Multidecadal variability of ENSO in a recharge oscillator framework

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ENSO presents multidecadal variability

- What properties of ENSO show multidecadal variations during the observational record?
- Why do those properties change?
- Can we relate those changes to changes in the dynamics of ENSO?

Fedorov and Philander (2000)
A conceptual model for ENSO: The recharge oscillator

The recharge oscillator model (Jin 1997) is based on the cyclic recharge-discharge process of the upper ocean equatorial heat content and is based on the coupling between SST and thermocline.

Schematics: Meinen and McPhaden 2000
Simplified Recharge Oscillator model (Burgers et al. 2005)

Model parameters

- $a_{11}$ = SST growing rate
- $a_{12}$ = coupling of $h$ to SST
- $a_{21}$ = coupling of SST to $h$
- $a_{22}$ = $h$ growing rate

\[
\frac{d}{dt} SST = a_{11} SST + a_{12} h + N_T
\]
\[
\frac{d}{dt} h = a_{21} SST + a_{22} h + N_h
\]

$\text{SST Niño3 region}$

$h$ = zonal average of equatorial Pacific thermocline depth

Methodology

i) Fit the parameters of the model to the observations in 30-yr running windows for the period 1900-2010.

(Vijayeta and Dommenger 2018)

ii) Add white noise to create variability.

iii) Integrate the model forward in time in 1000yr simulations.
Multidecadal changes in SST-h coupling

- The SST impact on thermocline is active for all periods in the observations and the ReOsc model.

- The feedback of h on SST is only active in the period 1970-2000.

(a) SST-h Observations

(b) SST-WWV ReOsc  SST-h ReOsc
We find that the strength of the SST-h coupling in ENSO changes at multidecadal timescales in observations.

Can climate models capture these changes?

i) Do CMIP5 models reproduce different behaviours?

ii) Do they show multidecadal variability?

iii) Do they correspond to the observed changes?
Multidecadal variability SST-h coupling (CMIP5 models)
We find that the strength of the SST-h coupling in ENSO changes at multidecadal timescales in observations.

Can climate models capture these changes?

i) Do CMIP5 models reproduce different behaviours? Yes

ii) Do they show multidecadal variability? Some of them do

iii) Do they correspond to the observed changes? No

But the observed behaviour lies within all the different realisations of the climate models.
Drivers of multidecadal variability of ENSO

- The coefficients of the ReOsc model show a multidecadal variability.
- The coefficients of the ReOsc are influenced by global warming since the 1950s.
- Ocean-atmosphere coupling is getting stronger under global warming.
- Multidecadal changes of the recharge oscillator dynamic resemble Atlantic Multidecadal Variability SST pattern.
Summary and conclusions

• ENSO properties show a pronounced multidecadal variability.

• The mechanism of recharge-discharge of the equatorial heat content is the main driver of ENSO dynamics since the 1970s.

• The multidecadal modulation of ENSO appears related to the Atlantic Multidecadal Variability pattern and global warming.

• The thermocline depth is a good predictor of ENSO in recent decades.

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References


