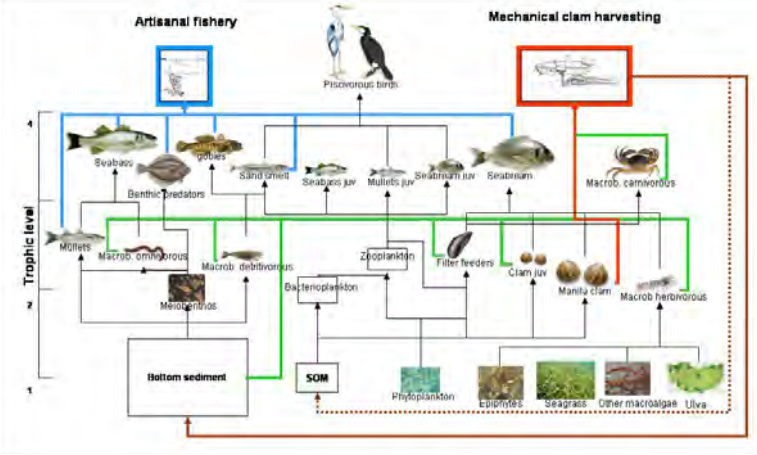
Model structure

- Parts:
  - Size classes
  - Functional groups
  - Trophic levels
  - Species
  - Life-history stages





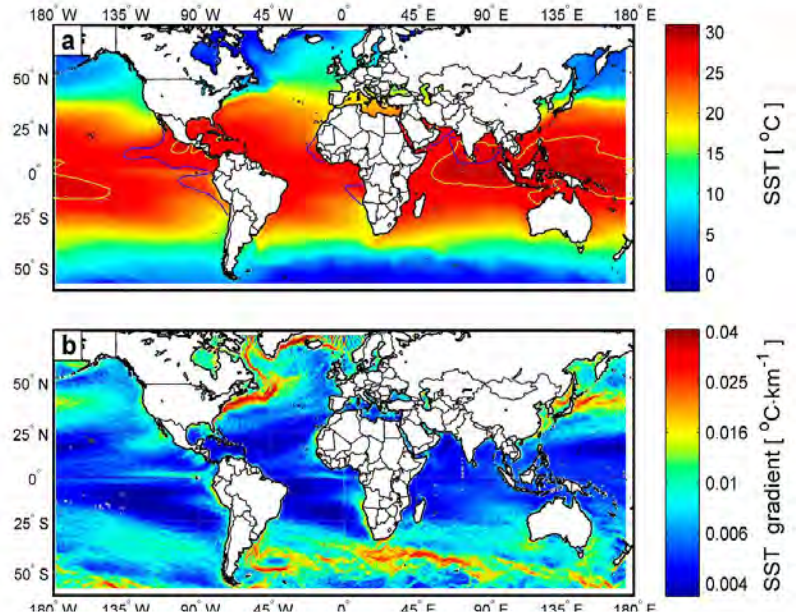
- Links:
  - Who-eats-whom
  - Diet composition
  - Energy transfer

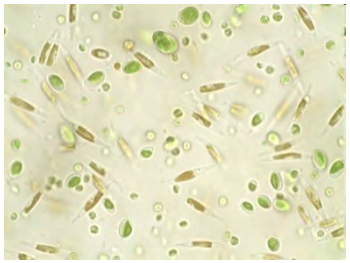


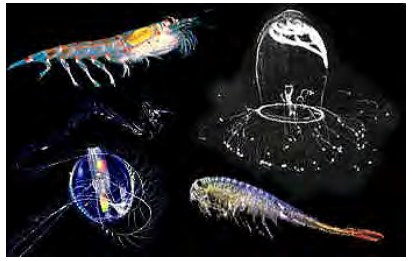
Common Inputs

- Climate, physics, chemistry
  - Temperature
  - Currents (u,v)
  - Salinity, pH, O2
- Biological
  - Primary Production (PP)
  - Phytoplankton (sm/lg)
  - Zooplankton (sm/lg)
- Fisheries
  - Effort, catch, mortality

  ⇒ Spatially resolved data later this year through MOU with SAUP







GCM selection

- GCM 1 = HadGEM2-ES (size-resolved plankton, but dodgy data)
- **GCM 2 = IPSL-CM5ALR** => Tilla Roy
- GCM 3 = MIROC-ESM-CHEM (no size-resolved plankton groups)
- **GCM 4 = GFDL-ESM2M** => John Dunne
- GCM 5 = NorESM1-M (no size-resolved plankton groups)
- new: **CESM1-BGC** (RCPs 4.5 & 8.5 only) => Keith Lindsay

- RCPs 2.6, 4.5, 6.0, 8.5
- Ocean Acidification yes-no

SSPs => OSPs

Shared Socioeconomic Pathways

- SSP 1 – sustainability
- SSP 2 – middle of the road
- SSP 3 – fragmentation
- SSP 4 – inequality
- SSP 5 – conventional development

Ocean System Pathways

- OSP 1 – sustainability first
- OSP 2 – conventional trends
- OSP 3 – dislocation
- OSP 4 – global elite & inequality
- OSP 5 – high tech & market

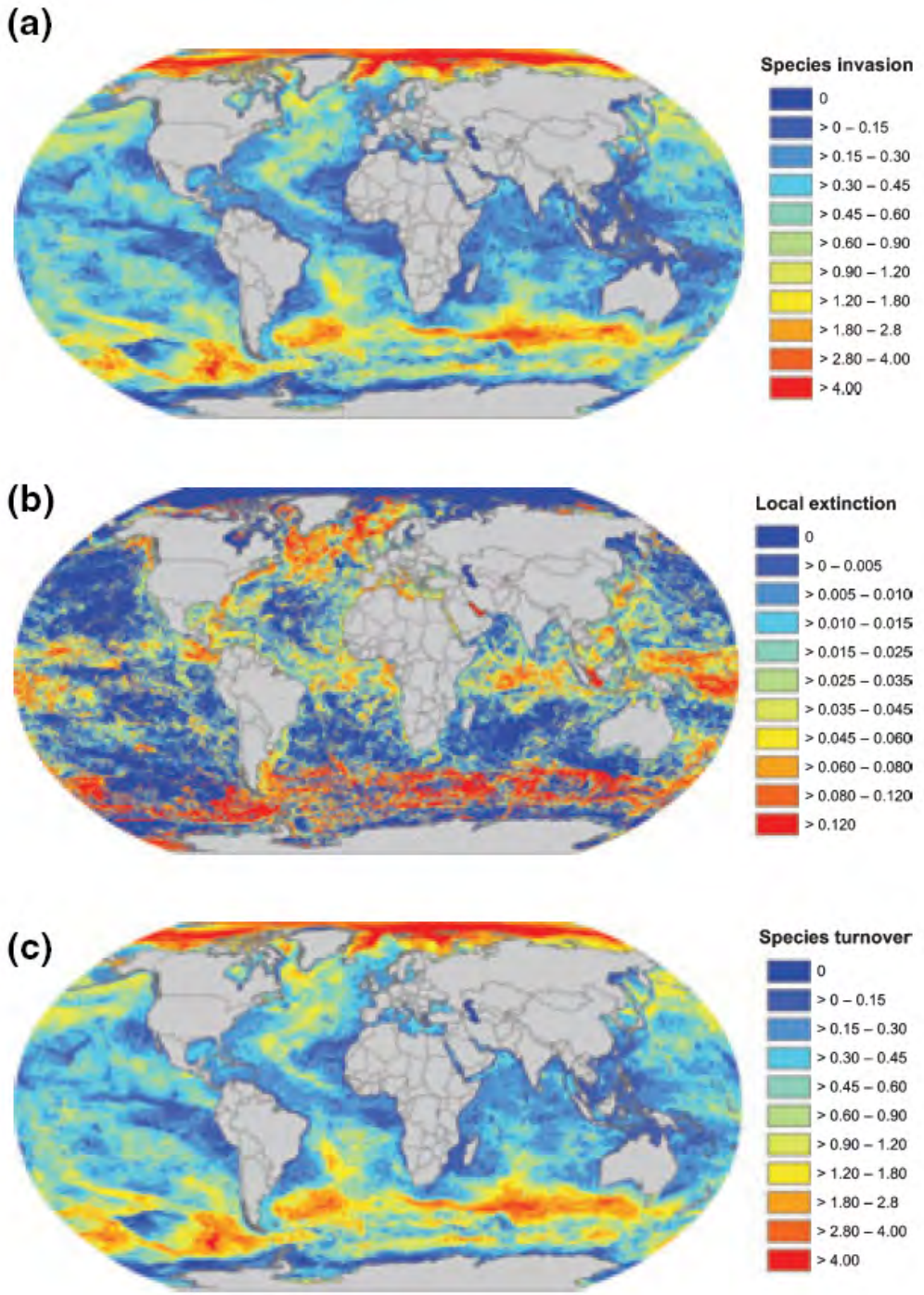
Include:

- Economy: wild fish demand, fishing costs, markets
- Management objectives & tools
- Governance structure & politics

Maury et al. 2014, CLIOTOP

Common Outputs

- Biomass
  - Total
  - By Functional group / Size class / Commercial species
  - Spatial / Temporal, 2D / 3D
- Catch
  - Total
  - By Functional group / Size class / Commercial species
  - Spatial / Temporal, 2D / 3D
- Species distribution
- Ecosystem parameters
  - Species richness, Functional richness
  - Mean trophic level, other food-web properties
  - Production, growth rates



Species distribution shifts

Cheung et al. 2009, Fish & Fisheries

Scenarios & Syntheses

Historical runs (1950/70 – 2005):

- **Climate**: 1 historical re-analysis ("observational") & 3 GCM hindcasts
- **Fisheries**: YES (time-varying) vs. NO fishing
- **Ocean acidification**: YES (time-varying pH)

Future scenarios (2005 – 2100):

- **Climate**: 3 GCMs, 4 RCPs
- **Fishing**: YES (constant at 2005 levels) vs. NO fishing

  => Future: 5 OSPs
- **Ocean acidification**: YES vs. NO (constant pH)

Syntheses:

- Global model comparison
- Regional model comparison within / across regions
- Regional – Global model comparison within regions

Cross-sectoral ideas

(1) Biodiversity changes on land and in the sea

⇒Link with ***Biodiversity*** sector

(2) Change in global food /animal protein supply

⇒ Link with ***Agro-Economics*** sectors

(3) Consequences of land-use changes and nutrient run-off on coastal ecosystems

⇒ Link with ***Biomes/Agriculture/Water*** sectors