Chaire Hydrologie pour une ville résiliente

Multiscale Resilience, some achievements and prospects

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Day 2019 of the Chair
Veolia, Aubervilliers
7 May, 2019

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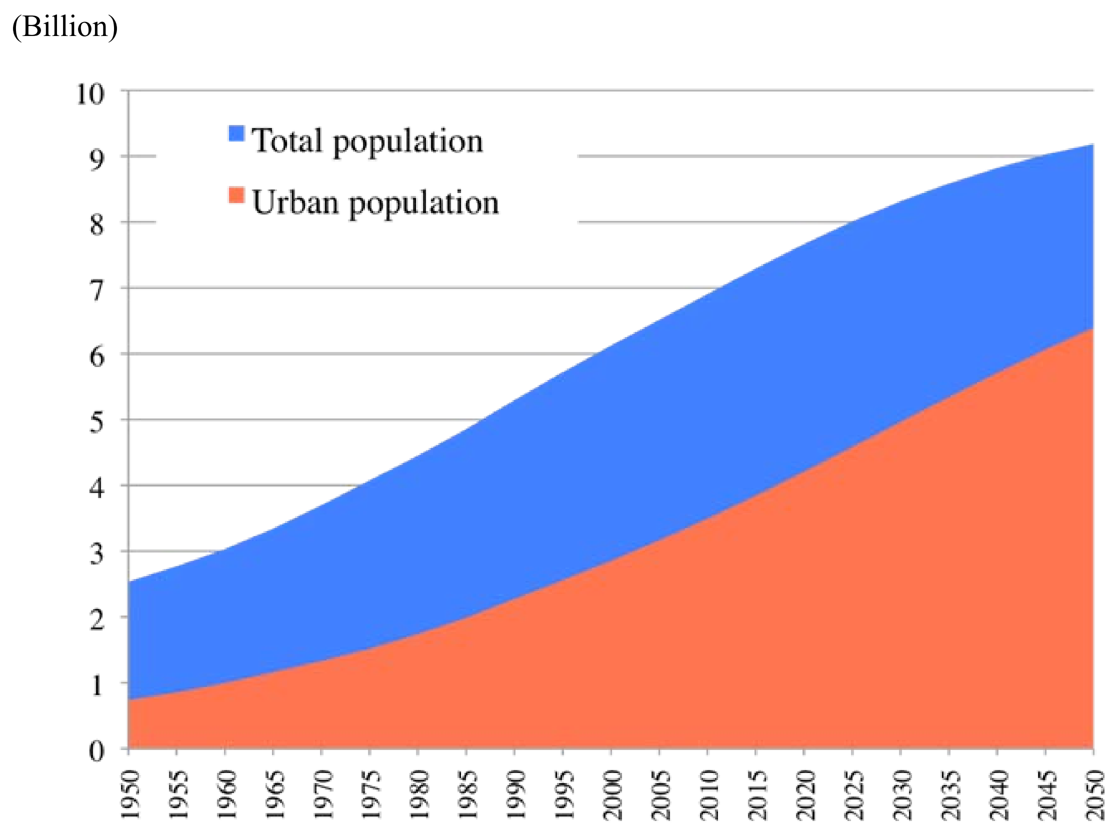
Why Cities ?

Growing Urban Population



- a few key UN figures
  - majority of the wor urbanised
    - by 2050: 80% / emerging countr
    - total growth of th expected in citie
  - most assets are al
  - 70-80% of GHG p production

IPCC process

- IPCC reports the most developed attempts of a dialogue between Science and Policy
  - a 3-step filtering

    climate research (which is vast!)

    —> Assessment Reports (AR):

    —> Synthesis Report (SYR)

    —> Summary for Policymaker (SPM)

    => evolution of an extremely complex system in few lines, e.g.,

SPM 1. Observed Changes and their Causes

> **Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.** *{1}*

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Economical scenarios

SPM 2.1 Key drivers of future climate

Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socio-economic development and climate policy. *{2.1}*

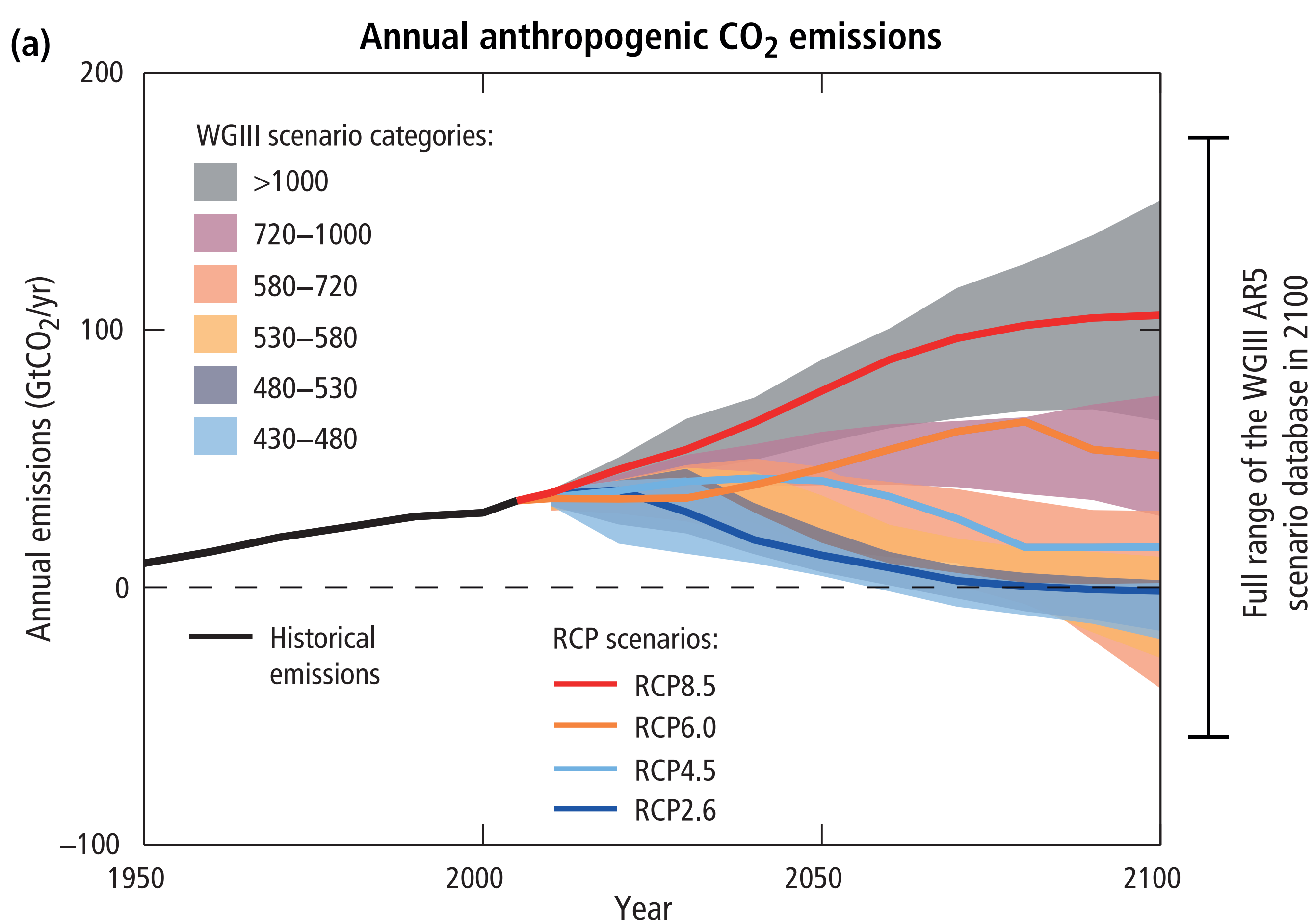

Figure SPM.5 | (**a**) Emissions of carbon dioxide (CO_2) alone in the Representative Concentration Pathways (RCPs) (lines) and the associated scenario categories used in WGIII (coloured areas show 5 to 95% range). The WGIII scenario categories summarize the wide range of emission scenarios published in the scientific literature and are defined on the basis of CO_2-eq concentration levels (in ppm) in 2100.

SPM 2.2 Projected changes in the climate system

Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is *very likely* that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise. *{2.2}*

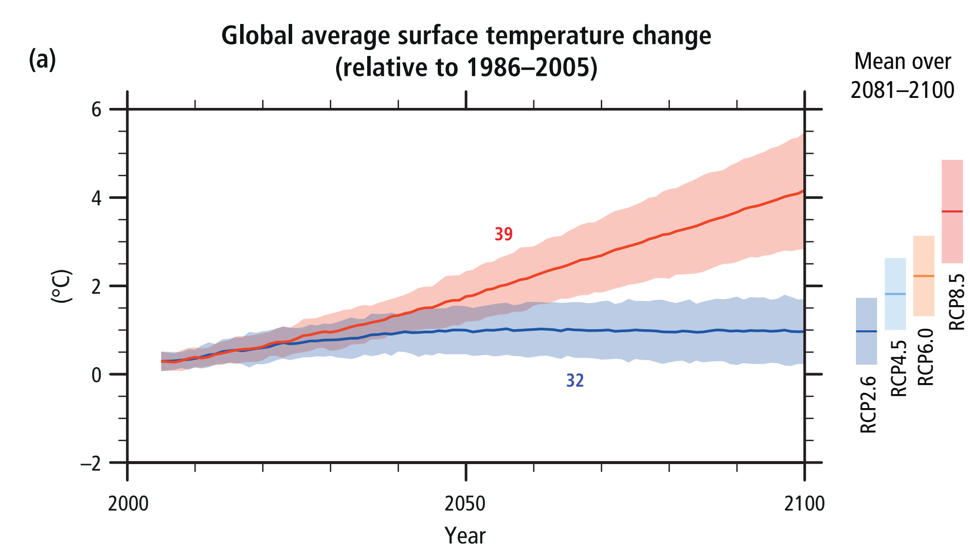

Figure SPM.6 | Global average surface temperature change (**a**) All changes are relative to 1986–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). The mean and associated uncertainties averaged over 2081–2100 are given for all RCP scenarios as coloured vertical bars at the right hand side of each panel. The number of Coupled Model Intercomparison Project Phase 5 (CMIP5) models used to calculate the multi-multi-model mean is indicated

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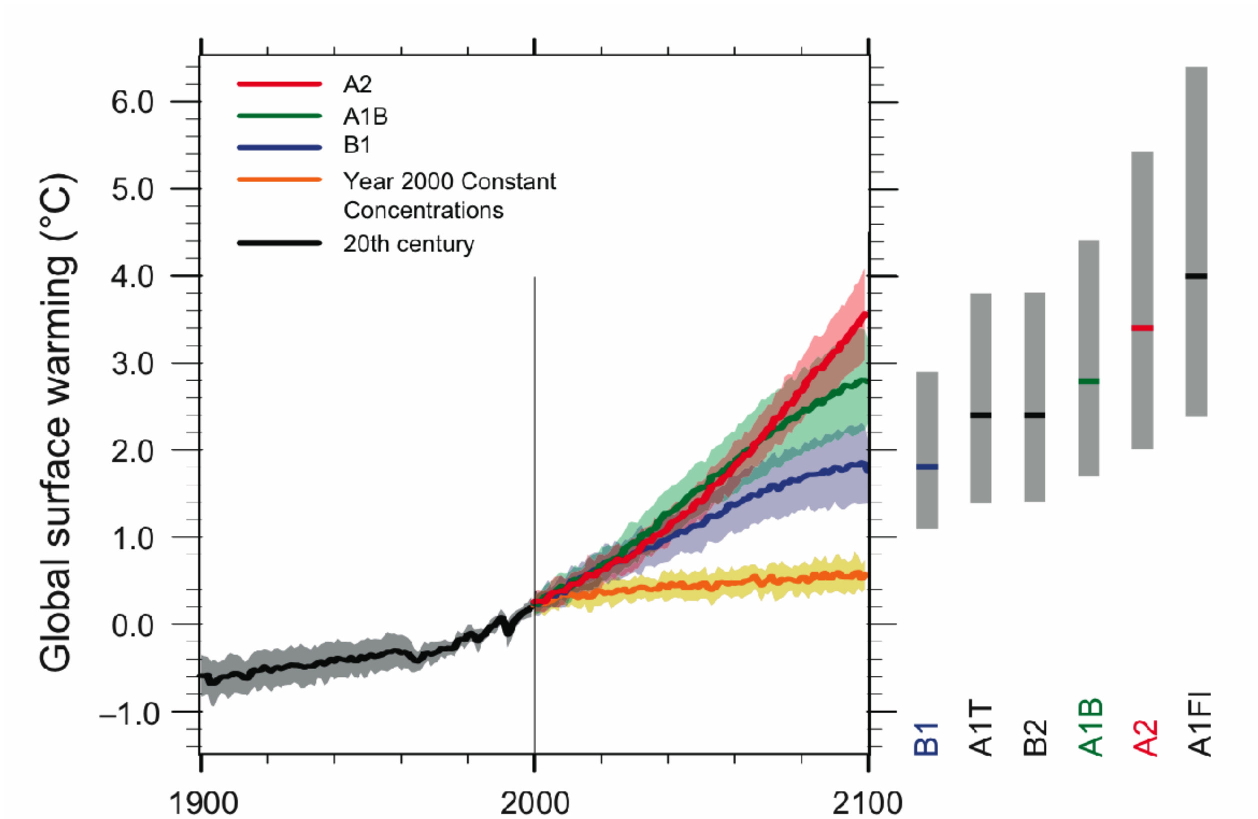
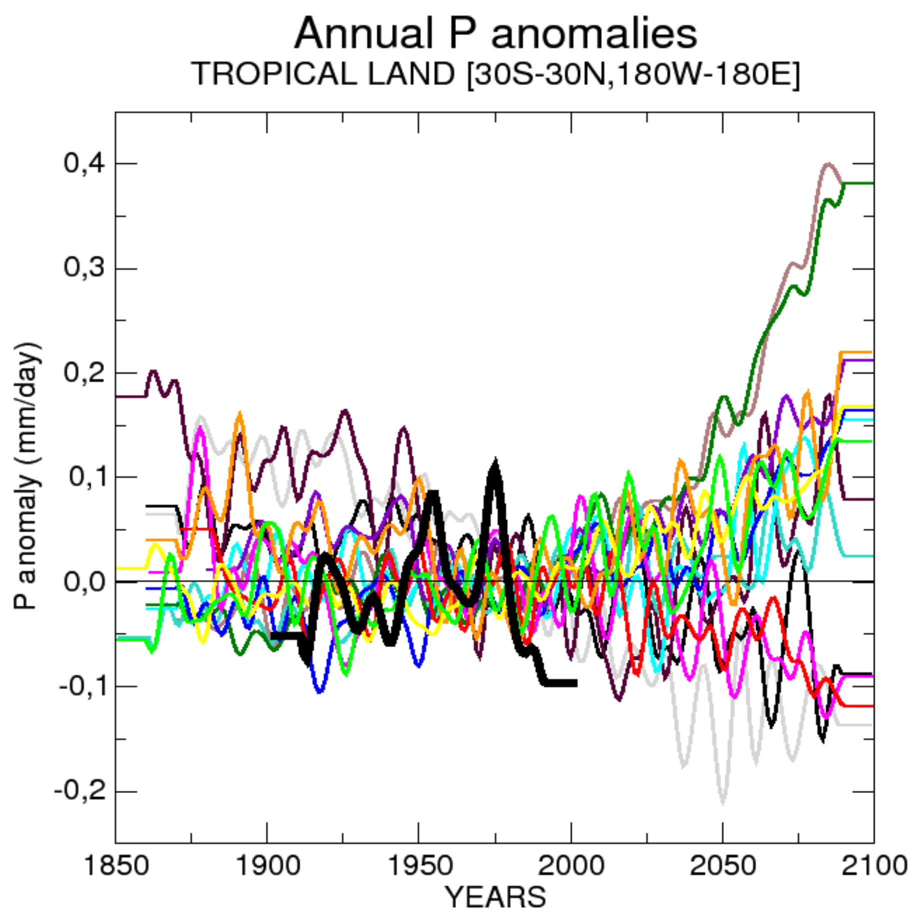
IPCC AR4

- IPCC reports crucial





Agreement of models on a temperature increase…

but **disagreement** on the evolution of precipitation extremes !

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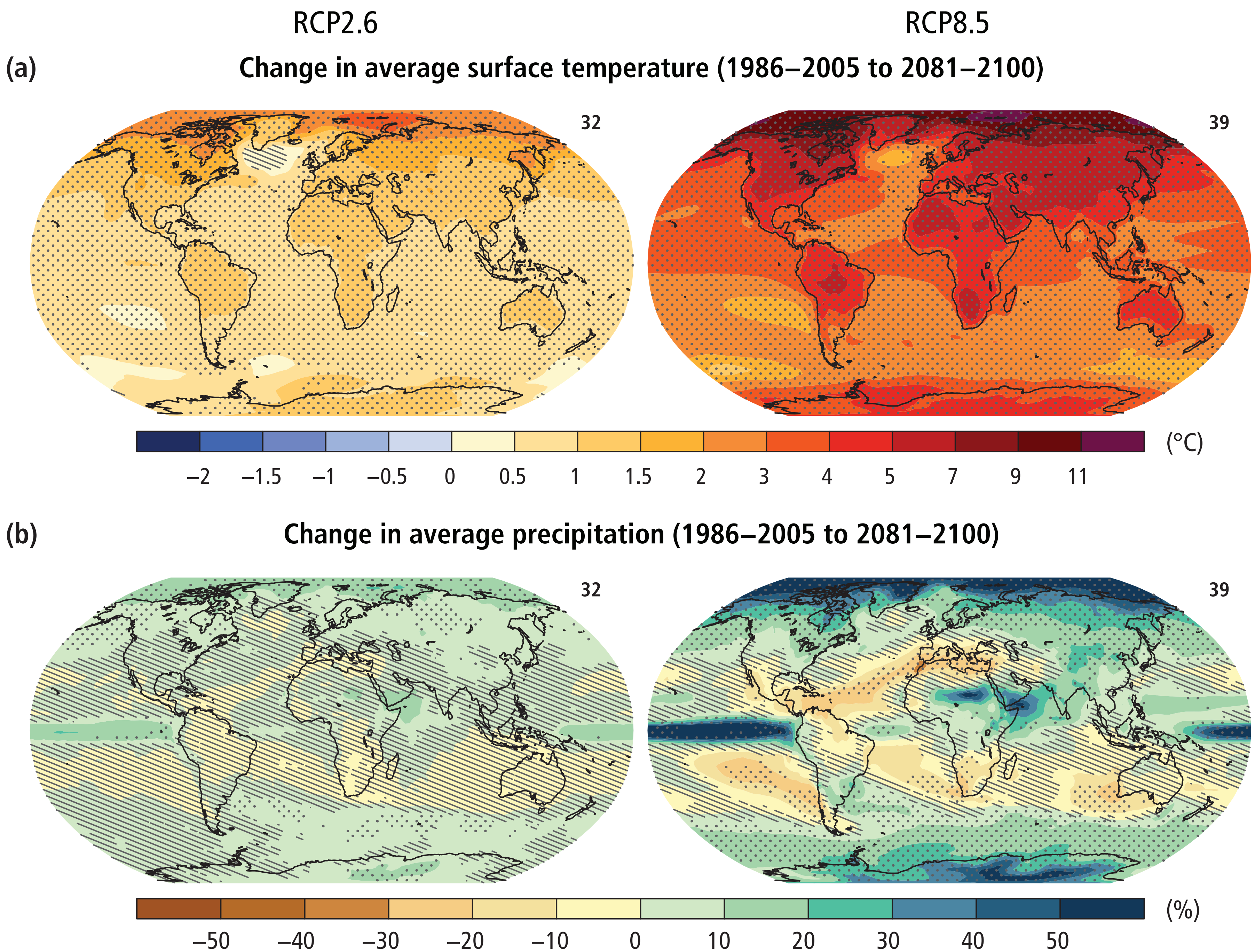
IPCC AR5



Dotted areas: projected change larger than natural internal variability

Hatched areas: projected change less than one standard deviation than natural internal variability

SPM 2.2 Projected changes in the climate system

Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is *very likely* that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise. *{2.2}*

Figure SPM.7 | Change in average surface temperature **(a)** and change in average precipitation **(b)** based on multi-model mean projections for 2081–2100 relative to 1986–2005 under the RCP2.6 (left) and RCP8.5 (right) scenarios.

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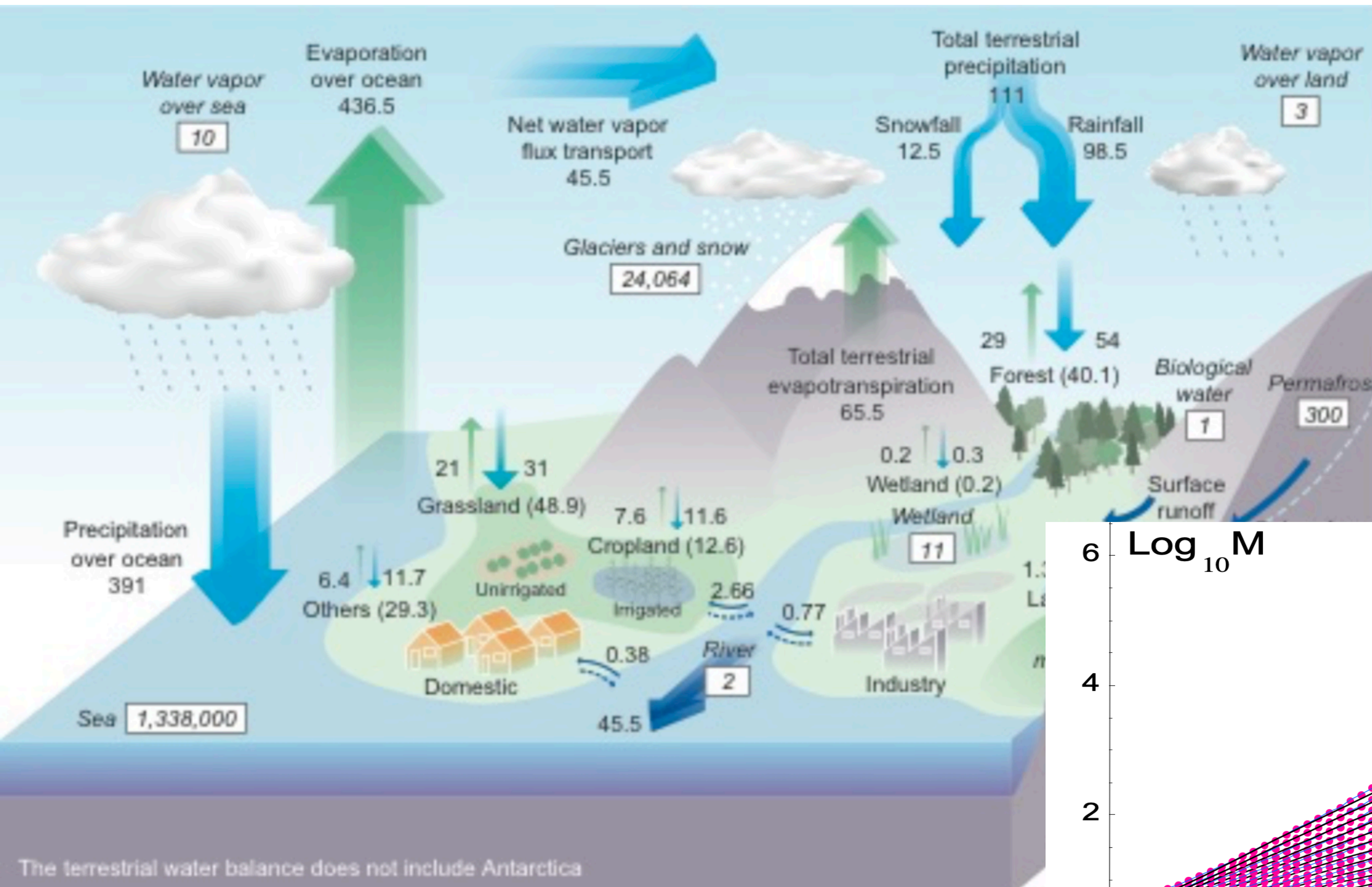
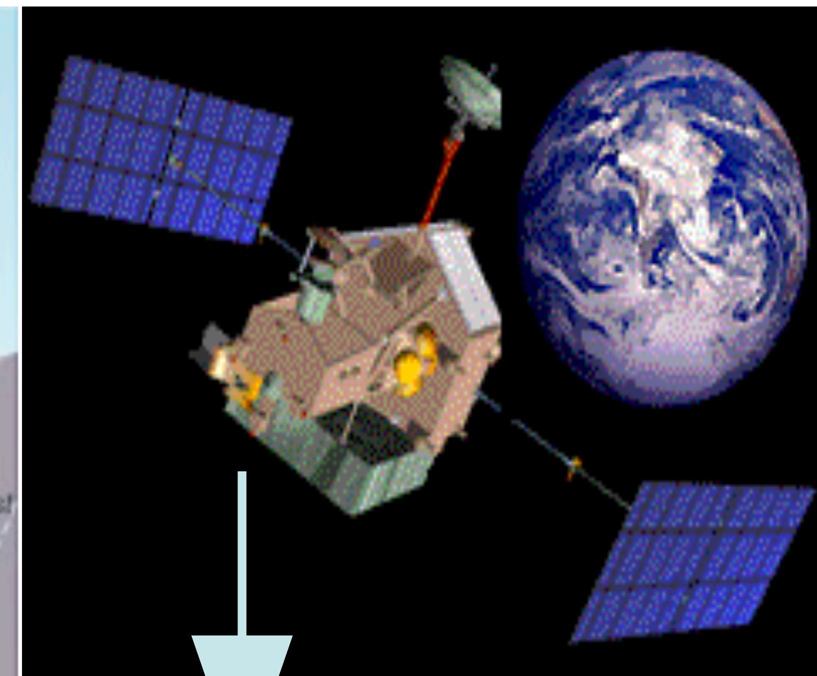
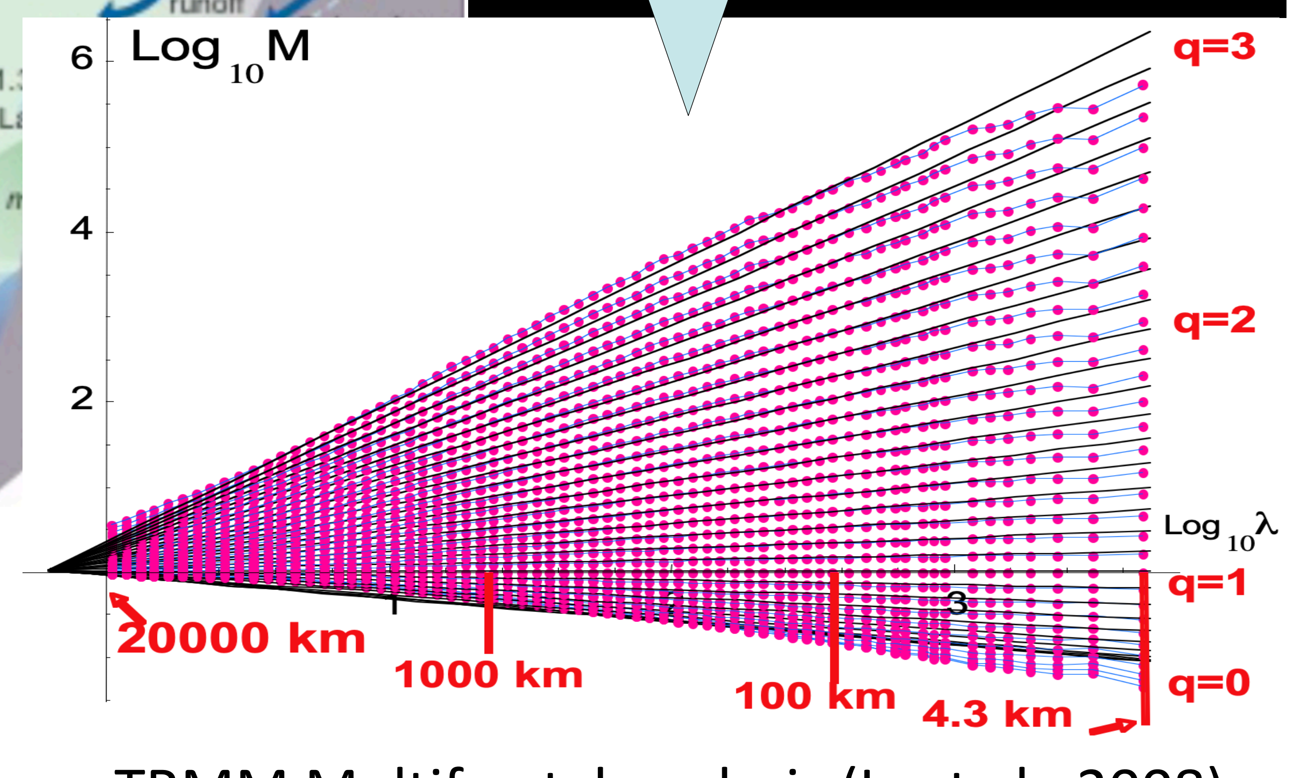
Deadlock: water cycles



Global hydrological cycle (Oki & Kanae , 2006)



TRMM, JAXA and NASA



TRMM Multifractal analysis (L. et al., 2008)

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Integrative approaches vs. silo thinking

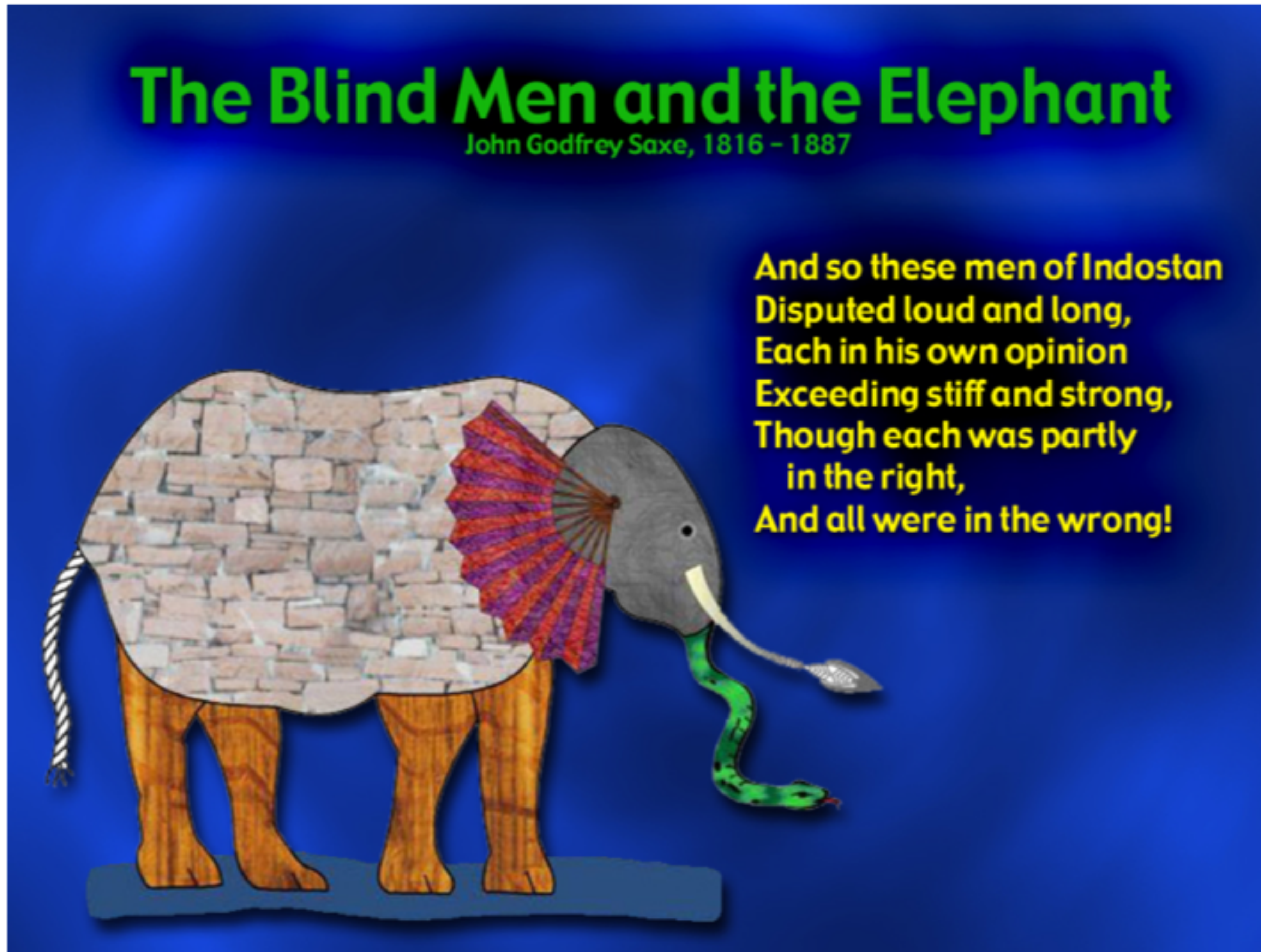
PUB decade 2003-2013
Prediction in Ungaged Basins

PREDICTIONS IN UNGAUGED BASINS: PUB KICK OFF

IAHS AISH

Author / Editor: D. Schertzer et al.
Publication Number: 309
ISBN Number: 978-1-901502-83-1
Year: 2007
Pages: 322

Price: £0.00



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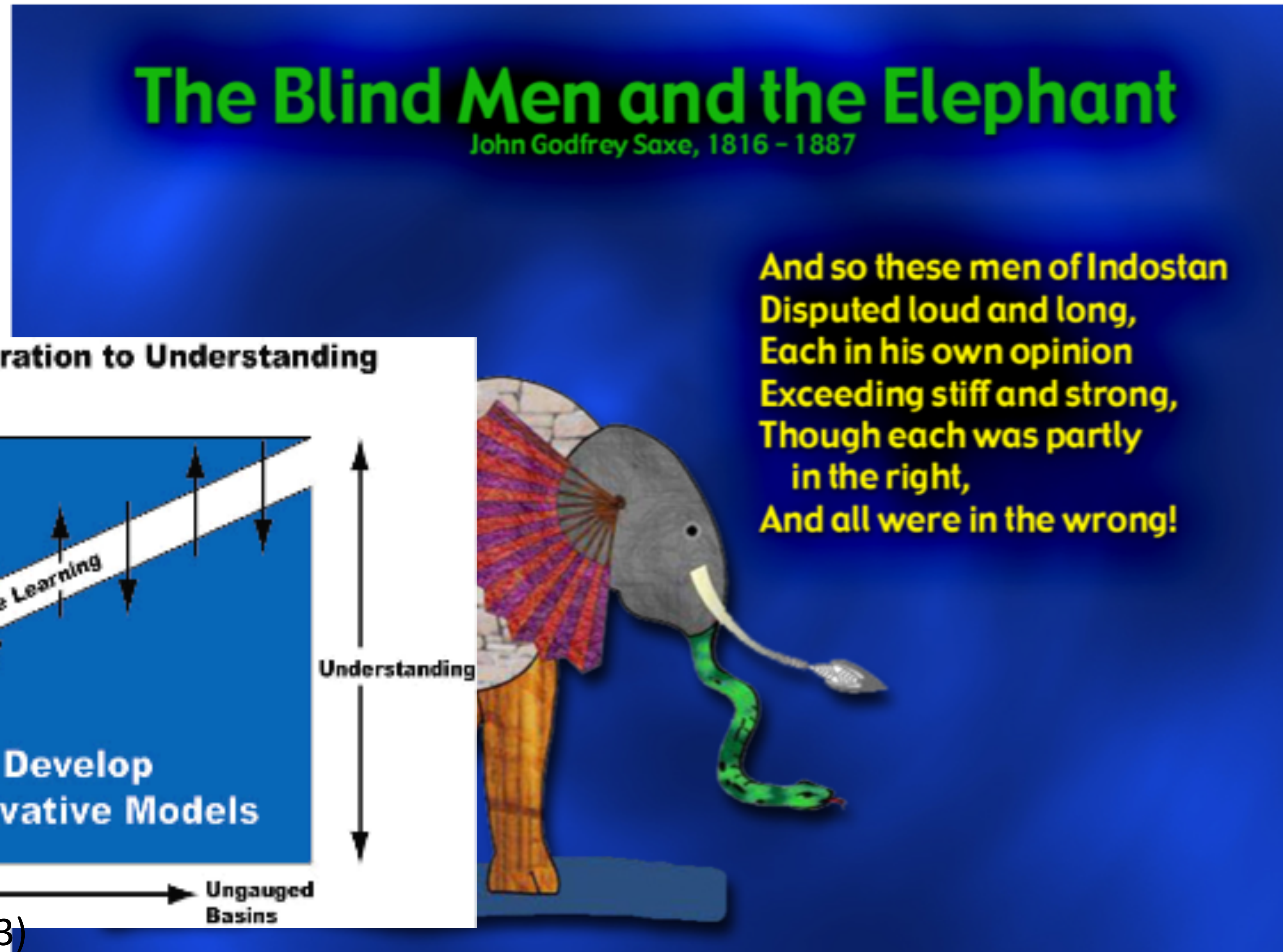
Integrative approaches vs. silo thinking



PUB decade 2003-2013
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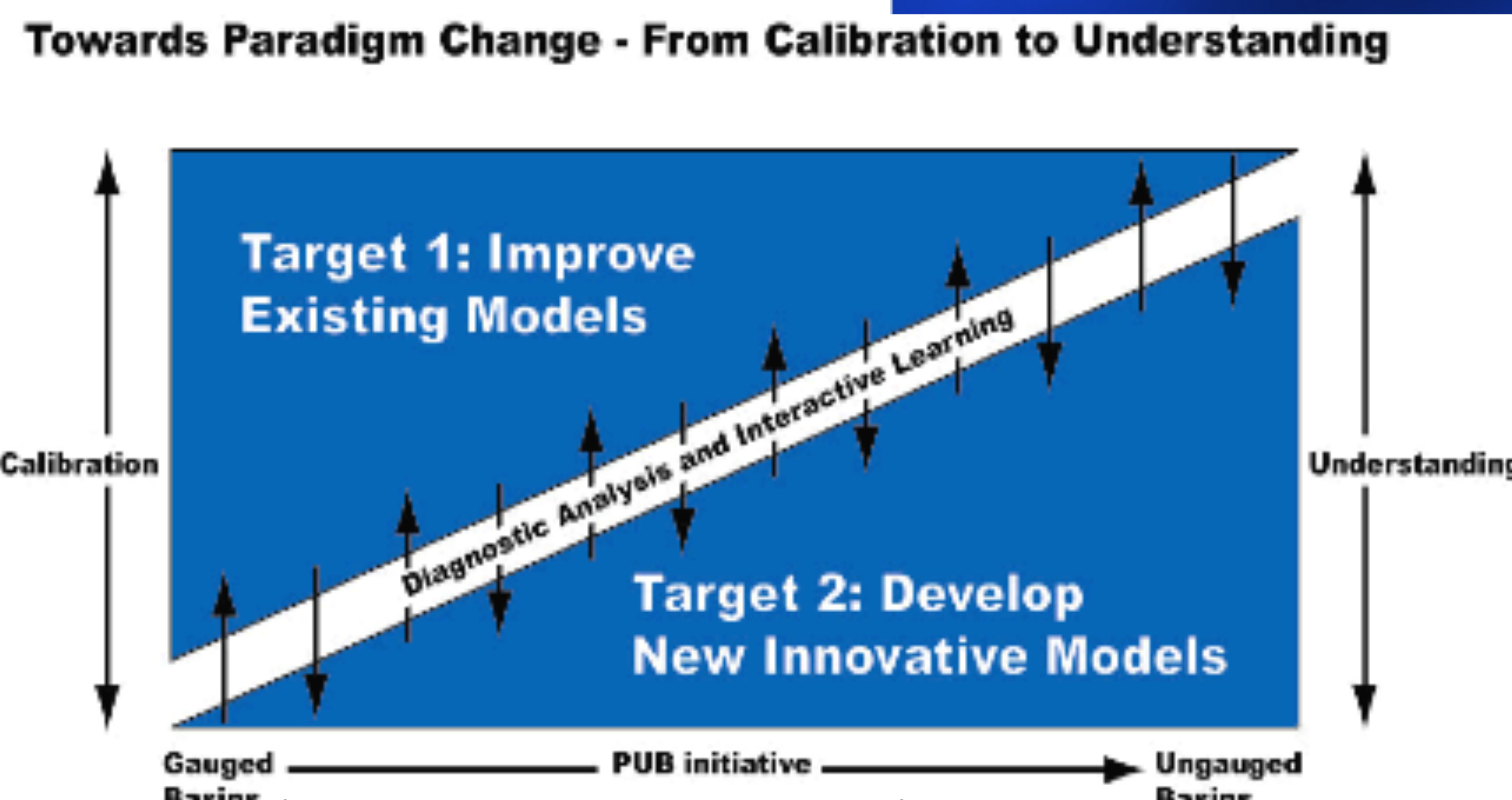
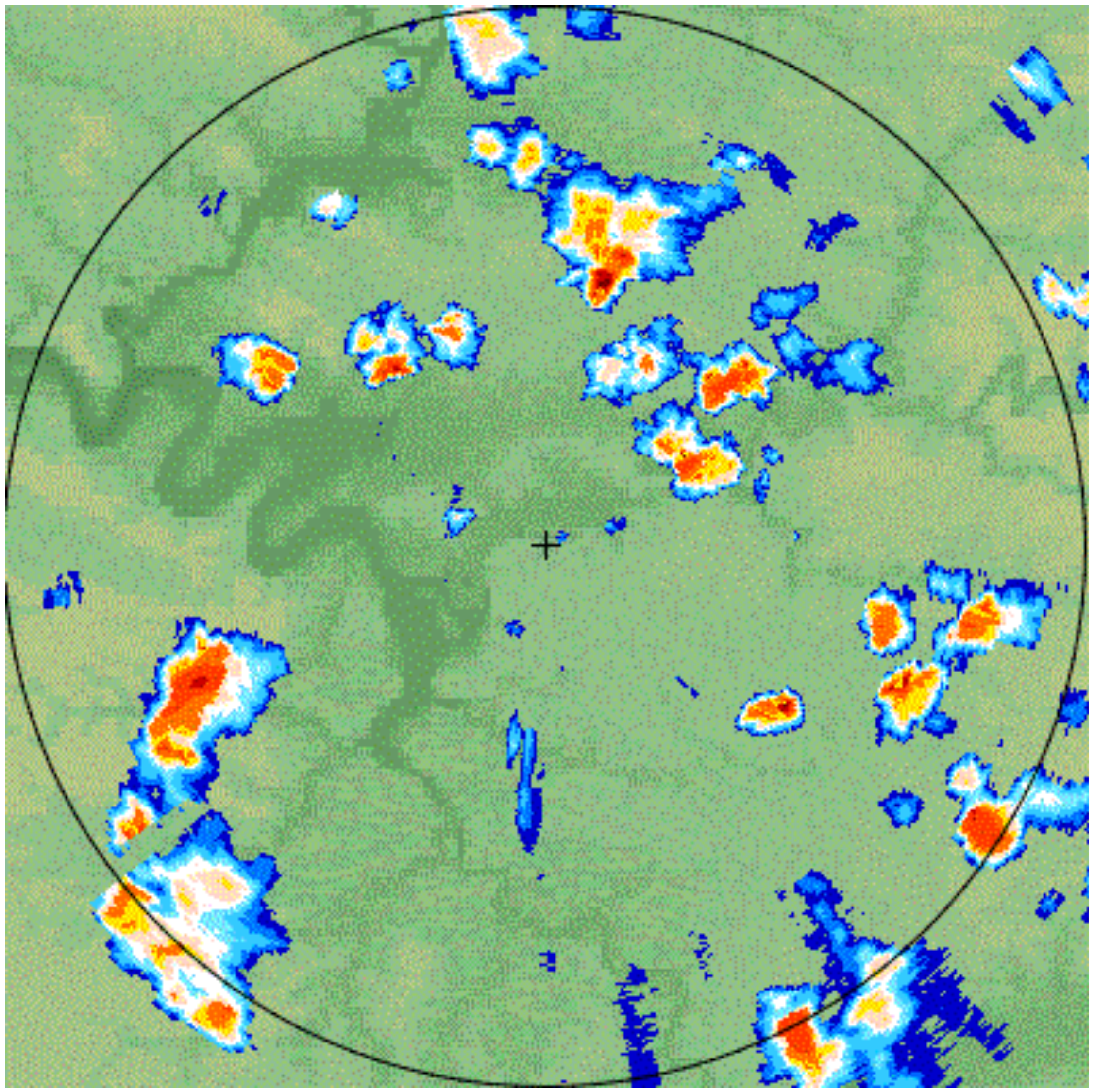
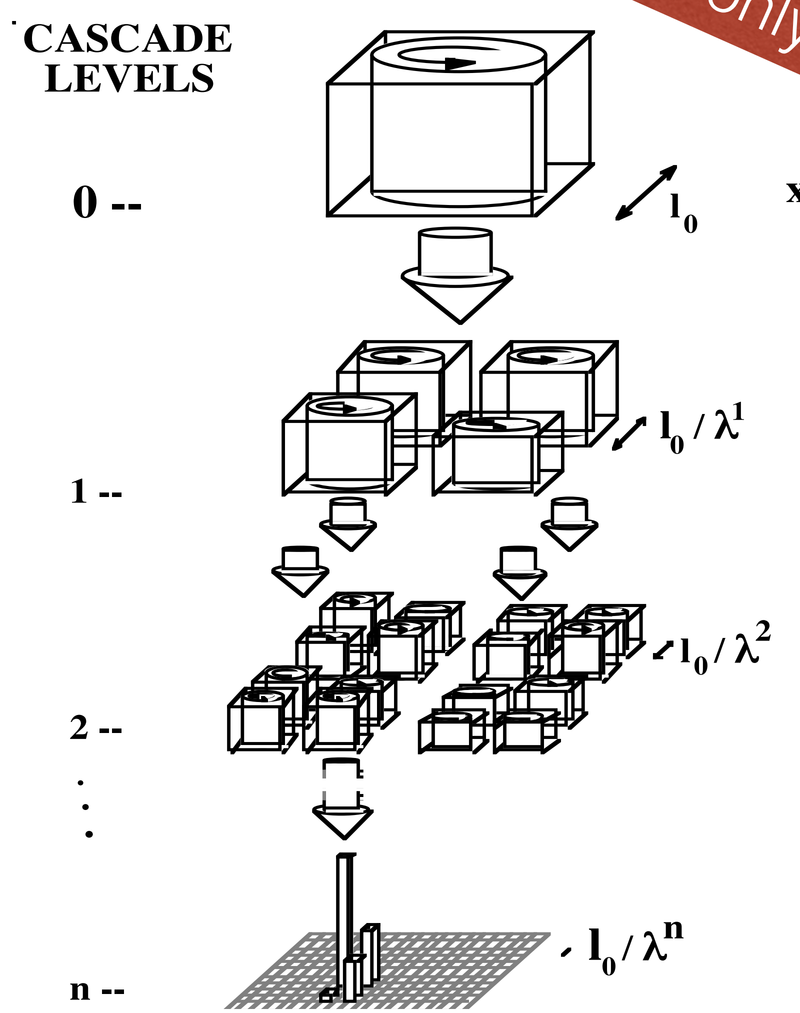


(Schertzer and Gupta, 2013)

Russian dolls… and multiplicative cascades

Discrete in scale cascades only for pedagogy !





Polarimetric radar observations of heavy rainfalls over Paris region during 2016 spring (250 m resolution):

- **heaviest rain cells** are much smaller than **moderate ones**
- true for their dimensions => **multifractal field**
- **complex dynamics** of their aggregation into a large front

To downscale climate scenarios?

Consensus on the need to downscale simulations:

- to manage water
- modelling cities below a kilometer?

but a fondamental obstacle :

- relationships large/small scales
- *stationnary?* (« stationnarity is dead ! »)
- Implicit hypothesis in:

- correlations (linear or not) large/small scales or neural networks: training on « non perturbated » data sets;
- weather types: stationnary basis, only frequences change;
- GCM: stationnary parametrisations of small scales…

Alternative:

- Analyze and take into account the evolution of **fluxes through scales!**
- Example: **rainrate** for the water cycle.

Scaling of precipitations

1. **Parsimonious description: only 3 exponents:**

– intermittency:

- average intermittency $\boldsymbol{C_1}$: how sparse is the average rainfall?

$C_1 \neq 0$: it does not rain everyday, everywhere!

- intermittency variability α : diversity of rainfall regimes

$\alpha \neq 0$: not only the alternative rain/no rain!

– scale dependence $\boldsymbol{H}$ of the average rainfall $<R_l>$?

For rainfall **H**≈0

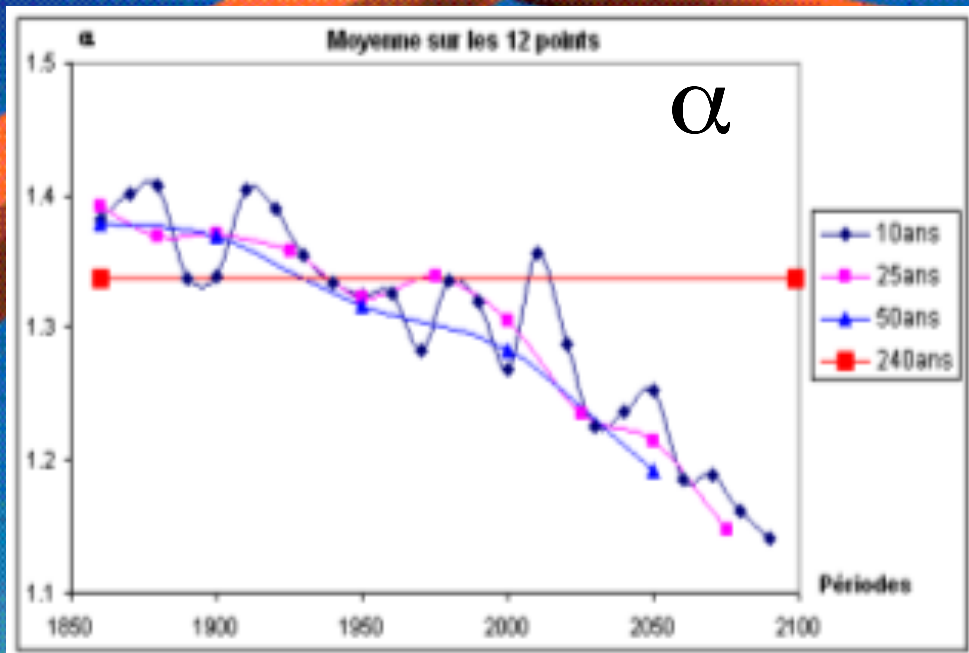
a **Trivial conséquences for the extremes:**

C_1 and α ↑ => extremes ↑ or C_1 and α ↓ => extremes↓

a **More generally:**

- these exponents define the Intensity-Duration-Frequency (IDF) curves over a wide range of scale and intensities (Benjdoudi et al., 1987, Tchiguirinskaia et al 2010) ;
- allow to compare quantiles over various durations

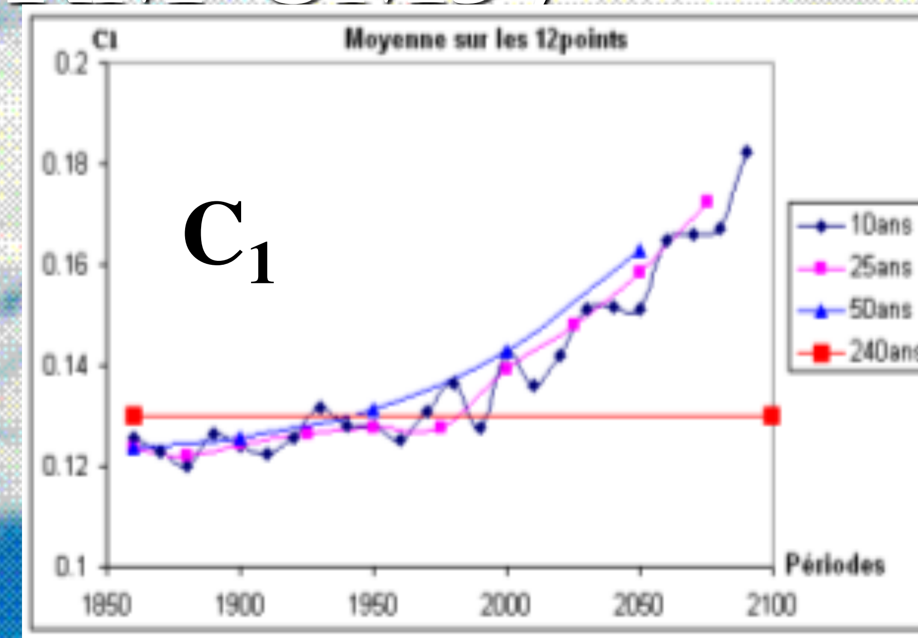
Multiscale analysis of the scenario A2 1860-2100 (CNRM-CM3)

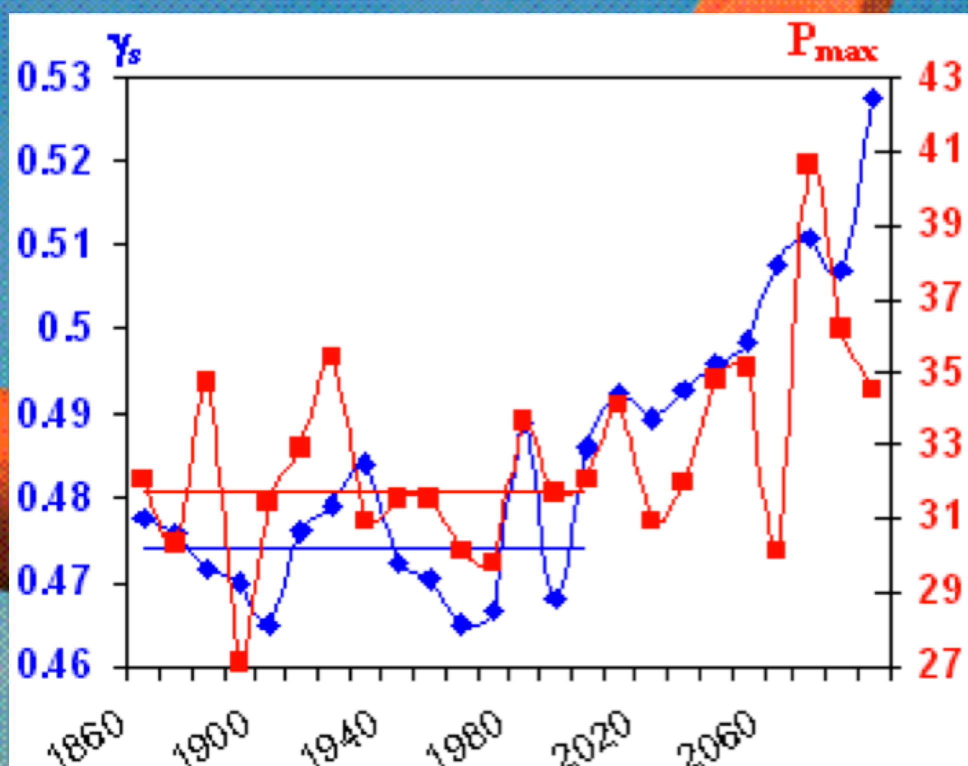


• **average intermittency C1** ↑

•**intermittency variability** α ↓,

=> difficulty to evaluate extremes of precipitations





=> refined analysis :

- time volution of the **Most Probable Singularity** γ_s (Hubert et al, 1993; Douglas & Barros, 2003):

- a scale invariant statistic, more stable than the maximal simulated precipitation P_{max}.

- Enable us to conclude: **extremes** ↑ (Royer et al., 2008),

-- seasonality can be taken into account (Royer et al., 2010)

Context

- Recent international agreements
  - 18/03/2015, Sendai Framework for Disaster Risk Reduction 2015 – 2030:
    - 3rd priority/4: invest in resilience
  - 21/10/2015, UN 2030 Agenda for Sustainable Development
  - 11/12/2015, COP21 “Paris Agreement”:
    - develop/ increase resilience to climate change
  - UN-Habitat City Resilience Profiling Programme, CRPP: to measure and improve resilience to multi-risks
  - 30/05/2016, Urban Agenda for the EU: EU, as UN partner, support all these agreements

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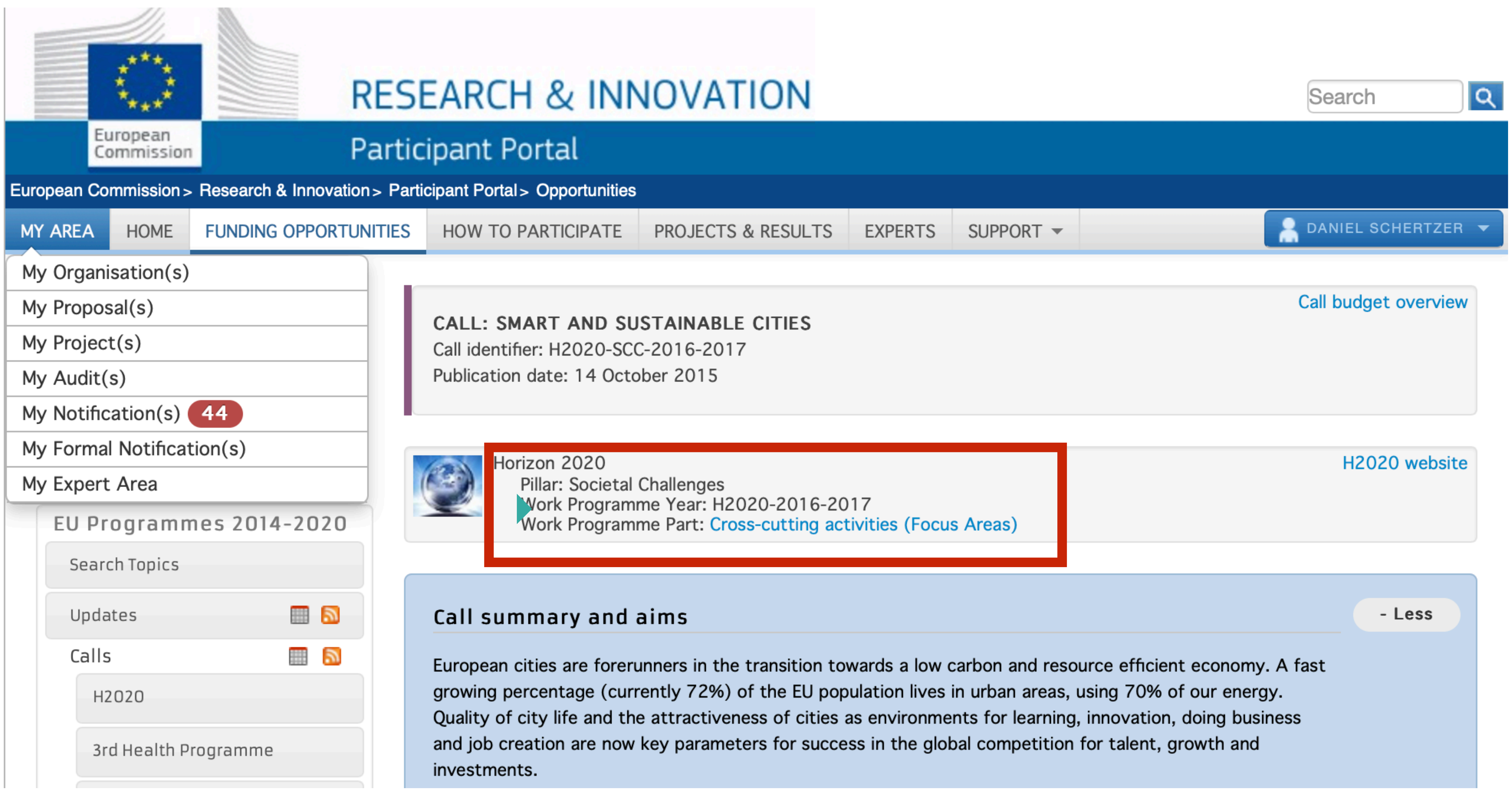
Europe engagement

Cities to become smart, safe, resilient, sustainable, inclusive, enjoyable, and to increase well-being and health.



Corporate engagements

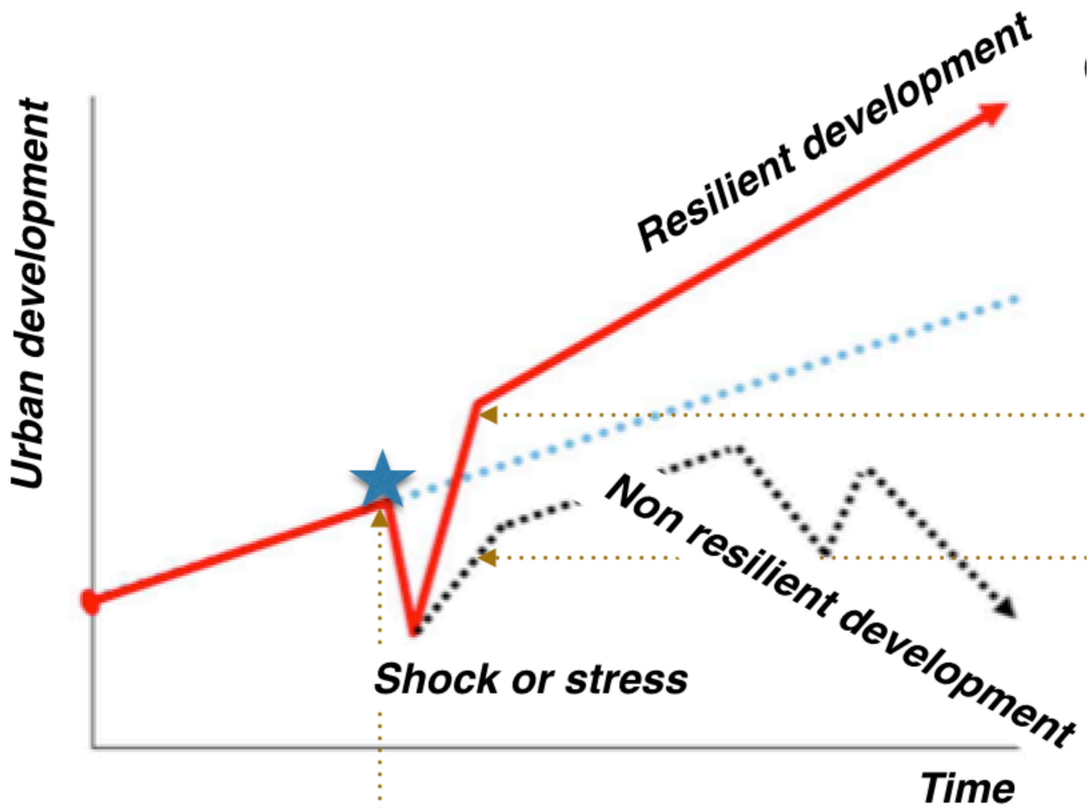
"Une ville durable est résiliente, inclusive, sobre et futée" Antoine Frérot, PDG de Veolia

"L'eau est déjà le sujet numéro un dans des régions comme la Californie, le Moyen-Orient ou la Chine du Sud. Des solutions de réutilisation des eaux usées existent, moins coûteuses que le dessalement. Elles peuvent servir à l'irrigation pour le maraîchage périurbain, le nettoyage des voiries, l'arrosage des golfs, etc.", explique le Pdg de Veolia quand on lui demande comment aller vers la ville sobre. (Crédits : Reuters)

Antoine Frérot, Pdg de Veolia, partage avec "La Tribune" sa vision des défis auxquels sont confrontées les villes du monde. Il nous détaille les offres complémentaires à ses métiers historiques qu'il leur propose pour y faire face et accroître leur résilience.

26/03/2018

Context



- Large city networks
  - 100 Resilient Cities (100RC),
    - pioneered by the Rockefeller Foundation
    - AGU is a partner
  - ICLEI - Local Governments for Sustainability
  - C40
  - etc.

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Urban Geosciences

- EGU 2017 Great Debate "Transition to Next Generation Cities and Planet Earth future"
  - large attendance
  - vital two-way interactions between geophysical and urban systems
  - from architect dreams to geophysical realism?
  - no longer silo thinking, requires an holistic approach

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Urban Geosciences

EGU General Assembly 2019

Vienna (Austria) on 7–12 April 2019

AGU 100 ADVANCING EARTH AND SPACE SCIENCE | FALL MEETING

Washington, D.C. | 10–14 Dec 2018

Urban challenges, AGU centennial kick-off

ITS6 – Urban Geoscience

ITS6.1/NP8.5/AS4.50/CL2.26/HS11.31/NH9.23
Urban Geosciences (co-organized)
Convener: Daniel Schertzer | Co-conveners: Klaus Fraedrich, Stefano Tinti
Convener login

ITS6.2/NH9.20/HS11.13
Resilience studies & Adaptive Capacity (co-organized)
Convener: Bruno Barroca | Co-conveners: Damien Serre, Charlotte Heinzlef, Mattia Leone, Xun Sun, Elisabeth Krueger, Vincent I
Convener login

ITS6.4/BG1.29/EOS7.3/AS4.52/CL2.27/HS10.13/SSS13.30
Urban Ecohydrology: from building greening to future cities (co-organized)
Convener: Thomas Nehls | Co-conveners: Simone Fatichi, Günter Langergraber, Gabriele Manoli, Athanasios Paschalis
Convener login

TM19
Cities and Interdisciplinary Geosciences

Convener: Daniel Schertzer
Co-conveners: Klaus Fraedrich, Stefano Tinti

Geosciences are more than ever solicited in their full interdisciplinarity to meet the urgent need to make our cities climate neutral and proof, smart, safe, resilient, sustainable, inclusive, enjoyable, and to increase well-being and health.

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Conclusions and prospects

- UN 2030 Agenda:

  a vibrant call to intelligence and innovation
- no success without:
  - **advanced observation technologies** (e.g., small radars et lidars)
  - **innovations** (e.g., Blue Green/Nature Based solutions)
  - **disruptive methodologies** (multiscale analysis, modelling and simulation)
  - **integrative and synergic approaches:** beyond silo thinking
    - similar to PUB decade, but at **much lower scales**
    - **common concepts** (e.g., resilience) et tools (e.g.,. integrativesplatforms

"We can not reasonably expect to do today's job with yesterday's methods and be in business tomorrow"

J. Salter