WGI assessment of regional information and lessons learned

Jens Hesselbjerg Christensen (CLA: AR5, AR4; LA: AR5, TAR; RE: AR6 (Atlas))

Sonia I. Seneviratne (CLA: AR6 (Extremes), SREX; LA: SR15)

WGI regional climate change chapters

- SAR – regional information imbedded in other chapters
- TAR – Chapter 10; Regional Climate Information – Evaluation and Projections.
  - Giorgi, F., B. Hewitson, J.H. Christensen, M. Hulme, H. von Storch, P. Whetton, R. Jones, L. Mearns, and C. Fu **(9)**
- AR4 – Chapter 11; Regional Climate Projections
  - Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton. **(17)**
- AR5 – Chapter 14; Climate Phenomena and their Relevance for Future Regional Climate Change
  - Christensen, J. H., K. Krishna Kumar, E. Aldrian, S.-I. An, I. F. A. Cavalcanti, M. de Castro, W. Dong, P. Goswami, A. Hall, J. K. Kanyanga, A. Kitoh, J. Kossin, N.-C. Lau, J. Renwick, D. Stephenson, S.-P. Xie and T. Zhou. **(17)**
- AR5 – Atlas
  - van Oldenborgh, G. J., M. Collins, J. M. Arblaster, J. H. Christensen, J. Marotzke, S. Power, M. Rummukainen, T. Zhou **(established within WG1, LA1)**

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AR4: Chapter 11 objective

Regional projections	- large-scale (GCM resolved) - small-scale (sub-GCM to point)
Confidence	- statistical (ensembles) - physical (understanding)

Approach:

Consider climate processes (WG-I) and policy relevance (WG-II)

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Implications for AR4 chapter 11

Methods:

For large-scale – GCMs (coupled or atmosphere)

For small-scale – All (GCMs and regionalizing)

To assess uncertainty:

Physical understanding of mechanisms

Statistical treatment of (weighted) ensemble results

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AR5 Integration chapters 13 & 14 objectives

- Two chapters that build on the previous chapters, integrating all relevant information for two key topics in WGI AR5:
  - sea level change (Chapter 13)
  - climate phenomena across the regions (Chapter 14)

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AR5 Chapter 14 specifics

- The chapter on Climate Phenomena (Chapter 14) will assess the most important modes of variability in the climate system and extreme events.
- Modes relevant across many regions are monsoon systems, El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), Quasi-Biennial Oscillation (QBO), North Atlantic Oscillation (NAO), and others.
- Furthermore, this chapter deals with interconnections between the climate phenomena, their regional expressions, and their relevance for futurere regional clim
- As an integra assessed in t
- Maps produc 11 and 12 , form Projections.

Approach – not obviously anymore

- **Consider climate processes (WG-I) ✓**
- **and policy relevance (WG-II) ???**

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Specific challenges to AR5 chapter 14

- Dependency on other chapters is large
- IPCC experience in LA team limited
- Steep learning curve in IPCC terminology
- Broader involvement not easy
- Reliance on CA is large – implying large editorial efforts by CLAs
- Need for major revisions after each review and LA meeting
- Keep the dialogue with WGII

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Relevance table

Phenomena Regions	Section	Monsoon Systems *MP – see Section 14.2*	Tropical Phenomena[a] *HP/MP/LP/LP – see Section 14.3*	ENSO *LP – see Section 14.4*	Annular and Dipolar Modes *HP – see Section 14.5*	Tropical Cyclones *MP – See Section 14.6.1*	Extra-Tropical Cyclones[b] *MP/HP – See Section 14.6.2*
Arctic	*14.8.2*				*HP/HI* The small projected increase in NAO is *likely* to contribute to wintertime changes in temperature and precipitation.		*MP/HI* Projected increase in precipitation in extra-tropical cyclones is *likely* to enhance mean precipitation.
North America	*14.8.3*	MP/HI It is *likely* the number of consecutive dry days will increase, and overall water availability will be reduced.	HP/LI Projected ITCZ shifts unrelated to ENSO changes will impact temperature and precipitation, especially in winter.	LP/HI *Likely* changes in N. American precipitation if ENSO changes.	HP/MI The small projected increase in the NAO index is *likely* to contribute to wintertime temperature and precipitation changes in NE America.	MP/HI Projected increases in extreme precipitation near the centres of tropical cyclones making landfall along the western coast of US and Mexico, the Gulf Mexico, and the eastern coast of US and Canada.	MP/HI Projected increases in precipitation in extra-tropical cyclones will lead to large increases in wintertime precipitation over the northern third of the continent.
Central America and Caribbean	*14.8.4*	*MP/HI* Projected reduction in mean precipitation .	*HP/HI* Reduced mean precipitation in southern Central America if there is a southward displacement of the East Pacific ITCZ.	*LP/HI* Reduced mean precipitation if El Niño events become more frequent and/or intense.		*MP/HI* More extreme precipitation near the centres of tropical cyclones making landfall along the eastern and western coasts.	
South America	*14.8.5*	*MP/HI* Projected increase in extreme precipitation and in the extension of	*HP/HI* Projected increase in the mean precipitation in the southeast due to the	*LP/HI* Reduced mean precipitation in eastern Amazonia and increased	*HP/HI* Poleward shift of storm tracks due to projected positive trend in SAMS	.	*HP/HI* Southward displacement of cyclogenesis activity increases the

Table 14.3: Summary of the relevance of projected changes in major phenomena for mean change in future regional climate. The relevance is classified into high (red), medium (yellow), low (cyan), and "no obvious relevance" (grey), based on confidence that there will be a change in the phenomena ("HP" for high, "MP" for medium, "LP" for low), and confidence in the impact of the phenomena on each region ("HI" for high, "MI" for medium, "LI" for low). More information on how these assessments have been constructed is given in the Supplementary Material (Section 14.SM.6.1).

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Visibility in SPM – implied relevanse

- ….Warming will continue to exhibit interannual-to-decadal variability and will not be regionally uniform (see Figures SPM.7 and SPM.8). {11.3, 12.3, 12.4, 14.8}
- ….The Arctic region will warm more rapidly than the global mean, and mean warming over land will be larger than over the ocean (*very high confidence*) (see Figures SPM.7 and SPM.8, and Table SPM.2). {12.4, 14.8}
- Changes in the global water cycle ….although there may be regional exceptions (see Figure SPM.8). {12.4, 14.3}
- The high latitudes and the equatorial Pacific Ocean are *likely* to experience an increase in annual mean precipitation by the end of this century under the RCP8.5 scenario. In many mid-latitude and subtropical dry regions, mean precipitation will *likely* decrease, while in many mid-latitude wet regions, mean precipitation will *likely* increase by the end of this century under the RCP8.5 scenario (see Figure SPM.8). {7.6, 12.4, 14.3}
- **Globally, *it is likely* that the area encompassed by monsoon systems will increase over the 21st century. While monsoon winds are *likely* to weaken, monsoon precipitation is likely to intensify due to the increase in atmospheric moisture. Monsoon onset dates are *likely* to become earlier or not to change much. Monsoon retreat dates will likely be delayed, resulting in lengthening of the monsoon season in many regions. {14.2}**
- **There is *high confidence* that the El Niño-Southern Oscillation (ENSO) will remain the dominant mode of interannual variability in the tropical Pacific, with global effects in the 21st century. Due to the increase in moisture availability, ENSO-related precipitation variability on regional scales will *likely* intensify. Natural variations of the amplitude and spatial pattern of ENSO are large and thus *confidence* in any specific projected change in ENSO and related regional phenomena for the 21st century remains low. {5.4, 14.4}**

(Jens H. Christensen, UCPH)

Visibility scientifically – implied relevance

- Google scholar (as of 11-05-2018)
  - TAR ch10, 2001
    - 694
  - AR4 ch11, 2007
    - 4430
  - AR5 ch14, 2013
    - 586

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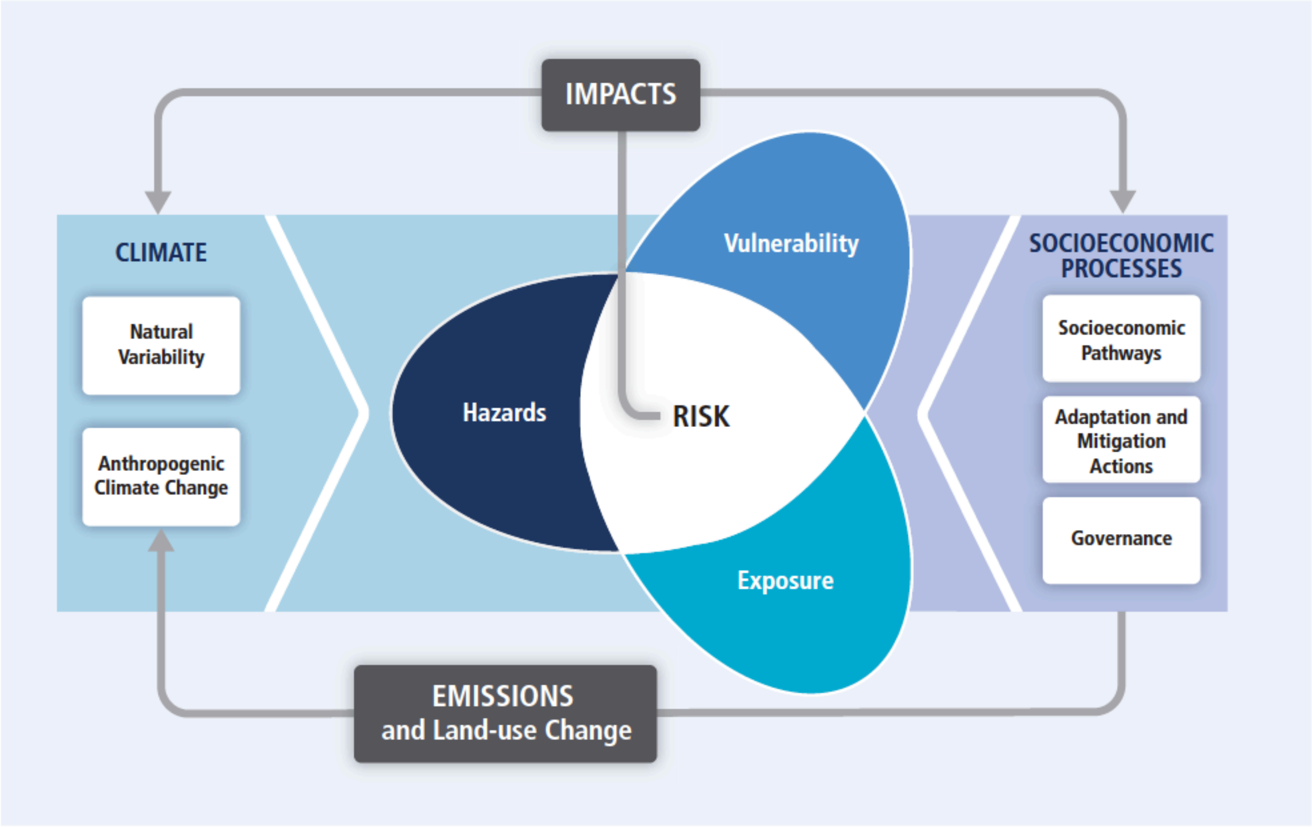
SREX and SR15 perspective

- Reports integrating WG1 scientists with further parts of community
  - SREX: WG1 (Chapter 3), WG2, IRDR
  - SR15: WG1, WG2, WG3
- Recognition:
  - Information from WG1 may not always be relevant for WG2 and impact science in general
  - Need for better integration and interaction

(Sonia I. Seneviratne, ETH Zurich)

SREX and SR15 perspective



(AR5 WG2, based on SREX)

- Risk perspective
  - Hazards (WG1) only part of the picture
  - Vulnerability and Exposure are key determinants of risks

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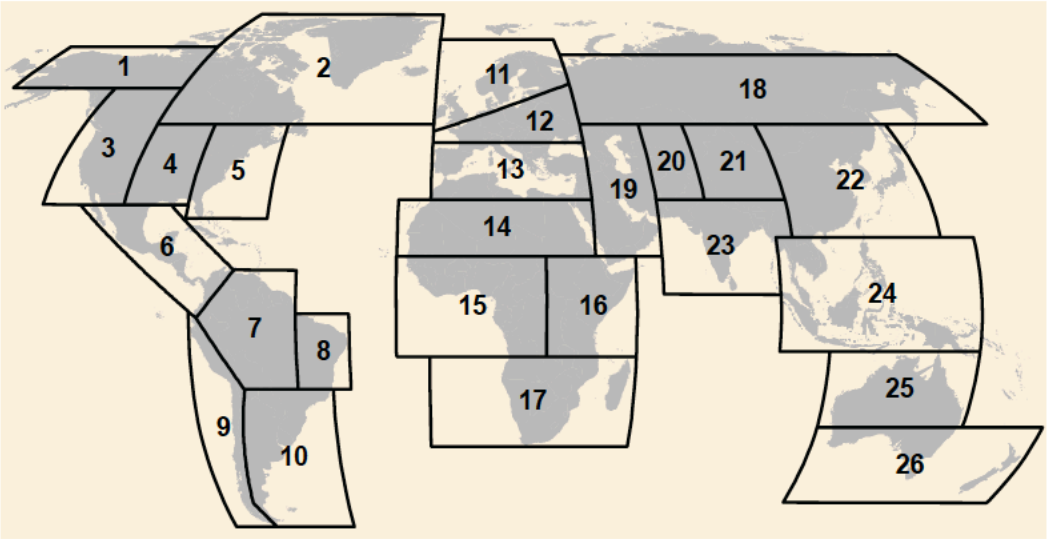
IPCC WG1: Regional information



IPCC SREX regions (IPCC 2012; Seneviratne et al. 2012)
- expansion of "Giorgi regions"

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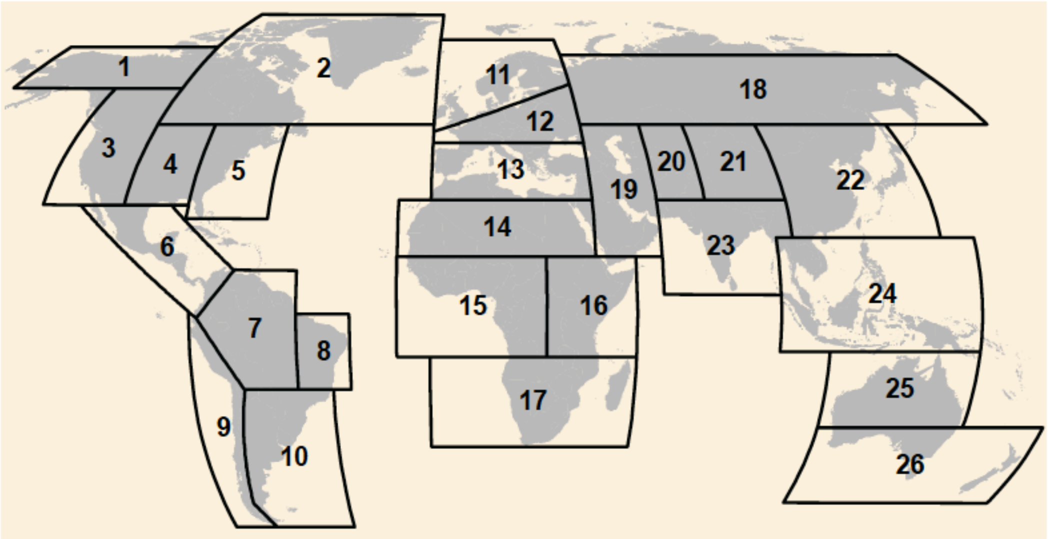
IPCC WG1: Regional information



IPCC SREX regions (IPCC 2012; Seneviratne et al. 2012)
- expansion of “Giorgi regions”

Rationale: Climatically “consistent” regions

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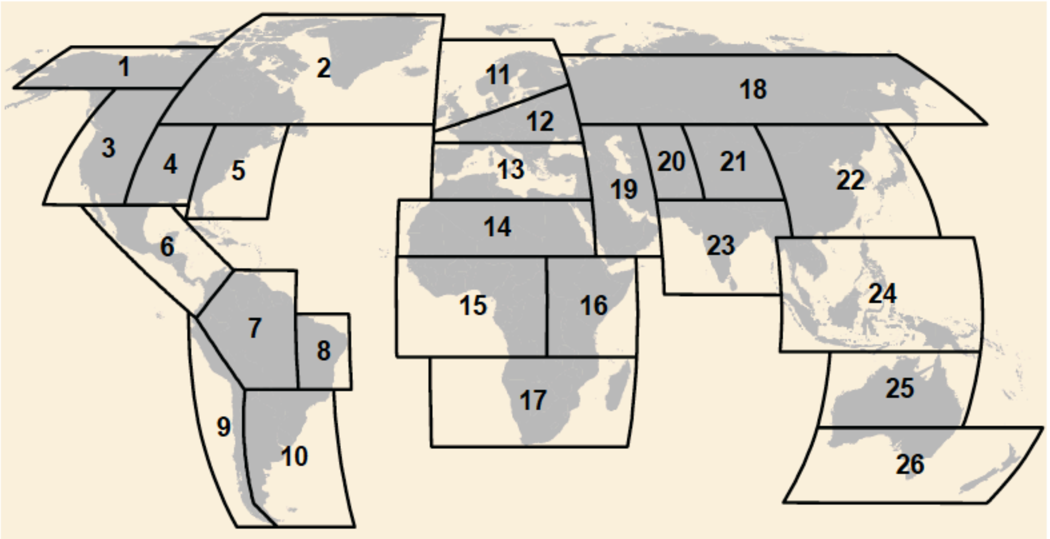
IPCC WG1: Regional information



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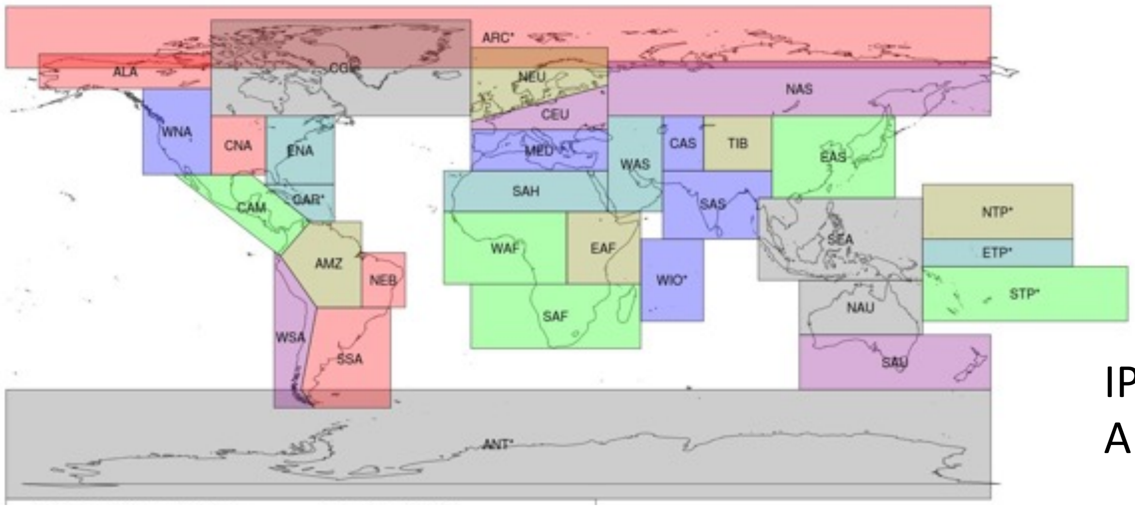

IPCC AR5 / IPCC data distribution center (including islands, Arctic and Antarctica)

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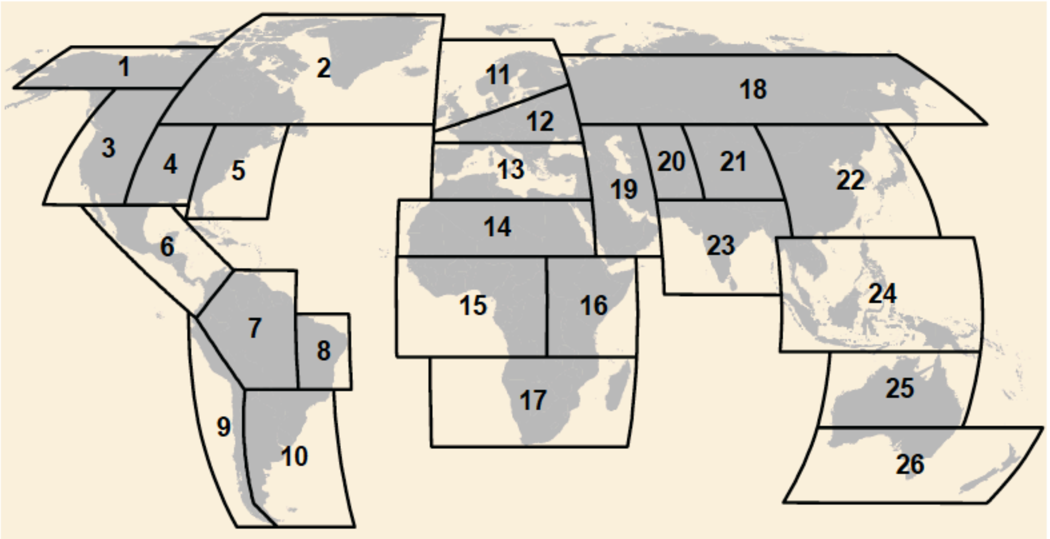
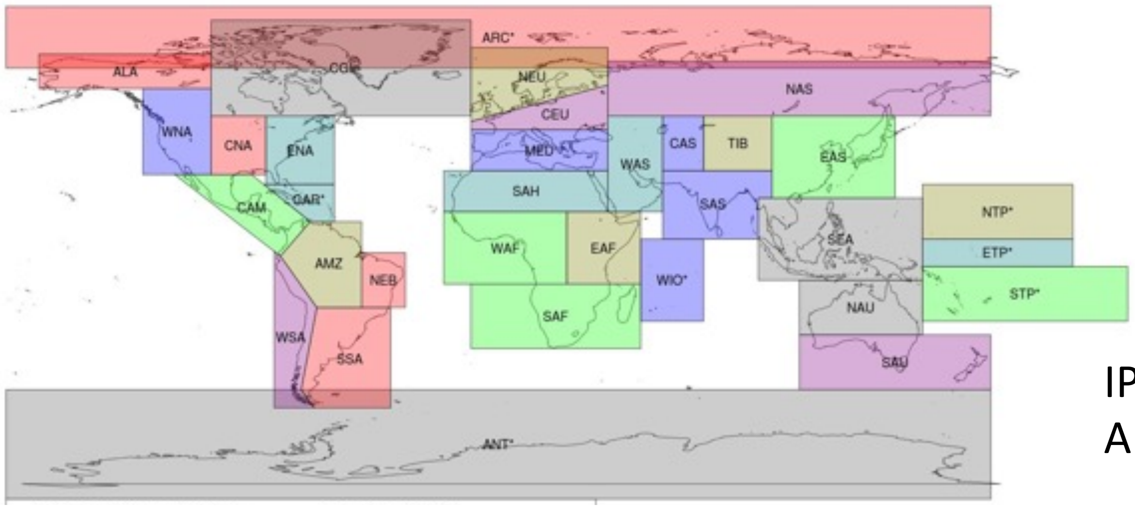
IPCC WG1: Regional information



Some problems:
- Some regions still suboptimal (e.g. WAF, Diedhiou et al. 2018)
- Does not consider vulnerability and exposure
- Not a perfect mapping to continents (e.g. MED region)

IPCC SREX regions (IPCC 2012; Seneviratne et al. 2012)
- expansion of "Giorgi regions"



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IPCC WG1: Regional information, how were regions used?

(Sonia I. Seneviratne, ETH Zurich)

IPCC WG1: Regional information, how were regions used?

Table 3-2 | Regional observed changes in temperature and precipitation extremes, including dryness, since 1950 unless indicated otherwise, and using late 20th-century values as reference (see Box 3-1), generally 1961-1990. See Figure 3-1 for definitions of regions. For assessments for small island states refer to Box 3-4.

A. North America and Central America

Regions	Tmax [WD = Warm Days CD = Cold Days; see Box 3-1] (using late 20th-century extreme values as reference, e.g., 90th/10th percentile)	Tmin [WN = Warm Nights CN = Cold Nights; see Box 3-1] (using late 20th-century extreme values as reference, e.g., 90th/10th percentile)	Heat Waves (HW)/ Warm Spells (WS) [WSDI = Warm Spell Duration Index, i.e., number or fraction of days belonging to spells of at least 6 days with Tmax >90th percentile] (using late 20th-century extreme values as reference)	Heavy Precipitation (HP) (using late 20th-century extreme values as reference, e.g., 90th percentile)	Dryness [CDD = Consecutive Dry Days SMA = (Simulated) Soil Moisture Anomalies PDSI = Palmer Drought Severity Index; see Box 3-3 for definitions]
All North America and Central America	*High confidence: Likely* overall increase in WD, decrease in CD (Aguilar et al., 2005; Alexander et al., 2006).	*High confidence: Likely* overall decrease in CN, increase in WN (Aguilar et al., 2005; Alexander et al., 2006).	*Medium confidence*: Overall increase since 1960 (Kunkel et al., 2008). Some areas with significant WSDI increase, others with insignificant WSDI increase or decrease (Alexander et al., 2006).	*High confidence: Likely* increase in many areas since 1950 (Aguilar et al., 2005; Alexander et al., 2006; Trenberth et al., 2007; Kunkel et al., 2008).	*Medium confidence:* Overall slight decrease in dryness (SMA, PDSI, CDD) since 1950; regional variability and 1930s drought dominate the signal (Aguilar et al., 2005; Alexander et al., 2006; Kunkel et al., 2008; Sheffield and Wood, 2008a; Dai, 2011).
W. North America (WNA, 3)	*High confidence: Very likely* large increases in WD, large decreases in CD (Robeson, 2004; Vincent and Mekis, 2006; Kunkel et al., 2008; Peterson et al., 2008a).	*High confidence: Very likely* large decreases in CN, large increases in WN (Robeson, 2004; Vincent and Mekis, 2006; Kunkel et al., 2008; Peterson et al., 2008a).	*Medium confidence*: Increase in WSDI (Alexander et al., 2006).	*Medium confidence*: Spatially varying trends. General increase, decrease in some areas (Alexander et al., 2006).	*Medium confidence:* No overall or slight decrease in dryness (SMA, PDSI, CDD) since 1950; large variability, large drought of 1930s dominates (Alexander et al., 2006; Kunkel et al., 2008; Sheffield and Wood, 2008a; Dai, 2011).
Central North America (CNA, 4)	*Medium confidence:* Spatially varying trends. Small increases in WD, decreases in CD in north CNA. Small decreases in WD, increases in CD in south CNA (Robeson, 2004; Vincent and Mekis, 2006; Kunkel et al., 2008; Peterson et al., 2008a).	*Medium confidence*: Spatially varying trends. Small decreases in CN, increases in WN in north CNA. Small increases in CN, decreases in WN in south CNA (Robeson, 2004; Vincent and Mekis, 2006; Kunkel et	*Medium confidence*: Spatially varying trends. Some areas with WSDI increase, others with WSDI decrease (Alexander et al., 2006).	*High confidence: Very likely* increase since 1950 (Alexander et al., 2006).	*Medium confidence*: Decrease in dryness (SMA, PDSI, CDD) and increase in mean precipitation since 1950; large variability, large drought of 1930s dominates (Alexander et al., 2006; Kunkel et al., 2008;

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IPCC WG1: Regional information, how were regions used?

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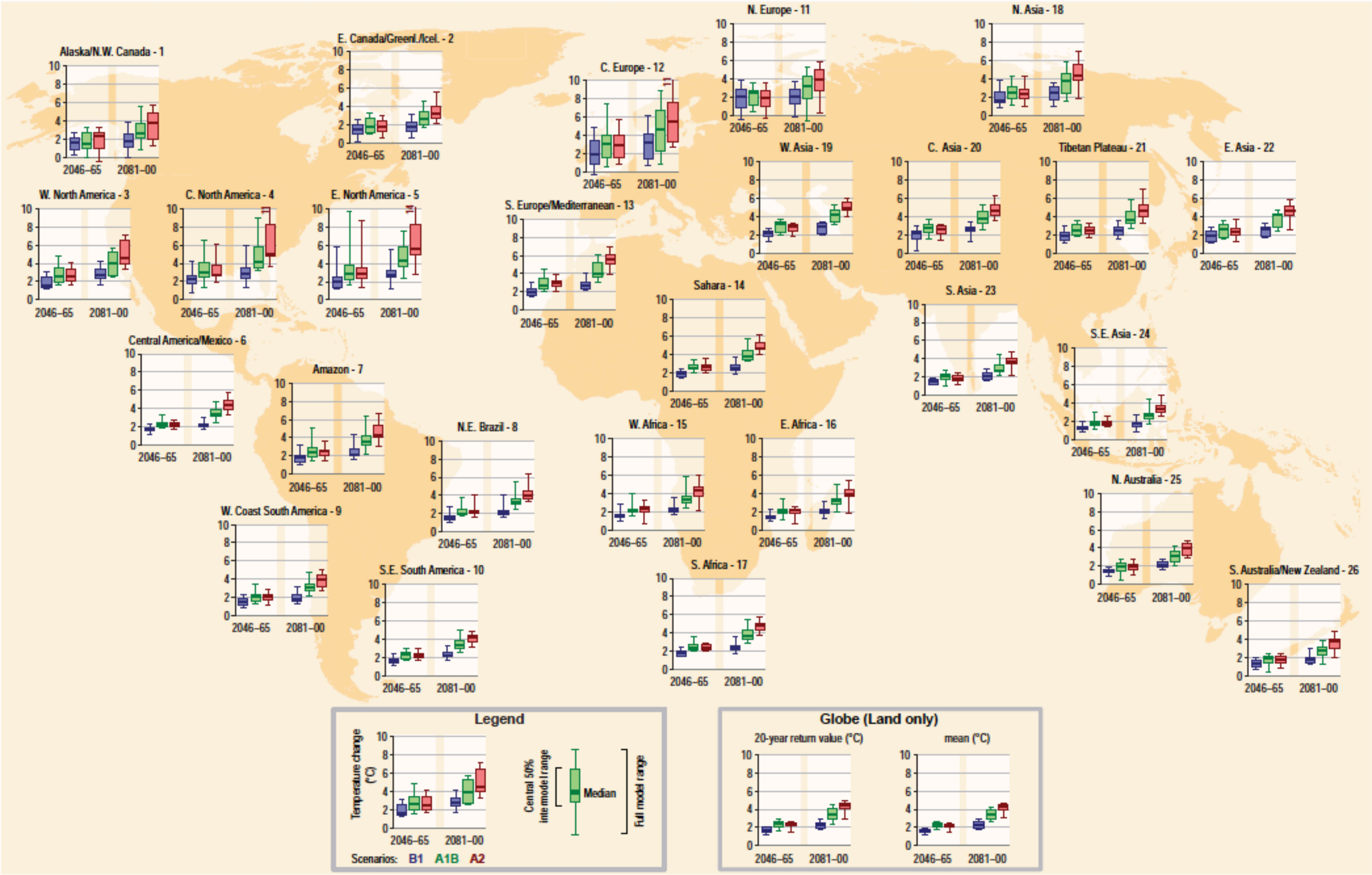

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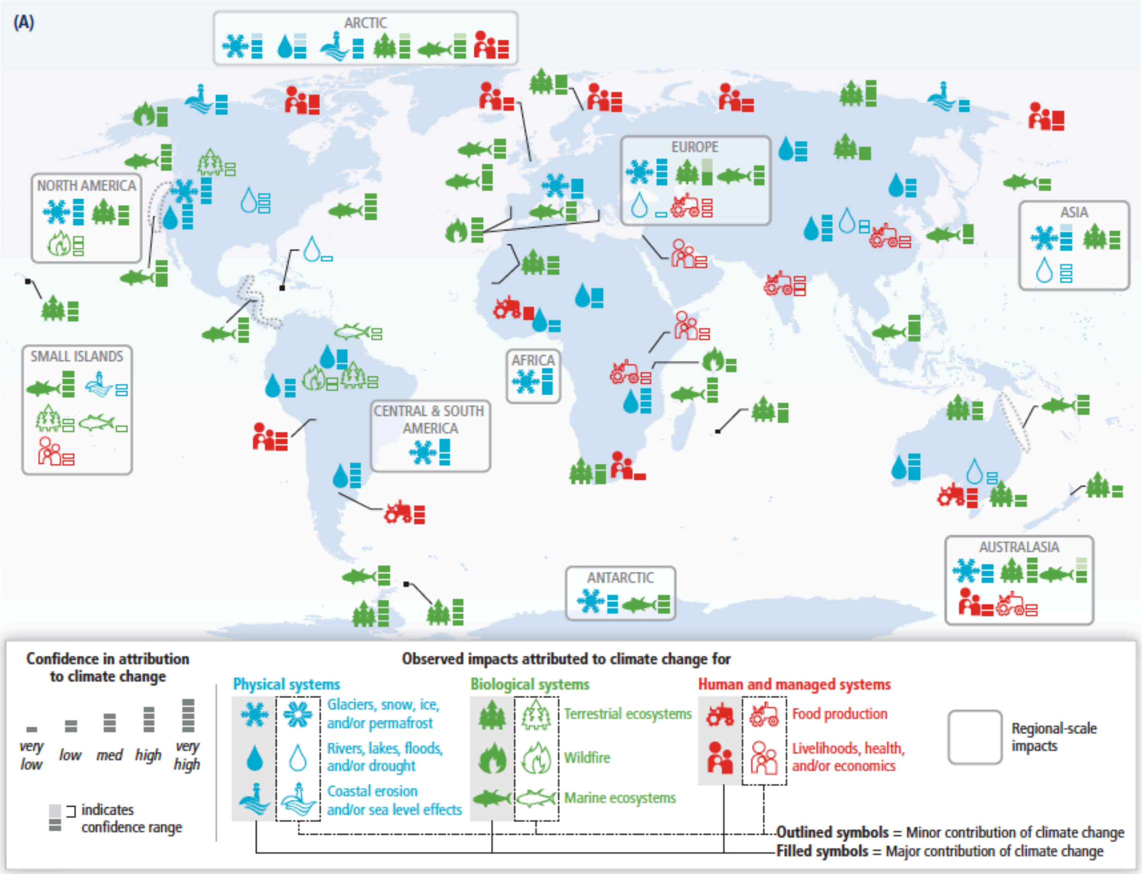
IPCC WG2: Regional information



NB: SREX used in part in WG2 (e.g. in TS)

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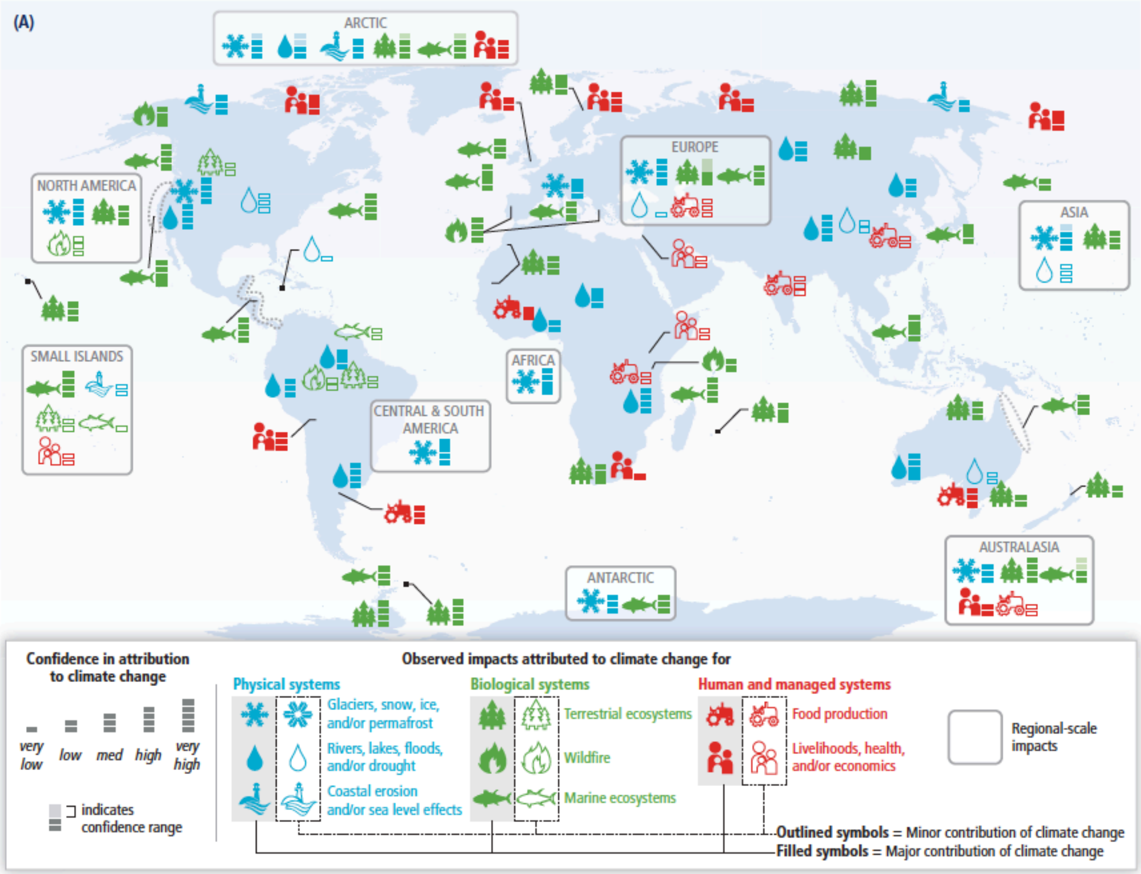
IPCC WG2: Regional information



Overall focus rather on continental scale (Europe, N. America, Africa, …)

Advantages:

- More integrated information
- Politically, and with respect to vulnerability and exposure, continental separation can make more sense (e.g. Africa vs Europe for MED)

Some issues:

- Plot is not clear regarding where e.g. “tractor” is relevant
- Mixes ups climatic regions
- Not so informative at country level

NB: SREX used in part in WG2 (e.g. in TS)

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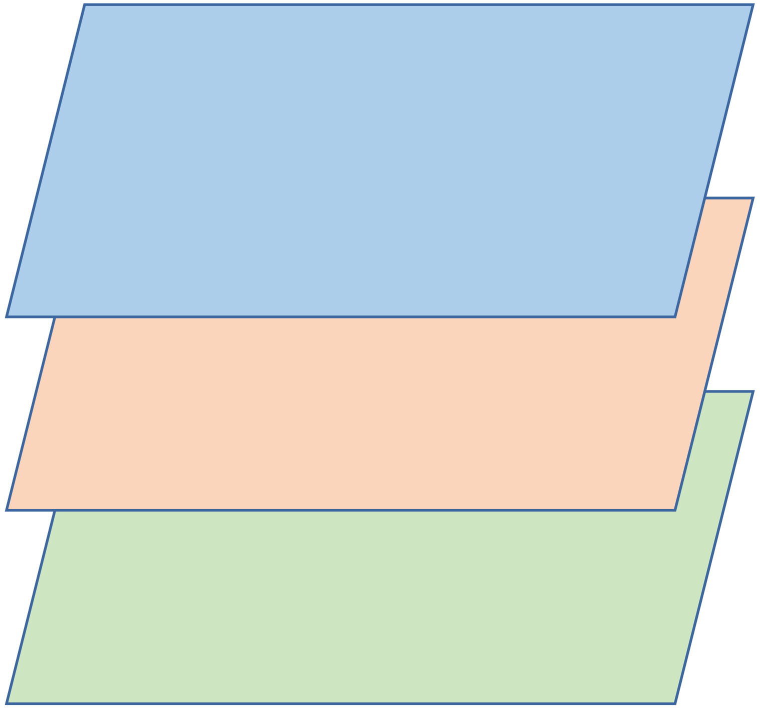
Perspectives for AR6

Consider "layered" regional information



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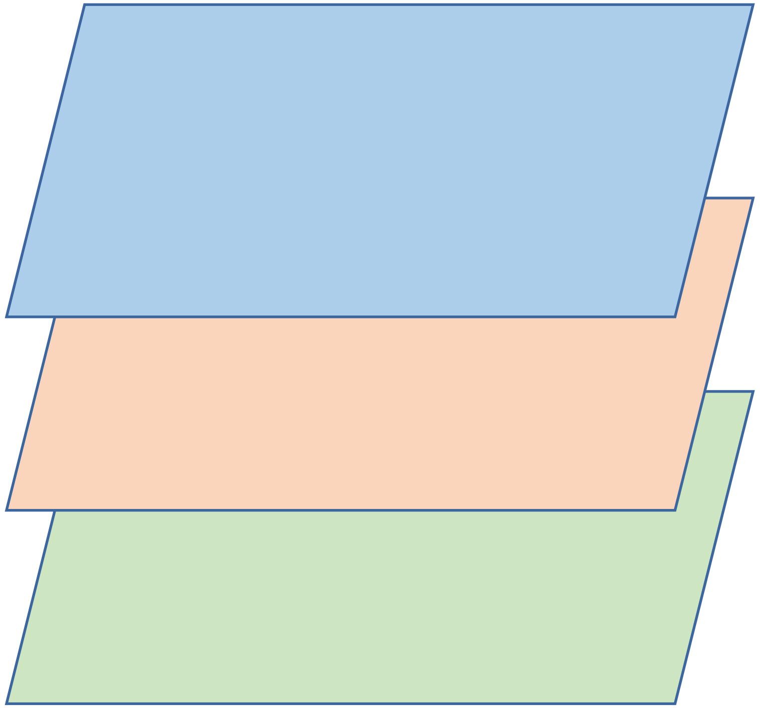
Perspectives for AR6



Consider “layered” regional information

Changes in climate variables, extremes

- SREX-type regions (not necessarily boxes)
- Based on climate zones

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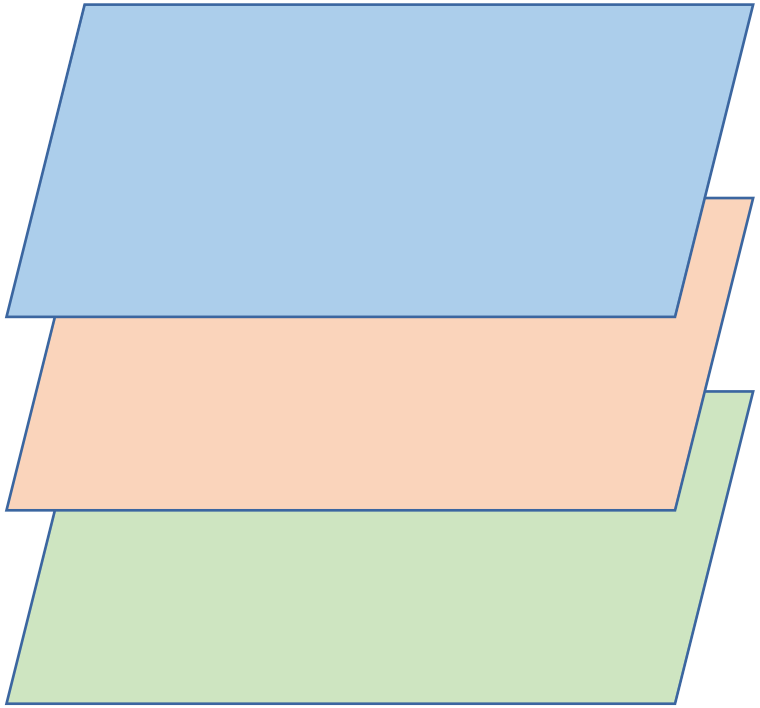
Perspectives for AR6



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Vulnerability:

- Countries/political units
- Poverty, demographics (age), adaptation, ecosystems

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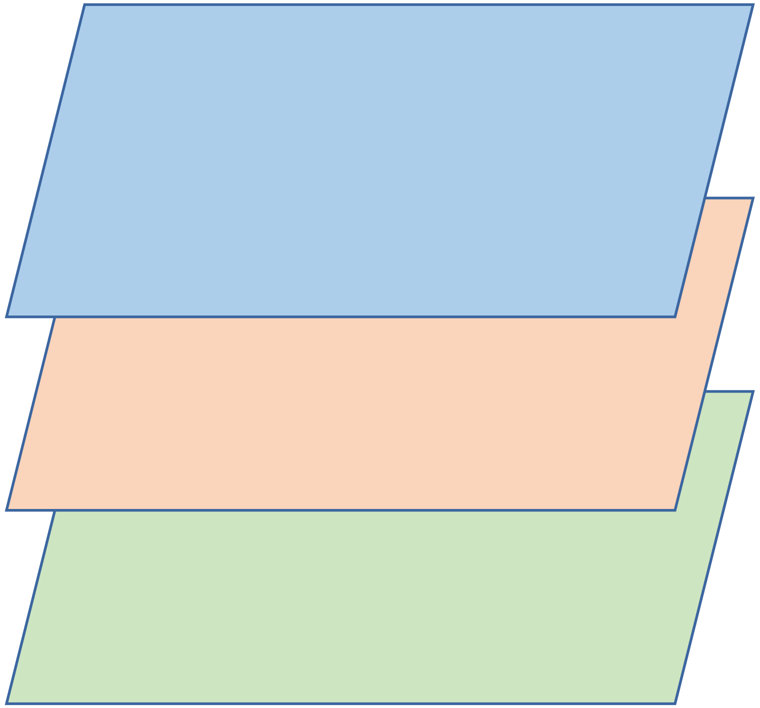
Perspectives for AR6



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Exposure:
- Population
- Inhabited regions, agriculture

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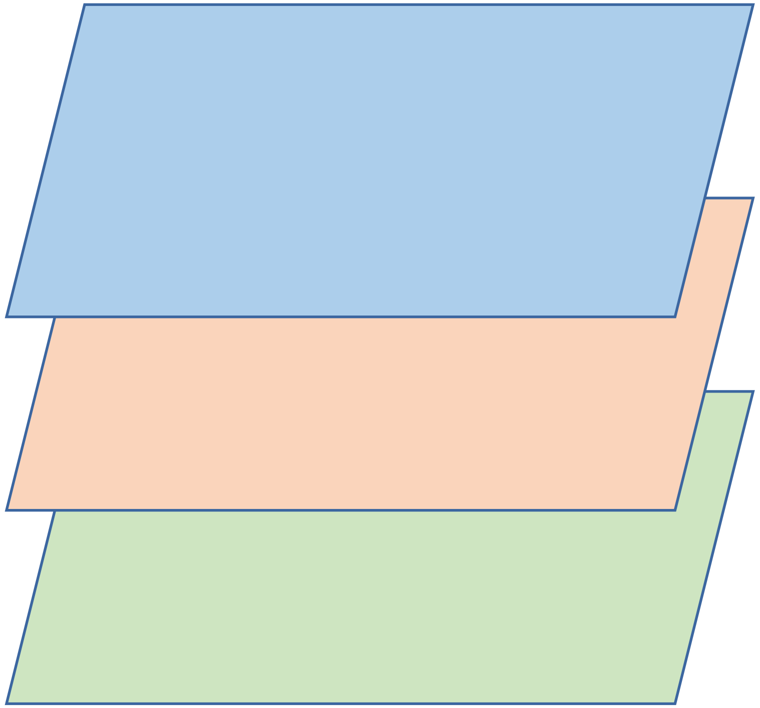
Perspectives for AR6



Consider “layered” regional information

Changes in climate variables, extremes

- SREX-type regions (not necessarily boxes)
- Based on climate zones

Vulnerability:

- Countries/political units
- Poverty, demographics (age), adaptation, ecosystems

Exposure:

- Population
- Inhabited regions, agriculture

Geophysical properties
Coastal regions, mountains, wetlands etc.

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Perspectives for AR6 (especially ch11, extremes)

Other elements:

- Top-down vs bottom-up impacts perspective (e.g. for definition of relevant hazards/ extremes, regional units, …)

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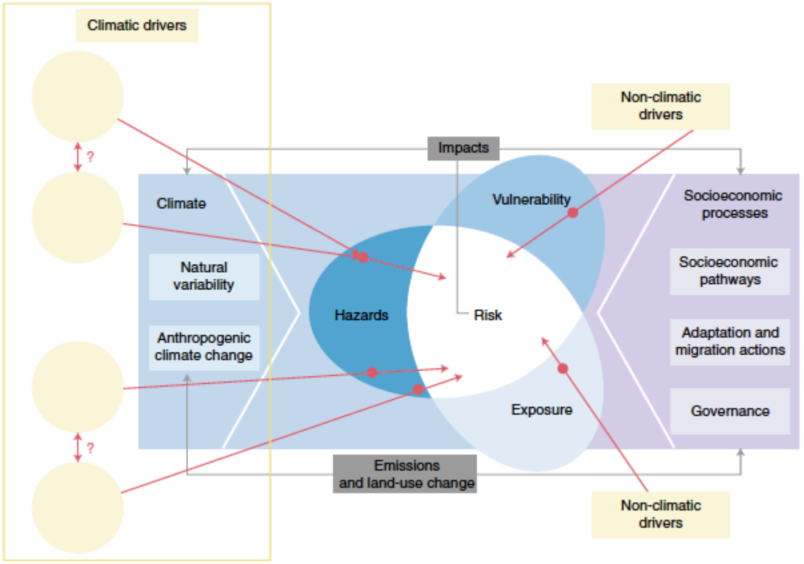
- Compound events, multivariate extremes



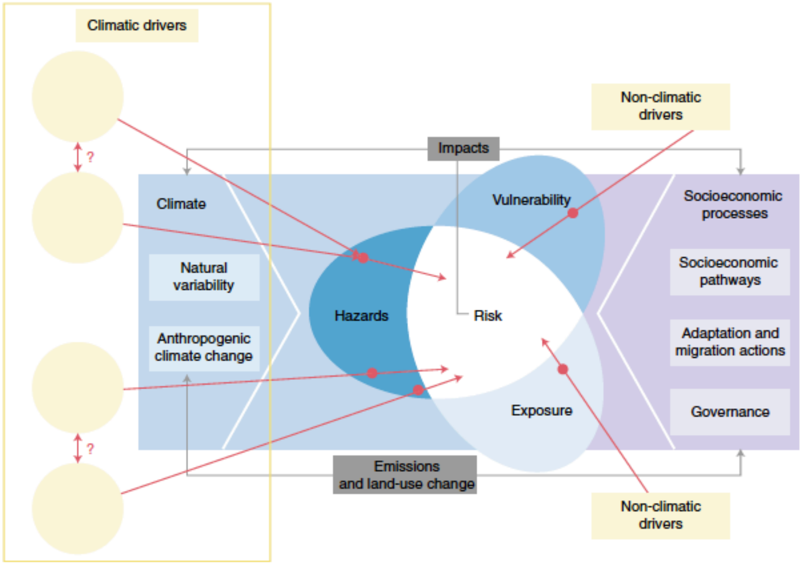
(Zscheischler et al. 2018, Nature Climate Change)

(Sonia I. Seneviratne, ETH Zurich)

Perspectives for AR6 (especially ch11, extremes)

Other elements:

- Top-down vs bottom-up impacts perspective (e.g. for definition of relevant hazards/ extremes, regional units, …)
- Compound events, multivariate extremes
- Storylines



(Zscheischler et al. 2018, Nature Climate Change)

(Sonia I. Seneviratne, ETH Zurich)

THANK YOU FOR THE ATTENTION!

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Chapter 11:
Weather and climate extreme events in a changing climate
Executive Summary

- Extreme types, encompassing weather and climate timescales and compound events (including droughts, tropical cyclones)
- Observations for extremes and their limitations, including paleo
- Mechanisms, drivers and feedbacks leading to extremes
- Ability of models to simulate extremes and related processes
- Attribution of changes in extremes and extreme events
- Assessment of projected changes of extremes and potential surprises
- Case studies across timescales

Frequently Asked Questions