Reflections on the Weather and Climate Forecast for Climate Services

再思天氣氣候無縫隙預報與氣候服務

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CWB 1500 Apr 13, 2021

A defining moment for me to engage in climate services …

World Climate Conference-3

VISION

Better climate information for a better future

An international framework for climate services that links science-based climate predictions and information with the management of climate-related risks and opportunities in support of adaptation to climate variability and change in both developed and developing countries.

WCC · 3

Geneva, Switzerland

31 August–4 September 2009

藉由發展與活用具有科學根據的氣候資訊與預測服務, 使國家各層面的規劃, 政策與實務達到有效管理與氣候變異與變遷有關的氣象災害風險的目標.

World Meteorological Organization
Weather • Climate • Water

UN SYSTEM DELIVERING AS ONE ON CLIMATE KNOWLEDGE

SEP 2009
WCC-3 unanimous proposal

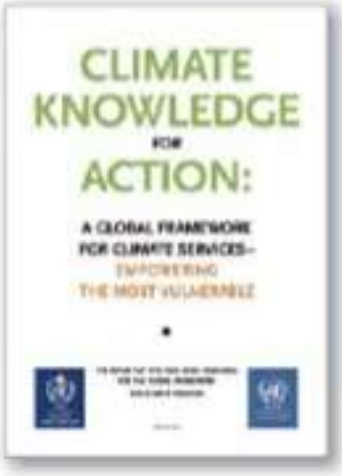
JAN 2010
Intergovernmental Meeting

MAY/JUN 2011
Cg-XVI unanimous approval

JUN 2011
EC-LXIII

JUN/JUL 2012
EC-LXIV

2009 2010 2011 2012



2010
High-level Taskforce

FEB 2011
HLT Report submitted

JUN 2011
GFCS office established

OCT 2012
GFCS user conference & WMO Congress extraordinary session

Global Framework for Climate Service

GOAL

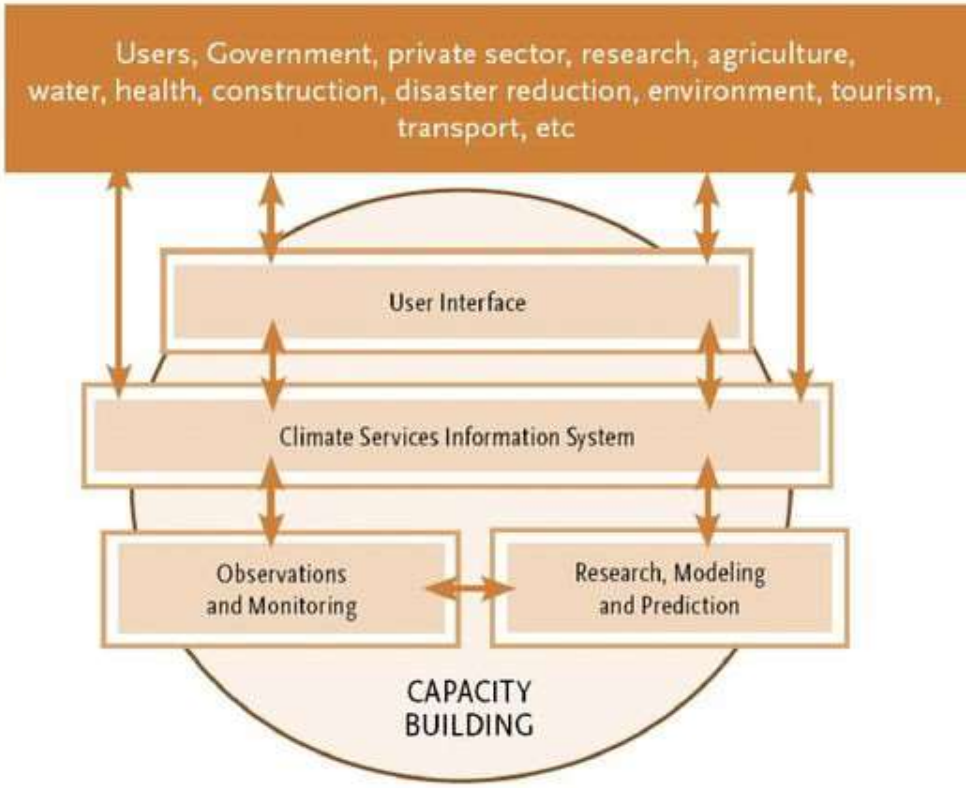
- Enable **better management of the risks of climate variability and change and adaptation to climate change at all levels**, through development and incorporation of science-based climate information and prediction into planning, policy and practice

Sectoral Priorities

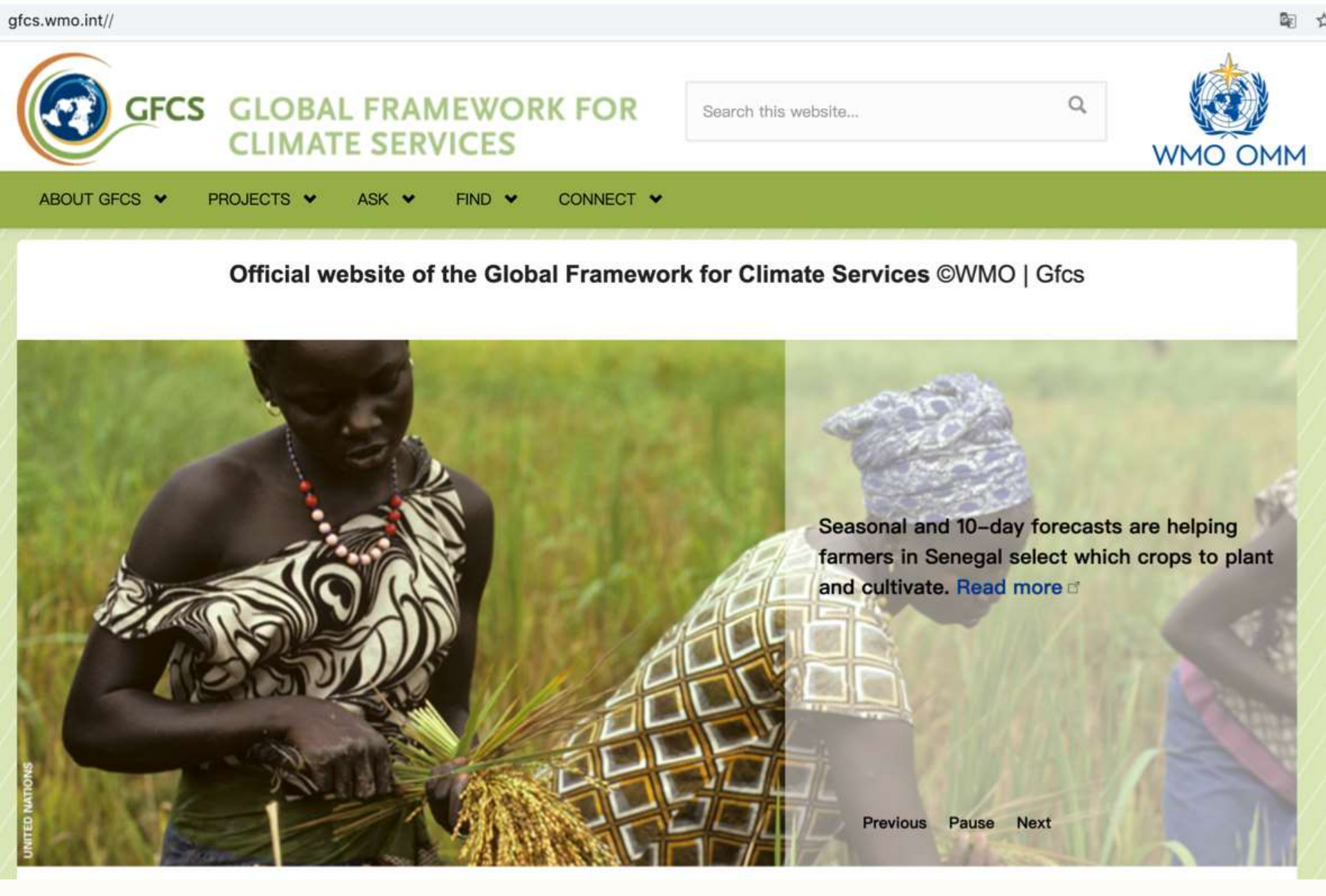
- **Agriculture and Food Security**
- **Disaster Risk Reduction**
- **Water**
- **Health**

2015+ ● **Energy**

Five Pillars of GFCS



https://gfcs.wmo.int//



https://gfcs.wmo.int//

Priority areas


Agriculture and food security


Disaster risk reduction


Energy


Health


Water

GFCS in action

Annual training/workshop : "Climatology, foundation for climate services" supported by **Météo-France** (France, Niger, Algeria, Benin, Burkina Faso, Burundi, Comoros, Congo, Democratic Republic of the Congo, Côte d'Ivoire, Egypt, Gambia, Guinea, Guinea-Bissau, Madagascar, Malawi, Mali, Morocco, Nigeria, Rwanda, Senegal, Sudan, United Republic of Tanzania, Togo, Tunisia, Zambia, Zimbabwe, Bangladesh, Bahrain, Kyrgyzstan, Lao People's Democratic Republic, Pakistan, Thailand, Viet Nam, Barbados, Haiti, Australia, Indonesia, Philippines, Austria, Bulgaria, Croatia, Estonia, Latvia, Luxembourg, The former Yugoslav Republic of Macedonia, Republic of Moldova, Switzerland, Ukraine, Armenia, Argentina, Bosnia and Herzegovina, China, Spain, Sierra Leone, South Sudan, Chad)

Tokyo Climate Center annual training seminar (Bangladesh, Cambodia, China, Hong Kong, China, India, Indonesia, Iran, Islamic Republic of, Kazakhstan, Republic of Korea, Lao People's Democratic Republic, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Qatar, Singapore, Sri Lanka, Thailand, Uzbekistan, Viet Nam)

Cooperation between **MET Norway** and **the NMHSs** in Bangladesh, Myanmar and Vietnam on Capacity Building (Myanmar, Bangladesh, Viet Nam)

Why Climate Services?

"The global temperature has already risen to 1 °C above pre-industrial levels. The time left to achieve commitments under the Paris Agreement to remain within 2 °C is quickly running out requiring immediate action. ***The Global Framework for Climate Services was created*** ***to provide the scientific basis for adaptation****.*

Climate services investments overall have a cost benefit ratio of 10 to one.

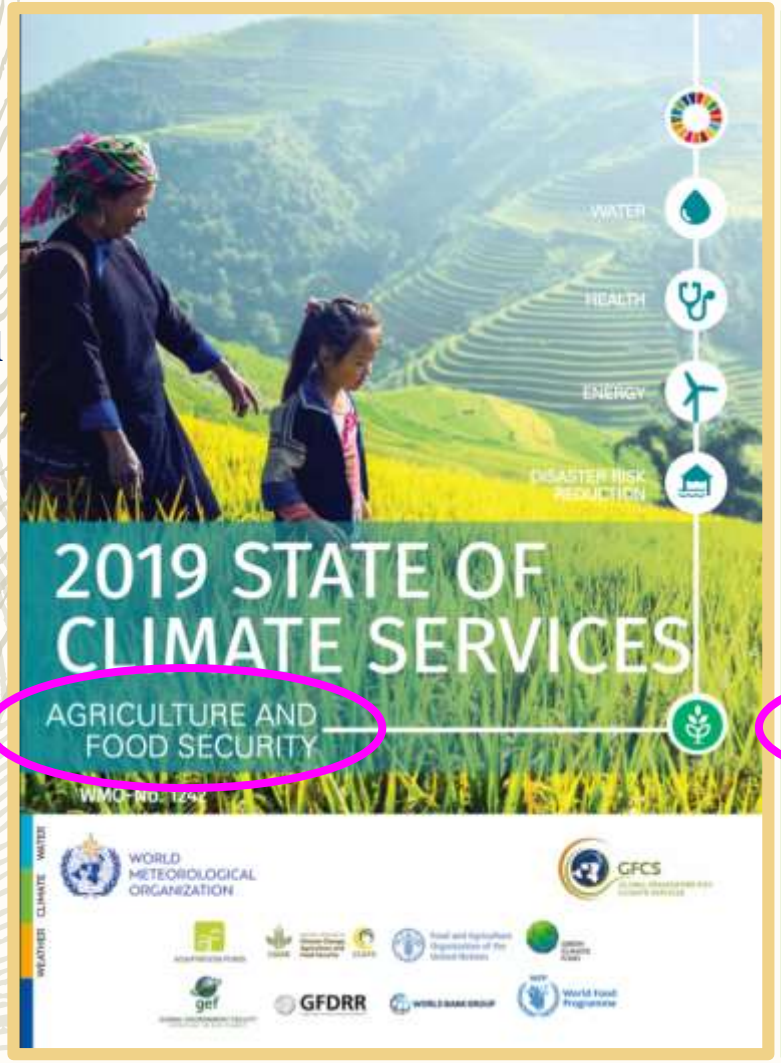
The provision of climate services at country level relies on a ***cascading global-regional-national Climate Information System*** *operated by WMO.*

More coherent financing is needed specifically to complete this system. *Financing invested holistically in* ***the WMO cascading operational system*** *provides a return on investment of* ***80 to one****."*

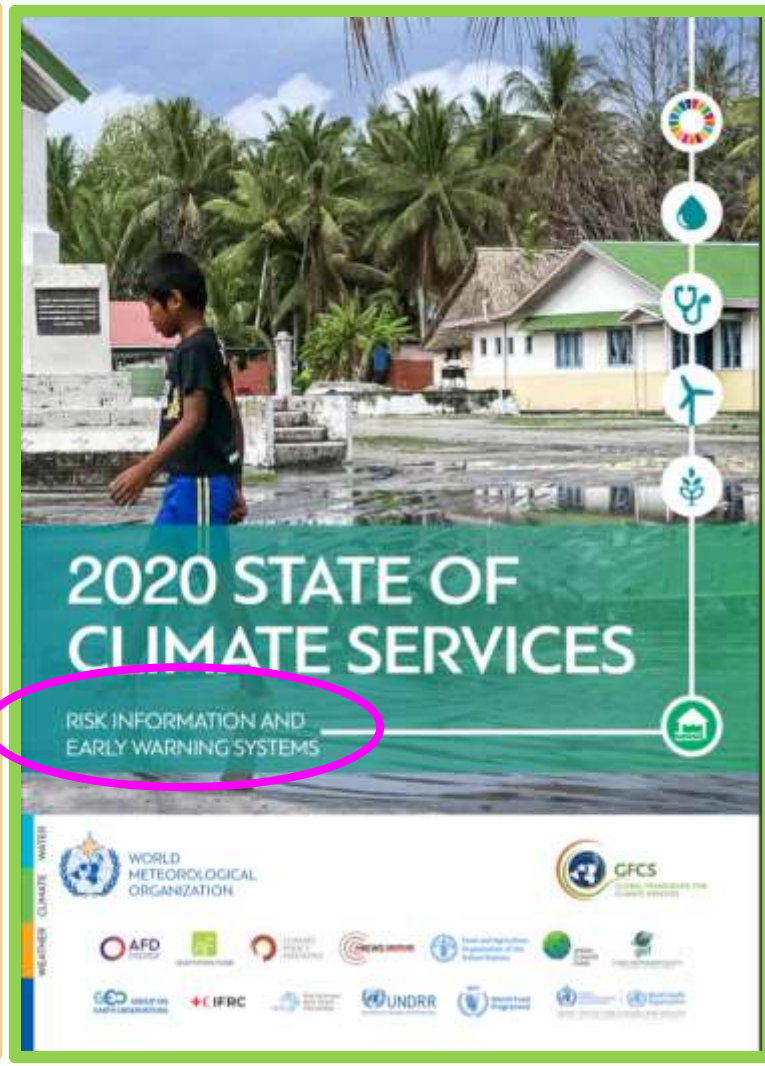
(2019 State of Climate Services, WMO-No.1242)

PETTERI TAALAS
SECRETARY-GENERAL OF THE
WORLD METEOROLOGICAL ORGANIZATION

In 2018, at the 24th Conference of the Parties (COP24) to the United Nations Framework Convention on Climate Change(UNFCCC) held at Katowice, Poland, the Parties called on the World Meteorological Organization (WMO) through its Global Framework for Climate Services (GFCS) **to regularly report on the state of climate services with a view to "facilitating the development and application of methodologies for assessing adaptation needs".**



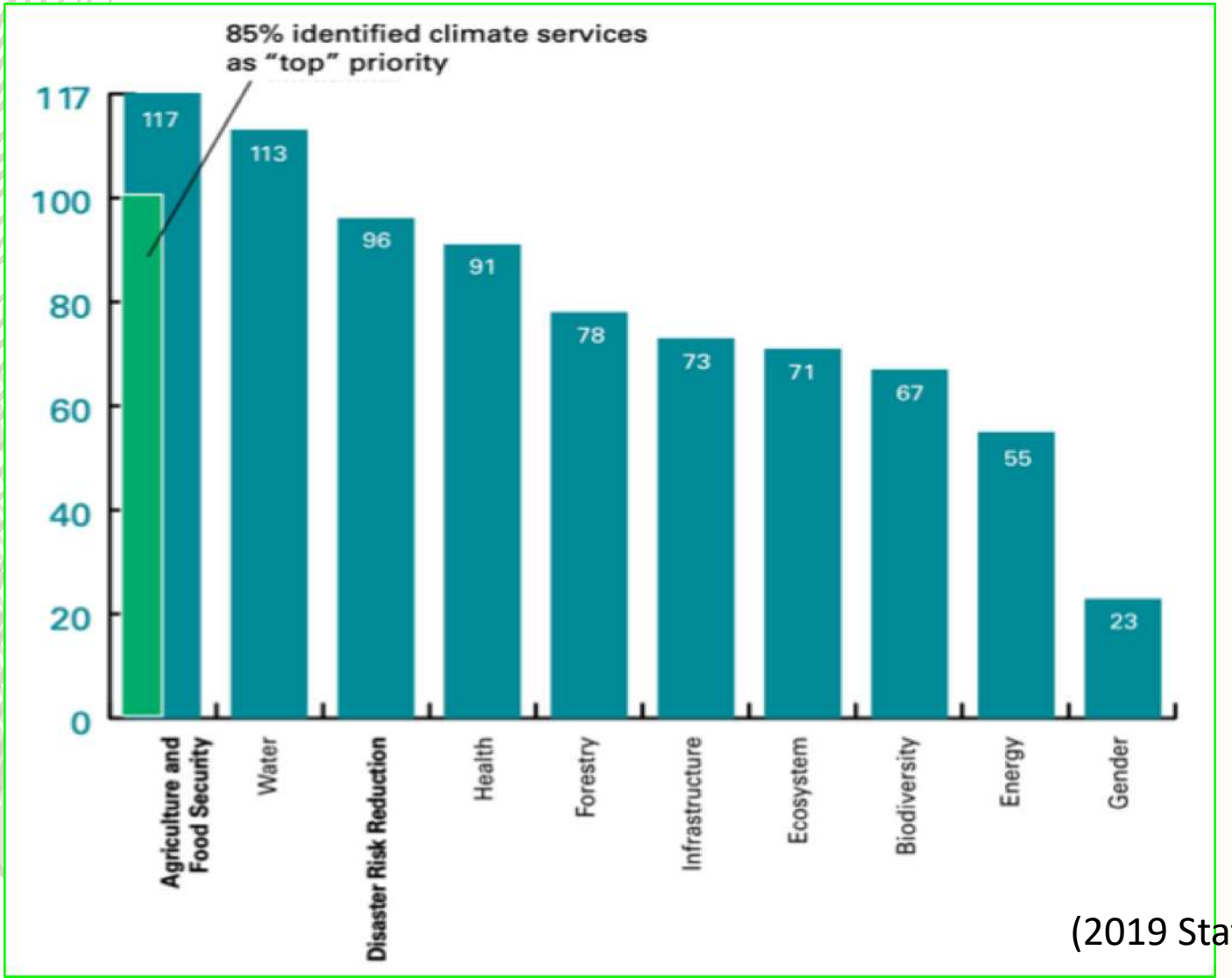
https://library.wmo.int/doc_num.php?explnum_id=10089



https://public.wmo.int/en/resources/library/2020-state-of-climate-services-report

A 2019 analysis of National Determined Contributors (NDCs) by WMO and FAO found that the majority of countries highlighted agriculture, food security and water as the top priority sectors for climate change adaptation.

In the area of agriculture and food security, 85% of countries (100 / 117) identified "climate services" as being a foundational element for planning and decision making.



(2019 State of CS)

Adaptation has become a **national priority** for many countries, including recognition of the value of **seamless weather and climate services**.

These services, and **the operational hydrometeorological systems** that support them, are critical to improve decision-making in climate-sensitive sectors.

The original usage of "**seamless**" (Palmer et al. 2008) referred to predictions across the range of weather and climate time scales.

Since then, the definition has evolved toward the idea of predicting "the spatial–temporal continuum of **the interactions** among weather, climate, and the Earth system" (Brunet et al. 2010, p. 1398).

In 2015, WMO and the World Bank compiled an **economic assessment** of meteorological and hydrological services, conceptualizing the connections between the production and delivery of those services into **a value chain** (WMO 2015).

This value chain links the production and delivery of these services to user decisions and to the outcomes and values resulting from those decisions.

Seamless Earth system science, guided by the value cycle approach, will allow us to understand better and simulate more completely the inherent feedbacks and to generate and deliver user-specific information on changes in the Earth system, over minutes to centuries in time, and local to global scales in space.

Further, it will enable an assessment of the resulting benefits to society.

Ruti et al. (*BAMS* 2019) https://doi.org/10.1175/BAMS-D-17-0302.1 (a summary of the "Science Summit on Seamless Research for Weather, Climate, Water, and Environment" organized by WMO in 2017)

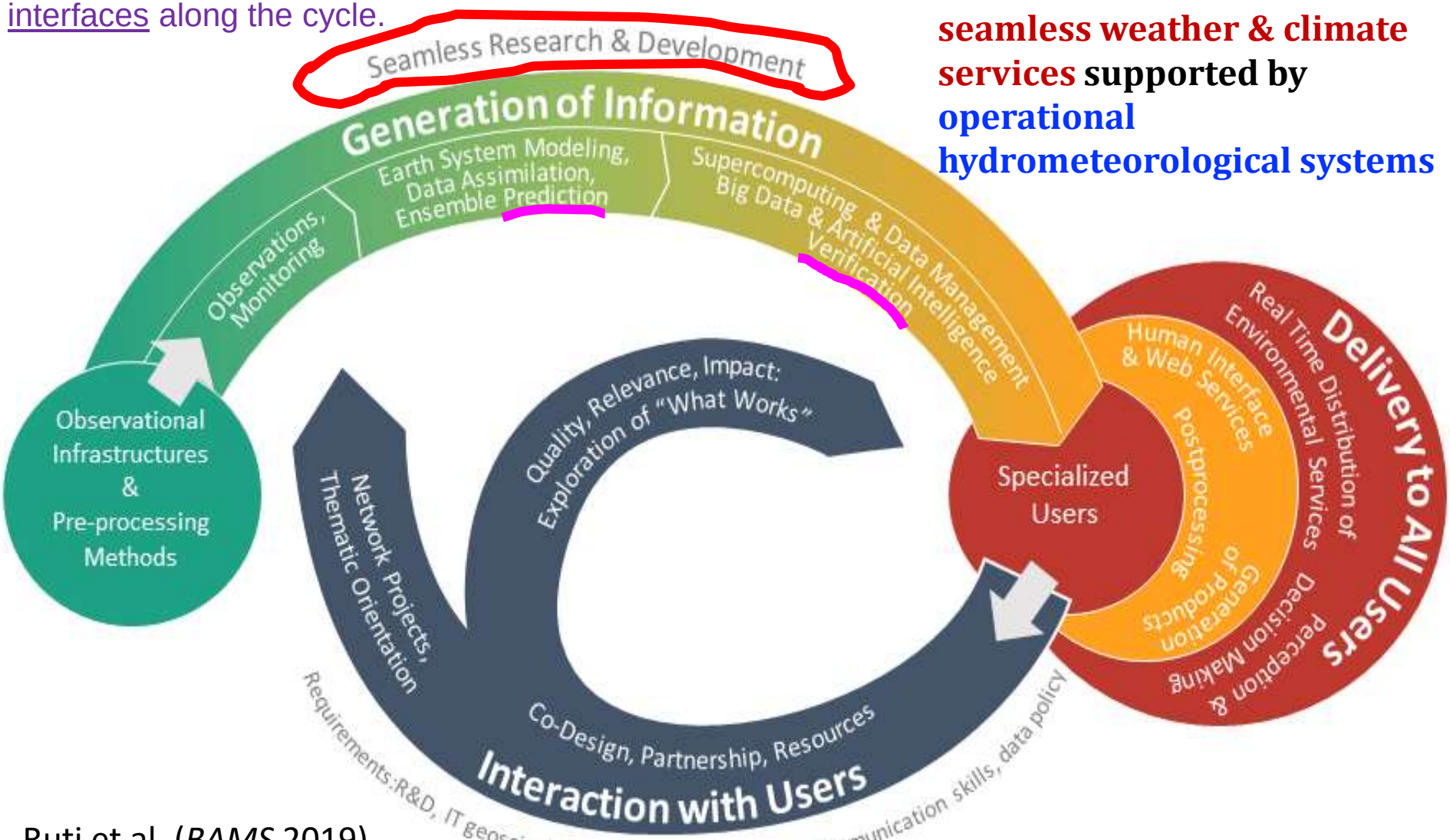
WMO, 2015: Valuing weather and climate: Economic assessment of meteorological and hydrological services. WMO-1153, 308 pp., https://library.wmo.int/doc_num.php?explnum_id=3314.

Seamless Weather and Climate Services

SCIENCE FOR SERVICES JOURNEY

The value cycle identifies the fundamental bricks of **the seamless Earth System** and details the interfaces along the cycle.

seamless weather & climate services supported by operational hydrometeorological systems



Ruti et al. (*BAMS* 2019)
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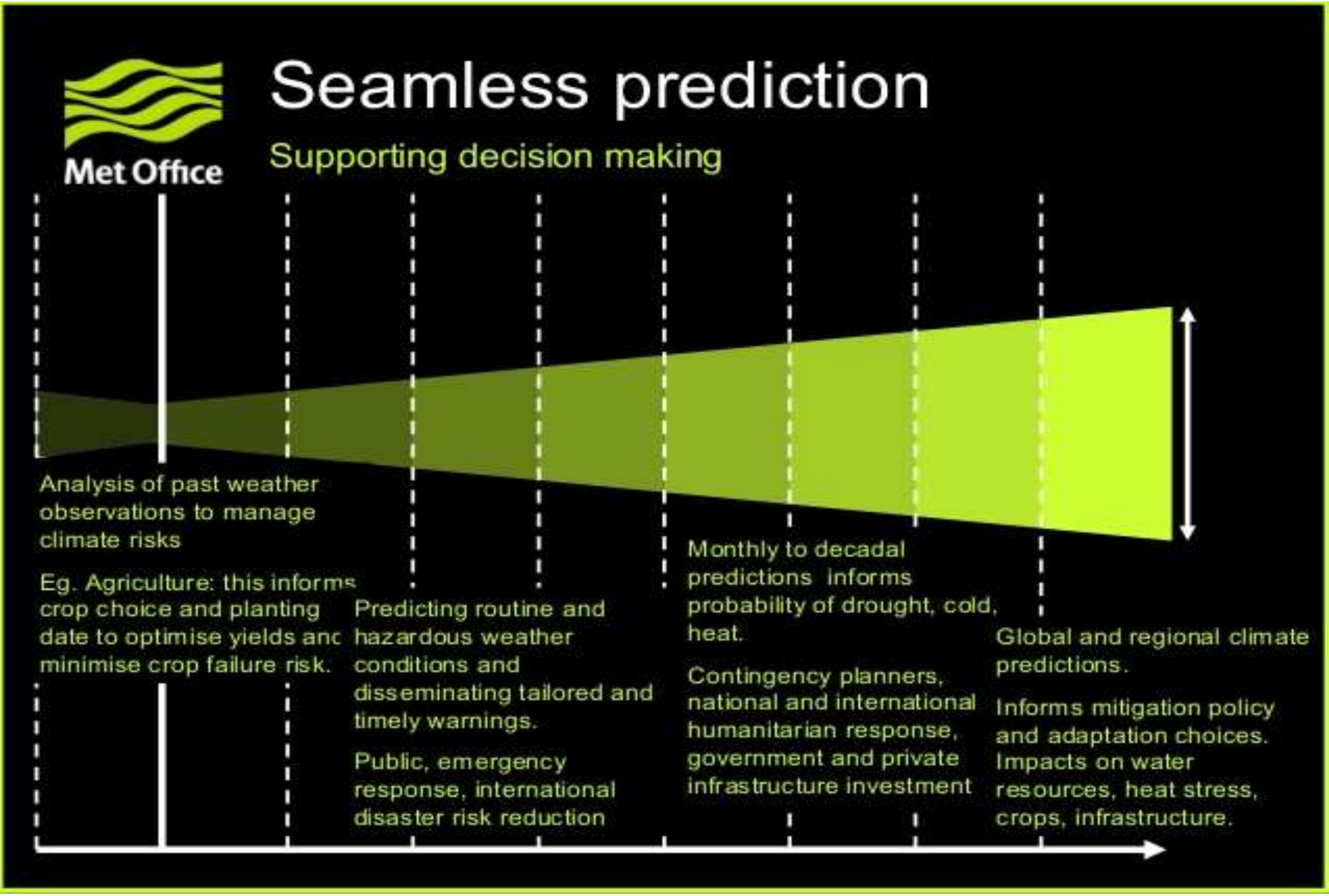
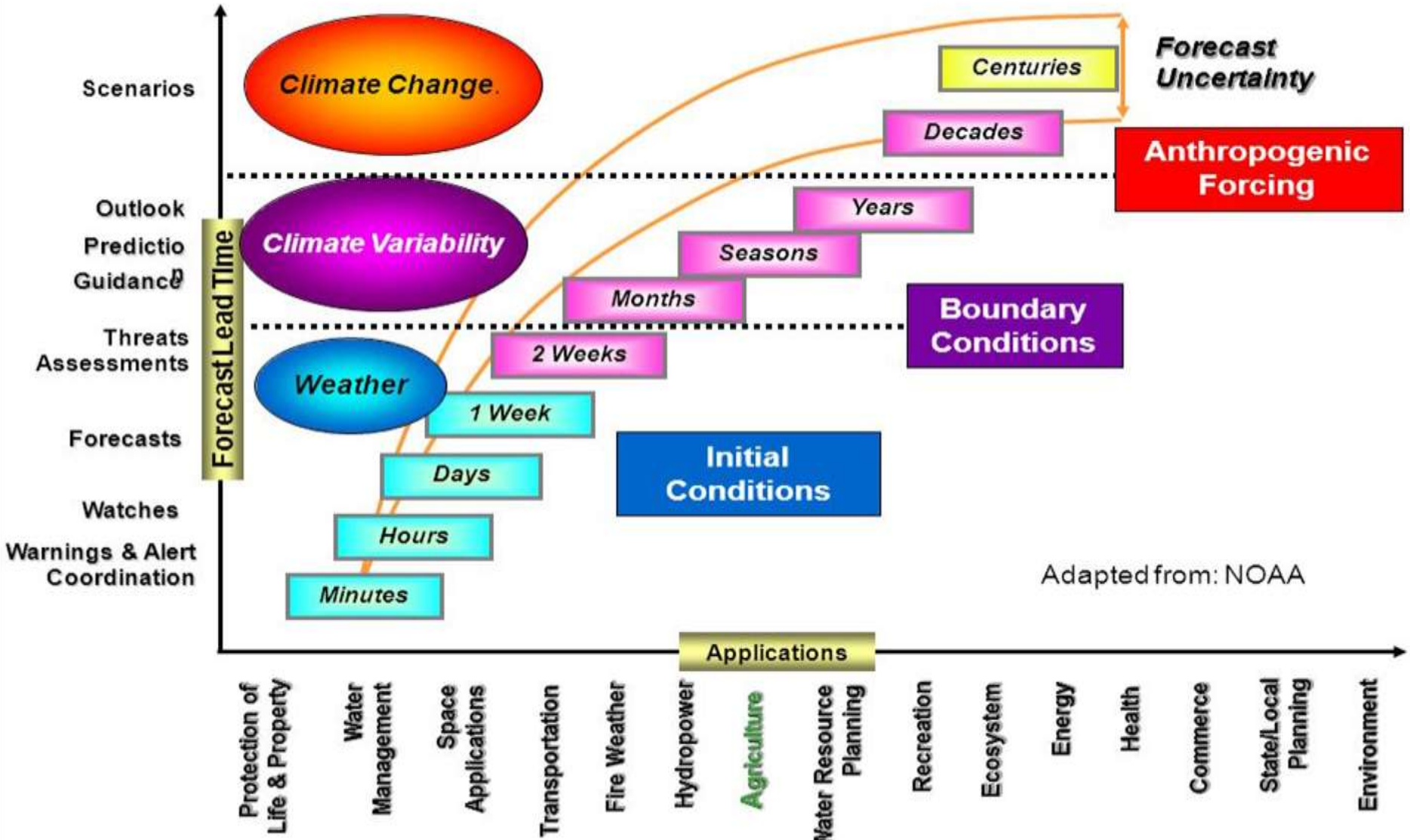


https://www.metoffice.gov.uk/research/climate/understanding-climate/seamless-assessment

A Seamless Prediction Framework



More reading - https://journals.ametsoc.org/doi/10.1175/BAMS-D-17-0302.1

https://public.wmo.int/en/our-mandate/climate/global-seasonal-climate-update

Global Seasonal Climate Update

The WMO Global Seasonal Climate Update is based on an ensemble of global prediction models run by WMO-accredited centers around the world.

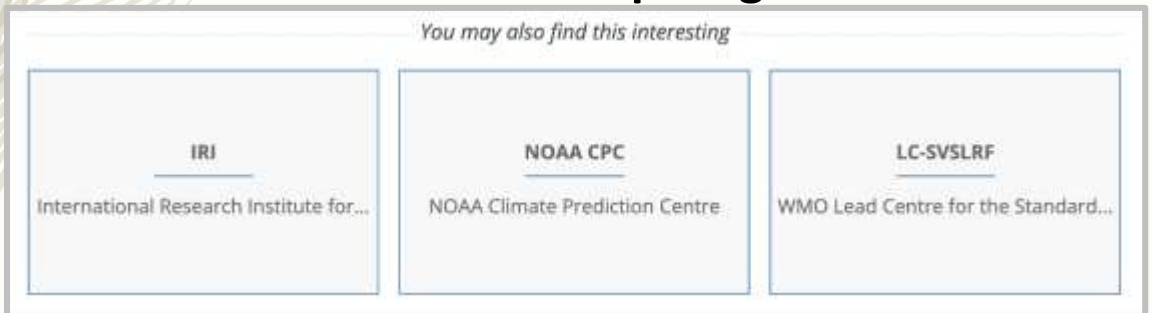
Seasonal forecasts are **probabilistic** in nature. Although the text and figures used in the GSCU highlight the **tercile categories** that is predicted with the highest probability, it is important to recognize that the other tercile categories may also have substantial (though lower) probability.

The geographical areas occupied by the forecast signals should not be considered precise.

Similarly, **signals with small spatial extent may be unreliable.**

The skill of seasonal forecasts is **substantially lower** than that of weather timescales and **skill may vary considerably with region and season.**

It is important **to view the forecast maps together with the skill maps**.



WMO Lead Centre for
Long-Range Forecast Multi-Model Ensemble

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Latest Forecast data

Beijing | CPTEC | ECMWF | Exeter | Melbourne | Montreal | Moscow | Offenbach | Pretoria | Seoul | Tokyo | Toulouse | Washington

click

Notice & News

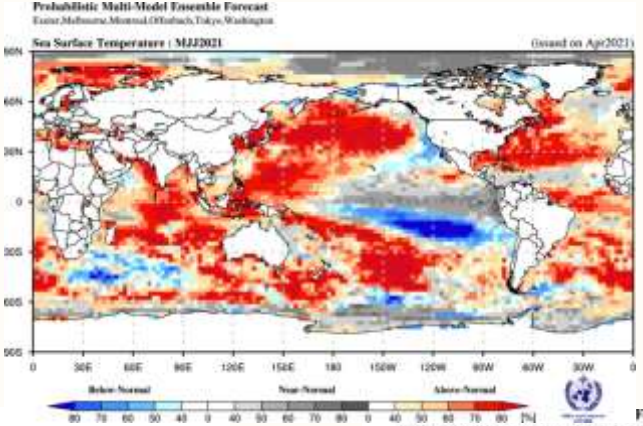
More ▸ **Links**

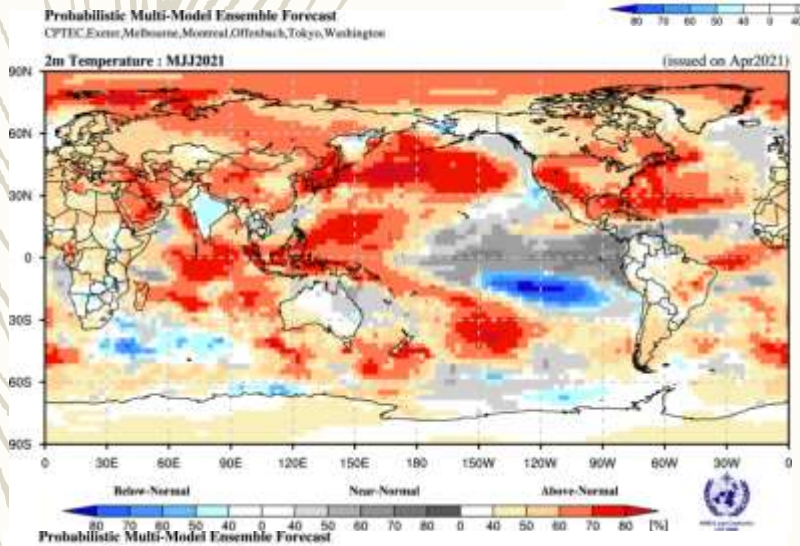
Check! System Requirements	
NOTICE WMO Global Seasonal Climate Update (GSCU) for AMJ 2021	2021-03-25
GPCs(12) for AMJ 2021 are uploaded	2021-03-22
GPCs(12) for MAM 2021 are uploaded	2021-02-22
GPCs(12) for FMA 2021 are uploaded	2021-01-22
GPCs(12) for JFM 2021 are uploaded	2020-12-23

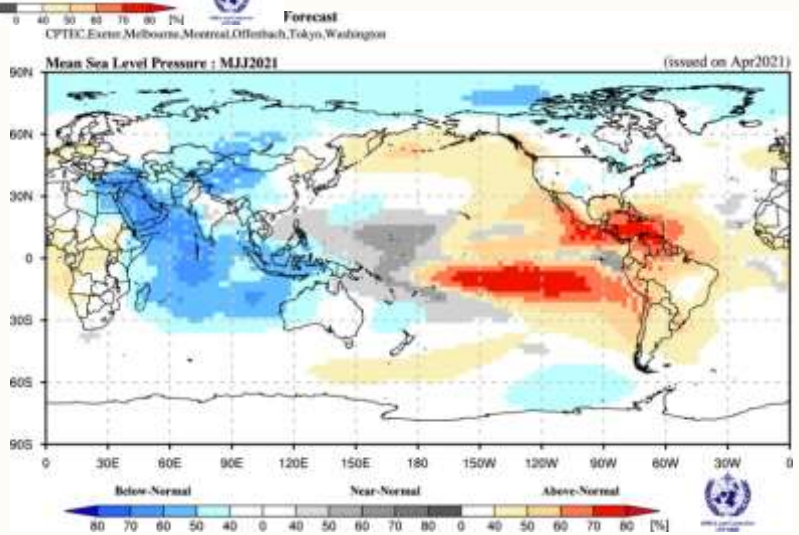
PMME | DMME | ENSO

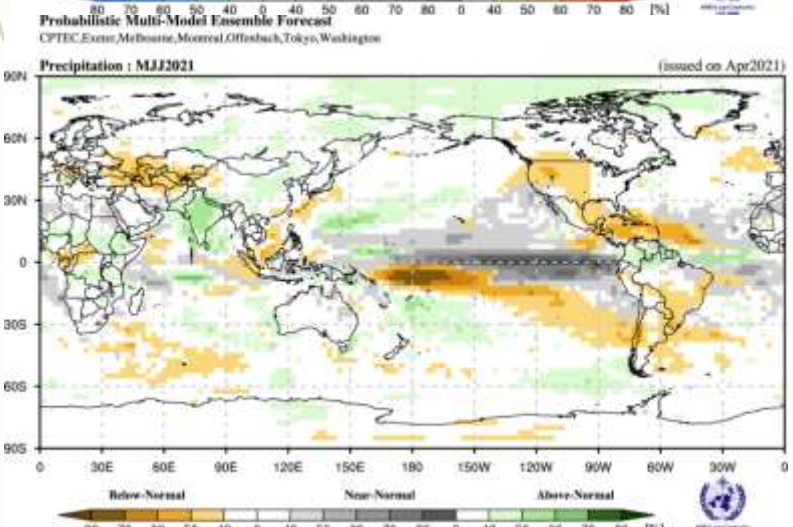
today : 1318
total : 1247278

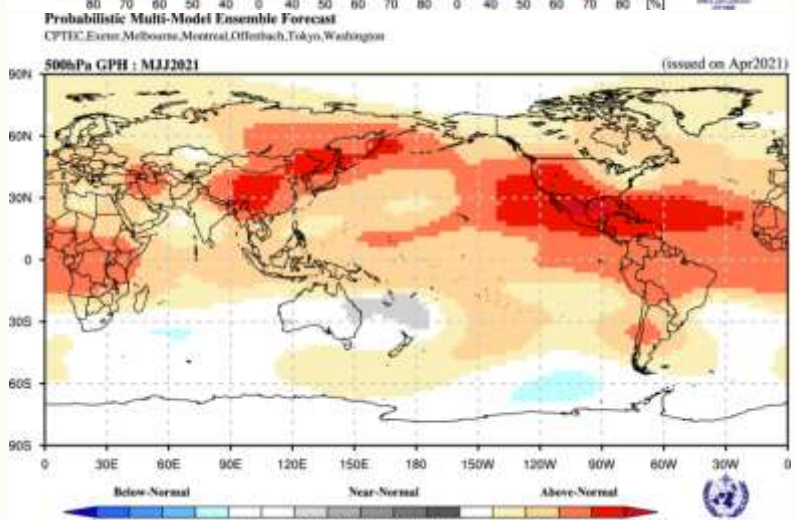
https://www.wmolc.org/seasonPmmeUI/plot_PMME#





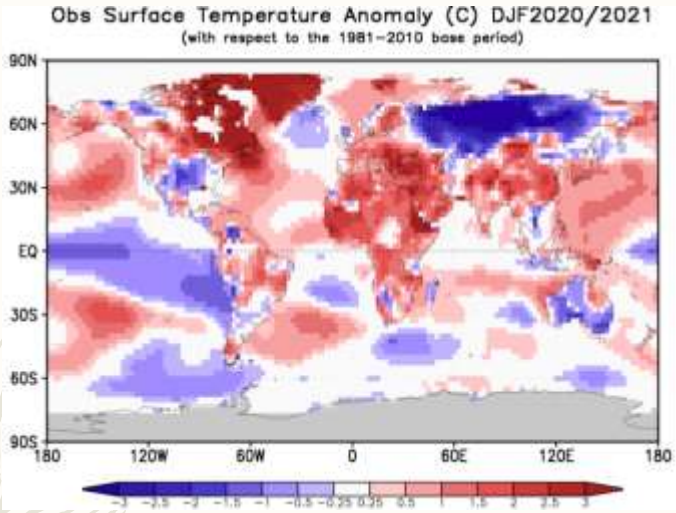


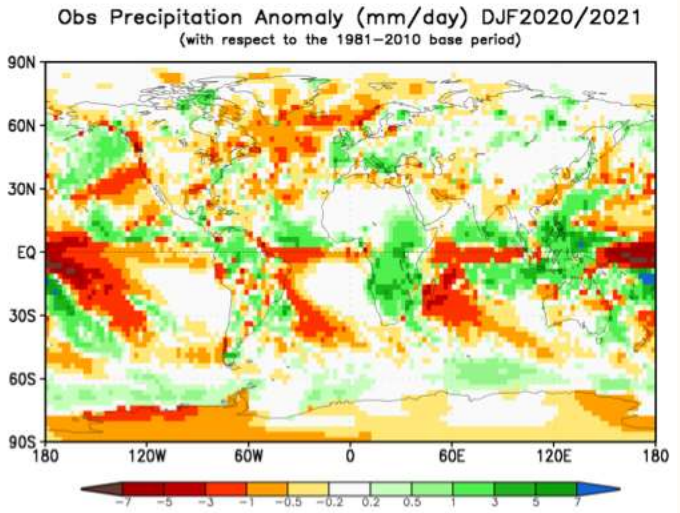




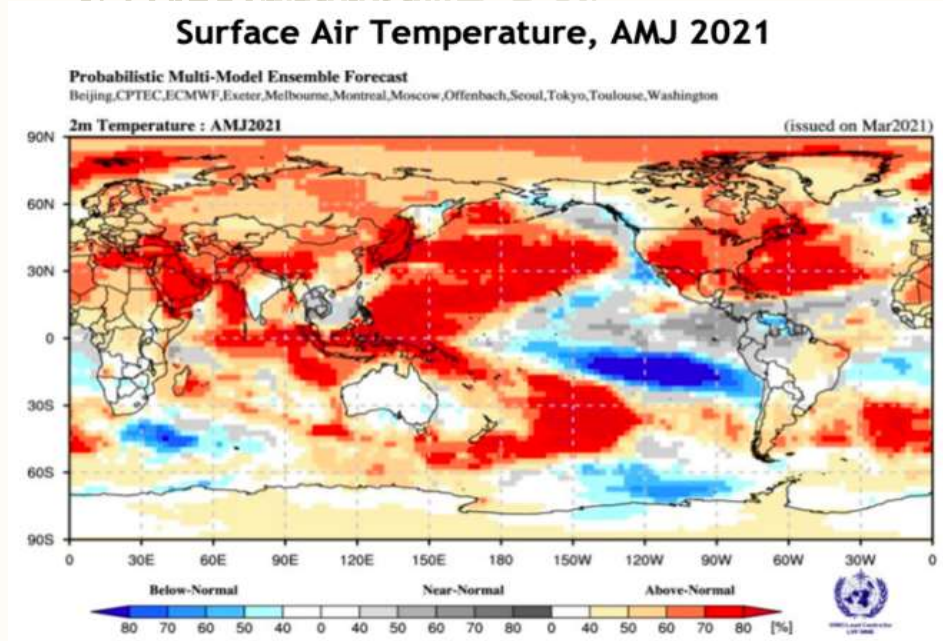
Observation – current climate

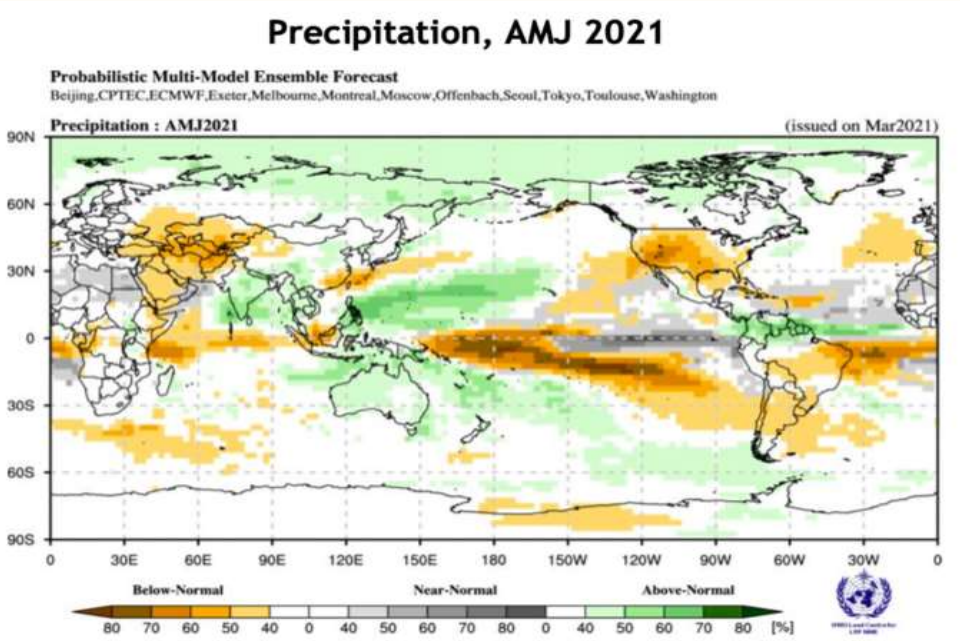
Dec.2020 ~ Feb.2021 anomalies: difference with the 30-year (1981-2010) mean





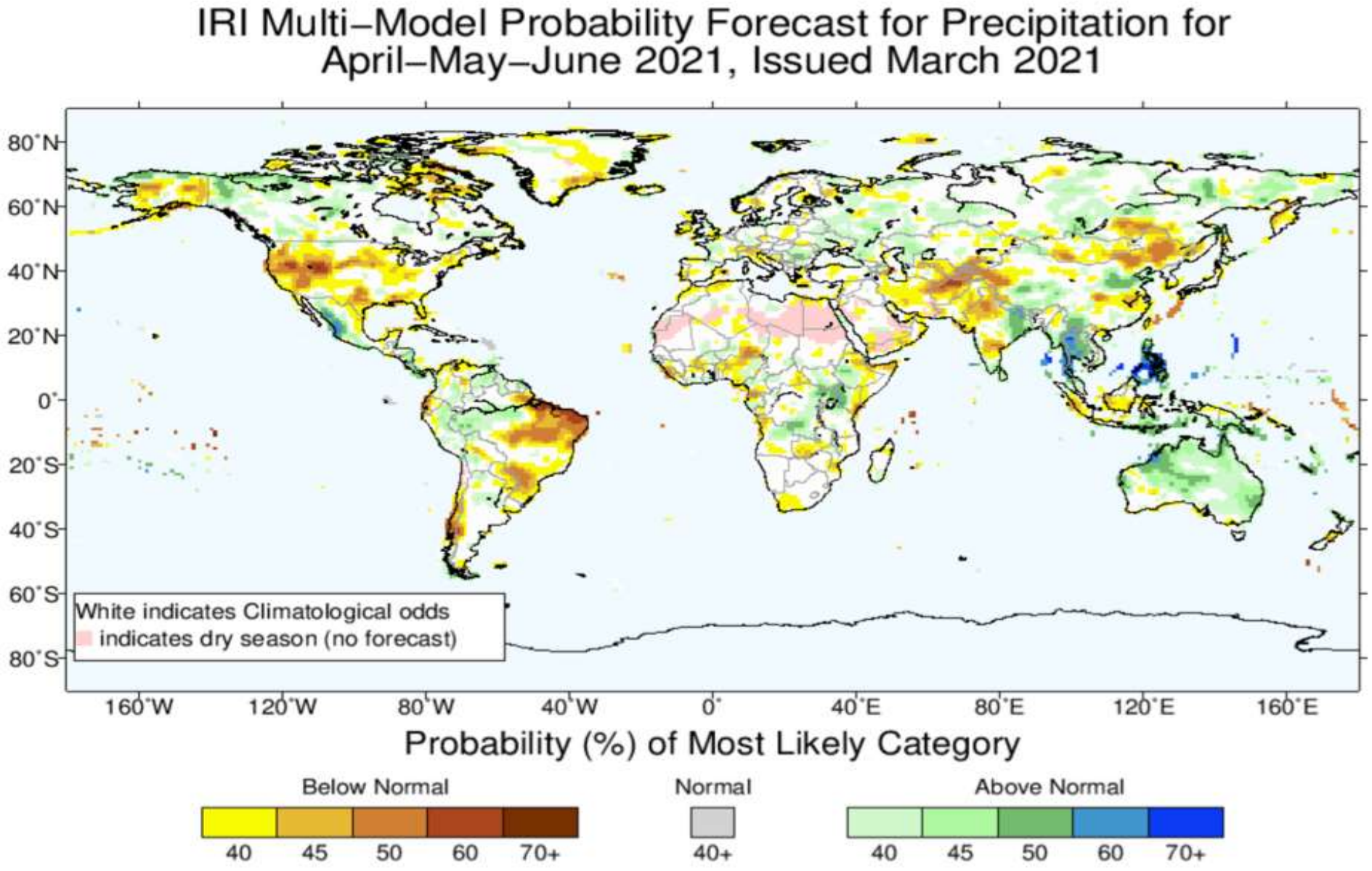
Seasonal forecast – the highest probability in the tercile categories





Region	Type	Issue Year	Issue Month	Leads
Global	Precip	2021	March	AMJ21

https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/



Region	Type	Issue Year	Issue Month	Leads
Global	Temp	2021	March	AMJ21

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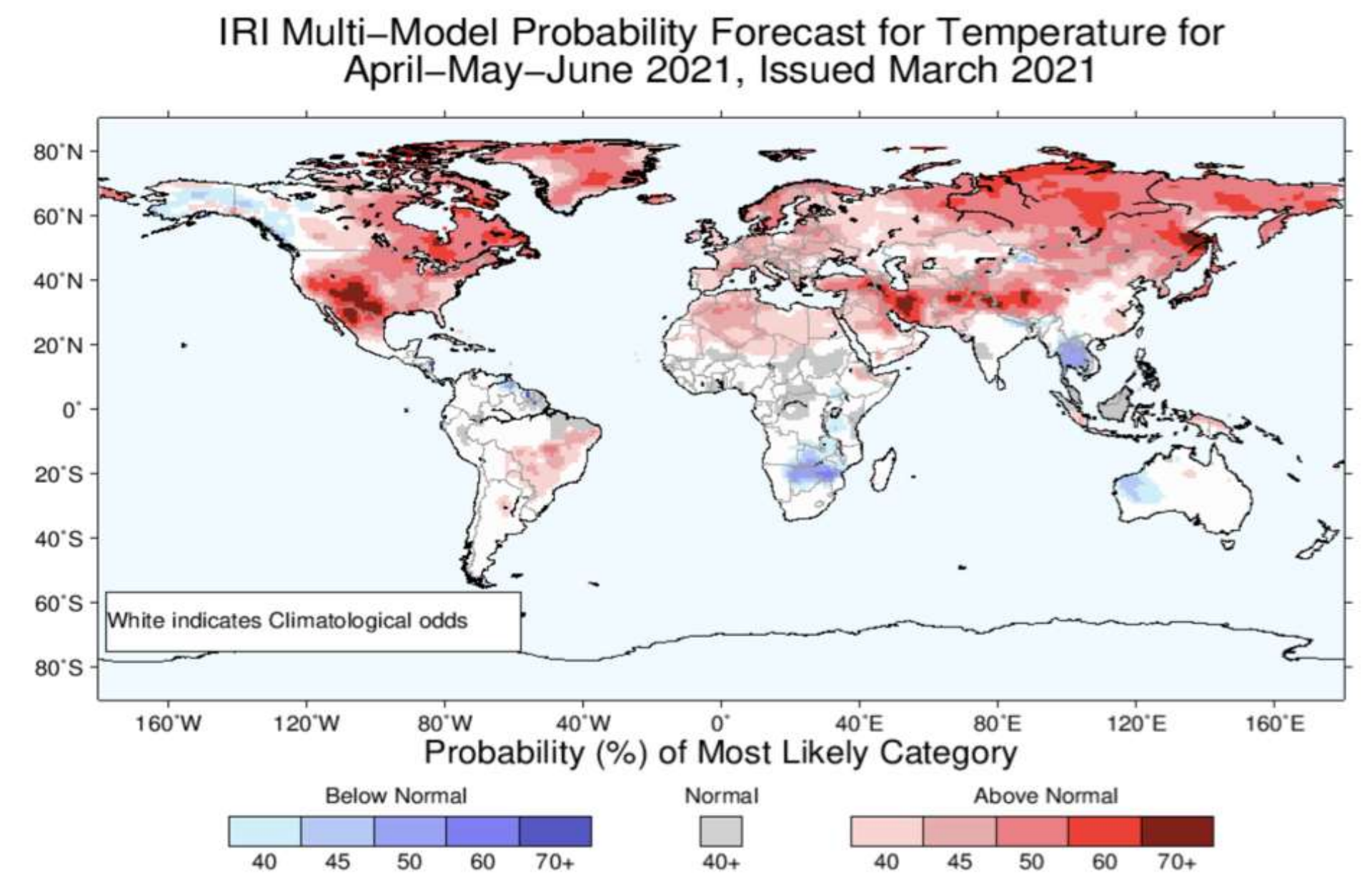
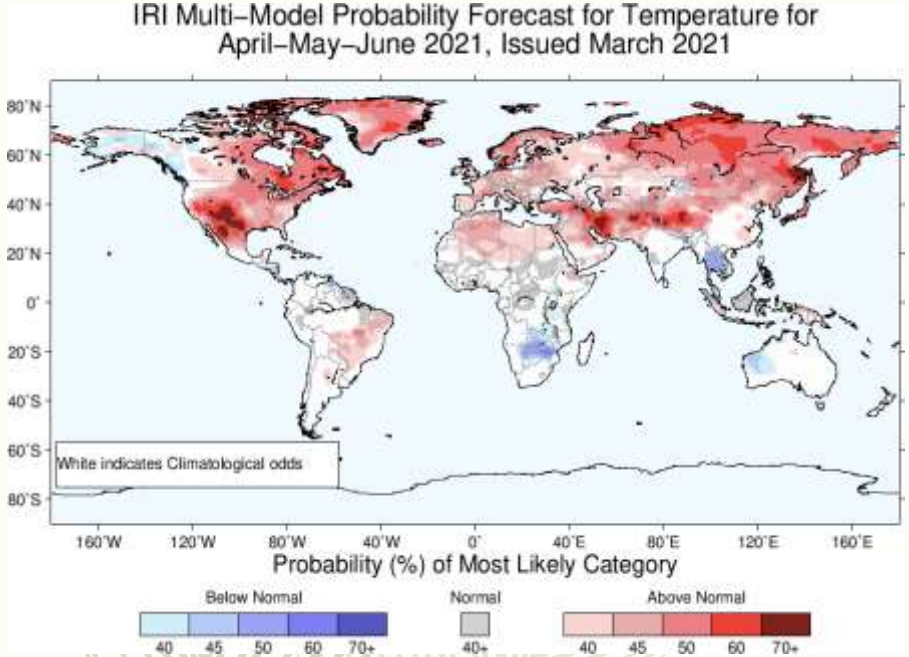
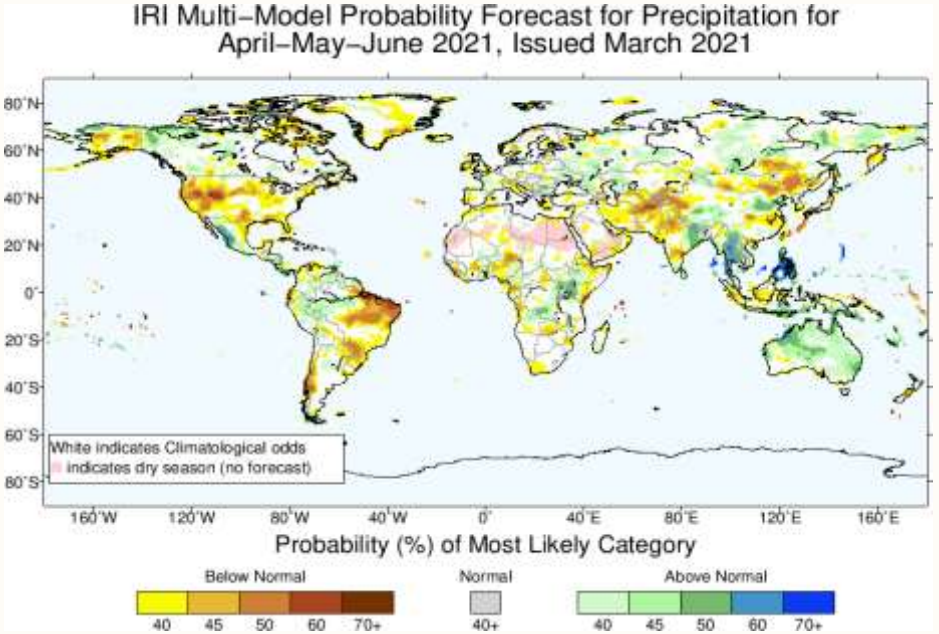
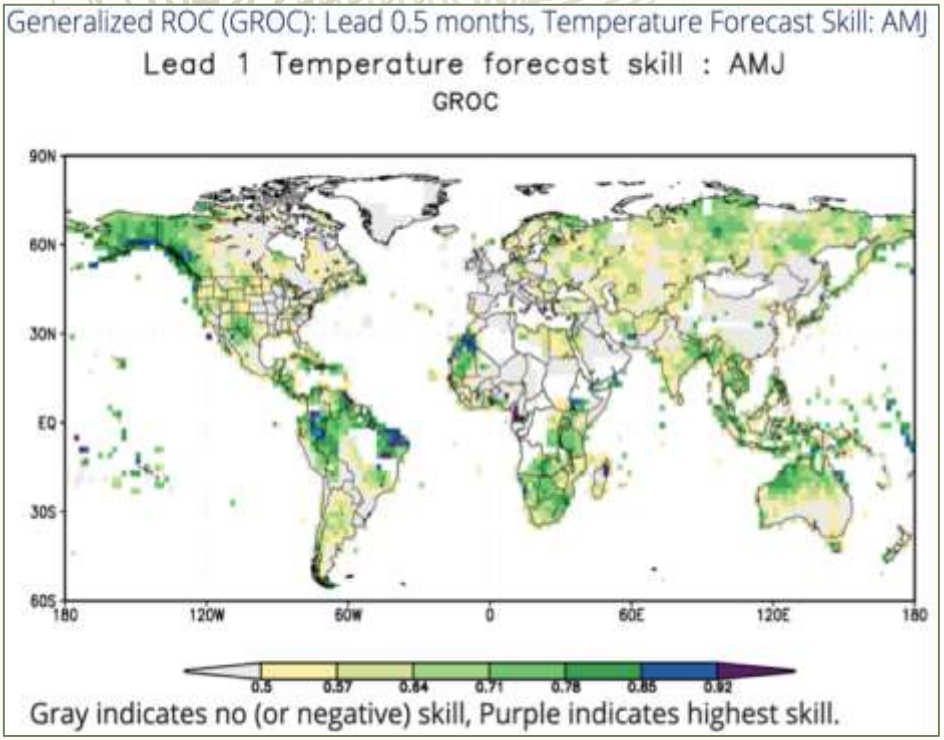
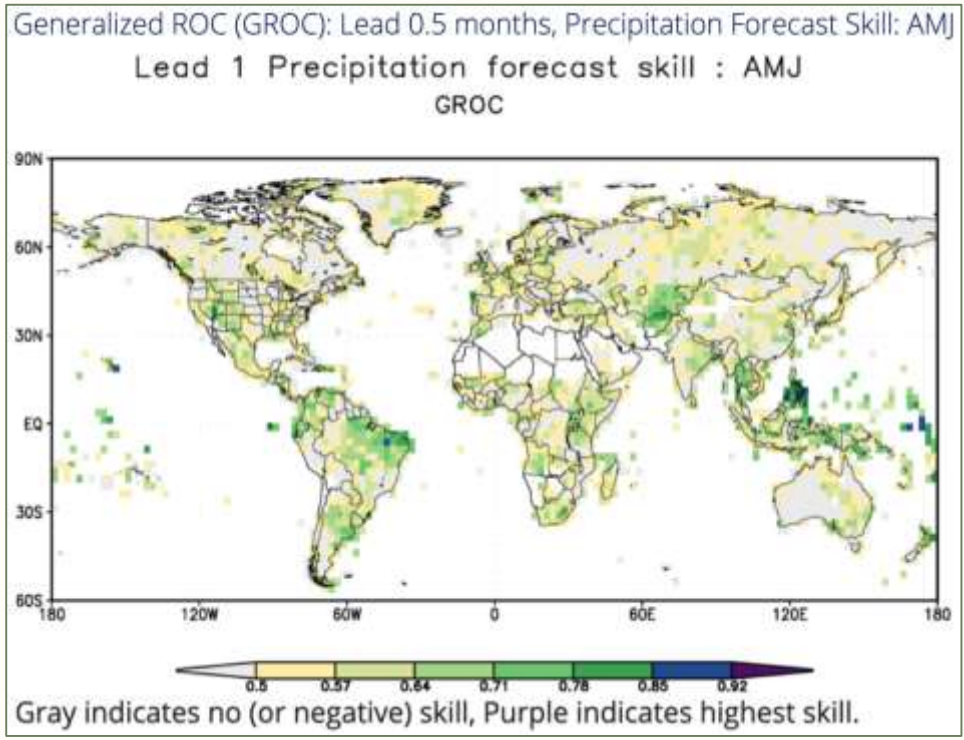



IRI Multi-Model Probability Forecast for Temperature for
April–May–June 2021, Issued March 2021
White indicates Climatological odds
Probability (%) of Most Likely Category
Below Normal
Normal
Above Normal
40 45 50 60 70+
40+
40 45 50 60 70+


IRI Multi-Model Probability Forecast for Precipitation for
April–May–June 2021, Issued March 2021
White indicates Climatological odds
indicates dry season (no forecast)
Probability (%) of Most Likely Category
Below Normal
Normal
Above Normal
40 45 50 60 70+
40+
40 45 50 60 70+


Generalized ROC (GROC): Lead 0.5 months, Temperature Forecast Skill: AMJ
Lead 1 Temperature forecast skill : AMJ
GROC
0.5 0.57 0.64 0.71 0.78 0.85 0.92
Gray indicates no (or negative) skill, Purple indicates highest skill.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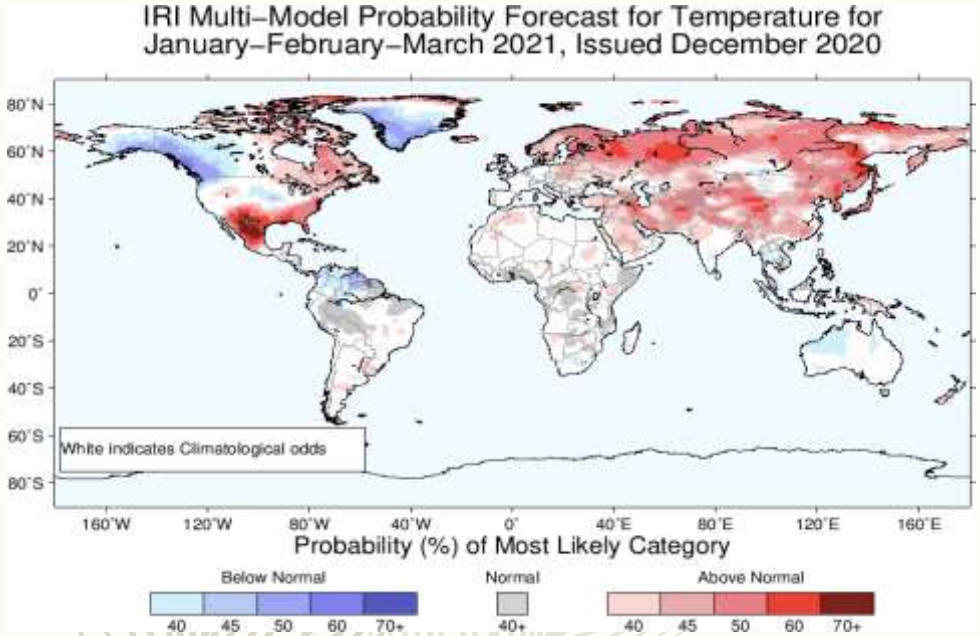
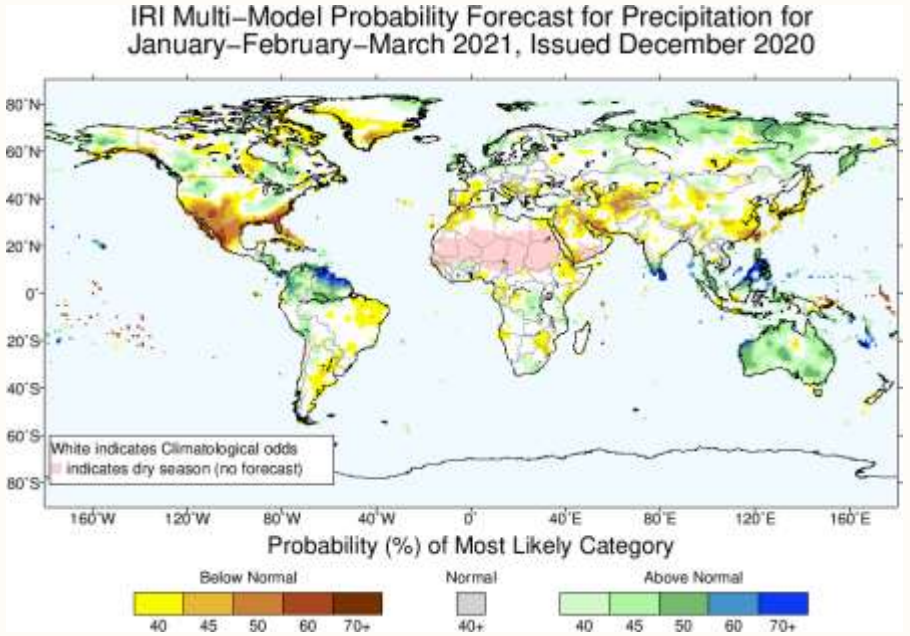

IRI Multi-Model Probability Forecast for Temperature for
January–February–March 2021, Issued December 2020
White indicates Climatological odds
Probability (%) of Most Likely Category
Below Normal
Normal
Above Normal
40 45 50 60 70+
40+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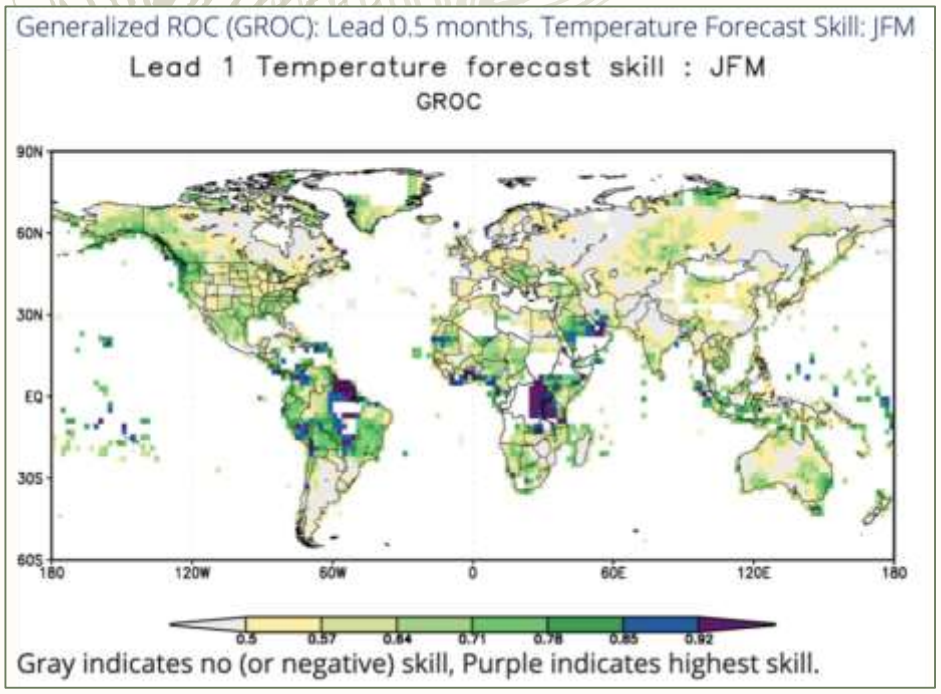
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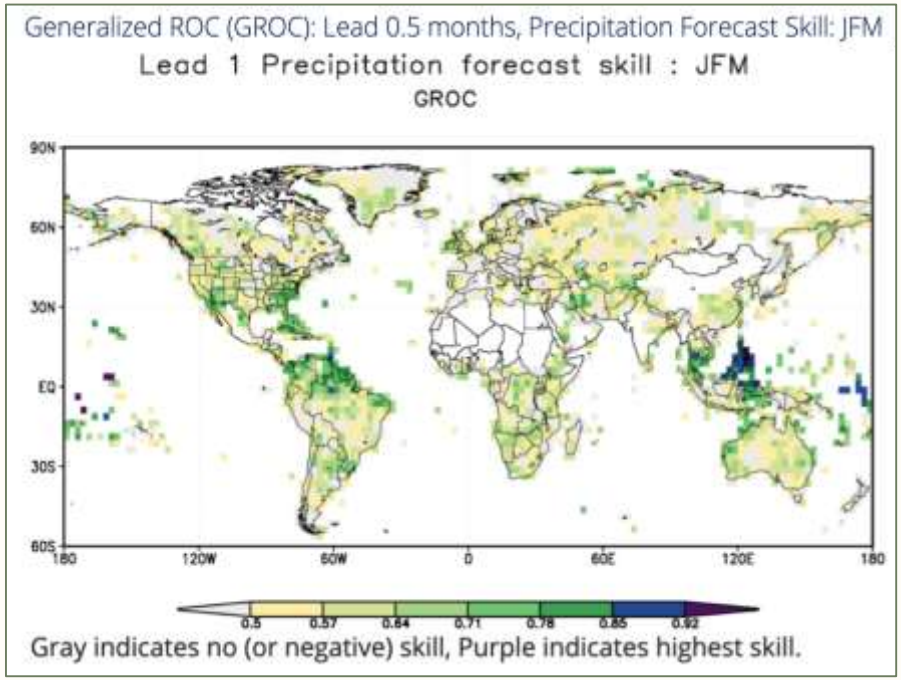
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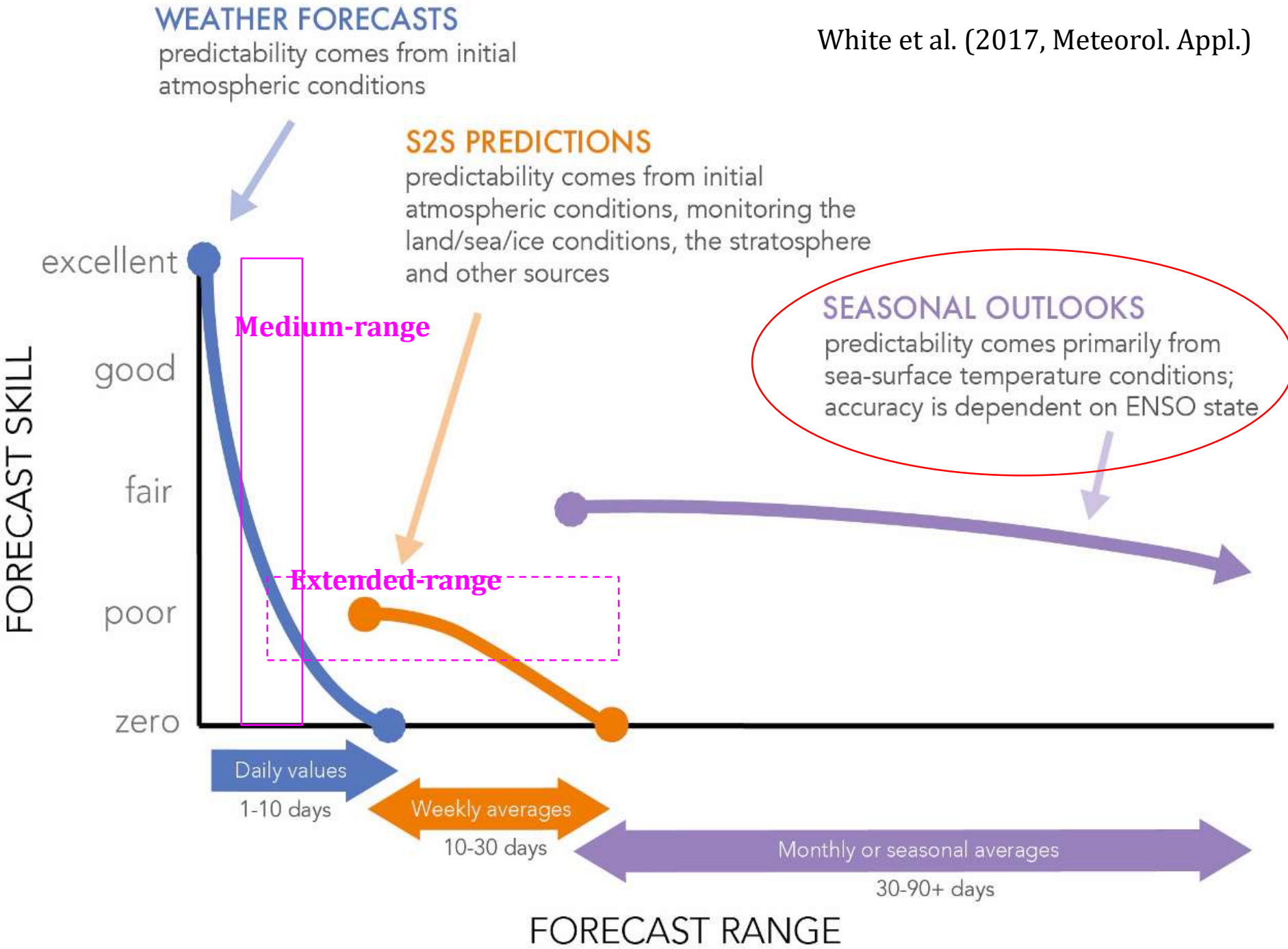


White et al. (2017, Meteorol. Appl.)

S2S - filling the gap between medium-range and seasonal forecasting

The American Meteorological Society (AMS) has some sage advice for anyone who routinely accesses deterministic forecasts more than **8 days** into the future: "***Presently, forecasts of daily or specific weather conditions do not exhibit useful skill beyond eight days, meaning that their accuracy is low.***" (https://www.ametsoc.org/ams/index.cfm/about-ams/ams-statements/statements-of-the-ams-in-force/weather-analysis-and-forecasting/)

Medium-range forecast: A forecast for a period extending from about **3~7 days** in advance; there are no absolute limits to the period embraced by the definition. (AMS https://glossary.ametsoc.org/wiki/Medium-range_forecast)

Extended-range forecast: The extended-range forecast provide an overview of the forecast for the coming **46** days, focusing mainly on the week-to-week changes in the weather. (ECMWF https://www.ecmwf.int/en/forecasts/documentation-and-support/extended-range-forecasts)

Seasonal forecast: While it is generally not possible to predict these day-to-day changes in detail beyond about a week ahead, it is possible to say something about **likely conditions averaged over the next few months**. Seasonal forecasts provide information about these long-term averages. (UK Met Office https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/user-guide/background)

WWRP/WCRP Sub-seasonal to Seasonal Prediction Project (S2S)

The World Weather Research Programme (WWRP) and the World Climate Research Programme (WCRP) Sub-seasonal to Seasonal Prediction Project (S2S) was launched in November 2013, with the primary goals of **improving forecast skill and understanding the dynamics and climate drivers** on **the sub-seasonal to seasonal timescale (from 2 weeks to a season)**.

The S2S project has a special emphasis on **high-impact weather events**, developing coordination among operational centers, and on promoting uptake of S2S information by the applications communities.

S2S is the first major joint research project between WWRP and WCRP.

A key motivation of S2S was to capitalize on the expertise of the weather and climate research communities and WMO/WWRP/WCRP programmes - filling the gap between medium-range and seasonal forecasting - to address issues of importance to the Global Framework for Climate Services (GFCS; https://www.wmo.int/gfcs/).

APCC News

APCC officially commits to serving as the WMO Subseasonal-to-Seasonal Prediction Project "International Coordination Office"

Starting in January 2021, the APEC Climate Center committed to serving as the International Coordination Office (ICO) to coordinate the international joint research effort, "WWRP/WCRP Sub-seasonal to Seasonal Prediction Project (S2S) Phase II under the World Meteorological Organization (WMO).

The S2S project was launched in November 2013, and the Korea Meteorological Administration (KMA) and the National Institute of Meteorological Sciences (NIMS) were in charge of operating the ICO until 2020.

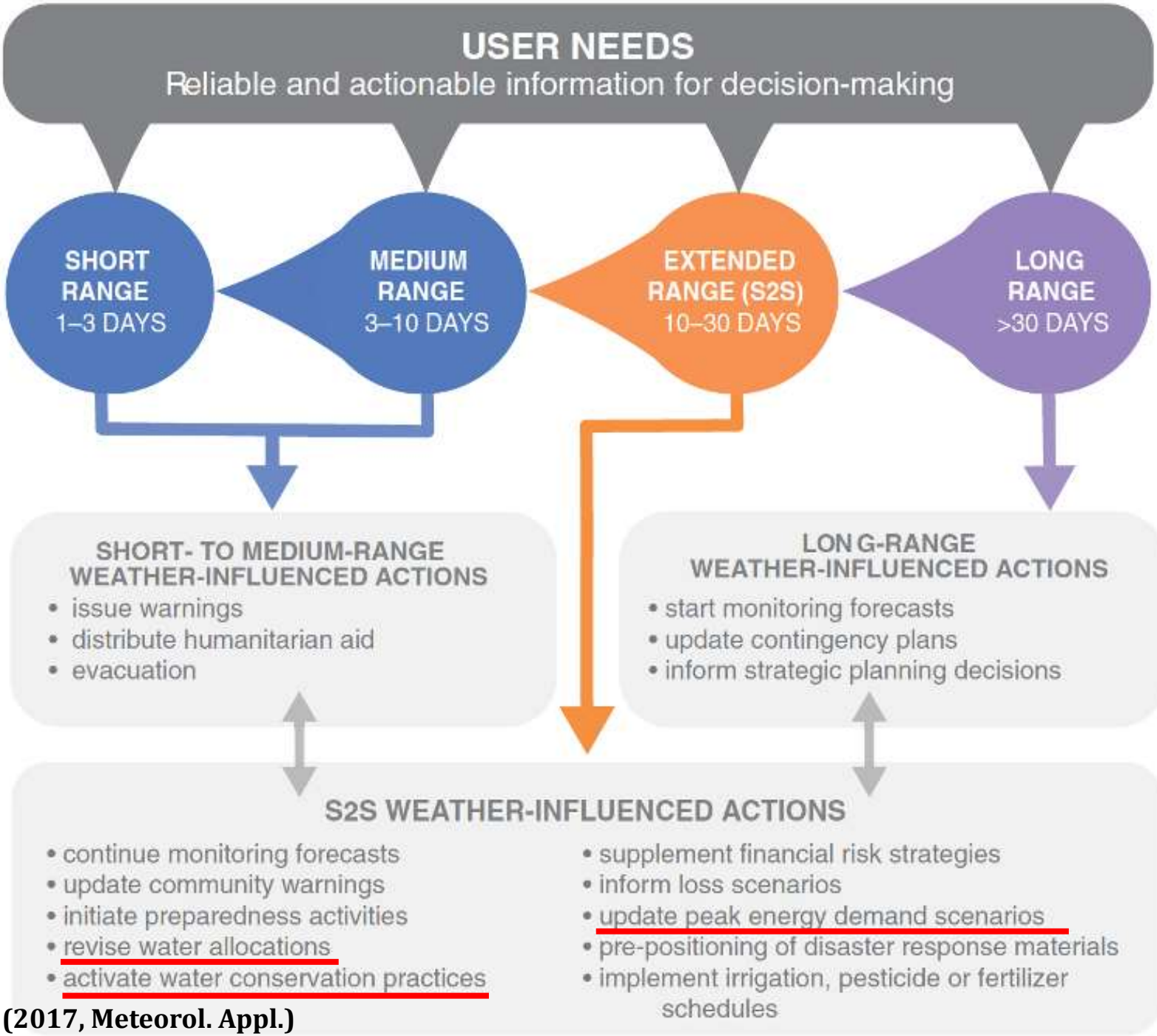
WMO is promoting and implementing this joint international meteorological and climate research project with leading scientists around the world in order to improve forecast skill and understanding on the S2S timescale. S2S predictions have great socio-economic ramifications but much remains to be done to improve the skill of the forecasts as well as creating forecast products.

APCC, as the ICO, will support and coordinate the overall implementation of the international joint research activities related to the S2S Prediction Project, and support cooperation with other international programs.

The Subseasonal to Seasonal (S2S) Prediction refers to climate prediction information spanning the two-week to two-month period, which is serves to close the gap between the currently existing short-term and long-term prediction information.

As the ICO, APCC is expected to establish its position as a leading research institute in the field of climate prediction. In addition, there may be opportunities to host international conferences and expert workshops in Busan, contributing to the vitalization of the local economy in Busan Metropolitan City.

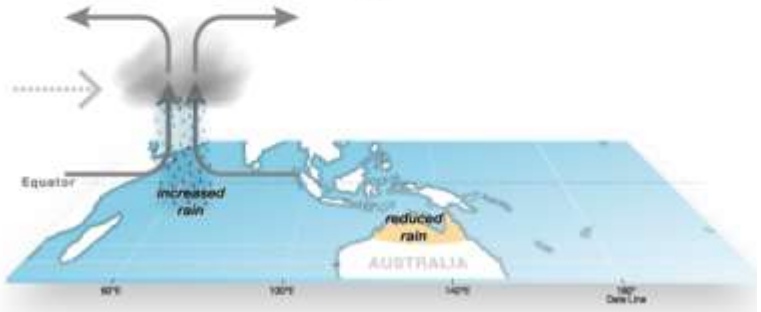
http://s2sprediction.net



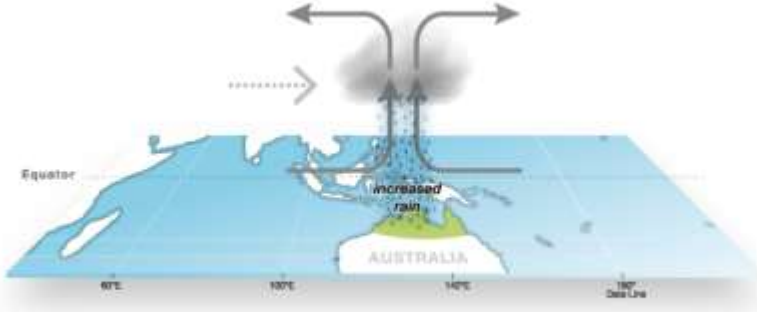
White et al. (2017, Meteorol. Appl.)

Madden–Julian Oscillation (MJO)

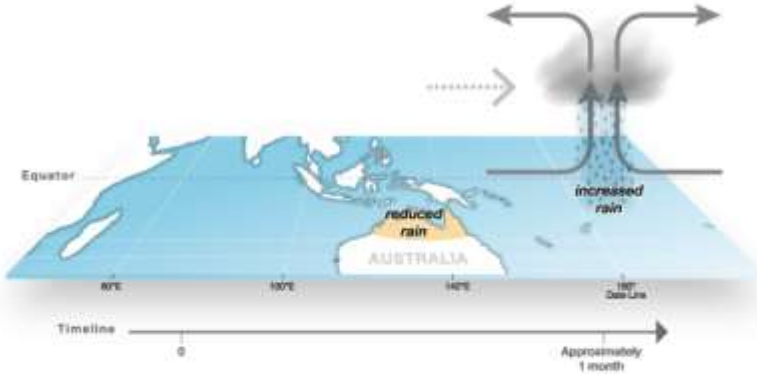
Example cycle: Week 1



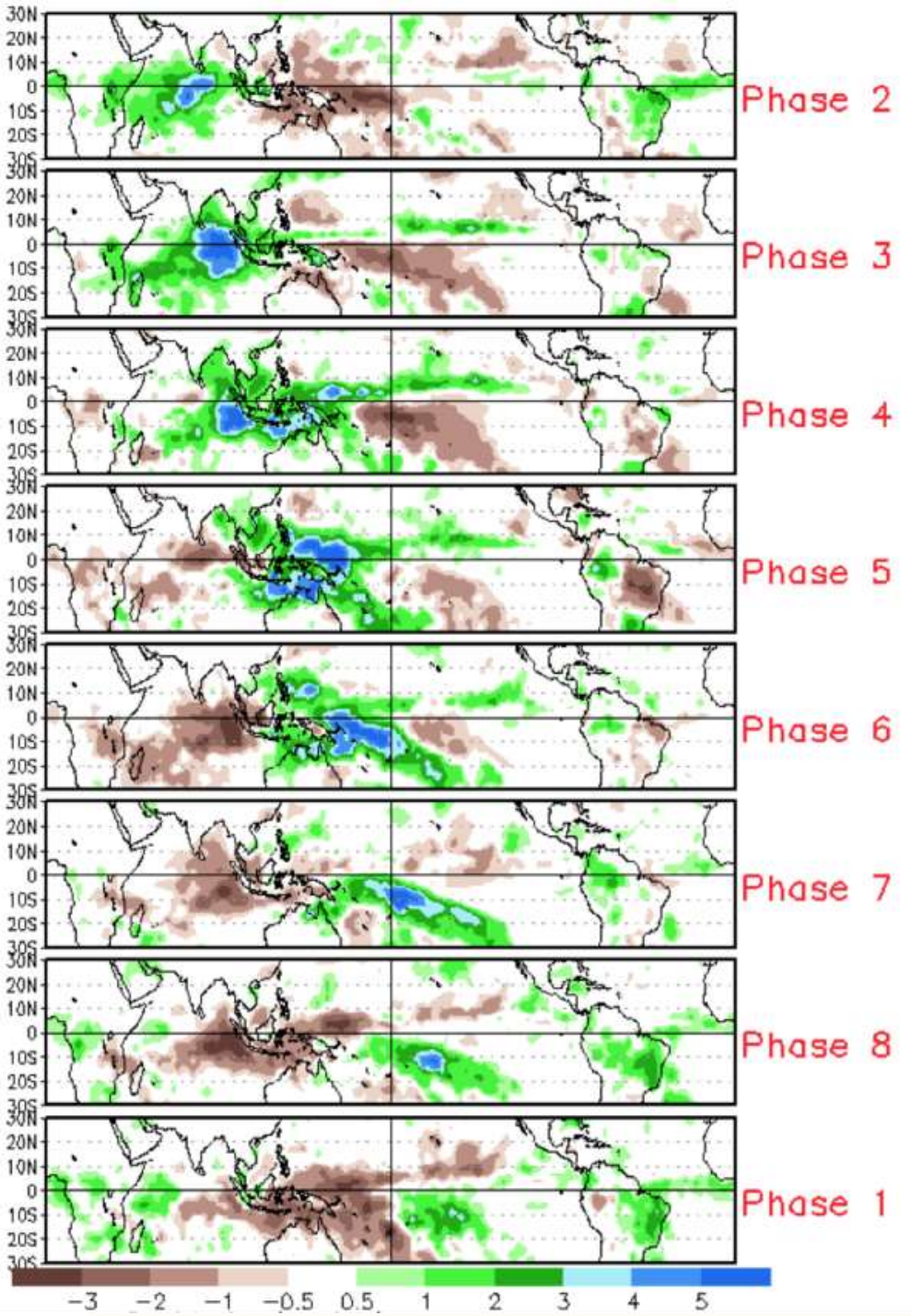
Example cycle: Week 2-3



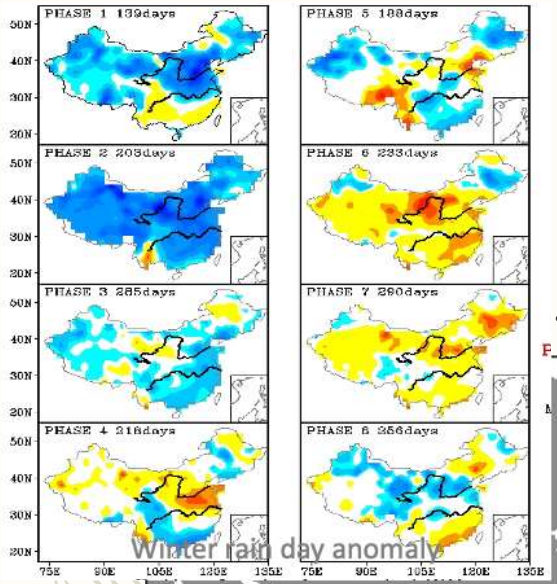
Example cycle: Week 4-5



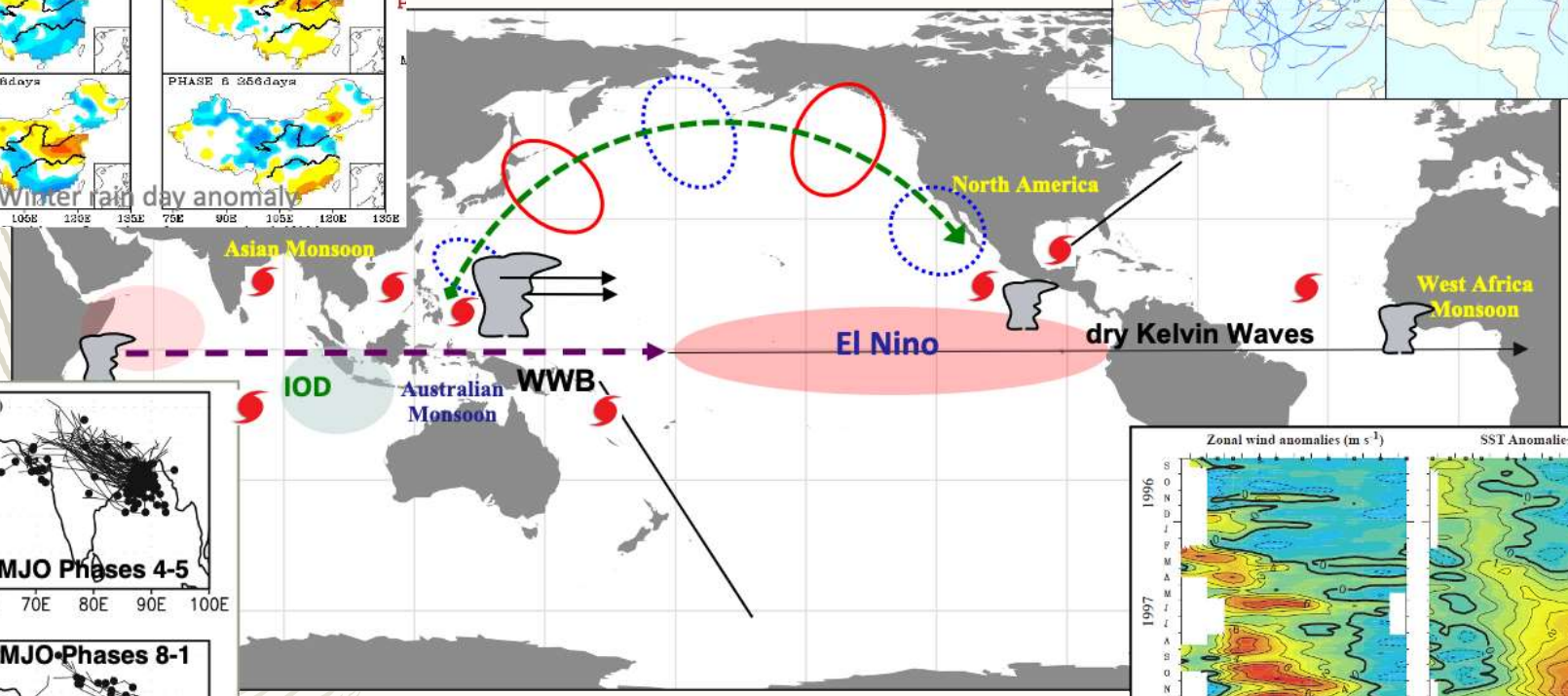
Australian Government
Bureau of Meteorology



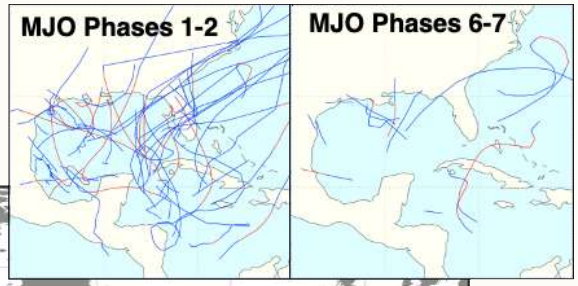
MJO Global Impacts

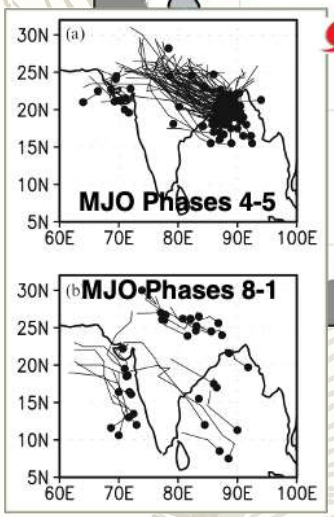


Jia et al (2010)



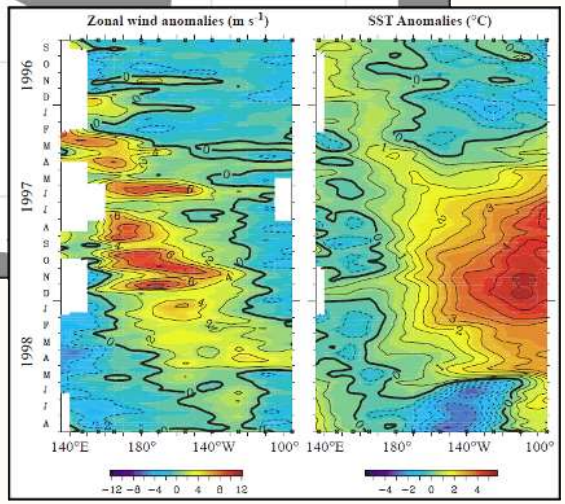
Maloney and Hartmann (2000)





Goswami et al (2003)

- Monsoon onset/break ; rain days
- Tropical cyclone formation
- ENSO triggering
- Mid-latitude circulation (wave train/teleconnection ; NAO)
- WMO WCRP/WWRP S2S forecast



McPhaden (1999)

http://www.bom.gov.au/climate/mjo/

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Madden-Julian Oscillation (MJO)

Climate

- Outlooks & drivers
- Rainfall & temperature outlooks
- Outlook video
- Climate driver update
- Streamflow outlooks
- Tropical monitoring
- Northern rainfall onset
- Tropical cyclone outlook
- Climate model

The Madden-Julian Oscillation (MJO) is the major fluctuation in tropical weather on weekly to monthly timescales. The MJO can be characterised as an eastward moving 'pulse' of cloud and rainfall near the equator that typically recurs every 30 to 60 days.

Read more: About the MJO

MJO summary (PDF 4MB)

MJO phase | Average conditions | Average OLR | Cloudiness

Regional cloudiness | Time longitude | Weekly note

MJO phase diagram

Current Phase: 40 days

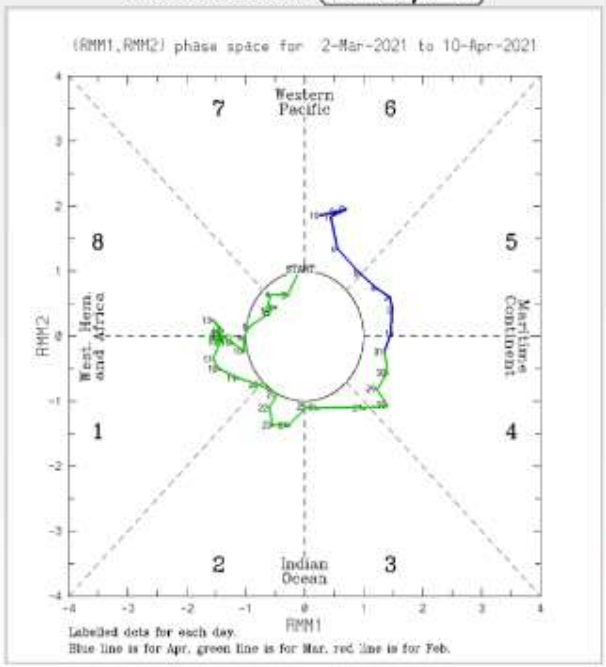
The MJO phase diagram illustrates the progression of the

MJO phase | Average conditions | Average OLR | Cloudiness

Regional cloudiness | Time longitude | Weekly note

MJO phase diagram

Current Phase: 40 days

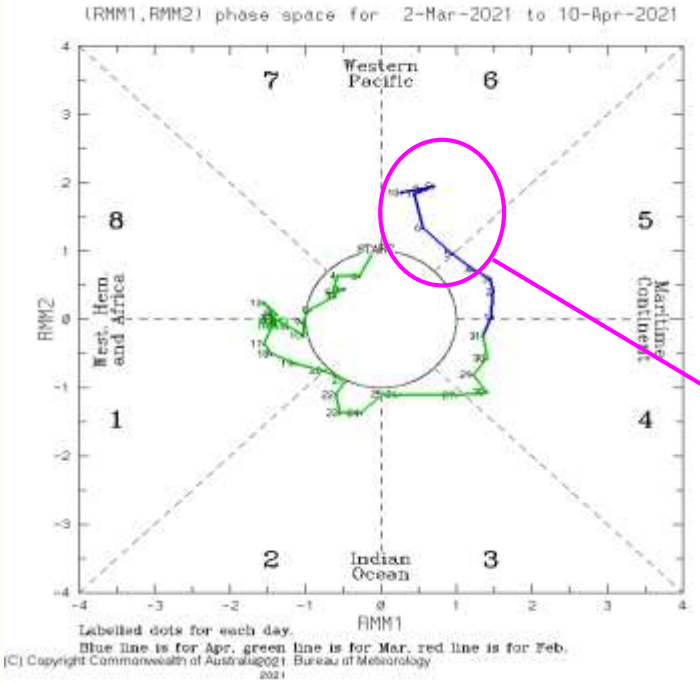


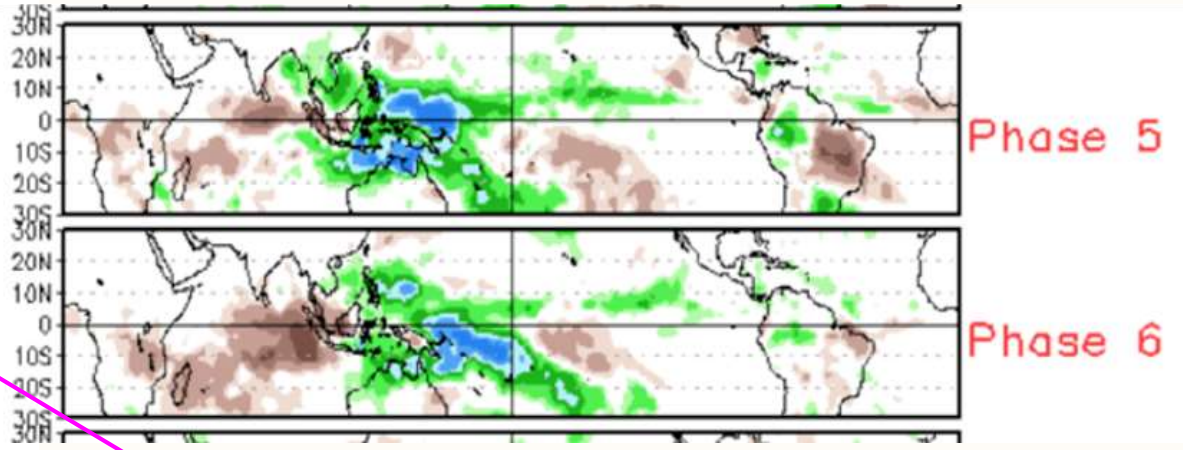
Archive:

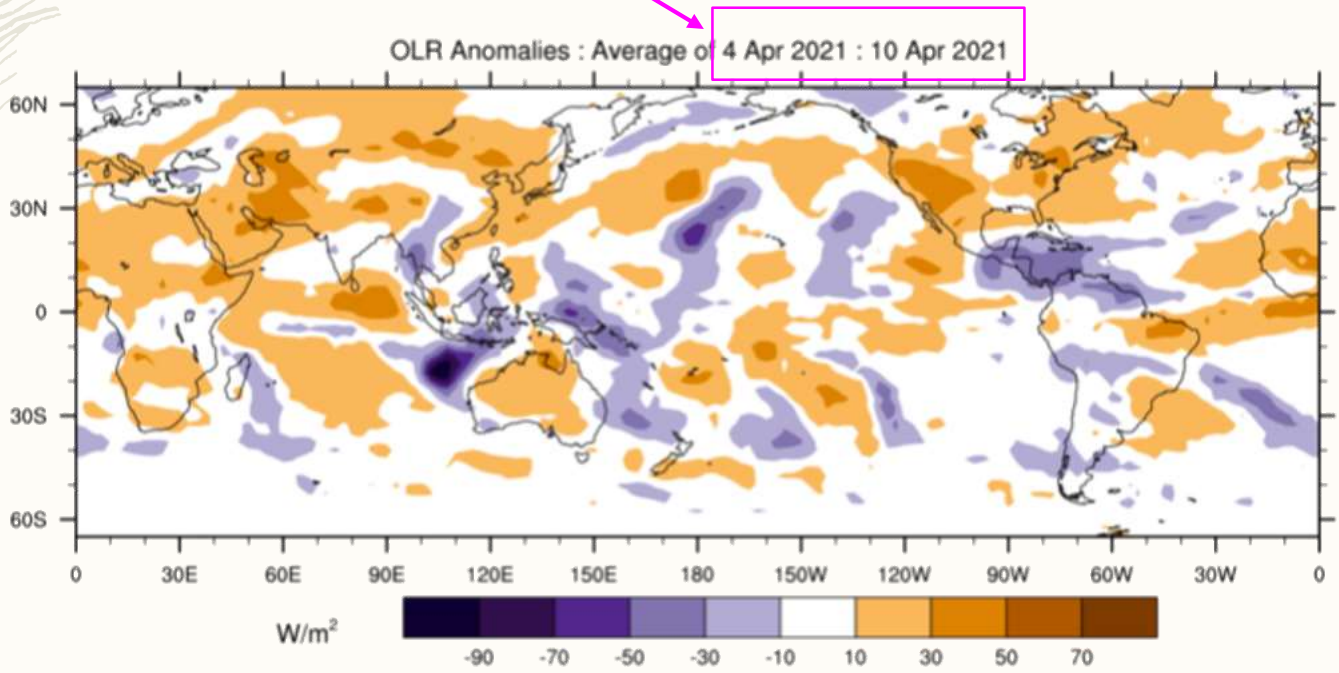
Year: 2020 Months: Jan-Mar

*Note: There are missing satellite observations from 16/3/1978 to 31/12/1978.

The MJO phase diagram illustrates the progression of the MJO through different phases, which generally coincide with locations along the equator around the globe. RMM1 and RMM2 are mathematical methods that combine cloud amount and winds at upper and lower levels of the atmosphere to provide a measure of the strength and location of the MJO. When the index is within the centre circle the MJO is considered weak, meaning it is difficult to discern using the RMM methods. Outside of this circle the index is stronger and will usually move in an anti-clockwise direction as the MJO moves from west to east. For convenience, we define 8 different MJO phases in this diagram.







One-month Prediction (Tropics and Asia)

This product is displayed for use by National Meteorological and Hydrological Services (NMHSs). It does not constitute an official forecast for any nation.

Forecast Maps

forecast period
the first week

initial date
2021.04.07.12 Z

area
- 60N-60S
- Asia

corresponding verification

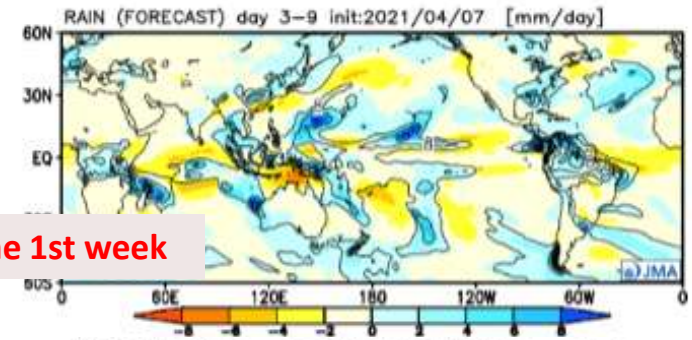
[Contour interval]
CHI200 : 2x1.0E6m^2/s
RAIN : 4mm/day
Z500 : 120m
TS : 4C
PSI200 : 20x1.0E6m^2/s
PSI850 : 5x1.0E6m^2/s
PSEA : 4hPa

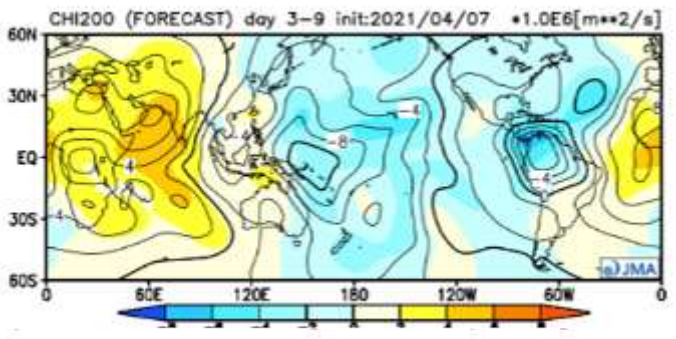
(Shaded patterns show anomalies.)

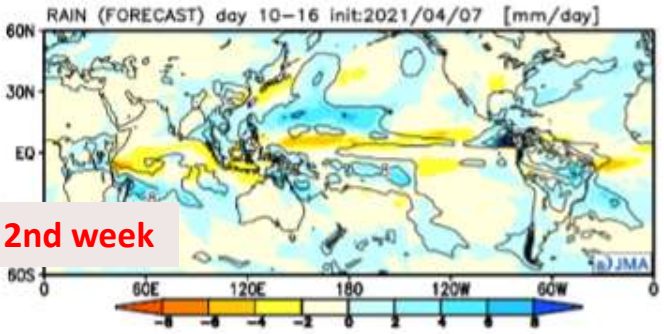
the 1st week

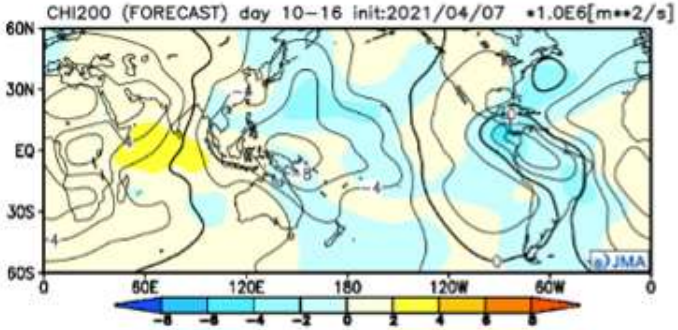
the 2nd week

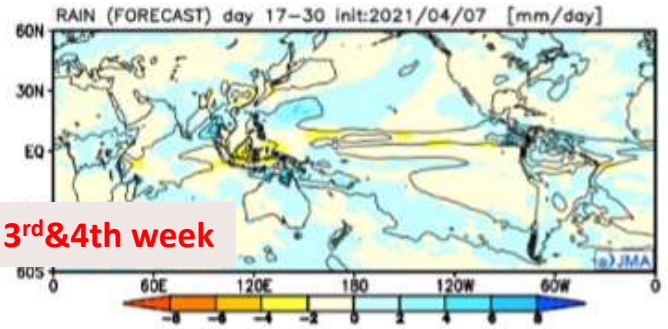
the 3rd&4th week

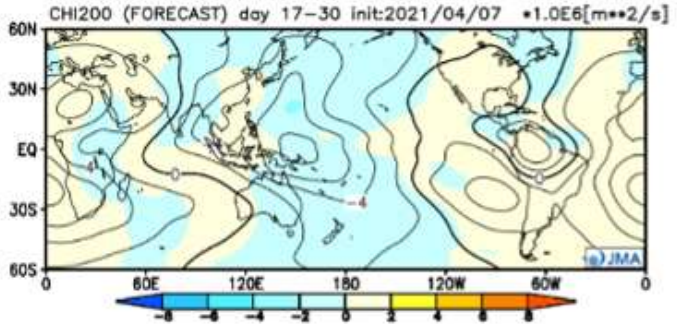












28 days mean

Forecast Maps

forecast period
28 days mean

initial date
2021.04.07.12 Z

area
- 60N-60S
- Asia

corresponding verification

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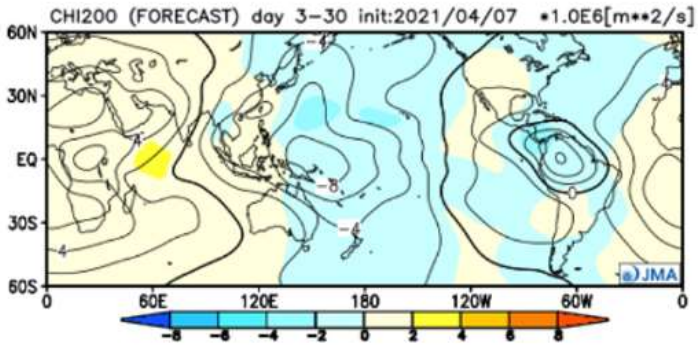
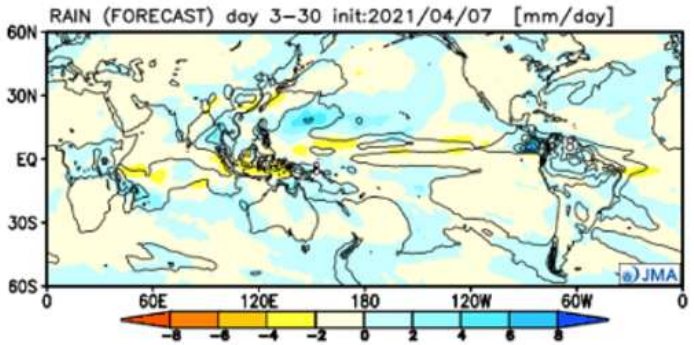
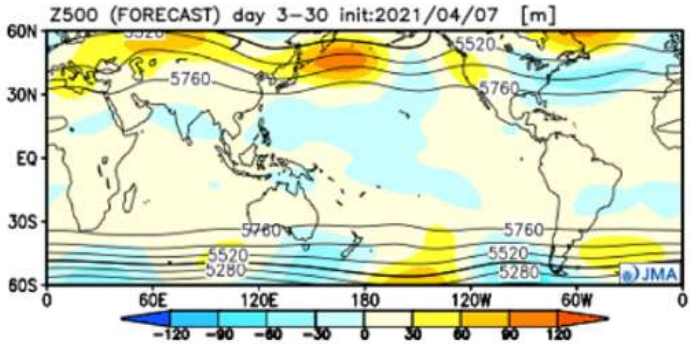
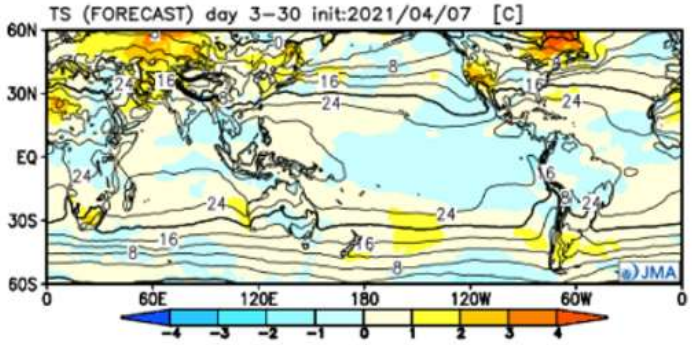
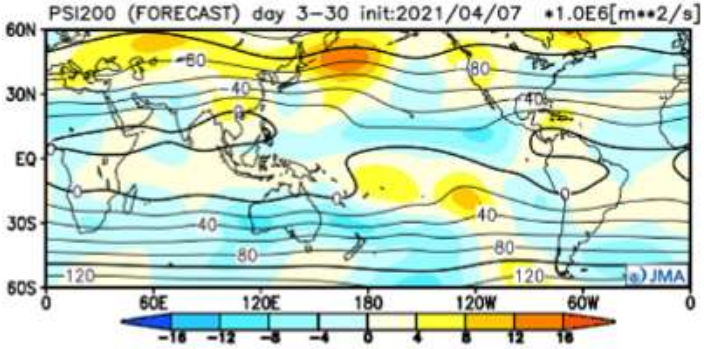
(Shaded patterns show anomalies.)

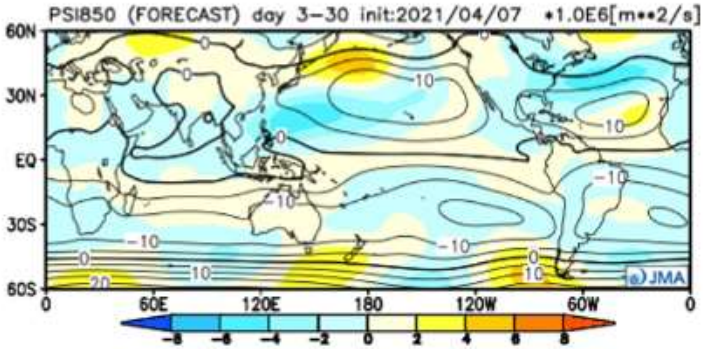


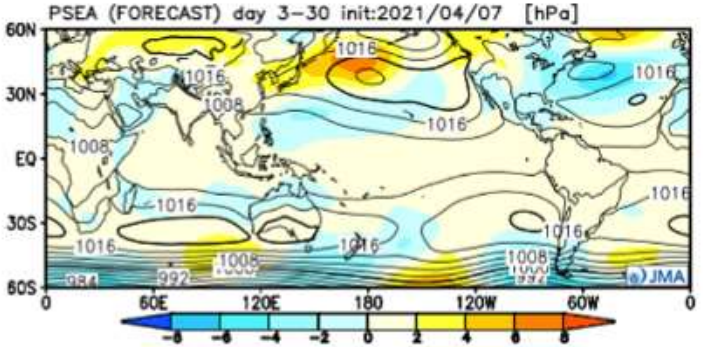


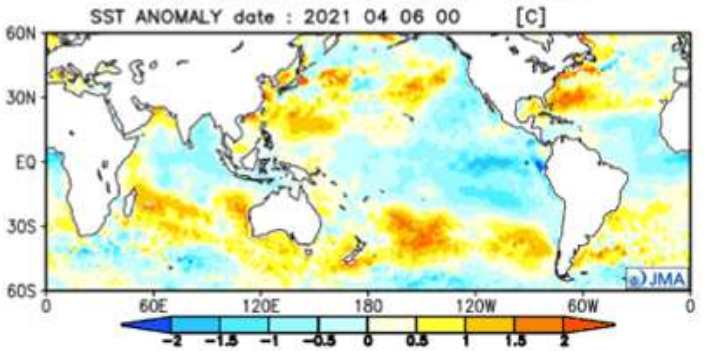












One-month Prediction (Tropics and Asia)

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Forecast Maps

forecast period
the first week

initial date
2021.04.07.12 Z

area
- ○ 60N-60S
- ◉ Asia

corresponding verificatio

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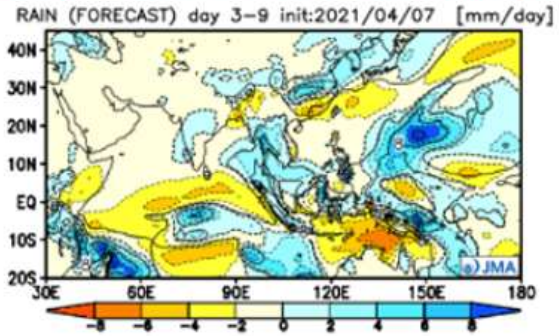
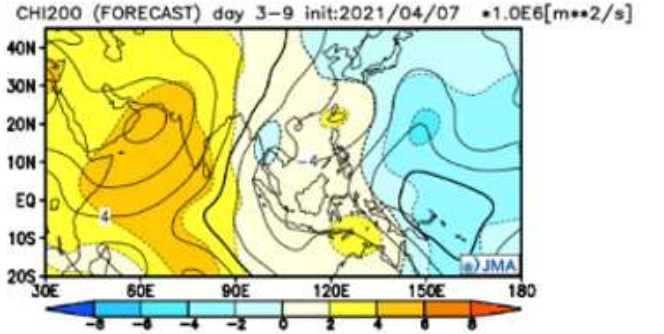
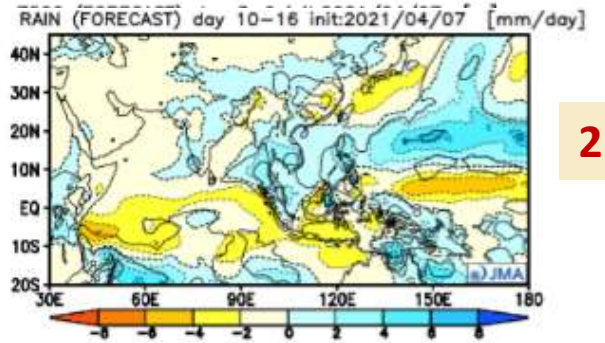
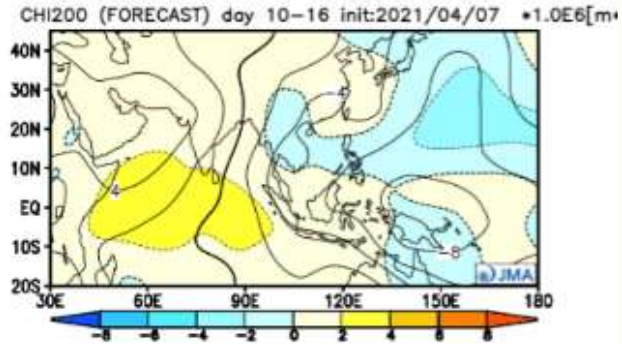


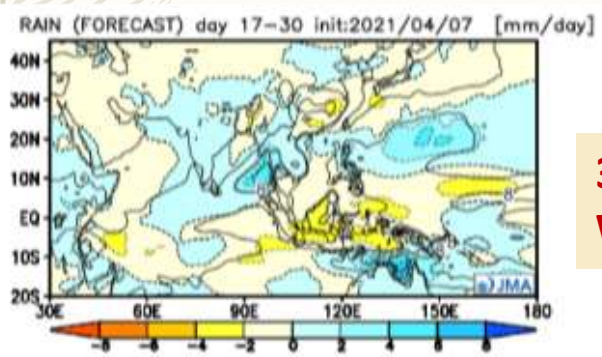
1st Week



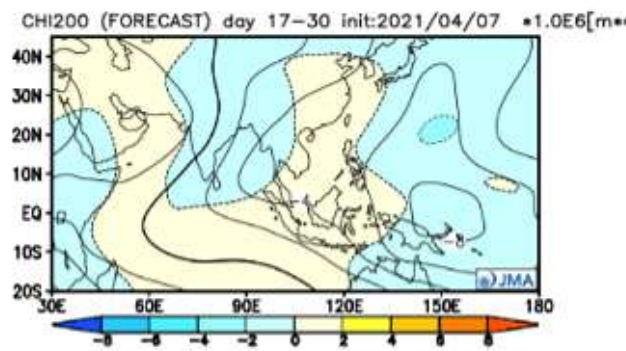


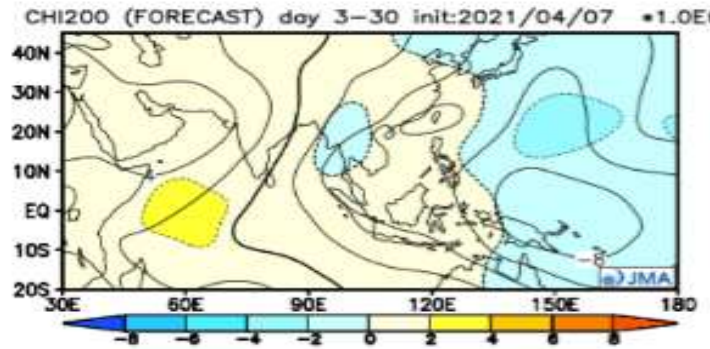
2nd Week



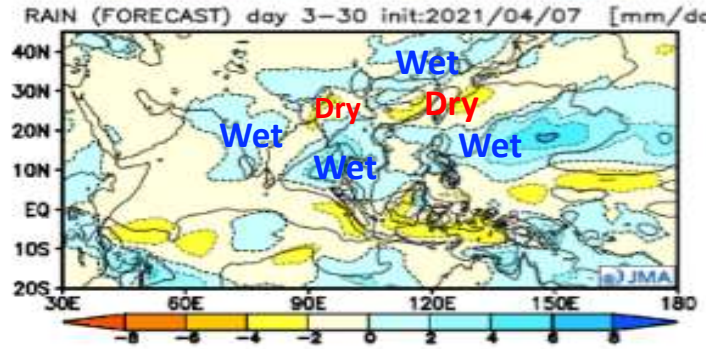


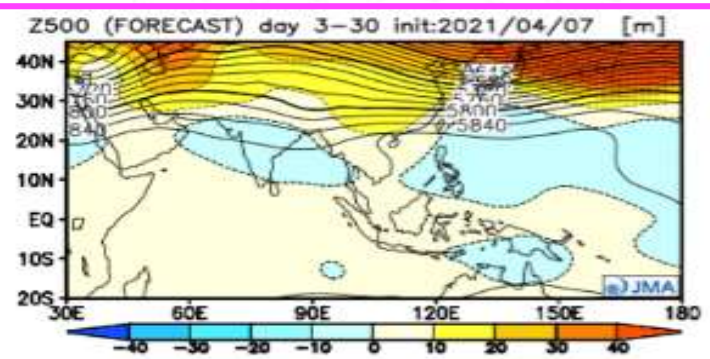
3rd & 4th Week

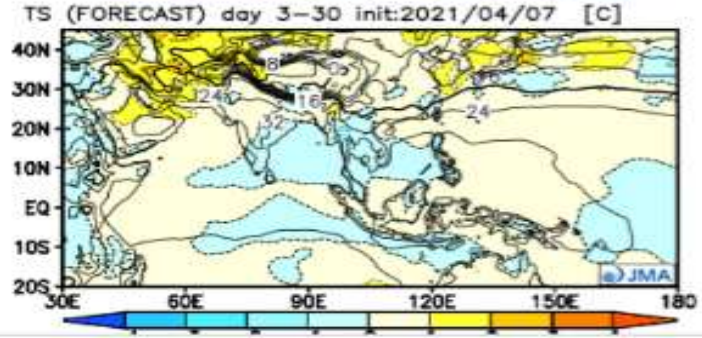


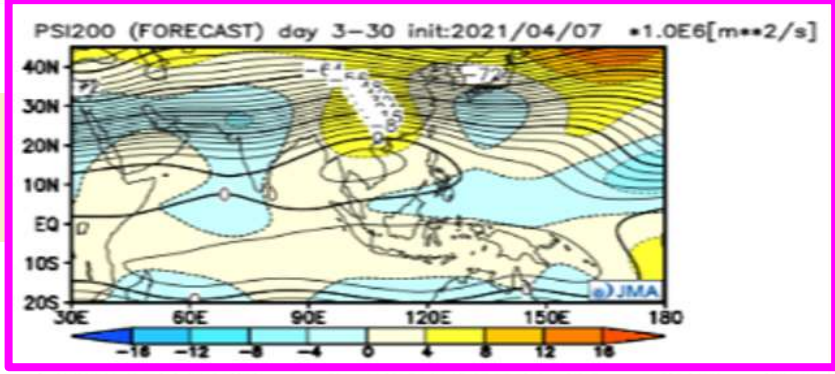


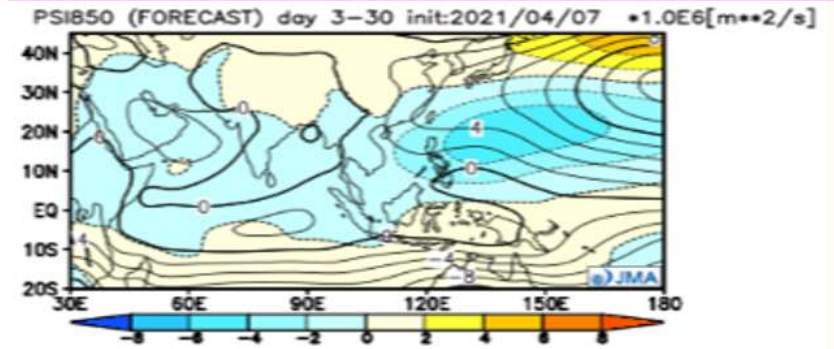
Apr. 3-30,
28 days mean

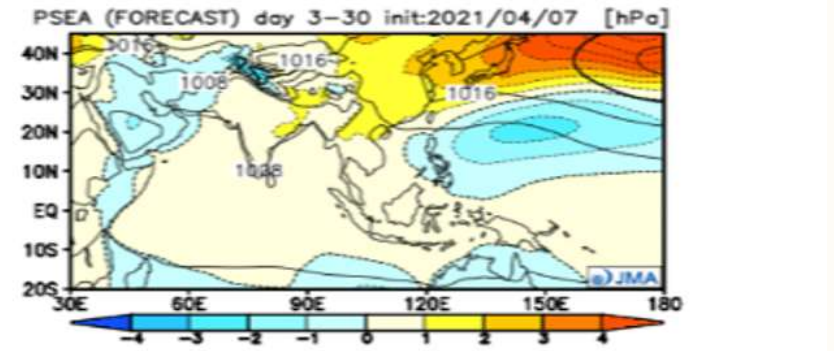


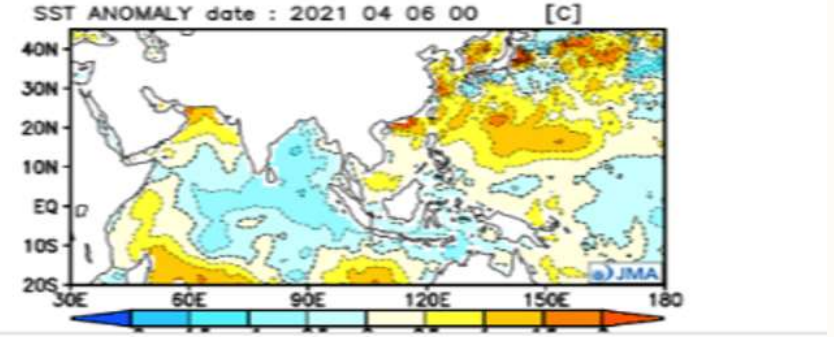










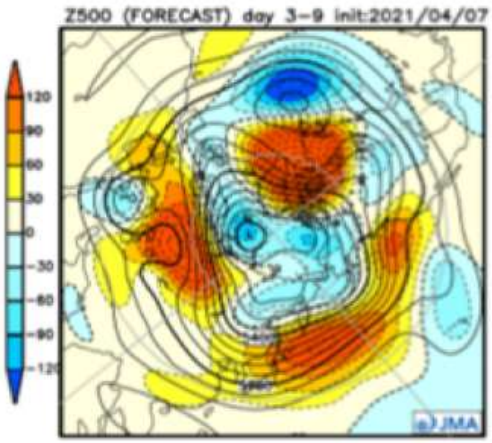


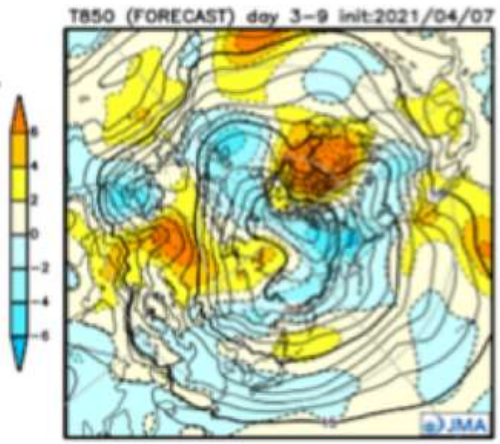
Forecast Maps

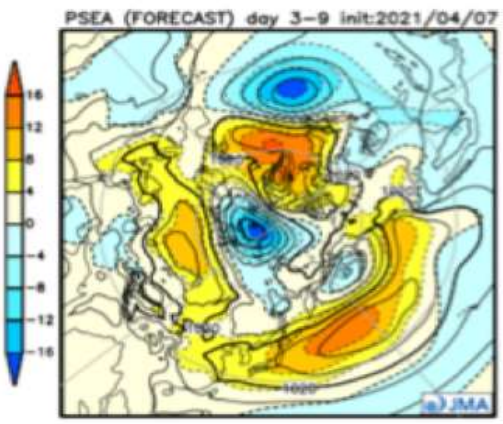
forecast period
the first week

initial date
2021.04.07.12 Z

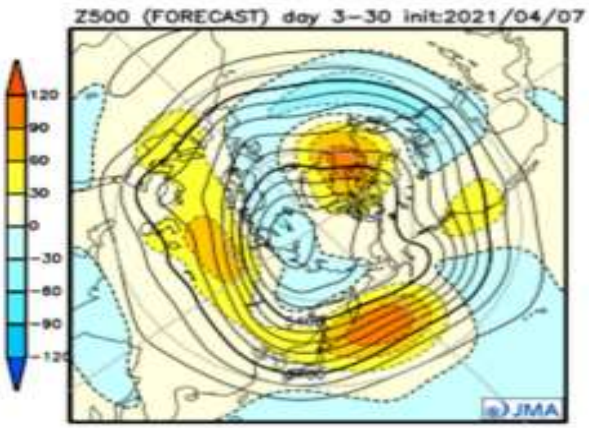
Ensemble Mean forecast (07 day mean)

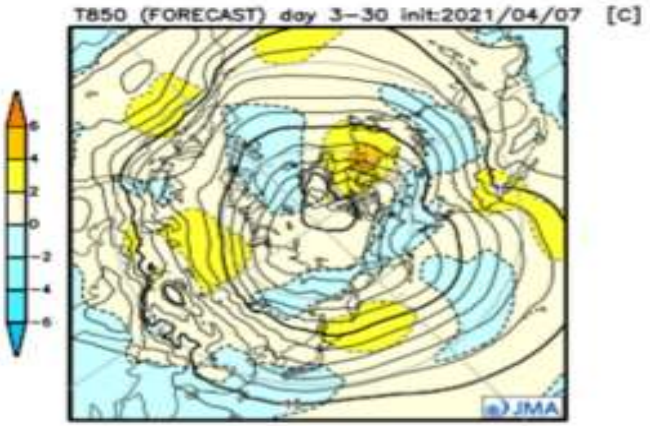


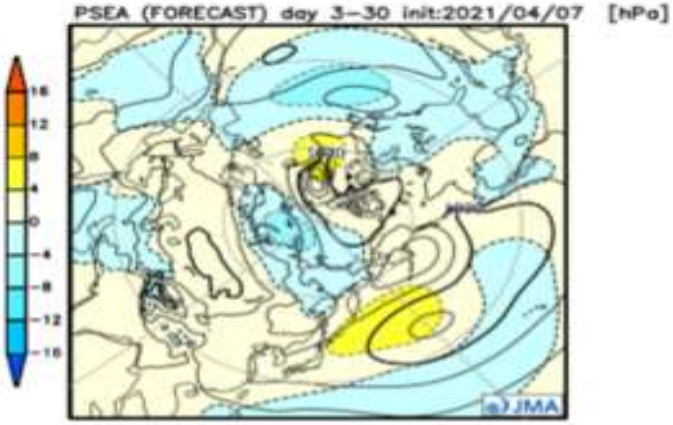


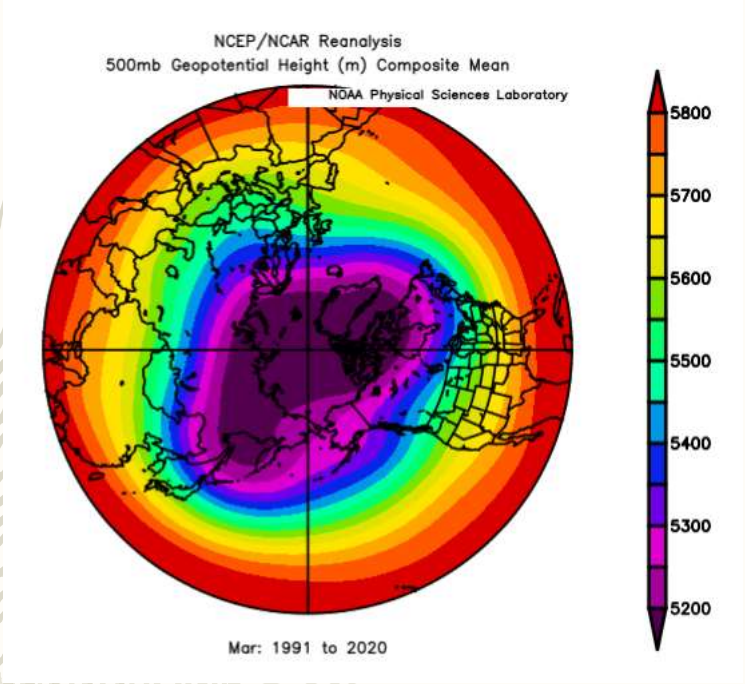


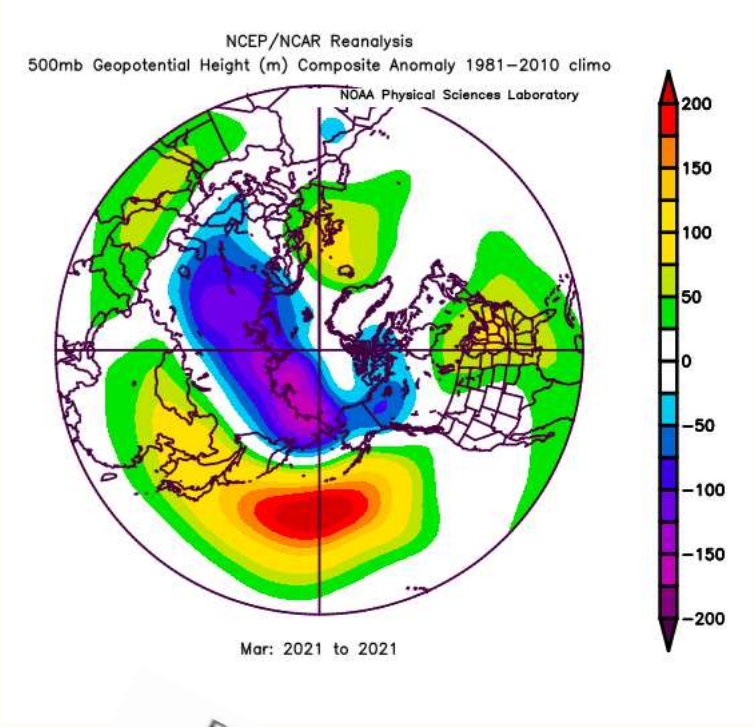
Ensemble Mean forecast (28 day mean)

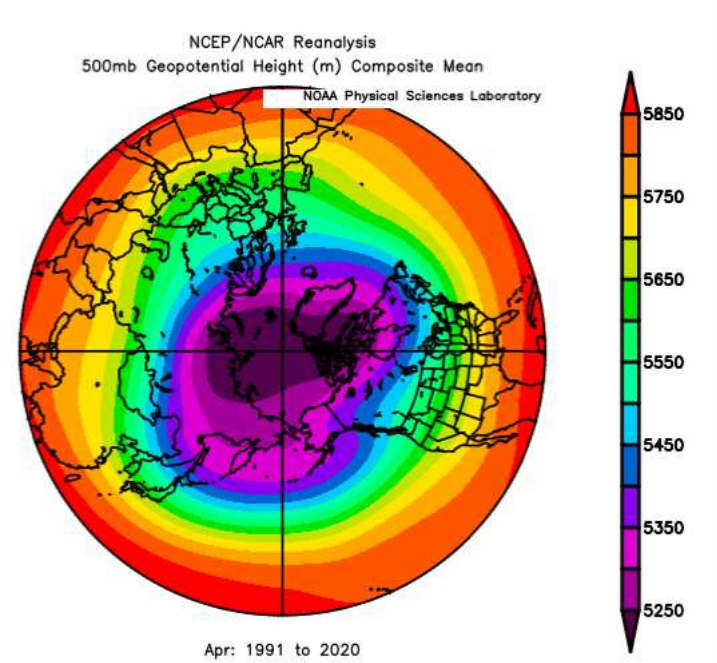


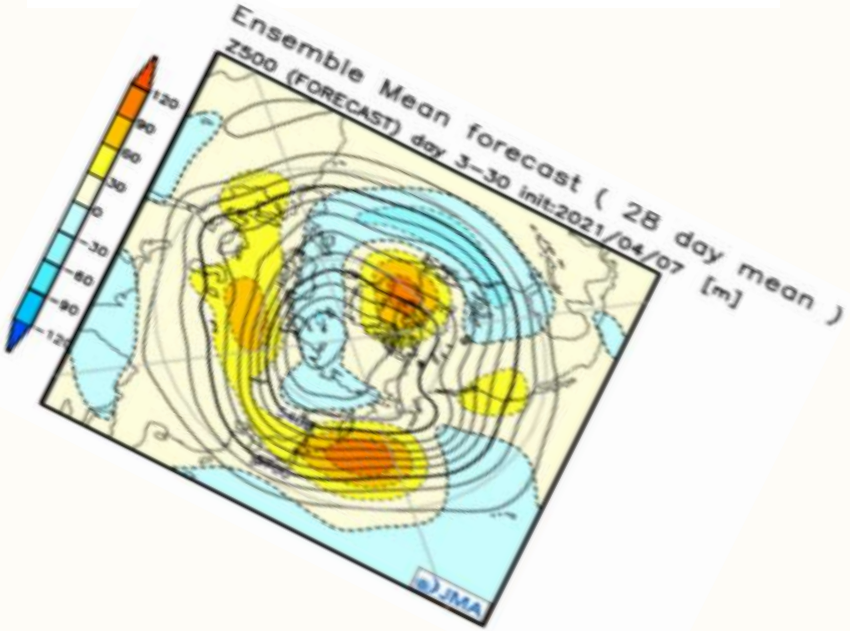





NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Mean
NOAA Physical Sciences Laboratory
5800
5700
5600
5500
5400
5300
5200
Mar: 1991 to 2020

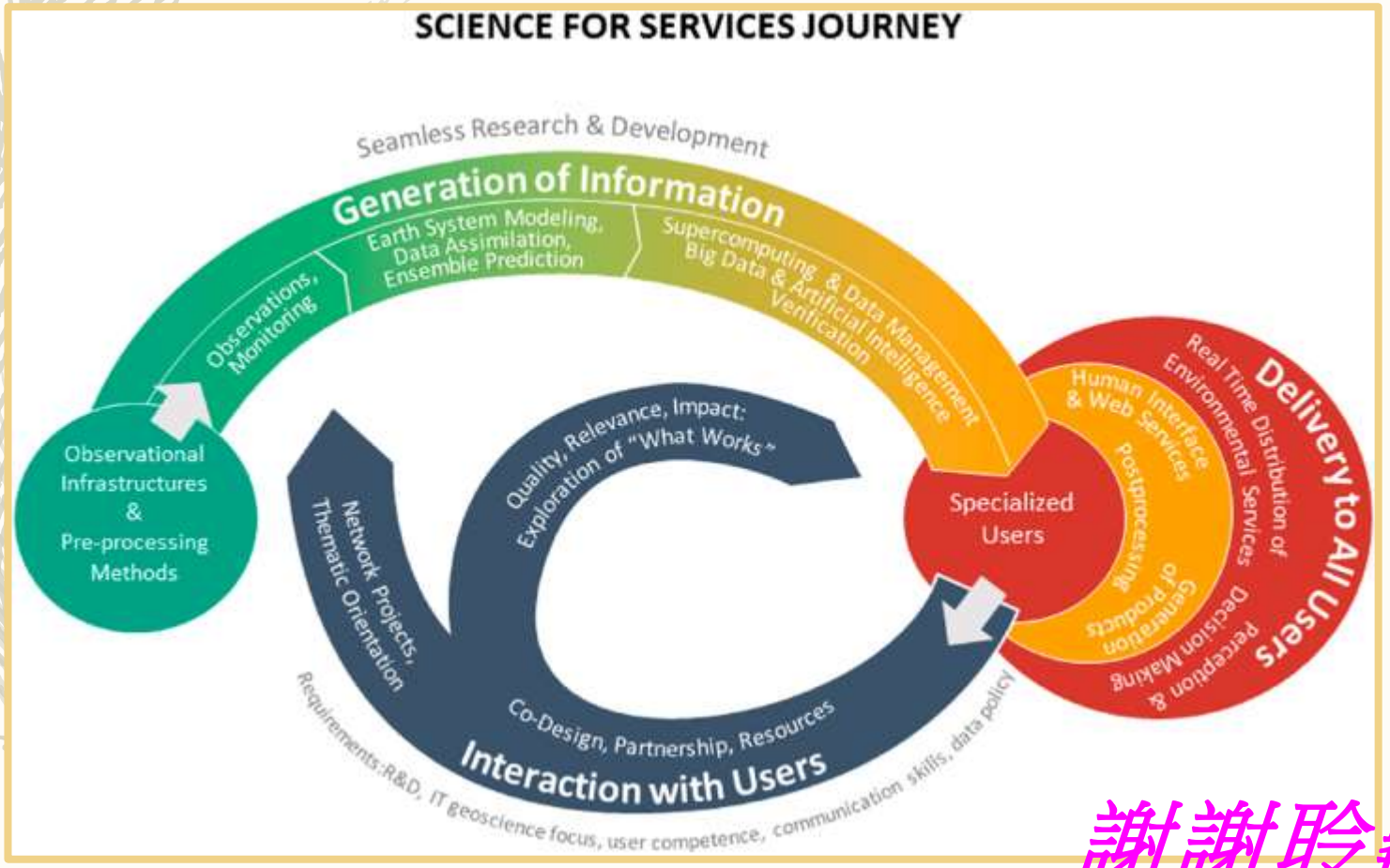

NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Anomaly 1981–2010 climo
NOAA Physical Sciences Laboratory
200
150
100
50
0
−50
−100
−150
−200
Mar: 2021 to 2021


NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Mean
NOAA Physical Sciences Laboratory
5850
5750
5650
5550
5450
5350
5250
Apr: 1991 to 2020


Ensemble Mean forecast (28 day mean)
Z500 (FORECAST) day 3-30 init:2021/04/07 [m]
JMA

結語

- GFCS自2012年正式通過實施至今「氣候服務」的全球-區域-國家架構儼然成形
- 氣候服務價值循環(the value cycle approach)是WMO專家構思的氣候服務科學精神具體化旅程路線圖，值得重視



謝謝聆聽！