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PROJECTION OF CLIMATE CHANGE IN INDONESIA:
Preliminary analysis for the Bengawan Solo River Basin

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Chair, Working Group on Climate Services, RA-V, WMO.

Outline

- State of the global climate and its change
- Cities – emission – pollution – climate change: Indonesian context
- Impacts of climate change: when hazards meet with vulnerable society
- Future projected climate change in Indonesia
- Specific Climate Change Analysis for the Bengawan River Basin (Preliminary): plots of ETCCDI indices
- Summary

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State of the global climate and its change

Recent Global Reports Related With Climate

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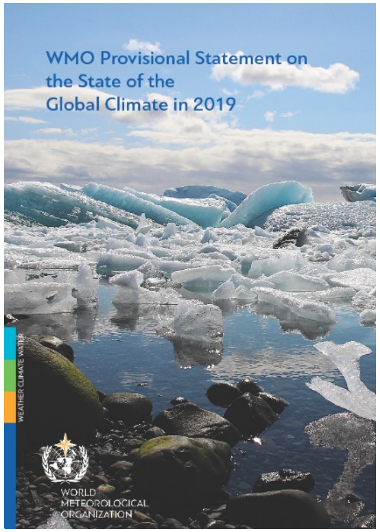
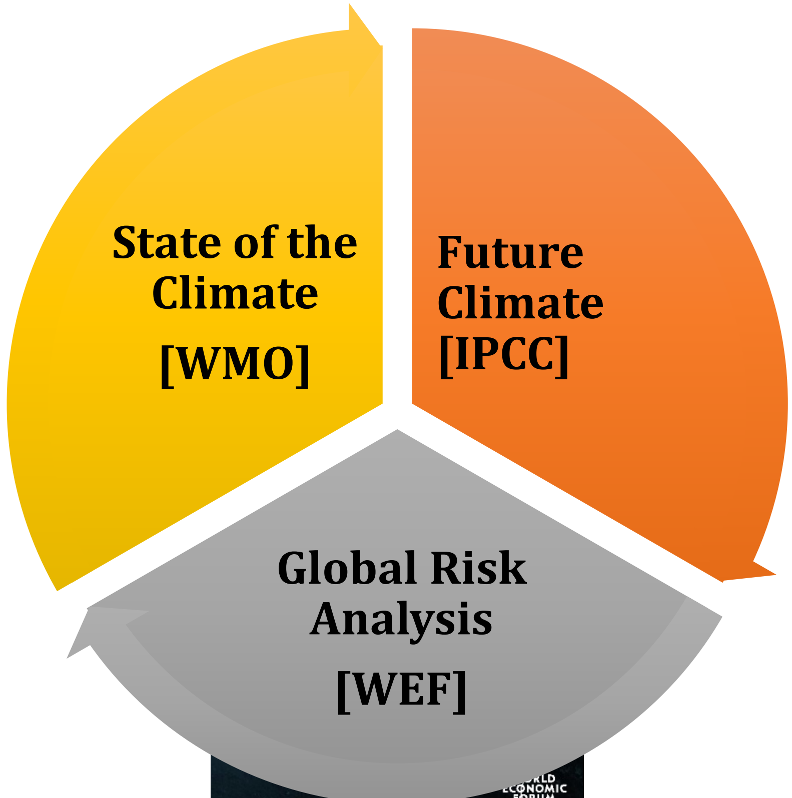
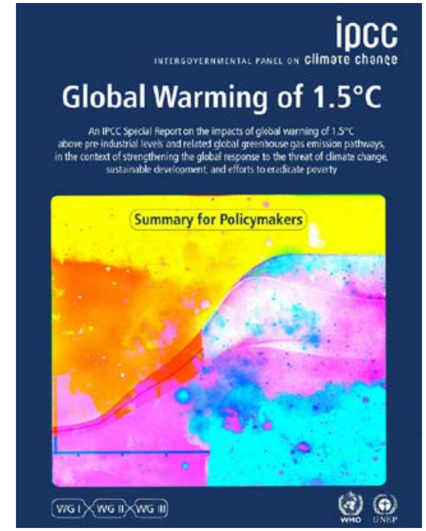
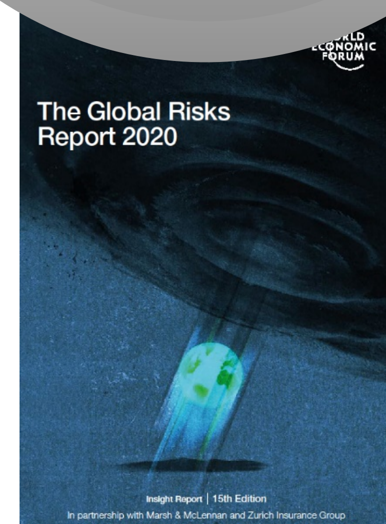


Present State
of the Global Climate





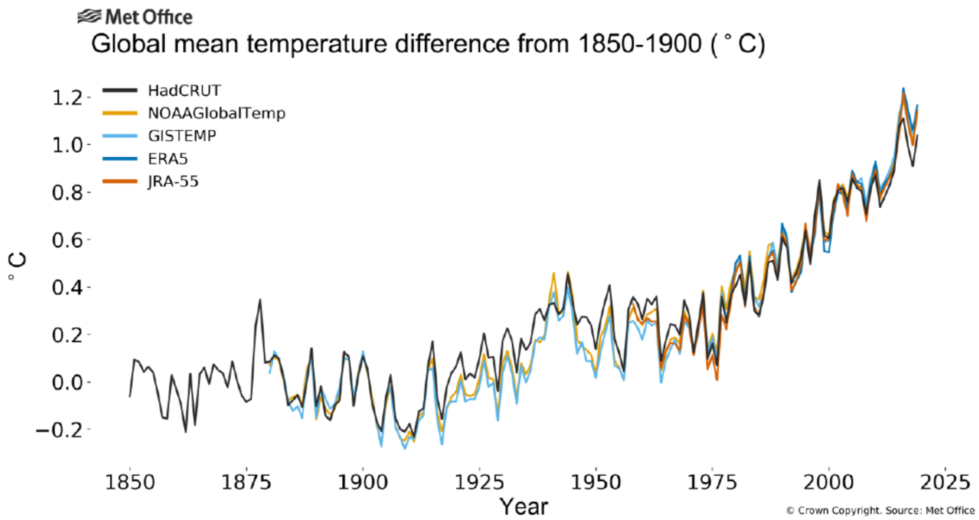
Future Climate



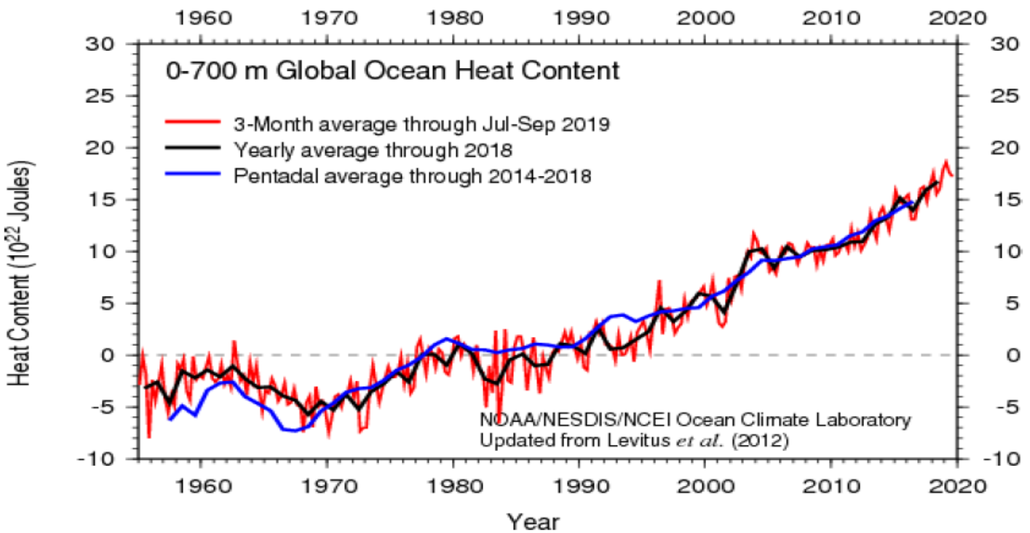
Global risks

Present state of the global climate (WMO)

(Provisional statement)

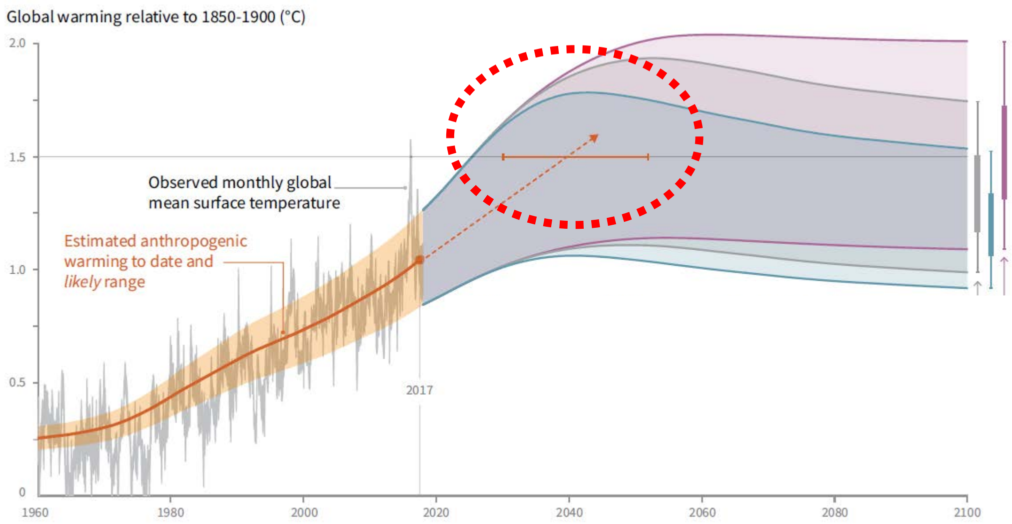


- 2nd or 3rd warmest year on record. (After 2016, 2019-2017)
- 2015–2019 were the five warmest years on record as the long-term warming trend continues
- 1.1 ± 0.1 °C above the preindustrial baseline (1850–1900)

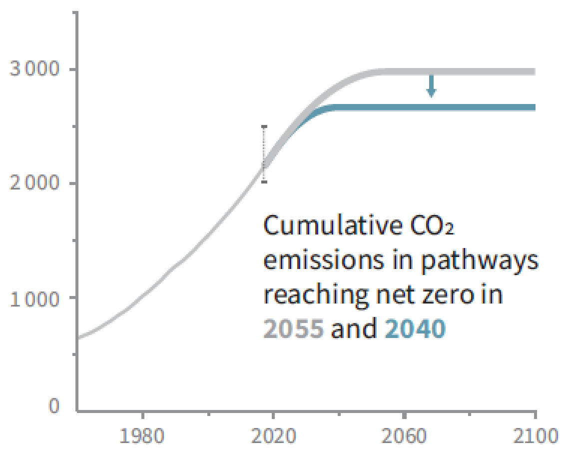


- Ocean heat content is at a record high

Future Climate (IPCC)

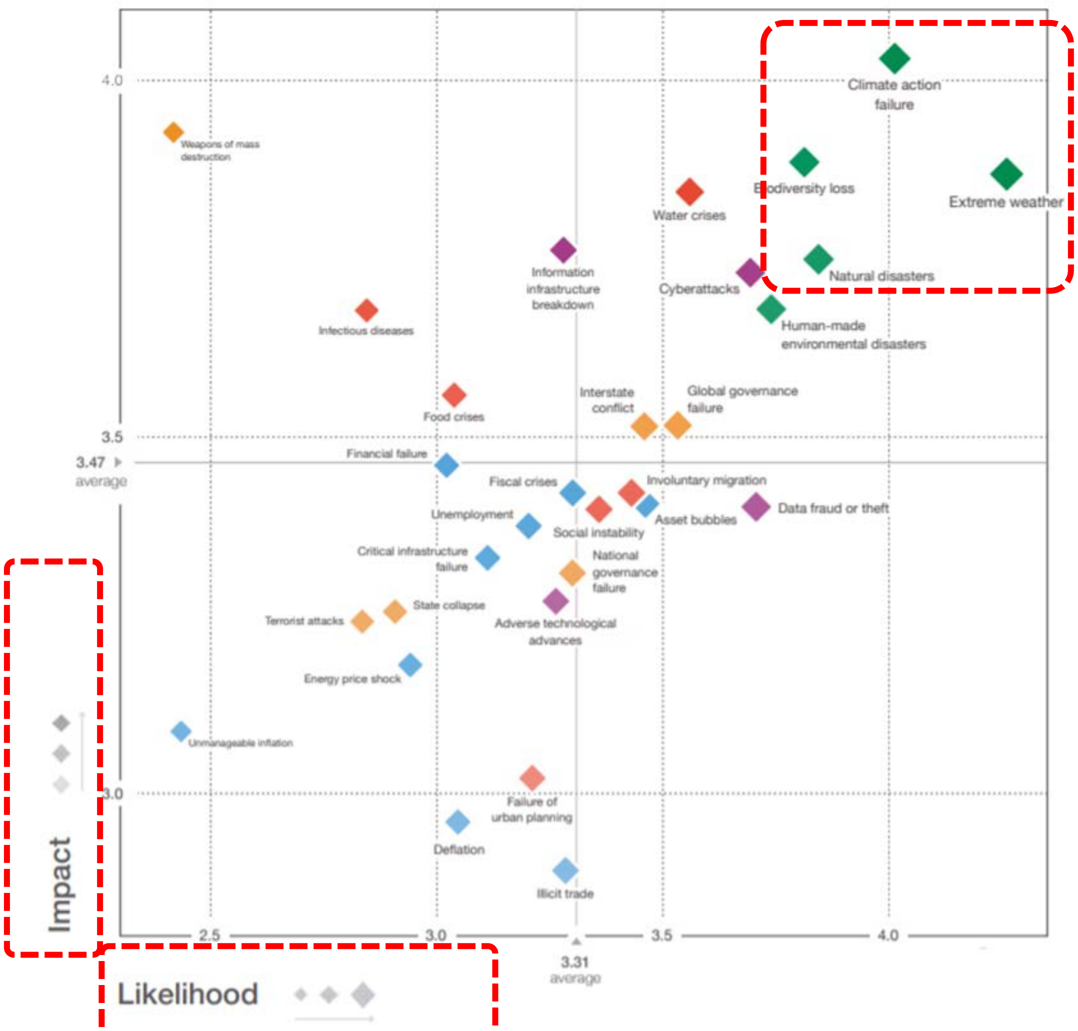


- Countries agreed in Paris agreement to put much effort to limit global warming below **1.5º**
- At current rate, **will reach 1.5º** between **2032 and 2050**



- Pathways for not exceeding **1.5º , green house gas emission in 2030: 25-30 Gigaton CO_2 equivalent**
- **Interpetation: if human stop emitting immediately, chances of not exceeding 1.5º is small**

Global Risk Landscape (WEF)



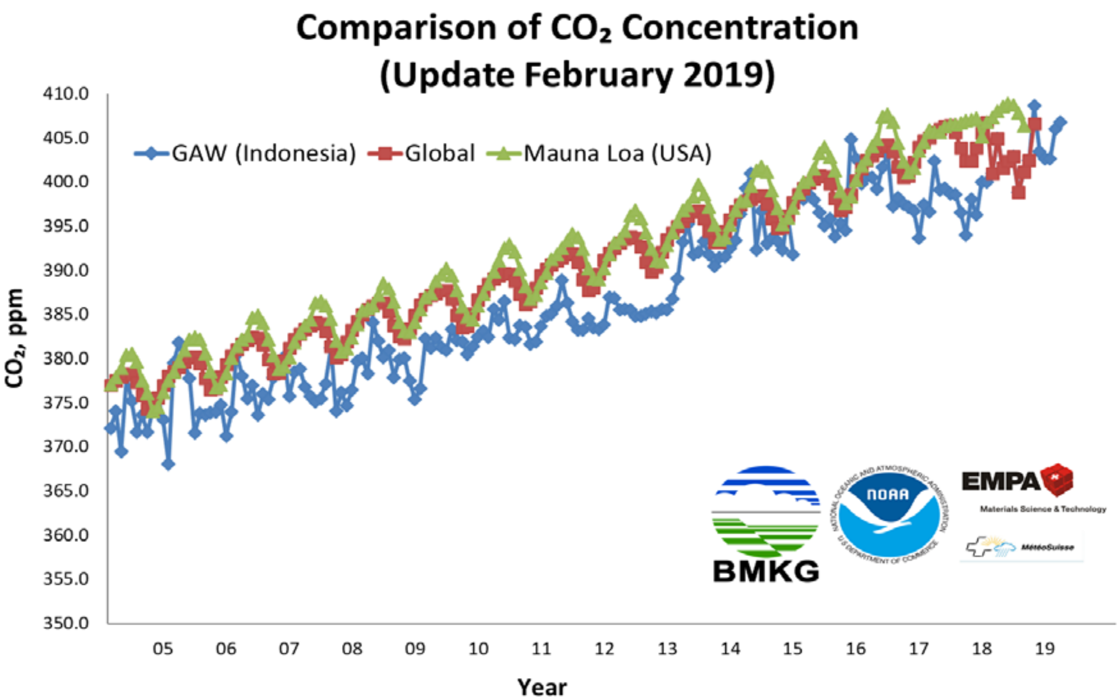
WORLD ECONOMIC FORUM

Global Risk Report 2020

Top three risks in impact and likelihood:

- Extreme weather events
- Failure of climate change mitigation and adaptation
- Natural disasters

Measurement of background CO_2 concentration: Indonesia vs Global

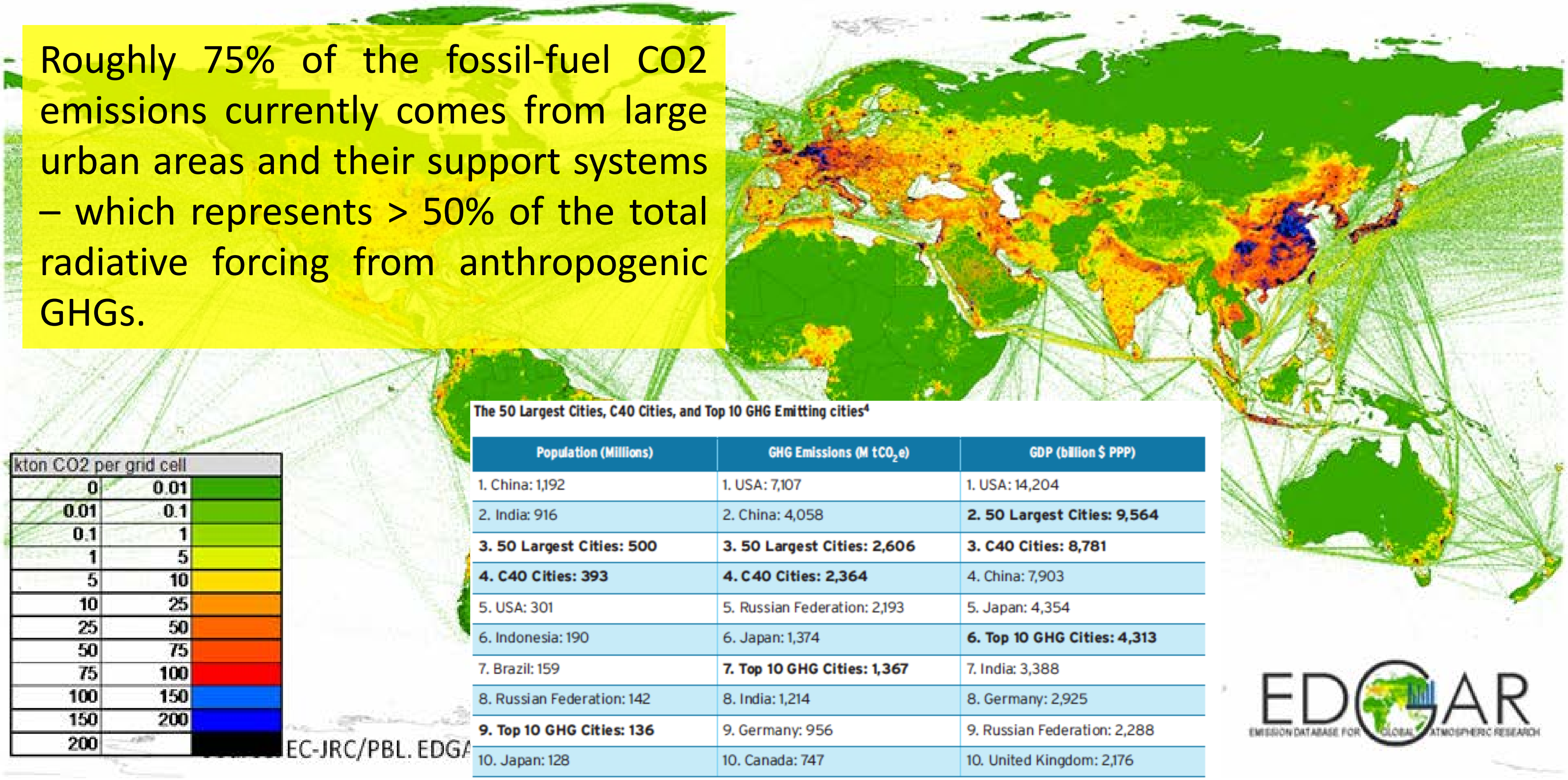


- CO2 concentration measured in GAW Kototabang is less than global average concentration
- Recent measurements:
  GAW Kototabang: 398.5 ppm,
  Global average: 402.2 ppm
- But increasing with the same rate (or trend) of 2 ppm / year.

Cities – Emission – Pollution – Climate change: Indonesian Context

Cities and climate: source of GHG emission

Roughly 75% of the fossil-fuel CO2 emissions currently comes from large urban areas and their support systems – which represents > 50% of the total radiative forcing from anthropogenic GHGs.



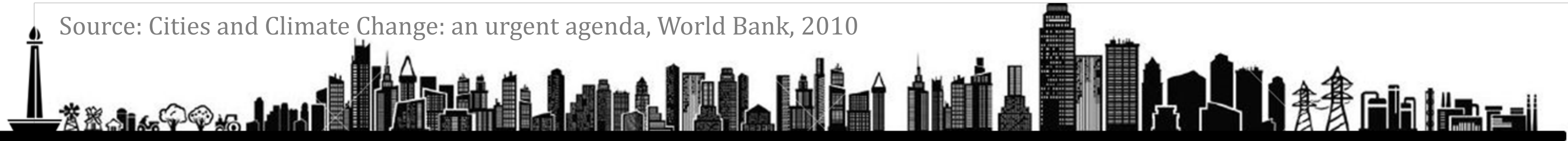
The 50 Largest Cities, C40 Cities, and Top 10 GHG Emitting cities[4]

Population (Millions)	GHG Emissions (M tCO_2e)	GDP (billion $ PPP)
1. China: 1,192	1. USA: 7,107	1. USA: 14,204
2. India: 916	2. China: 4,058	**2. 50 Largest Cities: 9,564**
3. 50 Largest Cities: 500	**3. 50 Largest Cities: 2,606**	**3. C40 Cities: 8,781**
4. C40 Cities: 393	**4. C40 Cities: 2,364**	4. China: 7,903
5. USA: 301	5. Russian Federation: 2,193	5. Japan: 4,354
6. Indonesia: 190	6. Japan: 1,374	**6. Top 10 GHG Cities: 4,313**
7. Brazil: 159	**7. Top 10 GHG Cities: 1,367**	7. India: 3,388
8. Russian Federation: 142	8. India: 1,214	8. Germany: 2,925
9. Top 10 GHG Cities: 136	9. Germany: 956	9. Russian Federation: 2,288
10. Japan: 128	10. Canada: 747	10. United Kingdom: 2,176

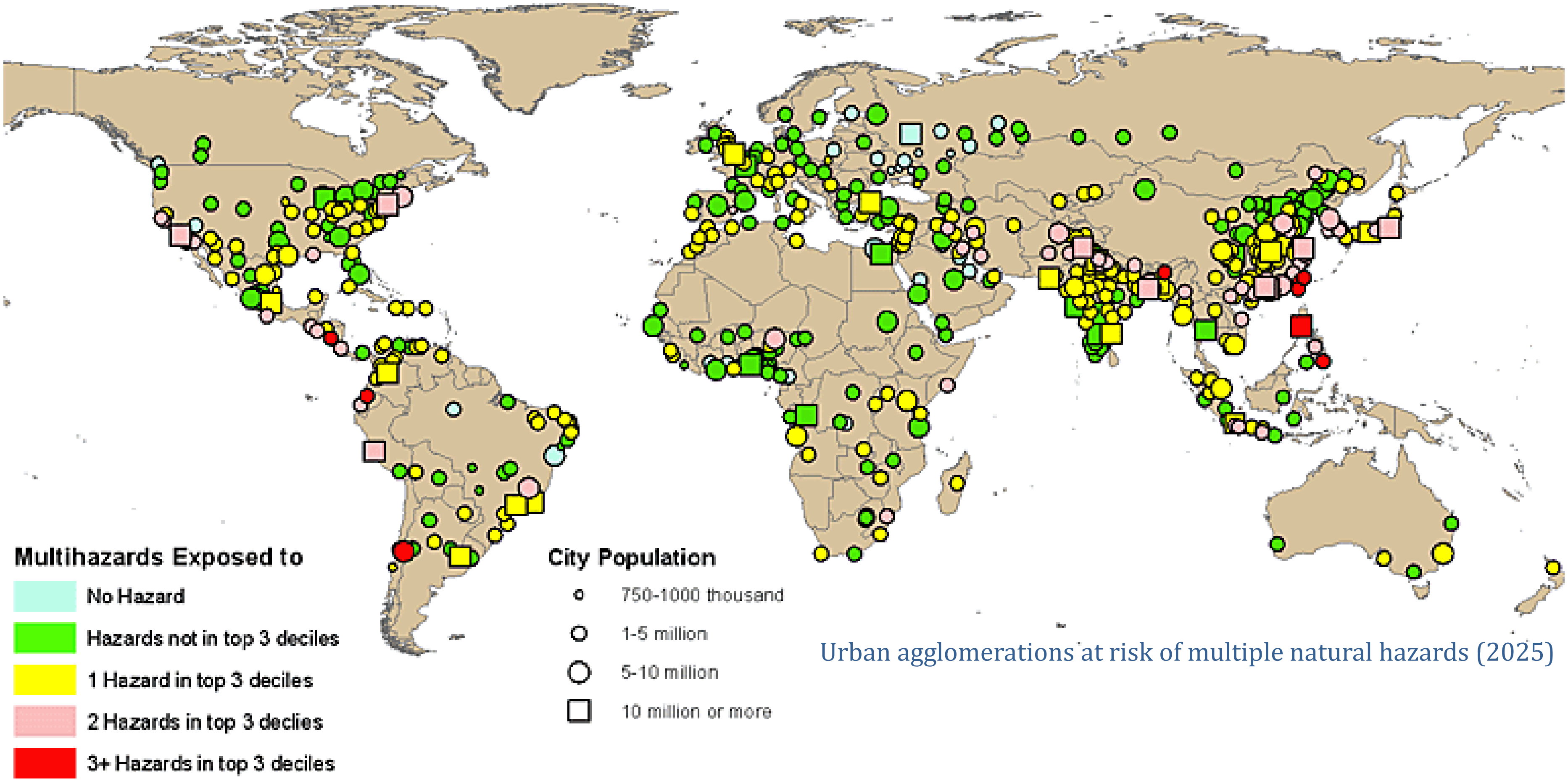
Source: See Annex D. Data for the urban agglomeration associated with each C40 city is used in calculations to maintain consistency with the 50 largest cities, 2005.

Cities are the (primary) source of Green House Gases emission

Source: Cities and Climate Change: an urgent agenda, World Bank, 2010



Cities and climate: severely impacted



Urban agglomerations at risk of multiple natural hazards (2025)

Cities are exposed to multiple weather and climate related hazards

P. Ruti, WMO.

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The urban landscape in Indonesia: population & regional GDP

City	Population	Regional GDP
Jakarta	9.98 M	Rp. 2172 T
Surabaya	2.8 M	Rp. 451 T
Medan	2.46 M	Rp. 186 T
Bandung	2.33 M	Rp. 217 T
Makassar	1.65 M	Rp. 127 T
Semarang	1.62 M	Rp. 145 T
Palembang	1.54 M	Rp. 118 T
B. Lampung	1.16 M	Rp. 47 T
Batam	1.02 M	Rp. 130 T
Padang	0.87 M	Rp. 49 T

Data: Ministry of Domestic Affairs, 2015

Number of (recorded) hydromet disasters since 2000

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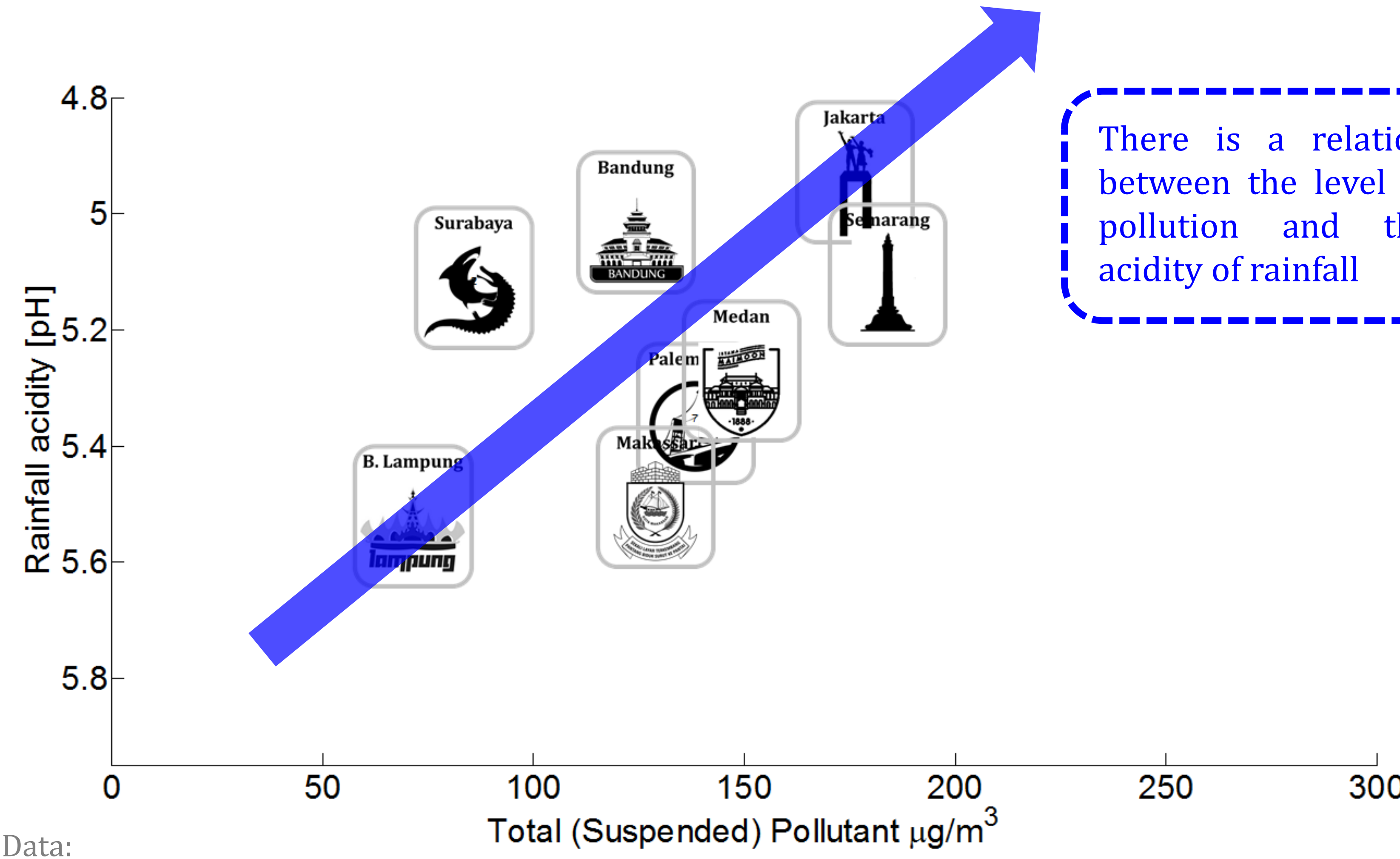
	Jakarta	Surabaya	Medan	Bandung	Makassar	Semarang	Palembang	B. Lampung	Batam	Padang
#Flood	217	15	43	18	16	31	18	13	10	36
#Tides/ abrasion	7	-	2	-	-	-	-	1	1	9

- Recurring floods mostly during rainy season
- (On average) at least one event annually
- Jakarta is the most impacted by flood, related to uncontrolled urbanization

Data: National Disaster Management Agency (BNPB, 2018)

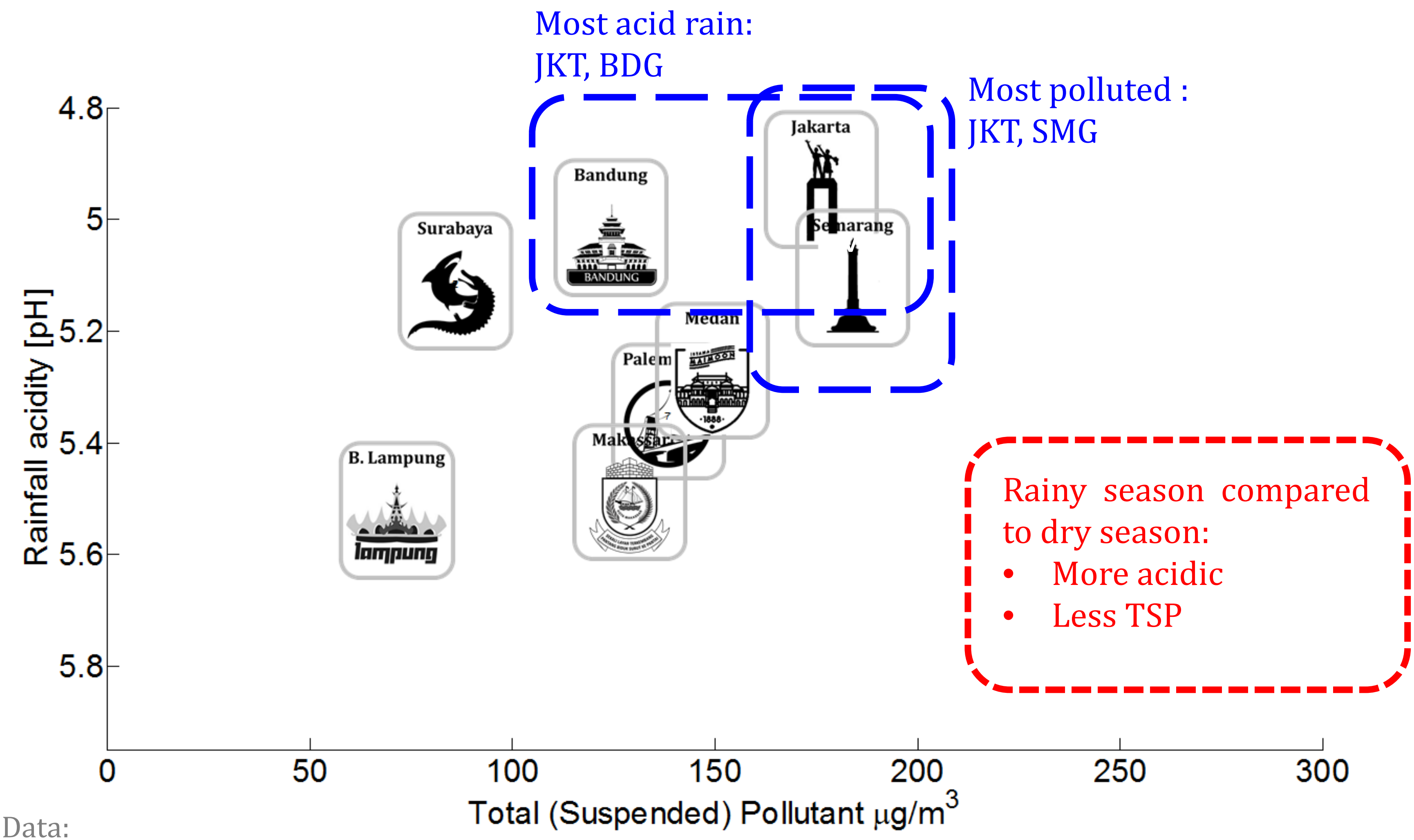
The urban landscape in Indonesia: pollutant and acid rain



There is a relation between the level of pollution and the acidity of rainfall

Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)

The urban landscape in Indonesia: pollutant and acid rain



Data:
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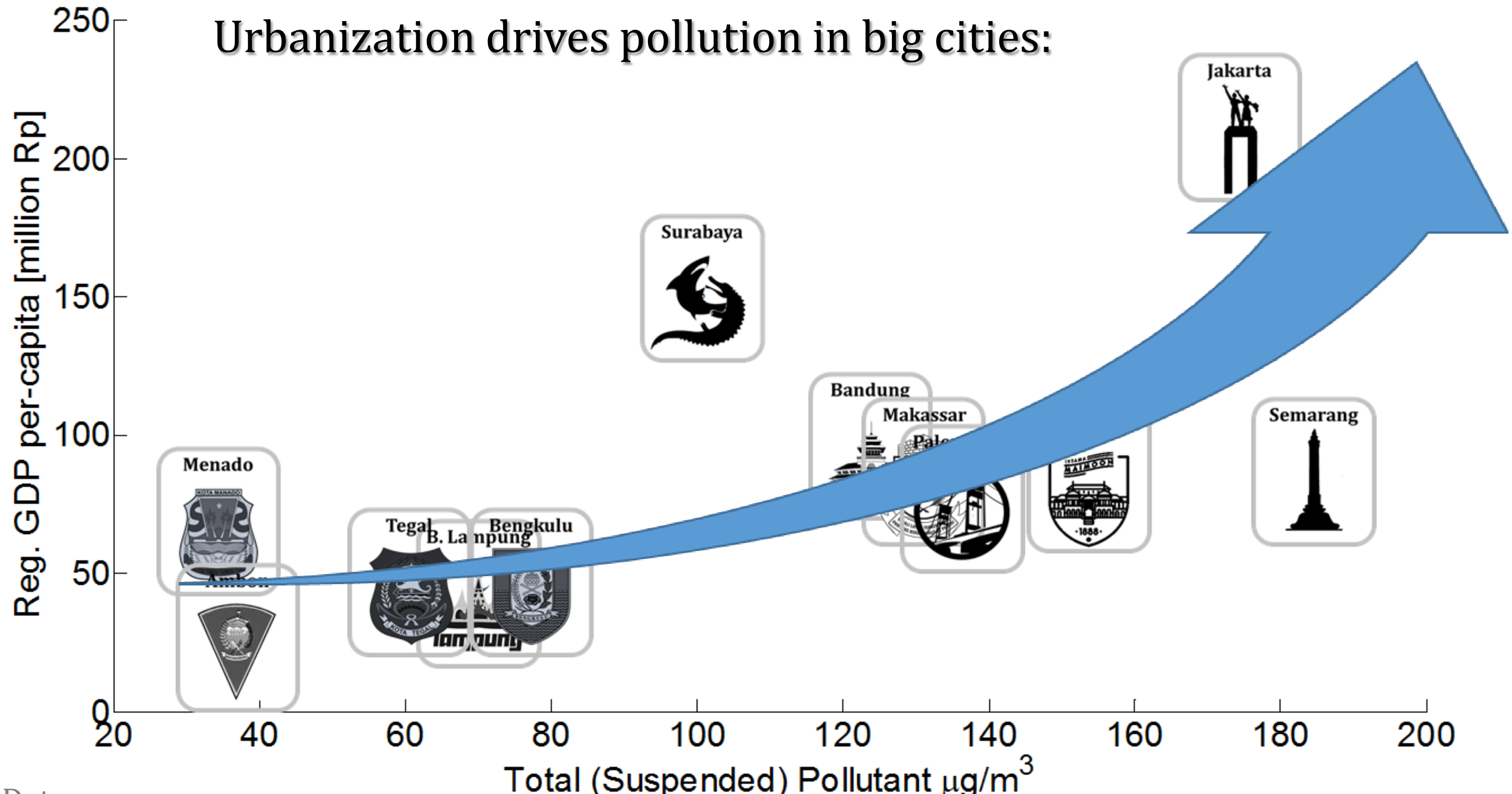
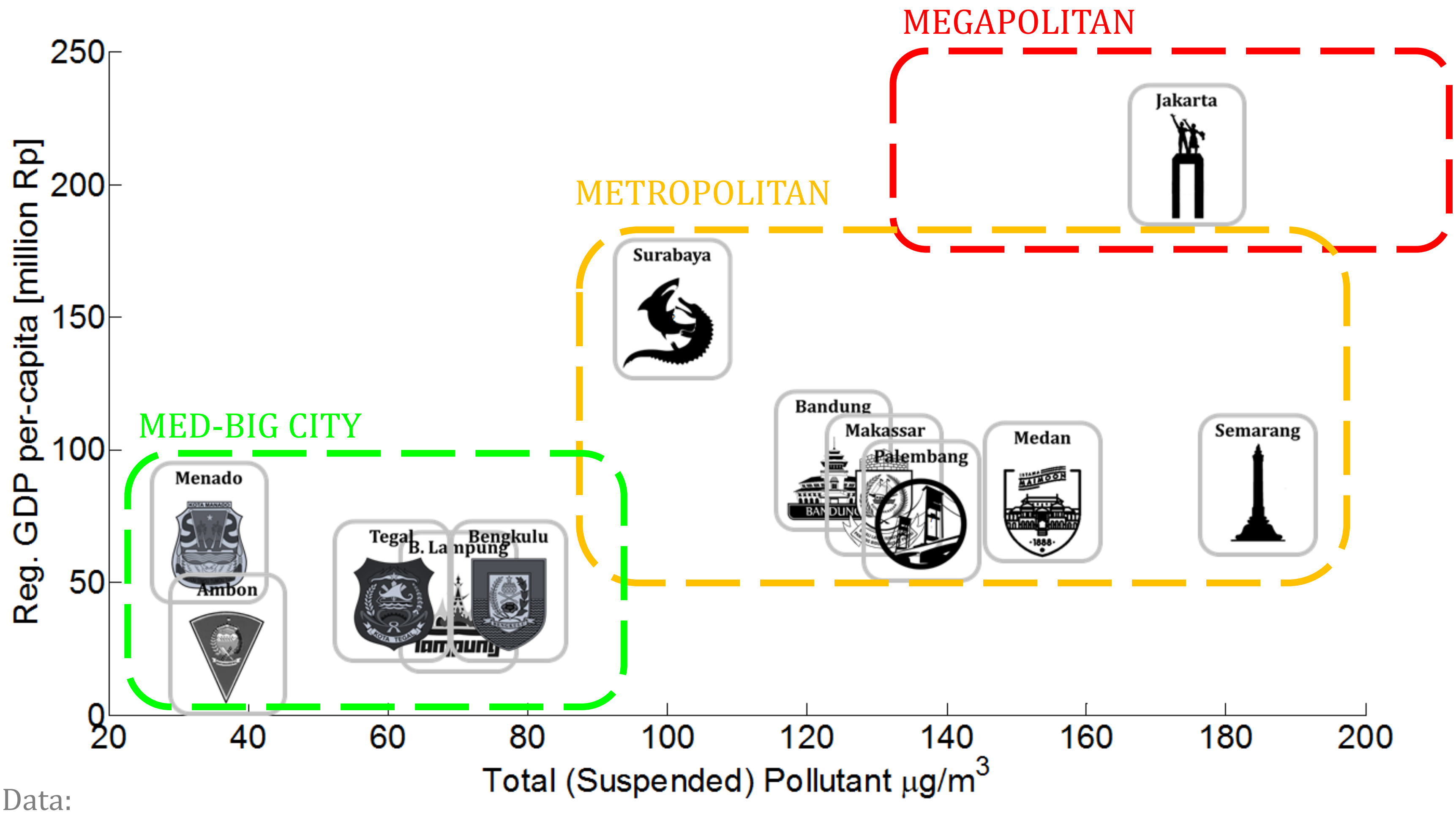
The urban landscape in Indonesia: pollutant and economy



Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
Central Statistics Agency, (BPS, 2017)

The urban landscape in Indonesia: pollutant and economy



Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
Central Statistics Agency, (BPS, 2017)

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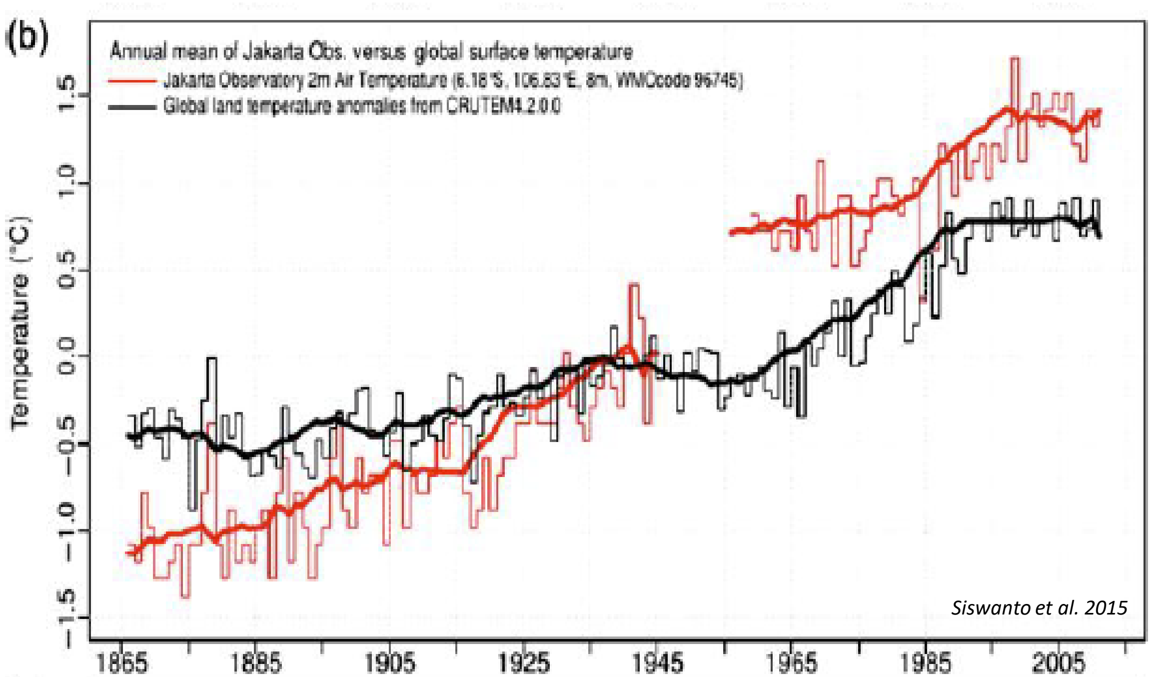
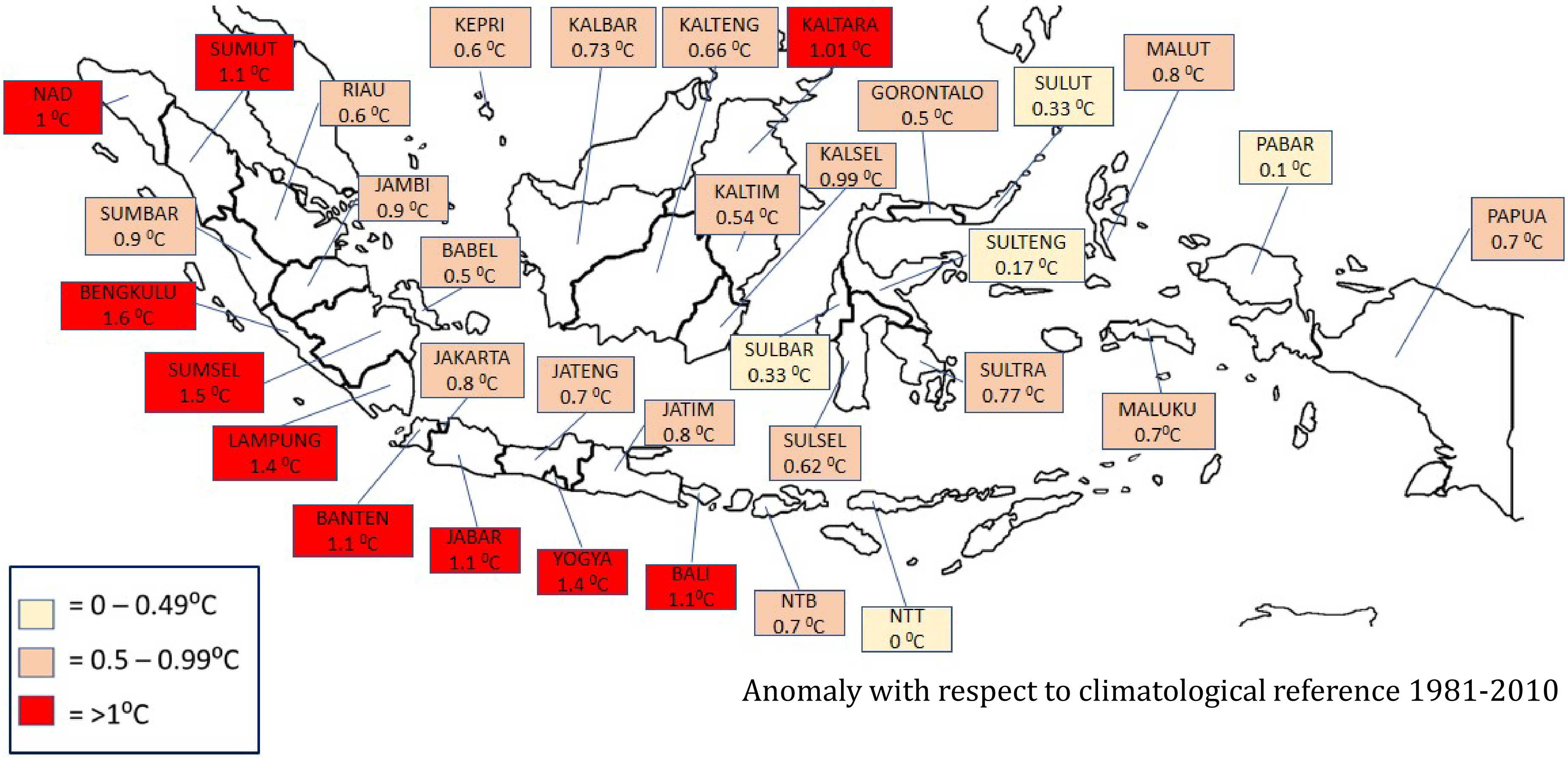
Warming trend in Indonesia



- Measurement of temperature in Jakarta also showing increasing trend.
- Higher trend than global average (1.4x)

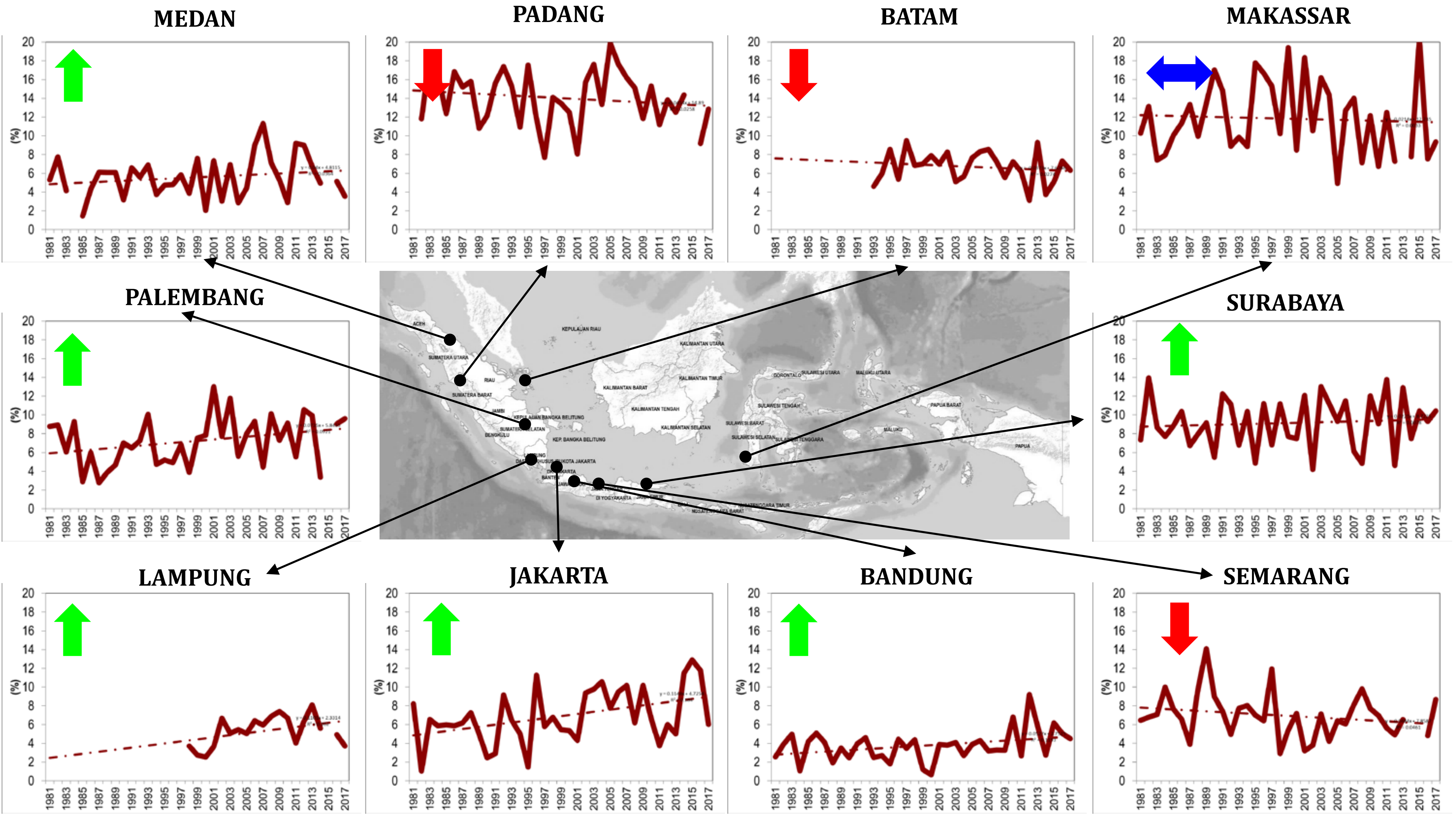
Recent temperature anomaly



Anomaly with respect to climatological reference 1981-2010

Data: Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)

Trend of heavy rainfall (> 50mm/day)

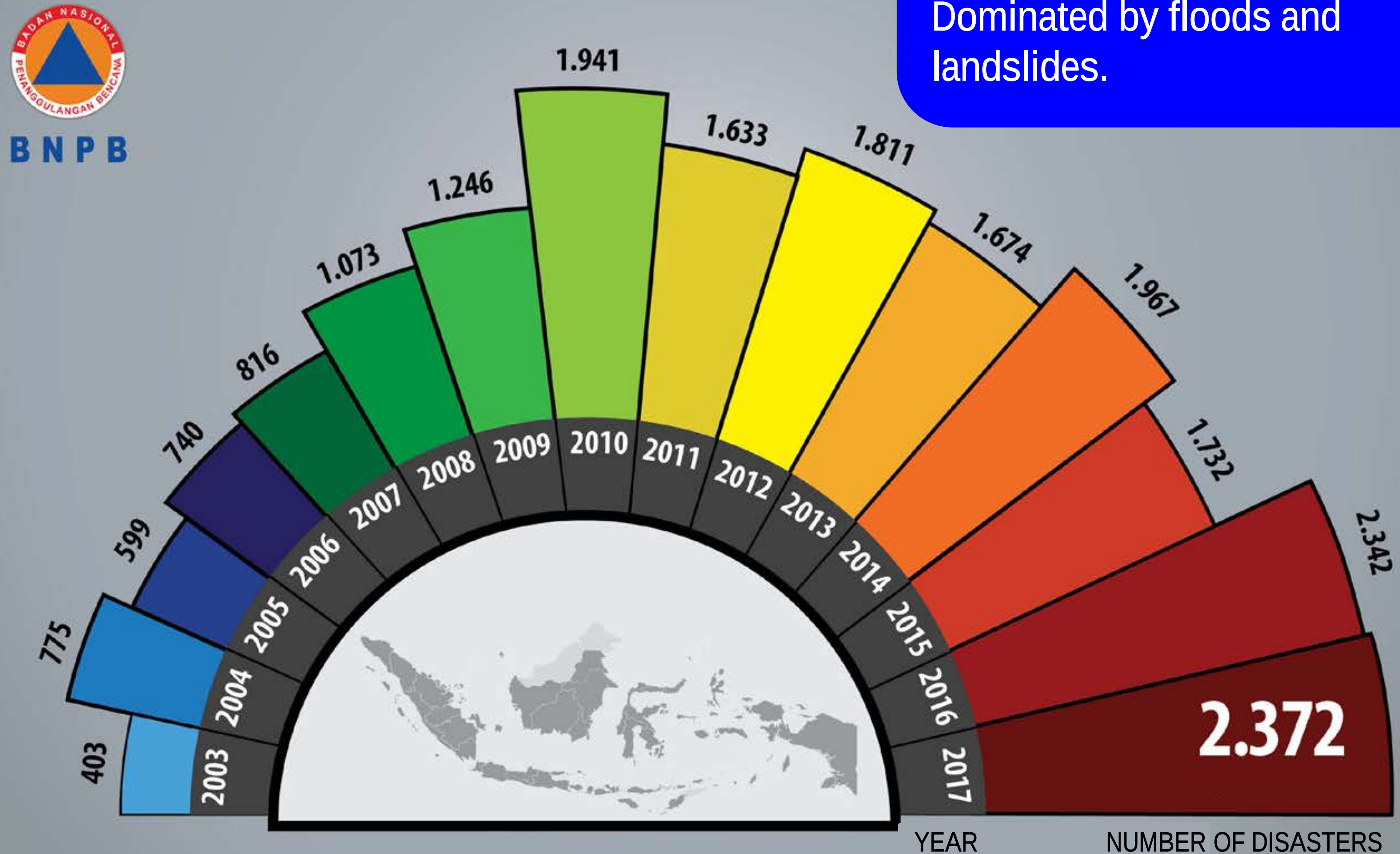


Data: Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)

Impacts of Climate Change:
When hazards meet with vulnerable society

DISASTERS TREND IN INDONESIA FROM 2003 – 2017

Data from BNPB (DMA) in 2017 there were 2372 disaster events recorded.
Dominated by floods and landslides.



BENCANA TAHUN 2018

BNPB

1 JANUARI 2018 - 31 DESEMBER 2018

Tahun 2018 tercatat 2.572 kejadian bencana (31/12/2018). Bencana hidrometeorologi mendominasi di tahun 2018. Puting Beliung menempati urutan pertama diikuti banjir. Bencana tahun ini menyebabkan 10 juta jiwa lebih masyarakat terdampak dan mengungsi, merenggut 4.816 jiwa serta merusak lebih dari 320 ribu unit rumah.

TOTAL BENCANA TAHUN 2018

1 Januari 2018 -31 Desember 2018

2.572

TANAH LONGSOR
TOBA SAMOSIR, SUMATERA UTARA
13 Desember 2018
- 8 Jiwa Meninggal Dunia
- 2 Jiwa Luka-luka

TANAH LONGSOR
SIBOLGA, SUMATERA UTARA
26 Maret 2018
- 2 Jiwa Meninggal Dunia
- 3 Rumah Rusak Berat

BANJIR
MANDAILING NATAL, SUMATERA UTARA
12 Oktober 2018
- 17 Jiwa Meninggal Dunia
- 500 Jiwa Mengungsi

TSUNAMI SELAT SUNDA
LAMPUNG & BANTEN
22 Desember 2018
- 437 Jiwa Meninggal Dunia
- 1.495 Jiwa Luka-luka

BANJIR
DKI JAKARTA
5 Februari 2018
- 1 Jiwa Meninggal Dunia
- 4.521 Jiwa Mengungsi

GEMPABUMI 7,4 SR
DONGGALA, PALU, SIGI & PARIMO
28 September 2018
- 2.101 Jiwa Meninggal Dunia
- 87.725 Jiwa Mengungsi

BANJIR
WAJO, SIDRAP & SINJAY
14 Juli 2018
- 19.000 Jiwa Terdampak
- 1 Unit Rumah Sakit Terendam

GEMPA BUMI 4,8 SR
SARMI, PAPUA
15 Juni 2018
- \- Jiwa Meninggal Dunia
- 4 Rumah Rusak Ringan

GEMPA BUMI 6,1 SR
LEBAK, BANTEN
23 Januari 2018
- 1 Jiwa Meninggal Dunia
- 1.018 Jiwa Mengungsi

TANAH LONGSOR
SUKABUMI, JAWA BARAT
31 Desember 2018
- 18 Jiwa Meninggal Dunia
- 3 Jiwa Luka-luka

GEMPA BUMI
BANJARNEGARA, JAWA TENGAH
18 Maret 2018
- 2 Jiwa Meninggal Dunia
- 41 Jiwa Luka-luka

LETUSAN GUNUNGAPI
MERAPI, DIY & JAWA TENGAH
11 Mei 2018
- \- Jiwa Meninggal Dunia & Hilang
- 1.375 Jiwa Mengungsi

GEMPA BUMI
SITUBONDO, JAWA TIMUR
11 Oktober 2018
- 4 Jiwa Meninggal Dunia
- 36 Jiwa Luka-luka

GEMPABUMI 7 SR
LOMBOK, NUSA TENGGARA BARAT
5 Agustus 2018
- 564 Jiwa Meninggal Dunia
- 1.584 Jiwa Luka-luka

KERUSAKAN AKIBAT BENCANA TAHUN 2018

- **320 Ribu** RUMAH RUSAK
- **1.736** FASILITAS PENDIDIKAN RUSAK
- **106** FASILITAS KESEHATAN RUSAK
- **857** FASILITAS PERIBADATAN RUSAK

DAMPAK BENCANA TAHUN 2018: 4.814 JIWA MENINGGAL DUNIA & HILANG 10,239 Juta JIWA TERDAMPAK & MENGUNGSI

1Januari 2018 - 31 Desember 2018

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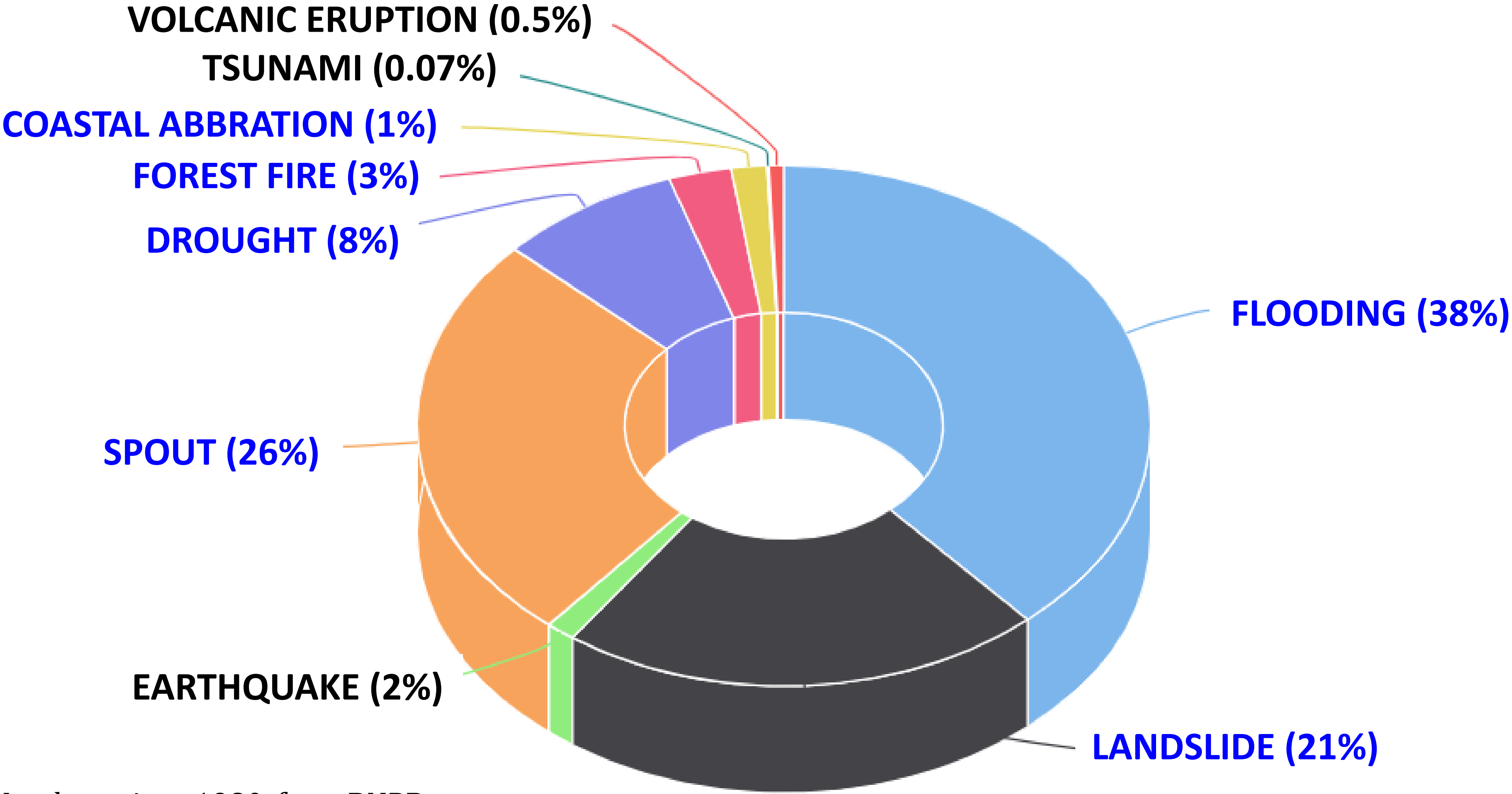
Proportion of natural disaster types



Numbers since 1980, from BNPB

HYDROMET RELATED DISASTERS: 96%

Jakarta, Indonesia
6 Februari 2007

Recurring major floods:

- ✓ 1996
- ✓ 2002
- ✓ 2007
- ✓ 2013
- ✓ 2015
- ✓ 2019
- ✓ 2020

City vulnerabilities to climate change in slum area

- Is urbanization contributing to this as well?
- Unskilled urban people live in most of the slum area


West Java, Indonesia
September 23, 2016
At least 33 people were killed in devastating flash floods and landslides.
Rural vulnerability induced by extreme weather due to the impact of climate change.
© 2016 Dasril Roszandi/NurPhoto/Sipa USA via AP Images
PMI
PALANG MERAH INDONESIA

Rongkop, Central Java, Indonesia
September 19, 2015

- Rural vulnerability to drought exacerbated by climate change
- Threatening food security

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Future Projected Climate Change in Indonesia

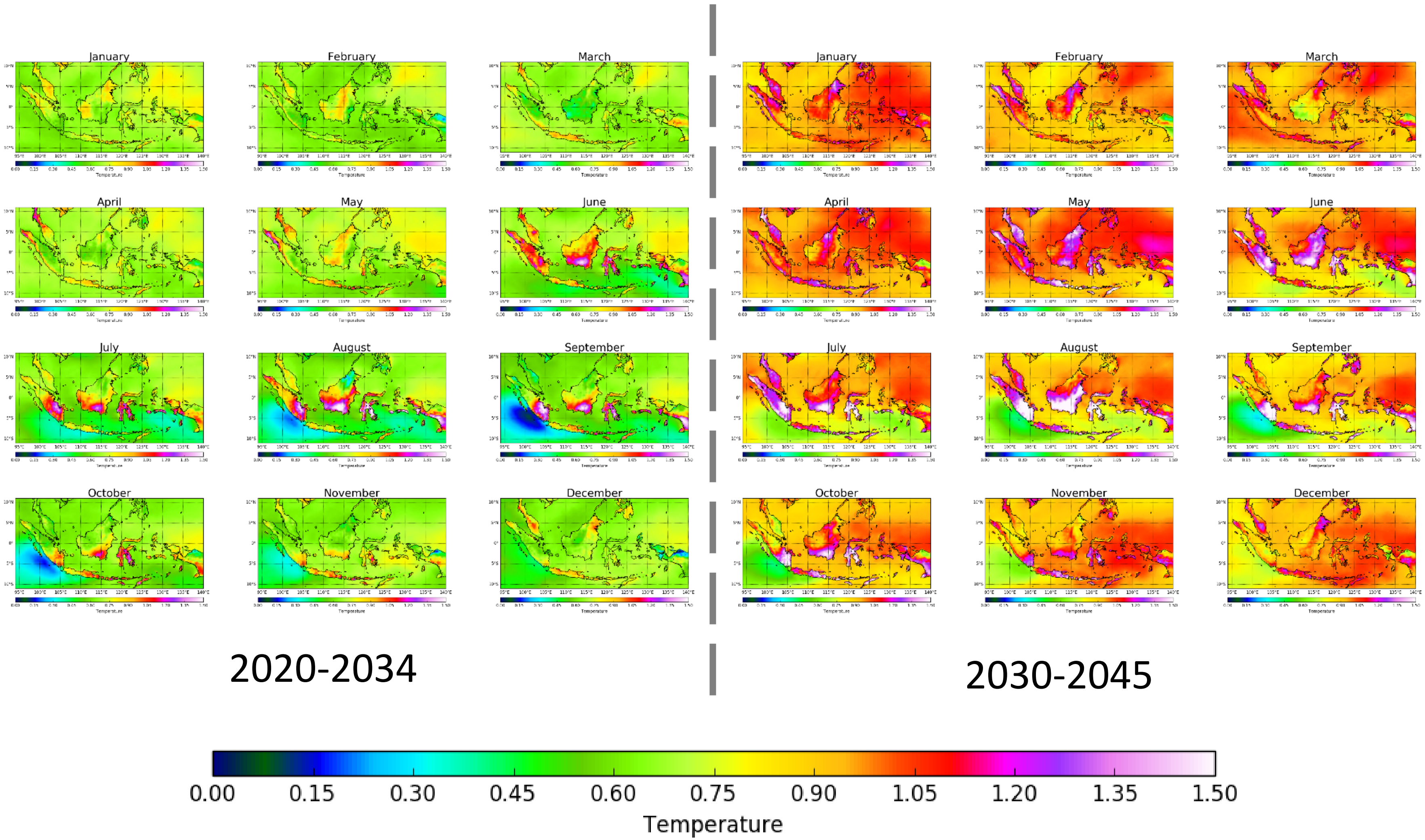
CORDEX-SEA Consortium

The CORDEX-SEA is a **collaborative climate downscaling initiative over the Southeast Asia**, involving a number countries in the region, aiming to develop detailed regional climate information necessary for vulnerability, impact and adaptation assessment.

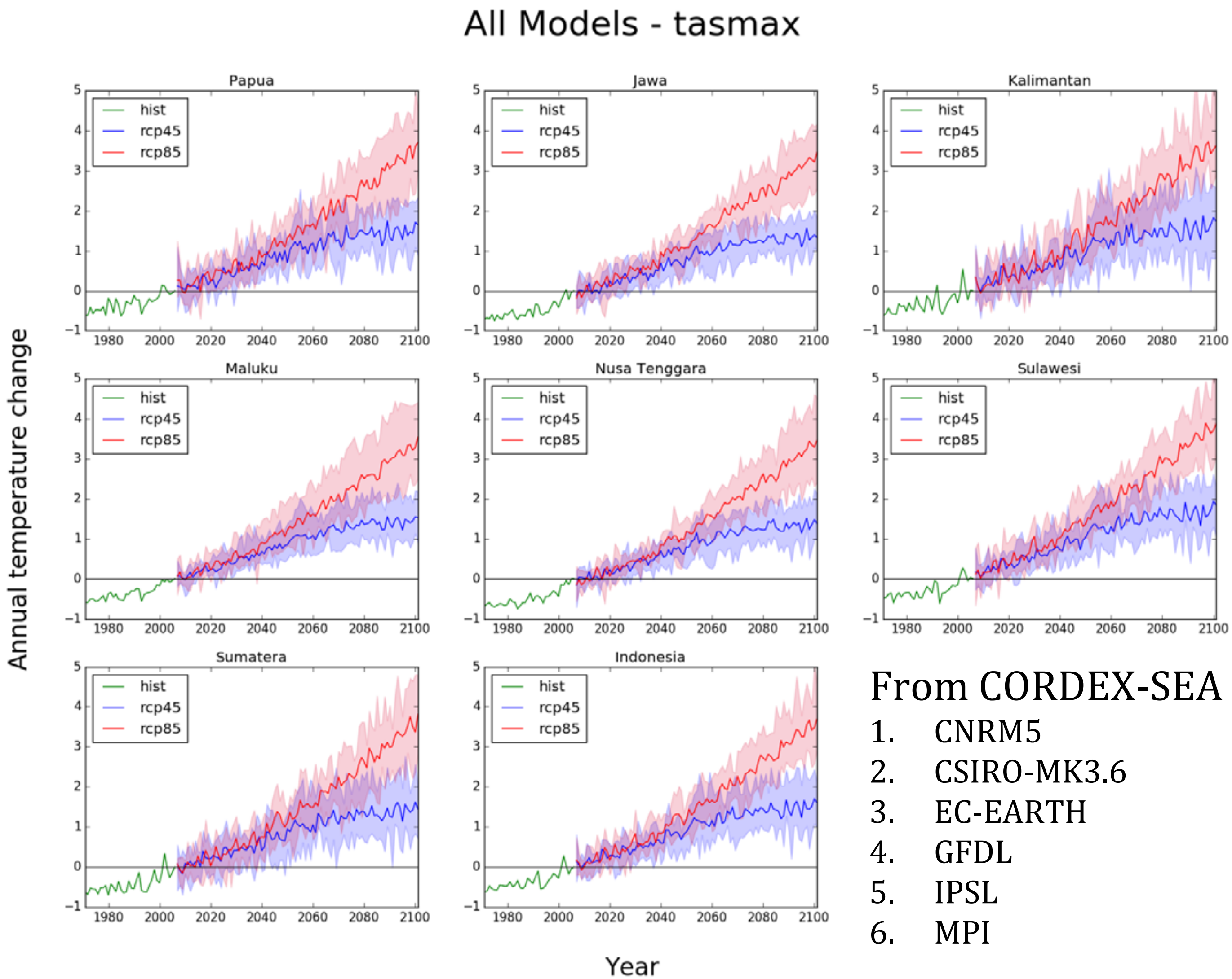
The initiative was designed to downscale **a number of CMIP5 Global Climate Model (GCM)** using **Regional Climate Model (RegCM4)**, employing **Representative Concentration Pathways (RCPs) 4.5 and 8.5, respectively**.

Participating members : 11 countries, 18 institutions
Numbers of GCM : 9 GCMs

Climate projections: max temperature



Climate projections: max temperature



From CORDEX-SEA models:

1. CNRM5
2. CSIRO-MK3.6
3. EC-EARTH
4. GFDL
5. IPSL
6. MPI

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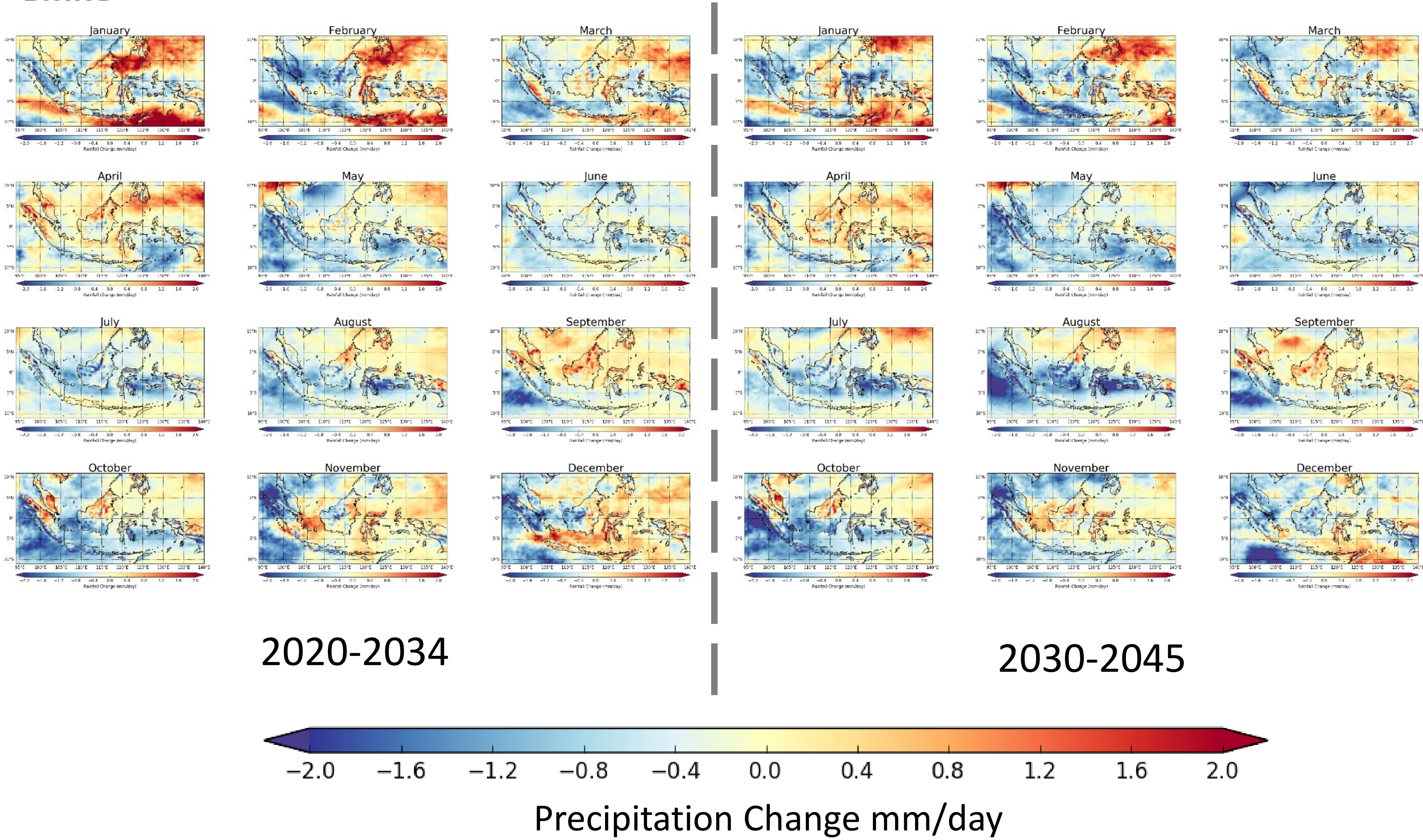
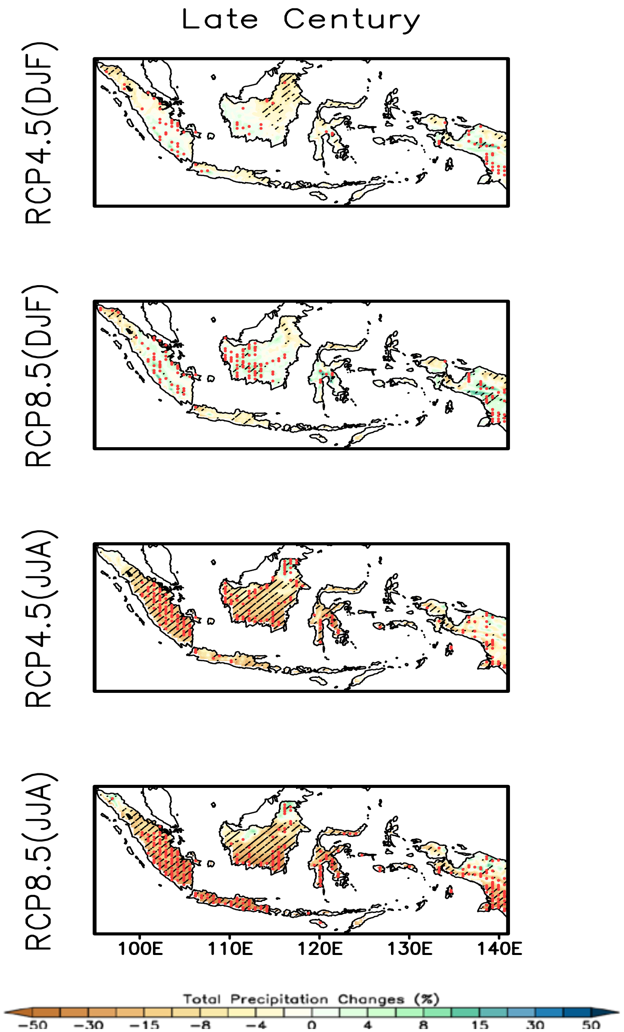
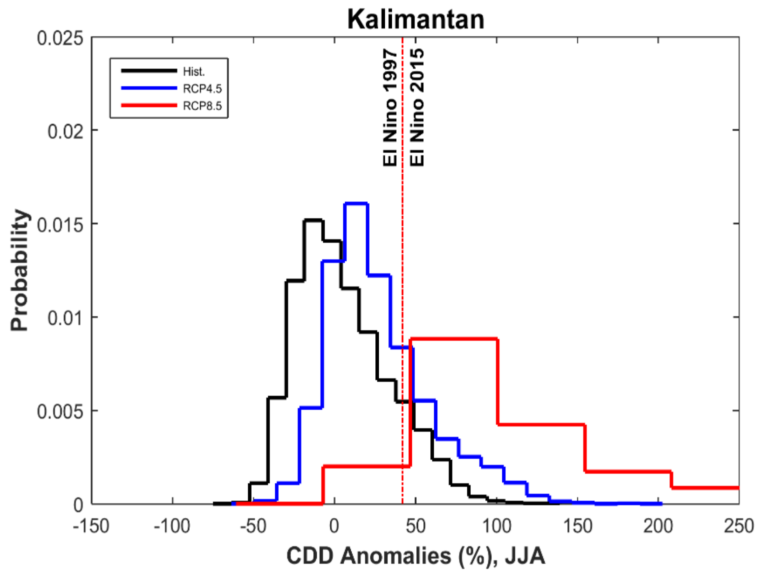
Climate projections: rainfall

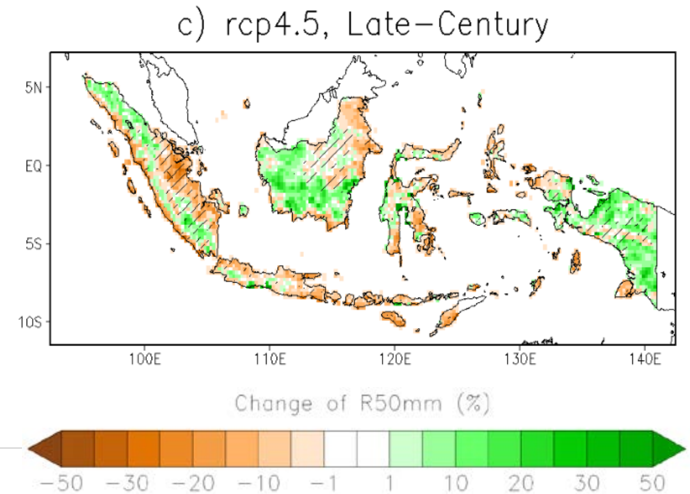


Climate projections: rainfall





Prolonged dry spell in end century



Increased extreme rainfall (R50mm)

Images from Supari et.al (2018)

Remarks:
What does climate change mean to Indonesia

- Continued increase of temperature, with increasing diurnal/daily temperature range (Tmax increase higher than Tmin).

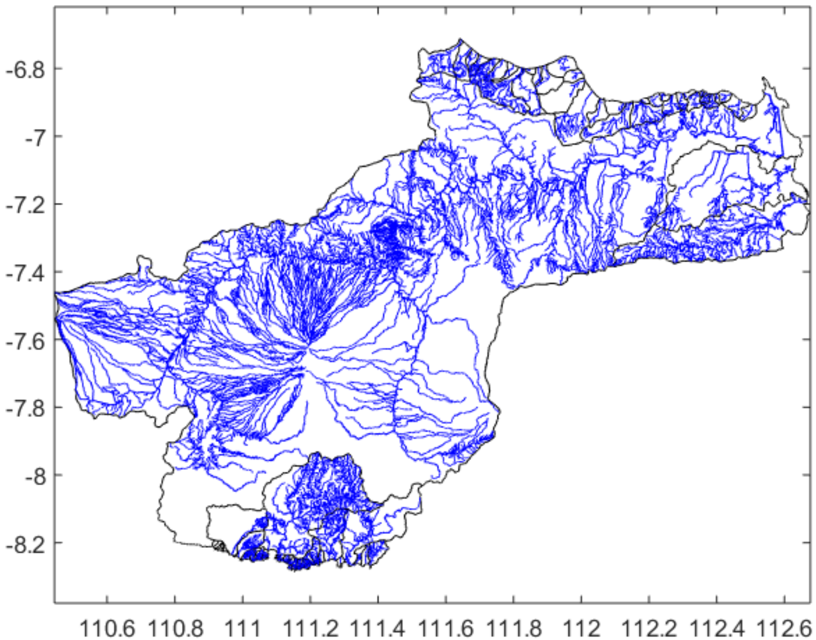
- Increasing extreme rainfall frequency, especially during rainy season (Dec-Jan-Feb), may lead to flooding event when vulnerability is high.

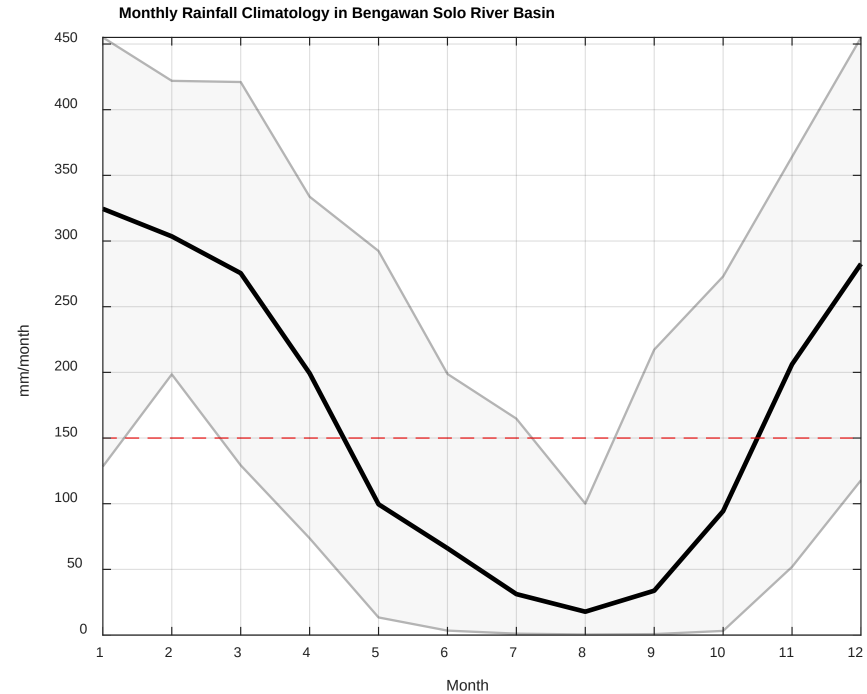
- Longer dry season, during mid year period (Jun-Jul-Aug).

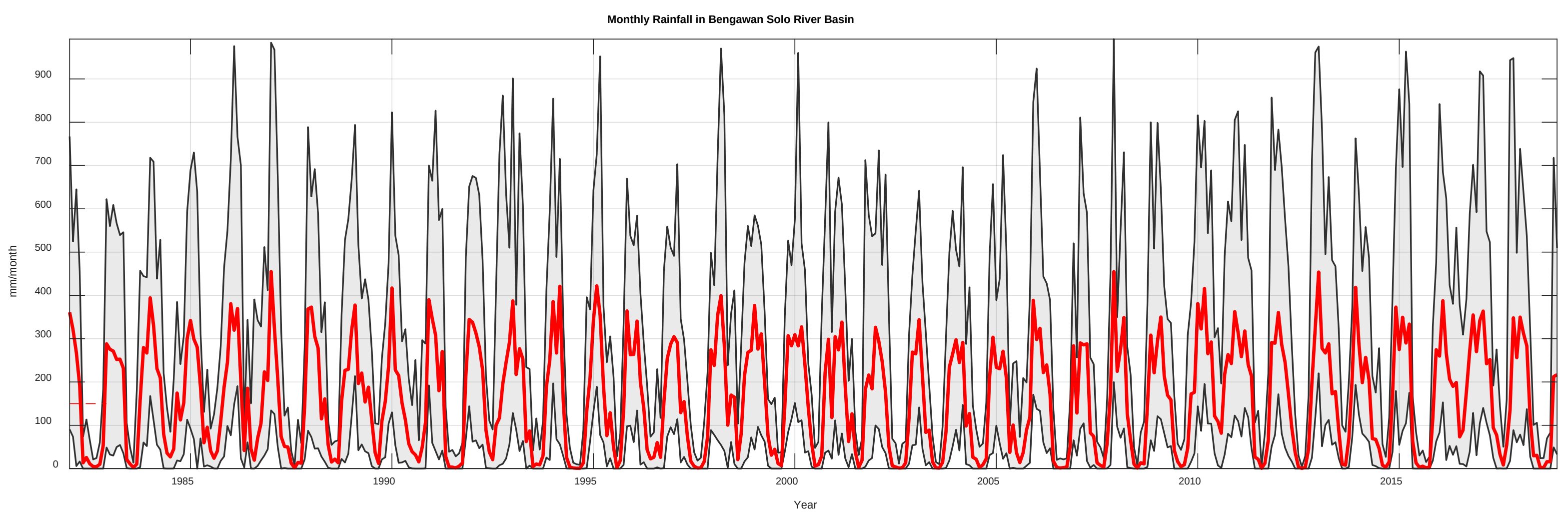
- Drying tendency for southern equator part:
  - Calls for better water resources management.
  - Increased risk for forest fire threat in peatland areas.

Specific Climate Change Analysis for the Bengawan River Basin *(Preliminary)*

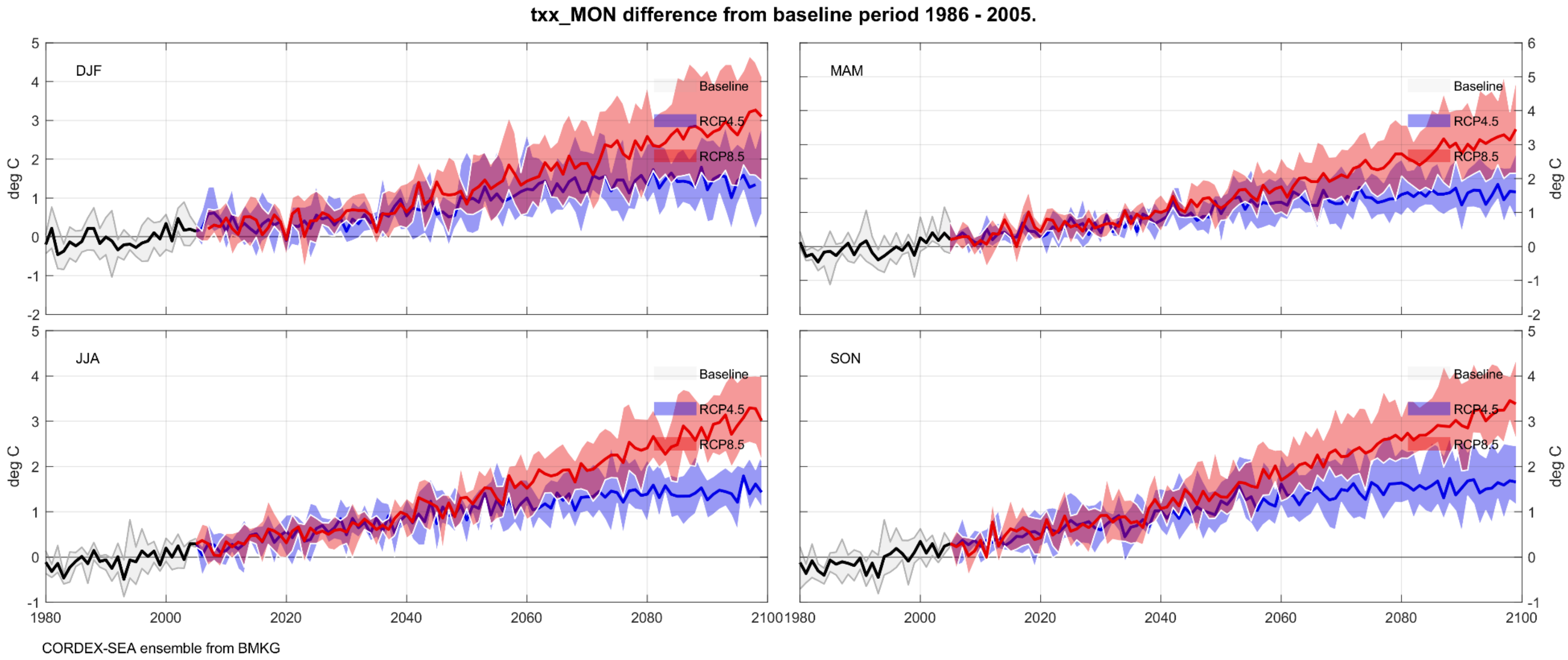
Climatology Bengawan Solo River Basin:
From gridded precip dataset





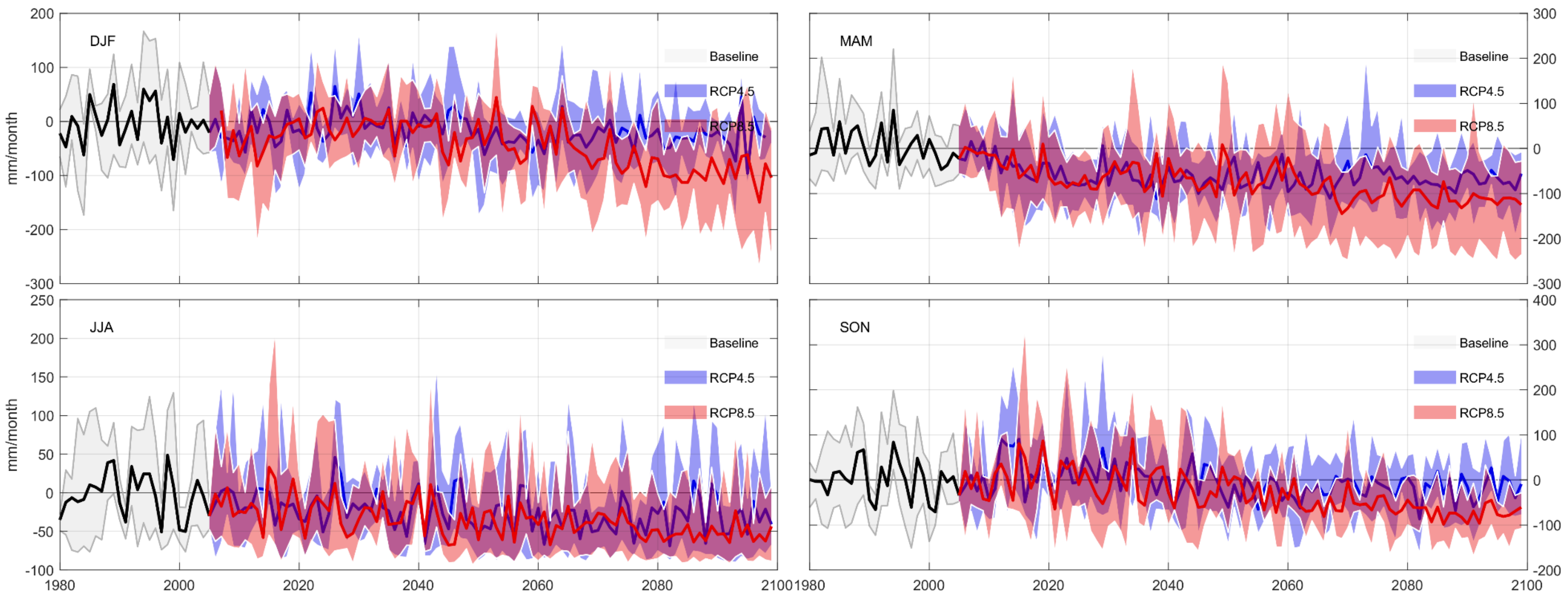


Monthly TXX


txx_MON difference from baseline period 1986 - 2005.
DJF
MAM
JJA
SON
Baseline
RCP4.5
RCP8.5
deg C
1980
2000
2020
2040
2060
2080
2100
CORDEX-SEA ensemble from BMKG

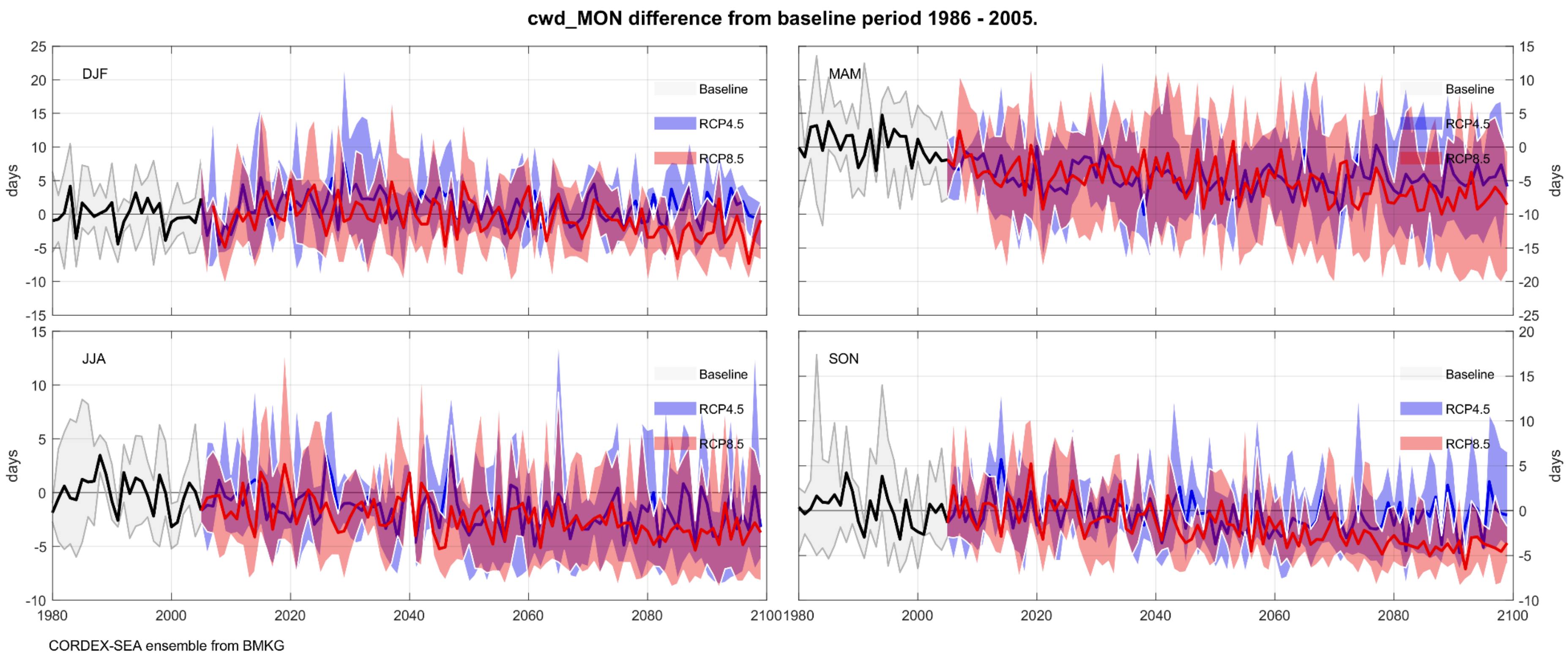
Monthly PRCPTOT

prcptot_MON difference from baseline period 1986 - 2005.



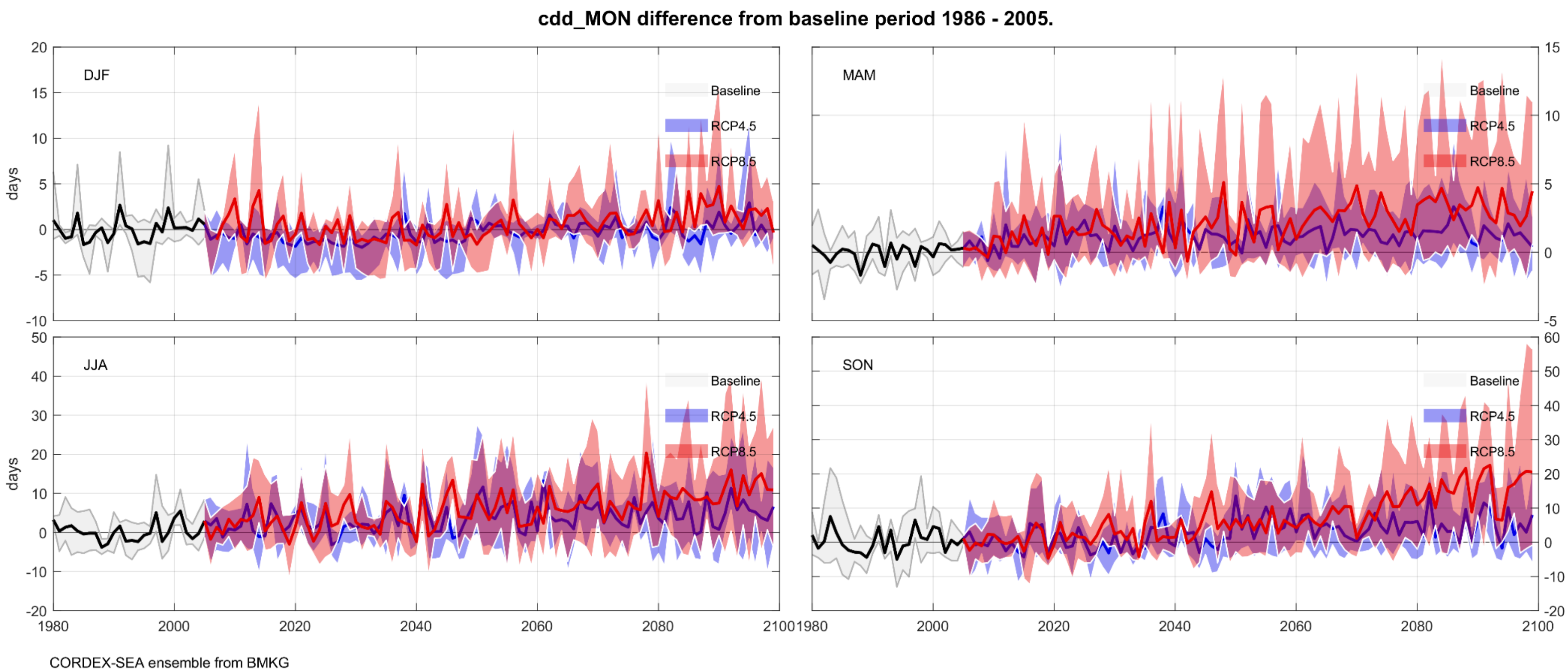
CORDEX-SEA ensemble from BMKG

Monthly CWD



cwd_MON difference from baseline period 1986 - 2005.
DJF
MAM
JJA
SON
Baseline
RCP4.5
RCP8.5
days
CORDEX-SEA ensemble from BMKG

Monthly CDD



cdd_MON difference from baseline period 1986 - 2005.
DJF
MAM
JJA
SON
Baseline
RCP4.5
RCP8.5
days
1980
2000
2020
2040
2060
2080
2100
CORDEX-SEA ensemble from BMKG

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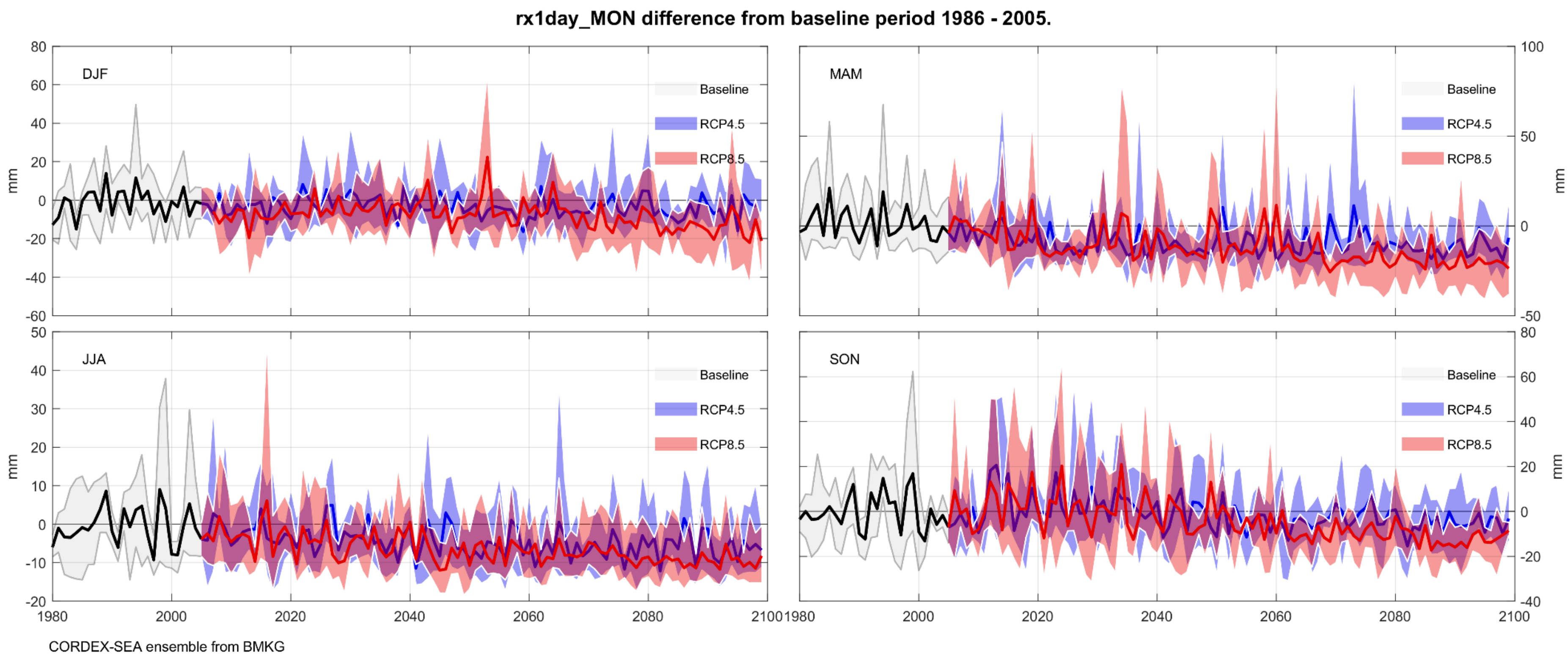
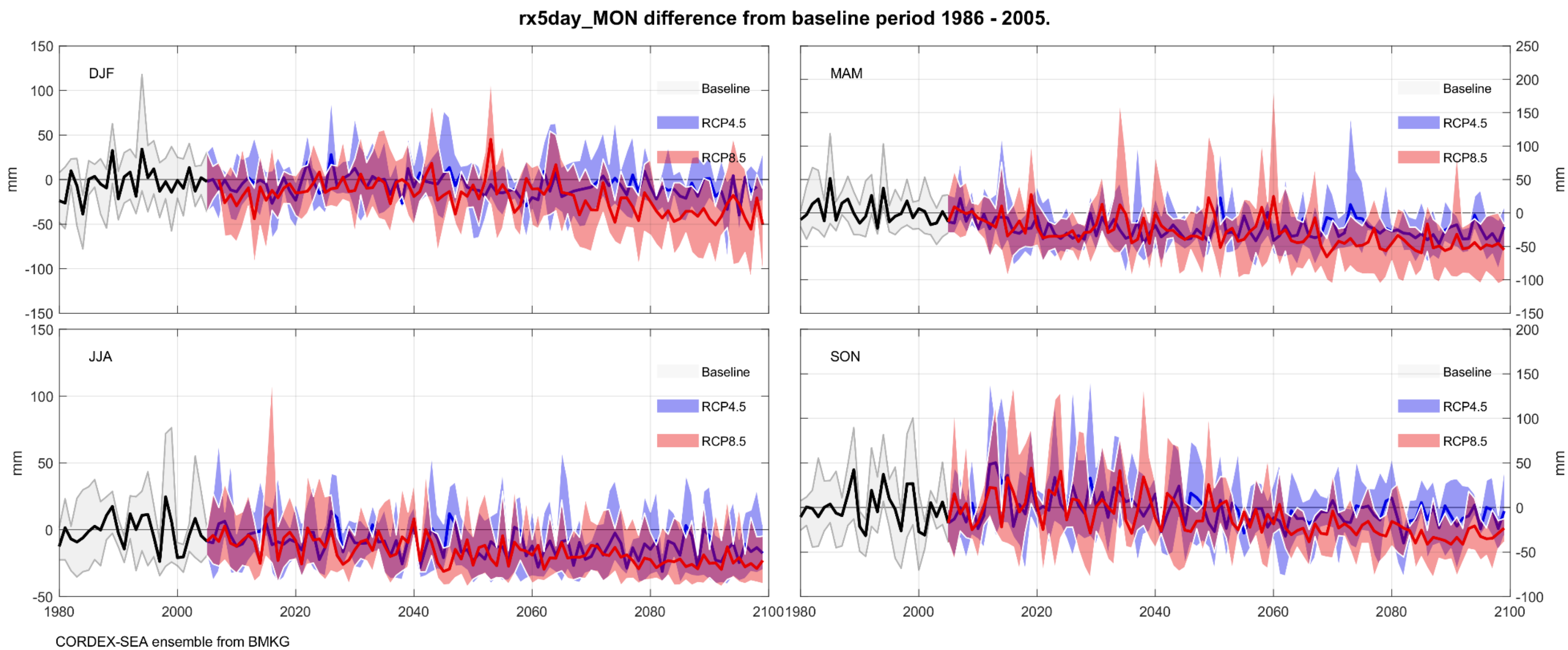
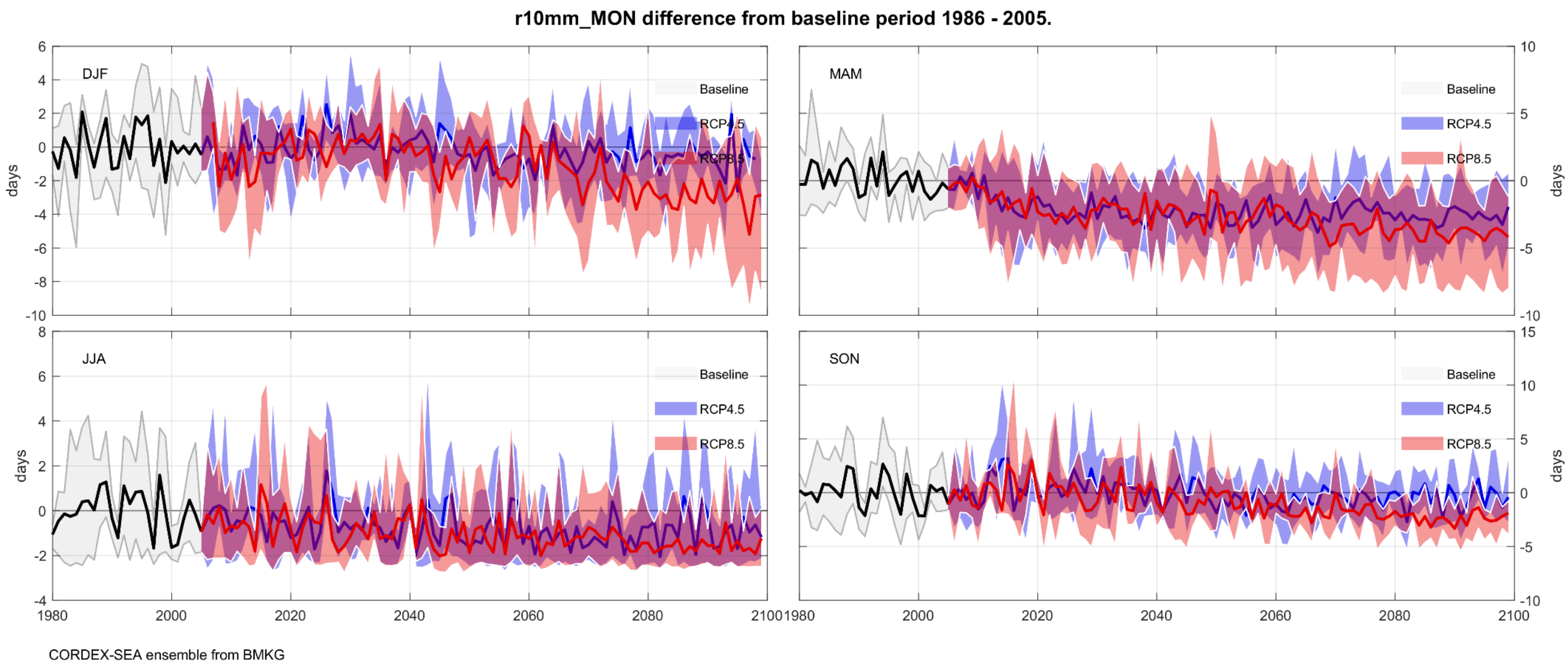
Monthly RX1DAY



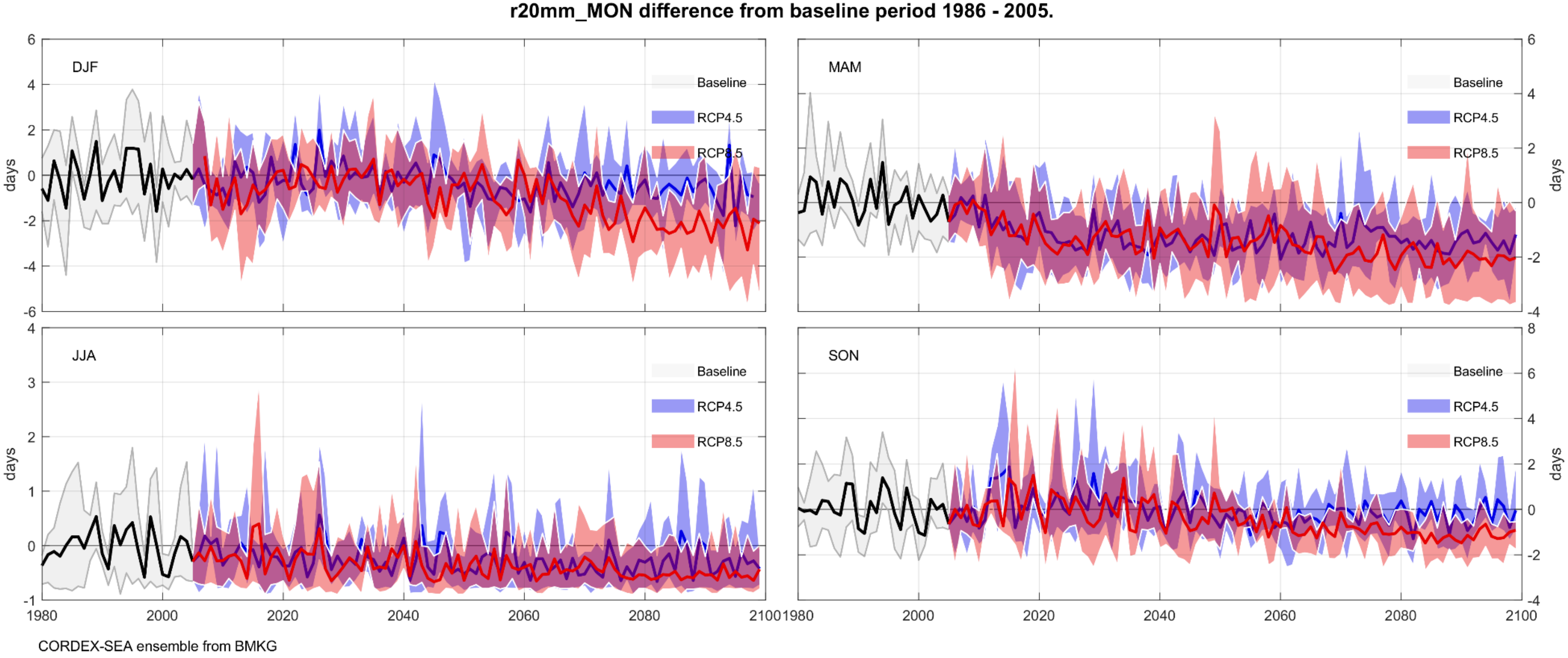
Monthly RX5DAY



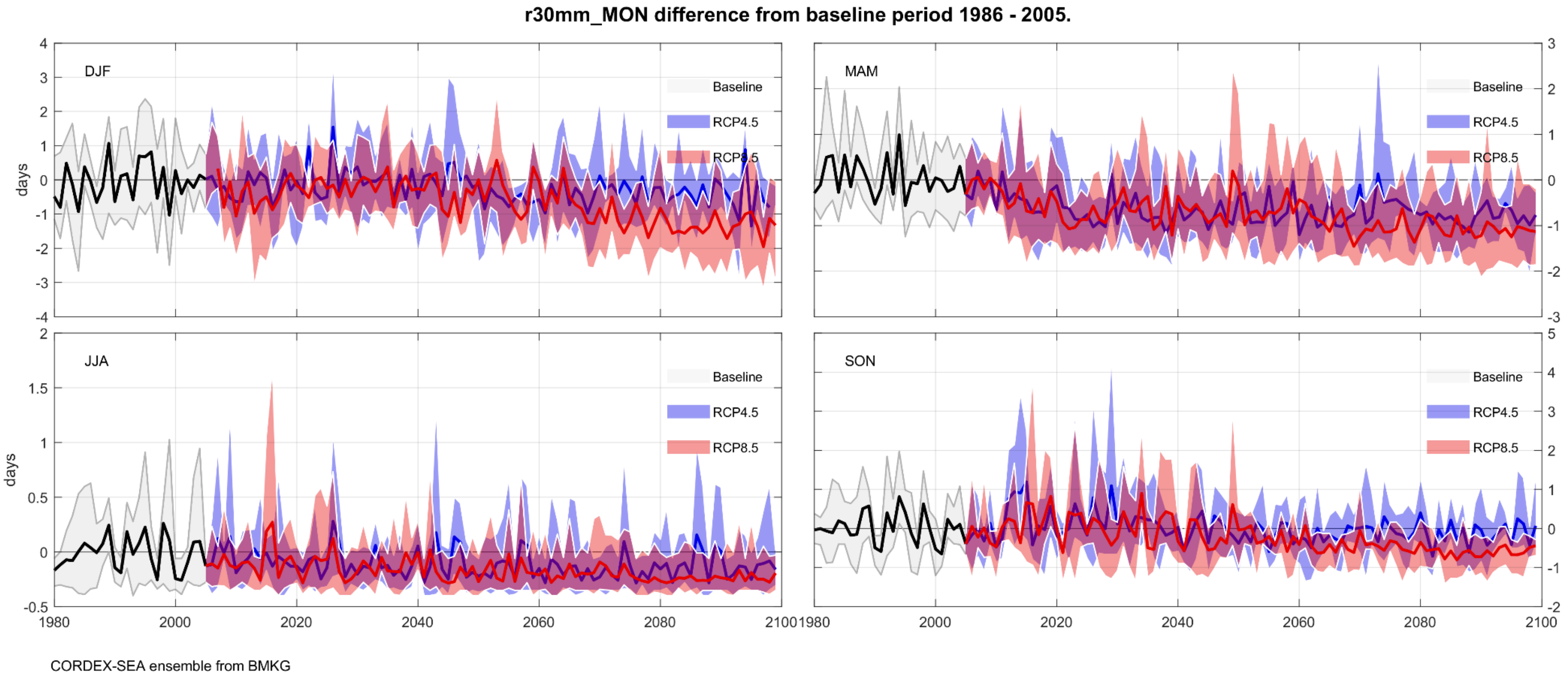
Monthly R10MM



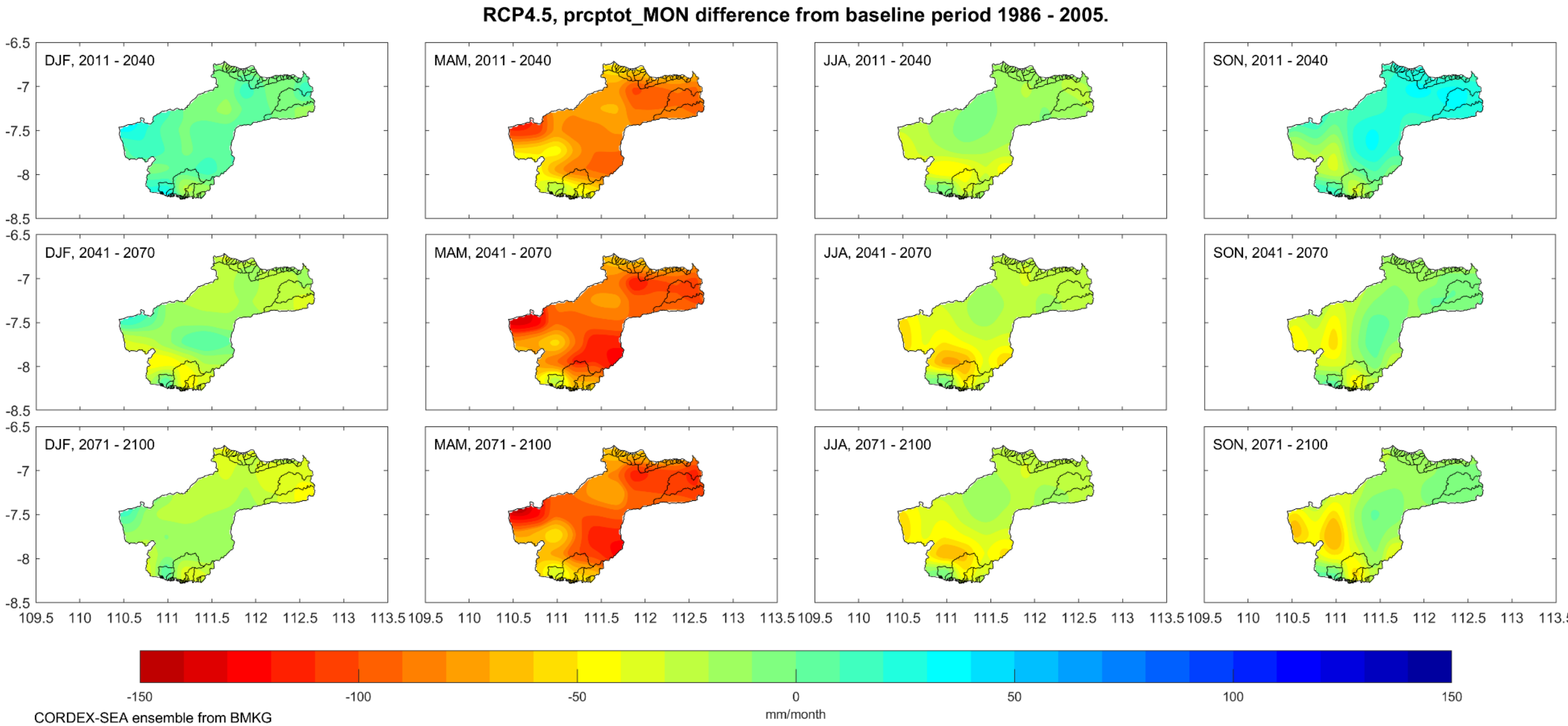
Monthly R20MM



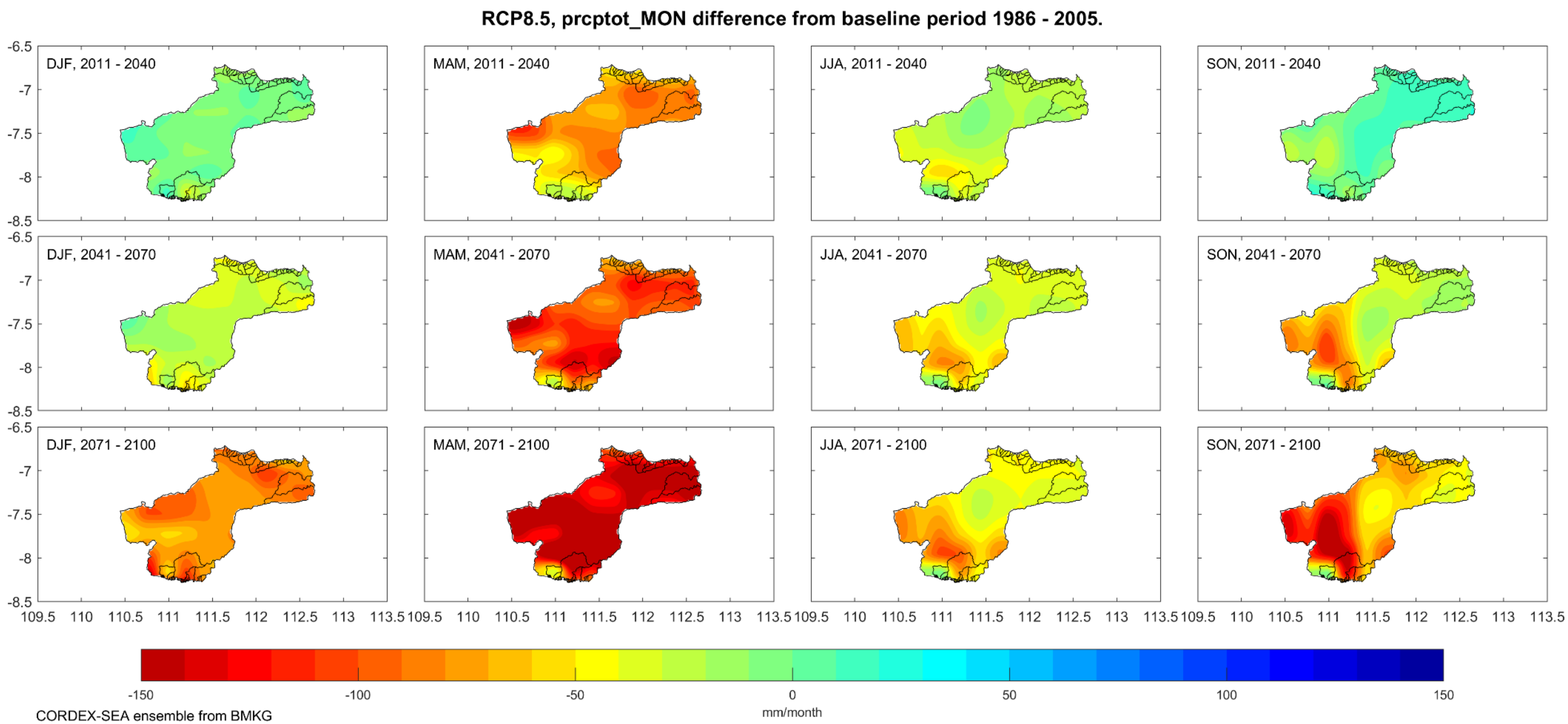
Monthly R30MM



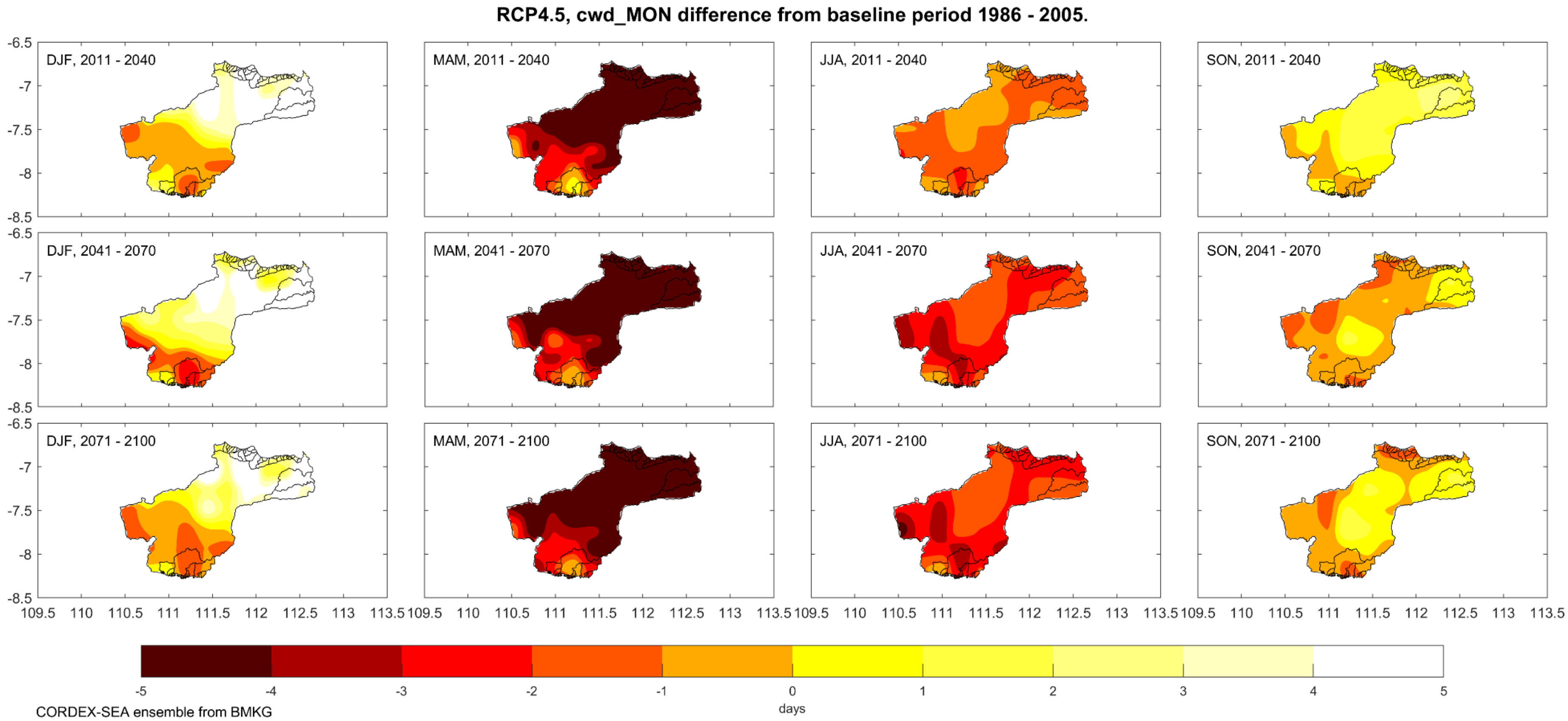
Seasonal PRCPTOT, RCP4.5



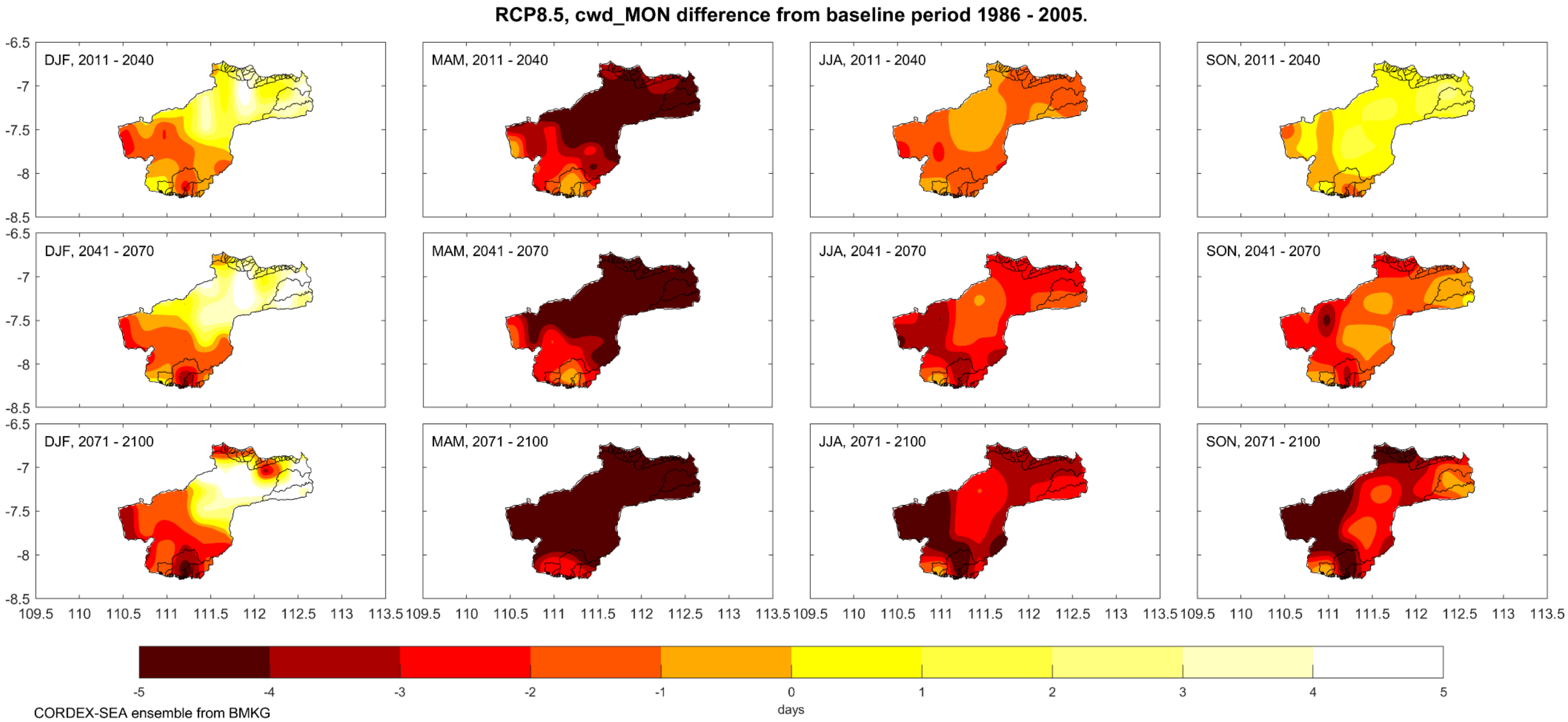
Seasonal PRCPTOT, RCP8.5



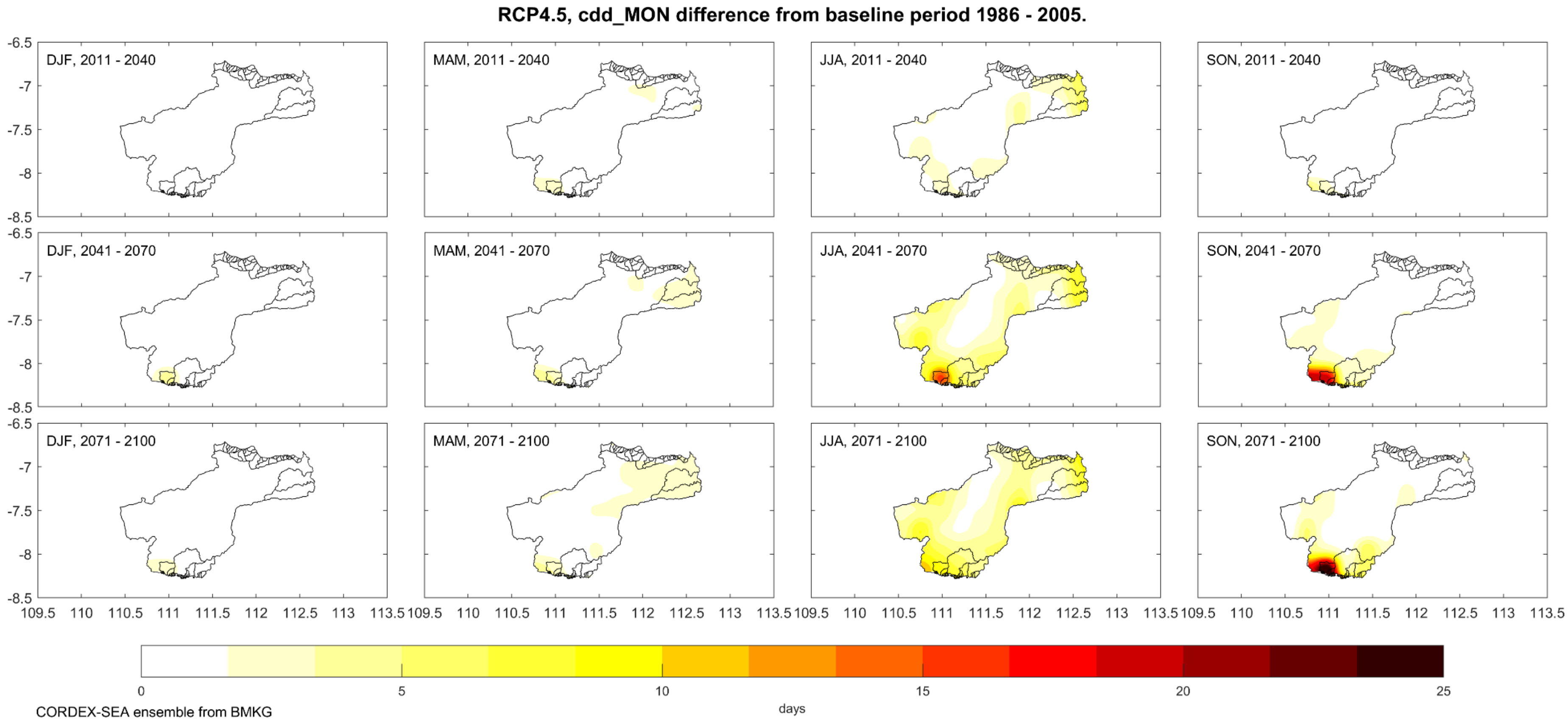
Seasonal CWD, RCP4.5



Seasonal CWD, RCP8.5

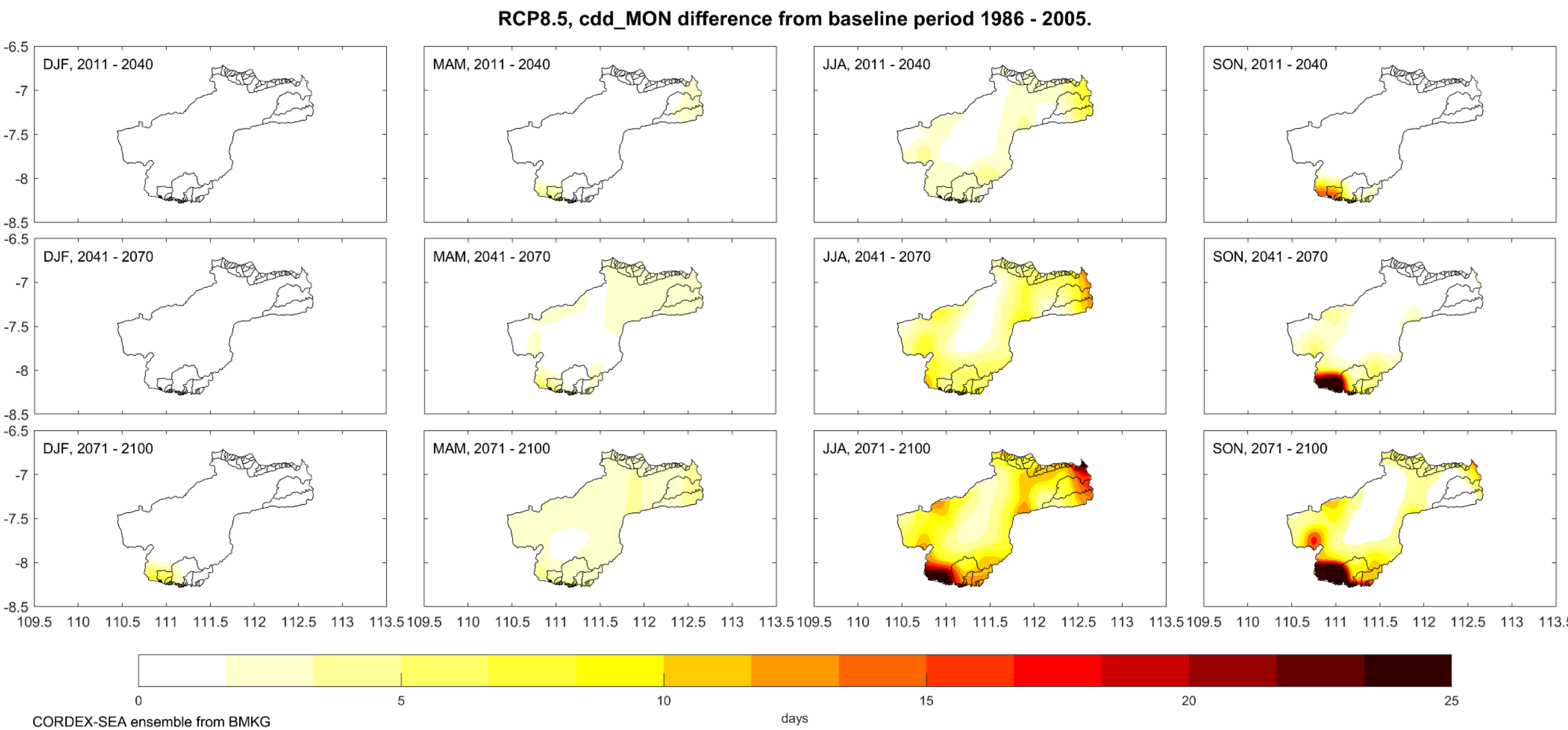


Seasonal CDD, RCP4.5

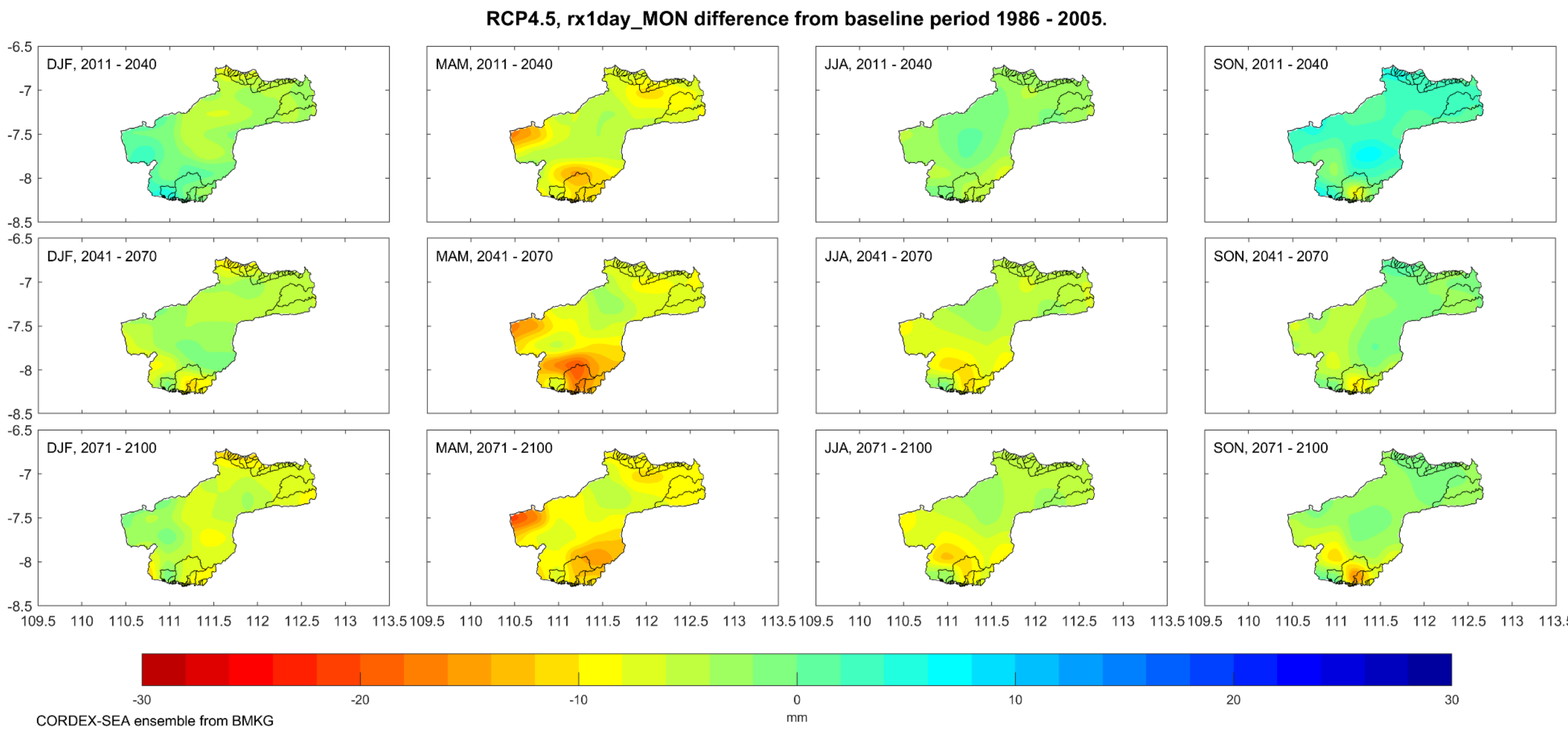


BMKG

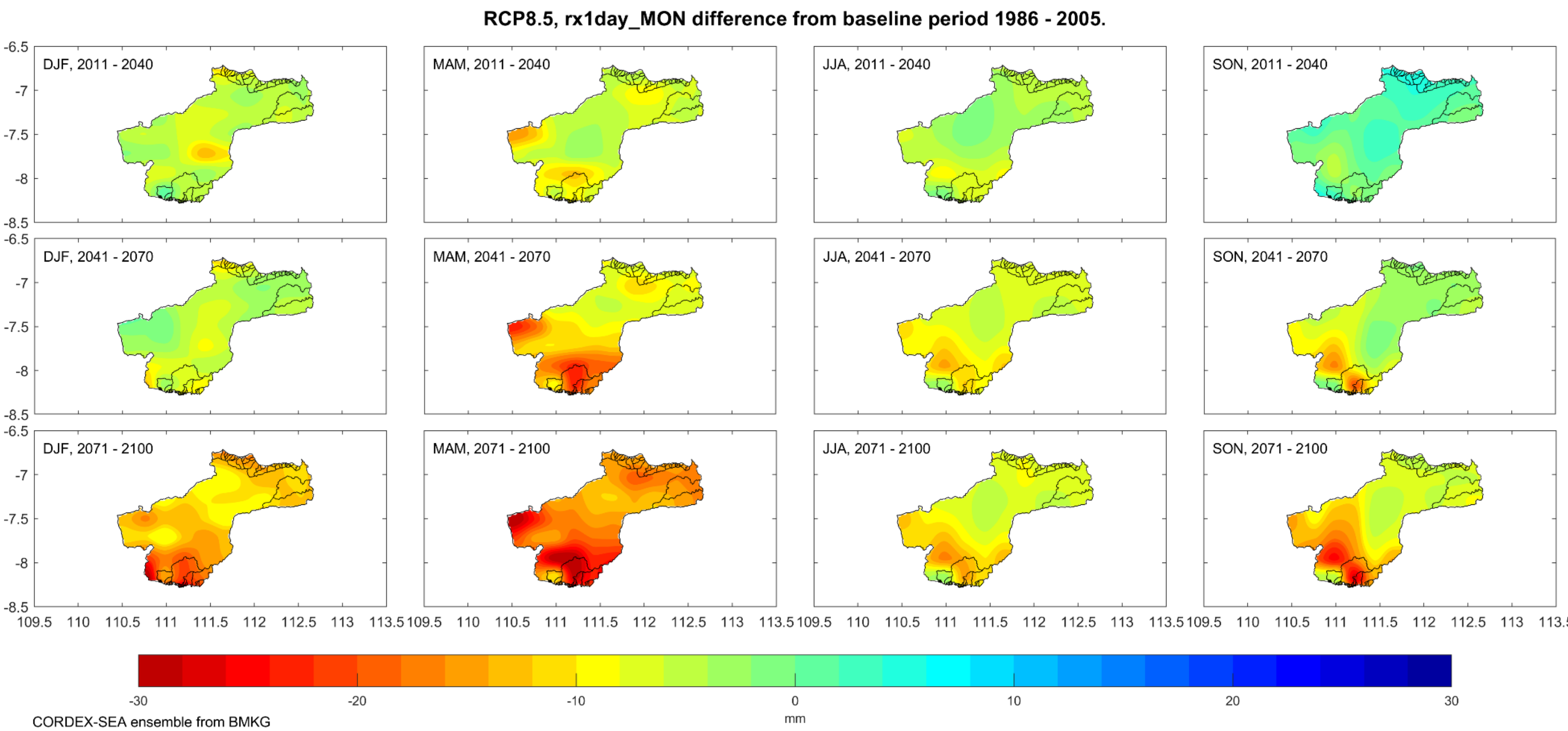
Seasonal CDD, RCP8.5



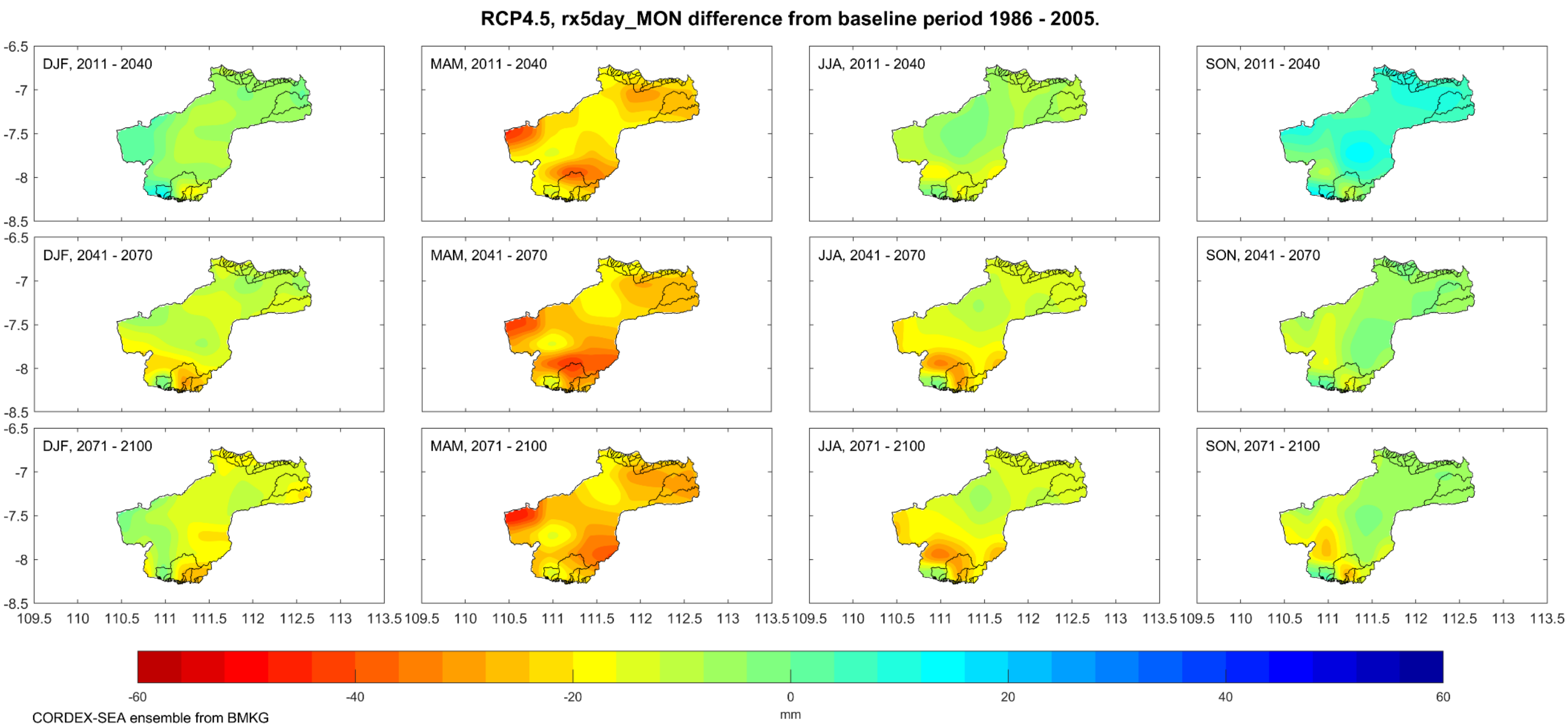
Seasonal RX1DAY, RCP4.5



SeasonaL RX1DAY, RCP8.5

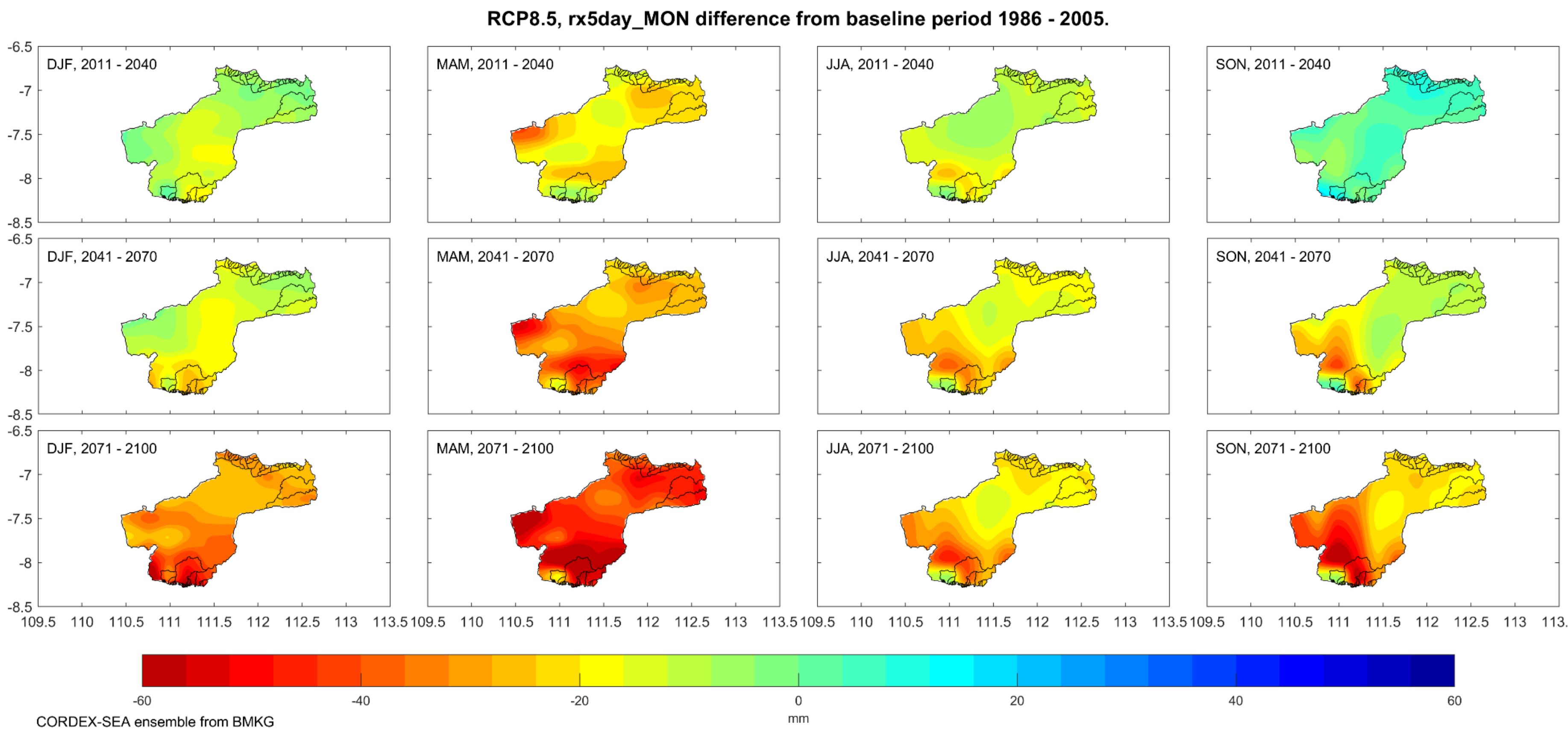


Seasonal RX5DAY, RCP4.5

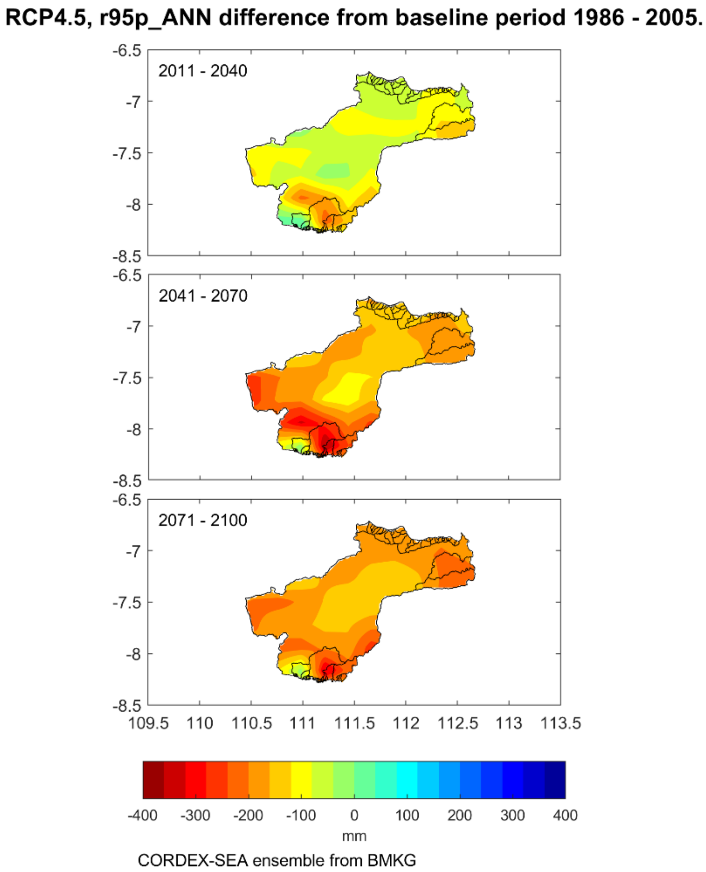


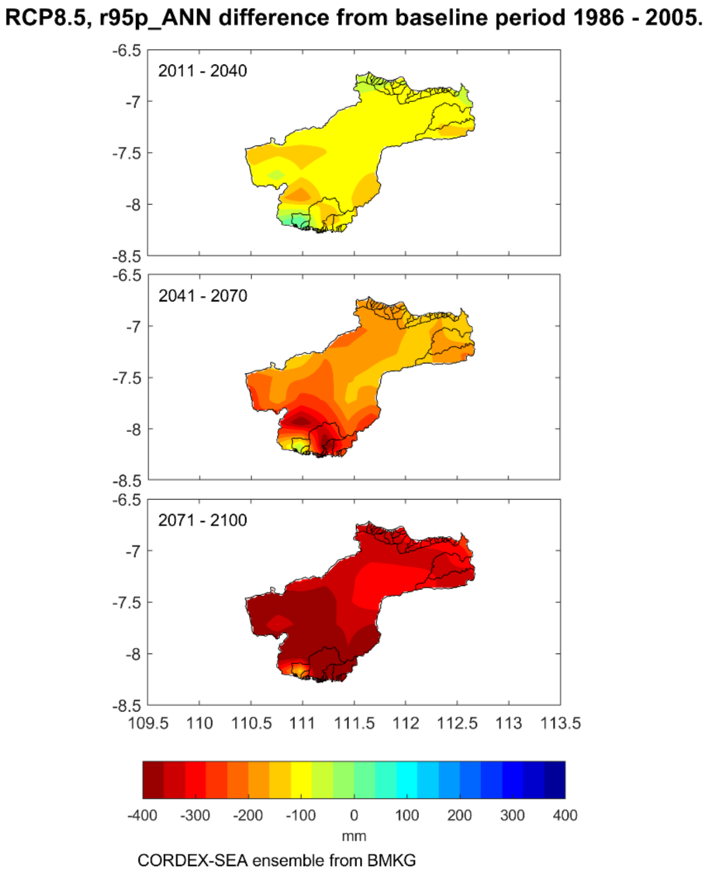
BMKG

Seasonal RX5DAY, RCP8.5



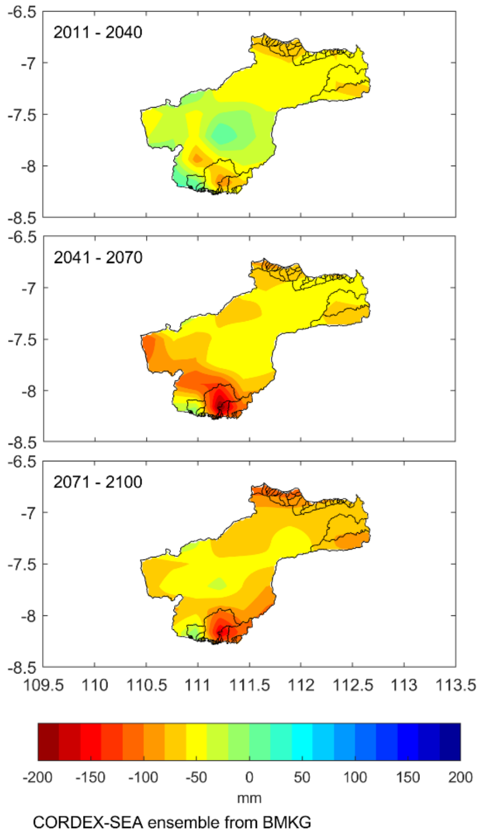
Annual R95P


RCP4.5, r95p_ANN difference from baseline period 1986 - 2005.
2011 - 2040
2041 - 2070
2071 - 2100
-6.5
-7
-7.5
-8
-8.5
109.5
110
110.5
111
111.5
112
112.5
113
113.5
-400
-300
-200
-100
0
100
200
300
400
mm
CORDEX-SEA ensemble from BMKG

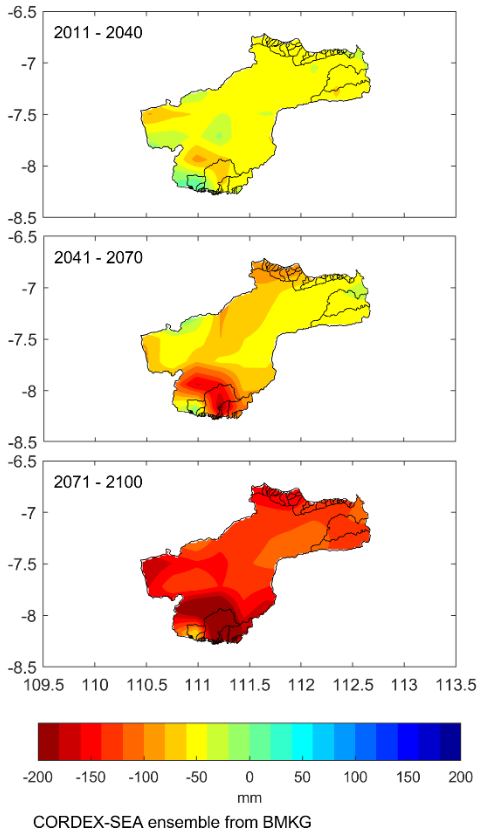

RCP8.5, r95p_ANN difference from baseline period 1986 - 2005.
2011 - 2040
2041 - 2070
2071 - 2100
-6.5
-7
-7.5
-8
-8.5
109.5
110
110.5
111
111.5
112
112.5
113
113.5
-400
-300
-200
-100
0
100
200
300
400
mm
CORDEX-SEA ensemble from BMKG

Annual R99P

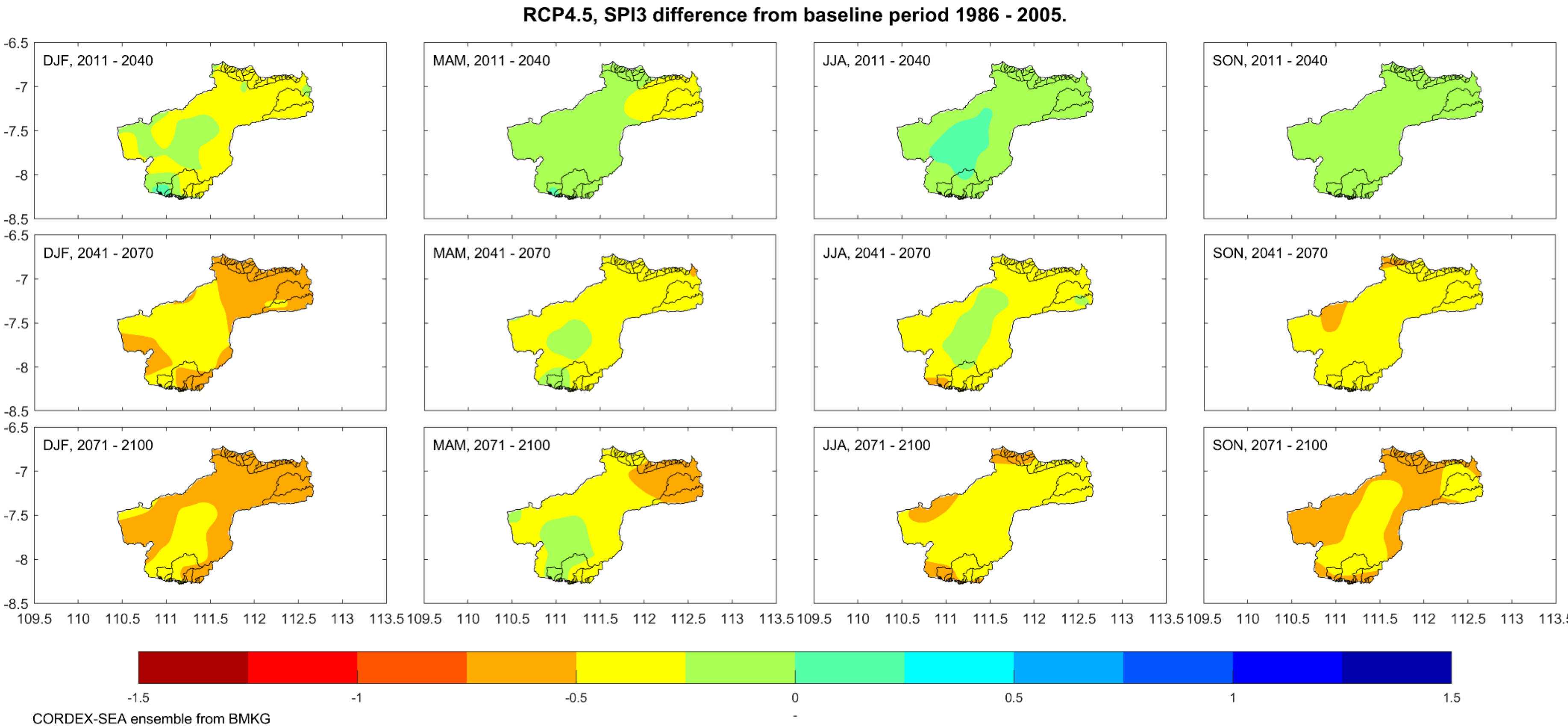
RCP4.5, r99p_ANN difference from baseline period 1986 - 2005.



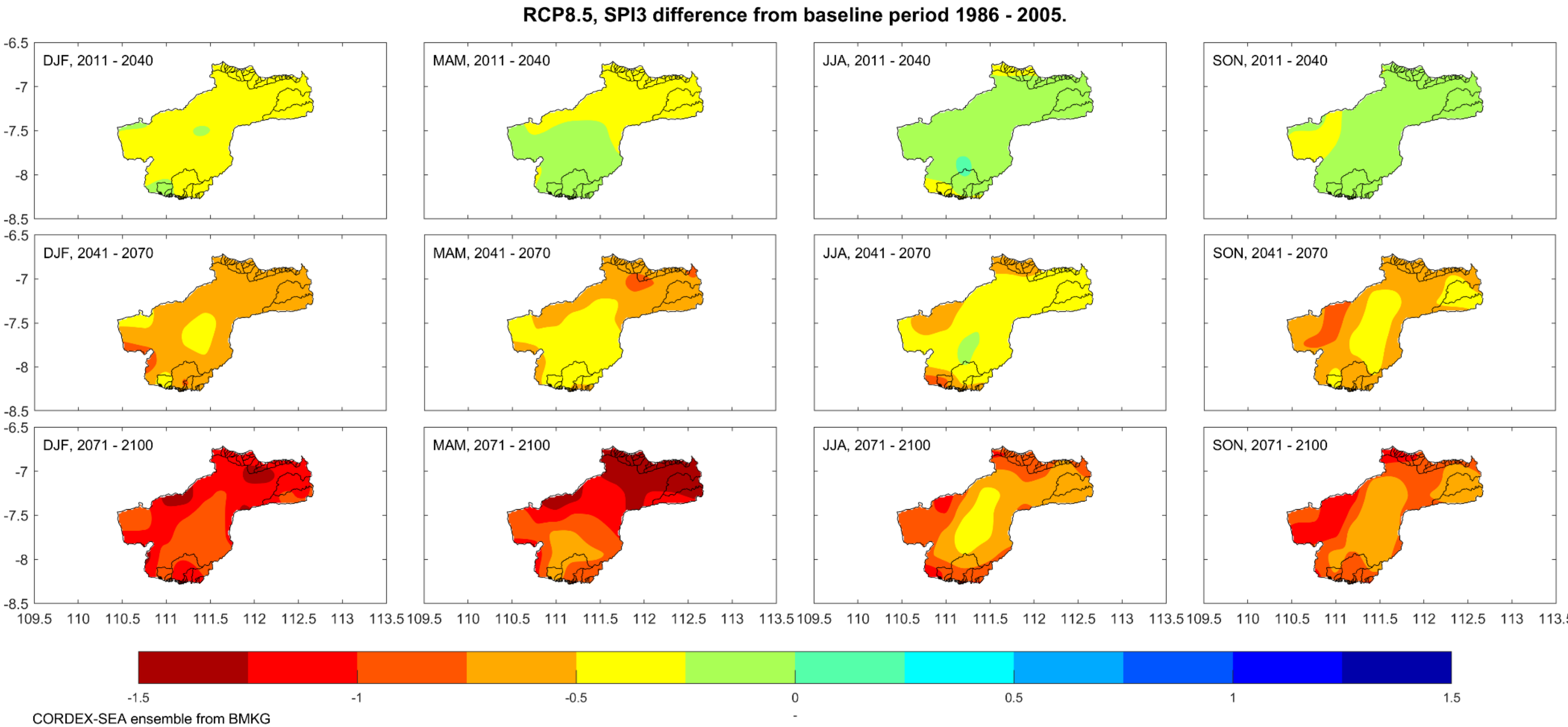
RCP8.5, r99p_ANN difference from baseline period 1986 - 2005.



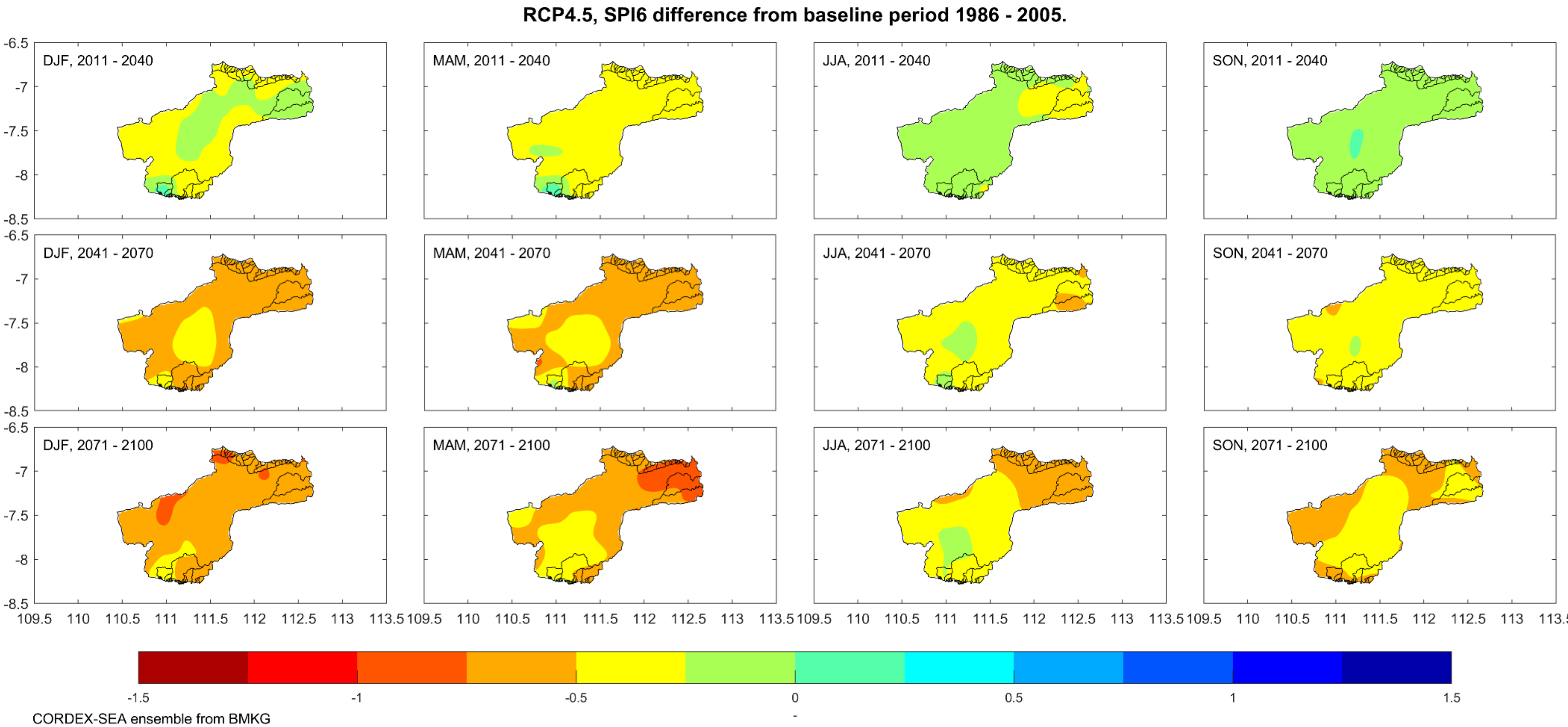
Seasonal SPI3, RCP4.5



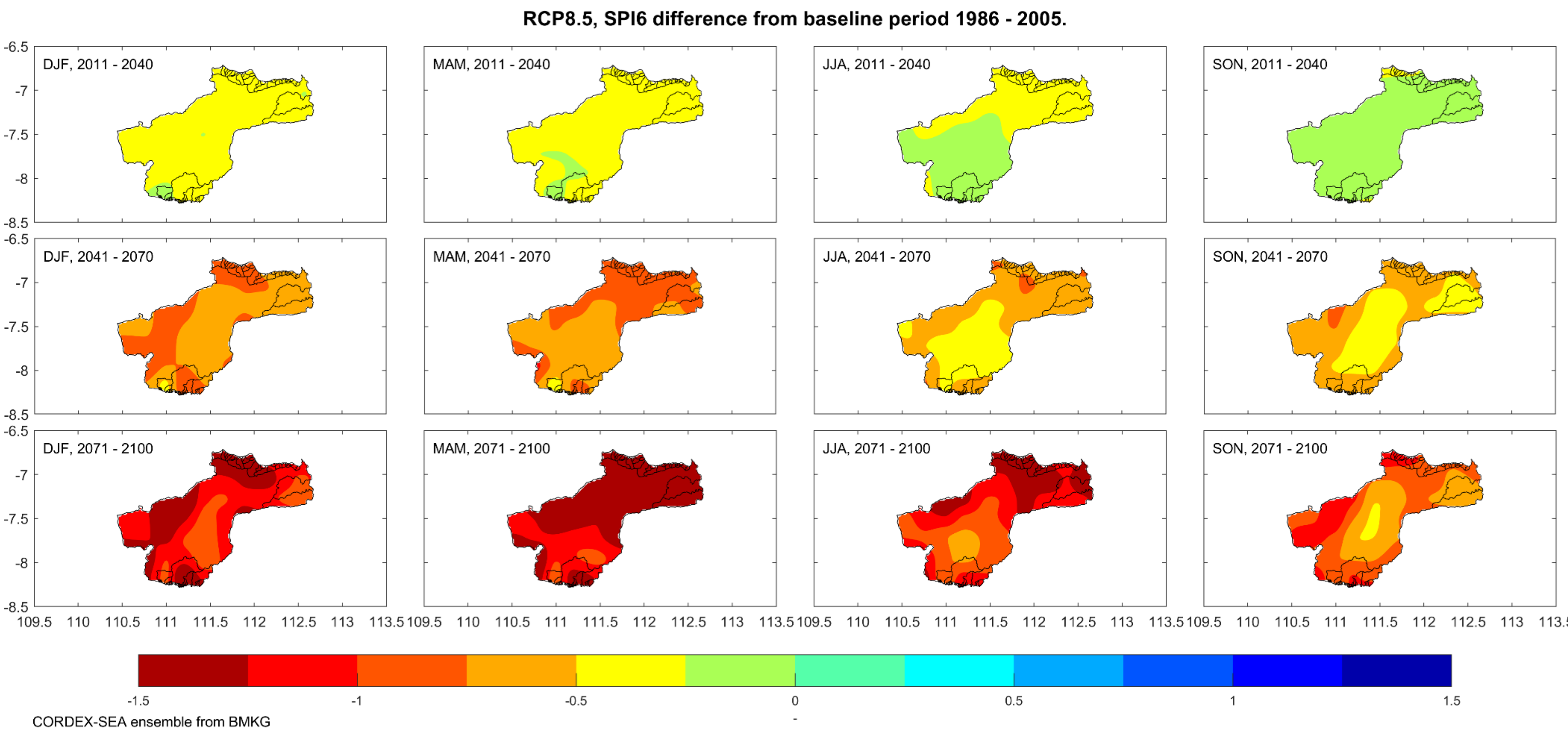
Seasonal SPI3, RCP8.5



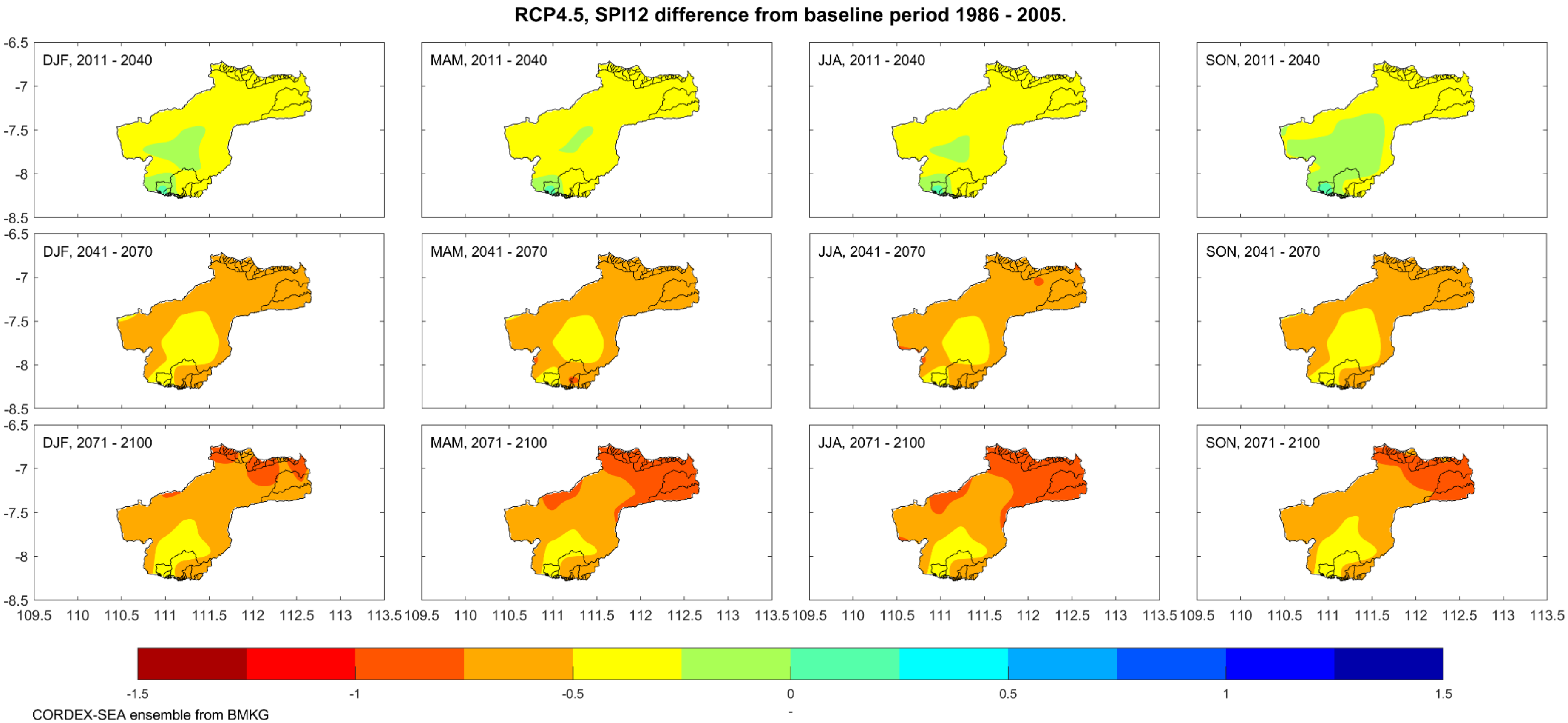
Seasonal SPI6, RCP4.5



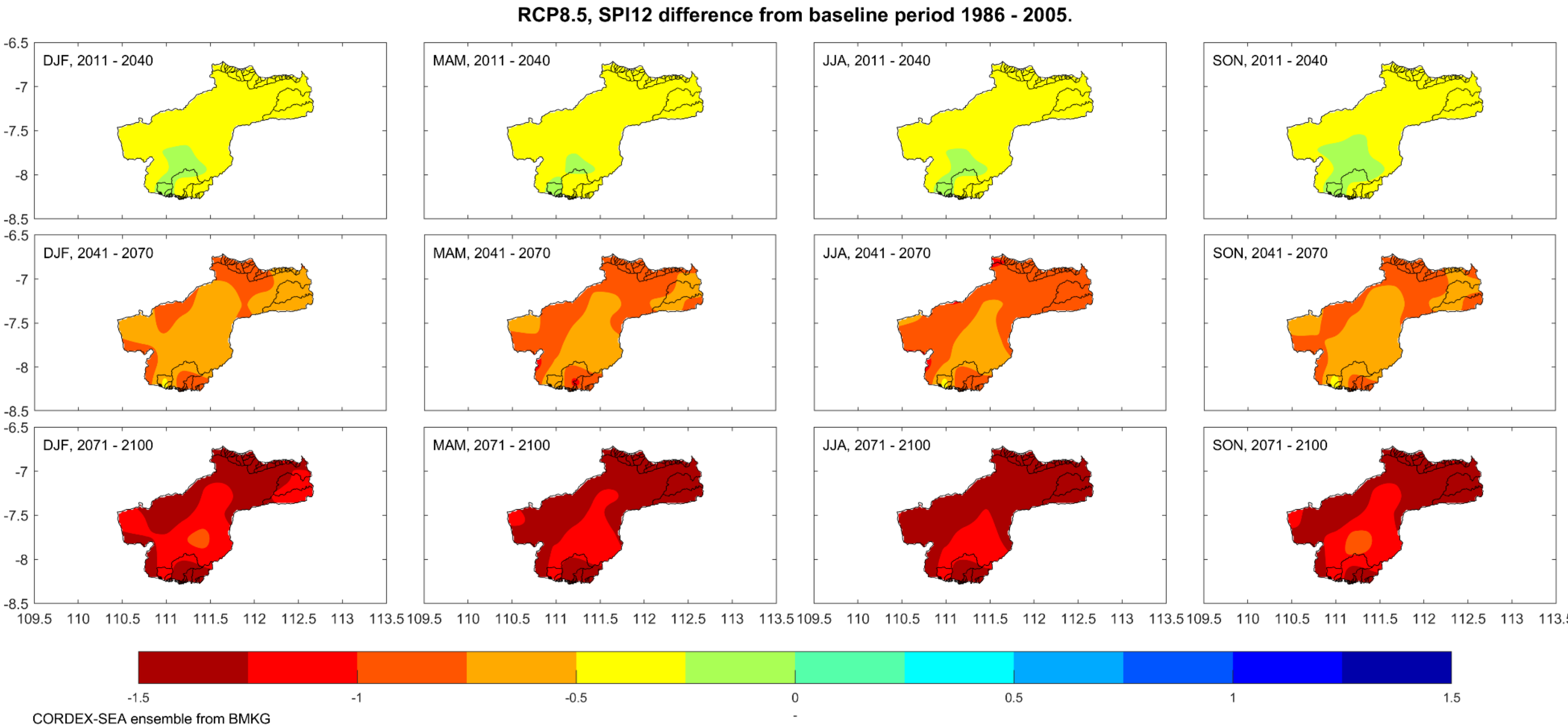
Seasonal SPI6, RCP8.5



Seasonal SPI12, RCP4.5



Seasonal SPI12, RCP8.5



Summary: For Bengawan Solo RB

- Temperature rise for both RCP4.5 and RCP8.5.

- Decay of PRCPTOT towards the end of the century, stronger decay for RCP8.5. Especially during for MAM season.

- Decrease (increase) of CWD (CDD) especially during MAM, JJA and SON. Not so much during DJF.

- Trend of extreme (RX1DAY & RX5DAY): tendency to increase for early century and decrease towards the end of century. Strongest decrease during MAM season.

- **Flooding and drought are the opposite faces of the same coin:** Should be managed together in-light of climate change. Storing water during rainy seasons (including the flood management) to mitigate drought impacts during dry seasons.

Thank you

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