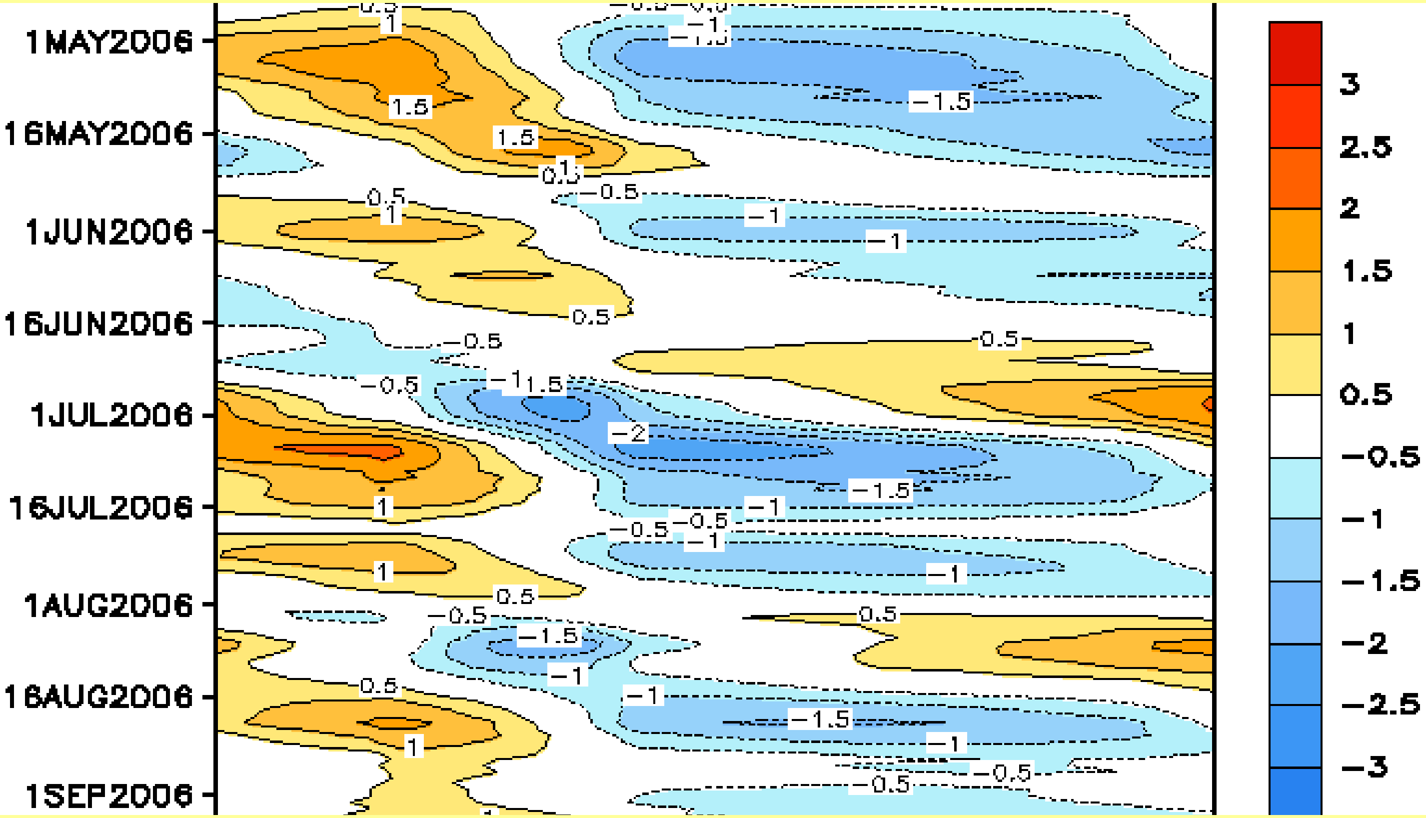
The Madden-Julian Oscillation

A weather system that Wikipedia lists under Climate Change



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Cruces Atmospheric Sciences Forum

17 March 2018

Acknowledgement:

Steve McGee, for providing the slowed-down version of the animated GIF, so that we can actually see, and learn from, the individual images.

Outline

References

Madden-Julian Oscillation -- Characteristics

Sidebars: Outgoing Longwave Radiation (OLR) the Maritime Continent

Why we should care about the MJO

Eight “Classic Phases” of the MJO

Impacts of the MJO in North America

Sea Level Pressure Anomalies and Outgoing Longwave Radiation Anomalies vs Precipitation Anomalies

NCAR’s Year of Tropical Convection

References:

https://en.wikipedia.org/wiki/Madden–Julian_oscillation

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/MJO_summary.pdf

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

https://www.esrl.noaa.gov/psd/mjo/MJOprimer/

https://www.esrl.noaa.gov/psd/mjo/

https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

Beginning Note:

I used the references in preparation of much of this presentation.

Numerous instances where these references are completely at odds with each other in this “survey article” context.

We are often told bythe Mainstream Media that the “science is settled.”

Clearly it’s not…as the last graphic demonstrates.

Madden-Julian Oscillation-- area of enhanced rainfall with these characteristics:

Starts in the Indian Ocean; usually moves from Indian Ocean into mid-Pacific

Has an associated area of Suppressed Precipitation in an out-of-phase area (ahead of it)

Moves eastward at speeds of 9-18 miles/hour

Primarily shows up as an Enhanced Precipitation Anomaly

Convective Signature is strongest within 15 Degrees north and south of the Equator

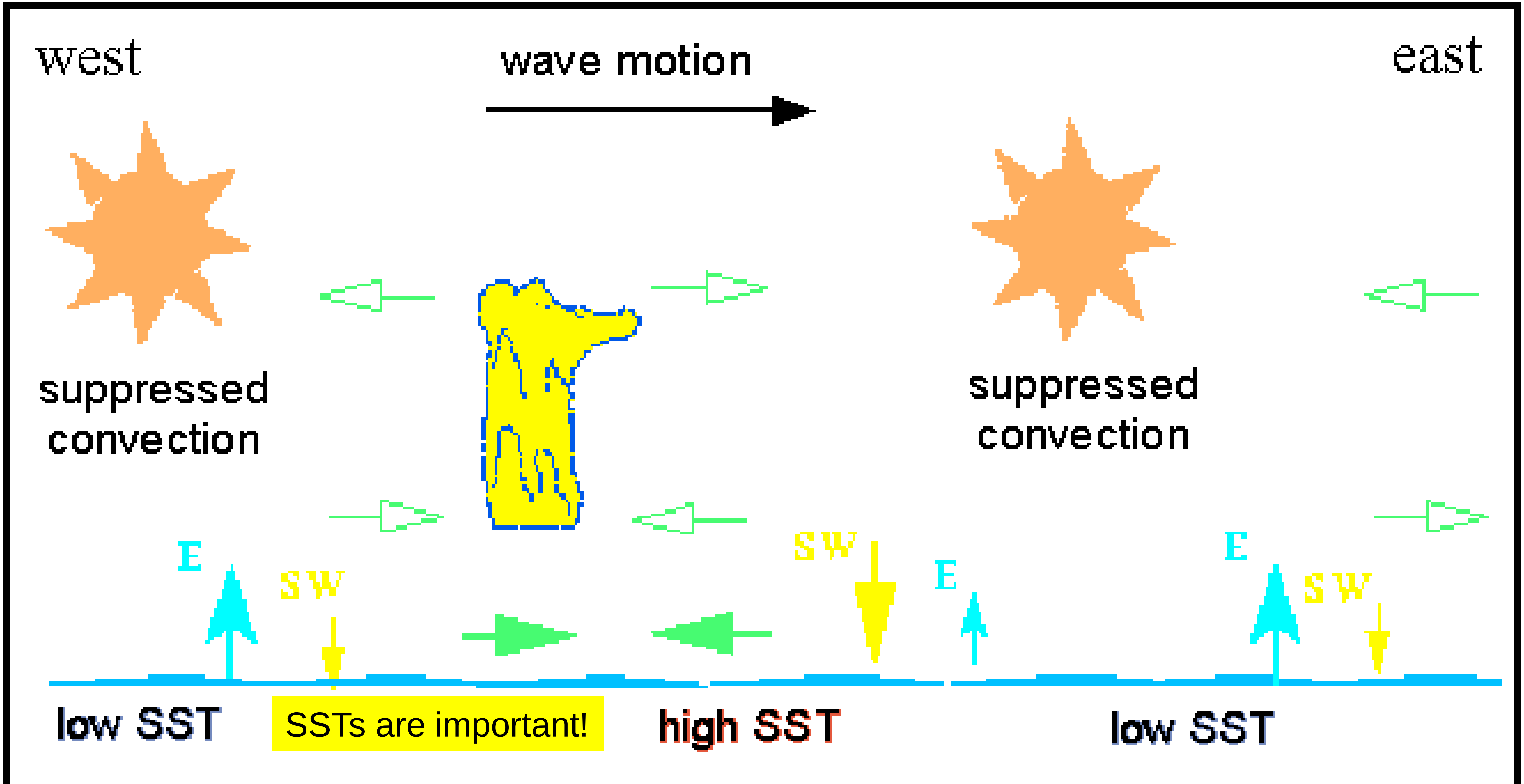
Stronger in the Southern hemisphere

Frequently becomes indistinct when approaching cooler (upwelled) water off the Americas, but sometimes not, and/or reappears over the equatorial Atlantic and into Africa.

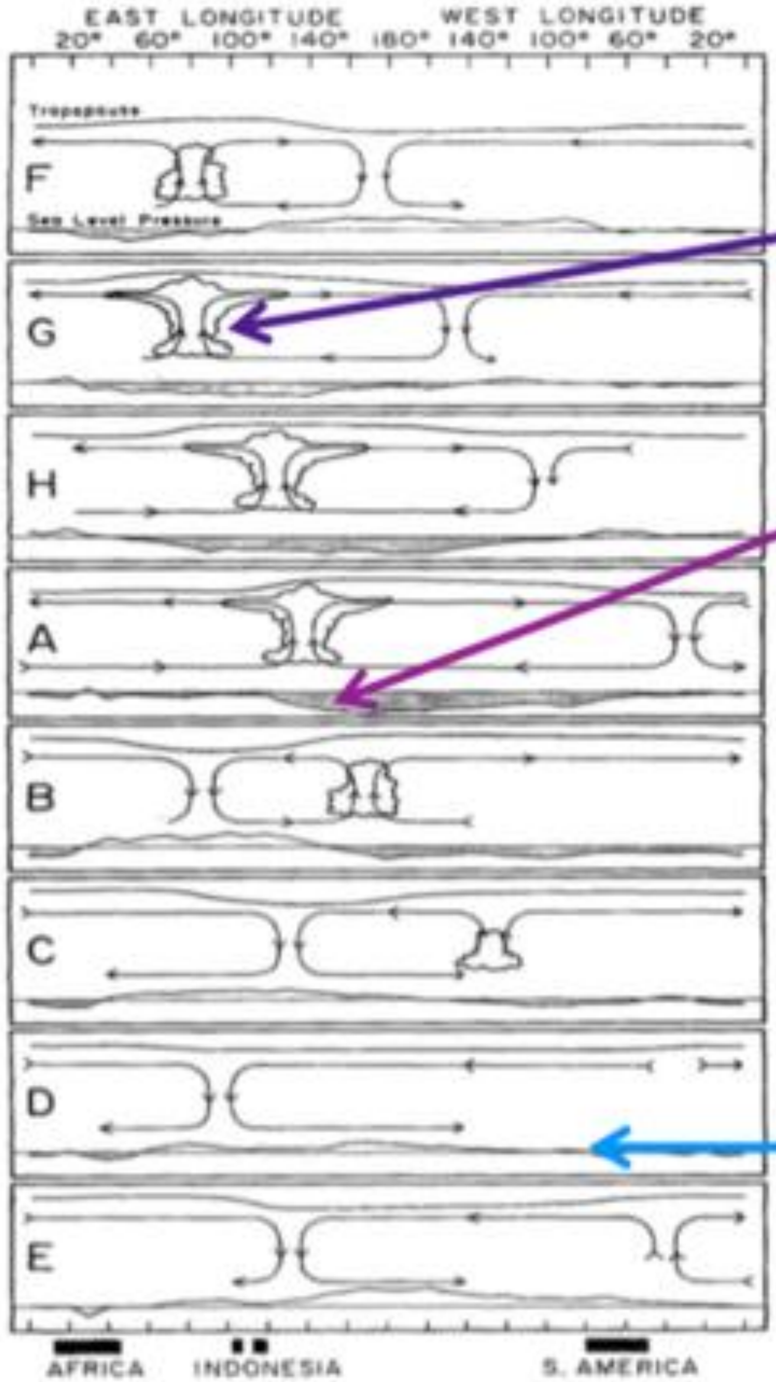
Cycles usually last 30-60 days, sometimes 90 days

Sometimes moves around the entire earth

Schematic of the MJO http://macegroup.chpc.utah.edu/class/1020/Atmos1020_class_slides_20171115.pdf



http://www.atmos.albany.edu/daes/atmclasses/atm421/Handouts_files/MJO.pdf



1) The MJO is a region of low level convergence, and thus convection.

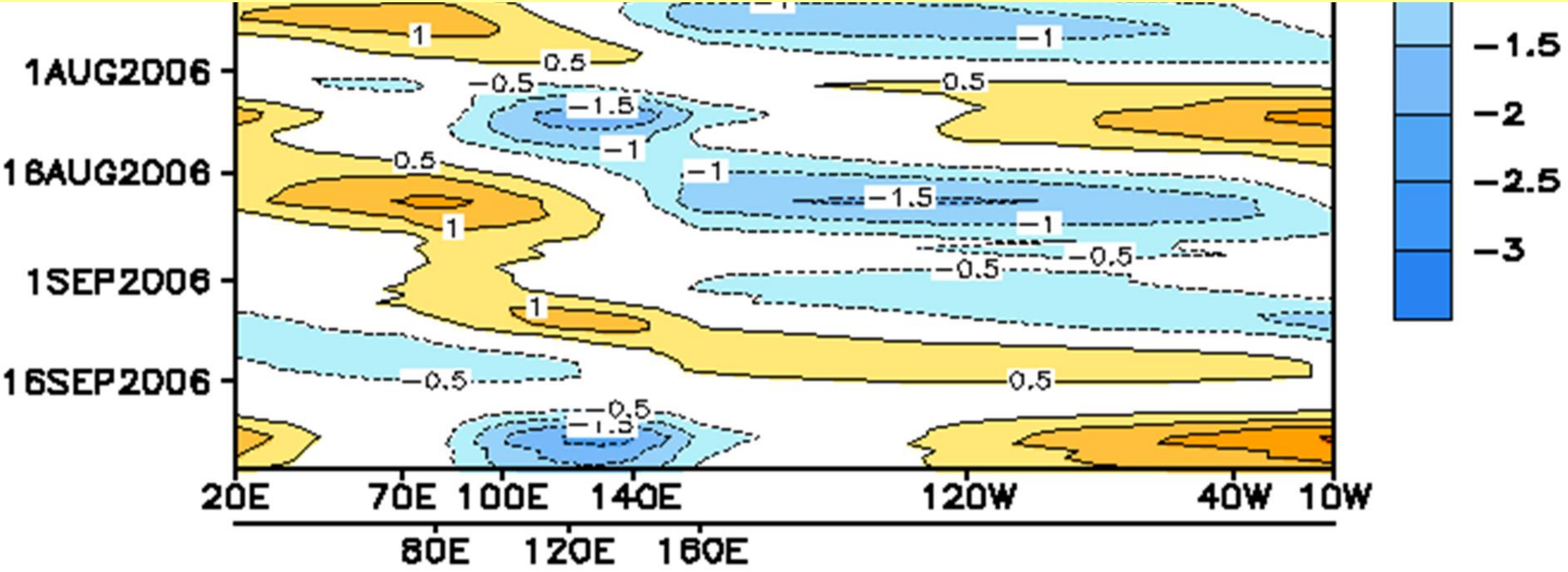
2) Pressure is low in the regions of strong convection.

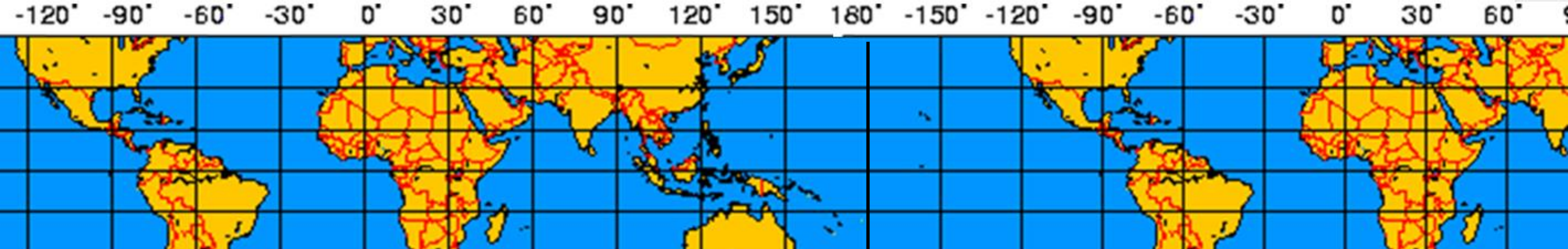
3) The convection only propagates eastward.

4) The circulation associated with the MJO circumnavigates the globe in ~40 days, but the oscillation weakens as it moves into the Western Hemisphere.

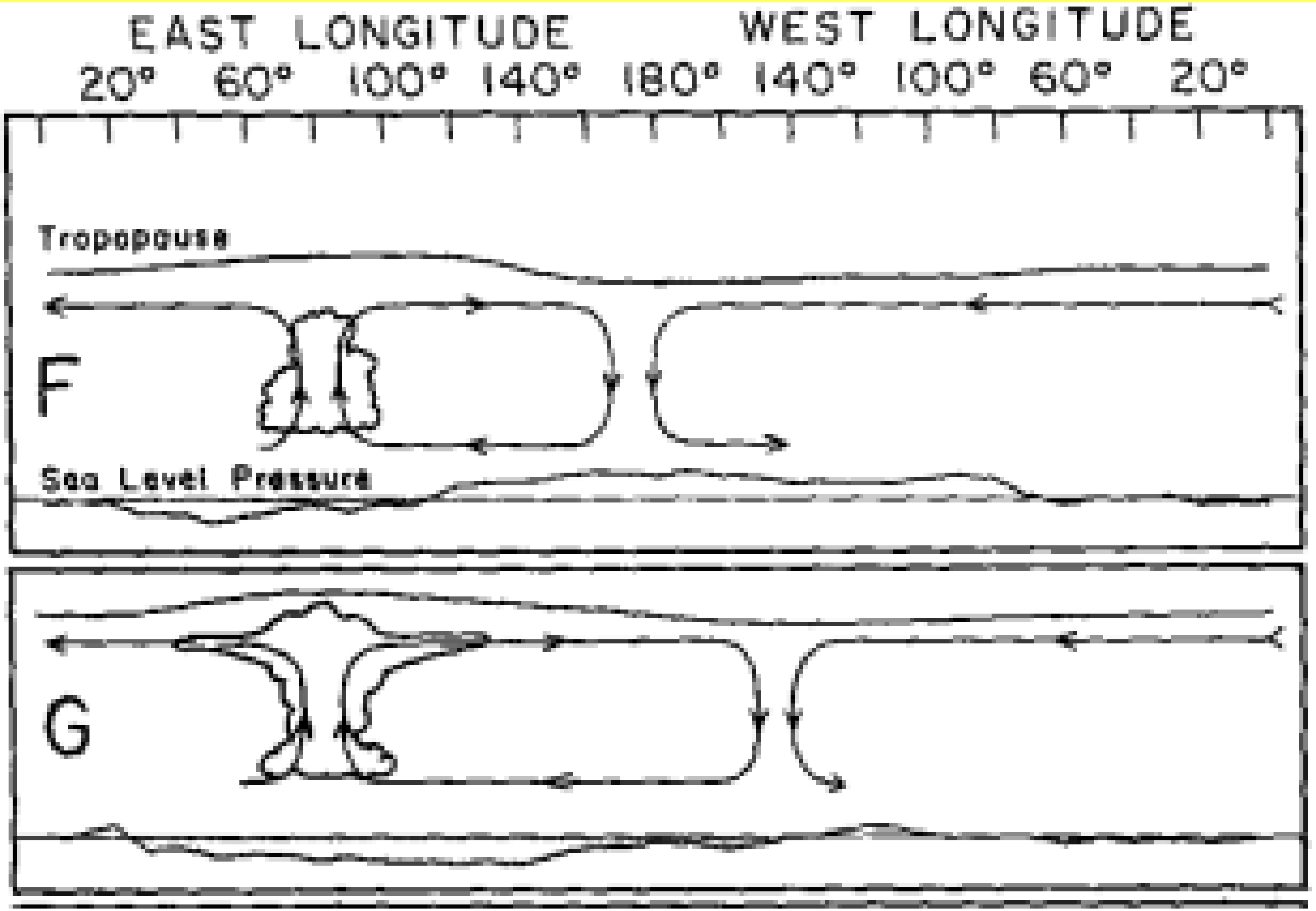
Madden and Julian (1972)

Geographic Extent of the Hovmuller Diagram



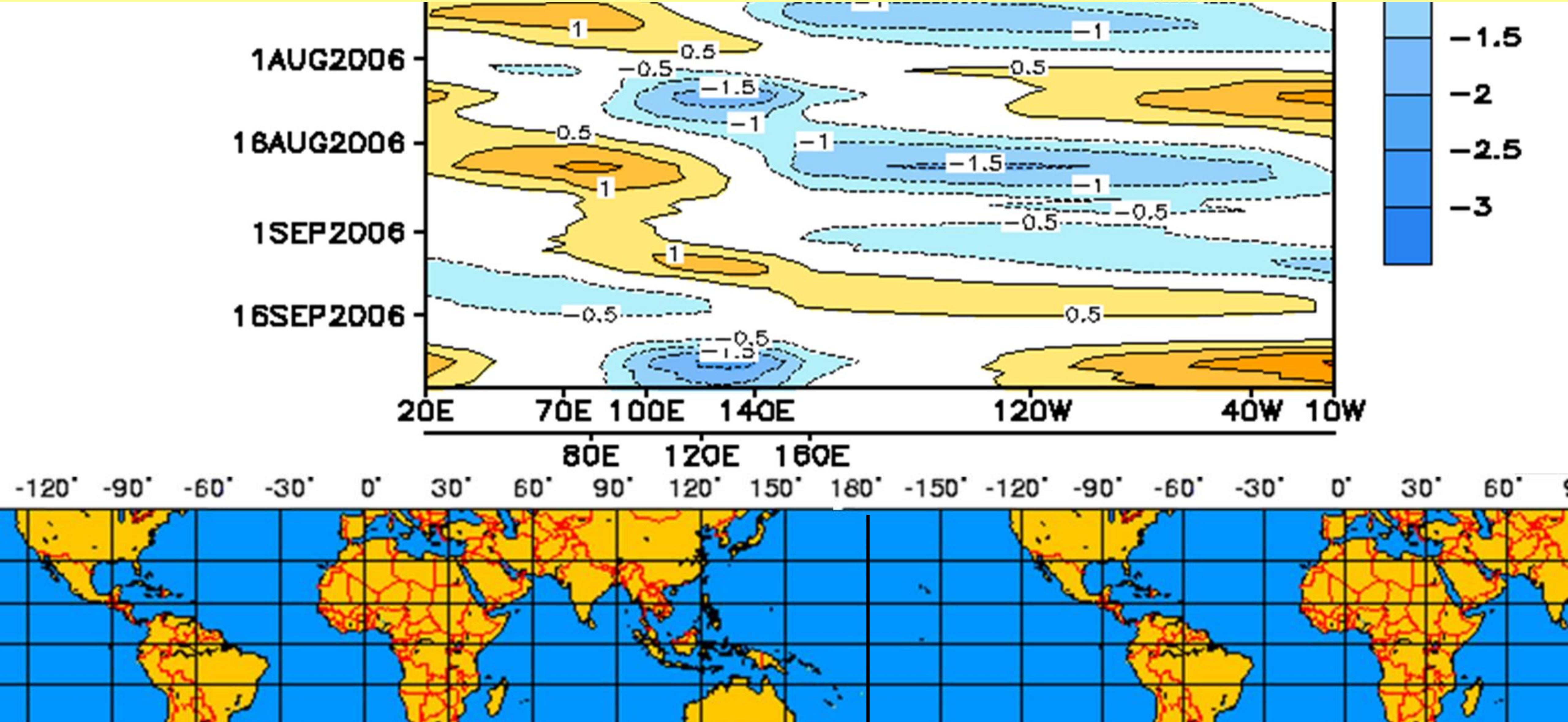


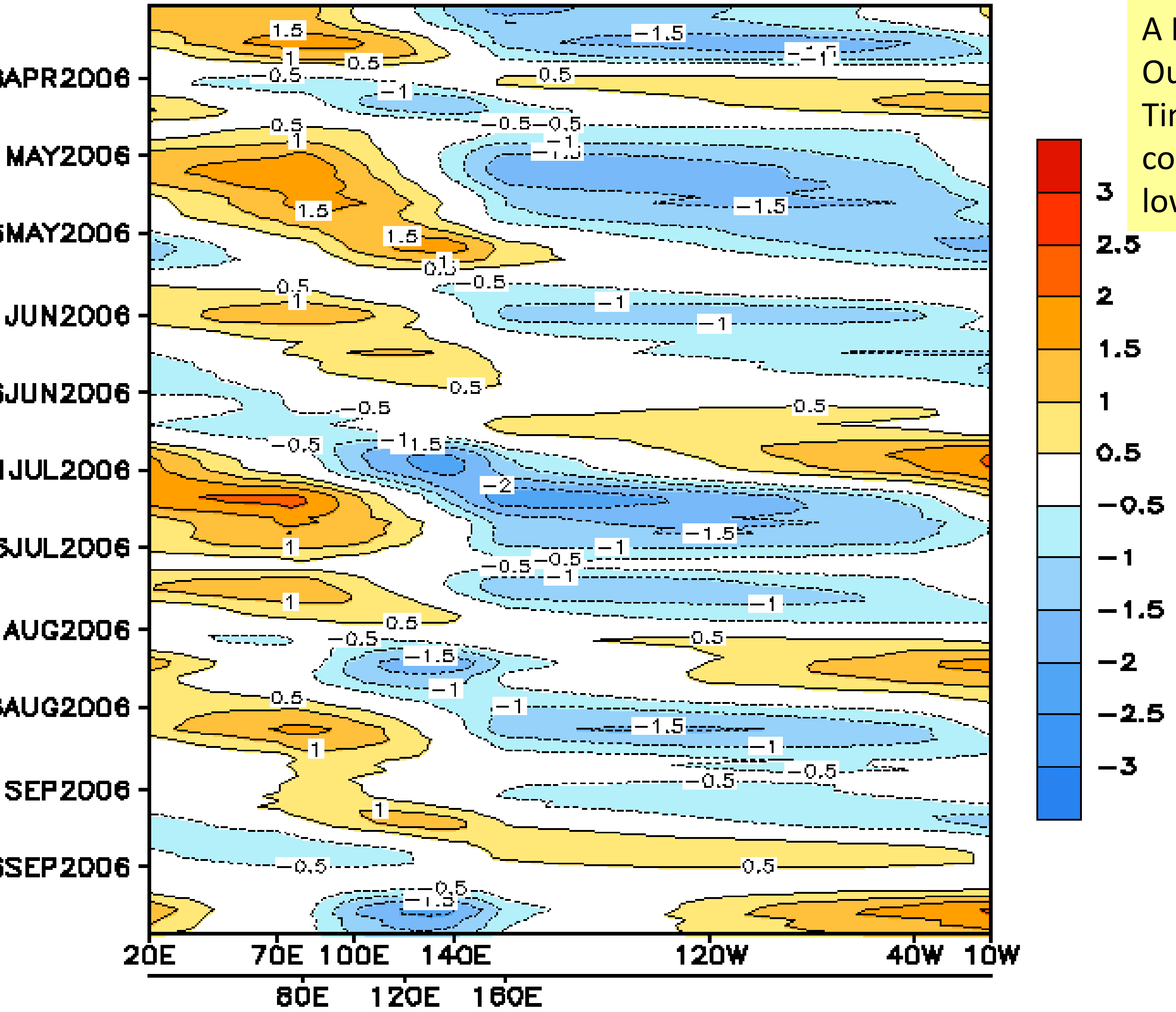
Schematic diagram-- changes in **tropopause height** and **sea level pressure** as the MJO propagates and strengthens. Other data show it takes about 5 days for the area of Enhanced Precipitation to pass a single station.



https://journals.ametsoc.org/doi/pdf/10.1175/1520-0493%281994%29122%3C0814%3AOOTDTO%3E2.0.CO%3B2

Geographic Extent of the Hovmuller Diagram





First instance has 180 degrees between enhanced & suppressed rainfall

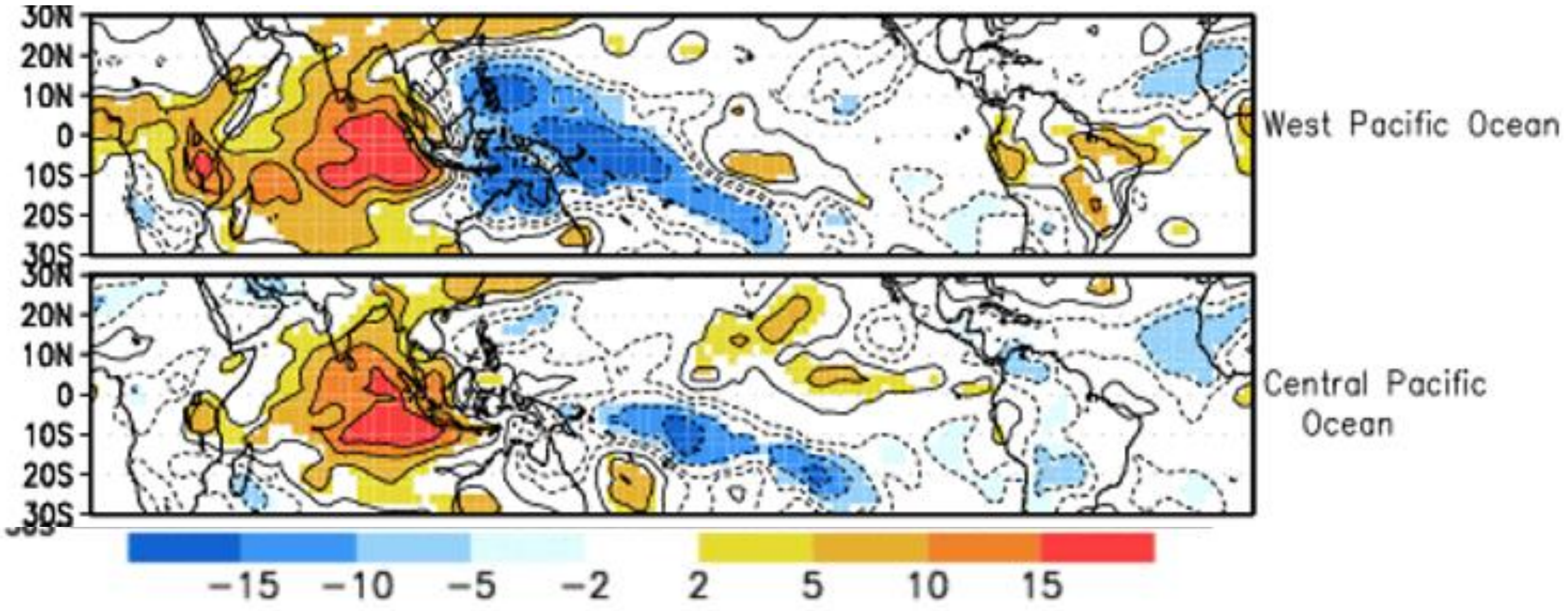
A Hovmöller diagram of the 5-day running mean of Outgoing Longwave Radiation showing the MJO. Time increases from top to bottom in the figure, so contours that are oriented from upper-left to lower-right represent movement from west to east.

https://en.wikipedia.org/wiki/Madden–Julian_oscillation#/media/File:MJO_5-day_running_mean_through_1_Oct_2006.png

Sidebar on Outgoing Longwave Radiation, adapted from https://www.ncdc.noaa.gov/teleconnections/enso/indicators/olr

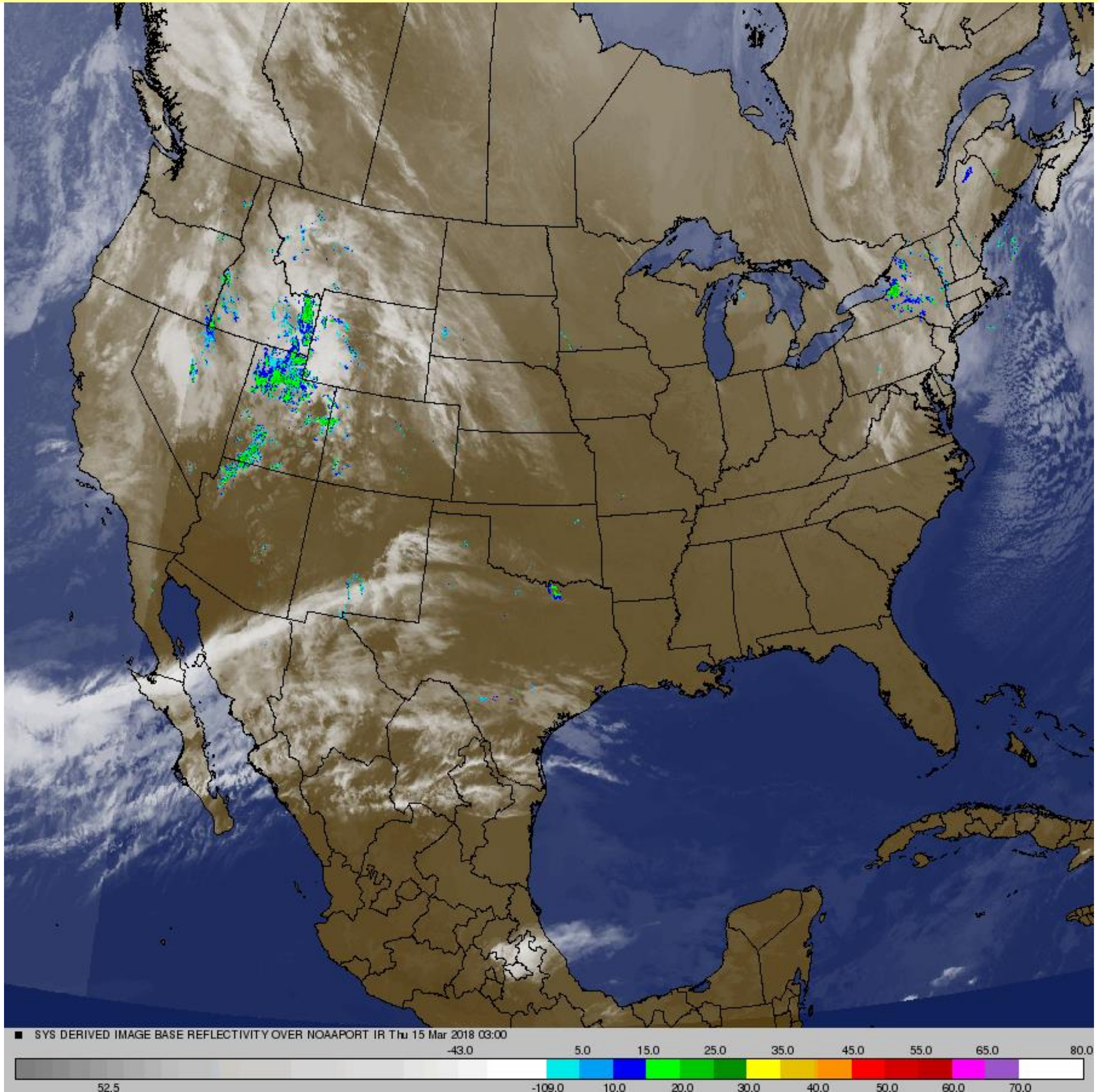
Negative Values of Outgoing Longwave Radiation (Blue colors) indicate enhanced convection, more cloud cover, and less longwave radiation lost to space

Positive Values of Outgoing Longwave Radiation (Red colors) indicate suppressed convection, less cloud cover and more radiation (a lot more) lost to space. (because black body radiation goes T**4)

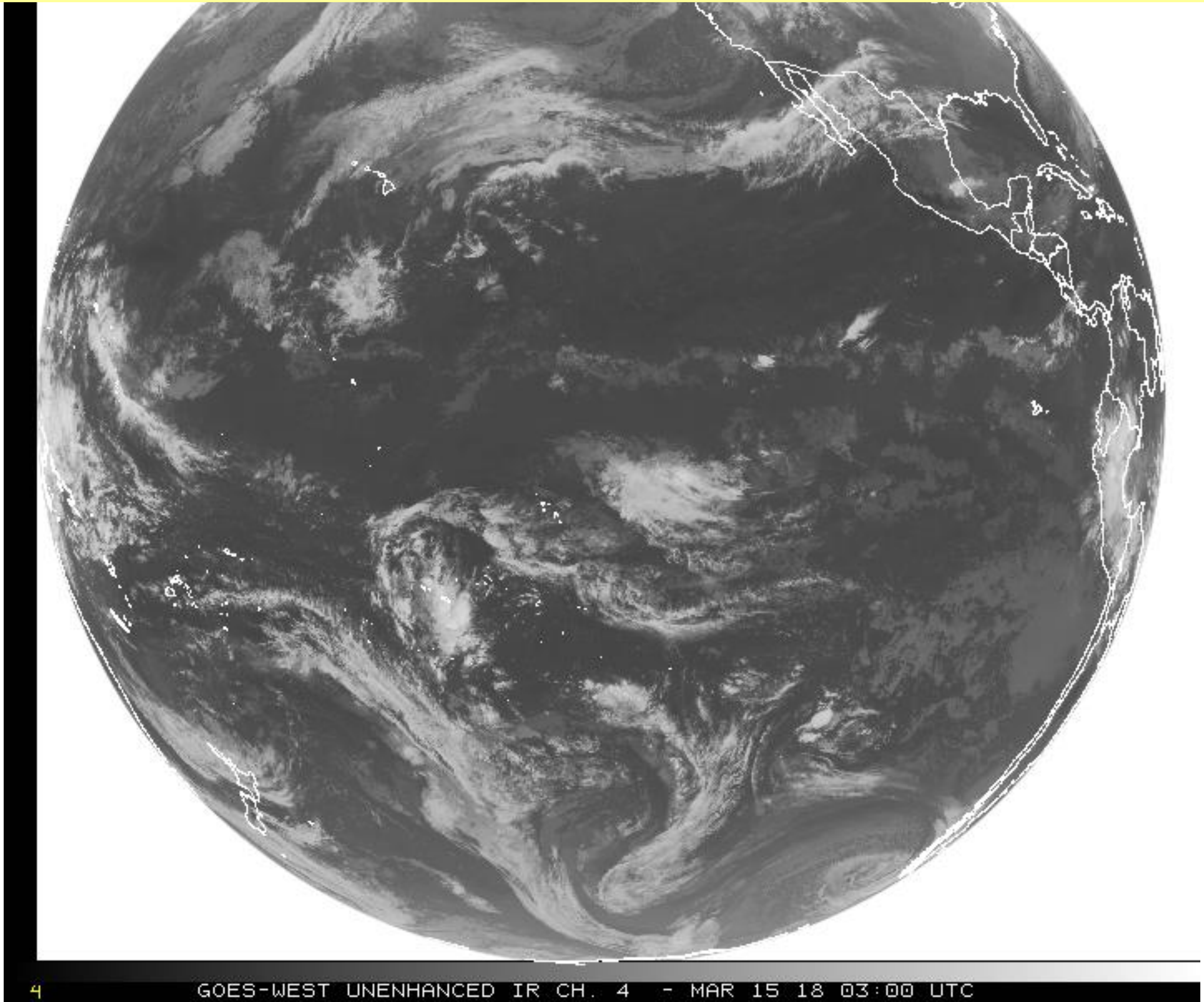


http://wxweb.meteostar.com/models/noaaport_loop.php?PATH=/var/www/leads_images/satellite/SYS/COMP/

15 March 2018/0300Z

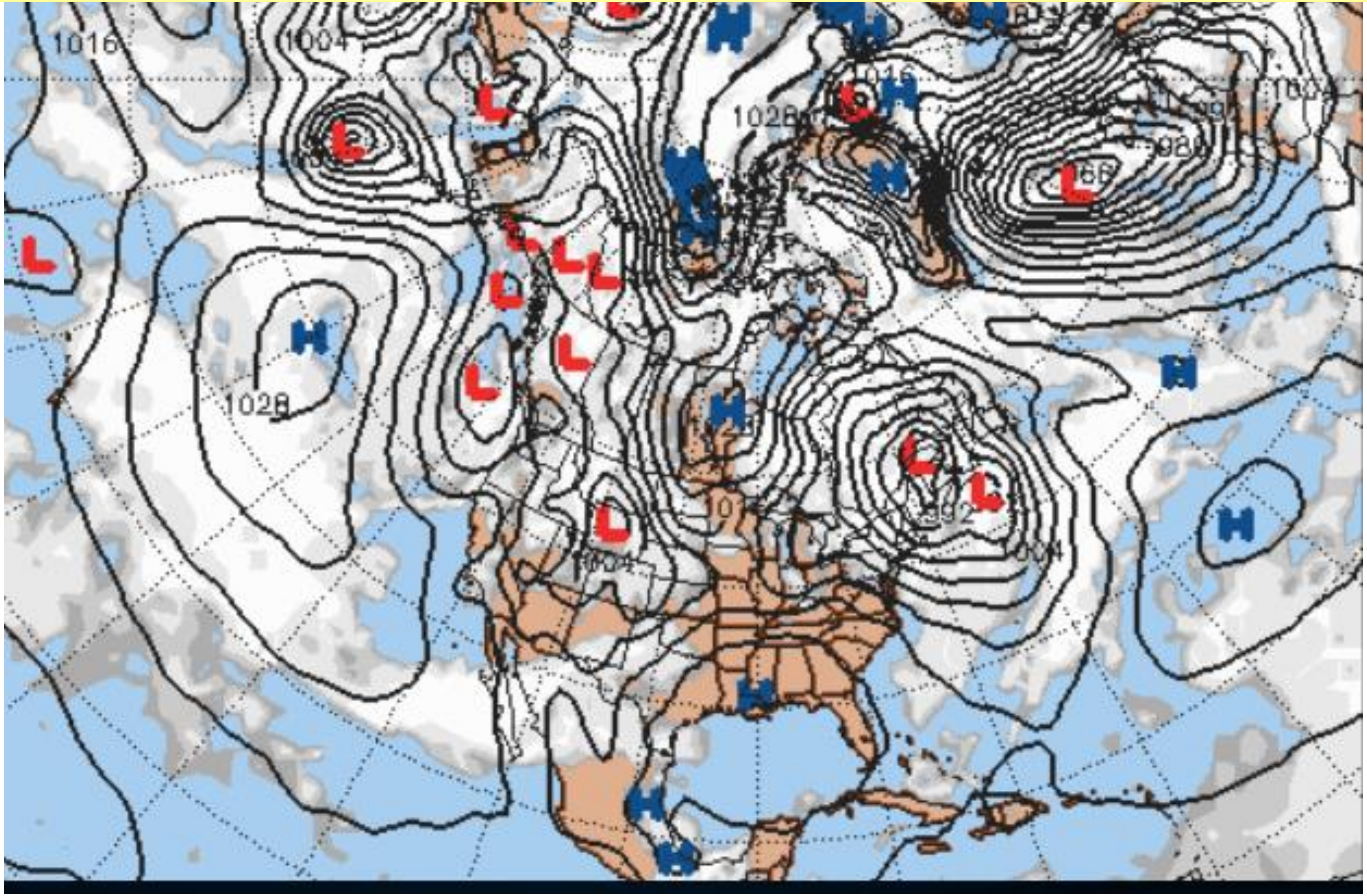


http://www.goes.noaa.gov/dimg/west/fd/ir4/10.gif 15 March 2018 0300Z

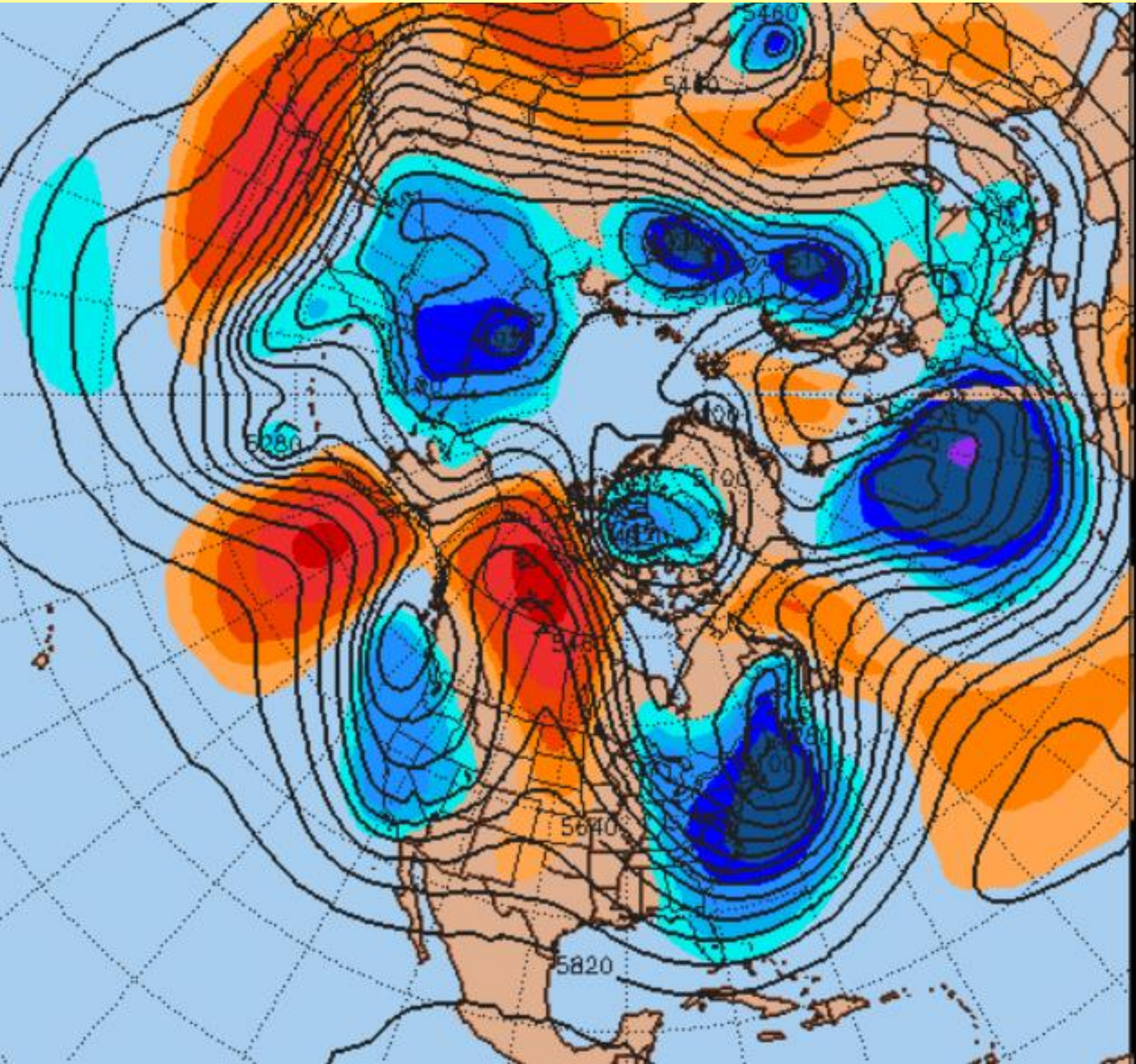


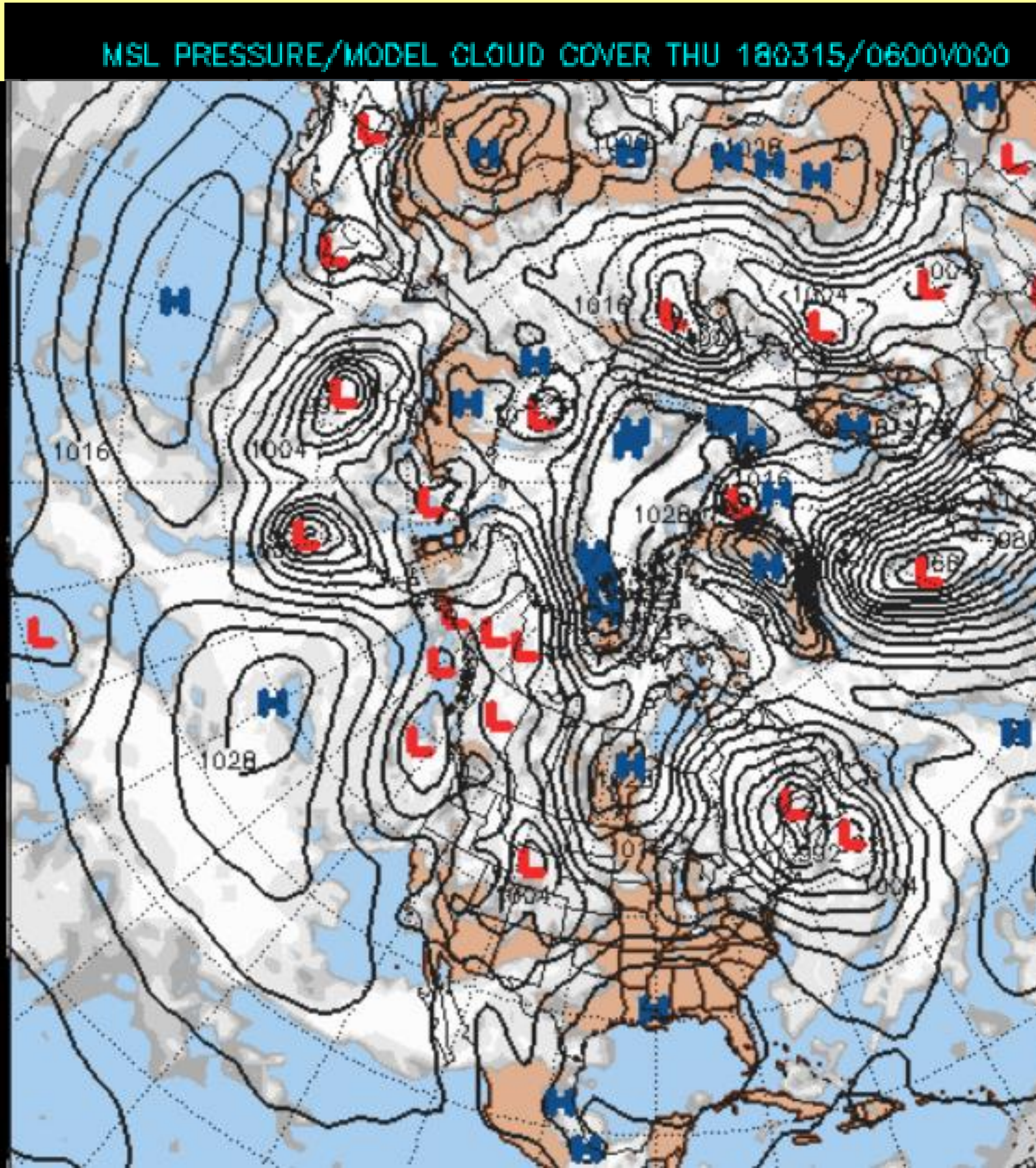
http://mp1.met.psu.edu/~fxg1/HEMI500/5dayloop.html#picture 15 March 2018/0600Z

MSL PRESSURE/MODEL CLOUD COVER THU 180315/0600V000



http://mp1.met.psu.edu/~fxg1/HEMI500/5dayloop.html#picture 15 March 2018/0600Z





https://www.esrl.noaa.gov/psd/map/clim/olr.shtml

U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research

Earth System Research Laboratory
Physical Sciences Division

Physical Sciences Division | About | Contact | Research | Data | Products | News/Events | Learn

Map Room Links

Climate Products

- Sea Surface Temperature (SST)
- Outgoing Longwave Radiation (OLR)
- El Niño/La Niña
- Global Circulation: Means & Anomalies
- Reforecast Products

Weather Products

- Ensemble Forecasts
  - NCEP Operational
  - PSD Experimental
- Forecasts of Teleconnection Indices

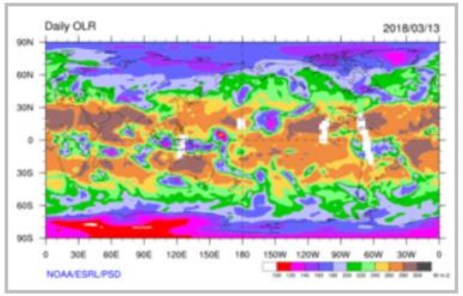
PSD Map Room Climate Products - Outgoing Longwave Radiation (OLR)

Plots created from daily NOAA Daily (non-interpolated) OLR data.

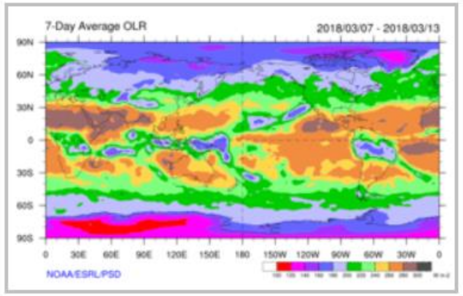
These graphical products are not guaranteed to be updated on a regular basis. They are intended to serve as examples of our ongoing work. You are free to use and distribute these i acknowledge PSD when you do use them. Please read the disclaimer page for additional information, including how to cite this work.

TOTALS

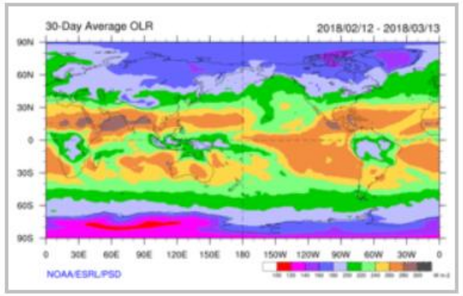
Latest Daily Product



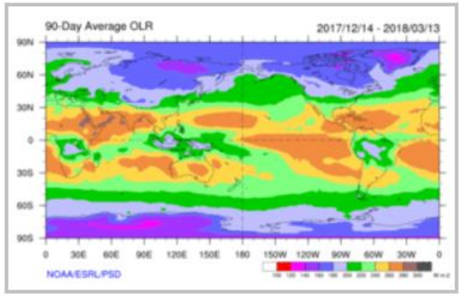
Latest Weekly Product



Latest Monthly Product



Latest Seasonal Product

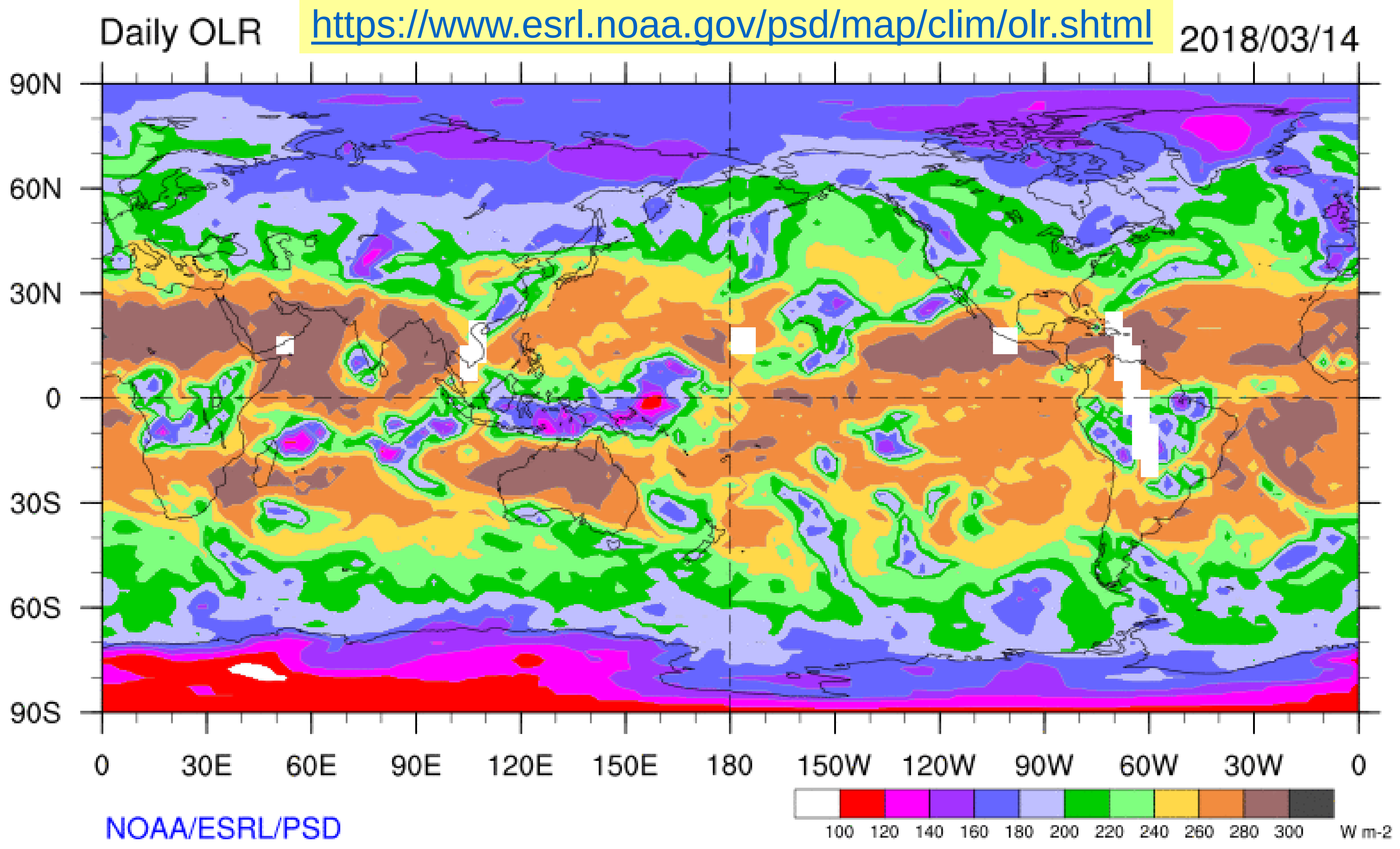


Animations

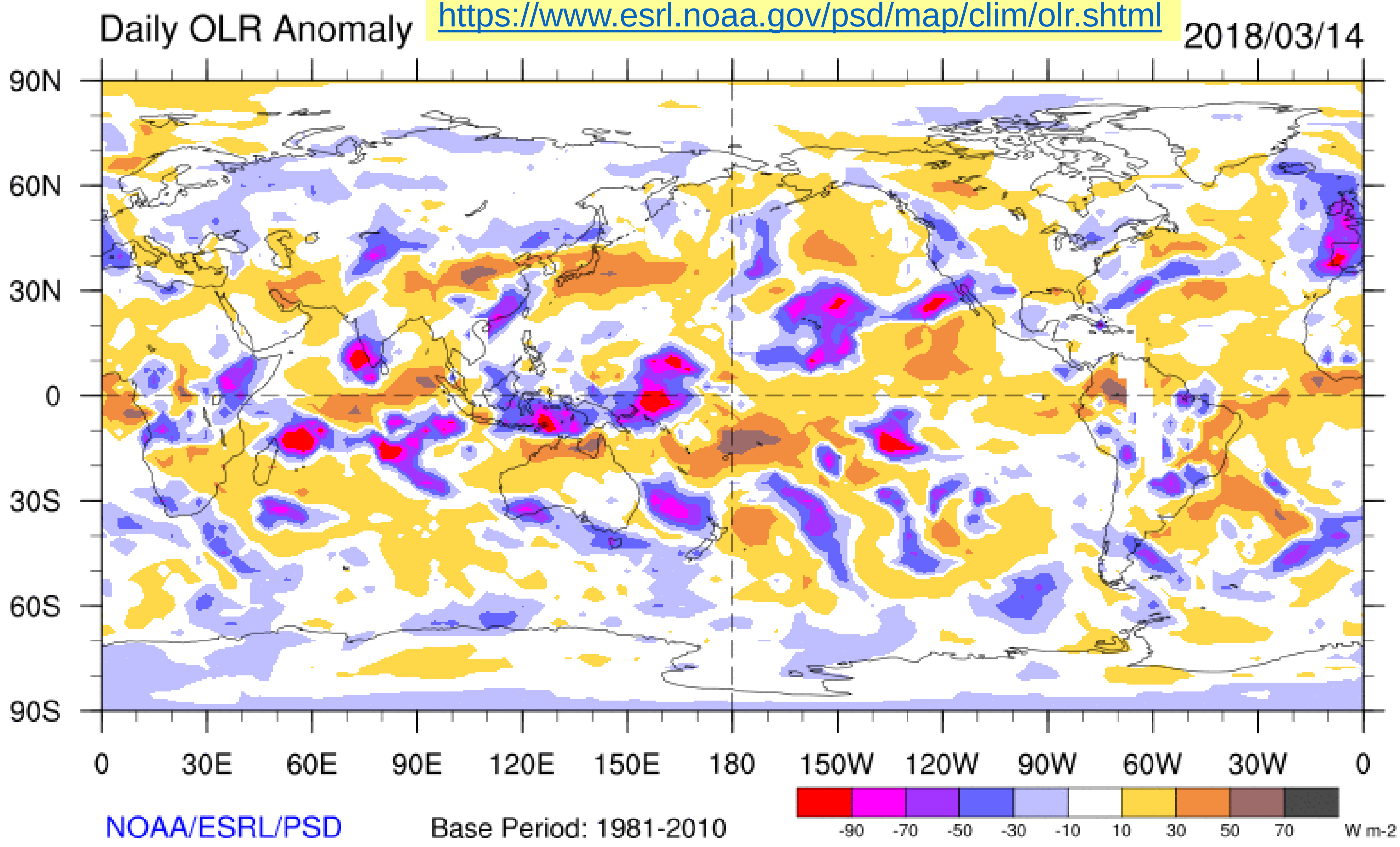
Weekly Loop

Monthly Loop

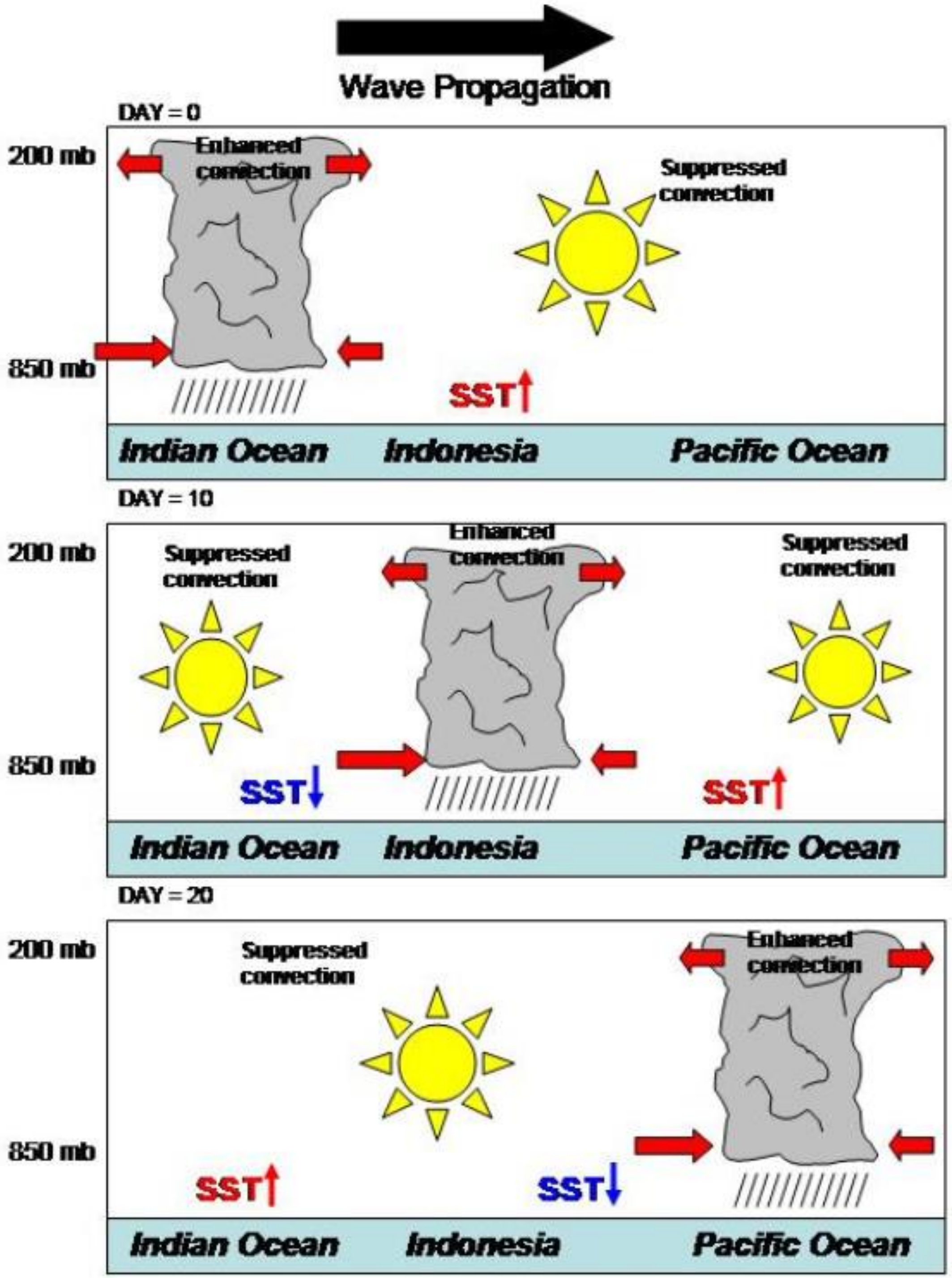
(Updated: Mar 14 12:03 MDT)


Daily OLR
https://www.esrl.noaa.gov/psd/map/clim/olr.shtml
2018/03/14
90N
60N
30N
0
30S
60S
90S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
100
120
140
160
180
200
220
240
260
280
300
W m-2
NOAA/ESRL/PSD

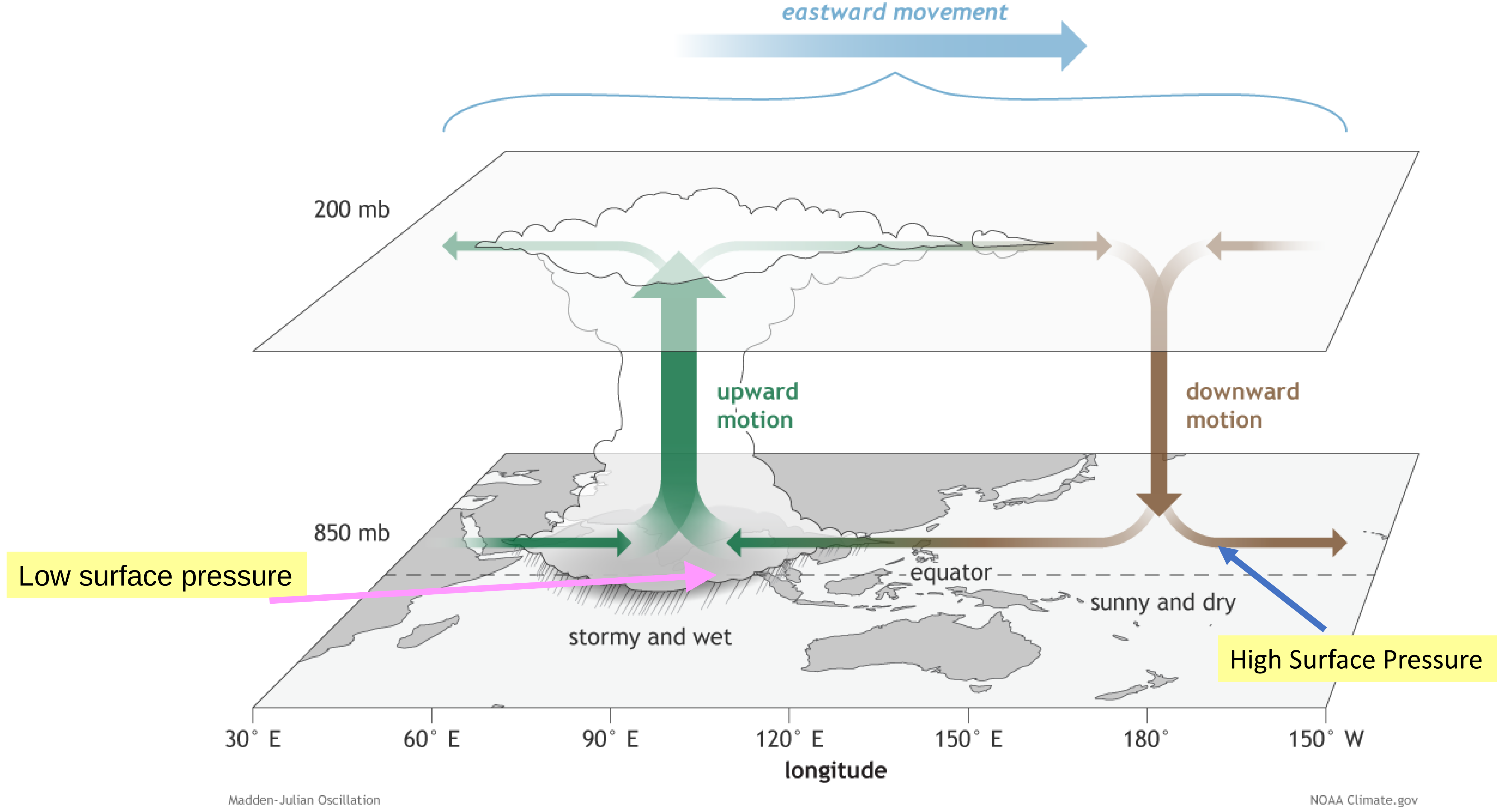
https://www.esrl.noaa.gov/psd/map/clim/olr.shtml



Another schematic of the MJO



http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/MJO_summary.pdf https://www.climate.gov/sites/default/files/MJO_large.png



Why should we care about the Madden-Julian Oscillation?

Effects of the MJO depend on the season when enhanced or suppressed precipitation occur in North America.

If enhanced precipitation occurs during the summer Hurricane Season it can make hurricanes stronger and have heavier precipitation.

If suppressed precipitation occurs during the summer Hurricane Season, it can act to cut off or interrupt otherwise strong Hurricane formation.

The phase difference between the enhanced and suppressed precipitation elements of the MJO is often attributed to when the North Pacific is active, the North Atlantic is not. And conversely.

If suppressed precipitation occurs during the height of the growing season in the Midwest, it could contribute to a “flash drought,” similar to such an occurrence in 2012 in the Southern Plains.

Enhanced precipitation during MJO during winter has caused an increase in frequency and intensity of “Pineapple Express” events along the US West Coast.

MJO has contributed to increased frequency and intensity of cold air outbreaks across the eastern USA.

Timing and climatology of Madden-Julian Oscillation events

MJO tends to be most active during ENSO-neutral years; often absent during moderate-to-strong El Niño and La Niña events.

Typically, northern Hemisphere late fall, winter, and early spring have greatest MJO activity.

MJO impacts are well known, especially in the tropics. Periods when the MJO is active offer opportunities for enhancing weather prediction and decision assistance.

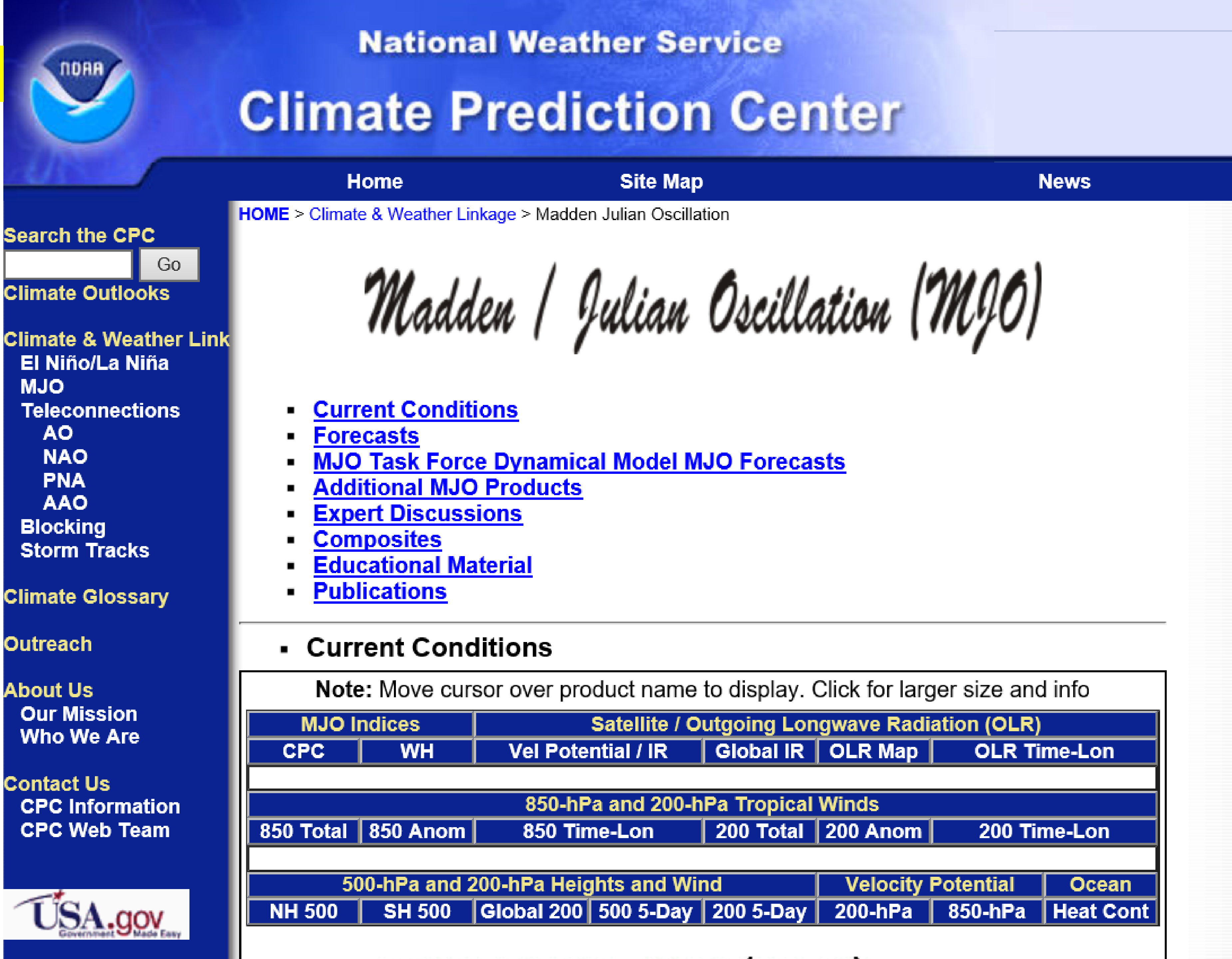
Climate Prediction Center calls the above “climate prediction.”

The MJO can have dramatic impacts in the mid-latitudes.

Several times a year the MJO is a strong contributor to various extreme events in the United States, including Arctic air outbreaks during the winter months across the central and eastern portions of the United States.

MJO Web Page

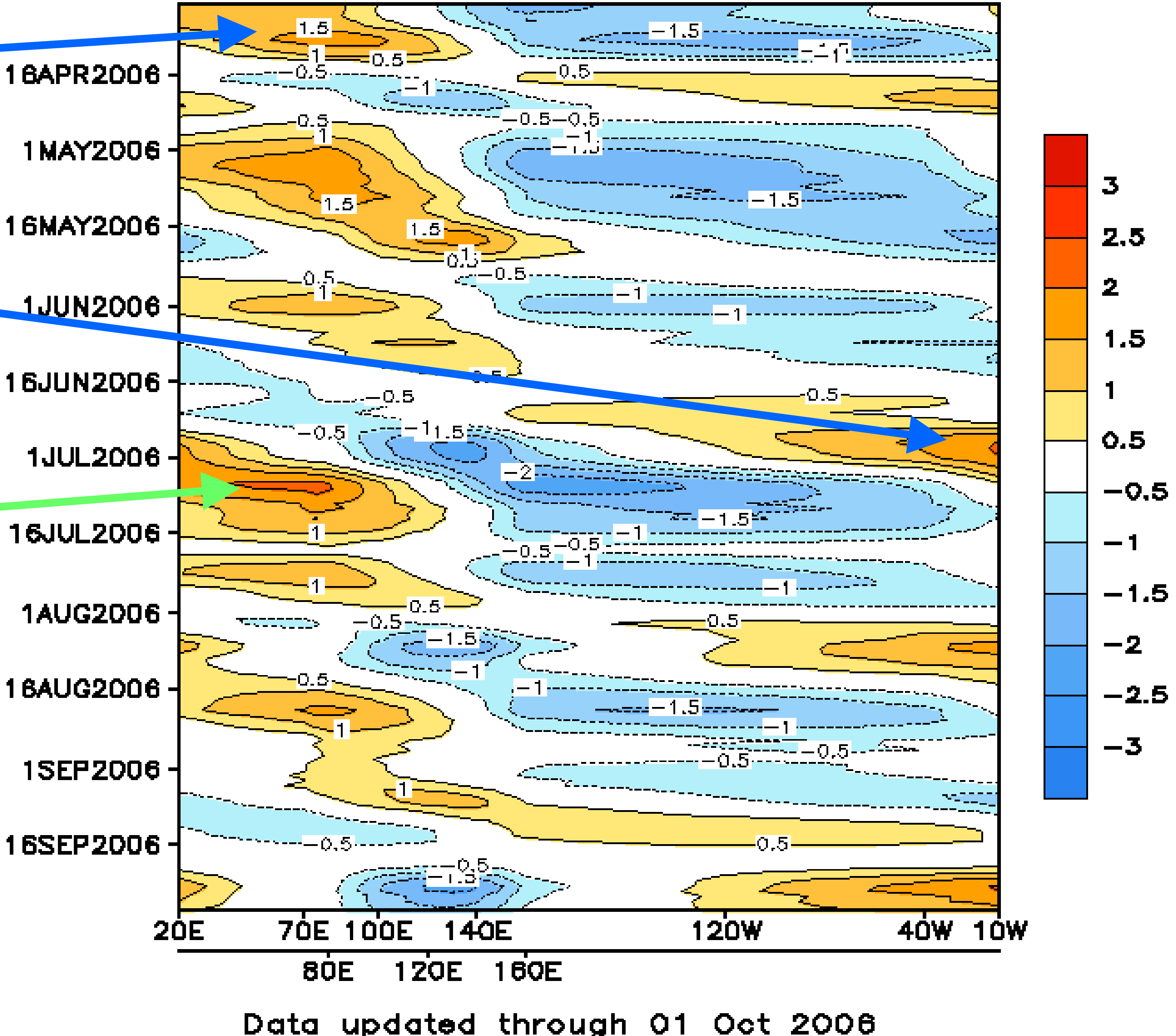
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml



First in sequence, 10 April

Here it is in Africa, early July

Next in sequence, ~90 days later



Arrows point to the suppressed
Convection areas of the MJO
in the OLR Hovmuller diagram.

In this chart, the enhanced
Precipitation areas are
the blue areas, having less OLR.

Gross estimate of travel speed of the MJO system:

Orange shading returns near the same location ~ 90 days.

Conversion to traveling speed:

This means 360 degrees of travel in 90 days

360/90 = 4 = 4 degrees/day

4*60 = 240 nautical miles/day

240 n miles/24 hours

= 10 knots

Sidebar: The Maritime Continent

http://www.bom.gov.au/climate/about/tropics/maritime-continent.png

This region is noted for the notable interactions between the mountainous terrain and shallow seas

http://www.bom.gov.au/climate/about/tropics/maritime-continent.shtml

Climate

Outlooks

- Rainfall & temperature outlooks
- Outlook video
- El Niño / La Niña
- Streamflow outlooks
- **Tropical monitoring**
- Tropical cyclone outlook

Bureau home > Climate > Tropical monitoring > About the Maritime Continent

About the Maritime Continent

The **Maritime Continent** is a term commonly used by meteorologists, climatologists, and oceanographers to describe the region between the Indian and Pacific Oceans including the archipelagos of Indonesia, Borneo, New Guinea, the Philippine Islands, the Malay Peninsula, and the surrounding seas. The region is made up of thousands of islands of various sizes, mountainous terrain, and many shallow seas. The terms *maritime* and *continent* are usually used to describe two opposite climate types. However together, they are used to describe the extensive interaction between ocean and land occurring across the Maritime Continent region.

Click image for larger view. Darker areas show Maritime Continent.

The Maritime Continent is a significant feature in the Earth's climate system. As easterly trade winds along the equator blow along the ocean surface it creates a build-up of warm ocean waters in the western Pacific and among the shallow seas of the Maritime Continent. This region, known as the Indo-Pacific warm pool, persistently has sea surface temperatures (SSTs) higher than about 28°C and is often the warmest ocean region in the world

https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

This, and the following graphic, is a “classic definition” of the different phases of the MJO

Greens and Blues show precipitation anomalies, Browns, precipitation deficits

East Indian Ocean

West Maritime Continent

East Maritime Continent

West Pacific Ocean

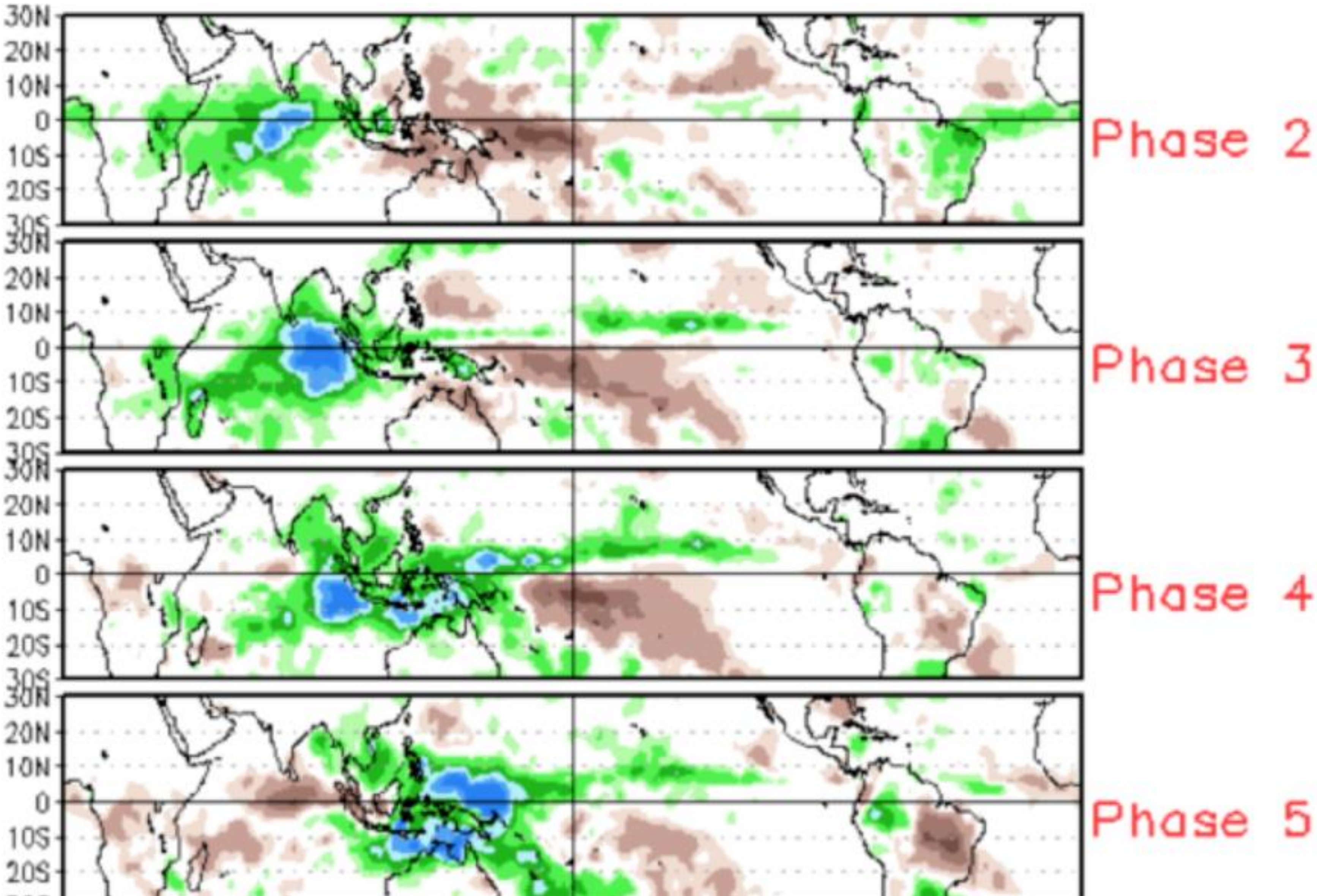


Figure 1: Difference from average rainfall for all MJO events from 1979-2012 for November-March for the eight phases described in the text. The green shading denotes above-average rainfall, and the brown shading shows below-average rainfall. To first order, the green shading areas correspond to the extent of the enhanced convective phase of the MJO and the brown shading areas correspond to the extent of the suppressed convective phase of the MJO. Note eastward shifting of shaded areas with each successive numbered phase as you view the figure from top to bottom.

https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

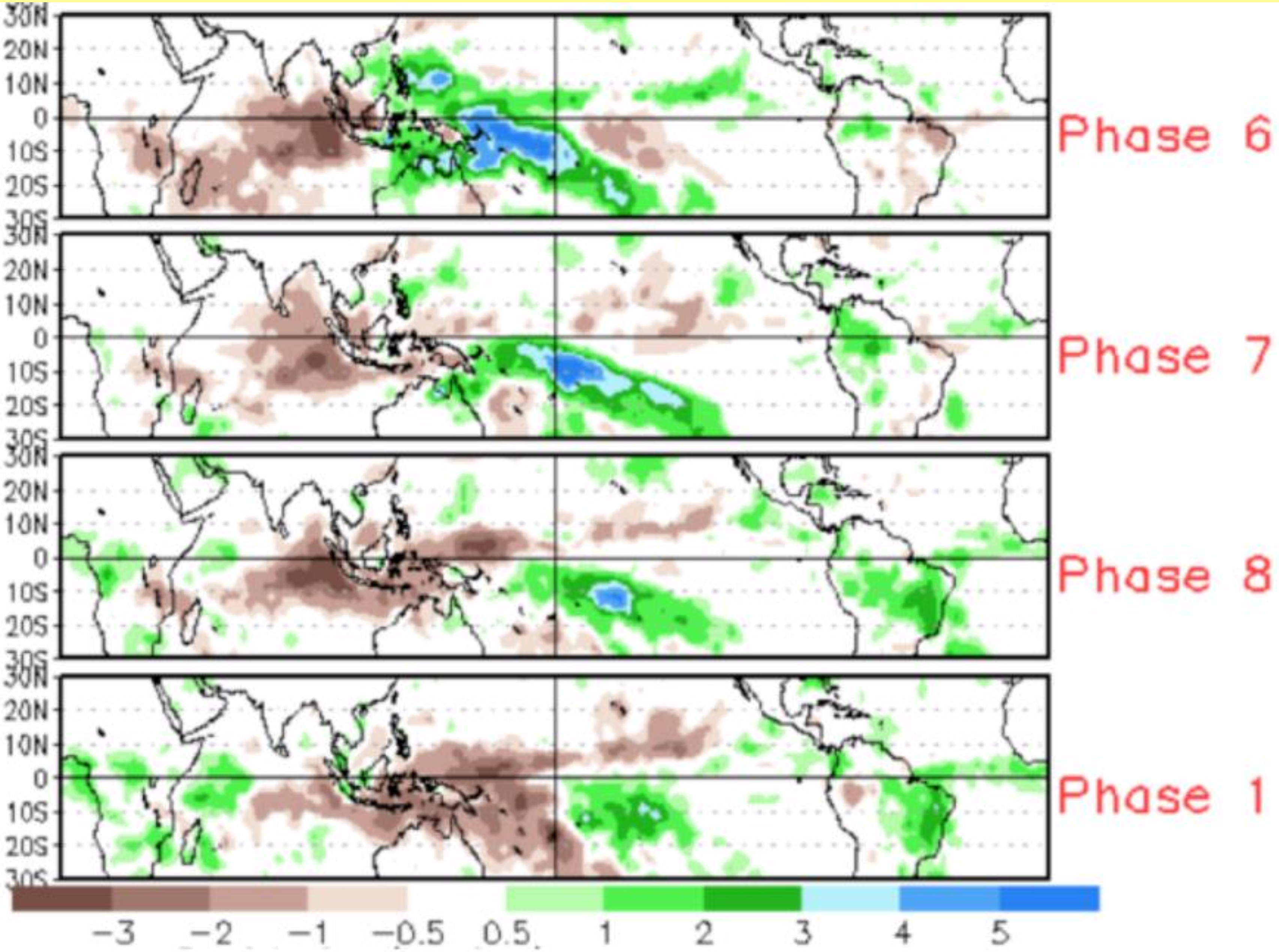
continues the “classic definition” of the different phases of the MJO

Central Pacific Ocean

East Pacific Ocean

Western Hemisphere

East Indian Ocean



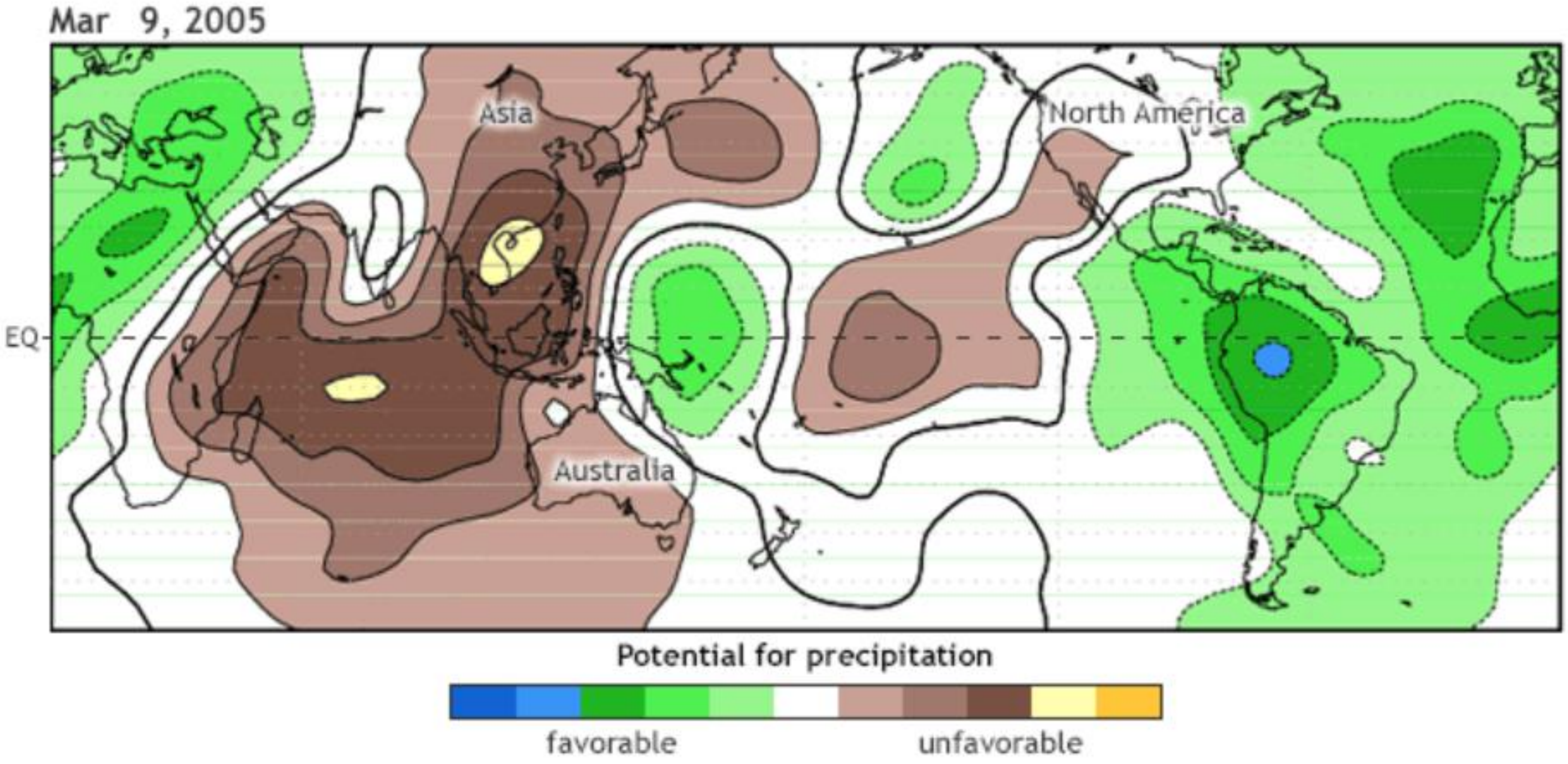
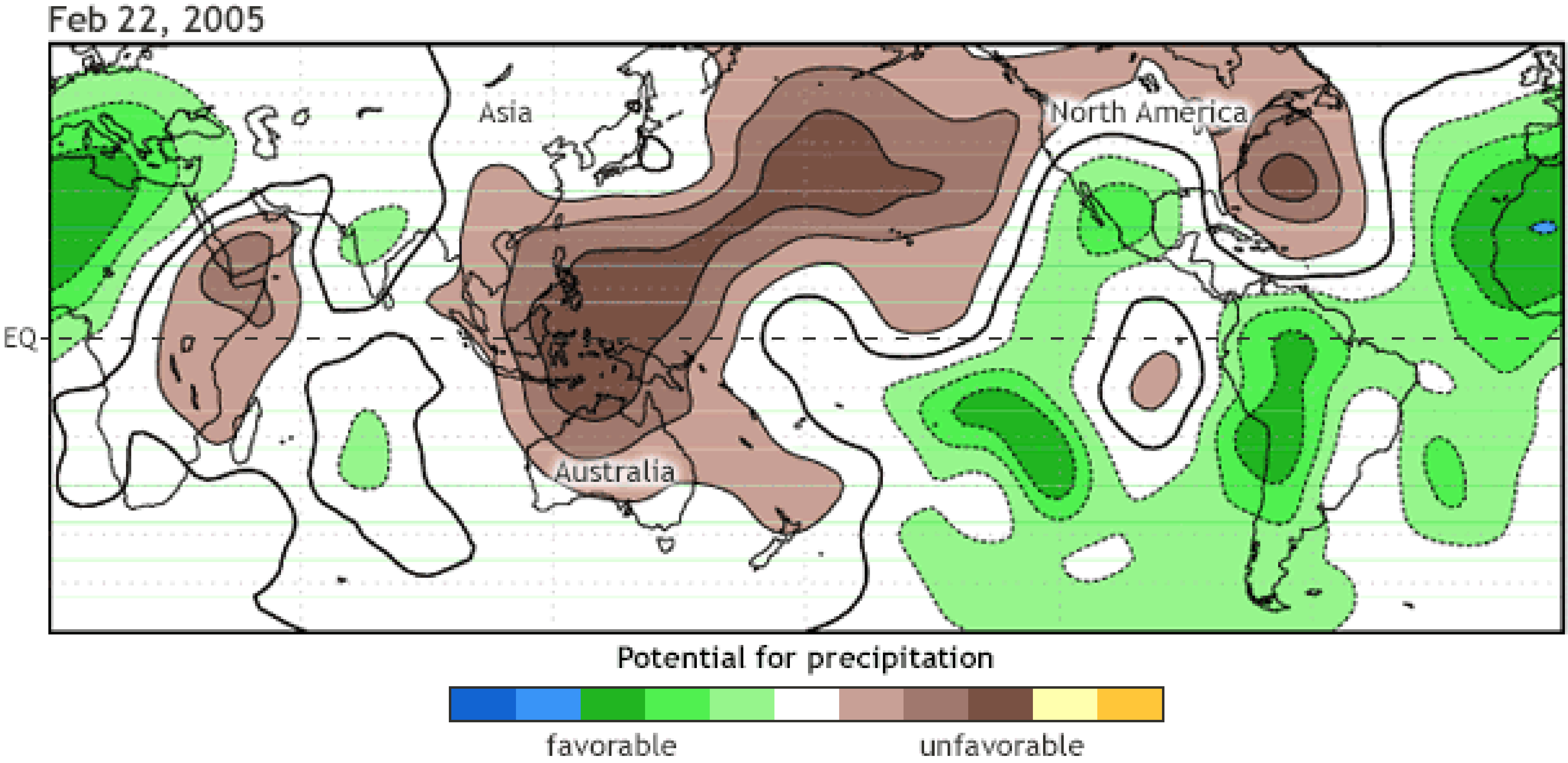


Figure 2. An animation illustrating the organization of the MJO into its enhanced and suppressed convective phases during an MJO event during the spring of 2005. The green shading denotes conditions favorable for large-scale enhanced rainfall, and the brown shading shows conditions unfavorable for rainfall. The MJO becomes organized during late March through May as the green shading covers one half of the planet, and brown shades the other half all along as these areas move west to east with time. Notice how the shading returns to the same location on the order of about 45 days.

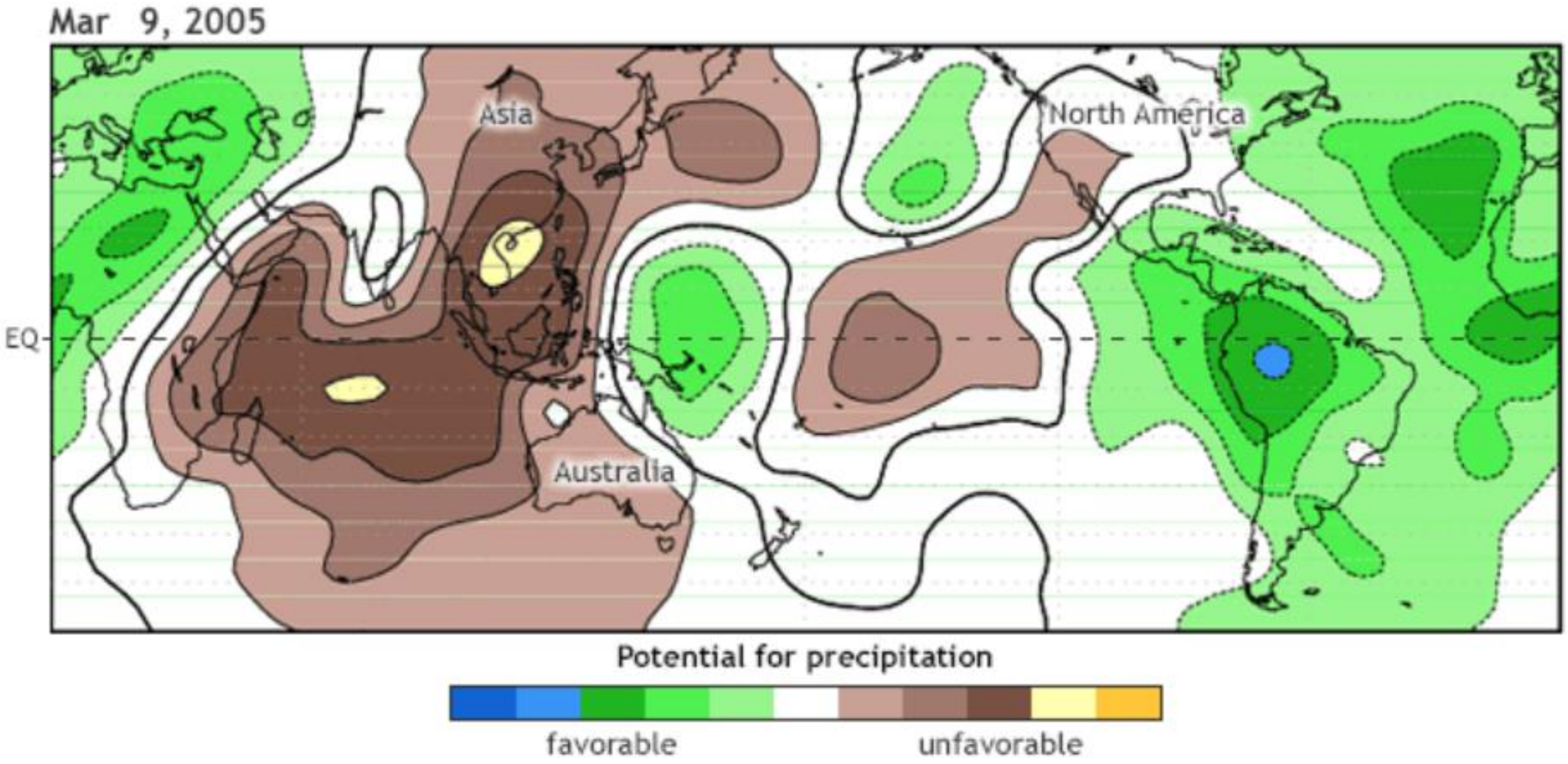
Next Graphic is an animated GIF of the sequence


Feb 22, 2005
Asia
North America
Australia
EQ
Potential for precipitation
favorable
unfavorable

Next graphics show the **geographic spread:**

from the **enhanced area** of precipitation to the **suppressed area** of precipitation

based on estimates from selected maps in the loop sequence.



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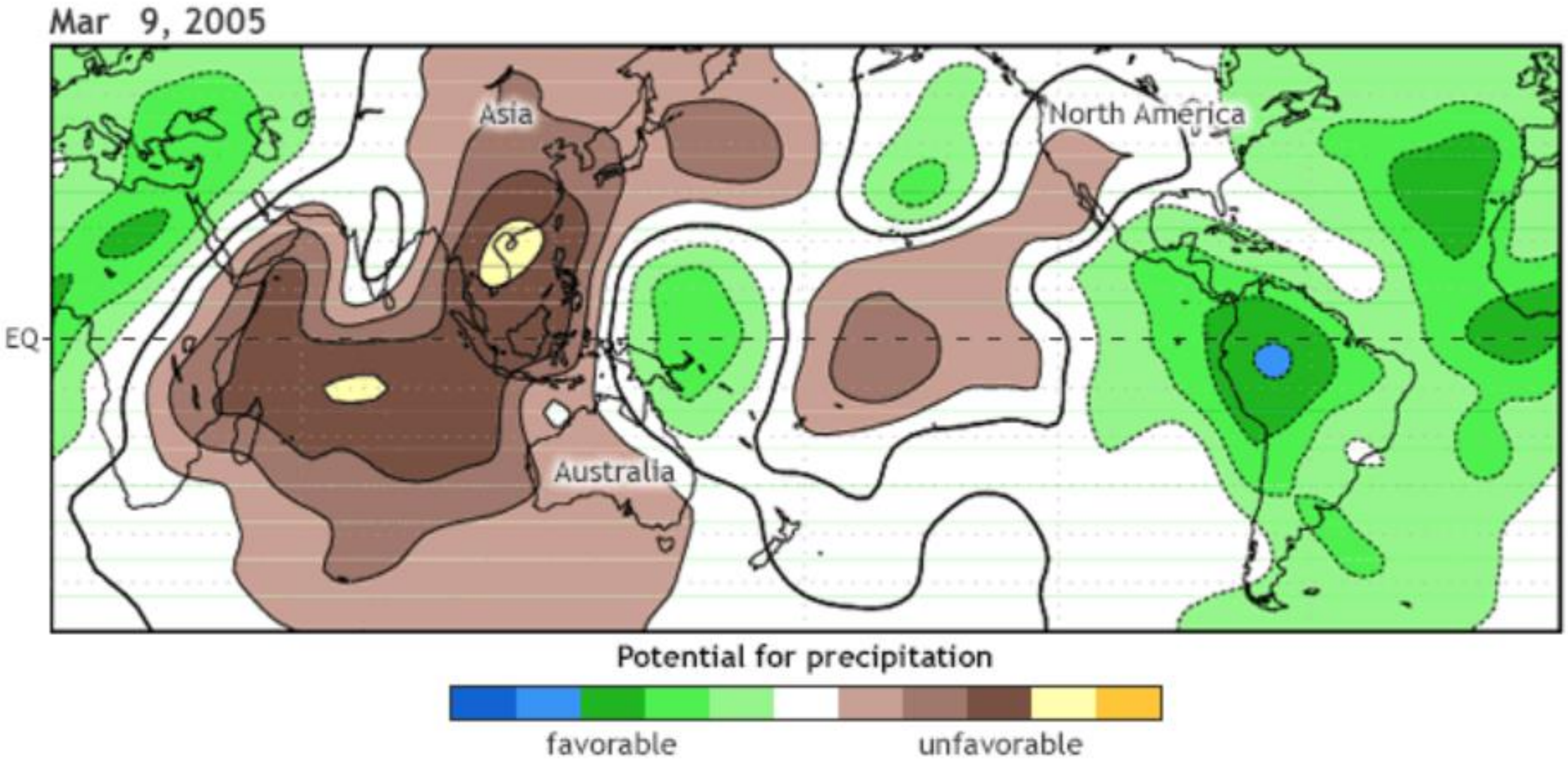
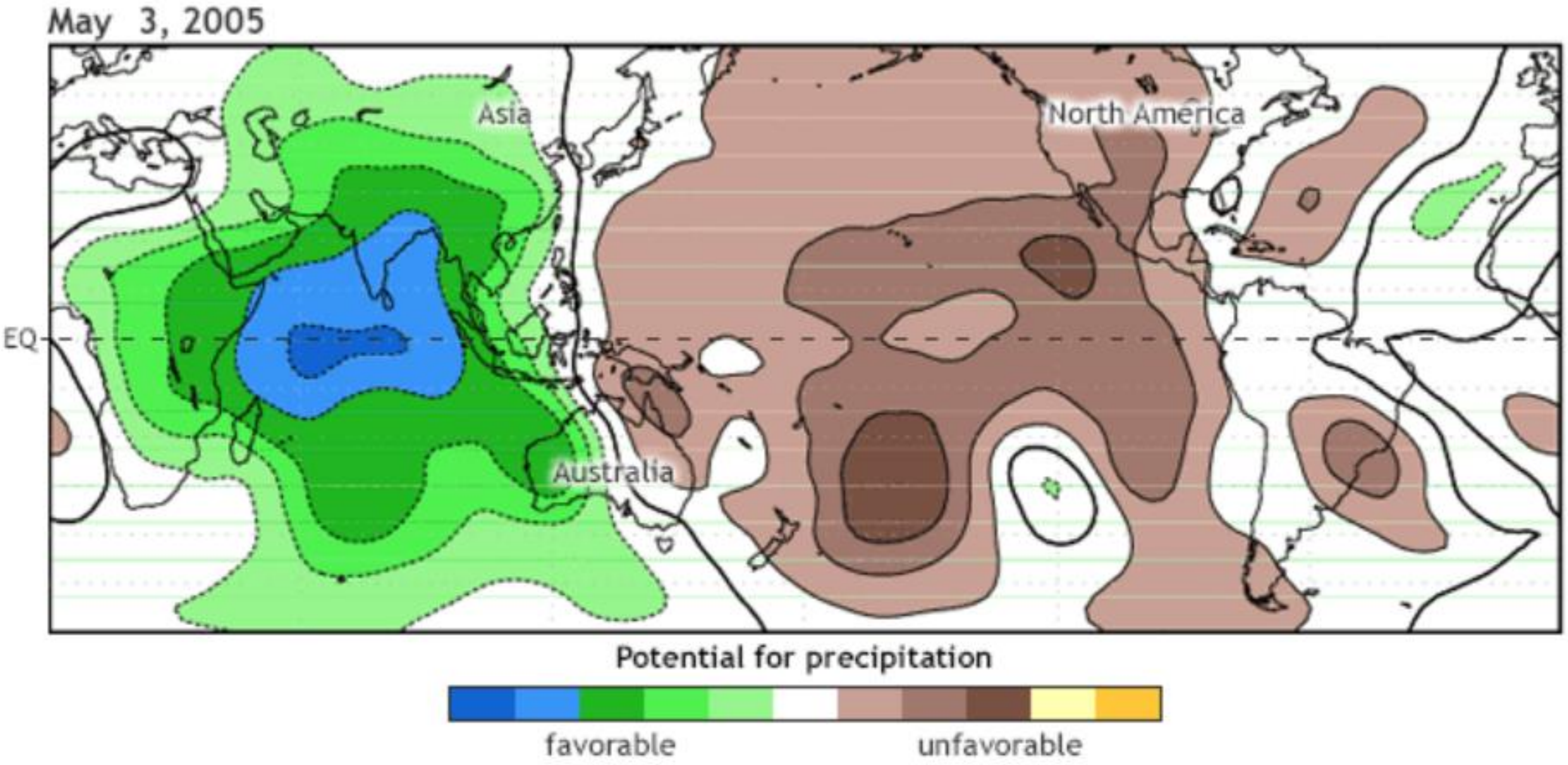


March 9th geographic spread

DaNang, Vietnam to W. Brazil
110 + 70 = 180

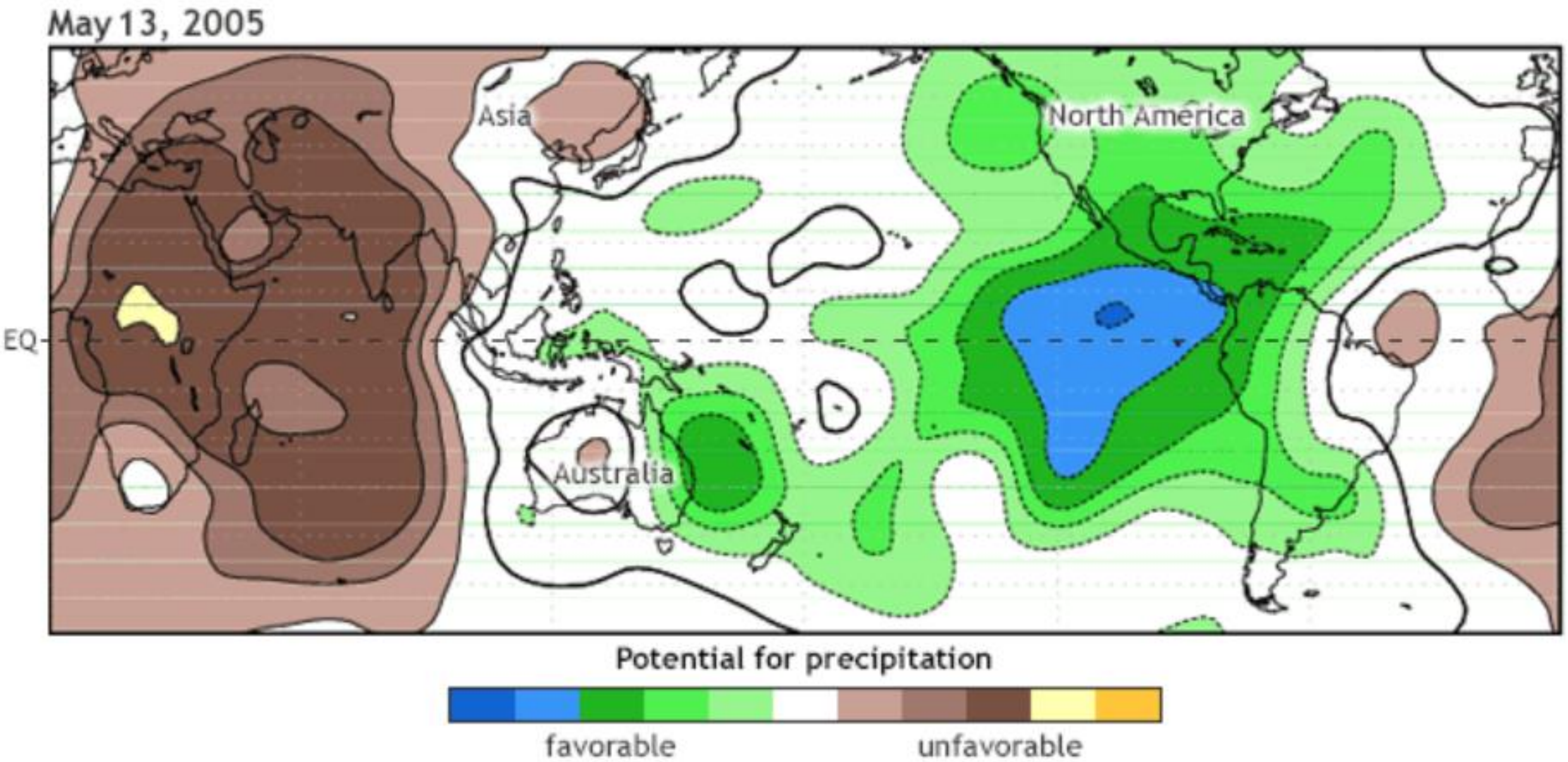
180/360 = .5   Halfway around the Earth



3 May geographic spread:

India to latitude of Kauai Island, HI
75 to 180E + 180W to 160W = 105+20 = 125

125/360 = .34 1/3d of Earth's Circumference

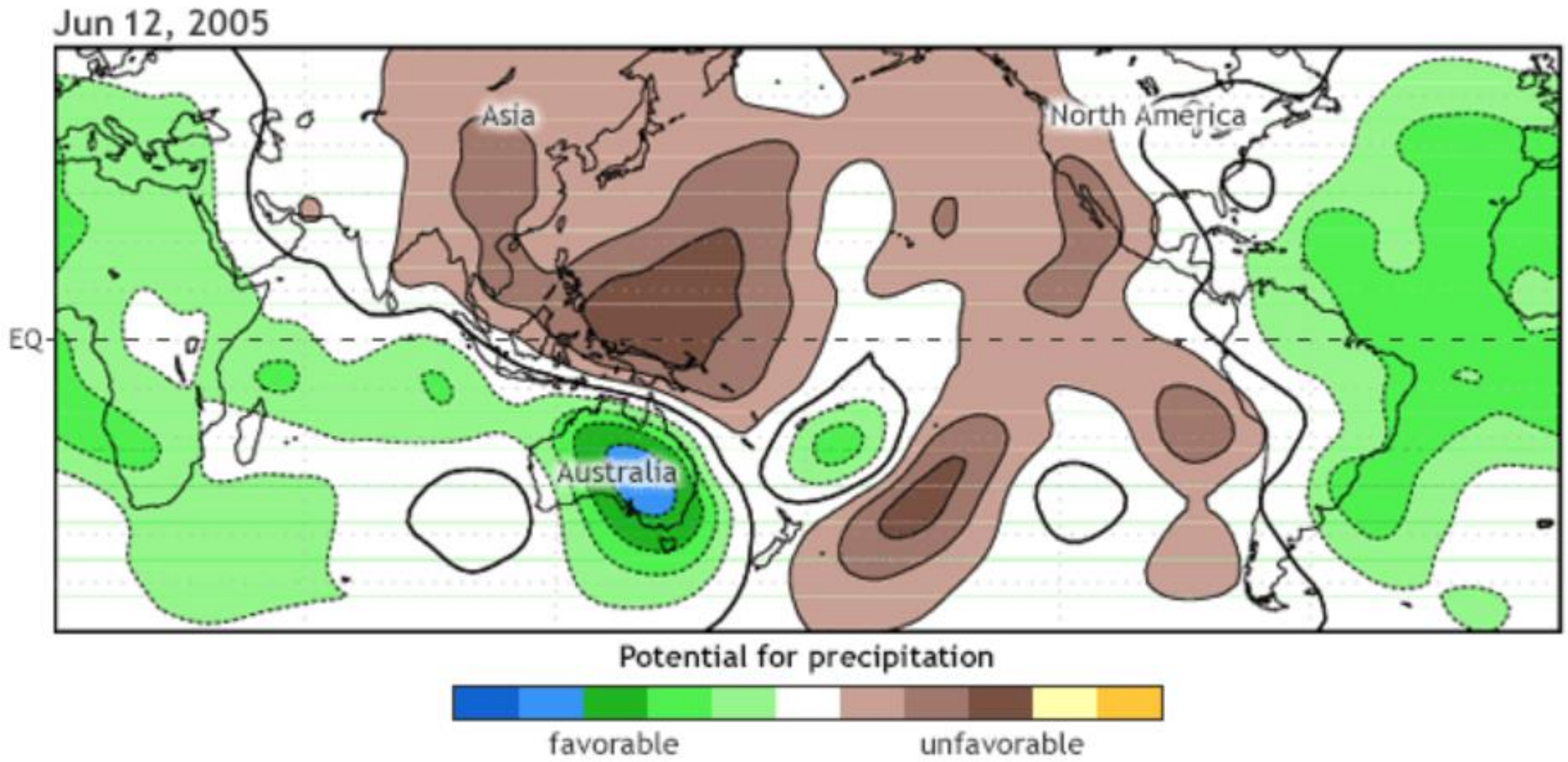


13 May geographic spread

Central Africa to W. Mexico

105W + 15 = 120

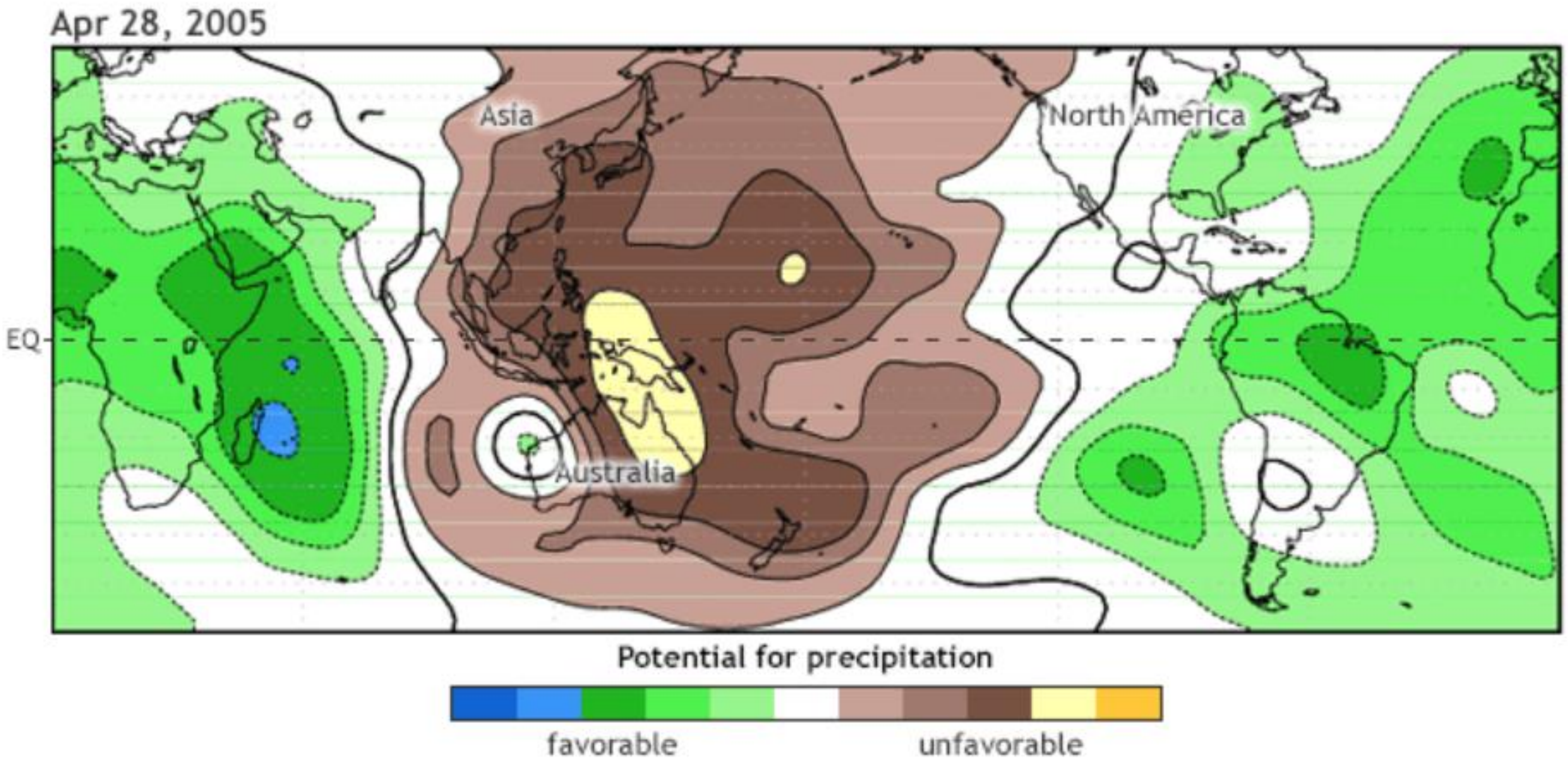
120/360 = .33 1/3 of Earth's Circumference



12 June geographic spread:

Guam to West Africa* <* Australia - Guam Dipole>

145+15 = 160 160/360 = .44* 44% of Earth's Circumference



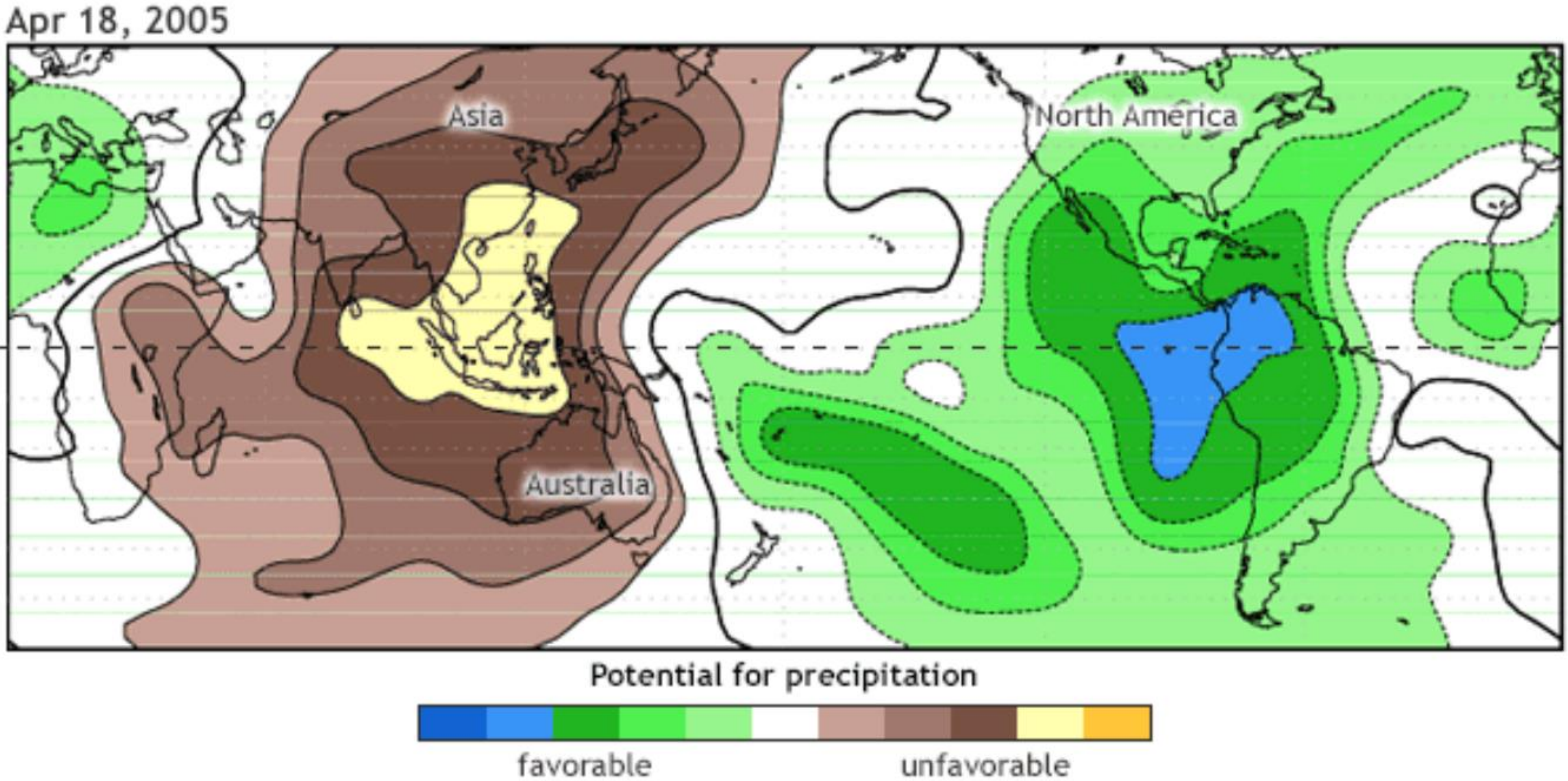
28 April Two Geographic Spreads

Queensland to Madagascar
50 to 140 = 90   90/360 = .25

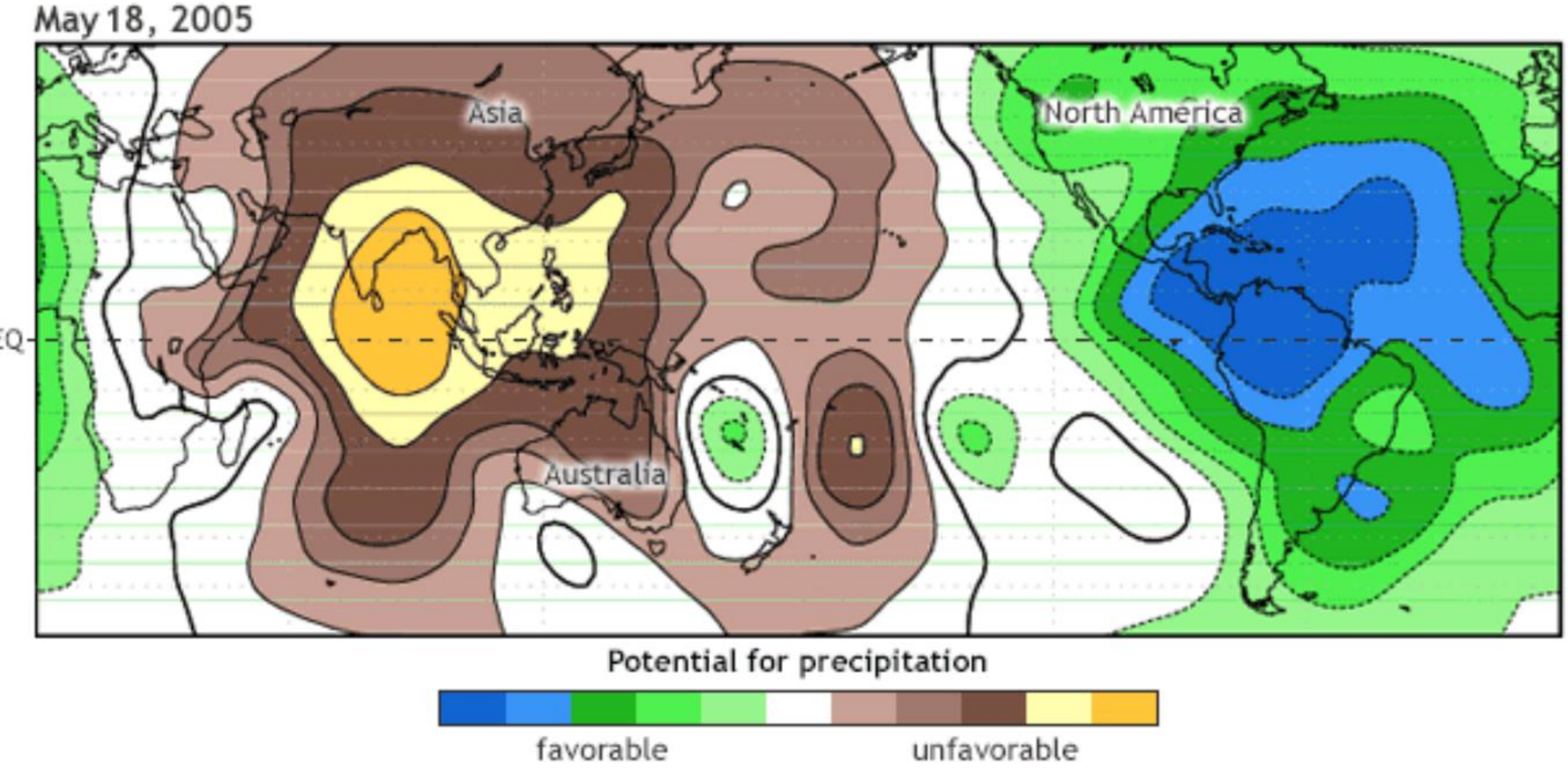
ALSO: Queensland to Guyana
40 + 140 = 180   180/360= .5

Significant impacts from the animated GIF file.

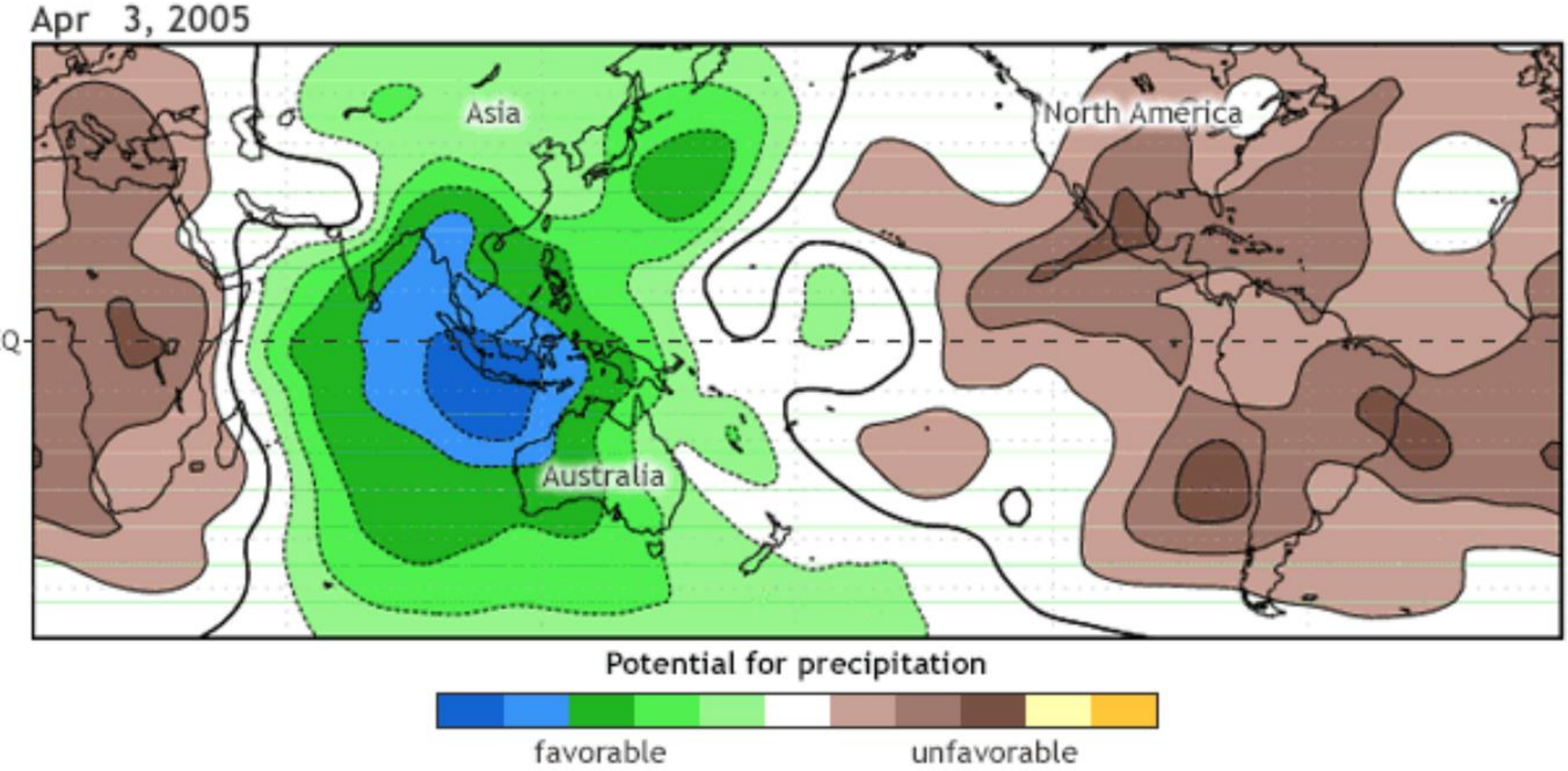
Enhanced precipitation for much of the Western Hemisphere, including the southwest states, but suppressed precipitation for all of East Asia and Australia.



This huge Western Hemisphere area of enhanced precipitation occurred just before 2005's Atlantic Hurricane Season. Four hurricanes pounded Florida in 2005; Katrina and Rita both hit Louisiana after hitting Florida.

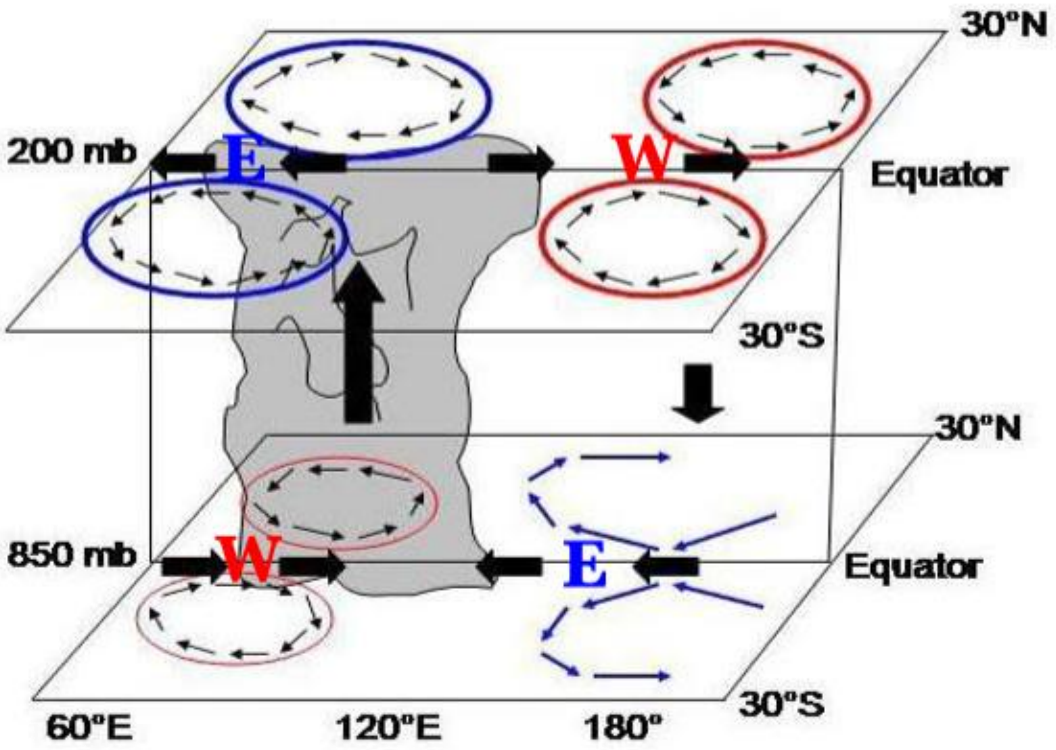


If an area of suppressed precipitation similar to this in North America occurred in mid-summer, it could seriously cut down on corn-belt crop harvest, and cause an important pause in the North American Monsoon in Arizona and New Mexico. Similar effects on South America, Africa and Europe.



http://www.atmos.albany.edu/daes/atmclasses/atm421/Handouts_files/MJO.pdf

Schematic of MJO structure

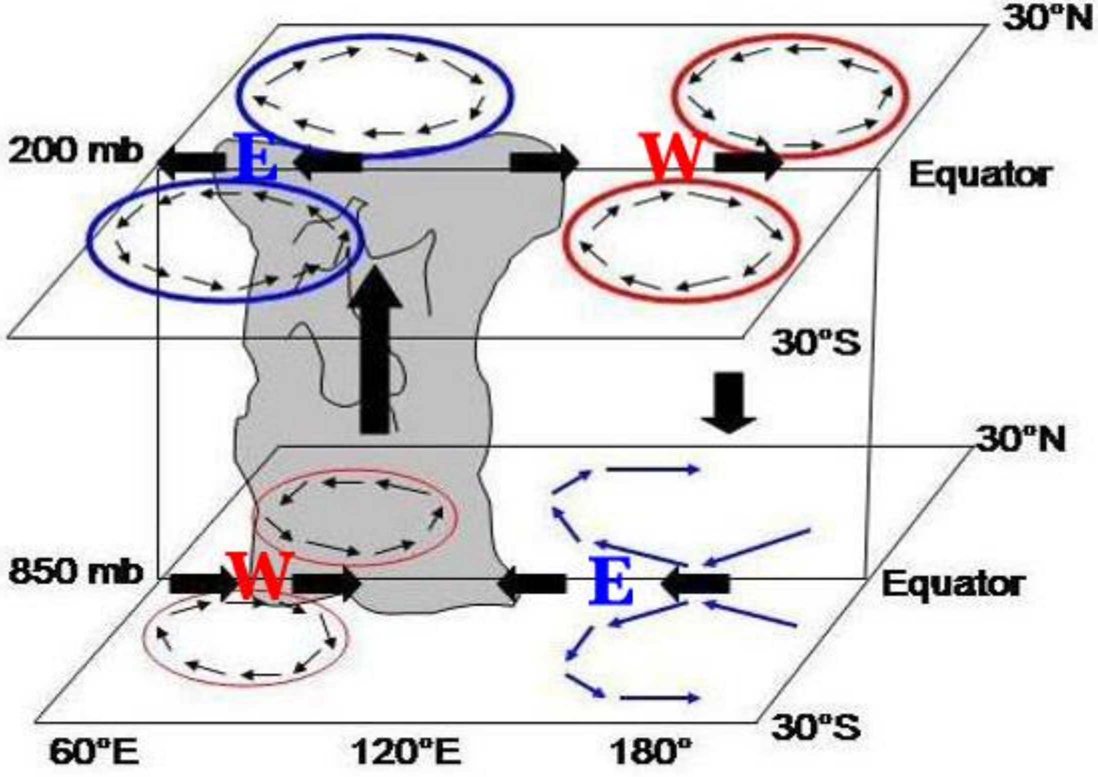


As the convection approaches, easterly (westerly) trade winds are enhanced at the Equator at low levels (aloft).

This enhanced flow creates counter-rotating vortices to the north and south = shear vorticity!

http://www.atmos.albany.edu/daes/atmclasses/atm421/Handouts_files/MJO.pdf

Schematic of MJO structure

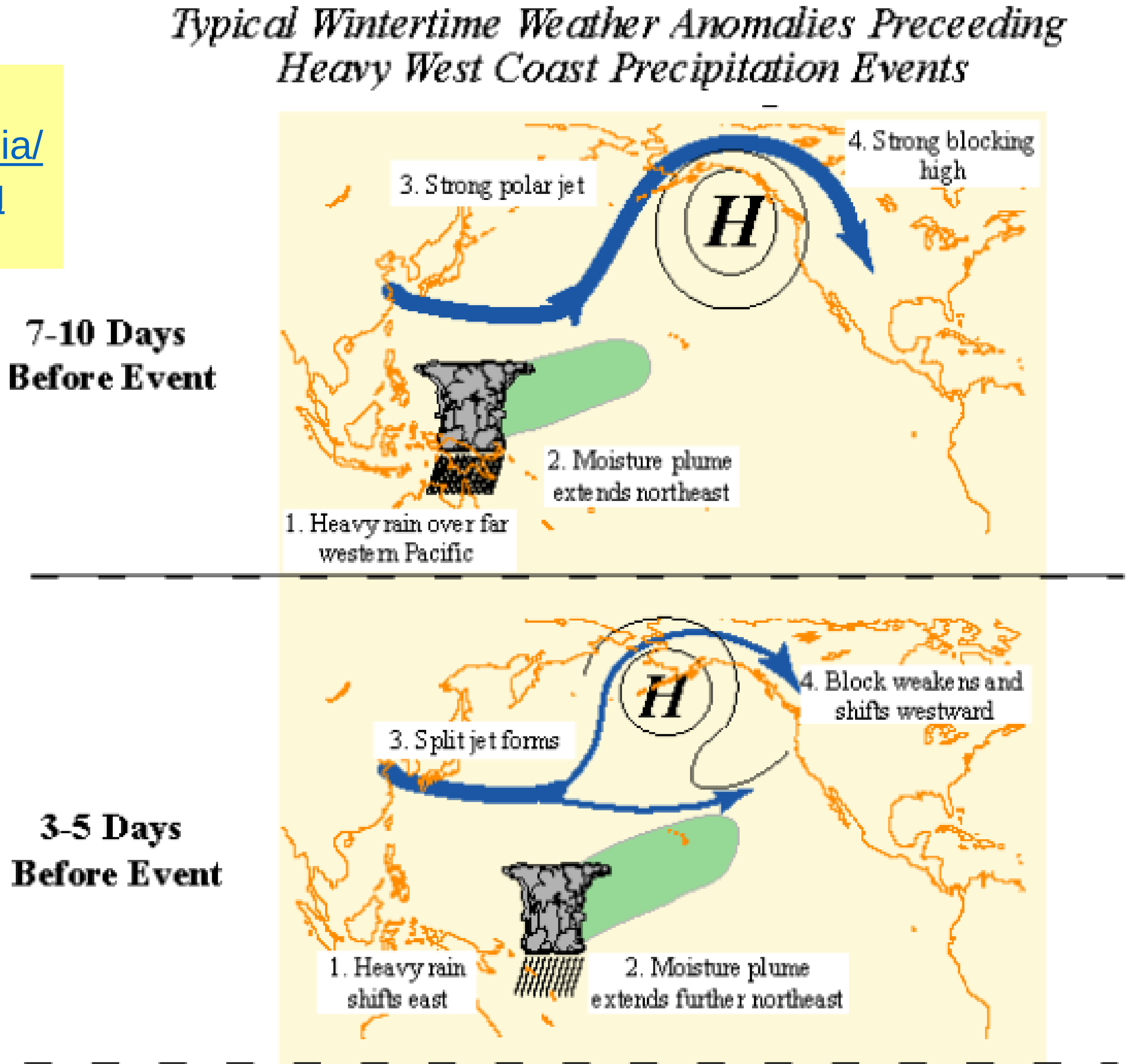


Associated with, and behind the convection, are strong westerly (easterly) winds at low levels (aloft).

Twin cyclones @ low levels   Anticyclones @ upper levels

https://en.wikipedia.org/wiki/Madden–Julian_oscillation#/media/File:Mjo_north_america_rain.png

Sequence of events before the Onset of a
“Pineapple Express” Event



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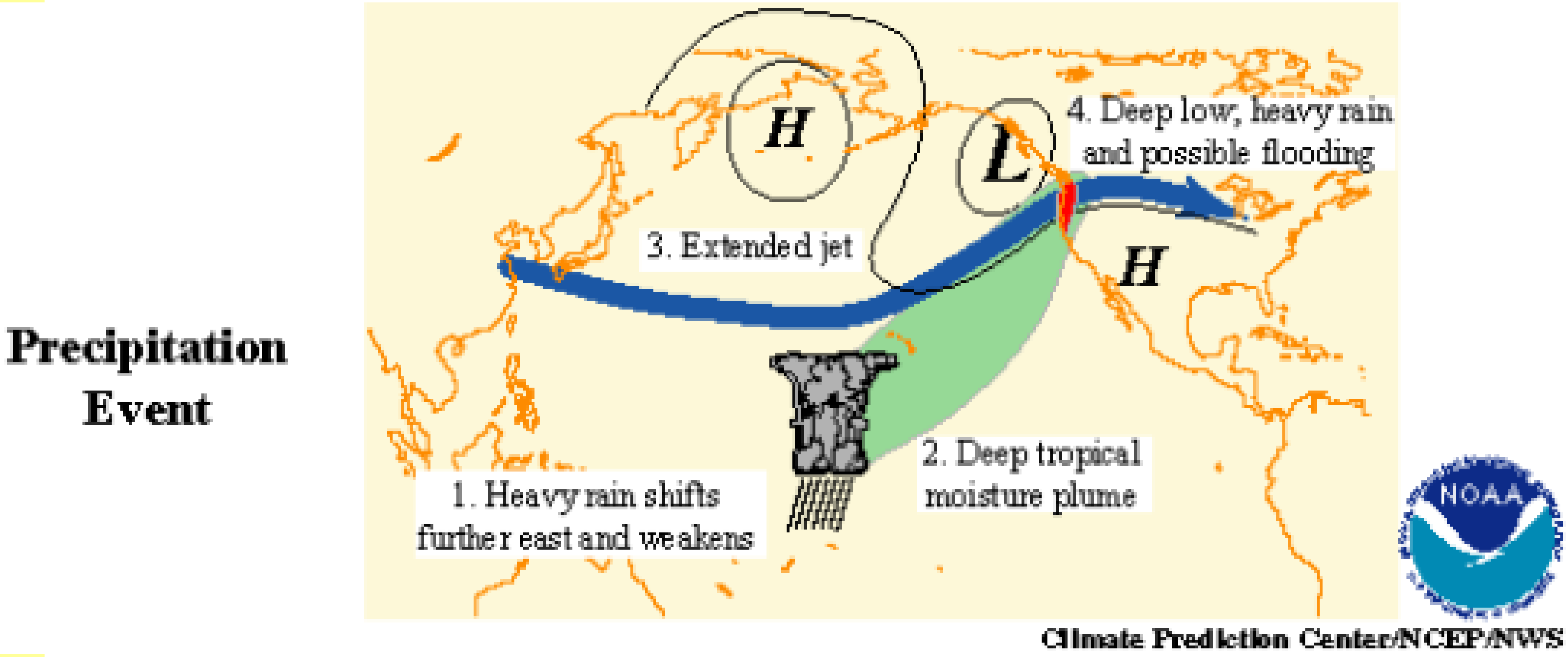


Onset of a "Pineapple Express" Event

Gulf of Alaska Low

Jet Stream-enhanced "River of Moisture" from Hawaii to the West Coast

The Madden-Julian Oscillation in charts from NOAA’s Climate Prediction Center

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/MJO_summary.pdf

THREE elements <1979-2004> for the eight ‘standard’ phases of MJO moving from west to east.

The three elements

- Sea Level Pressure
- Precipitation
- Outgoing Longwave Radiation

Charts show:

Sea Level Pressure vs Precipitation and Outgoing Longwave Radiation vs Precipitation.

Two separate time phases:

November-March (Southern Hemisphere Summer) and

May-September (Northern Hemisphere Summer)

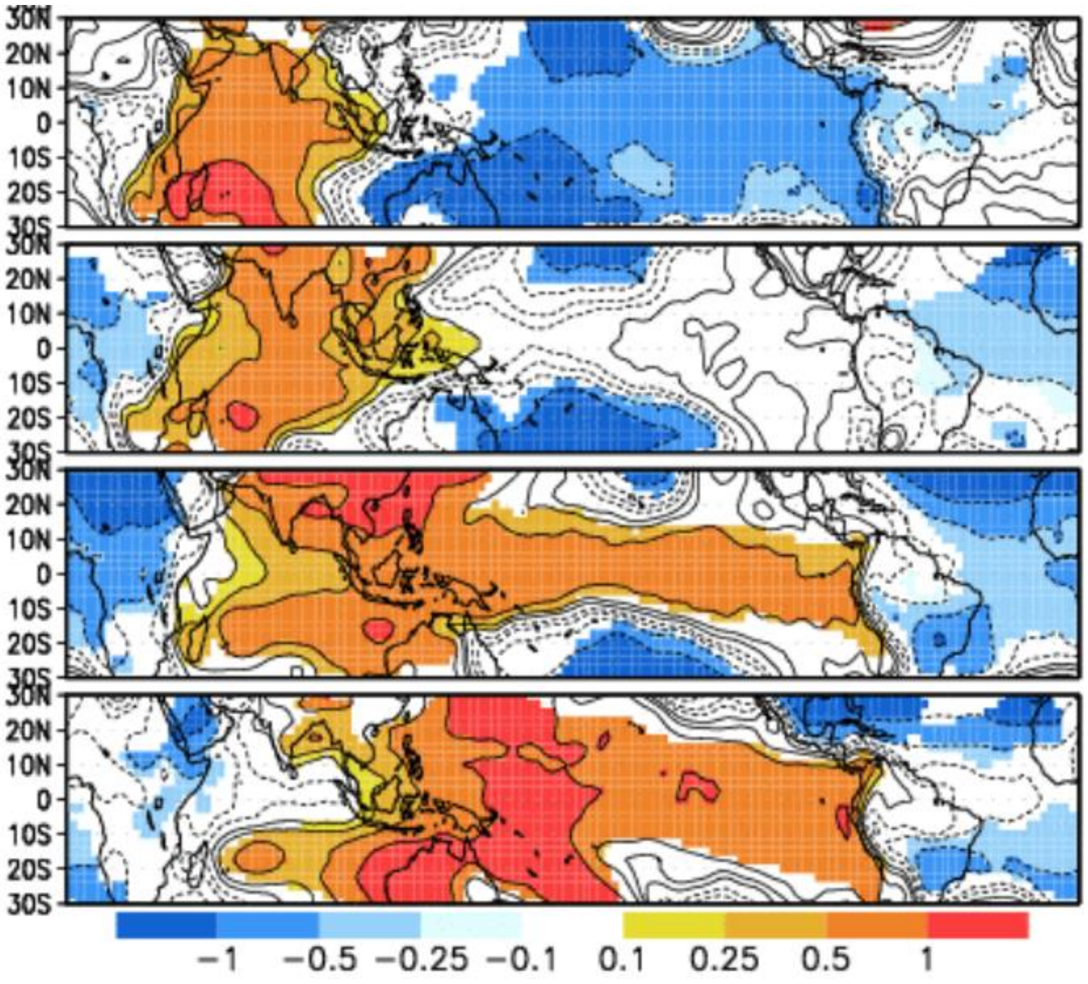
November through March

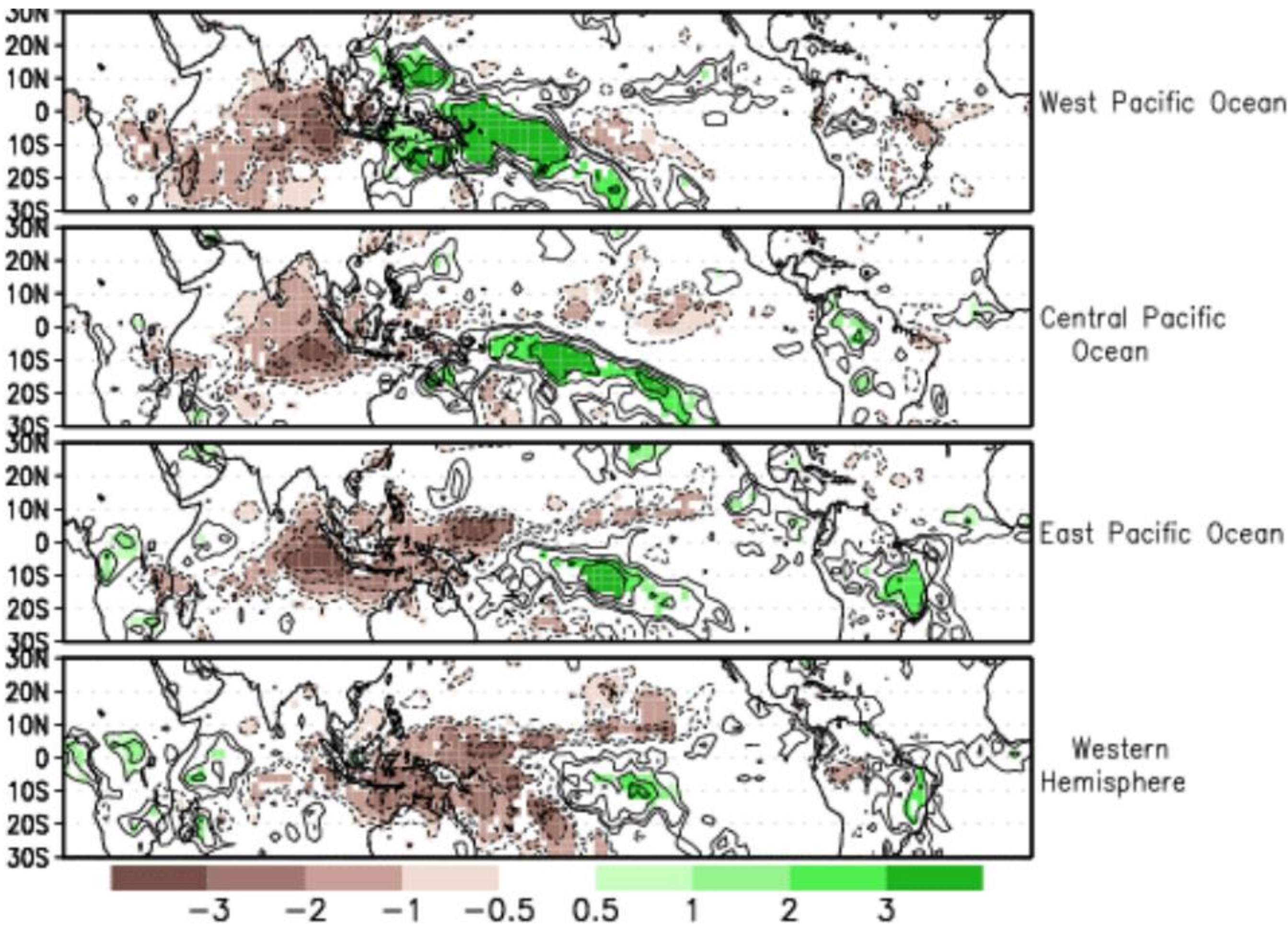
Southern Hemisphere Summer

Sea Level Pressure anomalies   Precipitation anomalies

Bright REDs…. higher sea level pressures.   BLUEs, lower sea level pressures, correspond to GREEN rain areas.

Bright REDs, higher sea level pressures correspond with strong precipitation deficits, the BROWNs on the right side.





8A SEA LEVEL PRESSURE anomalies, November through March
Millibars

6A PRECIPITATION anomalies, November through March,
millimeters

Sea Level Pressure anomalies　　　　　　　　　　Precipitation anomalies

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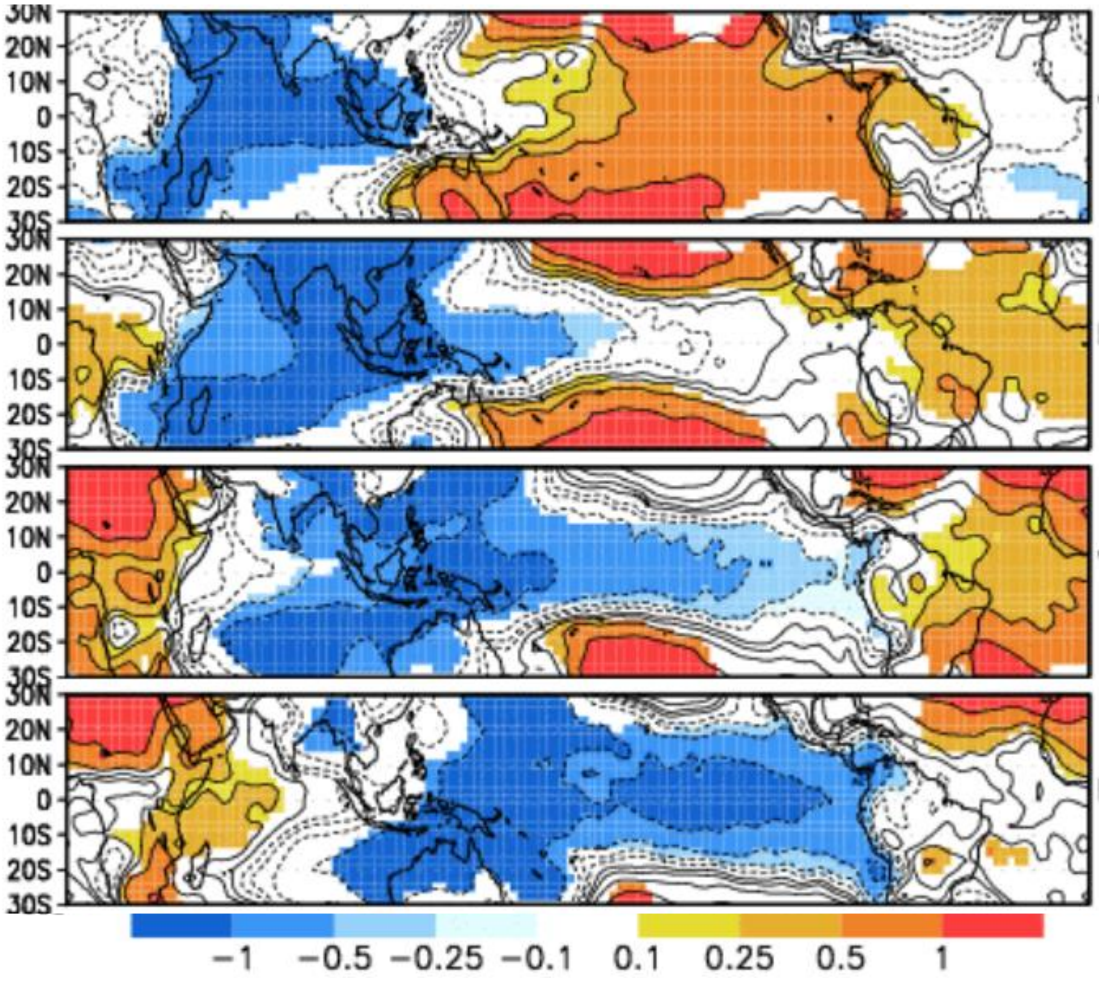

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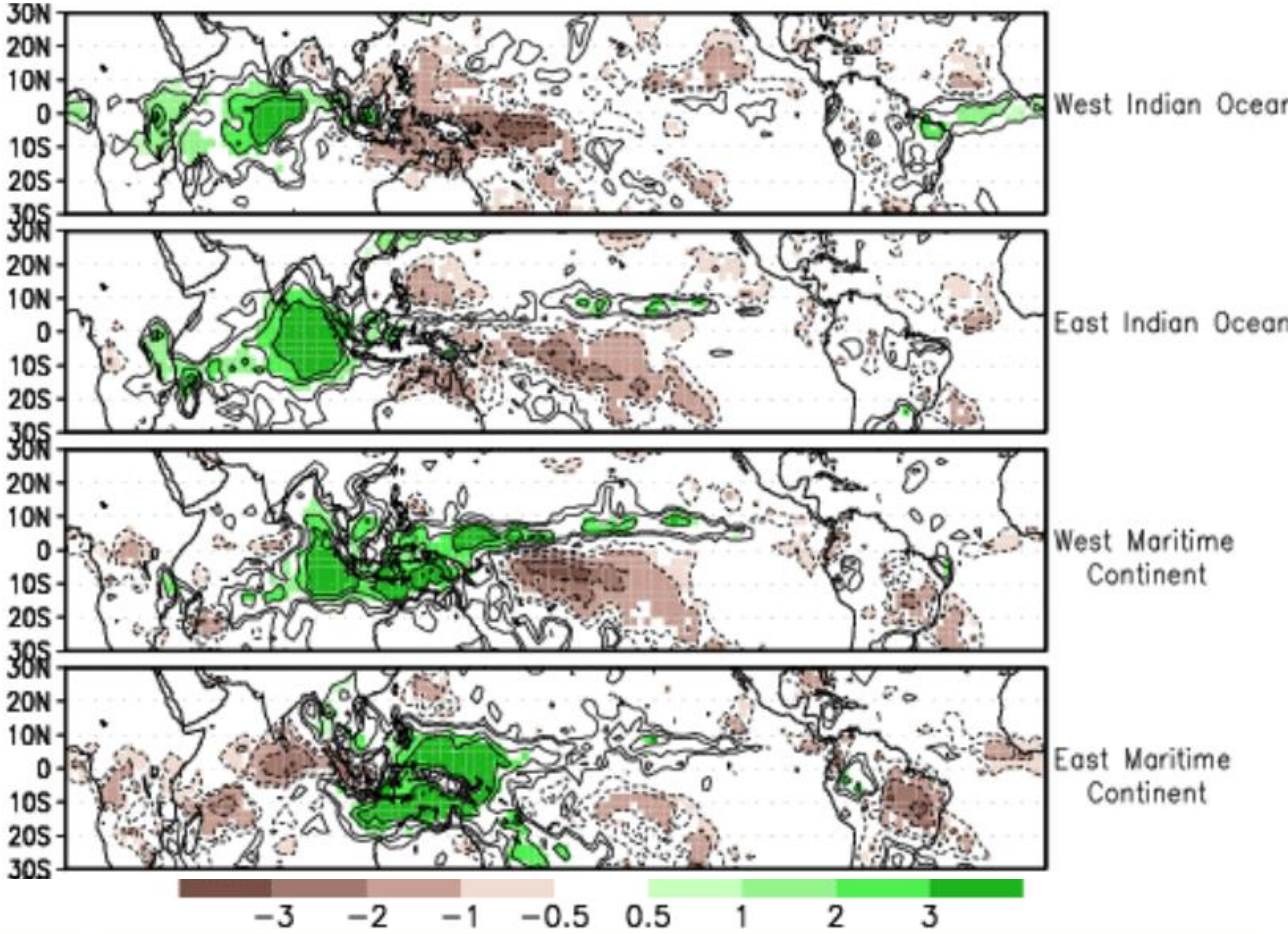
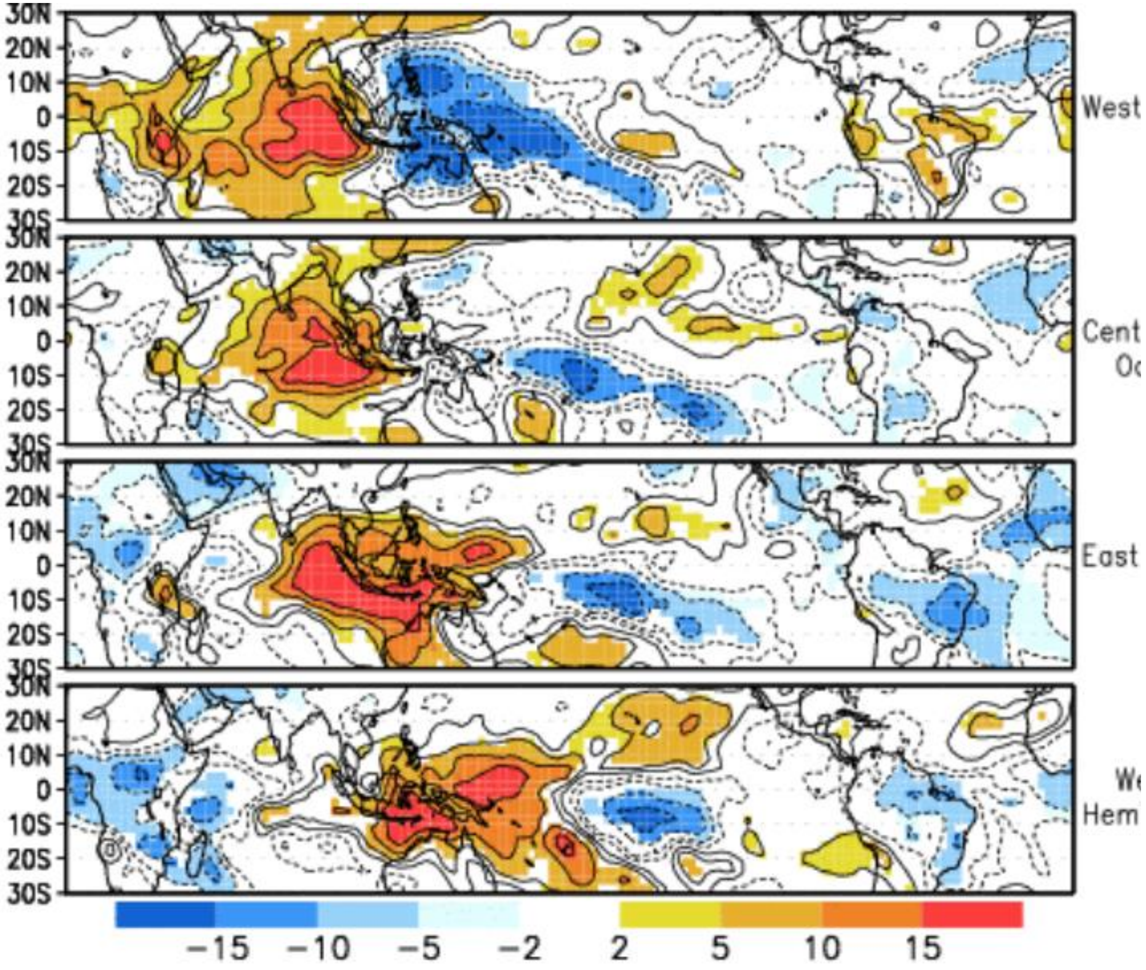


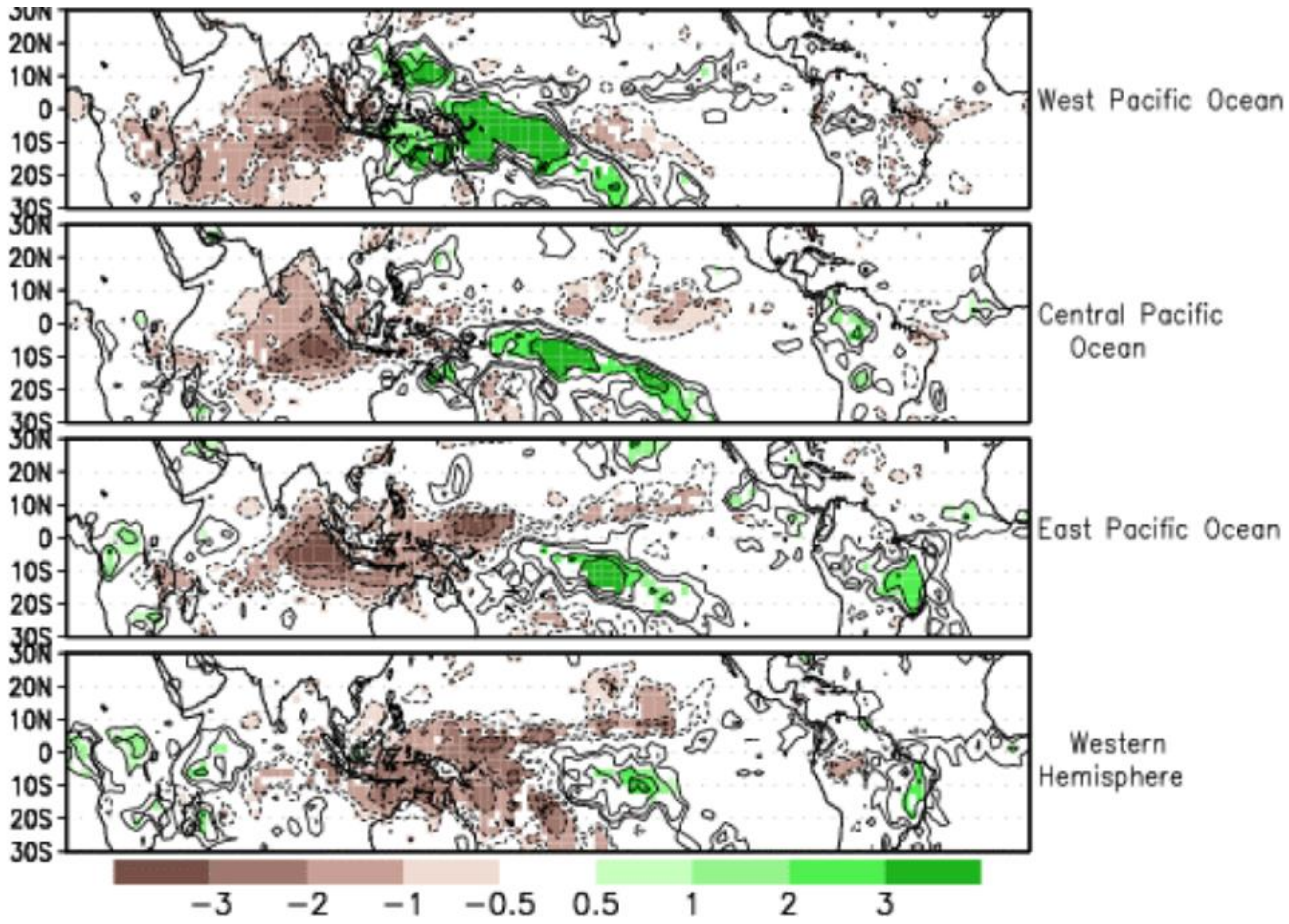
6A PRECIPITATION anomalies, November through March,
millimeters

Outgoing Longwave Radiation anomalies
REDs, HIGH OLR: bright emissions from HOT surface..
BLUE: LESS OLR, emissions from cooler cloud tops…

Precipitation anomalies
BROWNs… precipitation deficits.
correspond to GREENS….enhanced RAIN activity



5A Outgoing Longwave Radiation anomalies, November Through March, Watts/M**2



6A Precipitation anomalies, November through March, Millimeters

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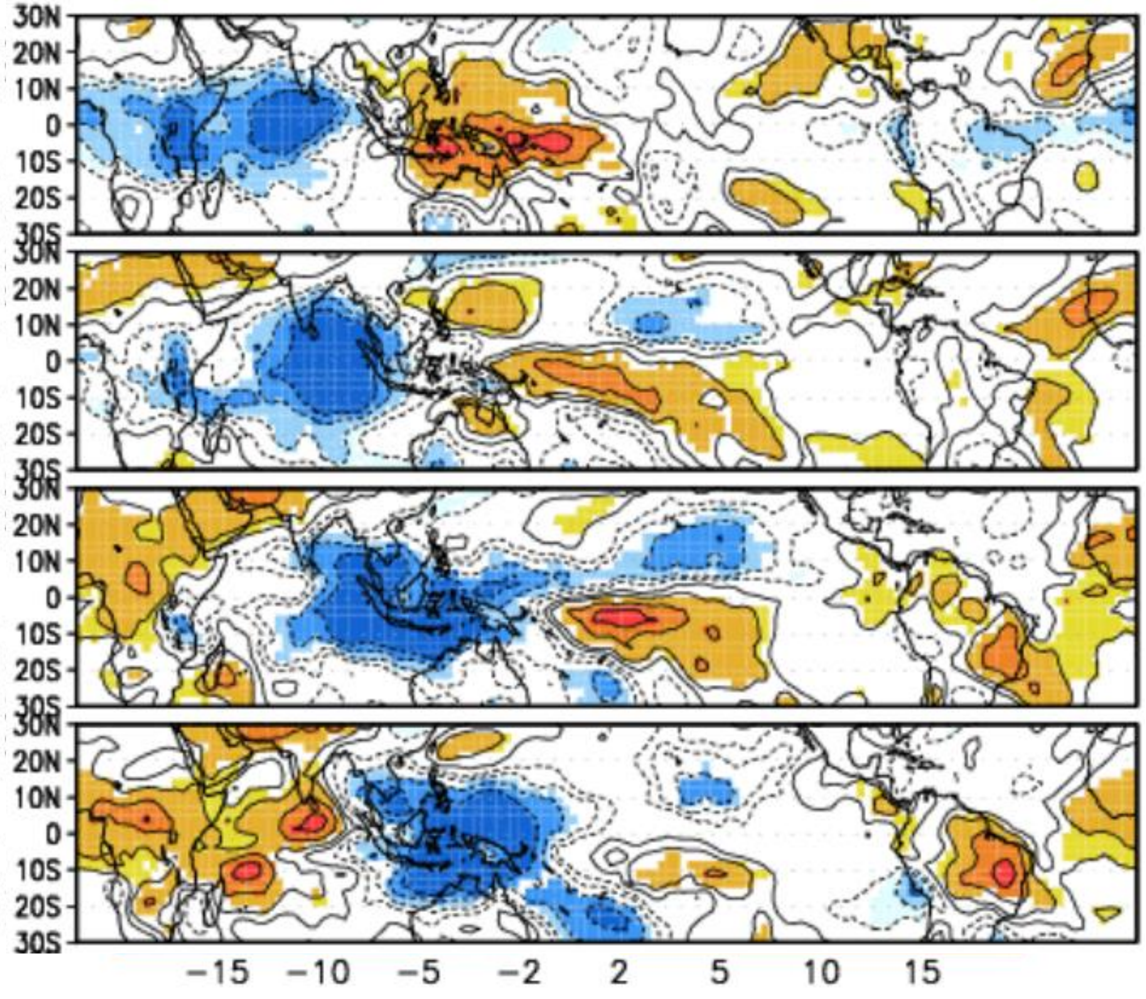

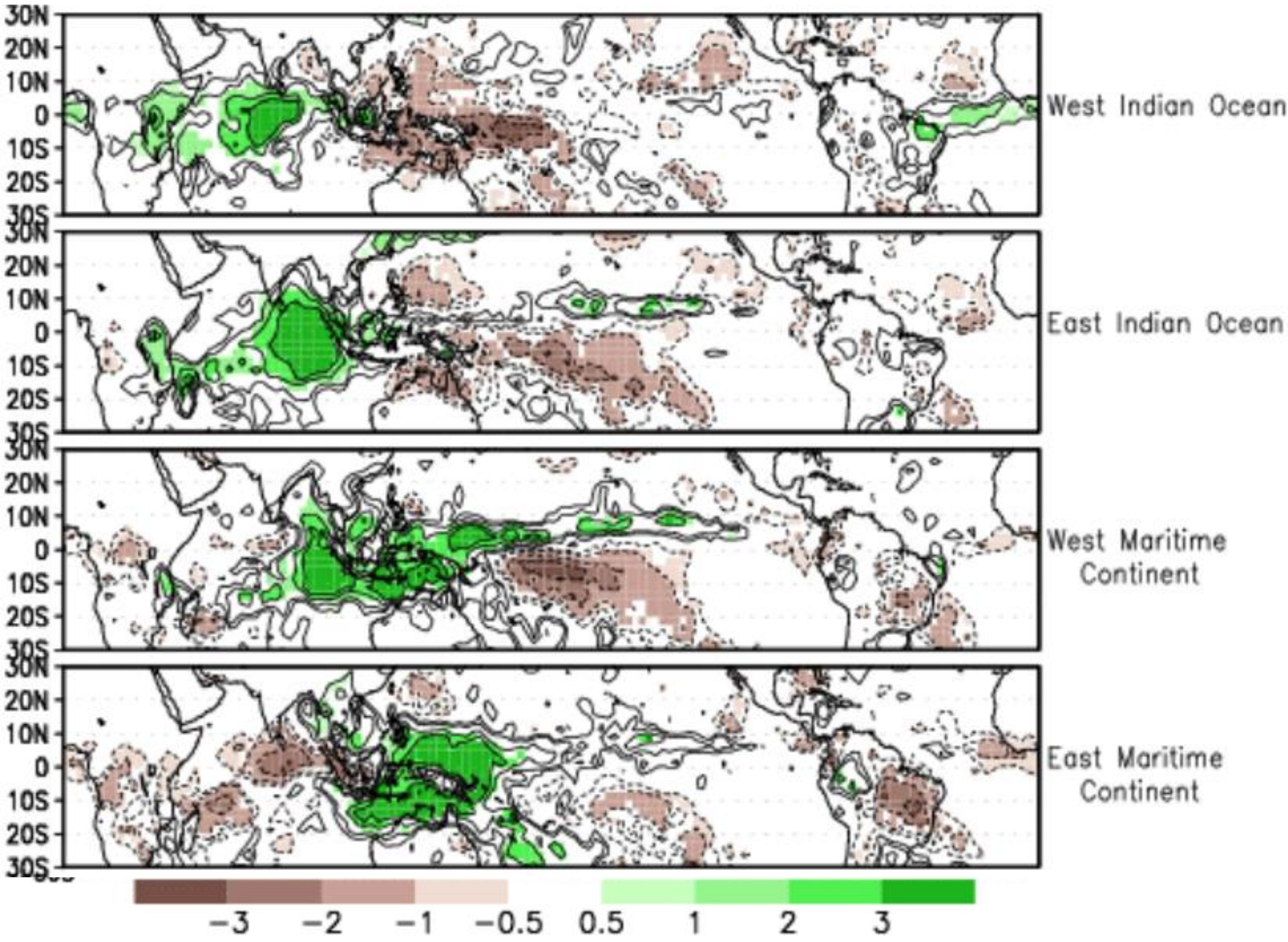

5A Outgoing Longwave Radiation anomalies, November Through March, Watts/M**2

6A Precipitation anomalies, November through March, Millimeters

May through September

Northern Hemisphere Summer

Sea Level Pressure anomalies

Precipitation anomalies

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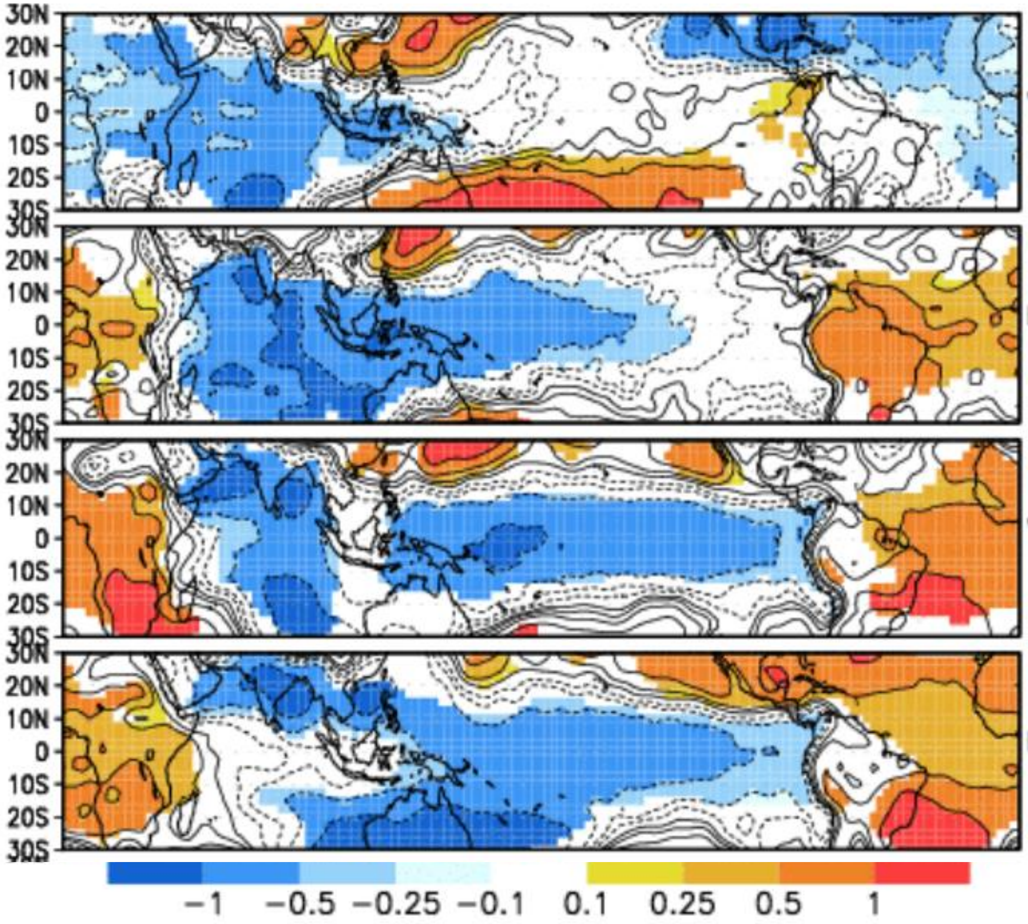
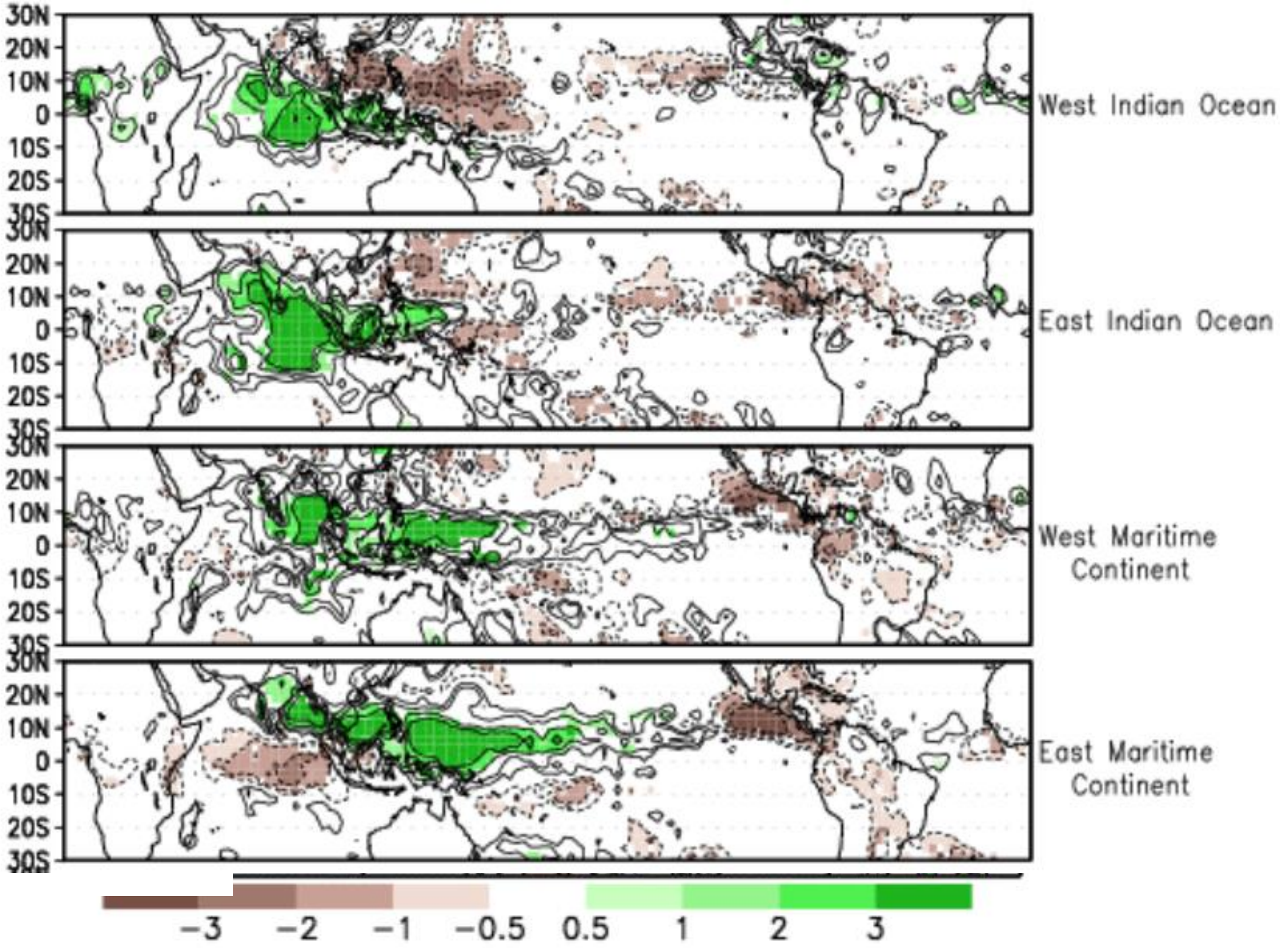


8B Sea Level Pressure Anomalies, May through September Millibars



6B PRECIPITATION anomalies, May through September, millimeters

Sea Level Pressure anomalies Precipitation anomalies

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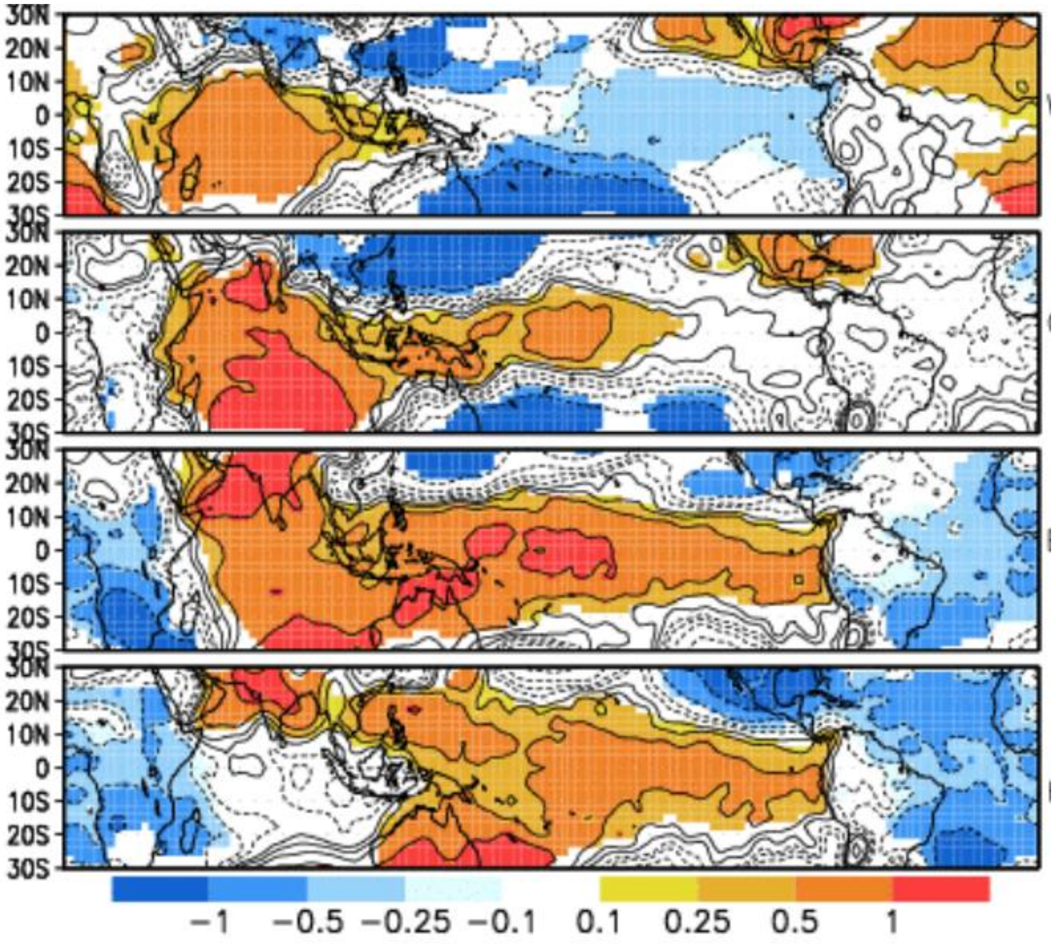
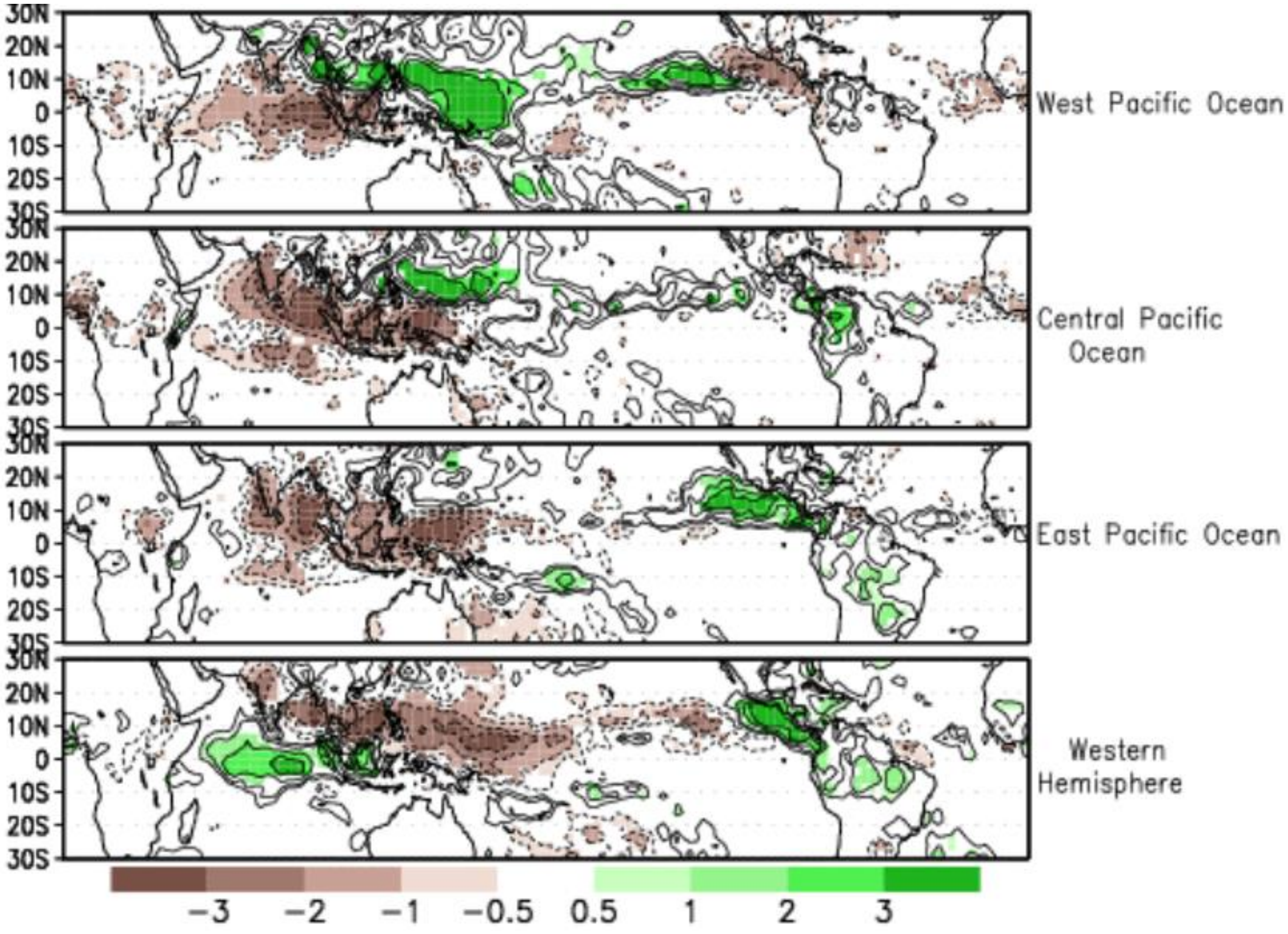


8B Sea Level Pressure Anomalies, May through September Millibars



6B PRECIPITATION anomalies, May through September, millimeters

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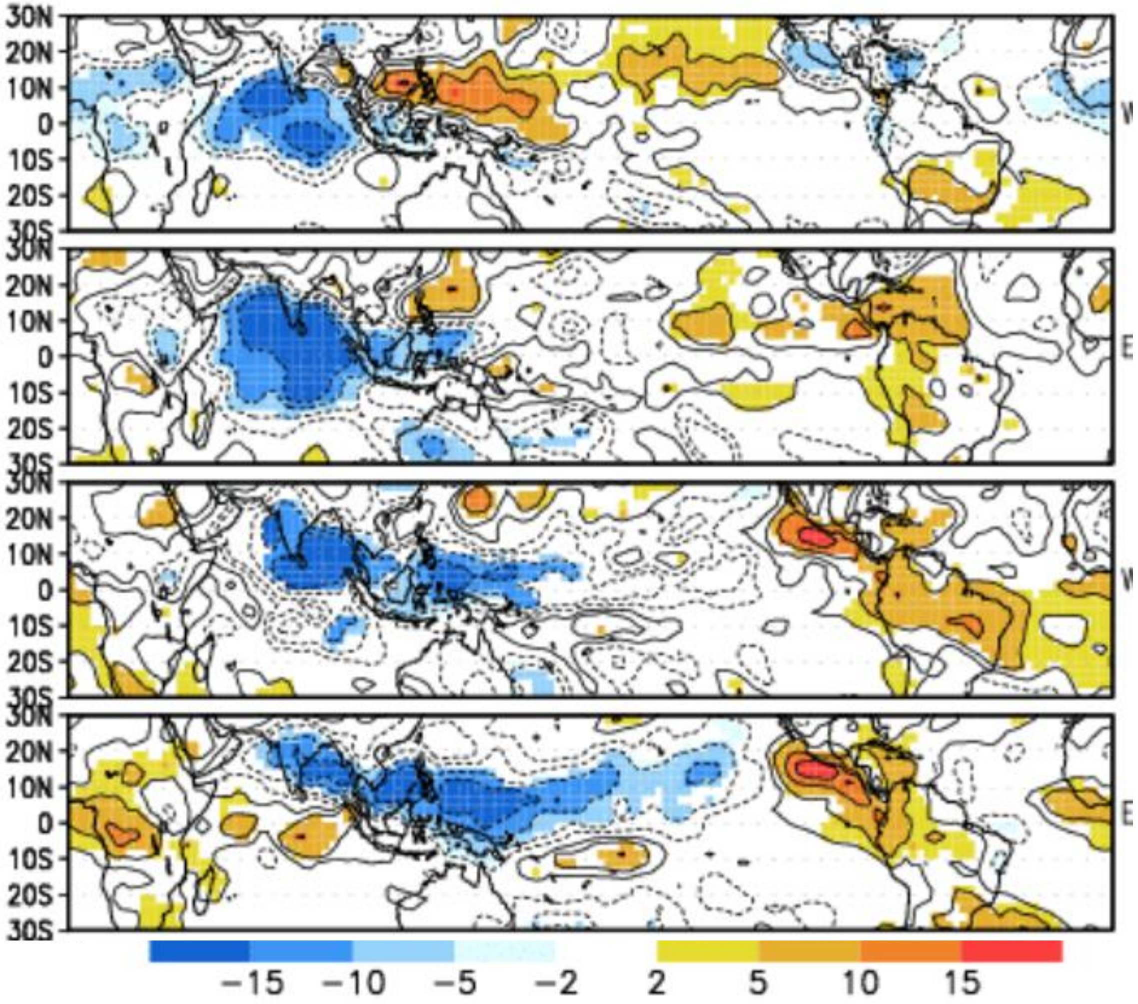
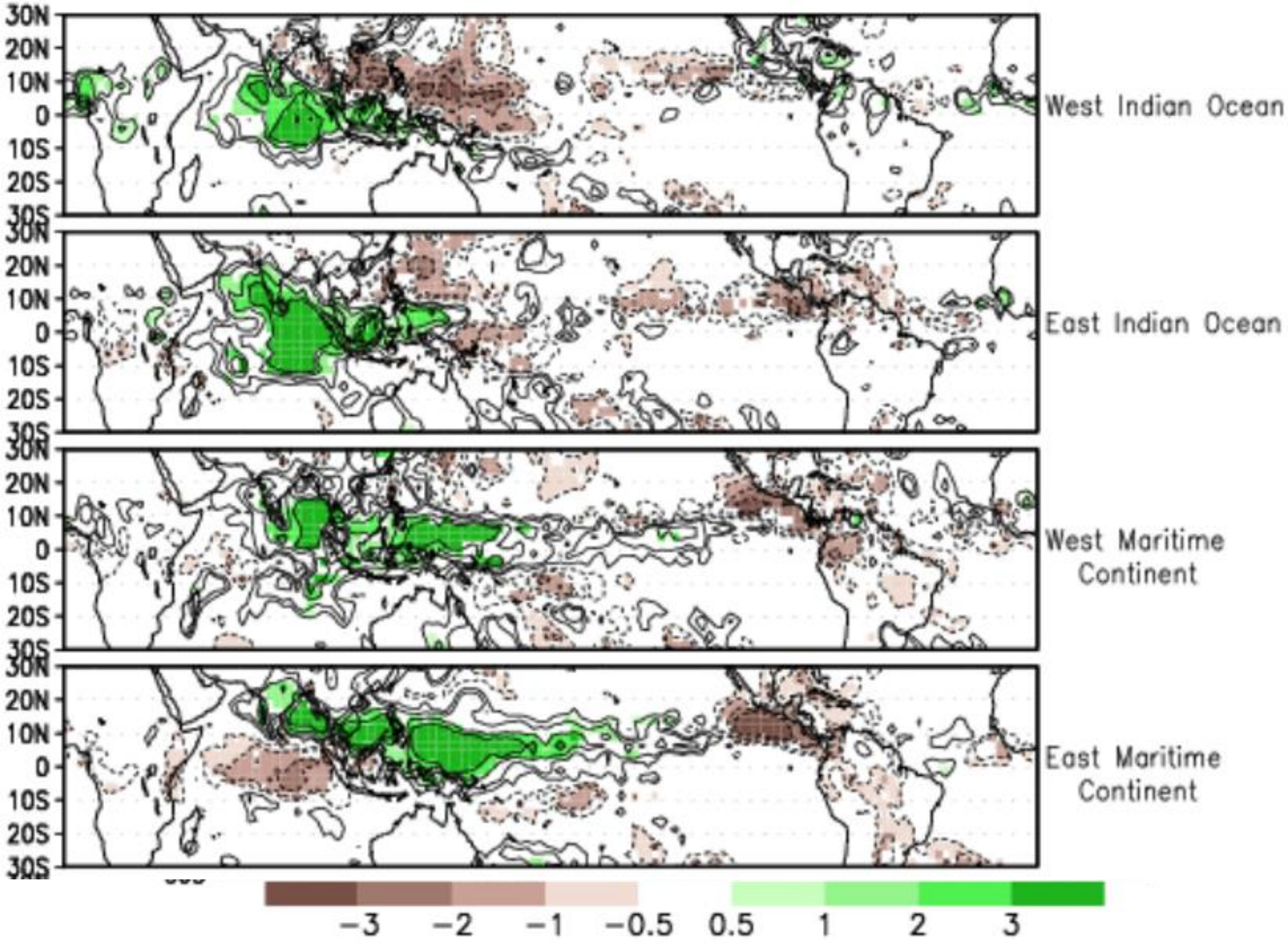


5B Outgoing Longwave Radiation anomalies, May through September, Watts/M**2



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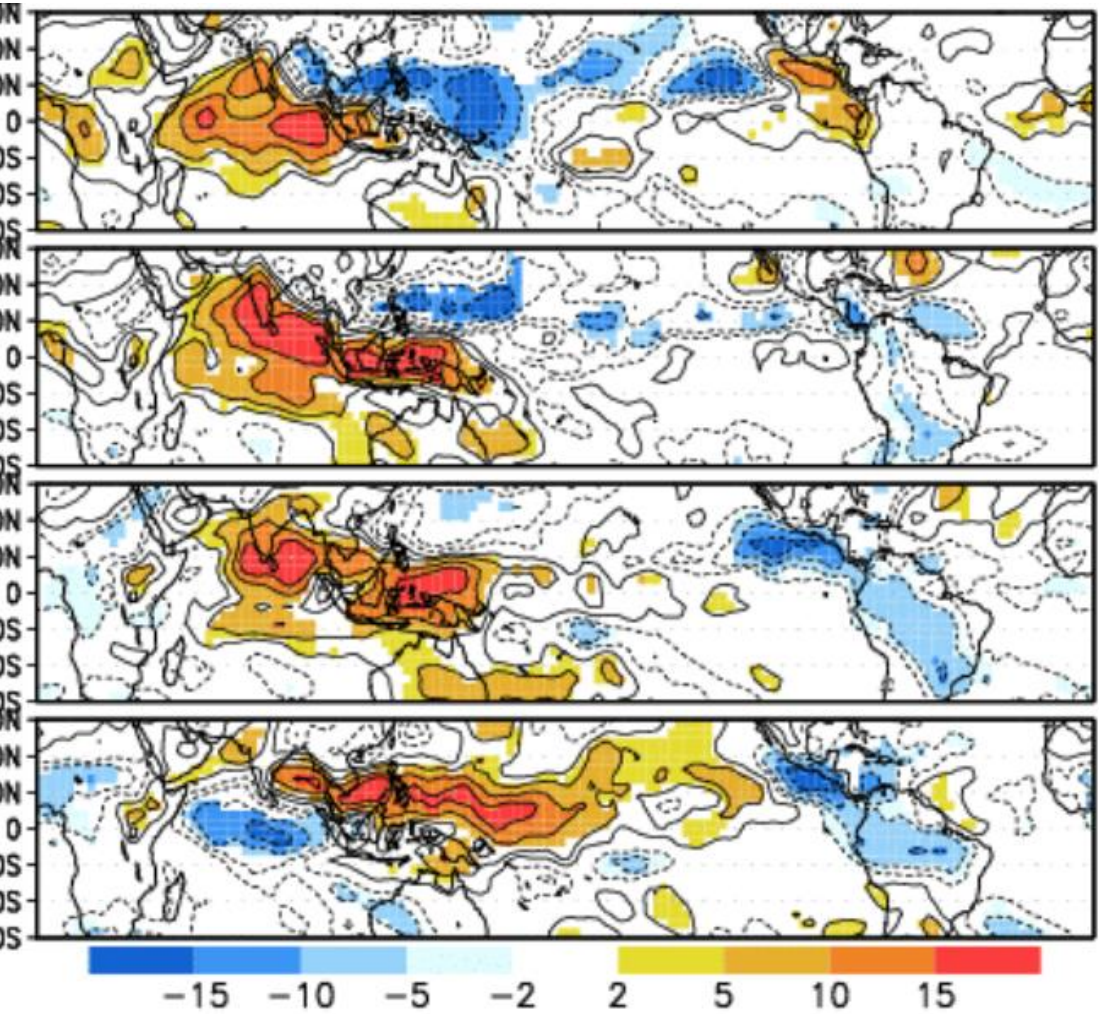
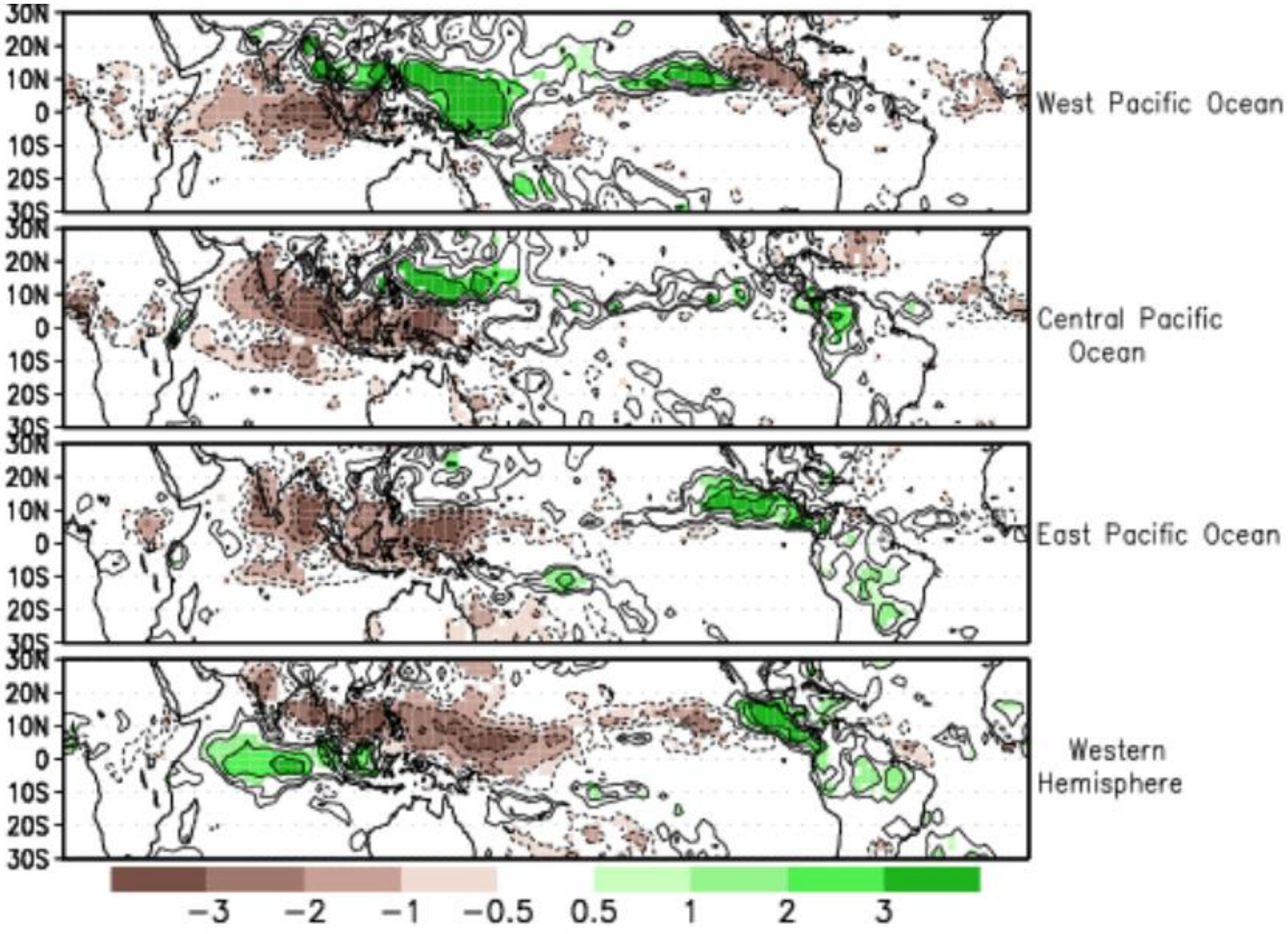


5B Outgoing Longwave Radiation anomalies, May through September, Watts/M**2



6B PRECIPITATION anomalies, May through September, millimeters

NCAR National Center for Atmospheric Research Initiative:

Year of Tropical Convection

About YOTC

http://www.cgd.ucar.edu/projects/yotc/about/

The realistic representation of tropical convection in our global atmospheric models is a long-standing grand challenge for numerical weather forecasts and global climate predictions.

Our lack of fundamental knowledge and practical capabilities in this area leaves us disadvantaged in modeling and predicting prominent phenomena of the tropical atmosphere such as the ITCZ, ENSO, TBO*, monsoons and their active/break periods, the MJO, subtropical stratus decks, near-surface ocean properties, easterly waves, tropical cyclones, bulk budgets of cloud microphysical quantities, and even the diurnal cycle.

*Tropospheric Bienneal Oscillation