Characteristics of the Benguela Upwelling System: High-Resolution Ocean Model Results on Glacial-Interglacial Changes

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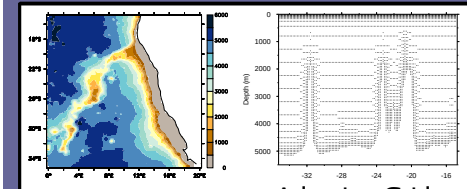
Question

How do Changes of Wind, Topography, and Preformation affect Upwelling Rate and Local Water Mass Properties?

VOM

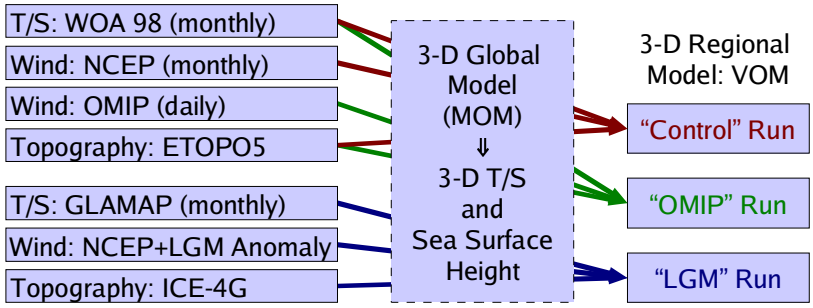


Topography, Depth (1/6°)

Adaptive Grid (Δz = 15-480 m)

Vector Ocean Model
J. Backhaus

Modelling Approach

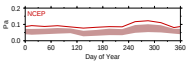


WOA 98: World Ocean Atlas 98, Nat. Oceanog. Data Center. **NCEP**: Kalnay et al., Bull. Am. Meteorol. Soc., 77, 437-471, 1996. **OMIP**: Röske, Rep. Max Planck Inst. f. Meteorol., 323, 2001. **ETOPO5**: Nat. Geophys. Data Center. **GLAMAP**: Sarnthein et al., Pflaumann et al., Gersonde et al., Niebler et al., Paleoceanogr., doi:10.1029/2002PA000769, ...774, ...809, ...902, 2003. **LGM Wind Anomaly**: S. Lorenz, from ECHAM3 experiments, pers. comm. **ICE-4G**: Peltier, Science, 265, 195-201, 1994.

Depths (m) of Mixed Layer - "ML", (ΔT = 0.5°C) and Ventilated Thermocline - "VT", (σ_t = 26.8 kgm^{-3})

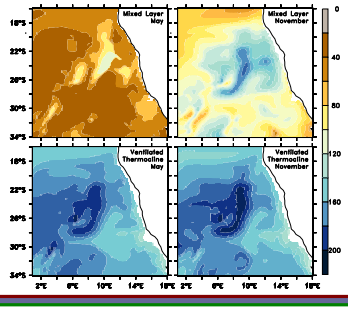
Temperature (°C) and Currents (ms^{-1})

Wind stress (Pa), mean±1σ and max

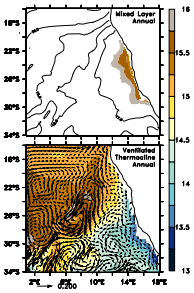


Control

- Intense seasonal cycle in the ML
- Meridional ML depth gradient
- No seasonal cycle in the VT

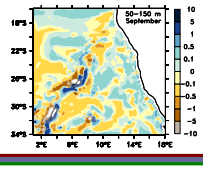


- Small influence of VT on ML
- Coastal inflow dominated from north



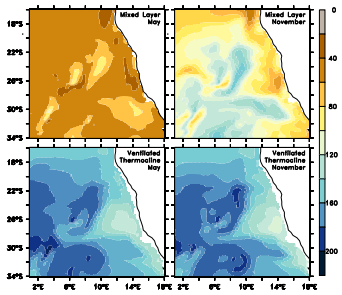
Vertical Velocity (md^{-1}, upward = blue) at 50-150 m Depth

- Sluggish coastal upwelling
- Maximum in September

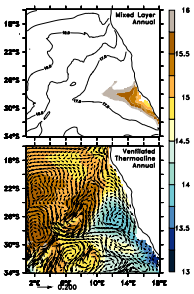


OMIP

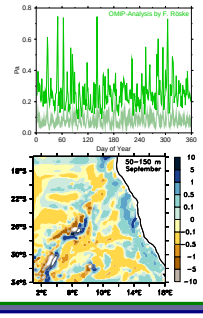
- Weaker seasonal cycle
- More homogeneous ML depth distribution
- VT slightly shal-lower



- Weak influence of VT on ML
- Enhanced inflow from north

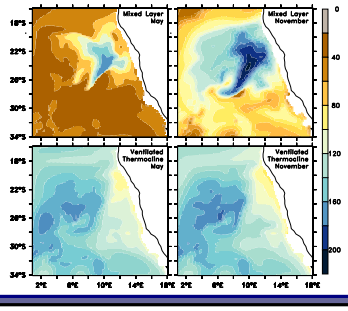


- Broad band with strongly intensified upwelling, comparable to observ-ations

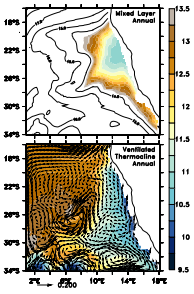


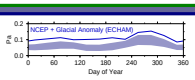
LGM

- Deeper ML
- Stronger seasonal cycle
- Much shallower VT (σ_t = 28.2 kgm^{-3})
- Levels intersect in November
- Easier vertical exchange

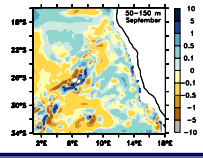


- Strong influence of VT on ML
- Intense southern inflow





- Coastal upwelling intensified at the very coast



Answers

General:
- Characteristics of the upwelled waters strongly depend on deeper inflow
- Daily wind fluctuations enhance upwelling, horizontal advection and nutrient supply, and smooth layer interfaces

LGM vs. today:
- Deeper mixed layer, shallower ventilated thermocline
- Easier vertical exchange, intensified upwelling
- Upwelling concentrated towards the coast
- Higher influence of waters of southern origin
- Opal Paradox: less silicate at higher upwelling rates?