On the Influence of Variability in the North Pacific and Tropical West Pacific on ENSO

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Extratropical and Tropical ENSO Precursors

- **ExtraTropical**
  - “Seasonal Footprinting Mechanism (SFM)”
    - North Pacific SLP anomalies in previous winter impact the subtropical SSTs spring/summer and ENSO in the next winter
  - Explore potential for SFM => ENSO

- **Tropical West Pacific**
  - Depth of thermocline on equator 12-18 month before ENSO event
  - Anderson (2007)

- **NCEP Reanalysis (1948-2009)**
- **NCAR’s CCSM4: 500 year control integration**
What is the Seasonal Foot Printing Mechanism (SFM)?

- NPO in NDJ (-1)
- Winds & Heat Flux
- SST in FMA (0)
- Tropical Winds
- Feedback (e.g. WES)
- El Nino in NDJ (0)

Vimont et al. 2001, GRL; 2003a&b, J. Climate
Niño-Niña SST/SLP Composite DJF(0/1)

based on Nino3.4 index +/- one stddev

NCEP R1 1948-2009

CCSM4 500 years
Niño-Niña SST/SLP Composite DJF(-1/0)-JJA(0) based on NDJ Nino3.4 index +/- one stddev
SST (°C) Shaded SLP (mb, contoured)
NCEP R1 1948-2009 CCSM4

Deser et al., 2012, J. Climate
SLP Index SST/SLP composite DJF(0)-JJA(0)

NDJFM(-1/0) SLP Index (175W-140W, 10N-25N) Composites (Neg-Pos)

NCEP Reanalysis

CCSM4

Correlation between SLPI and Niño3.4 SST Index in JFM(1) is 0.61 in nature (Anderson 2007) and 0.59 in the model

Deser et al., 2012
Second Index

Depth of thermocline in the Equatorial West Pacific
Z20 evolution

WP Z20 index (pos-neg)

WP Z20 & SLP index (pos-neg)
Composites based on West Pacific Z20 precursor:
Positive-Negative Z20 Jun-Oct(-1) (5N-5S, 150E-180W)
Nino 3.4 SST vs SLP and Z20 Index

Anderson 2007

Obs: $r = -0.72$; $r = -0.37$

Obs: $r = 0.69$; $r = -0.06$
Hovmöller of composite zonal wind stress 2N-2S

SLP Index (neg-pos)

Z20 Index (pos-neg)

Z20 & SLP Index (pos-neg)
Hovmöller of SST composites 2°N-2°S

Z20 index (pos-neg)

Combined: Z20(+)/SLP(-) minus Z20(-)/SLP(+)

SLP index (neg-pos)

Combined: Z20(+)/SLP(+), minus Z20(-)/SLP(-)
Subtropical => Tropical Connection

- Wind Evaporation SST (WES) feedback
  - In SFM: Vimont et al. 2009, Alexander et al. 2010
- Rossby wave excitation ~5°N and reflection off western boundary
  - Alexander et al. 2010 (J. Climate)
- Recharge-discharge ENSO paradigm

Others:
- Solar radiation
- Influence on the meridional mode (MM)
  - North-south dipole in precipitation (SST & wind signature) in the tropics
    - Also shown to be an ENSO precursor
SLP Index Monthly SST/SLP & Winds/Qnet
Dec(-1), Jan(0), Feb(0)
SLP Index Monthly SST/SLP & Winds/Qnet
Mar(0), Apr(0), May(0)
h(m) Exp-Cntl 5-day Hövmoller: Western Boundary

Alexander et al. 2010
Z20(m) Hovmoller based on SLPI composite (neg-pos)
Zonal Average Z20 2°N-2°S CCSM4

v and density at 2N
Zonally Integrated Sverdrup Transport Composites Nino3.4, SLP, Z20 Indices

Following Clarke et al. 2007 JPO
Summary & Conclusions

• SFM (- like) mechanism appears to be operating in nature (reanalysis) and CCSM4
  – Although some aspects deviate from
    • E.g. SST anomalies on the Eq. in Jan(0)
• Z20 in west equatorial Pacific good predictor for ENSO 12-18 month later

Hypothesis:
• z20 index measure of ENSO cycle: La Niña, deep thermocline in the west ~18 month prior to El Nino
• SFM is a way to enhance, kick start or even disrupt the cycle.
• Open question – What processes are key for communicating SFM information from the subtropics to the equator and when. Can it be understood via the recharge-discharge mechanism
Wind Evaporation SST (WES) Feedback

- Trough west of warm SSTs
- Southwest winds to the southwest of the +SSTA oppose trades
- Anomalous latent heat flux into the ocean
- Warm SSTs
- Southwest propagation of $Q_{lh}$ & SST

$Q_{lh} \sim \rho c_e (u'(q'_s - q'_a) + u'(q_s - q_a))$

Theoretical underpinning WES: Chang et al., 1997; Xie 1997, 1999; equatorward & westward propagation: Vimont 2010