

# IPCC Working Group I (WGI) Sixth Assessment Report (AR6)

Presented by Greg Flato (vice Chair), on behalf of:

Valérie Masson-Delmotte and Panmao Zhai  
Co-Chairs of IPCC WGI

## 2<sup>nd</sup> Lead Author Meeting Vancouver, 7-11 January 2019



**ipcc**  
climate change



# Working Group I AR6

- Chapter 1: Framing, context, methods
  - Chapter 2: Changing state of the climate system
  - Chapter 3: Human influence on the climate system
  - Chapter 4: Future global climate: scenario-based projections
  - Chapter 5: Global carbon and other biogeochemical fluxes
  - Chapter 6: Short-lived climate forcers
  - Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity
  - Chapter 8: Water cycle changes
  - Chapter 9: Ocean, cryosphere, and sea level change
  - Chapter 10: Linking global to regional climate change
  - Chapter 11: Weather and climate extreme events in a changing climate
  - Chapter 12: Climate change information for regional impact and for risk assessment
- Atlas of Regional Climate Information

Reference periods  
Scenarios & temperature levels  
SSPs and RCPs

In WGI :  
SSP1-1.9, SSP1-2.6, SSP3-7.0, SSP5-8.5  
Temperature : 1.5°C, 2°C, 3°C, 4°C  
(plus 1.5 to 6°C / 0.5°C step)

# Working Group I AR6

## Large-scale climate change

Chapter 1: Framing, context, methods

Chapter 2: Changing state of the climate system

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections and near-term information

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived climate forcers

Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

# Working Group I AR6

Targets, path dependence, overshoot  
Climate response to mitigation, CDR, SRM  
Climate change beyond 2100  
Potential for low-probability, high-impact change

Chapter 1: Framing, context, methods and metrics

Chapter 2: Changing state of the climate system

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections and near-term information

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived climate forcers

Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

# Working Group I AR6

Chapter 1: Framing, context, methods

Chapter 2: Changing state of the climate system

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections and near-term information

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived climate forcers

Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

## Climate processes

ipcc

INTERGOVERNMENTAL PANEL ON climate change



# Working Group I AR6

Chapter 1: Framing, context, methods

Chapter 2: Changing state of the climate

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections and near-term information

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived climate forcers

Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

Remaining carbon budgets  
Biogeochemical implications of CDR, SRM

# Working Group I AR6

Chapter 1: Framing, context, methods

Chapter 2: Changing state of the climate system

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections and uncertainty

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived climate forcers

Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

Scenarios and time-dependent  
implications for radiative forcing  
and climate response

SSPs

Urbanization

Air quality

ipcc

INTERGOVERNMENTAL PANEL ON climate change





# Working Group I AR6

Chapter 1: Framing, context, methods

Chapter 2: Changing state of the climate system

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived climate forcers

Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

Climate and Earth system feedbacks  
Estimates of ECS, TCR, TCRE  
Metrics to evaluate emissions

# Working Group I AR6

## Regional climate information

Chapter 1: Framing, context, methods

Chapter 2: Changing state of the climate system

Chapter 3: Human influence on the climate system

Chapter 4: Future global climate: scenario-based projections and near-term information

Chapter 5: Global carbon and other biogeochemical cycles and feedbacks

Chapter 6: Short-lived

Chapter 7: The Earth's

Chapter 8: Water cycle changes

Chapter 9: Ocean, cryosphere, and sea level change

Chapter 10: Linking global to regional climate change

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

Chapter 12: Climate change information for regional impact and for risk assessment

Atlas of Regional Climate Information

Regional messages, narratives and storylines

ivity

ipcc

INTERGOVERNMENTAL PANEL ON climate change



## Connections to WGCM and CMIP6

- The IPCC, and through it, many other users, relies on the provision of Earth System Model results from CMIP, as well as the large body of literature that CMIP has inspired.
- As in the AR5, this is facilitated by the common data format, the ESGF infrastructure, and the common experimental design and forcing data.
- CORDEX results were not heavily used in the AR5, but we anticipate much more visibility in the AR6.
- Both CMIP and CORDEX results will be used in the ambitious Interactive Atlas that is being developed (a large step beyond the Atlas in the AR5).
- WGII is planning to expand on this Atlas.

# WGI Interactive Atlas

## Prototype for FOD

### Datasets:

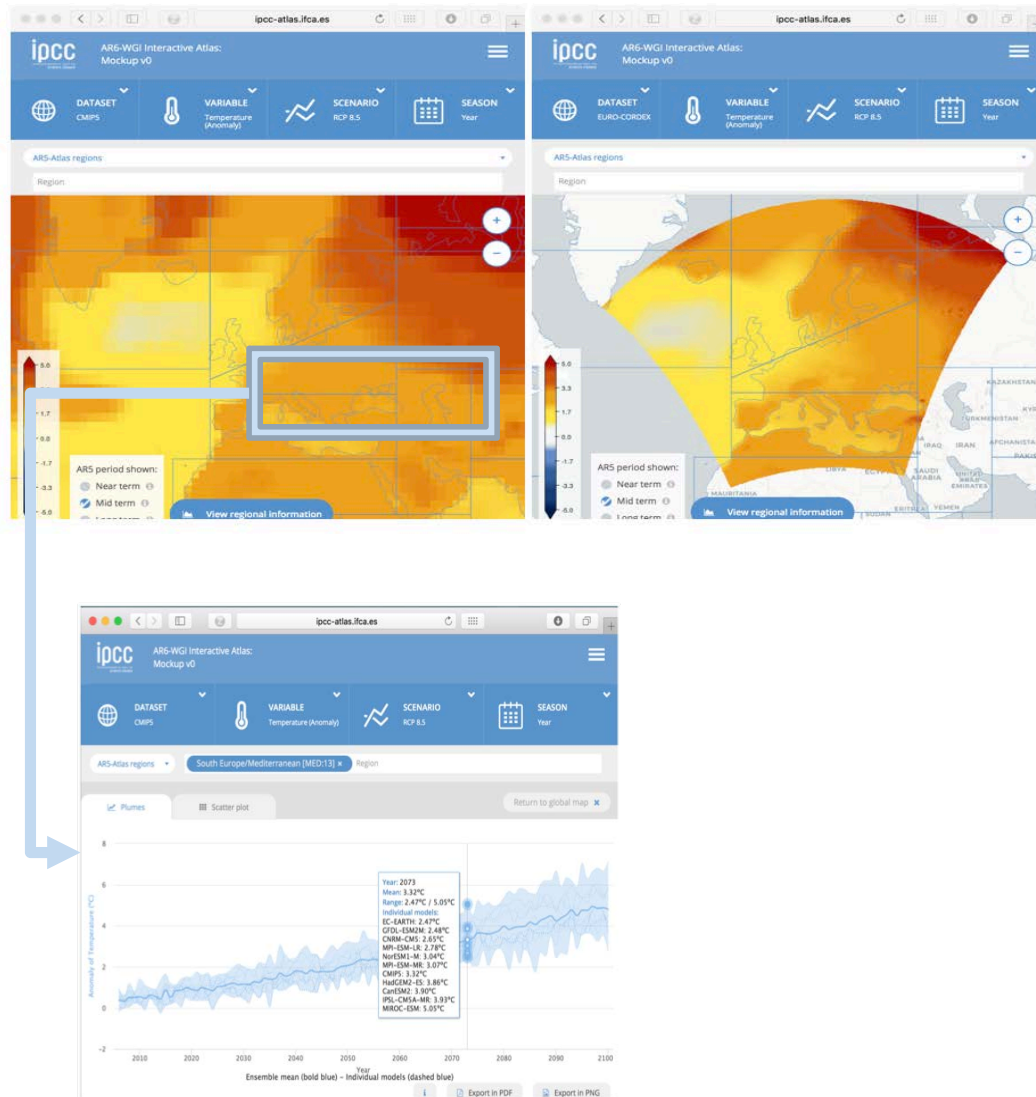
- CMIP5 and CORDEX data.

### Variables/indices:

- Temp. and precip.
- Indices (hazards)

### Options:

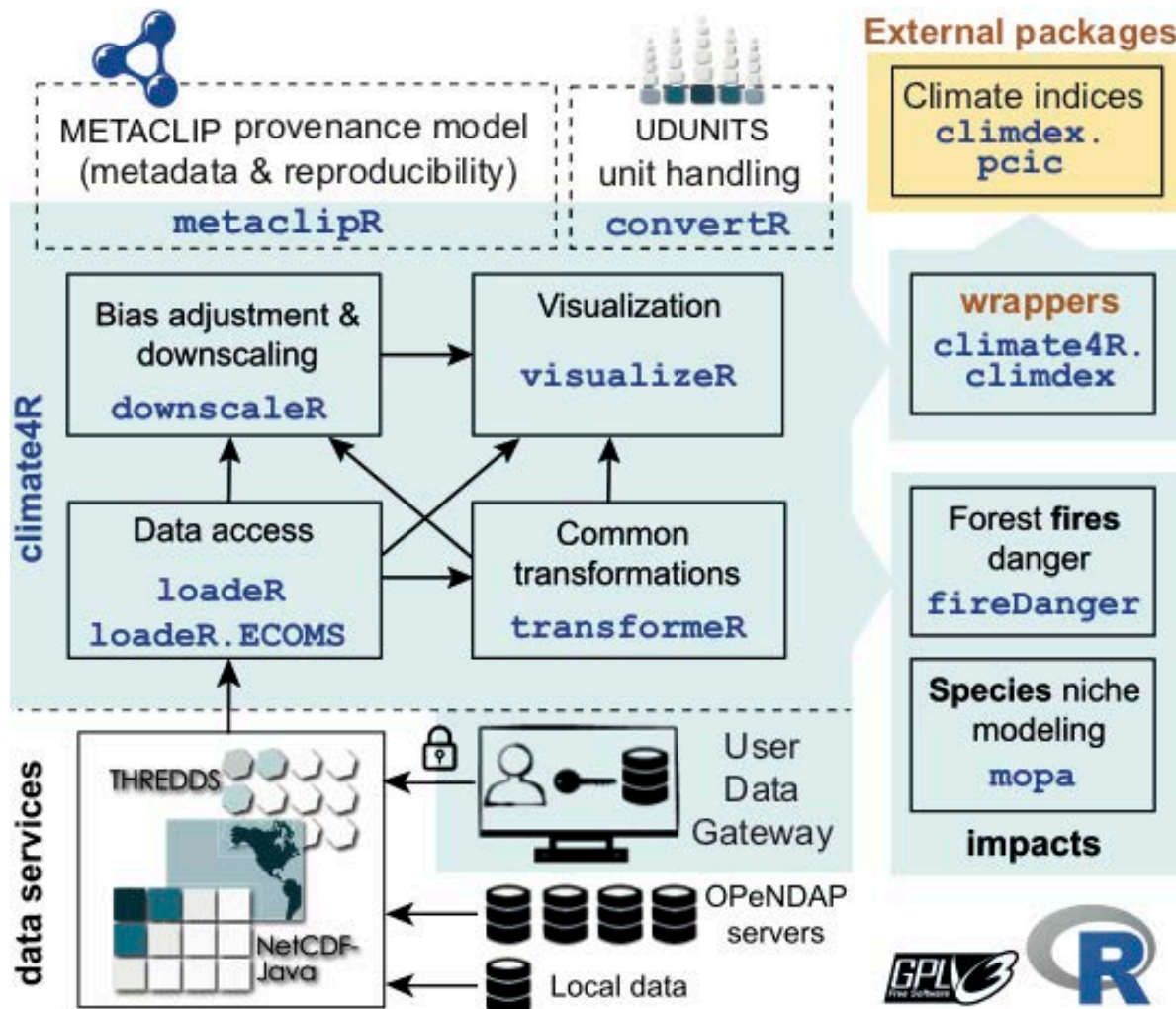
- Seasons
- Regions
- Scenarios:
  - RCP 2.6, 4.5, 8.5
  - Warming 1.5, 2, 3°
  - Baselines



Training will be provided to undertake review of FOD Atlas

# WGI Interactive Atlas

## climate4R: An R-based open framework



## Reproducibility:

The full code to reproduce all Atlas products will be publicly available.

## Metadata:

All products will have attached metadata for full provenance and traceability.

Gutiérrez et al. (2018), Iturbide et al. (2019)

# WGI Interactive Atlas

```
C4R <- list("loader", "transformer", "downscaleR", "visualizeR")
lapply(C4R, require, character.only = TRUE)
library(climate4R.climdex) #Wrapper for climate indices
lon <- c(-10,20); lat <- c(35,46); seas <- 1:12
eobs <- "http://opendap.knmi.nl/knmi/thredds/dodsC/...
e-obs_0.25regular/tx_0.25deg_reg_v17.0.nc"
obs.tx <- loadGridData(eobs, var = "tx",
  years = 1971:2000, season = seas,
  lonLim = lon, latLim = lat)
obs.su <- climdexGrid(tx = obs.tx, index.code = "SU")
spatialPlot(climatology(obs.su))
```

```
cordex <- UDG.datasets(pattern = "EUR44.*historical")$name
# [1] EUR44_ICHEC-EC-EARTH_r12i1p1_RCA4_v1_historical
# [2] EUR44_CERFACS-CNRM-CM5_r11p1_RCA4_v1_historical
# [3] EUR44_ICHEC-EC-EARTH_r11p1_RACMO22E_v1_historical
loginUDG("user", "password") # http://meteo.unicon.es/udg-wiki
#UDG use a single vocabulary, see C4R.vocabulary()
rcm.tx <- loadGridData(cordex[1], var = "tasmax",
  years = 1971:2000, season = seas,
  lonLim = lon, latLim = lat)
rcm.su <- climdexGrid(tx = rcm.tx, index.code = "SU")
spatialPlot(climatology(rcm.su))
```

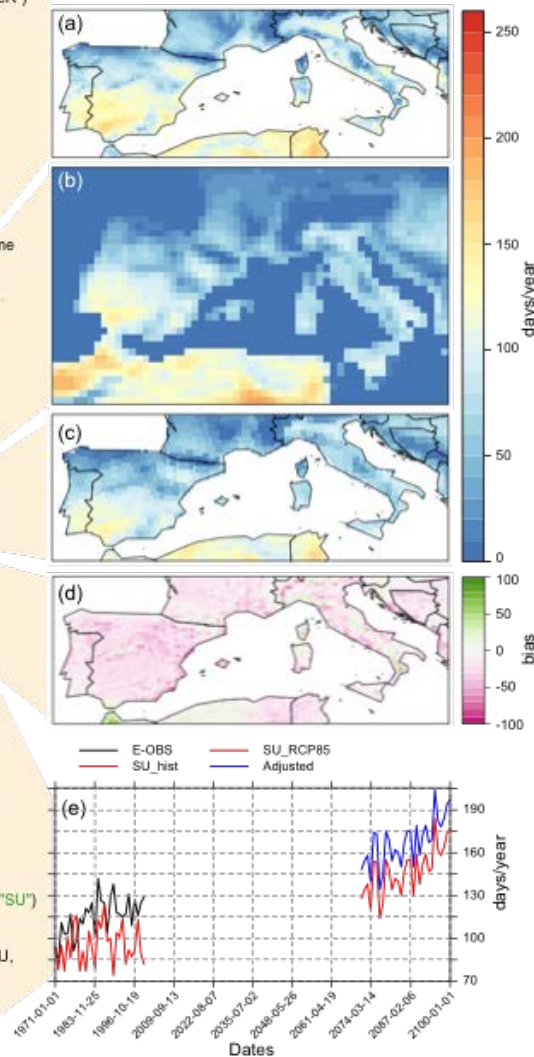
```
rcm.su <- interpGrid(rcm.su, getGrid(obs.su))
mask <- gridArithmetics(obs.su, 0, operator = "===")
rcm.su <- gridArithmetics(rcm.su, mask, operator = "+")
spatialPlot(climatology(rcm.su))
```

```
bias <- gridArithmetics(rcm.su, obs.su, operator = "-")
library(RColorBrewer)
b1 <- rev(brewer.pal(n = 9, "PIYG"))
spatialPlot(climatology(bias), at = seq(-100,100,10),
  col.regions = colorRampPalette(b1))
```

```
f <- "EUR44.*EC-EARTH.*RCA.*RCP85.*RCA4"
fut <- UDG.datasets(pattern = f)$name
rcp85.tx <- loadGridData(fut[1], var = "tasmax",
  years = 2071:2100, season = seas,
  lonLim = lon, latLim = lat)
rcp85.su <- climdexGrid(tx = rcp85.tx, index.code = "SU")
rcp85.su <- interpGrid(rcp85.su, getGrid(obs.su))

rcp85.bc.tx <- biasCorrection(y = obs.tx, x = rcm.tx,
  newdata = rcp85.tx, method = "eqm")
rcp85.bc.su <- climdexGrid(tx = rcp85.bc.tx, index.code = "SU")

temporalPlot("E-OBS" = obs.su, "SU_hist" = rcm.su,
  "SU_rcp85" = rcp85.su, "Adjusted" = rcp85.bc.su,
  latLim = 41.64, lonLim = -0.89,
  cols = c("black", "red", "red", "blue"))
```



## Jupyter Notebooks:

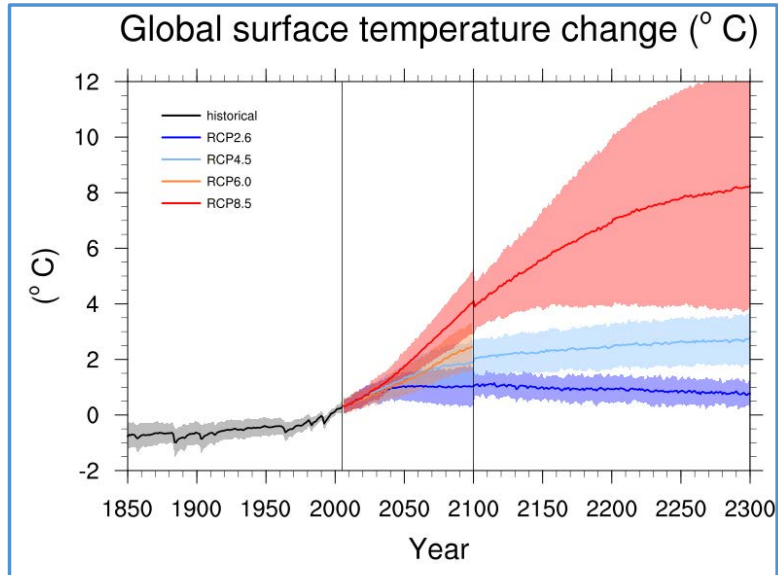
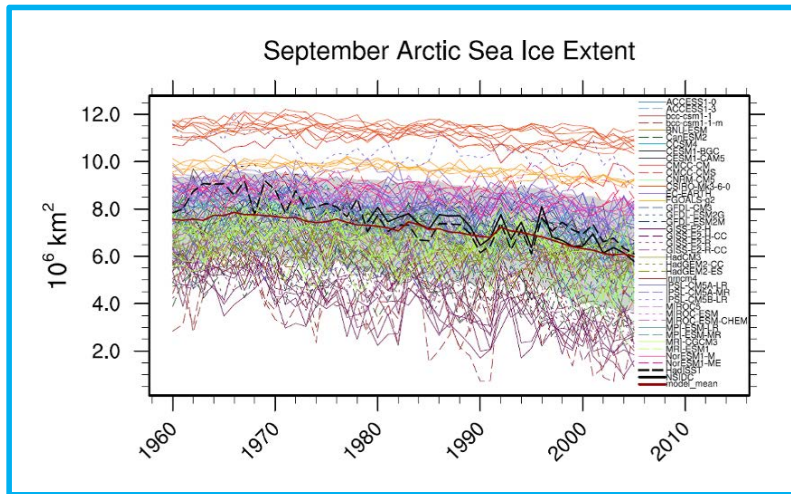
Documents combining formatted-text and code (R/Python) cells which can be executed interactively (remotely).

## Code for a typical product:

Future projections for a **ETCCDI index** (summer days) from **bias corrected CORDEX** data.

Output: products with attached metadata

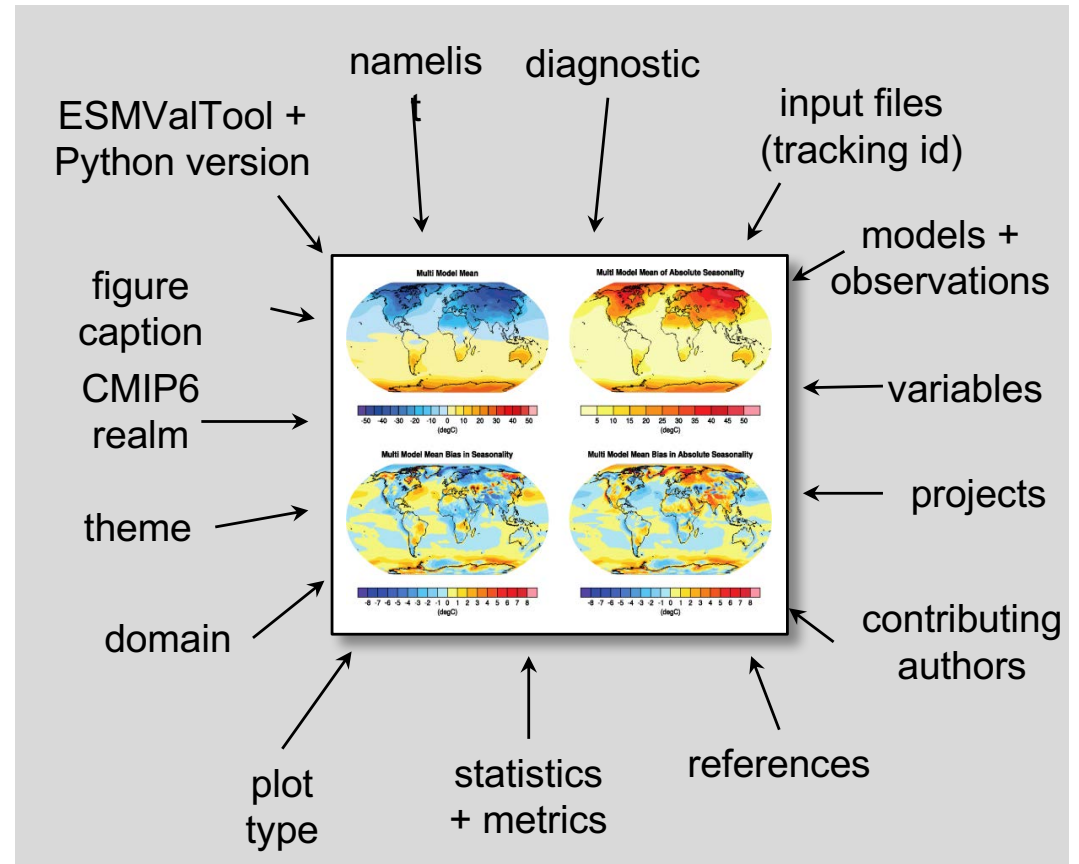
# Provenance for WGI figures



Eyring et al., GMD, ESMValTool v1.0, 2016



Tagging: meta data attached to image files



<https://cmip-esmvaltool.dkrz.de/>

# WGI Data and Infrastructure

Initiatives in progress with WGI Authors, DDC managers and community leads in WGI-related data issues, relevant for the establishment of TG-Data

- Development of an **interactive digital Atlas** as a product of the WGI report is an innovative aspect of the WGI Assessment. Training will be provided to review the draft Atlas.
- Best practices for the development of common software for end-to-end provenance to **ensure reproducibility of figures**.
  - A private Github repository has been set up for development.
  - **Accounts for analysis of CMIP6 data with ESMValTool** for IPCC authors at DKRZ
- WGI is collaborating with the CMIP Infrastructure Panel (WIP) to develop **training on CMIP6 data and the Earth System Grid Federation** for data access and analysis. This would be made available to the broader community and CMIP6 users.
- An **IPCC GitHub environment** is being set and scripts and post-processed data from the Special Report on Global Warming of 1.5°C are being prepared for publishing by the DDC.
- Preliminary discussions on IPCC authors being 'test users' of new prototype cloud-based infrastructure for access and server-side analysis of climate big data.



# AR6 Coordination on Scenarios

- Enhanced awareness and understanding (incl. underlying assumptions)
- Consistent terminology, information, data, uses of timeframes
- Consistency across chapters and reports
- Coordination in assessment of warming levels, key climate variables, natural and human system parameters (WGI-WGII)
- Consistency between climate system parameters (WGI) and reduced complexity models used for classification of scenarios (WGIII)
- Coordinated communication (storylines) and integration => SYR

## Integration across WGI and WGII

- Hazards for risk assessment, incl. compound events, air quality, low probability / high impact, physically plausible future changes
- Confidence in climate information used for impact / risk studies, incl. CMIP3-CMIP5-CMIP6, global / regional models, and water cycle changes

## Integration across WGI-WGIII

- Separation of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, other GHG, SLCF
- Health co-benefit of non CO<sub>2</sub> mitigation
- How to best assess “commitment” (climate system, current infrastructure and investments)

## Integration across WGI-WGII-WGIII

- Extremes and their impacts (incl. in IAM)
- Land use changes and implications
- Geophysical limits & clim. change (biomass, energy)

# WGI 2019 Timeline

<b>JAN</b>	7-12 January Second Lead Author Meeting (LAM2)
<b>APRIL</b>	7 April Submission of the First Order Draft (FOD) to TSU 8-21 April TSU compiles FOD 29 April - 23 June Expert Review of FOD
<b>JULY</b>	1 July TSU sends compiled Review Comments to CLAs
<b>AUG</b>	26-31 August Third Lead Author Meeting (LAM3)
<b>OCT</b>	7 October Comment responses & RE First interim report due to TSU
<b>DEC</b>	31 December <i>Literature submission cut off</i>

Scoping of the  
Technical Summary  
and Summary for  
Policy Makers

Strawman Technical  
Summary and Summary  
for Policy Makers  
discussed at LAM3



# WGI 2019 Timeline



# WGI Timeline

## 2019

29 April – 23 June

Expert Review of First Order Draft

26 August – 1 September

Third Lead Author Meeting, Toulouse, France

---

## 2020

2 March – 26 April

Expert and Government Review of Second Order Draft

1– 7 June

Fourth Lead Author Meeting (location tbd)

15 October

Cut-off date for accepted literature for inclusion in the Final Draft

7 December – 31 January

Final Government Distribution of Final Draft and Government Review of the Summary for Policymakers

## 2021

12 – 18 April

Submission to the WGI Session for approval of the Summary for Policymakers and acceptance of the underlying Report (location tbc)

---

# IPCC Sixth Assessment (AR6)

