The relationship between Japan's recent temperature and decadal variability

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Urabe, Y. and S. Maeda, The relationship between Japan's recent temperature and decadal variability, *SOLA, accepted*

Outline

Introduction
- Recent remarks about decadal variability -

Japan's temperature in recent decade
- Enhanced seasonal contrast -

Recent conditions in global ocean and atmospheric circulation
- La Niña-like conditions -
(Negative IPO)

Summary

Datasets

+ Atmospheric circulation field
  - JRA-55 (JMA; Kobayashi et al., 2015)

+ Sea Surface Temperature (SST)
  - COBE-SST (JMA; Ishii et al., 2005)

+ Ocean subsurface temperature
  - MOVE-G (JMA; Usui et al., 2006)
  - Objective analysis (JMA; Ishii and Kimoto, 2009)

+ Surface Air Temperature in Japan
  - In-Situ observation by JMA
(http://www.data.jma.go.jp/cpdinfo/temp/list/mon_jpn.html)

Introduction

- Recent remarks about decadal variability -

Decadal to Multi-decadal variability

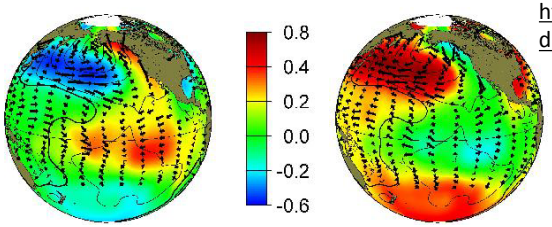
Pacific Decadal Oscillation (PDO)

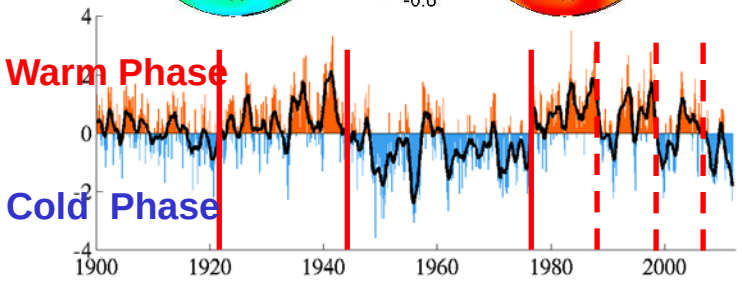
Mantua et al. (1997)

Warm (Positive) Phase

Cold (Negative) Phase

http://jisao.washington.edu/pdo/graphics.html

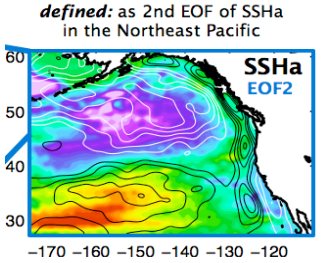


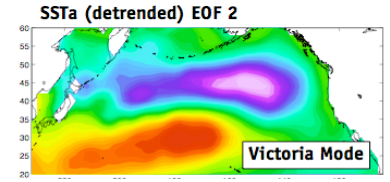


North Pacific Gyre Oscillation (NPGO)

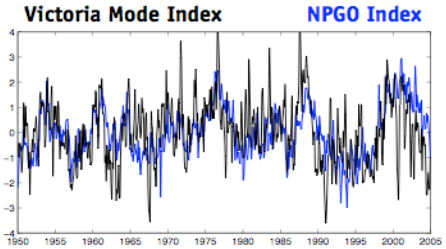
Di Lorenzo et al. 2008

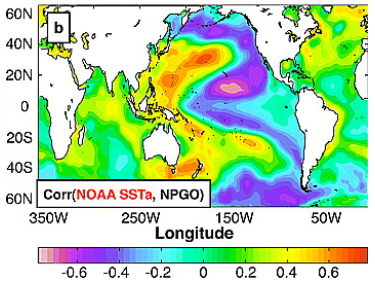
Bond et al. 2003





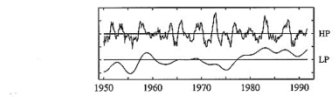
NPGO (SSH) = Victoria Mode (SST)

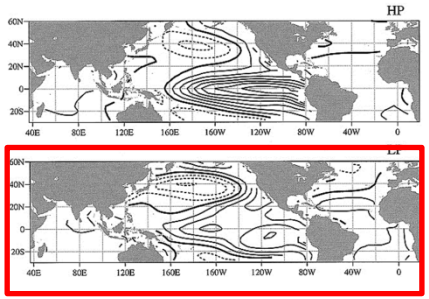




Interdecadal Pacific Oscillation (IPO)

Zhang et al. (1997)





EOF of SSTA in the Pacific.

(Upper)

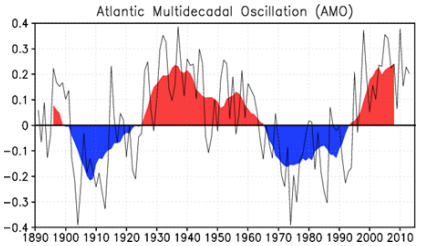
6 yr High-Pass → ENSO

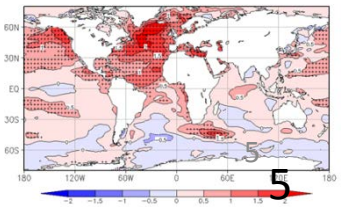
(Lower)

6 yr Low-Pass → IPO

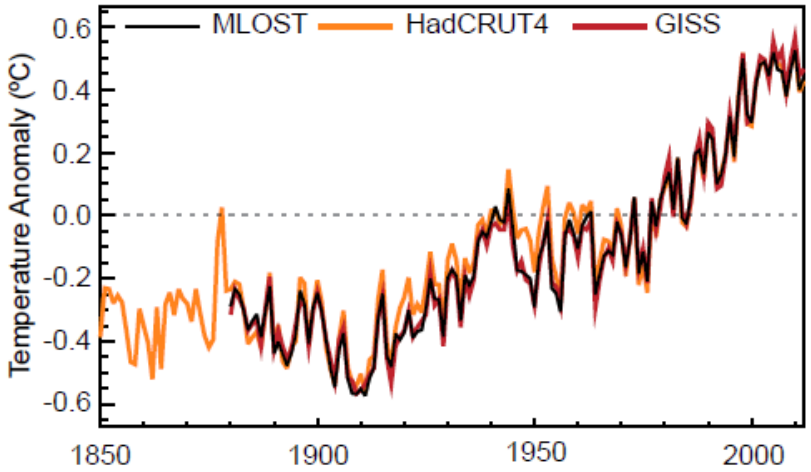
Atlantic Multidecadal Oscilaltion (AMO)

Averaged SSTA in the North Atlantic (0 – 70N).
Linear trend is removed.



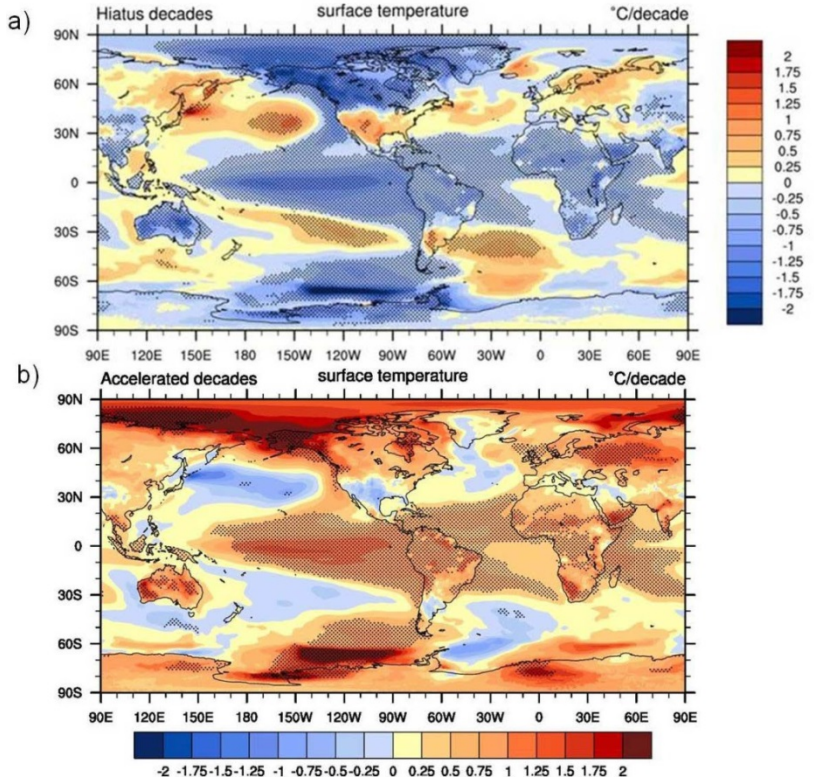


Global Warming Hiatus and IPO



Annual Global Mean Surface Temperature (GMST) anomalies relative to a 1961–1990 climatology from the latest version of the three combined Land-Surface Air Temperature (LSAT) and Sea Surface Temperature (SST)
datasets (HadCRUT4, GISS and NCDC MLOST).

IPCC AR5 (2014)



Five CCSM4 21st century simulations with RCP4.5
(uniform increase in GHGs, no volcanoes):
Composites of decades with near-zero warming trend (hiatus decades) and decades with rapid global warming (accelerated warming decades) show opposite phases of the IPO in the Pacific
(hiatus=linear trend of global T <-0.10K/decade; 8 hiatus decades
Accelerated=linear trend of global T>+0.41K/decade; 7 accelerated warming decades)

Meehl et al. (2013)

- IPO in positive phase → Accelerated warming decades
- IPO in negative phase → Hiatus decades

Japan’s temperature in recent decade

- Enhanced Seasonal Cycle -

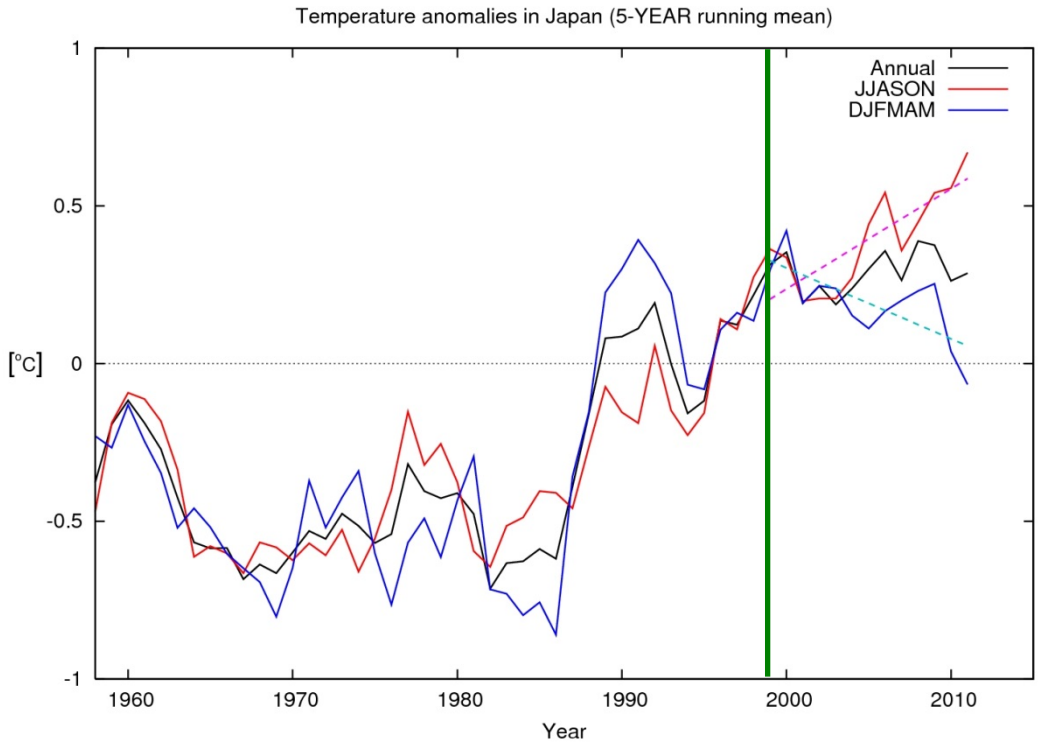
Japan's Temperature : Time series

Inter annual variability of surface air temperature in Japan* (5 year running mean)
- Black : Annual mean (December – November)
- Red : Summer-Autumn mean (June – November)
- Blue : Winter-Spring mean (December – May)

Dashed lines: Linear trend for 1999 - 2011
- Magenta : Summer-Autumn mean (+0.31 ˚C / 10yr)
- Cyan : Winter-spring mean (-0.22 ˚C / 10yr)

Both are significant at 95% confidence level

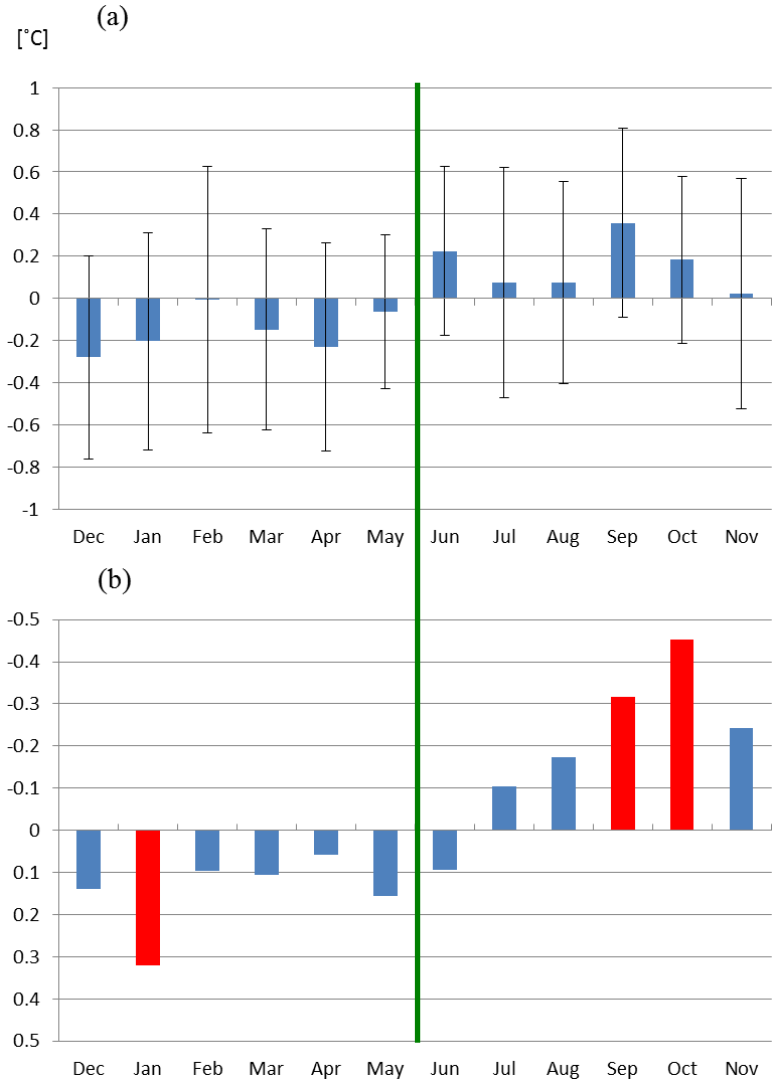
* 15 sites where temperature records are least affected by local urbanization.
Abashiri, Nemuro, Suttsu, Yamagata, Ishinomaki, Fushiki, Iida, Choushi, Sakai, Hamada, Hikone, Miyazaki, Tadotsu, Naze, and Ishigakijima.
http://www.data.jma.go.jp/cpdinfo/temp/list/mon_jpn.html



From the late 1990s
Increase trend for Summer-Autumn ⇔ Decrease trend for Winter-Spring

Urabe and Maeda (SOLA, accepted)

Japan's Temperature : Recent decades



(a) Japan's Monthly surface air temperature averaged from 1999 to 2012.

* Difference between DJFMAM and JJASON is statistically significant according to Wilcoxon rank sum test (Wilcoxon, 1945)

Urabe and Maeda (SOLA, accepted)

(b) Correlation Coefficients between Japan's temperature and NINO.3 Index from 1959 to 2012. Red box indicates the coefficients are statistically significant at 95% confidence level.
 # Notice : The vertical Axis is FLIPPED.

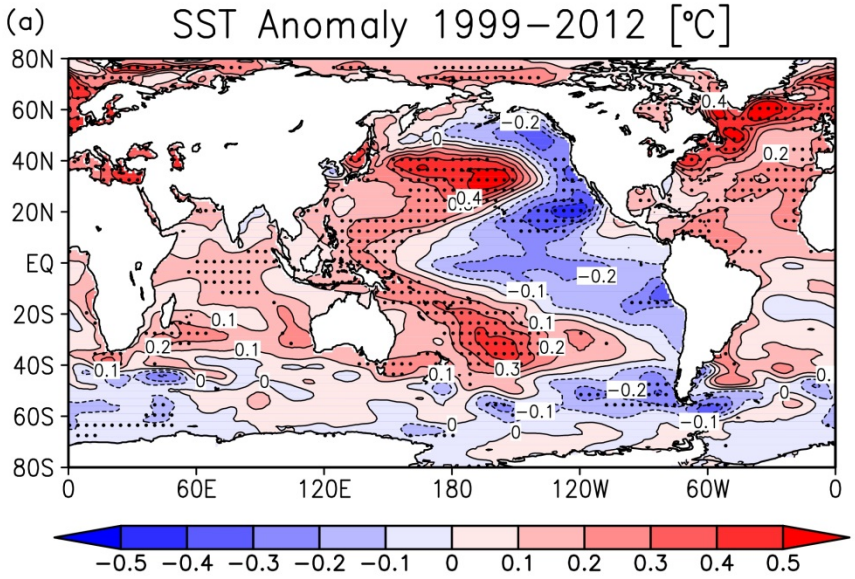
Hotter summer-autumn
Colder winter-spring
= ***Enhanced Seasonal Contrast***

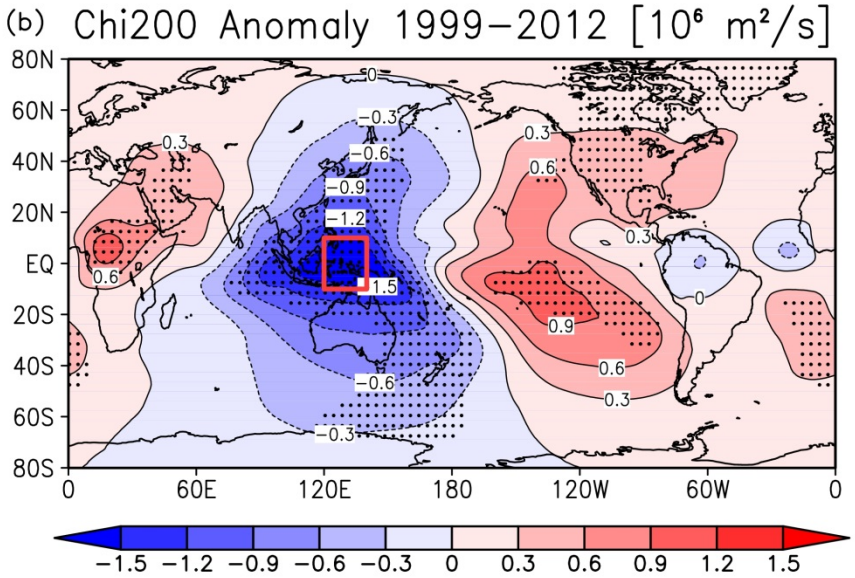
Similar to the influence of ***La Niña*** events

Recent conditions in global ocean and atmospheric circulation

- La Niña-like Conditions -

SST and Walker circulation





SST Anomaly

Tropical Pacific

	West	East
SST	Positive	Negative
Chi200	Divergence	Convergence

La Niña-like Conditions
(Negative IPO)

Velocity potential at 200 hPa
(Chi200) Anomaly

Urabe and Maeda(SOLA, accepted)

Influence from tropical area on global circulation

200 hPa height (Z200)
Anomaly

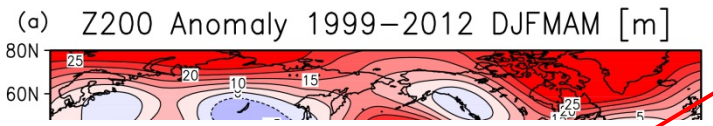
Z200 anomaly regressed on CHI200 around the Maritime-Continent [1959-2013]

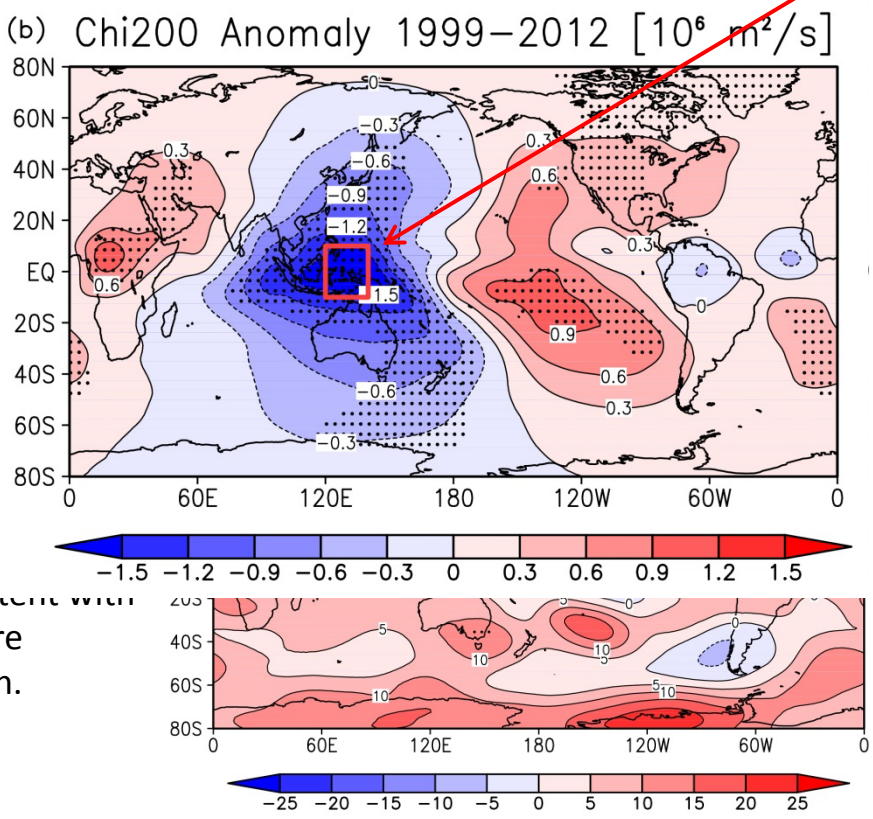
Winter – Spring

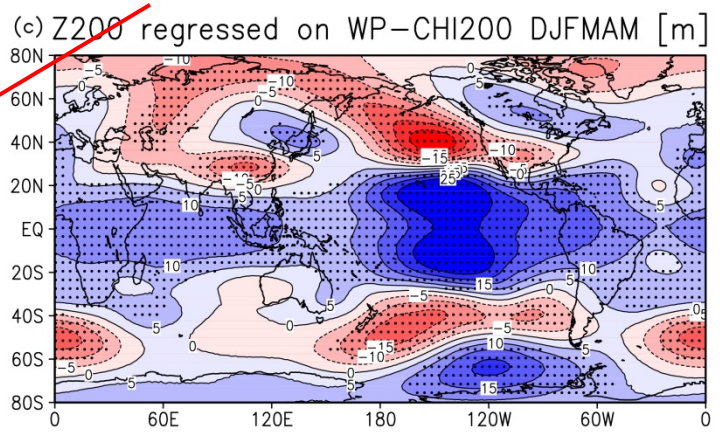
Far-Eastern troug
and Nakamura, 2(
enhanced.
→ Monsoon is En
consistent with cc
Japan's winter.

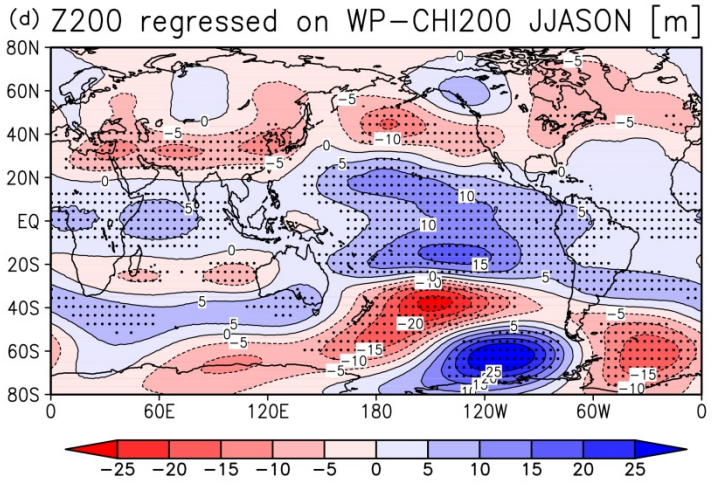
Summer – Au

Positive height an
near Japan.
→Westerly Jet sh
northward, consis
higher temperature
anomalies in Japan.









Urabe and Maeda(SOLA, accepted)

Response to the La Niña-like Conditions in the tropics.

Influence on Japan

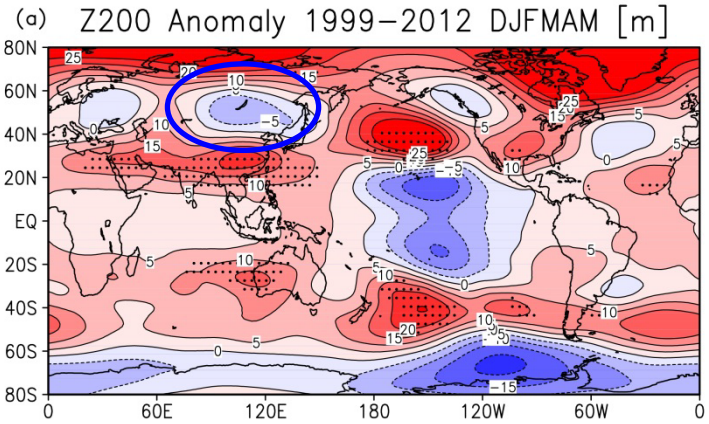
200 hPa height (Z200)
Anomaly

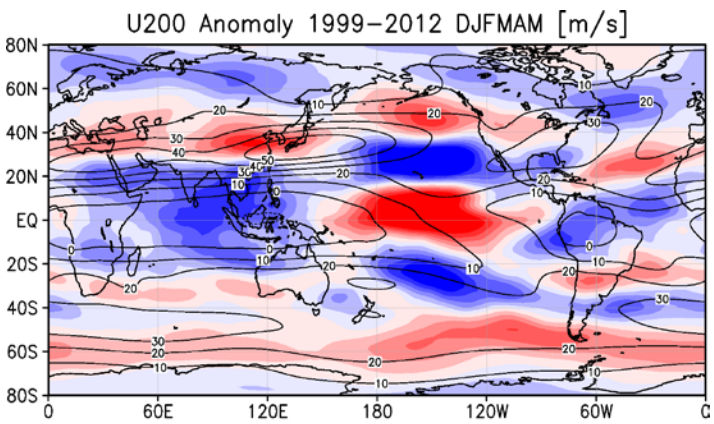
200 hPa Zonal Wind (U200)
Anomaly (Shade) / Climatology (Contour)

<u>Winter – Spring</u>

Far-Eastern trough (Takaya and Nakamura, 2013) is enhanced.

→ Monsoon is Enhanced, consistent with colder Japan's winter.

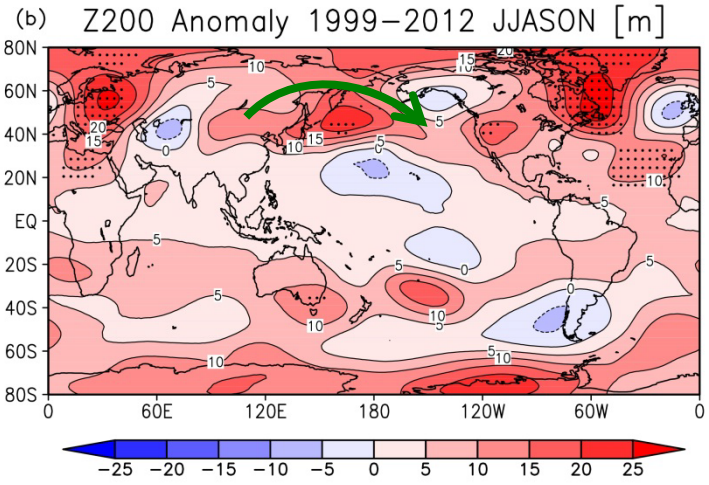


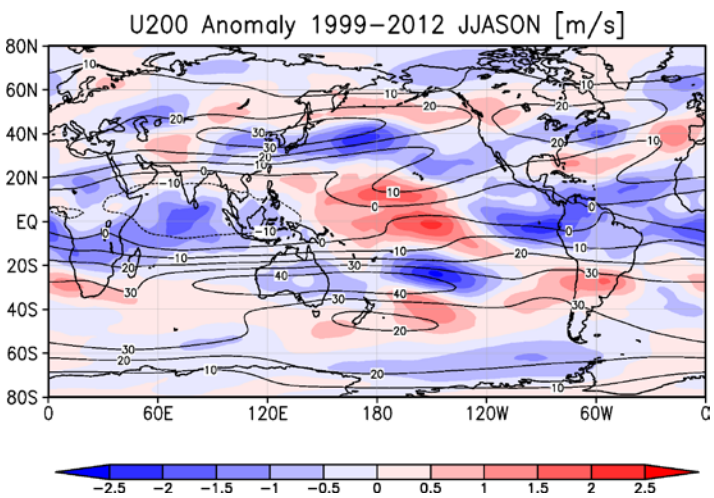


<u>Summer – Autumn</u>

Positive height anomalies near Japan.

→Westerly Jet shifts northward, consistent with higher temperature anomalies in Japan.

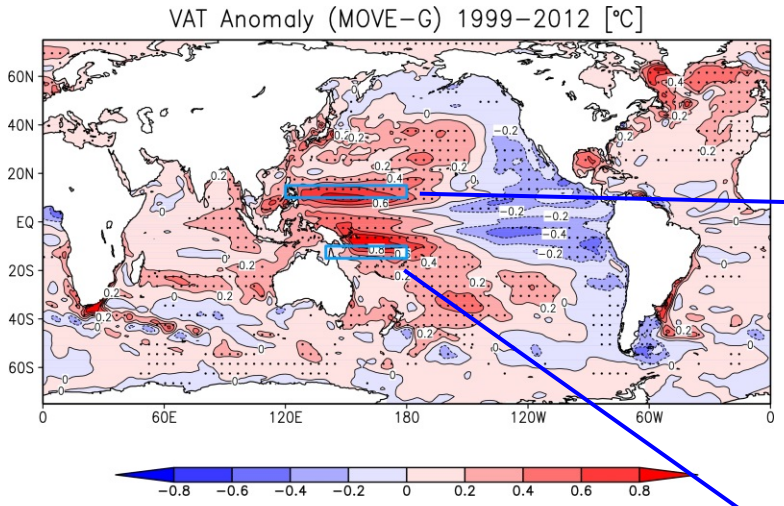




Consistent with enhanced seasonal contrast

Ocean subsurface region

Vertical Average Temperature
(Surface – 300m) Anomaly

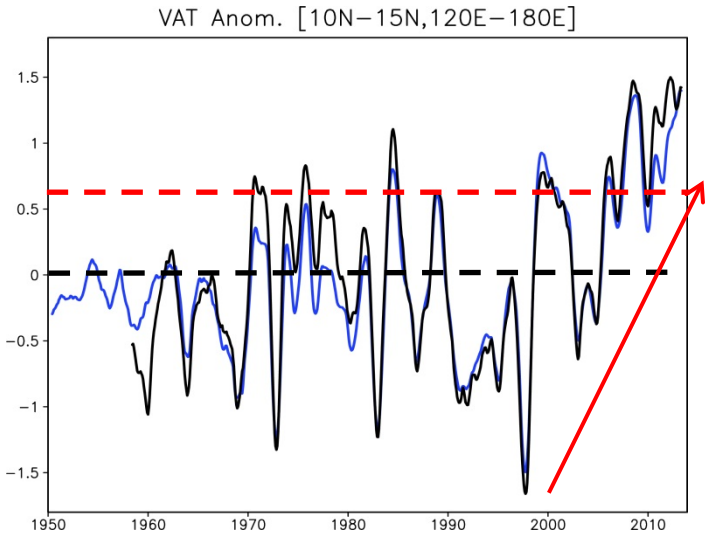


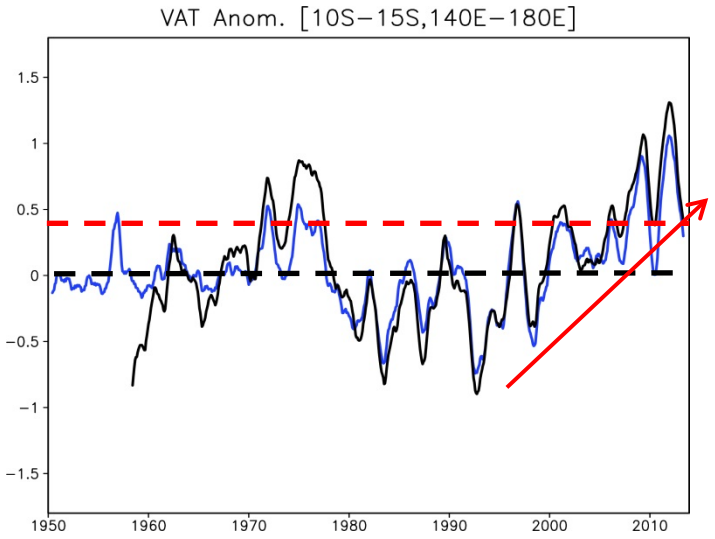
Urabe and Maeda(SOLA, accepted)

Amplitude of recent decadal – multi-decadal variability is nearly equal to the amplitude of interannual variability

Time series of Area average

Black : MOVE-G
Blue : Objective analysis (Ishii and Kimoto, 2009)

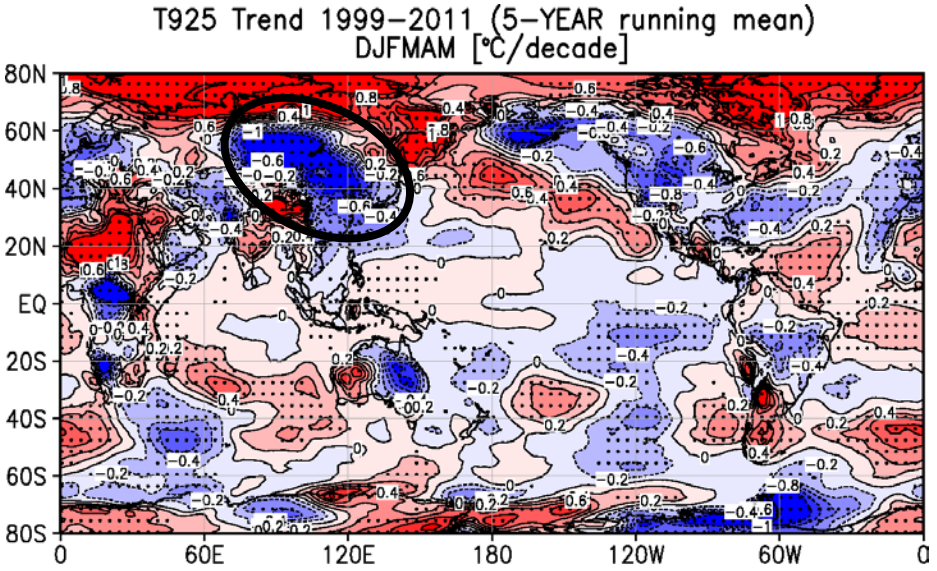




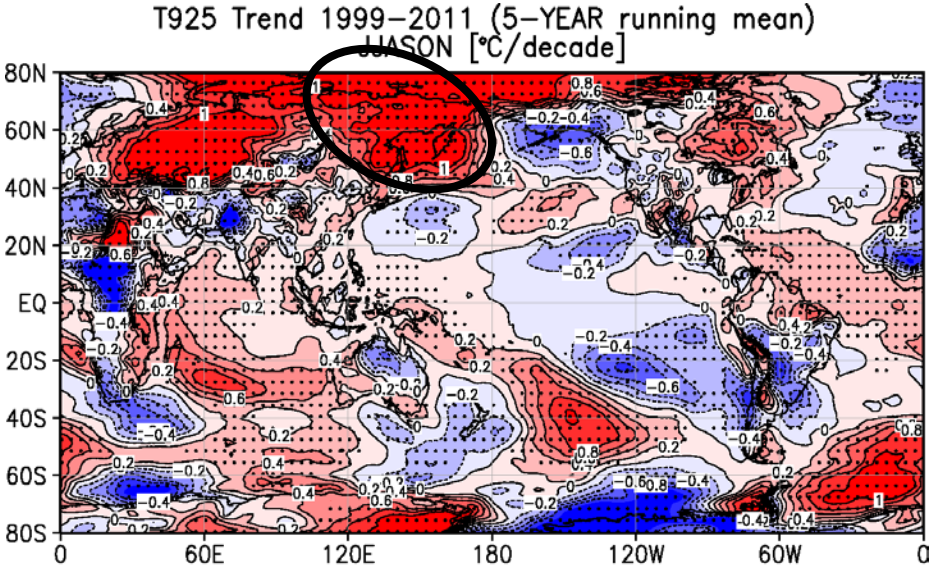
Air temperature trend : Spatial distribution

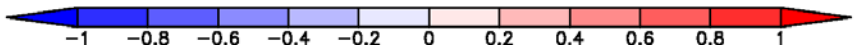
Air temperature anomaly trend at 925 hPa (5 year running mean) from 1999 – 2011

Winter-Spring



Summer-Autumn

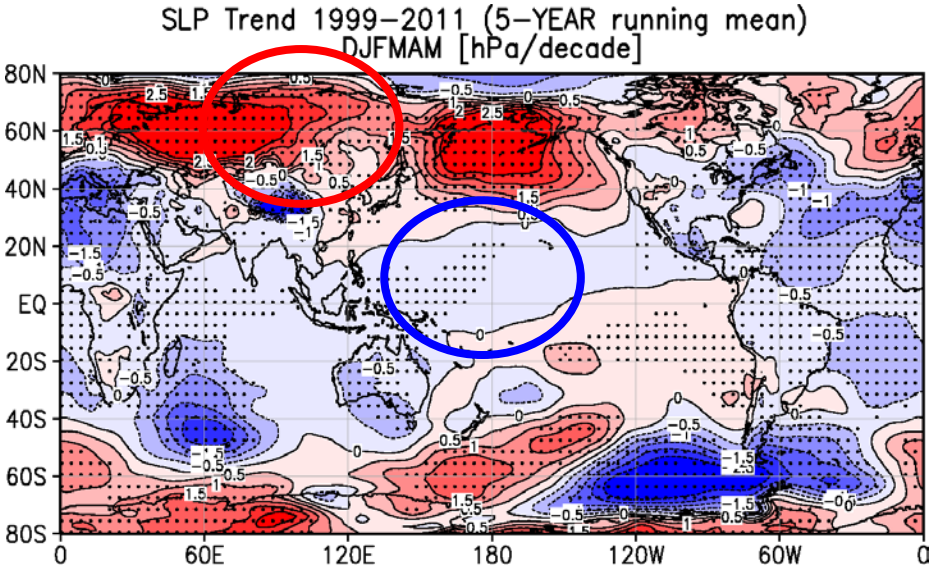




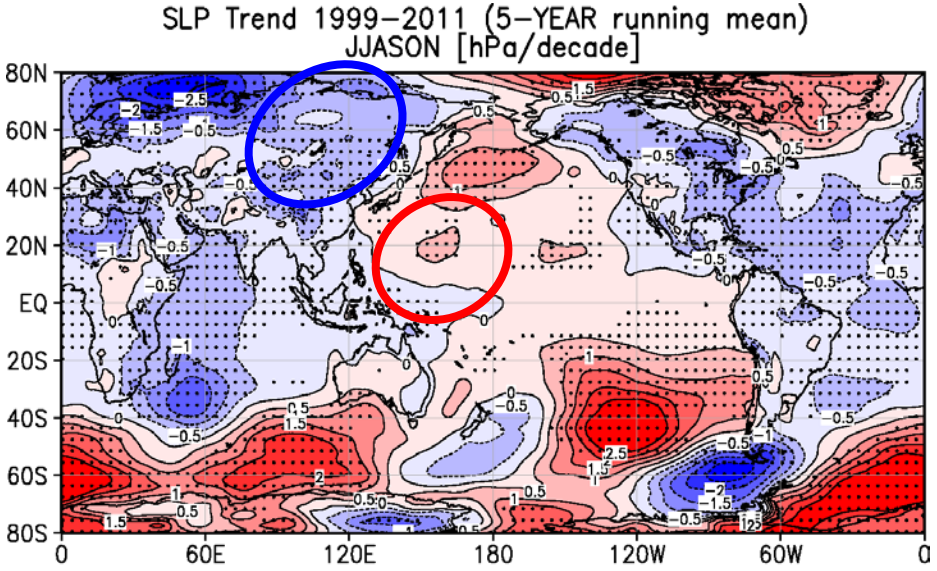
Surface pressure trend : Spatial distribution

Sea Level Pressure (SLP) anomaly trend
(5 year running mean) from 1999 – 2011

Winter-Spring



Summer-Autumn



Summary

- Conditions in recent decade -

- Japan's temperature shows significant increase (decrease) trend for summer – autumn (winter – spring)
- In the tropical Pacific, both SST and subsurface ocean temperature shows positive (negative) anomalies in the western (central to the eastern) parts. Convective activity around the Maritime Continent is enhanced, Walker circulation become stronger.

  → La Niña-like Conditions
- Conditions in global circulation fields are consistent with the La Niña-like Conditions.
- As a whole, negative phase of IPO has been dominant, and Japan's climate likely to have been affected.

JMA's approach

- Improve web sites about decadal variabilities.

✓ Introduction about decadal variabilities (PDO, NPGO, IPO, AMO).

✓ Possible relationships between decadal variabilities and climate.

✓ Information about global warming hiatus.

✓ Diagnostics of PDO (IPO?).

Thank you!

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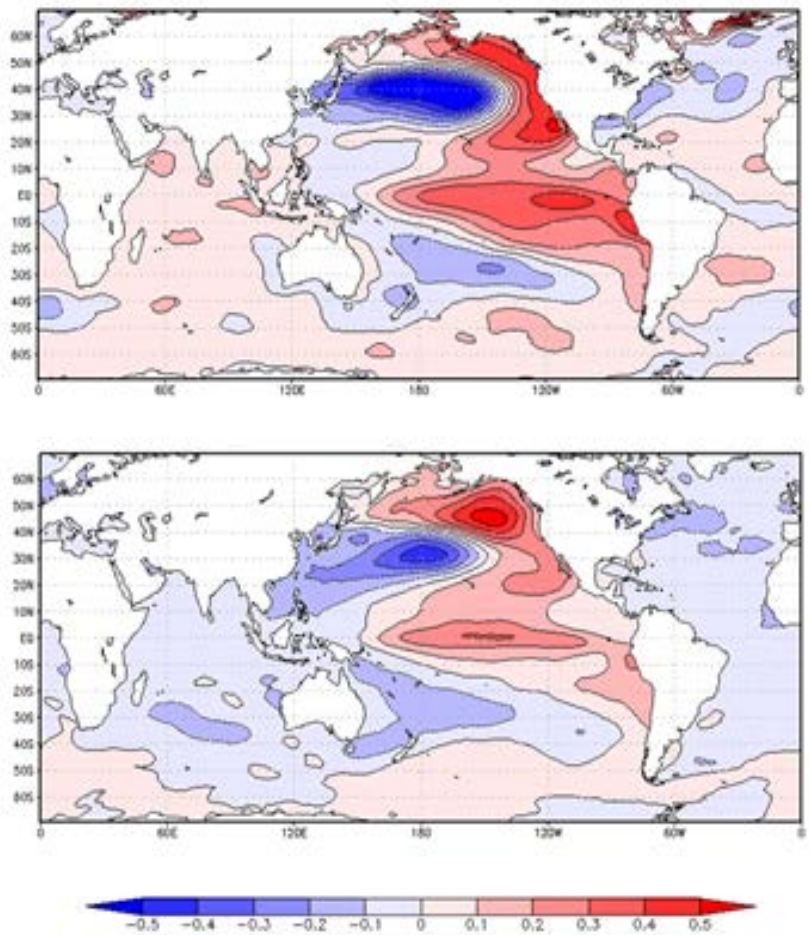
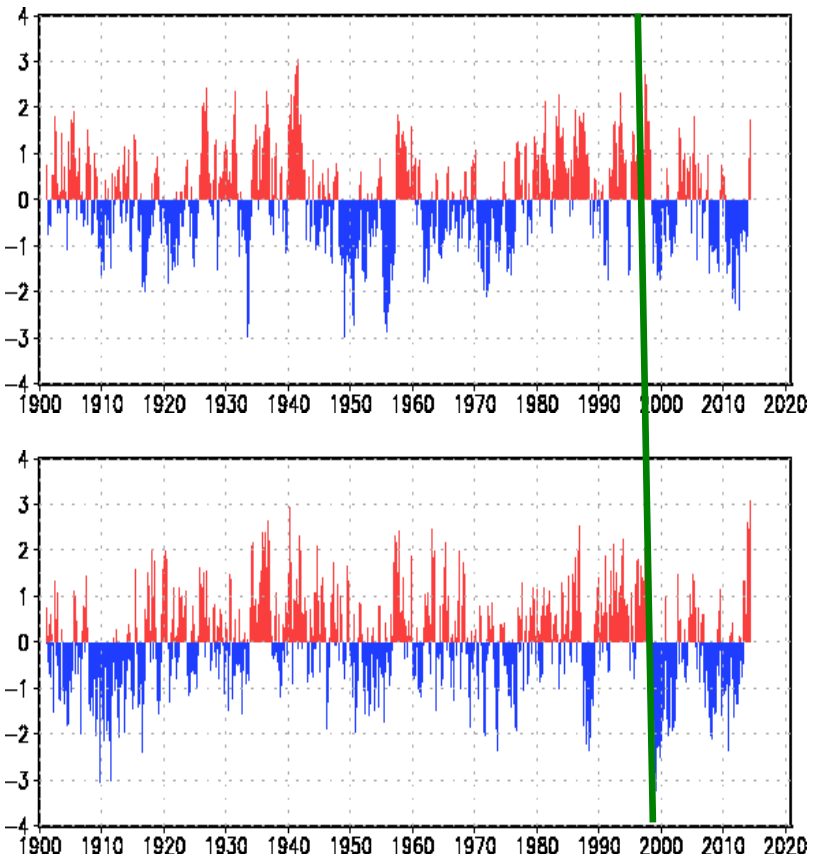
気象庁
Japan Meteorological Agency

Decadal variabilities in the North Pacific

EOF 1st (PDO) and 2nd (NPGO) patterns



PDO and NPGO index



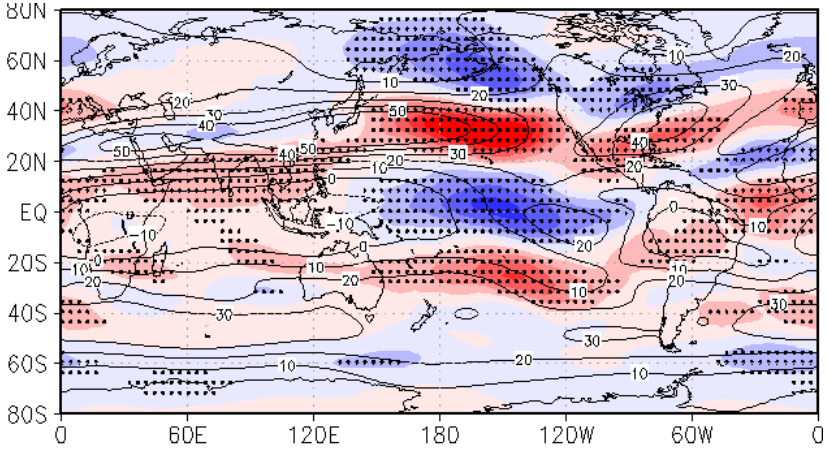
Negative phase is dominant since the late 1990s

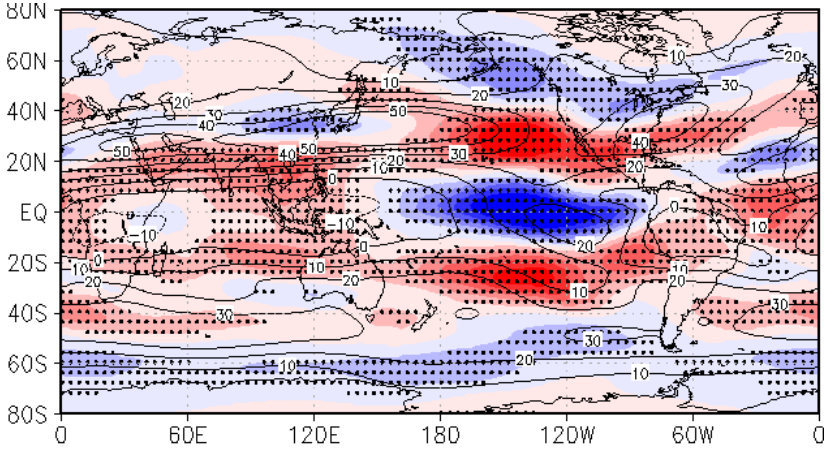
ENSO / PDO Effect

Zonal Wind (200hPa) anomaly regressed on PDO index

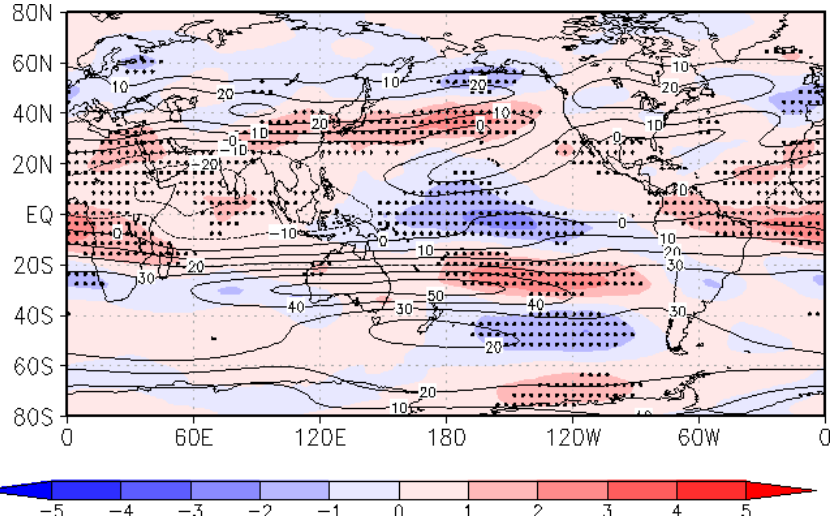
Zonal Wind (200hPa) anomaly regressed on NINO.3 index

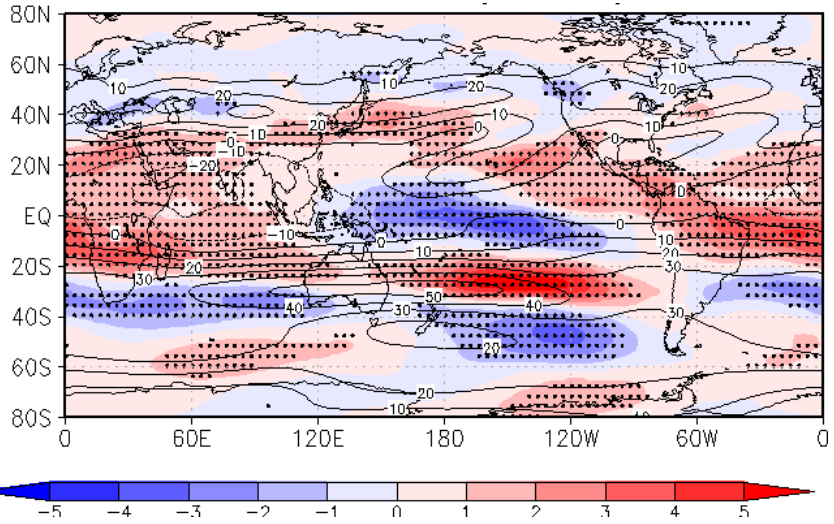
Winter





Summer





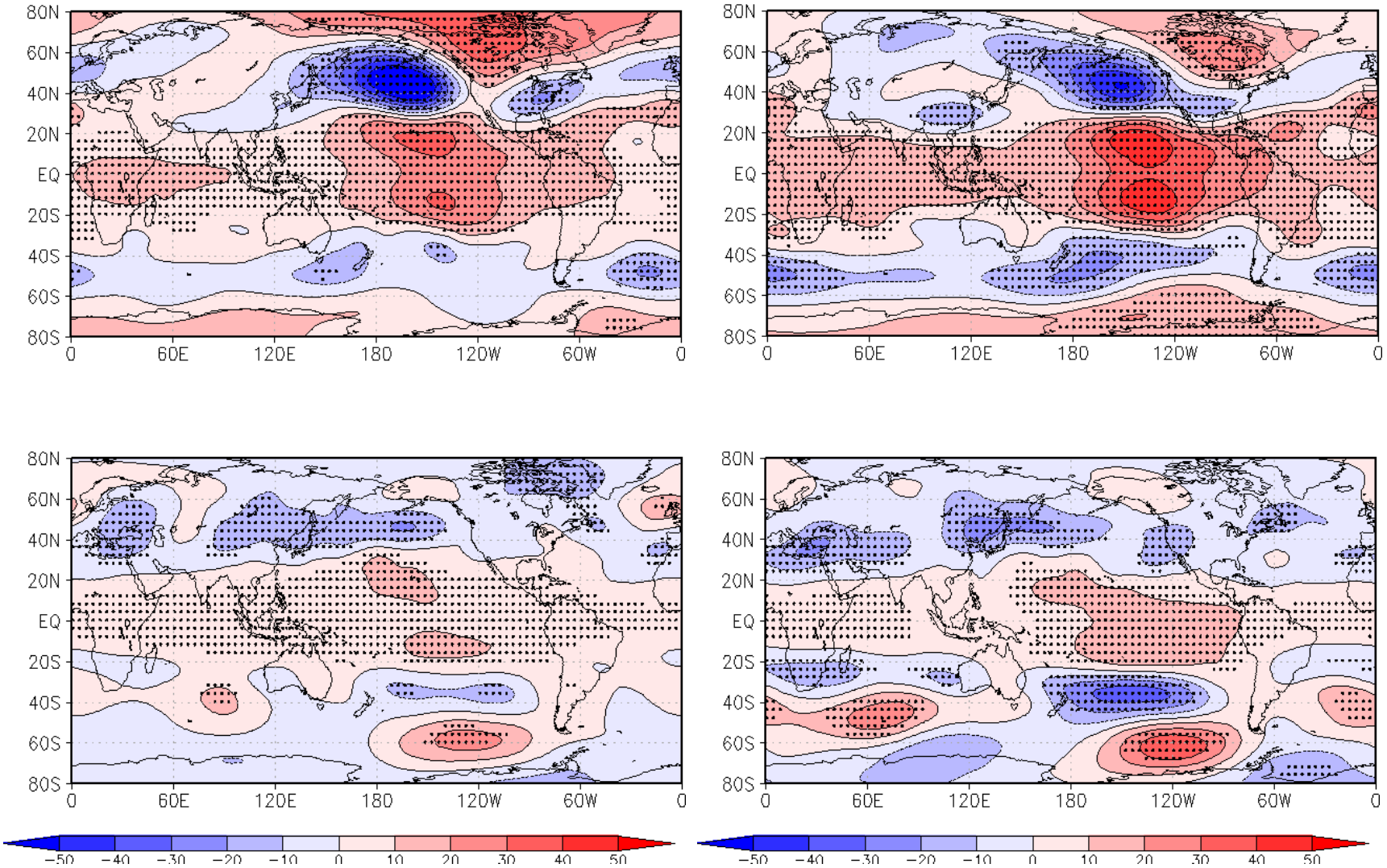
ENSO / PDO Effect

Z200 anomaly regressed on PDO index

Z200 anomaly regressed on NINO.3 index

Winter

Summer

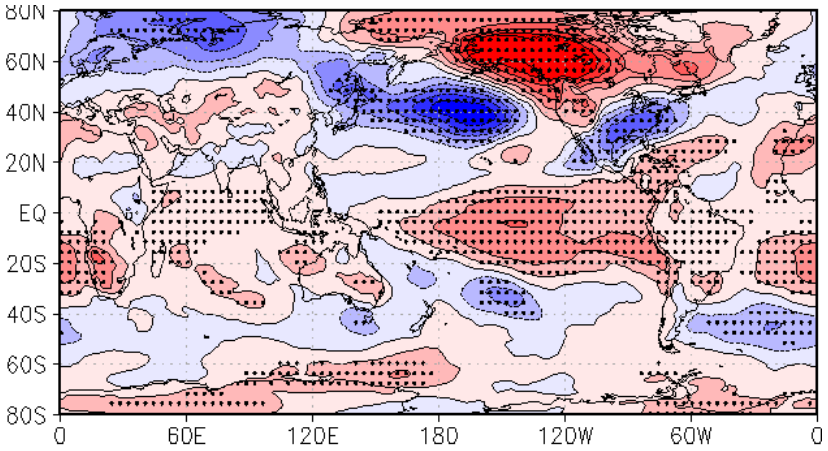


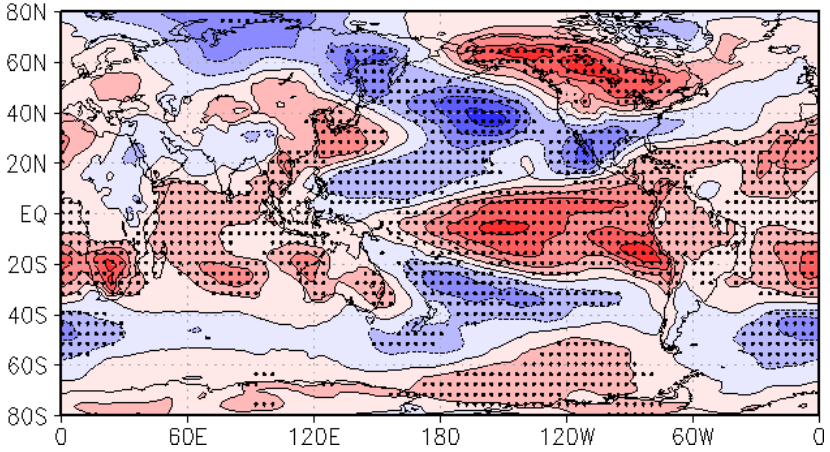
ENSO / PDO Effect

Temperature (850hPa) anomaly regressed on PDO index

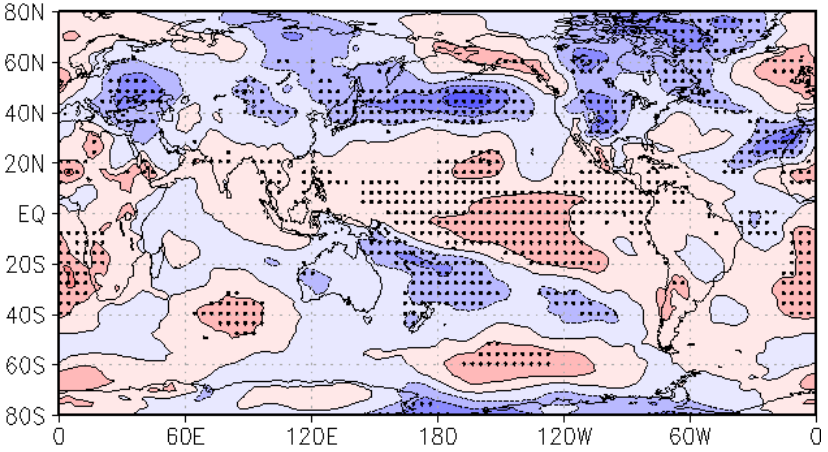
Temperature (850hPa) anomaly regressed on NINO.3 index

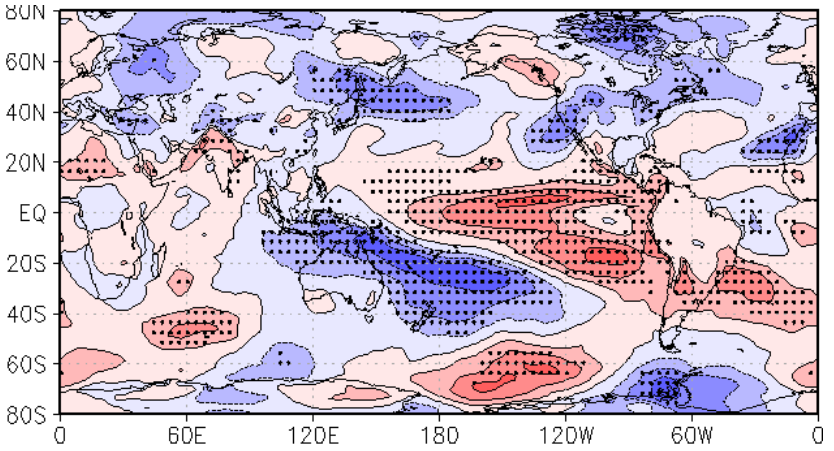
Winter

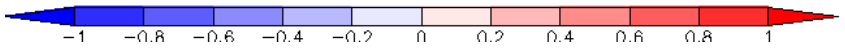


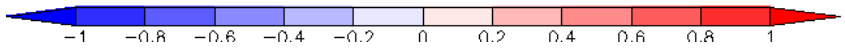


Summer



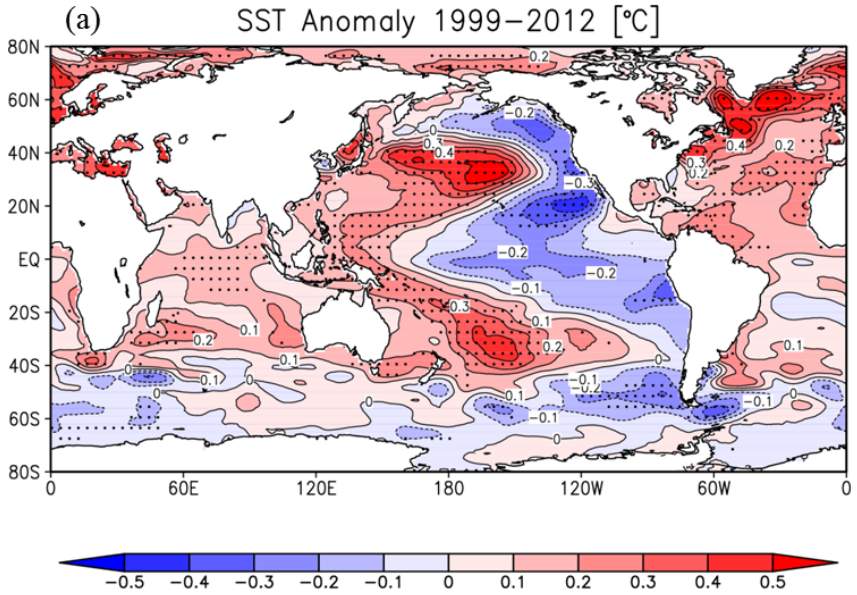




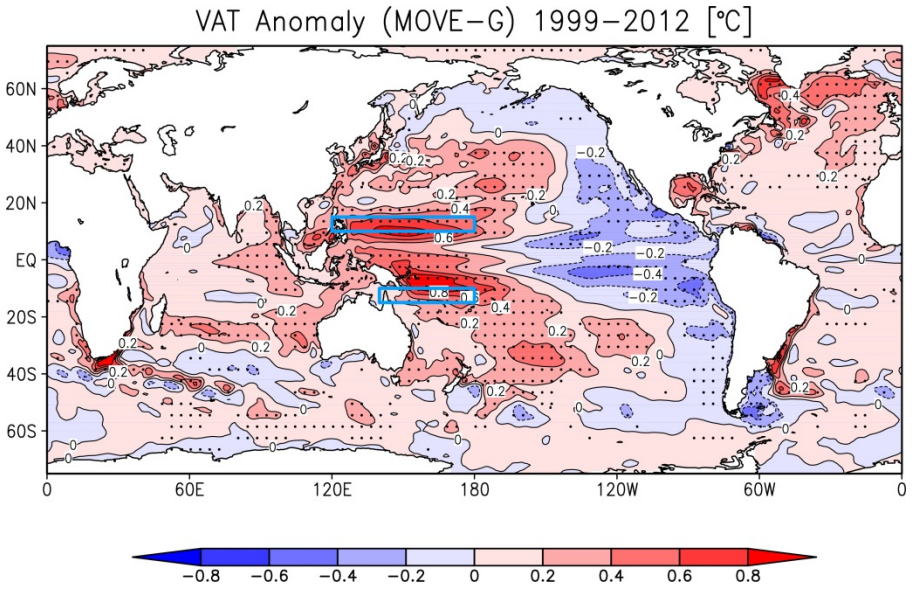


SST/OHC

SST Anomaly



OHC* anomaly

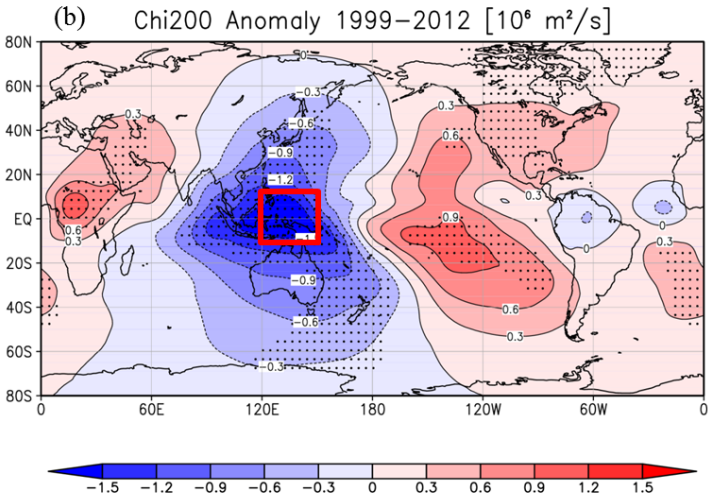


* Temperature averaged from surface to depth of 300m.

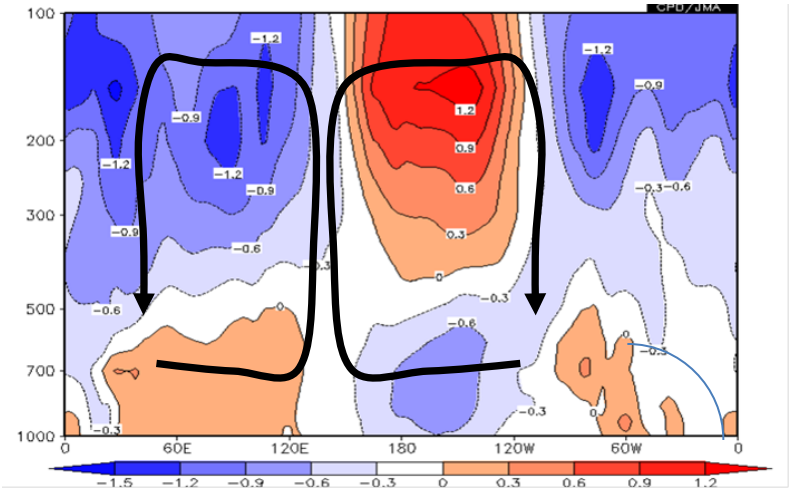
Urabe and Maeda(SOLA, accepted)

Walker circulation

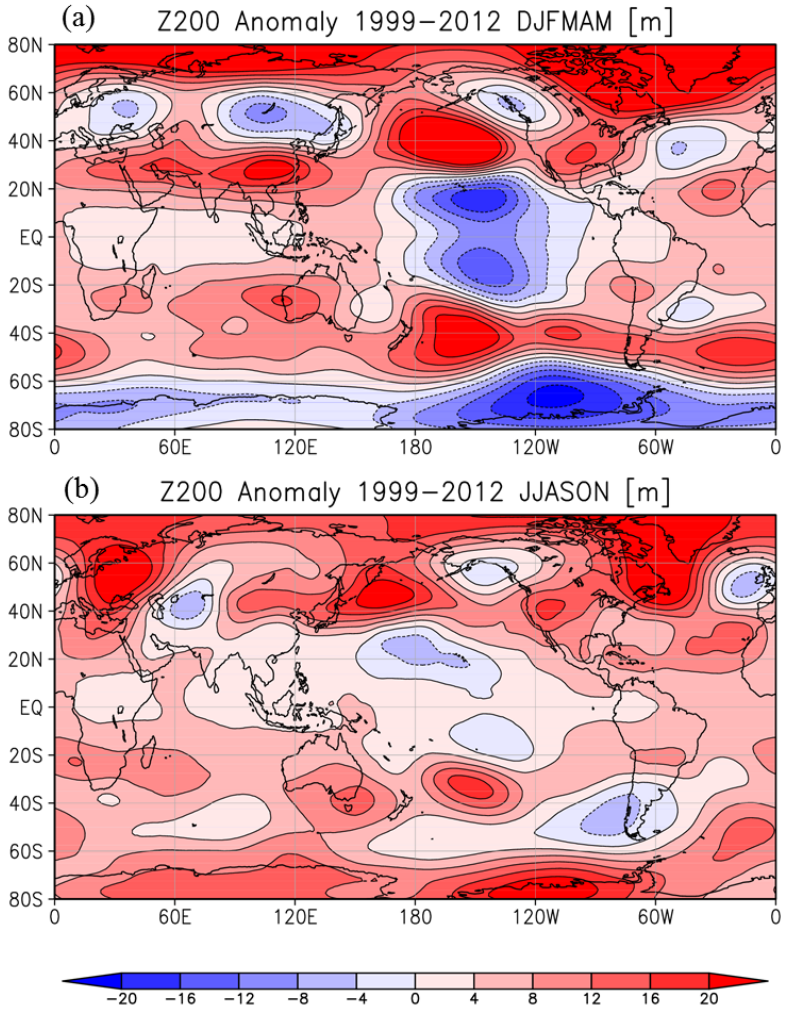
Chi200 anomaly



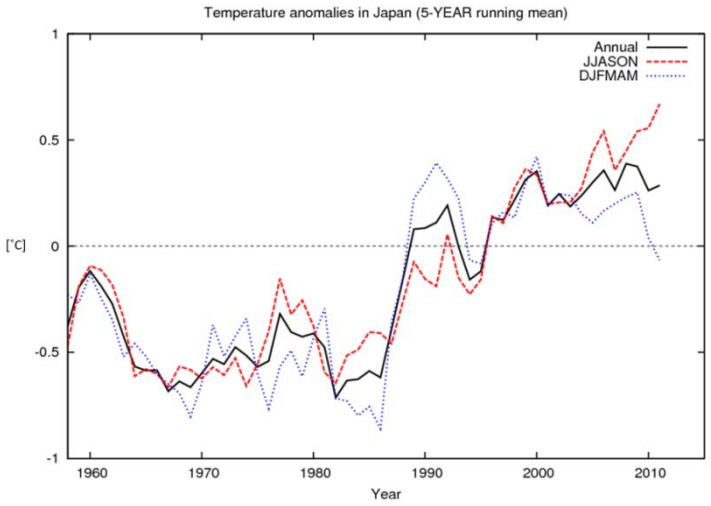
Zonal wind anomaly along EQ.

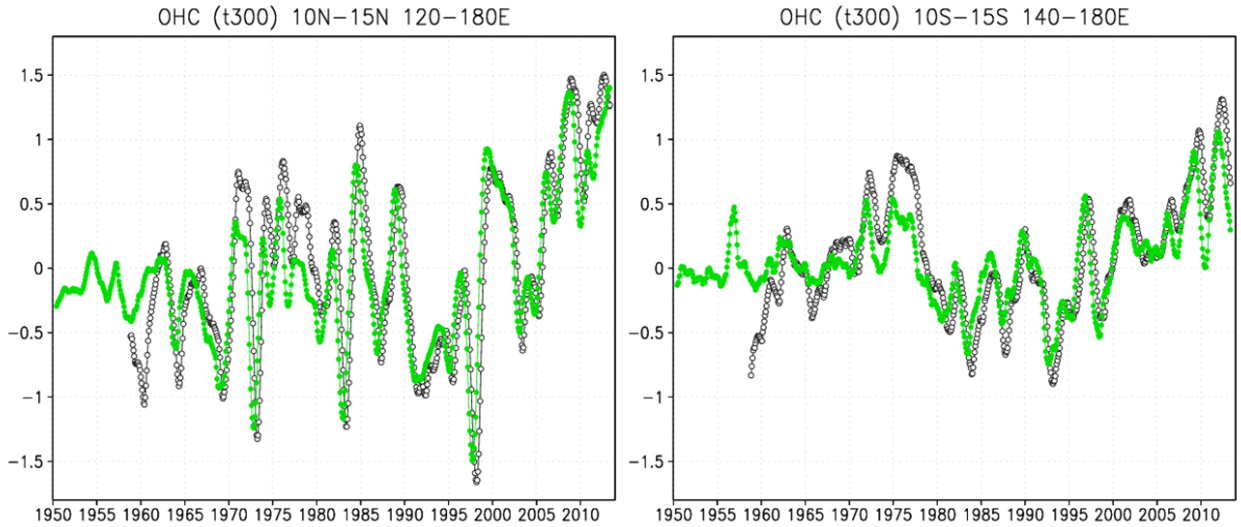


Z200 anomaly



Time series of Japan's temperature and OHC in the western tropical Pacific





Time series of OHC anomaly averaged for (left) 10˚N – 15˚N, 120˚E – 180˚E and (right) 10˚S – 15˚S, 140˚E – 180˚E as calculated using MOVE-G (black) and objective analysis by Ishii and Kimoto (2009) (green). These regions correspond approximately to the area in which strong positive OHC anomalies are observed

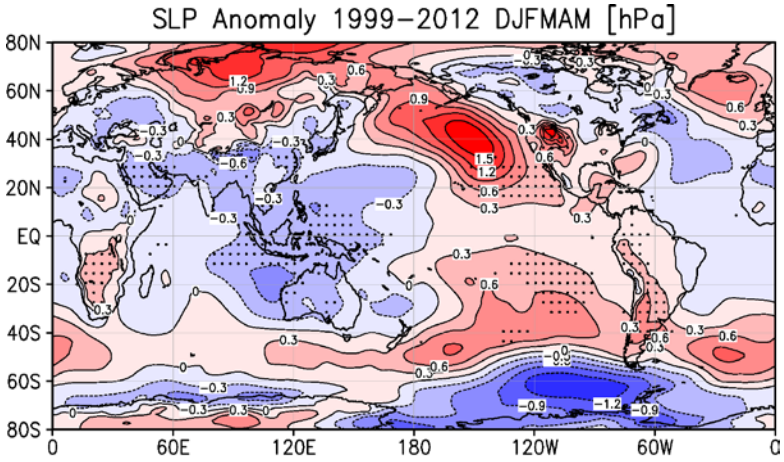
Urabe and Maeda(SOLA, accepted)

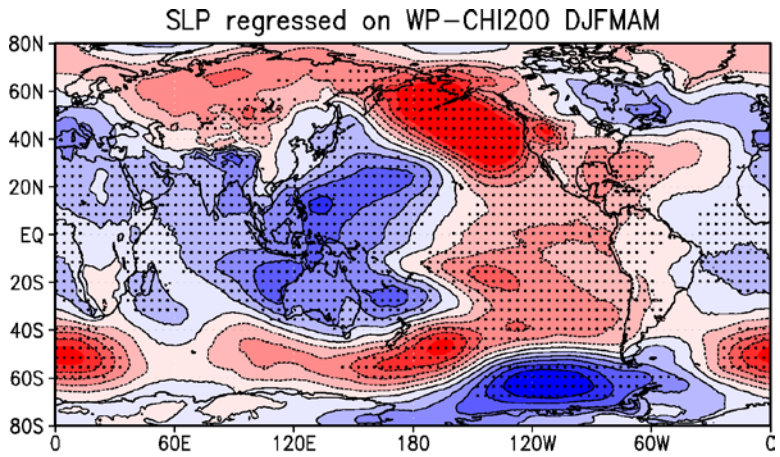
Influence from tropical area on SLP

SLP Anomaly (1999 – 2012)

SLP anomaly regressed on CHI200 around the Maritime-Continent [1959-2013]

Winter – Spring





Summer – Autumn