Super El Nino event and its impacts on climate in China in spring and summer

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Outline

- Introduction
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO
Introduction
SSTA, Nov. 2015 compared to 1981-2009 average

SSTA index for ENSO:
Mean of SSTA of 5N-5S: NINO4 (160E-150W), NINO3.4 (170W-120W), NINO3 (150W-90W), NINO1+2 (10S-EQ, 90W-80W)
1981-2010 SST & 2015 SST over NINO3.4 region
NINO3.4 Sea Surface Temperature Anomalies
(Reynolds OI.v2 through KNMI Climate Explorer)

Current Value = +1.08 Deg C

Nov 1981 to Apr 2016
Change: Apr 2016 Minus Mar 2016 = -0.59 Deg C

1982/83  97/98  2015/16

Bob Tisdale
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Thermocline: a thin but distinct layer in which the temperature changes more rapidly with depth that above and below

Wagg, Geography
Schematic representation of atmospheric teleconnection

**DJF:** El Nino impacts on the South Indian Ocean (IO) through westward Rossby waves

**MAM:** Rossby waves inducing Southwest IO warming, which in turn induces an anti-symmetrical wind pattern over the tropical IO

**JJA:** 2nd IO warming exciting a tropospheric Kelvin wave propagating into the western Pacific, forcing the AAC and PJ/EAP pattern to affect East Asia during the following JJA

Xie et al (2016)
“Two-stage thermal adaptation” of the atmospheric circulation to the SSTA in the northern Indian Ocean

Wu et al. (2000)
El Nino in 2015/2016

SSTA, Nov. 2015 compared to 1981-2009 average
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Nino3 index for normal-decay and later-decay

IOBI for ENSO normal-decay and later-decay

Interannual time scale:

Significant warmer/colder SST anomalies in the spring tropical Indian ocean can persist into summer in later-decay El Nino/La Nina years

Ren et al., 2016
NINO 3 index
Running Correlation

Decadal time scale

All Years  Warm Events  Cold Events

Auto-NINO 3 index

IOBI and NINO3 index

Late 70s

ENSO years  Correlation coefficient

Ren et al., 2016
Quantitative attributing analysis of the interdecadal summer IOB warming in recent decades through the CFRAM

Partial contributions between later-decay and normal-decay El Nino years
Partial contributions between later-decay and normal-decay El Nino years

Ren et al., 2016
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Percentage of rainfall amount

PRES: Persistence of rainfall in eastern China in spring

Hu, Liu, 2017
PRES: Persistence of rainfall in eastern China in spring

Land-sea thermal contrast (Tian and Yasunari, 1998)
Tibetan Plateau impacts (Wu, Wan et al., 2007, 2008)
Stationary wave patterns in winter and spring

850hPa $V^*$ and $\theta$

Winter: Dipole Mode
Distributions of wind vector and isotach at 850 hPa (left panels, unit is m s$^{-1}$, shaded indicate exceeding 4 m s$^{-1}$) and rain (right panels, unit is mm d$^{-1}$) in the perpetual spring sensitivity experiments with different TP elevations and averaged over 30 months. The black shaded in left panels and bold solid curve in right panels are the main part of TP. The TP maximum elevation is 0 km in (a) and (b), 2 km in (c) and (d), 4 km in (e) and (f), and 6 km in (g) and (h).

Wu et al., 2007
Bi-weekly Oscillation of the TP SH and its impacts on PRES

+SH: more PRES  -SH: Less PRES

Div & $-v \omega$
### PRES’s interannual variability

<table>
<thead>
<tr>
<th>Forecast?</th>
<th>Mostly on tropic oceans</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENSO</strong></td>
<td>刘永强和丁一汇，1995; 万日金等，2008; Feng and Li, 2011</td>
</tr>
<tr>
<td><strong>SSTA in West Pac.</strong></td>
<td>邓立平和王谦谦，2002; 陈艺敏和钱永甫，2005; 张博等，2011;</td>
</tr>
<tr>
<td><strong>Heat content in West Pac.</strong></td>
<td>尚可等，2013, 2014</td>
</tr>
<tr>
<td><strong>SSTA in Indian Ocean</strong></td>
<td>陈丹等，2012; 程慧萍和贾晓静，2014; Xie et al., 2016</td>
</tr>
<tr>
<td><strong>AAO</strong></td>
<td>郑菲和李建平，2012</td>
</tr>
<tr>
<td><strong>Vegetation in Southeastern TP</strong></td>
<td></td>
</tr>
</tbody>
</table>

**PRES’s definition:** 13-27 P  (Wu and Wan, 2007)

**Q1:** If fixed period of PRES is available?

**Q2:** PRES is not consistent for each factors, why?

**Q3:** Include multi-factors to improve the predictability?
PRES definition

Pre \geq 4 \text{mm/d}

850-hPa V \geq 4 \text{m/s}

SCS monsoon onset (Mao et al., 2004)

Start Pentad: Wan et al., 2008

End pentad: one pentad before SCS monsoon onset

PRES amount: Pre. From Start Pentad to End Pentad
PRES characters

START

Earliest 7th P
Latest 25\textsuperscript{th} (2011)
Mean : 12.6~13rd P

END

Earliest 21st P (2009)
Latest 31st (1991)
Mean : 25.3 P

DURATION

Longest 22 Ps (85, 98, 10)
Shortest 1 P (2011)
PRES amount

Pre. : Fixed dates & non-fixed dates

<table>
<thead>
<tr>
<th></th>
<th>Fixed</th>
<th>Non-fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (mm)</td>
<td>427.13</td>
<td>437.98</td>
</tr>
<tr>
<td>Stand.(mm)</td>
<td>71.99</td>
<td>136.10</td>
</tr>
</tbody>
</table>

Similar Mean Larger St.

Fixed as 13–27 P
Key SSTA area for the PRES variability

Correction bet. Pre & DJF-SSTA

Focus on South China in spring

Larger corr. Areas:
(1) Eastern P
(2) EQ of western P (- corr)
(3) Tropical Indian Ocean

Key area: Nino3.4 region

How ENSO influences?

Regression rainfall based 0-
DJF Nino3.4 (mm/°C),
Dotted: 0.01
Impacts of the ENSO

Regressed based NINO3.4

850-hPa V

Water vapor transport

Red: 0.05

OLR
Impacts of the ENSO

Regressed based NINO3.4

- Divergence - ascent
- Moisture

More Pre.
# Impacts of the ENSO: predictability?

**PRES**

<table>
<thead>
<tr>
<th>Year</th>
<th>El Niño 10</th>
<th>La Niña 7</th>
</tr>
</thead>
</table>

*Correlation: $\text{cor} = 0.69$*
Multi-factors regression

\[ y = -2.29 - 7.99 \times IOB + 67.67 \times Nino3.4 - 64.99 \times AAO \]

Corr. of New Pre & Pre: 0.76
Corr. Of Nino3.4 & Pre: 0.69

For extreme PRES year (1982, 2014), Stan. Of New Pre >±0.5
Non-agree year (1985, 87, 88, 95, 2007), better
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Pre* and 500-hPa H* (subtropical high) in JJA(+1) of El Nino

Duan et al., 2017
OLR* and 850-hPa V* in JJA(+1) of El Nino

May31-Jun14

Jun15-Jul24

Jul25-Aug13

Aug14-Aug29

Duan et al., 2017
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Pacific Decadal Oscillation

positive phase

negative phase

![Graph showing the Pacific Decadal Oscillation with positive and negative phases.](image)
Pre anomaly (mm m$^{-1}$) in the following El Nino with positive PDO

Mao et al., 2017
Pre anomaly percentage in spring
all El Nino               El Nino & +PDO
El Nino & -PDO     Diff of +PDO & -PDO

Mao et al., 2017
Pre anomaly +PDO -PDO After El Nino

Feng et al., 2014
Impacts of El Nino – beyond the precipitation: air pollution

Extreme PM2.5  Beijing Dec 2015

http://bbs.qianlong.com/thread-9587819-1-1.html
Impacts of El Nino – beyond the precipitation air pollution

Anomaly in Dec. 2015

Higher land T: weaker winter monsoon

Anticyclonic circulation: More moisture

Liu et al., 2017
Thank You!