

# Influence of atmospheric circulation and large-scale climate patterns on the Namibian upwelling system: analysis of atmosphere-ocean simulations

Nele Tim, Eduardo Zorita

24.09.2013 / Windhoek

## Motivation - Focus of interests

---

- Long-term trends of the Namibian upwelling
- Influence of large-scale atmospheric pattern
- Climate modes:
  - Antarctic Oscillation (AAO)
  - Tropical Atlantic variability
  - Pacific ENSO
  - Atlantic Meridional Mode (AMM)
  - Quasi-Biennial Oscillation (QBO)
  - St. Helena Index (HIX)
- Regional land-sea contrast of temperature and sea level pressure (SLP)
- Decadal variability of the Namibian upwelling
- Relationship with external forcings (GHG and solar variability)
- Analysis of Mode Waters and of the Oxygen Minimum Zone (OMZ)

# Genus Project

---

## Genus = Geochemistry and Ecology of the Namibian Upwelling System

**Project:** Analyses of the relationships between climate change, biogeochemical cycles and ecosystem structure in the large marine ecosystem off the Namibian coast

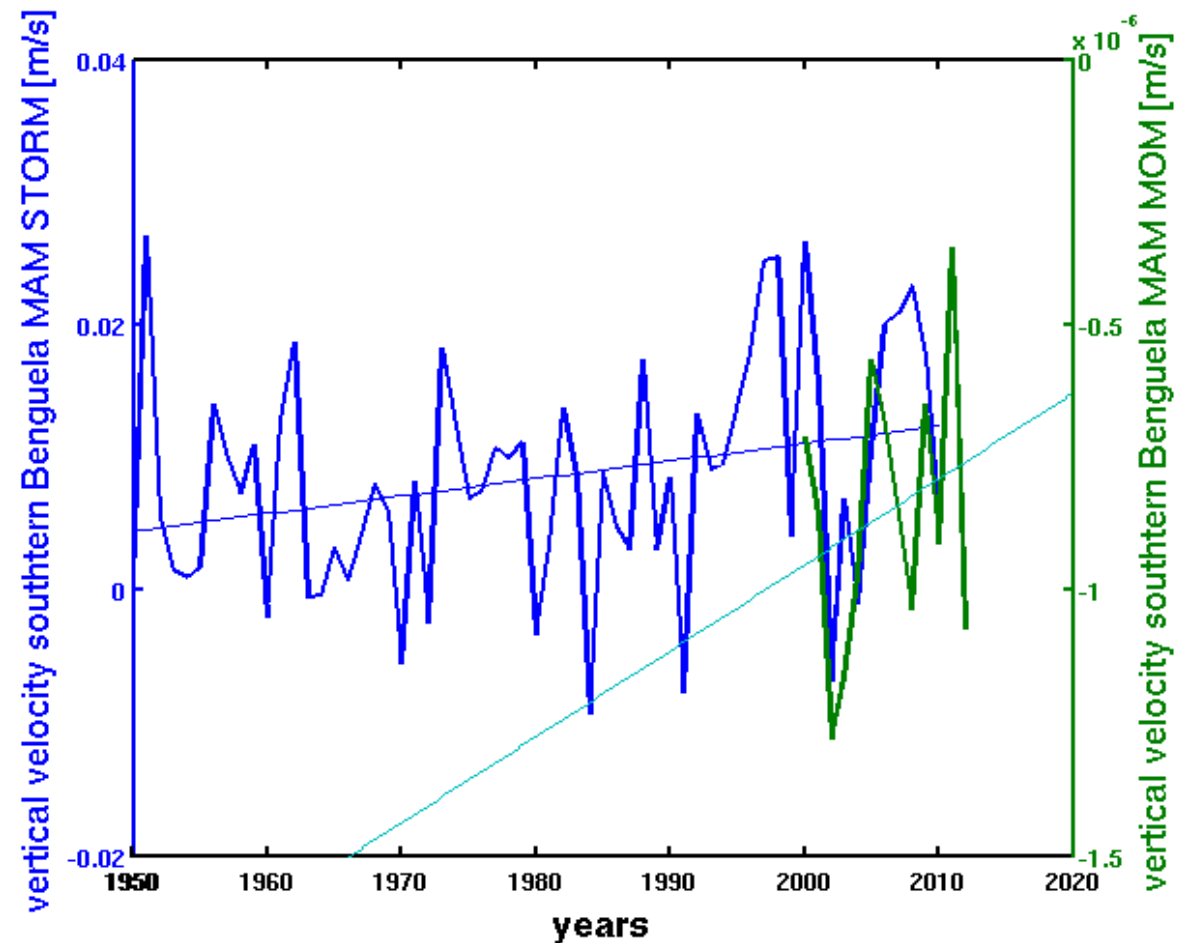
**Subproject 1:** relationship between the large-scale, low-frequency climate forcing and local processes that drive upwelling intensity in this region

Statistical analyses of the causes for the long-term variations at decadal and longer time scales of upwelling off the Namibian coast

- HadISST1 – gridded observation data;  
1870 – 2012;  
1°
  
- STORM – simulation of the global ocean model MPI-OM;  
1950 – 2010;  
0.1°
  
- MOM4 – regional simulation of the ecosystem model Modular Ocean Model 4.0;  
07/1999 – 05/2012;  
0.1°;  
6.63N – 34S, 10W – 18E
  
- Reanalysis Data:
  - NCEP; 1948 – 2011;  
2.5°
  - ERA Interim; 1979 – 2010;  
0.7°

# Long-term trends of Namibian upwelling

- vertical velocities of STORM and MOM4
- upwelling region separate in Northern - and Southern Benguela, border at 28°S
- negative trend in the north (except for DJF of STORM), positive trend in the south (except SON)
- trends in upwelling in Southern Benguela significant: MAM (+), SON (-), DJF (+)



# Correlations with atmospheric variables

---

- first EOF of SST of HadISST1, STORM, 10m-Temperatur of MOM4
- vertical velocities of MOM4 and STORM
  - strong anticyclone
  - strong southerly winds
  - strong southerly wind stress
  - air temperature contrast between land (positive) and ocean (negative)
- SSTs of HadISST1 and STORM present well the connection between upwelling and atmosphere. MOM4 provide mainly distinct results
- Northern Benguela:
  - STORM: expected pattern, except JJA (wind and air temperature)
  - MOM4: strongest correlations in SON and DJF; JJA only positively correlated with wind and SLP over northern Benguela
- Southern Benguela:
  - STORM, MOM4: no clear pattern: SLP positively correlated over southern South Atlantic, no southerly winds

# Correlations with climate indices

---

## Upwelling Index (SST)

- ENSO has significant influence in SON and DJF
- The tropical Atlantic seems to have a stronger influence than the Antarctic Ocean
- MOM4 upwelling is not influenced by ENSO

## Upwelling Index (vertical velocity)

- ENSO influences in DJF
- Impact of the Antarctic Ocean stronger than the of the tropical Atlantic
- MOM4 and STORM do not agree on the regional differences
- QBO and AMM: no significant influence

# Upwelling index derived from the 13°C isotherm

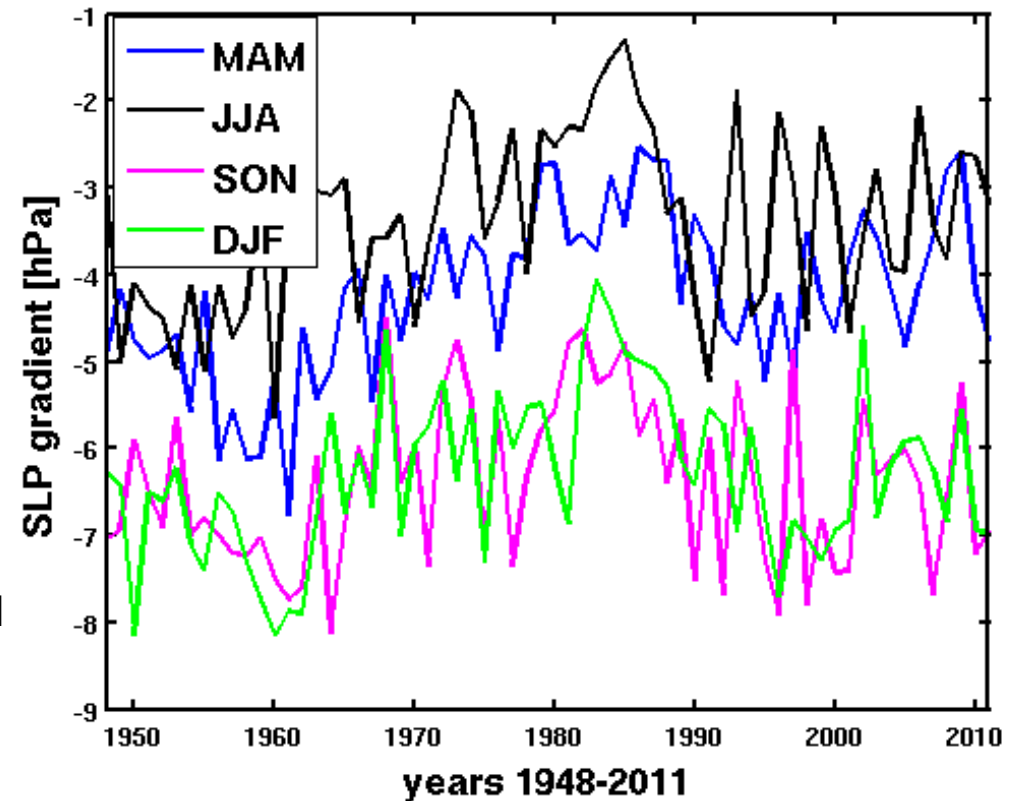
---

- Hagen defined an upwelling index derived from the 13°C isotherm of satellite data (AVHRR)
- Region between the 13°C isotherm and the coast is defined as the Intense Benguela Upwelling (IBU)
- SST of STORM
  - warm bias removed
- unbiased SST of STORM agrees quite well with the IBU of AVHRR
  - IBUs are larger in JJA and SON than in MAM and DJF



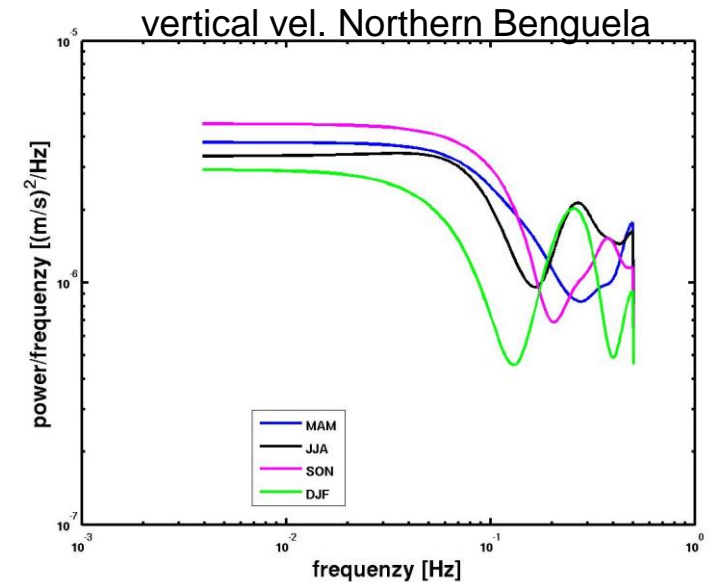
## Land-sea contrast: SLP gradient

- test Bakuns hypothesis
- SLP differences between land and ocean
- NCEP: significant positive trend in MAM and JJA
- correlations with upwelling index of vertical velocities:
  - Northern Benguela: in MAM and DJF
  - Southern Benguela: MAM

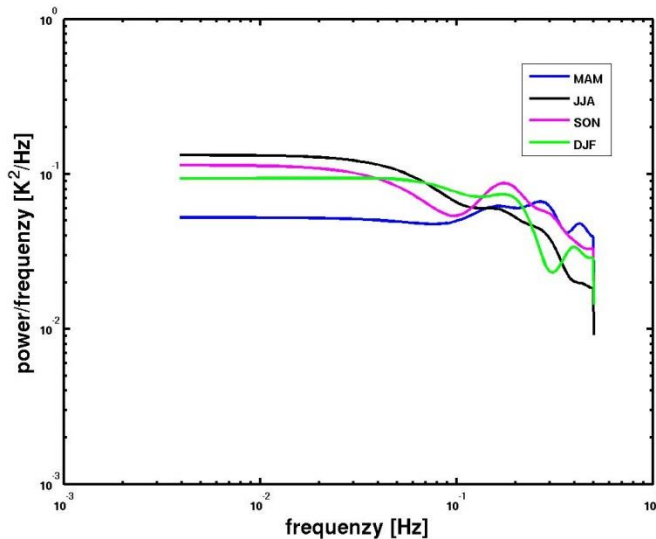
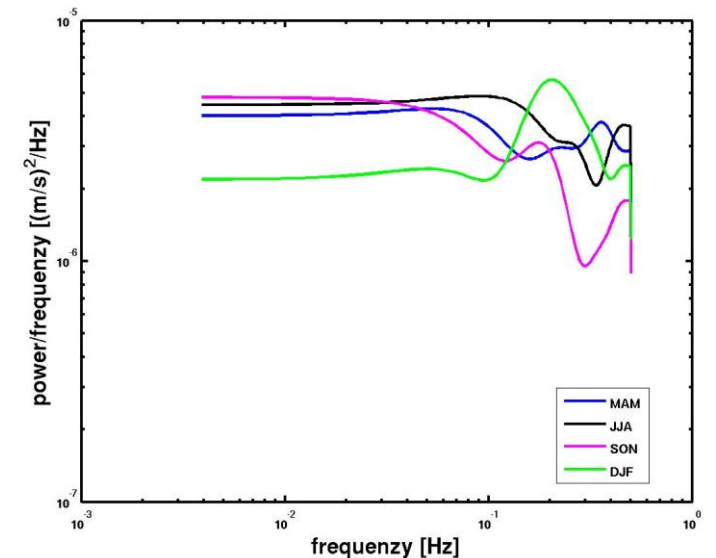


# Decadal variabilities – spectral analysis

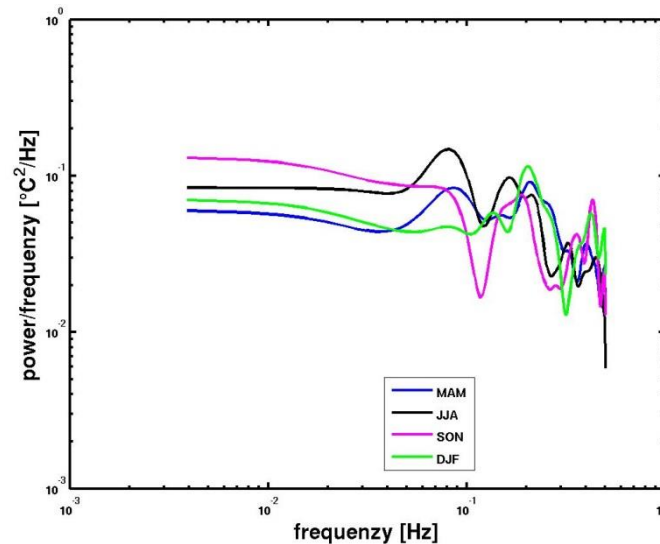
- Northern Benguela:
  - JJA, DJF 4 years; SON 2.5 years
- Southern Benguela:
  - DJF: peaks strongly at 5 years; SON weaker; MAM: 2.5 years
- STORM:
  - SON, DJF: 5 years; MAM: 3.5 years
- HadISST1:
  - DJF, SON: 5 years; JJA: 12.5 and 10 years; MAM: 12.5 and 5 years



vertical vel. Southern Benguela



SST STORM



SST HadISST1

# Summary

---

- SST, vertical velocity and 13°C isotherm provide good indices for upwelling
  - negative trends in upwelling in Northern Benguela, positive trends in upwelling in Southern Benguela
  - ENSO influences upwelling significantly in DJF
  - long-term evolution of the land-sea SLP gradient does not agree with Bakun hypothesis
  - Spectral analysis show periods of 5 years, 2.5 years and decadal variability of 10 and 12.5 years
  - External forcing, Mode Waters, OMZ: not yet analysed
-

**Thank you**

---