On the physical interpretation of the lead relation between the Warm Water Volume and the El Niño Southern Oscillation

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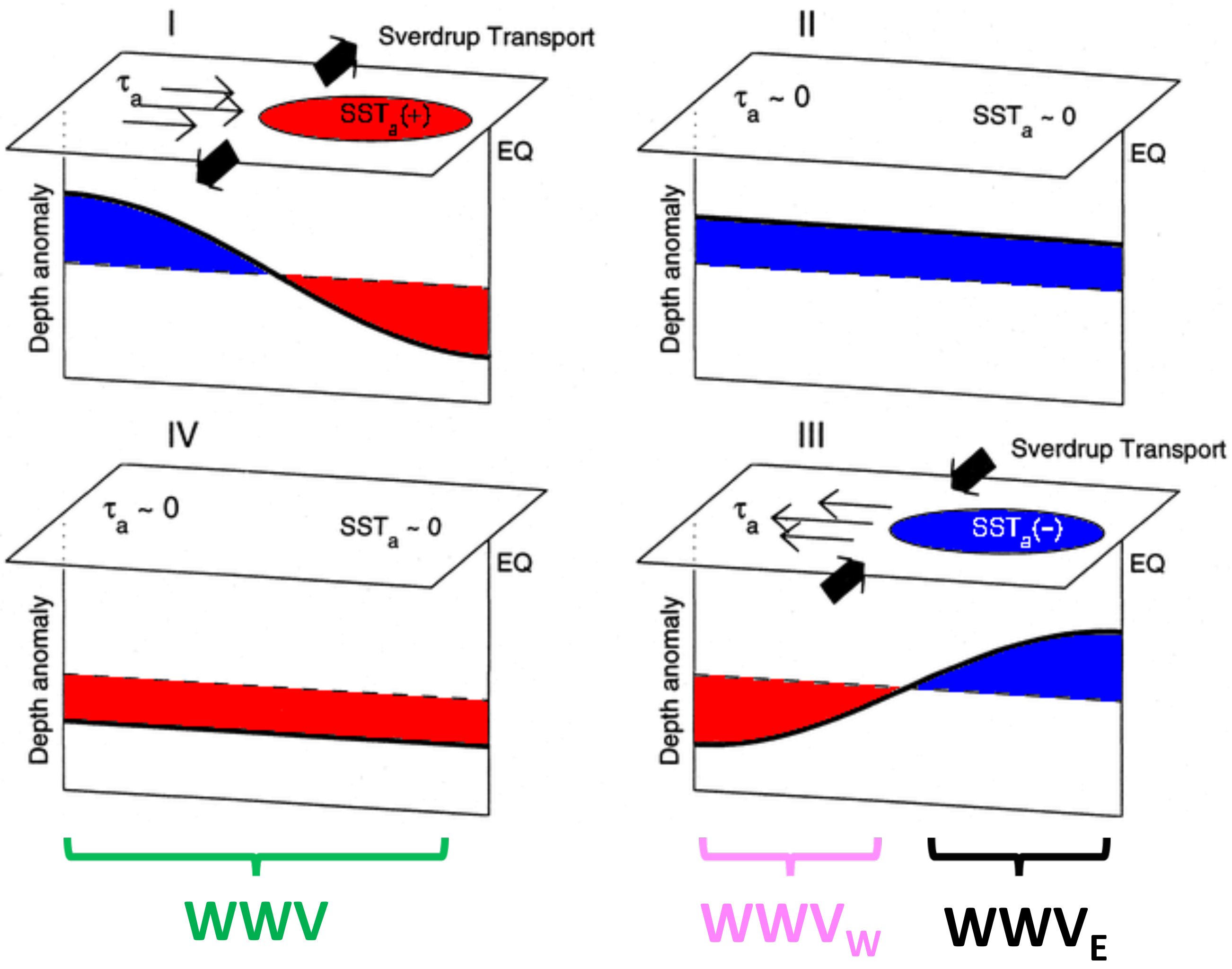
Under revision in Climate Dynamics

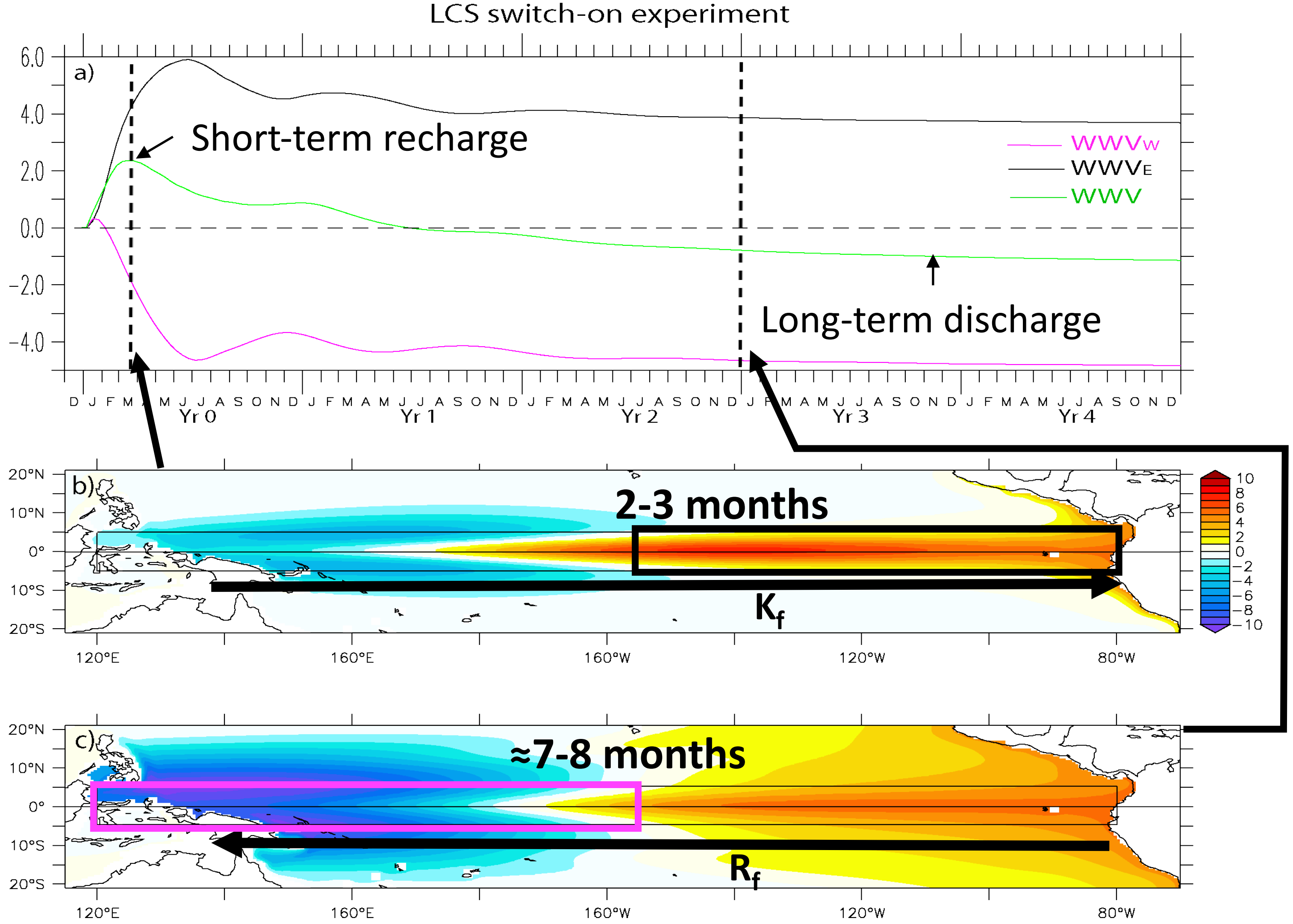
WWV and the recharge oscillator



- Memory across ENSO phases
- **(Wyrtki 1985; Jin 1997)**: focus on WWV_W
- Jin's sketch & **Meinen and McPhaden (2000)**: focus on WWV; widely-used ENSO predictor
- Westerlies/Niños: discharge

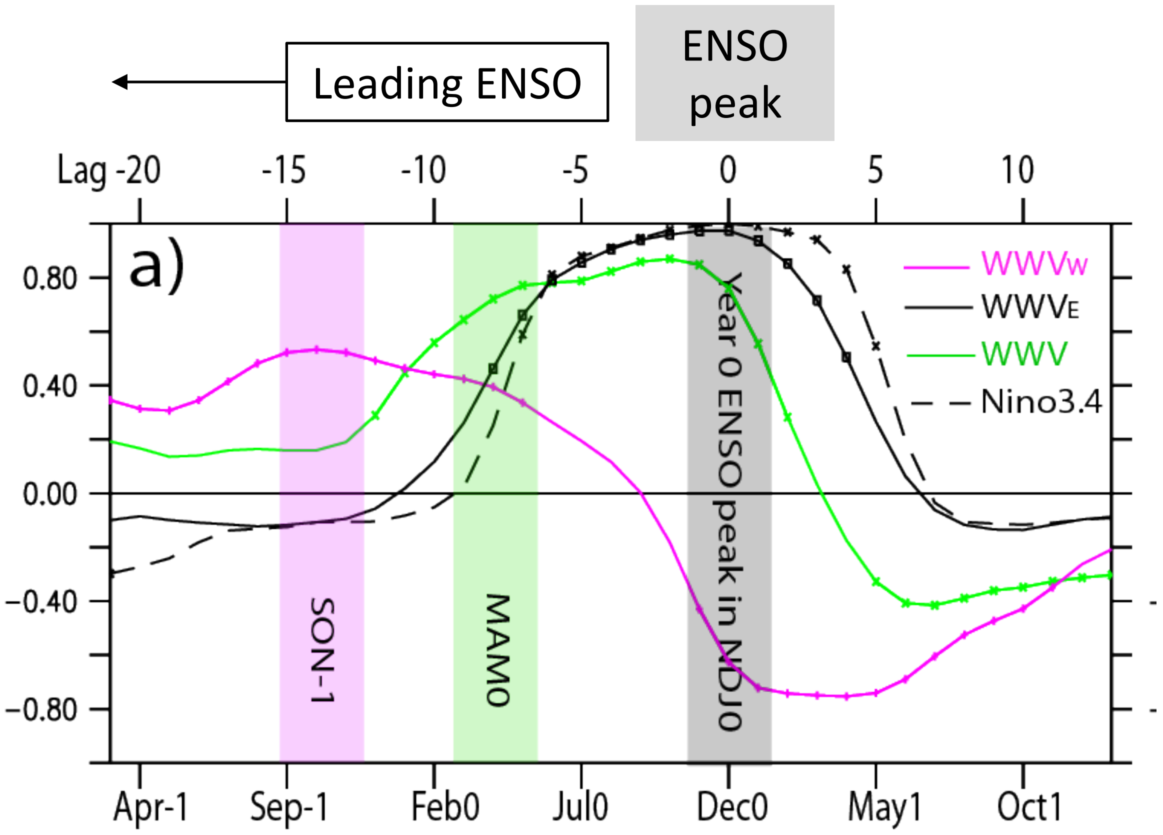
The two timescales of WWV dynamics

Response to switched-on Niño-like westerlies



- WWV: short term recharge in response to westerlies **(McGregor et al. 2016, Neske and McGregor 2018)**
- WWV_E ≈ Kelvin wave; fast
- WWV_W ≈ Rossby wave; slower

Best ENSO predictor: WWV or WWV_W ?



Observed lead/lag relation between equatorial Pacific heat content & ENSO peak amplitude.

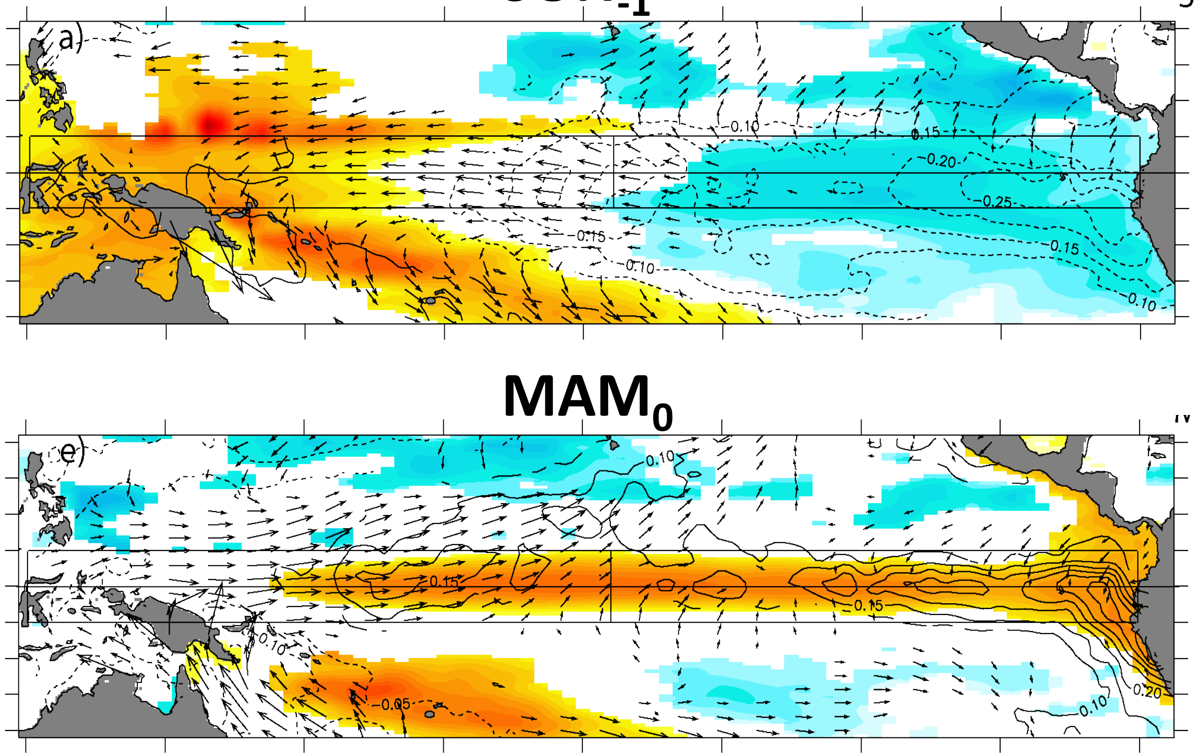
Same results in re-analyses, CMIP, model, ≠ periods

- WWV_W as a predictor **(e.g. Ramesh and Murtuggude 2013; Lai et al. 2015; Ballester et al. 2016; Petrova et al. 2017)**
- WWV_E or N3.4 best predictor @ short lead
- WWV best predictor in spring
- WWV_W best predictor before spring **(Meinen and McPhaden 2000)**

ENSO heat content precursors

SON_{-1}

MAM_0

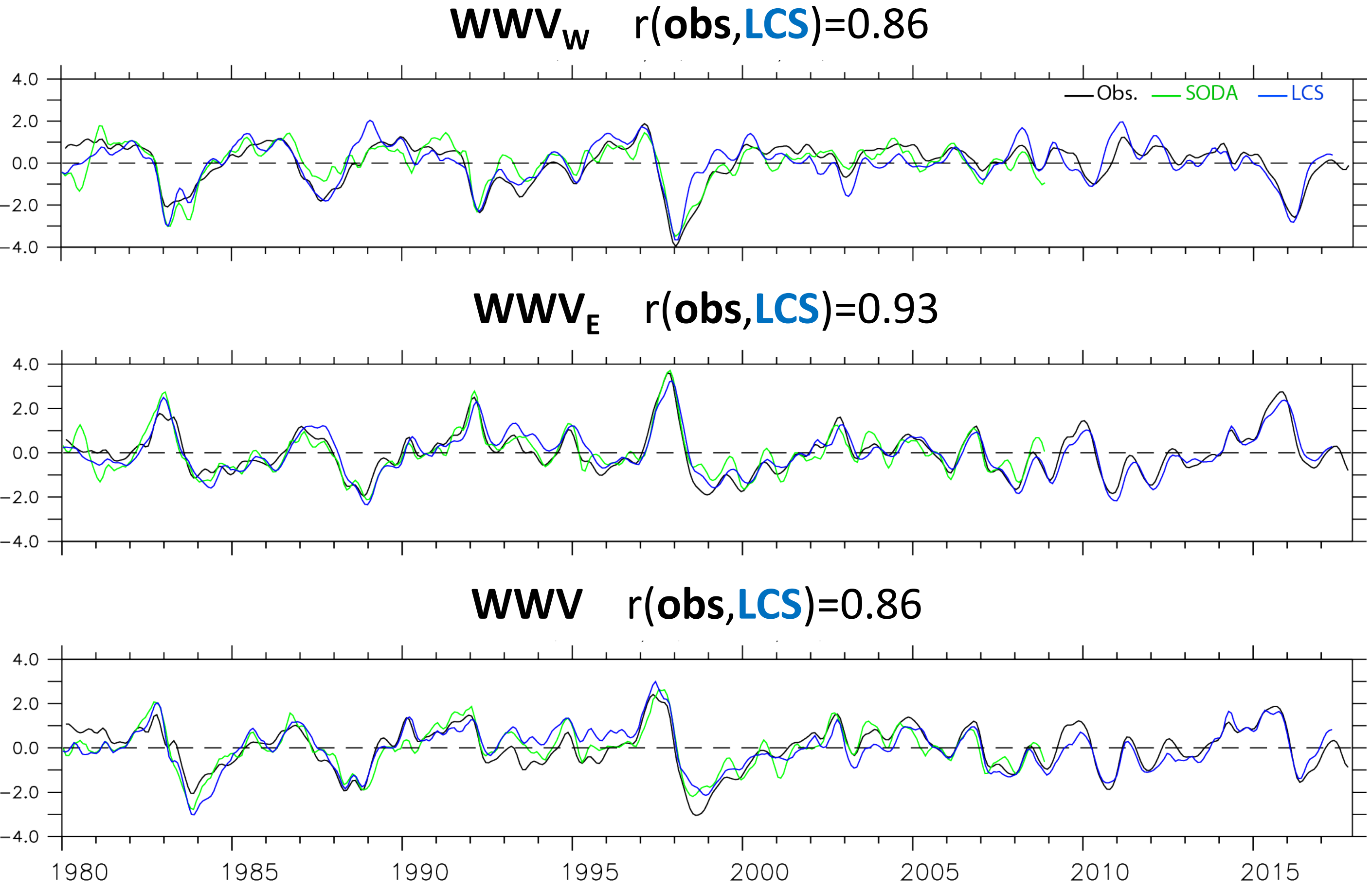


- SON_{-1} : western Pacific recharge
- MAM_0: looks like (fast) Kelvin wave response to a westerly wind anomaly
- Robust when removing tilt mode; in other datasets (e.g. CMIP5 HIS database)

Objectives

- Processes contributing to WWV, WWV_E and WWV_W (forced / reflected; K / R_1)?
- Timescales associated with WWV, WWV_E, WWV_W?
- Focus: WWV in MAM_0; WWV_W in SON_{-1}

Methods

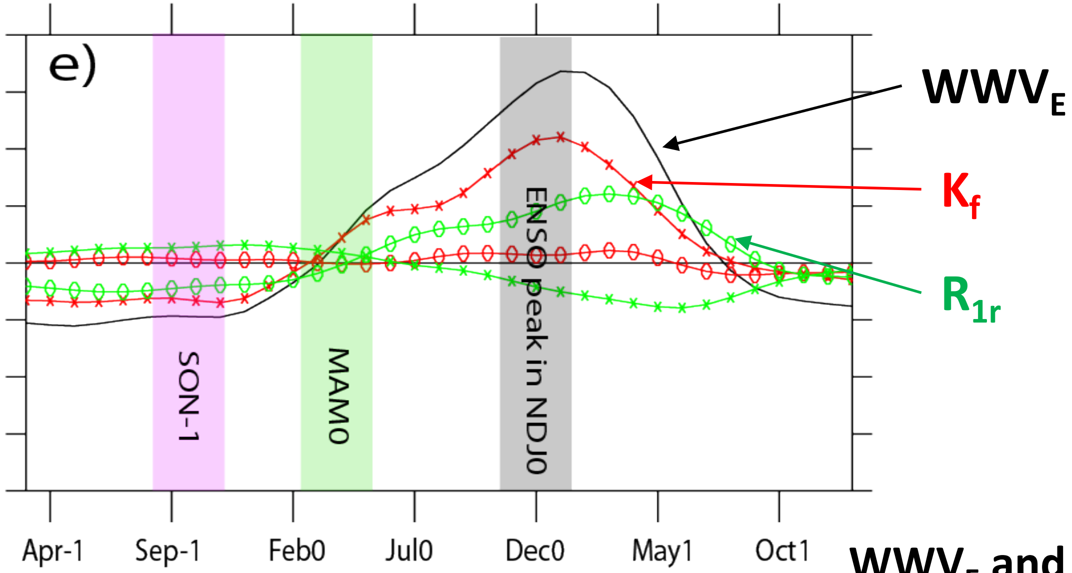


- LCS model, **(McCreary 1980)**
- ¼° Indo-Pacific, 5 modes **(Izumo et al. 2016)**
- Good performance for WWV, WWV_E, WWV_W
- Dampers allow to separate forced & reflected waves
- Wave projection method of **(Boulanger & Menkes 1995)**
- **Focus on baroclinic modes 1 & 2, Kelvin & Rossby 1 modes (explain 99% WWV)**

$$\mathbf{OHC} = K_f + R_{1f} + K_r + R1_r + \text{residual}$$

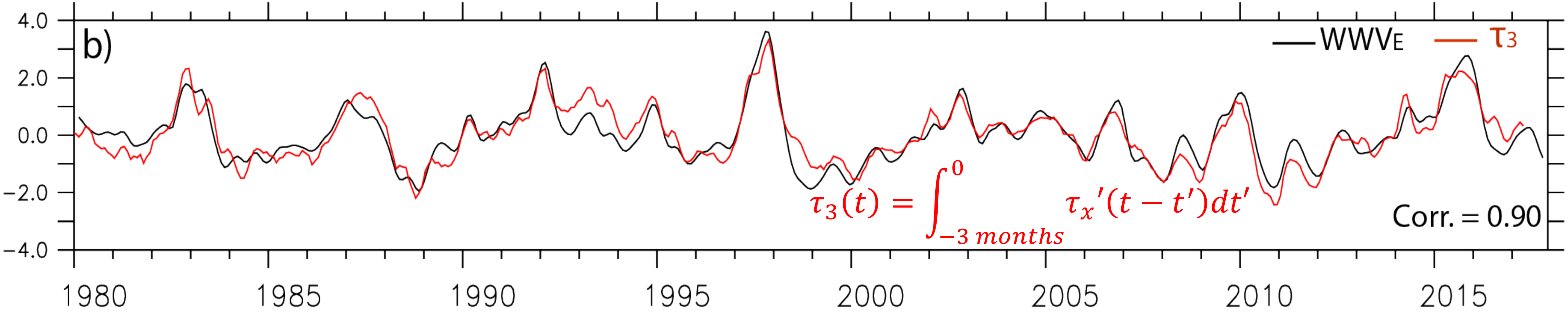
WWV_E dynamics

Typical WWV_E ENSO evolution & decomposition



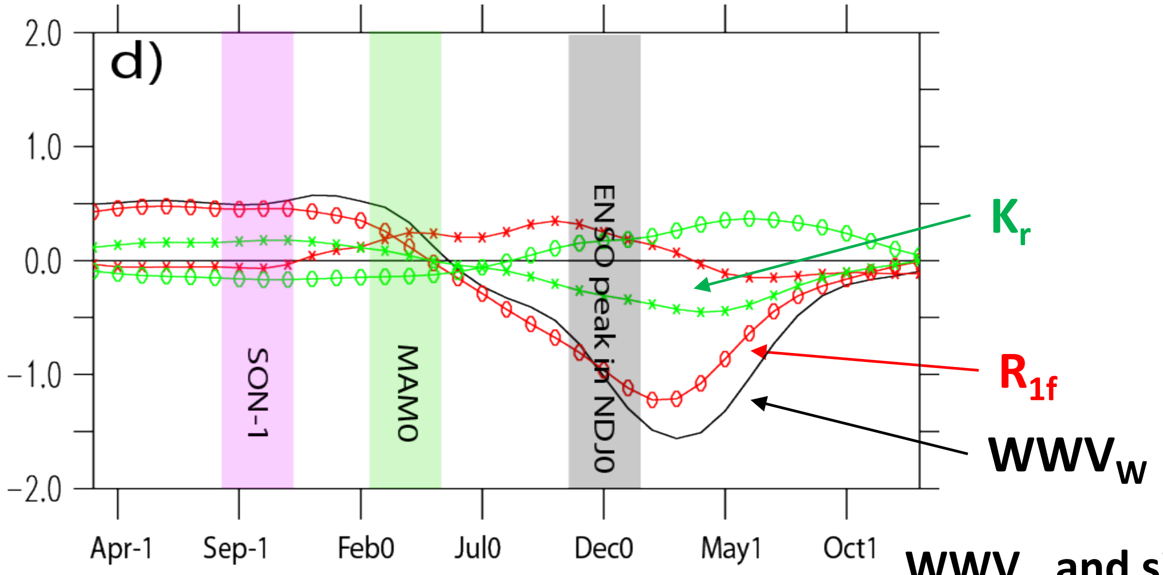
- $WWV_E \approx$ forced K (+ reflected R_1)
- $WWV_E \approx$ integral of equatorial Pacific wind stress anomalies over last 3 months
- Little memory from previous event

WWV_E and simple wind proxy



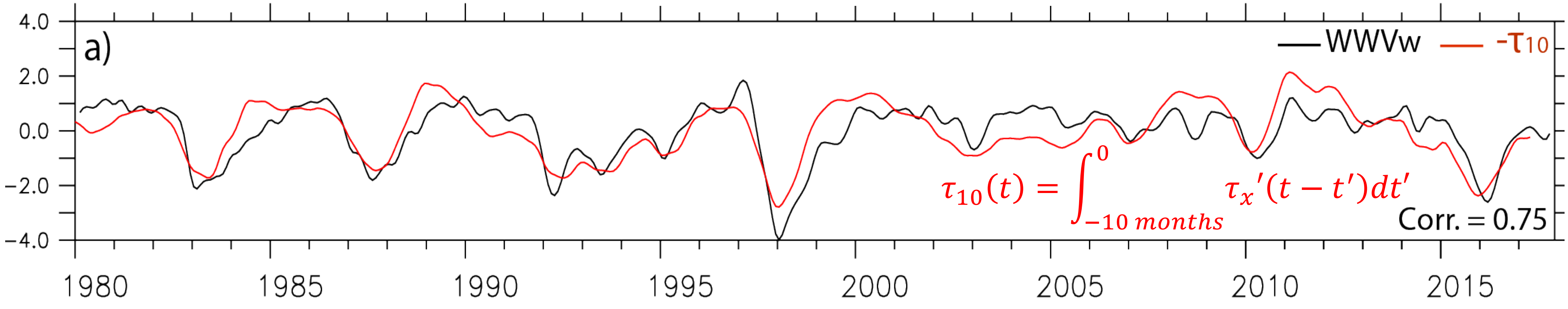
WWV$_W$ dynamics

Typical WWV$_W$ ENSO evolution & decomposition

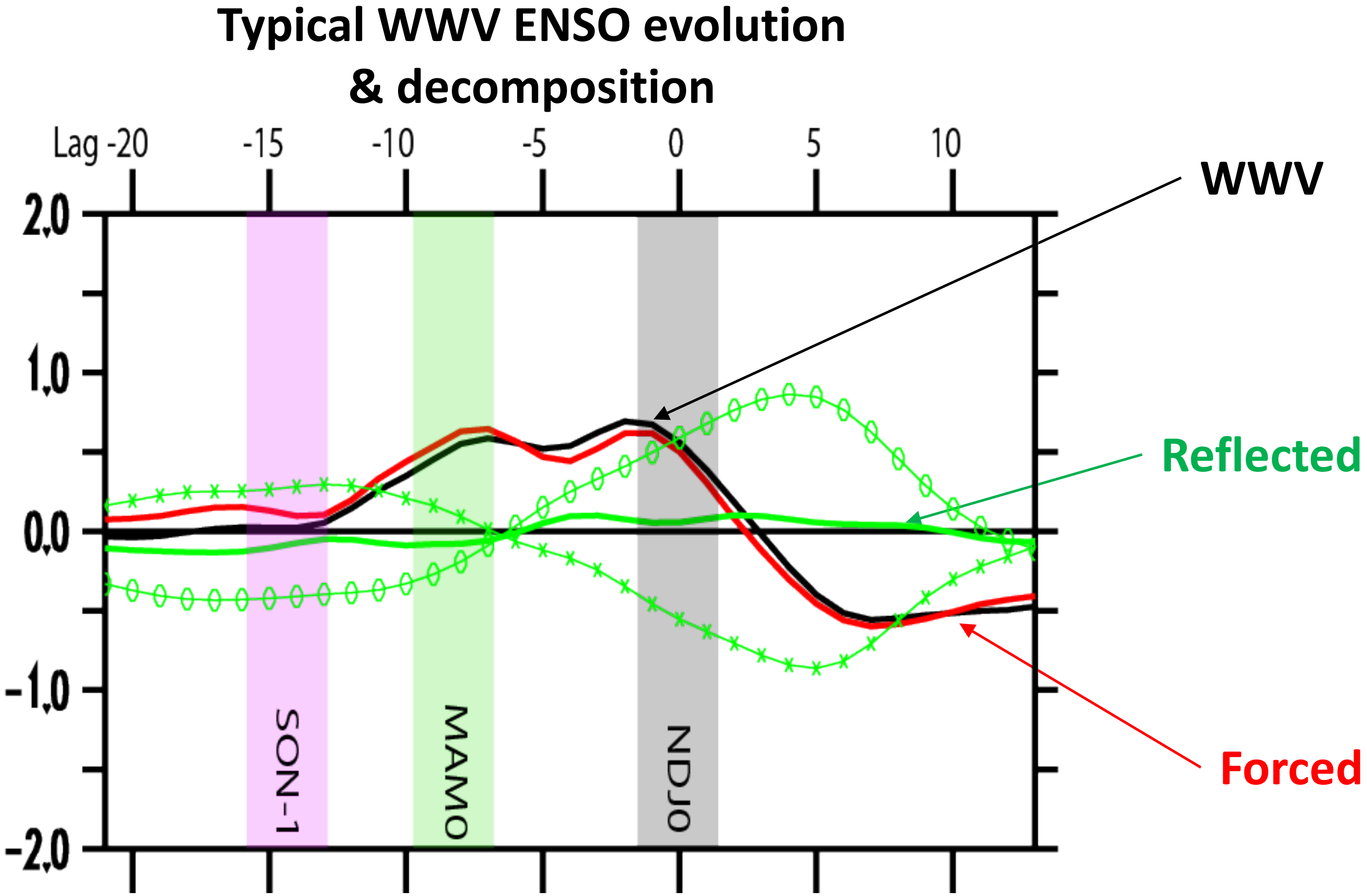


- WWV$_W$ ≈ forced R$_1$ (+ reflected K)
- WWV$_W$ ≈ integral of equatorial Pacific wind stress anomalies over last 10 months
- WWV$_W$: more memory from previous event

WWV$_w$ and simple wind proxy



WWV dynamics

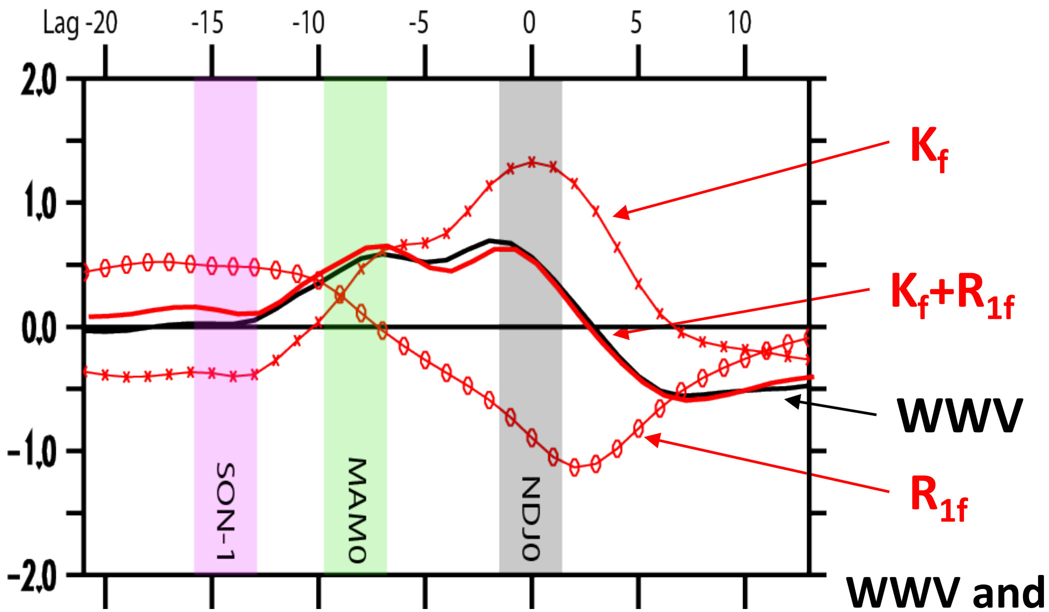


- K_r and $R1_r$ contributions to WWV compensate

➢ $WWV \approx K_f + R_{1f}$

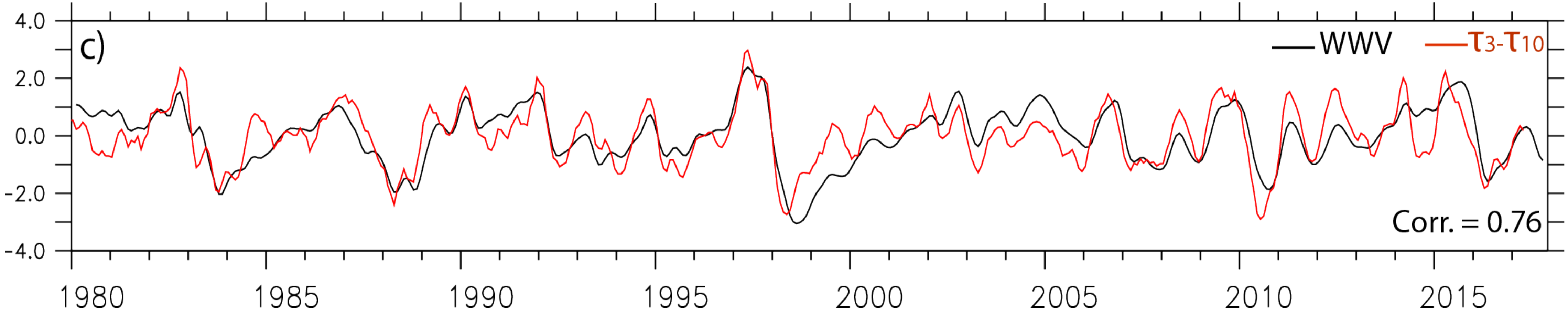
WWV dynamics

Typical WWV ENSO evolution & decomposition

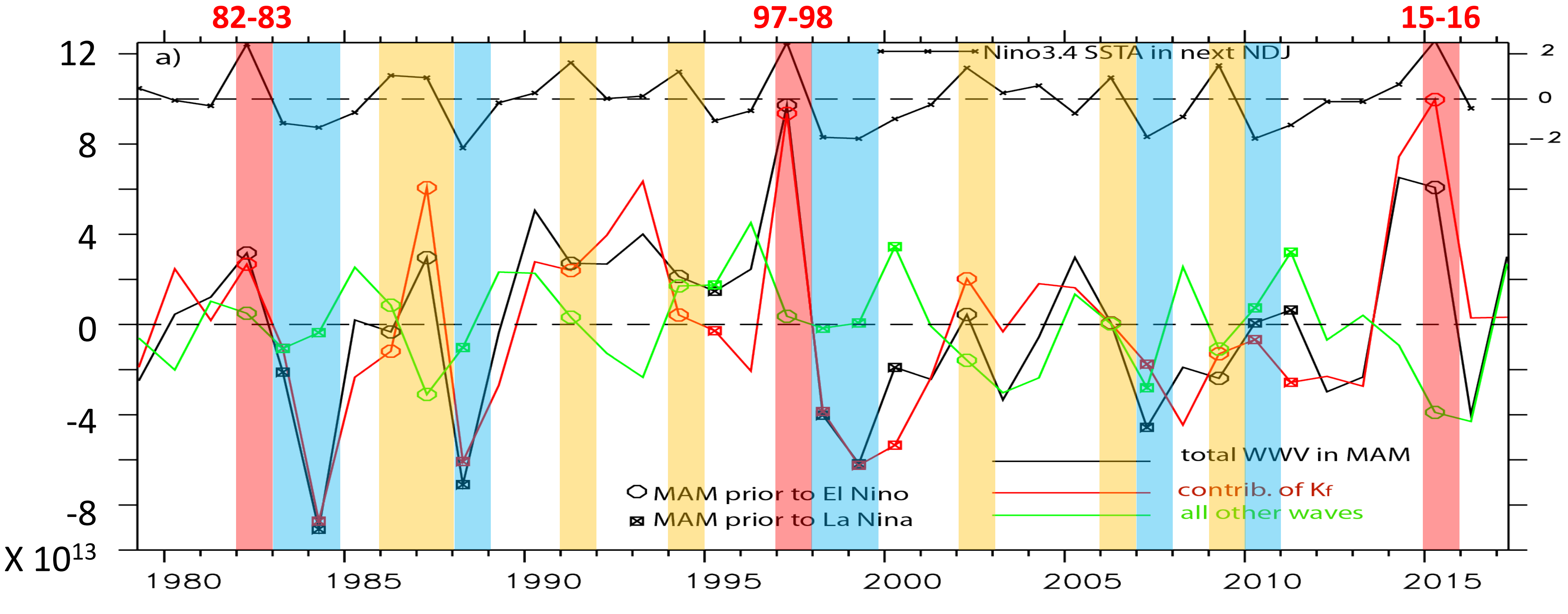


- WWV ≈ forced K + forced R_1 ≈ $\tau_3 - \tau_{10}$
- WWV in MAM_0, JJA_0 dominated by forced Kelvin wave contribution

WWV and simple wind proxy

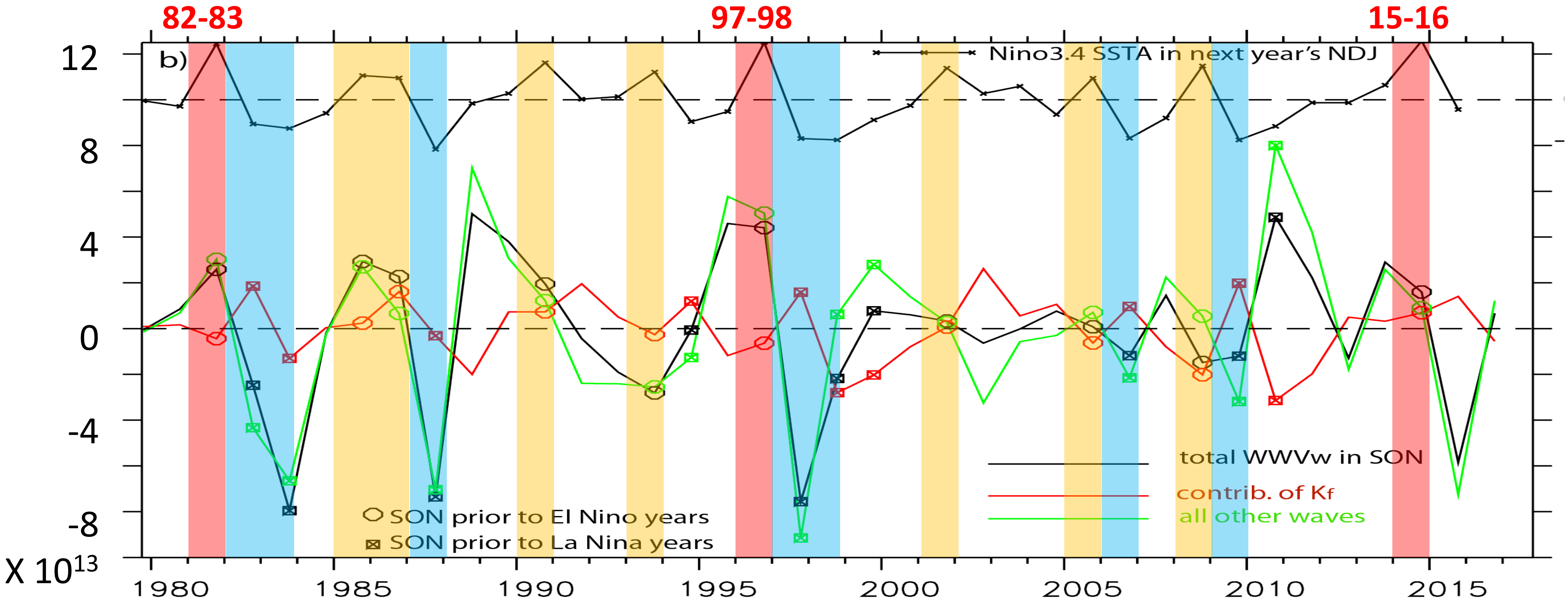


Little long-term memory associated with WWV in MAM_0



- Spring WWV dominated by forced Kelvin wave, in particular before extreme El Niños
- Niños to Niñas transitions: discharge also often dominated by forced Kelvin wave

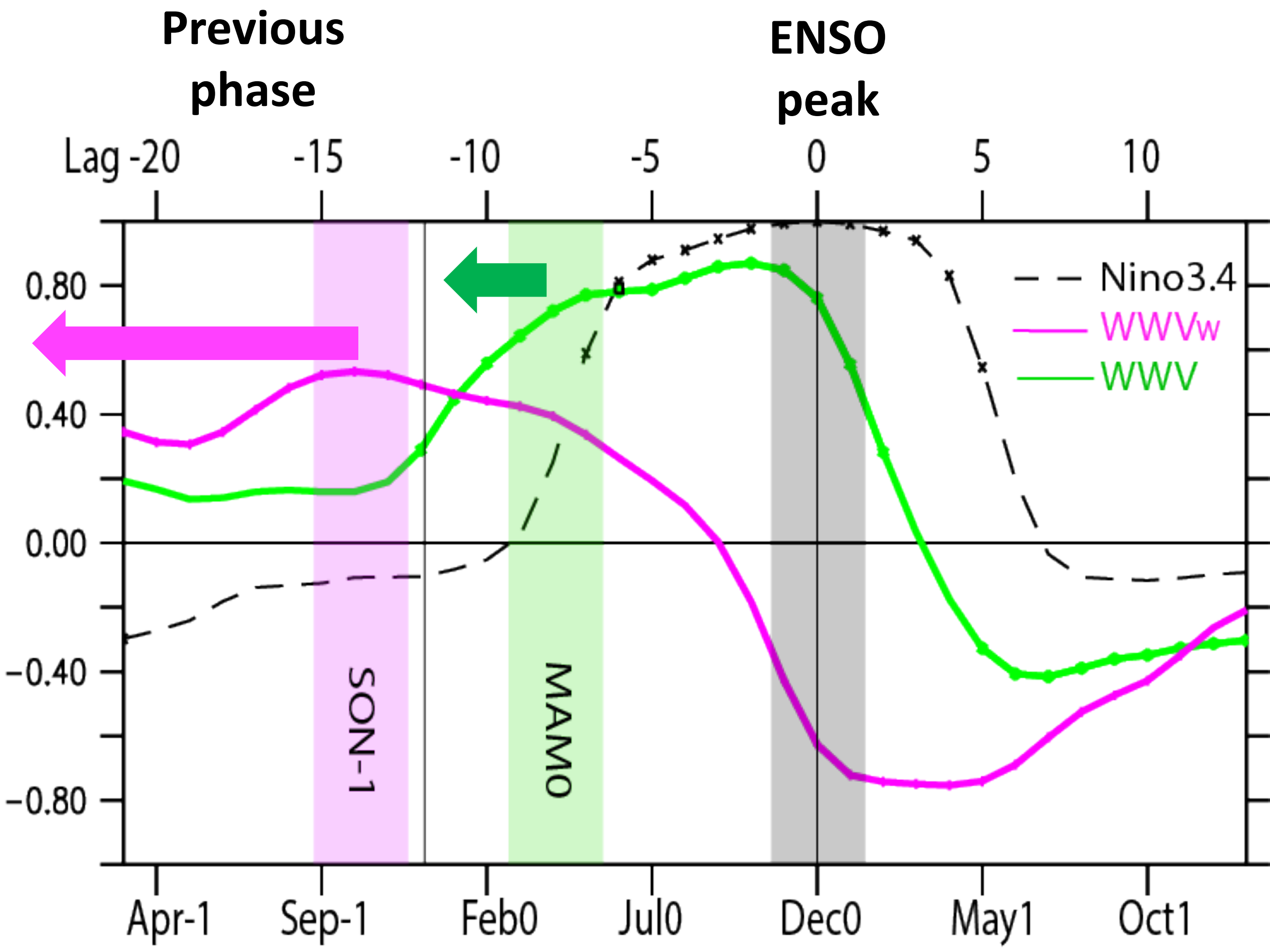
More long-term memory associated with fall WWV_W



- Fall WWV_W dominated by R_{1f} & reflected waves

Take-home messages

- Simple wind-based proxies for WWV, WWV_W and WWV_E
- WWV (best ENSO predictor in MAM_0) dominated by ≈ 3 month timescale forced Kelvin wave
- WWV_W (best predictor in SON_{-1}) dominated by ≈ 10 month timescale forced Rossby wave
- Use WWV_W rather than WWV as a measure of slow preconditionning **(cf. talk by Yann Planton)**



Consequences for recharge-oscillator theory

How does WWV in SON_{-1} favour the ENSO onset six months later?

- Wave reflection (the good old delayed oscillator ?)
- Probably rather advective feedback (in the central Pacific) than thermocline feedback
- Asymmetries between Niño → Niña and Niña → Niño phase transitions?