Primary factors of cold winter 2011/2012 in East Asia

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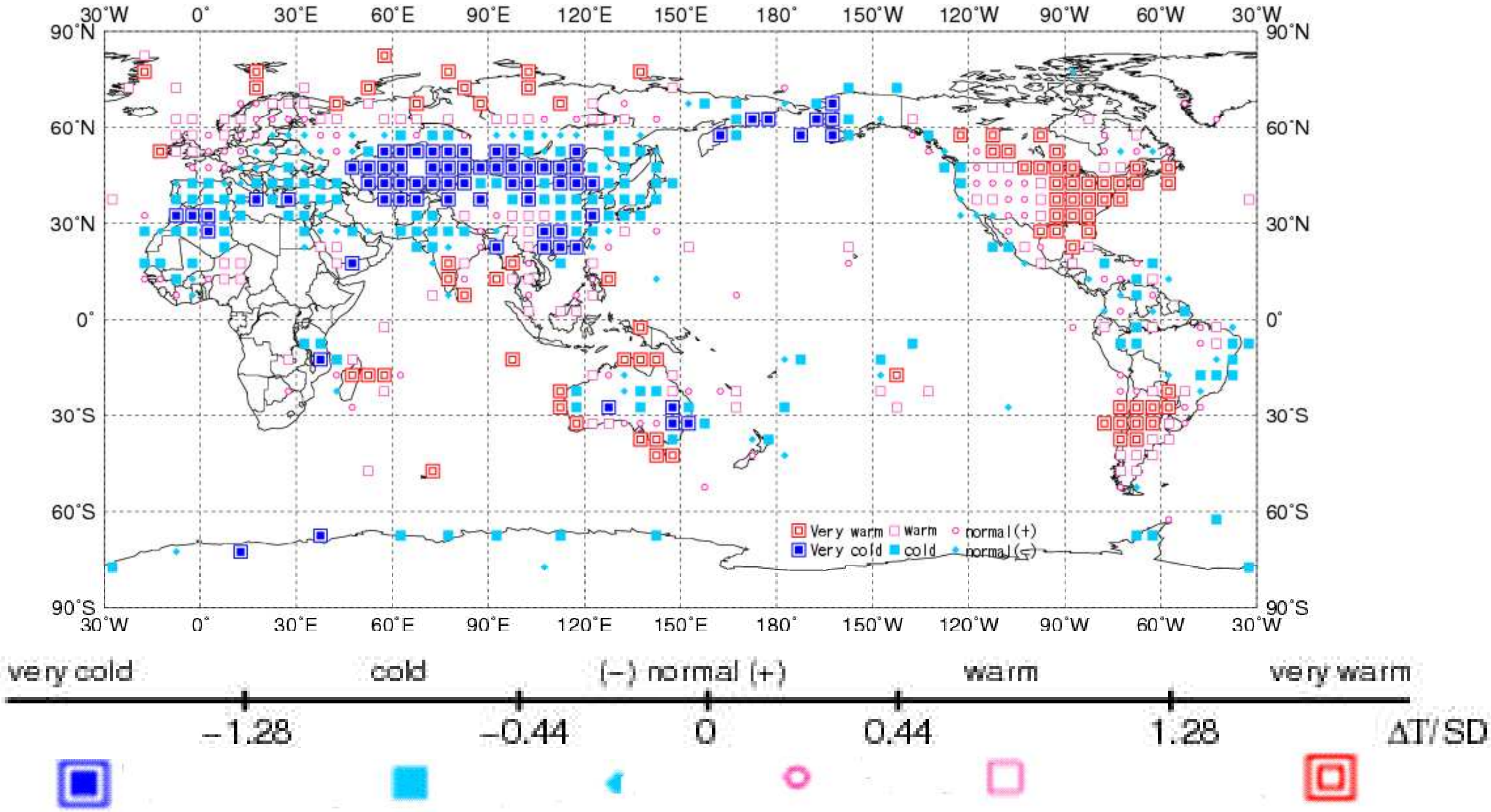
1.Introduction
(Characteristic atmospheric variation)

Seasonal mean normalized temperature anomalies in 2011/2012 winter(DJF)

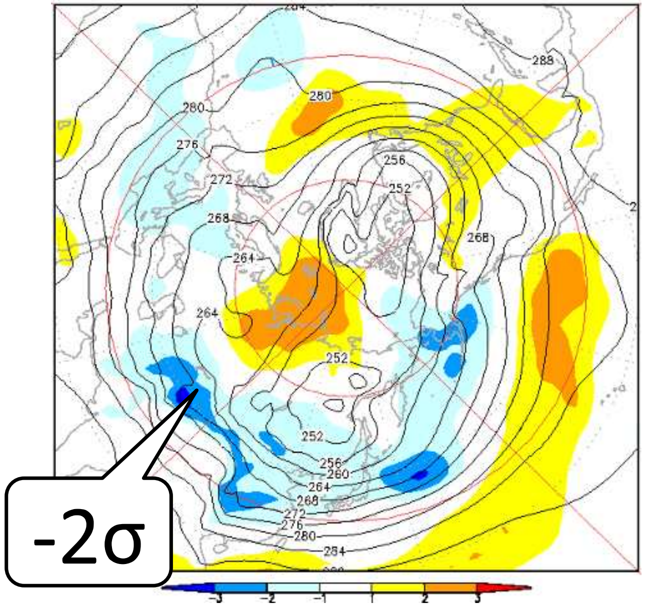


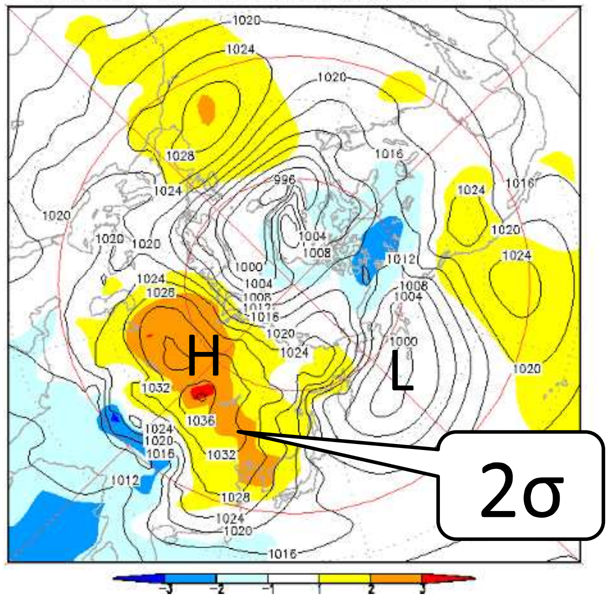
In wide areas over East and Central Asia, seasonal mean temperature anomalies for winter 2011/2012 were below normal

Strong Siberian High

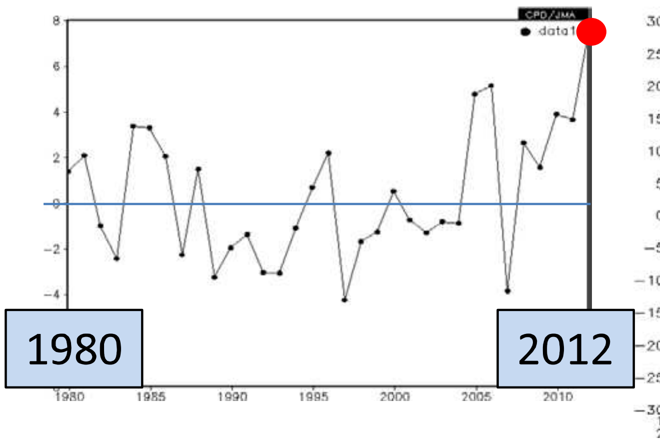
T850

SLP

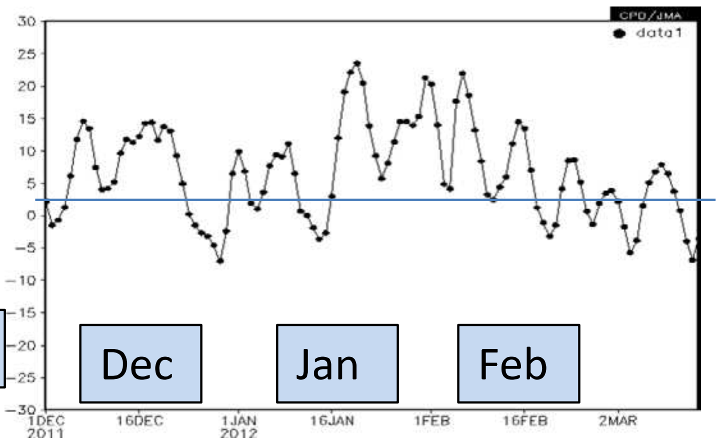




Seasonal Mean (DJF) T850 (left) SLP(right) and normalized anomaly in 2011/2012 winter



Area averaged (50N-60N,60E-120E) SLP anomalies in DJF from 1979/1980-2011/2012

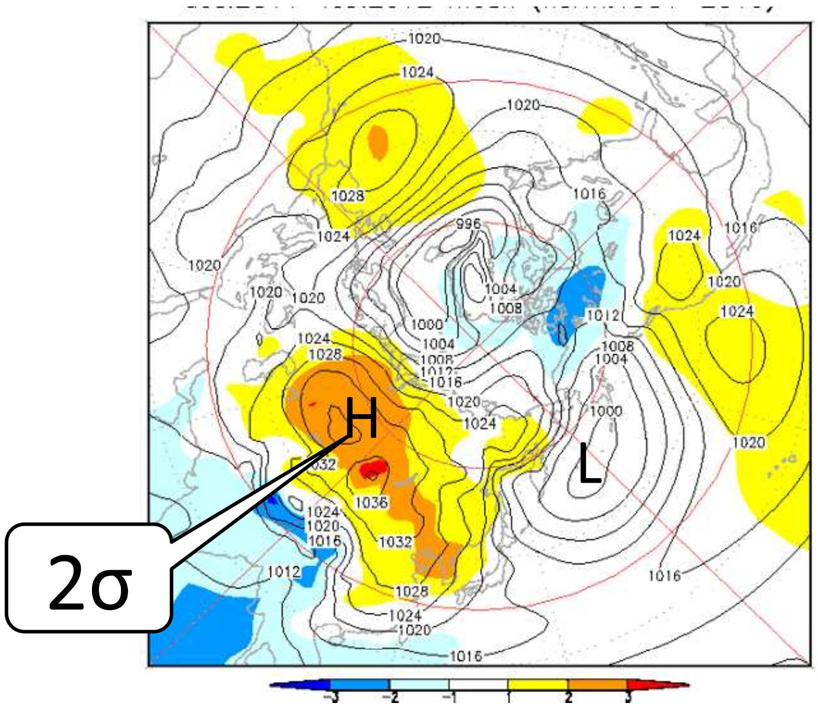


Area averaged (50N-60N,60E-120E) SLP anomalies from 1Dec 2011-15 Mar 2012

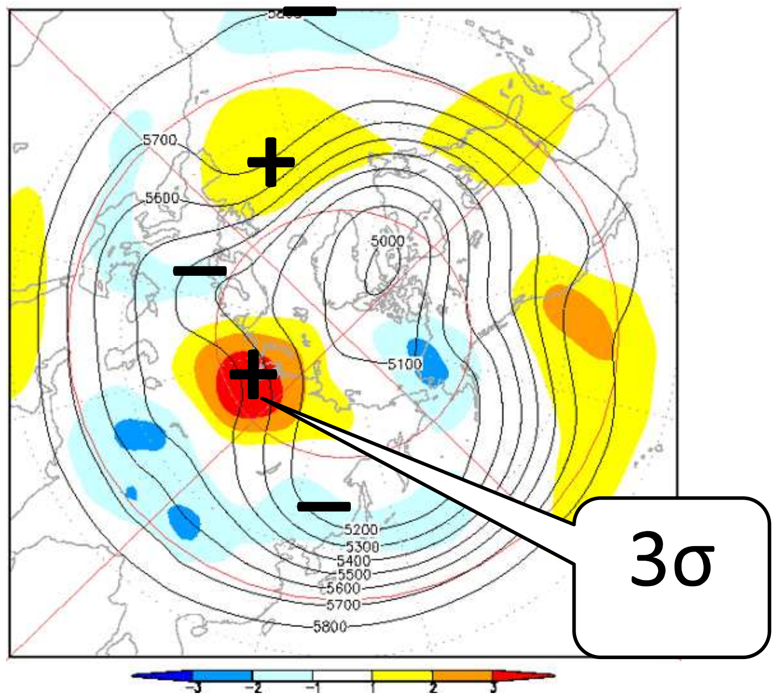
Cold air mass associated with the strongest Siberian High since 1979/1980 caused the long-lasting cold winter 2011/2012 in East and Central Asia

Significant meandering of Polar Front Jet

SLP



Z500

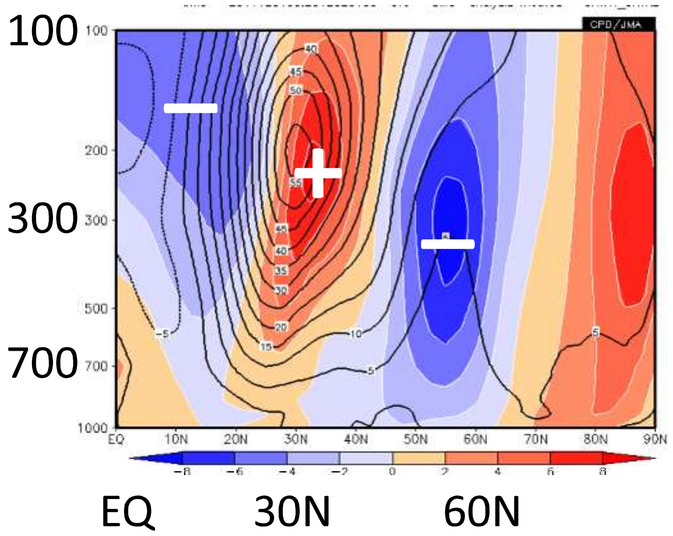


Seasonal Mean (DJF) SLP, Z500 and normalized anomalies in 2011/2012

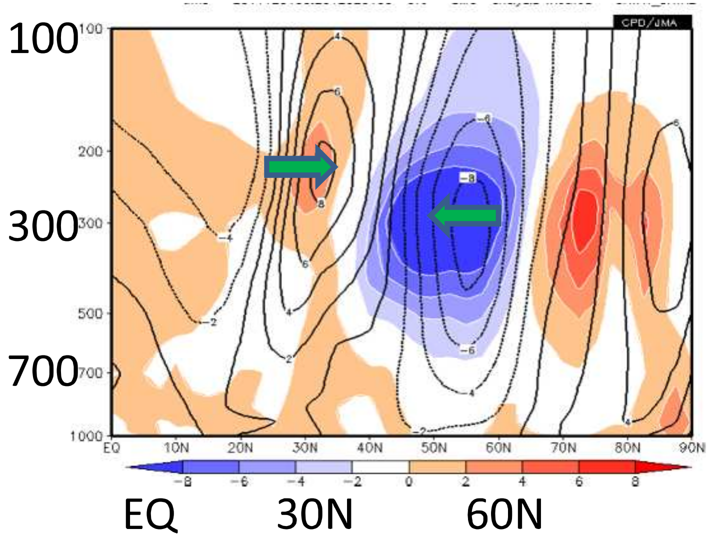
A distinct ridge over western Siberia contributed to the enhanced Siberian High.

Strong Sub-tropical Jet over Eurasia

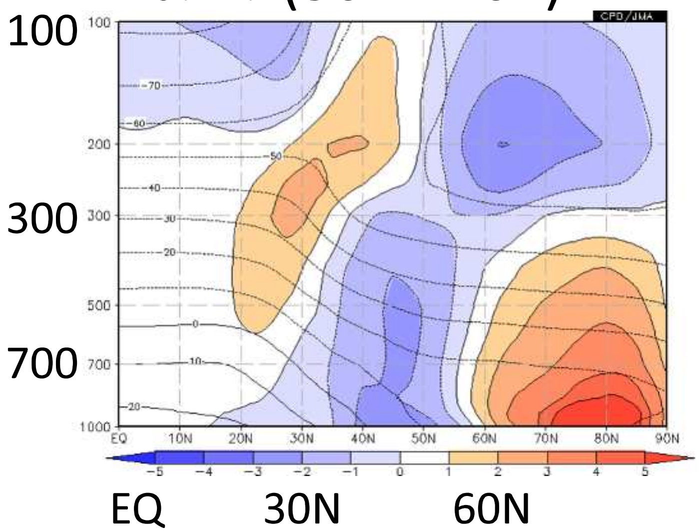
DJF U (30E-120E)



DJF U’V’ (30E-120E)



DJF T (30E-120E)



Zonal averaged (30E-120E) U and anomalies (upper left) , T and anomalies (lower left) , U anomalies and momentum flux anomalies by high-frequency eddies U’V’ (upper right) in DJF 2011/2012

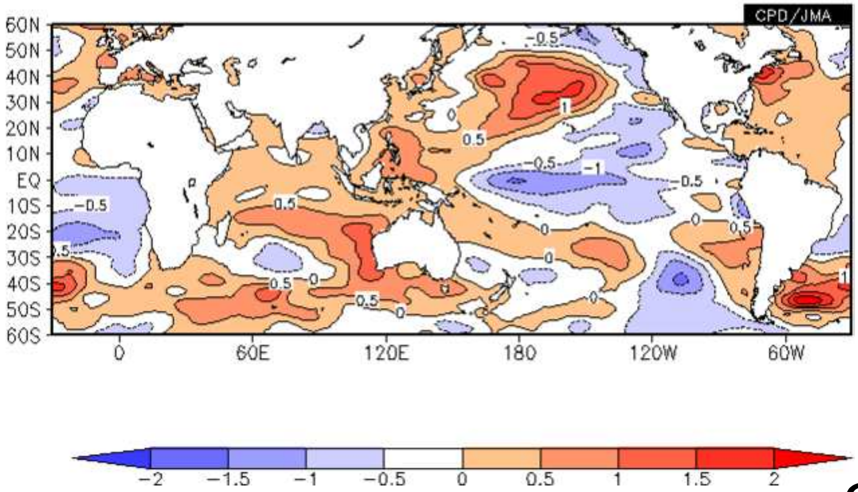
The strong sub-tropical jet, which was reinforced with weak northward momentum flux by eddies, also contributed to the cold winter

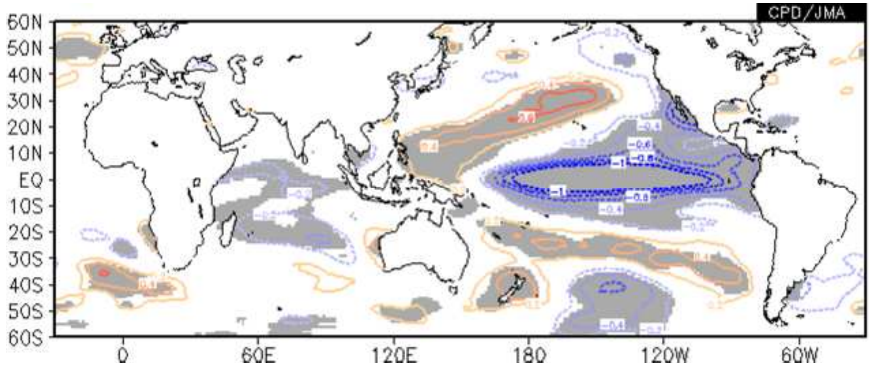
2. Direct influences of La Nina (External forcing)

Direct influences of La Nina on STJ

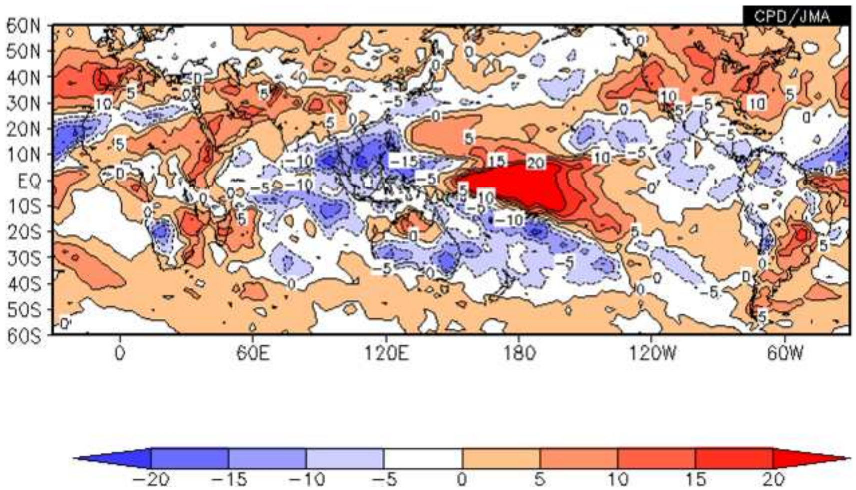
DJF 2011/2012 La Nina years composite

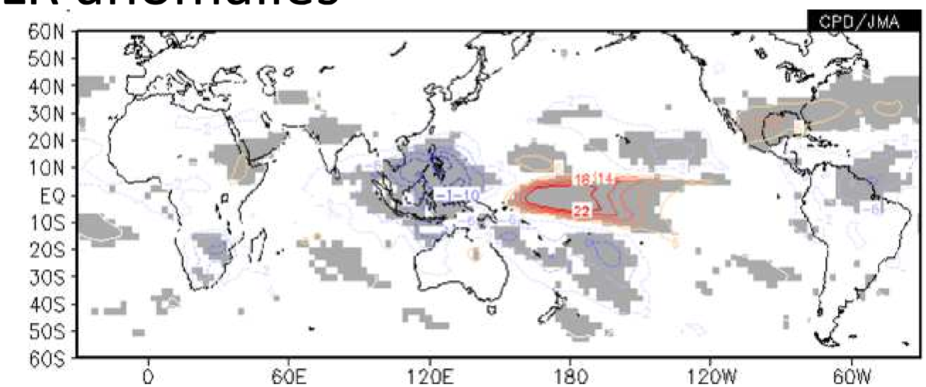
SST anomalies





OLR anomalies





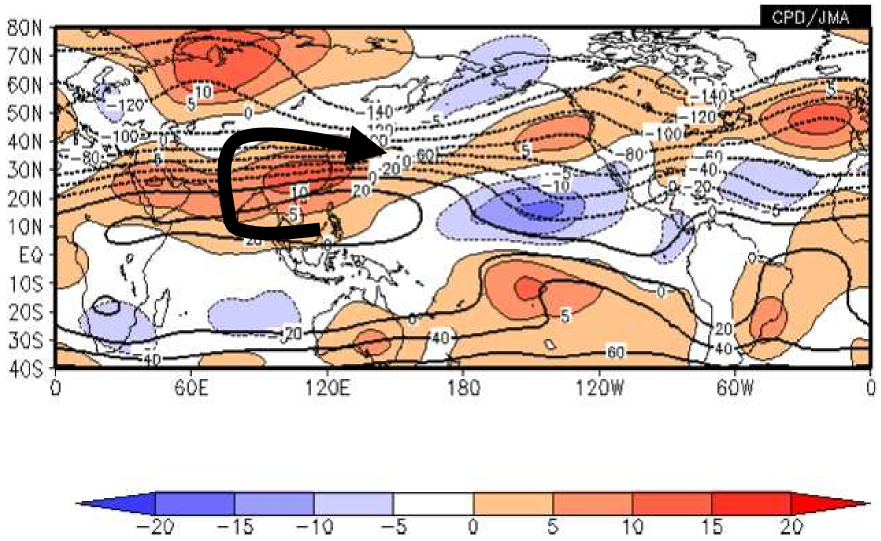
La Nina Years:1984/85, 1988/89, 1995/96, 1998/99, 1999/2000, 2005/6, 2007/8

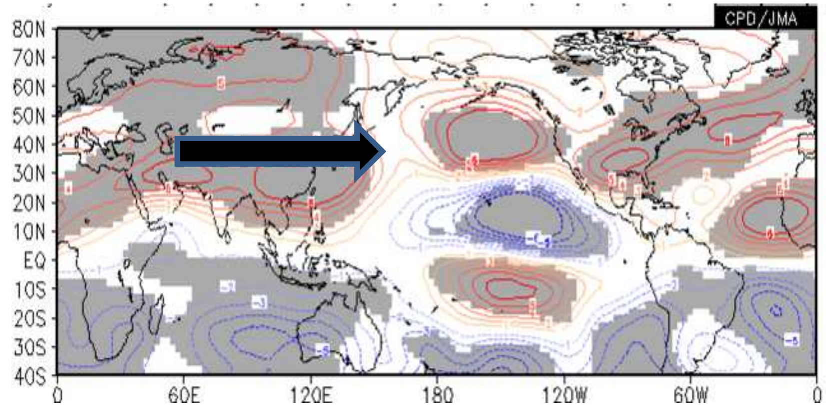
Shade : confidence level >90%

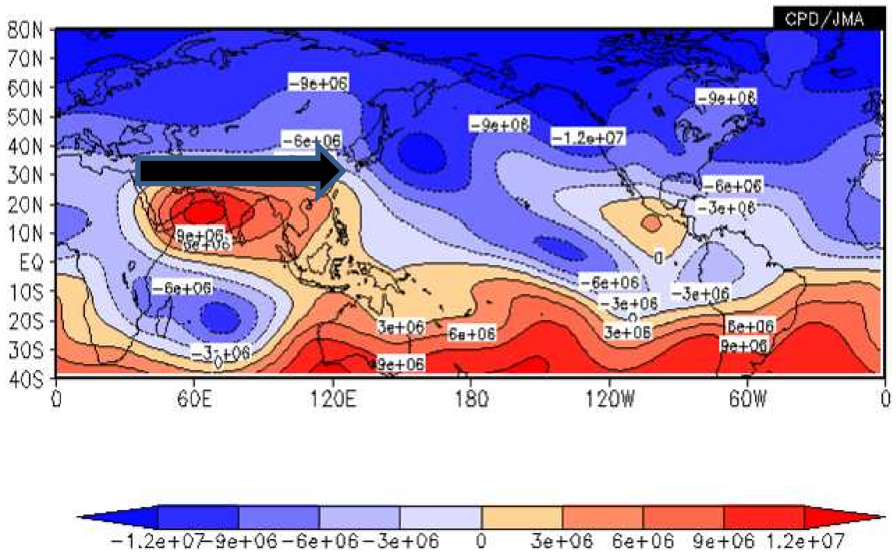
Direct influences of La Nina on STJ

DJF 2011/2012 — La Nina years composite

Stream function anomalies at 200hPa







LBM response to convective heating anomalies in the tropics (25S-25N) in DJF 2011/2012

La Nina

⇒ Heating anomalies in the tropics

⇒ Strong U in the sub-tropics

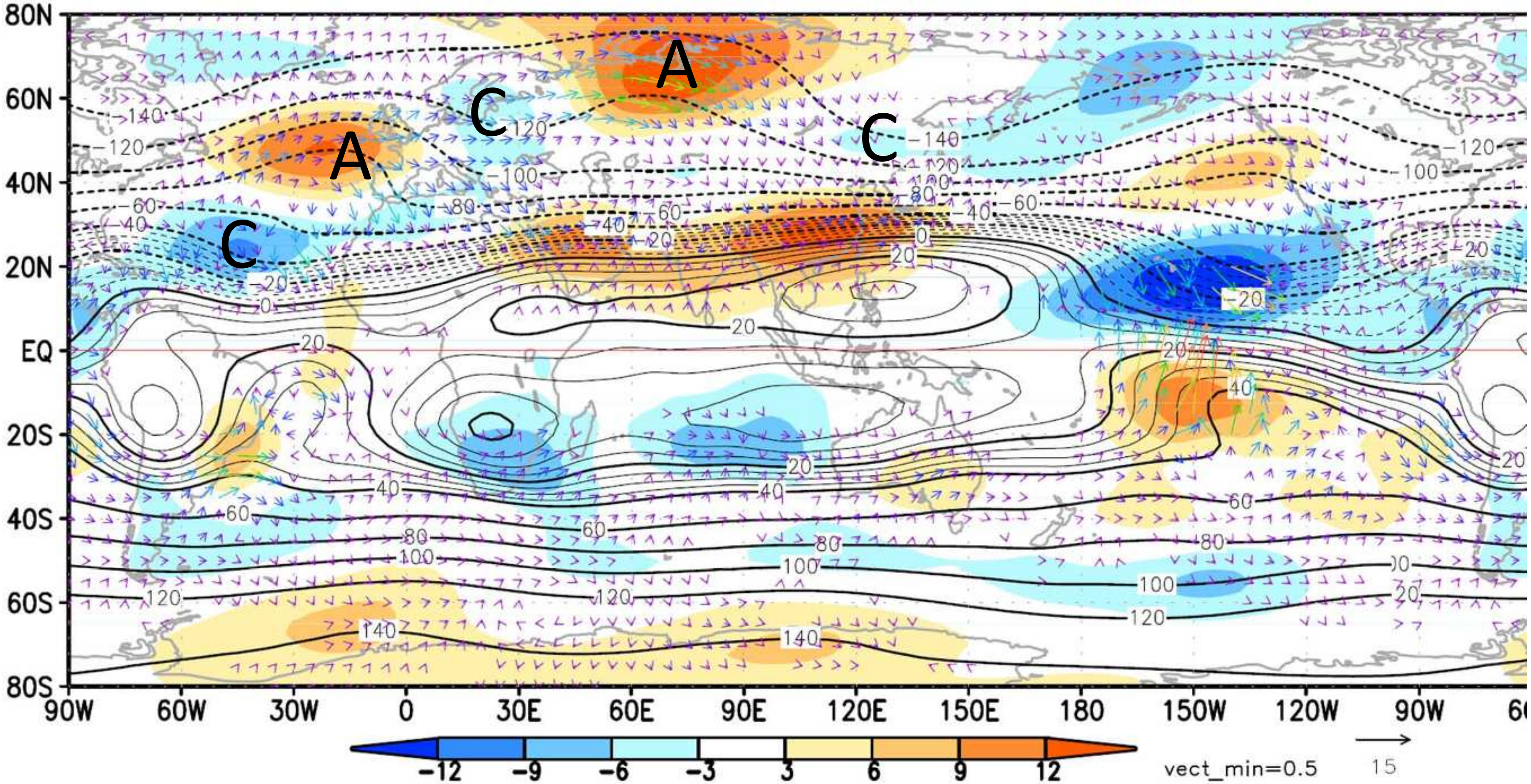
⇒ Eddies in the mid-latitude ??

⇒ Weak U in the mid-latitude

3.Influence of Tropical Atlantic SST Dipole (External forcing)

Significant meandering of Polar Front Jet

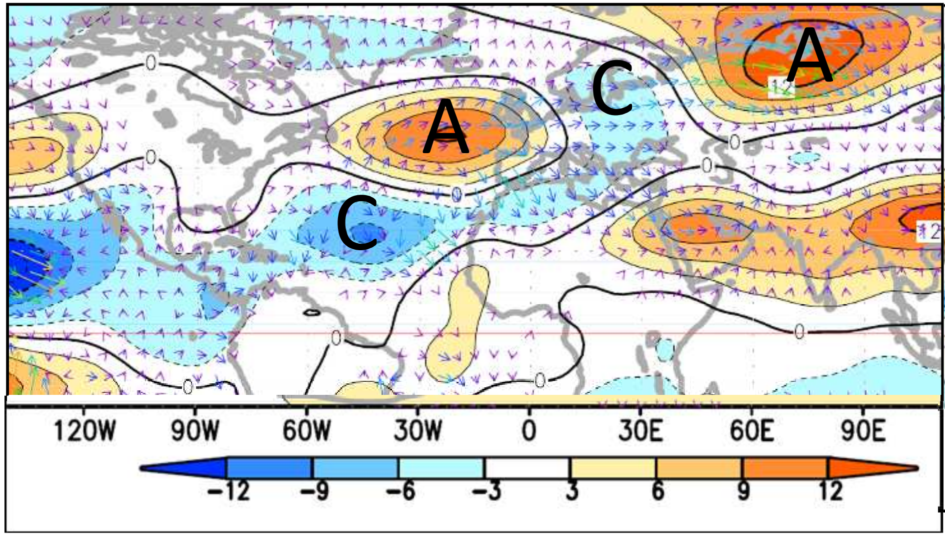
DJF 2011/2012 stream function, anomalies ,
wave activity flux(WAF) at 200hPa



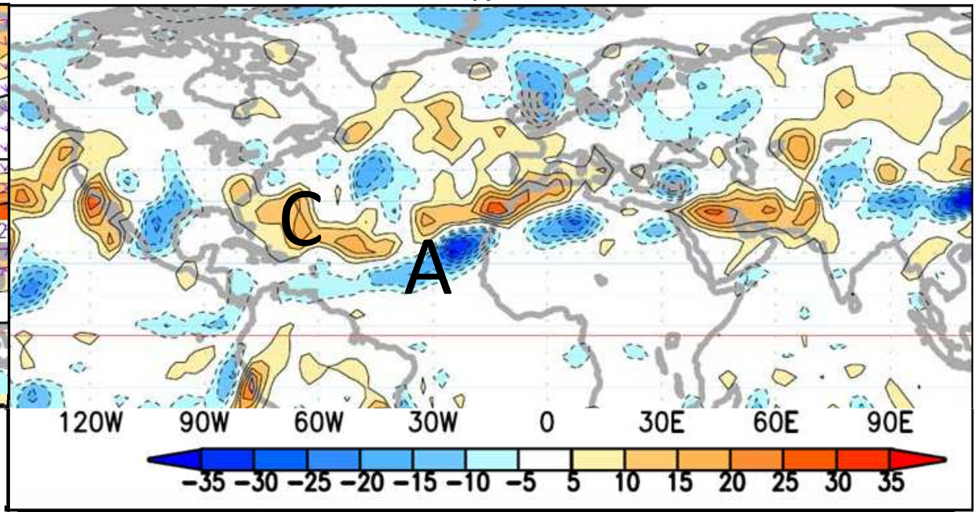
Meandering of Polar Front Jet associated with a Rossby wave train from the Atlantic

Rossby wave source over the Atlantic

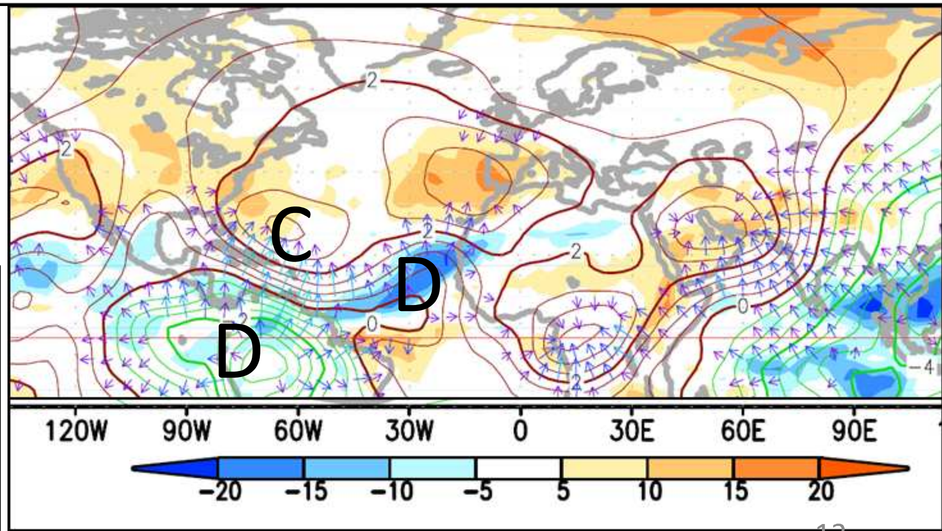
DJF 2011/2012 stream function anomalies and WAF at 200hPa



DJF 2011/2012 Rossby wave source (=- $\nabla(\mathbf{v}_\chi'(\overline{\zeta+f}))$ at 200 hPa



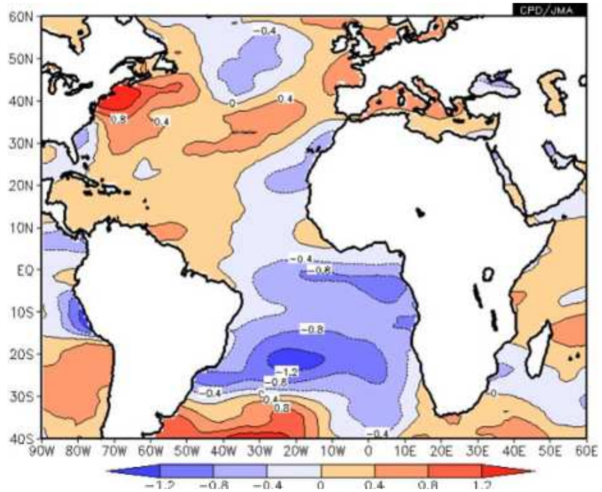
DJF 2011/2012 divergent wind anomalies at 200hPa and OLR anomalies



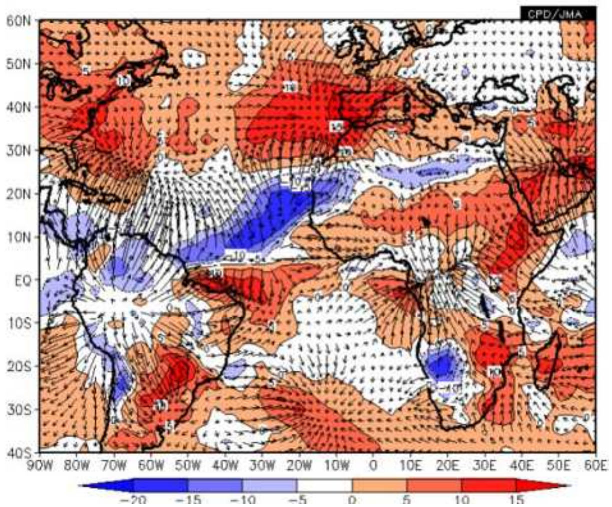
Rossby wave source over the Atlantic associated with upper level convergence may force the wave train.

Influence of Tropical Atlantic SST Dipole

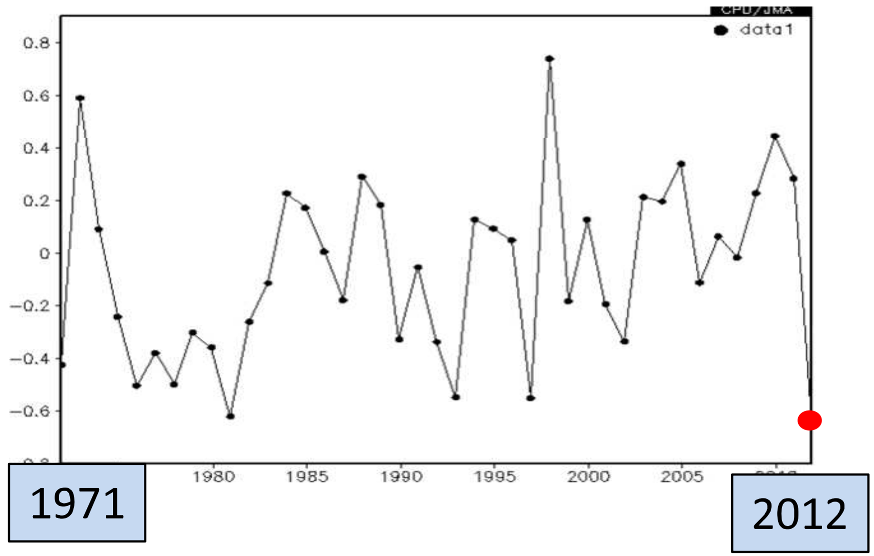
DJF 2011/2012 SST anomalies



DJF 2011/2012 OLR and 200hPa divergent wind anomalies



Area averaged(60W-20E,0-20S) DJF SST anomalies from 1971 to 2012

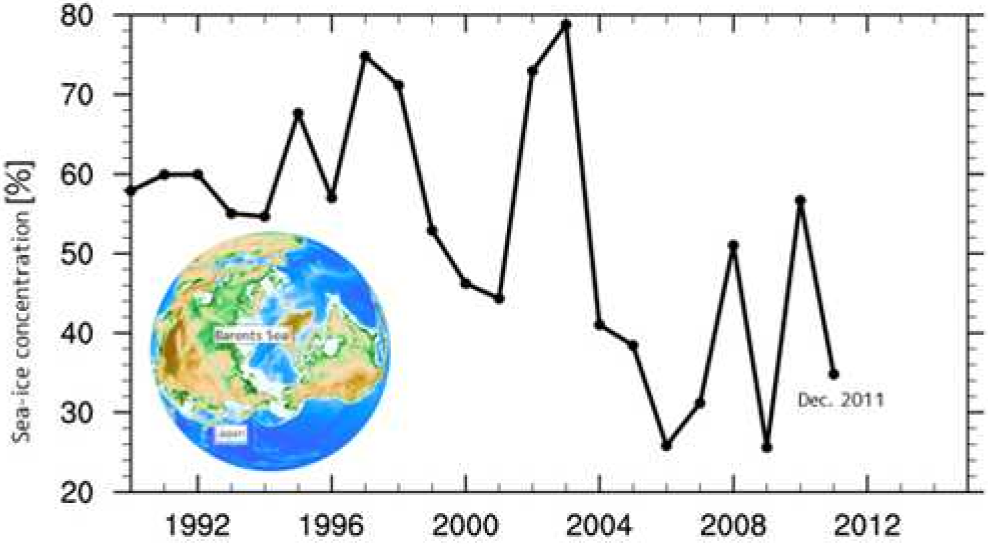


It is suggested that Meridional gradient of SST anomalies in the tropical Atlantic forced anomalous divergence flow in the upper troposphere which forced the Rossby wave train

4.Influence of Sea Ice in the Barents Sea (External forcing)

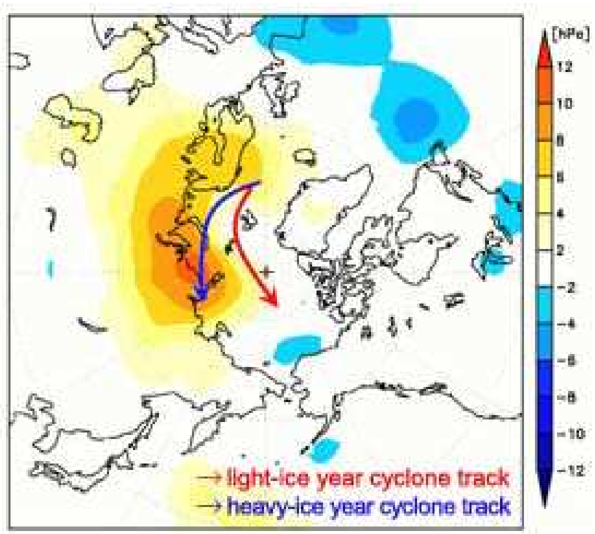
J. Inoue
Referred from JAMSTEC HP
http://www.jamstec.go.jp/j/about/press_release/20120201/

Inference of Sea Ice in the Barents Sea



Change in sea-ice cover in the Barents Sea during December from 1990 to 2011 (J. Inoue et. al., 2012)

Referred from JAMSTEC HP
http://www.jamstec.go.jp/j/about/press_release/20120201/

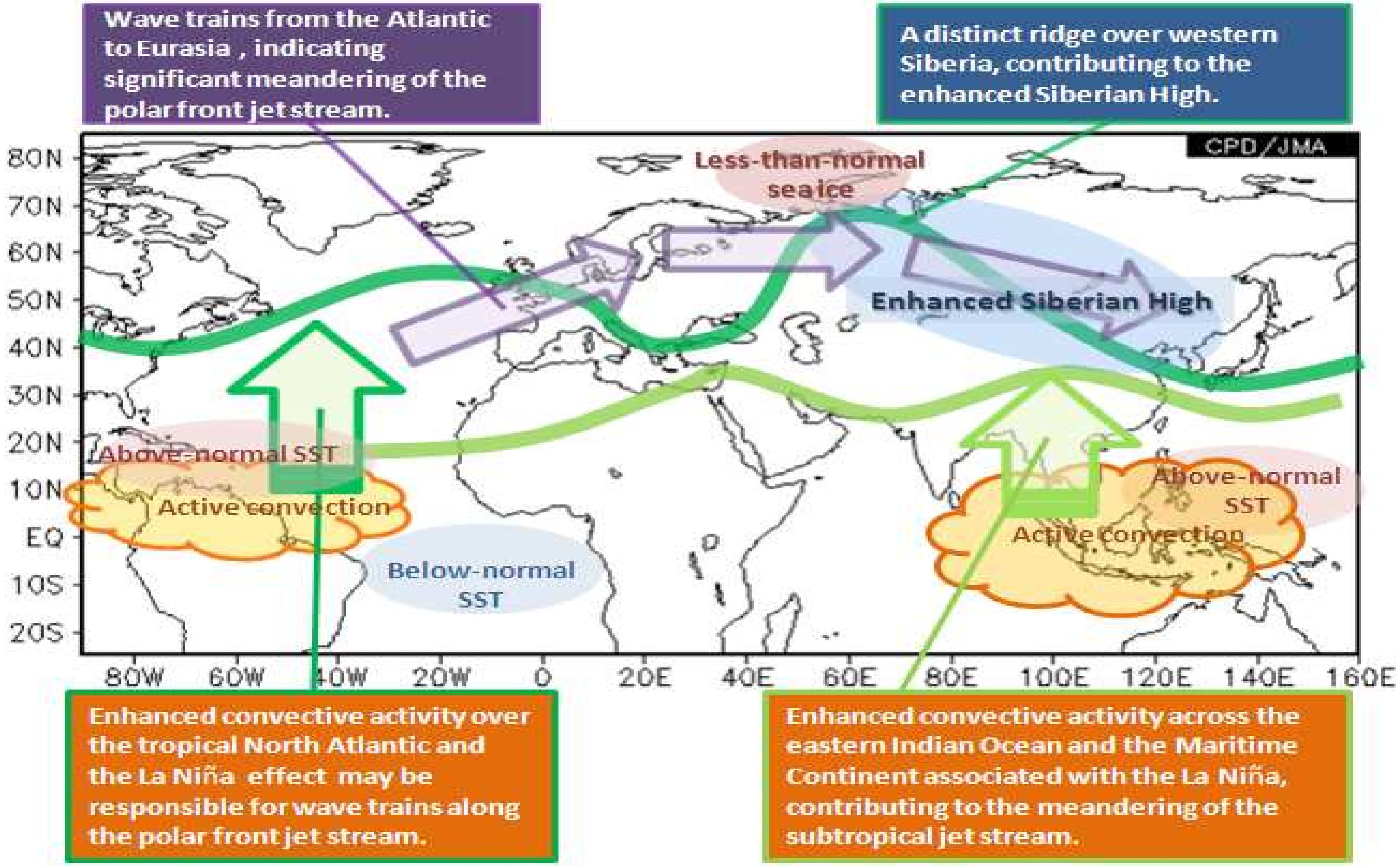


Sea-level pressure (hPa) anomaly and typical cyclone paths (Red arrow: light-ice year, Blue arrow: heavy-ice year). In the light-ice year, the cyclone path shifted northward and the Siberian High expanded up to the Arctic coast.

5.Summary

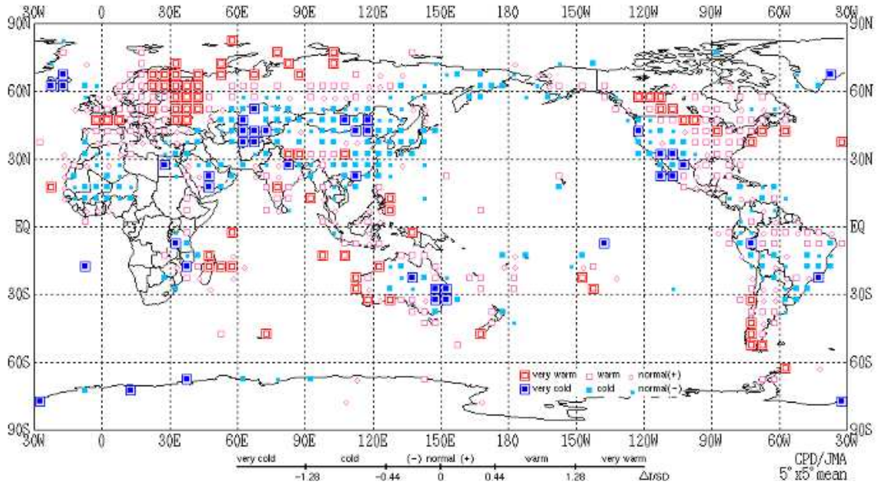
- Cold air mass associated with the strongest Siberian High since 1979/1980 caused the long-lasting cold winter 2011/2012 in East and Central Asia
- Meandering of polar front jet and strong sub-tropical jet in Eurasia contributed to the strong Siberian High and the cold winter
- The strong sub-tropical jet in Eurasia was forced by active convection near the Maritime continent (La Nina impact) and was reinforced with weak northward westerly momentum flux by eddies in the mid-latitude
- The Rossby wave train, which indicates meandering of polar front jet, might be forced by Tropical Atlantic Dipole SST
- The Siberian High also might be enhanced by below normal sea-ice cover in the Barents Sea

Schematic Charts issued by JMA with advices from "Advisory Panel on Extreme Climate Events

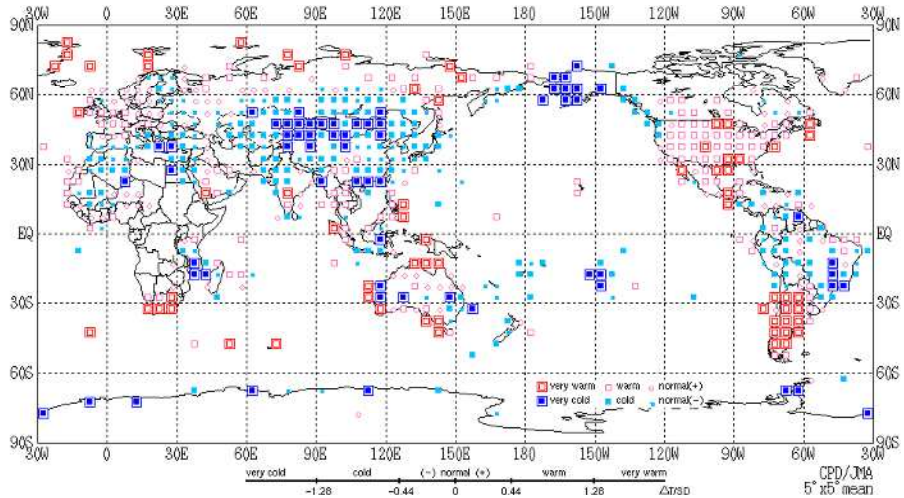


Monthly mean normalized temperature anomalies in 2011/2012 winter(DJF)

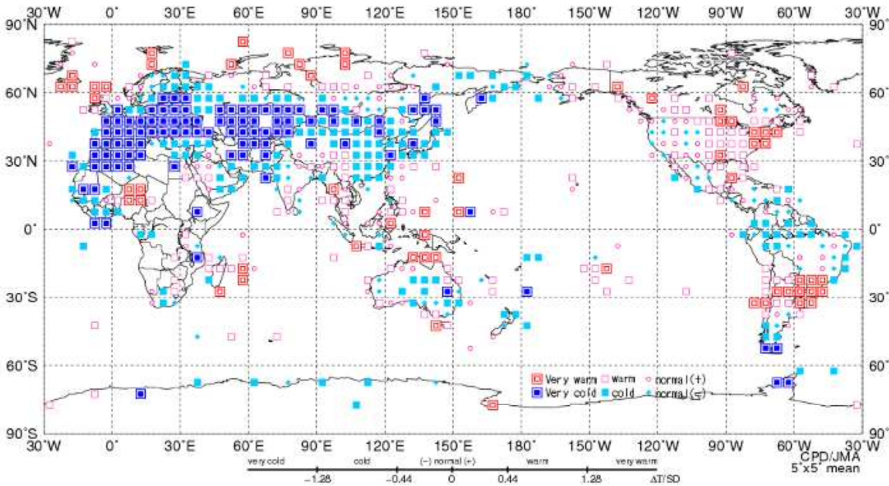
Dec.

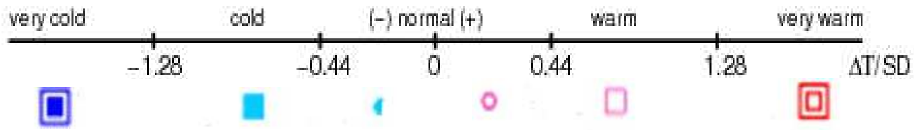


Jan.



Feb.



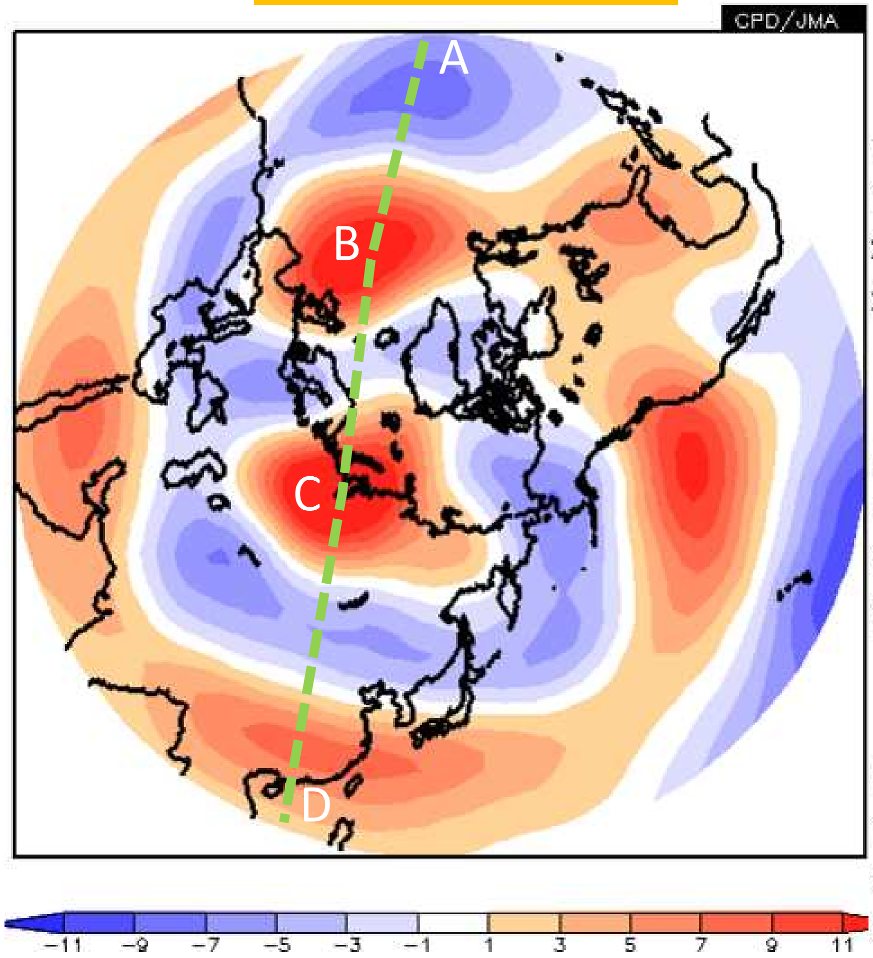


Wide areas over East and Central Asia experienced below-normal temperatures in consecutive three months from December 2011 to February 2012.

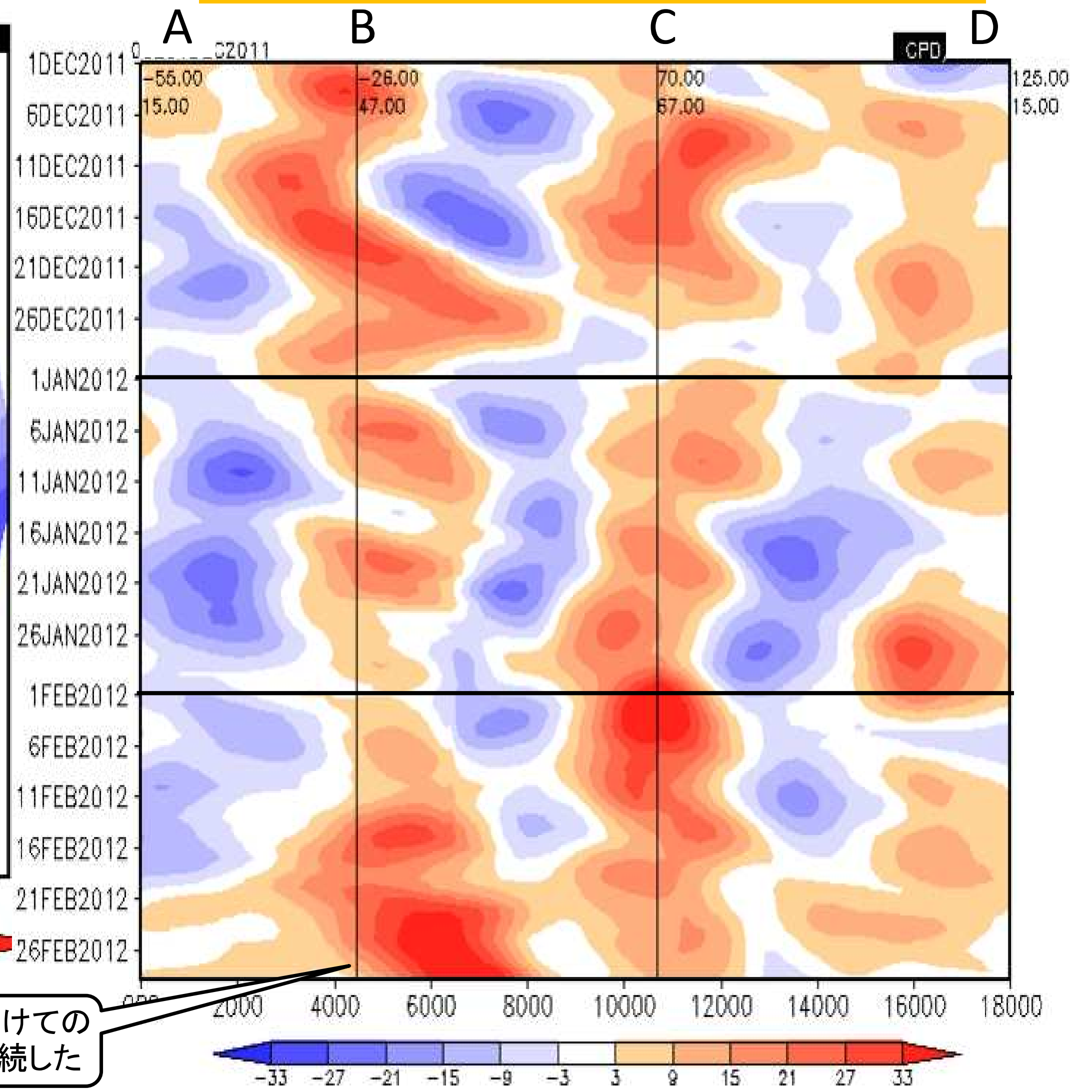
Long-lasting cold winter in East and Central Asia

Meandering PFJ

Ψ200偏差



Ψ200偏差 空間-時間断面
（切断面は左図参照; 5日移動平均）



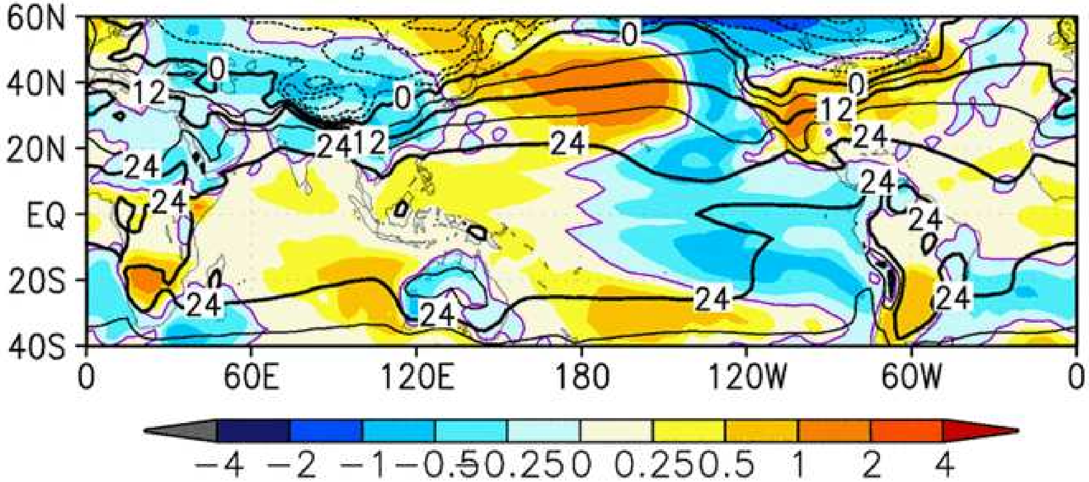
大西洋東部からユーラシアにかけての
波列パターンが季節を通して持続した

Wallace & Gutzler(1981)のEU指数（3か月平均）は1979年以降で1位

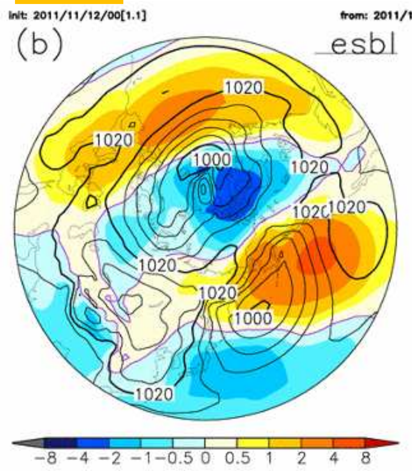
気象庁結合モデルの結果

ユーラシア大陸の中緯度から日本の東にかけて東西に伸びる低気圧性偏差と対応するユーラシア大陸の地上の低温を予測している。

T2m



SLP

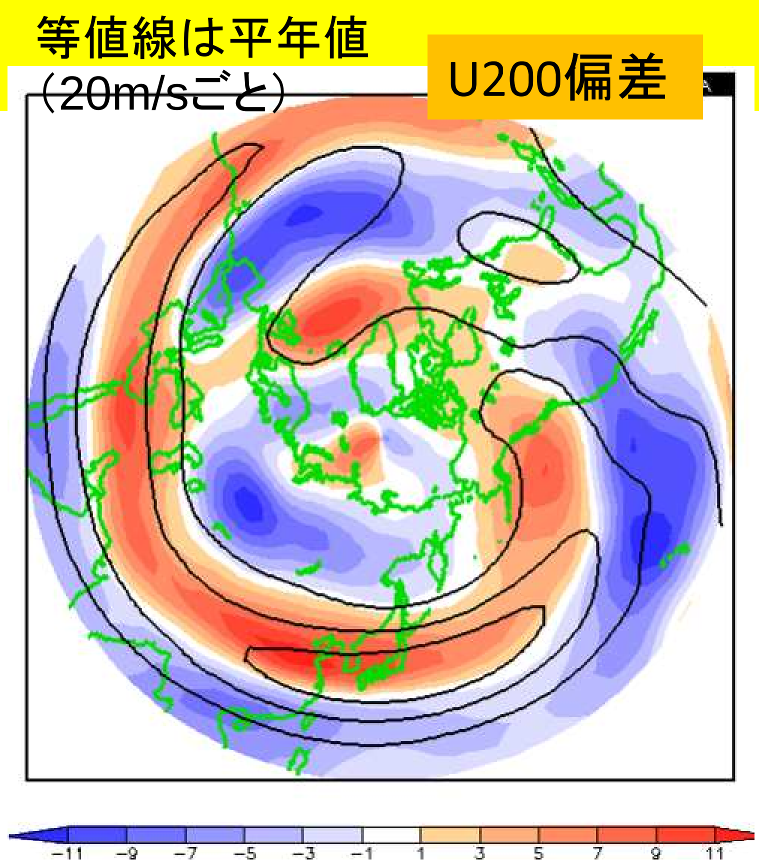


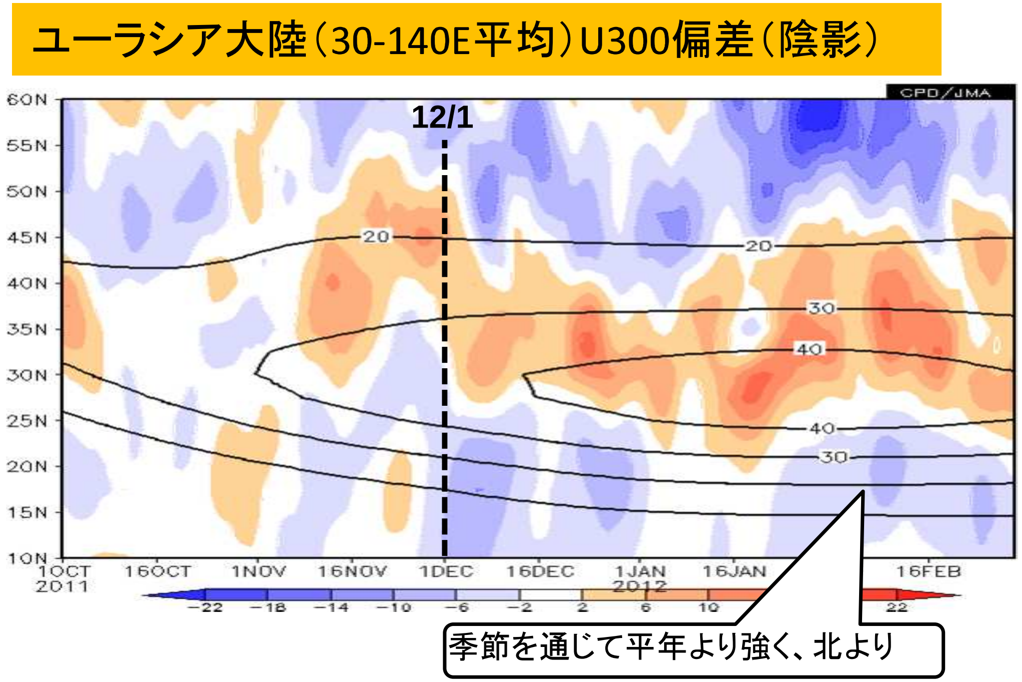
Z200

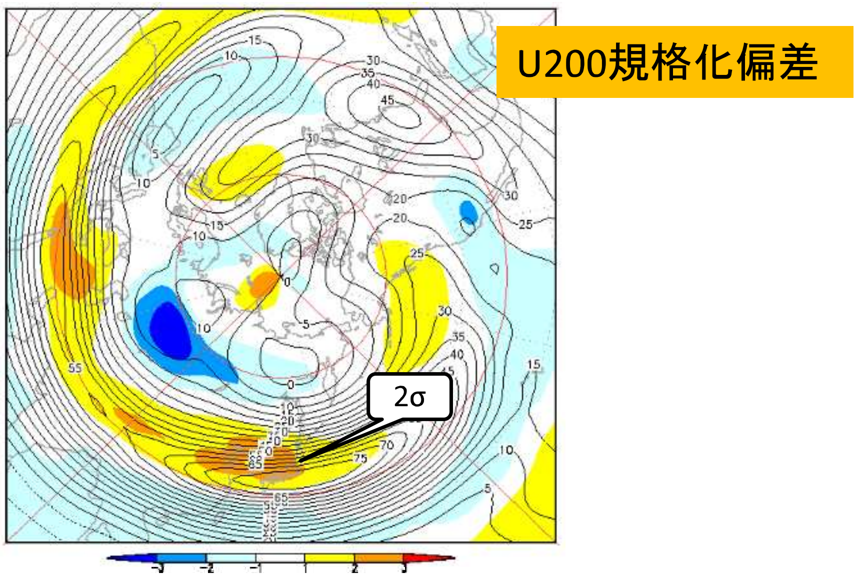
<u>11月初期値の気象庁大気–海洋結合モデルの結果（DJFの予測、アンサンブル平均）</u>

上：2m気温　下：200hPa高度　ｺﾝﾀｰ：実況値　陰影：平年差

偏西風(冬平均)







・ユーラシア大陸上では、季節を通じて平年より偏西風が強く、北より。

・一方、北緯50～60度帯では弱い。