Impacts of ENSO on Air-Sea O_2 Exchange: Observations and Mechanisms

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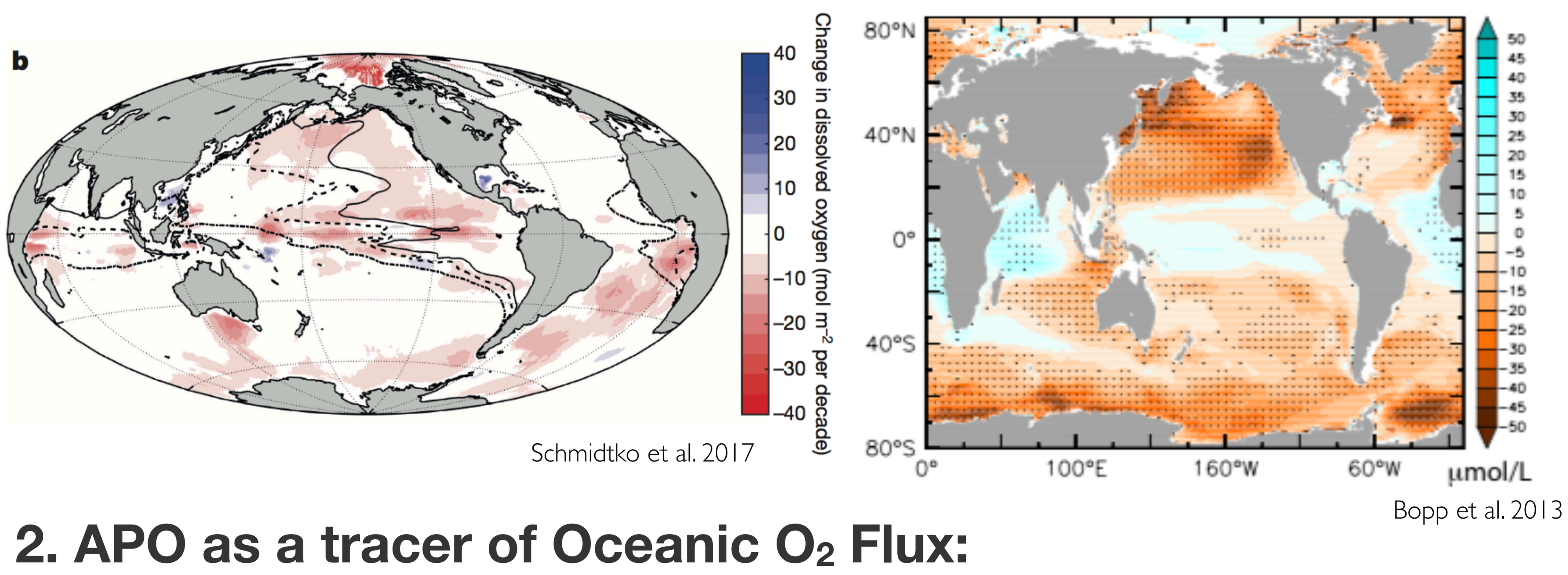
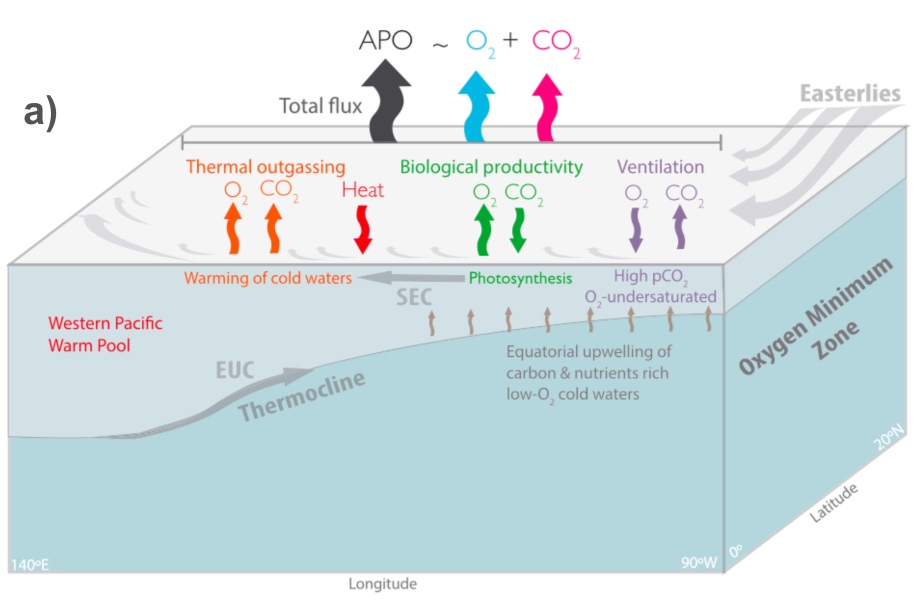
1. Motivation:

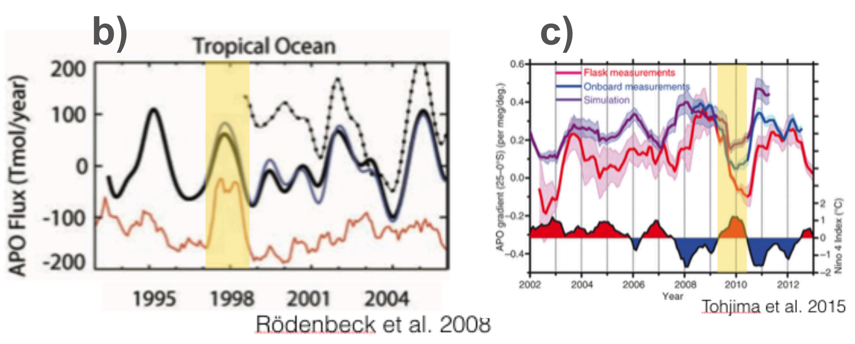
The detection and attribution of oceanic O_2 loss due to anthropogenic warming remain uncertain in the tropics due to lack of in-situ [O_2] observations and poorly known effects of natural variability (e.g. ENSO).



2. APO as a tracer of Oceanic O_2 Flux:

We use observations of Atmospheric Potential Oxygen (APO=O_2+1.1CO_2), an atmospheric tracer of oceanic O_2, and hindcast CORE2 ocean simulations of CESM, IPSL, and GFDL to assess ENSO effects on air-sea O_2 flux.



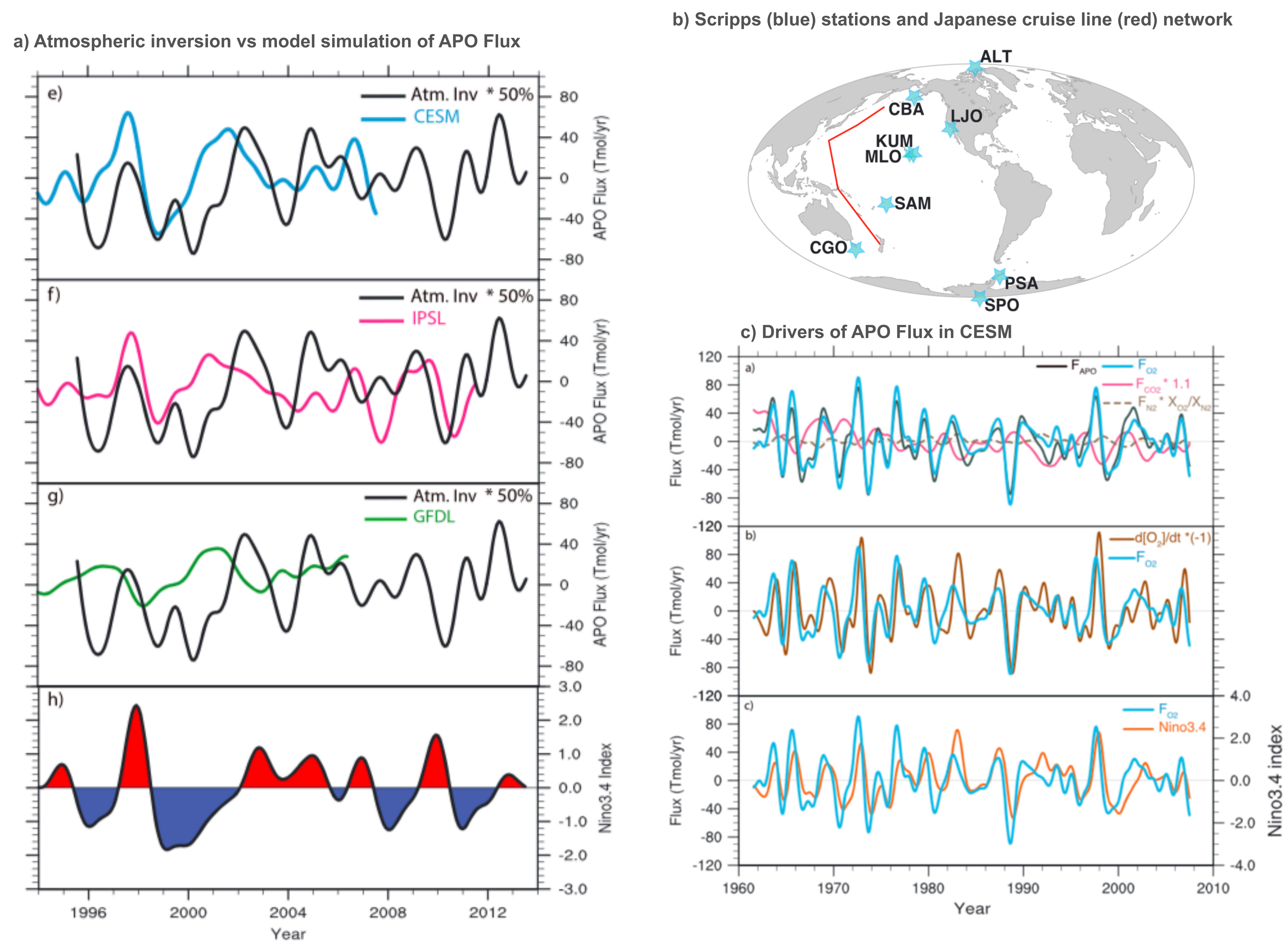


a) Illustration of processes driving APO, O_2 and CO_2 fluxes in tropical Pacific. b) and c) Observations of APO in tropical Pacific from Scripps (center) and Japanese (right) network show opposing APO responses to ENSO.

3. Research Questions:

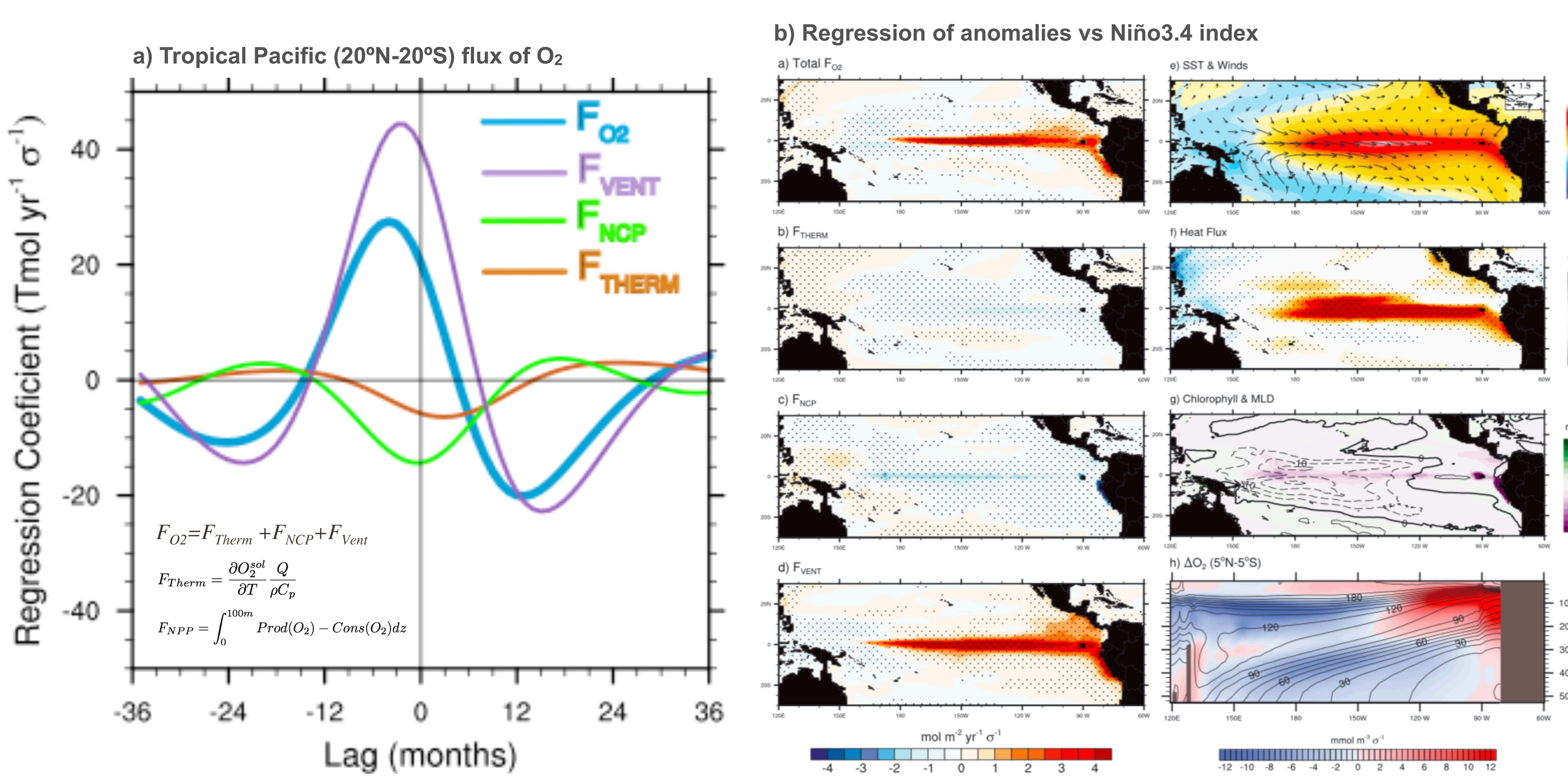
1. What can observations of APO (i.e. O_2 and CO_2) and models tell us about ENSO impacts on air-sea O_2 exchange and [O_2] variability?
2. What are driving mechanisms of ENSO-related O_2 variability?
3. What is role of atmospheric transport in observed APO variability?

4. Atmospheric Observations vs Models:

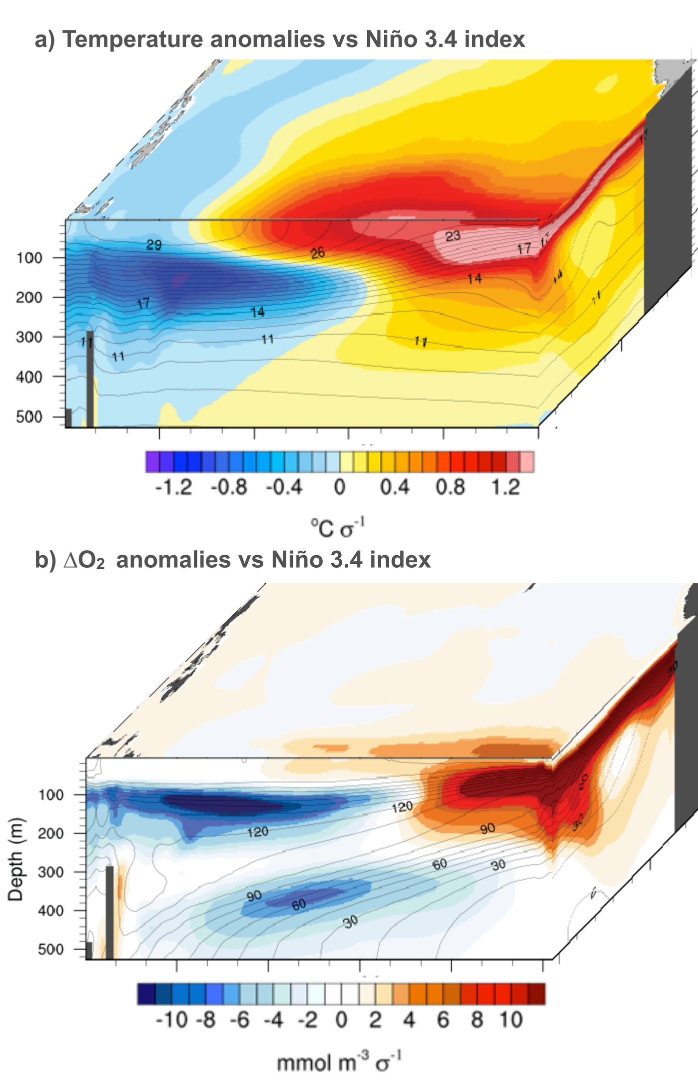


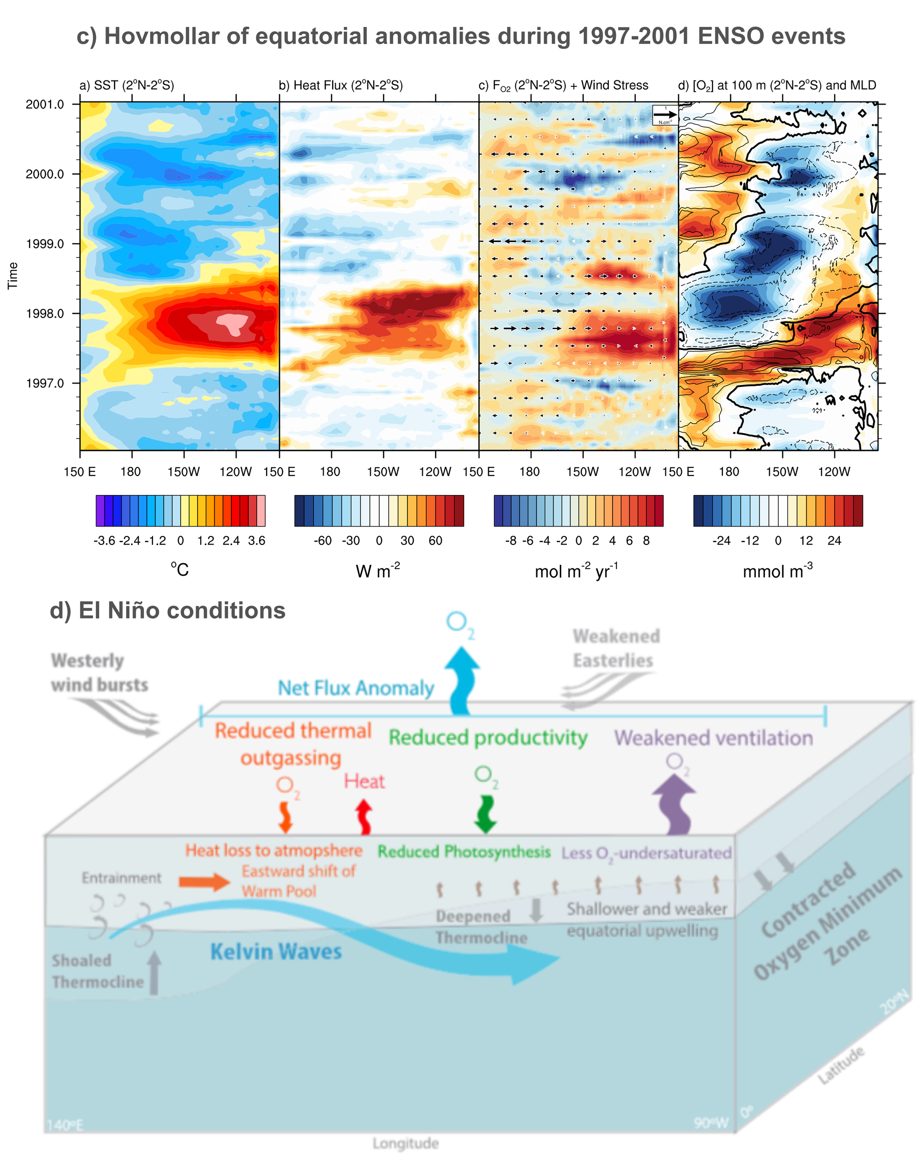
Both ocean models and atmospheric inversion show a positive correlation between Niño3.4 index and APO flux (R_{INV}=0.5; R_{CESM}=0.6; R_{IPSL}=0.6) with 3-5 months APO lead. APO is driven by O_2 flux (R_{O2}=0.8, 3 mo O_2 lead), suggesting **outgassing of O_2 during El Niño.**

5. Mechanism of ENSO-driven O_2 Variability:



ENSO variability of O_2 flux (F_{O2}) is dominated by transport processes (F_{VENT}), and is buffered by reduced biological production (F_{NCP}) and thermodynamic flux of O_2 (F_{THERM}).

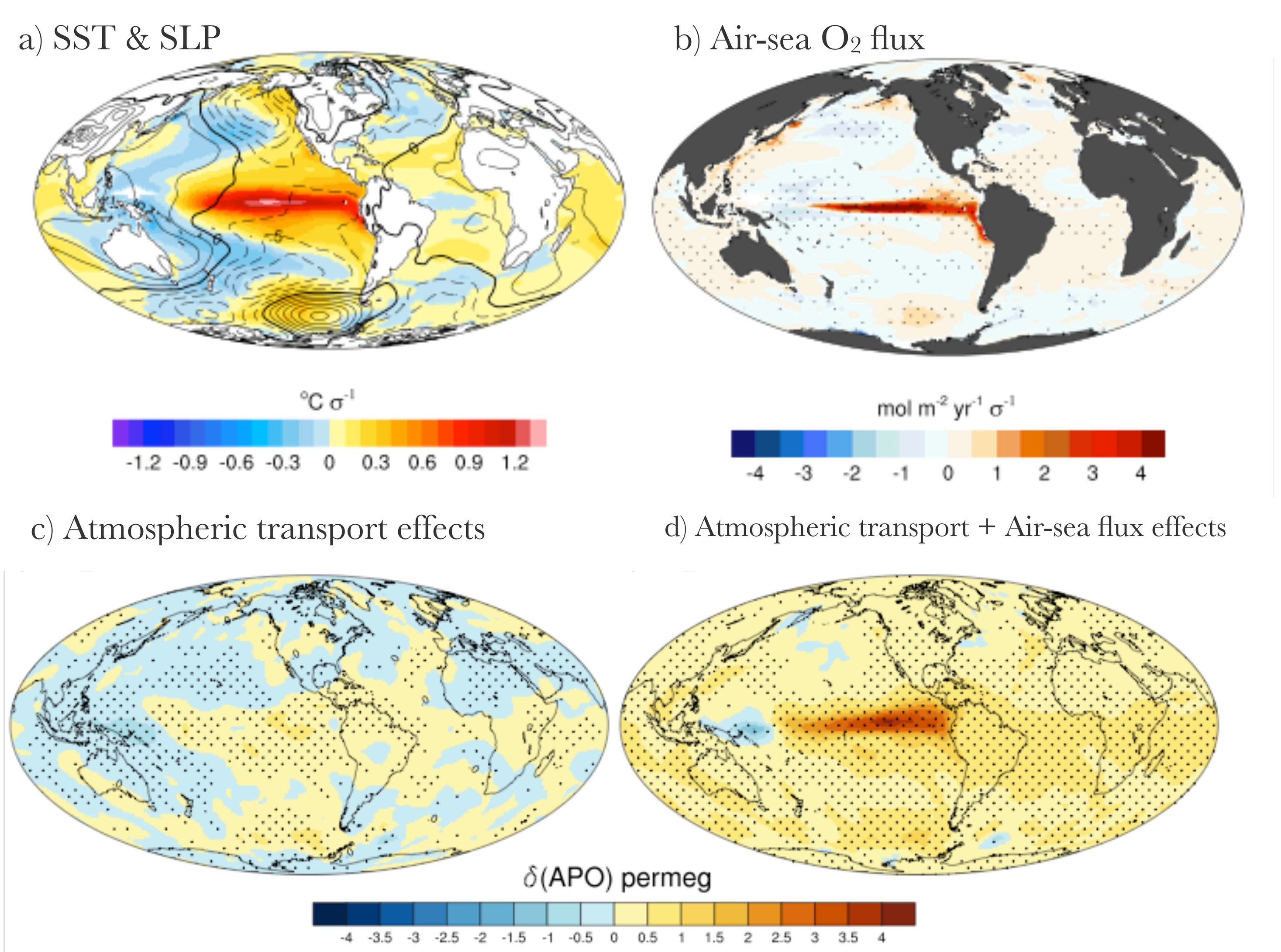




F_{VENT} reflects significant ΔO_2 anomalies along oxycline due to internal waves and ocean-atmosphere feedbacks (weaker easterlies, shallower and weaker upwelling during El Niño, weakened ventilation by zonal equatorial jets & weakened O_2 demand).

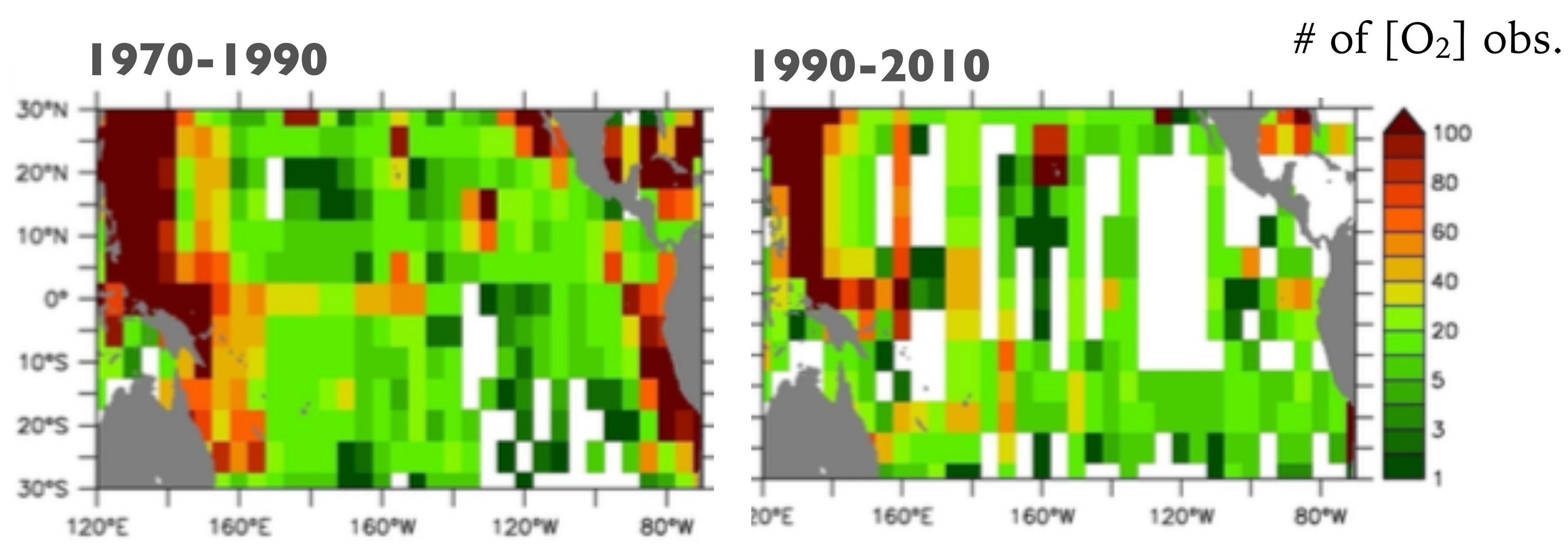
6. Atmospheric Transport Effects

APO anomalies due to ENSO effects on air-sea O_2 flux are amplified by atmospheric transport (weakened easterlies). East-west dipole explains observed discrepancies between Scripps and Japanese networks.



7. Implications for TPOS

In the absence of continuous interior [O_2] observations, impacts of ENSO on interior [O_2] distribution and budget remain poorly understood. Additional BGC sensors can provide deeper understanding of changes in OMZs. In turn, new O_2 observations can provide insights on physical dynamics (e.g. tracer of water masses and changes in thermocline depth, constraints on EUC strength and ventilation, etc.



References

Eddebbar, Y. A., M. C. Long, L. Resplandy, C. Rödenbeck, K. B. Rodgers, M. Manizza, and R. F. Keeling (2017), Impacts of ENSO on air-sea oxygen exchange: Observations and mechanisms, Global Biogeochem. Cycles, 31,

Acknowledgments