W70A

Seasonal Forecast System of Japan Meteorological Agency: Anomalous hot summer 2010 in Japan and its relationship to the tropical SST

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1. Introduction

See also a companion poster, Takaya et al. (W24A)

In 2010, Japan experienced its hottest summer in more than 100 years (Fig.1). There occurred a long living of the blocking high over Europe and a Pakistan flood (Dole et al. 2011, Hong et al. 2011). The La Niña event rapidly developed following the El Niño event and Sea Surface Temperature (SST) is anomalously warmer in the Indian and Atlantic Oceans (Fig.3b).

This study show that the seasonal forecast system of Japan Meteorological Agency (JMA) can predict the hot summer 2010 in Japan. Additional forecast experiments suggested that abnormal SST anomalies in the tropical Atlantic Ocean could cause the hot summer in Japan.

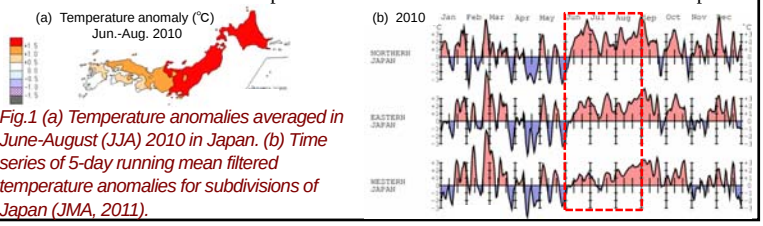


Fig.1 (a) Temperature anomalies averaged in June-August (JJA) 2010 in Japan. (b) Time series of 5-day running mean filtered temperature anomalies for subdivisions of Japan (JMA, 2011).

2. Seasonal Forecast Experiment

JMA/MRI-CGCM (operational seasonal forecast system of JMA: Takaya et al. poster W24A)
- AGCM: JMA unified AGCM. Resolution: TL95L40
- OGCM: Meteorological Research Institute Community Ocean Model (MRI.COM) version 2.4
  - ・domain: 75S-75N (prescribed sea ice climatology) (Ishikawa et al. 2005)
  - ・resolution: 1º (lon.) x 0.3-1º (lat.) x 50 (vertical)
- Monthly mean momentum and heat flux corrections

Prediction ("CTRL" experiment)
- 7-month forecast started from 00Z and 12Z of 26-30th, April 2010 (10 members)
- Biases corrections : calculated using the results of seasonal experiments started from the end of April, 1979-2006.

Initial data
- Japanese 25-years ReAnalysis (JRA-25) / JMA Climate Data Assimilation System (JCDAS)
- MRI Ocean Data Assimilation System (MOVE/MRI.COM-G; Usui et al. 2006) (Onogi et al. 2007)

Analyzed data for verification
- atmospheric fields: JRA-25/JCDAS - SST: COBE-SST (Ishii et al. 2005)
- outgoing longwave radiation (OLR): NOAA (Liebmann and Smith, 1996)

3. Seasonal prediction for the boreal summer 2010

Figs.2 and 3 show that our seasonal forecast system can predict the hot summer in Japan and related atmospheric and ocean fields.
- an intensification and a westward spreading of the Pacific High (Figs.2b and 2c)
- active convections in the tropical Atlantic, Indian Ocean, and western Pacific (Fig.2d)
- SST patterns in the tropical Pacific corresponding to the La Niña event (Figs.3a)
- high anomalies of temperature at lower atmosphere and SST in the tropical Atlantic and Indian Ocean in addition to the midlatitude North Pacific (Figs.2a and 3a).

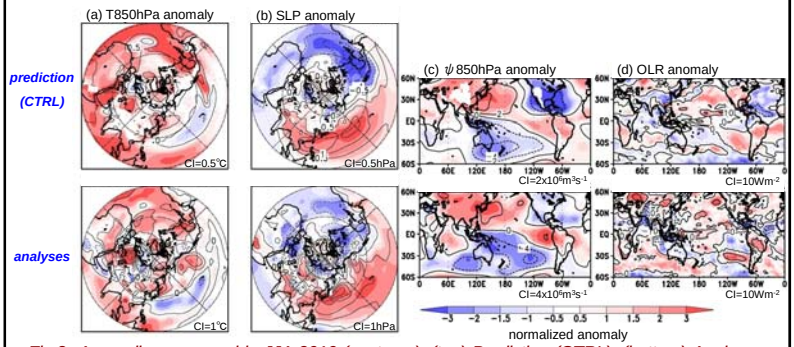
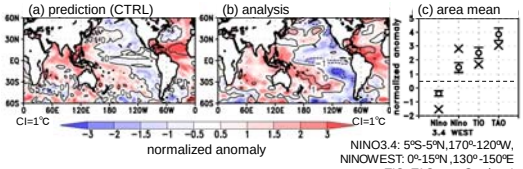


Fig.2 Anomalies averaged in JJA 2010 (contours). (top) Prediction (CTRL). (bottom) Analyses. (a) Temperature at 850hPa, (b) sea level pressure (SLP), (c) stream function at 850hPa , and (d) OLR. Colors indicate the anomalies normalized by the interannual standard deviation for JJA.



NINO3.4: 5ºS-5ºN,170º-120ºW,
NINOWEST: 0º-15ºN ,130º-150ºE
TIO, TAO: see Section 4
O: prediction with spread, X: analysis

Fig.3 (a) Predicted (CTRL) and (b) analyzed SST anomalies averaged in JJA 2010 (contours). Colors indicate SST anomalies normalized by the interannual standard deviation for JJA. (c) Area averaged normalized SST anomaly.

4. Response to the SST anomalies in the tropics

Tropical SST anomalies have a large impact on the global atmosphere and ocean (e.g., Alexander et al. 2002). In order to examine SST anomalies in which regions are important for the hot summer 2010 in Japan, we performed three additional forecast experiments that SST anomaly is prescribed to the analyzed one in the tropical regions (Table 1 and Fig.4).

TPAC experiment:	tropical Pacific (15ºS-20ºN, 125ºE-90ºW
TIND experiment:	tropical Indian Ocean (TIO: 15ºS-30ºN, 40º-100ºE)
TATL experiment:	tropical Atlantic Ocean (TAO: 15ºS-30ºN, 90ºW-20ºE)
CTRL experiment:	No constraint (the prediction shown in Section 3)

TATL experiment reproduce the atmosphere and ocean anomaly fields in CTRL experiment. SST warming in the tropical Atlantic during the boreal spring to summer changed the global convection system, intensifying the Pacific High. (See Figs.S1 and S2 to discuss the SST warming in the Indian and Atlantic Oceans in the boreal summer 2010.)

Table 1 Experimental designs. "2010": ocean initial conditions in the region is at the end of April 2010. "CLIM": ocean initial conditions in the region is climatology [1979-2006] of the end of April. "ANOM": model SST anomaly is prescribed to the analyzed one in the region. "CPLD": the atmosphere and ocean are coupled in the region. The atmospheric initial conditions at the end of April 2010 are used in all experiments.

		CTRL	TPAC	TIND	TATL
ocean initial condition in	Tropical Pacific Ocean	2010	2010	CLIM	CLIM
	Tropical Indian Ocean	2010	CLIM	2010	CLIM
	Tropical Atlantic Ocean	2010	CLIM	CLIM	2010
	Other area	2010	CLIM	CLIM	CLIM
sea surface during the experiment in	Tropical Pacific Ocean	CPLD	ANOM	CPLD	CPLD
	Tropical Indian Ocean	CPLD	CPLD	ANOM	CPLD
	Tropical Atlantic Ocean	CPLD	CPLD	CPLD	ANOM
	Other area	CPLD	CPLD	CPLD	CPLD

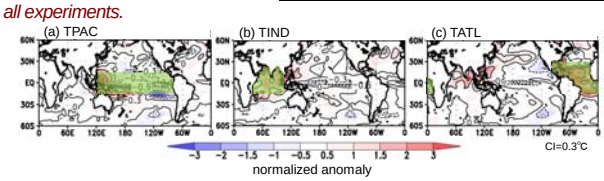
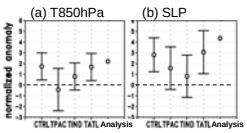


Fig.4 Same as Fig.3a but for (a) TPAC, (b) TIND, and (c) TATL experiments. The areas where SST anomaly is prescribed to the analyzed one are drawn in green.

Fig.5 Normalized anomalies of (a) temperature at 850hPa and (b) SLP in JJA 2010 averaged in the Japan area (30º-45ºN, 125º-145ºE). Error bars denote the spread of the ensemble prediction.



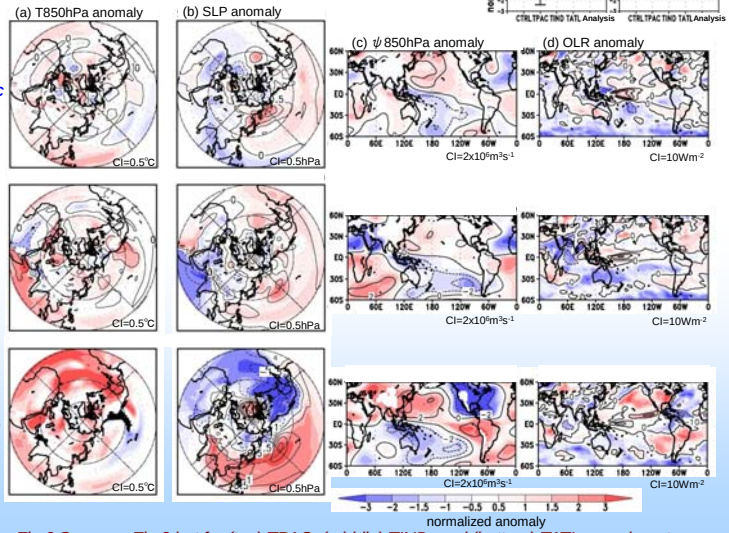


Fig.6 Same as Fig.2 but for (top) TPAC, (middle) TIND, and (bottom) TATL experiments.

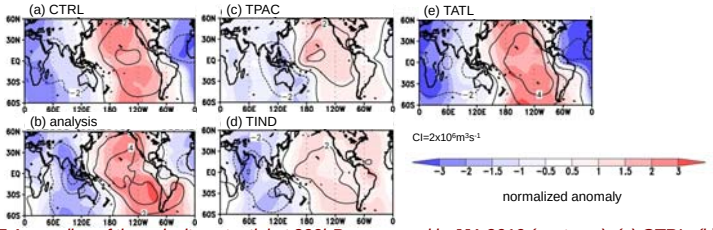


Fig.7 Anomalies of the velocity potential at 200hPa averaged in JJA 2010 (contours). (a) CTRL, (b) analysis, (c) TPAC, (d) TIND, and (e) TATL experiments. Colors indicate the anomalies normalized by the interannual standard deviation for JJA.

5. Summary

Seasonal Prediction for JJA 2010

- **The hot summer in Japan and related atmospheric and ocean anomalies can be predicted by the seasonal forecast system of JMA (Figs.2, 3 and 5).**

Role of SST anomalies in the tropical regions in the boreal summer 2010

a) Tropical Atlantic Ocean
- The SST warming in the Atlantic Ocean was caused by the abnormal negative NAO in 2009/10 winter (Fig.S1).
- **Abnormal SST warming in the tropical Atlantic Ocean during the boreal spring and summer changed the global convection system, which could contribute to the high temperature in Japan via an intensification of the Pacific High (Figs.4-7).**

b) Indian Ocean
- Since the 2009/10 El Niño was the Central Pacific El Niño /El Niño Modoki, response of Indian Ocean was different from that to the traditional El Niño (Fig.S2).
- It is suggested that the Indian Ocean Capacitor Effect which tends to cool Japan was weak in 2010 (Fig.S2).

c) Pacific Ocean
- Although a high convection in the western equatorial Pacific associated with the La Niña event influenced the hot summer 2010 in Japan, this contribution was considered to be smaller than that of the Atlantic SST anomalies.